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TRANSCRIPT OF RECORD.

SUPREME COURT OF THE UNITED STATES.

OCTOBER TERM, 1905.

No. 4, Original.

THE STATE OF MISSOURI, COMPLAINANT,

vs.

THE STATE OF ILLINOIS AND THE SANITARY DISTRICT OF CHICAGO.

IN EQUITY.

BILL FILED JANUARY 22, 1900.

SUPREME COURT OF THE UNITED STATES.

OCTOBER TERM, 1905.

No. 4, ORIGINAL.

THE STATE OF MISSOURI, COMPLAINANT,

vs.

THE STATE OF ILLINOIS AND THE SANITARY DISTRICT OF CHICAGO.

IN EQUITY.

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1 At the Capitol of the United States in the city of Washington and District of Columbia, being the present seat of the National Government of the United States, on the second Monday of October (being the ninth day of the same month) in the year of our Lord one thousand eight hundred and ninety nine, and of the Independence of the United States the one hundred and twenty-fourth, the Supreme Court of the United States met agreeably to law.

2 And afterwards, to wit, on the 17th day of January, A. D. 1900, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.

Mr. Edward C. Crow, of counsel for the complainant, submitted to the consideration of the court a motion for leave to file a bill of complaint herein

Which said motion is in the words and figures following, viz:

3 In the Supreme Court of the United States. In Equity.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY DISTRICT OF CHICAGO, Defendants.

Now comes the complainant, The State of Missouri, by Edward C. Crow, its attorney general, and B. Schnurmacher, its counsel, and moves the court for leave to file and to present the accompanying bill of complaint.

EDWARD C. CROW,
Attorney General.

B. SCHNURMACHER, Counsel.

4 And afterwards, to wit, on the 22d day of January, A. D. 1900, the following order appears of record, viz:

Supreme Court of the United States, October Term, 1899.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY DISTRICT OF CHICAGO.
No. 7, Original.

On consideration of the motion for leave to file a bill of complaint herein, it is now here ordered by the court that said motion be, and

the same is hereby, granted, and that subpœnas returnable
5 on Monday, April 2d next be issued and served herein.

January 22, 1900.

(Endorsed :) Supreme Court U. S. No. 7, original. October term, 1899. Order. Filed January 22, 1900.

And on the same day, to wit, on the 22d day of January, A. D. 1900, the bill of complaint was filed in the words and figures following, viz:

6 Supreme Court of the United States, October Term, 1899.

THE STATE OF MISSOURI, Complainant, *vs.* THE STATE OF ILLINOIS and THE SANITARY District of Chicago.	No. 7, Original.

Bill of Complaint.

Edward C. Crow, attorney general of Missouri.
B. Schnurmacher, of counsel.

7 In the Supreme Court of the United States.

THE STATE OF MISSOURI, Complainant, *vs.* THE STATE OF ILLINOIS and THE SANITARY District of Chicago, Defendants.	In Equity. Bill for Injunction.

To the honorable the Chief Justice of the United States and the associate justices of the Supreme Court of the United States:

The complainant, The State of Missouri, and one of the States of the United States, brings this its bill of complaint against The State of Illinois, one of the States of the United States, and The Sanitary District of Chicago, a public corporation, organized under the laws of the State of Illinois, and located in part in the city of Chicago and in the county of Cook, in said State of Illinois, and a citizen of the State of Illinois.

And your orator complains and says that it is a State containing a population of upwards of three millions of people, and lying on the west bank of the Mississippi river, a public, navigable, and running stream, and having a frontage on said stream of over four hundred miles.

And your orator shows that by the act of Congress providing for the organization and admission of Illinois and Missouri as States of the Union it was declared that the western boundary of Illinois and the eastern boundary of Missouri should be the middle of the main channel of the Mississippi river; that the shores of the Mississippi river, where its waters form the Missouri and Illinois boundary, and the soil under the waters thereof were not granted by the Constitution to the United States, but were reserved to the States of Illinois and Missouri respectively.

And your orator shows that the States of Missouri and
8 Illinois each have concurrent general jurisdiction over the
waters of the Mississippi river forming the boundary between them, and each of said States has exclusive territorial jurisdiction over that portion adjacent to its own shore, and your orator shows that the Illinois river empties into the Mississippi river at a point above the city of St. Louis, on the Illinois side of said Mississippi river.

And your orator further shows that within the territory of your orator and on the banks and shores of said Mississippi river and below the mouth of the Illinois river are many cities and towns in the State of Missouri, and many thousands of persons who are compelled to and do rely upon the waters of said river, in their regular, natural, and accustomed flow, for their daily necessary supply of water for drinking and all other domestic and agricultural and manufacturing purposes, and for watering stock and animals of all kinds, and that said Mississippi river has been flowing in its regular course and has been used for the purposes aforesaid by the inhabitants of the said State of Missouri for a time whereof the memory of man runneth not to the contrary, and that said river and its waters and the use thereof for drinking, agricultural, and manufacturing purposes, in their accustomed and natural flow, are indispensable to the life and health and business of many thousands of the inhabitants of the State of Missouri and of great value to your orator as a State.

And your orator shows that cities and towns below the mouth of said Illinois river, within the territory of your orator, do and are compelled, by means of water works, water towers, and intakes, built and constructed for that purpose, to supply the inhabitants of said cities and towns with an adequate supply of pure and wholesome water, fit and healthful for drinking and all other domestic purposes and uses, from the said Mississippi river so flowing in its ancient, accustomed, and natural course.

And your orator shows that said water-works systems are
9 constructed with reference to said Mississippi river and for
the purpose of taking water therefrom and not from any other source.

And your orator shows that heretofore, to wit, in 1889, the State of Illinois enacted a law known as the sanitary district act, together with an act for the improvement of the Illinois and Des Plaines rivers, and that under said act of said State the said corporation known as the said Sanitary District of Chicago was organized and is now existing and operating, and that by the express terms of said act any canal or drain corporation organized in accordance with its provisions may have conditions, restrictions, or additional requirements placed on said corporation, or the act authorizing the creation of said corporation may be amended or repealed, and that by the express provisions of said act, before any water or sewage shall be admitted into any channel constructed under said act, the trustees of said channel shall notify the governor of Illinois of the completion of said channel, and the governor of Illinois shall appoint three commissioners to examine said canal or channel and report to the governor if the same complies with the act of the State of Illinois; and if it does, the governor shall authorize the water and sewage to be turned into said channel; and that without the said permit it cannot be so turned in; and that by the general provisions of said act said channel is at all times subject to the control and supervision of the State of Illinois and her authorities.

And your orator further shows that the Chicago river is situated in the basin of Lake Michigan and has two forks or branches flowing through the city of Chicago and into Lake Michigan, and that the natural drainage of Chicago, Illinois, is into Lake Michigan, and the sewage and drainage of the territory embraced in the defendant's district, The Sanitary District of Chicago, is led into or flows into the Chicago river and Lake Michigan.

10 And your orator further shows that the defendant herein, The Sanitary District of Chicago, with the authority of the State of Illinois, and acting as a governmental agency of said State, and under the supervision and control and subject to the approval of the State of Illinois, has constructed a channel or open drain from the West fork of the South branch of the Chicago river, in the city of Chicago and county of Cook, in the State of Illinois, to a point near Lockport, in the county of Will, in said State, where said channel or drain connects with and empties into the Des Plaines river, which empties into the Illinois river, and which latter river flows and empties into the Mississippi river at a point distant about forty-three miles above the city of St. Louis, Missouri.

And your orator further states that the channel built by the Sanitary District of Chicago was so built by said Sanitary District as one of the governmental agencies of the State of Illinois, and by the pretended lawful authority of said State, and under the direction, supervision, and control and governmental power of the State of Illinois, and which said State has heretofore at all times sanctioned and now, through its governor and other officers, sanctions the building of said channel and opening thereof.

And your orator further shows that in the construction of said channel or drain the defendant The Sanitary District of Chicago, Illinois, with the sanction and approval of the State of Illinois, cut through the natural ridge or water-shed which divides the basin of Lake Michigan from the basins of the Des Plaines and Illinois rivers and the basin of the Mississippi river, and that having so constructed said channel and having about completed the same, and having, under the supervision of and with the sanction of the State of Illinois, extended said artificial channel through said natural divide of the water-shed, the defendants now propose and threaten to receive into said channel or drain the sewage matter and filth of the Sanitary District of Chicago, which embraces nearly the whole city of 11 Chicago and a portion of the county of Cook, and, without any legal authority so to do, has already in part effectuated its said threat and purpose and threatens to permit and to cause said sewage and filth, by artificial means of pumping and otherwise, to flow through the channel or drain towards and into the said Des Plaines river and eventually into the Mississippi river, thereby, with the approval of and subject to the inspection and control and supervision of the State of Illinois, and by the pretended authority thereof, reversing the natural flow of said Chicago river.

And your orator further shows that the sewage matter and poisonous filth which it is thus threatened to receive and to permit and to cause to flow through said artificial channel into said Des Plaines river, is that which is created by a population of upwards of one and one-half millions of people, besides that which is created by a great number of stock yards, slaughtering establishments, rendering establishments, distilleries, and other business enterprises and industries lining both sides of the Chicago river, producing filth and noxious matters; all of which are there discharged into the said Chicago river or drained therein from the surface.

And your orator further shows that for many years past the said city of Chicago, the greater portion of which is embraced in the limits of the defendant corporation, The Sanitary District of Chicago, as aforesaid, has been discharging its sewage matter and filth into the Chicago river and into Lake Michigan in such large quantities that much of it has accumulated in the bed and along the sides of the river and upon the bed of said Lake Michigan, near the shores thereof, and that the plan threatened and attempted now to be adopted by the defendant The Sanitary District of Chicago, acting in conjunction with and subject to the control of the defendant The State of Illinois, and by the pretended authority of the said State of Illinois, will loosen said accumulated matter and filth, and 12 will also direct it and cause it to flow towards and into said artificial channel or drain, and thence into said Des Plaines river, and finally into the Mississippi river and into the waters thereof within the jurisdiction and under the control of your orator and past the homes of the inhabitants of your orator and the towns and cities within the borders of your orator, and past the water works of said cities and towns within the State of Missouri.

And your orator further shows that the amount of said undefecated filth and sewage and poisonous and unhealthful and noxious matters proposed to be, and now about to be, permitted to be turned into said artificial channel and through said Des Plaines and Illinois rivers into the Mississippi river from the said Sanitary District of Chicago by the defendants, acting jointly, will amount daily to about fifteen hundred tons, and that if defendants should be permitted to carry their said threats into execution, and should cause said above amount of undefecated sewage and other poisonous and noxious matters, which would otherwise flow into Lake Michigan, to flow into the Mississippi river, that the waters of the Mississippi river within the jurisdiction of your orator will of a certainty be poisoned and polluted and rendered wholly unfit and unhealthul for drinking and domestic uses, and will render wholly valueless and entirely worthless the various water-works systems of towns and cities on the borders of the State of Missouri, established and acquired at great cost and expense, and will deprive your orator, The State of Missouri, and its inhabitants, of the right to the use of the waters of said river for drinking and all other domestic and manufacturing and agricultural purposes, as said water has been so used in its accustomed and natural flow heretofore for the length of time that the memory of man runneth not to the contrary thereof.

13 And that said threatened action of the defendants will amount to a direct and continuing nuisance and be an interference with the use by your orator and its inhabitants of the waters of the Mississippi river flowing in their natural state, polluting and poisoning the same by the means aforesaid, whereby the health and lives of the inhabitants of your orator will be endangered and the business interests of said State will be greatly and irreparably injured, and which said damage to the lives and health and the business interests of said State resulting from said poisoning and polluting of said waters, as aforesaid, to your orator cannot be estimated in money value.

And your orator on information and belief states and charges the fact to be that said fifteen hundred tons of poisonous undefecated filth and sewage of said Sanitary District of Chicago will be daily carried through said artificial channel and sent through the Des Plaines and Illinois rivers into the Mississippi, and great quantities thereof will be deposited in the bed and soil of said river belonging to your orator and wholly within the jurisdiction thereof, to your orator's great and irreparable damage, and that the fifteen hundred tons of undefecated sewage and filth now about to be daily injected into the waters of the Mississippi river and into the portion thereof over which the State of Missouri has jurisdiction and from which thousands of her inhabitants obtain drinking water, will pollute and poison the said water of the Mississippi river to such an extent as to render it unwholesome and unfit and unhealthful for use for drinking by the said inhabitants in the territory of your orator and unfit for use for watering stock and for manufacturing purposes.

And your orator further shows that great quantities of undefecated sewage turned into the Mississippi river in the manner and by the means aforesaid will poison and pollute said water with the germs of disease of various and many kinds. And your orator further shows that the acts herein complained of on the part of the

State of Illinois, acting in conjunction with one of her governmental
agencies, the said Sanitary District of Chicago, will cause a
14 continuing nuisance in the Mississippi river, and that the
said State of Illinois has no power or authority to cause or
permit or assist in causing the commission and continuance of a
nuisance in the flowing waters of the Mississippi river, a navigable
stream, to the detriment and irreparable and continuing damage
and injury of the State of Missouri, and the continuing and irreparable
injury to the lives and health of the citizens and inhabitants
of the State of Missouri, and that unless restrained by the order and
decree of this court the defendants, The State of Illinois and The
Sanitary District of Chicago, acting together, will, in accordance
with the terms of the act under which said Sanitary District is organized,
upon the permit and authority of the governor of Illinois
and of the State of Illinois, turn said water and sewage aforesaid, by
the manner and means aforesaid, into the Des Plaines and Illinois
rivers and thence into the Mississippi, all of which your orator says
and avers is contrary to equity and good conscience, and would result
in the manifest and irreparable injury of your orator and the
health of her citizens in the premises, and your orator is wholly
without remedy at law and without any adequate remedy to prevent
the flowing of said sewage, as aforesaid, save by the interposition of
this court.

Forasmuch as your orator can have no adequate relief except in
this court, and to the end, therefore, that the defendants may, if
they can, show why your orator should not have the relief prayed,
and to the end that the defendants may make a full, true, direct,
and perfect answer to the matters hereinbefore stated and charged,
but not under oath, an answer under oath being hereby expressly
waived, and to the end that the defendants, their officers, agents,
servants, and employés, may be restrained by injunction issuing out
of this court from receiving or permitting any sewage to be received
or discharged into said artificial channel or drain, and from permitting
the same to flow or causing the same to be made to
15 flow through said channel or drain towards and into the Des
Plaines river, your orator prays that your honors may grant
a writ of injunction, under the seal of this honorable court, properly
restraining and enjoining the defendants, the officers, agents, employés,
and servants of the Sanitary District of Chicago and the
State of Illinois, from permitting or causing any of said sewage to be
discharged into said channel or drain, and from permitting or causing
said sewage and poisonous filth thence to flow into said Des
Plaines river; that defendant The State of Illinois be enjoined and
restrained from issuing to its codefendant permission and authority
to do and perform the acts aforesaid or to allow them to be done;
and your orator also prays for a provisional or temporary injunction
pending this cause, restraining and enjoining the several acts aforesaid,
and for such other and further relief as the equity of the case
may require and to your honors may seem meet.

May it please your honors to grant unto your orator not only a writ of injunction conformable to the prayer of this bill, but also a writ of subpœna of the United States of America, directed to The State of Illinois, the governor and attorney general thereof, and to said Sanitary District of Chicago, its officers, trustees, and agents, commanding them on a day certain to appear and answer unto this bill of complaint, and to abide such order and decree of the court in the premises as to the court shall seem proper and required by the principles of equity and good conscience.

THE STATE OF MISSOURI,
By LON V. STEPHENS, Governor.

EDWARD C. CROW,
Attorney General of Missouri.
B. SCHNURMACHER, Of Counsel.

16 UNITED STATES OF AMERICA:

In the Supreme Court of the United States.

On this 17th day of January, 1900, before me, James D. Maher, notary public, personally appeared Lon V. Stephens, governor of The State of Missouri, the complainant above named, who, being by me duly sworn, deposes and says that he is the governor of Missouri and familiar with its affairs and business; that he has read the foregoing bill of complaint and knows the contents thereof, and that the same is true of his own knowledge, except as to the matters therein stated on information and belief, and as to those matters he verily believes it to be true.

LON V. STEPHENS.

Subscribed and sworn to before me this 17th day of January, A. D. 1900.

[SEAL.]

JAMES D. MAHER,
Notary Public, District of Columbia.

(Endorsed:) In the Supreme Court of the United States. The State of Missouri, complainant, *vs.* The State of Illinois and The Sanitary District of Chicago, defendants. In equity. Bill of injunction.

(Endorsed:) Supreme Court U. S., October term, 1899. No. 7, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Bill of complaint. Filed January 22, 1900.

17 And on the same day, to wit, on the 22d day of January, A. D. 1900, an order for appearance for complainant was filed in the words and figures following, viz:

Order for Appearance.

Supreme Court of the United States, October Term, 1899.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
} No. 7, Orig'l.

The clerk will enter our appearance as counsel for the complainant.

EDWARD C. CROW,
Jefferson City, Mo.
(Name.) B. SCHNURMACHER,
(P. O. Address.) St. Louis, Mo.

☞ NOTE.—Must be signed by a member of the bar of the Supreme Court United States. Individual and not firm names must be signed.

(Endorsed :) Supreme Court U. S. October term 1899. Term No. 7, original. Appearance for complainant. Filed Jan'y 22, 1900.

18 And afterwards, to wit, on the 23d day of January, A. D. 1900, a subpœna was issued and delivered to the marshal for service.

And afterwards, to wit, on the 29th day of January, A. D. 1900, the subpœna, and proof of service of same, was filed in the words and figures following, viz :

19 THE UNITED STATES OF AMERICA, ss :

[SEAL.] The President of the United States of America to the State of Illinois and the Sanitary District of Chicago, Greeting :

For certain causes offered before the Supreme Court of the United States having jurisdiction in equity, you are hereby commanded that laying all other matters aside and notwithstanding any excuse, you be and appear before the said Supreme Court holding jurisdiction in equity, on the first Monday of April next at the city of Washington, in the District of Columbia, being the seat of the National Government of the United States, to answer unto the bill of complaint of the State of Missouri in the said court exhibited against you. Hereof you are not to fail at your peril.

Witness the Honorable Melville W. Fuller, Chief Justice of the United States, at the city of Washington, the 23d day of January, A. D. 1900.

JAMES H. McKENNEY,
Clerk of the Supreme Court of the United States.

Supreme Court of the United States.

MARSHAL'S OFFICE, January 23, 1900.

I, J. M. Wright, marshal of the Supreme Court of the United States, do hereby authorize and deputize John C. Ames, United States marshal for the northern district of Illinois, to serve the within writ, and make due return thereof, on the Sanitary District of Chicago.

J. M. WRIGHT,
Marshal, Supreme Court of the United States.

20 Supreme Court of the United States.

MARSHAL'S OFFICE, January 23, 1900.

I, J. M. Wright, marshal of the Supreme Court of the United States, do hereby authorize and deputize Charles P. Hitch, United States marshal for the southern district of Illinois, to serve the within writ on the State of Illinois and make due return thereof.

J. M. WRIGHT,
Marshal, Supreme Court of the United States.

UNITED STATES OF AMERICA,
Northern District of Illinois, Northern Division, } *ss:*

This writ came to hand the 25th day of January, 1900, and executed the 25th day of January 1900,—by making known the contents hereof to William Boldenweck, president of the Sanitary District of Chicago,—State of Illinois,—by reading to him this process, (or writ), by showing seal to him, and by delivering to him a copy of the bill in this cause and a copy of this process.

JOHN C. AMES,
U. S. Marshal, Northern Dist. of Ills,
By GEORGE Q. ALLEN, Deputy.

Fees.

1 service	$2.00
1 mile	.06
Total	$2.06

21 UNITED STATES OF AMERICA,
Southern District of Illinois, } *ss:*

This writ came to hand the 26th day of January, A. D. 1900. And executed the 26th day of January, A. D. 1900, by making known the contents hereof to John R. Tanner, governor, and Edward C. Akin, attorney general, of the State of Illinois, by reading to them this process, by showing seal to them, and by delivering to each of them a copy of the bill in this cause and a copy of this process.

CHARLES P. HITCH,
U. S. Marshal, Southern District of Illinois,
By E. E. WATTS, Deputy.

Fees.

2 services	$4.00
1 mile	.06
	$4.06

Endorsed: Supreme Court U. S., October term 1899 No. 7 original. The State of Missouri, complainant, *v.* The State of Illinois and the Sanitary District of Chicago. Subpœna and proof of service. Filed January 29, 1900.

22 And afterwards, to wit, on the 5th day of March, A. D. 1900, an order for appearance for defendants was filed in the words and figures following, viz:

Order for Appearance.

Supreme Court of the United States, October Term, 1899.

THE STATE OF MISSOURI
vs.
THE STATE OF ILLINOIS & THE SANITARY DISTRICT of Chicago.
} No. 7, Orig'l.

The clerk will enter my appearance as counsel for the defendants.
(Name.) WM. M. SPRINGER,
(P. O. address.) Kellogg Building, Washington, D. C.

☞ NOTE.—Must be signed by a member of the bar of the Supreme Court United States. Individual and not firm names must be signed.

(Endorsed:) Supreme Court U. S., October term, 1899. Term No. 7, orig'l. Appearance for def'ts. Filed Mar. 5, 1900.

23 And afterwards, to wit, on the 9th day of April, A. D. 1900, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
} No. 7, Original.

On motion of Mr. William M. Springer, of counsel for defendants, leave is hereby granted to file a demurrer herein, and leave is granted counsel for the complainant to file a printed brief thereon within twenty days.

24 And on the same day, to wit, on the 9th day of April, A. D. 1900, a demurrer was filed in the words and figures following, viz:

25 In the Supreme Court of the United States, October Term, 1899.

THE STATE OF MISSOURI, Complainant, *v.* THE STATE OF ILLINOIS and THE SANITARY District of Chicago, Defendants.	Number 7, Original.

Demurrer of Defendants to Bill of Complaint.

Now comes the State of Illinois by its attorney general, Edward C. Akin, and the Sanitary District of Chicago, by its attorneys, and demur to the bill of complaint filed herein, and say, that the said bill of complaint and the matters therein contained, in manner and form as the same are above stated and set forth, are not sufficient in law for the said State of Missouri to have and maintain its aforesaid action against the said State of Illinois and the Sanitary District of Chicago, and that said defendants are not bound by the law of the land to answer the same; and the said defendants, according to the form of the statute in such case made and provided, state and 26 show to the court here the following causes of demurrer to the said bill of complaint:

First. That this court has no jurisdiction of either the parties to, or of the subject matter of, this suit, because it appears upon the face of said bill of complaint that the matters complained of, as set forth therein, do not constitute, within the meaning of the Constitution of the United States, any controversy between the State of Missouri and the State of Illinois, or any of its citizens.

Second. That the matters alleged and set forth in said *said* bill of complaint show that the only issues presented therein arise, if at all, between the State of Illinois and a public corporation created under the laws of said State, and certain cities and towns, in their corporate capacity as such, in the State of Missouri, and certain persons in said State of Missouri, residing on or near the banks of the Mississippi river, and which matters so stated in said bill of complaint, if true, do not concern the State of Missouri as a corporate body or State.

Third. That said biil of complaint shows upon its face that this suit is in fact for and on behalf of certain cities and towns in said State of Missouri, situate on the banks of the Mississippi river, and certain persons who reside in said State on or near the banks of said river; and that, although the said suit is attempted to be prosecuted for and in the name of the State of Missouri, said State is, in effect, loaning its name to said cities and towns and to said individuals, and is only a nominal party to said suit, and that the real parties in interest are the said cities and towns in their corporate capacity as such, and said private persons or citizens of said State.

Fourth. That it appears upon the face of said bill of complaint,
that the said State of Missouri, in her right of sovereignty, is
27 seeking to maintain this suit for the redress of the supposed
wrongs of certain cities and towns in said State, in their corporate capacity as such, and of certain private citizens of said State, while under the Constitution of the United States and the laws enacted thereunder, the said State possesses no such sovereignty as empowers it to bring an original suit in this court for such purpose.

Fifth. That it appears upon the face of said bill of complaint, that no property rights of the State of Missouri are in any manner affected by the matters alleged in said bill of complaint; nor is there any such property right involved in this suit as would give this court original jurisdiction of this cause.

Sixth. That in order to authorize this court to maintain original jurisdiction of this suit as against the State of Illinois, or against any citizens of said State, it must appear that the controversy set forth in the bill of complaint and to be determined by this court, is a controversy arising directly between the State of Missouri and the State of Illinois, or some of its citizens, and not a controversy in vindication of the alleged grievances of certain cities and towns in said State or of particular individuals residing therein.

Seventh. That said bill of complaint is in other respects uncertain informal and insufficient, and that it does not state facts sufficient to entitle the said State of Missouri to the equitable relief prayed for in said bill of complaint.

Wherefore, for want of a sufficient bill of complaint in this behalf, the said defendants pray judgment; and that the said State of Missouri may be barred from having or maintaining the aforesaid action
against said defendants, and that this court will not take fur-
28 ther cognizance of this cause, and that the said defendants be
hence dismissed with their costs.

THE STATE OF ILLINOIS,
By EDWARD C. AKIN,
Attorney General of the State of Illinois.
CHARLES C. GILBERT,
SAMUEL M. BURDETT,
Attorneys of the Sanitary District of Chicago.
WILLIAM M. SPRINGER,
Of Counsel for Defendants.

I, William M. Springer, of counsel for the said defendants, do certify that the above demurrer is, in my opinion, well founded in point of law.

WILLIAM M. SPRINGER,
Of Counsel for Defendants.

I, William M. Springer, of counsel for said defendants, upon my oath do say, that the above demurrer is not interposed for delay.

WILLIAM M. SPRINGER,
Of Counsel for Defendants.

Subscribed and sworn to before me this 17th day of March, 1900.

[L. S.]

EDW'D N. LEWIS,
Notary Public.

(Endorsed:) Supreme Court U. S., October term 1899 No. 7, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Demurrer of defendants to bill of complaint. Filed April 9, 1900.

29 And afterwards, to wit, on the 30th day of April, A. D. 1900, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
No. 7, Original.

This cause was submitted to the consideration of the court on the demurrer of the defendants on printed arguments by Mr. E. C. Crow and Mr. B. Schnurmacher, of counsel for the complainant, and Mr. W. M. Springer and Mr. E. C. Akin, of counsel for the defendants, with leave to counsel for defendants to file brief within one week.

30 And afterwards, to wit, on the 21st day of May, A. D. 1900, the following order appears of record, viz:

Supreme Court of the United States, October Term, 1899.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
No. 7, Original.

It is ordered by the court that this cause be, and the same is hereby, restored to the docket for oral argument May 21, 1900.

(Endorsed:) Supreme Court U. S., October term, 1899. No. 7, original. Order. Filed May 21, 1900.

31 And afterwards, to wit, on the 9th day of October, A. D. 1900, a motion to assign demurrer for argument was filed and submitted in the words and figures following, viz:

32 Supreme Court of the United States, October Term, 1900.

THE STATE OF MISSOURI
vs.
THE STATE OF ILLINOIS and THE SANITARY DISTRICT of Chicago. } No. 5, Original.

Come now the said defendants and move this honorable court to set down the demurrer in this case for oral argument on Monday, November 12, 1900, or as soon thereafter as it may please the court to hear the same; and that there be allowed two hours for argument to counsel on each side of the case.

Counsel for said defendants respectfully submit that this motion as to the time for oral argument meets the approval of counsel for plaintiff.

Respectfully submitted,

WM. M. SPRINGER,
Counsel for Defendants.

33 Coat of Arms
of
State of Missouri.

State of Missouri, City of Jefferson, Legal Department.

Edward C. Crow, Attorney General; Sam. B. Jeffries, Assistant.

OCTOBER 3, 1900.

Hon. Wm. M. Springer, Kellogg building, 1416 F street, Washington, D. C.

DEAR SIR: I have communicated with Hon. Benj. Schnurmacher, counsellor for St. Louis city, and he states that your suggestion about the argument of the demurrer in Missouri *vs.* Illinois being postponed until Nov. 12th, will be agreeable to him, and I write to say that it will suit me exactly; I shall act upon the theory that the matter will be heard on November 12th.

Very truly yours, EDWARD C. CROW,
Attorney General.

Endorsed: Supreme Court U. S, October term, 1900. No. 4, original. The State of Missouri, complainant, *v.* The State of Illinois *et al.* Motion to assign demurrer for argument. Office Supreme Court U. S. Filed Oct. 9, 1900. James H. McKenney, clerk.

34 And on the same day, to wit, on the 9th day of October, A. D. 1900, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
No. 5, Original.

On motion of Mr. William M. Springer, of counsel for the defendants, it is ordered by the court that this cause be, and the same is hereby, assigned for argument on Monday, November 12th.

35 And afterwards, to wit, on the 12th day of November, A. D. 1900, an order for appearance for respondents was filed in the words and figures following, viz:

Order for Appearance.

Supreme Court of the United States, October Term, 1900.

THE STATE OF MISSOURI
vs.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago.
No. 5, Orig'l.

The clerk will enter my appearance as counsel for the respondents.

(Name.) CHARLES C. GILBERT,
(P. O. address.) 1106 Security Bldg., Chicago, Ills.

☞ NOTE.—Must be signed by a member of the bar of the Supreme Court United States. Individual and not firm names must be signed.

(Endorsed:) Supreme Court U. S., October term, 1900. Term No. 5, orig'l. Appearance for respondents. Filed Nov. 12, 1900.

36 And on the same day, to wit, on the 12th day of November, A. D. 1900, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
No. 5, Original.

The argument of the demurrer in this cause was commenced by Mr. Charles C. Gilbert, of counsel for the defendants, and continued by Mr. B. Schnurmacher of counsel for the complainant.

And afterwards, to wit, on the 13th day of November, A. D. 1900, the following entry appears of record, viz:

37 THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
No. 5, Original.

The argument of the demurrer in this cause was continued by Mr. B. Schnurmacher, of counsel for the complainant, and concluded by Mr. William M. Springer, of counsel for the defendants.

38 And afterwards, to wit, on the 28th day of January, A. D. 1901, the following order appears of record, viz:

Supreme Court of the United States, October Term, 1900.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago.
No. 5, Original.

This cause came on to be heard on the bill of complaint and demurrer of the defendants thereto, and was argued by counsel. On consideration whereof, it is now here ordered, adjudged, and decreed by this court that said demurrer be, and the same is,
39 hereby, overruled, and leave is given to the defendants to file answers to the bill.
January 28, 1901.

(Endorsed:) Supreme Court U. S., October term, 1900. No. 5, original. Order. Filed January 28, 1901.

And on the same day, to wit, on the 28th day of January, A. D. 1901, an opinion and dissenting opinion were filed in the words and figures following, to wit:

40 Supreme Court of the United States, October Term, 1900.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago.
No. 5, Original.

(January 28, 1901.)

In January, 1900, the State of Missouri filed in this court a bill of complaint against the State of Illinois and the Sanitary District of Chicago, a corporation of the latter State, in the following terms:

"The complainant, The State of Missouri, and one of the States of the United States, brings this its bill of complaint against the State of Illinois, one of the States of the United States, and the Sanitary District of Chicago, a public corporation, organized under the laws of the State of Illinois, and located in part in the city of Chicago and in the county of Cook, in said State of Illinois, and a citizen of the State of Illinois.

"And your orator *complains and says that it is a State containing* a population of upwards of three millions of people, and lying on the west bank of the Missouri river, a public, navigable and running stream, and having a frontage on said stream of over four hundred miles.

"And your orator shows that by the act of Congress providing for the organization and admission of Illinois and Missouri as States of the Union it was declared that the western boundary of Illinois and the eastern boundary of Missouri should be the middle of the main channel of the Mississippi river; that the shores of the Mississippi river, where its waters form the Missouri and Illinois boundary, and the soil under the water thereof, were not granted by the Constitution of the United States, but were reserved to the States of Illinois and Missouri respectively.

"And your orator shows that the States of Missouri and Illinois each have concurrent general jurisdiction over the waters of the Mississippi river forming the boundary between them, and each of said States has exclusive territorial jurisdiction over that portion adjacent to its own shore, and your orator shows that the Illinois river empties into the Mississippi river at a point above the city of St. Louis, on the Illinois side of said Mississippi river.

"And your orator further shows that within the territory of your orator and on the banks and shores of said Mississippi river and below the mouth of the Illinois river are many cities and towns in the State of Missouri, and many thousands of persons who are compelled to and do rely upon the waters of said river, in their regular, natural and accustomed flow, for their daily necessary supply of water for drinking and all other domestic and agricultural and manufacturing purposes, and for watering stock and animals of all kinds, and that said Mississippi river has been flowing in its regular
41 course and has been used for the purposes aforesaid by
the inhabitants of the said State of Missouri for a time whereof the memory of a man runneth not to the contrary, and that said river and its waters and the use thereof for drinking, agricultural and manufacturing purposes, in their accustomed and natural flow, are indispensable to the life and health and business of many thousands of the inhabitants of the State of Missouri and of great value to your orator as a State.

"And your orator shows that cities and towns below the mouth of said Illinois river, within the territory of your orator, do and are compelled, by means of water works, water towers and intakes, built and constructed for that purpose, to supply the inhabitants of said cities and towns with an adequate supply of pure and wholesome water, fit and healthful for drinking and all other domestic purposes and uses, from the said Mississippi river so flowing in its ancient, accustomed and natural course.

"And your orator shows that said water works systems are constructed with reference to said Mississippi river and for the purpose of taking water therefrom and not from any other source.

"And your orator shows that heretofore, to wit, in 1889, the State of Illinois enacted a law known as the Sanitary District act, together with an act for the improvement of the Illinois and Des Plaines rivers, and that under said act of said State the said corporation known as the said Sanitary District of Chicago was organized and is now existing and operating, and that by the express terms of said act any canal or drain corporation organized in accordance with its provisions may have conditions, restrictions or additional requirements placed on said corporation, or the act authorizing the creation of said corporation may be amended or repealed, and that by the express provisions of said act, before any water or sewage shall be admitted into any channel constructed under said act, the trustees of said channel shall notify the governor of Illinois of the completion of said channel, and the governor of Illinois shall appoint three commissioners to examine said canal or channel and report to the governor if the same complies with the act of the State of Illinois; and if it does, the governor shall authorize the water and sewage to be turned into said channel; and that without the said permit it cannot be so turned in; and that by the general provisions of said act said channel is at all times subject to the control and supervision of the State of Illinois and her authorities.

"And your orator further shows that the Chicago river is situated in the basin of Lake Michigan and has two forks or branches flowing through the city of Chicago and into Lake Michigan, and that the natural drainage of Chicago, Illinois, is into Lake Michigan, and the sewage and drainage of the territory embraced in the defendant's district, the Sanitary District of Chicago, is led into or flows into the Chicago river and Lake Michigan.

"And your orator further shows that the defendant herein, The Sanitary District of Chicago, with the authority of the State of Illinois, and acting as a governmental agency of said State, and under the supervision and control and subject to the approval of the State of Illinois, has constructed a channel or open drain from the West fork of the South branch of the Chicago river, in the city of Chicago and county af Cook, in the State of Illinois, to a point near Lockport, in the county of Will, in said State, where said channel or drain connects with and empties into the Des Plaines river, which empties into the Illinois river, and which latter river flows and empties into the Mississippi river at a point distant about forty-three miles above the city of St. Louis, Missouri. 42

"And your orator further states that the channel built by the Sanitary District of Chicago was so built by said Sanitary District as one of the governmental agencies of the State of Illinois, and by the pretended lawful authority of said State, and under the direction, supervision and control and governmental power of the State of Illinois, and which said State has heretofore at all times sanctioned and now, through its governor and other officers, sanctions the building of said channel and opening thereof.

"And your orator further shows that in the construction of said channel or drain the defendant, The Sanitary District of Chicago, Illinois, with the sanction and approval of the State of Illinois, cut through the natural ridge or watershed which divides the basin of Lake Michigan from the basins of the Des Plaines and Illinois rivers and the basin of the Mississippi river, and that having so constructed said channel and having about completed the same, and having, under the supervision of and with the sanction of the State of Illinois, extended said artificial channel through said natural divide of the watershed, the defendants now propose and threaten to receive into said channel or drain the sewage matter and filth of the Sanitary District of Chicago, which embraces nearly the whole city of Chicago and a portion of the county of Cook, and, without any legal authority so to do, has already in part effectuated its said threat and purpose and threatens to permit and to cause said sewage and filth, by artificial means of pumping and otherwise, to flow through the channel or drain towards and into the said Des Plaines river and eventually into the Mississippi river, thereby, with the approval of and subject to the inspection and control and supervision of the State of Illinois, and by the pretended authority thereof, reversing the natural flow of said Chicago river.

"And your orator further shows ,that the sewage matter and poisonous filth which it is thus threatened to receive and to permit and to cause to flow through said artificial channel into said Des Plaines river is that which is created by a population of upwards of one and one-half millions of people, besides that which is created by a great number of stock yards, slaughtering establishments, rendering establishments, distilleries and other business enterprises and industries lining both sides of the Chicago river, producing filth and noxious matters; all of which are there discharged into the said Chicago river or drained therein from the surface.

"And your orator further shows that for many years past the said city of Chicago, the greater portion of which is embraced in the limits of the defendant corporation, The Sanitary District of Chicago, as aforesaid, has been discharging its sewage matter and filth into the Chicago river and into Lake Michigan in such large quantities that much of it has accumulated in the bed and along the sides of the river and upon the bed of said Lake Michigan, near the shores thereof, and that the plan threatened and attempted now to be adopted by the defendant, The Sanitary District of Chicago, acting in conjunction with and subject to the control of the defendant, The State of Illinois, and by the pretended authority of the said State of Illinois, will loosen said accumulated matter and filth, and will also direct it and cause it to flow towards and into said artificial channel or drain, and thence into said Des Plaines river, and finally into the Mississippi river and into the waters thereof within the jurisdiction and under the control of your orator and past the homes of 43 the inhabitants of your orator and the towns and cities within the borders of your orator, and past the water works of said cities and towns within the State of Missouri.

"And your orator further shows that the amount of said undefecated filth and sewage and poisonous and unhealthful and noxious matters proposed to be, and now about to be, permitted to be turned into said artificial channel and through said Des Plaines and Illinois rivers into the Mississippi river from the said Sanitary District of Chicago by the defendants, acting jointly, will amount daily to about fifteen hundred tons, and that if defendants should be permitted to carry their said threats into execution, and should cause said above amount of undefecated sewage and other poisonous and noxious matters, which would otherwise flow into Lake Michigan, to flow into the Mississippi river, that the waters of the Mississippi river within the jurisdiction of your orator will of a certainty be poisoned and polluted and rendered wholly unfit and unhealthful for drinking and domestic uses, and will render wholly valueless and entirely worthless the various water works systems of towns and cities on the borders of the State of Missouri, established and acquired at great cost and expense, and will deprive your orator, The State of Missouri, and its inhabitants, of the right to use of the waters of said river for drinking and all other domestic and manufacturing and agricultural purposes, as said water has been so used in its accustomed and natural flow heretofore for the length of time that the memory of man runneth not to the contrary thereof.

"And that said threatened action of the defendants will amount to a direct and continuing nuisance and be an interference with the use by your orator and its inhabitants of the water of the Mississippi river flowing in their natural state, polluting and poisoning the same by the means aforesaid, whereby the health and lives of the inhabitants of your orator will be endangered and the business interests of said State will be greatly and irreparably injured, and which said damage to the lives and health and the business interests of said State resulting from said poisoning and polluting of said waters as aforesaid to your orator cannot be estimated in money value.

"And your orator on information and belief states and charges the fact to be that said fifteen hundred tons of poisonous undefecated filth and sewage of said Sanitary District of Chicago will be daily carried through said artificial channel and sent through the Des Plaines and Illinois rivers into the Mississippi, and great quantities thereof will be deposited in the bed and soil of said river belonging to your orator and wholly within the jurisdiction thereof, to your orator's great and irreparable damage, and that the fifteen hundred tons of undefecated sewage and filth now about to be daily injected into the waters of the Mississippi river and into the portion thereof over which the State of Missouri has jurisdiction, and from which thousands of her inhabitants obtain drinking water, will pollute and poison the said water of the Mississippi river to such an extent as to render it unwholesome and unfit and unhealthful for use for drinking by the said inhabitants in the territory of your orator and unfit for use for watering stock and for manufacturing purposes.

"And your orator further shows that great quantities of undefecated sewage turned into the Mississippi river in the manner and by the means aforesaid will poison and pollute said water with the germs of disease of various and many kinds. And your orator further shows that the acts herein complained of on the part 44 of the State of Illinois, acting in conjunction with one of her governmental agencies, the said Sanitary District of Chicago, will cause a continuing nuisance in the Mississippi river, and that the said State of Illinois has no power or authority to cause or permit or assist in causing the commission and continuance of a nuisance in the flowing waters of the Mississippi river, a navigable stream, to the detriment and irreparable and continuing damage and injury of the State of Missouri, and the continuing and irreparable injury to the lives and health of the citizens and inhabitants of the State of Missouri, and that unless restrained by the order and decree of this court the defendants, The State of Illinois and The Sanitary District of Chicago, acting together, will, in accordance with the terms of the act under which said Sanitary District is organized, upon the permit and authority of the governor of Illinois and of the State of Illinois, turn said water and sewage aforesaid, by the manner and means aforesaid, into the Des Plaines and Illinois rivers and thence into the Mississippi, all of which your orator says and avers is contrary to equity and good conscience, and would result in the manifest and irreparable injury of your orator and the health of her citizens in the premises, and your orator is wholly without remedy at law and without any adequate remedy to prevent the flowing of said sewage, as aforesaid, save by the interposition of this court.

"For as much as your orator can have no adequate relief except in this court, and to the end, therefore, that the defendants may, if they can, show why your orator should not have the relief prayed, and to the end that the defendants may make a full, true, direct and perfect answer to the matters hereinbefore stated and charged, but not under oath, an answer under oath being hereby expressly waived, and to the end that the defendants, their officers, agents, servants and employees may be restrained by injunction issuing out of this court from receiving or permitting any sewage to be received or discharged into said artificial channel or drain, and from permitting the same to flow or causing the same to be made to flow through said channel or drain towards and into the Des Plaines river, your orator prays that your honors may grant a writ of injunction, under the seal of this honorable court, properly restraining and enjoining the defendants, the officers, agents, employees and servants of the Sanitary District of Chicago and the State of Illinois, from permitting or causing any of said sewage to be discharged into said channel or drain, and from permitting or causing said sewage and poisonous filth thence to flow into said Des Plaines river; that defendant, The State of Illinois, be enjoined and restrained from issuing to its codefendant permission and authority to do and perform the acts aforesaid or to allow them to be done; and your orator also prays for a provisional or temporary injunction pending this cause, restraining and enjoining the several acts aforesaid, and for such other and further relief as the equity of the case may require and to your honors may seem meet.

"May it please your honors to grant unto your orator not only a writ of injunction conformable to the prayer of this bill, but also a writ of subpœna of the United States of America, directed to the State of Illinois, the governor and attorney general thereof, and to said Sanitary District of Chicago, its officers, trustees and agents, commanding them on a day certain to appear and answer unto this bill of complaint, and to abide such order and decree of the court in the premises as to the court shall seem proper and required by the principles of equity and good conscience."

45 In March, 1900, came the defendants and filed a demurrer to the bill of complaint, in the following terms:

"Now comes the State of Illinois by its attorney general, Edwin C. Akin, and the Sanitary District of Chicago, by its attorneys, and demur to the bill of complaint filed herein, and say that the said bill of complaint and the matters therein contained, in manner and form as the same are above stated and set forth, are not sufficient in law for the said State of Missouri to have and maintain its aforesaid action against the said State of Illinois and the Sanitary District of Chicago, and that said defendants are not bound by the law of the land to answer the same; and the said defendants, according to the form of the statute in such case made and provided, state and show to the court here the following causes of demurrer to the said bill of complaint:

"*First.* That this court has no jurisdiction of either the parties to, or of the subject matter of, this suit, because it appears upon the face of said bill of complaint that the matters complained of, as set forth therein, do not constitute, within the meaning of the Constitution of the United States, any controversy between the State of Missouri and the State of Illinois, or any of its citizens.

"*Second.* That the matters alleged and set forth in said bill of complaint show that the only issues presented therein arise, if at all, between the State of Illinois and a public corporation created under the laws of said State, and certain cities and towns, in their corporate capacity as such, in the State of Missouri, and certain persons in said State of Missouri, residing on or near the banks of the Mississippi river, and which matters so stated in said bill of complaint, if true, do not concern the State of Missouri as a corporate body or State.

"*Third.* That said bill of complaint shows upon its face that this suit is in fact for and on behalf of certain cities and towns in said State of Missouri, situate on the banks of the Mississippi river, and certain persons who reside in said State on or near the banks of said river; and that, although the said suit is attempted to be prosecuted for and in the name of the State of Missouri, said State is, in effect loaning its name to said cities and towns and to said individuals, and is only a nominal party to said suit, and that the real parties in interest are the said cities and towns in their corporate capacity as such, and said private persons or citizens of said State.

"*Fourth.* That it appears upon the face of said bill of complaint that the said State of Missouri, in her right of sovereignty, is seeking to maintain this suit for the redress of the supposed wrongs of certain cities and towns in said State, in their corporate capacity as such, and of certain private citizens of said State, while under the Constitution of the United States and the laws enacted thereunder, the said State possesses no such sovereignty as empowers it to bring an original suit in this court for such purpose.

"*Fifth.* That it appears upon the face of said bill of complaint that no property rights of the State of Missouri are in any manner affected by the matters alleged in said bill of complaint; nor is there any such property right involved in this suit as would give this court original jurisdiction of this cause.

46 "*Sixth.* That in order to authorize this court to maintain original jurisdiction of this suit as against the State of Illinois, or against any citizens of said State, it must appear that the controversy set forth in the bill of complaint and to be determined by this court, is a controversy arising directly between the State of Missouri and the State of Illinois, or some of its citizens, and not a controversy in vindication of the alleged grievances of certain cities and towns in said State or of particular individuals residing therein.

"*Seventh.* That said bill of complaint is in other respects uncertain, informal and insufficient, and that it does not state facts sufficient to entitle the said State of Missouri to the equitable relief prayed for in said bill of complaint.

"Wherefore, for want of a sufficient bill of complaint in this behalf, the said defendants pray judgment; and that the said State of Missouri may be barred from having or maintaining the aforesaid action against said defendants, and that this court will not take further cognizance of this cause, and that the said defendants be hence dismissed with their costs."

On November 12, 1900, the case came on to be heard on bill and demurrer, and was argued by counsel.

Mr. Justice SHIRAS delivered the opinion of the court.

This cause is now before us on the bill of complaint and the demurrer thereto.

The questions thus presented are two: First, whether the allegations of the bill disclose the case of a controversy between the State of Missouri and the State of Illinois and a citizen thereof, within the meaning of the Constitution and statutes of the United States, which create and define the original jurisdiction of this court; and, second, whether, if it be held that the allegations of the bill do present such a controversy, they are sufficient to entitle the State of Missouri to the equitable relief prayed for.

The question whether the acts of one State in seeking to promote the health and prosperity of its inhabitants by a system of public works, which endangers the health and prosperity of the inhabitants of another and adjacent State, would create a sufficient basis for a controversy, in the sense of the Constitution, would be readily answered in the affirmative if regard were to be had only to the language of that instrument.

"The judicial power of the United States shall be vested in one Supreme Court, and in such inferior courts as the Congress may from time to time ordain and establish. * * * The judicial power shall extend to all cases, in law and equity, arising under this Constitution, the laws of the United States, and treaties made, or which shall be made, under their authority, * * * to controversies between two or more States, between a State and citizens of another State. * * * In all cases, * * * in which a State shall be a party, the Supreme Court shall have original jurisdiction." (Constitution, article 3.)

47 As there is no definition or description contained in the Constitution of the kind and nature of the controversies that should or might arise under these provisions, it might be supposed that, in all cases wherein one State should institute legal proceedings against another, the original jurisdiction of this court would attach.

But in this, as in other instances, when called upon to construe and apply a provision of the Constitution of the United States, we must look not merely to its language, but to its historical origin, and to those decisions of this court in which its meaning and the scope of its operation have received deliberate consideration.

After the declaration of independence the united colonies, through delegates appointed by each of the colonies, considered articles of confederation, which were debated from day to day, and from time to time, for two years, and were on July 9, 1778, ratified by ten States; by New Jersey, on November 26 of the same year; by Delaware, on the 23d of February, 1779, and by Maryland on March 1, 1781.

The first article was as follows: "The style of this confederacy shall be, 'The United States of America.'"

The ninth article contained, among other provisions, the following: "The United States in Congress assembled shall also be the last resort on appeal in all disputes and differences now subsisting, or that may hereafter arise, between two or more States, concerning boundary, jurisdiction or any other cause whatsoever; which authority shall always be exercised in the manner following: Whenever the legislative or executive authority, or lawful agent, of any State, in controversy with another, shall present a petition to Congress,

stating the matter in question, and praying for a hearing, notice thereof shall be given by order of Congress to the legislative or executive authority of the other State in controversy, and a day assigned for the appearance of the parties, by their lawful agents, who shall then be directed to appoint, by joint consent, commissioners or judges to constitute a court for hearing and determining the matter in question; but if they cannot agree, Congress shall name three persons out of each of the United States, and from the list of such persons each party shall alternately strike out one, the petitioners beginning, until the number shall be reduced to thirteen; and from that number not less than seven nor more than nine names, as Congress shall direct, shall, in the presence of Congress, be drawn out by lot; and the persons whose names shall be so drawn, or any five of them, shall be commissioners or judges, to hear and finally determine the controversy, so always as a major part of the judges, who shall hear the cause, shall agree in the determination; and if either party shall neglect to attend at the day appointed, without showing reasons which Congress shall judge sufficient, or being present shall refuse to strike, the Congress shall proceed to nominate three persons out of each State, and the secretary of Congress shall strike in behalf of said party absent or refusing; and the judgment or sentence of the court, to be appointed in the manner before prescribed, shall be final and conclusive; and if any of the parties shall refuse to submit to the authority of such court, or to appear or defend their claim or
cause, the court shall nevertheless proceed to pronounce judg-
48 ment or sentence, which shall in like manner be final and
decisive—the judgment or sentence, and other proceedings, being in either case transmitted to Congress, and lodged among the acts of Congress for the security of the parties concerned; provided, that every commissioner, before he sits in judgment, shall take an oath, to be administered by one of the judges of the supreme or superior court of the State where the cause shall be tried, well and truly to hear and determine the matter in question, according to the best of his judgment, without favor, affection or hope of reward; provided, also, that no State shall be deprived of territory for the benefit of the United States."

It will therefore be perceived that under the confederation the necessity of a tribunal to hear and determine matters in question between two or more States was recognized; that a court was provided for that purpose; and that the scope or field within which it was expected such matters in question or controversies should or might arise for the determination of such court, extended to "*all disputes and differences now subsisting or that may hereafter arise between two or more States concerning boundary, jurisdiction or any cause whatever.*"

When the Federal convention met in 1787 to form the present Constitution of the United States several drafts of such an instrument were presented for the consideration of the convention. One of these was offered on May 29 by Edmund Randolph, of Virginia, in the shape of resolutions covering the entire subject of a national government. The ninth resolution prescribed the formation of a national judiciary, to consist of a supreme and inferior tribunals, with jurisdiction to hear and determine, among other things, "questions which involve the internal peace or harmony." (Elliot's Deb. vol. 1, p. 143.) On the same day Charles Pinckney, of South Carolina, submitted a draft of a Federal Government, the seventh article whereof was as follows:

"The Senate shall have the sole and exclusive power to declare war and to make treaties, and to appoint ambassadors and other ministers to foreign nations, and judges of the Supreme Court."

"They shall have the exclusive power to regulate the manner of deciding all disputes and controversies now subsisting, or which may arise, between the States respecting jurisdiction or territory." (Elliot's Deb. vol. 1, p. 145.)

On June 19 the committee of the whole, to which had been referred the several propositions and drafts, reported to the convention for its consideration a draft as altered, amended and agreed to in the committee. The thirteenth resolution was as follows:

"That the jurisdiction of the national judiciary shall extend to cases which respect the collection of the national revenue, impeachment of any national officers, and questions which involve the national peace and harmony." (Elliot's Deb. vol. 1, p. 182.)

49 On August 6 a committee of five members, to which the various propositions, as originally made and as amended in the committee of the whole, reported to the convention a draft of the Constitution, the ninth article of which was as follows:

"SEC. 1. The Senate of the United States shall have power to make treaties and appoint ambassadors and judges of the Supreme Court.

"SEC. 2. In all disputes and controversies now subsisting, or that may hereafter subsist, between two or more States, respecting jurisdiction or territory, the Senate shall possess the following powers, &c. [And here follows a scheme for a special court, in terms similar to that provided in the articles of confederation.]

"SEC. 3. All controversies concerning lands claimed under different grants of two or more States, whose jurisdiction, as they respect such lands, shall have been decided, or adjusted subsequent to such grants, or any of them, shall, on application to the Senate, be finally determined, as near as may be, in the same manner as is before prescribed for deciding controversies between different States."

The eleventh article contained, among other sections, the following:

"SEC. 1. The judicial power of the United States shall be vested in one Supreme Court, and in such inferior courts as shall, when necessary, from time to time, be constituted by the legislature of the United States. * * *

"SEC. 3. The jurisdiction of the Supreme Court shall extend to all cases arising under laws passed by the legislature of the United

States; to all cases affecting ambassadors, other public ministers and consuls; to the trial of impeachment of officers of the United States; to all cases of admiralty and maritime jurisdiction; to controversies between two or more States, except such as shall regard territory or jurisdiction; between a State and citizens of another State; between citizens of different States; and between a State or the citizens thereof and foreign States, citizens or subjects." (Elliot's Deb. vol. 1. p. 224.)

It may be observed, in passing, that, in this draft, all disputes and controversies between two or more States, respecting jurisdiction or territory, are to be determined by a special court to be constituted by the Senate; and the controversies between two or more States, except such as shall regard territory or jurisdiction, are determinable by the Supreme Court. It is therefore apparent that other disputes or controversies between States were regarded and provided for besides those respecting territory or jurisdiction.

This draft, together with numerous suggestions and amendments, was on August 7 submitted to the committee of the whole.

On September 12 a committee on revision reported a draft of the Constitution as revised and arranged. This draft, which, as respects our present subject, was in the terms of the Constitution as finally adopted, took from the Senate the power to constitute a court to try disputes between the States respecting territory or jurisdiction,
and struck out the provision excluding from the jurisdiction
50 of the Supreme Court disputes between the States in matters
respecting jurisdiction and territory. The entire jurisdiction of controversies between States was bestowed upon the Supreme Court, in the second section of article three, in the following terms:

"The judicial power shall extend to all cases in law and equity, arising under this Constitution, the laws of the United States and the treaties made, or which shall be made, under their authority; to all cases affecting ambassadors, other public ministers and consuls; to all cases of admiralty and maritime jurisdiction; to controversies to which the United States shall be a party; to controversies between two or more States; between a State and citizens of another State; between citizens of different States; between citizens of the same State, claiming lands under grants of different States, and between a State or the citizens thereof, and foreign States, citizens or subjects.

"In all cases affecting ambassadors, other public ministers and consuls, and those in which a State shall be a party, the Supreme Court shall have original jurisdiction. In all other cases before mentioned the Supreme Court shall have appellate jurisdiction, both as to law and fact, with such exceptions, and under such regulations, as the Congress shall make."

As in this section power is conferred on Congress to make regulations affecting the exercise by the Supreme Court of its jurisdiction, it may not be out or place to quote the provisions in this respect of he judiciary act of 1789:

"The Supreme Court shall have exclusive jurisdiction of all controversies of a civil nature where a State is a party, except between a State and its citizens, or between a State and citizens of other States or aliens, in which latter cases it shall have original, but not exclusive jurisdiction." (Revised Stat., sec. 687.)

The case of New York *v.* Connecticut *et al.*, (4 Dall. 3,) in 1799, was the first instance of an exercise by the Supreme Court of its jurisdiction in a controversy between two States. It was a case of a bill in equity filed by the State of New York against the State of Connecticut and certain private persons who were grantees of the latter State of lands, the jurisdiction over which was claimed by both States. The object of the bill was to obtain an injunction to stay proceedings in ejectment pending in the circuit court of the United States for the district of Connecticut.

The court was of opinion that, as the State of New York was not a party to the suits below, nor interested in the decisions of those suits, an injunction ought not to issue. No argument was made that the court had not jurisdiction, and the court proceeded on the assumption that it possessed jurisdiction, although, under the facts of the case, it refused the injunction prayed for.

New Jersey *v.* New York, (5 Pet. 285,) was the case of a bill filed by the State of New Jersey against the State of New York for the purpose of ascertaining and settling the boundary between the two States. In an opinion awarding the process of subpœna Chief Justice Marshall said:

51 "The Constitution of the United States declares that 'the judicial power shall extend to controversies between two or more States.' It also declares that 'in all cases affecting ambassadors, other public ministers and consuls, and those in which a State shall be a party, the Supreme Court shall have original jurisdiction.' * * * It has been settled by our predecessors, in great deliberation, that this court may exercise its original jurisdiction in suits against a State, under the authority conferred by the Constitution and existing acts of Congress."

In March 1832, the State of Rhode Island filed in this court a bill against the State of Massachusetts, for the settlement of the boundary between the two States, and moved for a subpœna to be issued, according to the practice of the court in similar cases. An appearance was entered for Massachusetts, and a motion was made to dismiss the bill for want of jurisdiction. In support of the motion it was contended that this court had no jurisdiction because of the character of the respondent independent of the nature of the suit, and because of the nature of the suit independent of the character of the respondent. It was not denied that Massachusetts had agreed, by adopting the Federal Constitution, to submit her controversies with other States to judicial decision, but it was claimed that Congress had passed no law establishing a mode of proceeding, the character of the judgment to be rendered, and means of enforcing it. As respects the nature of the suit, it was argued that it was in its character political, brought by a sovereign, in that avowed character; that the judicial power of the United States extended, by the Constitution, only to cases of law and equity, and that questions of jurisdiction over territory were not cases of that kind, nor of "a civil nature."

The court held that jurisdiction was conferred by the Constitution and the judiciary act, and that, as Massachusetts had appeared, submitted to the process, and pleaded in bar of the plaintiff's action certain matters on which the judgment of the court was asked, all doubts as to jurisdiction over the parties were at rest.

As respected the power of the court to hear and determine the subject matters of the suit, it was held that jurisdiction existed; that the dispute was a controversy between two States within the judicial power of the United States. (12 Pet. 657; 13 Pet. 23.)

Before leaving this case it is to be remarked that the principal contest was as to whether a question of boundary, involving as it did the question of sovereignty over territory, was a judicial question of a civil nature. The implication was that the controversies between two or more States, in which jurisdiction had been granted by the Constitution, did not include questions of a political character. In some of the later cases the contention has been the very opposite; that the intention of the Constitution was only to apply to questions in which the sovereign and political powers of the respective States were in controversy.

52 In Florida *v.* Georgia, (11 How. 293,) leave was given by this court to the State of Florida to file a bill against the State of Georgia, and process of subpœna was directed to be issued against the State of Georgia. The object of the bill was to ascertain and establish the boundary between the two States, which was in controversy. The State of Georgia answered, and the cause was proceeded in in pursuance of the prayers of the bill. Subsequently an application was made by the Attorney General of the United States, alleging that the latter were interested and concerned in the matter in controversy, and moving the court that he be permitted to appear in the case, and be heard in behalf of the United States, in such time and form as the court should order. This motion was opposed by the States, and the matter was argued at length. The judges differed, but neither in the opinion of the majority, granting the motion of the Attorney General, nor in that of the dissenting minority, was any doubt expressed of the existence of the jurisdiction of the court over the controversy between the two States.

Pennsylvania *v.* Wheeling & Belmont Bridge Company, (9 How. 647;) *Idem v. Idem,* (11 How. 528;) *Idem v. Idem,* (13 How. 518;) *Idem v. Idem,* (18 How. 429,) was a case in equity, in which the State of Pennsylvania filed a bill against the Wheeling and Belmont Bridge Company, a corporation of Virginia, and certain contractors, charging that the defendants, under color of an act of the legislature of Virginia, were engaged in the construction of a bridge across the Ohio river at Wheeling, which would, as was alleged, obstruct its navigation to and from the ports of Pennsylvania, by steamboats and other crafts which navigated the same. Many different questions were discussed by counsel and considered by the court, respecting the nature and extent of the jurisdiction of this court, the right of the complainant State, whether at law or in equity, and the character of the decree which could be rendered. Several observations made in the opinion of the court will be hereafter adverted to when we come to consider the second ground of demurrer urged in the case before us. It is sufficient for our present purpose to say that the original jurisdiction of the court was sustained, a commissioner was appointed to take and report proofs, and a decree was entered declaring the bridge to be an obstruction of the free navigation of the river; that thereby a special damage was occasioned to the plaintiff, for which there was not an adequate remedy at law, and directing that the obstruction be removed, either by elevating the bridge to a height designated, or by abatement.

South Carolina *v.* Georgia, (93 U. S. 4,) was a suit in equity brought in this court, whereby the State of South Carolina sought an injunction to restrain the State of Georgia, the United States Secretary of War, the Chief Engineer of the United States Army, their agents and subordinates, from obstructing the navigation of the
53 Savannah river, in violation of an alleged compact subsisting between the States of South Carolina and Georgia, and which had been entered into on April 24, 1787. This court, not denying but assuming jurisdiction in the case, held that, by adopting the Federal Constitution, and thereby delegating to the General Government the right to regulate commerce with foreign nations and among the several States, the compact between the two States, in respect to the Savannah river, ceased to operate, and that the acts complained of, being done in pursuance of congressional authority, and designed to improve navigation, could not be deemed an illegal obstruction, and accordingly the special injunction previously granted was dissolved and the bill dismissed.

Wisconsin *v.* Duluth, (96 U. S. 372,) was the case of a bill in chancery filed in this court by the State of Wisconsin, by virtue of the constitutional provision which confers original jurisdiction of suits between the States and between a State and citizens of other States. The city of Duluth, a corporation and citizen of the State of Minnesota, was defendant; and, after answer, replication and the taking of a large amount of evidence, the case came on for a final decree. The nature of the case and the reasoning upon which this court proceeded in disposing of it will sufficiently appear in the following quotations from the opinion delivered by Mr. Justice Miller:

"The present suit was brought by the State of Wisconsin on the ground that the channel of the St. Louis river, as it flowed in a state of nature, was the common boundary between that State and the State of Minnesota, and that she had an interest in the continuance of the channel as an important highway for navigation and commerce in its natural and usual course; that the canal cut by Duluth across Minnesota point, deeper than the natural outlet of the St. Louis river at its mouth, has diverted, and will continue to divert, the current of that river through Superior bay into the lake by way of that canal; that the result of this is, that while the current cuts that canal deeper and gives an outlet for the water there at a lower level, it at the same time, by diverting the current from the old outlet, causes it to fill up, and thus destroy the usefulness of the river and bay as an aid of commerce, on which the State had a right to rely. The bill, after reciting the facts which we have already detailed, insists that the city of Duluth cannot, by any right of her own, nor by any authority conferred on her by the State of Minnesota, thus divert the waters of the stream—the St. Louis river—from their natural course, to the prejudice of the rights of the State of Wisconsin or of her citizens; declares that this canal at Duluth does this in violation of law; and it prays of this court to enjoin Duluth from protecting or maintaining it, and by way of mandatory injunction to compel that city to fill up the canal and restore things in that regard to the condition of nature in which they were before the canal was made.

"The answer, while admitting the construction of the canal, denies almost every other material allegation of the bill. It denies especially that the canal has the effect of changing the course of
54 the current of the river, or does any injury to the southern
entrance to Superior bay or diminishes the flow of water at that point. A large amount of testimony, professional and non-professional, is presented on that subject.

"The answer also sets up, as an affirmative defense to the relief sought by the bill, that the United States, by the legislative and executive departments of the Government, have approved of the construction of the canal, have taken possession and control of the work, have appropriated and spent money on it, and adopted it as the best mode of making a safe and accessible harbor at the western end of the great system of lake navigation.

"Many interesting questions have been argued, and ably argued, by counsel, which we have not found it necessary to decide. The counsel for defense deny that the State of Wisconsin has any such legal interest in the flow of the waters in their natural course as authorizes her to maintain a suit for their division. It is argued that this court can take cognizance of no question which concerns alone the rights of a State in her political or sovereign character; that to sustain this suit she must have some proprietary interest which is affected by the defendant. This question has been raised and discussed in almost every case brought before us by a State, in virtue of the original jurisdiction of the court. We do not find it necessary to make any decision on the point as applicable to the case before us. Nor shall we address ourselves to the consideration of the mass of conflicting evidence as to the effect of the canal on the flow of the waters of Superior bay.

"We will first consider the affirmative defense already mentioned;

for, if that be found to be true in point of fact, it will preclude any such action by this court as the plaintiff has prayed for."

The court then proceeded to inquire into the action of the General Government in the matter of the canal in question, and found that, as matter of fact, the United States had taken possession and control of the canal as a public work. The opinion concluded as follows:

"If, then, Congress, in the exercise of a lawful authority, has adopted and is carrying out a system of harbor improvements at Duluth, this court can have no lawful authority to forbid the work. If that body sees fit to provide a way by which the great commerce of the lakes and the countries west of them, even to Asia, shall be securely accommodated at the harbor of Duluth by this short canal of three or four hundred feet, can this court decree that it must forever pursue the old channel, by the natural outlet, over water too shallow for large vessels, unsafe for small ones, and by a longer and much more tedious route?

"When Congress appropriates $10,000 to improve, protect and secure this canal, this court can have no power to require it to be filled up and obstructed. While the engineering officers of the Government are, under the authority of Congress, doing all they can to make this canal useful to commerce and to keep it in good condition, this court can owe no duty to a State which requires it to order the city of Duluth to destroy it.

"These views show conclusively that the State of Wisconsin is not entitled to the relief asked by the bill, and that it must, therefore, be dismissed with costs."

The court, therefore, did not decline jurisdiction, but exercised it, by inquiring into the facts put in issue by the bill and answer, and by dismissing the bill for want of equity.

55 In Virginia *v.* West Virginia, (11 Wall. 39,) a bill was filed in this court to settle the boundaries between the two States. There was a demurrer to the bill. In delivering the opinion of the court Mr. Justice Miller said:

"The first proposition on which counsel insist in support of the demurrer is that this court has no jurisdiction of the case, because it involves the consideration of questions purely political; that is to say, that the main question to be decided is the conflicting claims of the two States to the exercise of political jurisdiction and sovereignty over the territory and inhabitants of the two counties which are the subject of dispute. This proposition cannot be sustained without reversing the settled course of decision in this court and overturning the principles on which several well-considered cases have been decided."

And, after citing Rhode Island *v.* Massachusetts, (12 Pet. 794;) Missouri *v.* Iowa, (7 How. 660;) Florida *v.* Georgia, (17 *id.* 478,) and Alabama *v.* Georgia, (23 *id.* 505,) the conclusion of the court was thus expressed:

"We consider, therefore, the established doctrine of this court to be that it has jurisdiction of questions of boundary between two States of this Union, and that this jurisdiction is not defeated because in deciding that question it becomes necessary to examine into and construe compacts and agreements between those States, or because the decree which the court may render affects the territorial limits of the political jurisdiction and sovereignty of the States which are parties to the proceeding."

In New Hampshire *v.* Louisiana and others, and New York *v.* Louisiana and others, (108 U. S. 76,) it was found that, in view of the eleventh amendment to the Constitution of the United States, declaring that "the judicial power of the United States shall not be construed to extend to any suit in law or equity, commenced or prosecuted against one of the United States by citizens of another State, or by citizens and subjects of any foreign State," as matter of fact, under the pleadings and testimony, the suits were commenced and were prosecuted solely by the owners of the bonds and coupons, to collect which was the object of the suits, and it was accordingly held "that the evident purpose of the amendment, so promptly proposed and finally adopted, was to prohibit all suits against a State by or for citizens of other States or aliens, without the consent of the State to be sued, and, in our opinion, one State cannot create a controversy with another State, within the meaning of that term as used in the judicial clauses of the Constitution, by assuming the prosecution of debts, owing by the other State to its citizens. Such being the case we are satisfied that we are prohibited, both by the letter and the spirit of the Constitution, from entertaining these suits, and the bill in each case is dismissed."

In Wisconsin *v.* Pelican Insurance Company, (127 U. S. 265,) the nature of the case and of the question involved was thus stated by Mr. Justice Gray, in delivering the opinion of the court:

56 "This action is brought upon a judgment recovered by the State of Wisconsin in one of her own courts against the Pelican Insurance Company, a Louisiana corporation, for penalties imposed by a statute of Wisconsin for not making returns to the insurance commissioner of the State, as required by that statute. The leading question argued at the bar is whether such an action is within the original jurisdiction of this court.

"The ground on which the jurisdiction is invoked is not the nature of the cause, but the character of the parties, the plaintiff being one of the States of the Union, and the defendant a corporation of another of three States."

After citing and considering the cases, the justice expressed the following conclusions:

"The rule that the courts of no country execute the penal laws of another applies not only to prosecutions and sentences for crimes and misdemeanors, but to all suits in favor of the State for the recovery of pecuniary penalties for any violation of statutes for the protection of its revenue, or other municipal laws, and to all judgments for such penalties. * * * From the first organization of the courts of the United States, nearly a century ago, it has always been assumed that the original jurisdiction of this court over controversies between a State and citizens of another State, or of a foreign country, does not extend to a suit by a State to recover penalties for a breach of her own municipal law. * * * The statute of Wisconsin, under which the State recovered in one of her own courts the judgment now and here sued on, was in the strictest sense a penal statute, imposing a penalty upon any insurance company of another State, doing business in the State of Wisconsin without having deposited with the proper officer of the State a full statement of its property and business during the previous year. The cause of action was not any private injury, but solely the offense committed against the State by violating her law. * * * This court, therefore, cannot entertain an original action to compel the defendants to pay the State of Wisconsin a sum of money in satisfaction of the judgment for that fine."

And consequently judgment was entered for the defendant on the demurrer that had been interposed to the declaration.

Hans *v.* Louisiana, (134 U. S. 1,) was an action brought in the circuit court of the United States for the eastern district of Louisiana, against the State of Louisiana, by Hans, a citizen of that State, to recover the amount of certain coupons annexed to bonds of the State. The circuit court, on motion of the attorney general of the State, dismissed the case for want of jurisdiction. This court affirmed the judgment of the circuit court, and held that the judicial power of the United States did not extend to the case of a suit brought against a State by one of its own citizens.

In the course of the opinion, delivered by Mr. Justice Bradley, the following observations were made:

"The truth is, that the cognizance of suits and actions unknown to the law, and forbidden by the law, was not contemplated by the Constitution when establishing the judicial power of the 57 United States. Some things, undoubtedly, were made justiciable which were not known as such at the common law; such, for example, as controversies between States as to boundary lines, and other questions admitting of judicial solution. And yet the case of Penn *v.* Lord Baltimore, (1 Vesey, Sen. 444,) shows that some of these unusual subjects of litigation were not unknown to the courts even in colonial times; and several cases of the same general character arose under the articles of confederation, and were brought before the tribunal provided for that purpose by those articles. (131 U. S. App. 1.) The establishment of this new branch of jurisdiction seemed to be necessary from the extinguishment of diplomatic relations between the States. Of other controversies between a State and another State, or its citizens, which, on the settled principles of public law, are not subjects of judicial cognizance, this court has often declined to take jurisdiction. See Wisconsin *v.* Pelican Ins. Co., (127 U. S. 265, 288, 289,) and cases there cited."

The last case which we have had occasion to examine is that of

Louisiana *v.* Texas, (176 U. S. 1, 15). The case was brought before us by a bill in equity, filed by the State of Louisiana against the State of Texas, her governor and her health officer. The bill alleged that the State of Texas had granted to its governor and its health officer extensive powers over the establishment and maintenance of quarantines over infectious and contagious diseases; that this power had been exercised in a way and with a purpose to build up and benefit the commerce of cities in Texas, which were business rivals of the city of New Orleans, and prayed for a decree that neither the State of Texas, nor her governor, nor her health officer, have the right, under the cover of an exercise of police or quarantine powers, to declare and enforce an embargo against interstate commerce between the State of Louisiana, or any part thereof, and the State of Texas, or the right to make discriminative rules affecting the State of Louisiana, or any part thereof, and different from and more burdensome than the quarantine rules and regulations applied to other States and countries; and the bill asked for an injunction restraining the Texas officials from enforcing the Texas laws in the manner in which they were enforced. To this bill a demurrer was filed, assigning the following causes:

"First. That this court has no jurisdiction of either the parties to or of the subject matter of this suit, because it appears from the face of the bill that the matters complained of do not constitute, within the meaning of the Constitution of the United States, any controversy between the States of Louisiana and Texas. Second. Because the allegations of the bill show that the only issues presented by said bill arise between the State of Texas or her officers, and certain persons in the city of New Orleans, in the State of Louisiana, who were engaged in interstate commerce, and which do not in any manner concern the State of Louisiana as a corporate body or State. Third. Because such bill shows upon its face that this suit is in reality for and on behalf of certain individuals engaged in interstate commerce, and while the suit is attempted to be prosecuted for and in the name
of the State of Louisiana, said State is in effect loaning its
58 name to said individuals and is only a nominal party—the
real parties at interest being said individuals in the city of New Orleans who are engaged in interstate commerce. Fourth. Because it appears from the face of said bill that the State of Louisiana, in her right of sovereignty, is seeking to maintain this suit for the redress of the supposed wrongs of her citizens in regard to interstate commerce, while under the Constitution and laws the said State possesses no such sovereignty as empowers her to bring an original suit in this court for such purpose. Fifth. Because it appears from the face of the bill that no property rights of the State of Louisiana are in any manner affected by the quarantine complained of, nor is any such property right involved in this suit as would give this court original jurisdiction of this cause."

In the opinion of the court, delivered by Mr. Chief Justice Fuller, after a consideration of the cases hereinbefore mentioned and of others, it was said:

"In order then to maintain jurisdiction of this bill of complaint, as against the State of Texas, it must appear that the controversy to be determined is a controversy arising directly between the State of Louisiana and the State of Texas, and not a controversy in the vindication of grievances of particular individuals.

"By the Constitution the States are forbidden to enter into any treaty, alliance or confederation; grant letters of marque and reprisal, or, without the consent of Congress, 'keep troops or ships of war in time of peace, enter into any agreement or compact with another State or with a foreign power, or engage in war, unless actually invaded, or in such imminent danger as will not admit of delay.'

"Controversies between them arising out of public relations and intercourse cannot be settled either by war or diplomacy, though, with the consent of Congress, they may be composed by agreement. * * *

"In the absence of agreement it may be that a controversy might arise between two States for the determination of which the original jurisdiction of this court would be invoked, but there must be a direct issue between them, and the subject matter must be susceptible of judicial solution. And it is difficult to conceive of a direct issue between two States in respect of a matter where no effort at accommodation has been made; nor can it be conceded that it is within the judicial function to inquire into the motives of a State legislature in passing a law, or of the chief magistrate of a State in enforcing it in the exercise of his discretion and judgment. Public policy forbids the imputation to authorized official action of any other than legitimate motives. * * *

"But in Debs, petitioner, (158 U. S. 564,) involving a case in the circuit court, in which the United States had sought relief by injunction, it was observed: 'That while it is not the province of the Government to interfere in any matter of private controversy between individuals, or to use its great powers to enforce the rights of one against another, yet, whenever the wrongs complained of are such as to affect the public at large, and are in respect of matters which by the Constitution are entrusted to the care of the nation, and concerning which the nation owes its duty to all the citizens of securing to them their common rights, then the mere fact that the Government has no pecuniary interest in the controversy is not sufficient to exclude it from the courts or prevent it from taking measures therein to fully discharge those constitutional duties.'

59 "It is in this aspect that the bill before us is framed. Its gravamen is not a special and peculiar injury such as would sustain an action by a private person, but the State of Louisiana presents herself in the attitude of *parens patriæ*, trustee, guardian or representative of all her citizens. She does this from the point of view that the State of Texas is intentionally absolutely interdicting interstate commerce as respects the State of Louisiana by means of

unnecessary and unreasonable quarantine regulations. Inasmuch as the vindication of the freedom of interstate commerce is not committed to the State of Louisiana, and that State is not engaged in such commerce, the cause of action must be regarded not as involving any infringement of the powers of the State of Louisiana, or any special injury to her property, but as asserting that the State is entitled to relief in this way because the matters complained of affect her citizens at large. Nevertheless if the case stated is not one presenting a controversy between these States, the exercise of original jurisdiction by this court as against the State of Texas cannot be maintained."

After quoting the provisions of the statute of the State of Texas regulating the subject of quarantine, the chief justice proceeded to say:

"It is not charged that this statute is invalid, nor could it be if tested by its terms. While it is true that the power vested in Congress to regulate commerce among the States is a power complete in itself, acknowledging no limitations other than those prescribed in the Constitution, and that where the action of the States in the exercise of their reserved powers comes into collision with it, the latter must give way, yet it is also true that quarantine laws belong to that class of State legislation which is valid until displaced by Congress, and that such legislation has been expressly recognized by the laws of the United States almost from the beginning of the Government. * * * The complaint here, however, is not that the laws of Texas in respect of quarantine are invalid, but that the health officer, by rules and regulations framed and put in force by him thereunder, places an embargo in fact on all interstate commerce between the State of Louisiana and the State of Texas, and that the governor permits these rules and regulations to stand and be enforced, although he has the power to modify or change them. The bill is not rested merely on the ground of the imposition of an embargo without regard to motive, but charges that the rules and regulations are more stringent than called for by the particular exigency, and are purposely framed with the view to benefit the State of Texas, and the city of Galveston in particular, at the expense of the State of Louisiana, and especially of the city of New Orleans.

"But in order that a controversy between States, justiciable in this court, can be held to exist, something more must be put forward than that the citizens of one State are injured by the maladministration of the laws of another. The States cannot make war, or enter into treaties, though they may, with the consent of Congress, make compacts and agreements. Where there is no agreement, where breach might create it, a controversy between States does not arise unless the action complained of is State action, and acts of State officers in abuse or excess of their powers cannot be laid hold of as in themselves committing one State to a distinct collision with a sister State.

"In our judgment, this bill does not set up facts which show that

the State of Texas has so authorized or confirmed the alleged
60 action of her health officer as to make it her own, or from
which it necessarily follows that the two States are in controversy within the meaning of the Constitution.

"Finally, we are unable to hold that the bill may be maintained as presenting a case of controversy 'between a State and citizens of another State.' Jurisdiction over controversies of that sort does not embrace the determination of political questions, and, where no controversy exists between States, it is not for this court to restrain the governor of a State in the discharge of his executive functions in a matter lawfully confided to his discretion and judgment. Nor can we accept the suggestion that the bill can be maintained as against the health officer alone on the theory that his conduct is in violation or in excess of a valid law of the State, as the remedy for that would clearly lie with the State authorities, and no refusal to fulfill their duty in that regard is set up. In truth it is difficult to see how on this record there could be a controversy between the State of Louisiana and the individual defendants without involving a controversy between the States, and such a controversy, as we have said, is not presented."

Accordingly the demurrer was sustained and bill dismissed.

From the language of the Constitution, and from the cases in which that language has been considered, what principles may be derived as to the nature and extent of the original jurisdiction of this court in controversies between two or more States?

From the language, alone considered, it might be concluded that whenever, and in all cases where one State may choose to make complaint against another, no matter whether the subject of complaint arises from the legislation of the defendant State, or from acts of its officers and agents, and no matter whether the nature of the injury complained of is to affect the property rights or the sovereign powers of the complaining State, or to affect the rights of its citizens, the jurisdiction of this court would attach.

Chief Justice Marshall in the case of Cohens *v.* Virginia, (6 Wheat. 364, 392,) said:

"The Constitution gives the Supreme Court original jurisdiction in certain enumerated cases, and gives it appellate jurisdiction in all others. Among those in which jurisdiction must be exercised in the appellate form are cases arising under the Constitution and laws of the United States. These provisions of the Constitution are equally obligatory, and are to be equally respected. If a State be a party, the jurisdiction of this court is original; if the case arise under a constitution or a law, the jurisdiction is appellate. But a case to which a State is a party may arise under the Constitution or a law of the United States. What rule is applicable to such a case? What, then, becomes the duty of the court? Certainly, we think, so to construe the Constitution as to give effect to both provisions, as far as possible to reconcile them, and not to permit their seeming repugnancy to destroy each other. We must endeavor so to construe them as to preserve the true intent and meaning of the instrument.

"In one description of cases the jurisdiction of the court is founded entirely on the character of the parties, and the nature of the
61 controversy is not contemplated by the Constitution. The character of the parties is everything, the nature of the case nothing. In the other description of cases the jurisdiction is founded entirely on the character of the case, and the parties are not contemplated by the Constitution. In these the nature of the case is everything, the character of the parties nothing. When, then, the Constitution declares the jurisdiction, in cases where a State shall be a party, to be original, and in all cases arising under the Constitution or a law to be appellate, the conclusion seems irresistible that its framers designed to include in the first class those cases in which jurisdiction is given, because a State is a party; and to include in the second those in which jurisdiction is given, because the case arises under the Constitution or a law."

But it must be conceded that upon further consideration, in cases arising under different states of facts, the general language used in Cohens *v.* Virginia has been, to some extent, modified. Thus, in the cases of New Hampshire *v.* Louisiana, and New York *v.* Louisiana, *ut supra*, jurisdiction was denied to this court where the cause of action belonged to private persons, who were endeavoring to use the name of one State to enforce their rights of action against another. Though, perhaps, it may be said that jurisdiction was really entertained, and that the bills were dismissed, because the court found that, under the pleadings and testimony, the States complainant had no interest of any kind in the proceedings.

So, too, in Wisconsin *v.* Pelican Insurance Company, *ut supra*, the court held that, notwithstanding the action was brought by a State against the citizens of another State and was thus within the letter of the Constitution, yet that the court had a right to inquire into the nature of the case, and, when it found that the object of the suit was to enforce the penal laws of one State against a citizen of another, to refuse to exercise jurisdiction.

In the case of Louisiana *v.* Texas, *ut supra*, the bill was dismissed because a controversy between the two States was not actually presented; that what was complained of was not any action of the State of Texas, but the alleged unauthorized conduct of its health officer, acting with a malevolent purpose against the city of New Orleans. Here again it may be observed that the court did not decline jurisdiction, but exercised it in holding that the facts alleged in the bill did not justify the court in granting the relief prayed for.

The cases cited show that such jurisdiction has been exercised in cases involving boundaries and jurisdiction over lands and their inhabitants, and in cases directly affecting the property rights and interests of a State. But such cases manifestly do not cover the entire field in which such controversies may arise, and for which the Constitution has provided a remedy; and it would be objectionable, and, indeed, impossible, for the court to anticipate by definition what controversies can and what cannot be brought within the original jurisdiction of this court.

An inspection of the bill discloses that the nature of the injury complained of is such that an adequate remedy can only be
62 found in this court at the suit of the State of Missouri. It is true that no question of boundary is involved, nor of direct property rights belonging to the complainant State. But it must surely be conceded that, if the health and comfort of the inhabitants of a State are threatened, the State is the proper party to represent and defend them. If Missouri were an independent and sovereign State all must admit that she could seek a remedy by negotiation, and, that failing, by force. Diplomatic powers and the right to make war having been surrendered to the General Government, it was to be expected that upon the latter would be devolved the duty of providing a remedy and that remedy, we think, is found in the constitutional provisions we are considering.

The allegations of the bill plainly present such a case. The health and comfort of the large communities inhabiting those parts of the State situated on the Mississippi river are not alone concerned, but contagious and typhoidal diseases introduced in the river communities may spread themseves throughout the territory of the State. Moreover substantial impairment of the health and prosperity of the towns and cities of the State situated on the Mississippi river, including its commercial metropolis, would injuriously affect the entire State.

That suits brought by individuals, each for personal injuries, threatened or received, would be wholly inadequate and disproportionate remedies, requires no argument.

It is further contended, in support of the demurrer, that even if the State of Missouri be the proper party to file such a bill, yet that the proper defendant is the Sanitary District of Chicago solely, and that the State of Illinois should not have been made a party, and that, as to her, the demurrer ought to be sustained.

It can scarcely be supposed, in view of the express provisions of the Constitution and of the cited cases, that it is claimed that the State of Illinois is exempt from suit because she is a sovereign State which has not consented to be sued. The contention rather seems to be that, because the matters complained of in the bill proceed and will continue to proceed from the acts of the Sanitary District of Chicago, a corporation of the State of Illinois, it therefore follows that the State, as such, is not interested in the question, and is improperly made a party.

We are unable to see the force of this suggestion. The bill does not allege that the sanitary district is acting without or in excess of lawful authority. The averment and the conceded facts are that the corporation is an agency of the State to do the very things which, according to the theory of the complainant's case, will result in the mischief to be apprehended. It is State action and its results

that are complained of—thus distinguishing this case from that of Louisiana *v.* Texas, where the acts sought to be restrained
63 were alleged to be those of officers or functionaries proceeding in a wrongful and malevolent misapplication of the quarantine laws of Texas. The Sanitary District of Chicago is not a private corporation, formed for purposes of private gain, but a public corporation, whose existence and operations are wholly within the control of the State.

The object of the bill is to subject this public work to judicial supervision, upon the allegation that the method of its construction and maintenance will create a continuing nuisance, dangerous to the health of a neighboring State and its inhabitants. Surely, in such a case, the State of Illinois would have a right to appear and traverse the allegations of the bill, and, having such a right, might properly be made a party defendant.

It is further contended that, even if this court has original jurisdiction of the subject matter, and even if the respective States have been properly made parties, yet the case made out by the bill does not entitle the State of Missouri to the equitable relief prayed for.

This proposition is sought to be maintained by several considerations. In the first place, it is urged that the drawing, by artificial means, of the sewage of the city of Chicago into the Mississippi river may or may not become a nuisance to the inhabitants, cities and towns of Missouri; that the injuries apprehended are merely eventual or contingent, and may, in fact, never be inflicted. Can it be gravely contended that there are no preventive remedies, by way of injunction or otherwise, against injuries not inflicted or experienced, but which would appear to be the natural result of acts of the defendant, which he admits or avows it to be his intention to commit?

The bill charges that the acts of the defendants, if not restrained, will result in the transportation, by artificial means and through an unnatural channel, of large quantities of undefecated sewage daily, and of accumulated deposits in the harbor of Chicago and in the bed of the Illinois river, which will poison the water supply of the inhabitants of Missouri and injuriously affect that portion of the bed or soil of the Mississippi river which lies within its territory.

In such a state of facts, admitted by the demurrer to be true, we do not feel it necessary to enter at large into a discussion of this part of the defendants' contention, but think it sufficient to cite one or two authorities.

Attorney General *v.* Jamaica Pond Aqueduct Co., (133 Mass. 361,) was a proceeding in equity in the supreme judicial court to enjoin the defendants from lowering the water in one of the public ponds of Massachusetts. It was claimed that the necessary effect of such lowering would be to impair the rights of the people in the use of the pond for fishing, boating and other lawful purposes, and to create and expose upon the shores of the pond a large quantity of slime, mud and offensive vegetation, detrimental to the public health,

The defendants demurred, claiming that no case was stated which
came within the equity jurisdiction of the court, and ques-
64 tioning the power of the attorney general, on behalf of the
Commonwealth, to maintain the proceedings. Speaking for
the court the chief justice said:

"The cases are numerous in which it has been held that the attorney general may maintain an information in equity to restrain a corporation exercising the right of eminent domain under a power delegated to it by the legislature, from any abuse or perversion of the powers which may create a public nuisance or injuriously affect or endanger the public interests,"—citing many cases, and proceeding:

"The information in this case alleges not only that the defendant is doing acts which are *ultra vires*, and an abuse of the power granted to it by the legislature, but also that the necessary effect of said acts will be to create a public nuisance. This brings the case within the established principle that the court has jurisdiction in equity to restrain and prevent nuisances. And when the nuisance is a public one an information by the attorney general is the appropriate remedy. This information, therefore, can be sustained on the ground that the unlawful acts of the defendant will produce a public nuisance by partially draining the pond and exposing its shores, thus endangering the public health."

And replying to the claim that resort to equity was unnecessary, the court further said:

"The defendant contends that the law furnishes a plain, adequate and complete remedy for this nuisance by an indictment or by proceedings under the statutes for the abatement of a nuisance by the board of health. Neither of these remedies can be invoked until a part of the mischief is done, and they could not, in the nature of things, restore the pond, the land and the underground currents to the same condition in which they now are. In other words, they could not remedy the whole mischief. The preventive force of a decree in equity, restraining the illegal acts before any mischief is done, gives clearly a more efficacious and complete remedy."

The nature of equitable remedy in the case of public nuisances was well described by Mr. Justice Harlan, speaking for the court in the case of Mugler *v.* Kansas, (123 U. S. 623, 673):

"The grounds of this jurisdiction, in cases of purpresture, as well as of public nuisances, is the ability of courts of equity to give a more speedy, effectual and permanent remedy than can be had at law. They cannot only prevent nuisances that are threatened, and before irreparable mischief ensues, but arrest or abate those in progress, and by perpetual injunction protect the public against them in the future; whereas courts of law can only reach existing nuisances, leaving future acts to be the subjects of new prosecutions or proceedings. This is a statutory jurisdiction, especially where a nuisance affects the health, morals or safety of the community."

In Coosaw Mining Co. *v.* South Carolina, (144 U. S. 550,) it was said by this court, through Mr. Justice Harlan, after citing English and American cases:

"Proceedings at law or by indictment can only reach past or present wrongs done by appellant, and will not adequately protect the public interests in the future. What the public are en-
65 titled to have is security for all time against illegal interference with the control by the State of the digging, mining and removing of phosphate rock and phosphatic deposits in the bed of Coosaw river."

It is finally contended that, if the bill was not prematurely filed, then it was filed too late; that, by standing by for so long a period, the complainant was guilty of such laches that a court of equity will not grant relief.

The inconsistency between these contentions is manifest, and, on consideration, we are of opinion that the suggestion that the complainant's remedy has been lost by delay, is not founded in fact or reason.

In Goldsmid *v.* Tunbridge Wells, (L. R. 1 Eq. 161,) answering a similar contention, it was said by Romilly, M. R.:

"If the plaintiff comes to the court and complains very early, then the evidence is that the pollution is not perceptible, it is wholly inappreciable, and you get evidence after evidence for the defendants, (the pollution being slight and perhaps only observable at some times and on some occasions,) saying you have no proof at all that there is any appreciable pollution, and you must wait until it becomes a nuisance. Then he waits for five or six years, until it is obvious to everybody's sense that the pollution is considerable, and then they say 'You have come too late, you have allowed this to continue on for twenty years, and we have acquired an easement over your property, and the right of pouring the sewage into it.' My opinion is that any person who has a water course flowing through his land, and sewage which is perceptible is brought into that water course, has a right to come here to stop it; and that when the pollution is increasing, and gradually increasing from time to time, by the additional quantity of sewage poured into it, the persons who allow the polluted matter to flow into the stream are not at liberty to claim any right or prescription against him. * * *

"This is a matter of very great importance, and it has been suggested to me in argument as a matter that ought to be regarded that private interests must give way to public interests; that the court ought to regard what the advantage to the public is, and that some little sacrifice ought to be made by private individuals. I do not assent to that view of the law on the subject, and I apprehend that the observations which were quoted to me of Vice Chancellor Sir William Page Wood, in the Attorney General *v.* The Mayor of Kingston, (13 W. R. 888,) are perfectly accurate, and that private rights are not to be interfered with. But my firm conviction is that in this, as in all the great dispensations and operations of nature, the interests of the individuals are not only compatible with but

identical with the interests of the public; and although in this case I have only to consider an injury to the private individual, the plaintiff in the present action, yet I believe that the injury to the public may be extremely great by polluting a stream which flows for a considerable distance, the water of which cattle are in the habit of drinking, the exhalations from which persons who reside on the banks must necessarily inhale, and this at a time when the attention of the people and the court is necessarily called to the fact that the most scientific men who have examined the subject are unable to say
whether great diseases among cattle and contagious diseases
66 affecting human beings, such as cholera, and typhus, and the
like, may not in a great measure be communicated or aggravated by the absorption of particles of feculent matter into the system, which are either inappreciable or scarcely appreciable by the most minute chemical analysis. It is impossible in that state of things to say what amount of injury may be done by polluting even partially a stream which flows a considerable distance. I am of opinion that Mr. Goldsmid was not bound to remain quiet until this stream had become such a nuisance that it was obvious to everybody near its banks; and the result is that he is entitled to a decree for an injunction to restrain the defendants from causing or permitting the sewage and other offensive matters from the town of Tunbridge Wells to be discharged into the Calverly brook, or stream, in such a manner as to affect the waters of the brook as it flows through the plaintiff's land."

This decree of the master of the rolls was subsequently affirmed on appeal. (1 Ch. L. R. 348.)

Similar views prevailed in Chapman *v.* City of Rochester, (110 N. Y. 273,) where a bill was filed to enjoin the defendant city from polluting, by the discharge of sewage by artificial means, a natural stream flowing through his lands.

In the opinion of the New York court of appeals, it was said by Danforth, J., after citing the Goldsmid *v.* Turnbridge Wells:

"In view of the principle upon which this and like decisions turn, the objections of the learned counsel for the defendant against the judgment appealed from are quite unimportant. The filth of the city does not naturally flow to the grounds of the plaintiff, as surface water finds its level, but is carried thither by artificial arrangements, prepared by the city, and for which it is responsible. Nor is the plaintiff estopped by acquiescence in the proceedings of the city in devising and carrying out its system of sewage. The principle invoked by the appellant has no application. It does not appear that the plaintiff in any way encouraged the adoption of that system, or by any act or word induced the city authorities to so direct the sewers that the flow from them should reach his premises. There is no finding to that effect, and the record contains no evidence. In fine, the case comes within the general rule, which gives to a person injured by the pollution of air or water, to the use of which, in its natural condition, he is entitled, an action against the party, whether it be a natural person or corporation who causes that pollution."

Cases cited by defendants' counsel, where injunctions were refused to aid in the suppression of public nuisances, were cases where the act complained of was fully completed, and where the nuisance was not one resulting from conduct repeated from day to day. Most of them were cases of purpresture, and concerned permanent structures already existing when courts in equity were appealed to.

The bill in this case does not assail the drainage canal as an unlawful structure, nor aim to prevent its use as a waterway. What is sought is relief against the pouring of sewage and filth through it, by artificial arrangements, into the Mississippi river, to the
67 detriment of the State of Missouri and her inhabitants, and the acts are not merely those that have been done, or which when done cease to operate, but acts contemplated as continually repeated from day to day. The relief prayed for is against not merely the creation of a nuisance but against its maintenance.

Our conclusion, therefore, is that the demurrers filed by the respective defendants cannot be sustained. We do not wish to be understood as holding that, in a case like the present one, where the injuries complained of grow out of the prosecution of a public work, authorized by law, a court of equity ought to interpose by way of preliminary or interlocutory injunction, when it is denied by answer that there is any reasonable foundation for the charges contained in the bill. We are dealing with the case of a bill alleging, in explicit terms, that damage and irreparable injury will naturally and necessarily be occasioned by acts of the defendants, and where the defendants have chosen to have their rights disposed of, so far as the present hearing is concerned, upon the assertions of this bill.

We fully agree with the contention of defendants' counsel that it is settled that an injunction to restrain a nuisance will issue only in cases where the fact of nuisance is made out upon determinate and satisfactory evidence; that if the evidence be conflicting and the injury be doubtful, that conflict and doubt will be a ground for withholding an injunction; and that, where interposition by injunction is sought, to restrain that which is apprehended will create a nuisance of which its complainant may complain, the proofs must show such a state of facts as will manifest the danger to be real and immediate. But such observations are not relevant to the case as it is now before us.

The demurrers are overruled, and leave is given to the defendants to file answers to the bill.

68 Supreme Court of the United States, October Term, 1900.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago.
No. 5, Original.

(January 28, 1901.)

Mr. Chief Justice FULLER, with whom concurred Mr. Justice Harlan and Mr. Justice White, dissenting:

Controversies between the States of this Union are made justiciable by the Constitution because other modes of determining them were surrendered; and before that jurisdiction, which is intended to supply the place of the means usually resorted to by independent sovereignties to terminate their differences, can be invoked, it must appear that the States are in direct antagonism as States. Clearly this bill makes out no such state of case.

If, however, on the case presented, it was competent for Missouri to implead the State of Illinois the only ground on which it can be rested is to be found in the allegation that its governor was about to authorize the water to be turned into the drainage channel.

The Sanitary District was created by an act of the General Assembly of Illinois, and the only authority of the State having any control and supervision over the channel is that corporation. Any other control or supervision lies with the lawmaking power of the State of Illinois, and I cannot suppose that complainant seeks to coerce that. It is difficult to conceive what decree could be entered in this case which would bind the State of Illinois or control its action.

The governor, it is true, was empowered by the act to authorize the water to be let into the channel on the receipt of a certificate, by commissioners appointed by him to inspect the work, that the channel was of the capacity and character required. This was done, and the water was let in on the day when the application was made to this court for leave to file the bill. The governor had discharged his duty, and no official act of Illinois, as such, remained to be performed.

Assuming that a bill could be maintained against the Sanitary District in a proper case, I cannot agree that the State of Illinois would be a necessary or proper party, or that this bill can be maintained against the corporation as the case stands.

69 The act complained of is not a nuisance, *per se*, and the injury alleged to be threatened is contingent. As the channel has been in operation for a year, it is probable that the supposed basis of complaint can now be tested. But it does not follow that the bill in its present shape should be retained.

In my opinion both the demurrers should be sustained, and the bill dismissed, without prejudice to a further application, as against the Sanitary District, if authorized by the State of Missouri.

My brothers Harlan and White concur with me in this dissent.

70 And on the same day, to wit, on the 28th day of January, A. D. 1901, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago.
} No. 5, Original.

On motion of Mr. William M. Springer, of counsel for the defendants, it is ordered by the court that the answers of the defendants herein be filed.

71 And on the same day, to wit, on the 28th day of January, A. D. 1901, the answer of the defendant, The State of Illinois, was filed in the words and figures following, viz:

72 In the Supreme Court of the United States, October Term, 1900.

STATE OF MISSOURI, Complainant,
v.
STATE OF ILLINOIS and THE SANITARY District of Chicago, Defendants.
} Number 5, Original.

Separate Answer of the State of Illinois to the Bill of Complaint of the said State of Missouri.

Now comes the State of Illinois by Edward C. Akin, attorney general of the State of Illinois, not waiving the demurrer filed herein, and in which this defendant joins but wholly relying thereon, for answer to so much of said bill of complaint as it is advised it is material and necessary for this defendant to answer unto, does say:

That this defendant, The State of Illinois, has by its attorney general, read the separate answer of The Sanitary District of Chicago, its co-defendant, and that in so far as said separate answer admits certain allegations contained in the complainant's bill of complaint, filed herein, this defendant, The State of Illinois, makes the 73 same admissions in this its separate answer without repeating the same admissions to said answer of its co-defendant thereon. That this defendant, The State of Illinois, as to all allegations contained in said bill of complaint, which are specifically denied by the separate answer of its co-defendant, filed herein, unites in such denial and makes said bill of complaint its own in this respect. And furthermore, this defendant unites with its co-defendant in making the allegations of new matter by way of defense set up by its co-defendant in its answer, filed herein, and makes said allegations its own in so far as this defendant is required to make answer to said bill of complaint; and this defendant refers this honorable court to the separate answer of its co-defendant, filed herein, and makes said answer its own, in so far as this defendant, The State of Illinois, is required to make answer in this cause.

This defendant avers that the laws of the State of Illinois, mentioned in its co-defendant's answer, and filed as exhibits therein, were passed by the General Assembly of the said State of Illinois, at the times mentioned, in pursuance of the authority vested in said General Assembly, and that the said acts are valid under the constitution of the State of Illinois, and that said General Assembly was clothed with ample authority by the constitution of the State of Illinois to pass said laws; and that the passage thereof was a proper and constitutional exercise of the power conferred upon said General Assembly.

And for further answer herein, this defendant avers that The Sanitary District of Chicago, its co-defendant, in exercising the authority conferred upon it by the laws of the State of Illinois, is not subject to the control of the executive department of the State of Illinois, and that it is not within the power of the governor of said
74 State to control the officers of its co-defendant, said Sanitary District of Chicago, in the performance of their duties as such officers.

And this defendant, The State of Illinois, admits that under said laws of the State of Illinois, it was the duty of the trustees of the Sanitary District of Chicago to notify the governor of the said State of Illinois of the completion of the said canal or channel, and that it was the duty of the governor of the State of Illinois to appoint three commissioners to examine said canal or channel, as alleged in complainant's bill of complaint. And this defendant alleges that prior to the time when the complainant in this case presented its motion in this honorable court, for leave to file its bill of complaint herein, that the governor of said State had appointed said commissioners as required by the laws of said State, and the said commissioners had reported to him that they had examined said canal or channel, and had found it in all respects completed in conformity with law, and that the governor of said State, prior to said time, issued a permit to the trustees of the said Sanitary District of Chicago, to turn the water and sewage of said drainage district into the Des Plaines and Illinois rivers; and that said trustees did, prior to the time aforesaid, turn said water and sewage into said rivers, as this defendant is informed and believes, as will more fully appear to this honorable court, by reference to the separate answer of the said Sanitary District of Chicago, filed herein; and as to all said allegations in the said separate answer of the Sanitary District of Chicago, filed herein, in reference to the appointment of said commissioners, their report to the governor, and the action of the governor of said State of Illinois in the premises, this defendant avers that the allegations in the answer of its co-defendant are true; and that 75 the said acts of the governor of the State of Illinois were all done and performed prior to the 17th day of January, 1900, when the complainant herein moved this honorable court for permission to file said bill of complaint.

Therefore this defendant avers that the State of Illinois cannot now be enjoined or restrained from issuing to its co-defendant herein, permission or authority to do and perform the acts aforesaid, or to allow them to be done.

This defendant, The State of Illinois, further admits as alleged in said bill of complaint, that by the general provisions of the act of the State of Illinois, creating the Sanitary District of Chicago, the said canal or channel to be constructed by said sanitary district is at all times subject to the control and supervision of the State of Illinois and of her authorities. But this department avers that said control and supervision can only be exercised by and through the law-making power of the said State of Illinois; and that the only authorities of said State, authorized by said laws to control and supervise said canal or channel are the board of trustees of the Sanitary District of Chicago, their officers, agents and employees.

And this defendant, The State of Illinois, denies all unlawful combination in said bill charged without that any other matter or thing material for it to make answer to, and not herein sufficiently answered, avoided, or denied, is true, to the knowledge or belief of this defendant. All of which matters and things this defendant is ready to aver and prove, as this honorable court shall direct, and it prays to be hence dismissed with its reasonable costs and charges in this behalf most wrongfully sustained.

THE STATE OF ILLINOIS,
By EDWARD C. AKIN,
Attorney-General of the State of Illinois.

76 UNITED STATES OF AMERICA:

In the Supreme Court of the United States.

On this 7th day of March, 1900, before me, James T. Jones, clerk of the circuit court of the United States for the southern district of Illinois, personally appeared John R. Tanner, governor of The State of Illinois, one of the defendants in the foregoing bill of complaint above named, (who) being by me duly sworn, deposes and says, that he is the governor of the said State of Illinois, and familiar with its affairs and business; that he has read the foregoing separate answer of this defendant, The State of Illinois, and also the separate answer of its co-defendant, The Sanitary District of Chicago, and that he knows the contents thereof, and the same are true of his own knowledge, except as to the matters stated on information and belief, and as to those matters he verily believes them to be true.

JOHN R. TANNER,
Governor of the State of Illinois.

Subscribed and sworn to before me by John R. Tanner this 7th March, 1900.

[L. S.] JAMES T. JONES,
Clerk Circuit Court U. S., South. Dist. Ills.

(Endorsed:) Supreme Court U. S., October term, 1900. No. 5, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Separate answer of the State of Illinois. Filed January 28, 1901.

77 And on the same day, to wit, on the 28th day of January, A. D. 1901, the answer of the defendant, The Sanitary District of Chicago, was filed in the words and figures following, viz:

78 In the Supreme Court of the United States, October Term, 1900.

STATE OF MISSOURI, Complainant,
v.
STATE OF ILLINOIS and THE SANITARY DISTRICT of Chicago, Defendants.
} Number 5, Original.

Separate Answer of the Sanitary District of Chicago to the Bill of Complaint of the State of Missouri.

Now comes The Sanitary District of Chicago, one of the defendants in the above-entitled cause, not waiving the demurrer to the said bill of complaint heretofore filed in this cause, but wholly relying thereon, for answer to so much of said bill of complaint as it is advised is material and necessary for this defendant to answer unto, does say:

That it admits that the complainant herewith is one of the States of the United States, and that The State of Illinois, one of the defendants herein, is one of the States of the United States, and that 79 this defendant, The Sanitary District of Chicago, is a public corporation, organized under the laws of the State of Illinois and located as in said bill described, and is a citizen of said State. This defendant further admits that the population of the State of Missouri is upwards of three millions of people, and that said State lies on the west bank of the Mississippi river, a public, navigable, and running stream, having a frontage on said stream of over four hundred miles; that by act of Congress providing for the admission of Illinois and Missouri as States of the Union, it was declared that the western boundary of Illinois and the eastern boundary of Missouri should be the middle of the main channel of the Missisippi river; that the shores of the Mississippi river, where its waters form the Missouri and Illinois boundaries, and the soil under the waters thereof, were not granted by the Constitution of the United States, but were reserved to the States of Illinois and Missouri respectively.

This defendant further admits that the States of Missouri and Illinois, each have concurrent general jurisdiction over the waters of the Mississippi river, forming the boundary between them, and each of said States has exclusive territorial jurisdiction over that portion adjacent to its own shore; and that the Illinois river empties into the Mississippi river at a point above the city of St. Louis, on the Illinois side of said Mississippi river.

This defendant further admits that within the territory of the State of Missouri and on the banks of said Mississippi river, and below the mouth of the Illinois river are many cities and towns in the State of Missouri, and many thousands of persons who rely upon the waters of said Mississippi river, in their regular, natural, and accustomed
flow, for their daily necessary supply of water, for drinking
80 and all other domestic, agricultural, and manufacturing pur-
poses, and for watering stock and animals of all kinds, and that said Mississippi river has been flowing in its regular course, and has been used for the purposes aforesaid by the inhabitants of said State of Missouri for a time whereof the memory of man runneth not to the contrary. But whether the river and its waters, and the use thereof, for drinking, agricultural, and manufacturing purposes, in their accustomed and natural flow, are indispensable to the life, health, and business of many thousands of inhabitants of the said State of Missouri, and whether said inhabitants are compelled to use said waters for said purposes, this defendant neither admits nor denies, but leaves said complainant to make proof thereof; but said defendant denies that said river and its waters, and the use thereof, for drinking, agricultural, and mechanical purposes are of value to the State of Missouri as a State or as a body politic.

This defendant further admits that the cities and towns below the mouth of the said Illinois river, within the territory of the said State of Missouri, do by means of waterworks, water-towers, and intakes, built and constructed for that purpose, supply the inhabitants of said cities and towns with an adequate supply of water for drinking and other domestic uses, from the said Mississippi river; but whether said cities and towns are compelled to use the water for drinking and other domestic purposes, or whether said cities and towns are furnished with an adequate supply of pure and wholesome water, fit and healthful for drinking, and other domestic purposes and uses, from said Mississippi river, this defendant neither admits nor denies, but leaves complainant to make proof thereof.

Further, this defendant neither admits nor denies that
81 said waterworks systems are constructed with reference to
said Mississippi river, for the purpose of taking water therefrom, and not from any other source, and leaves complainant to make proof thereof.

This defendant admits that heretofore, to wit: in 1889, the State of Illinois enacted a law known as the sanitary district act, together with an act for the improvement of the Illinois and Des Plaines rivers, and that under said act of said State, the said defendant corporation, known as The Sanitary District of Chicago, was organized and is now existing and operating, and that by the express terms of said act, any canal or drainage corporation organized in accordance with its provisions may have conditions, restrictions, or additional requirements placed on said corporation, or the act, authorizing the creation of said corporation may be amended or repealed, and that by the express provisions of said act, before any water or sewage shall be admitted into any channel constructed under said act, the trustees of said channel should notify the governor of the State of Illinois of the completion of said channel, and that the governor of the State of Illinois should appoint three commissioners to examine said channel or canal and report to the governor of said State of Illinois, whether the same complied with the said act of the State of Illinois; and that if it does, the governor should authorize the water and sewage to be turned into said canal or channel; and without the said permit said water and sewage cannot be so turned in; and by the general provisions of said act, said channel is at all times subject to the control and supervision of the State of Illinois and her authorities; but this defendant avers that such control and supervision can only be exercised by the law-making power of said State.

82 This defendant further admits that the Chicago river is situate in the basin of Lake Michigan, and has forks or branches flowing through the city of Chicago and into Lake Michigan, and that the natural drainage of Chicago is or has been into Lake Michigan, but this defendant denies that the drainage and sewage of the territory embraced in this defendant's district, namely, the Sanitary District of Chicago, is led or flows into the Chicago river and Lake Michigan; but this defendant avers and will establish the fact by sufficient proof to the satisfaction of this honorable court, if permitted to do so, that the greater portion of the water and sewage of said territory has been, for many years discharged into the Des Plaines and Illinois rivers, in the manner which will be pointed out and particularly described hereinafter in its answer.

This defendant, further answering admits, as will be hereinafter more fully shown, that it has constructed a drainage canal, having origin and extent described in said bill; that in the construction of said canal or drain, this defendant cut through the natural ridge or water-shed, which divides the basin of Lake Michigan from the basin of the Des Plaines and Illinois rivers, and of the Mississippi river. The origin, extent, and public history of said drainage channel will hereafter be more fully recited in this answer.

But this defendant denies that all or any considerable portion of the sewage and drainage of the territory embraced in its said district is led into or flows into the Chicago river and Lake Michigan, and to this allegation this defendant will make fuller answer as hereinbefore stated.

This defendant expressly denies that its acts and doings in complainant's bill mentioned, and hereinafter described, have been without legal authority, but on the contrary says that each and every of its acts have been in strict pursuance of authority given it by the State of Illinois.

83 This defendant further admits, not alone that it has about completed the said drainage channel, but states that it has completed the same, and that it is about to receive and has received into said channel the sewage matter and filth of the Sanitary District of Chicago, which embraces nearly the entire city of Chicago, and a portion of the county of Cook, and that it is about to cause and has caused said sewage and filth to flow through said channel or drain towards and into the Des Plaines river; but that the said sewage and filth will be carried into said Mississippi river, and that it will pass by the homes of the inhabitants of the State of Missouri, or of the cities and towns and their waterworks, within said State, this defendant denies.

This defendant admits that the sewage matter and filth which it is now receiving and causing to flow through said drainage channel into said Des Plaines river, is that which is created by the population and activities and industries of the district of this defendant; that among those industries are stockyards, slaughtering establishments, and rendering establishments, but not distilleries; and this defendant denies that noxious matters created by said establishments will be received into said channel, but on the contrary thereof, this defendant alleges that the said noxious matters are in large part, if not wholly, rendered innocuous before being received into the sewage system of the city of Chicago and of said drainage district, and this defendant denies that there are any distilleries within the said district. This defendant further denies that it is true, as stated in said bill of complaint, that the city of Chicago has been discharging its sewage matter and filth into said Chicago river and into Lake Michigan, in such large quantities, that much of it has accumulated upon the bed and along the sides of said river, and upon
84 the bed of said lake, near the shores thereof; and it especially denies that the plan adopted and in operation by this defendant will loosen said matter and filth so alleged, to be deposited upon the bed of the lake and the sides of the river, and the shores of said river and lake and cause it to flow into and towards said Des Plaines river; but on the contrary thereof, defendant says, as it is more particularly hereinafter set forth, that for many years a large portion of the sewage matter arising in said drainage district has been turned into the Chicago river, and has been pumped into a drainage channel heretofore constructed, and has flowed into the Des Plaines river. This defendant especially denies that the plan of operation adopted by it will loosen any accumulated matter or filth, but on the contrary thereof, it says, that it denies the presence of said accumulated matter and filth, at the points and to the extent in said bill alleged, and states that during a long time preceding the opening of defendant's channel, such of the sewage and filth of said district as has been discharged into the Chicago river and

flowed thence into Lake Michigan, had been taken up and dissipated by the cross-currents of Lake Michigan, and carried to distant points, and has wholly lost its noxious character, and that much of said matter as might from time to time have accumulated in the past has been covered upon the bottom of said lake by the deposits thereon of earth excavated from the foundations of the city, and deposited in said lake for the making of new lands.

This defendant denies that if it shall carry its plans into execution, and shall carry all the sewage and alleged noxious matters arising in said Sanitary District into the waters of the Des Plaines river, through said drainage channel, that the waters of the Mississippi river will of a certainty or at all be poisoned and polluted
85 thereby, as alleged in said bill of complaint, and it expressly denies that the carrying out of its plans will destroy the flow and adaptability of the waters of the Mississippi river, along the territory of complainant, for domestic or other uses. And it expressly denies that such use will render wholly valueless and entirely worthless the said waterworks systems of the cities and towns located in State of complainant; or that it will injure and destroy the business of the cities and towns in State of complainant, in furnishing and selling water to private consumers, or that it will disable them from furnishing water for domestic or any other purposes. And this defendant expressly denies that it will injure the property and business of said cities and towns, or that it will establish and create as to them a direct and continuing nuisance, with the results in said bill described, or any injurious results; and it expressly denies that any damage will result to said complainant or to said cities and towns, or inhabitants of complainant, from such use and carrying out of the plans of this defendant.

This defendant neither admits nor denies, as alleged by complainant in its bill of complaint, that the filth and sewage of the Sanitary District of Chicago, which will be turned into the Des Plaines river, will amount to 1,500 tons daily, but leaves the complainant to make proof thereof; but this defendant denies that said filth and sewage, or any part thereof, will be deposited in the bed or soil of the Mississippi river, within the jurisdiction of complainant; and this defendant denies that the filth and sewage of the said Sanitary District of Chicago will pollute and poison the waters of the said Mississippi river to such an extent as to render said waters unwholesome, unfit, and unhealthful for drinking and other domestic uses, by the inhabitants in the territory of complainant,
86 or unfit for watering stock and for manufacturing purposes, and this defendant denies that said sewage from the Sanitary District of Chicago will poison and pollute the waters of the said Mississippi river along the territory of complainant with germs of diseases of various kinds, or with any germs of disease whatever; and this defendant denies, as alleged in said bill of complaint, that this defendant will cause a continuing nuisance in the Mississippi river, to the detriment, and irreparable and continuing damage and

injury of the said State of Missouri, or an irreparable injury to the lives and health of the citizens or inhabitants of the said State of Missouri; but on the contrary, this defendant expressly avers, and if permitted, will prove to this honorable court, that the turning into the Des Plaines river of the sewage of the Sanitary District of Chicago, together with 300,000 cubic feet per minute of the pure water of Lake Michigan, which will accompany the same, will greatly improve the quality of the waters of the Illinois and Mississippi rivers, and also greatly improve the conditions which existed prior to the time said sewage and water were turned into said Des Plaines and Illinois rivers, as will more fully appear hereafter in this answer.

And for other and further answer in this behalf, this defendant says that the Sanitary District of Chicago is a corporation organized and existing under the laws of the State of Illinois; that it is wholly within the county of Cook, in said State; with power to extend its operations and works beyond the territorial limits of its existence, as will be more particularly hereinafter shown.

This defendant alleges that in the year 1822 the proper authorities of the United States enacted a law granting to the State of Illinois the right for a route for a canal connecting the Illinois river with the southern bend of Lake Michigan; that on the 2d day of 87 March, 1827, a further act of Congress of the United States was approved, and by which a quantity of land equal to five sections in width on each side of the canal proposed by said act, was granted to the State of Illinois to aid in the construction of said canal. That subsequently thereto the State of Illinois entered upon the construction of said canal according to various acts of the legislature, and prosecuted the work of completing said canal, so that it was long since opened from Bridgeport to La Salle upon the Illinois river. That there were in the course of the construction of said canal divers levels provided, one of which was known as Summit level, properly connected with the remaining course of said canal. That a large quantity of the water necessary to supply the said Summit level of said completed canal was obtained by means of a pump or pumps at or near Bridgeport in Cook county, Illinois, by which the waters of the Chicago river were pumped and discharged into the said Summit level of said canal. That said pumping was begun in the year 1848 and continued until the year 1871. That said pumps were operated by and at the expense of the State of Illinois, in order to supply said canal with water. But during said period, viz., from 1865 to 1871, the city of Chicago assisted in bearing the expenses of such work, and used the said Chicago river and said canal for the discharge of its sewage, and the said arrangement continued until the year 1871. That in 1865 the legislature of Illinois by law authorized the city of Chicago to deepen the said Illinois and Michigan canal, and thereby effect a flow by gravity from the Chicago river into said Summit level. Reference is hereby made to said public law of 1865, and the same will be exhibited to this court upon the hearing of this cause, and the same

is hereby made a part of this answer and is marked "Exhibit A." And this defendant avers and shows the
88 court that in and by said law of 1865, the city of Chicago was authorized to deepen and did promptly thereafter deepen the said Illinois and Michigan canal for the express purpose of disposing of the sewage received into the said Chicago river, and did thereafter use said canal for said purpose. That the said Chicago river itself has in ordinary times no current that is perceptible, but maintains a level with the water of Lake Michigan, and is rather an estuary of said lake than a river, except in case of flood, when it has a sluggish current settling, not by descent, but by propulsion into the lake. That since a time prior to 1865, and since the year 1849, since when a large share of the drainage of the city of Chicago has been into said Chicago river, and that from that time until now, by means of said pumps at Bridgeport, and the said deep cut made in pursuance of said act of 1865, the discharge of nearly all of the sewage of the Chicago river has been into said canal and through and down said canal to the Des Plaines river at Lockport.

And this defendant further answering, says, that the population of the city of Chicago in the year 1890, as determined by the Federal census, was about 1,100,000. That from that time until the filing of the bill of complaint in this case, there has been an increase of 400,000. That of the 1,500,000 people thus embraced within the limits of the city of Chicago, the sewage of 200,000 of them has been discharged at other points than into the Chicago river, and that the sewage of the residue of the population of said city has at all times been discharged into the Chicago river, and that the whole of the sewage of said residue of said people has been carried by the said pumps into the said deep cut during the whole period aforesaid into the said canal and into the said river, save and
89 except upon such occasions of flood or unusual instances, few in number, when the current of the river was set into the lake, causing the lake to be roily and polluted near the mouth of said river, and along the shores of Lake Michigan, until the subsidence of said flood.

This defendant, further answering, says, that such has been, in the period aforesaid, the increase of population and extent of sewage discharged into the Chicago river, that in 1881 it was found necessary to aid the gravity flow of water from the Chicago river into the deep cut by the establishment of larger pumps at Bridgeport, which is a point within the limits of said Sanitary District, in the said county of Cook, and that since said year 1881, a period of nineteen years, the said deep cut and the said pumps have been continuously working, carrying away the said sewage into the said deep cut, and through said canal into the Des Plaines river. And this defendant alleges that the work of deepening said canal by the deep cut, as it is popularly called, was so extensive that the city of Chicago expended thereon the sum of about three million dollars, viz:

$2,955,340; and also a very great sum of money in the erection and operation of the pumps at Bridgeport, as aforesaid, and that all of this work was open and notorious, and in the sight of all men.

And defendant, further answering, says, that in the year 1889 the legislature of the State of Illinois passed an act entitled, "An act to create sanitary districts, and to remove obstructions in the Des Plaines and Illinois rivers," which was duly approved on the 29th day of May, and went into force and effect on the 1st day of July thereafter. That immediately thereafter such proceedings were had that a Sanitary District was formed under the provisions of
90 said act, which is the district of this defendant in this cause. That said district, duly officered, has been in existence since January of the year 1890. Special reference is made to said act, a copy of which is attached to this answer for greater accuracy, and made a part hereof, and marked " Exhibit B."

And this defendant, further answering, says, that in pursuance of said act it immediately entered on the discharge of the duties imposed upon it by said act. That it adopted a general plan of construction for the channel, to be of the size, dimensions, and general character mentioned in said act, of 600,000 cubic feet of water per minute. That said channel originates at Robey street in the city of Chicago, and passes thence through the counties of Cook, Will and Du Page, by the best determinable lines to Lockport on the Des Plaines river. That in and about preparing for the construction of said channel, this defendant, in the most open and notorious manner acquired by deed, where possible, the right of way for its various structures, placing the said deeds for said premises upon record in the recorders' offices, of Cook, Will and Du Page counties, as obtained, beginning in the year 1891. That where necessary it instituted condemnation proceedings in the proper courts, of Du Page, Will and Cook counties. That all of these, its said acts were open and notorious, and this defendant expressly avers that by the act incorporating it, all of its acts and doings are matters of public record, whereof people and courts are required to take notice, and that its records are and at all times have been open to the inspection of all citizens, and of all persons interested therein. That there are a number of lines of railway passing between the cities of Chicago and St. Louis, one of the cities in the State of complainant, near to and within plain sight of the work progressing from
91 time to time upon said channel, traversed by hundreds of thousands of citizens day and night. That such has been the extent and character of the work performed by this defendant within the time stated, that it became a matter of notoriety to all persons traversing said roads, and that such was the magnitude of the undertaking, the difficulties experienced and overcome, the greatness and scope of the work, that it became noted to all the world, and the subject of innumerable dispatches, communications and publications made from time to time in all cities of the United States. That in the prosecution of this work it has occupied more

than four thousand acres of land in the county of Cook alone, more than five hundred acres of land in the county of Du Page, and nearly three thousand acres in the county of Will, at a total cost of more than three million dollars. That during the whole of the nine years since the institution of work upon this enterprise, as aforesaid, this defendant, The Sanitary District of Chicago, has expended upon said work more than thirty-three million dollars. That these expenditures have all been openly, notoriously and of record made in and about the public interest.

And this defendant, further answering, says, as it has heretofore said, that it had completed its said channel, prior to the filing of the bill of complaint in the said cause. That that which physically prevented the opening of the said channel, was but the interposition of a few cubic yards of earth left to protect the work and workmen from the inflow of the Chicago river. That these were removed on the 2d day of January, 1900; and the water turned from the Chicago river into said channel and down to the controlling works at Lockport, filling the said drainage channel for a distance of twenty-eight miles, to an average depth of twenty-two feet, with prisms of
water varying from 110 feet in width at the bottom to 200
92 feet in width at the bottom, and the width at the water line
varying from 160 feet to 290 feet. That this vast body of water moved from the Chicago river and Lake Michigan into this channel between the 2d day of January and the 16th day of January, 1900; and that all that remained to do, in order to complete the great work for which the aforesaid great expenditures have been made was the raising of the gates and the lowering of the bear-trap dam at the bottom of said prism, twenty-eight miles away from the source of supply, and that this was duly and lawfully accomplished at 11.16 o'clock a. m., on the 17th day of January, 1900, prior to the time when complainant presented its motion to this court for leave to file its bill of complaint herein, and five days prior to the time said bill was filed by leave of this court.

Wherefore, and by reason of the premises aforesaid, this defendant alleges that the said State of Missouri, complainant herein, had notice of the premises, and of the great work and the great expenditures, which this defendant alleges were the expenditures of public money raised by taxation, and by the sale of bonds, which are liens upon the tax funds of said district to be hereafter levied; and having such notice as aforesaid, and having so waited as aforesaid, it has been guilty of laches, and has slept upon its rights, if any it ever had, and is estopped to further urge its cause.

And this defendant, further answering, says, that the drainage channel hereinbefore mentioned was commenced September 3, 1892, that it is constructed through glacial drift, earth and rock, through glacial drift for a distance of 13.1 miles, and through solid rock for a distance of 14.95 miles. That the width of said channel where
the same is constructed through glacial drift for 7.8 miles is
93 110 feet at the bottom and 193 feet at the water line, and has
a capacity of 360,000 cubic feet of water per minute, with a

velocity of one and one-quarter miles per hour. That for a distance of 5.3 miles said channel has a width at the bottom of 202 feet, and of 290 feet at the water line, and a capacity of 600,000 cubic feet per minute, with a velocity of one and one-quarter miles per hour. That where said channel is cut through solid rock, it has an average width from top to bottom of 161 feet, with a capacity of 600,000 cubic feet per minute, and a velocity of 1.9 miles an hour. That the carrying capacity of the total channel at the rate of three miles per hour exceeds 360,000 cubic feet per minute, and that this capacity of channel will be sufficient to and will furnish pure water from Lake Michigan at the ratio of twenty cubic feet to one cubic foot of the liquid sewage of every description furnished or to be furnished from the Chicago river and the sanitary district aforesaid. That by the terms of the organic act creating the said Sanitary District of Chicago, defendant was fully empowered and enjoined to do and perform all the acts, and make and construct all the improvements, channels, and outlets that it has constructed, at a cost to the Sanitary District of Chicago of over thirty-three million dollars.

And this defendant, as to so much of said bill as alleges that it, "without any legal authority so to do, has already in part effected its said threat and purpose, and threatens to permit and to cause said sewage and filth, by artificial means of pumping and otherwise, to flow through the said channel or drain towards and into the said Des Plaines river, and eventually into the Mississippi river," answering, says: That all of its acts and doings hereinbefore and in said bill set forth, have been done in pursuance of the powers given in and the duties devolved upon it by the said act of
94 May 29, 1889. That after having prosecuted its said work from the beginning continuously as aforesaid until the 27th day of May, 1897, a certain joint resolution was adopted by the legislature of the State of Illinois which, among other things, recited as follows:

"Whereas, the General Assembly in 1889 passed an act to create sanitary districts, and provided thereunder for the disposal of the sewage of the city of Chicago, through the Des Plaines and Illinois rivers, by means of a canal across the Chicago divide, of such capacity as to dilute the sewage beyond offense, and such sewage disposal was granted on the condition that said channel should be so constructed as to form part of a navigable waterway between Lake Michigan and the Mississippi river. * * *

"And whereas, under the legislation aforesaid and acts supplemental thereto, the works of the Sanitary District of Chicago are so far advanced that the water will be turned through the same in the year 1899.

"Therefore, be it resolved, first; That it is the policy of the State of Illinois to procure the construction of a waterway of the greatest practicable depth and usefulness for navigation from Lake Michigan, by way of the Des Plaines and Illinois rivers to the lower Mississippi river, &c., &c." Which said joint resolution is to be found in the

Session Laws of the State of Illinois for the Year 1897, on page 309. By which said joint resolution the extent and progress of the said work of this defendant was recognized and publicly declared. A copy of said joint resolution is attached to this answer as a part thereof, and marked, "Exhibit C."

That in the original act under which this defendant was incorporated, and by section 27 thereof, it was provided: "If any
95 channel shall be constructed under the provisions of section
23, of this act, it shall be the duty of the trustees of such district, when such channel shall be completed, and before any water or sewage shall be admitted therein, to duly notify in writing the governor of this State of such fact, and that the governor shall thereupon appoint three discreet persons as commissioners, one of whom shall be a resident of the city of Joliet, or between said city and the city of La Salle, and one a resident of the city of La Salle, or between said city and the city of Peoria, and one a resident of the city of Peoria, or between said city and the mouth of the Illinois river, to inspect said work. The said commissioners shall, within ten days after such appointment, meet at the city of Chicago, and shall appoint a competent civil engineer, and they may employ such other assistants as they may require to expeditiously perform their duties. * * * And in case they shall find the work in all respects in accordance with the provisions of section 28, of this act, they shall so certify to the governor, who shall thereupon authorize the water and sewage to be let into said canal."

That in pursuance of said section the governor of the State of Illinois, the Honorable John R. Tanner, upon notice in writing of the substantial completion of said work by said trustees, did appoint such a commission as is provided for in said section 27. That in all respects as to personnel and locality said section was complied with by the appointment of E. S. Taylor, John Lambert and Alfred Schoch. That after such appointment the said commission went upon and examined the said channel and the said work, and thereupon, and on the 16th day of January, 1900, reported to the governor as follows:

96 "Governor John R. Tanner:

Your special committee reports the work of the sanitary trustees on the drainage channel substantially completed, and meets the requirements of the law, with the exception of the removal of the State dams, which are in the hands of the supreme court. We recommend the granting of the official permit. Full official report will follow telegram. William Boldenweck, president, board of trustees is at St. Nicholas hotel, Joliet.

(Signed)

E. S. TAYLOR.
JOHN LAMBERT.
ALFRED SCHOCH."

That thereupon and on the 17th day of January, 1900, the said governor authorized the opening of the said channel by the following message:

SPRINGFIELD, ILLINOIS, January 17, 1900.
VIA JOLIET, ILLINOIS, January 17, 1900.

To William Boldenweck, Lockport, Illinois.
To the board of sanitary trustees, Chicago Drainage District, Chicago, Illinois.

GENTLEMEN: The board of commissioners heretofore appointed by the undersigned to make an examination and survey of the Chicago river and the chicago drainage Channel, to determine whether the said channel has been completed in accordance with the requirements of sec. 23, of the act entitled, "An act to create sanitary districts, and to remove obstructions in the Des Plaines and Illinois rivers, approved May 29, 1889, in force July 1, 1889, having certified to me that said channel has been and is now completed in accordance with the law creating said sanitary district. Now, therefore, I, John R. Tanner, governor of the State of Illinois, do hereby authorize and direct you, the said board of sanitary trustees, to open and let into the said channel the waters of Lake Michigan and of the Chicago river, and the sewage of the said sanitary district, and to use and employ said channel for all the uses and purposes
97 for which said channel was constructed.

In witness whereof I have hereunto set my hand and seal, this 17th day of January, A. D. 1900.

JOHN R. TANNER, Governor.

That thereupon the said trustees, having received the said message and permit and authorization, did open the controlling works, and did permit the flow of the water of Lake Michigan and the sewage of the Sanitary District of Chicago as aforesaid into the Des Plaines river.

Wherefore, this defendant says that in all respects it hath proceeded with full legal authority so to do.

And this defendant, further answering, says that the distance by way of the drainage channel and the Illinois river, from Robey street, Chicago, in the said sanitary district, to the mouth of said Illinois river, is 322 miles. That the said Illinois river, into which the said Des Plaines river empties, is formed by the junction of the Des Plaines and the Kankakee rivers, that the Fox river empties into the Illinois river at Ottawa, and that these three rivers uniting to form the Illinois river with their tributaries, are the natural drainage system for an area of country thickly populated and occupied by not less than a million and a half of people outside of said sanitary district, and embracing an area of twenty-five thousand square miles. That upon the banks of said rivers, among very many smaller cities, all of them draining into the said rivers, and from thence into the Mississippi river, are the principal cities of

Joliet, with a population of over 40,000, and having immense manufacturing establishments of the same nature and character as those in this defendant's district, being the establishments of a varied industry carried on by a working population; and
98 the city of Aurora, with a population of 40,000, and a drainage and sewage system in all respects like that of Joliet. That these cities are respectively forty miles nearer to St. Louis by running water than is the drainage district of your defendant. That lower down upon said Illinois river is the city of Peoria, with a population of 60,000, wherein is conducted the greatest distilling industry in the United States, together with stock-yards and cattle pens, as well as other large industries, all of which have their discharge into the said Illinois river. That the distance from the said Peoria to the mouth of the said Illinois river is about 160 miles. That in addition to the foregoing, may be mentioned the cities of Springfield, with a population of 25,000; Jacksonville, Carrolton, Beardstown, Pekin, Havana, Rushville, Mt. Sterling, Pittsfield, Lewiston and La Salle, all of which empty their sewage into the said Illinois river, by direction or indirection; and that the various sewage of this great population and these great cities is received into the said Illinois river before its junction with the Mississippi river, and that in addition thereto, as hereinbefore stated, the sewage of the Sanitary District from the same extent of territory, as is now discharging its sewage through the Sanitary District channel, has been for the last thirty years received into said Des Plaines river, and from thence into the Illinois river.

And this defendant, further answering, says, that in addition to the sewage and drainage carried into the Illinois river, and from thence into the Mississippi river, is the sewage and drainage of the vast territory tributary to the Mississippi river and its tributary streams. That this territory so drained is substantially all of the land of the United States between its northern border and the central line running east and west of the State of Kansas, prolonged
99 eastward through the State of Missouri, and from the Rocky mountains on the west to a line running from northeast to southwest, through the State of Illinois from the city of Chicago to the city of St. Louis, and in addition thereto, the western half of the State of Wisconsin, and the western two-thirds of the State of Minnesota. That the population of this region so drained into the Mississippi river, is in the neighborhood of fifteen million people. That an uncounted number of cities and towns, with populations ranging from two thousand to two hundred and fifty thousand, are situated upon the banks of the said Mississippi river and its tributaries, and discharge their sewage therein. That chief among these cities and towns may be mentioned Minneapolis and St. Paul in the State of Minnesota; Des Moines, Sioux City, Dubuque, Burlington, Davenport, and Keokuk, in the State of Iowa; Rock Island and Quincy in the State of Illinois; Kansas City in the State of Missouri, whose population is about 200,000, and St. Joseph, Boonville, St. Charles,

and Jefferson City in said State, all of which are populous, and which discharge their sewage into the Missouri river; and Omaha and Nebraska City in the State of Nebraska. That the distance from St. Paul and Minneapolis to the mouth of the Illinois river is 700 miles. That the distance from Omaha to the mouth of the Illinois river is 682.8 miles. That the distance from Kansas City to the mouth of the Illinois river is 413.7 miles. That the distance from Nebraska City to the mouth of the Illinois river is 630.7 miles. That in all these towns are carried on the industries such as are practiced by the citizens of this country, and similar in variety and character to those carried on within the district of this defendant. That especially at Kansas City and Nebraska City and at Omaha, there are vast
100 cattle yards, slaughter houses, rendering establishments and
other industries, such as are particularly mentioned in the bill filed herein as being carried on within the limits of the drainage district.

And this defendant says, that the said Mississippi river and the said Missouri river and their tributaries above the cities and towns in the State of complainant, mentioned in said bill, constitute the natural, uncontrollable drainage system of this whole region, this whole vast population and this whole system of industries, and that said cities and towns use the said system for their sewage from their location downward. That the additional amount of sewage which is being discharged through the drainage channel of this defendant, if it shall not be interfered with by the order of this honorable court, is but trifling in amount as compared with the enormous volume of sewage received into said Mississippi river above the cities and towns in the State of complainant, mentioned in said bill.

And yet so it is, may it please your honors, that by the natural law relating to sewage and drainage, and to running water in large bodies, the said sewage, instead of contributing a harmful element, is deprived of all of its deleterious qualities by processes of vaporization, attrition, lodgment, absorption, chemical conversion and bacteriologic changes, so that in the end the water purifies itself. That in addition to the foregoing, this defendant, in pursuance of the act incorporating it, is removing from its sewage all of the solid material, and is diluting all of the liquid material by an addition thereto of twenty cubic feet of water, drawn from Lake Michigan, to every cubic foot of sewage. Wherefore, this defendant says, that it will not, in and by the operation of its said system, contaminate, pollute, or destroy the water supply from the said Mississippi river and its tributaries, to the inhabitants, cities and towns in the State of
101 complainant, as in and by said bill declared. This defendant
attaches hereto and makes a part of this answer a certain table, which it marks "Exhibit D," of its answer, showing therein the extent and population of some of the cities and towns of the said territory now being drained and sewaged into the said Missis-

sippi river and its tributaries, above the city of St. Louis and their respective distances from St. Louis.

And, further answering, this defendant denies each and every other allegation of said bill of complaint, not herein and hereby admitted, traversed, confessed or denied; and this defendant denies all and all manner of unlawful combination and confederacy wherewith it is by said bill charged, without this, that there is any matter, cause or thing in complainant's bill of complaint contained, material or necessary for this defendant to make answer unto, and not herein and hereby well and sufficiently answered, confessed, traversed, and avoided or denied, is true to the knowledge or belief of this defendant, this defendant is ready and willing to aver and maintain and prove as this honorable court shall direct, and prays to be hence dismissed with its reasonable costs in that behalf most wrongfully sustained.

BERNARD A. ECKHART,
Trustee of the Sanitary District of Chicago.
THE SANITARY DISTRICT OF CHICAGO,
By CHARLES C. GILBERT,
SAMUEL M. BURDETT,
Attorneys for the Sanitary District of Chicago.
WILLIAM M. SPRINGER, Of Counsel.

102 UNITED STATES OF AMERICA:

In the Supreme Court of the United States.

On this 13th day of March, 1900, before me, S. W. Burnham, clerk of the circuit court of the United States for the northern district of Illinois, personally appeared B. A. Eckhart, one of the trustees of The Sanitary District of Chicago, one of the defendants in the foregoing bill of complaint of the State of Missouri, against the State of Illinois and the Sanitary District of Chicago, who, being by me duly sworn, deposes and says, that he is a duly elected and qualified trustee of the Sanitary District of Chicago, and that he is familiar with its affairs and business; that he has read the foregoing separate answer of this defendant, The Sanitary District of Chicago, and knows the contents thereof, and that the same are true of his own knowledge, except as to the matters herein stated on information and belief, and as to those matters he verily believes them to be true.

S. W. BURNHAM,
Clerk U. S. Circuit Court, Northern District of Illinois.

(Endorsed:) Supreme Court U. S., October term 1900. No. 5. original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Separate answer of the Sanitary District of Chicago. Filed January 28, 1901.

(Exhibits mentioned in foregoing answer not filed therewith.)

103 And afterwards, to wit, on the 13th day of May, A. D. 1901, a motion for leave to file a supplemental bill was filed in the words and figures following, viz:

104 In the Supreme Court of the United States. In Equity.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago, Defendants.
} No. 5, Original.

Motion for Leave to File Supplemental Bill.

To the honorable the Chief Justice of the United States and the associate justices of the Supreme Court of the United States:

The State of Missouri, complainant in the above entitled cause, by Edward C. Crow, its attorney general, and B. Schnurmacher, its counsel, respectfully represents that since the filing of the original bill herein, on the 17th day of January, 1900, the defendants have opened and put in operation the channel referred to and de-
105 scribed in said bill of complaint, the opening and operation of which was sought to be enjoined by this proceeding, and have since said 17th day of January, 1900, been doing the things against which complaint is made in said bill.

That defendants have also, since the filing of said bill, diminished the dilution of the sewage transmitted through said channel from a flow of 20,000 cubic feet per minute for each 100,000 inhabitants of the Sanitary District of Chicago, to not exceeding 10,000 cubic feet per minute for each such number of inhabitants.

To the end that the matters so occurring since the filing of said bill may be made to appear herein, complainant moves and prays the court to permit it to file the accompanying supplemental bill, and to make a rule upon the defendants to plead thereto.

E. C. CROW,
Attorney General of Missouri.

B. SCHNURMACHER, Of Counsel.

(Endorsed:) Supreme Court U. S., October term, 1900. No. 5, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Motion for leave to file supplemental bill. Filed May 13, 1901.

106 And on the same day, to wit, on the 13th day of May, A. D. 1901, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
No. 5, Original.

On motion of Mr. B. Schnurmacher, of counsel for the complainant, leave is hereby granted to file a supplemental bill of complaint herein, and on motion of Mr. William M. Springer, of counsel for the defendants, leave is hereby granted to file a demurrer to the 107 fourth paragraph of said supplemental bill and an answer to said supplemental bill, and on motion of Mr. B. Schnurmacher, of counsel for the complainant, leave is hereby granted to file a reply to said answer.

108 And on the same day, to wit, the 13th day of May, A. D. 1901, the supplemental bill of complaint was filed in the words and figures following, viz:

109 Supreme Court of the United States, October Term, 1900.
In Equity.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago, Defendants.
No. 5, Original.

Supplemental Bill.

E. C. Crow, attorney general of Missouri.
B. Schnurmacher, of counsel.

110 In the Supreme Court of the United States. In Equity.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago, Defendants.
Supplemental Bill.

To the honorable the Chief Justice of the United States and the associate justices of the Supreme Court of the United States:

Your orator respectfully complains and says that heretofore, to-wit, on the 17th day of January, 1900, your orator filed in this honorable court, at the present term thereof, its original bill of complaint against the State of Illinois and the Sanitary District of Chicago, in which bill of complaint your orator did show and make it appear that the defendants, having constructed an artificial channel or open drain from the West fork of the South branch of the 111 Chicago river in the city of Chicago and county of Cook, in the State of Illinois, to a point near Lockport, in the county of Cook in said State, where said channel or drain connects with and empties into the Desplaines river, which empties into the Illinois river, and which latter flows and empties into the Mississippi river at a point distant about 43 miles above the city of St. Louis, in the State of Missouri, did on said 17th day of January, 1900, threaten and propose to receive into said channel or drain the sewage matter and filth of said Sanitary District of Chicago, and did threaten and propose to permit and to cause the said sewage and filth to flow through said channel towards and into the Desplaines river and eventually into the Mississippi river, and thereby, as is charged in said original bill of complaint, to pollute the water of said Mississippi river to the injury of the complainant and its inhabitants, destroying said water for primary uses, and rendering it unfit for drinking and for domestic purposes; and your orator did thereupon pray that defendants, and each of them, and their officers, agents, employés and servants, might be enjoined from permitting or causing any of said sewage to be so discharged into said channel or drain, and from permitting or causing the same thence to flow into said Desplaines river, and that defendant, The State of Illinois, might be enjoined from issuing to defendant, The Sanitary District of Chicago, permission or authority to do and perform said acts, or to allow the same to be done or performed.

Complainant further states and shows that thereupon a subpœna was issued out of this court, directed to the said defendants, and they were duly served with said process to appear, and that defendants, and each of them, did accordingly appear and put in their demurrers to said original bill of complaint, which demurrers having 112 been duly argued and heard by the court, were, on the 28th day of January, 1901, by the court overruled. Thereupon said defendants did file their answers to said bill of complaint.

And your orator further complains and shows that notwithstanding the filing of said original bill of complaint herein, on the 17th day of January, 1900, the defendants on said day did proceed to open the said channel or ditch, and did permit and cause the sewage, filth and other noxious matters of the Sanitary District of Chicago to flow therein, and thence into the Desplaines river, all as it is charged in the bill of complaint, defendants proposed and intended to do, and that they have ever since said 17th day of January, 1900, permitted and caused the said sewage, filth and noxious matters to flow into and through said channel and thence into said Desplaines river, and that that which your orator did in its bill complain and charge would result, has in point of fact resulted and ensued, in this, that the said sewage, filth and noxious matters thus transmitted into said channel, and permitted and caused to flow through the same and into said Desplaines river, have polluted the water of the Mississippi river along the borders of your orator, and have destroyed the value of the same for primary purposes and uses, and for drinking and domestic purposes, and have caused and are causing much sickness to persons living along the banks of said river in the State of your orator, and will continue to do so unless said acts of the defendants are restrained and enjoined by this court in conformity with the prayer of the original bill.

And your orator further shows and represents that whereas under the act of the General Assembly of the State of Illinois authorizing the construction and operation of said channel, it was required 113 that said sewage and filth be diluted with not less than 20,000 cubic feet of water per minute for each 100,000 inhabitants of said sanitary district, the defendant, The Sanitary District of Chicago, has not at any time since the opening and operation of said channel furnished such an amount of water dilution; and that since the 20th day of April, 1901, said defendant, acting under orders of the Secretary of War, has reduced such dilution to not exceeding 200,000 cubic feet of water per minute in the aggregate, or about 10,000 cubic feet for each 100,000 inhabitants of its district, and proposes hereafter to limit the maximum dilution to that amount.

To the end, therefore, that the matters and things aforesaid, so occurring since the filing of the original bill, may be considered by this court, and that your orator may have the benefit thereof herein, your orator prays that the defendants, and each of them, may by rule of this honorable court be required to answer or otherwise plead to this supplemental bill, and for such other and further relief in the premises as may be meet and proper.

E. C. CROW,
Attorney General of Missouri.

B. SCHNURMACHER, Of Counsel.

(Endorsed:) Supreme Court U. S., October term, 1900. No. 5, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Supplemental bill. Filed May 13, 1901.

114 And on the same day, to-wit, on the 13th day of May, A. D. 1901, an order for appearance for defendants was filed in the words and figures following, viz:

Order for Appearance.

Supreme Court of the United States, October Term, 1900.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago, Defendants.
No. 5, Original.

The clerk will enter our appearance as counsel for the defendants.

JOHN G. DRENNAN,
Chicago, Ills.
H. J. HAMLIN,
Att'y Gen'l, Springfield, Ill.

☞ NOTE.—Must be signed by a member of the bar of the Supreme Court United States. Individual and not firm names must be signed.

[Endorsed:] Supreme Court U. S., October term, 1900. Term No. 5, orig'l. Appearance for def'ts. Filed May 13, 1901.

115 And on the same day, to wit, on the 13th day of May, A. D. 1901, a demurrer to the fourth paragraph of the supplemental bill of complaint was filed in the words and figures following, viz:

116 In the Supreme Court of the United States, October Term, 1900. In Equity.

THE STATE OF MISSOURI, Complainant, *v.* THE STATE OF ILLINOIS and THE SANITARY District of Chicago, Defendants.	No. 5, Original.

The Joint Demurrer of the Defendants to so Much of the Supplemental Bill of Complaint as is Embraced in the Fourth Paragraph Thereof.

Now come the State of Illinois, by Howland J. Hamlin, its attorney general, and the Sanitary District of Chicago, by James Todd and P. C. Haley, its attorneys, and, as to so much of the said supplemental bill of complaint as is set forth in the fourth paragraph of said supplemental bill, in the words and figures as follows:

"And your orator further shows, and represents that whereas under the act of the General Assembly of the State of Illinois 117 authorizing the construction and operation of said channel, it was required that said sewage and filth be diluted with not less than 20,000 cubic feet of water per minute for each 100,000 inhabitants of said sanitary district, the defendant, The Sanitary District of Chicago, has not at any time since the opening and operation of said channel furnished such an amount of water dilution; and that since the 20th day of April, 1901, said defendant, acting under orders of the Secretary of War, has reduced such dilution to not exceeding 200,000 cubic feet of water per minute in the aggregate, or about 10,000 cubic feet for each 100,000 inhabitants of its district, and proposes hereafter to limit the maximum dilution to that amount."

Which said paragraph seeks that these defendants may answer and set forth whether the defendant, The Sanitary District of Chicago, since the opening and operation of said channel, has furnished an amount of water dilution equal to 20,000 cubic feet per minute for each 100,000 inhabitants of said sanitary district; and whether since the said 20th day of April, 1901, the said sanitary district, acting under orders of the Secretary of War, has reduced such dilution to not exceeding 200,000 cubic feet per minute, or to about 10,000 cubic feet for each 100,000 inhabitants in said sanitary district, and whether the said defendant, The Sanitary District of Chicago, proposes hereafter to limit the maximum dilution to that amount,—

Said defendants doth demur and for cause of demurrer saith that, whether the said Sanitary District of Chicago has or has not complied with the law of the State of Illinois in reference to the amount of water which should be required to flow through the channel of said canal, is a matter which does not concern said complainant; that it, the said Sanitary District of Chicago, is alone accountable to the said State of Illinois for any alleged failure on its part 117½ to comply with the provisions of its organic act; that the alleged ultimate object sought by the original bill of complaint and the supplemental bill of complaint filed in this cause, is the prevention of the pollution of the Mississippi river, where the same flows along the banks of the said State, the complainant, and that whether said pollution is caused by a large discharge in the channel of said Sanitary District of Chicago, or a small discharge of water and sewage into said channel, cannot affect the principal question in the case, which is, whether or not the waters of the said Mississippi river, where the same flow along the banks of the said State, the complainant, are polluted, to the injury and detriment of the said complainant and the health of its people, so as to render said waters unfit for agricultural, domestic and manufacturing purposes, as alleged in said supplemental bill of complaint.

Wherefore, and for divers other errors and imperfections appearing in the said bill, the said defendants humbly pray the judgment of this honorable court, whether they shall be compelled to make any answer to such part of the said supplemental bill as is so demurred unto as aforesaid. And the said defendants humbly pray to be hence dismissed as to such part of said bill with their costs in this behalf most wrongfully sustained.

THE STATE OF ILLINOIS,
By H. J. HAMLIN,
Attorney General of the State of Illinois.
JAMES TODD,
P. C. HALEY,
Attorneys for the Sanitary District of Chicago.

JOHN G. DRENNAN,
WILLIAM M. SPRINGER,
Of Counsel.

118 I, William M. Springer, of counsel for said defendants, do certify that the above demurrer, is, in my opinion, well founded in point of law.

WILLIAM M. SPRINGER,
Of Counsel for Defendants.

I, William M. Springer, of counsel for said defendants, upon my oath do say that the above demurrer is not interposed for delay.

WILLIAM M. SPRINGER,
Of Counsel for Defendants.

Subscribed and sworn to before me this 10th day of May, 1901.

[L. S.] R. B. H. LYON,
Notary Public.

(Endorsed:) Supreme Court U. S., October term, 1900. No. 5, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Demurrer to part of supplemental bill. Filed May 13, 1901.

119 And on the same day, to wit, on the 13th day of May, A. D. 1901, an answer to the parts of the supplemental bill not demurred to was filed in the words and figures following, to wit:

120 In the Supreme Court of the United States, October Term, 1900. In Equity.

THE STATE OF MISSOURI, Complainant,
v.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago, Defendants.
No. 5, Original.

The Answer of the Defendants to the Parts of the Supplemental Bill of Complaint to which a Demurrer Has Not Been Filed.

Now come the defendants in the above-entitled cause, not waiving their said demurrer, but relying thereon and saving and reserving unto themselves all benefit and advantage of exception to the many errors, uncertainties, and imperfections in the residue of said supplemental bill contained, for answer to so much of the supplemental bill of complaint as they are advised is material and necessary for said defendants to answer unto, do say:

121 That they deny that heretofore, to wit, on the 17th day of January, 1900, the said complainant filed in this honorable court, its original bill of complaint against said defendants; but defendants allege and the records of this court will show that on said 17th day of January, complainant moved the court for leave to file its said bill of complaint herein, and that said motion was not allowed by this court until five days thereafter, when said bill of complaint was filed in this court.

Defendants admit that said original bill of complaint contained the several allegations as alleged in complainant's supplemental bill of complaint, and defendants further admit that they were duly served with subpœnas issued out of this court, and did appear and file their demurrer to said original bill, and that said demurrer was by this court overruled on the said 28th day of January, 1901, and that thereupon defendants filed their separate answers herein to said original bill of complaint. Defendants further admit that, on the said 17th day of January, 1900, which was five days before said complainant's original bill of complaint was filed in this court, the *defendant, The Sanitary District of Chicago, did proceed to open* said channel or canal, and did permit and cause the sewage of the said Sanitary District of Chicago to flow therein, as stated in said defendant's separate answer heretofore filed in this cause.

But defendants deny that said sewage, so permitted to flow into the Des Plaines and Illinois rivers, has polluted the waters of the Mississippi river along the borders of the State of Missouri, and defendants deny that said sewage has destroyed the value of the waters in said river for primary uses, and for agricultural, manufacturing, drinking, and domestic purposes, and defendants deny that 122 said sewage, so permitted to flow into the Des Plaines and Illinois rivers, has heretofore caused sickness to persons living along the banks of said Mississippi river, in the State of Missouri, or that it will hereafter cause sickness to any such persons; but, on the contrary, defendants expressly aver, and, if permitted, will prove to this honorable court, that the turning into the Des Plaines river of the sewage of the Sanitary District of Chicago, together with the pure waters of Lake Michigan, which accompany the same, has not polluted or in any way impaired the value of the waters of the Mississippi river for primary uses, or for agricultural, domestic or manufacturing purposes, or in any manner injured the health of the inhabitants of complainant living on the banks of said river; but defendants aver that the large volume of pure water, which accompanies said sewage when it enters into the Des Plaines river, has improved the quality of the waters of the Illinois and Mississippi rivers, and also greatly improves the conditions which existed prior to the time when said sewage and waters were turned into said Des Plaines and Illinois rivers, as is fully explained in the separate answer of the defendant, The Sanitary District of Chicago, to the original bill of complaint filed herein, which said separate answer said defendants pray this honorable court to take and consider as their answer, not only to the original bill of complaint, but also in part to the supplemental bill filed herein.

And said defendants, further answering said bill of complaint and said supplemental bill, say: That the said city of St. Louis, situated about forty miles below the mouth of the said Illinois river, on the west bank of the said Mississippi river, in the State of complainant, having a population of 575,238 inhabitants by the Federal census of 1900, and suburban towns and villages, having a population of 50,000 in addition thereto, discharge their sewage and 123 filth into the said Mississippi river opposite said city; that said sewage and filth, coming directly and undefecated from the sewers of said city, towns, and villages, cause a much greater pollution of the waters of said river from said city to the southern boundary of said State than can possibly be produced by the waters coming from the said Illinois river, which waters have flown in their natural course for about three hundred and fifty-eight miles, after having received the sewage from the Sanitary District of Chicago; that said waters, so flowing for said distance in their natural course, have been relieved of their noxious character by the natural law relating to sewage and drainage and to running waters in large bodies, as fully explained and set forth in the separate answer of the Sanitary District of Chicago to the original bill of complaint in this cause; and that if it should appear that the waters of the said Mississippi river below the said city of St. Louis have been polluted or their value impaired for primary uses or for agricultural, domestic, and manufacturing purposes, or so polluted as to injure the health or endanger the lives of the inhabitants of said State, such pollution, impairment of value and unhealthful conditions cannot be imputed to the defendants in this cause, but, on the contrary, they must be imputed to the said city of St. Louis, a municipality in the State of complainant, and to its suburban villages and towns, whose aggregate population is over 625,000, or about one-half of the population of the drainage district of the Sanitary District of Chicago, whose sewage is now drained into the said Des Plaines and Illinois rivers.

And defendants, further answering said bill of complaint and said supplemental bill, say: That the intake of the water works and water supply of the said city of St. Louis is located on the west bank of said Mississippi river only about three miles below the 124 mouth of the Missouri river, which river is nearly as large as the Mississippi river at the point of confluence; that the waters of the Mississippi river flow in an easterly direction and bear directly across the said Mississippi river towards the Illinois shore, pressing upon that shore the water flowing from the Mississippi and Illinois rivers; that by this natural flow of the waters of all said rivers, the waters flowing from the Illinois river are pressed upon the east bank of the Mississippi river and do not mix with the waters flowing along the west bank of said Mississippi river until said waters have passed the intake of the water supply of the said city of St. Louis; that the waters received at the intake of said water supply of said city of St. Louis flow wholly from the Missouri river; that if said waters, so furnishing the water supply of said city, are polluted to any extent whatever, such pollution is caused by the sewage and filth from the cities and towns on the banks of said Missouri river above its mouth, many of which cities and towns are situated in the State of complainant.

And defendants further answering the said bill of complaint and said supplemental bill, say: That the Mississippi river, at the mouth of the Illinois river, is a much larger stream than is the Illinois river; that the flow of water from said Mississippi river at that point exceeds the flow from said Illinois river, under normal conditions, at

low water stage, about six times in quantity, even since the increased flow from the waters of Lake Michigan; that in consequence of this fact, the waters flowing from said Illinois river are pressed upon the Illinois shore, until said waters have passed the mouth of said Missouri river, and that at no point in said Mississippi river, below the mouth of said Illinois river and above the city of St. Louis, do the waters of said Illinois river reach a line west of the
125 center of said Mississippi river, which is the boundary line between the said State of Missouri and State of Illinois.

And defendants, as to all the matters and things charged in complainant's supplemental bill of complaint, expressly reiterate all allegations contained in their separate answers to the original bill of complaint filed herein, which may be applicable thereto. And defendants say that they have not, in and by the operation of the said system of sewage and drainage, as fully explained in their separate answers to the original bill of complaint, contaminated, polluted, or destroyed the water supply from the said Mississippi river and its tributaries, to the inhabitants, cities and towns, of the State of complainant, or injured the health of said inhabitants as in and by the original bill of complaint and said supplemental bill declared.

And, further answering, defendants deny each and every other allegation of said supplemental bill of complaint, not herein and hereby admitted, traversed, confessed or denied, and every matter, cause or thing in said supplemental bill contained, material or necessary for defendants to make answer unto, and not herein and hereby well and sufficiently answered, confessed, traversed, and avoided or denied. And said defendants are ready and willing to prove every allegation in this answer contained as this court may direct, and pray to be hence dismissed with their reasonable costs in this behalf most wrongfully sustained.

THE STATE OF ILLINOIS,
By H. J. HAMLIN,
Attorney General of the State of Illinois.
JAMES TODD AND
P. C. HALEY, Attorneys, and
JOHN G. DRENNAN AND
WILLIAM M. SPRINGER,
Of Counsel for the Sanitary District of Chicago.

(Endorsed:) Supreme Court U. S., October term 1900. No. 5, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Answer to parts of supplemental bill. Filed May 13, 1901.

126 And on the same day, to wit, on the 13th day of May, A. D. 1901, a replication was filed in the words and figures following, viz:

127 In the Supreme Court of the United States, October Term, 1900. In Equity.

THE STATE OF MISSOURI, Complainant, *vs.* THE STATE OF ILLINOIS and THE SANITARY District of Chicago, Defendants.	No. 5, Original.

Replication.

Edward C. Crow, attorney general of Missouri.
B. Schnurmacher, of counsel.

128 In the Supreme Court of the United States. In Equity.

THE STATE OF MISSOURI, Complainant, *vs.* THE STATE OF ILLINOIS and THE SANITARY District of Chicago, Defendants.	No. 5, Original.

Replication.

The repliant, The State of Missouri, saving and reserving to itself all and all manner of advantage of exception which may be had and taken to the many manifold errors, uncertainties and insufficiencies of the answers and amended answers of the defendants herein, for replication thereunto says that it does and will aver, maintain and prove its said bill and its supplemental bill to be true, certain and sufficient in the law to be answered unto by the said defendants, and each of them; and that the said answers of 129 said defendants, and each of them, are very uncertain, evasive and insufficient in law to be replied unto by this repliant; without that, that any other matter or thing in the said answers, or any or either of them, contained, material or effectual in the law to be replied unto, confessed or avoided, traversed or denied, is true.

All of which matters and things this repliant is ready to aver, maintain and prove, as this honorable court may direct, and respectfully prays as in its said bill and supplemental bill it has already prayed.

EDWARD C. CROW,
Attorney General of Missouri.

B. SCHNURMACHER, Of Counsel.

(Endorsed:) Supreme Court U. S., October term, 1900. No. 5, orig'l. The State of Missouri, complainant, *v.* The State of Illinois *et al.* Replication to answer to supplemental bill. Filed May 13, 1901.

130 And afterwards, to wit, on the 27th day of May, A. D. 1901, the following order appears of record, viz:

Supreme Court of the United States, October Term, 1900.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
} No. 5, Original.

This cause came on to be heard on the supplemental bill and the demurrer of the defendants to the fourth paragraph of the same.

On consideration whereof, it is now here ordered by the court
131 that said demurrer be and the same is hereby sustained.

May 27, 1901.

(Endorsed:) Supreme Court U. S. No. 5, original, October term, 1900. State of Missouri, complainant, *vs.* State of Illinois *et al.* Order sustaining demurrer to 4th paragraph of supplemental bill. Filed May 27, 1901.

132 And afterwards, to wit, on the 20th day of October, A. D. 1902, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
} No. 4, Original.

On motion of Mr. William M. Springer, of counsel for the defendants, leave is hereby granted to file a motion to dismiss this case for want of prosecution.

133 And on the same day, to wit, on the 20th day of October, A. D. 1902, a motion to dismiss and proof of service of same was filed in the words and figures following, viz:

134 In the Supreme Court of the United States, October Term, 1902.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE Sanitary District of Chicago, Respondents.
} No. 4, Original. In Equity.

Motion to Dismiss.

Come the said respondents by their solicitors, H. J. Hamlin, attorney general of the State of Illinois, in behalf of the State, and James Todd, John G. Drennan and William M. Springer, in behalf of the Sanitary District of Chicago, and move this honorable court to dismiss said cause for want of prosecution, and for the reasons therefor, they state :

First. Because it appears from the record of this court, that the bill of complaint was filed herein January 22, 1900, nearly two years ago; that proof of service of subpœnas was filed January 29, 1900; that the demurrer to bill was argued November 12th and 13th, 1900; that the demurrer was overruled January 28, 1901, and separate answers filed by respondents on the same day; that a supplemental bill was filed May 13, 1901; that demurrer was filed to the 4th paragraph of the supplemental bill and answer to the other parts of said bill May 13, 1901; that on the same day a replication was filed to the answers to the supplemental bill; and that on May 27, 1901, the demurrer to the 4th paragraph of the supplemental bill was sustained by the court.

Second. Because since May 27th, 1901, when the issues were by the pleadings joined for trial, an entire term of this court has
135 elapsed, and no effort has been made by the complainant to
further prosecute said cause or to sustain its said bill of complaint by testimony of any kind.

Third. Because the burden of proof is on the complainant to establish by competent evidence the allegations in its bill, which it has wholly failed to do.

Fourth. Because the pending of said cause is a constant menace to respondents and has a tendency to create doubt and mistrust as to the utility and success of the great sanitary canal which they have constructed, and necessarily retards the improvement of the same.

Fifth. Because respondent, The Sanitary District of Chicago, has been subjected to great expense in the preparation for a trial of said cause, and such expense must continue until it is definitely determined whether there is to be a trial of the issues of fact in said cause.

Respectfully submitted,

H. J. HAMLIN,
Attorney General of Illinois.
JAMES TODD,
JOHN G. DRENNAN,
By WM. M. SPRINGER,
WM. M. SPRINGER,
Solicitors for Respondents.

Registry Return Receipt.

19011. Received from the postmaster at Jefferson City, Mo., delivering office registered letter No. 43947 from postoffice at Washington, D: C. Addressed to Hon. Edward C. Crow (name of addressee) Date —— (Date of delivery) 190– E. C. Crow. (Signature or name of addressee) W. C. Archer, (signature of addressee's agent.)

When delivery is made to an agent of the addressee, both addressee's name and agent's signature must appear in this receipt.

A registered article must not be delivered to any one but the addressee, except upon addressee's written order.

When the above receipt has been properly signed, it must be postmarked with name of delivering office and actual date of delivery, and mailed to its address, without envelope or postage.

136 This card must be neatly and correctly made up and addressed at the post office where the article is registered.

The postmaster who delivers the registered article must see that this card is properly signed, postmarked and mailed to the sender.

Post Office Department.	Post mark of delivery office, Jefferson City, Mo., Oct. 18, 5.30 p. m., 1902,
Official business.	
Penalty of $300 for private use.	and date of delivery.

Return to:
Name of sender—Wm. M. Springer.
Street and number or post office box—Kellogg bldg., Washington, D. C.
Washington, D. C. Rec'd, Oct. 20, 7 a. m. 1902.

Registered Letter No. 34946, P. O., Washington, D. C.

Received, Oct. 16, 1902, of Wm. M. Springer, 1416 F St.
1st class.
A letter addressed to Hon. B. Schnurmacher, St. Louis, Mo.
Station C. Postmaster per Ransdell.

Registered Letter No. 43947, P. O., Washington, D. C.

Received Oct. 16, 1902, of Wm. M. Springer, 1416 F street.
1st class.
A letter addressed to Hon. Edw. C. Crow, att'y general, Jefferson City, Mo.
Station C. Postmaster per Ransdell.

137 UNITED STATES OF AMERICA, } *ss:*
District of Columbia, }

William M. Springer, being first duly sworn according to law, deposes and says; that he is one of the solicitors for respondents in the case of The State of Missouri *v.* The State of Illinois and The Sanitary District of Chicago, now pending in the Supreme Court of the United States; that on the 16th day of October, A. D. 1902, this affiant deposited in the mail the motion to dismiss, the notice to attorneys of record for the claimant and brief of counsel for respondents in said cause to the proper addresses of said counsel, and duly posted the same at such time as to reach them by due course of mail, three weeks before the time fixed by the said notice. That said letters were registered and receipt of postmaster at Washington, and registry return receipt, signed by E. C. Crow, attorney general of Missouri, are hereto attached.

WILLIAM M. SPRINGER,
Solicitor for Respondents.

Subscribed and sworn to before me this 20th day of October, 1902.

JAMES D. MAHER,
[SEAL.] Notary Public, District of Columbia.

Endorsed: Supreme Court U. S., October term, 1902. No. 4, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Motion to dismiss and proof of service. Filed Oct. 20th, 1902.

138 And afterwards, to wit, on the 10th day of November, A. D. 1902, an order for appearance for the complainant was filed in the words and figures following, viz:

Order for Appearance.

Supreme Court of the United States, October Term, 1902.

STATE OF MISSOURI, Complainant,
vs.
STATE OF ILLINOIS ET AL.
} No. 4, Orig'l.

The clerk will enter my appearance as counsel for the complainant.

(Name.) CHAS. W. BATES,
(P. O. address.) ——.

☞NOTE.—Must be signed by a member of the bar of the Supreme Court United States. Individual and not firm names must be signed.

[Endorsed:] Supreme Court U. S., October term, 1902. Term No. 4, or'g'l. Appearance for comp't. Filed Nov. 10, 1902.

139 And on the same day, to wit, on the 10th day of November, A. D. 1902, an order for appearance for one of the defendants was filed in the words and figures following, viz:

Order for Appearance.

Supreme Court of the United States, October Term, 1902.

THE STATE OF MISSOURI, Compl't,
vs. } No. 4, Or'g'l.
THE STATE OF ILLINOIS ET AL.

The clerk will enter my appearance as counsel for the def't The Sanitary Dist. of Chicago.

(Name.) JAMES TODD,
(P. O. address.) 1106 Security Bldg., Chicago, Ills.

☞ NOTE.—Must be signed by a member of the bar of the Supreme Court United States. Individual and not firm names must be signed.

[Endorsed :] Supreme Court U. S., October term, 1902. Term No. 4, or'g'l. Appearance for a def't. Filed Nov. 10, 1902.

140 And on the same day, to wit, on the 10th day of November, A. D. 1902, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
vs. } No. 4, Original.
THE STATE OF ILLINOIS ET AL.

On motion of Mr. James Todd, of counsel for the defendants, leave is hereby granted to withdraw the motion to dismiss this cause for want of prosecution.

141 And on the same day, to wit, on the 10th day of November, A. D. 1902, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
vs. } No. 4, Original.
THE STATE OF ILLINOIS ET AL.

Mr. James Todd, of counsel for the defendants, submitted to the consideration of the court a motion and a stipulstion of counsel for the appointment of a commissioner to take testimony herein and for the taking of the testimony.

142 And on the same day, to wit, on the 10th day of November, A. D. 1902, a motion for the appointment of Mr. Frank S. Bright as special commissioner to take testimony and a stipulation as to same were filed in the words and figures following, viz:

143 Supreme Court of the United States, October Term, 1902.
In Equity.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago, Defendants.
No. 4, Original.

Motion for Appointing a Commissioner to Take Testimony.

Now come the plaintiff and defendants in the above-entitled cause, by their attorneys respectively, and move the court that Mr. Frank S. Bright be appointed a special commissioner, under the rules of the court relating to masters in chancery, to take the testimony in this case and to report the same to the court, without findings of fact or his conclusions of law.

STATE OF MISSOURI,
By CHAS. W. BATES, Its Attorney.
STATE OF ILLINOIS,
By H. J. HAMLIN, Attorney General.
THE SANITARY DISTRICT OF CHICAGO,
By JAMES TODD AND
P. C. HALEY,
JOHN G. DRENNAN,
WM. M. SPRINGER,
Its Attorneys.

144 (Endorsed:) Supreme Court U. S., October term, 1902. Term No. 4, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Motion for appointment of Frank S. Bright as special commissioner to take testimony. Filed Nov. 10, 1902.

In the Supreme Court of the United States, October Term, 1902. In Equity.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago, Defendants.
No. 4, Original.

Stipulation as to Taking of Testimony.

Now come the plaintiff and defendants in the above entitled case, by their attorneys respectively, and submit to this honorable court that an order may be entered in this case as follows:

Ordered by the court, that Mr. Frank S. Bright, a member of this bar and resident of the District of Columbia, be appointed a com-

missioner to take the testimony in this case; that the taking of testimony will begin on the first day of December, 1902, at such place as counsel for the plaintiff may indicate, notice of ten days as to the place to be furnished the counsel for the defendants; that the taking of such testimony for and on behalf of plaintiff may continue until the first day of March, A. D. 1902, at which time the
145 plaintiff shall conclude the taking of such testimony; that thereafter, commencing on the first day of March, 1902, the testimony in behalf of defendants shall be taken and shall be concluded on or before the first day of June, A. D. 1902. Ten days' notice as to the place where said testimony for the defendants shall be taken shall be given to counsel for the plaintiff; that thereafter rebutting testimony on behalf of the plaintiff may be taken at such place as counsel for plaintiff may indicate, five days' notice being given to counsel for defendants as to the place where such rebutting testimony shall be taken, plaintiff being required to conclude the taking of such rebutting testimony on or before the fifteenth day of June, A. D. 1902. The defendants shall then conclude the taking of any further testimony on or before the first day of July, A. D. 1902, at which time all of the testimony in said case shall be concluded.

One-half of the compensation and expenses of the commissioner shall be advanced by the plaintiff and one-half by the defendant The Sanitary District of Chicago, and each side shall pay such fees to its witnesses as may be necessary to secure their attendance, but not exceeding the fees allowed by law in such cases, the costs of the case to be taxed by the court on the final disposition of the case, to be paid in such manner as the court may at any time determine.

The commissioner shall be allowed twenty dollars per day for his compensation and his actual traveling and hotel expenses, an itemized statement of which shall be submitted to the court in his final report. He shall report to the court a stenographic copy of the testimony taken by him, to be furnished to him by the parties to the suit, but he shall not report any findings of facts or his con-
146 clusions of the law. The said commissioner shall have the powers and perform the duties of a master in chancery as provided in rules of this court, and said rules shall apply in all respects to the proceedings to be taken under this order.

All of which is respectfully submitted.

STATE OF MISSOURI,
By CHAS. W. BATES, Its Attorney.
STATE OF ILLINOIS,
By H. J. HAMLIN, Attorney General.
THE SANITARY DISTRICT OF CHICAGO,
By JAMES TODD AND
P. C. HALEY,
JOHN G. DRENNAN,
WM. M. SPRINGER,
Its Attorneys.

(Endorsed:) Supreme Court U. S., October term, 1902. Term No. 4, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Stipulation as to appointment of commissioner and as to taking testimony. Filed Nov. 10th, 1902.

147 And afterwards, to wit, on the 17th day of November, A. D. 1902, the following order appears of record, viz:

148 Supreme Court of the United States, October Term, 1902.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
No. 4, Original.

This cause coming on to be heard on the application of the parties, duly appearing by their counsel, for the appointment of a special commissioner to take testimony herein, and their stipulation in regard to the same heretofore filed by leave, and said application and stipulation having been duly considered:

It is ordered, That Mr. Frank S. Bright, a member of this bar and a resident of the District of Columbia, be and he is hereby appointed a commissioner to take and return the testimony in this cause, with the powers of a master in chancery as provided in the rules of this court; but said commissioner shall not make any findings of fact or state any conclusions of law.

It is further ordered, That the taking of testimony on complainant's behalf shall begin on the first day of December, A. D. 1902, at such place as counsel for complainant may designate, ten days' notice thereof to be given counsel for defendants; and shall be concluded on or before the twenty-eighth day of February, A. D. 1903; that the taking of testimony on behalf of defendants shall commence on the second day of March and be concluded on or before the first day of June, A. D. 1903, ten days' notice of the place where such testimony will be taken being given to counsel for complainant; that testimony in rebuttal shall then be taken, five days' notice of the place being given, and shall be concluded on or before the fifteenth day of June, A. D. 1903; and thereafter defendants may take further testimony until the first day of July, A. D. 1903, at which time the taking of testimony in the cause shall be closed.

Said commissioner shall report to the court the testimony taken by him, without findings of fact or conclusions of law, with all convenient speed, and shall receive, as agreed by the parties, twenty dollars per day for his compensation, and his actual expenses, an itemized statement of which shall accompany his report.

November 17, 1902.

149 (Endorsed:) Supreme Court U. S., October term, 1902. No. 4, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Order appointing Frank S. Bright commissioner to take testimony, &c. Filed November 17, 1902.

150 And afterwards, to wit, on the 19th day of November, A. D. 1902, the oath of Frank S. Bright as commissioner was filed in the words and figures following, viz:

151 I, Frank S. Bright, a commissioner designated and appointed by the Supreme Court of the United States to take and return the testimony in the cause of The State of Missouri, complainant, *vs.* The State of Illinois *et al.*, (No. 4 original of Oct. term, 1902), do solemnly swear that I will faithfully and impartially discharge and perform all the duties devolved on me as such commissioner, according to the best of my abilities and understanding: So help me God.

FRANK S. BRIGHT.

Subscribed and sworn to before me this 19th day of November, A. D. 1902.

JAMES D. MAHER,
[SEAL.] Notary Public, District of Columbia.

Endorsed: Supreme Court U. S., October term, 1902. No. 4, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Oath of Frank S. Bright as commissioner. Filed Nov. 19, 1902.

152 And afterwards, to wit, on the 2d day of February, A. D. 1903, a motion to modify order as to taking testimony was filed in the words and figures following, viz:

153 In the Supreme Court of the United States, October Term, 1902.

THE STATE OF MISSOURI, Complainant,
v.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago, Respondents.
} No. 4, Original. In Equity.

Motion to Modify Order for Taking Testimony.

William M. Springer, on behalf of solicitors for plaintiff and defendants.

153½ Supreme Court of the United States, October Term, 1902.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
} No. 4, Original.

Motion to Modify Order for Taking Testimony.

Now come the solicitors for plaintiff and defendants in the above-entitled cause, and move the court to modify the order for the appointment of a special commissioner to take testimony in this case, entered November 17, 1902, so that the second paragraph of said order will read as follows:

It is further ordered, that the taking of testimony on complainant's behalf shall begin on the fifth day of March, A. D. 1903, at such place as counsel for complainant may designate, ten days' notice thereof to be given counsel for defendants, and shall be concluded on or before the thirtieth day of April, A. D. 1903; that the taking of testimony on behalf of defendants shall commence on the first day of May, and be concluded on or before the first day
154 of July, A. D. 1903, ten days' notice of the place where such testimony will be taken being given to counsel for complainant; that testimony in rebuttal shall then be taken, five days' notice of the place being given, and shall be concluded on or before the fifteenth day of July, A. D. 1903; and thereafter defendants may take further testimony until the first day of August, A. D. 1903, at which time the taking of testimony in the cause shall be closed.

This motion is submitted on account of the serious illness of Attorney General Crow, one of the solicitors on behalf of the complainant.

WILLIAM M. SPRINGER,
On Behalf of the Solicitors for the
Plaintiff and Defendants.

(Endorsed:) Supreme Court U. S., October term, 1902. No. 4, orig'l. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Motion to modify order as to taking testimony. Filed Feb'y 2, 1903.

155 And on the same day, to wit, on the 2d day of February, A. D. 1903, the following entry appears of record, viz:

156 Supreme Court of the United States, October Term, 1902.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
No. 4, Original.

On motion of Mr. William M. Springer, of counsel for defendants, it is ordered by the court that the order entered on November 17th, 1902, providing for the taking of testimony in this cause be, and the same is hereby modified so as to provide that the taking of testimony on complainant's behalf shall begin on the 5th day of March, 1903, at such place as counsel for the complainant may designate, ten days' notice thereof to be given counsel for the defendants, and shall be concluded on or before April 30th 1903; that the taking of testimony on behalf of defendants shall commence May 1st, 1903, and be concluded on or before July 1st, 1903, ten days' notice of the place where such testimony will be taken being given to counsel for complainant; that the testimony in rebuttal shall then be taken, five days' notice of the place being given, and shall be concluded on or before July 15th, 1903; and thereafter defendants may take further testimony until August 1. 1903, at which time the taking of testimony in the cause shall be closed.

February 2d, 1903.

157 And afterwards, to wit, on the 2d day of March, A. D. 1903, an order for appearance for the complainant was filed in the words and figures following, viz:

Order for Appearance.

Supreme Court of the United States, October Term, 1902.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
} No. 4, Orig'l.

The clerk will enter my appearance as counsel for the complainant.

(Name.) WM. F. WOERNER,
(P. O. Address.) —— ——.

☞ NOTE.—Must be signed by a member of the bar of the Supreme Court United States. Individual and not firm names must be signed.

[Endorsed:] Supreme Court U. S., October term, 1902. Term No. 4, or'g'l. Appearance for compl't. Filed Mar. 2, 1903.

158 And on the same day, to wit, on the 2d day of March, A. D. 1903, a stipulation as to taking testimony was filed in the words and figures following, viz:

159 In the Supreme Court of the United States, October Term, 1902.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE Sanitary District of Chicago, Defendants.
} No. 4, Original. In Equity.

Stipulation as to Taking Testimony.

Now come the complainant and defendants in the above entitled cause, by their respective attorneys and by agreement submit to this honorable court that the orders heretofore made in this cause as to the time in which and for which the respective parties are required to take and complete the taking of their testimony be set aside, and that the following order in relation thereto be made:

1st. It is hereby ordered by the court that the orders here-
160 tofore entered in this case in reference to the time in which
and for which the respective parties are required to take and complete the taking of their testimony be set aside.

2nd. That the complainant having heretofore taken testimony from February 17th to the 28th inclusive, may resume the taking of testimony on March 9, 1903, and shall conclude on or before the 21st day of April thereafter.

3rd. That the defendants may begin the taking of testimony in the city of Chicago in the State of Illinois, on the 23rd day of April, 1903, and shall conclude on or before the 19th day of June, thereafter.

4th. That thereafter rebutting testimony on behalf of the complainant may be taken at such time and place as counsel for complainant may designate, such rebutting testimony to be concluded on or before the 26th day of June, 1903.

5th. That the defendants shall then conclude by taking any further testimony they may desire in rebuttal on or before the 3rd day of July, 1903, at which time all the testimony in the cause shall be concluded unless the counsel on both sides shall mutually agree to a further extension of time for concluding the taking of testimony, and such agreement, if made, shall have the same effect as an order made by the court.

6th. Either party may use any time in taking rebuttal testimony, not exceeding ten days in all, which may not be used by them in taking testimony in chief, and in that event the dates for beginning and concluding the taking of testimony by the respective parties, as set forth above, shall be changed accordingly.

Both parties to this stipulation hereby waive formal notice
161 of the times and places for beginning and concluding the
taking of testimony as provided in the foregoing order, if made by the court.

STATE OF MISSOURI,
By EDWARD C. CROW,
Attorney General of Mo.
SAMUEL B. JEFFRIES,
Ass't Att'y Gen'l of Mo.
H. J. HAMLIN,
Att'y Gen'l of Illinois.
JOHN G. DRENNAN,
WILLIAM M. SPRINGER,
Att'ys Sanitary Dist. of Chicago.

CHARLES W. BATES,
WM. F. WOERNER,
Of Counsel for Complainant.

(Endorsed :) Supreme Court U. S., October term, 1902. No. 4, orig'l. The State of Missouri, complainant, *v.* The State of Illinois *et al.* Stipulation as to taking testimony. Filed March 2, 1903.

162 And on the same day, to wit, on the 2d day of March, A. D. 1903, the following entry appears of record, viz :

THE STATE OF MISSOURI, Complainant, } No. 4, Original.
vs.
THE STATE OF ILLINOIS ET AL. }

Mr. William F. Woerner, for the complainant, submitted to the consideration of the court a stipulation of counsel in regard to the taking of testimony in this cause.

163 And afterwards, to wit, on the 3d day of March, A. D. 1903, the following order appears of record, viz :

164 Supreme Court of the United States, October Term, 1902.

THE STATE OF MISSOURI, Complainant, } No. 4, Original.
vs.
THE STATE OF ILLINOIS ET AL. }

On consideration of the stipulation of counsel as to the taking of testimony in this cause, filed and submitted herein on March 2d, 1903,

It is now here ordered by the court that in addition to the testimony heretofore taken herein the parties may resume the taking of testimony on March 9th, 1903, and proceed with all convenient speed so that all of the testimony shall be filed in the office of the clerk of this court on or before Monday, October 12th next.

March 3, 1903.

Endorsed : Supreme Court U. S. No. 4, original, October term, 1902. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Order as to taking testimony. Filed Mar. 3, 1903.

165 And afterwards, to wit, on the 13th day of October, A. D. 1903, the following entry appears of record, viz :

THE STATE OF MISSOURI, Complainant, } No. 4, Original.
vs.
THE STATE OF ILLINOIS ET AL. }

On motion of Mr. William C. Prentiss, in behalf of counsel for all the parties, leave is hereby granted to file the preliminary report of the commissioner herein, and it is ordered by the court that the time for taking testimony herein be extended to January 1, 1904.

166 And on the same day, to wit, on the 13th day of October, A. D. 1903, a preliminary report of the commissioner was filed in the words and figures following, viz:

167 In the Supreme Court of the United States.

In re THE STATE OF MISSOURI
vs.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago.
Original, Number 4.
October Term, 1903.

To the honorable the Supreme Court of the United States:

As the duly appointed commissioner in the above entitled cause, I beg to report that on the 17th day of February, 1903, I opened my commission in said cause at the city of St. Louis and have since continued to execute it.

I beg further to report, that since the last extension of time by the court for the taking of testimony in said cause, the parties have been diligently engaged in pursuance of the court's order, and are now so engaged, and that I have taken some 8500 pages of testimony, but considerable further time will be required to complete the testimony.

I am advised that the parties to said cause will on the sitting of the court on the 12th day of October, 1903, move the court to extend the time for taking testimony in said cause until January 1st, 1904. In the event that said motion is granted, I will comply with such order as the court may make in the premises. In the event that such motion is denied, I will at once close my commission and return the record to the court as heretofore ordered.

Respectfully submitted,

FRANK S. BRIGHT,
Commissioner of the Supreme Court of the U. S.

Chicago, Illinois, October 7th, 1903.

168 Endorsed: In the Supreme Court of the United States. The State of Missouri *vs.* The State of Illinois and The Sanitary District of Chicago. Original No. 4. Oct. term, 1903. Preliminary report of Frank S. Bright, commissioner. Office of the clerk. Received Oct. 9, 1903. Supreme Court U. S.

Endorsed: Supreme Court U. S., October term, 1903. No. 4, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Preliminary report of Frank S. Bright, commissioner. Filed Oct. 13th, 1903.

169 And on the same day, to wit, on the 13th day of October, A. D. 1903, a motion to extend time to take testimony was filed in the words and figures following, viz:

170 In the Supreme Court of the United States, October Term, 1903.

THE STATE OF MISSOURI, Complainant, *vs.* THE STATE OF ILLINOIS and THE Sanitary District of Chicago, Defendants.	No. 4, Original. In Equity.

Motion to Extend the Time for Taking Testimony.

Comes now William M. Springer, of counsel for defendants in the above entitled cause and submits to the court herewith a stipulation signed by the counsel for complainant and defendants respectively asking an extension of the time for taking the testimony in said cause, and moves the court to enter an order in conformity with said stipulation for the reasons stated therein.

WILLIAM M. SPRINGER,
Attorney for Defendants.

Endorsed: Supreme Court U. S., October term, 1903. No. 4, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Motion that the time for taking testimony be extended. Filed Oct. 13th, 1903.

171 And on the same day, to wit, on the 13th day of October, A. D. 1903, a stipulation that time for taking testimony be extended was filed in the words and figures following, viz:

172 In the Supreme Court of the United States, October Term, 1903.

THE STATE OF MISSOURI, Complainant, *vs.* THE STATE OF ILLINOIS and THE Sanitary District of Chicago, Defendants.	No. 4, Original. In Equity.

Stipulation as to the Taking of Testimony.

Now come the complainant and the defendants in the above entitled cause, by their attorneys respectively, and by agreement submit to this court that the order heretofore entered in this case requiring the taking of testimony in this case to be closed and the testimony submitted to the court on the first day of this term, be rescinded, and an order entered requiring counsel to conclude the taking of testimony at the earliest time practicable, not later than January 1st, 1904; and that when all the testimony is taken, the special commissioner, Frank S. Bright, Esq., may be directed to report the same to this honorable court without any findings of fact or conclusion of law.

The reasons for asking this further extension of time are as follows:—

1. The attorney general and the assistant attorney general of Missouri, who represent the complainant, were compelled to ask delays in the taking of testimony, on account of other business of the State which imperatively required their attention, and were not able to conclude complainant's testimony in chief until July 6th, 1903.

2. That defendants began the taking of testimony in their behalf on the 10th day of July, and continued without interruption until
the 24th day of that month. At that time, on account of
173 pressing engagement of counsel for complainant, a postponement was agreed upon until August 10th, at which time the taking of testimony was renewed and continued until August 18th; at which time another postponement was agreed upon on account of the pressing engagements of counsel for complainant.

3. The great flood in the month of June last prevented communication with St. Louis for two or three weeks.

4. The amount of testimony which has been taken and which will be taken hereafter far exceeds the expectations of counsel at the beginning of the litigation.

5. In view of the facts above set forth, it will be utterly impossible for defendants to conclude the taking of their testimony in chief at the time the court convenes for the October term, 1903, even if it is continued from day to day without any interruption.

All of which is respectfully submitted.

STATE OF MISSOURI.
By EDWARD C. CROW, Attorney General.
SAM. B. JEFFRIES, Ass't Attorney General.
WILLIAM F. WOERNER AND
CHARLES W. BATES,
Of Counsel for Complainant.
STATE OF ILLINOIS,
By H. J. HAMLIN, Att'y Gen'l.
THE SANITARY DISTRICT OF CHICAGO,
By JAMES TODD,
JOHN G. DRENNAN,
WILLIAM M. SPRINGER, Its Attorneys.

Endorsed: Supreme Court U. S., October term, 1903. No. 4, original. State of Missouri, complainant, *vs.* State of Illinois *et al.* Stipulation of counsel that the time for taking testimony be extended to January 1, 1904. Filed Oct. 13th, 1903.

174 And afterwards, to wit, on the 14th day of December, A. D. 1903, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
No. 4, Original.

Mr. Frank S. Bright, in behalf of counsel, asked and obtained leave of the court to file a motion in relation to the printing of the record herein, and, in pursuance of said motion, leave is hereby granted the complainant to have said record printed as provided in said motion.

175 And on the same day, to wit, on the 14th day of December, A. D. 1903, a motion for an order to print record was filed in the words and figures following, viz:

176 In the Supreme Court of the United States, October Term, 1903.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago, Defendants.
Original, No. 4.

Comes now the complainant by its attorney-general, Edward C. Crow, and moves the court to pass its order herein authorizing complainant to have the record herein printed at such place as may be selected by complainant (provided said record is printed in conformity with the rules of the court for the printing of records); that said record shall be printed under the supervision of the commissioner herein, and when so printed the usual number of the printed copies of said record shall be returned to the court by said commissioner, together with the original record herein, and that this cause shall thereafter be proceeded with upon said printed record so returned by said commissioner as the printed record in this case; that
177 for the purpose of having said record printed as aforesaid, said commissioner shall be authorized to turn over to the printer from time to time such portions of the original record as may be necessary for the use of the printer.

Further, that there shall be omitted from said printed record such portion of the original record as solicitors for the respective parties shall agree in writing, to be immaterial, but that all of said original record shall be returned to the court by the commissioner to the granting of all of which said motion defendants assent as is evidenced by the signatures of their solicitors hereto.

Further, that such exhibits as cannot be reproduced and incorporated in the record shall be returned to the court by the commissioner with the original record.

EDWARD C. CROW,
Attorney-General of Missouri,
SAM B. JEFFRIES,
Ass't Attorney-General of Missouri,
Counsel for Complainant.

CHAS. W. BATES AND
WM. F. WOERNER,
Of Counsel for Complainants.

H. J. HAMLIN,
Attorney-General of Illinois,
JAMES TODD,
Counsel Sanitary District,
Counsel for Defendants.

JOHN G. DRENNAN,
HUGH CREA,
Of Counsel for Defendants.

178 (Endorsed:) Supreme Court U. S., October term, 1903. No. 4, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Motion for order to print record. Filed Dec. 14, 1903.

179 And on the same day, to wit, on the 14th day of December, A. D. 1903, a motion for extension of time for taking testimony was filed in the words and figures following, viz:

180 In the Supreme Court of the United States, October Term, 1903.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago, Defendants.
} Original, No. 4.

Comes now the complainant by its attorney-general, Edward C. Crow, and showing to the court that certain continuances in the taking of testimony herein having been rendered necessary by engagements of complainant's solicitors, since the last extension by the court of the time for taking testimony, said continuances having been granted upon motion of complainant.

And showing further that owing to said continuances time, in addition to that heretofore granted by the court will be required to complete the taking of the testimony herein, leave being first had therefor, moves the court, will be required to complete the taking of

the testimony herein, until the first day of April, 1903, and
181 that on said first day of April, 1903, or as soon thereafter as possible the commissioner herein shall return to the court all the testimony taken by him, without findings of fact or conclusions of law, to the granting of which said motion defendants assent, as is evidenced by the signatures of their solicitors hereto attached.

EDWARD C. CROW,
Attorney-General of Missouri,
SAM. B. JEFFRIES,
Ass't Attorney-General of Missouri,
Counsel for Complainant.

CHAS. W. BATES AND
WM. F. WOERNER,
Of Counsel for Complainants.

H. J. HAMLIN,
Attorney-General of Illinois,
JAMES TODD,
Counsel Sanitary District,
Counsel for Defendants.

JOHN G. DRENNAN,
HUGH CREA,
Of Counsel for Defendants.

182 In the Supreme Court of the United States, October Term, 1903.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago, Defendants.
} Original, No. 4.

Sam B. Jeffries, being first duly sworn, deposes and says that he is assistant attorney-general of the State of Missouri, and as such, has assisted in the conduct of this case on behalf of complainant; that since the granting by the court of the last extension of time for taking testimony in this case until January 1, 1904, complainant's solicitors have been compelled to ask continuances of the taking of testimony in order to attend to other matters of the State of Missouri devolving upon them, which could not be delayed; that by reason of the foregoing continuances, defendants have not been able to complete the taking of their testimony, and that there will be required to complete the record in this case about three months, in addition to the time heretofore granted by the court as this affiant is informed by counsel for the defense, and that it will require about one week for the taking of complainant's rebuttal testimony.

SAM B. JEFFRIES.

Subscribed and sworn to before me this 8th day of December, 1903.

My term expires January 22, 1907.

[SEAL.] GEO. A. BOCKRATH,
Notary Public, Cole County, Missouri.

(Endorsed:) Supreme Court U. S., October term, 1903. No. 4, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Motion for extension of time for taking testimony. Filed Dec. 14, 1903.

183 And on the same day, to wit, on the 14th day of December, A. D. 1903, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
} No. 4, Original.

On motion of Mr. Frank S. Bright, in behalf of counsel, it is ordered by the court that the time for taking testimony herein be, and the same is hereby, extended to April 1st, 1904.

184 And afterwards, to wit, on the 11th day of April, A. D. 1904, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
} No. 4, Original.

On motion of Mr. W. F. Woerner, of counsel for the complainant, it is ordered by the court that the time for taking testimony herein be, and the same is hereby, extended to June 1st next.

185 And on the same day, to wit, on the 11th day of April, A. D. 1904, a motion to extend time for taking testimony was filed in the words and figures following, viz:

186 In the Supreme Court of the United States, October Term, 1903.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY DISTRICT of Chicago, Defendants.
} Original, No. 4.

Complainant's Motion for Extension of Time for Taking Testimony.

Edward C. Crow, attorney-general of Missouri, Sam B. Jeffries, assistant attorney-general of Missouri, solicitors for complainant.

C. W. Bates. Wm. F. Woerner, of counsel for complainant.

H. J. Hamlin, attorney-general of Illinois, James Todd, counsel sanitary district, solicitors for defendants.

John G. Drennan, of counsel for defendants.

187 In the Supreme Court of the United States, October Term 1903.

THE STATE OF MISSOURI, Complainant, *vs.* THE STATE OF ILLINOIS and THE SANITARY District of Chicago, Defendants.	Original, No. 4.

Comes now the complainant, by its attorney-general, Edward C. Crow, and showing to the court that certain continuances in the taking of testimony herein have been rendered necessary by reason of the serious illness of the said Edward C. Crow since the last extension by the court of the time for taking testimony, and showing also, that defendants did not conclude the taking of their testimony until the 29th day of March, 1904, and within two days of the time limit for the taking of testimony herein.

And showing further, that owing to the said facts above referred to, time in addition to that heretofore granted by the court will be required to complete the taking of testimony herein, leave first being had therefor, moves the court further to extend the time for taking of testimony herein until the first day of June, 1904, which said testimony shall thereafter be printed, under the supervision of the commissioner and returned to the court, as heretofore provided by a rule of the court, to the granting of which said motion
188 defendants assent, as is evidenced by the signatures of their solicitors hereto attached.

EDWARD C. CROW,
Attorney-General of Missouri,
SAM B. JEFFRIES,
Assistant Attorney-General of Missouri,
Solicitors for Complainant.
C. W. BATES,
WM. F. WOERNER,
Of Counsel for Complainant.

H. J. HAMLIN,
Attorney-General of Illinois,
JAMES TODD,
Counsel Sanitary District,
Solicitors for Defendants.
JOHN G. DRENNAN,
Of Counsel for Defendants.

(Endorsed:) Supreme Court U. S., October term, 1903. No. 4, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Motion to extend time for taking testimony. Filed April 11, 1904.

189 And afterwards, to wit, on the 29th day of May, A. D. 1905, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
} No. 4, Original.

Mr. Frank S. Bright, the commissioner appointed to take the testimony in this cause presented his report and the same was ordered to be filed.

190 And on the same day, to wit, on the 29th day of May, A. D. 1905, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
} No. 4, Original.

On motion of Mr. S. B. Jeffries, of counsel for the complainant, it is ordered by the court that the evidence herein be opened, published and filed.

191 And on the same day, to wit, on the 29th day of May, A. D. 1905, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
v.
THE STATE OF ILLINOIS ET AL.
} No. 4, Original.

Mr. S. B. Jeffries, of counsel for the complainant, submitted to the consideration of the court a motion for an order fixing the compensation of the commissioner for his services in supervising the printing of the record herein.

192 And on the same day, to wit, on the 29th day of May, A. D. 1905, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
} No. 4, Original.

On motion of Mr. S. B. Jeffries, of counsel for the complainant, leave is hereby granted to withdraw certain exhibits filed herein for the purpose of reproducing the same.

193 And on the same day, to wit, on the 29th day of May, A. D. 1905, the following entry appears of record, viz:

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS ET AL.
} No. 4, Original.

Mr. S. B. Jeffries, of counsel for the complainant, submitted to the consideration of the court a motion to fix a day for the argument of this cause.

194 And on the same day, to wit, on the 29th day of May, A. D. 1905, the report of the commissioner as to taking testimony was filed in the words and figures following, viz:

195 Office Supreme Court U. S. Filed May 29, 1905. James H. McKenney, Clerk.

In the Supreme Court of the United States.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY District of Chicago.
} Original, No. 4.

Report of Commissioner.

To the honorable the Chief Justice and the associate justices of the Supreme Court of the United States:

The undersigned commissioner, appointed by an order entered in the said cause on November 17, 1902, to take and return such evidence as the parties to said cause should produce, respectfully reports to the court that pursuant to the said order and the stipulation of counsel of the said parties, he opened the commission conferred on him in the chambers of the city counselor, in the city hall, in the city of St. Louis, Missouri, February 17, 1903, at ten o'clock a. m., and, the parties to the cause being present by their respective counsel, proceeded to execute the said commission on that day and on the subsequent days, and at that place and at the other
196 places indicated in the record, until the 28th day of May, 1904, when the said commission was declared closed without day.

That said commission was executed by receiving the testimony of the witnesses named in it, who were sworn to testify to the truth, the whole truth, and nothing but the truth, before giving their evidence, and the testimony so given by them was taken down word for word by a stenographer in the presence of the undersigned, and, when transcribed, read over to the said witnesses respectively (or read over by them) and signed by them, respectively, in the presence of the undersigned and the respective counsel (except as otherwise appears in the testimony), and, further, by receiving the documents, maps, charts, materials, and diagrams produced and offered in evidence as exhibits by the parties to the said cause, and designated and marked as appears in the record, all being identified by the signature of the undersigned as commissioner, which said evidence is all the evidence that was offered before him by the parties to the said cause, and is contained in eight bound volumes filed herewith, marked with the title of the cause and consisting of 13,160 pages of typewritten evidence, and in said exhibits.

That the commissioner has deposited said testimony with James H. McKenney, Esquire, clerk of the Supreme Court of the United States, and has filed all said exhibits, so marked as aforesaid, with the said James H. McKenney, except Complainant's Exhibits 14, 15, 16, 18, 19, 20, 43, and 45, and Defendants' Exhibits Jordan 197 A, B, C, and D; Randolph's B, and Spencer's A, B, and C, which have been filed with the marshal of the Supreme Court under the provisions of the 33d rule.

The commissioner has also filed herewith a table of witnesses examined and the pages at which their testimony may be found; an alliterated index of the names of the witnesses and the page at which their testimony is found; also an index of said exhibits showing the pages of the record on which they were offered; also a description of said exhibits by serial numbers; also an itemized statement of the expenses of the commissioner, as required by the said order of the court, said statement being filed with the clerk of the court, the amount covered thereby having been paid in equal portions by the parties to said cause.

The commissioner was engaged in going to, attendance upon and returning from the hearings of the testimony and in preparing the record to be returned to the court four hundred and fifty-five days, for which, by the rule of the court, he was to be paid in equal parts by complainant and defendants at the rate of twenty dollars per day. The share of said compensation due by defendants has been paid in full and that part unpaid by the complainant has been assured to the commissioner.

Respectfully submitted, FRANK S. BRIGHT,
Commissioner.

May 29, 1905.

(Endorsed:) Supreme Court U. S., October term 1904. No. 4, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Report of commissioner as to taking testimony. Filed May 29, 1905.

198 And on the same day, to wit, on the 29th day of May, A. D. 1905, a report of the commissioner as to printing of testimony was filed in the words and figures following, viz:

199 In the Supreme Court of the United States.

The State of Missouri, Complainant,
vs.
The State of Illinois and The Sanitary District of Chicago, Defendants.
} Original, No. 4.

Report of Commissioner as to Printing of Testimony.

To the honorable the Chief Justice and the associate justices of the Supreme Court of the United States:

The undersigned commissioner has the honor to report that, in pursuance of the order of the court, entered in said cause on the 14th day of December, 1903, wherein it was provided that the record in the above entitled case should be printed under the supervision of the commissioner, and when so printed the usual number of printed copies should be returned to the court by the commissioner, 200 and that said cause should thereafter be proceeded with upon such printed record, so returned by said commissioner, as the printed record in said case, there has been printed under his supervision the testimony taken by him and heretofore filed by him in said cause, and he has this day deposited 25 copies of said testimony, so printed as aforesaid, with James H. McKenney, Esquire, clerk of the Supreme Court of the United States.

That under the authority granted by said order of the court, the undersigned from time to time furnished the printer designated by complainant with consecutive parts of the original record; that the printer thereupon prepared a proof of the part furnished him, which he returned with said portion of the original record, and the undersigned thereupon compared said proof with the original record, until when produced it was a literal reproduction of said original record, and as deposited with this clerk said printed record is word for word a copy of the original 13,160 pages of manuscript, which as printed, consists of 7,975 pages contained in eight volumes.

That none of the exhibits filed in the case has been reproduced.

There has also been deposited with the clerk of the court an index of the evidence showing the volume and page of both the 201 original and printed records, upon which the evidence is found; also an alliterated index of the names of the witnesses and the pages of their testimony; also an index of the exhibits and the name of the witness to whose testimony they were offered as exhibits.

That by agreement between counsel for complainant and the commissioner, his compensation for supervising the printing of the record, as aforesaid, is to be settled by the court.

Wherefore the undersigned prays the court to fix the amount of his said compensation.

Respectfully submitted, FRANK S. BRIGHT,
Commissioner.

May 29, 1905.

(Endorsed:) Supreme Court U. S., October term, 1904. No. 4, original. The State of Missouri, complainant, *vs*. The State of Illinois *et al*. Report of commissioner & motion to fix his compensation for supervising the printing of the testimony. Filed May 29, 1905.

202 And on the same day, to wit, on the 29th day of May, A. D. 1905, a motion to open and publish testimony and print pleadings was filed in the words and figures following, viz:

203 In the Supreme Court of the United States.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY DIStrict of Chicago, Defendants.
} Original, No. 4.

Motion to Open and Publish Testimony and Print Pleadings.

Charles W. Bates, Samuel B. Jeffries, of counsel.
The State of Missouri by Herbert S. Hadley, its attorney general.

204 In the Supreme Court of the United States.

THE STATE OF MISSOURI, Complainant,
vs.
THE STATE OF ILLINOIS and THE SANITARY DIStrict of Chicago, Defendants.
} Original, No. 4.

To the honorable the Chief Justice and the associate justices of the Supreme Court of the United States:

Comes now the complainant by its attorney general Herbert S. Hadley, and showing to the court that the commissioner heretofore appointed by order of the court to take and return the testimony in the above entitled cause has this day deposited with the clerk of this court the depositions taken by him as commissioner and has deposited the exhibits referred to in said depositions, part with the clerk of this court and part with the marshal, as more specifically appears from the report of said commissioner, moves the court for leave to file said depositions, open and publish them and to file said exhibits.

And the complainant showing further that by rule entered herein on the 14th day of December, 1903, it was ordered that the record herein should be printed by the complainant under the supervision of the commissioner, and that when so printed this cause 205 should be heard on said record printed under the supervision of the commissioner as aforesaid as the printed record in the cause, and that said commissioner has this day deposited with the clerk of the court twenty-five copies of the testimony taken before him, printed pursuant to said order of December 14, 1903, and has also filed in manuscript an index thereof, the complainant moves the court to enter an order to fix the compensation of the commissioner for his services in supervising the printing of said record and an order for printing the usual number of copies of the pleadings and motions and said index upon complainant's advancing to clerk of the court his fees for printing and supervising the printing of said pleadings, motions and index, as by the rule of this court is provided.

THE STATE OF MISSOURI,
By HERBERT S. HADLEY,
Its Attorney General.

CHARLES W. BATES,
SAMUEL B. JEFFRIES,
Of Counsel.

Defendants assent to the granting of the above motions.

STATE OF ILLINOIS,
By W. H. STEAD,
Its Attorney General.
THE SANITARY DISTRICT
OF CHICAGO,
By JAMES TODD, Attorney.

H. J. HAMLIN,
JOHN G. DRENNAN,
Of Counsel.

206 (Endorsed:) Supreme Court U. S., October term, 1904. No. 4, original. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Motion to open and publish testimony & print pleadings. Filed May 29, 1905.

207 And on the same day, to wit, on the 29th day of May, A. D. 1905, a motion to fix day for hearing, &c., was filed in the words and figures following, viz:

208 In the Supreme Court of the United States.

The State of Missouri, Complainant,
vs.
The State of Illinois and The Sanitary District of Chicago, Defendants.
} Original, No. 4.

Herbert S. Hadley, attorney-general of Missouri.
Chas. W. Bates, city counselor of St. Louis, and
Sam. B. Jeffries,
Solicitors for complainant.
W. T. Stead, attorney-general of Illinois.
H. J. Hamlin, solicitor for State of Illinois.
James Todd and John G. Drennan, solicitors for Sanitary District of Chicago.

209 In the Supreme Court of the United States.

The State of Missouri, Complainant,
vs.
The State of Illinois and The Sanitary District of Chicago, Defendants.
} Original, No. 4.

Motion.

Now comes the complainant, by its attorney-general, Herbert S. Hadley, and moves the court to set the above entitled cause for hearing at a day to be named by the court in the October term, 1905.

That an order shall be entered that the case be heard upon the pleadings, the evidence taken by the respective parties, and the briefs of the respective parties.

That the briefs of the complainant shall be filed with the clerk of the court, and copies thereof shall be served upon the solicitors of each of the defendants not later than the 30th day of August, 1905.

That reply briefs of defendants shall be filed with the clerk of the court, and copies thereof served upon the solicitors for complainant not later than the 15th day of October, 1905; and that complainant's reply brief shall be filed with the clerk, and copies 210 served on defendants' solicitors not later than one week before the day set by the court for the hearing of the cause.

That Complainant's Exhibits Nos. 1 to 13, both inclusive, Nos. 21 and 22, and the charts prepared by Professor Keizer, Nos. 23 to 35, both inclusive, and all of Professor Teichman's charts, Nos. 52 to 70, both inclusive, shall be withdrawn by complainant and reproduced, and when reproduced copies thereof shall be served upon the defendants' solicitors, the same to be done on or before the date of the filing of complainant's brief as hereinabove set forth: Provided, however, that any or all of complainant's exhibits not heretofore printed may be withdrawn and reproduced in accordance with the terms hereof.

To the granting of all of which said motion defendants assent, as is evidenced by the signatures hereto of their respective solicitors.

HERBERT S. HADLEY,
Attorney-General of Missouri.
CHAS. W. BATES,
City Counselor of St. Louis, and
SAM B. JEFFRIES,
Solicitors for Complainant.

W. T. STEAD,
Attorney-General of Illinois.
H. J. HAMLIN,
Solicitor for State of Illinois.
JAMES TODD AND
JOHN G. DRENNAN,
Solicitors for Sanitary District of Chicago.

211 (Endorsed:) Supreme Court U. S., October term, 1904. The State of Missouri, complainant, *vs.* The State of Illinois *et al.* Motion to fix day for hearing and as to filing briefs and withdrawing exhibits and consent thereto. Filed May 29, 1905.

212 And on the same day, to wit, on the 29th day of May, A. D. 1905, the evidence returned by the commissioner was opened, published and filed.

(Which said evidence, as printed under the supervision of the commissioner, accompanies this record, marked vol. 1, 2, 3, 4, 5, 6, 7 & 8.)

IN THE

Supreme Court of the United States.

OCTOBER TERM, 1904.

Original No. 4.

THE STATE OF MISSOURI, COMPLAINANT,

vs.

THE STATE OF ILLINOIS AND THE SANITARY DISTRICT OF CHICAGO, DEFENDANTS.

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1.—Ravold. Chart showing bacteria per cubic centimeter, year 1900, at various points. Page 579 original, 364 print.

2.—Ravold. Results showing mixture of waters, Mississippi and Missouri at Intake. Page 608 original, 381 print.

3.—Ravold. Chart showing numbers of bacteria from Mississippi river at Grafton and heights of Mississippi river at Louisiana, Missouri. Page 613 original, 385 print.

4.—Ravold. Weekly averages of number of bacteria collected daily from the Mississippi river at Grafton, together with heights of river at Grafton. Page 617 original, 387 print.

5.—Ravold. Numbers of bacteria collected at Hartford, together with height of the river at that point. Page 621 original, 390 print.

6.—**Ravold.** Number of bacteria at Bellefontaine, Missouri river, with height of that river there. Page 626 original, 393 print.

7.—**Ravold.** Numbers of bacteria at Chain of Rocks, Missouri shore, together with height of river there. Page 632 original and 397 print.

8.—**Ravold.** Weekly average numbers of bacteria, water collected in Mississippi river, Chain of Rocks, Illinois shore, with height of river there. Page 636 original, 400 print.

9.—**Ravold.** Weekly average number of bacteria, samples of water collected from Mississippi river, Chain of Rocks, Intake Tower, with height of river at that point. Page 643 original, 404 print.

10.—**Ravold.** Curve showing weekly averages of river stages at St. Louis, number of typhoid cases and deaths, 1890-1900. Page 718 original, 449 print.

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32.—Keiser. Curve showing amounts of nitrates at Illinois shore, Chain of Rocks. Page 1682 original, 1030 print.

33.—Keiser. Curve of nitrites, Illinois river above Grafton, and above Peoria, showing continuous increase of impurities in Illinois river. Page 1699 original, 1044 print.

34.—Keiser. Curve showing increase of impurities ascending Mississippi to mouth of Illinois. Page 1733 original, 1066 print.

35.—Keiser. Map of Illinois river, Drainage Canal to St. Louis, with averages of the condition of the water before and after the opening of the canal. Page 1756 original, 1079 print.

36.—Keiser. Page 418 from Annual Report of Water Commissioner of St. Louis for year ending April, 1894. Page 2848 original, 1727 print.

37.—Keiser. Twenty-one analyses made from December 15, 1902, to April 20, 1904, in chemical laboratory, Washington University. Page 2849 original, 1727 print.

38.—Keiser. Sanitary water analyses, Missouri river, Fort Bellefontaine. Page 2851 original, 1729 print.

39.—Keiser. Twenty-eight sheets of analyses of water taken in Missouri river and points below the mouth of the Missouri in Mississippi river and at a point above Grafton in the Mississippi and at points in the Illinois river, the Drainage Canal, the Michigan Canal and Lake Michigan in the years 1899, 1900 and 1901. Page 2853 original, 1730 print.

40.—Van Ornum. Chart showing flow of the Drainage Canal and the Illinois river to St. Louis. Page 2934 original and 1779 print.

41.—Van Ornum. Graphic representation of gauge reading of the Mississippi river at Keokuk, Grafton and St. Louis, March, 1903, and at Hermann, Missouri, for that river, same time. Page 2940 original and 1783 print.

42.—Van Ornum. Chart showing gauge readings, March, 1903, Peoria, Beardstown and Grafton, Illinois. Page 2941 original and 1783 print.

43.—Van Ornum. Float used in obtaining flow of river. Page 2947 original and 1787 print.

44.—Van Ornum. Chart No. 116, survey of Mississippi river. Page 3106 original, 1885 print.

45.—Van Ornum. Sixty-eight bottles of water taken by complainant and sent to George Chandler Whipple, originally in three boxes, marked A, B, C; transferred to four packages for shipment. Page 3135 original, 1903 print.

46.—Whipple. Fifteen tables, sub-numbers 46-0 to 46-14, results of microscopic examinations of samples of water contained in complainants's exhibit No. 45. Original page 3165, print, 1922.

47.—Whipple. Seven tables containing results of microscopic examinations of samples contained in complainant's exhibit 45. Page 3190 original, 1937 print.

48.—Whipple. Chart showing graphically turbidity observations made at section I from samples of water contained in exhibit 45. Page 3216 original, 1953 print.

49.—Wipple. Chart showing turbidity examinations at section C. Page 3217 original, 1954 print.

50.—Whipple. Chart showing turbidity observations at section M. Page 3218 original, 1955 print.

Complainant's exhibit No. 1 for identification, containing 117 pages of water analyses made by various witnesses for complainant.

51.—Whipple. Chart showing graphically average amount of nitrites and chlorines at various cross-sections at various dates and per cent of Illinois river water at the cross-sections. Page 3285 original, 1995 print.

52 to 70. Teichmann. Charts used by W. C. Teichmann to illustrate his testimony. Page 4545 original, 2758 print.

71 to 72.—Weather Bureau charts showing annual rainfalls at points given. W. B. Stockman. Page 4740 original, 2874 print.

73.—Stockman. Certified copies of total annual precipitation from records of the Weather Bureau, at points therein indicated. Page 4740 original, 2874 print.

74.—Woodward, W. C. Certified copies of statement showing number of deaths from various diseases therein indicated in the District of Columbia, from January, 1885, to December, 1895. Page 4745 original, 2877 print.

DEFENDANTS' EXHIBITS.

1 to 20 for identification offered by the State of Illinois, being cards attached to samples of water by water takers for the State of Illinois, which said cards were subsequently identified by the witnesses who examined said samples.

1 to 22 for identification offered by the Sanitary District of Chicago, being cards attached to samples of water by water takers for the Sanitary District of Chicago, which said cards were subsequently identified by the witnesses who examined the samples.

23 for identification. Palmer. Page 8582 original, 5306 print. Offered by the State of Illinois, being printed copy of the preliminary report by Arthur W. Palmer, chemical survey of the water supplies of Illinois, also subsequently offered as defendants' Exhibit A.

24 for identification. Palmer. Page 8616 original, 5331 print. Offered by the State of Illinois, being data already offered in evidence, represented on curves.

A for identification. Long. Offered by the State of Illinois, being certain indicated pages of preliminary report to the Illinois Board of Health. Page 6741 original, 4032 print.

A for identification. Palmer. Page 6741 original, 4032 print. Offered by the State of Illinois, identical with Exhibit 23 for identification.

B for identification. Palmer. Page 8736 original, 5397 print. Offered by the State of Illinois, being table representing dissolved oxygen in the Illinois river at Havanna.

C for identification. Palmer. Page 8868 original, 5491 print. Offered by the State of Illinois, being ten sheets containing various tables of monthly averages.

D for identification. Burrill. Page 9250 original, 5728 print Offered by defendants. Photograph of 62 flasks.

E for identification. Burrill. Page 9250 original, 5728 print. Offered by defendants, being photographs of 79 flasks.

1. H. E. Beasley. Page 5827 original, 3505 print, being sewer map of the city of Peoria.

2. Burke. Pages 6847 and 7040 original, 4094 and 4243 print, being cards of water taker on the Kaw river, of Frank C. Burke, water taker on the Kaw river.

3. Long. Page 6879 original and 4113 print, being sample of card used for water takers of the Illinois State Board of Health.

4. Long. Page 6879 original and 4113 print, being sample of shipping envelope used by Prof. Long.

5 to 13. Palmer. Page 8965 original and 5566 print, being charts showing graphically results of chemical data, as indicated on them.

14. Schule. Page 9381 original and 5805 print, being

sample card used by water takers for the collection of samples for the Sanitary District of Chicago.

Jordan's Exhibits A, B, C, pages 9923 and 9925 original, 6194 and 6195 print, being certain typhoid fever plates.

Jordan's Exhibit D. Page 9990 original, 6228 print, being control sack used in the Drainage Canal experiment.

Randolph's Exhibit A. Publication of laws in reference to the Sanitary District of Chicago, published by the Board of Trustees. Page 10723 original, 6625 print.

Randolph's Exhibit B. Page 10763 original, 6649 print, being Sanitary District of Chicago map of the Illinois river watersheds.

Spencer. Page 10917 original, 6734 print.

Complainant's rebuttal Exhibit No. 1 for identification. Page 13101 original, 7942 print. Lockridge. Being transcript made by witness from the mortuary record of the health office of St. Louis.

Defendants' sur-rebuttal exhibit. Page 13160 original, reports of the HealthCommissioner of St. Louis for years indicated. Page 7975 print.

IN THE

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Supreme Court of the United States

THE STATE OF MISSOURI
vs.
THE STATE OF ILLINOIS
and
THE SANITARY DISTRICT OF CHICAGO.

Original,
Docket No.

Before
FRANK S. BRIGHT,
Commissioner of the Supreme Court of the United States.

Testimony begun at the City Hall, in the City of St. Louis, Missouri, February 17, 1903, at 10 o'clock, a. m., pursuant to an order heretofore entered in said cause.

Present:
THE COMMISSIONER,
ATTORNEY-GEN'L. EDWARD C. CROW,
CHARLES W. BATES, Esq., and
S. B. JEFFRIES, Esq.,
Appearing in behalf of the complainant.
ATTORNEY-GENERAL H. J. HAMLIN,
Appearing in behalf of the State of Illinois.
JUDGE WILLIAM M. SPRINGER, and
J. G. DRENNAN, Esq.,
Appearing in behalf of the Sanitary District of Chicago.

The Commissioner—My Commission is now open and I am ready to hear testimony, pursuant to the rule heretofore entered by the Supreme Court and the notice of Complainant's Solicitors.

Whereupon an adjournment was taken until two o'clock the same day, February 17, 1903.

Met pursuant to adjournment at the same place at two
2 o'clock, p. m., February 17, 1903.

Present, the same parties, and Mr. Alexander Nicholson, also representing complainant.

And thereupon complainant produced Dr. Amand Nicholas Ravold, who was duly sworn by the commissioner.

AMAND NICHOLAS RAVOLD,

a witness called in behalf of the complainant, after being duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION.

By Attorney General Crow,

Q. What is your name?

A. Amand Nicholas Ravold.

Q. Where do you reside, Doctor?

A. St. Louis, Mo., 2806 Morgan street.

Q. What is your profession or occupation?

A. I am a physician.

Q. How long have you been a practicing physician?

A. Since 1881.

Q. Have you ever engaged in any other calling than that of the ordinary business of a practicing physician?

A. Yes, since 1885 I have been a professional bacteriologist.

Q. Well, have you been attached in an educational way to any institution of learning in this city?

3 A. Yes, sir.

Q. What one and in what capacity?

A. I was first connected with the Shaw School of Botany; that was in 1886. I was assistant to Prof. William Trelease at the Washington University. Then in 1887 I became a lecturer on bacteriology in the medical department of Washington University. It was then known as the St. Louis Medical College.

Later I was made Professor of Bacteriology in the medical department of Washington University, and continued so until last year, when I resigned to go abroad.

Q. The Washington University Medical Department and the Missouri Medical have been consolidated, have they not?

A. Yes, the St. Louis Medical College and what is known as the Missouri Medical College have come together, and now form the Medical Department of Washington University.

Q. Do you know when the Missouri Medical College was founded?

A. I do not. Ffty or more years ago.

Q. Do you know when the St. Louis Medical College was organized?

A. I do not. It is a very long time ago, a great many years.

Q. Are you acquainted with the general character and reputation of the medical schools throughout the United States?

A. Yes, I have attended most of them.

4 Q. Do you know in what position relatively the Washington University Medical College stands now with reference to other schools?

A. Yes, sir. It is one of the great schools of the country.

Q. Do you know anything about the number of students that attend there?

A. I do not now. I have not been connected with it for a year, but always a large number.

Q. At the time you ceased your connection with it?

A. I resigned last year.

Q. At that time about what number were there?

A. Oh, it always varied. It would depend upon the class, from 30 to 60 or 70 men in a class, and they take four years, so it would be about four times that many.

Q. That is, in the medical department?

A. Yes sir.

A. They have a four years course?

A. Yes sir.

Q. Any preparatory work before entering college?

A. In the medical schools?

Q. Yes.

A. O yes indeed. A man has to—I think he must pass through the high school and a certain amount of preliminary training in a college, but just what that is I don't know.

5 Q. Do you mean preliminary medical training?

A. No sir, not before he begins.

Q. Now what was the first work you say you did as a bacteriologist with the Shaw school?

A. At the Shaw school of botany.

Q. Now where is that located?

A. It is connected with the Washington University.

Q. Where is it located?

A. It was then between 17th and 18th streets on Washington avenue. It is now in the Missouri Botanical Garden. It is out at the Shaw Garden.

Q. It is maintained now as a public garden, is it, a botanical garden?

A. The botanical garden is maintained as a public garden. It was given by Mr. Shaw to the city.

Q. Is there any institution, any botanical institution connected with it?

A. Is there what?

Q. Is there ay botanical institution run in connection with the garden?

A. Yes, it is a school of botany. That is part of the university.

Q. It is now conducted out there?

A. I think part of it goes on out there, part is there and
6 part in the university proper down town.

Q. It is all connected with the Washington University?

A. Yes sir.

Q. Now what was the character of your work with the Shaw school?

A. In the beginning I had the ordinary technical training of bacteriologists, which they go through. The salad days, I suppose you would speak of it, learning how to clean a test tube, and how to make soup for bacteria, and growing bacteria, and such things, and distinguishing between the different kinds of bacteria, that is the pathogenic and non-pathogenic bacteria.

That was during the first year. The second year I taught that to the students in that institution.

Q. Now wait a minute. Before you proceed any further I want to get you to explain some terms. You spoke of making soup for bacteria. Explain the method of making that and the object of it.

A. Well, in order to have the bacteria grow and multiply they have to be fed; and to feed them you have to give them food that they like best, that they can live on best. And it has been discovered after years of labor that certain nitrogenous compounds put in assimilable form at the proper temperature for them encourages them to grow and multiply, and a variety of media are used for that purpose. In the beginning various soups are made out of vegetable or animal products. Now following
7 the method laid down by the American Public Health Association, of the bacteriological department of which I am a member, we have regular rules for making media, and the definite reaction that must be in the media. That has all been worked up carefully by a body of experts.

Q. Will you explain what you learned there about the making of what you call soup for the bacteria, what the process was at that time?

A. You want to know the way we made soup then?

Q. Yes.

A. Well, we took a pound of lean beef free of fat, and put upon it a litre of water, and that was allowed to stand in an ice chest over night. In the morning that was squeezed through a sieve, and filtered and cooked, and to it was added a certain amount of peptone, that is a digested meat product. This mixture was boiled, filtered, and when perfectly cooled it was sterilized. That was a stock product. That was the beginning of all media of a certain kind, and to that was added if we cared to have solid medium, a definite per cent of gelatine, ten or twelve per cent., or a Japanese seaweed known as ager ager.

Q. Now one or two per cent. of ager ager was added to it?

A. That is a so-called solid medium, that is, gelatine and the ager ager, and we will speak of that as solid media right straight along. Those practically are the fundamental food pro-

8 ducts that we use. The gelatine and the ager ager are solid media; then there are various special media. We use the potato; we use milk, and then we have various special media that are made up for certain classes of work that are to be carried through. There are a large variety.

Q. Now I want to get another thing into the record before we go any further. You used a term a while ago that indicated that bacteria in one form was injurious and in one not injurious. Give those terms to me.

A. I said pathogenic. A non-pathogenic organism is one that does no harm to an animal, while a pathogenic organism is one that lives in his tissue and does him harm.

Q. Now will you go on and explain what were the next steps in your bacteriological experience?

A. I was employed by the St. Louis Medical College, that is, the medical department of the Washington University, and taught bacteriology from the last part of September until April or May of each year.

Q. Now what year did you begin there?

A. I began in 1887, and later, as I say, I was made professor, but still continued in that work. In 1894 I was employed by the St. Louis health department—

Q. The city government?

9 A. The city government, yes sir, to aid in the bacteriological work of the health department. I was an employe and my title was consulting bacteriologist. I then made bacterial culture experiments, and did any work of that kind that came in; I carried out experiments for the department working on tuberculosis, diphtheria, typhoid, blood and various things that came up at that time, and made diphtheria anti-toxin.

MR. DRENNAN: That was in 1894?

A. In 1894 I began.

MR. CROW: Still retaining your connection with the college?

A. Yes sir; I worked four or five hours a day right straight along.

Q. During that time you have also been in practice?

A. Yes sir.

Q. Not in the general practice, but more as a specialist?

A. Office practice.

Q. What do you mean by that?

A. Genito-urinary work, diseases of the privates, venerial diseases and things of that kind.

Q. Now doctor, what does the term bacteriology in the medical world mean?

A. It means the study of bacteria.

Q. Now what do you mean by bacteria?

A. Bacteria are the lowest forms of vegetable life. They
10 are closely allied to the algae. They belong to the group
thallophyta, and come in the division known as schizomycetes or fission fungi.

Q. Now where are they found?

A. They are found everywhere on earth, on the surface of the earth, more or less on the surface or in the earth, in the waters of the earth and in the air close to it, even extending up to some height, as high as they can go, as high as the currents of the air will carry them above the earth's surface.

Q. As high as the currents of air above the earth's surface?

A. Yes sir.

Q. Now you are familiar with the origin and development of this particular branch of science, are you?

A. Yes sir, I have been watching it since 1881.

Q. Making it a study?

A. I did some microscopical work in 1881, but I didn't really take hold of that subject, of bacteria, with serious interest and vigor until 1885.

Q. Well, from that period to this period, 18 years, you have made it the principal study of your scientific researches?

A. Yes sir.

Q. Now will you please tell me if you know who first discovered the existence of vegetable organism known as bacteria?

A. Well, that credit is given to Anthony von Leeuven-
11 hork, a Dutchman of Delf, Holland. He is the so-called
father of microscopy. He succeeded in making a magnifying lens powerful enough to see micro-organism floating about in various fluids, in water from street gutters, in his own urine

and in spittle and things of that kind, and to see minute organisms floating about in these fluids. He drew pictures of them and made drawings of them and described objectively what he saw. Those are still in existence.

Q. Now about what date was that?

A. 1675.

Q. What was the business of this man?

A. He was a linen draper, I believe, a man somewhat interested in scientific pursuits, especially in lens grinding, and he saw these things.

Q. That is the first recorded instance in which these organisms were identified?

A. Yes. Another man by the name of Kepner, in 1671, is also credited with having seen these minute organisms in fluids. Also as the powers of the microscope were increased and as better microscopes were made, and the chromatism overcome, that is, the irregular lighting or prismatic display of colors in the old microscopic lenses, after that was overcome pretty well, minute organisms began to be studied and from that time up until the time of Pollander and Davaine very little was done. These men, however, discovered in the blood of an animal dead,
or an animal sick with the disease known as anthrax, a
12 micro-organism.

Q. When was that?

A. In 1849.

Q. Where did these men live, in what country?

A. Germany and France. Davaine was a French physician. He also in 1850 saw the bacillus in the blood of an animal, and in 1863 succeeded in giving a well animal the disease anthrax, by taking the blood from a diseased animal and putting it into a well animal.

Q. Explain to us what anthrax means, so that we may get it into the record.

A. It is a disease of cattle, produced by these micro-organisms called anthrax bacilli.

Q. What is the outward appearance of the disease and what effect does it have?

A. An animal affected with that disease—if it is injected into the skin, you understand—at the site of the injection there is an induration, or hardness and swelling; that swelling extends to the whole body and the animal sometimes dies in convulsions or just simply lies over and dies with a gigantic struggle for breath.

Q. Well, are there any eruptions on the skin?

A. Yes sir, sometimes.

13 Q. How does it develop in man?

A. It produces a malignant carbuncle in man. The disease is known as malignant carbuncle. If the bacillus gets into the tissues, in the skin or mucous membrane, it produces this disease anthrax. On the outside of the body it produces a little pimple and a great deal of swelling follows an induration, hardness, and the swelling spreads rapidly like erysipelas. This is followed by fever, profound poisoning and rapid death. There are two forms in man, what is known as the local form of the disease, in which it remains localized, and can be cured, but the other in which the disease enters into the blood and the bacillus circulates in the blood, death invariably follows it, and this is the disease of the blood in which bacillus was first discovered in 1849.

Q. What was the next step?

A. Well, it was claimed by Davaine in 1863 that this microorganism was the thing that caused the disease, this rod that was found in the blood was declared to be the cause of the disease.

Q. What was this rod?

A. This rod was the bacillus of anthrax. During all this time the question of spontaneous generation had been coming up and had been fought over savagely by scientists on both sides. Going back as far as we can go in literature we have accounts of spontaneous generation, things coming out of nothing, or growing from nothing. But Plenciz, in 1749, announced the doctrine with a good deal of vigor. It was combatted by a number of men, especially by Spallanzani, an Italian, and he
14 claimed that by putting fluids in hermetically sealed vessels and cooking them, that he could prevent spontaneous generation in these fluids, and he denied the doctrine of spon-

taneous generation. He further showed that when this sterilized material in flasks, if the air was allowed to gain entrance to it through a crack, made in the flask, that immediately growth occurred in this medium, demonstrating to his mind that the thing that grew in the medium must enter with the air that entered the crack. Of course it was combatted in a variety of philosophical and metaphysical speculations until it was finally proved that the doctrine of spontaneous generation rested on false premises, that there could be no life if there had been no previous life. That is, you cannot have life in a fluid unless the fluid had contained some living thing.

Q. Now this Frenchman, who in 1863 made the statement that this rod shaped bacillus caused anthrax, did he make any experiments demonstrating his theory?

A. Yes, he did, but he was unable to separate out these micro-organisms into what we call pure culture.

Q. Just explain what pure culture is, because the term will be used throughout the investigation, as far as bacteria is concerned.

A. Pure culture means that a micro-organism, say anthrax bacilli, are separated out and made to grow alone in the medium,
or upon the medium. It is free of every other micro-or-
15 ganism, it is a pure culture and if it is not free of every
other micro-organism, it is impure culture.

Q. Explain his failure to demonstrate this fact, and what was the next step in the history of the science?

A. Now comes in the work of Pasteur.

Q. That is the French physician?

A. The great French scientist.

Q. That treated rabies?

A. Yes sir, Pasteur, who had been working on the question of spontaneous generation and fermentation. Swan, immediately before, in 1854, after it was demonstrated that the cause of fermentation in certain kinds of fluids was due to a micro-organisms, an yeast cell called saccharomyces cerevisiae. Swan showed that this micro-organism was the probable cause of fermentation, and Pasteur took it up and cleared up the whole subject.

Q. When did he begin his investigation?

A. He began his investigation before 1860—he was a chemist then and took up the question of spontaneous generation, or rather, fermentation, in opposition to Levbig, and demonstrated very clearly that micro-organisms yeast cells were the cause of fermentation, and it resulted in the better production of wines and beers and whiskey and alcohol. That is from the industrial side. He later became interested in disease and took up the study of various diseases.

16 Q. Now let me ask you a question right there. Prior to 1849, had there been any demonstration in the scientific world that showed that bacilli had any particular relation to diseases of the human body?

A. No sir.

Q. That first developed along about 1849 or 1850?

A. Yes sir.

Q. Now go ahead.

A. Now, Pasteur began separating out these yeast cells of which we spoke in pure culture, and his method of working was exquisitely minute and tedious. It is difficult to believe now that he ever succeeded in getting any kind of bacteria separated out in pure culture with his method.

Q. What was that method?

A. It was simply a transfer from one broth culture to another, material that was to be studied. There were a series of test tubes aranged along in a line containing soup made in some one of the various ways in which we make soup. The medium in these tubes was all thoroughly sterilized. Everything in them was dead, no life in them. Now say it was an yeast cell he wished to separate out. He began by taking a little yeast and mixing it into tube Number 1, then from tube Number 1 to tube Number 2, then to tube Number 3, then to tube Number 4,—in that way finally hoping that he could take out a drop from one of these later tubes that would have one micro-organism in one drop. Now if he did succeed in separating it out until
17 he had one or two micro-organisms to a drop then he
had little trouble in separating them from one another.
In that way, a vastly tedious way, he succeeded in separating out

quite a number of micro-organisms from one another. As a result of his work he succeeded in separating out the micro-organism which caused fermentation in urine.

Q. That was in 1868?

A. Yes sir. In 1868 or 1866, Lister's attention was called to Pasteur's work. He was an Englishman, an English surgeon, and he reasoned that if bacteria did not exist in the blood proper but could exist on and in the skin and in the air, that it would not be difficult to keep them out of a wound, and prevent fermentation in a wound. His tests were followed by success and that is how we treat wounds today. This is the basis of our asceptic surgery of today. He said if these micro-organisms caused fermentation in fluids outside of the body they must cause fermentation in wounds, and if we keep them out of the wound, the wound won't ferment. That is what that Listerism means. It means washing and cleaning carefully the wound and keeping out micro-organisms.

Q. He demonstrated that bacilli would ferment a wound?

A. Yes sir.

Q. The same as they ferment wine or urine?

A. Yes sir.

Q. Now was it Pasteur that first classified bacteria?

18 A. No sir.

Q. Now go ahead with Pasteur's experiments.

A. Pasteur then continued his work, and he began one of his earliest pieces of work in the study of disease. It was the silkworm disease. He was employed by the French government to find the cause of the death or disease in the silkworm. He succeeded in cleaning that up before 1860, showing the cause of the disease of the silkworm was due to a certain living thing. That was his first piece of work. He demonstrated clearly that a micro-organism was the cause of a disease in an animal,

Q. And that animal was the silkworm?

A. Yes sir.

Q. And he demonstrated there was a certain bacillus that caused that disease in the silkworm?

A. Yes sir.

Q. That is the first known instance where Pasteur demonstrated disease was traced directly as caused by a micro-organism?

A. Yes sir, that was the first one. Then he followed that up with work on the chicken cholera. Later upon hog erysipelas. Then he took up the question of rabies or mad dog bite, or hydrophobia, and not only studied the subject very carefully, but produced a cure for it. He then took up the question of anthrax, and produced, or rather invented a method of preventing
19 the disease—the so-called inoculating method.

Q. Similar to the smallpox virus?

A. Somewhat, yes sir. The idea of this method of his is to give the animal a first dose of an attenuated form of the micro-organism, and then afterwards giving it a strong dose of the virus, or a second dose of the growth of the bacillus, and finally it is given a highly virulent organism and in that way the animal is protected. In other words, the animal is encouraged to manufacture within its own tissues anti-toxins that are antagonistic to the toxins of the micro-organism.

Q. What did those experiments with reference to rabies demonstrate?

A. He demonstrated that he had a cure.

Q. Did he demonstrate the cause of it?

A. It never has been found.

Q. The cause of rabies?

A. It was probably too small to see. That is, to see with our present high power lenses.

Q. Is it known as the absolute cause of rabies?

A. No sir.

Q. Then the origin of rabies is unknown?

A. Yes, unknown.

20 Q. But the cure for it is what?

A. This Pasteur method.

Q. What does that consist of?

A. That consists in giving the individual or animal a dose of attenuated virus first, the so-called attenuated virus I spoke of. I worked in the Pasteur Institute for quite a little while, watching this work go on, and I remember the details very well, and if you care to hear it I will tell you. It is hardly bacteriological.

Q. What is that virus made of?

A. It is made of the spinal cord of rabbits.

Q. What was the next work of M. Pasteur?

A. Other bacteriologists were working, and one of the great discoveries that comes in here on the question of spontaneous generation was made when Spallanzani showed that by sterilizing fluids in hermetically sealed vessels growth would occur in the fluids. Then Swan showed that by heating air as it passed through a long tube before passing over a fluid, that no growth would occur in the fluid.

Q. Over the sterilized fiuid?

A. Yes sir. And next Schroeter and Van Dusch plugged the vessel with a cotton stopper and this is one of the greatest discoveries in bacteriology.

Q. When was that?

21 A. That was, I think, in 1854. I am not positive about that date. Now these cotton stoppered flasks containing steril fluids were used in growing and separating out bacteria in pure cultures, until we come to Koch, his work, begins in 1876.

Q. Who was he and where was he located?

A. He was a German, and where he was located I don't know, at the time that he began work. I think it was in Göettingen.

Q. That is in Germany?

A. Yes sir.

Q. Working in one of the German cities?

A. He began his work on anthrax?

Q. Is he still working or dead?

A. He is at work.

Q. Now what time did he begin on anthrax?

A. 1876 and 1878, and published his work on traumatic diseases in 1880.

Q. What is that?

22 A. Traumatic disease—that is diseases of wounds. He brought a scientific mind to bear upon the whole question

of suppuration in wounds, and what caused it. Lister's work before that had already robbed surgery of some of its terrors had advanced the science of surgery immensely, to almost its present condition, but Koch's work improved it so much that most any man can now become a surgeon.

Now his work on traumatic diseases I think came in 1878, and later, in 1880 he did his work upon anthrax, upon the spores of anthrax. In 1881 or 1882 he pronounced his discovery of the bacillus of tuberculosis, and in 1884, in conjunction with Eberth announced the discovery of the typhoid fever bacillus.

Q. What was his nationality?

A. He was a German.

Q. Was that the first discovery of the typhoid fever bacilli?

A. Yes. It was discovered in the tissue. It was afterwards separated out in pure culture, and developed by Klebs, and known as the Klebs-Eberth bacillus. In 1884 and 1885 he discovered the cause of cholera.

Q. Was that a bacillus?

A. It is a spirellum.

23 Q. That is a form of bacillus?

A. Yes sir.

Q. Is it in the form of a spiral?

A. Yes, sir, and it takes its name from the form of it.

Q. And it takes its name from the form of it?

A. From the spiral form in which it grows, and it is also known as the come-bacillus. The second great discovery in bacteriology, and the great advance in the science of bacteriology dates from the discovery by Koch in 1881, of what is known as the solid medium. Heretofore, as I told you, bacteria were grown in fluids, but Koch came along and demonstrated to bacteriologists that bacteria could be grown on solid media as well as in fluids. I suppose there is no use going into the history of the how or why of this thing, but the fact occurred to me—

Q. Just give the story as science gives it.

A. The story is this, that a piece of moist bread upon a table had been lying there for quite a little while, and was noted by this scientist. He saw upon the surface of the bread, but separated from one another, that various moulds had grown.

Where the spore fell on the bread it grew and formed a colony. It occurred to his mind at once, the thing to do was to make other bacteria grow, if they would grow, where they fell, and form a colony, he simply added gelatine or ager ager to soup and he had a solid medium. Now then, when a micro-organism
24 was put into this solid medium, and grew, a colony formed which could be seen first with a low power lens, and later with the unaided eye. Ten per cent gelatine medium liquefies at 30 centigrade. If we take this liquefied medium not too hot, and put into it, say pus from a wound, and then the medium is poured out on a sterilized plate in a thin layer, wherever the micro-organism is fastened, when the medium cools, there it stays. And inasmuch as it multiplies rapidly in a favorable temperature, one becomes two, and two becomes four, and so in that way in a little while a good many grow, to form what we call a colony. Although bacteria are exquisitely small when alone, in bunches they form colonies large enough to be seen. Thus one isolated colony, of a particular bacterium forms a pure culture and can be very quickly separated out. We may have ten or fifteen distinct micro-organisms in a fluid, but when spread out in a solid medium on a glass plate, or in a Petrie dish, the micro-organisms can all be separated out very easily from one another and grown in pure culture. This is the solid medium method of Koch. Well, dating from this discovery, bacteriology has become a science, because it will allow the merest tyro in bacteriology to begin work and separate out bacteria in pure culture.

Q. That was in the year 1880?

25 A. In 1880, yes sir.

Q. Now along what lines did he pursue his investigations of bacteria?

A. I have given you that. He worked on various micro-organisms; he followed up this work by going further, not only discovering the particular micro-organism which caused a particular disease, but studied micro-organisms in their action upon the body tissues. The toxins produced by bacteria and their action upon the body tissues. Some micro-organisms produce a poison which resembles somewhat rattlesnake poison. Many others of these toxins, of different characters, such as Diphtheria and Tetanus, were studied by Koch. Like Pasteur, his practical mind led him to try and produce cures as well as discover the causes of disease. Among his first efforts we have Koch's lymph, which we have all heard so much about, the so-called cure for tuberculosis.

Q. He first identified the typhoid bacilli in 1884?

A. He and Eberth.

Q. Now is there a diphtheria bacillus?

A. Yes. It was discovered in 1884, by Leoffler, a German.

Q. The cure for that has been discovered also?

A. Yes sir, that came later. Work began upon it in 1891.

Q. In what way is the anti-toxin manufactured that is used for diphtheria bacillus?

A. It is manufactured all over the world.

Q. I say in what way?

A. Do you want the method of producing diphtheria anti-toxin?

Q. Yes, how do you produce it?

26 A. Now the first thing that is done is this. The first movement is to get a diphtheria bacillus that is virulent, one that will kill, kill an animal.

JUDGE SPRINGER: That is, you mean, an organism of a particular disease?

A. Mr. Crow wants to know about the manufacture of anti-toxin for diphtheria that he is speaking of, and if we speak of the method of production of the anti-toxin of diphtheria we will cover all anti-toxins. We will have to go into that later, so perhaps it would be better to go into it now. The first thing to do, as I said, is to take a highly virulent micro-organism, a diphtheria bacillus that will kill an animal quickly, and of all the virulent diphtheria bacilli that have been found in the world, the one that is most virulent, was found by Dr. Park of the New York health department. This is known as Park's bacillus No. 8. Now that micro-organism is taken and put in a soup, a special kind of broth. That broth is made up so that its reaction is 1.5 per cent acid, to phenolphthalein from the meat of beef—

best old beef—from which the muscle sugar has been removed. This muscle sugar can be taken out, be broken up, with bacillus coli communis, so that the sugar which existed at first, in the beef, can be gotten rid of by the colon bacillus. Now a broth is
made of this beef free of muscle sugar, and its reaction
27 must be 1.5 acid to phenolphthalein, or neutral to litmus.

This broth is put into large flasks, flasks containing from 800 to 1000 cubic centimeters, sterilized, and into that is sown a virulent pure culture of Park's No. 8. The flask is now put into an incubator and kept at body temperature, say 36 1-2° centigrade, and grown from 5 to 10 days. At the end of that time it is taken out, tricresol or carbolic acid in a small percentage, one-half per cent as a rule, added. The idea of adding tricresol or carbolic acid is to keep other micro-organisms from growing in it when it is exposed, and also kill the diphtheria bacilli which are there. It is allowed to stand for a little while and then filtered through an ordinary paper filter, and then afterwards filtered through a Pasteur filter, or a Birkefeld filter. Now we have soup containing the toxins produced by the diphtheria bacillus. We are now ready to find out what is the effect of this broth, how many drops of it will kill a guinea pig weighing a definite number of grams. We take a guinea pig weighing 300 grams, and inject into it a definite amount of this material. The idea is to have a toxin of which 1-100 cubic centi-
meter will kill a guinea pig weighing 300 grams in from
28 three to five days. When this strong it is called a good
toxin. Now with this good toxin—strong toxin, we begin injecting a horse, the horse must be a strong, vigorous animal, about 6 years old, used to hard work and free from disease, free from kidney diease especially, free from tuberculosis, and free from glanders. Having a good strong horse the hair is shaved off over an area in which to inject the broth with a steril syringe a small amount of this material, half a cubic centimeter, say four or five drops, to begin with, are injected under the skin. This makes the horse quite sick. At the point of the injection it first produces a hardness, then a swelling wide in area. The temperature of the horse rises within 24 hours, and goes up to 104° or 105° Fahrenheit, the normal temperature of the horse

being 99°. That temperature continues to fluctuate running as high as 105° and 106° for 4 days then drops to the normal on the 5th or 6th day. The sixth day it rises again, and then drops to normal at the end of the 6 days, and remains so. At the end of ten days or two weeks another injection is given of this same poison, twice as large as the first injection, ten drops. The horse is again made sick in the same way; has its high temperature recorded; on the 5th day the temperature reaches normal; then runs up again, and at the end of the 6th day, normal, and then the horse practically retains his normal temperature. At the end of ten days or two weeks, he is given another dose twice as large—20 drops, and so we increase it gradually, watching the horse to see if he loses weight
29 or refuses his food. The doses are either decreased in quantity or made larger, and in that way the horse is finally given an enormous quantity of this toxin, as high as a quart of this virulent toxin can be given to a horse, if he is properly prepared for it. After a time, say two or three months, the horse is bled. He is bled by shaving an area over the jugular vein, and with all aseptic precautions imaginable the blood is drawn from that vein into a sterilized flask. The blood is allowed to stand, and as a result of this standing, the blood clots, the blood serum—the water of the blood separates from the blood corpuscles and fibrin then results from the clotting. The serum is poured off and to it a small quantity of tricresol is added—5-10 per cent, to protect it. Now then we test the serum to ascertain its anti-toxic potency, how many units of anti-toxin it contains, and this is done by now going back again to our original toxin and finding out exactly what is the minimum lethal dose, or smallest dose that will actually kill a guinea pig weighing 300 grams, say that is 1-100 of a drop. Now then, we take ten times that much. We find 1-100 of a drop will kill a guinea pig weighing 300 grams in from three to five days. Now take ten times that amount, which is 10-100 or 1-10 of a
30 drop, and we mix it with a small quantity of this blood serum, or anti-toxin, as we know it, and we inject them together into a series of animals using smaller and smaller quantities of our anti-toxin. In this way we reach the point

where a certain amount of anti-toxin will prevent the death of a guniea pig, and the smallest amount of anti-toxin that will keep a quinea pig from dying when injected with ten times a minimum lethal dose of that toxin, is 1-10 of a unit, or in other words, ten times the amount of anti-toxin that will keep a guinea pig from dying when injected with ten times the minimum lethal dose of toxin is an anti-toxin unit, and our anti-toxins now contain anywhere from 100 to as high—I saw one sample of anti-toxin which contained 2000 units to the cubic centimeter—it is very good anti-toxin when it contains 500 units to the cubic centimeter. Now for the cure of diphtheria, this is the anti-toxin which is used both for the cure and prevention of diphtheria. When a case of diphtheria breaks out in a household, the rest of the household can be inoculated with a minute dose of anti-toxin and be protected for a short while. For the cure of it we inject from 1500 to 3000 units, depending on the severity of the case. It is a specific cure for diphtheria.

Q. Now what other disease has the science of bacteriology traced up as originating in bacteria, since the time you mention of Koch's discovery?

A. Well, we have first of all, infectious wound diseases.
31 Ogsten, an Englishman, in studying these diseases—saw Micrococci in the pus from wounds, but did not separate them out in pure culture. Then Obermeir, a German, who found in relapsing fever a spirillum in 1879, Spirillum Obermeieri.

Q. That is a form of bacilli?

A. Yes sir. That was in 1879, and it is known as the spirillum of Obermeir. Then another German Fehleisen, discovered the cause of erysipelas in 1879, and the cause of gonorrhea was discovered by Neisser in 1879.

Q. What were those specific causes?

A. Gonococcus was the cause of gonorrhea, that was the discovery by Neisser, a German.

Q. That was a bacillus?

A. No, it belongs to the family of bacteria, but it is a micrococcus. The cause of erysipelas is known as the streptococcus-erysipelatis.

Q. That is a micro-organism?

A. Yes, it belongs to the coccus group. Then Ogsten in working in 1880 on pus, saw quite a number of different forms of micro-cocci in pus and he named them the streptococcus resembling a chain, staphylococcus taking the form of a bunch of grapes, and later they were separated out in pure culture by Rosenbach, and given the scientific names which they now bear.

We have in this septic group the staphylococcus—pyo-
32 genes aureus, the staphyloccus pyogenes albus, the staphy-
lococcus pyogenes citreus, and the streptococcus pyogenes, and the sterptococcus of erysipelas. The strepococcus pyogenes produces septicemia. Quite a number of micro-organisms were found to produce supuration in wounds, and the method of keeping them out of wounds I have spoken of, which accounts for the wonderful advance in surgery. I spoke about the discovery of Koch in 1881, the cause of tuberculosis; then we have glanders discovered in 1884, typhoid fever in 1885, and then the bacilli coli communis separated out by Emmerich in 1884. Pfeiffer and Canon discovered the cause of la grippe.

Q. What was that?

A. That was a bacillus. In 1894, we have the work of Kitasoto. He discovered the bubonic plague bacillus.

Q. Who was he?

A. He was a Jap.

Q. A Japanese?

A. Yes sir, and in 1898, we had the discovery of the cause of dysentery by Shega.

Q. Who was he?

A. He was another Jap. He discovered the cause of dysentery.

Q. What was that cause?

33 A. The Shega bacillus.

Q. A form of bacteria?

A. Yes sir. That practically covers the field of bacteria of infectious diseases.

Q. No discoveries in 1890, and 1891?

A. No, nothing new in pathogenic micro-organisms. Then began the work on anti-toxin in 1891. Wernicke and Kitasoto whom I spoke of, and the others, began work on anti-toxins.

Q. You said that these micro-organisms known as bacteria in general terms, were found in the air and water and in the soil?

A. Yes sir.

Q. Now some of them are water born and others are not?

A. Yes sir.

Q. Will you tell us what of them are water born?

A. Well, most of the bacteria can be water born for a short distance, but many of them die—very many—in water. The water born diseases as we know them are typhoid fever, the cholera and dysentery.

Q. That is dysentery?

A. Yes sir, but as I said, most bacteria can be carried and
34 live for a short distance, anthrax, for instance.

Q. Now most of the other bacteria are in the soil or in the air or both?

A. Yes sir.

Q. Now what, if any, relation do bacteria bear to life—animal life and vegetable life, and its growth and development, and its decay and its rehabilitation in different forms, in animal and vegetable matter, and so on?

A. There would be no life on earth without bacteria, consequently they are the undertakers of the organic world.

Q. Now what do you mean by that, when you say undertakers?

A. I mean this, that when an animal dies or a tree falls, in a short while, as we know, that material begins to break down, after it lies awhile we see that it gradually disappears, breaks apart and finally disappears, and so with an animal dead upon the field. It swells up and stinks for a while and then disappears, leaving nothing but bones. Now the cause of the disappearance of a tree and the meat of a dog or dead animal, are the result of a destructive action of the bacteria upon the chemical compounds that compose the structure, the heterogeneous structure of that animal. They reduce, in other words, the highly complex nitrogeneous compounds and carbon compounds to the
35 lower forms of carbon, hydrogen, oxygen and nitrogen.

Q. Those are the four basic forms of animal and vegetable life?

A. Yes, those heterogeneous molecules are broken up so that in the end we have ammonia and carbon dioxide as a result. The carbon dioxide passes off in the air. Ultimately these complex heterogeneous structures are reduced to the elements from which they came. These simple compounds form the food for the plants again, and the plants take up this broken material, and grow. Plants are food for animals, hence animals upon earth; so that without bacteria there wuold be no life upon earth. They are also the destroyers of the organic world.

Q. Well then, scientifically and practically speaking, you mean to say that bacteria are both economic and industrious?

A. Yes, sir.

Q. One equally with the other?

A. Yes, sir.

Q. Now just carrying out that thought of economy and industry that bacteria occupies in the scientific world and in the practical world, what relations, if any, exist between bacteria and the production and manufacture and consumption of food of the human race?

A. Yes, indeed they do. They are very closely asso-
36 ciated with life in that way. For instance, they bring
about the souring of milk and the cheese that results from it, that is a food product which they produce.

Q. Now wait a minute. Is that souring of milk an artificial process or a natural one?

A. It is a natural process produced by the micro-organisms that grow in milk. They produce acids which sour and some of them produce a substance like rennet, which coagulates the milk at once without souring it.

Q. That would take place in the open air in a state of nature?

A. Yes, sir. And that cheese becomes food, from the cottage cheese up to the elaborate cheeses of the Germans. The ripening of the cream and the production of butter, and especially good butter, the butter flavor that we know, rich butter flavor, is produced by Cohn's bacillus No. 41.

Q. What is that?

A. That is a micro-organism. A bacillus which was separated out by Mr. Cohn of the Wesley Institute or University. Cohn's No. 41, and gives its flavor to butter. It is now manufactured by him or his people, and sent to dairies all over the United States, and I believe is sent all over the world.

Q. Who purchase it and consume it?

37. A. The dairies, the great dairy interests of the whole country use it constantly every day.

Q. What is the effect of that on the butter?

A. It has no deleterious effect, but produces from the oil and the sugar an aromatic odor, the so-called flavor of butter.

Q. Has it any beneficial effect on the butter?

A. It makes it beneficial. It makes it butter, better tasting, consequently easily digested, largely consumed, more readily sold, and thus a higher priced product.

Q. Then, this operation of the bacilli on the fatty matter of the butter is what causes that aromatic odor?

A. Yes, in the cream. Bacteria destroy sewage, for instance. That is, sewage in a tank is destroyed by them.

Q. Now what is it the septic tank produces?

A. It consists in running sewage, crude sewage, into tanks heremetically sealed, and the bacteria there being of two kinds, aerobic and anaerobic, break up the organic compounds of the sewage.

Q. You are using sewage in the technical sense?

A. Yes, sir, crude sewage.

Q. Do you know what percentage of ammonia and alcolines sewage in water contain?

A. No, sir, it doesn't make any difference whether it is
38 diluted or concentrated sewage. It is run into these practically heremetically sealed tanks. The idea is this, the aerobic micro-organisms act upon the sewage, first working in the presence of the oxygen of the air in the sewage; so soon as the available oxygen is used up, the aerobic bacteria cease their destructive action on the sewage which gives the anaerobic bacteria which flourish best in the absence of oxygen a chance to attack the organic compounds in the sewage. The result of the destructive action of these two kinds of bacteria on the sewage it to quickly liquify the solid organic materials and to reduce them to lower and lower nitrogeneous and carbonaceous com-

pounds. Ultimately ammonia, carbon dioxide, hydrogen and marsh gas are produced, which are gases and lower forms of nitrogen and carbon compounds which are food for plants.

Q. Have you ever seen any of these septic tanks?

A. Yes, sir.

Q. How are they arranged?

A. I have one at work in my cottage in the north. It works during the whole summer, and it works in the way I spoke of it.

Q. How is it constructed?

39. A. This particular one is a tank in the ground made of brick and the sewage runs into it. It is underneath the ground, and the bacteria do the work upon excreta as thrown into it, the sewage in it rises to a definite height, and remains in it until flushing carries out the liquefied material by siphonage into a field.

Q. Are those bacteria present in all sewage mostly?

A. Yes sir.

Q. Now are the different forms of bacteria necessary to the proper and successful culture of the soil?

A. Yes, sir, for the proper destruction of some of these materials it is necessary to have a certain class of non-pathogenic bacteria, they fertilize the soil. In fact, they are sown upon the soil in some agricultural regions in pure cultures.

Q. Now in the bacteriological world the injurious and non-injurious bacteria exist in about what proportion?

A. How do you mean?

Q. That is, in greater numbers. Are the bacteria that are non-injurious in greater numbers in the water, air and soil, than the others, in the human system?

A. An enormous number of bacteria in the world are beneficial, and a great number of them are harmless. There is only an occasional one that is harmful.

Q. What do you call the bacteria that is found in the
40 water, and that is found in the water fed by sewage, and is found in the stomach of animals, including man—or rather in the intestinal canal?

A. The one that has been looked upon as the index of fecal pollution? That one is called bacillus coli communis.

Q. What do you mean by fecal pollution, Doctor?

A. Whenever the discharge is from the intestinal canal of man or animal—

Q. But it has always been supposed that these bacilli or bacteria would be found there and nowhere else?

A. Whenever there is sewage from man or animals, the bacillus coli communis is generally found present.

Q. They are also found in discharges from man or animals on the soil or anywhere else?

A. Yes sir.

Q. Now have you discovered any other place where they exist?

A. In some of our work we found that it does not exist in the intestinal canal of fish in the ordinary streams, but in the fish of the Illinois river it exists in very large numbers in the intestinal canal—in about 70 per cent. of the fish. In the fish in ordinary streams it dosn't exist, but in the highly polluted
water of the Illinois river we found the bacillus coli com-
41 munis in the intestinal contents of the fish taken from that
river. I am stating from memory, I don't know exactly; I think it is about 69 or 70 per cent. of the fish in that stream which we studied. I think we studied 68 fish of five or six varieties or more.

Q. Now going back to the discovery in 1884 by Koch and Eberth of the typhoid bacilli, do you know in what way they discovered that, or in what animal and in what portion of the animal?

A. They discovered it in the intestinal contents, or rather in the intestinal mucous membrane and glands of a man dead of the disease.

Q. Dead of the typhoid disease?

A. Yes sir. In cutting sections and staining them and studying them from the intestinal contents, the intestinal walls, rather, they discovered in the tissues bunches of short bacilli which they described and also photographed. Koch photographed them. This was supposed to be the cause of typhoid fever, inasmuch as it was found in no other intestinal disease, but later Klebs found it not only in the intestinal contents and the intestinal glands of people dead of the disease, but also in

the spleen and in the blood, and he separated it out into pure culture and described very carefully its cultural characteristics, the way in which it can be distinguished from other micro-
42 organisms. Later work on this bacillus has shown that it is very probably the true cause of the disease. It is found in the intestinal contents, and in the mucous membrane of the intestines. It is found in the spleen and other organs. It is found in the blood, circulating in the blood, and is discharged from the body in the intestinal contents, and also with the urine, in enormous numbers, at about the beginning, or rather, towards the end of the second week. There may be discharges from the body for quite a number of years afterwards in the urine.

Q. After the patient has recovered?

A. Yes sir. In some cases it has been found as high as eight years. It has been found in urine eight years after an attack of the disease.

Q. In the urine?

A. Yes sir.

Q. In the urine of a patient that was apparently fully recovered from the disease?

A. Yes sir.

Q. Now you spoke of a process of staining they discovered?

A. Yes sir.

Q. While they were staining sections taken from the intestinal canal of a man dead from that disease. Explain
43 so that I can get it into the record what the surgical process of staining means.

A. That is an important question, too, because in 1877 Weigert discovered that bacteria had an affinity for aniline dyes.

Q. You mean bacteria?

A. Yes sir, the bacteria.

Q. Harmful as well as harmless?

A. Any kind. They have an affinity for analine dyes. They took the dyes within their structure, consequently they became stained blue, red, pink, or green. They took the color that you cared or wished them to.

Q. That is, the bacteria partook of the hue of the dye?

A. Yes sir. Well, consequently, the tissues could be made to be dyed green or red or blue, but the dye could be taken out of the tissues much more easily that they could be taken out of the bacteria, so that these micro-organisms could be seen distinctly standing out as, say, green bacilli on a field of red.

Q. It would be very plainly discernable?

A. Yes, sir, the typhoid bacillus does not stain so well as some of the other pathogenic bacteria. Neverthless it was seen very distinctly with the coloring methods used by Koch and Eberth, working independently. They were not working together, but were working independently, and both saw it
44 in the same year, and discovered it and described it.

Q. Described that process of staining?

A. Well, if they were simply staining it for the typhoid bacilli, they would take any one of the basic aniline dyes, such as methylene blue, make a saturated alcoholic solution of that first, and then an aequeous solution is made from that. The alcohol solution is added to water until we have a slightly opaque fluid. The tissues are cut in very minute sections, which are immersed in this fluid and left in it for a time. They are then taken out and washed and mounted, studied with a microscope, and the bacteria will have taken up the color to themselves so that they will appear much darker than the surrounding tissues which are also stained blue, and part of that color can be taken out of the tissues by alcohol afterwards, so that part of the color out of the tissue leaves the dye more distinct in the bacilli than in the tissue.

Q. What do you mean by the tissue?

A. The mucous membrane of the intestine of the patient dead of the disease.

Q. You use that?

A. Yes sir, or usually the spleen.

Q. Now going back to the cholera bacteria, I believe you
45 said awhile ago, that is what is considered a water-born bacteria?

A. Yes sir.

Q. Now what is the form of that bacteria?

A. Koch's word covers it very clearly. He calls it a comma.

Q. Did he discover it?

A. Yes sir.

Q. When and where?

A. He discovered it in 1885 in India in the intestines of people sick, in the intestinal contents of people sick with cholera, or in the intestinal contents of people dead with cholera.

Q. He was a German, how did he come to be sent there?

A. He was sent there by the English government.

Q. For what purpose?

A. To study the cholera.

Q. The result was the discovery of this bacteria?

A. Yes sir.

Q. Now did he discover any other characteristics other than what you have named?

A. He discovered it in the intestinal contents of people sick or dead of the disease, and he found it in the water of one of the tanks in India, from which the cholera had come, from which an epidemic of cholera had spread.

Q. Did he make any further experiments with that
46 bacteria?

A. Yes, quite a number of them.

Q. In what way?

A. He put it in steriled water and also studied it in living water, and he found out that it would live a definite number of days in various kinds of water.

Q. Is it subject to changes of temperature—water hot and cold?

A. Yes sir.

Q. And what degree of heat does it take to kill it?

A. It takes a temperature of boiling water to kill it.

Q. What degree of heat is boiling water?

A. Well, if you are speaking of centigrade—100 centigrade, five or ten minutes.

Q. And freezing, how much will it stand?

A. It will stand indefinite freezing.

Q. It is impervious then to freezing?

A. Freezing does not destroy it; that is, steady cold; but alternate heat and freezing will destroy great numbers of the bacteria very rapidly.

Q. Now is it an active bacteria?

A. Yes, highly active; it is motile, a swimmer.

Q. Now as to propagation, does it increase rapidly or slowly?

A. Rapidly, very rapidly.

Q. In what form does it increase most rapidly, in water
47 or in the human system.

A. In the human system.

Q. Does it increase in the water at all?

A. I think no experiments have shown that it multiplies in the water.

Q. Is there any culture in which it can grow?

A. Yes, it will grow in all media easily.

Q. It is a bacteria that is easily experimented with?

A. Yes sir.

Q. Now is it a disease that is considered contagious through liquid, or contagious through the air mostly?

A. It is a water-born disease.

Q. Can it be taken through the air?

A. Yes, there is a possibility in that. It retains its vitality for quite a little while when it is dried. In the mucous discharge from the bowels, for instance, that can be dried and float into the air and remain virulent for a long time. There is a possibility of it being conveyed in that way; shaking sheets that are not sterilized in the air, and throwing a dust of that character in the air, that is remotely possible, and then people who are about cholera, handling people sick of the disease, they have great dis-
charges from the bowels and vomit a great deal, and con-
48 sequently more or less dejecta from the body all about
them, so that those who handle the disease are very liable to contract it from the fact that they have put their hands to their mouths and their noses and they convey it into their mouths and their noses. There is that method of conveyance, but the great method, or way in which it is generally carried, is by water carriage, drinking water that has contained the discharge of the people sick or dead of the disease.

Q. Is there any connection between that common method of conveyance and the fact that it easily follows the given routes of travel around the world?

A. It follows the routes of travel because people sick of the disease travel along certain routes.

Q. Give us that method?

A. Because they move in that direction. People coming up from India through Russia, go down into Germany, over into France or England, and across to America, that is the route it takes, affecting as it goes.

Q. Now, then, bacteria might be communicated from the deads' clothing or from the affected individuals in the same manner, possibly?

A. Yes sir.

Q. What is the usual method of conveying it?

A. Water carriage.

49 Q. Water or milk, or some such liquid form?

A. Water carriage—it gets into the water supply, it gets into the drinking water of a community, and is carried into the intestines of those who drink the water, and those susceptible contract the disease.

Q. It can go then into milk, through the connection of a pump and a milk can?

A. Yes sir.

Q. In that way it might be conveyed?

A. Yes sir.

Q. Now there are certain bacteria that arrest their own destructiveness, isn't that so?

A. All of them do.

Q. The injurious and non-injurious?

A. Yes sir.

Q. Now, will you just describe that process?

A. Why, bacteria produce toxins or poisons, as I showed you before, the diphtheria bacillus, for instance.

Q. Explain that, Doctor.

A. Bacteria growing on or in a medium produce toxins, and after a time when they accumulate in sufficient quantities, stop the growth of the bacteria. They do not destroy exactly, but there is not enough nutritive media left for them to grow upon, besides the toxin prodaced inhibit the growth of the microorganism.

50 Q. That is, a man might have diphtheria, or might have typhoid fever, and not be free of poison, and still recover?

A. Yes sir.

Q. Now that would indicate there is something in the human system that has the effect or power of overcoming the bacteria that caused the disease?

A. Yes sir, that is anti-toxin.

Q. And that is the anti-toxin that is in the system, is it?

A. Yes sir.

Q. And that is caused by other bacteria—by the same bacteria that cause disease?

A. The body itself produces anti-toxin to the specific bacteria.

Q. Well, does the poison that is thrown off with this bacteria, so that a man gets well without the pure anti-toxin, does that have the effect of curing him of his disease?

A. Yes sir.

Q. Now there are certain bacteria known as spores, are there not?

A. No sir, not certain bacteria, but some forms of bacteria produce spores. A spore is known as the resting stage of the micro-organism.

Q. It is a micro-organism that belongs to the bacteria
51 group?

A. No. I think, Mr. Crow, you have not clearly in mind what a spore is.

Q. No, perhaps not.

A. A spore is something like a grain, like a wheat grain on a wheat stalk. I think we had better go back to the structure of bacteria before we begin about spores. After we get that, we can get a simple classification.

Q. Go ahead with that, then.

A. Now, bacteria, as we know them, consist of a cell wall, and cell contents. Speaking of classes, I will speak of the bacillus first. I will represent it as resembling a wienerwurst sausage, perhaps not so complicated. We have the skin on the sausage, and the meat on the inside of it. Now, the bacillus is made up something similar to that, they have an outside cell wall, composed of cellulose, and an inside contents not quite so complicated as a sausage, but it is composed of protoplasm known as the micro-protein, and that is the cell contents. That outside cell wall of cellulose has attached to it, or part of it, a

gelatinous wall, and that gelatinous wall, when the micro-organism is dry, is tight to the bacillus, but when the bacillus is moistened it separates out and form a thick layer upon it, making a thick coat upon it. Now from that cell wall in some of
52 the micro-organisms we have whip-like processes extending out 15 or 20 times as long as the bacillus itself. They are long threads. They are known as flagella. If there is only one of these little threads, it is known as the flagellum. If there are many they are known as flagella. Now by means of these flagella on the micro-organisms, motion is produced. These flagella are spiral, and they whirl in the water and send the micro-organisms along as swimmers. Now there is the cell contents, cell wall, outside capsule, and the flagella on some of them. Now these micro-organisms when brought into suitable conditions of temperature and moisture and nutrient media, grow. They are unicellular, almost transparent, or translucent, when you look at them when unstained. When the media and temperature suit, they grow, and then reach a certain size, and when they reach that size they stop growing and send a division down through the middle of the cells. If I could project a partition right down through the middle of my finger like this (indicating) that would give you some idea of the process. Where there was one, there are now two, and each grow into a micro-organism in about a half an hour under suitable conditions, so that in that way it has been calculated that there are 17,000,000 bacteria can grow from one cell in 24 hours, so that they
53 grow very rapidly, although exquisitely minute. Now, some of them, instead of dividing in the way I spoke of, do another thing. In the cell contents of the micro-protein little bright specks appear and coalesce and form finally a hard resisting body within the cell wall of this micro-organism. All the micro-protein in the cell wall goes into this body and forms what is called a spore, that is the seed of this bacillus, and that spore puts on a very thick, highly resisting membrane, and has a contents within it like the yolk in an egg. That wall is very thick and highly resisting, so that it makes these spores the most highly vitalized things on earth. Absolute cold does not freeze or destroy them, and to destroy the spores, a very high

temperature is necessary; 150 degrees centigrade for an hour, or an hour and a half, dry heat, and anywhere from five minutes to one hour boiling temperature, temperature of boiling water, or from five to thirty minutes streaming steam, and from five to ten or twenty minutes steam under pressure, one and one-half atmospheres. The thing that resists these high temperatures is the most highly vitalized thing on earth, and that is the spore.

Q. Now are they found in the water or in the air—these spores?

A. Oh, they are everywhere, everywhere on earth. They are ubiquitous.

Q. Now are they inimical to health in any way?

54. A. Some of the pathogenic organisms form spores, the anthrax bacillus for instance. That is a hightly resisting spore. Tetanus (lockjaw) has a highly resisting spore that is especially obnoxious.

Q. Does the typhoid fever have any spores?

A. No sir.

Q. Or cholera?

A. No sir.

Q. Or diphtheria?

A. No sir.

Q. Then it is found in no other diseases except tetanus and anthrax?

A. Well, those are the principal ones that produce spores.

Q. Now bacteria are also used for the purpose of water filtration, are they not?

A. Yes sir.

Q. Now will you explain in what way bacteria are useful as water filters?

A. In the construction of a sand filter for the artificial filtration of water (what is known as the English system), large reservoirs are constructed, and these reservoirs have, first, large rocks at the bottom, and then heavy gravel, and then smaller gravel, and then coarse sand and then sand not so coarse,
and then a layer of fine sand on top of that. On that
55 bed, on top of this sand, water is allowed to flow,
and percolates through. The effluent runs out of those
filter beds, unchanged for several days—ten or twelve days or

two weeks sometimes—and then the filter begins to act properly. The sediment in the water is taken out, and as high as 99 per cent. of the bacteria are removed. Now what has occurred in the filter to remove all the sediment and bacteria is an extremely interesting thing. I spoke of the structure of bacteria, the cell wall and the gelatinous layer upon it. What occurs here is that the micro-organisms that are in the water—water born bacteria—form a sticky membrane which sticks to the rocks and sand, so that when you take hold of the sand or feel the rocks at the bottom of the filter the bacteria have developed a layer which feels like slime to the fingers. It means that each micro-organism settled on the sand or rock stuck to it, and as his neighbor came along, it stuck to him, and in that way they soon form a blanket of bacteria stuck together on and in the sand, making a top layer on the sand, so that the water which is two or three or four or five feet above the sand layer is resting on a layer of bacteria, which is a blanket of bacteria on this sand. They are slimy, stick together, and consequently catch every solid particle that falls through the water. They catch not only the solid organic matter, but all the solid inorganic matter. They catch all the bacteria that come within this field, consequently
56 they separate out all the pathogenic and non-pathogenic bacteria. The water running into the filter may contain many thousands of bacteria, but very few run out. Some filtered waters contain very few, in fact, the German regulation is to have filtered waters contain not more than a hundred bacteria to the cubic centimeter, or some similar standard. In a short while they cover the sand layer and all the stones in it to such an extent that they prevent the water from passing through rapidly, and finally the filter ceases to act properly. Then the water is allowed to run off, the top layer of sand taken off and cleaned. Water is then run in again and the filter will ripen up and go to work again in a few days. That is what I mean when I say that the filteration of water in a sand filter is a biological phenomenon.

Q. That is what is known as the ordinary sand filter?

A. Yes sir.

Q. For use in settling basins for water supplies?

A. Yes sir.

Q. And has it proved efficient and perfect?

A. Yes sir. I saw such filters at work in London, in Berlin and Hamburg. They were very efficient.

Q. Now these grown bacteria that settle on top of this sand and rock and form this blanket as you express it, that causes a cessation of the passage of the organic and inorganic matter. They are the common bacilli, they are harmless and found ever present in water of all kinds, in living water?

57 A. Yes sir.

Q. If the fact is a fact that the typhoid bacilli will occasionally go through this—

A. Yes sir.

Q. That is demonstrated in what way?

A. By typhoid breaking out in a community.

Q. Where these filters exist?

A. Yes sir.

Q. Now, is there any natural filter that is absolutely germ proof? In speaking of a natural filter I mean a filter that is not like a tripoli stone—anything of that kind?

A. It would depend upon the thickness of the tripoli stone. If it is perfectly hard and no cracks whatever in it, if it is a perfect stone in other words, under those conditions, and the conditions about the filter were right, all rubber gaskets are right and all the clamps secured down snugly so that the bacteria cannot pass through the sand or through the stone itself, or the rubber gaskets at the top or bottom of the filter, why a stone of that kind is really germ proof for a time. The stone must be sterilized before putting it into the filter, and the water will run through it perfectly free from bacteria for three or four or five days; then the bacteria have grow through the stone out into the water again.

Q. Have grown through the stone—what do you mean
58 by that process, when you say have grown through the
stone?

A. I showed you. The bacillus grows long, about that long (indicating). It divides into—these bacteria are anywhere for 1-1000 to 1-100,000 of an inch in diameter. Now one of those bacilli sticks his head or end of him into the little crevices or holes in the stone, and it grows. When it grows it will twist about in the little crevice or tunnel in the stone so that finally it will grow through any distance of stone and appear at the other side. It finds nutrient medium all around it in the stone. It is nice and moist and the temperature is right, so that the bacteria soon grow through. They will go through a Birdfelt filter or a Pasteur filter in three days.

Q. Then after a period of ten days or two weeks there is no filter which is absolutely proof against the typhoid germs?

A. No sir.

Q. And that is true of the cholera, isn't it?

A. No. I said no. I didn't quite catch a portion of the question. You spoke of the typhoid bacillus coming through the filter. The typhoid bacillus doesn't grow in water very rapidly, if it grows at all, so that for the typhoid bacillus growing through the stone, that is not so, unless the conditions
59 were very favorable for it.

Q. What form of bacillus would do that?

A. The common water born bacteria.

Q. One that is harmless?

A. Yes sir.

Q. Then your idea is that a filter would stop the typhoid bacillus?

A. A good filter will stop typhoid.

Q. Kept in proper shape at all times?

A. Yes sir.

Q. But it would have to be used constantly?

A. It will work if the individual who is using it is a skilled man and will take care of it himself, but if it is left to the ordinary servant it will be in bad condition at all times.

Q. Now what different classes of bacteria are found in the sewage that comes off from a city?

A. Now, do you want me to give you the classification of bacteria?

Q. Yes.

A. Bacteria are classified in a variety of ways, but by bacteriologists who do not go into the exquisite detail of the botanist, the bacteria are classified according to form. We say bacteria are classified according to form into the micrococcus first. These are spherical bodies like an orange or a billiard

60 ball; secondly, another form is that of a bacillus like a short rod, rod-bacillus, it is called. It is a short rod. Then the third is the spiral form I spoke of. That is in form more or less like an open spiral.

Q. Represented by a comma?

A. Yes sir, the punctuation mark, comma. Now that is the classification according to form. Then they are classified according to whether they contain spores or not. The spore-bearing and the non-spore-bearing. Then they are classified into aerobic and anaerobic, as to whether or not they grow in the presence of oxygen. They are classified into the pathogenic or non-pathogenic; those that produce disease and those that do not produce disease.

Q. Those are the different classifications?

A. Yes sir.

Q. Now which are the most prevalent of the different kinds?

A. The non-pathogenic.

Q. That is a general classification?

A. A general classification shows the non-pathogenic, exist in vastly great numbers.

Q. Now there are two classes of these non-pathogenic that represent a certain agency in the destruction or elimina-
61 tion of sewage matter from water, isn't there? What do you call those two classes?

A. You mean the aerobic and an-aerobic?

Q. Yes.

A. You ask me the question, coming from the water, do you mean containing, both containing the pathogenic and non-pathogenic?

Q. Yes, you have stated that. Now, then, the other two represent two other forms of bacteria, that represent the opposition or rather the opposing forces in the destruction of sewage, one producing in the presence of certain substances in the sewage matter, and the other not.

A. Yes sir.

Q. Now the sewage that is running in the open water of the river, which of these two forms of bacteria will be the most active agency in that?

A. In the destruction of the sewage?

Q. Of the sewage, yes.

A. In the open stream?

Q. Yes.

A. The aerobic.

Q. Now what would be the effect of that upon the sewage in the running water?

A. It would be its gradual reduction from the higher compounds to the lower compounds.

Q. Now would that reduction affect the vitality or ex-
62 istence of the disease bearing bacteria in that running
water?

A. Not the mere destruction of the bacteria in the water, no, but the action of the toxins of the individual bacteria upon one another is a vital problem.

Q. What do you mean by that?

A. I mean this: You take bacteria confined in a space all growing vigorously and active, and each producing its kind, and giving forth its products, these products are not only poisonous to themselves, but poisonous to other bacteria around them, and some bacteria produce poisons that are very deleterious to others.

Q. That was true of the bacteria in the running water?

A. Yes sir.

Q. Is it known that the injurious agencies are running and operating in the running water, and whether in that way they tend to destroy the cholera or typhoid or dysentery bacteria?

A. Now if the waters available were merely polluted, the action would be much less where the water was confined than where it was running.

Q. In this form of water there would be less liability of the destruction of these bacteria than there would be if they were confined and the water was still?

A. Yes, they woul die much quicker in stagnant water
63 than in running water.

Q. In other words, the toxin would be much freer to have its effect?

A. Yes sir.

Q. I believe you said that bacteria belong to the vegetable kingdom?

A. Yes sir.

Q. What is the reason scientifically that they are classed as belonging to the vegetable kingdom?

A. First, the structure of the microbe is purely vegetable, cellular in contents; then the method of feeding—some of the forms closely allied to the algae contain chlorophyl, the green coloring matter of plants. In the presence of sunlight the chlorophyl breaks up carbon dioxide, retaining the carbon and giving off oxygen. Some of these forms have green coloring matter in them, showing that they belong close to the algae. Then the way in which they break up these highly complex compounds, albuminous molecules, for instance, is characteristic. They have to have organized food. When they get it they break it up into lower and lower compounds. This action is seen in the destruction of organic matter in sewage from organic matter to ammonia, to nitrites, to nitrates, and thus sewage can be traced in a running stream.

Q. Then the science of bacteriology as taught in modern
64 times is that these bacteria in some form are ever present
in the air and water, and in animal and vegetable life, all
animal and vegetable life?

A. Yes sir.

Q. And that they are the source of most, if not all, of the diseases that the body is heir to?

A. Yes sir.

Q. There are some, however, of the bacilli that have not been discovered?

A. Yes sir.

Q. What diseases and what particular bacilli cause them?

A. Syphilis, for instance, smallpox, measles, and diseases of that kind.

Q. Scarlet fever?

A. Scarlet fever. A gentleman from Chicago by the name of Class discovered a coccus which he claims to be the cause of scarlet fever, and I saw in the newspaper today an account of a German having discovered the same thing, several years afterwards. I suppose he will get the credit for it.

Q. Do you know whether there are any septic tanks in use in this country, by cities, for the destruction of their sewage?

A. There is one right here in Clayton.

Q. How large a place is that, a small place?

65 A. A small place. Washington University has a septic tank. At least, they were to have one put in. I was consulted about it some time ago.

Q. Do you know whether Kansas City has any?

A. I do not. I know they have large cess pools.

Q. Into which sewage is allowed to run?

A. Yes sir, into which sewage is allowed to run. They are practically septic tanks.

Q. When you cover a septic tank, do you wall it with brick or sheet iron or something of that kind and close it up tight?

A. Yes sir.

Q. Shutting the air out?

A. Yes sir.

Q. You put nothing in there whatever to hasten decomposition?

A. No sir.

Q. You just simply let nature do its work?

A. It takes it course, yes, sir.

Q. What is the result?

A. The reduction of the higher heterogeneous nitrogenous compounds into the lower and lower and lower forms of chemical compounds, until they get back to the simple compounds of hydrogen, menthane, nitrogen, carbonoxide, ammonia and water.

Q. Now in that process is there any unhealthy or deleteri-
66 ous odors that come from these tanks that would be injurious?

A. Not if the tanks are covered. It is only so if the gases are allowed to be discharged from these tanks. This remaining material is generally used for irrigation puposes.

Q. Now does this process tend to destroy typhoid germs?

A. Yes sir.

Q. Does it destroy them?

A. Yes sir.

Q. And cholera germs?

A. Yes sir.

Q. And dysentery germs?

A. Yes sir.

Q. Then a septic tank properly constructed and maintained in a proper way would be an absolutely sure way of destroying any germ bearing bacteria in the sewage of a city, if the sewage of the city was confined exclusively in septic tanks?

A. Yes, but it would depend upon the time the sewage remained in tanks.

Q. I say, a proper length of time, and properly maintained?

A. Yes sir.

67 Q. I mean that if kept in the tanks a sufficient length of time for nature to perform its work and reduce the sewage?

A. To the lower compounds, yes, sir.

Q. After that it would be safe to scatter it upon the fields for the purposes of irrigation?

A. For sewage farms and things of that kind?

Q. Yes.

A. Yes sir, for fertilization.

Q. Do you know of any cities where they have built that system?

A. Yes sir, there are several in England.

Q. What cities?

A. I saw one, I think, in Exeter.

Q. Do you know how large a city that is?

A. No sir, I don't remember. I saw some septic tanks quite a number of years ago, somewhere along in 1896, I think it was, when they were first constructed.

Q. Those you saw were a success, were they?

A. They were under trial. Then I have spoken or talked over the subject a number of times with Mr. Clark of the Massachusetts Board of Health in regard to their results with septic tanks and the destruction of sewage with them.

Q. Do they use septic tanks in Massachusetts?

A. They were experimenting with septic tanks.

68 Q. Do you know of any place where they have got beyond the experimental stage?

A. I do not just now.

Q. Did you say Exeter?

A. Yes sir.

Q. Do you know anything about the experiments that were made at a place called Exeter?

A. I know what is in the literature, anybody knows that.

Q. Did you ever inspect the sewage system of Berlin?

A. Yes, I went all over it.

Q. Have they what you call the sewage farm system in Berlin?

A. Yes sir.

Q. What is that?

A. There the sewage is collected in large reservoirs in the town and from these reservoirs it is pumped out on to what used to be a sandy waste, which are now productive farms. The water is pumped up into the tanks upon those places, and then distributed for irigation all over those farms, and it lies upon the surface for a time, percolates down through the sand, and a good deal of it passes into large ditches at the side of the field and out into the water courses.

Q. In what stage of that process is it supposed that the bacteria are eliminated?

69 A. On the fields.

Q. On the sand fields?

A. Yes.

Q. By the filtration?

A. Yes, at the top of the soil they are held and destroyed; their action is something like that of the bacterial blanket I spoke of which forms on the surface of the sand in the sand filter.

Q. Do you know what the results of that sanitary arrangement has been as to whether or not it has tended to reduce diseases that were conveyed by water born germs?

A. Yes, it destroys the germ on the field.

Q. Then it would be a safe way to conduct a city sewage system?

A. Yes, that is a very fine way. Paris was constructing sewage farms when I was there in 1896; in fact, they had one under trial. I didn't go out to see it, but I know that it was there, and they were building it, and when a Frenchman adopts a German method, it must be a pretty good one.

Q. Now are there any other cities that have any similar system of handling their sewage matter?

A. Well. I know that one in Berlin. I went all over it, and I had a personal experience with it. I know there was one at Pullman, Illinois. What became of it I don't know. There are a number of the small cities and institutions of vari-
70 ous kinds, insane asylums, poor houses, places of that
kind that use them throughout this country, and they work satisfactorily.

Q. Now do you know at what point or percentage the sewage matter in running water is so great as to cause experts to say that the water is no longer healthful to use for domestic purposes?

A. Do you mean how far it will carry?

Q. No sir, I mean how much must be the pollution of sewage in running water?

A. It must be very great.

Q. The greater the volume of water, of course, the greater amount of pollution it would carry?

A. Yes sir.

Q. The greater the volume of water doesn't affect the liability to disease that might come from water born bacteria?

A. We will probably illustrate that better if we take one bacterium to a quart of water. Then we add three or four hundred gallons to that. The chances of that bacterium being again found in that three or four hundred gallons is so many times less.

Q. That wasn't the point of the question.

A. But it doesn't destroy the bacteria.

Q. It doesn't affect the vitality of the bacteria or de-
71 stroy it?

A. No sir.

Q. Now take cholera or typhoid or dysentery bacteria, will they generate and increase on the soil?

A. It depends upon the amount of nutritive matter that they receive. Some recent experiments have shown that the typhoid bacillus, for instance, will live a long time on the soil, a year or more, live and multiply if the conditions of growth be made favorable. That is, if the conditions around them are made satisfactory for growth, they live a very long time and they multiply there.

Q. Well, do the substances that flow as a city sewage, or what you term broth for the generation of the disease, bear germs?

A. Yes, for disease bearing germs, but not unless it was sterilized. If the broth were cooked all the bacteria would be killed in it. It would then be a medium for some of these micro-organisms to grow in.

MR. DRENNAN: Has that ever happened?

A. Not unless it is a laboratory experiment.

MR. CROW: The bacteria of typhoid and cholera and dysentery coming from city sewage will come from that class of sewage that came mostly from hospitals, or mostly from homes—which?

A. Homes.

Q. Why is that?

72 A. Because hospitals usually use better disinfecting methods.

Q. Now explain why they use better disinfecting methods, and what those methods are?

A. Well, any well organized hospital has an efficient force, and it has certain rules for the destruction of infectious material, burning up the old clothes about the wards, and so on. That is the natural purpose of a hospital—cleanliness. Then the dejecta, those things from the bowels, the materials ejected from the stomach, etc. To these materials invariably, in hospitals that are well conducted, disinfectants are added. They are kept for a certain time after the disinfectants are added to destroy the micro-organisms. I mean in the well conducted hospitals. But in a home the physician gives his instructions and they are carried out by a quasi scientist, one who means well, but doesn't know how. The result is the material is thrown into the sewer as quickly as possible, either improperly disinfected or not at all.

Q. Then your experience would be, and you believe the fact to be, that the disease bearing germs that flow away from a city in the sewage of that city would be borne mostly from the homes of the city where the disease existed?

A. Yes sir.

Q. Of course, in the case of an epidemic of disease,
73 these micro-organisms scatter themselves promiscuously
throughout the city, do they?

A. Yes, if it was the general water supply that was scattering it.

Q. I am speaking about that kind of an epidemic now?

A. Yes sir.

Q. Now the epidemics of typhoid and cholera and dysentery are usually caused, or believed at least to be caused, by what?

A. By the water born micro-organisms.

Q. That means a tainted water supply, doesn't it?

A. Yes sir.

Q. Is that true in this country at this date?

A. Yes sir.

Q. Has it always been true?

A. Yes, where precautions are not taken to separate out the disease producing bacteria.

Q. What is the most common disease bearing bacteria that is born in the water of this country?

A. Typhoid.

Q. Is there any specific reason for that fact existing?

A. Yes sir.

Q. What is it?

A. Because crude sewage is discharged into the water
74 closets, and water closets discharge into sources of water
supply.

Q. You use the word "crude" sewage, what do you mean by that?

A. Sewage that is not treated.

Q. That is not disinfected, or incinerated, or something of that kind?

A. Yes sir.

Q. Nothing done to it that would destroy the germs of disease?

A. Which has germs of disease in it.

Q. Now, are you acquainted with the length of time that the cholera germ will live in water?

A. Yes sir. I have carried out some personal experiments, if you want to know about them.

Q. That is a pretty good source of information. Give the conditions under which they were made.

A. I found they would live in the Mississippi river here, in the sunlight and dark, from 12 to 25 days.

Q. What do you mean by that, in the sunlight and dark?

A. I mean this, that a sterilized flask was secured, and into it was put from four to six ounces of Mississippi river water taken from the river. That was living water. Into that water was inoculated or sown cholera bacilli, taking a large loopful of the growth, off slant ager. That was stirred
75 about in the water.

Q. Whereabouts was that taken from?

A. The Mississippi river, out in the middle of the river.

Q. At what point in the river?

A. Below the intake.

Q. Below the intake at the city of St. Louis?

A. Yes, sir. Now these bacilli were inoculated into the water and placed in a window facing south so that the sunlight was upon them a definite number of hours per day. Every day the water in those vessels were stirred up, so that the sediment that had collected on the bottom of the vessel was mixed throughout, and with about three hours and a half daily exposure to sunlight, the micro-organisms live as high as twelve days in some of these flasks. That is, some bacteria were still found alive at the end of twelve days, in sunlight, while in the gloom—

Q. What do you mean by that?

A. Why, some of the flasks were put in an ice chest and kept at a temperature of from 15 to 20 degrees centigrade, always in the dark.

Q. What was the ordinary temperature?

A. 68 degrees temperature, Fahrenheit, 60 to 70.

Q. How long did you say they lived in that condition?

A. They lived in that condition as high as 25 days, not exposed to the sunlight.

76 Q. The same character of water that those were in that were exposed to the sunlight?

A. Yes, living water, gradually becoming stagnant.

Q. Now, when were those samples taken by you?

A. Three years ago.

Q. Were those experiments made immediately after the water was taken?

A. Yes sir.

Q. How does cold affect this cholera germ?

A. Alternate thawing and freezing kills them.

Q. Well, supposing the Mississippi river had cholera germs in it, and it should freeze over, what would be the effect?

A. It would not hurt them.

Q. It wouldn't hurt the bacteria at all?

A. No, sir.

Q. Supposing it had typhoid fever germs in it?

A. It would not hurt them.

Q. Now, are you familiar with any epidemics caused by cholera germs in water supply?

A. Yes, sir; at Hamburg, in Germany.

Q. When did that happen?

A. In 1892.

Q. Do you know what caused that epidemic?

A. Yes, sir. The Jews were being driven from Russia
77 at that time and some of them settled on the Quay, at Hamburg, waiting for ships to transport them to the United States. There was cholera among them, and their dejecta was thrown into the river Elbe, below the water works. There is a tide in the river, which carried this material upstream, which was caried into the intake of the Hamburg water supply. There were no filter beds there then, the water was used unfiltered, and in the course of a very few days there were a great many thousands of cases, some 18,000 cases, developed. There is a town just next to Hamburg called Altoona. It is situated below Hamburg on the river, as Carondelet is related to St. Louis. The water supply of this town is taken from the Elbe below the sewers of Hamburg. Nevertheless this town was free from cholera. Wherever the Altoona water supply went, even right up against the Hamburg line, there was no cholera, except among those that drank water in Hamburg and lived in Altoona. Later a break occurred in the filter bed in one of the Altoona sand filters and a flurry of cholera followed. That break was corrected, and the cholera disappeared from Altoona. This is one of the most beautiful examples in the world

of a water born disease carried by a water supply. Professor Koch was called to Hamburg and studied the water supply of both places and found the cholera bacillus in the river water, the river Elbe.

78 Q. That is subsequent to the time that he made the discovery in India?

A. Yes, sir.

Q. Now, do you know how long the dysentery germ will live in the water?

A. I do not.

Q. Do you know how long the typhoid bacteria will live?

A. I know of my own experience, sir.

Q. Well, that is a good way of finding out.

A. It depends on where the water comes from. If it is from the lake or the drainage canal of Chicago, or the Illinois river at Joliet, or at Peoria or at Grafton, or the Mississippi river, or the tap water here. I have got all those facts in some work I have done on that question.

Q. Take the Mississippi river water here at St. Louis. What length of time do your experiments lead you to believe that the typhoid germ will live?

A. I think it is from as high as 8 to 21 days.

Q. Is that in sunlight or dark?

A. In the sunlight as high as 8 days, and in the dark as high as 21.

Q. When did you make those experiments?

A. All last summer. I worked from June until September.

Q. You did that by taking samples of the water?

79 A. Yes, sir. Now, that is living water I am talking about. In the year before that we worked constantly for several months on that same subject, with sterilized water, from this same source, and we found the micro-organism would live from 25 to as high as 60 days in the sterilized water.

Q. That is to say, they retained their vitality that long?

A. Yes, sir; they were found alive.

Q. I believe you testified a while ago that these typhoid bacteria were known to live and retain their vitality in a man's organization for as high as eight years after he had been attacked with the disease?

A. No, I didn't make that statement. I said bacteria were found in the urine of a man eight years after he had had typhoid fever. That wouldn't mean that the bacilli had lived all that time in him. It simply means that this man had a good culture medium for growing typhoid bacilli in his bladder, and that he probably had a large prostatic gland with a small pocket behind it, in which urine collected, and in which the typhoid bacilli found comfortable conditions for growth. It is a snug place containing nutrient medium and the bacillus grew abundantly there.

Q. Have there been any experiments made to discover how long typhoid bacteria will exist in a man, that is, the identical bacteria?

A. No, that would be extremely difficult.

80 Q. It would be almost impossible to do that?

A. You would have to label the bacillus and send him through.

Q. The only experiment you can make is to put the bacteria in water in a bottle, and that has been a common form of making those experiments?

A. Yes, sir.

Q. Now, do you know of any other experiments made by any other than yourself?

A. There are a great many on record.

Q. What were those experiments?

A. Well, the scientists of the Massachusetts state board of health found they would live 25 days in the water of the Merrimac, in experiments at Lawrence and Lowell.

Q. Is there any other place where they have ever experimented?

A. Yes, throughout the literature, quite a number.

Q. What would be the average time?

A. About that time, from a few days to as high as 25 and 30 days, and always longer in steriled water, of course.

Q. Now, I believe you testified that the effect of the sand filters at the places where you observed it, in London and other places, was to diminish the amount of typhoid and other diseases from the water-born bacteria?

A. Yes, sir.

Q. Now, do you remember any facts or statistics in connection with that?

81 A. No, I do not remember the exact figures. I know there was a large percentage of typhoid fever in Hamburg before the filters were put in and the number of cases was very rapidly reduced after the filters began to work. Those statistics are recorded in books on that subject and can easily be put in evidence.

Q. Have you had any experience with any typhoid epidemics in this country, other than in the city of St. Louis?

A. No, sir.

Q. Have you had some experience with them here in this city?

A. Yes, sir.

Q. How many of them?

A. We had one great typhoid epidemic here in 1892.

Q. That was prior to the time that the present intake was placed at its present existing spot?

A. Yes, the intake was then at Bissell's point.

Q. Where is that with reference to where the present intake is?

A. The present intake I suppose is six or eight miles above that on the river.

Q. Both on the Mississippi river?

A. Yes, sir.

82 Q. How far is the present intake from the west shore of the Mississippi river?

A. How far out in the water?

Q. Yes.

A. I think it is 1,500 feet. I never measured it, but I was told that.

Q. How far out was the former intake?

A. It depended upon the stage of the river, just a few feet out in the river, but they had a sliding intake, that was adjustable, could be run it out. As the water became low I think they would send this flexible intake out to it.

Q. Do you know the width of the river at the present place of the intake?

A. I do not.

Q. You never had it measured?

A. No, sir.

Q. Do you know whether it was half-way across the river or more?

A. It was not quite half way across. It is on the Missouri side.

Q. How far above the city is it?

A. Fourteen miles, I believe.

Q. How far below the mouth of the Missouri, the confluence of the two streams?

A. Six or eight miles.

83 Q. Six or eight miles from the confluence?

A. Yes, sir.

Q. Now, you have been to the confluence of the two rivers?

A. Yes, I am on the river a great deal.

Q. The division of the waters there is quite perceptible, isn't it?

A. Yes, sir.

Q. It isn't perceptible, however, is it, at the intake?

MR. HAMLIN: I would suggest, General Crow, that your questions are leading, and I object.

MR. CROW: I supposed the object of this inquiry was to get the facts as quickly as possible.

THE WITNESS: I can say this. I have traveled up and down the river a great deal, and I know a great deal about the character of the waters from its visual appearance.

Q. Well, at the present intake of the St. Louis water works is there anything in the water that would indicate the presence of two distinct streams?

A. The number of bacteria per cubic centimeter would be an index. Also take a cross section of the stream, which would show the percentage of total solids.

Q. Well, in the appearance of the water of the streams, is there anything to indicate in the stream that there is present more than one stream in that body of water at the place
84 of the intake?

A. Yes, depending upon the stage of either river. Now, if the Missouri river is very high, it can be very distinctly seen at the intake. Its great volume of yellow water runs down clinging to the Missouri shore, and can be seen. If the Mississippi is high and the Missouri not high, the effect of its waters can be seen at the intake.

Q. Well, if the Mississippi is very high and the Illinois is very high and the Missouri is not, what effect has that on the volume or character of the volume of water that comes over to the intake and into the waterworks?

A. Well, as a rule, under those conditions the Missouri predominates.

Q. Where the Mississippi is high?

A. Not where the Mississippi is high.

Q. I mean where the Mississippi is high and the other two are low, in ordinary stages?

A. Then the waters exist in about equal quantities, or the Mississippi water may predominate. It appears that way to the naked eye.

Q. Now, you stated that the bacteria in the water at the intake tower, when you cross sectioned the river there, would indicate the presence of more than one stream?

A. Yes, sir.

85 Q. What is there in the indication of that bacteria that indicates that to a scientific investigator?

A. Well, we know the numbers of bacteria in the Missouri river before it enters the Mississippi; we know the numbers of bacteria in the Mississippi above the junction with the Missouri river, and that these two streams flow down together, the Missouri clinging to the Missouri shore, the Illinois and Mississippi rivers combined, clinging to the Illinois shore, now the cross-section of the stream will show whether the greater number of bacteria are on the Missouri side or on the Illinois side; then we can finally reach the point where we can see the two streams are about to touch one another, or commingle.

Q. Now you use the term "bacteria" without regard to whether they are injurious or non-injurious?

A. They are non-injurious.

Q. That is, they are simply indigenous to running water?

A. Water-born.

Q. And are found everywhere in the water of these two streams?

A. Yes sir.

Q. Now are those the same bacteria?

A. Yes sir.

Q. Now you are acquainted with the waters around the mouth of the Illinois river?

A. Yes sir.

Q. You have made investigations there yourself?

86 A. Yes sir.

Q. And made examinations of the bacilli in that water?

A. Yes sir.

Q. Is there anything to indicate after the Illinois enters the Mississippi below the mouth, the presence of the Illinois river, in the Mississippi river water?

A. No sir. The bacteria of the Illinois are very similar in numbers and character to those in the Mississippi, and it is only by putting different kind of bacteria in the Illinios river and watching them as they flow, that we can trace the Illinois river water, species of bacteria that are not indigenous to either stream.

Q. Now you are acquainted with the character of the Missouri river as to its flow and volume of water?

A. Yes sir.

Q. And are you acquainted with the Mississippi also?

A. Yes sir.

Q. And as to the volume of water it flows, and as to the character of the stream, whether it is turbid or rapid?

A. Yes sir.

Q. Now do you know whether or not there is more or less soil or sand rolling with the waters of the Mississippi or with the Missouri, or have you ever investigated that question?

A. I couldn't say, but a visual inspection will show that.

87 Samples from the Illinois and Mississippi are of a less muddy color, and contain less sediment than the samples from the Missouri in the greater part of the year.

Q. Are you acquainted with the velocity of the currents of the two streams?

A. I have some figures on it, yes.

Q. In a general way do you know which is the more rapid?

A. Well, my impression was that the Mississippi above the Illinois was the more rapid stream.

Q. More rapid than the Missouri above the Illinois?

A. Yes sir.

Q. Now do you mean to say at the equal stage of water in the two streams?

A. That is in equal stages of water of course.

Q. No, would that fact that the Mississippi is the more rapid of the two, and the Missouri, as you seem to think, the less rapid, and its water more filled with sand and soil, have any effect on the elimination of bacteria from the water of the rivers as they run?

A. No, the more rapid the stream the further the bacteria carry.

Q. Otherwise it would have no effect?

A. That is right.

Q. Is there more or less of settling of sand and dirt in the Mississippi than there is in the Missouri?

88 A. Well, I think the Missouri would sediment its bacteria much quicker, because the sediment in the stream is very much larger. All inorganic particles are larger and would carry down the bacteria in the water very much more rapidly than the Mississippi river will.

Q. What would be the result of that on the number of bacteria, the non-injurious bacteria that are just useful water-born bacteria, in the two streams, in the same volume of water?

A. Both running at about equal speed?

Q. Yes.

A. For some reason or other the Missouri has the larger number.

Q. Now they are non-pathogenic, are they?

A. Yes sir, a great majority of them.

Q. Now the sand in the soil above the mouth of the Missouri river, have you ever bacteriologically examined that?

A. Yes sir.

Q. What was the result of that examination?

A. It contains large numbers of bacteria. I am speaking of the Missouri.

Q. Were they dead or alive?

A. Alive.

Q. Any of them dead—you couldn't tell that?

A. I couldn't tell that.

89 Q. Now are they non-pathogenic?

A. A great majority of them.

Q. Harmless?

A. Yes sir.

Q. Now have you ever examined at the confluence of the two rivers, the soil and the sand in the bottom of the Mississippi?

A. Yes sir.

Q. What was the result of that investigation?

A. A large number of bacteria, a very large number.

Q. What was the character of those bacteria?

A. Mostly harmless.

Q. Now do you know anything about the proportion of the bacteria in the two rivers and the sand and soil on the bottom of the two rivers at the point I mention, the confluence, as to which has the greater number of bacteria?

A. Practically about the same.

Q. Could you distinguish between the pathogenic and non-pathogenic bacteria?

A. What do you mean?

Q. Why in counting these bacteria that you discovered in your examination, in your estimate of the two rivers, or in the waters of the two rivers?

A. Not without separating out each individual bacterium to get it as a pure culture.

Q. Have you done that?

90 A. I have separated out different varieties or different species found in the rivers, the Missouri, the Mississippi, and the Illinois, at Peoria and Grafton.

Q. Well, by this method of separation then, the numbers of pathogenic and non-pathogenic bacteria could absolutely be determined?

A. Yes sir, but not absolutely.

Q. But it would be a slow process?

A. Yes sir, a gigantic task.

Q. Now you have examined the bacteria below the intake in the Mississippi river water, below the intake of the St. Louis water works?

A. Very slightly.

Q. Did you ever examine it prior to moving the intake?

A. Yes, I examined it in 1892, during a typhoid epidemic.

Q. Did you examine it in the waters of the Mississippi adjacent to the intake of the St. Louis waterworks, in 1898 and 1899?

A. In 1899 I did. In the fall of 1899 I examined the water all about the intake.

ATTORNEY-GENERAL HAMLIN: I object to that as to the years 1898 and 1899.

ATTORNEY-GENERAL CROW: For what reason?

ATTORNEY-GENERAL HAMLIN: On the ground that it does not sustain any issue in this case, from 1892 to 1899.

91 MR. DRENNAN: On behalf of the sanitary district of Chicago I object to it, on the ground that it does not tend to sustain any of the issues in this case.

ATTORNEY-GENERAL CROW: You made such examination in the years 1898, 1899 and 1900, did you not?

A. I examined the water bacteriologically, as I say, in August, September, October, November and December, I think, of 1899, and January of 1900, through to December of 1900. I examined the water in the months of 1900 up to December 1, and then in 1901 from September until December 1, we carried out a systematic bacteriological survey of the rivers and their waters.

Q. What waters?

A. First Lake Michigan, Chicago drainage canal, the Desplaines river at Joliet and at Lockport. The Illinois at Peoria on the south and Beardstown and Grafton on the Illinois; the Mississippi at Grafton; the Mississippi at Alton; the Mississippi at Hartford; the Missouri river at Bellefontaine. The Mississippi river at the intake; the Missouri shore; in the middle of the river, and on the Illinois side. That work was carried on in all of 1900 and from September to December 1, 1901. I conducted the

work personally, and samples were sent to me for special pur-
poses until April, and then later I worked from June until
92 December 1.

Q. What year?

A. 1902. I was from January to April, 1902, carrying out special work on samples from the rivers, and from June until September I carried out a series of investigations on the typhoid bacillus, on the longevity of typhoid bacillus in the living waters from all these points, both in the sunlight and in the gloom of an ice chest.

Q. Now at the same time you carried on your bacteriological experiments there were also chemical experiments being carried on in behalf of the city of St. Louis?

A. Yes, I saw them carried on, but I had nothing to do with them.

Q. You had numerous assistants there helping you in this work?

A. Yes sir.

Q. And they are mostly here in the city of St. Louis, are they?

A. I think all but two or three.

Q. In the results of these experiments you have preserved data which you have chronologically arranged?

A. Yes sir.

Q. And that covers these periods of time?

A. Yes sir.

It is agreed that all the witnesses in the case that may here-
93 after be called, including the present witness, may make
any verbal corrections in their testimony, without submitting them to counsel on either side, but any material difference must be submitted to counsel on both sides, and be made also with the permission of the Commissioner.

Adjourned at five o'clock, p. m., February 17, 1903, to meet at Southern Hotel, St. Louis, February 18, 1903, at ten o'clock, a. m.

Met pursuant to adjournment, at the Southern Hotel, at ten a. m., February 18th, 1903.

Present: The Commissioner and the same counsel representing the respective parties.

DR. AMAND NICHOLAS RAVOLD,

resumed the stand for further direct examination by Attorney General Crow.

Q. Doctor you are familiar wtih what is known as the Chicago Drainage Canal, that is to say, you are familiar with its location, etc.?

A. Yes, I have traveled up and down it.

Q. Now can you describe the location of that canal, just in a general way?

A. Well, I know—I have read the reports of the engineer, I went over the canal with the chief engineer, and from what I can understand, the Chicago Drainage canal connects the west fork of the south branch of the Chicago river with the Desplaines river at Lockport.

Q. Well, at what point in the state of Illinois or the city of Chicago does the drainage canal touch the south fork of the south branch of the Chicago river?

A. I understand, sir—I believe at Robey street, I don't know exactly.

Q. Where is Robey street located with reference to Chicago, is it in or out of the city limits?

A. It is well away from the centre of the city, I don't
95 know just exactly how many miles.

Q. Have you any personal knowledge as to whether or not it is within the corporate limits of the city of Chicago?

A. I don't know.

Q. You know whether or not it is within the limits of the sanitary district?

A. I don't know.

Q. You know it is located in the state of Illinois?

A. In the State of Illinois, yes.

Q. Now beginning at the point where it intersects with the south branch of the Chicago river, will you trace the general direction and the characteristics, size and depth, etc., as near as you can of the Chicago Canal, down to its point of outlet whereever that may be?

A. I would simply be speaking by the book and the figures of the engineer; I know that it runs pretty nearly directly west to Lockport. Its width in the clay portions, that is, where it passes through the earth, I do not exactly know, but I know in the rock section I was told it is 160 feet wide by 38 feet deep, the walls being perpendicular, but it seems to me you can get all of these details from their own reports.

Q. Well, that might be, but I want whatever knowledge you might have on the subject. I wish to put it in the record. Now at what point, if any, does that canal in its westerly course,
96 intersect any other body of water?

A. I don't know that any other body of water runs into it at all.

Q. At what point in its course does it have confluence with any other body of water?

A. As I say, it connects with the south branch of the Chicago river, and not to my knowledge does any other stream meet it until it gets to Lockport.

Q. Well, is there any stream there?

A. There is the Desplaines river, there.

Q. Do you know anything of the size of that river?

A. It is a small river during the dry stages, but in flood season or in the rainy season it is quite a stream.

Q. Well, could you give an idea of the ordinary size of the stream in the usual stage of water?

A. During the dry season, I see from their own reports that the amount of water in the stream would pass through an 8 inch pipe, which would be very small. Well, in the rainy season the flow is a good many hundred gallons a minute, it is quite a large stream, draining a great district.

Q. Now do you know the distance from Lockport to Robey street?

A. I never measured it, I think it is 30 miles.

Q. Now do you know the distance from Robey street by the Chicago river to this outlet in Lake Michigan?

A. No sir, I do not. 4½ miles, simething like that.

Q. Is the course of that river through the city of Chicago, or through the open country?

97 A. Through the city of Chicago?

Q. Entirely?

A. Yes sir.

Q. Now do you know the distance from Lockport on the Desplaines river to the point of confluence, if there is any, of the Desplaines river with any other stream?

A. Where the Desplaines river joins the Kankakee, do you mean?

Q. Well, any other stream coming down there?

A. Besides the Chicago drainage canal, which flows into the Desplaines river, the Illinois and Michigan canal discharges its water into the Desplaines river.

Q. At what point does it come into the Desplaines river?

A. It discharges its waters into the Desplaines river east of Joliet.

ATTORNEY-GENERAL HAMLIN: What river are you speaking of?

A. I am speaking of the Illinois and Michigan canal discharging its waters into the Desplaines river.

ATTORNEY-GENERAL CROW: Do you know how far distant from either point?

A. The discharge is irregular or broken, rather. The Illinois and Michigan canal passes through several turbines, or mills along there, along the shore at Lockport, so that the water is discharged at various points, from Lockport west.

Q. What is that?

98 A. Is used there for power purposes, they have several mills along there, and then running across a portion of the country below the Ninth street bridge in Lockport, to join the Desplaines river, and then further the Illinois and Michigan canal crosses the Desplaines river in Joliet.

Q. In what general direction does the Illinois and Michigan canal run?

A. It runs parallel with the Chicago drainage canal.

Q. Then what would be the direction?

A. From east to west.

Q. What is its western terminus?

A. The western terminus I think are the pumps at Bridgeport.

Q. Where is Bridgeport?

A. That is on the south branch of the Chicago river.

Q. In the city of Chicago, or out of it?

A. In the city of Chicago.

Q. Do you know how long the Illinois and Michigan canal has been open?

A. I do not.

Q. Now, how far from the Chicago drainage canal is it down to the exit of the Illinois and Michingan canal on the south branch of the Chicago river?

A. I don't know how many blocks, a few blocks.

Q. Now, gòing on down the Desplaines river, does it have 99 a confluence with any other stream of water below Joliet?

A. Below Joliet it joins the Kankakee.

Q. How far below Joliet?

A. I don't know exactly.

Q. Well, do you know anything of the size of the Kankakee river?

A. In flow of water, I do not.

Q. Do you know anything about its width?

A. I did have the figures somewhere, but I cannot remember them.

Q. Now you have got the drainage canal, the Desplaines river, and the Kankakee river, and the Illinois and Michigan canal all into one body of water?

A. Yes sir.

Q. Now, passing on what is the next stream, if any that these waters join with?

A. There are several rivers which join the Illinois, the Vermilion is one of them.

Q. Do you know anything of the size of it?

A. No sir, I do not.

Q. Any other stream?

A. Yes, but I have forgotten. I do not remember the typography of the rivers that come in there, nor how they come in. That is in my report, though.

Q. Do you know how far it is to where they join the Illinois river?

A. Where the Kankakee and Desplaines river come together? 100

Q. Yes.

A. I am not so sure, but I think it is 9 miles below Brandon's bridge. That would be 14 to 16 miles below Joliet, but that is mere guessing.

Q. Do you know how far it is from Lockport to the Illinois river?

A. I would make it about 26 miles.

Q. Well, now do any streams come into the Illinois river after it is joined by the waters of the drainage and the Michigan canal, and the Kankakee and the Vermilion river, and the Desplaines river, prior to its exit into the Mississippi?

A. Yes, the Illinois and Michigan canal again empties into this stream at LaSalle.

Q. Any other body of water come into it?

A. Yes, there are several rivers that discharge into the Illinois river—you mean between Peoria, and down where it empties into the Mississippi river?

Q. Yes.

A. Yes, there are some eleven streams, I believe, in all.

Q. Do you know the names of them?

A. I do not.

Q. You don't know anything about the volume of water?

A. No sir.

Q. Do you know anything of the size of the Illinois river at the point were it joins the water of these three canals, the Desplaines, the Kankakee and Vermilion rivers?

A. I didn't understand the question.

Q. Do you know anything about the size of the Illinois river at the point of conjunction with these other streams you have mentioned?

A. No sir, none other than what the government report gives us. I have been on these rivers. I know the character, about how wide they are at certain seasons of the year depending on the flood volume of the river. 101

Q. At the ordinary stage of water, do you know anything about it?

A. About a half a mile wide.

Q. Do you know anything about the depth?

A. It is a shallow river there and the depth is maintained by the dams that are thrown across it at various places.

Q. For the purpose of aiding navigation?

A. Yes sir.

Q. How far up is it navigable?

A. It is navigable I think—we sent one small boat up to LaSalle.

Q. How far is that above the mouth?

A. Nearly 200 miles.

Q. Is there any town at the mouth of the Illinois river?

A. Grafton.

Q. Is that right at the mouth?

A. Yes sir.

Q. Now what stream does it join there?

A. It joins the Mississippi river.

Q. Do you know whether there is now, and was at the time
of the institution of this suit, on the 23d of January, 1900,
102 any cities or towns on the Illinois or Desplaines river or
the Vermilion river or any of the streams that are contributory thereto, below the point where the Chicago drainage canal enters the Desplaines river, that empty sewage, discharge it from the sewer system, into any of these streams?

A. I know that Lockport and Joliet and Peoria—most of the towns along the river that have any sewage supply whatever, discharge the sewage into the river.

Q. How large is Lockport?

A. Lockport is not very much of a town, I don't know how many inhabitants it has.

Q. Have you any idea?

A. I should say from looking at the town it had 400 or 500 inhabitants.

Q. That is 29 miles from Chicago?

A. Yes sir.

Q. That is, at the point of confluence of the drainage canal with the Desplaines river?

A. Yes sir.

Q. Is there any dam or trap at that point?

A. Yes, at the end of the drainage canal they have what they call a bear trap dam, at that point.

Q. Describe what that dam or trap is, the structure?

A. Well, at the end of the drainage canal they have sluice gates, gates that can be raised and lowered through which
103 the water can be discharged, and then a dam known as a bear trap dam, which is extremely ingenious as a piece of mechanism, over which the water can be discharged by the lowering or raising of the gate.

Q. Well, can the volume of water that flows from the canal into the Desplaines river be enlarged or diminished by means of that trap?

A. By the raising and lowering of that dam, yes.

Q. Can it be so diminished as to exclude the water from the canal entirely?

A. Yes, it can be raised above the water level of the canal.

Q. Well, then it is really a controller of the volume of water from the canal into the river?

A. Yes sir.

Q. Now what is the distance, if you know from Grafton, the mouth of the Illinois river to the present intake of the St. Louis water works?

A. About 30 miles.

Q. When was the present intake of the St. Louis water works located?

A. It was located at—

Q. When was it located?

A. Just exactly when it was put there I don't know, but the pumps were put in action up there in 1895 pumping water
104 at that point.

Q. Now are you familiar with the St. Louis intake?

A. Yes sir.

Q. The construction, etc.?

A. Yes sir.

Q. Just describe it, what it is, and how the water is got from the river into the intake tower, and from there into the pipes, and finally to the consumer in the city.

A. Well, in the river 1500 feet from the shore is built—

Q. In what river?

A. The Mississippi river. On the Missouri side of the river, 1500 feet from the shore is built a large tower—

Q. What is it built of?

A. It is built of stone. Connecting with that tower there is a tunnel in the river.

Q. In the bed of the river?

A. In the bed of the river to the shore. It runs alongside of what is known as the Chain of Rocks. The Chain of Rocks, put out there to deflect the flow of the river away from the Missouri shore. The water passes down through openings in this tower into the tunnel; from the tunnel it runs into what is known as the uptake and reservoir there, and from there to the pumps or to the reservoir, from which the pumps pump the water into large reservoirs, six in number. After settling in these reservoirs, the water is allowed to rest in these reservoirs from 24 to 48 hours, generally 36 hours. It passes out into a
105 conduit and is carried to St. Louis. On the way it meets the
pumps at Baden, the high service pumps there, and the water at that particular point is pumped into what is known as the high surface tower which is located on Grand avenue and Lafayette avenue. From there it is distributed throughout the western part of the city, and the high portions of the central portions of the city. The remaining part of the water passes on to Bissel Point, and there passes into reservoirs, and rests for a time in the reservoirs, to pass from the reservoirs into a series of low service pumps which supply all this part of the city, the low part of the city, the central part of the city.

Q. What is the distance from the settling basins where the water is pumped into the first conduit down to the city of St. Louis, at Baden?

A. I think it is six miles to Baden and eight miles to the low service pumps or low service reservoir at Bissell Point.

Q. What distance is it from Baden down to the high service point, to the reservoir?

A. From Baden to the high service reservoir, I suppose it is three or four miles.

Q. What is the distance down to where the low service basins are located?

A. The distance from where?

Q. Well, from Baden?

106 A. Two miles.

Q. Now what is the size of the tunnel that runs from the tower in the river to the shore?

A. I don't remember exactly, I think it is an eight foot tunnel.

Q. Do you know the depth of that tunnel below the body of the river?

A. I do not.

Q. Is that tunnel walled?

A. Yes sir.

Q. What with?

A. Stone and brick.

Q. Is there any filtration plants or processes anywhere that the water passes through or over between the time that it enters the tower in the river up to the time that it goes out in the service pipes, the low service and the high service stations direct to the consumer?

A. No sir.

Q. No processes whatever?

A. Well, the subsidence that occurs while the water is resting in the reservoirs at the Chain of Rocks is the only treatment whatever that the water receives.

Q. Is there any sand or rocks or other things placed in there?

A. No sir.

Q. No filtration scheme whatever?

A. No sir, no filtration scheme whatever, it is merely subsidence. 107

Q. What is the size of these basins?

A. They are very large, I don't remember the size, I have that in my report.

Q. Do you know whether or not the tower in the river is at a point where the main channel of the Mississippi river is?

A. Yes, it is in the channel.

Q. In what is known as the channel at that place?

A. Yes sir.

Q. Do you know the width of the river at that point?

A. Exactly, no. In the ordinary stages of the river I would say it was a mile across.

Q. At that point?

A. Yes sir.

Q. Now how far from the water tower in the river, if you know, is it to the point of conjunction of the Mississippi and the Missouri rivers?

A. Eight miles.

Q. How far would it be from the conjunction of the Missouri and Mississippi rivers with the conjunction of the Illinois and Mississippi?

A. About 24 or 25 miles.

Q. Now you testified on yesterday that all fecal matter of man or animal contains what is known as bacillus coli communis?

A. Yes sir.

Q. Now will you please explain so I can get it into the record, in shape so we can understand it, we are not scien-
108 tific men, what you mean by the term fecal matter from animal or man.

A. It is the intestinal contents discharged from man, from the bowels of man and animal.

Q. Now is this character of bacilli found anywhere else?

A. Found in nature anywhere else?

Q. Yes?

A. We find it in animals, as I say and we find it also in fish.

Q. Was it ever found in fish prior to your investigation?

A. I have been unable to find any reference whatever that shows that it has.

ATTORNEY GENERAL HAMLIN: Are you speaking from the books, or are you speaking from your own investigation?

A. I undertook this investigation in July 1899 Of course I looked up the literature at the time, and found that no worker anywhere had gone into this subject.

MR. DRENNAN: Of fish?

A. The intestinal contents of fish, yes sir. There has been a good deal of work done since then, since we reported our result.

ATTORNEY GENERAL CROW: Well, did you find that bacillus in the waters of the drainage canal, the Desplaines river, the Illinois river and the Mississippi river?

A. Yes sir.

Q. What, if anything does the presence of that bacillus, 109 in running waters indicate in streams?

A. It has been looked upon by bacteriologists as the index to fecal pollution.

Q. Now explain what you mean by that?

A. Whenever these micro-organisms have been found in water the conclusion is reached that the water must contain sewage, either from the intestinal contents of man or animals.

Q. And it is an indication of sewage in water?

A. Yes, sir.

Q. I will ask you to state whether there is any other bacillus that is found in running streams that is an indication also of sewage in water.

A. There are several, but there really is no good index. There are micro-organisms that are found in sewage steadily wherever sewage is present, they are present in large numbers, but a true index to fecal pollution, I don't know a single one.

Q. Now do you mean to include in that statement the bacilli that we have been talking about?

A. Yes sir. That is, previous to our work upon the intestinal contents of fishes, these micro-organisms were really looked upon, and I believe it is still held by Prof. Jordan, looked upon as an index to fecal pollution, but our own experience robbed it of that dignity.

Q. Well, what reason do you assign for that?

A. What is that?

Q. Why is that?

A. Why, if it is found in a stream steadily, and we know that there are fish in the stream at the same time, which
110 have it in their intestinal contents, and are discharging it from their intestines, then the bacillus coli-communis found in that particular water may be either from sewage, from man, or from animals, or fish.

Q. Now you found it, you say, in fish?

A. Yes sir.

Q. Where did you find the fish that had this bacillus?

A. In the Illinois river.

Q. Did you investigate the intestinal portions of fish in the Mississippi rver?

A. Yes, sir.

Q. Did you find it there?

A. Yes, certain kinds of fish, carp for instance.

Q. Did you find it in the fish of the Missouri river?

A. I am not sure, I think not. I am not so certain about that, but I think very rarely, if at all. I have got the exact figures here, if you care to have me refer to them to refresh my memory.

Q. Did you investigate the fish in the canal, the Chicago drainage canal?

A. Well, whatever fish we found there were dead. We didn't go into their intestinal contents at all.

Q. What was the reason of that?

A. Well, they were dead, killed by the fact that the
111 micro-organism used up the oxygen of the water.

Q. What micro-organism do you refer to?

A. All the aerobic micro-organism.

Q. You mean by that the micro-organisms that are present in sewage polluted water?

A. Well, organisms are present in any water that is freely exposed to the air, but the water of the Chicago drainage canal contained large numbers of bacteria, and the oxygen consumers consumed the oxygen that was in the air in the water. That leaves the water without air for the fish to breathe, and having no air to breathe, they die.

Q. What was the direct cause of the immense activity of these micro-organisms?

A. So many of them there.

Q. What was the cause of their presence in such great numbers?

A. Sewage.

Q. Where there were lots of sewage there would be lots of these bacteria?

A. Yes sir.

Q. And that is the reason that fish cannot exist in the drainage canal?

A. Because the bacteria consume the oxygen that is in the air, in the water.

Q. Do fish exist in the Desplaines river?

112 A. I saw men fishing there, I don't know whether there are any fish there or not.

Q. You caught no fish there?

A. No sir.

Q. You don't remember the number of fish you examined?

A. I think it was 68.

Q. During what period of time was that?

A. Extending over several months.

Q. In what year?

A. 1900.

Q. Did you make any investigations after that?

A. I should have said 1899 and 1900. No, not after that. It is very tedious business.

Q. Now you say in July, 1899 that you were city bacteriologist, consulting bacteriologist for the city of St. Louis.

A. Yes sir.

Q. How came you to go to investigating the water supply for the city of St. Louis?

A. I was instructed by the Health Commissioner to get the necessary apparatus and go to work to ascertain the bacteriological contents of the Mississippi river at the intakes of the

St. Louis water works, and also to examine the waters of the Mississippi river between the mouth of the Illinois and the intake, the Missouri river water and the Mississippi river water, and the waters of the Illinois river above the conjunction.

Q. Do you know what caused the Health Commissioner
113 to give you that order?

A. I know there was a great deal of talk about the Chicago drainage canal.

Q. I don't refer to that, I mean any official authority for it.

A. Yes sir. The reason was this. We have to speak about the Chicago drainage canal because that canal was to have been opened, it was nearing completion—

Q. You don't catch the point of my question. Was there any official action by which the Health Commissioner—

A. Yes, there was a motion I believe introduced into the city council and house, by which the city counsellor was empowered or instructed to have these examinations made, and he directed the Health Commissioner to have the bacteriological department do it.

Q. That was the cause of your action?

A. Yes sir.

Q. That's what I wanted to get at.

A. Yes sir.

Q. Now this suit was permitted to be filed on the 22nd day of January, 1900; prior to that time, between that date and July, 1899, had you made any investigation of the waters of the Mississippi and the Illinois rivers?

A. Yes sir.

Q. And the drainage canal?

A. Yes sir.

Q. Do you remember the date on which you first began
114 that investigation?

A. Well, we were instructed July 23d, I think, and we began work on August 10th, 1899.

Q. Did you establish any laboratory at any place?

A. We established a temporary laboratory at the Chain of Rocks.

Q. What was the character of the work that you carried on, was it chemical or bacteriological?

A. Bacteriological.

Q. Wholly?

A. Yes, wholly.

Q. Now beginning on the 10th day of August, 1900, what was the nature of the examinations that you carried on and at what point did you carry them on up to the 30th of August?

A. In 1899 we established a temporary laboratory, had an ice chest in it, and a frame for plating.

Q. You have got some memorandum there that you can refresh your memory from as to the dates, so there will be no question as to the dates.

A. Well, that was on August 10th, 1899 that the temporary laboratory was established at the Chain of Rocks, in a small building.

Q. Now where was the Chain of Rocks?

A. The water works at the Chain of Rocks.

Q. The intake towers?

A. Yes. In the Mississippi river, the Missouri shore.

115 Q. Now what was the nature of those investigations you made from the 10th of August to the 30th of August, 1899?

A. It consisted in the examination of the water at and around the intake to find the number of bacteria per cubic centimeter in it and beside several boat trips were made up the river taking samples around the intake, the Missouri river, the Mississippi river at several points between the mouth of the Missouri and the mouth of the Illinois, the Illinois river and the Mississippi river above the mouth of the Illinois.

Q. Well, you took samples of water from the river?

A. We took samples of water, yes sir.

Q. In what quantity did you take the water?

A. We took about a hundred cubic centimeters in a bottle, 4 oz. bottle.

Q. How much would that represent?

A. About 4 ounces.

Q. What did you do with that water?

A. That water was taken with a special apparatus designed by us in sterile vessels, from about 3 feet below the surface of the river. These samples were immediately taken ashore, when they were taken at the intake or at the uptake, and plated at once or when a sample was taken on the boat, a skiff pulled out from the boat and secured the water, and it was taken and covered and kept cool and taken right back to the boat and plated immediately.

Q. Now explain what you mean by sterile, you say the
116 vessels were sterile?

A. I said that we used sterile glass vessels. That brings up the question of sterilization. There are 3 methods of sterilizing vessels. Sterilizing anything by means of heat, we have first what is known as the dry heat method, putting a vessel into an oven and heating it, like baking bread.

Q. Now what is the object of that?

A. It is to kill the bacteria on or in the vessel or in the fluid in it. The temperature must be from 150 degrees to 170 degrees Centigrade and this must be continued for an hour and a half.

Q. What does that represent in Fahrenheit?

A. Well multiply that by 2½ practically.

Q. Multiplying that by 2½ would be about 350.

A. Yes sir, and it must be maintained at that temperature for an hour and a half. So our glass vessels then, were put into an oven and heated for an hour and a half at a temperature of 150 Centigrade. The Thermometer or thermo-regulators were regulated to do that. At the end of that time they were taken out and set aside. Now then there is the method of sterilization by steam. We have a vessel closed in which the steam can be generated but can escape through cracks in it. The temperature is brought to the boiling point of water which generates steam, and the temperature then reaches 100 centigrade 212 Fahrenheit. In this moist atmosphere, in this steam, bacteria
117 are destroyed in a comparatively short time, but the spores
retain their vitality for a great while so if we wish to heat the media, say continuously, we can do so by this temperature, but we must continue the process for an hour or to an hour and a half, depending on the bulk of the material and the steam

sterilizer. Our gelatine and nutritive media are heated discontinuously, that is, we heat it for about half an hour, at this temperature, 100 centigrade, in the steaming steam, the first day, the idea being to kill all the bacteria that do not contain spores and besides not injuring the gelatinizing quality, say of gelatine, for gelatine heated too long will not jell harden. Then the material is allowed to stand, the hope being that the spores which may be present, will take the hint and grow out into bacteria, and the moment they have passed from the spore stage into bacillus, why they are tender and easily killed, so on the second day the material is again sterilized for 20 minutes and allowed to rest for 24 hours and again heated on the third day, so three days of discontinuous sterilizing is necessary. Now then, we have another method, of steam under pressure. We have an apparatus a chamber that can be sealed and with a Thermoregulator in it we can raise the temperature to any degree we please under any pressure, but the idea is to raise the temperature to 115 degrees centigrade, that is a pressure of 1½ atmospheres, making about 23 lbs. in all, so with such an
118 apparatus, with a pressure of 1½ atmospheres and a temperature of 115 degrees centigrade, the bacteria are killed, spores and all in from 15 to 30 minutes. All our material were always heated 30 minutes. That assured not only the death of the bacteria, but all the spores in the media, no matter how bulky the material in the steam sterilizer. Is that plain?

Q. Yes. Now you have an apparatus you designed yourself for taking these samples of water?

A. Yes sir.

Q. Describe that.

A. Why a look at it is sufficient, but the idea is this. An apparatus was to be constructed that would hold a bottle snugly so that it cannot escape or could not escape when it was plunged beneath the running water. First we had a frame constructed and a method of holding the bottle snugly. That frame had a handle to it. That handle was hollow, down through the handle ran a rod, on the end of that rod was a clamp, which clamped to the cork of the bottle, on the other end of that rod was a ring, now when it was desired to open the bottle, all you had to do was to pull on this rod which ran down through the hollow handle of the apparatus and that lifted the cork out, allowing the water to run in to the bottle and a little spring forced the cork back into the bottle. The apparatus was designed and made in the water works blacksmith shops, and afterward adopted by the bacteriologists of the Chicago drainage canal.

Q. Now was that apparatus used in taking the samples
119 that you have bacteriologically examined in this work?

A. Yes sir.

Q. Now are there any particular rules or methods adopted generally by bacteriologists in this country, in the examination of water and other things for the discovery of bacteria?

A. Yes sir.

Q. Will you tell about what they, are, please?

A. In the first place, there is a sterile vessel.

Q. Well, in the first place, is there any organization in this country that has adopted a scientific method?

A. Yes. The American Public Health Association. The bacteriological committee of the American public health association, of which I am a member, have published a report, which is here. This is the first report published. It was in 1898 and is called "Procedures recommended for the study of bacteria, with special reference to a greater uniformity in the description and differentiation of species."

"Being a report of a committee of the American Bacteriologist to the committee on the pollution of water supplies of the American Public Health Association, submitted at the meeting of the Association in Philadelphia September, 1897, published by the Rumford Press, 1898."

Q. Does that outline the method that is approved by
120 bacteriologists generally?

A. Yes sir, bacteriologists in this country. Uniformity is the idea.

Q. Have these methods or rules ever been amended or Altered in any way since that date?

A. At a meeting in 1901, I think, the whole subject was gone over again and a few changes made in some of the details of preparing media.

ATTORNEY GENERAL HAMLIN: Give me the name of that volume?

A. (witness hands Mr. Hamlin the volume last referred to).

ATTORNEY GENERAL CROW: Have you more than one copy of that?

A. This is the only copy I have, but it is published also in the reports of the American Public Health Association.

Q. Could we get a copy of that report?

A. Yes, we can easily get it from the secretary of the American Public Health Association.

MR. CROW: I will put it in the record, if you have no objection gentlemen. As a matter of information I would like to have it go to the court.

MR. HAMLIN: We will decide later on. You go ahead and ask him about these matters.

MR. CROW: Now, in your bacteriological work, from first to last, what methods did you follow in making these examinations?

A. Well, now, I say we designed that apparatus, then we had—

Q. Now wait a moment, you don't catch the point of my
121 questiion. Did you or not follow the method—

A. We followed the methods there laid down, yes sir. For the preparation of media throughout.

Q. Now just indicate where. When you say "where" the record does not disclose what you mean.

A. I say, we made a media, according to the methods laid down by the bacteriological committee of the American Public Health Association.

Q. Now just describe the method you followed again in making these examinations?

A. Do you want me to collect these samples first?

Q. Yes.

A. The collecting apparatus, I described that. Now then the sample was collected 3 feet below the surface, in a sterile wide mouthed glass vessel.

Q. At what point in the stream?

A. At the intake, that is, outside. We collected it at the

intake in the river outside of the intake, on the Illinois shore, and in the uptake, in the well of the uptake. The difference between the water flowing in 1500 feet from the river in the tunnel to a well was not shown bacteriologically. The number of bacteria flowing into the intake and flowing into the uptake were the same. It is practically the same water, no bacteria lost in travelling 1500 feet, so instead of sending a man out in a boat, that is, a bacteriologist out in a boat, every day,
122 we took the water from the uptake, where it runs out of the long tunnel, a series of experiments showing us that the number of bacteria at both points were the same. That was one set. Then the other sets of samples were collected up the river at various points, which are recorded in my report on page 4. Now about this report?

Q. Well, you have there the figures, have you?

A. Yes, I have the figures here in a report which I made to the city counselor, and also have those in the books recorded in sequence taken at that time. Now which one do you want at the present time?

Q. Wait a minute until I get to that. After you took those samples of water, what did you do?

A. Brought them directly to the shore. They were then taken to this room I spoke of in the little building at the chain of rocks, and immediately plated. I should say first, immediately put on ice and then preparations made for the plating.

Q. What do you mean by plating?

A. By plating we mean this: a definite quantity of the water is taken, one cubic centimeter.

Q. That is, about 16 to 20 drops?

A. Yes, about 16 to 20 drops of this water. It is mixed with gelatine. The medium that we speak of, the gelatine medium, containing 10 per cent. of gelatine and having a reaction of 1.5 per cent. to phenol phthalein. Now with this medium, it is mixed in a tube and poured out in what is known as a petri dish.

123 Q. Now what is a petri dish?

A. It is a dish about 4 inches in diameter, with a flange upon it, and on top of that fits a cover with a flange, so that one sets snugly over the top of the other. Into a sterile dish of this kind is poured the water mixed with gelatine. That is put in the ice chest, kept at a temperature of 20 Centigrade, about 60 Fahr., and the bacteria allowed to grow. The plates are watched and at the end of two or three days, three days as a rule, the colonies which have formed are counted.

Q. You mean the colonies of bacteria?

A. Yes, and each colony is considered one bacterium. The number is then recorded. Now for each sample of water we made from two to three plates.

Q. Now that is the process you went through with those samples?

A. Yes sir, that is the process of making plates to get at the number of bacteria in each sample of water.

Q. Now this investigation was only to determine the number of bacteria without regard to a classification thereof?

A. Yes sir, no attempt made to classify at that time.

Q. And the result of these investigations simply gives the unclassified number of bacteria?

A. Yes. Besides that we carried out some work identifying the number of bacillus coli communis in sterilized water collected at these points. 124

Q. Will you name the points where these collections were made and the dates?

A. Yes sir. The Mississippi river just above the intake of the St. Louis water works, August 10, and August 30, 1899.

Q. Now give also the dates, Mr. Ravold, or rather the result that is, the result, the total number of the bacillus coli communis or of the total number of bacteria.

A. The total number of bacteria without the coli?—I wish to say that this is the average of two or three plates, this number represents the amount, 300 on one plate and 350 on another. I have added together and divided, making 325.

Q. So the number represents—

A. The mean.

Q. Not less than the two plates?

A. The two plates always. Sometimes a plate is liquified and lost.

Q. So it always represents a total of from 20 to 25 drops?

A. Sometimes a plate is liquefied too rapidly to get at it, to count the liquefied colonies in it and then only one plate is taken, but that is generally recorded in the book. Now do you want me to go on? The Mississippi river just above the intake August 10,—275 bacteria.

ATTORNEY-GENERAL HAMLIN: This is per cubic centimeter?

A. Yes sir. August 30, 275, same place.
September 12, 650 bacteria.
125 September 13, 1500 bacteria.
September 15, 2300 bacteria.
September 16, 1700 bacteria.
September 20, 1200 bacteria.
September 25, 3600 bacteria.

MR. DRENNAN: This is in 1899?

A. Yes sir. The collection of the sample of the Illinois side of the intake, that is toward the Illinois shore—

MR. CROW: But immediately adjacent to the intake?

A. Directly in line with it. When the samples were taken, that was on the 23d of August, at that point, the number of bacteria was 240. Now then, in the intake, as the water flowed into the intake, the samples were taken there. On
August 10, 500 bacteria.
August 21, 375 "
August 22d 950 "
August 23d 550 " That is all for that point. Now then,
the uptake. After the water had flown from the river through
the tunnel and discharged into the uptake, a sample of water
was taken from the uptake. From the tower to the shore is a
tunnel, and when it flowed out of the end of the tunnel, 1500 feet
from the river, a sample was taken there. As I say, we
126 found no difference in the numbers in the intake and the
uptake,
August 10, uptake, 600
August 11 " 650
August 12 " 650
August 14 " 650
August 15, " 1500

August 17, uptake, 750
August 18, " 650
August 19, " 400
August 21, " 325
August 22nd " 150
August 23d, " 1300
August 24, " 475
August 25, " 400
August 26 " 275
August 28 " 275
August 29 " 170
August 30 " 300
Sept. 4 " 300
Sept. 5 " 270
Sept. 11 " 300. That's all. Now then, do you want the result of the boat trips?

Q. Now how many trips were made between August and January 23d?

A. Six.

Q. Now to what points were they made?

A. They were made up the river in the harbor boat.

Q. Up what river?

A. Up the Mississippi river in harbor boat to the mouth of the Missouri.

Q. As far as what point?

A. In the Illinois we went as far as the brick house club,
127 5 or 6 miles up the river; and 2 or 3 or 4 miles up the Mississippi river, above the conjunction with the Illinois river and collected samples at different points.

MR. DRENNAN: That is, in 1899?

A. Yes sir.

MR. CROW: It extends up to January 23d, between August and January 23d, 1899 is the period of time that was covered, isn't that right, doctor?

A. Yes sir.

Q. Now do you know how many samples of water were taken?

A. In these boat trips and all?

Q. Yes.

A. I can count them—32.

Q. Before you begin to explain about these trips, will you explain what you mean by coli work in bacteria?

A. I find 32 samples collected. Now in order to detect colon bacillus in the water several procedures have been recommended. We have developed—

Q. What do you mean by colon bacillus?

A. The same as bacillus coli communis. It is the same micro-organism, but we speak of it in the laboratory in that way for brevity. The colon bacillus in the presence of sugar produces fermentation, it breaks up the sugar, producing
128 gases. Now if we can put sugar broth into a U tube closed at one end known as a fermentation tube, and have the closed arm filled with broth and the open arm made so that we can put water into it, if the bacillus coli communis present in the water, it will break up that sugar and form gases in the closed tube. The gases of course collect at the top and force down the broth. Now it produces as a rule about 60 per cent. of gas in the tube, when we put a small quantity of water in the fermentation tube and 40 to 60 per cent. of gas forms sometimes, 75 per cent. we know there is a gas producing bacillus there, and then we merely search for this gas producer by plating and studying the colony characteristics of the micro-organism that we think produce this gas. That micro-organism is picked off and shown on a variety of media. Its microscopic form studied, and its growth characteristics on quite a number of media and its motility.

Q. What do you mean by Motility?

A. Meaning whether it swims or not in a fluid.

Q. Now is that the character of coli work that is described which was carried on on these boat trips?

A. No, not on all the boat trips. Samples were returned to my laboratory in the city chemists office, and there these experiments were carried out. It took some time to get the department going, and I did that work myself.

Q. Do you know at what point on the river, in these boat

129 trips, in the Illinois and Mississippi Rivers that samples were taken, and the dates?

A. Yes sir.

Q. Have you the result of that examination?

A. Yes sir.

Q. Now the result, as you give it, would be simply the number of bacteria unclassified?

A. Yes sir. September 6, Illinois River,—at what is known as Wheeler's ferry, three miles above the mouth, 130 bacteria.

Illinois River, five miles above the mouth, Grafton, at what is known as Brick House Club, 170 bacteria.

The Illinois River seven miles above Grafton,—at what is known as six mile Island, 160 bacteria. Now then we go over to the Mississippi River.

MR. DRENNAN: The same day?

A. The same day. Mississippi River opposite Grafton, 190 bacteria.

Mississippi River four miles above Grafton, 550.

Mississippi River 6 miles above Grafton, 276.

All the above samples were plated on the harbor boat immediately after collection.

On September 9th, we made another trip. Mississippi River, —Chain of Rocks, 160 bacteria.

Mississippi River,—Madison landing, that is above the mouth of the Missouri River, just above, 210.

Missouri River near the mouth, just above the mouth, 180.

Mississippi River, one and a half miles below Alton, that 130 is, in the channel, 190.

Mississippi River one mile above Alton, 240.

Mississippi River, one mile below Grafton, 160.

Illinois River just above Grafton, 90.

Mississippi River opposite Grafton, 150.

That's all on September 9th.

September 16th, Mississippi River, Chain of Rocks, 1700.

Mississippi River, Madison landing, 800.

Missouri River, near the mouth, 2600.

MR. SPRINGER: Is that above the mouth or below?

A. That is above the mouth of the Missouri.

Mississippi River two miles above the mouth of the Missouri, 700.

Mississippi River one and a half miles below Alton, 800.

Mississippi River one mile above Alton, 700.

That's all that day.

September 21, Illinois River one and a half miles above Grafton, 450, and the bacillus coli communis, present. Now bacteriologists marks a bacillus coli communis positive or negative. They mark it with a cross if the bacillus coli is present, and if it is not present, it is marked "minus." Zero means sample not examined for coli.

Illinois River one and a half miles above Grafton, 450 bacteria, and the bacillus coli communis present.

MR. SPRINGER: What do you mean by the word "present?" 131

A. I mean that it was a positive reaction; that it showed the coli communis were present in the sample. I found bacillus coli communis in it.

Q. That is September 21, 1899?

A. Yes sir.

September 21, three miles above Grafton, 400 bacteria and the bacillus coli communis present.

Illinois River five miles above Grafton, 425 bacteria bacillus coli communis present. Now we go to the Mississippi.

Mississippi River one mile above Grafton, 500 Bacillus coli communis absent.

Mississippi River four and a half miles above Grafton 500 bacteria to the cubic centimeter. Bacillus coli communis present. That's all on that date.

September 25, Mississippi River, Chain of Rocks 3600. Bacillus coli communis present.

Mississippi River, Madison Landing, 750 bacteria coli absent. Missouri River, near mouth, that is, just above the mouth, 5600 bacteria to the cubic centimeter. Bacillus coli communis present.

Mississippi River, half way between Alton and the mouth of the Missouri, 750 bacteria. Bacillus coli communis present.

Missouri River, opposite Clifton, 750 bacteria. Bacillus coli communis present.

Mississippi River, half a mile below Portage—

MR. SPRINGER: Where is that?

132 That is above Alton. It is a place called Portage, where the Indians used to carry boats across to the Missouri River.

Q. What is the number?

A. 600. Bacillus communis coli absent. That's all.

MR. CROW: Now between September, 1899, and January 23, 1900, were there any bacteriological investigations carried on by you to determine the presence of these coli communis in the waters of the Mississippi?

A. Between what dates?

Q. Between September, 1899 and January 23rd, 1900—in the Mississippi River and Illinois River other than what you have mentioned?

A. No sir.

Q. Now do the investigations you have stated cover bacteriologically all the work you did in the period of time from August 1899 to January 23rd 1900?

A. All that was done is here recorded.

Q. This work was done under your personal supervision?

A. This work was done under my personal supervision. The media made in my laboratory, City Chemists' office, and the plating done at the Chain of Rocks, and I did the coli work personally.

Q. Now beginning on the 23rd of January, 1900, can you tell me how long prior to that date the Chicago Drainage Canal was formally opened?

A. Six days prior to January 23rd.

Q. Now do you know when the Bear Trap dam at Lock-
133 port that you have described was raised?

A. Or lowered so that the water could flow?

Q. Yes, or lowered?

A. I understood that was January 17th and I have so recorded it in my report.

Q. Well, the lowering of that dam would mark the entry of the waters of the canal into the Des Plaines River?

A. Yes sir.

Q. Now, to go back a little bit. Are you acquainted with the natural course of the Chicago River and the place into which it would naturally drain?

A. Yes sir.

Q. What would be the general course of the flow of that stream?

A. It would be towards the Lake.

Q. Well, in what direction would that be?

A. That would be east.

Q. And into what Lake?

A. Into Lake Michigan.

Q. What is the general course and the natural watershed of the Des Plaines River?

A. The Des Plaines River watershed discharges its waters toward the west into the Mississippi River valley.

Q. Then there must be a natural divide between the waters of the Des Plaines River and the Chicago River?

A. Yes sir.

Q. Is there, or is there not?

134 A. Yes sir. There is!

Q. Do you know anything about the elevation of that divide above the level of the two rivers?

A. I do not.

Q. Do you know anything about the current of the Chicago River with reference to whether it was rapid or slow as it flowed naturally into Lake Michigan?

A. I did, depending upon the flood volume.

Q. At the ordinary stage of water?

A. It was a very feeble current towards the Lake, and in fact most of the time it was stagnant.

Q. Do you know how many branches of the Chicago River there are?

A. I knew there were two branches, the north and south branch.

Q. Do you know whether there are any others?

A. Well the small branches that discharge into the south branch. That south branch and west branch. I know nothing very much about the North branch.

Q. Do you know anything about the size of the Chicago River from Robey Street into the Lake?

A. No, I don't know the exact size. I know they are trying to make it 160 feet.

Q. Well, prior to this opening of the canal?

A. No, I do not.

Q. Do you know anything about its depth?

A. No sir.

Q. Well that was used somewhat for harbor purposes
135 near its mouth?

A. Yes sir.

Q. Now do you know in what direction the Chicago River flows at this time?

A. The Chicago River flows west.

Q. Since what period has is flowed west?

A. Since the opening of the Chicago Drainage Canal.

Q. What was the cause of the reversal of the current?

A. The discharge of the water over the Bear Trap Dam at the controlling works at Lockport.

Q. Well, what caused that water to be discharged there?

A. Because the dam was lowered below the level of the Lake.

Q. Below the level of the Lake?

A. Below the level of the water in the Lake.

Q. Now do you know who constructed the Chicago Drainage Canal?

A. I don't know.

Q. Do you know the object of its construction?

A. Well I heard it was for a ship canal. The Health Commissioner of Chicago told me that.

Q. Do you know for what purpose it has been used since its opening?

A. It has been used as an open sewer.

Q. For what city?

A. Chicago.

Q. Have you any knowledge of the amount of sewage that
136 has gone into it since its opening?

A. I have not, none other than the figures obtained from Mr. Reynolds.

Q. Who is Mr. Reynolds?

A. The Chief Engineer,—Randolph, isn't it? Mr. Randolph was kind enough to give them to me.

Q. The chief engineer?

A. The amount of water discharged from the dam and some figures in regard to the amount of sewage discharged into it.

Q. That is, the Chief Engineer of what?

A. Of the Chicago Drainage Canal.

Q. The Chicago Drainage Canal or the Chicago Sanitary District?

A. I don't know the distinction.

MR. SPRINGER: The Sanitary District of Chicago official designation?

A. It is the Chicago Sanitary District then.

MR. SPRINGER: The Sanitary District of Chicago is the title?

A. He is the chief engineer of that.

MR. CROW: Have you got those figures with you?

A. I have not. They are in the hands of Dr. Teichmann.

Q. From whom did he get them?

A. From the Chief Engineer of the Chicago Sanitary District—of the Sanitary District of Chicago.

Q. Do you know anything as to the volume of water that
137 passed into the Des Plaines River from the Chicago drainage canal at is opening?

A. At its opening at the time?

Q. Yes?

A. No, I do not, but I understood though there were something like 300,000,000 gallons in 24 hours.

Q. Do you know the capacity of that canal?

A. That is 300,000,000 cubic feet in 24 hours; I think those are the figures we got.

MR. SPRINGER: 300,000 cubic feet a minute?

A. Yes sir.

MR CROW: Do you know anything about the capacity of that canal? How much water it can flow?

A. I do not. I know it is a magnificent piece of work, 160 feet across and 38 feet deep through rock.

Q. You never made any estimate of the volume of water that can be sent through there?

A. No sir, that was left to the engineers. They are better able to tell about it than I am.

Q. Well, what enabled the waters of the Chicago Canal and the Chicago River to pass through the natural divide between the watersheds of the Des Plaines and the Chicago river?

A. This ship canal that was cut through this divide.

Q. Well, it is known as the Chicago Drainage Canal?

A. The Chicago Drainage canal, yes sir.

Q. Now what is the effect of that on the waters of the
138 Des Plaines River, whether it increased it or diminished it?

A. It increased it.

Q. What is the character of the banks and the soil along the Des Plaines River?

A. It is an alluvial country,—clay, low.

Q. Is it flat or rolling?

A. Rolling country.

Q. Did the emptying of this water into the stream have any effect as to the widening of it? I mean, increasing the shore line?

A. Well, I don't know that. I haven't been there long enough. I never was there long enough. I don't know the extreme limits of the flow, when the greatest volume of water is running through the Des Plaines. I have seen it at a very low stage. It is constantly adding to the stream—300,000,000 cubic feet of water in 24 hours; that ought to widen up the stream just a little bit.

Q. Well now, beginning the 23rd of January, 1900, did you pursue any bacteriological investigation in the waters of the Chicago Drainage Canal, Lake Michigan, the Illinois River, Des Plaines River and the Mississippi River?

A. Yes sir.

MR. DRENNAN: Beginning with January 23, 1900?

A. Yes sir.

Q. MR. CROW: Well, what was the character of those examinations?

A. We began work on January 23, taking samples from 139 a number of points on the Illinois River, the Mississippi River, the Missouri River and the reservoir at the Chain of Rocks, and studying this water for its bacteriological points, that is the number of bacteria per cubic centimeter; for the detection of bacillus coli communis, and the study of the bacteriological flora of the water. That is the different species found in it; carried out a series of special observations which can be taken up in their order, and also made microscopic study for a time of the water.

Q. Now do you know in a general way the distance up the River from the St. Louis in-take to Lake Michigan, Lockport, Joliet, Peoria, Grafton, Hartford, Alton and Bellefontaine?

A. I have the figures here, taken from the report of the Chicago Drainage Canal people. From Lake Michigan to St. Louis at the in-take, 357 miles.

Q. Is that measurement made from the exit of the Chicago River into Lake Michigan?

A. From the mouth of the Chicago River, yes sir.

Q. From what was the mouth—the source now?

A. Yes sir.

Q. Go ahead?

A. Lockport, 327 miles,
Joliet, 320 miles,
Peoria, 196 miles,
Grafton, 39 miles,
Alton, 23 miles,
140 Hartford, 12 miles,
Bellefontaine, on the Missouri River, 14 miles.

Q. Are all of the points mentioned located in the State of Illinois except Bellefontaine?

A. Yes sir.

Q. Where is Hartford located?

A. It is below Alton.

Q. Just locate Bellefontaine, will you—tell where it is?

A. It is very difficult to locate; it is a little bit of a town where the Burlington Road crosses the Missouri river at Bellefontaine Bluffs.

Q. Well, it is up the Missouri River, four or five miles above the mouth?

Q. That locates it sufficiently?

A. Yes sir.

Q. On the south bank of the river?

A. On the south bank of the river, yes sir.

Q. MR. SPRINGER: What distance did you call it?

A. 14 miles.

Q. MR. CROW: From the in-take to Bellefontaine, and four or five miles up the Missouri?

MR. SPRINGER: Yes.

MR. CROW: Have you any knowledge of the flow of the water from the point of conjunction with the Chicago River and Lake Michigan down to the St. Louis in-take?

141 A. I have been over it.

Q. I know, but I mean the rapidity of the current.

A. That depends upon the volume of water in the River.

Q. Have you ever undertaken to investigate that question?

A. Personally, no sir, except traveling in a boat and swimming against it.

Q. Well, of course it is hardly necessary to suggest that if its volume increases, that increases the flow?

A. Yes sir, the greater the volume of water in the river the faster it flows.

Q. Do you know anything about the difference in the altitude or the difference in the level between the St. Louis in-take at the water works, and Lake Michigan at the mouth of the Chicago River—or what was its mouth?

A. I have the figures somewhere; I think they are in that map you have there.

Q. At the noon recess will you find that?

A. Yes sir.

Q. Now have there been any artificial means of any kind used by any persons or corporations or anyone at any point on the Chicago River to aid in the turning of the natural current of the river?

A. The natural current of the river?

Q. Chicago River?

A. Why yes, this lowering of the dam at Lockport in the Drainage Canal.

142 Q. That is not on the Chicago River.

A. That will run the water the other way.

Q. Well, on the Chicago River is there any?

A. The pumps at Bridgeport.

Q. Where are those pumps?

A. I believe they were originally established to help to purify the River.

Q. In the first place, where is Bridgeport?

A. In Chicago.

Q. In the City of Chicago?

A. Yes sir.

Q. What part of the city?

A. In the Southern part of the city.

Q. Can you describe these pumps, how they operate?

A. I cannot; I never saw the pumps; but I have seen the building. I know they pump the water into the Illinois and Michigan canal, and did that before the Drainage Canal was opened.

Q. Located at a point where the Illinois and Michigan Canal joins the south branch of the Cheiago River; is that right?

A. Yes sir, near there.

Q. That point near Bridgeport?

A. Yes sir.

Q. Now you collected samples of water at Lake Michigan, Lockport, Joliet, Peoria and Grafton, beginning at this period on the 23rd day of January, 1900.

143 Q. Now those samples of water were taken from the water daily or weekly or how?

A. Every day.

Q. Now were they taken from boat or from the shore?

A. They were taken from a boat or a bridge where it crosses the river conveniently. Our instructions were to take it from the channel where the water flowed the most rapidly and deepest—three feet below the surface, with the apparatus designed by us.

Q. Have you any record of the water that you took from Lake Michigan? Just begin there at the point, with Lake Michigan and come down?

A. I have a record of eleven samples.

Q. Now where was this water taken from?

A. Taken from Lake Michigan.

Q. At what points?

A. The four mile crib, Carter Harrison crib. Ten miles from the Chicago shore, Lakeview, 68th Street, 2 mile crib, Lake View, three-mile crib, four-mile crib, 68th Street, four mile crib.

Q. Now have you the dates upon which you took these various samples of water and the amounts you took?

A. Yes sir.

Q. Now beginning with the four mile crib, what date was the sample of water taken there? July 23rd?

144 A. Yes sir.

Q. Do you know what time of day?

A. July 23rd, 11:45 A. M.

Q. What was done with that sample of water?

A. The sample was sent to St. Louis and examined here.

Q. Now was that sample taken from the surface of Lake Michigan or from underneath the surface?

A. From below the surface three feet.

Q. Now do you know where the four mile crib is located with reference to any of the in-takes of the City of Chicago for water supply?

A. That is an in-take.

Q. The four mile crib is one of the in-takes of the water supply of the City of Chicago?

A. Yes sir.

Q. Or was at that time?

A. Yes sir, and is now I think.

Q. Now have you the result of the number of bacteria found in that centimeter of water?

A. Yes sir, 1600.

Q. Now was this bacillus coli communis present or not present?

A. It was found present.

Q. The Carter Harrison Crib; where is that located?

A. Ten miles from the Chicago shore.

Q. In Lake Michigan?

145 A. Yes sir.

Q. Have you given the date?

A. July 30th, 11:30 A. M., 1900.

Q. Have you a record of the number of bacteria found in that sample?

A. 12,300.

Q. Now did you find these coli communis present there?

A. Yes sir, that sample was taken ten feet below the surface.

Q. Do you know what the depth of the water was at that point?

A. No, I do not.

Q. Was there any investigation made at that time to learn?

A. No sir.

Q. How is, what is called the ten mile crib located with reference to any water supply of Chicago?

A. I know nothing about it. First we had the Carter Harrison crib; that was 12,300. Now we have got the ten mile crib; that is what we are dealing with now.

MR. DRENNAN: The Carter Harrison crib is not ten miles out.

A. We are dealing with the ten mile crib, ten miles from Chicago, ten feet below the surface. I suppose that is the same day we went out to the Carter Harrison crib.

Q. There was not a crib ten miles out.

A. Simply ten miles out they got the sample. A place ten miles out, ten feet below the surface. That was taken

146 August 9th, 4:00 P. M. Number of bacteria 16,300. Bacillus coli communis present.

MR. CROW:

Q. Well, in order to shorten the matter we will get you to state if these stations that are called cribs are the general water supplies for the City of Chicago?

A. They are points of in-take.

Q. In Lake Michigan?

A. In Lake Michigan.

Q. That isn't ten miles out?

A. No. On the same day that the Carter Harrison, or rather later, my collector must have gone out that far, because the record made of the Carter Harrison crib says ten miles from the shore and ten feet below the surface. They went out in the Drainage Canal boat.

Q. The next crib you have there is the Carter Harrison crib?

A. The Carter Harrison crib 31st of August, 10:30 A. M., and the number of bacteria present, 21,400. Bacillus coli communis present.

Lake View Crib, September 7, 11:30 A. M.—5200. Bacillus coli communis not found.

Two mile crib, September 15, 10:30 A. M., 909,700 bacteria. Bacillus coli communis present.

Three mile crib, September 15, 11:45 A. M., 111,500. Bacillus coli communis present.

Two mile crib September 22nd, 2:00 P. M., 61,000. Bacillus coli communis not found.

147 Sixty-eighth Street Crib, September 22, 11:15 A. M., 44,000. Bacillus coli communis not found.

Two-mile crib, September 28, 10:45 A. M. Bacteria per cubic centimeter 11,300. Coli communis not found.

Lake View Crib, September 28, 12:15 P. M., 3,100 bacteria. Bacillus coli present.

Two Mile Crib, October 11, 12:15 P. M., bacteria per cubic centimeter, 1100. Coli not found.

Three Mile Crib, October 11, 11:30 A. M. Bacteria per cubic centimeter 1,000. Bacillus coli communis not found.

Two Mile Crib, October 19, 11:00 A. M., 4,400. Bacillus coli communis present.

Three Mile Crib, October 19, 10:30 A. M. 1100 bacteria. Bacillus coli communis not found.

Four Mile Crib, October 26, 11:45 A. M. Bacteria per cubic centimeter 90,000. Bacillus coli communis not found.

68th Street Crib, October 26, 12:30 P. M., 157,500 bacteria. Coli not found.

68th Street Crib November 9, 11:30 A. M., 3,300 bacteria per cubic centimeter. Bacillus coli communis not found.

Four mile crib, November 9, 11:00 A. M., 2900 bacteria per cubic centimeter. Coli not found.

That is the number that we have from Lake Michigan—eleven in all—eleven samples taken.

Q. Was there any examination made of any of these samples for the purpose of classifying the bacterial flora taken therefrom? 148

A. Yes sir.

Q. What was the date of that examination?

A. This sample was collected October 11.

Q. Where?

A. At the two mile crib, and contained the following species of bateria. If you want that?

Q. Have you got the result of that investigation there?

A. Yes sir. Do you want that.

Q. Yes.

A. Organisms bacillus coli communis—bacillus deli catulus; bacillus fluorescens incognitus; bacillus helvolus; bacillus proteus mirabilis; bacillus pyocyaneus; bacillus stellatus; bacillus superficialis; bacillus viridis.

That represents the species found.

Q. Are you familiar with the character of these different bacteria?

A. Yes sir.

Q. Just explain their nature.

A. They are all harmless except the bacillus coli communis—except when injected beneath the skin. It is harmless in the individual except when it gets into the appendix and causes appendicitis.

Q. That causes appendicitis?

A. Yes sir. The mucous membrane of the appendix is very delicate.

149 Q. Are these other bacteria, other than the bacillus coli communis all inhabitants of fresh water?

A. Yes sir.

Q. Both lake and river water?

A. Yes sir.

Q. Their presence does not indicate the absence or presence of sewage?

A. Well, if you use bacillus coli communis—

Q. I say except that?

A. Except that, yes.

Q. Now beginning at that point and passing down the canal or the Chicago River, at what point was the next examination of the water made?

A. At Lockport.

Q. Was that a weekly analysis?

A. Daily analysis.

Q. When did it begin?

A. I can tell you exactly from the records—exactly when we did commence.

Drainage Canal at Bear Trap Dam began March 3 and continued daily until October 9, 1900.

Q. Did it not extend beyond that period also?

A. At this particular time, no—oh, and from September 26 to November 25, 1901.

Q. Now, speaking generally, was there any bacteriological variation or fluctuation in the examinations? 150

A. Oh, yes, a very great fluctuation.

Q. At that point?

A. Yes sir.

Q. What was the character of that fluctuation?

A. Remarkable. It ran from millions of bacteria per cubic centimeter down to a few thousand per cubic centimeter.

Q. Do you know of any reason for that vast fluctuation in that period of time?

A. It will go with the amount of sewage discharged into the water and the pollution in that sewage.

Q. Sewage from where?

A. From Chicago.

Q. Discharged into the canal?

A. Discharged into the canal. It depends upon the quantity of sewage.

Q. What effect did that examination generally speaking, during this first period of time, disclose with reference to the presence or absence of the coli bacillus?

A. It showed it present. It was almost a constant inhabitant of the canal at this point.

Q. Do you know in what percentage they were found?

A. Being found in 87 per cent. of the samples collected.

Q. Have you any record of the percentage of samples in which it was found in the month of March, 1900?

A. Seventy-two per cent.

Q. Have you any record of the percentage for May, June and July?

A. Eighty-seven per cent.

151 Q. Have you any for August, September and October up to the 10th, in this investigation?

A. 100 per cent.

Q. Have you any general record of it from October 5th to the 28th, 1901?

A. Yes. 81.2 per cent.

Q. Did you make any examination—microscopical examinatoin of the waters in the canal at this point?

A. Yes, they were made under my direction. Samples were collected and submitted to Mr. Johnson, and to Mr. George C. Whipple, of New York.

Q. Do you know the number of bacterial flora that the examination at this point disclosed from October, 1900, to September, 1901?

A. Well, we collected—we separated out a number of microorganisms at these different periods. I have them here, a record of them.

Q. Will you please put into the record an explanation of what you mean by bacterial flora?

A. The bacterial flora of the water—inasmuch as bacteria belongs to the vegetable kingdom, we speak of the bacteria found in water as the bacterial flora of that water.

Q. Then it means a class of bacteria?

A. Yes the class of bacteria,—schizomycetes, order thelophyta.

Q. Have you any record of the number of organisms that 152 were isolated from the waters there at the Bear Trap Dam?

A. Yes, four sets of ten organisms each and 80 at another time; so that out of all that we have got quite a number of microorganisms here.

Q. Have you the dates, showing when the sets of samples were collected from the water at that particular point?

A. Yes sir.

Q. What were those dates?

A. September 16, May 31, June 14 and July 9, 1900. Eighty organisms were isolated from the water during the months of October and November, 1901.

Q. Have you any record of the bacterial flora taken at the junction of the canal and the Des Plaines River there at Lockport?

A. Yes sir. That is, I have the names here of those taken out during the second investigation, from March 3, to October 11, 1900.

Q. What year?

A. 1900.

Q. What are they, what were the different—

A. Do you want all these different names of these different bacteria?

MR. HAMLIN: Where is the place?

A. Drainage Canal above the Bear Trap Dam.

Q. MR. CROW: Have you got any record of the analyses 153 of the water at the Bear Trap Dam before it passes over that dam,—testing it for bacillus coli communis during March, April, May, June, July and August,—September and October, 1900?

A. Yes, I have the record together with the number of bacteria found per cubic centimeter.

Q. Well, will you just give me that?

A. You don't want these beautiful names then, associated with those species?

Q. No sir. Now let the stenographers understand that this is a test for bacilli coli communis.

A. Don't you want the number of bacteria also?

Q. Yes, I want that also before the water goes over the Bear Trap Dam.

MR. DRENNAN: And the time and place.

MR. CROW: The Bear Trap Dam. Prior to passing over that dam?

A. Yes, before it passes over the Bear Trap Dam.

MR. DRENNAN: I want the particular dates.

A. This is water taken from the Chicago Drainage Canal before the water passed over the Bear Trap Dam at Lockport, Illinois. March 3rd, number of bacteria 541,000, bacillus coli communis not present.

March 4, 304,000, not present,
March 5 1,014,000, coli communis present,
March 6, 1,602,100, coli communis present,
March 7, 873,900, coli communis absent,
March 8, 408,600, bacillus coli communis found,
154 March 9, 552,400, bacillus coli communis present,
Samples for the 10th and 11th were lost,
March 12, 1,614,000, coli communis present,
March 13, 1,836,000, coli communis present,
March 14, 4,082,000, coli communis present,
March 15, 5,644,000, coli communis present,
March 16, 3,182,000, coli communis—not made—sample lost,
March 17, 12,130,000, coli communis present,
March 18, 11,200,000, coli present,
March 19, 34,300,000, coli communis not found,
March 20, 27,800,000, coli communis not found,
March 21, 21,450,000, coli communis found,
March 22, 22,600,000, coli communis found,
March 23, 15,000,000, coli communis not found,
March 24, 12,450,000, coli communis found,
March 25, 10,880,000, coli communis found,
March 26, 3,450,000, coli communis not found,

March 27, 3,480,000, coli communis found,
March 28, 6,250,000, coli communis not found,
March 29, 275,000, coli communis found,
March 30, 8,100,000, coli communis found,
March 31, 2,633,000, coli communis found,
Now April, same place; same year, same time.
April 1, 11,092,000, coli communis found,
April 2, 2,715,000, coli communis not found,
155 April 3, 3,410,000, coli communis found,
April 4, 4,425,000, coli communis present,
April 5, 1,900,000, coli communis present,
April 6, 3,075,000,—coli communis present,
April 7, 670,000, coli communis found,
April 8, 2,350,000, coli communis present,
April 9, 1,600,000, coli communis present,
April 10, 1,675,000, coli communis present,
April 11, 1,225,000, coli communis present,
April 12, 1,950,000, coli communis absent,
April 13, 5,390,000, coli communis present,

April 14, 1,080,000, sample lost. That is, the bottle was probably broken before a record was made. The record is not made. A bottle sometimes is broken after the counters get through with it, or a particular plate is dropped and spoiled, with which this work has been done, so wherever a zero is marked here, it means that the sample was lost.

Q. MR. JEFFRIES: And the coli communis not examined?

A. It was not examined for coli.

April 15, 4,425,000,—coli communis present,
April 16, 990,000, coli communis present,
April 17, 340,000,—coli communis present,
April 18, 230,000,—coli communis present,
April 19, 90,000, coli communis absent,
April 20, 155,000,—coli communis present,
April 21, 2,843,000,—coli communis present,
156 April 22, 440,000, coli communis present,
April 23, 247,000,—coli communis absent,
April 24, 245,000, coli communis present,
April 25, 105,000, coli communis absent,

April 26, 325,000—coli communis absent,
April 27, 97,000,—coli communis absent,
Sample of April 28th lost.
April 29, 185,000,—coli communis present,
April 30, Sample lost.

RECESS until 2:00 P. M. same day, Wednesday, February 18, 1903.

157 2:00 P. M., Wednesday, February 18, 1903.
Continuation pursuant to adjournment.

Present, Commissioner and same counsel as before.

DR. AMAND M. RAVOLD,

DIRECT-EXAMINATION CONTINUED,

By Mr. Jeffries.

Q. Now doctor, just before adjournment—

A. In May.

Q. Yes, go ahead with your statement.

MR. HAMLIN: We are at the Bear Trap.

A. We are at the Bear Trap dam. On May 1st, 1900—

Q. MR. JEFFRIES: Now you are showing there the results of the determination of bacilli in the canal?

A. Yes sir, discharged by the Chicago Drainage Canal before it passes over the Bear Trap Dam at Lockport, Illinois.

Q. Now go ahead with May 1st.

A. May 1st, 24,500—No determination made of coli.
May 2, 612,,500,—coli present,
May 3, 350,000,—coli present,
May 4, 18,800,—coli present,
May 5, 900,000,—coli present,
May 6, 1,294,000,—coli present,
May 7, 2,524,000,—coli present,
May 8, 114,500,—coli present,
May 9, 149,500,—coli present,
May 10, 188,000,—coli present,
May 11, 663,000,—coli present,
158 May 12, 795,000,—coli not found,
May 13, 255,000,—coli present,

May 14, 128,000,—coli present,
May 15, 78,000,—coli not found,
May 16, 376,500,—coli present,
May 17, 96,000,—coli present,
May 18, 85,000, coli present,
May 19, 28,000,—coli absent,
May 20, 40,000,—coli present,
May 21, 273,000,—coli present,
May 22, 2,725,000,—coli present,
May 23, 1,395,000, coli present,
May 24, 394,500,—coli present,
May 25, 1,311,000,—coli present,
May 26, no samples taken,
May 27, 832,000 coli present,
May 28, 736,000, coli present,
May 29, 15,000, coli present,
May 30, 2,510,000, coli absent,
May 31, no record.

Same place:

June 1, 485,000, bacillus coli present,
June 2, 232,000,—coli present,
June 3, 149,000, coli present,
June 4, 415,000, coli present,
June 5, 296,000, coli present,
June 6, 95,000, coli present,
June 7, 196,000, coli present,
159 June 8, 133,000,—coli present,
June 9, 1,770,000, coli present,
June 10, 1,565,000,—coli present,
June 11, 2,520,000,—coli present,
June 12, 808,000, coli present,
June 13, 281,000,—coli present,
June 14, 376,000,—coli present,
June 15, 2,200,000,—coli present,
June 16, 4,050,000,—coli present,
June 17, 4,860,000,—coli not found,
June 18, 380,000, coli not found,
June 19, 66,000,—determination not made.

June 20, 22,000,—coli present,
June 21, 3,700,000, coli present,
June 22, 1,412,000,—coli present,
June 23, 1,480,000,—coli absent—not found,
June 24, 3,250,000,coli present,
June 25, 5,480,000, coli present,
June 26, 365,000,—coli present,
June 27, 665,000,—coli present,
June 28, 92,000,—coli present,
June 29, 4,500,—coli present,
June 30, not made.
July 1, 214,000,—coli present,
July 2, 1,095,000,—coli present,
July 3, 370,000,—coli present,
160 July 4, 60,000,—coli found,
July 5, 4,640,000,—coli found,
July 6, 450,000, coli present,
July 7, 662,000, coli present,
July 8, 240,000,—coli present,
July 9, 2,150,000,—coli present,
July 10, 133,000,—coli present,
July 11, 109,000,—coli present,
July 12, 94,000,—coli absent,
July 13, 94,000,—coli present,
July 14, 302,000,—coli present,
July 15, 148,500,—coli present,
July 16, 388,000,—coli absent,
July 17, 82,000,—coli present,
July 18, 495,000,—coli present,
July 19, 444,000,—coli present,
July 20, 84,000, coli present,
July 21, 146,000,—coli present,
July 22, 130,000,—coli present,
July 23, 99,000,—coli present,
July 24, 26,310,000—coli absent,
July 25, 137,000, coli present,
July 26, 184,000,—coli present,
July 27, 644,000,—coli absent,

161 **July 28, 870,000,—coli present,**
July 29, 650,000,—coli present,
July 30, 390,000,—coli present,
August 1, 700,000, coli present,
August 2, 388,000,—coli present,
August 3, 261,000,—coli present,
August 4, 204,000,—coli present,
August 5, 294,000,—coli present,
August 6, 330,000,—coli present,
August 7, 172,000,—coli present,
August 8, 130,000,—coli present,
August 9, 325,000,—coli present,
August 10, 240,000,—coli present,
August 11, 279,000,—coli present,
August 12, 129,500,—coli present,
August 13, 184,000,—coli present,
August 14, 45,500,—coli present,
August 15, 40,500,—coli present,
August 16, 161,000,—coli present,
August 17, 236,000,—coli present,
August 18, 197,000,—coli present,
August 19, 126,000,—coli present,
August 20, 1,400,000,—coli present,
August 21, 338,000,—coli present,
August 22, 117,500,—coli present,
162 **August 23, 3,850,000,—coli present,**
August 24, 3,300,000,—coli present,
August 25, 1,390,000,—coli present,
August 26, 244,000,—coli present,
August 27, 2,460,000,—coli present,
August 28, 160,000,—coli present,
August 29, 152,000,—coli present,
August 30, 412,000,—coli present,
September 1, 470,000,—coli present,
September 2, 130,000,—coli present,
September 3, 209,000,—coli present,
September 4, 71,000,—coli present,
September 5, 240,000,—coli present,

September 6, 186,000,—coli present,
September 7, 118,500,—coli present,
September 8, 222,000,—coli present,
September 9, 251,000,—coli present,
September 10, 740,000,—coli present,
September 11, 836,000,—coli present,
September 12, 1,330,000—coli present,
September 13, 3,160,000—coli present,
September 14, 2,225,000,—coli present,
September 15, 1,040,000,—coli present,
September 16, 2,960,000,—coli present,
September 17, 134,000,—coli present,
163 September 18, 106,000,—coli present,
September 19, sample lost.
September 20, 98,000,—coli present,
September 21, 322,000,—coli present,
September 22, 55,000,—coli present,
September 23, 24,500,—coli present,
September 24, 86,000,—coli present,
September 25, 3,390,000,—coli present,
September 26, 740,000,—coli present,
September 27, 1,215,000,—coli present,
September 28, 174,000,—coli present,
September 29, 69,000,—coli present,
September 30, 316,000,—coli present.
That is all for that month.
October 1, 1,825,000,—coli present,
October 2, 137,000,—coli present,
October 3, 186,000,—coli present,
October 4, 180,000,—coli present,
October 5, 254,000,—coli present,
October 6, 204,000,—coli present,
October 7, 166,000,—coli present,
October 8, 156,000,—coli present,
October 9, 58,000,—coli present.

That is the end of that. That is the baccillus for that
164 particular period above the Bear Trap Dam.

JUDGE SPRINGER: What was the 30th?

A. It only went to the 9th; that runs from the 3rd of March up to the 9th of October.

Q. MR. JEFFRIES: In your statement, doctor,—I noticed you stated sometimes—that you called the bacilli absent; at other times you would say "not found"—what do you mean by those two terms?

A. It means the same thing; it means this: that in examining a quantity of water, that we did not detect the presence of the baccillus. If it was there we failed to fish it out.

Q. Does that necessarily mean that it was not there?

A. No, it doesn't mean that at all. It means that they were unable to find it. When that was absent, or not found, it means the same thing,—but we were unable to find it in the sample.

Q. State whether or not any examination was made, of a biological character of the water in the Des Plaines River at Joliet?

A. Yes sir.

Q. If so, state fully and clearly what that examination was.

MR. DRENNAN: This question applies to 1900?

MR JEFFRIES: Yes sir.

A. An examination was made for the same period of time,—from the 3rd of March through.

Q. At the dam?

A. No, I will give you the place that was made at Des Plaines River at McDonnough Street Bridge Joliet, Illinois. 165

MR SPRINGER: Is that in the body of the city?

A. Yes.

MR. SPRINGER: Does the sewage of Joliet enter the stream at that place?

A. No, sir, not all of the sewage,—but sewage comes in further down,—some of the sewage from the penitentiary and from the iron works above does come in.

Now this is in the second period,—now there is a third period beyond this.

Q. MR. JEFFRIES: The second period was in 1900?

A. 1900, yes, and they were collected from the McDonnough Street bridge, and the record is made here, together with the coli communis. Do you want this record to go in just the same as the other?

Q. Just the same as the other exactly.

Q. GEN. HAMLIN: Now the dates are from what to what?

A. From March 3rd until October,—that would be the 24th, the samples were taken; that was the last sample taken from the 3rd of March to the 24th of October.

JUDGE SPRINGER: What year,—1900?

A. 1900. Now, do you want percentages, the same as we gave before,—the percentage of coli baccilli, for instance, found—

Q. MR. JEFFRIES: Just as you have it in your table.

A. Before I began reading numbers, I stated the percent-
166 age of times that the coli baccilli was found in the particular samples of water collected for a definite month.

The coli baccilli was found in 73 per cent. of the samples collected daily at McDonnough Street Bridge in the five months, March to July inclusive. This organism was found 64 per cent of the time--

Q. That means of the time—of the number of the examinations made?

A. Yes, 64 per cent of the examinations made. In August 78 per cent; in the period September 1st to October 9th inclusive it was found 99 per cent of the time.

Now then, we have a third period. Do you wish me to read that also?

Q. Yes, you may state that also, and what that period refers to.

A. The third period, or the Ruby Street Bridge, 83.3 per cent of the time, and at Brandon's Bridge—

Q. JUDGE SPRINGER: All in Joliet?

A. Yes sir, all in Joliet—at Brandon's bridge, 79.2 per cent of the time. That was in the third period.

Q. MR. JEFFRIES: Now that was the third period?

A. The third period extended to some time in October,—I can not get that exactly.

Q. 1901?

A. Yes,—October and November, 1901. Now then, the
167 results, March 3, at Des Plaines River,—McDonnough
Street, Joliet, 494,200,—coli communis present.

March 4, 714,100, coli absent,
March 5, 536,300,—coli present,
March 6, 1,114,600, coli present,
March 7, 476,000,—coli present,
March 8, 839,000,—coli absent,
March 9, 4,605,000,—coli absent,
March 10, 4,633,500,—coli present,
March 11, 3,899,400,—coli present,
March 12, 3,974,800, coli present,
March 13, 2,858,800,—coli present,
March 14, 4,612,500, coli present,
March 15, 5,691,000,—coli absent,
March 16, 807,400,—coli absent,
March 17, 7.640,000,—coli present,
March 18, 33,640,000, coli present,
March 19,—no sample.
March 20, 16,300,000,—coli present,
March 21, 14,705,000—coli present,
March 22, 14,550,000,—coli present,
March 23, 17,400,000,—coli present,
March 24, 14,900,000,—coli present,
March 25, 8,000,000,—coli present,
168 March 26, 7,300,000,—coli absent,
March 27, 4,760,000,—coli present,
March 28, 2,830,000,—coli present,
March 29, 1,190,000,—coli absent,
March 30, 9,375,000,—coli present,
March 31, 2,940,000,—coli absent,
April 1, 9,872,000,—coli present,
April 2, 3,054,500,—coli present,
April 3, 14,960,000,—coli absent,
April 4, 5,460,000,—coli present,
April 5, 3,850,000,—coli present,
April 6, 8,450,000,—coli present,

April 7, 645,000,—coli present,
April 8, 2,400,000,—coli present,
April 9, 3,450,000,—coli present,
April 10, 4,700,000,—coli present,
April 11, 3,275,000,—coli absent,
April 12, 7,720,000,—coli absent,
April 13, 5,075,000,—coli present,
April 14, 1,900,000,—coli absent,
April 15, 9,450,000,—coli present,
April 16, 580,000,—coli present,
April 17, 2,380,000,—coli present,
April 18, 490,000,—coli present,
169 April 19, 1,500,000,—coli present,
April 20, 190,000,—coli present,
April 21, 1,320,000,—coli absent,
April 22, 245,000,—coli absent,
April 23, 415,000,—coli present,
April 24, 185,000,—coli present,
April 25, 270,000,—coli absent,
April 26, 200,000,—coli present,
April 27, 129,000,—coli present,
April 28, 390,000,—coli present,
April 29, 110,000,—coli absent,
April 30, 365,000,—coli absent,
May 1, 12,500,—coli determination not made,
May 2, 345,000, coli present,
May 3, 430,000,—coli present,
May 4, 18,300,— coli absent,
May 5, 412,500,—coli present,
May 6, 92,600, coli present,
May 7, 164,800, coli present,
May 8, 420,000,—coli present,
May 9, 1,516,000,—coli present,
May 10, 592,000,—coli absent,
May 11, 7,500,—coli present,
May 12, 366,000,—coli absent,
May, 13, 584,000,—coli present,
May 14, sample lost,

170 May 15, 710,500,—coli not found,
May 16, 164,000,—coli not found,
May 17, 593,000,—coli not found,
May 18, 129,000,—coli not found,
May 19, 319,000,—coli not found,
May 20, 472,000,—coli present,
May 21, 89,000,—coli present,
May 22, 2,810,000,—coli present,
May 23, 1,500,000,—coli absent,
May 24, 92,000,—coli present,
May 25, 157,000,—coli present,
May 26, sample lost,
May 27, 111,000, coli absent,
May 28, 28,000,—coli present,
May 29, 20,000,—coli present,
May 30, 84,000,—coli present,
May 31, 188,000,—coli absent,
June 1, 308,000,—coli present,
June 2, 590,000,—coli present,
June 3, 19,500,—coli present,
June 4, 283,000,—coli present,
June 5, 117,000,—coli present,
June 6, 179,000,—coli present,
June 7, 70,000,—coli present,
June 8, 214,000,—coli present,
June 9, 360,000,—coli present,
171 June 10, 109,000,—coli present,
June 11, 136,000,—coli absent,
June 12, 316,000,—coli present,
June 13, 1,275,000,—coli absent,
June 14, 568,000,—coli present,
June 15, 400,000,—coli absent,
June 16, 178,000—determination not made,
June 17, 135,000,—coli present,
June 18, 370,000,—determination not made,
June 19, 83,500,—coli absent,
June 20, 53,000,—coli absent,
June 21, 93,000,—coli absent,

June 22, 87,500,—coli absent,
June 23, 172,000,—coli absent,
June 24, 83,000,—coli present,
June 25, 251,000,—coli absent,
June 26, 90,500,—coli present,
June 27, 26,500,—coli absent,
June 28, 330,000,—coli present,
June 29, 177,000,—coli present,
June 30, 124,000,—coli present,
July 1, 60,000,—coli absent,
July 2, 178,000,—coli present,
July 3, 180,000,—coli present,
July 4, 44,000,—coli present,
172 July 5, 214,000,—coli present,
July 6, 36,000,—coli present,
July 7, 38,000,—coli present,
July 8, 110,000,—coli present,
July 9, 228,000,—coli present,
July 10, 109,000,—coli present,
July 11, 149,000,—coli present,
July 12, 105,000,—coli absent,
July 13, 107,000,—coli present,
July 14, 79,000,—coli present,
July 15, 27,000,—coli present,
July 16, 55,000,—coli absent,
July 17, 102,000,—coli present,
July 18, 70,000,—coli absent,
July 19, 82,000,—coli present,
July 20, 144,000,—coli present,
July 21, 122,000,—coli absent,
July 22, 90,000,—coli present,
July 23, 48,000,—coli absent,
July 24, 79,000,—coli absent,
July 25, 96,000,—coli absent,
July 26, 71,000,—coli absent,
July 27, 763,000,—coli absent,
July 28, 110,000,—coli present,
July 29, 22,000,—coli present,

July 30, 35,500,—coli present,
173 July 31, 82,000,—coli present,
August 1, 198,000,—coli present,
August 2, 59,500,—coli present,
August 3, 2,600,000,—coli present,
August 4, 132,000,—coli present,
August 5, 29,000,—coli present,
August 6, 51,000,—coli present,
August 7, 67,000,—coli present,
August 8, 55,000,—coli present,
August 9, 42,000,—coli present,
August 10, 160,000,—coli present,
August 11, 58,500,—coli present,
August 12, 37,000,—coli present,
August 13, 351,000,—coli present,
August 14, 78,000,—coli present,
August 15, 114,000,—coli present,
August 16, 218,000,—coli present,
August 17, 98,500,—coli present,
August 18, 30,500,—coli present,
August 19, 28,000,—coli present,
August 20, 66,000,—coli present,
August 21, 108,000,—coli present,
August 22, 468,000,—coli present,
August 23, 99,000,—coli present,
August 24, 318,000,—coli present,
August 25, 129,000,—coli present,
August 26, 10,500,—coli present,
174 August 27, 322,000,—coli present,
August 28, 204,000,—coli present,
August 29, 83,000,—coli present,
August 30, 55,000,—coli present,
August 31, 69,000,—coli present,
September 1, 33,500,—coli present,
September 2, 42,500,—coli present,
September 3, 32,000,—coli present,
September 4, 57,000,—coli present,
September 5, 1,540,000,—coli present,

September 6, 608,000,—coli present,
September 7, 97,000,—coli present,
September 8, 2,100,000,—coli present,
September 9, 48,000,—coli present,
September 10, 106,000,—coli present,
September 11, 134,000,—coli present,
September 12, 210,000,—coli present,
September 13, 218,000,—coli present,
September 14, 2,075,000,—coli present,
September 15, sample lost,
September 16, 3,230,000,—coli present,
September 17, 540,000,—coli present,
September 18, 32,000,—coli present,
September 19,—sample lost,
September 20, 114,000,—coli present,
September 21, 108,000,—coli present,
175 September 22, 430,000,—coli present,
September 23, 1,390,000,—coli present,
September 24, 975,000,—coli present,
September 25, 2,900,000,—coli present,
September 26, 112,000,—coli present,
September 27, 434,000,—coli present,
September 28, 87,000,—coli present,
September 29, 134,000,—coli present,
September 30, 77,000,—coli present,
October 1, 1,125,000,—coli present,
October 2, 98,500,—no determination made,
October 3, 100,000,—coli present,
October 4, 140,000,—coli present,
October 5, 220,000,—coli present,
October 6, 114,000,—no determination made,
October 7, 68,000,—coli present,
October 8, 133,000,—coli present,
October 9, 34,000,—coli present.

There was a determination made on the 17th,—16,000, coli present, and on the 24th of October, 146,000,—coli present.

Q. MR. JEFFRIES: Now at this time, doctor, did you make any examination as to the bacteria flora?

A. Yes sir.

Q. Did you examine the water taken from the Des Plaines 176 River at that time?

A. Yes,—seventeen distinct species were isolated.

Q. Will you name them?

A. Yes, I can name them. Do you want them?

Q. Yes sir.

A. The bacterial flora of the Des Plaines River at Joliet at McDonnough Street Bridge,—baccillus albus, baccillus aquatilis, sulcatus No. 1; baccillus aquatilis sulcatus No. 5; baccillus cloacae; baccillus coli commus, baccillus delicatulus baccilli fluoresens tenuis, baccillus helvolus; baccillus iridescens; baccillus lacti viscosus; baccillus liquefaciens, baccillus ocracous; baccillus proteus mirabilis; baccillus proteus zenkeri; baccillus stellatus; baccillus superficialis, sarcina lutea.

Q. MR. CROW: Are you through with that table, doctor?

A. Yes sir.

Q. Now this last table that you gave us is the different classes of bacteria that were found in the water at Joliet?

A. Yes sir, 1900.

Q. Did you fix any particular date?

A. No, it is during that investigation of 1900.

Q. Now what is the next point on the river—

A. That we collected material?

Q. Yes.

A. At Peoria, Illinois; that is during this second period of investigation you mean?

Q. Yes, during the second period of investigation.

177 A. That is above Peoria.

Q. How far is that from Joliet?

A. 120 miles I believe, by river.

Q. By river?

A. Yes sir.

Q. Well, have you got the dates and the results of that investigation?

A. Yes sir. Result of the determination of bacteria in the Illinois River three miles above Peoria, Illinois.

MR. CROW: First I want to get the formation of the Illinois River; what is it that forms the Illinois River?

A. The Illinois River is formed by the joining of the Des Plaines and the Kankakee Rivers at a point 23 miles below Joliet.

Q. At what point? At a point 23 miles below Joliet.

Q. Below Joliet?

A. Yes sir.

Q. Now are there any other streams besides the Kankakee that come in there below?

A. Yes sir, at LaSalle, Illinois, about 102 miles below Chicago, the Vermillion river comes in and the Illinois and Michigan canal.

Q. That also enters the Illinois river at that point,—at
178 LaSalle?

A. Yes, at that point, yes. Then there are small rivers and creeks come in between LaSalle and Peoria. There are no large streams entering the Illinois.

Q. Now what is the general characteristic of the water at LaSalle with reference to the number of bacteria in it, compared with the water at Lockport?

A. Well, we went below; we went to Peoria.

Q. I am asking you about that proposition now—

A. Well, we had that in the third period.

Q. I am asking you not for the details of it, but for the general condition of the water

A. Do you mean bacteriologically?

Q. Yes.

A. I can't say because I made no examination at that particular period.

Q. Did you observe the speed of the canal?

A. The speed of the river?

Q. The speed of the canal?

A. The speed of the canal—yes I examined that quite a number of times.

Q. Well at the time of these examinations,—at the time these examinations were begun, the 23rd of January, did you pay any attention to the speed of the water?

A. I wasn't up there on the 23rd of January, but I was there later and there was a perceptible movement of the water; what the speed was I don't know.

Q. Was it rapid or slow?

A. Slow.

Q. How was the speed of the Des Plaines and Illinois
179 River?

A. Why the Des Plaines River, you mean from Lockport, after the Drainage Canal joins it?

Q. Yes.

A. It runs at a very high rate; that is down a declivity; it runs down a hill there.

Q. Is there any difference between that speed at the time it leaves Lockport and the time it reaches Grafton at the mouth of the Illinois River?

A. Oh yes, very great.

Q. Where is the slackening in speed?

A. After it joins the Kankakee River.

Q. At LaSalle?

A. No, some twenty-three miles below Joliet.

Q. That is below LaSalle?

A. No, that is above LaSalle.

Q. Now between LaSalle and Peoria, are there any large streams that come in?

A. The Vermillion River.

Q. Is that a large stream?

A. Yes, a good large stream.

Q. Now, the next collection you made, you say was at Peoria?

A. Yes sir.

Q. Was that made immediately at the town, or above or below?

A. It was made at Averyville, above the town.

180 MR. DRENNAN: Is that above the sewage?

A. Yes, that is above Peoria,—the sewage there.

Q. MR. CROW: Do you know at what point sewage of Peoria enters the river?

A. Yes, a good distance below.

Q. A good deal below?

A. Yes sir, this is up at the water-works; this is up where Peoria has some water-works.

Q. Does Peoria take her water supply from the Illinois River?

A. Drinking water supply?

Q. Yes.

A. Oh, No sir.

Q. What water works?

A. There is a water works there for some damming purposes, I don't know what they do with the water.

Q. Do you know it is not for drinking purposes?

A. I do know it.

Q. What?

A. Yes sir.

Q. Now do the results as to the number of bacilli found in the water at the examinations at Joliet vary during this period of time?

A. At Joliet?

Q. Yes?

A. Oh yes, it varies very greatly you see.

Q. Did it at Peoria, also?

181 A. Yes sir.

Q. How did the variations compare?

A. They seemed to fluctuate somewhat during the seasons, to very high numbers at the Bear Trap Dam. There seems to be a perceptible rise in the number of micro-organisms at Peoria in this period.

Q. Well now, have you anything,—any data that will give you the number of coli bacillus, or the percentage made in the daily tests,—made at the point three miles above the City of Peoria in the first period?

A. Yes.

Q. About what per cent would that average?

A. Colon bacillus was found in 75 per cent of the daily tests made.

Q. Well now during the second period, running up to October 1901—

A. That was in the second period of the daily tests made of samples of water collected at this point,—the second perio

Q. MR. SPRINGER: At the Peoria Water works, above Averyville?

A. Yes sir.

Q. MR. JEFFRIES: Now do you know at what point—at what particular point in the Illinois River this period of tests was taken with reference to the shore?

A. Out in the stream where the current was running 182 fastest, in the channel.

Q. Now have you got the result of that there—you have kept a table, have you?

A. Yes sir.

Q. Covering what period of time?

A. We have during the second period beginning January 23, 1900, and extending until October 9, 1900.

Q. Well, will you just give us that table?

A. Yes sir.

Q. If you have the data giving the result of those analysis and the dates, showing the number of the bacteria, I suppose it is, taken per cubic centimeter?

A. Yes, per cubic centimeter; that is the determination.

Q. This is for the bacillus coli communis?

A. Yes sir.

Q. The total number and the bacillus, coli communis?

A. Yes sir.

Q. At a point three miles above the city of Joliet?

A. No,—Peoria.

MR. DRENNAN: Opposite the water works?

A. Well, I can't say it is opposite the water works.

Q. MR. JEFFRIES: But near to the water works and in the channel of the stream?

A. Yes, we had one of the water works men go out with us in a boat, you know, above the bridge up there.

January 23, 22,900,—coli present,
183 January 24, 284,900,—coli present,
January 25, 211,600,—coli present,
January 26, 85,100,—coli present,
January 27, 49,200,—coli present,
January 28, 363,400,—coli present,
January 29, 173,800,—coli present,
January 30, 336,900,—coli present,
January 31, 365,400,—coli present,

February 1, 268,800,—coli present,
February 2, 392,900,—coli not found,
February 3, 324,300,—coli present,
February 4, 543,100,—coli not found,
February 5, 294,600,—coli present,
February 6, 239,500,—coli not found,
February 7, 167,300,—coli present,
February 8, 64,900,—coli not found,
MR. DRENNAN: That is 64,500 here.
A. It is corrected in ink here—64,900,—coli not found.
February 9, 25,400,—coli present,
February 10, 21,200,—coli present,
February 11, 48,700,—coli present,
February 12, 72,800,—coli not found,
February 13, 126,800,—no determination,
February 14, 761,600—coli not found,
184 February 15, 653,800—coli present,
February 16, 696,400—coli present,
February 17, 745,100—coli not found,
February 18, 800,800—coli present,
February 19, 571,700—coli present,
February 20, 771,300—coli present,
February 21, 540,000—coli present,
February 22, 377,300—coli present,
February 23, sample lost,
February 24, 99,400—coli not found,
February 25, 215,100—coli present,
February 26, 262,000—coli not found,
February 27, sample lost,
February 28, 484,500,—coli present,
February 29, sample lost,
March 1, 347,600—coli absent,
March 2, 471,100—coli present,
March 3, 379,000—coli present,
March 4, 199,000—coli present,
March 5, 362,100—coli not found,
March 6, 175,600—coli present,
March 7, 358,600—coli not found,
March 8, 188,900,—coli not found,

March 9, 186,100—coli present,
March 10, 158,800—coli present,
185 March 11, 156,800—coli not found,
March 12, 244,300, do.
March 13, 270,600, do.
March 14, 138,440—coli present.
March 15, 617,200, do.
March 16, 544,500, do.
March 17, 943,600, do.
March 18, 963,000, do.
March 19, 579,500, do.
March 20, 777,500—No determination.
March 21, 601,300—coli present,
March 22, 535,500, do.
March 23, 508,500, do.
March 24, 510,000—coli not found,
March 25, 546,000—coli present,
March 26, 270,000, do.
March 27, 287,500—coli not found,
March 28, 153,500, coli—no determination,
March 29, 486,300—coli not found,
March 30, 328,500—coli present,
March 31, 275,600—coli not found,
April 1, 185,000—coli present,
April 2, 213,000—coli present,
April 3, 253,500—coli present.

MR. DRENNAN: These tables do not show the stage
186 of water?

A. No, they don't show the stage of water—no.

April 4, 309,800—coli not found,
April 5, 278,500—coli present,
April 6, 283,000—coli not found,
April 7, 587,500—coli present,
April 8, 274,000—coli not found,
April 9, 182,500—coli present,
April 10, 81,500, do.
April 11, 98,000—coli not found,
April 12, 37,000—coli not found,
April 13, 50,000. do.
April 14, 58,500—no determination,

April 15, 65,100—no determination,
April 16, 65,100—coli not found,
April 17, 36,500—coli present,
April 18, 95,500—coli not found,
April 19, 11,000, do.
April 20, 65,100—coli present,
April 21, 51,500—coli not found,
April 22, 118,400—coli not found,
April 23, 78,000—coli present,
April 24, 19,900—coli not found,
April 25, 67,000, do.
April 26, 19,900, do.
April 27, 20,800, do.
April 28, 10,100, do.
187 April 29, 900—coli not found,
April 30, 500, do.
May 1, 750—no determination,
May 2, 500—coli present,
May 3, 950—coli not found,
May 4, 275—coli present,
May 5—sample lost,
May 6, 14,700—coli present,
May 7, 14,800—coli present,
May 8, 10,500, do.
May 9, 5,500, do.
May 10, 4,600, do.
May 11, 68,800, do.
May 12, 98,000, do.
May 13, 249,000, coli not found,
May 14, 112,000, coli present,
May 15, 615,500,—coli not found,
May 16, 1,585,000,—coli not found,
May 17, 152,500, do.
May 18, 531,400, do.
May 19, 155,000, coli present,
May 20, 149,000, do.
May 21, 47,000, coli not found,
May 22, 62,300,—coli present,
May 23, 40,000, coli not found.
188 May 24, 85,800, coli present,

May 25, 23,500, coli present,
May 26, sample lost,
May 27, 62,300,—coli present,
May 28, 100,000, do.
May 29, 522,000,—coli not found,
May 30, 179,000,—coli present,
May 31, 279,000,—coli not found.
June 1, 118,000, coli present,
June 2, 670,000, do.
June 3, 56,500, do.
June 4, 69,600, do.
June 5, 85,000, do.
June 6, 320,000, do.
June 7, 106,500, coli not found,
June 8, 77,000, do.
June 9, 216,000, do.
June 10, 154,000,—coli present,
June 11, 358,000, do.
June 12, 161,000, do.
June 13, 196,000, do.
June 14, 172,000, do.
June 15, 668,000, do.
June 16, 343,700,—no determination,
189 June 17, 460,000,—coli present,
June 18, 405,000, do.
June 19, 320,000, do.
June 20, 460,000, do.
June 21, 818,000, coli not found,
June 22, 840,000, do.
June 23, 2,315,000, coli present,
June 24, 3,780,000, do.
June 25, 3,830,000, coli not found,
June 26, 270,000,—coli present,
June 27, 207,000, do.
June 28, sample lost,
June 29, 59,500, coli present,
June 30, 168,500, do.
July 1, 570,000,—coli not found,
July 2, 550,000, do.
July 3, 400,000, coli present,

July 4, 39,000, coli present,
July 5, 754,000, do.
July 6, 960,000, do.
July 7, 696,000, do.
July 8, 1,250,000, do.
July 9, 1,435,000,—no determination,
July 10, 9,460,000—coli present,
July 11, 801,000,—coli not found,
190 July 12, 65,000,—coli present,
July 13, 376,000, do.
July 14, 404,000, coli present,
July 15, 243,000, do.
July 16, 498,000, coli not found,
July 17, 1,361,000, coli present,
July 18, 500,000, do.
July 19, 998,000, do.
July 20, 286,000, do.
July 21, 14,500, do.
July 22, 59,000, do.
July 23, 128,000, do.
July 24, 87,000, do.
July 25, 750,000, do.
July 26, 43,000, do.
July 27, 326,000, coli not found,
July 28, 174,000, coli present,
July 29, 42,500, do.
July 30, 2,200,000, do.
July 31, 620,000, do.
August 1, 1,185,000, do.
August 2, 460,000, do.
August 3, 313,000, do.
August 4, 139,000, do.
August 5, 212,000, do.
August 6, 488,500, do.
191 August 7, 47,000, coli present,
August 8, 158,000, do.
August 9, 295,000, do.
August 10, 68,000, do.
August 11, 7,700,000, do.
August 12, 770,000, do.

August 13, 940,000, coli present,
August 14, 570,000, do.
August 15, 680,000, do.
August 16, 290,000, do.
August 17, 1,350,000, do.
August 18, 1,175,000, do.
August 19, 25,500, do.
August 20, 6,700,000, do.
August 21, 298,000, do.
August 22, 368,000, do.
August 23, 66,000, do.
August 24, 101,000, do.
August 25, 340,000, do.
August 26, 188,500, do.
August 27, 1,250,000, do.
August 28, 950,000, do.
August 29, 175,000, do.
August 30, 340,000, do.
August 31, 229,000, do.
192 September 1, 1,175,000, coli present,
September 2, 4,250,000, do.
September 3, 192,000, do.
September 4, 845,000, do.
September 5, 2,350,000, do.
September 6, 272,000, do.
September 7, 890,000, do.
September 8, 1,000,000, do.
September 9, 508,000, do.
September 10, 455,000, do.
September 11, 721,000, do.
September 12, 142,000, do.
September 13, 142,000, do.
September 14, 178,000, do.
September 15, 181,000, do.
September 16, 28,000, do.
September 17, 115,000, do.
September 18, 117,000, do.
September 19, sample lost,
September 20, 840,000, coli present,
September 21, 350,000, do.

September 22, 326,000, coli present,
September 23, 28,000, do.
September 24, 218,000, do.
September 25, 1,040,000, do.
193 September 26, 200,000, do.
September 27, 346,000, do.
September 28, 184,000, do.
September 29, 81,000, do.
September 30, 24,000, do.
October 1, 138,000, coli present,
October 2, 266,000, do.
October 3, 755,000, do.
October, 4, 274,000, do.
October 5, 790,000, do.
October 6, 49,000, do.
October 7, 2,500, do.
October 8, 5,000, do.
October 9, 4,500, do.
October 10, sample lost.

Q. Now what is the next point at which you made an examination of the water for the purpose of determining the number of bacteria, and the presence or absence of the coli communis?

A. Grafton.

Q. Have you got a statement of that?

A. Yes sir. Grafton examination, about 163 miles below Peoria, Illinois—

Q. What period of time does that cover?

194 A. That covers the period of time extending from January 23 to October 9.

MR. DRENNAN: 1900?

A. 1900, yes sir.

MR. DRENNAN: Was that above or below where the sewage of Grafton goes in?

A. It was taken at a point two miles above Grafton.

Q. MR. CROW: A point above where the sewage from the city of Grafton empties into the Illinois river?

A. Yes, it empties some sewage, but we took it up above there.

Q. What is the size of Grafton, do you know?

A. I don't know.

Q. Is it a small place?

A. 1,800 or two thousand.

Q. Now you have the data, giving the result of the analyses at this point, three miles, you say above Grafton?

A. Yes, sir, two miles I said.

Q. In the channel of the stream?

A. Yes, we always went out in the river in a boat.

Q. In the channel of the stream, of the Illinois river, between January 23 and October 9, 1900?

A. Yes, sir.

Q. Will you please give them to me for the purpose of determining the number of bacteria in the water analyzed and also the presence or absence of this coli communis?

195 A. Do you want the entire facts—the records that come in there?

Q. Yes sir.

A. The streams that run into the Illinois river between Peoria and Grafton is the Mackinaw, entering the river about sixteen miles below Peoria, the Spoon river, entering about forty-five miles below Peoria, and the Sangamon river, entering about 66 miles below Peoria, Crooked Creek, entering 79 miles below Peoria. I wish to amend that record. It says three miles on this chart. My collectors were instructed to go well above any influence coming from Grafton sewage. They have reported this as three miles above Grafton, where they took the sample.

Q. Well, give us that statement now that I called for in the last question I asked.

A. Yes. We begun taking samples on January 23, 1900, for the quantitive determination of bacteria in the Illinois river three miles above Grafton, Illinois, together with the results of tests for the bacillus coli communis. We finished October 9.

January 23, 241,000, coli not found,
January 25, 170,200, coli present,
January 26, 25,100, coli not found,
January 27, 37,000, do.
January 28, 296,700, coli present,
196 January 29, 81,300, no determination,
January 30, 174,400, coli not found,

January 31, 165,100, coli present.
February 1, 125,400, coli not found,
" 2, 332,400, coli present,
" 3, 252,300, not found,
" 4, 76,700, do.
" 5, 195,700, do.
" 6, 142,400, do.
" 7, 63,000, do.
" 8, 97,100, do.
" 9, 62 700, coli present,
" 10, 203,200, do.
" 11, sample lost,
" 12, 84,300, not found,
" 13, 134,800, no determination,
" 14, 360,200, coli present,
" 15, 294,400, do.
" 16, 361,300, do.
" 17, 174,700, do.
" 18, 281,600, not found,
" 19, 145,000, coli present,
" 20, 182,400, do.
" 21, 140,400, do.
197 " 22, 113,800, coli not found,
" 23, 157,500, do.
" 24, 247,500, coli present,
" 25, 233,300, coli present,
" 26, 378,000, coli present,
" 27, sample lost,
" 28, 588,400, coli present.
March 1, 180,400, coli present,
" 2, 198,700, do.
" 3, 321,300, do.
" 4, 145,600, do.
" 5, 127,600, not found,
" 6, 227,100, do.
" 7, 260,500, do.
" 8, 326,000, coli present,
" 9, 315,900, do.
" 10, 234,000, do.
" 11, 252,800, not found,

March 12, 257,300, not found,
“ 13, 196,900, coli present,
“ 14, 209,300, do.
“ 15, 216,800, do.
“ 16, 245,600, do.
“ 17, 279,800, do.
198 “ 18, 291,000, coli not found,
“ 19, 239,800, coli present,
“ 20, 184,000, do.
“ 21, 444,600, not found,
“ 22, 193,400, coli present,
“ 23, 199,000, not found,
“ 24, 196,000, present,
“ 25, 210,800, not found,
“ 26, 65,000, coli present,
“ 27, 49,500, not found,
“ 28, 88,700, coli present,
“ 29, 29,500, not found,
“ 30, 48,800, present,
“ 31, 41,500, do.
April 1, 56,500, not found,
“ 2, 54,000, present,
“ 3, 53,000, do.
“ 4, 37,500, do.
“ 5, 17,300, not found,
“ 6, 38,500, do.
“ 7, 24,800, present,
“ 8, 73,500 do.
“ 9, 17,800, do.
199 “ 10, 24,500, do.
“ 11, 18,500, do.
“ 12, 15,400, not found,
“ 13, 24,200, not found,
“ 14, 10,400, coli present,
“ 15, 62,000, no determination.
“ 16, 18,500, not found.
“ 17, 10,500, do.
“ 18, 6,200, coli present,
“ 19, 13,000, do.

April 20, 6,000, coli present,
" 21, 65,000, do.
" 22, 21,300, not found,
" 23, 1,500, coli present,
" 24, 4,800, coli not found,
" 25, 2,900, do.
" 26, 250, do.
" 27, 1,250, do.
" 28, 1,200, do.
" 29, 4,300, do.
" 30, 600, do.
May 1, 600, no determination,
" 2, 1,700, coli present,
" 3, 750, not found,
200 " 4, 150, coli not found,
" 5, 600, do
" 6, 9,100, no determination,
" 7, 3,500, do.
" 8, 10,600, present,
" 9, 9,700, do.
" 10, 6,800, do.
" 11, 5,200, no determination.
" 12, 15,400, not found,
" 13, 6,400, do.
" 14, 32,100, present,
" 15, 7,600, do.
" 16, 7,100, not found,
" 17, 2,600, do.
" 18, 2,400, present,
" 19, 6,300, not found,
" 20, 8,500, do.
" 21, 5,900, present,
" 22, 6,400, present,
" 23, 7,200, present,
" 24, 8,600, not found,
" 25, sample lost,
" 26, 3,300, coli found,
" 27, sample lost,
" 28, 3,900, present,
201 " 29, 3,200, present,

May 30, 3,500, present,
“ 31, 1,900, do.
June 1, 34,400, present,
“ 2, 16,400, do.
“ 3, 7,500, do.
“ 4, 9,300, do.
“ 5, 13,900, do.
“ 6, 6,600, do.
“ 7, 6,600, do.
“ 8, 7,000, do.
“ 9, 6,600, do.
“ 10, 8,700, do.
“ 11, 4,000, not found,
“ 12, 357,000, present,
“ 13, 26,600, not found,
“ 14, 16,900, present,
“ 15, 15,800, present,
“ 16, 15,800, do.
“ 17, 15,800, not found,
“ 18, 4,000, no determination,
“ 19, 2,300, coli present,
“ 20, 36,500, do.
“ 21, 5,800, not found,
202 “ 22, 57,400, present,
“ 23, 13,800, do.
“ 24, 23,200, do.
“ 25, 79,000, not found,
“ 26, 3,600, present,
“ 27, 7,400, not found,
“ 28, 5,300, do.
“ 29, 8,700, do.
“ 30, 15,500, do.
July 1, 5,100, present,
“ 2, 6,600, do.
“ 3, 18,400, do.
“ 4, 20,600, present,
“ 5, 1,700, present,
“ 6, 26, 000, present,
“ 7, 13,100, present,
“ 8, 17,000, present,

July 9, 7,100, no determination,
“ 10, 8,600, present,
“ 11, 4,000, do.
“ 12, 22,900, not found,
“ 13, 34,600, present,
“ 14, 14,800, not found,
203 “ 15, 14,600, present,
“ 16, 4,000, present,
“ 17, 41,000, not found,
“ 18, 11,400, not found,
“ 19, 11,400, present,
“ 20, 11,400, present,
“ 21, 3,200, not found,
“ 22, 3,800, present,
“ 23, 8,600, present,
“ 24, 6,300, present,
“ 25, 4,400, present,
“ 26, 9,000, present,
“ 27, 1,300, present,
“ 28, 38,000, present,
“ 29, 32,000, present,
“ 30, 18,200, present,
“ 31, 8,800, present,
August 1, 8,800, present,
“ 2, 8,800, present,
“ 3, 9,100, present,
“ 4, 4,800, present,
“ 5, 12,400, do.
“ 6, 8,800, present,
“ 7, 25,600, “
204 “ 8, 13,800, present,
“ 9, 13,800, present,
“ 10, 6,400, present,
“ 11, 4,000, present,
“ 12, 13,800, present,
“ 13, 19,300, present,
“ 14, 3,700, present,
“ 15, 33,000, present,
“ 16, 42,600, present,
“ 17, 5,300, present,

August 18, 1,300, present,
" 19, 2,500, present,
" 20, 2,800, present,
" 21, 8,000, present,
" 22, 15,400, present,
" 23, 15,400, present,
" 24, 2,200, present,
" 25, 35,800, present,
" 26, 15,400, present,
" 27, 15,400, present,
" 28, 15,400, present,
" 29, 1,700, present,
" 30, 5,100, present,
" 31, 26,400, present,
205 September 1, 10,300, present,
" 2, 26,400, present,
" 3, 17,300, present,
" 4, 29,600, present,
" 5, 41,500, present,
" 6, 15,400, present,
" 7, 22,000, present,
" 8, 29,600, present,
" 9, 53,000, present,
" 10, 16,400, present,
" 11, 30,400, present,
" 12, 4,900, present,
" 13, 2,000, present,
" 14, 3,200, present,
" 15, 7,300, present,
" 16, 1,900, present,
" 17, 1,600, present,
" 18, 2,400, present,
" 19, sample lost,
" 20, 22,000, present,
" 21, 1,500, present,
" 22, 2,900, present,
" 23, 7,800, present,
" 24, 3,000, present,
" 25, 39,200, present,
206 " 26, 56,200, present,

September 27, 1,300, present,
" 28, 1,100, present,
" 29, 4,200, present,
" 30, 5,200, present,
October 1, 7,100, present,
" 2, 10,000, present,
" 3, 13,000, present,
" 4, 22,400, present,
" 5, 60,600, present,
" 6, 1,400, present,
" 7, 1,400, present,
" 8, 8,400, present,
" 9, 400, present,
" 10, 850, present,

That is all.

MR. JEFFRIES: Now, doctor, in making these examinations when this water was taken from the Illinois river above Grafton, which you have just explained, state whether or not you examined with reference to the bacterial flora of the water?

A. Yes, sir, I did.

Q. Can you give that?

A. The results of the number of the species found there?

Q. That is right, doctor.

207 Bacterial flora of the Illinois river just above Grafton, Illinois—Species:

Bacillus aquatalis sulcatus V,
" aurescens,
" aureus,
" cereus,
" cloacae,
" coli communis,
" delicatulus,
" desiziosus,
" fleuorescens tenuis,
" lacti viscocus,
" liquifacians,
" magaterium,
" mesentericus vulgatus,
" ocraceus,
" plicatus,

Bacillus protens mirabilis,
" proteus zacarei,
" stellatus,
" subflavius,
" ubiquitus,
" ureae,
" veredis,

That is all, Mr. Jeffries,

208 Q. Now, following this second period of the examinations, doctor, in the Mississippi river, what examination was made of that water. Give the time and place.

A. These samples were taken for the quantitive determination of bacteria and for the detection of bacillus coli communis from January 23, until October 29.

Q. What year?

A. 1900.

Q. Where were those samples taken from?

A. Three miles above Grafton.

Q. Now, you have the result of that examination, have you?

A. Yes.

Q. Now, you may give that.

A. Mississippi river now, above Grafton. We just gave you the Illinois three miles above Grafton. This is before it mixes with the Illinois. This is above where any of the bayous flow in; it is way above it.

January 23, 17,000, coli present.
" 24, 30,500, not found,
" 25, 38,300, present,
" 26, 54,300, present,
" 27, 29,100, not found,
" 28, 70,000, present,
" 29, 48,000, not found,
" 30, 66,200, do.
" 31, 48,700, do.
February 1, 86,400, no determination,
209 " 2, 39,700, not found,
" 3, 42,800, coli present,
" 4, 13,700, no determination,
" 5, 27,000, not found.

February 6, 28,400, not found.
" 7, 39,600, do.
" 8, 21,200, do.
" 9, 57,800, present,
" 10, 58,500, not found,
" 11, 20,600, do.
" 12, 74,400, present,
" 13, 98,300, no determination,
" 14, 214,800, not found,
" 15, 158,100, do.
" 16, 158,300, do.
" 17, 170,800, do.
" 18, 150,800, present,
" 19, 174,400, not found,
" 20, 172,000, not found,
" 21, 139,900, do.
" 22, 121,500, present,
" 23, 70,500, present,
" 24, 68,500, not found,
" 25, sample lost,
210 " 26, 61,500, not found,
" 27, sample lost,
" 28, 78,600, present,
March 1, 76,800, present,
" 2, 38,200, present,
" 3, 59,100, present,
' 4, 58,700, present,
" 5, 33,600, not found,
" 6, 69,000, not found,
" 7, 84,000, present,
" 8, 125,900, present,
" 9, 109,000, present,
" 10, 171,000, present,
" 11, 121,700, present,
" 12, 193,500, not found,
" 13, 172,800, present,
" 14, 355,400, present,
" 15, 513,000, present,

March 16, 437,000, present,
“ 17, 669,600, present,
“ 18, 713,000, not found,
“ 19, 576,900, present,
“ 20, 465,700, no determination,
“ 21, 681,800, present,
211 “ 22, 358,700, present,
“ 23, 662,000, present,
“ 24, 313,000, not found,
“ 25, 309,500, present,
“ 26, 245,300, not found,
“ 27, 158,000, no determination,
“ 28, 221,500, no determination,
“ 29, 139,000, not found,
“ 30, 158,700, do.
“ 31, 200,000, do.
April 1, 129,500, present,
“ 2, 104,000, present,
“ 3, 175,500, not found,
“ 4, 142,300, do.
“ 5, 161,000, do.
“ 6, 175,000, not found,
“ 7, 76,000, do.
“ 8, 134,000, do.
“ 9, 132,500, do.
“ 10, 101,000, present,
“ 11, 124,500, present,
“ 12, 75,000, not found,
“ 13, 58,000, present,
“ 14, 21,000, present,
212 “ 15, 63,000, not found.
“ 16, 44,000 do.
“ 17, 30,000, present,
“ 18, 16,800, present,
“ 19, 6,500, present,
“ 20, 5,100, present,
“ 21, 34,300, not found,
“ 22, 22,000, do.
“ 23, 12,600, do.

April 24, 19,700, not found,
" 25, 6,400, present,
" 26, 8,300, present,
" 27, 22,500, present,
" 28, 5,200, present,
" 29, 3,200, present,
" 30, 1,100, not found,
May 1, 1,100, no determination,
" 2, 600, present,
" 3, 1,000, not found,
" 4, 950, present,
" 5, 1,200, present,
" 6, 11,500, present,
" 7, 3,000, not found,
" 8, 7,900, present,
213 " 9, 7,300, present,
" 10, 6,400, present,
" 11, 11,300, not found,
" 12, 8,300, not found,
" 13, 7,600, present,
" 14, 8,400, present,
15, 13,000, present,
" 16, 5,100, present,
" 17, 3,700, present,
" 18, 6,200, not found,
" 19, 3,000, do.
" 20, 11,200, present,
" 21, 5,400, not found,
" 22, 4,800, present,
" 23, 11,500, present,
" 24, 8,800, present,
" 25, sample lost,
" 26, 3,200, present,
" 27, sample lost,

No test made for bacteria or coli present. Quantitive determination of numbers not made, but the coli bacilli found present.

May 28, 3,600, present,
" 29, 4,200, not found,

May 30, 2,300, not found,
" 31, 8,300, do.
214 June 1, 5,800, not found,
" 2, 7,600, present,
" 3, 4,800, not found,
" 4, 11,800, present,
" 5, 4,900, present,
" 6, 4,600, present,
" 7, 8,900, present,
" 8, 3,700, not found,
" 9, 6,900, present,
" 10, 2,000, no determination,
" 11, 17,600, not found,
" 12, 3,300, present,
" 13, 23,100, present,
" 14, 11,400, not found,
" 15, 48,300, present,
" 16, 20,300, present,
" 17, 24,000, present,
" 18, 10,900, no determination,
" 19, 12,000, present,
" 20, 12,000, not found,
" 21, 12,000, present,
" 22, 2,100, present,
" 23, 27,900, present,
" 24, 4,700, not found,
" 25, 13,200, not found,
215 " 26, 9,600, present,
" 27, 15,300, present,
" 28, 9,500, present,
" 29, 14,600, present,
" 30, 11,800, present,
July 1, 7,800, present,
" 2, 33,900, not found,
" 3, 12,600, present,
" 4, sample lost, no determination,
" 5, 12,000, coli present,
" 6, 25,500, do.

July 7, 13,900, coli present,
" 8, 5,500, do.
" 9, 19,100, not found,
" 10, 2,100, do.
" 11, 16,900, do.
" 12, 5,300, do.
" 13, 7,700, present,
" 14, 16,700, not found,
" 15, 50,400, present,
" 16, 72,300, present,
" 17, 15,800, not found,
" 18, 6,200, present,
" 19, 16,200, present,
" 20, 9,200, present,
216 " 21, 2,300, present,
" 22, 6,300, not found,
" 23, 8,100, do.
" 24, 5,200, present,
" 25, 2,900, present,
" 26, 11,800, present,
" 27, 6.700, present,
" 28, 11,800, present,
" 29, 11,800, present,
" 30, 32,600, not found,
" 31, 28,900, present,
August 1, 28,500, present,
" 2, 48,800, present,
" 3, 4,600, present,
" 4, 7,300, present,
" 5, 7,400, present,
" 6, 19,700, present,
" 7, 20,600, present,
" 8, 16,200, present,
" 9, 12,500, present,
" 10, 9,200, present,
" 11, 1,500, present,
" 12, 7,500, present,
" 13, 20,100, present,
217 " 14, 12,200, present,

August 15, 17,800, present,
“ 16, 17,800, present,
“ 17, 35,600, present,
“ 18, 29,000, present,
“ 19, 7,500, present,
“ 20, 4,900, present,
“ 21, 27,100, present,
“ 22, 67,500, present,
“ 23, 5,600, present,
“ 24, 37,200, present,
“ 25, 20,600, present,
“ 26, 48,800, present,
“ 27, 53,800, present,
“ 28, 134,000, present,
“ 29, 10,100, present,
“ 30, 16,000, present,
“ 31, 12,800, present,
September 1, 9,200, present,
“ 2, 32,200, present,
“ 3, 11,300, present,
“ 4, 17,000, present,
“ 5, 9,800, present,
“ 6, 17,000, present,
“ 7, 33,900, present,
218 “ 8, 25,600, coli present,
“ 9, 45,600, present,
“ 10, 4,400, present,
“ 11, 4,700, present,
“ 12, 3,600, present,
“ 13, 5,100, present,
“ 14, 7,300, present,
“ 15, 8,000, present,
“ 16, 16,000, present,
“ 17, 12,300, present,
“ 18, 5,800, present,
“ 19, sample lost—no determination,
“ 20, 6,500, present,
“ 21, 5,200, present,

September 22, 20,800, present,
" 23, 4,200, present,
" 24, 77,500, present,
" 25, 12,500, present,
" 26, 95,000, present,
" 27, 3,700, present,
" 28, 31,200, present,
" 29, 12,800, present,
" 30, 9,200, present,
October 1, 26,400, present,
" 2, 46,600, present,
219 " 3, 12,200, present,
" 4, 11,600, present,
" 5, 44,000, present,
" 6, 19,000, present,
" 7, 2,200, present,
" 8, 9,400, present,
" 9, 4,400, present,
" 10, 6,300, present,
" 11, no determination—sample lost,
" 12, do.
" 13, do.
" 14, 9,100, present,
" 15, 2,200, not found,
" 16, 17, 18, 19, 20, 21, 22, samples were not received and no determination made.

October 23, 1,800, coli present,

On the 24th, 25th, 26th, 27th, and 28th, samples not received and no determination made,

October 29, 4,400, coli present,

ADJOURNED until 10:00 o'clock A. M., Thursday, February 19, 1903.

Met pursuant to adjournment at the Southern Hotel, at
220 ten o'clock, A. M., February 19, 1903.

Present: The Commissioner, and the same counsel, representing the respective parties.

DR. AMAND NICHOLAS RAVOLD,

resumed the stand for further direct examination by Assistant Attorney-General Jeffries.

Q. A similar examination was made of the water of the Mississippi river a mile above Alton, was there not?

A. Now with that we have the coli, you know, and this special work. The bacteriological character of the Mississippi river water, one mile above Alton. Do you want me to read that?

Q. I want to know when that was made.

A. That was made from January 24 to October 30, 1900. There was a sample taken on October 30.

JUDGE SPRINGER: How far above Alton was this?

A. One mile above Alton.

MR. JEFFRIES: Now, you may give the result of that examination.

A. The results of the examination—do you want me to read them out?

Q. Yes.

A. I think I told you yesterday about the 29 of October, 221 three miles above Grafton on the Mississippi.

MR. DRENNAN: The Doctor, as I recollect it, drew out some paper and started to give the flora and other stuff, yesterday, when we quit, and that was not yet given. This paper he had before him when we adjourned.

A. There was this. I had that bacterial flora—

Q. I know there was something before you that was not read at the time we quit. That is it.

MR. JEFFRIES: Before you answer the last question, doctor, you may go back to the bacterial flora of the Mississippi river just above Grafton with the result of the examination that you gave yesterday afternoon at the close of the testimony.

A. The bacterial flora of the Mississippi river water just above Grafton, Illinois:

Bacillus arborescens,
" aquatilis sulcatus I,
" aquatilis " III,
" " " V;

Bacillus aureus,
" aurescens,
" cereus,
" cloacae,
" coli communis,
222 " fluorescens liquefaciens,
" " termo,
" helvolus,
" lacti viscosus,
" liquefaciens,
" ocraceus,
" proteuszenkeri,
" viridis,

Q. Now you say an examination was made of the water of the Mississippi river about a mile above Alton?

A. Yes sir.

Q. Do you know how far Alton is from the mouth of the Illinois river?

A. On the Mississippi river from the mouth?

Q. Yes.

A. It is about 18 miles. This sample was collected 17 miles below the mouth of the Illinois river, in the channel of the Mississippi river, one mile above Alton.

Q. In general terms, what was the result of that examination?

A. The coli bacillus was found in 52 per cent of the daily tests made for it in this period.

Q. With reference to the number of bacteria?

A. The bacteria. We began taking samples January 24, 1900, and collected the last sample on the 30 of October, 1900.
I found it in 52 per cent. of the daily tests made at this
223 point in that period.

Q. The coli?

A. The coli, yes sir. Do you want the results?

Q. Yes, now I want the results.

A. This table is to be submitted, is it?

Q. No, it is to be read.

A. Do you want me to read it now?

Q. Yes, so as to get it into the record.

A. It is table No. 9. January 24, 1900.

January 24, 1900, 96,400. Is that what you have got on yours?

MR. JEFFRIES: Yes.

A. Coli present.

Q. Go ahead.

A. January 25, 190,600, coli present,
January 26, 119,400, coli absent,
January 27, 119,800, coli absent,
January 28, 119,400, coli absent,
January 29, 111,000, tests not made,
January 30, 115,100, coli absent,
January 31, 118,500, coli absent,
February 1, 1900, 166,900, coli absent,
February 2, 149,500, coli absent,
February 3, 48,900, tests not made,
224 February 4, 92,500, coli absent,
February 5, 114,300, coli absent,
February 6, 151,300, coli absent,
February 7, 47,400, coli absent,
February 8, 80,900, coli absent,
February 9, 91,900, coli absent,
February 10, 113,900, coli absent,
February 11, 118,200, coli absent,
February 12, 100,600, coli absent,
February 13, 166,600, no tests made,
February 14, 203,400, coli present,
February 15, 277,800, coli absent,
February 16, 429,400, coli absent,
February 17, 119,600, coli absent,
February 18, 236,400, coli present,
February 19, 459,300, coli absent,
February 20, 191,500, coli absent,
February 21, 396,400, coli present,
February 22, 287,400, coli absent,
February 23, 130,100, coli absent,

February 24, 265,100, coli absent,
February 25, 271,800, coli absent,
February 26, 204,900, coli present,
February 27, no tests made,
February 28, no tests made,

225 There were no tests made on the 27th and 28th. Now comes March.

March 1, 169,400, coli present,
“ 2, 145,500, coli absent,
“ 3, 105,200, coli present,
“ 4, 205,900, coli present,
“ 5, 156,300, coli absent,
“ 6, 233,900, coli present,
“ 7, 164,600, coli absent,
“ 8, 232,700, coli present,
“ 9, 213,800, coli absent,
“ 10, 288,100, coli absent,
“ 11, 203,000, coli present,
“ 12, 178,000, coli absent,
“ 13, 204,600, coli present,
“ 14, 248,500, coli present,
“ 15, 454,100, coli present,
“ 16, 242,500, coli absent,
“ 17, 115,500, coli absent,
“ 18, 242,300, coli absent,
“ 19, 229,500, coli present,
“ 20, 206,500, coli present,
“ 21, 193,100, coli present,
“ 22, 133,000, coli present,
“ 23, 147,000, coli present,
226 “ 24, 174,000, coli absent,
“ 25, 117,500, coli absent,
“ 26, 132,000, coli absent,
“ 27, 59,000, coli present,
“ 28, 87,750, coli absent,
“ 29, 80,800, coli absent,
“ 30, 119,000, coli absent,
“ 31, 89,800, coli present,

April 1, 112,000, coli absent,
" 2, 80,000, coli present,
" 3, 64,500, coli present,
" 4, 46,000, coli absent,
" 5, 38,000, coli absent,
" 6, 57,000, coli present,
" 7, 57,000, coli absent,
" 8, 70,500, coli absent,
" 9, 82,000, coli absent,
" 10, 36,500, coli present,
" 11, 31,800, coli present,
" 12, 13,000, coli absent,
" 13, 17,300, coli present,
" 14, 23,200, coli absent,
" 15, 24,300, coli not made,
227 " 16, 16,300, tests not made,
" 17, 15,000, coli absent,
" 18, 13,500, coli present.
" 19, 4,200, coli absent,
" 20, 3,900, coli present,
" 21, 20,600, coli present,
" 22, 5,700, coli absent,
" 23, 5,700, coli absent,
" 24, 17,900, coli absent,
" 25, 4,500, coli present,
" 26, 7,700, coli present,
" 27, 7,200, coli absent,
" 28, 3,850, coli absent,
" 29, 3,450, coli absent,
" 30, 700, coli absent,
May 1, 900, coli test not made,
" 2, 1,600, coli test not made,
" 3, 700, coli absent,
" 4, 2,000, coli absent,
" 5, 700, coli absent,
" 6, 37,800, coli present,
" 7, 13,400, coli absent,
" 8, 17,600, coli present,

May 9, 13,400, coli absent,
" 10, 14,300, coli present,
228 " 11, 12,100, coli present,
" 12, 13,000, coli present,
" 13, 13,400, coli absent,
" 14, 10,000, coli present,
" 15, 11,100, coli present,
" 16, 16,100, coli absent,
" 17, 5,200, coli absent,
" 18, 7,400, coli present,
" 19, 3,100, coli absent,
" 20, 52,400, coli present,
" 21, 18,000, coli absent,
" 22, 2,700, coli test not made,
" 23, 18,200, coli absent,
" 24, 6,300, coli present,
" 25, sample lost,
" 26, 3,800, coli present,
" 27, sample lost,
" 28, 8,900, coli present,
" 29, 4,000, coli present,
" 30, 8,200, coli present,
" 31, 2,700, coli absent,
June 1, 9,100, coli absent,
" 2, 16, 300, coli absent,
" 3, 4,100, coli absent,
" 4, 3,100, coli absent,
229 " 5, sample lost,
" 6, 12,500, coli absent,
" 7, 8,100, coli present,
" 8, 12,900, coli present,
" 9, 7,900, coli present
" 10, 27,000, coli present,
" 11, 5,300, coli present,
" 12, 14,300, coli absent,
" 13, 23,400, coli present,
" 14, 5,000, coli absent,
" 15, 5,000, coli present,

May 16, 4,400, coli absent,
“ 17, 7,300, coli present,
“ 18, 3,800, coli present,
“ 19, 2,400, coli test not made,
“ 20, 1,600, coli present,
“ 21, 3,600, coli present,
“ 22, 2,500, coli present,
“ 23, 2,500, coli absent,
“ 24, 9,600, coli present,
“ 25, 15,400, coli present,
“ 26, 9,500, coli absent,
“ 27, 7,200, coli present,
“ 28, 6,500, coli present,
“ 29, 4,600, coli absent,
230 “ 30, 3,100, coli present,
July 1, 7,900, coli present,
“ 2, 4,900, coli absent,
“ 3, 2,200, coli absent,
“ 4, 6,100, coli present,
“ 5, 2,700, coli present,
“ 6, sample lost,
“ 7, 1,800, coli present,
“ 8, 5,900, coli present,
“ 9, 3,600, coli present,
“ 10, 3,800, coli absent,
“ 11, 2,400, coli absent,
“ 12, 3,600, coli present,
“ 13, 10,600, coli absent,
“ 14, 8,600, coli present,
“ 15, 3,000, coli absent,
“ 16, 2,000, coli absent,
“ 17 32,000, coli absent,
“ 18, 7,400, coli present,
“ 19, 10,000, coli absent,
“ 20, 38,800, coli absent,
“ 21, 2,800, coli present,
“ 22, 31,800, coli present,
“ 23, 8,200, coli present,
231 “ 24, 6,700, coli present,

July 25, 5,100, coli absent,
" 26, 5,600, coli present,
" 27, 2,000, coli absent,
" 28, 4,700, coli absent,
" 29, 4,600, coli present,
" 30, 7,200, coli absent,
" 31, 2,600, coli test not made,
August 1, 1,800, coli present,
" 2, coli test not made,
" 3, 2,400, coli present,
" 4, 1,300, coli present,
" 5, 2,100, coli present,
" 6, 800, coli present,
" 7, 1,100, coli present,
" 8, 900, coli present,
" 9, 400, coli present,
" 10, 600, coli present,
" 11, 1,000, coli present,
" 12, 1,400, coli present,
" 13, 2,000, coli present,
" 14, 1,400, coli present,
" 15, 3,200, coli present,
" 16, 1,400, coli present,
232 " 17, 2,000, coli present,
" 18, 2,200, coli present,
" 19, 3,600, coli present,
" 20, 1,700, coli present,
" 21, 3,100, coli present,
" 22, 3,200, coli present
" 23, 3,900, coli present,
" 24, 5,200, coli present,
" 25, 2,200, coli present,
" 26, 1,400, coli present,
" 27, 2,800, coli present,
" 28, 1,700, coli present,
" 29, 3,600, coli present,
" 30, 6,700, coli present,
" 31, 26,500, coli present,

September 1, 3,500, coli present,
" 2, 3,800, coli present,
" 3, 4,300, coli present,
" 4, 1,500, coli present,
" 5, 3,200, coli present,
" 6, 2,200, coli present,
" 7, 1,500, coli present,
233 " 8, 1,300, coli present,
" 9, 1,000, coli present,
" 10, 1,300, coli present,
" 11, 15,300, coli present,
" 12, 750, coli present,
" 13, 1,500, coli present,
" 14, 950, coli present,
" 15, 1,400, coli present,
" 16, 900, coli present,
" 17, 1,000, coli present,
" 18, 1,500, coli present,
" 19, 1,300, coli present,
" 20, no sample taken,
" 21, 1,800, coli present,
" 22, 1,400, coli present,
" 23, 1,900, coli present,
" 24, 4,600, coli present,
" 25, 4,400, coli present,
" 26, 2,200, coli present,
" 27, 5,400, coli present.
" 28, 3,400, coli present,
" 29, 7,800, coli present,
" 30, 3,100, coli present,
234 October 1, 1,700, coli present,
" 2, 3,200, coli present,
" 3, 3,600, coli present,
" 4, 1,400, coli present,
" 5, 1,600, coli present,
" 6, 3,200, coli present,
" 7, 1,400, coli present,
" 8, 1,100, coli present,
" 9, 2,400, coli present,

October 10, 2,600, coli present,
" 11, no sample taken,
" 12, 10,500, coli present,
No sample taken until the 17th.
October 17, 1,300, coli present,
October 22, 1,300, coli present,
" 30, 760, coli present,

Q. Now, you say the other dates in the month of October of that year there were no samples taken?

A. There were no samples taken.

Q. They were omitted?

A. Yes, sir.

MR. SPRINGER: That concludes that table, does it?

A. That concludes that table. Now you want the bacterial flora?

235 MR. JEFFRIES: Now, you made an examination of the bacterial flora in the Mississippi river at that same point just above Alton?

A. Yes, sir.

Q. Have you that?

A. Yes.

Q. Give it to us, please?

A. The bacterial flora of the Mississippi river just above Alton, Illinois, for the 1900 period. Species:

Bacillus aquatilis sulcatus III.
" " " V.
" aureus,
" cereus,
" cloacae,
" delicatelus,
" fluorescens liquefaciens,
" " termis,
" fulves,
" helvolus,
" liquefaciens,
" megaterium,
" proteus zenkeri,
" stellatus,

Q. Where is Hartford, Illinois?

236 A. It is seven miles below Alton, and one mile above the Missouri river, where it empties into the Mississippi.

Q. That is where the Missouri river empties into the Mississippi?

A. Yes, sir.

Q. Did you make any examination of the water of the Mississippi at or near Hartford?

A. Yes, sir.

Q. Hartford is in Illinois?

A. Yes, sir; Hartford is in Illinois.

Q. Now, at what point was the examination made?

A. At this point a boat was sent out into the middle of the stream, out into the channel, and the sample collected. Those samples were collected from January 24, 1900, to October 31, 1900.

Q. Now, can you state the per cent. of the colon bacillus?

A. Yes, sir. The colon bacillus was found in 61 per cent. of the daily samples collected at this point.

Q. What relation did that bear to the percentage of the samples of this organism found at Alton?

A. A slight increase over the average in which this organism was found at Alton. We found it in 52 per cent. in Alton and 61 per cent. here.

Q. Did you preserve the result of your examination of the water collected at this point?

237 A. Yes, and I have here recorded the results of the quantitive determination of bacteria in the Mississippi river opposite Hartford, Illinois, together with results of tests for the bacillus coli communis.

Q. Now, you may give that.

A. The bacteria per cubic centimeter. To begin:

January 24, 43,500, coli present,
" 25, 159,000, coli absent,
" 26, 4,600, coli test not made.
" 27, 32,800, coli absent,
" 28, 38,300, coli absent,
" 29, 100,500, coli test not made,
" 30, 53,100, coli absent,
" 31, 137,300, coli absent,
February 1, 178,400, coli test not made,

February 2, 163,800, coli absent,
" 3, 153,900, coli present,
" 4, 196,000, coli test not made,
" 5, 137,500, coli present,
" 6, 95,700, coli test not made,
" 7, 39,100, coli absent,
" 8, 90,500, coli absent,
" 9, 119,900, coli absent,
238 " 10, 125,900, coli absent,
" 11, 106,900, coli absent,
" 12, 170,100, coli absent,
" 13, 134,900, coli test not made,
" 14, sample lost,
" 15, 276,300, coli test not made,
" 16, 311,800, coli absent,
" 17, 272,800, coli absent,
" 18, 185,300, coli present,
" 19, 217,700, coli absent,
" 20, 276,900, coli present,
" 21, 319,700, coli present,
" 22, 173,300, coli present,
" 23, sample lost,
" 24, 224,600, coli present,
" 25, 275,700, coli absent,
" 26, 261,900, coli present,
" 27, sample lost,
" 28, sample lost,
March 1, 464,300, coli absent,
" 2, 118,900, coli present,
" 3, 134,800, coli absent,
" 4, 172,000, coli present,
239 " 5, 76,400, coli absent,
" 6, 186,700, coli absent,
" 7, 159,300, coli absent,
" 8, 296,500, coli absent,
" 9, 250,200, coli present,
" 10, 201,800, coli present,
" 11, 208,100, coli absent,
" 12, 179,700, coli absent,
" 13, 139,100, coli present,

March 14, 212,600, coli present,
" 15, 283,000, coli absent,
" 16, 297,500, coli present,
" 17, 486,500, coli present,
" 18, 345,600, coli present,
" 19, 379,000, coli present,
" 20, 309,000, coli present,
" 21, 282,000, coli present,
" 22, 213,500, coli absent,
" 23, 194,000, coli present,
" 24, 115,000, coli present,
" 25, 262,000, coli absent,
" 26, 178,000, coli present,
" 27, 58,000, coli absent,
" 28, 72,500, coli absent,
" 29, 43,300, coli absent,
240 " 30, 60,400, coli absent,
" 31, 57,000, coli present,
April 1, 64,000, coli absent,
" 2, 63,000, coli absent,
" 3, 45,500, coli present,
" 4, 58,500, coli absent,
" 5, 66,000, coli present,
" 6, 51,000, coli absent,
" 7, 75,000, coli absent,
" 8, 56,000, coli present,
" 9, 52,300, coli absent,
" 10, 43,500, coli present,
" 11, 38,000, coli present,
" 12, 50,500, coli absent,
" 13, 26,500, coli absent,
" 14, 21,000, coli test not made,
" 15, 32,500, coli absent,
" 16, 27,000, coli absent,
" 17, 13,500, coli present,
" 18, 24,800, coli present,
" 19, 13,300, coli present,
" 20, 6,400, coli present,
" 21, 10,400, coli present,

April 22, 10,000, coli absent,
241 “ 23, 23,900, coli absent,
“ 24, 15,900, coli present,
“ 25, 4,700, coli absent,
“ 26, 6,800, coli present,
“ 27, 8,700, coli absent,
“ 28, 6,900, coli absent,
“ 29, 3,900, coli absent,
“ 30, 1,650, coli absent,
May 1, 600, coli test not made,
“ 2, 1,200, coli test not made,
“ 3, 1,500, coli present,
“ 4, 500, coli present,
“ 5, 4,900, coli present,
“ 6, 49,200, coli present,
“ 7, 20,100, coli test not made,
“ 8, 21,500, coli absent,
“ 9, 15,700, coli present,
“ 10, 13,900, coli present,
“ 11, 15,800, coli present,
“ 12, 13,500, coli present,
“ 13, 15,700, coli present,
“ 14, 13,800, coli present,
“ 15, 14,600, coli test not made,
242 “ 16, 22,600, coli present,
“ 17, 8,800, coli absent,
“ 18, 11,700, coli present,
“ 19, 5,400, coli absent,
“ 20, 43,700, coli absent,
“ 21, 19,800, coli present,
“ 22, 3,800, coli present,
“ 23, 11,900, coli test not made,
“ 24, 7,200, coli present,
“ 25, numbers not given; coli present,
“ 26, 2,100, coli present,
“ 27, numbers not given; coli present,
“ 28, 6,200, coli present,
“ 29, 18,600, coli present,
“ 30, 5,000, coli present,
“ 31, 2,800, coli present,

June 1, 9,800, coli present,
“ 2, 12,500, coli absent,
“ 3, 5,500, coli absent,
“ 4, 3,300, coli present,
“ 5, 3,800, coli absent,
“ 6, 15,200, coli present;
“ 7, 7,500, coli present,
“ 8, 3,600, coli absent,
243 “ 9, 4,300, coli absent,
“ 10, 7,300, coli present,
“ 11, 1,600, coli absent,
“ 12, 2,300, coli present,
“ 13, 10,200, coli absent,
“ 14, 2,700, coli present,
“ 15, 1,600, coli present,
“ 16, 3,500, coli present,
“ 17, 3,100, coli present,
“ 18, 3,300, coli present,
“ 19, 3,600, coli test not made,
“ 20, 2,100, coli present,
“ 21, 11,500, coli absent,
“ 22, 2,300, coli not present,
“ 23, 1,600, coli absent,
“ 24, 8,100, coli present,
“ 25, 6,800, coli present,
“ 26, 9,600, coli absent,
“ 27, sample lost,
“ 28, 4,100, coli present,
“ 29, 4,800, coli present.
“ 30, 3,600, coli present.
July 1, 2,200, coli present,
“ 2, 2,200, coli present,
244 “ 3, 1,600, coli absent,
“ 4, 3,600, coli present,
“ 5, 2,100, coli absent,
“ 6, 3,300, coli absent,
“ 7, 3,000, coli present,
“ 8, 6,600, coli absent,
“ 9, 3.500, coli present,
“ 10, 10,600, coli present,

July 11, 17,300, coli present,
“ 12, 66,800, coli present,
“ 13, 1,400, coli present,
“ 14, 3,800, coli present,
“ 15, 5,700, coli present,
“ 16, 1,800, coli present,
“ 17, sample lost,
“ 18, 3,800, coli absent,
“ 19, 3,100, coli present,
“ 20, 9,500, coli absent,
“ 21, 3,500, coli absent,
“ 22, 1,400, coli absent,
“ 23, 3,200, coli absent,
“ 24, 3,100, tests not made,
“ 25, 2,000, coli present,
“ 26, 2,800, coli absent,
“ 27, 2,500, coli absent,
245 “ 28, 2,700, coli present,
“ 29, 3,200, coli absent,
“ 30, 3,600, coli present,
“ 31, 3,100, coli test not made,
August 1, 1,400, coli present,
“ 2, sample lost,
“ 3, 1,700, coli present,
“ 4, 1,500, coli present,
“ 5, 1,200, coli present,
“ 6, 1,100, coli present,
“ 7, 2,300, coli present,
“ 8, 850, coli present,
“ 9, 400, coli present,
“ 10, 1,700, coli present,
“ 11, 1,400, coli present,
“ 12, 1,900, coli present,
“ 13, 1,400, coli present,
“ 14, 2,800, coli present,
“ 15, 700, coli present,
“ 16, 1,400, coli present,
“ 17, 1,700, coli present,
“ 18, 1,500, coli present,

August 19, 3,600, coli present,
246 " 20, 1,200, coli present,
" 21, 1,300, coli present,
" 22, 9,800, coli present,
" 23, 3,800, coli present,
" 24, 4,100, coli present,
" 25, 3,000, coli present,
" 26, 2,600, coli present,
" 27, 1,700, coli present,
" 28, 2,400, coli present,
" 29, 1,800, coli present,
" 30, 3,300, coli present,
" 31, 1,200, coli present.
September 1, 2,200, coli present,
" 2, 10,100, coli present,
" 3, sample lost,
" 4, 2,600, coli present,
" 5, 2,800, coli present,
" 6, 7,800, coli present,
" 7, 1,300, coli present,
" 8, 1,100, coli present,
" 9, 1,200, coli present,
" 10, 2,100, coli present,
" 11, 1,500, coli present,
" 12, 1,000, coli present,
247 " 13, 650, coli present,
" 14, 1,000, coli present,
" 15, 1,500, coli present,
" 16, 800, coli present,
" 17, 1,300, coli present,
" 18, 1,500, coli present,
" 19, 1,100, coli present,
" 20, sample lost,
" 21, 2,500, coli present,
" 22, 1,400, do.
" 23, 6,900, do.
" 24, sample lost,
" 25, 3,200, coli present,
" 26, 3,700, do.
" 27, 4,700, do.

	September	28,	2,300,	do.
	"	29,	5,700,	do.
	"	30,	4,200,	do.
	October	1,	3,500,	coli present,
	"	2,	2,300,	do.
	"	3,	3,400,	do.
	"	4,	1,000,	do.
	"	5,	3,600,	do.
248	"	6,	3,700,	do.
	"	7,	1,600,	do.
	"	8,	1,600,	do.
	"	9,	2,600,	do.
	"	10,	1,700,	do.
	"	11,	sample lost,	
	"	12,	do.	
	"	13,	2,600,	coli test not made,
	"	19,	1,700,	coli test not made,
	"	24,	1,600,	coli test not made,
	"	31,	3,000,	coli present.

That ends that table.

Q. Have you examined the bacterial flora of the river at that place?

A. Yes sir. The bacterial flora of the Mississippi, opposite Hartford, Illinois, 1900:

Bacillus albus,
" acquatilis sulcatus III,
" arborescens,
" aureus,
" aurescens,
" baunneus,
" cereus,
" cloacae,
249 " delicatulus,
" fluorescens incognitus,
" " liquefaciens,
" " tenuis,
" " termo,
" helvolus,
" iridenscens,
" lactis erythrogenes,

Bacillus mugaterium,
" mesentericus vulgatus,
" proteus mirabilis,
" proteus zenkeri,
" stellatus
" superficialis.

Q. Now during this period of 1900, did you make an examination of the water of the Missouri river opposite Bellfontaine?

A. Yes sir.

Q. When was that made?

A. That was made from October 24 to January 25, 1900.

JUDGE SPRINGER: Was that in Missouri or Illinois?

A. In Missouri. Bellfontaine is situated on the Missouri river, six miles above the mouth, on the Missouri shore, the south shore.

250 MR. JEFFRIES: Now let us have the result.

A. Do you want the percentage of coli?

Q. Yes.

A. The colon bacillus was found in 58 per cent. of the daily samples collected at this point at this period.

January 24, 158,300, coli test not made,
" 25, 245,200, coli present,
" 26, 236,300, coli absent,
" 27, 560,000, coli absent,
" 28, 195,600, coli present,
" 29, 196,200, coli test not made,
" 30, 278,800, coli not present,
" 31, 235,700, coli absent.
February 1, 178,200, coli absent,
" 2, 98,700, do.
" 3, 76,000, do.
" 4, 69,000, do.
" 5, 52,500, do.
" 6, 49,100, do.
" 7, 150,100, do.
" 8, 42,200, do.
" 9, 53,800, coli test not made,

February 10, 36,300, coli absent,
" 11, 61,000, coli absent,
251 " 12, 40,200, coli absent,
" 13, 22,600, do.
" 14, 124,300, do.
" 15, 68,600, do.
" 16, 53,200, do.
" 17, 35,000, do.
" 18, 31,900, do.
" 19, 33,500, do.
" 20, 39,000, do.
" 21, 55,600, do.
" 22, 54,500 coli test not made,
" 23, 63,100, coli absent,
" 24, 120,000, do.
" 25, 68,200, do.
" 26, 85,800, do.
" 27, sample lost,
" 28, do.
March 1, 63,500, coli present,
" 2, 68,900, do.
" 3, 40,600, do.
" 4, 85,600, do.
" 5, 59,000, coli absent,
" 6, 105,300, coli present,
" 7, 173,700, do.
252 " 8, 154,500, coli absent,
" 9, 136,000, do.
" 10, 255,900, do.
" 11, 227,100, coli present,
" 12, 183,200, coli absent,
" 13, 229,200, coli present,
" 14, 246,900, coli absent,
" 15, 485,900, coli present,
" 16, 401,500, do.
" 17, 821,500, do.
" 18, 393,800, do.
" 19, 596,600, coli absent,
" 20, 354,000, coli present,
" 21, 290,000, coli absent,

March 22, 217,000, coli present,
" 23, 271,500, do.
" 24, 302,200, coli absent,
" 25, 233,000, do.
" 26. 233,000, do.
" 27, 147,000, coli test not made,
" 28, 251,500, coli absent,
" 29, 113,000, coli present,
" 30, 91,300, coli absent,
" 31, 172,500, coli present.
253 April 1, 42,000, coli present,
" 2, 155,000, coli absent,
" 3, 162,500, do.
" 4, 111,000, do.
" 5, 135,500, do.
" 6, 114,500, do.
" 7, 277,500, coli present,
" 8, 77,500, coli absent,
" 9, 101,500, coli present,
" 10, 65,900, coli absent,
" 11, 66,000, coli absent,
" 12, 31,500, coli present,
" 13, 65,000, coli present,
" 14, 58,500, coli absent,
" 15, 87,000, coli present,
" 16, 87,500, coli test not made,
" 17, 168,500, coli not present,
" 18, 64,500, coli present,
" 19, 59,500, do.
" 20, 58,300, do.
" 21, 38,000, coli absent,
" 22, 21,500, coli present,
" 23, 13,900, coli absent,
" 24, sample lost,
" 25, 15,400, coli present,
254 " 26, 32,000, coli absent,
" 27, 10,800, coli present,
" 28, 16,800, coli absent,
" 29, 7,650, coli present,
" 30, 1,400, coli absent.

May 1, 3,800, coli test not made,
“ 2, 1,800, coli test not made,
“ 3, 4,200, coli present,
“ 4, 4,200, do.
“ 5, 4,100, do.
“ 6, 88,000, do.
“ 7, 40,200, coli test not made,
“ 8, 33,100, coli absent,
“ 9, 33,100, do.
“ 10, 33,100, coli present,
“ 11, 33,100, do.
“ 12, 33,100, coli absent,
“ 13, 33,100, do.
“ 14, 33,100, coli present,
“ 15, 67,400, do.
“ 16, 27,000, do.
“ 17, 51,500, coli absent,
“ 18, 53,500, do.
“ 19, 27,500, do.
255 “ 20, 45,400, do.
“ 21, 45,400 coli test not made,
“ 22, 36,000, coli test not made,
“ 23, 38,000, coli present,
“ 24, 50,500, coli absent,
“ 25, 83,800, coli absent,
“ 26, 20,000, coli test not made,
“ 27, sample lost,
“ 28, 15,600, coli present,
“ 29, 23,500, do.
“ 30, 50,000, do.
“ 31, 31,000, do.
June 1, 78,000, coli present,
“ 2, 44,000, do.
“ 3, 34,500, do.
“ 4, 28,000, do.
“ 5, 19,000, coli absent,
“ 6, 41,000, coli present,
“ 7, 41,500, coli absent,
“ 8, 71,000, coli present,
“ 9, 51,000, coli absent,

June 10, 85,000, coli absent,
" 11, 57,000, coli present,
" 12, 27,500, coli absent,
256 " 13, 47,000, coli present,
" 14, 71,000, coli absent,
" 15, 64,000, coli absent,
" 16, 31,000, coli present,
" 17, 87,000, coli present,
" 18, 62,500, coli present,
" 19, 47,500, coli test not made,
" 20, 25,500, coli present,
" 21, 80,000, coli absent,
" 22, 78,000, coli absent,
" 23, 43,500, coli present,
" 24, 68,500, do.
" 25, 76,000, do.
" 26, 153,000, do.
" 27, 118,500, do.
" 28, 112,300, coli absent,
" 29, 165,000, coli present,
" 30, 112,300, do.

That is all for that month.

July 1, 60,000, coli absent,
" 2, 65,000, do.
" 3, 93,000, coli present,
" 4, 189,000, do.
" 5, 240,000, do.
257 " 6, 57,500, do.
" 7, 67,000, do.
" 8, 43,000, coli absent,
" 9, 47,500, coil present,
" 10, 21,000, do.
" 11, 18,500, do.
" 12, 28,500, coli test not made,
" 13, 15,500, coli present,
" 14, 62,000, do.
" 15, 52,000, do.
" 16, 28,500, do.
" 17, 18,500, do.
" 18, 26,000, coli absent,

" 19, 46,500, coli present,
" 20, 34,400, coli present,
" 21, 11,800, coli present,
" 22, 11,900, coli test not made,
" 23, 34,400, coli present,
" 24, 37,400, coli present,
" 25, 10,200, coli absent,
" 26, 22,900, do.
" 27, 18,300, coli present,
" 28, 19,000, coli present,
" 29, 29,500, do.
" 30, 8,700, coli absent,
258 August 1, 14,900, coli present,
" 2, 18,200, do.
" 3, 5,800, do.
" 4, 4,500, do.
" 5, 11,700, do.
" 6, 4,100, do.
" 7, 4,100, do.
" 8, 13,000, do.
" 9, 11,400, do.
" 10, 16,100, do.
" 11, 22,300, do.
" 12, 7,300, do.
" 13, 5,600, do.
" 14, 11,500, do.
" 15, 5,300, do.
" 16, 12,400, do.
" 17, 1,400, do.
" 18, 6,300, do.
" 19, 6,100, do.
" 20, 6,700, do.
" 21, 6,900, do.
" 22, 3,900, do.
" 23, 3,400, do.
" 24, 7,400, do.
" 25, 6,500, do.
" 26, 5,900, do.
259 " 27, sample lost,
" 28, 7,500, coli present,
" 29, 9,800. do.

August 30, 8,300, coli present,
“ 31, 6,300, do.
September 1, 10,900, coli present,
“ 2, 46,100, coli present,
“ 3, 9,700, do.
“ 4, 6,500, do.
“ 5, 19,800, do.
“ 6, 16,700, do.
“ 7, 15,200, do.
“ 8, 12,600, do.
“ 9, 6,300, do.
“ 10, 9,100, do.
“ 11, 6,700, do.
“ 12, 7,700, do.
“ 13, 5,800, do.
“ 14, 4,300, do.
“ 15, 4,100, do.
“ 16, 4,400, do.
“ 17, 13,200, do.
“ 18, 9,100, do.
“ 19, 13,400, do.
“ 20, sample lost,
260 “ 21, 64,000, coli present,
“ 22, 40,000, do.
“ 23, 105,500, do.
“ 24, 69,300, do.
“ 25, 64,200, do.
“ 26, 34,900, do.
“ 27, 48,000, do.
“ 28, 4,700, do.
“ 29, 27,000, do.
“ 30, 26,200, do.
October 1, 16,600, coli present,
“ 2, 22,600, do.
“ 3, 24,800, do.
“ 4, 30,000, do.
“ 5, 21,600, do.
“ 6, 29,600, do.
“ 7, 22,400, do.
“ 8, 16,800, do.

October 9, 26,000, coli present,
" 10, 36,400, do.
" 19, 9,000, do.
" 25, 29,500, do.

Q. Now you have the bacterial flora in the Missouri river, have you?

261 A. Yes, sir, the bacterial flora of the Missouri river opposite Bellfontaine, Missouri, specimens taken from the channel.

Q. Covering the same period?

A. Covering the same period, whatever those dates are, from January 24, to October 25, 1900.

Q. Give them, please.

A. They are as follows:

Bacillus albus,
" antenniformis,
" aquatilis sulcatus III,
" arborescens,
" aurescens,
" cereus,
" cloacae,
" fluorexcens incognitus,
" fulvus,
" liquefaciens,
" megaterium,
" nubillis,
" proteus zenkeri,
" stellatus,
" viridis,
" sarcinalutea.

Q. Now, doctor, during a certain period we have been
speaking about, to-wit, 1900, was an examination made
262 of the character of the Mississippi water at or near the
chain of rocks?

A. Yes sir, three separate examinations were made, what is known as the Missouri shore sample, the intake and the Illinois shore.

Q. You have the result of those examinations?

A. Yes sir.

Q. Separately?

A. Yes sir.

JUDGE SPRINGER: I wish you would state how far each one of these is from the St. Louis intake?

A. The idea was to take a sample not too near the shore, and yet not in front of the intake in the Missouri shore sample. I think the sample was taken about 300 years from the shore in the channel on the Missouri side of the stream.

Q. On the Missouri side of the intake?

A. On the Missouri side of the intake, yes sir.

MR. JEFFRIES: Now with reference to the Illinois shore, where was the sample taken?

A. Do you mean the Missouri sample? If this be the river (indicating), you cross the river like this, and the intake tower is out here toward the center; the Missouri sample is taken 300 yards from the shore where the stream was running rapidly.

Q. 300 yeards from the west shore of the river?

263 From the west shore of the river. The other sample was taken from a boat out in front of the intake, just above it. Not always in the same place exactly. Two or three hundred feet above the intake so as not to get tangled up with it. The third sample was taken in a line with it over toward the Illinois shore. It was enough away to be in the stream several hundred yards away from the shore. Several samples are taken, of course. It is a cross section of the stream.

JUDGE SPRINGER: Which is the first?

A. The Missouri shore together with the results: Colon bacillus was found in 58 per cent. of the daily samples collected at this point.

MR. JEFFRIES: That is, near the Missouri shore?

A. In the Missouri shore sample. The samples were collected from January 25, 1900, to October 30, 1900:

January 25, 262,100, coli absent.

MR. JEFFRIES: Now this is the result of the quantitative examination of bacteria?

A. This is the result of the quantitative determination of the bacteria in the Mississippi river water between the chain of rocks intake and the Missouri shore, together with results for the tests of the bacillus coli communis. Bacteria per cubic centimeter.

Q. This examination also applies to what you said a moment ago. It was made next to the Missouri shore but near the intake?

264 A. Between the intake and the shore, about 300 feet from the shore.

January 25, 262,100, coli absent,
" 26, 329,700, do.
" 27, 121,400, do.
" 28, 222,700, coli present,
29, 264,000, coli test not made,
" 30, 263,400, coli absent,
" 31, 102,800, coli absent.
February 1, 125,500, coli absent,
" 2, 122,500, do.
" 3, 113,900, do.
" 4, 205,100, do.
" 5, 82,900, do.
" 6, 82,900, do.
" 7, sample lost,
" 8, 63,000, do.
" 9, 58,200, do.
" 10, 27,300, do.
" 11, 64,000, do.
" 12, 51,500, coli test not made,
" 13, 34,200, coli absent,
" 14, 100,000, coli absent,
" 15, 191,400, coli present,
265 " 16, 71,800, coli present,
" 17, 60,500, coli absent,
" 18, 139,200, do.
" 19, 97,200, do.
" 20, 76,000, do.
" 21, 107,100, do.
" 22, 84,400, coli present.
" 23, 44,800, do.
" 24, sample lost,
" 25, do.
" 28, do.

Tests for the coli on the 24th and 25th were negative.

MR. JEFFRIES: That is, absent?

A. Yes sir, absent. The last quantitative estimation of the number of bacteria was February 23, when the coli was present; on the 24th and the 25th the samples were lost in the bacteriological laboratory some way. They were tested for the colon bacillus and it was not found present on the 24th and 25th.

Q. Now, then, give us March.

A. It is as follows:

March 1, 50,500, coli present,
" 2, 93,900, do.
" 3, 27,500, coli absent,
" 4, 40,100, coli present,
" 5, 39,200, coli absent,
266 " 6, 107,000, coli test not made,
" 7, sample lost,
" 8, sample lost,
" 9, 164,200, coli present,
" 10, 230,900, coli present,
" 11, 191,800, coli absent,
" 12, 190,100, coli present,
" 13, 237,000, coli present,
" 14, 277,200, coli absent,
" 15, 524,300, do.
" 16, 377,900, coli present,
" 17, 841,100, do.
" 18, 440,800, coli absent,
" 19, 695,100, coli present,
" 20, 474,500, coli present,
" 21, 345,800, coli absent,
" 22, 368,000, coli present,
" 23, 315,500, coli present,
" 24, 175,000, coli absent,
" 25, 288,500, coli present,
" 26, 236,500, coli absent,
" 27, 53,300, coli absent,
" 28, 88,000, coli present,
" 29, 47,500, coli absent,
" 30, 44,300, do.
" 31, 81,000, do.

267 April 1, 82,500, coli absent,
" 2, 84,000, coli present,
" 3, 68,500, do.
" 4, 111,000, do.
" 5, 91,000, coli absent,
" 6, 39,000, coli present,
" 7, 62,500, coli absent,
" 8, 60,500, do.
" 9, 75,400, coli present,
" 10, 92,000, do.
" 11, 39,500, do.
" 12, 50,500, do.
" 13, 52,000, do.
" 14, 55 500, coli test not made,
" 15, 57,500, do.
" 16, 89,500, coli present,
" 17, 44,000, do.
" 18, 29,000, do.
" 19, 18,500, do.
" 20, 12,000, coli absent,
" 21, 16,800, coli present,
" 22, 7,000, coli absent,
" 23, 19,900, coli absent,
" 24, 29,000, coli present,
" 25, 16,400, do.
" 26, 6,800, coli absent,
268 " 27, 7,000, coli present,
" 28, 10,300, coli absent,
" 29, 13,500, do.
" 30, 1,600, do.
May 1, 1,300, tests not made,
" 2, 1,300, coli present,
" 3, 2,000, coli absent,
" 4, 2,500, coli present,
" 5, 2,400, coli present,
" 6, 27,000, coli absent,
" 7, 37,300, tests not made,
" 8, 27,600, coli present,
" 9, 41,400, do.
" 10, 112,200, coli absent,

May 11, 79,600, coli present,
" 12, 48,500, coli absent,
" 13, 106,000, coli absent,
" 14, 33,100, do.
" 15, 20,800, coli present,
" 16, 26,000, do.
" 17, 16,200, do.
" 18, 77,000, coli absent,
" 19, 42,800, coli present,
" 21, 77,000, coli absent,
269 " 22, 29,400, coli absent,
" 23, 39,300, coli present,
" 24, 61,100, coli present,
" 25, 29,400 do.
" 26, 5,200, do.
" 27, sample lost,
" 28, 11,900, coli present,
" 29, 96,000, coli absent,
" 30, 10,200, coli present,
" 21, 8,800, do.
June 1, 37,700, coli present,
" 2, 24,900, do.
" 3, 48,600, do.
" 4, 19,100, do.
" 5, 49,400, do.
" 6, 11,000, coli absent,
" 7, 11,300, do.
" 8, 15,300, coli present,
" 9, 32,300, do.
" 10, 19,200, do.
" 11, 18,200, coli absent,
" 12, 38,300, do.
" 13, 49,200, coli present,
" 14, 40,500, coli absent,
270 " 15, 21.600, coli present,
" 16, 38,000, coli present,
" 17, 32,200, coli absent,
" 18, 48,500, do.
" 19, 34,000, do.
" 20, 27,400, do

June 21, 38,700, coli absent,
" 22, 42,000, do.
" 23, 27,300, do.
" 24, 41,100, coli present,
" 25, 60,500, do.
" 26, 39,300, do.
" 27, 31,100, do.
" 28, 11,900, coli absent,
" 29, 10,500, coli present,
" 30, 12,200, coli absent,
July 1, 18,300, coli absent,
" 2, 13,900, coli present,
" 3, 1,200, do.
" 4, 1,100, do.
" 5, 2,200, do.
" 6, 1,900, do.
" 7, 1,100, do.
" 8, 2,300, do.
271 " 9, 2,200, coli absent,
" 10, 3,300, coli present,
" 11, 1,100, do.
" 12, 13,200, do.
" 13, 18,800, do.
" 14, 13,000, do.
" 15, 26,000, do.
" 16, 15,800, do.
" 17, 29,600, coli absent,
" 18, 31,300, do.
" 19, 34,500, coli present,
" 20, 11,700, coli absent,
" 21, 23,500, coli present,
" 22, 6,500, coli test not made,
" 23, 7,600, coli absent,
" 24, 11,200, coli present,
" 25, 27,800, coli absent,
" 26, 31,200, coli absent,
" 27, 15,600, coli present,
" 28, 15,000, do.

July 29, 6,600, coli present,
“ 30, 15,800, do.
“ 31, 37,000, do.
August 1, 8,300, coli present,
“ 2, 10,100, coli present,
272 “ 3, 5,800, coli present,
“ 4, 8,100, do
“ 5 7,200, do
“ 6, 5,100, do
“ 7, 7,300, do
“ 8, 4,000, do
“ 9, 7,900, do
“ 10, 6,300, do
“ 11, 8,500, do
“ 12, 5,900, do
“ 13, 4,800, do
“ 14, 41,400, do
“ 15, 2,700, do
“ 16, 3,400, do
“ 17, 5,600, do
“ 18, 4,200, do
“ 19, 2,100, do
“ 20, 8,500, do
“ 21, 5,600, do
“ 22, 3,100, do
“ 23, 16,800, do
“ 24, 19,900, do
“ 25, 7,700, do
“ 26, 10,100, do
“ 27, 8,100, do
“ 28, 11,100, do
273 “ 29, 15,100, do
“ 30, 6,900, do
“ 31, 6,900, do
September 1, 15,600, coli present,
“ 2, 7,900, do
“ 3, 9,500, do
“ 4, 7,500, do

	September	5,	9,600,	coli present,
	“	6,	10,900,	do
	“	7,	16,400,	do
	“	8,	11,600,	do
	“	9,	22,700,	do
	“	10,	5,400,	do
	“	11,	6,000,	do
	“	12,	4,300,	do
	“	13,	5,800,	do
	“	14,	4,900,	do
	“	15,	3,800,	do
	“	16,	4,300,	do
	“	17,	7,800,	do
	“	18,	7,600,	do
	“	19,	7,100,	do.
	“	20,	sample lost,	
	“	21,	63,000,	coli present,
274	“	22,	21,900,	do
	“	23,	57,000,	do
	“	24,	sample lost,	
	“	25,	43,600,	coli present,
	“	26,	18,000,	do
	“	27,	42,500,	do
	“	28,	11,600,	do
	“	29,	18,800,	coli present,
	“	30,	20,000,	do
	October	1,	29,000,	coli present,
	“	2,	24,400,	do
	“	3,	37,600,	do
	“	4,	29,600,	do
	“	5,	15,400,	do
	“	6,	30,800,	do
	“	7,	17,600,	do
	“	8,	10,600,	do
	“	9,	19,200,	do
	“	10,	12,600,	do
	“	11,	sample lost,	
	“	16,	sample lost,	

October 17, 5,400, coli present,
" 18, 4,100, do
" 19, 6,400, do
" 20, 5,000, do
275 " 21, 7,300, do
" 22, 5,300, do
" 23, 7,000, do
" 24, 9,000, do
" 25, 11,800, do
" 26, 11,600, do
" 27, 24,600, do
" 28, 9,200, do
" 29, 14,000, do
" 30, 23,200, do
" 31, 13,900, do

Adjourned until two o'clock P. M., February 19, 1903.

2:00 P. M., Thursday, February 19, 1903.

276 Continuation after recess.

Present, Commissioner and same counsel.

DR. AMAND N. RAVOLD,

DIRECT-EXAMINATION, (Cont'd),

By Mr. Jeffries.

Q. Doctor, you have just given the result of the examination of the character of the Missouri River water on the Missouri side of the in-take—

A. Mississippi River water.

Q. Mississippi River water, yes.

MR. HAMLIN: On the Missouri side.

A. On the Missouri side.

Q. MR. JEFFRIES: Now you also stated that you examined the water during this same period near the mouth of the in-take and on the Illinois side?

A. Yes sir.

March 18, 351,600, coli present,
March 19, 587,000, do.
March 20, 539,500, do.
March 21, 243,000, coli absent,
March 22, 141,500, do.
March 23, 263,500, coli present,
280 March 24, 213,000, coli present,
March 25, 200,000, coli absent,
March 26, 176,000, do.
March 27, 59,000, coli present,
March 28, 118,500, do.
March 29, 52,800, do.
March 30, 113,800, do.
March 31, 38,000, do.
April 1, 72,500, coli absent,
April 2, 2,600, coli present,
April 3, 38,500, coli absent,
April 4, 37,500, do
April 5, 26,500, do.
April 6, 34,500, do.
April 7, 66,000, do.
April 8, 59,000, do.
April 9, 71,000, coli present,
April 10, 70,500, do.
April 11, 22,500, do.
April 12, 29,800, coli absent,
April 13, 27,500, do.
April 14, 21,000, coli test not made,
April 15, 39,500, coli test not made,
April 16, 49,500, coli test not made,
April 17, 29,500, coli present,
281 April 18, 6,800, coli absent,
April 19, 14,500, coli present,
April 20, 4,400, do.
April 21, 8,400, coli absent,
April 22, 9,300, do.
April 23, 27,500, coli present,
April 24, 27,600, coli absent,

April 25, 54,000, coli absent,
April 26, 6,900, do.
April 27, 2,400, do.
April 28, 2,700, do.
April 29, sample lost,
April 30, 750, coli present.
That's all.

MR. DRENNAN: That is in October?

A. April.

May 1, 500, coli test not made,
May 2, 600, coli present,
May 3, 950, do.
May 4, 450, do.
May 5 1,400, do.
May 6, 12,500 do.
May 7, 6,300, coli test not made,
May 8, 16,600, coli present,
May 9, 4,200, coli present,
282 May 10, 17,500, do.
May 11, 41,900, coli present,
May 12, 12,700, coli absent,
May 13, 41,000, do.
May 14, 16,400, do.
May 15, 14,500, do.
May 16, 17,900, do.
May 17, 14,300, coli present,
May 18, 10,700, do.
May 19, 13,600, do.
May 20, 23,800, coli absent,
May 21, 7,200, do.
May 22, 4,900, do.
May 23, 13,000, coli test not made,
May 24, 14,000, coli present,
May 25, sample lost,
May 26, 74,000, coli test not made,
May 27, sample lost,
May 28, 6,500, coli present,
May 29, 13,200, do.

May 30, 23,300, coli present,
May 31, 36,500, do.
June 1, 31,800, coli present,
" 2, 11,300, coli absent,
283 " 3, 16,200, coli present,
" 4 22,300, do
" 5, 5,000, do
" 6, 15,500, do
" 7, 4,400, do
" 8, 62,200, do
" 9, 20,000, do
" 10, 41,100, do
" 11, 33,600, do
" 12, 12,100, do
" 13, 23,300, coli absent,
" 14, 29,000, coli present,
" 15, 33,200, coli present,
" 16, 12,600, do
" 17, 12,400, do
" 18, 29,300, do
" 19, 19,700, coli absent,
" 20, 11,500, coli present,
" 21, 9,900, coli present,
" 22,45,600, coli absent,
" 23, 17,100, coli present,
" 24, 26,600, coli present,
" 25, 14,700, coli present,
284 "26, 19,000, coli present,
" 27, 13,100, do
" 28, 9,800, do
" 29, 9,200, do
" 30, 4,500, do
That is all for June.
July 1, 8,000, present,
" 2, 8,600, do
" 3, 8,100, present,
" 4, 3,900, present,
" 5, sample lost,

July 6, 21,000, coli present,
" 7, 6,800, do
" 8, 6,100, do
" 9, 18,000, do
" 10, 12,900, do
" 11, 5,100, absent,
" 12, 7,800, present,
" 13, 7,000, do
" 14, 8,300, do
" 15, 4,800, absent,
" 16, 8,900, do
" 17, 12,900, present,
" 18, 11,500, absent,
" 19, 8,500, present,
285 " 20, 2,900, present,
" 21,10,500, absent,
" 22, 4,900, present,
" 23, 2,600, present,
" 24, 1,000, present,
" 25, 5,600, absent,
" 26, 6,600, present,
" 27, 5,200, present,
" 28, 4,000, absent,
" 29, 4,400, present,
" 30, 3,000, absent,
" 31, 4,000, present,
August 1, 7,100, present,
" 2, 5,700, present,
" 3, 7,400, present,
" 4, 1,800, present,
" 5, 3,200, present,
" 6, 3,800, present,
" 7, 2,700, present,
" 8, 9,100, present,
" 9, 4,500, present,
" 10, 3,000, present,
286 " 11, 4,400, present,
" 12, 2,400, present,

August 13, 650, present,
" 14, 25,500, present,
" 15, 2,800, present,
" 16, 1,900, present,
" 17, 1,600, present,
" 18, 2,200, present,
" 19, 1,000, present,
" 20, 3,000, present,
" 21, 3,100, present,
" 22, 3,000, present,
" 23, 2,600, present,
" 24, 5,300, present,
" 25, 3,400, present,
" 26, 1,700, present,
" 27, 3,900, present,
" 28, 4,800, present,
" 29, 3,000, present,
" 30, 2,300, present,
" 31, 1,500, present,
September 1, 21,700, present,
" 2, 18,500, present,
" 3, 7,600, present,
" 4, 2,000, present,
287 " 5, 2,100, present,
" 6, 1,600, present,
" 7, 2,400, present,
" 8, sample lost,
" 9, 1,100, present,
" 10, 2,900, present,
" 11, 850, present,
" 12, 1,400, present,
" 13, 1,900, present,
" 14, 1,200, present,
" 15, 1,300, present,
" 16, 800, present,
" 17, 1,700, present,
" 18, 2,000, present,
" 19, 2,400, present

September 20, sample lost,
" 21, 87,500, present,
" 22, 5,300, present,
" 23, 22,100, present,
" 24, 8,900, present,
" 25, 7,000, present,
" 26, 8,800, present,
" 27, 34,000, present,
" 28, 4,700, present,
288 " 29, 22,600, present,
" 30, 8,800, present,
October 1, 4,000, present,
" 2, 56,000, present,
" 3, 9,000, present,
" 4, 7,600, present,
" 5, 7,400, present,
" 6, 2,800, present,
" 7, 4,000, present,
" 8, 4,000, present,
" 9, 2,600, present,
" 10, 2,500, present,
" 11, sample lost,
" 12, no sample,
" 13, no sample,
" 14, no sample,
" 15, do
" 16, do
" 17, 2,100, present,
" 18, 750, present,
" 19, 2,500, test not made,
" 20, 1,300, present,
" 21, 1,100, coli test not made,
" 22, 6,600, present,
289 " 23, 1,200, coli present,
" 24, 1,500, present,
" 25, 1,200, do
" 26, 1,700, do
" 27, 850, do

October 28, 1,000, present,
" 29, 750, do
" 30, 6,200, do
" 31, 2,750, do

That is the end of that.

MR. JEFFRIES: At what distance was the other examination made of this series of three examinations from the intake?

A. From the intake?

Q. Yes.

A. Well, as I said, the Missouri sample was taken about 300 yards from the Missouri shore in a line about 100 yards or, well say 100 yards above the intake. The idea was to have a line run straight across the rvier just in front of the intake so that the men in the boat went out and collected the samples at practically the same place every morning.

Q. Then it would be about 100 yards up the river from the mouth of the intake.

A. About 100 yards up the river. Yes.

Q. Now what was the relative per centum of coli bacillus in this examination at the mouth of the river?

A. I gave you that just a moment ago. The colon bacilli
290 was found in 68 per cent. of the samples collected daily at this point.

MR. DRENNAN: That is, it was found in 68 per cent of the samples?

A. Yes.

MR. DRENNAN: That is, it is not 68 per cent of the samples themselves?

A. No.

MR. JEFFRIES: That is, it was found in 68 out of 100 samples taken

A. Yes sir.

Q. Now that is at the mouth of the intake, immediately above the intake?

A. No sir, that was on the Illinois shore.

Q. I am speaking with reference to the per cent at the mouth of the intake

A. Now we are going back. The bacteriological character of the Mississippi river at the intake of the St. Louis water works, chain of rocks—

Q. That is it. What was the per centage?

A. Colon bacillus was found in 62 per cent. of the daily samples taken at this point.

Q. This examination was made at the same time?

A. This examination was made for the results of quanti-
291 tive determination of bacteria in the Mississippi river
water at the intake of the St. Louis water works, at the Chain of Rocks together with results of tests, for bacillus coli communis.—bacteria per cubic centimeter. We began on the 23rd of January, 1900, and ended October 31, 1900.

Q. Now you can give us the result of this third table of examinations.

A. Beginning January 23.

January 23, 16,000, coli absent,
" 24, sample lost,
" 25, 123,400, coli absent,
" 26, 81,400, coli present,
" 27, 344,400, do
" 28, 170,700, do
" 29, 174,300, test not made,
" 30, 299,000, absent,
" 31, 126,200, coli absent,
February 1, sample lost,
" 2, 78,700, coli absent,
" 3, 130,300, do
" 4, 68,100, do
" 5, 107,500, do
" 6, 70,200, do
" 7, 88,900, do
" 8, 103,600, do
292 " 9, 339,700, do
" 10, 64,400, do
" 11, 78,700, do
" 12, 80,600, do
" 13, 75,300, test not made,
" 14, 145,900, coli present,

February 15, 181,500, coli present,
" 16, 132,300, do
" 17, test not made,
" 18, sample lost,
" 19, sample lost,
" 20, 107,000, coli absent,
" 21, sample lost,
" 22, 154,300, coli present,
" 23, 74,000, do
" 24, sample lost,
" 25, "
" 26, "
" 27, "
" 28, "
March 1, sample lost,
" 2, 51,300, coli present,
" 3, 481, absent,
" 5, 63,000, absent,
" 6, 135,700, present,
" 7, sample lost,
" 8, 236,700, absent,
" 9, 106,200, absent,
" 10, 216,500, "
" 11, 197,800, absent,
" 12, 186,100, present,
" 13, 241,300, absent,
" 14, 227,500, absent,
" 15, 420,900, present,
" 16, sample lost,
" 17, 887,000, absent,
" 18, 575,700, present,
" 19, 559,300, present,
" 20, 538,500, present,
" 21, 469,500, absent,
" 22, 493,000, present,
" 23, 599,000, present,
" 24, 672,000, absent,
" 25, 431,000, present,

March 26, 379,000, present
" 27, 166,500, absent,
" 28, 131,300, absent,
" 29, 89,000, absent,
294 " 30, 117,300, absent,
" 31, 128,500, present,
April 1, 104,000, absent,
" 2, 93,000, present,
" 3, 107,000, present,
" 4, 60,000, present,
" 5, 20,700, absent,
" 6, 127,500, absent,
" 7, 160,000, absent,
" 8, 203,000, absent,
" 9, 149,500, present,
" 10, 197,500, present,
" 11, 88,000, absent,
" 12, 71,500, present,
" 13, 84,500, present,
" 14, 57,000, absent,
" 15, 70,500, present,
" 16, 59,500, coli test not made,
" 17, 58,000, present,
" 18, 24,500, absent,
" 19, 27,500, present,
" 20, 9,700, present,
" 21, 30,800, absent,
" 22, 56,300, absent,
" 23, 28,500, present,
295 " 24, 11,800, present,
" 25, 14,600, present,
" 26, 18,500, absent,
" 27, 19,600, present,
" 28, 11,800, absent,
" 29, 5,600, present,
" 30, 850, absent,
May 1, 1,400, coli test not made,
" 2, 1,700, coli absent,

May 3, 3,300, present,
" 4, 1,900, present,
" 5, 1,700, present,
" 6, 181,000, present,
" 7, 21,200, coli test not made,
" 8, 23,500, present,
" 9, 15,500, present,
" 10, 97,400, present,
" 11, 63,700, present,
" 12, 30,600, present,
" 13, 81,500, present,
" 14, 38,500, present,
" 15, 36,300, present,
" 16, 26,100, absent,
" 17, 23,200, absent,
" 18, 12,300, absent,
296 " 19, 23,200, absent,
" 20, 27,400, absent,
" 21, 42,200, absent,
" 22, 14,800, present,
" 23, 22,200, present,
" 24, 60,500, present,
" 25, sample lost,
" 26, 5,200, present,
" 27, sample lost,
" 28, 9,800, present,
" 29, 17,000, present,
" 30, 6,300, present,
" 31, 5,000, present,
June 1, 12,500, present,
" 2, 29,400, present,
" 3, 22,500, absent,
" 4, 25,300, present,
" 5, 9,200, present,
" 6, 15,000, present,
" 7, 21,100, absent,
" 8, 16,700, present,
" 9, 32,400, absent,

June 10, 31,500, present,
" 11, 39,800, present,
" 12, 17,100, present,
297 " 13, 48,000, present,
" 14, 37,400, absent,
" 15, 12,100, present,
" 16, 12,200, present,
" 17, 21,000, absent,
" 18, 36,200, absent,
" 19, 25,000, coli test not made,
" 20, 17,600, coli absent,
" 21, 26,000, do
" 22, 29,400, do .
" 23, 27,600 present,
" 24, 32,300, present,
" 25, 25,600, present,
" 26, 42,300, absent,
" 27, 22,300, present,
" 28, 11,000, present,
" 29, 13,500, absent,
" 30, 8,200, absent,
July 1, 13,200, coli present,
" 2, 9,100, do
" 3, 14,000, absent,
" 4, 10,000, coli test not made,
" 5, sample lost,
" 6, 15,700, present,
298 " 7, 8,300, present,
" 8, 14,300, present,
" 9, 14,400, present,
" 10, 21,500, present,
" 11, 8,900, absent,
" 12, 9,200, present,
" 13, 7,900, present,
" 14, 28,300, present,
" 15, 9,300, present,
" 16, 4,100, absent,
" 17, 29,400, present,

July 18, 11,200, absent,
" 19, 16,000, absent,
" 20, 7,800, absent,
" 21, 13,400, coli test not made,
" 22, 8,100, absent,
" 23, 48,400, present,
" 24, 12,900, present,
" 25, 13,000, absent,
" 26, 15,800, present,
" 27, 8,800, present,
" 28, sample lost,
" 29, 18,300, present,
" 30, 9,500, present,
" 31, 8,700, present,
August 1, 11,600, present,
" 2, 5,400, present,
299 " 3, 5,800, "
" 4 5,700, "
" 5 3,300, "
" 6 10,500, "
" 7, sample lost,
" 8, 6,900, present,
" 9, 5,100, "
" 10, 4,200, "
" 11, 10,100, "
" 12, 2,800, "
" 13, 4,300, "
" 14, 24,800, "
" 15, 14,100, "
" 16, 1,600, "
" 17, 2,700, "
" 18, 8,900, "
" 19, 3,100, "
" 20, 4,400, "
" 21, 8,900, "
" 22, 4,400, "
" 23, 9,200, "
" 24, 7,600, "

August 25, 3,300, present,
" 26, 5,300, "
" 27, 6,200, coli present,
" 28, 11,200, do
" 29, 8,700, do
300 " 30, sample lost,
" 31, 6,800, present,
September 1, 45,000, coli present,
" 2, 7,300, do
" 3, 5,100, do
" 4, 6,000, do
" 5, 6,000, do
" 6, 7,100, do
" 7, 9,900, do
" 8, 8,400, do
" 9, 8,600, do
" 10, 67,000, do
" 11, 5,400, do
" 12, 4,400, do
" 13, 4,100, do
" 14, 3,900, do
" 15, 3,600, do
" 16, 4,200, do
" 17, 6,200, do
" 18, 5,300, do
" 19, 9,000, do
" 20, sample lost,
301 " 21, 91,000, present,
" 22, 45,900, present,
" 23, 58,100, present,
" 24, 53,800, "
" 25, 33,000, "
" 26, 48,400, "
" 27, 34,500, "
" 28, 9,900, "
" 29, 13,800, "
" 30, 21,400, "

October 1, 19,200, coli present,
" 2, 17,000, do
" 3, 16,600, do
" 4, 21,400, do
" 5, 26,000, do
" 6, 17,800, do
" 7, 10,200, do
" 8, 8,800, do
" 9, 13,400, do
" 10, 10,700, do
" 11, 7,700, do
" 12, 17,600, do
" 13, 5,600, do
" 14, 16,400, do
" 15, 6,800, do
" 16, 4,600, do
302 " 17, 5,400, do
" 18, 2,800, do
" 19, 5,300, do
" 20, 4.300. do
" 21, 5,800, coli test not made,
" 22, 6,900, coli present,
" 23, 5,300, do
" 24, 7,400, do
" 25, 4,700, do
" 26, 5,400, do
" 27, 9,600, do
" 28, 7,500, do
" 29, 8,800, do
" 30, 5,400, do
" 31, 9,600, do

That ends that. Do you want the bacteriological flora at the Mississippi river intake tower?

Q. Yes.

A.

(The bacteriological flora of the Illinois shore sample to be inserted here.) Not furnished, F. S. B., Com'r.

THE WITNESS: The bacteriological flora of the Mississippi river at the intake tower:

Bacillus antitenniformis
" aquatilis sulcatus V
" aurescens
" cereus
" cloacae
" delicatulus
" fluorescens liquifaciens
" helvolus
" iridescens
" lacti viscosus
" liquidus
" megaterium
" stellatus
" subtilis
" ubiquitus
" viridis

MR. JEFFRIES: During this second period, what examination was made of the water from the reservoir?

A. Samples of water were collected for analysis from basin No. 3, the water having rested 70 hours.

Q. What is the capacity of basin No. 3, if you know?

A. It has a holding capacity of 29,000,000 gallons.

MR. SPRINGER: Have you the data for that?

A. Yes. Quantative determination of sample from the reservoir, Chain of Rocks, varies somewhat. Each reservoir has a capacity of 29,000,000 gallons. There are six of these basins.

The samples of water collected for this analysis were taken
304 from basin No. 3, the water having a subsidence of about
70 hours. Do you care to know what the per centage of
figures are in that sedimentation?

Q. Yes, you might just as well give that here, Doctor.

A. It is interesting to note that the average number of bacteria in samples collected at this period—during the second period of 37 weeks was 56 per cent. of the number found in samples collected at the intake tower. 44 per cent. of the bacteria in the water taken into the reservoir, therefore, were removed by this 70 hours subsidence—by this sedimentation.

We don't care to say anything about the third period at all.

Q. When the water goes into these reservoirs it becomes perfectly still, doesn't it?

A. No, it is not absolute quiescence, but it is the water flowing from one end of the large reservoir to the other.

MR. SPRINGER: Within that time?

A. Yes, 70 hours.

MR. JEFFRIES: The only movement of the water is that caused by the water flowing into and on through the reservoirs?

A. Yes, the quantity flowing in and flowing out, during the time it is in transit, during the time it travels across it would be about 70 hours.

MR. DRENNAN: When you refer to the intake tower, you
305 refer to the samples taken just above the intake tower?

A. Yes, I refer to samples taken just above the intake tower.

Q. But the last one of the series you have just given?

A. Yes sir, it is a sample right in front of the tower. You see it is difficult to get a sample in the tower.

Q. That you have compared with the set that you have just read last?

A. Yes sir. The colon bacillus was found in 65 per cent. of the daily samples collected at this point during this period.

MR. SPRINGER: Inside of the tank in the reservoir?

A. Yes, in this water going through.

Q. After the sedimentation?

A. Yes sir.

MR. JEFFRIES: While it is in a state of sedimentation?

A. Yes, sir, after the 70 hours we found 65 per cent of coli in the daily samples collected at this point during this period.

MR. DRENNAN: 65 per cent. of coli and not 65 per cent. of the samples?

A. No, 65 per cent. of the number of samples collected.

MR. DRENNAN: You found coli in 65 per cent. of the samples collected?

A. Yes sir.

306 MR. SPRINGER: Out of 65 of every 100 samples you found coli?

A. Yes, sir; that is it.

MR. SPRINGER: That is, in the reservoir?

A. Yes, sir; that is the water as it flows out of the reservoir into the conduit.

MR. JEFFRIES: Now, you say you have the quantitive determination in the samples collected from those reservoirs?

A. Yes.

Q. When were those collections and examinations made?

A. If you will just let me get the good one of these tables I will give you the results.

Results of the quantitive determination of bacteria in samples of water collected from the reservoir of the St. Louis water works at the Chain of Rocks, together with the results of tests for bacillus coli communis, from January 23, 1900, to October 10, 1900.

January 23, 5,400, coli absent,
" 24, sample lost,
" 25, 87,500, coli present,
" 26, 7,400, do.
" 27, sample lost,
" 28, 50,400, no tests made for coli,
" 29, 97,500, do.
" 30, 105,100, coli absent,
307 " 31, 124,700, coli absent,
February 1, 94,900, coli absent,
" 2, 118,800, coli present,
" 3, 110,600, absent,
" 4, 87,300, do.
" 5, 127,500, do.
" 6, 41,700, do.
" 7, 2,700, do.
" 8, 15,500, tests not made,
" 9, 18,300, absent,

February 10, 23,400, absent,
" 11, 38,000, absent,
" 12, 58,600, absent,
" 13, 47,500, coli test not made,
" 14, 90,200, coli absent,
" 15, 104,000, do.
" 16, 119,000, do.
" 17, 90,800, do.
" 18, 108,200, do.
" 19, 86,000, do.
" 20, 176,700, do.
" 21, 86,000, do.
" 22, 131,300, coli test not made,
" 23, 81,200, present,
308 " 24, 104,000, present,
" 25, 79,700, absent,
" 26, 85,500, absent,
" 27, sample lost,
" 28, sample lost,
March 1, 73,400, present,
" 2, 58,100, present,
" 3, 29,300, absent,
" 4, 50,700, present,
" 5, 54,200, absent,
" 6, 48,300, absent,
" 7, 52,100, absent,
" 8, 72,400, absent,
" 9, 60,800, absent,
" 10, 75,800, absent,
" 11, 96,100, present,
" 12, 83,200, present,
" 13, sample lost,
" 14, 104,100, present,
" 15, 157,700, present,
" 16, 149,500, absent,
" 17, 408,200, present,
" 18, 370,600, present,
" 19, 327,000, present,

March 20, 431,300, present,
309 " 21, 252,000, present,
" 22, 346,300, present,
" 23, 404,500, do.
" 24, 298,000, absent,
" 25, 499,000, absent,
" 26, 215,500, present,
" 27, 106,000, absent,
" 28, 129,000, absent,
" 29, 58,300, absent,
" 30, 63,300, absent,
" 31, 61,500, absent,
April 1, 94,000, coli present,
" 2, 25,000, do.
" 3, 46,300, do.
" 4, 47,800, absent,
" 5, 37,000, present,
" 6, 25,000, absent,
" 7, 65,000, absent,
" 8, 49,500, present,
" 9, 116,500, absent,
" 10, 28,800, present,
" 11, 66,500, absent,
" 12, 36,500, present,
" 13, 34,500, absent,
310 " 14, 22,000, absent,
" 15, 34,000, coli test not made,
" 16, 26,000, do.
" 17, 21,500, present,
" 18, 9,500, present,
" 19, 8,000, present,
" 20, 3,600, present,
" 21, 10,000, absent,
" 22, 2,900, present,
" 23, 3,800, absent,
" 24, 43,000, present,
" 25, 4,100, absent,
" 26, 5,300, absent,

April 27, 10,800, absent,
" 28, 3,450, present,
" 29, 1,900, absent,
" 30, 300, present,
May 1, 400, coli test not made,
" 2, 750, do
" 3, 1,000, absent,
" 4, 1,500, present,
" 5, 1,200, present,
" 6, 32,500, present,
" 7, 12,400, coli test not made,
311 " 8, 15,200, present,
" 9, 7,600, absent,
" 10, 16,400, present,
" 11, 34,100, present,
" 12, 21,600, absent,
" 13, 53,500, absent,
" 14, 14,800, absent,
" 15, 14,400, absent,
" 16, 15,200, present,
" 17, 4,000, absent,
" 18, 5,900, absent,
" 19, 4,400, present,
" 20, 14,500, absent,
" 21, 43,200, coli test not made,
" 22, 3,300, do
" 23, 4,500, present,
" 24, 5,000, present,
" 25, no test,
" 26, 3,300, present,
" 27, sample lost,
" 28, 4,100, present,
" 29, 1,400, present,
" 30, 10,400, present,
June 1, 10,000, coli present,
" 2, 12,300, do
" 3, 4,900, do
312 " 4, 14,300, do

June 5, 3,500, coli present,
" 6, 11,000, do
" 7, 3,400, do
" 8, 3,700, do
" 9, 4,000, do
" 10, 4,700, do
" 11, 2,900, do
" 12, 9,800, absent,
" 13, 11,700, present,
" 14, 7,100, absent,
" 15, 12,900, present,
" 16, 6,200, present,
" 17, 31,400, present,
" 18, 7,100, present,
" 19, 6,000, test not made,
" 20, 6,400, present,
" 21, 4,600, absent,
" 22, 9,900, absent,
" 23, 10,300, present,
" 24, 18,200, present,
" 25, 8,800, present,
" 26, 9,100, absent,
" 27, 6,600, present,
313 " 28, 3,600, present,
" 29, 6,400, absent,
" 30, 2,800, absent,
July 1, 21,500, absent,
" 2, 3,800, coli present,
" 3, 8,100, do
" 4, 4,800, do
" 5, 3,400, do
" 6, 6,700, do
" 7, 1,600, do
" 8, 4,700, do
" 9, 4,600, do
" 10, 8,700, do
" 11, 2,600, do
" 12, 4,200, do

July 13, 6,100, coli present,
" 14, 5,100, do
" 15, 5,400, do
" 16, 6,000, absent,
" 17, 9,400, present,
" 18, 1,800, present,
" 19, 2,800, present,
" 20, 3,900, absent,
" 21, 2,900, present,
314 " 22, 2,000, present,
" 23, 2,400, absent,
" 24, 550, present,
" 25, 3,100, present,
" 26, 2,600, test not made,
" 27, 2,000, present,
" 28, 2,700, present,
" 29, 5,400, present,
" 30, 2,500, present,
" 31, 5,500, present,
August 1, 5,000, present,
" 2, 6,400, present,
" 3, 2,300, present,
" 4, 1,300, present,
" 5, 600, present,
" 6, 4,300, "
" 7, 1,400, "
" 8, 4,100, "
" 9, 1,200, "
" 10, 1,900, "
" 11, 2,100, "
" 12, 1,600, "
" 13, 2,600, "
315 " 14, 4,400, "
" 15, 4,700, "
" 16, 3,300, "
" 17, 5,800, "
" 18, 800, "
" 19, 3,600, "

August 20, 500, present,
" 21, 1,500, "
" 22, 1,100, "
" 23, 2,800, "
" 24, 2,300, "
" 25, 2,400, "
" 26, 2,400, "
" 27, 2,500, "
" 28, 1,200, "
" 29, 2,500, "
" 30, 3,800, "
" 31, 3,300, "
September 1, 3,300, coli present,
" 2, 5,700, do
" 3, 4,200, do
" 4, 2,100, do
" 5, 1,700, do
" 6, 4,100, do
316 " 7, 2,700, do
" 8, 3,600, do
" 9, 2,800, do
" 10, sample lost,
" 11, 1,000, coli present,
" 12, 1,100, do
" 13, 1,100, do
" 14, 2,800, do
" 15, 16,000, do
" 16, 650, do
" 17, 2,600, do
" 18, 4,400, do
" 19, 2,600, do
" 20, sample lost,
" 21, 175,200,—this looks like a misprint, but we will have to put it in. It looks like a mistake of the stenographer. We will have to look up that number, because that is an outrageous jump. No, just cut that out entirely.

September 22, 5,200, coli present,
" 23, 2,800, do

September 24, sample lost,
" 25, 5,900, coli present,
" 26, 4,000, do
" 27, 7,200, do
" 28, 1,800, do
317 " 29, 26,000, do
" 30, 31,000, do
October 1, 2,700, do
" 2, 2,600, coli present,
" 3, 2,300, do
" 4, 3,100, do
" 5, 5,100, do
" 6, 2,300, do
" 7, 3,900, do
" 8, 3,200, do
" 9, 4,400, do
" 10, 4,100, do

That is all.

MR. JEFFRIES: Now following this line of examination on out into the city supply, doctor, I will ask you to state what other examination or further examination was made during this period of 1900?

A. The water collected from a tap in the old city hall during this second period is here reported.

Q. Now where is the old city hall located?

A. On 11th street, between Market and Chestnut streets.

Q. Now it gets its supply from these reservoirs, does it?

A. Yes sir.

Q. That you have testified about?

318 A. Yes sir. I can read you that, which I have written here, and it is right in line.

Q. If that gives the location, you might read that.

A. The water pumped from the Mississippi river at the Chain of Rocks passes through the settling basins at this point, then after about 70 hours subsidence, it passes through an 11 foot conduit to the high service pumps at Baden, which is situated four and one-half miles from the chain of rocks. From this point the water is pumped into the stand pipe located at Compton

Hill reservoir, and distributed to the western part of the city, while the remainder flows through a nine foot conduit and empties into four reservoirs at Bissell's Point. Each of these reservoirs has a capacity of 15,000,000 gallons, and while the actual periods of subsidence of the water in these reservoirs cannot be accurately determined, it is stated to be three or four days on the average. During the second periods samples were collected from the outlets of these basins.—No samples were collected from these basins rather. There is no record of the samples taken in the basins.

Q. That comes at a later period?

A. Yes, that comes at a later period, we did that in the later period.

From these reservoirs the water passes into the distribut-
319 ing system of the city, so the water is turned in to the
stand-pipes at the foot of Grand avenue, and distributed to the eastern part of the city, in which the old city hall is located. So that is the low service pumps.

Q. Can you state about what the distance would be from the old city hall to the reservoir at Chain of Rocks?

A. From the old city hall, to Chain of Rocks, or Bissell's point?

Q. Well, Bissell's point first. We will follow it around as it goes.

A. I should say it is three miles from the city hall, as the crow flies, to Bissell's point, and from there it is here recorded, the distance, I just gave you, 4½ miles from Baden, and so many miles from Chain of Rocks.

Q. That is off in a northerly direction from the city hall?

A. Yes, northwest. During this period it is interesting to note that the average per centage removal of bacteria during the second period, 22 weeks from May 1 to October 9, 1900, found on comparing the results obtained from samples collected at the intake of the St. Louis water works, Chain of Rocks, and the tap in the bacteriological department of the old city hall, respectively was 90 per cent.

MR. HAMLIN: What was that?

A. 90 per cent, of bacteria removed from the intake be-
320 tween those points.

MR. SPRINGER: That is between the intake and the tap?

A. Yes. The bacillus coli communis was found in 71 per cent. of the samples collected during this period from May 1st to October 31st, 1900. This is what is known as the second period.

Q. Now you have the results of the analyses of the water taken at the tap at the old city hall?

A. Yes sir.

Q. Now will you give that?

A. Yes sir. Results of quantitative determination of bacteria and results of tests for bacillus coli communis from samples taken at the old city hall, 11th and Market streets, beginning May 11,—that is when we moved into this laboratory,—together with the results of tests for bacillus coli communis per cubic centimeter. May 11, 1900,—8,400, coli test not made.

May 12, 12,900,coli test not made,
" 13, 13,700, do
" 14, 5,100, do
" 15, 7,100, coli absent,
" 16, 5,800, do
" 17, 1,900, do
" 18, 1,900, do
" 19, 2,100, do
321 " 20, 3,600, "
" 21, 1,900, "
" 22, 1,000, "
" 23, 3,300, "
" 24, 3,700, "
" 25, 7,800, "
" 26, 3,000, coli present,
" 27, sample lost,
" 28, 2,500, coli present,
" 29, 1,600, "
" 30, 1,600, "
" 31, 2,100, "

June 1, 4,600, coli present,
" 2, 2,100, "
" 3, 1,600, "
" 4, 1,000, "
" 5, 1,300, "
" 6, 2,700, "
" 7, 1,100, absent,
" 8, 2,700, absent,
" 9, 1,500, present,
" 10, 2,400, present,
" 11, 2,800, absent,
" 12, 2,100, present,
322 " 13, 2,700, coli absent,
" 14, 1,400, "
" 15, 1,300, coli present,
" 16, 1,500, absent,
" 17, 1,400, "
" 18, 1,000,coli present,
" 19, 1,200, "
" 20, 800, "
" 21, 1,100, "
" 22, 1,600, coli absent,
" 23, 900, coli present,
" 24, 2,100, coli absent,
" 25, 1,700, coli present,
" 26, 1,800, "
" 27, 650, "
" 28, 500, "
" 29, 400, "
" 30, 600, "
July 1, 1,500, coli present,
" 2, 1,100, "
" 3, 750, "
" 4, 650, "
" 5, 375, "
" 6, sample lost,
323 " 7, 600, coli present,
" 8, 2,200, "

July 9, 1,400, coli present,
" 10, 700, coli test not made,
" 11, 700, coli present,
" 12, 1,300, coli absent,
" 13, 1,650, coli present,
" 14, 600, do
" 15, 700, coli absent,
" 16, 400, "
" 17, 400, coli present,
" 18, 600, "
" 19, 550, "
" 20, 650, coli absent,
" 21, 650, "
" 22, 800, coli present,
" 23, 350, coli test not made,
" 24, 900, coli present,
" 25, 750, "
" 26, 750, "
" 27, 750, "
" 28, 1,500, present,
" 29, 1,300, present,
" 30, 1,400, coli absent,
" 31, 1,100, coli present,
August 1, 1,600, coli present,
324 " 2, 350, "
" 3, 1,500, "
" 4, 1,100, "
" 5, 1,500, "
" 6, 900, "
" 7, 900, "
" 8, 1,300, "
" 9, 900, "
" 10, 700, "
" 11, 1,000, "
" 12, 450, "
" 13, 650, "
" 14, 1,700, "
" 15, 450, "

August 16, 900, coli present,
" 17, 550, "
" 18, 1,600, "
" 19, 200, "
" 20, 275, "
" 21, 350, "
" 22, 700, "
" 23, 900, "
" 24, 1,700, "
" 25, 1,000, "
325 " 26, 700, "
" 27, 850, "
" 28, 700, "
" 29, 700, "
" 30, 1,000, "
" 31, 500, "
September 1, 9,000, coli present,
" 2, 950, "
" 3, 650, "
" 4, 1,000, "
" 5, 1,100, "
" 6, 1,100, "
" 7, sample lost,
" 8, 950, coli present,
" 9, 900, "
" 10, 1,000, "
" 11, 800, "
" 12, 500, "
" 13, 750, "
" 14, 500, "
" 15, 700, "
" 16, 550, "
" 17, 950, "
" 18, 1,000, "
326 " 19, 800, "
" 20, sample lost,
" 21, 1,200, coli present,

September 22, 1,000, coli present,
" 23, 1,300, "
' 24, sample lost,
" 25, 1,200, coli present,
" 26, 1,900, "
" 27, 2,000, "
" 28, 1,400, "
" 29, 1,300, "
" 30, 2,600, "
October 1, 1,700, coli present,
" 2, 1,100, "
" 3, 1,200, "
" 4, 1,600, "
" 5, 1,700, "
" 6, 2,000, "
" 7, 2,100, "
" 8, 1,300, "
" 9, 1,700, "
" 10, 1,200, "
" 11, 1,600, "
" 12, 1,500, "
327 " 13, 1,400, coli absent,
" 14, 2,900, coli present,
" 15, 1,400, "
" 16, 1,900, coli absent,
" 17, 750, coli present,
" 18, 1,100, "
" 19, 650, "
" 20, 750, "
" 21, 950, "
" 22, 750, "
" 23, 750, "
" 24, 1,300, "
" 25, 800, "
" 26, 900, "
" 27, 1,400, "
" 28, 1,300, "
" 29, 1,400, "

October 30, 1,100, coli present,
" 31, 1,700, "

MR. JEFFRIES: Now the bacterial flora of the water that you have just testified about, was also examined was it not?

A. Yes sir.

Q. I would like you to give that if you will.

A. Bacterial flora of water taken from tap of the bacteriological laboratory, old city hall, St. Louis, Missouri, May to October, 1900.

Bacillus arborescens
" candicans
328 " cereus
" cloacae
" coli communis
" delicatulus
" desidiosus
" fluorescens teneus
" fulvus
" helvolus
" lacti viscosus
" liquefaciens
" megagerium
" proteus mirabilis
" proteus zenkeri
" rubefaciens
" stellatus
" viridis
Micrococus cremoides
" flavus liquefaciens
Sarcina lutea.

Q. Doctor, in your evidence heretofore, you have referred to what was known as the third period of examination?

A. Yes sir.

Q. I would like you to explain that and state fully what 329 was done in connection with that period, and also the time, month and years, in which it took place?

A. In July, 1901, a motion was adopted by the Municipal Assembly ordering a third investigation of the city water supply to be made. This period of investigation embraced the work done between August 26, and December 1, 1901.

Q. Now then, as to the plan of examination.

A. The plan of procedure was as follows: Temporary bacteriological laboratories were established and equipped with the necessary apparatus at the following points:

ATTORNEY GENERAL HAMLIN: This is between August 26 and—

A. And December 1.

MR. JEFFRIES: This period embraces work done between those two dates?

A. Yes sir, between those two periods inclusive.

Q. Inclusive?

A. Yes sir.

Q. Now then, give us the plan, doctor?

A. The first laboratory was established at Joliet, Illinois, 306 North Joliet street. It was under the charge of Dr. W. C. G. Kirchner.

A second laboratory was established at Peoria, Illinois, in the Young Men's Christian Association Building. Dr. William H. Rush was in charge of that laboratory.

330 The third laboratory was established at Grafton, Illinois, in the Dempsey House. Mr. Leon G. Tedesche was in charge of that laboratory.

A laboratory was established at 1141 Market street, St. Louis, with five assistant bacteriologists under the charge of the witness.

Samples were collected from the following points:

Desplaines river, above Lockport, from October 5, to November 25, 1901. That sample was collected about two miles up the river, well out of the reach—

Q. Above Lockport?

A. Above its junction with the Chicago drainage canal water, so there would be no back water in it.

Drainage canal, Bear Trap dam, above dam, September 26, to November 25, 1901.

Q. Now where was that collection made?

A. That was in the Chicago drainage canal above the dam.

MR. NICHOLSON: At Lockport?

A. At Lockport ,above the controlling works.

Illinois and Michigan canal, 9th street brdige, Lockport, Illinois, September 25, to October 30, 1901.

Drainage canal, 9th street bridge, Lockport, Illinois.

Now that was called the Desplaines river formerly, but now it is called the drainage canal.

MR. SPRINGER: Above the controlling works?

A. As the water flows through Lockport towards Joliet,
why, Mr. Randolph, in his nomenclature, constantly calls
331 it the drainage canal, and said that the Sanitary District
practically owned it down through Joliet. So when I say
drainage canal, 9th street bridge, Lockport, Illinois, that means
the Desplaines river to which is added the effluence from the
Chicago drainage canal. That is called there the canal.

MR, JEFFRIES: Now state the date of that?

A. October 2 to November 26.

Q. 1900?

A. 1900.

Drainage canal below Rubey street, Joliet, Illinois, September 25 to November 26, 1901.

Drainage canal, Brandon's bridge, Joliet, September 25 to November 26, 1901.

Illinois river, at a point known as Shady Beach, about three miles above Peoria, Illinois, October 1, to November 27, 1901.

Illinois river, above railroad bridge, Pekin, Illinois. October 1, to November 27. This station is five miles below the lowest Peoria sewer.

Illinois river, Kingston, three miles below Pekin, Illinois, October 4 to November 27, 1901.

Illinois river, three miles above Grafton, Illinois, October 4 to November 27, 1901.

Mississippi river, two miles above Grafton, Illinois, Octo-
332 ber 4, to November 30, 1901.

Mississippi river, one mile above Alton, Illinois, October 5, to November 30, 1901.

Mississippi River, opposite Hartford, Illinois, October 5, to November 30, 1901.

Missouri river, opposite Fort Bellefontaine, October 4 to November 30, 1901.

Mississippi river, Chain of Rocks near Illinois shore, September 14 to November 30, 1901.

Mississippi River, Chain of Rocks near the Missouri shore, September 14, to November 30, 1901.

Mississippi river, intake tower, September 14 to November 30, 1901.

Q. Now that is intake tower at the Chain of Rocks?

A. At the Chain of Rocks, yes.

Reservoir at Chain of Rocks, September 15 to November 30.

Reservoir, Bissell's Point, September 16 to November 30.

Tap laboratory 1141 Market st., St. Louis, September 17 to November 30, 1901.

Tap, residence, 5946 Garfield avenue, October 2 to November 30, 1901.

MR NICHOLSON: That is at St. Louis also?

A. St. Louis also.

333 Seven samples were collected at LaSalle, Illinois, from the Illinois, and 24 at Beardstown, Illinois. Both samples were sent to Peoria—

MR NICHOLSON: Packed in ice for analysis.

A. Yes sir, packed in ice for analysis.

Q. That is, all these samples?

A. That is all the samples collected at LaSalle and Beardstown.

MR JEFFRIES: A few moments ago you referred to statements made to you by Mr. Randolph.

A. Engineer Randolph.

Q. And to the fact that he called the Desplaines river part of the canal, or called it canal.

A. Yes sir.

Q. Do you know what position he occupied with reference to the Sanitary district of Chicago?

A. He is chief engineer. He and I together selected these points of collection at Lockport and Joliet, and he of course knows the topography of the country better than I. While driving along the canal he would constantly speak of it as the drainage canal, and I noticed the people afterwards constantly spoke of it as the drainage canal.

MR. DRENNAN: They call it canal as far as they made the improvements.

MR. SPRINGER: They made some improvements?

334 A. That is, down to the bridge. It is commonly spoken of there as the drainage canal.

MR. JEFFRIES: Now, doctor, do you know the number of samples daily that were collected during this period?

A. There were daily samples collected, and I have got a list of the number collected at the different points.

Q. Give those. A number of samples collected daily for the determination of bacteria per cubic centimeter and the presence of bacillus coli communis.

Desplaines river at Lockport, two miles above its junction with the drainage canal water, 40 samples.

Drainage canal, Lockport, above Bear Trap dam, 52 samples.

Q. Now then, how far is that from the place where the samples were collected in the Desplaines river at Lockport?

A. The samples collected in the Desplaines river at Lockport were collected two miles above this point of collection, the controlling works.

Q. Then that is two collections taken out of the Desplaines river two miles above the controlling works?

A. Yes, a man drove up in a buggy, up the river and got a sample. It is quite a distance from Joliet, about 15 miles. A man went there to collect samples daily. Illinois and Michigan canal, Lockport, 9th street bridge, 34 samples.

Q. How far is that from the Bear Trap dam at Lockport?

335 A. Oh, four or five hundred yards, I think.

MR. SPRINGER: They run parallel with one another. They are the same stretch.

A. It is a convenient place to take samples.

MR. JEFFRIES: Bear trap dam is the end of the canal, is it?

A. No, of the Chicago drainage canal, while the Illinois and Michigan canal lies further south. And in passing through Lockport a bridge is thrown over. It is an easy place to collect samples, so we took samples from that bridge over the Illinois and Michigan canal.

MR. DRENNAN: The Illinois and Michigan canal and Chicago drainage canal are entirely separate and distinct?

A. Although both of them hold sewage of Chicago.

Illinois and Michigan canal, 34 samples.

Drainage canal, 9th street bridge, Lockport, 41 samples.

MR. JEFFRIES: Now what is the distance between the point where those samples were taken and the drainage canal 9th street bridge at Lockport and the Desplaines river at Lockport?

A. About 300 yards, I would say. I am simply guessing at it as measured by the eye.

Q. Now do I understand that the Desplaines river, the Chicago river, the Illinois and Michigan canal and the
336 drainage canal all get together about this point.

A. They get together a little bit below, and become very friendly as you will see.

Drainage canal below Rubey street, Joliet, Illinois—

Q. How far is that from the 9th street bridge?

A. I think it is 6 or 7 miles.

Q. How many samples did you collect there?

A. 51.

The only way I can estimate the distance, we seemed to be all day driving there.

Drainage canal, Brandon's bridge, 49 samples.

Brandon's bridge is 5 miles below this Rubey street sample, so that would be about 12 miles from the drainage canal at Lockport.

From the Illinois river, Shady Beach, above P[illegible], 54 samples. That is 120 miles down the river.

ATTORNEY GENERAL HAMLIN: Three miles above Peoria?

A. About three miles above Peoria, Shady Beach, it is called.

Illinois River, above Railroad bridge, Pekin, Illinois, 57 samples.

MR. JEFFRIES: How far above the bridge?

A. Oh, the sample was taken from the bridge.

Q. And that is how far from Peoria?

A. Ten miles from the center of Peoria to the center of Pekin. It is five miles here below the last sewage dis-
337 charge, Peoria sewage, into the Illinois river.

Kingston, three miles below Pekin, 55 samples. ?

Illinois river, three miles above Grafton, Illinois, 56 samples.

Mississippi river, two miles above Grafton, Illinois, 56 samples.

Mississippi river, one mile above Alton, Illinois, 52 samples.

Mississippi river, opposite Hartford, Illinois, 51 samples.

Missouri river, opposite Ft. Bellefontaine, 55 samples.

Mississippi river, Chain of Rocks, Illinois shore, 74 samles.

Mississippi river, Missouri shore, 72 samples.

Mississippi river, intake tower, 70 samples.

Reservoir, outlet screen chamber it is called, Chain of Rocks, 75 samples.

Q. State what you mean by the outlet screen chamber where these are located?

A. That is located in about the middle of the end of the reservoir, facing south, and the water discharges out of this hole in the wall through a screen, and consequently they call it the outlet screen chamber, there is a little building there.

Q. It is out at the end of the reservoir?

338 A. It is out at the end of the reservoir. There is a little building there that is constructed for the purpose of controlling the valve that allows the water to exit or to be shut off.

Q. How far is that from the shore of the river?

A. From the Mississippi river?

Q. Yes.

A. I suppose that is 300 or 400 feet.

Q. Out in the water?

A. No, no, the reservoir is up on the land, high on the bank, but the river is 300 or 400 feet away.

Q. Then this screen chamber is situated near the reservoir?

A. The screen chamber is part of the reservoir. It is the south end of the reservoir, the reservoir and settling basins at Bissell's point.

Q. Now that is the same Bissell's Point that you described in your testimony with reference to period No. 2?

A. Yes sir, it is the same point lower down. Do you want the number of samples taken at Bissel's point?

Q. Yes.

A. 72.

Tap laboratory 1141 Market street, 69 samples.

339 Tap, 5946 Garfield avenue, St. Louis, 49 samples.

Illinois river, LaSalle, 7 samples.

Illinois river, Beardstown, Illinois, 24 samples, making a total of 1215.

Q. Now during this period the work was done under your supervision, was it?

A. Yes sir, entirely.

Q. How soon did you plate the samples that you collected from the canal at Lockport and the river at Peoria?

A. They were taken at once to the laboratory, placed on ice and plated without delay.

Q. Now that is this true of all of these samples?

A. All of these samples that were collected at points where laboratories were established. Now in St. Louis a room was secured from the water commissioner at the Chain of Rocks pumping house, and the samples were collected in the river for the Chicago and St. Louis experts at the same time and place. A Chicago and a St. Louis bacteriologist plated the samples in this same room, so that the samples were plated immediately when brought ashore.

Q. Now what were the facilities furnished by the city at that time?

A. The city furnished a good room and it was kept warm. I believe Chicago paid for some of that heat, anyhow it was a convenient place for the men to do their plating. The 340 plates were then brought to the laboratories of both parties, brought to 1141 Market street by Mr. Damon, who did our plating and to the Chicago laboratory by the Chicago expert located somewhere on Locust street, both going in and out together to the Chain of Rocks.

Q. By whom?

A. I don't know who did the Chicago plating. I met the young man, but I have forgotten his name.

Q. You know that they collected the samples at the same place?

A. I know they were collected, because these men went out together.

Q. How were the samples collected?

A. They were collected with an apparatus designed by myself in wide mouthed steriled flasks, at 3 feet below the surface.

Q. In the same manner that you collected them in the second period?

A. Yes sir.

Q. And with the same apparatus?

A. With the same apparatus, yes sir. The temperature being taken and recorded at the same time of the water and the air, with a thermometer that was part of the apparatus.

Q. What was the total number of samples collected?

A. 2325 were collected at the various points noted above, and analysis for quantative determination of bacteria and tests made for bacillus coli communis.

Q. In addition to that, did you investigate the bacterial
341 flora of the water?

A. Yes sir. Besides that a systematic study of the flora was made by an expert microscopist.

Q. Who was that?

A. Mr. George C. Whipple, of Brooklyn, New York.

Q. How many sets of organisms did you have in the bacterial flora examined?

A. We separated out eight sets of ten organisms each—were separated out in pure culture, 80 organisms at each station.

Q. Now, explain that culture.

A. Why, the sample collected at a definite time each week, once or twice a week, was plated according to the method described in the first period, and then ten colonies were selected from that plate, always trying to select a colony that was new to the bacteriologist. He selected the first ten that were familiar to him and the next time he went over that plate he tried not to select any of that same form, the idea being to try to find all the different species of micro-organisms in that particular water.

Q. Plating for what?

A. For variety of species. Now then, when a colony was seen to be different from the others it was picked out and sown on agar agar. Of this growth on the agar agar a strained
342 preparation slide was made and we studied that microscopic form. If the culture proved to be a pure one, then it was sown in a variety of media to ascertain its cultural characteristics.

Q. That was done to cultivate it.

A. Yes sir, it was cultivated on a variety of media, and the results were recorded on a chart that was original with our laboratory. Of these charts there, 300 of them, some 30 different varieties of media were used.

Q. Now in the examinations made in this third period and the manner in which the culture was conducted, you used the same precaution and exercised the same safeguards that you did in the number of the second division of your investigation, did you not?

A. Yes sir. In fact to a greater skill, more accuracy.

Q. Well, you testified clearly and fully in the second division as to the manner in which these experiments were conducted?

A. Yes sir.

Q. What I want to know is if these experiments in the third period were carried on in the same manner?

A. Yes sir.

Q. And according to the same rules?

A. Yes sir, and according to the same rules and with exquisite care by a bacteriologist at each one of the points.

Q. Now have you the result of those examinations with
343 reference to the tests for bacillus coli communis?

A. Yes, we have got that, bacillus coli communis, and the quantative determination of bacteria at all of these places the Desplaines rives, the Bear-trap dam, Lockport, Drainage canal, Lockport; Illinois and Michigan canal; drainage canal below Rubey street; drainage canal at Brandon's bridge. That is the one you want first.

Q. Yes, we will start at the other end, at the Chicago end of it.

A. Yes, well I have got that, Desplaines river, we went up the river to get beyond the backwater of the Chicago drainage canal at its union with the river. We began taking samples from the Bear-trap dam.

Q. Now then, doctor, give us the result of your examination of the waters at the various places at which samples were taken, as to containing bacteria per cubic centimeter and also as to the evidences of the bacillus coli communis.

Adjourned until ten o'clock a. m. February 20.

344 Met pursuant to adjournment at the Southern Hotel, at ten o'clock, a. m., February 20, 1903.

DR. AMAND NICHOLAS RAVOLD

resumed the stand for further direct examination by Mr. Jeffries.

MR. JEFFRIES: Mr. Reporter, repeat the last question that was asked yesterday.

THE REPORTER: (Reading). Now, then, will you give the result of your examination of the water at the various places where samples were taken, as containing bacteria per cubic centimeter, and also evidence as to the bacilli coli communis.

A. At what points?

Q. That is, at the points where these samples were taken, concerning which you testified yesterday afternoon, at the close of your testimony?

A. Yes sir.

Q. You can state again the different points at which these samples were taken.

A. Yes sir. I had a list that I read from.

Q. It is on pages 11 and 12, doctor.

A. Yes. The Desplaines river two miles above Lockport. Do you want that copied to-day? Do you want the reporter to take this?

345 Have you got it in the record?

November 20, 5,010,000, coli test not made,
“ 21, 1,600,000, do.
“ 22, 4,960,000, do.
“ 23, 7,200,000, do.
“ 24, 5,075,000, do.
“ 25, 2,725,000, do.

That ends that story. Now September 26th, 1901, we begin again in another place. The Illinois and Michigan canal, 9th street bridge, Lockport, Illinois, for the quantitative determination of bacteria per cubic centimeter and the test for the bacillus coli communis. The Illinois and Michigan canal. I took some samples from this canal to see what were the numbers in it also, because the Chicago sewage is being pumped into it from the south fork of the Chicago river. This is not the Chicago Drainage canal.

349 September 26, 205,000, coli absent,
“ 27, 787,000, present,
“ 28, 70,700, absent,
“ 29, 117,000, present,
“ 30, 1,300,000, test not made.

Illinois and Michigan canal for October:

October 1, 300,000, coli absent,
“ 2, 58,000, present,
“ 3, 75,000, present,
“ 4, 50,000, present,
“ 5, 1,600,000, present,
“ 6, 189,000, absent,
“ 7, 420,000, coli test not made,
“ 8, 815,000, do.
“ 9, 435,000, absent,
“ 10, 530,000, present,
“ 11, sample lost,
“ 12, 760,000, present,
“ 13, 690,000, absent,
“ 14, 460,000, absent,
“ 15, 860,000, absent,
“ 16, 3,280,000, coli test not made,
“ 17, 480,000, absent,
“ 18, 1,010,000, present,
“ 19, 780,000, absent,

350 October 20, 390,000, test not made,
“ 21, 440,000, do.
“ 22, 355,000, absent,
“ 23, 310,000, not made,
“ 24, 560,000, present,
“ 25, 890,000, coli test not made,
“ 26, 970,000, do.
“ 27, 690,000, do.
“ 28, 620,000, do.
“ 29, 472,500, do.
“ 30, 2,850,000, do.

That is all for that month. In fact, that is all for the Illinois and Michigan canal. Now the Drainage canal, Rubey street, Joliet, Illinois.

MR. JEFFRIES: That is, just below Rubey street?

A. Yes sir, just below Rubey street. The Desplaines river here is called the drainage canal.

JUDGE SPRINGER: But it is really the Desplaines river?

A. It is really the Desplaines river. Now the quantitative determination of bacteria per cubic centimeter, and the detection of the bacillus coli communis:

September 26, 870,000, present,
“ 27, 71,000, do.
“ 28, test not made; sample lost,
“ 29, 220,500, present,
“ 30, 1,250,000, absent,
351 October 1, 21,000, test not made,
“ 2, 29,000, do.
“ 3, 335,000, do.
“ 4, 48,000, present,
“ 5, 355,000, present,
“ 6, 585,000, test not made,
“ 7, 245,000, present,
“ 8, 50,000, present,
“ 9, 50,000, test not made,
“ 10, 60,500, present,
“ 11, sample lost,
“ 12, 30,000, test not made,

October 13, 54,500, present,
“ 14, 86,000, do.
“ 15, 3,640,000, absent,
“ 16, 112,000, present,
“ 17, 39,000, present,
“ 18, 109,000, “
“ 19, 96,000, “
“ 20, 276,000, “
“ 21, 63,500 “
“ 22, 65,000, test not made,
“ 23, 56,000, present,
“ 24, 131,000, “
“ 25, 120,000, “
352 “ 26, 652,000, test not made,
“ 27, 183,000, absent,
“ 28, 1,110,000, absent,
“ 29, 219,000, test not made,
“ 30, 330,000, do.
“ 31, 346,000, do.

Now for November: The colon tests were not made throughout this month.

November 1, 328,000,
“ 2, 635,000,
“ 3, 213,000,
“ 4, 153,000,
“ 5, 102,000,
“ 6, sample lost,
“ 7, sample lost,
“ 8, 143,000,
“ 9, 400,000,
“ 10, 148,000,
“ 17, 392,000.

None between the 10th and the 17th.

November 18, 1,525,000,
“ 19, 1,700,000,
“ 20, 2,200,000,
“ 21, 3,500,000,
353 “ 22, 3,600,000,
“ 23, 3,180,000,
“ 24, 3,400,000,

November 25, 2,390,000.

That is the end of November. Now the Desplaines river at Brandon's bridge, below Joliet. September 26, bacteria per cubic centimeter, no sample taken.

September 27, 344,000, coli test not made,
“ 28, 418,000, present,
“ 29, 172,000, present,
“ 30, 328,000, coli test not made.

Brandon's bridge at the same place.

October 1, not satisfactory,
“ 2, 39,000, coli test not made,
“ 3, 335,000, present,
“ 4, 34,000, present,
“ 5, 1,850,000, coli test not made,
“ 6, 770,000, do.
“ 7, 900,000, present,
“ 8, 32,000, test not made,
“ 9, 37,500, present,
“ 10, 64,000, test not made,
“ 11, sample lost,
“ 12, 57,000, absent,
354 “ 13, 68,000, present,
“ 14, 64,000, present,
“ 15, sample lost,
“ 16, 110,000, test not made,
“ 17, 66,000, do.
“ 18, 47,500, do.
“ 19, 46,000, present,
“ 20, 29,500, test not made,
“ 21, 79,000, do.
“ 22, 37,500, present,
“ 23, 44,00, absent,
“ 24, 1,950,000, present,
“ 25, 213,000, test not made,
“ 26, 153,000, do.
“ 27, 93,000, do.
“ 28, 555,000, do.
“ 29, 619,000, do.
“ 30, 221,000, do.
“ 31, 280,000, do.

Colon tests not made at all in this next month.
November 1, 498,000, coli test not made,
“ 2, 300,000,
“ 3, 151,000,
“ 4, 190,000,
“ 5, no samples,
355 “ 6, no sample,
“ 7, do.
“ 8, 160,000,
“ 9, 447,500,
“ 10, 150,000,
“ 11—Now until the 17th no samples taken.
November 17, 400,000,
“ 18, 2,070,000,
“ 19, 1,250,000,
“ 20, 2,280,000,
“ 21, 3,270,000,
“ 22, 3,315,000,
“ 23, 2,405,000,
“ 24, 3,150,000,
“ 25, 3,580,000.

That is the last of the drainage canal, Brandon's bridge, below Joliet.

MR. JEFFRIES: Now there are two other places.

A. Yes sir. Now we go to the Desplaines river, beginning October 6.

JUDGE SPRINGER: Where is this, in the Desplaines river?

A. The Desplaines river, two miles above the conjunction, with the effluence of the Chicago Drainage Canal.

October 6, 202,000, coli absent,
“ 7, 2,500, do.
356 “ 8, 3,000, absent,
“ 9, 2,000, absent,
“ 10, 2,200, present,
“ 11, no sample taken,
“ 12, 3,300, present,
“ 13, 4,400, absent,
“ 14, 3,700, test not made,
“ 15, 5,300, absent,

October 16, 25,800, questioned, coli absent,
" 17, 4,200, absent,
" 18, 4,100, present,
" 19, 152,000, absent,
20, 15,200, test not made,
" 21, 1,200, present,
" 22, 1,400 absent,
" 23, 2,300, present,
" 24, 1 900, do.
" 25, 3,200, test not made,
" 26, 1,400, do.
" 27, 1,600, absent,
" 28, 1,800, do.
" 29, 2,400, coli test not made,
" 30, 1,300, do.
" 31, 1,900, do.

That is the last of October.

357 November 1, 1,700, coli test not made,
" 2, sample lost,
" 3, 7,100, coli test not made,
" 4, 3,700, do.
" 5, sample lost,
" 6, sample lost,
" 7, sample lost,
" 8, 1,800, coli test not made,
" 9, 2,800, do.
" 10, 1,200, do.
" 17, 2,400, do.

None between the 10th and 17th.

November 18, 10,100, coli test not made,
" 19, 2,000, do.
" 20, 2,900, do.
" 21, 2,300, do.
" 22, 4,500, do.
" 23, 6,500, do.
" 24, sample lost,
" 25, 1,900, do.

That ends the Desplaines river.

Drainage canal and Desplaines river at 9th street bridge, Lockport. We get a mixture of the two waters here, the drainage canal and the Desplaines river.

The quantitative determination of the bacteria per cubic
358 centimeter and bacillus coli communis.

October 2, 57,000, present,
“ 3, 110,000, test not made,
“ 4, 85,000, absent,
“ 5, 291,000, absent,
“ 6, 930,000, absent,
“ 7, 540,000, test not made,
“ 8, 32,000, absent.
“ 9, 54,000, coli test not made,
“ 10, 58,000, present,
“ 11, sample lost,
“ 12, 53,500, present,
“ 13, 1,610,000, absent,
“ 14, 54,000, absent,
“ 15, 85,000, absent,
“ 16, sample lost,
“ 17, 830,000, coli test not made,
“ 18, sample lost,
“ 19, 84,000, present,
“ 20, 58,000, test not made,
“ 21, 56,000, do.
“ 22, 41,000, present,
“ 23, 50,000, present,
“ 24, 59,000, test not made,
“ 25, 1,000,000, present,
“ 26, sample lost,
359 “ 27, 156,000, present,
“ 28, 554,500, absent,
“ 29, 115,000, absent.
“ 30, 323,000, absent,
“ 31, 339,000, test not made.

That is all for October.

Drainage canal, 9th street bridge, Lockport:

November 1, 215,000, coli test not made in November at this point.

November 2, 902,000,
“ 3, 895,000,

November 4, 270,000,
“ 5, 96,000,
“ 6, test not made,
“ 7, do.
“ 8, 940,000,
“ 9, 690,000,
“ 10, 191,000,
“ 17, sample lost,
“ 18, 5,511,000,
“ 19, 3,320,000,
“ 20, 2,710,000,
“ 21, 1,850,000,
“ 22, 4,470,000,
“ 23, 6,000,000,

That is the end of that examination. It ended on the 23rd
360 of November.

MR. JEFFRIES: Now, Doctor, during this third period, was there any examination made of the character of the Desplaines river at Joliet?

A. Yes, sir.

JUDGE SPRINGER: That is where he has given all of those numbers. He has given those, Rubey street, and Brandon's bridge. That is in Joliet.

MR. JEFFRIES: Oh, yes.

Q. Can you give the percentage of samples in which bacilli coli communis was found in this examination we have just gone over, at these various places?

A. Yes, sir.

Q. Now, please state that.

A. The colon bacillus was found in 73 per cent. of samples collected daily at McDonough street. That was in the second period we have just mentioned. That was given yesterday.

MR. JEFFRIES: The day before yesterday, rather.

A. At Rubey street, in 83 per cent. of the samples. That is, the Desplaines river at Joliet and at Brandon's bridge in 79 per cent. of the samples examined.

MR. JEFFRIES: At Brandon's bridge, how much?

A. 79 per cent. Do you want this average of bacteria found above the Bear Trap dam to go in, so as to compare with the drainage canal at the 9th street bridge?

361 Q. Yes, put that in.

ATTORNEY-GENERAL HAMLIN: How is that?

A. We have here a table showing the daily average bacteria per cubic centimeter, found at Lockport, Illinois, above the Bear Trap dam, drainage canal, above the Bear Trap dam, in the Desplaines river, and the drainage canal at the 9th street bridge, Lockport, for the months of October and November, 1901. We found that the average number of bacteria for the month of October, 1901, in the Desplaines river, two miles above its union with the effluence of the drainage canal, contained 18,004 bacteria, for the month of October; the Desplaines river, November, 1901, 4,235. Drainage canal above the Bear Trap Dam for the month of October, bacteria per cubic centimenter, 440,150, and for the month of November, 2,263,530.

The drainage canal, 9th street bridge, Lockport, for the month of October, bacteria per cubic centimeter, 293,270, and for November, 1,997,180.

MR. JEFFRIES: Now, during this third period, Doctor, what examination was made of the water below Joliet on the Illinois river?

A. The next examination made—the laboratory was established at Peoria, in the Y. M. C. A. building, and a few samples were collected at LaSalle, in the Illinois river, and samples
362 taken daily from the river at Peoria.

Q. And those examinations were made immediately, as you testified?

A. As they came to the laboratory. They were carried to the laboratory immediately and plated. That was samples collected above Peoria, below Peoria, at Pekin, and at Kingston. Further down, the Beardstown samples were collected and sent back to the Peoria laboratory encased in ice.

Q. Now, at any other point below Beardstown?

A. At Grafton also.

Q. And they were plated and sent to St. Louis?

A. No, they were plated, and examined right at the laboratory at Grafton.

Q. Now, during that period and at these respective places can you give the percentage of colon bacillus that was found in the water in the tests?

A. Yes, sir.

Q. Now, what is that?

A. The colon bacillus was found in October, 1901, in 87.1 and in November 79.1 per cent.

Q. Now, at what points?

A. That is above Peoria, at Shady Beach.

Q. How far above Peoria?

A. Three miles.

Q. That is above the entrance of the Peoria sewage into
363 the Illinois river?

A. Yes, sir.

Q. Now, what rivers enter into the Illinois river between Joliet and Peoria, if you know, Doctor?

A. Well, quite a number. Do you mean enter in to make up the Illinois here?

Q. Well, give the distance if you can between Joliet and Peoria on the Illinois river.

A. 120 miles.

Q. Now, then, what rivers enter into the Illinois river in that distance, 120 miles, between Peoria and Joliet?

A. Well, we have the Dupage forming with or joining the Desplaines river to form and join the Kankakee. I mean before the Desplaines river meets the Kankakee, the Dupage river discharges into it.

Q. Into the Kankakee?

A. No, into the Desplaines. And they meet the Kankakee and make the Illinois river, form the Illinois river. The river passes along then, and the Fox comes in from the north, and the Vermillion from the south.

Q. Now, do you know anything of the relative size of those various streams?

A. Yes, I have got Mr. Harmon's figures on it, and Mr. Cooley's figures, showing the size of these streams.

Q. Who is Mr. Cooley?

364 A. Mr. Cooley was, I believe, the first engineer of the Chicago Drainage canal.

Q. Who is Mr. Harmon?

A. Mr. Harmon is a gentleman with a red beard, often seen around here, and is an engineer living at Peoria, Illinois, who made the sanitary survey of the river, giving the volumes, etc.

ATTORNEY-GENERAL HAMLIN: He is with the state board of health now.

A. Is he now?

Q. He has been all the time.

A. That survey was made for the state board of health, then.

MR. JEFFRIES: What was the size of those rivers, from the information you have? In addition to this, you have viewed those rivers personally, have you not?

A. All but the Dupage river. I was never on the Dupage river. I doubt very much one of these figures, those of the Vermillion river, but here it is, flow per cubic feet per second of water. This is taken from the report of Mr. Harmon, made during the low stages in October, 1889, and represents approximately the average condition of these streams during the late summer and early fall months. The Desplaines flows per cubic feet per second (not gallons, but feet) 13.21. The Dupage 32.77, the Kankakee, 509.24, the Fox, 329.95. He has the Vermillion marked here, 4, which is probably wrong, because the Vermillion is a very much larger river than the Desplaines. These 365 are the rivers that come in above Peoria.

Q. You say that estimate was made at the time when the river was low?

A. It states here, made during the low water stages in October, 1899, and these figures are copied by Mr. Cooley in his work on the waterways, lakes and waterways, of which you have a copy.

Q. Now, are they the same as Mr. Harman's?

A. Yes, they are the same. They give four cubic feet per second for the Vermillion, which is small. Besides that, at LaSalle, discharges into the Illinois, the Illinois and Michigan canal, but at this particular time last year, when bacterialogical work was going on, the water was stagnant and very little water flowing out of it.

Q. Out of the canal?

A. Out of the canal, into the river.

Q. That is, into the Desplaines or Illinois?

A. Into the Illinois river at LaSalle. I sent a man up there and he informed me about the place, and I also had a man collecting samples at LaSalle.

Q. Now, I understand you to say you made examinations during the months of October and November, 1901, of the water of the Illinois river, at Peoria, Pekin, Kingston, Beardstown?

A. Yes, sir.

Q. Now, that examination was made with a view to obtaining the number of bacteria per cubic centimeter, and also

366 evidence of coli communis?

A. Yes, sir.

Q. I would like to have you give the result of your examination, Doctor?

A. All right, sir. You already have the places marked for the collection of these samples, at Shady Beach, above Peoria.

Q. Now, before we go into this, Doctor, I would like to have you state where the examinations were conducted from the tests taken at LaSalle?

A. The sample was packed in ice, collected at LaSalle with the apparatus which has been described, by a man employed there, and collected above the point of discharge of the Illinois and Michigan canal into the Illinois river, so as not to have the effluence of the Illinois and Michigan canal mixed with this water.

Q. Where was the examination of the tests made?

A. The sample was collected at LaSalle and shipped at once to Peoria, a few miles below, and examined there as soon as it arrived.

Q. Now, where were the tests made of the water that was taken from the river at Peoria?

A. The water was taken from Peoria at Shady Beach, three miles above Peoria, and immediately carried to the laboratory and placed on ice or examined at once.

Q. The laboratory at Peoria?

A. At Peoria, yes, sir; in the Y. M. C. A. building.

367 Q. Now, with reference to Pekin?

A. The Pekin sample was collected and carried directly to the laboratory at Peoria, and examined there.

Q. Now, then, give the result of the examination of the samples of water taken at LaSalle?

A. Seven samples in all received.

Q. Now, the dates to which you refer are the dates on which the sample was collected?

A. Yes, sir; the date on which the sample was collected is here recorded.

October 28, 1901, bacteria per cubic centimeter, 7,500, coli present.

Q. Just a moment, Doctor. Now was it analyzed the same day?

A. Yes, but it would have made very little difference, though; it was packed in ice. The numbers would have been smaller, if anything.

October 29, 16,500, absent.

Now, then, we go to November.

November 15, 9,000.

Coli tests not made in the November samples at this point.

November 16, 38,000,
" 17, 19,500,
" 18, 13,500,
" 21, 68,500,

368 And that is the last. There are seven samples in the examination.

Q. Now, then, with reference to the examination made of the water at Peoria, the dates you give will be the dates that the sample was collected, and it was carried immediately to the laboratory at Peoria and examined?

A. Yes, plated at once.

Q. And the tests made that day?

A. Yes, sir. Beginning October 1, three miles above Peoria, quantitative determination of bacteria per cubic centimeter, and the results of the tests for the coli.

October 1, 2,350, coli present,
" 2, 2,500, absent,
" 3, 1,750, present,
" 4, 350, "
" 5, 300, "
" 6, 230, absent,
" 7, 290, present,
" 8, 660, "
" 9, 320, "
" 10, 360, "
" 11, 200, "
" 12, 750, "

October 13, 5,800, present,
“ 14, 390, “
369 “ 15, 500, “
“ 16, 220, “
“ 17, 220, “
“ 18, 220, “
“ 19, 150, “
“ 20, no numbers counted, but coli present,
“ 21, do do
“ 22, 300, present,
“ 23, 360, “
“ 24, 280, “
“ 25, numbers not counted; coli absent,
“ 26, 350, present,
“ 27, 510, “
“ 28, 350, “
“ 29, 550, “
“ 30, 1,200, “
“ 31, 350, absent,

That is all for October.

Q. Now, Doctor, on the 20th, 21st and 25th, I notice you say no numbers counted. Does that mean no bacteria found?

A. No, it means that the sample was lost. That is, a man drops a plate, or a plate liquifies on him, before he can count it. Those are little accidents that occur in bacteriological laboratories, in spite of all one can do.

Q. What is the next?

A. November, the same place. Bacteria per cubic centimeter.

370 November 1, 1,300, absent,
“ 2, 600, “
“ 3, 350, present,
“ 4, 250, “
“ 5, no count made, but coli present,
“ 6, 350, present,
“ 7, 120, present,
“ 8, 140, present,
“ 9, 350, present,
“ 10, 220, test not made,
“ 11, 230, present,

November 12, 450, present,
“ 13, 2,450, “
“ 14, 3,700, “
“ 15, 3,800, absent,
“ 16, 4,300, present,
“ 17, 6,500, “
“ 18, 2,500, “
“ 19, 750, “
“ 20, 2,300, “
“ 21, 1,300, absent,
“ 22, 4,600, “
“ 23, 9,000, present,
“ 24, 3,850, “
“ 25, 2,700, “
371 “ 26, 360, coli test not made,
“ 27, 1,860, do.

That is the last sample taken in November.

Pekin Bridge, Pekin, Illinois.

Q. Now, those samples were collected and returned to the laboratory at Pekin on the same day?

A. They were taken to Peoria. There is a street car that runs from Pekin to Peoria. The samples were collected and carried right to Peoria.

Q. And an examination made immediately?

A. Made at once. The collector collected the samples. The bacteriologist remained in the laboratory, and when the sample was brought to him, it was immediately used.

Q. This was after all the Peoria sewage had got in the river?

A. Yes, it was about five miles below.

Q. About five miles below Peoria?

A. Yes, sir.

JUDGE SPRINGER: But not Pekin?

A. It is above Pekin. Bacteria per cubic centimenter, quantitive determination and result of tests for coli communis.

October 1, 1,170, present,
“ 2, —

It is above the railroad bridge in the channel at Pekin, Illinois, five miles below the lowest Peoria sewer.

372 October 2, 24,000, present,

October 3, 96,000, present,
" 4, 25,000, "
" 5, 27,000, "
" 6, 14,500, "
" 7, 15,800, "
" 8, 48,000 "
" 9, 26,000, "
" 10, 5,800, "
" 11, 5,900, "
" 12, 23,500, "
" 13, 4,000, "
" 14, 1,300,000, "
" 15, 12,700, "
" 16, 5,000, "
" 17, 8,500, "
" 18, 57,500, "
" 19, 433,000, "
" 20, 36,500 "
" 21, 4,000, "
" 22, 7,500, "
" 23, 5,000, "
" 24, 4,500, "
" 25, sample lost, present,

That is, the bacterial plate apparently was lost.

373 " 26, 9,800, present,
" 27, 2,500, "
" 28, 400, "
" 29, 3,900, "
" 30, 5,000, "
" 31, 26,000, absent.
November 1, 16,500, absent,
" 2, 9,500, present,
" 3, 6,400, present,
" 4, 3,500, present,
" 5, 2,900, present,
" 6, 4,700, present,
" 7, 4,000, present,
" 8, 4,200. present,
" 9, 4,100, present,
" 10, 8,900, present,

November 11, 20,500, present,
“ 12, 3,600, present,
“ 13, 2,200, “
“ 14, 2,600, “
“ 15, 7,300, “
“ 16, 7,900, “
“ 17, 2,600, “
“ 18, 3,500, “
374 “ 19, 750, present,
“ 20, 4,000, “
“ 21, 4,200, “
“ 22, 7,600, “
“ 23, 7,500, coli test not made,
“ 24, 4,300, do.
“ 25, 1,950, do.
“ 26, 400, do.
“ 27, 2,200, do.

That is all the samples collected at that place.

Q. Now at Kingston, where was the examination made?

A. In the channel at Kingston, three miles below Pekin, I think it is.

Q. That is, the test was made there?

A. The sample was obtained and the test made at Peoria, traveling by train. Sample collected by a collector and taken directly to the laboratory and there plated.

Q. It may have been the same day that the sample was collected?

A. Yes, it was within a few minutes after being taken.

Q. Now, you say Kingston is about three miles below Pekin?

A. Yes sir.

Q. Where were those samples taken with reference to Kingston?

A. Well, they were taken well below Kingston. A man
375 went down in a buggy as far as he could drive and drove
out into the stream and collected this sample. The river
was low during this time.

Q. He collected them from the current?

A. Yes sir, from the current of the river some distance below Kingston.

Q. Now, you may give the result of the tests at Kingston.

A. The quantitative determination of bacteria and examination of water collected below Kingston per cubic centimeter and tests for the bacilli communis.

October 4, 1901, 285,000, present.

This is the water of Peoria and Pekin together, you see.

October 5, 440,000, present,
“ 6, 137,500, present,
“ 7, 797,500, present,
“ 8, 94,000, present,
“ 9, 530,000, present,
“ 10, 485,000, present,
“ 11, 225,000, present,
“ 12, 487,500, present,
“ 13, 320,000, present,
“ 14, 1,120,000, present,
“ 15, 400,000, present,
“ 16, 67,500, present,
376 “ 17, 122,500, present,
“ 18, 174,000, “
“ 19, 258,000, “
“ 20, 950,000, “
“ 21, 4,000, “
“ 22, 118,500, “
“ 23, 99,000, “
“ 24, 100,000, “
“ 25, 17,500, “
“ 26, 529,500, “
“ 27, 213,000, “
“ 28, 3,300, “
“ 29, 2,115,500, “
“ 30, 287,500, “
“ 31, 365,000, “
November 1, 54,000, absent,
“ 2, 1,750,000, “
“ 3, 26,500, present,
“ 4, 21,500, “
“ 5, 16,500, “
“ 6, 14,500, “

November 7, 33,000, present,
" 8, 65,000, "
" 9, 62,000, "
377 " 10, 61,000, "
" 11, 42,000, "
" 12, 60,000, "
" 13, 36,000, "
" 14, 10,500, "
" 15, 14,500, "
" 16, 12,900, "
" 17, 16,500, "
" 18, 31,500, "
" 19, 12,500, "
" 20, 16,500, "
" 21, 18,500, "
" 22, 39,400, "
" 23, 25,300, coli test not made,
" 24, 28,000, "
" 25, 6,500, "
" 26, 10,000, "
" 27, 9,300, "

That is the end of Kingston.

Q. Now explain, doctor, where the samples were taken from at Beardstown?

A. The Beardstown sample was taken in the river above Beardstown, right out from in front of it, in front of the town.

Q. Now where were the examinations made, the tests?

378 A. The samples were packed in ice and shipped to Peoria where they were examined in the bacterial laboratory by Dr. Rush.

Q. Well, you say the samples were gathered just above Beardstown?

A. Yes sir.

Q. And packed in ice and shipped to Peoria?

A. Yes sir.

Q. How long would it take to ship them to Peoria and have the tests made after they were gathered?

A. In a very short time, depending upon the train. It is a very short distance from Beardstown, a couple of hours.

Q. It may have been made that same day?

A. Most always made the same day.

Q. And you stated—

A. They were made the same day. They were shipped to Peoria, so that they would arrive in Peoria and be plated that same day.

JUDGE SPRINGER: You didn't superintend that part of it?

A. No, I didn't superintend that part of it, but I saw it was working right.

MR. JEFFRIES: You had general charge of it?

A. Yes sir, I traveled up and down from those points
379 all the time. The distance from Beardstown to Peoria
is very short.

ATTORNEY GENERAL HAMLIN: Did you ever travel over it?

A. Yes, I traveled over it on the Bluff line.

Q. By rail?

A. Yes sir, I have traveled it quite a number of times, and also by boat.

MR. JEFFRIES: Give us the result of that examination.

A. All right.

October 24, 4,400, test not made,
" 27, 4,850, coli test not made,
" 29, 3,950, "
" 30, 4,300, "
" 31, 4,950, "
November 1, 5,600, present,
" 2, 2,200, "
" 3, 1,950, "
" 4, count not made; present,
" 5, 13,500, present,
" 6, 36,600, "
" 7, 47,500, "
" 8, 77,500, "
" 9, count not made; coli present,
" 10, " "
" 11, 40,000, present.
380 " 12, 34,500, present,
" 13, 85,000, present,
" 14, 51,500, present,

November 15, 45,000, present,
“ 16, numbers not counted; present,
“ 17, numbers not recorded; present,
“ 18, 148,500, present,
“ 19, numbers not recorded; present,
“ 20, 28,500, present,
“ 21, 52,000, present,
“ 22, 185,000, “
“ 23, coli present; numbers not counted.
“ 24, “ “
“ 25, 378,500, present,
“ 26, 185,000, “
“ 27, 46,500, “

Adjourned until 2:15 p. m. February 20th.

2:15, p. m., Friday, February 20, 1903.
381 Continuation after recess.
Present, the Commissioner, and same counsel as before.

DR. AMAND NICHOLAS RAVOLD

resumed the stand for further direct examination by Mr. Jeffries.

Q. Now, the next examination, doctor, during this third period, of the waters in the Illinois river, was where?

A. At Grafton, Illinois; a laboratory was established in the Dempsey House under the charge of Mr. Leon G. Tedesche, and with collectors, he collected samples from the Illinois river three miles above Grafton.

Q. And Grafton, you stated the other day, was about 160 miles below Peoria?

A. Yes sir.

Q. Now, when were these collections made, in the third period?

A. For the quantitative determination of bacteria per cubic centimeter and examination for the bacillus coli communis were begun October 4, and continued until the 27th of November, 1901.

Q. Do you know the percentage of colon bacillus that was found in the samples for October, 1901?

A. Yes sir. October, 1901, 53.6 per cent., for the two
382 months.

Q. For November of the same year?

MR. HAMLIN: The entire time, that is?

A. Yes, 53.6 per cent.

MR. HAMLIN: From October 1st?

A. From October 4 to November 27. For October, 1901, the coli was found in 53.6 per cent. of the cases.

MR. JEFFRIES: And for November?

A. For November, 29.17 per cent.

Q. Now then, state the average for the two months.

A. An average of 45 per cent.

Q. Where did you say the laboratory was located?

A. It was in the Dempsey House in Grafton.

Q. Now you commenced taking samples on the 4th day of October, you say?

A. Yes sir.

Q. Were those samples examined and worked on the day that they were taken?

A. Yes sir, collected by the bacteriologist, and they collected together as a rule and brought them right back to the laboratory and examined them at once.

Q. How far is the laboratory situated from where the samples were taken?

A. Three miles on the Illinois.

383 Q. Now they were taken from the middle of the stream, were they?

A. Yes, out in the current, in the channel.

Q. Three feet below the surface?

A. About three feet below the surface.

Q. Taken with this same apparatus that you testified to two days ago?

A. Yes sir.

Q. And the same precautions were used and the same instruments were used?

A. Yes sir.

Q. Now you may commence and give the result of those experiments.

A. The quantitative determination and coli?

Q. Yes.

A. October 4, Grafton, Illinois river, 1,400, bacillus coli present.

October 5, 1,600, bacillus coli absent,
" 6, 1,800, " " present,
" 7, 1,700, present,
" 8, 1,100, "
" 9, 1,200, absent,
" 10, 1,300, present,
" 11, 1,200, absent,
" 12, 1,000, "
384 " 13, 1,300, coli absent,
" 14, 800, "
" 15, 1,300, coli present,
" 16, 850, present,
" 17, 900, present,
" 18, 1,000, present,
" 19, 2,000, present,
" 20, 2,100, absent,
" 21, 1,600, absent,
" 22, 2,000, present,
" 23, 2,200, absent,
" 24, 2,700, present,
" 25, 2,300, absent,
" 26, 2,200, absent,
" 27, 2,800, present,
" 28, 2,600, absent,
" 29, 3,400, absent,
" 30, 2,600, present,
" 31, 2,900, present.
November 1, 1,900, coli present,
" 2, 2,900, absent,
" 3, 1,200, present,
" 4, 2,700, present,
" 5, 2,600, absent,
" 6, 1,600, absent,
385 " 7, 1,800, absent,
" 8, 1,900, present,
" 9, 1,500, absent,
" 10, 1,800, absent,
" 11, 1,600, absent,

November 12, 2,000, present,
“ 13, 1,600, absent,
“ 14, 2,700, absent,
“ 15, 1,300, absent,
“ 16, 1,500, absent,
“ 17, 9,000, absent,
“ 18, 3,900, absent,
“ 19, 5,200, absent,
“ 20, 4,600, present,
“ 21, 6,600, absent,
“ 22, 3,000, present,
“ 23, 4,200, absent,
” 24, 4,800, present,
“ 25, 1,800, test not made for coli,
“ 26, 4,900, do.
“ 27, 2,600, do.

That is the last for the Illinois river at Grafton.

Q. State whether or not at this same time there was an examination made from samples of water collected from the Mississippi river near Grafton?

386 A. Yes sir.

Q. Where was that collected?

A. It was collected from two miles above Grafton on the Mississippi.

Q. At what particular place in the river?

A. In the channel.

Q. Selected in the same manner as the water selected in the Illinois river above Grafton?

A. Yes sir.

Q. With the same apparatus and under the same precautions?

A. Under the same precautions, yes sir.

Q. Now where was the test made of those samples?

A. These samples were carried directly to the bacteriological laboratory in the Dempsey House in Grafton and there immediately plated.

Q. The same day that they were obtained?

A. Yes sir.

Q. Now you may give the results of those examinations.

A. Mississippi river, quantitative determination of bacteria per cubic centimeter and tests for the bacillus coli communis, Mississippi river two miles above Grafton.

October 4, 500, coli present,
“ 5, 1,500, absent,
“ 6, 1,300, present,
387 “ 7, 850, absent,
“ 8, 1,100, present,
“ 9, 450, absent,
“ 10, 275, absent,
“ 11, 275, absent,
“ 12, 750, absent,
“ 13, 400, absent,
“ 14, 1,100, present,
“ 15, 900, present,
“ 16, 850, present,
“ 17, 425, present,
“ 18, 400, present,
“ 19, 400, absent,
“ 20, 750, absent,
“ 21, 1,000, absent,
“ 22, 650, absent,
“ 23, 475, absent,
“ 24, 425, absent,
“ 25, 1,100, absent,
“ 26, 350, absent,
“ 27, 500, absent,
“ 28, 650, absent,
“ 29, 900, absent,
“ 30, 850, present,
“ 31, 850, present.

388 So much for October.

November 1, 850, coli present,
“ 2, 850, absent,
“ 3, 1,200, absent,
“ 4, 1,200, present,
“ 5, 1,300, present,
“ 6, 1,300, absent,
“ 7, 1,200, present,
“ 8, 1,200, absent,
“ 9, 800, present,

November 10, 1,000, absent,
" 11, 475, absent,
" 12, 1,000, present,
" 13, 800, present,
" 14, 1,200, present,
" 15, 1,600, present,
" 16, 1,900, absent,
" 17, 2,600, absent,
" 18, 2,000, present,
" 19, 4,100, present,
" 20, 2,700, present,
" 21, 2,800, present,
" 22, 2,600, absent,
" 23, 3,500, present,
" 24, 6,600, present,
389 " 25, 3,600, coli present,
" 26, 5,500, do.
" 27, 7,400, do.

That is the end of that.

Q. Can you give the percentage of instances in which the coli was found present in the samples taken from the Mississippi river above Grafton?

A. This is Mississippi river water above Grafton; this is October, the Mississippi river, 33.33 per cent. Mississippi river for November 62.50 per cent. Total per cent. 47.

Q. For the two months?

A. For the two months, yes. Those two rivers run very uniformily.

Q. Now, doctor, during this same period an examination was made from tests of water taken from Mississippi river at Chain of Rocks at three distinct places, as I understand?

A. Yes sir.

Q. State, please, the different places where the samples were taken?

A. Samples were taken at Mississippi river, at Alton, Illinois, that is one mile above Alton; Mississippi river, Hartford, Illinois; Missouri river, Ft. Bellefontaine; intake tower, Chain of Rocks, Illinois shore; Chain of Rocks, Missouri shore; Chain of Rocks, outlet screen chamber reservoir; Chain of Rocks, outlet stream chamber, basin, Bissell's point; tap in the

390 city chemist's office, 1141 Market street; tap at 5946 Garfield avenue.

Q. Now give the dates of the commencement of this series of tests to the end or conclusion.

A. Beginning at the intake tower—

Q. No, the date now. Give the date the first test was taken, the first sample of water was taken.

A. Well, the first samples of water during this investigation were taken at the intake tower beginning at St. Louis September 14.

Q. Now continuously on until when?

A. And from that on until November 30. While the samples from the Missouri river at Ft. Bellefontaine, Mississippi river at Hartford, Illinois, and Mississippi river at Alton, Illinois, began October 4, October 5, October 6, rather, for Hartford, Illinois; and October 5 for Alton.

Q. These samples seem to have been taken at different dates, and we will take up each one and give the date as we go through it.

A. Yes. Now where do you wish me to begin?

Q. Commence at the Chain of Rocks, the three different samples.

A. Don't you think we had better go down the river, Mr. Jeffries, and begin up here at Alton?

Q. All right.

391 A. If you begin below Alton, just below Hartford, and the Missouri, you will have these things in sequence.

Q. One mile above Alton, when did that commence?

A. That began on October 5—the first sample was taken, 1901. This was for the quantitative determination of bacteria per cubic centimeter and result of test for bacillus coli communis, Mississippi river one mile above Alton, Illinois.

Q. That was taken in the channel of the river?

A. That was taken in the channel of the river.

Q. Where were those samples taken?

A. They were collected from a boat, taken ashore and brought back to St. Louis, carried there by the collector.

Q. The same day they were collected?

A. The same day they were collected, they were collected at ten o'clock, and arrived at the laboratory about two, packed in ice.

Q. They were plated at once?

A. They were plated at once, plated that same day; they came, packed in ice.

October 5, 1,200 per cubic centimeter, coli present,
" 6, 250, coli bacillus present,
" 7, 100, do.
" 8, 750, do.
" 9, sample lost, coli present,
" 10, 330, coli present,
392 " 11, 750, coli present,
" 12, 600, "
" 13, 675, "
" 14, 425, "
" 15, 500, "
" 16, 650, "
" 17, 1,050, "
" 18, 900, "
" 19, 1,700, "
" 20, 1,360, "
" 21, 1,500, "
" 22, 1,100, "
" 23, 1,900, "
" 24, 1,700, "
" 25, 1,700, "
" 26, 1,700, "
" 27, estimation not made; coli present,
" 28, 1,700, coli present,
" 29, 1,700, "
" 30, 2,100, "
" 31, 2,500, "

That was for October.

Q. Now take November.

393 A. November 1, 1,500, coli present,
" 2, 1,200, "
" 3, 800, "
" 4, 1,300, coli absent,
" 5, 1,000, coli test not made,
" 6, 700, do.

November 7, sample lost,
" 8, numbers not made, but coli absent,
" 9, 1,300, coli present,
" 10, 1,000, "
" 11, 1,100, "
" 12, 1,200, "
" 13, 1,500, coli absent,
" 14, 2,100, coli present,
" 15, 2,000, "
" 16, 1,800, "
" 17, 1,300, "
" 18, 1,400, "
" 19, 1,500, "
" 20, 1,200, absent,
" 21, 1,500, absent,
" 22, 1,500, absent,
" 23, 1,600, absent,
" 24, 1,600, absent,
" 25, 2,700, present,
" 26, 2,200, absent,
394 " 27, 3,100, coli absent,
" 28, sample lost,
" 29, 2,300, coli present,
" 30, 2,000, "

So ends that story. There is wounderful uniformity in those numbers.

Q. Now will you take the Mississipi river at Hartford?

A. Hartford, Illinois.

JUDGE SPRINGER: Where is that?

A. Hartford is six or seven miles below Alton and one mile above the mouth of the Missouri river, where it empties into the Mississippi river.

MR. JEFFRIES: And how far below the mouth of the Illinois river where it empties into the Mississippi river?

A. I don't remember exactly, we have got those figures down though somewhere.

Q. About how far?

A. It was 39 miles from the mouth, to the mouth of the Missouri, about 30 miles, 27 to 30 miles.

MR. HAMLIN: Hartford is located below Alton?

A. Yes sir.

Q. How many miles?

A. About 6 or 7 miles by river.

MR. JEFFRIES: Now those samples were sent to St. Louis, were they?

A. Yes sir. They were brought to St. Louis by the col-
395 lector, immediately after being taken, and reached the
laboratory about two o'clock.

Q. They were plated immediately?

A. They were plated immediately, yes sir.

Q. Now we will have the result of the investigation.

A. Beginning October 6, the quantitative determination of the number of bacteria per cubic centimeter and the tests for bacilli coli communis at Hartford, Illinois, on the Mississippi river:

October 6, 450, coli present.
" 7, 950, "
" 8, 1,600, "
" 9, 850, "
" 10, 300, "
" 11, 300, "
" 12, 1,700 "
" 13, 3,250, "
" 14, 600, "
" 15, 650, "
" 16, 500, "
" 17, 2,000, "
" 18, 1,700, "
" 19, 2,300, "
" 20, 2,500, "
" 21, 1,400, "
396 " 22, 1,670, "
" 23, 4,400, coli absent,
" 24, 4,200, coli present,
" 25, 1,480, "
" 26, 4,200, "
" 27, sample lost; coli present. That is no numbers taken, but coli present.
" 28, 3,500, coli present,
" 28, sample numbers lost; coli present,

October 30, 8,200, coli absent,
" 31, 1,000, "
November 1, 750, coli absent,
" 2, 1,600, coli present,
" 3, 5,300, coli absent,
" 4, 1,700, coli present,
" 5, 2,900, coli test not made,
" 6, 2,300, "
" 7, sample lost,
" 8, 1,100, coli absent,
" 9, 2,000, coli present,
" 10, the numbers not recorded, but coli present,
" 11, 9,800, coli present,
" 12, 3,300, "
397 " 13, 1,300, coli present,
" 14, 3,100, coli absent,
" 15, 1,400, "
" 16, 2,100, coli present,
" 17, 1,300, coli absent,
" 18, 400, "
" 19, 1,300, "
" 20, 1,100, "
" 21, 2,500, coli present,
" 22, 1,800, coli absent,
" 23, 2,300, "
" 24, 3,000, present,
" 25, 4,400, coli absent,
" 26, 5,100, "
" 27, 9,500, coli test not made,
" 28, sample lost,
" 29, 5,700, coli present,
" 30, 4,300, coli absent.

That is all for that story.

MR. SPRINGER: That ends Hartford?

A. That ends Hartford. You see sometimes a little effect of the Alton sewage on the numbers of bacteria. The next place, the Missouri river.

MR. JEFFRIES: Missouri river at Ft. Bellefontaine?

398 A. Yes sir.

Q. That is how far from the mouth of the Missouri?

A. Six miles above the mouth of the Missouri where it empties into the Mississippi river.

Q. Now, when did you commence taking samples of water there?

A. Began October 4.

Q. Now, how soon after the samples were collected until they were plated?

A. They were collected by one collector, who took this one sample; he got that sample about ten o'clock in the morning and returned at once to the laboratory, reaching there about two o'clock—between noon and two o'clock.

Q. Was that at the Chain of Rocks?

A. He took a train to Ft. Bellefontaine and came right back again.

Q. Back to St. Louis?

A. Yes sir.

Q. That is, back to your office?

A. Yes, he left the office and went right out there and then back that same day, as fast as he could come back with the train that brought him back; he regulated his time accordingly.

This is for the quantitative determination of the number of bacteria in samples of water collected at Ft. Bellefontaine on the Missouri river, and for the result of the tests
399 for the detection of the bacillus coli communis.

October 4, 7,000, coli test not made,
" 4, 19,200, coli present,
" 5, 19,200, coli present,
" 6, 3,100, coli present,
" 7, 2,250, "
" 8, 22,500, "
" 9, 10,500, "
" 10, 9,200, "
" 11, 10,800, "
" 12, 5,000, "
" 13, 6,000, "
" 14, 104,600, "
" 15, 53,500, "

There must have been a rain up there.

October 16, 6,400, coli present,
" 17, 21,400, "
" 18, 26,000, "

October 19, 37,600, coli absent,
" 20, 52,300, coli present,
" 21, 20,400, coli absent,
" 22, 48,700, coli present,
" 23, 34,700, "
" 24, 34,700, "
" 25, 37,300, "
" 26, 35,900, "
400 " 27, 35,000, "
" 28, 40,000, "
" 29, 37,200, "
" 30, 32,000, "
" 31, 29,400, "

That is October.

Q. Now you are in November.

A. November 1, 25,900, coli present,
" 2, 25,800, "
" 3, 22,100, "
" 4, 28,200, coli absent,
" 5, 15,200, coli test not made,
" 6, 30,000, "
" 7, 20,000, "
" 8, 10,300, coli present,
" 9, 31,000, "
" 10, 34,400, coli absent,
" 11, 54,000, coli present,
" 12, 43,500, "
" 13, 69,700, "
" 14, 69,700, "
" 15, 41,900, "
" 16, 20,000, coli absent,
" 17, 7,800, coli present,
" 18, 11,200, coli absent,
401 " 19, 37,300, coli test not made,
" 20, 49,000, coli present,
" 21, 41,500, "
" 22, 46,000, coli absent,
" 23, 59,200, coli present,
" 24, 60,400, "
" 25, 63,000, coli test not made,

November 26, 26,500, coli present,
“ 27, 45,700, “
“ 28, sample lost,
“ 29, 49,700, coli present,
“ 30, 68,600, “

That is the end of that.

MR. SPRINGER: The next place is what?

A. The next place we go to the intake tower.

MR. JEFFRIES: That is down at the Chain of Rocks?

A. That is on the Chain of Rocks.

MR. SPRINGER: This is the nearest point to the intake?

A. We can begin on the Missouri, Illinois shore, or intake tower.

MR. JEFFRIES: Now explain how that was done first.

A. A cross section was taken of the river here about 100 yards—

ATTORNEY GENERAL CROW: What do you mean
402 by cross section?

A. A line drawn across the river—

MR. CROW: I know what you mean, but I want the record to show.

A. At 300 yards from the Missouri shore, a sample was taken. This is above the intake, about 100 yards. That is a line drawn from the shore through the intake. The second sample or what is known as the intake tower sample was taken in front of the intake tower anywhere from 100 to 300 feet in front of it, as the man rowed across the river. And the third sample was taken on the Illinois shore, 300 yards from the shore in the channel.

MR. SPRINGER: 300 yards or 300 feet?

A. 300 yards. 300 feet would be in the shallow water there.

MR. SPRINGER: That would be 900 feet, then.

A. That would be 900 feet at least.

MR. JEFFRIES: Where were those samples taken afterwards?

A. They were taken ashore and plated immediately, and then the plates when the gelatine solidified were carried to the bacteriological laboratory at 1141 Market street, the city chemist's office, and there incubated, and counted when ripe.

Then we will begin with this Missouri shore-sample, shall we?

Q. Yes, we will commence with the Missouri shore sample.

403 MR. SPRINGER: Intake tower, Chain of Rocks.

A. Yes, the Missouri shore, Chain of Rocks.

MR. SPRINGER: That is 300 yards out?

A. 300 yards from the shore.

MR. JEFFRIES: And just above—

A. Just above a line drawn through the intake. You see it is impossible to get a sample below there because it is rocky, a chain of rocks has been thrown out into the river to deflect the water away from the shore, so it would be shallow water below the chain of rocks; consequently the samples were taken above the chain of rocks, where the water was deep.

September 14, for the quantative determination, of the number of bacteria per cubic centimeter in samples collected at the Missouri shore, Chain of Rocks, and for the detection of the bacillus coli communis, per one cubic centimeter of water.

September 14, 1,000, bacillus coli test not made.
“ 16—we jump the 15th there; no test.
“ 16, 900, coli test not made,
“ 17, 700, coli present,
“ 18, 600, “
“ 19, 1,000, coli absent,
“ 20, 2,400, coli present,
“ 21, 325, test not made,
“ 22, 2,800, coli present,
404 “ 23, 350, coli absent,
“ 24, sample lost, coli not present,
“ 25, numbers not recorded; coli present,
“ 26, 7,200, coli present,
“ 27, 7,100, “
“ 28, 10,700, “
“ 29, 2,500, “
“ 30, 2,100, “
October 1, 1,800, coli present,
“ 2, 4,900, test not made,

October 3, 3,500, coli present,
“ 4, 4,500, “
“ 5, 7,950, “
“ 6, 2,500, “
“ 7, 2,800, “
“ 8, 12,300, “
“ 9, 8,100. “
“ 10, 9,000, “
“ 11, 11,300, “
“ 12, 7,000, “
“ 13, 4,000, coli absent,
“ 14, 5,400, coli present,
“ 15, 9,600, “
“ 16, 8,600, “
405 “ 17, 10,800, “
“ 18, 28,100, “
“ 19, 26,400, “
“ 20, 42,100, “
“ 21, 33,200, “
“ 22, 31,900, “
“ 23, sample lost; coli present,
“ 24, 28,600, coli present,
“ 25, 36,400, “
“ 26, 29,900, “
“ 28, 20,800, “
“ 29, 24,700, “
“ 30, 24,000, “
“ 31, 31,000, “

So much for October. They run uniformly with the Missouri, you will notice.

Now begins November. Missouri shore, Chain of Rocks, November 1, 22,800, coli present.

November 2, 22,400, coli present,
“ 3, 21,100, “
“ 4, 17,300, coli absent,
“ 5, 10,700, coli test not made,
“ 6, 18,300, “
“ 7, 17,400, “
“ 8, 11,600, coli present,
406 “ 9, 23,400, “

November 10, 22,300, coli present,
" 11, plate lost; coli bacillus present,
" 12, 43,800, coli present,
" 13, 66,300, "
" 14, 56,200, "
" 15, 33,700, coli absent,
" 16, 61,500, "
" 17, 59,000, coli present,
" 18, 66,000, present,
" 19, 48,700, coli present,
" 20, 44,500, "
" 21, 42,700, "
" 22, 42,200, coli absent,
" 23, 50,600, coli present,
" 24, 35,000, "
" 25, 28,100, "
" 26, 42,500, "
" 27, 4,100, "
" 28, sample lost,
" 29, 37,300, coli present,
" 30, 52,500, "

MR. JEFFRIES: Now give us the result of the examination on the Illinois shore during this same period.

A. All right. Illinois shore, Chain of Rocks, quantative
407 determination of the number of bacteria in samples collected at this point, together with the results of the test for the baccillus coli communis, quantity of water per one cubic centimeter.

September 14, 700, coli test not made,
" 15, sample not taken,
" 16, 450, coli test not made,
" 17, 550, coli present,
" 18, 375, coli test not made,
" 19, 510, coli absent,
" 20, 1,000, coli present,
" 21, 1,800, coli present,
" 22, 3,000, coli absent,
" 23, 22,500, coli present,
" 24, 2,100, "
" 25, 1,500, "

September 26, 1,500, coli present,
" 27, 4,800, "
" 28, 1,700, coli absent,
" 29, 1,700, coli present,
" 30, 1,500, "

So much for September.

Q. Now as to October?

A. October, the Illinois shore, bacteria per cubic centimeter.

408 October 1, 1,800, bacilli coli communis present,
" 2, 1,800, coli test not made,
" 3, 2,200, coli present,
" 4, 2,500, "
" 5, 4,600, "
" 6, 23,500, "
" 7, 650, "
" 8, 1,700, "
" 9, 8,600, "
" 10, 16,800, "
" 11, 3,600, "
" 12, 1,800, "
" 13, 5,500, "
" 14, 1,900, "
" 15, 1,200, "
" 16, 800, "
" 17, 1,200, "
" 18, 2,300, "
" 19, 2,200, coli absent,
" 20, 2,300, coli present,
" 21, 2,700, "
" 22, 2,200, "
" 23, 3,100, "
" 24, 3,600, "
" 25, 2,800, "
" 26, 1,900, "
409 " 27, 1,300, "
" 28, 410, "
" 29, plate lost; coli present,
" 30, 2,300, coli present,
" 31, 2,500, "

Are you ready for November?

MR. SPRINGER: Yes.

A. Illinois shore, November 1, 1,900, coli present,
November 2, 9,800, coli absent,
“ 3, 2,400, coli present,
“ 4, 2,000, coli absent,
“ 5, 1,500, coli test not made,
“ 6, 1,500, “
“ 7, 2,200, “
“ 8, plate lost; coli present,
“ 9, 2,100, coli present,
“ 10, 2,300, “
“ 11, 2,800, “
“ 12, 2,200, “
“ 13, 2,400, “
“ 14, 2,000, “
“ 15, 3,100, coli absent,
“ 16, 2,100, coli present,
“ 17, 2,000, “
“ 18, 2,400, “
“ 19, 2,100, coli absent,
410 “ 20, 1,700, coli present,
“ 21, 1,400, “
“ 22, 4,000, “
“ 23, 2,500, “
“ 24, 2,600, coli absent,
“ 25, 3,000, “
“ 26, 7,500, coli present,
“ 27, 7,800, “
“ 28, sample lost,
“ 29, 5,500, coli present,
“ 30, 7,200, “

MR. SPRINGER: That was Illinois shore?

A. That was the Illinois shore.

MR. JEFFRIES: That is the last of the test of the water taken from the Illinois shore, or near the Illinois shore?

A. Yes, sir.

Q. Now, we will take the results of the test taken at the intake.

A. Yes, sir. These were taken at the intake tower from

100 to 300 feet above the tower in the river where the river was running fast.

MR. SPRINGER: This was not taken in the intake tower itself?

A. No. The intake tower is there, 1,500 feet from the
shore, and the samples were taken in the channel in front
411 of it. It is difficult to take a sample in a tower, because
the water is pouring into it from all sides, and it is very
difficult for a man to get down there.

MR. SPRINGER: This is the intake?

A. This is intake, sample of water that was taken in front of the tower, of water that was running in there, comparative tests showed the bacterial contents to be alike.

Intake tower, Chain of Rocks, September 14.

This is intake tower, Chain of Rocks, for the quantative determination of the number of bacteria per cubic centimeter, and the result of tests for bacillus coli communis, intake tower, Chain of Rocks.

September 14, 1,950, coli test not made,
" 15, sample lost,
" 16, 1,450, coli test not made,
" 17, 2,300, coli present,
" 18, 750, coli absent,
" 19, 1,240, "
" 20, 3,000, coli present,
" 21, 2,900, "
" 22, 1,700, "
" 23, 5,600, coli absent,
" 24, sample lost,
" 25, 3,700, coli present,
" 26, 3,900, "
412 " 27, 3,200, "
" 28, 3,300, "
" 29, 2,200, "
" 30, 3,200, "
October 1, 3,600, coli present,
" 2, 9,200, coli test not made,
" 3, 5,400, coli present,
" 4, 6,200, "
" 5, 8,250, "

October 6, 1,550, coli absent,
" 8, plate lost; coli present,
" 9, 9,700, coli present,
" 10, 4,500, "
" 11, 10,200, "
" 12, 5,700, coli absent,
" 13, 5,400, coli present,
" 14, 11,200, "
" 15, 8,700, "
" 16, 22,000, "
" 17, 13,900, "
" 18, 34,600, "
" 19, 36,200, "
" 20, 48,800, "
" 21, 41,400, coli absent,
413 " 22, 35,500, coli present,
" 23, 49,300, "
" 24, 40,600, "
" 25, 28,300, "
" 26, 43,100, "
" 27, plate lost; coli present,
" 28, " "
" 29, " "
" 30, 33,000, coli present,
" 31, 33,800, "

Intake tower, Chain of Rocks.
November 1, 29,900, coli present,
" 2, 28,700, "
" 3, 28,800, "
" 4, 23,100, coli absent,
" 5, 23,000, coli test not made,
" 6, 22,100, "
" 7, 22,000, "
" 8, 13,900, coli present,
" 9, 20,900, "
" 10, 35,400, "
" 11, 37,800, "
" 12, 40,300, "
" 13, 70,700, "
" 14, 67,300, "

414 November 15, 42,400, coli absent,
“ 16, 50,000, “
“ 17, 69,200, coli present,
“ 18, 67,200, coli absent,
“ 19, 48,800, coli present,
“ 20, 51,600, “
“ 21, 43,400, coli absent,
“ 22, 45,800, coli present,
“ 23, 49,000, “
“ 24, 28,200, coli absent,
“ 25, 28,800, coli present,
“ 26, 36,100, “
“ 27, 28,700, “
“ 28, sample lost,
“ 29, 49,700, coli present,
“ 30, 53,700, “

MR. SPRINGER: Is that all of that?

A. That is the end of that. We go to outlet screen chamber, Chain of Rocks.

MR. JEFFRIES: Is that in the reservoir?

A. Yes, that is in the reservoir.

MR. SPRINGER: This is after sedimentation?

A. Yes, this is after 70 hours' rest in the reservoirs now.

MR. SPRINGER: How does this one compare with that one a year ago?

415 A. I think it is about the same, or a little bit better during that time. I think there wasn't so many bacteria in the water.

MR. JEFFRIES: Now, an examination also was made at the outlet screen in the chamber of the Chain of Rocks?

A. Yes, sir; of the reservoir of the Chain of Rocks.

Q. Those samples were taken from the same place?

A. Yes, sir.

Q. In the outlet screen, same as in period No. 2, the second period testified to a few days ago?

A. Yes, I think it was reservoir No. 3, but it makes no difference. They have one of those reservoirs—it is after the subsidence.

Q. Where were those samples taken after they were collected?

A. They were taken as soon as they were collected, they were taken to the house or pumping station there, and plated immediately.

Q. And the plates were—

A. And the plates were put into a special apparatus designed by Mr. Damon and carried to the city chemist's office, 1141 Market street, and there incubated and counted afterwards.

Q. Now, let us have the result from those examinations, giving the dates.

A. Quantative determination of the bacteria per cubic
416 centimeter and the results of the tests for the bacillus coli communis.

Outlet screen chamber, Chain of Rocks reservoir.

September 14, 350, test for bacilli coli communis not made,
" 15, sample lost,
" 16, 250, test not made,
" 17, 500, coli absent,
" 18, 400, test not made,
" 19, 400, coli present,
" 20, 850, "
" 21, 900, coli absent,
" 22, 1,100, test not made,
" 23, 1,300, coli present,
" 24, 1,400, "
" 25, 1,300, "
" 26, 1,400, "
" 27, 1,000, "
" 28, 9,100, "
" 29, 950, "
" 30, 1,000, "

October 1, outlet screen chamber, 370, bacillus coli communis present,

October 2, 1,600, coli test not made,
" 3, 1,150, coli present,
417 " 4, 1,250, bacilli coli communis present,
" 5, 820, " "
" 6, 3,200, " "
" 7, 410, " "
" 8, plate lost,
" 9, 950, coli present,

October 10, 2,000, coli present,
" 11, 3,100, "
" 12, 1,900, "
" 13, 1,500, "
" 14, 1,900, "
" 15, 4,900, "
" 16, 1,900, "
" 17, 4,100, "
" 18, 4,500, "
" 19, 4,000, "
" 20, 6,200, "
" 21, 7,100, "
" 22, 6,600, "
" 23, 6,300, "
" 24, 7,500, "
" 25, 1,200, "
" 26, 11,400, "
" 27, 5,400, "
" 28, 6,900, "
418 " 29, 7,200, "
" 30, 7,700, "
" 31, 6,200, "

Now comes November.

November 1, 6,800, coli present,
" 2, 5,600, "
" 3, 5,900, "
" 4, 5,600, "
" 5, 6,400, coli test not made,
" 6, 5,300, "
" 7, 6,500, "
" 8, 5,000, coli present,
" 9, 6,300, "
" 10, 6,600, coli test not made,
" 11, 6,300, coli present,
" 12, 6,200, "
" 13, 8,100, "
" 14, 6,100, "
" 15, 10,000, "
" 16, 11,800, "
" 17, 8,200, "

November 18, 10,700, coli present,
" 19, 6,300, "
" 20, 7,500, "
419 " 21, 10,800, "
" 22, 14,100, "
" 23, 12,200, "
" 24, 7,800, "
" 25, 5,600, "
" 26, 7,800, "
" 27, 7,900, "
" 28, sample lost,
" 29, 4,600, coli absent,
" 30, 8,400, "

That is the end of that outlet screen business.

MR. JEFFRIES: Now, during this same period at this same time, was there an examination made of the water in the settling basin at Bissell's Point, as I understand it?

A. Yes, outlet station, settling station, Bissell's Point.

Q. Now, those samples were taken out of the settling basin?

A. Out of the settling basin outlet, where the water was flowing out into the deep well there.

Q. What became of the samples taken from there?

A. The samples were taken by Mr. Damon himself and brought directly to the laboratory and plated—plated at 1141 Market street.

Q. And from that they were developed?

A. They were brought right back. He went out in the
420 morning and took the samples at the outlet screen, the
samples at the large reservoir, and then took the Chain
of Rock samples and came back that way, but it was plated
within a half an hour after he took it.

Q. Now give us the results of those tests?

A. Results, September 16, is the first number, bacteria per cubic centimeter:

September 16, 200, test not made,
" 17, 100, "
" 18, 100, "
" 19, 140, "
" 20, 80, "
" 21, 250, coli present,

September 22, 150, coli absent,
" 23, 120, coli present,
" 24, 340, coli test not made,
" 25, 700, coli present,
" 26, 1000, "
" 27, 750, "
" 28, 850, "
" 29, 325, "
" 30, 350, "

Q. Now for the month of October.

A. Outlet to settling basins, October:

421 October 1, 300, coli absent,
" 2, 650, coli test not made,
" 3, 450, coli absent,
" 4, 550, coli present,
" 5, 380, "
" 6, 575, "
" 7, 200, "
" 8, plate lost; coli present,
" 9, 1200, coli present,
" 10, 1200, "
" 11, 475, "
" 12, 700, "
" 13, 450, "
" 14, 725, "
" 15, 600, "
" 16, 750, coli absent,
" 17, 1500, coli present,
" 18, 1700, "
" 19, 2400, "
" 20, 1800, "
" 21, 1800, "
" 22, 2400, "
" 23, 1900, "
" 24, 1700, "
" 25, 1700, "
" 26, 1200, "
422 October 27, 1250, coli present,
" 28, 1130, coli absent,

October 29, plate lost; coli present,
“ 30, 1600, coli present,
“ 31, 1500, “
November, 1, 1600, “
“ 2, 8700, “
“ 3, 1100, “
“ 4, 1600, “
“ 5, 1000, coli test not made,
“ 6, 1000, “
“ 7, 1400, “
“ 8, 1300, coli present,
“ 9, 1800, “
“ 10, 2500, “
“ 11, 1870, “
“ 12, 3000, “
“ 13, 3900, “
“ 14, 2700, “
“ 15, 2500, “
“ 16, 3400, “
“ 17, 3300, “
“ 18, 2100, “
“ 19, 1900, “
423 November 20, 2100, coli present,
“ 21, 3000, “
“ 22, 2100, “
“ 23, 3600, coli absent,
“ 24, 2000, coli present,
“ 25, 3200, “
“ 26, 3300, “
“ 27, 2600, “
“ 28, sample lost,
“ 29, 2700, coli present,
“ 30, sample lost,

That is the end of the outlet screen chamber, Bissell's point.

MR. JEFFRIES: Now the samples taken at the tap in the city chemist's office.

A. Yes sir. 1141, Market street. It was the bacteriological laboratory at the city chemist's office. The water was allowed to run five minutes before the sample was taken. The sample was then taken in a steriled flask and plated immediately.

Q. Now what was the result of those experiments?

A. Tap at the city chemist's office, 1141 Market street, September 17.

MR HAMLIN: Your table shows the year above there, doesn't it?

424 A. Yes sir, 1901.

MR. JEFFRIES: All of these tests and samples that were taken and made during the third period, the period that we have been dealing with today, were taken in 1901?

A. Yes sir, September, October and November.

Q. We went over that yesterday.

MR. SPRINGER: Yes, that is all in the record.

MR. JEFFRIES: Now go ahead with your results.

A. September 17, 1895, coli bacillus present.
September 18, 170, coli absent,
" 19, 170, "
" 20, 210, coli present,
" 21, 210, "
" 22, 120, "
" 23, 500, "
" 24, plate lost, coli present,
" 25, 600, coli present,
" 26, 275, "
" 27, 700, "
" 28, 275, "
" 29, sample lost; coli present,
" 30, 275, coli present.
October 1, sample lost; coli present,
" 2, 650, coli test not made,
425 October 3, 375, coli absent,
" 4, 525, "
" 5, 885, coli present,
" 6, 185, "
" 7, 970, "
" 8, 1500, "
" 9, 900, "
" 10, 360, "
" 11, 600, "

	October	12,	600,	coli present,
	“	13,	500,	“
	“	14,	635,	“
	“	15,	475,	“
	“	16,	1100,	“
	“	17,	1500,	“
	“	18,	1800,	“
	“	19,	2000,	“
	“	20,	3000,	“
	“	21,	2700,	“
	“	22,	3300,	“
	“	23,	1800,	“
	“	24,	1600,	“
	“	25,	1700,	“
	“	26,	2500,	“
	“	27,	plate lost;	coli present,
426	October	29,	800,	coli present,
	“	30,	1700,	“
	“	31,	2300,	“
	November	1,	2200,	coli present,
	“	2,	1500,	coli absent,
	“	3,	1000,	coli present,
	“	4,	950,	“
	“	5,	1200,	coli absent,
	“	6,	1000,	“
	“	7,	1000,	“
	“	8,	1000,	coli present,
	“	9,	1700,	“
	“	10,	2100,	“
	“	11,	2800,	“
	“	12,	2100,	“
	“	13,	3400,	“
	“	14,	3200,	“
	“	15,	2300,	coli absent,
	“	16,	3200,	“
	“	17,	3400,	“
	“	18,	3200,	coli present,
	“	19,	3200,	“
	“	20,	3400,	“

November 21, 2500, coli present,
427 November 22, 3700, coli present,
" 23, 4500, coli absent,
" 25, 2800, coli test not made,
" 26, 2300, coli present,
" 27, 1700, "
" 28, sample lost,
" 29, 2800, coli present,
" 30, 3300, "

MR. JEFFRIES: Now, an examination of the water was made during this period at the tap at 5946 Garfield avenue?

A. Yes sir.

Q. That was in a private residence, was it?

A. Yes, that was in the residence of one of our bacteriologists, Mr. Snodgrass. He lived far west on Garfield avenue, and the water supplied to him came from the Compton Hill stand pipe or from the high water service at Baden.

Q. How far from that?

A. It is about 4 miles directly across there, but you see it first comes to the stand pipe and goes back to him, so it must have traveled six miles to the stand pipe and received its pressure there, and then was carried out to this district.

Q. That is, it traveled six miles before it went to the standpipe?

A. Yes sir.

428 Q. And from that standpipe it was carried out to his residence?

A. Yes, sir.

Q. How far is this residence from the standpipe?

A. Four miles.

Q. That would be about eight miles?

A. Oh, it would be more than that; it would be pretty nearly ten miles to get to him. It goes right straight across from Baden in through the cemetery to Grand avenue. Now he lives west of Grand avenue, 5900.

Q. That would be about ten miles, would it?

A. That the water would have to travel to go from Baden to the standpipe and back to him.

Q. Ten miles from Baden?

A. Yes, sir.

Q. Now then how far from Baden to the reservoir?

A. No, about six miles from the reservoir to Baden and about four miles from Baden to the Garfield avenue house. You see it goes straight across the town to this standpipe and this standpipe supplies this region right across here.

Q. Now after these samples were got at the tap, 5946 Garfield avenue, the bacteriologist brought them down to the laboratory immediately.

429 A. Yes, he brought the samples directly to the laboratory and there it was plated.

Q. Well now, give us the result of that examination.

A. Beginning October 3, 1901, we took samples from this residence at 5946 Garfield avenue.

	October	3,	225,	coli test not made.
	"	4,	450,	coli present,
	"	5,	225,	"
	"	6,	485,	"
	"	7,	plate lost;	coli present,
	"	8,	"	"
	"	9,	275,	coli absent,
	"	10,	300,	coli present,
	"	11,	250,	"
	"	12,	300,	"
	"	13,	425,	"
	"	14,	360,	coli test not made,
	"	15,	350,	"
	"	16,	450,	coli present,
	"	17,	375,	"
	"	18,	425,	"
	"	19,	300,	"
	"	20,	410,	"
	"	21,	650,	"
	"	22,	600,	coli test not made,
430	October	23,	725,	coli present,
	"	24,	550,	"
	"	25,	500,	"
	"	26,	275,	coli test not made,

October 27, 230, coli present,
" 28, 450, "
" 29, 675, "
" 30, 300, "
" 31, 550, "

Q. Now for November.

A. November 1, 1300, coli present,
" 2, plate lost; coli present.
" 3, 3300, coli present.
" 4, 5000, "
" 5, 900, "
" 6, 4400, coli test not made,
" 7, 1900, "
" 8, plate lost; coli present,
" 9, 3100, coli present,
" 10, 11,200, "
" 11, plate lost; coli present,
" 12, 2200, coli present,
" 13, 2300, "
" 14, 2300, "
" 15, 2100, "
431 November 16, 6800, coli present,
" 17, 2200, "
" 18, 2200, coli absent,
" 19, 2000, coli present,
" 20, 2000, coli present,
" 21, 2300, "

No sample taken until the 25th.
November 25, 500, coli present,
Next sample taken on 27th, 700, coli absent,
None on 28th.
November 29, 1900, coli present,
" 30, 975, "

Q. Now can you give us the percentages?

A. Of coli at each one of these places?

Q. Yes, give us the percentages of coli in these examinations.

A. One mile above Alton, Illinois, coli for October, 1901, 100 per cent.

MR. SPRINGER: What is this? Number of coli in each sample?

A. Yes sir, the percentage. It was found in 100 per cent in October.

In November, 1901, in 77 per cent. making an average of 88.6 per cent. of samples collected.

For the third period percentage of colon baccillus at Hart-
432 ford for October, 1901, was 86.4 per cent.

For November, 56 per cent.

The average of this was 70 per cent.

Hartford, it is understood, is seven miles below Alton.

MR. JEFFRIES: Now get Bellefontaine.

A. During the third period the percentage of coli baccillus, at Ft. Bellefontaine, in the Missouri river, October, 1901, in 92.6 per cent.

In November, 1901, 80 per cent. of the times.

The average of this is 86.2 per cent.

During the third period the bacillus coli communis was found on the Missouri shore, Chain of Rocks, in September 76.9 per cent. In October, 97 per cent. In November, 84.6 per cent. The average for this period is 88.4 per cent.

Chain of Rocks, Illinois shore, the percentage of coli bacillus for September, 1901, was 76.9 per cent. October, 97 per cent. November, 77 per cent. of the time. The average is 81.7 per cent.

Coli bacillus, Mississippi river intake tower, Chain of Rocks, September, 1901, 76.9 per cent. October, 90 per cent. November, 77 per cent. Average, 80 per cent.

Q. That is the average for the three months?

A. The average for the three months, yes sir.
433 The reservoir, Chain of Rocks—

MR. SPRINGER: That is after sedimentation?

A. Yes sir, that is after sedimentation. Colon bacillus, September, 1901, 83.5 per cent. October—There is something wrong in this typewritten copy here, and I will have to go over the results. Will you leave that out for the present, the reservoir at the Chain of Rocks? There is some mistake of some kind for October. I will go over those calculations tonight.

We have the outlet settling basins, Bissell's Point for September, 86.4 per cent. October 94.04 per cent. November, 93.8 per cent. The average of those is 91.41 per cent.

The tap at 1141 Market street, September, 85.7 per cent. October, 97 per cent. November, 80, per cent. The average of this is 87.5 per cent of the samples collected at 1141 Market street.

MR. JEFFRIES: Now those collected at 1141 Market street are those referred to as the city hall collections?

A. Yes sir, at the city chemist's office.

MR. SPRINGER: Have you Garfield avenue?

A. Garfield avenue I have not calculated. I can give you those averages if you wish them.

MR. SPRINGER: You mean at the reservoir?

A. Yes sir, average of bacteria at the Chain of Rocks in-
434 take for the month of September, is 2,686, 14 days. I am
giving you the average of the bacteria for 14 days.

MR. SPRINGER: Oh yes.

A. The average of bacteria for the 14 days of September here is 2,686 at the Chain of Rocks.

MR. JEFFRIES: Now this does not have reference to the bacilli coli communis at all?

A. No sir, not at all. I take the number of bacteria each day and divide it by 14, which gives you this number, 2,686, the whole number divided by 14. That was at the outside of the intake in the river.

Q. Now then give it for the Illinois shore.

A. No, we are not going over to the Illinois shore at all. Now the outlet screen chamber settling basins, Chain of Rocks, after passing through the reservoir, 1375 is the average, 14 days, after settling 70 hours, or the percentage removal of bacteria is 48.43 per cent. The average for 14 days at Bissell's Point, outlet of the basins, the number of bacteria is 363, or the percentage of bacterial removal to this point after passing through both reservoirs, is 86.05 per cent.

Q. Now that doesn't mean the loss of bacteria from the reservoir?

A. In the one reservoir, and before they go out of another;
that means 86.05 per cent. have been removed to the out-
435 let chamber of the second reservoir.

Q. From the river?

A. From the river, yes, from the intake. Now then, the removal to the tap, 300— The number of bacteria per cubic centimeter, average 14 days, is 300. The percentage of removal is 88.83.

October, the average number of bacteria for the whole month is 20,500, at the intake in the river. The average number for the month of October in the outlet screen chamber in the settling basins at the Chain of Rocks is 2975. The percentage removal for this month is 85.6.

Bissell's point, outlet of the basins, the number of bacteria averaged for the month, 1,137. Percentage removal, 90 per cent.

Average number of bacteria for the month of October at the tap 1141 Market street is 843. Percentage removal, 95.9 per cent.

The average for the month at 5943 Garfield avenue, the tap, the average for the month is 412, or the percentage removal, 98 per cent.

Now then, for November, total number of bacteria found at the intake for the month of November, the average is 39,518.

The total of the outlet screen chamber, Chain of Rocks settling basins, for the month of November, is 7,600. That
436 is the average for the month. Percentage removal, 81.5.

Bissell's Point, outlet settling basins, average number of bacteria per month, 2,545. Percentage removal, 93.5 per cent.

Tap, 1141 Market street, the average is 2,560. Percentage removal is 93.2 per cent.

5946 Garfield avenue tap, the average number of bacteria for the month was 2,880.

MR. SPRINGER: More than the other place?

A. Yes.

MR. SPRINGER: How do you account for that?

A. I don't know how to account for it except that they were stirring things up in the pipes.

The percentage removal is 92.7, or I can give you the total percentage lost for those three months. The total percentage lost for these three months, 14 days in September, all of October and all of November, at the outlet of the seven settling basins, and the outlet screen chamber Chain of Rocks, 71.84 per cent.

Bissell's Point, outlet settling basins, 90 per cent.

Tap, 1141 Market street, 92.64 per cent.

Tap, Garfield avenue, 95. 3 per cent.

Adjourned until 10 o'clock, Saturday morning, February 21, 1903.

437 Met pursuant to adjournment at the Southern Hotel at ten o'clock a. m., Saturday February 21, 1903.

Present, the Commissioner and the same Counsel representing the respective parties.

DR. AMAND NICHOLAS RAVOLD, resumed the stand for further direct examination by Mr. Jeffries.

Q. Now, doctor, you may give the percentage of bacteria found at the different places on the Illinois river.

A. The Illinois river and the Mississippi river at Grafton for this third period. Now the average number of bacteria per cubic centimeter for the month of October, 1901, Mississippi river above Grafton, is 717.

The average number of bacteria per cubic centimeter, Mississippi river above Grafton for the month of November, 2,290.

The average number for the Illinois river above Grafton, Illinois for the month of October, 1,780, and for the month of November, 3,050. I am not giving the averages for the three months, but for each month. It is easier. You see the Illinois contains quite the larger number there.

JUDGE SPRINGER: Did you give Peoria, above Peoria?

A. Didn't I give you that?

Q. No sir.

438 A. I have not the totals for Peoria for that period.

Q. You didn't give it at Bellefontaine, either.

A. Well, I want to make a comparison between Bellefontaine and Hartford later on. I will make a comparison between Bellefontaine and Hartford and then we will get at the results. I think I have got that. Later along when we again come to Peoria, coming down the river, I think I have got averages for the three months.

MR. JEFFRIES: Now give us the result of the cultural and bacterial features of the bacteria found in the Illinois river, the Mississippi river, the Missouri river, Lake Michigan and the canal—that is the Chicago Drainage canal during the second period from January to October, 1900.

A. Now this is a chart original with this laboratory, presenting the morphological cultural and biochemical features of the micro-organism found in the waters of Lake Michigan, the Chicago Drainage canal, the Illinois river and the Mississippi river, at the intake. I will read the name of the organism, but how to present that chart I don't know.

JUDGE SPRINGER: I think the stenographer should take that chart and copy it into the record.

MR. JEFFRIES:—Just wait until I examine him about it. I asked you a few minutes ago, doctor, if you could give the cultural and bacterial features of the waters of the various 439 rivers in question and the lake, and the Chicago Drainage canal. I would like to have you state fully and clearly the cultural and bacterial features as found upon an examination of the waters.

JUDGE SPRINGER: Give us a general explanation about this first.

MR. JEFFRIES: That question can come next. I want to get this into the record first. First give the name of the organism, then the properties.

A. The bacteria here are classified into types according to the colors which they produce upon the media, or certain other characteristics by which they can be confined to groups, distinctive groups, and the morphological, cultural and biochemical features which carry it through a variety of media.

Now shall I begin and go right through with this thing?

Q. Go right through with it.

A. We have under the fluorescens type, first, the bacillus fluorescens incognitis. The first investigator was Wright.

ATTORNEY-GENERAL CROW: What does that mean—the first investigator?

A. It means that he discovered it or found it in the water.

Q. I understand what it means, but I want to get it into the record.

A. Yes sir. It is a bacillus, motile, does not form spores. 440 Under cultural features now: In nutrient broth it produces a scum and the nutrient broth is made turbid by it. In an agar tube it shows a wrinkled membrane.

Gelatine plate colony characteristics not distinct.

Potato, a luxuriant and visible growth.

Fermentation tube does not produce gas.

Grows best at body temperature.

In gelatine it does not liquify.

In milk it does not coagulate.

It does not liquify blood serum.

It does not ferment.

It produces no gas.

Does not reduce nitrates.

Does not produce indol.

Again it does not coagulate milk.

Is chromo-genic on nutrient agar, and it produces fluorescens of the media.

MR. JEFFRIES: I notice you said a moment ago that it is a particular branch or type?

A. The fluorescent type.

Q. It grows at body temperature?

A. Yes. Well, that is a temperature, 98 3/5 F. or 36½ centigrade.

Q. What you mean by that is that it developed?

A. It grows best.

441 Q. The vitality is active?

A. It grows best on our nutrient media, more vigorous in a definite period of time.

Q. Now the second type.

A. The second type or the next one following do you mean?

Q. Yes.

A. Number 2, bacillus fluorescens liquefaciens. First investigator Fluegge.

Diameter greater than one M, that is one micro-millimeter. It is less than one micro-millimeter.

It is motile.

Does not form spores or scum and the nutrient broth turbid.

Growth on nutrient agar tube not dull, not wrinkled.

On gelatine plate, appearance characteristic.

Body tube, growth visible, not abundant or not luxuriant.

Does not grow in closed arm of fermentation tube.

Does not grow well at body temperature.

It is not facultative an-aerobic.

Q. State what you mean by facultative an-aerobic.

A. We have two words in bacteriology, aerobic and an-aerobic. Aerobic bacteria grow best in the presence of oxygen. The an-aerobic bacteria grow best in its absence.

Now there are classes of micro-organism that grow under
442 both conditions. They grow nearly as well under an-aerobic conditions as they do under aerobic conditions. Since they have this faculty of doing this thing they are called facultative an-aerobic or facultative aerobic, depending upon which condition they grow best.

It liquifies gelatine.

Produces and liquifies blood.

Liquifies casein in milk.

Produces no gas in Dextrose broth.

Reduces nitrates,

Does not produce indol,

Coagulates milk,

Q. What do you mean by indol?

A. Indol is one of the products, one of the putrefactive products the result of destructive decomposition or the destructive action of bacteria upon organic matter.

Q. Then that particular branch of that type does not produce destruction of solid matter?

A. It does not produce indol. Yes, it produces the destruction of the solid matter without the production of indol. That is all for that.

Q. Now let us have the following one.

443 A. The third one is bacillus pyocyaneus.

Lesage is the first investigator.

Morphology bacillus,

Diameter less than 1 M, micro-millimeter,

It is motile and does not produce spores,

On nutrient broth produces a scum, broth turbid,

Nutrient agar tube, growth not dull and not wrinkled,

On gelatine plate it has a characteristic appearance,
Body tube, growth visible and luxuriant,
Fermentation tube grows in the closed arm,
Grows well at body temperature,
Facultative an-aerobic,
Liquifies gelatine,
Liquifies casein,
Liquifies blood serum,
Gas production in Dextrose broth,
Nitrates reduced,
No indol produced,
Coagulates milk,
Not chromo-genesis, fluorescent.

444 Number 4, bacillus fluorescens tenuis.
First investigator is Zimmerman.
It is a bacillus in diameter less than one M,
It is motile and forms spores,
Nutrient broth scum,
Nutrient broth is turbid,
Nutrient agar tube growth,
Not dull, not wrinkled,
Gelatine plate's appearance characteristic,
Body tube growth visible and luxuriant,
Fermentation tube, grows in the closed arm,
Grows at body temperature,
Facultative an-aerobic,
Does not liquify gelatine,
Does not liquify casein,
Liquifies blood serum,
Does not produce gas in Dextrose broth,
Nitrates reduced,
Produces indol,
Does not coagulate milk,
Fluorescent.

445 No. 5. Bacillus fluorescens termo.
Discovered by Mace,
Diameter less than one M,
Motile and does not form spores,
Produces a scum,

Medium turbid in nutrient broth,
Nutrient agar tube growth not dull and not wrinkled,
Gelatine plate appearance not characteristic,
Body tube visible growth, luxuriant growth,
Fermentation tube, does not grow in the closed arm,
Does not grow at body temperature,
Not facultative an-aerobic,
Liquifies gelatine,
Liquifies casein,
Does not liquify blood serum,
Nitrates reduced,
Indol not produced,
Milk not coagulated,
Fluorescent,
Non-chromo-genic.

446 Number 6, bacillus viridis.
Discovered by Lesage,
Diameter less than one M,
Motile and does not form spores,
Produces scum and turbidity in nutrient broth,
No characteristic growth,
Nutrient agar not dull and not wrinkled,
Gelatine plate growth characteristic,
Body tube, visible and luxuriant,
Fermentation tube, growth in closed arm,
Grows at body temperature,
Facultative an-aerobic,
Liquifies gelatine,
Liquifies casein,
Liquifies blood serum,
Does not produce gas in Dextrose broth,
Reduces nitrates,
Indol production,
Milk coagulated.
Not chromo-genic,
Fluorescent.

447 Number 7, chromo genic, type red,
Bacillus rubefaciens,

Discovered by Zimmerman,
It is a bacillus with a diameter less than one M,
Motile and does not form spores,
On broth we have a scum,
No turbidity, growth,
Growth on nutrient agar tube not dull, not wrinkled,
Gelatine plate, characteristic appearance,
On body visible growth, not luxuriant,
Does not grow in closed arm of fermentation tube,
Grows well at body temperature,
Not facultative an-aerobic,
Does not liquify gelatine,
Does not liquify casein,
Does not liquify blood serum,
Does not produce gas in Dextrose broth,
Reduces nitrate,
No indol production,
Milk not coagulated,
Chromo genic,
Produces a pink color,
Not fluorescent.

448 Number 8, type chromo-genic, orange,
Bacillus arborescens,
First discoverer Franklin,
Bacillus less than one M in diameter,
Motile and does not form spores,
Does not produce scum, but growth has turbidity in nutrient broth.
Nutrient agar tube growth not dull, not wrinkled,
Gelatine plate appearance characteristic,
Body tube visible and luxriant growth,
Grows in the closed arm of fermentation tube,
Does not grow at body temperature,
Facultative an-aerobic,
Liquifies gelatine,
Liquifies casein,
Liquifies blood serum,
Does not produce gas,

Does not reduce nitrates,
Does not produce indol,
Coagulates milk,
Chromo genesis,
Fluorescence.
449 Number 9, bacillus aurescens,
Discovered by Ravenel,
It is a bacillus, diameter less than one M,
Motile and does not form spores,
Nutrient broth, no scum,
Broth turbid,
Nutrient agar tube, growth not dull, not wrinkled,
Body tube growth visible and luxuriant,
Gelatine plate appearance not characteristic,
Fermentation tube, does not grow in closed arm,
Grows at body temperature,
Not facultative an-aerobic,
Liquifies gelatine,
Liquifies casein,
Liquifies blood serum,
Does not produce gas in Dextrose broth,
Does not reduce nitrates,
No indol production,
Coagulates milk,
Chromo genesis, orange,
Not fluorescent.
No. 10. Bacillus fulvus,
450 Discovered by Zimmerman,
Bacillus diameter less than one M,
Non-motile and does not form spores,
Nutrient broth, no scum,
Growth, turbidity,
Nutrient agar tube not dull, growth wrinkled,
Appearance characteristic on gelatine plate,
Body tube growth, visible, not luxuriant,
Fermentation tube, growth in closed arm,
Grows at body temperature,
Facultative an-aerobic,

Liquifies gelatine,
Does not liquify casein,
Does not liquify blood serum,
Does not produce gas in Dextrose broth,
Does not reduce nitrates,
Does not produce indol,
Does not coagulate milk,
Chromo-genesis, orange,
Not fluorescent.
Number 11, Bacillus nubilis.
451 Discovered by Frankland,
It is a bacillus in diameter less than one M,
Motile,
Does not form spores,
Produces scum in nutrient broth,
Broth turbid,
Nutrient agar tube growth not dull, not wrinkled,
Appearance not characteristic on gelatine plate,
Growth on body tube visible, not luxuriant,
Grows in the closed arm of fermentation tube,
Grows at body temperature,
Facultative an-aerobic,
Liquifies gelatine,
Does not liquify casein,
Liquifies blood serum,
Does not produce gas in Dextrose broth,
Nitrates reduced,
Indol not produced,
Coagulates milk,
Chromo-genesis, orange,
Number 12. Bacillus plicatus,
452 Discovered by Zimmerman,
Bacillus in diameter less than one M,
Motile and does not form spores,
Does not produce scum,
Does not produce turbid growth,
Nutrient agar tube not dull, growth wrinkled,
On gelatine plate appearance not characteristic,

Body tube growth visible, not luxuriant,
Does not grow in closed arm of fermentation tube,
Grows at body temperature,
Not facultative an-aerobic,
Does not liquify gelatine,
Does not liquify casein,
Liquifies blood serum,
Does not produce gas in Dextrose broth,
Does not reduce nitrates,
Does not produe indol,
Does not coagulate milk,
Chromo genesis, orange,
Not fluorescent.

Number 13. Bacillus aureus,
453 Discovered by Adametz,

It is a bacillus less than one M in diameter,
Motile and does not form spores,
Nutrient broth turbid,
No scum,
Nutrient agar tube not wrinkled, not dull,
Gelatine plate appearance not characteristic,
Body tube, luxuriant and visible growth,
Fermentation tube, grows in closed arm,
Grows at body temperature,
Facultative an-aerobic,
Does not liquify gelatine,
Does not liquify casein,
Does not liquify blood serum,
Does not produce gas in Dextrose broth,
Does not reduce nitrates,
Does not produce indol,
Coagulates milk,
Chromo genesis, yellow.

Number 14. Micrococcus cremoides,
454 First investigator, Zimmerman,

It is a micrococus, diameter greater than one M,
Not motile,
No spore production,

Nutrient broth turbid,
No scum,
Growth on nutrient agar tube not dull, not wrinkled,
Gelatine plate, appearance not characteristic,
Body tube, growth visible and luxuriant,
Does not grow in closed arm of fermentation tube,
Grows at body temperature,
Not facultative an-aerobic,
Liquifies gelatine,
Does not liquify casein,
Does not liquify blood serum,
Produces gas in Dextrose broth,
Reduces nitrates,
Produces indol,
Does not coagulate milk,
Chromo genesis, faint yellow.

Number 15. Bacillus desidiosus,
455 Discovered by Wright,
Bacillus less than one M in diameter,
Not motile,
Does not form spores,
Produces turbidity,
No scum, in nutrient broth,
Growth not dull, not wrinkled on nutrient agar,
Gelatine plate appearance not characteristic,
Body tube, growth visible and luxuriant,
Does not grow in closed arm of fermentation tube,
Does not grow at body temperature,
Not facultative an-aerobic,
Liquifies gelatine,
Liquifies casein,
Liquifies blood serum,
Does not produce gas in Dextrose broth,
Does not reduce nitrates,
Does not produce indol,
Coagulates milk,
Chromo genesis yellow.

Number 16. Micrococcus flavus liquefaciens,
456 Discovered by Fluegge,
In diameter less than one M,
Non-motile,
Does not form spores,
Grown in nutrient broth turbid,
No scum,
Nutrient agar tube not dull, not wrinkled,
Gelatine plate appearance not characteristic,
Body tube, visible not luxuriant growth,
Does not grow in closed arm of fermentation tube,
Is not facultative an-aerobic,
Liquifies gelatine,
Does not liquify casein,
Liquifies blood serum,
Does not produe gas in Dextrose broth,
Reduces nitrates,
Does not produce indol,
Does not coagulate milk,
Chromo genesis, yellow.

Number 17. Bacillus helvolus,
457 Discovered by Zimmerman,
It is a bacillus in diameter less than one M,
It is motile,
Does not form spores,
No scum,
Broth turbid,
Nutrient agar tube not dull, not wrinkled,
Gelatine plate appearance not characteristic,
Body tube, visible, not luxuriant,
Fermentation tube, grows in closed arm,
Grows at body temperature,
Facultative an-aerobic,
Liquifies gelatine,
Does not liquify casein,
Liquifies blood serum,
Does not produce gas in Dextrose broth,
Nitrates reduced,

Indol produced,
Does not coagulate milk,
Chromo genesis, yellow,
Number 18. Bacillus iridescens,
458 Discovered by Tataroff,
It is a bacillus in diameter greater than one M,
Non-motile,
Produces spores,
Nutrient broth scum turbid,
Nutrient agar tube not dull, not wrinkled,
Gelatine plate appearance characteristic,
Body tube growth visible, not luxuriant,
Fermentation tube, no growth in closed arm,
Grows at body temperature,
Not facultative an-aerobic,
Liquifies gelatine,
Does not liquify casein,
Does not liquify blood serum,
Does not produce gas in Dextrose broth,
Does not reduce nitrates,
Does not produce indol,
Does not coagulate milk,
Chromo genesis, yellow.
Number 19. Bacillus lactis erythrogenes,
459 Discovered by Hueppe,
It is a bacillus in diameter less than one M,
Non-motile,
Does not produce spores,
Nutrient broth scum,
Turbidity,
Nutrient agar tube not dull, wrinkled,
Gelatine plate appearance characteristic,
Body tube growth visible and luxuriant,
Fermentation tube no growth in closed arm,
No growth at body temperature,
Not facultative an-aerobic,
Liquifies gelatine,
Liquifies casein,

Liquifies blood serum,
Does not produce gas in Dextrose broth,
Reduces nitrates,
Does not produce indol,
Coagulates milk,
Chromo genesis, yellow pink,
Number 20. Bacillus Ocraceus,
460 Discovered by Zimmerman,
It is a bacillus with diameter greater than one M.
It is motile,
Forms spores,
Nutrient broth produces scum and turbidity,
Nutrient agar tube, not dull not wrinkled,
Gelatine plate appearance not characteristic,
Body tube visible, not luxuriant,
Fermentation tube, no growth in closed arm,
Grows at body temperature,
Not facultative an-aerobic,
Liquifies gelatine,
Liquifies casein,
Liquifies blood serum,
No gas produced in Dextrose broth,
Nitrates reduced,
Indol not produced,
Coagulates milk,
Chromo genesis, yellow.
Number 21. Bacillus sub flavus,
461 Discovered by Zimmerman,
Bacillus diameter less than one M,
Motile,
Does not produce spores,
Produces scum turbidity in nutrient broth,
Nutrient agar tube not dull, not wrinkled,
Appearance on gelatine plate not characteristic,
Body tube, visible, not luxuriant,
Fermentation tube, no growth in closed arm,
Growth at body temperature,
Not facultative, an-aerobic,

Does not liquify gelatine,
Does not liquify casein,
Does not liquify blood serum,
Does not produce gas in Dextrose broth,
Reduces nitrates,
No indol produced,
Does not coagulate milk,
Chromo genesis, yellow,
Number 22. Sarcina lutea,
462 Discovered by Schroeter,
Not a bacillus, in diameter less than one M
Not motile,
Does not form spores,
Nutrient broth, no scum or turbidity,
Nutrient agar tube, not dull, not wrinkled,
Gelatine plate growth characteristic,
Body growth, visible and luxuriant,
Growth in closed arm of fermentation tube,
Grows at body temperature,
Facultative an-aerobic,
Liquifies gelatine,
Does not liquify casein,
Does not liquify blood serum,
Does not produce gas in Dextrose broth,
Does not reduce nitrates,
Does not produce indol,
Does not coagulate milk,
Chromo genesis, yellow.
Number 23. Proteus type,
463 Bacillus mesentericus vulgatus,
Discovered by Eisenberg,
Bacillus, diameter larger than one M,
Motile,
Forms spores,
Nutrient broth, scum and turbid,
Nutrient agar not dull, wrinkled,
Gelatine plate appearance characteristic,
Body tube, visible and luxuriant growth,

Growth in closed arm of fermentation tube,
Grows at body temperature,
Facultative an-aerobic,
Liquifies gelatine,
Liquifies casein,
Liquifies blood serum,
Does not produce gas in Dextrose broth,
Reduces nitrates,
Produces indol,
Coagulates milk,
No chromo genesis.

Number 24. Bacillus Proteus mirabilis,
464 Discovered by Hauser,
Bacillus diameter less than one M,
Motile,
Does not form spores,
Nutrient broth scum turbid,
Nutrient agar tube not dull, not wrinkled,
Gelatine plate, growth not characteristic,
Body tube, visible and not luxuriant
Fermentation tube growth in closed arm,
Grows at body temperature,
Facultative an-aerobic,
Does not liquify gelatine,
Does not liquify casein,
Does not liquify blood serum,
Does not produce gas in Dextrose broth,
Does not reduce nitrates,
Does not produce indol,
Does not coagulate milk,
No chromo genesis.

Number 25. Proteus zenkeri,
465 Discovered by Hauser,
Bacillus, diameter less than one M,
Motile,
No spores produced,
Nutrient broth scum, but not turbid,
Nutrient agar tube, not dull but wrinkled,

Gelatine plate growth characteristic,
Body tube growth visible and luxuriant,
Fermentation tube, grows in closed arm,
Grows at body temperature,
Not facultative an-aerobic,
Liquifies gelatine,
Does not liquify casein,
Liquifies blood serum,
Does not produce gas in Dextrose broth,
Does not reduce nitrate,
Does not produce indol,
Coagulates milk,
Not chromogenic.

Number 26. Bacillus subtilis-cereus,
466 Discovered by Frankland,
It is a bacillus in diameter greater than one M,
Motile,
Produces spores,
Nutrient broth produces scum,
Not turbid,
Nutrient agar tube dull but wrinkled,
On gelatine plate appearance characteristic,
Body tube visible and luxuriant growth,
Fermentation tube, growth in closed arm,
Grows at body temperature,
Facultative an-aerobic,
Liquifies gelatine,
Liquifies casein,
Liquifies blood serum,
Does not produce gas in Dextrose broth,
Reduces nitrates,
Does not produce indol,
Coagulates milk,
Non-chromogenic,

Number 27. Bacillus subtilis,
467 Discovered by Ehrenberg,
Bacillus, diameter greater than one M,
Motile,

Produces spores,
Nutrient broth turbid and scum,
Nutrient agar tube growth, dull and wrinkled,
Gelatine plate growth characteristic,
Body tube visible and luxuriant growth,
Grows in the closed arm of fermentation tube,
Grows at body temperature,
Facultative an-aerobic,
Liquifies gelatine,
Liquifies casein,
Liquifies blood serum,
Does not produce gas in Dextrose broth,
Does not reduce nitrates,
Does not produce indol,
Coagulates milk,
No chromo genesis.

Number 28. Type cloacae,
468 Discovered by Jordan,
Diameter less than one M,
Motile,
Does not produce spores,
Nutrient broth, scum and turbid,
Nutrient agar tube not dull, not wrinkled,
Gelatine plate not characteristic,
Body tube, visible, luxuriant,
Fermentation tube, growth in closed arm,
Grows at body temperature,
Facultative an-aerobic,
Liquifies gelatine,
Liquifies casein,
Liquifies blood serum,
Produces gas in Dextrose broth,
Reduces nitrates,
Produces indol,
Coagulates milk,
Non-chromogenic.

Number 29. Bacillus delicatulus,
469 Discovered by Jordan,

Diameter greater than one M,
Motile,
Does not produce spores,
Nutrient broth turbid but no scum,
Nutrient agar tube not dull, not wrinkled,
Gelatine plate, appearance not characteristic,
Body tube, visible but not luxuriant growth,
Grows in the closed arm of fermentation tube,
Grows at body temperature,
Facultative an-aerobic,
Liquifies gelatine,
" casein,
" blood serum,
Does not produce gas in Dextrose broth,
Reduces nitrates,
Produces indol,
Coagulates milk,
No chromo genesis.

Number 30. Bacillus Hyalinus,
470 Discovered by Jordan,
Diameter greater than one M,
Non-motile,
Does not produce spores,
Nutrient broth, no scum, but turbid,
Nutrient agar tube, not dull but wrinkled,
Gelatine plate appearance not characteristic,
Body tube luxuriant and visible growth,
Fermentation tube, growth in closed arm,
Grows at body temperature,
Facultative an-aerobic,
Liquifies gelatine,
Does not liquify casein,
Liquifies blood serum,
Produces gas in Dextrose broth,
Reduces nitrates,
Produces indol,
Coagulates milk,
No chromo genesis,

Number 31. Bacillus liquefaciens,
471 Discovered by Eisenberg,
Bacillus diameter less than one M,
Non-motile,
No spore production,
No scum, turbid growth,
Nutrient agar tube not dull, not wrinkled,
Gelatine plate appearance not characteristic,
Body tube luxuriant and visible growth,
Fermentation tube, growth in closed arm,
Grows at body temperature,
Facultative an-aerobic,
Liquifies gelatine,
Does not liquify casein,
Does not liquify blood serum,
Produces gas in Dextrose broth,
Reduces nitrates,
Does not produce indol,
Coagulates milk,
Non-chromogenic.

Number 32. Type liquidus,
472 Bacillus antenni formis,
Discovered by Ravenel,
Morphology bacillus,
Diameter less than one M,
Motile,
Does not produce spores,
Does not produce scum on nutrient broth,
No turbidity,
Nutrient agar tube, not dull, not wrinkled,
Gelatine plate not characteristic,
Body tube, growth visible and luxuriant,
Fermentation tube, growth in closed arm,
Facultative an-aerobic,
Liquifies gelatine,
Does not liquify casein,
Liquifies blood serum,
Produces no gas in Dextrose broth,

Nitrates reduced,
Indol produced,
Coagulates milk,
Non-chromogenic.
Number 33. Bacillus liquidus,
473 Discovered by Frankland,
In diameter less than one M,
Motile,
Does not produce spores,
Nutrient broth produces scum and turbidity,
Nutrient agar tube not dull, not wrinkled,
Gelatine plate appearance not characteristic,
Body tube growth visible and luxuriant,
Growth in closed arm of fermentation tube,
Does not grow at body temperature,
Facultative an-aerobic,
Liquifies gelatine,
Does not liquify casein,
Does not liquify blood serum,
Does not produce gas in Dextrose broth,
Does not reduce nitrates,
Does not produce indol,
Coagulates milk,
Non-chromo-genesis.
Number 34. Type superficialis,
474 Bacillus megaterium,
Discovered by DeBarry,
Morphology bacillus,
Diameter greater than one M,
Motile,
Produces spores,
Nutrient broth produces scum and turbidity,
Nutrient agar tube not dull, not wrinkled,
Gelatine plate growth not characteristic,
Body tube not visible, not luxuriant
Fermentation tube, no growth in closed arm,
Growth at body temperature,
Not facultative an-aerobic,

Liquifies gelatine,
Does not liquify casein,
Does not liquify blood serum,
Does not produce gas in Dextrose broth,
Does not reduce nitrates,
Does not produce indol,
Coagulates milk,
No chromo genesis.

Number 35. Bacillus superficialis,
475 Discovered by Jordan,
Diameter less than one M,
Motile,
Does not form spores,
Nutrient broth produces scum and turbidity,
Nutrient agar tube, not dull, not wrinkled,
Gelatine plate not characteristic,
Body tube, visible and luxuriant growth,
Fermentation tube, growth in closed arm,
Grows at body temperature,
Not facultative an-aerobic,
Liquifies gelatine,
Does not liquify casein,
Does not liquify blood serum,
Does not produce gas in Dextrose broth,
Nitrates not reduced,
Does not produce indol,
Does not coagulate milk,
No chromo-genesis.

Number 36. Coli type,
476 Bacillus coli communis,
Discovered by Escherich,
Bacillus diameter less than one M,
Motile,
Does not form spores,
Produces turbidity in nutrient broth, but no scum,
Nutrient agar tube, growth not dull, not wrinkled,
Gelatine plate appearance not characteristic,
Body tube growth, visible and luxuriant,

Fermentation tube grows in closed arm,
Grows at body temperature,
Facultative an-aerobic,
Does not liquify gelatine,
Does not liquify casein,
Does not liquify blood serum,
Produces gas in Dextrose broth,
Reduces nitrates,
Produces indol,
Coagulates milk,
Non-chromogenic.

Number 37. Bacillus aquitilis sulcatus No. 1,
477 Discovered by Weichselbaum,
Diameter less than one M,
Motile,
Does not form spores,
Nutrient broth turbid, no scum,
Nutrient agar tube not dull, not wrinkled,
Gelatine plate not characteristic,
Body growth visible and luxuriant,
Fermentation tube, growth in closed arm,
Grows at body temperature,
Facultative an-aerobic,
Does not liquify gelatine,
Does not liquify casein,
Does not liquify blood serum,
Does not produce gas in Dextrose broth,
Does not produce indol,
Does not reduce nitrates,
Coagulates milk,
Non-chromo-genic.

Number 38. Bacillus aquitilis sulcatus No. 3,
478 Discovered by Weichselbaum,
Bacillus diameter less than one M,
Motile,
Produces spores,
Nutrient broth is turbid, no scum,
Nutrient agar tube not dull, not wrinkled,

Gelatine plate not characteristic,
Growth visible and luxuriant on body,
Growth in closed arm of fermentation tube,
Growth at body temperature,
Facultative, an-aerobic,
Does not liquify gelatine,
Does not liquify casein,
Does not liquify blood serum,
Does not produce gas in Dextrose broth,
Does not reduce nitrates,
Does not produce indol,
Coagulates milk,
Non-chromo genesis.

Number 39. Bacillus aquatilis sulcatus No. V,
479 Discovered by Weicheselbaum,

Bacillus diameter less than one M,
Motile,
Does not form spores,
Produces turbidity, but no scum,
In nutrient agar tube, not dull, not wrinkled,
Gelatine plate not characteristic,
Growth on body not visible, not luxuriant,
Growth in the closed arm of fermentation tube,
Does not grow at body temperature,
Facultative an-aerobic,
Does not liqify gelatine,
Does not liquify casein,
Does not liquify blood serum,
Does not produce gas in Dextrose broth,
Does not reduce nitrates,
Does not produce indol,
Does not coagulate milk,
Non-chromo genic.

Number 40. Bacillus stellatus,
480 Discovered by Zimmerman,

Bacillus, diameter less than one M,
Motile,
Does not produce spores.

Nutrient broth turbid,
Scum,
Nutrient agar tube growth not dull, not wrinkled,
Gelatine plate not characteristic,
Body tube visible and luxuriant growth,
No growth in closed arm of fermentation tube,
Grows at body temperature,
Not facultative, an-aerobic,
Does not liquify gelatine or casein,
Does not liquify blood serum,
Does not produce gas in Dextrose borth,
Does not reduce nitrates,
Does not produce indol,
Does not coagulate milk,
Non-chromo-genic.

Number 41. Type candicans,
481 Bacillus albus,
Discovered by Eisenberg,
In diameter less than one M,
Motile,
Does not form spores,
Turbidity but no scum in nutrient broth,
Nutrient agar tube not dull, not wrinkled,
Gelatine plate not characteristic,
Body tube, visible and luxuriant growth,
Fermentation tube, growth in closed arm,
Does not grow at body temperature,
Facultative, an-aerobic,
Does not liquify gelatine,
Does not liquify blood serum,
Does not liquify casein,
Does not produce gas in Dextrose broth,
Reduces nitrates,
Does not produce indol,
Does not coagulate milk,
Non-chromo-genic.

Number 42. Bacillus bruneus,
482 Discovered by Adametz,

Morphology bacillus,
In diameter less than one M,
Non-motile,
Produces spores,
Nutrient broth turbid, no scum,
Nutrient agar tube not dull, not wrinkled,
Gelatine plate appearance not characteristic,
Body tube, visible and luxuriant growth,
Fermentation tube, growth in closed arm,
No growth at body temperature,
Not facultative an-aerobic,
Does not liquify gelatine,
" casein,
" blood serum,
Does not produce gas in Dextrose broth,
Does not reduce nitrates,
Does not produce indol,
Does not coagulate milk,
Non-chromo-genic.

Number 48. Bacillus candicans,
488 Discovered by Frankland,
In diameter less than one M,
Motile,
Does not produce spores,
Nutrient broth turbid, no scum,
Nutrient agar tube growth not dull, not wrinkled,
Gelatine plate not characteristic,
On body visible growth not luxuriant,
In fermentation tube, no growth in closed arm,
Does not grow at body temperature,
Not facultative an-aerobic,
Does not liquify gelatine,
Does not liquify casein,
Does not liquify blood serum,
Does not produce gas in Dextrose broth,
Does not reduce nitrates,
Does not produce indol,
Coagulates milk,

Non-chromo-genic.

Number 44. Bacillus lactiviscossus,

484 Discovered by Adametz,

In diameter greater than one M,

Motile,

Does not produce spores,

In nutrient broth turbidity, no scum,

Nutrient agar, not dull, not wrinkled,

Gelatine plate not characteristic,

Body tube, visible and luxuriant growth,

Fermentation tube,no growth in closed arm,

No growth at body temperature,

Not facultative, an-aerobic,

Does not liquify gelatine,

Does not liquify casein,

Does not liquify blood serum,

Does not produce gas in Dextrose broth,

Does not reduce nitrates,

Does not produce indol,

Does not coagulate milk,

Non chromo-genic.

Number 45. Bacillus ubiquitus,

485 Discovered by Jordan,

In diameter greater than one M,

Motile,

Produces spores,

Produces turbidity and scum in nutrient broth,

Nutrient agar tube, not dull, not wrinkled,

Gelatine plate not characteristic,

Body tube, visible but not luxuriant growth,

Fermentation tube, no growth in closed arm,

Grows at body temperature,

Facultative an-aerobic,

Does not liquify gelatine,

Does not liquify casein,

Does not liquify blood serum,

Does not produce gas in Dextrose broth,

Reduces nitrates,
Does not produce indol,
Coagulates milk,
No chromo genesis.
Number 46. Urea type,
486 Bacillus urea,
Discovered by Zaksch,
Morphology type of bacillus,
Diameter less than one M,
Motile,
Does not produce spores,
Nutrient broth turbid and scum,
Nutrient agar tube, not dull, not wrinkled,
Gelatine plate not characteristic,
Body growth visible and luxuriant,
Fermentation tube, growth in the closed arm,
Grows at body temperature,
Facultative an-aerobic,
Does not liquify gelatine,
" casein,
" blood serum,
Does not produce gas in Dextrose broth,
Reduces nitrates,
Does not produce indol,
Herring brine odor,
Non-chromo genesis.
Number 47. Type sarcina. alba,
487 Discovered by Maschek,
Not a bacillus,
Diameter greater than one M,
Non-motile,
Does not form spores,
No scum or broth turbidity,
In agar tube, growth not dull, not wrinkled,
Gelatine plate not characteristic,
Body tube visible and luxuriant growth,
Fermentation tube, no growth in closed arm,
Grows at body temperature,

Not facultative an-aerobic,
Liquifies gelatine,
" casein,
Does not liquify blood serum,
Does not produce gas in Dextrose broth,
Does not reduce nitrates,
Does not produce indol,
Coagulates milk,
Non-chromo-genic.

ADJOURNED until 2:15 P. M., same day, February 21, 1903.

488 2:15 p. m., Saturday, February 21, 1903. Continuation pursuant to adjournment. Present, the Commissioner and counsel same as before.

DR. AMAND N. RAVOLD,

Direct Examination (continued), by Mr. Crow.

Q. Doctor, we were to put in the record here an explanation of these terms—now those terms that are technical there, that need explanation in connection with that table—please give the sense and the definition of each one of them?

A. The stenographers will make a copy of this exhibit, will they?

Q. Well, we will do that in the course of time, but not at this state of the record.

THE COMMISSIONER: It has not yet been offered, has it?

MR. CROW: Oh no, it has not been offered.

THE COMMISSIONER: Because I want to have it marked for identification when it is offered.

THE WITNESS: Under the head of morphology, we have here the question of the form of the micro-organisms—bacillus, meaning a rod, and it is marked either positive or negative. If it is a bacillus, it is marked with a cross, positive; if in any form other than bacillus, it is marked negative, with a minus sign. 489

The next under morphology comes the diameter greater than 1 M. "M" stand for the Greek word micron, and micron is 1-1,000 of a millimeter, or 1-25,000 of an inch, so that a micro-organism here recorded will be larger or smaller than 1-25,000 of an inch, according to this chart.

Under the head of morphology comes motility. A micro-organism may be motile, that is, swim about, or it does not do so.

Under the form morphology comes the word spore. The word spore was explained in the early talk made on micro-organisms; it means that these micro-organisms contain within themselves bodies for the preservation of the species, so that the chart is marked positive and negative whether it be present or absent.

Now under cultural features are the growth characteristics, upon certain nutritive media which will be named as we approach them.

Nutritive broth—that is nutritive broth as will be described, in test tubes, and into it the micro-organism is sown. Now it grows in that medium or it does not grow. If it grows in the medium making a cloudy condition in the medium, that is recognized as turbidity. Then if the micro-organism grows out on the surface of the medium, forming a pellicle or membrane on it, it is called a scum, and is here so recorded, and if it is either one of these it is marked positive and if neither one negative.

490 Under cultural features comes nutrient agar-agar. That is a medium composed of agar-agar of a definite per cent. in nutrient broth. This material is a solid medium and is slanted in the tube as we speak about it, and on the surface of that medium is sown the micro-organism in pure culture. Now the micro-organism grows and whether it grows with a dull growth—it is practically not transparent or translucent—and if the growth be wrinkled, it is so recorded here. If it does neither one, it is marked negative. If it grows dull or wrinkled, it is so marked.

The third feature is growth in gelatin plate. The micro-organism in pure culture is plated as described, generally in a petri dish, and this allowed to grow at 20 centigrade—

MR. SPRINGER: What would that be in Fahrenheit?

A. About 60 degrees Fahrenheit. The growth that occurs here is called a colony, which is a growing out of the micro-organisms into numbers sufficiently large to be seen either with the unaided eye or with the microscope. The colony has certain characteristics, and these are marked as its appearance is characteristic, or as it is not characteristic.

On potato—that is a potato cut into cylinders and then cut cross-wise, so as to afford a slant surface, it making a surface upon which growth can be easily made. Upon the ster-
491 iled potato then, is sown the micro-organism and the micro-organism grows either with visible growth or with invisible growth, and the growth is luxuriant or not so.

Under cultural features we have fermentation tubes. Now the question is whether a micro-organism in this fermentation tube, which is a "U" tube, grows in the closed arm or not. The heating of medium in fermentation tubes drives the air out of it, so that the medium in this closed arm is practically free from air, consequently a strictly aerobic or a so-called obligatory aerobic will not grow in that arm, while one that is facultative, or has the faculty of growing in the absence of any oxygen, will grow.

Then we come to the biochemical features we have here recorded, growth at body temperature. Now the micro-organism is sown upon agar-agar as a rule, and kept at the incubated temperature of the body, that is 98 3-5 degrees Fahrenheit, or 36½ degrees centigrade, or it is kept at 20 degrees centigrade, which is the ordinary temperature of about 60 degrees Fahrenheit.

Now, at which of these temperatures it grows best is here recorded, so that if it grows at body temperature—if it grows at that temperature best—it is marked positive. If marked negative it does not grow that way best, while at that temperature. It does not mean that it does not grow at all, but that it does not grow so well as it does at the temperature below.
492 Facultative an-aerobic—I described that this morning, do you want to hear it again?

MR. CROW: No.

A. (Continuing) Affected by range of reaction. Now in making up these tables I did not record that fact. In giving the details of the growth of the different micro-organisms I left that out—I left out this affected by range of reaction.

MR. JEFFRIES: And that was omitted in your testimony this morning?

A. Yes. Range of reaction means whether it grows in the presence of an alkali, neutral or in the absence of an alkali or acid and in the presence of an acid. We have first, a medium alkaline to phenolphthalein 1.5 per cent.

A second medium neutral to phenol phthalein, and a third acid, 1.5 per cent. to phenol phthalein. Upon these three media the micro-organism is sown and the luxuriancy with which it grows indicates the reaction at which it grows best alkaline, acid or neutral.

Under biochemical we have liquification, and we have first liquification of gelatin. Some micro-organisms have the faculty of digesting gelatin and liquifying it, and this is so recorded. It either liquifies or it does not liquify. That is quite a cultural characteristic of these organisms—of most of these organisms. 493

The next feature is casin. The word "casin" is next used, which is the cheese of milk. Some micro-organisms have the faculty of growing in milk, precipitating the casin and reducing it to a liquid, others have not, so that is recorded.

Upon blood serum collected and sterilized in test tubes with the slanting surface the micro-organism is sown, and kept at room temperature for twelve days and if the micro-organism liquifies that blood serum, it turns it to a fluid, it is so recorded. If it does not do that, is is so recorded—positive or negative.

MR. JEFFRIES: What temperature did you say that was kept at?

A. Generally kept at the room temperature, twenty degrees centigrade.

Dextrose broth—that means a nutrient broth prepared as we will show, and with one per cent. of dextrose—sugar—added to it. Now that is put in a fermentation tube and the micro-organisms inoculated into it. If these micro-organisms break up the sugar so as to form a gas in the closed arm of the tube we speak of that as gas production, and it is marked positive. If it does not produce gas it is marked negative—if it does not produce gas in the presence of dextrose broth. In the reduction of nitrates—a nitrate broth is made up and in it the micro-organism is sown—nitrate broth I should say—and if it reduces the nitrates to nitrites why that is so recorded—positive or negative.

494 Under the bio-chemical feature next is indol production. It is the result of the destructive action of micro-organisms on organic matter. It produces a peculiar odor—a fetid odor, and whether it produces it or not, it is so recorded.

In milk sterilized in tubes, the micro-organism is shown. Now whether it coagulates the milk or not, it is so recorded—if it makes cheese. Then upon nutrient agar-agar slanted in a tube, the micro-organism is grown, and whether it produces a color upon the medium or not, that is whether the bacterium itself has a color within its cell walls. It is spoken of as chromogenesis, or pigment productive. Fleuorescent means that the toxines or whatever it may be which is produced by the micro-organism, colors the medium. The color does not remain within the micro-organism as in pigment production, but it gives off a material which colors the medium itself. Then we have fleuorescent coloration.

That is the description, sir.

Q. MR. JEFFRIES: Now, what you have testified to in reference to the bacterial qualities of this water in the forenoon, and this afternoon, is the result of practical experiments with the water under your supervision, is it not?

A. Yes sir.

495 MR. CROW: Just give the period of time.

A. Samples collected from January 23 to October 11, I think it is.

Q. MR. JEFFRIES: 1900?

A. 1900.

Q. Now, what system of rules did you use in those experiments, those tests?

A. Every micro-organism or colony upon a gelatine plate which seemed to be different from other micro-organisms, and was first, picked off and sown in agar-agar after the agar-agar culture was obtained, sown in broth and its form and motility recorded from that. You see the bacterium undergoes three different transfers from the gelatine plate to agar-agar, to get a good growth of it, and then into broth so as to get as nearly as possible constancy of form under these new conditions, and then here are recorded motility, size and form, and whether it contains spore or not, and from this culture, if pure all other cultural media was inoculated and recorded after a definite period of time. We were looking for constancy of form and optimum reaction, and then recorded the results in books kept for that purpose and afterwards charted out as here shown.

ADJOURNED until 10:00 a. m., Monday, February 23, 1903, same place.

496 Met pursuant to adjournment at the same place at ten
o'clock a. m., February 23, 1903.

Present, the Commissioner and the same counsel as before.

AMAND NICHOLAS RAVOLD

resumed the stand for further direct examination, by Mr. Jeffries, and testified as follows:

Q. Now, doctor, you may state what you mean by a microscopical examination of water, from a scientific standpoint?

A. Well, in the sanitary examination of water there are several procedures: first, the physical aspect of the water, that is, testing its temperature, its color, its turbidity, its sediment, its odor, hot and cold, that is the physical appearance. Then we have the chemical examination for the organic and inorganic constituents in the solution, and then the microscopical examination for the lower and higher forms of animal and vegetable life. Under the microscopical examination we have two kinds of examinations that will here be presented, first, the larger forms, what is known as the floating matter in the water, the animal and vegetable life, and known as plankton from planktos, the Greek, meaning wandering. Then we have the so-called
bacteriological examination of the water which is an ex-
497 amination of the lower forms of vegetable life. Do you
want an historical sketch of that?

Q. Yes.

A. As soon as the microscope was developed sufficiently to see these lower forms of animal and vegetable life in water a number of observers began studying and recording the forms seen. And we date back now to 1675 again with von Leeuwen-

hork, and from that time until 1850 records were made, but the significance of the micro-organisms in water was not noted until Dr. Hensel in London at that time called attention to the value of these examinations from the sanitary standpoint. In 1887 the Massachusetts state board of health began investigations of the waters of the Massachusetts rivers and lakes, and established a laboratory in which the microscopical examination of the water for the lower and higher forms of animal and vegetable life was conducted. Two years later the Connecticut state board of health begun a series of the same investigations and the establishment of laboratories. Boston, in 1889, established a biological laboratory at the Chestnut Hill reservoir. The microscopic part being under the charge of Mr. George Whipple. In 1897 Brooklyn established a laboratory at Prospect Park, and so throughout the country a number of biological and marine stations have been established for the study of micro-organisms
in water. The method of catching these micro-organisms
498 in a definite quantity of water has gradually developed.
First, a definite quantity of water, say a gallon, was allowed to sand until the micro-organism had settled to the bottom of the vessel. Then they were collected and studied. Next the water was filtered through a seive and the micro-organism caught upon the seive cloth, or whatever it might be, and then turned out on a glass slide, as we turn fish out of a net.

Later, Mr. Kean used a large funnel and in the neck of the funnel he placed a sand filter, and ran the water through this sand, the sand was put into a test tube and he washed it, decanted the fluid, and studied a definite quantity of it, one cubic millimeter upon a glass slide. In this way he secured a definite measurement of the water and attempting to discover the number of micro-organisms in the water.

Following that, Drs. Sedgwick and Rafter—which is now known as the Sedgwick-Rafter method—improved this method of Mr. Kean's, the slide method, and it was used for studying in this laboratory the waters of the various rivers which will be named. A definite quantity of water is taken, 500 cubic centimeters in our experiments was put into a special filtering apparatus which has a glass cylinder 9 inches long by 2 inches

499 in diameter at the top. It is funnel shaped at the bottom, that funnel portion being about 2½ inches to 3 inches long. Then there is a small neck 2½ inches long, and the diameter of the neck is about a half an inch. Into the neck of this filter of glass is placed a perforated cork, and on top of that cork is placed a piece of silk, so as to cover the hole in this cork. On top of that is placed about three quarters of an inch of green quartz, sand, not being used. The sand is of a size so that it will pass through the seive having 60 measures to the square inch, and not more than 120. That is the size of the sand grain. To the side or connected through the cork to one side is a small tube through which the water passes as it filters through the sand. That tube reaches as high as one inch, or to the height of the sand in the neck on the side of the glass. With the apparatus in order, 500 cubic centimeters of water are put into it, and the water allowed to filter through. When it has filtered, through, the tubelature on the side of the apparatus, allows all of the water to pass out except about one cubic centimeter which remains in the sand. The cork is removed and the sediment, this sand, is washed into a test tube with five or ten cubic centimeters of water, ten as a rule. The water and sand are stirred about, and then a definite quantity of it taken off. The quantity in this case was one cubic centimeter, say, that was pipetted off,
500 taken out in a pipette. That water is now floated on a
glass slide, which was prepared in this way. The glass slide had a brass rim upon it, a rectangular brass rim. That rim is 50 millometers long, 20 millometers wide, and 1 millometer deep. On top of this brass rim is placed a large cover of glass. The water is run into this slide—this one space will contain just one cubic centimeter of water—now, this rectangular space has poured into it this one cubic centimete [illegible] water. The cover-glass is slipped upon it so as to have as few air bubbles as possible underneath the cover glass, and the micro-organisms studied with a microscope.

In order to measure the micro-organisms in a definite quantity of water, the cover glass was at first ruled out into squares by Sedgwick, but later by Whipple the measuring apparatus was put into the ocular of the microscope. The measuring apparatus is a piece of glass one millometer square. This is divided into four cross lines, which gives four spaces. One of these spaces is divided into 25 squares, and each one of these squares is divided into 25 parts, and one of these 25ths is what is known as the standard unit of measure. Now with this measuring apparatus in the ocular the micro-organisms are studied, the whole field gone over, and a definite number of spaces measured and studied, and the number of micro-organisms of the different kinds counted and recorded.

501 The object of this examination, or rather, it had for its object, a study of the micro-organisms in all the waters under consideration, to discover micro-organisms connected with sewage pollution; and also to attempt to trace distinctive forms which are found in the Lake Michigan water, from those forms existing in the rivers and tributaries of the Illinois river and its tributary; the Missouri river, the Mississippi river above its junction with the Illinois, and the Mississippi river water at the intake, and in the St. Louis reservoir.

Two different sets of examinations were made, one in 1900, by Mr. George A. Johnson in my own laboratory at the old city hall in the city of St. Louis, and the other series of examinations were made by Mr. George H. Whipple, of Brooklyn, New York.

Q. Now you say you conducted the examination with a microscope?

A. I supervised this work.

Q. Examination of the water?

A. Yes sir.

Q. Now you examined in this connection the water of Lake Michigan, did you?

A. Yes sir.

Q. Where were these samples of water taken from and when? State briefly.

A. The samples for the microscopical examination for
502 Lake Michigan were collected first, July 23, from the four
mile crib.

Q. That is out in the lake from Chicago?

A. Out in the lake, four miles out. The next was collected July 30th from the Carter Harrison crib. This is 1900. And the third sample was collected August 9th ten miles out from the Chicago shore. The fourth sample was collected September 7th from the Lake View crib. And the fifth sample was collected September 15th from the two mile crib.

Q. When you mention the crib you mean the intake crib for the water supply of the city of Chicago?

A. Yes sir.

Q. Now that applies to all these samples except the sample taken ten miles from the Chicago shore?

A. Ten miles from the shore, yes sir.

Q. What year were those samples collected in?

A. 1900.

Q. Now you may give the result of that microscopical examination in detail?

A. Now this is from the four mile crib. And from the genus diatomaceae we have the asterionella, 100,

Cyclotella, 19,
Diatoma, 33,
503 Fragilliara, 6,
Navicula, 11,
Nitzschia, 60,
Synedra, 680,
Tabellaria, 30.

Now under the genus Cyanophycae we have:

Chrococcus, 3,
Oscillaria, 30.

Now under the genus Chloraphyceae we have:

Closterium, 1,
Pediastrum, 6,
Rephidium, 4,
Scenedesmus, 10,
Spyrogyra, 1,
Ulothrix, 22.

Now under the genus Shycomycetes we have:

Crenothrix, 6.

Now under the genus Protezoa we have:

Anoba, 2,
Cryptonomas, 2,
Dinobryon, 25,
Glenoinium, 15,
Protozoa monas, 6,

Pendinium, 10,
Synura, 2,
Vorticella, 1.

Now under the genus Rotifera we have the

Anaurea, 4,
504 Rotifier, 2,
Polyarthara, number not given.

Now under the genus Crustacae, daphnia, number not given.

Now we have the miscellaneous. Under that comes:

Vegetable hair, 4,
Ober, 21,

So we have the total number here, 1118,

Genera, 30.

Now that is for the sample collected July 23.

Now for the sample collected July 30th, at the Carter Harrison crib:

Under the genus diatomacae we have:

Asterionella, 42.

Q. Do you mean this is the number of organisms per cubic centimeter?

A. Per 500 cubic centimeters. You see 100 asterionella would keep things pretty busy in one cubic centimeter.

Cyclotella, 12,
Diatoma, 65,
Fragilliara, not found in Carter Harrison crib.
Navicula, 4,
Nitzschia, 93,
505 Synedra, 400,
Tabellaria, 12.

Genus cyanophyceae:

Chrococcus, not found in the Carter Harrison crib,
Oscillaria, 20.

Genus Chlorophyceae:

Closterium, 1,
Pediastrum, 9,
Rephidium, 16,
Scenedesmus, 4,
Ulothrix, 10.

Genus Shycomycetes:
Crenothrix, 3.
Genus Protozoa:
Dinobryon, 31,
Glenodinium, 6,
Monas, 15,
Peridinium, 3,
Synura, 6,
Vorticella, 2.
Genus Rotifiera:
Anaurea, 1,
506 Rotifer, 4,
Polyarthara, 1.
Genus, Crustaceae:
Daphnia, 1.
Miscellaneous:
Vegetable hair, 7,
Ober, 6.
Total number, 774.
Genera, 26.

Amorphus matter very abundant in all samples.

Q. It applies to all samples taken out of all these cribs?

A. Very abundant in all samples, yes sir. So I can wipe that out of this particular examination. Going back again to the samples collected August 9, 1900, ten miles from the Chicago shore. Under the

Genus diatomacae:
Asterionella, 10,
Diatoma, 3,
Frageliera, 12,
Navicula, 14,
Nitzschia, 86,
Synedra, 290,
Tabellaria, 26.
Genus Chlorophyceae:
Pediastrum, 2.

Q. Now about the Cyanophyceae being out, do you mean 507 it was absent or not found?

A. It was not found.

Scenedesmus, 4,
Ulothrix, 6.
Genus protozoa:
Amoba, 6,
Cryptomas, 1,
Dinobryan, 14,
Genodinium, 8,
Monas, 9,
Synura, 4,
Bordacella, 1.
Genus rotiferia:
Anaurea, 3,
Rotifer, 1,
Polyarthara, 2.
Genus crustaceae:
Daphnia, 1.
Miscellaneous:
Vegetable hair, 4,
Ober, 10.
Total number, 517,
Genera, 23,
Amorphus matter abundant.

Q. That is in the waters of Lake Michigan?

508 A. Yes sir. Now the sample collected September 7 from the Lake View Crib was as follows:

Genus Diatomacae:
Asterionella, 84,
Cyclotella, 4,
Diatoma, 31,
Nitzschia, 47,
Synedra, 100.
Genus Cyanophycae:
Chrococcus, 6.
Genus chlorophyceae:
Clostrium, 1,
Pediastrum, 12,
Rephidium, 4,
Scenedesmus, 3,
Spyrogyra, 4,

Ulothrix, 14.
Genus shycomycetes:
Chenothrix, 2.
Genus protozoa:
Glenodinium, 2,
Monas, 12.
Genus rotifera:
Anaura, 1,
509 Rotifer, 2,
Miscellaneous:
Vegetable hair,
Ober, 16,
Total number, 347,
Genera, 19.

Amorphus matter abundant in all samples.

Sample collected September 15, from two mile crib is as follows:

Genus diatomacae:
Asterionella, 100,
Cyclotella, 16,
Diatoma, 14,
Nitzschia, 62,
Synedra, 200.
Genus Scanophyceae:
Oscillaria, 15.
Genus Chlorophyseae:
Pedeastrum, 9,
Spyrogyra, 1,
Ulothrix, 6.
Genus schycomycetes:
Crenothrix, 1.
Genus protozora:
Amoba, 1,
Dynobryon, 6,
Glenodinium, 4,
510 Monas, 19,
Synura, 1.
Genus rotifiera:
Rotifer, 1.

Miscellaneous:
    Vegetable hair, 6,
    Ober, 10,
.Total number, 472,
Genera, 18.

Q. Give us the result of the microscopical examination of the discharge of the Chicago Drainage canal before it passes over the bear trap dam at Lockport, Illinois, and state when they were made.

A. Do you want me to state it now as I go along?

Q. As you go. .

A. Collected May 27, 1900, as follows:

Genus diatomacae:
    Asterionella, 71,
    Cyclotella, 8,
    Diatoma, 32,
    Himantidium, 2,
    Navicula, 4,
    Nitzschia, 23,
    Synedra, 313,
    Tabaleria, 55.
Genus cyanophyceae:
511 Oscillaria, 15.
Genus chloraphycae:
    Closterium, 5,
    Hydrodiction, 12,
    Protocockys, 2,
    Rephidium, 17,
    Ulothrix, 15.
Genus Shycomycetes:
    Beggattoa, 2,
    Crenothix, 6.
Genus protozoa:
    Monas, 32,
    Paramecium, 13,
    Synura, 19,
    Vordicella, 7.
Genus crustaceae:
    Bosimia, 1,

Daphnoa, 1.
Miscellaneous:
  Mouldohifphe, 3,
  Amoeba, 23.
Total number, 681,
Genera, 24,
Amorphus matter abundant.
Sample collected June 3, 1900,
Genus diatomacae:
  Asterionella, 73,
512 Cyclotella, 2,
  Fragelleria, 6,
  Diatoma, 22,
  Himantidium, 4,
  Navicula, 6,
  Nitzschia, 7,
  Cynedra, 116,
  Tabilleria, 16.
Genus Cyanophyceae:
  Oscilleria, 22.
Genus Chlodaphyceae:
  Arthrodesmus, 2,
  Endoria, 1,
  Hydrodiction, 19,
  Protococcus, 4,
  Rephidium, 7,
  Unithrix, 11.
Genus protozoa:
  Protomonus, 8,
  Dinobryon, 2,
  Monus, 19,
  Synura, 6,
  Trchelomonas, 8,
  Vordicella, 4.
Genus rotifiera:
  Anaurea, 2,
513 Vegetable hair, 15,
  Ober, 12.

Total number, 402,
Genera, 27.
Sample collected June 10, 1900, is as follows:
Genus diataneace:
    Asterionella, 18,
    Cyclotella, 1,
    Diatoma, 4,
    Navicula, 1,
    Stephnodiscus, 1,
    Synedra, 101,
    Tabileria, 5.
Genus cyanophyceae:
    Oscilleria, 38.
Genus chloraphycae:
    Arthrodesmus, 1,
    Rhephidium, 2,
    Ulothrix, 16.
Genus schizomycetes:
    Beggattoa, 4,
514 Crenothrix, 3,
    Liptothrix, 6.
Genus protozoa:
    Protomonus, 12,
    Monus, 21,
    Paramacium, 14,
    Placus, 2,
    Cynora, 3,
    Vordicella, 4.
Genus rotifiera:
    Rotifer, 2.
Genus crustacae:
    Bosmia, 1.
Miscellaneous:
    Mouldhifphe, 10,
    Vegetable hair, no number.
Genera, 25,
Total, 296.
Amorphus matter abundant.
Sample collected June 17, 1900, as follows:

Genus diatomacae:
  Asterionella, 120,
515 Cymbella, 14,
  Diatoma, 23,
  Myrodeon, 6,
  Nitzschia, 1,
  Stephnodiscus, 1,
  Synedra, 180,
  Tabilleria, 16.
Genus canophyceae:
  Chrococcus, 4,
  Lyngbia, 1,
  Oscileria, 4.
Genus chlorophycae:
  Pedeastrum, 2,
  Pandoriana, 3,
  Protococcas, 1,
  Spyrogyra, 4,
  Ulothrix, 10.
Genus protozoa:
  Protomonus, 2,
  Monus, 6,
  Paramecium, 12.
Genus crustaceae:
  Daphnia, 1.
516 Miscellaneous:
  Anguilulla, 1.
Total number, 412,
Genera, 21.
Amorphus matter very abundant.
Sample collected June 25, 1900, is as follows:
Genus diatomacae:
  Asterionella, 40,
  Cymbella, 20,
  Himantidium, 1,
  M, 10,
  Nitzschia, 14,
  Synedra, 96,
  Tabilleria, 3.

Genus cyanophycae:
    Anabaene, 2,
    Coelosphaerium, 1.
Genus chlorophycae:
    Arthadesmus, 4,
    Prosterium, 1,
    Hydrodiction, 6,
517 Pedeastrum, 2,
    Scenedesmus, 5.
Genus schizomycetes:
    Crenothrix, 2.
Genus protozoa:
    Monus, 47,
    Paramacium, 38,
    Placus, 2,
    Cynura, 1,
    Vorticella, 6.
Genus rotifiera:
    Polyauthra, 1,
    Rotifer, 2.
Miscellaneous:
    Vegetable hair, 3,
    Ober, 1,
    Mouldhifphe, 10.
Genera, 25.
Amorphus matter abundant.
The sample collected July 11th, 1900, is as follows:
Genus Diatomaceae:
    Asterionella, 10,
518 Cyclotella, 4,
    Diatoma, 32,
    Meridiom, 6,
    Nitzschia, 6,
    Senedra, 30,
    Caballeria, 10.
Genus Cyanophyceae:
    Endoriana, 3,
    Chrococcus, 6,
    Coelesphaerium, 4,

Lyngbia, 2,
Oscillaria, 10.
Genus Chlorophyceae:
Dictospherium, 1,
Endoriana, 1,
Protococcus, 1,
Rephidium, 2,
Ulothrix, 8.
Genus Schizomycetes:
Beggatoa, 10.
Genus Protozoa:
Protococcus, 8.

The sample collected July 11th, 1900, is as follows:

Genus Diatomaceae:
Asterionella, 10,
519 Cyclotella, 4,
Diatoma, 32,
Meridiom, 6,
Nitzschia, 6,
Senedra, 30,
Caballeria, 10.
Genus Cyanophyceae:
Endoriana, 3,
Chrococcus, 6,
Coelesphaerium, 4,
Lyngbia, 2,
Oscillaria, 10.
Genus Chlorophyceae:
Dictospherium, 1,
Endoriana, 1,
Protococcus, 1,
Rephidium, 2,
Ulothrix, 8.
Genus Schizomycetes:
Beggatoa, 10.
Genus Protozoa:
Protococcus, 8,
520 Protomonas, 8,
Monas, 6,

Perimecium, 10,
Chelomonas, 1,
Vorticello, 2.

Genus Rotifera:
Rotifa, 3.

Miscellaneous:
Anguillulla, 1,
Mouldhifpe, 5.

Total number, 185,
Genera, 25.
Amorphous matter very abundant.

The sample of July 20th, 1900, is as follows:

Genus Diatomaceae:
Asterionella, 6,
Diatoma, 10,
Navicula, 6,
Nitzschia, 28,
Cynedra, 40,
Cabellaria, 14.

Genus Cyanophyceae:
521 Coelosphaerium, 2,
Oscillaria, 6.

Genus Chlorophyceae:
Arthrodesmus, 2,
Dictiosphaerium, 1,
Pediastrum, 6,
Ulothrix, 2.

Genus Schizomycetes:
Beggattoa, 8,
Chrenofix, 12.

Genus Protozoa:
Monas, 2.

Miscellaneous:
Vegetable hair, 2.

Total number, 147,
Genera, 16.
Amorphous matter abundant.

Sample collected July 30th, 1900, is as follows:

Genus Diatomaceae:

Asterionella, 128,
Cyclotella, 16,
Hymentidium, 6,
522 Nitzschia, 4,
Cynedra, 88,
Genus Cyanophyceae:
Lyngbia, 2.
Genus Chlorophyceae:
Hydrodiction, 4.
Genus Schizomycetes:
Beggattoa, 3.
Genus Protozoa:
Protö monas, 2,
Parimecium, 14,
Synura, 2.
Genus Rotifero:
Rotifa, 2.
Crustaceae Genus:
Daphnia, 1.
Miscellaneous:
Mouldhifpe, 6,
Vegetable hair, 4,
Ober, 2.
Total number, 284,
Genera, 16.
Sample collected August 10th, 1900, is as follows:
Genus Diatomyceae:
Asterionella, 130,
Cyclotella, 3,
523 Diatoma, 16,
Meridiom, 7,
Cynedra, 300,
Tabellaria, 6.
Chlorophyceae genus:
Arthrodesmus, 1,
Protomonas, 4,
Rephidium, 2.
Protozoa genus:
Protomonas, 2,

Monas, 4,
Parimecium, 31,
Vorticello, 1.
Miscellaneous:
Mouldhiphe, 7,
Total number, 514,
Genera, 14.
Amorphous matter abundant.
Sample collected August 18th, 1900:
Diatomaceae:
Asterionella, 39,
Diatoma, 9,
Navicula, 14,
Nitzschia, 12,
524 Cynedra, 220,
Tabellaria, 4.
Genus Cyanophyceae:
Chrococcus, 2,
Lyngbya, 2,
Oscillaria, 6.
Genus Chlorophyceae:
Ebdoriana, 1.
Genus Protozoa:
Monas, 6,
Paramecium, 4,
Vorticella, 2.
Genus Rotifera:
Rotifa, 2.
Total number, 329,
Genera, 15.
Amorphous matter present in abundance.

Microscopical examination of the Des Plaines River at Joliet. The sample collected May 17th, 1900, is as follows:

Genus Diatomaceae:
Asterionella, 34,
Cyclotella, 3,
Diatoma, 17,
Hymentidium, 10,
525 Navicula, 5,

Nitzschia, 40,
Cynedra, 153,
Tabellaria, 6.
Genus Cyanophyceae:
Lyngbya, 3,
Oscillaria, 58.
Chlorophyceae Genus:
Spyrogyra, 4.
Schizomycetes genus:
Chrenothrix, 3,
Protozoa genus:
Monas, 2,
Protomonas, 7,
Vorticella, 4.
Rotifiera:
Rotifa, 3.
Miscellaneous:
Anguillula, 1,
Ober, 5.
Total number, 389,
526 Genera, 18,
Amorphous matter abundant.

MR. JEFFRIES: Now before we go to the next sample let me ask you if you know the particular place in the river that these samples were taken, whether above or below Joliet?

A. These samples were all collected at the same place, McDonnough Street, the same as the bacterioligical samples for this 1900 period. It represents the mixture of the Des Plaines River water; of the Chicago Drainage Canal and the waters of the Illinois and Michigan Canal.

Q. Is that above the entrance of the Joliet sewage?

A. Yes sir, it is above the Joliet sewage. The sewage comes in along there from the supply works; it does not enter here.

May 3rd, 1900. Result of the microscopical examination of the Des Plaines River at Joliet, Illinois: The Genus is as follows:

Diatomaceae:
Asterionella, 82,
Cyclotella, 6,

Diatoma, 29,
Hymentidium, 8,
Navicula, 5,
Nitzschia, 12,
Cynedra, 196,
Tabellaria, 42.
Cyanophyceae:
527 Lyngbya, 3,
Oscillaria, 60.
Chlorophyceae:
Prosterium, 2,
Desmidium, 1,
Pediastrum, 2,
Scenedesmus, 2.
Protozoa:
Protomonas, 2,
Monas, 27,
Paramecium, 3,
Vorticella, 3.
Rotifera:
Rotifa, 1,
Miscellaneous:
Vegetable hair, 21,
Ober, 1.
Total number, 507.
Genera, 21.
Amorphous matter abundant.
Sample collected June 10th, 1900:
Genus Diatomaceae:
Asterionella, 96,
528 Navicula, 12,
Nitzschia, 34,
Cynedra, 200,
Tabellaria, 12.
Cyanophyceae:
Oscillaria, 10.
Chlorophyceae:
Desmidium, 2,
Pediastrum, 5,

- Protomonas, 4,
  - Rephidium, 2,
  - Scenedesmus, 6.
- Protoza:
  - Monas, 10,
  - Paramecium, 1.
- Miscellaneous:
  - Vegetable hair, 10,
  - Ober, 4.
- Total number, 408,
- Genera, 16.
- Amorphous matter very abundant.
- Sample collected June 17th, 1900, as follows:
- Diatomaceae:
  - Asterionella, 38,
  - 529 Cynedra, 90,
  - Cyclotella, 2,
  - Diatoma, 2,
  - Nitzschia, 20.
- Cyanophyceae:
  - Oscillaria, 19.
- Chlorophyceae:
  - Closterium, 1,
  - Hydrodictyon, 1,
  - Endoria, 1,
  - Rephidium, 1,
  - Ulothrix, 20.
- Schizomycetes:
  - Chrenothrix, 1,
- Protoza:
  - Protomonas, 6.
- Miscellaneous:
  - Vegtable hair, 28,
  - Ober, 12.
- Total number, 242,
- Genera, 15.
- Amorphous matter very abundant.
- Sample collected June 25th, 1900:
- Genus Diatomaceae:

Asterionella, 138,
530 Cyclotella, 4,
Diatoma, 6,
Nitzschia, 49,
Cynedra, 290,
Tabellaria, 14.

Cyanophyceae:
- Oscillaria, 61.

Chlorophyceae:
- Desmidium, 4,
- Endoriana, 2,
- Bandoriana, 1,
- Pediastrum, 7,
- Protomonas, 5,
- Scenedesmus, 16,
- Spyrogyra, 2,
- Ulothrix, 10.

Protozoa:
- Monas, 12,
- Paramecium, 4,
- Cynedra, 2.

Rotifera:
- Rotifa, 2.

Miscellaneous:
- Anguillula, 1,
- 531 Vegetable hair, 12,
- Ober, 2.

Total number, 654,
Genera, 23.
Amorphous matter very abundant.
Sample collected July 11th, 1900:
Genus Diatomaceae:
- Asterionella, 80,
- Cyclotella, 1,
- Diatoma, 6,
- Hymentidium, 2,
- Navicula, 19,
- Nitzschia, 60,
- Cynedra, 240,

Tabellaria, 4.

Cyanophyceae:

Lyngbya, 1,

Oscallaria, 75.

Chlorophyceae:

Pediastrum, 1,

Ulothrix, 6.

Protozoa:

Monas, 2,

532 Paramecium, 2,

Synura, 3,

Protomonas, 2,

Vorticella, 1.

Rotifera:

Rotifa, 1.

Crustaceae:

Daphnia, 1.

Miscellaneous:

Vegetable hair, 2,

Ober, 33.

Total number, 542,

Genera, 21.

Amorphous matter very abundant.

Q. MR. JEFFRIES: Now doctor, with reference to the microscopical examination of the Illinois River, I will ask you to state where that water was taken from?

A. It is a microscopical examination of the Illinois River two miles above Peoria, Illinois, organisms per cubic centimeter and taken upon the dates last before named.

Q. The samples of all these waters were taken out in the current were they?

A. Out in the channel?

533 Q. Three feet from the surface?

A. Three feet from the surface, yes sir, according to the method laid down by Mr. Whipple.

Samples collected July 27th, 1900 is as follows:

Genus Diatomaceae:

Asterionella, 41,

Diatoma, 12,

Nitzschia, 23,
Cynedra, 71.
Cyanophyceae:
Oscillaria, 5.
Chlorophyceae:
Closterium, 1,
Pediastrum, 19,
Protomonas, 4,
Scenedesmus, 14,
Spyrogyra, 5.
Protozoa:
Protomonas, 9,
Monas, 22,
Synura, 3,
Rotifera:
534 Anaurea, 4,
Polyarthro, 4.
Crustacae:
Cyclops, 2,
Daphnia, 4.
Miscellaneous:
Aerina, 4,
Ober, 4.
Total number, 252,
Genera, 20.
Amorphous matter very abundant.
Sample collected June 3rd, 1900:
Diatomaceae:
Asterionella, 61,
Cyclotella, 8,
Diatoma, 38,
Navicula, 9,
Nitzschia, 6,
Cynedra, 100,
Tabellaria, 12.
Chlorophyceae:
Closterium, 2,
Pediastrum, 29,
535 Protomonas, 6,

Scenedesmus, 9,
Spyrogyra, 12.
Protozoa:
Protomonas, 6,
Monas, 12,
Vorticella, 3.
Rotifera:
Anaurea, 1.
Crustaceae:
Cyclops, 2,
Daphnia, 1.
Miscellaneous:
Ober, 12.
Total number, 327,
Genera, 19.
Amorphous matter very abundant.
Sample collected June 10th, 1900:
Genus Diatomaceae:
Asterionella, 186,
Diatoma, 6,
Nitzschia, 27,
Cynedra, 22,
Chlorophyceae:
Arthrodesmus, 1,
536 Closterium, 1,
Conferva, 6,
Bandoriana, 1,
Pediastrum, 12,
Scenedesmus, 18,
Spyrogyra, 12,
Ulothrix, 6.
Protozoa:
Monas, 4,
Paramecium, 2,
Synura, 2,
Rotifera:
Anaurea, 2,
Rotifa, 1,
Crustaceae, 1.

Miscellaneous:
    Ober, 6.
Total number, 316,
Genera, 19,
Amorphous matter very abundant.
Sample collected June 18th, 1900:
Genus Diatomaceae:
    Asterionella, 21,
537 Diatoma, 31,
    Nitzschia, 31,
    Cynedra, 98.
Cyanophyceae:
    Oscillaria, 16.
Chlorophyceae:
    Closterium, 2,
    Pediastrum, 6,
    Protococcus, 5,
    Scenedesmus, 6,
    Spyrogyra, 12,
    Zynmena, 2.
Protozoa:
    Protomonas, 2,
    Paramecium, 2,
    Vorticella, 2,
Miscellaneous:
    Anguillula, 1,
    Aorina, 1.
Total number, 238,
Genera, 16,
Amorphous matter very abundant.
Sample collected June 25th, 1900:
Diatomaceae:
    Asterionella, 94,
538 Clycotella, 16,
    Navicula, 12,
    Nitzschia, 40,
    Cynedra, 209.
Cyanophyceae:

Oscillaria, 64.
Chlorophyceae:
Arthrodesmus, 1,
Protococcus, 10,
Scenedesmus, 5,
Ulothrix, 30.
Protozoa:
Peredinium, 1,
Vorticella, 5.
Crustaceae:
Cyclops, 2,
Daphnia, 1,
Miscellaneous:
Anguillula, 3,
Vegetable hair, 16,
Ober, 24.
Total number, 542,
539 Genera, 17,
Amorphous matter very abundant.
Sample collected July 11th, 1900:
Genus Diatomaceae:
Asterionella, 120,
Cyclotella, 4,
Diatoma, 4,
Nitzschia, 14,
Cyclotella, 153,
Tabellaria, 12.
Cyanophyceae:
Oscillaria, 50,
Chlorophyceae:
Bandoriana, 1,
Protococcus, 6,
Scenedesmus, 5,
Ulothrix, 40.
Protozoa:
Monas, 3,
Paramecium, 1.
Rotifera:
Rotifa, 1.

Crustaceae:
Cyclops, 2
540 Daphnia, 2.
Miscellaneous:
Vegetable hair, 4.
Total number, 420,
Genera, 16,
Amorphous matter very abundant.
ADJOURNED until 2:00 P. M., Monday, February 23, 1903.

541 2:00 P. M., Monday, February 23, 1903, Continuation after recess. Present, the Commissioner and same counsel representing the respective parties.

DR. AMAND NICHOLAS RAVOLD, resumed the stand for further direct-examination, by Mr. Jeffries.

Q. Where are we now, doctor?

A. We are at microscopic examination of the Illinois River just above Grafton, Illinois. Now we begin on the microscopic examination of the Illinois River water just above Grafton,—three miles—

Q. Three miles above Grafton?

A. Three miles above Grafton, yes sir.

The next is genus diatomaceæ—this sample was collected May 28, 1900. Of the asterionella we have 18.

Cyclotella, 1,
Diatoma, 7,
Himantidium, 1,
Melosira, none,
Navicula, 2,
Nitzschia, 4,
Stephanodiscus, 1,
Synedra, 46.

542 Under Genus Cyanophyceæ, we have—
Lyngbya, 1,
Oscillaria, 1.
Genus cholorophyceæ:
Hydrodiction, 1,
Pediastrum, 4,

Scenedesmus, 4,
Spyrogyra, 2,
Ulothrix, none.
Genus Schizomycetes:
Crenothrix, 1.
Under Protozoa, we have
Cryptomonas, 2,
Monas, 8,
Synura, 3,
Vorticella, 1.
Miscellaneous:
Vegetable hair, 5,
Total number, 114,
Genera, 20.
Amorphous matter very abundant.

We go to sample collected June 3, 1900, under the genus diatomaceæ:

Asterionella, 43,
Diatoma, 4,
Melosira, 2,
Nitzschia, 14,
543 Pleurosigma, 1,
Synedra, 280.
Genus cyanophyceæ:
Species Oscillaria, 28.
Under Chlorophyceæ, we have
Endoriana, 2,
Pediastrum, 8,
Protococcus, 4,
Scenedesmus, 24,
Ulothrix, 11.
Under Protozoa:
Monas, 12,
Paramecium, 1,
Synura, 2,
Total number, 436,
Genera, 15,
Amorphous matter abundant.

June 10, under genus Diatomaceæ:

Asterionella, 7,
Diatoma, 2,
Nitzschia, 12,
Synedra, 140,

Under Cyanophyceæ, we have
Oscillaria, 20.

Under Chlorophyceæ we have
Protococcus, 19.

544 Under Protozoa we have
Monas, 6,
Perimecium, 1,
Total number, 207,
Genera, 8.

Sample collected June 8:
Asterionella, 8,
Cyclotella, 3,
Nitzschia, 3.
Synedra, 22.

Under Cyanophyceæ:
Oscillaria, 4.

Under Chlorophyceæ:
Arthrodesmus, 3,
Closterium, 1,
Pediastrum, 4,
Synura, 4,
Vorticella, 2.

Under Rotifera:
Rotofa, 2,
Total number, 56.
Genera, 11,
Amorphous matter very abundant.

June 25:

Diatomaceæ:
Asterionella, 30,
Cyclotella, 2,
545 Nitzschia, 6,
Synedra, 90.

Under Chlorophyceæ, we have
Protococcus, 6,

Scenedesmus, 8,
Spyrogyra, 3,
Ulothrix, 6.

Under Protozoa, we have
Cryptomonas, 1,
Monas, 1,
Total number, 155,
Genera, 11,
Amorphous matter abundant.

Illinois River at Grafton, July 11.

Diatomaceæ:
Diatoma, 2,
Navicula, 2,
Nitzschia, 6,
Pleurosigma, 1,
Synedra, 170.

Under Chlorophyceæ:
Arthrodesmus, 6,
Closterium, 1,
Protococcus, 7,
Scenedesmus, 10,
Spyrogyro, 3,
Ulothrix, 9.

546 Under the protozoa we have:
Monas, 2,
Peremecium, 1,
Synura, 4.

Under Miscellaneous:
Vegetable hair, 4,

Total number, 244.

Genera, 16.

Amorphous matter very abundant.

That ends that.

Now the microscopic examination of the Mississippi River water two miles above Grafton, Illinois,—organisms per cubic centimeter. Sample collected May 28, 1900:

Under Diatomaceæ:
Asterionella, 4,
Diatoma, 3,

Meridiom, 4,
Navicula, 6,
Nitzschia, 9,
Synedra, 30,
Tabellaria, 7,
Under Cyanophyceæ:
Oscillaria, 2,
Under Chlorophyceæ:
Desmedium, 1,
Hydrodictyon, 17,
547 Pediastrum,
Scenedesmus, 8,
Ulothrix, 12,
Protozoa:
Cryptomonas, 1,
Monas, 3,
Synura, 5,
Roteferia anoria, 1.
Miscellaneous:
Vegetable hair, 6.
Total number, 125,
Genera, 18,
Amorphous matter very abundant.
Sample collected June 3, 1900:
Diatromaceæ:
Asterionella, 39,
Cyclotella, 4,
Diatoma, 12,
Nitzschia, 60,
Synedra, 49,
Tabellaria, 2.
Cyanophyseæ:
Oscillaria, 14.
Chlorophyceæ:
Pediastrum, 17,
Scenedesmus, 16,
Ulothrix, 22.
548 Protozoa:
Monas, 10,

Perimesium, 1,
Synura, 2.
Miscellaneous:
Vegetable hair, 12.
Total number, 260,
Genera, 14.
Amorphous matter very abundant
July 11:
Diatomaceæ:
Asterionella, 12,
Cymbella, 2,
Nitzschia, 12,
Synedra, 239,
Tabalaria, 6.
Cyanophyceæ:
Oscillaria, 2.
Chlorophyceæ:
Closterium, 1,
Protococcus, 5,
Glenodinium, 1.
Protozoa:
Monas, 5,
Synuria, 2.
549 Under Rotifera:
Rotofa, 1,
Vegetable hair, 2,
Total number, 286.
Genera, 13.
Amorphous matter very abundant in all.

Q. MR. JEFFRIES: Now the microscopic examination of the Mississippi River water one mile above Alton?

A. Sample collected May 28, 1900:
Diatomaceæ:
Asterionella, 12,
Cyclotella, 4,
Cymbella, 2,
Diatoma, 8,
Meridiom, 6,
Narvicula, 8,

Nitzschia, 10,
Synedra, 41,
Tabellaria, 9.
Cyanophyceæ:
Lyngbya, 2,
Oscillaria, 2.
Under Chlorophyceæ we have:
Arthrodesmus, 4,
Closterium, 2,
Hydrodictyon, 4,
550 Pediastrum, 9,
Protococcus, 3,
Scenedesmus, 4,
Spyrogyra, 1,
Ulothrix, 4,
Under Protozoa:
Cryptomonas, 3,
Monas, 12,
Paramecium, 1,
Vorticella, 1.
Miscellaneous:
Vegetable hair, 5.
Total number, 153,
Genera, 25,
Amorphous matter abundant.
June 3, 1900:
Diatomaceæ:
Asterionella, 4,
Diatoma, 4,
Navicula, 2,
Nitzschia, 5,
Synedra, 220,
Taballaria, none.
Cyanophyceæ:
Oscillaria, 19.
Chlorophyceæ:
Pediastrum, 38,
551 Protococcus, 4,
Scenedesmus, 16,

Spyrogyra, 5,
Ulothrix, 29.

Protozoa:
Monas, 8,
Synura, 3.

Rotiferia:
Rotofa, 1.

Miscellaneous:
Vegetable hair, 6.

Total number, 314.

Genera, 15,

Amorphous matter very abundant.

Sample collected July 11, 1900:

Diatomaceæ:
Asterionella, 60,
Diatoma, 4,
Navicula, 2,
Nitzschia, 15,
Synedra, 96,
Tabellaria, 6.

Chlorophyceæ:
Arthrodesmus, 1.
Desidious, 2.
Pediastrum, 11.
Scenedesmus, 12.

552 Protozoa:
Monas, 3,
Perimecium, 1.
Synura, 3.

Rotiferia:
Anaurea, 1.

Miscellaneous:
Vegetable hair, 2.

Total number, 219.

Genera, 15.

Amorphous matter abundant.

Q. MR. CROW: Now, have you made a microscopic examination of the Mississippi river water opposite Hartford, Illinois?

A. Yes, sir.

Q. Where is Hartford, Illinois?

A. Hartford, Illinois, is about seven miles below Alton, about one mile above the mouth of the Missouri river, where it empties into the Mississippi.

Q. Have you got a statement of the result of that analysis?

A. Yes, sir.

Q. Just give it, please.

A. May 29, 1900:

Diatomaceæ:
- Asterionella, 9.
- Cyclotella, 4.
- Cymbella, 3,
- Diatoma, 6.
- 553 Himantidium, 3.
- Meridiom, 2.
- Navicula, 5.
- Nitzschia, 19.
- Synedra, 50.
- Tabellaria, 12.

Under Cyanophyceæ:
- Coelophaerium, 4.
- Lyngbya, 6.
- Oscillaria, 4.

Chlorophyceæ:
- Flosterium, 1.
- Desmidium, 2.
- Dictiospherium, 6.
- Hydrodictyon, 1.
- Pediastrum, 12.
- Protococcus, 2.
- Scenedesmus, 6.
- Spyrogyra, 4.

Protozoa:
- Cryptomonas, 3.
- Monas, 10.
- Synura, 9.

Miscellaneous:
- Vegetable hair, 7.

Total number, 191.

Genera, 25.

Amorphous matter abundant.

554 Sample collected June 3, 1900:

Diatomaceæ:
  Asterionella, 14.
  Cyclotella, 1.
  Nitzschia, 30.
  Synedra, 60.
  Tabellaria, 4.
Cyanophyceæ:
  Coelosphærium, 4.
  Oscillaria, 10.
Chlorophyceæ:
  Desmidium, 2.
  Dictiospherium, 2.
  Pediastrum, 6.
  Scenedesmus, 12.
Protozoa:
  Cryptomonas, 4.
  Monas, 12.
  Synura, 3.
Miscellaneous:
  Vegetable hair, 11.
Total number, 171.
Genera, 14.
Amorphous matter abundant.

July 11, 1900:
Under Diatomaceæ:
  Asterionella, 4.
555 Cymbella, 2.
  Diatoma, 5.
  Hymentidium, 2.
  Navicula, 6.
  Nitzschia, 12.
  Synedra, 22.
  Tabellaria, 4.
Cyanophyceæ:
  Coelosphærium, 5.
  Oscillaria, 10.
Under Chlorophyceæ:
  Arthrodesmus, 2.

Cloesterium, 1.
Desmidium, 3,
Pediastrum, 4.
Protococcus, 5.
Scenedesmus, 19.
Spyrogyra, 8.
Ulothrix, 10.

Under Protozoa:

Monas, 8.
Perimecium, 2.
Synura, 3.
Vorticella, 2.

Under Rotifera:

Rotifo, 1.

Miscellaneous:

Vegetable hair, 2.

556 Total number, 142.
Genera, 24.

Amorphus matter abundant.

That is the last one of that.

Q. Now, was there a microscopic examination of the Mississippi River water at In-take tower at St. Louis waterworks?

A. Yes sir.

Q. At what time?

A. On the dates thereon.

Q. May 28, June 3, July 11, of what year?

A. 1900.

Q. You have got the result of that examination, have you?

A. Yes sir.

Q. Just put it in the record.

A. May 28, 1900, microscopical examination of Mississippi River water at the in-take of the St. Louis waterworks:

Diatomaceæ:

Asterionella, 21,
Merediom, 6,
Nitzschia, 32,
Synedra, 40,
Tabellaria, 8.

Cyanophyceæ:
  Oscillaria, 20.
Chlorophyceæ:
  Arthrodesmus, 1,
  Closterium, 3,
557 Desmedium, 3,
  Pediastrum, 16,
  Protococcus, 5,
  Scenedesmus, 26,
  Ulothrix, 4,
Protozoa:
  Monas, 6,
  Perimecium, 1,
  Synura, 3.
Rotiferia:
  Rotifo, 2.
Miscellaneous:
  Vegetable hair, 3,
  Total number, 194,
Genera, 16,
Amorphous matter abundant.
Sample collected June 3, 1900:
Diatomaceæ:
  Asterionella, 4,
  Cyclotella, 2,
  Cymbella, 1,
  Navicula, 14,
  Nitzschia, 24,
  Synedra, 12,
  Tabellaria, 6.
Cyanophyceæ:
  Oscillaria, 16.
559 Chlorophyceæ:
  Desmedium, 3,
  Pediastrum, 9,
  Scenedesmus, 8.
Protozoa:
  Cryptomonas, 2,
  Monas, 12.

Miscellaneous:
    Anguilula, 1,
Total number, 114.
Genera, 14.
Amorphous matter abundant—very abundant.
July 11, 1900:
Diatomaceæ:
    Asterionella, 16,
    Cyclotella, 2,
    Diatoma, 2,
    Hymentidium, 2,
    Meridiom, 8,
    Navicula, 11,
    Nitzschia, 16,
    Synedra, 39,
    Tabellaria, 12,
    Caelosphaerium, 2,
    Oscillaria, 22,
Chlorophyceæ:
    Arthrodesmus, 1,
    Closterium, 2,
    Hydrodictyon, 4,
    Pediastrum, 3,
    Scenedesmus, 14,
    Spyrogyra, 1,
    Ulothrix, 8,
Protozoa:
    Monas, 9,
    Perimecium, 1.
Miscellaneous:
    Anguilula, 1,
    Vegetable hair, 1,
    Total number, 176,
    Genera, 21,
Amorphous matter very abundant.
That is all the tables.

Q. Now, doctor, I want to identify this thing. In the first place is there anything on it that will identify it?

A. It is marked on the side here.

Q. Whereabouts?

A. Bacteria per cubic centimeter.

Q. Now doctor, what is this chart that I show you?

A. This chart is a graphic representation of the number of micro-organisms found in the Illinois River at Grafton, a weekly estimation.

560 Q. Weekly examination?

A. No, it is a weekly estimation, taken from the daily numbers in samples obtained of numbers of bacteria in samples obtained at this point.

Q. In what time?

Beginning January 23,—the next estimation January 30,
February 6, 13, 20, 27,
March 6, 13, 20, 27,
April 3, 10, 17, 24,
May 1, 8, 15, 22, 29,
June 5, 12, 19, 26,
July 3, 10, 17, 24, 31,
August, 7, 14, 21, 28,
September 4, 11, 18, 25,
October 2, 9.

Q. Of what year?

A. For the year 1900.

Q. Now the estimates are made of the total number of bacteria in the river at that point during the designated periods of time, without regard to the classification of the bacteria?

A. Yes sir.

Q. Now doctor, will you please explain this chart in your own way. In the first place, this chart was made under your supervision?

A. Yes sir.

Q. And by your direction? A. Yes sir.

561 Q. And is intended for what specific purpose?

A. To represent graphically,—that is to the eye easily,—a picture of the number of bacteria weekly calculated from the daily numbers collected in samples at this point.

Q. As shown by the tables?

A. As shown by the tables which have already been submitted for these different points.

Q. Now doctor, will you please explain the details of the map,—what the coloring and the lines mean?

A. Well, arranged perpendicularly here you see the numbers of bacteria, beginning with zero, 1,000, 2,000, 3,000, on up until there are 200,000 spaces here. In some places the number has run above 200,000, as for instance in the week ending February 13, large numbers are recorded. This piece of paper is not large enough to graphically represent that. The number consequently is written at the top of that week, 257,000, 441,000, 443,000, 267,000, 239,000, 204,000. The map would have to be extended twice as far to represent that. Now that is graphically represented for Grafton, from this date, January 23, to October 9.

Q. Now doctor, you have there then the variations?

A. Yes sir.

Q. The weekly variations?

A. Yes sir.

Q. At Grafton during that period?

A. Yes sir.

562 Q. Will you please give them as indicated by your map here?

A. The first week the total number, ending January 30, 1900, is 116,000; for the second week, ending February 6, it drops to 109,000,—estimated by the week. Week ending February 13, the number amounts to 257,600.

Week ending February 20, 221,800,
Week ending February 27, 223,100,
Week ending March 6, 267,700,
Week ending March 13, 239,900,
Week ending March 20, 204,000,
Week ending March 27, 158,000,
Week ending April 3, 142,000,
April 10, 24,000,
April 17, 9,000,
April 24, 2,500,
May 1, 125,000,
May 8, 4,000,
May 15, 4,000,
May 22, 4,000,

May 29, 9,500,
June 5, 6,500,
June 12, 1,600,
June 19, 3,100,
June 26, 2,500,
July 3, 1,700,
July 10, 1,500,
July 17, 11,500,
563 July 24, 1,800,
July 31, 9,000,
August 7, 14,000,
August 14, 12,500,
August 21, 15,000,
August 28, 26,000,
September 4, 30,000,
September 11, 7,500,
September 18, 3,000,
September 25, 3,000,
October 2, 16,500,

Now that represents graphically the bacteria per cubic centimeter shown weekly from the bacterial contents of samples collected daily, and weekly averages made of water collected daily in the Illinois River at Grafton.

Q. MR. JEFFRIES: Take the Mississippi River now at Grafton and describe the weekly average of bacteria per cubic centimeter as shown by the chart or the exhibit.

ATTORNEY GENERAL CROW: In the first place, though, this test was made in the same manner as the other one that you have described, weekly from averages?

A. Yes.

Q. An average made from the daily examinations?

A. Yes.

Q. Just state how you obtained that, just in order to get that method into the record, explain it to Judge Springer.

564 A. From samples taken daily the bacterial contents was obtained, and at the end of the week these numbers of bacteria were added together and an average obtained, which gives the weekly estimation of the number of bacteria per cubic centimeter, and that is here recorded graphically upon the chart

already identified. For Mississippi River two miles above Grafton.

Q. How are the increases indicated? How the increases in the number of bacteria and the decreases, indicated by the lines on the map?

A. This is what is known as a profile map, and it is marked so that every line running horizontally across it represents 500 bacteria per cubic centimeter, beginning with zero it runs to 200,000. Perpendicularly along the front of this profile paper on the left hand side the numbers from zero to 200,000 are written. On every other line where the number of bacteria per week averaged more than 200,000, the figures are written in at the top.

Q. On the white margin? A. Yes, on the white margin, while below the white margin is written the week beginning with January 23 and continuing weekly to October 9.

Q. State how the variations in the number of bacteria are indicated on the surface of the paper by the lines?

A. Now there are horizontal lines on this paper also, and in the space between the horizontal lines at the number of bacteria, is drawn a line in black ink across that space, which
565 indicates the beginning and ending of that week. Now
black lines perpendicularly, connect the weeks, so that the numbers are easily read from that, reading across on the horizontal line, and the number on the left margin of the chart.

Q. Where is the next point located on that chart?

A. The next point on this chart is Mississippi River two miles above Grafton.

Q. Above Grafton?

A. Yes sir, above Grafton. In the week beginning January 23 and ending January 30, 40,500,—

Q. Now these figures indicate the average number weekly per cubic centimeter of water?

A. Yes sir, the average of the numbers collected daily.

February 6, 46,000,
February 13, 43,000,
February 20, 161,000,
February 27, 105,500,
March 6, 55,000,
March 13, 125,000,

March 27, 437,700,
April 3, 142,500,
April 10, 17,500,
April 17, 69,500,
April 24, 18,500,
May 1, 11,000,
May 8, 2,500,
566 May 15, 7,000,
May 22, 6,000,
May 29, 6,000,
June 5, 5,500,
June 12, 6,500,
June 19, 20,000,
June 26, 12,000,
July 3, 12,500,
July 10, 24,500,
July 17, 8,500,
July 24, 11,500,
July 31, 20,000,
August 7, 12,500,
August 14, 17,500,
August 21, 37,500,
August 28, 32,500,
September 4, 17,000,
September 11, 7,500,
September 18, 8,000,
September 25, 14,500,
October 2, 19.500.

Q. What is the next point at which these examinations were made?

A. Mississippi River at Alton.

Q. Alton, Illinois?

567 A. Alton, Illinois, yes. Each of the green squares on this chart, the lines running horizontally, reading upward represent 25,000 bacteria per cubic centimeter.

Q. Go ahead with the next.

A. Beginning with the week of January 23, ending January 30, 119,000,

February 6, 116,000,
February 13, 100,500,

February 20, 296,000,
February 27, 249,600,
March 6, 156,500,
March 13, 214,900,
March 20, 312,300,
March 27, 151,000,
April 3, 88,000,
April 10, 52,000,
April 17, 21,000,
April 24, 7,000,
May 1, 5,000,
May 8, 5,500,
May 15, 8,500,
May 22, 11,000,
May 29, 6,500,
June 5, 12,500,
June 12, 9,000,
June 19, 5,500,
June 26, 6,000,
568 July 3, 3,000,
July 10, 3,000,
July 17, 19,000,
July 24, 5,000,
July 31, 2,000,
August 7, 1,000,
August 14, 2,000,
August 21, 3,000,
August 28, 7,000,
September 4, 2,000,
September 11, 1,000,
September 18, 2,000,
September 25, ,4,000,
October 2, 2,000.

Now, the Mississippi River at Hartford, Illinois.

Q. ATTORNEY GENERAL CROW: Where is Hartford?

A. Hartford is 7 miles below Alton and one mile above the point of union of the Missouri River and the Mississippi River, —one mile about the mouth of the Missouri River.

Q. Now go ahead with the results of that.

A. Beginning January 23 and ending January 30, 87,500.
February 6, 147,000,
February 13, 106,500,
February 20, 233,500,
February 27, 266,900,
March 6, 193,000,
March 13, 209,000,
569 March 20, 320,500,
March 27, 227,600,
April 3, 60,500,
April 10, 58,000,
April 17, 34,000,
April 24, 13,000,
May 1, 8,000,
May 8, 11,500,
May 15, 15,500,
May 22, 17,500,
May 29, 8,000,
June 5, 6,000,
June 12, 4,000,
June 19, 4,000,
June 26, 4,500,
July 3, 3,000,
July 10, 7,000,
July 17, 4,000,
July 24, 4,000,
July 31, 1,500,
August 7, 1,500,
August 14, 2,000,
August 21, 3,500,
August 28, 3,500,
September 4, 3,000,
September 11, 1,000,
570 September 18, 2,500,
September 25, 3,500,
October 2, 3,500.

ATTORNEY-GENERAL CROW: What was the next point at which you made an examination?

A. Missouri river at Fort Bellefontaine, beginning January 23 and ending January 30, 213,000.

February 6, 141,000,
February 13, 63,000,
February 20, 55,200,
February 27, 70,000,
March 6, 63,500,
March 13, 176,000,
March 20, 453,500,
March 27, 270,500,
April 3, 139,000,
April 10, 140,000,
April 17, 66,000,
April 24, 44,000,
May 1, 16,500,
May 8, 21,000,
May 15, 32,500,
May 22, 45,500,
May 29, 40,500,
June 5, 41,500,
571 June 12, 55,500,
June 19, 62,000,
June 26, 112,000,
July 3, 105,500,
July 10, 32,500,
July 17, 26,000,
July 24, 21,000,
July 31, 10,500,
August 7, 11,500,
August 14, 6,500,
August 21, 5,500,
August 28, 14,000,
September 4, 12,000,
September 11, 6,000,
September 18, 40,500,
September 25, 26,000,
October 2, 24,000.

Q. Now, give us the next point?

A. Missouri shore, Chain of Rocks—beginning January

23—that is, samples were taken about 300 yards from the Missouri shore in the cross-section of the stream about 100 yards up the river in front of the intake of the St. Louis waterworks, and that is weekly averages—these weekly averages are of the bacterial contents of samples taken daily at this point.

Q. Well, have you got the figures there?

A. Yes, sir. Now, for the week beginning January 23,
572 1900, 240,000.
January 30, 142,500,
February 6, 57,000,
February 13, 99,000,
February 20, 77,000,
February 27, 50,500,
March 6, 177,500,
March 13, 484,800,
March 20, 314,800,
March 27, 70,000,
April 3, 75,500,
April 10, 62,500,
April 17, 25,000,
April 24, 11,000,
May 1, 10,500,
May 8, 46,000,
May 15, 42,500,
May 22, 29,000,
May 29, 25,000,
June 5, 22,000,
June 12, 28,000,
June 19, 28,000,
June 26, 17,000,
July 3, 1,500,
July 10, 12,500,
July 17, 20,500,
573 July 24, 17,000,
July 31, 10,000,
August 7, 6,500,
August 14, 10,000,
August 21, 10,000,
August 28, 10,500,
September 4, 12,000,

September 11, 5,500,
September 18, 24,000,
September 25, 30,500,
October 2, 23,500.

Q. MR. JEFFRIES: Where do we go next?

A. Illinois shore, Chain of Rocks—week beginning January 23, 1900—155,500.
January 30, 76,500,
February 6, 106,000,
February 13, 224,400,
February 20, 190,500,
February 27, 77,500,
March 6, 174,000,
March 13, 345,300,
March 20, 253,800,
March 27, 76,000,
April 3, 47,500,
April 10, 37,000,
April 17, 15,000,
574 April 24, 9,000,
May 1, 3,000,
May 8, 21,000,
May 15, 24,000,
May 22, 9,000,
May 29, 20,000,
June 5, 26,000,
June 12, 22,500,
June 19, 20,500,
June 26, 10,500,
July 3, 10,500,
July 10, 7,500,
July 17, 7,000,
July 24, 4,500,
July 31, 4,500,
August 7, 4,500,
August 14, 5,500,
August 21, 3,500,
August 28, 5,500,
September 4, 2,000,
September 11, 1,500,

September 18, 4,500,
September 25, 12,500,
October 2, 6,000.

575 The next sample is taken at the In-take tower, Chain of Rocks, in the river about one hundred feet in front of the tower, up the river.

Beginning week of January 23, 154,000,
January 30, 135,000,
February 6, 75,000,
February 13, 133,500,
February 20, 112,500,
February 27, 53,000,
March 6, 177,000,
March 13, 200,000,
March 20, 200,000,
March 27, 118,000,
April 3, 90,000,
April 10, 37,000,
April 17, 12,000,
April 24, 7,000,
May 1, 23,500,
May 8, 13,500,
May 15, 4,000,
May 22, 16,500,
May 29, 23,500,
June 5, 26,500,
June 12, 26,000,
June 19, 17,000,
July 3, 13,000,
576 July 10, 14,000,
July 17, 19,000,
July 24, 13,000,
July 31, 7,000,
August 7, 4,500,
August 14, 5,500,
August 21, 6,000,
August 28, 14,000,
September 4, 6,000,
September 11, 4,500,
September 18, 30,500,

September 25, 25,500,
October 2, 16,500.

The next sample was taken at outlet chamber, reservoir, at the Chain of Rocks.

Q. MR. JEFFRIES: That is as the water goes out of the reservoir into the conduit?

A. As the water comes out of the reservoir into the conduit which carries the water over to Baden, leading into the conduit at Bissell's Point, from the reservoir.

The first date is January 23, 28,000,
January 30, 110,000,
February 6, 31,000,
February 13, 42,000,
February 20, 106,500,
February 27, 53,000,
577 March 6, 70,000,
March 13, 200,000,
March 20, 2000,000,
March 27, 76,500,
April 3, 85,500,
April 10, 35,500,
April 17, 3,500,
April 24, 10,500,
May 1, 6,500,
May 8, 23,000,
May 15, 14,500,
May 22, 4,000,
May 29, 9,500,
June 5, 4,500,
June 12, 12,500,
June 19, 9,000,
June 26, 7,000,
July 3, 5,000,
July 10, 5,500,
July 17, 3,500,
July 24, 2,500,
July 31, 3,500,
August 7, 2,000,
August 14, 3,000,
August 21, 2,000,

August 28, 3,500,
578 September 4, 3,000,
September 11, 1,500,
September 18, 3,000,
September 25, 3,500,
October 2, 3,000.

Now, the next samples were collected in the tap in the bacteriological laboratory at the Old City Hall, corner Eleventh and Chestnut streets, beginning May 8 and continuing to October 2, 1900.

Week beginning May 8, 10,000,
May 15, 3,500,
May 22, 3,500,
May 29, 2,000,
June 5, 2,000,
June 12, 1,500,
June 19, 1,500,
June 26, 1,000,
July 3, 1,000,
July 10, 500,
July 17, 500,
July 24, 1,000,
July 31, 1,000,
August 7, 1,000,
August 14, 1,000,
August 21, 1,000,
August 28, 500,
September 4, 1,000,
579 September 11, 500,
September 18, 1,000,
September 25, 1,500,
October 2, 1,500,

That is all of it.

ATTORNEY-GENERAL CROW: We want to offer this map as an exhibit.

MR. SPRINGER: We have no objection.

Map received in evidence and marked "Complainant's Exhibit No. 1, Frank S. Bright, Commissioner."

Adjourned until 10:00 o'clock following morning, Tuesday, February 24, 1903, at same place.

Southern Hotel, St. Louis, Missouri. 10:00 a. m., Febru-
580 ary 24, 1903. Present, the Commissioner and same counsel representing the respective parties.

DR. AMAND NICHOLAS RAVOLD

Resumed the stand for further direct examination by Mr. Jeffries, and testified as follows:

MR. JEFFRIES: Now this map I speak of is the same map we introduced the last thing yesterday afternoon, it being numbered Complainant's Exhibit 1.

Q. Now, Doctor Ravold, I will get you to take that chart and explain what that shows with reference to the numbers of bacteria in the waters of the Illinois, Mississippi and the Missouri rivers at the various points and times designated on the map and what it shows, if anything, with reference to the commingling of the waters of the Illinois and the Mississippi and the waters of the Mississippi and Missouri after the Illinois and Mississippi have commingled, and how those facts are indicated by the lines and marks on this map marked Complainant's Exhibit 1.

A. Now what this chart shows is what I have already explained.

Q. (Question repeated.)

A. You want a description of this chart?

581 Q. Yes?

A. This chart shows the bacteria per cubic centimeter. The numbers recorded perpendicularly along the profile lines. The weekly averages have been obtained by adding the bacterial contents, obtained from samples collected daily, dividing by seven, which gives the weekly averages. These weekly averages are recorded, beginning January 23rd, and ending October 9, 1900. Now what do you want?

Q. Answer that question; what those facts are. Explain what those lines indicate, how indicated and the facts called for in the question.

A. These weekly numbers of bacteria are recorded for the Illinois river at Grafton, Illinois; the Mississippi river at Grafton, Illinois; the Mississippi river at Alton one mile above the town; the Mississippi river at Hartford seven miles below Alton;

the Missouri river at Fort Bellefontaine; the Missouri shore, Chain of Rocks; the Illinois shore, Chain of Rocks; the tap, bacteriological laboratory old City Hall, beginning May 8th and ending October 9th.

Q. You haven't answered all my question. Just bear that question in mind. You only answered the first part of it.

A. What is the rest of it?

Q. (Question repeated.)

MR. JEFFRIES: I undertook to put it all in one so that 582 you could go right ahead.

A. In order to answer the second part of that question, we will have to make a comparative estimate beginning with the weekly averages at Grafton from January 23rd to 30th and compare it with each one of these elevations upon this chart for the individual stations where the samples were collected.

Q. Well, have you got the data on that map to do that?

A. The data is right there, yes sir.

Q. Go ahead and do it.

A. For the week beginning January 23rd:

Number of bacteria found at Grafton:
Illinois, Illinois river, 116,000,
Missouri river, Grafton, 41,000,
Mississippi river at Alton, 120,000,
Mississippi river, Hartford, 88,000,
Missouri river, Bellefontaine, 213,000,
Missouri shore, Chain of Rocks, 240,000,
Illinois shore, Chain of Rocks, 155,000,
Intake, 154,000,

583 Week beginning January 30th:
Number of bacteria found at Grafton:
Illinois, Illinois river, 189,500,
Mississippi river, Grafton, 46,000,
Mississippi river at Alton, 115,000,
Mississippi river at Hartford, 147,000,
Missouri river at Fort Bellefontaine, 141,000,
Missouri shore, Chain of Rocks, 147,000,
Illinois shore, Chain of Rocks, 76,000,
Intake, Chain of Rocks, 135,000,

Week beginning February 6th:
Number of bacteria found at Grafton:
Illinois, Illinois river, 257,600,
Mississippi river, Grafton, 43,000,
Mississippi river at Alton, 100,000,
Mississippi river at Hartford, 106,500,
Missouri river, Fort Bellefontaine, 63,000,
Missouri shore, Chain of rocks, 58,000,
Illinois shore, Chain of Rocks, 106,000,
Intake, 75,000,

Week beginning February 13th:
Illinois River at Grafton, 221,800,
584 Mississippi River at Grafton, 161,000,
Mississippi River at Alton, 296,000,
Mississippi River at Hartford, 233,000,
Missouri River, Ft. Bellefontaine, 52,000,
Missouri Shore, Chain of Rocks, 98,000,
Illinois shore, Chain of Rocks, 224,400,
Intake, 133,500.

Week beginning February 20th:
Illinois River at Grafton, 221,800,
Mississippi River at Grafton, 105,500,
Mississippi River at Alton, 249,600,
Mississippi River at Hartford, 266,700,
Missouri River, Ft. Bellefontaine, 70,000,
Missouri shore, Chain of Rocks, 77,000,
Illinois shore, chain of rocks, 192,000,
Intake, 112,000.

Week beginning February 27th:
Illinois River at Grafton, 223,100,
585 Mississippi River at Grafton, 55,000,
Mississippi River at Alton, 156,500,
Mississippi River at Hartford, 193,000,
Missouri River, Ft. Bellefontaine, 63,000,
Missouri Shore, chain of rocks, 50,500,
Illinois Shore, Chain of Rocks, 77,000,
Intake, 53,000.

Week beginning March 6th:
Illinois River at Grafton, 267,700,
Mississippi River at Grafton, 125,000,
Mississippi River at Alton, 214,900,
Mississippi River at Hartford, 209,200,
Missouri River, Ft. Bellefontaine, 176,000,
Missouri Shore, Chain of Rocks, 177,000,
Illinois shore, Chain of Rocks, 174,500,
Intake, 177,000.

Week beginning March 13th:
Illinois River at Grafton, 276,700,
586 Mississippi River at Grafton, 490,200,
Mississippi River at Alton, 312,300,
Mississippi River at Hartford, 320,500,
Missouri River, Ft. Bellefontaine, 435,500,
Missouri Shore, Chain of Rocks, 484,800,
Illinois Shore, Chain of Rocks, 374,300,
Intake, 484,900.

Week beginning March 20th:
Illinois River at Grafton, 204,300,
Mississippi River at Grafton, 433,700,
Mississippi River at Alton, 156,000,
Mississippi River at Hartford, 227,600,
Missouri River at Ft. Bellefontaine, 271,500,
Missouri Shore, Chain of Rocks, 314,800,
Illinois Shore, Chain of Rocks, 253,800,
Intake, 511,800.

Week beginning March 27th:
Illinois River at Grafton, 158,500,
587 Mississippi River at Grafton, 142,000,
Mississippi River at Alton, 90,000,
Mississippi River at Hartford, 60,500,
Missouri River, Bellefontaine, 139,000,
Missouri Shore, Chain of Rocks, 70,000,
Illinois shore, Chain of Rocks, 76,000,
Intake, 118,500.

Week beginning April 3rd:
Illinois River at Grafton, 142,500,
Mississippi River at Grafton, 37,500,
Mississippi River at Alton, 59,500,
Mississippi River at Hartford, 58,000,
Missouri River, Ft. Bellefontaine, 140,000,
Missouri shore, Chain of Rocks, 76,000,
Illinois shore, Chain of Rocks, 47,500,
Intake, 118,000.

Week beginnig April 10th:
Illinois River at Grafton, 24,000,
588 Mississippi River at Grafton, 69,000,
Mississippi River at Alton, 23,500,
Mississippi River, Hartford, 34,000,
Missouri River, Ft. Bellefontaine, 66,000,
Missouri Shore, chain of rocks, 62,500,
Illinois Shore, Chain of Rocks, 37,000,
Intake, 90,000.

Week beginning April 17th:
Illinois River at Grafton, 9,000,
Mississippi River at Grafton, 18,500,
Mississippi River at Alton, 9,500,
Mississippi River at Hartford, 16,000,
Missouri River, Ft. Bellefontaine, 49,000,
Missouri Shore, Chain of Rocks, 21,000,
Illinois Shore, Chain of Rocks, 14,500,
Intake, 37,000.

Week beginning April 24th:
Illinois River at Grafton, 2,500,
589 Mississippi River at Grafton, 11,000,
Mississippi River at Alton, 10,000,
Mississippi River at Hartford, 7,500,
Missouri River, Ft. Bellefontaine, 49,000,
Missouri shore, Chain of Rocks, 11,500,
Illinois shore, chain of rocks, 9,000,
Intake, 12,000.

Week beginning May 1st:
Illinois River at Grafton, 2,500,
Mississippi River at Grafton, 2,000,
Mississippi River at Alton, 7,000,
Mississippi River at Hartford, 11,500,
Missouri River, Ft. Bellefontaine, 16,500,
Missouri shore, Chain of Rocks, 10,500,
Illinois shore, Chain of Rocks, 2,500,
Intake, 7,000.

Week beginning May 8th:
Illinois River at Grafton, 12,500,
590 Mississippi River at Grafton, 7,000,
Mississippi River at Alton, 13,500,
Mississippi River at Hartford, 15,500,
Missouri River, Ft. Bellefontaine, 22,000,
Missouri Shore, Chain of Rocks, 46,000,
Illinois Shore, Chain of Rocks, 21,500,
Intake, 23,500.

Week beginning May 15th:
Illinois River, Grafton, 6,000,
Mississippi River, Grafton, 6,500,
Mississippi River at Alton, 16,000,
Mississippi River at Hartford, 18,000,
Missouri River, Ft. Bellefontaine, 45,500,
Missouri Shore, Chain of Rocks, 43,000,
Illinois Shore, Chain of Rocks, 24,000,
Intake, 13,500.

Week beginning May 22nd:
Illinois River at Grafton, 6,000,
591 Mississippi River at Grafton, 6,500,
Mississippi River at Alton, 8,000,
Mississippi River at Hartford, 6,000,
Missouri River, Ft. Bellefontaine, 40,500,
Missouri Shore, Chain of Rocks, 29,500,
Illinois Shore, Chain of Rocks, 9,000,
Intake, 4,000.

Week beginning May 29th:
Illinois River at Grafton, 9,500,
Mississippi River at Grafton, 5,500,
Mississippi River at Alton, 7,000,
Mississippi River at Hartford, 8,000,
Missouri River at Ft. Bellefontaine, 52,000,
Missouri Shore, Chain of Rocks, 25,000,
Illinois Shore, Chain of Rocks, 20,000,
Intake, 17,000.

Week beginning June 5th:
Illinois River at Grafton, 6,500,
592 Mississippi River at Grafton, 7,000,
Mississippi River at Alton, 12,500,
Mississippi River at Hartford, 6,000,
Missouri River at Ft. Bellefontaine, 55,500,
Missouri Shore, Chain of Rocks, 22,500,
Illinois Shore, Chain of Rocks, 26,000,
Intake, 23,500.

Week beginning June 12th:
Illinois River at Grafton, 16,000,
Mississippi River at Grafton, 20,000,
Mississippi River at Alton, 9,000,
Mississippi River at Hartford, 5,000,
Missouri River at Ft. Bellefontaine, 63,500,
Missouri Shore, Chain of Rocks, 38,500,
Illinois Shore, Chain of Rocks, 21,500,
Intake, 26,500.

Week beginnig June 19th:
Illinois River at Grafton, 31,000,
593 Mississippi River at Grafton, 12,000,
Mississippi River at Alton, 5,500,
Mississippi River at Hartford, 5,000,
Missouri River at Ft. Bellefontaine, 112,500,
Missouri shore, Chain of Rocks, 38,500,
Illinois shore, Chain of Rocks, 20,500,
Intake, 17,500.

Week beginning June 26th:
Illinois River at Grafton, 6,500,
Mississippi River at Grafton, 14,500,
Mississippi River at Alton, 6,000,
Mississippi River at Hartford, 4,500,
Missouri River, Ft. Bellefontaine, 105,500,
Missouri Shore, Chain of Rocks, 17,000,
Illinois Shore, Chain of Rocks, 10,500,
Intake, 13,000.

Week beginning July 3rd:
Illinois River at Grafton, Illinois, 17,000,
594 Mississippi River at Grafton, 15,500,
Mississippi River at Alton, 3,500,
Mississippi River at Hartford, 3,500,
Missouri River at Ft. Bellefontaine, 29,500,
Missouri Shore, Chain of Rocks, 1,000,
Illinois Shore, Chain of Rocks, 10,500,
Intake, 14,000.

Week beginning July 10th:
Illinois River at Grafton, 15,000,
Mississippi River at Grafton, 24,000,
Mississippi River at Alton, 3,500,
Mississippi River at Hartford, 7,000,
Missouri River, Ft. Bellefontaine, 27,500,
Missouri shore, Chain of Rocks, 20,500,
Illinois shore, Chain of Rocks, 8,000,
Intake, 19,000.

Week beginning July 17th:
Illinois River at Grafton, 11,500,
595 Mississippi River, Grafton, 9,000,
Mississippi River, at Alton, 18,000,
Mississippi River at Hartford, 4,000,
Missouri River at Ft. Bellefontaine, 21,000,
Missouri Shore, Chain of Rocks, 17,500,
Illinois Shore, Chain of Rocks, 7,500,
Intake, 13,000.

Week beginning July 24th:
Illinois River at Grafton, 18,000,
Mississippi River at Grafton, 12,000,
Mississippi River at Alton, 5,000,
Mississippi River at Hartford, 3,000,
Missouri River, Ft. Bellefontaine, 10,500,
Missouri Shore, Chain of Rocks, 10,000,
Illinois Shore Chain of Rocks, 4,500,
Intake, 7,000.

Week beginning July 31st:
Illinois River at Grafton, 9,000,
596 Mississippi River at Grafton, 20,000,
Mississippi River at Alton, 2,500,
Mississippi River at Hartford, 1,500,
Missouri River at Ft. Bellefontaine, 10,500,
Missouri shore, Chain of Rocks, 6,500,
Illinois shore, Chain of Rocks, 5,000,
Intake, 4,500.

Week beginning August 7th:
Illinois River at Grafton, 14,000,
Mississippi River at Grafton, 12,500,
Mississippi River at Alton, 1,000,
Mississippi River at Hartford, 1,500,
Missouri River at Ft. Bellefontaine, 7,000,
Missouri shore, Chain of Rocks, 10,000,
Illinois shore, Chain of Rocks, 4,500,
Intake, 8,500.

ADJOURNED until 2:00 P. M., same day, February 24th, 1903. Southern Hotel, St. Louis.

Southern Hotel, St. Louis, Missouri.
597 2:00 P. M., Tuesday, February 24, 1903.
Continuation after recess.

Present, the Commissioner and same counsel representing the respective parties.

DR. AMAND NICHOLAS RAVOLD,

resumed the stand for further direct examination by Attorney-General Crow, and testified as follows:

Q. Go ahead doctor.

A. Week beginning August 14:
Illinois River at Grafton, 12,500,
Mississippi River at Grafton, 18,000,
Mississippi River at Alton, 2,000,
Mississippi River at Hartford, 2,000,
Missouri River, Ft. Bellefontaine, 5,500,
Missouri shore, Chain of Rocks, 10,000,
Illinois shore, Chain of Rocks, 5,500,
Intake, 6,500.

Week beginning August 21:
Illinois River at Grafton, 15,500,
Mississippi River at Grafton, 36,500,
Mississippi River at Alton, 3,000,
Mississippi River at Hartford, 3,500,
Missouri River, Ft. Bellefontaine, 14,000,
Missouri shore, chain of rocks, 10,500,
598 Illinois shore at Chain of Rocks, 3,500,
Intake, 14,000.

Week beginning August 28:
Illinois River at Grafton, 26,500,
Mississippi River at Grafton, 32,000,
Mississippi River at Alton, 7,000,
Mississippi River at Hartford, 3,500,
Missouri River, Ft. Bellefontaine, 12,500,
Missouri Shore, Chain of Rocks, 12,000,
Illinois Shore, chain of rocks, 8,500,
Intake, 6,500.

Week beginning September 4:
Illinois River at Grafton, 29,000,
Mississippi River at Grafton, 17,000,
Mississippi River at Alton, 1,500,
Mississippi River at Hartford, 2,500,

Missouri River, Ft. Bellefontaine, 6,500,
Missouri Shore at Chain of Rocks, 5,500,
Illinois Shore at Chain of Rocks, 2,000,
Intake, 4,500.

Week beginning September 11:
Illinois River at Grafton, 7,500,
Mississippi River at Grafton, 8,000,
Mississippi River at Alton, 1,000,
Mississippi River at Hartford, 1,000,
Missouri River, Ft. Bellefontaine, 40,500,
599 Missouri Shore at Chain of Rocks, 24,000,
Illinois Shore at Chain of Rocks, 1,500,
Intake, 30,500.

Week beginning September 18:
Illinois River at Grafton, 3,000,
Mississippi River at Grafton, 8,500,
Mississippi River at Alton, 2,000,
Mississippi River at Hartford, 2,500,
Missouri River, Ft. Bellefontaine, 36,000,
Missouri Shore, Chain of Rocks, 30,500,
Illinois Shore, Chain of Rocks, 8,000,
Intake, 25,500.

Week beginning September 25:
Illinois River at Grafton, 3,000,
Mississippi River at Grafton, 14,500,
Mississippi River at Alton, 4,000,
Mississippi River at Hartford, 4,000,
Missouri River, Ft. Bellefontaine, 36,000,
Missouri Shore, Chain of Rocks, 30,000,
Illinois Shore, Chain of Rocks, 13,000,
Intake, 25,500.

Week beginning October 2:
Illinois River at Grafton, Ill., 16,500,
Mississippi River at Grafton, 20,500,
Mississippi River at Alton, 2,000,
Mississippi River at Hartford, 2,500,
600 Missouri River at Ft. Bellefontaine, 24,000,

Missouri Shore, Chain of Rocks, 23,500,
Illinois Shore, Chain of Rocks, 6,000,
Intake, 17,000.

Q. ATTORNEY GENERAL CROW: Doctor, that is all of that, is it?

A. That is all of that, yes sir.

Q. I will ask you if there is anything on this map that indicates that the water of the Mississippi and Illinois Rivers —that the water of the Illinois River come into it, and if so at what point?

A. We have two points on the Mississippi River,—at Alton, and at Hartford, and as far as can be ascertained from the bacterial contents of the stream taken in the center of the river, we show a mixture both at Alton and at Hartford, with this chart, of the waters of the two rivers.

Q. That is of the Illinois and the Mississippi?

A. Of the Illinois and the Mississippi, yes,—that is in the channel now.

Q. Now is there anything in this chart, and if so, what is it, that indicates the commingling of the waters of the Mississippi and the Missouri, after the Illinois has flown into the Mississippi?

A. Yes sir. This is a comparative estimate of the numbers of bacteria in the waters,—that is, of a cross-section of the Mississippi river, Missouri shore, Intake,—Illinois shore as can be seen on this chart, which shows that quite often there
601 is an intimate mixture at the Intake of the waters of the
3 rivers, that is bacteriologically, as is indicated on the two sides of the Intake.

Q. I will get you to state, if you know, whether or not the waters of the Mississippi River and the Missouri River, commingle at the Intake?

A. Yes sir, at times they do markedly,—that is estimating by the number of bacteria.

Q. Well, what I mean to ask you is, if from a bacteriological examination of the water, whether or not the result of that would lead you to believe, as an expert, that there is a commingling of those waters at the Intake?

A. You don't wish this for any specified period, do you? Yes.

Q. I will ask you this question; Are you familiar with the stage of the Missouri and the Mississippi and the Illinois River at the time covered by this chart?

A. Yes sir.

Q. Beginning the 23rd of January, 1900, and ending October 9, 1900?

A. Yes sir.

Q. Now I will ask you to state what were the different stages of the river, that is to say, I don't mean the government stages of the water, actual water, but the conditions as to high or low or ordinary stage, if you are able to tell from your knowledge of these rivers, what would be the different stages?

602 A. Well, I have the official figures of the Government, and the meteriological department, and I have also the numbers of bacteria graphically demonstrated in curves on a series of charts. I know this—

Q. Where are those charts?

A. They are here. I know that at a certain time,—from memory, I remember this, that the Illinois River for instance, was high in—say February 12 to 20, 1900. I know that the Mississippi River was covered with ice at the time and it was low, comparatively speaking. I know that the Missouri River was covered with ice at the time, and was comparatively low. In fact I know that at this period a thaw occurred in the whole Illinois River valley, and the Illinois river was swept out.

Q. In what period?

A. The period mentioned.

Q. In February, 1900?

A. Yes sir.

Q. Now at what stages were these various rivers, the Illinois, the Missouri and the Mississippi, during the spring and summer and autumn?

A. I don't remember the definite periods of time, but after the date mentioned, beginning in the middle of February and running up to quite a long time,—a couple of months,—two or three months, all the rivers were high. The spring freshets occurred then. That is when the bacteria appear in such enormous numbers, in all rivers.

603 Q. Do you know whether or not the flushing of streams by the rains and floods has any effect on diminishing or increasing the number of bacteria in the channels of the rivers?

A. It increases it markedly.

Q. Do you know the flood tide of the Missouri river—at what period of the year it is?

A. I know there are generally two periods of rise; there is the spring rise and then the flooding of the river with the thawing of the ice on the mountains, which generally is in June.

Q. What period usually does the spring rise occur in the river?

A. As soon as the thaws and rains of spring begin. That may be more or less late; it may begin in February, or it may not begin until the latter part of March, depending on the weather entirely.

Q. Do you know anything about the flood tides of the Mississippi, as to what period it is highest?

A. Yes, either in the spring—

Q. In the spring?

A. Yes sir. If there should be heavy rains in June there would also be a rise then.

Q. Do you know anything about its period of being at flood tide above the Missouri river, the confluence of the two streams?

A. I know that when those two streams are high, either 604 one of them, the Mississippi river above the mouth of the Intake is high, the flood volume—I don't know at this time, from memory, but by taking the reports of the Mississippi river survey and the Missouri river survey commission—

Q. Do you know from your bacteriological examination of the water and your personal observation, that you have made in it, at what period of time as shown by that chart, the most of the water from the Mississippi river came into the Intake of the St. Louis waterworks?

A. I cannot state that from memory; I can state it from the charts, and I also have that information on another chart, showing as I say, by projected curves—

Q. Does it show at what time it appears, on that chart?

A. It shows markedly in a rise. It shows on this chart of the Illinois river, for the week beginning February 13, there was a very high rise in the Illinois river which extends to the week beginning March 27. February 13 to March 27.

MR. DRENNAN: Six weeks?

A. Yes sir.

ATTORNEY-GENERAL CROW: Now during that period of time does that bacteriological examination disclose to you, as a bacteriologist, that the water from the Illinois and Mississippi rivers was coming into the Intake tower?

A. Yes sir.

Q. At St. Louis waterworks?

A. Yes sir. Here is the period of time at which the
605 Illinois river was flushed. I call attention especially to the dates beginning in the week of February 13, and say extending to the week beginning February 20, during which time the numbers of bacteria in the Illinois river at Grafton, were 257,600 and 221,800 respectively, for those two weeks.

The Mississippi river at that time was covered with ice, and the river fairly high. For the week beginning February 6, the number of bacteria in the Mississippi river at Grafton was 46,000, and the week ending February 13, the number of bacteria was 161,000. For the week February 20, at Grafton, Mississippi river, it was 105,500; week beginning February 27, 55,000. Now if you will give me those dates, I will give you the numbers at Grafton, Illinois.

Week beginning February 6, 109,000,
" February 13, 257,600,
" February 20, 221,800,
" February 27, 223,100.

I will give you the same thing from Alton, just to show you that there is a mixture in the channel there.

February 6, at Alton, Mississippi river, 100,500.
February 13, 296,000,
February 20, 249,000,
February 27, 157,000.

Mississippi river at Hartford, week beginning February 6, 106,500,
Week beginning February 13, 233,100,
606 Week beginning February 20, 266,700,
Week beginning February 27, 142,500.

Now then, we will go over to the Missouri river.

MR. DRENNAN: You are now giving the high stages?

A. I am giving the bacteria per cubic centimeter for weekly averages, taking a definite period of time, and I show you by the river stages that the Illinois river was high at this particular time and contained enormous numbers of bacteria; that these other rivers were covered with ice, and were low in bacteria. I want to show mixture of the Illinois and Mississippi rivers at St. Louis, Missouri:

Ft. Bellefontaine, February 6, 63,000,
Week ending February 13, 52,500,
Week ending February 20, 69,500,
Week ending February 27, 63,500.

Now that is the Missouri river at Fort Bellefontaine, at those dates.

Now beginning February 6, on the Missouri shore, Chain of Rocks, it was 58,000.

Week beginning February 13, 99,000,
Week beginning February 20, 77,500,
Week beginning February 27, 50,500.

Illinois shore, Chain of Rocks:

Week beginning February 6, 106,000,
Week beginning February 13, 224,400,
Week beginning February 20, 190,000.

607 Week beginning February 27, we have a drop to 77,500.

Now Intake at these periods:

February 6, 75,000,
Week beginning February 13, 133,500,
Week beginning February 20, 112,000,
Week beginning February, 27, 53,500.

Showing a mixture first of the Illinois and Mississippi rivers at Hartford, and the mixture of the Mississippi river and the Illinois river and the Missouri river at the Intake. This chart shows that.

Q. ATTORNEY-GENERAL CROW: And your examination discloses it?

A. Yes sir.

ATTORNEY-GENERAL HAMLIN: That is on the bacterial proposition?

A. Quantitative determination of the numbers of bacteria. I have made a table of total solids and all that sort of thing, but that doesn't belong to my department. The chemists get a chance at that.

ATTORNEY-GENERAL CROW: Now, Dr. Ravold, what is this chart intended to represent, that I now show you?

A. This chart is made upon cross-section, profile paper, ruled ten times ten to the square inch. This is exhibit number 2, and—

Q. I haven't offered it yet.

A. It is marked, "Results showing mixture of the waters of the Mississippi and the Missouri river at the Intake of the St. Louis waterworks, bacteria per cubic centimeter from
608 weekly estimations."

Q. Now what do the different colored lines on this chart represent?

A. The Illinois shore is marked in black. The bacteria per cubic centimeter. The Intake tower is marked red and the Missouri shore is marked blue.

Q. Now what do the figures on the left hand column indicate?

A. The bacteria per cubic centimeter.

Q. Now please explain the relation, if any, between the figures and the different colored lines in the chart?

A. Well, as I say, the weekly estimations are here marked in black, upon the dates named, in the lower margin of the chart beginning January 23, 1900, and extending through until October 2.

ATTORNEY-GENERAL CROW: Now I will offer this, if you gentlemen have no objection to it I will offer it as complainant's Exhibit Number 2.

JUDGE SPRINGER: We have no objection.

Said chart received in evidence and marked "Complainant's Exhibit No. 2. Frank S. Bright, Commissioner."

Q. ATTORNEY-GENERAL CROW; Now will you explain how you could determine from the number of bacteria and place a corresponding mark on this chart showing when there was a mixture of the waters of the Mississippi and the Missouri rivers?

A. Why, here at almost any date here, we can take any one of these dates.

Q. Well, that is just what I want you to explain, so I
609 can look at the chart and understand the use of it?

A. January 23, we find the number of the bacteria in the Illinois river marked 240,000 here. The number in the Missouri river 155,000.

The number at the Intake between these points—150,000 for these three points. The red is the Intake. The Intake corresponds very closely, as you will notice, with the number in the Missouri river.

When we get to January 30, we find the number of bacteria in the Mississippi river 150,000; the number of the bacteria at the Intake 135,000; the number on the Missouri shore 75,000. Here then we have the Intake standing between those two numbers—not quite midway, but showing more Mississippi river water coming into the Intake containing 135,000, and the Mississippi river 150,000. These figures would indicate that the water at the Intake is more Mississippi river than it is Missouri river water, and so we can go throughout the large map. The Illinois river does not appear on this chart at all, just simply the Mississippi river showing at the Intake; the Missouri shore and the Illinois shore.

Q. Now what is this chart that I show you?

A. This is a chart of the weekly average of the result of quantitative determination of the number of bacteria in samples of water collected daily from the Mississippi river at Grafton, two miles above the town, together with the stages of
610 the river at Missouri shore.

Q. What are the different colors on that map? What do they represent?

A. The red indicates the bacteria per cubic centimeter, and the blue represents the stages of the river.

Q. Those are the only two colors on the chart?

A. Yes sir.

Q. Now what relation, if any, is there between the column of figures on the left hand side of that chart, and the blue and red curved lines?

A. On the left hand side we have the number of bacteria per cubic centimeter, in five thousands, running from zero up to 250,000—the bacteria per cubic centimeter first. Next to that we have a column bearing the stages of the river in feet, running from zero to 25 feet.

Q. Who made that chart?

A. My assistant, Mr. Johnson, made this chart, at my direction.

Q. Was that true of the other chart marked Complainant's Exhibit Number 2?

A. He wrote in the figures, yes.

Now on the upper margin of these figures, is marked the average daily observance for week ending January 30, and extending to October 2.

Q. Observance of what?

611 A. Observations of the average—the daily observance for week beginning—that of bacteria, which is here recorded.

Q. Then of the river stages?

A. And of the river stages.

Q. Now what result, if any, is shown there between the varying stages of the river and the number of bacteria found in a centimeter?

A. Well, as a rule, running through the chart when the river is falling it will be seen that the number of bacteria decreases markedly; when the river is rising the number of bacteria run up to great heights.

Q. Now this chart is made from data gathered at a point above the entry of the Illinois river into the Mississippi river?

A. Yes sir, two miles above Grafton in the Mississippi.

Q. Do you know what was the stage of the Mississippi river at that point at that time with reference to its being high or low or ordinary—the condition of the water?

A. At what particular time?

Q. Well in the period of time covered by that chart?

A. Well from January 30 the stage of the Mississippi river at Louisiana, Missouri, was two feet. I don't know what their gauge is up there, these figures came from there.

JUDGE SPRINGER: Two feet above low water?

A. Two feet above low water I suppose. Then we have

612 it dropping down to low water here on January 30, it tumbled to practically zero at Louisiana on the 30th; then there was a rise of nearly three feet on February 6—a rise to three feet and five-tenths February 13, and on the 20th, a little bit over 3.5 feet. Then it dropped on February 27th to one foot; then a rapid rise to 4.5 feet; then March 13 it reached the eleven foot stage; on the 20th it dropped to 7.5 feet; on the 27th it dropped to 5.5 feet. It rose April 3rd to 7.5 feet. Now this is weekly estimations from daily observations. You see we have daily observations recorded here to show you, taken at Louisiana, Missouri, and we have simply added the different observations together and made this estimation of the weekly average.

April 10, it was 7 feet; April 17, about 7.3 feet; April 24, 7.6 feet; the river is holding itself rather steady at this time. March 1st, about 7.2 feet; March 8th, 7.5 feet. During this stage from April 3 to May 1, when the river held steadily apparently at that stage, the number of bacteria dropped down markedly, showing that when a river steadies itself and is not washing the surface soil—

ATTORNEY-GENERAL CROW: Settling it?

A. Why a great many bacteria disappear.

Q. By settling?

A. No, not by settling. They are not washed into the stream; it simply holds itself steadily, which shows on the chart right straight along. Then there was a steady fall from
613 May 1st to May 8th. Then the river fell on the 15th to five feet; on the 22nd to four and one-half feet; on the 29th to 3.5 feet; June 5, 2.5 feet; June 12, one foot and eight-tenths; a slight rise here on the 19th, 2.5 feet; a fall again on the 26th to two feet. July 3, 1.4 feet; July 10, about 1.1 feet; then a rise again on the 17th to three feet.

July 24, 4.4 feet,
July 31, 4 feet,
August 7, 2.4 feet,
August 14, 2.5 feet,
August 21, 4.4 feet,
August 28, 3.7 feet,
September 4, 3.7 feet,
September 11, 3.2 feet,

September 18, 3.4 feet,
September 25, 5.2 feet,
October 2, 6 feet.

ATTORNEY-GENERAL CROW: I will offer this chart in evidence.

Said chart received in evidence and marked "Complainant's Exhibit 3, Frank S. Bright, Commissioner."

Q. Now what is that chart I hand you?

A. That shows a weekly average of the results of quantitative determination of the number of bacteria in samples of water collected daily from the Mississippi river one mile above Alton, Illinois, together with the height of the Mississippi river at Alton, Illinois.

614 Q. Now just please explain the lines on that chart and what relation they bear to the figures. In the first place, explain who made the chart and from what data?

A. The chart was made from the data collected during this period, January 23 to October 9, 1900.

Q. Under whose supervision?

A. Under my supervision. The determinations were made in the bacteriological laboratory at the Old City Hall, and at the bacteriological laboratory, Medical Department of the Washington University. These figures of stages of the river were obtained from the Government meteorological department. The bacteria per cubic centimeter is arranged perpendicularly, on the left hand margin of the page, beginning at zero and running to 250,000.

Q. And what does the line of figures between the two dark lines indicate?

A. Those figures are marked in red—the bacteria per cubic centimeter; they are perpendicular. Next to that, marked in blue are the stages of the river, running from zero to 25 feet. The figures at the top are per cubic centimeter in one column, and stages of the river in feet in another, and average daily observations for week beginning January 23 to October 2, of bacteria per cubic centimeter.

Q. Now the data from which this chart was made, the material was gathered at a point below the confluence of the

Illinois and the Mississippi river, was it not?

615 A. Below the confluence of the Illinois and Mississippi?

Q. Yes.

A. Yes sir.

Q. That is one mile above Alton?

A. One mile above Alton, yes sir, samples collected from the channel of the river.

Q. Now what, if anything, do these curved blue and red lines indicate and what is their relation to those columns of figures?

A. The curve in red beginning January 23 at 120,000, and rising and falling from that until October 2, indicates the number of bacteria per cubic centimeter, weekly, obtained by adding the daily quantitative determinations, and dividing by seven. That is how the weekly average was obtained and is here recorded.

The blue curved line, beginning January 23, at five feet and so rising and falling, indicates the stage of the river in feet. It is the weekly average from daily observations taken from the chart supplied by the government, and divided by seven, and so this record rises and falls from January 30 to October 2. Do you wish me to read the figures of the rise and fall of the river here?

Q. Well, what generally is the relation between the rise and fall of the river or the river remaining steady, in regard to the number of bacteria found?

616 A. We have, when the river is high, the number of bacteria is high, and when the river rises the number increases with the height, until at the greatest height of the river the greatest number of bacteria are recorded.

Q. At what period of that time was the greatest height of the river reached?

A. The greatest height of the river is reached on March 13, when it was sixteen feet and about 4-10, and the number of bacteria recorded for that week is 312,000 on this chart, per cubic centimeter.

Q. How does that number compare as to being the highest in the period covered?

A. That is the highest at that particular point, at that particular period.

Q. Is there any other point indicated on that chart that is higher than that during that period?

A. No sir, the next highest point is 296,000.

Q. On what date was that?

A. That was on February 13, the week beginning February 13. At that time the river was rising and reached the height of eight feet, steadily rising from the week beginning January 30th—

Q. Until what time?

A. When it was two feet until the week beginning February 20th, that is when it reached eight feet.

617 Q. Was that the highest stage of the river?

A. No sir, the river then fell until it reached 5.6 feet, in the week beginning February 27th.

Q. What occurred then?

A. From that date it rose rapidly—that number then was 5.6; it rose to 16.4 feet, in the week beginning March 13.

Q. And that was the highest point that was reached?

A. That was the highest point that was reached, and the numbers of bacteria, as I said before, reached the enormous number of 312,000. Then the river fell steadily, rising occasionally, and when a rise occurred the number of bacteria increased with it.

Q. Do you know whether or not the Mississippi river at that point was in the average condition for the period of time covered by this table, that it is usually for that period in each recurring year?

A. We can refer to that chart—

Q. You don't know that fact?

A. I can't state it from memory.

Q. All right, just say that you can't state that from memory then, that is all right.

ATTORNEY-GENERAL CROW: I will offer that chart in evidence.

Said chart received in evidence and marked "Complainant's Exhibit 4, Frank S. Bright, Commissioner."

618 Q. Now I will show you a chart and ask you to state what that is, who made it, under whose direction, and where the data was gathered from?

A. This chart was made under my direction. It is the weekly average of results of quantitative determination of the numbers of bacteria found in samples of water collected daily from the Mississippi river at Hartford, Illinois, together with the heights of the Mississippi river at that point.

Q. What period of time is covered by that chart?

A. Beginning January 30, and ending October 9, 1900.

Q. Now I will get you to state where Hartford, Illinois is located with reference to the confluence of the Illinois and Mississippi rivers, and the Intake tower of the St. Louis waterworks?

A. Why, the point of the collection of these samples is in the channel one mile above the mouth of the Missouri river, where it joins the Mississippi river or empties into the Mississippi river, seven miles below Alton, and that is about nine miles above the Intake of the St. Louis Waterworks, Chain of Rocks.

Q. Now please explain what the different markings on that map mean?

A. The figures in red, arranged along the left hand margin of the paper, beginning with zero and being arranged perpendicularly along the edge, to 250,000, represent the number of bacteria, the weekly average number of bacteria 619
per cubic centimeter, made from daily determinations at this point. The figures are in red ink. The stages of river in feet is in the next column and they are marked in blue. At the top margin of the chart are bacteria per cubic centimeter; stage of river in black ink, and then the average of daily observations for week beginning January 23, and ending October 2, 1900.

Q. Well at the top, between the two dark lines, are the dates?

A. The weeks beginning January 23, January 30 and so on, until the week beginning October 2.

Q. Now what relation is there between the red and the blue curved lines?

A. The red lines indicate the curves of bacteria, beginning with the number about 87,000 on January 30, it rises to 147,000, say, in the week beginning January 30, then falls to 105,000 in the week beginning February 6. For the week beginning February 13, the number rises to 232,000 or 233,000. In the week of February 20, they reach the figures 266,700, as shown in the week beginning February 27, they fall to 193,000. On March 6, 208,000 or 209,000, on March 13, they reach the highest number here recorded, 320,500. They then drop steadily in the week beginning March 20, to 226,000.

Week beginning March 27 to 60,000,
Week beginning April 3 to 59,000,
620 Week beginning April 10 to 34,000,
Week beginning April 17, 15,000,

And so rising and falling until the week beginning October 2, when there are less than 5,000.

Q. Now what, if anything, does the bacteriological examination as disclosed by that chart, show with reference to the rise of the waters of the river and the fall of the waters, and the increase or the decrease in the number of bacteria per cubic centimeter, in the water bacteriologically examined?

A. With the rise of the river we find an increased number of bacteria in the water, and with the fall of the river, as a rule we find a decrease in the number of the bacteria; so rising and falling then, as the river rises, beginning at its lowest period, that is here recorded for the week of January 30, at two feet, it rises steadily until February 20, when the height of 7.9 feet is recorded; the number of bacteria at that time being 266,700. The river then drops to 5.6 feet in the week beginning February 27, when the number of bacteria dropped to 193,000 or 194,000, and then the river rises rapidly, in great volume, until the week of March 13th, when 320,500 bacteria are recorded, as the weekly average; then with the fall of the river the bacteria drop very rapidly. The river falls in the week beginning April 27th, to 2.2 feet about. The bacteria in that week fall to 60,000. The
river seems to hold itself steadily here, falling until July
621 10, then there is a slight rise, the bacteria holding them-
selves steadily in the meanwhile, fluctuating between 7,-
000 and about 2,000.

ATTORNEY-GENERAL CROW: I will offer that chart in evidence.

Said chart received in evidence and marked "Complainant's Exhibit No. 5, Frank S. Bright, Commissioner."

Q. Now doctor, what is this chart that I show you?

A. For the year 1900. Chart showing the weekly average of the results of quantitative determination of the numbers of bacteria in samples of water collected at Ft. Bellefontaine, on the Missouri River, together with the height of the river at that point for the weeks beginning January 23, and extending until October 2, 1900.

Q. Now who made that chart?

A. This chart was made under my direction in the bacteriological laboratory.

Q. From what data?

A. From the data collected at this point and the River stages from records obtained at Fort Bellefontaine.

Q. Now explain what the two rows of figures on the left of that chart mean, and the curved lines in blue, and the date lines between the two black lines above the column of figures?

A. On the left hand margin arranged perpendicularly are the bacteria per cubic centimeter, beginning at zero and extending to 250,000, and these figures are in red. The second column contains the stages of the river in feet, ranging from zero
622 —low stage, to 25.5 feet.

The curved lines here, or the curves here marked in red, show the weekly average taken from the daily quantitative determination of the number of bacteria in samples collected at this point, beginning with the week of January 23, the number of bacteria recorded here is about 214,000. After that week the number dropped. In the week of January 30, to 140,000.

In the week beginning February 6th, to about 63,000,

A drop in the week of February 13th, to 54,000,

Week of February 20, a rise to 70,000,

Week of February 27, to 65,000,

Week of March 6th, a rise to 175,000,

Week of March 13, 453,500,—the highest number here recorded for an average.

Q. What date is that?

A. That is week beginning March 13, 1900.

Week beginning March 20, 170,500,

The next week, March 27th, the bacteria tumble to 140,000.
Week of April 3rd, a slight rise to 141,000,
Week of April 10, a fall to 65,000,
Week of April 17, 50,000,
Week of April 24th, 15,000,

623 And then there is a steady rise in May and June up to the week beginning June 26th, when the number of 111,000 is recorded. The next week there is a fall—July 3, 105,000, and in the week of July 10th, to 30,000.

July 17th, 25,000,
July 24th, 20,000,
July 31st, 11,000,
August 7, 11,000,
August 14, 6,000,

August 21st, when the lowest number recorded on this chart is reached,—5,000. Then there is a steady rise until the week of September 18th, when the number 40,000 is recorded; then a fall until the week of October 2, when 24,000 are recorded.

Now the rise and fall of the river is indicated by the curved lines in blue, beginning in the week January 23rd.

MR. DRENNAN: Which river?

ATTORNEY GENERAL CROW: Missouri River at Fort Bellefontaine.

A. Ft. Bellefontaine, on January 23 we have recorded 5 feet. In the week beginning January 30, a drop to 3 feet, and a slight rise February 6th, to 3.5 feet. A steady fall for the week of February 13th,—3 feet. A rise in the week of February 20, to 4.5 feet.

Q. That much of a rise, or it rose to that point?

A. It rose to 4.5 feet.

Q. It is a slight rise?

624 A. A rise of a foot and a half. The river is still rising, February 27, 6 feet are recorded.

March 6th, 13.4 feet.

March 13th, 16 feet, and the number of bacteria recorded is 453,500.

The river falls in the next week to 10.5 feet, and the number of bacteria recorded for that week, beginning March 20, are 271,500.

There is a fall March 27th, to 8.5 feet,
April 3, 9.2 feet,
April 10, 11 feet,
April 17, 11 feet,
April 24, 11.5 feet,
May 1, 11 feet,
May 8, 11 feet,
May 15, 11.4 feet,
May 22, 11.3 feet,
May 29, 11.6 feet,
June 5, 11.2 feet,
June 12, 11.5 feet,
June 19, 11.5 feet,
The river falls steadily now,
June 26, 11.7 feet,
July 3, 11.4 feet,
July 10, 10.5 feet,
July 17, 10 feet,
625 July 24, a rise to 11 feet,
July 31, a fall to 8.5 feet,
August 7, 6.5 feet,
August 14, 6 feet,
August 21, 6.7 feet,
August 28, 8.6 feet,
September 4, 7.9 feet,
September 11, a fall to 5.4 feet,
September 13, 5.5 feet,
September 25, 6.4 feet,
October 2, 9.5 feet.

Q. What relation if any, is there between the rise and fall of the stages of river and the rise and fall of the number of bacteria as shown by this chart at Bellefontaine?

A. When the river is falling the number of bacteria rapidly fall; when the river is rising and in its high stages, it shows enormous numbers of bacteria. When the river steadies itself as it does from April 10 to May 29, the bacteria fall rather steadily.

Q. Now where is Fort Bellefontaine with reference to the confluence of the Missouri and the Mississippi Rivers, and the Intake tower of the St. Louis waterworks?

A. Fort Bellefontaine, where these samples were collected, is six miles above the mouth of the Missouri River, where it discharges into the Mississippi; that would be fourteen miles from the Intake of the St. Louis waterworks, by river.

626 Q. Does this chart disclose bacteriologically at what time there was the greatest number of bacteria in the waters of the Missouri River at Fort Bellefontaine?

A. It does, sir.

Q. During this period?

A. This is the weekly estimation.

Q. What period of time was that?

A. The very highest numbers reached were in the week beginning March 13th, when the number of bacteria reached 453,500,—the stages of the river at that time being 16.1 feet.

ATTORNEY GENERAL CROW: Now I will offer that chart in evidence.

Said chart received in evidence and marked "Complainant's Exhibit 6, Frank S. Bright, Commissioner."

Q. Now what is this that I show you?

A. It is a chart showing the weekly average of the results of the daily determinations of the numbers of bacteria in samples of water collected at the Chain of Rocks, Missouri shore, together with the heights of the Mississippi River at that point.

Q. Well, under whose supervision and from what data was this chart made?

A. It was made under my supervision; it was made from samples collected at this point and examined in the bacteriological laboratories from January 23, 1900, to the week beginning October 2, 1900.

627 On the left hand margin of the map are written in red the bacteria per cubic centimeter beginning at zero and running to 250,000.

In the next column are the stages of the river in feet, beginning at zero and going to 25.5 feet.

Q. Well now, will you please explain what the blue and red lines on this chart mean?

A. The red lines beginning, January 23,—do you want me to say what the column is at the top?

Q. Yes, didn't you put that in?

A. The column at the top of the chart records the daily observations for the weeks beginning January 23, and extending to October 2, for the year 1900.

Now the curved mark in red ink begins January 23, and shows the weekly average of the numbers of bacteria at that point and the number of 240,000 is recorded for the week beginning January 23rd.

Week beginning January 30, 145,000,
do. February 6, 57,000,
do. February 13, 97,000,
do. February 20, 76,000,
do. February 27, 50,000,
do. March 6, 176,000,
do. March 13, 484,800,
do. March 20, 314,000,
do. March 27, 70,000,
do. April 3, 75,000,
628 do. April 10, 62,000,
do. April 17, 21,000,
do. April 24, 10,000,
do. May 1, 10,000,
do. May 8, 50,000,
do. May 15, 47,000,
do. May 22, 34,000,
do. May 29, 30,000,
do. June 5, 20,000,
do. June 12, 41,000,
do. June 19, 44,000,
do. June 26, 21,000,
do. July 3, 21,000,
do. July 10, 14,000,
do. July 17, 20,000,
do. July 24, 15,000,
do. July 31, 10,000,
do. August 7, 10,000,
do. August 14, 10,000,
do. August 21, 10,000,
do. August 28, 11,000,

Week beginning September 4, 12,000,
do. September 11, 5,000,
do. September 18, 24,000.
Week beginning September 25, 30,000,
629 do. October 2, 24,000.

Do you want the stages of the river?

Q. Now what do the blue lines indicate?

A. The blue lines indicate the stages of the river.

Q. Now what connection, if any, is there or relation—what relation is shown between the rise and fall of the number of bacteria in the river, and the stages of the river as it rises and falls during that period?

A. When the river falls the number of bacteria decrease. In high stages and when the river rises, as it does in some cases here, the numbers of bacteria increase enormously.

Q. What reason in bacteriology is assigned for that state of affairs?

A. The rise of rivers is caused by either thawage of snow and ice, upon the drainage area of the river, or rainfall upon it. This means water rushing towards the lowest part of the drainage area, sweeping the surface of the soil of its bacteria and carrying them with the water and debris into the river, and when the river falls and no longer has the bacteria swept into it from the surface washings, the river depends upon springs and sewers for water. That is, these particular rivers. Spring water is a good water and contains very few bacteria, consequently the numbers of bacteria during the falling or low stages of river, are small.

Q. At what period of time does that chart show that the
630 Mississippi River at the Chain of Rocks on the Missouri
shore, was the highest during that period?

A. The highest period reached at that point was in the week beginning March 13th.

Q. 1900?

A. 1900, when the highest number of bacteria are recorded.

Q. What was the stage of the river?

A. 22.5 feet.

Q. And what was the number of bacteria?

A. 484,800.

Q. What is the location of the Chain of Rocks with reference to the Intake tower of the Mississippi River, and the confluence of the Illinois and the Mississippi River and the Missouri River?

A. The Chain of Rocks of the Intake tower is situated or located at the end of the Chain of Rocks, and the Chain of Rocks is built out into the river some fifteen hundred feet, about eight miles above the center of the city,—a line running through Market Street on the river. This point, the Intake, is eight miles below the point where the Missouri River joins with the Mississippi to form the Mississippi River.

Q. Then it is sixteen miles from the foot of Market Street in this city to the confluence of the two rivers, the Mississippi and the Missouri?

A. Yes sir.

Q. Eight miles to the Intake?

631 A. Yes sir.

Q. Now what is the location of the Chain of Rocks with reference to the Intake and what is the Chain of Rocks?

A. The Chain of Rocks, is, as I understand it—it was built by the government some years ago, rocks were dumped into the river—

Q. Is it a dike?

A. It is a dike built out from the shore some—I don't know the exact number of feet, fifteen hundred feet, say, for the purpose of deflecting the river from the shore—

Q. From what shore?

A. From the Missouri Shore.

MR. DRENNAN: It would be called a wing dam, wouldn't it?

A. I am not sure. They call these things dikes, do they not?

MR. JEFFRIES: Well, just describe what it is anyhow; it don't matter what you call it.

ATTORNEY GENERAL HAMLIN: I think it would be well to call someone who knew all about it. It would save time.

THE WITNESS: I have seen these rocks in low water, standing up out of the body of the river.

MR. DRENNAN: It is a wing dam; that's what it is.

A. It is a dike, as I understand it.

Q. ATTORNEY GENERAL CROW: Well, where does it extend from, and to where?

A. It extends from the Missouri shore out into the stream.

632 Q. At what point?

A. Oh, some fifteen hundred feet out.

Q. Whereabouts its it located with reference to the Intake tower of the St. Louis Waterworks?

A. The Intake tower at this point is at the eastern end of that dike or this wing dam, whatever you may call it.

Q. Which is called the Chain of Rocks?

A. Which is called the Chain of Rocks.

Q. That is what I wanted to get into the record, that it was located at that point.

A. Here we have got a name for it,—the Chain of Rocks.

Q. Now what is the lowest stage of the water there on that chart?

A. The lowest stage of the water recorded here is about nine-tenths of a foot.

Q. On what date?

A. On January 30th, in the week beginning January 30, 1900.

Q. Now what is the number of bacteria in that water on that date?

A. 45,000. The bacteria falling, the river had been falling —it had been high previous to that and had been falling. The number of bacteria also at a lower stage below, was 55,000.

ATTORNEY GENERAL CROW: I will offer that chart in evidence.

Said chart received in evidence and marked "Complainant's Exhibit 7, Frank S. Bright, Commissioner."

Q. What is that I show you now?

633 A. This is a chart representing the weekly average results of the quantitative determination of the number of bacteria in samples of water collected daily from the Mississippi River at the Chain of Rocks, Illinois shore, together with the height of the river at that point.

Q. Now from what data was that chart made?

A. Data made from samples collected daily at the Illinois shore, Chain of Rocks, and examinations made in the bacteriological laboratory under my direction, from the week beginning January 23 and ending October 9th, 1900.

Q. Who caused that chart to be made?

A. I did.

Q. Who made it?

A. Mr. Johnson.

Q. Was it made under your direction or supervision?

A. Under my supervision, yes sir.

Q. Do you know whether or not that chart was correctly made from the data collected by you?

A. I think it was sir, yes.

Q. Is that true of the other charts of this series already in evidence, that I have introduced?

A. Yes sir.

Q. Now will you explain the different figures and columns and lines on that chart and what they mean? In the first place, before you do that, locate that point on the Mississippi 634 River. Wait a minute, I can do it quicker this way. At what point was this data got from and what point on the river does this chart represent that refers to the Intake Tower at the Chain of Rocks on the Missouri shore?

A. It is in a direct line of a cross section of the Chain of Rocks, 300 feet from the Illinois shore.

Q. Well then, to speak as a layman would about that matter, it is immediately across the river from the Intake Tower at Chain of Rocks on the Illinois side of the Mississippi River?

A. Yes sir.

Q. Now go ahead please and explain what those marks and lines and figures represent on that chart?

A. On the left hand margin of the chart are written the bacteria per cubic centimeter. In red, beginning with zero and reaching 250,000. In the column next to it are the stages of the river in feet, and the number of feet extending from zero to 25.5 feet, written in blue. On the upper margin is written in a column, the average of daily observations per week beginning January 23 and so on until October 2.

Q. What do those cross lines represent, the red ones, and the blue ones?

A. In red the bacteria per cubic centimeter, connecting the weekly average written in at these points.

Q. The average of what?

A. The weekly average of bacteria from daily quantitative determinations.

Q. What relation, if any, is shown by that chart between
635 the rise and fall of the waters of the river and the increase or the decrease in the number of bacteria in a cubic centimeter of water examined during that period?

A. This chart shows that when the river falls, the bacteria decrease in numbers; when the river rises the bacteria increase, —in some cases, when the river is very high,—to enormous numbers.

Q. What period is shown by the chart at that point, that the stage of the Mississippi was the highest between January 25 and October 9, 1900?

A. This chart shows in the week beginning February 27th the number of bacteria are 772,000.

Q. No, I asked you for the state of the water?

A. The highest stage of the water recorded in this chart is March 13, when the stage of water was 22.6 feet. Do you want the bacteria?

Q. Yes.

A. Per cubic centimeter at that time, weekly determination, 374,000.

Q. At what period was the lowest stage of the water reached?

A. The lowest recorded here was January 30, 1900.

Q. What was the number of bacteria then?

A. The number of bacteria—the river was falling then, it had been high and fell to 75,000.

Q. Now do you know what the fact was as to whether the Mississippi River was frozen over at that point at the time when it was at its highest stage?

A. The river was not frozen over. The river was full of
636 ice floating.

Q. What date did you say was the lowest stage?

A. The lowest stage recorded here was January 30th.

Q. Do you know whether or not it was frozen over at that time?

A. I do not.

Q. You have no record?

A. At this particular point?

Q. You have no record of that?

A. I have a record, yes, but I don't remember. I have a record.

Q. Of that fact?

A. That the river at this time along in here anyhow, from along in that period the week beginning January 30th, the river was frozen over because our men had to cut the ice with an ax to get the samples out. There is a record of that.

Q. You have that?

A. Yes sir.

ATTORNEY GENERAL CROW: Now I will offer that chart in evidence.

Said chart received in evidence and marked "Complainant's Exhibit 8—Frank S. Bright, Commissioner."

Q. Now what is that chart I show you?

637 A. This is a chart showing the weekly average results of the quantitative dtermination of the number of bacteria in samples of water collected daily from the Mississippi River at the Chain of Rocks, Intake tower, together with the height of the river at that point.

Q. Now who made that chart?

A. Mr. Johnson.

Q. What was it made from?

A. Made from data, from the quantitative determination of daily samples collected at this point.

Q. During what period of time?

A. Samples collected and sent to the bacteriological laboratory—bacteriological department of the St. Louis laboratory.

Q. From what time?

A. January 23rd to October 9, 1900.

Q. Who was in charge of that laboratory?

A. I was in charge of that laboratory.

Q. Who was Mr. Johnson?

A. He was first assistant.

Q. First assistant bacteriologist?

A. Yes sir, first assistant bacteriologist.

Q. Do you know that this chart was made from that data?

A. Yes sir.

Q. Do you know whether or not the chart is accurately made?

A. I think it was.

Q. Did you examine it with reference to that?

638 A. Yes sir.

Q. Now please explain those lines on there?

A. On the left hand margin of the chart will be seen figures written in red; they represent the bacteria per cubic centimeter and extend from zero to 250,000.

Q. That is at the Intake, isn't it?

A. At the Intake Tower, yes sir.

Q. Go ahead.

A. The stages of river in feet are in the next column, and extend from zero to 25.5 feet.

Q. Now the stages of the river are marked in blue?

A. The stages of the river are marked in blue, yes sir.

Q. And what do the figures and the dates and letters between the two black lines above the column in red and blue figures, represent?

A. That represents the average of daily observations for the week beginning January 23, and ending in the week beginning, October 2.

Q. Well, that gives the dates of these observations?

A. Yes sir.

Q. Those letters representing the months together with the figures representing the days of the months?

A. Yes, dates beginning—

Q. And those between the two black lines that are perpendicular, and the two columns of figures, is that right? 639

A. Yes sir.

Q. Now I wish you would just give me the stages of the water there at the Intake tower of the St. Louis water works, and locate that Intake tower with reference to the Missouri and the Missouri River?

A. The Intake tower is 1500 feet from the Missouri shore, and is in the channel of the river.

Q. Is this the source of the St. Louis water supply?

A. This is the source of the St. Louis water supply.

Q. Now give me the stages of the river there during this period.

A. The stages of the river,—in the week beginning January 23rd, 1900, 4.4 feet,

Week beginning January 30, 1 foot,
do. February 6, 4.5 feet,
do. February 13, 6 feet,
do. February 20, 7.6 feet,
do. February 27, 6.4 feet,
do. March 6, 16.6 feet,
do. March 13, 22.6 feet,
do. March 20, 17.8 feet,
do. March 27, 14.5 feet,
do. April 3, 15.5 feet,
do. April 10, 15.5 feet,
do. April 17, 16.5 feet,
do. April 24, 16.9 feet,
640 do. May 1, 16 feet,
do. May 8, 16.5 feet,
do. May 15, 15 feet,
do. May 22, 14.2 feet,
do. May 29, 13 feet,
do. June 5, 11.5 feet,
do. June 12, 12 feet,
do. June 19, 13.4 feet,
do. June 26, 12.5 feet,
do. July 3, 11 feet,
July 10, 10 feet,
July 17, 10 feet,
July 24, 12.5 feet,
July 31, 10 feet,
August 7, 7 feet,
August 14, 6 feet,
August 21, 9 feet,
August 28, 9.3 feet,

September 4, 9.5 feet,
September 11, 6.7 feet,
September 18, 6.5 feet,
September 25, 9.4 feet,
October 2, 12.6 feet.

Q. Now give me, please, as shown by that chart, the
641 **number of bacteria for the corresponding dates?**

A. Week beginning January 23, 154,000,
January 30, 135,000,
February 6, 75,000,
February 13, 134,000,—approximately,
February 20, 116,000,
February 27, 54,000,
March 6, 176,000,
March 13, 484,900,
March 20, 511,800,
March 27, 118,000,
April 3, 118,000,
April 10, 95,000,
April 17, 43,000,
April 24, 11,000,
May 1, 6,000,
May 8, 50,000,
May 15, 25,000,
May 22, 26,000,
May 29, 21,000,
June 5, 29,000,
June 12, 26,000,
June 19, 26,000,
June 26, 16,000,
642 **July 3, 12,000,**
July 10, 14,000,
July 17, 18,000,
July 24, 14,000,
July 31, 6,000,
August 7, 5,000,
August 14, 9,000,
August 21, 6,000,
August 28, 14,000,

September 4, 6,000,
September 11, 5,000,
September 18, 30,000,
September 25, 25,000,
October 2, 16,000.

Q. Now what, if anything is disclosed by this chart with reference to any relationship between the rise and fall of the Mississippi River at the Intake Tower of the St. Louis Waterworks, as to the increase or decrease in the number of bacteria found in the water during the period covered by this chart at said point?

A. When the river rises the number of bacteria increases.

Q. Well designate the place there?

A. At the Intake tower of the St. Louis Waterworks. This is weekly average results of the quantitative determination of bacteria per cubic centimeter of water, in samples of water collected daily in the Mississippi River at this point, and it shows that when the river falls the number of bacteria decreases, 643 but when the river rises at this point the number of bacteria rises also. When the river is at its greatest height, the number of bacteria is the greatest.

ATTORNEY GENERAL CROW: I will offer this chart in evidence.

Said chart received in evidence and marked by the Commissioner, "Complainant's Exhibit 9. Frank S. Bright, Commissioner."

Q. What is this chart that I show you?

A. It is for the year 1900, Grafton Illinois, River. This chart shows the weekly average results of the quantitative determination of the number of bacteria in samples of water collected daily from the Illinois River three miles above Grafton, Illinois, without the height of the river recorded.

Q. Now who made this chart?

A. Mr. Johnson.

Q. Who is Mr. Johnson?

A. My chief assistant during this time,—January 23, to October 2, 1900.

Q. From what data was it made?

A. Made from data collected from daily samples of water collected at a point three miles above Grafton, Illinois, on the Illinois river,—weekly averages obtained from it, and these weekly averages recorded upon this chart.

Q. Now what do the figures in the black and blue columns in the left represent?

A. On this chart on the left hand margin are the bacteria per cubic centimeter, and written in red from zero to 250,-
644 000 are recorded the number of bacteria.

Q. Do you know whether those figures and those dates, and the cross lines, are correctly made, based upon the data that you have described?

A. Yes sir, they are.

Q. Now, will you please give me the stages of the water at Grafton, for that period, if you have it?

A. I have, but not on this chart.

Q. Have you got them?

A. I have got the stages of the river at Grafton, Illinois. I have not averaged them up. I have them daily, and it would be quite a little labor to average them up.

Q. You have got the daily averages, though? The daily stages?

A. Yes sir.

Q. Well, you have got this other report here, as shown by this chart?

A. Yes sir.

Q. You have the stage of the water here, haven't you?

A. Yes sir.

Q. On this chart here?

A. No, I haven't the average of the water, I have the average number of bacteria.

Q. What does the blue column mean?

A. The blue column was intended to represent the stages
645 of the water, but they were not put in. We had a great deal of difficulty in getting these figures.

Q. Well, we can complete that and put them in.

JUDGE SPRINGER: Just put it in with the understanding that you can complete it.

ATTORNEY GENERAL CROW: No I will not put it in until he gets it completed and gets it straight.

THE WITNESS: It is not completed, it simply shows the bacteria per cubic centimeter at that time. I have got the figures here but I have not put them in.

Q. Now doctor, do you know anything about the condition or rather the location of the Intake tower of the St. Louis Waterworks prior to 1895?

A. I do, sir.

Q. Where was it located?

A. At Bissell's point,

Q. Where is Bissell's point?

A. Bissell's point is about three,—I suppose three and one-half miles from Market Street measuring by river.

Q. Which way?

A. Northwest. Up the river.

Q. Up the Mississippi River?

A. Yes sir, up the Mississippi River. It is located on the Mississippi River at a place called Bissell's Point.

646 Q. Now what was the shape or condition of that Intake tower at Bissell's Point, was it built similar to the one that is at the Chain of Rocks now?

A. No sir, not near so well built as the one now, nor so far from the shore. It was built a short distance from the shore, connecting by a bridge. It is an iron tower into which the water flowed and was lifted by pumps,—low service pumps to reservoirs that were located at this point. When the river was very low,—they had a movable intake which ran out on a tramway, carrying a flexibile tube to follow the river out. In that way, in low stages of the river, the water was pumped directly from the river instead of running into the Intake.

Q. Was that location at that time above the sewage from the City of St. Louis?

A. No sir, there was a creek, about 1,000 feet,—or rather about 1,000 feet above the Intake at Bissell's point, a creek known as Harlem Creek discharged itself into the Mississippi River. This has a drainage area upon which there resided at that time probably 10,000 people. The sewage from these 10,000 people discharged upon this drainage area and into this creek, also the offal from a number of dairy stables that were built on and projected over this creek. All of this material during freshets was washed into the Mississippi River and at times flowed directly into this Intake at Bissell's Point, I have seen it do it.

647 Q. Now do you know when the Intake was established at Bissell's Point,—what year?

A. I do not know.

Q. Do you know approximately how far back?

A. No sir.

Q. How long do you know of your own knowledge of its having been at Bissell's Point, prior to 1895?

A. I remember visiting—I remember it used to be quite a thing for the boys about town to visit the Park there, that is when I was a boy, twelve or fifteen years old—that is twenty-five years ago.

Q. Then twenty-five years ago it was located at Bissell's Point, was it?

A. Yes sir.

Q. That would be twelve or thirteen years prior to 1895?

A. Yes sir.

Q. Now do you remember the year in which it was moved from Bissell's Point?

A. Well, you mean—The Intake is still there,—the Bissell's Point Intake still remains; you can see that any time.

Q. But the water supply, I mean?

A. But the City stopped pumping from the river at that point, and began taking water from the Intake Tower at the Chain of Rocks in 1895.

648 Q. And the city takes no water for settling basins from Bissell's Point at this time?

A. The city pumps no water directly from the intake tower at Bissell's Point, but the water that flows into the Intake at the Chain of Rocks is lifted into a series of reservoirs, at the Chain of Rocks. From these reservoirs, part of it runs through a conduit to Baden, where it is pumped into the high-water service, and the remaining part of it runs to Bissell's Point and there discharges into reservoirs, and there rests for a time and finally runs into what is called the Big Well there, and is pumped by the low service pumps at that point throughout the eastern part of the city.

Q. Do you know why the city ceased taking its supply of water at Bissell's Point, and moved it further up the river?

A. I really don't know the reason for that, but I believe the pumps at that particular point were old and out of date, and new pumps had to be located to keep pace with the increasing demand for more water that the city was making upon it as it grew, so this point was selected, the land bought, and the Intake tower built, and new pumps put in at that point.

Q. Now do you know whether or not the sewage from Harlem Creek at this time, that is, January, 1900, ran into the Mississippi above Bissell's Point?

A. I know that in '92 it did run into the Mississippi River about 1,000 feet above the Intake at Bissell's Point, because I saw it doing it. That was early in '92, and the water ran into this intake—black, oily looking water that was discharged 649 from Harlem Creek ran into the yellow water of the Mississippi River at this point, and could be seen floating down the river, clinging to the shore on the Missouri side, and could be seen at times running directly into the Intake. I have stood on the bridge several times, with other gentlemen,—other physicians, and looked at it.

Q. Upon what bridge?

A. Upon the bridge that connected the Intake tower with the low service pumps.

Q. Do you know whether or not that is true at this time, or not?

A. I know that in '92 (1892) the attention of the Health Commissioner was called to this thing, of the typhoid epidemic having resulted from this Harlem Creek discharging the sewage into the Intake, and a dam was thrown across Harlem Creek and pumps used so that the water that came into Harlem Creek was stopped and pumped across, and discharged below the Intake of the waterworks.

ATTORNEY GENERAL HAMLIN: Into the Mississippi River?

A. Into the Mississippi River, yes sir.

ATTORNEY GENERAL CROW: What year was that?

A. '92.

ADJOURNED until 10:00 A. M., following day, Wednesday, February 25, 1903, at same place.

650 Southern Hotel, St. Louis, Missouri, 10:00 a. m., February 25th, 1903.

Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

DR. AMAND NICHOLAS RAVOLD, resumed the stand for further direct examination by Attorney-General Crow and testified as follows:

Q. Now, Doctor, I believe you stated you were acquainted with the conditions at the old Intake in 1892, at Bissell's Point?

A. Yes, sir.

Q. Now, do you know what time of year the typhoid epidemic followed the running of the sewage into that place?

A. Yes, sir.

Q. What time of year was it?

A. I wrote a paper on the subject.

Q. You wrote a paper on the subject?

A. Yes, sir.

Q. You have got the date, then?

A. Yes, I wrote a paper and read it before the Academy of Sciences here in 1894.

Q. What was the date?

A. It was in 1892, beginning in the latter part of August, 1892, and extending until February, 1893.

Q. Now, did you make a personal investigation to see whether or not the sewage was passing from Harlem creek into the Intake at Bissel's Point at that time?

A. Yes, sir.

Q. What was the result of that examination?

A. Standing on the bridge out on the Intake Tower at Bissell's Point, the black dirty water from Harlem creek could be seen running along in the yellow water of the Mississippi and entering the Intake tower of the St. Louis Waterworks.

Q. What time of year was that observation made.

A. I made that in October.

Q. 1892?

A. Yes, sir, in 1892. My attention was called to the fact that this thing was occurring, by Mr. Francis, Charles W. Francis, then Health Commissioner, and now Assistant Health Commissioner of St. Louis.

Q. Now, what steps, if any, were taken to remedy this, did you say?

A. The attention of the Water Commissioner was called to it—

Q. At what time?

652 A. In November, I believe, by Mr. Francis. With the aid of the St. Louis Medical Society—Mr. Francis called the attention of the medical society to this fact which I here relate, and he took with him five gentlemen, members of the medical profession, and went to this place and showed them this very thing I have described, the water of the Harlem creek entering the Intake of the St. Louis Waterworks. They, as a committee, reported back to the medical society and the attention of the Water Commissioner was called to it, and he put a dam across Harlem creek, over 500 yards back from the river. Pumps were established and the water pumped from this Harlem creek dam to a point below the Intake of the waterworks.

Q. When was that done; what time of year?

A. I don't remember.

Q. Well, it did happen after you made the observation?

A. Yes, it happened after we made the observation.

Q. Now, what was the effect of that?

A. That was practically the end of the typhoid fever there. There were little flurries following, but not to amount to anything, though.

Q. Now, have you any record of the number of typhoid cases in this city at that time?

A. Yes, sir.

Q. How many were there?

653 A. Well, from the report of the chief sanitary officer of the Health Department, for the fiscal year ending April 1st, 1893, 3,624 cases of typhoid fever were reported to the health authorities by the physicians of the city, with a total of 514 deaths.

Q. That was April, 1893?

A. April, 1893, his report was filed.

Q. For the year ending April?

A. He makes an annual report and the fiscal year ends March 31st.

Q. Now, have you got it for the preceding year?

A. I have it, not in figures here, but I have it on a chart.

Q. Do you know what it was?

A. I do not, but I can consult the chart, though.

Q. Where did you get these figures on the chart?

ATTORNEY-GENERAL HAMLIN: That is, for the preceding fiscal year?

A. Yes, the preceding fiscal year.

ATTORNEY-GENERAL CROW: Where did you get those figures on that chart?

A. From the annual report of the Health Department.

Q. Of this city?

A. Yes, sir, of this city.

Q. What do they show with reference to the years 1891
654 and 1892?

A. They say that from July, 1891, there were— The highest number of cases was recorded in a week in September, in the month of September, when 32 cases were reported, and the number of deaths—

Q. Yes, but haven't you got the total for the year there?

A. No, sir, I haven't the total for the year, but I can obtain the total for the year by adding these together; that will take time. I can obtain this from the reports of the Health Department. I haven't got the report here. This epidemic practically began in September and ended the latter part of January.

Q. Have you got the figures showing percentage of the increase during the year 1893, of typhoid over the preceding year?

A. No, I haven't the preceding year. I have the figures on the cases and deaths for the years 1892 and 1893 here, if you can have those entered now.

Q. Put them in.

A. For the month of April 14 cases and eight deaths, 1892 and 1893. You see the fiscal year began April 1st, that is the reason these figures run that way:

May, 13 cases reported, 9 deaths,

June, 32 cases reported, 4 deaths,
655 July, 35 cases recorded; 15 deaths,
August, 70 cases, 11 deaths,
September, 142 cases; 23 deaths,
October, 261 cases; 48 deaths,
November, 1,923 cases, 124 deaths,
December, 945 cases; 205 deaths,
January, 1893, 114 cases; 42 deaths,
February, 35 cases; 18 deaths,
March, 40 cases; 7 deaths.

That is all I have for that year. A great majority of the cases, 3,385, with 442 deaths, occurred during the months of September, October, November and December, 1892, and January, 1893.

Q. Now, Doctor, did you make any examination of the water bacteriologically of this Mississippi river and this creek at this time?

A. Yes, sir, I examined the Mississippi tap waters, from the tap in the bacteriological laboratory.

Q. What was the result?

A. I carried out a series of investigations and especially searching for the bacillus typhosus in the water.

Q. That is the typhoid bacillus?

A. Yes, and succeeded in separating out a micro-organism that resembled a stock culture very closely. This micro-organism I sent to some bacteriologists, among them William
656 Welsh of the Johns Hopkins University. I have his letter with his opinion upon that micro-organism, at the time, if you care to hear it.

Q. Well, was that micro-organism ever identified as anything other than the typhoid bacillus?

A. No, sir. I thought it was the typhoid bacillus at the time, and I still think so.

Q. What time was that taken from the tap; was it during this epidemic of the typhoid?

A. Yes, sir, it was November 8th.

Q. Now, did you make any bacteriological examination of the waters of that creek?

A. No, sir, I did not. It was crude sewage, and the numbers of bacteria would have been up into the hundreds of thousands, so I did not plate it.

Q. Did you examine the conditions along the banks of that creek up above its source?

A. Yes, I have gone all over that creek from its mouth.

Q. I mean at that time?

A. Yes, sir.

Q. What were the conditions of that stream?

A. I drove through there with a buggy twice; once in October and later on, I think it was in November, from the mouth of the river back to Broadway.

657 Q. What do you mean, the mouth of Harlem creek?

A. Yes, to Broadway. The country is flat; the creek runs through a deep gully, a very little piece south of Broadway, across Broadway and along it. All along here (indicating), from probably 500 yards from the mouth up to quite a distance along the creek I remember are a number of dairies, with their cow sheds projecting over this creek, and the manure is pitched out through the holes in the floor into the creek, great masses of it.

Q. That is, it was at that time?

A. Yes, lying, fermenting there, and is still.

Q. Well, that is unimportant now, but still, put it in.

A. I was over there the other day and saw it. Now, a part of this drainage district extends up into Bellefontaine cemetery, and the other part is a rolling upland, and is inhabited and the sewage from all the people on this drainage area, some probably 10,000, discharge into this creek, so that in dry weather, the dry weather flow of this small creek has black fetid water flowing in it.

Q. Were there any investigations made to determine whether or not the drainage of this creek prior to the breaking out of this epidemic—there were any cases of typhoid?

A. There were cases of typhoid.

Q. Among the population that was tributary?

658 A. On that drainage, yes, sir.

Q. Is there any record of those cases?

A. There is a record in the Health Department.

Q. Of this city?

A. Yes, sir.

Q. Now, have you made any study of the supply from a sanitary standpoint, of water for the use of cities, and for primary use, such as drinking and cooking purposes, as a bacteriologist?

A. Yes, I investigated that whole thing and went over the question of the water supply, the ice supply, the milk supply and all that sort of thing, of the city. Do you wish to read the opinion of Dr. Welsh?

ATTORNEY-GENERAL CROW: No, sir, unless the other side wants it. I have no objection to putting it in; but it wouldn't be competent evidence.

THE WITNESS: It is simply his opinion as to this micro-organism.

JUDGE SPRINGER: He is good authority.

A. Well, just a little bit.

Q. Now, Doctor, say within the limits of this city, is there any other source or supply of water, or was there at that time, in 1892, other than the water which was pumped from Bissell's Point?

659 A. Yes, sir; there were some 7,000 wells, shallow wells.

Q. Now, was there any investigation made at that time to determine whether or not any of the typhoid cases were among the people who used the well water?

A. A number of the wells throughout the city were inspected, and it was found that the typhoid fevers were uniformly distributed throughout the city and not around any particular well or wells, distributed independently of any well water.

Q. In your investigation of the matter at that time did you discover any cases among the families that used well water?

A. No, sir.

Q. Was the water of the river at that time filtered?

A. Filtered by the city?

Q. Yes.

A. It was pumped directly from the river into, I think, the settling basins there, but the demand was so great for water in the city that it rested for but a short time; it was practically water delivered from the river to the consumer, with the delay incidentally necessary to that of flowing through the pipes.

Q. Was there any investigation made of the ice and milk supply at that time?

A. Yes, I went over the ice question carefully, not only this time, but from my own home.

660 Q. Well, did you find anything wrong with the ice bacteriologically?

A. I found some ice, some Illinois river ice, which was used for cooling purposes here by the Loomis Ice Company; that ice contained quite a large number of bacteria. It was cut from sluices up above Peoria.

Q. *Did you examine the milk supply?*

A. Yes, sir.

Q. What did you find about that?

A. I found that a greater part of the milk that comes to the town, or that was distributed in the town, comes from the surrounding country. It is brought in by rail from a distance as high as 100 miles from St. Louis, in Missouri and Illinois, and is distributed by several dairy companies here, and there are also quite a number of small dairies in the outlying district, some of them in the city, but they are very small.

ATTORNEY-GENERAL HAMLIN: You are speaking of 1892, now, are you?

A. Yes, sir, 1892.

ATTORNEY-GENERAL CROW: Now, will you describe the methods you followed in that examination at that time?

A. Yes, sir. Instead of plating the water directly as it flowed from the tap, the sediment of the water was collected in this manner: We had a Pasteur filter in the college, and 661 the porcelain filter was taken out of it and sterilized, and then the water allowed to run through, the tap water. When a sediment had collected on the surface of the Pasteur filter about one millimeter deep, a sterilized platinum needle was taken and the mud scraped from off this filter. This was done a number of times, extending through quite a number of months. This sediment was sown in what is known as Pariettie's solution, that is, a broth neutral to litmus was made up and into ten cubic centimeters of it was dropped five drops of Pariettie's solution. Pariettie's solution is made up of carbolic acid, five parts, hydrochloric acid four parts and water 100. The intention here is to inhibit or hinder the growth of the number of micro-organisms that will not grow in the presence of carbolic acid, or in the presence of acids. Well, the typhoid

bacillus and the coli bacillus group do grow in the presence of this acid. The growth was incubated, or rather tubes were placed in an incubator at 37 centigrade and kept there for two days, and then plated in gelatine and the non-liquefying colony studied for colony characteristics. They have quite a number of colony characteristics on gelatine. I also used at that time a medium somewhat like Elsner's medium. That was made up of potato juice, a small quantity of potassium iodide and gelatine. I have forgotten how many colonies I studied.
662 The figures are there. Two or three hundred different colonies that resembled the typhoid bacillus were picked off and studied. Among them—they were numbered from 1 to whatever number—among them was number 21, and number 21 responded in nearly every way that was then known morphologically and culturally to which a typhoid stock culture was submitted. I received that stock culture from Dr. Cheesman, of the College of Physicians and Surgeons of New York City, and compared this micro-organism with it.

Q. That is No. 21?

A. Yes, sir, that is No. 21.

Q. What is the result of that comparison?

A. They resembled one another very closely. This microorganism which I had, No. 21, was a little bit shorter, I think, but otherwise it resembled it in its cultural characteristics very closely, so closely that it would come within the limits of variation of any one of the typhoid bacilli.

Q. Well, was there any scientific or bacteriological test for determining what was a typhoid bacillus?

A. Yes, I say, all known tests then.

Q. Were those tests that were then known applied to this bacillus?

A. Yes, it was submitted to every known test for the typhoid bacillus.

Q. What was the result?

663 A. The result was that it responded to all of them.

Q. Indicating that it was a typhoid bacillus?

A. Yes, and I so declared it.

Q. Now, did you make any test to see what might be the longevity of this bacillus?

A. Yes, I carried out a number of experiments with this micro-organism that were very interesting to me.

Q. Well, as to the length of life of this culture, were you enabled to grow this culture?

A. Yes.

Q. Now, what is the result of the longevity as compared with the longevity of typhoid bacillus?

A. In the tap water sterilized, in the cold, in an ice chest right up against the ice, why they lived, that is, this particular micro-organism lived from thirty to sixty days. That is steriled water now. Steriled tap water. Well, in the non-steriled water, waters that flowed from the tap, in the sunlight, they lived from twelve to fifteen days, and in the gloom or dark of that ice chest from 25 to 30 days.

Q. In non-steriled water?

A. Non-steriled water, yes, sir—tap water.

Q. Now, what is this map or chart that I show you?

664 A. The chart here shown shows the number of cases of typhoid fever and the number of deaths in St. Louis from 1890 to 1900, graphically.

Q. From what period of time?

A. From January, 1890, to December, 1900. It is a graphic representation.

Q. Now, who made that map?

A. I did.

Q. From what data did you make it?

A. Besides that, let me say further: Graphically represented in groups showing the weekly averages of the river stages at St. Louis—the Mississippi river.

Q. Does it show anything else besides these facts?

A. That is from this period of January, 1890, to December, 1900. The map goes further and shows another period which we will describe later.

Q. Now from what data did you make that map?

A. This was made from data secured from the St. Louis Health Department. The official statistics of the health department.

Q. Well, does that map show the number of typhoid fever cases?

A. Yes, sir.

Q. Does it show the number of typhoid deaths during that period?

A. Yes, sir.

665 Q. Now, during this period from 1890 to 1900, where was the water supply taken from?

A. From 1890 to 1895, the water supply was taken from the Mississippi river at Bissel's Point.

Q. Then from 1895 to the present time where has it been taken from?

A. At the present time it is taken from the Intake tower at the Chain of Rocks, Mississippi river.

Q. How far apart?

A. Six or eight miles from the Intake tower at Bissell's Point.

Q. Well, is the present source of supply further out in the channel of the river than was the supply at Bissell's Point?

A. Yes, sir.

Q. Have you any idea how much further?

A. I suppose a thousand feet further, but that is guessing.

Q. Now, will you explain what the different curved lines in the columns of figures on the left hand side of this map mean?

A. Well, on the left hand margin of this map are written figures beginning with zero and running up to 200.

ATTORNEY-GENERAL HAMLIN: What color are they in?

A. They are written in black ink and they represent the cases and deaths.

Q. ATTORNEY-GENERAL CROW: Of typhoid fever?

666 A. Of typhoid fever, yes sir. Well, in the second column, or third from the left hand margin, the stages of the river.

Q. The stages of the river at what point?

A. In feet.

Q. At what point?

A. They are taken from the government reports, and I think they are taken from the river at the foot of Market Street.

Q. In this city?

A. Yes sir, in this city.

Q. What do those curved lines indicate? Explain their relation if any, to those figures?

A. The curved line in blue indicates the stage of the river. It begins in January, 1900, and the stage of the river was 6.1 feet.

JUDGE SPRINGER: Does that mean above low water?

A. Yes sir.

Q. ATTORNEY GENERAL CROW: What do the black lines indicate?

A. They indicate the number of cases of typhoid fever reported to the Health Department.

Q. And what do the red lines indicate?

A. They indicate the deaths from typhoid fever.

Q. Now what connection, if any, is intended to be shown by these curved lines, irregular lines on the map, and the
667 figures on the left?

A. Well, the figures on the left as I say, indicate the number of cases and deaths, the extreme left hand figures on the second column from that. The figures in blue represent the stages of the river. On the lower margin of the map, are written the year and the months of the year, or is written the time, beginning 1900, January, February, March, April, May, June, July, August, September, October, November and December for each year.

Q. Now will you give me the figures you have there of the typhoid cases or the number of deaths for 1890?

A. I can read it, but that will be a laborious process.

Q. Well shorten it any way you can.

A. The better way to do that would be to have the report of the health department and read the figures directly from that.

Q. Have you got a copy of that?

A. I have not with me.

Q. Now have you those figures I asked you about?

A. Yes, I have. Beginning the week ending January 4th, 1890, 3 cases and 4 deaths.

Week ending January 11, 8 cases and 4 deaths. New cases recorded ending January.

668 Week ending January 18th, 2 cases reported, no deaths.

Week ending January 25th, 5 cases, 4 deaths,
do. February 1st, 5 cases, 3 deaths,
do. February 8th, 1 case, 1 death,
do. February 15th, 4 cases, 1 death,
do. February 22nd, 3 cases, 1 death.
March 1st, 2 cases, 1 death,
" 8th, 1 case, no deaths.
" 15th, 4 cases, 2 deaths,
" 22nd, 7 cases, no deaths,
" 29th, 3 cases, no deaths,
April 5th, no cases reported, 1 death,
" 12th, 3 cases, 1 death,
" 18th, 3 cases, no death,
" 26th, 2 cases, 2 deaths,
May 3rd, 1 case, no deaths,
" 10th, 5 cases, 2 deaths,
" 17th, 4 cases, 2 deaths,
" 24th, 2 cases, 4 deaths,
May 31st, 1 case, 1 death,
June 7th, 3 cases, 2 deaths,
June 14th, 1 case, 1 death,
June 21st, 1 case, 1 death,
669 June 28th, 5 cases, 4 deaths,
July 5, 7 cases, 2 deaths,
July 12th, 6 cases, 2 deaths.

Q. Have you got the totals of the months?

A. No sir, I have not. We will put that in.

Q. Have you got the totals for the months on your map?

A. Yes, but I didn't add them up as this was put down. That is, I didn't add them and record them.

Q. I don't think you understand me.

A. Yes, I do.

Q. Have you got the totals of those for each month from 1890, on your map?

A. Yes sir.

Q. In figures?

A. Yes, I have got the weekly estimates put in here of deaths for the month of January.

Q. You don't estimate a death do you? A death is a fact.

A. Well, a death is a fact.

Q. Do you mean the average deaths?

A. If we have four deaths they are recorded here.

Q. That is what I want. You have those on that map?

A. Yes, I have those on that map.

Q. What is the reason you can't read those figures?

A. It is impossible to read off of that. You want me to
670 read them off the map and it is almost impossible to do
that, as my eyes are troubling me, (Reading):

July 26, 11 cases reported, 3 deaths,
August 2, 13 cases, 4 deaths,
August 9, 21 cases, 5 deaths,
August 16, 20 cases, 4 deaths,
August 23, 13 cases, 4 deaths,
August 30, 19 cases, 4 deaths,
September 6, 13 cases, 10 deaths,
September 13, 28 cases, 4 deaths,
September 20th, 12 cases, 4 deaths,
September 27, 30 cases, 8 deaths,
October 4, 25 cases, 27 deaths,
October 11, 22 cases, 4 deaths,
October 18, 2 cases, 2 deaths,
October 25th, 25 cases, 8 deaths,
November 1, 16 cases, 5 deaths,
November 7, 7 cases, 3 deaths,
November 15, 15 cases, 4 deaths,
November 22, 11 cases, 1 death.
November 29, 17 cases, 8 deaths,
December 6, 7 cases, 3 deaths,
December 13, 8 cases, 1 death,
December 20, 3 cases, no deaths,
December 27, 4 cases, no deaths,

671 Q. Figure those up and give the totals?

A. You can't give those in that way. It takes too long to go through each year.

Q. How many of them have you got?

A. I have got from 1890 to 1900, also 1900.

Q. Go ahead.

A. (Reading): 1891, January 3, 7 cases, 3 deaths,
January 10, 2 cases, 2 deaths,
January 17, 1 case, 1 death,
January 24, 3 cases, 1 death,

January 31, 3 cases, no deaths,
February 7, 1 case, no deaths,
February 14, 1 case, 2 deaths,
February 21, 6 cases, 5 deaths,
February 28, 4 cases, 1 death,
March 7, 4 cases, 1 death,
March 14, 2 cases, 2 deaths,
March 21, 1 case, no deaths,
March 28, 5 cases, 1 death,
April 4, 2 cases, 3 deaths,
April 11, 7 cases, 2 deaths,
April 18, 1 case, no deaths,
April 25, 2 cases, 2 deaths,
672 May 2, 3 cases, 3 deaths,
May 9, 3 cases, 3 deaths,
May 16, 7 cases, 2 deaths,
May 23, 4 cases, 2 deaths,
May 30, 7 cases, 3 deaths,
June 6, 3 cases, 1 death,
June 13, 5 cases, 3 deaths,
June 20, 4 cases, 2 deaths,
June 27, 6 cases, 4 deaths,
July the 4, 6 cases, no deaths,
July 11, 11 cases, 3 deaths,
July 18, 6 cases, 1 death,
July 25, 9 cases, 7 deaths,
August 1, 12 cases, 6 deaths,
August 8, 5 cases, 1 death,
August 15, 19 cases, 4 deaths,
August 22, 11 cases, 8 deaths,
August 29, 11 cases, 2 deaths,
September 5, 10 cases, 5 deaths,
September 12, 13 cases, 3 deaths,
September 19, 20 cases, 9 deaths
September 26, 31 cases, 11 deaths,
October 3, 6 cases, 1 death,
October 10, 16 cases, 7 deaths,
673 October 17, 21 cases, 4 deaths,
October 24, 19 cases, 6 deaths,
October 31, 16 cases, 7 deaths,

November 1, 10 cases, 6 deaths,
November 7, 10 cases, 6 deaths,
November 14, 4 cases, 2 deaths;
November 21, 5 cases, 2 deaths,
November 28, 8 cases, 2 deaths,
December 5, 5 cases, 2 deaths,
December 12, 9 cases, 5 deaths,
December 19, 9 cases, 3 deaths,
December 26, 8 cases, 4 deaths.

(The witness did not have the statistics for the years 1893 and 1894, and by agreement they are to be inserted at some future time.)

674 1895—January 5, 6 cases, 4 deaths,
January 12, 4 cases, 2 deaths,
January 19, 5 cases, 3 deaths,
January 26, 2 cases, 2 deaths,
February 2, 5 cases, 2 deaths,
February 9, 2 cases, 2 deaths,
February 16, 2 cases, no deaths,
February 23, 5 cases, no deaths,
March 2, 3 cases, 1 death,
March 9, 2 cases, 1 death,
March 16, 6 cases, no deaths,
March 23, 5 cases, no deaths,
March 30, 1 case, no deaths,
April 6, 8 cases, 2 deaths,
April 13, 3 cases, one death,
April 20, 3 cases, 1 death,
April 27, 4 cases, 1 death,
May 4, 4 cases, 1 death,
May 11, 4 cases, 1 death,
May 18, 4 cases, 2 deaths,
May 25, 5 cases, 1 death,
June 1, 2 cases, no deaths,
June 8, 1 case, no deaths,
June 15, 1 case, 2 deaths,
675 June 22, 3 cases, 1 death,
June 29, 8 cases, 3 deaths,
July 6, 4 cases, 2 deaths,
July 13, 8 cases, 4 deaths,

July 20, 11 cases, 2 deaths,
July 27, 12 cases, 1 death,
August 3, 16 cases, 1 death,
August 10, 10 cases, 3 deaths,
August 17, 9 cases, 2 deaths,
August 24, 24 cases, 6 deaths,
August 31, 21 cases, 5 deaths,
September not given.
October 5, 11 cases, 2 deaths,
October 12, 13 cases, 2 deaths,
October 19, 16 cases, 5 deaths,
October 26, 12 cases, 4 deaths,
November 2, 4 cases, 4 deaths
November 9, 5 cases, 1 death,
November 16, 10 cases, 2 deaths,
November 23, 11 cases, 4 deaths,
November 30, 4 cases, no deaths,
December 7, 5 cases, 4 deaths,
December 14, 6 cases, no deaths,
December 21, 14 cases, 1 death,
December 28, 7 cases, 3 deaths,
676 1896. Week ending January 4, 9 cases, 2 deaths,
January 11, 3 cases, no deaths,
January 18, 6 cases, no deaths,
January 25, 5 cases, 1 death,
February 1, 21 cases, 4 deaths,
February 8, 1 case, 2 deaths,
February 15, 1 case, 1 death,
February 22, 1 case, no deaths,
February 29, 4 cases, no deaths,
March 7, 3 cases, no deaths,
March 14, 1 case, 1 death,
March 21, 3 cases, no deaths,
March 28, 5 cases, 2 deaths.
April 4, 9 cases, 1 death,
April 11, 2 cases, 1 death,
April 18, 2 cases, 2 deaths,
April 25, 3 cases, no deaths,
May 2, 4 cases, 2 deaths,
May 9, 4 cases, 2 deaths,

May 16, 2 cases, no deaths,
May 23, 3 cases, 1 death,
May 30, 5 cases, no deaths,
June 6, no cases, no deaths,
June 13, do.
677 June 20, 5 cases, 3 deaths,
June 27, 4 cases, 1 death,
July 4, 7 cases, 3 deaths,
July 11, 5 cases, 3 deaths,
July 18, 10 cases, 4 deaths,
July 25, 7 cases, 2 deaths,
August 1, 12 cases, 3 deaths,
August 8, 8 deaths—cases not counted,
August, 15, 17 cases, 7 deaths,
August 22, 12 cases, 7 deaths,
August 29, 16 cases, 3 deaths,
September 5, 9 cases, 8 deaths,
September 12, 13 cases, 3 deaths,
September 19, 4 cases, 2 deaths,
September 26, 7 cases, 2 deaths,
October 3, 9 cases, 1 death,
October 10, 5 cases, 4 deaths,
October 17, 7 cases, 1 death,
October 24, 10 cases, 2 deaths,
October 31, 2 cases, 3 deaths,
November 7, 1 case, 2 deaths,
November 14, 6 cases, 1 death,
November 21, 2 cases, 3 deaths,
November 28, 8 cases, no deaths,
678 December 5, 6 cases, 3 deaths,
December 12, 5 cases, 1 death,
December 19, 5 cases, 1 death,
December 26, no cases, no deaths.

Year 1897:
January 2, 1 case, 1 death,
January 9, no cases, no deaths,
January 16, 2 cases, no deaths,
January 23, 1 case, no deaths,
January 30, 6 cases, 4 deaths,

February 6, 7 cases, no deaths,
February 13, 4 cases, 2 deaths,
February 20, 2 cases, 1 death,
February 27, 3 cases, 2 deaths,
March 6, 2 cases, 2 deaths,
March 13, 2 cases, 1 death,
March 20, no cases; no deaths,
March 27, 3 cases, 3 deaths,
April 3, 8 cases, 3 deaths,
April 10, 5 cases, no deaths,
April 17, 2 cases, 1 death,
April 24, 7 cases, 2 deaths,
679 May 1, 3 cases, no deaths,
May 8, 3 cases, 3 deaths,
May 15, 7 cases, 3 deaths,
May 22, 4 cases, no deaths,
May 29, 6 cases, no deaths,
June 5, 11 cases, 2 deaths,
June 12, 6 cases, 4 deaths,
June 19, 5 cases, 2 deaths,
June 26, 6 cases, 1 death,
July 3, 1 case, 1 death,
July 10, 6 cases, 4 deaths,
July 17, 7 cases, no deaths,
July 24, 6 cases, 4 deaths,
July 31, 7 cases, 2 deaths,
August 7, 14 cases, 5 deaths,
August 14, 7 cases, 1 death,
August 21, 8 cases, 2 deaths,
August 28, 13 cases, 7 deaths,
September 4, 12 cases, 7 deaths,
September 11, 13 cases, 2 deaths,
September 18, 12 cases, 3 deaths
September 25, 22 cases, 4 deaths,
October 2, 21 cases, 4 deaths,
October 9, 14 cases, 6 deaths,
680 October 16, 24 cases, 4 deaths,
October 23, 13 cases, 2 deaths,
November 6, 14 cases, 1 death,
November 13, 16 cases, 3 deaths,

November 20, 15 cases, 4 deaths,
November 27, 17 cases, 5 deaths,
December 4, 14 cases, 2 deaths,
December 11, 11 cases, no deaths,
December 18, 7 cases, 2 deaths,
December 25, 8 cases, 1 death,

Year 1898:
January 1, 9 cases, 1 death,
January 8, 7 cases, 3 deaths,
January 15, 6 cases, 1 death,
January 22, 2 cases, no deaths,
January 29, 3 cases, no deaths,
February 5, 7 cases, 1 death,
February 12, 4 cases, no deaths,
February 19, 9 cases, 1 death.
February 26, 6 cases, 2 deaths,
March 5, 6 cases, 2 deaths,
March 12, 3 cases, 1 death,
March 19, 6 cases, 1 death,
681 March 26, 7 cases, 2 deaths,
April 2, 7 cases, 3 deaths,
April 9, 6 cases, 3 deaths,
April 16, 5 cases, 1 death,
April 23, 2 cases, no deaths,
April 30, 6 cases, 2 deaths,
May 7, 3 cases, no deaths,
May 14, 2 cases, no deaths,
May 21, 2 cases, no deaths,
May 28, 6 cases, 2 deaths,
June 4, one case, no deaths,
June 11, 4 cases, 2 deaths,
June 18, no cases, no deaths,
June 25, 7 cases, 1 death,
July 2, 6 cases, 4 deaths,
July 9, 3 cases, 2 deaths,
July 16, 12 cases, 3 deaths,
July 23, 10 cases, 2 deaths,
July 30, 15 cases, no deaths,
August 6, 20 cases, 5 deaths,

August 13, 6 cases, no deaths,
August 20, 8 cases, 2 deaths,
August 27, 6 cases, no deaths,
September 3, 20 cases, 5 deaths,
September 10, 19 cases, 2 deaths,
682 September 17, 21 cases, 4 deaths,
September 24, 21 cases, 3 deaths,
October 1, 15 cases, 4 deaths,
October 8, 13 cases, 3 deaths,
October 15, 20 cases, 2 deaths,
October 22, 6 cases, 2 deaths,
October 29, 10 cases, 3 deaths,
November 5, 16 cases, 1 death,
November 12, 8 cases, 2 deaths,
November 19, 5 cases, 2 deaths,
November 26, 10 cases, 2 deaths,
December 3, 5 cases, 1 death,
December 10, 14 cases, 3 deaths,
December 17, 14 cases, 3 deaths,
December 24, 6 cases, 3 deaths,
December 31, 10 cases, 2 deaths,

Year 1899:

First week in January, 9 cases, 3 deaths,
Second week, 9 cases, 6 deaths,
Third week, 5 cases, 1 death,
Fourth week, 3 cases, no deaths,
Total cases 28, deaths 10.

February—

First week, 3 cases, 2 deaths,
Second week, 3 cases, 4 deaths,
Third week, 3 cases, 1 death,
Fourth week, nothing,
683 Total cases, 9; deaths, 7.

March—

First week, 3 cases, 1 death,
Second week, 2 cases, two deaths,
Third week, 2 cases, 1 death,
Fourth week, 3 cases, no deaths,
Total cases, 10; deaths, 4.

April—
First week, 3 cases, no deaths,
Second week, 1 case, 1 death,
Third week, 2 cases, no deaths,
Fourth week, 9 cases, 2 deaths,
Fifth week, 3 cases, 2 deaths,
Total cases, 18; deaths, 5.

May—
First week, 1 case, no deaths,
Second week, 2 cases, no deaths.
Third week, no cases; no deaths,
Fourth week, 2 cases, no deaths,
Total cases, 5; no deaths.

June—
First week, 10 cases, 2 deaths.
Second week, 2 cases, 1 death,
Third week, 7 cases, 2 deaths,
Fourth week, 7 cases, 1 death,
Total, 26 cases, 6 deaths.

684 July—
First week, 10 cases, 1 death,
Second week, 4 cases, 3 deaths,
Third week, 7 cases, 3 deaths,
Fourth week, 11 cases, 1 death,
Fifth week, 7 cases, 2 deaths,
Total, 39 cases, 10 deaths.

August—
First week, 5 cases, no deaths,
Second week, 14 cases, 2 deaths,
Third week, 17 cases, 1 death,
Fourth week, 10 cases, 2 deaths,
Total cases, 46; deaths, 5.

September—
First week, 19 cases, 3 deaths,
Second week, 22 cases, 5 deaths,
Third week, 21 cases, 5 deaths,
Fourth week, 14 cases, 2 deaths,
Fifth week, 13 cases, 1 death,
Total, 89 cases, 16 deaths.

October—
First week, 25 cases, 4 deaths,
Second week, 22 cases, 5 deaths,
Third week, 9 cases, 2 deaths,
Fourth week, 19 cases, 4 deaths,
685 Total cases, 75; deaths, 15.

November—
First week, 21 cases, 2 deaths,
Second week, 62 cases, 5 deaths,
Third week, 190 cases, 8 deaths,
Fourth week, 171 cases, 12 deaths,
Total, 444 cases, 27 deaths.

December—
First week, 52 cases, 5 deaths,
Second week, 44 cases, 3 deaths,
Third week, 31 cases, 5 deaths,
Fourth week, 18 cases, 3 deaths,
Fifth week, 13 cases, 5 deaths,
Total cases, 158, deaths, 21.

January, 1900—
First week, 9 cases, 6 deaths,
Second week, 15 cases, 4 deaths,
Third week, 9 cases, 5 deaths,
Fourth week, 11 cases, 2 deaths,
Total, 44 cases; 17 deaths.

February—
First week, 18 cases, 5 deaths,
Second week, 10 cases, no deaths,
Third week, 7 cases, 1 death,
686 Fourth week, 5 cases, 1 death,
Total cases 40, deaths, 7.

March—
First week, 15 cases, 2 deaths,
Second week, 30 cases, 3 deaths,
Third week, 40 cases, 4 deaths,
Fourth week, 21 cases, 4 deaths,
Fifth week, 17 cases, 4 deaths,
Total 126 cases, 17 deaths,

April—
First week, 15 cases, 1 death,
Second week, 9 cases, 2 deaths,
Third week, 3 cases, 1 death,
Fourth week, 4 cases, no deaths,
Total, 31 cases, 4 deaths,

May—
First week, 6 cases, 2 deaths,
Second week, 6 cases, no deaths,
Third week, 6 cases, no deaths,
Fourth week, 6 cases, no deaths.
Total, 24 cases, 3 deaths.

June—
First week, 4 cases, 1 death,
Second week, 5 cases, 2 deaths,
Third week, 6 cases, 1 death,
687 Fourth week, 5 cases, 1 death,
Fifth week, 9 cases, 4 deaths,
Total cases 29, deaths 9.

July—
First week, 9 cases, 3 deaths,
Second week, 12 cases, 5 deaths,
Third week, 9 cases, 2 deaths,
Fourth week, 7 cases, 4 deaths,
Total cases, 37; deaths, 14.

August—
First week, 15 cases, 4 deaths,
Second week, 18 cases, 3 deaths,
Third week, 32 cases, 2 deaths,
Fourth week, 37 cases, 9 deaths,
Total cases 102; deaths 18.

September—
First week, 23 cases, 6 deaths,
Second week, 25 cases, 2 deaths,
Third week, 52 cases, no deaths,
Fourth week, 62 cases, 4 deaths,
Fifth week, 104 cases, 4 deaths,
Total cases 266; deaths 16.

October—

First week, 85 cases, 7 deaths,

688 Second week, 75 cases, 4 deaths,

Third week, 44 cases, 6 deaths,

Fourth week, 40 cases, 8 deaths,

Total, 244 cases; 25 deaths,

This is as far as this table goes.

Q. October, what year?

A. October, 1900.

Q. Now from this map you have I will get you to state if there is any relationship, if so, what, between the stages of the river as indicated by that map and the increase or decrease of typhoid fever in the city of St. Louis, in the years 1890, to 1900?

A. Why we find, in consulting this map, that as a rule, when the river is low, the typhoid fevers were high, the number of cases and deaths.

ATTORNEY GENERAL HAMLIN: Do you mean water low at the In-take?

A. The water low in the river.

GENERAL CROW: I will get you to state if there have been any epidemics of typhoid from 1890 up to 1900, that is up to the 1st of January, 1900?

A. Well, there was that great epidemic of which I spoke, that was in 1892. That is shown very markedly here.
689 It runs off the map in fact (indicating).

Q. Now coming down to the right hand side of this map. What is the chart that is drawn separate on the right hand side of this ruled paper?

A. There is a separate chart running to December, 1900. Upon this chart is shown the curves showing the weekly average of the stage of the Mississippi River at St. Louis; percentage of Mississippi water in; total solids, flowing into the Intake, and number of typhoid fever cases for the year 1900.

Q. Explain what you mean by total solids?

A. Total solids is a term used by chemists, and is the residue or rather the sediment remaining after evaporating, definite quantities of water at boiling temperature, water at 100 Centigrade; 212 Fahrenheit. At that temperature water is evaporated, and the residue, remaining is the total solids.

Q. Who made this map?

A. I did, or rather it was made under my direction.

Q. Where did you get the data from which to make it?

A. The data of the typhoid cases was taken from the Health Department.

Q. Where did you get the other data?

A. The total solids were taken from the figures of Dr. William C. Teichmann, City Chemist. The river stages were taken from the Government reports.

690 Q. Now what do the various lines on there indicate and the numbers?

A. The numbers on the left hand side of the map here, written in black ink are for the number of cases and deaths from typhoid fever.

Q. During what period or term?

A. During the period from January 1st, 1900, to December 29th, 1900. The figures to the right of this written in blue are for the stages of the river.

Q. Now, what do the lines on the surface of this map indicate?

A. The curved green line shows the weekly averages of the Missouri River; the stages of the Missouri River.

Q. At what point?

A. At Herman, Missouri.

Q. Where is that located with reference to the Intake tower of the Waterworks of the City?

A. It is some distance up the Missouri River, over a hundred miles, so that it is quite a distance from the Intake tower. That is the point at which the Government made its readings. It is in the meteriological report which I can show you. The line in blue is the weekly averages of the stage of the Mississippi River at the foot of Market Street.

691 Q. What are the other lines?

A. The brown line shows the percentage of Mississippi River water going into the Intake.

Q. At the Chain of Rocks?

A. At the Chain of Rocks.

Q. That is the Intake of this city?

A. The Intake of the St. Louis Water works.

Q. What do the other lines represent?

A. The red line indicates the number of cases of typhoid fever reported to the Health Department.

Q. Is there anything on this map to indicate the number of deaths?

A. No sir.

Q. You say the brown line represents the percentage of Mississippi River water?

A. Yes sir.

Q. Now from what data was that taken?

A. Taken from the data of Dr. William C. Teichmann, City Chemist.

Q. What kind of details was that?

A. Chemical details; total solids the results of chemical analyses of samples taken at the Intake Tower.

Q. Now will you please take your figures and the lines on
that map there and just give the number of typhoid cases
692 beginning in January, and the percentage of the water of
the Mississippi River, and the stages of the river up to
the 29th of December as shown by this map?

A. The figures for 1900 have been all given; do you want me to give them again?

Q. They have not been given as shown on this map.

A. Yes, those are the figures there.

Q. Doctor, just give the percentage that is shown on the map.

A. 1900, week ending January 6, 9 cases, 6 deaths,
Week ending January 13, 15 cases, 4 deaths,
Week ending January 20, 9 cases, 5 deaths,

Q. January 6, you have nine cases?

A. Yes sir. The Mississippi River stage, that is the datum point here on Market Street—a piece of iron is sunk into the river at Market Street, and from this the stages of the river are read from the first, up and down. We find on the 15th, the week ending January 6, the river stage here is marked one below zero, that is, for the Mississippi River, and for the Missouri River it is marked 1.9.

January 13th we find fifteen cases; four deaths.
Stage of the Mississippi River 2.3.
Stage of Missouri River 3 feet.

January 20, number of cases 9; deaths 5.
Stage of the Mississippi River 3.2 feet;
693 Stage of Missouri River 4.4 feet.

January 27, 11 cases, 2 deaths,
Stage of the Mississippi River 6.4 feet,
Stage of the Missouri River, 5.4 feet.

February 3, 18 cases, 5 deaths,
Stage of the River 2.8 feet for the Mississippi.
Stage of the Missouri River 3.6 feet.

Week ending February 10, ten cases, no deaths.
Height of the River—Mississippi, 2 feet,
do. Missouri, 2.9 feet.

February 17th, or third week, 5 cases, 1 death:
Height of Mississippi River 6.6 feet,
Missouri River 3.6 feet.

February 24th, 7 cases, 1 death,
Height of the Mississippi River, 6.7 feet.
Height of Missouri River, 3.4 feet.

March 3rd, 15 cases, 2 deaths,
Height of Mississippi River 7.2 feet,
Height of Missouri River 5.8 feet.

694 March 10th, 30 cases, 3 deaths,
Height of Mississippi River 12.5 feet.
Height of Missouri River 10.6 feet.

March 17th, 40 cases, 4 deaths,
Height of Mississippi River 22.4 feet,
Height of Missouri River 16.2 feet.

March 24th, 24 cases, 4 deaths,
Height of Mississippi River 19.4 feet,
Height of Missouri River 12.2 feet.

March 31st, 17 cases, 4 deaths,
Height of Mississippi River 15.2 feet,
Height of Missouri River 8.4 feet.

April 7th, 15 cases, 1 death,
Height of Mississippi River 14.6,
Height of Missouri River 9 feet.

April 14th, 9 cases, 2 deaths,
Height of Mississippi River 16.8 feet,
Height of Missouri River 10.2 feet.

April 21st, 3 cases, 1 death,
695 Height of Mississippi River 16.8 feet,
Height of Missouri River 11.4 feet.

April 28th, 4 cases, no deaths,
Height of Mississippi River 17 feet,
Height of the Missouri River 11.4 feet.

May 5th, 6 cases, 2 deaths,
Height of Mississippi River 15.8,
Height of Missouri River 11.4 feet,

May 12th, 6 cases, no deaths,
Height of the Mississippi River 15.8 feet,
Height of the Missouri River 11 feet.

May 19th, 6 cases, 1 death,
Height of Mississippi River 14 feet,
Height of Missouri River 11.2 feet.

May 26th, 6 cases, no deaths,
Height of the Mississippi River 14 feet,
Height of the Missouri River 11.4 feet.

June 2, 4 cases, 1 death,
Height of Mississippi River 13.2 feet,
Height of Missouri River 11.6 feet.

696 June 9th, 5 cases, 2 deaths,
Height of the Mississippi River 12.2 feet.
Height of the Missouri River 10.8 feet.

June 16th, 6 cases, 1 death,
Height of Mississippi River 11.6 feet,
Height of Missouri River 11.4 feet.

June 23, 5 cases, 1 death,
Height of Mississippi River 12.3 feet,
Height of Missouri River, 11.8 feet.

June 30th, 9 cases, 4 deaths,
Height of Mississippi River 13.6,
Height of Missouri River 12.3 feet.

July 7th, 9 cases 3 deaths,
Height of Mississippi River 11.4 feet,
Height of Missouri River 11.4 feet.

July 14th, 12 cases, 5 deaths,
Height of Mississippi River 10.4 feet,
Height of Missouri River 11 feet.

697 July 21st, 9 cases, 2 deaths,
Height of Mississippi River 9.14 feet,
Height of Missouri River 9.8 feet.

July 28th, 7 cases, 4 deaths,
Height of Mississippi River 12.4 feet,
Height of Missouri River 11.2 feet.

August 4th, 15 cases, 4 deaths,
Height of Mississippi River 11.4 feet,
Height of Missouri River 9.2 feet.

August 11th, 18 cases, 3 deaths,
Height of Mississippi River 8 feet,
Height of Missouri River 7 feet.

August 18th, 32 cases, 2 deaths,
Height of Mississippi River 5.4 feet,
Height of Missouri River 5.8 feet.

August 25th, 37 cases, 9 deaths,
Height of Mississippi River 8.6 feet,
Height of Missouri River 6.8 feet.

698 September 1st, 23 cases, 6 deaths,
Height of Mississippi River 9 feet,
Height of Missouri River 7.6 feet.

September 8th, 25 cases, 2 deaths.
Height of Mississippi River 10 feet,
Height of Missouri River 8.2 feet.

September 15th, 52 cases, no deaths,
Height of Mississippi River 7.6 feet,
Height of Missouri River 5.8 feet.

September 22nd, 62 cases, 4 deaths.
Height of Mississippi River 6.4 feet,
Height of Missouri River 5.1 feet.

September 29th, 104 cases, 4 deaths.
Height of Mississippi River 8 feet,
Height of Missouri River 6.1 feet.

October 6th, 75 cases, 7 deaths,
Height of Mississippi River 12 feet,
Height of Missouri River 8.6 feet.

October 13th, 75 cases, 4 deaths,
Height of Mississippi River 12.3 feet,
Height of Missouri River 8.7 feet.

699 October 20th, 44 cases, 6 deaths,
Height of Mississippi 10.3,
Height of Missouri 5.8 feet.

October 27th, 40 cases, 8 deaths.
Height of Mississippi river 11.8 feet,
Height of Missouri river not recorded.

November 3rd, 33 cases, deaths not recorded.
Height of Mississippi river 12.4 feet.
Height of Missouri river not recorded.

November 10th, 33 cases; deaths not recorded.
Height of Mississippi river 13 feet.
Height of Missouri river not recorded.

On October 20th we run out of deaths and Missouri river stages. I didn't have the data.

November 17th, 23 cases,
Height of Mississippi river 12.2 feet.

November 24th, number of cases 42.
Height of Mississippi river 12.1 feet.

700 December 1st, 23 cases.
Height of Mississippi river 11.2 feet.

December 8th, 41 cases.
Height of Mississippi river 8 feet.

December 15th, 19 cases.
Height of Mississippi river 6.3 feet.

December 22, 24 cases.
Height of Mississippi river 4.6 feet.

December 29th, 15 cases.
Height of Mississippi river 3.5 feet.

Q. Now, doctor, what does this map show with reference to the whole period of ten years, with reference to what period or year typhoid was the most prevalent?

A. The typhoid was the most prevalent in 1892, and in this period and in the period before—

Q. You don't understand my question. I want to know at what season of the year prior to January 1st, 1900, this map shows that typhoid fever was the most prevalent in the City of St. Louis, if it shows that fact?

701 A. In the fall and winter months.

Q. Now, does the latter part of this map on the right hand side indicate the percentage of Mississippi river water that is going into the Intake. It is given on the lower side of the map?

A. Yes, sir.

Q. Now, with reference to the highest number of typhoid cases recorded and the lowest number, is there any relationship between the percentage of Mississippi river water as shown by this map going into the Intake tower of the St. Louis Waterworks, if so, what is that relationship?

A. Well, we find that in the early part of the year from February 6th, the quantity of water estimated by total solids in the Mississippi river increased at the Intake and reached a hundred per cent. on February 8th, 1900.

Q. I will ask you a question right at that point—well, go ahead.

A. It fell on the 9th to 78 per cent., and on the 10th of February it fell to 62 per cent.

On the 12th it fell to 46 per cent.,

On the 13th to 35 per cent.,

On the 14th to 24 per cent.,

On the 15th to 12 per cent.

Q. Well, now, what is the period of time do you say from
702 your medical knowledge that after a person receives the
typhoid bacillus into his stomach, that the disease will
develop?

A. That varies from five or six days, to three or four weeks. You mean the period of incubation?

Q. Yes?

A. Yes, sir.

Q. Now, is there any relationship as shown by this map between the rise in the number of cases of typhoid fever and the rise in the percentage at the times you mention of the water in the Mississippi river at the Intake tower?

A. Yes, sir.

Q. Just explain what that is?

A. As I showed you already. That is, on the 8th, 100 per cent. of Mississippi river water, as it came into the Intake tower of the St. Louis Waterworks.

Q. What do you mean when you say 100 per cent?

A. 100 per cent. of Mississippi river water. In other words, the Mississippi water only, not mixed with the Missouri water, went into the Intake tower, and on March 3rd there was an increase in the typhoid cases.

Q. How many days later is that?

A. That is February 8th and March 3rd, and 23 days later a rise in the typhoid death rate was noted, and that increased until March 17th, gradually decreasing with the falling out of the Mississippi water here. The Mississippi water at the intake reached 12 per cent. on the 17th of February, and the
703 typhoid fever cases on April 21st were recorded only 4.
So that there was an increase of the typhoid cases from March 3rd up to March 17th, then a gradual decrease to March 24th, and from March 31st to April 7th, and as I say, reached the low number of four on the 21st.

Q. Now, do you know anything about how long the water is allowed to remain in the settling basins after it is pumped from the Intake tower?

A. Yes, from 36 to 70 hours.

Q. Before it is sent directly to the consumer?

A. Yes, sir.

Q. Do you know anything about the amount of consumption of water in this city in the year 1900, with reference to the volume that was sent out every twenty-four hours from the basin?

A. I do not.

Q. I suppose the waterworks people will tell us that?

A. That is in the Waterworks Commissioner's report.

Q. Now, go ahead and trace the relationship, the percentage of the Mississippi river water to the increase or decrease?

A. What I want to call attention to at that time is, that both rivers were falling, at this particular time.

704 Q. Both of what rivers?

A. The Mississippi and the Missouri. From January 27, to February 10th the Mississippi river was falling, in 1900, and the Missouri River also at those dates was falling.

Q. That is from January 27th to February 10th?

A. Yes.

Q. Do you know anything about the condition of the Illinois river from January 27th to February 10th?

A. I know that from February 6th, I think it is, to February 20th, the Illinois river was high.

Q. Do you know whether or not the Mississippi and Missouri were frozen over from February 3rd, to February 20th?

A. Yes, they were frozen over in that period. I think about the 20th they broke up.

Q. What effect on the oxidation by bacteria or organic matter, and animal and inorganic matter, in the water, does the freezing over of the river have?

A. The bacteria do not multiply very rapidly in cold water; they remain dormant.

Q. Well, the oxygen is shut out of the water by the freezing of the ice?

A. Yes, but there is enough oxygen in the water for the bacteria, if they could multiply in the temperature, but not so much as when the river is open?

Q. But not so much as when the river is open?

A. No, sir.

705 Q. What is the result of the decomposition of the inorganic matter in the water?

A. It is not decomposed.

Q. In so great a quantity?

A. In so great a quantity.

Q. If there was organic animal matter in the water of the Mississippi river and in the Missouri at this time, its decomposition would be the result, if it was open and not frozen?

A. Yes, and the temperature higher, and the temperature not near freezing point.

Q. Now, do you know the stage of the Illinois river at this period, have you got that?

A. I haven't it, no, sir; I haven't recorded it, but I have it at Peoria.

Q. At this time?

A. Yes, sir.

Q. Just give that, will you? Turn to it and we will put it in the record right here.

A. I have the stages for Peoria and Grafton.

Q. Well, just give them to me at this period.

A. Do you want the Illinois first?

Q. Yes, sir.

A. Beginning what date?

706 Q. Well, beginning—

A. Well, the Chicago Drainage Canal was opened on January 17th, 1900. Do you want me to begin with that?

Q. Yes.

A. January 17th, at Peoria, 5.1 feet,
January 18th, 5.7 feet,
January 19th, 6.1 feet,
January 20th, 6.6 feet,
January 21, 7.1 feet,
January 22, 7.5 feet,
January 23, 7.7 feet,
January 24th, 7.8 feet,
January 25th, 8.1 feet,
January 26th, 8.1 feet,
January 27th, 8.1 feet,
January 28th, 7.9 feet,
January 31st, 7.8 feet,
February 1st, 7.7 feet,
February 2nd, 7.8 feet,
February 3rd, 7.8 feet,
February 4th, 7.9 feet,
February 5th, 7.7 feet,
February 6th, 7.7 feet,
February 7th, 7.5 feet,
707 February 8th, 8.3 feet,
February 9th, 9.3 feet,
February 10th, 10 feet,
February 11th, 10.5 feet,
February 12th, 11 feet,

February 13th, 11.5 feet,
February 14th, 11.5 feet,
February 15th, 11.5 feet,
February 16th, 11.4 feet,
February 17th, 11.4 feet,
February 18th, 11.5 feet,
February 19th, 11.5 feet,
February 20th, 11.5 feet,
February 21st, 11.4 feet,
February 22nd, 11.5 feet,
February 23rd, 11.6 feet,
February 24th, 11.4 feet,
February 25th, 12 feet,
February 26th, 12.3 feet,
February 27th, 12.3 feet,
February 28th, 12.4 feet,
March 1st, 12.3-feet,
708 March 2nd, 12.2 feet,
March 3rd, 12 feet,
March 4th, 11.8 feet,
March 5th, 11.6 feet,
March 6th, 11.6 feet,
March 7th, 11.4 feet,
March 8th, 11.3 feet,
March 9th, 11.4 feet.
March 10th, 11.8 feet,
March 11th, 12.5 feet,
March 12th, 13.8 feet,
March 13th, 15.4 feet,
March 14th, 17.4 feet,
March 15th, 19.2 feet,
March 16th, 19.9 feet,
March 17th, 19.9 feet,
March 18th, 19.5 feet,
March 19th, 19 feet,
March 20th, 18.7 feet,
March 21st, 18.3 feet,
March 22nd, 17.8 feet,
March 23rd, 17.6 feet,
March 24th, 17.3 feet,

March 25th, 17 feet,
March 26th, 16.7 feet,
709 March 28th, 16.1 feet,
March 29th, 16 feet,
March 30th, 15.8 feet,
March 31st, 15.7 feet.

Q. What, if anything, do those figures show as to whether or not the Illinois River was rising from the 27th of January on up to the 20th of February?

A. It shows that from the 23rd day of January, or from the 17th of January there was a steady rise in the Illinois River until the 29th of January, when eight feet were recorded, then there was a fall of seven and 9-10 feet, and 7.8 feet on February 1st.

February 2nd, 7.8 feet,
February 3rd, 7.8 feet,
February 4th, 7.9 feet,
February 5th, 7.7 feet,
February 6th, 7.6 feet.

JUDGE SPRINGER: When did the rise begin?

A. The rise began on the 8th, when 8.3 feet was recorded, and on the 9th, 9.3 feet, and on the 10th, ten feet.

Q. There is no use repeating. Say it rises in the river steadily.

A. Rising through February, March and April.

Q. When was the maximum?

710 A. 19.9 feet was reached on the 17th of March, that is the highest.

Q. Do you know what date the Illinois River broke up?

A. Well, from what I understand, there was a thaw along the Illinois River beginning the 7th of February and it extended to April 12th. The river I see here begins to rise on the 8th, and rises steadily, from the 8th of February, and from the bacteriological record, and from personal recollection of samples collected at Peoria, at Joliet and Grafton, I know the condition of that water.

Q. Now you have got the stages of the river at Grafton for those dates?

A. Yes sir.

Q. Now give them to me from the 17th of January up to the 20th of February: That is all I want.

A. Hold on. I meant to say that for the Illinois River at Grafton, or the Mississippi at Grafton, this chart is not marked.

Q. Will you look that up and see?

A. Yes I will look that up.

Q. Now answer the other question I asked you there. Trace the relationship there between the percentage of the Mississippi River water as shown by this map and the increase or decrease of the typhoid fever rate?

711 A. We have traced that increase from March. That is for February, and the increase of typhoid fever that occurred in March in St. Louis, and no such thing has ever been known before in the history of this town; the Illinois River high, and the other two rivers covered with ice, and the Mississippi water coming into the Intake in 100 per cent. Now as the rains began and the spring thaw began on the drainage area of all these rivers in the latter part of February, and in March, there was high water for all these rivers, so that the flood flowing into the Mississippi River was very great. From the 17th of February on, we find the highest stage of the Mississippi reached at this point was on March 17th, 1900, and the highest stage also recorded for the Missouri at this period.

JUDGE SPRINGER: What was the stage?

A. The Mississippi 22.4 feet, and for the Missouri River 16.2 feet. Then the rivers fell until March 31st, when again there was a rise. Then a gradual fall until the fall rise, which began on September 29th. Now at this time, according to the total solids, that is, beginning on March 3rd, and reaching its acme on March 24th, we find that on March 24, 25, 26, 27, and 28th there was 100 per cent of Mississippi River water going into the Intake at St. Louis Waterworks, Chain of Rocks.

712 Then there was a fall to 62 per cent on the 29th of March; again a rise on the 31st to 100 per cent; then a fall to 87 per cent on the first of April and on the 2nd of April to 50 per cent. Then a rise on the 3rd of April to 62 per cent, and a fall to 56 per cent on the 5th. And on the 6th to 32 per cent, and then on April 7th to 1 per cent; then again it rapidly rose.

Q. Now what was the number of typhoid cases?

A. At flood volume of the river. It was very high at this time and the number of typhoid cases rapidly diminished. All the rivers were very high, and the quantity of the pollution was very great.

Q. And the percentage of the Mississippi River water at the Intake was high?

A. High at one period, at the very high period.

Q. It wasn't high when all the rivers were at flood tide?

A. Yes, it was high once.

Q. At what time?

A. That is the period I have just referred to from March 24th to 31st.

Q. How high was it?

A. 100 per cent. I named the dates.

Q. Did it reach 100 per cent. twice in the spring and fall of 1900?

A. Yes sir.

713 Q. Go ahead.

A. So the quantity rises and falls; that is, the percentage of the Mississippi River water at the Intake rises and falls until May 28th, when it is at its lowest; then it remained low, that is, rising and falling to a slight degree until July 29th, when it again rose, and the amount of Mississippi River water going into the Intake reached 39 per cent. I can read farther on if you care to have me. I can read right straight through.

Q. Well just trace the relationship there is in it between the typhoid rate and the percentage of the Mississippi River water.

A. The rivers during this stage now, are—The Mississippi at the Intake is falling when its percentage reaches 39; then the percentage fluctuates between the dates July 29th to August 7th, when it reaches six per cent. On August 31st the percentage again reaches fifty per cent. It falls on August 2nd, to 2 per cent; then rises again to 28 per cent until the 5th of September. On the 7th of September it falls to four per cent, then it rapidly rises to the 12th, when it reaches 40 per cent.

Q. Now what is the number of typhoid cases at that time?

A. The number of typhoid cases at that time was in-
714 creasing, with the increase of the Mississippi River water
at the Intake at this low stage of the river.

Q. What was the number at that particular point?

A. Forty cases. The percentage now fluctuates between 26 per cent on the 15th of September to 46 per cent on September 22nd; then there is a fall again, September 25th to 34 per cent; then a steady rise until the percentage of 64 per cent is reached on October 4th. Then it falls on October 6th, to 27 per cent. Rises on the 7th, October 7th, to 42 per cent; falls on October 9th to 24 per cent; on October 10th to 26 per cent, and the record ends there.

I want to say this: When the flood volume of the river is very great the percentage of typhoid is very low.

Q. What water?

A. The percentage of the Mississippi River water at the Intake, when the river is high, the typhoid is low. The typhoid fever rate increases with the increased per centage of Mississippi River water going into the Intake.

ADJOURNED until 2:15 P. M., same day, February 25th, 1903 at same place.

715 2:15 P. M., Wednesday, February 25, 1903, Southern Ho-
tel, St. Louis, Missouri. Continuation after recess. Present, the Commissioner and same counsel representing the respective parties.

DR. AMAND NICHOLAS RAVOLD,

Resumed the stand for further direct-examination by Attorney General Crow, and testified as follows:

Q. Let us see; where did we stop with this. doctor? Let us finish it up?

A. We finished it up.

Q. Take all this period here, the latter part or half of 1900, just give us the periods of time—just the dates, that is all, at which the typhoid was the greatest in the City of St. Louis—I just simply want the dates as shown by your map.

A. For the March term,—for March 3rd to March 31, extending into April 7th,—March 3rd to April 7th, was one period, and from August 1st to December 15th.

Q. Now have you ever made any calculation to determine what percentage of increase there was in March, 1900, of the typhoid rate in this city, or with that of the month preceding, February, 1900?

A. It was greater for the period of March,—you mean 716 for the period of February there is very little difference. For March there is an increase.

Q. Over February?

A. Over March of the previous year.

Q. Well how about February though?

A. It is greatly increased here in March over February of the present year, 1900.

Q. Now as to the preceding year, 1899?

A. I have not made a calculation of it.

Q. Well, never mind, then.

A. I mean I haven't it in figures here, but you can show what it is.

Q. Well, what was it?

A. The number of cases 5. The highest number recorded for February in cases, is 8—February, 1898, that was.

Q. For 1899?

A. For February, cases and deaths, the highest number of cases recorded was three cases,—four deaths, that is the highest recorded for February, 1899?

Q. What was it in March, 1899?

A. For March, 1899, lower than that; it was three cases,—is the highest,—the highest for any one week.

ATTORNEY GENERAL HAMLIN: Reported?

A. Reported as to deaths.

Q. ATTORNEY GENERAL CROW: How was it in March and February, 1897?

717 A. March, 1897, one week here, three cases, the highest in any one week in March.

Q. How was it in 1896?

A. March, six cases.

Q. Do you know what time in 1895, the Intake was moved from Bissell's Point to where it is at present?

A. I do not. I know that the Intake was up there, but I don't know when they began pumping water.

ATTORNEY GENERAL HAMLIN: What was the highest number recorded in March, 1895?

A. March, 1895, six.

ATTORNEY GENERAL CROW: You can run on back to 1894; put it in from way back if you want to.

A. Now the highest recorded in March, 1894, is fifteen cases—that is the last week in March, 1894.

Q. Now at that time where was the Intake?

A. The Intake was at Bissell's Point.

Q. How far below the present place?

A. About six miles.

Q. Well, go ahead, back to 1893?

A. In 1893, March, fourteen is the highest in that month.

Q. Go on back?

A. March, 1892, five cases.

Q. March, 1891?

A. March, 1891, six cases.

Q. March, 1890?

A. Seven cases

718 Q. That runs it back to 1890?

A. To 1890.

Q. Now doctor, is there anything else you want to say about this map?

A. The highest recorded in March was on the 17th of March, 1900, forty cases.

Q. Now is there any further explanation you want to make about this map?

A. I see no other.

ATTORNEY GENERAL CROW: I will offer this as an exhibit then.

Said map received in evidence and marked by the Commissioner "Complainant's Exhibit No. 10. Frank S. Bright, Commissioner."

Q. Now what is that map I show you?

A. This chart is for the third period, 1901, for the months of October and November.

Q. Now what is that chart?

A. It shows the results of the daily determination of the number of bacteria in samples of water collected from Drainage Canal at Bear Trap Dam, Lockport, below Ruby Street, Joliet, and Brandon's Bridge, Joliet.

Q. Well now, just explain the marks and the figures on that map, will you?

A. The bacteria per cubic centimeter are ranged along the left hand margin of the map, beginning with 200,000 and extending up to 5,000,000 bacteria per cubic centimeter. Now the bacteria at the Bear Trap Dam, Lockport, are marked in black ink. The bacteria at Ruby Street, Joliet, are in red; Brandon's Bridge, Joliet is in green.

719 Q. Well, what do the cross lines on there represent?

A. Well, on the fourth space at the top of the map are the dates, beginning September 26 and ending November 29, the number of bacteria are recorded every third day,—no, they are recorded every day. Now the black lines, beginning at 1,250,000 for the Bear Trap Dam, Lockport; that was on September 26th. On the 27th it drops to 650,000;

On the 28th, 650,000,
September 29, 1,250,000,
" 30, 3,075,000,
October 1, 350,000,
" 2, 75,000,
" 3, 350,000,
" 4, 50,000,
" 5, 300,000,
" 6, 875,000,
" 7, 775,000,
" 8, 25,000
" 9, 75,000,
" 10, 200,000,
' 11, —The figures for October 11th are not in.
We begin on the 12th,—50,000,
720 October 13, about 75,000,
" 14, 75,000,
" 15, about 175,000,

Then it takes a jump.

October 16, 2,150,000,
" 17, 1,100,000,
" 18, 1,750,000,
" 19, 150,000,

October 20, 100,000,
" 21, 100,000,
" 22, 50,000,
" 23, about 50,000,
" 24, 175,000,
" 25, 1,800,000,
" 26, 225,000,
" 27, 250,000,
" 28, 1,825, 000,
" 29, 125,000,
" 30, 275,000,
" 31, 300,000,
November 1, 235,000,
" 2, 245,000,
" 3, 350,000,
" 4, 275,000,
" 5, 300,000,

721 Then we have no data until the 8th of November,—from the 5th to the 8th we have no data. Bacteria per cubic centimeter, November 8, 1,250,000,
November 9, 1,050,000,
" 10, 200,000,
Now then, there is a gap again in numbers until
November 17, 625,000,
Then it takes a dear little jump:
November 18, 5,180,000,
It drops on the 19th to 3,100,000,
November 20, 6,000,000,
" 21, 1,600,000,
" 22, 5,200,000,
" 23, 7,200,000,
" 24, 6,025,000,
" 25, 2,725,000.

Q. ATTORNEY GENERAL CROW: Now at what date there was the greatest number?

A. The greatest number recorded on this map is 7,200,000, on the 23rd of November. Now do you want those at Ruby Street Bridge?

Q. Well, they are the same figures?

A. No, no, the one at the Bear Trap Dam. Now the water tumbles over the Bear Trap Dam and mixes it with the Des Plaines River and pollutes it somewhat, so that we see the pollution in this graphic representation.

722 Q. All right.

A. 875,000 on the 26th of September. It tumbles to 75,000 on the 27th. Then on the 29th of September it is 225,000,

September 30, 1,250,000,
October 1, 25,000,
“ 2, 35,000,
“ 3, 325,000,
“ 4, 50,000,
“ 5, 350,000,
“ 6, 575,000,
“ 7, 245,000,
“ 8, 50,000,
“ 9, 50,000,
“ 10, 60,000,

Now then, we skip to the 12th,—25,000
October 13, 75,000,
“ 14, 85,000,
“ 15, 3,600,000,

Then it tumbles down,
October 16, 125,000,
“ 17, 50,000,
“ 18, 100,000,
“ 19, 85,000,
“ 20, 275,000,
“ 21, 65,000,
“ 22, 75,000,
723 October 23, 50,000,
“ 24, 125,000,
“ 25, 125,000,
“ 26, 650,000,
“ 27, 185,000,
“ 28, 1,025,000,
“ 29, 225,000,
“ 30, 325,000,
“ 31, 350,000,

November 1, 350,000,
“ 2, 625,000,
“ 3, 225,000,
“ 4, 150,000,
“ 5, 100,000,
Then we skip to the 8th, 150,000,
November 9, 400,000,
“ 10, 150,000,
Then we go to November 17, when we have 400,000,
November 18, 1,552,000,
“ 19, 1,700,000,
“ 20, 2,200,000,
“ 21, 3,500,000,
“ 22, 3,600,000,
“ 23, 3,200,000,
“ 24, 3,350,000,
“ 25, 2,650,000,

724 That is the last record on there. Now then we have that record,—the green line, for Brandon's Bridge.

Q. Where is Brandon's Bridge located?

A. Brandon's Bridge is five miles below Joliet. It is below a mixture of every stream and everything else that comes into the Des Plaines River.

Q. What does it show?

A. It shows a mixture of the Drainage Canal with the Des Plaines River; the Illinois and Michigan Canal with the Des Plaines River, and the sewage of Joliet.

It begins on the 27th of September, 350,000,
September 28, 375,000,
“ 29, 175,000,
“ 30, 325,000,
October 1, 75,000,
“ 2, 50,000,
“ 3, 325,000,
“ 4, 35,000,
“ 5, 350,000,
“ 6, 575,000,
“ 7, 245,000,
“ 8, 60,000,

October 9, 75,000,
" 10, 80,000,
Now then, we jump to the 12th, 25,000,
725 October 13, 65,000,
" 14, 80,000,
" 15, 3,650,000,
" 16, 125,000,
" 17, 50,000,
" 18, 100,000,
" 19, 90,000,
" 20, 275,000,
" 21, 60,000,
" 22, 65,000,
" 23, 60,000,
" 24, 135,000,
" 25, 125,000,
" 26, 650,000,
" 27, 175,000,
" 28, 1,025,000,
" 29, 200,000,
" 30, 325,000,
" 31, 350,000,
November 1, 325,000,
" 2, 625,000,
" 3, 225,000,
" 4, 150,000,
" 5, 100,000,
Then we jump to the 8th,—150,000,
November 9, 400,000,
726 November 10, 150,000,
Then we jump to the 17th of November, 400,000,
November 18, 1,525,000,
" 19, 5,700,000,
" 20, 2,175,000,
" 21, 3,500,000,
" 22, 3,600,000,
" 23, 3,175,000,
" 24, 3,350,000,
" 25, 2,650,000,
That is, on November 25th, this map is finished.

Q. ATTORNEY GENERAL CROW: Now, what periods of time does this map show these bacteria were the highest, and at what point?

A. They were the highest beginning the 17th of November, –there was a lapse between the 10th and 17th–

Q. On the 23rd?

A. No sir, beginning on the 17th and up until the 23rd, when they reached the highest; but they were still high on the 25th at all of these points.

Q. At what points?

A. At all these points?

Q. What points are they?

A. At Bear Trap Dam, Lockport, at Ruby Street Bridge and at Brandon's Bridge, Joliet.

727 Q. What point was the highest of all?

A. The Chicago Drainage Canal.

Q. Well, at what point on the canal?

A. The Bear Trap Dam, Chicago Drainage Canal.

Q. Is that where the Canal empties into the Des Plaines River?

A. Yes sir.

ATTORNEY GENERAL CROW: Now I wish to offer that map in evidence.

Said map received inevidence and marked "Complainant's Exhibit 11, Frank S. Bright, Commissioner."

Q. Now what is this chart I show you?

A. This chart is the result of daily quantitative determinations of the number of bacteria in samples of water collected at Peoria, Illinois, at Shady Beach, above the city.

Q. How far is that from the last collection in the map just preceding this one?

A. 120 miles.

Q. What is the period of time covered by that map?

A. October 1st to November 27th.

Q. Now explain the lines and the figures on that map.

A. The lines and figures on this map, beginning on the left hand margin show the number of bacteria per cubic centimeter, ranging from zero to 10,000,–those figures are in black,–bacteria per cubic centimeter. The river stages in feet are printed in red and range from zero to 10 feet. At the top margin

728 of the map are the dates from October 1st, consecutively to November 30. Do you want these lines (indicating).

Q. Yes.

A. The lines in red are river stages at this point from October 1st to November 28, while the dark line represents the bacteria per cubic centimeter.

Q. Now that represents then a stretch of river 120 miles in the Illinois River.

A. 120 miles in the Illinois River.

Q. Now just give the figures there of the—what it shows there for those dates with reference to the number of bacteria.

A. The number of bacteria at this point are, beginning October 1st, 2,325,

October 2, 2,500,
" 3, 1,750,

Now the next record I have got is October 5, 425,

October 6, 375,
October 7, 375,
" 8, 650,
" 9, 325,
" 10, 400—approximately,
" 11, 200,
" 12, 850,
" 13, 600,
" 14, 400,
" 15, 500,
729 October 16, 500,
" 17, 400,
" 18, 375,
" 19, 250,

Now then we jump to the 22nd,—300,

October 23, 400,
" 24, 350,

Now we jump to the 25th,—450,

October 27, 650,
" 28, 500,
" 29, 650,
" 30, 1,200,
" 31, 400,

November 1, 1,300,
“ 2, 700,
“ 3, 500,
“ 4, 400,

We jump then until the 6th, 500,

November 7, 300,
“ 8, 250,
“ 9, 450,
“ 10, 350,
“ 11, 375,
“ 12, 500,
“ 13, 2,450,
“ 14, 3,700,
730 “ 15, 3,000,
“ 16, 4,300,
“ 17, 6,500,
“ 18, 2,500,
“ 19, 1,800,
“ 20, 2,300,
“ 21, 1,300,
“ 22, 4,600,
“ 23, 9,000,
“ 24, 3,800,
“ 25, 2,700,
“ 26, 500,
“ 27, 1,900.

Q. Now, what period of time is it shown by that map that at Peoria, 125 miles below where the last examination was made, that the number of bacteria was the greatest?

A. There was a decided and rapid rise from November 13th to November 17th; then it dropped until November 21, and then a rapid rise on November 23 to 9,000, and then a drop for the 26th to 500.

Q. How does that correspond with the increase as shown on the map at a point 120 miles above on the Illinois river?

A. It seems to correspond with the rise and fall of bacteria at Bear Trap Dam, Ruby street and Brandon's bridge at Joliet.

Q. Now, at this point in the river, the current is less than at any other place in the Illinois river?

A. No, I won't say that, but it is below what is called Peoria Lake, the river widens out into a lake above Peoria, and flows quite slowly, but we haven't said anything about the stage of the river.

Q. What was the stage of the river during that period?

A. During this period, the stage of the river remained remarkably even throughout, and when the bacteria was so high, for the two periods in November, the water was a little bit lower than it had been for previous weeks. Beginning October 1st, it was 6.2 feet.

October 2, 6.2 feet,
" 3, 6.2 feet,
" 4, 6.2 feet,
" 5, 6.1 feet,
" 7, 6 feet,
" 8, 5.9 feet,
" 9, 5.9 feet,
" 10, 6 feet,
" 11, 6 feet,
" 12, 6.1 feet,
" 13, 6.1 feet,
" 14, 6.1 feet,
" 15, 6.1 feet,
" 16, 6.1 feet,
732 " 17, 6.1 feet,
" 18, 6.1 feet,
" 19, 6.1 feet,
" 20, 6.1 feet,
" 21, 6.1 feet,
" 22, 6.2 feet,
" 23, 6.2 feet,
" 24, 6.2 feet,
" 25, 6.2 feet,
" 26, 6.2 feet,
" 27, 6.2 feet,
" 28, 6.2 feet,
" 29, 6.2 feet,
" 30, 6.2 feet,
" 31, 6.2 feet,

November 1, 6.2 feet,
“ 2, 6.4 feet,
“ 3, 6.4 feet,
“ 4, 6.4 feet,
“ 5, 6.4 feet,
“ 6, 6.3 feet,
“ 7, 6.3 feet,
“ 8, 6.3 feet,
“ 9, 6.3 feet,
“ 10, 6.3 feet,
“ 11, 6.3 feet,
733 “ 12, 6.4 feet,
“ 13, 6.4 feet,
“ 14, 6.4 feet,
“ 15, 6.4 feet,
“ 16, 6.4 feet,
“ 17, 6.3 feet,
“ 18, 6.3 feet,
“ 19, 6.3 feet,
“ 20, 6.3 feet,
“ 21, 6.3 feet,
“ 22, 6.3 feet,
“ 23, 6.3 feet,
“ 24, 6.4 feet,
“ 25, 6.5 feet,
“ 26, 6.5 feet,
“ 27, 6.5 feet,
“ 28, 6.5 feet.

You see the river fluctuated an inch or two only.

Q. Now, with reference to the increase of bacteria there, what is indicated, if anything, bacteriologically by the even stage of the water during the period and at the place mentioned?

A. The river remained stationary practically during this period from October 1st to November 29. In any ordinary river the bacteria would have remained practically stationary, but in the dates as given before, you find a remarkable
734 rise without any rise in the river.

Q. Well, what does that indicate, if anything?

A. It indicates that large numbers of bacteria put in above apparently came through to Peoria.

Q. Now, above the Bear Trap Dam, in the Des Plaines river, have you any analyses of that water?

A. Yes, that has already been submitted.

Q. Now, you have investigated those analyses, have you?

A. Yes, sir.

Q. What does it show, a larger or smaller number of bacteria above the Bear Trap Dam than it does below?

A. Oh, a very small number, comparatively.

Q. Is there any other place than the Chicago Canal at the Bear Trap Dam from whence this large number could come into this river at this stage of the water?

A. None that I know of.

Q. Have you got the rain precipitation in that tributary of that river for that period?

A. I have.

Q. Where is that?

A. It is in my government reports which I have downstairs. There was no precipitation practically in that area at that time.

Q. There was not?

A. No.

735 Q. Well, we will get those charts.

A. We will get those charts and introduce them.

Q. Now, is there anything else you want to say about that map?

A. No, I think everything is written on it.

ATTORNEY-GENERAL CROW: I will offer that map in evidence.

Said map received in evidence, and marked by the Commissioner "Complainant's Exhibit 12. Frank S. Bright, Commissioner."

Q. Now, what is this map I show you?

A. This map is made up from results of the daily quantitative determination of the number of bacteria in samples of water collected from the Illinois river at Grafton, Illinois, from October 1st to November 27th, 1901.

Q. Now, how far below Peoria is the point at which this map was made?

A. I think it is 163 miles.

Q. By river?

A. By river.

Q. Do you know the fall of the river, the mean fall of the river between Peoria and Grafton?

A. I remember that it is thirteen feet.

Q. Thirteen feet, well, about that, in the neighborhood of that, is it?

A. Yes, sir.

Q. Now, you just indicate to us what the figures and the
736 lines on that map mean?

A. The figures on the right hand margin are the bacteria per cubic centimeter, ranging from zero to 10,000, and written in black ink. In the next column are the stages of the river in feet, running from zero to 4.5 feet. At the top of the map we have the point, Illinois river at Grafton, together with the months of October and November, and the dates running from October 1st, consecutively, to November 29, 1901.

Q. This is for the third period? Well, now, what do the cross lines indicate?

A. The cross lines indicate first those in black indicate the bacteria per cubic centimeter taken daily at this point, and the red lines the stages of the river.

Q. Now, at what period of time there was the greatest number of bacteria found per cubic centimeter?

A. 17th of November.

Q. 17th of November, 1901?

A. Yes, sir.

Q. Now, what is the stage of the river on the 17th of November here as to being the highest or the lowest during the period October 1st to November 27, 1901?

A. There was a slight rise at that date, but it was not as high as it had been at a previous period—from October 21 to October 30th, the stage of the river was 4.2 feet, while at the period when it was the highest here—

737 Q. When the river was the highest?

A. No, when the bacteria were the highest, the stage of the river was 3.5 feet and 3.7 feet.

Q. Now, when the river was highest, what was the number of bacteria?

A. The number of bacteria at a high point here, was 34,000 at that period.

Q. Now, what was the period you mentioned there, what is that period?

A. On the 17th of November.

Q. On the 17th of November, what was the number of bacteria?

A. 9,000.

Q. And the river was how many feet lower then than it was on this date here—what date is that?

A. That date is the 29th of October.

Q. 29th of October?

A. Yes, sir; and the difference in the stage of the river there was the difference between 3.7 feet and 4.2 feet.

Q. Well, that is seven inches?

A. No, seven-tenths of a foot.

Q. Then the river was seven inches lower when the greatest number was found?

A. Yes, sir, 3.7 feet, and the other was 4.2 feet. It would be a difference of five-tenths of a foot.

Q. Yes, it is five tenths. Now, do you remember the rain precipitation during that period?

738 A. I don't from memory; I have that in the charts.

Q. Well, we will get that and put it in a little later.

A. Yes.

Q. Is there anything else you want to say about that map?

A. No, sir.

ATTORNEY-GENERAL CROW: I will offer that map in evidence.

Said map received in evidence and marked by the Commissioner. "Complainant's Exhibit No. 13. Frank S. Bright, Commissioner."

Q. And the river was how many feet lower than it was on the 27th of October?

A. I said five-tenths of a foot; that is a half a foot—six inches lower.

Q. You have read the subject of bacteriology with reference to the sanitary supplies of waters for towns, cities, villages, etc., have you?

A. Yes, sir, I have lectured on hygiene for a number of years.

Q. Whereabouts?

A. Medical Department, Washington University, St. Louis.

Q. Now, you are acquainted with the conditions that are required for sanitary water for primary purposes, that is for domestic use, such as drinking, cooking, etc.?

A. Yes, sir.

Q. You are also acquainted with the history of the examinations of the conditions surrounding the sanitary supplies of different cities of the world, as connected with epidemics of typhoid fever and cholera? 739

A. Yes, sir.

Q. Now were you ever at a place called Lausen, in Switzerland?

A. Yes, sir.

Q. Where is that place located?

A. That is near Basle, about fifteen miles from it.

Q. Is it on a stream?

A. Yes, there is a small brook that runs by it, in a gulch.

Q. Were you there as a bacteriologist and hygiene expert?

A. Yes, that is, I was there as a hygienist sanitarian.

Q. Now, you examined this town and the waters surrounding it?

A. Yes, sir, it is one of the classic typhoid epidemics of the world in the literature.

Q. Well, now, just describe how the town is located?

A. It was—I was at Basle in 1896, and took a ride down to this small place; there is a railroad runs through it.

Q. That is in Switzerland?

A. Yes, sir, that is in Switzerland—and it is classic—

Q. How is it located, the town?

A. It is in the mountains.

Q. On the mountain or in the valley?

A. No, sir, it is in the valley; it is at the foot of Stockholen.

Q. What does that mean?

740 A. Oh, it is the name, like your name, like my name; it is the name of a mountain. At the foot of this mountain there is a spring, and that spring is enclosed and pipes lead from it and supply the town with water; that is it is led into several fountains that are along the street and to these fountains the people go and get their drinking water.

Q. How large a town is that?

A. The town contains 90 houses, and about 700 people.

Q. That is about the size of it when you were there?

A. Yes, when I saw it; it was quite a prosperous little town.

Q. Now, have you any knowledge of the great epidemic of typhoid fever that occurred there, and when it occurred?

A. I know that it occurred in August, in 1872, and was investigated by Dr. Haegler. He lived at Basle; he went there and investigated this epidemic after it occurred.

The water from this spring that I speak of, conducted through these pipes to the fountains in the town, was the source of the drinking water for the greater part of the inhabitants of the town. Some had shallow wells connected with their homes and took water from them, a few families, but the great majority of the population took their water from the fountains from that spring. On the other side of this mountain there is a village and there is a little brook called the Fuerlen. This little brook empties into a larger stream below Lausen.

741 In, I think it was in August—August 7th, or about that time, 1872, the first cases of typhoid fever occurred in Lausen. Within a very short period—within a few weeks, 140 cases occurred, with eight fatalities.

In the investigation it was found that the Fuerlen brook at one time had been discharged into an opening in the mountain a little bit lower down than its natural drainage bed, and that this water, or rather that the water in the spring at Lausen had become slightly turbid, and the in-flow had increased very greatly. After a time this brook was again confined to its course, and the hole that had appeared in the side of the mountain was filled up. I should say this brook was used in the summer time for irrigating or watering the fields—the brook was turned in on a field for irrigation purposes; that had been a yearly affair.

In June, a man had typhoid fever in that region, and his wife and daughter, I believe, and a girl, and from June until August their discharges were thrown into the Fuerlen brook, and the Fuerlen brook was used for irrigating this field, and ran down into this old hole in the mountain and down into the brook, which before this typhoid fever broke out, was turbid, that is, the water of the spring, I should say, that supplied the water to Lausen, was turbid. Following that came this typhoid epidemic. Dr. Haegler undertook to discover whether the water passed down through this mountain or not to the spring below.

742 He put quite a number of pounds of salt something like 1,800 pounds at first and at a later time 5,000 pounds of salt, in the hole, and the salt—chloride of sodium was easily detected in the water flowing from the spring below. He also emptied quite a number of hundreds of pounds of flour into this hole, but none of it came through; there were no starch particles detected in the water at the spring, the source of this water supply of Lausen. It may be said there had been no typhoid fever in that district for some sixty years before.

ATTORNEY-GENERAL HAMLIN: What is the purpose of this examination?

ATTORNEY-GENERAL CROW: Well, the doctor visited that point, Lausen, Switzerland, as a scientist, a hygienist and also as a bacteriologists. I wanted to qualify him as an expert on the proposition. I have asked him what he knows of the history of this epidemic at this place, for the purpose of showing the manner in which it has been demonstrated that the typhoid bacillus will travel.

JUDGE SPRINGER: How far did it go?

A. It went through the mountain, about a mile and affected the spring at its base—at the base of this mountain, and this mountain acted as a filter sufficiently good to keep out starchy particles of flour, but it was too porous to keep out, apparently, the typhoid bacillus. This spring is enclosed; the spring is in an enclosed space; it is not open at all.

743 Q. ATTORNEY-GENERAL CROW: Have you ever been at Plymouth, Pennsylvania?

A. No, sir, never been there.

Q. As a bacteriologist are you acquainted with the epidemic of typhoid fever and its causes at that place?

A. Well, I am acquainted with the literature on the subject, and the report that was made to the Pennsylvania State Board of Health and published by them.

Q. When did that occur, do you know?

A. 1885.

Q. Do you know what was the occasion of it?

A. Well, it was—the investigators came to the conclusion that it was due to the discharges of a typhoid fever patient that were thrown upon the bank of the reservoir that was the source of the water supply of this town.

Q. Do you know how many cases there were there?

A. There were 1,104 cases.

Q. How large was this town?

A. Eight thousand.

Q. Are you acquainted with the investigations made by Dr. Sedgwick, at Lowell, Lawrence and Newburyport on the Merrimac river in the state of Massachusetts, in 1891, 1892 and 1893?

A. I am acquainted with the reports of the State Board of Health of Massachusetts and of his writings on the epidemic.

Q. What is supposed to have been the cause of those epidemics?

744 A. Well, that has been very vigorously discussed. It seems that discharges from some typhoid fever cases were emptied into Stony Brook, above the water supply, about three or four miles from the Intake—

Q. Well, what was the result of that epidemic at that place?

A. I don't remember from memory.

ATTORNEY-GENERAL HAMLIN: I believe I will enter an objection to this testimony as not being relevant to the issues, and not competent.

ATTORNEY-GENERAL CROW: For the reason that the man that investigated it is not testifying?

ATTORNEY-GENERAL HAMLIN: Well, that is not the only reason. We are going to get an awful record here if we get all the literature of all the cases. Still, you can pursue your own course; I will enter the objection.

THE COMMISSIONER: Just note the objection.

Q. GENERAL CROW: Do you know how many cases there were reported in 1896, at the town of Lawrence, Massachusetts?

A. I don't from memory.

Q. Do you know what caused that epidemic?

A. The epidemic was due to dejecta, at least ascribed to dejecta of typhoid fever patients getting into the water supply and being drank by these people.

Q. Whereabouts in the water supply did it go; do you know where the town got its water from?

A. Merrimac river.

745 Q. Was there any experiment made to determine the question as to whether or not it was in the Merrimac river?

A. I think so; I think Dr. Sedgewick carried out some experiments, but I am not positive about that.

Q. Is typhoid fever more prevalent in the winter or in the summer months?

A. In the fall, fall and early winter, as a rule.

Q. Does the movement, or the flow of the water, the speed of it, have anything to do with the danger to be apprehended from the injurious germs of bacteria in the water?

A. Yes, sir.

Q. In what way?

A. The faster the water flows, the further it will carry bacteria.

Q. Well, then, in slow flowing waters, what is the result?

A. In waters that flow very slowly, or are stagnant, or still, the bacteria are precipitated into the silt or slush at the bottom of the river—

Q. Now, does the slow speed of the river, or the fast speed of the river destroy the bacteria?

A. No, sir.

Q. Does the volume of water, whether large or small, destroy the bacteria?

A. No, sir. That is, you are speaking about any particular bacillus—you are speaking about a typhoid bacillus?

Q. Yes, sir.

746 A. No, sir.

Q. Now, is there any difference in the conditions surrounding the typhoid bacillus in sterilized water in a bottle, and the ordinary tap water in this city, or the ordinary water taken from the In-take tower of the Mississippi river—

A. Yes, sir.

Q. Wait until I get through with my question—and the condition that would surround that same bacillus if it were alive and in the flowing waters of the Mississippi river?

A. Yes, sir, the differences are very great in a steriled water. Do you mean a steriled water or a distilled water?

Q. I mean sterilized water.

A. A water that has been sterilized by heat contains the inorganic matter of the water, but the bacteria have been destroyed in it. It still has food for bacteria, and it has no other bacteria. Now, the typhoid bacilli put into that water have no other form of organic life to contend with, and in my experience, and I think in the experience of all bacteriologists, the bacteria will live a great deal longer in sterilized water of a district than they do in the living water of that district in a bottle.

Q. Now, how long did they live, you say?

A. Sixty days, sir; I have some tables showing that.

Q. Well, they have been introduced?

A. Those tables have not been introduced.

Q. Well, just get them, and we will put them in the record
747 right now.

A. We have another, a second period, the longevity of the life of the bacillus typhosus in sterilized waters,—distilled first. Now the environments, the surroundings—take distilled water in total darkness at ten degrees centigrade,—experiments A, B, and C, here, three different cultures, 51 days, 25 days and 22 days.

Q. With the same surroundings?

A. With the same surroundings; they were in darkness, in an ice chest, against the ice, with a temperature there of 10 degrees centigrade, and the three different cultures were used, and they lived 51 days, 25 days and 22 days. That is in distilled water. Now, that is pure water, the artificial product of the laboratory.

Now the Mississippi River water at Grafton, in total darkness, ten degrees centigrade—

Q. That is 25 degrees Fahrenheit?

A. Yes, about 25.

JUDGE SPRINGER: It must be above freezing.

THE WITNESS: It is above 32. Lived 59 days for the first culture and for the third culture "C" 40 days. "B" not recorded.

Illinois River, Lockport,—that is wrong,—that ought to be the Drainage Canal water, Lockport.

Drainage Canal water, Lockport, Illinois, in total darkness, ten degrees centigrade, 50 degrees Fahrenheit, lived 45
748 days, "A" culture, "B" not recorded. "C" 22 days.

Missouri River water, Bellefontaine, sample collected at Bellefontaine, lived in total darkness, ten degrees centigrade, —50 degrees Fahrenheit, 59 days; B 57 days; C. 57 days.

Mississippi River, Intake, water, total darkness, 10 degrees centigrade, lived:

A culture, 59 days,
B culture, 59 days,
C culture, 34 days,

Distilled water, total darkness, at 20 degrees Centigrade, which is 68 Fahrenheit, in distilled water; A culture lived 22 days; B culture 54 days; C culture 30 days.

Mississippi River water, Grafton, total darkness, twenty degrees Centigrade, 68 Fahrenheit:

A culture, not recorded,
C culture not recorded,
B culture, 37 days.

Drainage canal, Lockport, Illinois, in total darkness 68 degrees Fahrenheit; 20 degrees Centigrade,

A culture lived 54 days,
B culture lived 54 days,

Missouri River, Bellefontaine, sample collected:

C culture lived 57 days; the other two not recorded.

749 Mississippi River, Intake water,

A culture lived 54 days,
B culture, lived 55 days,
C culture 54 days.

Distilled water, open window, facing east; it was in the middle of the window, facing east, and the sun was on it all morning, 100 cubic centimeters in a bottle. Distilled water, open window, months of July August and September, 1900. Distilled water 22 days, A culture; B culture 25 days; C culture 45 days.

Mississippi River, Grafton:
B culture 45 days,
C culture 60 days,
A culture not recorded.

Drainage Canal water, Lockport,
A culture lived 40 days,
B culture lived 31 days,
C culture lived 22 days.

Missouri River water, Bellefontaine, open window. All of these are open window now. This is not recorded.

Mississippi River, Intake tower:
B culture lived 46 days,
C culture lived 45 days,
A culture not recorded.

Where you have "not recorded" I see there is a cross; that cross refers to the lower part of the page where it says
750 "Still living at the end of 65 days."

These experimnets were conducted by Mr. C. A. Snodgrass, with the assistance of Mr. Johnson, Dr. Kirchner and myself.

Q. At what place?

A. At the Bacteriological laboratory old City Hall.

Q. St. Louis?

A. St. Louis, yes sir.

Q. That is all the experiments you have as to the longevity of this bacillus?

A. Oh no, that is the longevity of the bacillus in steriled water.

Q. Now the natural water; have you got the result of the experiments in that?

A. Yes sir. Now in connection with these experiments, I would like to record the facts, before introducing the third table, because this is a very much more complicated and difficult procedure than the other. The one recorded is simply of a man taking some water out of the river, sterilizing and using ordinary care that bacteria from the air do not get into the water.

Sufficient evidence having been obtained in the second period of the determination of the longevity the typhoid bacillus in steriled waters, a series of experiments were conducted in June, July, August, 1901, by myself, assisted by Mr. George M.

Ravold, to determine the length of life of the bacillus—

751 ATTORNEY-GENERAL HAMLIN: The first part of the answer is objected to, that sufficient evidence having been obtained, etc., down to the point where he commenced to state "A series of experiments," etc.

THE COMMISSIONER: Note that objection.

ATTORNEY GENERAL CROW: Just strike that out.

A. A series of experiments were conducted in June, July and August, 1901, by myself, Dr. Amand Ravold, assisted by Mr. George M. Ravold, as medium maker, to determine the length of life of the bacillus typhosus in samples of living water from the Chicago River, Chicago Drainage Canal, at Lockport, Illinois; Illinois River at Peoria; Mississippi River at the Intake.

Plan of procedure. Samples of water were collected at different times from the above points, and 200 cubic centimeters poured into sterilized Erlemeyer flasks, and corked with cotton stoppers. Some were exposed to sunlight, others kept in darkness at a temperature of about 16 degrees Centigrade,—60.8 Fahrenheit. Those exposed to sunlight were placed on a shelf in a window facing south, and the direct rays of the sun impinged full upon the western flask in the window, at 10:45 A. M., and left the flask furtherest east at 2:15 P. M. The total time of exposure daily being about three hours, approximately, and I have that in another table, upon which is recorded a table showing the hours of sunshine in the month of July, temperature of the water in the flask recorded daily at 10:00

752 A. M., and 2 P. M. I would like to record that all samples from Illinois River, Peoria, Pekin and laboratory tap, were turbid. Here is the table of sunshine—

ATTORNEY GENERAL CROW: You have no objection to the sunshine going into the record, have you?

A. It is important to the bacteriologists, to know how much sunshine they get.

JUDGE SPRINGER: The more sunshine the less bacteria.

A. Well, yes; then we have got the weather conditions and the number of hours of direct sunshine.

ATTORNEY GENERAL CROW: Then we will just insert that here.

The table is in words and figures as follows:

Date.	Temperature in Window.	
1902.	11. A. M.	2. P. M.
July 7,	36 c.	39 c.
“ 8,	36	38
“ 9,	34	39
“ 10,	24	36
“ 11,	23	37
“ 12,	22	35
“ 13,	22	35
“ 14,	25	38
“ 15,	25	39
“ 16,	25	38
“ 17,	25	40
July 18,	24 c.	34 c.
753 “ 19,	24	34
“ 20,	22	34
“ 21,	22	34
“ 22,	23	36
“ 23,	22	35
“ 24,	24	34
“ 25,	25	36
“ 26,	24	40
“ 27,	31	40
“ 28,	26	39
“ 29,	28	40
“ 30,	26	39.5
“ 31,	27	40.5

Number of hours of direct sunshine on water samples:

July 7,	Weather	clear	3 .30	hours,
July 8,	“	cloudy	2.15.	“
July 9,	“	cloudy	2	“
July 10,	“	clear	3.30	hours
July 11,	“	clear	3.30	“
July 12,	“	clear	3.30	“
July 13,	“	clear	3.30	“
July 14,	“	clear	3.30	“
754 July 15,	weather	clear	3.30	hours
July 16,	“	cloudy	0000	“
July 17,	“	“	.30	“

July 18,	"	cloudy	2.	hours,
July 19,	"	clear	3.30	"
July 20,	"	"	3.30	
July 21,	"	"	3.30	
July 22,	"	"	3.30	
July 23,	"	"	3.30	
July 24	"	"	3.	
July 25,	"	"	3.30	
July 26,	"	"	3.30	
July 27,	"	"	3.30	
July 28,	"	"	3.30	
July 29,	"	cloudy	2.	
July 30,	"	"	2.	
July 31,	"	"	2.30	

A series of trials—just simply say a number of trials were made with a number of special media for the purpose of finding the medium on which the typhoid bacillus would grow best, and we finally adopted two—Hiss' medium and Elsner's medium, prepared according to the following method—do you want to hear these methods?

Q. No, just in the usual manner.

A. No, it is not made in the usual manner; this is entirely original.

755 Q. Well then, just put it in.

A. Do you want to say that you will just simply enter into the record, or would you rather have me read this interesting thing?

ATTORNEY GENERAL HAMLIN: Yes, if it is different from what we have struck we want to know how.

A. We clean and scrape 1,000 grams of Potato, allowed to stand over night in a refrigerator; press out all juice in a meat press the next morning, filter while cold, through an absorbent cotton filter, and boil for five minutes. Filter through a cotton filter, titrate—The reaction should be three per cent acid to phenol phthalein; if too acid, enough water is added to make the reaction three per cent. If less than three per cent, evaporate until the required reaction is obtained. Add ten per cent gelatine and one per cent of potassium iodide. The gelatine is acid and will increase the acidity of the medium. Enough caustic soda is added to overcome the acid reaction of the gelatine and

leave the medium three per cent acid, titrate, and when proper reaction is obtained, heat in a water bath at boiling temperature three quarters of an hour; filter and allow to stand in a funnel over night in a refrigerator. In the morning cut off the sediment which has sedimented. Heat the filter tube
756 and sterilize for twenty minutes three days in succession, at 100 degrees centigrade. Into each flask of living water three loop-fuls of a typhoid growth on slant agar were sown, care being taken to remove none of the nutritive medium, in lifting off the growth, Elsner's medium, although the more difficult to prepare, was preferred, because of the distinctive character of the typhoid colonies upon it, besides it seemed to inhibit the growth of the number of saprophytic water bacteria. Every day one cubid centimeter of the inoculated water was plated in both Hiss and Elsner media. Hiss plates were incubated at 37 degrees Centigrade, for twenty-four hours and the Elsner's plates at 20 degrees centigrade for from two to four days. At the end of that time colonies were picked off on slant agar and inoculated. After twenty-four hours incubation the slant agar growth was studied for purity of culture, and if pure sown in broth, litmus milk and glucose agar. The growth in the broth culture was submitted to the Widal test after the following method: The blood serum used in this work came from the City Hospital through the kindness of Dr. W. C. G. Kirchner, and the blood was kept cold for several days, the serum bipetted off and dried on glass slides; it was discovered that quite a number of motile water bacteria agglutinated in this serum in dilutions as high as one to thirty. On
757 this account a series of tests were made with the dried serum, definite quantities weighed and mixed with normal salt solution in varying proportions, and it was found that in a dilution of one to one hundred and fifty, both the Wesbrook and Kirchner cultures would agglutinate firmly in one hour at 37 degrees centigrade. The Wesbrook and the Kirchner typhoid cultures,—two distinct cultures were used in the conduct of these tests. All suspected bacilli picked off the plates were made to conform to this test. Dilutions of one to one hundred and fifty in one hour at 37 degrees centigrade, otherwise rejected. The typhoid culture used in these experiments were number 1 from Dr. Wesbrook of the University of Minnesota,

said to have been found by him in the waters of the Mississippi River at Minneapolis, No. 2 came from a spleen sent in by Dr. W. C. G. Kirschner from a patient dead of typhoid fever at the City Hospital, and separated out in this laboratory July 8, 1902. It will be noted that the results of the two cultures are practically the same, in the following table—do you want to put the table in evidence?

Q. If you have nothing else to say about it; indicate what it is—what kind of water and where it is at?

A. This is all recorded here. The third period, 1901,
758 Longevity of the typhoid fever bacillus,—bacillus typhosus. Sample inoculated with the bacillus typhosus; the location is given, it is either in the window or in the ice chest. That is also recorded as we go down. Now first in the window, Illinois and Michigan Canal, Lockport, July 5, number of days that the bacillus lived was five. Drainage canal, Western Avenue, Chicago, Illinois, June 13th, longevity five days.

July 15, seven days.

Drainage Canal, Lockport, June 13th, four days.

July 5, eight days.

Illinois River above Peoria, June 13th, five days.

July 5th, ten days.

Illinois River, Pekin—

ATTORNEY GENERAL HAMLIN: Is the sun shining?

A. Yes, this is open window, sunshine.

July 11, eight days.

Illinois River Bridge, Pekin, June 13th, four days.

July 5th, ten days,

Chicago River, Adams Street, June 13th, four days.

Tap in the laboratory, St. Louis, June 13th, seven days.

Tap in the laboratory, St. Louis—

759 ATTORNEY GENERAL HAMLIN: This is all in 1901?

A. 1901. Tap in the laboratory, St. Louis, sample inoculated July 13th, lived twenty-four hours.

Chicago River, Adams Street, July 5th to 21st; water sample sterilized, the bottle was broken accidentally. On the 16th day the bacteria were still alive.

July 5th it lived sixteen days—or the bottle was broken on the sixteenth day. This is in the refrigerator. Temperature sixteen degrees Centigrade.

Drainage Canal, Western Avenue, June 13th, seven days.

July 5th, eight days.

Drainage Canal, Lockport, July 5th, ten days.

Drainage Canal, above the controlling works, Lockport, June 13th, lived nine days.

Illinois River, above Peoria, June 13th, ten days.

July 5th, thirteen days,

Illinois River water, Pekin, June 13th, eight days.

July 5th, twenty-one days;

July 17th, sixteen days,

Chicago River, Adams Street, June 13th, four days;

July 5th, seven days,

Tap in the laboratory, St. Louis, June 13th, twelve
760 days.

Tap in the laboratory, St. Louis, June 13, exposed to direct sunshine all day, in 100 degrees centigrade, flask lived twenty-four hours.

Q. ATTORNEY GENERAL CROW: That is 100 cubic centimeters.

A. One hundred cubic centimeters.

Chicago River, Adams Street, in sterilized water, July 5th, 23 days.

We have some for Drainage Canal, Lockport, July 17th, eleven days.

Drainage Canal, Jackson Street, Joliet, for July 17th, thirteen days.

Illinois River, Bridge, at Pekin, for July 17th, sixteen days.

Now the average number of days alive in the window we have two columns here, one in the window and one in the refrigerator.

Q. This is in what kind of water?

A. This is in the sterilized water.

Q. Well, in the natural water?

A. In the natural water. Illinois and Michigan Canal, Lockport, average number of days alive, five, in the window; no record in the refrigerator.

761 Drainage Canal, Western Avenue. In the window, six days; in the refrigerator seven and one-half days.

Drainage Canal, Lockport, in the window four and three-fourths days; in the refrigerator ten and two-thirds days.

Drainage Canal above controlling works, Lockport, average number of days alive in the refrigerator nine days.

Drainage Canal, Jackson Street, Joliet, average number of days alive in the window, nine days, and in the refrigerator thirteen days.

Illinois River above Peoria, average number of days alive in the window seven and two-thirds days; in the refrigerator eleven and one-half days.

Illinois River water, Pekin, in the window, seven days. In the refrigerator fifteen days.

Chicago River, Adams Street, in the window, four days; in the refrigerator, five and one-half.

Tap in the laboratory, St. Louis, seven days in the window and twelve days in the refrigerator.

Chicago River, Adams Street—this is now sterilized water, average number of days in the window, sixteen days.

Drainage Canal, Lockport, average number of days alive in the refrigerator, 23.

I have the averages of the results in the steriled waters for the period of 1900, if you care to put that in.

762 Q. Of the typhoid bacillus?

A. Yes, for the 1900 period.

Q. Beginning in January and ending in October?

A. No, that was in June, July and August.

Q. Where did you get that culture from?

A. That culture was a culture obtained from Dr. Wyatt Johnson of,—I think he is at Montreal; he was at Montreal, Canada.

Q. You can put that in there if you want to?

A. I have given you the average number of days. I will give you the days, yes sir, but the average is also worked out here.

Q. Well, give us the average, that is for 1900, is it.

A. Yes sir.

Q. These are all laboratory experiments?

A. Yes sir. Above results average allowing the period of

65 days for this culture life when this work stopped, would be as follows:

Average of results, conditions of light and temperature—there are two columns here, the first one is at ten degrees centigrade, and the second one at 20 degrees centigrade. That was in total darkness. Then one at the open window.

First, sterilized distilled water, and the number at ten
763 degrees Centigrade, was, "A" lived 33 days; B 35 days;
C 31 days.

Sterilized Mississippi River water, from Grafton, A 55 days; B 52 days; C 57 days.

Sterilized Illinois River water, Lockport, A culture 44 days; B culture 58 days; C culture 31 days.

Sterilized Missouri River water, Bellefontaine, A culture 55 days; B, 62 days, C, 65 days.

Sterilized Mississippi River water at the Intake, A culture 51 days; B culture 54 days; C culture 52 days.

Q. Now doctor, these are all laboratory experiments?

A. Yes sir.

Q. Now are conditions favorable or unfavorable for the longevity of bacilli of any kind in a laboratory experiment, either in sterilized or non-sterilized waters, or the natural waters?

A. Well from those results, they would seem to be favorable, in the sterilized waters and unfavorable in the stagnant living water in the bottle.

Q. Now compared with the conditions in a running stream, or living water, Illinois River, Missouri River or the Mississippi
River, where oxidation is taking place and full of organic,
764 animal and vegetable substances, would the conditions for
longevity for typhoid bacillus be greater than it would be in any laboratory experiments, what would you say about that as a bacteriologist?

A. It is impossible to carry out in a laboratory experiment the conditions which obtain in a running stream, but the conditions in a living water in a flask in a laboratory experiment, the bacteria are there in evidence, all the bacteria in that particular water each of which produces a particular toxin or toxins, which is either favorable to or deleterious to the life of the typhoid bacillus also the contained infusorial life, so that in a flask in the living water in a very short time the toxins produced by the micro-organisms that are at work, seem to act unfavorbly upon the typhoid bacillus placed in that water. In steriled water, the typhoid lives, you see, quite a number of days. Now what obtains in a running stream would seem to be this, that the typhoid bacillus would not be subjected to the poisons produced by other bacteria, so much as it would be in the stagnant water in a flask. In the running stream it certainly would not be confined to a given water; because it can swim about and also be carried along by the running stream, so that its chances of prolonged life would be, it seems to me, vastly greater.

Q. Well is there more or less food supply for bacteria in the running water?

765 A. I don't see where that cuts any figure in these experiments. I find that in steriled, distilled water, the typhoid bacillus lives for a long time. There is no assertion here made that the typhus bacillus lives and multiplies in the water. It simply remains dormant until its life history is over, unless in the meanwhile it reaches a favorable condition, for growth and multiplication.

Q. The death of the typhoid bacillus in running water is due to toxins produced by bacteriological conditions that exist there?

A. I don't know that.

Q. How is it in water, in a bottle?

A. I think so.

Q. You think it is?

A. Yes sir.

Q. Well, is there anything that leads you to believe from your experiments as a bacteriologist, that any other cause, produces its death in the running water?

A. It lives out its period and dies after a time.

Q. Is its period of longevity definitely known in running water?

A. No sir.

Q. Is it possible to ascertain that?

A. Well, I have been racking my brains for two or three

766 years to try to devise a scheme for ascertaining its longevity in running water, but I have never succeeded yet; however it never has been done.

Q. I say, up to this time,—up to this time bacteriologically it has not been found how long bacilli will live in running water.

A. No sir, not in a running stream.

Q. The distance they would be carried, according to what men know of the longevity now, from bacteriological experiments, would depend entirely on the rapidity of the flow of the stream?

A. Yes, sir.

Q. In the flood tide of the Illinois and Mississippi rivers, if typhoid bacilli came down from the Chicago river and emptied it in the Illinois river, they would come into the Intake tower much more rapidly than they would if the waters were low?

A. Yes, sir.

Q. Now, do you know from your own knowledge anything about how long it takes, water to come from the dam at Lockport or from the canal there in Chicago, the Chicago river, down to the City of St. Louis?

A. I do not. AMAND N. RAVOLD.

Adjourned until ten o'clock following morning, Thursday, February 26, 1903.

Southern Hotel, St. Louis, Missouri,
767 10:00 A. M., February 26th, 1903.
Continuation pursuant to adjournment.

Present, the Commissioner, and same counsel representing the respective parties.

By consent of counsel on both sides, Dr. Amand N. Ranvold is withdrawn from the stand, and the State of Missouri, the Complainant, by Attorney General Crow of Missouri, proceeds to examine

BENNEZETTE WILLIAMS, who

called as a witness in behalf of the complainant, after being first duly sworn by the Commissioner, testified as follows:

DIRECT-EXAMINATION,

By Attorney General Crow.

Q. What is your name?

A. Benezette Williams.

Q. Now, Mr. Williams, where do you reside?

A. I reside near Chicago. My business is in Chicago.

Q. What is your occupation?

A. My occupation is civil engineer and consulting engineer.

Q. How long have you been residing in Chicago?

768 A. For thirty years.

Q. How long have you been following your profesion?

A. About thirty, thirty-one or thirty-two years.

Q. Are you familiar with the geography and the location of the City of Chicago?

A. I am very familiar with it.

Q. Will you just describe the geographical condition there of Chicago, with reference to the Lake and the Chicago River and also the geographical condition of the Chicago River with reference to the City.

A. The geographical condition can best be shown by the map, but the topographical condition—

Q. Perhaps that is what I mean.

A. Chicago lies very low. The elevations of the ground within the city of Chicago with perhaps, but one minor exception, you may say, is from the lake level to a height of about 25 feet above the lake level, and a very large portion of the city lying but a few feet above the lake level, both the old central portion of the city and other portions, so that the process has been in the settled parts of the city, to raise the grades in order to get the depth to cover their sewers, and to get sufficiently out of the mire, you might say. That is to fill the streets
and raise the grade of the street above the original surface
769 of the ground. In other portions of the city they are over-
coming that difficulty now by building sewer districts; building the sewers in districts and pumping the sewage. That is, they build sewers below the lake level and pump a flow.

Q. What do you mean by pumping a flow?

A. Well they put in pumps at the outlet of the sewer and pump the sewer.

Q. Pump the sewer back to the lake level?

A. To the lake level or to a point of discharge.

Q. What is the original character of the principal portion of the soil on which the city of Chicago is built, with reference to whether it is soft, or marshy or firm foundation?

A. It is reasonably firm soil. The greater portion of the City of Chicago is clay soil, overlaid of course with prairie soil originally.

Q. What is the character of that; is it a loamy soil?

A. A soft, loamy soil.

Q. Free of stone?

A. Yes, free of stone.

Q. Any gravel?

A. No gravel in the surface of loamy soil. You find stone in the underlying clay. It has a glacial portion. Clay has what we term a glacial portion, and it is more or less filled with stone; that is boulders in size sometimes larger and sometimes 770 cobble stone size, and a gravel material to a greater or less extent. In some places you will find this clay quite pure, with very little of that with it. In other places you will find almost a complete mass of boulders cemented together with clay; then another portion of the city lying directly along the lake at a certain depth consists of this same clay, but it is overlaid with a sand ridge, a ridge has been formed by the flowing up of the lake and the washing and blowing of the sand into the ridges. That is close to the lake, however, and none of that occurs at much distance from the lake.

Q. What proportion of the surface of the city limits of the City of Chicago is on the lake level or below the lake level?

A. Well, but a small portion is as low as that, but there are a great many square miles that are so low that you have to pump in order to get drainage.

Q. Now with reference to the fact as to whether or not without regard to the level (whether on the lake level or above it,) but the surface of the ground itself—is it rolling or flat?

A. It is flat apparently, in its natural condition. It would seem like a dead level, with the few exceptions of these sand ridges.

Q. Have you any idea what distance above the level of 771 Lake Michigan the majority of the land on which Chicago stands would lie?

A. Yes sir.

Q. Please give me that.

A. The greater portion of it would be about 12 or 14 feet above the low water of the lake, what you call Chicago datum.

Q. About fourteen feet?

A. Yes sir.

Q. Now will you describe the Chicago River and its various branches with reference to the city and the sources originally of the rivers, the river or branches thereof; also the points into which the river emptied.

A. The Chicago River and in fact all of the rivers that empty into the lake along the southern and western portions of Lake Michigan, you may say, have been formed as the Lake Shore—as the water receded, and the lake shore was built up so that they have been formed, so that they run parallel with the lake. They have been shut out from the lake as the waters receded, by ridges of sand or drift, or something that has come in and left them running parallel with the lake. That is a peculiarity of that portion of Lake Michigan. There are no rivers
772 reaching back into the country and discharging directly
into the lake in the ordinary form of drainage, but the rivers are all parallel, with occasional points where they break through the obstruction into the lake, and hence they are rivers of minor importance, only covering a few square miles of drainage territory tributary to them. The Chicago River proper is short, originally not over a mile long from the lake back to the confluence of the two forks one leading from the south and one from the north; the southern fork called the south branch and the northern fork called the north branch. The northern branch really drains the most territory and from a district of higher elevation somewhat as its source, which is in the State of Wisconsin. The south branch at a distance of about five miles from the lake, as it originally existed, has two branches, one known as the west fork, and the other as the south fork. Those branches—the south fork draining a very limited territory, wasn't much, you could hardly call it a stream except in floods. The west fork only drained a small territory also, except as the flood waters of the Des Plaines River at a distance of about nine or

ten miles from the lake would break over and come down the west fork of the river; then that would become a large stream.

The Des Plaines River is another stream running parallel
773 with the lake, but it is more remote from the lake.

Q. Where was the exit of the Des Plaines River naturally?

A. The upper Des Plaines river heads in Wisconsin and flows southward until it comes to South Chicago, and about ten miles distant from the lake, when it turns southwest and joins the Kankakee, below Joliet, forming the Illinois River.

Q. Is there a watershed between the Des Plaines and the South Branch of the Chicago River?

A. Yes sir. That is, you mean—

Q. That divided the waters?

A. Yes sir, there is a divide. That is, the Des Plaines never flows into the Chicago River except at one point, at the point where it turns southwest to the Illinois River, it has always within recent geological times, at high stages flowed both ways. It would divide, one portion going to the southwest; the other portion going to the east and through the Chicago River to the lake.

Q. How close in the ordinary stage of the water is this point on the south branch of the Chicago River and the Des Plaines River, where at flood time of the Des Plaines there is an overflow both ways to the southwest and into the lake, from the Chicago River?

A. I don't catch you question.

774 Q. I want to get the distance between the Des Plaines
River and the Chicago River, at the point where you say the Des Plaines at flood tide sometimes empties itself into the Chicago River?

A. Well the distance to the extremity of the west fork of the Chicago River, of the south branch of the Chicago River was only a very few miles, and really, within thirty years you may say it has been practically connected with the Des Plaines River. They built out there, that is, they cut a ditch, the land owners did, and absolutely tapped the Des Plaines River and drew it to Chicago, even at low water, until the city went and built a dam and shut that off and restored the natural condition.

Q. Is that in the city limits of the City of Chicago?

A. No sir, that is outside of the city limits and the distance from the present city limits is about three miles and a half.

Q. Now as to the north branch of the Chicago river; where does it take its origin?

A. Well, I cannot answer that exactly now.

Q. Well, approximately, do you know?

A. It couldn't be over twenty or twenty-five miles.

775 Q. What is the natural volume of that stream of water, about what size river is it?

A. That depends on the conditions of the floods.

Q. I mean in the ordinary stage?

A. In the ordinary stage it is not large, and in extremely dry weather it disappears practically.

Q. That is the north branch?

A. Yes, practically so. In high floods it has been gauged. We have had floods there that discharged about 210 cubic feet a minute in the North branch.

Q. That is a pretty good sized volume of water?

A. Yes, it was quite a volume of water at that time.

Q. Could you give me an idea of about how wide the stream is at the city of Chicago?

A. Well that is a harbor now; it has been dredged and docked.

Q. Do you know what is was originally?

A. No, I couldn't say.

Q. You didn't see it originally?

A. I didn't see it originally.

Q. The stream has been widened now?

A. Yes sir, widened and deepened.

Q. Widened and deepened by dredging?

A. Yes sir.

776 Q. Now has it been dredged and docked any since you have been in Chicago to your knowledge?

A. Yes sir. As you go further up the stream you will find the stream where it is in its natural condition.

Q. Outside of the limits of the city of Chicago?

A. Even within the limits of the city of Chicago.

Q. Now at that point where it is in its natural condition have you any idea of the volume of water that flows in the ordinary water stage, and the speed of the current?

A. I just gave you that. At low water it is practically dried up.

Q. But in the ordinary stage of water?

A. I have no gaugings at ordinary stage, I could not say. I have an idea, it is very small at the ordinary stage.

Q. Have you any estimate of the amount of flow and the speed?

A. You are wishing to get at the speed of the flow, in the lower portion of the river proper?

Q. No sir, I am asking you up there now.

A. Up there (indicating on the map)?

Q. Yes.

A. No sir, I cannot give you that, I haven't got the data for that.

Q. Now have you any idea of the speed of the channel between where it has been dredged and docked in the central
777 portion of the city?

A. It varies from a rapid current in high stages to no perceptible current at all.

Q. In ordinary water stages?

A. In ordinary times. It is modified, however, by some artificial work that has been done by the city, pumping works connected with it.

Q. Where are the pumping works?

A. They are at Fullerton Avenue.

Q. Well, what is the character of these works, and what is the effect of it upon that north branch?

A. There is a conduit extending from the lake to the north branch on Fullerton Avenue, twelve feet in diameter, and a pumping works connected therewith.

Q. Are the pumping works at the lake?

A. It is at the river, but the conduit is below the lake, so that it acts the same as if it was at the lake. It don't matter what end the pumping works is at, it merely takes the water from the conduit and throws it into the river.

Q. Pumps it up into the river?

A. Yes sir.

Q. What is the volume of the water?

A. The capacity of those works, when running to the
778 usual working capacity, is 15,000 cubic feet a minute.

Q. Fifteen thousand cubic feet a minute?

A. Yes sir, for the pumps.

Q. When was that pumping station at Fullerton Avenue built?

A. That was done about 1879, that is, the pumps were put in. The conduit was built—it took several years to build it, previous to that.

Q. Where does that conduit strike the lake?

A. It strikes the lake on the shore through Lincoln Park; on the shore of Lincoln Park.

Q. Well, with reference to the northern and southern lake front of the city?

A. Well it strikes the north shore.

Q. The north shore?

A. Yes sir.

Q. Is it in or adjacent to a densely populated portion of the city?

A. Yes, quite densely populated.

Q. In which direction does that conduit extend?

A. It extends west from the lake to the river, directly west.

Q. How far is that distance, do you know?

A. Twelve thousand feet.

779 Q. Is that conduit in operation with the pumping works now?

A. Yes, at intervals, sometimes it isn't working.

Q. What was the effect of that upon the water in the north branch of the Chicago river?

A. The effect of it was to flush the river out to a greater or less extent, depending upon the amount of water put in.

Q. When flushed out where did it empty?

A. It emptied at the confluence of the south and west branch of the river.

Q. And from thence into Lake Michigan?

A. Into Lake Michigan, except as it went down the south branch due to a change of the regimen of the river.

Q. There was no change in the river until the opening of what is known as the Chicago Drainage Canal?

A. Yes sir.

Q. There was?

A. Yes sir, for thirty years.

ATTORNEY-GENERAL HAMLIN: For how many years?

A. For thirty years or thereabouts, there has been a flow through the south branch, southwest to the Illinois & Michigan Canal.

Q. To the Illinois & Michigan Canal?

A. Yes sir.

780 Q. Now which is the larger, the south branch or the north branch of the Chicago river?

A. The north branch carries the most water.

Q. In its natural state?

A. In its natural state, except as I say, in the Des Plaines river flood. As far as the size goes, in the rivers, as they stand today, perhaps there isn't much difference; they have been docked and dredged to the same depth and width.

Q. Now are you familiar with the amount of deepening that was done in the north branch of the Chicago river by dredging?

A. Only in a general way. I know that the government has dredged there, and the city and the dock owners. There has been a continuous process of docking it and bringing it to the usual depth there, extending upward all the time, as there has been a demand for property.

Q. How far is it from the confluence of the south branch and the north branch of the Chicago river to its exit into Lake Michigan?

A. I suppose before the canal was in operation, as it exists today, that is, with the piers that have been extended out into the lake, and caused a channel, it is about, I think, 7,400 feet. I have the exact distances here somewhere.

Q. Seventy-four hundred feet?

A. I will give it right. It is 7,113 feet.

781 Q. Now how far out into the lake, beyond the natural opening of the river, has the present opening been extended by artificial means, such as piers, etc?

A. I cannot answer it exactly.

ATTORNEY-GENERAL HAMLIN: Do you mean out into the lake?

Q. Yes, out into the lake.

A. Nearly half of that distance is an extension from the original. That is in the state of nature before they had any other.

Q. Now, has there been a filling in of the lake front at the mouth of the Chicago river with soil, debris, etc.?

A. Yes sir. I would explain that the mouth of the Chicago river was at one time, nearly half a mile south of where it is now. It turned south. It didn't change the river where it was naturally, you may say, from Rush Street to the confluence of the forks, and at that point it turned south and entered the lake nearly half a mile south of where it is now. There was a bar existing there at what is now the outlet. They cut through that and have filled that old channel of the river.

Q. South of the river?

A. South of the river, what was the old channel of the river, and they have been filling continuously more or less, and are today, out into the lake.

782 Q. Now how far up into the city of Chicago is the north branch dredged and docked?

A. I couldn't say positively, I think about four miles from the conjunction of the main river, but it is being dredged up as far as Lawrence Avenue.

Q. And how far would that be?

A. It would be about six miles above the river.

Q. Six miles from the confluence of the two branches of the Chicago river?

A. Yes sir.

Q. Now up as far as it is dredged and docked at the present time is it opened for shipping?

A. Yes sir.

Q. Is it used for shipping?

A. Yes sir.

Q. Have you any idea of the depth of the North branch of the Chicago river at that point?

A. It is very near fifteen feet.

Q. Fifteen feet?

A. Yes sir. Sixteen feet has been about the deepest they have dredged up to within a few years.

Q. Now you talked about the Lawrence Avenue conduit, what kind of a conduit is that?

A. I said Lawrence Avenue.

783 Q. Well, is there a conduit there?

A. Yes sir, there is a conduit at Lawrence Avenue partially—it is not done yet; it is being built.

Q. Being built now?

A. Yes sir. You may say it is in process of building. It was begun some years ago, and progressed to a certain point and then there was difficulty with the contractor, and at present it is tied up.

Q. Who has been building it?

A. There is no work being done on it. The city of Chicago is building it.

Q. The city of Chicago or the Sanitary District?

A. The city of Chicago.

Q. Do you know the size of that conduit?

A. Yes sir.

Q. What is it?

A. It is sixteen feet circular inside.

Q. Does it connect with the lake, or will it?

A. It will connect with the lake and extend across to the north branch of the river, similar to the manner of the Fullerton Avenue conduit.

Q. And it is in the northern portion of the city of Chicago?

A. Yes sir.

784 Q. What is the design of that conduit?

A. That conduit is to take away by means of a system of intercepting sewers the sewage that now discharges into the lake along the north shore over to the north branch of the Chicago river, and it is also to take the supply of water from the lake to the north branch.

Q. With the view of emptying that sewage into it?

A. By means of the pumping station.

Q. Into the North branch of the Chicago river?

A. Yes sir.

Q. Which now goes into Lake Michigan?

A. Yes sir.

Q. Now let us go down to the South branch of the Chicago river; where does the west fork of the South branch of the Chicago river have its origin with reference to the city of Chicago?

A. It has its origin, putting it by streets, very near to Ashland Avenue and Thirty-first Street.

Q. In the limits of the city of Chicago?

A. I want to correct that. I should say Ashland Avenue and 26th Street. Yes sir, in the limits of the city of Chicago.

Q. Now in what general direction does that West fork naturally flow?

A. Why it flows only one way; that flows to the east.

785 Q. To the east or northeast?

A. Well, slightly to the north.

Q. Well, does it flow in that direction now?

A. Yes sir.

Q. Now how does the volume of water in that compare with the volume of water in the North branch of the Chicago river?

A. It is less for ordinary times, but more at other times. That is, there have been, especially in the past, before there were any changes in the conditions of the river, flood waters of the Des Plaines which have overflowed into that river, and swelled that river to a greater volume than the North branch.

Q. Well, at what particular time does the West fork carry more water than the North fork, aside from any artificial interference that has been made with it?

A. At high floods of the Des Plaines.

Q. Where the Des Plaines overflows, breaks over and connects with it?

A. Yes sir.

Q. Does that happen now?

A. Yes, but to a somewhat reduced extent. A flood must now be higher than in the past, in order to furnish the supply to the North branch, but in very high floods it still furnishes a large amount of water there.

Q. Do you know anything about the speed of the current 786 naturally, in the West fork of the South fork of the Chicago river?

A. There is very little, almost no speed.

Q. An almost imperceptible flow?

A. Yes sir.

Q. Is the West fork of the South branch dredged and docked at all?

A. Yes, for a considerable distance.

Q. Above the confluence of the South branch of the West fork?

A. Yes sir.

Q. How far?

A. Well, I should say two miles more or less.

Q. Do you know anything about how far it is from the confluence of the South branch of the Chicago river and the West fork of the South branch, down to the exit of the river, or what was the exit of the Chicago river into Lake Michigan?

A. Repeat that question.

Q. Do you know what the distance is from the confluence of the two branches of the South fork of the Chicago river to what was formerly the mouth of the Chicago river at Lake Michigan?

A. Yes sir, it was about five miles.

Q. Now where is the origin of the south fork of the South 787 Branch of the Chicago River?

A. Its origin proper is three miles south of its confluence with the South Branch and it was, you might say, merely gullies leading into a larger channel, it ran out into the prairies. It was practically no river at all.

Q. Connected with what is known as the west fork?

A. Yes sir, that's right.

Q. The drainage area of it was originally open country was it, or prairie?

A. Yes sir.

Q. With a rolling or flat surface?

A. A flat surface.

Q. Now what was the volume of water in that in its ordinary stage compared with the volume of water in the west fork?

A. There was no water in the ordinary stage. It was only a storm water drain.

Q. That is, you mean by that, when there is a precipitation of rain on the drainage area, tributary to it, the water would run down?

A. That was the out-flow from storm water, and that ran off in a short time and disappeared.

788 Q. Now at this time is the south fork of the South Branch of the Chicago River dredged and docked any?

A. Yes, to the stock yards.

Q. Now how far is that from the point of confluence of the west and south forks of the South Branch of the Chicago River?

A. It is one and a half miles, but I think a little more than that.

Q. Is that open now up through to that point? Is it dredged and docked for shipping?

A. Yes sir.

Q. What is the volume of water in there; I mean the depth of it?

A. That isn't far from the usual depth of the river; I expect about fourteen feet. Lake vessels can pass in it there to the stock yards; that is, they did do it.

Q. Now you say the stock yards are located there; when you say that what do you mean? Do you mean to say the principal stock yards of the city of Chicago?

A. Yes sir the stock yards and the slaughter houses.

Q. Do you mean the packing plants?

A. The large packing houses are located there.

Q. Do you know the names of the packing plants?

789 A. All of the live stock that goes into the city of Chicago goes to those stock yards, except some that goes, perhaps to Hammond, Indiana. That goes through the City to Hammond, Indiana, near by. That is where the packing plants are located.

Q. Is there any connection at the present time between the south fork of the South Branch of the Chicago River and Lake Michigan, other than up through the South Branch of the River?

A. No sir.

Q. Has there a conduit been built down there at any place?

A. There is a conduit that has been built from what we call the east arm of the south fork; that arm is merely a slip dredged out for docks—or laid out for docks.

Q. A slip for ships?

A. Yes sir, and there is a conduit built from there to the lake twenty feet in diameter.

ATTORNEY-GENERAL HAMLIN: Did you locate that conduit?

A. No sir, I did not; I say I did not; not at this time; I figured on conduits there some years ago.

ATTORNEY GENERAL CROW: You know where that conduit is located?

A. Yes sir.

Q. Do you know for what purpose it is used?

A. It is not used at all; it is to be used to carry sewage
790 from the district, from Lake Michigan on the south shore, and south side, to the stock yards slip, and to take the sewage in from the lake to the stock yards.

Q. To the stock yards? For what purpose was it taken?

A. It is to be taken in for the purpose of supplying water to the river and flushing that south fork, that is, purifying it, putting in better and making it better, in a sanitary way, and of furnishing water to the Drainage Canal.

Q. Do you know the capacity of that conduit?

A. The pumps are being built there for a capacity of 120,000 cubic feet a minute.

Q. That is to be a large conduit there; larger than the Lawrence Avenue conduit, or the Fullerton Avenue conduit?

A. Yes, it is twenty feet in diameter.

Q. It isn't finished yet?

A. The main conduit is finished; they are cleaning it out now.

Q. Are the pumps at work?

A. No sir, the pumps have not been built yet.

Q. Do you know when it is proposed to open that?

A. No one knows exactly; you can only estimate it; probably in the course of a year.

Q. Do you know the length of that conduit down there?

791 A. That is close to 12,000 feet.

Q. Something over two miles?

A. Yes, something over two miles.

Q. Do you know whether the channel of the south fork of the south branch of the Chicago River has recently been deepened?

A. Yes, there has been dredging going on there. Dredging especially up to the mouth of this conduit, or the outlet of this conduit that is to be.

Q. Within what period of time?

A. Within the past year.

Q. Do you know the extent of the deepening of that channel?

A. No, not exactly.

Q. Approximately, do you?

A. Well, they are certainly deepening it. They must have deepened it in the neighborhood of twenty feet. They are deepening at least at the outlet of this conduit, to the bottom of the conduit, which would be over twenty feet.

Q. That is, it would make over twenty feet of water level in the south fork of the south branch of the Chicago River?

A. At that point at least, the outlets usually carry that depth of water.

Q. Do you know anything about the rate of flow in the south fork of the South Branch of the Chicago River at this time?

A. There is no flow in it except as comes from the sewage
792 discharged into it and from the various sewers that connect with it?

Q. What do you mean when you say there is no flow except what comes from the sewer that is discharged into it?

A. Well I mean this; you might say this is an arm of the river extending out, without any drainage area to it, except what comes from the sewers, and any sewage or stream sewage entering the south fork from those sewers, will finally pass into the Chicago River,—the south Branch of the Chicago River.

Q. Well, is that a perceptible flow in that South Branch?

A. Many times it wouldn't be perceptible at all, with variations of the wind or the lake or something of that kind. Which would make it flow up the other way sometimes. However, there is a working out of the contents of the south fork.

Q. Now do you know how much territory there is in the city limits of Chicago that is drained by sewers?

A. No, not in that form. Answering the question in that form I do not. I can give you how much territory there is in the City of Chicago, and how the sewerage goes. How the sewers are built; into what points they empty, and the population of the various sewer districts.

Q. What I was trying to get at was, what was the amount of surface within the territorial city limits of the City of Chicago?

A. That I cannot give you exactly. The area of the city 793 of Chicago is 190.6 square miles.

Q. Do you know the area of what is known as the Sanitary District of the city of Chicago?

A. Yes, it is 185 square miles.

Q. Were you ever connected with the Sanitary District of the City of Chicago?

A. Yes sir.

Q. At what time and in what capacity?

A. After the Sanitary District was formed, that is, after the legislation establishing the Sanitary District Board, I was chief engineer of the work from January, 1892, to some time in 1893, about a year and a half.

Q. You were the first civil engineer then?

A. No sir, I was not the first; there were several before.

Q. Well, in your capacity as engineer did you have charge of the work?

A. I did.

Q. Was there any superior officer in your department above you?

A. No sir, none but the Board. I reported directly to the Board.

Q. You became in that way, familiar with the territorial 794 limits of the City of Chicago?

A. Yes sir.

Q. Now has that area of territory been enlarged or diminished any since that time?

A. No sir, it remains just as it was established.

Q. The same now as then?

A. Yes sir.

Q. Now will you please tell me how the territorial area of the Sanitary District of Chicago lies with reference to the territorial limits of the City of Chicago?

A. The Sanitary District of Chicago is bounded on the north by Devon Street.

Q. In or outside of the city limits of Chicago?

A. Partly in and partly on the borders of the city limits.

Q. The northern limits?

A. Yes, the northern limits partly, and partly Devon Street. The North Sanitary District boundary line is south of a portion of the city of Chicago. The City of Chicago extends beyond the lines and it is bounded on the south by 87th Street.

Q. In or outside of the City limits?

A. In the City of Chicago for most of the way and following 87th Street outside of the city for a distance of three miles.

And it is bounded on the west in a general way by Harlem
795 Avenue. The Western boundary is somewhat irregular.

Q. Is that in or out of the city?

A. This is shown on this map that is before you, by a yellow shading—

Q. (Question repeated).

A. That is out of the city. That is, the western boundary is beyond the boundary of the city for a part of the way. It conforms to the boundary for about five miles.

Q. Now where is the eastern boundary?

A. It is Lake Michigan.

Q. That is concident with the boundaries of the city limits?

A. No sir.

Q. It is not?

A. No sir.

Q. What is the difference?

A. There is a part of the city that lies south of 87th Street.

A. Yes sir.

Q. Then it concides with the city limits from Devon Street on the North to 87th Street on the south?

A. Yes sir.

Q. Then the territory lying south of 87th Street and on
796 the lake front is not in the Sanitary District?

A. No sir, it is not in the Sanitary District.

Q. Now do you know how much area surface there is outside of the Sanitary District in the limits of the City of Chicago?

A. I said the area of the Sanitary District was 185 square miles. Of that area 141.8 square miles is within the city limits of the City of Chicago.

Q. At this time?

A. At this time. And 43.2 of it lies outside of the City limits.

Q. Now that portion outside of the city limits of the City of Chicago, where does it lie—in the state of Illinois?

A. Yes, it lies in the State of Illinois, and Cook County, just west of the City of Chicago.

Q. Now how far is it from the southern boundary of the Sanitary District of the City of Chicago, to the Indiana state line?

A. Well, the Indiana State line runs north and south at right angles to that southern boundary.

Q. At exact right angles?

A. At exact right angles, yes sir.

Q. I thought it ran in triangular shape?

A. No sir, it runs at exact right angles, or following the lake shore. There is the lake front between the two, a direct north and south line for two miles.

Q. That's what you make it?

797 A. Yes sir, following the lake shore it is a little more than that.

Q. Now do the city limits of the city of Chicago join the western boundary of the State of Indiana at its northern limit?

A. The eastern limit of the southern part of the City of Chicago joins the state of Indiana.

Q. The western and northern boundary line of the State of Indiana?

A. It joins the western boundary line of the State of Indiana.

Q. It is connected with the line that runs up to Lake Michigan?

A. Yes sir.

Q. And the city of Chicago is built on the Lake front, up to the point where the northern line of Indiana strikes Lake Michigan?

A. Yes sir, and south of that.

Q. Yes, but it is built up to that point north?

A. Yes sir.

Q. Now how far is that on the Indiana state line—how
798 far does the City of Chicago run?

A. From where the Indiana state line strikes Lake Michigan to the Southern boundary line of the City of Chicago is four and one-half miles.

Q. Four and one-half miles?

A. That is, the eastern boundary line of the city of Chicago conforms to the western boundary line of the state of Indiana for a distance of about four and one-half miles.

Q. Now going to the northern and western portion of the City of Chicago, how far is it from the city limits on the west of the City of Chicago to the Wisconsin State line?

A. That wouldn't reach Wisconsin.

Q. It wouldn't reach Wisconsin?

A. No sir, Wisconsin is north, immediately north, directly north, not immediately north.

Q. What is adjacent to Cook County on the west?

A. DuPage County; that is, for a part of the way. Cook County is a very long county, and Will county adjoins it.

Q. What lies immediately north of Cook County?

A. Lake County, Illinois.

Q. Does that touch Wisconsin?

A. That goes to the Wisconsin line.

Q. Well, the Des Plaines River in running northwest,
799 runs into Will County?

A. It passes through Will County, yes.

Q. And into Wisconsin?

A. Yes, but of course that is the reverse way from which the river runs. It heads in Wisconsin and runs south.

Q. Of course it comes south, but I am now ascending the river.

A. That's right, you pass Will County then into the territory of Wisconsin. No, I beg your pardon, change that. It is Lake County, not Will County. Wherever I said Will County I should have said Lake County.

Q. Now as engineer of the Sanitary District of Chicago did you become acquainted with the sewer system of the City of Chicago at that time?

A. Yes, but I became more acquainted with it when I was in charge of the sewers and when I was City Engineer of Chicago.

Q. When were you city engineer of Chicago?

A. I was City engineer of Chicago in 1878 or 1879, I have forgotten which, about that time.

Q. For two years?

A. Not two years. I was in charge of sewers for several years before that.

800 Q. So that you are familiar then with the sewer system of Chicago?

A. Yes sir.

Q. Now in your profession as civil engineer, it has been principally your business to study the building of sewers?

A. Yes sir.

Q. And the out-fall for sewers, and the manner in which they had to be constructed?

A. Yes sir, I have done a great deal of sewer work.

Q. Are you familiar with the sewer systems of different cities in this and other countries?

A. In a great many of them I am.

Q. Are you familiar with the city sewer systems in this country?

A. I laid out sewer systems, plants for the sewer systems in a great many cities in this country, and others, and I merely know their general manner of drainage, that's all.

Q. You have inspected some of them?

A. Yes sir, somewhat.

Q. Now are you familiar from a professional standpoint, with the adaptability of the sewage disposition of the sewage matter of the City of Chicago as compared with the relative sewage disposition of the same amount of sewage in other cities, as large or the same size in this and other countries?

A. Yes sir.

801 Q. Now what would you say as to whether or not the City of Chicago from its topographical and geographical location, is naturally adapted to the easy disposition of its sewage system as compared with that of other large cities or cities of the same size?

ATTORNEY GENERAL HAMLIN: I object to that question on the ground that it has no relation to the issues here made by the bill and answer.

THE COMMISSIONER: You can answer the question. The objection is passed on by the Court.

A. It depends on what you term the disposition, in that way. The sewers of the City of Chicago were originally built—it was very small. The territory was low-lying and the sewers used not extremely deep, and discharged into the river for the most part and part of them into the lake. It was not a complicated problem in its original inception except in the matter of grades to give to the sewers. That was a matter that had been considered and was considered a great deal by the engineer who inaugurated the system in Chicago. He went to Europe. As to whether in these long stretches of flat country he could build sewers and keep them under ground, and have the grades steep enough to carry the sewage away properly, and finally a system of grades was established and used. That was what might be called unprecedently low; that is, the inclination was very slight.

Q. Now that sewer system—

802 A. Now that wasn't a difficult thing, only it was somewhat of a doubtful thing, that's all.

Q. Now that was caused by the level surface of the ground on which Chicago was built?

A. Yes, and the long distances you had to traverse with the sewers.

Q. Now is there any great extent of natural drainage in the City of Chicago?

A. Well, you may say that of a territory when it has some slope to some point or other, but still in its natural condition water would flood it and in streams, and stay flooded a good while, but you could and did adapt or fix the sewers to a natural slope to a certain extent.

Q. What I am trying to get at is, whether the natural condition of the ground there—was there a good drainage surface on the surface of the ground?

A. Well the surface was practically prairie soil. No, there is not a good drainage, of course not for a long distance run. You had frequent connections with sewers, they could be made to take off the surface water promptly.

Q. In other words when this precipitation of rain or water on the natural surface of the ground would accumulate, it would not be drained by the natural conditions?

A. Not by the natural conditions rapidly, but slowly.

803 Q. And in consequence of that then, frequent connections had to be made with the sewer to take care of the rain precipitation?

A. Yes sir.

Q. Now is there any difference in a city with reference to the amount of sewage matter produced?

A. Yes sir.

Q. According to the population?

A. Yes sir, a good deal of difference.

Q. What causes that difference?

A. Generally depending upon the manufacturing conditions, as to the character of manufacturing that goes on, and sometimes, as to the general custom of connection of the sewers.

Q. Explain what you mean by that? Manufacturing produces more or less sewage. What do you mean with reference to the custom of connecting with the sewers?

A. Well, an iron foundry and a machine shop or a planing mill wouldn't greatly affect the system of sewage, of the quality of sewage, but slaughter houses and stock yards and cattle pens are very liable to affect it materially, and do.

Q. What lines of manufacture would affect it?

A. Well, particularly—that don't apply to Chicago—but in the east, various kinds of textile manufacture,—the dyes
804 and colorings, and the tanneries—Chicago has some tanneries—usually have a great many more than any other lines of manufacture. They generally affect the sewage. A distillery and to a certain extent breweries—various things of that kind affect it.

Q. That is, increase the amount of sewage?

A. Increase the amount of organic matter that goes into the sewage.

Q. Then the outflow of the sewage would be increased?

A. Yes sir.

Q. What did you mean by saying that the manner of connecting the sewers in the city would affect the out-flow of the sewage?

A. Well, in some city, if you notice, that has a system of sewers, the people will not all connect, unless they are forced to by some board of health or something of that kind. In the City of Chicago, I suppose, practically all connect with the sewer as soon as one is built in the street. It is not a good place for cess--pools.

Q. Why is that?

A. Because of the impervious clay.

Q. You mean by that, that percolations from the cess-pool would be great?

A. Would not be great.

Q. Would not be great?

805 A. No sir, it would accumulate there and overflow.

Q. And for that reason then the sewer connections in the City of Chicago is extremely large, is it?

A. It is very general indeed. You might say practically that the only population in the City of Chicago that has not sewage connections in their houses, are districts that have not got main sewers built.

Q. Where no connections can be made?

A. Yes where no connection can be made, and those are of minor importance.

Q. Do you know whether or not the city officials charged with the sewer connections and looking after those matters in the City of Chicago compel sewer connection wherever they can?

ATTORNEY GENERAL HAMLIN: That question is objected to.

A. My recollection is that they have health regulations. They used to when I was familiar with them, with reference to the connection and requiring them to abandon cess-pools, outhouses, in that connection.

Q. Well, as compared with your knowledge of the sewage out-flow of other large cities, what would you say with reference to the volume of sewage out-flow of the City of Chicago, as to whether it was greater or less in proportion to the population? 806

A. I think the proportion of organic matter flowing out through the sewer is greater in proportion to the population than is usual, and only very extraordinary cases would have a greater amount than Chicago.

Q. Do you know what proportion of the sewer system of the City of Chicago, or the territory of it, is lying below the level of Lake Michigan?

A. Not exactly, I never figured it out. All that is laid below the level of Lake Michigan is in the Southern districts, about 60th Street. South to 60th Street and east of State Street. Compared to the whole city, it is small, although it is large in itself. It would make quite a large city in itself.

Q. Is that a densely populated portion of the city?

A. Some portions of it quite densely and other portions even that are not sewered are densely populated.

Q. A good many thousand people in that area?

A. Oh yes; there are districts there where they haven't got any sewers at all, with 19,000 people in a district, in these flat, low districts.

Q. Now in the territory that is sewered, where the sewer is laid below the level of the lake, does that have to be pumped up to the water level to dispose of it?

A. Yes sir, that has to be pumped in that case.

807 Q. Now are you familiar with the location of the Illinois and Michigan Canal?

A. Yes sir.

Q. Now will you describe to me where that canal starts and how and where it touches Chicago if at all, and what connection, if any, there is between any stream from the City of Chicago and that canal?

A. Well, I suppose you mean in the city. In the upper portion of that canal—The canal starts up the Illinois River at La-Salle and continues along the river and then to the Des Plaines, and by the Des Plaines to the city of Joliet, and to Lockport.

At Lockport the level of the canal rises to what is known as Summit level. That level extends to the City of Chicago joining the south fork of the south branch of the Chicago River at Ashland Avenue south of 26th Street.

Q. Now do you know when that canal was built?

A. I think it was built in the '40s. In forty something, during that time.

Q. Where is the southwestern outlet of that canal?

A. As I explained, the outlet of the canal is at Lockport.

Q. The southwestern outlet?

A. That is the southwestern outlet. The beginning of the canal on the southwest is at LaSalle.

Q. It goes beyond that?

808 A. That follows up the river and raises with locks at various places.

Q. Now what is there at 26th Street there?

A. At the place where the canal joins the south fork there is a pumping works.

Q. That is at 26th Street?

A. Near 26th Street, south of 26th Street. Not at 26th Street. It is near to Ashland Avenue. Ashland Avenue passes at the side of the pumping works. The streets right in there run irregularly, but it is really about a quarter of a mile south of 26th Street.

Q. Now how far is it from the point where these pumping works are up to the confluence of the west fork and the south fork of the South Branch of the Chicago River?

A. About a quarter of a mile.

Q. Now what is the use to which these pumping works are put at this place, and who maintains them?

A. They were built by the city of Chicago for the purpose of creating a greater flow through the canal, for the sanitary benefit of the Chicago River, and were maintained by the city and operated by the city until 1900 I think, when they were turned over to this Sanitary District Board. The Sanitary District Board has since turned them over to the Illinois and Michigan Canal Commissioners. The State commission
809 that has charge of the Illinois & Michigan Canal.

Q. What did you say they had been used for?

A. For pumping water from the river into the upper level of the canal for the purposes of sanitation originally. They are now maintained for the purpose of keeping up the level in that canal for navigation purposes.

Q. Well, do you know whether or not the pumping there is constant, or whether there is a cessation in it?

A. For the most part it is constant, or used to be, but there have been times when there was a cessation.

Q. Do you know the object of the building of what is called the Chicago Drainage Canal?

A. I think so; I ought to.

Q. What was it?

ATTORNEY GENERAL HAMLIN: I object to that question on the ground that the Act creating the Sanitary District determines the object of the construction better than the recollection of the witness.

ATTORNEY GENERAL CROW: Go ahead.

A. It was done for the purpose of keeping the sewage in the City of Chicago out of the lake and polluting its water supply —and thereby polluting its water supply, and for the purpose of improving the condition of the river and branches.

810 Q. Now you are familiar of course with where the outflows of the sewers in the City of Chicago are, with reference to the canal?

A. Yes sir.

Q. Where were they?

A. They are scattered all along; I cannot begin to name them.

Q. Just generally with reference to the outflow of the sewage of the City of Chicago?

A. It is mostly in the Chicago River and branches, although a portion goes into Lake Michigan, and some into the Calumet River.

Q. Now where is the Calumet River?

A. The Calumet River is in the southern part of the city, entering the lake about 92nd Street, that is, the mouth of it.

Q. Now where does the Calumet River have its origin?

A. It has its origin in Indiana. There are two branches of the river and they both head in Indiana around the end of the lake.

Q. In what general direction do they flow?

A. They flow generally westward, turning for a time. One of the branches turning almost eastward, and a little south of eastward, and joining the other branch, and then flowing northward and slightly eastward.

811 Q. What is the size of that Calumet River after it strikes the City of Chicago?

A. That has been dredged and docked I think, to a width of 200 feet.

Q. How deep?

A. I think eighteen or twenty feet in depth. I don't mean all the way. I mean only its mouth. The other portions are probably—the river in its natural condition ends at the southern boundary line of the city. This is guesswork now somewhat. I have seen it a great many times, but it is probably 100 feet across,—may be 125, and in places 150 feet and more. It has a depth of ten or twelve feet.

Q. A pretty good sized stream?

A. A pretty good sized stream, yes sir.

Q. How far up it, has it been docked and dredged?

A. It has been dredged continously for three miles at least, and then it has been done in places, so that the river has been navigable for boats of lighter draft clear up to Hammond, Indiana, a distance of nearly 20 miles from its mouth, that is, following the windings.

Q. Now right in that connection could you give me an idea of the width of the South Branch of the Chicago River before it was dredged and docked?

A. Nothing authentic. This is, I have no records of that.
812 It was all dredged and docked before I ever saw it.

Q. Now do you know something about the width of the South Branch of the Chicago River now?

A. Yes sir.

Q. What is it now?

A. It is very variable. I know more about it as to its hydraulic proportions than I do as to its exact dimensions, but it ranges from 150 to 200 feet. At the bridges, there is less than 100 feet.

Q. That is, up to the point of confluence of the west fork and the south fork?

A. Yes sir.

Q. Now has the dredging and docking of it increased the flow of current?

A. You mean from what it was in the state of nature?

Q. Yes.

A. No, I don't know whether it has or not.

Q. Well, has the dredging and docking in recent years increased the speed of the flow?

A. The Sanitary District of Chicago has been dredging and docking it; that is I mean they had been dredging, and are preparing to widen and dock so as to increase the flow, and in places they have made it possible to increase the flow, but it
813 don't necessarily mean that the flow has been increased, though.

Q. Is it being widened all along?

A. Not every place, but they are working to get a standard width or a minimum width of 200 feet, and a depth of 26 feet to the central portion of the stream and 16 feet at the docks.

Q. The river banks have not been walled, have they?

A. They are docked with timber piles.

Q. No stone?

A. No masonry walls except at the bridge abutments.

Q. Now there are bridges over the river at all streets?

A. A great many of them; not all of them.

Q. Now what proportion of the sewage system, or population, either way you want to put it, of the city of Chicago has its sewage out-flow into the Calumet River?

A. Based on the census made by the Board of Education of the City of Chicago in 1900—

Q. The population census?

A. The population census made by the Board of Education of the City of Chicago in 1900, there is a population of 70,636 that drains into or is tributary to the Calumet River. It don't mean by that that all those people have sewer connection. A far greater part have, however.

Q. Now what was the amount of that population tribu-
814 tary to the Calumet River, say the first of January, 1900?

A. It was substantially that. This is estimated in the early part of January. It was made in May or June, somewhere along there.

Q. Substantially the same number?

A. Yes sir.

Q. Now do you know anything about the amount of the population in Chicago where the sewage out-flow is into the south fork of the south branch of the Chicago River?

A. Yes sir.

Q. Have you made any estimation on that?

A. I have represented all these things on the maps. I don't know whether reference is made to the map or not.

Q. I want to get it in the record so as to read it in the first place. You talk of a thing being represented on the map, and talk into the record, and when a man reads it, it is pretty hard to get at.

A. I could probably shorten that thing if you will allow me to go through and describe what I have.

Q. For those drainage areas and the population?

A. Yes sir.

Q. You can do that if you want to.

A. Without putting this in the record?

Q. I want to put it in the record?

815 A. Wait until I am through stating what I am saying now.

ATTORNEY GENERAL CROW: Repeat that question of mine.

(Question repeated).

A. I have made a distribution of the population of the City of Chicago according to the points of watercourse to which it is tributary for the whole city, and I have represented that distribution and division of the city into districts on the accompanying map. The boundary of the city, except the lake shore, is shown in blue. The dividing lines of the several districts, of the several sewer districts are also shown in blue, and I have numbered those sewer districts from 1 to 12, inclusive. I have determined the population for each of the several districts by means—Strike that out. I want to say something else first—I established those dividing lines between the several districts by means of a sewer map obtained from the Sewer Department of the City of Chicago that showed the main sewers. I then distributed the population to those districts by means of the detailed census of the Board of Education, and the wards and election precincts which I obtained from the Board of Election Commissioners.

Q. Now before we go any further, let me ask you. You made this map?

A. Yes sir.

Q. That is so far as the sewer districts are concerned?

816 A. So far as what appears on there in that way, is concerned.

Q. Made from official data you gathered yourself as engineer?

A. As I just described it, yes sir.

Q. What is the map, aside from the sewer districts you have laid off on it, what does it purport to be?

A. It purports to be a map made by Rand & McNally,—a standard map of the City of Chicago, dated 1902, scale two and one-half inches to the mile.

Q. Do you know from your personal knowledge of the city of Chicago and your knowledge of the map, as to whether or not it is a correct representation of the location of the City of Chicago with the streets and alleys, and the water-ways, and the lake front thereon?

A. Yes sir, it is a very good map so far as I can discover.

ATTORNEY GENERAL CROW: Now I want to offer the map in evidence as an exhibit.

ATTORNEY GENERAL HAMLIN: I don't think I understand some portions of it, and before it goes in, I would rather cross-examine him on it; but suppose you go ahead with the other matters.

ATTORNEY GENERAL CROW: I will withdraw the offer.

817 ATTORNEY-GENERAL HAMLIN: The only objection I have to it is that I don't think it is very accurate if it is based upon the census taken by the Board of Education.

ATTORNEY-GENERAL CROW: I can remove that objection by having him reduce it to the proportion of the Federal census.

Q. You have made that reduction, have you, Mr. Williams?

A. Yes, as a whole I have, but not individually.

ATTORNEY-GENERAL HAMLIN: Not as to districts?

A. No sir, but if I go through it and testify as to that I think I can explain all those matters, so that anyone could understand it.

Q. Is there much variation between the two?

A. Yes, very material, over three hundred thousand.

ATTORNEY-GENERAL CROW: Increase or decrease?

A. The Board of Education was over 300,000 greater than the Federal census.

JUDGE SPRINGER: That is for the whole city?

A. Yes sir, for the whole city as it stands today and as it stood then. I mean the boundaries being just the same then as they are today, and they were. There has been no change in the boundary of the city since 1899, before these two censuses were taken.

ATTORNEY-GENERAL CROW: Before I offer it, I will ask you to explain just the method by which you obtained 818 the population of these sewer districts, and then explain the relation between the population of the sewer districts as ascertained by the manner in which you ascertained the same, and the population of the same area or territory, as shown by the Federal census?

A. I first obtained the sewer districts by getting the map of the main sewers of the city of Chicago, showing which way they emptied and where they emptied and laying out their boundaries between the several districts, as shown on the map in blue lines, heavy blue lines, and these districts are numbered from one to twelve, being twelve in all. After those sewer district lines were established, I then took the ward maps, upon which the election commissioners' precincts were shown and the census of the Board of Education which gave the population of each individual precinct, and by means of comparing those maps with the boundaries of those sewer districts which I have put upon the map before you, why I was enabled to distribute the population very closely; in some cases absolutely. Where the dividing line fell on the precinct line, why there was no question about the distribution. Sometimes the dividing line between the

drainage districts would cut across a precinct, and then there would be a liability of a little variation as to what proportion of the population to put in one district, and what in an-
819 other, but it did not affect the results in any material way, not nearly as much as the errors in the census itself.

Q. Well, in what way did you reduce those same sewer district areas to the population as shown by the Federal census in 1900?

A. Merely by percentages.

Q. By percentages?

A. Yes, that is, the difference. For instance, I have not in comparing the wards, the then wards, 31, 33 and 34, are extended down into what you call the Calumet District of the city, south of 87th Street. As to those, the Federal census and the Board of Education census substantially agree. There was very little difference in those three wards. So for the district shown as No. 4, which is the Calumet district of the city of Chicago, I have assumed that the population, or rather have taken that population as the true population. Now taking that off of the remaining proportion of the city and comparing it with the Federal census, I find that there is a difference of sixteen per cent. That is, that the Board of Education census would have to be reduced sixteen per cent to correspond with the Federal census. Now that is the standard of reduction which I have used, and I determined the population of the Sanitary district by that method, which is shown by the yellow lines and figures on this map. That population of the
820 sanitary district is made up in this wise—

Q. Let me ask you a question. Does the total area of your sewer districts as you have divided them correspond with the sanitary lines, the lines of the sanitary district of the city of Chicago? That is to say, have you confined your sewer districts within the limits of the city of Chicago?

A. I have confined it within the limits of the boundaries of the city of Chicago. These sewer districts are all within the city of Chicago. They do not go outside.

Q. Well, are they all within the limits of the Sanitary district of Chicago?

A. No sir, as I was just saying, District No. 4 is all outside of the Sanitary district and there is a small part of districts Nos. 11 and 10 that is outside of the Sanitary district, but the population of the Sanitary district of Chicago consists by taking the school census inside of the city, and reducing it sixteen per cent, which gives 1,621,311. That is the population of the Sanitary district of Chicago within the limits of the city of Chicago for the Federal census basis.

Q. When you say for the Federal census basis, you mean that is the Federal census of that area of territory within the Sanitary district?

A. No sir, I do not. I mean that it is—yes, it alludes to 821 that, although I have based it on that school census, reducing it sixteen per cent, which can be applied to all of these districts.

Q. I understand what you mean, but I want the record to show this point. At first there is no Federal census separate, of the Sanitary district of the city of Chicago?

A. No sir, nor of the several parts of the Sanitary district.

Q. But not as an individual item?

A. No sir.

Q. But there is a Federal census of the city of Chicago?

A. Yes sir.

Q. And the reduction you made in the Sanitary district is on the basis of the number of people as disclosed by the Federal census in that sanitary area, or territory of the Sanitary district?

A. That's right, yes sir. Now, outside of the city of Chicago, within the Sanitary district is the town of Cicero, lying west, and having a population by the Federal census, of 16,310. There is also within the Sanitary district outside of the city of Chicago, the villages of Lyons, Summit, part of Riverside, a small part of Riverside, and a certain rural territory, which is estimated, making in all, including Cicero, 18,145 in population, in the Sanitary district of Chicago, outside of the 822 city limits of Chicago.

ATTORNEY-GENERAL HAMLIN: Based on what?

A. Based on the Federal census. That makes the total population of the Sanitary district based on the Federal census, 1,639,456.

ATTORNEY-GENERAL CROW: How does that correspond with the Federal census of the city of Chicago?

A. The Federal census of the city of Chicago is 1,698,575.

Q. Well, is it greater or less than that of the Sanitary district?

A. It is greater than that of the Sanitary district, the population of the city of Chicago is greater than the population of the Sanitary district. That is, I mean that the total population of the city of Chicago is greater than the total population of the Sanitary district.

Q. There is a portion of the city of Chicago that is not in the Sanitary district?

A. Yes sir, some small districts on the north.

Q. Now you are familiar with the population of the city of Chicago itself, are you, in a general way?

A. I am only familiar with it, as I get it from the census reports and seeing the people on the streets.

Q. You have lived there for thirty years?

A. Yes sir.

823 Q. What is your judgment as to whether or not that population is correct?

A. Well I have studied the question of the growth of the population of the city of Chicago, that is, the rates of growth. We did that before the Sanitary district was organized, and made diagrams showing what would be the probable population of the city of Chicago at times in the future, so that in that way I have familiarized myself with the rates of growth.

Q. Well, what do you say as to this increase that is shown by the school census, is it greater or less than you think it ought to be?

A. Well, the increase of the school census—the difference between the school census and the Federal census were irreconciliable, on the theory that each is accurate. One or the other or both are wrong, because they are made the same year and substantially at the same time.

Q. Do you know how the school people made their census?

A. They are supposed to make it by employing men and sending them out to take the census.

Q. They do it through enumerators?

A. They have individual enumerators, yes.

Q. Not on any basis of enumeration?

A. No sir, it is an actual enumeration.

Q. When was the census made?

824 A. Made in 1900.

Q. At the same time?

A. About the same time, I don't know whether it was the same month or not.

Q. Made under an ordinance of the city of Chicago?

A. Under a State law. The State law requires a census of the school children every year or two years, and also I think, gives the Board the right to make a complete census if they so elect, and they have for a number of years past, elected to make the school census complete, that is, of all the population. Those of school age and those not of school age.

Q. Now give me the population there according to the school census, then according to your reduction, corresponding with the same area as the Federal census, in the sewer districts as you have divided them.

ATTORNEY-GENERAL HAMLIN: Now at this point, as you are proceeding along another branch, I move to exclude from the consideration of the Court, all the testimony introduced with relation to the Calumet district or district No. 4 as marked on this map, as that territory is not involved in this suit; this being an action against the Sanitary district and that territory lies outside of the district.

ATTORNEY-GENERAL CROW: It is in the State of Illinois, isn't it, General?

825 ATTORNEY-GENERAL HAMLIN: Yes. I make that objection in behalf of the State of Illinois. Judge Springer, you can make it for the District.

JUDGE SPRINGER: Let the record show that I make that objection in behalf of the Sanitary district.

ATTORNEY-GENERAL CROW: I wiil offer this map in evidence.

ATTORNEY-GENERAL HAMLIN: I object to it on the ground that it is not based, as far as the population is concerned, upon a proper basis; that it is based upon the school census and not on the Federal census. These objections and motions are made on behalf of both defendants.

Map above offered in evidence marked by the Commissioner "Complainant's Exhibit No. 14, Frank S. Bright, Commissioner."

(This exhibit is not printed.)

ADJOURNED until 2:00 p. m., same day, February 26th, 1903, at Southern Hotel, St. Louis, Mo.

826 Southern Hotel, St. Louis, Missouri, 2:00 p. m., Thursday, February 26, 1903. Continuation after recess.

Present, the Commissioner and same counsel representing the respective parties.

BENEZETTE WILLIAMS,

Resumed the stand for further direct examination by Attorney-General Crow, and testified as follows:

Q. Now Mr. Williams, will you just go ahead with your explanation of that map and the sewer districts, giving the area and the population, etc.?

A. I forget just where I left off.

Q. Just give him a start will you Mr. Reporter?

THE REPORTER: The last question was: Now give me the population there, according to the school census, then according to your reduction to that corresponding with the same area as the Federal census in the sewer districts as you have divided them.

A. There was no answer to that?

ATTORNEY-GENERAL CROW: No answer.

A. The population of the city of Chicago by the school census of 1900 was 2,007,695. That has been distributed through
the several sewer districts which I have mentioned be-
827 fore numbers 1 to 11 inclusive, and the population marked
on the map, and they are as follows: Consolidating certain districts in accordance with the source of water, or rather the point to which they drain, I find the population tributary to the main river and the south branch which is carried directly into the Drainage Canal by the flow from the Lake, and is included in Districts 1, 8 and 12, about 791,677. The population

tributary to the Lake on the south shore, and which will ultimately be discharged into the South Park through the 31st Street conduit in District 2, 175,182.

The population that is tributary to the south fork in District No. 5 is 282,655.

The tributary to the west fork within the city limits, in District 7, is 74,899. In addition to that I would add that a considerable portion of the town of Cicero has been sewered which lies within the Sanitary district and that also drains into the west fork. The population tributary to the North branch of the Chicago river and that is included in Districts 9 and 10, is 555,789.

The population that is tributary to the Lake on the north shore, District No. 11, is 28,878.

Now aside from those districts as described there is a dis-
trict shown on the map there as No. 3 in the south part
828 of the Sanitary district with a population of 18,827; that
has not yet a system of sewers otherwise, and while there
is considerable population there, they have no sewage outlet.

There is also District 6, with a population of 9,152, which has no considerable amount of sewers, practically no drain at all.

District 4, which is the Calumet district lying in the city of Chicago south of the Sanitary district, has a population of 70,636.

ATTORNEY GENERAL HAMLIN: That is objected to and I move to exclude it on the ground that it is not in the Sanitary district, and not relative to the issues in this case.

ATTORNEY-GENERAL CROW: The latter part of the answer as applied to District No. 4.

THE WITNESS: I have to do something with the population of the city, you know, and tell what it is.

ATTORNEY-GENERAL HAMLIN: That is all right; we just object to it.

ATTORNEY-GENERAL CROW: That is for the Court at Washington.

THE WITNESS: Summarizing a little further, I would say
that there drains into the main river the south branch and the
various forks which are tributary to those rivers, a total
829 of 1,705,020 by the school census, and that there drains

into the lake on the north shore and the south shore that are ultimately to go to the Lawrence Avenue conduit, and the 39th Street conduit now in the course of construction, 204,060. After those conduits are put into operation, and the sewage intercepted and turned into the river that would have been distributed on the face of this population directly into the main river, the south branch and the Drainage Canal, 800,829.

Into the south fork, 476,664;
Into the west fork, 74,899;
Into the north branch, 584,664,

And the same quantity into the Calumet river before mentioned, making up the total population of the city in its manner of drainage.

Now to reduce them to the United States census, of those districts—all those districts except District No. 4, I would apply sixteen per cent reduction. District 4 comprises wards or parts of wards that were found not to differ materially from the United States census.

Q. Now do you know approximately the amount of population of the Sanitary district that drains into the North branch of the Chicago river in say about up to the first of January, 1900?

830 A. I have just given it.

Q. You gave it from the census of 1900, which was based on June, 1900.

A. Oh no, I couldn't tell you hardly how to get at that, but I suppose a little reduction would need to be made, but I couldn't tell you what, now.

Q. Well, five per cent reduction would cover it, wouldn't it?

A. Yes, more than cover it.

Q. Sir?

A. More than cover it.

Q. Then would you be willing to testify that five per cent less than the figures you have given were draining into the north branch of the Chicago river at that time, the first of January, 1900?

A. I would testify that five per cent reduction on what I count the basis of the United States census would probably give too small a result.

Q. Well that many anyhow, at least were draining into that north branch of the Chicago river on the first of January, 1900?

A. Yes sir, I should say so.

Q. Well now, how about the south branch of the Chicago River?

831 A. The same thing would apply.

Q. And the south fork of the south branch?

A. The same would apply.

Q. And the west fork of the South branch?

A. I would apply the same. Of course, now, you understand it is impossible to tell you how rapidly one part of the city grows in comparison to another part, save as you get the census returns.

Q. Yes. Now how much in January, 1900, what proportion of the sewage of the city of Chicago and the Sanitary district went into Lake Michigan, other than that which went through the Chicago river?

A. About 200,000.

Q. About 200,000 people?

A. Yes sir.

Q. Do you know at this time?

A. That is by the school census.

Q. Well, by the Federal census?

A. By the Federal census it would reduce it 32,000—well, say 30,000; that would make it 170,000.

Q. Now how much of the population of Chicago drains into Lake Michigan at this time, of the sewers?

A. I gave that a while ago exactly.

Q. Did you, that alone?

A. Yes, when I previously went over it.

832 Q. Well, you need not answer that then. I had forgotten; that is in there is it?

A. Yes, that is in there, relative to that population is all in there.

Q. Did you state this morning, or did you not, the object of starting a pumping works at 26th Street, at the head of the Illinois and Michigan Canal?

A. I think I stated it, but it was for the purpose of improving the sanitary condition of the city, and the water supply.

Q. In what way?

A. Improving the condition of the river by having lake water pumped into it—putting lake water into it, and keeping the sewage out of the lake.

Q. Well, how would the pumping at 26th Street, five miles from the Lake, take lake water into the Chicago river?

A. It set the current the other way.

Q. In what way?

A. From the lake.

Q. From the lake?

A. Yes sir.

Q. Then it reversed the flow of the Chicago river?

A. Yes sir.

833 Q. That was the intention of it, and did it do that?

A. It did do that and at certain stages of the storm water flows, which you may say was the most of the time—

Q. Now are you familiar with the condition of the different branches of the Chicago river in the Sanitary district of Chicago and the city of Chicago prior to January, 1900?

A. Yes sir.

Q. Well, what was the condition of those waters with reference to whether or not they were polluted?

A. They were very badly polluted.

Q. What with?

A. Sewage and drainage from manufacturing establishments.

Q. Do you know whether or not the pumps at 26th Street at the head of the Illinois and Michigan Canal were sufficient to meet the purpose for which you say they were erected, and used at that time, turning the Chicago river backwards and pumping the sewage out of the Chicago river and protecting the water supply of the city of Chicago?

A. They were entirely inadequate.

Q. How do you know that fact?

A. By survey and an examination of the whole question.

Q. You did examine it, did you?

A. Oh yes.

Q. As a civil engineer?

834 A. Yes sir.

Q. Officially?

A. Officially, yes sir.

Q. When did you make that examination?

A. In 1886 and 1887.

Q. Well then the result was—

A. And prior to that for that matter, but this was special then; that was specific.

Q. Then I will get you to state if you know whether or not the water supply at that time was polluted by this sewage?

A. It was.

Q. Now do you know where the city of Chicago from 1886 on up to January, 1900, was taking their water from?

A. Taking it from the lake at various points of intake, according to the dates and times.

Q. Well what portion of the lake, in front of the city of Chicago?

A. In front of the city of Chicago, yes sir.

Q. How far out into the lake?

A. From two to four miles.

Q. From two to four miles?

A. Yes sir.

Q. None less than two miles from the intake?

A. I think none less than two miles.

835 Q. How far out was the nearest one?

A. They may have been taking a short time from an intake less than two miles; it didn't exist long; it was extended.

Q. Do you know how many intakes there were?

A. Well, there are now five intakes, I believe is the correct number.

Q. Five intakes?

A. Five intakes.

Q. Do you know what there was in January, 1900?

A. The same.

Q. Do you know how far out in the lake the most remote one of them is?

A. Four miles.

Q. Four miles?

A. Yes sir.

Q. Do you know the distance between those intakes, up and down the lake front, north and south?

A. Well I could tell you where they are and then I could tell you the distances then.

Q. Well just locate them then.

A. There is one opposite 67th Street or 68th Street; there is another one opposite 14th Street, about this point. It is opposite 14th Street, that is where the Four Mile crib is. There is another one opposite Chicago Avenue, north of the
836 river; that is two miles to the crib.

Now there is another one further north; I can't tell exactly what street it is opposite if projected, but it starts out from the park on the north shore; it is called the Carter Harrison crib. Then there is one—nothing on here (indicating map) seems to indicate the exact location of it, but it is north of Fullerton Avenue some distance, perhaps a couple of miles—what was originally the Lake View intake.

Q. Now those intakes supply respectively different portions of the city I suppose?

A. They are all connected.

Q. They are all connected?

A. They are all connected, yes sir. Of course the supply depends on the pumping works. Now that varies. There is a great number of pumping works in the city and of course from every pumping works there is a certain district that the supply from those predominates.

Q. Where are these pumping works located, at the Lake Front?

A. Some of them, and some of them on the interior, a great many miles on the interior.

Q. Are there settling basins with these pumping stations?

A. No sir, no settling basins.

837 Q. No settling basin used in the Chicago water supply?

A. No sir, take it right from the lake.

Q. Take it from the lake?

A. Yes sir, there are tunnels leading inland to the various pumping stations from these sources of intake.

Q. And that water, is it taken from the level or from the bottom of the lake?

A. No sir, it is taken at an intermediate point.

Q. Between the surface and the lower level of the lake?

A. Between the surface and the bottom of the lake.

Q. Do you know how deep?

A. Well, I couldn't tell you; in the most of those intakes they have, they have different inlets where they can take it from the upper surface, or further down, at their option. Now just how they operate them I couldn't answer that.

Q. Then after the water runs through these conduits as you might call them, from the intake towers in the lake to the pumping station, it is forced by the pumps through the mains to the consumer?

A. Yes sir.

Q. That is the mode of supply?

A. Yes sir. But that network of pipes is all connected up without regard to the special pumping works.

Q. So that the force and power of each pump operates throughout the entire city?

A. So far as it reaches, yes. If one of the works was 838 shut down the people within that district would still continue to get water from the other works, with perhaps a reduced head.

Q. Then the force that they have in the water works system there is entirely supplied by pumps?

A. Yes sir.

Q. And there is no natural pressure?

A. No sir.

Q. Or water tower?

A. No sir.

Q. Now is there any system of filteration?

A. No sir.

Q. None whatever?

A. No.

Q. Can you describe to me what is called the drainage canal on that map, where it begins and where it ends and the size of it?

A. Beginning in the city at Robey Street about a quarter of a mile north of 31st Street, and follows parallel with the old Illinois and Michigan Canal to Lamont, that is to range line, just east of Summit. That is the point where the Des Plaines river turns to the Southwest. That stretch of the canal is 41,100 feet in length.

JUDGE SPRINGER: Is it 28.5 miles?

839 A. That is the total length.

JUDGE SPRINGER: That is from Robey Street to the controlling works?

A. Yes sir, I think that is right—not five-tenths, but five hundredths.

JUDGE SPRINGER: Yes, five-hundredths; that is correct, from Robey Street to the controlling works?

A. Yes sir. The grade, the bottom of the channel at Robey Street is minus 24.45 feet.

ATTORNEY GENERAL CROW: Explain what you mean by that?

A. I mean that it is below the datum to which all the levels are referred.

Q. In the City of Chicago?

A. Yes sir, which was low water mark of 1847.

Q. Low water mark of what?

A. Of the lake.

Q. In 1847?

A. In 1847.

Q. And how much is that low water mark for 1847 below the usual level of the lake now?

A. Taking a series of years, the lake fluctuates over a range of four or five feet, and over a range of several years
taking the series of years up to a few years ago I found
840 that the datum was 1.9 feet lower than the mean level of
the lake.

Q. You mean the low water mark of 1847?

A. Yes sir, the low water mark of 1847 datum.

Q. How long a series of years did you cover for that experiment?

A. Well it was all the records we had up to that time, I have forgotten how many years it covered; it was a good many years though, twenty-five to thirty years probably.

Q. How much did you say?

A. One foot and nine-tenths below the mean level of the lake.

Q. The ordinary level?

A. Now there comes the maximum rise of the lake, which would go three or four feet above datum; and then there come times when it is a foot below datum.

Q. Now are those maximum and minimum waters in the lake affected by the seasons?

A. Yes sir. In every year there is a period of minimum level and a period of maximum level, the minimum level coming almost invariably about January. The maximum level sometime in the summer, I have forgotten the exact month, probably August; then there are daily fluctuations, and hourly fluctuations due to the variations of the wind. If the wind changes suddenly from one direction to the other, there will be a change
841 in the level of the lake. Then there are seasonal fluctuations; there are a term of years, often over ten years at a time that the lake will be continuously rising, these seasonal fluctuations, that is from August to January still going on just the same, but the general trend is a rise—

Q. An upward trend?

A. Yes; then there is the reverse—those are due doubtless, or probably ascribed to the rainfall—

Q. Precipitation of the drainage area?

A. And the drainage area of the lake.

Q. Now with that as an initial point, describe that canal from a hydraulic and from a shipping standpoint, its capacity and size.

A. Starting at Robey Street the grade of the bottom is 24.45 feet below datum. The inclination as we term it, of the canal in glacial drift—I would say there are two sections of the canal, I mean two sections as far as the manner of treatment.

The canal from Robey Street to Willow Springs which is a distance of 13.2 miles has an inclination of one in 40,000—

Q. Now explain what you mean by that, so we can get it in the record.

A. I mean that in 40,000 feet the bottom of the canal falls one foot.

Q. One foot of fall to forty thousand feet of canal?

842 A. Yes sir. So that at Willow Springs the grade of the canal is minus 26.2 feet below datum. The first part of this section—while this is dug in glacial drift,—that is, the first part from Robey Street to the range line at Summit is dug in glacial drift and is 110 feet wide on the bottom and slopes two for one,—that is two horizontally to one vertically.

Q. Making the width 160 or 165 feet?

A. Making the width about 200 feet.

Q. Two hundred feet?

A. Yes, at the water line. From the range line at Summit, to Willow Springs it is in glacial drift, all except for a short distance where it strikes some rock, but it is built in the same manner, 210 feet wide on the bottom and with slopes two to one.

Q. Through the rock?

A. Whatever rock they encountered; they only encountered a little rock in the bottom, but through the rock; it is a glacial drift section,—so considered.

Q. Now when you use the term "Summit" there at this point in the canal, what summit do you refer to,—the watershed between Chicago and the Des Plaines River?

A. I refer to the village of Summit, and that takes its 843 name from the fact that it was the point and is the point where the Des Plaines river at flood, discharges both ways. That is it is the summit of the valley between the Lakes and the Mississippi.

Q. At that point?

A. Yes sir.

Q. Well now, go ahead.

A. From Willow Springs to the controlling works, or rather to within four thousand feet of the controlling works, the channel is 160 feet on the bottom with vertical sides, taken out by excavating the rock vertically by means of tunneling where rock existed, which was the most of the way, and in filling up the gaps with the masonry wall, so that it is a uniform channel 160 feet wide on the bottom and about, I suppose at the flow line, owing to the offsets in the tunneling, operation, it was about 162 feet.

Q. At the top?

A. At the top. Now that section of the canal has an inclination of one in twenty thousand; it doubles the inclination at the glacial drift section.

Q. And there is a fall of one foot for every twenty thousand feet—lineal feet of canal?

A. A fall of one foot for every twenty thousand lineal feet of canal. When the canal reaches within four thousand feet of the controlling works, it widens out fan shaped, or gradually into a basin, that at the controlling works, or just 844 above the controlling works, is several hundred feet wide. I don't remember the exact width of that; it is not very material; it is meant for a turning basin where vessels could turn or manouver, and the same grade is continued to the controlling works, the portion of the canal at the controlling works being minus 30.1 feet; that gives a total fall in the bottom of the canal between Robey Street and the controlling works of 5.55 feet.

Q. 5.55?

A. Yes sir.

ATTORNEY GENERAL HAMLIN: Hadn't you better locate the controlling works?

ATTORNEY GENERAL CROW: I will do that.

THE WITNESS: As to the capacity of this canal—

Q. Well, in the first place, before you do that—are the sides of this fan shaped extension or basin at the controlling works walled?

A. They are walled so far as they are not in rock; they are solid, vertical face, by reason of the walls built above the natural rocks.

Q. Now where are the controlling works; where are they located?

A. The distance of the controlling works, from Robey 845 street is 28.01 miles.

Q. At what point?

A. The controlling works is near to Lockport, somewhat above Lockport.

Q. Well then it is a small town?

A. A small town on the Illinois and Michigan canal, at the point which was the end of the Summit level of the Illinois and Michigan Canal.

Q. Now as to the volume of water that that canal carries?

A. The original design,—that is I mean as prescribed by the law is intended to be 600,000 cubic feet a minute, the water in the Lake being datum.

Q. That is to say at the low level of 1847?

A. Except that the first section from Robey Street to the range line at Summit was made smaller with a view to being widened in the future as the demand of the city should arise. The law called upon the Sanitary District in all the rock sections, to build to the full capacity of 600,000 cubic feet a minute, and the other portion could be built smaller and enlarged as needed. When that is enlarged to the standard size adopted for the glacial drift section, that is 210 feet on the bottom with slopes of two to one, then it will be of uniform dimensions all the way through the glacial drift section.

Q. What you call the glacial section is the earth section? 846

A. The earth section.

Q. What is the character of that soil?

A. Well it is clay soil, embodying boulders, in some places, a great many boulders in some places; in some places they made up pretty nearly half of the amount of the material; in other places there was not but a small amount of them.

Q. Do you know when that canal was first begun?

A. This drainage canal?

Q. Yes?

A. The first excavation was made in—it was either August or September, of 1892.

Q. 1892?

A. Yes sir, I forget the exact date.

Q. Which end of the canal did they begin at?

A. Well that was in neither end; it was down on the lower half near to the village of Lamont.

Q. Do you know when the canal was completed in its present condition?

A. The water was turned into it, or it was accepted by the Governor of Illinois on the 17th day of January, 1900.

Q. Do you know when the water was first turned into it by the Drainage Board Trustees?

847 A. On the 6th day of January, 1900,—I don't mean into it; that was when the water first flowed through the controlling works.

Q. That was when the water first flowed through the controlling works?

A. Yes sir, the 6th day of January, 1900.

Q. Now do you know the volume of water, of cubic feet per minute that went through that canal on the 17th day of January?

A. I don't think I could give it. I have some flows, but they are average flows; they are not in detail by the days.

JUDGE SPRINGER: Three hundred thousand cubic feet a minute, wasn't it?

A. At that time, I don't think it was that much; I think it was considerably short then; they began a little gradually.

Q. ATTORNEY GENERAL CROW: Well if you can't find that, never mind.

A. I can't give it by the day; I can give you some data by the averages; by weekly averages.

Q. For what period of time?

A. From January 20, 1900, to March 30, 1901.

Q. You have got those averages, have you?

A. Yes sir.

Q. Where did you get them?

848 A. I got them from the reports of the printed proceedings of the Sanitary District Board.

Q. What was the average amount that went through there at that time? I don't care about the series of weeks—have you got the general average?

A. I think it is just as well to give them just as they stand here, or just as I have them. They can be averaged. The average for ten weeks from January 20 to March 31, 1900—that was flowing through the Chicago River, as given by their reports there, an average of 179,741 cubic feet a minute.

The average of thirteen weeks from March 31st to June 30, 1900, was 211,577 cubic feet a minute.

Thirteen weeks from June 30 to September 29, 1900, 210,317 cubic feet a minute.

For thirteen weeks from September 29 to December 29, 250,635 cubic feet a minute.

Thirteen weeks from December 29th, 1900, to March 30, 1901, 303,736 cubic feet a minute.

The maximum flow during that period occurred on March 16th, 1901, and was 356,723 cubic feet a minute.

Q. Do you know what the flow or the speed of the canal is, and what it was for the period of time you mention?

A. Yes sir, I have some data on that.

849 On June 20th, 1900, Major Willard, the United States Engineer in charge of the government work in Chicago, reported to the Chief of Engineers some data which was as follows:

When the river was flowing, he took these measurements at eight bridges; that was taking the narrow openings through the bridges, and this is the average for those. When there was a discharge of 150,000 to 210,000 cubic feet a minute, the average velocity was 1.79 feet per second, or 1.22 miles per hour.

ATTORNEY GENERAL HAMLIN: I believe I will object to this as not being competent,—not given by anyone who is competent to state as to that question.

Q. ATTORNEY GENERAL CROW: You took this information from the United States government report?

A. No sir, I took it from the reports of the proceedings of the Sanitary Board.

Q. Official records?

A. Yes sir, official records.

Q. For what year?

A. It was; this was published in the year 1900.

Q. Well, go ahead with it?

ATTORNEY GENERAL HAMLIN: Then I object to it on the ground that the official record is the best evidence and not the statement of the witness.

850 ATTORNEY GENERAL CROW: Q. Have you got a copy of that?

A. Not here; I have it in my office.

Q. Well, go ahead, and put this in; we can put the other in later on.

A. When the discharge was from 270,000 to 310,000 cubic feet a minute, the average velocity at the bridges was 2.72 feet per second, or 1.85 miles per hour.

Q. Now you are familiar with the conditions that exist there at 26th Street, where the pumping works are at the head of the Illinois and Michigan Canal,—the situation of the river there, the south fork of the Chicago River and the south branch of the Chicago river?

A. Yes sir.

Q. Now do you know what kind of water it was in 1900, January 1st, 1900, was being pumped out of that south fork, whether it was lake water or whether it was Chicago River water?

A. The pumps at the end of the Illinois and Michigan canal are on the south fork about a quarter of a mile south of the south branch of the Chicago River, which is the channel leading to the main drainage channel, and it takes its water from the south fork. The south fork is a very foul, black and malodorous stream and as fast as this water works out of the 851 south fork towards the south branch it is taken in by the pumps going into the Illinois and Michigan Canal, hence the preponderance of at least all that comes up to the capacity of the works from the south fork, goes into the Illinois and Michigan Canal when they are in operation.

Q. Well, do the same conditions exist now as did formerly with reference to that?

A. Yes sir, that condition exists now.

Q. Is there any perceptible current to the south fork of the south branch of the Chicago River in ordinary times?

A. No sir, you wouldn't detect it by looking at the stream. Of course there is.

Q. Is there any perceptible flow?

A. There is a flow due to the sewage and storm water that reaches that branch.

Q. Which way?

A. Well it flows northward, towards the south branch.

Q. Towards the south branch?

A. Yes sir.

Q. I believe you gave the depth of that this morning?

A. I think so, approximately.

Q. Do you know anything about the size or area of the stock yards district there on the south fork of the south branch?

A. Well I only know it—I have not computed it, if that is
852 what you mean.

Q. You have not computed it?

A. No sir, I haven't computed it. It could be done from that map.

Q. Do you know where the drainage from those stock yards goes?

A. The drainage from the stock yards is all into the south fork or the slips of the south fork at the head of the south fork.

Q. Now do you know whether or not the pumps of the Illinois and Michigan Canal are in operation now?

A. I couldn't answer for just at this moment.

Q. No, but generally?

A. But generally they are in operation. The Board of Canal Commissioners has taken possession of them and is putting in improvements there to operate them by electricity,—water power transmission from Joliet.

Q. Is it necessary to do that in order to flush out that south fork of the Chicago river?

A. No sir, it has no reference to that. They operate those pumps purely now for the purpose of navigation of the canal to keep the level of it, ostensibly at least that is what it is done for.

Q. Well, with the present flow of water through the
853 Chicago River, and the Drainage Canal, is the south fork
of the Chicago River yet stagnant water?

A. Yes sir.

Q. How about the appearance of it at this time?

A. Oh, it is black; absolutely black.

Q. Now at what point does the lake water enter the Chicago River that flows into the Drainage Canal?

A. No sir, through the mouth of the main river.

Q. Through the mouth of the main river; then in what direction?

A. This is westward to the south branch; thence the southward and again westward, through the Drainage Canal.

Q. Now the north branch of the Chicago River, that is the confluence with the south branch; it joins the stream of water from the lake coming westward, does it?

A. Yes sir, westward and southwestward.

Q. Is there a perceptible current in the North Branch of the Chicago River at this time?

A. I couldn't answer you just at the present time; there is at times, and at other times it is not perceptible.

Q. Is it affected by the storms?

A. It is affected by the storms, and affected by the operation of the Fullerton Avenue conduit; it is rather irregular—intermittent.

Q. Well, the Fullerton Avenue conduit, if the pumps are
854 at work there, what is the result?

A. When they are working, they put in near to 15,000 cubic feet a minute.

Q. What is the effect?

A. Which would make a slow velocity in the canal.

Q. When they are not at work what is the condition?

A. When they are not at work and when there is no storm water flowing, then it is stagnant.

Q. How long did you say that Fullerton Avenue conduit had been in operation?

A. It has been in operation I think, it was put into operation in the year 1879.

Q. What is the condition of the Illinois and Michigan Canal with reference to the appearance of the water therein?

A. The only times that I have seen it, since the main Drainage Canal was open it was apparently like it used to be before that channel was put into operation.

Q. Well how was that?

A. Very black and odorous.

Q. Well was there any flow in the channel?

A. Oh yes.

Q. Was there prior to January, 1900?

A. Yes sir.

855 Q. Was it rapid flow or slow?

A. Well, when they are operating the pumps to their rated capacity there is a flow of about a foot in a second. That would be about two-thirds of a mile an hour.

Q. Have there been any intercepting sewers built since January, 1900, in the City of Chicago, for the purpose of cutting off the sewage from the city that now drains into the lake, or that did drain into the lake?

A. None except the progress that has been made on the intercepting systems that they had in hand on Lawrence Avenue, and the Thirty-ninth Street system. They have been working on those.

Q. Well just explain what that system is?

A. The Lawrence Avenue system consists of an intercepting sewer beginning at the upper end of the sewer, at the north line of Lincoln Park, and running northwardly to Lawrence Avenue; and another one beginning at the city limits, or near the city limits, on the extreme north and running southward to Lawrence Avenue.

Q. And making connection?

A. With Lawrence Avenue, and on the line of Lawrence Avenue to the river, and the north branch of the river,—those intercepting sewer systems, I would say are built; that is the sewers I have described are built,—are finished, and the 856 Lawrence Avenue conduit is built within a few hundred feet of Clark Street. The remaining portion of it is not built.

Q. Well now what is the theory upon which that is to be operated?

A. That is to collect the sewage from all the sewers that enter into the lake on the north shore within the city limits, and conduct it through the North branch of the Chicago River.

Q. By way of?

A. Lawrence Avenue.

Q. The sewage from the North end of Lincoln Park upward to the Lawrence Avenue conduit?

A. Yes sir, and another one from the north line of the city to the Lawrence Avenue conduit.

Q. Down to the point of confluence of the Lawrence Avenue conduit, with the north Branch of the Chicago river?

ATTORNEY GENERAL HAMLIN: That is rather leading, General.

ATTORNEY GENERAL CROW: Yes, I know it is.

A. No, they lead down to Lawrence Avenue; these sewers don't go clear through the North Branch of the Chicago River, except the Lawrence Avenue conduit.

Q. What method is to be put into force for the purpose of
857 putting that into the Chicago River?

A. Pumps—by means of pumps.

Q. I believe you stated the level of the Lawrence Avenue conduit with reference to the river. What is it?

A. It is built below the lake level.

Q. What is it with reference to the river level?

A. Well, that is the same thing, substantially the same when we speak of below the level of the river and the lake.

Q. Now how about the 29th Street conduit?

A. The 39th Street conduit is laid out in the same way. There is an intercepting sewer starting on the south at 73rd Street running north on Stony Island Avenue and along the lake shore to 39th Street, and another one from 35th Street south to 39th Street. Those two sewers will collect all the sewage now flowing into the lake on the south shore of the city, and deliver the sewage at 39th Street. This system has been built from 39th Street south to 60th Street and is in process of construction. The conduit on 39th Street is finished with the exception of cleaning up, and the water from the lake and the sewage from that district is to be put through the 39th Street conduit with pumps.

Q. What will be the location of the 39th Street sewer or conduit at this point—at its point of confluence with the south fork of the south branch of the Chicago River with refer-
858 ence to whether it is on a level with the—

A. It is all below the river and the lake.

Q. What means have been provided for lifting that sewage into the south fork of the Chicago river?

A. They are providing pumps.

Q. Pumps?

A. Yes sir, and located at the lake.

Q. Located at the lake?

A. Yes sir.

Q. Do you know the population that would be contributed to that intercepting sewer on the north there, that is connected with the Lawrence Avenue conduit?

A. Yes sir, I have given it in my testimony, but I can give it again. It is 28,878 by the school census.

Q. 28,000?

A. 28,878.

Q. Is there an intercepting sewer connected with the Fullerton Avenue conduit?

A. No sir, there is no intercepting sewer connecting with that; that is, a few minor sewers along the line that may go into it, but not much.

Q. Do you know the population of the area that is connected with the 39th Street conduit?

A. Yes, from the school census, 178,182.

859 Q. What by the Federal census?

A. Well, that 16 per cent reduction which probably is too much for that part of the city.

Q. Well, make it on that basis?

A. I know it is too much on that basis; I would have to compute it. The population by the Federal census on that basis would be something less than 150,000.

Q. Do you know what place the sewage in January, 1900, and at this time, what district,—at what place it ran, or the territory embraced in that which will have its out-flow into the 39th Street conduit?

A. That is covered by this intercepting system you mean?

Q. Yes, 39th Street.

A. Why, it went into the lake.

Q. Into the lake?

A. Yes sir.

Q. It didn't go into the south branch of the Chicago River?

A. No sir, not without this portion of District 2 there, the part that I have been talking about.

Q. Well that is all that will be affected by the building of that intercepting sewer, that connects with the 39th Street conduit?

A. Yes, that is all that will be affected.

Q. Well now, considering that all those intercepting sewers were completed and the systems in operation, would there
860 yet be any of the population of Chicago that would have the out-flow of their sewage into Lake Michigan, and if so, how many?

A. There would be none direct from the outlet of Chicago, as some of the Chicago goes into the Calumet, and goes indirectly into the lake, but nothing direct into the lake.

Q. Is Evanston outside the city limits?

A. Yes, Evanston is outside of the city limits; it is a city of itself.

Q. Is that in the Sanitary District?

A. No, it is not in the Sanitary District.

Q. Calumet is in the Sanitary District?

A. No sir, but it is in the city.

Q. It is in the city?

A. Yes sir.

CROSS-EXAMINATION,

By Attorney General Hamlin.

Q. Well, Mr. Williams, I don't know as I want to ask you very much. The Illinois and Michigan Canal was constructed when?

A. I think it was in the forties some time, the exact time I haven't got. I didn't come expecting to be asked on that question at all. That is in 1840 something. It may have been
861 begun in 1837, or along there.

Q. When were these pump works established?

A. They were established about 1879 or 1880.

Q. And they have been in operation ever since?

A. Yes sir, at intervals, most of the time. There have been intervals when they did not operate.

Q. Well, from the time that they were put in operation up to the time the Drainage Canal was put in operation how much of the time were they in operation?

A. Pretty much all the time. There were some cases, I think where they were shut down, but not much; they were not shut down much.

Q. That was in 1879?

A. I won't say that that is the exact date that they were put into operation; it was near then; that was the time they were agitating it, and they may not have got into operation until 1880.

Q. Well, you know they were put in operation; after they were put in operation, under whose control were they?

A. They were under the control of the City; operated by the city until 1900.

Q. And the Illinois and Michigan Canal connects with the Illinois River, does it not?

A. In that way, yes.

862 Q. Through the canal it finally connects with the Illinois River, and the foot of the canal is at La Salle?

A. And connects with the Illiois River—yes,—I beg your pardon—yes sir, the out-flow, though of this summit level is into the Des Plaines River at Lockport.

Q. And it connects with the Illinois River?

A. It connects with the Illinois River, yes sir.

Q. Now after 1879, from 1879 to January, 1900, the north branch of the Chicago River carried sewage, did it?

A. Yes sir.

Q. To what point?

A. To the confluence with the main river, and with the south branch.

Q. Then where did it go?

A. Well, sometimes it went to one place; sometimes another; sometimes the lake, sometimes down the south branch.

Q. Well when these pumps were in operation where did it go?

A. The same answer, depending on the quantity of flood water reaching the river.

Q. Well now, the south fork, or the south branch of the

Chicago River, and the south fork of the south branch, reached the stock yards district, didn't it?

A. The South fork of the south branch reached the stock yards, yes sir. 863

Q. The stock yards at that time, say from 1879 up to 1900, were about the same size, continuously, were they not?

A. I think it is about the same, perhaps increasing some in the actual number of animals killed there.

Q. Do you know how that is; do you know about that?

A. I haven't got the statistics for it now, I have looked it up at various times, but I couldn't give them now.

Q. When these pumps were in operation from 1879 to 1900, what per cent of the sewage if you know, was discharged into the canal through the pumps?

A. That was variable; you take it in a dry time, when there was very little or no flood water reaching the Chicago River or its branches, and the pumps in operation to their capacity, which was then not far from 45,000 cubic feet a minute, when they were working to their full capacity, there would be none of the sewage that went into the river reached the lake, only such sewers as had their direct outlet into the lake, would reach the lake during that period, and during the conditions as I state them.

Q. What would they reach?

A. They would ultimately go into the canal.

Q. Through the pumping works?

A. Through the pumping works, yes.

864 Q. Now for how many years to your knowledge, you say you have lived in Chicago for thirty years—for how many years would you say that condition has existed?

A. That existed about twenty years; in that direct form part of the time, one way, and part of the time another.

Q. As you have explained?

A. Yes sir.

Q. And that sewage eventually reached the Des Plaines River?

A. Yes sir.

ATTORNEY GENERAL CROW: What per cent did he say went in there?

ATTORNEY GENERAL HAMLIN: He didn't give the percentage.

THE WITNESS: I said all that went into the river.

ATTORNEY GENERAL HAMLIN: He placed it on the condition of the streams.

Q. That has been about twenty years?

A. That was not far from twenty years.

Q. What did you say the flow was from Robey Street to Lockport in the Drainage Canal,—the rate?

A. I didn't give it.

Q. What did you say the fall was?

A. I said that the fall from Robey Street to as far as
865 Willow Springs, was at the rate of one in forty thousand,
and from Willow Springs to the Controlling Works, one in twenty thousand.

Q. Then did you state what the fall was from Robey Street to the Controlling works?

A. The total fall?

Q. Yes sir?

A. In feet, I put it, I think it was 5.55 feet; that is the bottom of the canal.

Q. Yes, I understand.

A. That don't necessarily mean that that is the water surface at all.

Q. These sewers, these intercepting sewers that are to finally connect at Lawrence Avenue and at the other points that you mentioned, have not yet been constructed and are not yet in operation, are they?

A. They are not in operation; they are partly constructed.

Q. Yes, but they are not in operation?

A. No sir.

Q. And the sewage that they will carry is now going directly into the lake?

A. Yes sir.

Q. Well, they were not in January and February and March
or say the first three or four months of 1900, they were not
866 even in process of construction, were they,—some of them?

A. I think they had begun work on them at that time. Yes, I am sure they had, on parts of them. I think that they had all the contracts let, and some considerable part of the work done.

Q. Can you tell in point of population how many, taking into consideration these sewers that have been constructed, in point of population, how many of population drain into the lake; that the sewage went into the lake?

A. Well, based on the United States census, would be not far from 150,000.

RE-DIRECT-EXAMINAITON.

By Attorney General Crow.

Q. I would like to ask him a question, or you can ask it for me, if you will. I have not had him describe,—I don't know whether he can,—what the controlling works at Lockport are; we ought to put that in the record here, somewhere, so that when we talk about the controlling works, we will know what they mean.

ATTORNEY GENERAL HAMLIN: He has stated where that is.

ATTORNEY GENERAL CROW: He has not described them, you know. You know that, do you?

A. Yes sir.

ATTORNEY GENERAL HAMLIN: You can ask him to describe them.

Q. ATTORNEY GENERAL CROW: Well, I will ask 867 him to describe them then, the controlling works at Lockport?

A. The controlling works consist of seven sluice gates, that is, they are gates that move in guides and are operated by certain mechanical appliances. Each of those gates has an opening of thirty feet, clear opening.

Q. Thirty feet in width?

A. Thirty feet in width, yes. Now those gates were not all in use; they have not needed to use them, but they are there as a reserve, when the flow becomes so great that they may need them. Then the only appliance relied upon for the main control now, is what is known as the Bear Trap Dam, which is 160 feet long; that is, in its horizontal section, and it has an oscillation vertically of seventeen feet.

Q. What do you mean by that? Explain that?

A. Well, the dam is made out of steel, a steel caisson, and the upper edge of that points up-stream can be lowered or raised by the water. By letting in underneath the dam, the water, it will be raised by letting that water out into the tail race, it will be lowered so that that dam can be oscillated just by operating valves.

Q. Up and down?

A. Up and down.

Q. How much of the seventeen feet?

868 A. Over a range of seventeen feet.

Q. That is to say you can make a difference of seventeen feet in the amount of water in the face of the trap?

A. No, I don't mean that. No, I mean that if you put the dam down to the lowest point it will be seventeen feet below what would be if it was at its highest point. It might not lower the water materially in front of it, it would be just pouring out as a mass over that dam you know, a good many feet deep.

Q. You described what those sluice gates were, didn't you?

A. I have told what they were; what they consisted of, yes sir.

Q. Now that is all of the appliances that there are there?

A. That is all of the appliances there are there.

Q. Now where is the town of Lockport located with reference to this dam and these sluice gates?

A. It is located off to the southeast.

Q. Off to the southeast?

A. Yes sir.

Q. Now does the Illinois and Michigan Canal lie between the drainage canal and the town?

A. Yes, partially so. At this point the drainage canal is off from the Illinois and Michigan Canal a considerable

869 distance.

Q. But between the town and the Drainage Canal?

A. To go to the town you would have to cross the Illinois and Michigan Canal.

Q. Do you know the largest amount of water that can be discharged through these sluice gates and over the Bear Trap dam?

A. I never have computed it, but I have no doubt that depending upon the height of the water in the channel above, I suppose it is good for 800,000 or 1,000,000 cubic feet a minute.

Q. In other words you suppose it is made to equal the capacity at the Intake of the Canal at the mouth of the Chicago River?

A. Yes sir, to more than equal it.

Q. 800,000 cubic feet, that is per minute?

A. Per minute, yes sir.

JUDGE SPRINGER: In short, then Mr. Williams, these controlling works at the Bear Trap Dam were constructed for the purpose of controlling the amount of water that passed out of the canal into the Des Plaines River?

A. Yes sir.

Q. What is the necessity for controlling that outlet of
870 water?

A. Sometimes they would want to shut it off entirely possibly, and sometimes you must limit the flow through the river, and as a matter of fact that is what they have been compelled to do all the time, by the United States government. They have had to cut down the flow through the Chicago River in accordance with the standard set by the Secretary of War, and it is only by means of this controlling works, that they could do that.

Q. Without these controlling works then, there would be a tremendous flood?

A. It would simply run wild, you might say, that is, it would simply flow all that the hydraulic conditions would allow.

Q. And become a menace to property?

A. Until it would flow all the water that could go through the river and canal under the conditions of cross section and head and fall, and all of that. That is, in other words, it would do like a river itself; it would take its uniform flow and you would have no control over it.

Q. And this was a measure of precaution for the purpose of controlling the out-flow of water at all seasons?

A. Yes sir.

JUDGE SPRINGER: That is what I wanted. That is all.

ATTORNEY GENERAL CROW: That is all Mr. Williams.

871 **DR. WALTER C. G. KIRCHNER,**

Called as a witness in behalf of the complainant, being first duly sworn, was examined in chief by Attorney-General Crow and testified as follows:

Q. Now what is your name?

A. Walter C. G. Kirchner.

Q. What is your occupation?

A. Physician.

Q. Where do you live?

A. 1211 North Grand Avenue.

Q. How long have you been a physician?

A. For nearly two years.

Q. Do you occupy any position here in the city?

A. I am senior physician at the City Hospital.

Q. At the City Hospital?

A. Yes sir.

Q. What is your age?

A. Twenty-eight.

Q. Do you know Dr. Amand Ravold?

A. Yes sir.

Q. Did you assist him in any bacteriological work connected with the examination of waters of the Illinois and Missouri and the Mississippi rivers and the Chicago drainage canal and the Des Plaines river and Lake Michigan?

872 A. Yes sir.

Q. What waters did you assist him in investigating; do you know what particular waters?

A. Ocasionally the Chicago river, the Des Plaines river; the Drainage Canal itself; the Illinois and Michigan Canal; Illinois river, Missouri river and Mississippi river.

Q. What portion of the work did you do?

A. I worked and assisted mainly in quantitative analyses of the water.

Q. What do you mean by that?

A. Principally the determination of the numbers of bacteria.

Q. Is that what they called the plate-work?

A. Yes sir.

Q. Now just describe what that is, will you?

A. It consists in plating a certain quantity of water to be examined, which, if necessary is diluted to the proper amount and is mixed with culture media, and introduced into a so-called Petri dish and put into proper surroundings so that the bacteria may grow.

Q. Well now, you began working with Dr. Amand Ravold on this matter about the 10th of August, 1899, didn't you?

A. I think it was that date.

873 Q. And that examination ended in October, 1899?

A. There was a short period when I conducted an examination at the Intake, I don't know whether you referred to that or not.

Q. That is the time, at the Intake?

A. Yes sir.

Q. Do you remember how many samples of water were taken there?

A. I do not.

Q. Well, there were thirty-four samples taken. Now do you know how often those samples were taken at that place?

A. They were taken daily and sometimes twice daily for the period of investigation.

Q. That was at the Intake tower of the St. Louis Waterworks?

A. Well, do you mean the exact place at which the samples were collected?

Q. Yes.

A. Well the majority of the samples at that place were taken from the so-called Uptake.

Q. Uptake—what do you call the Uptake?

A. The uptake is a well on the shore.

Q. On the shore?

874 A. On the shore, which contains practically the same water as that in the Intake.

Q. Well this well is connected by tunnel with the Intake, 1,500 feet out in the channel of the Mississippi river?

A. Yes sir.

Q. Now what was done with those samples of water when they were taken out?

A. They were taken to the laboratory which was located at the Chain of Rocks.

JUDGE SPRINGER: Did this witness take these samples himself?

THE WITNESS: Yes, I took these samples myself.

Q. Now state where you took them then.

A. These particular samples were taken at the Chain of Rocks.

ATTORNEY-GENERAL CROW: Now you had a temporary laboratory at the Chain of Rocks?

A. Yes sir.

Q. Now what did you do with those samples?

A. They were plated in the usual way and after a proper period of incubation, counted.

Q. Who did the counting?

A. I did the counting.

Q. You did all the counting for that period of time, did you?

875 A. Yes sir.

Q. Do you recognize that work (handing witness paper)? It is a table of collection of water, read the top of that.

A. "Results of quantitative determination of bacteria in samples of water collected at different points near the Intake of the St. Louis waterworks, located at the Chain of Rocks—bacteria per cubic centimeter; date of collection and place of collection of samples."

Q. Well, is that the lot of samples of water at that place that you helped to collect?

A. Well this looks very much like the work that I had been doing, without referring specially to it; it covers the work that I had done there.

Q. Well, you made your reports direct to Dr. Ravold?

A. Well, this particular report was made to the Water Commissioner.

Q. The water commissioner?

A. Yes sir.

Q. Who was the Water Commissioner?

A. Edward Flad.

Q. Did you report to him?

A. This particular report was made to him.

Q. You reported it to him—did you report to him or did Dr. Ravold report to him?

876 A. Well this particular report went to Mr. Flad.

Q. From you?

A. Yes sir.

Q. You didn't give it to Dr. Ravold?

A. Well the work was done under Dr. Ravold's direction.

Q. Well, it was turned over to Dr. Ravold then, wasn't it, and he carried it to the water commissioner?

A. I think that was the understanding.

Q. You made a report of the work you did to Dr. Ravold, as your superior officer, didn't you?

A. Well at that time my report stated, it went to Edward Flad, who was then water commissioner.

Q. What did you do with it? It doesn't matter what it stated.

A. Why, I gave it to the Water Commissioner.

Q. Then you didn't give it to Dr. Ravold?

A. No, I didn't give it to him except for verification.

Q. Was there an official report made?

A. Why this was to be the official report.

Q. It was to be?

A. It was.

Q. Is that true of all collections you made during this period of time?

A. No sir.

Q. Up to October, 1899?

877 A. Up to October, 1899, yes sir.

Q. That is true of all those?

A. Yes sir.

Q. I will get these reports that you made and let you identify them. Now the next period of time. During that same period however, you took—there was thirty-two other samples of water taken at different points on the Mississippi and the Illinois River; did you participate in that?

A. Yes sir.

Q. Where were those taken from, on a boat or on the land?

A. They were taken from a boat.

Q. In what river?

A. In the Mississippi River. You are now referring to this first period of examination?

Q. Yes. Any other place besides the Mississippi?

A. I am not sure whether we went up the Missouri River or not. I can't recall the time just now.

Q. Now what became of these reports; were they given to Flad too?

A. I don't recall that exactly. I have not gone over that.

Q. You don't know?

A. I haven't gone over that recently and can't tell posi-
878 tively.

Q. Who had charge of that work, you or Dr. Ravold?

A. Dr. Ravold superintended the work, though I reported to the Health Commissioner, or to the Water Commissioner.

Q. Well, did you take these thirty-two samples from the river?

A. This is the first period of work?

Q. Yes?

A. Yes sir.

Q. From a boat—You don't understand me, do you?

A. I don't quite understand, no sir.

Q. I am asking you now about the samples of water that were taken on the boat—did you take those samples from the river,—from the Mississippi and the Illinois River?

A. Why all the bacteriological samples that were taken on the boat, I took in conjunction with Dr. Ravold, and I did all the quantitative work that was done.

Q. Well, did you take the water from the river?

A. I took the water from the river, yes.

Q. That is what I am trying to get at. All of them?

A. Yes sir.

Q. You did it alone? Anyhow, you took the samples on the boat and examined them, did you?

A. Yes sir.

Q. How were the samples taken—in bottles?

A. Yes sir.

879 Q. Didn't you have an apparatus that you collected them with?

A. Yes sir.

Q. Then were they transferred from the apparatus into the bottles?

A. The bottle was placed into the apparatus.

Q. And then you transferred the bottle?

A. Transferred the bottle to the proper receptacle.

Q. What did you do with the bottle after you took it out of the apparatus?

A. The bottle was sealed.

Q. And then you transferred the bottle?

A. We had a laboratory—a temporary laboratory on the boat.

Q. And you proceeded to make these analyses of the water there?

A. Yes sir.

Q. They were what you call plated on the boat, were they?

A. Yes sir.

Q. Now did you help do any work under the supervision of Dr. Ravold between January 23rd and October 11, 1900, in the Illinois River and the Mississippi River, and at the reservoir at the chain of rocks?

A. Yes sir.

Q. Now do you know who took these samples of water
880 from the River?

A. I do not.

Q. You don't know that?

A. No.

Q. Well, do you know where you did the work?

A. That work was done at the Medical College, I believe.

Q. What time?

A. At that time, we did it at the St. Louis medical college.

Q. All of it; was it all done there?

A. Later I think, the second portion of the work was done at the Old City Hall, what is now the Old City Hall, the Health Department.

Q. What part of the work did you do?

A. I did mainly the quantitative work.

Q. What do you mean by that?

A. I mean the counting of the bacteria.

Q. You didn't plate the bacteria?

A. Oh yes, that belongs to the quantitative work.

Q. This is part of the quantitative work is it?

A. Yes sir.

Q. From whom did you receive these bottles?

A. These bottles were received by—I received these from the collectors,—special collectors for this purpose.

881 Q. Well, did you open the bottles?

A. Yes sir.

Q. Then what did you do?

A. I took out the quantity of the water under the regular bacteriological conditions, and put them through the process of plating.

Q. How much water did you take out?

A. I almost uniformly took out one cubic centimeter of water, which was diluted under proper conditions, so that counting would be possible.

Q. What was the object of diluting the water?

A. So that in case the bacterial number should be very great the bacterial growth on the plate would be such that it could be more rapidly counted.

Q. Well, what was it that you diluted the water with?

A. With steriled water—steriled water was used in diluting.

Q. Was there a tag put on the bottles?

A. All of these bottles were tagged and labeled.

Q. What with?

A. The location, the time of collection, temperature of the water and temperature of air, and the name of the collector and such other information as the collector would sometimes obtain.

Q. Well, did you keep a record of all this matter and also of the plating?

882 A. All of these tags were filed, and the record of the counting was also kept in a special book for the purpose.

Q. That is the result of your work?

A. Yes sir.

Q. That was the official record of it, was it?

A. Yes sir.

Q. How many plates did you make from that set?

A. It was a rule to make duplicates; make the plates in duplicate.

Q. And then how did you get the results; did you count both plates?

A. Both plates were counted and an average was struck.

Q. At what temperature were the plates kept?

A. They were kept at a temperature of about eighteen to twenty degrees centigrade.

Q. For how long?

A. I usually counted on the third day; that was a little over forty-eight hours.

Q. Then where was this official record—who was it filed with?

A. It was filed with Dr. Ravold.

Q. Dr. Ravold?

A. It was placed in Dr. Ravold's hands.

Q. You did all of that plating between the period of
883 January 23 and October 11, did you, 1900?

A. Yes sir.

Q. Were you at Joliet, Illinois, doing bacteriological work under Dr. Ravold in the autumn of 1901, between the dates of October 1st and November 22?

A. Yes sir.

Q. At what place in Joliet were you?

A. Our laboratory was on—the exact number, I don't know—it is North Joliet Street.

Q. Were you working under Dr. Ravold at that time?

A. Yes sir.

Q. Did you make your reports to him?

A. Yes sir.

Q. Now do you know where the water came from that you examined bacteriologically?

A. It was usually submitted to me by the collectors.

Q. Well, do you know where they brought it from?

A. And it came from the various sources, the Des Plaines River, the Illinois & Michigan Canal, the Drainage Canal itself.

Q. What was the exact location of the place?

A. The exact location of the place that was taken from where this principal street crosses the—I don't remember the name of the street,—Ninth, perhaps, where the principal street crosses the Illinois & Michigan Canal on the way to the
884 Bear Trap Dam, controlling works,—Ninth Street.

Q. Well, were these bottles that you received, tagged?

A. Yes sir.

Q. What did the tags show?

A. The tags showed the date, the name of the place of collection, the temperature of the water and of the air; name of the collector, and possibly such other information as would be useful. At the Bear Trap Dam the regular readings or reading of the gauge, and such other information was also recorded on the tag; the condition of the water was also noted and recorded.

Q. Did you collect any water in Joliet?

A. Yes sir.

Q. Did you do that or did you have it done?

A. Occasionally I would collect myself, and more often the collectors. I would do some collecting, but more often the collectors sent me the bottles.

Q. What did you do with these samples after you received them, in the bottles of water?

A. These samples were plated immediately.

Q. Who did that?

A. I was the one who plated the samples.

Q. Did you collect samples at any other pla

885 A. Samples were also collected below Joliet at what was called Brandon's Bridge.

Q. What did you do with those samples?

A. Those samples were plated in the usual way immediately upon their arrival at the laboratory.

Q. Were they tagged?

A. They were also tagged.

Q. Did you make an official report of all that work to anybody?

A. All this work was embodied in a report and sent to Dr. Ravold.

Q. Did you send out all the bottles in which samples were collected, at Joliet?

A. Yes sir.

Q. Were those bottles sterilized before they were sent out?

A. Yes sir.

Q. In what way?

A. They were put into a hot air oven and sterilized at a high temperature for an hour.

Q. Do you belong to the health department of this city?

A. Yes sir.

Q. Then can't you get those official reports of your work and bring them down here tomorrow morning?

A. I think I can.

Q. In whose department are they? Are they in Mr. Francis'?

886 A. I think so.

Q. Or are they in the Bacteriological Department?

A. I think they are in Mr. Francis' charge.

Q. Will you get them and bring them down here so we can utilize them in the morning?

A. Yes sir.

ATTORNEY GENERAL CROW: You can cross-examine. I want the privilege of putting him on again in the morning on these reports.

JUDGE SPRINGER: Yes, certainly.

CROSS-EXAMINATION,

By Judge Springer.

Q. You stated that these samples at Joliet were taken by collectors, is that right?

A. Yes sir, some of them; in fact most of them.

Q. Most of them were?

A. Yes sir.

Q. What proportion of them did you take yourself?

A. I don't know; occasionally I would go with the collectors and see that the work was properly done; in fact I would quite frequently go with them to inspect their work.

Q. Go where?

A. Go with the collectors and assist them in collecting the samples.

887 Q. To what places did you go with the collectors?

A. To all the places at which samples were collected; that is to say while I was in Joliet.

Q. How much of the time were you engaged at Joliet in making these examinations and collections of water?

A. Well I spent all my time in this work; in this bacteriological work.

Q. How long was that?

A. I don't remember the exact date, but for this period of October to about December,—beginning of December.

Q. What proportion of these samples did you collect yourself or participate in collecting?

A. I can't tell exactly, but as I said before, I frequently went with the collectors to superintend the work.

Q. You couldn't tell whether you collected half of them or one-quarter of them, or any other part of them?

A. Well, I feel sure it was more than one-quarter.

Q. The samples that were collected by the collectors and brought to you were unknown to you except as to what the labels showed on the bottles?

A. Yes sir.

Q. Do you know how much time elapsed between the time of the taking of these samples in the water, and the time they were plated in your laboratory?

888 A. I can't tell exactly; the records will show that. They were plated usually as soon as possible upon arrival at the laboratory.

Q. Well how much time elapsed?

A. In some case, in those samples that were collected in Joliet, or near Joliet, those were often plated within fifteen minutes after collection.

Q. How about those collected at the Bear Trap Dam, Lockport?

A. Well, those samples were transported from the Bear Trap Dam to the laboratory, and it usually took—well, I can't tell exactly either, but it took possibly more than an hour for the samples to arrive.

Q. How were they brought?

A. They were brought properly sealed and tagged, packed in ice.

Q. By what means of transportation I mean?

A. They were brought in a buggy which had been hired for that purpose—horse and buggy.

Q. How many miles was it from Lockport to Joliet?

A. I don't remember exactly, possibly eight or ten miles; I don't remember exactly.

Q. Did you note, doctor, what kind of bacteria you found in those samples that you took or examined in Joliet?

889 A. Well, I did examine a number of the cultures as to the coli communis, but I didn't make it a point to make a qualitative analysis, that is to say, determining the kind of bacteria. Of course I incidentally met with some organisms that I was acquainted with.

Q. Your examination then was principally quantitative?

A. Yes sir.

Q. If you made any examination as to the quality of the bacterial, state what it was,—what you found?

A. I found that in the majority of samples examined, coli communis was present—the bacilli coli communis.

Q. Did you make any experiments with those bacteria, the bacilli coli communis, to ascertain whether they were virulent or not, or whether pathogenic or not?

A. No sir, I did not.

WALTER W. KIRCHNER.

890 **EDWARD JAMES RAVOLD,**

called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Attorney General Crow, and testified as follows:

Q. What is your name?

A. Edward James Ravold.

Q. Where do you live?

A. 2806 Morgan Street this city.

Q. You are a brother of Dr. Ravold?

A. Yes sir.

Q. Have you any recollection of being employed by Dr.

Ravold, your brother, to go up the Illinois River in the autumn of 1901 and collect samples of water?

A. Yes sir.

Q. Do you know what time that was?

A. Well that was about—that was in the latter part of November of the same year.

JUDGE SPRINGER: What year?

A. 1901.

Q. ATTORNEY GENERAL CROW: Do you know about what day of the month you commenced?

A. Well, it was along about—I don't know exactly the date.

Q. Well, approximately?

891 A. Along about the 10th some place, I started out.

Q. What were your duties under that employment?

A. Well I was instructed to take samples of the water that was flowing from streams into the Illinois River.

Q. Beginning at what point on the Illinois River?

A. Well, I started in at Grafton, and began to go right straight up.

Q. That is the mouth of the Illinois River?

A. That is the mouth of the Illinois River, and every river flowing into it of any size, I took water from it; I would go quite a distance up the river and take samples.

Q. Did you travel on a boat?

A. Yes sir, there was a Captain Fluent had a boat at Alton, and he started up the river, left Alton and went right straight up the river and when we came to a river of any size, we would go up the river as far as we could get—we had a twenty foot naptha launch,—and we would go up the river and get out into the stream and take a sample.

Q. What was done after you took the sample?

A. We tagged it.

Q. How would you take the sample?

A. We had a large bottle with us; we took the sample of water and the bottle was tagged; we took the temperature of the water at the time, and the time of the day that it was

892 taken, and that water was sent to Dr. Whipple, in Brooklyn.

Q. New York?

A. Yes sir.

Q. Who sent it?

A. I sent it.

Q. How did you send it?

A. Why, I crated it; that is the bottles were put in a large box and the box was sealed, and each bottle, as the sample was taken, the cork was sealed; that is, a wax label was put on it, or a wax seal.

Q. Was this packing and shipping done after the water was all collected?

A. Why, how do you mean—after it was sent to Mr. Whipple, oh, no. When I got up to Joliet, I shipped the water from Joliet that I had collected up to that point, right straight up the river.

Q. Well, did you ship any from Peoria—you got to Peoria before you got to Joliet, didn't you?

A. Certainly. Peoria was the first shipment.

Q. Well, you shipped water from Peoria first?

A. Yes sir.

Q. And that which you got between Peoria and Joliet you shipped from Joliet?

A. Yes sir.

893 Q. And this occurred right up around there as far as you went?

A. Well, I stopped when I got up to where there weren't any more rivers, when I got up to the canal.

Q. When you got up to Lockport?

A. Yes sir.

Q. Then what did you do?

A. Then I came home.

Q. Then you came home?

A. Yes sir.

Q. How far did you go up the river?

A. I went up to—we went up to Ottawa is where we stopped in the boat.

Q. How did you get the rest of the samples above Ottawa?

A. I had to take a train.

Q. Well now, at what other points did you collect above Ottawa?

A. Why there was three rivers above that—

Q. Three rivers?

A. Yes sir.

Q. What were they?

A. Well, the Fox River is the first river above that, that we took; that is right there just a little bit above Ottawa—in fact it almost flows through Ottawa.

894 Q. Did you get any from the Kankakee River?

A. Yes sir, we took that.

Q. LePage River?

A. We took the LePage, yes sir.

Q. Any other streams? Where is the Vermillion River?

A. That flows in above there too; we also got that.

Q. Any other streams?

A. Well that has been over a year ago, you know.

Q. Did you take any from the Des Plaines River?

A. Yes sir, we got one from that river too.

Q. Well, generally speaking, did you take them from all tributaries flowing into the Illinois River?

A. All tributaries flowing into the Ilinois River, we got a sample of.

Q. You shipped these samples sealed and crated, to Dr. Whipple?

A. Dr. Whipple.

Q. What was his first name?

A. I don't know.

Q. William C. Whipple, wasn't it?

A. I think it was George Whipple.

Q. George Whipple of Brooklyn, New York?

A. Yes sir.

Q. Now do you know whether he received them?

895 A. Oh yes, I know he received them. My brother told me he received them.

Q. Were they shipped in your name?

A. Yes sir.

Q. Did you sign the tag?

A. Yes sir.

Q. On the bottle?

A. Yes, I signed every tag. You know there is a small little tag put on every bottle and I also signed that, and I got a receipt from the express company.

Q. How much water was in a bottle?

A. Like one of these crystal water bottles; I don't know how much exactly.

Q. About a gallon?

A. About a gallon, I should judge, yes.

Q. Do you know how many samples you collected?

A. Well I couldn't state exactly, but it seemed to me it was around twenty-one, samples I think.

Q. Up to that point or altogether?

A. Altogether.

Q. Now did you—

A. I wouldn't be sure of that.

Q. Did you take any from the Illinois River?

A. Illinois River,—no, they were taking samples in the Illinios River all along you know.

896 Q. Well, did you take any?

A. No sir, I don't think I did.

Q. Did you take any water out of Lake Michigan?

A. No sir.

Q. Did you collect any water at Grafton for your brother, Dr. Ravold?

A. Yes sir.

Q. Did you collect any for Dr. Tiechmann?

A. Yes sir.

Q. Did you make collections for chemical—

A. I made both bacteriological and chemical collections.

Q. How did you collect that water?

A. Why I would get up at five o'clock in the morning and take two bottles, two of these large bottles, you know; that is chemical bottles, and two of the small bacteriological bottles and walked up—first I rowed up—I found that was too hard you know, so when it would be very high—sometimes about a mile or probably a mile and a half up to where there is an Island—

Q. In the Illinois River?

A. In the Illinos River, where the Illinois and Mississippi come together there, I would go up there. There was a man there by the name of Homer, had a little boat—he was a fisherman up there and I hired his boat, and at first I collected 897 both samples, I would go up there, go up into the Mississippi River—in the Mississippi first and get a sample of water—

Q. Well, you would get a sample for both Dr. Ravold and Dr. Teichmann, of the Mississippi river water?

A. Yes sir.

Q. Did you do that?

A. The chemical water for Dr. Teichmann—that is the big sample, you know.

Q. That is what you got in the Mississippi river?

A. That is what I got in the Mississippi. Then I came down and got the bacteriological sample in the Illinois river.

Q. But you didn't get both the chemical and bacteriological sample in the Mississippi?

A. No sir, I don't think I did.

Q. Were those tagged the same as the others?

A. They were tagged the same as the others.

Q. What did you do with them?

A. I just came down in time to catch the first morning train out of Grafton and shipped the water in here, so they got the water around about ten o'clock.

Q. Were all the bottles sealed?

898 A. Yes sir, sealed with a stamp.

Q. With a stamp?

A. Yes a stamp—with a city stamp.

Q. With wax?

A. With regular sealing wax, yes sir.

Q. You collected there from the first of December to about the middle?

A. Yes sir, 15th, I think it was, yes sir. You know after I made these trips—

Q. Did you take any hourly or half hourly samples at that point?

A. Oh yes, that is what I was going to get at. I found out I could hire this man to take day and night samples, every hour of the day and night.

Q. This man Homer?

A. Yes. I think it was to be so much whether he was to work day and night or day, and so I let him take samples day and night?

Q. Every hour?

A. Every hour he took these samples.

Q. Now where did you take them?

A. In the Illinois river.

Q. Now what samples?

899 A. These were bacteriological samples.

Q. Only?

A. Only. These were taken every hour.

Q. Continuing during the same period, all the time that you were taking samples for both chemical and bacteriological work?

A. Yes sir—well, half of the samples that I took the first thing in the morning.

Q. Do you know of your own personal knowledge that this man Homer did this work?

A. I was there and saw that he did that work, yes sir.

Q. Did he seal the bottles?

A. No, I sealed the bottles.

Q. He brought the bottles to you and you sealed them?

A. Yes sir.

Q. They were sent to whom?

A. They were sent to the City Chemist's office.

Q. To the City Chemist's office?

A. Yes sir.

Q. That is the bottles that Homer brought to you and you sealed?

A. Yes sir.

Q. To whom did you send your bottles?

A. To Dr. Teichmann.

900 Q. Bacteriological as well as chemical?

A. Yes sir.

Q. How did you send them, by express?

A. Yes sir.

Q. On what railroad?

A. The railroad that runs out of Grafton there—the Bluff Line, I think it is—Peoria and St. Louis.

Q. You didn't keep any record of this work?

A. How do you mean?

Q. Have you got a record of this work?

A. Oh, I kept a record of everything that I did, yes sir.

Q. Where is that record?

A. It is out at the house.

Q. Will you bring that down tomorrow, or send it down?

A. Why yes, I can do that.

Q. You made a memorandum, did you? At the time?

A. I think I have it out there, yes.

Q. You give it to the doctor and let him bring it down?

A. Yes sir.

CROSS-EXAMINATION, By Judge Springer.

Q. Mr. Ravold, did you sterilize the bottles which you used for taking these samples, before you put water into them?

901 A. These bottles were all handed to me by Dr. Teichmann.

Q. Well then if they were sterilized you knew nothing about it?

A. That was all done by them I should judge, yes sir.

Q. You simply took the bottles that were furnished to you?

A. I merely took the samples, yes.

Q. What kind of bottles were furnished you?

A. Why, it was a bottle, something like one of these crystal water bottles.

Q. Do you know how much they held each?

A. I should judge they were about a gallon.

Q. Were there more than one size?

A. No sir, they were all the same size.

Q. What kind of bottles did you use?

A. For which samples?

Q. For taking samples. I am asking for all the different kinds.

A. Why there was a small bottle taken for the bacteriological sample.

Q. How much did that hold?

A. Well I don't know; I think about a cupfull, I should judge.

Q. A pint?

A. I don't think there was that much in it. There might have been.

902 Q. How much would the other size hold, the next size?

A. Well, those large ones, they would hold about a gallon, I should judge.

Q. Were there three sizes or two?

A. There were two sizes.

Q. How many bottles did you take at each place?

A. Now which samples are these?

Q. Well, I am asking you.

A. I know, but which sample, when I was at Grafton or when I was going up the river?

Q. I am speaking about Grafton now.

A. Oh, why those samples were the same size, that I took chemically, those taken in the morning, and the samples that were taken for the bacteriological work were both the same size.

Q. How far up the mouth of the Missouri river did you go before you took your samples?

A. Missouri—I wasn't in the Missouri.

Q. Mississippi river I mean. Excuse me, up at Grafton, Mississippi river at Grafton?

A. Well, I don't know how far above it was; it was above that island there, where that island comes in.

ATTORNEY-GENERAL CROW: The Judge doesn't know where that is. Just give him an idea, just where it was.

903 A. It is about two miles above where the Illinois and the Mississippi river join, there at Grafton.

JUDGE SPRINGER: Q. Two miles above the confluence of the Illinois and Mississippi rivers?

A. It looked to be about that.

Q. How far out did you go into the stream?

A. Into the middle of the stream.

Q. Into the middle of the stream, for all your samples?

A. Yes sir.

Q. How deep down into the water did you go to take your samples?

A. Well, we went down a little more than a foot; foot and a half probably.

Q. How did you proceed to get the water at a lower depth than the surface?

A. Why, the samples that were taken bacteriologically were taken with a machine that was made purposely for that.

Q. What kind of a machine is that?

A. I can make a drawing of it.

Q. The one that was in here the other day?

A. I wasn't here the other day. It was a machine that you can pull the stopper out when it is under the water, you can pull the stopper out and then let it loose; then it corks up so no water comes into it.

904 Q. You inserted this apparatus into the water at what depth?

A. The machine was about that tall (indicating), say three feet, and we put that down in quite a depth down to my hands, and put the sample in and took it out; I don't know what the depth was, I didn't measure it.

Q. How far down do you think it was?

A. If I had the machine here I could measure it and tell you.

Q. Well you could give some idea of it without having the machine, whether it was one foot, two feet or three feet?

A. Those bacteriological samples were taken three feet under the water.

Q. Three feet under the water?

A. Yes sir.

Q. And what did you do with the samples when you took them?

A. The samplse were taken and sent to Dr. Ravold; that is, they were sent to the City Chemist's office.

Q. You sent all of them to him?

A. Yes sir. They were sent to Dr. Teichmann of course, that is the man that the label was shipped under; they were shipped to Dr. Teichmann, and from Dr. Teichmann they were turned over to Dr. Ravold.

Q. Did you use any means for keeping them cool while 905 they were in transit?

A. Why yes.

Q. What was it?

A. Up until when I got up there it was very, very cold, when I was up there; at first they were shipped in ice; they were packed in ice.

Q. You did that yourself?

A. Yes sir.

Q. What time of the year was this?

A. Well this was along about—from the first to the 15th of December; it was very cold weather.

Q. Well how long a time did you spend at that point?

A. I should say about fifteen days, I should judge.

Q. Did you send one every day?

A. Every morning, yes sir.

Q. Every morning?

A. Every morning, yes.

Q. Well that completed your work at Grafton?

A. At Grafton, yes sir.

Q. Now tell me about what time—about the time when you went up the river to take the samples in the streams emptying into the Illinois river; when was that?

A. I don't know exactly the date; it was along about, I should judge about the middle of November we started in, 906 and we went until probably about the 10th, I should judge won't say for certain, along in there some place; we went right straight up.

Q. Where did you get the bottles used on that expedition?

A. Those bottles were delivered to me here; that is, they were shipped to Alton. I received them at Alton and went right straight off with them.

Q. You know nothing then about how they were prepared?

A. No, I don't; I wasn't hired—I was only hired to take the samples.

Q. Just to take the samples?

A. Yes sir.

Q. Well how far below the surface of the water did you take those samples?

A. Those were taken eighteen inches under the water.

Q. Eighteen inches under the water?

A. Yes sir.

Q. Where were they taken with reference to the stream itself?

A. In the middle of the stream.

Q. In the middle of the stream?

A. Yes sir.

Q. How far above its confluence with the Illinois River?

A. Well it varied; the larger the stream was, the higher up the river we went; some streams we went two miles up the river.

907 Q. Did you go far enough up to keep out of any possibility of mixing the waters of the stream out of which you were taking the samples, with the Illinois River?

A. That I don't know; you mean in the rivers that were flowing into the Illinois River?

Q. Yes sir.

A. Oh yes, I am pretty sure we got above that.

Q. You aimed to get above the mixture of the waters of the two streams?

A. Yes sir.

Q. You continued taking those samples from the mouth of the Illinois River and the Des Plaines River?

A. Yes sir, right straight up.

Q. That is the last one, isn't it?

A. I think that was the last one, I took, yes sir.

Q. What did you do with those samples?

A. Those were sent to Dr. Whipple.

Q. Dr. Whipple of New York?

A. George Whipple, yes sir.

Q. How did you ship them?

A. Shipped them by express.

Q. You shipped them by express?

A. Yes sir.

Q. How were they prepared for that shipment?

A. Why they were crated.

908 Q. Explain how you did that?

A. Why, I had a box and I put six of these large bottles—I think it was six large bottles in a box; each bottle was sealed and we also sealed and stamped the cover of the box.

Q. Did you use any ice in that?

A. No sir, no ice used in that.

Q. Do you know what was the condition of the temperature, of the atmosphere at that time?

A. Why it was about the same as it is now.

Q. The report won't tell what that is?

A. It was pretty cold.

ATTORNEY GENERAL CROW: Well, it wasn't freezing?

A. No, I don't think it was freezing.

JUDGE SPRINGER: What state was the thermometer?

A. I say, I don't know exactly what the temperature was. You know I can't remember that now.

Q. The thermometer is the only thing that would indicate the temperature in the record?

A. Well that was all put on the tag.

Q. That was all put on the tag?

A. Yes sir, that was all put on the tag.

Q. What was it you put on each tag?

A. Well, we put the name of the river that it was taken from, the temperature of the water and the location—

909 ATTORNEY GENERAL CROW: And the time?

A. Yes sir, the time of the day it was taken; temperature of the water and the temperature of the air; both were taken.

Q. JUDGE SPRINGER: That all appears on the tag?

A. Yes sir, that is all on the tag.

Q. I believe you stated that you knew that Dr. Whipple got these samples. How did you know that?

A. I was told afterwards that he got them.

Q. You were told by whom?

A. By my brother.

ATTORNEY GENERAL CROW: You needn't waste any time on that; we will put Dr. Whipple on the stand.

JUDGE SPRINGER: All right. I understood him to say before that he got a receipt for them.

ATTORNEY GENERAL CROW: From the express company.

THE WITNESS I got a receipt from the express.

Q. JUDGE SPRINGER: So you know nothing about their receipt in New York, except what you were told by others?

A. That is all, yes sir.

Q. Do you know how long it would take for those samples to go from the place at which they were shipped, to New York City?

A. No sir, I don't.

E. J. RAVOLD.

ADJOURNED until 9:30 A. M., Friday, February 27, at Southern Hotel, St. Louis.

910 Southern Hotel, St. Louis, Missouri. 9:30 a. m., Friday, February 27th, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

DR. W. C. G. KIRCHNER re-called for further direct examination by Attorney-General Crow, testified as follows:

Q. Now, doctor, turn to the work in 1899, and we will identify that in the first place. I believe you began on August 10th, 1899. The first was taken near the St. Louis Waterworks at the Chain of Rocks, August 10th, 1899. Now, did you collect samples at that place?

A. At the Chain of Rocks, 1899, yes, sir.

Q. Now, you had a temporary laboratory there?

A. Yes, sir.

Q. And you made a bacteriological examination?

A. Yes, sir.

Q. And did you make any data at the time of the results?

A. Yes, sir.

Q. Have you got those?

A. Yes, sir.

911 Q. Now, what period of time does it cover and what points with reference to the Intake? Some at the Intake and some at the Uptake?

A. I have here some data with reference to the Uptake. The first record was made here August 10th, 1899.

Q. When was the last one?

A. And they continued August the 10th and 11th, and through August to September 11th.

Q. They run along further than that, along to the 25th?

A. I have some records here also as to September 20th. Of course, those were afterwards collected. In these details it is a little more difficult for me to give them just straight in that way.

Q. What details do you refer to?

A. These details I submitted to Dr. Ravold.

Q. Well, here are the details (handing paper to witness). That was made from your data there. Now, that runs to September the 25th.

JUDGE SPRINGER: The record won't show what you handed to him.

ATTORNEY-GENERAL CROW: It is the quantitative determination of bacteria in samples of water collected at different points near the Intake of the St. Louis Waterworks, located at the Chain of Rocks. The bacteria per cubic centimeter.

912 Q. Now, that is the first detail. Haven't you got the data there?

A. Yes, but I was giving you the results of the Uptake, which are recorded up to the 11th, which was what I said—

Q. Now, that's all?

A. Now, some of the other records here at the Intake were collected in a special report. I have a note here, September 25th, 3,610. This may have been taken from one of those harbor boat trips.

Q. I know, but what I want you to do, doctor, is to say whether you have got the data from which this detail was made. That's all we want. We want to put that into the record. We don't want to go all through those figures.

A. I have it here. This detail has been arranged differently from the one I have made out. This is Dr. Ravold's arrangement, probably.

Q. It is more compact?

A. It is more compact, yes.

ATTORNEY-GENERAL CROW: I don't think it is necessary, gentlemen, to identify those. If he will examine those and state that the figures there correspond with the notes that were made at the time, and that the statement is correct.

A. I didn't compile this detail.

Q. You have got this data and know as to whether they correspond?

913 A. September 25th, 3,600. I cannot state whether on that date at the Uptake they were. I have collected it in different details. This is one of the harbor boat trips and came in a special list, but this list here from the Uptake, I will read and it will correspond exactly.

Q. I don't want you to read that. That's what I want to avoid.

JUDGE SPRINGER: Let him state whether he examined these figures and whether they correspond with the notes he made at the time in his own detail.

ATTORNEY-GENERAL CROW: I know what I want to get at. Now, this detail here that has been described as the determination of bacteria in the samples of water at the different points near the Intake, commenced August 10th, 1899, and ended September 25th, 1899, is that correctly made and based upon the data that you made as a bacteriologist in the examination of that water at that time?

A. It is.

Q. And you took that water from the river?

A. Yes, sir.

ATTORNEY-GENERAL CROW: I think that will cover that.

Q. Now, have you got the data you made on the harbor boat trip commencing September 6th and ending September 25th? There is the detail I hand you now, you can examine it and see.

914 A. The details presented here of the harbor boat trips of September 6th, 9th, 16th, 21st and 25th, correspond with the data I collected, referring to these respective dates.

Q. And you have that data there?

A. I have that data, the original.

Q. And this detail is correctly made from that?

A. Yes sir.

Q. Now in carrying out the results in this detail, do the exact number of bacteria correspond with the number you had, or was there any change made in the numbers, and if so, explain why, their exact number does not correspond.

A. Because in accordance with the general rules of the Bacteriological Association or the American Public Health Association a certain arrangement has been made as to the recording of results. It is something like this: The method of recording results of bacteria: One to fifty recorded to the nearest unit; fifty-one to one hundred to the nearest five; 101 to 250 to the nearest ten; 251 to 500 to the nearest twenty-five; 501 to 1000 to the nearest fifty; 1001 and over to the nearest 100.

Q. Explain what you mean by that. By changes with reference to that.

A. So that in my original details for instance, if a number would read 159, it would be recorded to the nearest
915 number with reference to this detail, which would be 150.

Q. The nearest even unit?

A. Yes sir.

Q. Now you worked on this matter under Dr. Ravold in 1900?

A. Yes sir.

Q. Now this begun January 23rd, and ran to October 11th, 1900. The first work seems to have been done in the Illinois River, three miles above and below. Now have you got the data that you made at the time you did that work?

A. Yes sir.

Q. Now where were you located when you did that work?

A. The St. Louis Medical college, the medical department of Washington University.

Q. What time did you commence that work?

A. The work was started January 23rd, 1900.

A. Did anybody assist you in that work?

A. In this work I was assisted by Dr. Rush.

Q. Did Dr. Rush analyze bacteriologically the same samples that you did?

A. The same samples that were examined by me.

Q. Now explain the method that you worked under.

A. These samples were examined in duplicate, and Dr. Rush and myself examined each of these samples so that in this way the work was divided, and in general, duplicates were made of all samples; that is to say, by two different persons.

916 Q. Explain your method of procedure, what you mean

by your work there; what did you do? You plated them and counted them, didn't you?

A. The general work consisted in plating and counting the bacteria.

Q. Now how did you ascertain the results after you had counted them. Did you always get the same?

A. The results were averaged.

Q. Well, how. Explain how you averaged them?

A. Each would refer to his own analysis, to his own results. The figures obtained from the similar samples were averaged.

Q. Is that in accordance with the proper way to do that bacteriologically where two men work on the same samples?

A. It is the safer way, it is a check. One individual checks the work of the other by this method.

Q. Well, is that the way, scientifically, this class of examinations are made bacteriologically, of water where two men work on the same samples?

A. Yes sir.

Q. Now have you got the results or data there?

A. Yes sir.

Q. What was the first examination you made, beginning September 23rd?

A. No, January 23rd.

Q. At what point?

917 A. Various samples were taken at that time: from Peoria, Grafton, Elsah, at Chain of Rocks, Illinois shore, Intake, Uptake and Reservoir.

JUDGE SPRINGER: What do you mean by uptake?

A. The uptake is the well which is situated on the shore at the Chain of Rocks and is connected with the Intake by a tunnel.

ATTORNEY GENERAL CROW: At what point did you begin?

A. These various samples were submitted on this day.

Q. At what point in the river did you begin three miles above Poria?

A. On January 23rd at Peoria, I counted 22,880.

Q. Hold on a minute. I don't want you to read those figures. That's what I am trying to avoid. Wait until I get this detail here. We want to save time on this if we can.

A. I have also Grafton records. What do you want, three miles above Peoria, beginning on the 23rd of January?

Q. Now you take that examination and see if your data there corresponds with that detail.

THE WITNESS: Did you read that detail, Dr. Ravold?

Q. What detail is it?

DR. RAVOLD: This is the results of quantitative determination of Illinois River three miles above Peoria, beginning the 23rd of January and ending October 11th.

918 THE WITNESS: This detail corresponds with my results.

Q. Now you made those examinations?

A. Yes sir.

Q. Where did you get the water from?

A. The water was sent to the laboratory by collectors.

Q. Do you know who collected it?

A. I do not.

Q. Now who was it sent to, to Dr. Teichmann or to whom?

A. They were sent to the Medical College.

Q. Now the next point there is three miles above Grafton, see if you have got the data from which this detail was made. This detail is the quantitative determination of bacteria in the Illinois River three miles above Grafton, together with results of tests for the coli communis from January 23rd to October 11th, 1900.

A. This detail corresponds with the results I have collected.

Q. Now the next one is the Mississippi River two miles above Grafton. The results of determination of bacteria in the Mississippi river water two miles above Grafton, from January 23rd, to October 11th, 1900. Now I will ask you if you have got the data from which that examination, or that detail was made, and if you made a bacteriological analysis of the water?

A. I did.

919 Q. Now the next one is the Mississippi River above Alton, Illinois, the same period. The quantitative results of the tests for bacteria on the same dates.

A. I did.

Q. Did you make an analysis of the waters?

A. Yes sir.

Q. Now have you got the data from which this detail was made?

A. I have.

Q. Were the details correctly made?

A. Yes sir.

Q. Did you make the data at the time?

A. The data was made at the time.

Q. The next is, the Mississippi River opposite Hartford, Illinois, same period, January 23rd to October 11th, an examination of the Mississippi River water for the determination of the number of bacteria per cubic centimeter between January 23rd and October 11th, 1900. Please examine that and see if you have the data from which that was made and as to whether or not you made an analysis of the water at that time?

A. I have this data, and made an analysis of the water.

Q. And is this detail that I have referred to correctly made?

A. Yes sir.

920 Q. The next is the Missouri River opposite Ft. Bellefontaine, on the Missouri shore, being results of the quantitative determination of bacteria in the Missouri River, between January 23rd and October 11th. Please examine that detail and see if you have got the data from which that bacteriological detail was made, and state whether or not you made an examination of the water?

A. The detail corresponds to my original data, and I also made the examination of the waters from which the data were obtained.

Q. Is the detail correctly made?

A. Yes sir.

Q. The next is the Mississippi River at Chain of Rocks, near the Illinois shore, being result of the determination and examination of the water for bacteria at the point above named, between January 23rd and October 11th, 1900. I will ask you to please state if you made an examination of that water at that time, and if you have the bacteriological result or data which you made at the time, of the examination, and whether or not that detail is correctly made from that data?

A. I made the examination and the detail corresponds with the original results, and it is correct.

Q. Did you make a memorandum of the data at the time you made the examination?

921 A. Yes sir.

Q. Now the next is the Mississippi River, Chain of Rocks, near the Missouri shore, being the results of the quantitative determination of bacteria in the Mississippi River water near the Missouri shore at the Chain of Rocks, between January 23rd, and October 11th. I will ask you to examine that detail.

A. This is the Intake. I have here the detail of the Intake which corresponds to the original data collected and is correct.

Q. You made the examination of the water at that time?

A. I did.

Q. Now you see you have got the details mixed here. Here is the one I asked you about before, and I asked you about this one at the Chain of Rocks, and the other at the Missouri shore. Here is the one at the Chain of Rocks, near the Illinois shore. You have got these details mixed.

A. I was comparing them with the results down here (indicating paper).

Q. You see this is the Intake of the St. Louis waterworks at the chain of rocks (indicating).

A. Yes sir.

922 Q. Now here is the one at the Chain of Rocks near the Illinois shore. Now you see you had that above there. Now you turn back in your data. You have got your data mixed up. Turn back there and see.

A. I have it right here.

Q. Does that correspond?

A. Yes, that corresponds.

Q. Well you have put that detail in?

A. Yes sir.

Q. Now the next detail is at the Chain of Rocks near the Missouri Shore, have you got that?

A. Yes sir.

Q. Now I will show you the detail, being the result of the quantitative determination of bacteria in the Mississippi River water at the Intake of the St. Louis Waterworks, at the Chain of Rocks, made between the 23rd of January, 1900, and the 11th of October, and will ask you if you made the examination of the water and if you have the original data of the bacteriological result of that examination, and if so please compare it with the detail I presented to you and state whether or not this detail is correctly made?

A. I have compared the detail with the original results, and made the examination of the water and find the detail to be correct.

923 Q. Now the next is the reservoir at the Chain of Rocks. I show you the detail, being the quantitative determination of bacteria in the water collected from the reservoir of the St. Louis waterworks at the Chain of Rocks between January 23rd, and October 11th, 1900, and ask you if you made that examination bacteriologically, and if you have the data which you made at the time, and if so please compare it with the detail I present you and state whether or not it is correctly made?

A. I have compared the detail with the original data and find that the detail is correct, and that I also made the examination from which the detail was made, the bacteriological examination.

Q. Now that is the end of that period, isn't it?

A. Yes sir.

Q. Now I show you a detail, being the result of examination for bacteria in the discharge of the Chicago Drainage Canal before it passes over the Bear Trap Dam at Lockport, Illinois, made between the 3rd day of March, and October 11th, 1900, and ask you if you made these bacteriological examinations, and if so where you made them, and where you received the water from and whether or not the detail which I have shown you, was correctly made from the data obtained at the
924 time?

A. I have the original data from which the detail was made, covering the period stated from March 3rd to October 11th, and find that the detail is correct and that the water was sent to the laboratory having been collected by collectors; that the examination was conducted at the medical college of the medical department of the Washington University and also at the Old City Hall in the City of St. Louis.

Q. In what year was this?

A. In 1900.

Q. Now I show you the detail being the result of the quantitative determination of the water in the Des Plaines River at McDonnough Street, Joliet, Illinois, made between March 3rd and October 11th, 1900, and ask you if you made that bacteriological examination, where you received the water from, whether or not you made any data at the time and if so examine the same and see if this detail I present you is correctly made from that data?

A. I made data on the bacteriological investigation of the water from the Des Plaines River at Joliet collected near McDonnough Street; that data corresponds with the detail and I find it to be correct.

Q. I show you now the detail, being the determination of the examination of water for bacteria collected at the
925 different cribs in Lake Michigan, with the results of the
tests for the bacillus coli communis between July 23rd and November 9th, 1900, and ask you if you made that bacteriological examination and where you received the water from and if you made any data at the time of the examination, and if so, if the detail I show you is correctly made from the data which you have?

A. The samples of water were sent to the laboratory, having been collected by collectors for that purpose; the results were recorded at the time and compared with the detail and the detail is found to be correct, except that the coli record as given here was not made by myself.

Q. State where. "Here" don't mean anything in the record.

A. It is stated here in the record, "result of tests for bacillus, cold communis"—I didn't make such test: I simply made the quantitative determination.

Q. I show you a detail, being the quantitative determination of bacteria in samples of water collected from the reservoir of the St. Louis Waterworks, Chain of Rocks, between

January 23rd, and October 11th, 1900, and ask you if you made an analysis of this water and if you made any data on the bacteriological results, and if the detail I show you was correctly made from the data made by you at the time of that examination of the water?

A. The detail was correctly made from data collected at the time; the samples were collected, and such samples
926 were submitted to me having been sent by the collectors.

Q. Now I show you a detail showing the determination of bacteria in samples of water collected at the tap in the bacteriological laboratory in the Old City Hall, City of St. Louis, Missouri, between the 11th day of May and October 31st, 1900, and ask you if you made the bacteriological tests of this water and if you have the data, made by you as the results of such tests at the time, and whether or not the detail I show you is correctly made from that data?

A. I made the bacteriological examinations of the tap water and recorded the results, and have compared them with the detail submitted here and find that detail is correct.

Q. I show you now a detail showing the quantitative examination of the water of the Des Plaines River made between October 5th and November 25th, 1901—at what point was this?

A. About a mile above the point where the Des Plaines River flows into the Drainage Canal or meets the Drainage Canal.

Q. (Continued) —about a mile above the confluence of the drainage canal and the Des Plaines River and I will ask you if you made an examination of that water at that time, and if you made any data, and if this detail is correctly made from that data?

A. I made an examination of the water of the Des Plaines River as indicated in the detail, recorded the results at
927 the time, and find that these results correspond with those in the detail.

Q. I will get you to examine this detail showing the bacteriological examination above the Bear Trap Dam on September 26th, 1901, and continuing until November 25th, 1901 and see if that detail is made correctly from the data you have, and if you made that examination?

A. I find that the detail as presented here, corresponds with the results which were obtained by the bacteriological examination of the water taken from the Bear Trap Dam, above the Bear Trap Dam at Lockport.

Q. I show you now the detail purporting to be the bacteriological examination of the waters of the Drainage Canal at the 9th Street Bridge, Lockport, and ask you if you made the examination and if you have the data made at the time and if the detail here presented is correct, extending from October 2nd, 1901 to November 25th, 1901.

A. Yes sir. I find that this detail as presented corresponds with the results of the examination bacteriologically of the water taken from the Drainage Canal at Lockport at the Ninth Street bridge.

Q. I show you now the detail disclosing the bacteriological examination made at the Illinois & Michigan Canal, 9th Street
Bridge, Lockport, Illinois, between September 26th and
928 October 30th, 1901, and ask you if you made that bacteriological examination and if this detail is correctly made from the data gathered by you as the result of that examination.

A. I find that this detail corresponds with the original data obtained by the examination of the water of the Illinois & Michigan Canal at Lockport, at the 9th Street bridge.

Q. Now I show you a detail representing an examination bacteriologically of the water of the Drainage Canal below Rubey Street, Joliet, Illinois, between September 25th, and November 25th, 1901, and ask you to state if you made an examination and if this detail is correctly made from the data gathered by you as a result of that examination?

A. I find that the detail corresponds with the results obtained by making the bacteriological examination of the drainage canal below the Rubey Street bridge at Joliet.

Q. I show you now a detail made of the bacteriological examination of the Drainage Canal above Brandon's Bridge, Joliet, between September 27th, 1901, and November 25th, 1901, and ask you if you made that examination and if you have the data gathered as a result of that examination, and if the detail presented to you is correct as made from that data?

A. I made the bacteriological examination of the Drain-

age Canal at Brandon's Bridge, above Joliet, and recorded the results at the time, and find that these results correspond
929 with the detail presented.

Q. Now you stated that you made all these examinations in pursuance of the ordinary and proper method of bacteriologists in the examination of this water?

A. Yes sir.

Q. Made under the supervision of Dr. Ravold, was it?

A. Yes sir.

Q. Did you have any instructions as to the manner in which these were to be made?

A. Instructions as to the general routine work were given, and these were based mainly upon the procedures for bacteriological work recommended in the American Public Health Association's report.

CROSS EXAMINATION,

By Judge Springer.

Q. Doctor, you stated yesterday, the course which you pursued at Joliet in reference to making bacteriological examinations of the water taken at that place—State whether the examinations to which you have testified today, were made under the same circumstances and conditions?

A. Are you referring to my statement of yesterday, Judge?

Q. Yes.

A. In general, all the examinations as reported this morning are in accord with the methods I indicated in yesterday's testimony.

930 Q. You pursued substantially the same methods in making your examinations of the samples to which you have referred today, that you pursued at Joliet?

A. Yes sir.

Q. Do you know where the samples came from to which you have testified today, any further than they were reported to you by those that had taken them?

A. With the exception of those samples received at the Joliet laboratory I have no other information than that which was indicated on the label attached to the sample.

Q. Do you know the names of the persons who took these samples?

A. Yes sir.

Q. Were they upon the labels accompanying these bottles?

A. Yes sir.

Q. And what other data, if any, were upon that label?

A. There was the date, location, temperature of the air and water, the name of the collector, and the weather indications, and often such other information as would be collected by the collector.

Q. Your examinations of the water to which you have referred today, began at what date?

931 A. They began—I can refer to them exactly. On those details which I reported today, the examination began August 8th, 1899.

Q. And ended when?

A. And ended October 31st, 1900. I should say there was an intermission in my work which I have not stated.

Q. Have you testified today in reference to any examinations made in 1891?

A. Then there was a period of examination in 1901 which began September 25th, and ended November 25th, 1901.

Q. Where were the examinations made of the water taken in 1899?

A. Those examinations were made in the laboratory at the Chain of Rocks.

A. At what place were those samples taken?

A. They were taken at the Intake or Uptake, the so-called Uptake and at various points in the river at the Chain of Rocks, on the Illinois side and on the Missouri side.

Q. How long after the samples were taken was it, until you plated them in your laboratory?

A. Are you referring now to this first period?

Q. I am referring to the time of which we are now speaking.

A. The samples were plated immediately upon arriving at the laboratory, and usually from five to fifteen minutes 932 elapsed between the time they were collected and plated at the laboratory.

Q. That refers to those that were plated at the laboratory at the Intake?

A. Yes sir.

Q. In 1899?

A. Yes sir. In addition there were also some samples taken on the boat in this period. Those samples were plated on the boat directly after collection.

Q. Now that covered all the samples in 1899, did it?

A. Yes sir.

Q. Now where were the samples taken in 1900 plated?

A. Those samples were plated first at the medical department of Washington University,—in the laboratory of the medical department of Washington University, and later in the old City Hall at St. Louis.

Q. At what place were those samples taken for that year?

A. They were taken at the Bear Trap Dam at Lockport, and the Des Plaines River at McDonnough Street, Joliet; the Illinois River three miles above Peoria; the Illinois River three miles above Grafton; the Mississippi River two miles above Grafton, Illinois. The Mississippi River one mile above Alton; the Mississippi River opposite Hartford, Illinois; the Missouri River opposite Ft. Bellefontaine, Missouri; the Mississippi 933 river at the Chain of Rocks near the Illinois shore; the Mississippi river at the Chain of Rocks near the Missouri shore; the Mississippi River at the Chain of Rocks, Intake tower, and the reservoir at the Chain of Rocks.

Q. Now were all those examinations made in the city of St. Louis?

A. I should include in that the tap of the bacteriological laboratory.

Q. Yes.

A. All those examinations were made in the city of St. Louis.

Q. How long after the sample was taken from Bear Trap Dam was it until it was plated in St. Louis?

A. The samples were usually plated on the next day. Of course for each particular sample I had a particular record.

Q. I am not asking you for that.

A. In general?

Q. Yes, I am speaking generally?

A. Usually on the next day, as soon as they arrived at the laboratory, having been sent from the station.

Q. How were they sent from the station?

A. They were sent by express.

Q. Can you state how they were packed?

A. They usually came cold; they were cold when they were received.

934 ATTORNEY GENERAL CROW: Explain what you mean by cold.

A. They had been transported in ice:

JUDGE SPRINGER: About how many hours then elapsed between the taking of the samples in the Drainage Canal at Joliet and Peoria, before those samples were plated in your laboratory in St. Louis?

A. From 24 to 48 hours. I can refer to it definitely.

Q. Well, you may state one of them definitely from each place, if you please?

A. On May 14th, the sample was collected at 9:00 A. M., at Lockport above the Bear Trap Dam and was plated May 15th, at 4:00 P. M.

Q. Now take one from Joliet.

A. I will take a different date. May 20th a sample was collected at 11:00 A. M. and plated May 21st at 3:00 P. M.

Q. Now take one at Peoria?

A. Peoria, May 18th, collected 8:40 A. M.; plated May 19th, 4:00 P. M.

Q. That was how many days elapsed then?

A. That was, well, just about a day, between the 18th and 19th.

Q. A little over 24 hours?

A. Yes sir.

Q. Will those three samples compare as to time fa-
935 forably with the others or unfavorably?

A. I think they compare favorably with the length of time, except that when the results were very bad the record wasn't placed in the official record.

Q. Did you take any samples at Beardstown, Illinois?

A. No sir.

Q. And none at Pekin Bridge?

A. The only record I have is that which was attached to the label, and that wasn't one of our regular collecting points.

Q. You didn't receive any samples then that came from the Pekin Bridge below Peoria, or from Beardstown?

A. Not regularly.

Q. Are any of the examinations to which you have referred in the detail presented by Dr. Ravold from those two places, that you examined also?

A. No.

Q. The next place then would be the mouth of the Illinois River at Grafton. What time elapsed between the time of the taking of those samples and the time they were examined in St. Louis?

A. On the 21st of May, for instance, a sample was collected in the Illinois River at 6:00 A. M. and was plated on the same day at 3:00 P. M.

936 Q. That is nine hours?

A. Yes sir.

Q. Is that a fair statement as to the others, as to the time elapsing between the taking of the other samples and their examination?

A. It compares favorably with those. Sometimes the time was a little shorter I think, and sometimes a little longer, but it compared favorably with the time.

Q. Now the other examinations to which you refer were at Alton, at Hartford and near the Chain of Rocks. Did you also make an examination of water taken at Ft. Bellefontaine, Missouri River?

A. Yes sir.

Q. State how long a time elapsed between the taking of the samples at that place and the plating in your laboratory?

A. I have here a record. On May 19th, a sample was collected at Ft. Bellefontaine, Missouri at 10:40 A. M., and was plated on the same day at 4:00 P. M.

Q. Six hours?

A. Yes sir, and this compares favorably with the time required in the other examinations.

Q. The samples taken near the Intake I presume, were

plated much sooner, according to your statement made heretofore, is that right? The samples taken at the Chain of
937 Rocks I mean, along that line, were plated sooner?

A. Some of those were plated sooner, yes. They were plated sometimes within a few hours. When we were at the laboratory at the point of collection, I will say, immediately after collection.

Q. You were going to make a further statement.

A. No, not unless you ask.

Q. Have you any statement as to the time which elapsed between the taking of the samples at Hartford, Illinois, and the time of their examination in the laboratory?

A. Yes sir.

Q. What is that?

A. I have here for instance, a record on the 17th of May where a Hartford sample was collected at 9:45 A. M. and was plated the same day at 4:00 P. M. I have also another record of a sample collected on May 20th at noon and this sample was plated on the next day.

Q. What time?

A. At three P. M. but usually samples were plated on the same day within a few hours after collection.

Q. Can you put in the record that sample that was plated the next day after it was taken. Have you identified it?

A. It could be identified by the serial number. It sometimes happened that on Sunday or on special occasions
938 when the train was late, it was impossible to plate the sample on the same day.

Q. Can you state the conditions in which the samples were at the time you made an examination of them as far as the temperature is concerned?

A. All samples which were plated were cold.

Q. What do you mean by cold. Give me the temperature according to the Centigrade or Fahrenheit, whichever you care to. There are so many different terms.

A. When the sample was not cold, it was not used, or a special record was made.

Q. Well, what do you mean by cold in temperature?

A. Now the samples when received were packed in ice.

Q. When you received them?

A. Yes sir.

Q. What was the temperature which you noted, if any, according to the thermometer?

A. Well, it varied; I do not remember the exact temperature.

Q. Did you note the temperature?

A. It has been done.

Q. That was part of the examination, to note the temperature at the time of the examination.

A. Well I didn't make a routine practice of taking the temperature of the water of the samples. 939

Q. Did Dr. Ravold make those entries?

A. I don't know.

Q. Isn't it important to make a record of the temperature of water when you make an examination of a sample of it?

A. It is in certain respects.

Q. Will there not be a greater number of bacteria in the water at what we call body temperature, than if it is down towards the freezing point?

A. Yes, but I said that all these samples were packed in ice and that the samples were taken from the receptacle containing ice.

Q. That completes your examination for the year, 1900?

A. Yes sir.

Q. Did you go beyond that?

A. Yes sir, 1901.

Q. Now state when you made the examinations in 1901, or rather, where you made them?

A. The examinations in 1901?

Q. I mean state where the samples were obtained for the examinations which you made in 1901?

A. The examinations in 1901 were made at the laboratory situated in Joliet, Illinois.

940

RE-DIRECT EXAMINATION.

By Attorney General Crow.

Q. These samples came packed in ice, in an ordinary bottle?

A. Well, the samples were properly sealed.

Q. I know, but the bottle was packed in ice?

A. Yes sir.

Q. I will get you to state if it would have been possible to have obtained the temperature of that water without spoiling the sample?

A. Well, it would have been impossible to get the temperature of the water directly without spoiling the sample for bacteriological purposes.

Q. Now, was a record made of the temperature of the air and water at the time the sample was taken out of the water?

A. Yes sir.

Q. Where is that record?

A. That record was placed on the label and was also referred to in some of the detail.

Q. Well it should be on each one of the labels on the bottle?

A. Yes sir.

Q. Do you know who put that label on there?

A. The label was put on by the collector who signs his name to the label.

941 Q. Now you made a record of the temperature of the air and water at the time it was taken and placed in these books about which you have been examined there?

A. Such a record has been made.

Q. Is it in these books, the memorandum which you had?

A. Yes, sir.

ATTORNEY-GENERAL CROW: Now, I offer counsel on the other side an examination of that part of the record any time they wish to. I don't care to put it into the record; it is too much and is not necessary.

RE-CROSS-EXAMINATION, by Judge Springer.

Q. Now, what proportion of the sample that you received was used by you in making the examination?

A. The portion selected directly for the examination depended upon the number of bacteria which experience showed us that particular sample would probably contain. For instance, it was necessary in some cases, to dilute one cubic centimeter for the purpose of obtaining a satisfactory count of the bacterial numbers.

Q. You never used more than one cubic centimeter of the sample for one examination, is that right?

A. Uniformly, one cubic centimeter was taken for a particular plate. 942

Q. Then, couldn't you have inserted a thermometer into the rest of it and obtained the temperature at the same moment? That water was thrown away after it was taken?

A. In some cases these samples were reserved for qualitative determination. We didn't care often to destroy the sample. This is the way samples were kept for more than twenty-four hours, often, for the purpose of determining as the case may be, some qualitative determination.

Q. Well, were they kept in ice during these 24 hours?

A. They were kept in the ice box.

Q. Under the same conditions of temperature that you found them in the first place?

A. Well, yes, under the same conditions of temperature.

WALTER C. G. KIRCHNER.

943 DR. AMAND NICHOLAS RAVOLD, resumed the stand for further direct examination by Attorney-General Crow and testified as follows:

Q. Now, Dr. Ravold, these examinations that Dr. Kirchner testified to were made under your supervision?

A. Yes, sir.

Q. Now, you heard and saw the comparisons made from the data he had and those I presented to him, and I will ask you if the details I presented to him, are the same details for the corresponding period that you have heretofore read into the record in this case. Examine them and see.

A. Yes, sir, they are. I read over all these details.

Q. These details were read into the record?

A. Yes, sir, by me.

Q. Those are the details that Dr. Kirchner has identified as having been made from the data collected at the time stated by Dr. Kirchner?

A. Yes sir.

944 **JAMES J. MOORE**, called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Mr. Jeffries, and testified as follows:

Q. What is your name?

A. James A. Moore.

Q. Where do you live, Mr. Moore?

A. I live at 1415 North Ninth street, St. Louis.

Q. How long have you lived in St. Louis?

A. I have lived here all my life, 28 years.

Q. State whether or not you ever did any work for the Health Department of St. Louis?

A. Yes, sir.

Q. Any work in connection with collecting samples from the Missouri river for Dr. Teichmann and Dr. Ravold, and if so, when?

A. From October 4th, 1901, until December 1st, 1901.

Q. At what point did you make those collections?

A. At Ft. Bellefontaine on the Missouri river.

Q. You commenced, then, on the 4th of October, 1901?

A. The fourth of October, yes, sir.

Q. Under whose direction did you work?

A. Well, I worked under Dr. Teichmann's direction.

Q. Who was Dr. Teichmann?

945 A. He was city chemist.

Q. Of the City of St. Louis?

A. Yes, sir.

Q. What time of day did you make those collections?

A. I left the office about 8:20.

Q. What office?

A. The city chemist's office, and took a Burlington train up to Bellefontaine and arrived there at 9:20, and returned with the sample about twelve o'clock, between eleven and twelve o'clock.

Q. Now, what part of the river did you take the samples from?

A. Well, the samples were taken from the north side of the river in the middle of the channel.

Q. Does the channel run to the north side of the river?

A. On the north side of the river, yes.

Q. What did you take them with?

A. They had an apparatus there that they fitted the bottle in. This is one of them here (indicating.) And they were supposed to be taken as near three feet as possible below the surface or top of the water.

Q. You say this is one of the instruments?

A. Yes, one like that.

946 Q. You used an instrument like this in collecting the samples?

A. Yes, sir, for the large bottles and the small ones.

Q. Now, can you describe that?

A. Describe it in what way?

Q. Well, how it works?

A. Well, the bottle is fitted in here, into this business here, into this apparatus at the bottom of it. This part would come out here.

ATTORNEY-GENERAL CROW: You let Dr. Ravold describe that and the record will show it.

MR. JEFFRIES: Now, this is the character of instrument you used in the collection of these samples?

A. Yes, sir.

Q. You used an instrument modeled like this?

A. Yes, sir.

Q. In every particular?

A. No, sir, for the large bottles we had a larger machine.

Q. I have reference to the small bottles?

A. Yes, sir.

Q. Now, when you collected the larger samples you used a larger instrument?

Q. Patterned on the same order?

A. On the same order, yes, sir.

947 MR. JEFFRIES: Now, we offer this instrument in evidence to be known as complainant's Exhibit 15.

So marked by the Commissioner.

Q. Now, how deep under the surface of the water did you select the samples, or collect the samples?

A. About three feet. I should judge it would be three feet.

Q. The full length of the instrument, of the handle of the instrument?

A. Yes, sir.

Q. How large were the small bottles?

A. Do you mean the exact size?

Q. About how large?

A. I don't know exactly. That is one of them there (indicating bottle in Exhibit 15). About that size. I don't know how much that would hold.

Q. How large are the larger bottles, about how much would they hold?

A. I don't know exactly.

Q. Now, how often did you collect these samples?

A. Every morning.

Q. Sunday included?

A. Yes, every day.

948 Q. Now, after you drew the instrument out of the water that contained the bottle with the water in it, what did you do with that bottle?

A. Well, for the small bottles we had this tinfoil there that was packed around the top of them and a cloth placed over them and tied and sealed with a tag.

Q. How did you seal it?

A. With sealing wax.

Q. Did you put anything with a stamp on the wax?

A. Yes, we had a seal.

Q. What kind of a tag did you put on it?

A. Well, we had a tag that gave the place where the sample was taken, Ft. Bellefontaine, the time it was taken, and the temperature of the air and the water and the date and the name of the collector.

Q. You always put your name on that tag, then?

A. Yes, sir.

Q. Now, then, as soon as these samples were collected, what did you do with them after you had put the tinfoil around them and wrapped them in a cloth and put a tag around them and sealed them?

A. Well, they were packed in tin cans containing ice, packed with ice, with the ice packed around them.

Q. Now, was the ice directly on the bottles?

A. Yes, packed all around the bottles.

949 Q. All around the bottle, on the top and underneath?

A. Yes, sir.

Q. Then what was done with them?

A. Well, they were taken on the train and then I brought them to the Union Station and then to the office of the city chemist.

Q. How long did it take you to get from Ft. Bellefontaine after you had packed them, until you got to the city chemist's office?

A. Probably an hour; I guess about that time.

Q. Now, what did you do with them after you got to the city chemist's office?

A. Well, they were delivered. The small bottles were delivered to Dr. Ravold's assistant and were placed in the ice box in his place, and the large bottles were delivered to a gentleman by the name of LeRue, I believe his name was. He received all the bottles from all the collectors that came in, that is the large bottles.

Q. What did he do with them if you know?

A. I don't know what he did with them.

Q. Now, you collected all these samples under instructions, did you?

A. Yes, sir.

950 Q. What kind of instructions did you have?

A. Well, we had instructions as to where to take the samples and how to take them and to bring them back.

Q. Where did you get those instructions?

A. I had typewritten instructions from Dr. Teichmann.

Q. Did you have any from Dr. Ravold?

A. Well, I think that the instructions I got from Dr. Teichmann covered that part of it.

Q. You followed those instructions, did you?

A. Yes, sir.

Q. Now, you say you collected these samples continuously from October 4th, 1901, to December 1st, 1901?

A. Yes, sir.

Q. And you put tags on each one?

A. Every one.

Q. And you wrapped them and sealed them and packed them in ice, every one?

A. Every one, yes, sir.

Q. And brought them down to the city chemist's office and turned them over to the parties there, did you?

A. Yes, sir.

Q. What did you say you did with the small bottles that went to Dr. Ravold?

A. The small bottle was placed in the ice box, in Dr. 951 Ravold's department. There was always someone there that saw it go in, either him or someone there, that would take it from me.

Q. Well, was it put directly on the ice, or on the chest?

A. There was a kind of rack. It was placed on the rack up against a cake of ice.

Q. Up against a cake of ice?

A. Yes, sir.

Q. You saw that done, if you didn't do it yourself?

A. Yes, sir, I saw it done or did it myself.

JUDGE SPRINGER: I don't want to ask any questions.

JAMES J. MOORE.

952 FRANK J. BROWN, called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, testified as follows:

DIRECT-EXAMINATION, by Mr. Jeffries.

Q. What is your name?

A. Frank J. Brown.

Q. Where do you live?

A. 2754 Lawton avenue, St. Louis.

Q. How long have you lived in St. Louis?

A. About twenty years.

Q. Were you living in St. Louis between January and May, 1900?

A. My home was in St. Louis; I was out of town at that time, at Peoria, Illinois.

Q. What were you doing there?

A. Collecting water samples for Dr. Teichmann, city chemist of the City of St. Louis.

Q. Where were you making those collections?

A. At a point about three miles north of Peoria in the Illinois river.

Q. When did you commence?

953 A. On the 23rd day of January, 1900, and continued them until May the 8th, 1900.

Q. From the 23rd of January to the 8th of May, 1900?

A. Yes, sir.

Q. Who employed you to do this work?

A. Well, I was working in the water department; I was under the personal supervision of Dr. Teichmann.

Q. You were working for the water department of the City of St. Louis?

A. Yes, sir.

Q. What time of day did you make those collections?

A. About 9:00 a. m.

Q. How did you make those collections?

A. I had a wire cage that I used until I got the model that has been shown here this morning—something similar to it. A large cage, and I collected this water about three feet as near as I could get at it, from the surface of the water.

Q. That is, you had a large cage until you got the model?

A. No, I never had a cage like that, but I had a large cage similar to that, that was shipped to me after I had been there about a month. The first thirty days I took this water from a cage that I borrowed from the water works. It was a wire cage, with lead at the bottom; it sunk very rapidly and took the water from the surface about three feet, and later on, I had a

954 model like that, only larger.

Q. That is a model similar to this—complainant's Exhibit 15?

A. A model made to hold a bottle holding a gallon.

Q. Similar to complainant's Exhibit 15?

A. The same apparatus as that, same model.

Q. Now, how deep under the surface of the water were those samples taken?

A. About three feet, as near as possible.

Q. How many different kinds of samples did you take in reference to quantity?

A. I have taken four bottles, gallon size, and two bottles of about six or eight ounces, whatever that bottle is, that is the size.

Q. Now, state what you did with those samples after they were collected?

A. I collected them and first put tinfoil over them.

Q. That is over the sample, the small sample?

A. Over the larger ones, too, for a long time until I was instructed not to. About the time I was to quit, they told me not to do that. That was a mistake, I guess. I put a white cloth around it, tied it with string, sealed it up with sealing wax. I had a seal that said City Chemist, St. Louis, on it, 955 stamped across the face.

Q. What one do you refer to?

A. They had this method of testing, and they could look at the seal of the bottle and see.

Q. You say you packed them in ice?

A. Yes, sir.

Q. State how you packed them in ice?

A. Chipped ice, small particles, and put it all around the bottles, as near as I could.

Q. And put a tag on it?

A. Yes, sir.

Q. What did you put on the tag?

A. The point at which I collected samples, the hour and the temperature of the water and the temperature of the air, and I believe the condition of the weather, and the condition of the wind, I think, if I remember right.

Q. Did you put your name on it?

A. Yes, signed it.

Q. Now, after you had packed the bottles in ice, what did you do with them?

A. I took them to the Adams Express Company's office at Union Station, Peoria, and shipped them.

Q. State how you prepared them for shipment?

A. The first samples that were taken up for the first 956 month, they were in a tin box and I had little tags, or little stickers, I guess you call them. I wrote my signature across the face of them and put six of them on each one.

Q. What did you do that for?

A. So the box couldn't be opened without breaking the little stickers, so that they could tell when it arived at St. Louis, if it had been opened.

Q. Now, what particular place in the river were those samples collected?

A. I got them as near as possible in the middle of the channel.

Q. Of the Illinois river?

A. The Illinois river channel at Peoria. And the channel at Peoria is inclined to be a little bit to the west side, I believe, a little to the west side, just at that point.

Q. And three miles above Peoria?

A. Three miles above Peoria.

Q. Now, then, how soon after the collection of these samples was made until shipment was made?

A. Well, about three hours.

Q. How prepared?

A. You see, I had to go up the Illinois river to get these
samples and preparing them and packing them to ship,
957 that would take an hour and a half to two hours to make
the trip and get down. I would take them to the Union
Station.

Q. Did you collect those samples each day?

A. Every day, yes, sir.

Q. About seven o'clock in the morning?

A. Yes, sir.

Q. And you kept that up from January 20th to the 8th of May, 1900?

A. Yes, sir.

Q. You haven't any of those tags you put on, have you?

A. No, sir, I have not. I could very readily tell if I should see them.

MR. JEFFRIES: That's all for the present, Mr. Springer.

CROSS-EXAMINATION, by Judge Springer.

Q. How many samples did you say you took each day?

A. Four large bottles and two small ones, I think. That is, most of the time, when I collected first. They hadn't any necessary arrangement made to collect the full amount. I was sent out twice the first few days there.

Q. How deep below the surface did you collect the samples?

A. About three feet, as near as I could make it.

958 Q. At what part of the river with reference to its respective banks, did you take your samples?

A. Which way does the Illinois river run along there; does it run north and south? I don't know which way the Illinois river runs at Peoria.

Q. Straight north and south along there?

A. I think the channel at that point, to the best of my knowledge of the business, is a little bit inclined to be to the west shore, but it is very near the center at that point. It was very narrow there, and it is almost the center.

Q. You haven't answered the question yet. What part of the river with reference to its respective banks did you take the samples?

A. Nearest to the west.

Q. Did you take them all at the same place?

A. Yes, sir.

Q. All at the same place and taken at the same spot in the river?

A. Yes, sir.

Q. Was that done every day?

A. Every day, yes, sir.

Q. Why did you not take a line across the stream?

A. I wasn't instructed to do that.

959 Q. You followed instructions?

A. Yes, sir.

Q. I suppose you knew nothing about what became of those samples after they left the express office?

A. No, sir, I hadn't any idea.

RE-DIRECT-EXAMINATION, by Mr. Jeffries.

Q. Who did you say you expressed them to?

A. I addressed the tag to the city chemist, 1141 Market street, St. Louis.

Q. Where did you get these bottles in which you collected the samples?

A. I got them at the Adams Express Company's office at Peoria.

Q. Where did they come from?

A. The city chemist, St. Louis.

Q. Who do you mean by the city chemist?

A. Dr. Teichmann was the city chemist at that time, but I never used the words Dr. Teichmann on any of my samples. I addressed them to the city chemist, City of St. Louis.

Q. Giving the number of the office?

A. 1141 Market street, yes, sir.

960 RE-CROSS-EXAMINATION, by Judge Springer.

Q. Were these bottles when you received them, securely corked?

A. Yes, sir.

Q. Tightly?

A. Yes, sir.

Q. Air tight?

A. Air tight, yes, sir.

RE-DIRECT-EXAMINATION, by Mr. Jeffries.

Q. How were the small bottles wrapped when you received them?

A. The small bottles when I received them at the station in Peoria were wrapped in tissue paper.

Q. Each individual bottle?

A. All the small bottles, yes, sir.

(Subsequently recalled.)

961 EUGENE BRUNK, called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, testified as follows:

DIRECT-EXAMINATION, by Mr. Jeffries.

Q. What is your name?

A. Eugene Brunk.

Q. Where do you live?

A. 2615 Whittier street.

Q. How long have you lived here in St. Louis?

A. About fifteen years.

Q. What business are you engaged in?

A. At the present time I am in the bricklaying business.

Q. What business were you in, in January, 1900?

A. Working as an inspector in the water department.

Q. In connection with the water department, state whether or not you were ever detailed to gather any samples of water on the Mississippi river?

A. I was. I was taking samples under the directions of Dr. Teichmann.

Q. When?

A. Starting about—I am not sure of the date, but I think it was January 23rd, 1900.

Q. Where did you collect those samples?

962 A. At the chain of rocks.

Q. How long a time?

A. I think it was five days that I took the samples, I am not certain about it.

Q. I will ask you to examine Complainant's Exhibit 15, and state whether or not that is a correct copy of the instrument which you used in the collection of the samples, a correct model?

A. That is a model of the instrument.

Q. You used an instrument like that?

A. Yes sir.

Q. State what particular part of the river these samples were collected from?

A. I took one sample out of the Missouri, close to the Missouri shore.

Q. How far from the shore?

A. Well on the Missouri shore side; I think it was three or four hundred feet, until we got out in the channel, and took one at the Intake tower and one from the Illinois side of the channel about 300 feet from the shore.

Q. You took samples then from the three places on the same day?

A. Yes sir, the same day.

963 Q. How often did you take them at the respective places?

A. The first day I took two samples at each place. After that I just took it once a day.

Q. How large were the samples of water you took?

A. These bottles that I took in the river were gallon bottles, I think that's what they were. I am not certain, but they were large bottles.

Q. They were the samples you took out of the river?

A. The larger bottles, and I also took two small bottles.

Q. Where did you take that from, the small bottle?

A. I am not certain but I think I took them at the Intake tower, a little above the Intake tower.

Q. In the Mississippi River?

A. In the river, I think; I am not certain about it any more; it is a long time and I made no record of it.

Q. Where did you obtain the bottles that you used in the collection of the samples?

A. The first bottles that I used, I got them out of the City Chemist's office and after that they were brought up by horse and wagon.

Q. They were handed to you by the City Chemist?

A. They were handed to me by one of the City Chemists.

Q. Now then as soon as you gathered the samples, what did you do with the bottles containing this water?

A. Well, the large bottles, they are corked up under the 964 water with the instrument that was used, and I took and wrapped a cloth around them, a piece of white duck I think it was, and then sealed them and put a tag on stating the temperature of the water and the temperature of the air, put my name on it and the time they were taken. The small bottles were wrapped with tinfoil and then sealed, and the same thing.

Q. Did you wrap a rag or anything around them?

A. I wrapped a rag and sealed them.

Q. What kind of a tag did you put on?

A. Just a pasteboard tag.

Q. What did you put on the tag?

A. My name and the temperature of the water and the temperature of the air and the weather outside.

Q. Did you state anything as to the time of its being collected?

A. Also the time.

Q. You put that on all the tags?

A. I tagged each bottle the same way.

Q. Now then, what did you do with these bottles, with the water in them after you had taken them, put the tinfoil around them and corked them up?

A. Well, the first two or thre days; I think it was the first three days, there was a wagon there, and I made that
965 drive and we took the bottles down and delivered part of them at the City Chemist's office and part of them to Dr. Kiser at Washington University, and the small bottles were taken to the St. Louis Medical College, to Dr. Ravold I believe, or his assistant.

Q. Now how soon after you had gathered the bottles before you wrapped them and put a tag on them?

A. Well, a period of fifteen minutes to half an hour; it would take that time.

Q. In other wards, just as soon as you could do it?

A. Just a soon as I could handle them.

Q. How long did it take you to take the bottles from that point at the Chain of Rocks, where they were taken, to the City Chemist's office here in the city of St. Louis and the different places where they were delivered?

A. About an hour and a half I think.

Q. State who you turned them over to at the City Chemist's office?

A. At the City Chemist's office I turned them over to Dr. Teichmann.

Q. Do you know what he did with them?

A. I do not.

Q. What did you do with those you took out to the St. Louis Medical college?

A. I turned them over to a doctor there, I don't know his
966 name.

Q. Under Dr. Ravold?

A. Under Dr. Ravold, I think, under his instructions.

Q. Now those that you turned them over to were there in a professional capacity?

A. One time Dr. Kiser and one time his assistant there at Washington University.

Q. First one and then the other?

A. Yes sir.

Q. Now were those small bottles prepared when you first got them, and where did you get them?

A. I got them at the City Chemist's office the same as the large bottles, and then after that they were sent out.

Q. What condition were those small bottles in; how were they wrapped, if they were wrapped?

A. They were wrapped in paper I believe.

Q. What kind of paper?

A. Tissue paper I believe. I am not certain of it any more.

Q. How deep under the surface of the water were those samples collected?

A. About two feet ten, or three feet.

Q. Now these various samples you said a few moments ago, were collected continuously from the time you commenced until you quit, each day?

A. They were continued from the time I started until I
967 quit.

Q. Did you take samples at any other place than what you took in this city in the river?

A. I did.

Q. Did you take any in the Intake tower?

A. Not in the Intake tower, but I took some of them in the Uptake tower.

Q. Where is the Uptake tower?

A. Right opposite the pumping house.

Q. What kind of samples did you take there, small bottles or large ones?

A. Large bottles I believe, but I am not certain about it.

Q. Now did you take any samples at the reservoir?

A. I took a sample at the reservoir, also.

Q. At the same time?

A. At the same time.

Q. What did you do with those?

A. I turned them over to the same place that I took the others, or turned the others.

Q. Did you take them in the same way you took the others?

A. I took them all the same way.

Q. In the same kind of bottles?

A. The same kind of bottles.

968 Q. What disposition did you make of them after you had gathered the samples?

A. I don't quite understand.

Q. State whether you wrapped them and put tinfoil around them and tagged them the same as you did the others?

A. I did, I used the same method with each bottle.

Q. And did you make the same disposition of them?

A. The same disposition.

Q. State whether or not the same time was employed in disposing of those samples that were collected in the reservoir as was employed in those that you collected in the river?

A. Well, those taken in the river were taken first and then I would take those in the resevoir and bring them all down together.

Q. But you prepared them and wrapped them just as soon as you took them out of the water?

A. Just as soon as I took them out of the water and got them in shape I wrapped them.

CROSS-EXAMINATION,

By Judge Springer.

Q. How long a period were you engaged, did you state?

A. About five days I think it was.

Q. What days were those? You haven't stated it I believe?

A. I think the first day I took them was the 23rd of
969 January.

Q. And five days after that consecutively?

A. Yes sir.

Q. Then you didn't take any samples subsequent to those five days?

A. No sir.

Q. You said you took some samples on the Illinois shore opposite the Intake, how far was that place from the Illinois shore?

A. Well, it was the Illinois side of the channel, I couldn't say accurately,—somewhere about three or four hundred feet.

Q. Three or four hundred feet from the shore?

A. Yes sir.

Q. What do you mean by saying on the Illinois side of the channel? In the channel of the Mississippi?

A. The channel of the Mississippi River, yes sir.

Q. Was it three hundred feet or 300 yards from Illinois shore?

A. Well I have no accurate way of measuring it, but just judging it, I should say 300 or 400 feet, may be further than that on water. I wouldn't be accurate about that.

Q. You didn't measure that distance?

970 A. No sir.

Q. Did you go over there at all, to the Illinois shore?

A. I didn't go to the shore.

Q. You didn't go to the shore; you simply went out in a boat to a point opposite the Intake towards the Illinois shore?

A. Yes sir, towards the Illinois shore.

Q. And you said you took the sample about 400 feet from the Illinois shore?

A. About that.

Q. That is your impression?

A. Yes sir.

RE-DIRECT-EXAMINATION,

By Mr. Jeffries.

Q. State whether or not you were working under the supervision of anybody, under the direction of any person, and who that was?

A. Dr. Teichmann.

Q. State what his instructions were to you?

A. His instructions were to take these samples according to the way I was directed, and he sent a man out with me,—I think his name was Unger, who was working in his office, and he showed me where to take the samples the first morning that I went out.

Q. That is, he showed you the particular place in the
971 river he wanted you to collect the samples each morning?

A. That's it.

Q. Now state whether or not you followed out those instructions?

A. I did follow them out as near as I could locate myself in the river. I tried to get the exact spot, as near as possible.

RE-CROSS-EXAMINATION,

By Judge Springer.

Q. How long a time elapsed between the time you took the sample nearest to the Illinois shore, and the time when you delivered them in the City Chemist's office or that other place, or the St. Louis Medical College in St. Louis?

A. Well from the time I took the first sample until I got to Dr. Teichmann's office, it was about two hours.

Q. Where did you take the first sample?

A. To Teichmann's office.

Q. Where did you take it in the river?

A. On the Illinois side.

Q. You began there?

A. Yes sir.

Q. And it was about two hours until you delivered that sample at the place designated in the City?

A. Yes sir.

EUGENE BRUNK.

972 JAMES GOLDEN,

called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, testified as follows:

DIRECT-EXAMINATION,

By Mr. Jeffries.

Q. What is your name?

A. James Golden.

Q. Where do you live?

A. 3010 North Market Street.

Q. St. Louis, Missouri?

A. Yes sir.

Q. How long have you lived in St. Louis?

A. Forty years, I was born there.

Q. You are about forty years old?

A. Yes, pretty near it.

Q. What business are you engaged in?

A. At the present time I am an inspector in the Sanitary Division of the Health Department.

Q. What were you doing between the months of May and July, 1900?

A. I was working under Dr. Teichmann at the Chain of Rocks getting samples.

Q. Who is Dr. Teichmann?

973 A. He is City Chemist.

Q. City of St. Louis?

A. Yes sir.

Q. What were you doing?

A. Getting samples of water for the City Chemist with Mr. Hart at the Chain of Rocks.

Q. When did you begin?

A. 8th of May, 1900, and I was getting samples until the 2nd of July. I used to transfer the wagon that held the samples in.

Q. Now state please where in the river you selected or collected the samples?

A. Well, I was taking out Mr. Hart and I together, on the Missouri shore about 300 feet from the bank. I used to get two large bottles, half-gallon, and then there was a small bottle for Dr. Ravold; then we went to the Illinois shore about the same distance from the shore.

Q. Three hundred feet or 300 yards?

A. Three hundred yards. Over there we took the sample at the Intake, floated down to the Intake, I should say two or three hundred yards north of the Intake in the river and get the next sample; then pull for the shore; then in the meantime we packed the bottles and they were corked like this (indicating).

That corked it under water. We would pull it up and 974 it would cork as we raised this machine. We took the bottle and sealed it and put a cloth on it, and tinfoil.

Q. Now just a moment. A few moments ago you said when you collected the sample on the Missouri shore, that it was three hundred feet from the shore.

A. Three hundred yards, more than three hundred feet; I know it was further than that.

Q. Look at complainant's Exhibit 15, and state whether or not that is a model of the instrument used in the collection of the samples?

A. That is the same kind of a bottle, and a larger one also.

Q. Now how far from the surface of the water did you collect the samples?

A. About three feet, three and a half feet.

Q. The full length of the instrument?

A. Yes sir.

Q. I understand you to say you collected the samples daily from three different places?

A. Yes sir, three different places in the river.

Q. State again clearly the place?

A. Three hundred yards from the Missouri shore, and the same distance from the Illinois shore, and about two or three hundred yards north of the Intake tower.

Q. Now then, the places were north of the Intake?

975 A. Yes, all north of the Intake.

Q. On a direct line with each other?

A. Yes sir.

Q. Now you say you commenced on the 8th of May, 1900?

A. Yes sir, and worked until the second of July.

Q. State whether or not these samples were collected daily and Sunday?

A. Daily, Sunday and every day.

Q. Where did you get the bottles that were used in collecting the samples?

A. We didn't get the bottles. We would go on the train and they went on the train with us in the morning, on the Burlington train.

Q. Where did they come from?

A. They came from the Chemist's office.

Q. What Chemist's office?

A. The City Chemist.

Q. Of the City of St. Louis?

A. Yes.

Q. Both large and small?

A. Both large and small.

Q. How were the small bottles packed?

A. They were wrapped in tissue paper.

976 Q. You put the small bottles in the machine, did you?

A. Yes sir.

Q. State how the water was kept out of the bottle until you got ready to fill it, and dipped it down into the river?

A. The bottles are air tight,

Q. What kind of a cork did you have?

A. The same kind of a cork that is in there now, a glass cork.

Q. There was no water went into the bottle until you wanted it?

A. Until this was raised (indicating).

Q. What do you mean?

A. Until the cork was raised.

Q. By the wire?

A. Yes sir.

Q. You pulled with your hand on the trigger?

A. Yes sir.

Q. Now after these samples were taken out of the river what did you do with them?

A. Immediately after taking them out we would take them out of the machine and they were wrapped and tagged.

Q. Wrapped how?

A. Wrapped with a cloth and tagged.

Q. Now then how about those small bottles?

977 A. There was tinfoil put over the bottle and a cloth and also wrapped in paper and tagged.

Q. What about being sealed?

A. Put a seal on them with sealing wax, and brought back to the Chain of Rocks and then to the City Chemist's office, St. Louis.

Q. What did you put on the tag?

A. Put the place that the water was taken from, the temperature of the water and the air and the time and by whom taken.

Q. Now then, if taken at the Missouri shore that would be three hundred yards out in the river?

A. Yes sir.

Q. And the same thing was true with reference to those taken on the Illinois shore and at the Intake?

A. Yes sir.

Q. How long did it take you to wrap and seal those samples?

A. Well, we would get out there at nine o'clock and bring them into the chemist's office around one o'clock. Mr. Hart had a good deal to do with it, and sometimes it would be three quarters of an hour longer, and would make it one or two o'clock.

Q. What did you do with them at the Chemist's office?

978 A. Bring them upstairs and unpack them out of the ice that they were on and Mr. Taylor would take charge of them, the large bottles, and the small bottles went to Dr. Ravold's laboratory.

Q. What was done with them?

A. Put on ice if he wasn't there.

Q. Well, if he was there?

A. He took charge of them himself, or his assistant did.

Q. Would he go right to work?

A. Sometimes he would and sometimes he wouldn't. As fast as we would come in. We were generally the first to bring the samples in.

Q. State whether or not you were instructed where to collect the samples?

A. We had instructions from Dr. Teichmann the City Chemist, where to take them, and we had detail instructions what to do with the bottles.

Q. You followed out the instructions the city Chemist gave you?

A. As closely as we could.

Q. Do you know whether or not Dr. Ravold gave you any instructions as to the small sample?

A. I couldn't say as to Dr. Ravold giving instructions, I think Dr. Teichmann's instructions covered it all.

979 Q. The instructions you received from Dr. Teichmann covered the taking of the small samples?

A. Yes, the small and large.

Q. You took them according to instructions?

A. Yes, according to instructions as near as it was possible to take them.

Q. And what you have said with reference to any particular sample taken here, as to what was done at that time, applies to every sample taken?

A. Every sample taken, the same thing was done with them.

Q. Did you state a few moments ago that these samples were packed in ice?

A. Yes sir, chipped ice.

Q. At the time they were wrapped?

A. They were wrapped and put in the ice immediately.

CROSS-EXAMINATION,

By Judge Springer.

Q. How long a time were you engaged in this manner?

A. From May 8th to July 2nd, I think it is July 2nd.

Q. Of 1900?

A. Yes sir.

Q. How long a time elapsed from the time you took the sample on the Illinois shore, nearest the Illinois shore, until you reached the Chemist's office in the city?

980 A. We generally left the Chain of Rocks, after we had the samples packed in ice, everything all packed and wrapped, at ten o'clock or a little after, and probably reached at one or half-past one the chemist's office.

Q. How long was it before you left the Chain of Rocks, that you had taken the sample nearest the Illinois shore?

A. Well, we had taken them probably an hour at the time they were packed in ice and everything packed.

We generally stopped over there an hour before we started in, to rest up the team.

Q. It is your opinion, as I understand it then, that the point at which you took these samples nearest the Illinois shore was about 300 yards?

A. About that to the best of my opinion, yes sir.

JAMES GOLDEN.

BENJAMIN FRANKLIN HART,

called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, testified as follows:

981

DIRECT-EXAMINATION,

By Mr. Jeffries.

Q. What is your name?

A. Benjamin Franklin Hart.

Q. Where do you live?

A. Hotel St. Louis, Fourth and Locust.

Q. St. Louis, Missouri?

A. Yes sir.

Q. What business are you engaged in?

A. I am a water inspector for the water department.

Q. Of the City of St. Louis?

A. Yes sir.

Q. How long have you been engaged in that business?

A. I have been there about seven years.

Q. I would like to have you state what you were doing during the period of April to August, 1901.

A. Well, that is 1900, I was taking samples of water for Dr. Teichmann.

Q. Where were you taking those samples?

A. At the Chain of Rocks.

982 Q. Now when did you commence?

A. First of April, 1900.

Q. And when did you conclude?

A. The 15th of July.

Q. Now was it July or August?

A. The 15th of August, that's right.

Q. The same year?

A. Yes sir.

Q. State what particular place in the Mississippi River these samples were collected, place or places?

A. Well first we took the water from the Missouri side, about four hundred feet from the Missouri shore. We took that about eight o'clock in the morning, 8:00 A. M.; then we went across the stream and took the Illinois side, four hundred feet, that is, about nine o'clock A. M. Then we took at the Intake one bottle, on each side of the Intake, then we took a sample from the well.

Q. Where is that?

A. That comes from the Intake, into the tower house or pumping station.

Q. Before it is pumped into the reservoir?

A. Yes sir.

Q. From there where did you take the next sample?

A. Took a sample from one of the basins.

983 Q. One of the settling basins at the power house?

A. Yes sir.

Q. You say that the sample on the Missouri shore was taken 400 feet from the shore; do you mean 400 feet or 400 yards?

A. Four hundred feet.

Q. State whether or not you were directed as to the particular place the samples should be taken?

A. We had a stake driven on the Missouri side and on the Illinois side, and we were supposed to go into the channel. You see there are two channels there. Then, if the river was low we would have to take out where the channel was; we had a Missouri channel and a Mississippi channel.

Q. You always took it in the Missouri channel on the Missouri side?

A. Yes sir.

Q. Whether that would be 400 feet or 800 feet?

A. Well, if the water was pretty high.

Q. It depended on the stage of the water, did it?

A. Yes sir.

Q. Now with reference to the Illinois shore, state whether or not you always took the sample from the channel of the Illinois shore?

A. We always took it from the channel. We drove it down and took the water as we drove it.

Q. Now how far under the surface of the water did you

984 take it?

A. Three feet.

Q. I will ask you to examine Complainant's Exhibit 15, and state whether or not that is a model of the instrument used by you in the collection of these samples?

A. Yes sir. A small one of these for the City Chemist.

Q. For what?

A. For the City Chemist. We had three bottles in all, one directed to the City Chemist, and they were taken at the same time that the large ones were taken. They were taken in gallon bottles, a size a great deal larger than this.

Q. You don't know of your own knowledge that these small ones were taken for the City Chemist?

A. That is all I know, that we took them to the City Chemist.

Q. You took them all down there?

A. Yes sir, the big ones and little ones.

Q. That model 15 is the model of the instrument used by you in the collection of samples?

A. Yes sir.

Q. Both the large and small samples?

A. Yes sir.

Q. Now then, Mr. Hart, state what you did with those samples of water after you had gathered them; after you had taken them out of the river?

985 A. We put tinfoil on the small bottles; then we put a little piece of muslin over it, tied it around with a string and sealed it with the city seal; then the large ones the same way.

Q. Then what else did you do after you sealed it?

A. Packed them in a box.

Q. Did you put anything on it?

A. Put the wax and the seal on it.

Q. Then what else was there to indicate what it was?

A. That had a tag on it.

Q. What was on that tag?

A. First was the time and then the place where we took it; temperature of the water and the temperature of the air at the time we took it and the name.

Q. What name?

A. The inspsctor's name that took the water.

Q. The collector's name you mean?

A. Yes sir, the collector's.

Q. So if you took it you put your name on it?

A. Yes sir.

Q. Now then, where did you get those bottles?

A. They were sent up from the City Chemist's office in a 986 wagon.

Q. How were the small bottles wrapped?

A. Wrapped in tissue paper.

Q. Before they were used?

A. Yes sir.

Q. Now then, after these collections of water hal been prepared by you, wrapped, sealed and tagged, what else did you do with them?

A. We had wooden boxes, and there was a partition where we put the ice in between, and we put two big bottles on each side, which made four, and put the ice in the center.

Q. Upon them?

A. No, the ice was in a partition between them; it didn't touch them.

Q. You nailed those boxes up?

A. We had them locked; there was a spring lock on them.

Q. What did you do with them?

A. We sent them down to the City Chemist's office.

Q. Did you ever bring them yourself?

A. No sir, I loaded them on the wagon and sent them in. We were supposed to get them finished at eleven o'clock A. M. and have them all ready for the wagon.

Q. You were supposed to have them all ready for the wagon at eleven o'clock in the morning?

A. Yes sir.

Q. State whether or not you collected samples at any
987 other place than those two places in the river at this time?

A. Only the wet well.

Q. No other place?

A. The wet well and the reservoir.

Q. What kind of collections did you make in the reservoir and the wet well?

A. We had two large gallon bottles—we always took them every day.

Q. Did you make any smaller collections?

A. No sir.

Q. From the wet well?

A. No sir.

CROSS-EXAMINATION,

By Judge Springer.

Q. What period of time did you say your labors covered?

A. From the first of April to the 15th of August, 1900.

Q. And the places at which you took these samples were near St. Louis?

A. Yes sir, the Chain of Rocks.

Q. All at the chain of rocks?

A. Yes sir.

Q. How far did you state the stations at which you took the samples were from the Illinois shore?

988 A. It was about four hundred feet three or four hundred feet.

Q. From the Illinois shore?

A. Yes sir, but it was a good way from the Intake. It was about a half a mile up the river where these stakes were placed on both sides of the shore.

Q. Some of these witnesses stated that the place nearest the Illinois shore was about three hundred yards from the shore and you and one other witness testified four hundred feet. Now can you account for this discrepancy, or explain it?

A. I don't think the channel would allow it to be that wide. We had two channels there to take from. We had water coming from the Missouri River that clung to the Missouri side; then we had the Mississippi water that clung to the Illinois side, and we had to go into the channel of each one of those.

Q. Did you get in the channel of the Mississippi River when you were nearest the Illinois shore?

A. Yes sir, always; that was the Mississippi channel.

Q. Did you see anything of the Illinois River channel along there?

A. No, I don't know. We could always detect the dif-
989 ference because one was so much colored and the muddy river was on the other side of the river; that was the Missouri.

Q. The water on this side?

A. Was muddy water.

Q. It was the muddiest?

A. Yes sir.

Q. Was that water clean from the Missouri River?

A. Yes sir, dark.

Q. You are certain of that?

A. I know that, yes sir.

Q. In every instance did that occur?

A. Yes sir, when the river was high and low both; it was the same thing all the time over there.

Q. Where did the water come from the sample of which you took nearest the intake?

A. At the intake?

Q. Yes?

A. We got most of it from the Illinois side, because the opening of the intake was on the Illinois side.

Q. I mean what river did that water come from, the Missouri River or Mississippi River that went into the intake?

A. That was a sort of a mixture. It ground about three or four hundred yards, just in front of the intake, it
990 went around like a whirlpool.

Q. It seemed to be a meeting of the waters there?

A. Yes sir, a meeting of both of the waters.

B. FRANK HART.

ADJOURNED until 2:00 P. M., same day, Friday, February 27th, 1903, at Southern Hotel, St. Louis, Mo.

Southern Hotel, St. Louis, Missouri.
991 2:00 P. M., Friday, February 27, 1903.
Continuation after recess.

Present, the Commissioner, and same counsel representing the respective parties.

C. V. MERSEREAU,

called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Mr. Jeffries, and testified as follows:

Q. What is your name

A. C. V. Mersereau.

Q. Where do you live?

A. 3830 Shenandoah Street.

Q. St. Louis, Missouri?

A. Yes sir.

Q. How long have you lived in St. Louis?

A. About twenty years.

Q. What business are you engaged in, Mr. Mersereau?

A. Civil engineer.

Q. Civil Engineer?

A. Yes sir.

Q. What busness are you now engaged in?

A. Civil Engineering.

Q. In what capacity?

A. Assisstant Engineer in the water department.

Q. In the City water department?

992 A. Yes sir.

Q. Of St. Louis?

A. Yes sir.

Q. What were you doing from January 22, 1900, to May of that year?

A. I was working with men who were taking samples of water for the City Chemist.

Q. Where were those samples of water being taken?

A. Being taken at Bellefontaine bridge, from the Missouri River; at Alton from the Mississippi River; at Grafton, Illinois, from the Illinois River; from the Mississippi River, and for a short time at Elsah a short distance below Grafton. Also at Hartford about a mile above the mouth of the Missouri River. At the chain of Rocks, and at Peoria, and later on at Lockport.

Q. Now what particular part of that work did you have in charge?

A. I was supposed to look after the collectors and see that they took their samples correctly.

Q. State what directions you gave with reference to the gathering of samples of water at the Chain of Rocks?

A. Well the directions were plain to all the inspectors, but in regard to the location at the Chain of Rocks, they were to be taken about three hundred feet from the Missouri shore.

Q. Three hundred feet or yards?

993 A. About three hundred feet. Now that distance there may vary a little, according to the stage of the water. On the Missouri shore it was taken about 300 feet; at the Illinois shore at low stage of water, it would be about three hundred

feet from the sandbar; but at a higher stage of the water they may have taken them further from the bank.

Q. Now then, with reference to the channel of the river, where were those samples to the taken?

A. The samples were taken in good running water; the channel where the water was taken from the Missouri shore, is rather close to the Missouri shore.

Q. The channel is very close?

A. Yes sir. They went nearly over to the opposite side, and the samples were taken practically from the channel on the Illinois shore.

Q. Now then, where was the sample taken or where were your instructions given with reference to taking the sample at the Intake?

A. The samples at the Intake; they generally started to collect it about 100 feet,—about the in-let tower.

Q. Now do you know who you placed in charge at the Chain of Rocks to take those samples?

A. The first man there was Mr. Brunk, who was sent up there from the City Chemist's office,

994 Q. Do you know his initials?

A. Yes sir. Edgar B.

Q. Now was he there all the time that you had charge of this work?

A. No sir, he was only there for a few days.

Q. Then it was turned over to another party?

A. Then it was turned over to A. J. Winchell.

Q. Now who did you place in charge at Bellefontaine?

A. Fred Dieselhorst.

Q. Now what instructions were given him with reference to gathering these samples of water?

A. He was to take the samples about three hundred feet above Bellefontaine bridge, and get it out from the channel. When he first started taking those samples they were taken in that way, but part of them later were taken from the bridge.

Q. What were your instructions in taking all of these samples as to the particular depth below the surface of the water that they were to be taken?

A. When we first started, for a few days they had no machine then we had to reach down in the water uncork the bottle, let the water fill the bottle and then cork it under water; but after we received the machines the men were instructed to take the samples about three feet down below the surface of the water.

Q. Do you know the character of the instrument that
995 they used in gathering this water?

A. Yes sir.

Q. Is this it? (Indicating Complainant's Exhibit 15).

A. Yes sir.

Q. Now I will ask you to examine the complainant's Exhibit 15, and state whether or not that is the instrument or a pattern of the instrument placed in the hands of the water gatherers by you and your instructions to them when they were given charge of this work?

A. Those instruments were supplied to the collector; they were used, and instructions given.

Q. That is the pattern or model of the instrument you used?

A. That is the pattern, yes sir.

Q. Now do you know who had charge, or whom you placed in charge to gather samples at Grafton?

A. Wenzell,—the initials I am not sure of, but I think it was Albert J.

Q. Now at what place did he get samples of water?

A. At Wheelers' Ferry on the Illinois River.

Q. Now where is that?

A. It is about three miles above Grafton, three or three and a half.

Q. And about three miles—

A. About three miles above Grafton in the Mississippi River.

Q. Now what were your instructions to him with refer-
996 ence to where the samples should be taken, and how?

A. The samples in the Illinois River were to be taken far enough up the river to be sure to avoid any back water from the Mississippi. The samples from the Mississippi were to be taken far enough above Grafton to prevent any contamination from the Illinois River. A sample was also taken at Elsah, for a short time, about five or six miles down the river from Grafton.

Q. Now were those samples collected from these points during all the time that you had charge of this business?

A. The sample at Elsah I would not be sure, how long that was taken.

Q. Yes, but with reference to Grafton in the Illinois River?

A. Yes sir.

Q. And Grafton in the Mississippi River?

A. The samples were taken in the Illinois River and the Mississippi River at Grafton during the whole time that I had charge.

Q. When was the date that you commenced this work?

A. I believe I left the city January 21st, but January 23rd was the first sample.

Q. Now then when did your connection with this particular work cease?

A. First day of May.

Q. 1900?

997 A. 1900.

Q. And you commenced on the 23rd of January—of January, 1900?

A. Yes sir.

JUDGE SPRINGER: No. January, 1899, and May 1900, you say?

A. No, 1900 entirely.

MR. JEFFRIES: No, this is this man's particular period.

JUDGE SPRINGER: State that again.

A. From January 23rd, 1900, to May 1st, 1900, that was the period of time in which the work was being paid for by the water department direct.

Q. MR. JEFFRIES: Now you spoke of samples being collected at Hartford. Do you know whom you placed in charge there to collect those samples?

A. Mr. A. Huth.

Q. Now what was the character of the samples that were to be gathered by him with reference to quantity?

A. My recollection is that he was to take four bottles; they were to be five-pint bottles for chemical analyses and one for bacteriological samples.

Q. That was a smaller bottle?

A. That was a smaller bottle, yes sir.

Q. How much would those bottles hold?

998 A. The small bottles?

Q. Yes.

A. Oh, I should say a little less than—about a pint. That is one of the bottles (indicating).

Q. Now what you said with reference to the different characters or quantities of water that were selected by those men at Hartford, is also true with reference to these other collectors that you have also explained about; they not only took samples for the chemical analyses, but also for the bacteriological examinations?

A. Yes, they took both samples.

Q. In the small and large bottles?

A. Yes sir, at all places.

Q. Now do you know about what time they commenced to gather the samples at Hartford?

A. I think it was January 23rd or 24th.

Q. And they all commenced about the same time?

A. About the same time, yes sir.

Q. Now what were your instructions to this collector, with reference to how the collections should be made, and where?

A. They were to be made in the channel of the river which at Hartford is very close to the bank, and were to be taken as far under water as he could reach until the machine was obtained, and then they were to be taken three feet below the surface. The bottles were not to be opened in the air, but to
999 be opened under water and corked under water, as soon as the samples were taken.

Q. Now that was true with reference to the samples of water that were taken prior to obtaining this machine, known as Complainant's Exhibit 15, was it?

A. Yes sir.

Q. In other words, they were to do what?

A. They were to take the sample as far under water as they could reach.

Q. What about corking it under water?

A. They were to be corked under water.

Q. The empty bottle should be what?

A. Opened under water.

Q. And corked under water?

A. Yes sir.

Q. Uncorked under water?

A. Yes sir.

Q. And the water then let run in?

A. Yes sir.

Q. And corked up under water?

A. Yes sir. They were also instructed that if at any time the bottle should be partly filled with water and opened, that the bottle should be rinsed out, that is, with the river water and then cork the bottle and take the sample as though the bottle had not been opened.

1000 Q. You say you went up as far as Peoria?

A. Yes sir.

Q. Who did you put in charge at Peoria?

A. F. J. Brown.

Q. Now what were your instructions to him?

A. Similar to what I have already stated.

Q. Did you give him instructions as to the place in the Illinois river that he should obtain these samples?

A. We went to the bridge across the Illinois river at the upper part of Peoria and selected the place where the samples were to be taken and he was instructed to take all samples at that place.

Q. Now then, what were your instructions to all of these collectors with reference to the preservation of the water in its original state after it was taken out of the river?

A. As soon as possible the chemical sample was to be covered with cloth that was furnished for the purpose; it was securely tied, sealed and a tag put on the bottle.

Q. Now how about the bottle for the bacteriological department?

A. The bacteriological sample was to be covered with tinfoil; then with cloth and sealed.

Q. Were there tags or anything of that kind on these bottles?

A. Yes sir.

1001 Q. Now what was to be put on those—on the tags?

A. The date, the time of day, the point of collection, the temperature of the air; the temperature of the water, and the name of the collector.

Q. And what were your instructions to the collector or what instructions did you give your collectors in disposing of these samples of water?

A. As soon as they were sealed and tagged, that they were to be packed and delivered to the express office where they had to be shipped or brought to the city Chemist's office by the man who brought them in.

Q. To be packed how?

A. At first they had wooden boxes; they were packed in the wooden boxes with excelsior and delivered.

Q. Did you put anything in the boxes besides the bottles?

A. At the point when we started in, it was cold weather, and we didn't pack in ice, but later on there was an arrangement made that they were to be packed in ice.

Q. Now what were your instructions as to the time to be consumed in preparing these bottles of water for shipment, after they were collected?

A. They were to be delivered as soon as possible, and most of the inspectors—now you take the inspector for instance at Peoria, he generally made his collection in such time that he could then make connections with the train. The other men,
the men at Bellefontaine Bridge, Chain of Rocks, at Hart-
1002 ford, and at Alton, delivered the samples at the city
Chemist's office.

Q. Here in St. Louis?

A. Yes sir. And they generally collected the sample so that they just had time to prepare it, and catch the train and get to the City Chemist's office.

Q. Now at what other place did you station collectors, other than those you have mentioned?

A. Well, I believe about the first of February, I will not be sure of the date, Mr. Otten, who was collecting, was taken from Alton to Lockport, and two samples collected, one—or the first place was at the Bear Trap dam, right in front of the dam.

Q. Just above or below the dam?

A. Just above the dam. The second place was at the foot of McDonnough Street, if I remember rightly.

Q. Now what instructions were given him with reference to this?

A. The same instructions. He had also been taking samples at Alton, and followed the same system here.

Q. Now where did you get your instructions?

A. From Dr. Teichmann.

Q. Now in what way did you give these collectors their instructions?

A. Well all of us were given instructions in the first place
1003 by Dr. Teichmann, and then afterwards I simply went around to see that those instructions were followed out.

Q. State how often you would go to the respective collectors and see what they were doing, and how they were doing?

A. Well, I was going most of the time.

Q. State whether or not they knew exactly when you were coming to see what they were doing?

A. They did not; I had no regular routine of going around.

Q. Then state fully the purposes and objects of your visits to them after they had been stationed there?

A. To see that they were properly taking the samples, and to see that their expenses were being kept within proper limits.

Q. Now do you remember of any other collectors that were under your charge during that time?

A. I think I have mentioned Mr. Apel—Jacob Apel.

Q. Where was Mr. Apel stationed?

A. He went to Alton when Mr. Otten went to Lockport.

Q. How long did he stay at Alton?

A. Why he was still doing the work at Alton when I quit attending to the work.

Q. Now anybody else?

A. T. G. Ruff was sent to Grafton in place of Mr. Wenzell.

Q. Now do you know when Mr. Ruff was sent to Grafton?

A. Now I am under the impression that it was somewhere
1004 about the 6th of March—6th or 7th of March.

Q. Now state whether or not there were any others that you have not mentioned, that were under your charge?

A. Why, Mr. Winchell took the place of Mr. Brunk at the

Chain of Rocks, and later on Mr. Hart took the place of Mr. Winchell.

Q. What Mr. Hart?

A. B. F. Hart.

Q. Frank Hart?

A. No, I am mistaken about that; that is not B. F. Hart; it is Mr. E. Hart.

Q. Mr. E. Hart?

A. Yes, it was the one that testified this morning.

Q. Mr. Eugene Hart. Then it was Mr. Eugene Hart?

A. Yes sir.

Q. That took the place of whom?

A. Of Mr. Winchell.

Q. Now then, who took Mr. Hart's place if you know.

A. Mr. Hart, I think, was still working there when I quit.

Q. Now then, who else was under your charge in this connection?

A. Those were the only men.

Q. Now state the character of instructions that you gave each one of these collectors of samples of water. In other words, state whether or not the instructions that you gave to each one of them differs materially, or is not the same instruction that you gave to those that you explained in your testimony in the beginning?

A. The same instructions were given to all of the collectors.

JUDGE SPRINGER: Mr. Jeffries, the witness has not stated whether these instructions were in printing or not. The printed instructions would be the best evidence.

MR. JEFFRIES: Well I suppose we could get a copy of them.

THE WITNESS: When I started at work, we had no printed instructions.

JUDGE SPRINGER: You had none?

A. No sir, those came later.

Q. MR. JEFFRIES: Those instructions, you say, as to the precautions to be taken in the collection of these samples, were given to each one of the collectors?

A. Yes sir.

Q. Did you give them instructions as to where they would receive the bottles?

A. Yes sir. The men at Bellefontaine—at Alton and at Hartford received bottles at the City Chemist's office. The men at the Chain of Rocks, had the bottles delivered to them either at Baden or at the Chain of Rocks. At first—I am under the impression that for the first few days the bottles were obtained at the City Chemist's office.

1006 Q. That was for the Chain of Rocks?

A. That was for the Chain of Rocks, but later on they were either delivered at Baden or the Chain of Rocks.

Q. Now where were the bottles to be obtained for the collection of the samples of water at Peoria and Lockport?

A. At Peoria, Lockport and Grafton the bottles were sent by express.

Q. To the collectors?

A. To the collectors, yes sir.

Q. Where were they sent from?

A. From the City Chemist's office.

Q. State whether or not these collectors were instructed to use those particular bottles that were sent to them, or not?

A. They were instructed to use those bottles, but in case of accident they were instructed to buy bottles. I believe that one or two samples of water were sent in in bottles that had been bought.

Q. Now in those cases, the bottles were noted as having been bought?

A. I think so; I think the only case of that was at Peoria or Lockport, I have forgotten which it was.

CROSS-EXAMINATION, By Judge Springer.

Q. What is your occupation?

A. Civil engineer.

1007 Q. Civil engineer?

A. Yes sir.

Q. Did you have charge of all the samples that were collected between January 23 and May 1, 1900?

A. I think—It is my opinion that I had charge of all the samples that were collected during that time. That would be a matter of record, though, would it not?

Q. Yes. Did you prepare these bottles for use before they were sent out?

A. No sir, I did not prepare them for use, although I helped to pack a great many of them; also to send them out.

Q. Were these bottles sterilized before being sent out?

A. All of the bacteriological bottles were sterilized.

Q. Who did that?

A. I think that Mr. Taylor did that; he was the janitor in the City Chemist's office.

Q. You didn't do that yourself?

A. No sir, I did not.

Q. You know nothing about the method pursued?

A. No sir. All the work that I did in that connection was merely to expedite the work; it was really not part of my duty.

Q. Who furnished the collectors with the tags that they were to put upon the bottles?

1008 A. They came from the City Chemist's office.

Q. You didn't furnish them?

A. No sir; I generally saw that they had the tags when they asked for them.

Q. Yes sir, your business simply was to instruct the collectors as to what they should do with reference to taking these samples, and to send them to the different places?

A. To see that they did the work according to instructions, and to see that their expenses were kept within proper limits.

Q. Did you go to the places where the samples were taken at those times?

A. Yes sir.

Q. Where did you go personally?

A. I went to every place where samples were taken.

Q. You did?

A. Yes sir. Whenever I was at those places I helped the inspector take the sample.

Q. Do you know whether they were taken then in accordance with your instructions?

A. Yes sir.

C. V. MERSEREAU.

1009 **HENRY R. TAYLOR,**

Called as a witness in behalf of the complainant, being first duly sworn, by the Commissioner, testified as follows:

DIRECT EXAMINATION, By Mr. Jeffries.

Q. What is your name?

A. Henry R. Taylor.

Q. Where do you live?

A. 2659 Morgan.

Q. How long have you lived in St. Louis?

A. I have lived in St. Louis ever since March 6th, 1866.

Q. State whether or not you have ever been employed in the office of the City Chemist of the city of St. Louis?

A. Yes sir, I have.

Q. About when were you first employed in that office?

A. I think it was—about, well, 1895, I think.

Q. 1895?

A. Somewhere in there, I don't exactly remember.

Q. When did your connection with that office terminate?

A. It terminated the 13th—I don't exactly remember what day it was—the 13th about, a year ago, just about a year exactly, a little over a year.

Q. What were the duties that devolved upon you in that position? 1010

A. Well I was janitor of the building.

Q. I will ask you whether or not, if you had anything to do with the bottles that were sent out to the different persons who gathered samples of water from the Mississippi river and the Illinois river?

A. Yes sir, I did; I prepared all the bottles and shipped them.

Q. Now state how that preparation was done?

A. Well the bacteriological bottles, they were sterilized; they were washed and cleaned and dried and put in the oven at about 150 Centigrade, for an hour.

Q. Any longer than an hour?

A. Well some times; nothing shorter than an hour.

Q. Nothing shorter than an hour?

A. No, and sometimes longer.

Q. What was done with them after they were taken out of the oven?

A. They were left in there until they were cooled down, and after they were cooled, then they were taken out and wrapped in tissue paper, ready for shipment.

Q. Did you superintend the shipment of them?

A. Well, I did all the packing, and particularly most all the packing of those bacteriological bottles, shipped to all 1011 places.

Q. Now then, what was done in the preparation of the chemical bottles?

A. Well, they were cleaned and dried; they were not sterilized; they were cleaned and dried; they were air tight bottles; when they were brought to us, to see that they were air-tight, the corks were ground and the bottles numbered, and also the cork was numbered, the bottle and cork was numbered the same number, and then the cork was tied onto the bottle, so that in case that the string broke, or anything, they would always know where that cork belonged to and the chemical bottles were also air-tight—that is one of them now (indicating). That is the numbers (indicating). These are the bottles.

Q. Well never mind. How long did this work continue as your official duty there?

A. Well I was with it from the commencement until it was finished.

Q. You were there during the whole time of the investigation then?

A. Yes sir.

Q. In other words when you went into that office in 1895, you remained continuously there until—

A. About a year ago.

Q. February, 1901?

A. Yes sir.

1012 Q. What was the comparative size of the bottles that were sterilized and used for bacteriological samples?

A. They were about four ounces.

Q. What was the size of those used in the chemical department?

A. About gallons.

Q. What did you do with these bottles you say, after you had sterilized them?

A. They were allowed to get cold in the oven; after that they were taken out and wrapped in paper.

Q. What kind of paper?

A. Tissue paper.

Q. Then what was done with them?

A. Then they were ready for shipment; put in boxes for shipment.

Q. You put them in the boxes, did you?

A. Yes, I put them in boxes for shipment.

Q. Now what was done with those used in the chemical department?

A. We had a place for them; we kept them on the shelf, and packed and shipped them in the same way; we had both big and little boxes.

Q. Do you know who they were shipped to, or expressed to?

1013 A. To the collectors, whoever they were; I can't recall them all, I don't remember, but I know I shipped to all the stations that we had.

Q. Can you name some of those stations?

A. Yes, we shipped them to Chicago and some to Peoria, Grafton, and also prepared them for the Chain of Rocks. The bottles for the collectors that brought in the samples, of course they wasn't shipped; they took their bottles and brought them in, and the bottles were always ready for them.

Q. Now these chemical bottles were sent out also, were they not?

A. Yes sir.

Q. In the same way?

A. In the same way. Those were packed in boxes, four in a box, or four or two, whatever the station may require, the same number as the bacteriological bottles, whatever the station may require, whether it was two or four or more.

Q. I will ask you if you know what that is (handing witness a bottle).

A. That is one of the bottles that we used for chemical samples.

Q. Is that one of the bottles that was actually used in this work?

A. Yes sir.

Q. How do you know?

1014 A. From the number. I know every bottle that was in the business.

ATTORNEY-GENERAL CROW: Is the number on the bottle?

A. Yes sir, and the cork both.

Q. MR. JEFFRIES: What is the number on the bottle?

A. Fifty-three.

Q. What is the number on the cork?

A. The same.

Q. That is the same kind of bottle that was used for all the chemical experiments, was it?

A. Yes sir, excepting in a few cases, when we run short of them; then we used another bottle, a half gallon bottle.

Q. That was only in a few cases?

A. Yes sir, that was only in a few cases; but this is the same bottle.

ATTORNEY-GENERAL CROW: Made in the same way?

A. Yes sir—well, this is a mushroom top; some of the bottles didn t have the mushroom top; they had a square top.

Q. MR. JEFFRIES: They all had the number on?

A. Yes sir.

Q. Both on the bottle and the cork?

A. Yes sir. The cork was investigated to see if they were air-tight. If the corks wasn't air-tight they were ground.

1015 MR. JEFFRIES: The complainant now offers the bottle identified by the witness as having number 53 scratched on the body of the bottle, and number 53 on the cork, as complainant's Exhibit No. 16.

Said exhibit received in evidence and marked by the Commissioner "Complainant's Exhibit No. 16. Frank S. Bright, Commissioner."

JUDGE SPRINGER: Will you state that it is a glass bottle holding how much water?

Q. How much does this bottle hold?

A. About one gallon.

MR. JEFFRIES: He stated that before.

JUDGE SPRINGER: What kind of a stopper?

MR. JEFFRIES: Mushroom shaped glass stopper, is it?

A. Yes sir, we have others square shaped.

Q. Now I will ask you if the glass bottle attached to and forming a part of Complainant's Exhibit 15, is one of the bottles that was used in the bacteriological examination?

A. Yes sir, that same kind of a bottle.

Q. I will ask you if these were—if that is one of the pattern that you referred to in your examination and which you stated you sterilized?

A. Yes sir, that is the kind, sir.

1016 CROSS-EXAMINATION, By Judge Springer.

Q. How long a period does this time cover, in which you have been employed in the Health Department of St. Louis?

A. Well it covered from the time—from the commencement of the work until the practical ending of it.

Q. Give the dates, please?

A. Well, up to about a year ago. I went in the office about 1895, and that is about a year ago I quit, a little over a year.

Q. When did you begin to take samples of water for examination?

A. Well, I don't remember the dates that I commenced to take any of them. I used to take samples occasionally up to Grafton and Chain of Rocks, but I don't know the dates, because I didn't have that to do regularly; I would only do that occasionally.

Q. During the period to which you have referred were all the bottles used for the purpose of taking samples for examination, prepared by you?

A. Yes sir.

Q. You stated that they were sterilized. Explain that again, please?

A. The bacteriological were all sterilized, yes sir.

1017 Q. The bacteriological bottles were all sterilized?

A. Yes sir.

Q. What temperature did you state they were subjected to?

A. About 150 degrees centigrade.

Q. What would that be Fahrenheit?

A. Well I don't know; that is what I run them to.

Q. Do you know how to transpose them from Centigrade to Fahrenheit?

A. No sir, I don't.

Q. It would be about 270 degrees Fahrenheit, as I understand it. It would be above the boiling point anyway, wouldn't it?

A. Yes sir, oh yes,

Q. The Centigrade thermometer begins at freezing point and runs to boiling point, 100, isn't that right?

A. Yes sir.

Q. And Fahrenheit begins at 32 below freezing and runs to boiling point. What is that, 212 degrees?

A. Yes sir.

Q. This would be above the boiling point then?

A. Yes sir.

Q. And they remained an hour?

A. An hour or longer, but not less than an hour.

Q. Was that sufficient to kill all kinds of germs?

A. Yes sir, so I was informed by the bacteriological—by Dr. Ravold; that that was sufficient to kill them all. 1018

Q. That was according to his instructions?

A. That was according to his instructions, yes.

Q. You followed his instructions as near as you could—as near as possible?

A. Yes sir.

HENRY R. TAYLOR.

1019 FRANK J. BROWN,

Recalled as a witness in behalf of the Complainant, testified as follows:

DIRECT EXAMINATION, By Mr. Jeffries.

Q. What is your name?

A. Frank J. Brown.

Q. Now I will ask you to examine that and state what that is? (Handing witness paper.)

A. It is a tag that I put on the bottle that I shipped by express from Peoria, Illinois, to the City Chemist's office, city of St. Louis, on the 3rd of May, 1900.

Q. What do you say you put that on?

A. On one of the samples of water that I sent to Dr. Teichmann, City Chemist at St. Louis, from Peoria, Illinois, where it was shipped from. The sample was taken three miles above.

Q. Read all that there is on that card?

A. Date, May 3rd, 1900;
Time, 9:00 a. m.;
Location, Illinois river, three miles above Peoria, Illinois;
Temperature of air 52 degrees above;
1020 Temperature of water 61.
Name of collector: Frank J. Brown;
Gauge of the river that day was 34.30;
Weather clear.

Q. Was that temperature Centigrade or Fahrenheit?

A. That was Fahrenheit.

MR. JEFFRIES: Now we will offer this card or tag, identified by the witness, in evidence as complainant's Exhibit 17.

Said tag received in evidence and marked by the Commissioner "Complainant's Exhibit No. 17. Frank S. Bright, Commissioner." And is in words and figures, as follows:

"Date: 5/3/00.
Time: 9 A. M.,
Location: Illinois river, three miles above Peoria, Illinois.
Temp. Air: 52 above.
Temp. Water: 61 degrees above.
Name of Collector: Frank J. Brown.

On the opposite side appears the following:

"Gauge of River: 34.30,
Weather clear.
No. 1346."

Q. Now all samples collected by you were tagged with a similar tag to this?

1021 A. Yes sir.

Q. I will ask you whether or not the same data was put on those cards or on those tags by you as has been registered on this one?

A. Yes sir, same thing.

Q. Depending altogether on the variations of the temperature of the weather and the water?

A. Yes sir.

Q. And this practice you followed from the beginning of your connection with the work until the end?

A. Until the end of it, yes sir.

CROSS-EXAMINATION, By Judge Springer.

Q. Are those tags before you on the table those which you put upon the bottles and forwarded to the laboratory in St. Louis?

A. Why, they are the kind I put on, yes sir.

Q. And the one you have is a specimen of all of them?

A. Yes sir.

MR. JEFFRIES: That is the tag that you actually put on the bottle that you identified?

A. I actually put it on the bottle.

JUDGE SPRINGER: Just glance through those and see 1022 if they are, or appear to be the same kind?

A. Yes sir, there are several here that are in my writing, yes sir, that I prepared.

(Subsequently called again.)

1023

JACOB APEL,

Called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION, By Mr. Jeffries.

Q. What is your name?

A. Jacob Apel.

Q. Where do you live Mr. Apel?

A. I live now at 2026 South Second Street.

Q. St. Louis, Missouri?

A. Yes sir.

Q. How long have you lived in St. Louis?

A. All my life—thirty-three years.

Q. Were you ever connected with the water department of the city of St. Louis, or the Health Department?

A. Yes sir.

Q. Are you connected with them at the present time?

A. No sir.

Q. I will ask you if you were connected with the Water Department or the Health Department rather, in 1900?

A. Well, I don't know whether I was connected with the Health Department then; I was working for the Water Department when I first started to get this water.

1024 Q. What water?

A. The water that I got up the river at Alton?

Q. What did you get the water for?

A. Samples.

Q. Who had you get them; who employed you; under whose instructions were you?

A. Dr. Teichmann's.

Q. Dr. Teichmann's?

A. Yes sir.

Q. Now who is Dr. Teichmann?

A. City Chemist.

Q. Of the city of St. Louis?

A. Yes sir.

Q. Now then, when did you commence getting this water?

A. The 27th day of February, three years ago today.

Q. That would be the 27th of February when?

A. 1900—three years ago today, is the first day I went up there.

Q. Now then, how long did you continue your work of gathering samples?

A. Up until September. I don't know whether if was the 17th or 18th, was the last date I got water; in September of that year.

Q. Of that year 1900?

A. Yes sir.

1025 Q. Now state, Mr. Apel, where you got these samples of water?

A. Up in Alton, right about—well about half a mile above the Waterworks in Alton, or a mile above the Waterworks, out in the channel of the river.

Q. Now how did you obtain those samples?

A. With one of these machines, something like that there (indicating Complainant's Exhibit 15).

Q. Now I will ask you to examine Complainant's Exhibit No. 15, and state whether or not that is a model of the instrument used by you in gathering these samples of water?

A. Yes sir, that is the machine we used for to get the sample bottle of water.

Q. Now what difference was there between the machine used in obtaining the small bottles of water and the machine used in obtaining the large bottles of water?

A. What difference?

Q. Yes, was there any difference in the construction or in the size?

A. For the large bottles, the machine was larger, and the bottle was larger.

Q. And that was all the difference?

A. Yes sir.

Q. And the construction of the machine is the same?

A. Almost the same, I suppose, as I understand or know about it.

1026 Q. Now state how far under the surface of the water these collections were obtained?

A. Why, I guess it was about four feet.

Q. The full length of the arm of the machine?

A. The full length of the arm of the machine, yes sir.

Q. Where did you get the bottles that you got the water in?

A. At the City Chemists' office.

Q. Did you get them personally, or did he send them to you?

A. I got them myself, personally.

Q. How often would you get them?

A. Every morning.

Q. How long would it take you to make the trip?

A. I would get back around two o'clock in the afternoon.

Q. What time would you go there to make the collection?

A. Make the collection between ten and 10:30.

Q. Now what would you do immediately after you made the collection?

A. Seal up the bottle, go to shore at first, and seal up the bottles and then take them up in the Waterworks and fix it up —seal it up, and fix up my tag.

Q. These small bottles, what would you put around them first?

A. Tinfoil.

Q. Then what?

A. Seal it up.

1027 Q. Before you sealed it did you put something around it besides tinfoil?

A. I think I put a rag over it.

Q. You put the tinfoil on first?

A. Yes sir.

Q. Then the rag; then the seal?

A. Yes sir.

Q. Now then, what else would you do to it?

A. Fix up my tag; tie my tag around it.

Q. What was there on that tag? What would you put on that tag?

A. Take the temperature of the water and the temperature of the air, the time I got the water, and so forth.

Q. And the gauge of the river?

A. No.

Q. Then as soon as the package was prepared what would you do with it?

A. Put it in my box.

Q. Then what?

A. Take it back to the depot and go on home; when a train would come along—I would wait for the train to come.

Q. And you would go direct to the City Chemists' office?

A. Yes sir.

Q. What did you do with it?

1028 A. I gave it in the City Chemists' office; put it in charge of the man there.

Q. Now I will ask you to state whether or not the same disposition was made of every collection that you made?

A. Yes sir.

Q. You delivered them to the City Chemist's office?

A. Yes, every one of them.

Q. How many collections did you make? Did you make collections each day?

A. One. There was two or three days I made two. That is when the boat went up the river and dropped stuff into the water, and I had a boat and kept pulling in across the river, and just kept dipping up, dipping up, all the time. They dropped some stuff in there, but I don't know what that was for.

Q. Did you deliver the small bottles to the City Chemist's office also?

A. All of them; all of the bottles.

Q. How did you open the bottle to let the water in?

A. Opened it under water.

Q. Did you ever open it out of water?

A. No sir.

Q. Who were you working under; who instructed you about how to gather the samples?

1029 A. Why, Dr. Teichmann and this other man. I forget his name; I don't know his name.

Q. Did you hear him testify?

A. I came in just as he got through. I forget his name—Mersereau, I think that is his name; some name like that.

Q. Now, you carried out his instructions, did you?

A. Yes sir.

Q. And that was with reference to every sample that was collected?

A. Yes sir.

Q. How long did you say you worked?

A. I worked from February 27th up until September 17th or 18th; I ain't certain of that date—February 27th was my first trip.

Q. Did you get collections at any other place than at Alton?

A. No sir, that is the only place.

CROSS-EXAMINATION, By Judge Springer.

Q. How long a time elapsed from the time you took the samples from the river until you delivered them to the City Chemist's office, in St. Louis?

A. Well, until I would get down here; that would be about between ten and half-past ten I would get the water, and I
1030 would get down here about two o'clock.

Q. Then you left the samples with somebody in the City Chemist's office?

A. Yes sir.

Q. Well who was that person, if you know?

A. Well, I don't know exactly his name; I know him when I see him. Dr. Teichmann used to be there a whole lot of times, he would be there and receive it, or Mr. Thomas Buckland, the assistant. Either he or Dr. Teichmann received the samples.

Q. Did you use any ice in packing these samples?

A. Yes sir, when the water got warm—when the weather was hot. I didn't use it in February.

RE-DIRECT EXAMINATION, By Mr. Jeffries.

Q. I will ask you to examine Complainant's Exhibit 16, being the gallon bottle used in obtaining chemical samples, and state whether or not that is one of the same kind of bottles that you used in obtaining samples in the Mississippi river at Alton?

A. Yes sir; that there was used, and also this here one (indicating).

Q. Well, we are talking about this one now.

A. Yes.

Q. This is the particular bottle used?

A. Well, part of the time.

JACOB APEL.

1031 DR. WILLIAM C. TEICHMANN,

Called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION, By Attorney-General Crow.

Q. What is your name?

A. William C. Teichmann.

Q. How old are you doctor?

A. Forty-three.

Q. Where do you live?

A. 3624 Shaw Avenue.

Q. Whereabouts, at what place?

A. That is about a half a block west of Grand Avenue.

Q. Is it in London or St. Louis?

A. St. Louis.

Q. Do you occupy any office in the city government of this city?

A. Yes sir, I am City Chemist.

Q. How long have you been City Chemist?

A. Since April, 1893.

Q. Well, doctor, do you occupy now the position of City Chemist?

A. Yes sir.

1032 Q. Now do you have any recollection about the chemical and bacteriological investigation of the waters of the Mississippi and the Missouri river, and the Chicago Drainage Canal and the Illinois and the Des Plaines river having been begun along in 1899 and continued through 1899, 1900, 1901 and 1902?

A. Yes sir.

Q. What connection, if any, did you have with any of that work?

A. I had charge of the chemical part of the investigation.

Q. Well, when you say you had charge of it, just explain what you mean by that?

A. Well, I organized the system of the collection of the samples, and—

Q. Well, the chemical samples or the bacteriological samples?

A. The chemical samples.

Q. Well, go ahead and explain what you did, how you organized it?

A. Well, the system varied according to the period of investigation. The first period of investigation began on July—let's see, I will have to look up my data here to be absolutely correct. On August 23rd, 1899, the first period of investigation began which continued until January 22, 1900.

1033 Q. You say you organized the chemical portion of that; what do you mean by organized it; just tell what you did, who you had to work for you and how they operated. That is what I want to know.

A. I was ordered by the Health Commissioner of St. Louis, the superior official of my department, to take samples of water for chemical examinations from the mouth of the Illinois river and the Illinois river itself, as well as from a point in the Mississippi river not very far above the mouth of the Illinois, and then to take samples between the mouth of the Illinois river and the Chain of Rocks. These samples were not taken at regular intervals; they were only taken from the mouth of the Illinois river at such times when the harbor boat of the city of St. Louis was available and when the funds permitted us—the limited funds —to send a collector of samples to Grafton, and to take the samples there as directed by myself.

The total number of samples collected during this period was 142, and they were taken from the following points, shall I enumerate those points?

Q. Yes, just give the points.

A. Mississippi river, Chain of Rocks, near Intake Tower, of St. Louis, 26 samples. That is of the St. Louis Waterworks I mean, 26 samples.

1034 Mississippi river, Chain of Rocks, Missouri shore, three samples.

Mississippi river, Chain of rocks, Illinois shore, three samples.

St. Louis Waterworks, distributing well, 28 samples.

Q. What do you mean by distributing well? Explain that. I don't know what you mean. Do you mean the Intake?

A. No, the water enters the St. Louis Waterworks through the tunnel under the river.

Q. You mean what we call the Up-take?

A. Yes. After it has passed through the reservoirs, it goes in there, goes into the mains of the city of St. Louis, and the distributing well is where the water is distributed among the reservoirs, after it enters the waterworks from the river through the Intake, at the tunnel, called the distributing well.

Q. Well, you call that the Up-take; that has been explained; we know what that is, the Up-take.

A. Yes sir.

Q. Go ahead.

A. Mississippi river, Madison landing, between Chain of Rocks and the mouth of the Missouri river near the Missouri shore, three samples.

1035 Mississippi river, Madison landing, between Chain of Rocks and the mouth of the Missouri river, near the Illinois shore, seven samples.

Mouth of the Missouri river, ten samples.

JUDGE SPRINGER: Where is that—mouth of the Missouri river?

A. Mouth of the Missouri river?

JUDGE SPRINGER: Where is that? We never heard that before. Was this at Bellefontaine?

A. No, not at Bellefontaine; that was at the mouth, at the confluence of the Missouri and Mississippi rivers.

JUDGE SPRINGER: This is a place that has never been mentioned before.

A. No it has not. You see these samples were all taken on the trips made by the harbor boat, and we ran into the mouth of the Missouri river on such occasions.

Mississippi river points between Alton and the mouth of the Missouri river, thirteen samples.

Mississippi river, near Clifton Terrace, between Alton and Portage, six samples.

Mississippi river at Elsah, near Piasa Bluffs, between Portage and Grafton, five samples.

Illinois river at points located one, two, three and five miles above Grafton, 19 samples.

1036 Mississippi river at points one, two, three and five miles above the mouth of the Illinois river, 19 samples, which makes a total of 142 samples.

Q. With reference to the stream where were these taken; from the center of the stream or the channel?

A. Always taken from the stream, from the channel.

Q. From where the current ran?

A. Yes sir.

Q. Well now, who took those samples?

A. Those samples were taken either by myself or the assistants, or they were taken by Henry R. Taylor, Sr., the janitor who testified a short time ago, or his son, H. R. Taylor, Jr.

Q. Were you present when they were all taken?

A. No sir, I was not.

Q. Do you know what ones of them you took?

A. Yes, I can identify those from the tags, or they were taken from Assistant Collector of samples and helper at the distillation table, Herman Ungar.

Q. Where is Ungar?

A. He was at that time assistant collector.

Q. Where is he now?

A. He is in the city now, I presume.

Q. He is alive is he?

A. I don't know; I haven't seen him for a long time.

Q. Well now, what was done with those samples after
1037 they were taken?

A. These samples were taken to the City Chemist's office, St. Louis.

Q. What was done with them there?

A. They were analyzed by myself and my assistant, Mr. Thomas A. Buckland.

Q. In the first place, how did you take these samples? How did you take them? They were taken in bottles, weren't they?

A. Yes sir, I am just trying to recollect during what period they were taken in demijohns, and what periods they were taken in bottles with the machine.

When we began the work, August 23rd, and from that time on for about two months, we collected these samples in demijohns by holding the demijohn in the hand and filling the demijohn under the surface of the water. After two months we had certain machines made, and certain bottles placed in these machines, and the samples were then collected under the surface of the water, by dipping the machine under the water about three to four feet below the surface.

Q. What is the number of that exhibit, that bottle?

THE COMMISSIONER: That is Exhibit 16.

ATTORNEY GENERAL CROW: Is that exhibit No. 16 the character of bottle that you used?

1038 A. Not during that period; we used a smaller bottle, half gallon bottle for the machine.

Q. Were those bottles sealed when they were taken from the water?

A. Yes sir every sample.

Q. What were they sealed with?

A. There was always a rag tied over the stopper and the neck of the bottle or demijohn, and tied very closely around with a string, and a tag was attached to the neck of the demijohn or bottle, and sealing wax was used to attach the tag,—the string of the tag to the neck of the bottle, and the seal which we used at the City Chemist's office—City Chemist's office numbe so-and-so was pressed on the sealing wax, and thus the bottle identified. It was never opened—the seal could not be broken except by myself or my assistant, when we would proceed with the analysis in the laboratory.

Q. Well, who received these bottles when they were sent to the laboratory from August, 1899 up to what period did you say?

A. To January 22, 1900.

Q. To January 22, 1900, who received those?

A. Either myself, or my assistant, Mr. Buckland.

Q. Well, do you know whether or not you kept a record of the receipt of those bottles other than by the tags?

1039 A. No sir, we didn't keep a record of that kind; we had the record of the analysis.

Q. Well, now have you got those tags that came on those bottles?

A. Yes, I have them.

Q. Where are they? Here in the room?

A. Yes sir.

Q. Now these tags were taken off the bottles and numbered, were they?

A. Yes sir.

Q. To correspond with the number on the bottle?

A. Yes sir.

Q. That was done all the way through that period?

A. Yes sir, either by myself or my assistant, Mr. Buckland.

Q. Do you know whether these tags that you have here now are the identical tags that came on those bottles?

A. Yes sir, I have identified them as such today.

Q. Now were those bottles properly sealed and handled from the time that they were filled with water until the chemical examination was made in accordance with the proper rules for the conduct of chemical analyses of water?

A. Yes sir; whenever they were not, we would throw out the sample and not analyze it.

1040 Q. Well, answer my question Yes or No?

A. Yes sir.

Q. Now you are acquainted with what the proper method is in handling those things preparatory to making a chemical analysis of water?

A. Yes.

Q. You have had experience in the chemical examination of water?

A. Yes sir.

ATTORNEY GENERAL CROW: Now, Judge, this period now covers from the 10th of August, 1899, up to the 2nd of January, 1900. Now he testifies that he has got all the tags here numbered with the corresponding number on the bottle, and he or his assistant there in his office took them all and we can just let the record show that these are in evidence, but not made a part of the record proper, but can be used by either side as evidence if they want to refer to them.

JUDGE SPRINGER: That is satisfactory.

ATTORNEY GENERAL CROW: Then we will just consider them in evidence.

Q. Now go to the next period—the next period, Judge, begins on the 23rd of January.

JUDGE SPRINGER: Did you want to qualify him as an expert now, or leave that to some subsequent period?

ATTORNEY GENERAL CROW: Well, I have not asked 1041 him about any examination, you know; but I have qualified him as to his knowledge of the method to be pursued in taking care of water preparatory to its analysis. If you prefer, I can qualify him to speak on that.

JUDGE SPRINGER: You can pursue your own course;

I just wanted to know whether or not you were going to do that at this time.

ATTORNEY GENERAL CROW: My intention was to prepare him when I put him on the stand afterwards.

JUDGE SPRINGER: Just as you like.

Q. ATTORNEY GENERAL CROW: Where were you educated?

A. I was oringinally educated at the Washington University, academic department.

Q. Where did you receive your medical education?

A. I have no medical education; it is chemical.

Q. Chemical?

A. I left the academic department of the Washington University in 1875, and entered in the fall of 1875, the polytechnic College of Brunswick, Germany. I studied chemistry at that college from 1875 to 1879, until the summer of 1879. In the fall of 1879 I proceeded to Berlin and entered the University of Berlin.

Q. Berlin, Germany?

A. Berlin, Germany, yes, and studied chemistry and a
1042 number of other corresponding branches like history and
literature, for general educational purposes, in the University of Berlin from the year 1879 until 1881.

In Berlin I studied principally under Professor Ferdinand Tiemann, who is considered one of the leading authorities on water analysis, and the author of a well known standard work on water analysis.

In 1881, in the summer, I left the University of Berlin and studied what they call the Semester, that is a half year's course in the University at Liepsic, and in the spring of 1882—

Q. Well, what did you study at Liepsic?

A. Well there I studied history, and at the University of —Then I proceeded to the University of Munich in Germany and studied history from 1882 until 1885, and I graduated as a doctor of philosophy in chemistry and history in the year 1885, from the University of Munich.

Q. Munich where?

A. Munich, Germany.

Q. Well, then you have had practically ten years of education as a chemist and along the lines that a chemist is educated?

A. Yes, about six years, of which,—or five years strictly confined to the study of chemistry.

1043 Q. Now in your studies, did you make any specialty of the study of the analysis of water?

A. I did that at the University of Berlin, under Professor Tiemann.

Q. Now what experience have you ha since you left the University at Munich, Germany, in 1885?

A. In 1885 I returned to this country, and entered a literary career, that is, I was principally occupied in literary pursuits until 1890. I again took up the chemical pursuit and became the private assistant of Professor Charles O. Curtman, Professor of Chemistry in the Missouri Medical college.

Q. At St. Louis?

A. Yes sir. In 1891 I became the assistant instructor of chemistry, as assistant to Professor Curtman, in the Missouri Medical College, which position I retained until 1895. That is, both the position as private assistant to Professor Curtman, as well as assistant instructor to Professor Curtman in the Missouri Medical College, and as private assistant of Professor Curtman, I assisted in quite a number of analyses of water.

In 1893 I was appointed City Chemist of St. Louis and I have occupied that office since that time.

Q. Since 1893?

1044 A. 1893.

Q. Well now, as the City Chemist of this city, what line of work in Chemistry have you been called upon to follow?

A. The duties of the City Chemist are multifold. There is first of all, analytical work for the Health Department of St. Louis, which includes a constant analysis of samples of well water and of cistern water.

Q. That is continuous work, is it?

A. Yes, that is some branch of it; then the analysis of disinfectants used by the Health Department; the analysis of all kinds of medicines, of articles of food, which are purchased by the city institutions, and which require an analysis occasionally. That is the work of the Health Department. Then I perform the toxicological work for the police department—

Q. Now explain what you mean by that term?

A. Toxicological analysis would be the analysis of various kinds of articles, either in liquid form or in solid form, which involve some kind of foul play, that is the use of poisons, the use of knockout drops; samples of opium; samples of dynamite, on occasions of the use of such materials for criminal purposes. The analysis of blood-stains, etc.

Then another kind of work performed by this office is the toxicological work for the Corner's office, that is the an-
1045 alysis of viscera in cases of suspected poisoning, or an-
alysis of chemicals and of articles of food which are suspected of containing poison, in cases involving an accused murderer, and such things.

Then I also analyze or make analyses for the School Department of St. Louis, for the Board of Education, analyzing the air in the school rooms to find out the character of the atmosphere judged by the carbonic acid gas found, etc., by the impurity of the atmosphere.

Then, finally, I perform analytical work for the Water Department, that is in making a daily analysis of the water from the City water supply.

Q. When you use the term water supply, what do you mean? Do you mean the reservoirs, the Intake or the taps?

A. Well, in 1899, since this investigation began, I have analyzed the water from the Chain of Rocks, not only for this litigation, but also for the water department, in order to give them a correct daily record of the water supplied to the city.

Q. Prior to 1899 where did you take the water which you analyzed?

A. Well, in 1899, I took the water from the reservoir, one of the reservoirs.

Q. Prior to August, 1899?

1046 A. Well, prior to August, 1899, the analyses were more
of a sporadic character; that is, there weren't regular intervals—it was only at times when the Board of Health just wanted to know how the City water supply was; its chemical character, I was ordered to make analyses. I took samples then from the tap, and on one occasion, in the year 1893, in October, I took a number of samples from the mouth of the Illinois, and

from various points, about twenty-two samples, from various points between the mouth of the Illinois and the Chain of Rocks, but that was only one collection made, and I consider that analytical survey of a sporadic character, and I don't consider myself justified in drawing definite conclusions of the character of the water at that time from this sporadic series of collections. I wasn-t authorized, and not allowed to take more samples.

Q. Now you say samples taken from August 11, 1899 to January 22nd, 1900, were properly cared for chemically, as water should be that was going to be used for the purpose of making analyses thereof, from the time it was taken from the river to the time it was opened for the purposes of being analyzed?

A. Yes sir.

Q. Now go to the next period, doctor, beginning January 23rd, 1900.

A. This period begins on January 23, and ends for the
1047 larger part of the collection of the samples on October 11th.

Q. What year?

A. 1900.

Q. Well, do you know how many samples of water were taken?

A. Yes sir.

Q. How many?

A. Well now, I have not got the total figure. I have got the total number collected at each collection point during that period.

Q. Never mind the total number.

A. By the way, I have the number here,—3492 samples were collected from January 23rd until October 11th.

Q. Now where were they taken from, just give me the points.

A. They were taken from the following points—Shall I give the number of samples taken at each point?

Q. Oh, just as you like about that?

A. Well just as you direct.

Lake Michigan, Drainage Canal above the Bear Trap Dam at Lockport,

Des Plaines River at Joliet,

Illinois River, three miles above Grafton, Illinois,
Illinois River at Wesley, Illinois,
Illinois River at Pekin Bridge, Illinois,
Illinois River three miles above Pekin, Illinois,
Mississippi River, two miles above Grafton, Illinois,
1048 Mississippi River one mile above Alton, Illinois,
Mississippi River opposite Hartford, Illinois,
Missouri River opposite Fort Bellefontaine, Missouri,
Mississippi River near Missouri shore, at Chain of Rocks,
Mississippi River near Illinois shore at Chain of Rocks,
Intake tower, St. Louis Waterworks, Wetwell,
St. Louis Waterworks, outlet of reservoir,
Tap at City Chemist's Office at St. Louis,
Harbor boat and special samples.

Now this period extended for part of the points, these collections of samples therefrom extended until November 30th, by which I mean to say that there were samples outside, or samples continued after October 12th, or samples taken from the following points, until November 30:

Lake Michigan,
Lockport,
Illinois & Michigan Canal, Lockport,
River Des Plaines above the Chicago Drainage Canal, Lockport,
Ninth Street bridge, Lockport,
Drainage Canal, Bear Trap Dam,
Joliet—Des Plaines River,
1049 Illinois River three miles above Peoria,
Illinois River above Grafton—that is three miles above Grafton,
Illinois River three miles below Pekin,
Mississippi River two miles above Grafton,
Mississippi River one mile above Alton,
Mississippi River, Hartford,
Missouri River, Bellefontaine.

The entire number of samples analyzed from August 23rd, 1899 until January 1st, 1900, amounted to 4,000.

Q. Now do you know in what vessel those samples were taken; what kind of a vessel?

A. January 1st, 1901, all samples were collected by a collecting machine in bottles with glass stoppers.

Q. Were these bottles made especially for this purpose?

A. No, but the glass stoppers were all re-ground so that we would have an absolutely tight fit. They were specially reground before they were used.

Q. What was done with the bottles after the water was put into them?

A. Well, those bottles were numbered.

Q. Did you give any instructions to the people that took them?

A. Yes sir.

1050 Q. Was this work all done under your direction?

A. Yes sir.

Q. Were those instructions in writing?

A. Not during that period.

Q. Well, what were your instructions, doctor?

A. They were personal, verbal instructions that I gave to every collector, carefully designating how the samples should be taken; how the bottles should be sealed, and how they should be shipped, at what time, so that we would receive them as soon as possible after collection, and so forth.

Q. Well, what did you say to them. You say you gave them instructions; just tell us what you told them to do?

A. The first instruction was, that they should be careful to observe when they received their bottles, either at the City Laboratory, for those collectors who got their bottles every morning, and took them out to the station and filled them with water and brought them back personally, and to those collectors who were stationed at the various collection stations along the entire route from Chicago to St. Louis, the instructions were always to look that the bottle was clean; that if their personal inspection should notice anything in the bottle, that wasn't clean, or that the stoppers,—the glass stoppers didn't fit, so that there was a possibility of the water not being closed as air-tight
1051 as possible under the circumstances, that they should reject the bottle and call my attention to it and demand another bottle and not leave until the person who would give them the bottles,—the janitor,—until they had received the

proper bottle. Then that they should be careful when they used the machine, that the stopper was attached to the machine, the glass stopper, in such a way that the bottle could easily be closed. Then furthermore, that they should note on the tags that they attached to the bottle, they should note several things that were represented there in printed questions, the number of the bottle—

Q. When were they to be attached?

A. They were to be attached when they took the samples of water.

Q. Well, immediately, or an hour afterwards?

A. No, they were to be taken as soon as possible after they had filled the bottle, to put the tag on right away, and to seal it right there. They were to have sealing wax in their possession and were to have each one a seal, a numbered seal. I haven't got one here, but it is an ordinary stamp seal with the engraving "City Chemist's Office" and the number—giving the number of the collector.

Q. Stamping the number of the collector on the wax?

A. Stamping the number of the collector on the wax, yes.
1052 Now for instance the collector at Alton, I would say, might have seal No. 4, so that the seal would be numbered 4, and then not to deliver any bottle to the express office, —or if he brought the bottle to the City Chemist's office, not to carry it without having it sealed in such a way so that I would be absolutely certain that the bottle could not be opened en route from the collection point to the City Chemist's laboratory, and when the chemist would analyze each sample, he would have to open it.

Q. Now what did you instruct these water collectors to put on the card that they attached, or the tag,—to each bottle?

A. They were to put on their name—

Q. Well, whose name?

A. The name of the collector, the time and the hour of the collection exactly.

Q. What time?

A. By the minute, and the date of the collection.

Q. Day of the month?

A. Day of the month; they were to take the temperature—that is, that was optional with them, to take the temperature of the air and take the temperature of the water. For that purpose they all were provided with a thermometer which had been tested in the City Chemist's laboratory for its accuracy
1053 a thermometer that they would carry with them for the purpose of ascertaining the temperature of the water when taking the sample and the temperature of the atmosphere.

Q. And if they did take the temperature of the air and the water, that was to be placed on the card?

A. On the card, yes.

Q. Well now, do you know that these collections were made at these various places,—of the water?

A. Yes sir.

Q. And they were all made in bottles, were they?

A. Yes sir.

Q. Now where were they instructed to send those bottles, and how did they send them after they collected them—just take the various points there and tell how they sent them?

A. Well now, they had certain wooden boxes that were furnished us by the Water Department of St. Louis during this part of the investigation, and these boxes were to be carefully packed—the bottles were to be carefully packed into these boxes for the earlier part of the period, up to about May 1st, these bottles were simply put in the boxes and surrounded with excelsior,—what they call excelsior packing material.

Q. How many in a box?

A. Well, that depended upon the number of samples taken. Usually there were taken from January 23rd on, duplicate
1054 samples. That is, on January 23rd began a duplicate chemical investigation of samples of water taken from these points, in the laboratory of the Washington University, under the supervision of Professor Edward H. Kiser. Every collector was instructed every time that he would collect samples to collect at least two bottles, each one sealed in the proper way, as explained, and these bottles to be delivered at the City Chemist's laboratory, and to the clerk who had charge of that work, —that is to receive and enter those bottles. After that I and

my assistant, the Assistant City Chemist, found that our time was too valuable to receive those bottles, and enter them ourselves on the record books,—what I call the register of the sample, up to that time. After that we had a special clerk for that, who attended to that work.

Q. Under your supervision?

A. Yes sir, under my supervision and responsible to me.

Q. How much water did these bottles contain?

A. Originally we had half gallon bottles.

Q. During this period?

A. Yes, because we could not obtain the larger sized bottles, and for several months we were confined to what we call five pint bottles, and four pint bottles.

Q. Have you got one of those there?

A. Yes sir.

1055 Q. Well, just put it up there and we will offer it as an exhibit.

A. This is one of the four pint bottles (indicating). That is a half gallon (indicating).

Q. That is what you used in the earlier part of 1900?

A. In addition to these bottles—we were unable to obtain a sufficient number of bottles to supply our demands of those kinds here,—the white bottles—

Q. Well, the four pint bottle?

A. The four pint bottle, and we used the five pint bottles for a certain period until—I don't recollect exactly when that was—until we received a large assortment of the gallon bottles and used those. The machine was so constructed that we could easily alter the mechanism so as to put the gallon bottle into the machine. I have the machine here; we have two sizes, but they don't vary much.

Q. They are constructed on the same principle as Exhibit No. 15?

A. Yes sir. This was more adapted for the smaller bottle, but it was finally changed so that we could use the larger bottle on it too.

Q. Well now, have you—

A. I beg you pardon—

Q. What were you going to say?

A. I wanted to say, regarding the packing of these samples in ice, that when the warm weather set in, beginning 1056 with May 1st, 1900, we began to require our collectors to provide themselves with ice at all the stations where they were permanently located, and to pack every sample in ice when they would ship them to St. Louis, and those collectors who received their bottles every morning in St. Louis and went out to the Chain of Rocks, or to Alton, to Hartford or Bellefontaine, those collectors received the ice at the City Chemist's office, and packed their bottles in ice from the beginning, and took them to the stations. That is for a time, for a part of the period, the collectors at Alton and at Hartford would buy their ice there, but the other collectors took the ice from the City Chemist's office and took the samples along in that way, or at the Chain of Rocks for a time,—the period I don't recollect, they were provided with ice, but the object was attained throughout the entire route of the stations everywhere during that summer, the samples were packed in ice, and no samples were accepted unless they arrived in a condition that we could see that the ice had not melted entirely and that the water was ice cold. That was beginning with May 1st, and while we didn't begin the packing of the samples in ice at every station on May 1st, it was practically accomplished throughout those spring months.

Q. Well how about the summer months; was that continued throughout the summer months? 1057

A. All throughout the summer months.

Q. And up to what period?

A. That was continued up to the time of the cessation of the collection of samples outside of St. Louis.

Q. On what date?

A. On October 12th, for the daily samples and for the weekly samples, and for the semi-weekly collections on November 30th. This period of investigation from January 23rd, 1900, to October 12th, 1900, really covered a period of daily collection of samples from all these points, with the exception of a number of samples taken from Lake Michigan and from a few points near Peoria. But the principal object was a daily collection of samples from these points. October 12th this daily collection of samples outside of St. Louis ceased, and we only collected weekly or semi-weekly samples after that period.

Q. Until what time?

A. Until November 30th.

Q. 1900?

A. 1900. After November 30th, no more samples were collected outside of St. Louis until October, 1901, at another period of the investigation which I have not reached yet.

Q. Now then, do you know whether or not each and every 1058 one of those bottles thus packed and shipped in ice during the warm season and without the ice in the cold season as you have described, when it was not necessary to pack them in ice—were received at the laboratory of the City Chemist's office in the City of St. Louis, Missouri, with tags attached thereto?

A. Yes sir.

Q. Have you got each and every one of those tags?

A. Yes sir. Now I will not say every one of them, because a small number of them here and there, breaking the consecutive number are missing—that is, in the removal from the Old City Chemist's office quarters to the new quarters last summer a few of these were lost, I will admit that.

Q. Well, how many of them?

A. Well, I don't think that they would exceed 100 tags. I have not counted them, but I don't think they would exceed 100 tags.

Q. And how many tags were there altogether?

A. Well, this investigation has been practically continued until the present day, although the data to be presented in this litigation—

Q. Well, but tell me how many tags there were?

A. I will tell you, because it depends upon when we shall terminate the data to be presented to this Court—

Q. I don't care when you terminate it. How many tags 1059 have you got here?

A. Well, I presume we have analyzed 8,500 samples—

Q. Well, have you got 8,500 tags, less what you lost? That is what I want you to answer yes or no to.

A. I have not seen all the tags, I couldn't say positively, but I gave orders this morning at my laboratory to turn all the tags that we had over to yourself this afternoon.

Q. What do you know about those tags? Have you got any idea of about how many you have got?

A. As I say, I have not had the time this forenoon to identify them sufficiently so as to say that there are 8,000 here. But I gave orders to present 8,500.

Q. Oh well, estimate them. How many have you got there do you think?

A. Well,I can't honestly estimate them, because I have not gone over them to see how many have been delivered.

JUDGE SPRINGER Just give your opinion?

A. Well I expect 8,500 tags to be included in this bunch.

ATTORNEY GENERAL CROW: Less what were lost last summer?

A. I mean deducting perhaps 100 that have been lost last summer.

Q. Well that is what I say, less what were lost last summer?

A. Yes sir, that would be 8,400, yes sir.

1060 Q. Well, did those tags have any numbers on them?

A. Yes, everyone.

Q. What did those numbers represent?

A. These numbers represent every one, one bottle of water analyzed in the City Chemist's office, and for such parts of the investigation where duplicate work was performed by Professor Kiser of the Washington University it represents also a duplicate bottle of water analyzed by Professor Kiser and his assistants.

Q. Well now, to get back to the original question that I asked you; do those numbers correspond with numbers anywhere else, the numbers on the tags?

A. Beginning with Number 148, those numbers all correspond to an official register of the samples of water, which was kept at the City Chemist's office in which was registered every—

Q. What is the date of the beginning of number 148?

A. Tuesday, January 23rd, 1900.

Q. Then it is at the beginning of the second period?

A. Yes sir, until the present day; every sample of water collected and analyzed—that is every sample.

Q. Now don't get off—the number of the tags corresponds then to the records that you have entered on the book there,

ATTORNEY GENERAL CROW: Now, Judge, I want to
1061 just have those books considered in evidence. You can
consider them in the record too, so that if you want to refer to them for any specific purpose, it can be done. I don't think it will be necessary. I don't want them.

JUDGE SPRINGER: It is agreed that these books are to be considered in evidence, but not to be printed. Any of the counsel for either side may examine them at any time when they see fit.

(The books are before the commissioner at this time, but were retained by witness. F. S. B., Com'r.)

Q. ATTORNEY GENERAL CROW: Now these books contain what?

A. These books contain the official register of the City Chemist's office, of all samples of water beginning with sample No. 148, until the present date, which have been collected from the—

Q. Wait now; you can explain that briefer than that. Here is what I mean: Don't the entries in the record correspond with the memorandum on the tags?

A. Yes sir.

Q. Well, that tells the whole story—that is what that is a record of then?

A. Yes, but in addition to what is contained on the tags, this register also states in every case that whenever duplicate sample was turned over to Professor Kiser—or a bacteriological
sample had been collected at the same time by that col-
1062 lector, that the duplicate chemical sample was turned
over to Professor Kiser and that the bacteriological sample was turned over to the bacteriologist. That is the additional information that this official register of samples contains, which is not stated on the tags.

ATTORNEY GENERAL CROW: Now I think he has explained what is in that book sufficiently. Now that agreement there, Judge, you had probably better change the phraseology of that so as to show that they are in evidence.

It is agreed that tag Exhibit No. 17, is a sample of all these tags.

It is agreed between counsel that these tags referred to, numbering in the neighborhood of 8,000, and a representative sample of which has been introduced in evidence and marked Complainant's Exhibit No. 17, shall all be considered as evidence offered in the case by the complainant, but the same need not be printed in the record of the evidence of either side, but counsel on either side may refer to any or all said tags, or any memorandums thereon for any purposes whatever. F. S. B., Com'r.

JUDGE SPRINGER: That is satisfactory.

ATTORNEY GENERAL CROW: Now I think we will put in these bottles.

Three of said bottles received in evidence and marked
1063 by the Commissioner respectively "Complainant's Exhibit
18, 19 and 20. Frank S. Bright, Commissioner."

Q. Now you have got another period there?

A. Yes sir, there are five periods of investigation altogether.

Q. Well go ahead with the others.

JUDGE SPRINGER: What were these periods?

A. This was the first and second period.

ATTORNEY GENERAL CROW: Before we go any further we might just as well state that those tags just put in evidence will cover all the periods.

THE WITNESS: Yes sir.

ATTORNEY GENERAL CROW: We can let the record show that, Judge.

JUDGE SPRINGER: Yes.

Q. ATTORNEY GENERAL CROW: Now then, go ahead with the next period.

A. The next period, I haven't got my report here; that is up in your room.

Q. Well, go down there and get it.

A. That was the report that was presented for last November to you. It is in Mr. Jeffries' room. I would need that in order to get the corect data of the investigation.

MR. JEFFRIES: What is that?

1064 A. That is the supplemental report, presented last November.

(Witness procures the report refered to).

Q. ATTORNEY GENERAL CROW: Just go on doctor, with your next period. Now this is the third period.

JUDGE SPRINGER: Just give the date.

Q. ATTORNEY GENERAL CROW: Go ahead, doctor, and give the dates now, that you commenced—

A. This is the third investigation, the date particularly as far as the collection of samples at the Chain of Rocks is concerned, was from October 12th, 1900, to September 30, 1901. During this period of collection analysis of samples was confined to such as were taken from the Mississippi River at the Chain of Rocks daily, from the following points:

Illinois shore,
Missouri shore,
Intake tower.

In addition thereto, one daily sample was taken—

Q. Wait a minute, that kind of location put into the record wouldn't convey anything to a man's mind that didn't understand the location. What you mean to say when you say Illinois shore, is that it was taken at points opposite the Intake tower, on the Illinois shore, in the Mississippi River?

A. Yes sir.

Q. Well, just say that?

1065 A. At the chain of rocks—

Q. Leave out the Chain of Rocks, just say at the Intake Tower: Everybody understands that in this record.

A. Yes sir.

Q. Then another sample was taken from the Missouri shore?

A. One sample was taken near the Intake tower and one was taken opposite the Intake tower from the Illinos shore, and another sample was taken from the Missouri shore, Intake tower.

Q. How often were those samples taken?

A. Also every day a sample was taken from the outlet chamber of the St. Louis Waterworks, that is after the water enters the Intake and passes through the tunnel or distributing well, and from there it goes into the reservoirs and after it leaves the reservoirs it passes through the chamber which is called the Outlet Chamber, and from there is sent through the mains of the city water supply.

Q. And were those samples taken daily?

A. And from the tap of the City Chemist's office,—every day, yes sir.

Q. During that period of time mentioned?

A. Yes sir.

Q. From what time to what time?

A. From October 12, 1900 to September 30, 1901.

1066 Q. Now, who took these samples?

A. Those samples were collected by collector Charles F. Werner.

Q. Were they collected in a manner similar to what you have heretofore described?

A. Yes, sir, according to similar instructions, as described previously.

Q. Well, were they taken from the current of the stream? How far from the shore were those, on the Illinois and Missouri shores taken?

A. Well, they were taken as close to the Illinois shore and as close to the Missouri shore as in the judgment of this collector was necessary in order to get the characteristic water flowing at the shores, and also to get at the Intake tower which is located at the edge of the channel, to get the water from the edge of the channel just as it flows into the Intake.

Q. Did you give this collector any instructions?

A. Yes, sir, personal instructions.

Q. Well, what were the instructions you gave him?

A. The instructions were—shall I describe—

JUDGE SPRINGER : Were they the same as they were before?

A. Yes, sir.

1067 Q. ATTORNEY-GENERAL CROW: Well, just say they were the same as given before.

A. The same as before.

Q. As given to the other collectors heretofore mentioned?

A. Yes, sir.

Q. Now, what was done with these bottles after they were taken from the water?

A. After they were taken from the water, this collector brought them down to the city chemist's office every day.

Q. Brought them himself?

A. Yes, sir, carried them down every day.

Q. Now, during the warm season did they come with ice, or without ice?

A. They came with ice.

Q. With ice?

A. Yes, sir, they came with ice all the time during this entire period; they were packed in ice at the Chain of Rocks.

Q. Well, was there any record entries made of those bottles when they arrived at the laboratory?

A. Yes, sir.

Q. Of the city chemist's office?

A. Yes, sir.

Q. Who made that record?

1068 A. The record was made by myself or my assistant, Mr. Buckland, and by a clerk who officiates in the city chemist's office.

Q. Well, you know that that record was made?

A. Yes, sir.

Q. It was kept in the books heretofore introduced in evidence?

A. Yes, sir, in the register of samples.

Q. Now, was there anything put on those bottles when they were sent down?

A. Yes, they were covered—that is the stopper and the neck were covered with a piece of muslin, around which string was tied, and a tag was attached in the manner and form previously described, and sealing wax was applied to the string and the muslin so that they could not be disconnected in any way from the bottle, and a seal pressed on the sealing wax every time a bottle of water was collected in that manner by the collector.

Q. Were the bottles numbered?

A. Yes, sir.

Q. Was there any numbers on the tags?

A. Yes, sir.

Q. Was there any correspondence between the numbers on the bottles and the numbers on the tags?

A. No, sir; the number on the tag is to correspond with the number of this glass stopper. The object of this cor-
1069 respondence of the two numbers is that in cleaning the bottles, sometimes the stoppers would get changed and they would not fit so tight, and it was my earnest desire to obtain samples only that had been collected in bottles where the glass stopper was as tight as possible—air tight as could be, and every one of those stoppers was reground when the bottle was sold to the City, so that we were anxious to have the same stopper on the same bottle, so strings were tied to them and they were tied—the stopper was tied to the bottle that way; but the consecutive number of samples of water collected for this investigation was entered on the official register every time a sample was brought in by Mr. Woerner.

Q. Well, did the numbers on the tags correspond to the number of the entry in the books heretofore introduced in evidence, and in which is recorded a record of the bottles?

A. Yes, sir.

Q. Now, what was on the tags?

A. On the tags was the name of the collector, the date and the time of collection. There was also given the temperatures and place where the sample was collected from.

Q. Well, you have got those tags here?

A. Yes, sir.

1070 Q. They are part of the tags heretofore introduced in evidence?

A. Yes, sir, they are all here today.

Q. Now, go to your next period?

A. The next period was the investigation from October 1st 1901, to November 30th, 1901. This was the most extensive period, or the period of the most extensive investigation connected with this litigation.

Q. Well, was it a daily collection of samples?

A. It was principally a daily collection of samples with the exception that at some points, cross-sections were taken and for special scientific reasons connected with the investigation samples at random had to be taken, but not consecutively every day, from day to day, but there was from a large number of points during this two months, daily samples were collected.

Q. Well, now, what points were they?

A. Chicago, Illinois & Michigan Canal at Bridgeport.

Chicago Drainage Canal at Bridgeport.

Lockport, Chicago Drainage Canal, Bear Trap Dam.

Lockport, Illinois & Michigan Canal.

Des Plaines River above Bear Trap Dam at Lockport.

Des Plaines River at Ninth Street Bridge, Lockport.

1071 Des Plaines River at Ruby Street Bridge, Joliet.

Des Plaines River at Brandon's Bridge, Joliet.

Illinois River at LaSalle, Illinois.

Illinois River at Peoria, Illinois, three miles above the railroad bridge.

Illinois River at Pekin, Illinois.

Illinois River at Kingston, Illinois, eight miles below Pekin.

Illinois River at Beardstown, Illinois.

Illinois River at Grafton, Illinois.

Mississippi River at Grafton, Illinois.

Mississippi River at Alton, Illinois.

Mississippi River at Hartford, Illinois.

Mississippi River at Chain of Rocks, St. Louis, Illinois shore.

Mississippi River, Chain of Rocks, St. Louis, midstream.

Mississippi River at Chain of Rocks, St. Louis, Intake of Waterworks.

Mississippi River at Chain of Rocks, St. Louis, Missouri shore.

Missouri River at Fort Bellefontaine.

St. Louis Waterworks at outlet screen or outlet chamber.

1072 St. Louis Waterworks, from tap in city chemist's office.

Those were daily collections.

Tri-weekly samples were collected from Lake Michigan at Chicago during this period.

Q. Have you given the period to the stenographers?

A. Yes, this is the fourth period of investigation, from October 1st, 1901, to November 30th, 1901. As I said before, the most comprehensive investigation—

JUDGE SPRINGER: That is one month?

A. Two months, October 1st, 1901, to November 30th, 1901. As I said, tri-weekly samples were collected from Lake Michigan at Chicago; semi-weekly samples were taken from the south branch of the Chicago River at a point near the Chicago & Alton Railroad bridge; also at Wesley, Illinois, left, right and center section of the Illinois River.

JUDGE SPRINGER: Where is Wesley located? Locate that. I know where it is, but the record doesn't show it?

A. Wesley is south of Peoria.

Q. South of Peoria, how far?

A. Three miles. Between Peoria and Pekin, yes, it is south of Peoria about three or four miles.

Four samples were collected during this period from the Missouri River at Omaha, above and below the City of Omaha.

1073 Four samples from the Missouri River at Kansas City, above and below the city.

Four samples were collected from the Missouri River at Jefferson City, above and below the city.

Four samples from the Missouri River at Hermann, Missouri, above and below the city.

Four samples from the Missouri River at St. Charles, Missouri, above and below the city.

Two samples were collected from the Missouri River at Wathena, Kansas.

Two from the Missouri River at St. Joseph, Missouri.

Two samples from the Kaw River, near Argentine, Kansas.

During this period occasional cross-sections of samples were taken at various points. These cross-sections at a certain point —I will say at Alton, for instance, right across the river, at equal distances between the various points from twelve points across that river. Samples were taken ten or twelve points, or more, just according to the requirements. Cross-sections of such samples were taken at Pekin Bridge, Illinois River, at Kingston, Illinois River at Peoria, Illinois River. At Joliet, Des Plaines River,

At Alton, Mississippi River,

At Chain of Rocks, Mississippi River,

1074 At Hartford, Mississippi River,

At Chain of Rocks, Mississippi River, St. Louis Waterworks, and at Fort Bellefontaine, Missouri River.

During this period the daily collections at Grafton were extended. To December 1st, or November 30th, all the daily collections outside of St. Louis ceased. We still continued the daily collections at Grafton, until December 18th.

Q. ATTORNEY-GENERAL CROW: Now, that is the only places you made collections at during this period—those are the only places?

A. Yes, sir.

Q. These collections were made in bottles, were they?

A. Yes, sir.

Q. And made under your supervision?

A. Yes, sir.

Q. And how were they shipped to you? Just tell it in a general way; don't go into the details?

A. Now, a certain number of the samples that were collected at Fort Bellefontaine, at Alton and Hartford, those samples were carried by the collectors from those points of collection to the City Chemist's laboratory; they were collected in the morning and delivered to the City Chemist's office at noon time for analysis, on the same day. The samples at all 1075 the other points between Grafton and Chicago were shipped by express from those points to St. Louis by collectors that were stationed at those points.

Q. Well, were they packed in ice or otherwise?

A. All of them were packed in ice, and all the samples brought to the laboratory by the collectors from the points at Fort Bellefontaine, Hartford, Illinois, and Alton were brought packed in ice, and the same applies to the samples collected at the Chain of Rocks; they were also packed in ice.

Q. No use repeating that. How about the Missouri River points, were they all packed in ice too?

A. Yes, they were all packed in ice too.

Q. They were all taken under your supervision?

A. Yes, sir.

Q. Was there anything put on those bottles?

A. Yes, sir.

Q. What was it?

A. There were tags attached to the bottles, and the bottles were properly sealed, and the tags were sealed onto the muslin cover of the stoppers in the same manner as described heretofore.

Q. The bottles were all received at the laboratory of the City Chemist's office in the City of St. Louis?

1076 A. Yes, sir.

Q. You know that?

A. Yes, sir.

Q. And they all bore these tags?

A. Yes, sir.

Q. Was there a record made of these bottles?

A. Yes, sir.

Q. Where is that record?

A. The record is contained in the Register—Official Register of Samples.

Q. Heretofore introduced in evidence?

A. Yes, sir.

Q. Now, have you got those tags?

A. Yes, sir.

Q. Where are those tags?

A. They are in the bunch that was presented today.

Q. That was offered in evidence heretofore?

A. Yes, sir.

Q. Now, what is your next period?

A. This period extended properly from December 1st, 1901, to July 1st, 1902, and represents a daily collection of samples by collector Charles F. Woerner, from the Mississippi River at the Intake Tower of the Waterworks, and from the Missouri and Illinois shores, opposite, or from the Mississippi near 1077 the Illinois and Missouri shores opposite the Intake tower, and also from the outlet chamber of the St. Louis Waterworks, and from the tap in the City Chemist's office.

Q. Well, these were all taken under your supervision?

A. Yes, sir.

Q. Done under the same method, and in bottles, as heretofore described for the other periods of time?

A. Exactly.

Q. How were they shipped?

A. They were collected early in the morning by collector Woerner and they were brought to the laboratory at noon time on that same day.

Q. By whom?

A. By Woerner personally.

Q. Personally?

A. Yes, sir, every day, including every holiday.

Q. Was the bottle sealed?

A. Yes, sir.

Q. In the manner you have heretofore described?

A. Yes, sir.

Q. Were they tagged?

A. Yes, sir.

Q. In the same manner as heretofore described for the other periods during which you received bottles?

1078 A. Yes, sir.

Q. Have you got those tags?

A. Yes, sir.

Q. They are part of the tags heretofore introduced in evidence?

A. Yes, sir.

Q. Have you got a record of the tags?

A. They are all entered on the Register of samples.

Q. These books already introduced in evidence?

A. Yes, sir.

Q. Now, those are all the periods of time during which you have had samples collected?

A. I had samples collected from July 1st to January 1st, but I will not present those in evidence.

Q. Have you got a record of them?

A. I have got a record of them and they are included in the official register there, presented today.

Q. You mean July 1st, 1902?

A. Yes, sir, July 1st, 1902.

Q. Well, have you got the tags?

A. Yes, sir.

Q. Where are the tags?

A. The tags are included here in the bunch that was presented today.

Q. Well, were these various bottles, for all these five
1079 periods, were they all examined chemically in that laboratory that you had charge of?

A. Yes, sir, except the duplicate samples that were sent to Professor Kiser during those periods.

Q. Well, who did the examination of this work?

A. The examination was made by a corps of assistants—

Q. Well, was it done under your supervision?

A. Yes, sir, all of it.

Q. Well, you kept a record of that?

A. Yes, sir.

Q. And those are the samples that constitute your record of the chemical analyses of these various waters?

A. Yes, sir.

Q. That have been mentioned?

A. Yes, sir.

Q. Have you got a list of the men that collected these water samples for you?

A. Yes, sir.

Q. And they all worked under your instructions?

A. Yes, sir.

CROSS-EXAMINATION, by Judge Springer.

Q. Were any of these samples to which you have referred during these five periods used for bacteriological examinations?

A. No, sir, not the samples of water collected in the
1080 bottles as described today.

Q. These were only used for chemical analyses?

A. Yes, sir.

Q. You spoke about having collected during these various periods something like 8,000 samples?

A. Yes sir.

Q. Did you superintend the analysis of those 8,000 samples yourself?

A. Well, I superintended them in so far as that the analyses were in—they were not performed by myself, or parts of the analyses not performed by myself; they were performed by my assistants under directions and instructions presented by me.

JUDGE SPRINGER: The manner of making these analyses will properly belong to the next time this witness is introduced, I presume, General?

A. ATTORNEY GENERAL CROW: Oh yes, I didn't go into that at all.

JUDGE SPRINGER: I will not ask him anything about that then. That is all.

Q. JUDGE SPRINGER: I will ask the professor one question. Did you indicate the places near the Chain of Rocks at which the samples should be taken?

A. Yes sir.

Q. How far was the first place at which samples were to 1081 be taken from the Missouri shore—I mean the State of Missouri shore?

A. You mean the point of collection?

Q. Yes.

A. From the Missouri shore?

Q. Yes.

A. Well, that was—

Q. Chain of Rocks?

A. That was supposed to be anywhere from 25, to fifty or seventy-five yards. It is impossible to designate a particular point there on account of the current, but the general instruction was that the collector was to get a sample from the Missouri River current, which is generally supposed to hug the Missouri shore very closely, to get a sample of that current.

Q. Now what were your instructions with regard to the point on the opposite shore or, the Illinois shore?

A. Exactly the same, only applied to the general supposition of a certain current hugging the Illinois shore there.

Q. How far was that point from the land, from the shore on the Illinois side?

A. Well now, that varies very much according to the 1082 point taken at the shore, and it has to be left to the judgment of the collector largely.

Q. What were your instructions in regard to it at that particular point?

A. Well they were to get water that was close to the Illinois shore, a certain current there with which the collector would very soon become familiar after entering upon his duties.

Q. Was there any distinction at that point between water which it was supposed by you or your collectors to come from the Mississippi River proper, or from the Illinois River in part —in other words, had the Illinois and Mississippi waters commingled at that point so that they could not be designated or separated from each other by the eye?

A. Well we could only determine by the chemical analysis,—that is, the results of the chemical analysis would demonstrate that.

Q. I thought you were speaking of physical conditions, of the commingling of the various waters here?

A. No, I was only referring to a current always existing there close to the Illinois shore, and that from that current the samples were to be taken. What kind of water that is of course only chemical analysis could determine.

Q. Well, wouldn't that chemical analysis tell whether that
1083 water came from the Illinois River or the Mississippi River proper, above the Illinois River?

A. Well, that would depend entirely upon conditions of mixtures prevailing at certain times, and which vary very considerably. It is hardly possible to make a direct assertion there which would be a condition applicable for all times. It varies very much.

Q. Have you visited the point of confluence of the Illinois River with the Mississippi River?

A. Yes sir, quite a number of times I have been up there.

Q. In ordinary stages of water, what would be the relative volume of water from each of those streams?

A. Well now that depends again upon the volume of water coming down those watersheds. It varies very much.

Q. The volume of water depends upon the amount of water that is coming down I suppose?

A. Well, you wanted to have an approximation, which is difficult to give.

Q. Well, I ask you if you could state the relative amount, or the proportionate amount of water which came together there from the respective streams, how much of the volume was contributed by the Missouri River and how much by the Illinois River?

A. You mean at the confluence of the two rivers?

1084 Q. Yes sir.

A. At Grafton?

Q. Yes.

A. Well now, I don't think that any fair average can be drawn there, because it varies so much at times.

Q. I spoke of the ordinary condition or stage of the rivers.

A. Well, one never is sure.

Q. The Mississippi River is much larger than the Illinois River, that is certain.

A. The Mississippi River is larger. There is always a swifter current in the Mississippi River. The average rate of flow of the Mississippi River is larger than that of the Illinois river. Those are general facts which—

Q. Then from your personal—from the appearance of the two streams, you couldn't state what would be the difference between the volume of water carried by one as compared with the other. You couldn't state that?

A. No, not from my own personal observation, that is right.

RE-DIRECT EXAMINATION,

By Attorney General Crow.

Q. You stated in answer to one of Judge Springer's questions that there were no bacteriological collections of water made, that is to say, water for the purposes of bacteriological examination during the five periods that you mentioned. Did you mean to testify to that? 1085

A. No, I meant to say that I didn't collect any bacteriological samples.

JUDGE SPRINGER: My question was confined to the samples that he took himself; not to any other.

THE WITNESS: I didn't take any bacteriological samples. I took quite a number of samples myself in 1899.

ATTORNEY GENERAL CROW: There were also bacteriological samples collected by those various collectors a good deal of the time during these five periods?

A. Yes sir.

Q. And these samples were sent along with the chemical samples to you?

A. Yes sir.

Q. In the same manner and at the same time and received at the same place that you received the chemical samples?

A. Yes sir.

RE-CROSS EXAMINATION,

By Judge Springer.

Q. Well do these tags represent the bacteriological samples as well as the chemical?

1086 A. The collector that collected the two kinds of samples delivered them at the City Chemist's office and they were—they were numbered in the consecutive order of the official register and this number was also placed on the tag from the bacteriological bottle.

Q. The same number?

A. Yes sir, the same number.

Q. So that the numbers then would be duplicate?

A. Yes sir.

Q. In case one sample was to be used for bacteriological purposes and the other for chemical—

A. Yes, that is the same number was placed on the tag for the bacteriological bottle, and the bottle turned over to the bacteriologist. This had that same number on that was copied in the official register, but whether he followed a different numbering, that of course I can't tell. It is my impression that that was done; that they had separate numbering.

ATTORNEY GENERAL CROW: Well do you know what was done with these bacteriological water samples after they were sent to your office?

A. They were—

Q. Where were they sent to?

A. They were sent to the bacteriologist, who had charge of that work. For a time they were sent to the St. Louis

1087 Medical College where Dr. Ravold and his assistants, who had charge of the bacteriological work performed their work.

Q. Was that done under your supervision—I mean were those bottles sent up there under your supervision?

A. Yes sir.

Q. By employes in your office?

A. Yes sir. Then for a certain period of this entire investigation bacteriological work was performed in the Old City Hall in certain quarters, and the samples were sent over there then.

JUDGE SPRINGER: Were all the chemical analyses made of these various waters to which you have referred, made in the City of St. Louis?

A. Yes, all made in St. Louis. The work conducted in the City Chemist's office under my supervision, as well as the separate chemical work performed in the laboratory of the Washington University under the supervision and responsibility of Professor Kiser.

ATTORNEY GENERAL CROW: Now Judge, we will just let the record show that he is withdrawn for the present after having given this preliminary testimony.

JUDGE SPRINGER: Witness withdrawn for the present and to be introduced later for the purpose of explaining his chemical analyses, is that right?

ATTORNEY GENERAL CROW: Yes, of continuing his testimony.

WILLIAM C. TEICHMANN.

1088 CHARLES F. WERNER,

called as a witness on behalf of the plaintiff, now being first duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION

By Attorney General Crow.

Q. What is your name?

A. Charles F. Werner.

Q. You live in St. Louis, Mr. Werner?

A. Yes sir.

Q. Were you employed by Dr. Teichmann to collect water samples?

A. Yes sir.

Q. From what points, in what streams did you collect samples?

A. I collected water at Joliet.

Q. Sir?

A. I collected water at Joliet.

Q. Out of the Illinois River?

A. Out of the Illinois River.

Q. Where else?

A. Lockport, at the Bear Trap Dam.

Q. At what period of time did you make that collection?

A. That was in 1900.

Q. 1900?

A. But what date I could not say.

Q. Did you collect water at any other place?

1089 A. Yes, sir I collected water at Peoria, Illinois, that is, three miles above Peoria.

Q. At any other point?

A. At Chain of Rocks.

Q. At Peoria you collected in the Illinois River?

A. At Peoria I collected in the Illinois River, yes sir.

Q. Three miles above Peoria in the Illinois River?

A. Yes sir, I collected three miles above Peoria. Peoria is where I was stationed at.

Q. At the Chain of Rocks what river did you collect in?

A. Mississippi River, Illinois shore; Missouri Shore and In-take Tower.

Q. Do you remember when you began work?

A. Well, 1900, I believe. It was in March, if I am not mistaken, the latter part of March, if I am not mistaken.

Q. Did you work continuously?

A. Yes, sir.

Q. When did you quit?

A. I think January, 1903.

Q. January, 1903?

A. Yes, sir.

Q. And you have been collecting water continuously for Doctor Teichmann?

A. Yes. sir.

Q. Up to January, 1903?

A. Yes sir.

1090 Q. Now, any other place besides these you mention that you collected water?

A. Well, occasionally I would go up to Hartford.

Q. Hartford, Illinois?

A. Yes sir. I went up there two or three times, that I went up there.

Q. Where did you collect water from there?

A. I collected right in the channel of the Illinois.

Q. Where?

A. At Hartford, Illinois.

Q. Now, what did you collect this water in, bottles?

A. I collected that water in these gallon bottles (indicating).

Q. Collected it on the surface of the water or underneath?

A. No, sir, two and a half to three feet about as far as I could reach the machine down. I had it corked. I placed the machine down under water, then when I would get it down as far as I could, if the current was not too strong, I would push up the cork and let the water in and when I thought it was full I would cork it and raise it up.

Q. Were these samples taken out in the stream each time?

A. Every time.

Q. What did you seal the bottle with?

A. I would take a cloth and wrap it up around the bottle and tie it down, tie it with string or twine, and take sealing wax and seal it up, heating it up and then I would 1091 take my sealer and press down on it, and that would answer the purpose for the city chemist of St. Louis. Well, I don't know which I had, I had a number and I think I had number five sealer.

Q. Now, did you put any tag on the bottle?

A. Yes, sir, I put a tag on there, put on the date that I collected the water.

Q. Put that on the tag?

A. Yes, sir, put that on the tag and the hour I collected and the notation where I collected the water, the temperature of the air and the temperature of the water and my name on every tag.

Q. Now, when you collected at any other place than the In-take Tower at the Chain of Rocks, or opposite the In-take Tower on the Illinois shore of the Mississippi River or at Bellefontaine, did you ship the bottles?

A. Well, at Chain of Rocks, no, or either at Hartford, I never did. I carried them home in my own hands.

Q. Well, you did not carry them from Joliet?

A. No, no, I shipped them from there.

Q. Now, from what places did you bring them in personally to the laboratory?

A. Well, from Hartford.

Q. From Hartford, Illinois?

A. Yes, and from Chain of Rocks and I have been twice,
1092 two or three times, that I have been up at Bellefontaine.
I carried them from there. That is to the train and had them in my possission in front of me so they wouldn't get out of my reach, and I took them right to the City Chemist's; take them out of the cans and place them on the table, and have one of the chemists to know it, or Dr. Teichmann, and they would number that and start to work on it. If they wouldn't work on them right away, they would lay them right in ice boxes.

Q. Were these bottles packed in ice at any time?

A. In the warm spells they were.

Q. When you collected up the Illinois River, Bear Trap Dam, etc., how did you get them down here then?

A. I collected the water and placed them back into the boxes; there was a tin box, kind of a refrigerator we called it, packed with ice and then on the sides of it to keep it from warming, we packed excelsior, and the bottles were placed in the refrigerator to keep them cold. I sealed the boxes with a wire seal and then put the tag on with string,—with twine and sealed that with wax the same way as I did with the sealer, with the lead seal, and sealed it right on the box, on the lid, so in case she was opened up, or that they wasn't there, they would know that it was opened up by someone.

1093 Q. Then what did you do with it?

A. I took it to the express office and had it shipped to St. Louis.

Q. Where did you ship it to?

A. To the City Chemist.

Q. Now any other places than those you have mentioned, that you took samples?

A. No sir.

Q. Were those samples taken daily or weekly by you?

A. Every day.

Q. Every day?

A. Sundays, holidays and every day.

Q. Did you take any bacteriological samples?

A. Yes sir.

Q. During what period did you take them?

A. Well I have taken some of them up at the Bear Trap Dam in 1900.

Q. March, 1900?

A. Well, I wouldn't say for sure whether it was March; it was around that time, anyway, March, February, January, or April.

Q. Did you take any at any other time or place?

A. Yes, I have taken them up at Hartford, Illinois and Peoria, Illinois.

1094 Q. At what times?

A. Well, whenever I would take the big sample I would take the small sample.

Q. Always?

A. All the time.

Q. Did you do that throughout all your collections of water?

A. Yes sir.

Q. Up to what period?

A. Let me see; that was until about 1902, if I ain't mistaken, around December; I ain't right certain,—or November, something like that.

Q. November, 1902?

A. Yes, around November, 1902.

Q. Around November, 1902?

A. Yes sir.

Q. What was the size of the bottles that you took the bacteriological samples in?

A. They were about the size,--about this size; we had an extra machine for that.

Q. Just indicate; state about the size, about how much would they hold?

A. About half a pint, I guess, something similar to it;
I ain't right certain. Those are the machines we used
1095 (Indicating Complainant's Exhibit 15.) I don't know
what they should hold; I ain't got an idea.

ATTORNEY GENERAL CROW: Get it into the record that it was a bottle the same as is in Exhibit 15.

Q. Now what did you do with those samples when you took them?

A. I took them the same as I did the Chemical samples; took them under water—not to get no air, and in case the cork should come off, to put it to one side and not use it. Send it back. I would place the machine in the water about that depth (indicating).

Q. About what depth?

A. About two and one-half feet, is it not?

Q. That is about three feet.

A. I had hold like this and—

Q. Right hand on the top of it, and left hand horizontally on the bottom.

A. Then I would raise this—

MR. JEFFRIES: What do you call that?

A. Well, the trigger, the spring of it, or lever, I call it.

Q. ATTORNEY GENERAL CROW: Well, what did you do with those samples you collected?

A. I would take them and put tinfoil right over them,
1096 I mean I would take them out of the machine and place
a rag around it,—tie the rag around here and seal it up.

Q. Then what did you do with them?

A. Placed them back in the boxes, until I got to pack them away.

Q. Put them in the same box with the Chemical samples?

A. Yes, that is if I was to ship them, yes sir, put them right against the refrigerator to keep them cold.

Q. Well, what you call a refrigerator was a box of ice?

A. Yes sir, with ice.

Q. In which you shipped them?

A. Yes sir.

Q. Then you put these bacteriological samples in there with the chemical bottles?

A. Yes sir.

Q. And then what did you do with them?

A. I shipped them.

Q. Shipped them where?

A. To the City Chemist.

Q. Right with the chemical samples?

A. Yes sir.

Q. In cases where you didn't ship them what did you do with these bacteriological bottles?

I carried them home—carried them down to the City 1097 Chemist's office.

Q. And delivered them at the same place?

A. And delivered them at the same place, only the bacteriological bottles, I turned them over to Dr. Ravold, or either of his assistants.

Q. You did turn them over to Dr. Ravold?

A. I turned them over to him.

Q. At the City Chemist's office?

A. At the City Chemist's office.

CROSS EXAMINATION.

By Judge Springer.

Q. When did you begin your work of taking samples of water for examination?

A. 1900.

Q. What part of the year?

A. Well, say about the latter part of March.

Q. And you continued up to—

A. 1903.

Q. 1903?

A. Yes sir.

Q. Did you take samples for bacteriological examination during this period?

A. Yes sir.

1098 Q. Did you take any samples for bacteriological examination in the Chicago Drainage Canal and the Des Plaines River.

A. Yes.

Q. How?

A. Yes sir.

Q. And in the city of Joliet?

A. Yes sir.

Q. How long a time was it after those samples were taken until they arrived in St. Louis?

A. How long?

Q. Yes.

A. They would arrive either—They would arrive in the evening. I would collect them in the morning, something around half-past seven or eight o'clock was the latest; then as quick as I would have them collected and packed away, put in ice, and put a tag on and sealed it up with the lead seal, and had the box sealed and ready to be shipped, and about twelve, something around twelve o'clock I believe, the train backed in there and they loaded up.

Q. Back in where?

A. Back into the express office, or at the depot.

Q. At Joliet?

A. Yes sir, and they would be on the way to St. Louis—
1099 now what time they arrived, I couldn't swear to. I think
they arrived in the evening or either in the morning.

Q. Next morning?

A. Because they were delivered to the express—they should have been in the City Chemist's office early in the morning. Now whether they were delivered at night or early in the morning, I could not say.

Q. But they were sent by express?

A. Yes sir.

Q. Upon the date on which they were taken?

A. Yes sir, shipped the very same day.

Q. And you think the train left Joliet about twelve o'clock on that day?

A. Something around that time.

Q. That applies to the samples taken in the Drainage Canal and Des Plaines River, and at the City of Joliet itself, too?

A. Yes sir.

Q. Did you take any samples above Peoria, at a place called Shady Beach?

A. Yes sir, that is Averyville.

Q. What did you do with those as far as shipping them is concerned?

A. Shipped those the same way. Took them to the Adams Express Company.

1100 Q. What time in the morning, did you take them?

A. Took them down around half-past seven or eight o'clock.

Q. Then what did you do after taking them at Peoria?

A. Carried them to the express office, and in the warm spells packed them in my cans, packed in ice, then took a street car and rode to the express office, and then I packed them in the shipping box with ice another time and placed my bottles up against it, and packed them with excelsior on the sides to keep them from breaking.

Q. What time would that express package leave the City of Peoria that day?

A. Well, let's see; sometimes one o'clock; sometimes before; sometimes at one; sometimes a little earlier than one.

Q. How?

A. Sometimes at one, and sometimes a little earlier than one.

Q. Do you know what time those were examined in St. Louis?

A. Well that I couldn't state, because I haven't been there then.

Q. You wouldn't get into there that day, I presume?

A. I was stationed right there at Peoria.

1101 Q. I mean they wouldn't get into St. Louis in time to be examined the same day; it would probably be the next morning?

A. That is something I couldn't state for certain.

Q. Now those samples that you took at Grafton, what did you do with those?

A. At Grafton?

Q. At Grafton, Illinois River, mouth of the Illinois River?

A. I guess I did go up there too, I just collected one, I believe one or two samples at Grafton.

Q. How?

A. I believe I only collected one or two samples at Grafton, Illinois. I brought them with me.

Q. Brought them with you?

A. Yes sir.

Q. Did you take any samples at Omaha, Kansas City, or Jefferson City?

A. No sir.

Q. You didn't take those?

A. No sir.

Q. Did you observe strictly the instructions which had been given you in regard to taking these samples, both for chemical analyses and bacteriological examinations?

A. Yes sir.

CHAS. F. WERNER.

1102 DR. W. C. G. KIRCHENER,

Re-called for further direct-examination by Attorney General Crow, testified as follows:

Q. The samples which you received at the laboratory, how did they come there, for bacteriological examination?

A. The bacteriological. Are you referring to what place?

Q. Well, any of the laboratories that you used to work at—where did you get the samples that you analyzed?

A. With the exception of those samples taken at the Chain of Rocks in the first period of examination, in 1899; and with the exception of a few samples taken at the first period of my examination at Joliet, the samples came to me through the collectors.

Q. Well, who did you receive them from?

A. I received them from collectors, or in case they were shipped from other sources, from a person properly designated for that purpose.

Q. What do you mean by that?

A. The samples—those samples that were shipped to the City Chemist's office, and from there were sent either to the medical college or to the old City Hall.

Q. By whom, by some employe?

A. By some employe whose business it was to transport these samples.

1103 Q. Do you know who it was that brought them, usually?

A. I don't know.

Q. At what period of time did you receive any of these samples yourself in the laboratory?

A. At the medical college between the period of January 23rd and May 1st, 1900, the samples were received by myself, or by Dr. Rush, or by an assistant which—who is employed in the laboratory.

Q. What condition were these bottles in when you received them from the collectors, or when you received them at the laboratory, with reference to being open or otherwise?

A. The bottles were properly sealed and had attached to them the label.

Q. You mean the tags?

A. The tags.

Q. Examine those tags in front of you and see if those are similar to the tags on the bottles delivered to you?

A. Those tags are similar to those that were attached to the bottles.

Q. Did you have any instructions about receiving the bottles or refusing to receive them or analyze them as to whether or not they ought to be in a certain condition?

A. Well, in all this bacteriological work, notes were taken of the condition in which the sample was received. If a 1104 sample in a bottle—if a bottle would be broken, a note would be made of that particular sample, or if they would contain sediment, or the stopper would contain some evidence of contamination—all of these samples would be properly noted, and a record and special reference would be made, and if the bottle would be contaminated the results would not be recorded as the official result.

Q. Well, were these bottles packed in ice, any of them?

A. They came to me packed in ice.

Q. Those that were received at the laboratory?

A. Those that I received, were packed in ice.

JUDGE SPRINGER: I don't care to ask him anything.

WALTER C. G. KIRCHNER.

1105 LOUIS SAUER,

called as a witness in behalf of the complainant, being first duly sworn, by the Commissioner, testified as follows:

DIRECT EXAMINATION.

By Mr. Jeffries.

Q. What is your name?
A. Louis Sauer.
Q. Where do you live?
A. 2000 South Second.
Q. St. Louis, Missouri?
A. St. Louis, Missouri.
Q. How long have you lived in St. Louis?
A. All my life, 34 years.
Q. What business are you engaged in, Mr. Sauer?
A. Saloon business at present.
Q. Were you ever employed by the City government here?
A. Yes sir.
Q. In what connection?
A. In the City Chemist's office.
Q. What particular work did you have to do with reference to the City Chemist's office?
A. Why I made a collection of water.
1106 When?
A. 1900, about September 17th or 18th, somewhere about that, for about one month.
Q. From September 17th or 18th?
A. Somewhere about that.
Q. 1900, extending through a period of about a month?
A. One month, yes sir.
Q. Who employed you?
A. Dr. Starkloff.
Q. Who is Dr. Starkloff?
A. He is health commissioner for the City of St. Louis.
Q. Who did you make reports to?
A. To Dr. Teichmann, City Chemist.
Q. Under whose supervision were you?
A. Dr. Teichmann's.

Q. Who is Dr. Teichmann?

A. He is City Chemist of St. Louis.

Q. Now state at what particular point you made collections of water?

A. Here at the Alton Waterworks; that is out in the river.

Q. How far out in the river?

A. Well out about where the current was about the strongest.

Q. That is the Mississippi River?

1107 A. Yes sir, about half a mile above the Waterworks.

Q. Now then, how often did you gather these samples?

A. Every day during that period.

Q. How far under the surface of the river did you go to get them?

A. Why, I would use that machine and go down as far as I could with it.

Q. Do you mean Complainant's Exhibit 15 (Indicating)?

A. Yes sir, this one and the smaller one.

Q. And the machine you used then was patterned after complainant's Exhibit 15?

A. Yes sir.

Q. And the bottle that you used in collecting the sample was a bottle similar to the one found in this machine?

A. Well one of those and two, gallon bottles.

Q. Well with reference to this particular sample?

A. Put it in the same bottle.

Q. Do you know what those samples were collected for?

A. I haven't the least idea.

Q. You don't know whether it was for chemical or bacteriological examination?

A. Didn't pay any attention to that, no sir.

Q. In addition to collecting these smaller samples, you
1108 collected larger samples too, did you?

A. Yes sir.

Q. What was the size of those larger bottles?

A. Half gallon,—the size of that larger bottle there (indicating).

Q. Complainant's Exhibit 16?

A. Yes, sir.

Q. Now, you collected the water in those larger bottles by means of the machine, one similar to the—

A. Similar to the smaller machine.

Q. Similar machines to complainant's Exhibit 15?

A. Yes, sir.

Q. You say you made collections every day?

A. Every day.

Q. Of both kinds of samples?

A. Both kinds.

Q. How many samples would you take each day?

A. That is, one sample each day, that is one small sample bottle and two large ones.

Q. One small bottle and two large ones?

A. Yes, sir, at one time.

Q. What would you do after you had collected those samples. In the first place state how you collected them?

A. I placed the bottle in the machine, the large bottle
1109 first, and then I would sink it down as far as I could; then draw up the stopper and fill the bottle and then drop it back onto it again and take it out of the water.

Q. In other words, you would open and close the bottle underneath the water?

A. Underneath the surface of the water, that is right.

Q. At that depth?

A. Yes, sir.

Q. Three feet?

A. Yes, sir.

Q. Now, what did you do after you took that bottle out?

A. Took it back to shore and sealed it.

Q. At once?

A. Well, I would put canvas over it.

Q. That is, the larger bottles you would?

A. The larger bottles I would put string around it, tie it up and seal it, and the seal was from the City Chemist's office; then I would put on the date, place of collection, my name, temperature of the water; temperature of the air and point it was collected at.

Q. Now, what would you do with it?

A. Bring it back to the City Chemist's office.

Q. Do that at once, would you?

A. Why, take the first train that I could and get back to the City here—get back about two o'clock.

1110 Q. How long would it take you to go out and get back to the City, after you left there?

A. I would make the collection of the water about ten o'clock, and get back to the City Chemist's office, about two o'clock, or five or ten minutes after two.

Q. Now, then, after you brought the bottles back to the City Chemist's office, what then did you do?

A. Turned them over to Mr. Teichmann, or Mr. Buckland, his assistant.

Q. What did they do with them?

A. That I don't know.

Q. Did you pack them in ice?

A. Put them into a can and packed them with ice and excelsior.

Q. Now state what you did with the smaller bottles when you collected them?

A. I put a piece of tinfoil over the top of it and then pasted canvass over it, put on the address, sealed it and put a tag on it similar to the one I put on the larger bottles.

Q. And put the same facts on the tags?

A. Put the same facts on the tags as on the others.

Q. What disposition did you make of it?

A. I placed it in with the other bottles in the chest.

Q. You made the same disposition of it?

1111 A. Same disposition that I made with the larger bottles.

Q. Did you make these collections on Sunday?

A. Every day, yes, sir.

Cross-examination waived.

LOUIS SAUER.

1112 DR. W. C. G. KIRCHNER, re-called for further direct-examination by Attorney-General Crow, testified as follows:

Q. These tags that I show you, what are they?

A. They are the tags that were attached to bottles that were collected for the Joliet station for bacteriological samples.

Q. Well, at what time?

A. From the period of November—of October to November.

Q. What year?

A. 1901.

Q. Are these tags from the bottles that were sent to you for your chemical or bacteriological analyses there, of the water?

A. Yes, sir.

Q. You know those are the same tags?

A. They are the same tags.

Q. What have they got on them?

A. They have on them the date; location of the places from which the sample was taken, the condition of the temperature; record of the water and the air; name of the collector and such other information as the collector would gather.

1113 Q. Did you inspect the work of those collectors up there while they were under your supervision at Joliet, and along the Illinois River up there, with reference to how they were doing their work?

A. I did.

Q. Well, how did they follow their instructions?

A. They followed their instructions very closely. I made frequent tours of inspection.

Q. You say you did make frequent tours of inspection?

A. I made frequent tours of inspection, yes, sir.

ATTORNEY-GENERAL CROW: Now, Judge Springer, let the record show the same thing with reference to this bunch of tags as the other; that they are offered in evidence, but not to be printed.

JUDGE SPRINGER: No objection.

No cross-examination.

WALTER C. G. KIRCHNER.

Adjourned until 9:30 a. m., following day, Saturday, February 28th, 1903, at same place.

Southern Hotel, St. Louis, Mo.

1114 9:30 a. m., February 28, 1903.

Continuation pursuant to adjournment.

Present, the Commissioner and the same counsel representing the respective parties.

ALBERT WINSCHELL,

a witness on behalf of the complainant, after being duly sworn by the Commissioner, was examined by Mr. Jeffries and testified as follows:

Q. What is your name?

A. Albert Winschell.

Q. Where do you live?

A. 3006 Missouri avenue.

Q. What city?

A. St. Louis, Missouri.

Q. How long have you lived in St. Louis, Missouri?

A. Eight years.

Q. Have you been engaged with the water works department of the city of St. Louis?

A. I have.

Q. What business are you in now?

A. Barber business.

Q. What were you from January 7 to March 28, 1900?

A. I was collecting water up on the river of the city of St. Louis.

Q. At what particular point of the Mississippi river?

A. It was at the Chain of Rocks.

1115 Q. Who were you collecting or making these collections for?

A. The city chemist, Dr. Tiechmann.

Q. When did you commence?

A. I think it was about the 6th of January, 1900, up until the 28th day of March, I think, something like that. I am not very sure, but it was between the 6th of January and the 28th of March.

Q. How often did you make collections?

A. I made collections every day.

Q. Sunday also?

A. Sunday and every day, yes sir, from the time I started until I finished.

Q. What was the character of the samples you collected, as to quantity?

A. Well, it was taken from the Missouri side.

Q. No, I mean the quantity, how much?

A. I guess a half a gallon bottle or a gallon bottle, I forget which. I don't know which. That is it right there (pointing to complainant's exhibit 15).

Q. I will ask you if complainant's exhibit 18 is a pattern or sample of the bottles you used in making collections?

A. Yes sir. That one and the other one too.

Q. Also complainant's exhibit 20?

A. Yes sir.

Q. Those are samples of the bottles you used?

A. Yes sir.

1116 Q. In addition to this size did you make any other collections?

A. Yes sir, the small size.

Q. Now I will ask you if the bottle complainant's exhibit 15 is a sample of the bottle used?

A. Yes sir.

Q. Where did you get the bottles that you used?

A. They were sent up, I suppose, from the city chemist's to Baden. I got a train there, you know, and went out from there. They were delivered there.

Q. Did you know they came from the city chemist's office?

A. Yes sir. The driver was ordered to deliver them there. I put them on the train myself.

Q. The driver was in the employment of Dr. Teichmann, was he?

A. Yes sir.

Q. Under whose instructions did you work?

A. Mr. Teichmann.

Q. Now state the particular places in the river you gathered these samples?

A. Well, the first sample started on the Missouri side about 400 yards above the Intake tower.

Q. How far from the shore?

A. About 300 feet.

Q. It would always be 300 feet?

A. No, it would vary sometimes. I would come as close to the same place as I possibly could, but on account of the ice I could not take it at the same place. Then I would go
1117 right straight across to the Illinois side and take on the Illinois side, and I would come back from the Illinois side and take it as I was coming down to the intake tower.

Q. Now with reference to the channel in the river, where would you take the sample?

A. Well, I would try to get as close to the Illinois side as possible, say 200 yards from the tower.

Q. Would you get in the channel?

A. Yes sir. There would be times I could not very well do it. The ice would be so, great chunks of ice would take me on the other side. I would try to get in the channel on the Illinois side.

Q. Now with reference to the intake, where would you take the sample?

A. About 100 or 200 feet from the tower, right straight from the intake tower as I was coming down.

Q. Now how deep under the surface of the water would you take the sample?

A. I supose it would be about two feet, a foot and a half or two feet.

Q. Now I will ask you to examine complainant's exhibit 15 and ask you whether or not that is a model of the instrument used by you in collecting this sample?

A. Yes sir.

Q. You used both of these sizes and a larger size?

A. Yes sir.

1118 Q. You used this size for one sample of bottles and the larger size for the larger bottles?

A. Yes sir.

Q. Now state just exactly in your own way how you worked this instrument, how you collected these samples?

A. Well, when I started out I took the temperature of the air in the first place, and when I got ready with my bottles I would take the temperature of the water.

Q. Did you open the bottle before putting it under water?

A. No sir. I had to take the temperature of the air first. As soon as I got the temperature of the air I had to put my bottles down and pull out the cork.

Q. Now state whether or not you put the bottle down under the water before pulling the cork out?

A. Yes. I took the temperature of the water and put this in there; after I had it under the water I pulled the cork out with a wire that was connected with one of those things.

Q. Then what did you do?

A. After it was full, when I thought it was full, I would let it fly back again and pull it out.

Q. Let the cork fly back?

A. Yes.

Q. Now you did that with reference to all these samples?

A. Yes sir.

Q. Both large and small?

1119 A. Yes sir.

Q. Now after you drew the machine with a bottle of water in it out of the water, what did you do with it?

A. I took the temperature of the air and water and the time of taking it out.

Q. Before that what did you do with the bottle?

A. I put it back in the little box I had.

Q. What did you wrap it with?

A. With some cloth or something, I don't know what it was. A piece of cloth.

Q. You wrapped it and sealed it then, did you?

A. Yes sir.

Q. Then what did you put on it after you had sealed it?

A. Well, I would not seal it until I got to the shore, because I had no chance of sealing it. Then I had a piece of sealing wax.

Q. After you had sealed it what did you do?

A. I would take it over to the depot.

Q. Did you tag it?

A. Yes sir.

Q. What did you put on the tag?

A. The date and the time of taking it out, and the temperature of the air, with my name on it.

Q. And the place?

A. Yes sir, the place.

1120 Q. That is the place where it came from?

A. Yes sir, the Illinois or the Missouri side.

Q. What did you do with them after that?

A. I would take them over to the office over there and seal them and put them in a little box and wait for the train to come down and take them down. I went down with them to the city chemist's office.

Q. You took them to the city chemist's office yourself?

A. Yes sir.

Q. Whom did you deliver them to?

A. There was a buggy waiting for me at Baden when the train got down, and I delivered it directly to the city chemist.

Q. Now you made the same disposition of all the samples you collected?

A. Yes sir.

Q. From the 6th day of January to the 28th day of March, 1900?

A. Yes sir.

CROSS-EXAMINATION,

By Mr. Springer.

Q. You stated, I believe, that the places on the Missouri 1121 shore were 400 feet from the land?

A. No, it varied.

Q. 400 yards, you said?

A. No sir, from the intake tower up above. I went from the intake tower that far above on the river, you know, to take my samples. Then I went out 100 or 200 feet from the shore to take the water from there.

Q. How far from the Missouri shore was it that you took your samples?

A. It varied from 100 feet to 200 feet.

Q. I thought you said 400 feet?

A. No sir.

Q. I think you said 400, and I thought you were mistaken.

MR. JEFFRIES: He says he said 400 feet above.

THE WITNESS: I went from the tower.

MR. SPRINGER: 400 feet above the intake tower—above what did you go 400 feet?

A. The intake tower. I took the water 100 or 200 feet from the Missouri shore up. Sometimes I took the same place, but the ice was so heavy I could not get out to the same place, and it would be 100 or 200 feet.

Q. How far from the Illinois shore was it that you took the samples?

A. It would be about the same thing as on this side. I
1122 could not get near to the shore. The ice would not let me go over. If I got over there I would have a time getting back. It would be about the same distance. I would try to get as close as I could. It would sometimes be 100 feet and sometimes 200 feet.

Q. From the Illinois shore?

A. Yes sir.

Q. Where is Baden—is that the place you mentioned?

A. Yes sir. Within the city limits, I guess.

Q. On this side of the river?

A. Yes. Right at the end of the Broadway car line.

Q. How long from the time you took the first sample until these bottles would reach the city chemist's office?

A. About four o'clock I would come in. I would get through with the bottles about two o'clock or half past one, and I would try to catch that train that comes in there a quarter to three at the Chain of Rocks. I would have my samples there and come down with them. Sometimes it would take me a little longer to get my boat through the ice.

Q. What time in the morning did you take them?

A. Why, I left—or started at nine o'clock, generally.

Q. And generally you would reach the city chemist's office at four o'clock?

A. Four o'clock or half past four.

1123 RE-DIRECT-EXAMINATION,

By Mr. Jeffries.

Q. You mean you would leave St. Louis at nine o-clock in the morning?

A. Yes sir, I would start at nine o'clock. I would catch that train at Mound street here. ALBERT J. WINSCHELL.

1124 FRED DIESELHORST,

a witness called on behalf of the complainant, after being duly sworn by the Commissioner, was examined by Mr. Jeffries, and testified as follows:

Q. What is your name?

A. Fred Dieselhorst.

Q. Where do you live?

A. 1222 Hebert street.

Q. St. Louis, Missouri?

A. Yes sir.

Q. How long have you lived at St. Louis?

A. All my life, 31 years.

Q. State whether or not you ever collected any samples of water out of the Missouri or Mississippi or Illinois river for Dr. Teichmann of the city chemist's office?

A. Well, I collected from the Missouri river for about five months I guess every day.

Q. Well, when?

A. I cannot just remember the date, whatever time they started—When was that, in January, 1901—from January until—

Q. January 1900 until when?

A. From January 1900 for about five months straight, I guess, from the Missouri river.

Q. Then where did you go?

1125 A. Then they had me one day at Grafton, one day at Alton, one day at Hartford, and the next day at Bellefontaine, four times a week, one day at each place.

Q. Each week?

A. Each week, yes sir. That was for about two months I guess I went up there. tt was about eight months all told, all the time I went there.

Q. Now whom did you work under?

A. Well, for the first couple of months I worked under Flad.

Q. The water commissioner?

A. Yes sir, for a couple of months, and after that for a couple of months I worked under the city chemist.

Q. During all the time, who gave you instructions as to the manner of collecting these samples?

A. Why some engineer by the name of Mercereau, I believe.

Q. Do you know his first name?

A. No sir.

Q. Now after Mr. Mercereau quit issuing orders whom did you work under?

A. Under Dr. Teichmann.

Q. State the particular place that you obtained the samples in the Missouri river?

A. Why, right at Ft. Bellefontaine, Missouri.

Q. You say you commenced in January 1900 and for five
1126 months you took samples?

A. For five or six months at the same place.

Q. How often?

A. Every day.

Q. How many samples did you take each day?

A. When I first started I took four big bottles, I believe, and two small bottles, and afterwards only two large bottles and one small bottle.

Q. Now state the manner in which you took those samples?

A. It was with these machines here.

Q. I will ask you if complainant's exhibit 15 is a pattern of the machine used by you in taking the samples?

A. Yes sir. And a machine the same as this was used for the small bottle.

Q. The small bottle in one of these machines is one of the bacteriological samples you collected daily?

A. Yes sir.

Q. Now the larger bottles were taken in the larger pattern of machine?

A. Yes sir.

Q. Now what time of day did you generally take those samples?

A. Well, different times. Usually catch the Burlington train here at 8:20 and get up there about 9:30; generally got
the train back, the first train to leave, about 1:10, I think,
1127 and I took them any time in between, generally took the
Burlington back. Sometimes took the 10 o'clock, sometimes maybe the 11.

Q. And start back at one o'clock?

A. Start back at one o'clock. 1:09 I think it is.

Q. Now state the manner in which these collections were made and the particular places in the river you took them?

A. Why we took the sample right at the channel of the river.

Q. How deep under the surface of the water?

A. About three feet, I guess.

Q. The full depth of the machine?

A. About three feet down in the water. Just kept our hand from getting into the water.

Q. Just state whether or not you would open the bottle under the water or out of it, to pull the cork out?

A. Always supposed to cork them under water.

Q. To open them and cork them under water?

A. Yes sir.

Q. You always did that?

A. We always tried to, when I was there; sometimes it would not work. The ice would be coming down and the water would get in there and it would not work, and you could not close them.

Q. What did you do after you brought the samples out?

A. Up on the bank there was a little shanty, and we
1128 would go right up there and get a piece of white cloth and
put it around the stopper and seal them, and put them on tight, and take the temperature of the air and the water and the place where it was taken, and sign our name to it on the tag.

Q. That is what you did with the larger bottles?

A. The large and the small bottles too.

Q. Did you put tin foil around the small one in addition to the rag?

A. Didn't put any rag around the small ones at all. Just the tin foil.

Q. And then you wrapped them?

A. Wrapped them and sealed them.

Q. What did you do with them after that?

A. We had these tin boxes that we placed them in, and we put them in ice and had them right there; they would not get out of our sight until the train came.

Q. After you did that what did you do?

A. Put them in the box and when the train came along brought them down to the chemist's office.

Q. What did you do with them then?

A. Turned them over to some fellow by the name of Taylor, who took them in charge.

Q. Both the chemical and bacteriological samples?

A. Yes sir.

1129 Q. Now that same routine of work you went through every day during the whole time of your employment?

A. Yes sir.

Q. Now what did you do with the samples that you collected at Grafton?

A. Just the same way.

Q. And you brought them right down to the chemist's office?

A. Yes sir.

Q. The same day?

A. Yes sir.

Q. How about the samples collected at Hartford?

A. They were all taken the same way, Hartford, Grafton and Bellefontaine.

Q. Now did you work at any other place collecting samples?

A. No sir. The time I went to Bellefontaine, though, there were some days the river was so bad I could not go out on it. The machine would not work. There was so much ice coming, down, so I got me a bucket and we took the water out of the bucket, but only certain days the river was so bad up there and the ice was coming down. I would not go out there for anybody when that ice was coming down. Then we dropped the bucket right from the bridge. The watchman there used to help me drop the bucket.

Q. In the channel?

A. Right in the channel, yes sir.

1130 Q. What did you do with the samples after you brought them to the city chemist's office? Did you see them do anything with them?

A. There was a fellow there by the name of Taylor who took charge of them.

Q. Did he put the bottles in the refrigerator?

A. Yes sir.

Q. Did you always see him do that?

A. Not always, but sometimes.

FRED. DIESELHORST.

1131 THOMAS A. BUCKLAND,

A witness called on behalf of the complainant, after being duly sworn by the Commissioner, was examined by Mr. Jeffries and testified as follows:

Q. What is your name?

A. Thomas A. Buckland.

Q. Where do you live?

A. St. Louis, Missouri.

Q. How long have you lived in St. Louis?

A. Very nearly all my life.

Q. What is your business or occupation?

A. Assistant city chemist.

Q. How long have you been assistant city chemist?

A. About ten years.

Q. Do you mean assistant city chemist of the city of St. Louis?

A. Yes sir.

Q. You are under Dr. Teichmann?

A. Yes sir.

Q. How many years, did you say?

A. About ten.

Q. You have been assistant city chemist continuously during that time, ten years, down to the present time?

A. Yes sir.

1132 Q. I will ask you what you know about receiving various samples of water that were brought to the city chemist's office for chemical and bacteriological analysis, from January, 1900, down to September, 1901, or during the whole time of that investigation?

A. Well beginning, I think it was, about January 23—

the "Register of samples" will show the exact date. I could identify it.

Q. I will ask you to examine these tags, showing the registry of samples so collected from the various records, and state whether it is a correct record of the various samples that came to your office?

A. I can identify this one. Do you want me to look over them?

Q. You can tell by looking at them?

A. Yes, I can tell. This shows the receiving of the samples for analysis during this entire investigation.

Q. Now then, as these samples came in, what was attached to the bottle?

A. Tags.

Q. What was on the tags?

A. The tag contained the date, place of collection, the name of the collector, the temperature of the air and the temperature of the water; the place of collection, indicating the river and the location on the river, as far as I remember, in most cases.

Q. Now state where these collectors obtained the bottles
1133 that were used in collecting the samples?

A. They obtained them from the city chemist's office.

Q. Were these particular bottles subjected to any particular treatment before sent out?

A. Well, they were thoroughly cleaned.

Q. How about the bottles for the bacteriological samples?

A. The bottles for the bacteriological samples were thoroughly cleaned and sterilized.

Q. Now state whether or not these samples were sealed when they came in?

A. Yes sir.

Q. Always?

A. Always sealed with sealing wax, and the seal prepared for the purpose by the city chemist's office.

Q. What was the object in having them sealed?

A. To prevent the possibility of any tampering with or contamination of the sample.

Q. You assisted in keeping this record of samples as they came in, did you?

A. Yes sir.

Q. And saw that it was done?

A. Yes sir.

Q. Now I will ask you to examine this bunch of tags, and ask you if these are a part of the tags received in your office, attached to the bottles of samples of water?

1134 A. Yes sir. I can say this, that I have examined the tags.

Q. I will ask you to examine complainant's exhibit 17 and state whether that is a sample of the tags that came in on the bottles?

A. Yes sir.

Q. Now what disposition was made of the smaller bottles of water, the bacteriological samples?

A. The bacteriological samples were turned over to Dr. Ravold and his assistants for bacteriological examination.

Q. Now whom did you turn them over to?

A. Well, part of Dr. Ravold's work was done at the office of the city chemist; that is in the quarters connected with the office of the city chemist, adjacent to the office of the city chemist, and I believe that the first lot that was received were examined there.

Q. They were always turned over by you or someone in charge, were they?

A. They were either turned over personally or placed in the ice chest.

Q. Where they came in and got them?

A. Yes sir.

Q. What does the 2L and 1L on these different tags mean?

A. Well, I can't say that I remember just what it does mean.

1135 Q. State whether or not you received any bottles that were unsealed. If so, what disposition did you make of them?

A. What is that?

Q. Suppose a bottle would come in with the seal broken or unsealed?

A. If they were not immediately turned over to someone responsible present, it would be sealed. That is my recollection.

Q. Supposing it would come in from the collector unsealed, take these samples that were shipped in or expressed in.

A. Well, I could not say that I remember.

Q. Were they thrown out, the bottles thrown out, or not?

A. Well, I know sometimes they were thrown out, and I presume they were, any one that happened to come unsealed, but I cannot remember.

Q. State whether or not you know that the bottles were sterilized before they were sent out?

A. Well, that was a part of the bacteriological work with which I was not connected, but I saw the bottles in process of sterilization frequently.

Q. They were sterilized there in your office, were they not?

A. They were sterilized in the adjacent quarters, not in the rooms in which we worked. I do not believe the bottles got out without being sterilized.

1136 CROSS-EXAMINATION, By Mr. Springer.

Q. Mr. Buckland, did you assist in the chemical analyses of these waters?

A. Yes sir.

Q. What part of this work did you perform yourself?

A. Well now, Dr. Teichmann wishes me to reserve my testimony.

ATTORNEY-GENERAL CROW: You answer his question. Never mind Teichmann or what Teichmann wants.

MR. SPRINGER: What part of the work did you perform?

A. Well, I had more or less work in all various estimations, the ammonias I worked on mostly at first and the nitrites later.

Q. How long a time elapsed after the samples were received at the city chemist's office, until you made the chemical analysis?

A. Well, the analysis was commenced frequently almost immediately after the samples were received. A very short time after the samples were received.

Q. Those witnesses who took the samples stated that the samples generally arrived in your office between four and five o'clock in the afternoon?

A. Yes sir.

Q. Were those examined that day or later?

A. Well, the analysis was commenced that day as a rule.

Q. What were your office hours for that purpose?

1137 A. Well, probably the first period of investigation, that is commencing I think January 23, we frequently worked until twelve o'clock at night, and later.

Q. What year?

A. 1900, I believe that was January 23.

Q. When these bottles contaning samples of water were received at the city chemist's office, what was usually the condition as far as the temperature was concerned?

A. As a rule they were cold.

Q. What do you mean?

A. Right cold. I mean they were cold to the touch of the hand.

Q. What temperature about?

A. I could not say. I did not take the temperature.

Q. You did not take the temperature?

A. No sir.

Q. Were they in ice at the time they were received at your office?

A. Well, I think most of the time they were.

Q. How long a time was required for the analysis of each particular sample?

A. Well, certain portions of the analysis were done immediately. That is, those in which changes were likely to take place; and with other portions it was immaterial how long a time elapsed.

1138 Q. What portion did you regard as material to be taken up at once?

A. The nitrites and the ammonia were the most important.

Q. State what you did in regard to the analysis for the purpose of ascertaining the amount of ammonia in the water?

A. Well now, gentlemen, I would like to have my testimony in this respect put off until after Dr. Teichmann testifies. I have absolutely no memorandum—

ATTORNEY-GENERAL CROW: He means the method you followed. He don't mean for you to give any minute analysis of what you did.

A. In estimating the ammonia we used the general and usual ammonia method. The first time we used the modification recommended by Mr. Mason.

Q. Who is he?

A. He is the author of a book on water analysis and is connected with the Rensselaer Polytechnic Institute. And a part of the time the original method of Wankly and Smith was used.

JUDGE SPRINGER: It is understood that these gentlemen will be recalled.

ATTORNEY-GENERAL CROW: Yes sir.

JUDGE SPRINGER: Gentlemen, I would like for the record to show that Attorney-General Hamlin of Illinois may have the privilege of recalling any of these witnesses when the 1139 investigation is resumed, if he desires to ask any questions in behalf of the State of Illinois.

ATTORNEY-GENERAL CROW: Yes, I have no objection to that. I do not suppose he will want to ask any questions.

JUDGE SPRINGER: I do not know that he will, but he might.

THOS. A. BUCKLAND.

1140 EDWIN A. SLUDER,

A witness called on behalf of the complainant, after being duly sworn by the Commissioner, was examined by Mr. Jeffries, and testified as follows:

Q. What is your name?

A. Edwin A. Sluder.

Q. Where do you live?

A. 3707 Page Bl.

Q. How long have you lived in St. Louis?

A. All my life.

Q. I will ask you if you have done any work in the way of collecting samples here in the Missouri river under the direction of Dr. Teichmann, city chemist, city of St. Louis?

A. Yes sir.

Q. State the particular points from which you gathered this water?

A. Above and below Omaha, Nebraska, and above and below St. Joe, above and below Kansas City, Missouri, on the Missouri river, and on the Kaw river, above Kansas City, Kansas.

Q. When you speak of Omaha and Kansas City, you mean in the Missouri river?

A. Yes sir. On the Kaw river, there was one taken right near the Missouri river, just up the Kaw river some distance.

Q. Up the mouth?

A. Yes sir.

1141 Q. What other places?

A. Jefferson City, and near Herman.

Q. In Jefferson City and at Herman?

A. And Herman, Missouri, and St. Charles, Missouri.

Q. When was it you took the samples at Omaha?

A. I have a record of it here, if I can look at that.

Q. You made those things at the time you took the samples?

A. Yes sir.

Q. You can refresh your recollection.

A. November 13, 1901.

Q. How many samples did you take at Omaha?

A. I took two samples, one above the city and one below the city.

Q. Now then, what particular part of the river did you take them in, with reference to the channel of the river?

A. Well, a copy of the tag reads like this: That was on the bottle I shipped to St. Louis. The date, 11/13/01. Time, 5:45 p. m. Location, Bellevue, Nebraska. Nebraska bank current. Temperature of air, 7; temperature of water, 5½. Collector, Ed. A. Sluder. Sample taken in current about 75 feet from Nebraska bank, 1½ miles below Bellevue, Nebraska.

Q. That temperature was Fahrenheit, was it?

A. No sir, that was Centigrade.

Q. Did you make any other collections there than those 1142 two you mentioned?

A. Not at Omaha that first trip. Later on I made some.

Q. When did you go back?

A. November 24, 1901. I was in Omaha and took a sample at the Omaha waterworks.

Q. You took it out of the waterworks?

A. No sir, out of the channel near the waterworks.

Q. Now coming down to St. Joe, when did you take the sample out of the river at St. Joe?

A. On the 14th of November, 1901.

Q. Now state the particular place in the river that you got that sample?

A. Just out from the pumping house about three feet deep, it was taken in the channel; that is above St. Joe.

Q. How far above?

A. By water or by land?

Q. By water?

A. By water it is about 16 or 17 miles. Or two miles and a half by land.

Q. Now how many trips did you make to St. Joe?

A. Two.

Q. When was the second trip, or was that the second trip you gave there?

A. No sir. November 25 was the second trip.

1143 Q. Did you collect water at the same place you did at the first trip?

A. Yes sir.

Q. Now state when you made a collection of the samples at the Kaw river, in the Kaw river.

A. On November 17, 1901.

Q. Now at what particular point on the river did you take that sample?

A. Above Argentine, Kansas, on the Kaw river.

Q. How far is that from the mouth of the river approximately?

A. About four miles, I think.

Q. Now where did you make the collection, what part of the river?

A. In the channel of the river, 3½ feet deep.

Q. How many collections did you make there?

A. One large and five small samples.

Q. Now how many trips did you make?

A. I made two.

Q. Now when was the second trip?

A. November 29, 1901.

Q. Now how many collections did you make then?

A. I made one.

Q. In the same place, was it?

A. Yes sir. One large sample made in the same place, 1144 and five small ones made in the same place.

Q. That is, you made those collections the last trip in the same place in the river, or at the same point in the river, that you made the collections on the first trip?

A. Yes sir, as near as I could get it.

Q. Now then, the Kansas City—when did you make that trip and where did you make collections?

A. In the Missouri below Kansas City.

Q. How far below, do you remember?

A. Ten miles below Kansas City. About ten miles.

Q. What part of the river with reference to the channel?

A. In the channel of the river.

Q. How many collections did you make?

A. One large bottle and five small ones. The small ones were taken across the river, all the way across.

Q. You cross-sectioned the river?

A. Yes sir.

Q. With these small bottles you cross-sectioned the river?

A. Yes sir.

Q. How far apart did you take these samples?

A. I tried to take them in equal distances across the river.

Q. So that you got five of them?

A. Yes sir.

Q. How wide was the river where you took the samples?

A. Nearly half a mile wide.

1145 Q. How far from the shore did you take the first samples, or did you take the samples? The first sample of the cross-section, how far was it from the shore?

A. Well, I tried to divide it up. I would not take it in shallow water where there was no current at all. I got out where the water was running, and I would begin there.

Q. The samples then were taken from the current, running water?

A. Yes sir, running water.

Q. When did you go back there for the second trip?

A. I took them above that on that same trip.

Q. How far above?

A. At the waterworks.

Q. Did you cross-section the river there?

A. Yes sir.

Q. How many samples did you take there?

A. Five small samples and a large one.

Q. Were the small samples taken in the same way?

A. Cross-section samples.

Q. They were cross-section samples and taken in the same manner as this taken ten miles below Kansas City?

A. Yes sir.

Q. How many large samples did you collect?

A. One.

Q. Now then, after that, when did you go back to Kansas City?

1146 A. On the 28th of November, 1901.

Q. Where did you take the sample?

A. I took one large sample and five small samples. Cross-sectioned the river there.

Q. In the cross-sections were the samples taken in the same manner as the cross-sections on the first trip?

A. Yes sir.

Q. How far above or below the city?

A. This one was taken at the waterworks. And then there was one set of samples taken at the waterworks, and one set of samples taken about ten miles below.

Q. Now then, each trip you collected samples, cross-section samples, numbering five of the small bottles and one sample of the larger bottle?

A. Yes sir.

Q. Now then did you go back to Kansas City any more?

A. No sir. That was my second trip. I only made two trips.

Q. Now coming on down the river to Jefferson City, state from what particular place in the river those samples were taken, and when?

A. November 19, 1901, one mile above the waterworks, Jefferson City, Missouri, in the channel six feet deep. The channel was six feet deep. The sample was taken about three.

Q. How many samples did you take there?

1147 A. One large sample only.

Q. Did you go back there any more after that? First I will ask you, when was that sample taken?

A. That was taken on the 19th.

Q. Now then, did you go back there?

A. Yes sir.

Q. When?

A. December 1, 1901.

Q. When did you take the sample then?

A. I took the sample in the same place.

Q. As the previous sample?

A. Yes sir.

Q. Was it a large sample or a small one?

A. A large sample.

Q. That was all the samples you took at Jefferson City?

A. No sir. I took a sample below the city.

Q. Now when did you take that, at the same time?

A. Yes sir, the same dates.

Q. How far below?

A. Five miles below Jefferson City.

Q. Almost to the mouth of the Osage. Do you know where the Osage goes into that?

A. Yes sir.

Q. Was it below or above that?

A. It was above that. I tried to go down the Osage and could not. 1148

Q. Now where did you take those samples, with reference to the channel of the river?

A. In the channel of the river three feet deep. The channel there was about 12 feet deep.

Q. Did you take large or small samples?

A. Large samples only.

Q. How many times did you visit that place and take samples?

A. Twice.

Q. The samples were taken at the same place both times?

A. Yes sir.

Q. And you took only large samples?

A. Yes sir.

Q. Now coming on down the river to Herman.

A. November 20, 1901, was one large sample taken, and one mile above Herman, the south shore, in the channel.

Q Any small samples taken there?

A. No sir.

Q. Now then, where was the next sample taken?

A. On the same day there was one large sample taken about three miles below Herman.

Q. Did you go back there any more after that?

A. Yes sir.

Q. When?

A. On December 1, 1901.

Q. How many samples did you take and where?

1149 A. One mile above Herman, Missouri. One large sample in the channel, on December 1, 1901, about three miles below Herman, one large sample.

Q. Those samples were taken out in the Missouri river?

A. Yes sir, in the Missouri river.

Q. Now were those all the samples you collected in the Missouri river near Herman on that trip, those two trips?

A. Yes sir. I made two trips there.

Q. Now coming on down the river, where were the next samples collected?

A. At St. Charles, Missouri.

Q. State what you did at St. Charles.

A. November 22, 1901, location, one-half mile above St. Charles, Missouri, in the channel. One large sample taken; that was all.

Q. Now there was no other place in the river you collected any samples at all?

A. Yes sir, on the same day, 1½ miles below St. Charles, Missouri, there was one large sample taken.

Q. No small ones?

A. No sir.

Q. Did you go back there?

A. Yes sir, I went back there, December 3, 1901, and took one large sample at a mile and a half below St. Charles, and I took a set of cross-section samples at the same place.

1150 Q. How many trips did you make there?

A. Two.

Q. You cross-sectioned at both trips?

A. No sir, only the last trip. Then I took a set of cross-section samples and one large sample 1½ miles above St. Charles, Missouri.

Q. Now these cross-section samples were all selected from running water, were they, in the channel?

A. Not in the channel, no sir. They were collected in running water. They were not collected where the water was lying stagnant or anything of that sort. Simply where the water was running all the time, if it was right up against the shore and six inches deep it was taken there, to start with, and if it was 40 feet away from the bank it was taken there. I took them in that way.

Q. Now these samples that you took running across the river, cross-sectioning the river, were small samples?

A. Yes sir.

Q. Now those were all the samples you collected from the Missouri river and the Kaw river, that you have just stated?

A. Yes sir.

Q. Who sent you up there?

A. Dr. Teichmann.

Q. Who is Dr. Teichmann?

1151 A. The city chemist of the city of St. Louis.

Q. Who instructed you how to do the work, did he?

A. Yes sir, he gave me instructions how to take the samples.

Q. I will ask you to examine complainant's exhibit 15 and state whether or not this is a model of the machine used by you in collecting these samples?

A. Not on the Missouri river, not that size.

Q. You had a larger size?

A. I had one larger than that, but it worked about the same as that, in taking the bottles, like that.

Q. Take the size of samples known as complainant's exhibit 16.

A. Yes sir, that is the bottle.

Q. And when you spoke of the larger samples, you had reference to bottles of this character and size, did you?

A. Yes sir.

Q. Now when you spoke of the smaller samples, or the small samples, you had reference to bottles of the size contained in complainant's exhibit 15, did you?

A. No sir.

Q. Similar to that?

A. No sir, it is larger. I think it holds about a pint. There was no machine or apparatus to put them in, used to hold them in at all. I had to hold them in my hand.

Q. How far down under the surface would you go?

1152 A. Some were taken as deep as I could reach with my arm, some of them, and the others were taken on the surface.

Q. Right on top of the water?

A. Yes sir. Let the surface water run into it.

Q. Now the larger samples were taken three feet under the surface of the water?

A. About three feet under the surface of the water.

Q. And in the channel?

A. Yes sir.

Q. Now after those samples were collected by you, what did you do with them?

A. They were all sealed and cloth put over them and tied with a string and sealed, packed in ice and shipped to the city chemist's of St. Louis.

Q. Now how soon after you collected the samples before you shipped them?

A. Why, the first train that I could ship them on.

Q. How soon after they were collected before you packed them?

A. That would depend upon how far I had to travel to get back to the hotel.

Q. What I want to know is, you did it at once, did you?

A. I did it immediately, as soon as I could get where I could.

1153 Q. When you shipped them you directed them to whom?

A. The city chemist's, St. Louis, Missouri.

Q. Did you ship or express small bottles the same way?

A. Yes sir.

Q. From the same place?

A. Yes sir.

Q. Now how did you seal those, or wrap them?

A. There was a piece of cloth put over them and tied.

Q. Any tin foil put on them?

A. No sir, not over the cross-section samples.

Q. Now what you said with reference to sealing or tying these bottles applies to all the samples you collected, does it?

A. On the Missouri river, yes sir.

Q. And you shipped them all, or expressed them all to the same place?

A. Yes sir.

Q. Now in addition to this work, state whether or not you did any work in the way of collecting samples, and if so where and when?

A. I collected samples in the Mississippi river above Alton.

Q. When?

A. I think it was begun in September, 1901.

Q. How long a time?

A. And lasted until about the first week of November, 1901.

Q. Now how far up the Mississippi river from Alton did 1154 you collect those samples?

A. About a mile and a half, I think or two miles.

Q. What part of the river did you take them from?

A. From the channel.

Q. How deep under the surface of the water did you collect?

A. About three feet deep.

Q. Did you use the machine to collect this?

A. Yes, all except the cross-section samples I took there.

Q. Did you use or take the cross-section samples daily?

A. No sir, only part of the time, whenever I had instructions to take them.

Q. Now you collected daily samples, didn't you, of a particular kind?

A. Yes sir.

Q. What were those?

A. That was the large gallon bottles, collected two of them. I collected one small sample like you showed me the apparatus and bottle of.

Q. Well, you collected one small sample in the bottle similar to the bottle contained in complainant's exhibit 15, did you?

A. Yes sir.

Q. And used the machine of the same model?

A. Yes sir.

1155 Q. Now what did you do after you pulled the samples out of the water?

A. I saw they were thoroughly corked, and then there was a piece of tin foil that had been dipped in a solution of carbolic acid that was put around the stopper, and a piece of cloth put over that and tied. Then they were sealed, packed in ice and brought down to St. Louis.

Q. And where delivered?

A. To the city chemist.

Q. When you put the machine in the water you uncorked the bottle and corked it before you drew it out, did you?

A. Yes sir.

Q. What did you do with the larger samples, the same thing?

A. No sir, the larger samples we didn't use any tinfoil.

Q. Did you pack them in ice?

A. Packed them in ice and brought them down to the city chemist's office here in the city.

Q. How often did you take those samples?

A. Daily.

Q. You made the same disposition of them every day?

A. Yes sir.

Q. Sundays included?

A. Sundays included.

Q. You say you worked under instructions?

A. Yes sir.

1156 Q. From whom?

A. Dr. Teichmann.

CROSS-EXAMINATION, By Judge Springer.

Q. You spoke about taking samples at cross-sections below Kansas City, and some other places; what do you mean by that?

A. There were five samples that were taken across the river. There was surface water in four of them, and in the channel it was taken below the surface. A small bottles that held about a pint. I would go straight across the river.

Q. Did you take those in the Missouri river, did you take those cross-section samples?

A. Two places on the first trip, that was above and below Kansas City. And the second trip I took them at Omaha, above and below Omaha; above and below St. Joe, above and below Kansas City; and then at St. Charles, Missouri, I took them above and below St. Charles.

Q. You stated the last time you took them in St. Charles you didn't take cross-sections from above or below?

A. The last time I did take samples there.

Q. When was it you didn't take them?

A. On the first trip.

Q. Why didn't you take them?

1157 A. I didn't have instructions to.

Q. How long after you took these samples in the small bottles was it, from the time you took them up until the time they reached the city chemist's office in St. Louis?

A. From where?

Q. Beginning with Omaha.

A. I do not know just how long it took the express company to get them there or what time they were delivered.

Q. You put them in the express office the day you took them?

A. Yes sir.

Q. How many hours after taking them before the train would leave, carrying them to St. Louis?

A. From the time I took them until they were on their way here, on the train, do you mean?

Q. Yes.

A. One was taken at 10:30 in the morning and the other at 4:30 in the afternoon the same day. And I think the train left between seven and eight that evening.

Q. They would reach St. Louis the next day or the next morning sometime?

A. I think they arrived here sometime the next day.

Q. How were those small samples packed, do you know?

A. Thoroughly packed in ice.

Q. Were those small samples intended for bacteriological examinations or chemical?

1158 A. I could not say. I was not told.

RE-DIRECT EXAMINATION, By Mr. Jeffries.

Q. Where did you get these bottles you collected the samples in?

A. For where?

Q. For the various places, where did you get the bottles?

A. Some I took with me from the city chemist's office and others were shipped to me from the city chemist's office.

ATTORNEY-GENERAL CROW: Now I would like to have an understanding with you, Judge, and that is if we want to we can make this time up at nights. I do not expect we will need it.

JUDGE SPRINGER: That will be all right.

ED. A. SLUDER.

Whereupon an adjournment was taken until ten o'clock Monday morning, March 9, 1903, at the Southern Hotel.

1159 Southern Hotel, St. Louis, Mo. 10 a. m., March 9, 1903.

Present, Frank S. Bright, Esq., Commissioner of the Supreme Court of the United States, Attorney-General Crow, S. B. Jeffries, Esq., William F. Woerner, Esq., representing the complainant; Attorney-General Hamlin, W. C. Johns, Esq., representing defendant, State of Illinois; Judge William M. Springer, representing defendant Sanitary District of Chicago.

1160 Session resumed at the Southern Hotel, St. Louis, Mo., pursuant to the following order of the Supreme Court of the United States

On the consideration of the stipulation of counsel as to the taking of testimony in this case, filed and submitted herein on March 2nd, 1903.

It is now here ordered by the Court that in addition to the testimony heretofore taken herein the parties may resume the taking of testimony on March 9th, 1903, and proceed with all convenient speed, so that all the testimony shall be filed in the office of the clerk of this Court on or before Monday, October 12th, next.

March 3rd, 1903.

1161 THEODORE G. RUFF, called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION, by Mr. Woerner.

Q. Your name is Theodore G. Ruff?

A. Yes, sir.

Q. What is your business, Mr. Ruff?

A. I am porter and grain sampler for the John Wall Commission Company, St. Louis.

Q. What was it prior to that time?

A. Up to that time I was travelling for a wholesale grocery house, Wolffing & Co.

Q. Wholesale grocers?

A. Yes, sir.

Q. Were you in the employ of the City of St. Louis at any time?

A. Yes, sir.

Q. When?

A. I was employed by the City of St. Louis under Mr. Holmes—I had an appointment as clerk of the settling basins.

Q. Clerk for the settling basins?

A. Yes, sir.

Q. Did you have anything to do with the collection of water samples?

A. Yes, sir.

1162 Q. State when?

A. I think it was on the 6th of March.

Q. Of what year?

A. 1900, that Mr. Fladd sent for me, and Mr. Adkins had sent me up to Grafton to sample water in the Illinois and Mississippi Rivers.

Q. Mr. Fladd is the Water Commissioner and Mr. Adkins is his assistant?

A. Yes, sir.

Q. What year was this, are you sure?

A. 1900.

Q. Now, are you sure?

A. Pretty positive.

Q. About the year I mean?

A. Three years ago.

Q. Do you mean two years ago last fall?

A. Now, you have got me right there on that date.

Q. Three years ago was it or two?

A. Three years ago.

Q. Well, then it was 1900, wasn't it?

A. I followed Mr. Wenzel, I think it is.

Q. Well, you are sure it was three years ago?

A. About three years ago.

Q. Now, Mr. Ruff, state what you did?

A. I used to leave at a certain time every day and travel
1163 up to Wilson's Ferry and draw the water from the Illinois channel and come back and go up the Mississippi about three miles north of Grafton and draw about two bottles, two one gallon bottles, and two small bottles, about 3½ feet under the water. We corked and uncorked under the water and brought them back to the hotel and sealed them and put them into a box, packed in ice, and then got up the fish from the fishermen which he had caught, live fish, and also put them back in this package, sealed this package and sent it to the Health Commissioner of the City of St. Louis.

Q. During what period of time did you do that?

A. From the 6th of March to the 1st of October in the same year.

Q. And how often during that time, every day?

A. Every day, Sundays, holidays, rain and shine.

Q. You say you sent them to the Health Commissioner?

A. Yes, sir, to the city chemist, Mr. Teichmann, is what we addressed them to.

Q. Now, Mr. Ruff, just state at what points you took this water?

A. In the Illinois River at Wilson's Ferry and the Mississippi River.

Q. Now, wait a minute. Just state where Wilson's Ferry is, on the shore of the Illinois?

A. Three miles above Grafton.

1164 Q. And at what other points?

A. And Mississippi River 3 miles above Grafton.

Q. Any other points?

A. No, sir.

Q. Well, what part of the river did you collect them from?

A. From the channel.

Q. How far from the shore and which shore?

A. From the shore—in those rivers, why it is generally almost the center of the river.

CROSS-EXAMINATION, by Judge Springer.

Q. You were engaged in collecting samples of the water in the rivers at these two places you state?

A. Yes, sir.

Q. What did you say you did with these samples?

A. I had a sort of a driver, what you might call it, an instrument which held the bottle, with a wire which would uncork the bottle and cork it under water, and after I had them filled, why I would bring them back to Grafton, to the hotel and seal these bottles and pack them in the box and ship them to the city chemist.

Q. How did you ship them?

A. Shipped them in a wooden case packed in excelsior and ice.

1165 Q. In what way I mean, by express?

A. By express.

Q. By express?

A. Yes, sir.

Q. What time in the morning would you collect these samples?

A. That would be about two o'clock in the afternoon, just before train time.

Q. Just before train time?

A. Yes, sir, just so I could make the trip before train time.

Q. What time did the train leave Grafton?

A. Five-thirty.

Q. And what time would they be due in St. Louis according to that?

A. I couldn't tell you.

Q. You didn't know anything about that after they left you?

A. No, sir, not after they left me.

Q. Did you pack them in ice?

A. Yes, sir.

Q. Were you acting under instructions from any one, and if so, from whom?

A. From Mr. Teichmann, city chemist.

Q. Did you have written or verbal instructions?

1166 A. Written instructions.

Q. Did you follow those instructions?

A. Yes, sir.

Q. Strictly?

A. Yes, sir.

JUDGE SPRINGER: That is all.

THE COMMISSIONER: Did you give the stenographers your address? You know you will have to sign your evidence.

THE WITNESS: 1110 Mallinkrodt street. You can catch my address at the John Wall Commission Company, that is on Main and Market. THEO. G. RUFF.

1167 ED. BOCHERT, called as a witness on behalf of the complainant, being first duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION, by Mr. Jeffries.

Q. What is your name?

A. Ed Bochert.

Q. Where do you live, Mr. Bochert?

A. 2514 North Market.

Q. St. Louis, Mo.?

A. St. Louis, Mo.

Q. State whether or not you ever got any samples of water for the city chemist's office of the City of St. Louis, Mo.?

A. I didn't gather any samples. I received the samples—I drove the wagon—I received the samples at the Chain of Rocks, got them from the collectors that were up there getting the samples and delivered them to the city chemist, and from the city chemist—

Q. You delivered them to the city chemist, where?

A. City chemist.

Q. In the City of St. Louis?

A. City of St. Louis.

Q. At his office?

A. At his office.

1168 Q. On Market street?

A. On Market—12th and Market.

Q. Now, when was that, that you did this work?

A. That was in 1900.

Q. How long did you work at it?

A. I don't exactly remember how long. It was about eight or nine months. Exactly I couldn't say how long.

Q. Do you remember about the time that you commenced?

A. It was in November, I think it was.

Q. You commenced in November 1900?

A. Yes, sir.

Q. And you continued then in that work for eight or nine months?

A. Yes, sir.

Q. You don't know exactly when you quit?

A. It was some time in October when they done away with it, or that it was all off.

Q. Well, that would be over a year. Was there any time between then, the time that you commenced and the time you quit, that you did not work?

A. No. I don't remember how long I hauled, but I know I did haul about that time.

Q. Where were you stationed?

1169 A. I was stationed at the city chemist's office, 12th and Market.

Q. Who brought those bottles to you, those samples?

A. There was a collector there by the name of Mr. Hart, Mr. Toohey, and after that there was a collector there by the name of Mr. Werner. That is at the Chain of Rocks, getting the samples.

Q. Now, then, what did you do with reference to their work?

A. Well, all I done was receive the samples from them and put them in the wagon and haul them down to the chemist's office.

Q. You hauled them down, did you?

A. I hauled them down to the chemist.

Q. What kind of bottles were they?

A. They were gallon glass bottles.

Q. Any small bottles?

A. And small bottles.

Q. How small were the small bottles?

A. They were about 4 or 8 ounce bottles, I don't remember now.

Q. What was in them, do you know?

A. I couldn't say what was in them.

Q. What did it look like?

A. It looked like water.

1170 Q. How were they fixed?

A. They were sealed and packed and put in wooden boxes—tin boxes—and ice around them.

Q. You brought them from the Chain of Rocks down to the city chemist's office?

A. Yes, sir.

Q. What did you do with them there?

A. Brought them upstairs and laid them all out on the table.

Q. What was done with them after that?

A. They would take one sample of each for themselves. Whatever they done with it I don't know. And the other one they would give me one sample back to deliver to the Washington University and to the St. Louis Medical College.

Q. That is, one sample of each?

A. Yes, sir.

Q. The small or large bottles, or both?

A. Both, large and small.

Q. Did you receive any of the samples in the express office?

A. Yes, sir.

Q. Where did they come from?

A. They come from Grafton, Peoria, Joliet, Lockport.

Q. Now, where did you receive those?

A. Received those some times from the Adams Express, sometimes from the Pacific.

1171 Q. How were they packed?

A. Same way.

Q. Packed in ice?

A. All packed in ice.

Q. Tagged and sealed?

A. Tagged and sealed.

Q. What did you do with them when you received them?

A. I brought them down the same as I did those Chain of Rock samples.

Q. They had the same disposition?

A. Same thing, and I shipped the empty cases out every morning.

Q. What was in those empty cases?

A. There was nothing in them but the empty bottles tha. I shipped away.

Q. Where did they come from?

A. From the city chemist's office. They had them all washed out, had the bottles all laying in a rack there washed out.

Q. That was the large bottles?

A. Large and small, both.

Q. Do you know whether the small ones were sterilized or not?

A. I couldn't say anything about that.

Q. They were simply put there for you to get?

1172 A. They were put there for me to get.

Q. And you took them?

A. I took them and put them in the boxes and shipped them to the different collectors.

CROSS-EXAMINATION, by Judge Springer.

Q. What time did you say was it that you obtained these bottles from the express office in this city?

A. Well, sometimes it was in the morning and sometimes in the afternoon, just the way the train was, if it was delayed, if the train was delayed, I got them in the afternoon, if it was not delayed I got them in the morning.

Q. What time in the afternoon?

A. Well, about two o'clock--two or three o'clock.

Q. Those that came from Grafton and above there, what time did those arrive?

A. They came in the morning.

Q. You got those the next morning after they were taken?

A. Yes, sir.

Q. What is your address?

A. 2514 North Market.

EDW. BOCHERT.

1173 ANTON KREH, called as a witness on behalf of the complainant, being first duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION, by Mr. Jeffries.

Q. What is your name?

A. Anton Kreh.

Q. Where do you live, Mr. Kreh?

A. I live at 2827 S. Jefferson avenue.

Q. St. Louis, Mo.?

A. St. Louis, Mo.

Q. How long have you lived in St. Louis?

A. I have lived all my life in St. Louis.

Q. State whether or not you ever got any water for the city chemist's office in the City of St. Louis?

A. Yes, sir, I did.

Q. Where did you get this water?

A. I got some at the Chain of Rocks and some at Alton.

Q. Now, when was this?

A. I started the second Monday in October.

Q. What year?

A. 1901. And I left the Department the first of December, 1901.

1174 Q. Now, you were working continuously at this work? Yes, sir.

Q. From the time you commenced until you left?

A. Yes, sir.

Q. State how often you gathered the samples of water?

A. Every day, Sunday included.

Q. Now, taking the work at the Chain of Rocks, state the particular place as near as you can in the river that the samples were gathered?

A. Well, we used to take a boat out every morning and go up, I think almost a mile, and we would start on the Missouri side about, say 30 feet, between 50 and 75 feet; we would gather there two large bottles and one small one. Then we would pull out to the center and get one large one, then we would go to the Illionis side almost between 200 and 300 feet and gather two large ones and one small one. Then we would pull down to the Intake tower and gather two large ones—one large and one small.

Q. That is at the Intake tower?

A. At the Intake tower.

Q. Do you remember the stage of the river at this time?

A. Well, no, I don't remember.

Q. Was it low or high?

A. Well, it was kind of low.

1175 Q. Low?

A. Low.

Q. In gathering these samples, on either shore, or on either side of the river, state whether or not you got them from the channel of the river or from the running water?

A. Well, we gathered them from the running water—no from the channel, in the channel as it was coming down stream.

Q. From the channel?

A. Channel, yes.

Q. Now, state whether or not you gathered any samples from the reservoir?

A. Yes, I gathered one bottle and one small bottle at the outlet at the reservoir.

Q. One large bottle?

A. One large bottle and one small bottle.

Q. At the outlet?

A. At the outlet.

Q. Now, did you get any from the well?

A. From the well?

Q. Yes?

A. At the outlet, right there.

Q. At the outlet?

A. Yes, sir, at the well.

Q. Just before it goes into the reservoir or basin?

1176 A. No, after it goes out.

Q. As it comes out of the reservoir?

A. As it comes out of the reservoir, and goes to the city.

Q. Now, how often did you gather these samples?

A. Up at the Chain of Rocks I gathered them for about two weeks.

Q. Yes, but how often; every day?

A. Every day.

Q. What time of the day generally?

A. Well, at the Chain of Rocks we would go out about eight o'clock in the morning.

Q. Now, what kind of an instrument did you use to gather these samples?

A. Well, we used to have an instrument that held the bottle at the neck and a stand underneath it held it tight, and then a spring held to the cork and as we would lower it about three feet under the water we would raise up the cork, and as soon as we saw it was full, drop it down, shut it down tight and bring the bottle up immediately and tag it.

Q. So you opened and closed the bottle under the water?

A. Under the water.

Q. About how far?

A. Well, about three feet under the water.

Q. The full length of the instrument?

1177 A. Full length of the instrument.

Q. Now, you brought those bottles up—what did you say you did?

A. We put a tag on where it was taken from; then we would take the bottles and bring them over to the little office we had there and seal them and pack them into boxes, and put ice in between them, and pack them and ship them on the wagon to St. Louis.

Q. Now, then, what did you put on the tag?

A. We put on the tags the Missouri side, center. Illinois side—

Q. It depended on the sample?

A. It depended on the sample.

Q. In other words, you put the place where the sample was collected?

A. Yes, sir.

Q. On the tag?

A. Yes, sir; took the temperature of the water.

Q. Did you put that on?

A. Yes, sir, and the air temperature; we would put that all on the tag.

Q. Where did you get the thermometers that you used?

A. Mr. Teichmann gave us the thermometer.

1178 Q. Who is Mr. Teichmann?

A. City chemist.

Q. Of the City of St. Louis?

A. Of the City of St. Louis.

Q. Now state whether or not you wrapped anything around the smaller bottles?

A. Yes, sir; I wrapped some tinfoil.

Q. Then what did you wrap around them?

A. Then I tied the rag around it and tied it up tight, so that nothing could be destroyed while it was going—sealed the string.

Q. Sealed the string?

A. Yes, sir.

Q. Where did you get the bottles used in collecting these samples?

A. At the city chemist's office, between Eleventh and Twelfth on Market.

Q. And you turned them over to the water carriers?

A. Yes, sir.

Q. That brought them down?

A. Yes, sir.

Q. What time would he get up there?

A. He would get up there about half past ten, ten o'clock and so on—well, sometimes half past nine.

Q. You would have them ready for him when he got there?

1179 A. I would have them ready for him when he got there; I stayed there with the box until he came, and put them on his wagon and let him go ahead.

Q. Now, then, while gathering at Alton, state the particular places in the river that you gathered the samples of water at Alton?

A. Well, I would go to Alton every morning; get up there about nine o'clock and would take a boat and go up about a mile above. I would go up to the waterworks and at the dike there, and pull up above the upper portion of the dike and there about 100 feet from the Illinois side I would collect a large bottle and a small one underneath the water, and would do the same thing about one hundred feet on the Missouri side, a large and a small one.

Q. Now, you made the same disposition of these bottles that you did with those others at the Chain of Rocks?

A. Yes, I brought them down myself; I didn't ship them.

Q. And you wrapped them and sealed and tagged them?

A. Yes, sir, wrapped them and sealed and tagged them.

Q. And put on the tag what?

A. The temperature of the air and where the water was collected.

Q. And the name of the collector?

1180 A. And the name of the collector.

Q. That would be your own name?

A. That would be my own name.

Q. And you made the same disposition of those that you did with the others?

A. Yes, sir, I also used to get five bottles, skimming the top of the river.

Q. At Alton?

A. Yes, sir, at Alton; go right straight across the river in one straight line.

Q. And you made the same disposition of those?

A. The same disposition.

CROSS-EXAMINATION, by Judge Springer.

Q. You stated that you took some samples on the Illinois shore above the St. Louis Intake. Will you describe that place as near as you can, and the distances from the Illinois shore?

A. Well, of course I couldn't get exactly to the feet of it. My idea would be about 100 feet.

Q. From the Illinois shore?

1181 A. Yes, sir, between 100 and 75 feet.

Q. How far would that be above a line drawn across the river at right angles to the current, through the Intake?

A. Well, that of course—I couldn't get down to the exact number of that.

Q. Your best judgment, of course?

A. Well, I would say it would be about four hundred, five hundred feet, something like that—six hundred.

Q. Six hundred feet?

A. Yes, sir.

Q. Above a line drawn through the Intake from shore to shore?

A. From shore to shore, at the Intake tower; I would take it right in the center.

Q. I am speaking of that taken on the Illinois shore?

A. Well, that would be about six or seven hundred feet—I couldn't tell exactly—from the shore.

Q. I thought I understood you to say you went up the river about a mile?

A. I did go up the river about a mile to get the first bottles on the Missouri side and on the Illinois side.

Q. I am speaking about the Illinois side. How far was that above the intake?

A. That was about a mile.

Q. Above?

1182 A. Above.

Q. From the appearance there could you tell whether that water had come from the Illinois River, or the Mississippi River?

A. Yes, sir, because the Missouri River was very muddy, and the Illinois water was clear.

Q. The Illinois water was clear?

A. Yes, sir.

Q. Well, was this apparently Illinois water that you took over on that side?

A. Yes, sir, it was Illinois water we were taking.

Q. And you could see the difference, you state, by the appearance of the water?

A. Yes, you could see the difference.

Q. Did you notice that difference where you took these samples at Alton?

A. Well, Alton, it was the same there; it was both clear.

Q. How?

A. They were both clear there because it was just coming all the way from the Mississippi, all the way down, you know.

ANTON KREH.

1183 FRED B. WENZEL, called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, testified as follows:

DIRECT-EXAMINATION, by Mr. Jeffries.

Q. What is your name?

A. Fred B. Wenzel.

Q. Where do you live, Mr. Wenzel?

A. 4653 Michigan avenue.

Q. St. Louis, Missouri?

A. St. Louis, yes, sir.

Q. How long have you lived in St. Louis?

A. Twenty-seven years.

Q. What were you doing in February, 1900?

A. Working for the St. Louis Water Department.

Q. What particular work were you engaged in?

A. I was at that time collecting samples.

Q. Where—samples of what?

A. Water, in the Illinois and Mississippi Rivers.

Q. Where?

A. I was stationed at Grafton.

Q. Now, then, what time did you gather these samples?

1184 A. I would gather them about nine o'clock in the morning; I would start at nine o'clock and I would finish about—

Q. Now, during what time of the year—the date of your employment in this work?

A. It was either on the 5th or 6th of January, 1900, that I started, and I continued until the last day of March, or last day of February, 1900, and came back to the city then and stayed there.

Q. You discontinued gathering water?

A. I discontinued gathering water, yes, sir.

Q. Now, then, state the particular place in the river that you gathered these samples at Grafton; that is, in the Mississippi River?

A. The Mississippi River—why, I guess I had better tell you the trip I would take every morning, the regular route—

Q. Yes?

A. I would start away from the hotel about nine o'clock in the morning, and during the weather that would allow us taking a skiff or boat, we would pull up the Illinois River in the neighborhood of say three or four miles to a place there they called the Ferry; we would pull above the ferry about half a mile, and we would take a sample—the first sample.

Q. What ferry is that, do you know? Wheeler's Ferry?

1185 A. Wheeler's Ferry. We would take two large bottles and a small bottle.

Q. Well, can you—now how did you take these samples?

A. We was furnished a machine by the city chemist's office.

Q. Now, how deep under the surface of the water would you take them?

A. We would leave the machines down about three feet, or the instrument.

Q. Tell what you did when you got this sample, what did you do with the machine?

A. The machine was fixed so that we could place a bottle. It had a stand there, there was an attachment, or wire tied to the cork. Just as soon as we got the bottle down into the water we would raise up the cork—pull up the cork—

Q. In other words, you opened the bottle?

A. Opened the bottle underneath the water.

Q. Now, then, how would you close it?

A. We would close it underneath the water, just as soon as we seen we had it full, we could just about guess after you had taken a few of those samples, a man could just about tell the time that the bottle would be filled.

Q. What did you do with it after you took the samples; after you drew them out of the river?

A. Drew them up to put them in the boat, put a tag on
1186 them and kept the bottles separate so we would know
where we took the sample.

Q. What did you do with the bottle?

A. Put it in the boat; put it in a box we had—we had tin boxes with excelsior and we packed those two large bottles in there.

Q. Did you wrap them with anything?

A. Not at that time. We couldn't wrap—well, sometimes we wrapped them when the water would permit, but sometimes it was so cold that you couldn't—at that time it was cold—so cold that your fingers would get numb on you.

Q. What did you finally do with them in the way of wrapping and packing them?

A. Took them down to the hotel then, just as soon as I could, all the samples together, and put cloth around the large bottles, tied them and then sealed the strings, the ends.

Q. What did you do with the small bottles?

A. I put tinfoil around the small bottles.

Q. And then the tag?

A. And then the tag, yes sir.

Q. And then sealed them?

A. And then sealed them.

1187 Q. What did you put on the tag?

A. We put on the tag the date, place,—the location and—

Q. These places where the sample was taken?

A. These places where the sample was taken, yes sir, and the temperature of the air and my name.

Q. Temperature of what?

A. Temperature of the water.

Q. And the temperature of the air?

A. And the temperature of the air.

Q. And your name?

A. And my name.

Q. Then what did you do with them?

A. We would see that they were in first class shape for shipment, pack the boxes and lock them. These tin boxes, we would only take them with us after we got the samples. After we had the bottles in the tin boxes then we would have another wooden box for these tin boxes. Set these tin boxes in the wooden box and secure them and deliver them to the express company and ship them down to St. Louis to the City Chemist's office.

Q. Now, then what particular place in the Mississippi river did you get samples?

A. We would pull up about three miles or four miles above
Grafton, before where the Mississippi river and Illinois
1188 river come together, and I would get a sample there, and
I would do the same thing I done at Illinois.

Q. In other words, it would be three or four miles above the mouth of the Illinois river?

A. Exactly, it would be about 3 or 4 miles above the mouth of the river.

Q. What kind of samples did you get there?

A. I got one large and two small.

Q. And you made the same disposition of those?

A. Made the same disposition of those.

Q. And you got them in the same way?

A. I did, sir.

Q. How often did you get the samples?

A. Once a day.

Q. Sunday included?

A. Sunday included, yes.

CROSS EXAMINATION,

By Judge Springer.

Q. At what time in the day did you ship these samples to St. Louis?

A. I would deliver them to the express company in the neighborhood of 3 o'clock every day.

Q. What time would they leave Grafton?

1189 A. They would leave there about 5:30.

Q. That day?

A. That day.

FRED B. WENZEL.

1190

WILLIAM TOOHEY,

called as a witness on behalf of the complainant, being first duly sworn by the Commissioner, testtified as follows:

DIRECT EXAMINATION,

By Mr. Jeffries.

Q. What is your name?

A. William Toohey.

Q. Where do you live, Mr. Toohey?

A. 2323 Olive St., St. Louis, Mo.

Q. How long have you lived in St. Louis?

A. Nine years.

Q. State whether or not you ever got any samples at the Chain of Rocks.

A. I did for about five months in 1900.

Q. Who did you gather them for?

A. The City Chemist.

Q. Of the City of St. Louis?

A. Yes sir.

Q. When did you say you gathered these samples?

A. I am not positive, it was in the first of June, I believe until the 15th of October.

Q. What year?

1191 A. 1900.

Q. Now, what was the character of samples of water that you gathered with reference to quantity?

A. Well, I had every morning—well not every morning, I might miss one or two mornings, but every morning that I did go out, I went up about a mile on the Missouri side and took two samples there of the large bottles and one small one. I crossed the river then as near that point as we could possibly get opposite across the river going up and got nearest opposite that point as we could possibly get and took the same number of samples there. Then dropped down to the Intake tower and took the same number there. Then go in and take two samples out of the basin and one at what thy call the screen house--I don t know just exactly what it is, they call it the screen house.

Q. You took one sample there?

A. Two samples there.

Q. One each?

A. One each.

Q. What did you say the quantity of the large bottle was?

A. About a gallon.

Q. And the small one?

1192 A. Well, about four or six ounce bottles, about that, along there.

Q. Give the means that you used in selecting these samples, the instrument, what kind of an instrument?

A. They had an instrument made out of gas pipe It had a spring on it. They would set the bottle in it and fasten it and put the cork into this little spring and close it. Put that down in the water where they had it marked on the machine, 3 ft., and after they got it down that far they would pull the cork out and as quick as the bubbles stopped coming up pushed that back down again.

Q. Why did you wait for the bubbles to stop?

A. Well, that was natural that it was filled then?

Q. When you brought it up what did you do?

A. We took and put heavy pieces of linen, I guess it was, took and wrapped that around it and tagged it, put a tag on it—

Q. You put the tag on it?

A. I put the tag on.

Q. What did you put on the tag?

A. The time it was taken.

Q. What else?

1193 A. Temperature of the water and the temperature of the air.

Q. Anything else, did you put your name on?

A. Yes, I never put my name on. Mr. Hart was with me; he always wrote the tag.

Q. Mr. Hart was with you?

A. Yes, he always wrote the tag. I would tie them on.

Q. You say you gathered them with the exception of one or two days, every day?

A. Sundays and all.

Q. Were samples gathered those days that you were not there?

A. Yes sir.

Q. And they were turned over to Mr. Hart?

A. Two or three times I would miss the train and I could not get out there in time. I always tried to get the water at a certain time in the morning.

Q. How long would it take you to get them down to the City Chemist's office?

A. Well, we would take the water on the road and carry them down there, the driver would be there at half past nine, and we would have everything ready, and he would rest his team a few minutes and load up the wagon and he would start right back in again. When he didn't bring the water in on the wagon we would ship it in on the train in the afternoon.

1194 Q. What did you put around the small bottles?

A. We tied them up and put tinfoil around them and packed them in in tin boxes with ice and then packed the tin boxes in the wooden box.

Q. And you tagged those the same way?

A. They were all tagged, every bottle.

CROSS-EXAMINATION

By Judge Springer.

Q. When did you say you took these samples and at what places?

A. On the Missouri side; on the Illinois side; at the Intake tower; at the settling basin and what they they call the screen house. That is the only name I ever heard given it. It is where all the water goes into the water works.

Q. What period of time did you cover when you were taking these samples?

A. From June 1st about until October 15th.

Q. 1900?

A. 1900, yes, sir.

Q. What was the stage of the river at that time, of the water in the river?

1195 A. Well, the stage in which way, rough?

Q. High water or low water?

A. Well, no not very high.

Q. Ordinary stage?

A. Ordinary stage, yes.

Q. How far from the Illinois shore was it that you took the sample to which you have referred as having been taken on the Illinois side of the river?

A. How far from the shore we would take the sample?

Q. Yes?

A. Well, I never measured, but I would naturally think we never went any closer than 20 or 30 ft.

Q. Never went closer than 20 or 30 ft.

A. No sir.

Q. Did you observe the appearance of the water at that point as compared with the water on this side of the river, on the Missouri side?

A. Yes, sir, naturally.

Q. Well, could you tell whether that water had come from the Illinois river or from the Missouri river?

No, I couldn't.

1196 Q. Was there any difference in color or appearance?

A. Yes sir.

Q. What was it?

A. The water that we got on this side was muddy and dirty looking and the water on the Illinois side was clear looking.

WILLIAM TOOHEY.

1197

DR. AMAND NICHOLAS RAVOLD

resumed the stand for further direct examination by Attorney General Crow, and testified as follows:

Q. Do you remember the last question, Dr. that was asked you?

A. No, sir.

Q. Wasn't it about Lausen?

A. No, I think it was about Plymouth. We were through with Lausen and we had begun with Plymouth, Pa.

Q. Well, now in the first place I will ask you if you are familiar with the history of that epidemic at Plymouth, Pa.?

A. I am familiar with L. H. Taylor's report to the City Board of Health of Plymouth, Pa. I never was in Plymouth.

Q. Well, have you investigated that epidemic as a bacteriologist and as a physician also?

A. More as a hygienist. I was looking over the classic cases in literature epidemics of typhoid fever caused by dejecta from a typhoid fever patient getting into the water supply.

Q. Well, you have investigated that epidemic then, from a sanitary standpoint and from the standpoint of a hygienist, and from the standpoint of a bacteriologist?

1198 A. Yes sir.

Q. Now, I will ask you to state if you know, as a bacteriologist and as a hygienist, what is assigned as the origin of that epidemic?

A. Why, it seems from the report—

ATTORNEY GENERAL HAMLIN: Doctor, as I understand it, you get this from a report.

A. I got it from a report, yes sir.

ATTORNEY GENERAL HAMLIN: That is objected to as not being relative and proper evidence in support of this bill.

ATTORNEY GENERAL CROW: Well, of course that is coming, that evidence, we can put it in the record.

Q. All right, Doctor, go ahead.

A. Plymouth is a small town in Pennsylvania on the Susquehanna River. It has two sources of water supply. Water is pumped from the Susquehanna river in the winter time, but not in the summer time; during the spring and summer time water is taken from a reservoir system that is situated in the hills above the town.

There are four reservoirs, one above the other. The lowest reservoir, which is the distributing reservoir, holds 300,000 gallons, the second one above holds 1,700,000 gallons, the third, 3,000,000 gallons and the fourth 5,000,000 gallons.

1199 In 1885 a typhoid fever epidemic broke out in this town

of some 8000 inhabitants, the first case appearing on April 9, 1885, and in a very short time there occurred in this town, 1104 cases of typhoid fever with 114 deaths, a death rate of 10.3 per cent. Dr. Taylor investigated the epidemic and discovered this fact, that a man living above the reservoir on the hill had visited Philadelphia in December and no doubt there contracted typhoid fever. He came home and was sick in January with diarrhea, fever and other symptoms of typhoid fever and was sick for quite a while. His dejecta urine and feces were thrown out upon the side of the mountain towards the reservoirs. Here in the ice, but exposed to the sun, it remained frozen until March. Early in March when the spring rains began and the thawing of the ice on the mountains occurred, the water ran down, containing the feces, into the reservoir, and when the superintendent of the reservoir found the lowest reservoir full enough to permit him to turn the water into the water supply system of the town, the pumping was stopped from the Susquehanna river and this water supplied. Within an incubation period of from two to three weeks thereafter, April 9th the first case of typhoid appeared, and the epidemic followed. The amount of water in the reservoir was probably about 5,000,000 gallons and
1200 was infected by the discharges of one person.

Q. What was the population of that town?

A. 8000.

Q. How many cases were there?

A. 1104.

Q. How many deaths?

A. 114.

Q. Have you ever been to Hamburg, Germany?

A. Yes sir.

Q. Do you know whether or not they have a water filter there?

A. Yes sir.

Q. For their city water supply?

A. Yes sir.

Q. What is that water filter?

A. The water is pumped from the river Elbe, the Norder Elbe.

Q. The what?

A. The North Elbe. And first it is carried into a series—

or rather two sedimentation tanks, very large ones. I think each tank is about 1000 feet long by 300 or 400 feet wide. There
are two of these tanks, these sedimentation tanks or res-
1201 ervoirs and together with the filters are on an island in
the river. In the reservoirs the water is allowed to settle from 24 to 36 hours. It is then carried across a series of sand filters. These sand filters probably—they are of different size and forms—

Q. How are they constructed?

A. They are rectangular reservoirs of masonry and cement floors with a drain through the middle and lateral veins running into it.

Q. On a small, level bed?

A. No, that is on the bottom of the reservoir. The filters beds are made of layers of rather large rocks or boulders, heavy sand, coarse sand and very fine sand finally comes on top of these sand layers, making a bed of 40 to 50 inches in depth.

Q. In thickness?

A. In thickness, yes. Filtered water is admitted slowly from below.

Q. From below?

A. Yes, sir, slowly admitted from below until the sand
in this whole mass of rock, etc. is wet, saturated with
1202 water. The water is allowed to cover the surface of it.
Then the unfiltered water is run in, so as not to disturb the filter bed too much and anywhere from 30 to 50 inches of water are allowed to stand on top of the sand. The water that first passes through the filter is bacteriologically practically the same as that which runs into it, that is, contains the same number of bacteria.

Q. They each come from the settling basins?

A. They each come from the settling basins, but after a time the filter begins to filter, to do as I have explained before, by the action of the bacteria upon the sand grains. Each bacterium has a little gelatinous capsule on its cell wall which permits it to adhere to a grain of sand or to one another and in this way a glue-like mass forms in the sand layer of the filtering tank, or as the Germans call it, a smutzdecke is formed. This bacterial layer now catches all bacteria and solid particles that are in the water as it passes through the filter and holds them tenaciously.

The water passes through, the filter having very few bacteria remaining in it. It now passes from the filters into what is called a clear well, at Hamburg. The clear well is covered. Every few hours a sample of this water is taken, for bacteriological examination.

1203 Q. What is that well, is it in the open or is it walled?

A. Oh, it is walled.

Q. With masonry?

A. With masonry. The water taken from this clear well, according to the German law, must not contain more than 100 bacteria per cubic centimeter. If it does the filter is not working properly and is put out of use. I was told that the water in this clear well as a rule contained anywhere from 30 to 50—to as high as 70 bacteria per cubic centimeter, and these were mainly water bacteria that had grown down through the filter.

These filters are very fine. It is a very beautiful system. They are what are known as open filters, not covered, as in Berlin.

Q. The wells are not covered?

A. No, the filter basin is open.

Q. Where the sand filtration occurs it is not covered?

A. No, sir.

Q. Now, just to go back a step. That number of bacteria found per cubic centimeter in the wells, is considered harmless, is it?

A. Yes, they are ordinary water bacteria that grow
1204 in the lower layer of the filters.

Q. But I mean that number is harmless?

A. That number is harmless. The number of bacteria is an index, it is a bacteriological index to the efficiency of the filter.

Q. As to whether or not the filter is efficient?

A. Yes sir.

Q. Now, do you know what has been the effect of that filtration upon the typhoid death rate, etcetera in the city of Hamburg?

A. Yes.

Q. Well, what has been the effect of that?

A. Well, previously—these filters were put in operation in May, 1893 after that cholera epidemic which I related in the last examination, in 1892. The City of Hamburg worked night and day until these filters were completed and then the difference before and after the use of filtered water in the typhoid death rate, was very markedly shown. I have some figures here graphically showing this fact.

Q. What is that chart that you have?

A. I have a chart here which I made of the death rate from typhoid fever in Hamburg. I will read it to you.

1205 Chart showing the course of typhoid fever in Hamburg before the filtration of the municipal water supply, deaths per 100,000.

On the left hand side of this chart are figures ranging from 0 to 100. This represents deaths per 100,000 of population.

Along the lower margin are written figures in ink, the years from 1880 to 1898. Then I have columns here in black with numbers on top of the columns so that deaths per 100,000 can be read from the left hand side of the map, and also from the figures written on top of each column.

Q. In what colors are the columns represented?

A. The column is in solid black, we find that from 1880 to 1893, in May, the average typhoid death rate was 39.7 per 100,000 before the water was filtered.

For the years 1893 to 1898 the average death rate after this filtration of the water supply, is nine per 100,000.

Q. Have you got the difference, being a difference of how much?

A. Oh, the difference between 39.7 and 9.

Q. About 30 per cent?

A. Oh, no, not per cent.

1206 Q. About 30 to the 100,000?

A. The percentage would be different entirely. It is a great per cent.

Q. Now, you made that map?

A. I made this map, sir, from statistics that I received.

ATTORNEY GENERAL CROW: I want to offer that map in evidence.

JUDGE SPRINGER: No objection.

Said map received in evidence and marked by the Commissioner "Complainant's Exhibit 21, Frank S. Bright, Commissioner."

THE WITNESS: I received through Doctor Seibert of New York, in the New York Medical Journal, information that in 1901 the typhoid death rate in that city was one death to 60,000 of population, so that would be not quite two deaths per 100,000.

Q. In Hamburg?

A. In Hamburg, yes. So if that were marked on this map it would be a very small column showing the efficiency of filtration against water-borne diseases.

Q. Now, did you personally investigate this filtration plant?

A. Yes, I went there and saw it.

Q. Now, are you familiar with the water supply of London?

A. Yes sir.

Q. Have you ever investigated it?

1207 A. Well, I went up to Lambeth and Hampstead. I travelled up the river Thames and have seen—

Q. Now, wait a minute? Did you investigate it as a water expert, bacteriologist and hygienist?

A. I did no bacteriological work on it. I went up to look at the filters, the character of the filters from a sanitary standpoint.

Q. From a sanitary standpoint?

A. These are the oldest filters in the world, or rather oldest sand filters.

Q. When were they put in?

A. Oh, they were put in as early as 1829.

Q. How were they made, similar—

A. Very similar, yes, to the Hamburg filters. Some of them are circular, some being square. The Hamburg filter is rectangular in shape and from 1 1-2 to 2 acres of area, while some of the filters on the Thames are smaller.

Q. How many of the filters of London did you investigate?

A. I saw those at Lambeth and at Hampstead.

Q. How many water supplies have they?

A. Oh, there are a number of water companies that 1208 supply water to London, both filtered water from the River Thames and from the river Lee and then they have water from deep wells. I didn't go to the river Lee. I travelled up the river Thames in a boat just to see the sand filters, to know that they were there.

Q. Where was the water taken from?

A. From the river Thames, pumped from the river Thames.

Q. Then it goes through a process something similar to the one you have described?

A. Something similar to this one.

Q. Now, do you know where the outfall of the sewage of the city of London is?

A. I know a good deal is discharged into the river Thames, and much of it is carried out to sea.

Q. Have you any statistics in regard to the effect of filtration plants on the typhoid rate in London?

A. I have not.

Q. You have not?

A. No, but it is very low.

Q. Well, was it decreased?

A. Oh, there was a great decrease following the introduction of good water.

1209 Q. Are you familiar with the water supply of the City of Vienna?

A. Yes sir.

Q. What is that water supply, where is it taken from?

A. The water supply of Vienna is taken from the Springs in the Schneeberg mountains; they are 67 miles away from the city.

Q. Away from the city?

A. Away from the city, southwest, a mountain stream is brought into the water supply of the city.

While I was in Vienna Mr. Max Judd of this town, was the United States Consul there and he did everything for my comfort. I went over the water supply and learned that they were also putting in filters to filter some of the Danube water, the river Danube passes through the city—the beautiful Danube is anything but a beautiful blue river. It is a very dirty looking mess, something like the Missouri river water. And they were intending to filter this water with what is known as the Wormse or Plaque filters. That is another kind of a filter—Fisher's plaque filters.

Q. What kind of a filtration plant is that?

A. It was not in operation when I was there.

1210 Q. Have you ever seen one?

A. Oh, yes. There is one in East St. Louis in operation.

Q. What kind of a filter is that?

A. The plaque is made up of sand and pounded glass. Those ingredients are mixed in varying proportions heated and molded so that a more or less porous material is obtained, that is, the finer the glass, the finer the porosity of the material. They are moulded into Plaques, into rectangular bottles, say about 3 feet square and about 8 feet deep. The interior of this plaque is hollow. It is a hollow square. A pipe is fastened into the top of the plaque, a hole being left for the purpose, clamped down snugly on a rubber gasket and the plaque is ready to be used as a filter. A series of these plaques are emersed in water in a reservoir and the pressure ot the water drives the water—the pressure in the reservoir drives the water through the walls of filter into the hollow space in the center of the rectangular plaque then out through the tube in the top and it is conducted away by a series of pipes.

1211 The efficiency of the filtration is due to the bacterial coat of slime that grows on the outside surface of this rectangular plaque, the same as in sand filters.

Q. On the same principle as the sand filter?

A. The very same principle exactly.

Q. The result would be in a turbid stream, that that filter would not be a success.

A. No, sir it is not a success in this water at all.

ATTORNEY GENERAL HAMLIN: This East St. Louis one you say is not a success?

A. No, I say this: there is a firm here, I have forgotten their name. It is not the East St. Louis Filter Co., but a firm here in town that own a manufactory in East St. Louis, and it is owned by St. Louis people, Stieffel and somebody else, and known as the Wormse Filter Company. They have an office down on Locust Street. They manufacture the plaque in East St. Louis and have a plant over there to show the method of working the filter. It is there that I saw it at work, within the last two years.

1212 ATTORNEY GENERAL CROW: Did you go and investigate the lake from which Vienna draws its water supply?

A. No, it comes from a spring high in these mountains.

Q. From a spring?

A. Yes, sir.

Q. Is the spring above the agricultural line?

A. Yes, sir.

Q. No farms or residences whose sewage is discharged into it?

A. No, sir, it comes right out of the mountain.

Q. The outfall would be towards the spring.

A. No, sir.

Q. Do you know anything about what the death rate is in Vienna from typhoid?

A. Yes, very low.

Q. What is it per 100,000?

A. Well, I have got some statistics here. Do you want these now?

Q. Well, you might give me that for Vienna, as long as we are on that.

A. Vienna, 1890, deaths per 100,000 from typhoid fever, 9.

Q. Now, doctor, have you ever been to the city of Berlin in Germany?

A. Yes, sir.

Q. Did you investigate their water supply from a sanitary standpoint?

A. Yes, sir.

1213 Q. What kind of water supply have they?

A. They have a filter water supply.

Q. From whence does the water come?

A. The water comes from—Berlin has two filtration plants, the old works—the Stralau works—are on Lake Havel, and inasmuch as they were not in operation when I was abroad in 1896, I did not go out to them, but I took a boat on the river Spree and went up to the Friedrichshagen works on Lake Muegel, and there went over that filtration plant. They have a very great many filters at this place. The Friedrichshagen works, I think, were put in operation in 1892. They filter the water from Lake Muegel. This Lake Muegel is practically an enlargement of one of the branches of the river Spree, probably two or three miles long by a couple of miles wide. They say it is 26 feet deep. The little boat I was on ran through it. The water is pumped from this lake and is filtered through a series of filters, sand filters, and these filters at Friedrichshagen are covered. They cover the filters to keep them from freezing in the winter time; some 44 filters are at this point.

Q. Well, do you know anything about the death rate from typhoid in the city of Berlin?

A. Yes, sir.

Q. Well, what is it?

1214 A. Per 100,000 in 1890 we had nine.

Q. Do you want me to read all of these figures?

Q. No. Now, when was this filtration plant put in?

A. I think the first, the Stralau Works, were put in about 1856; the Friedrichshagen Works were put in in 1892.

Q. Do you know what the effect of the filtration was upon the typhoid rate?

A. Yes, sir.

Q. Just give it to me, will you?

A. Why, before 1856, the typhoid death rate was 1 to 900 among the inhabitants of Berlin.

Q. 1 to 900?

A. 900. 1843 to 1853 the typhoid death rate was 1 to every 900 of the inhabitants of the town.

1853 to 1893, that is with the old works, the Stralau Filtering plant, before bacteriologists had really taken hold of this subject of filtration; before we understood it, in other words, what it meant and how to be properly conducted, the typhoid death rate was 1 to 900. But Berlin in the meanwhile had some shallow wells from which some of the water supply of the town was taken, but from 1892 on when the new works were put in—

1215 Q. With all water filtered?

A. With all water filtered.

Q. For the public water supply?

A. For the public water supply. Here the typhoid death rate was high, great for a number of years, and we find that in 1900, it is recorded that there was one typhoid case to over 50,000 inhabitants, or one or two cases to every 100,000 of the population. That is a remarkable reduction.

Q. Have you ever investigated the water supply of Edinburgh?

A. Edinburgh?

Q. Yes?

A. I was in England for a time, but I did not investigate the water supply. There were too many other interesting things there.

Q. Did you investigate the water supply of Paris, France?

A. Yes, sir, I did.

Q. Do you know whether or not there is a filtration plant there?

A. Yes, they have some filtered water there, besides water is brought a long distance from springs in the mountains, as high as 100 miles away.

Q. One hundred miles from the city?

1216 A. Yes, sir. Then water is pumped directly from the Seine. In some houses you will see two faucets. One faucet has a sign on it "This is dangerous. Do not drink it." The other is the good water, which has been filtered or has been brought in from the mountains.

Q. What is the system of filtration they have?

A. Sand filters.

Q. Pretty much the same as the Hamburg and Vienna and Berlin filters?

A. Yes, sir.

Q. Any other city of continental Europe whose filtration plants you have investigated?

A. No; those are the only ones that I have investigated. Hamburg I studied particularly on account of its remarkable experience with cholera.

Q. Are you familiar with the history of the typhoid epidemic in Catterham, England?

A. Well, I am familiar with the report of the man who made this investigation, Dr. Thorne Thorne—of Catterham and Red Hill—the two towns that were affected by one water supply.

Q. Well, what is supposed to have been the origin of that?

A. In 1879 a typhoid fever epidemic broke out in these 1217 two towns. On January 19th, 1879, the first case of typhoid occurred in Catterham. Two weeks afterwards it reached its height, and at the end of a month it practically ceased.

This epidemic was investigated very carefully. I find that in six weeks, while it lasted, there were 352 cases and 21 deaths.

It seems that the water supply of Catterham and Red Hill was supplied by a water company which pumped water from deep wells, and two of the wells were somewhat near together, and it was decided to connect them with a tunnel or an adit, as they call it. They spell it A-d-i-t—it was a small tunnel for the purpose of connecting these two wells together.

Among the workmen at work in this adit was one man who had diarrhoea, and he worked in the tunnel from January 5th to 20th. He had diarrhoea all this time and on the 20th was so sick that he was taken to his bed, and remained there. Being a skilled workman, he was kept at work and his discharges were carried up in a bucket that carried up rock.

Now, it seems that the water company knew of his 1218 diarrhoea and insisted that when his bowels moved, he must use one of the rock buckets; that they must be discharged into one of the large buckets. Now, it was a liquid discharge, and when one of these buckets filled with rocks was lifted through one of the wells, the discharge leaked out and fell into the water. It is quite interesting to hear that on January 5th he was at work there with a diarrhoea and that on January 19th the first case of typhoid occurred. That incubation period of two weeks is quite interesting, showing the period of time elapsing before the earliest case occurred, while the later cases came in within three or four weeks after the water was taken, which shows the incubation period of typhoid in this particular case—Red Hill and Catterham both suffered. Catterham contained 558 houses and 419 took water from the common supply. Red Hill contained 917 houses, and 824 took

their water from this common supply, and it was in these houses the typhoid occurred in the two towns. I think it is in Caterham that there was an insane asylum having two thousand inmates, none of whom were sick, and a military barracks with a great many men, none of whom were sick. They had
1219 an independent water supply; used water from their own wells.

Q. Now, are you familiar with what is known as the Bond street pump epidemic?

A. Yes, the Bond street pump—I chased all over London to find it. I wanted to find the Bond Street Pump, or some signs of it, at least I was in hopes there would be a placard on a building to show where that pump formerly stood, because it has a remarkable history.

Q. Did you locate the place?

A. Yes, I found Old Bond street, but not the pump, nor any signs of it remaining

The Bond Street Pump cholera epidemic in London was investigated very carefully. It was found that discharges from a case of cholera infected the well and 700 cases of cholera followed the use of the water. The pump was in a well sunk into the ground on Bond street and the water was used by a number of people living in that neighborhood, and was considered a good drinking water because it sparkled and tasted very nicely. When this cholera epidemic was investigated by the authorities it was found that close to the well was a cess
1220 pool which leaked into the well.

The walls of the well were broken and allowed the liquids from the cess pool to enter almost directly into this well. A case of cholera existed in the house which used this cess pool and the dejecta from the patient were thrown into it, and ran thence into the well water. 700 cases of cholera resulted from drinking this water in the immediate neighborhood of the well and several at a distance. It was found that an old lady who lived at Hampstead had a bottle of this well water sent to her every day, and that she became infected from drinking the water and also a niece who was visiting her, both died.

Q. Now, have you got the statistics of the mortality from typhoid in Rotterdam?

A. Yes sir.

1221 Q. Will you please read them if you have them—where did you get them from?

A. I got these Rotterdam statistics from Hill's Work on Public Water Supplies.

Q. Well, now give them to me with the years, will you?

A. This water supply is filtered, the water being taken from the river Rhine and the river Maas, and it is filtered by sand filtration. Now, do you want the figures from the various cities?

Q. Yes?

A. This is a table—Foreign Cities, deaths per 100,000.

ROTTERDAM.

1890, 6 cases,
1891, 4 cases,
1892, 6 cases,
1893, 5 cases,
1894, 5 cases,
1895, 2 cases,
1896, 12 cases.

MUNICH, BAVARIA.

ATTORNEY-GENERAL CROW: This is all per 100,000?

A. Yes, I say, deaths per 100,000 for foreign cities and we had Rotterdam first. Now comes Munich. The Munich 1222 water supply is brought from Mangfall Valley from springs in the mountains, about 38 miles away.

Q. You have been there, have you?

A. Yes, sir.

MUNICH.

1890, 8 cases,
1891, 7 cases,
1892, 3 cases,
1893, 15 cases,
1894, 2 cases,
1895, 3 cases,
1896, 3 cases.

BERLIN.

1890, 9 cases,
1891, 10 cases,

1892, 8 cases,
1893, 9 cases,
1894, 4 cases,
1895, 5 cases,
1896, 5 cases.

VIENNA.

1223 Vienna, as I said before, takes its water supply from springs in the Schneeberg mountains.

1890, 9 cases,
1891, 6 cases,
1892, 8 cases,
1893, 7 cases,
1894, 5 cases,
1895, 6 cases,
1896, 5 cases.

That is the foreign cities. Do you wish me to compare it with—

Q. Well, now, have you got a comparative list there of American cities that use unfiltered water?

A. Yes, sir, in the United States?

Q. Yes?

A. I have Chicago, lake water unfiltered:

1890, 92 cases,
1891, 154 cases,
1892, 106 cases,
1893, 45 cases,
1894, 31 cases,
1895, 32 cases,
1896, 46 cases,

1224 That is, per 100,000 of population.

For Pittsburg, unfiltered river water:

1891, 100 cases,
1892, 100 cases,
1893, 111 cases,
1894, 56 cases,
1895, 77 cases,
1896, 61 cases.

LOUISVILLE, KENTUCKY.

Unfiltered river water.

1890, 88 cases,
1891, 81 cases,
1892, 72 cases,
1893, 84 cases,
1894, 72 cases,
1895, 77 cases,
1896, 45 cases.

ST. LOUIS, MO.

JUDGE SPRINGER: I didn't understand, what was this, cases or deaths?

A. Deaths per 100,000. I was simply reading it so as not to confuse it. I will read it year and deaths.

1225 JUDGE SPRINGER: Well, you need not every time, doctor.

A. 1890, St. Louis, Mo., 94 deaths per 100,000,
1891, 30 deaths,
1892, 37 deaths,
1893, 103 deaths,
1894, 31 deaths,
1895, 19 deaths,
1896, 19 deaths,

ATTORNEY-GENERAL CROW: Have you the figures with you for 1900, 1901 and 1902 for St. Louis?

A. Yes, sir.

Q. Please give me those?

A. I also have the figures for 1893, 1894 and 1895, I think.

Q. I just want those for 1900, 1901 and 1902.

JUDGE SPRINGER: What was the last one you gave for St. Louis?

A. 1896, 19 cases.

Do you want from 1896 on?

Q. Yes, you can put them right in there.

1226 A. 1897—but I have not deaths per 100,000, I would have to calculate that out. I have not the deaths per 100,000. I have the total number of deaths.

Q. Well, that don't go in here, because this is per 100,000.

A. Yes, sir, this is per 100,000. I would have to work that out here.

ATTORNEY-GENERAL CROW: Now, I have got a witness that wants to get away.

JUDGE SPRINGER: All right, the doctor may stand aside.

1227 ARTHUR C. LOOLEY,

Called as a witness on behalf of the complainant, being first duly sworn was examined in chief by Mr. Woerner and testified as follows:

Q. Your name is Arthur C. Looley?

A. Yes sir.

Q. What is your business?

A. Grocery clerk.

Q. Where do you reside?

A. 1034 South 8th St.

Q. In St. Louis?

A. Yes sir.

Q. You say you are a grocery clerk?

A. Yes sir.

Q. What was your business before that?

A. Well, I have always followed that.

Q. What were you doing in October, 1901?

A. I was in a grocery and saloon.

Q. Were you ever engaged in the collection of water?

A. Yes sir.

Q. When?

A. The 7th day of October I started collecting.

Q. Of what year?

1228 A. 1901.

Q. Now, how long did you continue?

A. About 10 days.

Q. By whom were you employed?

A. Dr. Teichmann.

Q. The City Chemist of the city of St. Louis?

A. City Chemist, yes sir.

Q. Well what did you do?

A. I went up to the Chain of Rocks every morning and

I took 8 samples out of the river and three out of the outlet screen chamber, two large ones and one small one.

Q. How many did you take at the Chain of Rocks?

A. Out of the river?

Q. Yes.

A. Eight. And three out of the outlet stream chamber.

Q. Wait a minute. How did you take them out? What part of the river did you take them out of?

A. Two from Missouri and two from Illinois; two from the middle and then two from the tower.

Q. Two from the tower?

A. Yes sir.

Q. When you say two you mean two bottles?

A. Two, yes, of the large bottles.

1229 Q. What kind of bottles were they?

A. Gallon bottles.

Q. Describe their appearance—how did you take the water out of the river?

A. Put it in one of them machines over there and put it under the water, then pulled up the lever—

Q. Describe the machine as well as you can.

A. Well, there is one of them all right (indicating).

ATTORNEY-GENERAL CROW: Well, that is Exhibit No. 15.

MR. WOERNER: All right, that is what you refer to.

A. Yes, sir, that large one.

Q. That sample you took is taken from under the surface of the water?

A. Yes sir.

Q. And corked underneath?

A. Yes sir, corked underneath.

Q. Did you take that every day?

A. Yes, every day for about 10 days is all I was up there.

Q. Any other place that you took samples from?

A. No sir.

Q. What did you do with the bottles after you got them out?

A. I would tag them, where I had taken them from.

Q. You would tag them would you?

1230 A. Yes, sir.

Q. What would you put on the tag?

A. Whatever time I had taken it out of the water and the temperature of the air and of the water.

Q. Anything else?

A. No sir.

Q. Did you put your name on it?

A. Yes sir, put my name on it.

Q. Then what would you do with them?

A. Then I brought them up to this laboratory up there.

Q. Where?

A. There at the Chain of Rocks.

Q. And then what would be done with the bottles?

A. They used to cork them up up there and then tie them up with a little cloth, I put around them.

Q. Just go on and say what was done with them as far as you know?

A. That is all I see was done with them and they put a seal on them. Then would pack them in ice; then they brought them down to this chemist's office.

Q. How were they sent down?

1231 A. In a wagon. They were put in a box with ice in it and then sealed up and then put on this wagon and brought down to the chemist's office.

CROSS-EXAMINATION,

By Judge Springer.

Q. What season of the year was this?

A. October 7, 1901, I was up there about 10 days that was all.

Q. What was the stage of the water in the river at that time, if you know, high or low was it?

A. Why it was kind of high.

Q. High?

A. Yes sir.

Q. Did you notice the difference in the appearance of the water—

A. No sir, I never paid any attention to it.

Q. You did not?

A. No, sir.

Q. You went out in a skiff?

A. Yes, sir went out in a skiff.

Q. How far from the Illinois shore did you take the
1232 sample that you have spoken of as having been taken
from the Illinois shore, how far from the shore was it?

A. I just couldn't say how far.

Q. About how many feet?

A. About 100 ft or two.

Q. 100 ft.?

A. Yes, sir.

Q. Was that in the channel of the river, was the water running there, or was it near enough to the shore to be quiet?

A. It was running.

Q. Running water?

A. Yes, sir.

Q. Did you notice any difference between the water on that side of the river and the Missouri side?

A. No, sir I never paid any attention to that.

Q. You never paid any attention to that.

A. No, sir.

MR. WOERNER: Q. How far beneath the surface did you take this water from?

A. About 3 ft.

1233 DR. AMAND NICHOLAS, RAVOLD,

Resumed the stand for further direct-examination by Attorney General Crow, and testified as follows:

Q. I show you a map, Doctor Ravold; what is that?

A. It is a chart prepared by me. It reads as follows:

Chart showing cases and deaths from typhoid fever in St. Louis, Missouri when water supply was taken from the Mississippi River at Bissell's Point, from January, 1890 to September 28, 1894, and from September 28, 1894, to December, 1902, when the water was taken from the river at the Chain of Rocks.

The next below that is written January 17, 1900, Chicago Drainage Canal first put in operation—no, below that is written Water from Bissell's Point, January, 1890 to September

28th, 1894, five years. Cases of typhoid fever 6222; deaths from typhoid fever 1268. Now below that is written; Water from Chain of Rocks, 1895 to 1900, five years.

Typhoid fever cases, 2490; deaths from typhoid fever, 562.

And back of that is written, with an index pointing to the percentage decrease in typhoid fever death rate 125 per cent.

Q. From what time to what time?

1234 A. From these. The difference between the number of deaths when the water was taken from Bissell's Point, January, 1890, to September 28th, 1894, and when the water taken from the Chain of Rocks, beginning at each date, September 28th, 1894, and running to 1900—

MR. WOERNER: The percentage is how much?

A. Now the percentage is 125. It is a decrease of 125 per cent in the number of cases between the two periods when the water was taken from the two pumping stations.

Q. ATTORNEY GENERAL CROW · Now do you know any reason, as a bacteriologist and as a hygienist for that great decrease? If so, what was it?

A. The Intake of the Waterworks at Bissell's Point is located—6,800 feet on the river below Harlem Creek, and the creek drains an area upon which dwell some 10,000 people, and they discharge their sewage into it. Harlem Creek discharges into the Mississipp river and ran for a time into the Intake of the St. Louis water supply?

Q. Did you investigate that at the time?

A. Yes sir.

Q. Did you trace the sewage from Harlem Creek into the Mississippi?

1235 A. I saw the black water from Harlem Creek running into the Intake at Bissell's Point in 1892. In 1893 a dam was built across Harlem Creek, pumps put in and the water pumped from above this dam to below Bissell's Point. A remarkable fall in the number of cases and typhoid deaths followed.

Q. What was the decrease?

A. Well the difference was between 488 deaths in 1892, 215 in 1893, and 178 deaths in 1894. That is for the fiscal year; that is the difference in the typhoid deaths it made to have the sewage pumped and discharged into the sewers below the Intake. Still, in high water the sewage would run over the dam—

Q. The dam in Harlem Creek?

A. The dam in Harlem Creek, yes sir.

Q. What was done to remedy that?

A. The pumps of the water works were moved to Chain of Rocks.

Q. How far above Bissell's Point?

A. Six or eight miles.

Q. By River?

A. By river.

Q. Now what year were they moved there?

A. They were moved on September 28th, 1894.

Q. Now what does that chart show with reference to the
1236 increase or decrease of the typhoid in this city after that
removal, up to 1900?

A. Well, next below that, that 125 per cent is written.

Water at Chain of Rocks since the opening of the Chicago Drainage Canal, January 17th, 1900, three years,—3426 cases and 588 deaths.

Water at Chain of Rocks three years before opening of the Chicago Drainage Canal, for the years, 1897, 1898 and 1899, 1807 cases; 350 deaths.

Back of that is shown, Increase in typhoid death rate since opening of the canal, three years, 68 per cent.

Do you want a further description of this chart?

Q. Yes, you might just describe it and then I will put it in, or explain it rather.

A. On the left hand margin of this chart are written figures beginning with zero and extending to 2,000 whch indicate the number of deaths and cases.

On the lower margin of the chart is written the year, 1890, 1891, 1892, up to 1902. Below that, water from Intake at Bis-
sell's point until September 28th, 1894, and the index
1237 shows this date. Then back of that water from Intake at
Chain of Rocks, St. Louis waterworks.

Now then, columns in solid black and solid red rise on this chart; at the top of them are written, on the black, number of cases—

Q. Of typhoid?

A. Of typhoid. And on the red columns number of deaths by typhoid. The cases are in black; the deaths in red. I should say that these are the official statistics of the Health Department furnished me—I have it here:

"An executive session of the Board of Health was held this date. Present, Mayor Wells, Dr. Starkloff, Dr. Merrill; Dr. Chapman, and Mr. Blong.

Mayor Wells in the Chair.

The attached is a full, true and correct copy from the executive proceedings of the Board of Health, in the matter and of the date above set forth.

Signed by Mark Kauffman, Clerk of the Health Commissioner, and Board of Health."

And from these statistics this chart has been prepared to show graphically the number of cases reported to the Health
Department by the physicians of the City of deaths from
1238 typhoid fever reported by the physicians of the city and
to show the decrease in the death rate following the placing of the pumps at the Chain of Rocks for five years, and the increase following the opening of the Chicago Drainage Canal.

Q. Now what was the date of the epidemic caused as you said, by the Harlem Creek sewage?

A. That was in 1892.

Q. Now give me the death rate for the three years just back of that, including 1892?

A. We have for 1890, 277 cases—or deaths rather. For 1891, 160 deaths—Do you want cases and deaths both?

Q. Yes.

A. Well, you will have to begin again then:
1890, cases 547; deaths 277,
1891, cases 447; deaths 160,
1892—this is the celendar year,—3624 cases, 488 deaths.

Q. That was the year that the Harlem Creek sewage ran into the Intake?

A. Yes, typhoid on the watershed.

Q. Now what was the date that the dam was built across
1239 Harlem Creek?

A. I haven't that. I can give you that later.

Q. Well, what year?

A. The fall of 1892.

Q. Now do you know of your own personal knowledge that there was typhoid on the sewage area whose sewage out-fall went into Harlem Creek in 1892?

A. Do you mean did I treat the case?

Q. No, I don't mean that.

A. No, I know from the Health Department statistics, that cases existed there.

Q. Now will you give me the three years immediately succeeding the removal of the Intake from Bissell's point, six miles above Harlem Creek to this present location, 1500 feet from the shore line of Missouri in the Mississippi River at the Chain of Rocks?

A. I gave you 1890, 1891 and 1892. Now you want 1893, and 1894 do you?

Q. Well, yes, you can put them in, but I wanted the other—Well, just strike out that question.

A. What question?

Q. About 1893 and 1894—put 1893 and 1894 in.

A. All right. 1893, cases 788; deaths 215;
1894, 816 cases; 178 deaths.

1240 Q. Now was the typhoid rate there still affected by the Harlem Creek sewage?

A. After 1894?

Q. Yes?

A. No sir.

Q. Well, but during the years 1893 and 1894?

A. Oh yes, a little bit, because in high water, the pumps were not heavy enough to take all of the water that is discharged on that watershed, so it ran over the dam.

Q. For 1893 and 1894?

A. Yes sir.

Q. Now answer my previous question. Give me the typhoid cases and death rates for the three years preceding January, 1900?

A. Oh, we have 1897, 433 cases; 125 deaths;
For 1898, 426 cases, 95 deaths,
For 1899, there is 948 cases, 130 deaths.

Q. Now do you know the occasion of that increase?

A. In 1899?

Q. Yes, in 1899?

A. I have looked over the Health Statistics. In 1899 we have a remarkable number of cases, in November, 488 cases reported and 31 deaths; and in December 116 cases, 20 deaths, which makes the great increase in this year. It was as-
1241 certained at this time, in fact I saw the men at work.—The river was so low in 1899 that it was feared by the Water Commissioner that the lowest gates in the Intake tower would not be low enough to admit enough water for the pumps, so a coffer dam was built about the Intake and men put at work breaking a hole through the tower for the purpose of putting a gate in.

Q. Where abouts did they work now?

A. They worked at the Intake tower out in the river.

Q. Yes, but what part of it?

A. That would be on the east side of the tower.

Q. How high up?

A. They were down as low as they could go so as to have a very low gate for low water periods.

Q. Beneath the water?

A. Yes sir.

Q. Did they go down to the bottom of the river?

A. They had things stirred up pretty well, yes sir.

Q. They worked at the bed of the river and stirred up the mud?

A. Yes sir.

Q. Now from a bacteriological and sanitary standpoint, what was the effect of that stirring up of the silt and mud in the bottom of the river where it had settled at the bottom of
1242 the Intake tower since it had been put in there?

A. The result would be, of course, to stir up any bacteria,—any typhoid or pathogenic bacteria in the water there.

Q. From a scientific standpoint as a bacteriologist and hygienist then, do you think that would account for the increase in the death rate?

A. Well, if it were due simply to the stirring up of the mud, there would be a suspicion that that was the cause, but I have not sufficient data to enable me to draw the conclusion that that was really the cause ,although the cause for that particular flare in November has been ascribed to the work that was going on in October, in that tower.

Q. Do you know whether or not at that time there was any dredging going on at Kampsville, in the Illinois River?

A. I know there were dredges at work in the Illinois river below Kampsville.

Q. Do you know what they were doing?

A. I think they were digging out a channel for boats.

Q. Digging out the bottom of the bed of the river?

A. Yes sir.

Q. What was done in this dredging process, with the
1243 matter when it was abstracted from its resting place on the bottom of the river, this mud and silt?

A. Carried off to one side.

Q. Out of the stream?

A. Yes,—deposited back into the stream.

Q. Not thrown from the river onto the bank, but back into the water?

A. Yes sir. I saw the dredges at work on it, that is, digging up the bottom with a great apparatus, that they have for that kind of work.

Q. Now take the next three years?

A. 1900, 1901 and 1902?

Q. No sir, 1897, 1898 and 1899?

A. Yes sir.

Q. After the removal of the Intake tower from Bissell's Point to the Chain of Rocks, from your knowledge of the typhoid rate of mortality in the city, would you say that that was a fair average?

A. Of deaths to cases here?

Q. Yes sir?

A. Oh no.

Q. Well, will you please give me the next that would indicate a fair average, prior to the opening of the canal?

1244 A. Prior to the opening of the canal. When we go back over the statistics, that is of the typhoid fever cases and deaths take the case at Plymouth, for instance; there were 1104 cases and 114 deaths, 10.3 per cent,—in other words 10 out of every 100 died.

ATTORNEY GENERAL HAMLIN: I object to that. That is an argument.

A. (continuing) And my personal experience in this city in hospitals would make the per cent anywhere from 7 to 15, depending upon the stage of the disease in which the typhoid cases reached the hospital. While my experience for twenty years as a practicing physician in this city in the treatment of typhod fever, the relation of deaths to cases would not be 1 to 15. That is, practicing in the homes of the individuals sick. The reason for this is that we see the cases early and can do more for them at home. While in the hospitals the patient reaches there after he is seriously sick, and the chances for treatment and recovery are not so good, so these figures on the chart showing the relation of cases to deaths are not comparable at all.

Take any one of these years, any one you may please. We find that for 1892, for instance, we have 488 deaths and 3624 cases recorded. There ought to be at least 5,000 cases recorded by physicians,—or take the lowest there, 1898, 95 cases, which
would mean 950 cases in the town—if there were 95
1245 deaths, if there were only one death in ten cases.

Q. You only get from the health statistics then the reported cases?

A. That is all. A physician does not report every case; he reports every death.

Q. Then the death rate is more nearly the index than the cases reported?

A. Yes sir.

Q. Now will you give me the number of cases with the death rate for the years 1900, 1901 and 1902?

A. Yes sir. In 1900 there were 1213 cases reported by the physicians of the city to the Health Department, and 168 deaths.

In 1901 there were 1101 cases reported, with 198 deaths.

In 1902 there were 1112 cases reported, with 222 deaths.

ATTORNEY GENERAL CROW: Now I want to offer that map as an exhibit.

Said map received in evidence and marked by the Commissioner "Complainant's Exhibit No. 22. Frank S. Bright, Commissioner."

ADJOURNED until 2:00 P. M., same day, Monday, March 9, 1903.

Southern Hotel, St. Louis, Missouri.
1246 2:00 P. M., Monday, March 9th, 1901.
Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

DR. AMAND NICHOLAS RAVOLD,

Resumed the stand for further direct-examination by Attorney General Crow, and testified as follows:

Q. Now doctor, I want to turn to another portion of this investigation; that part of it about what is termed excrementatious matter that comes from the City of Chicago—together with the population of that city, and the drainage area, etc.

Now do you know—Have you ever investigated and ascertained what the census of 1900 gives Chicago?

A. The population of the City of Chicago is estimated, or rather the census of the United States for 1900 gives it 1,650,000 people.

Do you know what portion of the population of the State of Illinois discharges sewage—throws sewage out into the canal above Lockport?

A. The proportion of population of the State of Illinois, in the vicinity of Chicago, which also discharges its sew-
1247 age into the Chicago Drainage Canal above Lockport, at which point the controlling works of the Chicago Drainage Canal is situated, is roughly estimated at 350,000 people.

Q. This is outside of the city limits?

A. Yes sir.

Q. Of the City of Chicago or the Sanitary District

A. Yes sir.

Q. Did you make a table of about how much—

A. 2,000,000 people, whose waste products are emptied into the Drainage Canal above Lockport—

Q. That Drainage Canal is approximately how far from Chicago?

A. But the Drainage Canal runs there—

Q. No, I mean the emptying of it at Lockport—

A. Well, the waste products of these 2,000,000 people are emptied into the Drainage Canal above Lockport, twenty-seven miles approximately, from the City of Chicago proper.

Q. Are you acquainted, from a scientific standpoint with the amount of solid and liquid matter of which the ordinary sewage is composed, according to the population of cities?

A. Well, I have made some measurements myself. They vary in myself, for instance from three to six ounces of excrementatious matter per day. The physiologists also give figures on that. Quite a number of them are authorities on that
1248 subject.

Q. Have you got those figures. Do you know what they are?

A. Well, there are about three ounces of solid excrementatious matter and 40 ounces of urine.

Q. That is per capita per day?

A. That is per capita per day.

Q. Well now, is that from the statistics and experience of people who have made experiments; is that a fair average?

A. Yes sir, that is a low average.

Q. How have you ever figured on a population of 2,000,000 people draining into that canal, to see how much solid matter and how much liquid sewage would pass in in the course of a day?

A. Yes sir, if each of those 2,000,000 people discharged three ounces a day, the total results would be about 187 to 190 tons.

Q. Of solid matter?

A. Yes sir.

Q. That is of human offal?

A. Yes sir.

Q. Now have you figured on the amount of liquid material?

A. Forty ounces a day would give 670,000 gallons of urine.

Q. Of urine?

A. Yes sir.

1249 Q. Per 24 hours?

A. Yes sir.

Q. Now have there ever been any figures made by sanitarians and water experts, with reference to the amount of sewage as proportioned to the water consumption?

A. Yes, it is commonly assumed that the sewage is within reasonable limits, proportional to the water consumption of the city, and within the city limits it is very nearly so, but deductions must be made for evaporation and other causes.

Q. When you say sewage sewage do you mean the liquid sewage?

A. I mean the liquid matter flowing in a sewer.

Q. That does not include the solid organic substance?

A. Yes it does; it is the solid organic substances of man, the urine and feces.

Q. And it includes the volume that flows through the pipes of the sewers?

A. Yes sir.

Q. Of the tunnels?

A. Yes sir.

MR. RANDOLPH (Chief Engineer Sanitary District of Chicago): That is based on 43 ounces per head?

A. Yes sir, three ounces of feces.

MR. RANDOLPH: That is a total of 43 ounces?

1250 A. Yes sir.

Q. ATTORNEY GENERAL CROW: Have you any idea of the water consumption of the City of Chicago per day in gallons?

A. I believe it is 150 gallons per inhabitant a day. That would be 300,000,000 gallons per day, something like 360,000,000 gallons a day for the whole population.

Q. Then would their water consumption reach 360,000,000 gallons there?

A. Yes sir.

Q. For the 2,000,000 people?

A. Yes sir.

Q. Then what would be the proportion of water that went into the sewers and thence into the canal, if all the water from the sewers went into the canal, and all the sewage that entered, what proportion of water to the total amount of liquid and solid sewage?

A. Well I have made an estimation of that kind, based upon the fact—or, it is not a fact, but we believe that Chicago was discharging—or the Drainage Canal was discharging 300,000 cubic feet of water per minute—but it is not doing that—but based upon those figures, we find that the sewage of Chicago would be diluted by the amount of water which is flowing into the
1251 canal, assuming that 300,000 cubict feet are discharged per minute—as 1 to 9.

ATTORNEY GENERAL HAMLIN: One of sewage to nine of water?

A. Yes sir.

Q. ATTORNEY GENERAL CROW: Now what is the effect of this sewage, or the water in the canal as it approaches Lockport with reference to whether or not it approaches more nearly water, or what you call crude sewage?

A. Well, this sewage of this portion of Illinois is diluted to the extent of one to nine, approximately, with Lake Michigan water. It is readily seen by a persual of the bacteriological results which have been submitted here, obtained from an analysis of samples collected daily at Locqport, that the diluted sewage at this point does not approach in the slightest degree to the resemblance of a sanitary water.

ATTORNEY GENERAL HAMLIN: Of what point are you speaking?

A. At Lockport.

Q. JUDGE SPRINGER: Sanitary water?

A. Yes sir.

ATTORNEY GENERAL CROW: Now what was the effect of that sewage on fish at Lockport?

A. Well, at times depending upon the quantity of sewage discharging into the stream, I have seen the water dis-
1252 charging over the Bear Trap Dam—quite a number of times, I have seen dead fish floating in the water in quite large numbers once or twice; but we sent a man up there to study that subject and in November of 1900 five hundred fish were observed passing over the Bear Trap Dam in the space of ten minutes.

ATTORNEY GENERAL HAMLIN: Wait a minute. Is that your observation?

A. That was from the observation of Mr. Miller, who was sent there to look after that question—500 fish in ten minutes.

Q. ATTORNEY GENERAL CROW: Well, have you seen the fish yourself, pass over there?

A. Yes, I have seen the fish myself pass over the Bear Trap Dam.

Q. Now, just below Lockport does the canal join any other stream?

A. Yes, the canal joins the Des Plaines River.

Q. Now between Lockport and Joliet, the distance is how great?

A. Sixty or seventy miles.

Q. What is the fall—do you know?

A. 22 feet.

Q. That approaches something like three feet to the mile?

1253 A. Yes sir.

MR. RANDOLPH (Chief Engineer of the Sanitary District of Chicago): You are off on that. It is 4 and one-half.

ATTORNEY GENERAL CROW: How about the fall?

MR. RANDOLPH: The fall is about 37 feet.

THE WITNESS: If you will permit me, I will take the figures of Mr. Randolph, four and one-half miles, and the fall is 37 feet, say, make it five miles and 37 feet and it is easy to get at the details.

ATTORNEY GENERAL CROW: Well, you had better make the statement that these are his figures and not your figures.

A. Yes sir.

Q. Say that they are the figures of Mr. Randolph. I presume they are correct?

A. Yes, he knows much more about it than I do.

JUDGE SPRINGER: If you have no objection, you may state that Mr. Isham Ranholph is the Chief Engineer of the Sanitary District of Chicago, and he may appear in the record as having made this statement. That will make it more clear.

Q. ATTORNEY GENERAL CROW: That is very near a cascade, isn't it, a fall of 37 degrees?

A. Yes sir.

Q. Now do you know what the census of 1900 gave the
1254 City of Peoria in population?

A. 1900 census gave the poulation of Peoria as 56,100.

Q. Do you know what the minimum flow of the Illinois River at Peoria was before the Drainage Canal was opened?

A. Taking Mr. Harmon's figures, from his report to the Illinois State Board of Health, and we have 1221 cubic feet—we figured it 1200 cubic feet per second.

Q. Now assuming that the people in Peoria had an out-fall of sewage equivalent to the same number of people in the City of Chicago, how many gallons per day per capita at Peoria would go into the water of the Illinois River?

ATTORNEY GENERAL HAMLIN: That is objected to on the ground that there is no allegation in the bill, charging the discharge of sewage at Peoria, or any claim made growing out of any such discharge.

THE WITNESS: Ask the question again?

Q. (Question repeated).

A. Assuming the same we would have 150 gallons per capita.

Q. Now, if the flow of the Canal is 300,000 cubic feet per minute; if that was true what would be the proportion of dilution of Peoria sewage in the water of the Illinois River?

A. Well, basing it on a flow of 1200 cubic feet per second,
1255 and taking 56,100 people with a discharge of 150 gallons
per head per day, that would give a dilution of 1 to 92 at this low river stage. That is, the Peoria sewage.

ATTORNEY GENERAL HAMLIN: I don't think I quite understand your answer.

A. You see the sewage of each person there would be diluted nine thousand times with this low river flow of 92 feet,—the quantities of the water of the Drainage Canal—

Q. What is the distance from Peoria to Grafton?

A. 160 miles.

Q. Is that by river or by the winding of the wagon road, or rail?

A. I think that is by river. I never measured it. This is taken from the report. Do you want the dilution of the Drainage Canal in here with the Peoria sewage?

Q. Yes, what would that be? If you let the water of the Drainage Canal in, what would be the dilution, along with the Illinois River water?

A. Well, with that 300,000 cubic feet per minute added by the Drainage Canal, if that were added to the low river stage of the River, the Illinois River at Peoria, the dilution would be 1 to 413.

Q. Now would that amount of sewage render the Illinois
1256 River water at Grafton unpotable the amount that comes
in from Peoria?

A. Well now the question is, what do you want it with: with that low river?

Q. No, just scratch that question out. I will put it in shape where he will understand it.

If the Chicago canal water were free from sewage contamination and was emptying this lake Michigan water in the pure state into the Illinois River at Peoria, at low stage of the Illinois River, would the pollution from Peoria, if the pollution in the sewage is in the proportion that you have stated heretofore,—render unpotable the water of the Illinois river, at its confluence with the Mississippi at Grafton 160 miles below, from a bacteriological standpoint?

A. By potable,—Unpotable, I suppose you mean—

Q. I mean fit for domestic purposes, drinking, and cooking?

A. Well it would reduce the danger to a minimum, that is just dilution alone?

Q. Yes.

A. At Grafton.

JUDGE SPRINGER: I want to enter an objection to that question and answer from the fact that it does not illustrate any issue in this case, and from the further fact that there
is a great deal more pollution from Peoria comes into
1257 the stream from Peoria, and the Illinois River.

THE WITNESS: You mean from around Peoria?

JUDGE SPRINGER: I mean more than comes in from Peoria. There is Sangamon, Pekin—

ATTORNEY GENERAL CROW: This is a hypothetical question purely, I assumed that your lake water was all right, too.

JUDGE SPRINGER: Well the hypothesis is not based upon any possible condition that can exist; that is the reason I object to it.

ATTORNEY GENERAL CROW: Now doctor, in case of towns not sewered, rural districts in proximity to rivers or the feeders thereof, brooks and streams, what proportion of the population in making a sanitary estimate, is usually figured as sending its sewer outfall into the street?

A. Well it has generally been said by sanitarians as equal to one-sixth of the sewage of those people that eventually gets into the river.

Q. Now have you got a table showing the population of the drainage basin of the Illinois River, with the flow per cubic feet—all its territories, with the urban and rural population on the census of 1890?

A. I have a report of Mr. L. E. Cooley. Yes, I have the numbers taken from Mr. Cooley's work on Waterways.

1258 Q. At the time he made that report, do you know what official position he occupied with reference to the drainage canal?

A. No, I do not know, but was he not the Chief Engineer of the Drainage canal then?

Q. Anyhow, you have got the table of figures?

A. We can get the exact date of this table.

Q. Yes. You can do that later.

A. Yes, I have got a report of Mr. L. E. Cooley, giving the total population of the drainage basin of the Illinois River, with flow, cubic feet per second; urban population, census of 1890; rural population, census of 1890, with totals.

Now we have, Rivers, the Des Plaines River. Cubic feet of flow per second, 13.21.

Urban population census, 1890, 20,354.
Rural population, 45,247,
Total population, 75,601.

The DuPage river:

Flow per cubic feet per second, 32.77,
Urban population, census, 1890, 5,344,
Rural population, 10,890,
Total, 16,234.

Kankakee River:
509.24 cubic feet per second.
Urban population, 26,697,
1259 Rural population, 140,441,
Total, 170,138.

Fox River:
329.95 cubic feet per second,
Urban population, census 1890, 72,763,
Rural population, 89,889,
Total, 162,652.

The Vermillion River:
This is Mr. Harmon's report, he personally informed me that this is correct.
4 cubic feet per second,
Urban population, 17,543,
Rural population, 43,257,
Total, 60,800.

Mackinaw River:
Flow, cubic feet per second, not given,
Urban population, 5,247,
Rural population, 30,106,
Total, 35,353.

Spoon River:
87.76 feet—cubic feet per second,
Urban population, 19,619,
Rural population, 56,428,
Total, 76,047.

1260 Sangamon River:
Flow per cubic feet per second, 372.30,
Urban population, 103,720,
Rural population, 177,638,
Total, 281,358.

Crooked Creek:
Flow not given,
Urban population, 12,739,
Rural population, 44,289,
Total, 57,028.

Macoupin Creek:
Flow not given,

Urban population, 9155,
Rural population, 32,296,
Total, 41,453.

McKee's Creek:

Flow is not given,
Urban population not given,
Rural population, 8,823,
Total, 8,823.

1261 The Illinois River direct:

Flow not given.
Urban population, 135,139,
Rural population, 184,877,
Total, 320,016.

Sanitary District of Chicago:

Urban population, 1,800,000,
Rural population not given,
Total, 1,800,000.
No flow for the Sanitary District of Chicago for 1890.

Totals:

Urban population, 2,241,320,
Rural population, 864,183,
Total, 3,105,503.

Q. Now do you know what the city of Alton, what their population is?

A. The city of Alton, population is 15,000.

Q. Do you know where the out-fall of the sewage of the city of Alton is?

A. Yes sir.

Q. Where is it?

A. It discharges its sewage into the Mississippi river.
1262 They have five main outlets, three of which empty into the Mississippi river, behind dikes which quite effectually check that portion of the sewage from becoming mixed at once with the waters of the main channel of the river.

Q. Do you know where Hartford is?

A. Yes sir.

Q. Where is it, on the Missouri shore?

A. It is on the Illinois shore.

Q. How far from Alton?

A. Five or six miles below Alton.

Q. Below Alton?

A. Yes sir, about one mile above the point where the Missouri river enters into the Mississippi river.

Q. Have you got the average number of bacteria found in the waters of this river at these two points, Alton and Hartford?

A. Yes sir.

Q. What were they?

A. Monthly average results of quantitative analyses of Mississippi river water one mile above Alton and opposite Hartford respectively, together with the average results of the tests for the bacillus coli communis—month and year, 1900—

ATTORNEY-GENERAL HAMLIN: Now this is at one place?

1263 A. No this is at two places.

JUDGE SPRINGER: The average of the two?

A. Yes, we are giving the averages; average one mile above Alton and average at Hartford, five or six miles below Alton.

January, 1900, bacteria, Alton, 118,800.

ATTORNEY-GENERAL CROW: That is the coli bacillus?

A. The bacillus coli communis. 14 per cent of the time.

Bacteria at Hartford, same date, month of January, 90,600,
Coli communis 17 per cent.
February, bacteria at Alton, 192,500,
Bacillus coli communis, 17 per cent.
Hartford, 190,600,
Bacillus coli communis 50 per cent.
March: Alton, 192,300,
Coli communis 51 per cent.
Hartford, 208,300,
Coli communis 52 per cent of the time.
April, 29,400, for Alton.
Coli, 39 per cent of the times.
Hartford, 29,700,
Coli 41 per cent.
May: Alton, 10,300,
Coli 54 per cent.

1264 Hartford, 12,800,
Coli 86 per cent.
June, Alton 8,200,
Coli 60 per cent,
Hartford, 5,800,
Coli 61 per cent.
July, Alton, 7,700,
Coli 52 per cent,
Hartford, 61,000,
Coli 55 per cent.
August, Alton 2,400,
Coli 88 per cent.
Hartford, 2,100,
Coli 89 per cent.
September, Alton 2,600,
Coli 90 per cent,
Hartford, 2,800,
Coli 93 per cent.
October, Alton, 2,100,
Coli 100 per cent.
Hartford, 2,400,
Coli 100 per cent.
Period of 1901. Do you want that?

Q. Have you got the figures for October and November, 1900, the average at these two points for the months of October and November only? 1265

A. Yes sir. Now 1901, October, Alton 1,137,
Coli 100 per cent,
Hartford, 2,141.
Coli 86.4 per cent.
November, Alton, 1,566,
Coli 77 per cent.
Hartford, 3,000,
Bacteria 56 per cent.
Do you want to know the dilution there?

Q. Have you got it? Yes, you may give it.

A. Now the sewage hangs behind these dikes and is only flushed out at times when the river is flooded. Assuming, however, that the whole of the sewage of Alton becomes mixed with the Mississippi river water, and is carried directly towards Hartford, with a minimum flow of 25,000 cubic feet per second, in the Mississippi, it will be seen that the sewage of this city of 15,000 people is diluted in a minimum of over one to 70,000. That is supported by bacteriological results, so the extent to which the Alton sewage is disposed of by dilution, the bacteriological results of Alton and Hartford respectively show no material difference.

Do you want the conclusion on that, Mr. Crow?

1266 Q. Now, doctor, that statement, that it is diluted 1 to 70,000, is upon the assumption that the sewage when it leaves the outfall of the sewers at Alton would become diluted with the whole body of the water of the Mississippi river at that point?

A. Yes sir.

Q. In other words, that there would be a general mixing of all of the waters of the Mississippi river running via the sewage outlets from the outfall of the sewers?

A. Yes sir.

Q. What was it you asked me?

A. I want to know if you want the conclusions of the biological and bacteriological results?

Q. Yes, give that?

A. From these figures it will be concluded from the biological results, that the sewage of the city of Alton has no effect on the sanitary condition of the Mississippi river water at Hartford.

Q. That is six miles below?

A. Yes sir.

Q. Please explain the bacillus prodigiosus; what is the bacillus prodigiosus?

A. The bacillus prodigiosus is a micro-organism, a bacterium that was discovered by Ehrenberg. It is a bacillus a little bit larger than the typhoid bacillus. It is non-spore forming; it is non-pathogenic. It is founded on the word 1267 "prodigious" as I understand it, and comes from the fact that the host sometimes in the chalice in the Catholic Church, has a red growth upon it, which is declared to be the blood of Christ. This red growth was investigated, and it was found in one case to be a micro-organism producing a red material within its cell, a red pigment. You see, the name, this prodigious thing that is the legend connected with this micro-organism.

Q. Yes, put it in there; that is all right; put it in the record.

A. Now it grows freely on all of our media, but it does not grow, as we shall see, very well in river water. It has been very rarely found in the river waters of this country. It is not domestic to the waters of the United States, although I was told that in Egypt it is found abundantly in some of the river waters there, and occasionally in some of the river waters in Europe. It grows freely, as I say, on all of our culture media. It liquefies gelatine; it is non-motile, and produces a red pigment which makes it very easy of identification.

Now in our search of the river waters beginning in August, 1899, and extending through until August, 1900, in every sample of water that we examined, where we were hunting for distinctive forms as well as examining every plate that came
1268 in, this micro-organism was never found. We naturally concluded that it was not a normal inhabitant of the streams under investigation, any of them, and that if at all present, very rarely so.

We have examined over 10,000 samples of water from Lake Michigan, the Drainage Canal, Illinois river and the Mississippi river, and have never found it in any one sample except when we put it in the river ourselves—

Q. Yourself?

A. Ourselves; with these facts in our minds in August—August 31, 1900, we prepared in a forty-gallon whiskey barrel, forty gallons of broth culture of this bacillus prodigiosus, and we grew it for several days in that barrel.

Now that barrel was first sterilized with steam heat; then it was filled with boiling hot water, and that water allowed to stand until it cooled, but while the water was boiling hot, there was mixed into it one pound of Liebig's extract which had been boiled thoroughly before mixing with this solution, so it remained in this boiling hot water until that barrel cooled, which took two or three days—

Q. Now explain in that connection what Liebig's extract is, what was the purpose of putting it into the barrel?

A. The Liebig extract of beef is an extract of beef that 1269 is sold commercially here in the market by the Liebig company. It is an extract of beef made by evaporating beef juice. Now this material as we see it in the market, in porcelain jars in which it is sold, contains quite a number of bacteria, but in order to kill all the bacteria in the extract, we first boiled it thoroughly, besides that we put boiling water in the barrel. Nothing will grow in boiling water, so that if there had been any bacteria remaining alive in that beef extract after we boiled it, it would be killed by the continued heat in that barrel, and it took two or three days to cool sufficiently to allow us to put the prodigiosus in it. The bung was closed with a cotton stopper.

Now we put into that barrel a great number of bacillus prodigiosus, in a broth culture. This particular culture of bacillus prodigiosus came from Europe. It was given to me by Dr. Ludwig Bremer several years ago in this city, and I had kept it in my laboratory growing ever since then.

Q. Now wait a minute.

A. The water, the broth in this barrel was studied, and we found that we had over one thousand million bacteria to the cubic centimeter in the broth in this barrel.

On August 31st, 1900, this broth, containing over one 1270 thousand million bacteria per cubic centimeter, was emptied into the Mississippi river just below the mouth of the Illinois river. That is where the Illinois river discharges into the Mississippi. We carried it up there in the harbor boat, and it was emptied from the harbor boat into the river. On the way down on the boat samples were taken right straight along, of the Mississippi river water, the samples were collected hourly and studied.

September 3rd, four days later, this organism was found in a sample collected in the channel of the river at Alton, but at no other place.

On September 20th, this experiment was repeated, a barrel containing 40 gallons of bacillus prodigiosus broth was emptied at the same point, and on September 23rd this organism was found in a sample collected near the Illinois shore at the Chain of Rocks.

Q. Now, doctor—

A. Shall I go on?

Q. Did you continue this experiment on a larger scale?

A. I am not through with this particular experiment—

Q. Go ahead.

A. On October 18th, this bacterium was found in a sample
1271 collected from the laboratory tap, in the old City Hall,
and on October 24th, found in a sample collected near the Illinois shore, Chain of Rocks.

Q. Now, doctor, you continued this experiment later on, a year or so later on, on a larger scale?

A. Yes sir.

Q. Further up?

A. Yes sir.

Q. On the Drainage Canal?

A. Yes sir.

Q. Now will you please relate what you did there, with reference to putting this bacteria into the water?

A. At Lemont?

Q. Yes, and what was the result of it? How far is Lemont now from the city of Chicago?

A. Well, Lemont is eight miles from the Controlling Works on the Drainage Canal, towards Chicago.

That would make it about twenty miles from Chicago, 21 or 22 miles.

Q. And that is the point in the canal, eight miles above?

A. Eight miles above the Controlling Works.

This was during the third period; 107 barrels of prodigiosus broth each containing 40 gallons were prepared at the old pumping station at the St. Louis water works, Bissell's Point, by Mr. E. J. Ravold, my brother, and shipped to Lemont, Illinois, of the active vigilance of the canal police, successfully emptied miles east of the Bear Trap Dam at Lockport, and in spite of the active viligance of the canal police, successfully emptied in the Chicago Drainage Canal on the evening of November 6th, by Mr. Ravold.

Q. How much bacteria was there in a cubic centimeter of these 107 barrels?

A. There were over one thousand million per cubic centimeter. I examined every one of them myself.

ATTORNEY GENERAL HAMLIN: November 6th, what year?

A. 1901.

Q. ATTORNEY GENERAL CROW: Now what effort was made and at what points, to see if these bacteria came down the river? Well, you go ahead and tell the experiment in your own way.

A. I must say that in the first place I needed a courageous man to do this thing, a very powerful man, and I didn't know where to look for him, except in a brother of mine whom I brought up from Arizona; he knows a thing or two about taking care of himself, and is physically a powerful man, and he handled these barrels, containing 40 gallons of broth, himself. He emptied nearly all of them himself into the canal, as I related to you, on the afternoon and night of that November day.

Now all of the laboratories were notified, and samples were
1273 collected every hour of the day and night at the Controlling Works, Drainage Canal, and at Joliet, Peoria, Grafton, on the Illinois river, and the intake of the water works, Chain of Rocks.

Q. Intake St. Louis water works?

A. Yes sir. We put—our men lived in a room at the Chain of Rocks, and they went down and took the samples—

Q. Went down inside the intake?

A. Sometimes inside of the intake, but that is dangerous business. There is a ladder on the outside of the intake and men went up and down the ladder and took the sample from the river.

Now Mr. Ravold left Lemont rather hurriedly, and went to Joliet, and then to St. Louis, bringing with him six samples from barrels, as they were discharging into the canal. These samples I examined myself, and they contained over 500,000,000 to 1,000,000,000 prodigiosus to each cubic centimeter of broth. The bacillus was not found by Mr. W. C. G. Kirschner, who was stationed at Joliet—

ATTORNEY GENERAL HAMLIN: Now wait a minute, doctor, you are stating now not what you know yourself, but from what they have reported to you?

A. They reported to me. In fact, I went up there.

1274 Q. Then you know this personally?

A. Well, I didn't know; I didn't examine these samples myself. We will get to my own work in this experiment if you wish.

ATTORNEY GENERAL HAMLIN: I want the record to show—

A. I didn't examine the samples collected at Joliet, nor at Peoria, but at Grafton, for a time, and those collected at the intake, and also from the tap of the St. Louis laboratory.

Q. State where you did examine them?

A. I examined personally all the samples collected from December 1st, to December 15th, at Grafton. I examined all the samples that were collected at the intake tower, Chain of Rocks, and every one of the samples from the tap of the laboratory, and that examination continued several months—

Bacillus prodigiosus was found in the St. Louis laboratory in samples collected by Collector Werner, Intake Tower, Chain of Rocks, December 4th, sample was collected at 8:45 a. m.

Another sample taken by Collector Werner at 9:00 a. m. on December 5th contained the prodigiosus.

Q. Now these samples were all taken at the intake?

A. Intake tower, yes sir. Collector Stevenson, Intake Tower, Chain of Rocks, found the prodigiosus at midnight.

The prodigiosus was found by Collector Homer, Grafton,
1275 Illinois, Illinois river, December 6th, at 8 a. m. Found
again in a sample collected by Collector Homer, Grafton,
Illinois, Illinois river, December 7th, midnight.

Q. Now, doctor, go to the characteristics of this bacillus prodigiosus. In the first place give us the longevity of this bacterium in water from the Chicago river and the Drainage Canal and the Illinois river at Pekin and the laboratory tap at St. Louis?

A. A series of experiments were made with the bacillus prodigiosus, Ehrenberg, to ascertain its longevity in samples of water collected from Chicago river, Drainage Canal, Illinois river at Pekin, and laboratory tap, St. Louis. A summary of the results is as follows:

ATTORNEY GENERAL HAMLIN: That is objected to.

A. This is personal work.

ATTORNEY GENERAL CROW: You did this work yourself?

A. Yes sir.

ATTORNEY GENERAL HAMLIN: Go ahead.

ATTORNEY GENERAL CROW: Do you want to put in your objection, General?

ATTORENY GENERAL HAMLIN: No.

A. (Continuing): In laboratory tap water, in sterilized water, 8:00 a. m. to 5:30 p. m., exposed to the direct rays of the
sun—I must say about this sample, a bottle suspended on
1276 a string, about eight feet from the south wall of the house,
so that the sun came upon it early in the morning and left
it at sundown. It was in the sunlight all day. That bacillus lived in this water 48 hours, in sterilized water. Now in the Drainage Canal water, taken above Lockport, not sterilized, in window exposed to sunlight from 11:00 a. m. to 2:00 p. m., it lived ten days.

Drainage Canal at Joliet, not sterilized water, in window exposed to sunlight, 11:00 a. m. to 2:00 p. m., seven days.

In Chicago river, Adams street, sterilized in window exposed to sun, 11:00 a. m. to 2:00 p. m., it lived 11 days.

In Drainage Canal, Lockport water, in non-sterilized water, in refrigerator, temperature 16 degrees centigrade, it lived 32 days. That is, in the dark.

In Drainage Canal water from Joliet, not sterilized, in refrigerator, temperature 16 degrees centigrade, it lived 41 days, and was still alive when the experiment was stopped.

Drainage Canal Western Aveneue, not sterilized—

Q. Western Avenue, Chicago?

A. Western Avenue, Chicago, not sterilized, in refrigerator, temperature 16 degrees centigrade, lived 31 days.

In Illinois river, Pekin bridge, non-sterilized, in refrigera-
1277 tor; temperature 16 degrees centigrade, it lived 53 days,
and was still alive when these experiments ceased.

Q. Now did you make any experiment exposing it to the sunlight in samples of water not sterilized?

A. Yes, I have read that. I said exposed to sunlight in samples of various waters, not sterilized, it lived from two to ten days. In sterilized water, Chicago river, exposed to the sunlight, in window, it lived 11 days.

In refrigerator in the dark, at a temperature of 16 degrees centigrade, it lived 31 to 53 days, and was still alive at the time the work ceased.

Q. Now what does your experiment show about the typhoid bacillus right, in this connection, about its longevity?

A. The results show or demonstrate that in sterilized water, distilled, as well as that from Lake Michigan, Drainage Canal, Illinois river, Peoria and Grafton, Mssissippi river water, intake and laboratory tap, the bacillus lived 61 days.

Q. What bacillus?

A. Typhosus. While in the living water, not sterilized, from Chicago river, Drainage Canal, Illinois river at Peoria and Pekin, Misssissippi river water from the laboratory tap, in the
sunlight, hot summer days, and in the darkness, at 16 de-
1278 degrees centigrade, from 24 hours to 21 days.

Q. What bacillus are you talking about?

A. Bacillus typhosus. This bacillus which lived only 24 hours was exposed similar to the bacillus prodigiosus which I have described heretofore. The bottle was suspended by a string from a rod that projected eight feet from a south wall and the sun came upon it early in the morning, shone upon it all day, of a hot summer day, and left it when the sun went down.

Q. Now from your experiments, it is notable that the typhoid bacillus disappeared somewhat quickly from living waters, more quickly than from steriled waters?

A. Yes sir.

Q. Now in that connection I will ask you to state what you call plankton?

A. Plankton is the floating life in the water, floating vegetable and animal life, microscopic in size.

Q. Now in your opinion as a bacteriologist, does that plankton in the waters of the Mississippi, the Illinois, the Drainage Canal, the Desplaines river, shorten the longevity or would it shorten the logevity of the typhoid bacillus?

A. Not unless it would eat it.

Q. Would it do that?

A. I don't know.

1279 Q. That is an unknown quantity yet, isn't it?

A. That is an unknown quantity.

Q. That is what I wanted to know.

Now have you made a comparative estimation of the longevity of the typhoid bacillus with this bacillus prodigiosus, that you had put into the waters of the Chicago Drainage Canal?

A. Yes sir, I carried on a series of experiments myself.

Q. Well, just give us the result of your experiments, will you?

A. With these micro-organisms side by side, comparative estimation of the longevity of the bacillus typhosus, and the bacillus prodigiosus, in separate samples of water collected at the same time and place, and kept under the same conditions as to sunlight, temperature and darkness, the bacillus prodigiosus in sunlight, in living waters, that is, nonsterilized waters, lived from two to ten days. The bacillus typhosus in sunlight, and in living waters, non-sterilized, lived from 24 hours to ten days.

The bacillus prodigiosus in the dark lived, in the non-steriled, living waters, from 31 to 53 days, and was still alive when the experiments ceased.

The bacillus typhosus, in the dark in living waters, non-sterilized, lived from 24 hours as I stated, to 21 days.

1280 Q. Now is there any resemblance between the bacillus prodigiosus and the bacillus typhosus?

A. Yes, they are both bacilli; they are both non-spore forming, and from the above table it is seen that the bacillus prodigiosus is an organism which closely resembles the bacillus typhosus in its power to resist unfavorable surroundings.

Q. Any difference in their cultural characteristics?

A. Oh yes, widely different, the bacillus prodigiosus being the most easily identified of all bacteria, while the bacillus typhosus is one of the most difficult to identify.

Q. Now, doctor, having carried out these experiments, having treated typhoid fever for twenty years, having been a professor of hygiene in the Washington University, as a practical bacteriologist I will ask you in your judgment, if typhoid bacillus coming from the out-falls of the Chicago sewers into the Chicago river and carried into the Canal, could come into the Intake tower of the St. Louis waterworks, still retaining its vitality?

A. That will depend upon the time that it takes the waters to come from Chicago to St. Louis.

Q. Well, considering your knowledge of the flow?

A. But basing my conclusions upon the experiments that I have carried out, and showing that the Mississippi and
1281 Illinois river water comes into the Intake of the St. Louis waterworks, I am inclined to believe it is highly probable that a typhoid bacillus can live and be carried by water carriage from the Chicago sewers into the Intake of the St. Louis waterworks, especially in high water conditions in the Illinois river.

ATTORNEY-GENERAL HAMLIN: I will enter a motion to exclude that answer as not responsive to the question.

Q. ATTORNEY-GENERAL CROW: Now doctor, does the speed of water affect the life of the bacillus typhosus or the typhoid bacillus? In other words does the rapidity of the current tend to destroy the typhoid bacteria?

A. No sir.

Q. Well, does the volume of water into which a typhoid bacillus may be put affect in any manner its vitality?

A. No sir, it does not kill it.

ATTORNEY-GENERAL HAMLIN: I move that that question and answer be excluded, as not responsive.

Q. Now doctor, you are acquainted, as a bacteriologist, and also as a physician, with the relative number of typhoid bacteria that will be passed with the feces, and with the urine of a patient sick of typhoid fever in the different stages of the fever?

A. Yes sir, I have made—

1282 Q. Can you give me this?

A. (Continuing.) Some experiments on this my very brother who put the prodigiosus in the Canal; he was sick in 1899 and 1900—

Q. With typhoid?

A. With typhoid.

Q. Now will you please give us this experiment?

A. I examined his urine and also his feces once or twice—

Q. To ascertain the number of bacteria?

A. To ascertain whether they were there or not, and in the urine to ascertain the number.

Q. Yes?

A. In the second week of his disease, this typhoid bacillus was found in great numbers in his feces, in the discharges from his intestines.

In the third week they grew less, and in the fourth week they were difficult to find in his feces, but about the end of the second week they began to appear in his urine, so much so, as to be a source of annoyance to him, as to give him trouble, and he began to complain of pain in his bladder, and in the passing of urine. The number of typhoid bacteria in the urine was small, but after a time they reached enormous numbers. I made some calculations, and there were several hundred thou-
1283 sand to the cubic centimeter. I thought that was a pretty large number, but it simply pales before the number found by Petrosky and Mark Richardson. Mark Richardson found bacillus typhosus in the urine of a typhoid fever patient after the second week, 172,000,000 bacilli to the cubic centimeter, of urine. Such urine is very turbid. My brother's urine was turbid when I looked at it. It looked smoky, cloudy.

Q. Now how long will the typhoid patient continue to discharge in the urine, typhoid bacilli?

A. Well, in his urine, after being perfectly certain that they were there in quantity, and were the source of irritation to him, I killed them in his urine by giving him urotropine. That is a drug which is broken up in the intestines, and as a result of this breaking up, formaldehyde is given off. Formaldehyde is destructive to and kills bacteria in urine. This can be done at any time, with any patient, without injury to the patient; but a series of experiments have been made and quite a number of men have been examined and although the typhoid bacilli disappear in the majority of the cases, soon after convalescence, still, they have been found as high as eight years afterwards in the urine of typhoid fever convalescents, 1284 or people practically well of the disease, and there is a surgical case recorded in which eighteen years afterwards, after the typhoid infection, the bacilli set up a suppuration in a bone, so that they were in the bone marrow, and caused a suppuration, an abcess in other words in that bone, and were there detected.

Q. The typhoid bacteria thrown off from a patient in his urine, who has recovered, apparently from that disease, but while it is still passing from his urine, would they be dangerous?

A. Yes sir.

Q. They are vitalized?

A. Highly vitalized, highly virulent.

Q. Is the origin of the typhoid bacteria known?

A. It is found in people sick and dead of the disease. It is found in the intestinal contents of people sick of the disease, and in people dead of the disease—in the cadaver; it is found in the lymphatics of the intestinal wall; in the intestinal follicles. It is found in the so-called mesenteric glands; in the spleen, in the liver, in the kidney, in the marrow of bones, and in the living subject it has been found floating in the blood.

Q. In the blood?

A. Yes, that is one of the tests for typhoid fever now.
1285 A definite quantity of the blood from a typhoid fever patient is taken out of him, and sown into broth, and the bacillus searched for and if found the case is typhoid.

Q. And if the bacilli are found he has—

A. He has typhoid fever.

Q. What if they be not found, is it an absolute test that he didn't have it?

A. No sir, we would make the experiment over and over again. One test itself is not enough. One negative test is of no value in making a diagnosis.

Q. I will ask you if it has ever been possible, so far as you know, to determine the absolute longevity of the typhoid bacillus in running water?

A. It is almost impossible to do it, and it is not known.

Q. Why is that?

A. Because the conditions which obtain in a running stream cannot be produced in the laboratory experiments, and to put living typhoid bacilli in the living water, a water that was being used by human beings, to drink, would be simply pure murder, so that the experiments cannot be made in a living stream.

Q. Now do other bacteria in the water prey upon the typhoid bacteria?

A. They do not eat one another.

1286 Q. No form of bacteria?

A. No sir.

Q. Does the action of anerobic and the aerobic bacteria in disorganizing organic substances in the water destroy the life of the typhoid bacilli?

A. That seems to be the reason why they disappear in the stagnant waters in our laboratory experiments, we find that when we take water for instance from the drainage canal, that it contains on an average of three or four hundred thousand bacilli to the cubic centimeter. We sow typhoid bacilli in this water and for the first two, three or four days the water bacteria not the typhoid bacilli, increased enormously, and use up the nutritive material in the flask for food. The results of this destructive action on the organic matter both solid and liquid in the water results in the production of poisons. True toxin and enzymes and these products seem to act not only deleteriously upon one another but upon the pathogenic micro-organism in the water also, so that we see in the laboratory experiments that the bacteria in the living waters die much quicker than they do in steril distilled waters, or than in river waters sterilized.

Q. But in the water in the running streams of course there is no means of judging of the results of that?

A. No, the conditions are these: That the toxins or products produced by water bacteria that are deleterious to 1287 the typhoid bacillus would be greatly diluted by the flowing water. Besides, typhoid bacillus is a mover, it can swim and get out of the way of anything that would be deleterious to it in a river, get out of the way of them, he can swim away.

Q. And that is the reason then that the typhoid bacillus can exist in water highly charged with sewage, because of the fact that he has motility and can move away from these toxins?

A. Yes sir.

Q. Which he cannot do in the laboratory experiment where he is confined?

A. No sir.

Q. Now, the speed of the water in which a typhoid bacillus should be placed, and the longevity of the typhoid bacillus are the two factors, are they not, from a bacteriological standpoint, that would determine how far by that current a typhoid bacillus would be carried?

A. Yes sir, speed and time are the important factors.

Q. And in making the estimate then in the running water where there was an active current, you would not as a bacteriologist consider as retarding, the distance to which the germ might be carried, in any manner by the extent of sewage pollu-
1288 tion that might be in the water up to the point where the sewage pollution did not interfere with the flow of the current?

A. No sir.

Q. Now, have you got a record there of the experiments you made as to the longevity of the typhoid bacillus in these waters?

A. Yes, sir.

Q. Would you please turn to them ? I want to put them in this record right at this place.

ATTORNEY GENERAL HAMLIN: Didn't he have that in once?

ATTORNEY GENERAL CROW: I think he did, in his general testimony but I want it put in the record right here.

A. I have here a table on the longevity of the typhoid bacillus in the steriled water. I have the original papers for all this if you want to submit them. Also here is the paper or book, where the records were made daily.

Q. Well, you can bring them down?

A. But I have got total results here on the paper? This is the chart.

Q. That is better.

A. This is for the third period of our investigation in
1289 1901. Longevity of the typhoid bacillus. Non-steriled water. Location.

Q. Well, now non-sterilized—

A. That is non-sterilized, that is living water.

Q. Then say non-sterilized or normal water?

A. Yes, sir.

Q. Of what streams?

A. These samples now were kept in a window facing south exposed to the sun, and I have a table showing the temperature number of hours of sunshine and the conditions of the water for that day. Another set were kept in a refrigerator at a temperature of 16 degrees centigrade.

Illinois & Michigan Canal Water taken at Lockport. The samples was collected on July 5th. The day's alive 4. We found it for four days. The water bacteria in the meanwhile had increased in enormous numbers. All other bacteria had decreased.

The Drainage Canal, Western Ave., Chicago, Date June 13th.

I must say that these samples were collected one day by my collector and inoculated by me the next day after collection. They were kept cold in the meanwhile.

June 13, days alive five, in the sunlight.

Days alive in the refrigerator June 13, seven days.

In the window, sample collected July 5, days alive seven.

1290 July 5th in the refrigerator eight days.

Drainage Canal—

Q. Now, wait a minute Doctor. What was the condition with reference to whether or not that water was polluted with sewage?

A. Oh, it is sewage polluted water.

Q. Was it what is termed bacteriologically, crude sewage?

A. Well, crude sewage would mean sewage floating in the sewer. It was a discharge of sewage mixed with water which contained over 500,000 bacteria when I got it, to the cubic centimeter.

Drainage Canal, Lockport, above the Controlling Works. Now this is above the Controlling Works.

In the window, date June 13, alive four days.

In the window July 5th, alive eight days.

July 17, in the window alive eight days.

In refrigerator, July 5, days alive ten.

July 17, days alive eleven.

Drainage Canal below controlling works.

Q. Now, wait a minute. What was the condition of the water in which these last experiments were made as to whether or not it was polluted with sewage?

1291 A. Oh, yes it was sewage polluted water. It was taken from the Drainage Canal above Lockport.

Q. Greatly polluted or slightly?

A. Oh, yes, it was greatly polluted. It was sewage containing anywhere from 500,000 to two or three million bacteria.

Drainage Canal below Controlling Works at Lockport, that is 9th Street Bridge at Lockport, samples collected on June 13th, and it lived in the refrigerator nine days.

The sample collected July 5th and put in the window was accidently broken.

Drainage Canal, Jackson St., Joliet. Sample collected by myself July 17th. Mr. Charles W. Bates was with me, the City Counselor. It lived nine days in the sunlight July 17th and lived 13 days in the refrigerator.

Illinois River above Peoria is the next place.

Samples collected June 13. Bacteria lived five days.

Sample collected July 5, Bacteria lived 10 days. In the sun this is, in the window.

July 11th, in the window lived eight days.

1292 In refrigerator June 13, lived 10 days.

July 5, lived 13 days.

Illinois River, bridge, Pekin. That is below the bridge. In window June 13, days alive four.

Sample collected July 5, days alive 10.

In the refrigerator, in the dark, same place, June 13, lived eight days.

July 5, lived 21 days.

July 17, lived 16 days.

Q. Is that in the sunlight?

A. That is in the refrigerator, 21 days there.

Chicago River, Adams St., June 13, in the sunlight lived four days.

In the refrigerator June 13, lived four days.

July 5, lived seven days in refrigerator.

The sample colected on July 5th and in the window was broken, I dropped it.

Tap, laboratory St. Louis, sample collected June 13, in window bacillus lived seven days.

In refrigerator bacillus lived twelve days.

Now, if you want the distilled and steriled waters indicated here we can put them in.

Q. All right, you can put them in.

A. Longevity or life of the bacillus typhosus in sterilized
1293 water?

JUDGE SPRINGER: I desire to enter an objection to that statement with reference to the longevity of the typhoid bacillus in sterilized water as no such condition can exist in reference to the case pending?

A. (Continuing) We have environments or surroundings, rather, and we have the three cultures, A B and C. Now, in distilled water in total darkness at 10 degrees centigrade, lived days—

A culture 51 days
B " 25 "
C " 22 "

Mississippi River water, Grafton. Total darkness, 10 degrees centigrade, days alive.

A Culture 59 days
B " still alive at the end of 65 days when this experiment was ended.
C culture 40 days

Drainage Canal water above Controlling Works at Lockport in total darkness, 10 degrees centigrade, lived:

A culture 45 days
B " 65 days, when the experiment ceased.
C " 22 days.

Missouri River at Bellefontaine, total darkness 10 degrees
1294 centigrade:

A culture 59 days

B culture 59 days
C " 57 "

Mississippi River water, Intake Tower, total darkness 10 degrees centigrade:

A culture lived 59 days
B " " 59 "
C " " 34 "

Distilled water, total darkness, 20 degrees centigrade, A, B & C cultures,

Distilled water

A culture lived 22 days
B " " 54 "
C " " 30 "

Mississippi River water at Grafton, total darkness, 20 degrees centigrade:

A culture lived 65 days
B " " 37 "
C " " 65 "

Drainage Canal above Lockport:

A culture lived 54 days
B " " 54 "
C " " 65 days and still alive when the experiment ceased.

1295 Missouri River water Bellefontaine, total darkness, 20 degrees centigrade:

A culture lived 65 days
B " " 65 "
C " " 57 "

Mississippi River water intake, total darkness, 20 degrees centigrade:

A culture lived 54 days
B " " 55 "
C " " 54 "

Distilled water, open window, months of July, August and September 1900. These experiments were all made in 1900. Distilled water, open window:

A culture lived 22 days
B " " 25 days

C culture lived 45 days

Mississippi River, Grafton:

A culture lived 65 days
B " " 45 "
C " " 60 days.

Drainage Canal, Lockport, open window:

A culture lived 40 days
1296 B " " 31 "
C " " 22 "

Missouri River, Fort Bellefontaine water, open window:

A culture lived 65 days
B " " 65 "
C " " 65 "

Mississippi River water Intake:

A culture lived 65 days
B " " 46 "
C " " 45 "

That is the end of that.

Q. Now, Doctor, I will ask you if you know whether or not any other bacteriologist ever made any experiment with these waters?

A. I don't know. I know that Dr. Jordan examined the longevity of the typhoid bacillus in the lake water. He is recorded as having had it live 90 days.

Q. Do you know whether or not any bacteriologist ever made any experiments as to the longevity of the typhoid bacilli in the Mississippi River water beside yourself?

A. No, sir.

1297 Q. Wasn't there a man at Minneapolis who made some experiments?

A. That was Westbrook, but whether he made any experiments on longevity of bacteria I do not know.

Q. He was the man that found typhoid bacillus.

A. He was the man that found typhoid bacillus in the water at Minneapolis?

Q. Now, what heretofore had been regarded as the effect of sunlight upon the typhoid bacillus?

A. Supposed to destroy it quickly.

Q. Was it ever successful, was its life ever successfully prolonged for any period of time beyond a few hours prior to your experiments?

A. Oh, yes, there have been experiments of this kind. Mr. Westbrook has made some himself.

Q. How long did he get it to live in the sunlight?

A. There was a conversation in which we discussed the question of the life of the bacillus typhosus in sunlight in living waters.

Q. Well, what is your scientific knowledge on the question?

A. I haven't any except what he has told me, except that this destruction of bacteria within a few hours in the sunlight or the destruction of the typhoid bacilli by sunlight in water, in a few hours, is a myth; it is not so.

1298 Q. Well, has the sunlight any effect on the longevity?

A. Yes sir, if they are exposed directly to the sunlight.

Q. What is that effect?

A. To destroy them.

Q. To destroy them?

A. Yes sir.

Q. What is the result of that as to what portion of the stream with reference to being light or dark or in the light, or coming into the darkness, would the typhoid bacillus naturally seek?

A. They would naturally seek the darker regions.

Q. Where would that be found?

A. It would depend upon the character of the water, whether it was turbid or not. The sunlight probably could penetrate to do them harm in the Illinois River, say one foot, probably not any more than that.

Q. Do you know at about what mean depth of the stream the change in the current occurs from the surface?

A. Well, I know that the surface of the river, that the water on the surface does not flow so fast as water just a foot or two below the surface, and that the water at the bottom of
1299 the stream moves much slower, so that there would be a
curve in the stream, representing the effect of air in retarding the flow of the water, and the effect of the sides and bottom upon the flow.

Q. The friction?

A. The friction. So that the curve would be—I have seen it demonstrated by Mr. Seddonys before the Academy of Sciences. It would be an O. G. or something like that.

Q. Well the fact is that the most rapid moving portion of the stream is at a point somewhere between the bottom and the surface?

A. Yes sir.

Q. And not either on the surface or on the bottom?

A. Yes sir.

Q. And the result of that would be, so far as typhoid bacteria is concerned, that if it sought shelter from the sunlight, that it would descend towards the more rapid portion of the stream?

A. Yes, unless it got to the bottom.

Q. Yes, unless it got too far down?

A. Yes sir.

Q. Now do you know whether or not any experiments have ever been made—in the first place, did you ever make 1300 any experiments for the purpose of determining whether or not the silt and mud and sand in the bottom of the stream will destroy the life of the typhoid bacteria?

A. Well, the artificial, laboratory experiments are difficult to carry out—

Q. No, I say in the bed of the stream.

A. I never made any in the bed of the stream itself. I have taken mud from the Drainage Canal at Brandon's Bridge, and mud from the river at Peoria and tried to ascertain the longevity of the typhoid bacillus in that, but it is almost impossible to obtain accurate results from those experiments.

Q. That is the fact which the circumstances surrounding it, render it impossible almost to accurately determine from actual experiments?

A. Yes sir.

Q. Now from your knowledge as a bacteriologist, and from the knowledge you have of the Chicago Drainage Canal, the Des Plaines River, the Illinois River, the Mississippi River, and the distances, and the speed of the streams, can you state whether or not when the water is running through the Chicago Canal, with the sewage running into it, bacteria could come from 1301 the Drainage Canal into the Mississippi River?

A. Yes sir. I think the bacteriological experiments indicate that bacteria discharged by the Drainage Canal especially in high river stages, are carried into the Mississippi River by way of the Illinois River.

Q. Well, do you say that as a fact?

A. Yes sir.

Q. Now from the same state of facts, above mentioned, as to the rivers and the relative geographical location of the Illinois River, the Mississippi and the Chicago Canal, etc., do you say, or can you say whether or not the bacteria coming out of the Illinois River, being discharged into the Mississippi River may or do enter the Intake of the St. Louis Water Works?

A. I think they not only may, but they do, and I base this statement upon the bacteriological investigation that has been conducted by me from 1899 to the present time, from special experiments that were carried out which lead me to assert that they do from the mixture of the waters that takes place at the Intake.

Q. Now can you state from your bacteriological examination, the average number of bacteria found in the Intake of the St. Louis Water Works?

A. For that 1900 period, I think it is 76,000—wait a minute —(Reading) Contain on an average of 72,600 bacteria—

1302 JUDGE SPRINGER: What period?

A. This is Mississippi River water, Intake, St. Louis Water works—contain on an average of 72,600 bacteria per cubic centimeter, and bacillus coli communis 62 per cent of the times.

JUDGE SPRINGER: You didn't state the time?

A. Mississippi River, taken at the Intake, St. Louis Water works, during this whole investigation.

JUDGE SPRINGER: Begins when and ends when?

A. That would begin January 23rd, 1900, and extending through that period to October.

Q. ATTORNEY GENERAL CROW: Now, is the bacillus, coli communis always a non-pathogenic bacteria?

A. Bacillus coli communis,—oh, no.

Q. Is it a pathogenic bacteria?

A. Yes sir.

Q. Does its presence always destroy the potability of water?

A. No sir.

Q. When does it destroy the potability of water?

A. I don't know that it ever does.

Q. Well, what is it about the bacillus coli communis that makes it contaminate water?

A. Well, I cannot say that it contaminates at all; it is an index of pollution.

1303 Q. Is the bacillus coli communis itself dangerous?

A. Taken in drinking water?

Q. Yes?

A. No sir.

Q. Is it never dangerous to the human being?

A. It is never dangerous to the human being, except when injected beneath his skin, or when it gets out into the blood stream or lymphatic stream from the intestinal canal. It is one of the most active causes of appendicitis.

Q. Is it the sole cause?

A. Oh no. It is probably the greater percentage of times, —it is the bacillus coli communis that is the cause of the inflamation in the appendix. Then besides, it appears in a great many secondary affections. It appears in an ordinary throat trouble, such as folicular tonsilitis, and in the secondary affections following typhoid fever. When this micro-organism gets into the blood, which it does sometimes, it follows up the destructive action of typhoid bacillus on the body. It produces very uncomfortable conditions.

Q. What are they; what are the symptoms?

A. The secondary poison that follows the affection of typhoid, or secondary fever that comes up after typhoid the great prostration emaciation, sweating, etc. that follow;
1304 in fact it produces a condition resembling some what typhoidal poisoning.

Q. They are caused by the bacillus coli communis?

A. Yes sir.

Q. And they are enabled to cause this condition by reason of the weakened condition of the system?

A. Yes sir.

Q. Which in the same person perhaps, in a normal state of health, it would not affect?

A. Yes, and sometimes they have been found in abcesses alone.

Q. They are injurious to any kind of an open sore, are they?

A. Well, no, I think not. An open sore is able to take care of itself.

Q. It throws them off, does it?

A. Yes sir.

Q. Then a large number of bacillus coli communis in drinking water is considered unpotable?

A. It is looked upon as an index of fecal pollution in a stream.

Q. Well, are they classed as pathogenic bacteria?

1305 A. They are not by the water bacteriologists, but by the pathologists, on account of the pathologic conditions which they produce, which I have already explained, they are classed as pathologic when they get into the tissues.

JUDGE SPRINGER: Pathogenic?

A. Pathogenic, yes sir; that would be the better word. You can say pathologic too.

Q. ATTORNEY GENERAL CROW: Can you state from your examination bacteriologically of the waters in the Intake of the St. Louis Water Works, the Mississippi River at St. Louis Water Works, whether or not that water supply is pure or impure, and if it is impure whether it is a menace to the health of this city?

A. Bacteriologically it is an impure water; it is not a potable water, and it is unfit for human consumption. That is, as it flows in the river.

Q. Do you know whether or not there is any difference of opinion among bacteriologists, as to whether or not the bacillus coli communis is one form of typhoid bacilli?

A. I think no true working bacteriologist believes that the bacillus coli communis is anything else than the bacillus coli communis, or that the typhoid fever bacillus is anything else than the typhoid fever bacillus. There may be varieties which approach one another closely, but it would be just the same thing

as asking an oak to become a maple, as to assert that a col-
1306 on bacillus could become a typhoid bacillus, so that has
never been experimentally shown by any system of treatment, that either micro-organism has been encouraged to change into the other—that a typhoid bacillus became a bacillus coli communis, or a bacillus coli communis became a typhoid bacillus.

Q. Now, I will ask you this question, doctor, is there any form of bacteriological life that is more highly vitalized than typhoid bacteria, except a spore form?

A. Some of the non-spore bacteria are more resisting than typhoid.

Q. What is one?

A. The bacillus prodigiosus is just a little bit hardier.

Q. Well, there are very few of them?

A. There are very few of them?

Q. It is considered one of the highly vitalized and hardy bacteria?

A. Yes sir.

AMAND N. RAVOLD.

ADJOURNED until 10:00 A. M., Tuesday, March 10th, 1903, at Southern Hotel, St. Louis.

1307 Southern Hotel, St. Louis, Mo. 10:00 a. m., Tuesday,
March 10, 1903.

Present, the Commissioner and same counsel representing the respective parties.

DR. AMAND NICHOLAS RAVOLD, resumed the stand for further direct examination by Mr. Jeffries and testified as follows:

Q. Dr. Ravold, distinguish the difference between the life of typhoid bacillus in bottles and in running water, if you can?

A. Well, water in bottles?

Q. Yes?

A. A series of experiments were made by us by placing the typhoid bacilli in various waters, steriled, distilled water, steriled river waters, or steriled waters rather from Lake Michigan, the Drainage Canal, the Illinois River, the Mississippi River, the Missouri River, and the laboratory tap. Then a

series of experiments were carried out upon living waters, that is, waters collected at Chicago in the Chicago River, and the Chicago Drainage Canal at Western avenue, the drainage
1308 canal at Lockport; in the Illinois River at Peoria and Pekin; in the laboratory tap water, St. Louis.

It was found that in the distilled water the bacteria lived—that is the typhoid—

ATTORNEY-GENERAL HAMLIN: Excuse me; hasn't this been introduced once?

THE WITNESS: Yes, but we are talking again now.

MR. JEFFRIES: Just state it briefly, doctor?

A. In distilled waters, the average time in total darkness, was 35 days, and in the open window, 31 days; while in the steriled waters the average time for the Mississippi River water at Grafton was—the lowest was 52 and the highest was 57 days.

Q. Days?

A. Yes, days, alive.

Drainage Canal at Lockport, the lowest was 31 days in the window and 58 days in darkness.

Missouri River at Bellefontaine, the lowest was 55 days. That was in total darkness, and in the open window 65 days That is when the experiment stopped.

Mississippi River water at the Intake, the lowest in darkness was 51 days; in the window 52 days.

Now, then, we will go on to the living waters—

Q. We went over that yesterday with you, but what I want you to do if you can is to distinguish the relative import-
1309 ance of these examinations with a view to determining the life of the bacteria in running water?

A. Well, to do that I will have to show you this table. The fact that the micro-organism lives in distilled water which contains no food—

Q. Then do it in your own way?

A. That is what I will have to do. I will have to make a large circle to reach it, to get to your question.

Now, we find that in distilled, steriled water, without food whatever, the bacterium lives a great number of days—the bacillus typhosus; that in a water from these rivers which have the bacteria killed in them, although they still contain many of the toxins produced by the bacterial life that was in the water; still, in these waters they live a great number of days. You see when some of our experiments stopped here, 65 days after the bacilli were put in the water the bacilli were still alive.

Then we go to the living waters. Now, in these living waters the bacteria—

Q. You mean in bottles?

A. Yes. These samples were collected at the various stations and shipped to me in ice. The bacteriological contents were obtained by plating. Now, it was seen in these ex-
1310 periments the numbers of bacteria ascertained in samples
shipped from these various points, throughout this investigation were. Now, into the water sample were sown typhoid bacilli, the attempt being made to sow typhoid bacilli and nothing else, no food with it. Now, in these living waters, the bacteria, the living bacteria, the so-called water bacteria, both in the window and in the dark ice chest where the bottles were kept, the bacteria increased enormously. In the window they increased much more rapidly than they did in the ice-chest, so that at the end of three or four days in the window, the maximum number of bacteria were reached. That is, from thousands they had increased to millions. The bacteria increased in the water because they had food there. When they exhausted that food as a result of their destructive activity, they stopped growing. That is one reason. And the other is that the toxins produced by them, the poisons that they produced as a result of this destructive activity, are deleterious to one another—in some cases killing directly.

Now, here we have a typhoid micro-organism which lived a number of days in distilled waters and other steril waters without bacteria, disappearing in a short while in living
1311 waters. However, the bacteria lived, as we saw, from
four days in the window to as high as 21 days in some of the samples. Now, what was the cause of this disappearance of these micro-organisms in the living waters?

Q. That is typhoid bacilli?

A. Typhoid bacillus that we had sown there.

Q. In the bottles?

A. In the bottles, in the living water, non-sterilized. The particular cause of the disappearance—there are various theories—

ATTORNEY-GENERAL HAMLIN: There are what?

A. There are a number of theories that have been advanced as the cause of the disappearance. First, planckton in the water. These are the lower form of animal and vegetable life that float in the water and are accused of feeding upon bacilli. This is not substantiated by any scientific proof. That is one theory.

The second is the absorption of food supply by the associated bacteria. Now, we saw that it is not necessary for the typhoid bacilli to have food to live. The distilled water experiments show that they live without food for a number of days in water. Then there must be something else in the water, and the next theory is the destructive action of the toxins produced by the associated bacteria, upon the typhoid bacilli and this undoubtedly is the cause of our inability to discover them in these experiments in the water for a number of days.
1312 Now, this lack of ability to discover does not mean that the bacteria were dead, necessarily. It means that we were unable to encourage them to grow artificially on the nutritive media that we supplied them. We don't say that the micro-organism in that flask if taken into the intestinal canal of a man would not grow. We simply mean that with our methods we are unable to encourage them to grow. Now, it is well known that it is impossible to produce in a laboratory experiment in a flask, the conditions which exist in a running stream, and that conclusions drawn from what is known to take place in a laboratory flask and applied to what is supposed might occur in a running stream, must be made with caution. As already stated, in the laboratory flask, the food supply is quickly exhausted by the associated bacteria. The toxins produced accumulate and remain, to the detriment of the typhoid bacilli sown in the water, but in the running stream these conditions do not obtain. The water is in constant motion, carrying away the toxins produced, the food supply is more abundant, and the bacteria less numerous, and the poisons produced by them greatly diluted, and as I said, quickly carried away, and further, the micro-organism can swim away inasmuch as it is motile—from uncomfortable surroundings.

1313 Q. Now, you are talking about the typhoid bacillus?
A. Yes, sir, the typhoid bacillus.

It would, therefore, seem that the conditions which make for the prolongation of the life of the typhoid bacillus in a running stream, would be more favorable than in the stagnant water of the laboratory experiment.

That is what you want, is it?

Q. That is it. Now state in your opinion, and from the examinations that you have made of the water in the canal, the Des Plaines, the Illinois and Mississippi Rivers, how long the typhoid bacilli would live in the running water in going from Chicago to St. Louis?

A. Well, drawing conclusions from the laboratory experiments we find that the bacteria live from four days to as high as 21 days —

Q. That is in a flask?

A. In the laboratory flask, in living, non-sterilized waters. Basing conclusions on them, I would be inclined to believe that the bacilli would live much longer in a running stream, living water, than that period.

Q. How much longer?

A. Anywhere from fifteen to thirty days, and that would be a very small limitation.

Q. A conservative estimate?

1314 A. A very conservative estimate.

Q. Now, you spoke with reference to the period in which the bacilli would be vitalized and capable of producing disease when injected into the human system?

A. Yes, sir.

Q. You are speaking of the typhoid bacillus?

A. Typhoid bacillus.

Q. Doctor, assuming that it requires the water seventeen days to run from the sewage openings at Chicago, down the river to the canal, the canal to the Des Plaines, the Des Plaines to the Illinois, and thence to the Mississippi; the intake at the Chain of Rocks, and thence into the reservoir, when in two days thereafter it is distributed and used by the people of St. Louis, what would you say with reference to typhoid bacillus discharged into the Chicago Drainage Canal through the sewage system of Chicago, finding its way into the water distributed to the people of St. Louis as above described, and be sufficiently vitalized to produce disease, and taking into consideration your actual experiments with the typhoid bacilli in connection with the water in the various streams through which it would run?

ATTORNEY-GENERAL HAMLIN: I object to that on the ground that the question fails to include the material facts sworn to by Dr. Ravold in regard to his experiments with 1315 the typhoid bacillus, and on the further ground that the question fails to assume that the typhoid bacillus was present in the waters of the Chicago River or Drainage Canal.

THE COMMISSIONER: Note the objection.

Q. MR. JEFFRIES: Go ahead, doctor.

A. Now, the time consumed, then, in traveling from Chicago, of the sewage would be 17 days in the river to the Intake and three days—that is twenty days. I think it highly probable from my experiments that typhoid bacilli discharged by the sewage system of Chicago into the Drainage Canal, could live—retain its vitality the while, enter the Intake of the St. Louis Waterworks, and be distributed to a user of the water sufficiently vitalized to cause disease in a susceptible individual.

ATTORNEY-GENERAL HAMLIN: Now, I move to exclude the answer on the ground stated in the objection to the question.

Q. Now, in connection with your answer to the last question and taking into consideration the great number of typhoid bacilli that come from a patient afflicted with the disease, and all other information that you possess on the subject—from the examination that you have made, what would you say with reference to the typhoid bacillus finding its way into the reservoir and water supply of St. Louis?

ATTORNEY-GENERAL HAMLIN: The same objection 1316 as to the previous question.

Q. MR. JEFFRIES: That is, assuming that these immense numbers of typhoid bacilli coming from a patient afflicted with the disease were discharged into the sewage at Chicago?

A. Well, do you want me to say whether I believe typhoid bacilli are in the Chicago sewage?

Q. No, that is not the question. The question is, assuming that they are there; that the bacteria, the typhoid bacteria—the immense number of them coming from a patient afflicted with the disease, are discharged into the sewage at Chicago?

A. Well, as I said before, I think it is highly probable that they could be carried into the Intake and reservoir of the St. Louis water supply, and retain their vitality meanwhile.

Q. Would they be sufficiently vitalized when found in the water supply at St. Louis to produce disease?

A. I think so. I would not like to try the experiment upon myself.

Q. State the length of time in your opinion the typhoid bacilli would live in the waters, running between the City of Chicago and the City of St. Louis, and being sufficiently vitalized when arriving in the water supply of the City of St. Louis to produce disease?

1317 A. I said 15 to 30 days. I thought I had answered that question. That is a conservative estimate.

Q. Doctor, explain the disappearance of bacteria in running water?

A. We find—take the drainage canal, for instance, at Lockport, where the drainage canal discharges into the Des Plaines River, we have great numbers of bacteria, ranging from 50,000 to many millions per cubic centimeter. A little lower down we find that there has been a decrease in that number. At Peoria we find a remarkable decrease sometimes.

Now, what was the cause of the disappearance of these bacteria which were in such large numbers at the drainage canal and lower down have decreased in number?

A number of theories are advanced. We have first—it was for a time thought that the mere aeration of the water and especially the agitation, shaking, would devitalize bacteria, but it has been shown by—

ATTORNEY-GENERAL HAMLIN: Doctor, would you just as leave put in there what you mean by aeration?

A. Aeration means adding air to the water, and it was thought that the oxygen of the air would injure the bacteria. It is known that the oxygen in the water causes the anaerobic bacteria to cease their activity, but the experiment, as I say, has shown that agitation and aeration do not kill the bacteria and consequently do not reduce the number.

1318 The next is dilution. Now, we find that the Des Plaines river and other rivers, as the water flows along from the drainage canal, are added to the total quantity passing over the dam. So here we have quantity of water. We can look at it in this way: if we have a quart of water containing 100 bacilli and we add 99 quarts of water to that one quart and shake it up we will have one bacterium to one quart of water. In other words, dilution removes the bacteria further apart, so that in taking a particular sample from that water we do get less numbers to a definite quantity of water. The bacteria, however, are all there, but simply removed further apart by the quantity of water that is added to it.

Next we come to the action of sunlight on the waters. During these experiments throughout we noted the conditions of water we collected on hot summer sunshiny days—sunshiny days in winter and on cloudy days in summer and winter, but there was very little difference noted in the numbers of bacteria in the samples collected, between bright sunlight shining on the stream and the gloom of a foggy day. And the depth that the sunlight can penetrate to the injury of bacteria is not very great. Of course, it is more in clear waters than in turbid waters and the actual depth to which the rays can penetrate to the injury—say of typhoid bacteria, we have shown
1319 by laboratory experiments, in a flask where the sunshine was on them all day on sunshiny days that they still retained their vitality quite a while. Now, those were summer days when the action of the actinic rays was said to be the most active. So that sunlight does very little towards decreasing bacteria in a given quantity of water.

Now, we come to the important consideration in the cause of the disappearance of bacteria, and that is sedimentation. Take sewage, for instance, discharged into a given quantity of water, if it be solid feces discharged into the water, part of the sewage immediately goes into solution, just the same as if you add sugar to the water. Other parts of it are solid and float along. Those particles are heavy, and if the stream is not too rapidly flowing, fall to the bottom and form the black muck on the bottom of the stream. These falling heavy particles carry with them the bacteria which follow them for food to the

bottom of the stream and break it up so that the mere falling of the sedimentary particles has something to do with the disappearance. Then the bacteria themselves are particulate particles. They have weight—not very great, that is true—but still those that can not swim are gradually carried to the bottom of the stream and we find in our experiments as I can show, that one or two feet below the surface quite a number of bacteria will
1320 be found, but down near the bottom of the stream much larger numbers are found, showing that these bacteria are carried down and are there alive. So sedimentation, then, has a great deal to do with the disappearance of bacteria in a running stream.

Now, this does not mean that the bacteria are dead. It simply means that they have been carried to the bottom of the stream and remain in the muck and slime at the bottom of that stream. These solid particles which are black, the feces or organic matter are broken up first, by the aerobic bacteria—those bacteria which live best in the presence of oxygen and the oxygen in the air in the water is soon used up, then begins the destructive and liquefying action of anaerobic bacteria which breaks up this material, and in the breaking of it up produce gases and these gases in septic tanks can be conducted off and used as gas to burn in a lamp, for instance. The gases that are produced by these bacteria are nitrogen, carbonide oxide, C.O.2, Metham's H.H.4, March gas and hydrogen. These last two burn easily. So that I say from a septic tank these gases can be conducted away and burned—these gases on the surface of the water—have been set on fire. I believe that happened on the Chicago River once.

Well, these bacteria then break up the food supply which is on the bottom of the river, and as it is liquified, it is
1321 carried along. If a stream is rapid moving, the bacteria are carried very much further. If the stream is a slow moving one or the water becomes stagnant, stands still, the bacteria eventually are precipitated to the bottom. Water flowing into a lake, for instance, would have large numbers of bacteria at the point of entrance of the stream, while at the point where the water passes out of the lake, very few will be found in a definite quantity of water, because the bacteria had fallen to the bottom. Not dead, but there.

Now, there is another reason given for their disappearance, and that is exhaustion of food supply. This depends on whether the food is exhausted, whether the sewage is all broken up in the stream before it gets to a definite place. That may have something to do with it. But, in my opinion, dilution and sedimentation are really the prime factors and the cause of the disappearance of the bacteria in a running stream.

Q. That what?

A. That sedimentation and dilution are the prime factors in the causation of the disappearance of bacteria in a running stream.

Q. What would be the effect of these bacteria that have gone to the bottom by the force of sedimentation in case or a freshet, a washout, or an increase in the flow of water
1322 in the river.

A. I said that the ordinary river water bacteria and sewage bacteria that are carried to the bottom of the river by sedimentation are not killed by that process and a freshet coming along would take them up and carry them further down the stream and as far as the velocity of the stream will carry them. If the river was moving slowly they would be deposited much sooner than if the stream was running rapidly, and this same reason can be applied to the pathogenic bacteria which lie in the mud and the slime at the bottom of the stream.

Q. Now, as particularly applied to the typhoid bacilli?

A. If they were carried to the bottom of a stream they would not necessarily be killed by that process and the first freshet that would come along or dredging boat or by whatever method this mud would be stirred up and put into the water the bacteria would be carried further down the stream.

Q. In this connection do you place any weight on th longevity of the typhoid bacilli?

A. Yes, sir.

Q. That would be quite a factor, wouldn't it?

A. Yes, sir.

Q. State, Doctor, whether or not the agitation of the water will cause the disappearance of the bacteria?

1323 A. No. Water has been shaken thoroughly and in some of the experiments it seemed to increase the numbers in the water, seemed to be favorable to growth, it would rather increase the number than decrease them if food were present.

Q. On that same principle, then, that would apply to a swift running stream?

A. Yes, sir.

Q. What did you say with reference to the disappearance on account of the planckton?

A. I spoke about the planckton in the water, that is the moving microscopic animal and vegetable life in the water. Now, some of those are infusorial life and it is contended that some of these infusoria take the bacteria into themselves and digest them. But take the Illinois River and the small number of infusoria in it, it would have very little effect upon the total number of bacteria in a definite quantity of water, if it were true that they do feed upon the bacteria.

Q. Well, what do you say as to that?

A. I haven't any personal knowledge as to that. That is an extremely difficult experiment to carry out.

Q. What do the various authorities say on the subject?

A. Some authorities seem to think that some of the infusorial life do take up the bacteria, but as I say that is an
1324 extremely difficult thing to prove.

Q. Well, there are authorities that take up with the opposite theory?

A. Oh, yes, there are others who believe nothing of the kind occurs.

Q. Doctor, you may at this time, I suppose, explain the method used in cultivating these typhoid bacilli that you experimented upon in the water of the Mississippi River and the canal?

A. Well, what you want to know is where I got my cultures that we used in the experiments?

Q. Yes, explain the whole process.

A. The typhoid cultures used in these experiments were:

No. 1. That in the living water experiments, that was received from Doctor F. F. Westbrook of the University of Minnesota. It was said to have been found by him in the living waters of the Mississippi at Minneapolis.

No. 2 came from a spleen sent to me by Dr. W. C. G. Kirchner from a patient dead of typhoid fever at the city hospital and was separated out by me in my laboratory July 8, 1902.

Now, that spleen when received was cut across a raw surface exposed under aseptic precautions and small particles of
it taken out, that is small particles were sown in broth
1325 and placed in an incubator. In the tubes a vigor-
ous growth of the bacteria occurred which in stained preparations showed a pure culture of a short, thick bacillus. This broth, some of it, was plated on two different kinds of media, that known as Elsner's medium or potato gelatine, and Hiss medium, that is a gelatine agar medium of a definite reaction. Now, the colony growth on both these media are quite characteristic of typhoid bacillus. Characteristic colonies were now picked off from the Hiss medium, and sown on the surface of slant agar agar in test tubes. A vigorous growth occurred and this growth was put through a series of special media and tested with the blood serum of a typhoid fever patient, in Widal's reaction, for the purpose of being certain that the micro-organism we were dealing with was the true typhoid bacillus. It proved to be a true typhoid bacillus both in form motility, in cultural characteristic and by Widal's tests.

Now, this bacterium on this slant agar grew abundantly and a loop, a planinum loop—I want to give you the size of that loop—well, it matters not. Three loopfuls of this growth upon the agar were taken off the surface of the medium, care being taken that none of the medium was scrapd up with the growth.
The growth was sown into living water in a flask, the
1326 water in the flask stirred up so that the bacteria were
disseminated throughout it and an attempt made by plating immediately to ascertain the number of typhoid bacteria to the cubic centimeter of water.

Now, then these flasks containing water from the various sources—each flask contained 200 cubic centimeters—were placed, some in a window facing south and others in an ice chest in the dark. Those exposed to sunlight in the window, the direct rays of the sun impinged full upon the western flask in the window at 10:45 a. m. and left the flask furthest east at 2:15 p. m. The total time of exposure daily being about 3 hours approximately to the sun of the hot summer days.

These experiments were made in June and July.

Now, each day a cubic centimeter of this water was taken out and plated in Hiss and Elsner media. The Elsner medium was kept at 20 degrees centigrade. The Hiss medium was put into an incubator at 37 degrees centigrade. The next day, that is 24 hours after, the colonies on the Hiss medium which looked like the typhoid colonies, having the colony characteristics of the typhoid, I should say, were picked off and sown upon slant agar agar. On the second and third days the same thing
1327 was done for the Elsner medium, for the colonies upon
the Elsner medium. When the typhoid bacteria began to be scarce or were few in number upon the culture medium, instead of at once plating in Elsner and Hiss medium the water was first sown in broth kept at 37 degrees Centigrade for 24 hours. A cubic centimeter of this broth was then sown into a broth containing Parietti's fluid, 5 to 7 drops of it to 10 cubic centimeters of broth in test tubes. The reason for this is, that acids such as carbolic and hydrochloric acid which Parietti's solution contains, prevent the growth of many kinds of water bacteria, while they do not interfere with the growth of the typhoid bacilli. After 24 to 48 hours' growth, depending upon the turbidity of the specimen in the broth tube, this broth was now plated again in Hiss and Elsner medium and studied for colony characteristics and the results here reported are the results of this work.

Now, then, the growths which were obtained on slant agar, were first studied for purity of culture, then stained for form, then sown in broth, litmus milk, glucose, agar and Dunham's solution for the production of indol. Besides this the bacteria obtained were tested with the Widal method upon blood
1328 serum that came from a patient just dead of typhoid
fever. It was discovered that quite a number of motile water bacteria agglutinated or clumped in this serum, in a solution of one part of blood serum to 30 of normal salt solution. On this account a series of tests were made with the dried serum. Definite quantities were weighed and mixed with a normal salt solution in varying proportions and it was found that in a dilution of one to 150, both the Westbrook and the Kirchner cultures would agglutinate firmly in one hour at 37 degrees centigrade.

So all suspected bacilli picked off the plates were made to conform to this test, dilutions of 1 to 150 for one hour, 37 degrees centigrade; otherwise rejected.

I have those tables, on the charts, if you care to have them. This is a resume of the work. I have a chart showing that work as it was carried on daily.

Q. You have them here?

A. I haven't them with me but I can submit them.

Q. That is the method that you pursued in reference to two tests or all of the tests that you made?

A. Well, for proving the presence of the typhoid bacillus in living water, in the experiments carried out in June and July, 1901.

Q. That is to prove its longevity in this water?

A. Yes, sir. 1902, that would be June and July 1902.

1329 In the other experiments where distilled water and steriled waters were used there were no other bacilli present, so that the mere plating showed the presence of the typhoid bacillus at once.

Q. And at all times?

A. Yes, whenever it was plated. It did not need the exhaustive method and the great care and detail that was so essential in this other experiment. By the way, this was my personal work. I did this myself, every bit of it, except collecting samples, and I collected two of those samples.

ADJOURNED until 2 o'clock p. m. same day, Tuesday, March 10, 1903.

1330 Southern Hotel, St. Louis, Mo., 2. p. m. Tuesday, March 10, 1903. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

DR. AMAND NICHOLAS RAVOLD.

Resumed the stand for further direct examination by Mr. Woerner.

Q. Doctor, this morning you were engaged in explaining a method used in your experiments with reference to the typhoid bacillus. Now, I will ask you to explain the method used by you in the examination and tests made for the bacillus in the waters of these various rivers during these various periods of examination?

A. You want me to begin at the beginning then?

Q. At the beginning, yes?

A. When I began the work it was apparent at once that an apparatus must be devised that would permit us to collect aseptically a specimen of the water from the river and that this apparatus must be a rigid one, a strong one, in order to collect
the samples in the Mississippi river, the Mississippi river
1331 and the Missouri river, on account of speed of the rapid
current.

This apparatus is the result of a great deal of thought on that subject by Dr. Kirchner and myself.

Q. Now, when you speak of this apparatus you have reference to complainant's exhibit No. 15?

A. Complainant's exhibit No. 15, yes. And with the aid of the machinist of the water department this apparatus was built. It consists of an oblong piece of metal having at its center concentrically arranged, 45 degrees apart, four small posts about 1-4 inch high. The diameter of this piece is 2 1-4 inches so as to hold the bottom of the bottle snugly. From either end arise perpendicularly two tubes 14 inches high, connected at the top with a cross bar and another cross bar 4 inches above the base. Along one of these erect tubes to the right is a clamp with a screw arrangement for tightening. This moves freely up and down upon the tube, allowing it to be brought snugly over the neck of the bottle and there clamped so as to hold the bottle securely. Now, arising from these two cross bars is a handle, or rather a hollow tube, 22 inches long, with a handle arranged at the top. Through this hollow tube a small solid bar passes with a trigger through the handle of the apparatus. This small bar connects with a clamp, which can be securely clamped to the
cork in the bottle. Between the lowest cross bar and
1332 when pulled up, the cork is removed from the bottle and
when the trigger is released the spring just mentioned
pushes the cork back into the bottle.

Now, instructions were given to the collectors. These were the instructions that were given to the collector, the directions for collecting bacteriological samples—they were written by me and typewritten by Dr. Teichmann's typewriter and each man received the instructions:

"The small bacteriological bottle has been sterilized and must not be opened in the air. Put the bottle in the machine and fasten the clamp tightly on the stopper. The stopper must not be taken from the bottle in making the attachment. Now plunge the collecting machine containing the bottle at least two feet below the surface of the water in that part of the river where the current is most rapid. Now pull the trigger in the handle which will lift out the stopper and allow the bottle to fill. When the bottle is filled remove the apparatus from the water, take the bottle out of the machine carefully and put a piece of tinfoil over the stopper and neck of the bottle. Over this put a piece of cloth, cotton domestic. Now tie a tag to the neck of the bottle bringing the ends of the string together and seal on the top. Now put carefully into the inside cylinder
1333 in the shipping bucket. Put cover on cylinder; then pack in ice. Close the lid of this bucket and seal."

Now, in this way, samples were collected in 4 oz. bottles, which were carefully sterilized in a dry oven at a temperature of 150 centigrade for over one hour.

Q. That is, the bottle was sterilized before the sample was collected?

A. The bottle was first sterilized, then it was wrapped in tissue paper, placed in a box and sent to the station where the sample was to be collected, and the instructions to the collectors were such as I have just read.

The sample having been collected it was shipped in ice. It was received at the laboratory and immediately placed against the ice, awaiting plating, which took place as soon as possible. So we see that throughout this investigation the water was collected in steriled wide mouthed glass stoppered bottles as I said, containing 4 oz. or about 100 cubic centimeters, with this apparatus which was designed, by us.

Now, when received at the laboratory and placed on ice the water in it was treated as follows:

The bottle was thoroughly shaken before plating, at least 25 times. The bacteriologists of the American Public
1334 Health Association say the bottle should be shaken 25 times in order to have the sediment and bacteria evenly

distributed throughout the water. Besides this shaking of the water air was blown through this so as to distribute the sediment throughout the water. Then one cubic centimeter was taken out and put into a Petri dish.

Now, I call attention to the fact that the water was put directly into the Petri dish and not into a tube. If it were found necessary to dilute the specimen this one cubic centimeter was mixed with nine,—99, 999 or 9999 parts, depending upon the experience of the individual who did the plating.

This was thoroughly mixed with the steriled distilled water with which this one cubic centimeter was mixed, and from that one cubic centimeter of water was taken.

In making the dilution the idea in mind was not to have more than 250 bacteria at any time growing upon a plate,—an ideal condition was 150 to 250 bacteria upon a plate.

The nutritive medium was then poured into the plate, mixed freely with the gelatine, put on a level surface and when the gelatine hardened, put into an incubator running at a temperature of 20 degrees centigrade.

1335 When the bottle was received in the laboratory, the seal was removed and the information upon the tag recorded in a book. The location, temperature of air, temperature of water, name of collector, and any other remarks that the tag contained were recorded. This tag was kept and put to one side and they have been exhibited here.

The cloth and the tinfoil were then removed and before opening the bottle the neck of it was heated in the free flame of a Bunsen burner to kill any bacteria that might be around the mouth of the bottle. Then, as I say, one cubic centimeter was taken and either plated directly or diluted—generally diluted from one to sometimes as high as 10,000, depending upon the number of bacteria that was supposed to be in the water. Two plates were made.

Now, in 1899, at the Chain of Rocks, they were kept in an ice chest and the temperature carefully watched—

MR. JOHNS: Do you mean in 1899?

A. Yes, in 1899, the samples were kept in an ice chest at the Chain of Rocks and the plates counted there at the end of three days.

In the 1900 period until May, the samples went to the St. Louis Medical College, bacteriological laboratory, and when the sample was plated the plates were put into a closet. The 1336 temperature ranges of that closet are here recorded in charts, showing that the temperature ranged from 18 to 20 degrees constantly. There was a slight variation, colder in the evening as a rule than in the morning. For a time the temperature of this closet was regulated by ice. In this closet were also placed vessels containing water so that the atmosphere of this closet was constantly saturated. When we removed to the old City Hall on Eleventh Street between Chestnut and Market Street, an old vault in this room was utilized as an incubator. It was carefully prepared, padded and had double doors. In this closet or vault were placed self-registering thermometers, the wet and dry bulb thermometer for recording moisture and ice.

The plates were placed in this chest at a height where it was found the temperature did not run over 20 degrees centigrade. At intervals of every few hours a record of the temperature was made upon a chart on the door. There were double doors on this vault and it was very easy to pass in and out without disturbing the air in it very much.

I think the average for the months from May to the latter part of October, of temperature in that vault was 19 degrees centigrade for the plates. The plates were kept for three days.

1337 Now, the idea of the moisture here was to have an optimum growth of bacteria and it was found that in a moist atmosphere the bacteria grew better than if the atmosphere were dry.

Now, the media in which these bacteria were grown was gelatine, the best Gold Seal gelatine was used, 12 per cent. having been found the best throughout this experiment and the reaction 1.5 per cent. acid phenol phthalein.

A series of investigations were made to ascertain the optimum reaction—or rather, put it the other way—the reaction which would give optimum results, and these are recorded in a table—in a series of tables.

Q. What do you mean by optimum results?

A. The largest number of bacteria that will grow upon a medium.

Q. That is the largest number?

A. The largest number that will grow.

Q. The largest number of any particular bacteria?

A. All bacteria that were in the water.

Q. Of all kinds?

A. Yes, sir.

1338 Now, here is a table showing the number of tests—or the number of tests showing the optimum growth on media of different reactions.

Location, Lockport.

Number of samples 3 at 1.5 per cent. acid.

I want to say, and for the benefit of the stenographers also, that where we say "Acid," if you will just put "plus" in front of the figure, it means that it took 1.5 per cent of acid in the media. While if you put minus in front of it it means that it was alkaline to the per cent that will be read.

Number of tests.

Lockport, 1.5 per cent acid, plus—3.

Number of tests at 2, the optimum reaction in which the greatest number of bacteria grew was 1.5 per cent.

Joliet. Medium containing 5-10 per cent acid, one test, 1.5 per cent acid,—2, and at 2 per cent, acid—1.

I can give the table to be inserted, and I can give the results, the table showing a summary of results of the growth of bacteria on media of different acid reactions.

The points from which these samples were taken—location, Lockport, that is, above the Bear Trap Dam, Joliet. 1339

Peoria,
Illinois River, Grafton
Mississippi River, Grafton
Mississippi River, Alton
Mississippi River, Hartford
Missouri River, Fort Bellefontaine
Mississippi River, Intake Tower
Reservoir at the Chain of Rocks
Illinois Shore, Chain of Rocks

Missouri Shore, Chain of Rocks

Tap

The total number of tests in a media showing a neutral reaction were five.

In media showing a 5-10 per cent reaction, were 4.
Medium showing a 1 per cent reaction were 5.
Medium showing 1.5 per cent acid were 35
Medium showing 2 per cent reaction were 20.
Total percentage in neutral medium 7.
In medium of 5-10 per cent reaction 6 per cent.
In medium of one per cent reaction, 7 per cent
In medium of 1.5 per cent reaction, 51 per cent.
1340 In medium of 2 per cent reaction, 29 per cent.

The best medium then was shown to be medium of a recation of 1.5 per cent acid for all of these waters in our experience.

JUDGE SPRINGER: I don't think we need any more than that. You have given the results of the table.

THE WITNESS: If the stenographers want that table I can tear it out and give it to them; the results are sufficient.

JUDGE SPRINGER: I don't think that is needed, the results are sufficient.

THE WITNESS: The results of this work extending throughout a year show that the medium which gives the optimum reaction was a medium 1.5 per cent acid, and this reaction was adopted throughout all of our work.

Now, with each plating, in order to discover any errors that might take place, one cubic centimeter of distilled water was always plated with gelatine. The number of bacteria that would grow upon this medium would show the errors that would occur. This was done especially during the summer months
on account of the heat in the laboratory and the fact
1341 that when air currents were blowing through the labora-
tory at all times in opening a Petri dish and pouring the water into it—the diluted water into it—and then the gelatine on top of that and stirring about, there was a definite time in which the gelatine was exposed to the air, and these errors were sought for and it was found that as a rule there were very few. The error was about 2 bacteria to a plate but sometimes as high

as 15 bacteria were found during the summer months when the atmosphere of the laboratory was so warm and wind blowing through. So as you see, the check was kept constantly upon our results.

At the end of three days the plates were counted depending upon whether they were not liquified before that time. Sometimes there are so many liquifying bacteria in the waters that they liquefy the gelatine before the end of three days. So the colonies upon a plate were counted at the end of 48 hours, or the plates placed on ice to retard the growth and counted at the end of three days This necessitated a daily inspection of plates.

Shall I congratulate the man that did this?

JUDGE SPRINGER: You might as well.

A. This work was very earnestly and efficiently carried out by my very able assistant, Dr. W. C. G. Kirchner, who did all
of the plating from January, 1900, to October, 1900,
1342 in St. Louis and in Joliet in the bacteriological labora-
tory located there from September 26 to November 27; at the St. Louis Medical College from January 23rd up until May, two men, Dr. W. C. G. Kirchner and Dr. William H. Rush plated samples so that four plates were made from each sample of water that came in, each man preparing two plates and each man counted the other man's plating—

Q. Besides counting his own?

A. Besides counting his own, and the average of those countings were made. When we removed to the old city hall the work came entirely under Dr. Kirchner's care and the quantitative determination of the number of bacteria per cubic centimeter—a series of tests were also made constantly with all media prepared.

A lot of gelatine is prepared and labeled 1, 2, 3, and consecutively to the end of the investigation and a series of plates were made to ascertain upon each medium the decrease or the increase of percentage of growth between the two kinds of media, a very simple algebraic formula—B minus A, divided by A,
very easily gave the percentage on the plates of increase
1343 or decrease of each medium. Five litres of media of
gelatine were made at a time. It was stored in flasks.

The top of the flask was sealed with tinfoil. This allowed very little, if any, evaporation of water from the medium. When needed the medium was immediately tubed and sterilized, so the medium was always fresh and new when the platings were made with it. In the intervals it was kept in the ice chest near the ice,—little evaporation was possible taking place. It was kept in a saturated atmosphere and these records, if you care to have them, go in there—it makes a series of very long tables—

Q. No, you have given your results.

A. Yes. I have not only had the total results given, but I have had charts prepared showing this increase or decrease in the respective media as they were made.

I can give the method of making that media. It is one adopted by the American Public Health Association Bacteriological Committee.

Now, I want to say that this media up to the 1899 period was prepared by Dr. W. C. G. Kirchner. In the 1900 period, from January until May, it was prepared by Dr. Kirchner, Dr. Rush and Mr. Martin Schmidt, who was the janitor of the
1344 laboratory at that time.

Schmidt was an educated man, was trained in the laboratory methods and after three months was found skilful enough to prepare this medium, and probably is to day one of the most skilful media makers in the world, for his experience is as large as anybody's. He prepared all media from May until the end of the work in 1900, and during the 1901 period prepared all media used in the St. Louis laboratory.

The solutions of hydric oxide and hydric chloride that were used in these experiments were prepared by one man, tested by several, myself and my assistants before being used upon the medium.

I would like to give the method of preparing that medium.

Q. Well, that is what I want.

A. To make gelatine, it is first necessary to prepare broth. Broth in this laboratory was prepared in the following manner.

To each 500 grams,—1 lb.—of finely chopped lean meat add one litre of distilled water and allow it to macerate in a cool place from 18 to 24 hours; strain the infusion and press out the juice at the end of that time, using a cloth or a meat press.

Make up to the original quantity if necessary by the ad-
1345 dition of water, and after adding one per cent of dry
peptonenittes and five per cent of sodium chloride to the
filtrate measure the height of the fluid in the vessel or weigh it
on a balance.

Third: Heat over a water bath for 25 minutes and then boil for five minutes over a free flame. When all the ingredients are dissolved rendering the mixture slightly alkaline to litmus by the use of a normal solution of sodium hydroxide.

Fourth: Add water to make up for the loss of water by this cooking. Allow it to cool. Filter in standardized stock. If nutratitive broth to be used, fill in flasks or tubes and sterilize. Keep all the stock broth in a cool dark place and protect the mouth of the flask with tinfoil to prevent contamination or evaporation.

To nutrient gelatine and the broth stock here made is added two per cent of Gold Seal gelatine or a good quality of gelatine or when making up a lot directly from the meat infusion described in the preparation of broth proceed as in the first article, adding the gelatine with peptone and salt. After measuring the fluid heat over a water bath for 25 minutes and
when the gelatine has dissolved render the mixture
1346 slightly alkaline to litmus by the addition of the 4 per
cent solution of sodium hydroxide. It will then be practically neutral to phenol phthalein. Allow it to cool in a temperature between 45 and 50 degrees centigrade and for each litre stir in the white of one egg mixed with water; make up the loss due to evaporation by the boiling of the water and test to see if the reaction is slightly alkaline to litmus. Boil for five minutes over a free flame, stirring to prevent scorching and to make up the original quantity by the addition of water. Filter through filter paper or cotton, measure the filtrate and test the reaction and standardize to 1.5 per cent with phenol phthalein as an indicator in the titration. Fill in test tubes and when properly plugged sterilize for 15 minutes on each of 3 successive days, or once for 15 minutes in an autoclave under 6 lbs. pressure. The medium should now be perfectly clear and should remain solid at 24 degrees centigrade. Keep the standardized stock media properly labeled in a cool dark moist place.

Now, this is the method of preparing the gelatine which was used throughout this investigation.

1347 In the second period instructions were sent to the bacteriologists, typewritten—at Grafton, Peoria and Joliet. The gelatine was not prepared in St. Louis and shipped to them, but the test solutions for titrates on phenol phthalein were prepared in the St. Louis Laboratory and sent to each laboratory, the bacteriologist having been instructed in the St. Louis laboratory before going to their respective stations, upon the method of making this test and the color of the indicator desired.

In counting bacteria and in recording results the following scheme as arranged by Fuller and Johnson was adopted. Mr. Johnson was a member of our laboratory staff and was the originator of this method—he and Mr. Fuller.

The number of bacteria absolutely in a water are almost impossible to obtain. The idea is to have the greatest number that will grow upon a nutrative medium and this nutrative medium which we prepared and kept at a certain temperature under moist conditions brought about optimum results, so that the number on this medium is relative and not absolute.

Now, in order to facilitate the counting the number of bacteria per cubic centimeter, from 1 to 50 were recorded
1348 to the nearest unit.

From 51 to 100 were recorded to the nearest 5.
From 101 to 250 to the nearest 10.
From 251 to 500 to the nearest 25.
From 501 to 1000 to the nearest 50.
From 1001 and over to the nearest 100.

Further, a series of experiments were made by collecting samples at the points from which samples in this investigation were taken, plating them immediately, collecting similar samples at the same time, placing them in ice and allowing them to remain under the conditions which would obtain in a sample shipped from a station to the laboratory. We plated directly otherwise and then at the end of a definite time plated again, in six hours, 12 hours, 24 hours, 36 hours, to notice the increase or decrease in the number of bacteria.

I can put these tables in, they are great big fellows.

JUDGE SPRINGER: Oh, no.

MR. JEFFRIES: It is of no use to go into these tables, Doctor.

A. But it was found that as a rule in samples tested during this investigation that there was a loss of bacteria
1349 in the majority of cases. In some cases there was quite a decided gain, reaching as high as 35 per cent in one case of gain and as high as the loss of 50 per cent in another case, so that the numbers during these months packed on ice would show a decrease in the samples collected from these particular points which you say you don't care to record in the table.

When the sample was received at the laboratory, tests were also made from it for the presence or absence of the bacillus coli communis. During this investigation several methods were used. In the beginning this work was entirely under my care. I did it. A method known as the Thiebold Smith method, by which a cubic centimeter of water was added to a Dextrose broth, and a fermentation tube was used. The bacilli coli communis in the presence of sugar breaks the sugar up into carbon dioxide and hydrogen forming these gases, and these gases collect over the fluid in the closed arm of the fermentation tube. If the bacillus coli communis is young and active, as high as 60 per cent of gas is produced. It was thought that this was a thoroughly reliable method in the beginning, but every fermentation tube whether it contained gas or not, was plated by me for the purpose of ascertaining whether the coli really
1350 grew from tubes that did not produce gases and it was found that occasionally this was so, and later an effort was made extending through quite a number of months for the purpose of ascertaining the reason why this is so and it was found that the older the bacilli coli communis becomes the more it loses its power to break up sugar and produce gases. So, after three months' trial of this method, although the results are comparable throughout that period, the method was rejected.

The next method tried was the Wertz agar method. In this method glucose and litmus are added to a nutrative material known as agar agar. One cubic centimeter of water was added to this material—in the presence of sugar the bacillus breaks the sugar up and forms a little air bubble and it also decolorizes the litmus turning the blue litmus red, so that it was easy to pick off the coli bacillus. It exploded the medium with its little gas bubble and also turned the litmus red around it. A little later along a different method was adopted. In plating on a Wertz agar plate, that is, litmus agar plate, a number of bacteria grew freely, spoiling the work—retarding the work.

1351 In order to prohibit the growth of water bacteria that would interfere with the results, Parietti's fluid consisting of 100 parts of water, 5 parts of carbolic acid and 4 parts of hydrochloric acid, were added to a glucose broth—10 cubic centimeters in a test tube received five drops of this solution. When the sample was taken from the bottle one cubic centimeter was put in with this Dextrose broth, first containing the Parietti's solution and put in an incubator and grown from 24 to 48 hours, depending upon the turbidity of the broth. It was then plated in Wertz agar. Any old bacillus coli communis that were present had been encouraged to grow in this nutrative media in a warm temperature, first from 24 to 48 hours and then after being sown upon the plate would explode the medium by the production of gas and also decolorize the litmus—not decolorize but turn the blue litmus red, and the colony characteristics were quite marked and they were easily picked off the plate.

This work and this method fell to Mr. Snodgrass, who carried that work out from January until the latter part of May, 1900.

In the second period, 1901, at the St. Louis laboratory, this work fell to Mr. Philip Damon, he using the same
1352 method in this period of 1901.

Mr. Philip Damon also did the quantitative determination of the number of bacteria per cubic centimeter of water collected from Missouri River at Fort Bellefontaine
Mississippi River at Alton
Mississippi River at Hartford
Mississippi River at the Intake Tower
Mississippi River, Missouri Shore
Mississippi River, Illinois Shore
From the reservoir at the Chain of Rocks.
Reservoir at Bissell's Point
The tap in the laboratory at 1141 Market Street
And the tap from Garfield Avenue.

Mr. Damon every morning went to the Chain of Rocks. As soon as the samples were collected by the collectors they were brought ashore and plated in a room set apart for him by the Water Commissioner at the Chain of Rocks,—the Chicago bacteriologist doing the same thing, plating at the same place,—samples taken directly from the river. Mr. Damon carried to this Chain of Rocks station a sample, first from the reservoir at Bissell's Point, and a sample taken from the Chain of Rocks reservoir and these were plated there.

1353 Mr. Damon was an extremely ingenious young man and devised a very clever receptacle for carrying plates after they were plated. They were then carried from the Chain of Rocks laboratory to the bacteriological laboratory at 1141 Market street. This apparatus as well as this collecting apparatus was adopted by Dr. Jordan in charge of the bacteriological work for the drainage canal.

First, after the micro-organism—coli bacillus, supposed to be—was picked off the plate, it was sown upon agar agar, and if the growth looked right it was picked off and sown in glucose gelatine, that is, gelatine containing 1 per cent. of Dextrose or glucose was inoculated with it, also a tube for the production of the indol and a litmus milk tube inoculated and these were studied afterwards for the identification of the micro-organism.

If gas was produced in the gelatine and the gelatine not liquified, confidence was felt that this was the colon, but the different tests—the test for indol and the coagulation of milk and the reddening of litmus were also noted. So each micro-organism was carefully studied culturally before it was identified positively or negatively as a bacillus coli communis.

1354 A great deal of special work was carried out in the laboratory, especially on the search for distinctive forms of bacteria in the waters of Lake Michigan, Chicago Drainage Canal, Illinois river, Mississippi river, Missouri river and Intake reservoir. This work fell to my very able assistant, Mr. Johnson, whose work has been here recorded in the charts and tables showing the species of bacteria collected at the various points mentioned.

Now for that coli bacillus the following features considered as diagnostic for the identification of this organism, bacillus true form, motility determined in broth cultures two days old, production of gas without liquefication of Dextrose gelatine, production of indol, coagulation of milk, reduction of nitrites to nitrates, characteristic fecal odor of culture—

ATTORNEY-GENERAL CROW: You are through with your method that you want to put in, doctor?

A. Yes sir.

Q. MR. JEFFRIES: Now, doctor, state the cause of typhoid fever and the manner in which it is conveyed?

A. The cause of typhoid fever is a micro organism which
was discovered by Ebert and Koch independently in the
1355 intestinal wall of cadavers dead of the disease and later
studied by Gaffky who had separated it out into pure culture, so that it is known as the Koch-Elbert-Gaffky bacillus, or the bacillus typhoid abdominalis or the bacillus typhosus, or the typhoid bacillus.

This micro-organism is found in the intestinal canal of people sick of the disease; in the follicles and lymphatics of the mucous membranes of the intestines; in the messenteric glands; in the spleen; in the liver; in the kidneys; flowing in the blood: sometimes in the rose spots or eruptions that occur on the skin; in the brain, and is discharged from the body in the feces and in the urine.

Now, no animal other than man suffers with typhoid fever and in order for him to have the disease it must be taken into the intestinal canal, either though the mouth or through the nose and through the throat and thus into the alimentary canal. In the alkaline fluids of the small intestines it finds a congenial habitat and grows and multiplies enormously, producing toxins which, coming in contact with the mucous membrane
of the intestines, especially the mucous membranes near
1356 the lymphatic glands or the lymphatic tissues themselves
cause an exfoliation of the superficial lying cells, making a way for the entrance of the micro-organism into the lymphatic stream and thus into the various organs which I have already described.

So then in order for a man to get the disease he must take the bacillus into his mouth. There are a variety of ways in which he can do this. Principally by drinking the micro-organism in the water contaminated with it.

There are other methods also by which it can be conveyed.

It has been shown that the micro-organism will live quite a long time in earth and that when this earth is dried and blown about as dust the micro-organism retains its vitality for quite a while in it and when this dust is blown around in the air, into the nose of the individual, and if it goes so far in the nose as to be carried into the throat and down into the stomach, or if a man be a mouth breather and takes the micro-organism directly into his mouth, it may be carried into the intestinal canal in that way. But that is just one of the very remote possibilities.

A second method is by direct conveyance from sick to well
in nursing an individual. Attendants waiting upon a pa-
1357 tient sick with the disease, in handling the bed clothes,
or soiled linen or other material about the patient may have their hands inoculated with it and thus convey it into their mouth by picking their teeth or picking their noses or without washing their hands go to table to eat food and in this way convey it directly to the mouth.

I had a bacteriologist working for me in my laboratory, working on feces from typhoid fever patients who acquired the disease in this way.

The blowing of dust from sheets or soiled linen about a patient may convey the bacillus into the atmosphere and thence into man. It may be carried in food, food such as raw oysters fed at the mouth of a sewer. This was shown by Conn of Wellesley. He showed that an epidemic of typhoid fever was produced by eating raw oysters which had been fed at the mouth of sewers.

Or the micro-organism may be conveyed by flies as was shown to be the case among the soldiers in the typhoid epidemic that broke out among those stationed at Chicakamauga and Jacksonville, Florida. Here it was shown that swarms of flies would feed in the latrines in which the dejecta of the men were thrown, but that as soon as the mess was served, the food cooked and served on the tables the flies left the latrines in

1358 swarms and crawled all over the food of the soldiers carrying the infective feces with them. The skilled man who investigated the Chickamaugua epidemic, Professor Vaughn, and others, were convinced that flies were instrumental in a large degree, in causing the epidemics, for the typhoid was conveyed from the latrines to mess, the flies flying from the latrines to mess two or three times a day, having upon their feet the infected feces.

And then another method of conveyance is by milk, any direct infection from the hands of people who nurse sick people having the feces upon their hands or men having a walking case of typhoid, having their own bacilli from urine and feces upon their hands and conveying it directly to milk or to water put in milk for the purposes of sophistication, the water having the typhoid bacillus in it. Milk is a good nutritive medium in which to grow the bacillus. They grow in milk without producing any apparent change in it, so they may exist in large numbers in milk and not render the milk offensive.

Now, these are practically the secondary methods of conveying it.

The primary method is by infected water.

Does that answer your question?

1359 It has also been conveyed by vegetables, raw vegetables, such as lettuce sprinkled with typhoid water, or celery. Celery properly cleansed, of course, would not convey it.

Q. Now, what is the usual method by which it is conveyed?

A. Infection by polluted water.

Q. Polluted with what?

A. With the dejecta of typhoid fever patients containing the typhoid fever bacillus.

Q. Now state, doctor, the effect of the degenerated bacteria upon the human system, that is the character, whether the typhoid germs that produce mild cases—

A. Well, there is a double question and there is a double barrelled answer in that. This requires two ways of answering it.

We have an individual on one side and a micro-organism on the other. The micro-organism is more or less virulent. The individual is more or less susceptible. In an individual not susceptible or a very little susceptible to the typhoid infection, if he had sown in him a very virulent typhoid bacillus he will have a very mild attack of typhoid. hardly incapacitating him for business. He is tired, he may have a little headache and things like that, but not so uncomfortable as to make him 1360 leave his work. In fact it was shown that among the soldiers at Chickamaugua quite a number who were affected mildly would rather attend to the military duties required of them than go to bed, and walked about with typhoid fever. Some of them were quite sick and walked about rather than go to the hospital.

If we have a virulent typhoid bacillus sown into a susceptible individual we have a very malignant attack of the disease which may end in death. So on the other hand, we may have a micro-organism whose virulency is greatly reduced, sown into a highly resisting individual and it will have no effect upon him whatever. It will pass through him and out or be killed in his intestines, or if it is a very weak micro-organism that is sown in an individual of very low resistance he may have a more or less mild attack of typhoid fever. Does that answer the question?

Q. Yes.

JUDGE SPRINGER: Will you state what you mean by susceptible to disease, that is to the typhoid fever?

A. I mean that a micro-organism taken into the individual grows. It may happen to any one of us, but we are able to produce in our bodies anti-toxin matters that destroy the 1361 poisons that are absorbed from the intestines and some of us are more able to produce these antitoxins, that is all, that is, they produce antitoxic substances in quantities sufficient to combine and destroy all the toxins conveyed by a given number of typhoid bacilli in our bodies. Others are not able to do this and when that condition obtains typhoid fever results so that there are varying degrees of susceptibility in an individual.

JUDGE SPRINGER: Susceptibility means then, a greater or less power of resistance?

A. Yes sir. I may say this, that an individual once having had the typhoid fever is generally immunized for life. A second attack of typhoid fever is a rare thing.

ATTORNEY GENERAL CROW: Now, we would like to have 10 or 15 minutes conference and then we may turn him over to you right here. We want to reserve the privilege of putting Dr. Ravold on with that map when we get it.

ATTORNEY-GENERAY HAMLIN: Certainly, that is all right. I think you can shorten this cross-examination by conferring a little, so we may as well adjourn.

Adjourned until 10 o'clock sharp the following morning,
Wednesday, March 11, 1903.
Southern Hotel, St. Louis, Mo.
1362 10:00 A. M., Wednesday, March 11th, 1903.
Continuation, pursuant to adjournment.

Present the Commissioner and same counsel representing respective parties.

DR. AMAND NICHOLAS RAVOLD

resumed the stand for further direct examination by General Crow and testifies as follows:

Q. Dr. Ravold, what is the most specific test for typhoid fever in the case of an examination of a patient?

A. What is known as Widal reaction, that is, taking the blood of a patient sick of typhoid fever and diluting it a definite number of times and the mixing with it a typhoid bacillus in broth of recent culture, and allowing the mixture to remain in an incubator for a definite number of minutes or hours. In the experiments which I have made, in which I have examined something like 6,000 specimens of blood from typhoid patients, I found—arrived at a definite method of working. The first thing to ascertain is the dilution necessary, a specimen of blood sometimes would clump in dilutions as low as one to 30 and others in dilution as high as 300, depending upon the amount of the clumping material in the blood and the age of the disease, that is, whether it is in the first week, second week or third week.

Now when the dilution is found that will give the best
1363 results with a stock culture of B. typhosus in an incu-
bator after one hour at a temperature of 37 degrees centigrade, that dilution is to be used for testing bacilli—And if the bacilli submitted do not clump under the given conditions they

must be excluded. This is the best known test for separating the typhoid bacillus from any other of the forms which resemble it.

Q. So there are many other forms of bacilli that resemble the typhoid germ?

A. Oh, yes sir, I have presented here in my table—I had a table here, a chart, showing the different varieties of bacteria found in the water at various stations on the rivers, lake and canal. We have what is known to us as the pseudo-typhoid group; that is bacteria which resemble in form and cultural characteristics quite closely the typhoid bacillus, but if when it was put to this severe test of clumping with the blood which was diluted a definite number of times it did not respond, then it was thrown out as not the true form, but belonged to the pseudo-typhoid group.

Q. Now, Doctor, did you make any experiments with water that came into the intake tower of the St. Louis Water Works between the 1st and 15th of February, 1900, and if so, was there any time at which you observed any special turbidity in that water?

A. Yes sir.

1364 Q. Just state?

A. Samples coming in between the 8th and 20th, on the definite date at that particular time, the samples were so markedly characteristic in appearance, from Peoria, from Grafton, from the Mississippi above Alton, Hartford and on the Illinois shore, and the Mississippi water from the Mississippi above Grafton, and the Missouri river at Bellefontaine, that the naked eye appearance of these waters was remarkable. Do you want me to say what they were?

Q. Yes.

A. The water at Peoria—samples of water sent to us for bacteriological examination from Peoria were almost black. The water at Grafton was as dark as that at Peoria. The water flowing down at Alton and Hartford was both black but showed a mixture with the Mississippi water that came in at Grafton, it was not quite so dark as that at Grafton and Peoria in the Illinois river, because,—the Mississippi at the time was covered with ice and was very clear, remarkably so.

The sample from the Missouri river at Bellefontaine was as

clear as I ever saw a sample of water from the Missouri River. The sample from the Intake Tower, the samples taken from the Missouri shore, Intake Tower,—was also clear. On
1365 the Illinois shore the water was dark. I never saw,—
the water of Illinois shore so dirty looking. The water of the Missouri shore to the naked eye was about the color of that in the Missouri river, but at the Intake Tower there was a distinct mixture of the Illinois water with the Missouri shore sample shown by comparing the samples from the three points, Missouri shore, Intake, Illinois shore. The bacteriological result at that same time showed a remarkable condition. These have been already exhibited in that long chart which I showed here, showing the number of bacteria at Peoria and at Grafton.

In samples of water from the Illinois river at Grafton the number of bacteria were very high. A lower number in the Mississippi at Grafton and the lowest number in the Missouri at Bellefontaine the mixture of that Illinois water with the Mississippi river water above the Missouri and the Mississippi river and the Missouri River water showing a distinct mixture at the Intake. That was shown bacteriologically in the chart I exhibited here.

Q. What was the distinguishing characteristic of the three bottles of water and where were the three bottles taken from?

A. The three bottles were taken one at the Missouri shore, one at the intake and the other on the Illinois shore.

Q. Opposite the Intake?

A. On a line across from the intake, not right at the intake. The Chain of Rocks runs out from the intake and at the end of it is the tower and the water sweeps down along that shore. It does not give a representative sample to take
1366 the water sweeping these rocks. We went up above where
the Missouri river water comes down the Missouri shore, a sample was taken at similar points on the Illinois shore, and a sample at the intake. That was taken in the tower at that time because we could not go out into the river in boats. We had to cut through the ice. Our men had to cut around through the ice to get these samples.

Q. What was the difference in the appearance of the water taken at the tower and the water on the Illinois and Missouri shore?

A. The water on the Missouri shore was fairly clear. The sample on the Illinois shore was dark, black. The sample at the intake showed about an equable mixture of these two waters, and this is demonstrated in the bacteriological examination.

Q. What period was this?

A. That was in February from the 8th until the 20th, I think.

JUDGE SPRINGER: What year?

A. 1900.

ATTORNEY GENERAL CROW: What relation did those dates have to the epidemic of typhoid that ensued in the spring of 1900, that you have heretofore testified about?

A. Within an incubation period the typhoid death rate ran
up rapidly in this town in March. Samples were collected
1367 in February, and in March 117 cases and sixteen deaths
by typhoid occurred in St. Louis, a phenomena that never
had occurred previously, and I believe has not since.

JUDGE SPRINGER: What was that? I didn't get that last.

A. No such a flare of typhoid in March has ever been recorded in the history of St. Louis, as followed this mixture of this dirty water at the intake.

ATTORNEY GENERAL CROW: Now, Doctor, I will get you to state whether or not you considered this water potable and safe for drinking purposes that comes from the intake tower of the St. Louis Water Works now without filtration or without boiling?

A. I do not.

Q. Do you use it yourself personally without boiling it or filtering it?

A. No sir.

CROSS-EXAMINATION,

By Judge Springer.

Q. I will ask you a few questions right on this point. What time, if you know, was the Drainage Canal at Chicago open for the admission of the sewage of Chicago?

A. Into the canal itself?

Q. Into the canal itself and into the Des Plaines River.

A. I have the date, January 17th.

1368 MR. DRENNAN: 1900?

A. 1900. I always understood that the canal was opened on that date. Mr. Harmon corrected me the other day and said January 16th, but as it is a question of 24 hours it doesn't cut much figure.

Q. Now, what was the date you said that you took these samples at Peoria, Grafton and the Missouri shore and the Illinois shore and the Intake to which you have referred?

A. Well, the samples as you will notice by these charts here—we began taking samples at Peoria and Grafton and these other points on January 23rd at all these points, so that the samples were constantly coming to us every day from all of these points. But after February 10th samples were so remarkably different at the intake tower, the Illinois shore and the Missouri shore from one another that it was marked at the bacteriological laboratory and my attention called to it.

Q. The samples taken then were fixed up and retained and exhibited?

A. These samples with the labels on them after the bacteriological tests were made were stored and kept and exhibited.

Q. What for?

A. They were exhibited before the Round Table Club. And also I delivered a series of lectures here before the Washington University Association upon qualities of water, water supplies and things of that kind, and I have exhibited them before a large crowd of people showing this mixture. 1369

Q. How long did this dark coloration continue?

A. It continued until the samples were thrown out.

Q. I mean in samples taken after the 10th of February?

A. While the river was high the samples from the Illinois river previous to that date, the 10th, were fairly clear, running back a definite time, but this remarkable difference in the water followed a thaw in the Illinois valley and a precipitation of a good deal of water,—this whole sweeping out of the Illinois river, came. The Mississippi still remained covered with ice and the Missouri river was covered with ice, this thaw not having reached round to the entire region, and until this thaw did reach the Mississippi River above, towards St. Paul, and finally sweep down onto the Missouri and the waters of all these rivers raised then this difference could be noticed. So at a particular time the Illinois river was high, this flood volume was very great and the Missouri and Mississippi rivers were low and the difference in the aspects of the water were recorded.

Q. Now, will you state the first marked condition of discoloration which appeared at Grafton and on the Illinois shore? Was it about the 10th of February, 1900?

A. Yes sir, it may have been a few days before that, but 1370 I think it was about the 10th. I did not make an absolute record of it.

Q. There was a high stage of water then in the Illinois river?

A. Yes sir.

Q. From the spring rise?

A. Well, it was a thaw you see, that was in February, January, and February are winter months.

Q. Well, if this Chicago Drainage Canal was first opened on the 16th of January there would be to the 10th of February—that would be twenty-five days, would it not?

A. Yes sir.

Q. Wouldn't that be about the time required for an ordinary flow of water from the Drainage Canal to St. Louis?

A. Well, our work upon the rivers indicated, and we are pretty confident about that, that the first discharge of the Chicago River through the Drainage Canal at the opening which occurred on the 16th or 17th of January, reached here by the 29th or 30th of January, and passed, at which time fortunately the Missouri River was very high.

Q. The Missouri river was high?

A. The Missouri River was high.

Q. In your opinion then did this polluted condition or 1371 discoloration in the waters at Grafton and on the Illinois shore to which you have referred, come from the ordinary drainage from farms and inlets to the river?

A. At the time I thought over that very carefully and looked over the samples microscopically and my conclusion was this, if you care to hear it—if you care to hear that conclusion.

Q. Yes.

A. I reached a conclusion. It was this. This mass of filth that was in the Chicago River and in the Drainage Canal while it was retained there, after the waters of the Drainage canal were allowed to stand or the waters of the Chicago river were allowed to stand in the Drainage Canal for a time without being discharged. The opening of the canal discharged the water over the dam and came rushing down the Illinois valley and traces of it could be seen with the unaided eye for a great distance as the water traveling along. The Illinois river was not high at that time. The greater part of the sediment was carried down by a sedimentation, making a black nasty mud in the stream. It was winter and the anaerobic bacteria were not at work. Consequently they had not destroyed the organic sediment. And then I also ascribed it partially to taking mud that was in behind the dams along the Illinois river and also the muck and slime and sludge that was put into the river by the opening of the Chicago River.

. CROSS EXAMINATION

By Attorney General Hamlin.

Q. Doctor, how long have you lived in St. Louis?

1372 A. All my life, with the exception of a few years.

Q. Were you educated here?

A. I was educated in the public school, the high school, the school of mines, Rolla, Mo., and Washington University.

Q. How long have you been practicing your profession as a physician?

A. Since 1881, I graduated from the St. Louis Medical College, and competed for a position in the St. Louis City Hospital and won. Was there 14 months. I was at the Poor House here for about 14 months, and have been practicing medicine ever since professionally.

Q. Now, the questions I will ask you, you can answer very briefly, and I wish you would make them responsive to the question. Just notice the question. How long have you been practicing or investigating on the subject of bacteria?

A. Since the year 1885. You mean, when did I take it up seriously and began to work at it. I worked at it indefiinitely when a medical student, then I worked along staining tubercle bacilli in sputum. That is an easy trick, any neophyte can do that. From 1885 I began the study of bacteriology.

Q. In 1885?

1373 *A. Yes.*

Q. Since that time you have devoted more or less time to that subject?

A. Yes sir.

Q. And during the last few years you have been connected with some college here as a lecturer on bacteria?

A. Yes, I was employed by the Medical Department of the Washington University, one of St. Louis' Medical Colleges, in 1889, as lecturer upon bacteriology, and before that time I was also—

Q. That answers the question.

A. Well, I had, lectured one year before that.

Q. You had lectured one year before that?

A. Yes, in the Shaw School of Botany.

Q. Have you kept up lecturing on bacteria since?

A. Ever since until last year when I resigned from the Medical Department of Washington University to go abroad.

Q. You are not now lecturing?

A. I have not lectured since May 1902.

Q. But from 1889 until May 1902, you have lectured more or less on this subject of bacteriology in the high institutions or colleges of St. Louis?

1374 A. Yes.

Q. Now, in 1899, you took some samples of the water here, didn't you?

A. What water?

Q. Mississippi River Water.

A. Yes.

Q. At the Intake?

A. Yes.

Q. How many samples did you take?

A. I cannot speak from memory, I can give you the exact number (refers to memorandum). During this period 1899 34 samples of water were collected at the Intake near the water works.

Q. 34 samples?

A. Yes, sir.

Q. Was that all the samples you took in 1899 at the Intake?

A. Yes, sir.

Q. Who assisted you in collecting these samples?

A. Dr. W. C. G. Kirchner.

Q. Is that all?

A. These samples I said were for the quantitative determination of bacteria.

Q. You are not asked that question. Is that all?

A. That is all.

Q. Now, you took the samples in 1899 from where?

1375 A. 32 samples in different parts of the Mississippi and Illinois River.

Q. I will go back to the Intake. From what period of time were these 36 or 38 samples?

A. 34 samples.

Q. Over what period of time were these 34 samples taken?

A. August 10th to September 25th.

Q. That is all the samples that you took in 1899 at that place?

A. No, it is not.

Q. All right, go ahead.

A. These samples were taken for a definite purpose.

Q. I didn't ask you the purpose.

A. There were other samples taken until January, through until January at the Intake Tower.

Q. Have you testified about these?

A. I have not.

Q. All the samples you have testified about then are the 34 samples that were taken from the Intake Tower from August 10th until when?

A. Until September 25th.

Q. Now, state, the next place that you took any samples and the number of them in 1899?

1376 A. Now, besides these 34 samples—

ATTORNEY GENERAL CROW: I submit that the witness has the right to answer the question in his own way.

THE WITNESS: I want to answer the question my own way or I can't answer it at all.

ATTORNEY GENERAL HAMLIN: Dr., the questions are easily understood. I will withdraw the question.

Q. If you took any samples on the Missouri shore from the Intake Tower in 1899, you may state how many you took?

A. The Missouri Shore sample, that is the nearest to the Missouri Shore, was Mississippi river just above the Intake, that would be Missouri Shore sample taken in 1899. There were nine of these taken.

Q. Nine?

A. Yes sir.

Q. Is that the same point that you took samples designated on the Missouri shore or at the Missouri shore in 1900 and 1901?

A. No sir, we took them closer up there in the period of 1900 and 1901.

Q. You may state where you took them in 1899 again?

A. We took them above the Intake of the St. Louis Water Works, on the Missouri side of the Intake, near to the channel.

Q. How near to the middle of the channel of the river 1377 is the Intake Tower or the Intake?

A. The Intake Tower is pretty near the middle of the channel.

Q. On the Missouri side?

A. On the Missouri side.

Q. How many samples did you take on the Illinois shore in 1899?

A. One.

Q. One sample?

A. Yes sir.

Q. Who assisted you in taking the samples on the Missouri shore, as you described, above the Intake tower?

A. Dr. Kirchner.

Q. The same man?

A. The same man.

Q. Who assisted you on the sample you took on the Illinois shore?

A. Dr. Kirchner.

Q. If you took any samples during 1899 at Bellefontaine, you may state how many?

A. We did not. We did not go up to Bellefontaine.

Q. Did you take any samples in 1899 below Alton?

1378 A. We did.

Q. What place?

A. Above Alton.

Q. Below Alton?

A. The Mississippi River, and above the mouth of the Missouri.

Q. We don't know what place it is.

A. We took them below Alton between the Chain of Rocks and Alton.

Q. Below Alton and before you reached the mouth of the Missouri?

A. Madison Landing September 9th and 16th, September 25th, half way between Alton and Madison.

Q. Now, you call this Madison Landing?

A. Yes.

Q. September 9th?

A. September 9th, 16th and 25th, I gave you these dates.

Q. Who assisted you?

A. These samples were taken from a boat and I think I collected these samples myself, at least two of them. I think the 29th and 16th I collected myself from a boat in the river, 1379 and I think this one of September 25th was collected by Dr. Kirchner, we were both on the boat together.

Q. Well, now have you taken any samples—

A. There are other samples taken below Alton.

Q. I am speaking of the ones you have testified about?

A. Yes, but there are some others below Alton half way between Alton and the mouth of the Missouri River, there is another sample.

Q. I haven't come to that yet.

A. These were all below Alton.

Q. But at this particular point I am asking about now, I don't care so much about the other. Now, if you took any samples in 1899 above Alton, how many did you take?

A. We took Mississippi River opposite Clifton September 25th, one sample.

Q. Above Alton?

A. Above Alton.

Q. How far above Alton?

A. Really, I don't know how far Clifton is above Alton.

Q. It is above sewerage, of course?

A. Yes, it is up there opposite the Illini Island Club, that is above Alton about four or five miles, I don't know
1380 exactly how far.

Q. Who assisted you in taking that sample?

A. On September 25th I didn't take it myself, that was taken by Dr. Kirchner, Mississippi River one mile above Alton.

Q. I haven't asked you about that.

A. You asked me above Alton and I answered that question. I have got three different points above Alton from which samples were collected.

Q. You can give me any one of them of that number?

A. Mississippi River only a little above Alton.

Q. How many samples.

A. Two. September 9th and 16th, collected I think by myself, Mississippi River 3-4 of a mile below—

Q. That is above Alton is it?

A. I am not so sure about that, I think it is though. Yes, I am pretty sure it is.

Q. How many samples.

A. One sample September 25th, Mississippi River one mile below Grafton.

Q. How many samples?

A. One, September 9th.

1381 Q. Now, that is all the points above Alton on the Mississippi and below Grafton, that you took any samples in 1899, about which you have testified?

A. Yes sir.

Q. Now, then how many samples did you take in the Mississippi river above Grafton in 1899?

A. The Mississippi river opposite Grafton.

Q. How many samples?

A. We took two samples, September 6th and 9th, I collected those myself, Mississippi river four miles above Grafton, September 6th one sample. Mississippi river six miles above Grafton, on September 6th, four samples. Now, then there were two collected, Mississippi river one mile above Grafton, September 21st, Mississippi river 4½ miles above Grafton, September 21st, one sample.

Q. Is that all?

A. That is all, sir.

Q. In 1899?

A. In 1899.

Q. How many samples did you take in 1899 on the Illinois river above Grafton, that is immediately above Grafton or at the point where you took them?

1382 A. Illinois river just above Grafton, sample was taken September 9th, Illinois river, 1½ miles above Grafton. September 21st, one sample Illinois river.3 miles above Grafton Wheeler's Ferry. September 6th.

Q. Is that September 6th?

A. The first one was September 26th, Wheeler's Ferry, and September 21st Illinois river five miles above Grafton, Brick House Club September 6th, one sample, September 21st one sample Illinois river 7 miles above Grafton.

Q. Is that all?

A. That is all, sir.

Q. You got all the samples you took, that you have testified about, in the Illinois river above Grafton in 1899?

A. Yes.

Q. Now, where next did you take samples, in the Illinois river going up stream in 1899?

A. The Illinois?

Q. Yes?

A. This seven miles above Grafton, six miles I mean, that is the only sample.

1383 Q. That you have?

A. I find no other record of samples having been taken on these harbor boat trips.

Q. Dr., would you, as a bacteriologist, be willing to give an opinion as to the pollution or non-pollution of the waters out of the Intake for the year 1899, from the number of samples that you have now testified about in the cross-examination?

A. You mean as to the cause of the pollution, or whether it was polluted or not, the water at the Intake?

Q. Would you, as a bacteriologist, be willing to give an opinion as to the pollution or non-pollution of the waters out of the Intake for the year 1899, from the number of samples that you have now testified about?

A. I could give an opinion upon the number of samples taken out of the Intake at that particular time. I did.

Q. Would you, as a bacteriologist, be willing to give an opinion as to the condition of the waters in the Illinois river above Grafton in 1899, for that year?

A. For these particular samples at these particular times?

Q. No, for the year 1899.

A. Knowing the stages of the river, I could.

Q. Your opinion simply for the dates that you took the samples? 1384

A. Just upon the date that I took the samples?

Q. Yes, for no other time?

A. I couldn't give an opinion upon that of which I have not.

Q. From the samples that you took in the Illinois River in 1899, are you prepared to state what was the condition of these waters during that year, or any considerable portion of the year?

A. On none other than the time I took the samples.

Q. Would you, as a bacteriologist, state in your judgment as such, that that would be a fair test of the conditions of the water in the Illinois River above Grafton for the year 1899?

A. I would not.

Q. Do you know how much sewage was carried into the Illinois River from Chicago in the year 1899?

A. I do not.

Q. Do you know whether or not there was practically the same kind of sewage carried into the waters of the Illinois River from Chicago in 1899 as there is now?

A. I do not.

1385 Q. Do you know whether or not there was practically the same kind of sewage carried into the waters of the Illinois River from Chicago in 1899 as there is now?

A. I do not.

Q. You have no information on that subject?

A. No, sir.

Q. You made no examination for 1899 of the conditions of the water of the Missouri River at Bellefontaine or any point along the Missouri River?

A. I did.

Q. But none that you have testified to?

A. Yes, I have testified.

Q. I thought you stated that all of the examination of the Illinois River you testified about in your direct examination?

A. Yes.

Q. Doctor, I understand you to state that the primary cause for the disappearance or elimination of the bacteria known as typhoid bacillus is due to dilution and sedimentation?

A. Yes sir.

Q. What other causes do you give, besides these two?

A. I regard these two as the principal ones.

1386 Q. What others? You stated it yesterday?

A. The question came up; the question of aeration and agitation, sunlight, oxidation and exhaustion of food supply and planckton.

Q. Those are the other causes, all of them?

A. Those are the other causes that have been assigned by the various observers of water as the cause for the disappearance of bacteria.

Q. Do you recognize these causes also, the same as other bacteriologists?

A. I recognize planckton as probably having a nothing to do with it. I have no personal experience with it; hence can not make any definite statements. Some of the lower forms of infusorial life may take the bacteria into them as food. Sunlight upon a stream that was running in a very thin sheet over a wide expanse of country might have some effect upon the bacteria—the contained bacteria, but not as it runs in an ordinary stream. So I regard the two things, dilution and sedimentation as the principal causes for the disappearance of bacteria in a running stream.

Q. Don't you think sunlight has anything to do with it?

A. Very little.

Q. Very little?

1387 A. Very little whatever from our bottle experiments.

Q. Yes, but speaking outside of that, from your practical knowledge of the subject what would you say?

A. I have just answered that.

Q. You think not.

A. I have answered that. I said that if the river was spread out in a thin sheet over a wide expanse of country, as if the river should suddenly run out in a very shallow lake, and the sunlight upon it all day long might have some effect upon the bacteria, but that would depend upon the turbidity of the waters.

ATTORNEY GENERAL CROW: I want to ask a question for my own personal information.

JUDGE SPRINGER: Go ahead.

Q. He uses the term disappearance, and you use it. I want to know when you use it and he uses it if you use it with a similar meaning, that is to say are they destroyed or are they simply not found?

ATTORNEY GENERAL HAMLIN: Well, we will come to that.

ATTORNEY GENERAL CROW: Well, I want to understand your question and his answer. I think that is a fair proposition.

ATTORNEY GENERAL HAMLIN: I don't think it is a fair proposition to inject it into this cross-examination.

ATTORNEY GENERAL CROW: I don't think you ought to object to my asking what you mean by the question.

1388 ATTORNEY GENERAL HAMLIN: I think, gentlemen, when I get through on this line it will explain itself.

ATTORNEY GENERAL CROW: Then I will withdraw it as far as you are concerned and ask the doctor.

ATTORNEY-GENERAL HAMLIN: I will give you an opportunity after I get through with him.

ATTORNEY GENERAL CROW: I want to know what he means by it.

ATTORNEY GENERAL HAMLIN: Well, I will get him to enlighten you on that subject in a minute but I think I understand what he means and he understands what I mean.

THE WITNESS: You understand yourself and I understand myself.

ATTORNEY GENERAL HAMLIN: Yes.

ATTORNEY GENERAL CROW: That don't explain to me what you mean.

ATTORNEY GENERAL HAMLIN: I know, but it is between Dr. Ravold and me now.

Q. Now the turbidity of the water has something to do with it?

A. Yes, sir.

Q. Now, the water of the Mississippi River, is it in its natural stages, clear or turbid?

A. Now what do you mean by natural stages?

Q. Well, I will leave that to you, you are better posted on that than I am.

A. Do you mean that the water is running at a fairly aver-
1389 age stage in the river?

Q. That is what I think I mean.

A. The mean, between very high and very low.

Q. Yes, sir, the average, and when I speak of that, doctor, hereafter that is just what I mean.

A. All right sir.

Q. I guess that is right?

A. That is what I concede.

Q. Yes.

A. The Mississippi River above Grafton—now are you speaking of above Grafton or at the intake tower?

Q. Well, above the Missouri there you would get the waters of the Mississippi?

A. And the Illinois mixed.

Q. Well, take it above the Illinois River.

A. Above Grafton?

Q. Yes sir.

A. The waters there are fairly clear. The turbidity tests for a mean turbidity is in the chemistry report but the naked eye appearance is all I know about it and from having swam in the water and sometimes having rowed a boat in it.

Q. You say it is fairly clear?

A. It is fairly clear water.

Q. Now take the Illinois River above Grafton. How is
1390 that for turbidity?

A. That is a darker water or blacker water than the Mississippi as a rule at the times I have seen it.

Q. In the ordinary stages?

A. In the ordinary stages.

Q. Well, now, how is the Missouri River water?

A. It is a turbid water.

Q. Then the effect of the sunlight as an element of the disappearance of the typhoid bacillus would be less on the Missouri River than it would be on the other two rivers in your judgment?

A. Yes sir.

Q. What is the effect of sunlight upon this particular germ, the typhoid germ?

A. Exposed directly to sunlight, growing upon a medium it is destroyed in a few hours, but growing in our water experiments, we found that exposed to direct sunlight in a bottle containing 200 cubic centimeters, in what is known as an Erlenmeyer flask, a beautiful clear glass, with the direct sunlight of hot summer days on it, it had lived as long as our experiments lasted, in distilled water, that is the pure water of the laboratory, perfectly clear. It lived from the data I have as high as 55 days I believe, while in the direct sunlight, in waters from the various stations it lived as high as 65 days, exposed to the
1391 direct sunlight for a number of hours a day.

Q. Will it live longer in darkness than it will in light?

A. Yes sir.

Q. Will it live longer in turbid waters, testing it by the sunlight, than in clear water?

A. Our experiments show that it has a little longer period of life in highly turbid waters than in very clear waters, the difference being a few days, five or six, I believe, in these experiments.

Q. Now, Doctor Ravold, have you travelled from Bear Trap dam down the Illinois River to Grafton?

A. No.

Q. You have been at Joliet?

A. I have been at Joliet.

Q. How is the water of the Drainage Canal discharged into the River at Joliet or above Joliet wherever it is?

A. At Lockport do you mean?

Q. Yes. Take immediately above Bear Trap dam, what is the character of the channel?

A. The Des Plaines River and the waters of the Drainage Canal discharged into it come together at Lockport. The water in the Drainage Canal is what you want, is it?

Q. Yes.

1392 A. The waters in the Drainage Canal are fetid. There is a foul smell, foul odor.

Q. I am not asking about the character of the water but as to the channel—the channel at that point?

A. Now the water discharged over the Bear Trap dam runs down and meets at middle stages a fairly clear stream of water, that is the Des Plaines River. The two commingle and rush along, falling some 38 feet in four and a half miles to Joliet.

Q. Now, I want to go back a little. Above Bear Trap dam, if you know, what is the character of the channel, of the water and the banks and how wide is it and whether it is through stone or free soil or how is that, or whether you know it?

A. Yes, I have been there. I have been all over it with the chief engineer at that point. Some distance back I understood the canal was 160 feet wide and some 38 feet deep with perpendicular walls cut into the solid rock.

Q. How far above Bear Trap dam is that?

A. I should say that is a thousand feet above Bear Trap dam.

Q. And how far is the channel cut through the rock in the manner that you have described?

A. I don't know.

Q. And have no idea?

1393 A. Yes, I have an idea but it is all gathered entirely from the reports of the Drainage Canal engineer.

Q. Well, now, it passes over Bear Trap dam and joins the waters of the Des Plaines River?

A. Yes.

Q. And the stream is rapid and the fall is 37 feet.

A. Yes sir.

Q. To Joliet?

A. Yes sir.

Q. At Joliet there is a lake, isn't there, a basin?

A. Well, before it gets to Joliet—

Q. Wait a minute. Of the Illinois waters?

A. Of the Illinois and Michigan Canal, that comes into it and altogether flow along to Joliet. The water spreads out there for quite a distance, I suppose 300 yards.

Q. Yes.

A. And part of it is run through turbines, for power and the other part runs over a little dam.

Q. How large a pond or lake is that at Joliet?

A. Well, this is guessing. I should say that the river there is 200 feet wide and that spread of water about 1,000 feet long or longer than that, anywhere between one and two thousand feet.

Q. Is there a dam in the river?

1394 A. I don't know whether there is a dam there or not. There must be because there is a water fall.

Q. There is a lake there, isn't there?

A. There is a wide spread of water, yes.

Q. Well, you would call it a lake or a pond or a basin, wouldn't you?

A. I would hardly call it a lake. The water is a little too fast in it.

Q. Did you ever test how long it took any object two or three feet long and two or three inches thick to pass out of that lake or pond into the river below?

A. I have not.

Q. Well, there would be a good deal of sedimentation there, wouldn't there, doctor?

A. From the bacteriological results there is very little.

Q. Well, do you say whether there is or is not any sedimentation there?

A. There is some sedimentation. There must be.

Q. Did you ever examine as to the amount of sedimentation there?

A. I did not.

1395 Q. You made no examination?

A. I made no examination.

Q. At no time?

A. Other than the bacteriological samples collected in cross section there.

Q. Through the pond?

A. Through the pond, yes.

Q. About what part of the pond?

A. That would be about above the power house, that is above Jackson Street, is it not, Mr. Randolph?

MR. RANDOLPH (Chief Engineer Sanitary District of Chicago): Yes, Jackson Street is at the dam.

A. (Continuing) At the dam, yes. We collected samples about through what would be the center of that so called lake that you speak of. We took cross sections across that stream to find where the best sample could be taken in the channel of it.

Q. When did you take these samples?

A. In 1900 and 1901.

Q. You took none in 1899?

A. None whatever.

Q. You wouldn't undertake to say how much sedimentation was there then?

A. No sir, except bacteriologically.

1396 Q. That is examinations from samples?

A. Yes sir.

Q. Your system of settling basins here in your water works system is a system of sedimentation, isn't it?

A. Yes of deep tanks.

Q. In passing down the river from Joliet do you know where and at what place you strike the next pond or basin or lake?

A. I do not.

Q. Were you at La Salle?

A. No sir.

Q. Didn't go up to La Salle?

A. I did not personally.

Q. La Salle is below Joliet, isn't it?

A. Yes sir.

Q. You never examined the basin or lake of La Salle?

A. I never have, personally.

Q. You know nothing about it?

A. I know nothing about it personally.

Q. Assuming that there was a lake as large or larger than the one at Joliet, and that the water moves slowly, the current at this point, and through this lake or basin, would you say that there would be a sedimentation?

A. Yes sir.

1397 Q. Did you take any samples of water at La Salle?

A. Yes sir.

Q. What year?

A. 1901 and in part of the period—no, 1901 entirely.

Q. How many samples?

A. They were bacteriological samples taken at LaSalle—

Q. Yes, how many, first?

A. Seven samples at La Salle.

Q. During what months?

A. We took two in October.

Q. Give the dates please.

A. October 28th and 29th and November 15, 16th, 17th, 18th and 21st.

Q. What was done with those samples?

A. They were sent to Dr. William Rush, at Peoria, for examination.

Q. How long did it take them to reach there?

A. I don't know, a very short time, I understood.

Q. You don't know though.

A. I don't know. The records are all in Dr. Rush's work but I don't know from memory.

Q. Well, the next in going on down the river, what is the next pond, basin or lake that you know of?

1398 A. I know that the water spreads out in quite a little lake above Peoria.

Q. Well, before you reach Peoria?

A. I do not. I know that there is a dam in there but personally I don't know.

Q. A dam in where?

A. I understood there was a dam at Henry.

Q. How far above Peoria is Henry?

A. I don't know that.

Q. Well, assuming that there is a pond or lake at Henry, would there be more sedimentation there?

A. Yes sir.

Q. In any stream of water where there are places that we speak of it is as a still water which is as compared with the general current of the stream, will there be sedimentation?

A. Yes sir, there will.

Q. Well, now when you reach Peoria you say that there is another lake?

A. Yes sir, the water spreads out over quite an area there.

Q. And the sewage of Peoria, is it discharged above or below this lake?

1399 A. Below it I understand.

Q. How large an area is occupied by the lake or pond at Peoria?

A. I don't know. Three or four miles, I believe, by about 1,000 yards or more wide when I saw it.

Q. Was that in high water or low water?

A. That was low water.

Q. Low water?

A. Low water in 1901.

Q. Well, how was the current there?

A. It was slow, very slow. That was in the 1901 period.

Q. Well, there would be considerable sedimentation there?

A. Yes, sir.

Q. Then passing below Peoria where is the next pond?

A. There are three dams across the river now below Peoria.

Q. Well, take the first one.

A. I think it is the Copperas Creek dam.

Q. That is right.

A. Now, here I am familiar with the river. I have been up and down it a number of times, in a launch, the Copperas Creek dam, the dam backs the water or the water is backed up a great many miles and it makes quite a stream, navigable for large boats. In the low water season of 1901, I was in it. We had a launch drawing three and a half feet of water and occasionally it would hit the bottom and the water was running slowly at that time and the current in the river was slow. The water was running over the dam in a good volume.

1400 Q. There would be considerable sedimentation there?

A. A great deal.

Q. Do you know where Beardstown gets their water supply?

A. I don't know.

Q. Where is the dam located with reference to the city of Beardstown?

A. Below.

Q. Below the city is it?

A. Below the city, yes sir. That is LaGrange, you are speaking of now?

Q. Yes.

A. LaGrange dam is below Beardstown.

Q. Well, the Copperas Creek dam is above, isn't?

A. Above LaGrange.

Q. How far above?

A. I don't know what the distance is between these dams fifty, sixty or seventy miles.

Q. Well, then the next dam is at LaGrange?

A. The next dam is at LaGrange, yes sir.

Q. Well, tell us how large that is?

A. Well, the water backs behind this dam for quite a number of miles back. The river at the stage I saw it several times was anywhere from five hundred yards to a mile wide and the water was deep enough to have the boats run smoothly along up to Beardstown where the water was shallow.

1401 Q. Well, there would be considerable sedimentation there, wouldn't there?

A. Yes sir, a great deal.

Q. Well, give us the next.

A. The next one is at Campsville, I should say some seventy-five miles below but I don't know that positively. Here the water again is dammed and backs up, the current is retarded and a great deal of sedimentation will go on here in this flowing water.

There are no other dams from here through to the mouth of the river?

Q. Well, now the amount of dilution, what would you say of the amount of dilution at Joliet where you strike the first basin?

A. The dilution with the Des Plaines river?

Q. That is what it would be, wouldn't it?

A. Yes. I don't know what the ordinary seasonal fall is. We have the figures of the engineers that at times the waters from the Des Plaines river would pass through a six inch pipe. At other times there are eight hundred thousand cubic feet per minute.

Q. Well, take the average.

A. I don't know what the average is but I have seen this river a number of times and at no time that I saw it, would
1402 it pass through a six inch pipe, and I saw it in the dry
season, the fall of 1901, October and November but if it was the extreme mean it would certainly be—I don't know how many cubic feet a minute—but that has been recorded by Mr. Harmon in his report which you have.

Q. I was trying to put it all in here together.

A. Do you want me to read it?

Q. First I will go back and ask you about the dilution at the Drainage Canal. That is stated however, in the Act requiring the amount of flow?

A. Yes sir.

Q. Did you get as many parts of water to one of sewage?

A. I don't remember now. Calculating upon a 3,000 cubic foot flow a minute and taking all of the sewage of the two million people that discharged into it, we said there would be a dilution of one to nine, but that if 4-5 of the sewage is now discharged into the canal, as it is now claimed, the dilution would be one to eleven.

Q. Do you know as a matter of fact, that a certain amount of sewage now is discharged into the canal, that was at that time, discharged into the Illinois and Michigan Canal at Bridgeport?

ATTORNEY GENERAL CROW: You mean into the Drainage Canal?

1403 ATTORNEY GENERAL HAMLIN: The Drainage Canal, yes.

A. I think you were wrong in that question.

Q. (Question repeated)?

A. Chicago Sewage?

Q. Yes.

A. I don't know that and I don't believe it.

Q. Well, that wouldn't hardly be an answer that you don't believe it. You don't know it?

A. No.

Q. Well, there is a dilution. Assuming, as I understand, that the entire population, the sewage of the entire population is carried in of 1 to 9?

A. Yes.

Q. But assuming that 3-4—of the course the proportions would change correspondingly?

A. Yes sir.

Q. And if it was only the same that had been discharged for several years, in the Illinois and Michigan Canal, why it would be whatever the proportion of its sewage discharge was to the number of cubic feet from the lake which was poured into the Canal?

A. Yes sir.

1404 Q. Would it?

A. The dilution would be.

Q. There would be a greater dilution?

A. Yes sir.

Q. Certainly. Now, when you get to Joliet, what is the dilution there, if you know?

A. I do not know.

Q. What is the dilution at LaSalle?

A. I do not know.

Q. What is the dilution at Peoria?

A. I do not know, I have not measured the streams myself and do not know the volume discharged in there and can not consequently arrive at any personal conclusion on the subject.

Q. Then you have not figured out or ascertained how much dilution there is of the water discharged into the Drainage Canal, or sewage discharged in the Drainage Canal from the time that it enters the Des Plaines river at Lockport until it reaches the Mississippi at Grafton?

A. I have not.

Q. I believe you stated that the two primary causes for disappearance and elimination from the water of the typhoid—

A. No.

Q. Well I will drop "elimination." I didn't think you would like that. Disappearance was sedimentation and
1405 dilution?

A. Yes sir.

Q. Have you ever been up any of these tributaries of the Illinois from Lockport to Grafton?

A. Yes sir, I have been up to Sangamon a short distance, the Macoupin Creek, Crooked Creek—or Macoupin River, I believe they call it.

MR. DRENNAN: Macoupin Creek it is.

A. Macoupin Creek, and all of these small streams below Peoria.

Q. Can you tell me how many tributaries the Illinois has from Illinois to Grafton?

A. I can name them over as I know them.

Q. Well, commencing up the river if you can.

A. We begin at the Des Plaines and the Drainage Canal, they mix at Lockport.

Q. Just the tributaries I want, Doctor.

A. Now, then, we have got the DuPage, the Kanakakee, the Fox and the Vermillion, the Big Vermillion, Macoupin Creek, the Sangamon, Crooked Creek and other small streams, in all I believe about twenty-one.

Q. Twenty-one tributaries it has?

A. Yes sir.

1406 Q. Do you know the relative size of them, and the discharge of water in a general way?

A. None other than from figures of the Civil Engineer, I say I have gone into some of these streams but I know nothing about volumes and I couldn't measure it.

Q. Well, there is a large volume of water discharged into the Illinois River from these tributaries, from Lockport to Grafton, isn't there?

A. Yes sir.

Q. Do you know how much area of country is drained by the Illinois River and its tributaries?

A. I have no other means of knowing than the figures of engineers.

Q. Well, do you now recollect?

A. No sir, I do not.

Q. Have you stated in your examination in chief about how much area is?

A. I have not.

Q. And you have no recollection on the subject?

A. I have not.

Q. Have you any recollection or means of knowledge that you can tell us about how much water is discharged at ordinary stages by the tributaries into the Illinois?

A. None other than the figures of Mr. Harmon, which I have injected into this report, and testified to.

1407 Q. You didn't find the typhoid bacillus in any of the waters, did you, that you examined?

A. Never found the typhoid bacillus but once in my life; that was in 1892.

Q. Well, that didn't answer the question.

A. I have never found it in any of these waters.

Q. You spoke about a certain creek or branch here in St. Louis at the time that the water works was at Bissell's Point?

A. Yes sir.

Q. What was the name of that creek?

A. Harlem Creek.

Q. Harlem Creek?

A. Harlem Creek.

Q. And that creek discharged its waters into the Mississippi River above the Intake at Bissell's Point?

A. Yes sir, 6,800 feet above.

Q. 1892 was the year that you had quite an epidemic of typhoid fever in St. Louis?

A. Yes sir.

Q. Did you trace the cause of that epidemic?

A. I thought I did.

1408 Q. Did you find it from the pollution of this creek?

A. Yes sir.

Q. How far from the river was the source of the disease, from the Mississippi River and the Intake?

A. Do you mean where was the particular case of typhoid on that drainage area?

Q. Yes, how far?

A. About three miles—three or four miles.

Q. And just tell how the stream became polluted with typhoid germs?

A. Well, all the drainage from the houses of this whole area was discharged through open sewers or private sewer connections, which discharged into this stream, Harlem Creek, the drainage area extends as far south as Easton Avenue and it includes the cemeteries to the west and quite a district east of that. All of the water discharged on that area passes down through this creek. At the particular time that this epidemic occurred, the water in the creek was low; the volume was small, but on account of the sewage pollution and the pollution from cow sheds and things of that kind, the water was very black and very fetid, running in a very shallow stream and any little freshet of rain that occurred, carried out this mass of dirty water into the Mississippi River and some of it into the Intake of the water works which was located below the mouth 1409 of this stream.

Q. And as a result of that, in your judgment, you had this epidemic of typhoid fever?

A. Yes sir. The water at that time was pumped into Bissell's Point reservoirs, there rested some 36 hours or more and then into the water supply of the city.

Q. Then you moved the Intake up to the Chain of Rocks?

A. Yes sir.

Q. To avoid this pollution of this stream?

A. I don't know whether that was the reason or whether it was for some other reason that the engineers of the waterworks moved it. I wasn't in their confidence.

Q. Well, the city grew in that direction also, didn't it, and the sewage was discharged above Bissell's Point?

A. Yes sir.

Q. You discharge all of your sewage into the Mississippi River here don't you?

A. Yes sir.

Q. And have for many years?

A. Well, ever since the city was large enough to have sewers. I don't know the exact date. It seems to me it was 1849 that the first sewers were built, but I am merely trusting to memory for that.

Q. What is the present population of St. Louis?

1410 A. Over 600,000. I don't know the exact figures now.

Q. Have you ever been up the Missouri River, to its source?

A. No sir.

Q. How far up the river have you been?

A. Well, I have been to various points on it and have been in the stream. I have been up the—the highest point that I have been on this stream is Fort Leavenworth, at the Fort.

Q. What is the first town above St. Louis on the Missouri River?

A. St. Charles.

Q. How far is that?

A. I don't know, about twenty miles I believe.

Q. Do you know whether it discharges its sewage into the Mississippi River?

A. I have been told it does by Dr. Morgner of that town.

Q. You have had considerable typhoid fever in St. Charles haven't you?

A. I believe they had once a typhoid epidemic there, following the discharge of dejecta from a typhoid fever patient in a hospital, which was carried into the water supply.

Q. Wasn't there a good deal of typhoid fever in 1902 in St. Charles?

1411 A. I don't remember the year, sir.

Q. Do you know?

A. I do not.

Q. Was there in 1901?

A. I do not know.

Q. You spoke of the typhoid fever that you had in St. Louis in 1902?

A. Yes sir.

Q. What portion of the city was the largest number of cases?

A. It was widely distributed througout the city. I had a map at the time and I still have it, I think, showing the location of each of those cases, and I think if I remember well, most of the cases were north of Lafayette Avenue, or north of the line running through the reservoir on Compton Heights—a line running east and west.

Q. Didn't you have considerable typhoid fever in what is known as the West End?

A. Oh, it was disseminated throughout—

Q. Well, I am asking you particualarly as to that part of the city.

ATTORNEY GENERAL CROW: What year, General?

THE WITNESS: 1892 he is speaking of, are you not?

ATTORNEY GENERAL HAMLIN: Yes.

1412 A. I don't know whether it was in the West End any more than in other parts of the city.

Q. There was in 1901?

A. I don't know that.

Q. Didn't you know, Dr. Ravold, or do you know that the large per cent of your typhoid cases in 1901, was in the West End, and that the examination showed that it resulted—that the cause was defective sewers in the West End?

A. I know it was not caused by defective sewers. Typhoid doesn't arise from defective sewers.

Q. Well, wasn't that the claim that was made?

A. I don't know who made it. If it was made, somebody made it without knowing anything about typhoid.

Q. Well, do you know that you did have considerable typhoid in the West End?

A. I don't know that. You are speaking of 1901?

Q. Yes or 1902.

A. 1902—Oh, I thought you were speaking of 1891 and 1892.

Q. Oh no, 1901 and 1902.

A. Oh, I have no evidence of 1901 and 1902 at all. I paid little attention to the location of the typhoid cases in 1901 and 1902.

Q. So you know nothing about it?

A. I know nothing about it, but I do know that question
1413 that I answered.

Q. Well, you don't know anything about what was the condition of the sewerage system in the West End, in 1901 and 1902, do you?

A. Well, I know the condition of that Harlem Creek area and I know the condition of Cabanne Place, and running south from that, but then I know something about the open sewers about there.

Q. Well are there open sewers in Cabanne Place?

A. Yes, there are open sewers about Cabanne Place, they are about there.

Q. I say, is there?

A. Yes sir.

Q. To what area do the open sewers extend, or what area is covered by the open sewers?

A. I really don't know, but quite a large area. It carries this material to the River Des Peres.

Q. Now, Dr. Ravold, a typhoid bacillus if in the water at the Chicago River, will have to travel down the Drainage Canal —would it not?

A. Yes sir.

Q. Pass through all these sedimentations lakes and ponds that have been mentioned, would it not?

1414 A. Yes sir.

Q. Be diluted with the waters from Lake Michigan and the tributaries of the Illinois?

A. Yes sir.

Q. And join the waters of the Mississippi at Grafton?

A. Yes sir.

Q. Then join the waters of the Missouri and pass by St. Louis?

A. Yes sir.

Q. That is the route that it would have to take?

A. Route of travel, yes sir.

Q. If there was a case of typhoid fever on any of the tributaries of the Illinois River which would pass in the dejecta would pass into the Illinois River through any of its tributaries, you couldn't tell—

A. It would not be labeled.

Q. How?

A. It would not be labeled.

Q. Wait a minute, I have not finished the question. You could not tell whether that bacillus originated—or any typhoid bacillus, assuming that one would come this distance, you couldn't tell whether it came from the sewage of Chicago or came from some tributary of the Illinois, could you?

1415 A. No sir, not even if I found it in the water.

Q. You couldn't tell?

A. No sir, they have—it would have no distinctive marks that would make a Springfield typhoid bacillus different from that of Chicago.

Q. No sir, it would not be red-headed nor ring-tailed?

A. No sir, nor bald.

Q. The effect upon a typhoid bacillus coming from the sewage of Chicago of dilution, sedimentation and the light, and the other causes that you have attributed for the disappearance of the typhoid bacillus, would render it less liable to inoculate any one with the disease of typhoid fever than a bacillus that would come a distance of five or ten or fifteen or twenty miles, assuming that they were both equally virulent at the time they were discharged into the stream?

A. In a patient of the same susceptibility?

Q. Yes?

A. The chances are that the bacillus traveling from Chicago to St. Louis would lose its virulency sooner than one that had traveled only a few miles.

Q. A majority of the reported cases of typhoid epidemic from water pollution shows the origin to be less than 20 miles, doesn't it?

A. A majority of them do go back, because it is easy to trace them back. 1416

Q. You spoke of having examined the report made of the typhoid epidemic in Massachusetts. Where was that?

A. Well, that was a report which Dr. Sedgwick made, or Professor Sedgwick, for Lowell, Lawrence and Newberryport. I said I had information simply from that report, and it is in that report that he makes the statement that the evidence seems to show that there is no stream long enough to purify itself from sewage, even put in at its source.

Q. I will ask you, Dr. Ravold, if it is not a fact as a result of that report, that the Legislature of Massachusetts passed a law providing that there should be no sewage discharged into the streams in that state less than twenty miles above the intake of water supplies?

A. I think a law of that kind did come into force, following that.

Q. Do you say as a bacteriologist that in your judgment that limitation is a reasonably safe one?

A. It is an absolutely absurd one, it is not based on bacteriological evidence at all.

Q. You would not regard it as such?

A. No sir.

Q. And on your judgment twenty miles would not be a safe limitation?

1417 A. For any of the Massachusetts streams?

Q. Or for any streams?

A. That would depend upon the volume of the stream. If you had a tremendous volume of water, and a small town, why the danger would be greatly minimized, but from a bacteriological standpoint it would be unsafe to do it.

Q. Do you think that that is the consensus of opinion of the leading bacteriologists of this country and Europe?

A. I think it is.

Q. Do you say in your opinion it is?

A. Yes from conversations I have had with them and I know lots of them in this country and some of the good ones in Europe.

Q. What per cent of accredited cases that are reported in the books show the source of typhoid fever from water pollution to be exceeding fifty miles?

A. Well, I cannot say that definitely, and it would be an extremely difficult thing to do on account of the complexity of modern life.

Q. I am asking about the cases reported, that have come within your knowledge or reading?

ATTORNEY GENERAL CROW: We, he has answered it.

A. I said it would be a very small percentage of reported typhoid epidemics.

1418 Q. That occurred beyond fifty miles?

A. Yes, fifty miles, yes sir.

Q. Now name one if you have one in mind.

A. I have one in mind.

Q. Where was that?

A. Dredging at St. Clair.

Q. How?

A. Dredging of the St. Clair River, and the typhoid fever epidemic following in Detroit; that has been reported by Dr. Williams.

Q. Dr., that was a case when the river was being dredged?

A. It is a case. You asked me for a typhoid fever epidemic there were typhoid fever cases up the river above that. Typhoid fever discharges went into the river. They dredged into the silt and sludge and slime at the mouth of the Wolf river. This sludge was stirred up sometime afterwards and carried across Lake St. Clair into the water supply.

Q. I understand that. You did'nt answer the question. I asked you if that didn't occur when the river was being dredged?

A. Yes sir.

Q. Now what was the distance?

A. I don't know what the distance from the original typhoid case was to the waterworks at Detroit, but I think

1419 it is more than fifty miles.

Q. Well, it is not 300 miles, is it?

MR. DRENNAN: Forty seven miles.

A. I don't know exactly from the place where it originated, for it went across the lake.

Q. Well it had a chance for sedimentation there and there was so much of the deposit that was being carried across the lake, that it carried with it some of the typhoid bacillus, didn't it?

A. That seems to be the contention.

Q. Well, do you know the distance?

A. I don't. I have not measured it.

Q. Well, what was the reported distance?

A. I have Mr. William's report. I understood it was something over sixty miles.

Q. Well, what Mr. Williams is that?

A. Mr. Grander Williams—or Mr. Gardiner Williams, who investigated it. He is at Ithica. He is a civil engineer at Cornell University I believe, who has written a report on it, and who investigated it. Do you care to have me look up the distance?

Q. Now, isn't that the most extreme case on record?

A. My memory serves me with no other case at the present time.

Q. Then wouldn't you say that 95 per cent of the reported
1420 cases of typhoid fever epidemics or a large increase of
typhoid fever from water pollution, has been shown to be less than 50 miles?

A. Simply because of the facilities -

Q. Well, no, answer the question.

A. Yes sir.

Q. That is it. That answers it. What is the population of St. Charles?

A. I do not know.

Q. How far is it from the mouth of the Missouri to Kansas City?

A. I don't know that.

Q. Do you know that the sewage of Kansas City is discharged into the Missouri River?

A. Yes, sir, after resting in so-called cess-poools for a time.

Q. You don't know how long?

A. No, I do not.

Q. Is the sewage of St. Joseph Missouri carried into the Misssouri River?

A. I have been told that it is; I don't know.

Q. Is the sewage of Leavenworth and the hospitals there
1421 at Leavenworth carried into the Missouri river?

A. Yes sir.

Q. Doctor, in your opinion as a bacteriologist, there is only one absolutely safe and sure way of eliminating the bacteria, the pathogenic bacteria, from river water, and that is by filtration?

A. Oh, no.

Q. Well, I am speaking of the system of sewage—

A. System of the purification of waters?

Q. Of the purification of waters?

A. Yes sir.

Q. How much filtration in addition to what you have here in St. Louis, would have to be installed in your waterworks system to make it a successful system of filtration?

ATTORNEY-GENERAL CROW: Now we object to that for the reason that the question as to whether or not the city of St. Louis ought to have a filtration plant, or how much it would cost, or how it ought to be built, has no relevancy to the issues as to whether or not Chicago has added pollution to the water supply of this city, or the waters in the Mississippi river in addition to what was there prior to the opening of the Drainage canal, thereby endangering the safety of the health, and the lives of the people in the State of Missouri.

1422 THE WITNESS: Do you want me to answer the question?

Q. (Last question read):

A. That is not known by anybody. Do you want me to go on?

Q. Yes.

A. A body of engineers and expert filter men have been at work on that problem, and they have made recommendations without having carried out an adequate series of experiments on the water to ascertain the facts connected with it, and nobody knows how to filter this water supply, or what it will cost.

Q. You mean to say that a system of filtration could not be installed here?

A. I do not mean to say that, but it is not known how best to filter this water and what it will cost.

Q. Don't you know how best to filter this water?

A. I do not.

Q. You do not?

A. No sir.

Q. I believe you said that with the present system that you have, that there is removed from the water from 90 to 98 per cent of the bacteria?

A. In the reservoir system there is some seventy per cent
1423 removed and to the consumer, at a definite period of 1901, we found as high, I believe as you speak of, 90 to 95 per cent to the consumer, of bacteria removed.

ATTORNEY-GENERAL CROW: In what year?

A. 1901, in the period of October and November, 1901.

Q. ATTORNEY-GENERAL HAMLIN: And the addition --would the addition of additional settling basins eliminate the balance of the bacteria?

ATTORNEY-GENERAL CROW: Now we object to that as wholly irrelevant in this case.

A. The elimination do you want?

ATTORNEY-GENERAL CROW: Wait a minute. As wholly irrelevant for the reason that the question as to whether or not more settling basins would assist St. Louis, is not any defense for the pollution of our waters of the Mississippi river by the city of Chicago or the Drainage Canal.

ATTORNEY-GENERAL HAMLIN: Well, I will withdraw that question.

ADJOURNED until 2:00 p. m., same day, Wednesday, March 11, 1903, at same place.

1424 Southern Hotel, St. Louis, Mo., 2 p. m., Wednesday, March 11, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

DR. AMAND NICHOLAS RAVOLD,

Resumed the stand for further cross-examination by Attorney-General Hamlin, and testified as follows:

Q. Dr. Ravold, you made some examinations through the three periods, of the water of the Mississippi river above Grafton, did you not?

A. Yes sir.

Q. Now, have you been from that point up the Mississippi river?

A. I have traveled by boat as far as Dubuque.

Q. Can you name the principal towns from Grafton on the Mississippi river to Dubuque.

A. I cannot.

Q. Do you remember where Quincy is located, or about where?

A. Yes, sir, it is in Illinois, that is on the Illinois side.

Q. Keokuk, do you remember that place?

1425 Q. In Iowa?

A. Iowa, yes sir.

Q. And Rock Island?

A. Rock Island, yes.

Q. Burlington. That is in Iowa, isn't it, on the Mississippi?

A. Yes, sir.

Q. Davenport?

A. Yes, Davenport.

Q. Do you know whether or not these towns discharge their sewage into the Mississippi river?

A. I have seen the sewage discharging from some of those towns into the river. I think all of them do.

Q. Now, what do you say as to St. Paul and Minneapolis?

A. They also discharge their sewage into the Mississippi river.

Q. And do you know how many tributaries there are of the Mississippi river from Grafton to Minneapolis?

A. I do not.

Q. Well, do you know whether there are any?

A. Yes, sir, I know there are rivers discharging into the Mississippi, but I do not know the distance to them, the names of them, or the number. 1426

Q. But you know there are several?

A. Yes sir.

Q. Now, the Missouri river, what towns on the Missouri that you know of that discharge their sewage into the Missouri river?

A. I know Kansas City. I don't know of St. Joe by personal knowledge, but I know they discharge their sewage into the Missouri—I mean I know that St. Joe does. I know Kansas City does and I know that Leavenworth does.

Q. And the nearby towns?

A. St. Charles does also.

Q. How about Jefferson City?

A. Jefferson City, I believe, does also.

Q. How far is it from the mouth of the Missouri to Jefferson City by river?

A. I don't know.

Q. How far up is the Mississippi river navigable?

A. Well, in the period—in the dry weather period I traveled on it—I could travel as far as Dubuque only and had to travel from there north in a train.

Q. Is it navigated as far as St. Paul?

1427 A. At times it is, yes.

Q. How far is the Missouri river navigable?

A. Well, it is not navigable at all for anything but very flat boats, boats drawing very little water.

Q. To what extent is it navigated with flat boats?

A. Not very much.

Q. How far up?

A. I don't know how far they go now. The river is in very bad condition since the railroads have gotten after it.

Q. Now, then isn't it a fact from your understanding and knowledge, that the Mississippi river, the Missouri river and the Illinois river are used by the inhabitants of the various towns along those respective rivers, for the purpose of depositing their sewage in each of the rivers?

A. Yes sir.

Q. Now, isn't it also true that St. Louis, situated on the Mississippi river, below the mouth of the Illinois and the Missouri river, discharges its sewage into the same common drainage that the inhabitants of the other rivers do?

A. Yes sir.

Q. How many years has St. Louis, to your knowledge, been discharging its sewage into this common drainage canal?

1428 A. As I said before, I have looked over the statistics of the Sewer Commissioner here and if I am not mistaken, the first sewer, the mill creek sewer, was constructed in 1849. That is, the direct sewage discharge. That was the first sewer, that was the beginning of the large sewer system that we have now running through the town—Mill Creek sewer.

Q. What year was that?

A. I think that was in 1849, but I do not know that accurately.

Q. And it has been discharging its sewage continuously then from that time until this?

A. Yes sir.

Q. Now, what was the population of St. Louis in 1900?

A. I can not remember the figures; I do not know accurately from memory now.

Q. Well, have you some way—I want to ask you some questions on that, if you can have some means of—

ATTORNEY-GENERAL CROW: 575,000, something like 600,000.

ATTORNEY-GENERAL HAMLIN: 575,200?

A. A. Yes, the estimation has been made for easy reading at 600,000.

Q. Now, that is within the corporate limits, is it not?

1429 A. Yes, sir.

Q. Now what suburban population is there that discharges its sewage into the Mississippi?

A. Well, suburban population—you mean so as to come into that sewage system of the city?

Q. Well, I will ask you that first?

A. Well, I don't know that—what on the other side of that drainage area discharge their sewage into the river Des Peres and some of that sewage was carried through the Mill Creek part of it goes south through Carondolet, through the river Des-Peres.

Q. That discharges in the Mississippi?

A. That discharges in the Mississippi river, yes, sir.

Q. Well, if you know what suburban territory here discharges its sewage into the Mississippi river, you can tell us?

A. I do not know except the suburban along the river Des Peres drainage area, and that extends south and west of the city.

Q. You are speaking now of that portion of the population outside of the city limits?

A. Yes, sir.

Q. Could you give me approximately the amount of population outside of the city limits whose sewage is discharged into the Mississippi river?

1430 A. I can not.

Q. Well, now on the basis of a population of 575,000, can you tell me how much sewage is discharged daily by the inhabitants of the city of St. Louis into the Mississippi river?

A. The water consumption is about 130 gallons per inhabitant. 78,000,000 gallons.

Q. Every 24 hours?

A. Yes sir.

Q. And that calculation is based upon the same calculation that you made in regard to the city of Chicago?

A. That is the water consumption here of 130 gallons per head per day. I can make that for 150 gallons if you will agree to have it said that we pumped the same quantity of water to the individual.

Q. But you do not?

A. No, we do not.

Q. Well, then make it—

A. Make it 130 gallons, I think it is.

Q. Now what is the population of St. Charles?

A. I do not know.

Q. What is the population of Jefferson City?

1431 A. I do not know.

ATTORNEY GENERAL CROW: 9,700 for St. Charles.

Q. ATTORNEY GENERAL HAMLIN: Now, assuming that the population of Jefferson City is 9,700, how much sewage would there be?

A. And their water consumption what?

Q. Well, the usual average.

A. Say we allow them 100 gallons a day.

ATTORNEY GENERAL CROW: It doesn't run as large in small towns as it does in large cities.

THE WITNESS: No. Say they were using—pumping 100 gallons of water to each inhabitant and basing the present population upon 10,000, they would discharge 1,000,000 galons of sewage per day.

Q. Do you know the population of Kansas City?

A. It is about 200,000.

Q. Very well. On the basis of 200,000 what would be the discharge—

A. I do not know what the amount of water per inhabitant is, but we can take it the same as St. Louis, or 130 gallons, or make it 100 gallons. It is much easier figuring.

Q. Well, use anyting you want to.

1432 A. If it were 100 gallons per inhabitant, there would be 20,000,000 gallons of sewage a day.

Q. How well acquainted are you at Kansas City?

A. I have been there three times in my life and am not very well acquainted with it.

Q. Do you know anything about the location of its stock yard?

A. No, sir.

Q. Do you know whether or not the stock yards discharge their offal into the Missouri river?

A. I do not.

Q. Now, Doctor, I will ask you to state again, the cause of typhoid fever and how that disease may be communicated?

A. We have first air borne, carried in the air. The typhoid bacillus retains its vitality a long time in the earth and it is just possible that when the earth becoming dried and ground up as dust and blown into the air, the bacillus may be taken into the lungs of the individual, or rather into the respiratory passages and thus swallowed, and eventually into the stomach; and that was a remote possibility.

Then, we had air-borne and we can say insects under that, flies. Flies in the summer time, as I cited the instance at Chickamaugua, where this was claimed to have been the cause 1433 of the conveyance of the typhoid fever from the dejecta or the excrementatious matter that had collected in the latrines of the soldiers, not disinfected in any way. Flies settled upon this material, the feces stuck to their feet, they traveling from these latrines to the mess table, and crawled all over the food. The distance was short from the latrines to the table, and in that way it was claimed that some of those typhoid cases might have been conveyed. So, we have flies.

Now, food. Food such as lettuce sprinkled with typhoid water, celery and other green foods, oysters, raw, and milk that has in it—that has become infected with typhoid excreta either directly from the hands of milkers or by the addition of infected water to the milk.

Then the direct transmission by an individual nursing or handling a typhoid fever patient and without cleansing the hands carrying the bacillus directly into the mouth and thus conveying the disease—and I cited the case of a doctor working in my laboratory, named Beggs, working on a typhoid feces, who infected himself, through a lack of cleanliness. I think 1434 that is the number.

Q. Where does St. Louis get its milk supply?

A. It gets a great part of it from the rural districts of Illinois and Missouri.

Q. Do you know from your own knowledge what companies furnish this milk?

A. Well, I know that the St. Louis Dairy Company is one; the Union Dairy another one; the Bon Terre another one; the Graffman; the Keyes. I think that is about as far as I can remember.

Q. In your work as a sanatarian, have you ever visited these places?

A. Yes, sir.

Q. What do you know as to what they do in the way of sterilizing their cans?

A. In nearly all of these places they steam sterilize the cans before sending them away or they drive into them boiling hot water with streaming steam in it before sending the cans away from the city.

Q. Is there a company here known as the Union Dairy Company?

A. Yes, sir.

Q. Have they any system of sterilization?

1435 A. I really do not know that, I never visited that plant.

Q. Don't they handle a large quantity—

A. A large quantity of milk, yes sir; but just exactly what they do with the cans I do not know. I once requested entrance into that place but inasmuch as the superintendent was not present I was not admitted.

Q. Well, if the cans are not sterilized, as a sanitarian, do you regard that as likely to result in typhoid germs?

A. Well, I would say that it was a gross act of negligence, owing to the fact that there is a possibility of this typhoid bacillus being conveyed in that way.

Q. Do you know of any epidemics that have been caused from the milk supply?

A. Here?

Q. No, anywhere?

A. Oh, I know there are accounts in the literature of epidemics of that kind.

Q. Well, how often and how many and to what extent?

A. I have not the figures just now, but there are quite 1436 a number of them, quite a number of authentic cases recorded of milk producing local epidemics.

MR. DRENNAN: Of typhoid?

A. Of typhoid, yes sir.

Q. ATTORNEY GENERAL HAMLIN: Suppose that a well was inoculated with typhoid bacillus and that its water should be used in washing the milk bottles—

ATTORNEY GENERAL CROW: Diluting it you mean, don't you?

ATTORNEY GENERAL HAMLIN: No, I am not diluting now. I am on another branch of the case.

—and putting in the hot milk into these cans or bottles without sterilizing them, what would you say as to the propagation of typhoid bacillus?

A. There is a possibility of conveying them in that way into the milk.

Q. Have you known them to be conveyed in that way?

A. I have not personally.

Q. You do know in the books, I suppose?

A. I do know in the books where a man—not exactly, no, that is the milk bucket itself, or the can—undoubtedly that contained the milk was washed with this diseased water and not entirely drained and the typhoid bacilli had got into the milk.

Q. Have you the table which you gave as to the per cent 1437 of deaths to cases in St. Louis for the years 1897, 1898, 1899, 1900, 1901 and 1902?

A. It is in the building, sir. It is down in the General's room.

MR. DRENNAN: I have got an abstract of it. You may recognize it as correct.

A. Would you rather see the table?

MR. DRENNAN: You look and see if that is correct.

ATTORNEY GENERAL CROW: I will go down and get you the chart.

THE WITNESS: All right. These figures are correct, but he has gone to get the tables.

ATTORNEY GENERAL HAMLIN: I can drop this until General Crow comes back, and ask some questions on something else that is not perhaps so important.

MR. WOERNER: Just go ahead.

ATTORNEY GENERAL HAMLIN: You can cancel that question until Attorney General Crow comes back again.

Q. Now, Doctor, what is the relative volume of water forming the Mississippi river opposite the city of St. Louis, contributed by the Missouri and the Illinois and the Mississippi rivers above the mouth of the Illinois?

1438 A. I do not remember. I have some figures on that subject in my report, and I had better get that.

Q. Yes, you had better.

A. Yes, I had better get that report.

Missouri river during the 12 years 1879 to 1890 inclusive, has a minimum flow of 39,900 cubic ft. per second. These observations were recorded in the month of November, in November 1895 the lowest flow on record of this river was recorded as being 20,600 cubic ft. per second. These figures obtained through the courtesy of Mr. A. H. Blaisdell, of the Missouri River Commission, St. Louis. Now, that is the Missouri.

In 1880 the Mississippi river at Hannibal, the minimum about 100 miles above Grafton was a flow of 22,498 cubic ft. per second and a maximum of over 272,699. These observations were recorded on January 28 and April 29 respectively of that year.

Now, do you want to get this below Grafton?

Q. I want the Illinois river at Grafton?

A. Well, the Illinois River, I have no figures for that except what are in Mr. Harmon's book, Mr. Harmon's report.

Q. Did you state that, haven't you stated that?

1439 A. I stated the flow at Peoria at that time for ten years observation for low river stages, and it was 1221 ft.

ATTORNEY GENERAL CROW: Per second?

A. Yes, cubic ft. per second.

Q. ATTORNEY GENERAL HAMLIN: Well, did you get the volume of water at Grafton?

A. No, I did not.

Q. That is, after the waters of the—

A. Oh, below where the two had come together and are flowing in the Illinois River water and the Mississippi water?

Q. No, what I really wanted to get was this: the volume of water at Bellefontaine in the Missouri and of the Illinois river at Grafton and the Mississippi river above Grafton.

A. Well, the only observations that have been made near that point, the points you request on the Missouri river, are the figures I have just read of the Missouri River Commission and these figures are from the Mississippi river Commission. They have no flow records at Grafton nor at Bellefontaine— they have no measurements for that at all. They have no stations there in other words.

JUDGE SPRINGER: Well, was the Missouri River taken there?

A. I don't know where that was; that was above Bellefontaine somewhere on the river.

1440 ATTORNEY GENERAL HAMLIN: That was 39,000.

A. Yes, sir that was 39,000.

Q. Cubic ft. per second?

A. Yes sir.

If the square miles on the drainage area of the Missouri are wanted I have it here, from their report.

Q. Well, isn't it a fact that you know that the Illinois River only contributes about 1-10 of the volume of water that is contributed by the Mississippi above Grafton, and the Missouri at its mouth?

A. Well, we can easily get at that.

Q. I don't know whether you can or not if you take Hannibal as a basis.

A. Well, are there any very large rivers coming in below that?

Q. I don't know.

A. No, I think there are not.

MR. DRENNAN: There are a great many creeks and much drainage.

ATTORNEY GENERAL CROW: There isn't any difference much in the size of the river at Hannibal and at the junction of the Missouri and the Mississippi?

A. The nearest one, the West Fork River, enters about 15 miles above Grafton into the Mississippi about 40 miles
1441 above the mouth of the West Fork is the Salt River, which enters into the Mississippi.

There are one or two large rivers which join the Mississippi about 100 miles above Grafton.

Q. And that is below Hannibal?

A. I don't know whethere it is below Hannibal or not. Are you sure about that?

Q. I say I don't know.

Well, isn't it a fact, if you know, that the Illinois river only contributes about 1-10 of the volume of water that is contributed by the Mississippi above Grafton and the Missouri at its mouth?

A. In these low river stages this would seem to be the case because I find that just below Grafton in the Mississippi the minimum flow of 24,858 cubic ft. per second was noted on January 11th of this same year. So that would give the Illinois there 2360 cubic ft. per second. That would be about 1-10.

Q. Now, I will resume, or repeat the question I asked you a few moments ago?

You have given the number of cases of deaths from typhoid fever in St. Louis for the years 1897, 1898, 1899, 1900, 1901,
1442 1902, have you not?

A. Yes, sir.

Q. How many cases in 1897, and how many deaths?

A. In 1897, 433 cases and 125 deaths.

Q. Now what was the population of the city in 1897?

A. I do not know other than the figures that I have just seen on this piece of paper that Mr. Drennan gave me.

Q. Well, assuming these figures to be correct, you may state that the per cent—

MR. DRENNAN: Let him give the figures.

ATTORNEY GENERAL HAMLIN: You may state what the population was.

A. The population 533,921, calculated I suppose from the census 1900.

Q. Now, you may state what the per cent of deaths was to the population?

A. I would have to calculate that out. There is a percentage given here but these are the figures of somebody else, not mine.

Q. Well, now, suppose you make that calculation?

A. What do you want? You want deaths to cases, do you, in that particular case?

Q. Yes, deaths to 100,000 population.

A. Percentage of cases per 1000 you have got here.

1443 ATTORNEY GENERAL HAMLIN: Per 100,000 it means.

A. Well, General Hamlin, it will take me several hours to work this thing out.

Q. You may have that paper (handing witness paper). Now, if you will take that set of figures, I want to ask you a few questions based on that and you can figure it afterwards.

I will ask you if the percentage of deaths from typhoid fever for 1897, 1898, 1899, 1900, 1901, and 1902, based upon the cases for each of these years in St. Louis, is not for the year 1897, 28.21 per cent.

For 1898 22.3 per cent.
For 1899 13.6 per cent.
For 1900 13.85 per cent.
For 1901 17.38 per cent.
For 1902 19.99 per cent.

These are the figures here recorded by Mr. Randolph, are they not?

MR. DRENNAN: Yes. What is your answer?

A. They are not my figures. I would have to verify them. These are the figures here recorded by Mr. Randolph.

Q. ATTORNEY GENERAL HAMLIN: Would you verify them?

A. Yes, sir.

1444 Q. And place them in the record at this place?

A. Yes, I will verify them, yes sir. These are the percentages of deaths to cases.

Q. Recorded as to population?

A. No, oh no. It is simply the number of deaths to cases, which means nothing.

Q. What is this per cent of deaths and to what particular cases?

A. Yes.

Q. Based on the population?

A. Yes, sir.

Q. Now, I will ask you if the per cent of cases to population for 1897 is not .083 per cent?

For 1898 .0774 per cent.
For 1899 .17 per cent
For 1900 .21 per cent
For 1901 .184 per cent
For 1902 .179 per cent

These are the figures of Mr. Randolph?

MR. DRENNAN: Yes.

A. Yes, sir.

ATTORNEY GENERAL HAMLIN: And you will verify them and place them in the record?

1445 A. Yes, I will verify them.

Q. And I will ask you if the per cent of deaths to cases of typhoid fever in St. Louis for 1897, was not .023 per cent in 1897 and in 1898 .0172 per cent,

For 1899 .023 per cent
For 1900 .029 per cent
For 1901 .033 per cent
For 1902 .0357 per cent.

A. Those are the figures of Mr. Randolph, which I shall verify.

Q. Now, Doctor, just a few more question and I am through. Now, do you know what the area drained—do you know the extent of the area drained by the Missouri River?

A. I have some figures on that. The watershed of the Missouri River embraces 530,000 square miles.

Q. Now, the area drained by the Mississippi river above Grafton?

A. I can not give you that because I have been unable to obtain it even from the Commissioners themselves,—the Mississippi river Commission are unable to give me those figures. They promised them to me but I have them not yet.

Q. Well, do you know the area drained by the Illinois river?

A. I think I gave you that.

1446 Q. Not to me, did you?

A. Not to you, no sir, I beg your pardon. No, what I read in the other report was the area, square miles of the upper, middle and lower rivers of the Illinois river.

Q. Well, that added together would make all of it, wouldn't it?

A. Grand total 27,914.

Q. 27,914?

A. Yes, from the table bearing upon this subject taken from the Illinois and Gulf Water Ways as related to the Chicago drainage problem by L. E. Cooley, Civil Engineer.

Q. Well, now, do you know approximately what the drainage area of the Mississippi river is above Grafton?

A. I do not. I shall try to have that Mr. Hamlin.

Q. All right. The per cent of area of the Illinois and its tributaries is very small compared with the area drained by the Mississippi river above Grafton, and the Missouri, is it not?

A. The drainage area of the Illinois compared to the drainage of the Missouri, yes.

Q. Of the Missouri and the Mississippi added together?

A. Oh, yes.

1447 Q. Very small, isn't it?

A. Very small, yes, sir.

CROSS-EXAMINATION

By Mr. Drennan, on behalf of
the Sanitary District of Chicago.

MR. DRENNAN: I will not be able to be here to-morrow but there are a few questions I want to ask the witness and then I willl leave the further cross-examination to Judge Springer, because I do not want to conduct it on my part.

ATTORNEY GENERAL CROW: I have no objection. Go ahead and suit your own pleasure about that.

Q. Doctor, I understood you to say that the principal water borne pathogenic bacteria were typhoid, cholera, and dysentery.

A. Yes, sir.

Q. You found none of these in the Illinois river, as I understand it?

A. No, sir, I found none of them.

Q. I understood you to say that the pathogenic bacteria did not thrive well in sewage and that in sewage they displayed less vitality and their existence was ended quicker there than elsewhere. Is that correct?

A. Well, you mean now the sewage of the drainage canal, 1448 do you not?

A. The sewage from cities such as would be discharged in the city of Chicago in the sewerage system there, just the same as eleswhere?

A. I did not work upon the actual contents of the sewers. The only observations I carried out were upon the longevity of the pathogenic germs in the waters of the drainage canal and the Chicago river also.

Q. After it was diluted with lake water?

A. It was diluted with lake water, yes.

Q. But isn't it recognized as a scientific proposition that these pathogenic germs do not thrive in sewage?

A. No, it is not entirely that way. It depends upon the character of the sewage. Some observations by different men show that the typhoid bacilius has lived as high as five months in sewage, while others but a few days. So you see it depends upon the character of the sewage at the particular time.

Q. You made no investigations there as to the sewage there in Chicago?

A. None whatever.

Q. So you can not answer as to that?

1449 A. No, sir, personally I can not.

Q. You spoke of the septic tank system of handling sewage, doctor?

A. Yes, sir.

Q. And I understood you to say that that system was still in its experimental state?

A. Yes, sir.

Q. And isn't yet regarded as entirely practical?

A. For certain classes of sewage it does not seem to be.

Q. The septic tank system is still in its experimental stage, is that right?

A. Yes. It is very efficient in some localities and not at all so in some others.

MR. DRENNAN: That is all, I think, Dr.

CROSS-EXAMINATION

By Judge Springer in behalf of the Sanitary District of Chicago.

Q. Doctor, you are acquainted with the work known as "Micro-organisms in water" by Percy and G. C. Frankland?

A. Yes, sir.

Q. Is that an authority in bacteriology?

A. Yes, sir it is. What edition is that?

Q. This is the edition printed in 1894.

1450 A. In 1894? Yes, sir, that was an authority at this time.

Q. Since that time, I believe there have been discovered some pathogenic and non-pathogenic micro-organisms which were not referred to by Frankland?

A. Yes, sir.

Q. I have another work here entitled "Principles of Bacteriology by A. C. Abbot, M. D., Professor of Hygiene and Bacteriology in the University of Pennsylvania."

A. Yes, sir.

Q. The sixth edition published in 1902?

A. Yes, sir.

Q. Is that an authority also?

A. That is a very good work, sir.

Q. Well, taking the list of pathogenic micro-organisms from these two works down to the present time—

A. Yes.

Q. I find the following list as set forth in those two books: Koch's Comma Spirillum or Bacillus of Asiatic Cholera. That produces cholera.

A. Yes, sir. Discovered in 1884.

Q. That was the first one?

1451 A. Yes, sir.

Q. Second: Vibrio Berolinenses and Vibrio Proteus. These may produce cholera I believe?

A. No, I do not agree to that proposition.

Q. Well, that is what is stated in the text books.

A. It is Berolinenses and Vibrio Proteus.

Q. Yes.

A. They produce a disease resembling cholera but not the true cholera.

Q. Yes, they produce a disease resembling cholera?

A. Yes.

Q. And the third is the typhoid bacillus?

A. Yes, sir.

Q. We have had reference to that frequently?

A. Yes, sir.

Q. The fourth is Bacilli Coli Commni?

A. That is classed as pathogenic.

Q. It is classed as capable of exhibiting very different degrees of pathogenicity, according to its origin. Sometimes pathogenic and sometimes nonpathogenic?

A. Yes, sir.

Q. That is correct, is it?

1452 A. Yes, sir.

Q. You have classified it here, I believe, as a pathogenic germ?

A. Nonpathogenic germ, as flowing in a stream—we said river—. Under certain conditions I stated in any river it was regarded as nonpathogenic.

Q. It is generally regarded, though, as nonpathogenic?

A. By water bacteriologists, yes.

Q. The fifth that I have here is Bacterium Tholoeideum. This is found in water suspected of causing typhoid fever by Schardinger.

A. Yes, sir. What was the year?

Q. The year is not given.

A. It is in Frankland. That is before we had the typhoid reaction.

Q. The sixth is Bacterium Lactis Aerogenes?

A. Yes.

Q. This was found by Schardinger in water suspected of causing typhoid fever, according to the statement of Frankland?

The seventh is Bacillus Anthracis?

A. Yes, sir.

1453 Q. This produces the spleenic fever in cattle?

A. Yes, sir and malignant carbuncle in man.

Q. Eighth is Proteus Vulgaris?

A. Yes, sir generally found in sewage.

Q. Ninth is Proteus Mirabilis.

Tenth is Proteus Zenkari.

Eleventh is Bacillus Proteus Fluorescens.

A. Yes, sir.

Q. Pathogenic to some of the lower animals?

A. Yes, sir, said to be by Frankland.

Q. Twelfth, Tubercle Bacillus or Bacillus Tuberculosis?

A. Yes, sir.

Q. Thirteenth, Bacillus Tetanus, produces Lockjaw.

A. Yes, sir.

Q. Fourteenth, is Bacillus Pyocyaneus?

A. Yes, sir.

Q. Fifteenth, is Bacillus of Mous Septicaemia?

A. Yes sir.

Q. Bacillus Murisepticus, pathogenic to house mice.

A. Yes, sir.

Q. Sixteenth is Bacillus of rabbit Septicaema, Bacilius Croniculicidas.

A. Yes, sir.

1454 Q. Seventeenth, is Bacillus Brevis.

Eighteenth is Bacillus Capsulatus.

Nineteenth is Bacillus Hydrophilus Fuscus?

A. Yes, sir.

Q. Twentieth is Bacillus Cocous.

Twenty-first is Staphylococcus Pyogenes Aureus

Twenty-second Fusarium. Agualductuum.

Twenty-third Bacillus Saprogenes II

Twenty-fourth Dyphtheria Bacilli.

This was stated by Abbott and not by Frankland?

A. Yes, sir.

Q. Twenty-fifth, Bacillus Dysenteriae?

A. Yes.

Q. That is by Abbott?

A. Yes sir.

Q. Twenty-sixth Bacillus Influenzae?

Twenty-seventh is Bacillus Leprae?

A. Yes, sir, causes leprosy.

Q. Twenty-eight, is Bacillus Syphilidis, producing syphilis

A. That is Schardinger.

Q. No, it is recorded by Abbott.

A. Did he question it? That is questionable.

1455 Q. Twenty-ninth is what is known as what is known as the glanders Bacillus.

A. Yes, disease of horses and men.

Q. The Thirtieth is Bacillus of Malignant Oedema?

A. That is found in the soil.

Q. Found in the soil only?

A. Yes, sir.

Q. Thirty-first is the Bacillus of Bubonic Plague.

Thirty-second is Bacillus Smegmatis?

A. Yes, sir.

Q. That embraces the list so far as given in these two volumes. Did you find any of these in the waters of the Illinois River except the Bacilli Coli Communis?

A. Oh, yes, I found that Proteus Vulgaris, the Proteus Mirabilis, Proteus Zenkari and I think we once found Bacillus Pyocyaneus.

Q. Did you find those in the Missouri water also?

A. I don't remember whether I did or not. I can easily tell you. I found the Proteus Zenkari one time in the Missouri River water opposite Bellefontaine.

Q. Did you find any of the others there?

1456 A. No, sir, except the Bacillus Coli Communis.

Q. What kind of diseases do they produce?

A. They produce no disease in man, they are nonpathogenic to man.

Q. Are they regarded as injurious to drinking water?

A. They are related somewhat to sewage producing, when associated with others.

Q. Not of themselves?

A. No, not of themselves.

Q. So far as the Illinois river is concerned, above the mouth of the river, you found no germs that were disease bearing so far as man is concerned, except the Bacillus Coli Communis?

A. No, sir, and which, by the water bacteriologists, are not classed among the pathogenic bacteria.

Q. Then your conclusion, as to the dangerous quality of bacteria in the Illinois river, was not based upon the poison, the actual germs that produced disease there, but other germs which were kindred, or sometimes found with them?

A. Yes, sir.

Q. The same is true of the Mississippi river above the mouth of the Illinois river, is it?

A. Yes, sir.

1457 Q. And of the Missouri river above the mouth of that stream?

A. Yes, sir.

Q. You found then, substantially the same conditions existing in all these three rivers?

A. Yes, sir, only more of this sewage bacteria in the drainage canal and Illinois river than we found in these others.

Q. You mean more as to quantity?

A. Yes, we found them a greater number of times.

Q. But not a greater number as to quantity? You took more samples from the Illinois river than the others?

A. I think we took more samples from the Missouri river than from the drainage canal or from the water at any other station, we were always right up against the Missouri there and it was easy to get samples.

Q. Is there any means now known of obtaining absolute proof of the hygenic quality of water supply?

A. Well, bacterteriology will indicate the presence or absence of bacteria.

Q. Is that sufficient to determine the potability of the
1458 water supply itself?

A. Yes, sir, it was used by the German Government.

Q. It may be sufficient?

A. Yes, sir.

Q. Do not bacteriological examinations of water produce different results at different times when the conditions are slightly different?

A. I don't exactly get that question.

Q. The conditions under which samples of water are taken are so varied that you may find a very different result on one day, or a few days afterwards from what you found on the previous day?

A. That depends—you mean in the river?

Q. Yes.

A. That depends on the condition of the precipitation on the drainage area.

Q. Then all these samples that you have taken and have examined must be considered in the light of the stage of the river and rainfall at the time?

A. Yes, sir.

Q. And also the condition of life?

A. No, we found that practically meant nothing.

1459 Q. It would be very slight, if any?

A. It would be very slight, in the Drainage Canal, there was a variation there, too.

Q. In order to obtain a perfect, or approximately perfect knowledge of the bacteriological condition of running water, would it not be necessary to take samples every day in the year and under precisely similar conditions for those days in order to make your calculations reliable?

A. Yes, sir, that is what we did.

Q. Every day in the year?

A. Every day in 1900, from January 23rd to October—whatever date it was, the 11th I think.

Q. That was for 1901?

A. For 1900.

Q. You took the same for 1901?

A. For 1901 during the months of September, October and November.

Q. The samples that you took then, during the year 1901, covered only a small portion of that year?

A. Yes, sir, they covered the fall of that year, those months of that year, that is practically one-tenth of the year—no, two months—that would be practically one-sixth of it.

Q. What was, so far as you remember, the condition of
1460 the river, as far as rainfall was concerned, at that time, and the stage of water?

A. During that whole period of investigation from September 26th to October, when we stopped, or November, there was practically no rainfall in the Illinois river basin, and the same obtained on the Missouri and on the Mississippi river basins, there was very little, if any, rain during this whole period, it was a time of drouth, so that was taken during a period of drouth when all the rivers were depending on the springs that were discharging into them, and they remained practically level, as I showed in the charts.

Q. During the time of low water would not the effect of the Chicago sewage be more pronounced in the Illinois river than at flood time when the drainage from all other parts of the drainage area came into the river?

A. It has shown less after running a definite number of miles, there is less trace of it in the Illinois river than there is at higher periods.

Q. You mean by that that the water showed less pollution during the periods to which you refer?

1461 A. I say it showed fewer bacteria than were originally carried by the drainage canal after running to Peoria and then to Grafton than it did in the season either following a freshet or when the river was high but steady.

Q. Did the drainage from the farm region and from the pasturage of the country districts generally,—if that was coming into the stream, wouldn't it be more peculiarly a condition created by the ordinary flow of water from Lake Michigan and the Chicago Canal?

A. Yes, sir.

Q. So that would be a better time for determining the influence of the Chicago water on the Illinois water?

A. This particular time was an extraordinary time, the 1901 period was an extraordinary condition, there was very little water in the river other than that discharged into it by the Drainage Canal.

Q. That was a dry year?

A. Yes, sir, very dry.

Q. The water supply then was principally from the springs in the river and from the water from Lake Michigan and the Drainage Canal?

A. Yes, sir, during that period there was very little water running over the dam, Copperas Creek and La Grange
1462 and Campsville, I don't believe any more than what you were discharging was running over the dams, I heard the river men crying for more water all along the river.

Q. Isn't it true that water in streams is, by all recognized standards of potability, at one time and another, the subject of contamination?

A. Yes, sir.

Q. Is there such a thing as absolutely pure water found in nature?

A. Bacteriologically, absolutely pure water there is none except that of boiling springs.

Q. Does not all water, from whatever sources, save from the hot boiling springs, contain more or less bacteria?

A. Yes, sir, from very few numbers, from three or four per cubic centimeter, up to large numbers.

Q. Then the presence of bacteria in water is not of itself an evidence of fecal pollution?

A. No, sir, simply evidence of food supply for bacteria to grow upon.

Q. Have bacteria been found in fresh fallen snow?

A. Yes, sir.

1463 Q. In hail?

A. Yes, sir.

Q. In rain water?

A. Yes, I have found it in all of them.

Q. Have you made any examination of bacteria found in running water in other streams than in the Illinois, Missouri and Mississippi?

A. Yes, sir, I have examined the Meremac river here.

Q. In St. Louis?

A. Yes, sir.

Q. That is a kind of mountain stream, isn't it?

A. It has its source in the Ozarks, I have examined the streams at St. James, Mo., and I have examined the great St. James Spring, which is so much talked of as a source of water supply for St. Louis, and I have examined the waters of Hot Springs, Ark.

Q. Do you find bacteria in all these waters?

A. Yes, sir, except the boiling waters of Hot Springs, Ark.

Q. Then there is no such thing as running water, such as is found in rivers and streams of any country, being free from bacteria?

A. No, sir.

1464 Q. Have you examined the bacterial conditions of water in other rivers than those you have mentioned?

A. Personally I have not, but I have watched the work being done such as that at Hamburg and Berlin, in hygenic institutions of these cities, and in Paris, and in some of the water works of London, at Glasgow, Scotland, and some of the work at Munich, Germany.

Q. In the ordinary conditions of these streams did you find a large number of bacteria in them?

A. You mean without a rainfall on the drainage area?

Q. Yes, sir.

A. No, sir, without, a rainfall, that is with the river stationary, there were large numbers of bacteria as a rule in such streams as the Meremac.

Q. But in navigable rivers?

A. Yes, such as the Elbe, that is a dirty stream, it has large numbers of bacteria, so has the Spree at Munich, and the Danube and the Thames at London.

Q. How do the number of bacteria found in those streams compare with the number that you found in the Mississippi river, the Missouri river, the Illinois river, where you took samples and examined them?

1465 A. Well, depending on the flood volume now there is a difference here in the methods in our efforts to obtain results as indicating the growth of bacteria, some regard gelatine the best media for bacteria to grow upon, but we get higher results as a rule than other observers record when they use gelatine, when other media such as Bahrstöffe Hyden which is a proteid compound enormously large numbers are found, but the medium is erratic.

Q. Enormously large as compared with the rivers in this country?

A. I say in this country they were enormously large when we used this nutritive medium but the results were erratic, they had not the uniformity of the gelatine media, so that gelatine was used under the conditions we speak of, and in recording results these conditions must be taken into consideration when comparing them with other bacteriologists with other streams of other countries.

Q. Then, isn't it true that the conditions bacteriologically considered, of the Illinois, the Mississippi and Missouri rivers at the places where you have taken samples of water, are very similar to the conditions found in rivers of similar size in this country and in Europe?

1466 A. Yes, sir.

Q. Isn't it true of all the periods to which you have refered as the first, second and third period of our investigations here?

A. Yes, sir.

Q. So that you are not surprised to find then in all these waters a large number of bacteria at different times?

A. No, sir.

Q. You would have been very greatly surprised if you had not found any?

A. If I had not found any at Lockport I don't know what would have happened to me, but I would have been terribly disappointed.

Q. Are the rivers generally in this country and in Europe in such a condition as to render them unfit for water supply for cities without some kind of sedimentation or filtration?

A. Yes, sir.

Q. That is, they are unfit?

A. Yes, sir, as a rule.

Q. That applies to all the rivers to which you have referred in your examination here?

1467 A. Yes, sir.

Q. As a bacteriologist, then, you would not recommend supplying cities with water taken from the running streams of this country without some system of sedimentation or filtration being adopted for the purpose of removing bacteria?

A. No, sir, I would not.

Q. That opinion applies to all the rivers of which you have spoken in this examination, does it not?

A. Yes, sir, because all these rivers have sewage discharged into them.

Q. Is it possible from your observation of conditions, that exist in this country and in Europe where their populations are becoming dense, to prevent sewage from getting into running streams?

A. Yes, sir, they do that very effectually at Berlin with their irrigation farms; in Glasgow, Scotland, I drank the sewage that had been chemically treated before it was discharged into the river Clyde; at Paris the same thing is done after it is treated, and there are well known methods of purifying sewage before discharging it into a stream.

Q. You refer to the sewage refuse?

A. Yes, sir.

1468 Q. I would ask you generally, in regard to sewage such as comes ordinarily from farms and the rural population?

A. About one-sixth of that is discharged into streams, and before it gets in it is generally pretty old.

Q. You spoke about the contamination being greater at flood time in rivers?

A. Yes, sir.

Q. What was the cause of that?

A. The contamination—you mean the number of bacteria per cubic centimeter are larger in a running stream at that time?

A. Yes, sir.

Q. That means this, that the soil, all soil, surface soil, contains millions of bacteria upon it growing upon nutritive matter that there exists, vegetable matter, as a rule those bacteria are washed into the running streams by the rainfall, so the bacteria found at these particular times are soil bacteria in preponderance, as a rule.

Q. They can not be kept from the streams?

A. No, sir.

Q. Isn't that contamination sufficient to condemn all our running water for potable purposes?

A. No, sir.

1469 Q. Wouldn't it at flood time be unfit?

A. No, sir.

Q. Why not?

A. Because they are nonpathogenic germs.

Q. Couldn't pathogenic germs be there as well as elsewhere?

A. But not in such numbers.

Q. If there was a diphtheria epidemic at any of the towns in the vicinity of this city that had no other sewage than these rivers, and the flood time came and washed all these diphtheria germs into the river, wouldn't that contaminate the stream?

A. You said diphtheria, do you mean diphtheria?

Q. No, I mean typhoid fever, excuse me.

A. Yes, if this was thrown out on the soil, or from privy vaults it would sweep out into the stream in the mass of volume of water that washed all that surface and be carried along the Lord knows how far.

Q. It would be carried into the stream?

A. Yes, sir.

Q. And would be dangerous?

A. Yes, sir.

Q. Are not many well known cases of typhoid epidemic produced by the spring floods washing the dejecta into the
1470 river which has been deposited during the winter season and not from the sewage of cities?

A. There are not many cases of that kind. We had a remarkable case which I mentioned this morning at Detroit in which a mass of filth and sewage which had collected at the mouth of the Wolf river was cleared away and carried across Lake St. Clair into the water supply of Detroit, causing typhoid fever, but the other case I spoke of was at Plymouth, Pa., where the water washed down the sewage from one patient and which affected the whole water supply.

Q. That danger would exist at all times under like circumstances?

A. Yes, sir, if a mass of feces should be thrown out on the sides of a reservoir, that at any time would be a dangerous thing.

Q. May not that occur at any time in all the rural districts contiguous to the rivers?

A. Yes, sir, but it is such a very minute thing where there is a vast volume of water, here at Plymouth was a reservoir direct in contact.

Q. It only lessens it as to degree?

1471 A. Moves the bacteria further apart, that is all, they are still alive.

Q. And they are still dangerous?

A. Yes, sir.

Q. As a chain is not stronger than its weakest link the water supply is no better than its weakest place.

A. None whatever.

Q. Then you ought to have a water supply that would be good at all seasons, at all times, and under all conditions?

A. Yes, sir.

Q. Can you have that if you take your water supply from the rivers without filtration?

A. There is danger from a river that may contain, or does contain the sewage of any community, it is unsafe to drink and no matter how far above the sewage is thrown into the river it is unsafe to drink that water unless it receives some treatment for the purpose of removing bacteria.

Q. And it would be unsafe even if you eliminate the city sewage?

A. The danger would be very greatly minimized.

Q. Greatly reduced, of course, by the amount of sewage coming into the stream?

A. Yes, sir.

1472 Q. But still the danger would be there?

A. Yes, sir.

Q. You spoke of having visited Lausen, Switzerland?

A. Yes, sir.

Q. The cause of that epidemic, I understood you to say was the pollution of—

A. The pollution of a brook.

Q. That was in the immediate vicinity of the place where the water supply was obtained?

A. Well, as I told you at the time, Lausen, is in one valley and the brook is on the other side, the brook is on a mountain on the other side of this valley in which the valley of Lausen lies, and it was the water from that brook which discharging through an opening in the mountains and was percolated down through the mountain a mile or so.

ATTORNEY GENERAL CROW: By a conduit?

A. No, percolation down through the mountain did it.

MR. DRENNAN: Down a wall?

A. No, not down a wall, there is a large reservoir where the water is stored before being distributed to the town.

JUDGE SPRINGER: There was only a mile and a half in distance from the place of contamination to the place of
1473 distribution?

A. Yes, sir, but there was a whole mountain between it.

Q. When they ascertained that they put a deposit of salt in it?

A. 5,000 pounds.

Q. To see if it would come through on the other side?

A. Yes, sir, to see if soluble substances came through.

Q. So that there was an underground passage?

A. There was a percolation through rocks besides the investigators put flour and material of that kind in above to see whether the passage through the mountain was a tunnel or a large opening and they found was not, because particles of flour were too large to pass through the filter, but the typhoid bacteria were small enough to be carried through.

Q. And did go through, the places of contamination being only a mile or two from the place of distribution?

A. Yes, sir.

Q. I believe the same conditions as those existed at Caterham, England, to which you referred?

A. Yes, sir.

Q. The contamination was direct to the water supply, right in the well itself?

1474 A. Yes, sir.

Q. In the village?

A. Yes, sir.

Q. And Plymouth. Pa., you spoke of that also?

A. Yes, sir.

Q. And there the contamination was direct into the water supply?

A. Yes, sir.

Q. From the immediate locality?

A. Yes, sir.

Q. Have you examined into the epidemics that occurred at Zurich, in Switzerland?

A. No, sir, I have not, I was there but I did not look into the question.

Q. You know about it?

A. Yes sir.

Q. It came from the lake at which the city of Zurich is located?

A. Yes, sir.

Q. In the immediate vicinity?

A. Yes, sir.

Q. And that was supposed to be sewage contamination?

1475 A. Yes, sir, I did not stay long enough in Zurich to examine that, I intended to, but I stayed there only a few hours.

Q. Have you been advised as to an epidemic at a village called Springwater, New York?

A. I have read of it in the literature, I know nothing about it.

Q. In that case the cause of the pollution was in the immediate vicinity of the village?

A. So I undestand it, yes, sir.

Q. Do you remember whether or not there was a typhoid epidemic at Lowell, Mass., in the years 1890 and 1891?

A. Yes, sir, I read of it in Prof. Sedgwick's report on Lowell, Lawrence and Newburyport.

Q. From what source does Lowell obtain its water supply?

A. From the Merrimac river.

Q. And the pollution was from the waters of the Merrimac?

A. Yes, sir, from Stonybrook.

Q. Close to the city?

A. Stonybrook in which the water was carried to the intake, Stonybrook is above the intake.

Q. In the vicinity of the city?

A. Yes, sir, and that sewage was carried down to Lawrence and there caused a typhoid epidemic and then from there
1476 down to New Buryport down to the mouth of the river

Q. Have you had your attention called to Sault Ste. Marie in Michigan?

A. I saw an account of it in Mr. Hill's book, I have been at Sault Ste. Marie, but I did not investigate the typhoid fever epidemic.

Q. That occurred in the immediate vicinity, I believe, of the village?

A. Yes sir.

Q. Have you investigated the typhoid epidemic that occurred at Elmira, New York, in 1896?

A. No sir, none other than to read it in Hill's book.

Q. That you regard as a reliable statement of it?

A. Yes sir.

Q. In this statement of Mr. Hill's he says that the contamination came from the Chemung river and there were some places above, the highest above being fifty miles and the nearest sixteen miles, and that it must have come from some of these localities?

A. Yes sir.

Q. There was also an epidemic in Paris, France, in 1895, you have seen accounts of that?

A. Yes sir.

1477 Q. It affected the soldiers in the French army?

A. Yes sir.

Q. That pollution occurred in the vicinity of a camp of soldiers, I believe?

A. So I see it recorded, yes sir.

Q. Have you investigated the typhoid epidemic in San Francisco, California, recently?

A. No sir, I have not.

ATTORNEY-GENERAL CROW: How recently did that happen?

A. That is Hill's book in 1896, I believe.

ATTORNEY-GENERAL CROW: I thought he referred to something later than that.

JUDGE SPRINGER: No.

Q. That was in 1895?

A. Yes sir.

Q. Do you know how that occurred?

A. No sir, other than what is in the literature there, I never was in San Francisco.

Q. That occurred from a defect in the water pipe, I believe, in the vicinity of the city, there was a typhoid epidemic in Denver, Colorado, in 1896 also?

A. Yes sir.

1478 Q. Do you know how that occurred?

A. I do not.

Q. The books stated that it was some contamination in the river Platte just above the city?

A. That caused them to go high in the mountains to get a pure water supply.

Q. There was also an epidemic in Middletown, Connecticut in 1894, did you investigate that?

A. I did not.

Q. It is stated in the books that that occurred from a stream near by Middletown?

A. Yes sir.

Q. In Stanford, Connecticut, there was a similar epidemic about the same year, 1895?

A. Yes sir.

Q. It is stated in Mr. Hill's book, which I presume is reliable, that this Stanford epidemic was caused by the use of milk?

A. There are quite a number of milk epidemics recorded in literature, and all collected.

ATTORNEY-GENERAL CROW: You mean as an original source?

A. No sir, he don't mean that the cows had typhoid fever, 1479 but the milk had become contaminated with typhoid fever germs probably from a water supply.

JUDGE SPRINGER: There was also an epidemic at Elizabeth, New Jersey, and Evansville, Indiana, about the same time, although the time is not given here. I see from these recorded instances, which are the most classic, if I may use that word, in this connection, as to typhoid epidemics in this country and Europe, that all of them were caused by conditions which existed in the immediate vicinity of the place where the epidemic occurred, is that true?

A. Yes sir.

Q. The only exception to that is that of Elmira where the longest distance was fifty miles and the nearest was sixteen miles?

A. And New Buryport is recorded there also, Lowell, Lawrence and New Buryport at the mouth of the Merrimac river, and Lawrence is accused of being the source of that epidemic.

Q. Have you any information from your own investigations, or from the books, of a typhoid epidemic being caused, the cause having been ascertained definitely, by a pollution which occurred at a remote place from where the epidemic occurred, say more than fifty miles?

1480 A. Well, we had that one at Detroit caused by dredging of the St. Clair river, the typhoid bacilli came from Port Huron, which, I believe is 67 miles away, and they were carried across quite a large lake, Lake St. Clair, and into the water supply.

Q. That was a navigable stream, wasn't it?

A. Yes sir.

Q. Where vessels are plying all the time?

A. Yes sir.

Q. And there were dredging operations which were going on and which would disturb the waters, and which caused the flow to be carried more rapidly?

A. I don't know that the dredging operations would make the water flow any faster in the lake than it did before?

Q. The movements of a vessel in that direction would tend to carry some of it with it?

A. Yes sir, make some current.

Q. That was how many miles?

A. Sixty-seven miles to Port Huron, the source of the epidemic.

Q. Isn't that the only authenticated case on record where the place of pollution and the place of infection were as far apart as 67 miles?

1481 A. Yes sir, where it was so nicely traced, because the difficulties involved become enormous when we go further than that, because we have to cut out all possible sources of extraneous contamination, and the higher we go up the stream the more chances there are for contamination along the banks which we may not discover, so in trying to record a case of that kind it is extremely difficult to get all the facts. Modern life is so complex it is difficult to trace the sources the further we go up a stream.

Q. So that bacteriologists, in ascertaining the cause of typhoid epidemics, have not, up to this time, definitely located the cause of the infection at a greater distance than between Detroit and Port Huron?

A. Yes sir, simply because, as I said this morning, it is impossible even if typhoid bacilli were found at the place of entrance of sewage and then typhoid bacilli found in the water below it, could not be proven that they came from this particular place, because the bacillus is not labeled, has no sign or mark on it by which it could be distinguished from a typhoid germ, coming from any other source.

Q. Then there is no ascertained case of where the infection was brought further, than the case that you have just mentioned? 1482

A. I know of none.

CROSS-EXAMINATION, By Mr. Drennan.

Q. Mr. Randolph wants me to ask you one question; you spoke in your examination here of seeing, or some one informed you that they had seen a large number of dead fish going over Bear Trap dam?

A. Yes sir.

Q. Did you see that yourself?

A. No sir, I said that Mr. Miller of our office went there and saw it.

Q. Has he testified?

A. He has not, but he will.

Q. Do you remember the date of that?

A. Yes sir, it was in November.

Q. Give us the date, will you, about the time of day and who was present?

A. Early in November of 1900, five hundred dead fish were observed to pass over Bear Trap Dam in the space of 10 minutes, the range of actual vision being twenty feet.

Q. When was that, 1902?

1483 A. No sir, 1900.

At this point the further taking of testimony adjourned until 10 a. m., March 12, 1903.

1484 Southern Hotel, St. Louis, Missouri. 10:00 a. m., Thursday, March 12, 1903. Continuation pursuant to adjournment.

Present, the Commissioner, and same counsel representing the respective parties, and also Hon. James Todd, representing the Sanitary District of Chicago.

JUDGE SPRINGER: I want the stenographers to note the presence of the Honorable James Todd, General Counsel of the Sanitary District of Chicago.

DR. AMAND NICHOLAS RAVOLD, resumed the stand for further cross-examination, by Judge Springer, and testified as follows:

Q. Dr. Ravold, on Monday last you stated that you caused certain preparations of the bacillus prodigiosus to be deposited in the Sanitary Canal?

A. Yes, sir.

Q. And also in the Mississippi River above Alton?

A. The Mississippi River, just below the mouth of the Illinois.

1485 Q. Will you state the time at which you made the deposit in the Mississippi River below the mouth of the Illinois River.

A. Yes, sir. On August 31st, 1900, forty gallons of broth culture of the bacillus prodigiosus containing over one thousand million bacteria to the cubic centimeter, were emptied into the Mississippi River below the mouth of the Illinois River just below it.

Q. And the date was?

A. Now, that was August 31st. That was the first time.

Q. Any other deposits at that time?

A. On September 20th, this experiment was repeated, and a barrel containing 40 gallons of prodigiosus broth was emptied at the same point—no, you don't care anything about that; just the two dates.

Q. Well, I want to know all the deposits that were made in the Mississippi River at that time?

A. We have got, August 31st, 1900 and September 20, 1900.

Q. Does that constitute all that were deposited at that place?

A. In that period?

Q. In that period.

A. Yes sir.

Q. Did you make any deposits at this place at subsequent periods to that?

1486 A. No sir.

Q. Nor previous periods?

A. No sir.

Q. Then that comprises all that you did at this place?

A. At this place.

Q. In 1900?

A. In 1900, yes sir.

Q. Now state what investigations you made, if any, to ascertain the presence of the bacteria at points lower down the river?

A. Following this?

Q. Following those deposits?

A. We had samples of water collected at Alton, at Hartford, at the Illinois shore, Chain of Rocks, the Intake Tower of the Water Works, and on the Missouri Shore.

Q. When were those taken?

A. Immediately after depositing the material in the river.

Q. What do you mean by immediately?

A. The material was put into the river from a boat from the harbor boat, and as the boat descended the river, samples were taken,—collected as the boat—

Q. Floated down?

1487 A. Floated down. Not in a direct line, of where this material was deposited, but out in the channel. Samples were continuously taken there every two hours during the day, but not at night. We had no man there at night. Samples were taken though, every two hours during the day. On September 3rd, four days later, this organism was found in a sample of water collected in the channel of the river at Alton, not on the Alton side, but at another place.

In the September 20th experiment, on September 25th this organism was found in a sample of water collected near the Illinois shore, Chain of Rocks.

On October 18th, this bacterium was found in a sample of water collected from the laboratory tap in the old City Hall.

On October 24th, in a sample collected near the Illinois shore, Chain of Rocks,—the laboratory tap samples were taken every hour during the day—

Q. They were found in all of those samples?

A. It was found in the samples that I have recorded, September 23rd, Illinois shore, Chain of Rocks.

October 18th, in the laboratory tap.

October 24th in a sample collected on the Illinois shore, 1488 Chain of Rocks.

Q. Now how long a period elapsed from the time the first deposit was made at this point to the last examination of the samples which was made in that period?

A. Well, samples were continuously collected.

Q. I mean when was the last one in which you found the presence of this bacterium?

A. The first deposit was made on August 31st, 1900, as you see?

Q. Yes.

A. And it was found only once following that deposition. Then on September 20th, that is 20 days later, another barrel was sown in the river and on September 23rd, that is three days later, the bacillus was found in a sample taken at the Illinois shore Chain of Rocks, and on October 18th, in the laboratory tap.

Q. That was how many days later about?

A. That would be September 20th to 30th, ten days, to October 18th. That is 28 days.

Then it was found again on October 24th, in a sample collected near the Illinois shore, Chain of Rocks; that would be a month and four days—that would be 34 days.

Q. Was any further effort made by you to determine 1489 the presence of these bacteria in the waters in and about the Intake during the year 1900?

A. Yes sir. In all of the work in 1899, we searched the waters for distinctive forms of bacteria, beginning in August.

In 1900, from January 23rd to December, we searched these waters for distinctive forms, especially searching for the prodigiosus and we collected 6,000 samples at least, and found it only in the above mentioned samples after depositing the microorganisms in the river.

Then in the third period, over 10,000 samples of the water of Lake Michigan, Drainage Canal, Illinois River, Mississippi River, Intake Tower at Chain of Rocks, Reservoir and tap were studied and it was never found except when put in the river.

Q. The third period that you speak of, that was in 1901?

A. 1901, so you see we have examined thousands of samples of water and never found it except when put into the water of Lake Michigan, the Canal or the Illinois river.

Q. The question I asked was for the purpose of directing your attention to the latest examination which you made which revealed the presence of this bacterium after the deposits in the river above Alton?

A. October 24th.

Q. October 24th?

1490 A. Yes sir.

Now when was it that you made a deposit of this bacterium in the Drainage Canal near Lockport—was it?

A. During the third period, 107 barrels of prodigiosus broth—

Q. Will you state the date of that?

A. Yes sir. There were emptied into the Drainage Canal, 107 barrels of prodigiosus broth, containing more than one thousand million bacteria per cubic centimeter, and they were emptied in the Drainage Canal on the evening of November 6th, by Mr. Ravold—

Q. What year?

A. 1901. At Lamont, a small town on the Chicago Drainage Canal about eight miles east of the controlling works at Lockport.

A. You mean northeast, towards Chicago.

A. I don't know whether the canal runs directly east or northeast.

Q. That was in the Drainage Canal?

A. Yes, in the Drainage Canal at Lockport.

Q. How many barrels did you say?

A. One hundred and seven.

Q. And how many bacteria were deposited?

1491 A. One thousand million to the cubic centimeter.

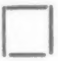
Q. It is possible that some persons may read this record and would not have an idea of the size of a cubic centimeter, and I would like the stenographers to note the size of this so they can reproduce it.

Look at that thing doctor, and see if it is about the size of a cubic centimeter (Handing witness a small cube).

A. Yes sir, that is about the size.

JUDGE SPRINGER: This was made by Mr. Randolph, Chief Engineer of the Sanitary District of Chicago. Just put one side of it in the record?

(One side of said cube is about the following size:)



ATTORNEY GENERAL CROW: Let the record show that you have a cube.

JUDGE SPRINGER: Yes, that means a cube.

ATTORNEY GENERAL CROW: I would rather you would put the whole thing in. I don't understand how you can put one side of it in.

THE WITNESS: It is a cube with a side so large (indicating).

ATTORNEY GENERAL CROW: I think you had better deposit it with the Commissioner.

1492 Q. JUDGE SPRINGER: Now you think it is possible then for as many as a thousand millions of distinct organisms to be embraced or comprised into as small a compass as a cubic centimeter?

A. Yes, and a good many more.

Q. And still not displace any of the water?

A. Of course they displace water. They have got a presence, and a form and all that sort of thing. They are particulate particles.

Q. Can you give the dimensions as ascertained by experts of the size of the bacillus prodigiosus?

A. Yes, they vary in size from young to old. In some about one-tenth of a micro-millimeter, to two micro-millimeters, in length, and five-tenths of a micro-millimeter in width, or putting that in other figures, a micro millimeter is equal to 1-25,000 of an inch, so that the length of this organism would be from 1-50,000, to 1-12,000 of an inch in length, and about 1-50,000 of an inch in diameter.

Q. Did you make any calculation for the purpose of ascertaining the probable number of the bacteria known as prodigiosus, that would be contained in one of these barrels, that would be deposited in the water there?

A. Yes sir, that has been calculated.

1493 Q. Have you made that calculation?

A. Yes sir, I have, but I haven't the figures here.

Q. It would be rather past comprehension, wouldn't it?

A. It goes into the quadrillions.

Q. Now what were the difficulties that confronted you or your assistants in making the deposit of these bacteria in the waters of the Drainage Canal at that time?

A. The canal police.

Q. Did you see any of these policemen?

A. Oh, yes.

Q. What were they doing?

A. Patrolling the canal we understood.

Q. How many were there, did you see?

A. I saw one only, but the man who threw the material in the canal saw several of them at a little hotel in Lamont.

Q. Did those gentlemen make any objections to the placing of the contents of these barrels into the canal?

A. They were never taken into the confidence of the man who deposited the material into the canal.

Q. Therefore they didn't know what was going on?

A. No sir.

Q. This was in the latter part of November, 1901, was it?

1494 A. Yes sir, November 6th, the early part.

Q. Have you any personal knowledge of how the contents of these barrels was dumped into the canal?

A. I was not present.

Q. I believe you stated that your brother made the deposits?

A. Yes sir. I can tell you how the barrels were prepared, the kind of bungholes in them, etc., because that was done here.

Q. Yes, that was done here. You have stated that.

At the time of the dumping of the contents of these barrels into the drainage canal had there not been an examination of the waters from Lake Michigan and the St. Louis Intake, by yourself and another representative of the complainant in this case, and by the experts employed by the defendants?

A. Yes sir.

Q. Was there any reason why you should not have consulted the experts on the part of the defendants, in the making of this deposit, and ask their assistance in making the preparation, and also in the subsequent investigations as to the appearance of these bacteria in the waters?

A. Yes sir.

Q. What was that objection?

A. There was no objection; there was an agreement that
we should collect samples at the same place, and at the
1495 same time but that if any special work was to be carried
out, we were to do it independently of the other.

Q. With whom did you make that agreement?

A. We made that agreement—I think it was with Mr. Randolph and the Board of Trustees, but that was made through Mr. Schnurmacher. He was then the City Counsellor, and that letter is in the files of the department.

The idea was this, that we didn't care to stop at any minute and notify the Chicago bacteriologist that we wanted to carry out some special work.

Q. Did you have this particular work in mind when you made that exception to the rule, which was to govern thereafter, namely, that they were to be taken in the presence of experts on both sides?

A. Yes sir.

Q. Had you any reason to believe that the experts on the part of the defendants would have objected to this kind of an experiment being made?

A. I had none whatever.

Q. Didn't you think it would have been more in accordance with the spirit of the existing agreement if you had invited these experts to participate in the preparation of these cultures, and also in the subsequent examinations as to their appearance in the waters? 1496

A. That seems to have been not the case when the matter was presented to the legal end of the investigation. We were instructed, that when we had any experiments to carry out specially, to do them ourselves.

Q. So you knew on your part then, of no objections that would be offered on the part of the experts of the defendants to this kind of an investigation?

A. None other than that they would have had to increase their bacteriological force to the extent of several men to carry out this experiment in the way in which we intended to do it.

Q. How were these barrels shipped from St. Louis to Lamont?

A. They were shipped by freight.

Q. On what railroad?

A. Now, I don't remember now. I think it was the Chicago & Alton, if I remember correctly. It passes through Lamont.

Q. That railroad that passes through the town of Lamont?

A. Yes, I think it was the Chicago & Alton.

Q. Was there not a statement made to the authorities with whom you came in contact at Lamont, to the effect that the contents of these barrels was vinegar that had been condemned, and was to be thrown out? 1497

A. I don't know what statements were made to these individuals.

Q. You made none yourself?

A. No sir.

Q. You don't know what pretext was offered so as to enable the parties to get the contents of these barrels into the canal?

A. I do not.

Q. Well now, what occurred after the emptying of the contents of these barrels at Lamont, so far as to tracing the presence of the bacteria at other places?

A. The samples were collected every hour, day and night.

Q. Where?

A. From all stations, Lockport, in the Canal, Joliet, above Peoria, or at Peoria, right at the town.

Q. In the lake?

A. No no, below the narrows:

Q. Below the narrows?

A. Yes sir.

Q. Doesn't the lake begin at the narrows?

A. Well, the lake empties into the Narrows, does it not?

Q. No, the narrows empties into the lake.

A. It was in front of the town, so that a man—in order
1498 to have a helper, we had to employ a man that lived on the river, and it was impossible to get a man on the river at the point of the regular collections of samples, so a man who lived near the city was employed by Dr. Rush.

Then at Grafton men were employed to collect samples day and night. Mr. Tedesche, a bacteriologist, was at that point with a collector, and arrangements were made to collect samples day and night, every hour. Then later, arrangements were made with a man named Homer and his son, by whom samples were collected day and night, and they were watched occasionally at night by a man stationed at Grafton, to see that they were doing their work carefully.

Then we had men stationed at the Intake Tower of the Water Works, St. Louis, these men lived in the Intake tower, and went down on a ladder to a boom or scow or something of the kind which was fastened in the water at the bottom of the tower and took samples there every hour, day and night.

Q. During what periods of time were these various samples taken?

A. They were collected—

Q. Beginning at Lockport and ending with the Intake tower, St. Louis?

1499 A. They were taken continuously and as soon as possible the laboratories were notified.

On the evening of November 6th, Mr. Ravold reached Joliet, went to the laboratory in which Dr. Kirschner lived and notified him. Men were sent out and began collecting samples at Joliet that night. The next day they began at Lockport, and samples were continuously collected day and night straight along through that time.

Q. From when?

A. Say beginning November 7th.

Q. And continuously taken from that point to what point?

A. To the Intake tower, and that work ceased about March 1st, 1902.

Q. Well, did you take samples upon the same days at these places or upon subsequent days?

A. That was every day.

Q. Every day at all the places?

A. No, every day at Lockport until the bacteriological laboratory staff left there.

Q. When was that?

A. That was on November 27th, I think.

Q. The 27th.

A. Yes sir.

1500 Q. Now how long did you take them at Peoria?

A. Same length of time.

Q. From October 9th to November 7th?

A. From November 7th to November 27th, at Lockport. At Peoria they began at about the same time.

Q. Same time as at Lockport?

A. Yes, it may have been the 8th; it was done within a day.

MR. TODD: I would like to ask you a question, doctor. Did you take samples at all these different locations that you have indicated, from Lockport to the waterworks in St. Louis on the same days?

A. Oh yes, that was continuously done. They began at Joliet, I think a day before Peoria. They would have begun then on the 7th, at Lockport and on the 8th, Dr. Rush at Peoria began taking samples, because Mr. Ravold, who emptied the broth into the Canal went straight to Joliet and notified the laboratorian there, he then took a train that night at midnight, the midnight train, and landed at Peoria the next morning and notified the laboratory there that the material was coming, and Dr. Rush began collecting at once, arrangements were made so that on the 8th of November, they were all at work.

Q. How many stations were you taking samples from on the 8th?

1501 A. Two.

Q. On the 9th?

A. Let's see—I must say three, say Lockport above the Controlling Works, Joliet and Peoria.

Q. That was on the 8th?

A. Yes sir.

Q. Now on the 9th?

A. On the 9th at those three points.

Q. On the 10th?

A. On the 10th, I think Mr. Tedesche was notified, to begin taking samples at Grafton, but I am sure that by the 12th, he was also taking samples at Grafton, so that by the 12th, we were taking samples every hour day and night at Lockport, Joliet, Peoria, Grafton.

Q. And on the 13th?

A. Continuously taken.

Q. Were there any other stations except those four?

A. None other.

Q. When did they begin taking samples at the Intake?

A. They began about the 15th of November; I don't remember the exact date, but it was about the 15th, and that was continued in that tower.

Q. So that on the 15th or 16th, they were taking at the stations previously mentioned by you, and at the Intake?

1502 A. Yes sir.

Q. Were those all the stations that you were examining then at that time, for the deposit of these samples at Lamont?

A. Understand they were taking hourly samples, day and night at these particular points. We were also collecting samples daily from the Mississippi River at Alton, the Mississippi River at Hartford, and hourly samples were being taken in a cross section of the river, from the Illinois shore, Chain of Rocks to the Missouri shore.

Q. What day was it that you began to take samples at all the stations from Lockport to the last station you mentioned, across the river?

A. Well, you understand we were taking daily samples right straight along, from early in September.

Q. The point I want to get at doctor, is the time that samples were being taken daily from all the stations that you had established between Lockport and St. Louis?

A. November 15th.

Q. Then they were in full operation?

A. They were all in full operation and we were taking cross-sections, across the river, right straight along. We were taking hourly samples in the river from a boat at the Chain of Rocks, but when the water got cold, and the ice began
1503 floating in the river, it was torture for a man to be on the
river at night so we put him in the tower.

Q. November 15th then, all stations were in operation?

A. November 15th, all stations were in operation.

ATTORNEY GENERAL CROW: What was that date?

A. November 15th.

BY JUDGE SPRINGER:

Q. Now how long did this continue then from the 15th of November to the date last mentioned?

A. Well, it continued at Lockport from November 7th until November—I will give you the exact date of when these men left—to November 25th at Lockport and Joliet.

From November 8th, at Peoria to November 30th.

Q. And at Grafton?

A. At Grafton, Mr. Tedesche began taking samples by the 12th. I have not the date in my possession, just exactly when he began taking samples hourly, but I have it in my notes from him, he ceased work on November 27th.

Q. At Grafton?

A. At Grafton. But we sent a man there immediately, so that one day elapsed between the time that Tedesche ceased

taking samples, and the time that we established another
1504 man in the laboratory there.

Q. How long did he continue there?

A. He remained there until December 15th, employing two men by the name of Homer, father and son.

MR. TODD: Did he begin about November 8th?

A. Tedesche?

Q. Yes?

A. No, I think he began later, I think he began about the 10th or 12th. You see Mr. Ravold went first to Peoria and then returned from Peoria to St. Louis, notifying me that the bacteria were coming, and I wrote to Tedesche to begin taking samples. My brother Mr. Ravold arrived from Lamont on the 9th, in St. Louis, and I wrote to Tedesche at once, so it would be between the 10th and 12th, somewhere, that he began taking samples hourly.

BY JUDGE SPRINGER:

Q. Now the next place at which samples were taken during that period was where?

A. Was the Intake Tower, Chain of Rocks, and the Illinois shore, Chain of Rocks, that would be November 15th.

Q. You began there November 15th?

A. Yes sir.

Q. 1901?

A. Yes sir.

1505 And when did you cease to take the specimens at these points with the view of ascertaining the presence of this bacterium prodigiosus?

A. In December, I think, the work ceased at these particular points, about the 15th or 18th of December, I have not the date exactly, but I know that our money ran out about that time, and that the men were taken out of the tower. I continued personally, collecting the samples from the laboratory tap, from about November 20th, night and day until March 1st, 1902. I collected a great many of the samples myself during the day time.

Q. Now about your investigations at what you call the tap in your laboratory office?

A. Yes.

Q. When did they begin with a view to ascertaining the presence of this bacterium?

A. I think about November 20th, that is the statement I made, Mr. Todd, wasn't it?

MR. TODD: Yes, November 20th to March 1st.

A. To March 1st.

JUDGE SPRINGER: 1902?

A. 1902.

Can you state at Lockport for instance, which was only
1506 a few miles from Lamont, when you first discovered the
appearance of this bacterium?

A. I never did any work at Lamont myself, or at Lockport.

Q. I mean at Lockport?

A. I did no work at Lockport myself.

Q. You have no means of knowing that?

A. I did not work there myself—but Dr. Kirschner did, he was the one in the laboratory there.

Q. And the same at Peoria?

A. Same at Peoria. I did no personal work at Grafton, I did no personal work at Peoria. The personal work I did and upon which I testified some time ago, was at the laboratory in St. Louis, and the work of plating was done by myself and several assistants who were put on to aid in the work because it was a tremendous task.

Q. Did you make the bacteriological examinations of the specimens taken at the St. Louis Intake, Chain of Rocks?

A. Yes sir.

Q. You made those yourself?

A. I made those myself, watched the plates and all that.

Q. You didn't make any others?

A. I made no others.

Q. Now will you state what you discovered,—or the
1507 first discovery of the bacillus prodigiosus in these investigations?

A. The bacillus prodigiosus was found in the St. Louis laboratory in samples collected by collector Werner—

Q. Chain of Rocks first?

A. I say, laboratory, St. Louis, some samples collected.

Now I will give you the man's name,—collector Werner, above Intake tower, Chain of Rocks, December 4th, at 8:45 in the morning, he collected a sample—

Q. That is the first one that you examined?

A. No, no, it was the first one in which I found the prodigiosus. He was collecting hourly. Let's see. He collected this particular sample at 8:45 in the morning, in front of the Intake tower.

Q. But you investigated previous to this time?

A. Oh, yes, it was December 4th that he collected this sample of water. I began on November 20th.

Q. That is, you were looking for this bacterium preceding December?

A. Yes, I began November 20th, on the samples collected hourly at this point, Intake, Chain of Rocks, and Illinois shore, Chain of Rocks—the men went out in a boat and collected samples every hour.

Q. And you found nothing?

1508 A. I found nothing up to this date.

Q. The first sample was?

A. December 4th, sample taken at 8:45 in the morning.

Q. What did you find then?

A. I found the bacillus prodigiosus in the sample.

Q. To what extent did you observe its presence at that time?

A. I found only one.

Q. Only one?

A. That is, I found one colony, I believe. Now, I can tell you how much water we plated, and all that sort of thing. In fact, your Health Commissioner was here with me while I was working, several times.

Q. You couldn't state, then, the number of bacteria per cubic centimeter on that specimen?

A. Oh, I don't think I found more than one in a cubic centimeter.

Q. Well, when did you begin to find some more?

A. I found another on December 5th.

MR. TODD: Let me understand. When you say you found one, does that mean one of these organisms, or one colony?

A. One organism, I suppose, one colony grew on a plate.

Samples were plated in gelatine, and wherever a bacillus
1509 happens to be fastened in the gelatine when it hardens
there he grows and forms a little colony.

JUDGE SPRINGER: The colony was formed after it was captured?

A. Oh, yes, the bacillus has to grow to form a colony, and this particular bacillus liquifies gelatine and produces a red pigment, so it was easy to find in this medium.

ATTORNEY-GENERAL CROW: That was on December 4th? The first one?

A. The first one was December 4th.

Q. What date did you say they were put in?

A. They were put in on November 6th.

Q. JUDGE SPRINGER: Those that you denominate as cultures, were not those that were deposited in the river, but were the off spring of the bacterium which you put in the water?

A. Well, that is a point for argument. It was in November. The water was very cold, the weather was cold, and the question of whether these bacteria would grow in cold water was taken into consideration and experiments carried out to ascertain this fact, and it was found that on the contrary they
would not grow in a water with the temperature near the
1510 freezing point, which obtained at this time, and during
December the water was frozen on the surface. Our men collecting in December at Grafton went out on the ice. The same thing at the Chain of Rocks, and as I say, I took the men off the river from the boats and put them in the tower, because there was ice floating in the river. The water was cold, and the chances are that there was very little growth, if any, of bacterium as it floated down the river, it simply depending upon its inherited vitality, to keep alive, so I will state emphatically that I think there was no growth of the bacteria at that time in the water. The individual bacterium put into the canal at Lamont undoubtedly floated all the way and lived.

Q. The first one you found was December 4th?

A. December 4th, at 8:45 a. m.

ATTORNEY-GENERAL CROW: Where was that?

A. At the Intake tower, Chain of Rocks, right above the Intake.

JUDGE SPRINGER: In the specimen collected there?

A. Yes, sir.

Q. At what subsequent time did you find this bacterium in the specimen of water taken from the Intake tower?

A. In another specimen taken at 9:00 a. m., on December 5th, collected by Collector Werner, I again found the bacillus prodigiosus.

1511 Q. To what extent was that?

A. That is qualitative; it is not quantitative results. In order to obtain the quantitative results, I would have to take one part of water and dilute it to 1,000 parts to see if the microorganism was in the water. On that day we took one cubic centimeter of the water sowed it in gelatine, in the hope we would find one or more prodigiosi. So a plate on December 5th showed a growth of the bacillus prodigiosus, and that sample, as I say, was collected at nine in the morning.

Q. Was that one or more?

A. Well, this plate was pretty well liquified, whether there was more than one on the plate, I could not say, but it showed a red coloration in a liquified medium, so I couldn't say whether it was one or several.

Q. When did you find it again?

A. In a sample collected at midnight on December 6th, by Mr. Stevenson, in the tower. He was in the tower at midnight and went down along the ladder and took a sample at the bottom of the tower in the river, at the foot of the tower, so that he collected this sample at midnight on December 8th and the bacillus prodigiosus was found in plates made from this sample.

Q. Well, did you state these investigations in your examination in chief?

1512 A. I did not.

Q. Then, when was the next investigation made and what did you find?

A. I next found the bacillus prodigiosus in sample of water collected by Mr. Homer at Grafton, Illinois, in the Illinois River on December 6th, at 8:00 a. m. He collected the sample at eight o'clock in the morning. It was sent to St. Louis and in that sample the bacillus prodigiosus was found by me.

Do you want the next sample?

Q. Yes, sir?

A. The next sample was found by Collector Homer at Grafton, Illinois, Illinois River, at midnight, December 7th.

That was all the times that I found it.

Q. That was all the times that you found it?

A. Yes, sir.

Q. Did you make any efforts subsequently to that date to ascertain the presence of this bacterium in the waters of the Intake Tower?

A. Yes, sir, continuously.

Q. Until when?

A. Until December 15th or 18th. I am not so sure, Judge, just exactly what time that work ceased, but it ceased when our money ran out.

Q. Yes, you didn't find it after that at all?

A. No. I continued searching the tap water in the laboratory until March 1st, 1902. 1513

Q. What did you find then?

A. I never found it again.

Q. How many samples did you examine in all for the purpose of ascertaining these five specimens personally, from the time that they were put in at Lamont until the close of your investigations?

A. December 15th, about, we began, and we collected samples day and night. That would be at this place 30 days, and 24 samples were collected a day. That is 720 samples that I personally examined at this point.

Q. And you only found in all those examinations the presence of this bacterium five times?

A. Now, hold on; you are talking about the Chain of Rocks now?

Q. Yes, I am talking about the Chain of Rocks.

A. Yes, I said 720 samples, being collected for this purpose. There were other samples being collected right along for quantitative determination of the numbers.

Q. But I mean these samples for the prodigiosus.

A. Yes, sir. Now, at Grafton, say 16 days, 24 samples a day, would be 384 samples—that would be —

Q. At Grafton?

1514 A. At Grafton, personally examined by me.

Q. And you found the bacterium how many times?

A. Twice.

Q. Twice?

A. On December 6th and 7th.

Q. Now, how many at the Chain of Rocks?

A. Three.

Q. How many samples, I mean, were examined at the Chain of Rocks?

A. There were 720 samples collected for this one purpose.

Q. I am speaking of this one purpose, yes?

A. There were samples collected for other purposes, and it didn't appear in them.

Q. And you found it in that period in how many?

A. 720 samples or five times in 1100 samples.

Q. Can you express in quantities such as are generally used in bacterial examinations, the numbers of this bacteria that were found on these five occasions?

A. That would be qualitative, wouldn't it—estimation?

Q. Yes, quantitative estimation, taken from your qualitative examinations?

A. I cannot tell how many bacteria—how many bacilli prodigiosi were in the particular sample of water, nor in
1515 the small quantity that I used. I know that the first plate had only one colony on it, and we were very much excited about that. That was December 4th.

Q. What was that?

A. There was only one colony on the plate on December 4th.

Q. That would indicate that there was only one?

A. That would indicate that there was only one in that particular cubic centimeter which was put in that plate, a number of plates were made from each sample.

Q. On the next one, how many colonies were produced?

A. I don't know. I said the plate when I saw it, was liquified.

Q. It was all run together?

A. It was all run together, so whether there was more than one colony at the time, I don't know.

Q. Well, the same conditions were substantially found on December 6th?

A. Yes, sir.

Q. And at the other places?

A. And at the other places. We allow the plates to rest as long as possible to gather the red color, and the plate might liquify before the color appears. It is impossible to say anything about the number on a plate.

Q. When you discovered the red color you had accom-
1516 plished all you were looking for and ceased?

A. No, the red color was an indication that a bacillus producing a red pigment was there; that bacillus had to be separated out in a pure culuture and put through all its cultural characteristics and studied for form. In fact we searched thoroughly to see whether it was the one we put in the canal or not, and compared it with the ones put in.

Q. Were you able to identify it as the genuine article?

A. It had no label on it; no name blown on the bottle, or anything of that kind, but it behaved like the original culture.

Q. It was of good behavior, was it?

A. Yes, sir.

Q. Doctor, have you ever examined any of the waters on this continent for the purpose of ascertaining the presence of the bacillus prodigiosus other than that which you have just mentioned?

A. No, sir, I have never undertaken such a tremendously extensive investigation as was included in this work on the Drainage Canal and the Illinois River, but I have never found it in any of the waters which I have examined in this country, and my laboratory assistant, my associate, was Mr. Johnson, as clever a water bacteriologist as there is in this country, he worked continuously on the Ohio River above Louisville and
Cincinnati, for two or three years and did not find it in
1517 that water, and I understand that a bacteriologist who
worked at New Orleans—one of them told me this—that he once found the prodigiosus in the Mississippi River near New Orleans, after we had emptied it into the Drainage Canal.

Q. And then as far as your knowledge extends, and from personal knowledge and from information of others, all examinations on this continent heretofore, have not revealed the presence—

A. Not in large numbers.

Q. —of this bacteria?

A. I would say that it has been found a very few times—I searched the literature on the subject—in the waters of the United States.

Q. What were the peculiar characteristics of this bacterium that enabled you to identify it?

A. It is one of the most easily identified of all bacteria.

Q. In what respect?

A. In its pigment production.

Q. Color?

A. The pigment that it produces. It liquefies gelatine, and produces pigment; it coagulates milk and turns that milk red without digesting the casein which is the result of the coagulation, and makes it very characteristic at once.

Q. But all bacteriological examinations carried on with the view to ascertaining the quantitative presence of bacteria in running water or lake waters, reveal the presence of this bacterium? 1518

A. Yes, sir.

Q. They would?

A. Oh, yes, every man who studies water quantitatively—Every bacteriologist is mad in the search of new forms. He wants to have a bacillus named after him if he can, or he wants to find one and name it. He wants to have his name go down in literature as associated with a bacterium—every man that plates a specimen of water is searching that water constantly for new forms.

Q. Well, doctor, there are a great many examinations of this kind that have been carried on in recent years?

A. Yes, sir.

Q. All over this country?

A. All over this country.

Q. And you will not say that no other bacteriologist than those you have mentioned, and yourself, have not found this—

A. Oh, no.

Q. —particular bacterium in the waters of the United States?

A. No, I couldn't say that.

Q. You simply haven't found it, and those with whom you have conversed, whose names you have mentioned, have not found it?

A. I see also from your investigation, the book published 1519 by the State Board of Health of Illinois, I don't see the prodigiosus named among the bacteria found by the Northwestern men.

Q. In the waters of the Illinois River?

A. Yes, although they have got quite a number of bacteria separated out, as distinctive for these waters.

Q. That report, however, did not include any specimens taken from the waters of Lake Michigan, did it, with the view to this particular bacteria?

A. I don't know whether it did or not.

Q. Have you ever made any examinations of the waters of Lake Michigan?

A. Yes, sir; oh, yes.

Q. Did you make that examination in connection with this investigation?

A. Yes, I have had samples collected, and the water was studied thoroughly, and I gave you the—

Q. All the flora?

A. I gave you all the bacteriological flora found by us in the Lake Michigan water. That has already been submitted in evidence.

Q. And you didn't find in those examinations, any evidence of the presence of the bacillus prodigiosus?

A. No, sir, nor in the Chicago River, or the Drainage Canal.

1520 Q. You have stated all that in your previous examination?

A. Oh, yes, that has already been gone over.

Q. That is all in the record?

A. Yes, sir.

Q. Now, what is your opinion as to the probability of reproduction or multiplication of numbers of the bacillus prodigiosus after being deposited in the waters of the Drainage Canal?

A. As I said before, that point was kept clearly in mind before the bacteria were deposited—the water was cold, almost to the freezing point, before the bacteria were put into the water. We felt perfectly confident that there would be no multiplication of micro-organisms under these conditions of temperature and nutritive pabulum, etc., which would surround the bacteria in the waters of the Drainage Canal or the Illinois River.

Q. So then, it is your opinion—

A. So it is my opinion that these micro-organisms did not multiply in the transit from the point where they were put into the canal to the intake, and if they did so, it was very feebly so, because they do not multiply under the conditions named; they do not multiply below 10 degrees centigrade.

Q. What would be the temperature of your water mains in reference to their possibility of reproduction?

1521 A. Here?

Q. Yes, in the City of St. Louis?

A. Well, the temperature of the water running from the tap at that particular time; I don't remember, but we took the temeprature of the water from the tap during this period and that is on record. I haven't the record with me, but the temperature would be higher than in the water of the running stream.

Q. It would not be quite so cold?

A. No.

Q. But would it be up to a point at which there would be a probability of reproduction or multiplication of species?

A. Not the production, no. It was low, but above freezing.

Q. Doctor, have any of the witnesses who took samples, who have testified heretofore—were any of those witnesses who took samples heretofore, the ones who have testified, up to this time, those who took the samples to which you have referred this morning, betwen Lamont and this city?

A. Yes, sir; Dr. Kirchner has testified here.

ATTORNEY-GENERAL CROW: Mr. Werner also.

A. Dr. W. C. G. Kirschner, the bacteriologist, who testified here. Doctor Rush, who did the work at Peoria is now in Berlin, Germany.

Mr. Tedesche is somewhere in this country, but Dr. Kirschner, who has already testified, and every one of the col-

1522 lectors who collected samples—Werner and all the others, I believe, excepting Stevenson, have testified about collecting samples.

Q. Up to this time?

A. Yes, sir.

Q. They are in the record some place, I do not remember?

A. Yes, they are in the record.

Q. Then you have identified the samples that were taken during this period with the view to ascertaining the presence of this bacterium by the persons who took the samples, and all those who made the bacteriological examinations other than those made by yourself?

A. Yes, sir.

Q. The others were made by Dr. Kirschner?

A. Dr. Kirschner at Joliet, and Dr. Rush at Peoria.

Q. Did Dr. Kirschner say anything in his examination about the presence of the bacillus prodigiosus?

A. Yes. I don't know what he said here; I was not present when he was examined. He said nothing to me about his examination.

Q. He didn't reveal that fact if he found the presence of this organism?

A. I don't know what he testified to, or whether his direct examination had anything to do with this prodigiosus, had it?

ATTORNEY-GENERAL CROW: No, I stated, if you will remember, that when Dr. Kirschner testified on the stand,
1523 that I would recall him.

JUDGE SPRINGER: It didn't come to my mind that he had testified about that, but you expect to recall him on that subject?

ATTORNEY-GENERAL CROW: Yes.

Q. Have you stated your opinion previously as to the probable longevity of the bacillus prodigiosus?

A. Yes. You will remember I gave you a series of tables on the longevity of the prodigiosus and also on the longevity of the prodigiosus as associated with the typhoid bacillus, in samples alongside of one another, in the window with the sun shining upon it, and in the ice chest?

Q. Yes, I remember.

A. Those tables are in the record.

Q. I remember that. Can you remember, now, what you stated was your opinion as to the longevity of this bacterium?

A. Yes, I can give you the exact facts.

Q. Well, you need not give all of them; I just wanted to get that one, if you have given it in complete tabulated form—

A. Do you want me to give you these different points, the longevity that was obtained in the waters at the different points of collection?

Q. No, not all of the points. You may state one.

A. Well, from ten days to 32 days in the sunlight, and as high as 53 days, at which time it was still alive, that is, the work ceased, as in the living waters.

1524 Q. In the living waters?

A. Yes, sir.

Q. You made no other examinations of sterilized waters; I presume it wasn't necessary?

A. In sterilized water of the Chicago River, exposed to the window, it lived 11 days.

Q. It lived 11 days?

A. Yes, lived 11 days. In the refrigerator, in the dark, in a temperature of 16 degrees centrigrade, it lived 53 days, and still alive when the work ceased.

Q. That was in sterilized water?

A. No, I said in sterilized water, in sunlight, we had one experiment, but in the living water is what we were talking about.

Q. That was the longest period of longevity which you ascertained, of this bacterium?

A. Yes, sir.

ATTORNEY-GENERAL CROW: No, that is not the Chicago River water.

JUDGE SPRINGER: No, I am speaking of this bacterium, where you found it.

A. In the Illinois River, Pekin, not sterilized, temperature 16 degrees centrigrade, it lived 53 days; that is at the end of 53 days it was still alive; but our work ceased; our pay

1525 ceased, and it was the end of the experiment.

Q. So that if it lived longer than that you have no record?

A. I have no record, but I have got 53 days longevity in the refrigerator, and that was about the temperature of the river water at the time the micro-organism was thrown into it, 16 degrees centrigrade, even lower than that.

Q. I believe you stated that this bacterium was of the ordinary water species ?

A. Yes, sir.

Q. And perfectly harmless?

A. Perfectly harmless, chromogenic species, a saprophite.

Q. You just used the word saprophite?

A. Yes, sir.

Q. Will you please explain what you mean by that?

A. It is used—"sapros" is from the Greek, "sapros" meaning dead, and phyte meaning the organism. They grow upon a dead body or in dead organic material.

Q. Animal or vegetable?

A. Yes, animal or vegetable, in contradistinction to parasite, which lives upon living structures.

MR. WOERNER: Phite means body, doesn't it?

A. No, it means fungus.

Q. JUDGE SPRINGER: That would indicate two general classifications of bacteria?

A. Yes, sir.

1526 Those known as saprophites and those known as parasites?

A. Yes, sir.

Q. Now, what is the peculiarity of the parasite?

A. The parasites are able to grow upon living structures and reproduce their kind.

Q Living organisms—you mean animal and vegetable?

A. Animal and vegetable; some live practically without doing injury to the individual, others are disease-producing and thence comes the classes, pathogenic and non-pathogenic.

ATTORNEY-GENERAL CROW: Some are both?

A. Under the word parasite we have pathogenic and non-pathogenic.

ATTORNEY-GENERAL CROW: Some bacteria grow on the dead and some on the alive—

JUDGE SPRINGER: Those are the saprophites, on the dead one.

A. The saprophite grows on dead animal and vegetable structures.

Q. And a parasite must be living?

A. The parasite must be living. The word "parasite" includes that.

Q. It mentions that it is found in the skin?

A. Yes, some in the skin, in the hair, in the—some of it lives in the intestinal canal.

1527 Q. In what class, then, does the pathogenic organism come?

A. They come under the parasite, pathogenic. Under the word "parasite" are included pathogenic and non-pathogenic bacteria, because some of the bacteria which live and grow upon our skin, for instance, are harmless, or those in our intestinal canal, are harmless to us, in fact, those growing normally in the intestinal canal might as well be on the skin, on the outside, for all the harm they do.

Q. Which of these classes do you find to be the most numerous?

A. The saprophites are distinctly the more numerous.

Q. And those are all mostly non-pathogenic—the saprophites, I believe?

A. Well, they are non-pathogenic except when injected under the skin. Some of them are pathogenic, but when they find a breach in the tissues of an animal in which they may grow,—some of them are able to grow as a saprophite, and are saprophitic by nature, but if they find entrance into the living structure, through a breach of the continuity in that structure—

Q. For instance, a wound may produce suppuration?

A. Yes, it might produce suppuration.

Q. But taken internally they are perfectly harmless?

A. As a rule.

1528 Q. Now, can you state what particular function in animal existence and in vegetable existence and reproduction, these saprophitic organisms play—what part they take?

A. The saprophites, as I said in my opening address, are the undertakers of the organic world; they reduce the dead structure of plant or animal by their actions upon the complex compounds of which they are composed; break them up into lower and lower compounds until resolved into nitrogen, carbon oxide, ammonia, hydrogen, and water, hydrogen and oxygen combined.

Life on earth would be impossible without them as they prepare, by their destructive action upon organic materials the compounds which are taken up by plants in their growth and the animals upon the earth feed upon the plants and each other.

Q. So, then, it is by means of bacterial activity that nature is restored after its exhaustion, from the production of the original matter?

A. Yes, sir.

Q. And without this there would be no continuation of animal existence or vegetable existence?

A. Yes.

Q. Allow me, doctor, to supplement your statement by a sentence taken from Dr. Abbott, in his work published in 1902, on this very point.

1529 He says:

"Were it not for the activity of these microscopic living creatures, all life upon the surface of the earth would cease." Is that correct?

A. That is right.

Q. "Deprive any vegetable of the carbon and nitrogen supplied to it as the result of bacterial activity, and its development comes rapidly to an end. Rob the animal kingdom of the food stuffs supplied to it by the vegetable world and life itself is no longer possible.

It is plain, therefore, that the saprophites which represent the large majority of all bacteria, can be looked upon in the light of benefactors; without them existence would be impossible." Is that correct?

A. Yes, sir.

Q. That is the well recognized theory of all bacteriologists upon this subject?

A. Yes, sir.

Q. Then in making mere quantitative tests as to the bacteria in water, a large or small number of saprophites would not be regarded as any indication of any evil or pollution in the water, would it—the mere numbers, I am speaking of?

1530 A. Oh, yest, it would. It would depend upon the stage of the river entirely. If the river were high, due to floods and rain upon the drainage area, the saprophitic organisms are found in large numbers in the water. Rain water washes them out of the soil into the river, and so they are carried along.

Q. I am not referring to that. I understand that.

A. But when the river is low and the number of bacteria discharged into it by brooks, by the springs which discharge their pure water into it, the numbers of bacteria are very low, and these are saprophites, as a rule, in nature. But if into this stream which was originally pure, is poured sewage, for instance, which is food for bacteria; so far as that sewage is carried, so far will the bacteria appear in increased numbers, because they find food to feed upon.

Q. But I am speaking now of the mere presence, without regard to the environment of the collection of samples?

A. No, do you mean, then, that the earth surface has been washed of its bacteria and they appear as in a freshet in large numbers, or that there was nutritive material either of vegetable or animal origin present in the water in such large quantities as to afford abundant food for an increased production of bacteria in it, these two points would have to be taken into consideration in a discussion? The question of rainfall on
1531 the area at the particular time when the numbers were
large, or if the number were large independent of the rainfall, it would indicate that there was food either of vegetable or animal origin in the water, and the source of that food supply would have to be searched for along the stream.

Q. Then your position is this, that the ordinary bacteria flourish where they find something to eat?

A. Yes, sir.

Q. And disappear when the supplies give out?

A. Yes, sir.

Q. So that they are plentiful where there is food adapted to their existence, and scarce when the food supply is exhausted?

A. Yes, sir.

Q. Now, does it not frequently happen that there is a large amount of these bacteria developed in places where there have been no pollutions from animal matter?

A. If the pollution is due to recent addition of vegetable matter, that would be food for them.

Q. Yes?

A. Yes, sir.

Q. It may solely come from decomposed vegetable matter?

A. Yes, sir.

Q. It is universally admitted, I believe, among bacteriologists that bacteria are of vegetable origin?

A. Yes, sir.

1532 Q. That includes both the saprophites and also the parisitic?

A. Yes, sir.

Q. All of vegetable origin?

A. Yes, sir.

Q. So these are simply low forms of vegetable life?

A. Yes, sir.

Q. Are these bacteria known as the saprophites, useful in any of the arts?

A. Oh, yes.

Q. What kind of production requires them?

A. First, the production of alcohol, and it is destined to become one of the great arts, because it is probably the future source of our fuel supply.

Q. What function is performed by bacteria in the production of alcohol, for instance?

A. The yeast cell, which is classed among bacteria, breaks up the prepared sugar in the wort of the distiller, into alcohol and carbon di-oxide. The carbon di-oxide passes off as a gas, and the alcohol remains in solution.

After the bacteria have produced from 12 to 16 per cent.
of alcohol in the wort, or broken up Dextrine and starch contained in the wort to the extent of producing 12 to 16 per cent.
of alcohol, their activity ceases, owing to this poison alco-
1533 hol which they produce themselves, the distiller knowing
the proper moment when this point is reached, distills off
the alcohol and runs out the bi-product as swill. That is the present method of producing alcohol—or one of them.

Yeast is used in brewing. In the production of yeast cakes for all industrial purposes in general. Bacteria are used in the production of good well flavored butter; for the production of cheese, and the ripening of the cheese, in the destruction of sewage in septic tanks, in the production of vinegar, and in a number of other industrial processes —

Q. In the tobacco culture?

A. Well, they are said to produce the delicate flavor or aroma that is connected with some better flavored tobacco such as Havanna tobacco.

Q. You stated that the saprophitic bacteria are used in the production of beer?

A. Yes sir.

Q. Can you make beer without the use of bacteria?

A. Not the German beer as we know it,—lager beer.

Q. The presence of bacteria is essential to the production of beer?

A. Yes sir.

1534 Q. And are the species required for that cultivated?

A. Yes sir.

Q. How are the cultures prepared?

A. There is one man at Copenhagen, who has done the most advanced work in that line. That is Hansen; but Pasteur was the first to take hold of this subject and straighten it out, so that in front of all breweries in France, you will see either a statute of Pasteur in the yard or a bust of him above the door, because he is the first who separated out the particular yeast cells which produce the best flavored beer. He was also the first to separate out the micro-organisms which cause the so-called disease of beer—sour beer or bitter tasting beer. He discovered some of the causes for that, and so put into the hands of the brewers of France a scientific method of working in place of the haphazard methods which they used before. Elevated it from an ordinary layman's work to a scientific process, and the Germans have improved upon it. Hansen, as I say, of Copenhagen, has carried on extensive work with different forms of yeast cells that singly or in combination with others, produce the best flavored beer.

Q. Was he able to name the bacteria?

A. Yes, they have been named in large numbers.

1535 Q. In German, principally, I presume? Not translatable?

A. No.

Q. You may give the name of the beer bacillus, could you?

A. Oh, well, there are several. There is saccharomycetes, —Cerevisceal.

Q. Any other species?

A. There are a number of them,—saccharomycetes Pasteuri, named after Pasteur. There is quite a list of them many of which I have forgotten.

Q. Are those cultures prepared by certain chemists, and introduced into the commercial world as an article of commerce?

A. Yes sir.

Q. So that bacteria have become an article of commerce?

A. Yes sir.

Q. That is a good one, the saccharomycetes?

A. Yes sir, it is a well-behaving bacterium.

Q. Well, what do you say as to the production of butter?

A. Professor Conn separated out while working on milk and butter, bacillus No. 41 of his list, and that is the micro-organism which produces the delicious flavor of good butter. A manufactory was started and this micro-organism grown in pure cultures and sent to dairies throughout this country.

1536 Q. Is that a permanent thing in Europe too?

A. Yes sir.

Q. More extensive than in this country isn't it?

A. More extensive than in this country, yes sir.

Q. Without the presence of bacteria it would be impossible to make butter wouldn't it?

A. Yes sir.

Q. And also cheese?

A. Yes sir.

Q. So that butter making is an adaptation of bacteria to the milk produced by the cow?

A. Yes, butter can be made without the aid of bacteria, but you mean a well flavored butter,—good butter?

Q. Yes, I mean the best qualities of butter?

A. Yes sir.

Q. And—well, can you make butter at all without bacteria?

A. Yes sir.

Q. Isn't the surroundings of the milk an indication of the presence of bacteria?

A. You can surround milk with rennet—

Q. Isn't that an indication of bacterial action?

A. No sir, not exactly,—oh, no, we can coagulate milk with the rennets of the calf's stomach—that is done right along.

Q. Isn't it substantially fermentation?

1537 A. It is not fermentation; it is distinct from bacterial action.

Q. But the process by which milk is converted into butter, or by which cream is converted into butter is a process of bacterial activity, is it not?

A. Yes sir.

Q. In the ordinary process?

A. Yes sir.

Q. The ripening of the cream, preparing it for churning purposes is done through the agency of bacteria?

A. Yes sir, entirely.

Q. And the cultures for this purpose are being furnished by certain chemists and others for the purposes of improving the quality of butter that is made in the world?

A. Yes sir.

Q. And so in cheese I presume?

A. Yes, a variety of cheeses owe their flavor to the peculiar qualities of the contained bacteria.

Q. You stated yesterday that the milk supplied to this city was brought in jars that had been sterilized—or cans?

A. Cans, yes sir.

Q. Would such sterilization be sufficient to eliminate the presence of parasitic germs, or germs carrying disease?

1538 A. Yes sir, such as are water-borne, such as the typhoid fever and cholera germs; both of these micro-organisms are tender when brought in the presence of heat. They are destroyed, both of them, at 56 degrees Centigrade, by heating for a few seconds, and water brought up to boiling point kills them at once, so boiling water in cans destroys these bacteria.

Q. That would be only so far as the can itself is concerned?

A. Yes, that would kill all typhoid bacilli in the cans or in water that was in it.

Q. Are you aware of the presence of bacteria in milk from other causes than from the can itself?

A. Yes sir.

Q. What are they?

A. Bacteria falling from the cow in the process of being milked. The bacteria from the hands of the individual milking, and hair blown, or hair deposited in the milk while it is standing.

Q. Isn't it impossible by ordinary precautions, to prevent the presence of bacteria in milk?

A. Their numbers can be very greatly reduced by care in milking; but it is impossible to keep them out.

Q. Impossible to keep them out?

A. One way to have sterilized milk is to sterilize it.

1539 Q. So that all milk unsterilized, as it is furnished in the milk cans in the market would have more or less bacteria?

A. Yes sir.

Q. Professor Conn states in his work to which you have referred that the numbers of bacteria which may be found in milk after twenty-four hours, are sometimes inconceivable?

A. Yes sir.

Q. Market milk may contain as many as 500,000,000 per cubic inch, is that correct?

A. Per cubic inch?

Q. Yes, per cubic inch I said. Professor Conn uses the word.

A. I am surprised that he used that word. Yes sir, that is so. I have found immense numbers in it.

Q. And he states that where this is an extreme number, that milk that is a day old will almost always contain many millions in each cubic inch?

A. Yes sir.

Q. The number depending upon the number of days old and its temperature?

A. Yes, it is fine nutritive medium for bacteria, and we use it in our laboratory for that purpose.

Q. It is a fine medium for cultures of all kinds of bacteria?

A. Yes sir.

1540 Q. And especially when it is in the temperature which it has when it comes from the cow?

A. Yes sir.

Q. Before it comes out of the cow, I believe that it is stated that is is free from bacteria—as it is found inside?

A. It may have a few that are in the milk ducts of the cow; in the teat, but it is practically free; it is practically sterilized.

Q. The typhoid fever would never come in that way?

A. No sir.

Q. The typhoid fever germs, if found in milk, would be from extraneous introduction?

A. Extraneous source, yes sir.

Q. Now considering the vast number of bacteria that must necessarily get into the milk which is furnished to the consumer of milk in cities, like St. Louis, isn't the liability very great for communicating typhoid germs by the use of milk?

A. The danger is great where precautions are not taken to first clean the cans with boiling hot water. The cow milked under aseptic precautions, the milk cooled to as low a temperature as the surroundings will admit,--generally spring water is used for that purpose, and it is possible that a typhoid bacillus may be conveyed from, either diseased water which may
1541 be put in the milk or from the hands of the individual
who has typhoid, or who is associated with typhoid cases.

Q. MR. WOERNER: What do you mean by aseptic?

A. That is free from sepsis, meaning free from septic germs, free from germs that can produce disease.

Q. JUDGE SPRINGER: That is the term used in surgery?

A. Yes sir.

Q. For the purpose of cleansing wounds?

A. Yes sir.

Q. Isn't the only means of relieving milk from the presence of bacteria boiling it to at least 100 degrees centigrade?

A. Yes sir.

Q. That is the boiling point?

A. Yes, that relieves it of pathogenic germs.

Q. Yes, that relieves it of pathogenic germs?

A. Yes sir.

Q. Well is any of the milk furnished by the dairymen who supply the St. Louis market thus sterilized before it is delivered to their customers, as far as you know?

A. Well, I know there are people or dairies that supply a concentrated milk, or sterilized milk.

Q. That is concentrated milk?

A. And also sterilized milk if it be asked for, but the vast majority of dairymen supply milk without treatment
1542 by heat, or with heat.

Q. Some dairymen supply what is called Pasteurized milk?

A. Yes sir.

Q. Will you state what process is necessary for producing Pasteurized milk?

A. Yes, sir, Pasteurized milk means heating the milk for some time at a low temperature, 60 degrees centigrade, for an hour or more, the idea being to kill all pathogenic germs in it. By this treatment, spores are not destroyed, but it would kill all such bacteria as typhoid, cholera, tuberculosis, etc., organisms which do not produce spores, in other words—

Q. Then is it your opinion that one of the most probable sources of communicating typhoid germs to the inhabitants of cities is through the use of the milk supply?

A. I don't think you have stated that question exactly the way you want to put it—the probable source, you say?

Q. Yes, probable?

A. Oh no, it is not probable. The most probable source of typhoid bacillus is the water supply. You can eliminate the water supply by having a pure water.

Q. Well, then I will put the question in another way:
Is it not your opinion that it is highly probable that the
1543 typhoid germs may be communicated to consumers of
milk in large cities, and thus cause what is known as a typhoid epidemic?

A. Yes. Probably hardly one per cent of cases that occur in cities is due to the typhoid pollution of milk,—that is, right straight through.

Q. How can you ascertain that? If there are various causes how do you trace the cause?

A. I said that over 95 per cent of the cases of typhoid fever in a town or community is due to polluted water supply. Then there were several extraneous sources of infection, among which were named air-borne bacilli food, such as bacilli in oysters, on fresh vegetables, in milk, etc., and that this was a very small percentage of the total; that there have been occasional epidemics of typhoid fever produced and traced directly to milk, is not denied, but it was always localized along the line of the route of the delivery of the particular milk.

Q. The milk may be contaminated by the same water that reaches the stomachs of the inhabitants, without going through the milk itself?

A. Yes sir.

Q. So that there may be indirectly a large amount of germs carried through the milk supply?

A. Yes sir.

1544 Well now. I believe you stated that the bacteria found in water were very largely of the non-pathogenic kind?

A. Yes sir.

Q. That they greatly predominate?

A. Yes sir.

Q. That the non-pathogenic germs were essential in the production of many useful articles of food and drink?

A. Yes sir.

Q. And that the presence therefore of ordinary water bacteria in drinking water was not of itself, free from the environments of it, an evidence of contamination or of disease bearing quality?

A. Yes, unless present in enormous numbers.

Q. To suggest a probable source of that kind?

A. Yes.

ADJOURNED until 3:00 P. M., same day. Thursday. March 12th, 1903.

1545 Session resumed pursuant to adjournment at 3 P. M. March 12th, 1903. Present, the Commissioner and same counsel representing the respective parties.

DR. AMAND RAVOLD, further testified as follows:

CROSS EXAMINATION

By Mr. Springer.

Q. Doctor Ravold, there are one or two matters I desire to call your attention to. There is some doubt in the mind of the counsel whether you have stated that disease bearing germs increase in number in the water?

A. In running water?

Q. In running water, yes?

A. It has never been proved satisfactorily that they do increase in numbers in running water.

Q. It is still an uncertain quantity?

A. It is still an uncertain quantity, the numbers practically remain the same.

Q. The disease bearing germs that are supposed to have their origin in the intestines of animals, including human beings, the question as to whether after being discharged from the intestines they increase in number is still an open question?

1446 A. Yes sir.

Q. I believe you stated in one of your elaborate descriptions of the bacillus prodigiosus that it was motile?

A. No sir.

Q. What was it you said?

A. I said it was not motile.

Q. I misunderstood you. What did you say its size was?

A. From two-tenths of a micro-millimeter to four micro-millimeters in length and about five-tenths of a micro-millimeter in width.

Q. The dimensions given by Franklin in the work to which you referred this morning are as follows, the work of 1894, the cells are rather longer than broad, the largest forms being about 1.7 micrones in length?

A. That is micrones, that is a micro-millimeter.

Q. And about one microne in width?

A. Yes sir.

Q. They are frequently found hanging together in pairs?

A. Yes sir. My measurements would make them a little longer than that, five-tenths to two, a half micron to two microns long, about two microns in width, that would be one fifty-thousandth of an inch to one twelve-thousandth of an inch in length and about one fifty-thousandth of an inch in width.

1547 Q. In ordinary measurements it seems trifling yet comparatively it makes considerable difference in the size of the microbes, does it not?

A. Yes sir, the species of prodigiosus differ from one another like the sizes of men differ from one another.

Q. It was a healthy growth you had?

A. It was a good vigorous fellow.

Q. Did you state in your examination in chief the distance between Chicago and the St. Louis intake by way of the Drainage Canal, the Desplaines, Illinois and Mississippi rivers?

A. Yes sir, I did. I can get those figures, I think it is 357 miles from the lake.

Q. That is the figure I remember.

A. Yes, I have it right here, from Lake Michigan to the Intake tower generally speaking by river, the distance from the Intake Tower of the St. Louis waterworks to Lake Michigan where the Chicago river now has its source, but used to empty three hundred and fifty-seven miles.

Q. I believe you stated in your examination of yesterday or the day before that the probabilities of contamination by reason of the presence of the typhoid bacillus would be
1548 greater the nearer the place of the introduction of the bacteria to the place of the consumption of water?

A. No, I do not think I made any such statement, as that.

Q. It that true?

A. That would depend entirely on the quantity and the two sources.

Q. I assume other conditions being equal.

A. Yes sir.

Q. The nearer you would be to the consumer the more likely would be the bacteria to be carried?

A. Yes, if you had one hundred men with typhoid fever discharging sewage into the river at the mouth of the Illinois river, at Grafton, the danger to St. Louis would be much greater than if one hundred men were discharging their typhoid fever discharges into the Illinois river at Lockport from the Drainage Canal.

Q. That is what I desired to bring out. Pursuing that suggestion further, suppose that there should have been twenty persons who died of typhoid fever within, we will say, the year 1900 or 1901 or 1902—yes.

And that there was a corresponding number of persons in the same vicinity in the village who recovered from 1549 the disease and the dejecta of all persons, those who died and those who lived, were deposited in the Illinois river say at the mouth of the Illinois river at Grafton, what would you say as to the probability of such a deposit producing typhoid fever in St. Louis?

A. It comes within—it is probable that if the micro-organisms were carried into the Intake from people sick of the disease that a person in St. Louis drinking the water or taking the bacillus into their intestinal canal would contract the disease provided they had not been immunized.

Q. Would it not be a dangerous proximity for so many cases of typhoid patients whose dejecta might be thrown into the river so near the Intake?

A. That would be forty people in a whole year, that would be four people a day constantly discharging their dejecta into the stream during the whole year?

Q. Yes.

A. There is a possibility of such bacteria being carried into the St. Louis Intake and producing disease in St. Louis.

Q. Would not there be more than a possibility, would it not be a dangerous proximity for so many typhoid fever patients whose dejecta were carried into the river?

1550 A. Only four in a day, the total number discharged from them that would go into the river would be relatively small and the dilution would be very great.

Q. Are not the microbes in the human dejecta very great?

A. Yes sir.

Q. What are the facts in regard to that as a quantitative statement?

A. I gave you a statement in regard to the number discovered in urine for instance, we find that one man, Mark Richardson, found one hundred and seventy million typhoid bacilli to the cubic centimeter in the urine of a typhoid fever patient. I suppose that would be a small number compared with the number found in the feces discharged from a typhoid fever patient.

Q. Now, suppose that four persons were afflicted at the same time and the urine and dejecta were deposited in the Missouri river within thirty miles of this city would not that be a sufficient number to create and probably cause at least, disease germs to appear in the St. Louis Intake?

A. The number that would reach the consumer would be extremely small from these four people, from the daily discharge
of four people into the Mississippi river, which we saw
1551 in a low river stage discharges something like twenty-
four thousand cubic feet a second so the separation of the bacteria which would be discharged by four patients into that volume of water would be very wide apart and it is possible that some of them might be carried into the Intake Tower and through it into the distribution system of the city to susceptible individuals, but the danger would not be very great.

Q. Take the city of Alton, 25 miles from St. Louis—

A. Yes sir.

Q. Suppose there were say four people a day, 48 cases in a year of typhoid fever, twenty of whom died with the disease, all of whom deposited urine and dejecta into the Mississippi river, what would you say would be the danger to St. Louis from the near proximity of cases of that kind?

A. We saw that the dejecta of each one of the inhabitants of Alton when discharged and mixed with the waters of the Mississippi river passing that point would be one to 70,000 and we—that we trace very little evidence of the sewage of Alton at Hartford seven miles below, bacteriologically, and consequently it would be again a very remote possibility of having bacteria coming from those patients into the Intake.

1552 Q. If you were afflicted with a typhoid epidemic in St. Louis where as many as two hundred persons were dying in a year during the recent years and you could not trace the cause to any other source than one which you have imagined, might be in existence at Alton, would not that sufficiently account for any trouble?

A. No, I think not sir. Two hundred deaths would mean three thousand cases at least of typhoid fever in the city and that is a great many sick at the same time out of a population of 675,000 to 700,000 with 90 per cent of the bacteria removed by the reservoirs to those who consumed the water. It would take a much larger infection than four people could produce even if above the Intake.

Q. Would you say that you would not regard that as worthy of consideration?

A. It is worthy of consideration.

Q. It is a factor to be considered?

A. Yes sir, it is a factor to be considered in this connection, in trying to trace the source of a typhoid epidemic every fact must be brought to light.

Q. Take the city of St. Charles, how far is it from here?

A. I really do not know, I believe by river it is something like 50 miles. 1553

Q. How far from St. Charles to the Intake?

A. About fifty miles.

ATTORNEY-GENERAL CROW: I think it is 60 or 65 miles.

THE WITNESS: I do not know, I have been there, it is under the actual distance, I know.

JUDGE SPRINGER: Q. Suppose there were as many as 18 or 20 cases a year in that city, I mean that many deaths from typhoid fever in a year and a corresponding number of patients who survived, all of whom deposited their discharges, both liquid and solid into the Mississippi river, would not there be danger from that source?

A. How many patients?

Q. Suppose twenty during the year?

A. Died?

Q. Yes, and the corresponding number, which would be one hundred—

A. It would be larger than that, two hundred—

Q. Who survived?

A. Yes sir.

Q. And all of whom deposited their urine and excreta into the Missouri river from the sewers of that town, would 1554 not that be a menace to the health of St. Louis?

A. Here again we have to take into the consideration the question of dilution. We find there would be seventeen people sick a month with the disease and that would not leave more than a certain number a day, it would be less than one a day, discharging feces, if we have 360 days and 200 people say one a day were discharging feces into the river with the death rate which you enumerated, that would be the dejecta of one typhoid patient in to 79,000 cubic feet of water per second in the Missouri river, at low water stage, so there again you have the remote possibility of the bacteria from one case a day or two cases a day reaching the Intake of the St. Louis water supply.

Q. There is no doubt but the typhoid bacillus would survive in that volume?

A. Easy.

Q. You stated a few minutes ago what would be the probable number that would be discharged into the sewers from even one patient in a day?

A. Yes sir.

Q. It would run up—

A. It would run up in very high figures, we would be dealing with trillions again.

Q. That would be some cause for alarm?

A. It is a factor.

Q. It is a factor to be taken into consideration?

1555 A. It is a factor, yes sir.

Q. Suppose you were looking for causes, suppose you were trying to trace the causes of the present condition in St. Louis of typhoid cases and deaths and you could not find any evidence anywhere else in nature then the fact that at St. Charles there were one or two patients who were sick with typhoid fever and were discharging their dejecta into the river, would not that furnish you some clew to a solution of your problem?

A. Yes sir, if there were no other cases anywhere except there.

Q. If you could not find any others you could attribute it to that?

A. Some of them to that one source, we would have to look for other sources.

Q. If a lively colony should happen to keep together and float into the intake you might get several millions into the waterworks from that source?

A. And ninety per cent taken out by the reservoirs before they got to the consumer so it would leave a few to be distributed throughout the city.

1556 Q. Of course, if there were a greater number of people should happen to be sick of typhoid fever at one particular time, making the average as we have stated, but if there should be eight or ten cases in existence at one time that would largely increase the probability of contamination here, would it not

A. Yes sir, provided there were no other source.

Q. Provided you could not account for it in any other direction. Have not most of the typhoid epidemics originated from a very small cause?

A. That small cause is the typhoid bacillus.

Q. One patient was the cause in Lausanne in Switzerland and the other was a case where the bucket slopped over?

A. That was in Catterham where the bucket with feces was constantly going up all day long.

Q. A little drainage from a bucket?

A. Yes sir.

Q. In Plymouth where the dejecta of an individual was washed into a reservoir after it remained there during the whole winter?

A. Yes sir.

Q. In that case there were 1,100 cases produced?

A. Yes sir.

1557 Q. And 114 deaths?

A. Yes sir.

Q. And all traced to that one individual?

A. Yes sir.

Q. So that when the dejecta of an individual is placed in proximity to the water supply it may cause a great deal of trouble?

A. Yes, sir, may affect all the water supply.

Q. Were you asked the question whether the typhoid bacillus existed, lived a longer time in turbid water?

A. That was asked by Mr. Drennan.

RE-DIRECT EXAMINATION

By Attorney General Crow.

Q. Now. Dr. Ravold, in the cross-examination of General Hamlin yesterday he persisted in using the term disappearance, asking the question as to whether or not the increased volume of water by the opening of the Chicago Drainage Canal and pouring the Lake Michigan waters into the same thereby causing dilution, would tend to increase the dilution in the Desplaines River and consequently the disappearance of bacteria of any kind that might be in the water of the Desplaines or Illinois Rivers, and I want to ask you to explain what you meant 1558 by the term disappearance as used in reply to his question?

A. I meant by this that the bacteria were not killed, that they were not destroyed by the dilution but that they were moved farther apart. I said at the time that if we had a gallon of water with 100 bacteria in it and added 99 gallons to it, we would have at first 100 to one gallon and by adding 99 to it it would be diluted one to 100 and there would be one bacillus to one gallon of water, the bacilli have not disappeared but they are farther apart.

Q. State whether or not dilution would in any way destroy pathogenic germs?

A. No, it does not destroy them.

Q. I will ask you this question, do you consider as a bacteriologist, from your knowledge of the water supply of the St. Louis prior to the opening of the Chicago Canal, and your knowledge of said supply since the time of the opening thereof, that the water supply at the intake tower of this city has been rendered less wholesome and safe for domestic and primary use than before the opening of the canal and if so is it occasioned by the waters from the canal?

A. I think it is less wholesome and I can prove it chemically and bacteriologically. Do you wish the reasons?

1559 Q. You can state them if you want to.

A. Formerly the sewage of Chicago, before the opening of the Chicago Drainage Canal was discharged into what was practically a large tank and that was the Chicago River, a river which discharged itself when the lake was lower than the water in the river or when freshets occurred which swept the water of the river out into the lake, which occurred semi-occasionally; but as a rule the water was stagnant in the river containing the sewage. That stagnant sewage putrified, was broken up by aearobic and finally by anaerobic action until the whole river was a fetid stinking mass. It remained in that river for quite a length of time. In order to purify the river and to create a current in it, pumps were put in at Bridgeport and the sewage pumped into the Illinois and Michigan canal in certain quantitie; a certain quantity was lifted from the South Fork into the Illinois and Michigan Canal. This sewage practically received the treatment afforded by a septic tank and all the pathogenic bacteria were practically dead in it before they reached Bridgeport because the pumps at Bridgeport made no perceptible current in the Chicago River towards the pumps. I tried this experiment several times myself by throwing a board into the river and watching it for several days and it never moved more than
a block either way in 24 hours, so the current towards the
1560 pumps was very small according to my actual experience,
so in my opinion the putrifying material in the river would destroy any pathogenic bacteria such as typhoid left in it for any length of time, or for a short time. Now, however, this condition does not obtain and the typhoid bacteria and other pathogenic bacteria discharged into the stream are hurried through it. In the Chicago River now the rate of flow is something like three miles an hour, sometimes more than that. In August or September, of 1901, Mr. Randolph and I watched a boat trying to get by a bridge, and the boat had not

enough power to force itself up the river towards the lake in a current then running fully three miles an hour. That was at five o'clock in the evening when the gates were lowered at Lockport and the full quantity 300,000 cubic feet was being discharged. The sewage is now carried from the Chicago river into the Drainage Canal and from there on to Lockport and then into the Desplaines and Illinois Rivers so that the chances of pathogenic bacteria vitalized and strong as they come from the bowels of an individual being carried down to St. Louis water supply is infinitely greater now than when the pumps were at work.

Q. I will get you to state if you are acquainted with the 1561 condition of the Illinois and Michigan Canal, as to whether there is any flow of current in this canal?

A. There is a current in that canal.

Q. Is it rapid or slow?

A. Slow, slow at all the periods when I saw it. There may be periods when it is rapid but I never saw one of those periods.

Q. Now, in answer to a question of Gen. Hamlin yesterday you stated that it might be that typhoid bacilli traveling from the sewage of Chicago by the canal, the Desplaines Illinois and Mississippi rivers and coming into the intake here of the Water Works of St. Louis, would be, perhaps, less virulent in form than if they traveled a distance of 10 or 15 miles and then came into the intake, I will get you to state whether or not, if they were still alive that would prevent them from causing typhoid fever?

A. No, sir.

Q. In taking them into the bowels?

A. No, sir. To an equally susceptible individual the chances of a nearby bacillus having greater vitality are greater so that the disease produced in an equally susceptible individual, the disease produced by a nearby typhoid bacillus would be 1562 of more severe type than that produced by bacilli carried some distance.

Q. But each would produce the typhoid disease?

A. Yes, sir.

Q. In an equally susceptible individual?

A. Yes, sir.

Q. But one would be of a milder form?

A. But one would be of milder form.

Q. Now, I will get you to state if there is any difference medically or bacteriologically from your knowledge as to the virulency of a typhoid disease conveyed in a germ of bacteria that comes from a man sick from a mild form of typhoid and one sick with a virulent disease of typhoid?

A. No, in passing through the individual their virulency is greatly increased. Bacteriologically that is a thing which is done every day. In order to increase the virulency of a micro-organism it is put into the blood of a susceptible animal and its virulency can be greatly increased in that way.

Q. That would be the effect on a person taking into the system a typhoid bacillus from one sick with mild form of that disease as to whether he would have a mild or severe form?

A. He would have a severe form if bacteria were to be
1563 put into a susceptible individual, coming from a mild case
or severe case it would not matter very much, the virulency would be heightened by the transit through the individual.

Q. Provided they were equally susceptible in both cases?

A. Yes, sir.

Q. General Hamlin asked you a question yesterday if it was not fact that the recorded cases showed 50 miles or less as the distance that bacilli traved through water and produce disease. I will ask you to show why the records show that to be more or less the fact?

A. Because of the difficulty of tracing the micro-organism under the complex conditions of modern life. If it were an open river in which the typhoid bacillus were under consideration the possibility of the river being affected from cases on its banks or other extraneous sources must be weighed, so that to trace an epidemic more than 50 miles is an extremely difficult thing to do except under such conditions as that of the St. Clair Lake, Detroit epidemic. If the river were covered with a tunnel or running through a tunnel such as the Croton Aqueduct, for a number of miles, then we could say absolutely—For if a typhoid epidemic were to occur in New York, we would feel perfectly confident that no extraneous case of sewage discharge came into

1564 the tunnel from any other source than where the aqueduct opened on the water shed. In the Detroit case we had a remarkable instance, here we had a bed of sewage in a river which had laid there for years and it was suddenly disturbed by dredging and was carried across a lake. It was practically as if in a tunnel, because the sides of the lake were so far away that the one or more cases which might have discharged feces on the periphery of the lake could have no effect. If the material had been carried straight away in a tunnel it could not have been carried more directly to Detroit than it was. That this was the cause of the outbreak of typhoid fever in Detroit Professor Williams has declared on and so reported.

Q. I will get you to state whether sand filtration or any other filtration is a full preventitive of typhoid fever?

A. Only relative.

Q. The effect is to minimize the danger, reduce the number of cases?

A. Greatly minimize the danger.

Q. Is there any reason for believing that typhoid bacilli exist a long time in moist earth?

A. Yes, sir.

1565 Q. What is it?

A. A number of experiments have shown that this is so. Experiments by Firth and Horniks show that these micro-organisms live a long time in earth and sand that is moist and retain their virulency.

Q. Do you remember the length of time?

A. Twenty-five days in dry earth and longer than that in moist earth. They carried out a series of experiments and were able to capture the typhoid bacillus in the dust stirred up in them in blowing across the infected earth.

Q. Dry earth?

A. Yes, sir.

Q. Did they make any experiments in moist earth?

A. Yes, sir, the longevity was much greater.

Q. Do you remember the time?

A. Several months ago, in 1902. I do not remember exactly the date.

Q. From your knowledge of bacteriology and your experiments I will get you to state whether there is great probability of this being a fact that typhoid germs, bacilli, are carried down in the mud and filth of a lake and river and under conditions that they may exist for a long time there, and retain their virulency and spread disease, they being swept out by floods or dredging?

1566 A. I tried to carry out some experiments on that point but found it a very difficult thing to do, but basing conclusion on dredging, such as that at Detroit, it would seem that typhoid bacilli will retain their vitality a great number of days in the sludge that exists in the bottom of a river or mouth of a river.

Q. What is the one thing aside from the aesthetic standpoint that renders sewage and polluted waters a warning against the use of the same from a medical, bacteriological and chemical standpoint?

A. It is the evidence of sewage pollution.

Q. The evidence of it but what is the one thing in sewage polluted water or connected with sewage polluted water that warns the sanitarian that it is not fit to use?

A. It is the pathogenic germs.

Q. I will get you to state as a bacteriologist, if there is an established connection between sewage and pathogenic germs that convey disease?

A. Yes sir, where sewage is found in a stream it is presumed that pathogenic bacteria may be there also because sewage polluted water contains the discharges of human beings and if there be typhoid or other diseases among them like diseases will follow in those drinking the water.

1567 Q. Aside from the repulsiveness of drinking sewage that comes from aesthetic reasons the real danger in sewage comes from the germs?

A. Yes, sir.

Q. Aside from the finding of bacteria that usually accompany sewage the ordinary scientific test of whether water contains sewage pollution is a chemical test?

A. Yes, sir.

Q. That is used in connection with the bacteriological test to determine the potability of water?

A. Yes, sir, there are three tests, the microscopic examination, the bacteriological examination and the chemical examination, they must be combined.

Q. It takes the three to determine the potability of a water supply?

A. Yes, sir.

Q. Do you know how many times in the history of typhoid bacilli it has been found in running waters?

A. Authentically probably a hundred times.

Q. In all the history of the world?

A. Yes, sir.

Q. You mean the germ itself?

A. The germ itself.

Q. The waters of the whole earth have been searched bacteriologically for the typhoid bacillus?

1568 A. Yes, sir.

Q. By a great number of men?

A. Yes, by bacteriologists working all over the earth.

Q. And it is now going on?

A. Yes, sir.

Q. It is not an inhabitant of salt water?

A. Yes, sir.

Q. It can live there?

A. It can live quite a long time in salt water.

Q. You mentioned yesterday the fact that the German Government prohibited the use of water failing to stand a certain bacteriological test, what is that?

A. They have what they speak of as pure water, what they speak of as pure, containing not more than one hundred bacteria to the cubic centimeter, water containing more than five hundred to the cubic centimeter is not considered potable water.

Q. That is without reference to the character of the bacteria?

A. Yes, sir, all waters coming from a filter must not contain more than one hundred bacilli to the cubic centimeter.

Q. General Hamlin asked you a question yesterday, if you knew of any water outside of the waters of boiling springs
1569 that were absolutely free of some kind of bacteria and your answer was you did not. I will get you to state if

there are any waters that are pure from a sanitary standpoint?

A. Yes, spring waters from an upland source.

Q. Are you acquainted with the history of the bacteriology of the waters of the Great Lakes in the Dismal Swamp?

A. No, sir.

Q. As a bacteriologist and hygienist I will ask you if you consider it safe for the citizens of any city to sewer into running streams the waters of which are used for primary and domestic purposes by those below?

A. I think it is a dangerous thing to do to use that water.

BY JUDGE SPRINGER: Q. Without a filter?

A. Yes, sir, discharging sewage in that way is a reprehensible practice and drinking the water is a dangerous experiment.

ATTORNEY GENERAL CROW: Are you familiar with the history of the work of the English Rivers Pollution Commission?

A. Yes, sir, I have read the work of the English River Pollution Commission.

Q. When was that commission organized?

1570 A. I think it worked eight years.

Q. What period of time?

A. I have forgotten the dates.

Q. Recently?

A. Compratively recently, several years ago it ceased.

Q. Do you know what was the result of their examinations as to the effect of sewage on running streams?

A. As I remember the conclusions they were something like this, that the evidence is overwhelming that sewage polluted waters are dangerous to drink and that no river in England is long enough to purify itself of sewage, consequently of pathogenic bacteria even if put in at its source.

Q. Did you find in the waters of the Illinois, Desplaines and Mississippi rivers coli communis in greater numbers in a flood stage than in ordinary seasons?

A. In flood stages the percentage was less than in low waters.

Q. In flood seasons the general forms of bacteria are found in greater numbers in the waters of rivers?

A. Yes, sir.

Q. The general bacteria are found in greater quantities in flood seasons in all streams?

A. Yes, sir.

Q. You said the Lausanne bacteria went through a solid
1571 mountain?

A. Yes, sir.

Q. What was the distance of solid earth it passed through to reach the water polluted?

A. Looking back on it I should say it was at least a mile through the mountain, coming down through the rocks a mile.

Q. They afterwards verified that by a salt solution?

A. By putting salt into the water and finding chlorine in the well below at the foot of the mountain.

Q. Is there any extended epidemic of typhoid recorded in the books that has been caused by any other fact than a polluted water supply?

A. No, the classical cases were all for a short period and ran their course and disappeared.

Q. Do you know whether or not there was any dredging going on in the Illinois river in the autumn of 1899?

A. I do not. I saw the dredges at work there in 1901 below Kampsville.

Q. What was the stage of the Desplaines and Illinois and Mississippi Rivers when you made the experiment with the bacillus prodigiosus in 1901?

A. The river was very low, lower than it had been for
1572 years.

Q. What was the effect of the low water stage on the current of the rivers?

A. The current was slow, retarded very greatly.

Q. Now, have you got any statistics of the typhoid death rate in the City of Chicago?

A. I have some statistics that were published by Dr. Jorden. I suppose they were compiled from the Health Department statistics, personally I have not secured statistics of that character.

Q. I will ask you if you have examined the statistics of typhoid fever in the City of Chicago?

A. I have in that article.

Q. How does the typhoid death rate, the number of deaths, compare in the City of Chicago with similar cities of a similar size in this and other countries, is it greater or less?

A. Greater, very high.

Q. Do you remember when it was, what year, that the greatest typhoid epidemic occurred in the City of Chicago?

A. The typhoid fever in Chicago, the highest death rate that I see in here was in 1891.

Q. What was the number of deaths?

1573 A. 1997.

Q. What was the population of the city at that time according to the census of 1890?

A. The population was 1,148,710.

Q. What was the death rate, the number of deaths, in 1892?

A. In 1892 there were 1,489 deaths.

Q. What was it in 1893?

A. In 1893 the water was taken from the four mile crib 670 deaths.

Q. What crib was it taken from prior to that?

A. Small cribs not very far out.

Q. Adjacent to the lake front?

A. Yes sir. That has been credited to Dr. Reynolds, had it not, the four mile crib put out in 1892?

Q. That is five miles.

MR. TODD: It was completed about six years ago, five years ago.

THE WITNESS: In 1893 670 deaths.

ATTORNEY GENERAL CROW: Q. Prior to this time do you know where the water cribs were located whence the
1574 supply was taken, have you any knowledge?

A. I have seen them, I really know but little about the geographical position of the cribs.

Q. What was the number of deaths in 1894?

A. Four hundred and ninety-one.

Q. What was it in 1895?

A. 518.

Q. What was it in 1896?

A. 751.

Q. What was it in 1897?

A. 437.

Q. What was it in 1898?

A. 636.

Q. What was it in the next year, 1899?

A. 442.

Q. What was it in 1900?

A. 337.

Q. What was it in 1901?

A. 509.

Q. What was it for the first 10 months in 1902?

A. 597.

1575 Q. The last two months not given?

A. Not given.

Q. Taking those statistics as being correct, as being reported by the health authorities of the City of Chicago, has the typhoid rate increased or decreased in Chicago since the opening of the Drainage Canal?

A. If we would take the Drainage Canal as opened in 1900—

Q. Take the entire period?

A. In that year there were recorded 337 deaths from typhoid; in 1901 there are recorded 509 deaths from typhoid and in the first ten months of 1902, 597 deaths from typhoid. That is a steady increase.

Q. What is the number of cases to the death recognized as a fair standard by the medical fraternity and health authorities of this country?

A. In hospitals cases about one in ten die; in household or home treatment of the disease on an average about one in fifteen.

Q. To what is ascribed the difference in mortality rate between the hospitals and homes?

A. In the cases taken to the hospitals generally the disease has advanced and the patient is bedridden, then he is taken

to a hospital very sick, and as a rule this applies to people
1576 of the poorer classes who exhaust their money in improperly caring for themselves the first week or two of the disease and then must be sent to a hospital where they arrive generally very sick and exhausted with the disease so that when the physician in the hospital sees the case it is more severe and has progressed further than when a family physician is called to a patient sick with the disease.

Q. Have you the typhoid death rate there for the first ten months of 1902?

A. Yes, sir, for January 1902, 21 deaths; February 14 deaths; March 20 deaths; April 16 deaths; May 24 deaths; June 22 deaths; July 44 deaths; August 193 deaths; September 165 deaths; and October 78 deaths are reported.

Q. That is the last of the months?

A. Yes, sir.

Q. Do you know whether or not as a rule in cities in the home treatment the dejecta and urine of typhoid patients are treated so that the germs are rendered not dangerous before they are put into the sewage?

A. I know it is very illy performed. I had a typhoid case in my own home, and I think I know something about
1577 disinfection yet in spite of the most rigorous precaution and rules laid down as to how to treat the dejecta of the patient half of the time they were thrown into the closet not disinfected.

Q. In your practice as a physician in this city would it lead you to believe as a rule that is the case?

A. Yes, sir.

Q. That they are not disinfected?

A. Yes, sir, it is much cheaper to empty the discharges from typhoid into the closet than it is to disinfect them, it is expensive to properly disinfect dejecta with chemicals and takes time. The vessel containing the discharges mixed with disinfectants must be covered and kept an hour, which militates against proper disinfection. In hospitals better results can be obtained because the staff of nurses are as a rule well trained in disinfection processes.

Q. There was a map you said you would make and have not made?

A. No, my eyes have been in too bad condition to take hold of the figures that Mr. Randolph gave me.

Q. I will get you to state whether the death rate or number of cases reported is taken as the standard in the sanitary or medical world as an index of the prevalence of typhoid fever?

A. The deaths only.

1578 Q. Why is that?

A. Because physicians do not report the cases, there is no penalty for not doing it, it is looked on as a courtesy, to the Health Department only. Physicians do it if they feel like it.

Q. Is there not walking typhoid?

A. Yes, sir, there are cases that do not get into the death list. Deaths physicians are compelled to report and the death rate is the only thing.

RE-CROSS-EXAMINATION

By Mr. Springer.

Q. You spoke about the sewage in the Chicago River which was pumped into the Illinois and Michigan Canal having been in the condition of sewage preserved in a septic tank?

A. Yes, sir.

Q. In your opinion the pathogenic germs had been destroyed?

A. Yes, sir.

Q. Upon what do you base that opinion?

A. On experiments, personal experiments.

Q. What kind of experiments?

A. To ascertain what occurred to bacteria such as the typhoid bacillus in the presence of anaerobic germs such as exist in a septic tank. It has been found that a septic tank as I have said before, acts in this way, that the aerobic bacteria first use up the oxygen of the air that is in the water, they take out 1579 that oxygen, and that gives the micro-organisms which exist only in the absence of oxygen a chance to begin their activity. These micro-organisms break up the organic compounds and liquify them very rapidly, and the result of the activity on the organic compounds is to produce large quantities of toxins and gases, carbon, dioxide, methane, N. H. 4, march gas, hydrogen and nitrogen and these concentrated poisons are spread throughout the septic tank in which the water is stagnant, standing still, the typhoid bacillus, although motile, cannot get away from its surroundings, no matter where it moves in this putrid field it still comes in contact with the toxins which are deleterious to its activity and destroy it.

Q. Did you make any bacteriological examination of the water in the Chicago River before the opening of the sanitary canal and at the time that the water was being pumped into the Illinois and Michigan Canal?

A. I did not.

Q. Your conclusions, then ,are based upon your knowledge of other matters in conditions which you regarded as somewhat similar?

A. Yes, sir.

Q. Was there not injected into the Chicago River daily
1580 during the time the water was pumped into the Illinois
and Michigan Canal the dejecta of typhoid patients from the city if there were any?

A. Yes, sir.

Q. Would not those pathogenic germs in the water be in a condition to be pumped into the Illinois and Michigan Canal?

A. If they got out that far.

Q. The sewers emptied all along the line?

A. Yes, sir, as I told you the current was not remarkable for the speed with which it moved towards the pumps.

Q. There were a great number of those germs put into the river at various places and they would permeate the whole lot?

A. Yes, sir, if they lived.

Q. Some of them would get into the Illinois and Michigan Canal?

A. A small number, possibly.

Q. Do you know how much water was pumped into the Illinois and Michigan Canal?

A. I have the figures.

Q. A large amount, was it not?

A. Something like 60,000 cubic feet a second or minute, I have forgotten the quantity, 60,000 a minute and now the Drainage Canal discharges 300,000 a minute.

Q. That went into the Illinois and Michigan Canal?

1581 A. Yes, sir.

Q. Would that canal have an outlet towards Joliet?

A. Yes, sir, at Lockport.

Q. Into what river?

A. The Desplaines.

Q. How is the control of that water managed?

A. Engineer Randolph showed me the water discharging through the turbines of mills that were alongside of the canal at Lockport, so it seemed to me that most of it went out that way, but some of it was carried on towards Joliet and on to La Salle.

Q. Did the Illinois and Michigan Canal act in any way as a sedimentation basin?

A. Yes, and tank, a septic tank.

Q. Does not the same condition exist with reference to the sanitary canal at this time?

A. O, no.

Q. Does it not act as a sedimentation basin?

A. Yes, but it is not a septic tank, I spoke of the Illinois and Michigan Canal being a sedimentation basin and septic tank.

Q. How long would sewage be required to remain in one place in order to reach the condition of what you call a septic tank?

A. A very few days, ten days.

1582 Q. During that time it becomes broken up?

A. Yes, sir, liquified and smells to heaven.

Q. Do you know what the current was in the Illinois and Michigan Canal?

A. When I saw it at one time it was covered with ice, and I thought there was no current whatever, there did not seem to be much discharge from it in the winter time, I do not know whether water was pumped into it in the winter time. Once I rode alongside of it in the Chicago and Alton train going into Chicago and at another stood on its banks and watched the current. It was very slow.

Q. What is the current in the Drainage Canal, if you know?

A. I do not know from personal experience. The velocity of flow will be given to you later. A stick thrown into the stream, if the canal police will let you do it, is taken along pretty rapidly. It depends on the height of Bear Trap Dam, the quantity of water flowing over the dam in the afternoon is quite large, making a rapid current in the Chicago River.

Q. I believe you stated that the dilution of the water in streams has a very material effect of lessening the chances of conveying germs to the place of consumption?

1583 A. Yes, sir, it moves the bacteria further apart, it does not destroy their vitality.

Q. The chances are reduced?

A. Yes, sir, the chances of an individual taking one of them in drinking a definite quantity of water.

Q. Have you estimated the effect on the waters of the Mississippi Rivers at St. Louis after taking in the sewage of the city and the suburban population, as to what effect it has on the cities down below?

A. No, I have not.

Q. Would not the same conditions prevail in reference to the cities south of here?

A. Yes, sir, if they were to take water from the river.

Q. How far down the river would this probably extend?

A. As far as the bacteria would retain their vitality and that is in this water from 15 to 30 days. They would be carried a long distance in that time with a swift flowing river.

Q. It is very swift here?

A. Yes, sir.

Q. Whose article is that you were reading from in reference to the death rate of typhoid fever in Chicago? 1584

A. Typhoid fever and Water Supply of Chicago by Edward Oakes Jordan, Associated Professor of Bacteriology, University of Chicago, Chicago, an article published in the American Journal of December 30th 1902.

RE-DIRECT-EXAMINATION

By Attorney General Crow.

Q. The condition of a septic tank in a stream or body of water can only obtain where the matter is not subject to any motion?

A. No, where it is stagnant water.

Q. In a lake where it is swept by the action of waves or in a stream moved by a current, open at either end, the condition of a septic tank cannot exist?

A. No, it means freedom from motion.

JUDGE SPRINGER: The Chicago River does not meet the conditions of a septic tank?

A. Now?

Q. Before?

A. Yes, it did before, in some portion of it, the portion on the South Fork looked like a boiling cauldron.

1585 ATTORNEY GENERAL CROW: That was not true in reference to all of the river?

A. No, not where the pumps were.

Q. Away from where the pumps were?

A. Towards the lake, near the pump it looked like a boiling cauldron owing to the action of the anaerobic bacteria in the bottom of the river and it smelled to Heaven.

MR. TODD: In proportion that the typhoid diminishes in Chicago the less danger there would be to the cities along the canal and the Illinois river and tributaries from typhoid fever?

A. Typhoid infection, yes sir.

AMAND N. RAVOLD.

1586 CHARLES LEWIS STEVENSON

being duly sworn on the part of the complainant, testifies as follows:

DIRECT-EXAMINATION

By Mr. Woerner.

Q. State your full name?

A. Charles Lewis Stevenson.

Q. Where do you live?

A. 2845 Clark Avenue City of St. Louis.

Q. How long have you lived in St. Louis?

A. Between 14 and 15 years.

Q. What is your business?

A. I am a traveling man at the present time.

Q. Were you ever employed by the St. Louis Water Department?

A. Yes, sir.

Q. When?

A. In March of 1901, first up until about the first day of April and then later, I think the 20th day of November, 1901, and from that up to the 15th, about the 15th of December.

Q. Of the same year?

1587 Q. What were your duties, what did you do?

A. My duties were to go out and take water, collect water samples. In March I collected one every hour during the day, twelve hours.

Q. Where was that?

A. That was at LaSalle, Illinois, four days, at Beardstown, Illinois, four days and the rest of the time at Grafton.

Q. Then, in the fall during what period?

A. From November 20th I think, if I had my book I could state exactly, I didn't know I was going on the stand, I think from November 15th to the 15th of December, at the Intake Tower at night.

Q. During the night you say?

A. Yes, sir.

Q. How often did you collect samples?

A. Every two hours.

Q. How did you collect them?

A. I crawled down a ladder about 60 feet to the water and collected with one of the machines over there, the small one (referring to an apparatus in the room).

Q. By the machine you mean one of the appliances in which a bottle is fastened?

1588 A. Yes, sir, the small one, Plaintiff's Exhibit No. 15, that sized bottle. I collected them that deep under water.

Q. The entire length of the instrument under water?

A. The entire length of the instrument under water.

Q. That is about three feet, is it?

A. Yes, sir.

Q. What portion of the tower did you get the water from?

A. I got the most of it on the east side of the intake, right down at the tower on the east side near the intake.

Q. Was that where the water was going in into the intake?

A. Yes, sir, it goes in the east side.

Q. You did not collect during the day, I suppose?

A. No, sir.

Q. You say you collected samples every hour?

A. Every two hours were my instructions.

Q. What did you do with them?

A. I closed them with tinfoil and a cloth and the next morning as early as I could possibly get down town I took them to the office.

Q. What office?

A. The City Chemist's office.

Q. You tagged the bottles?

1589 A. I tagged the bottles.

Q. What did you put on the tag?

A . I put on the date, the place, the time of collection and those that were taken there, the air and water was not taken.

Q. Put your name on it?

A. My name.

Q. Anything else?

A. Nothing else.

Q. You did that in each case?

A. In each case.

Q. During the period you have stated, during the fall and winter of the year?

A. Yes, sir, the last of November and the first days in December, 1901.

Q. You collected the specimens in the bottle beneath the surface?

A. Beneath the surface.

Q. Did the appliance permit you to lift out the glass stopper when it was beneath the surface?

A. Yes, sir.

Q. It was also closed when it was beneath the surface as soon as it was full?

A. Yes, sir.

CHARLES LEWIS STEVENSON.

1590 ADJOURNED until Friday, March 13, 1903, at 10:00 A. M.

1591 SOUTHERN HOTEL,
St. Louis, Missouri,
10 a. m., Friday, March 13, 1903.

Continuation, pursuant to adjournment.

Present: The Commissioner, and same counsel representing the respective parties.

EDWARD H. KEISER,

a witness of lawful age, being duly produced, sworn and examined on the part of the City of St. Louis, testified as follows:

DIRECT EXAMINATION.

By Mr. E. C. Crow.

Q. Please state your name. A. Edward H. Keiser.

Q. What is your occupation? A. I am professor of chemistry in Washington University, St. Louis, Missouri.

Q. How long have you been occupying that position in Washington University? A. Since the fall of 1899.

Q. From what institution did you come to Washington University? A. From Bryn Mawr College, near Philadelphia, Pennsylvania.

Q. How long were you there? A. Fourteen years.

Q. What position did you occupy there? A. Professor of chemistry.

Q. Prior to that time, what was your occupation?

A. I was instructor in chemistry in the Johns Hopkins University at Baltimore.

Q. For how long a time? A. For about eighteen months.

1592 Q. Have you occupied any other position in educational institutions?

A. I was Fellow in chemistry previous to that in Johns Hopkins University in Baltimore for two years.

Q. Where were you educated, professor?

A. I was graduated from Swarthmore College, Pennsylvania, in 1880,—that is, taking the degree of Bachellor of Science in 1880, and I took the degree of Master of Science in 1881 from the same institution. In 1884 I took the degree of Doctor of Philosophy in the Johns Hopkins University, Baltimore, and

I studied in Germany in the summer of 1884, at Freiburg, in Saxony, and in 1887 in Gottingen University, and in 1894 at Heidelberg, in Germany.

Q. Now, in your studies in Germany, what particular branches of education were you pursuing?

A. Chemistry.

Q. The schools to which you went in Germany, are those of recognized quality of excellence?

A. They are. They are the universities in Germany.

Q. Were you ever called upon to make an analysis of the waters of the Mississippi River at the In-take Tower of the St. Louis Water Works, of the Missouri River, and of the Mississippi River above the mouth of the Missouri, the Illinois River, the Des Plaines River, and the Chicago Drainage Canal? A. Yes sir.

Q. For whom did you make that analysis?

A. I was called upon in January, 1900, by the Water 1593 Commissioner of St. Louis and the City Chemist, and was asked to make an examination of these waters.

Q. In your education, did you pay any particular attention to the analysis of water?

A. Yes, I studied that as a student and had a good deal of practice in it as a teacher of chemistry.

Q. Whereabouts?

A. At Bryn Mawr College, and also at Johns Hopkins University, and at the Washington University in St. Louis.

Q. Just tell me what particular amount of experience you had in analyzing waters aside from these tests here?

A. I have every year analyzed waters in every laboratory where I have been. The analysis of water is a frequently occurring operation in a chemical laboratory. It is taught to the students in chemistry and water analyses are constantly made both by the instructors and students.

We are often called upon by individuals to pass judgment upon the character of drinking water, and before doing that we make an analysis of the water so it is a frequently occurring operation. It is one that a chemist is called upon to carry out right along in his practice.

Q. Have you made many examinations of different waters for the purpose of determining their potability?

A. I have made a great many.

Q. Enumerate some of the waters you have examined to determine their potability.

1594 A. I have examined the waters that are supplied to the city of Baltimore—not in an official way, but merely as a chemist in the laboratory for my own information. And I have examined the waters of Philadelphia—the water for our supply at Bryn Mawr College. And then a great many well waters and spring waters have been sent to my laboratory for analysis. And here in St. Louis I have from time to time analyzed the tap water—that is, the hydrant water in the laboratory. Together with a great many other waters that have been sent in. I have analyzed a great many waters for the railroad companies for the purpose of determining the value of these waters and their character.

Q. What railroad companies?

A. I have made several dozen analyses for the Missouri Pacific Railroad Company and the Iron Mountain Route. Every time they sink a new well they generally send a sample to my laboratory to have it tested before they use it on those roads.

Q. Have you ever examined any of the waters of the Northern Lakes, or those adjacent thereto, other than Lake Michigan, in this examination?

A. I have not.

Q. Have you ever examined the waters of any deep wells in the northern part of this country?

A. I have. I have examined some of the waters at Wequetonsing, Michigan. It is a summer resort. There were cases of typhoid fever occurring there in the summer of 1901, and samples of that water were sent to me for analysis.

1595 Q. I will ask you to state, professor, if, in determining the potability of water from chemical analysis, whether or not it is also necessary for the chemist to know something of the local history of the water which he examines?

A. It is very desirable in passing judgment upon the character of the water to know as much as possible about the surroundings of the well or spring from which the water is obtained.

Q. Or the river?

A. Or the river.

Q. And if there is contamination, is it necessary or expedient that the source of the contamination be known and examined? A. It is.

Q. Now what two other branches of science are used in connection with the chemical analysis of water in determining its potability and the propriety and safey of using it for domestic and sanitary purposes?

A. Bacteriology, bacteriological science is used.

Q. Any other?

A. Analytical chemistry.

Q. What about microscopic examination?

A. I include that in bacteriology.

Q. Microscopic examination for the purpose of determining the potability of water—has that any effect on the judgment of the chemist in determining the potability of the supply?

A. It certainly has.

Q. What effect has it?

A. In judging of the character of the water, the analyst is influenced by the number of bacteria found in a cubic centimeter of the water, and also by the character of the bacteria. 1596

Q. Does the flora of the water have anything to do with its potability?

A. That is more a matter for the bacteriologist to determine.

Q. The chemist does not consider that?

A. No, sir, the chemist does not consider that.

Q. Does the chemist consider the coloration of the water?

A. Yes, the chemist notices the color and appearance of the water; and whether there is a sediment there or not; and the odor and taste.

Q. What color indicates that suspicion should be cast upon the water? A. A pure water should be clear and colorless like a crystal, clear as crystal. Any color—a dark color indicates organic matter. A yellow color may be due to vegetable matter or to an earthy sediment in the water. The color is not a sure test, of course.

Q. It is one of the indications?

A. Yes sir, that is one of the indications.

Q. What weight does the chemist give to the brown color of water?

A. Well, brown waters are often regarded as suspicious, the brown color being due to organic matter. It may, however, be of vegetable origin, and then it may not be of a harmful character.

Q. Does the chemist consider the turbidity of the water?

A. Yes, he makes a record of it.

Q. It is one of the indications of the quality of the water?

A. Yes, of the quality of the water.

1597 Q. You stated that you made some examinations and made them for the city of St. Louis?

A. Yes, sir, for the City Chemist, and for the legal department of the city of St. Louis.

Q. Did you personally make these analyses yourself?

A. I was assisted by four assistants, and at times by five assistants, and together we made the analyses.

Q. Was the work done under your personal supervision?

A. Yes.

Q. And inspection?

A. And my inspection.

Q. Then are you able to speak for the accuracy of the work?

A. Yes, sir.

Q. And consider it your own chemical analysis?

A. Yes, sir.

Q. Where was this work performed?

A. In the chemical laboratory of the Washington University.

Q. Where did you receive the samples of water from?

A. I received them from the City Chemist's office. They were delivered to me in the laboratory of the Washington University.

Q. From the City Chemist's office in St. Louis?

A. Yes, sir.

Q. In what condition were these samples when they were received, and in what were they contained?

A. They were contained in glass bottles of one gallon ca-

pacity, and the stoppers were tied over with a cloth, and the cloth was fastened with strings, and the strings were
1598 sealed. And to each bottle was attached a label stating the point on the river where the water was taken or collected, and also the time when the collection had been made, and the name of the collector.

Q. I show you "Plaintiff's Exhibit No. 16," and ask you if that is one of the bottles, or character of the bottles, in which you received the samples?

A. (After examining "Exhibit 16") Yes, these are the bottles.

Q. Capacity one gallon?

A. One gallon.

Q. Were these samples received daily or weekly?

A. We received them daily.

Q. Were they encased in the proper manner that samples should be when transmitted for chemical examination?

A. Yes, sir. The samples that came from a further distance were packed in ice in warm weather.

Q. Is that necessary?

A. It is very desirable in warm weather that they should be packed in ice.

Q. Is there any difference in the results of the chemical analyses of the same water when made at varying temperatures?

A. Water changes very rapidly. The organic matter in water, especially that which we recognize as nitrites, are very apt to undergo a change if the water is kept at ordinary temperature or higher temperatures.

Q. Do you know who delivered these samples to you at your laboratory?

1599 A. I do not remember the names of the men who delivered them.

Q. Do you know with reference to the time you received them how long they had been taken from the waters?

A. Only a few hours, I think.

Q. They had been transmitted directly to you then through the City Chemist's office?

A. Yes, sir.

Q. Were these bottles sealed in any manner?

A. They were.

Q. With what?

A. They were closed with cloth over the stopper, and that was tied down over the neck of the bottle with strings, and the strings were sealed with sealing wax—attached with sealing wax.

Q. Did you find, you or any of your assistants, any of these seals broken on the bottles?

A. I do not remember any of them having been broken.

Q. If they had been found broken, would they have been used as samples?

A. No sir.

Q. Did you have any rule about that?

A. We had direct orders not to make any analyses of any bottles broken, or with seals broken.

Q. And all the analyses you made, or you testify about, were made from bottles that were sealed when they came into your possession? A. Yes.

Q. You are familiar with the proper method of making
1600 analysis of water for the purpose of determining its potability, are you? A. Yes sir.

Q. Will you please describe the methods that you followed in making these chemical analyses of the water which you made for the city of St. Louis?

A. I made eight determinations in the analysis of water. The first of these was a determination of the total solid matter in the water, and secondly, we determined the amount of free ammonia. And thirdly, the amount of albuminoid ammonia; and, fourthly, the total ammonia; and, fifthly, the oxygen consuming properties of the water; and, sixthly, the nitrogen present as nitrates; and, seventhly, the nitrogen present as nitrites; and, eightly, the chlorine.

Q. What was the state of the water you used for these different determinations; was it filtered or unfiltered?

A. For the first five determinations we used the water in an unfiltered state; for the determination of the nitrogen as nitrites and nitrates and of chlorine we used the filtered water.

Q. How was it filtered?

A. We filtered the water through paper filters, perfectly pure, washed, paper filters were used, and these filters had been tested before to make sure they were free from nitrites. A portion of the water was filtered through Pasteur filters. That used for nitrates and chlorine determinations were filtered through Pasteur filters.

1601 Q. You might give a description of the particular method you followed.

A. For the determination of the total solids, a measured volume of the water, 100 cubic centimeters of the water was evaporated down to dryness in a weighed platinum dish and it was heated for about fifteen minutes in an oven to make sure that all water had been driven off, and the residue of this water was weighed—the platinum dish with the residue was weighed. That we call the total solid matter in the water. That solid matter consists of mineral salts and of animal or vegetable matter that may be in the water. The next step was to heat this platinum dish, to heat it over a flame to a dull red heat. This heating burns away all the vegetable or animal matter that was in the water and that remained in the total solid residue. After heating and usually during the process of heating, the residue turns brown; if there is any animal or vegetable matter in the water it is charred and burned away; and after the heating we weigh again and we find now that this residue weighs less than before. We call this loss in weight the volatile and organic matter in the water, and the difference between the weight of the dish after this heating and before gives us the total amount of organic matter in the residue and also the amount of fixed solid matter or mineral matter that is in the water. Then we go on to determine the organic matter in the water that is of a nitrogenous character. We then determine the nitrogenous organic matter and we look for nitrogen in four forms. The chemist looks upon nitrogen as an element that is characteristic of living
1602 things. Nitrogen goes through a cycle of changes in living matter and the presence of nitrogen compounds in water shows that the water has become contaminated with matter of vegetable or animal origin; so that the chemist attaches very great importance to the detection of nitrogen in its various forms

in natural water. A pure water is free from all nitrogen compounds, but such water is never found in nature. All natural waters contain varying amounts of nitrogen in some form. Now the chemist looks for nitrogen in four forms: First, as free ammonia; second, as albuminoid ammonia; third, as nitrites, and, lastly, as nitrates. I might say the cycle of changes through which nitrogen goes is something like this: vegetable matter requires nitrates for its growth and development. The roots of plants take up nitrates from the soil or from water, and the plant builds up complex nitrogenous compounds or albuminoids, such substances as gluten of wheat and similar albuminous substances. These albuminous substances are the foods of animals, and animals live upon these albuminous substances. And in their life processes they break down the complex nitrogenous compounds that plants have built up and break them down to simpler compounds which are not albuminoids, and these products that are eliminated from animal bodies find their way into water and are broken down still further by still lower forms of life, by bacteria. They break down these products eliminated from animal bodies, into still simpler forms of nitrogenous compounds, namely, ammonia and nitrites and by still further action of bacteria the ammonia and nitrites are brought back 1603 again into the nitrates. An then it is in the condition for plants to again absorb it and take it and build up the complex nitrogenous compounds which serve as food for animals. So that nitrogen is going through a cycle of changes. It is being built up into complex compounds and animals live upon these substances and break them down partially, and then they are finally reduced to the nitrates by means of organisms in the soil and water. This is what we call the nitrogen cycle.

Q. And this nitrogen is taken by the soil and used until broken down by the cycle you have described?

A. Yes, sir. And, therefore, a chemist attaches very great importance to the detection of nitrogen compounds in water. If found in water it is evidence that there is nitrogenous organic matter undergoing putrefaction there. And we search for it in the form of free ammonia, albuminoid ammonia, nitrites and nitrates, those four forms. Shall I describe now the method of determining those forms?

Q. Describe the method you pursued in this investigation.

A. In determining free ammonia, a measured quantity of the water, 500 cubic centimeters, was placed in a glass flask that was connected with a condenser, and it was distilled, and the steam that comes off from that water carries with it any free ammonia that may be in the water, and it is condensed and collected in five separate glass vessels.

Q. Which, the steam?

1604 A. The steam is condensed and comes out of the condenser in the form of drops of water and those drops of water contain the drops of free ammonia.

Q. Is that distilled water?

A. Yes, that is distilled water; but contains the ammonia contained in the original samples of water. The five portions collected in that way have then added to them a solution called Nessler's solution. This Nessler's solution is a mixture of potassium iodide, mercurial iodide and caustic potash in definite quantities. Do you wish those proportions?

Q. Yes, give us the proportions you used there in order to see what the test was.

A. The Nessler's solution contained 35 grammes of potassium iodide, and to that was added a saturated solution of mercury iodide until a permanent precipitate was obtained. Then it was made up to 1,000 cubic centimeters with a 10 per cent solution of caustic potash. On adding this Nessler's solution to the five portions of the distillate containing free ammonia, a brownish-yellow color is produced and the strength of the color depends on the amount of ammonia present. We then make up similar colors by means of a standard solution of ammonium-chloride of known strength. We match these colors with the standard ammonium chloride and compare them and thus we determine the amount of ammonia present in the water. The standard solution of ammonium chloride contained 3.8133 grammes of ammonium chloride in the litre of water and for the usual work in the laboratory 10 cubic centimeters of 1605 this solution was taken and diluted to 1 litre for use in making the standard. Then the next step was the determination of albuminoid ammonia. The residue in the flask, consisting of 250 cubic centimeters of the water, was now treated with 40 cubic centimeters of alkaline solution of potassium permanganate, and it was again distilled; and five samples of 50 cubic centimeters each of distillate were collected and these five were again treated with the Nessler's solution and the ammonia that was in them gave the brown color and the amount of the ammonia was again determined by making up similar colors with the standard solution of ammonium chloride and the Nessler's re-agent. In this way the amount of albuminoid ammonia in the water was determined and in the analyses this amount is stated in parts per million, which means a certain number of parts by weight in a million parts of water.

Q. Is that the usual standard in determining the chemical constituents of water—to do it by parts per million?

A. Yes.

Q. Is that the equivalent of milligrammes per million?

A. Yes. Then the next determination was the total ammonia. The total ammonia in our work was determined by adding together the free ammonia found in the first operation described to the albuminoid ammonia found in the second operation. That gave us the total ammonia.

Then the next was the determination of nitrogen as nitrites.

1606 For this a filtered water was used. 100 cubic centimeters was placed in a clear glass cylinder and 2 cubic centimeters of a solution of sulphanilic acid was added and to that 2 cubic centimeters of (alpha) naphthy-lamine. The presence of nitrites is indicated by the production of a pink color. The pink color in this water after the addition of these re-agents indicates the presence of nitrites, and the amount of nitrites is determined by making up a similar color with the same reagents, but adding a known quantity of standard potassium nitrite solution. We thus match colors and having the amount of nitrite required to produce that color, we decide that that amount of nitrite was present in the water. The amount is again expressed as so much weight of nitrogen in the form of nitrite present in a million parts of water.

The next determination was the nitrogen present as nitrates. For this purpose, 100 cubic centimeters of the water were evaporated to dryness in a platinum dish—or a porcelain dish was often used. And the dry residue was treated with a solution

of phenol-sulphonic acid. The sulphonic acid was brought into contact with the dry residue of the water, a few drops of sulphuric acid added, and then ammonia in excess. By this treatment nitrates are converted into a yellow pigment, and water is then added to make up the volume of 100 cubic centimeters. The yellow solution thus obtained is now compared with similar yellow solutions that have been made in the same way; by starting with known amounts of potassium nitrate and by matching color, the amount of nitrates existing in the water is determined, and the result expressed as so many parts of
1607 nitrogen present as nitrates in a million parts of water.

The chlorine in water is determined by measuring off 100 cubic centimeters of water and adding to it 1 cubic centimeter of potassium chromate solution, and then running in from a burette a standard solution of silver nitrate. The strength of the silver nitrate is of such a value that 1 cubic centimeter of the nitrate solution corresponds with one part of chlorine per million parts of water. The standard silver nitrate is run into the measured volume of water until a faint red color is produced. From the amount of silver solution used we calculate the weight of chlorine per million parts of water.

Then the last determination was the oxygen consuming power of water. This is determined by measuring 100 cubic centimeters of water and adding an excess of standard potassium permanganate solution, usually about 30 to 40 cubic centimeters, and boiling for fifteen minutes. The liquid is then treated with standard oxalic acid until colorless and by calculation we find out the amount of permanganate used, and from that the weight of oxygen required to oxydize the organic matter in one million parts of water.

So with the figures obtained in all these determinations, they are the actual weights of the substances in one million parts of water.

Q. Now, is there anything further in reference to the methods that you want to state?

A. No, sir, I think that covers the analytical processes.

1608 Q. You are familiar with the different methods of chemical analyses, I suppose?

A. Yes, sir.

Q. In making these analyses, did you follow any one particular method, or did you follow what you considered the best of the different classes or methods?

A. This in general is the method recommended by the American Society for the Advancement of Science, and it is regarded as the standard method, that is in use generally at the present time.

Q. I believe you stated that these tests were conducted by you personally, or under your personal supervision?

A. Yes.

Q. Where were they made?

A. At the chemical laboratory of the Washington University.

Q. Where is the Washington University?

A. At present it is at Twenty-seventh and Locust streets, but at the time these analyses were made the university was located at Eighteenth and Washington avenue, and all these analyses were made in the building at Eighteenth and Washington avenue.

Q. At what time did you begin this work of analyzing the waters of the Mississippi River, Missouri River, Illinois River, Des Plaines River, and the Chicago Drainage Canal?

A. We began the analyses on the 24th of January, 1900.

Q. And how long did those analyses continue at that time?

1609 A. We made daily analyses of the samples sent to us by the City Chemist, 12 samples daily, until October 11, 1900.

Q. Was there any change in the number of samples analyzed in 1900?

A. At first we analyzed 12 samples daily, and during the last five months 14 samples were received and analyzed each day.

Q. Then did you do any other analytical work on these waters at any later time?

A. One year later, in 1901, a daily analysis was made during the months of October and November.

Q. Ending when?

A. Ending on the last day of November.

Q. How many samples daily were received and analyzed during that period?

A. 14 samples each day.

Q. Were there any directions given for the collection of these samples?

A. I gave no directions for that. They were collected according to the directions given by the City Chemist, and I understood that two samples were taken at each point. One sample was delivered to the City Chemist for analysis, and the other sample was brought to me for analysis at the chemical laboratory of the Washington University.

Q. Of identically the same waters?

A. Of the same waters, taken at the same time.

Q. And they were made by yourself and the City Chemist,
1610 acting as analysts of the water, as duplicate analyses of
the same water taken at the same time?

A. Yes.

Q. Can you give me the names of the places where samples of waters were collected?

A. The places were as follows: First, the reservoir at the Chain of Rocks.

Q. (By Mr. Springer): What year was that?

A. In January, 1900. The reservoir at the Chain of Rocks. The Wet Well, Chain of Rocks. The Intake Tower Waterworks Chain of Rocks. The Missouri shore, at the Chain of Rocks. The Illinois shore at the Chain of Rocks. A sample was brought from Bellefontaine, above the Missouri River, above the mouth of the Missouri River. Another sample from Hartford, on the Mississippi River. Another one from Alton, on the Mississippi River. Another sample was collected at Grafton, three miles above in the Mississippi, and another sample came from three miles above Grafton in the Illinois River. Another sample was collected from a point two miles above Peoria, on the Illinois river. Samples were also brought from Lockport and Joliet. And later on, when we analyzed fourteen samples a day, a sample was taken from the running water, the tap in the chemical laboratory.

Q. What chemical laboratory do you refer to?

A. The chemical laboratory of the Washington University.

Q. Is it necessary, to obtain an idea of the changes which
1611 water undergoes from a sanitary standpoint, to consider
the fluctuations in the quantities of nitrogen compounds
that are present?

A. Yes, sir.

Q. Did you do that with this water?

A. Yes, sir.

Q. Did you do that with the reservoir water of this city?

A. Yes, sir.

Q. In what way did you make that test—that is, from where did you get those samples?

A. The samples came from the reservoir, and were delivered in the usual way.

Q. You analyzed these waters to determine the presence of nitrites, nitrate, albuminoid ammonia, free ammonia and chlorine?

A. Yes.

Q. And the amount of oxygen consumed?

A. Yes.

Q. And these different forms of chemical constituents found in the water are of chief importance in judging of the sanitary conditions of the water?

A. The presence of nitrites and free ammonia I regard as of chief importance.

Q. For what reason?

A. For the reason that the presence of measurable quantity of nitrites in drinking water is often regarded as a
1612 sure sign of contamination, and a chemist finding a measurable quantity of nitrites in water would condemn that
water as unsafe for drinking purposes. And so free ammonia, likewise, is of great importance in judging of the sanitary conditions of the water for the reason that the first product produced by bacteria in decomposing sewage is free ammonia. We always find a quantity of free ammonia in sewage, so the chemist lays special stress on these two constituents, namely, nitrites and free amonia.

Q. Chemically, what is free ammonia?

A. Free ammonia is ammonium carbonate, or ammonium chloride existing in the water, that has been formed by the action of bacteria upon nitrogenous organic matter.

Q. Is free ammonia one of the chemical constituents of pure water?

A. No, sir; free ammonia is absent from pure water.

Q. Then it must get into that water from some organic matter?

A. Yes.

Q. Of what is free ammonia and nitrites evidence of in water?

A. Evidence of contamination with nitrogenous organic matter.

Q. Is it evidence of changes, and if so, of what character?

A. Of bacteriological action; the presence of nitrites especially.

Q. They produce fermentative action?

A. Yes, there is fermentation going on in the water when
1613 we find nitrites.

Q. When that is found, does that show whether or not the water is able to take care of its own organic contamination?

A. It shows it is not able to take care of this contamination, and that it is undergoing putrefaction and decay. The presence of these nitrites indicates there is decaying vegetable or animal matter in the water.

Q. And the same with free ammonia?

A. Yes.

Q. That is the reason these two chemical substances are indication or warning to the chemist that the water should be looked upon with suspicion?

A. Yes.

Q. Have you a record of the fluctuations of the nitrites in the reservoir of this city from January 14, 1900, to October 11, 1900?

A. Yes.

Q. Is that given in weekly or daily averages in the parts of nitrites in a million parts of water?

A. We made daily analyses and from them made daily averages, and from the daily averages we made weekly averages.

1614 Q. You made the comparison to determine the fluctuations in the amount of nitrites in the reservoir water of this city?

A. Yes, sir.

Q. And you have those weekly averages of the parts of nitrogen present in one million parts of water in the form of nitrites, have you?

A. Yes.

Q Did you do the same thing from January 24th to 31st, 1900, inclusive, with the water of the Drainage Canal?

A. You mean the water taken at Lockport?

Q. Yes?

A. No, sir, not at that time.

Q. From January 24 to 31, 1900, what part per million of nitrogen did that water in the reservoir contain?

A. It had .0044 parts of nitrogen as nitrites per million.

Q. Now, will you give me the highest and lowest, with the dates, of the amount of nitrogen found in the water at the Intake Tower of the St. Louis Waterworks, between January 24 and October 11, 1900?

A. I have not tabulated the Intake here (referring to paper). It is on the larger record.

Q. You have the figures?

A. Yes, but they are not in this report (indicating). The figures for the Intake are in the tables that are in the room below; shall I get them?

Q. Yes, you had better get it because I want it in the record, because that is the starting point at the Intake.

A. The highest amount was February 10, 1900, .048. The lowest amount was later on in the year, June 21, 1900, .002.

1615 Q. I will get you to state, Professor, whether or not you have the weekly averages of the amount of nitrites found for the weeks from January 24 to October 11, 1900; and if so, have you the same in the shape of a table?

A. Yes, sir, I have.

Q. Please give that table, being table No. 1, which is an examination of the reservoir in the St. Louis Waterworks from January 24, 1900, to October 11, 1900?

A. Nitrites, parts per million.

(Jan. 24th-31st,	.0044 before Canal opened.)	
Feb. 1- 7th,	.0074)	
Feb. 7-14th,	.0080)	Average February, .0133.
Feb. 14-21st,	.0140)	
Feb. 21-28th,	.0240)	

Nitrites, parts per million.

	Mar. 1- 7th,	.0100)	
	" 7-14th,	.0080)	Average March, .0107.
	" 14-21st,	.0120)	
	" 21-31st,	.0130)	
	Apr. 1- 7,	.0140)	
	" 7-14,	.0170)	Average April, .0180.
	" 14-21,	.0260)	
	" 21-30,	.0140)	
	May 1- 7,	.0097)	
	" 7-14,	.0046)	Average May, .0055.
	" 14-21,	.0049)	
	" 21-31,	.0031)	
1616	June 1- 7,	.0040)	
	" 7-14,	.0039)	Average June, .0032.
	" 14-21,	.0027)	
	" 21-30,	.0020)	
	July 1- 7,	.0017)	
	" 7-14,	.0013)	Average July, .0017.
	" 14-21,	.0021)	
	" 21-31,	.0017)	
	Aug. 1- 7,	.0004)	
	" 7-14,	.0018)	Average August, .0021.
	" 14-21,	.0035)	
	" 21-31,	.0025)	
	Sept. 1- 7,	.0015)	
	" 7-14,	.0011)	Average September, .0013.
	" 14-21,	.0016)	
	" 21-30,	.0010)	
	Oct. 1-10,	.0021)	Average October, .0021.

Q. Now, will you please give me the amount—average amount—of nitrites found in the reservoir water from January 24, 1900, to January 31, 1900?

A. It was .0044 parts per million. That was before the Canal opened.

Q. No, it was not before the Canal opened?

A. No, before it reached us here. We recorded it as such.

Q. Now, will you give me the average of nitrites found in that water for the month of February, 1900?

A. It was .0133.

1617 Q. Now, will you give me the average of the nitrites for March, 1900, in the water of the reservoir of St. Louis?

A. The average for March .0107.

Q. Now, give me the average for April for the same water?

A. .0180.

Q. Now, the average for May for the same water?

A. .0055.

Q. Now the average for June for the same water?

A. .0032.

Q. Now for July for the same water, the average?

A. .0017.

Q. Now for August?

A. .0021.

Q. Now the average for September for the same water?

A. 0013.

Q. Now, please give me the average for October for the same water?

A. .0021.

Q. Now, will you please give me the maximum of nitrites in the reservoir water between February 1st and February 28, 1900?

A. Between February 1st and February 28, maximum was .0240.

Q. Now, in what week in February, giving the dates, did that maximum occur?

A. In the week of February 21 to 28.

Q. Now, will you give me the maximum with the dates thereof in the month of March?

A. The maximum in the month of March was in the week of March 21 to 31, and the amount was .0130.

1618 Q. Now, will you please give me the maximum amount in April together with the date of the month thereof, the week?

A. The maximum amount was in the week of April 14 to 21 and the amount was .0260.

Q. Now, will you give me the maximum amount for May together with the beginning and ending of the week in which it occurred?

A. The maximum amount in May was in the week May 1st to 7th and the amount was .0097.

Q. Now, please give me the maximum amount for the month of June with the beginning and ending of the week?

A. The maximum occurred in the week June 1st to 7th, and the amount was .0040.

Q. Now, please give me the maximum amount for the month of July with the date of the beginning and ending of the week?

A. The week of July 14 to 21, the amount was .0021.

Q. Now, please give me the same for July, the maximum?

A. For August, you mean?

Q. Or August?

A. For August the maximum amount was in the week August 14 to 21, the amount was .0035.

Q. Now, please give me the maximum amount for September, together with the date?

A. September 14 to 21, the amount was .0016.

Q. Now, please give me the average for October 1st to 10th?

A. October 1st to 10th, the average .0021.

Q. I present you plate No. 1. Just please state what that is?

A. This is a curve showing the changes in nitrites in the reservoir water.

Q. Reservoir water of what place?

1619 Of St. Louis from January 24 to October 10, 1900, and is also in pencil a curve representing the changes of nitrites in the reservoir water of St. Louis from October 1st, 1901, to November 30th, 1901.

Q. Now, just explain the meaning of those curves on that chart?

A. This curve shows that early in February, 1900—

Q. No; explain the meaning of the curve?

A. Well, a curve meaning the varying amount of nitrites in the reservoir water in St. Louis, and it is made by plotting off—

Q. Just explain your map, what it reads—how to read your map?

A. The curve is made by plotting off the dates, the weekly dates on the horizontal line, and the quantities of nitrites found in the water on the vertical column, and the figures, the averages which have just been recorded in the tables, are here plotted out in the form of a curve.

Q. Here in table No. 1, say?

A. Yes, in table No. 1. And the points obtained have been joined by a red line showing the variance in the amount of nitrites in the reservoir water during the period of our analyses.

MR. CROW: Now, you just mark this as plaintiff's Exhibit No. 23.

Said chart is marked by the Commissioner "Complainant's Exhibit No. 23, Frank S. Bright, Commisioner."

Q. Now, you know when the Drainage Canal was opened?

A. January 17.

1620 Q. What year?

A. 1900.

Q. Now, this table and this chart, do they disclose anything with reference to the increase or decrease in the quantity of nitrites in the reservoir water as related to the opening of the Drainage Canal?

Q. It shows that early in February the quantity of nitrites in the reservoir water began to increase very materially, and the water of the reservoir was in a highly polluted condition.

Q. Go ahead with your statement there?

A. The water became badly polluted in the month of February, and this pollution continued during March and during April. In May—about the end of April and in the beginning of May, the quantity of nitrites materially diminished; and then during the summer months it was low, and in October they began to increase again—in 1900. Then in 1901 we continued the analyses, found that they were again higher.

Q. Now, what causes do you, as a chemist and analyst of these waters, attribute the rise in February to April and the decline in May, June and July?

A. The abnormal increase in February in nitrites in the reservoir water we attributed to the coming down in the Mississippi river of large quantities of sewage.

Q. From what source?

A. As shown by our other analyses, analyses borne out by analyses made at other points on the Mississippi—at Alton and Grafton on the Mississippi, and on the Illinois, it was shown that they came down this river.

Q. From whence did they come into the Illinois river?

A. Well, our analyses point to the Drainage Canal as the source of them.

1621 Q. To what do you attribute the decline in May, June and July from the pollution?

A. The falling off in the quantity of nitrites in the reservoir water in the spring months was co-incident with the heavy rains and the high stages of the river.

Q. What effect did the high stage of the river have that caused a diminution of the nitrites?

A. By the greater dilution by means of the large volume of rain water flowing into the rivers the quantity of nitrites was very materially diminished in the early part of May and during June, and in the summer months the high stages continued.

Q. What causes a high stage in the Mississippi usually in June at St. Louis?

A. Well, the melting of the snows.

Q. In the water shed of what river?

A. Of the Missouri river.

Q. What does the rainfall diminish the nitrites by?

A. By dilution.

Q. Simply by that you mean the increase in the volume?

A. In the volume of the water.

Q. Does that destroy the nitrites?

A. No, sir.

Q. What effect has it, then?

A. Simply to diminish the amount per cubic centimeter, or per million of water.

Q. The amount of nitrogen in a given quantity of water?

A. Yes, sir, the amount of nitrogen in a given quantity of water.

Q. Then, to put it inversely, it increases the amount of water to the given amount of nitrogen?

A. Yes, sir.

1622 Q. And the deduction from that is that the lowest quantity of the nitrogen would come with the water into the reservoir?

A. Yes, sir.

Q. Now, you made one year later an analysis of the water from the Intake of the St. Louis Waterworks, I believe?

A. Yes, sir.

Q. Now, you made that analysis for the purpose of determining the amount of nitrites in the water of the Intake Tower?

A. Yes, sir.

Q. What was the date of that examination?

A. It began in October, October 1st, 1901, and was ended November 30th, 1901.

Q. Have you the weekly averages of the nitrites in the period mentioned in 1901, of the examination of the water at the Intake Tower of the St. Louis Waterworks?

A. Yes, sir.

Q. Will you please furnish me that table?

A. Table No. 2, October 1st, 1901, to November 30th, 1901, of the examination of the water for nitrites at the Intake Tower of the St. Louis Waterworks:

1623

	Pts. per Million.
Oct. 1- 7,	.0037
" 7-14,	.0029
" 14-21,	.0050
" 21-28,	.0048
Oct. 28-Nov. 4,	.0131
Nov. 4-11,	.0131
" 11-18,	.0143
" 18-25,	.0130
" 25-30,	.0116

1624 Q. Now, will you give, if you have it, the maximum amount for the month of October of the nitrites found in Intake Tower of the Waterworks from October 1st to October 28, 1901?

A. The maximum amount in October was in the week of October 28 to November 4, and the amount was .0084.

Q. Now give the maximum amount for November, 1901, of this water at the Intake Tower of the St. Louis Waterworks for nitrites?

A. The maximum amount in November was in the week November 11 to 18, and the amount of nitrites was .0143.

Q. Now, how do these amounts of nitrites found compare with the nitrites found a year previous in 1900?

A. In 1901 there was an increase over what had been found in 1900.

Q. In nitrites?

A. In nitrites.

Q. Did you make any examination of the water for free ammonia?

A. Yes, sir.

Q. Now, is there any standard above which the amount of free ammonia should not rise in waters that are potable?

A. Yes, sir. When the amount of free ammonia in river water rises above .045 per million the water is regarded with suspicion, and it is generally recognized that such water is polluted.

Q. Now, Professor, that is not a hard and fast rule, however, that is applied under all circumstances?

A. No, sir.

Q. That will vary, will it not, with the local history of the water and the local surroundings?

A. Yes, sir.

1625 Q. For instance, a water might contain more free ammonia than that and it might be from a source that was absolutely harmless?

A. Yes, sir.

Q. To illustrate, the salt might be placed in such juxtaposition to a well or reservoir that it would cause a much higher percentage of free ammonia and be absolutely harmless from a sanitary standpoint?

A. Yes, sir.

Q. Now, this examination for free ammonia, was it made of the water in the reservoir?

A. Yes, sir.

Q. From what period of time to what period of time?

A. From January 24, 1900, to October 11, 1900.

Q. Was it made for the purpose of determining the amount of free ammonia in the reservoir?

A. Yes, sir.

Q. And was it made on a weekly average?

A. Yes, sir, we made daily analyses.

Q. In what manner did you obtain that weekly average?

A. We made daily analyses of the water brought to us from the reservoir, and the average results for each week were put down and were taken as the weekly average.

Q. Now, have you recorded the weekly average result of that investigation?

A. I have weekly and monthly averages of free ammonia in reservoir of St. Louis Waterworks between January 24, 1900, and October 11, 1900, which is table No. 3.

Q. Please give us that table?

A. The table is as follows:

1626 Weekly and Monthly Averages of Free Ammonia in Reservoir.

	Pts. per M.	
Jan. 24-31,	0.1112)	January average, .1112.
Feb. 1- 7,	.2265)	
" 7-14,	.2345)	February average, .2098.
" 14-21,	.1689)	
" 21-28,	.2094)	
Mar. 1- 7,	.1357)	
" 7-14,	.1643)	March average, .1890.
" 14-21,	.1980)	
" 21-31,	.2848)	
Apr. 1- 7,	.2690)	
" 7-14,	.2234)	April average, .1664.
" 14-21,	.1030)	
" 21-30,	.0703)	

		Pts. per M.	
May	1- 7,	.0417)	
"	7-14,	.0254)	May average, .0377.
"	14-21,	.0345)	
"	21-31,	.0491)	
June	1- 7,	.0234)	
"	7-14,	.0066)	June average, .0130.
"	14-21,	.0100)	
"	21-30,	.0120)	
July	1- 7,	.0117)	
"	7-14,	.0228)	July average, .0199.
"	14-21,	.0265)	
"	21-31,	.0186)	

1627

Aug.	1- 7,	.0320)	
"	7-14,	.0220)	August average, .0276.
"	14-21,	.0223)	
"	21-31,	.0343).	
Sept.	1- 7,	.0208)	
"	7-14,	.0348)	September average, .0250.
"	14-21,	.0263)	
"	21-30,	.0283)	
Oct.	1-10,	.0316)	October average, .0316.

1628 Q. Now will you, if you have it, give me the average amount of free ammonia per million found between January 24 and January 31 in the water of the reservoir of St. Louis?

A. The average for that time was .1112.

Q. Now will you give me the maximum amount of free ammonia found in the reservoir in February, 1900?

A. The maximum amount occurred in the week of February 7 to 14, and amounted to .2345 parts of nitrogen as free ammonia per million.

Q. Now will you give me the average of free ammonia in the reservoir for February, 1900?

A. The average amount was .2098 per million.

Q. Please give me the maximum amount for March, 1900, begin and end with the week?

A. The maximum amount occurred in the week of March 21 to 31, the amount .2848.

Q. Please give me the average of free ammonia for the month of March?

A. The average amount for the month of March was .1890 parts of nitrogen per million.

Q. Now give me the maximum amount for April, 1900?

A. The maximum amount occurred in the week April 1st to 7th, and amounted to .2690 parts of nitrogen per million of water.

Q. Now give me the average for April free ammonia?

A. And the average for April .1164 parts of nitrogen.

Q. Please state the maximum amount in May?

A. The maximum amount in May occurred in the week May 21 to 31, and amounted to .0491 parts of nitrogen per million.

Q. Please state the average amount of free ammonia?

A. The average amount .0377 parts nitrogen per million.

1629 Now please give me the amount for June, 1900?

A. And the maximum amount in June in the week for June 1st to 7th .0234.

Q. What was the average for June?

A. And the average for June was .0130 parts nitrogen per million.

Q. Please state the maximum amount for July?

A. Occurred in the week July 14 to 21, and amounted to .0265 nitrogen per million of water.

Q. What was the average of free ammonia for July?

A. The average of free ammonia for July was .0199 parts of nitrogen per million of water.

Q. What was the maximum for August, 1900?

A. The maximum for August occurred during the week August 21 to 31 and amounted to .0343 parts of nitrogen per million of water.

Q. What was the average for August?

A. The average for August .0276 parts of nitrogen per million.

Q. No, that is not nitrogen, it is free ammonia?

A. No, nitrogen as free ammonia.

Q. What was the maximum for September?

A. The maximum occurred during the week September 14 to 21, amounted to .0263 parts of nitrogen as free ammonia per million.

Q. And the average?

A. And the average for September was .0250 parts nitrogen per million.

Q. You are talking about August or September?

A. September.

1630 Q. Look at your figures?

A. For August the average .0276.

Q. Now for September?

A. Now the maximum occurred during the week September 21 to 30, .0283.

Q. What is the average?

A. .0250.

Q. On October 1st to 10th?

A. Of October, from October 1 to 10 was .0316, and that we take as the average for the month.

Q. Now what do these figures indicate with reference to the pollution of this water?

A. Well, these weekly averages and also monthly averages show great increase in the free ammonia immediately after the last week in January, and this high ammonia continued throughout the months of February, March and April. After the 21st of April there was an improvement in the water, which continued until the middle of June, and after June, there was a slight increase in July and August, and again in October. So that throughout the summer the water was much better than it had been in February and March.

Q. Now I will show you chart No. 2. What is that, and what does it purport to be?

A. Well, this is a chart on which there is plotted a curve, showing the changes in the amount of free ammonia in the reservoir water, in the St. Louis reservoir from January 24 to October 10, 1900.

Q. Now describe the map so anybody looking at it will understand what it means.

A. The dates are measured off on a horizontal line and
1631 the quantities of free ammonia are measured on the vertical line, and the weekly averages from the table that has just been read are plotted on this map, and these points are joined by a red line, and this red line shows the variation in the amount of free ammonia in the reservoir water from the time stated, from January 24th to October 10th, 1900.

Mr. Crow: I will offer it in evidence.

Said chart is marked by the Commissioner "Complainant's Exhibit No. 24, Frank S. Bright, Commissioner."

Q. Now what does this table and this map show with reference to the condition of the water at the Intake from January 24th to October 11th with reference to absence or presence of free ammonia?

A. It shows a very great increase immediately after the first week in February. The quantities of free ammonia increased very considerably in the reservoir water.

Q. In what time?

A. In 1900, in February, 1900.

Q. Did that extend into any other months besides that?

A. It extended into March and April and began to diminish then just as previously the nitrites were diluted by the spring rains, so we find that the ammonia was diluted and the quantity found in the reservoir water was very much less during the spring and summer months than it had been immediately after the opening of the Drainage Canal.

Q. Well, have you any explanation as a chemist to offer of the great increase in proportion of ammonia in February, March and April, 1901 at the water of the Intake at the
1632 Water Works?

A. The only explanation that I have to offer is at that time there was an enormous increase in the pollution in the Mississippi river.

Q. And where was that traceable to, if you know, chemically?

A. The analyses that were carried out at the same time simultaneously with these of water samples taken at Alton and at Grafton, Illinois river, and in the Mississippi river above Grafton and at Peoria showed there was simultaneously with this increase in the reservoir an increase in the free ammonia in the water at these points—that is, that the pollution came down the Illinois river.

Q. Was it traceable any farther than the mouth of the Illinois river?

A. Yes, sir, we traced it to Peoria and farther up beyond Peoria.

Q. How far up?

A. Up to Joliet and Lockport.

Q. What is at Lockport?

A. The opening of the Drainage Canal.

Mr. Woerner:

Q. You mean the end of it?

A. The end of it.

Mr. Crow: Then that was traced to the point where the Drainage Canal entered into the Des Plaines river?

A. Yes sir.

Q. Now was there any decrease in June and July in the free ammonia in the water at the Intake in 1900?

A. Yes sir.

Q. Was there any change in August and September?

A. There were slight changes, fluctuation in the amount; it was somewhat higher. It was somewhat higher in July, gradually began to increase. There was a slight increase in
1633 July and August and again in October.

Q. Now did you make any averages of the free ammonia found in the Intake of the Water Works of this city during the months of October and November, 1901?

A. Yes sir, I did.

Q. Have you that table?

A. Yes sir.

Q. Now please furnish me with that table?

A. Yes sir.

Mr. Crow: This is the table giving the weekly averages of free ammonia found in the water of the Intake of the St. Louis

Water Works during the month of October and November, 1901, being marked table No. 4.

Q. Please give that table?

1634 A. In the following table are given the weekly averages of free ammonia found in the water of the intake during the months of October and November, 1901:

Oct. 1- 7 incl.	.129.
“ 7-14 “	.051.
“ 14-21 “	.046.
“ 28-Nov. 4	.071.
Nov. 4-11	.070.
“ 11-18	.086.
“ 18-25	.072.
“ 25-30	.071.

1635 Q. Now just state how you arrived at these weekly averages?

A. These weekly averages were made from the daily analyses by adding together the results obtained from each day of the week and then dividing by 7 we obtained the weekly average.

Q. Can you give me the maximum of free ammonia found in the water of the Intake during the month of October, 1901, together with the beginning and ending of the week in which it was found?

A. The maximum in October occurred during the week of October 1st to 7th, and the amount was .129 parts of nitrogen as free ammonia in the reservoir water.

Q. Now give me please the maximum amount found in the month of November of free ammonia in the water of the Intake in 1901, together with the beginning and ending of the week?

A. In November the maximum occurred in the week of November 11th to 19th and the amount was .086 parts of nitrogen as free ammonia.

Q. Now what do these tables show, if anything, with reference to increase or decrease over the free ammonia found in the Intake during the months of October and November, 1900?

A. It shows that in 1901 there was a larger quantity of free ammonia in the water of the Intake than had been found in the previous year.

Mr. Springer: For the corresponding months of the previous year?

A. For the corresponding time in the previous year.

Mr. Crow: Did you make any examination of the water of the Intake or the reservoir for the nitrates in 1900?

A. Yes sir.

Q. Have you got a table of that?

1636 A. Yes sir, I have a table.

Q. This table then would be a table of nitrates from January 24th to October 10th, inclusive, 1900, of the water in the reservoir of the St. Louis Water Works and is table No. 5.

A. Yes sir.

Q. Now please give that table.

A.

1637

	Pts. per M.	
Jan. 24-31,	.50)	January average, .50.
Feb. 1- 7,	.52)	
" 7-14,	.49)	Average for February, .59.
" 14-21,	.57)	
" 21-28,	.78)	
Mar. 1- 7,	.61)	
" 7-14,	.91)	Average for March, .77.
" 14-21,	.89)	
" 21-31,	.67)	
April 1- 7,	.51)	
" 7-14,	.67)	Average for April, .56.
" 14-21,	.53)	
" 21-30,	.54)	
May 1- 7,	.51)	
" 7-14,	.38)	Average for May, .39.
" 14-21,	.32)	
" 21-31,	.35)	

		Pts. per M.	
June	1- 7,	.39)	
“	7-14,	.37)	Average for June, .41.
“	14-21,	.43)	
“	21-30,	.43)	
1638			
July	1- 7,	.51)	
“	7-14,	.49)	Average for July, .46.
“	14-21,	.34)	
“	21-31,	.51)	
Aug.	1- 7,	.48)	
“	7-14,	.27)	Average for August, .35.
“	14-21,	.22)	
“	21-31,	.42)	
Sept.	1- 7,	.39)	
“	7-14,	.36)	Average for September, .37.
“	14-21,	.36)	
“	21-30,	.38)	
Oct.	1-10,	.53)	Average for October, .53.

1639 Q. Now from this table and the averages thereof during the period from January 24th to October 10th, inclusive, 1900, can you state whether or not there was an increase or decrease in the amount of nitrates found in the reservoir of the St. Louis water works?

A. The table shows that there was a decided increase in February, also in March; then a gradual decrease in April, and that decrease became more pronounced in May. There was a slight increase in June, and a decrease in August and September. In October we find the value very near the same as at the beginning.

Q. Well was the increase in the month of February, March and April following the opening of the canal?

A. The increase began about the time when the water of the Drainage Canal reached St. Louis, and then it increased still more during the rest of the month of February and during the month of March. Then again as in the other cases when the spring floods came there was a diminution in the quantity of nitrates in the reservoir water.

Q. Now have you a record of your investigations of the water at the Intake of the St. Louis Water Works from October 1st, 1901, to November 30, 1901, to determine the quantity of nitrates in the same?

A. Yes sir.

Mr. Crow: This is table No. 6, being a table giving the nitrates found in the water of the Intake of the Water Works from October 1st to November 30th, 1901.

Q. Please give that table.

A.

1640

Oct.	1- 7,	.60
"	7-14,	.29
"	14-21,	.21
"	21-28,	.43
"	28-Nov. 4,	.38
Nov.	4-11,	.27
"	11-18,	.25
"	18-25,	.12
"	25-30,	.12

1641 Q. I show you now plate No. 3, will you please state what that is?

A. This plate contains a curve showing the changes in the amount of nitrates found in the reservoir water, and on the horizontal line the times are measured off, and on the vertical line the amount of nitrates are measured off and by means of weekly averages. They were found by analyses, and the curves were plotted and the points for each week joined by a red line, and this red line gives a graphic representation of fluctuation or changes of the amount of nitrates in the reservoir water from January 24 to October 10th, 1900, and then in pencil there is also a curve showing the amount of nitrates in 1901.

Q. At the time in the water in October and November, 1901?

A. We see from this curve that the maximum quantity of nitrates was reached in February and March, 1900, and it was higher during April, but during the summer months it was lower.

Q. How about 1901?

A. 1901 it was still high, about the same as it had been in 1900, in the corresponding months in 1900.

Q. Well, is there a decrease or increase in the nitrates in 1901 over that of 1900? Look at your table and see?

A. Nitrates are lower.

Q. Lower in 1901 than in 1900?

A. Than in the previous year.

Q. Now what would that indicate, if anything, chemically?

A. Well, it would indicate that the oxidation of the nitrites had not proceeded as far.

Q. What would that mean as to the purity or impurity of the water?

A. Well, it would indicate that fermentation was in active
process and had not yet been completed, the nitrates being
1642 the final products of the oxidation of the nitrogenous or-
ganic matter. The absence or presence of a small quantity of nitrates would show that the water was in an unstable condition.

Q. If the water had less nitrates in 1901 than in 1900 was it less pure or more impure?

A. It was more impure.

Q. Because of what fact?

A. Because the organic matter had not been completely oxidized.

Q. Now do you know whether or not from your examination of the water during this period, 1901, it showed more nitrites than it did in 1900?

A. Nitrites?

Q. Yes, sir?

A. There were more nitrites but less nitrates.

Mr. Crow: I now offer this map in evidence.

Said map is marked by the Commissioner:

"Complainant's Exhibit No. 25, Frank S. Bright, Commissioner."

Adjourned until 2 P. M., March 13, 1903.

IN THE

Supreme Court of the United States

THE STATE OF MISSOURI
vs.
THE STATE OF ILLINOIS
and
THE SANITARY DISTRICT OF CHICAGO.

Original,
Docket No.

Before
FRANK S. BRIGHT,
Commissioner of the Supreme Court of the United States.

VOLUME 2.

A—63½

VOLUME. 2.

1643 Session resumed pursuant to adjournment at 2 P. M. March 13th, 1903.

Present, the Commissioner and same counsel representing the respective parties.

EDWARD H. KEISER resumed the stand for further examination and testified as follows:

Direct examination resumed by Mr. Crow.

Q. Now, what is the fourth form in which nitrogen is found in water? A. The fourth form in which nitrogen is found in water is as albuminoid ammonia.

Q. Is that found in water in its natural state free from pollution?

A. No sir.

Q. What is it the product of? A. It is the product of decomposing nitrogenous organic matter.

Q. Now, would that albuminoid ammonia be derived from both vegetable and animal matter in water? A. Yes sir.

Q. What is the condition of reservoir water of the city of St. Louis as to whether it is turbid. A. It is turbid at nearly all times of the year.

Q. That means chemically it contains what? A. It contains washings of the surface of the earth, contains vegetable matter that has been carried in by rainfall.

Q. Are they materials from the soil and fields? A. Yes sir.

Q. Now, did you make an investigation of the reservoir water to determine the quantity of albuminoid ammonia contained in it if so during what periods of time? A. I determined the amount of albuminoid ammonia in reservoir water from January 24th, 1900 to October 11th, 1900, daily determinations.

Q. From those daily determinations did you make averages? A. I did.

Q. What were the averages, were they weekly or monthly?
A. Weekly averages at first and afterwards monthly averages.

Q. Have you got a table containing the result of that
1644 work as performed by you? A. I have.

Q. Please give that table? A. This is a table for determining the albuminoid ammonia in the water of the reservoir made by me between January 24th and October 11th, 1900, and is table No. 7.

1645 The following are the weekly averages for albuminoid ammonia obtained:

Jan. 24-31,	.214)	Average for January, .214.
Feb. 1- 7,	.199)	
" 7-14,	.285)	Average for February, .271
" 14-21,	.259)	
" 21-28,	.344)	
Mar. 1- 7,	.233)	
" 7-14,	.325)	Average for March, .410.
" 14-21,	.582)	
" 21-31,	.501)	
Apr. 1- 7,	.264)	
" 7-14,	.387)	Average for April, .313.
" 14-21,	.248)	
" 21-30,	.352)	

	May 1- 7,	.279)	
	" 7-14,	.285)	Average for May, .261.
	" 14-21,	.224)	
	" 21-31,	.257)	
1646	June 1- 7,	.155)	
	" 7-14,	.172)	Average for June, .182.
	" 14-21,	.161)	
	" 21-30,	.240)	
	July 1- 7,	.219)	
	" 7-14,	.192)	Average for July, .234.
	" 14-21,	.249)	
	" 21-31,	.275)	
	Aug. 1- 7,	.304)	
	" 7-14,	.233)	Average for August, .257.
	" 14-21,	.202)	
	" 21-31,	.289)	
	Sept. 1- 7,	.276)	
	" 7-14,	.238)	Average for September, .237.
	" 14-21,	.225)	
	" 21-30,	.210)	
	Oct. 1-10,	.335)	Average for October, .335.

1647 Q. Now, can you give the highest maximum for February of albuminoid ammonia in the reservoir water?

A. The highest maximum for February occurred in the week of February 21st to 28th.

Q. What was it?

A. .344 parts per million.

Q. What was the average of albuminoid ammonia in the reservoir water in February?

A. The average for February was .271 parts per million.

Q. What was the maximum for March?

A. The maximum for March occurred in the week from the 14th to the 21st and the amount of it was .582 parts per million.

Q. What was the average?

A. The average for the month was .410 parts per million.

Q. What was the maximum for April?

A. The maximum for April was in the week of April 7th to the 14th, and the amount was .387.

Q. What was the average?

A. The average for the month of April was .313 parts per million.

Q. What was the maximum for May?

A. The maximum for May occurred in the week of May 7th to 14th, and the amount was .285 parts per million.

Q. What was the average?

A. The average for May was .261 parts per million.

Q. What was the maximum for June?

A. For June the maximum occurred from June 21st to the 30th, and the amount was .240 parts per million.

Q. What was the average?

A. The average for June was .182.

Q. What was the maximum for July?

A. The maximum for July occurred in the week of July 21st to 31st, and the amount was .275.

Q. What was the average?

A. The average for the month of July was .234 parts per million.

Q. What was the maximum for August?

1648 A. The maximum for August occurred in the week from August 1st to 7th, and the amount was .304 parts per million.

Q. What was the average for August?

A. The average for the month was .271 parts per million.

Q. What was the average for September?

A. For September the maximum occurred in the week from September 1st to 7th, and the amount was .276 parts per million.

Q. What was the average?

A. The average was .237 parts per million.

Q. What was the average from October 1st to 10th?

A. The average was .335 parts per million of nitrogen as albuminoid ammonia.

Q. Now, have you the record of the work you did in October and November, 1901, upon the reservoir water of this city for determining the quantity of albuminoid ammonia therein?

A. I have.

Q. Please present that table?

A. This is a table containing the results of the determination of the water of the reservoir of St. Louis for the months of October and November, 1901, for albuminoid ammonia, and is table No. 8:

1649 Weekly averages of the amounts of albuminoid ammonia found in intake water during the months of October and November, 1901:

Oct. 1- 7, incl.,	.855
“ 7-14, “	.677
“ 14-21, “	.523
“ 21-28, “	.727
“ 28-Nov. 4,	.553
Nov. 4-11,	.493
“ 11-18,	.794
“ 18-25,	.536
“ 25-30,	.420

1650 Q. I show you plate No. 4 (handing paper to witness), what is that, describe it so that one examining it would be able to tell what the figures and lines thereon mean?

A. Plate No. 4 contains a curve showing the changes in the amount of albuminoid ammonia in the reservoir water. The curve is constructed by laying off the weeks in a horizontal line and the amounts of albuminoid ammonia in vertical lines and a point is thus obtained for the average quantity of each week. These points are connected with a red line and thus we get a curve showing the variation in the amount of albuminoid ammonia in the reservoir water during the time of the analyses.

Q. Now, according to these figures and that map when did the maximum pollution of the water of the reservoir occur?

A. The maximum pollution occurred in March and April, 1900.

Q. When was the minimum?

pounds to be in the shape they can be readily detected by the chemist?

A. A chemical analysis does not enable us to determine the number of bacteria in water, but it gives us the total weight of nitrogen which is there in the bacteria and in the food of the bacteria, and when we determine the amount of nitrogen in those four forms we are getting the characteristic elements of the substances in water that may cause disease.

Q. Are there any forms of bacteria or do the bacteria themselves of different kinds cause nitrites and albuminoid ammonia to be formed?

A. Our ideas in regard to this are that the bacteria first of all act upon the organic matter, the nitrogenous organic matter, a compound of carbon, hydrogen, oxygen and nitrogen, and convert this into simpler products, they liquefy it and one of the products, one of the first products formed, is ammonia, that which we call free ammonia.

Q. What class of bacteria is it that operates to cause free ammonia?

A. The anaerobic bacteria.

1653 Q. Do they carry on their operations best in the presence or absence of oxygen?

A. Absence of ogygen.

Q. What is the next stage—the process is to break it up?

A. Break it up, to liquefy it and we get ammonia, the nitrogen appears as ammonia, we call it free ammonia because it comes off by distillation, when water is distilled it passes off as ammonia gas with the steam and is condensed.

Q. What is the next step?

A. The next step is that the bacteria come in and convert a portion of the nitrogen into nitrites.

Q. What class of bacteria?

A. The aerobic bacteria.

Q. Do they work best in the absence or presence of oxygen?

A. In the presence of oxygen.

Q. When the anaerobic cease their work and the aerobic cease their work, does the first named bacteria die or are they suspended in the water?

A. I am not a bacteriologist.

Q. Your chemistry does not teach you?

A. It does not teach us that.

Q. You do not deal with that?

A. From our chemical standpoint we do not look for bacteria.

Q. What happens then?

A. Then the nitrites are oxidized still further to nitrates.

Q. How is that done?

A. That is brought about by the operation of the organism, the bacterium, that has the power of oxidation and makes the nitrites combine with more oxygen converting them into nitrates.

Q. Now, regarding these three forms of ammonia as indices of water containing pollution either of organic or animal matter, which is regarded as the higher form of pollution?

A. When we find free ammonia and nitrites present in considerable quantities we regard the pollution as of animal origin and caused by sewage. Albuminoid ammonia on the other hand is not in itself so characteristic of polluted waters because albuminoid ammonia may be there of vegetable origin.

1654 Q. Now, albuminoid ammonia is a product midway between nitrites and free amonia, is it not?

A. Nitrogenous organic matter is the starting point from which the albuminoid ammonia as ammonia is gotten out of the organic matter in water by treating it with an alkali and by potassium per manganate, and in that way we distill off ammonia from the organic matter which is not there as ammonia in the water. We decompose what organic matter is left in the water by chemical agents and measure the ammonia that distills over.

Q. It is a product of combining an outside agency with a substance in water?

A. Yes, sir.

Q. And produces albuminoid ammonia?

A. Yes, sir.

Q. And for that reason albuminoid ammonia is not an index of any particular pollution in water?

A. No, sir.

Q. Nitrates are regarded as a lower form of pollution, there is a lower form of pollution of water that contains nitrates than nitrites?

A. That is so, the nitrates are a final product, when we find very little ammonia and no nitrites, and a good deal of nitrates we know the water has been polluted at one time, and it has gone through the process of oxidation so the pollution has been rendered comparatively harmless.

Q. Please explain what you mean by the use of the term oxidation as applied to the chemical process that goes on in the oxidation of organic matter in water from its original form in which it is put into water down to nitrates?

A. That oxidation is brought about by bacteria, we look upon it as a process of the transference of ogygen from the air to the organic matter in the water so that the complex organic substances are resolved into simple inorganic material. I look upon the original form of polluted matter in water as a complex combination of carbon, hydrogen, ogygen and nitrogen.
1655 That would represent, for instance, albuminoids,
albuminous substances that are in water, compounds of that kind are in sewage, and the bacteria break up those substances and we get ammonia, a part of the nitrogen is evolved as ammonia and then afterwards the bacteria transfer the oxygen from the air to the nitrogen that is there, forming nitrites and then transforming the nitrites into nitrates.

Q. By adding still more oxygen?

A. By adding still more oxygen, and the carbon, that is in the original substance appears as carbon dioxide gas and carbonates that we have present in carbonated waters, that come out as gases, some carbon comes off as marsh gas in the early stages, the anaerobic bacteria emit some in the shape of marsh gas and carbon dioxide.

Q. The analysis of the water that you made was made at the intake of the reservoir for determining the presence of these four bodies?

A. Yes, sir.

Q. Nitrites, free ammonia, albuminoid ammonia and nitrates?

A. Yes, sir.

Q. Did you examine for the purpose of determining whether there was chlorine in the water?

A. I did; I have the record of chlorine at different points, weekly averages and so on.

Q. Now, did you make a comparison of the water on the Missouri and Illinois shores opposite the Chain of Rocks?

A. I did.

Q. Now, for what purpose did you make that comparison chemically?

A. For the purpose of determining whether the river at the intake was of homogeneous character, whether the water was of the same character on both sides of the river.

Q. I will ask you if, chemically, that fact can be established, as if there was a cross section of the stream, if a line was drawn across it, whether the water on both sides of
1656 the stream is of the same chemical constituents?

A. It can.

Q. That can be determined definitely?

A. Yes, sir.

Q. Did you find any difference in the character of the water, chemically, water taken at the Missouri shore opposite the Chain of Rocks and water taken at the Illinois shore opposite the Chain of Rocks?

A. I did, a very marked difference.

Q. What was the first difference that you found?

A. I found that there was a difference in the nitrites.

Q. Have you got a table of the weekly average of the nitrites found in waters opposite the intake on the Illinois shore and opposite the intake on the Misouri shore?

A. Yes, sir.

Q. Have you the table there?

A. I have (producing a paper). This is a table showing the parts of nitrites per million from January 24th, 1900, to October 11th, 1900, first at the Missouri shore opposite the intake and second at the Illinois shore opposite the intake, and is table No. 9.

A comparison of the water on the Missouri shore with that of the Illinois shore at the Chain of Rocks.

	Date.	Missouri Shore. Parts per Million.		Illinois Shore. Parts per Million.	
Jan.	24-31,	.0070)	Jan. average,	.0130)	Jan. average,
		)	.0070	)	.0130
Feb.	1- 7,	.0065)		.0214)	
"	7-14,	.0183)	Feb. average,	.0000)	Feb. average,
"	14-21,	.0123)	.0144	.0211)	.0187
"	21-28,	.0206)		.0136)	
Mar.	1- 7,	.0140)		.0123)	
"	7-14,	.0128)	Mar. average,	.0080)	Mar. average,
"	14-21,	.0183)	.0168	.0254)	.0164
"	21-31,	.0223)		.0200)	
Apr.	1- 7,	.0325)		.0365)	
"	7-14,	.0118)	Apr. average,	.0305)	Apr. average,
"	14-21,	.0080)	.0168	.0288)	.0308
"	21-31,	.0148)		.0274)	
May	1- 7,	.0057)		.0157)	
"	7-14,	.0028)	May average,	.0134)	May average,
"	14-21,	.0028)	.0035	.0148)	.0154
"	21-31,	.0023)		.0178)	
June	1- 7,	.0028)		.0050)	
"	7-14,	.0026)	June average,	.0032)	June average,
"	14-21,	.0028)	.0026	.0035)	.0050
"	21-30,	.0024)		.0084)	

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July	1- 7,	.0015)		.0041)	
"	7-14,	.0017)	July average,	.0043)	July average,
"	14-21,	.0010)	.0014	.0043)	.0041
"	21-31	.0014)		.0037)	
Aug.	1- 7,	.0001)		.0037)	
"	7-14,	.0015)	Aug. average,	.0077)	Aug. average,
"	14-21,	.0014)	.0012	.0102)	.0063
"	21-31,	.0017)		.0038)	

Date.		Missouri Shore. Parts per Million.		Illinois Shore. Parts per Million.	
Sept.	1- 7,	.0016)		.0070)	
"	7-14,	.0003)	Sept. average,	.0071)	Sept. average,
"	14-21,	.0004)	.0008	.0067)	.0068
"	21-30,	.0011)		.0067)	
Oct.	1-10,	.0011)	Oct. average,	.0064)	Oct. average,
		)	.0011	)	.0064

Q. How did you determine the weekly average, did you
1659 take samples weekly?

A. Samples were taken daily.

Q. How was the weekly average ascertained?

A. By adding our daily determination for each day of the week and dividing by seven.

Q. That product is used as the average?

A. As the average for the week.

Q. Can you give me from January 24th to 31st the average nitrites found on the Misouri shore per million parts?

A. The average amount found for the week of January 24th to the 31st was .007 parts per million.

Q. Can you give me the same figures for the Illinois shore for the corresponding period?

A. For the same period the average found at the Illinois shore was .013.

Q. Can you give me the maximum amount of nitrites found in the month of February, 1899, on the Missouri shore together with the average, and, also, on the Illinois shore together with the average?

A. During the month of February the highest amount was found during the week of February 21st to 28th on the Missouri shore and it was .0206, and the highest amount found on the Illinois shore for the month of February was in the first week, February 1st to the 7th, the amount was .0214.

Q. What was the average?

A. The average on the Missouri shore for February was .0144 and on the Illinois shore the average for February was .0187.

Q. Please give me the maximum on the Missouri and Illinois shores for March together with the average on each shore?

A. The maximum during the month of March occurred in the period from March 21st to the 31st and amounted to .0223; the average for March on that shore, the Missouri shore, was .0168; the maximum amount on the Illinois shore occurred during the week from March 14th to 21st; the amount was
1660 .0254 and the average for March was .0164.

Q. Please give me the maximum for April on the Missouri shore and on the Illinois shore and the average?

A. The maximum occurred the first week, from April 1st to the 7th, and was .0325.

Q. What was the average?

A. The average was .0168; the maximum amount on the Illinois shore occurred also in the first week, April 1st to 7th, and the amount was .0365; the average for April on that shore was .0308.

Q. Please give me the maximum for May on the Missouri and Illinois shores and also the average?

A. The maximum for May occurred in the first week of May, May 1st to 7th, and the amount was .0057; the average for May was .0035; the maximum amount on the Illinois shore during the month of May occurred in the period of May 21st to 31st and its amount was .0178; the average on the Illinois shore for May was .0154.

Q. Please give me the maximum for June on the Missouri and Illinois shores together with the averages?

A. The maximum for June occurred in the first week of June, the 1st to the 7th, and was .0028 on the Missouri shore; the same amount, however, was found in the week of June 14th to the 21st; the average for June on the Missouri shore was .0026; the maximum amount found on the Illinois shore in June occurred during the period of June 21st to the 30th and the amount was .0084; the average for June was .0050.

Q. Please give me the maximum for July on the Missouri and Illinois shores together with the average?

A. The maximum for July occurred in the week of July 7th to 14th, and the amount on the Missouri shore was .0017; the average for that month on the Missouri shore was .0014; the

maximum amount on the Illinois shore occurred in the
1661 week of July 7th to 14th and the same amount was found
in the following week, July 14th to the 21st; the quantity
was .0043 for the Illinois shore and the average for July was
.0041.

Q. Please give me the maximum nitrites for August on the Missouri and Illinois shores together with the average for the weeks?

A. The maximum amount during August occurred on the Missouri shore in the period from August 21st to 31st and the amount was .0017 parts of nitrites per million; the average for August on the Missouri shore was .0012; the maximum amount on the Illinois shore occurred in the week of August 14th to 21st and that amount was .0102; the average for August on the Illinois shore was .0063.

Q. Please give me the maximum nitrites in September on the Missouri and Illinois shores together with the average?

A. The maximum weekly average on the Missouri shore during September occurred in the first week, September 1st to 7th, and the amount was .0016; the average for September was .0008; the maximum amount on the Illinois shore during September occurred in the week from the 7th to the 14th, and the amount was .0071; the average for September was .0068.

Q. Please give me the average for October 1st to 10th, 1900, on the Missouri and Illinois shores?

A. The average of nitrites from October 1st to 10th on the Missouri shore was .0011; on the Illinois shore it was .0064.

Q. Have you the records of analyses of water made by you at the same points opposite the intake on the Missouri and Illinois shores in the year later in October and November, 1901?

A. Yes sir.

Q. Have you a copy of that?

A. I have one (producing paper). This is a table showing
the nitrites in October and November, 1901, in water ex-
1662 amined first opposite the intake on the Missouri shore
and second opposite the intake on the Illinois shore corresponding to the same points of examination as stated in the last table No. 9, and is table No. 10.

Nitrites.

Date (1901)	Missouri Shore Pts. per Million	Illinois Shore Pts. per Million.
Oct. 1- 7	.0024	.0110
" 7-14	.0027	.0124
" 14-21	.0057	.0144
" 21-28	.0048	.0160
" 28-Nov.4	.0082	.0123
Nov. 4-11	.0124	.0167
" 11-18	.0141	.0177
" 18-25	.0096	.0171
" 25-30	.0128	.0170

Q. I show you here the plate No. 6, please describe it so
1664 that one looking at it can tell what it means (handing
paper to witness)?

A. Plate No. 6 shows a curve giving the variations in the amount of nitrites at the Illinois shore opposite the Chain of Rocks and this table is made by marking off the weeks in a horizontal line at the bottom of the page and the amounts of nitrites in a vertical line on the left hand side and the points obtained for each week are connected with a red line and this red line is the curve showing the variation in the quantity of nitrites at the Illinois shore during the time of the analyses and this other plate 5 was made in the same way and shows the variation in the amount of nitrites at the Missouri shore at the Chain of Rocks.

Q. And these two plates were made to illustrate the examinations as disclosed in table No. 9?

A. Yes sir, the 1900 table.

Q. Of water analyzed opposite the intake on the Missouri and Illinois shores?

A. Yes sir.

Complainant's counsel offer in evidence the plates referred to by the witness and they are marked by the Commissioner respectively "Complainant's Exhibits 27 and 28. Frank S. Bright, Commissioner."

Q. Now, with reference to the table showing the amount of nitrites found in 1900 and 1901, first on the Missouri shore opposite the intake of our Water Works and second on the Illinois shore opposite said intake what, if anything, is disclosed as to the relative amount of nitrites on either side of the Mississippi River at that point?

A. Well, it will be seen that the nitrites in January are nearly twice as great on the Illinois side of the river as 1665 on the Missouri side. Soon after the beginning of the work it showed twice as great on the Illinois side as the Missouri side. They begin to approach one another in February.

Q. In point of numbers?

A. Yes sir, they are about equal in March but in April the quantity on the Illinois shore is twice that on the opposite side and this increase was maintained throughout the summer and it became six times as great in September and October, 1901.

Q. Do you know whether or not there was any rise in the Illinois river in February, 1900?

A. In February, 1900, there was a rise in the Illinois river coincident, I think, with the coming down of the water of the Drainage Canal.

Q. What was the condition of the Missouri and Mississippi rivers at that time as to the stage of water, high or low?

A. I have not the figures here as to the stage of the river.

Q. But from your recollection, I do not mean the Government stages, from your knowledge of the streams at that time?

A. The Missouri was low and the Mississippi river was low.

Q. Do you know whether the Missouri and Mississippi at the time of the rise in the Illinois river were frozen?

A. I don't remember whether they were or not.

Q. This would make then what condition with reference to pure or impure water on the eastern and western side of the Mississippi River opposite the intake during the period of time mentioned in 1900, and 1901?

A. During the period that we made the analyses there at the eastern shore of the river, the Illinois side of the river at the water works, the water was from four to five times more polluted than the water on the Missouri shore as shown by these nitrites, by the quantity of nitrites.

1666 Q. Now, was there during this period in 1900, a mixture of the water of the Mississippi and Missouri Rivers at the intake?

A. From the fact that the amount of nitrites in the reservoir was greater than that in the Missouri River on the Missouri shore and less, somewhat, than that on the Illinois shore we naturally conclude that it was a mixture of the two waters, in fact not only the nitrites but all of our determinations showed that the water taken in at the intake is a mixture of those two waters. The chemical analyses indicate that the water on the eastern shore at the Intake Tower is Mississippi River water and the water on the western shore is Missouri River water.

Q. Now, from the averages obtained from your analyses made in October and November, 1901, what would you say as to whether or not the condition of the river on the Illinois shore opposite the intake in the Mississippi River was more or less polluted than it was before the opening of the Drainage Canal?

A. In January, 1900, the average amount of nitrites was .013 and in February it went up, this is on the Illinois shore, to .0187, and it came down somewhat in March but it went up very high in April, .308, and gradually came down during the summer, but throughout the entire summer it was from four to five times as great as on the Missouri shore.

Q. Do you know what in September, 1901, the average value of the nirites was that was found?

A. They are stated in the table, the results of the chemical analyses are in weights.

Q. You have the figures there?

A. I have not for 1900. The average value of the nitrites was .0068 in 1900; in September, 1901, it was .0125, nearly twice as much.

Q. Did you make any analyses of the water from Bellefontaine on the Missouri River?

1667 A. Yes sir.

Q. Comparing that analysis with the analysis at the point opposite the intake on the Missouri shore what does it disclose as to whether or not the water running along at the point where you took the samples on the Missouri shore opposite the intake is Missouri or Mississippi River water?

A. The analysis shows it is Missouri River water.

Q. Did you make any analysis at Hartford?

A. Yes sir.

Q. Where is Hartford?

A. It is on the Illinois side of the river nearly opposite the mouth of the Missouri.

Q. What character of water did the analysis show was running opposite Hartford at the point where you took the samples?

A. The analysis showed that was Mississippi River water.

Q. Did you make any chemical test to determine the difference in the sanitary character of the water on the two sides of the river at the Chain of Rocks by determining the amount of free ammonia and nitrates?

A. Yes sir.

Q. Have you the table?

A. I have a table showing the average of free ammonia on each side of the river at the Chain of Rocks (producing same).

Q. Made in 1900?

A. Yes sir, this is the table showing the average of free ammonia on each side of the river at the Chain of Rocks, and is table No. 11.

1668 The following tables give the weekly average of Free Ammonia on each side of the river:

Date (1900)	Missouri Shore		Illinois Shore	
Jan. 24-31	.1208)	Jan. average .1208	.4920)	Jan. average .4920
Feb. 1- 7	.2200)	Feb. average .1673	.4670)	Feb. average .4180
" 7-14	.1800)		.....)	
" 14-21	.1431)		.4820)	
" 21-28	.1260)		.3050)	
Mar. 1- 7	.1048)	Mar. average .1457	.3000)	Mar. average .2981
" 7-14	.1582)		.2851)	
" 14-21	.1731)		.3020)	
" 21-31	.1468)		.3060)	

Apr.	1- 7	.0828)		.2930)	
"	7-14	.0525)	Apr. average	.2152)	Apr. average
"	14-21	.0582)	.0609	.1241)	.1770
"	21-30	.0503)		.0790)	
May	1- 7	.0445)		.0571)	
"	7-14	.0474)	May average	.0503)	May average
"	14-21	.0668)	.0614	.0506)	.0566
"	21-31	.0871)		.0685)	
1669					
June	1- 7	.0365)		.0351)	
"	7-14	.0277)	June average	.0162)	June average
"	14-21	.0374)	.0416	.0214)	.0267
"	21-30	.0648)		.0342)	
July	1- 7	.0560)		.0240)	
"	7-14	.0231)	July average	.0237)	July average
"	14-21	.0517)	.0504	.0300)	.0291
"	21-31	.0708)		.0388)	
Aug.	1- 7	.0388)		.0428)	
"	7-14	.0174)	Aug. average	.0260)	Aug. average
"	14-21	.0202)	.0322	.0157)	.0304
"	21-31	.0525)		.0371)	
Sept.	1- 7	.0368)		.0271)	
"	7-14	.0265)	Sept. average	.0394)	Sept. average
"	14-21	.0628)	.0454	.0506)	.0448
"	21-30	.0557)		.0768)	
Oct.	1-10	.0508)	Oct. average	.0448)	Oct. average
		)	.0508	)	.0448

1670 Q. Will you give me the average of free ammonia found in the water on the Missouri and Illinois shore from January 24th to 31st?

A. The average amount of free ammonia found during the week from January 24th to 31st, 1900, on the Missouri shore was .1208.

Q. What was it on the Illinois shore?

A. On the Illinois shore for the same period of time it was .4920.

Q. Will you please give us the maximum amount of free ammonia found on the Missouri and Illinois shore and then the average for the Missouri shore and Illinois shore of free ammonia?

A. The maximum amount on the Missouri shore during February occurred during the week from February 1st to 7th and was .2200; the average amount on the same shore, the Missouri shore, was .1673; the maximum amount on the Illinois shore occurred in February in the week from the 14th to the 21st and amounted to .4820; the average amount for February was .4180.

Q. Please give me the same figures for the month of March, 1900?

A. In March the maximum amount of free ammonia on the Missouri shore occurred during the week of March 14th to the 21st, and the amount of free ammonia was .1731; the average amount for the month on the Missouri shore was .1457; on the Illinois shore the maximum amount of free ammonia for the month of March occurred during the week of March 21st to the 28th and the amount was .3060; the average amount for the month of March on the Illinois shore was .2981 parts of free ammonia per million of water.

Q. Please give me the same figures in April?

A. The maximum amount of free ammonia on the Missouri shore for the month of April occurred in the week of April 1st to 7th; the amount was .0828; the average for the month of April on the Missouri shore was .0609; the maximum amount on the Illinois shore occurred April 1st to 7th; the amount was .2930; the average for April on the Illinois shore was
1671 .1770 parts of free ammonia per million of water.

Q. Give me the same figures for May?

A. The maximum amount of free ammonia on the Missouri shore in May was found in the week of May 21st to 28th and the amount was .0871 parts of free ammonia; the average for the month of May was .0614 for the Missouri shore; for the Illinois shore the maximum amount was found in the week of

May 21st to 28th and it amounted to .0685; the average of May was .0566.

Q. Please give me the same figures for June?

A. The maximum amount of free ammonia on the Missouri shore occurred in the week from June 21st to 28th and the amount was .0648; the average for June on the Missouri shore was .0416; the maximum amount found on the Illinois shore in the month of June was in the week of June 1st to 7th and it amounted to .0351; the average for the month of June was .0267.

Q. Give me the same figures for July.

A. For the Missouri shore the maximum amount was found in the week of July 21st to 28th, and the amount for that week was .0708; the average for July on the Missouri shore was .0504; the maximum amount found on the Illinois shore occurred in the same week, July 21st to 28th, and amounted to .0388; the average for the month of July was .0291.

Q. Give it to me for August?

A. For August on the Missouri shore the maximum amount was found in the week of August 21st to 28th; it amounted to .0525; the average amount for August was .0322; the maximum amount for August on the Illinois shore was .0428 and it occurred in the first week, August 1st to 7th; the average amount for August was .0304.

Q. Please give it to me for September.

A. For September the maximum amount occurred in the
week of September 14th to 21st; it amounted to .0628 on
1672 the Missouri shore; the average amount for September on
the Missouri shore was .0454; the maximum amount found
on the Illinois shore for September was during the week of September 21st to 28th; it amounted to .0768; the average for that month was .0484.

Q. Please give me the average from October 1st to October 10th, 1900?

A. On the Missouri shore the average from October 1st to October 10th was .0508 and for the Illinois shore it was .0448.

Q. Here are plates 7 and 8, please explain what they are and let them be marked?

A. Plate 7 shows a curve giving the variations in the amounts of free ammonia at the Missouri shore at the Chain of

Rocks. The time is laid off in a horizontal line at the bottom and the amount of free ammonia is laid off in a vertical line at the left hand side; the weekly points obtained by laying off the amounts are connected with a red line and this curve shows the variation in the amount of free ammonia at the Missouri shore at the Chain of Rocks.

Complainant's counsel offer in evidence plate No. 7 referred to by the witness and the same is marked by the Commissioner "Complainant's Exhibit 29, Frank S. Bright, Commissioner."

The Witness: This plate No. 8 shows the same thing for the Illinois shore at the Chain of Rocks.

Complainant's counsel offer in evidence plate No. 8 referred to by the witness and the same is marked by the Commissioner "Complainant's Exhibit 30. Frank S. Bright, Commissioner."

Q. These two plates disclose the opposite sides of the river at the same point?

A. Yes sir.

Q. Showing free ammonia?

A. Free ammonia.

Q. Did you make an examination chemically to determine the average quantities of free ammonia found on each side of the river opposite the intake tower of the St. Louis Water
1673 Works in October and November, 1901?

A. I did.

Q. Please present the table?

A. This is the table (producing paper) showing the average quantities of free ammonia found on each side of the river opposite the intake tower of the St. Louis Water Works in October and November, 1901, and is table No. 12.

1674 The average quantities of free ammonia found on each side of the river in October and November, 1901, are as follows:

1901	Missouri Shore.	Illinois Shore.
Oct. 1- 7	.0805	.0869
" 7-14	.0520	.0571
" 14-21	.0449	.0706
" 21-28	.0449	.0557
" 28-Nov. 4	.0717	.0957

1901	Missouri Shore.	Illinois Shore.
Nov. 4-11	.0634	.0714
" 11-18	.0894	.0720
" 18-25	.0810	.0489
" 25-30	.0844	.0648

1675 Q. From the above tables chemically which side of the river is shown to contain nitrogen in the form of free ammonia in the greatest quantity?

A. These tables show that much larger quantities of free ammonia are found on the Illinois side of the river during the months of January, February, March and April; during the remaining months both sides are practically alike as regards this form of nitrogen.

Q. How was it in October and November, 1901, as to the amount of nitrogen as free ammonia on either side of the river?

A. The analyses made in 1901, show the quantity of free ammonia was greater on the Illinois shore than on the Missouri shore.

Q. Now, did you make a chemical analysis to determine the proportion of nitrates in 1900, at either side of the Mississippi river opposite the Chain of Rocks?

A. Yes sir.

Q. Have you got that table?

A. I have (producing same). This is a table beginning January 24th, 1900, and ending October 11th, 1900, showing the nitrates first on the Missouri shore opposite the Intake and second on the Illinois shore opposite the Intake, and is table No. 13.

1676 The following are the weekly averages of nitrogen in the form of nitrates obtained at the two sides of the river at the Chain of Rocks:

Date (1900)	Missouri Shore.		Illinois Shore.	
Jan. 24-31,	.565)	Jan. average	1.040)	Jan. average
	)	.565	)	1.040
Feb. 1- 7,	.457)		.765)	
" 7-14,	.457)	Feb. average	....)	Feb. average
" 17-21,	.542)	.485	.882)	.790
" 21-28,	....)		....)	

Date (1900)		Missouri Shore.		Illinois Shore.	
Mar.	1- 7,	.688)		1.205)	
"	7-14,	1.343)	Mar. average	.822)	Mar. average
"	14-21,	.954)	.935	1.011)	1.004
"	21-31,	754)		.980)	
Apr.	1- 7,	.577)		.977)	
"	7-14,	.462)	Apr. average	1.022)	Apr. average
"	14-21,	.434)	.478	.897)	.936
"	21-30,	.497)		.851)	
May	1- 7,	.594)		.600)	
"	7-14,	.451)	May average	.331)	May average
"	14-21,	.371)	.455	.394)	.435
"	21-31,	.405)		.497)	
June	1- 7,	.325)		.422)	
"	7-14,	.285)	June average	.388)	June average
"	14-21,	.371)	.364	.434)	.435
"	21-30,	.474)		.494)	
1677					
July	1- 7,	.423)		.508)	
"	7-14,	.423)	July average	.514)	July average
"	14-21,	.434)	.483	.514)	.581
"	21-31,	.651)		.788)	
Aug.	1- 7,	.491)		.514)	
"	7-14,	.251)	Aug. average	.234)	Aug. average
"	14-21,	.314)	.345	.304)	.419
"	21-31,	.325)		.622)	
Sept.	1- 7,	.268)		.485)	
"	7-14,	.320)	Sept. average	.505)	Sept. average
"	14-21,	.365)	.358	.428)	.433
"	21-30,	.480)		.313)	
Oct.	1-10,	.617)	Oct. average	.388)	Oct. average
		....)	.617	....)	.388

Q. Now will you give me the average nitrates on the 1678 Missouri shore from January 24th to 31st, 1900, and on the Illinois shore opposite the same point from January 24th to 31st, 1900?

A. January 24th to 31st, in 1900, the average amount of nitrogen as nitrates on the Missouri shore was .565, and on the Illinois shore for the same time was 1.040.

Q. Now, will you please give me the maximum amount for the month of February of nitrates on the Missouri shore and also on the Illinois shore, together with the monthly average of nitrates on each shore opposite the Intake Tower of the St. Louis Water Works?

A. The maximum amount was found February 14th to 21st. The average for that week on the Missouri shore was .542, and the average for the month of February on the Missouri shore, was .485. On the Illinois shore the maximum amount was found to be during the week February 14th to 21st, and the amount was .822, and the average for February for that shore was .790.

Q. Now, please give me the same figures for March.

A. For March the maximum amount occurred during the week March 7th to 14th on the Missouri shore and the amount was 1.343. The average amount for March on the Missouri shore was .935. The maximum amount on the Illinois shore for the month of March occurred in the first week, March 1st to 7th, and the amount was 1.205. And the average for the month of March on the Illinois shore was 1.004.

Q. Now, please give me the same figures for April.

A. The maximum amount of nitrates was found in the first week of April, on the Missouri shore, April 1st to 7th, and the amount was .577. The average for April on the Missouri shore was .478. The maximum amount found during April on the Illinois shore was in the week April 7th to 14th, and it amounted to 1.022. And the average for April was .936.

1679 Q. Now, please me give the maximum amount of nitrates found at the two points, on the Missouri and Illinois shore respectively in May, together with the monthly average?

A. The maximum amount in May on the Missouri shore was found in the week of May 1st to 7th, and the amount was .594. The average for the month of May on the Missouri shore was .455. The maximum amount for May on the Illinois shore was .600. This occurred in the first week, May 1st to 7th. The average amount for May on the Illinois shore was .435.

Q. Now, please give me the same figures for the ensuing month of June at the two points—both shores of the Mississippi?

A. The maximum amount in June was found in the week June 21st to June 30th, on the Missouri shore and the amount was .474. The average for June on the Missouri shore was. 364. The maximum amount for the Illinois shore for the month of June, occurred in the week June 21st to 30th, and amounted to .494. The average for June was .435 parts of nitrogen as nitrates per million.

Q. Now, please give me the same figures for the next month, July, 1900?

A. For July, 1900, on the Missouri shore the maximum quantity of nitrates found occurred during the week of July 21st to 28th. It amounted to .651 parts per million. The average for July on the Missouri shore was .483. The maximum amount on the Illinois shore for July occurred in the week July 21st to 28th, and amounted to .788. The average for July on the Illinois shore was .581.

Q. Please give me the same figures for August?

A. The maximum amount of nitrates at the Missouri shore during the month of August occurred in the week August 1st to 7th. The amount found was .491. The average for 1680 the month of August for the Missouri shore was .345. The maximum amount for the Illinois shore for the month of August, 1900, was found in the week August 21st to 28th. It amounted to .622, and the average for the month of August for that shore was .419 parts of nitrogen per million.

Q. Please give me the same figures for September.

A. For the Missouri shore in September, 1900, the maximum amount of nitrates was found in the week September 21st to 28th, and the amount was .480. The average for September was .358. The maximum amount for the Illinois shore in the month of September, 1900, was .505, occurring in the week September 7th to 14th. The average amount for September was .433.

Q. Now, please give me the average for the time from

October 1st to 10th, 1900, at the two points on the Mississippi's shores.

A. The average amount on the Missouri shore for October 1st to 10th, 1900, was .617, and on the Illinois shore for the same time was .388 parts of nitrogen per million of water.

Q. Now have you any record of the parts of nitrogen in the form of nitrates as found by your chemical examinations of the waters opposite the intake of the St. Louis Water Works in October and November, 1901?

A. I have.

A. The weekly averages of nitrogen in the form of nitrates
1681 found in October and November, 1901, are as follows:

	1901 Missouri Shore	1901 Illinois Shore
Oct. 1- 7	.428	.485
" 7-14	.428	.291
" 14-21	.240	.269
" 21-28	.377	.331
" 28-Nov.4	.400	.360
Nov. 4-11	.234	.497
" 11-18	.257	.257
" 18-25	.260	.291
" 25-30	.184	.223

1682 Q. Now I show you here plates 9 and 10, and ask you to indicate what they are.

A. Plates 9 and 10 contain curves giving the changes in the amount of nitrates at the Missouri shore and at the Illinois shore, Chain of Rocks.

Q. At opposite points on the Illinois and Missouri shores of the Mississippi river?

A. Yes, sir.

Complainant's counsel offer in evidence charts referred to and the same are marked by the Commissioner respectively "Complainant's Exhibits 31 and 32. Frank S. Bright, Commissioner."

Q. Now on which side of the river do these tables last mentioned show the more nitrates?

A. There were more nitrates as a rule on the Illinois shore than on the Missouri shore.

Q. Now considering all the facts heretofore set out, with reference to your chemical work on the waters of the Mississippi river at points mentioned, the Intake Tower and points opposite the Intake Tower on the Missouri and Illinois shores of the Mississippi river, on which side of the river is the water most polluted from a chemical standpoint?

A. On the Illinois side.

Q. Now, in regard to the sanitary character of the water, which side of the river at this point is the better water, on the Missouri shore or the Illinois shore?

A. The Missouri shore.

Q. Now, on the Illinois shore, the waters of what river were found, according to your chemical analyses?

A. The chemical analyses showed that the water on the Illinois shore of the Mississippi river, is Mississippi river water.

Q. Now, on the Missouri shore what waters, or the waters of what river, are found?

A. The chemical analyses show that the water on the Missouri shore is the Missouri river water.

Q. Now, you determined the character of the water as to whether it is Missouri river water or Mississippi river water by the chemical tests which you applied?

A. Yes, sir.

Q. Now, the reservoir water of this city in the reservoirs up there at the Chain of Rocks, what are they, Missouri and Mississippi river water mixed, or are they the Missouri river water or the Mississippi river water, as disclosed by your chemical examinations?

A. The chemical analyses of reservoir water showed that the water in the reservoir is a mixture of these two waters. This is clearly shown by all of the data that we have, both for free ammonia, and albuminoid ammonia, and nitrates and nitrites and chlorine, and solid matter, all the data show that the water in the reservoir is a mixture of Mississippi river water and Missouri river water.

Q. How do you draw that deduction?

A. We reach that conclusion from the facts that the values obtained for these different quantities, namely, chlorine and solid matter, and free ammonia and albuminoid ammonia, in every case are a mean between the values obtained for the Mississippi side of the river, the water from the Illinois side, and the water obtained from the Missouri shore.

Q. Now, from a sanitary standpoint, what is the better water, that in the reservoir of this city at the intake or that of the Illinois shore opposite the Intake?

A. The reservoir water is better than the water from the Illinois shore opposite the Intake.

1684 Q. And from a sanitary standpoint is the water in the reservoir as good or better than the water of the Mississippi river on the Illinois shore opposite the intake?

A. It is better than the water on the Illinois shore.

Q. Now, the water in the reservoir of this city as compared to the water on the Missouri shore opposite the Intake, is it better or worse from a sanitary standpoint?

A. It is worse.

Q. Now, did you prepare any formula for calculating the proportions of the Missouri and Mississippi river waters that were present in the reservoir of this city?

A. I did.

Q. Chemically?

A. I did.

Q. Will you just describe that?

A. In order to determine exactly what proportions of each of the two waters are present in the reservoir water, I have, by two simple equations, calculated the amount at different times. These equations are as follows:

Let X represent the fractional part of the reservoir water that comes from the Missouri river, and Y equal the fractional part of the reservoir water that comes from the Mississippi river. Then let A represent the value of the nitrites, for example, in the Missouri water, and B equal the value of the nitrites in the Mississippi water, and C equal the value of the nitrites in the reservoir water, then X plus Y—

Q. Well, X plus Y meaning, Missouri and Mississippi river water?

A. Yes, X, the fraction consisting of the Missouri water plus Y, the fraction of Mississippi water, must equal 1.

Q. Or the water in the reservoir?

A. Or the water in the reservoir, also A—

Q. Now just explain what A means?

A. A, the value of the nitrites found in the Missouri water multiplied by the quantity of Missouri river, or the fractional part of Missouri water, AX, plus BY, in which B is the value of the nitrites in the Mississippi river water, multiplied by 1685 the fractional part of the reservoir water, giving us BY; the sum of these two quantities, AX plus BY must equal C, which is the value of nitrites found in the reservoir water.

Q. Now, that is the formula or basis for your—

A. Now, by means of these two equations, and the analytical data that have been given in the tables, the proportions of each of the waters in the reservoir can be calculated. Shall I give an example?

Q. Yes.

A. For example; in the week ending August 21st, the value of the nitrites were as follows:

A equaled .0014; that was the value of the nitrites on the Missouri shore on that day, and B equaled .0102. That was the value of the nitrites on the Illinois shore—

Q. In the Mississippi river?

A. In the Mississippi river water. The C equaled .0035. That was the value of the nitrites found in the reservoir water on the same day. Now substituting these values in the above equations, we get first: X plus Y equals 1, and then .0014X plus .0102Y equals .0035 or .0014X plus .0102 into (1 minus X) equals .0035. Now then .0088X equals .0067, and X equals .0067 divided by .0088, which equals ¾ very nearly. That is, during this week ¾ of the reservoir water came from the Missouri shore, or was Missouri river water, the remaining ¼ was Mississippi river water.

Q. Now, by applying that method, can you determine the proportion of each of the waters, that constitute the reservoir water daily?

A. Yes sir.

Q. Do those proportions vary from day to day?

A. They vary from day to day.

Q. What was the stage of the river as to whether it was high or low—the Missouri river and the Mississippi river at the time that you took to illustrate your algebraic equation
1686 there, August 21st?

A. Well, at this time the Missouri was high.

Q. And what was the stage of the Mississippi?

A. The Mississippi was lower.

Q. Can you determine from your chemical analyses whether or not the reservoir water is ever entirely free from the Mississippi river water?

A. As far as analyses enable me to judge, there would always be some of the Mississippi river water there.

Q. In the reservoir?

A. Yes, because it stands in the settling basins for several days and there is a constant mixture there of the two waters, so that although for a single day or perhaps two days the water would be largely Missouri river water, when it comes into the reservoir it mixes with the previous water contained there, which was Mississippi river water.

Q. Then in your judgment from a chemical standpoint, there is always more or less Mississippi river water coming into the Intake with the Missouri river water?

A. Yes sir.

Q. And consequently there must be more or less of it all the time in the reservoir?

A. Yes sir.

Q. Now, did you make any chemical analyses to determine whether or not the Mississippi river water was more polluted as you ascended it?

A. Yes sir.

Q. Now, above the mouth of the Illinois, is the Mississippi in a better or a worse condition than below the mouth of the Illinois?

A. Well, my analyses show that as we go up the Mississippi river, we find the water is badly polluted until we get above the mouth of the Illinois. Above the mouth of the Illinois the Mississippi is in a very much better condition.

Q. Now, how does the water of the Missouri river at Bellefontaine compare with the water of the Mississippi river above the mouth of the Illinois as to being wholesome?

A. They are both fairly good streams from a sanitary standpoint.

1687 Q. At those places?

A. At those places.

Q. Did you determine from your chemical analyses the source of the pollution of the Mississippi river below the mouth of the Illinois?

A. Chemical analyses were made of daily samples of water not only at the Illinois shore, Chain of Rocks, but also at Hartford and at Alton and in the Illinois river above Grafton, and in the Mississippi river above Grafton, and we found that the weekly average of nitrites were higher at Hartford than at the Illinois shore, Chain of Rocks. They were higher again at Alton and, as we go up the stream, we find they were higher in the Illinois river above Grafton; but they were very much lower in the Mississippi river above Grafton.

Q. Lower than what?

A. Lower than at any of the points.

Q. Well, name the points that they were lower than?

A. The nitrites in the Mississippi river above Grafton were lower than the nitrites in the Illinois river above Grafton, and also the nitrites at any subsequent places in the Mississippi below Grafton, namely, at Alton, and at Hartford, and at the Illinois shore, Chain of Rocks.

Q. Well, how about the Missouri shore at the Chain of Rocks?

A. The nitrites are quite low at the Missouri shore, Chain of Rocks.

Q. How about the nitrites in the Mississippi river between Grafton and the Intake Tower of the waterworks, and the nitrites in the river at the Intake Tower, as compared with the nitrites in the Mississippi river above the mouth of the Illinois?

A. They are lower above the mouth of the Illinois, the nitrites are considerably higher just below the mouth of the Illinois.

Q. Well, the nitrites above the mouth of the Illinois, in the

Mississippi are higher or lower than the amount of nitrites at the waterworks?

A. They are lower.

1688 Q. And they are less—there are less nitrites in the upper Mississippi?

A. There are less nitrites in the upper Mississippi—

Q. Above the mouth of the Illinois?

A. Yes. Than at our intake.

Q. Now did you make, from your chemical analyses a table disclosing the weekly and monthly averages of nitrites found on the Illinois shore at the Chain of Rocks and at Hartford, and at Alton?

A. Yes sir.

Q. Now please present this table.

A. This is a table, beginning January 24, 1900, and extending to October 11, 1900, showing the nitrites on the Illinois shore, at Alton above the sewage of the city and above Hartford—above the sewage of the city. This is table No. 14.

1689 Weekly and monthly averages of nitrites found at the Illinois shore, Chain of Rocks, the nitrite averages at Hartford and at Alton:

Date (1900)	Illinois Shore		Hartford		Alton	
Jan. 24-31,	.0130)	Jan.	.0183)	Jan.	.0225)	Jan.
	)	.0130	)	.0183	)	.0225
Feb. 1- 7,	.0214)		.0220)		.0263)	
" 7-14,	....)	Feb.	.0151)	Feb.	.0190)	Feb.
" 14-21,	.0211)	.0187	.0180)	.0199	.0225)	.0253
" 21-28,	.0136)		.0248)		.0334)	
Mar. 1- 7,	.0123)		.0234)		.0365)	
" 7-14,	.0080)	Mar.	.0128)	Mar.	.0225)	Mar.
" 14-21,	.0254)	.0164	.0140)	.0173	.0211)	.0248
" 21-31,	.0200)		.0191)		.0191)	
Apr. 1- 7,	.0365)		.0240)		.0205)	
" 7-14,	.0305)	Apr.	.0345)	Apr.	.0394)	Apr.
" 14-21,	.0288)	.0308	.0417)	.0358	.0428)	.0378
" 21-30,	.0274)		.0431)		.0485)	

Date	(1900)	Illinois Shore		Hartford		Alton	
May	1- 7,	.0157)		.0213)		.0223)	
"	7-14,	.0134)	May	.0285)	May	.0268)	May
"	14-21,	.0148)	.0154	.0340)	.0269	.0388)	.0289
"	21-31,	.0178)		.0240)		.0277)	
June	1- 7,	.0050)		.0080)		.0075)	
"	7-14,	.0032)	June	.0047)	June	.0048)	June
"	14-21,	.0035)	.0050	.0047)	.0099	.0053)	.0104
"	21-30,	.0084)		.0225)		.0243)	
July	1- 7,	.0041)		.0114)		.0153)	
"	7-14,	.0043)	July	.0105)	July	.0163)	July
"	14-21,	.0043)	.0041	.0123)	.0121	.0177)	.0159
"	21-31,	.0037)		.0143)		.0144)	
Aug.	1- 7,	.0037)		.0053)		.0071)	
"	7-14,	.0077)	Aug.	.0080)	Aug.	.0100)	Aug.
"	14-21,	.0102)	.0063	.0173)	.0095	.0180)	.0104
"	21-31,	.0038)		.0074)		.0064)	
1690							
Sept.	1- 7,	.0070)		.0100)		.0111)	
"	7-14,	.0071)	Sept.	.0084)	Sept.	.0103)	Sept.
"	14-21,	.0067)	.0068	.0084)	.0097	.0114)	.0115
"	21-30,	.0067)		.0120)		.0134)	
Oct.	1-10,	.0064)	Oct.	.0101)	Oct.	.0124)	Oct.
		)	.0064	)	.0101	)	.0124

1691 Q. Now, please give me the maximum nitrites on the Illinois shore for the period January 24th to 31st, for Illinois shore, opposite the Intake, and then at Hartford and at Alton?

A. January 24th to 31st, Illinois shore opposite Chain of Rocks, .0130. Hartford is the next city going up the river and is .0183 nitrites, and Alton, still further up, .0225.

Q. Now please give me the maximum amount of nitrites found in the month of February: First at the point on the Illinois shore opposite the Chain of Rocks, second at Hartford, Illinois, and third at Alton, Illinois, above the sewage of the city, together with the monthly averages at those three named places?

A. The maximum amount in February occurred in the week February 1st to 7th. It amounted at the Illinois shore, Chain of Rocks, to .0214. The average for that month at the same place was .0187. The maximum at Hartford occurred in the week February 21st to 28th, and amounted to .0248. The average for that month at Hartford was .0199. The maximum at Alton for February occurred in the week February 21st to 28th, and amounted to .0334. The average for February at Alton was .0253.

Q. Please give me the same figures for the same points for the month of March, together with the averages?

A. The maximum amount at the Illinois shore, Chain of Rocks, for the month of March occurred in the week March 21st to 28th, and amounted to .0200. The average for March at that place was .0164. The maximum amount for March at Hartford occurred in the first week, March 1st to 7th, and it amounted to .0234. The average for March at Hartford was .0173. The maximum amount for March at Alton occurred in the first week, March 1st to 7th. It amounted to .0365. The average for March at Alton was .0248.

Q. Please give me the same figures for April, 1900, at
1692 those points?

A. For April the maximum occurred in the first week of April, April 1st to 7th, at the Illinois shore, Chain of Rocks, and amounted to .0365. The average for April, Illinois shore, Chain of Rocks, was .0308. At Hartford for April the maximum occurred in the last week, April 21st to 28th and it amounted to .0431. The average for April at Hartford was .0358. At Alton the maximum occurred in the last week of April, April 21st to 30th, and amounted to .0485. The average for the month of April at Alton was .0378.

Q. Now, please give me the same figures for May.

A. For May, first, Illinois shore, Chain of Rocks, the maximum occurred May 21st to 28th, and amounted to .0178. The average for May at the Illinois shore, Chain of Rocks was .0154. At Hartford, during the month of May the maximum occurred in the week May 14th to 21st, and it amounted to .0340. The average for May at Hartford was .0269. For Alton the maximum in May at Alton occurred in the week May 14th to 21st and amounted to .0388. The average for May at Alton was .0289.

Q. Now, please give me the same figures for the same points for June?

A. The Illinois shore, Chain of Rocks, the maximum in June occurred in the week June 21st to 28th and amounted to .0084. The average for June, Illinois shore, Chain of Rocks, was .0650. For Hartford the maximum amount was found June 21st to 28th, and amounted to .0225. The average for June at Hartford was .0099. The maximum for June at Alton occurred June 21st to 28th, and it amounted to .0243. And the average for June at Alton was .0104.

Q. Now, please give me the same figures for July?

A. First, Illinois shore, Chain of Rocks, the maximum
amount in July occurred in the week July 7th to 14th, and
1693 also in the subsequent week—in the next week, was .0043.
The average for July at that place was .0041. The maximum at Hartford for July was .0143 in the week July 21st to 28th. The average was .0121. The maximum at Alton occurred in the week July 14th to 21st and amounted to .0177. The average for July was .0159.

Q. Please give me the same figures for the month of August at the same points?

A. First at the Illinois shore, Chain of Rocks, the maximum in August, 1900, occurred in the week August 14th to 21st and amounted to .0102. The average for August at that place was .0063. For Hartford for the same month the maximum occurred in the week August 14th to 21st, and amounted to .0173. The average for the month at Hartford was .0095. At Alton the maximum amount found in August was during the week August 14th to 21st, and amounted to .0180. The average for August at Alton was .0104.

Q. Please give me the same figures for September at the same point.

A. First the Illinois shore, Chain of Rocks, for the month of September, 1900, the maximum amount was found September 7th to 14th, and amounted to .0071. The average for September at that place was .0068. At Hartford during the period of September, the maximum amount occurred in the week September 21st to 28th, and amounted to .0120. The average for the month of September at Hartford was .0097: At Alton the maximum occurred in September during the week September 21st to 28th, and amounted to .0134. The average for September at Alton was .0115.

Q. Please give me the amount from October 1st to October 10th?

A. From October 1st to 10th, at Illinois shore, Chain of Rocks, the average amount of nitrogen as nitrites was .0064. At Hartford at the same time it was .0101. At Alton it was .0124.

1694 Q. Now, did you make a chemical analysis of the water at these same points on the Illinois shore for October and November, 1901, to determine the quantity of nitrites present?

A. I did.

Q. Please read that table.

A. The table is as follows: 1901.

Date.	Illinois shore, Chain of Rocks.	Hartford.	Alton
October 1 to 7	.0110	.0235	.0160
October 7 to 14	.0124	.0184	.0121
October 14 to 21	.0144	.0150	.0180
October 21 to 28	.0160	.0163	.0190
October 28 to November 4	.0123	.0137	.0102
November 4 to 11	.0167	.0191	.0103
November 11 to 16	.0177	.0190	.0124
November 18 to 25	.0171	.0167	.0072
November 25 to 30	.0170	.0186	.0088

Q. Now, from these figures, where are the nitrites greater along the Mississippi river, as we ascend it from a point opposite the Chain of Rocks?

A. These averages show that with very few exceptions the nitrites were higher at Hartford than they were at the Illinois shore, Chain of Rocks, and they were higher at Alton than they were at Hartford.

Q. Now, is the Mississippi river above Alton more or less impure than it is at Hartford, below Alton?

A. It is more impure.

Q. Where is Hartford?

A. Hartford is opposite the mouth of the Missouri river.

Q. How far below Alton?

A. I can give you the exact number of miles by looking on the map. Hartford is nine miles above the Intake and Alton is 23, that is 14 miles above Hartford.

Q. Alton is 14 miles above Hartford?

A. Yes, by river, that is.

Q. Yes sir, that is what I am talking about, by river.

A. Yes.

Q. Now, if that is true, that the Mississippi river above
Alton and below the mouth of the Illinois is more polluted
1695 than it is at Hartford, 14 miles below, what deduction, as
a chemist would you draw from that as to the effect of the
sewage of the city of Alton, on the waters of the Mississippi
river, as to whether or not it increased or diminished perceptibly
the pollution?

A. The sewage of Alton apparently has no effect upon the condition of the river at Hartford.

1696 Q. What is the reason of that?

A. Well, the volume of the river is so great that it is lost, or it is so small—

Q. Well, it is dilution, isn't it?

A. Its dilution is so great that it produces very little effect upon the character of the river as a whole.

Q. Now, what do the analyses in October and November, 1901, show comparatively for nitrites and the analyses of 1900, as to whether it was greater or lower in summer?

A. Well, it shows that the same conditions held in 1901, that we found in 1900; that the river is more impure as we ascend the stream.

Q. Well, was there more nitrites or less in 1901 than there was in 1900?

A. Our analyses show more.

Q. Now, going up to the mouth of the Illinois river, is there any difference shown by chemical analyses between the waters of the Illinois and the Mississippi above the mouth of the Illinois river near Grafton?

A. Yes sir.

Q. Well, are the nitrites higher or are they lower in the Mississippi above the mouth of the Illinois than they are in the Illinois above the mouth thereof?

A. My analyses show that the nitrites continually increase as we go up the river.

Q. What river?

A. Up the Illinois river.

Q. Well, that doesn't exactly answer my question. You say the nitrites are higher in the Illinois river above Grafton than they are in the Mississippi above Grafton?

A. Yes sir, they are higher in the Illinois river above Grafton, very materially higher.

Q. Well, are the nitrites in the Mississippi river above the mouth of the Illinois higher than they are at Alton and at Hartford and at the Chain of Rocks?

A. They are very much lower.

Q. Then is the Mississippi river above Grafton in a better or worse sanitary condition than it is below Grafton and at the Chain of Rocks? 1697

A. Very much better.

Q. Well, from your examinations can you state chemically whether or not the Illinois river pollutes the Mississippi river?

A. The chemical analyses show that the pollution of the Mississippi comes from the Illinois river.

Q. Now, if it were not for that pollution by the Illinois river, how would the water of the Mississippi river at the Intake or at the point opposite the Intake, compare with the water on the Missouri side of the Mississippi opposite the Intake?

A. It would be very similar in character as to the free ammonias and nitrites. The waters would be almost the same and there would be a higher chlorine found on the Missouri shore than on the Illinois shore, for the reason that the Missouri river always contains a larger quantity of chlorine—chlorides, than the Mississippi, but from a sanitary standpoint, the water from the Mississippi river above the mouth of the Illinois, is very similar to the water of the Missouri river, and were it not for the inflow of the waters of the Illinois river, the Mississippi on both sides of the river at the Chain of Rocks, would be of equal sanitary character. It would be a good drinking water on both sides. As it is now, the Illinois comes in and carries with it the nitrogenous organic matter which we find in the river at Grafton and at Alton and at Hartford, and on the Illinois shore at the Chain of Rocks.

Q. Do you know whether or not the Mississippi river above its confluence with the Missouri, and the Missouri above its confluence with the Mississippi, run through practically the same kind and class of agricultural region and whether or not the land in the drainage area of those two rivers for the first thousand miles of each stream is practically used for the same
1698 purpose by a similar class of people?

A. I belive it is.

Q. Have you any data as to the rain precipitation in the drainage area of the Missouri above its confluence with the Mississippi and the Mississippi above its confluence with the Missouri?

A. I have no data here.

Q. Have you ever investigated that question to see in which watershed the greater amount of rain precipitation occurs?

A. I have never investigated.

Q. Can you get that data?

A. I think I can.

Q. Now, I show you here a map which you have marked Plat No. 12. Will you please state what that is and explain the things that are found on the map in order that one examining it may be able to tell what those lines and marks indicate?

A. This map is intended to show the variation in the quantities of nitrites found in the Illinois River at a point above Grafton, and also at another point above Peoria.

The horizontal line on this map, or on the horizontal line the time is measured, and on the vertical lines on the left hand side of the map the amounts of nitrites in parts per million are measured. There are two curves on this map, one curve showing the variation in the amount of nitrites in the Illinois River above Grafton. This curve is made by plotting the weekly averages found by analyses, and then joining these points with a red line, or—I should say the monthly averages. It is made from the monthly averages, and joining these points with a red line.

The lower curve gives the average amount of nitrites at a point above Grafton in the Illinois River.

The upper curve gives the amount of nitrites in the Illinois River at a point above Peoria, throughout the time of our analyses, extending from January 24th to October 11th, 1900.

1699 Complainant's counsel offers the map referred to in evidence and the same is marked by the Commissioner "Complainant's Exhibit No. 33. Frank S. Bright, Commissioner."

Q. Now, did you make an analysis of the Illinois River above Grafton?

A. Yes sir.

Q. Now, what do those analyses show with reference to increase or decrease of nitrites and other nitrogenous substances indicating sewage pollution as you ascend the Illinois River?

A. Comparing the values found for nitrites and also free ammonia, the value found for these substances at Grafton with the same values found at a point above Alton, we find higher values, uniformly above Grafton, than we do at Alton, showing that as we ascend the Illinois River the impurities constantly increase.

Q. Now, did you make any analysis at Peoria—make any analysis of the water?

A. Yes, we have tabulated the daily analyses of the waters taken at Peoria.

Q. Now, what do the sepcimens analyzed from Peoria show with reference to whether or not they are polluted, and how do they compare with the water at Joliet and at Lockport?

A. We find that at Peoria the amout of pollution was very great and as we go up still further to Joliet and Lockport the analyses showed that the water is simply sewage, and the analyses there for free ammonia and nitrites are such as one obtains by analyzing sewage.

Q. Now, when you began in January, 1900, to analyze these waters, did you analyze any from Peoria?

A. Yes sir.

Q. Now, was the nitrite greater or less in the samples an-analyzed when you first began in January, 1900, at Peoria, than it

was at Grafton, in other words, was there more or less nitrites in
the water analyzed in the samples taken January 24th,
1700 from Peoria than there was in that taken from Grafton?

A. At first we found less nitrites at Peoria than we did at Grafton, in January.

Q. Now, after the opening of the Drainage Canal did the nitrites at Peoria increase or decrease?

A. They increased.

Q. Now, how did they compare after the opening of the Drainage Canal with the nitrites found at Grafton? Were they greater or less in number?

A. They were greater.

Q. Now, from these chemical facts, what conclusion do you draw?

A. I conclude from these analyses that before the opening of the Drainage Canal there was sewage matter in the waters of the Illinois River, but there was greater oxidation in the region above Peoria and immediately below Peoria—all along the river there was greater oxidation. That was shown by diminution.

Q. Greater oxidation than there was after the opening of the canal?

A. Yes sir, the sewage above Peoria.

Q. Why was that?

A. Well, it moved more slowly.

Q. Now does the rapidity of the current have any effect on the oxidation?

A. I should say that it retarded it, if anything.

Q. Now what were you going to say about the sewage above Peoria?

A. Well, before the opening of the canal, the movement was slower and while the water was impure above Peoria, we found a smaller quantity of nitrites there, showing that the oxidation had proceeded further, and then after the opening of the Drainage Canal the quantity of nitrites at Peoria increased enormously, and they kept on increasing throughout the time that we made these analyses, and from that I conclude that the effect of the opening of the Drainage Canal was to wash these oxidized materials further down the river. The region of bacterial action, and the conversion of the nitrogenous organic mat-

ter into nitrites was moved much further down the Illi-
1701 nois River and into the Mississippi River below the mouth of the Illinois.

Q. Now, did this large increase in the number of nitrites found in the chemical analyses of the water obtain in the waters above Peoria?

A. The nitrites increased all the way up.

Q. Up to where?

A. Up to Lockport.

Q. The point of entrance in the Des Plaines River of the Chicago Canal?

A. Yes sir.

Q. Now, that was the analysis made in 1900?

A. In 1900.

Q. Now, the analysis made a year later, in 1901, did that tend to disclose the same state of affairs?

A. In 1901, the analyses showed that the same state of affairs still existed. The quantities of nitrites found above Peoria were still very considerably greater than the nitrites found in the Illinois River above Grafton.

Q. Now, do you know whether these samples were taken at Peoria or two or three miles above Peoria?

A. I understood that they were taken above Peoria, three miles.

Q. Now with reference to your figures, is it disclosed whether or not the Illinois River above Grafton was more impure in 1901 than it was in 1900?

A. My analyses showed that the Illinois River above Grafton was more impure in 1901 than in 1900.

Judge Springer: You mean for the corresponding months?

A. For the corresponding months, yes—for October and November.

Attorney General Crow: Now, what was the condition of the Illinois river in 1901, as to whether it was high or low?

A. I think it was high. I am not sure.

Q. In 1901?

A. No, that was the drought year, that is true. I have not a record of the stages of the river.

Q. Well, we proved that the other day anyhow. Did you make any memorandum of your analyses, or table showing the monthly averages of nitrites and the free ammonia in the Illinois River above Grafton?

1702 A. Yes sir.

Q. Have you got that?

A. Yes sir, I have them here.

Q. Will you please give me the results of that, together with the dates to nitrites and free ammonia for the Illinois River above Grafton?

A. Illinois River above Grafton, January 24th to February 1st, 1900; the average amount of nitrites was .0300. Shall I give you the free ammonia at the same time?

Q. Yes, just put that in also.

A. And free ammonia for the same time was 1.498; then the monthly average for February, for nitrites was .0245, and for free ammonia was .946; the monthly average for March, nitrites, was .0170, and for free ammonia .322; For April the monthly average for nitrites was .0370, for free ammonia, .113; for May the nitrites, the monthly average was .0459; for free ammonia .1079; the monthly average for June in nitrites was .0193; free ammonia .0321; for July the monthly average of nitrites was .0352; free ammonia .0443; for August the monthly average for nitrites was .239; for free ammonia .0406; for September the nitrites, monthly average .0257; free ammonia .0517; October the nitrites .0428; free ammonia .0677.

Q. Now did you make any comparison of the Illinois River above Grafton for free ammonia and nitrites between October, 1900, and October, 1901,—that is, did you compare these two periods?

A. Yes sir.

Q. Have you got those figures?

A. I have the figures for 1901, on the large charts that I have.

Q. Well, I have got the two together right here. Examine them and see if they are correct, and if you made them?

A. Yes, these are correct; these are my figures. The Illinois River above Grafton in October, 1900, had nitrites .0428,

and in 1901, .0720; and free ammonia in October, 1900,
1703 was .0677; and October, 1901, .1502.

Q. Now, did you make any comparison of the figures from the result of your analyses, as to nitrites and free ammonia in the Illinois River above Peoria in the periods October, 1900, and October, 1901?

A. Yes sir.

Q. Please give them to me.

A. In October, 1900, the nitrites were .1857, and in 1901, they were .1240, and free ammonia, October, 1900, 1.404, and in 1901, .305.

Q. Now, comparing the amount of decomposed sewage in the Illinois River at a point above Peoria in January, 1900, with that supposed to be there in the early part of September and October 1900, as shown by your chemical analyses, what would you say were the relative proportions?

A. Is this above Peoria?

Q. Yes. Above Peoria.

A. It was very much greater.

Q. About how much?

A. Well eight or nine times as much.

Q. In September and October as compared with January, 1900?

A. Yes, that is shown by this red curve which constantly rises throughout that period.

Q. Well, now, can you state from your chemical analyses of these waters, whether or not the impurities coming down the Illinois River have been increased or diminished?

A. The impurities are somewhat diminished as they come down the Illinois River.

Q. No. Can you state whether or not they have been increased or diminished by the opening of the Canal?

A. Well, so far as my analyses go, there has been a decided increase since the opening of the canal in the amount of impurities that come down the Illinois River.

Q. Are these impurities sufficiently oxidized to be converted into harmless products by the time they reach the Mississippi River and the Intake Tower situated therein in this city?

1704 A. In my opinion they are not.

Q. As a chemist and from your chemical examination of these waters, is it or is it not your judgment that this pollution and the contamination from the Chicago River continues down through the Chain of Rocks?

A. Yes sir.

Q. Then would a portion of it finding its way into the Intake tower of the waterworks, and thence into the reservoir?

A. Yes sir.

Q. Then I will get you to state whether or not in your opinion as a chemist and from your analyses of these waters, the water supply of this city is contaminated by the Chicago Drainage Canal and the sewage emptied into it by the City of Chicago?

A. Yes sir.

Q. Is the volume of water going down the Illinois River greater or less since the opening of the canal?

A. It is greater.

Q. What has been the effect of this in disposing of the sewage. Has it caused it to disappear or does it cause it to be pushed further down the river?

A. It causes it to be pushed further down the Illinois River and into the Mississippi River in greater quantities than before the opening of the canal.

Q. Now, what effect on sedimentation does the increase in the volume of water by the outpouring of the Chicago Canal water, into the Illinois River, have upon the question of sedimentation in the Illinois River?

A. Well, it acts to prevent sedimentation.

Q. Well, would sedimentation be greater or less now than before the waters of the canal were turned into the Illinois River?

A. Less now than before.

Q. Why?

A. Because there is a more rapid current which carries the suspended matters further down in the stream and gives less opportunity for sedimentation.

Q. Now, as the result of your chemical analyses of these waters, I will ask you to state, if you know, whether or not

1705 there is a mixture of the waters of the Mississippi and Missouri Rivers as they come into the Intake Tower, 1500 feet from the Missouri shore in the Mississippi River?

A. My analyses show that the water that we get is a mixture of the Mississippi river water and the Missouri river water.

Q. Does its proportion vary?

A. It varies from day to day,—in fact from hour to hour.

Q. Now, from your examination can you state whether or not at all times there is some of the Mississippi River water in the reservoir of the St. Louis Water Works?

A. My analyses indicate that our water is always a mixture of these two waters.

Q. Well, the water in the reservoir?

A. Yes sir.

Q. Now, of these two waters, the Missouri and the Mississippi does your chemical analyses disclose which is the more potable and the better for domestic and primary uses, the Missouri River water or the Mississippi River water?

A. The Missouri River water is far superior to the Mississippi River opposite the Intake.

Q. Does the Missouri River water contain any particular 1706 chemical constituents in a greater quantity than the Mississippi does?

A. Yes sir.

Q. What is that chemical constituent?

A. It contains a larger proportion of common salt.

Q. Is it that that affects the flavor of the Missouri River water?

A. I think it does.

Q. Why is it that the Missouri River water is found to contain more of that salt than the Mississippi?

A. It has been found that one of the tributaries of the Missouri River that runs in from Kansas, flows over salt beds, and this gives it a large proportion of common salt, and that water mixing with the Missouri gives it a high proportion of salt.

Q. Now do you know whether or not the amount of the impurities increased or diminished in the reservoir after the opening of the Drainage Canal?

A. There was a decided increase in the impurities of the water in the reservoir after the opening of the Drainage Canal.

Q. Was there any coincident increase in the impurities of the water of the Mississippi?

A. There was a decided increase at that time, as shown by all these curves, or nitrites and free-ammonia that have been exhibited.

Q. Now, you have stated and shown by your figures that during the month of May there was a marked improvement in the reservoir water, did this improvement coexist with an improvement in the Mississippi River water?

A. Yes sir.

Q. In 1900?

A. In 1900.

Q. Now to what do you attribute the great improvement of the waters of running streams in spring and summer?

A. First to the greater oxidation which takes place in warm weather; secondly in these waters, to the much greater 1707 volume of the streams.

Q. What is the effect of that dilution?

A. Dilution?

Q. Dilution, or increase in volume?

A. The Missouri and also the Mississippi River are very much higher in the spring months than they are in the fall and winter.

Q. Now, can you state whether or not your chemical examination—whether or not the Mississippi River throughout the time of this examination at the Chain of Rocks,—at the Illinois shore opposite the Chain of Rocks, was in a potable condition and fitted for use for drinking purposes?

A. Throughout the time of this examination analytical results show that the water on the Illinois shore at the Chain of Rocks was in an unsanitary condition. It was water that would be condemned by water specialists. The figures for nitrites and free ammonia are beyond those that are allowable in a potable water.

Q. Now, please state again the amount of nitrites and free ammonia that is allowed in potable water?

A. In a surface water, the averages generally accepted are,

—that is, for free ammonia, the maximum amount is .05, when it goes above .05 parts per million the water is to be regarded with suspicion, and if the albuminoid ammonia goes above .2 parts per million, then there is so much organic matter in the water that the conditions are favorable for the growth and development of disease germs. Then, if there are measureable quantities of nitrites, if you can measure the nitrites, that is, express the result in numbers, we are usually inclined to condemn such water. If we can at all measure the amounts of nitrites we condemn the water, as good drinking water has no nitrites in it, and whenever the chlorine goes above the normal amount, that is indicative sewage pollution.

1708 Q. Now, are you acquainted with the articles by Thomas M. Brown, in the State Board of Health Report, State of Massachusetts, 1890, purporting to be an examination of the water supplies of that city?

A. Yes sir, I have read it.

Q. Mr. Brown and this book, which is the Water Supply of the State of Massachusetts, issued by the State Board of Health there, is it considered standard authority on the question of sanitary water supplies?

A. It is.

Q. Now, he says that "When we speak of a water having high nitrites, we have in mind the general low contents of nitrites in surface waters. The actual amount which would be called high in this case, might be low if applied to ammonia or to nitrates. Thus: .0010 parts in 100,000 of nitrogen, as ammonia, we would call low; as nitrites it would be high, and as nitrates very low; but the free ammonia and high nitrites give us characteristics of recent pollution, and when they are uniformly high in a surface water, they point to continuous pollution. In connection with chlorine above the normal they afford complete proof of sewage contamination." What do you say of these standards that he announces there?

A. Well, they are very similar to what I have stated.

Q. Well, are they standards that you recognized in this work that you have done?

A. Yes sir.

Q. Now, did you find that the high free ammonia and high nitrites gathered in the waters of the Mississippi River up at Grafton and up the Illinois River?

A. Yes sir, they were very high free ammonias and high nitrites in the Mississippi River.

Q. Well, were they to be found together in the water?

A. They were found together, and especially as Grafton we noticed a marked difference at Grafton in the quantities of
free ammonia, and nitrites in the Illinois River, and the
1709 same substance in the Mississippi River. In other words
the free ammonia was low in the Mississippi River at Grafton, and high in the Illinois River. The nitrites were very low in the Mississippi above Grafton and measurable quantities and high quantities in the Illinois River above Grafton.

Q. Well, what about the chlorine found above the confluence of the Mississippi and the Illinois, in the Mississippi, and above the confluence of the two streams in the Illinois?

A. I have the monthly averages for chlorine at those points. I will read you a few of them. I have here the monthly averages for chlorine at a point above Grafton on the Illinois River, and at a point above Grafton in the Mississippi River. Now for January, first Mississippi River above Grafton, and secondly the Illinois River above Grafton: January, Mississippi River above Grafton 5.7; at the same time, Illinois River 14.1; February: Mississippi river above Grafton 6.1; Illinois River above Grafton 13.1; March: Mississippi River above Grafton, 4.5; Illinois River above Grafton, 7.00; April: monthly average for chlorine, Mississippi River above Grafton, 4.8; Illinois River above Grafton, 6.1; May: Monthly average for chlorine, Mississippi River above Grafton, 4.2; Illinois River above Grafton, 10.9; June monthly average for Mississippi River above Grafton, 5.1; Illinois River above Grafton, 12.6; July: Monthly average for chlorine, Mississippi River above Grafton, 7.7; Illinois River, above Grafton, 18; August: Monthly average for chlorine Mississippi River above Grafton, 5.2; Illinois River above Grafton, 16.5; September: Chlorine, monthly average, Mississippi River above Grafton, 3.3; Illinois River above Grafton 14.8; October: average for Mississippi River above Grafton, 3.9; Illinois River above Grafton, 16.9.

1710 Mr. Johns: That is 1901.

The Witness: 1900, this was.

By Attorney General Crow:

Q. Please state the maximum that you found each month in the Mississippi and in the Illinois above Grafton?

A. The maximum for chlorine in the Mississippi above Grafton occurred in July, 1900, and amounted to 7.7.

The maximum chlorine in the Illinois above Grafton occurred in the same month, July, 1900, and amounted to 18 parts per million.

EDWARD H. KEISER.

Adjourned until 10:00 A. M., Saturday, March 14, 1903, at same place.

1711 Southern Hotel, St. Louis, Missouri. 10:00 a. m., March 14, 1903.

Present, the commissioner and same counsel representing the respective parties.

DR. EDWARD H. KEISER

Resumed the stand for further direct examination by Attorney-General Crow and testified as follows:

Q. Now, professor, I will get you to state, if you made any chemical analyses of the water at Lockport and Joliet?

A. I did.

Q. Well, do you know where the Illinois and Michigan Canal enters the Desplaines river?

A. The Illinois and Michigan Canal crosses the Desplaines river at Joliet and then comes down to La Salle where it enters the Illinois river.

Q. Now, have you got a table at Joliet?

A. Yes sir.

Q. Showing the nitrites?

A. Yes sir, I have.

Q. For what year?

A. I have the averages of nitrites, the weekly averages and monthly averages, beginning with March 1, 1900, down 1712 to October 10th inclusive. Then I also have the averages of nitrites from Oct. 1, 1901, to Nov. 30, 1901.

Q. Is that the weekly or daily averages?

A. I have the weekly averages made from the daily analyses.

Q. Now, will you please give me the maximum for the various months beginning in March, 1900, of the nitrites found in the Illinois river at Joilet beginning in March, 1900, and extending until October 11, 1900?

A. The maximum amount of nitrites in the water at Joliet in March occurred in the last week of March, 1900, and amounted to .067.

Q. What is that?

A. Nitrites, the parts per million. The average for that month was .0558.

The maximum amount for April occurred in the first week of April and it amounted to .1014.

The average for April was .0663.

Then for May the maximum amount occurred in the second week and amounted to .0340.

The average for May was .0256.

The maximum for June occurred in the last week in June and amounted to .0345, and the average was .0326.

1713 The maximum amount for July occurred in the third week of July and the amount was .0728 and the average for July was .0551.

The maximum amount for August was in the second week of August and the amount was .0597 and the average for August was .0465.

The maximum amount for September was in the second week of September and the amount was .0754 and the average for September was .0524.

The average amount for October from the first to tenth. .0562. That is the October average.

Now, for 1901, October, the maximum occurred in the third week of October and amounted to .0830 and the average for October, 1901, was .0780.

The maximum for November occurred in the first week of November, 1901, and was .0781, and the average for November was .0510.

Q. Now, have you a record of the free ammonias at the places which you have just given?

A. I have.

Q. State the tables that you have prepared and the dates and the maximum for each month and the average.

1714 A. The maximum amount in March, 1900. This is the free ammonia now for Joliet. The maximum amount in March, 1900, occurred in the first week in March and the amount was 3.491. The average for March was 2.689.

For April the maximum amount occurred in the first week of April and the amount was 3.140. The average for the month was 2.732.

For May the maximum amount occurred in the first week and was 3.604. The average for May was 2.995.

For June the maximum occurred in the second week of June and the value was 3.600. The average for June was 3.270.

For July the maximum occurred in the first week and the amount was 4.647. The average for the month was 3.701.

In August the maximum occurred in the last week and the value was 3.999. The average for August being 2.933.

For September the Maximum amount occurred in the third week and the value was 5.473. The average for the month of September was 4.498.

For October from the 1st to the 10th the value was 3.306.

Q. Is that for 10 days?

A. Yes, sir, just 10 days, we stopped at the 10th?

1715 Q. That is all you took in October?

A. Yes, sir, that is all I took in October, 1900, but in 1901 now—

MR. JOHNS: Was that the maximum or the average?

A. The average.

MR. WOERNER: It was both.

A. We did not select individual dates. The other was the highest for the week.

JUDGE SPRINGER: That was the average for 10 days.

A. The average for the first 10 days of October, 1900.

GENERAL CROW: Now go on with 1901.

A. In October, 1901, the maximum occurred in the second week and was equal to the value of 5.519, and the average for that month was 3.801.

For November the maximum occurred in the third week in

November and the value was 3.494, and the average for the month was 3.152.

Q. Is that all?

A. That is all.

Q. Now, give the data in the same way from Lockport.

JUDGE SPRINGER: Is this free ammonia?

A. I am starting now with free ammonia for Lockport. Had we better have the nitrites first?

1716 MR. WOERNER: Follow the same order.

A. Well, the order would be nitrites first, for 1900. The maximum amount in March, 1900, occurred in the fourth week and amounted to .0945 and the average for the month was .0643.

The maximum of April occurred in the first week in April and amounted to .1011, and the average for April was .0730.

The maximum for May occurred in the second week and it amounted to .0405, and the average for May was .0234.

The maximum for June occurred in the first week in June and amounted to .0295, and the average for June was .0114.

The maximum in July occurred in the third week in July and amounted to .0114, the average, however, for that month was .0081.

The maximum for August occurred in the third week in August and equalled .0140, and the average for the month was .0083.

The maximum for September occurred in the fourth week in September, 1900, and was equal to .0108 and the average in September was .0071.

Now for October the average was .0138.

1717 Now, for 1901: In October the maximum occurred in the third week and was .0172, and the average for the month was .0167.

For November, 1901, the maximum occurred in the first week from the 1st to the 7th, and amounted to .0210, and the average for that month was .0189.

Now, the free ammonia is at Lockport. We give the nitrates first and the free ammonia. Now, we have given the nitrites so we only have left the free ammonia.

Free ammonia, Lockport, 1900, for March: The maximum amount occurred in the second week and was 3.095, and the average was 2.437.

For April the maximum occurred in the first week and was 2.591, and the average was 1.806.

For May the maximum occurred in the first week and amounted to 2.236, and the average was 1.598.

For June the maximum occurred in the fourth week and amounted to 1.677 and the average for the month was 1.411.

For July the maximum occurred in the first week and amounted to 1.834, and the average for the month was 1.631.

In August the maximum occurred in the fourth week and amounted to 1.974, and the average for the month was 1718 1.589.

For September the maximum occurred in the third week and amounted to 2.685, and the average for the month was 2.195.

For October the average for the first 10 days was 1.555.

For 1901, October, the maximum occurred in the second week and amounted to 1.663, and the average for the month was 1.466.

For November the maximum occurred in the first week and amounted to 1.368, and the average for the month was 1.239.

Those are all the statistics for Lockport.

GENERAL CROW: Now, you have just given the maximum and average?

A. The monthly averages, yes sir, at Lockport and Joliet.

GENERAL CROW: These tables will be Nos. 15, 16, 17 and 18, and they will carry their own history with them. They are for the nitrites and free ammonia at Lockport and Joliet.

A. The tables are above referred to.

1719 GENERAL CROW: Now, have you made a chemical examination of the Illinois river above Peoria for the determination of nitrites?

A. Yes sir.

Q. For the period from January 24, 1900, to October 11, 1900?

A. I have.

JUDGE SPRINGER: Is this the nitrites?

GENERAL CROW: This is the nitrites in the Illinois river above Peoria.

Q. Will you please give me the maximum amount for the different months together with the average during that period?

A. The Illinois river above Peoria, nitrites parts per million. The maximum amount from January 24 to the 31st, 1900, was equal to .0248.

MR. JOHNS: That is the maximum?

A. Yes, that is the maximum for those 7 days. The maximum for February occurred in the first week and amounted to .0414, and the average for February was .0358.

The maximum for March occurred in the second week and amounted to .0268, and the average for March was .0209.

The maximum for April occurred in the fourth week and amounted to .0771, and the average for April was .0467.

1720 The maximum for May occurred in the second week and amounted to .1023, and the average for May was .0752.

For June the maximum occurred in the third week and amounted to .1448 and the average was .1317.

For July the maximum occurred in the third week and amounted to .2171, and the average was .1657.

For August the maximum occurred in the third week and amounted to .1743, and the average for the month was .1597.

For September the maximum occurred in the first week and amounted to .2171, and the average for the month was .1382.

For October the average for the first 10 days was .1857.

Shall I give the free ammonias now?

GENERAL CROW: Yes, give the free ammonias now.

JUDGE SPRINGER: For the same period.

A. The free ammonias for the same dates beginning with January. The average from January 24 to 31, was 2.485.

For February the maximum amount occurred in the first week and was 2.169 and the average for that period was 1.416.

For March the maximum amount occurred in the second
1721 week and was 1.021. The average for March being .685.

For April the maximum occurred in the third week and amounted to .455 and the average for that period was .392.

For May the maximum occurred in the third week and amounted to .361 and the average was .266.

For June the maximum amount occurred in the fourth week and was .319, and the average was .228.

For July the maximum occurred in the third week and amounted to .401, and the average was .230.

For August the maximum occurred in the fourth week and amounted to .172 and the average was .142.

For September the maximum occurred in the fourth week and amounted to .672 and the average was .255.

From October 1st to 10th the average was 1.404.

GENERAL CROW: Now, these tables will be 19 and 20, showing the nitrites and free ammonia in the Illinois River above Peoria.

GENERAL CROW: Have you got an analysis of the
1722 water, of the sample made in the canal above Lockport?

A. Yes, sir.

Q. Where is that?

A. I have that here. I have an analysis here of the water taken from the Drainage Canal off Pauline Street. The analysis extending from Oct. 9th to Nov. 30th, 1901.

Q. Now, does that table disclose the nitrites and the free ammonia?

A. It does.

Q. And does it show the chlorine?

A. Yes, sir.

Q. Will you please give me those results?

A. First for the nitrites?

Q. Yes.

A. The nitrites run as follows:

October	9th,	Nitrites,	.016
"	10th,	"	.040
"	11th,	"	.018
"	12th,	"	.017
"	13th,	"	.036
"	14th,	"	.015
"	15th,	"	.017
"	16th,	"	.018
1723 "	17th,	"	.018

Now skip to the 21st. There were three days when we received no samples.

October	21,	Nitrites,	.019
“	22nd,	“	.027
“	23rd,	“	.013
“	24th,	“	.016
“	26th,	“	.015
“	27th,	“	.014
“	28th,	“	.025
“	29th,	“	.016
“	30th,	“	.019
“	31st,	“	.018

November 1st 1901, Nitrites parts per million.

November	1st,	Nitrites	.028
“	2nd,	“	.016
“	3rd,	“	.017
“	4th,	“	.103
“	5th,	“	.017
“	6th,	“	.015
“	7th,	“	.018
“	8th,	“	.028
1724 “	9th,	“	.015
“	10th,	“	.015
“	11th,	“	.013
“	12th,	“	.025
“	13th,	“	.015
“	14th,	“	.015
“	15th,	“	.027
“	16th,	“	.016
“	17th,	“	.023
“	18th,	“	.015
“	19th,	“	.016
“	21st,	“	.007
“	22nd,	“	.013
“	23rd,	“	.018
“	24th,	“	.017
“	26th,	“	.017
“	27th,	“	.017
“	28th,	“	.016
“	29th,	“	.017
“	30th,	“	.015

GENERAL CROW: Now give us the chlorines next.

A. For the chlorines I will begin with October.

1725 JUDGE SPRINGER: What are you giving, the free ammonia or the chlorine?

A. The chlorines. The parts per million of chlorine for the same period, 1901, October 1st, Drainage Canal off Pauline St.

	October	9th,	Chlorine	22.8
	"	10th,	"	23.0
	"	11th,	"	18.0
	"	12th,	"	12.1
	"	13th,	"	20.8
	"	14th,	"	21.0
	"	15th,	"	19.0
	"	16th,	"	23.2
	"	17th,	"	19.5
	"	21st,	"	22.3
	"	22nd,	"	22.5
	"	23rd,	"	17.5
	"	24th,	"	18.2
	"	26th,	"	22.0
	"	27th,	"	21.3
	"	28th,	"	21.7
	"	29th	"	23.8
	"	30th,	"	29.0
	"	31st,	"	24.2
1726	November	1st,	Chlorine	21.5
	"	2nd,	"	23.0
	"	3rd,	"	13.8
	"	4th,	"	13.2
	"	5th,	"	11.3
	"	6th,	"	10.0
	"	7th,	"	16.0
	"	8th,	"	12.0
	"	9th,	"	10.8
	"	10th,	"	14.2
	"	11th,	"	14.8
	"	12th,	"	106.0
	"	13th,	"	12.2

	November	14th,	Chlorine	9.0
	"	15th,	"	8.0
	"	16th,	"	11.0
	"	17th,	"	11.0
	"	18th,	"	9.0
	"	19th,	"	11.2
	"	21st,	"	8.
	"	22nd,	"	11.9
	"	23rd,	"	11.3
	"	24th,	"	12.3
1727	"	26th,	"	9.0
	"	27th,	"	11.6
	"	28th,	"	16.1
	"	29th,	"	16.2
	"	30th,	"	29.0

Now, the free ammonias from October 9th, the parts per million,—

	October	9th,	Free Ammonia	.328
	"	10th,	"	2.860
	"	11th,	"	.676
	"	12th,	"	.812
	"	13th,	"	1.66
	"	15th,	"	1.072
	"	16th,	"	1.500
	"	17th,	"	.884
	"	21st,	"	.672
	"	22nd,	"	.334
	"	23rd,	"	.884
	"	24th,	"	.796
	"	26th,	"	.732
	"	27th,	"	1.020
	"	28th,	"	1.288
	"	29th,	"	.744
	"	30th,	"	.700
1728	"	31st,	"	.744

November 1901,	1st,	Free Ammonia	.968
"	2nd,	"	.628
"	3rd,	"	.648

	November 1901,	4th,	Free Ammonia	.988
	"	5th,	"	1.068
	"	6th,	"	.568
	"	7th,	"	.652
	"	8th,	"	.436
	"	9th,	"	.452
	"	10th,	"	.849
	"	11th,	"	.560
	"	12th,	"	5.192
	"	13th,	"	.568
	"	14th,	"	.640
	"	15th,	"	.468
	"	16th,	"	.428
	"	17th,	"	.588
	"	18th,	"	.452
	"	19th,	"	.560
	"	21st,	"	.716
1729	"	22nd,	"	.564
	"	23rd,	"	.504
	"	24th,	"	.628
	"	26th,	"	.404
	"	27th,	"	.968
	"	28th,	"	.256
	"	29th,	"	1.892
	"	30th,	"	2,140

Q. Now, Profesor Keiser, will you please state what conclusions as a chemist, you came to from your examinations and investigations from those tables which you have just read?

A. From these analytical results we see that the water of the Illinois River was more highly contaminated with nitrogenous organic matter at Joliet than it was at Peoria and likewise at Lockport there was a greater contamination than at Peoria.

Now, our results show higher values for free ammonia nitrites at Joliet than they do at Lockport. This I account for by the fact that the samples at Joliet were taken immediately under the Illinois and Michigan Canal that passes over the river at that point. The results for Joliet show, or rather the analyses

1730 show, that it is sewage. It cannot be called water. The samples we have were really to be called sewage instead of water and at Lockport while the proportions were less than at Joliet, nevertheless we must still call it a somewhat diluted sewage.

Now, I notice further than several months after our analyses began along in the spring months, the quantities of nitrites and free ammonia diminished both at Lockport and at Joliet. This is accounted for by the outflow of the water of the Drainage Canal. At Lockport the free ammonias diminish from 2.437 down to 1.411 in June. We find that they again increased and in the subsequent year, 1901, they did not diminish below 1.239, showing a partial improvement. In other words, after the opening of the Drainage Canal, this concentrated sewage at Lockport and Joliet was diluted. That in portion is the result of the analyses. That before the canal was opened there was concentrated sewage there and that after the canal was opened there was diluted sewage there and the results obtained at Peoria and points further down the river show that this sewage from Lockport and Joliet had been washed further down the river.

1731 My analyses show that this river was contaminated before the investigation began. The river was polluted with sewage long before the opening of the Drainage Canal but after the opening of the canal the sewage was diluted with water and carried farther down. We found at Grafton much higher nitrites and free ammonias after the opening of the canal than before and that, in my mind, is evidence of the flushing down of the sewage matter which had accumulated at Lockport and Joliet and in the upper regions of the river.

Q. By the opening of the canal?

A. Yes, by the opening of the canal. And where as formerly the sewage had collected in the upper part of the river, by the opening of the canal and the flowing down of the larger volume of water, the sewage was diluted and carried farther down the stream and that is shown very plainly by our curves of nitrites for Grafton and Alton and Hartford.

Q. Now, Professor, I show you here a chart marked Plat 11. Did you make this?

A. Yes, sir.

Q. Please state why and what it shows.

A. This map contains curves of the quantities of nitrites in the Mississippi River above Grafton, at the Illinois
1732 shore, Chain of Rocks, at Hartford and at Alton and also in the Ilinois River above Grafton. Those are the quantities of nitrites that have been read off in the table that have been platted on this chart.

Q. That is, it shows graphically what you have stated in your table?

A. Yes, sir. The chart is constructed by measuring off those months from January to October on a horizontal line and measuring the nitrites in the vertical column. The first dotted red curve shows the fluctuation in the amount of nitrites in the Mississippi River above Grafton. We see that this is the lowest curve, showing that in the river above the mouth of the Illinois there were less nitrites than at any other point here considered.

The second curve shows the fluctuation in the amount of nitrites at the Illinois shore, Chain of Rocks, from the period of January to October.

We see that in June it follows the same contour of the curve of the Mississippi River above Grafton but it is higher; that is, there were more nitrites at the Illinois shore, Chain of Rocks than there were in the Mississippi River above Grafton.
1733 The third curve shows the fluctuation of nitrites at Hartford. This again is somewhat higher than the curve of nitrites at the Illinois shore.

And the fourth, is Alton, which is very similar to the Hartford curve.

Then the last curve on here shows the fluctuation of nitrites in the Illinois river above Grafton. This is the dotted red line and this again is much higher than any of the others.

The map is offered in evidence and marked by the Commissioner "Complainant's Exhibit 34. Frank S. Bright, Commissioner."

Q. Now, you have the original notes made by you of the chemical analyses of the Canal, have you, and down the river?

A. Yes, sir.

Q. Now just state if your examinations show any odors or discoloration of the waters at the various points?

A. Yes, sir, from the record made from time to time of these daily samples—I made a record from time to time of these daily samples of the physical appearance.

Q. Well, would that examination disclose the presence or absence of sewage matter?

A. It would only show the presence of sewage provided
1734 there was a great deal of it in the water.

Q. Well, did it disclose that at any time and any point during these examinations in the Illinois River and Mississippi River?

A. It did. My original notes of analyses show that throughout the month of March, for example—

Q. March of what year?

A. 1900. My notes show the water had a decided odor of sewage as here recorded. March 12th to 28th the record is that the odor—

Q. At what place?

A. At Lockport. That the odor was that of sewer gas. Written here "Odor, sewer gas." That is, the odor of the water as it came to the laboratory for analyses.

On the third it had an odor resembling that of turpentine.

On the fifth it is described as an odor of coal gas.

On the 7th the odor is described as that of turpentine and on the 14th the odor is described as that of sewer gas and on the 15th the odor is described as that of sewage and so on through the month.

Q. Give it wherever the odors appear. Is there anything in the chemical analyses that would indicate whether the
1735 chemical constituents were warm or cold?

A. Yes, some of the odors were taken, most of the time both cold and hot. When the water was cold and when it was heated up. The odor was always more pronounced when heated.

Q. Well, is the odor distinguishable as to whether it was warm or cold?

A. I don't understand your question.

Q. Well, what I mean is could you tell from the odor whether the sewage was warm or cold?

A. I don't catch the question yet.

Q. What I want to get at is, is the heat disclosed by your chemical analyses?

A. Well, the water was cold when it came to me.

Q. You don't understand me yet. The chemical constituents of the analyses, from that can you tell whether it was hot or cold?

A. No, sir.

Q. You cannot except as you take the temperature of the water?

A. Yes, sir that is all.

Q. Now after you get the temperature is there any difference in the odor whether it is cold or warm?

1736 A. Yes, the odor is always more pronounced when it is warm than when cold.

Q. Now, just go through your analyses there and indicate the points and times when these odors were prevalent?

A. At Joliet during the month of March 1900, the water on the third day of the month had a very decided odor in the cold, of turpentine and of sewage when it was warm. On the sixth, 7th, 8th, 9th, 10th, 11th and 12th this condition continued. On the 17th the sample had a decided odor of sewage both hot and cold, likewise on the 21st. On the 29th of the same month the water although colored in appearance, had a distinct odor of turpentine in the cold and when heated up had a pronounced sewage odor.

Then passing down the river to Peoria, we find at Peoria in the early part of February 1900, that the samples had a characteristic odor of weeds or rather a musty smell, and on the 10th, the record is that there is a pronounced sewage odor of decaying animal matters when warm. On the 13th and 14th the odor is described here as that of decaying animal matter.

Q. Is that above or below Peoria?

1737 A. Above Peoria. In the month of March the records show that the water that came to the laboratory had an odor of decaying animal matters and the chart record is odor of turpentine.

Q. Where was that found, that water?

A. Still at Peoria.

Q. Above or below Peoria?

A. The Illinois River above Peoria. On the 10th of the same month the water had a decided musty odor and on the 23rd it is described as sewage. Now, the Illinois River 3 miles above Grafton during the month of February 1900. We will take February 10th for example. The notes show that the water had a decided musty smell and on the 15th the odor resembling that of kerosene or decaying matter and on the 18th it is described as a disagreeable odor.

Q. At what point?

A. At the same point, the Illinois River three miles above Grafton and the odor is described as musty, and on the 23rd a sewage odor.

Now, I have some here for the Mississippi River above Grafton. Do you want those?

Q. Yes, give those, give the year and the place?

A. February 25, 1900. The notes here show no odor, throughout the month, likewise it has no odor except on the 10th
1738 the record is, an earthy smell, the water had an earthy odor and that continued until the 15th and then on the 16th of February the notes show no odor and none the rest of the month.

The Mississippi River at the same point in 1900 in March. The water is described for the greater part of the month as having an earthy odor or clay odor, then again follows a long period with no odor noticeable in the river. There is difference between the waters at Grafton taken from the Illinois and Mississippi.

Q. Above or below the mouth of the Illinois and Mississippi?

A. Above the mouth. Whereas the water in the Illinois has a musty smell or a smell of sewage, that from the Mississippi has that odor of the earth, earthy or clay like smell.

Q. What is the cause of the two different smells in the water?

A. The clay or earth like odor of the Mississippi is due to earthy matters in the water, the earth being stirred up in the water is often cloudy. The other odor, the musty smell and sewage smell, can only be attributed to sewage impurity. I have some records for Alton.

Q. Give them.

1739 A. In February 1900 the Mississippi River at Alton. The physical properties of the river are described here as follows: February 1st found oily odor and a very slight odor on the 6th.

Q. Was that taken above or below the City of Alton?

A. Above the City of Alton. The odor continues. Found oil like odor through the remaining few weeks of February 1900. March 4th the river contained that odor of the water at Alton, was similar to that, of turpentine. That continued for several days. On the 8th, however, it had the earthy odor and on the 9th it had the odor of weeds and clay and on the 18th there was a pronounced odor of sewer gas in the Alton sample. During the rest of the month there was no characteristic odor noticed.

Q. Now, you have the record for Hartford, have you?

A. I also have the Hartford record. That is very similar again to the Alton record.

Q. That is for March 1900?

A. Yes, sir. On the 6th day of March the record is put down as musty or like weeds. On the 9th it is like clay, when heated up however, it had a characteristic turpentine
1740 smell.

Q. What is the cause of that turpentine smell?

A. I attribute that to the sewage. It is similar to the gas formed by the bacteria in the water; similar to marshy gases. Then, this musty smell was noticed on the 18th, 19th, 20th and 21st.

Q. What does the musty odor indicate?

A. That is due to bacterial action.

Q. Well, does it indicate animal organic matter in the water?

A. Yes, sir to my mind it does and when the water was warm these smells in March from the 19th until the end of the month—the warm water had a distinct odor of sewage. The record here is that the hot water had an odor of sewage from the 19th until the 31st.

Q. Will you state if that sewage odor from water in chemical analyses is an indication of sewage pollution?

A. Yes, it is. It is an indication of decomposing sewage matters in the water. I have here the Bellefontaine samples, or Missouri samples, do you want those?

Q. Yes.

A. During the same period of time observations were 1741 made on the odors of the water from the Missouri river at Bellefontaine. During February the odor is described here as earthy, both cold and hot. The Missouri water had a decided earthy odor from February 1st to 10th and from the 10th until the 19th there is also a record that the water had an earthy odor both hot and cold. From the 20th on to the rest of the month there was no odor noticed in the water of the Missouri.

I have here the Illinois Shore, Chain of Rocks. February 1st the laboratory notes show that the water collected at the Illinois shore Chain of Rocks during the month of February had a musty odor both hot and cold. February 1st there was an odor of weeds—decaying weeds. On February 9th it had more of an earthy smell, both hot and cold and on February 21st there was no odor noticed.

Q. Now, Professor, I want to ask you this question, as to whether or not decaying organic vegetable matter in water that is running will produce musty smells or turpentine odors or the odors of sewer gas or sewage odors?

A. As far as my experience goes, decaying vegetable matter produces carbon dioxide and marsh gases. These are two 1742 colorless and odorless gases. On the other hand, the decayed sewage produces gases such as phosphoretted hydrogen to a certain extent from phosphorus compounds, that is a characteristic smell, together with more complicated carbonaceous gaseous compounds that have disagreeable odors. For example we have an illustration in decaying albumen of the white of an egg. That is an albuminous substance and the odors produced from the albumen decayed is very marked and different from the odor when wood decays. Now, wood is a characteristic vegetable matter and albumen is of animal matters.

Q. Now, when you say decaying organic matter, either animal or vegetable, do you have reference to the action of the bacteria on the organic matter?

A. Yes, sir.

Q. That, is you use the term decaying as applied to the bacterial action upon substances in the water?

A. We look upon decay as a process brought out through the action of bacteria. They act as carriers of oxygen from the air to the organic matter.

1743 Q. Now, from your chemical analyses Professor, can you state if the nitrites or chlorine are higher at that point above Peoria than they were at Grafton in the Illinois river?

A. The cholrines above Grafton in the Illinois River steadily increased. I have here a table giving the average values of chlorine in the Illinois River above Grafton, above Peoria and at Joliet and at Lockport. We see a steady increase of chlorine as we ascend the river to Joliet. The Lockport samples show less chlorine than at Joliet.

Q. How do you explain that?

A. The explanation that I give for that is that the sample at Joliet was taken immediately under the canal, under the Illinois & Michigan Canal and probably contained water from that canal.

Q. That is the intersection of the two canals, that is this Illinois and Michigan canal crosses there?

A. It crosses the Desplaines River at that point.

Q. Now, can you state from your chemical examination and analysis of the waters, whether or not the nitrites are higher at a point above Peoria than they are at Grafton?

A. Yes, sir, they are decidedly higher at Joliet.

1744 Q. Now, how do the nitrites at Joliet and Peoria compare with the nitrites in the canal above Lockport? Just your general conclusions, I don't care about figures. Have you compared it?

A. I will just look up those statistics again. (Witness refers to memoranda.)

A. They are lower in the Drainage Canal showing that there has been less oxidation and I think they are a little lower at Lockport than they are at Joliet.

Q. Would that indicate more or less crude sewage in the Canal than at Lockport or Joliet?

A. That shows that there is more crude sewage in the canal than there is at points further down. The nitrites being formed gradually, free ammonia is first formed by the decomposing sewage then the oxidation processes set in and gradually form nitrites, so we find more nitrites at Peoria than we do at some of those higher points.

Q. At Joliet or Lockport?

A. At Joliet or Lockport. There hasn't been oxidation sufficient to produce large quantities but there are larger quantities of free ammonia at the higher points than at the lower points.

1745 Q. In other words, there is more organic matter in the same state that it came from the sewers in the canal than there is at Joliet or Peoria?

A. Yes, sir.

Q. Now, Professor, I will show you a map and ask you whether or not you had that made and if so show what it is?

A. Yes, I had this map constructed from the analytical results obtained in the analyses of the waters at the various points on the way from St. Louis to Chicago.

Q. Now, what is it a map of?

A. The map shows the Illinois River connecting the Drainage Canal with the Mississippi River at Grafton, then it shows the Mississippi River below Grafton, at Alton and at Hartford; it shows the flowing in of the Missouri River at Hartford; then it traces the Mississippi River down to St. Louis. The map is an enlargement of the map of the State of Illinois, taking only the Illinois River and the Mississippi River and these rivers.

Q. Well, proportionately, is it accurately drawn?

A. Well, approximately accurately. It was made by means of a pantagraph, an instrument that enlarges from a smaller map. The lines from the smaller map were enlarged and
1746 drawn on here, giving the contour of the Illinois River, so that it gives approximately the curves and the relative distances of the points on this river.

Then on the side of this map, are given the averages of the condition of the water, first before the opening of the canal, viz: in January, 1900, at the reservoir. First the table shows the condition of the water at the reservoir in St. Louis in black letters, the amounts of free ammonia, nitrites and albuminoid in January, 1900, and then below the values obtained for the same substances free ammonia, nitrites and albuminoid ammonias in February, 1900, after the opening of the Drainage Canal. These are averages taken from the tables that we have presented. For instance, the free ammonia before the opening of the canal averaged 0.111; after the opening, 0.210. The nitrites averaged before the opening 0.004 and after the opening 0.013. Albuminoid ammonia before the opening was 0.214 and after the opening 0.271. It shows a doubling of the free ammonias and trebling of the nitrites and some increase in the albuminoid ammonias in the waters of the reservoir in February over what there was in January.

Q. That was at what point?

1747 A. The reservoir of the St. Louis Water Works.

Q. Out or in the reservoir?

A. In the reservoir. It is the water that is furnished to our pumps.

Now, the next table shows similar results for Alton on the Mississippi River. The averages are given for January, 1900, and then for February, 1900, after the opening of the canal. For free ammonia and nitrites and albuminoid ammonia before the opening of the canal. Free ammonia was 0.288, after the opening it was 0.460.

The nitrites before the opening of the canal amounted to 0.212, after the opening 0.104.

The albuminoid before the opening of the canal amounted to 0.200 and after the opening 0.728.

Q. Now, in those two figures of tables you have stated, have the waters from the drainage canal reached Alton and reached the reservoir at any time during the period of these tables?

A. The water of the drainage canal?

Q. Yes.

A. I presume they have.

Q. At what time?

A. In the middle of February, from February 17, 1900.

1748 There was one month's difference between the opening of the canal and the time when this figure is given. 30 days at Alton. 30 days had elapsed.

Q. How about the first table you gave for the reservoir?

A. That is for the whole month.

Q. The month of what?

A. The month of February, 1900. That is the average for the whole month of February.

Q. Now, what is the next point at which you have the table?

A. There is a similar table for the Illinois River above Grafton showing the condition of the water there from January 23rd to the 31st, 1900, as compared with the condition of the water from Feb. 21st to the 28th, 1900? Before the opening of the canal free ammonia existed in the water to the extent of .0113 parts per million and after the opening .0946. The nitrites before the opening amounted to 0.005 and after the opening 0.025. The albuminoid ammonia before the opening amounted to 0.478 and after the opening 0.193.

Q. Now, what does that table show with reference to the
1749 increase or decrease of free ammonia, nitrites and albuminoid ammonia at Grafton in the mouth of the Illinois River before or after the opening of the canal?

A. It shows a very marked increase in the impurities, in the free ammonia and nitrites and albuminoid ammonia.

Q. Now, what is the next point at which the table is made?

A. The next point at which a table is made is the Illinois River above Peoria.

Q. Now, where is Peoria located and what distance from the mouth of the canal where it empties into the Desplaines river?

A. Peoria is 196 miles from the St. Louis water works by river and its distance to the mouth of the canal is 131 miles.

Q. Well, have you got a table for that point?

A. I have here a table giving the value of the free ammonia and nitrites and albuminoid ammonia as made in the year 1899; the average values made in the year 1899 by Professor J. H. Long and published in a report. I had to do this for the reason that my analyses were made in February and March, 1900, and after that time the water of the Drainage Canal had already reached Peoria.

1750 Q. Now, do you know whether the samples of water that you analysed, on which you base your calculations, were taken above or below the sewage of Peoria?

A. Mine were taken above Peoria.

Q. You don't know at what point with reference to Peoria in the Illinois River the samples reported by Professor Long were taken?

A. No, I do not.

Q. Give me the result of that Professor?

A. The values before the opening of the canal of free ammonia were 0.895 and after the opening of the canal 3.060 according to Professor Long, and according to my analysis 1.950.

The nitrites before the opening of the canal, were 0.141 according to Professor Long. After the opening 0.060, according to Professor Long. According to my analysis .030.

The albuminoid ammonia before the opening of the canal was 0.572 by Professor Long, after the opening of the canal 2.210 by Professor Long. According to my analysis 0.627.

Q. Now, Professor Long's were made in 1900 from what dates?

1751 A. From February to April, 1900.

Q. And in 1899 what were the dates?

A. From July to September, those are the averages.

Q. And those were made in 1900 at what dates?

A. In February and March, two months average.

Q. What chemically does that show with reference to the ammonias, nitrites, albuminoid ammonia, as to whether they have increased or diminished in the periods covered?

A. It shows there was a very great increase.

Q. Now, that table shows that from your figures alone or the combined figures of yourself and Professor Long?

A. From the combined figures there is a marked increase here of the free ammonia, nitrites and albuminoid ammonia?

Q. Do Professor Long's figures show the same thing?

A. They do.

Q. What would that indicate, an increase of nitrites?

A. That would indicate an increase of pollution of sewage.

Q. Now, have you a table or did you make a table of Grafton?

A. I have another table here showing the condition of the Mississippi River above Grafton before and after the opening of the Drainage Canal. We have here the condition of the Mississippi River above Grafton in the period immediately preceding and that succeeding the opening of the Drainage Canal. Before the opening of the drainage canal the free ammonia was 0.113. After the opening 0.176. The nitrites before the opening were 0.005 and after the opening the same thing. 1752

The albuminoid ammonia before the opening was 0.478 and after the opening 0.565.

Q. Now, does that table indicate more or less pollution for Grafton before the opening of the canal?

A. The Mississippi River shows that during this same period there was very slight if any increase in the impurities. The free ammonia increased slightly; the nitrites remained the same and the albuminoid ammonia increased in a very small amount.

Q. Now, were those samples taken from above or below the mouth of the Illinois River?

A. Above the mouth of the Illinois River.

Q. Now, have you made any comparison of the samples taken at Bellefontaine in the Missouri River?

A. I have also made a table of the condition of the water in the Missouri River at Bellefontaine.

Q. Now, where is Bellefontaine on the Missouri River with reference to distance from the intake of the Water Works at St. Louis?

1753 A. It is 14 miles from the intake of the St. Louis Water Works by river but it is above the mouth of the Missouri River. In order to get the idea of the condition of the water in the Missouri River during this same period immediately before and after the opening of the drainage canal I have taken the average of the analyses of the Missouri River saved from January, 1900, and I find that before the opening of the canal that free ammonia was 0.135 and after the opening the average for February was 0.148. The nitrites before the opening were 0.008 and after the opening 0.014.

The albuminoid ammonia before the opening was 0.063 and after the opening 0.395.

Q. Now, what does that table show with reference to whether or not the stability during that period of time in the waters of the Missouri River at Bellefontaine?

A. It shows that there was also a slight increase in the impurities in the Missouri River during the months of February to April, but this increase was very much less than the increase in the waters of the reservoir, in our reservoir water. Whereas, the increase in the free ammonia in the Missouri was only .013, the increase in the water of the reservoir was 100 per cent or 1/100.

Q. Increase of what?

1754 A. Free ammonia.

Q. How about the nitrites?

A. The nitrites in the Missouri River increased .006 in the reservoir to .009.

Q. How about the albuminoid ammonia?

A. The increase in the albuminoid ammonia in the Missouri was 0.332 and in the reservoir 0.057.

Q. Now, do you know whether or not the frequent or sudden changes of nitrites and free ammonia and chlorine in streams is looked upon as an indication of pollution?

A. Yes. The sudden changing in the nature of water is always to be regarded as suspicious.

Q. Why is that?

A. Because it shows that there is sewage pollution. Sewage pollution brings about changes in the composition of waters much more readily. These fluctuations vary more in samples taken at the same point in a stream charged with sewage pollution than you find in a stream containing vegetable or organic matter. Vegetable organic matter is much more stable than animal matter, that is very much less stable and we are apt to find greater changes and sudden fluctuations in the free ammonias and in the nitrites in sewage polluted water than in water containing vegetable organic matters.

1755 Q. Now, I believe you stated yesterday that you were acquainted with Dr. Drown's work on Water Analysis?

A. Yes, sir.

Q. Well, is that a recognized authority?

A. Yes, sir.

Q. Well, he states this "That it is most important to know if water is stable, since one of the best aphorisms ever contributed to the literature of the water analysis is a state of change is a state of danger." Now, as a chemist and water analyist, do you recognize that as one of the nitrites or dangerous waters?

A. Yes, sir, I do.

Q. Can you tell from you chemical analyses and results thereof whether or not the waters of the Mississippi River above Grafton and the Missouri above the confluence of the Mississippi are stable?

A. They are much more stable than the water of the Illinois River or of the Mississippi River below the mouth of the Illinois.

GENERAL CROW: Now, I want to offer that map referred to by the witness.

1756 Map offered in evidence marked by the Commissioner "Complainant's Exhibit No. 35. Frank S. Bright, Commissioner."

EDWARD H. KEISER.

Adjourned until 10 o'clock A. M., Monday, March 16th, 1903.

1757 Southern Hotel, St. Louis, Mo. 10:00 a. m., Monday, March 16, 1903.

Present, the Commissioner and same counsel representing the respective parties.

PROFESSOR EDWARD KEISER, resumed the stand for further direct examination by General Crow and testified as follows:

Q. Professor Keiser, will you please state what season of the year oxidation of running water occurs most rapidly?

A. In the spring and summer months. During the summer months when the temperature is high, oxidation takes place. I should say in June, July and August are the months of the year when there is the greatest self-purification of streams. I should think there would be and in fact, the analyses show that there is very little, comparatively little, purification in cold water, when the temeprature of the water is cold, at the freezing point and especially when the rivers are covered with ice.

CROSS-EXAMINATION, by Mr. Johns.

Q. How long had you been in St. Louis before you commenced these chemical analyses?

1758 A. I first came to St. Louis in June, 1899, and made a chemical analysis beginning on the 24th day of January, 1900.

Q. You did not then arrive here in the fall of 1899?

A. No systematic analyses—

Q. I beg your pardon. I am asking you as to the time of your coming here. When did you arrive in the City of St. Louis and take up your duties as a chemist?

A. September 20, 1899.

Q. In what capacity did you then pursue your profession?

A. As a Professor in Chemistry at Washington University.

Q. And during the time of these analyses, to which you have testified, were you a Professor of Chemistry at Washington University?

A. Yes, sir.

Q. Had you or were you continuously in St. Louis from September at the opening of Washington University, until the time these chemical analyses commenced?

A. Yes, sir.

Q. Had you traveled up the Missouri River any to examine the character of the soil, and the locality from which the waters came, the Missouri waters?

A. I have been to the waterworks and I have been to some points on the Missouri River.

Q. Well, before you commenced these analyses or afterwards?

1759 A. Afterwards.

Q. Before you commenced these analyses had you traveled up the Mississippi?

A. No, sir.

Q. Or up the Illinois?

A. No, sir.

Q. Have you since traveled up the Mississippi with a view of examining the soil and the water and the sources of the water?

A. No, sir.

Q. Have you since traveled up the Illinois with such a view?

A. No, sir.

Q. Have you ever traveled up the Illinois River with a view of determining the sources of its water supply?

A. No, sir.

Q. Were you ever at Joliet?

A. No, sir.

Q. Or at Lockport?

A. No, sir.

Q. So that with the physical situation of the waters and the origin and derivation of the waters of which you have been testifying, you have no personal knowledge?

1760 A. I have not.

Q. Isn't that knowledge regarded as important in making up a judgment as to the water?

A. Only in so far as the water is of different origin from that which we have examined in this case. A spring with water or a well water, it is especially necessary to know the surroundings, the country, the soil and the character of the buildings, and so on, with that kind of water but the topography of the country in general through which the Illinois river runs has been described so frequently in reports by various scientific bodies and I have read those descriptions so that I have been able to form a very clear opinion on that point.

Q. That is from the reading of reports in regard to the character of the country through which the Illinois river runs?

A. Yes, sir.

Q. Does that report also show the character of the country through which the numerous feeders of the Illinois flow?

A. Yes, sir.

Q. What report is that?

A. I have read the reports of the Illinois State Board of 1761 Health, and I have read the reports that were issued by the University of Illinois on the chemical survey of the waters in the State of Illinois, and especially the Illinois river and its tributaries.

Q. But you had no personal observation of it whatever?

A. I have not.

Q. Now, for instance, do you know the character of the waters of Macoupin creek?

A. I do not.

Q. Or of the Sangamon River?

A. Only in as far as I have read about it in these reports.

Q. Or of the Mackinaw?

A. No personal knowledge.

Q. Nor of the Des Plaines?

A. No, sir.

Q. Nor any other one of the rivers or creeks that empty into the Illinois River?

A. No, sir, I have not.

Q. Your laboratory in which you carried on these analyses is where?

A. 17th and Washington avenue, St. Louis.

Q. During the entire time?

A. Yes, sir.

1762 Q. Is that a part of Washington University, that place?

A. Yes, sir.

Q. Now, what kind of premises was it in which you conducted these analyses?

A. A two-story brick building with all the appliances of a chemical laboratory. It was especially built for chemical work, analytical work.

Q. Well, did you carry this on in one room or a number of rooms?

A. The ammonia determination and the nitrite determinations were made in a room that was expressly reserved for work of that kind. The chlorine determinations and the total solids and the nitrates were carried on in an adjoining room and these rooms were given up entirely to this work. No other work was carried on there at that time. The analytical part of the work is done entirely on the ground floor of this two-story laboratory that I have mentioned.

Q. Could you give me a brief description of the interior of that laboratory on the first floor as to the walls and furnishings and colors?

A. The room in which the ammonia distillations were carried on was well lighted and supplied with working tables and

sinks and was especially constructed with apparatus for making
fourteen distillations of water simultaneously. There was
1763 a large condenser that had 14 condensing worms in it
made of black tin pipe and to each of these condensers
there was a dish, by means of a cork and bottle of Jena glass of a capacity of one meter into which samples of 500 cubic centimeters of each water was poured and this apparatus was heated with a Bunsen burner. In each case the glass was heated with a Bunsen burner and on the other side of the condenser there were a series of Nessler tubes of 50 cubic centimeters capacity of which the distillate from each flask was collected. There was also in this room water baths.

Q. What do you mean by water baths?

A. A water bath is a copper vessel for holding water that is heated by steam and evaporating dishes are placed on concentric rings on the back of these copper boxes, so that the dishes are heated by the steam coming up through the copper box, and the measured samples of water were filtered in the platinum dishes placed upon this water bath. Then in the adjoining room, a small room adjoining, we reserved for the determination of nitrites. The samples of water here were filtered through Swedish filters, Swedish filter paper and 100 cubic centimeters of each specimen that was analyzed was treated with
the Alpha Naphthalyne and with Sulphanilic acid and
1764 allowed to stand for 30 minutes for the development of
the color that is produced if nitrites are present in the
water.

Q. Was the water in your evaporating dishes exposed to the steam?

A. No, sir; the steam was underneath the dishes and the dishes were held in these rings and they were exposed to the air above.

Q. But the steam did not pass over them and come in contact with the evaporating water?

A. Except so far as it escaped from the rings. A little steam escaped from the water bath, but did not come directly in contact with the water in the dishes.

Q. Now, in these operations or distillations, by whom were you assisted?

A. I was assisted by Dr. Gellert Alleman, who at that time was an instructor in chemistry at Washington University, also by Dr. William H. Warren, who is a Professor of chemistry in the Medical Department at Washington University and by Mr. E. B. Fulks and by Mr. Sherman Leavitt during a portion of the time, and by Mr. Alfred Kammerer and by Mr. Robert Schmidt.

1765 Q. Did those gentlemen have especial parts of these analyses confided to them?

A. Yes, sir.

Q. For instance, what did Dr. Alleman do?

A. Dr. Alleman determined the chlorines in the samples of water and assisted with the nitrates.

Q. What did Warren do?

A. Warren gave his attention exclusively, together with one of the assistants, to the determination of free and albuminoid ammonias and the oxygen consumed.

Q. What did Fulks do?

A. Fulks did nothing but total solids and loss on ignition of the total solids.

Q. What did Leavitt do?

A. Leavitt did nitrites and assisted with the nitrates.

Q. What did Kammerer do?

A. Kammerer only worked a portion of the time and relieved Fulks at times and at other times relieved Alleman. Alleman was absent during two months in the summer time, when his work was taken by Fulks.

Q. What did Schmidt do?

1766 A. Schmidt prepared solutions and in general assisted in the work especially of determining total solids and assisted in the laboratory in general.

Q. Now, how much of the actual work of analyses did you perform?

A. Well, I was with these men every day and I kept the records carefully and I kept the solutions from day to day to see that their solutions were accurate, and it was, of course, an impossibility for me to make complete analyses myself. I had to simply see that these men did their work carefully and to check them from day to day by making separate analyses and by testing their solutions and in general having an oversight to see that the work was done faithfully.

Q. You mean by solutions the various reagents that were used in making certain results?

A. Yes, sir.

Q. And the standard solution by which comparison was made?

A. Yes, the scales of color for the ammonias and nitrites and nitrates.

Q. Now, as to the actual work as distinguished from the actual supervision, you did little?

1767 A. Well, in the early part I made altogether I should say, several dozen analyses independently.

Q. Complete?

A. Yes, complete.

Q. Did you make many after that time with reference to any particular pollution?

A. Yes, during one week Dr. Warren was taken ill, a week in the early part of July, 1900, and I did all of the free ammonias and albuminoid ammonias and the oxygen consumed processes, myself for about 10 days with the assistance of one of the younger men. I actually made distillations of 14 samples a day of free ammonias and albuminoid ammonias and I Nesslerized those distillates.

Q. Every day, from those 14 flasks?

A. Yes, sir.

Q. That is when you used 14 and 12 when you used 12?

A. Yes, sir.

Q. And you applied Nessler's solution to those for the determination of ammonias?

A. Yes, sir.

Q. Otherwise your conclusions are drawn from reports made by these various men as to their various determinations on the various things with reference to which they analyzed?

1768 A. Yes, but they never reported to me final results of analyses. They reported to me for instance, that the readings in the ammonias were certain numbers for each Nessler tube and I added up these figures myself and made the calculation for the parts per million.

Q. You did the mathematical work in that?

A. I did all the mathematical work in every analysis.

Q. Assuming that a flask of water came to your laboratory on a certain time, how long until the analysis of that particular flask was commenced?

A. We began immediately for the determination of nitrites and the free ammonias were done immediately, that same day, we finished up the nitrites and the free ammonias the same day.

Q. When would the other determinations be made as to that particular flask?

A. The other determinations were made the next morning. Our samples reached us about half past three to four o'clock in the afternoon of each day. For example, a sample that was taken at the Chain of Rocks or at Alton or at Grafton was sent down by express. The samples were taken in the forenoon and reached us about half past three to four o'clock and we immediately determined the nitrites and the free ammonias that same day, but the albuminoid ammonias and the
1769 chlorines and the nitrates and the total solids were made next morning.

Q. Now did those samples uniformly reach you packed or cased in ice?

A. Only in the warm weather.

Q. Only in warm weather?

A. Yes.

Q. During what months?

A. During the months of June, July and August, as I remember, until the latter part of September. I am simply giving this as far as I remember.

Q. Now, with reference to the water arriving at your place in June, July, August and September. When the water arrived the temperature was lower than when taken out of the river at the various places?

A. I made no determinations of the temperature of the water.

Q. Did you determine the temperature of the water at the time you commenced your first operations or analysis?

A. You mean the water that was delivered to me?

Q. Yes.

A. No, sir.

1770 Q. At no time?

A. At no time.

Q. During no part of the investigation?

A. No sir.

Q. Was the temperature of the water in your opinion lower in June, July, August and September when it arrived at your laboratory than it was when it was taken from its source?

A. I can hardly express any opinion on that. Perhaps sometimes it was a little lower. It was not at the freezing point, of course. It may have been lower it probably was in some instances.

Q. Now, for instance do you know on any particular day when the water was taken at the Chain of Rocks, the temperature of the river at the point?

A. No sir.

Q. And as to a sample taken upon a particular day the temperature of that sample when it arrived at your laboratory?

A. I never took any determinations of the temperature, but it was probably lower. It was probably lower because 1771 these bottles were put into refrigerators and were kept cold.

Q. Now of course low temperature does not produce as much chemical change in the water as higher temperature, not up to the boiling point, in a given length of time?

A. No, sir.

Q. Does it produce such change as to any particular element?

A. I don't understand the question.

Q. Well a bottle of water is taken out of the Mississippi at a temperature of 65 at 10 o'clock in the morning, it arrives at your laboratory at a temperature of 37 at 3 o'clock in the afternoon and has been kept at that temperature for 5 hours. Would that fact produce any kind of a change chemically in the water and if so what kind and to what extent?

A. I know of no change that was produced in the water.

Q. Would it, if it was kept 24 hours at a temperature of 37, when its source was 65?

A. Not that I know of.

Q. Would it if it was kept four days.

A. The water would change naturally on keeping, whether the temperature was high or low, because water—

Q. Answer the question.

1772 A. There would probably be a change.

Q. In what elements and in what respect?

A. The water if kept at a lower temperature than that at which it has been collected would very slowly have a conversion of nitrites into nitrates and of free ammonia into nitrites but this change would be very much less than if the water had been kept at the original temperature.

Q. But there might be a change?

A. There would probably be a change, a very slow one.

Q. And as a matter of scientific knowledge if the water was taken at its source at 65 and maintained for 24 hours at 90, there would be still other changes and more rapid?

A. Very much more rapid. The best thing we can do with water if we have to transfer it at all from the place where it is taken is to keep it in ice. If we let it go at the ordinary temperature the changes will be more rapid.

Q. It is less liable to change if kept in ice than if kept at its normal temperature?

A. It is less liable to change if kept in ice.

Q. Before the determination of the solids what did you do?

A. We evaporated 100 cubic centimeters of the water to dryness in an evaporating dish, in a weighed evaporating 1773 dish, and when it had gotten dry on the water bath we transferred it to an air bath kept at a temperature of 110 degrees centigrade. We allowed this dish to remain there for 15 or 20 minutes, then we took it out and allowed it to cool in a dessicator and then weighed it.

Q. 110 degrees centigrade would be how much Fahrenheit?

A. May I figure it out for you?

Q. Yes, glad to have you.

A. 230 degrees Fahrenheit.

Q. Does the Mississippi River water have considerable matter in suspension?

A. Yes sir.

Q. The waters in the reservoirs at St. Louis Water Works, have they considerable matter in suspension?

A. Yes sir.

Q. Now would that on being allowed to stand, settle?

A. Yes sir.

Q. How great a per cent?

A. That varies very much on the condition of the river.

Q. Well, in a general way, as a general matter of opinion, what would you say?

1774 A. It varies with the length of time it is allowed to stand in the reservoir and it varies from day to day according to the way they draw off the water from the settling basin.

Q. Now I will change the question. Take the water as it goes into the intake tower, has it very considerable solids in suspension?

A. It has.

Q. About what per cent as a matter of your general observation?

A. You mean the amount that settles out in the reservoir?

Q. No, taking a glass tube full of water at the Intake, 2 feet high, we will say, being allowed to stand for four hours, how much of the solid matter would settle?

A. Well I should say that 75 per cent of the solid matter would settle.

Q. Well what per cent of the total contents would that be?

A. Of the original weight?

Q. Yes of the original weight of the water.

A. At least 50 per cent.

Q. One-half of the entire weight is solids in suspension?

A. Well, I couldn't say that for a certainty. I haven't weighed that, I have never made that experiment. It is purely guess work.

1775 Q. You have observed these waters at least during these examinations and I want your opinion?

A. Well, I have observed that at some times of the year the water is very full of mud and at other times it is very much clearer and with reference to the water full of mud a great deal of this mud will separate out in a short time. At other times, when there is some slight turbidity, as when the water is low, then it doesn't get clear, even though we allow it to stand for 48 hours.

Q. Have you at any time, at any stage of the water, ever allowed it to settle with a view of determining the weight of the matters in suspension?

A. I have not.

Q. Now in addition to the solids in suspension—do you term that mechanical suspension or natural suspension—what is the term?

A. We simply say suspended matter.

Q. Now do you recognize that some other solids exist in mechanical form that would not settle?

A. Yes sir.

Q. What do you term those solid matters as distinguished from matters in suspension?

1776 A. We call those in solution.

Q. Now when you endeavor to obtain the solids in these waters which you examined, you evaporated a given quantity of water in a dish to dryness, I presume?

A. Yes sir.

Q. Then you put that dish in a water bath for what purpose?

A. I put it into an air bath.

Q. I mean into an air bath?

A. For the purpose of completely drying it.

Q. For the purpose of completely drying it?

A. Yes.

Q. What kind of a thing is this air bath?

A. It is a copper box with a door in front and an opening at the top for the insertion of a thermometer. It stands on four legs and is heated with a lamp, a Bunsen burner at the bottom.

Q. How long would you allow it to remain in this air bath?

A. Allowed it to remain 15 or 20 minutes.

Q. Then you took it out and weighed the dish?

A. After it had cooled off in the dessicator.

Q. Then you weighed it?

A. Then we weighed it.

1777 Q. Now, in that way you determined the solids?

A. By subtracting the weight at the end, subtracting from that weight the weight originally of the dry dish.

Q. Now then, when you made these examinations, did you ever put these solid matters so obtained in this air bath more than once?

A. No sir.

Q. And never longer than 15 minutes?

A. No sir.

Q. Did you never take them and put them back in the air bath after they had cooled in the dessicator to heat them again?

A. Ordinarily in a careful water analysis we did that.

Q. I am asking you as to this particular instance?

A. In the regular routine work we did not. We heated it uniformly for 15 to 20 minutes in an air bath, then we assumed they were dry and cooled them in a dissicator and weighed them.

Q. Did you have in this drying process of the solids, a stated time from which you did not depart, of the remaining of the dishes in the air bath?

A. Our time was from 15 to 20 minutes.

1778 Q. Did you have any particular time which you carefully and conscientiously adhered to at all times?

A. Yes sir.

Q. What was it exactly?

A. Well, from 15 to 20 minutes.

Q. Now that is a range of 5 minutes; was it 18 minutes or 17 1-2 or any one particular time?

A. It wouldn't make any difference.

Q. I didn't ask you whether it made any difference, excuse me. I am asking you for a fact.

A. We tried to get the time as near as we could to 15 minutes.

Q. But your 15 minutes was not an absolute rule which if transgressed was broken?

A. We made it as nearly 15 minutes as we could working with 14 samples a day.

Q. You don't understand me, was it 15 minutes or any other time, an absolute rule which if transgressed was broken and you discarded that sample?

A. Yes, that was the rule.

Q. That was the rule absolutely now, 15 minutes?

A. Yes sir.

Q. And if it went on to 17 1-2 minutes would you discard the sample?

1779 A. If the time was noted, if we noted that we had run over the time very much, why of course we discarded it.

Q. I don't care whether it was a minute over or one second or one hour, if you had an absolute rule what was it?

A. The absolute rule for the man who made these determinations was to dry the solids for 15 minutes in the air bath but I know he couldn't take them all out in the same instant.

Q. That answers the question. How many did you have in at any one time?

A. We could put in 14 at one time.

Q. And at the expiration of the time you took them out?

A. We took them out and it would take a man more than a minute to take them out.

Q. I am aware of that, but if you commenced to take them out at the expiration now of an absolute time which was not between from 15 to 20 minutes but was at 15 minutes precisely?

A. Well, he took them out as nearly 15 minutes as he could tell.

1780 Q. Now when you put your 14 samples into the air bath did your assistant, Mr. Fulks, make a note of the time when they went in?

A. He looked at his watch and noted the time when it went in.

Q. Did he make a memorandum of that upon some record?

A. Yes, he had a large card over this air bath where the daily numbers were put on. Each bottle of water which, of course, had a serial number and he recorded the number of the sample that went into each numbered evaporating dish and the time when these dishes were put into the air bath was put down on this card and then the time when they were taken out.

Q. The hour and the minute and the second as nearly as possible?

A. Yes sir.

Q. Now, you don't know the name of the persons who brought you the samples? They came in the regular course of this investigation to you. You don't know the names of the persons who brought the samples to you?

A. Yes sir.

1781 Q. They were brought by some Express Company?

A. They were always delivered to me by certain men that were employed by the City Chemist and I did know the names of those men at the time, there were always two of them and sometimes three, one man drove the wagon. There was a special team that was used, that was furnished by the city.

Q. Now, were those samples first brought to the City Chemist's office and then sent from the City Chemist's office to your laboratory?

A. There were always two samples brought from the railroad station to the City Chemist's office and there one sample was left and then the same team brought them to my laboratory.

Q. So that for each set of two samples that arrived at the City Chemist's office during this entire investigation, you received one?

A. I think that was the case.

Q. Now, did you receive any samples from the Missouri river.

A. Yes sir.

Q. How many?

A. We got a daily sample from Bellefontaine.

1782 Q. Any other place on the Missouri?

A. No sir.

Q. At any time?

A. No sir.

Q. Did you receive any samples from the Mississippi River at any place above Alton?

A. Yes sir.

Q. From what place?

A. At a point above Grafton.

Q. On the Mississippi?

A. Yes sir.

Q. Well, above Grafton give those?

GENERAL CROW: What river do you mean, the Mississippi?

MR. JOHNS: Yes. At any other place above Grafton you received none?

A. Not regularly. I think in the early part there were a few that came from a point farther up.

Q. What point farther up?

A. I don't recollect the name now. It is in my notes however and I can find out for you.

Q. Not a great many?

A. Not a great many.

1783 Q. Did you receive samples each day of the Mississippi water at Grafton or above?

A. Yes sir.

Q. During the times here that you have testified concerning?

A. Yes sir.

Q. You have testified concerning times from the 24th of January, 1900, to the 10th of October, 1900? And then into October and November, 1901, I think?

A. Yes sir.

Q. Was that all the analyses you made of these various waters?

A. Yes sir, that was one period during which we analyzed them systematically daily.

Q. Did you analyze them unsystematically or irregularly from Oct. 10, 1900 to January, 1901, for example?

A. We took occasional samples in our laboratory for analysis, simply for the purpose of instruction. The students made the analyses.

Q. You kept no record of those?

A. Yes, I have a record of those but they have not been presented in this report.

1784 Q. Did you make an examination of the waters of the Illinois above Grafton and analyze them between October 1900 and February, 1901?

A. No sir.

Q. Did you of the Illinois above Grafton between October 5, 1900 and the time at which you commenced in October, 1901?

A. No sir.

Q. None whatever?

A. None whatever.

Q. You never heard of any analyses of any waters above Grafton in the Illinois during that period in your laboratory?

A. Well, you say have I heard of any analyses?

Q. In your laboratory?

A. We haven't made any in my laboratory.

Q. When you made the analyses of the waters of the Missouri, during what period was it?

A. First from January 24, to October 10, 1900, and then again from October 1st to November 30, 1901.

Q. And that is all the analyses of the Missouri waters that you have made in a systematic way?

A. Yes sir.

Q. Did you prior to those, that is prior to the commencing of those analyses under the direction of the City Chemist, analyse the waters of the Missouri from any point?

1785 A. No sir.

Q. You never had?

A. No sir.

Q. Was one of the samples which you analyzed always from the water cock in the laboratory during this entire period?

A. Not during the entire period. The tap sample was taken daily at 11 A. M. Not during the first two months but along in Aprid 1900 we began, in April, May, June, July, August and September and then again in October and November 1901. We always took the samples from the tap in the chemical laboratory.

Q. Now is there such a thing as standard of potable water?

A. Not a very definite standard.

Q. If there is an indefinite standard is it the same at all places?

A. No sir.

Q. Must the potability of water be determined by the locality?

A. The character of the water, yes sir.

Q. Well, the character of the water is determined by the locality, isn't it?

A. Well, there are various kinds of potable waters. We classify potable waters in the surface waters and subsoil
1786 waters and deep well waters and spring waters.

Q. Now surface water I suppose you would call river water?

A. Yes sir.

Q. Now is there a standard of potability for surface water in the Mississippi river?

A. Yes sir, there is a standard of potability for river water?

Q. Now what is that standard of potability for river water?

A. Well that standard is given in our text books something like this: Free ammonia not above .06 parts per million.

Q. Is that six tenths?

A. No, that is six hundredths, that means if we find free ammonia in river water higher than that we are inclined to look upon it with suspicion.

Q. Now, as to some other element?

A. Then as to albuminoid ammonia. If it goes above .18 that shows that the nitrogenous organic matter in that water has approached the danger limit.

Q. That is .18 in the million?

A. Yes sir.

Q. Now, some other?

1787 A. If nitrites are in measurable quantities, that is if we can estimate the number of nitrites and express it in figures. If we do not simply know what it is but if we get enough so that we can compare the colors and determine the parts per million. If we do get .001 per million or .002 per million, that condemns the water, because it has gone beyond the limit. Measurable quantities of nitrites condemn the water.

Q. Anything above those numbers?

A. Yes sir, those are the chief characteristics.

Q. That renders the water having nitrites in it of a measurable quantity, potable or nonpotable, which is it?

A. Unpotable, I think.

Q. Now, as to any other element of pollution?

A. Well, if the chlorine runs higher than the average for that section of the country then we suspect sewage contamination.

Q. Now what is the average of chlorine in the Missouri river at its mouth?

A. May I look at my notes?

Q. Yes.

A. I have the averages for chlorine at Bellefontaine, which is at the mouth. The averages are from 15 to 16 parts
1788 of chlorine in the Missouri.

Q. Now a higher per cent of chlorine in the Missouri river than .16, did I understand it—

A. 15 to 16 it would run. In my record it runs from 11 up to 23.

Q. Now then at 23 the waters of the Missouri become unpotable?

A. No. If it runs very much higher than that we would say it was.

Q. Say it was 50.

A. Yes, we would suspect then sewage contamination.

Q. Well, if it was .1112 would it be potable?

A. Do you mean .1112 parts per million?

Q. Yes.

A. That would be very much less. It never has been that small, it always has more than that. It never has so small a quantity as that.

Q. Now it did have that on the 24th of January, if I recollect your notes, unless there is a mistake in the typewriting? That is the reason I asked you?

A. You have given me one tenth of a part per million.

Q. 1112.

A. That would be a little over one-tenth of a part per million.

1789 Q. Now, when you read the figures I think you read that very number as to the chlorines in the Missouri river off the Intake tower at the Chain of Rocks on the Missouri shore. What did that mean?

A. Well, if I read that it meant that there was a little over one-tenth of a part per million chlorine in the water. There is always more than that. It runs all the way from 10 to 23 parts per million.

Q. Could you look at your notes for the chlorine?

GENERAL CROW: Are you referring to the nitrates?

MR. JOHNS: No sir, to the chlorine.

A. I don't think I gave the chlorines for the Missouri shore in the direct testimony.

Q. If there is such a thing as that in the testimony it is a mistake in the amount, you think?

A. You mean of the chlorine at the Missouri shore?

Q. Yes.

A. I can give you the monthly averages.

Q. Excuse me. I don't care for that just now. If there was any such statement as that it was either a mistake of the stenographer or a mistake of the tongue here in giving it?

A. Yes, it must be a mistake.

Q. There is no such state as that occurring in the Missouri river? 1790

A. No sir.

Q. I want to go back a moment again in your analyses. When you in analyzing find color in the analyzed water, then you make a color to match it in another tube by adding a standard and fixed quantity?

A. Yes sir.

Q. How do you determine the color on the analyzed water?

A. We compare the colors produced in the Nessler tubes, for instance, with a similar set of colors made in similar tubes with known quantities of ammonium chloride solution. Then we match these colors by placing them over a piece of white glass. At the bottom of this rack—there is an expressly constructed rack for holding these Nessler tubes and for the scale, and at the bottom of this there is a piece of white glass that throws a white light up through the tube.

Q. How long were those tubes?

A. These tubes were about 11 inches from the bottom up to the scratch. I think about 11; the whole length of the tube was about 12 inches.

Q. You didn't use 2 foot tubes?

A. The tubes holding the color like the samples of water and also the tubes holding the standard color, were about eleven inches up to the mark and up to the top twelve inches.

1791 Q. You didn't use two sets of tubes in the examination of colors at all?

A. We used one set of Nessler tubes for the free and albuminoid ammonias and for the nitrites we had a shorter Nessler tube. That was about an inch in diameter and about six inches high.

Q. Now, I understand you to say that you made a determination by a series of experiments whether the waters of a given river are homogeneous?

A. Yes sir.

Q. The waters of the Mississippi for instance, at the Chain of Rocks, you can by a series of experiments, determine whether they are homogeneous?

A. Yes sir.

Q. That would be by taking the samples across the river so as to substantially make a cross section of the river?

A. Yes sir.

Q. How frequently would you take such samples if you were to determine the homogeneity?

A. We took the daily samples of water at the Intake.

Q. I am asking you of a supposititious case, Professor, how many samples across the river at the Chain of Rocks would you take to determine the homogeneity or lack of it?

A. Well, we took three samples daily.

1792 Q. Would you if you were to determine that thing and that only and when working for that purpose and that only, take more?

A. Well, it would depend upon how accurately we wanted to know the variation in the river at different points. You can get a very fair idea with three samples, one at each side and one in the middle.

Q. But if you wanted to be very accurate about it you would take a greater number?

A. If you wanted to know how it varied all the way over you would take a greater number.

Q. You actually took in the Mississippi river, with these experiments at the Chain of Rocks, how many?

A. Three every day, one at the Intake and one at each shore.

Q. Will you please examine your notes or tables for the free ammonia on the Missouri shore, the maximum or average and on the Illinois shore for July 1900? What I would like to have you do is to take it from the same paper you testified from.

A. I have got the Illinois shore here for 1900. The maximum free ammonia for the Illinois shore July 1900 occured in the fourth week of July and was equal to .0388 parts of nitrogen per million of water. This is the Illinois
1793. shore and the average for July was .0291.

Q. Now, look at the Missouri shore. You have an algebraic formula by which you determine the amount of water or relative amounts of two sources of water in a given place at a given time?

A. Yes sir.

Q. Do I understand you that that is the actual water in the actual proportions. For instance you arrive at a conclusion in a calculation here by this algebraic formula "that the proportion of the Missouri to the Mississippi was three-fourths or it was three-fourths Missouri water?"

A. Yes sir.

Q. Now do you mean to say that that is actual water or is that a supposititious or chemically conceived stream made for the purposes of the calculation?

A. That is made from these results and shows that water taken at that time contains three-fourths of the Missouri water and one-fourth of the Mississippi water.

Q. Now, won't you on a piece of paper take down this supposition, "let X equal the fractional part of the Illinois River above Grafton and Y equal the Mississippi River at Hartford. A equals the nitrites above Grafton .0257, B equals the nitrites at Hartford on the Mississippi, .0120
1794. and C equals .0071, nitrites Illinois shore Chain of Rocks." Now give me the value of X and Y?

A. Do you want me to figure the value for X and Y provided these rivers mix?

Q. No supposition about it, I want you to give me the value of X and Y?

A. Well, I can do that but it does not mean anything.

Q. Well, I want it at any rate.

A. Now assuming those waters mix and they do not.

Q. I simply want your conclusion as a mathematician on that given state of facts?

A. $X=\frac{.0049}{.0137}$—which is an absurdity.

Q. That is an absurdity?

A. The rivers do not mix and we don't have that quantity.

Q. That proposition is of itself then an absurdity, is it?

A. Yes, if you take these numbers in this way.

Q. Now, assuming X to represent a fraction of the Illinois River above Grafton and Y a fraction of the Mississippi River above Grafton and A the nitrites in the Illinois River above Grafton .0257 and B the nitrites in the Mississippi River above Grafton .025 and C the Illinois Shore at the Chain of Rocks, nitrites .071 for the same period. Now, give me the value of X and Y?

1795 A. About one-fifth.

Q. X is one fifth of Y?

A. Yes, X is one-fifth and Y is four-fifths. The Mississippi mixes four-fifths. It is pretty nearly that.

Q. Approximately?

A. Approximately, yes sir.

Q. Well, if the fact was independent of the algebra that the Illinois River at Grafton at that time was less than one-tenth of the Mississippi in volume, your mathematics are not of much account?

A. Well, it shows that as far as the nitrites are concerned one-fifth of the nitrites were furnished by the Illinois river and four-fifths furnished by the other.

Q. That is precisely to the point I want to bring it. Your algebraic formula does not represent the amounts of water at all?

A. They represent the amounts of water that are necessary to furnish that constituent to the Illinois.

Q. As a matter of fact it represents the proportion of nitrites in the water and does not as a matter of fact represent the volume of water distinguished from some chemical conception or the conception of a chemist?

A. It means that that proportion of the whole that much of the other water is required to furnish that much nitrites.

1796. Q. Now, isin't it a theory that you might as well assume nitrates as nitrites in that action?

A. You can take any one of our measured quantities in this calculation.

Now as a mathematical opinion, and I have not much, would not those proportions vary as one-fifth and four-fifths upon any other element upon which this calculation might be made?

A. They would vary as the other elements varied.

Q. So that it is a calculation of the comparison of polution as to a certain element and not a determination of the actual volume of water?

A. It is not an actual determination of the volume of water.

Q. What you meant to attempt to do with that and what you do as far as the mathematical formula is concerned, or algebraic formula, is to determine that if at a given point there are .0120 of free ammonia and at some other point a certain other number of parts and at a certain other point a certain other number of parts, these two confluent sources furnish a certain ascertained amount of free ammonia at the given point?

A. Yes sir.

Q. So that it is theory and not actual water?

1797 A. Yes sir, it is theory.

Q. Now, with the waters of the Mississippi and Illinois mixed bearing nitrites into the Intake Tower and therefore into the reservoir at St. Louis of four parts of nitrites for the Mississippi and one for the Illinois, and supposing at the same time that of the total water going into the Intake tower the Missouri furnished three-fourths and the Illinois and Mississippi combined one-fourth, which is your algebraic equation here, that was the conclusion at which you arrived?

A. Yes sir.

Q. Now, what proportion of the Illinois nitrites under those proportions got into the Intake tower, what amount?

A. Well, if the Illinois furnished one part to the four parts of the Mississippi, which it never does, the Illinois always furnishes more than the Mississippi, but making this assumption one-fourth of the nitrites furnished by the Mississippi would come from the Illinois, and since one-fourth of the nitrites would come from the reservoir, come from that, one-fourth of one fourth is one-sixteenth, therefore, one-sixteenth of the nitrites in the reservoir would come from the Illinois.

Q. Why do you say that the Illinois never does furnish one part of nitrites to three to four parts of the Mississippi?

1798. A. My analyses show and all the analyses that I have seen of the water at the mouth of the Illinois and Mississippi, show invariably higher nitrites, especially in the winter time. The Illinois having greater nitrites than the Mississippi.

Q. Certainly, but when one-tenth of the volume comes out of the Illinois of the volume out of the Mississippi to make a total at the Chain of Rocks then the proportion of the nitrites to the whole body is much less for the Illinois than for the Mississippi?

A. Yes the proportion that came from that, certainly.

GENERAL CROW: Let me understand. You and the witness don't understand each other. You mean the proportion of nitrites in the whole body of water, the combined waters at the Intake, that is what you mean?

A. Yes sir.

GENERAL CROW: Let the records show that is the proposition he means.

CROSS-EXAMINATION.

By Judge Springer.

Q. Professor Keiser, you have stated that you made certain analyses of the waters found in the Missouri River at Fort Bellefontaine?

A. Yes sir.

1799 Q. Have you given the result of those samples?

A. I have given some of the results.

Q. What result did you give, without saying what they were, just what ones?

A. I have given the averages for the chlorines but I have put on a chart that was presented the averages for free ammonias and albuminoid ammonias and nitrites.

Q. Averages compared with what?

A. Well the averages taken during the month of January 1900 and then compared with the averages taken during February and March of the same year.

Q. That table has not been submitted yet has it?

A. Yes sir.

Q. It wasn't read?

A. Yes sir, the map with these figures on was submitted. I have them here if you would like to have me read them.

Q. They have been put in the record have they?

GENERAL CROW: Yes, they were put in the record.

JUDGE SPRINGER: Then I only want to ask you about one. Did you make the averages of the results of those samples?

A. Yes sir.

Q. Could you state briefly the averages for the entire period of your examinations without going into detail?

1800 GENERAL CROW: At what point?

JUDGE SPRINGER: Missouri River, Bellefontaine.

A. I have here the weekly averages and the monthly averages.

Q. State the monthly average then at Bellefontaine and for the period?

A. For free ammonias or nitrites or what?

Q. First for chlorine.

A. Weli, the chlorines at Bellefontaine run as follows:

The average for	January 1900 was	23.5
"	February,	18.6
"	March,	12.1
"	April,	12.5
"	May,	14.5
"	June,	11.4

	The average for	July, 1900 was	11.2
	“	August,	12.8
	“	September,	16.3
	“	October,	11.4

Q. Now give the averages for those same months for nitrites?

A. The average for 1900 was:

	“	January,	.008
	“	February,	.014
1801	“	March,	.023
	“	April,	.018
	“	May,	.013
	“	June,	.003
	“	July,	.001
	“	August,	.001
	“	September,	.002
	“	October,	.002

Q. Now give the nitrates?

A.

January,	.415
February,	.592
March,	.965
April,	.485
May,	.484
June,	.418
July,	.462
August,	.435
September,	.381
October,	.560

Q. Now give the free ammonia?

A.

	January, 1900 average;	.135
	February,	.232
	March,	.144
	April,	.069
1802	May,	.083
	June,	.067
	July,	.055
	August,	.038
	September,	.068
	October,	.055

Q. Now give the albuminoid ammonias for the same period?

A.

January,	.363
February,	.395
March,	1.182
April,	.775
May,	1.484
June,	1.181
July,	1.556
August,	.842
September,	1.133
October,	1.382

Q. Did you make an analysis for the required oxygen consumed?

A. Yes, I have those figures, however I have not averaged those up for the months. I didn't consider the required oxygen of such great importance for the reason that the 1803 waters of the Missouri are always charged with a great deal of earthy matter and I found that the oxygen consumed or required oxygen had very little significance. The albuminoid ammonia is largely of vegetable origin and the oxygen consumed does not furnish us any very valuable information in this case as it would in other waters where the contamination is more of a sewage character. The Missouri River is largely charged with vegetable organic matter in contradistinction to that which we find in the Illinois river, and therefore the required oxygen does not furnish us any very valuable evidence so I have not made the averages, although I have the daily determination.

Q. Then I will not go into that. Did you ascertain the total solids per million?

A. Yes but I haven't got the monthly averages. I have them for every day and they are very high. They run very high.

Q. High in solids?

A. Yes sir.

Q. Will you give one or two as averages so far as you can?

A. I haven't them here.

Q. What is your recollection?

A. Well, they run sometimes seven and eight hundred parts per million and sometimes a thousand parts per million.

1804 The Missouri often is very muddy and taking it unfiltered and simply shaking it up we got an enormous weight of total solids.

Q. You stated in explanation of the fact that the chlorines run high in the Missouri River that there was some river in Kansas that was supposed to be impregnated with saline matter, will you state what that river is?

A. I am not personally acquainted with the exact source, but I have been informed by the City Chemist of the City of St. Louis, Dr. Teichmann, here, that one of the tributaries of the Missouri coming in at Kansas City has gone across salt beds in Kansas, and that is very highly charged with chlorine, and that is the reason for chlorine in the Missouri River.

Q. You don't know anything about that except what Dr. Teichmann told you?

A. No, sir.

Q. You never made any analysis then of this Kansas River water?

A. I have not.

Q. Before it came into the Missouri River?

A. No, sir.

Q. You have no opinion then upon the subject so far as that is concerned, simply what you were told by the City Chemist?

1805 A. Simply what I was told by the City Chemist, who I believe, has made these analyses.

Now, if it should appear by analysis that the river from Kansas coming in from Kansas City, which I believe is called the Kaw?

A. Yes, I think that's it.

Q. That is if it did not run any higher in chlorine than the waters of the Missouri River above that point then the theory as to cholorine constituents coming from Kansas would not obtain?

A. That is so, I agree to that.

Q. During the period to which we have referred, viz.: January 24, 1900, to October, 1900, can you tell or have you any data by which to determine, by which you did determine the volume of the water in the Missouri River as compared with the Mississippi and Illinois River?

A. I did not.

Q. You made no determination of that?

A. I made no determination.

Q. Are there any data of that kind?

A. Yes, sir; the records have been made and these records have been made by the City Chemist of St. Louis.

Q. They will be put in later, I suppose?

A. They will come later.

1806 Q. In making your analyses of the various waters to which you have testified for albuminoid ammonia, were the waters examined as taken from the river or after filtration?

A. They were taken in the unfiltered state.

Q. Were you furnished with any data by which you determined the volume of water in the Illinois River which was contributed by its tributaries the Kankakee, the Vermillion, the Sangamon and other rivers?

A. No, sir.

Q. As compared with that which came through the Drainage Canal?

A. No, sir.

Q. You are familiar with the general features of the Illinois basin drained by the Illinois River?

A. Yes, sir.

Q. In making the analyses to which you have testified here as to the condition of the water at Grafton above the mouth of the Mississippi River, you did not take into account any supposed pollution that might have been brought to the Illinois River by the entering of its tributaries?

A. No, sir.

Q. If the waters coming into the Illinois River from the Kankakee River above the mouth of that river should contain free ammonia and albuminoid ammonia and nitrites and nitrates in pronounced quantities, what would you say as to the effect of the mixing of that stream with the Illinois river?

A. They would tend to pollute the Illinois River.

1807 Q. And so with the Fox River coming in?

A. Yes, sir.

Q. And of the Big Vermillion and the other streams, known to empty into the Illinois River?

A. Yes, sir.

Q. If it should appear upon investigation and reliable data that more than half of the waters constituting the Illinois River at Grafton were contributed by streams entering that river other than the Drainage Canal, and that the averages for chlorine, free ammonia, albuminoid ammonia, nitrites and nitrates, were larger or equally as large in the tributaries as in the main river, what would you say or what would be your opinion as to the amount of pollution if any contributed by the stream itself and by its tributaries?

A. In that case the proportion of these impurities which came from the tributaries would form a fraction of the impurity of the Illinois River and the magnitude of that fraction would depend upon the relative volumes of the Illinois and its tributaries and it would vary as the volumes of those tributaries vary.

Q. Then in your conclusions as to the amount of pollution that is contributed to the Mississippi River at Grafton for the Illinois River, you take no account whatever of what might have come from the tributaries of the stream?

A. No, sir, I simply analyze the water as it is taken out of 1808 the mouth of the Illinois River.

Q. Then so far as your analysis is concerned, you charged up all the impurities that you found at Grafton to the Drainage Canal?

A. Well, in this way, as we ascended the river and we found the impurities increasing steadily, as we went up the river, I reasoned that if the impurities came slightly from the tributaries of the river the quantities of free ammonia and albuminoid ammonia and nitrites would be pretty constant all the way up the river and up through the tributaries if the waters were homogeneous, they would show that on analysis, but we found as we ascended the Illinois river that there is a very great increase all the way up to Joliet where the analyses showed the water to be diluted sewage.

Q. Increased in what elements or what particulars?

A. In free ammonias and nitrites and in chlorine and in albuminoid ammonia.

Q. Now, the results of your analyses at the various places to which you have testified, in those results you have not taken into consideration one of the important factors, the presence of chlorine?

A. Yes, we determined the chlorine at all points.

Q. It wasn't stated in your conclusions, was it?

A. No, we didn't make a tabulated table of that but on the record or daily analysis, the chlorines are given.

1809 I have read off in the record the monthly averages for chlorines at Lockport, Joliet and Peoria and the Illinois shore at Grafton and the Mississippi River at Grafton, also the monthly averages at Hartford, of the Illinois shore and Missouri shore and at Lockport and Joliet for 1901.

Q. What significance do you attach to the presence of chlorine in potable waters?

A. Chlorine in potable water comes from the salt that is dissolved in the water and there is always a certain quantity present in natural water.

Q. Now, if we find that a given water has a proportion of chlorine higher than this co-called normal chlorine we at once suspect sewage contamination, for the reason that salt, common salt, is used so extensively in articles of food and it would thus find its way with the sewage into the water?

A. Yes, sir.

Q. In making your various analyses of water to which you have testified will you state what was the standard of purity for drinking and domestic purposes of river water which you carried in your mind as your idea of what it should be?

A. The standard for chlorine or for the free ammonia?

Q. I am asking you separately for each of them. What was your standard in making these analyses as to the amount of chlorine?

1810 A. Well, since my analyses disclose that the Mississippi River averaged in chlorine from four to five parts per million above Grafton, and since below Grafton the chlorine suddenly jumps to 15 and 16 parts per million, I conclude that that may be taken as evidence of contamination as regards chlorine.

Q. What is that?

A. That the Mississippi River running four and five parts above Grafton suddenly jumped up to 10 or 12 parts below Grafton, that is evidence of a contamination by the Illinois.

Q. What do you fix then as the safe standard?

A. Then the safe standard for the Mississippi should be four or five parts.

Q. What do you fix then for the Missouri River?

A. The Missouri River, however, runs from 15 to 16 parts normally and we cannot use that standard very well with the Missouri. If the chlorine goes higher than 15 or 16 parts then it indicates contamination, but owing to the fact that the Missouri is charged with salt from the salt beds we are deprived from using this standard in judging of the purity of the Missouri river. We then fall back upon the nitrites and free ammonias and albuminoid ammonias.

Q. How about the chlorine at the Chain of Rocks at the Illinois shore, what is your standard?

1811 A. We find at the Illinois shore it runs higher in chlorine than the Mississippi river above Grafton.

Q. What is the figure?

A. The chlorine at the Illinois shore, Chain of Rocks runs higher and the averages are higher than the averages for chlorine for the Mississippi river above Grafton. We find, however, that the averages for chlorine on the Illinois shore, Chain of Rocks, are very nearly identical with the averages for chlorine at Hartford, which is above the mouth of the Missouri.

Q. What was that average, just one of them, please?

A. Well, at the Chain of Rocks the chlorines run from 8 to 10, whereas on the Missouri shore the chlorines run from 14 to 15 to 16.

Q. So it depends entirely on where the water comes from as to the potability of the water in reference to chlorine?

A. Yes, in order to use the chlorine standard we have to have the so-called normal chlorine, an idea of what the average of chlorine would be in water in an uncontamniated state.

Q. Then when you gave it as your opinion as to the potability of water coming from the Missouri river at Bellefontaine and the waters coming from the Chain of Rocks, the Illinois shore, you had different standards in your mind?

A. As regarded the chlorine, yes, but not as regarded the free ammonia and nitrites and albuminoid ammonia?

1812 Q. I will come to that later, merely as to the chlorine?

A. Yes, as to the chlorine.

Q. Now, will you give the standard which you had in your own mind for determining the potability of the various waters in examination in reference to the presence of nitrites?

A. Measurable quantities of nitrites indicate that the water is contaminated. If you have nitrites that you can measure and readily represent in parts per million it shows contamination of the water.

Q. Is that the opinion of all writers upon this subject?

A. Well, it is the opinion of a good many of them. There are variations, of course. And our own water is not always free from nitrites. We have measurable quantities present most of the time?

Q. Have you ever examined the reports of Professor Mallet of the Wilmington Board of Health?

A. Yes, sir.

Q. Do you know what he fixes as standard for potable water with reference to nitrites?

A. Yes, sir; I think I have copied his standard. I have them here among my papers.

GENERAL CROW: That is Professor Mason's book you read from?

JUDGE SPRINGER: Yes, sir.

1813 THE WITNESS: This work of Professor Mallet was done a number of years ago and he allows .0135 parts per million, although he states that the average for nineteen waters that cause disease was .0403 and Leeds' standard for American waters was .003, that is the allowable amount of nitrites, the maximum amount.

Q. The standard you fix was that if there was a measurable quantity that would condemn the water for nitrites?

A. Yes, a measurable quantity would be about .001 to .002, as I would put it, because nitrites show that fermentation changes are going on in the water and that bacteria are at work in the water and therefore it is dangerous water. It is water that is unstable, it is undergoing change constantly and good drinking water should show no nitrites?

Q. What is your standard for potability of water in reference to nitrates?

A. In reference to nitrates?

Q. I mean the standard which you use in making your comparisons in regard to the analyses you have made yourself and to which you have testified here?

A. Well, above five-tenths parts per million.

Q. How?

A. When water comes above five-tenths parts per million of nitrites it is to be regarded with suspicion.

Q. Is that the amount that you had in your mind when you
made your comparisons of the potability of the various
1814 waters to which you testified?

A. Yes, sir.

Q. Now, as to the standard dictated by you, in estimating the importance of the presence of free ammonia, what standard did you use for potable water?

A. The standard for free ammonia is that when it gets above .06, it is to be regarded as not drinkable, or rather polluted, that is .06 parts per million. That is the average I should say for good waters and when it gets higher than that we regard it with suspicion.

Q. It may, however, contain much higher quantities and still be potable?

A. It may be used as drinking water but it is dangerous.

Q. Now, as to the albuminoid ammonia?

A. Whenever it gets above three-tenths it is a suspicious water, it is unsafe.

Q. On page 62 of Professor Mason's book, he places the result of analyses of an excellent mountain stream that he himself examined and found that albuminoid was .0230 parts per million, showing there was no pollution, being a perfect mountain stream. Do you recognize that as being a possible amount.

A. You will find in that same book that he puts down the
average for polluted waters for albuminoid ammonias as .228
and for free ammonia .182. He says when you get above
1815 that it is to be regarded as bad water. For nitrites he
gives for good water .000. That means none and for polluted water .006 and for free ammonias .063 in good waters and

for polluted water .082. They are very nearly the same as these which I have used in my examination.

Q. Now, with reference to the amount of total solids, did you have a fixed amount in your mind as to what was regarded as safe?

A. I had no fixed amount in mind because our solids varied so very much in the Missouri River. In high water it is so heavily charged with mud that the total solids cannot be used in judging of the purity of the water.

Whereupon an adjournment was taken until 2:15 p. m., March 16, 1903.

1816 Met pursuant to adjournment March 16, 1903, at 2:15 p. m. at the Southern Hotel.

Present, same as at morning session.

PROFESSOR KEISER resumed the stand for further cross-examination, by Judge Springer, and testified as follows:

Q. Professor Keiser, Saturday in your testimony you had occasion to refer to a report by Professor J. H. Long, with reference to analyses made from water taken from the Illinois River in the year 1899, do you remember that?

A. Yes, sir.

Q. I want to call your attention to some portions of your testimony taken at that time. You stated that the samples which you took were of waters taken from the river above Peoria?

A. Yes, sir.

Q. But that you did not know from what point Professor Long's samples were taken?

A. No, sir.

Q. I want to call your attention to the fact that if you had observed these tables you would have seen it distinctly stated where they were taken. I will call your attention to that on page 24 of his report. You see the words "Peoria Narrows" on page 24, it says Narrows.

GENERAL CROW: That means above the sewage of the city, doesn't it?

1817 JUDGE SPRINGER: Yes, that is above the sewage of the city. You see the word "Narrows."

THE WITNESS: That is above the city, isn't it?

Q. Yes, that is above the city.

A. I wasn't certain about that.

Q. Down below that you see also Wesley. Wesley is between Peoria and Pekin and after the sewage of the city of Peoria has been received into the Illinois River?

A. Yes, sir.

Q. I call your attention to that for the purpose of calling your attention to another report.

GENERAL CROW: The figures he refers to of yours were made from samples taken from above Peoria?

A. Yes, sir.

JUDGE SPRINGER: All together his work. I mean he took no samples at the point of Wesley below Peoria.

THE WITNESS: No, sir.

GENERAL CROW: But there were samples taken below Peoria?

JUDGE SPRINGER: Yes, by Professor Long.

GENERAL CROW: Yes, and by Prof. Keiser, too.

JUDGE SPRINGER: I am talking about what he testified to at this time, at this particular time, isn't that right Professor?

THE WITNESS: Yes, sir.

Q. You were asked this question: "Give me the result of
1818 that Professor?" "A. The values before the opening
of the canal of free ammonia were 0.895 and after the opening of the canal 3.060 according to Professor Long, and according to my analysis 1.950."

GENERAL CROW: At what point was that?

JUDGE SPRINGER: That was above Peoria. Will you look at that where I read from and see if you are reported correctly?

GENERAL CROW: Wait a minute. Now let the record show that you are reading from the stenographer's notes of his evidence and then ask him if that is correct?

JUDGE SPRINGER: I am coming to that. Is that a correct statement of your testimony?

A. Yes, sir.

Q. Now, let me call your attention to this book from which you read on page 36, table of averages given by Professor Long. Do you see that table?

A. Yes, I have it.

Q. Please run your eye along the line from Peoria Narrows to the word Free Ammonia at Peoria. Have you got that?

A. Yes, sir.

Q. What was it?

A. It is printed here .0895.

Q. Now, that is correct. That is for 1899 before the
1819 opening. Now, look at the table of averages on page 44?

A. Yes, sir.

Q. Run your eye along the line from Peoria, Wesley until you strike free ammonia, what do you find?

A. 3.060.

Q. That is the way you gave it in your testimony?

A. Yes, sir.

Q. Now, I want to call your attention to the fact that that is the river below Peoria and not above Peoria at the Narrows as you compared it with?

A. Yes, I see that is Wesley.

Q. That is after the river has been polluted by Peoria sewage

A. That is the analysis that is given. There is none given there above Peoria, that is as near as we could come to it.

Q. Now, if you will look at page 64 you will see another table, that is the averages for the summer of 1900 by Professor Long. Cast your eye along from the Peoria Nerrows until you get the free ammonia. What do you find?

A. The free ammonia there in the summer is .21.

Q. And at Wesley?

1820 A. And at Wesley 1.62.

Q Now, if you take .21 as the average for free ammonia at the Narrows above Peoria for 1900 and compare it with 1899 as appears by this first table on page 36, what will you find?

A. Well, we are comparing then the summer water with the water that is found in the late fall of the previous year, and that is not a just comparison.

Q. Well, on his comparisons, though, you are making your statement. You stated the value before the opening of the canal of free ammonia was .0895 and after the opening of the canal 3.060, according to Professor Long and according to my analysis .0950. You put the comparison after the opening of the canal at 3.060, didn't you?

A. Yes, sir.

Q. Now, couldn't you have put it Peoria at the Narrows free ammonia 0.21?

A. Well for the reason that that is a further period of time. The canal was opened in January and we have our analyses that run up to November of the previous year. These first analyses come up to the end of November, 1899, and then the next analyses, the nearest analyses that are published, after the opening of the canal at the point nearest Peoria, give
1821 the value I have stated in my report?

GENERAL CROW: Published by whom?

A. By Professor Long.

JUDGE SPRINGER: For what year were his analyses?

A. The first analyses were those for 1899 on page 24 I think of this report, those were the first.

Q. That began in July?

A. That began in July.

Q. And ran until November 23rd?

A. And went down until November 23rd.

Q. It was for the year 1899?

A. That is the nearest we have to the opening of the canal.

Q. Now, beginning on the other table for 1900, it began with June 7th and ran until October 9th, didn't it?

A. Well, there was an analysis before that, immediately after the opening of the canal.

Q. But this is the one upon which .021 is based. That was based upon the analyses of water taken between June 7th and October 9th, 1900, practically the same periods in the two years.

A. Well, one is July and runs until the end of November and the other one begins in June and ends in October,
1822 there is considerable difference.

Q. A difference without a distinction, practically?

A. My experience has been that November is a month in which the free ammonias run very high and in June they run very low, so that if you compare them that way the chances are in favor of getting a very much higher result the first month before the opening of the canal and a much lower one after the opening of the canal, but if you will take all the analyses that are here published immediately after the opening of the canal, together with the spring, and then average them up you will get a truer value.

Q. Is this free ammonia?

A. Yes, sir.

Q. They were greater in November, then?

A. They are greater in November. They begin to run high in November, December, January and February and then they go down in the spring months and they are low in the spring and the water will probably appear very fair in the summer time when it is very badly polluted in the winter time.

Q. What I want to call your attention to is the fact that in this statement you compare the water at Peoria before the opening of the canal, of the samples taken above the Nar-
1823 rows and after the opening of the canal with the samples
taken below the Narrows after the Peoria sewage was in, and on that basis you show a large increase in free ammonias. Isn't that right?

A. There is shown a large increase there, but the analyses come as nearly together as they have been published.

Q. Well, what I want to get into your mind if I can, is the fact that this statement here as to the difference between the conditions before the water was turned in and afterwards, was based upon two very different conditions?

A. Samples were taken at different places, I understand, but they were taken not so far apart in point of time.

Q. Well, there is a great deal of difference between the Illinois River below Peoria and above Peoria.

GENERAL CROW: Do you mean before or after the opening of the canal?

JUDGE SPRINGER: Both. Now, if you will apply the averages taken above Peoria in 1900 with those taken above Peoria in 1899 you will find a large decrease in free ammonias after the canal is opened, will you not?

A. Yes, in the spring months, but no analyses were made above Peoria immediately after the opening of the canal, but

they were made below Peoria soon after the opening of
1824 the canal and then they show those high figures and our
analyses here made above Peoria soon after the opening
of the canal show also a high increase in the free ammonias, viz.: 1.6.

Q. Now, I will frame my question a little differently. You have made a comparison to show a large increase in free ammonia in the Illinois River at Peoria before the opening of the canal and afterwards and you base that upon Professor Long's statement made in 1899 between July and November 28th, and you have compared that result which was properly stated here at .895 free ammonias, with the conditions at Wesley found in the year 1900, and the average of the samples taken between June 7th and October 9th of that year, and upon this you base a conclusion that there was a large increase. Now, the table shows, according to what you have already stated—

GENERAL CROW: The table of Professor Long, do you mean?

JUDGE SPRINGER: The table of Professor Long. The average you quoted shows that you have taken the wrong plat, and that the actual figure should have been 0.21 which would have shown a large decrease in the free ammonias after the opening as compared before the opening?

A. I cannot agree with that statement—

1825 Q. I am not asking you whether you agree with that or not?

GENERAL CROW: You stated to him that he had taken Long's statement? He says he doesn't agree with that statement.

JUDGE SPRINGER: What I want to get at is the fact that this book shows from which you assume to quote, that there was a large reduction instead of a large increase which you contended for in your first examination?

A. I admit there is large reduction, if you compare with the months preceding the opening of the canal, the winter months, the summer months following the opening.

Q. That is not in this book. There is no comparison of that kind here. One begins in July 10th and runs until November 28th.

GENERAL CROW: If I understand you Judge, what you are trying to get him to testify to is, not what Professor Long's table shows itself but what his comparison of his figures with Professor Long's figures show, isn't that it?

JUDGE SPRINGER: No, what I want the record here to show is that in the statement that he made on Saturday that from Professor Long's statement he found a large increase. That was a mistake, and there was a large decrease.

GENERAL CROW: He didn't testify that Professor
1826 Long's figures showed there was a large increase.

JUDGE SPRINGER: Yes he did.

GENERAL CROW: He testified in comparison it showed an increase.

JUDGE SPRINGER: What I want to get in the record is, that Professor Keiser was mistaken in making this statement here and that he should if he was quoting from Professor Long, read from the line below and not above. Now, answer that question?

A. The record as published by Professor Long, gives his average values as I have stated them there, for the period of time from July until the end of November in 1899. Those figures are correct. Immediately following that he gives us an analysis made after the opening of the drainage canal and here we find Peoria, Illinois River and the averages which I have quoted, viz: .306 free ammonia, and that is also the average shortly after the opening of the drainage canal.

Q. What page are you reading from?

A. Page 41. There are no analyses given here for Peoria immediately after the opening of the Drainage Canal and this is the nearest I can come to it.

1827 Q. Well, is it fair to compare the waters at Wesley, that is below the sewage of Peoria with the waters above Peoria, which is above the sewage of that city, for the purpose of making any sort of a calculation or deduction?

A. I assume that that made only a very slight difference for the reason that the volume of sewage added by Peoria is comparatively small as compared with the bulk of sewage coming down the drainage canal.

Q. Then what I want to get into the record is that the figures 3.060 as to the conditions of the Peoria water after the opening of the canal were based upon the conditions you found at Wesley and not upon the same conditions that Professor Long based his upon, viz: at the Narrows above Peoria.

GENERAL CROW: What is that?

JUDGE SPRINGER: I want the record to show that his deduction was based upon the conditions at Wesley and not at the Narrows, isn't that true?

A. State it again.

Q. That your comparison for this period of the conditions of the waters at the Illinois River at Peoria before the opening and after the opening of the canal, were based before the opening upon the waters above Peoria and after the opening upon the waters at Wesley, below Peoria, isn't that true?

A. My figures—

1828 Q. Isn't that true or not? Answer that yes or no.

A. I have followed the report as given here.

Q. You have followed it as far as Wesley is concerned?

A. Yes, sir, as far as that is concerned.

Q. You took it at Wesley, then for comparison after the canal was opened?

A. I tried to compare the points as close together as I could get them.

Q. What I want you to state is the fact that your comparison was based on the condition of the waters in the Illinois River below Peoria?

A. Well, it is so printed in Professor Long's report.

Q. Now, with reference to the nitrites you stated that the nitrites before the opening of the canal (this means at Peoria) were 0.141 according to Professor Long. This is your statement and after the opening 0.060 according to Professor Long. Is that your statement?

A. Well, .141 before and afterwards .06, yes sir. It is from the same report.

Q. The statement as to conditions stated by Professor Long before the opening are for the year 1899 is correct, one after the opening is placed at .060 is incorrect and based upon conditions of the Narrows, was 0.12?

1829 A. Yes. May I say a word in explanation?

Q. Yes.

A. And so that in that table, while I quoted Professor Long's report for these values, I gave my own values for a point above Peoria and the estimation is not affected at all by this. I find that my own analyses made immediately after the opening of the canal, while not showing as high impurities as those quoted from Professor Long's report, at the same time show a marked increase of impurities during the months of February, March and April, immediately succeeding the opening of the canal.

Q. Now, with reference to the albuminoid ammonias at the same places. You stated that the albuminoid ammonias, before the opening of the canal were 0.572 by Professor Long and after the opening of the canal 2.210 by Professor Long, and according to your analyses 0.627. Now, the statement is correct as to the condition for albuminoid ammonia before the opening, viz: 0.572.

A. Yes, sir.

Q. Now, after the opening, you stated it as 2.210?

A. Yes, sir.

Q. Now, I want to call your attention to the fact that at the Narrows the albuminoid ammonia was 0.34 by Professor
1830 Long and showed a reduction at the same place in comparison according to Professor Long's table, and the albuminoid ammonia in the water at Peoria above the Narrows, after the opening as compared with the condition before the opening?

A. The same answer that I gave for the other applies to this, it is the same thing again. I have made a comparison of the analyses that Professor Long has published immediately after the opening of the drainage canal, that is the analyses that he made before, but I have not relied upon that analysis in deducing the estimation that there was increased impurity there. My analyses show the same thing and the water from my analyses was taken at a point above Peoria.

Q. Then what I want to get into the record is that these comparisons set forth in your testimony here were based in the first instance upon water taken above Peoria and in the second instance after the opening on the waters taken below Peoria. That is true, isn't it?

A. As regards Professor Long's figures but not as regards mine.

Q. I am not speaking of yours. Yours were not challenged at all. Of course this puts Professor Long's Report in a very unfavorable light.

1831 A. Well, I wasn't aware that Peoria made very much difference in the water.

Q. Well, there is another question. We will reach that after a while as to whether it makes any difference. You were asked this question, "What chemically does that show with reference to the ammonias, nitrites and albuminoid ammonia as to whether they have increased or diminished in the period covered? A. It shows that there was a very great increase." That is your evidence?

A. Yes sir.

Q. Now, having called your attention to the fact that you are basing your estimate upon waters taken at different places, viz: in the first period above Peoria and in the second below Peoria, if it appears from these books that you took your second period at a place below then your conclusion wouldn't be borne out by the fact as it appears here?

A. My conclusion is borne out by the fact that I made the analyses myself of water taken above Peoria and upon those analyses showing an increase of impurities I based the conclusion that there was increased pollution after the opening of the drainage canal?

Q. And you based that solely upon your own figures?

A. Upon my own figures and I also thought it was confirmed by Professor Long's own figures.

1832 Q. But you find you are mistaken in that?

A. I am not sure about that. I don't know about that.

Q. Well, the book shows that.

A. It simply shows that Professor Long's analyses were made at a point lower down apparently, at one season of the year, but I took the analyses which he had published immediately after the opening of the canal. That was the point in mind. As to the condition of the water after the opening of the canal compared with the water before the opening, that was my point and I have taken his results for the point nearest to Peoria which I could get and they show a marked increase in impurities.

Q. You overlooked this table on page 64, if you say you took the nearest you could get, because that table is published in the same work?

A. The table on page 64 shows the results for the summer months and they are very different. The water is very different then from what it is in November.

Q. Now, let me take Professor Long's report and call your attention to page 36.

1833 I call your attention again to your testimony of Saturday in which it is stated: "Albuminoid ammonia before the opening of the Canal was 0.572 by Professor Long; after the opening of the canal 2.210, by Professor Long, and according to my analyses, 0.627."

Now you have Professor Long's report before you, please point out in it the page upon which you found the first figure, 0.572.

That was in the year 1899.

ATTORNEY-GENERAL CROW: Well, you didn't include the free ammonia.

JUDGE SPRINGER: I am simply confining him to that one item. You can extend it to the others if you like.

ATTORNEY-GENERAL CROW: I don't wish to interfere with your examination. I just wanted to know what you were doing.

A. This is on page 36.

Q. Now running along the line there, you see Peoria Narrows and Peoria, Wesley, Illinois River?

A. Yes sir.

Q. Now which one of these lines did you take that data from?

A. I took it from Peoria Narrows.

Q. 0.572?

A. 0.572.

ATTORNEY-GENERAL CROW: Just put in the record
1834 where Peoria Narrows are.

The Peoria Narrows is three miles above the city of

Peoria, before the sewage of the City of Peoria has been received in the Illinois River. This place that was called by Dr. Ravold, Shady Beach.

Q. JUDGE SPRINGER: Now where did you find in Professor Long's report the statement from which you took the comparison of the condition after the opening of the canal?

A. I found that on page 44, where the averages are given for the spring work of 1900.

Q. And that was 0.221.

A. That was as nearly after the opening as these analyses are given.

Q. Now what is it at the head of that line, that you begin to draw from?

A. I find there Peoria, Wesley, Illinois River.

Q. So that was taken from Wesley, Illinois River?

A. 2.210. And then my own determinations upon which I base the conclusions gave .627; also an increase over the original for the same period of time.

Q. Now turn to page 64 of Professor Long's report and on the left hand column you will find the Peoria Narrows, and run along until you come to albuminoid ammonia. What do you find?

1835 A. Well, we find there .34, but I maintain that that is not a fair comparison.

Q. But never mind; I am not asking you whether or not you consider it a fair comparison. I am simply asking you what you found. You found .34.

If you took Professor Long's data for comparison it would show a decrease in free ammonia after the opening of the Canal, as compared with the period before the opening, taken from Professor Long's statement?

A. As Professor Long—as there are no analyses of the river above Peoria, immediately after the opening of the canal, although his analyses are near Peoria, namely, at Wesley, Illinois River, I compared with the nearest I could get.

Q. You have stated that several times. Please read the question.

Q. (Question read.)

A. Well, the figures that Professor Long gives us for the summer months are lower than the figures which he gives us for 1899, for the fall months.

Q. Well, is not that period covered for 1900, between June 4th and October 1st, according to page 5— It is the period June 7th to October 7th, Peoria analyses?

A. Yes sir, that is June 7th to October 9th.

1836 Q. That is the period upon which he bases his comparison for the period after the opening?

A. Yes sir.

Q. Now the same fact will appear in reference to the findings for nitrates, free ammonia and nitrates, would it not, as far as Professor Long's tables are concerned?

A. Yes, I have used his tables for free ammonia, nitrites and albuminoid ammonia.

Q. Then according to these two tables to which I have called your attention, Professor Long's tables show a decrease in these items after the opening as compared with before the opening?

A. A very long time after the opening, in the summer months.

Q. I know, but I simply ask you according to his tables— These tables show exactly when they were taken?

A. Part of his tables do it and part do not.

Q. Well, I call your attention to the dates which I have in mind, namely as stated in the record, and whether on those dates, the tables referred to by me do not show a decrease in his tables between the water before the opening and the period after?

A. Yes, if you compare his last tables with his first tables they do, but not if you compare his first tables with his
1837 second tables.

Q. Well, the second table has no other finding above Peoria has it?

A. No sir.

Q. Now then, take the first period on page 36 and read please the finding for Peoria, Wesley, of free ammonia, in Professor Long's tables, Illinois river?

A. Yes, I have it.

Q. Read it please,—free ammonia?

A. Free ammonia 4.35.

Q. Albuminoid ammonia?

A. 3.20.

Q. Nitrates?

A. 0.06.

Q. Nitrites?

A. 0.026.

Q. Turn to page 44 and read Peoria, Wesley, same place, Illinois River, and give me the findings for free ammonia; this will be after the opening, won't it?

A. Yes, this would be after the opening.

Well, here is 3.06.

Q. That is free ammonia? Now what is albuminoid ammonia?

A. 2:21.

1838 Q. And nitrates, what is that?

A. Nitrates .37. That is higher you will notice, than the other one.

Q. And nitrites?

A. Nitrites are .06, whereas, before they were .02, so that shows that in two determinations that the water is more impure —just what I contended for in these figures.

Q. Now you look at the oxygen consumed in Peoria in the first period, Wesley, on page 36, not filtered. Did you find that?

A. The oxygen in filtered, Wesley, 17.44; the oxygen not filtered, Wesley, 16.93.

Q. No.

A. Isn't that it?

Q. Oh, on page 44, you made the comparison for the different periods?

A. No, the oxygen, according to my book is 16.93 not filtered. Oxygen absorption at Wesley, 16.93 in the spring months, and 17.44 in the fall.

Q. Now you stated further in your testimony, as follows: I will read this and see if you can correct this error:

"Q. What chemically does that show with reference to the ammonias, nitrites, albuminoid ammonia, as to whether
1839 they have increased or diminished in the periods covered?
(Answer) It shows there was a very great increase.
(Question) Now, that table shows that from your figures alone

or the combined figures of yourself and Professor Long? (Answer): From the combined figures there is a marked increase here of the free ammonia, nitrites and albuminoid ammonia. (Question): Do Professor Long's figures show the same thing? (Answer): They do. (Question) What would that indicate, an increase of nitrites? (Answer): That would indicate an increase of pollution of sewage."

Now, in the light of the tables to which I have called your attention, do you care to modify those statements so far as Professor Long's statements are concerned?

A. Yes, these last tables show an increase in nitrites even compared with the spring work. Here we find that nitrites have gone up at the same point, Wesley, Illinois river.

Q. Yes, but I am speaking about the Narrows, above Peoria, about which you spoke before. Your own statements are all compared on the Narrows above Peoria.

A. The argument was based on Professor Long's figures. My figures show that there was an increase, regardless of Professor Long's results. My own figures are made after the opening of the Canal, gave an increase in free ammonia and al-
1840 buminoid ammonia, so I maintain this statement, there
was shown an increased impurity in the Illinois River after the opening of the drainage canal.

Q. That is your statement?

A. Yes sir.

Q. Now do you care to correct your statement on that point, or do you prefer to stand upon the position that you took before?

A. Yes, because we have just read in Professor Long's analyses at Peoria, Wesley, that they showed increased nitrites and nitrates, and the oxygen consumption was practically the same.

Q. Well, you made no comparison as to Wesley yourself?

A. I made no comparison myself, no.

Q. Therefore you cannot compare Wesley with your analyses?

A. No sir.

Q. Now just let us leave Wesley out and go back to the Narrows.

A. I wasn't aware that there was any certain degree of difference in making this comparison. I found the table on page 44 was the nearest one that Professor Long has published of results immediately after the opening of the drainage canal, and I took Peoria here as being the nearest point to that point where I had taken samples for analysis.

1841 Q. Then you don't know that—you didn't know that Wesley was located below Peoria?

A. I didn't know where it was exactly, and I didn't know whether the sewage of Peoria got into the river at Wesley—I thought it was considerably below, if anything. I didn't think it was right in the town of Peoria.

Q. Well, assuming that Wesley is below Peoria, and below the sewers of Peoria, would a comparison at that point for results be properly made with the conditions at the Narrows, above Peoria?

A. Not if they receive the sewage of Peoria, but it might have been taken there in the middle of the stream, where it would not have been caused by any sewers going into it from the town.

Q. Well, what I desire to have you correct, if you desire to do so, is the impression which you left here, that Professor Long's tables sustain your conclusions as to the increase of these conditions at Peoria.

ATTORNEY-GENERAL CROW: Well, name the conditions, nitrites and albuminoids—

Q. Nitrites, nitrates, and free ammonia and albuminoid ammonia, at Peoria before the opening and after the opening of the canal?

A. Well they show an increase in nitrites and nitrates.

1842 Q. That is a question. I have not asked about that, I am speaking about above Peoria, in the Narrows, according to Professor Long's table—I am not asking you to support them or to say that they are correct.

MR. WOERNER: What he wants to know is whether it is fair in your mind to compare the conditions above Peoria with the place where Professor Long—

ATTORNEY-GENERAL CROW: You got the impression from reading his testimony that he had testified there that Professor Long showed there was a greater pollution by reason of larger amounts of nitrites and nitrates, and albuminoid ammonia, and free ammonia above Peoria at what you call the Narrows, and what we call Shady Beach, after the opening of the canal, than there was before the opening of the canal; is that correct, Judge?

JUDGE SPRINGER: Yes.

ATTORNEY-GENERAL CROW: Now, if he testified about that, I don't remember.

JUDGE SPRINGER: Well, I just read what he said.

ATTORNEY-GENERAL CROW: Well, does that refer to that point?

MR. JOHNS: The only question in the discusion is that the gentleman read from the wrong line, and therefore the conclusion is wrong.

1843 JUDGE SPRINGER: Now I will correct my question then, so that you can answer it.

Having Professor Long's tables, as appear in his report, to which reference has been made, of analyses of water taken from the Narrows, above Peoria, before the opening of the Canal and after the opening of the Canal, don't his figures show that there was at that point a decrease in free ammonia, albuminoid ammonia, nitrates and nitrites, in the year 1900, after the opening of the Canal, as compared with 1899, before the opening of the Canal?

A. Profesor Long's report contains—

Q. Wait now? Can't you answer that Yes or No, whether this report does not show that at the time. That is all I want to know and get into the record.

A. Well I maintain—

Q. Well, never mind what you maintain. Is that report true?

A. For a portion of the year it is true, and when the spring rains came and there was a heavy dilution, the water shows an improved character, but it didn't show that improved character according to my analyses, immediately after the opening of the canal.

Q. Well now, I wish you would answer that question, because I want to do Professor Long justice.

1844 I am not asking you to state anything that you haven't got before you, and these tables show exactly the periods covered, and do not require any explanation as to the periods covered. It is in the book.

I am asking you to state whether Professor Long's tables as published in this report, do not show that the analyses of water taken at the Narrows above Peoria, before the opening of the Canal, show a greater amount of free ammonia albuminoid ammonia, nitrates and nitrogen, than was shown afterwards?

MR. WOERNER: The complainants object to the insistence of the counsel for the defendants for a Yes or No answer, on the ground that the witness has stated that the same is not susceptible of a direct answer without further explanation.

JUDGE SPRINGER: Well, here is the book before him. Anybody can see whether that is so or not.

MR. WOERNER: You ask him whether it shows the condition before and after the opening; it might show the condition 100 years before and 100 years afterwards.

ATTORNEY-GENERAL CROW: You see his very answer conveys the reason of the objection. He says one season it does show that and at another season it does not.

JUDGE SPRINGER: Will you answer that now?

In order to relieve the witness of any chance of evading 1845 this question—

ATTORNEY-GENERAL CROW: Hold on now I object to—

JUDGE SPRINGER: Well, I will withdraw that statement.

Q. In order to direct the witness' mind to the question that I desire him to answer, I call his attention to page 36 of professor Long's report. Now that contains the averages at Peoria from July 5th to November 23, 1899, is that right?

A. Yes sir.

Q. Well, now, taking the averages found for free ammonia, albuminoid ammonia and nitrites and nitrates, at the Narrows, above Peoria, from samples of water taken during that period, namely, from July 5th, 1899, to November 23rd, 1899, compare those averages with the averages on page 64 for the summer of 1900, taken at the same place, namely, at the Narrows at Peoria above that city, during the period from June 7th to October 9th, 1900, do they not show that for free ammonia, albuminoid ammonia, nitrites, and nitrates, there was a material reduction in the latter period as compared with the former period?

A. Yes sir.

MR. WOERNER: Now, Judge, if you have no objection, we would like to have the witness say whether he wants to explain that answer or not.

1846 JUDGE SPRINGER: I am perfectly willing he should do that. If he desires now to explain—if you desire now to explain your answer, you may do so.

A. I wish to state that we are now comparing analyses of waters made at different seasons of the year. We are comparing analyses made in the fall of the year, from July down to the end of November, when the results are apt to be low. With the analyses made in the early summer, throughout the summer when the rivers are apt to be swollen with the rainfall, and therefore it is not altogether a good comparison, and in my work, I was not endeavoring to establish the yearly value; I was endeavoring to determine what the effect of the opening of the canal was, and for that purpose I compared with the analyses made immediately after the opening of the canal, and they are published on page 44 of Professor Long's report, and I found my own analyses showed an increase immediately after the opening, taking analyses as near as we have them to the opening.

Q. We now see that you refer to the samples taken below Peoria, do you not?

A. Well, not in my own analyses.

Q. Oh, in Professor Long's?

1847 A. Professor Long's were taken below, but he gave none of the points above. This is the nearest we could come to it.

Q. Now I want to call your attention—in your testimony on Friday you were asked this question:

(Question): Now how does the water in the Missouri river at Bellefontaine, compare with the water of the Mississippi river above the mouth of the Illinois river as being wholesome?

(Answer): They are both fairly good streams from a sanitary standpoint.

Is that correct?

A. Yes sir.

Q. Are we to understand from that that you regard the waters of the Missouri river as suitable for the water supply of a city?

A. Yes sir. It is not as good as it might be, but still it can be used.

Q. In your testimony this morning you were asked as to your standard of purity for river water. Do you remember that?

A. Yes sir.

Q. Well, without repeating that answer, I want to ask you whether you did not state that if there was an ascertainable amount of nitrites in the river water, that it was to be condemned?

A. To be regarded with suspicion, yes sir.

1848 Q. Regarded with suspicion for potable purposes?

A. Yes sir.

Q. Now in your testimony on Saturday last, you were asked: (Question) Now have you made any comparison of the samples taken at Bellefontaine in the Missouri river?

(Answer): I have also made a table of the conditions of the water in the Missouri river at Bellefontaine.

(Question): Now where is Bellefontaine on the Missouri river with reference to distance from the Intake of the waterworks at St. Louis?

(Answer): It is 14 miles from the Intake of the St. Louis waterworks by river, but it is above the mouth of the Missouri river. In order to get the idea of the condition of the water in the Missouri river during this same period, immediately before and after the opening of the drainage canal I have taken the average of the analyses of the Missouri river water from January, 1900, and I find that before the opening of the canal that free ammonia was 0.135, and after the opening the average for February was 0.148. The nitrites before the opening were 0.008, and after the opening 0.014.

The albuminoid ammonia before the opening was 0.063, and after the opening 0.395."

Now do not these conditions in the Missouri at Fort Bellefontaine show, according to the standard which you laid down

this morning, that the waters at that point are not suitable
1849 for drinking purposes?

A. During that period of time for which these analyses were made the nitrites ran high and the water was to be looked upon with suspicion, during the summer, however—

Q. Wait a minute. I am coming to that after a while.

ATTORNEY-GENERAL CROW: Let him put that in. He is answering the question.

Q. JUDGE SPRINGER: Go on then?

A. Well, during the summer the nitrites are very low, and sometimes you can measure them, and with that amount I say that the river is a fair stream. It is not as good as we would like to have it, but still—and during the winter months, I admit that it is to be looked upon with suspicion according to the standards that I have given.

Q. Well, not suspicion only, but according to the standards you gave, it should be rejected as polluted, should it not?

A. Yes, it ought to be rejected in its unfiltered state, according to these figures.

Q. And during what months in the winter do these conditions prevail usually?

A. Well, during the cold season of the year, in November, December, January, February and March, along when the spring
rains come the nitrites fall, and in June, July and August,
1850 they are low. Sometimes—well sometimes we get merely
a trace.

Q. Well, what would you say then of a source of water supply for a great city, that four months of the year the water was unfit for use, and they were compelled to take it always from the same place?

A. Well, I should say it ought to be filtered.

Q. It ought to be boiled in addition?

A. Boiled anyhow; you can filter it or boil and filter too.

ATTORNEY-GENERAL CROW: And stop sewers from running into it too.

A. Yes.

Q. JUDGE SPRINGER: How does the water compare at the point known as the Missouri shore, Chain of Rocks, in your examinations or analyses, with the water at Fort Bellefontaine in the Missouri river?

A. They are very similar.

Q. They are very similar?

A. Yes sir.

Q. Is it your opinion then that the waters at the Chain of Rocks, Missouri shore, as stated in this investigation, are substantially the same?

A. Of course, there are variations from day to day, but taking it altogether, they are substantially—the water there 1851 is substantially Missouri river water.

Q. How far out do you know from the shore, is that place at which the samples were taken?

A. You mean the Missouri shore samples?

Q. Yes, from the Missouri shore, how far from the land?

A. Not very far out.

Q. How far would you say?

A. I don't know just how many feet. They were taken under the instructions of the city chemist.

Q. He will be able to state that?

A. That will be stated.

Q. Dr. Ravold stated two or three hundred feet, I think.

ATTORNEY-GENERAL CROW: Oh no; not those samples.

JUDGE SPRINGER: I think the sample men stated two or three hundred feet.

THE WITNESS: I don't know exactly where they were taken.

Q. How far did you say the Intake tower was from the Missouri shore?

A. I believe it is about one-third way across the river.

Q. Fifteen hundred feet?

A. Fifteen hundred feet.

Q. How far would that tower have to be moved inward in order to put it at a point where it would take Missouri river water only?

A. I asked that same question of the water commissioner, 1852 and at the same time asked him why he didn't take the Missouri river water, and he informed me that it was necessary to have the tower out as far as this because in dry weather the river is so low that it is impossible to get enough water for the city without having the tower out at its present position; that at low water, when the rivers got low, there is not enough water any further to the Missouri shore than the present position of the tower.

Q. Then in low water, wouldn't the Missouri river be further from the shore proper?

A. At low water the water falls and the volume in the Missouri is very low, and we get much more Mississippi river water, so that it is necessary to have the tower out at least as far as it is now.

RE-DIRECT EXAMINATION, By Attorney-General Crow.

Q. Now Professor, I believe Judge Springer referred to a table of Professor Long's there, made from analyses taken at a point he calls Wesley, below the city of Peoria, before and after the opening of the drainage canal, is that correct, did he refer to that kind of a table there?

A. Yes sir, he did.

Q. I will ask you to state whether or not that table does
1853 show that there is an increase or decrease in any of the
nitrites and nitrates before and after the opening of the drainage canal, and if so was the increase afterwards, or did it show the greater part before?

A. This table shows an increase at Wesley, Peoria, for the nitrates after the opening of the canal and also for the nitrites after the opening of the canal at Peoria, Wesley, comparing the results of analyses made at that point in July, from July to November 30, 1899, with those made at the same point from March to April, 1900, show an increase in those two figures.

Q. Well, is that the table of Professor Long's?

A. Yes sir.

Q. Now did Professor Long make any analyses of the waters in the Illinois river at what Judge Springer terms the Narrows, or Shady Beach, above Peoria, before and after the opening of the canal?

A. He made some before and, and there are none given immediately after the opening of the canal. There are some given in the summer of 1900, from June to October.

Q. Now do the seasons of the year affect or cause variations in the chemical constituents of running waters in rivers like the Illinois, the Mississippi and the Missouri?

A. They do, and very greatly.

1854 Q. Now the analyses you state that Professor Long made before the opening of the canal were made in what months?

A. Before the opening of the canal, the analyses were made in July, August, September and October.

MR. WOENER: Was that before?

A. This was before.

The analyses began July 5th, 1889.

MR. WOERNER: 1899?

A. It should be 1899. That is a mistake in print there; it should be 1899, and they go down to November 23rd.

ATTORNEY-GENERAL CROW: Beginning in July and going to November 23rd?

A. 1899, yes sir.

Q. 1899?

A. Yes sir, although it is printed 1889, it should be 1899.

Q. Now during that period of time what would be the effect, ordinarily, of that season of the year on nitrites, free ammonia and nitrates in the river?

A. Well, that is the season of the year when we are apt to have dry weather, or drouth and I should imagine that during that season of the year the water would be low and I should think that that would have the effect of increasing the quantities of free ammonia and albuminoid ammonias, and nitrites in the water. In other words, at that season of the year I would 1855 expect to find rather high values for free ammonias, nitrites and nitrates.

Q. What season is that?

A. In the season of the fall and going down into the cold weather at the end of November.

Q. Well now, from a chemical standpoint, from the standpoint of a water analyst and as a chemist, is it fair to make comparison between the spring months and the summer months?

A. No sir.

Q. Over the same area of water in a running river?

A. I don't regard it as fair.

Q. For what reason?

A. For the reason that in the spring months we have heavy rain-falls; we have the melting snows and ice in the head waters of these rivers—we have an opportunity in the Missouri river flowing past St. Louis—

Q. You mean the Mississippi?

A. In the Mississippi, yes—coming from the head waters of the Missouri and likewise in the Mississippi proper, the rivers are apt to be high. We have a heavy rainfall as a rule in February and March and April, and then in the spring there is high water. Analyses then would show very much less impurities.

Q. Why?

1856 A. On account of the great dilution.

Q. The impurities then are not removed, but there are simply just a given amount scattered throughout a larger volume of water?

A. Yes sir.

Q. And therefore in a gallon of water at that time of the year you would perhaps not find as much impurity as you would in a gallon in August?

A. No sir.

Q. Now considering then the seasons of the year at which this table Professor Long has made, to which Judge Springer refers, would you consider that, as a chemist, a fair comparison from which to determine the standard of purity of the water in the Illinois river in deciding the question as to whether it was more pure before the opening than it was after the opening of the drainage canal?

A. I think these two tables are not strictly comparable. I think the important work should be added in, namely, the analyses, page 44, the averages should be struck for the whole time during which analyses were made, in drawing up the final averages only the summer months and spring were taken into consideration, and not the work that was done after the opening of the canal, namely, January work. The February, March and April work was not included in striking those averages.

1857 Q. Now Professor, do you know whether the analyses upon which these tables of Professor Long were based, were made from samples taken daily or from samples taken weekly from the Illinois river, during the period of time covered by those tables, or does that report disclose?

A. According to this report the samples were taken weekly, or approximately weekly, namely, we see here Peoria, the Narrows, June 7th, 14th, 21st and 26th—those are weekly samples, and then there is a break to July 10th, 17th, 24th, 31st. They are practically—approximately weekly, with few exceptions.

Q. Now your samples were daily samples?

A. Yes sir.

Q. Now as a chemist and water analyst, I will ask you if there is any difference in the value of the result of the analyses that are made daily and those that are made weekly from the waters of a running river?

A. Well, the daily samples of course, enable you to get a very much better weekly average than simply taking one result.

Q. Well, they approach very nearly the continuous condition of the stream?

A. They do.

Q. Then are they regarded as the better for the test as to the purity of water—the daily better than the weekly analyses? 1858

A. They are.

Q. Now, Judge Springer asked you a hypothetical question, and the result of the question was to draw from you an answer as to whether or not, if the Ottawa and the La Salle, or rather the Vermillion and the Kankakee and all the rivers that run into the Illinois river were highly polluted; if it would not have an effect upon the pollution of that stream, and of course you said yes.

Now I show you here in a book, called "The Illinois State Board of Health," published, I believe by the State Board of Health of Illinois, and I suppose being the book that Judge Springer read from—you may examine it and see. Turn to page

64, Professor Long's report, examine that and see if that is Professor Long's report there?

A. Yes sir, it is.

Q. As to what?

A. That is as to the condition of the Chicago, Lake, Bridgeport, Illinois and Michigan Canal, Western Avenue, Drainage Canal—as to the condition of the water at all these points.

Q. Well, what water—the waters of the tributaries of the Illinois?

A. Some of the tributaries of the Illinois, and the Illinois itself.

1859 Q. Now please examine that table and if you can, state from that table whether or not Professor Long's report there in May, discloses that the tributaries of the Illinois which he reports there, are more polluted than the Illinois river itself?

A. Well, if we take one example here, the Kankakee river, Wilmington, and run across the averages, we find that it is in very much better condition than the Illinois river. We find that it is not as highly polluted. Free ammonia is only .1, and albuminoid ammonia only .46; nitrites .06.

The Fox river—if we run across for the Fox river, we find free ammonia .1100, whereas, the Illinois river at the same place —Ottawa—is .8. We find nitrites, none in Fox river at Ottawa, whereas the Illinois river, Ottawa is .9, almost a unit, and the nitrates are .02 for the Fox river and for the Illinois river .37, so I conclude from that that the tributaries are very much purer than the Illinois.

Q. At least that you have encountered there and examined there in that table?

A. Yes sir.

Q. What was the date of that examination and report of Professor Long?

A. This is from June until October, 1900.

Q. Well now, at low stages of those tributaries that you 1860 have mentioned there as being less polluted, according to that report, than the Illinois river, would the pollution that would come from them affect the Illinois river much?

A. The analyses show that the Illinois river is very much more polluted than any of its tributaries, and at low stages of course less water would flow in.

Q. Now, I have here in my hand a preliminary report to the State Board of Health of Illinois, by Professor John H. Rouch, M. D., secretary.

There are two appendices—one, chemical investigation of the water supply of the Illinois, by Professor J. H. Long, and the other, Illinois Basin and its relation to sanitary engineering, by L. E. Cooley, civil engineer.

Turning to page 15, I find that Professor Long, in a note paged to table 7, states:

"From table 7, it will be seen that the amount of organic matter in this water as indicated by albuminoid ammonia and oxygen consumption, is quite large, and as both are undoubtedly chiefly of vegetable origin, its effect should not be lost sight of."

This refers to the table giving the physical conditions and constituents of the Kankakee river.

I will ask you to examine that table and see if it bears out the statement that Professor Long makes?

1861 MR. JOHNS: This is objected to for the reason that it is not re-examining and the tables and statements will show for themselves.

ATTORNEY-GENERAL CROW: Well, we certainly have a right to re-examine him as to matters that you bring out. We didn't examine him on that in chief. You brought out the matter of the tributaries.

A. Compared with the values for the Illinois river, there is very much smaller free ammonia and albuminoid ammonias. For instance, they only run up to .1—free ammonia .1, and the Illinois river running much higher.

Q. Now I show you here a report of the Illinois State Board of Health: Advance Notes of the Sanitary Investigation of the Illinois River and its Tributaries. Springfield, Illinois, 1900, with special reference to the effect of the sewage of Chicago on the Desplaines and Illinois river prior to and after the opening of the Chicago Drainage Canal. On page 34 thereof we find a table of averages of chemical constituents of the waters of the canal at Bridgeport, at Lockport, at Joliet, Wilmington, and then the Illinois river at Ottawa, and Peoria, and the different

streams that come into the Illinois, and I will ask you to take that, examine it, and say if you can determine from that table whether or not the tributaries there are less polluted, as shown by the nitrites, free ammonia and nitrates they carry, than
1862 that of the Illinois river?

MR. JOHNS: Objected to for the same reason as given in the objection to the preceding question.

A. The nitrites run very much lower. The free ammonias are also very much lower than of the Illinois river.

This holds for Wilmington and for Ottawa, on the Fox river, and for Havana on the Spoon river, and for Brownings. The free ammonias, and the nitrites, and the chlorines are all very much lower in these tributaries, than in the Illinois.

Q. Do you know, Professor, as to whether or not there are any large cities or towns whose sewage out-falls are into the—in any of the tributaries of the Illinois river below where the canal—the Drainage Canal, joins the Des Plaines river?

A. I do not. I know of no large towns that run sewage into the tributaries of the Illinois.

Q. I believe you said, however, you are not personally, by having passed over the territory, familiar with that drainage area?

A. No sir.

Q. The city of Springfield, Illinois, must be on one of these tributaries, I suppose?

MR. JOHNS: It drains into the Sangamon. That is a city of considerable size, I believe 20,000 to 25,000 people.
1863 It has nearly 50,000 with its suburbs.

Q. ATTORNEY-GENERAL CROW: Well, if most of the drainage from the tributaries of the Illinois, into the Illinois were what we would call the rural character—of rural character, that is to say, towns not having sewers, and the usual drainage from the farms—would that be any different in its effects on the water than if there came into those streams and tributaries sewage flowing through sewers from larger cities and towns?

A. Yes sir.

Q. What would be the difference, if any?

A. Well, we would find high chlorine, for instance. Now, we do find low chlorines in these tributaries that flow into the

Illinois—we find low chlorines, and we also find low free ammonia, whereas in the Illinois itself there is a higher free ammonia, and similarly with the nitrites—the nitrites in the tributaries are low.

Q. Now, chemically, does this indicate anything to the water analyst, as to whether the origin of organic matter in water is of vegetable or animal source?

A. Yes, it indicates that the organic matter is of vegetable source when we have low chlorines and now nitrates, whereas, when the chlorines are high, and the free ammonia is high, and the nitrites high—those three things together indicate animal sewage.

1864 Q. Now, Professor, Mr. Johns asked you the question as to whether or not your analyses made to determine the quantity of Mississippi and Missouri river water that came into the Intake of the St. Louis waterworks, was an actual measurement, scientifically made, of the amount of water of the two respective streams, the Missouri and the Mississippi, that came into the Intake of the waterworks at that point, and I will get you to state now, whether or not it was such a scientific measurement?

A. It was a scientific measurement, calculated from the measured quantities of nitrites in the water.

Q. Now is that the usual and ordinary method that water chemists use for the purpose of determining the relative amounts of two streams, whose waters have commingled at a given point?

A. It is.

Q. Now did that analysis thus made by you, determine chemically the amount of those waters?

A. It did.

Q. Now was that made for the purpose of determining the volume of water that flowed down the river from the Mississippi, and the volume that flowed down from the Missouri, as they commingled together in passing the Intake?

A. It was made for the purpose of tracing these impurities that I found in our reservoir water, to their origin.

1865 Q. Well then, a chemical analysis of water does not constitute the measurement of the volume of the flow of the water?

A. No, sir.

Q. Or body?

A. No sir.

Q. Well, doctor, the analyses as made by you determine the quantity of pollution as contributed by the two streams?

A. Yes sir.

Q. Is the chemist able to determine that from this method of water analysis?

A. Yes sir.

Q. Now isn't it a fact, is it a fact that the actual volume of water does not necessarily correspond with the volume of pollution where two streams commingle—from the respective streams.

Do you understand my question?

A. Not exactly.

Q. Well, I will try to make myself a little more plain. Suppose where the Missouri and the Mississippi come together the water of the Missouri was about one-third greater than that of the Mississippi—but the Mississippi was polluted twice as great as the Missouri at the point of confluence. Then would the amount of pollution found by water analyses below the junction
of the streams, correspond necessarily with the relative
1866 volumes of the two streams at the point of confluence?

A. No sir.

Q. Why?

A. It would show rather than the volume of the streams, it would show us the proportion of impurity which came from each of the streams.

Q. And that is just what the water analysts can do?

A. Yes, that is what we are for.

Q. That is the value of the analytical determination of the commingling waters of the two streams?

A. Yes sir.

Q. And that was the object of making this examination?

A. Yes sir.

Q. Now Judge Springer asked you, I believe, if professor Long's figures did not disclose—the tables that he made—two analyses, one before and one after the opening of the Drainage Canal at Shady Beach, above Peoria. Can you take those tables and tell me whether or not he did make any such analyses at any time, without reference to the season of the year, just so it was before or after?

A. He made analyses at Shady Beach in the summer of 1900.

Q. What months?

A. In the months of June, July, August, September and up to October 9th.

Q. Now did he make an analysis at the same point prior
1867 to the opening of the canal, if those tables show that fact?

A. These tables show that he made analyses for the Narrows from July to November, 1899—for Peoria at the Narrows, July to November 30th—practically December 1st.

Q. 1899?

A. 1899.

Q. Now Mr. Johns asked you this morning as to whether or not fifteen minutes was the standard of time you would set for leaving the dishes in the receptacle in to which you placed them—the air bath, I believe?

A. Yes, air bath.

Q. Now I will ask you if it matters materially as to the practical result, chemically, as to whether they are left in there exactly 15 minutes, or 18 minutes or 20 minutes?

A. No sir, it is of no significance. The idea is to heat them up until the water is driven off. Now the water is practically all off when we put them in there, and we simply heat to make sure for about fifteen minutes, that the moisture is driven off, and twenty minutes or an hour wouldn't make any difference.

Q. Now Professor, I will ask you, do you consider the water, commingling of the Missouri and the Mississippi, as it comes into the Intake of the St. Louis waterworks, since the opening of the canal, is a safe, sanitary water for the use of cities of this size?

1868 A. I do not.

Q. I will ask you to state if you personally use the same without filtering it or boiling it?

A. The water that I drink at my house is all boiled and filtered.

Q. Now Mr. Johns also asked you about some assistants you have had or did have, in the conducting of these analyses. I will ask you to state as a practical chemist, whether it is possible for a man to conduct twelve or fourteen analyses of water a day through a period of time, by himself?

A. No, I regard that as a physical impossibility, for one man to make fourteen determinations in a day, or even a smaller number than that.

Q. And as a practical proposition of analyses of waters in quantities of this kind, twelve or fourteen samples made daily over a period of months, must be conducted by more than one man?

A. Yes, and they can be conducted with very much greater efficiency by having trained assistants who do certain determinations day after day. They acquire skill in their routine work and their figures then give very reliable results, because they are strictly comparable, whereas, if one man attempts to do everything he does not acquire the same skill in all the processes, as he would if he confined his attention to one determination.

1869 Q. Now in the course of the analyses you made, you used a great many reagents?

A. Yes sir.

Q. Now did you investigate to determine the purity of the reagents that you used?

A. We did; we examined the purity of those reagents.

Q. What did you find with reference to them? Were they chemically in proper condition?

A. We found that those reagents, like the silver nitrate and the ammonium chloride, were chemically pure. We only used chemically pure reagents. In any case where it was not necessary to have chemically pure reagents we used the commercial articles. We took all the usual precautions that are outlined for such work in the standard reference books.

Q. Who is the leading manufacturer of what is regarded as absolutely pure chemical reagents?

A. Which reagents do you mean?

Q. Well, the chemicals used in the preparation of these analyses?

A. Well, we used the Kohlbaum reagents, for the organic chemicals like sulphanalic acid, and the alpha naphthylamine. We had the standard reagents from C. A. Kohlbaum, Germany, and we used pure chemicals for all of our work, as pure as we could get, and then we tested the purity.

Q. Now did you personally examine the condition from 1870 time to time of the apparatus that you used, the distillation apparatus with other things, in the laboratory?

A. Yes, I had supervision of the whole work, and I checked up the standard solutions used myself, and I made all the calculations. The notes furnished me by the assistants were not expressed in parts per million; they were expressed in so many cubic centimeters of water, standard solutions, and I made all calculations myself.

Q. Yes, but your apparatus there, did you keep them in proper cleanly condition from day to day?

A. Yes sir, certainly.

Q. Did you have a set of rules for your men to work by?

A. I did.

Q. Did you see that they were followed?

A. I did.

Q. If they were not followed, was the work rejected?

A. It was.

RE-CROSS-EXAMINATION, By Judge Springer.

Q. You stated in answer to a question put by General Crow, that before using the water furnished to the people of St. Louis through your waterworks, that you caused it to be filtered and boiled?

A. At my house, yes sir.

Q. At your house?

1871 A. Yes sir. I sometimes drink water when it has been run through a Pasteur filter. In the University we have a Pasteur filter, and that water has not been boiled, but it has been filtered very carefully.

Q. How much of the impurities would the Pasteur filter remove from the river water without boiling?

A. It would take out the larger proportion of the bacteria I believe.

Q. What would you say as to the waters in all the navigable rivers in the United States so far as their potable character was concerned?

A. Well, that is a very broad question and one that I am scarcely—

Q. Are there any waters in the navigable rivers of the United States that you would recommend people to use without being filtered and boiled, for drinking purposes?

A. Well, I imagine there are some rivers. The Upper Missouri is probably in a very good state, and it is navigable, I believe for many thousand miles. I believe the Missouri above Kansas City and St. Joseph, is a very fair stream and that it could be used as a potable water.

Q. Without filtration or without boiling, for drinking purposes?

A. I think so, I think above the larger towns it would be
1872 in good sanitary condition.

Q. Below Sioux City, Iowa on the Missouri river, and below St. Paul and Minneapolis on the Mississippi river, and below Pittsburg in the Ohio river, and below St. Louis on the Mississippi river, would you regard any of these waters as suitable for the best of purposes without some kind of treatment?

A. I think that all waters of our rivers ought to be filtered.

Q. Ought to be filtered?

A. Yes sir.

Q. Then there is danger of contamination from any of them unless they are filtered?

A. Yes sir. EDWARD H. KEISER.

1873 DR. WILLIAM C. TEICHMANN,

Resumed the stand for further direct examination by Attorney-General Crow, and testified as follows:

Q. Dr. Teichmann, please state your name, residence and occupation?

A. William C. Teichmann.

Q. What is your age?

A. Forty-three.

Q. Residence and occupation?

A. I live at 3624 Shaw Avenue, St. Louis.

Q. You were raised here in St. Louis?

A. Yes sir.

Q. Educated abroad and in this country?

A. Yes, partly in St. Louis and partly abroad.

Q. Just state your educational training, where you received it and what it has been?

A. I originally attended the Academic Department of the Washington University, and continued my education in the Polytechinc College at Brunswick.

Q. Whereabouts is Brunswick?

A. Brunswick, Germany, where I studied chemistry.

Q. How long did you study chemistry there?

A. For four years.

1874 Q. Then where did you go?

A. Then I studied chemistry in the University of Berlin, for a period of two years, particularly under Professor Tiemann, author of a well known book on water analysis, and considered in Europe as an authority upon the question of water.

Q. Well then where did you go to?

A. Then I studied a half year, or rather one semester as they call it, in Germany, in the University of Leipsic, and three and one-half years in the University of Munich, Germany. I graduated as a Ph. D. from the University of Munich, in 1885.

Q. Then what did you do?

A. I returned to this country at that time and for a number of years I was occupied with literary pursuits, and in 1890, I became private assistant to Professor Charles O. Curtman, who was Professor of Chemistry in the Missouri Medical College, of St. Louis, which college has subsequently been united with the Washington University.

Q. Then where was your next position?

A. And I was private assistant from 1890, until 1896, for Professor Curtman, and from 1891 until 1896, I was Assistant Instructor of Chemistry in the Missouri Medical College, assisting the professor of chemistry, Dr. Curtmann.

Q. Well, did you occupy any official position during this 1875 time?

A. Yes sir, in the year 1893, I was appointed City Chemist of St. Louis.

Q. Do you now hold that position?

A. Yes sir.

Q. And how many years did you put in on the exclusive study of chemistry and the allied subjects that were necessary to be understood to complete a practical chemical education?

A. Well, practically since the year 1875, when I entered college at Brunswick.

Q. Up to 1885?

A. Yes sir, ten years abroad.

Q. And then six years that you stayed abroad, in Germany?

A. No sir, I say—

Q. I say, six years of the ten years you had in Germany?

A. No, I was ten years abroad, I say, from 1875 until 1885.

Q. Now as a chemist, you have had occasion to analyze water and all classes and kinds of materials and substances, solid and liquid?

A. Yes sir.

Q. What class of work are you called upon to do in your position as City Chemist?

A. Well, the most important work and the largest part of the work consists of water analyses.

1876 Q. Well, what water is it you are called upon to analyze?

A. Well water, cistern water and river water, and water furnished by the City water supply.

Q. Is your office connected with the health department of this city?

A. Yes sir.

Q. Who is at the head of the Health Department?

A. Dr. Max C. Starkloff.

Q. Now what various branches of that department are there besides your own?

A. Well, the department is divided into sub-departments, and divisions.

Q. What are they?

A. Well, various city institutions are under the direct control of the Health Commissioner, and the Board of Health, also the Sanitary division, and the chemical division and the bacteriological division.

Q. Well now, who constitutes the Board of Health?

A. Six—the Mayor, President of the City Council, the Health Commissioner, one Police Commissioner, appointed by the Mayor, and two members of the medical fraternity of St. Louis who are appointed by the Mayor for a period of four years.

Q. Now who is the City Bacteriologist?

A. Mr. Charles A. Snodgrass.

1877 Q. Does he have any employes under him?

A. I think he has, yes sir.

Q. How many?

A. Well, to my knowledge he has a janitor and a stenographer.

Q. Now who is the Health Officer?

A. Do you mean the Health Commissioner?

Q. Health Commissioner?

A. Dr. Max C. Starkloff.

Q. No I mean the Sanitary officer.

A. The assistant health commissioner, who represents the Health Commissioner during his absence, is also chief Sanitary Officer.

Q. And who is he?

A. Mr. Charles W. Francis.

Q. Now how many people does he have under him?

A. Well, that I can't tell; that varies according to the appropriations and the requirements of the department.

Q. Well, how many—a great many, doesn't he?

A. Oh yes, it may vary from 25 to 50.

Q. Now what branch of the Health business does he look after?

A. Well, he represents the Health Commissioner and looks after the general health and the sanitary conditions of the community.

Q. Well, he enforces inspection of those too?

A. Yes sir.

Q. Now how many men have you got in your department?

1878 A. That varies according to the requirements. My regular employes consist of—well, there is myself, the City Chemist, the Assistant City Chemist, there is a clerk and helper at the distillation table, and the janitor.

Q. Well how many does that make?

A. Four. Four men constitute the regular force, but the milk inspection having been added to the City Chemist's office in August of last year, gives us five additional employes, two analytical chemists, two inspectors and a clerk.

Q. Now where is your office located?

A. It is located in the old City Hall of this city.

Q. In what part of the city?

A. In the eastern part of the city.

Q. Well, what street?

A. 11th and Chestnut.

Q. Have you a laboratory there?

A. Yes sir.

Q. Now you are acquainted as a chemist, with what it takes to equip a laboratory for practical chemical work?

A. Yes sir.

Q. Well, have you got the necessary equipment there to carry on practical water analyses, and such other analyses of substances as may be submitted to you?

A. Yes sir.

Q. How many rooms have you?

1879 A. I have six rooms.

Q. Well, did you make the analyses for the city of the water—City and State,—of the waters of the Mississippi, the Missouri and the Illinois Rivers, and the Drainage Canal and Lake Michigan?

A. Yes sir. I made them or superintended their analysis.

Q. Beginning in the year 1899, on up to December last year?

A. Yes sir, during that period beginning with August, 1899, up to the present time, I made water analyses of samples taken from these various places you have mentioned.

Q. Now, prior to your beginning that work, what experience had you had as a water analyst?

A. I had repeatedly analyzed samples of water from the river and I had made quite a number of analyses from the tap in the City Chemist's office, at that time, and I analyzed a large number of samples of water taken from wells and cisterns in St. Louis.

Q. Well, during the ten years, or the seven years that you have been City Chemist, prior to the period I have mentioned, in 1899, was it a part of your duty to make water analyses?

A. Yes sir.

Q. You have been making them how often, monthly or yearly?

A. Well, that depended upon the respective orders from the Board of Health, or from the Health Commissioner, and according to my own judgment, whenever I thought that the
1880 city water supply necessitated analysis of the water to find out its character.

Q. I believe you said that at some place in Germany, at Brunswick or Berlin, you took a special course of study under Tiemann, who is a water analyst, or water chemist?

A. I didn't exactly take a special course, but I worked under him. He was my instructor at that time.

Q. Well, did you make any analyses of water there?

A. Yes sir.

Q. How long a period did that cover?

A. While analytically working under him I performed them for a period of about one year.

Q. Well, at any other points did you perform any practical analytical work of analyses of water?

A. Yes sir.

Q. Where and when?

A. In Brunswick.

Q. Brunswick, Germany?

A. Yes sir.

Q. How long did you continue that work?

A. Well those analyses were simply made, as they were required in the course of instruction. That is part of the course to be followed.

Q. Well at any other points besides Brunswick, and this instruction under Tiemann, in which you made practical analyses of water during your student days?

1881 A. I didn't make any more water analyses after I left the University of Berlin until I returned to St. Louis.

Q. Well, as instructor or assistant instructor to Professor Curtman, were you called upon to make any water analyses?

A. Yes sir. It was part of the instruction of the laboratory but I performed more analyses in his private laboratory, private analyses that he was requested to make.

Q. Well, how often would you make these practical tests of water?

A. Well that I could not say exactly, because just from time to time as samples of water came in for analysis, they were analyzed.

Q. Well in the course of your experience prior to the investigation of these waters I have mentioned, beginning in 1899, have you had any practical experience in analyzing waters to determine their wholesomeness and potability for primary and domestic use?

A. Yes sir.

Q. What experience have you had?

A. Well, the experience that I acquired during the—principally as the private assistant to Professor Curtman, and as City Chemist, beginning with May, 1893.

Q. Did you have charge of the examination of these waters
of the Illinois, the Missouri and the Mississippi Rivers,
1882 and the Drainage Canal and Lake Michigan?

A. Yes sir.

Q. Were all the water analyses made under your supervision?

A. Yes sir.

Q. Did you procure Professor Keiser to do the work which he did?

A. I suggested to the City Authorities that Professor Keiser be engaged for duplicate work.

Q. Well, the work which he did, did it correspond with the work that you did, in quantity, in other words did you do duplicate work, the same as he did?

A. Yes sir.

Q. Worked on the same samples?

A. Yes I performed duplicate, or rather I superintended the analyses of duplicate samples, with the samples that Professor Keiser received in my laboratory.

Q. Now who provided the method that should be followed in the collection of these samples; who laid down those rules?

A. Well, I carefully prepared these rules, and submitted them to the Health Commissioner, and I discussed some of the rules with Professor Keiser, and the rules were practically the embodiment of our joint ideas.

Q. Did you have charge of the men that collected the water samples for the bacteriologist also?

1883 A. For part of the investigation, yes.

Q. What portion?

A. Well, all samples that were collected and sent to St. Louis or delivered at St. Louis by the collectors; they usually came to the City Chemist's office first and were then sent to the laboratory of Dr. Ravold, who had charge of the bacteriological work, but there have been a great many samples collected at various stations—the so-called bacteriological stations along the route between Chicago and St. Louis, and those collections were made under the direction and responsibility of the respective assistants of Dr. Ravold that had charge of those stations.

Q. Now did you follow any method or system, that is well known and recognized among water chemists and water analysts, in the rules laid down by you for the collecting of these samples of water?

A. Yes sir.

Q. What particular system of rules did you follow?

A. I studied the rules observed by leading water analysts of the country, and also some of the analysts of Germany, as recommended in standard books, and then considered the local conditions and tried to adapt the rules as much as possible to a most accurate result in the collection of samples.

Q. Well, you organized the inspection force then that went to work upon these samples of water?

1884 A. Yes sir.

Q. Now just tell me how you organized them, how many men you had and how you divided the duties?

A. I would have to refer to my report.

I mentioned in my previous testimony the various periods of investigation and the number of men employed, and the system of collection differed somewhat during those periods; that is, the investigation when it started, was not conducted on the comprehensive scale that it finally assumed, or rather assumed after the Drainage Canal was opened.

Q. Well, I am dealing now only with the question of the collection of the samples?

A. Yes sir.

Q. Not the method of the work pursued in the laboratory. Now just go ahead and give me the method which you followed in organizing the bureau for the collection of those samples?

A. During the first period of investigation, beginning August 23rd, and ending January 22nd, the samples were partly collected by myself, on occasions of personal visits to the various points of collection between St. Louis, and the mouth of the River and the Mississippi River a few miles above the mouth of the Illinois. They were partly collected by special collectors engaged for that purpose, and my janitor. 1885

Q. Well, do you know the names of those men that you engaged?

A. Yes sir. The force employed in this work consisted during this period, of myself and the Assistant City Chemist, Mr. Thomas A. Buckland, collector of samples and helper at distillation table, Henry R. Taylor, Sr.

Assistant collector of samples and helper at distillation table, Henry R. Taylor, Jr.

Assistant collector of samples and helper at distillation table, Herman Ungar.

Then during this period a number of trips were made by the Harbor boat at St. Louis, and on several occasions a private boat was engaged for these trips. The trips were made up to the mouth of the Illinois River and samples were collected as we proceeded up the river from the Intake to the mouth of the Illinois and returning, and also samples were collected from the mouth of the Illinois. On such occasions these samples were partly collected by myself, or by one of the assistants whom I have mentioned.

Q. Now how far up the Illinois River and the Mississippi River did those examinations extend?

A. They extended up the Mississippi River to a point five miles above the mouth of the Illinois River, and up the Illinois River to a point five miles above Grafton.

1886 Q. Did they extend into the canal?

A. No sir, that is investigations prior to the opening of the canal.

Q. Did they extend into the Chicago River?

A. No sir.

Q. Did they extend into Lake Michigan?

A. No sir.

Q. Now what means did you provide for getting these samples to St. Louis and into your laboratory?

A. These samples when I collected them, I usually had my janitor with me, who carried them after I had sealed them—carried them to the City Chemist's office, or when they were collected by anybody else, either from the harbor boat or from the private boat engaged for a few times, or when they were collected by special men sent up to the mouth of the Illinois river, on a few occasions, they were always brought by these people to the City Chemist's office,—that is, all samples in a sealed condition, because immediately when they were collected they were sealed.

Q. When they were received at the City Chemist's office was there any preparation there for the storage of them?

A. Yes sir.

Q. Or were they analyzed immediately?

A. They were usually analyzed immediately, if arriving during day time or not later than eight or nine o'clock in 1887 evening, when we would return from the harbor boat; sometimes we wouldn't get back until ten o'clock at night? Then of course the samples could not be analyzed right away, but when we got back to the city, if the samples reached the laboratory before eight o'clock, we would immediately proceed with the analysis for ammonia,—or the distillation process which I shall describe later on, and for nitrites.

Q. Well, was there any preparation made for the observation of the water, the temperature of it, after its being taken from the river prior to its being received into the laboratory?

A. The temperature of the water and the temperature of the air was always taken and recorded at the time of collection.

Q. Yes, but the water, was there any preparation made to preserve the temperature of the water either above or below what it was when taken from the river, at the time it was taken?

A. A part of the samples,—the earlier samples, they were not packed in ice at the time of their collection, and were brought to the laboratory in that form, without having been packed in ice, but that was only for a short time. For a few weeks, and then I had little tin boxes prepared where ice was contained in one section of the box, and the bottles placed in the other side so as to have a kind of an improvised refrigerator, and
1888 the samples were then brought to the laboratory, and all
samples, when they were brought to the laboratory were always put in an ice chest so as to keep them at a low temperature.

Q. Well, did you have any rules for these water collectors to follow specifically, when collecting water, as to where they should take it from or on the surface, at the bottom of the river in the middle of the river, or at the shore line?

A. The very first samples, for the first few weeks were taken in demijohns, and we would lie down in the boat and take the samples from a little skiff—rather—we would lie down in the skiff and reach down with our arms, reach down the demijohn as far below the surface of the water as we could possibly, so as to get the water at a depth of about an arm's length; but after a few weeks we had an apparatus constructed which I exhibited in my previous testimony.

Q. Well, Complainant's Exhibit Number 15. Just describe it that way?

A. Yes sir.

Q. Just describe it that way then?

A. Complainant's Exhibit Number 15. The collectors were instructed, and whenever I would collect the samples myself, the machines were extended into the water down to the handle, down as far as we could get it, so as to get it about three or four feet if possible—

1889 Q. Below what?

A. Below the surface.

Q. Now whereabouts, with reference to the shoreline of the river were these samples taken during this period from August 1899 to January 22nd, 1900?

A. Well, between the mouth of the Missouri and the Intake, these samples from the shores were taken from the Missouri shore and from the Illinois shore.

Q. No, you don't understand me, doctor. I guess you are confused a little bit there by that talk there, and you didn't notice.

I say whereabouts were these samples taken from, with reference to the location of the boat to the shore line; was it on the shore or off the shore, and if so, how far?

A. Well, we would get into a little skiff and we would watch the currents, and if we wanted a sample from either shore, we would endeavor—or the collector, if I would not be there,—would endeavor to get the samples—to get samples from those currents which hugged the shore. There was no measurement or anything; it was simply to get the water that runs along the shore line.

Q. Were any of the samples taken from mid-stream or out in the channel?

A. Yes sir.

1890 Q. Well, at what points were they taken, out in the mid-stream?

A. Well, that would be very hard to describe.

Q. Well, haven't you a record of that?

A. Well, there were no measurements from the shore, so that we could indicate how far from the shore it was taken; it was generally individual judgment. If we wanted to get a sample from mid-stream we would see where the current was and right from the middle of the current we would take the sample.

Q. Well, have you got any official record of this work?

A. Well, later on we took what we call cross-sections.

Q. What do you mean by later on? Do you mean in 1901, or do you mean in the fall of 1899?

A. In 1901, in the fall, we took what is called cross-sections, and of course we didn't know what the distances from the shore were, of those cross sections. Twelve samples were taken right across the river in a line—

Q. Have you got a record of those cross-sections?

A. Yes, but that is work that was performed in subsequent periods, and that don't belong to this period. Work was done in this period—

Q. I am asking you if you have got any record whatever of the work that you did from August, 1899 to January 22nd, 1900?

A. Yes sir.

1891 Q. Now what shape is that record in?

A. Well, the record of the collections is first recorded on the tags that were presented here.

Q. Now those tags and that record shows where the water was collected, don't they?

A. Yes sir.

Q. Then you were mistaken a while ago when you said that you had no record of the place where those samples were collected, weren't you?

A. Well, I undestood it this way, that you wanted exactly the location recorded, where those samples were taken. That of course, would be impossible. I misunderstood you.

Q. Now what does the record on the tag indicate?

A. The record on the tag on the samples collected from the Misouri shore, the sample collected from the Illinois shore—

Q. Well at any particular point?

A. Yes sir.

Q. Well, at Hartford, Alton or Chain of Rocks?

A. Well, it would say so—chain of rocks.

Q. But the record of the location in the particular part of the stream you haven't got?

A. No sir.

Q. But you say that it was taken off shore?

A. Yes sir.

1892 Q. Now how about the Illinois River; have you got any record of the samples you took up the Illinois River from August, 1899 to the 22nd of January, 1900?

A. Yes, there were 19 samples taken from the Illinois river at points one, two, three and five miles above Grafton.

Q. Now where were they taken with reference to the shore line of the Illinois River?

A. They were taken from the current.

Q. Well, when you use the term "current" do you mean the channel of the river?

A. Channel of the river, yes sir.

Q. Now what was the stages of the Mississippi, the Missouri and the Illinois Rivers from August, 1899 to January 22nd, 1900?

A. I have got the record of those stages—

Q. Yes, but generally speaking, were the rivers low or high or at mean stages of water?

A. The Illinois River at that time was comparatively low; I say comparatively, because it has been lower, at other times.

Q. How about the Missouri and the Mississippi?

A. The rivers were all comparatively low at that time. I can't tell exactly because I haven't got the data here just now.

Q. Now did you take any samples up the Missouri River?

1893 A. I took them at the mouth of the Missouri, but sufficiently far enough up into the river so as to get Missouri River water only and no back water from the Mississippi.

Q. Well, how far up the Missouri River did you go?

A. Probably a mile.

Q. Above the point of confluence of the two streams?

A. Yes sir.

Q. How many samples did you take?

A. Ten samples.

WILLIAM C. TEICHMANN.

ADJOURNED until following morning, Tuesday, March 17th, 1903, at ten o'clock A. M.

1894 Southern Hotel, St. Louis, Mo. 10:00 a. m., Tuesday, March 17, 1903.

Present, the Commissioner and same Counsel representing the respective parties.

DR. WILLIAM C. TEICHMANN resumed the stand for further direct examination, by General Crow, and testified as follows:

Q. Now, go ahead and tell what you did about investigating these waters in your own way?

A. The other samples collected from points between the mouth of the Illinois and the Intake tower in the Mississippi river during that period were from Madison Landing between the Chain of Rocks and the mouth of the Missouri River on the Missouri shore, three samples.

Then Madison Landing, Illinois shore seven samples.

Going farther up the Mississippi River between the mouth of the Missouri and the mouth of the Illinois there were thirteen samples collected at points between Alton and the mouth of the Missouri River.

Six samples between Alton and Portage—Portage is about half way between Alton and Grafton,

1895 Near Clifton Terrace six samples.

Then Elsa, near Piasa Bluffs, between Portage and Grafton, half way between Portage and Grafton, five samples.

Do you want anything about the method of collecting these samples and their treatment at the laboratory?

Q. Yes, put in there whatever you want about that?

A. All the samples collected during this period were properly sealed as heretofore described and opened at the laboratory for analysis by myself and my assistant, Mr. Thomas A. Buckland.

Do you want to have a general discussion of the period prior to the opening of the Drainage Canal now in connection with the analytical investigation?

Q. Well, just go ahead and describe what you have done there in investigating these waters?

A. Do you want to ask that in the line of regular questions or do you want me to give a general description of it?

Q. Go ahead and state what you did and we will get through quicker that way.

A. I mean do you want to have a description of the Illinois River water shed and a discussion of the volume of flow and its various tributaries?

Q. I don't think that is necessary, but you can put it in if you want to.

A. I will leave it to your judgment.

1896 Q. I would suggest to you just to answer my question.

A. Your question is so general I don't know what part of the investigation and what part of the results you want to have discussed first.

Q. I would start at the beginning if I were you and go right through. I think you can do that better than if I ask you detailed questions.

A. Well, in order to give proper weight to the sources of pollution which affect the sanitary character of the Illinois River we will have to consider some figures from responsible authorities on the effect of dilution from the Illinois and Michigan Canal and the tributaries.

Since it is of the greatest importance to find out the stages of the river during the periods of drouth we will look for the low water stages of the Illinois River water shed. Perhaps the lowest low water stage on record is that presented and discussed from the United States Government data by Lyman E. Cooley in a report published in 1890, entitled "Lakes and Gulf Water Ways, as related to the Chicago Sanitary Problem."

Mr. Cooley divides the Illinois River water shed into two divisions, Lake Joliet to Utica, and Utica to the mouth. Now, he gives the low water volume from Lake Joliet to Utica as follows: "The Des Plaines has been measured twice for low
water, in 1887 giving 256 feet per minute and in 1879
1897 339 feet per minute, I think between Riverside and Lock-
port. The extremely low water at Wilmington, on the
Kankakee river for 12 years, from 1871 to 1883 was 25,200 feet per minute. A measurement made September 9th, 1867, at the mouth of the Kankakee in connection with General Wilson's United States survey gave 27,377 cubic feet per minute. The water was said to be lower in 1867 than for the previous twelve years. The quantity in the Fox River September 17, 1867 was 31,539 feet per minute. The Mazon was practically dry. From May 13th to the 28th, 1887, at Morris the water was then two or three inches within the lowest since 1856, and it is doubtful if the amount was to exceed 15,000 or 20,000 cubic feet per minute, or 250 to 350 feet per second. At least 60 per cent. of the whole water volume passing Morris in 1887 came from Lake Michigan by the Illinois and Michigan Canal and probably one-half of the volume in ordinary low water years, comes from this source. A measurement has been made at La Salle by the Canal

authorities before the canal was deepened, of 37,900 cubic feet per minute, and doubtless Lake Michigan water has represented one-half of the volume passing in some recent low water periods. Now, this is a quotation from Cooley's work and I will add also a quotation on the low water volume from Utica to the mouth.

MR. JOHNS: The defendant, the State of Illinois, ob-
1898 jects to the reading into the record reports from books of whatever character or description, for the reason that if the evidence is competent the books themselves are the best evidence.

A. Well, I can present this report as it was published by Lyman E. Cooley at that time and I can refer to the quotations as coming directly from this scientific work.

MR. JOHNS: There is no question about the correctness of the work. It is simply incompetent as evidence.

MR. TODD: And the Sanitary District wishes to object on the ground of its incompetency.

THE WITNESS: What is your pleasure, Mr. Crow?

GENERAL CROW: Go ahead.

THE COMMISSIONER: You may go ahead and make your statement.

A. The low water volume from Utica to the mouth. "The low water volume of the Illinois after the ponds, lakes, sloughs and marshes have been drained out as they are in long seasons of drouth, shrinks to very small proportions, proof conclusive of the lack of permeability of the subsoil and underlying lakes of the Illinois River basin. In 1888, the water running over Henry Dam was less than 500 cubic feet per second for nine days, and at Copperas Creek, for 20 days. But the water at Copperas Creek was at or below the same level in 1887 for 117 days and in 1886, 18 days, and in 1879 for 44 days, and at Henry in 1877 for 30 days, and in 1875 for 47 days and in 1871 ap-
parently for a longer period. The volume in 1888 was less
1899 than that sent through the canal at Chicago for the same
period, about 700 cubic feet per second, and lake water from 300 cubic feet upward has been going to the valley since July, 1871. How much leakage there might have been through the dams at this time is unknown. In 1867 or earlier the measurement was made at La Salle of 633 cubic feet per second and

in 1879 in the lower section of the river 1566 cubic feet, and in 1887, 1685 cubic feet. Part of the water in the last two measurements is chargeable to Lake Michigan. It is probable that since the Bridgeport pumps were erected in 1883 over half of the minimum discharge above Havanna has come from Lake Michigan, and one-third of the minimum below the Sangamon. For the purposes of calculation the normal low water volume is taken at 600 cubic feet per second for the upper section of the river, (and this agrees with the figures I find in the report published by the Illinois State Board of Health and embodying a special report on this question by Civil Engineer Harmon). As I said I quote here from Cooley for the purpose of calculation the normal low water volume is taken at 600 cubic feet per second for the upper section of the river and of 1200 cubic feet per second for the lower section. If Chicago were to pump 2000 cubic feet pending the completion of the ship canal it would mean a great deal to the lower Illinois."

Now, I wish to state that it will be seen in the year 1887,
1900 60 per cent of the cubic feet per minute at Morris was
due to the flow of the Illinois and Michigan Canal, or in other words, the natural flow in the Illinois above that point was only 8000 cubic feet per minute, or 134 cubic feet per second. From Lyman Cooley's remark we may assume for the purposes of calculation, that the natural low water volume independent of Chicago sewage, above Havana is 300 cubic feet per second and below this point is 800 cubic feet per second. Now, this is the condition prior to the opening of the Chicago Drainage Canal. From those figures I have calculated the following ratio of dilution of Chicago sewage in the Illinois River prior to the opening of the Drainage Canal: Upper Illinois volume of flow 600 cubic feet per second, as established by Lyman E. Cooley and Civil Engineer Harmon.

Sewage of Chicago, 400 cubic feet per second, ratio of dilution 1:0.5.

Lower Illinois: Volume of flow: 1200 cubic feet per second—that is the upper district runs to Utica and the lower district from Utica to the mouth. That is, the lower Illinois had a volume of flow 1200 cubic feet per second and sewage of Chicago 400 cubic feet per second, making the ratio of dilution one to two. I deduct the sewage from the water.

Now for instance, 600 cubic feet of water I have there and I have 400 cubic feet of sewage, that leaves 200, 200 to 1901 400 equals 0.5, as the ratio of dilution, and in the same way we would refer to the 1200 cubic feet of volume per second in the lower Illinois and sewage 400. Deduct that 400 from the 1200 and it leaves 800, and 400 is to 800 as is one to two.

I will later on compare this low water dilution with the amount of water coming from the Chicago Drainage Canal added to it, and will then show a different ratio of dilution after the Drainage Canal has been opened.

Now, the amount of sewage from Chicago was obtained by taking it equal to the water supply which is 42,000,000 cubic feet per day. This is a rational assumption and it is often used in sewage computation. As Professor E. O. Jordan, in an article, written for the "Journal of Experimental Medicine" in 1900, states, that only four-fifths of Chicago sewage has been discharged by the Illinois & Michigan Canal, we have thus deduced 400 cubic feet per second as the amount of sewage discharged there prior to the opening of the main Drainage Canal.

Of course, these dilutions are given only to show just what proportion of the Illinois River is made up as the diluted sewage of Chicago and the purification of this sewage must be taken seriously into account before arriving at definite conclusions.

JUDGE SPRINGER: Will you repeat that again?

1902 A. Professor Jordan advances it in this article written for the Journal of Experimental Medicine, that four-fifths of the Chicago sewage went into the Illinois & Michigan Canal. That was prior to the opening of the Chicago Drainage Canal, and with the proper deductions there we got 400 cubic feet per second of the amount of sewage discharged therefrom into the Desplaines River or into the Illinois River prior to the opening of the main drainage canal. Mr. Crow, do you want the drainage areas?

Q. MR. CROW: Just go ahead and give your methods of making these analyses.

A. The population draining into the rivers?

Q. No that is not necessary.

A. It is an important statement made from data obtained from Lyman E. Cooley's report, as to what the amount of drainage area is.

Q. Just go ahead and give your methods of making these analyses.

A. In selecting the methods for analyses I studied the methods applied by Professor Thomas M. Drown in his investigation of the Massachusetts Water supplies. An investigation conducted on a very elaborate scale in the years 1887 and 1888 and the results of which were embodied in a report that is today considered a standard work on methods of analyses.
1903 I also considered the methods recommended by prominent authorities on water analysis such as Tieman of Berlin in his work "Unter-Suchung des Wassers." This work is really an enlargement of a previous work written by Kubel, the inventory of the Permaganate method of the determination of organic matter in water.

Furthermore, I considered such works as Mason's "Examination of Waters" and Leffman and Bean's Examinations of Waters, and a few other works of lesser importance.

For the determination of ammonias I found a process recommended by Mason and Leffman based upon a recommendation by the American Association for the Advancement of Science. This method varied somewhat from the ordinary method, what we call the Wanklyn and Chapman method for the determination of ammonias in so far as the total ammonia is estimated first by distillation through an ordinary condenser; the free ammonia is determined in separate samples and the free ammonia finally deducted from the total ammonia.

The original distillation method implies as it was designed by Wanklyn originally and modified by Chapman and Miller. I say the original Wanklyn and Chapman method implies a distillation of the free ammonia from one sample and after the free ammonia has been distilled over a Permaganate solution is added to the residue in the flask and distilled over.
1904 This Permaganate will liberate what is called the albuminoid ammonia.

Later on during the investigation I abandoned the so-called Mason method of distillation of the ammonia and returned to the Wanklyn and Chapman method, because I found the Mason method cumbersome and time robbing and came to the conclusion that results just as accurate could be obtained by the elder method.

The apparatus used for the determination of ammonia consists of round bottomed flasks of about one litre capacity, which were obtained from Schott & Genossen in Jena, Germany made of the so-called Jena glass, which glass has the advantage that it can stand any temperature of heat required for the distillation and that it will not give off any alkali which may happen to flasks of quality not as good as these of Schott & Genossen. These flasks were connected with a large condenser of galvanized iron with ten inner condensing tubes of block tin. They were connected with the condensing tubes by means of rubber stoppers, which had been previously boiled for several hours, to remove any ammonia possibly connected with the rubber stoppers, or rather surrounding them. These flasks and the apparatus before they were used for the analysis in each instance, were first freed from possible ammonia that
1905 might have been there, by filling the flasks with about
two-thirds of ammonia free water. They were connected with condenser and the water was distilled off through the condenser, until the distillate gave no color with Nessler reagents, in other words we observed the precaution to clean out the flasks as well as the condenser tubes through which the steam passes and is condensed again by the water flowing through the apparatus and cooling off the steam so as to change it back to water. I say there was a guarantee of no ammonia being present in these tubes. Then when we were certain that the condenser was free from ammonia and the flasks free from ammonia, these flasks were used as follows:

If it was a sample of unfiltered water to be analyzed 500 cubic centimeters were measured into an accurately colibrated flask and poured into the distillation flask. Ten cubic centimeters of a sodium carbonate solution was added, the flask connected with the condenser and the distillation of the free ammonia begun. This distillate was collected in 50 cubic centimeters of so-called Nessler tubes. When five tubes had been distilled off the apparatus was disconnected and allowed to cool slightly.

Now, when we applied the Wanklyn and Chapman method
100 cubic centimeters of ammonia free water and 50
1906 cubic centimeters of alkaline potassium Permanganate
solution the nature of which I shall describe yet, were added. The flasks were reconnected and the distillation of the albuminoid ammonia proceeded with until five tubes had been collected. The distillation tubes having been completed a set of standards containing definite quantities of ammonium chloride solution was prepared as follows, and that was for comparative purposes:

Into a set of Nessler tubes was placed respectively, .1, .3, .5, .7, 1, 1.3, 1.5, 2, 2.5, 4, 6, 8, 10, 12, 15, 18 and 20 cubic centimeters of the standard solution containing .01 milligrams of ammonium chloride in each cubic centimeter. The tubes were filled to the 50 cubic centimeter mark with ammonia free water, then to each of the set of standards and the distillates from the samples one cubic centimeter of the Nessler solution, which is alkaline mercuric potassium iodide solution, was added and the tubes allowed to stand for 10 minutes when the comparison of the samples with the standards was made and the results recorded in a book.

Now, as regards the Mason method for the determination of albuminoid ammonia, six tubes of free ammonia were distilled from five hundred cubic centimeters of the sample of water.

Then, as I said before, a fresh portion of water was
1907 taken for the albuminoid ammonia determination or
rather the total ammonia determination; 50 cubic centimeters of the Permanganate solution added and nine tubes of the distillate collected. This represented the total ammonia present in the sample and the albuminoid ammonia was ascertained by a subtraction of the free ammonia from the total ammonia as found in the second sample.

In all ammonia distillations a period of ten minutes was allowed for the collection of each tube of the distillate and I wish to say that I had employes stationed at the condenser with a clock in front of them and carefully keeping the time of each distillate, in other words they had to be careful that the tubes did not fill sooner than ten minutes or later than ten minutes. Some authorities raise the point that there ought to be uniformity in the time these ammonias require as they come over the condenser and go into these tubes; that if these tubes fill too soon or if it takes too long a time to fill them, that the results in the end may not be accurate. The controversy upon this matter is still going on and I think has not been definitely settled yet. The American Public Health Association has appointed a committee to formulate standard methods of analysis and it is to be expected that within a year from now their report will be forthcoming and this matter will be definitely settled then. 1908

In the meantime, in order to have accurate results we were careful to have the ten minutes limit observed by those working at the distillation table and collecting the distillates.

The ammonia reagents used in the analyses of these samples were as follows: Standard ammonia chloride solution 3.82 grams of ammonia chloride were dissolved in enough ammonia free distilled water. When I say ammonia free distilled water I mean this water was tested before being used for this purpose to see whether it contained ammonia or not, and only absolutely ammonia free distilled water was used for making up this standard solution. The standard solution from this strong solution is made by diluting ten cubic centimeters to a litre with ammonia free water. One cubic centimeter of the standard solution contains, therefore, .01 milligram of nitrogen.

The Nessler solution which was used was made up as follows, 62.5 grams of potassium iodide were dissolved or rather mixed with 250 cubic centimeters of distilled water also absolutely chemically pure. Twenty cubic centimeters of this solution were reserved and added to the remainder or rather the remainder was added to a cold saturated solution of mercuric chloride until a slight permanent red precipitate appeared. 1909 This was dissolved with the reserved portion of the potassium iodide solution and to it cautiously was added the mercuric chloride solution until a slight permanent red precipitate again appeared. Then 150 grams of potassium hydrate dissolved in 250 cubic centimeters of chemically pure distilled water were added and the entire mixture allowed to stand over night, when on the following day it was ready for use.

The alkaline potassium Permanganate solution which was used for the liberation of the albuminoid ammonia was composed of eight grammes of potassium Permanganate and 200 grams of potassium hydrate and dissolved in 1250 cubic centimeters of distilled water and boiled down to one litre. The boiling in this instance was required for the purpose of removing possible ammonia in the mixture.

The sodium carbonate solution was composed of 60 grammes of anhydrous sodium carbonate dissolved in 1250 cubic centimeters of distilled water and boiled down to one litre.

I now come to the method for the determination of nitrogen in the form of nitrites. For this purpose I investigated a number of methods recommended by the various authors I have mentioned and I came to the conclusion that the method recommended by Prof. Drown, what we call the Gries-Warrington
method was the best.With this method recommended in
1910 Professor Drown's report to the Massachusetts State
Board of Health in the chapter entitled Examination of
Water Supplies 1890," on page 527.

I furthermore wish to state that a work has since been published, since we began these investigations, by Richards & Woodman, who belong to this Massachusetts School of chemists and were trained under Thomas M. Drown and who have published an excellent work on water analysis entitled "Air, Water and Food." That they also recommend this method on page 94.

Furthermore, William P. Mason, in his book on "Examination of Water" also recommends it on page 36. It is the method that is generally recognized now as the most reliable method for the determination of nitrites in water.

I also wish to state that Professor Arthur W. Palmer of the Illinois State University in a report entitled, "The University of Illinois Chemical Survey of the Water Supply of Illinois," recommends the same method on page 13, and so does Leffman on page 49 in his work, "The Examination of Water for Sanitary and Technical" Purposes.

The method is as follows and was applied in the manner I describe it here:

The sample of water is clarified and decolorized. About

1911 200 cubic centimeters is placed in a wide mouthed glass stopper bottle of about 250 cubic centimeter capicity, and from threeto six cubic centimeters of the so-called milk of aluminus aluminum hydrate suspended in water, is added. It is thoroughly shaken and allowed to stand for about ten minutes. The sample is then rapidly filtered through an 18 1-2 cubic centimeter filter, previously washed with nitrate free water. The standards for comparison are as follows: In Nessler tubes of 100 cubic centimeter capacity are placed respectively, one cubic centimeter, three cubic centimeters, five cubic centimeters, seven cubic centimeters, ten cubic centimeters, twelve cubic centimeters, fifteen cubic centimeters, twenty cubic centimeters, of the standard nitrite solution containing sodium nitrite representing in quanity .0001 milligram of nitrogen per cubic centimeter. The tube is then filled up to the 100 cubic centimeter mark with nitrite free water. 100 cubic centimeters of a filtered sample of water is placed in a Nessler tube, to each tube of the set of standards and to the sample of water to be analyzed are added three drops of a one-half solution of hydro-chloric acid and two cubic centimeters each of a solution of sulphanilic acid and alpha naphthylamine. The solutions are then thoroughly mixed and after standing twenty minutes the pink shade of the samples is compared if it contains nitrites it will produce
1912 a pink shade, it is compared with that of the standards
above mentioned which contain relative quantities of the nitrites used for the reagent for comparative purposes and the result is noted. When a sample contains more than the amount of nitrites represented by 20 cubic centimeters of a standard solution, it is diluted with nitrite free water, that is water that had been previously examined to see whether it was free from nitrites. Usually in the proportion of 1 to 10. After the analysis of a few samples from each point of collection the necessary amount of dilution to bring each sample within the 20 cubic centimeter limit was readily anticipated. The milk of alumina or albuminum hydrate used in the clarification of the sample of water was made by precipitating the aluminum hydrate from a solution of aluminum sulphate by means of ammonium hydrate or sodium carbonate, the aluminum hydrate being washed by repeated decantations with nitrite free water

until no nitrites remained, if they were present. The standard nitrite solution, the pure silver nitrite used in making the solution is prepared by the double decomposition of silver nitrate and potassium nitrite and repeated crystallizátions. 1.1 grams of this silver nitrite are dissolved in nitrite free water, the silver completely precipitated by the addition of a solution of chlorine chloride and the solution made up to one litre. It is then kept in an amber bottle away from the light, in
1913 the dark.

This solution is diluted one cubic centimeter to one litre. One cubic centimeter then equalling .0001 milligrams of nitrogen.

The hydrochloric acid used was diluted one part of acid and two parts of nitrite free water. Sulphanilic acid was composed of 8 grams of sulphanilic acid dissolved in one litre of water. It is also kept in an amber bottle away from the light. The alpha napthalyne solution was prepared in the following way: 8 grams of napthalyne was dissolved in 992 cubic centimeters of water and 8 cubic centimeters of hydrochloric acid added. It was kept in an amber bottle and away from the light. The distilled water was river water redistilled continously with sulphuric acid until we had received absolutely pure water.

We now come to the nitrates.

Q. You did that in the ordinary method. You find the nitrates in the ordinary approved method, didn't you?

A. Yes, I use what you call the aluminum Poil method, also recommended by Professor Drown and other leading authorities. Do you think I had better read it?

Q. It is the same as with all the other constituent elements that you found in this water were found? You did it according to approved methods of analyses, didn't you?

1914 A. Yes sir.

Q. I wouldn't put in any more of that?

A. Do you want to have the chlorines in?

Q. There is no use in going into these methods in detail, just go ahead now and begin and give the results of your examinations?

A. I might state that I used the silver nitrate method for the determination of chlorine, also recommended by the various authorities whom I quoted. Shall I now proceed with the description of the conditions in the Illinois River prior to the opening of the Drainage Canal as far as my investigation is concerned as well as the investigation of other scientists in 1899?

Q. Yes, and make it as brief as you can?

A. As I stated on a previous occasion when I testified here our means or resources for the examination of the waters prior to the opening of the Drainage Canal were somewhat limited, and that we confined our collection of samples, as far as the Illinois River was concerned, to the mouth of the Illinois River. Therefore, I have no data for my own analytical work of the condition of the Illinois River in 1899, a point five miles above Grafton, but there are valuable contributions of analytical invegetations of the Illinois River that can give us a fair
1915 idea of the condition of that river in the year 1899, and
I have consulted the following reports: Long "Water Supplies of Illinois," that is a report published by John H. Rauch, M. D. Part 1 of this report, which was published in 1889 by the Illinois State Board of Health, and contains a contribution from Professor John H. Long of Chicago, entitled, "Chemical Investigations of the Water Supplies of Illinois."

Then, there is a contribution on this subject published by Professor Palmer, Professor of Chemistry in the University at Illinois, entitled Chemical Survey of the Water Supplies of Illinois.

Then, the Illinois State Board of Health report, "so-called advance notes of the sanitary investigation of the Illinois river and its tributaries," by Professor John H. Long, published in 1900.

Then an article written for the Journal of Experimental Medicine, Volume 5, December 15, 1900, written by Professor E. O. Jordan of the Chicago University, entitled, "Some Observations upon the Bacterial Self Purification of Streams."

Now, I have here some tables quoted from these reports and these reports, in their comparison, lead to the following deductions, first, that the Illinois River prior to the opening of the drainage Canal was being constantly polluted by the
1916 Illinois and Michigan Canal and to such an extent as to
give the entire water course the character of a carrier of

diluted sewage, which in a measure was proven already by the ratio of dilution that I spoke of before, showing that the dilution of sewage for the lower Illinois River, between Utica and the mouth, at times of drought was one to two.

Now, it is true that dilution, sedimentation and oxidation gradually lessen the quantity of characteristic ingredients of sewage present, but not sufficiently by the time the Illinois reaches its mouth to have completed the process of self purification; and the fact remains that all the tributaries entering the Illinois River are comparatively much purer than the Illinois itself. Now, that is a conclusion that I draw from these reports that I have mentioned just now, that the tributaries of the Illinois River are all comparatively much purer. The fact that they show low chlorines, although they all show some pollution from free ammonia, nitrites and others, sometimes quite high, the fact that the chlorines are very low would demonstrate from the standpoint of sewage pollution that these tributaries are considerably less and in some cases in an appreciable manner, to an appreciable degree less sewage polluted than the Illinois River proper, as it is analyzed in its entire course by samples taken from the entire course by these investigators whom I have quoted. 1917

MR. TODD: Is that previous to the opening of the Canal?

A. These are all conditions previous to the opening of the canal. I have not spoken of the condition of the tributaries after the opening of the canal as yet.

The second conclusion I draw, is, that there was a remarkable increase in the sewage pullution as evidenced by the higher nitrites, chlorine and free ammonia in the river since Long has examined it in 1888, and again since Palmer's investigation.

Now this pollution cannot be ascribed to accessions from the tributaries or from the Peoria and Pekin pollution, the reasons of which I will give later on when I discuss the condition of the Illinois River after the opening of the Drainage Canal, because during the same period practically no increase in the pollution from the tributaries is shown. In other words, during these long intervals between 1888, 1896 and 1899, the

Illinois River pollution continually increased, whereas the pollution from the tributaries did not increase correspondingly.

It is only necessary to consider the corresponding increase of water in the Illinois and Michigan Canal during this period between 1888 and 1896 and from 1896 to 1900 and to re-
1918 member the enormous growth of population and industries in Chicago to find the right explanation of the gradual conversion of the Illinois River at that time into a condition of very bad pollution.

Professor Palmer while declining to discuss prematurely in his report the analytical data collected for the Chicago Drainage Canal Board, nevertheless draws the following conclusion from his investigation: "Consequently, we confine ourselves for the present to merely calling attention to the fact which our results show conclusively, that the Illinois and Michigan Canal and the Illinois River were during the fall of 1895 and the year 1896, much more fully charged with sewage than they were in 1888 and 1889," the time of the extensive investigations made by Professor J. H. Long, under the direction of the State Board of Health.

"In several places we have inserted the averages of some of Professor Long's results in order to facilitate the comparison."

This is what Professor Palmer says in drawing conclusions from his investigations of the Illinois River and the tributaries in the years 1896 and 1897 as compared with previous analyses performed by Professor Long in the years 1887 and 1888.

Now, as to the examinations that I and my assistant made
1919 prior to the opening of the drainage canal, that is between August 23rd and January 22nd, at the mouth of the Illinois River above Grafton and from the Mississippi River above Grafton, I have presented a table of maximum, minimum and average results. I have got copies of these tables for the typewriters. Shall I read off that table or shall I just file it?

GENERAL CROW: Let them mark it table No. 1, Dr. Teichmann's testimony, and save time.

The table is as follows:

1920 TABLE OF MAXIMUM, MINIMUM AND AVERAGE RESULTS, 1899.

Estimated in parts per million.

Location.	Residue on evaporation.					
	Total.			Dissolved.		
	Max.	Min.	Av.	Max.	Min.	Av.
Illinois river above Grafton...	510	330	413	460	240	349
Mississippi river above Grafton	450	195	285	280	130	205

The above table gives average results of samples taken between September 6, 1899, and January 17, 1900, near the mouth of the Illinois river.

1921 TABLE OF MAXIMUM, MINIMUM AND AVERAGE RESULTS, 1899.

Estimated in parts per million.

Location.	Nitrogen, as Ammonia.					
	Free.			Albuminoid.		
	Max.	Min.	Av.	Max.	Min.	Av.
Ill. Riv. above Grafton.	0.440	0.091	0.215	0.763	0.317	0.553
Miss. Riv. above Grafton	0.134	0.030	0.069	0.614	0.394	0.503

The above table gives average results of samples taken between September 6, 1899, and January 17, 1900, near the mouth of the Illinois river.

1922 TABLE OF MAXIMUM, MINIMUM AND AVERAGE RESULTS, 1899.

Estimated in parts per million.

Location.	Nitrogen.					
	As nitrites.			As nitrates.		
	Max.	Min.	Av.	Max.	Min.	Av.
Illinois river above Grafton...	.020	.003	.012	1.1	0.4	0.8
Mississippi river above Grafton	.008	.000	.002	0.6	0.2	0.3

The above table gives average results of samples taken between September 6, 1899, and January 17, 1900, near the mouth of the Illinois river.

1923 TABLE OF MAXIMUM, MINIMUM AND AVERAGE RESULTS, 1899.

Estimated in parts per million.

Location.	Oxygen consumed.						Chlorine.		
	Total.			Dissolved.					
	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.
Illinois river above Grafton	6.0	3.1	4.1	4.9	2.3	3.4	36	15	25
Mississippi river above Grafton	11.4	4.6	6.9	8.9	2.9	5.6	9	4	6

The above table gives average results of samples taken between September 6, 1899, and January 17, 1900, near the mouth of the Illinois river.

1924 While we notice the fluctuations in these figures it can be seen that from the original data invariably the nitrites, free ammonia and chlorines of the Illinois River were found to exceed those of the Mississippi. On September the 30th, for instance, a sample from the Illionis River contained 31 parts of chlorine per million, 44 parts per million of free ammonia and .015 parts of nitrogen in the form of nitrites. I wish to say that the free ammonia, as well as the nitrites, are to be considered as nitrogen in the form of free ammonia and nitrogen in the form of nitrites. Whereas, in the Mississippi river we find five parts of chlorine per million, .134 parts per million of nitrogen in the form of free ammonia and .002 parts per million of nitrogen in the form of nitrites, that is in the Mississippi River, above the mouth of the Illinois.

It is true that the highest albuminoid ammonia in the Mississippi River was on the same day found to be higher in the former than in the Illinois River, but it was not accompanied by correspondingly higher nitrites and chlorines. Therefore, the conclusion is justified that the sanitary character of the Mississippi River at that time was better than that of the Illinois River. As to the explanation for the higher albuminoid ammonia, which frequently corresponds with the higher or-
1925 ganic matter, to total organic matter in the Mississippi
River, I shall discuss that subject later on when I reach the second period of the investigation.

GENERAL HAMLIN (Referring to Table No. 1): Is this your own wok?

A. Yes. I wish to state that all the analyses from these samples were performed by myself personally or by my assistant, the assistant City Chemist, Mr. Buckland.

MR. TODD: That is referring to the table which has been read?

A. Yes, the table that I prepared myself. We now come to the chemical character—

MR. TODD: Doctor, have you gotten in the record the number of samples that were taken and the method of taking them?

A. Yes.

Q. I don't remember hearing it.

A. I testified to that previously, about two weeks ago and then I testified again yesterday.

Q. That is all, then. That is previous to this table?

A. Yes. I have in my regular report all the dates of those collections all entered.

GENERAL CROW: Go ahead.

A. We now come to the chemical character of the
1926 Mississippi River water between Grafton and the Intake of
the St. Louis Waterworks in 1899. As I said before, samples along this route could only be taken occasionally, when the St. Louis Harbor Boat was available for the trip to Grafton, or another boat could be engaged or a few times I sent special collectors up to take samples. All together seven trips were made from September 6th until December 4th, on the boats. Samples were taken from points, as I said before, between Grafton and Portage, Portage and Alton, Alton and Grafton and also from the mouth of the Missouri. While the analytical data thus obtained were not as complete or desirable, yet they furnished some truth in each instance of the marked polluting effect of the Illinois River on the Mississippi below Grafton.

The characteristic ingredients of sewage pollution, nitrites, free ammonia and chlorine, were certainly not as high in the Mississippi below Grafton after the junction of the two rivers as they were in the Illinois River during this time from September 6th to December 4th, but they were invariably higher in the

Mississippi after its junction with the Illinois than prior to that time and there was no doubt of the polluting effect of the Illinois River on the Mississippi.

The samples collected at that time were always taken
1927 taken from the channel, from the narrow channel running around the various dykes which have been erected in the river between the mouth of the Illinois and the mouth of the Missouri River and while the water along the shore would be of a different character than in the channel, that water coming down much slower and partially impeded in its progress on the shore, we considered the samples from the channel as giving the best criterion for the character of the water and from this narrow channel, frequently circumventing the dykes, running out from the shore we think we got comparatively good samples, samples showing the mixture of the two rivers in the channel.

I come now down to the analyses of the water of the Intake of the St. Louis Waterworks in 1899.

GENERAL HAMLIN: Now, have you a table there?

A. No. What I have here is the maximum and minimum. It is a very brief table and I have no copies. I can dictate it in a few minutes, it won't take long:

From August 23rd to September 16, 1899, four samples were collected near the intake of the waterworks, but beginning with October 16, and ending January 22, 1900, semi-weekly analyses were made at the Intake. The averages of the most important chemical constituents were as follows:

1928 Table of averages, parts per milion.

Nitrogen as free ammonia, maximum, .138
minimum, .008
average, .0063(?)

JUDGE SPRINGER: Is that the whole of that period?

A. That is the whole of that period at the Intake, yes. I will give the number of samples, 26 samples.

Nitrogen as nitrites, maximum, .01
minimum, .0
average, .002

Nitrogen as nitrates, maximum, .8
minimum, .2
average, .4

Nitrogen as chlorine,	**maximum,**	**27.**
	minimum,	**9.**
	average,	**17.**

The variable character of the water at the Intake is demonstrated by the wide range of maximum and minimum figures as shown in this table. The maximum stamps the water as polluted where as the minimum characterizes it as good potable drinking water.

1929 These great fluctuations can only be ascribed to the daily varying mixtures of the Mississippi and Missouri River waters at the Intake which is located on the edge of the channel 1,500 feet from the shore, from the Missouri shore.

Seven samples taken from the Missouri River during this period, as a rule showed nitrites and free ammonias much less than found in the Mississippi above the mouth of the Missouri.

MR. JOHNS: During what period is that?

A. That is 1899 I am speaking of now. That is, I say that the Missouri River showed much lower nitrites and free ammonias than the Mississippi above the mouth of the Missouri at that time.

On those days when the Missouri River samples were collected, the low results in nitrites and free ammonias compared with those from the intake, would be about the same in both places, provided the Missouri River water prevailed at the Intake. But whenever the Intake results were high the Mississippi River water prevailed at the Intake and the impurities then were not much less at the Intake than in the Mississippi above the mouth of the Missouri. In other words, it depended on the character of the water going into the Intake. When the 1930 Missouri River water would go into the Intake the impurities in the water at the Intake would be low. Whenever the Mississippi River water prevailed, or, comparatively, a large percentage would go in the Intake, the impurities in the Intake would go up, that is the impurities in the water would show an increase.

The relative mixtures of those two rivers I will show later on when I come to the discussion of the 1900 results. I will then present tables showing mixtures based upon chemical analyses at the Intake.

Now, as to the final conclusions on the work performed in the year 1899, I have the following to say:

The Illinois River at its mouth was badly polluted during the entire period. The Mississippi River above the mouth of the Illinois, was much better in sanitary quality than the Illinois throughout the investigation.

The Mississippi River between Grafton and the St. Louis Intake showed very much the effects of pollution from the Illinois River and on such days when the Mississippi River water entered the Intake the result would be an increased pollution of our water supply.

The Missouri River was generally purer than the Illinois above Grafton and purer than the Mississippi after its junction with the Illinois River. Do you want to ask any
1931 questions regarding that period?

GENERAL CROW: No, sir, go ahead, take up the next period of your examination.

A. The second period of the investigation covers the time from January 23rd until October 11th and extending to Dec. 1st of the same year in a measure, that is, for some points from which samples were taken, the examination was continued until November 30th, 1900. As I previously stated, on January 23rd at a conference held at the City Hall with the authorities, it was determined to enter upon an extensive investigation embodying a daily collection of samples from a number of points which I believe I mentioned on the first day of my examination.

GENERAL CROW: Well, you had better state the points from which you took these samples for analyses and the period of time.

JUDGE SPRINGER: When he states the analyses just let him state where he took them?

A. I will state the points. From January 23rd until October 11th, 3,492 samples of water were collected and analyzed from the following points:

Lake Michigan, 11,
Drainage Canal above Bear Trap Dam, Lockport, 219,
1932 Des Plaines River, Joliet, Illinois, 219,
Illinois River, 3 miles above Peoria, Ill., 260,
Illinois River, 3 miles above Grafton, Ill., 265,

Illinois River, Wesley, 1,
Illinois River, Pekin Bridge, 1,
Illinois River, 3 miles below Pekin, 1,
Mississippi River, 2 miles above Grafton, Ill., 264,
Mississippi River, 1 mile above Alton, Ill., 260,
Mississippi River, opposite Hartford, Ill., 260,
Missouri River, opposite Bellefontaine, 261,
Mississippi River, near Missouri shore, Chain of Rocks, 253,
Mississippi River, near Illinois shore, Chain of Rocks, 246,
Mississippi River at Chain of Rocks, Intake Tower, 250,
St. Louis Waterworks, wet well, 260,
St. Louis Waterworks, outlet of reservoir, 261,
Tap at City Chemist's Office, St. Louis, 156,
Harbor boat and special samples, 47,

That is, during this second period occasional trips were made by the harbor boat along the route from St. Louis to the mouth of the Illinois. These trips were made for the purpose of taking samples at various points on the same day that
1933 the collectors were taking the samples, so as to check the
results and see whether they agreed. They were in the nature of inspections. Also special samples were taken for the purpose of being assured that all samples were collected by the collectors in the right way and at the right places. After October 12th weekly samples were collected from the following points until November 30:

Lake Michigan, 5,
Lockport, Illinois and Michigan Canal, 7,
Lockport, Des Plaines River, above Chicago Drainage Canal, 7,
Lockport, Ninth St. Bridge, 7,
Lockport, Drainage Canal, Bear Trap Dam, 7,
Joliet, Des Plaines River, 7,
Illinois River, 3 miles above Peoria, 7,
Illinois River, 3 miles above Grafton, 9,
Illinois River, 3 miles above Pekin, 7,
Mississippi River, 2 miles above Grafton, 9,
Mississippi River, 1 mile above Alton, 7,

Mississippi River at Hartford, 8,
Missouri River, Bellefontaine, 7,

The reason why the authorities favored a daily collection of samples I will give later on during a discussion of the 1934 results of 1900. When I reach the conclusions I will make a statement there and give an explanation of why the daily collections were considered necessary.

Do you want any more information about the system of collection of samples, etc., how the bottles were filled, etc.?

Q. That has all been gone over.

A. Yes, sir.

Q. These samples were collected in the same manner that the samples for the bacteriological experiments were collected?

A. Yes, sir.

Q. Well, you need not go into that in detail any more then. Go ahead with your examination?

A. Shall I give the names of the assistants that were employed in the investigations and the periods of time that they were and the helpers at the distillation table and the collectors of samples?

Q. You can do that if you want to, but I don't see any use in it.

A. I will leave it to your judgment.

Q. I wouldn't put it in the record, it is not necessary.

A. All right. Do you want to ask me questions about 1935 the second period of the investigation?

Q. No, go ahead and I think you will get through quicker in that way.

A. Well, the sources of pollution in the Illinois River, are the sewage of Chicago, the sewage from the towns along the banks of the Des Plaines and Illinois River and from the tributaries. Particularly a large percentage as I have already said, according to the statement of E. O. Jordan, a large percentage of the sewage from Chicago came by way of the Illinois and Michigan Canal. I wish to emphasize, though, that this is the opinion of Prof. Jordan and later on I shall discuss the point and bring out the investigations which show that the real conditions are somewhat different from the way they were estimated by Professor Jordan. Much of the Chicago sewage today passes through the main branch of the canal.

Now, the question arises as to the Chicago sewage, how much of the Chicago sewage enters the Chicago Drainage Canal and the Illinois and Michigan Canal to-day? Under what circumstances does the sewage reach the two canals and how much sewage is still flowing into Lake Michigan? From personal observations of mine in Chicago and from investigations made by Benizette Williams, Civil Engineer, I find that there must be a distinction drawn between the sewage of Chicago directly entering the Chicago river, the south branch of the 1936 Chicago River and being discharged through the south branch of the Chicago River into the Drainage Canal directly, and the sewage discharged into the north branch of the Chicago River and into the south fork of the south branch and into the lake. I will have to refer to the figures prepared by Mr. Benizette Williams as to the population draining directly into the Chicago River, the south branch of the Chicago River, into the north branch, into the south fork of the south branch and into the lake.

JUDGE SPRINGER: Are those figures taken from his testimony in this case before this Commissioner at this time?

A. Yes sir, from his testimony. These figures show that the population tributary to the main river, that is to the south branch and to the Drainage Canal amounts to 791,677, as testified to by Mr. Williams. In other words, the sewage passing or mixing with the lake water in the Chicago River, south branch and entering the Drainage Canal, that sewage represents the drainage of a population less than 800,000.

This is the sewage that enters the main branch of the Canal.

The sewage entering the Illinois and Michigan canal, according to my observation and the testimony of Mr. Williams—I say the sewage entering or pumped into the Illinois and Michigan Canal comes from the south fork of the south branch. The sewage that enters the south branch is of a different char- 1937 acter than the sewage in the south fork. The sewage in the south fork at various times, there being no current in the south fork—

Q. The south fork of what?

A. The south fork of the south branch of the Chicago River. It is kept there for a sufficient time to enable it to undergo preliminary purification. This is not the case with the sewage entering the south branch directly that is draining from the population of 791,677. The sewage in the south fork may be compared to a septic tank. I mean the south fork may be compared to a septic tank. In order to explain what I mean I will have to describe a septic tank.

A septic tank is probably an English invention. Experiments that have been made in that line in England and finally completed at the town of Exeter, demonstrated that if sewage is run into a tank and allowed to remain in that tank one day while passing through and being discharged the following day at the other end of the tank, that this sewage undergoes certain fermentative changes. That is, there are two kinds of bacteria that will disintegrate this sewage, probably liquifying the solid matter. These bacteria are called anaerobic bacteria.

1938 They are divided into two classes, the obligatory anaerobic bacteria and the facultative anaerobic bacteria. The former, or obligatory anaerobic bacteria cannot live in the presence of oxygen. The facultative anaerobic bacteria can live both in the absence and in the presence of oxygen, dissolved oxygen of course.

Now, when the sewage enters these tanks the anearobic bacteria of both varieties attack the solid matter and liquefy it, breaking up certain organic matter into carbonaceous and nitrogenous compounds, and when the sewage leaves this tank it is in a proper condition to be finally purified by the so-called nitrofying process by the aerobic bacteria.

Now, it is not said that in these tanks aerobic action does not take place. It has been proven by experiments that in a tank aerobic bacteria may be present and may produce the so-called nitrification, which is really the oxidation of organic matter, the oxidation of the nitrogenous matter.

Now, the chemical process which the sewage undergoes in this tank is, that these anaerobic bacteria break up the organic matter as I said, and liquefy it, producing carbonic acid gas, carbonic dioxide and ammonia.

1939 Carbonate of ammonia is the form, it is so-called free ammonia. Furthermore, other gases are eliminated. If other matters are in that sewage—this sewage contains principally compounds formed by the four elements, hydrogen, nitrogen, oxygen and carbon.

Frequently there are sulphurous compounds formed, sulphuric hydrogen and sulphur being present in some of the compounds and phosphoric acid and others of an organic character that might generate. Now, when this sewage leaves these tanks it leaves it in a liquified form, there being a sludge formed in the basin of the tank. The gases, the carbon dioxide gases, have a chance to escape through certain ventilators but not permitting the admission of air, it being thought that air should be kept out as much as possible.

Now, in this tank the preliminary purification process, as I say breaks up the solid organic matter and renders it easy for the aerobic bacteria subsequently to purify it. Usually that sewage is then run through filters and by the aerobic action the purification process is completed.

Now, it has been proven that water when it stagnates facilitates, to a great extent, purification, much more so than in running streams.

1940 These investigations of the septic tank, going together with other investigations, lead to the conclusion that the faster a sewage polluted river runs directly at the point where the sewage is discharged into the canal, the longer will it take for the anaerobic bacteria to perform the preliminary work. As I said the facultative anaerobic bacteria can live in the presence of dissolved oxygen and it is evident that the purification performed by these bacteria in running waters is proven, because in spite of the presence of oxygen the facultative anaerobic bacteria can carry on the work, but wherever dissolved oxygen is absent these anaerobic bacteria or facultative anaerobic bacteria are materially assisted by the obligatory bacteria which cannot live in the presence of dissolved oxygen. These bacteria can work much more effectively. It has been proven that in septic tanks the quanity of obligatory bacteria was very small and the facultative anaerobic bacteria was very large and yet these anaerobic obligatory bacteria performed better work, were more successful in this preliminary purification process than were the facultative anaerobic bacteria than in a different tank where the reverse conditions prevailed. In other words, the most effective are always the obligatory anaerobic bacteria.

Now, the Chicago Drainage Canal contains dissolved oxy-
1941 gen. The lake water provides the Chicago Drainage Canal
with large quantities of dissolved oxygen. They vary considerably but as a whole it can be stated that they are present. There is also dissolved oxygen present in the south branch today. The south branch is very much improved over its former condition, its appearance is different, you don't find any more gas bubbles rising there except on occasions when the north branch, which has not much of a current ordinarily, is swept out by storm water. As Mr. Williams testified, there is no appreciable flow in the north branch ordinarily, that the water almost stagnates. He said the same thing about the south fork and that only when the storm seasons come and the flood waters come, or when maybe the new sewer, the Fullerton Avenue conduit, when that is in operation, which is not regularly, the volume of the sewage discharged into that river is so large that it will force a current from the north branch into the south branch. At such times and also when some pressure comes from the south fork, so that the south fork sewage instead of running and being pumped into the Illinois & Michigan Canal, as is ordinarily the case, that some of this sewage is pushed beyond that point into the south branch there, then we find the appearance of the south
branch differing very much from that ordinarily when
1942 there is a steady flow of water and a steady current
through the Chicago River, and into the Drainage Canal. In other words, the south fork and the north branch are septic tanks.

Now, while I will admit that these are not covered tanks, that these conditions are not permanent, that they are very variable according to storm waters, or according to the volume of the sewage entering the south branch through those side branches, I say that at such times of storm water, of course, you will find the appearances differing very much and the quantities of sewage that enter the drainage canal at that time, very much increased, but ordinarily at fair weather conditions the south fork and the north branch are septic tanks.

Now it might be said that the septic tank at Exeter is covered, it is true, but there is an opening for the gas to escape. The carbon dioxide has to escape or otherwise it would explode.

Then you will say that the oxygen of the air might affect the purification of the sewage.

Now, that is a question which has been investigated by quite a number of secientists, whether in the process of sewage purification in rivers, the oxygen of the air directly affects the nitrification process. This is denied and the prevailing testi-
1943 mony of scientists is to the effect that dissolved oxygen
in the water is not taken up from the air by these bacteria and that consequently what we call the aeration process does not materially change the conditions as far as the purification of sewage is concerned in streams. Now I said the prevailing testimony. I admit there are still scientists who adhere to the old principle that dissolved oxygen is absorbed by the water from the air and assists in the purification but this is denied by a great many authorities, which authorities can be produced through the literature published on the subject.

Indirectly, yes, after the sewage has reached certain stages of preliminary purification it may be that this oxygen of the air assists, but it is questioned very much.

The main point is that in the south fork and in the north branch according to these scientific investigations, it is impossible at prevailing times, not always however, but, at prevailing times, for the sewage to be assisted by the oxygen of the air in the general purification process, and since the sewage remains in there for a long time—

Q. What do you mean when you say in there, where, are you talking about?

A. I mean in the south fork and in the north branch.
1944 I mean to say that these branches are usually, not al-
ways, in the condition of a septic tank. This is an advantage to the water as it enters and leaves the drainage canal and enters the Desplaines and Illinois Rivers. But if during high water this sewage, which in low water periods is allowed to stagnate and undergo fermentative preliminary changes in the south fork and in the north branch,—representing drainage from the larger part of the population of Chicago, if that were to be all swept into the drainage canal speedily it would bring this sewage in a less purified condition than formerly into the Drain-Canal and it would vastly increase the pollution of the Drainage

Canal, and, as will be shown later on, that sewage from the Drainage Canal affects the sanitary quality of the Desplaines, the Illinois and Mississippi Rivers; and it would vastly increase the pollution of those rivers down to the mouth of the Illinois, and according to the volume of the water coming down the Mississippi, if the upper Mississippi is high, it may not affect the water at the Intake Tower much, but if the Upper Mississippi is low then the increased volume of sewage coming down those rivers must, of necessity, affect the water running into the Intake Tower of the St. Louis Water Works.

Q. Now, will you please go back to the question of the examination of that water?

1945 A. I beg pardon, Mr. Crow, but I wish to state further, that there are three conduits in course of construction in Chicago which will, as Mr. Williams in his testimony stated, eventually flush out the south fork and flush out the north branch constantly. In a measure it is being already done by the so-called Fullerton Avenue new conduit, whenever that is in operation, but it will be done still more by the Lawrence Avenue Conduit and the 39th street conduit now in course of construction. This will then carry nearly all of the remaining sewage of the City of Chicago through those conduits directly from the Chicago river into the Drainage Canal, excepting that part of the sewage, of course, still being pumped into the Illinois and Michigan Canal whenever in operation.

There will still remain the sewage of the district of Calumet and the district of Evanston, representing in toto a population of about 100,000. They will still drain into Lake Michigan.

The remaining sewage will all be discharged into the Drainage Canal at the rate of flow fixed by the United States War Department at 250,000 cubic feet per minute.

Adjourned until 2 o'clock March 17, 1903.

Southern Hotel, St. Louis, Missouri.
1946 2:00 P. M., Tuesday, March 17th, 1903.
Continuation after recess.

Present, the Commissioner and same counsel as before representing the respective parties.

DR. WILLIAM C. TIECHMANN,

Resumed the stand for further direct-examination by Attorney General Crow, and testified as follows:

Q. Just go ahead Professor?

A. In discussing the period of investigation after the opening of the Drainage Canal, which period of investigation began January 23rd, and continued until October 11th, it will be necessary to speak of certain conditions prevailing in the Illinois River valley, and its tributaries.

As I stated, the sources of pollution in the Illinois River were sewage from the City of Chicago and from the towns along the banks of the Rivers Des Plaines and Illinois, and from its tributaries.

Now in all problems dealing with sewage disposal by method of discharge of crude sewage in streams, there are two important problems to be considered,

1947 First, the oxidation or mineralization of the organic matter in the sewage with subsequent absorption of final products by plant life.

Second, the destruction of pathogenic or disease-producing bacteria.

It is now a well established fact that these changes are taking place continually in all running streams, and by means of chemical investigations, it is possible to measure comparative quantities of organic matter present, and deduce therefrom the rate of oxidation and the degree of purification effected.

The prime factor which affects the capacity of the streams to accomplish the results as outlined above, are the volume of sewage discharged into it, the degree of dilution of the same, the volume and the velocity of flow in the stream, the length of the stream and finally, the character of its water, the chemical and bacteriological character of its water.

It is essential that oxygen should be at all times available, and that the organic matter present should not be so excessive as to materially reduce the amount of oxygen dissolved in the water below that necessary for saturation. If sufficient oxygen prevails it is certain that nitrification and oxidation will take

place as rapidly as is possible with this method of dis-
1948 posal.

The chemical and bacteriological principles as outlined above are continually active in the sewage polluted waters which contribute to the water supply of St. Louis. Although the Intake of the St. Louis Water Works is located in the channel of the Mississippi River it has been shown for some years that the sanitary quality of the water supply is affected by the Missouri River which empties into the Mississippi River eight miles above the Intake as well as by the Illinois River which joins the Mississippi River above the Intake.

Now the chemical analyses made during this investigation show that the waters of the above rivers are contaminated by sewage as would be naturally expected from existing conditions. However as the fundamental object of these analyses was to ascertain the effect of the Chicago sewage on the local water supply, it will not be necessary to detail the source of pollution of the Missouri River above its mouth, and those of the Mississippi River above Grafton, Illinois. It may suffice in this connection to produce data of collections of samples and produce analytical data from the analyses of these samples from the mouth of the Missouri River, and from the Mississippi River above the mouth of the Illinois,—far enough above the mouth to exclude back water from the other rivers to interfere with the correct estimate of the analytical results.

1949 In speaking of the Illinois River valley, and the pollution of the Des Plaines and Illinois Rivers, it is necessary to enter upon a description of the construction and operation of the Chicago Drainage Canal.

ATTORNEY GENERAL CROW: Well, that has been gone over.

A. All right; I can exclude that.

Q. Just give the facts. That has been described pretty well by Dr. Ravold.

A. Well, do you want any figures on the velocity of flow in the Canal and the ratio of dilution in the canal—in the Drainage Canal?

Q. Do you know the flow of the canal?

A. The flow of the canal is about 1.92 miles per hour in the rock section, and 1.26 miles per hour in the earth section.

Q. When was that taken, after the canal was opened?

A. Yes sir, after the canal was opened.

Q. Well now, go ahead with your examination of the water?

A. Now do you want the ratios of dilution of the Chicago sewage in the Drainage Canal?

Q. Well, have you got the figures there, so you can just state the figures?

A. Yes sir.

Q. Well, what are they, what is it?

1950 A. If we take the estimate of Professor E. O. Jordan, of the amount of Chicago sewage passing through the Chicago Drainage Canal, we would obtain from ordinary calculations of the volume of sewage from the City of Chicago, based upon the water supply and the flow in the drainage canal, a ratio of dilution of one to nine.

Now this is based upon Professor Jordan's calculation. However, this calculation should be modified in the following way:

As I said this morning, the sewage of less than 800,00 population of the City of Chicago drains directly into the Chicago River, that is the south branch and mixes directly with the 250,000 cubic feet of lake water running through the Drainage Canal.

MR. WOERNER: During what time? 250,000 cubic feet per what?

A. Per minute.

Now this sewage, as I said this morning, is running to the Drainage Canal, and mixes with the water and is really the only sewage from Chicago, upon which a normal calculation should be based as to the ratio of dilution. That ratio of dilution based upon the population of say, 800,000, would make a ratio of dilution from one to about twenty-one.

Q. Well what becomes of the sewage of the other 900,000 people in Chicago?

1951 A. That drains partly into the north branch of the Chicago River and partly into the south fork of the south branch of the Chicago River, and partly, according to estimates of Engineer Benezette Williams, into the lake, the latter representing the drainage of a population of 300,000 into the waters of the lake.

Q. Don't the waters of the north branch of the Chicago River run into the south branch?

A. Yes sir.

Q. And thence into the Canal?

A. Whenever storm water and heavy rains flush out the North Branch and the south fork much of this sewage which has largely undergone an advanced stage of preliminary purification, is rushed with recent accessions of fresh sewage into the Drainage Canal. Eventually it all goes in, but I draw the distinction this morning between the sewage previously decomposed and in the preliminary stage of purification by the action of the anerobic bacteria and fresh sewages. At such times of course, when the North Branch is high and the south fork too, and they are flushed out, an increased volume of fresh sewage is rushed into the Drainage Canal, and the ratio of dilution is then considerably lower than 1 to 21.

To make an accurate estimate of that ratio of dilution at such times, is an impossibility, because of the necessity of distinguishing between the character of the two kinds of 1952 sewage, the one in the north branch of the south fork, and the other in the south branch of the Chicago River. However, as I will demonstrate from my data, whenever an increased amount of sewage was run into the Drainage Canal during my investigation, the impurities at Lockport would increase, in fact, the impurities all along the line from Chicago down to the mouth of the Illinois River would show a subsequent increase, and it is for this reason that I assert that every time an additional amount of sewage in its fresh stage is rushed into the Drainage Canal from those branches, that the impurities in the canal and the impurities in the Des Plaines River and Illinois River will invariably rise in quantity.

Q. MR. WOERNER: So that in time of rain, when these streams are high, it all goes in the Draiange Canal except the sewage from about 300,000 people; is that right?

A. Yes sir. It may be that at such times the theory of Professor Jordan may be applicable as to the true amount of sewage entering the Drainage Canal. However, it has been impossible to obtain data to settle this point and no investigation could probably ascertain the facts as to the actual amount.

Q. Well, you have covered all that now. Go ahead.

A. And as to the actual amount—owing to the methods of construction adopted for the Chicago Drainage Canal, one of the principal defects of dilution of the sewage of Chicago in
1953 the Drainage Canal, is that the dilution cannot be effected
at the point of discharge at Lockport, and lags behind operations at the Controlling Works for a time necessary to displace the entire contents of the Canal. This condition maintains at all times and produces its evil results when the dam at Lockport is raised.

For instance, when the Drainage Canal was first opened, it gradually filled with sewage from the south branch of the Chicago River at that time; from day to day this sewage accumulated, that is fresh accessions were added to the sewage in the Drainage Canal continuously for a period of about two weeks. It is true that sometimes, for instance on and after the 6th of January, the canal was opened at the Chicago end on January 1st —it is true that after the 6th day of January there was at times an overrunning of the sewage into the Des Plaines River. However, this was not measured and it cannot be ascertained how much it amounted to, but it did run over. At the same time this sewage accumulated there, and when the canal was opened on January 17th, the conditions that I mention here resulted. That is, the sewage was rushed down the Des Plaines river and the Illinois River, and produced conditions which demonstrated that the pollution was very marked of the Des Plaines River and the Illinois River subsequently, as I will show when I present
1954 the analytical data.

Something similar to that occurred in the month of September, 1900. From my own personal observations, and from the reports of my collectors. I found out that in September the Canal was practically closed at Lockport sometimes for days, and nights; sometimes only for short periods.

The official records from the Drainage Board Engineer of the flow at that time of the Drainage Canal, into the Des Plaines River, prove what I state, that owing to repairs of the dams,—and owing to repairs of the works, the Canal had to be closed, and again daily accessions of sewage in the drainage canal increased the pollution of the drainage canal and fresh sewage daily being added, intensified the obnoxious character of this sewage to a degree that when the Canal was re-opened and this water was rushed down the Des Plaines River and Illinois River, the effect of the increased pollution could be noticed from the analytical results all along the line down those two rivers.

MR. WOERNER: Just cut it down as much as you can, Professor, and go ahead.

THE WITNESS: As I say, owing to the quiescent state of this sewage, and the circumstances mentioned, of these two cases in the canal, the organic matter soon used up the oxygen
1955 dissolved in the canal water and putrification set in. Then after the dam was lowered again and the normal operations resumed the proper dilution and aeration could not be effected until the entire accumulated contents of the canal were displaced, when such a large volume of unaerated sewage is discharged there results a killing of fish, which was noticeable to my collectors of samples and a chemist of mine who came up and saw these conditions at the Lockport dam.

ATTORNEY GENERAL HAMLIN: Did you see it?

A. I didn't see it.

ATTORNEY GENERAL HAMLIN: Then I object.

A. Because I was not there during the entire time of this period.

ATTORNEY GENERAL HAMLIN: I desire to enter an objection to all this testimony given by Dr. Tiechmann which is collected from reports, and from statements made by other witnesses, as hearsay, and not as the best evidence. I have no objection to anything he saw himself, or that he did himself.

MR. WOERNER: Confine yourself to what you know, doctor, and to your theoretical knowledge with respect to this matter.

THE WITNESS: Well, in connection with the question of pollution of the Des Plaines and Illinois Rivers, I thought that was all right.

Q. Yes, that is all right, but don't state any facts of which you, yourself are not cognizant.

MR. TODD: The Sanitary District joins in the same objection with the State. 1956

THE WITNESS: I might state various defects of the canal, and chiefly engineering defects, as showing the impossibility of permitting a flow of more than 250,000 feet per minute—cubic feet per minute of the Canal, but I can go over to the chemical examination and let that matter stand.

Chemical character of the water from Lake Michigan in the harbor of Chicago.

Thirty-two samples of water were collected during the period of July 23rd to November 17th, 1900, from Lake Michigan,at various distances of from two to ten miles from Chicago.

These samples were either collected from a harbor boat kindly furnished by the Sanitary District at that time, or private boats engaged for the purpose.

Since the opening of the Drainage Canal, the condition of this lake water has changed materially, because of the diversion of the flow of the sewage in the Chicago River from the Lake to the Drainage Canal. An improvement in the quality of the water feeding the cribs has certainly taken place as is shown by the average results of our analyses, as compared with those performed by other investigators in previous years.

We find an average of .045 parts per million of nitrogen as free ammonia—

1957 Q. In what part?

A. In the water from the Lake,—from the samples—the averages that we received from these 32 samples.

Q. You mean it improved in the lake?

A. No, I am now giving the averages of the results of analyses that we obtained from samples analyzed—

Q. Now wait a minute. Just answer the question. You said that there was an improvement in the water?

A. Yes, and I am showing these improvements of the water.

Q. Now you stated that that improvement was by reason of a diversion of the sewage?

A. Yes sir, the diversion of the Chicago River.

Q. Now you mean by that that the sewage went into the Chicago River instead of the Lake, is that it or not?

A. Oh no; the sewage went into the Chicago river before the opening of the canal, and still goes into the Chicago River? but the flow of the Chicago river before the opening of the Drainage Canal was into the lake.

Q. And now it is away from the lake?

A. And now that is reversed.

Q. That is right. Now go ahead.

A. Except when the Drainage Canal is closed temporarily, then the water flows back into the Lake, as was the case in September, 1900.

1958 Q. But that is not generally the case, is it?

A. No, I wanted to explain that, but I was cut off.

Q. Go ahead?

A. We found an average of the 32 samples of water collected from July to November, 1900, of free ammonia, .045 parts per million.

Nitrogen as nitrites, .005 parts per million.

Nitrogen as nitrates, .15 parts per million.

Chlorine 6 parts per million.

And these averages would probably be still lower were it not for the fact that during September on certain days the Chicago River again flowed into the Lake because of the temporary closing of the gates at Lockport, and this resulted in a re-pollution of the water on the Lake Front, and a sample taken near Lake View crib, December 7th, contained .086 parts per million, nitrogen as free ammonia.

.014 parts per million, nitrogen as nitrites.

.2 parts per million of nitrogen as nitrates.

Six parts per million of chlorine.

This shows an increase of nitrogen in the form of free ammonia,—a double of the average, and an increase of nitrites of nearly three times the amount found during the time when the lake flowed toward the Drainage Canal.

1959 Now I wish to call attention to the fact that investigations of—

Q. Profesor, I wish as nearly as you can, you would confine yourself to the results and not state about this unless it is necessary for us to know it in order to appreciate the results.

A. Well, I want to show now that important investigation performed by George W. Rafter for the United States Government, showed that the sewage of Milwaukee runs along the shore and goes to Chicago—

Q. Runs along that far?

A. Yes sir.

ATTORNEY GENERAL HAMLIN: Wait a minute. Let's see about that. I object to that sewage of Milwaukee. There is nothing in this bill charging that?

MR. WOERNER: Well, you can answer that by stating that it does.

Q. Does your knowledge as a chemist—

A. I wish to show that the lake water is not pure water, although it is purer since the flow of the Chicago River has been changed from east to west, and that it is subject to pollution, and that investigations show that pollution from Milwaukee may affect it to some slight extent which may increase.

Q. To a greater or less extent? To some slight extent,
1960 I suppose?

A. Well, to some slight extent, which may increase with the—

Q. Make that statement?

A. Rafter says in his report—

Q. Never mind what he says. You say now that you believe that to be the fact from your knowledge as a chemist?

A. Yes sir.

Q. You need not go into the reasons that induce you to believe that now; just omit that and go on.

ATTORNEY GENERAL HAMLIN: I move to exclude from the witness' answer anything touching the sewage of Milwaukee as not being charged in this bill, and not being relevant to the issues.

THE WITNESS: Rafter, during the years of 1890—

ATTORNEY GENERAL HAMLIN: I move to exclude from the answer the statement made by the witness in reference to what the investigation made by Rafter shows.

Q. MR. WOERNER: Now just omit this Milwaukee experiment and go on with your experiments. You didn't make those experiments, did you?

A. No sir.

Q. Well, just omit that and go on with your experiments.

A. Do you want to have a description of the Illinois and Michigan Canal?

1961 Q. Yes, that is all right, but confine that as nearly as you can to the facts that are relevant and essential to the issues in this case as you understand them to be?

A. Well, I can leave out a description of the engineering features of the canal—I have the canal depth and width, and so forth,—and come right over to the subject matter.

Q. Well state, if you can, the relative sanitary conditions between the Illinois and Michigan Canal, and the Drainage Canal growing out of the differences in their construction and engineering?

A. During the last ten years, the discharge from the pumps at Bridgeport—

Q. Please do that as quickly as you can, Doctor.

A. Well I have to be explanatory in order to get in all the facts involved.

During the last ten years, the discharge from the pumps at Bridgeport, into the Illinois & Michigan Canal was practically crude sewage, after having partly been disintegraded by anaerobic action in the Chicago River, and in the branches,—in the south fork and North Branch.

The analyses of samples of the contents of the canal showed an entire absence of dissolved oxygen, without which practically no oxidation can take place.

1962 In other words, you have here in the Illinois and Michigan Canal a septic tank. The amounts of the free and albuminoid ammonias found, and the absence of nitrates and nitrites frequently also verify the above statement. The conditions prevailing in the canal are entirely similar to those of the river—overcharged with sewage and yet performing the initial purification process in an ideal way—

Q. You are not talking about the Illinois and Michigan Canal now?

A. I am talking about the Illinois and Michigan Canal now. I have to add a few things there to exemplify that. I would like to cut this very short—

Q. Never mind the exemplifications, doctor, now, you confine yourself to the Chicago Drainage Canal and point out the differences there?

A. I want to give some analytical results, proving what I have said regarding the Illinois and Michigan Canal.

Q. Well, I guess you will have to go ahead. I can't stop you. Go ahead.

A. You must excuse me, but I would like to bear out some evidence that I have stated here scientifically.

The chemical changes which take place in this Illinois and Michigan Canal are disintegration of the complex organic
1963 contents, in which similar forms, such as nitrogen, ammonia, hydrogen sulphide, etc., and a conversion of some of the suspended organic matter into dissolved constituents—

Q. Well now, you have covered that all by this statement you have made?

A. These conclusions are largely confirmed by Professor Long's analyses of 1899, by whom 27 weekly samples were taken between July 1st and November 27th, 1899, with the following results:

At Bridegport, nitrites were absent, or present only in immeasurably small quantities or amounts, for all but three of these weeks. Twice they were as high as .01, and once reached .64 parts per million.

At Lockport almost identically the same conditions were found. The nitrates at Bridgeport were uniform—absent with but one exception.

Q. Now that was before the opening of the Drainage Canal?

A. That was before the opening of the drainage canal.

ATTORNEY GENERAL HAMLIN: I move to exclude that answer as being hearsay.

THE WITNESS: From these results it is found that nitrites and nitrates are present only on rare occasions, and that practically no oxidation of organic matter takes place in the Canal, while the increase of oxygen consuming power in
1964 the filtered samples, in spite of the fact that carbon is continually escaping in the form of carbonic acid and methan, it indicates that some of the suspended organic matter has gone into solution.

At Joliet, Ilinois, in the Illinois and Michigan Canal, practically the same conditions were found as at Lockport, in regard to nitrites and nitrates.

Q. Now you are talking about before the opening of the Illinois and Michigan Canal?

A. Before the opening of the Drainage Canal.

ATTORNEY GENERAL HAMLIN: I move to exclude from the consideration of this Court all the testimony given in answer to the last question in regard to the nitrates in the Illinois and Michigan Canal at Bridgeport and Lockport, as being hearsay.

THE WITNESS: I would like to make one more short conclusion—

Q. Well now, wait a minute—

ATTORNEY GENERAL HAMLIN: Dr. Tiechmann, just let me suggest to you that this is an argument to be made by the lawyers and not by you.

Q. MR. WOERNER: Now, doctor, come down to the Drainage Canal and give us the result of your investigations.

Now doctor, as much as you can, confine yourself to your
1965 investigations and to the Drainage Canal and the waters
between the Drainage Canal and the City of St. Louis?

A. Well, now, in order to do this I would have to have my charts here. I didn't expect to reach that stage of the testimony this afternoon and I haven't got my charts here. I would have to send for those, which would probably take a half an hour to get them here. I would need those absolutely, in order to present them to the Court.

ATTORNEY GENERAL CROW: I think we can get along without them, Doctor, just go ahead. You have got there the results of your investigations?

A. Yes, but I constantly refer to the charts.

Q. Well, give it to us without the charts—without the reference to the charts and we will get the charts afterwards.

A. I have got my analytical results from Lockport. I have got them on the charts and in the records.

Q. MR. WOERNER: Now just continue the report of your investigations where you left off, and omit the reference to experiments made by others, that you were not present at and have no personal knowledge about, doctor?

A. I must leave the discussion of the data from the point of collection in the Drainage Canal at Lockport to the time when I get my data from the office.

1966 I will begin with Joliet then.

The most noteworthy features of the Joliet results were the excessively high amounts of unoxidized nitrogen as free ammonia which were present throughout the period of the investigation found at Joliet. The low nitrates at that point showed that comparatively little oxidation of the sewage had taken place thus far.

The maximum, minimum and average amounts of free ammonia found in the Des Plaines River at Joliet during these investigations were respectively:

8.284 for the maximum.
1.246 for the mimimum, and
2.759 for the average parts per million.

Now as viewed in the light of the conclusions drawn by authorities on the sanitary quality of water, Rudolph Herring states that when free ammonia is greater than 1.2 parts per million, the conditions are probably objectionable.

We find here, a maximum free ammonia of 8.284, and we find that the minimum free ammonia obtained from the analyses there is 1.246, that the minimnm found during that time is below the amount of the free amonia considered objectionable by sanitarians like Rudolph Herring for river water. The minimum was greater than the limit, I say.

The results at Joliet show the combined effect of the

1967 Drainage Canal the Illinois and Michigan Canal and the Joliet sewage.

I have to constantly refer to my charts. I think it would be better for me to go down to the office and get them.

ATTORNEY GENERAL CROW: All right, if you must have them.

RECESS until 4:00 P. M.

4:00 P. M., Tuesday, March 7th, 1903.

Continuation pursuant to adjournment.

Present, the Commissioner and same counsel, representing the respective parties.

DR. WILLIAM C. TEICHMANN,

Resumed the stand for further direct-examination by Attorney-General Crow, and testified as follows:

Q. Now go ahead doctor?

A. This represents Chart 1, describing in curves the comparison between weekly averages of results of analyses of daily samples collected at Lockport, from the Drainage Canal, collected at Joliet after mixture of the Drainage Canal, and 1968 the Desplaines River, and also respecting the mixture of the Illinois and Michigan Canal.

The samples were taken at McDonough Street in Joliet, and samples taken three miles above Peoria. That is, the curves will show fluctuations at Lockport and Joliet, and that they produce similar fluctuations at Peoria, to show that there is little change and practically no material improvement in the Chicago sewage in traveling from the Lake Front to Lockport, and all that is accomplished by dilution is the prevention of anaerobic putrification. This is also embodied here on the map—written out, what I am stating.

Q. But the map is not in evidence.

A. This shows the—the blue line shows the Chicago Drainage Canal; its condition regarding nitrogen as free ammonia, chlorine, nitrogen as nitrates and nitrogen as nitrites.

At Lockport, Drainage Canal, the yellow line shows the Des Plaines River at McDonough Street, Joliet, and the red line shows the Illinois River, three miles above Peoria.

This represents the period from January to October, the weekly averages.

Q. Now doctor, if you will just take that map and put it down there at the table, you can go over the thing better.

A. It will show that you will find the high ammonias cor- 1969 responding there at the Des Plaines River, Joliet, and Chicago Drainage Canal, their fluctuations always go together, sometimes a little higher than in the Des Plaines River, because of the acquisition of the sewage from the Illinois and Michigan Canal where the preliminary purification has reached the stage that the Illinois and Michigan Canal shows very high —high free ammonia and you will therefore find free ammonias higher at Joliet than you will find them in the Drainage Canal.

Now take Peoria, the red line. Considerable purification has taken place of the sewage during its route from Joliet to Peoria, but you will see how the fluctuations go together pretty much. That is, you see here, for instance (indicating on map) a rise in the Drainage Canal in free ammonia, is followed by a rise of free ammonia at Joliet, and is followed by a rise of free ammonia at Peoria, and you will find here the amounts of free ammonia all figured out.

This is 1 part per million;
This is 2 parts per million,
This is 3 parts per million.

The same can be said regarding the chlorine.

Of course the crossing of the Des Plaines River at Joliet by the Illinois and Michigan Canal—the canal causes a large acquisition of the sewage there from the Illinois and Michigan
1970 Canal, and that must be taken into account in reviewing
this chart. That is what brings those high free ammonias, as I said before, at Joliet, and also brings the high chlorine up there at Joliet, running up as high as 32 parts per million of free ammonia; here as high as 54 parts per million, but you will notice that the fluctuations correspond pretty much. I don't say always, but it seems that during that period they go together pretty well.

As regards the nitrates, we find a considerable reduction now. Low nitrates you will find in the Des Plaines River and also in the Chicago Drainage Canal, that is the cycle of oxidation has not reached the stage either in the Drainage Canal or in the Des Plaines River at Joliet that we could say it is completed.

The nitrates are low, whereas, as we go down the river towards Peoria, we see the oxidizing effect of aerobic bacteria in that river, having increased the amounts of nitrates considerably.

Now let us see whether the intermediate product of oxidation,—the nitrites—which if high, demonstrate the unstability of the river, and that the river is still as far as its chemical character is concerned, in a state of change.

Let us look at those for Peoria and we will see for the summer months, an immense amount of nitrites in the Illinois River. That shows that the sewage came down 1971 gradually, and with the access of warmer weather the process of purification, as far as the change from free ammonias to nitrites is concerned, had progressed materially, and even the high nitrates running as high as over one and one-half parts per million, would indicate that for part of that sewage there had been an oxidation sufficient to say that that cycle of nitrification was completed; but not so for the entire sewage, and the extremely high nitrites, running as high as one-fifth of one part per million or .2 parts per million at Peoria during those summer months, demonstrate that the river was in a high state of fermentation, and that the oxidation process had not reached the stage yet that we could say that it was final.

In other words, the Illinois River as a result of the large accretions from the Drainage Canal, and probably also in a measure from the Illinois and Michigan Canal in its low advanced stage of purification, they cause this fermentation process to reach these enormous figures here of .2 parts per million, then down, and then up again at that time.

We will see, corresponding in a measure—we will see high nitrites coming along for the Drainage Canal, and for the 1972 Des Plaines River at Joliet. See here for instance (indicating). Now they go together very well, except in the summer, during the months of July and August, they are not so apparent any more, because of the large distances and the warmer weather there would produce conditions there at Peoria and the Drainage Canal, and the Des Plaines river, facilitating the process of oxidation materially, but not completing it as can be seen here.

I have a table of average results of daily analyses for the period from January 23rd to October 11, 1900, and I have also a table containing the maximum, minimum and average results of analyses from January 23rd to October 11, for the same year, 1900.

This would show for the Bear Trap Dam at Lockport, free ammonia on September 18th, the highest amount of free ammonia was reached at the Bear Trap Dam at Lockport,—4.8 parts per million; that is nitrogen in the form of free ammonia. I beg to emphasize that—nitrogen in the form of free ammonia at the Bear Trap Dam at Lockport was 4.8 parts per million.

The minimum was reached on May 18th,—.706 parts per million, making an average of 1.585 parts per million, which is represented on this map here.

1973 For the nitrites the maximum also at Bear Trap Dam at Lockport was .2 parts per million.

The minimum was zero.

The average was .026 parts per million, which is also noted here on the map.

Q. Now are you through with that map?

A. This is chart Number 2. The red line shows Illinois River, three miles above Grafton. The blue line represents the Illinois River three miles above Peoria.

I have here the Illinois River stages—

Q. That is the top line?

A. Yes, for the 1900 period. Now this map—

Q. Describe where it is? Describe what it is.

A. The curves representing the graphical condition of the Illinois River at Grafton, Illinois, and Peoria, Illinois during the months of January and February, 1900, prior to and immediately after the official opening of the Chicago Drainage Canal on January 17th, 1900.

Now, these results clearly show the enormous pollution caused by the flushing out of the Chicago River and the Drainage channel, and that owing to the excessive quantities of organic matter present, self-purification was practically impossible. The amounts of free ammonia, chlorine, and nitrates represented the effects produced, and although the incomplete purification is also demonstrated by the other results of the organic matter, the principal object of this chart is to make a comparison of the results at Peoria and at Grafton during the months of January and February, 1900. 1974

It will be noticed that in January, immediately after the opening of the canal, that the chlorines go up from 21 parts per million, they increase to 28 parts per million at Peoria. This is followed by an increase at Grafton from 15 to 23 parts per million, and it will be seen that the chlorines go pretty much together in their fluctuations at Peoria, as well as Grafton. You can see how they go up at Peoria. Then they go down at Peoria, and there are—and they are followed in the same way by the fluctuations at Grafton.

Now the chlorines are a splendid indication of the corresponding fluctuations in the river.

Now as regards the free ammonia, we notice the same conditions, Illinois River three miles above Grafton, as we do three miles above Peoria.

Following the opening of the Drainage Canal we find a great rise up here at Peoria, and we find a rise following soon after at Grafton, Illinois, and as this percentage decreases at Peoria, it is followed by a corresponding decrease at Grafton. In other words, the fluctuations correspond between Peoria and Grafton.

1975: Q. MR. WOERNER: Making allowance for the flow of the water?

A. Yes sir.

Now we find the river stages on top here (referring to chart) on this red line, indicating that the river rose, about January the 18th, or January 16th, it began to rise just at the time when the Drainage Canal was opened.

Now let us take a few days for the transit of the Chicago sewage there, and we get to a stationary height, continuing from January 22nd, until February 7th. After January 7th the river rises, and it rises from seven and one-half feet to ten and one-half feet; it rises four feet. During that rise we find the chlorines going down as a result of dilution produced by the increased volume of water, the flood volume of water coming down the Illinois. You will notice the same thing for nitrates and we notice the same thing for free ammonias.

MR. WOERNER: Now this is chart Number 3?

A. We find here the results at Grafton and Peoria again compared by covering a period from January until October, 1900, during the entire investigation—collection of daily samples.

We see here free ammonias,—in the Illinois River at Grafton, and free ammonias in the Illinois River at Peoria—

1976 Q. Now you mean the top line?

A. Yes sir, the top line.

We again see corresponding fluctuations in the free ammonias at Grafton, and Peoria, particularly during the early parts of the year,—during the months of January and February.

Now we find regarding the nitrates, we find a remarkable correspondence there in the fluctuations. We will see beginning with January that whenever they go down at one place, they go down at the other place. When they go up at one place they go up at the other place, again demonstrating that there is a correspondence in the results obtained from the fermentative process continuously going on in that river.

As regards the nitrites, we notice a significant correspondence of the fluctuations in nitrites results for the two points during the two months,but during the summer months, the warmer weather, facilitating the action of the aerobic bacteria in the Illinois River, we find much of those nitrites. We find them oxidized eventually, because the fluctations are not so high any more during those summer months for Grafton, as they are at Peoria.

This map again shows the enormous rise in the nitrites, due to the fermentative action of the upper Illinois River during those summer months.

1977 MR. TODD: I would like to ask you a question.

A. Yes sir.

Q. From what data is that chart constructed?

A. Those charts are prepared from the analytical data which I have collected from our analytical survey in 1900. That is, they are taken from the averages of weekly fluctuations of samples from January 23rd to October 11, 1900.

These are charts prepared by two of my assistants, who are civil engineers, but they are prepared under my direction and from my analytical data.

Now Chart Number 4, shows the results of the waters analyzed from the mouth of the Illinois River several miles above the mouth of the Illinois river, in the Illinois, and several miles above the mouth of the Illinois river in the Mississippi. They show above all, the peculiar unstability of the Illinois River at Grafton, as compared with the Mississippi River—a much more stable river, as far as its pollution is concerned, and as far as fermentative action itself takes place.

I have also here the river stages for the two rivers.

Now we see here from the river stages something that has frequently been noticed, and that is still a matter of discussion between scientists, whether the rise of a river will increase
1978 or decrease the ammonias. A rise of the river will always decrease the chlorines. There will be more water and the quantity of chlorine dissolved will diminish materially. The larger the rise of the river is, the more water there will be to dilute the chlorines.

Now regarding the ammonias, we notice in the beginning of the year, between February and March there, during the latter part of February and during the month of March, we notice a rise in the stage of the rivers, the Illinois and the Mississippi. We notice also a rise of the free ammonia in both rivers at that time, but we notice in the month of January that owing to an increased volume of sewage pollution coming down the Illinois River, we notice tremendously—I won't say tremendously high—I will say remarkably high free ammonia in the Illinois River at Grafton. It runs up as high as 1.67 parts per million of nitrogen in the form of free ammonia.

We notice also a remarkable decrease in those ammonias eventually, after normal conditions of the river had been reached these normal conditions, taking into consideration the seasonal changes produced during the summer months, we find that the free ammonia goes down low again and is almost like that of the Mississippi River at times.

But when we look at the nitrites, we notice that the Illi-
1979 nois River at Grafton throughout that year shows much higher nitrites than the Mississippi River, and we notice also the chlorines. The chlorines are much lower in the Mississippi during that entire year, and the nitrates are lower, and we notice, excepting for that peculiar rise in free ammonia in the Mississippi River during the month of March, we notice a coincidence in stability of these ammonias, with the stability as shown by the nitrites and shown by the chlorines, and the nitrates, the remarkable fluctuations here in the nitrites in the Illinois River at Grafton, in 1900. They show that the river is still

at Grafton in what we call a state of fermentative change; that is, the purification process in the Illinois River has not been completed; the nitrites are high; the intermediate product between free ammonia or carbonate and chloride of ammonia properly, and the nitrates—in the final state of the purification process—I say the intermediate stage,—the nitrites are high, and they show considerable fluctuation, demonstrating the instability of that river, and in pollution, as compared with the Mississippi River, the higher chlorines and the higher nitrites with comparatively high free ammonia, the three together representing what we call the characteristic ingredients of sewage pollution as declared by Professor Drown in his famous Massachusetts
1980 Board of Health report.

Q. MR. WOERNER: And your conclusion is?

A. That the Illinois River was very much more impure than the Mississippi River above the mouth of the Illinois during the year 1900, and was evidently in a badly polluted condition.

Now I have some notes here I want to read.

MR. WOERNER: Now are you ready to state your conclusions in general, doctor, from these charts, or do you want to give any more data from which your conclusions are reached?

A. Well, my conclusions regarding the pollution of the Illinois River; you mean, or do you mean the final conclusions? I have not reached that yet, because I have not spoken of the Mississippi River yet.

Q. Well, you have stated then what you think about the Illinois?

A. Yes sir.

Q. Well now, go on about the Mississippi. Follow your next investigation.

A. Now I have a number of points that are embodied in my report Mr. Crow, which might be brought out, and I would like to discuss those.

MR. WOERNER: With respect to these matters?

A. Yes, very important points. We have to discuss the
1981 pollution of the Illinois River by the City of Peoria, what effect it has on the river, the sanitary character of the river, and we have to discuss a few other points of value.

Q. All right, doctor, just continue along your own lines?

A. Well, I stated that the Chicago sewage is only partly purified by the time it reaches Peoria, as was shown on the chart by the high free ammonia, high nitrites and the high chlorines coming together, we must certainly admit a large amount of nitrification and oxidation between Lockport and Peoria, but it is in no sense sufficient to render the Illinois River potable by the time it reaches Peoria.

In comparison of the analytical results attained by our investigation from a point three miles above Peoria, compared with tables prepared by sanitarians, and authorities on questions of water supply, it would prove that the amounts found in our investigations three miles above Peoria, would be sufficient to establish the polluted character of the water of the Illinois river by the time it reaches Peoria.

Now I have a number of tables here from various authorities, showing what they consider a pure water, normal water, and polluted water. Do you want that to be discussed? It would take quite a time to take that matter up.

1982 MR. WOERNER: Well, that is without reference to the particular waters here?

A. No, that is only in reference to the waters of the Illinois River—

MR. WOERNER: You say you have authorities there about what is pure water and what is not, drawn from various authorities?

A. Yes and tables.

Q. Well, we won't stop for that just now, you may perhaps refer to that later, but we won't do it now.

A. All right. I have already quoted Professor Drown as having stated that high free ammonia, with high nitrites and high chlorines together, establish water as sewage polluted, and if uniformly high—they show a continuous pollution in connection with chlorine, above the normal, affording complete proof of sewage contamination.

Now regarding Peoria sewage, the population of the city of Peoria, according to the census of 1900, is 56,100 and we calculate the sewage discharge on a ratio compared with the population, that is, we figure on 150 gallons of sewage there per inhabitant. On this basis we take 8,415,000 gallons or 1,122,000 cubic

feet of sewage per 24 hours, running into the Illinois River from
the City of Peoria; that is, if we take the total poulation.
1983 But from recent data I have learned that the sewage
draining from the city of Peoria into the Illinois River
would represent only 47 per cent of the population.

MR. WOERNER: Where does the rest of it go?

A. Well, the rest of it goes into the privy vaults, the sewerage system not covering the entire system, that of course is lost in the ground.

Now as I previously stated, the minimum flow of the Illinois River at Peoria prior to the opening of the Chicago Drainage Canal, was according to Lyman E. Cooley, 72,000 cubic feet per minute. Now if we add to this the discharge from the Canal of 250,000 cubic feet per minute, we have a minimum flow of the Illinois River at Peoria of 322,000 cubic feet per minute.

Now we take the above value of 1,122,000 cubic feet of sewage per 24 hours, or 779 cubic feet per minute, and we will find that the dilution of the Peoria sewage at a low river stage, a low river stage as was recorded by Government data, government investigations and presented in the report of Lyman E. Cooley, which I have frequently quoted today, and giving this caluculation the benefit of the doubt, in so far as admitting that all the population—that the sewage from all the population of Peoria is included in this calculation, which as I say I have recently
discovered is not the case,—we find a ratio of dilution
1984 of the Peoria sewage in the Illinois River of 1 to 413.

MR. JOHNS: That is at low stage, doctor?

A. Yes, that would take the lowest stage of the river.

MR. WOERNER: Now would that materially affect the pollution of the Illinois?

A. In other words, if we take the sewage of the City of Peoria and run it into water at such a ratio of dilution, the sewage would, in my opinion, after a run of from 25 to 50 miles, be sufficiently purified with so much water added to the sewage, so as to remove the effect,—the polluting effect of the Peoria sewage on that river.

Q. Now answer the question please, the question was whether or not in your opinion the sewage from the town of Peoria materially added to the pollution of the Illinois River?

ATTORNEY-GENERAL HAMLIN: I object to that; it is assuming that the river is already polluted.

Q. MR. WOERNER: Did you get the question, doctor?

A. Yes sir.

Q. Now answer it Yes or No. The question is whether in your opinion the town of Peoria materially adds to the pollution of the Illinois River—

A. I would rather change that question, whether it has any effect.

1985 ATTORNEY-GENERAL HAMLIN: Never mind, doctor, you are not the lawyer; you are the witness.

THE WITNESS: Excuse me.

MR. WOERNER: Well, is the sewage from Peoria, in your opinion, such as to materially add to the pollution of the Illinois River

A. It adds to the pollution of the Illinois River, but only to an extent that if the Illinois River were pure, that would be what I would call a comparatively pure water, because absolutely pure water is only distilled water which you find in the laboratory, but I mean to say an ordinary good river water, potable—I will say that if it were a potable water before it came to Peoria, that the sewage entering the Illinois River from the city of Peoria would, after running from 25 to 50 miles, purify itself so as to remove the polluting effect of the Peoria sewage on the Illinois River.

Q. You mean by that chemically or bacteriologically?

ATTORNEY-GENERAL HAMLIN: That I object to as not being proper; that the answer doesn't require any explanation; it sufficiently explains itself, hence your question is not proper.

ATTORNEY-GENERAL CROW: It is a question about which counsel might differ.

1986 ATTORNEY-GENERAL HAMLIN: That is true, but we will see what the Court has to say.

MR. WOERNER: Now answer the question, whether by purification running that length of time, you mean chemically or bacteriologically?

A. Chemically yes.

Q. Do you mean that that would also be bacteriologically purified?

A. Well, that would involve a consideration of the bacterial action of facultative anaerobic bacteria and aerobic bacteria.

Q. Well, go ahead.

A. That is, would certainly have finished the purifying process after having run the distance that I have mentioned.

ATTORNEY-GENERAL CROW: Well go ahead doctor, we are waiting for you.

A. In conclusion I wish to say that the Illinois River as a whole, furnishes a good example of the inability of an excessively polluted stream, excessively polluted at the point where the Des Plaines river enters it, shows the inability of an excessively polluted stream to recover itself.

It is seen that the ability of such a stream to purity itself is dependent on the amount of sewage added, and the volume of water coming down the river, and the results at Grafton plainly show that the Illinois River is at times overloaded with sewage, and literally fails in this capacity of recovering itself or of purifying itself. 1987

WILLIAM C. TEICHMANN.

ADJOURNED until 10:00 A. M., following day, Wednesday, March 18th, 1903, at Southern Hotel, St. Louis.

1988 Southern Hotel, St. Louis Mo. 10:00 A. M. Wednesday, March 18, 1903.

Present: The Commissioner and the same Counsel representing the respective parties.

DR. WILLIAM C. TEICHMANN

resumed the stand for further direct examination by General Crow.

Q. Go ahead Doctor?

A. I will now show the santiary condition of the Mississippi River between Grafton, Illinois and St. Louis, that is after the Mississippi River and the Illinois River join at Grafton. I have here the curves representing nitrogen as free ammonia, nitrogen as nitrates and nitrogen as nitrites.

I am testifying from Chart No. 5.

The red line represents the Illinois River three miles above Grafton.

The blue line represents the Mississippi River one mile above Grafton and the yellow line represents the Mississippi River at Hartford and the brown line represents the Mississippi
1989 River at Alton.

It will be seen that during the months of January and February (this represents 1900 from January 23rd until October 12th) that there was a marked pollution of the Illinois River water at Grafton.

You see this line coming down here, this red line, then the Mississippi River below Grafton showed a corresponding pollution and that the rise during the last week of January, that the rise in the Grafton sample,—you see the rise at Alton, one mile above Alton, the rise at Hartford, on the yellow line with a fall of the free ammonia at Grafton. We see a corresponding fall during the latter part of February and early in March of the free ammonia. We see the fall at Alton and also at Hartford, the yellow line.

During that same period from January 23rd to about the latter part of February there was no corresponding rise of free ammonia in the Mississippi River above Grafton, you see the dark line there is quite low. You find the free ammonia highest point during that period being reached as .28 parts of nitrogen in the form of free ammonia, parts per million, whereas the free ammonia in the Illinois River at Grafton—

GENERAL HAMLIN: What date was that did you say?

A. It represents its highest point on January 29th or 30th, 1900.

1990 As I say, there had been a corresponding rise in free ammonia during the preceding week at those three points, Grafton on the Illinois River, Alton in the Mississippi and Hartford in the Mississippi, and during that time the Mississippi River above the mouth of the Illinois, did not show a corresponding rise.

MR. WOERNER: Rise in what?

A. Rise in free ammonia. In other words, there were corresponding fluctuations in the ammonia, that is in rising up to very high figures and going down again later on and subsequently in the middle of March, going up again. This rise and fall, rise in free ammonia and subsequent fall in free ammonia all corresponded, demonstrating that the Illinois River pollution in free ammonia at that time affected the Mississippi River correspondingly at Alton and Grafton. The same applies to the chlorines and also to the nitrogen as nitrites. It will be seen that the fluctuations always go together as regards nitrites. It can be seen by the curves and can be noticed during the summer months, during the latter part of May and June and July and August, particularly June, July and August, as I said, you will see the rise in the quantity of nitrites corresponds in the water from Grafton, Illinois River, Hartford and Alton. You see they always go up and down together, whereas during that time this 1991 fermentation action of the nitrites did not take place to any such extent in the Mississippi River; the Mississippi River showing a comparatively even curve.

GENERAL CROW: Well, at what point in the Mississippi River?

A. Well, that is above the mouth of the Illinois in the Mississippi River.

In other words, it is again demonstrated by the results as shown here for nitrites during 1900, that high nitrites at Grafton in the Illinois River were always followed by an increase in nitrites at Alton and Hartford..

Q. What did that indicate?

A. That indicates that the Illinois River effectually pollutes the Mississippi River after joining it at Grafton.

I have here a chart No. 6, showing a comparison of the Missouri River water taken from Bellefontaine, Missouri, and the water taken from the Missouri Shore at Chain of Rocks.

MR. WOERNER: In the Mississippi?

A. Yes, sir. It will show from the chlorine, from the total solids or the total residue on evaporation, that is when a certain quantity of water is evaporated in a platinum dish and the platinum dish weighed of course, before the water is 1992 evaporated, and after evaporation of the water the residue weighed again and the difference deducted by the subtraction of the original weight of the platinum dish.

JUDGE JOHNS: What period is that?

A. That is for 1900, from January 23rd until October 12th.

It shows clearly that the water coming down the Mississippi River along the Missouri shore as it passes St. Louis, is principally consisting of Missouri River water. You have here the red line representing the Missouri River at Bellefontaine and the dark line representing the Missouri shore at Chain of Rocks. It will be seen how the chlorines run together, very close together and it will be seen from the total solids that these are almost identical, almost alike.

GENERAL CROW: Now, what time is that Doctor, the same period?

A. That is in 1900, the same period, yes sir.

I will state here that whenever the Missouri River is high and is flushed out or rather, storm water comes down the river, that there is a marked stirring up of the river and the increased sedimentation produces very high total solids or residue on evaporation. This can be seen if you look at the chart for February and March and April, where the amount of solids estimated in parts per million, rose from 800 on the 27th of February to
1993 3750 parts per million of total residue was found then in
both waters, the waters of the Missouri River at Bellefontaine as well as the Missouri River at Chain of Rocks, and the subsequent remarkable drop back again to about 1200 in the latter part of March, again shows how closely those waters resemble each other, the waters of the Missouri River at Bellefontaine and the water on the Missouri shore and you will find that all throughout this comparison.

GENERAL HAMLIN: The Missouri shore there at the Chain of Rocks?

A. Yes, sir the Missouri shore and you will find it as regards nitrites. It proved conclusively that the water that hugs the Missouri shore as it passes the water works of St. Louis at the Chain of Rocks, is practically Missouri River water. I am now speaking of the Missouri shore. I am not speaking of the channel nor of the Intake Tower, which I will discuss later.

I have here chart numbered 8. This represents a cross-section of the Chain of Rocks St. Louis, where the intake of the St. Louis Water Works is located.

GENERAL CROW: Doctor, you might just explain in that connection, in connection with your testimony, if you haven't explained it yet, what you mean by a cross-section?

A. A cross-section is a line run right straight across the
river and samples are collected right on this straight line
1994 at certain distances between the two shores. In this case
three such points were designated and the samples were
taken from each point and compared in their results on this chart. The object of this cross-section was to get an accurate estimate of the quantities of impurities in the water running along the Missouri shore representing the Missouri River water. The water going into the Intake Tower, which is located 1500 feet from the Missouri Shore, right on the edge of the narrow river channel, at that point of the river, and the third sample was taken as close to the Illinois shore as was necessary to get a sample from the water hugging the Illinois shore.

Q. What period does that map cover?

A. That represents the period of 1900 from January 23rd until October 12th.

Q. Now just explain at what point this cross-section of the river was?

A. That point is 8 miles south of the mouth of the Missouri river?

Q. That is at the Intake?

A. Yes, at the Intake Tower, just where the Intake is located. It is at the most northern city limits.
1995 I have here the total residue and the chlorine and nitrogen as nitrites. The total residue on evaporation shows
for the Missouri shore, in the red line, very high total solids nearly all the time; much higher total solids or residue on evaporation than the samples from the Illinois shore. This has been the case throughout the entire period with the exception of one occasion in March.

Q. Doctor, when you say it shows very high for the residue, you mean that there are more solids in the water after it is evaporated?

A. Yes sir.

Q. On the Missouri shore than on the Illinois shore?

A. Yes sir, that is what I mean.

Q. And when you use the term high or low, you mean there is more or less solids?

A. Yes sir.

Q. Give us those dates that you made the tests upon the solid residue after the water had been evaporated?

A. Yes sir, after the water had been evaporated. This does not represent the volume of flow because that is something entirely different. It merely is to show what the chemical proportions as far as the solids, the total solids or residue on evaporation is concerned, what the proportions are as represented
1996 in those samples. That is to what extent the mixture of the rivers takes place as far as that can be ascertained by the chemical ingredients, or rather, by this test, by applying the total solids.

Q. Well, you obtained that result by taking the total solids on either side of the river and then at the cross-section of the river and the middle and averaged the mean between the two and determined as a result that that was a mixture of the water because of the amount of solids?

A. Yes, I have a table which I shall present after resuming the discussion on these points and from my report, which will show the daily percentage calculation as obtained from this estimation based on the total solids. It shows that the Intake Tower invariably has higher total solids than the Illinois shore except on the occasion here shown on the map in the month of March when they came very close together, and the Missouri shore has, of course, always higher total solids except on the occasion there where the mixtures result in slightly higher total solids at the Intake.

Q. Now, chemically, what does that indicate?

A. The conclusion is this, that since the results at the Intake and the results at the Missouri shore differ as a rule, although they come close together sometimes, as is shown in the month of August, 1900, that there must be a mixture of the water running along the Illinois shore and of the water running
1997 along the Missouri shore.

Q. At what point?

A. At the Intake Tower. You can see here (referring to map) that the percentages at the Intake are always lower than those of the Missouri shore as already explained, with a few exceptions, and that they are always higher than on the Illinois shore. There are a few points there that demonstrate that they come close together.

Q. Now explain your other curves?

A. (Continued) and the estimates will show that.

Q. (Question repeated.)

A. The same conclusion applies to the chlorines. We find the highest chlorines in the Missouri River and also in the Missouri River water which hugs the Missouri Shore at Chain of Rocks. Then we find chlorines of the Illinois shore most of the time lower than those of the water at the Missouri shore and lower than the water at the Intake Tower, which has a few exceptions, when they come together.

Q. So that the water at the Intake Tower as a rule, is intermediate between the other two?

A. Yes. You will always find that the chlorines on the Missouri shore are higher than the chlorines at the Intake Tower, demonstrating that the water at the Intake Tower is not altogether Missouri River water which is running along
1998 the Missouri shore but is a mixture of the two currents
that run along the two shores. That applies to the channel water. Now you will see great variations in the percentage of this mixture which is due to the fact that a rise of the Missouri River will show a marked increase in the volume of water coming down the Mississippi River from the Missouri and it will at such times crowd the water that comes along the Illinois shore toward the Illinois shore and that will reduce the percentage of mixture to such an extent as to give us at such times almost pure Missouri River water or solely Missouri River water at the Intake, but at most of the times during the year this is not the case. There is a mixture there in the channel and when the Missouri River happens to be low and there is a rise in the Illinois or a rise in the upper Mississippi River, the water that hugs the Illinois shore will naturally push over to the Missouri shore and it will produce a mixture in the channel and this mixture you see represented in an invariably lower curve for the Intake, that is the blue line in the center between the two. This can be a very high percentage of Mississippi River water at times. At times

it has run as high as 100 per cent, that is, as far as we can estimate it from the total residue and chlorines it will.' They de-
monstrate that the Missouri River curve was pushed by
1999 the larger volume of Mississippi River water coming down
the Illinois shore, and was pushed so far over toward the Missouri shore that while the water at the Missouri shore nearest to the shore, would show nothing but Missouri River water in its chemical characteristics, the water running in the channel would be principally Mississippi water and would accordingly affect the quality of the water going into the Intake Tower.

Q. When you say the channel, does that mean the river location of the Intake Tower?

A. Yes sir.

Q. So that when you say 100 per cent of the water seems to be Mississippi water you mean by that the water that goes into the Intake Tower is practically all Mississippi?

A. All Mississippi water.

Q. Excluding the water that comes from the Missouri?

A. That is at that point of the river where the Intake is located 1500 feet from the Missouri shore. It may be that 500 feet nearer to the Missouri shore, there is nothing but Missouri water, but at the Intake we have, on such occasions, Mississippi River water only and the percentage tables I bring into evidence will demonstrate that.

What I said about the mixture there in regard to chlor-
2000 ines and residues on evaporation also applies to the nit-
rites. You will see here the red line representing the nitrites on the Missouri shore, which are, with one exception, in the month of March, always lower than the nitrites found in the water on the Illinois shore. The blue line representing the Intake tower shows that the nitrites are always, with two exceptions, lower than the nitrites on the Illinois shore. Now, this is another strong proof that the water going into the Intake Tower is a mixture of the two rivers, because if it were not the case, the nitrites would not be lower at the Intake Tower than they are at the Illinois shore. Of course, it happens that they are alike sometimes, but as a rule, for the larger part of the year, the nitrites in the Intake, represent a mixture of the two rivers.

Q. Now, Doctor, the exceptions that you have stated are practically insignificant are they not?

GENERAL HAMLIN: I object to the question.

GENERAL CROW: Well, state what they are.

A. Those exceptions will be shown, that is, their importance, or rather what they amount to, will be shown in a table that I am going to present, which represents the daily percentage calculation during that entire period.

Q. Can't you say it now in a few words, without going
2001 into a big explanation?

A. Well, I can by glancing over my table.

Q. Never mind, go right ahead then.

A. These exceptions are few when the nitrites at the Intake are as high as those at the Illinois shore.

Q. Isn't that all?

A. I would consider that insignificant.

GENERAL HAMLIN: Have you got a copy of that chart, Doctor?

A. No, I have not. Now, in discussing the results of the analyses of samples taken in 1900 from January 23rd until October 11th, from the Mississippi River between Grafton, Illinois and the Intake, I wish to call attention to the excessive pollution of the Mississippi River during the months of February and March as resulting from the excessive pollution of the Illinois River. I have demonstrated that from the charts.

Q. In 1900?

A. Yes. I will just take the week beginning January 30, 1900 and take the averages of the results for this week: The average free ammonia in the Illinois River at Grafton for the week beginning January 30, 1900, the nitrogen in the form of free ammonia found in the Illinois River a few miles above
Grafton amounted to 1.675 parts per million, while in the
2002 Mississippi River, a few miles above the mouth of the
Illinois, the corresponding average amounted to .175. That is only one-tenth of the free ammonia was found in the Mississippi River above the mouth of the Illinois that was found in the Illinois River at Grafton. At Alton and at Hartford we find 1.055 and .865 parts per million respectively, so that we see here from the figures a remarkable increase in free ammonia at Hartford and Alton after the two rivers had mixed. Now these samples were taken from the channel and as I explained yesterday, that is a very narrow channel circumventing a great many

dykes that run out into the river from both shores, and we can consider these samples as a pretty fair criterion of a mixture resulting from the two rivers. Now, as regards the Missouri River, I wish to state that it is noted for its great variations in the amount of suspended matter that it carries, which variations are most noticeable at the times of freshets, when it may contain as much as 4000 parts per million of suspended clay and silt.

Another characteristic feature of this water is its high chlorine contents. This high chlorine content is due to the drainage of the Kaw River through large districts in Kansas of salt deposits.

Q. The Kaw being a tributary of the Missouri at what
2003 point?

A. The Kaw is tributary to the Missouri at Kansas City.

Q. Distant about how far?

A. Well right at Kansas City.

Q. Well, distant about how far from St. Louis?

A. Well, that I couldn't tell at this moment.

In the investigation conducted in the year 1901, I had samples of water collected from the upper Missouri River above and below Kansas City and also from the Kaw River which demonstrated chemically the very high chlorines in the Kaw River as drained from these salt beds—I will refer again to the analytical data of these examinations when I come to the discussion of the fourth period, 1901.

It may suffice to state that it is positively proven that the high chlorines in the Missouri River between Kansas City and St. Louis are principally due to the drainage from these salt beds in the state of Kansas.

A very important point as regards the character of the Missouri River is the condition of the banks which owing to enormous corroding action of the current this current daily washes away large portions of the soil which is particularly the case as the river approaches its mouth.

Now, we find high suspended solids and correspondingly
2004 high albuminoid ammonias in the Missouri River. Our
examinations of the samples from Fort Bellefontaine

show that. The soil which is washed by the freshets into the Missouri River carries an abundance of organic matter contained in this soil, of vegetable origin principally. If the high albuminoid ammonias that are found in the Missouri River were due to sewage contamination they would be accompanied by high nitrites and high chlorine. Now, I have demonstrated that the high chlorines in the Missouri River between Kansas City and St. Louis are not of sewage origin, are of salt drainage origin in Kansas, because the Missouri River above Kansas City shows comparatively low chlorines.

The nitrites in the Missouri River throughout the year are low. They are frequently absent. The fact that they are low or absent and that the variations between the highest nitrites found and at times when they are absent, the variations being very small, shows that there is a very little fermentative action going on in the Missouri River, particularly as it approaches its mouth. We are justified in stating that the general chemical character of the Missouri River as it approaches the mouth is one of great stability, as I said, demonstrated by the comparatively uniform nitrites. If the nitrites were high, with
2005 the albuminoid ammonias and if the free ammonias were
very high and if high chlorines found in the Missouri were due to sewage pollution, these stable conditions would not prevail in the Missouri River. It would be in a state of change, which according to Professor Drown's now famous axiom for determining sanitary quality of river water, would be "A state of danger." This is not the case with the Missouri River. Although it may show at times, high free ammonias, it never shows high nitrites and the chlorines coming from the salt beds of Kansas, by the Kansas River, we cannot ascribe the impurities that we find at the mouth of the Missouri River, to sewage origin.

GENERAL HAMLIN: I desire to enter a motion that as there are no questions being asked I move to exclude the evidence given in reply to the last several questions in regard to the Missouri River, for the reason that it is not a statement of fact but is in the nature of an argument and it is not an opinion for the reason that no facts have been stated upon which an expert could render an opinion, are appearing in the record in regard to the Missouri River water.

GENERAL CROW: Go ahead.

A. The table of maximum, minimum and average results which I presented yesterday, contained analytical data for Fort Bellefontaine in the Missouri River.

2006 MR. WOERNER: Upon which you base your opinion?

A. Upon which I base my conclusions to-day. These tables that I refer to show that at all the times during this investigation,—the second period from January 23rd until October 12, 1900,—the Missouri River water was better in its sanitary quality than the Mississippi River water at the mouth of the Missouri River. While the averages may show free ammonias quite high in the Missouri River, the averages for the nitrites show much lower results for the Missouri river than for the Mississippi.

Q. At what point?

A. At the mouth of the Missouri. And that would stamp the Mississippi River as a more polluted stream than the Missouri River. And since the chlorines, nitrites and free ammonias in the Mississippi River at Hartford and Alton, Hartford being situated one mile above the mouth of the Missouri River, I say since those results from those points of collection at Alton and Hartford, show correspondingly high nitrites, free ammonias and chlorines, that the pollution of the Mississippi River at these points, must be principally of sewage origin.

I have here a table of the percentage calculations of which I spoke in discussing the charts of the Missouri and 2007 Mississippi River water at the Intake, the mixture as represented by the analytical results, of total solids determinations. Now, shall I offer those as evidence?

Q. Yes, have them inserted.

The tables offered by witness are numbered 1, 2, 3, 4, and 5 of Dr. Teichmann's testimony of March 18, 1903, and are as follows:

2008

PERCENTAGES OF MISSOURI AND MISSISSIPPI RIVER WATER AT THE INTAKE OF THE ST. LOUIS WATER WORKS.

CALCULATIONS BASED UPON THE DAILY ESTIMATION OF TOTAL SOLIDS IN SAMPLES COLLECTED AT BELLEFONTAINE, INTAKE AND HARTFORD, JANUARY 23RD to OCTOBER 11, 1900.

	Date. 1900.	Bellefontaine.	Intake.	Hartford.	Bellefontaine minus Hartford.
	Jan. 24,	800	720	500	300
	25,	740	670	580	160
	26,	710	685	380	390
	27,	710	670	390	320
	28,	690	690	460	....
	29,	720	570	400	320
	30,	700	590	340	360
	31,	640	580	370	270
	Feb. 1,	....	....	....	....
	2,	535	450	330	205
	3,	500	450	380	120
	4,	540	490	410	130
	5,	470	460	320	150
	6,	...	...	...	...
	7,	1540	400	400	1140
	8,	...	...	...	...
	9,	1500	1290	1230	270
	10,	1160	1430	1680	520
2009	11,	....	....	....	....
	12,	1050	1120	1200	150
	13,	1020	1220	1590	570
	14,	770	920	1430	660
	15,	500	600	1300	800
	16,	500	540	2325	1825

Date. 1900.	Bellefontaine.	Intake.	Hartford.	Bellefontaine minus Hartford.
Mar. 4,	690	640	450	240
8,	3430	2940	1130	2300
9,	2435	1900	1180	1255
10,	2520	2040	1060	1460
11,	....	....	....	....
12,	3410	2340	1115	2295
13,	3940	3100	1420	2520
14,	4050	3180	1485	2325
15,	4050	3180	1310	2740
17,	3590	2680	1210	2290
18,	3430	2380	1240	2190
19,	....	....	....	....
20,	2370	1600	1250	1120
21,	2010	1890	1420	590
22,	2375	1205	1091	1284
23,	1575	891	806	769
2010 24,	1470	678	830	....
25,	1233	728	765	....
26,	1142	640	831	....
27,	1363	528	670	....
28,	1142	554	647	....
29,	928	627	439	489
31,	1010	590	600	....
Apr. 1,	1180	590	510	670
2,	1280	870	460	820
3,	1400	880	480	920
4,	1510	860	480	1030
5,	1540	935	455	1085
6,	1530	1200	480	1050
7,	1570	1595	630	....
8,	1785	1220	545	1240
9,	1875	1235	545	1330
10,	1735	1300	480	1255
11,	1675	1150	500	1175
12,	1860	1085	455	1405
13,	1965	1240	450	1515

	Date. 1900.	Bellefontaine.	Intake.	Hartford.	Bellefontaine minus Hartford.
	Apr. 14,	2955	2110	415	2540
	15,	3402	3542	376	....
2011	16,	1861	2048	....	....
	17,	3604	1842	401	3203
	18,	2395	1807	424	1871
	19,	2410	1488	410	2000
	20,	2384	1309	425	1959
	21,	2300	1611	458	1848
	22,	4374	1342	520	3854
	23,	1987	1657	493	1494
	24,	1755	1354	615	1140
	25,	1938	1488	1444	494
	26,	1574	1375	469	1105
	28,	2000	1455	521	1479
	29,	1730	1310	440	1290
	30,	1438	1240	458	980
	May 1,	1655	1245	455	1200
	2,	1665	1260	420	1245
	3,	1845	1435	445	1400
	4,	2287	1535	380	1887
	5,	2600	1485	415	2185
	6,	2880	1685	1235	1645
	7,	2110	1485	510	1600
	8,	1951	1449	1091	860
2012	9,	1913	1390	545	1368
	10,	2013	1300	555	1458
	11,	1696	1202	491	1205
	12,	1885	1258	448	1437
	13,	2198	1884	453	1745
	14,	3563	2147	410	3163
	15,	3010	2120	420	2590
	16,	2380	1960	415	1965
	17,	2495	1930	450	2045
	18,	2335	2050	405	2430
	19,	2615	2396	545	2070
	20	2160	1945	505	1655

	Date. 1900.	Bellefontaine.	Intake.	Hartford.	Bellefontaine minus Hartford.
	May 21,	2340	1985	490	1850
	22,	2280	2033	546	1734
	23,	2358	2032	565	1793
	24,	2136	2007	526	1610
	25,	2204	1917	575	1689
	26,	2283	1834	457	1826
	27,	2120	1805	502	1618
	28,	1743	1918	440	1303
	29,	2280	2122	420	1805
	30,	3480	2255	380	2090
	31,	2290	2290	435	....
2013	June 1,	2200	2090	410	1790
	2,	2580	2005	390	2190
	3,	2280	2180	335	1945
	4,	2170	2285	430	1740
	5,	2455	2155	460	1995
	6,	2360	2105	435	1925
	7,	2355	1950	410	1945
	8,	2375	1825	390	1985
	9,	2405	2010	380	2025
	10,	2475	1935	330	2145
	11,	1950	1858	340	1610
	12,	2015	2030	425	....
	13,	2315	2215	595	1720
	14,	4315	3955	320	3995
	15,	3538	3730	375	....
	16,	2562	2935	335	....
	17,	2326	2657	324	....
	18,	2545	2412	340	2205
	19,	2189	2280	345	....
	20,	2179	2080	335	1844
	21,	2210	2100	305	1905
	22,	3258	3055	315	2943
2014	23,	3683	3910	363	....
	24,	3205	4184	471	....
	25,	3506	3892	471	....

Date. 1900.	Bellefontaine.	Intake.	Hartford.	Bellefontaine minus Hartford.
June 26,	3330	3503	....	....
27,	3170	3156	470	2700
28,	3325	2870	455	2870
29,	2760	2805	405	....
30,	2686	2805	405	....
July 1,	2440	2770	380	....
2,	2515	2867	345	....
3,	2115	2800	325	....
4,	2782	2873	335	....
5,	3945	3000	330	3615
6,	3400	4175	331	....
7,	3125	3193	364	....
8,	3060	3234	864	....
9,	3435	3490	343	....
10,	3822	3400	330	3492
11,	2690	2855	320	....
12,	2430	2655	540	....
13,	2175	2415	310	....
14,	1970	2210	290	....
2015 15,	1450	2100	270	....
16,	2433	2315	280	2155
17,	2575	2405	415	2160
18,	2360	1880	310	2050
19,	2415	2300	327	2088
20,	2293	2050	610	1683
21,	2020	1800	370	1650
22,	1895	2132	380	....
23,	2780	2760	344	2436
24,	3885	3210	310	3575
25,	4580	3420	335	4245
26,	3791	3277	408	3383
27,	3157	2500	480	2677
28,	2730	2371	450	2280
29,	....	....	....	....
30,	2310	1995	408	1902
31,	2061	1972	512	1549

	Date. 1900.		Bellefontaine.	Intake.	Hartford.	Bellefontaine minus Hartford.
	Aug.	1,	2127	1795	522	1605
		2,	1725	1807	495	1230
		3,	1975	1693	455	1520
		4,	1812	1630	382	1430
		5,	1622	1339	340	1282
2016		6,	1530	1393	315	1215
		7,	1530	1045	302	1228
		8,	1294	1069	305	989
		9,	1243	1008	305	937
		10,	1226	990	289	937
		11,	1220	970	240	980
		12,	1082	935	280	802
		13,	1060	890	292	768
		14,	1110	904	300	810
		15,	1000	860	270	730
		16,	1053	860	234	730
		17,	1053	860	284	769
		18,	960	890	260	700
		19,	1343	1061	283	1060
		20,	1482	1305	318	1164
		21,	1785	1305	405	1380
		22,	1845	1525	665	1180
		23,	1760	1445	685	1075
		24,	1610	1470	688	922
		25,	1556	1320	584	972
		26,	1556	1320	584	972
		27,	1410	1358	538	872
2017		28,	1595	1422	445	1150
		29,	1565	1379	420	1145
		30,	1881	1125	375	1508
		31,	1881	1125	375	1506
	Sept.	1,	1376	1315	430	946
		2,	1460	1450	420	1040
		3,	1610	1414	445	1165
		4,	....	....	....	....
		5,	1930	1489	365	1565

	Date. 1900.	Bellefontaine.	Intake.	Hartford.	Bellefontaine minus Hartford.
Sept.	6,	1600	1545	370	1230
	8,	1635	1436	354	1281
	9,	1570	1308	352	1218
	10,	1430	1240	340	1090
	11,	....	....	....	....
	12,	1492	1033	359	1143
	13,	1305	1048	340	965
	14,	1213	931	348	865
	15,	1110	896	298	812
	16,	1270	900	345	945
	17,	1186	900	330	856
	18,	1230	853	300	930
	19,	1210	864	340	870
	20,	1428	970	311	1117
2018	21,	2200	1380	311	1889
	22,	3230	1900	313	2917
	23,	2985	1920	327	2658
	24,	3116	1980	330	2786
	25,	2558	1836	360	2198
	26,	2365	1640	320	3045
	27,	1970	1500	580	1390
	28,	1870	1325	350	1520
	29,	1785	1330	605	1180
	30,	1840	1373	400	1440
Oct.	1,	1847	1357	444	1403
	2,	1990	1320	365	1625
	3,	2960	1990	448	2512
	4,	2920	1332	455	2465
	5,	2677	2036	394	2283
	6,	2480	1895	376	2104
	7,	3095	1937	370	2725
	8,	2578	1878	357	2221
	9,	2605	2095	355	2250
	10,	2807	2165	370	2437

2019 SECTION NO. 2 OF TABLE:

Percentages of Missouri and Mississippi River Water at the Intake of the St. Louis Waterworks. Calculations based upon the daily estimation of total solids in samples collected at Bellefontaine, Intake and Hartford, January 23 to October 11, 1900.

Date. 1900.	Intake minus Hartford.	Percentage Mo. River.	Percentage Miss. River.
Jan. 24,	220	73	27
25,	90	56	4
26,	305	78	22
27,	280	87	13
28,	230	100	0
29,	170	53	47
30,	250	69	31
31,	210	78	22
Feb. 1,			
2,	120	58	42
3,	70	58	42
4,	80	62	38
5,	140	93	7
6,			
7,	0	0	100
8,	....	....	....
9,	60	22	78
2020 10,	200	38	62
11,			
12,	80	53	47
13,	370	65	35
14,	510	77	23
15,	700	88	12
16,	1785	98	2
Mar. 4,	190	79	21
8,	1810	79	21
9,	720	57	43
10,	980	67	33
11,			
12,	1225	53	47
13,	1680	67	33

	Date. 1900.	Intake minus Hartford.	Percentage Mo. River.	Percentage Miss. River.
	Mar. 14,	1895	81	19
	15,	1870	68	32
	17,	1410	62	38
	18,	1140	52	48
	20,	350	31	69
	21,	470	80	20
	22,	114	9	91
	23,	85	11	89
2021	24,	...	0	100
	25,	...	0	100
	26,	...	0	100
	27,	...	0	100
	28,	...	0	100
	29,	188	38	62
	31,	...	0	100
	Apr. 1,	80	12	88
	2,	410	50	50
	3,	400	44	56
	4,	380	37	63
	5,	480	44	56
	6,	720	68	32
	7,	...	100	0
	8,	675	55	45
	9,	690	52	48
	10,	820	65	35
	11,	650	55	45
	12,	630	45	55
	13,	790	52	48
	14,	1695	67	33
	15,	...	100	0
2022	16,	...	100	0
	17,	1441	45	55
	18,	1383	70	30
	19,	1078	54	46
	20,	884	45	55
	21,	1153	63	37
	22,	822	21	79

Date. 1900.		Intake minus Hartford.	Percentage Mo. River.	Percentage Miss. River.
	23,	1154	78	22
	24,	739	65	35
	25,	44	9	91
	26,	906	82	18
	28,	934	63	37
	29,	870	68	32
	30,	782	80	20
May	1,	790	66	34
	2,	840	67	33
	3.	990	71	29
	4,	1155	61	39
	5,	1070	49	51
	6,	430	26	74
	7,	955	60	40
	8,	358	42	56
2023	9,	845	62	38
	10,	745	51	49
	11,	717	59	41
	12,	810	56	44
	13,	1431	82	18
	14,	1737	55	45
	15,	1700	66	34
	16,	1545	79	21
	17,	1480	72	28
	18,	1645	68	32
	19,	1851	90	10
	20,	1440	87	13
	21,	1495	81	19
	22,	1487	86	14
	23,	1467	82	18
	24,	1481	83	17
	25,	1402	83	17
	26,	1377	75	25
	27,	1303	81	19
	28,	1478	100	0
	29,	1702	94	6
	30,	1865	89	11
	31,	....	100	0

	Date. 1900.		Intake minus Hartford.	Percentage Mo. River.	Percentage Miss. River.
2024	June	1,	1680	94	6
		2,	1615	74	26
		3,	1845	95	5
		4,	....	100	0
		5,	1695	85	15
		6,	1660	86	14
		7,	1540	79	21
		8,	1433	72	28
		9,	1630	81	19
		10,	1605	75	25
		11,	1515	94	6
		12,	....	100	0
		13,	1620	94	6
		14,	3635	91	9
		15,	....	100	0
		16,	....	100	0
		17,	....	100	0
		18,	2072	94	6
		19,	....	100	0
		20,	1670	91	9
		21,	1795	94	6
		22,	2740	93	7
2025		23,	....	100	0
		24,	....	100	0
		25,	....	100	0
		26,	....	100	0
		27,	2685	99	1
		28,	2415	84	16
		29,	....	100	0
		30,	....	100	0
	July	1,	....	100	0
		2,	....	100	0
		3,	....	100	0
		4,	....	100	0
		5,	2660	74	26
		6,	....	100	0
		7,	....	100	0

	Date. 1900.	Intake minus Hartford.	Percentage Mo. River.	Percentage Miss. River.
	8,	....	100	0
	9,	....	100	0
	10,	3070	88	12
	11,	....	100	0
	12,	....	100	0
	13,	....	100	0
	14,	....	100	0
2026				
	15,	....	100	0
	16,	2135	94	6
	17,	1990	92	8
	18,	1570	77	23
	19,	1973	95	5
	20,	1440	86	14
	21,	1430	87	13
	22,	....	100	0
	23,	2416	99	1
	24,	2900	81	19
	25,	3090	73	27
	26,	2869	85	15
	27,	2020	76	24
	28,	1921	84	16
	29,	....		
	30,	1587	83	17
	31,	1460	94	6
	Aug. 1,	1273	79	21
	2,	1312	100	0
	3,	1238	82	18
	4,	1248	87	13
	5,	999	78	22
	6,	1078	89	11
2027	7,	743	61	39
	8,	764	77	23
	9,	703	75	25
	10,	701	75	25
	11,	730	75	25
	12	655	81	19

Date. 1900.	Intake minus Hartford.	Percentage Mo. River.	Percentage Miss. River.
Aug. 13,	598	78	22
14,	604	75	25
15,	590	81	19
16,	576	75	25
17,	575	67	33
18,	630	90	10
19,	778	73	27
20,	988	85	15
21,	900	65	35
22,	860	73	27
23,	760	71	29
24,	782	85	15
25,	736	76	24
26,	736	76	24
27,	820	94	6
28,	977	85	15
29,	951	83	17
2028 30,	750	50	50
31,	750	50	50
Sept. 1,	885	94	6
2,	1030	99	1
3,	969	82	18
4,			
5,	1124	72	28
6,	1175	96	4
8,	1082	84	16
9,	1056	87	13
10,	900	83	17
11,			
12,	674	60	40
13,	708	73	27
14,	583	67	33
15,	598	74	26
16,	555	60	40
17,	570	67	33
18,	553	60	40
19,	524	60	40

Date. 1900.	Intake minus Hartford.	Percentage Mo. River.	Percentage Miss. River.
Sept. 20,	659	56	44
21,	1069	57	43
22,	1597	54	46
2029			
23,	1593	60	40
24,	1650	59	41
25,	1476	67	33
26,	1320	65	35
27,	920	66	34
28,	975	64	36
29,	925	68	32
30,	973	68	32
Oct. 1,	913	65	35
2,	965	59	41
3,	1542	61	39
4,	877	36	64
5,	1642	72	28
6,	1519	72	28
7,	1567	58	42
8,	1521	68	32
9,	1740	77	23
10,	1791	74	26

The figures from a small number of dates are missing because of the imposibility of collecting samples on some of those days. For instance, during the period from February 17th to March 3rd, when ice in the Mississippi river prevented collections at the Intake.

2030 Q. Now, Doctor, take up your map. Just state generally what that map is and indicate what the figures and curves on it represent and the object of it and state what it shows from a chemical standpoint, as to the waters that it was made from, etc.?

MR. TODD: You are referring to chart No. 9, now are you?

THE WITNESS: Yes. This chart represents a comparison of the percentage of Mississippi River water pumped at the Intake of the St. Louis Waterworks as represented by the determination of total solids or residue on evaporation, from January 23rd until October 10th, and until October 30th for the typhoid fever cases.

The percentage of Mississippi River water pumped at the Intake during this period as compared with the number of typhoid fever cases for the years representing 1895 until 1899, inclusive. An average was drawn from a number of cases reported by the physicians of St. Louis officially to the Health Department of the typhoid fever cases in St. Louis from 1895 until 1899, inclusive, and also the number of typhoid fever cases reported for the year 1900. The reason why I took the period from 1895 until 1899 was this, prior to 1895 the water pumped from the Mississippi River into the St. Louis Waterworks
2031 was pumped at a point called Bissell's Point, which is
several miles below the Chain of Rocks. In 1895 the waterworks were removed to the Chain of Rocks, and I considered it best to compare the conditions prevailing since that time because it represents the conditions as they exist in St. Louis to-day.

It will be seen from this chart that during the month of March, 1900, or rather during the month of February and during part of the month representing February 15th until about February 25th, a marked increase in the percentage of Mississippi River water in distinction from the percentage of Missouri River water which was pumped into the Intake. Following an increase in the percentage of Mississippi River water pumped into the Intake, there followed, taking into account an incubation period for typhoid fever of from two to three weeks, there followed a remarkable increase in the number of typhoid cases reported to the Health Department of St. Louis.

I also show here in the blue line the normal number of cases, or rather the average of the typhoid fever cases reported to the Health Department for 1895, 1896, 1897, 1898 and 1899. They show a very low number of cases during that period and the increase in the number of typhoid fever cases reported in March, 1900, over the average found for the
2032 five preceding years amounts to 1300 per cent. This fol-
lowed, as I said before, the large increase of percentage of Mississippi River water going into the Intake Tower previously.

Q. What do you mean by previously, what period of time?

A. You have got to take into account the incubation period. I mean several weeks preceding it.

We notice during the latter part of the summer again an increase of percentage of Mississippi River water entering the Intake and we see subsequently a large increase in the number of typhoid fever cases reported by the physicians of St. Louis to the Health Department, over the average of the five preceding years. I have got the percentage figure recorded here for those calculations. In September, 1900, the increase in the number of typhoid fever cases reported over the average of the five preceding years amounted to nearly 70 per cent.

Q. Now, what does this chart No. 10 relate to, explain the figures and curves thereon?

A. Chart No. 10 represents a comparison of the water at the Intake, the water after it has been in the reservoir for two days and just before it leaves the reservoir.

Q. St. Louis?

A. The St. Louis Reservoir.

2033 Q. The reservoir of the City of St. Louis?

A. And the tap of the water supply as we have it in the City Chemist's office.

Q. And at the Intake?

A. At the Intake, yes, sir.

Q. Explain the lines and what they mean?

A. The blue line represents the Intake, the yellow line the reservoir and the red line the tap in the City Chemist's office and the top line represents the stage of the Mississippi River at St. Louis and the number of feet are marked up here in lead pencil.

Q. On the left hand side?

A. Yes. They simply show the enormous removal of suspended matter in the subsiding reservoir; the average percentage of removal of suspended matter in the reservoirs for the period of 1900 from January 23rd until October 12th represents 85 per cent. That is 85 per cent. of the sediment of the water passing through the reservoir remains in the reservoir.

GENERAL HAMLIN: How much is that?

A. 85 per cent.

GENERAL CROW: That relates purely to the chemical contents of the water?

2034 A. Yes, sir. Now, as regards the free ammonia, we see that whenever there is a marked rise of free ammonia at the Intake, it is followed by a marked rise in free ammonia in the water of the reservoir, that is after it has practically passed through the reservoir and just before it leaves the reservoir. Whenever there is a fall in the percentage of free ammonia at the Intake, this fall is followed by a fall of free ammonia in the reservoir, in other words, increased pollution of the water entering the Intake, is always followed by increased pollution of the water in the reservoir. While the suspended matter is removed 85 per cent., the purification process that we expect of the reservoirs there, while occurring at times, such times are an exception, as is shown here on July 24th, and as a rule, there is no marked purification as far as the free ammonia is concerned in the reservoir. Whenever the Intake water is bad the sanitary quality of the water leaving the reservoir and the sanitary quality of the water drawn from the hydrants in St. Louis must be correspondingly affected. No samples were taken from the tap during that period until May 8th, but we can see from the curve here of the red line how the chemical character of the reservoir water corresponds to that of the water going

2035 into the Intake with that one exception that I recorded here, which was July 10th, during the whole year, and that fluctuation is followed again in the water as we draw it from the hydrants in St. Louis.

In other words, pollution of the water entering the Intake must affect the reservoir water; it must affect the water leaving the hydrants of St. Louis. The same applies to nitrites. We can see here how the nitrites run very close together for the Intake and the reservoir during the first four months of 1900, and that when they go down again they go down together. Fluctuations always correspond between the Intake, the reservoir, and the tap.

Now, I wish to call attention to a marked increase in pollution of the water at the Intake during the early part of 1900. You will see that there is a tremendous rise in the free ammonia and you will see a tremendous rise in nitrites. You will see these rises going together during those months.

GENERAL CROW: What indicate those rises?

A. It indicates a remarkable pollution of the water supply of St. Louis during that period.

Q. What, show it on that map? I want to get that into the record.

A. The ammonia lines and the nitrite lines.

2036 Q. Well, the curves?

A. The curves show that. From all available data regarding water collected from the Mississippi river at the Intake and from the water collected from the reservoirs at St. Louis, and from the water analyzed from the hydrants of St. Louis—I say in all the data that we could get, we tried to get the results of all the analyses that have been made. There are analyses on record that were made by chemists during the last 20 years. None of these analytical results ever showed such a remarkable quantity of free ammonia and corresponding with it a large increase in nitrites, at the Intake Tower or the reservoir, or the water of the hydrants of the City of St. Louis. This marked increase of pollution of the St. Louis water supply during the early part of 1900, not only followed a marked increase of pollution in the Mississippi River between Grafton and the Intake Tower. It followed a marked increase in pollution in the Illinois River at Grafton at a time when there was no marked increase of pollution in the Mississippi River above the mouth of the Illinois. It followed a marked increase of pollution at Peoria, I mean at the point of collection of samples three miles above the City of Peoria, and a marked increase of pollution of samples taken from Joliet and Lockport.

In other words, there was a wave of pollution coming
2037 down the Des Plaines River, the Illinois River, entering the Mississippi River at Grafton, running along the Illinois shore opposite the St. Louis Waterworks at Chain of Rocks. and, as shown by the percentage mixture entering the Intake of the Waterworks of St. Louis. We find during that period the percentage of Mississippi River water entering the Intake varying from 19 to 100 per cent.

Q. During this period?

A. During this early period of 1900.

Q. That was after the opening of the Canal?

A. After the opening of the Drainage Canal.

Q. Now Doctor, state what is the result of your conclusions from the map and from the tables you have there concerning these facts from a chemical standpoint?

A. (No answer.)

Q. Now, Doctor, have you any data comparing the chemical results of the analyzation of these waters for the period of 1899 and 1900 covered by your examination?

A. Yes, sir.

Q. Please state them?

A. Generally comparing the results of the analyses of waters collected between Grafton, Illinois River and the Mississippi River and the St. Louis Intake, and also from the
2038 Missouri River for the periods of 1899 and 1900, we notice from the averages an increase in the nitrites and free ammonia in 1900 as compared with 1899, for the route between Grafton, Illinois, and the St. Louis Intake. It shows that the sanitary character of the water as discharged by the Illinois River into the Mississippi at Grafton was more polluted in 1900 than in 1899, and it shows that this increased pollution of the Illinois River as found in the samples taken from Grafton, resulted in an increased pollution of the Mississippi River at Alton and Hartford for 1900 over 1899, and furthermore shows that this increased pollution of the water between Grafton, Illinois, and Hartford was extended to the water going into the Intake tower. In other words, our analytical results show that the water entering the Intake in 1900 was more polluted than the water entering the Intake in 1899, and that the increased pollution, since there was no corresponding increased pollution in the Mississippi River above the mouth of the Illinois, nor was there an increased pollution in the Missouri River above its mouth, it shows that the increased pollution of the water going into the Intake Tower must be ascribed to the increased pollution of the Illinois River in 1900, and since I have shown that the increased pollution of the Illinois River at Grafton was
2039 due to the increased pollution of the Des Plaines River following the opening of the Drainage Canal, I feel justified in declaring that the opening of the Drainage Canal resulted in an increased pollution of our water supply.

Q. Now, there is another period of examination following that, isn't there?

A. Yes, sir.

Q. Is there anything further that you want to say in that connection?

A. Yes, but I haven't got my report on that. That is down stairs in your room, and I might take that up after lunch. It being in that period.

Adjourned until 2 p. m., March 18, 1903.

2040 Southern Hotel, St. Louis, Mo. 2 p. m., Wednesday, March 18, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same Counsel representing the respective parties.

DR. WILLIAM C. TEICHMANN resumed the stand for further direct examination, by Attorney-General Crow, and testified as follows:

Q. Professor, did you make any investigations after the one that closed in October, 1900?

A. Yes, sir; a number of samples were still collected between October 12th and November 30th, from points in the Illinois River, and these samples were promptly analyzed at the City Chemist's office. But these samples were not collected daily, and, therefore, in the general view and the averages that I have drawn from the tables, this analysis of samples collected outside of St. Louis are not included.

Q. Well, you have the result of your investigation, have you?

A. Yes, sir

Q. What period of time did it cover?

A. For the samples taken outside of St. Louis, October 12th to November 30th. Then we quit taking samples outside of St. Louis, but from October 12 to November 30, 2041
1901, the third period of investigation, covered in addition to those sporadic samples outside of St. Louis, they covered the analyses of samples collected daily at the Chain of Rocks opposite the St. Louis Waterworks in the Mississippi River.

A daily sample during this period was collected at the Chain of Rocks from the Mississippi River close to the Illinois shore. Then a sample close to the Missouri shore.

A sample was also taken from the water right at the entrance of the Intake Tower and one sample was taken from what is called the outlet chamber of the St. Louis Water Works. That is after the water has slowly passed through the reservoir covering an average period of about two days, it passes through a small chamber called the outlet chamber, and from there is distributed into the mains over the city of St. Louis.

A daily sample was taken in this outlet chamber and one was daily taken from the tap in the City Chemist's office.

The object of this continued survey in its limited form was to obtain a consecutive daily record of the daily character of the St. Louis Water supply.

Q. Well, will you please give the results of that?

A. Yes. Well, I am briefly summarizing in a few words, the results for this period.

2042 The analytical data thus collected have all been noted down in the report which can be presented if required. They demonstrate the continued polluted character of the St. Louis water supply during this period.

Furthermore, that the water along the Illinois shore during this period was at all times more polluted than the water running along the Missouri shore and that during such periods when a mixture of the waters from these two rivers entered the Intake, as occurred frequently on such occasions, the impurities found in the samples from the Intake were higher than those found in the samples from the Missouri shore, indicating that the mixing of the two currents in the narrow channel on the edge of which the Intake Tower is located, invariably resulted in an increased pollution of our water supply.

The next period of investigation, the fourth period, covers the time from October 1st, 1901 to November 30, 1901. It was the most comprehensive investigation conducted since the beginning of the analytical survey of these waters in August, 1899.

It was our endeavor to obtain samples from all points along the route between Chicago and St. Louis, which would give us information regarding the subject of whether or not sewage from the city of Chicago pollutes the St. Louis water 2043 supply.

I, therefore, collected samples and had them shipped to the City Chemist's office from the following points during this two months' investigation and the samples were collected daily from the points that I mention now.

Chicago, Bridgeport, Illinois and Michigan Canal.
Chicago, Bridgeport, Chicago Drainage Canal.
Lockport, Chicago Drainage Canal, Bear Trap Dam.
Lockport, Illinois and Michigan Canal.
Desplaines River above Bear Trap Dam at Lockport.
Desplaines River at 9th Street Bridge, Lockport.
Desplaines River at Ruby Street Bridge, Joliet.
Desplaines River at Brandon's Bridge, Joliet.

Now, I wish to say in explaining these various points, that we endeavored to obtain, by taking samples at those points, analytical data of the character of the Illinois and Michigan Canal, the sanitary character of the Illinois and Michigan Canal, of the Chicago Drainage Canal at its entrance and at the western end at the Bear Trap Dam. Also, from the Illinois and Michigan Canal at Lockport before it crosses the river at Desplaines, which it does in the City of Joliet. Then, from the
2044 Desplaines river before it meets the Drainage Canal or rather before the water from the Drainage Canal enters the Desplaines River.

Then, from Ninth Street Bridge, Lockport, after the Drainage Canal has entered the River Desplaines.

At Ruby Street, Joliet, before the Illinois and Michigan Canal enters the Desplaines River and before any sewage from Joliet could possibly enter the River Desplaines.

Then at Brandon's Bridge, Joliet, from the Desplaines River, after the Illinois and Michigan Canal has crossed the Desplaines River and after the sewage from Joliet had been discharged into the Desplaines River.

Then we had daily samples collected from the Illinois River at La Salle, from Peoria, Illinois, three miles above the railroad bridge, what is called the Narrows, ordinarily, then at Pekin, Illinois, from a point where the Pekin Bridge is located, then at Kingston, Illinois, eight miles below Pekin and at Beardstown, Illinois.

These samples were all taken from the Illinois River and at Grafton several miles above the mouth of the Illinois River.

Then, the following samples were taken from the Mississippi River.

2045 At Grafton several miles above the mouth of the Illinois River.

At Alton, one mile above Alton.

At Hartford, Illinois, which is located one mile above the mouth of the Missouri River.

Then, at the Chain of Rocks, St. Louis Water Works, Illinois shore.

Chain of Rocks, mid-stream.

Chain of Rocks at the Intake Tower of the Water Works.

Chain of Rocks, Missouri Shore.

Missouri River, Fort Bellefontaine.

St. Louis Water Works at Outlet Screen or Outlet Chamber, rather. It is given both names but I will call it Outlet Chamber, as the better name.

From the tap in the St. Louis City Chemist's office.

During these two months, tri-weekly samples were collected from Lake Michigan at Chicago.

Q. At what point in the lake were they taken?

A. Well, that was—it was arranged there by the collector who lives in the City of Chicago, that he should go out in a boat to the various cribs, just according to arrangements that he could make at that time, but he always got samples
2046 of the Lake Michigan water from what could be considered Lake Michigan water proper.

Semi-weekly samples were taken from the South Branch or rather the South Fork of the South Branch of the Chicago River.

Semi-weekly samples were also taken from the Illinois River at Wesley, Illinois, a point between Peoria and Pekin, and these samples at Wesley were taken close to the right and left shore and in the center of the Illinois River, a cross-section, so to speak, four samples were collected during these few months, from the Missouri River at Omaha, above and below the city.

Four samples from the Missouri River at Kansas City, above and below the city.

Four from the Missouri River at Jefferson City, above and below the city.

Four from the Missouri River at Herman, Missouri, above and below the city.

Four from the Missouri River at St. Charles, Missouri, above and below the city.

Two samples were taken from the Missouri River at Wathena, Kansas. That is at a point above Kansas City.

Q. Above the mouth of the Kaw River?

A. Yes. Two samples were taken from the Missouri
2047 River at St. Joseph, Missouri, above and below the city.

Two samples were taken from the Kaw River which empties into the Missouri River at Kansas City.

The samples were taken at a point near Argentine, Kansas.

During this period also, cross-sections of samples were taken at Pekin Bridge, Illinois River,

At Kingston, Illinois river,

At Peoria, Illinois River,

At Joliet, Des Plaines River,

At Alton, Mississippi River,

At the Chain of Rocks, Mississippi River,

At Hartford, Mississippi River,

At Fort Bellefontaine, Missouri River.

After the cessation of the collection of daily samples from the river above the Chain of Rocks, outside of St. Louis, daily collections were still continued at Grafton, Illinois, from the Illinois, from the Illinois River until December 18th, 1901. Since that time no additional samples have been taken from any points above the City of St. Louis.

Q. 1901 or 1902?

A. Yes, 1901.

ATTORNEY GENERAL HAMLIN: Are those which you have just been stating—I thought they were 1902?

2048 A. No sir, 1901. The first period of investigation was
from August 23rd until January 22nd, 1900; the second period of investigation was the big investigation of 1900, from January 23rd until October 12th, covering the collection and analyses of a large number of samples from the route between Chicago and St. Louis, the number of occasional samples were still taken after October 12th, until November 30th, 1900, from

points along the Illinois River and Mississippi above St. Louis, and daily samples were taken during this third period of investigation from October 12th, 1900, until September 30th, 1901.

Five daily samples were taken, three from the Mississippi River at the Chain of Rocks, and one from the Outlet Chamber of the St. Louis Water Works, and the fifth sample was taken from the tap in the City Chemist's office,—daily samples.

Then on October 1st, the large investigation, covering collection and analyses of samples outside of St. Louis was resumed, and continued until December 1st.

ATTORNEY GENERAL HAMLIN: 1901?

A. 1901. And then I said that no samples were collected outside of St. Louis after December 1st, 1901, excepting from the Illinois River several miles above the mouth of the Illinois at Grafton and from the Mississippi above Grafton. This was kept up until December 18th.

2049 Q. ATTORNEY GENERAL CROW: Of what year?

A. December 18th, 1901.

Q. Well, that is the third period of investigation?

A. Yes. No, this is the fourth period, you see, the second and fourth periods were the periods covering the investigation outside of St. Louis, and the first period covered investigation up to Grafton, Illinois, and the third period covered investigation only at the Chain of Rocks. That was simply to keep a check on the character of the City water supply.

Now the resumption of the collection and analyses of samples along the water route from Chicago to St. Louis in October and November, 1901, was undertaken for the chief purpose of ascertaining whether the continued operation of the Chicago Drainage Canal during the interval between the cessation of the investigation in October, 1900, and the resumption of the investigation for samples outside of St. Louis in October, 1900, had produced any improvement of the sanitary conditions of the water as established by the former investigation along this route in 1900.

I will now present a number of charts, briefly explaining these conditions as we found them.

These charts were prepared under my directions by the

same engineers who prepared the charts for the investi-
2050 gation of 1900, presented this morning, Mr. Alexander
N. Miller, and Mr. William H. Goetz, so that I may say that I did not prepare the charts myself, but that we consulted over the method of preparing them and the data, etc., and the charts themselves were prepared by Messrs. Miller and Goetz.

Q. MR. TODD: Are those charts made up from the examination of the waters that you have just described, as being taken at these different places?

A. Yes sir, they have been.

MR. TODD: I want to interpose an objection on the ground that the water that has been testified to here as being taken at these points,—there is no evidence to show that they were really taken at those points at the time and place as indicated.

ATTORNEY GENERAL CROW: Well, we went into that before your arrival.

MR. TODD: Have you proven that at each place?

ATTORNEY GENERAL CROW: We put a man on the stand that we sent up the Missouri River as far as Omaha.

MR. TODD: Well I mean for any points that have not been proven; we know that some points have been proven, but I don't know whether every one of them has or not.

Q. ATTORNEY GENERAL CROW: Now what is the chart that you have there and what does it represent, and please explain the curves and figures thereon.

2051 MR. TODD: What is the number of that, doctor?

A. We will number that No. 1, 1901, Chart No. 1, 1901.

ATTORNEY GENERAL HAMLIN: Now I want to put in the record his statement in regard to that chart, that he is testifying from, for the reason that I don't think it is permissable for him to testify to that chart.

ATTORNEY GENERAL CROW: Well, in order to save the record I can offer the memorandum or whatever he has got there,—analytical sheets there.

ATTORNEY GENERAL HAMLIN: But he doesn't say that he made the comparison.

ATTORNEY GENERAL CROW: But they were made under his supervision, in his office—were they or were they not, professor?

A. Yes sir, they were made under my supervision and I carefully scrutinized the original records as presented by the chemists, as well as the entry sheets prepared by the clerk from those records, in order to form my conclusions on the results of the analyses.

Q. Who made the sheets?

A. They were made by my clerk at that time.

Q. Where did the data come from that they were made from?

A. The data came from the original record books of the various assistant chemists.

MR. WOERNER: You can get their testimony, can't you?

A. Yes sir.

2052 ATTORNEY GENERAL HAMLIN: As I understand from you, you did not make this chart?

A. No sir, I did not.

Q. And I understand further that the tables from which this chart was made, you didn't make?

A. No sir. They were made by my assistants.

Q. That all the data from which this chart was made was obtained by someone else than you—other than you?

A. Yes, under my direction and supervision.

Q. Well, what do you mean by under your direction and supervision?

A. Well, when I started on this large investigation, I carefully mapped out a system of collection of samples of water. I selected the points of collection myself, and I prepared a system of analyses, designating the tests to be made, and selecting personally the assistant chemists, among whom the various tests were divided, and they were all instructed to perform these analyses in methods that we carefully discussed with them and decided upon finally, and sanctioned by me personally before they entered on these analyses, and then they all received their books and had their names on their books, and these books had also the name of the test performed, and the analytical data that each assistant chemist obtained were entered in his particular book, and these books at the conclusion of the work
2053 were all turned over to me.

Q. Now the investigations that you directed to be made were made by some one else besides you, that is the tests were made by your assistants, and not by you?

A. Yes sir.

Q. And you took their report of those tests as being correct?

A. Yes sir.

Q. Not from any knowledge that you had of the tests, but from the report that they made to you?

A. Well, I had knowledge of their tests, because I was constantly in the various rooms of the laboratory during the time that they were working, except when I was attending to business connected with the investigation in a different building, called the New City Hall.

Whenever I was in the laboratory I would observe their work and carefully note the character of their work, and discuss the various features of the analytical work with them, as the work proceeded, during these two months, that is, I considered that as supervision of the work.

Q. And then this chart was made from the examinations that your assistants made?

A. Yes sir. One of the chemists that took part in that
2054 investigation is here in the room, Mr. Miller. He performed certain tests and frequently consulted me regarding those tests and the results obtained, etc.

Q. This chart was made not from the books, but from a general report that was prepared from the books, is that right?

A. No, they were made from those books.

ATTORNEY GENERAL HAMLIN: Well, you can go ahead and I will reserve the right to object further along.

BY ATTORNEY GENERAL CROW:

Q. This work was done under your personal supervision?

A. Yes sir.

Q. And was your work, and you were responsible for it?

A. Yes sir.

Q. It would have been impossible for you or any other man to have carried out all the details of this work yourself?

A. Yes sir.

Q. And it is the customary method that is pursued in doing this class of chemical work, by a chemist?

A. Yes sir.

Q. He has assistants?

A. Yes sir.

ATTORNEY GENERAL HAMLIN: I think that is true if it is followed up by the assistants. I think you are right about that, General.

2055 ATTORNEY GENERAL CROW: I think so, where they are all working on one thing, you know. You will meet the same proposition when you come to your people, you know.

ATTORNEY GENERAL HAMLIN: I will see when we get further along, if we want to, I will ask to confirm it by the assistants.

ATTORNEY GENERAL CROW: Yes, if you want to, we will put the men on.

Q. Go ahead, Professor?

A. This is chart Number 1 for the investigation of 1901, October and November.

MR. TODD: I would suggest that you follow it consecutively. Ten was the last one.

ATTORNEY GENERAL CROW: Yes, I think that will be better.

(Chart No. 11.)

A. This chart represents a comparison of results obtained from the analyses of water in the months of October and November, 1901, from the Illinois and Michigan Canal at Lockport; from the Desplaines River at Brandon's Bridge, Joliet; from the Drainage Canal, Bear Trap Dam, Lockport, and from the Desplaines River, above Bear Trap Dam at Lockport.

The red line represents the Illinois and Michigan Canal.

2056 The blue line represents the Desplaines River at Brandon's bridge, Joliet.

The green line represents the Drainage Canal, Bear Trap Dam, Lockport, and the yellow line represents the Desplaines River above the Drainage Canal, that is before they meet.

It will be seen from this chart that during that period the Illinois and Michigan Canal was highly charged with free ammonia. It reached the figure of 22.4 parts per million of nitrogen in the form of free ammonia. During the last week a considerable fluctuation can be noted and at the time the collection and analyses was started the amount represented the figure of

19.8 parts per million of nitrogen as free ammonia. In a few weeks this figure was lowered down to 15.2 parts per million. It went up enormously, up to 22.1 parts per million during the period from October 25th until November 8th, and then down again within one week from 22.1 to 18.7 and then during one week went up again to the highest figure or amount, 22.4.

The same is true as to the chlorines found in the Illinois and Michigan Canal at that time. We see variations there in the chlorine representing parts per million from 106 up to 150.8; then going down again within one week to 120.6; going up again and reaching the high figure of 169.5; then jumping down again, away down to the figure of 128 parts per million
2057 and then rising again.

If we look at the nitrites we find fluctuations in the nitrites but notice that the nitrites do not fluctuate as much as the free ammonia and the chlorines. They are either absent as is seen here from the results and at times, for two weeks, the first two weeks, there are no nitrites in the Illinois and Michigan Canal. Then they rise up a little, up to 0.002 and 0.003. Then we find great fluctuations there in the nitrates representing a minimum of .007 and a maximum of .15.

Now, that would indicate that the Illinois and Michigan Canal at that time was in a great state of fermentation. The action of the facultative anaerobic bacteria in this canal resulted in a considerable advance in the initial process of purification usually performed by these bacteria.

The variations in chlorine show that the amount of sewage coming into the Illinois and Michigan Canal during this time, together with the varying amounts of free ammonia and nitrites, that the amount of sewage pumped into that canal must have been of great variable quantity. The water condition at that time may have influenced the action of the anaerobic bacteria somewhat and as it is an established fact that during the colder season of the year the purification process in the rivers
2058 is retarded considerably, the results would in a measure explain themselves.

Now, if we compare the results for free ammonia with the results obtained from the main Drainage Canal at that time, represented by the green line, we see considerably less free ammonias in the main Drainage Canal than we find in the Illinois and Michigan Canal.

If we take the results obtained from the Desplaines River at Brandon's Bridge, where we have the sewage from the two canals and the sewage of Joliet included—we find that represented in the blue line there—we find more free ammonia and we find more cholrine and we find more nitrites and more nitrates in the Desplaines River at Brandon's Bridge, Joliet, partly due to the accessions of sewage from the Illinois and Michigan Canal at that time.

We also see that after the sewage from the canal has entered the Desplaines river—

ATTORNEY GENERAL CROW: Both canals?

A. Both canals at the Desplaines River. The sewage in the Drainage Canal being in a less advanced stage of purification as shown by the lower ammonia, than the sewage in the Illinois and Michigan Canal, we see a marked increase in nitrites. These nitrites at Brandon's bridge, Desplaines River, run very high, much higher than the nitrites in the Drainage Canal; 2059 much higher than the nitrites in the Illinois and Michigan Canal. This was due to the fact that when the Desplaines River mixed with the sewage from these two canals the aerobic bacteria prevailing in the much purer Desplaines River, assisted materially in performing the purification process in the Desplaines River. However, the very high nitrites in the Desplaines River after the two canals mix with the Desplaines River at Joliet, show that the process of purification was in an intermediate stage as yet. That is, the fermentative action was still going on and it was going on still in its preliminary stage as is seen by the comparatively high free ammonias during that period. You take the blue line there, it represents the Desplaines River at Brandon's Bridge. We have free ammonia there, 3.2 parts per million, which stamps that water as sewage. The highest found was on the 4th of October, the first week when we began—

Q. At what point?

A. At Brandon's Bridge in the Desplaines River. That is after the canals had mixed with the Desplaines River. After the preliminary more advanced purified sewage from the Illinois

and Michigan struck the Desplaines and the less advanced purified sewage from the Drainage Canal was discharged into the Desplaines River, a tremendous pollution of the Des-
2060 plaines river took place. This is shown, as I said before, by the amount of free ammonia being shown on this chart found at Brandon's Bridge,in the Desplaines River,amounting to a maximum of 3.2 parts per million and a minimum October 25th of 2.3 parts per million. The minimum amount there is the characteristic amount for sewage and a large amount of course, stands for a still higher sewage polluted river. If we take the Desplaines River before it reaches the Drainage Canal we find very high free ammonia in the Desplaines River. It amounts to .1 part per million for two weeks. Then it goes down to about .005 parts per million and remains that way for the five weeks following this very slight, inappreciable, rise.

Q. That is above the Drainage Canal?

A. Above the Drainage Canal and above the Illinois and Michigan Canal.

Now, we take nitrites. We find correspondingly low nitrites in the Desplaines River before the Illinois and Michigan Canal and the Chicago Drainage Canal strike it. These nitrites are remarkably low. At times there are no nitrites in this river and since there is such a small amount of free ammonia in that river and the chlorines are exceedingly low, we must call this—the Desplaines River before it is polluted by the sewage from the Drainage Canal and the sewage from the Illinois and
2061 Michigan Canal, a comparatively potable river water.

After the main Drainage Canal strikes the Desplaines River, the main Drainage Canal showing at that time, during those months, a maximum amount of free ammonia of 1.3 parts per million, a very high amount of free ammonia, which stamps the Canal as badly sewage polluted at Lockport. We find that the Drainage Canal and the Illinois and Michigan Canal after they strike the Desplaines River, increase the amount of free ammonia remarkably. They increase the amount of chlorine; they increase the amount of nitrogen as nitrites very much. In other words, the comparatively pure Desplaines River is badly sewage polluted by the main Drainage Canal and by the Illinois and Michigan Canal as demonstrated by this chart.

The conclusion was drawn from the samples collected daily at those points for the two months, October and November, 1901, and since the sewage in the main Drainage Canal was at that time not as much purified, in its preliminary stage, as the sewage in the Illinois and Michigan Canal and as to the sewage in the Drainage Canal in volume, as mixed with the water of the Drainage Canal represents a much larger percentage of sewage
2062 than its total volume discharged into the Desplaines River, this pollution must largely be, and the somewhat dangerous pollution must largely be attributed to the accession —this pollution of the Desplaines River must largely be attributed to the main Drainage Canal, because of its less advanced state of preliminary purification.

MR. WOERNER: By main Drainage Canal do you mean the Chicago Drainage Canal?

A. Well, that is the Drainage canal which enters or connects with the Desplaines River at Lockport.

MR. TODD: The data from which this map was made only goes to Brandon's road?

A. Brandon's Bridge, yes. The comparisons are made at Brandon's Bridge. This map is principally to show the effect of the pollution of the Desplaines River by the Drainage Canal and the Illinois and Michigan Canal, the pollution being comparatively greater and more effective as a factor of pollution than that of the Illinois and Michigan Canal.

ATTORNEY GENERAL CROW: Now, Professor, what does that chart No. 12 represent?

A. This is a map giving a comparison of analytical results obtained from the daily collection of samples of water taken from the Desplaines River above Bear trap Dam,
2063 taken from the Desplaines River at the Ninth Street Bridge in Lockport, that is at the point in the Desplaines River above the point where the Illinois and Michigan Canal crosses the Desplaines River and at Brandon's Bridge, Joliet.

Q. Now, please explain the curves and the figures on the map, and the colors?

A. Yes. In other words, it shows you the result of the mixture of the water from the Drainage Canal and the Desplaines River and the result of the mixture of the Desplaines River, the

Drainage Canal and the Joliet sewage in the Illinois and Michigan Canal.

The green line represents Brandon's Bridge at Joliet.

The red line represents the Desplaines River at Ninth Street Bridge, Lockport, and the black line or the partly black line and partly blue line—the dark line, in other words, represents the Desplaines River above the Bear Trap Dam. If you will look at that dark line—

MR. TODD: Is this map made substantially as you have testified in regard to the other charts?

A. Yes, just as I have mentioned.

You will see the dark line showing quite low free ammonia, the highest being .2 parts per million and the lowest being .1 part per million. 2064

The Desplaines River at Ninth Street Bridge, Lockport, which represents the mixture of the water from the Drainage Canal and the Desplaines River just above the point where the Joliet sewage enters the Desplaines River, and above the point where the Illinois and Michigan Canal crosses the Desplaines River, you have represented in the enormous figure for free ammonia of 1.3 parts per million of free ammonia. That is the maximum. And the minimum during this time, during these two months, of .85 parts per million.

If we compare the chlorines—I mean if we compare the nitrites with the free ammonia, we notice that the Desplaines River for several weeks shows no nitrites and, going with comparatively low free ammonia would demonstrate a purity of the stream far superior to that of the Desplaines River after it receives the accessions of the sewage entering the Desplaines River from the main Drainage Canal. We find that represented in the increase in nitrites from zero or no nitrites at the beginning of this investigation up to .02 parts per million. 2065 The maximum nitrites reached during this period at Ninth Street Bridge amounts to .03 parts per million which is comparatively high.

In other words, if we set aside the pollution from the Illinois and Michigan Canal and the Joliet sewage, we find that the main Drainage Canal pollutes the Desplaines River before the Illinois and Michigan Canal and before the Joliet sewage are discharged into the Desplaines River to such an extent as to stamp the Desplaines River as a highly sewage polluted stream owing to accessions of the sewage discharged from the Chicago Drainage Canal.

Q. Professor, please explain that chart No. 13 and what the lines and figures on it mean?

A. These curves represent comparison of the chemical character of the two canals at Bridgeport and at Lockport.

Q. Now where is Bridgeport?

A. Bridgeport is the point located—

Q. It is in the City of Chicago, isn't it?

A. Yes, in the City of Chicago on the south fork of the south branch of the Chicago River.

Q. Isn't in only on the south branch?

A. It is on the south fork of the south branch of the Chicago River. There are two branches, the north branch
2066 and the south branch and the south fork runs into the
south branch at Bridgeport.

Q. Did you locate it on the south branch?

A. On the south fork of the south branch, that is what I meant to say.

Q. Now, where is Lockport? Just locate that. Don't talk about "those two points."

A. Lockport is 29 miles from Bridgeport. The western end of the Drainage Canal is at Lockport.

Q. Where it joins the Desplaines River?

A. Yes, and the Illinois and Michigan Canal runs through Lockport and crosses at Lockport—runs through Lockport and crosses the Desplaines River at Joliet.

Q. Five or seven miles or four miles below?

A. Yes, and then proceeds on its route to LaSalle, Illinois.

Q. Well, now, go on and explain the lines and curves on your map and what they mean.

A. We have here curves representing nitrogen as free ammonia in the Illinois and Michigan Canal. You can see from the great variation in the amounts of free ammonias running—

Q. Well, Professor, you didn't explain what the different colors meant?

A. The green color, or this top curve represents the Illinois and Michigan Canal at Lockport. The red color, or
2067 the red line represents the Illinois and Michigan Canal at Bridgeport.

What I wanted to show by these curves is the remarkable fluctuations in the amount of free ammonia in that canal, showing its fermentative character?

Q. Which canal?

A. In the Illinois and Michigan Canal, as compared with the Drainage Canal, the Drainage Canal being represented by the curves, the yellow line representing the Drainage Canal at Bridgeport and the dark line representing the Drainage Canal at Lockport.

We notice that the very much higher free ammonias in the Illinois and Michigan Canal as compared with the free ammonias in the Drainage Canal, while high in both canals—for instance. the Drainage Canal here at Bridgeport and the Drainage Canal at Lockport showing free ammonias above one part per million in the form of nitrogen as free ammonia, that is high free ammonia, stamp that water as sewage, but the ammonias in the Illinois and Michigan Canal are very much higher, showing that the an-aerobic bacteria have performed their work in the old Illinois and Michigan Canal much more effectively than in
2068 the Drainage Canal. The sewage in the Drainage Canal
as it reaches Lockport does not show very much improvement during its route from Bridgeport to Lockport. It demonstrates that the facultative an-aerobic bacteria do not work so effectively in the main drainage canal as they do in the Illinois and Michigan Canal. The sewage from the Drainage Canal is in a much more retarded state of purification.

MR. WOERNER: In a much cruder state?

A. Yes, in a much cruder state, and it is very much less purified in its initial stage of purification at Lockport than the Illinois and Michigan Canal sewage when it reaches Lockport.

Q. Now, Professor, what does chart No. 14 represent?

A. Chart No. 14 represents the comparison of results at Joliet and at Peoria, Ill.

Q. Results of what?

A. Results of analyses of samples of water collected during the months of October and November, 1901.

The green line represents the Desplaines River at Joliet; the yellow line represents the Illinois River at LaSalle. The dark line represents the Illinois River three miles above Peoria.

2069 Q. Well, you mean it represents the water in the river?

A. Yes sir. The very high results of free ammonia found in the water at Joliet are reduced somewhat by the time the water reaches Peoria. In other words, the initial process of purification has been materially facilitated during the transit of the water in the Illinois River from Joliet to LaSalle and Peoria.

This map will also show that the nitrites found in the Desplaines River at Joliet at that time, during those two months, were lower than the nitrites found at Peoria and at LaSalle. While this would indicate that the process of purification had advanced somewhat for the sewage running down the Illinois River between those points, the very high nitrites found at LaSalle and Peoria—at LaSalle representing a maximum of .164 parts per million and at Peoria a maximum of .154, I say they demonstrate that the process of purification of that sewage in the river coming from the main Drainage Canal principally, and from the Illinois and Michigan Canal, and from Joliet, that the process of purification has by no means been completed when the water reaches Peoria. The Illinois River in other words, is found to be highly sewage polluted by the time it reaches Peoria.

2070 How far is it to Peoria from Joliet?

A. 124 miles between Joliet and Peoria.

I wanted to say, while the ammonias are much lower at those points of LaSalle and Peoria, they are still quite high and, going with comparatively high chlorines and going with very high nitrites, that stamp the water of the Illinois River as it reaches Peoria as badly polluted water, during this entire investigation.

Another thing that is shown by this map is that the colder weather setting in during the month of November, the process of purification is considerably retarded. The result is that the ammonias go up at LaSalle and Peoria. In other words, the weather being colder the bacterial activity and purification of the river, principally in its preliminary stage, has not been great and it has been lessened by the colder weather. The result is higher ammonia and lower nitrites at Peoria and LaSalle.

ATTORNEY GENERAL CROW: What does this chart No. 15 represent?

A. This represents a comparison of results of the chemical analyses of samples collected during this period from October 1st to November 30th, 1901, from the Illinois River at the
2071 point of Beardstown, Peoria, Kingston, Pekin and Grafton.

. If we take the free ammonias here we will notice that as I said, with the approach of colder weather, with the approach of colder weather the process of purification is retarded in the Illinois River as well as every other river in such climates.

We see the ammonias going up correspondingly at all these points in great variation. I mean, as to the minimum and maximum results during the month of November.

I want to say here that in order to show the effect of this cold weather in retarding the purification of the sewage in the Illinois River that I have run the curve for Grafton up to December 18th. You will remember that I stated that we continued collection of daily samples of the Illinois River, Grafton, until December 18th and that at that time we obtained nitrogen in the form of free ammonia one part per million at that point.

What I want to demonstrate now is that the decrease and increase of pollution in the Illinois River produces corresponding fluctuation in the results. In increase of pollution, as you see hereby Beardstown, Peoria, Kingston, Pekin and Grafton, all go together. In other words, if a wave of polluted
2072 water proceeds down the Illinois River it increases pollution of the Illinois River correspondingly during its entire course.

Thus we see this big rise in nitrogen in the form of free ammonia at all those towns in the first week of November and continuing until the end of November. We see this increase of pollution followed by an increase of pollution at Grafton, running the free ammonia as ascertained by the analysis of a sample taken from the Illinois river at Grafton on December 18, 1901, as high as one part per million. This almost approached the pollution which we found at Grafton in the Illinois River soon after the opening of the Drainage Canal, that is, when it could reasonably be calculated that the first sewage flushed out of the Drainage Canal had come down the Illinois River.

As I said, there is no doubt that in colder weather the process of purification is much slower in all respects than it is during the warmer months, that is during the summer months, and we find that the last samples that we took from the Illinois River in December, 1901, show an enormous pollution of the Illinois River at its mouth, following an enormous increase in pollution at points up to Peoria. That is, when I speak of
2073 Peoria here, at a point three miles above Peoria, and since I have stated that the sewage of the Desplaines River pollutes the Illinois River above Peoria to such an extent as to characterize the Illinois River three miles above Peoria as a sewage polluted river. I say that this pollution found at Grafton on December 18th 1901, must be ascribed to pollution of Peoria, and the pollution of Peoria must be ascribed—at the point three miles above Peoria—must be ascribed to Pollution at Joliet, and the pollution at Joliet, as we have seen, partly being due to the Illinois and Michigan Canal, yet to large extent being due to sewage accessions from the Drainage Canal, we were justified, and I feel justified, in stating that the great pollution of the Illinois River during those two months found at Grafton, can be ascribed to a certain extent to the sewage accessions from the main Drainage Canal and to a large accession at that as demonstrated by the chart, in which I show the polluting effect of the main Drainage Canal on the comparatively pure Des Plaines River at the Ninth Street Bridge at Joliet above the point where the Joliet sewage and the Illinois and Michigan Canal sewage contaminate the Des Plaines River

I can demonstrate these corresponding fluctuations
2074 by the nitrites. You will see that the nitrites go up and down correspondingly at all these points in the Illinois River, again demonstrating what the ammonias show, that the pollution of the Illinois River at the point where the Des Plaines River enters the Illinois River is always followed by a pollution

at the mouth of the Illinois. The results show that this pollution corresponds in its increase and decrease in the Illinois River.

Q. Now, what is that Chart No. 16?

A. Chart No. 16 represents a comparison of the results obtained from the analyses of samples taken during the months of October and November daily from a point in the Mississippi River several miles above the mouth of the Illinois and from the Illinois River several miles above its mouth.

The blue line represents the Illinois River at Grafton. The red line represents the Mississippi River at Grafton.

If we take the ammonias—

Q. At Grafton or above Grafton?

A. The Illinois River at Grafton several miles above its mouth.

The red line represents the Mississippi River several miles
2075 above the mouth of the Illinois and the blue line represents the Illinois River several miles above its mouth.

You will see that the free ammonias and the chlorines and the nitrites during these two months are always higher in the Illinois River than they are in the Mississippi River at Alton.

The highest free ammonia found at Grafton during the last week of November was nitrogen in the form of free ammonia, .17 parts per million.

The lowest free ammonia found in the Illinois River during these two months represented .06 parts per million.

Until the week beginning the 15th of November there was not much difference between the free ammonias of the two rivers although the free ammonias in the Illinois River were always higher, but when the cold weather set in during the latter part of November, the free ammonia in the Illinois River at Grafton went steadily up, so that finally on the 18th of December it showed one part per million of nitrogen in the form of
2076 free ammonia.

Now, during that same time, samples were also taken from the Mississippi River at Grafton.

Now, I don't know whether I stated that fact in my statement today when I spoke of the samples being collected after November 30th, but samples were collected during that period also from the Mississippi River above Grafton.

Now, there is no corresponding rise to that extent shown in the Mississippi River, while there is an increase there in free ammonias, and you can see the effect of the colder weather, yet the Mississippi River must not have been sewage laden to any extent whereas the Illinois River being a river of great instability, because as we see, from the nitrites, the intermediate state of purification, as represented by the nitrites, is varying continuously. This demonstrates that the Illinois River was much more polluted at that time. and the unoxidized sewage because of the colder weather, along the entire river increasing in analytical figures from place to place as the water of the river proceeds toward the mouth. This increased sewage is represented by the high figures found at Grafton, Illinois.

In other words, if the Illinois River were not a heavily
2077 sewage laden river, the sewage would have been oxidized
much more readily and better, but being in large quantities the effect of the colder weather proportionately retarded the process of purification so much the more and there being evidently considerably less pollution in the Mississippi River the effect of the cold weather there was not so material because of the absence of pollution to any material extent.

Let us take the nitrites in the Mississippi River at Grafton. They amount to almost nothing. They show results, like the lowest result, .001 and .0005 which is a very inappreciable amount and very often carries a trace only, often being absent altogether.

ATTORNEY GENERAL HAMLIN: Is that the maximum or the minimum?

A. That is the minimum amount found in the Mississippi River at Grafton during those two periods.

The maximum runs up to .0015. In other words, there were no such variations as to nitrites in the Mississippi River during those two months, as were shown by this blue curve here in its great variation for the Illinois River results, showing nitrites as high at the beginning of the investigation as .06 parts per million.

2078 The fluctuations are shown by the minimum amount of
nitrites found in this river at that time, representing .033 parts per million.

I have not drawn out the curve for the nitrites at that point for the results obtained for the month of December during that period but I remember that the nitrites were low at that time, only demonstrating in this case that the purification process in the Illinois River had so much been retarded that it was largely in its primary state when reaching Grafton at that time during the cold weather, showing high free ammonias and low nitrites, so that the intermediate stage between the free ammonia and the nitrates had evidently not been reached for a large amount of that sewage. In other words, that the sewage was in a much more crude state when it reached Grafton in the Illinois River during the month of December than it was during the month of October and the early part of November before the cold weather set in.

When we look at the nitrates, the final stage of purification, to demonstrate to you how much purer and how much more stable the Mississippi River was at that time, we find very low
nitrites; we find low free ammonia and we find high nit-
2079 rates. In other words, the final stage in the process of
nitrification or oxidation of sewage had been reached in the water of the Mississippi River above Grafton to a much higher degree and in a much more advanced state than in the Illinois River where the nitrates are very low and the nitrites much higher than in the Mississippi River and the free ammonias higher and going up to the large figure of one part per million at the close of our investigation for that period.

Mr. WOERNER: Now, I want to ask you, how far is Grafton from St. Louis?

A. Grafton is 39 miles from the Intake.

Based upon the weekly averages calculated from the analytical results as also shown by the curves drawn on the charts presented, I am prepared to state that the same condition regarding the chemical character of the water along the route between Chicago and the mouth of the Illinois, as demonstrating pollution in the Illinois River by the main Drainage Canal and extending down to the mouth of the Illinois, were found to exist in October and November, 1901, and at the mouth of the Illinois up to December 18, 1901.

The principal conclusions therefore, which I have drawn

from the analytical results of our investigation of the
2080 waters of Lake Michigan, the main Drainage Canal, the
Des Plaines River and the Illinois River for the period of investigation in 1900 previously discussed, also applied to the second analytical survey of the water along the route from Chicago to the mouth of the Illinois.

It has been shown that the water as it leaves the Drainage Canal at Lockport to enter the Des Plaines River was on several days found to contain nitrogen in the form of free ammonia exceeding—

ATTORNEY GENERAL HAMLIN: I object to this sort of testimony as it is apparently merely argumentative.

A. (Continuing) exceeding 1.3 parts per million of water, nitrogen in the form of nitrites to the extent of .028 parts per million and chlorine 20 parts per million.

The pollution of the comparatively pure Des Plaines River by the sewage from the main Drainage Canal has been shown as also the pollution of the Illinois River by the sewage of the Des Plaines River.

At Peoria we find, three miles above Peoria, the Illinois River polluted to a high degree, as evidenced by the presence of nitrogen in the form of free ammonia to the extent of 1.348
parts per million; nitrogen in the form of nitrites .13 parts
2081 per million and chlorine 26 parts per million.

A water containing these three characteristic ingredients of sewage pollution to the extent represented by these figures, must be considered a badly polluted water. It demonstrates that the process of self purification of sewage from Chicago in the Illinois River had not been completed before it reaches Peoria and that the conditions as proven to exist in 1900 had not improved one year later.

The Illinois River at its mouth, Grafton, shows during this period from October 1st until November 30th, the presence of nitrogen in the form of free ammonia to the extent of .25 parts per million.

Nitrogen in the form of nitrites .07 parts per million.

Chlorine 26 parts per million.

The corresponding highest figure during this period for the Mississippi at a point several miles above the mouth of the Illinois were found to be:

Free ammonia .11 parts per million.

Nitrites .003 parts per million.

Chlorine 9.6 parts per million.

Comparing the results from these two points just dis-
2082 cussed we find again as was found in 1899 and 1900, that
the water from the Illinois River at its mouth, is decidedly more polluted than that from the Mississippi River above the junction of the two rivers.

The high free ammonia and nitrites, together with comparatively higher chlorines in the Illinois River as compared with the Mississippi River, characterize the Illinois River as a badly sewage polluted river during this period.

The high free ammonia found during the latter part of December at Grafton, representing the figure of one part per million of nitrogen in the form of free ammonia, proves conclusively that the pollution of the Illinois River along its route has not reached a stage when the river, or rather when the water of the river, arrives at Grafton, to justify any other conclusion than the one drawn from the investigation of 1900, that the Illinois River is so overcharged with sewage that it cannot purify itself by the time it reaches the mouth.

2083 Q. Now, what is this chart No. 17, which you have?

A. Chart No. 17 represents the results of the chemical analyses of the samples of water taken daily during the months of October and November, 1901, from a point several miles above the mouth of the Illinois River also from a point in the Mississippi River one mile above Alton and from a point in the Mississippi River above Hartford, Illinois and from a point in the Mississippi River at Grafton, several miles above the mouth of the Illinois.

The red line represents the Illinois River at Grafton.

The blue line represents the Mississippi River at Alton.

The yellow line represents the Mississippi River at Hartford.

The green line represents the Mississippi River at Grafton.

You will see that the free ammonia for the larger part of this period was lowest in the Mississippi River above the mouth of the Illinois. It was highest in the Illinois River several

miles above the mouth of the Illinois and that for most of the time the free ammonia at Alton and the free ammonia at Hartford were higher than the free ammonia in the Mis-
2084 sissippi River above Grafton, showing that the mixture must have taken place of the Mississippi and Illinois River after their junction resulting in an increase in the free ammonias at Alton and Hartford. That is for the larger part of the period. During one week the free ammonias were a little lower at Alton than they were in the Mississippi River above Grafton. They were also a little lower during the first week in October but only to a very small extent. For the remaining six weeks, the free ammonia was higher at Alton than it was in the Mississippi River at Grafton. The highest free ammonia found during this period in the Illinois River was .17; the lowest found in the Illinois River was .06. The highest free ammonia found in the Mississippi River at Alton during this period was .07—I wish to correct that, that is .08 and the lowest is .04. The figures obtained for Hartford were almost like those found at Alton. The variation was slight. The maximum variation amounting to .015, so that I need not quote those figures. I will say the maximum variation, showing that the free ammonias at Alton and the free ammonias at Hartford did not vary to any extent.

2085 Now, we will take the chlorines. We find the chlorines lowest for this period in the Mississippi River at Grafton and we find it highest in the Illinois River at Grafton running as high as twenty six parts per million. At all times during this period the figures for chlorine at Alton and Hartford were higher than those of the Mississippi River at Grafton and lower than the Illinois River at Grafton, demonstrating that the mixture of the two rivers had taken place in the channel from which the Alton and Hartford samples were collected, and demonstrating further with the increase in free ammonias and chlorines and also a corresponding increase in nitrites, an increased pollution of the Mississippi River from the higher polluted river water of the Illinois River.

The nitrites in the Mississippi River, above the mouth of the Illinois for this period were very low, as I have already stated for several weeks practically absent. The nitrites in the

Illinois River during this period were comparatively high. The nitrites obtained from the Illinois of the samples at Alton and Hartford during this period, always showed an intermediate figure between the always lower figure from the Mississippi River and always higher figure from the Illinois River, clearly demonstrating the mixture of those two rivers and as a
2086 result, an increased pollution of the Mississippi River
coming from the Illinois River.

Q. Now what is this chart No. 18?

A. Chart No. 18 represents the results of the chemical analyses of samples of water collected in the months of October and November daily in the year 1901 from the Mississippi River at Hartford and at the Intakes of the St. Louis Water Works, Chain of Rocks and from the Missouri River at Fort Bellefontaine.

Q. Please explain what the lines and curves and colors mean on the chart?

A. The blue line represents the Mississippi River at Hartford.

The green line represents the Intake and the red line represents the Missouri River.

The highest chlorines during this period were found in the Missouri River.

The lowest chlorines were found in the Mississippi River at Hartford and the chlorines at the Intake represented during this entire period, an intermediate figure, between the high chlorines of the Missouri River and the low chlorines of the Mississippi River. This demonstrates that during this
2087 period a mixture of the waters of the Mississippi and Mis-
souri was taking place in the Mississippi River after the junction of the two and its effect could be shown in th[illegible]ver chlorines at the Intake.

Q. Lower than what?

A. Lower chlorines than in the Missouri River.

Q. And higher than where?

A. Higher than at Hartford. It would show the mixtures.

GENERAL HAMLIN: Where is Hartford?

A. One mile above the mouth of the Missouri River.

The free ammonias for the three points here are almost alike.

Q. Suppose you give the percentage that you have there?

A. What's that?

Q. Have you got your precentages?

A. No sir, I haven't got any precentages out in this chart at all, not in this fourth investigation.

Q. This is 1901?

A. Yes sir, 1901. It shows that the free ammonias during the months of October and November at these three points were not differing much; in fact at times the free ammonia of the Missouri River would be higher than the free ammonia of the Mississippi River and then again at times the free ammonia of the Mississippi River would be higher than the Missouri River. The variations are not great, in fact calculated 2088 out in figures the greatest variation between the Missouri River free ammonia and the Mississippi River free ammonia at Grafton, the amount would be .04 parts per million. If at this time, the nitrites of the Missouri River would be as high as those found in the Mississippi River at Hartford, or higher as was shown by the free ammonia, we could ascribe the higher free ammonia in the Missouri River to sewage pollution, but the nitrites are lower, and since the high chlorines in the Missouri River are not attributable to sewage pollution of the towns and cities on the upper Missouri but are proven to be due to the drainage of the Kaw River, which runs into the Missouri River at Kansas City, due to the drainage of the Kaw River through districts vast areas in Kansas of salt beds it is to be concluded that the sanitary character of the Missouri River was better during this period than that of the Mississippi River after it was joined by the Illinois River and increasingly polluted by the Illinois River.

If we take the figures for nitrites for this period we notice that the nitrites in the Missouri River at Fort Bellefontaine were low. They varied from .001, as the minimum, to .0065 the maximum.

MR. WOERNER: Where is that?

2089 A. That is the nitrites in the Missouri River, the maximum found during this period at Bellefontaine. The figures for the nitrites at the Intake Tower during this period are almost similar to those of the Missouri River.

GENERAL HAMLIN: What months were those figures for?

A. October and November 1901.

WILLIAM C. TEICHMANN.

Adjourned until 10 A. M., March 19, 1903.

2090 Southern Hotel, St. Louis, Mo., 10:00 A. M., Thursday, March 19th, 1903.

Present, the Commissioner and the same Counsel representing the respective parties.

DR. WILLIAM C. TEICHMANN.

Resumed the stand for further direct-examination by General Crow and testified as follows:

Q. Doctor, what is chart No. 19? Explain the curves and lines on that Chart and what is shows.

A. Chart No. 19 shows the correspondence between the curves representing the chemical examination of the samples of water collected during the months of October and November daily in the year 1901 from the Mississippi River at the Intake tower at St. Louis Water Works, from the outlet chamber of the St. Louis Water Works for the water as it passes through the reservior. The average time allowed for the passage of this water through the reservoir amounts to two days, sometimes it is less and sometimes it is a trifle more, but the average is about two days that this water is in the reservoir. The water from the river that is pumped in enters the reservoir from 2091 one side and leaves the reservoir at the other side which allows practically two days for sedimentation in the reservoir.

Now, I want to demonstrate by this chart that there is a partial purification taking place in the reservoir. As I stated previously in discussing the analytical results of our investigation of 1900, the amount of sediment that remains in the reservoir is about 85 per cent, that is the average. Now, while the sediment remains in the reservoir to such a large extent the quantities of impurities are not reduced so much, they are reduced some but it is very small. So small that practically we can say that the amounts of free ammonias and chlorines found in the water at the Intakes and the amounts of chlorines and free ammonia found in the outlet of the reservoir, do not differ materially. As regards the nitrites, there is some oxidation taking place in the reservoir at times, but we will see that the nitrites for the month of October do not vary much in the reservoir. These nitrites found in the water as it enters the Intake and in the water as it leaves the reservoir and in the water as it is drawn from the tap in the hydrant in the City Chemist's office, show hardly any significant variation.

During the month of November there appears a slight difference in the nitrites between the water taken from the
2092 river at the intake tower and from the water drawn from
the tap. We find the maximum variation there amounting to .003 parts per million. Now, this is not a very large variation. The amount of nitrites there found at the intake at that time in the Mississippi River, the highest amounted to .006, and the lowest found amounted to .001, which shows a rise in the amount of nitrites during the month of November, but not of any great significance because as I stated, the variations here are between very low figures. What can be noticed on this chart as very significant of the river is the remarkable correspondence in the fluctuation of impurities at the intake tower, at the outlet of the reservoir and the tap in the City Chemist's office. In other words, whenever the impurities rise in quantities in the water from the Mississippi River at the intake, a rise in quantity of these impurities follows in the reservoir and follows in the water taken from the tap of the city water supply. Whenever the quantity of impurities decreases at the intake we notice a subsequent decrease in the outlet of the reservoir, and notice a subsequent decrease in the water taken from the tap at the City Chemist's office, and again as we notice during this period, the rise takes place and the quantity of impurities at the intake is again followed by a corresponding rise of impurities in
2093 the water as it leaves the reservoir and as it leaves the
tap of the hydrant in the City Chemist's office. What I said for free ammonia applies also to nitrites, as you can see from these curves and it applies to the chlorines and it applies, in a measure to the nitrates. Of course, the nitrification process going on in the reservoir, that is the change in the chemical

character of the water from free ammonia to nitrites and nitrates, continually goes on in the reservoir and we see accordingly lower nitrite results and lower nitrate results for the water taken from the outlet of the reservoir and tap as compared with the water entering the intake. That much must be admitted that the purification process goes on in the reservoirs, but as we will see from these figures the purification process is limited and there still remains considerable of the impurities unoxidized that leaves the reservoirs and passes through the mains and leaves the taps or hydrants in the city. As I said before, the most significant conclusion we can draw for the comparison of these results is that the fluctuation in the impurities is in the rise and fall of the degree of impurities. These fluctuations always correspond between these three points of collections, the intake, outlet and the tap. In other words, whenever an in-
2094 creased pollution of the water entering the intake is shown
it is followed by increased pollution of the water passing through the reservior and an increased pollution of the water leaving the city mains. I stated previously in my testimony that samples of water had been collected under my instructions by a collector. I believe it is E. A. Sluder, in the year 1901 during the months of November and December, from points in the Missouri River above the mouth of the Missouri. The sample was taken from the Missouri River above Omaha, Nebraska, in the channel of the river near the Nebraska shore, on November 13th.

Q. Above Omaha?

A. Above Omaha. The sample showed 1325 parts per million of total solids.

Nitrogen in the form of free ammonia, .062.
Nitrogen in the form of nitrites, .004.
Oxygen consumed from the raw water, 7.1.
Nitrogen in the form of nitrates, .18.
Chlorine, 10 parts per million.

Q. When you say raw water you mean natural water?

A. Unfiltered, yes sir, the natural water. We call that raw in distinction from the filtered water.

Q. Call it natural water?

A. Yes sir. The filtered water from this point showed

2095 oxygen consumed 2.2 parts per million, chlorine 10 parts per million.

On the same day a sample was taken 10 miles below Omaha at Belle View, Nebraska, one and a half miles below this town and 10 miles below Omaha. The sample was taken from the channel of the river.

The first sample I mentioned and the data of which I quoted, had been taken far enough above the City of Omaha so as to exclude the Omaha sewage which is discharged into the Missouri River.

The result of the analysis of the second sample taken at Belle View, Neb., on November 13th, was:

Total solids 1074 parts per million.

Nitrogen in the form of free ammonia .136 parts per million.

Nitrogen in the form of nitrites was found to be .006 parts per million.

Chlorine was found to be 11.5 parts per million.

The nitrogen in the form of nitrates found at Belle View amounted to .16 parts per million.

Another sample was taken from a point above Omaha in the channel of the Nebraska shore near the water works of Omaha on November 24, 1901:

The total solids found in the analysis of this sample amounted to 1290 parts per million.

2096 Nitrogen in the form of free ammonia, found in the sample collected on that day from this point, was .056 parts per million.

The nitrogen found in the form of nitrites in the sample of water collected from this point on that day amounted to .001 parts per million.

The nitrogen found in the form of nitrates at this point on that day amounted to .18 parts per million.

The oxygen consumed found in the sample collected on this day at that point amounted to .6 parts per million for the unfiltered natural water and 2.6 for the filtered water, parts per million.

Chlorine from this sample collected at this point on that day amounted to 11 parts per million.

On the same day, November 24th, a sample of water was also collected from the Missouri River 10 miles below Omaha, near Belle View, Nebraska. The sample of water was found to contain total solids to the extent of 1050 parts per million.

The nitrogen in the form of free ammonia found in the water at this point collected on that day, amounted to .126 parts per million.

The nitrogen in the form of nitrites found in the samples of water collected from this point on that day amounted to .0025.

2097 Nitrogen in the form of nitrates found in the sample of water collected on that day was found to be .14 parts per million. The oxygen consumed for the unfiltered sample on this day was found to be 6.2 parts per million and for the filtered water from this same sample the oxygen consumed was found to be 2.2 parts per million. The chlorine found in this sample was 11.5 parts per million.

These results show that the Missouri River, as it approached Omaha, Nebraska, on November 13th and November 24th was polluted as shown by the presence of free ammonia of nitrites and chlorine. However, the nitrites found on both days being very low, showing only .004 parts per million, on November 13th and .001 parts per million on November 24th, together with comparatively low free ammonia and chlorine, and demonstrating that the pollution cannot be designated as sewage pollution. The low nitrites on both days would have been higher and the nitrates considerably lower, if the character of the Missouri River water as it approached Omaha had been of an unstable character indicating fermentative processes in the river.

Q. Professor, do you mean by that statement that the condition of the water there did indicate active fermentation process?

A. No, I mean to say that it did not, that the low nitrites 2098 and the low nitrates show that in the process of purification there, the organic matters present in the river had undergone—that these processes of purification had in a large manner, been completed, that is the water is of stable character.

Q. Now let me ask you a question. When you used the term purification did you use that from a chemical standpoint or in an ordinary acceptation of the term, or did you mean to convey the idea of oxidation taking place?

A. Oxidation taking place and producing chemically this change, which is not to be understood as implying exactly a definition of purity of water in general. It is only to be understood as connected with the fermentative and oxidation processes taking place in polluted rivers. As the Missouri River proceeds along its route it approaches St. Joseph, Missouri.

GENERAL HAMLIN: Did you take any samples below Omaha?

A. Yes, I got two from Belle View, Nebraska.

Q. That is the place, is it?

A. Yes, that is the place about 10 miles below Omaha. Strictly speaking it is one and a half miles below Belle View, Nebraska.

As I say, as the river approaches St. Joseph, we took
2099 samples, or rather I had samples collected from the pump
house of the Water Works of the City of St. Joseph in the channel of the Missouri River on November 14, 1901, and on November 26, 1901, from the analysis of these samples as follows:

The sample collected on November 14th. This water was found to contain total solids to the extent of 1225 parts per million.

Nitrogen in the form of free ammonia, .076 parts per million.

Nitrogen in the form of nitrates .22 parts per million.

Oxygen consumed for the unfiltered water from that sample, 9 parts per million, and for the filtered water from this sample the oxygen consumed showed 2.5 parts per million.

The chlorine amounted to 12.5 parts per million.

On the same day, November 14, a sample of water was collected from a point in the Missouri River, 12 miles below St. Joseph. The point is located 2 miles above a town called Wathena, Kansas. The result of the analysis of this sample was:

Total solids 1150 per million.

2100 Nitrogen in the form of nitrites, .007 parts per million.

Nitrogen in the form of nitrates, .26 parts per million.

Oxygen consumed from the unfiltered water from this sample, 8.7 parts per million.

Oxygen consumed from the filtered water of this sample, 2.8 parts per million.

Chlorines, 7 parts per million.

On November 26th another sample of water was collected from the Missouri River at St. Joseph near the Water Works and on the 25th of November another sample was collected from the Missouri River at Wathena, Kansas, 12 miles below St. Joseph. The results of these analyses were as follows:

Of the sample collected November 26, at St. Joseph above the waterworks of the City of St. Joseph, the total solids amounted to 1135 parts per million.

The nitrogen in the form of free ammonia was found to be .08 parts per million.

Nitrogen in the form of nitrites was found to be .006 parts per million.

Nitrates were found to be .2 parts per million.

The oxygen consumed was 7.1 parts per million for the unfiltered water from this sample, and 1.8 parts per million for the filtered water from this sample. The chlorine amounted to 16 parts per million from this sample.

2101 On November 18, 1901, a sample of water was collected from the Missouri River at Kansas City, one-half mile above the waterworks.

Q. Is that above or below the city?

A. Well, that is above the city where the waterworks are located.

The result of the analyses of the water from this sample was total solids 1152 parts per million.

Free ammonia .07 parts per million.

Nitrogen in the form of nitrites .005 parts per million.

Nitrogen in the form of nitrates .026 parts per million.

Oxygen consumed for the unfiltered water from this sample 8.1 parts per million.

For the filtered water from this sample 2.5 parts per million.

Chlorine 24.2 parts per million.

A sample collected from the Missouri River on November 17, 1901, from a point 10 miles below Kansas City, showed an analytical result as follows:

Total solids 1290 parts per million.

Free ammonia .112 parts per million.

Nitrites .005 parts per million.

2102 Oxygen consumed for the unfiltered water from the sample 8.5 parts per million.

From the filtered water 2.7 parts per million

Chlorine 18 parts per million.

A sample was collected on November 17, 1901, from the Kaw River at Argentine, Kansas. It was on the same day that the sample was collected from below Kansas City on the Missouri River. The analytical results from this sample show:

Total solids 687 parts per million.

Nitrogen in the form of free ammonia, in the sample from the Kaw River is found to be .062 parts per million.

Nitrogen in the form of nitrites was found to be .004 parts per million.

Nitrogen in the form of nitrates was found to be .1 part per million.

Oxygen consumed was found to be for the water from the unfiltered sample 7.8 parts per million.

For the filtered water from this sample 4.1 parts per million.

Chlorine from this sample taken from the Kaw River at Argentine, Kansas, on November 17, 1900, was found to contain 89.8 parts per million.

2103 On November 28th another sample of water was collected from the Missouri River at Kansas City at the point where the waterworks of Kansas City are located. The amount of total solids found in the analytical results of this sample showed the figure of 1070 parts per million.

The free ammonia, and the nitrogen in the form of free ammonia, amounted to .116 parts per million.

Nitrogen in the form of nitrites was found to be .004 parts per million.

Nitrogen in the form of nitrates .24 parts per million.

Oxygen consumed showed 6.2 parts per million for the water from the unfiltered sample and 1.9 parts per million for the water from the filtered sample.

The chlorines found in this sample amounted to 16 parts per million.

On November 28th, a sample of water was also collected from the Missouri River 10 miles below Kansas City. The analysis showed the following result:

Total solids 1100 parts per million,

Nitrogen as free ammonia .13 parts per million,

Nitrogen as nitrites .004 parts per million,

Nitrogen as nitrates .24 parts per million,

2104 Oxygen consumed for the water from the unfiltered sample 6.7 parts per million,

Oxygen consumed for the water from the filtered sample 1.9 parts per million,

Chlorine 23 parts per million.

A sample of water collected from the Kaw River at Argentine, Kansas, on November 29, showed the following results in the analyses:

Total solids 650 parts per million.

Free ammonia .036 parts per million.

Nitrites, none.

Nitrates .04 parts per million.

Oxygen consumed for the unfiltered water of the sample, 5.9 parts per million.

And for the filtered water from the sample 3.4 parts per million.

Chlorine 109 parts per million.

I shall continue to read off this data and then, in expressing my conclusions on the results as found at Kansas City and the Kaw River and the Missouri above and below Kansas City, I mean to put that all in together. I will finish the data first.

Q. Get through as quickly as possible.

2105 A. On November 19, 1901, a sample of water was collected from the Missouri River at Jefferson City, one mile above Jefferson City.

Q. Did you say that was above or below the city?

A. Above the city, one mile above the waterworks of Jefferson City.

The analysis of this sample shows the following result:

Total solids 1295 parts per million.

Nitrogen in the form of free ammonia .094 parts per million.

Nitrogen as nitrites .005 parts per million.

Nitrogen as nitrates .36 parts per million.

Oxygen consumed 9.6 parts per million for the unfiltered water from this sample and 3.1 for the filtered water from this sample.

Chlorine 20 parts per million.

A sample of water collected on November 19th, 1901, at a point five miles below Jefferson City, showed the following results:

Total solids 1315 parts per million.

Nitrogen in the form of free ammonia .09.

Nitrogen as nitrites .006 parts per million.

Nitrogen as nitrates .3 parts per million.

2106 Oxygen consumed 7.4 parts.

Chlorine 21 parts per million.

That oxygen consumed 7.4 parts per million was for the unfiltered water from this sample and 2.3 parts per million for the filtered water from the sample.

On December 1st, 1901, samples of water were again collected from points above and below Jefferson City in the Missouri River as follows:

December 1st sample collected from the Missouri River above Jefferson City near the waterworks at Jefferson City. The result of the analysis of this sample showed:

Total solids 1055 parts per million.

Nitrogen in the form of free ammonia .136 parts per million.

Nitrogen in the form of nitrites .008 parts per million.

Nitrogen in the form of nitrates .28 parts per million.

Oxygen consumed 6.7 parts per million for the unfiltered water from the sample and 2.7 parts per million for the filtered water from the sample.

Chlorines 23 parts per million.

The result of the analysis of the sample take on this date from the Missouri River five miles below Jefferson City is as follows:

2107 1005 parts per million total solids.

Nitrogen as free ammonia .136 parts per million.

Nitrogen as nitrites .007 parts per million.

Nitrogen as nitrates .26 parts per million.

Oxygen consumed for the unfiltered water from the sample 6.6 parts per million.

For the filtered water from sample 2.2 parts per million.

Chlorine 24 parts per milion.

On November 20th, 1901, a sample of water was collected from the Missouri River one mile above Hermann, Missouri.

Q. Where is Hermann, how far from here?

A. I couldn't tell you exactly.

Q. About 125 miles by river, isn't it?

A. It is between Jefferson City and St. Louis, I couldn't tell you exactly.

Q. It is 85 miles by rail and 125 miles by river.

A. 125 miles from the mouth of the Missouri. The amount of total solids found on this day, or rather found in the sample of water collected on this date at this point, showed in the analysis as follows:

Total solids 1740 parts per million.

2108 Nitrogen in the form of free ammonia .09 parts per million.

Nitrogen in the form of nitrites .005 parts.

Nitrogen in the form of nitrates .36 parts per million.

Oxygen consumed from the water of the unfiltered sample, 9 parts per million.

From the filtered sample 23 parts per million.

Chlorines 9 parts per million.

A sample of water collected in the Missouri River on the same date, November 20, 1901, at a point three miles below Hermann showed the following results:

Total solids 1155 parts per million.

Free ammonia .09 parts per million.

Nitrogen in the form of nitrites .005 parts per million.

Nitrogen as nitrates .36 parts per million .

Oxygen consumed for the water in the unfiltered sample 5.5 parts per million.

And for the filtered water from the sample 2.4.

Chlorines 18.5 parts per million.

On December 1st a sample of water was collected from the Missouri River at a point one mile above Hermann, Mo.

The total solids found by the analysis of this water amounted to 950 parts per million.

2109 Nitrogen in the form of free ammonias .106 parts per million.

Nitrogen in the form of nitrites .0045 parts per million.

Nitrogen in the form of nitrates .28 parts per million.

Oxygen consumed 6.5 parts per million for the unfiltered water from the sample and for the filtered water from the sample 2 parts per million.

Chlorine showed 19 parts per million.

The sample of water collected from the Missouri River December 1, 1901, from a point 3 miles below Hermann, Mo., showed total solids 170 parts per million.

Nitrogen in the form of free ammonia .126 parts per million.

Nitrogen in the form of nitrites .004 parts per million.

Nitrogen in the form of nitrates .26 parts per million.

Oxygen consumed from the water of the unfiltered sample 6.4 parts per million, and

For the filtered water from this sample 3.1 parts per million.

The chlorine was lost in analysis.

The sample of water collected from the Missouri River on November 22, 1901, at a point half a mile above St. Charles showed the following results:

2110 Total solids 1101 per million.

Nitrogen in the form of free ammonia .0834 parts per million.

Nitrogen in the form of nitrites .004 parts per million.

Nitrogen in the form of nitrates .56 parts per million.

Oxygen consumed for the water from the unfiltered sample 9.1 parts per million and for the water from the filtered sample 2.6.

Chlorine 18.5 parts per million.

Sample of water collected in the Missouri River on Nov. 22, 1901, at a point one and a half miles below St. Charles showed the following results:

Total solids 1072 parts per million.

Free amonia .046 parts per million.

Nitrogen as nitrites .0035 parts per million.

Nitrogen as nitrates .62 parts per million.

Oxygen consumed for the unfiltered sample 9.5 parts per million.

For the filtered water from the sample 2.8 parts per million.

Chlorine 19 parts per million.

The sample of water collected in the Missouri River December 3rd, 1901, at a point half a mile above St. Charles, Mo.

2111 The total solids found in this sample by the analysis amounted to 950 parts per million.

Nitrogen as free ammonia .246 parts per million.

Nitrogen as nitrites .005 parts per million.

Nitrogen as nitrates .26 parts per million.

Oxygen consumed for the unfiltered sample 6.5 parts per million.

For the filtered water from the sample 2.2 parts per million.

Chlorine 23 parts per million.

Sample of water collected on the same day, December 3, 1901, from the Missouri River, from a point one mile and a halt below St. Charles, Mo., showed the following analytical results:

Total solids 940 parts per million.

Free ammonia .112 parts per million.

Nitrogen as nitrites .006 parts per million.

Nitrogen in the form of nitrates .24 parts per million.

Oxygen consumed for the unfiltered water from the sample 6.6.

For the filtered water from the sample 2.1 parts per million.

Chlorines 23 parts per million.

Adjourned until 2 p. m., Thursday, March 19, 1903.

2112 Southern Hotel, St. Louis, Missouri. 2:00 p. m., Thursday, March 19th, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

DR. WILLIAM C. TEICHMANN resumed the stand for further direct examination, by Attorney-General Crow, and testified as follows:

Q. Now, doctor, what do those examinations show with reference to chlorines in the Missouri River?

A. They show that there is an accession of chlorines in the Missouri River at Kansas City from the Kaw, also called the Kansas River, a river which has a length of about 300 miles and drains through a number of counties in which large salt deposits have been located, as it is reported by the United States geological survey. In other words—

Q. Well, that is sufficient on that. Now, you have got another chart there, haven't you—another map?

Is the Missouri River a stable or an unstable stream chemically?

2113 A. The chemical analyses show that the Missouri River as analyzed from Omaha down to St. Louis, has a character of considerable stability. The results are pretty much uniform along the route, with the exception that the high chlorines coming from the Kaw river increase somewhat the amount of chlorine in the Missouri River between Kansas City and St. Louis.

Q. Now, you have one more chart there, haven't you?

A. No, I have not.

Q. Have you got the general averages that you spoke of yesterday and said you would get?

A. The analyses? Yes, sir, I have them.

Q. Well, get them, please?

A. The curves on the chart presented yesterday—

MR. TODD: What numbers?

A. Charts numbered from 11 to 19.

ATTORNEY-GENERAL CROW: Inclusive?

A. Inclusive, representing the analytical data for the investigation of 1901, from October 1st, until November 30th, showed weekly averages. They did not show the maximum and minimum results for each week, but presented the weekly average drawn from the weekly maxima and minima.

I now read from the official analytical record the maximum results, together with the averages.

2114 Q. Now, don't put those averages in again.

A. Well, I can read the maximum then on the free ammonia, the nitrites and the chlorines for those points represented yesterday.

Q. Yes, those three things.

A. Yes, that is all the maximum figure for each week and the minimum.

Q. Haven't you got those in already?

A. No, sir; they were not presented yesterday. It is only the average that was presented.

ATTORNEY-GENERAL HAMLIN: You didn't present the average in figures?

A. No, they were on the charts.

Q. But didn't you give the average figures from the chart?

A. Well, I quoted them, but only as far as I thought it was necessary to explain the curves on the charts.

ATTORNEY-GENERAL CROW: Now, in order to save time, why not have copies of these made and furnish to the stenographers instead of reading them?

A. Oh, I can get through this quickly, it won't take me long to enter them.

Q. It will take you two hours and a half, won't it?

A. Oh, no, you see I can glance over them quickly. You see I have not presented a table for the analytical data 2115 for 1901.

Q. Well, now give us the tables without any remarks about them just put that in?

A. The free ammonias, nitrites, nitrates, and chlorines.

Q. That is the order in which you have them?

A. Yes, sir.

Q. Now, give them to us just as you have them.

ATORNEY-GENERAL HAMLIN: Now, give us the place first.

A. Bridgeport, Drainage Canal.

Q. ATTORNEY-GENERAL HAMLIN: Now, the first column is the maximum?

A. Yes, sir. The figures I am presenting now are the maximum results obtained from the chemical analyses of samples of water collected during the months of October and November beginning with October 7th daily from the Drainage Canal at Bridgeport, Chicago.

I also give the average figures as calculated from the analytical data:

Four samples representing dates of collection from October 7th to October 10th, inclusive, show on October 9th the maximum amount of nitrogen in the form of free ammonia to the extent of 1.508 parts per million.

The average for those four days amounts to .938 parts per million of nitrogen in the form of free ammonia.

2116 · Q. Now, Professor, it seems to me that those things could be copied very much more readily. Now, it would only take the time of all these gentlemen and the Commissioner and yourself, and I think it would suit the other gentlemen much better, and I know it would me.

ATTORNEY-GENERAL HAMLIN: I would be perfectly willing to have it copied.

THE WITNESS: The data on these sheets represent the analytical results obtained from a chemical examination of samples of water collected from—shall I mention all the points?

Q. Oh, no.

A. From various points indicated upon the tables?

Q. Give them, the period of time.

A. Which samples were collected and the analyses of the same performed daily during the months of October and November, 1901.

Q. Now, that is enough. The table can be inserted here: (Table not subsequently furnished. F. S. B., Com'r.)

2117 Q. Now, go ahead, Professor?

A. The fifth period of investigation began on December 1, 1901, and continued to July 1, 1902.

As already stated yesterday during this period samples of water were collected above Chain of Rocks from two points only during this period, that is from the Illinois River several miles above the mouth of the Illinois River at Grafton. Daily samples were collected until December 18, 1901, and daily samples were collected from the Mississippi River a few miles above the mouth of the Illinois River from December 1 to December 14, 1901.

With the exception of these samples taken at Grafton from the two rivers—there were no samples collected from any point during this investigation above the Chain of Rocks, St. Louis, in the Mississippi River.

Five samples were collected daily during this investigation. Three from the Mississippi River at Chain of Rocks opposite the St. Louis Waterworks.

One sample from the Illinois shore.

One sample from the entrance to the Intake Tower.

One sample from the Missouri shore.

One sample from the outlet chamber of the St. Louis Waterworks.

2118 The fifth sample from the tap in the City Chemist's office, St. Louis.

I have shown in the curves on Chart No. 16 presented yesterday, the results of the analyses of the samples of water taken from the Ilinois and the Missisippi River at Grafton from December 1 until December 18. The results obtained from the analyses of the samples collected during this period from the Mississippi River at the Chain of Rocks, at the outlet screen of the waterworks, and the tap at the City Chemist's office, continued to prove the pollution of our water supply in constantly varying degrees, from the Mississippi River.

The free ammonia during this period frequently rose to very high figures as found in the water collected from the Illinois shore. The enormous rise in free ammonias in the water collected from the Illinois River a few miles above Grafton during the second and third week of December, 1901, was followed by an increase in the amount of free ammonia found in the samples taken from the Illinois shore and also by an increase in the amount of free ammonia found in the samples taken at the Intake Tower during the winter months, January, February and March, while the free ammonia found on the Missouri shore showed higher figures than during the summer months in
2119 1901 and 1902. The rise in the figures of free ammonias found in the samples taken from the Illinois shore of the Mississippi daily and from the samples taken at the Intake, was comparatively much higher. In other words, during those months the sanitary character of the Mississippi water running along the Illinois shore was very bad, and in a measure affected

the sanitary character injuriously of the water supply of St. Louis.

On March 13, 1902, the amount of free ammonia, or nitrogen in the form of free ammonia, found in the sample of water collected at the Chain of Rocks at a point close to the Illionis shore —I say nitrogen in the form of free ammonia on that day from this sample amounted to 1.014 parts per million. This amount of free ammonia must be considered excessively high for a river water.

During that week the average amount of nitrogen in the form of free ammonia found in the samples collected on the Illinois shore of the Mississippi River amounted to .839. Every day during that week the nitrogen in the form of free ammonia exceeded .544 parts per million and while the figure of 1.014 was not reached again since that time, during the remainder of the month, the free ammonia remains very high. The lowest free ammonia found in the sample from the Illinois shore during that month was .26; still a very high figure of ammonia and an evidence of considerable pollution. 2120

Now, during this month at the Illinois shore the nitrites ran very high.

On March 28, we found in a sample collected from the Illinois shore .046 parts per million of nitrogen in the form of nitrites.

The chlorine on that date amounted to 8 parts per million.

The amount of nitrates found on this occasion was high—two parts per million.

During this month of March, 1902, samples collected from the Missouri shore of the Mississippi River showed free ammonias invariably much lower than those found in the samples from the Illionis shore, while the highest free ammonia found in the sample from the Illinois shore during this month amounted to 1.014 parts per million of nitrogen in the form of free ammonia.

The highest amount of nitrogen in the form of free ammonia found in the water collected from the Missouri shore 0.192 parts per million.

The highest nitrites found in the water from the Missouri shore during this month was 2.024 parts per million, found on March 20th, March 23rd and March 30th.

2121 The highest chlorines found in the sample from the Missouri shore during the month of March, 1901, amounts to 27 parts per million. The lowest amounted to 10 parts per milion.

Now, when we take the samples from the intake during the month of March we find the highest free ammonia during this month showed .254 nitrogen in the form of free ammonia. The highest nitrites showing .028 parts per million. The highest chlorine for this month amounting to 25 parts per million and the lowest to 10 parts per million, demonstrating great variation in the amount of chlorine in the water at the Intake Tower. Variations that are quite frequent during the month as they are during the other months and the seasons because of the unstable character of the water entering the Intake Tower and the constantly varying mixtures of Mississippi and Missouri River water going into the intake due to the frequently varying volume of the water coming down the water sheds of the Missouri, the Illinois and the Mississippi River.

The results for the analyses of the samples of water collected during this period from the outlet screen and the tap of the City Chemist's office again shows the same fluctuations, corresponding fluctuations in the chemical character of the water at the Intake, reservoir and the tap.

2122 Whenever the samples taken at the Intake Tower showed an increased pollution, this increased pollution was noticeable in the results of samples of water taken and analyzed from the outlet screen, or outlet chamber rather and the tap in the City Chemist's office. In other words, during this entire period, the character of the river water entering our Intake materially affected the character of the water supply of St. Louis.

During the spring and summer months of 1902, owing to the warmer weather facilitating oxidation processes in the waters, the Mississippi River water, as it entered the Intake showed some improvement. It was not sufficient to change the general unsanitary character of that water. The analytical results for ammonia, nitrites and chlorines remained high enough during this entire period, (until the cessation of this investigation on July 1st, 1901, at the old City Chemist's office, number 1141 Market street), to condemn the water as unfit for drinking purposes in its natural state.

The investigation, as far as reported to the authorities, terminated on July 1st, in the laboratory of the City Chemist's office of the Health Department of St. Louis, because of the removal of the City Chemist's office to new quarters in the old City Hall.

After the equipment of the new laboratory in the new City Hall, had been completed the investigation was re-
2123 sumed on October 1st and continued until January 1st, 1903, as follows:

Three samples were collected from the Mississippi River at the Chain of Rocks, one close to the Illinois shore, the other close to the Missouri shore and the third one at the Intake.

Daily samples were also taken during this period from the outlet chamber of the St. Louis Waterworks, and from the tap in the new quarters of the City Chemist's office.

The results of these analyses do not show any improvement in the sanitary quality of the water supply of St. Louis as compared with the results obtained from the previous investigations conducted in the City Chemist's office since August 23rd, 1899.

With the approach of the winter weather during the latter part of this investigation, the retarded oxidation characteristic of the winter season again resulted in an increase of the amount of free ammonia and nitrites found in the samples collected from the Mississipi River at the Chain of Rocks as well as from the outlet screen and the tap in the City Chemist's office.

Now, do you want me to give my final conclusions?

Q. Well, you have got another chart there, haven't you?

2124 A. No, I have not. What I wanted to read was from the official analytical data, those columns on the ammonias in March, 1903.

Q. Now, Professor, are you acquainted with the character of the Lake Michigan Water in front of the City of Chicago, in Lake Michigan, as to whether or not it is sanitary?

A. Yes, sir. I consider the Lake Michigan Water as it enters the Chicago River, polluted. It is not a pure water.

Q. Now, from your examination of these streams can you state whether or not the waters of the Drainage Canal pollute the Des Plaines river?

A. It is my opinion that they do.

Q. Can you state whether or not the Illinois River is polluted by the Drainage Canal?

A. Well, it is polluted by the Des Plaines river. You mean the Des Plaines river, do you?

Q. No, I am asking you if it is polluted by the Drainage Canal?

A. Well, indirectly, yes. The Drainage Canal doesn't connect directly with the Illinois River.

Q. I know that.

A. Yes, sir; indirectly, through the Des Plaines River.

Q. Can you state from your examination of these waters 2125 that the water coming into the intake of the St. Louis Waterworks now is less wholesome or less pure and less fit for sanitary use and domestic use than it was before the opening of the canal?

A. I think it is.

Q. I mean the Drainage Canal?

A. Yes, sir.

Q. Do you recognize as a chemist in analyzing water any difference between daily and weekly analyses in the results obtained chemically?

A. I do.

Q. What is the difference?

A. The most accurate results analytically are obtained from samples collected daily.

Q. Are you acquainted with the English Rivers Pollution Commission?

A. Yes, sir.

Q. Are you acquainted in a general way with the results of their work from a chemical standpoint and sanitary standpoint as to its effect upon sanitary water?

A. The English Rivers Pollution Commission was created in 1866 by the British Government for the purpose of investigating the question of the pollution by sewage from cities 2126 of the rivers in Great Britain. The investigations cover a period of eight years. During this period six reports were published. It was perhaps the most comprehensive investigation of the kind ever attempted until then and while a variety of opinions have been expressed as to the conclusions to be drawn from these reports, the predominating opinion after the publication of the reports—

ATTORNEY-GENERAL HAMLIN: I object to any opinion given by the English Commission or any statement as to what those reports contain on the ground, first that the reports would be the best evidence; second, that the evidence is not relative to the issues here.

MR. TODD: The Sanitary District joins in the same objection with the State.

ATTORNEY-GENERAL CROW: Go ahead.

A. The predominating opinion among sanitarians has been that the pollution of streams by sewage from cities and towns located on the banks of these rivers should be prevented by legislation, because the investigations conducted by the commission resulted in establishing the fact that pollution of streams by sewage of towns and cities in England was being carried on to an extent rendering the streams unfit for drinking purposes.

2127 ATTORNEY-GENERAL HAMLIN: I move to exclude all of the answer to the last question for the same reasons that are given in the previous objection.

MR. TODD: The Sanitary District joins in the same motion.

ATTORNEY-GENERAL CROW: Now, are you acquainted with the fact as to whether or not they have a septic tank system in Kansas City, Mo., for a large portion of their sewage?

A. The conditions of sewage disposal for the city of Kansas City are exceptional. It is a hilly city and the city grew up very fast and the sewerage system is very much behind the times. The development of the sewer system did not keep pace with the growth of the population and as a result to-day only 60 per cent. of the sewage of Kansas City goes into the sewers and drains into the Missouri River.

There are as many as 4,000 cess pools in Kansas City into which the sewage of the city is placed and kept there for some time, until the tanks are filled up and the sewage is then disposed of in various ways, used for manuring purposes—some burn it up, and about one-fifteenth of this sewage eventually reaches indirectly, the Missouri River, but when it reaches the

Missouri River it is sewage far advanced in its purification or rather in its oxidation and has an entirely different char-
2128 acter than the fresh sewage run into the river from the sewers.

Q. Now, do you know the distance by river from here to Kansas City?

A. No, sir; I haven't got the data at hand just now.

Q. Now, from your chemical examination as heretofore detailed by you of the waters of the Missouri River and of the Mississippi River at the confluence of the two streams, will you please state, if you know the fact, which is the better for use for domestic purposes and which is the more sanitary drinking water?

A. The Missouri River.

Q. Now, can you state from your examinations of these waters which is the better water for drinking purposes, that in the Mississippi River above the mouth of the Illinois River or the waters of the Mississippi River below the mouth of the Illinois and prior to its junction with the Missouri?

A. The Mississippi River above the mouth of the Illinois.

Q. Now, can you state from your examination of the water in these rivers whether or not the water coming in January, 1900, and from that time on, into the Intake Tower of the St. Louis Waterworks, whether or not it has as a rule, been potable water?

A. It has not.

2129 Q. Now, are you familiar with the theories of Tidy and Letheby, and other English scientists with reference to the effect of sewage upon running streams?

A. Yes, sir.

Q. Well, can you state whether or not the water in sanitary science as applied to the problem of drinking water supplies for large cities agree with the opinions of Tidy and Letheby and other English scientists of later days?

A. The theory of Tidy and Letheby originally attracted much attention. It practically amounts to this, that sewage diluted in pure water at the ratio of one part of sewage to fifteen parts of water would purify itself after running a distance of about 10 or 12 miles. It was this very theory that in its application in England proved to be fallacious in many instances, that led to the creation of the Rivers Pollution Commission in England, to which you referred in a previous question. The result of this investigation was that a new theory practically supplanted the theory of Tidy and Letheby in England, and that is that there is no river in England long enough to purify itself. I consider Tidy and Letheby's theory from the facts ascertained by a careful study of the question of river pollution, as antiquated and overthrown by the experiences of many communities in England as well as in other countries. 2130

This theory of Tidy and Letheby was tested so to speak by investigations carried on in England on the rivers Irwell and Mersey by Frankland, a prominent chemist and sanitarian of England in the seventies, in the years between 1870 and 1880, I can't recollect just now what years.

The conclusions drawn by Frankland from these investigations were that sewage discharged into a river at the ratio of a dilution of 1 to 15 as recommended by Tidy and Letheby, instead of purifying itself after a run of from 10 to 12 miles, only two-thirds of the sewage would purify itself after running a distance of 168 miles.

Q. Now, have you got a record of the low stages of the Illinois River?

A. Yes, sir.

Q. Have you got the stages of the river that show the lowest stage recorded for that river between the mouth of the canal at Lockport and the mouth of the Illinois at Grafton?

A. For what year do you mean?

Q. For the years 1900, 1901 and 1902?

A. Now, do you want the stages after the opening of the Drainage Canal or before?

2131 Q. After.

A. After the opening of the Drainage Canal it was very low. In February 1900 the Illinois River at Grafton showed the highest stage, during the month of January, 1900. On January 21st when it showed 5.9 feet. It then began to fall steadily until February 3rd when it showed only 1 foot at Grafton. Then there began a rise steadily almost from day to day and within a week the stage was 7.3 feet.

It remained close to that figure, that is varying between 6.6 and 6.9 for the following week. In the third week in February the river took a sudden rise on the 21st. On the 20th the stage was 6.9, and on the following day it was 8.3 and it remained at 8 feet, and went up to 8.5 and in the following week began to fall again down to 7.4, 6.1 and at the end of the week was 5 feet.

During March it fell down to 4.8 and beginning with the 6th of March showed a big rise. It rose from the 5th to the 6th of March from 5.1 to 7 feet. The next day from 7 feet to 9.3. The following day from 9.3 to 10.3, and so on, from day to day it rose averaging about a foot until the 13th of March it reached 14.8 feet—or rather that was on March 13th, it 2132 reached 14.8. Next day, on March 14th, 16.1; then it rose on the 16th to 17.3. That was its highest during that month and from that day on it fell steadily, varying from one to one-half feet per day until it got down to 13 feet and in the following week it fell to 12.6 on the 29th and ended with 11.8 on the 31st. Then for the next month it didn't vary so much but remained pretty steady for the next week between 11.5—no. it did rise again some to 13.3, but in the following week it only varied from 13.6 to 12.3 and for the next weeks or for the remaining two weeks in March it varied between 11 feet and 12.7. That is for the first four months from January to April, 1900, the stages at Grafton, of the Illinois River at Grafton.

Q. Now, have you got the stages of the Missouri and the Mississippi Rivers at that time?

A. Yes. Do you want to take the Mississippi first?

Q. Yes, come right down the river.

A. The Mississippi above the mouth of the Illinois?

Q. Yes.

A. These are the stages recorded at Louisiana, a town situated on the Mississippi River above the mouth of the Illinois. I can't tell exactly how far it is from the mouth.

Q. Well, anyhow, it don't cut any figure, the distance.

2133 A. No, there would not be much variation between the stage at Louisiana and at the mouth.

Q. No?

A. I don't think it would materially affect the figures.

The Mississippi River at Louisiana, Mo., showed during the month of January, 1900, throughout a very low stage varying between 1 and 3. There was a period of very cold weather prevailing at that time and in the beginning of the month in the first week, the river was frozen over and again at the end of the month, so that would have to be taken into account in calculating the measurements. Hence, there are such low figures as .7, that means 7-10 of a foot. That is the way it is measured out, it goes by decimals, you see. You see, it was ice frozen over—

MR. JOHNS: 7-10 of a foot of water in the Mississippi River at Grafton?

A. No, no, that was in the Mississippi River at Louisiana.

ATTORNEY-GENERAL CROW: 7-10 above or below the low water stage?

A. I have the official records for Keokuk for the same period, and they show this distinctly, and it was on those days that the river was frozen that we got these very
2134 low stages of water, because the rest was ice. It is just
measuring the water under the ice. The stage of three feet was only reached once during that month, on January 19th, for the major part of the month the height of the river varied between one and two and one-half feet.

MR. TODD: Doctor, do you mean that the ice was frozen so that there was only seven-tenths of a foot of water from the ice to the bottom of the river?

A. Yes, you see it wasn't frozen solidly, that is the idea. That is the way they estimate it at the Weather Bureau. It has been explained that way. You see, it is simply the gauge of the river—the gauge of the water of the river.

ATTORNEY-GENERAL CROW: Explain what that 7-10 means?

A. It means, calculated on the gauge.

Q. Well, put it in the record. Explain it?

A. These estimates are based upon the regular gauge of the river as taken for the United States Weather Bureau.

During the month of February—I will call it the gauge hereafter, that is just what it is meant to be. The gauge was for the period of very cold weather prevailing and the river was frozen over for about twelve days. The gauge for the second and the third was again below one foot, that is a decimal. During the second week the river rose a litle 2135 and it went up as high as 2.9 feet. Then in the next week it went up to 3.8. And in the following week it showed some slight variation only from 3.4 to 4 feet, the highest reached during the month, and at the end of the mouth it fell somewhat to 1.5 feet. It remained low again for about a week in March when it rose again, as follows:

On March 8th, the gauge was 3.1 feet,
March 9th, 5 feet,
March 10th, 5.1 feet,
March 11th, 6.9 feet,
March 12th, 8.3 feet.
March 13th, 11 feet,
March 14th, 11.7 feet,
March 15th, 12 feet,
March 16th, 11.9 feet,
March 17th, 10.5 feet,

Then it fell again.

On the 18th the river fell again to 9.1 feet,
On the 19th, to 8.5 feet,
On the 20th, to 8 feet,
On the 21st, 8 feet,
On the 22nd, 8.2 feet,
On the 23rd, 7.6 feet,
On the 24th, 6.9 feet, and it fell steadily during the 2136 last week of March to 5.1 on the last day of March.

I didn't give the Grafton, Illinois River stages for April did I?

MR. TODD: You didn't give Grafton.

A. Yes, I gave Grafton, Illinois River up to April 1st I am sure, but I was asking whether I gave it after April 1st. I can't remember this minute.

Mr. Crow, do you want the gauges of the two rivers for the months of April, 1900?

ATTORNEY GENERAL CROW: Yes, if you have got them. Just give the averages, don't give it every day. Just give the minimum and maximum stages, say one a week and shorten it up.

A. The fall in the rivers, in the Illinois and Mississippi at those points continued until the 3rd of April when there was a corresponding rise again in both rivers to 8.7 in the Mississippi River and 13.6 in the Illinois River at Grafton, which was the maximum gauge for both rivers during that time.

They began to fall down to 5.9 for the Mississippi and 11 feet in the Illinois River during the next week and during the last week of April both rivers rose about a foot, reaching a maximum height during that week of 8.4 feet for the
2137 Mississippi River and 12.7 for the Illinois River. In
other words during this month the heights, the rises and falls in the two rivers were corresponding for the month of April.

Q. Now, are you acquainted with the character of the Drainage Canal, with the character of the water, the appearance of it after its opening in January 1900?

A. Yes sir.

Q. Well, what was the character of that water?

A. From the samples you see—do you say whether I was acquainted with the water of the Drainage Canal?

Q. Drainage Canal, yes sir.

A. In January 1900?

Q. Yes.

A. No sir.

Q. Are you acquainted with the appearance of the Chicago River and its different branches prior to the opening of the Drainage Canal in 1900?

A. No sir.

Q. Do you remember being up there and seeing the waters?

A. Yes, I have been to Chicago and I have seen the Chicago River; I had seen the Illinois and Michigan Canal,
2138 and I had seen the main Drainage Canal prior to the open-
ing of the latter and on various occasions prior to the opening of the Drainage Canal.

Q. What was the appearance of the Chicago River as to whether or not it was a clean looking stream or unclean?

A. You mean prior to the opening of the Drainage Canal.

Q. Yes prior to the opening of the Drainage Canal.

A. Well, most of the times when I was in the City of Chicago the Chicago River had the appearance of a dark colored sewer water, emitting offensive odors and gas bubbles.

Q. Well now what was the appearance of the Illinois and Michigan Canal, of the water in it?

A. The water in the Illinois and Michigan Canal had the appearance of sewage and it was also of a dark color and emitting offensive odors and gas bubbles.

Q. Do you know anything about the cost of the St. Louis Water Works?

A. I have never studied that question; I couldn't give you any figures.

WILLIAM C. TEICHMAN.

Adjourned till the following day 10:00 A. M., Friday, March 20, 1903.

2139 Southern Hotel, St. Louis, Mo., 10:00 A. M., Friday, March 20, 1903. Present, the Commissioner and same Counsel representing the respective parties .

DR. WILLIAM C. TEICHMANN

resumed the stand for further direct examination by Attorney General Crow, and testified as follows:

Q. Now, Dr. Teichmann, are you acquainted with what is known as the Pettenkofer theory of the effect of pollution of waters upon running streams?

A. Yes sir.

Q. What was that theory?

A. The theory was that sewage discharged into a river and diluted at the rate of one part of sewage to fifteen parts of water would purify itself after a run of fifteen miles, provided that the velocity of the river into which the sewage was being discharged, was at least about the velocity of the sewage and that this velocity was at all times three-fifths of one metre which is equal to about two feet and one inch per second; that would be the least velocity per second.

2140 JUDGE JOHNS: You mean three feet and three inches a metre?

A. No, it was .6 metres. That is six-tenths of a metre or three-fifths of a metre. That will be about equal to two feet and one inch and it would have to have, at least that velocity per second.

GENERAL CROW: Now when was that theory first advanced?

A. That theory was advanced some time in the seventies, between 1870 and 1880, I don't know exactly when. I cannot find anywhere what time but during that period.

Q. Well, does that theory maintain today among sanitary scientists in water supplies?

A. No sir. Do you want my explanation why?

Q. Yes, you can explain why.

A. The experiences of various communities in applying this ratio of dilution on sewage discharged in running rivers in Europe has been such as to demonstrate that the theory cannot be applied any more with success. One of the greatest difficulties in the country is that running streams in themselves are not pure.

The ratio of dilution is based upon a mixture with pure water and whenever the ratio is applied, of a mixture of sewage with polluted waters, it proves to be fallacious.

It is true that a number of scientists have declared in
2141 various instances and quoted in scientific publications that
the theory proved to be successful, but other investigators have shown that those investigations upon which these scientists based their conclusions were carried on in an inaccurate manner. For instance, it was proven that the velocity of the current differs, that is the velocity of the water running along the shore and the velocity of the water running in the channel, differ.

It was furthermore proven that the velocity of the water on the surface of the river differs from the velocity in the middle depth of the river. It has been shown that the velocity of a channel is greatest in the middle of the depth of the river. Some investigators claim that the greatest velocity occurs at the depth of six-tenths.

Now, in taking samples a great many of these investigators who agree with Pettenkofer evidently have made the mistake of taking samples from the surface. The character of the water, I will say on the surface of the river is different than the character of the water at the middle of the depth, that is oxidation processes are somewhat facilitated by light, and the top water in the channel would present a different chemical character accordingly than the water running at a certain depth, as I said before, half of the depth of the height of the river. Therefore, such investigators as Classen, who is a chemist and a water specialist of much distinction in Germany—I say such 2142 men as Classen and others challenged the correctness and reliability of the analytical results upon which many of the followers of the Pettenkofer theory base their conclusions, that the Pettenkofer theory was correct. They proved contradictory data showing that this so-called self purification as announced by Pettenkofer, was in reality impossible, because, first of all as I have said, many of the samples were taken from the surface water and then again at the lowest velocity suspended organic matter would deposit at the bottom of the river not purified. This suspended matter having been deposited during the slow flow of the current at the bottom of the river, would at the next rainfall and heavy rise of the river, increasing the velocity, be carried up from the bottom of the river and then if that water would be analyzed it would show that the organic matter not yet oxidized coming from the sewage discharged into the river and supposed to have been purified at a flow of fifteen miles, was still there, it had not been purified and was then being swept with the increased velocity again from the bottom to the top and carried down the river, and analyses would show that the impurities that were supposed to have disap- 2143 peared, that were supposed to have been removed by the so-called self purification, had been removed from the surface only and had been deposited at the bottom of the river and turned up to the surface again as soon as the river was being flushed out by rain water coming up, so that the purification claimed by the Pettenkofer theory had not taken place. These investigations have been published in one of the greatest works that has been written on the pollution of waters, by an investigator of great prominence in Germany, who worked for many years on this book and brings in this publication all the researches pro and con on the subject of the so-called self purification for rivers.

Q. Who is that?

A. Julius Keonig and the title of this work is "Die Verunreinigung Der Gewasser," published in 1899.

Q. Well, what is the modern theory of this question of running water?

A. Well, according to the researches as described in this work a conclusion is justified that the oxidation of sewage discharged in the rivers depends so much upon various conditions and circumstances constantly varying and differing so materially as applied to various streams, that a hard and fast rule as to a ratio of dilution cannot be considered reliable any
2144 more.

Q. Now, have you got any data here showing the flow through the Chicago Canal, from an official source?

A. Yes sir.

Q. Where is it and what shape is it in?

A. I have an official tabulation.

Q. Where did it come from?

A. By courtesy of Mr. Todd, Counsel for the Sanitary District of Chicago, I have received the tabulations for the year 1900 and 1901, of the average daily and weekly rate of flow in cubic feet per minute of the water in the Illinois and Michigan Canal at Chicago, the main Drainage Canal at Chicago, the Chicago River at Chicago, the Desplaines River at Riverside, the Desplaines River at Joliet, including notes on water shed areas and weekly and quarterly summary of the above. This data having been compiled by Engineer E. L. Cooley, presumably under the directions of the Chief Enginer—

MR. TODD: Mr. Cooley is one of the assistant engineers of the Board.

A. Presumably under the directions of the Chief Engineer Isham Randolph.

GENERAL CROW: Do you know whether the Drainage Canal was closed during the greater part of September, 1900?

2145 A. Well, it was closed during the day time for several weeks excepting Sundays. The volume of water running over the dam at night is estimated and represented in the table there. There was some water coming in but in comparison to the regular flow it was a small flow. Do you want me to testify to that—this daily closing of the Drainage Canal at that time, in September, 1900, resulted in the reversion of the flow of the Chicago River back into the lake and as I have already testified, evidently resulted in an increase of the pollution of the water taken from the lake front, and as I also testified, I believe, but I am not sure about it, but think I did, that the Chicago River at that time, in the reversion of the flow back to the lake, again assumed this character which it had shown prior to the opening of the Drainage Canal, that is its color was darkened again and offensive odors and gas bubbles were noticeable along the route of the Chicago River during that period.

MR. TODD: Did you see this yourself?

A. Yes sir, I was in Chicago during that time. After the reopening of the Canal, with the regular average flow, the average flow at that time of the water was 300,000 cubic feet per minute, after that time of temporary closing in September, 1900 the accumulated accretions of Chicago sewage in the Drainage Canal being discharged into the Desplaines 2146 River and subsequently into the Illinois River, resulted in increased pollution of these rivers as traced along the route down to the mouth of the Illinois by the analyses of samples collected at points between Chicago and St. Louis at that time.

In other words, during that time there re-occurred what had happened soon after the opening of the main Drainage Canal, that, so to speak, a wave of pollution came down the Desplaines River from the Drainage Canal, down the Illinois River and into the Mississippi, increasing the pollution of the Mississippi River between Grafton and the Intake, and was followed by increased pollution of our water supply, as shown by the analytical data we obtained from the analyses of the samples collected along that route.

GENERAL CROW: Now, Doctor, after you have examined these waters chemically in the manner in which you describe, and having had experience in water analysis which you have, are you able to state whether or not, the sewage in the outfalls of the sewers in Chicago into the Drainage Canal reached by way of the Desplaines and Illinois River and the

Canal, and the Mississippi River to the intake of the St. Louis Water Works?

2147 A. Yes sir.

Q. Well, does that sewage come in there?

A. Yes sir.

Q. Now, having made these examinations of the water supply of this city prior to and since the opening of the Chicago Drainage Canal, are you able to state whether or not the water of St. Louis is more polluted now by reason of the opening of the Chicago Canal and the inflow of the sewage from the City of Chicago, than it was prior thereto?

A. I think it is.

WILLIAM C. TEICHMANN.

2148 THOMAS A. BUCKLAND

called as a witness on behalf of the Complainant, the State of Missouri, having been duly sworn by the Commissioner, was examined in chief by General Crow and testified as follows:

Q. Mr. Buckland, what is your occupation?

A. I am Assistant City Chemist of St. Louis.

Q. How long have you been occupying that position?

A. Well, about ten years.

Q. What chemical training have you had?

A. My chemical training, that is the college training, was in the St. Louis College of Pharmacy, from which I graduated in 1882.

Q. You have been following the business of chemist since that time.

A. Chemist and druggist, yes sir.

Q. Were you present in the City Chemist's office during the period of investigation and analyses of the waters of the Mississippi, the Missouri and the Illinois Rivers and the Illinois and Michigan Canal, the Lake Michigan water and the Drainage Canal water, beginning in 1899 and running up to January, 1903?

A. Yes sir.

Q. Now, what part in that work did you take?

2149 A. Well, at different times I took different parts. The largest part of the work I had was the ammonias and nitrites but at different times I made other determinations.

Q. Where did you work, in what place?

A. On the north-east corner of Twelfth and Market Streets.

Q. Well, what is that at the north-east corner of Market and Twelfth?

A. Well, it was at that time, the laboratory of the City Chemist. It has since been removed to the old City Hall.

Q. Well, it was in the laboratory of the City Chemist's office in this city where you performed your work?

A. Yes sir.

Q. Now, are you familiar in the first place with the methods of obtaining water samples?

A. Yes sir.

Q. Who delivered the samples at your office?

A. Well, various collectors employed for the purpose.

Q. Who employed them?

A. Well, at first they were employed by the Water Commissioner and later by the City Chemist under an Ordinance authorizing their employment.

Q. Now, was there any one in the laboratory whose business it was to receive these samples?

2150 A. Yes sir.

Q. Who was that?

A. During the first part of the investigation Dr. Teichmann and I used to attend to that.

Q. Now, what do you call the first part of the investigation, beginning in 1899?

A. No, I mean at the beginning of the large investigation when these men were employed by the Water Department, I think that was in January 1900. I haven't looked at those records. This is a matter of record and you will be able to tell from the records exactly.

Q. Have you got any memorandum of that showing when it was that you inspected these samples, when they were sent in?

A. I think so.

Q. Well, did you have any rule for the inspection of them?

A. Well, what do you mean by rule for the inspection of them?

Q. Well, how did they come to the office and what condition were they in when they came there?

A. Well, the bottles came capped with a piece of muslin and sealed with wax. The muslin was tied around with a string and the string sealed with wax and they were usually carried in the bottles which were brought in personally by the 2151 collectors, were usually brought in tin boxes made for the purpose. The samples received by express were contained in wooden boxes in the center of which was a tin box made for the purpose of holding ice and they were sealed. The box itself was also sealed according to my recollection.

Q. What time of year, if any, did you use ice to pack the bottles?

A. Well, in the hot weather we used ice as long as it was necessary to keep the samples cool.

Q. Now, suppose the bottles came there with the seals broken, were the samples used?

A. Well, I should think they wouldn't be, I don't think they were if the seal was broken. I should certainly have thrown one out if I had it.

Q. Now, when did they begin to send their samples from the City Laboratory over to Professor Keiser?

A. Well—

Q. Haven't you got some memorandum that will give those dates?

A. No sir, unless Dr. Teichmann has I have not.

Q. Well, do you know whether or not the samples were sent from the City Laboratory over to Professor Keiser?

A. Yes sir.

2152 Q. What condition were the samples in when they were received and in what condition were they when they left your office to go to Professor Keiser?

A. The samples were taken under the same conditions the others were taken and were sent as soon as possible up to Professor Keiser.

Q. Were they duplicate samples of what you analyzed?

A. They were duplicate samples of what we analyzed.

Q. The work you did in analyzing was a duplicate of the work Professor Keiser did?

A. Yes sir.

Q. Did you begin with them in January, 1900, in that investigation?

A. Yes sir.

Q. Did you continue that work there in the laboratory until it closed on January 1st, 1903?

A. Yes sir.

Q. Well, are you familiar with the practical methods that are used in analyzing water?

A. Yes sir.

Q. Well, what were the methods that you used, were they those that are usually and properly applied?

A. Yes, we attempted as a rule to follow the Massachusetts State Board of Health method in our examinations,
2153 but in each determination I can give you any information you want.

Q. I don't understand you?

A. I say our endeavor was to follow the methods of the Massachusetts Board of Health.

Q. Well, what was the last part of your sentence?

A. Well, I say in regard to any individual determination I can give you the information.

Q. I don't want any individual determination. Do you know how many analyses you made altogether?

A. Well there were about 8000 analyses made.

Q. Of water samples?

A. Yes sir.

Q. Well, did you have a man by the name of Taylor around your office, there, a colored man?

A. Yes sir.

Q. What capacity was he engaged in?

A. He was a janitor.

Q. What did he have to do with these samples?

A. Well, he put them in the ice chest and got the bottles ready for the collector.

Q. What did he do to get them ready?

A. He washed them out and placed them in boxes.

2154 Q. Is that all he did? Who sterilized the bottles?

A. Do you mean the bacteriological bottles?

Q. Yes, you furnished the bottles for the bacteriologist.

A. Yes, the bacteriological bottles were sterilized. I am not sure whether Taylor did any of that work or not. I think he possibly did some of it. The bacteriological work was under the control of Dr. Ravold and his assistants who attended to that.

Q. Well, what else did Taylor do, did he receive the bottles?

A. I think he did occasionally.

Q. Well who took the bottles over to Professor Keiser?

A. Well, they were sent to Professor Keiser in a wagon that was employed for the purpose of bringing samples down from the Water Works at the Chain of Rocks?

Q. You hadn't had any work or didn't do any work at any of these emergency laboratories that were had along on the route between here and Chicago?

A. No sir.

Q. You know nothing about that work?

A. No sir.

Q. Your knowledge is confined wholly then to the work that occured in the laboratory of the City of St. Louis?

A. Yes sir.

2155 Q. Now, was that work done under the personal supervision of Dr. Teichmann and his assistants?

A. Yes sir.

Q. Who else worked there with you during this period of time?

A. Well, there was quite an army of men.

Q. I mean as chemists or helpers and assistants?

A. They were Dr. L ttmer, Mr. Beneker, Mr. Miller, Mr. Goetz, Mr. Leavitt and Mr. Hammerer.

Q. They did different parts of the work?

A. Yes sir.

Q. Now, did you examine the results of the work there and tabulate it?

A. No sir.

Q. Who did that?

A. Well I think that was done by Dr. Teichmann, Mr. Miller and Mr. Goetz.

Q. You are still employed out there at the City Chemist's office?

A. Yes sir.

Q. Who made the entries of the data that was obtained
2156 as a result of these charts?

A. That is, you mean who made the entries in the books as the analyses were made?

Q. Yes.

A. Well, in most of the cases the determinations were made, and the entry made by the chemist who made the determination. And in case of the ammonia determination they were generally called off by the chemist who was reading the ammonias and copied into the book by one of the clerks.

Q. Well, it is the usual method followed in making these chemical analyses, employed by the men having different portions of the work?

A. Well, in such a large undertaking it certainly would be, yes sir.

CROSS-EXAMINATION BY MR. JOHNS.

Q. Where were the emergency laboratories connected with this work?

A. One was located at Grafton, one at Peoria and the other at Joliet, I think.

Q. What do you mean by an emergency laboratory?

2157 A. Well, they were temporary laboratories established for the purpose of making bacteriological tests.

Q. Well, were they also for the purpose of making chemical analyses?

A. No sir.

Q. No chemical analyses were made at any of these emergency laboratories?

A. Not to my knowledge. I am not certain. There is none of these results so far as I know, made at those laboratories. The emergency laboratories were under the control of Dr. Ravold, that being bacteriological work, and so far as I know, there was no chemical analysis made.

Q. As far as you know there was no chemical analysis made at any of these emergency laboratories?

A. No sir.

Q. If any were made at such laboratories they have been tabulated in the books and reports of the City Chemist in reference to this analysis that has been going on?

A. Well, I should suppose they would be, but I don't know anything about those tabulations.

Q. As I understand you, you do not personally know whether any chemical analyses were made at any of the emergency laboratories?

A. No sir, my impression was that there weren't any 2158 analyses made there.

Q. That is your best impression?

A. Yes sir.

THOS. A. BUCKLAND

No re-direct examination.

Adjourned until 2 P. M., March 20th.

2159 Southern Hotel, St. Louis, Mo., 2 p. m. Friday March 20, 1903. Continuation after recess.

Present, the Commissioner and same Counsel representing the respective parties.

HENRY DETTMER

called as a witness on behalf of the Complainant, being first duly sworn by the Commissioner, testified as follows:

DIRECT-EXAMINATION BY ATTORNEY GENERAL CROW.

Q. What is your name?

A. Henry Dettmer.

Q. Now, what is your profession?

A. Chemist.

Q. Where were you educated, Professor?

A. In Germany.

Q. Whereabouts?

A. I was educated—I graduated from the University of

Goettingen. I was educated in Germany and studied at the University of Goettingen in Prussia in 1880. Then I was two years and a half Instructor of Chemistry at the
2160 University of Bonn. In 1884 I came to this country and worked here for a large dairy company and then I became Professor of Chemistry at the College of Physicians and Surgeons, St. Louis.

Q. Professor of Chemistry?

A. I took the chair of Professor of Chemistry for four years in the St. Louis College of Physicians and Surgeons. Then I went to Germany and took a position there for four years at the Agricultural Experimental Station of Coeslin in Prussia.

In 1900 I came back and then I was engaged by Dr. Teichmann in this Drainage Canal, especially for the purpose of determining the total solids, and at the present time, I am first Assistant Chemist in our milk examination department in the City Chemist's office.

Q. And you have followed chemistry as a profession all your life, have you?

A. All my life, yes sir, all the time.

Q. You are familiar then with the modern practical methods of water analysis?

A. Yes sir.

Q. Now, when did you begin assisting Dr. Teichmann in the analyses of the water samples sent to your office?

A. I was engaged on January 24, 1900.

Q. Is that the date you began work?

A. Yes sir, I think that is the date, that is the 24th.

2161. Q. Now, where was your work done, at what place? The City Laboratory in the City Chemist's office?

A. Yes sir, the City Laboratory.

Q. In St. Louis, Mo?

A. Yes sir, in St. Louis, Mo.

Q. Now, what was the character of the water you worked on, that is how did the water come there that you worked on, did it come in barrels or how?

A. Oh, no, in bottles.

Q. In bottles?

A. Yes sir, sealed bottles.

Q. Sealed bottles?

A. Yes sir.

Q. Now, how long did you continue in that work. Have you continued in it ever since?

A. Yes sir, I worked on it from January 24, 1900, to December 1st.

Q. 1900?

A. 1900, and then the second time I worked from October 1, 1901, to December 1st.

Q. 1901?

A. 1901, the second time.

Q. And then you worked the third time?

2162 A. No.

Q. Only two periods?

A. Only two periods, yes.

Q. Now, what was the class of work that you did on these analyses?

A. To determine the residue or total solids after evaporation.

Q. Now, just tell me me how you did that, in what way?

A. Well, I worked—the amount of solids was determined in the unfiltered and filtered samples, 100 cubic centimeters of the sample was measured into a platinum dish of a capacity of about 1x150 cubic centimeters; evaporated on a large water bath to dryness. The dish was then placed in a drying oven and heated to a temperature of 110 degrees centigrade for one hour when it was transferred to a dessicator containing calcium chloride and cooled. The dish was weighed and the weight of total solids noted. Then the dish with contents was ignited over a Bunsen burner at a dull red heat and after cooling as before, weighed and the loss by ignition noted.

Q. Now who recorded the results of those analyses that you made?

A. We, ourselves, the chemists.

2163 Q. You did that?

A. Yes, I did that myself, figures and everything, yes.

Q. Now that is all of the chemical work that you did?

A. Yes sir.

Q. Now there were other men at work there that did other portions of these analyses?

A. Yes sir.

Q. Now, this work that you did was done under the supervision and direction of Dr. Teichmann?

A. Yes sir.

Q And those results as to total solids were a part of the analytical results that went to make the record of the analyses complete, of the water samples that were sent there?

A. That is right.

Q. Now, was the same method followed by you in the second period during which you examined these waters for the determination of total solids?

A. Exactly, yes sir.

Q. Now at what place in the analyses of water samples does the determination of total solids take its value?

A. Well, it shows, it gives us an idea of how much mineral matter there is in the water. Now, in the unfiltered sample and the filtered sample it is different. The unfiltered sample shows the mud, you know, the suspended matter, and if I make 2164 one sample of the unfiltered matter and then the filtered, the difference would give me the residue in suspension.

Q. Now will you please explain the difference between the suspended matter in water and the constituents or elements of water that are suspended chemically?

A. Well, in filtered water it is the ordinary—what we find in almost every water, spring water. Those are generally the chlorides of potassium and sodium calcium carbonate generally in the form of calcium bi-carbonate, calcium bi-sulphate, silica and magnesia.

Q. Well, now go ahead and finish the explanation as to the difference between suspended matter and the other substances in the water?

A. Now, in the unfiltered water what remains in the filter is nothing but suspended matter, generally clay and organic matter.

Q. Then, Doctor it is this, what you term suspended matter in the water, is matter that is put into the water and is not one of the chemical constituents thereof?

A. No, that is natural.

Q. Whenever you use the term suspended matter, it ap-

2165 plies then to some substance that is foreign to that water in its natural state?

A. Yes sir.

MR. WOERNER: And not salt?

A. Oh no.

ATTORNEY GENERAL CROW: Now then, Doctor, the record of these determinations of total solids were recorded in the office there at the time?

A. Yes, oh yes.

Q. Have you examined the records of those results as kept in the custody of Dr. Teichmann?

A. Yes sir.

Q. Do you know whether those results that he has, and the analytical charts recording the analyses of the water are correct as to the total solids?

A. Oh, yes.

Q. The method that you followed to determine these total solids is a practical and proper method to determine the total solids in water in the chemical analysis of the present day?

A. Yes sir.

2166 CROSS-EXAMINATION BY MR. JOHNS.

Q. What per cent of solids in suspension are in the water at the Intake Tower?

A. Well, I haven't got the records here, I don't know them by heart.

Q. Well give it from your best recollection?

A. I couldn't recollect that, I made so many and they were so different, you know. I have got everything in my book.

Q. Have you got in your mind the general average or general idea of the total amount in suspension.

A. No sir. Really, I don't know it by heart.

Q. Now, when you examined the unfiltered water you evaporated it to dryness?

A. Yes sir.

Q. And then you put that residue in a platinum dish?

A. Yes sir.

Q. And exposed it to the water bath?

A. Yes sir.

Q. For what purpose?

A. Well, to get rid of the water itself.

Q. Then it remained on the water bath how long?

2167 A. Well, that would depend on how much the residue was, sometimes several hours.

Q. Several hours?

A. Yes sir at least longer than two hours. In other words, so long until I was satisfied as a chemist that it was perfectly dry, all the water evaporated.

Q. After that you put it in an oven exposed to a Bunsen burner?

A. No, I put it in the oven for one hour at a temperature of 110 degrees centigrade.

Q. Well that heat was created by a Bunsen burner?

A. No, this was for the purpose you know, to satisfy us chemists that all the water what we took, chemical water, H_2O that is evaporated and then it was transferred to the dessicator and cooled down.

Q. And allowed to cool?

A. And allowed to cool and then weighed.

Q. How long did it remain in this oven?

A. For the second drying?

Q. Yes.

A. For the second drying, you mean in the dessicator?

Q. No. It was first exposed as being evaporated to dryness, it was exposed first to the water baths?

2168 A. Yes sir.

Q. And then, if I understand you, it was next exposed tc heat in some kind of an oven?

A. In the oven.

Q. And how long was it allowed to remain in that oven?

A. One hour.

Q. One hour?

A. Yes sir.

Q. Not fifteen minutes?

A. No.

Q. Never fifteen minutes?

A. No.

Q. Always one hour?

A. Yes sir.

Q. Was it weighed before it was put into the dessicator?

A. No sir.

Q. It was not weighed until after it had been in the dissicator?

A. Yes, until after it had been in the dessicator, yes.

Q. How long did it remain in the dessicator?

A. About fifteen minutes.

Q. Now, you put into that dessicator calcium chloride?

2169 A. Put in calcium chloride, yes sir.

Q For what purpose?

A. Well, calcium chloride is put into the dessicator to keep the air in it perfectly dry, to keep all the water out.

Q. To absorb all the moisture?

A. Yes sir. We used either calcium chloride—we had to transfer it from the oven to the balance.

Q. You didn't weigh this evaporated matter for the determination of solid matter, for the suspension, until after it had been in the dessicator?

A. Yes sir.

Q. And then that weight taken from the total weight of the water determined the matter in suspension?

A. Yes sir.

Q. Did you ever try and put it in the water baths or in the oven more than once?

A. Several times, yes sir.

Q. Was it your custom to put it in the oven and then take it out and put it in the dessicator and then take it out of the dissicator and put it back in the oven?

A. You mean, in other words, after I made the first weighing?

Q. Yes.

2170 A. I put it back and weighed it over again. Not always, no.

Q. How frequently?

A. Well, I couldn't tell.

Q. What was your general custom?

A. Just to weigh it once.

Q. Just to weigh it once?

A. Yes sir, because I made the first researches in my examination about those, upon this point, and my experience as an expert chemist taught me it is absolutely not necessary to put it back again out of the oven and weigh it. It is not necessary. It says, of course, in the books, to constantly weigh it. That is right, but it is not necessary.

Q. Now let me see if I understand you. Now, your general custom was to weigh it at once?

A. Yes, sir.

Q. Your general custom was to put it in the oven but once?

A. Yes, sir.

Q. And if you weighed it more than once or put it in the oven more than once, that was the exception and not the rule?

A. No.

Q. Well, no, you mean—

2171 A. Well, I mean—that is right. It is not the rule to put it back two times or three times because we found out by our researches that it was sufficient. We watched the temperature all the time. It was 110 degrees all the time.

Q. What is 110 degrees centigrade in terms of Fahrenheit? About 214 or 230 degrees?

A. Oh, it is many degrees above the boiling point.

Q. About 230 degrees or 240?

A. I think so, yes.

Q. Now, in determining the solids in solution, what did you do in the filtered water?

A. Well, you see—the same thing.

Q. You evaporated it again to dryness?

A. Evaporated it, yes; put it in the oven and after it was perfectly dry, in the water bath, we put it in an oven for one hour at 110 degrees centigrade and the difference between the filtered water and the unfiltred water gives us the matter in suspension.

Q. In solution?

A. In suspension; the difference between the solids of the filtered water and the unfiltered water gives us the matter in suspension.

Q. Yes. That is right. And the difference between the 2172 solids in solution and the solids in suspension?

A. Yes. Just to give you an example, we found in 600 samples of distilled water, that has no solids at all, but what spring water and river water contain naturally—those are the solids we call in solution. Now, our unfiltered water, the muddy water, you know that is the mud is nothing but suspended matter. If you get it settling it gets clear. Now you see, supposing I make a sample of total solids and in one unfiltered sample supposing I found 600 parts per million and I filtered this water through a filter—we filter it through paper—

ATTORNEY-GENERAL CROW: Swedish filtering paper?

A. Swedish filtering paper, yes, and we get it perfectly clear and everything remains in the filter, and then we found perhaps 200. Now, the difference from 200 to 600 is 400. Those 400 parts is the matter in suspension, generally clay or mud.

Q. MR. JOHNS: Now, in getting the solids in solution you pursue substantially the same process as in the solids in suspension?

A. Yes, sir.

Q. Through the unfiltered water?

2173 A. Yes, sir; the same process.

Q. How long did you expose the residue after evaporation of the filtered water, to the water bath?

A. The same, just the same like the other one.

Q. How long did you expose the residue, the same residue to heat in the oven?

A. The same.

Q. One hour?

A. The same, one hour.

Q. As to the solids in solution did you ever dry them more than once or put them in the oven more than once as a rule?

A. Not as a rule, no.

Q. You occasionally might have done it?

A. Yes, in the first time I made this research to satisfy myself that it was all right.

Q. Now, what per cent. of solids in solution would you say existed in this water as an average, to your best recollection?

A. Well, I could not recollect it at all as we made so many rivers and so many samples that really I couldn't give even the average of our Intake Tower except I get my record.

Q. Well, having done this so many times, have you not a general idea which you could give of the amount of solids 2174 in solution?

A. Well, I tell you. I didn't expect to be here and Dr. Teichmann just when I entered the office, told me to come right here to the court and so I wasn't prepared at all, otherwise I would get my notes. Excuse me for not answering that question.

Q. I mean merely in your mind in its present state, this moment, have you no idea of the amount of solids in solution as a general thing which you found. I don't want you to be accurate. I simply want your general idea as you now recollect it.

A. I couldn't answer that question now.

Q. Now, you made a record of the amount of solids that you found in suspension and also of the amount of solids which you found in solution?

A. Yes, sir.

Q. You put them in a book?

A. Yes, sir.

Q. You did that personally?

A. Yes, sir.

Q. What book?

A. Well, small note book.

Q. Now, then, were those records copied into still an- 2175 other book?

A. No, they were entered right away in our schedule, those long tables.

Q. In your tables?

A. Yes, sir.

Q. By whom?

A. Well, I couldn't tell. I gave my books to Dr. Teichmann and Dr. Teichmann attended to this.

Q. Dr. Teichmann put that down?

A. Yes, sir.

Q. Now, did you ever examine the record in this table and compare it with the record that you made yourself in your book?

A. Sometimes, yes, sir.

Q. How frequently?

A. Well, I couldn't tell.

Q. About how many times?

A. Well, I couldn't give a definite—anyhow more than twenty times or forty times.

Q. More than forty times?

A. Oh, sure, yes, because I looked it over all the time. I don't recollect who entered those things in our tables but I compared it with my original book.

2176 Q. As many as forty times?

A. Oh, I think so, yes, sir.

Q. Did you have a regular habit of doing that at any regular or certain time?

A. No, sir.

Q. You had no rule with reference to it whatever?

A. No.

Q. Then, have you any recollection of any particular date when you did so, examine the copy in the tables which was taken from your book?

A. No, I haven't got that.

Q. So, if any particular table of the originals, was presented to you here now, you could not identify it as having been examined by you and known to correspond with your record from your own personal examination?

A. No, I could not.

Q. Now, do you know whether or not copies of those tables made from your book were made for use in this testimony here?

A. Oh, yes.

Q. Well, did you ever examine the copies you have used in evidence here, with the originals as to the work on the solids which you did?

2177 A. I don't understand your question.

Q. If I understand you, the memoranda of data in your book—

A. Yes, sir.

Q. Was copied by some clerk of Dr. Teichmann on a table?

A. That is right.

Q. Now, that table so prepared, was again copied, was it not?

A. No, I think that is our original table.

Q. Is it here?

A. Oh, yes, they are here .

Q. Whether or not any particular original sheet in which your memoranda from your book was copied, if it were presented to you, you could not say you had examined it, you don't know?

A. No, not each sheet. It was impossible.

Q. So, that in reference to any particular sheet containing your determination of solids you could not now say that they were correctly copied from the book?

A. No, I could not say that, but I think they are checked up all right. We have got our original books there.

Q. Excuse me, but I am asking you of your own personal knowledge.

2178 A. That is right. No, I couldn't say that.

RE-DIRECT EXAMINATION, by Attorney-General Crow:

Q. You made the original entries in a little book, did you?

A. Oh, yes, then they were stored away.

Q. And then they were copied from the books on to these sheets?

A. Yes, sir.

Q. Now, the comparison that you spoke of that you had made so many times, were by comparing the book in which you had made the original entries, with these sheets?

A. It was all right, yes, sir.

Q. You did yourself?

A. Yes, sir; over forty times, at least.

Q. Did you make a habit of doing that to see that your work was correctly copied?

A. Oh, yes, from time to time, because the clerk was sitting here at the work and I looked there at my work, whether it was copied right or not; but of course, we were very busy, I couldn't look after every figure.

HY. DETTMER.

2179 SHERMAN LEAVITT called as a witness on behalf of the complainant, being first duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION, by Attorney-General Crow:

Q. What is your name?
A. Sherman Leavitt.
Q. What is your occupation, Mr. Leavitt?
A. Chemist, Instructor at Washington University.
Q. Instructor in what?
A. Chemistry.
Q. Chemistry?
A. Yes, sir.
Q. How long have you occupied that position?
A. Since last November, the 24th of last November.
Q. Where did you study chemistry?
A. Washington University.
Q. Washington University?
A. Yes, sir.
Q. You have graduated, have you, in that science?
A: Yes, sir.

2180 Q. What practical experience have you had in chemistry?

A. Well, I was with the National Lead Company in Chicago for a year as chemist for them and then I was connected with Dr. Keiser as his assistant for about a year, a little over a year, and I worked on this work in the City Chemist's office under Dr. Dettmer.

Q. Talk a little louder.

A. I was down at the City Chemist's office under Dr. Dettmer and Dr. Teichmann for about four months, I believe. It was from the first of August, 1900, until the first of December, 1900.

Q. Now, what work did you do in the City Chemist's office?

A. I was under Dr. Dettmer, or rather I have worked on the total solids for Dr. Dettmer. I was under him.

Q. What time did you begin work there?
A. August 1st.
Q. What year?
A. 1900.
Q. How long did you work?
A. Until December 1st.

Q. December 1st, 1900?

A. Yes, sir.

Q. Did you work any more there?

2181 A. Not at the City Chemist's office.

Q. Did you work with Dr. Keiser afterwards?

A. Yes, I worked with Dr. Keiser in 1901.

Q. On samples of these waters?

A. Yes, sir.

Q. Well, you were an assistant to Dr. Dettmer, were you?

A. Yes, sir.

Q. You aided him in making his determinations for total solids?

A. Yes, sir.

Q. Are you familiar with the proper process to be had chemically for the determination of the total solids in water analyses?

A. Yes, sir, quite.

Q. Please state whether or not the usual and proper methods were employed there by Dr. Dettmer in making that determination?

A. Well, I think that was the method that was generally given by the best authorities.

Q. Where were these determinations made, in the city laboratory?

A. It was made in the City Chemist's office at 1141 Market street.

Q. Well, that is where the laboratory of the City

2182 Chemist's office is situated?

A. Yes, sir.

Q. Now, did you record the results of any determinations made by you?

A. Yes, sir; I recorded all of my results in my own book.

Q. In your own book?

A. Yes, sir.

Q. Then, what did you do with that book?

A. I turned it over to Dr. Dettmer and he then—he turned it over to Dr. Teichmann after seeing that it was all right.

Q. Now, was your work checked up and inspected by Dr. Dettmer?

A. Why, my work was entirely directly under his supervision. We worked almost side by side and I was under his authority and took all his directions. Whatever he told me to do I did, we worked exactly the same, at the same time.

Q. Now, you said you worked some with Dr. Keiser?

A. Yes, sir.

Q. In 1901.

A. 1901

Q. What was your part of the chemical work there?

A. Well, my part consisted—it was mere general work.
2183 I determined nitrites and nitrates and chlorides, and, well,
that was all I did, the main part of my work, nitrates, nitrites and chlorides.

Q. Now, in carrying on an extended examination of the waters of different streams, in a number of different streams, is it usual and necessary to have different chemists working on different portions of the work?

A. Yes, sir, it is; very often we have to do that. You see, with a large number of samples it is almost impossible for one man to cover any great amount of the work. There are so many things to be done, and it takes so much time.

Q. How many samples of water did you and Dr. Dettmer examine daily for the determination of total solids during the year 1901, from August to December?

A. In 1900, as I remember, we had 14. I think it was 14.

Q. Fourteen samples daily?

A. I think so, I am not positive about that.

Q. You were furnished samples every day, were you?

A. Yes, sir.

Q. Now, when you worked with Dr. Keiser, how many did you determine a day?

A. Well, Dr. Keiser and I did not do all of the samples that were taken there, we only did fourteen up there, whereas
I remember there were twenty-two taken altogether, some-
2184 wheres around there and we did fourteen of the principal
analyses out of the twenty-two.

Q. Well, fourteen samples daily was about as much as two men can handle for the determination of solids?

A. Determination of solids?

Q. Yes.

A. It was what we were doing. We did it very completely. We did it in the filtered and the unfiltered water and we did the loss on ignition and it made a great deal of work for two men, it kept two men busy, you see, we made a good many weighings in a day and if a man checked up his dishes faithfully, his platinum dishes, his changes in weight—we used it again and a great many weighings.

Q. And that was all detail work that had to be carried out?

A. Yes, sir.

Q. And the result thereof recorded as you pursued the investigation?

A. Yes, sir, recorded every day and each day's work dated. Anything that was out of order, it was recorded in a book. If anything didn't go just as it should I recorded it.

Q. You saw the samples as they came into the office?

A. Yes, sir.

Q. Were they all properly sealed?

A. As far as I saw them they were all properly sealed.

Q. Did you use any unsealed samples?

A. No, sir.

2185 Q. You had instructions against that?

A. When they were handed to me, you know, they had been opened, that is the men that did the nitrites— it was always customary to do the nitrites first, you know the oxidation is very rapid and they do the nitrites as soon as possible.

Q. That is the first thing that is done after the opening of the sample?

A. That was the first thing that was done after the opening of the sample.

Q. What did they do, take out a sample of the water?

A. Took out a sample for nitrites immediately.

Q. Now, then what was the next thing done with them?

A. It doesn't make any great difference, the ammonias should come next, the ammonias should come close to the nitrites, but the solids don't change, you know, the solids remain the same.

Q. And that would probably be done at the latter part of the work?

A. The solids could be done at leisure, almost any time.

Q. And the question of the length of time that the water had been kept would not interfere with the determination of the solids?

A. No, sir, not the total solids. It might be barely possible that some more might go into solution on standing

2186 any length of time. Of course, it is possible, you might have a little higher soluble solids as total solids, but the total solids of course, will be the same.

Q. What do you understand was the object of determining the total solids in water with reference to water analyses, what purpose does it show in the chemical examination of water?

A. Well, it merely shows the amount of matter which was held in solution. Of course, that shows more than the suspended matter. The suspended matter of course, is matter which can be filtered out and if it was removed of course, it would have nothing to do with the final quality of the water. That would largely settle out in a settling basin, but the dissolved solids, to my mind, show more than anything else, as far as solids are concerned, because they show the actual amount of solid matter which has been taken into solution.

Q. In other words, they show the natural chemical constituents of the water?

A. They show the natural chemical constituents of the water, that is the total chemical constituents.

CROSS-EXAMINATION, by Mr. Johns.

Q. You saw these packages with the seals upon them sometimes?

2187 A. Yes, sir.

Q. Where were they sealed?

A. Why, the seals were right on, as I remember it, they were on the side of the bottle, that is the stopper was always covered with a cloth and the seal as I remember, was on the side.

Q. Were the cloths tied down with a string?

A. Yes, I think it was tied with a string and then the seal placed on the string.

Q. On the string?

A. Yes, sir.

Q. Now, that seal was a wax seal?

A. Yes, sir; sealing wax.

Q. Now, did it have any designation on it, any stamp?

A. Well, I don't remember, I don't remember that fact.

Q. As to whether there was any designating mark on the seal?

A. No, sir; I haven't any recollection of that, because the samples as they came to me—that was merely what I noticed outside of my regular work.

Q. Now, the first thing done with water for analysis is the determination of the nitrites?

A. Yes, sir.

Q. And then the determination of free ammonia?

A. Free ammonia and albuminoid ammonia.

2188 Q. And then chlorines, and so forth, afterwards?

A. Chlorines and nitrates afterwards.

Q. You had a particular book in which you recorded the results of your labors?

A. Yes, sir.

Q. Dr. Dettmer had also a book in which he recorded his?

A. Yes, sir.

Q. You didn't work upon the same samples as Dr. Dettmer?

A. No, sir.

Q. But you worked side by side upon different samples?

A. Different samples.

Q. And then when you had your data reported in your book, and you delivered that to Dr. Dettmer?

A. Yes, sir; I delivered it to Dr. Dettmer.

Q. And then Mr. Dettmer's book and yours, do you understand that the results were noted onto tables or charts?

A. As I understand it, they were, yes, sir.

Q. Each sample that came in was numbered?

A. Yes, sir.

Q. When it came to you was it numbered?

A. Yes, sir.

Q. And then you put down in the book the number on the card on the sample?

A. The number on the card.

Q. And you put down the date, did you?

2189 A. The date of analysis, yes.

Q. You didn't put down the date that was upon the card, but the date of analysis, in your book?

A. Date of analysis, yes, sir; which was generally the same date.

Q. Generally the same day, I was about to ask you that?

A. Yes, as close after it as possible.

Q. Do you, as a rule—did you determine the solids very soon after the samples arrived in the office, in the laboratory?

A. Well, as soon as we could.

Q. What would prevent your doing it immediately?

A. Well, the rate of evaporation, the gas supplies had a great deal to do with it. Of course, some days we would not get as much gas supply as we would on others, after the evaporation, and then we were limited in our platinum ware. The platinum ware is very expensive and we were limited to a certain extent, limited in platinum ware, that is we could not keep up if extra samples were sent in as they were very often. We would get three or four days behind.

Q. Would there be some days in which you did not analyze for solids until 24 hours or 36 hours after samples arrived in the office?

A. There have been occasions when that has occurred, yes, sir.

Q. Now, your samples arrived at your place what time in the day?

2190 A. Well, as I remember it, it was about two o'clock in the afternoon.

Q. How long did it take you to conduct the analysis of one sample for solids?

A. Well, we didn't carry on one at a time, you know, we always carried on—

Q. You carried fourteen?

A. No, sir; we had eight dishes, we did it in sections. As I remember it, each man had eight dishes—that is, I am speaking entirely of my own work now. I had eight dishes and there were four samples of water. One dish was for the unfiltered sample and there was a corresponding dish for the filtered sample. That would make four samples at a time in a set.

Q. Well, when you commenced evaporation, for instance, of the unfiltered water, you put in four samples to be evaporated?

A. Yes, sir.

Q. And in the same way as to the filtered water?

A. Yes, sir.

Q. Now, did you evaporate the unfiltered and the filtered water at the same time?

A. I did.

Q. Did you dry the samples of the residue from the unfiltered water and the filtered water in the same water bath?

2191 A. Yes, sir.

Q. And at the same time?

A. At the same time, yes, sir.

Q. Did you then heat the samples of the residue of the unfiltered and the filtered water in the oven at the same time?

A. I did.

Q. How many samples would Dr. Dettmer have under his direction at the same time that you were operating on four?

A. The same number.

Q. Four?

A. Yes, sir.

Q. And the ones that he used were put in the water bath at the same time as yours?

A. They were put in his water bath and mine were put in my own.

Q. You each had separate water baths?

A. We each had separate water baths, yes, sir.

Q. Did you have separate ovens?

A. We had separate ovens, yes, sir.

Q. So that the four samples handled by each of you were dried in separate places?

A. Yes, sir.

Q. How long did you dry samples of residue in the water baths?

2192 A. One hour.

Q. How long did you dry them in the oven?

A. Oh, in the water bath?

Q. Yes?

A. I beg your pardon, it took longer than that as a rule. It took about an hour and a half anyway to dryness. As I say, that depends upon the gas supply and the rate of evaporation.

Q. Now, it varied according to your gas supply, and according to the rate of evaporation, of course?

A. Yes, sir.

Q. The dryness was determined by observation merely and knowledge of the dryness came from your experience and observation of it?

A. Certainly.

Q. Then after it was dried in the water bath, was it immediately taken to the oven ?

A. Yes, sir.

Q. And kept in the oven how long?

A. One hour.

Q. One hour?

A. Yes, sir.

Q. And then taken out and put in the dessicator?

A. Put in the dessicator.

2193 Q. And then when cool—how long, as a rule?

A. About fifteen minutes is the usual time allowed for dessicating.

Q. And then it was weighed?

A. Yes, sir.

Q. And after the weighing it was then heated to ignition?

A. It was.

Q. You never dried the samples twice in the water bath, or three times?

A. I don't exactly understand—

Q. You never exposed the residue of either filtered or unfiltered water to the drying process twice or three times?

A. Any of them?

Q. In the water baths?

A. Why, no, sir.

Q. Did you ever expose them or was it your custom to expose them twice or three times to drying in the oven?

A. No, sir.

Q. Not but once, as a rule?

A. Once, as a rule.

Q. And were they weighed between the water bath and the oven?

A. Between the water bath and the oven?

Q. Yes.

A. Oh, no, never.

2194 Q. Never?

A. Always after.

Q. Then they were never weighed but once?

A. They were weighed once after coming from the air bath, and then weighed once after ignition.

Q. Well, perhaps I misunderstood you. Do I understand you that the air bath is the oven?

A. Yes, sir. I didn't understand what you were getting at.

Q. Air bath is the proper term. They were weighed only once before ignition and that was after they came out of the water or air baths?

A. That is all.

Q. And then they were weighed after ignition again?

A. They were weighed again after ignition, yes, sir.

Q. And so the total solids both in suspension and solution were determined?

A. Yes, sir.

Q. Now, you put down in your book for your samples the total solids and matters in suspension, I presume?

A. First, in suspension.

Q. Second in solution?

A. Second in solution.

Q. Third after ignition, after heating to ignition?

A. Third after ignition. That was suspended, and then
2195 fourth after the ignition of the soluble matter.

Q. So that you made in your book each time, as to each sample, how many entries?

A. Well, there were four general entries there.

Q. Just for solid matter in suspension?

A. For solid matter in suspension.

Q. And solid matter in solution?

A. And solid matter in solution after ignition and soluble matter after ignition.

Q. The heating to ignition drives off everything but minerals, does it not, all vegetables?

A. It burns off any organic matter.

ATTORNEY-GENERAL CROW: Carbonaceous matter?

A. Carbonaceaus matter.

Q. MR. JOHNS: Now, these entries were made in your book in separate columns under separate headings?

A. Yes, sir; two pages were devoted to each sample. The left hand page was devoted to the solids in suspension and underneath it would be the ignition. Then on the right hand page would be the solids in solution and underneath that the ignition of the solids in solution.

Q. That would make two entries on each page?

A. That would make two entries on each page?

Q. Then you delivered your book to Dr. Dettmer?

A. Yes, sir.

2196 Q. And do you know as a matter of fact, what afterwards was done with the entries made by you?

A. Nothing that I know of personally except that the books were locked up in the safe afterwards. That is all I know about that.

Q. As to the copying into the table, you had nothing to do with that?

A. I had nothing to do with that, no responsibility about that.

Q. And you made no observations after that?

A. No, sir.

Q. Nor any comparisons?

A. Nor any comparisons.

Q. Was this copying done on the same day on which the entries were made on the tables, or do you know that?

A. I don't know.

A. Were these tables—if I understand you, you have not examined these tables as to correctness, as compared with your books?

A. No, sir, I have not been over them at all.

2197 RE-DIRECT EXAMINATION, by Attorney-General Crow.

Q. The work that was done by Professor Keiser and you on these samples in 1901, do you know where these samples came from?

A. In 1901?

Q. Yes.

A. Well, I don't know as I can remember them all right now.

Q. Well, but I don't mean places on the river. From what source did you receive the samples?

A. Well, they came from the City Chemist.

Q. What condition were they in when they came to your office?

A. They were still sealed in exactly the same way as they were when I worked on them there, just the same kind of a bottle.

Q. Now, was the proper process followed there for the determination of the chemical elements in the water?

A. Yes, sir.

Q. You worked, I believe you said, for nitrites and nitrates?

A. Nitrites, nitrates and chlorides.

Q. And that is all you had anything to do with?

2198 A. That is all I personally had anything to do with.

RE-CROSS-EXAMINATION, by Mr. Johns.

Q. You were with Dr. Keiser in 1901?

A. Yes, sir.

Q. I haven't a minute here of the time, what time were you there?

A. Well, it was October 1st, I think, to December 1st.

Q. What time in the day would the samples arrive at Dr. Keiser's office?

A. We received them there about 2 o'clock. I always received them when they came in. They would arrive about 2 o'clock as I remember.

Q. That is, they were brought to your place from the City Chemist's Office?

A. Yes, sir.

Q. And the samples were delivered to you?

A. Yes, sir, personally.

Q. Now, then, you saw the seals upon those, I presume?

A. Yes, sir, I did.

Q. Was there any designating mark upon those seals?

A. Well, I never noticed a mark, I never took the trouble to notice what was the designating mark on them. I merely noticed whether they were sealed or not.

2199 Q. Now did you then commence analyses for nitrites, nitrates and chlorides immediately?

A. I commenced the nitrites immediately, yes sir.

Q. Took nitrites immediately?

A. Took nitrites immediately always started with that immediately.

Q. How long would that operation take?

A. Well, it would take about—well, to draw the samples from the bottles, it would take perhaps fifteen minutes, and then the addition of reagents would take perhaps fifteen minutes more, and then they were allowed to stand for an hour and then they were filtered, and then allowed to stand, so that all together I suppose it didn't take over an hour.

Q. For each sample?

A. Yes, for the set, for the series, you know—for the fourteen.

Q. For the fourteen?

A. For the fourteen.

Q. If fourteen samples came in you commenced examination on the nitrites on the fourteen samples at once?

A. Nitrites were done immediately—we always made it a point to do the nitrites just as soon as possible.

Q. Now, did some other person work with you, side by side, in the determination of nitrites, or did you do that all
2200 yourself?

A. I did that entirely under Dr. Keiser's supervision; that is, he had general supervision over me.

Q. But you did the work on the fourteen samples?

A. I did the work on the fourteen samples.

Q. Of course that consisted of in each case of drawing a certain number of centimeters of the water?

A. Yes sir.

Q. And of putting in the reagents?

A. Yes sir.

Q. And of making the standard test tubes?

A. Yes sir.

Q. And the comparisons.

A. Yes sir.

Q. So that you could perform the work upon the nitrites during ordinary working hours?

A. Yes sir

Q. Before six o'clock, say?

A. Oh, yes sir.

Q. Well then, when did you commence on nitrates?

A. As soon after as I could,—as soon after the nitrites, as I could.

Q. Did you complete your work upon nitrites before you did any work upon the nitrates?

2201 A. No sir, while the nitrites were filtering, I then started my nitrates evaporating.

Q. So that the two processes went on simultaneously?

A. The two processes went on simultaneously—together, the nitrates of course being behind the nitrites in the readings.

Q. Now when did you commence work on the chlorides?

A. The chlorides I generally did the following morning.

Q. The following day?

A. Yes sir.

Q. But before you left the samples of that certain day the nitrites and the nitrates had been determined?

A. Had been determined, yes sir.

Q. What kind of tubes did you use for comparison?

A. The ordinary Nessler tube, 100 cubic centimeter Nessler tubes.

Q. Of what length, ten, twelve or fourteen inches?

A. I don't remember, I think they were about twelve inches.

Q. About twelve inches?

A. Yes sir.

Q. Both for the samples to be examined, and for the standard?

A. For the standard, yes sir.

Q. Those standards of course were built up after the sample under examination had assumed color?

2202 A. No sir, the standards were made up at the same time that I was preparing to put my reagents into the waters themselves, so that the reagents went into the standards at the same time that they went into the waters. They developed together.

Q. Of course in ascertained quantities?

A. Yes sir.

Q. And that work all could be done at the same time,—the reagents could be put into both tubes?

A. Yes that could be done at the same time.

Q. Then the determination of nitrites is by observation of the colors of the standard and the sample?

A. By comparison.

Q. By comparison?

A. Yes sir.

Q. How was that comparison made?

A. By the eye.

Q. Under what circumstances of observation?

A. Reflected light, from white surface.

Q. Upon a white surface?

A. Upon a white surface.

Q. What kind of a white surface—porcelain?

A. Either porcelain or paper.

Q. Or paper?

2203 A. Of course being under the same conditions. It wouldn't make any difference provided you had them both in the same condition, it was all right.

Q. If paper, what kind of paper was used ?

A. Well, writing paper.

Q. Ordinary writing paper?

A. Un-ruled writing paper.

Q. Now you made records of these examinations for nitrites, nitrates and chlorides?

A. Yes sir.

Q. In books?

A. In books.

Q. How many samples would you carry along at one time—fourteen?

A. Fourteen—kept the whole fourteen together.

Q. Well, as to nitrites, you did that?

A. I personally did nitrites, nitrates and chlorides.

Q. And you carried the fourteen samples along together?

A. I carried the fourteen samples along together.

Q. Now how many entries would be made in your book as to one particular sample, for nitrites?

A. Well, there would be an entry of the number of cubic centimeters of the standard nitrites solution which would match that water. There would be one entry for nitrites.

2204 Q. There would be one entry for nitrites?

A. Yes, of course the number, and one single entry.

Q. Number of the sample and one entry for nitrites, and that would be the constituents of the standard?

A. Yes sir.

Q. How many did you make for nitrates?

A. One entry for nitrates, with the number.

Q. In addition to the number?

A. Yes sir.

Q. And how many for chlorides?

A. There would be one—the same way.

Q. Were they all made in the same book?

A. No sir, there were three separate books.

Q. Each in a separate book?

A. Each in a separate book.

Q. And those entries when made by you were delivered to whom?

A. Dr. Keiser.

Q. What became of them after that?

A. Well, we worked over them after that, we worked together in making up our final records. Of course they have to be changed, you know, that is, as they are in the books, you have to compute them in different values, and parts per million.

2205 Q. Well now, was that entry made in your book, in your original book, the parts per million, after the calculations were made?

A. Yes sir.

Q. So as to each sample then there would be the number and the first entry as to nitrites and then the parts per million?

A. Then the parts per million.

Q. And then as to each sample in your book for instance there would be three entries?

A. There would be three final entries.

Q. There would be three final entries?

A. Yes sir.

Q. Now, after that was done your custody or supervision of the book ceased as to any particular entry?

A. They were drawn up on the charts of course, afterwards.

Q. Well, did you do that work?

A. Yes sir, I did.

Q. In putting these upon charts, did you do it entirely during the time you were there?

A. Yes sir.

Q. Both for yourself and any other person as to those three things,—you did it entirely on the charts?

A. I put that entirely down myself.

2206 Q. Those entries upon the charts were directly from your books?

A. Directly from my books.

Q. They were not entered into a larger book, much in the character of a ledger, and then copied from the ledger on the charts?

A. No sir, they went directly from the books onto the charts.

Q. And during the entire time that you were there you copied from your book directly upon the charts?

A. Yes sir.

Q. And what became of those charts afterwards, do you know?

A. I presume they are in Dr. Keiser's possession.

Q. Do you know whether or not a copy of that entry upon the charts was made upon another similar chart?

A. I do not.

Q. Do you know whether the originals of those charts were embodied in a report of Dr. Keiser to the City Chemist, and became a part of his report to the municipal government of St. Louis?

A. I do not. You see I left the city shortly after that work was done and what occurred after that, I have no knowledge of.

Q. Now as to nitrites and nitrates, the quantity in the sample is determined by observation of a standard tube made 2207 up with certain known quantities?

A. It is.

Q. And whether the color in the known standard test tube is the same as the color in the tubes, containing the sample, is a matter of correctness of eye-sight?

A. It is a matter of personal judgment, by eye-sight.

Q. Of personal judgment?

A. Yes sir.

Q. Placed side by side for observation, the two tubes?

A. Yes sir, under the same conditions.

Q. So that if a man was color-blind, the two tubes, if they were not the same, would look the same to him at any rate?

A. Well, that would depend entirely, I think, upon the degree of color-blindness.

Q. Now for instance, supposing a man who is unable to tell any shade of red from any shade of green—that happens to be my individual misfortune—could he be used to determine these colors by observation?

A. Well, I am not very well posted on that subject, but I think it is more the intensity of the degree of color rather than the color itself that counts. I don't know how a man would be fixed on that.

Q. Well if for instance your eyes were entirely correct and you had no defect as to color, no color-blindness, in 2208 order to determine the nitrites, your correct vision would show you by observation that the colors in the sample tube and the standard were the same?

A. Yes sir.

Q. And of the same intensity?

A. As near alike as possible.

Q. If a man had some slight color-blindness, do you know whether the two, if they appear exactly alike to the person of normal sight, whether the two would appear exactly alike to the man so affected?

A. I should think they would; I don't think it would have anything to do with that.

Q. Nothing to do with it?

A. I don't think so.

Q. So that whether a man was color-blind or not in any degree would not make any difference as to the observation of differences between the two tubes?

A. I should not think so. I don't see any reason why it should.

Q. It is purely a matter of observation?

A. I think so.

Q. And the more experienced the observer, the more likelihood of correctness in the results?

A. Yes sir.

2209 Q. And the less experience of the observer, the less the likelihood of correctness in the results?

A. I think so.

RE-RE-DIRECT EXAMINATION.

By Attorney General Crow.

Q. Those bottles were all tagged, were they not, when they came to your office—that is, tags were attached to them?

A. The number of the tag—The tag numbered and sealed, yes sir.

Q. Well, they had a tag also, didn't they?

A. The tag with the number on—the number and the place they were from, yes sir.

ADJOURNED until 10 o'clock A. M. following day, Saturday, March 21, 1903.

2210 Southern Hotel, St. Louis, Mo., 10:00 A. M. Saturday. March 21st, 1903. Present, the Commissioner and same Counsel representing the respective parties.

WILLIAM H. GOETZ,

a witness called on behalf of Complainant, the State of Missouri, after being duly sworn by the Commissioner, was examined in chief by General Crow and testified as follows:

Q. What is your name?

A. William H. Goetz.

Q. What is your address?

A. 5328 North Broadway.

Q. What is your occupation?

A. I am in the mechanical department of the City Water Works.

Q. What is your profession?

A. I am a civil engineer.

Q. Have you ever studied chemistry?

A. Yes sir.

Q. What education have you had in a chemical way?

A. I had two years at college and then my experience since.

Q. What kind of a college do you mean?

2211 A. The Cincinnati University.

Q. Is that a Chemical College?

A. Well, it has a complete chemical course.

Q. Whom did you study under there?

A. Professor Thomas H. Norton.

Q. What particular experience have you had as a chemist?

A. Well, I worked in the investigation at Cincinnati under Mr. George W. Fuller.

Q. What investigation?

A. The investigation there, prior to the installation of the new water works to determine the best system of filtration or the best method for purification of the water.

Q. Well, you worked on water analysis there?

A. Yes sir.

Q. What waters were you working in?

A. The Ohio River.

Q. How long a period of time did that cover?

A. Well, that covered four months about on that examination.

Q. What class of work were you doing there?

A. The chemical analysis of the water.

Q. Now, what other experience of water analysis have you had?

A. Well, after that investigation we didn't do any regular chemical work on water but samples were coming in 2212
there from time to time for about a year after that from different parts of the country.

Q. Well, you worked on that did you?

A. Yes sir.

Q. What other experience have you had on water analysis?

A. Just what I have had here in St. Louis.

Q. How long a period of time did that cover?

A. That was from about the 25th of February, 1900, to the 8th of January, 1901, and about the 6th of September, 1901, to the 8th of January, 1902.

Q. Whom did you work for here?

A. For Dr. Teichmann.

Q. What part of the work did you perform?

A. Well, I performed the analytical work, that is assisted in the analytical work, and working up the results afterwards, getting them tabulated and averaged in the form of charts.

Q. Now when did you first go to work for Dr. Teichmann?

A. I think it was either the 25th or 26th of February, 1900.

Q. How long did you work at that time?

A. I worked until the 8th of the following January, very nearly a year.

2213 Q. Now did you do nearly all your work in the City Laboratory here?

A. Yes sir.

Q. In the City Chemist's office?

A. Yes sir, I think it was all done there as near as I can remember.

Q. Did you do any particular branch of the work, as to solids or nitrites or nitrates?

A. We divided up the work and then traded around, I think during the course of the work, I did at one time or another, all the determinations except on the ammonias, I don't remember doing that.

Q. Now, after the result of the analysis was obtained, was there an estimate made any place of that result?

A. Yes, it was always copied in note books.

Q. Made at the time of the analysis?

A. Yes, right at the time.

Q. Well, was there any record made from those note books?

A. Those were afterwards collected and systematized into these large record sheets which were printed for the purpose and the analyses from the different points were collected and then averaged and then in the 1900 results there were also extra sheets made of weekly averages from the different points.

2214 Q. Did you have anything to do with that work?

A. Yes sir.

Q. What did you have to do with that work?

A. Well, Mr. Miller and myself practically had charge of that work, of getting those together, we had about four clerks that were helping us.

Q. Mr. Miller and you superintended the transcribing from the note books on to these analytical sheets the results of the analyses of the water samples?

A. Yes sir.

Q. Did you and Mr. Miller check all that work and see that it was correct?

A. Yes sir, we checked everything.

Q. Have you got those sheets here?

A. Yes sir.

Q. Just get them and see that they are the same sheets and if there is anything indicating that you did that work?

A. These are the same. These are the ones containing the weekly averages during 1900 for the different stages.

Q. Well, those sheets were made from the note books, were they?

A. Yes sir.

2215 Q. Then they were checked over to see if they were correct?

A. They were checked, yes sir.

Q. By whom?

A. They were checked by Mr. Miller and myself.

Q. Well, are those sheets you have there correct transcribings of the work from the notebooks.

A. Yes sir.

Q. Now do you know what waters these samples came from that these results here are the analyses of. Do you know where the waters were from that were analyzed?

A. Yes sir.

Q. Where were they from?

A. They were, a very few samples, from the lake and samples from the old Canal at Bridgeport and the Drainage Canal at Chicago and at Lockport, in the Desplaines River and the Canal and the mixture of the two, and the samples above Joliet and below Joliet and down at various stations along the Illinois River to Grafton and samples in the Mississippi and Illinois Rivers at Grafton.

Q. Well, the various locations from which the samples were taken are set down on these charts?

A. They are all marked on the charts, yes sir.

Q. Now did you have anything to do with the making of these maps on which the curves are?

2216 A. Yes sir.

Q. Who made those?

A. Well, Mr. Miller and myself made those.

Q. You made them under the supervision of Dr. Teichmann?

A. Yes sir.

Q. Now from what were those charts made?

A. Those were made directly from these weekly averages.

Q. And they are based on these figures and are the results of the analyses of these water samples?

A. Yes sir.

Q. Now what other periods besides from February, 1900, to January, 1901, did you work for Mr. Teichmann?

A. From about the 6th of September, 1901, until about the 8th of January, 1902.

Q. Now, what portion of the work did you do then?

A. The work was very similar to what had been done the previous year. We helped in the analytical work and we were collecting data afterwards and systematizing.

Q. Do you know where these samples came from you were working on?

A. Yes sir.

Q. Where?

A. Approximately they were about the same places as the others, with some changes.

2217 Q. Well, were the results transcribed in the books?

A. They were taken down in books, yes sir, transcribed to the sheets.

Q. Did you check those sheets, you and Mr. Miller?

A. Yes sir.

Q. You have those sheets here?

A. Yes sir, we have them here.

Q. Are these the sheets (referring to tables)?

A. Yes, those are the 1900 and 1901 sheets.

Q. Well, from checking and examining that you and Mr. Miller did and comparing those results with the data in the books, I will ask you are these sheets a correct record of the result of the analyses of these water samples?

A. Yes sir.

Q. Now, were there any maps and curves made from these?

A. Yes, we made curves similar to the ones we had made the previous year.

Q. And these curves on these maps were based on these figures?

A. Yes sir, on the weekly averages.

Q. Now, what other period did you work, if you did work any other period?

A. No sir, that was all.

2218

CROSS EXAMINATION

By Judge Johns.

Q. Of what college are you a graduate?

A. The Cincinnati University.

Q. When did you graduate there?

A. In 1897.

Q. You worked in the laboratory connected with that college in a course of chemistry?

A. Yes sir, two years.

Q. Was it during your under-graduate course that you assisted in the analysis of the water of the Ohio River?

A. No sir, it was afterwards.

Q. You afterwards did that?

A. Yes sir.

Q. How long were you connected or engaged regularly and continually in the analysis of waters at Cincinnati?

A. About four months.

Q. How long did you remain in Cincinnati after that?

A. I remained there a year after that.

Q. Were you in the laboratory continuously after that studying chemistry?

A. Yes, I was in the laboratory after that.

Q. Continuously after that year?

A. Yes sir.

2219 Q. Engaged in the general study of chemistry?

A. Yes, general work connected with that department.

Q. With what department?

A. With the laboratory which had been built for the purpose I have just stated, for the new water works they were building there.

Q. Well, under some officials of the City of Cincinnati?

A. Well, under Mr. George W. Fuller, who was employed by the City.

Q. And you worked in that laboratory continuously, a year?

A. Well Mr. Fuller was only there the first four months, then after he left I was there about a year afterwards under a man who had been the principal chemist while Mr. Fuller was there.

Q. Well, were you at that time a resident of St. Louis?

A. No sir.

Q. When did you become a resident of St. Louis?

A. I will have to ask you what you call becoming a resident?

Q. Coming here to live permanently.

A. The 25th of February, 1900.

Q. You went then directly into the laboratory of the City Chemist, Dr. Teichmann?

2220 A. Yes sir.

Q. What did you first do in the laboratory?

A. Well, as soon as we could get the things or work definitely outlined we took up the analysis of the samples that were coming in.

Q. Wasn't the laboratory organized and in full working order for the analyses of waters before the 25th of February, 1900?

A. Yes, I guess it was but being a number of new men at that time they had to increase the facilities.

Q. So some addittions were made to the laboratory at that time?

A. Yes sir.

Q. Were you engaged in making these additions before you commenced the work of analysis?

A. Well, I was indirectly interested in them but I had no supervision over them.

Q. Well, before the 25th of February had you anything to do with them?

A. No sir, nothing to do before the 25th of February.

Q. Now, when after the 25th of February did you actually commence as an assistant in the analyses of these waters?

A. Well, it wasn't over three or four days probably.

2221 Q. What did you first do?

A. Well, the first thing we did, or rather the first thing I did—

Q. Yes, you individually?

A. Was to make the chlorine determination on some samples which were at that time in the laboratory; some back samples in which all the other determinations had been made except the chlorines, I worked those up the first day.

Q. How old were those samples when you worked on them?

A. Those were samples which had been taken before I came there, there was comparatively few of them.

Q. How many?

A. I don't think over 100 of them.

Q. Do you know from what points they were?

A. They were taken from the same points as the samples which were taken later, only there were not so many stations of collection at that time.

Q. Now, take any one particular sample in which you determined the chlorines, can you tell how long it had been in the laboratory before this chlorine determination?

A. No sir, I couldn't say just how long.

Q. Did you do any other work in analysis than chlorines?

A. Yes sir.

2222 Q. What else?

A. Do you mean right here at the start?

Q. Yes.

A. We divided up that work, the different analyses, and each one of us took two or three of them approximately to make the work even. Then we would change about once a month but I don't remember just what analyses I had at first.

Q. Do you remember what you were next engaged in analyzing, what elements you looked after, after the chlorines?

A. I don't remember which ones.

Q. How many people were in that laboratory when you went there?

A. Dr. Teichmann, Mr. Buckland, Dr. Dettmer and a clerk. There were several others around there, I don't remember the names of them at present.

Q. How many people all together now, from the janitor up to Dr. Teichmann, including the whole force were in that laboratory while you were there?

A. When I came there first, do you mean?

Q. Yes.

A. Well, I don't remember distinctly, I should say somewhere from eight to nine.

2223 Q. Did you work at any time individually, on the solids in suspension?

A. I did for a short time, I think about two or three days was all I had.

Q. Did you work at any time in nitrites?

A. Yes.

Q. How long a time did you work on them?

A. Well I took about a month at a time, several times. I suppose two or three months all together, I don't know exactly.

Q. You changed around?

A. Yes sir.

Q. No one of the men or two men devoted their entire time and attention to the determination of any one particular element of pollution in water?

A. We did it by the month or so at a time.

Q. I mean during the entire period?

A. No sir, at least I didn't.

Q. So that your force were constantly shifting?

A. Well, the shifting principally was confined mostly to the three of us, Mr. Benneker, Mr. Miller and myself. I don't think there was any change amongst the others. Dr. Dettmer, for instance, devoted his time to solids during the entire investigation.

2224 Q. And Mr. Buckland, what did he do?

A. This shifting arrangement was merly between us three, Mr. Miller, Mr. Benneker and myself.

Q. What did Mr. Buckland do?

A. This shifting arrangement was merly between us three, Mr. Miller, Mr. Benneker and myself.

Q. What did Mr. Buckland do?

A. Well he is the Assistant City Chemist there, and had charge of the different parts of the work. I don't remember just exactly the schedule?

Q. What work did he actually perform himself?

A. Well, he had charge of the ammonia distillation for a part of the time. I couldn't say just exactly what his work was? My work was mostly in the adjoining room.

Q. Did you have any person there working with you, by your side, as a companion during this time?

A. In the nature of an assistant do you mean?

Q. Yes or companion. That is, did you work in teams?

A. No sir we worked singly.

Q. For instance, if a person would work at the determination of solids in suspension, he would have charge of a certain number of instruments to use for the evaporation of the water?

A. Yes sir.

2225 Q. And some other person would have charge of a certain number of others, of the flasks for evaporation?

A. Yes sir.

Q. But when you were doing the work, say nitrites for instance, who worked with you?

A. On those determinations?

Q. Yes on those determinations?

A. Nobody.

Q. You did that entirely?

A. I did that myself, yes sir.

Q. When you worked at the chlorines who worked with you?

A. No one.

Q. You did the work yourself?

A. Yes sir.

Q. And how many samples of the chlorines would you determine each day?

A. Why, that we—we determined the number of chlorines in the number of samples that were taken that day.

Q. Well, if there were fourteen samples that day, you determined the chlorines in them?

A. We did fourteen chlorine determinations.

Q. Now if the samples came in at two o'clock in the afternoon, or three o'clock, did you work on the chlorines for
2226 that day on those samples?

A. Worked upon all samples that were unpacked on that day. The samples which came in too late were kept packed in ice until the following day.

Q. Then if some were kept over until the following day, you worked on them until the arrival of the others the following day?

A. Sir?

Q. If some samples were kept over in ice, you worked upon them in the forenoon of the next day until the samples arrived for that day?

A. The samples began coming in early in the day, in the morning, and those samples we worked up that day.

Q. From what points did the samples come in, in the morning?

A. I am not familiar with the time of the arrival of the samples.

Q. Do you know that any did come in the morning of any day?

A. Yes sir, I do.

Q. Well, where from and who brought them and what time did they arrive?

A. I am not familiar with the schedule of those samples coming in, except as I incidentally saw them coming in.

Q. You think your recollection is you saw samples coming in in the morning?

2227 A. Yes sir, that's my recollection; not early in the morning, probably around eleven o'clock, or so.

Q. Now when you made the determinations for chlorine, for instance, you put down in your own handwriting in the book kept by you, that determination?

A. Yes sir.

Q. So many parts per million, I presume?

A. We put down all the figures connected with the determination, not merely the final result in parts per million, but the two readings which were taken to determine that. That is we read the burette before making the determination and afterwards and then substracting those two readings, and the diffrence represents so many parts per million.

Q. Now how many entries in the book was it necessary to make in order to determine the parts per million of chlorine for instance?

A. It required two readings and the result.

Q. Now in the first place you found upon the samples a tag?

A. Yes sir.

Q. With a number?

A. Yes sir.

Q. And the statement of the place from which it was taken?

A. Yes sir.

2228 Q. The temperature of the water and the air, didn't you?

A. Yes sir.

Q. Did you put them all down in a book?

A. We put down the place and number,—that is we always put down the number.

Q. Did you always put down the place?

A. I think very nearly always, but I wouldn't be positive as to that.

Q. Now did you put down the temperature of the water?

A. No sir.

Q. Or of the air?

A. No sir.

Q. After you had recorded so much as you did, off the tag, what was next put on the books?

A. Well, the books were ruled up for the different determinations.

Q. I am confining your attention at this moment to the chlorines?

A. Well, there was a column in which we put down the initial and final readings of the burette, and then the third column.

Q. That would be two entries?

A. That would be two entries, and then there would be the third column for parts per million.

Q. And that third column would be arrived at by subtracting the second from the first wouldn't it?

2229 A. Well, possibly we would need an extra column in there because one cubic centimeter represented ten parts per million so the result would have to be, if you substracted your results, as to cubic centimeters, you would have to multiply your result by ten for parts per million.

Q. Now do you remember whether you put down that column from which the multiplication arose?

A. The multiplication of it is to be done afterwards.

Q. You substracted and carried out the multiplication and then put down the final result?

A. It was merely changing the position of the decimal point.

Q. After the subtraction?

A. Yes sir.

Q. Now when you got that down in the book it was afterwards transcribed onto the sheets was it?

A. Yes sir.

Q. Onto these sheets and such sheets as you have now before you?

A. Yes sir.

Q. Well, the determinations in the book were each for a different sample?

A. Yes sir.

Q. And on different days?

A. Well, the determinations of record in the note books
2230 was kept in regular order; that is, numbered.

Q. According to number?

A. Yes, according to number.

Q. That determination was for every day, for daily samples from some particular place, each of a number of particular places?

A. Yes sir.

Q. Then you added up those determinations and divided them by seven?

A. Yes, after sorting them out, collecting and transcribing the results onto these sheets, we put all of the results on one sheet and from another point onto another sheet, that is, separated the different points.

Q. You never transcribed from your book literally, line for line and figure for figure, the result of each day's determination of each sample, onto the sheet did you?

A. You mean those extra columns that you were speaking about?

Q. Yes?

A. No sir.

Q. Did you transcribe from your book each day all the results of the final results of the determinations for chlorine, for example, from your book, each day onto the same sheet?

2231 A. No sir, that wasn't done until afterwards. This transcribing, if that's what you mean, wasn't done every day.

Q. You don't understand me. Did you ever transcribe from that book upon a sheet the result daily of the determination of chlorine of each sample analyzed that day?

A. All results were transcribed onto these sheets for every analysis that was made; the results were put onto these sheets in the order in which they were made from each place. That is, say the first month and second month and so on in regular order.

Q. You don't understand me, I am afraid. Suppose you analyzed a sample on the 15th of February, 1901, of chlorine?

A. Yes sir.

Q. And suppose, in addition to that one sample you analyzed thirteen others on that day?

A. From different places?

Q. From different places.

A. Yes sir.

Q. Now each one of those determinations was put down in a book?

A. Yes sir.

Q. Making thirteen separate entries upon thirteen separate horizontal lines, for those thirteen samples?

2232 A. Yes sir.

Q. Now then, did you ever transcribe those as they were for that day upon any sheet, each one of the thirteen?

A. Taking them in the same order?

Q. Yes.

A. No sir.

Q. Did you ever transcribe those as for one particular place for instance, the Intake Tower on the one particular sheet?

A. Taking all these from the Intake Tower on the days as they succeeded each other, on the one particular sheet?

Q. Yes.

A. Yes sir.

Q. Now for example, suppose if you took samples from January 3rd to January 10th, 1900, at the Intake Tower, and you analyzed them for chlorines, and you set down in your book the results of the analyses of each sample during that week from the Intake Tower, did you then copy that directly upon a sheet, each one of the seven?

A. Yes, each one of the seven.

Q. What sheet is that upon?

A. That is, personally I didn't make those, but I checked everything. I didn't do the clerical work.

2233 Q. I am not confining you to that. Take one sheet, the top one for instance, and show me on that sheet where is recorded the daily results of the analysis taken as to the particular element mentioned there, at a particular point?

A. Do you want to see it?

Q. Yes.

A. Here is the sheet (showing table to counsel).

MR. JOHNS: Intake, Chain of Rocks, 1901, November 1st to November 30th. That's the heading.

Q. In the first column headed "Total" the figures on the first line are 1175, what does that mean?

A. That is the residue on evaporation and the parts per million.

Q. Of one particular sample?

A. That particular sample taken at the Intake on November 1st.

Q. No. 6007?

A. Yes sir.

Q. And those are each set down there?

A. Yes sir.

Q. And that was done?

A. Some of them were, either done—

Q. By you or under your direction?

2234 A. They were all checked up, yes sir, that is by Mr. Miller and myself.

Q. Now have you in addition to these, weekly averages made up from these daily tables?

A. We have on this night work that was done in 1901, weekly averages are made right onto these sheets, and the work done in 1900 they were made on separate sheets.

Q. Now then for 1900, as far as you know, you put down upon these tables, the results of the daily analyses of each sample?

A. Yes sir.

Q. And in 1901 you put down, as far as you know, the weekly averages?

A. We put down the same thing, daily results for 1901.

Q. Of each sample, each day?

A. Each sample, each day.

Q. Well, in 1901, from that, did you make up weekly averages?

A. Yes sir.

Q. Now the weekly averages in 1901 were determined by whom?

A. Those were made by Mr. Miller and myself?

Q. All of them?

A. We had some help but we checked all that work.

2235 Q. Now the process of making that weekly average was to take one of those daily sheets and add up the seven days and divide by seven, wasn't it?

A. Add up the number of determinations made that week and divide them by seven, unless there had been a sample broken.

Q. Whatever the number of samples was?

A. Yes sir.

Q. And that result was set down upon the table which contains the weekly averages?

A. This separate table wasn't made out in 1901, but it was in 1900.

Q. I misunderstood you.

A. Those results were kept right on these same sheets in 1901, you can see them.

Q. But were the results kept and reduced to weekly averages in 1900?

A. Yes sir, and put on separate sheets.

Q. Then the correctness of these results as weekly averages depended upon the correctness with which the columns were added and the divisions made, and the transcriptions from that addition and division correctly transcribed onto the tables?

A. Yes sir.

2236 Q. If a mistake was made, in the addition or in the division or in the transcription, then that table wouldn't be correct?

A. No sir.

Q. Now when you say "checked up" the same thing, what was it you checked up after it had got onto the tables?

A. This work was all done by one man and then done by another man independently and if the results didn't check why we found out where the mistake was.

Q. What two men?

A. They were independently done by two different men.

Q Did you and Mr. Miller do that as a rule?

A Yes sir.

Q. How many other people worked at it?

A. In 1900, we had while we were at that work, four assistants, I think.

Q. Now whose work did you check?

A. Well, there is a difference between the work in 1900 and 1901. In 1901 the work was kept practically up to date, on these record sheets, and in 1900, these transcriptions were not made until afterwards, and then in 1900, we had a great accumulation of results there which had to be worked up and

2237 transcribed onto these sheets. For instance, in the ammonia readings, there would be say ten readings, which it was necessary to add, and that work was done by those assistants and checked by us. The checking not necessarily by us, but checked by two men independently.

Q. That is to say, two different men added up certain readings and divided up the proper number, and if their results were the same, then it was concluded to be the correct result and recorded?

A. Yes sir.

Q. Now in 1900, was this work of making the tables done daily at the time the analyses were made?

A. No sir.

Q. Were they done after the work was completed?

A. Largely, yes sir.

Q. After the active work of analyses was completed, these tables of results were made up?

A. They were made up from the note books.

Q. Where in the meantime were those note books?

A. They were kept in the safe locked up, in the City Chemist's office.

Q. In whose custody?

A. Dr. Teichmann's.

Q. Who had the combination of the safe?

A. Yes sir.

2238 Q. Did anybody else?

A. I think Mr. Buckland had it.

Q. Now in 1900, if I understand you, they were kept up pretty well, to date, all these tabulations?

A. Yes sir.

.Q Now when you say that one of these tables was checked up by you and Mr. Miller, do you mean to say more than that you checked the results of such calculation as you made, with some other person that was making the same calculation at the same time?

A. In the actual additions that I spoke of, in the ammonia readings for instance, where you have a number of results, when you have read a number of tubes and you add those, and the sum then is what you take, those additions were all checked up by two men,

Q. They made all the additions?

A. Well that is, four men and Mr. Miller and myself, we made all those additions.

Q. Now, if the ammonias that you were instancing, for the ammonias, two men added up independently these readings?

A. Yes sir.

Q. And then finding that they corresponded, they were taken as correct and transcribed?

2239 A. They were transcribed onto those sheets by some clerk.

Q. Now in checking that work, you checked so far as you added, some of these readings, that somebody else had checked up?

A. They were checked by being added by two different people.

Q. That's what you mean by checking?

A. That is, checking that addition; then they were transcribed, and Mr. Miller would either take the sheet or I would take the sheet, either way, and put it on the other side, then the transcription was checked from the book onto the sheets for the daily results.

Q. Now these additions or readings, and divisions to determine the weekly averages, were they set down on separate sheets? Different average sheets?

A. Those additions were made right in the note books.

Q. In which they were made?

A. Yes sir.

Q. Then when the weekly sheet, the sheet of weekly averages was made up, you would either read off, or Mr. Miller would, the result as found in the book and either one of you would transcribe it?

A. The daily sheets you mean, don't you—not the weekly?

Q. I understand you that these weekly averages were de-

2240 termined and put down from the original entry books?

A. Those weekly averages were made from those transcribed sheets.

Q. They weren't made from the original entry books at all?

A. No sir: Here is a sheet showing that if you wish to see it.

Q. Wait a moment. Then the weekly averages weren't set down in the books of original entry?

A. No sir.

Q. They were made up on sheets from these daily sheets?

A. They were made up on the daily sheets.

Q. Now after they were made up on the daily sheets they were transcribed again onto the sheets for weekly averages?

A. Yes sir.

Q. Who did that?

A. Mr. Miller and I, I think, did all of that.

Q. Now have you a sheet there, of these weekly averages as calculated and set down from the daily results upon the same sheet?

A. Yes sir.

Q. I have in my hand now the paper of water analyses, and on the first line is the reading 6768—Intake, Chain of Rocks, 1901, December 1st, and running in that style until December 31. When you had this sheet in your possession, to be 2241 transcribed into weekly averages, did you add up this column under the head of free ammonia?

A. Yes sir.

Q. And determine that it was 586?

A. Yes sir, that is either Mr. Miller or myself did that. We both did it. One did it and the other checked up.

Q. It had previously been added by someone else placed there?

A. No sir. I think we did that work personally.

Q. After that was done upon this daily sheet, those results were transferred to another sheet?

A. In 1900, but not in 1901.

Q. Now how many persons did this work of adding and dividing and putting down the results in the daily sheets in 1900?

A. Six of us. Not in entering these figures here, but in checking. In 1900 we had a great deal of that work to do, and we very often had two or three men checking at the same time. That is, one man would add that and another man check it and Mr. Miller and I always checked them all ourselves.

Q. So if on this sheet which I have described, if some person other than you or Mr. Miller, added up the column for free ammonia and made it 586, and the average 84, then either you or Mr. Miller again added up?

A. Yes sir.

2242 Q. Before it was transcribed into the books?

A. Yes sir.

Q. And was that the universal rule?

A. Yes sir, we personally checked every one of those additions and the divisions.

Q. Well, if you did that personally as to everyone of those weekly averages, what was the necessity of having somebody else add it up beforehand?

A. I don't think there was any one added it up beforehand. It is simply added by Mr. Miller and me; we did all this, the final additions and divisions in getting the weekly averages.

Q. I understood you to say that there were four or five different people doing this work of checking, in addition to you and Mr. Miller?

GENERAL CROW: You misunderstood him.

THE WITNESS: I think you misunderstood me; I didn't mean this part of the work; they were checking on the other work.

Q. On what other work?

A. On getting these results from the note-books onto the sheets?

MR. JOHNS: On to the tables?

A. Yes. But on this work, Mr. Miller and I did it.

Q. On the work of transcribing or determining the averages you and Mr. Miller worked exclusively?

2243 A. Yes sir.

Q. But the other people did the work, the several other people did the work of transcribing from the book onto these sheets, setting forth the daily results?

A. Yes, doing the clerical work.

Q. Now as to these daily results done by other persons did you and Mr. Miller compare them with the book from which they were taken?

A. Yes sir.

Q. In each instance?

A. As I recollect it.

Q. Entirely?

A. Yes sir.

RE-DIRECT EXAMINATION BY ATTORNEY GENERAL CROW

Q. What you and Mr. Miller actually did with reference to these sheets was to determine that the sheets were correctly made from the original data made in the books?

A. Yes sir.

Q. And you did that?

A. Yes sir.

2244 ## ALEXANDER N. MILLER.

called as a witness on behalf of the Complainant being first duly sworn by the Commissioner, testified as follows:

DIRECT-EXAMINATION BY ATTORNEY GENERAL CROW.

Q. What is your name?

A. Alexander N. Miller.

Q. Give your residence and occupation, please?

A. I live at 5222 Delmar Avenue and am employed by S. B. Russel a local consulting engineer as chief draughtsman.

Q. What is your profession?

A. I am a graduate civil engineer, that is I am a graduate in civil engineering. I have not a degree of civil engineer but as a B. B. C. E., a Bachelor of Science in Civil engineering.

Q. Have you ever studied chemistry?

A. Yes sir.

Q. Where?

A. In connection with my course in civil engineering at the University of Cincinnati from which I graduated in 1897. I studied chemistry for a period of two years, including qualitative, quantative and organic chemistry

2245 Q. What experience have you had as a chemist?

A. Since graduation I have been employed by Mr. George W. Fuller at Louisville, in connection with an investigation to determine the most feasible method of water purification in that city, and also at Cincinnati for a period of one year and about a month—

Q. What work, if any did you do on the waters of the Ohio River in connection with your employment with Mr. Fuller?

A. I made a large number of analyses of the Ohio River water at Louisville, Kentucky in January 1897, as I remember, for a period of three months, under Robert S. Weston and Mr. Fuller.

Q. That is at Louisville?

A. Yes sir.

Q. Did you do any work in Cincinnati?

A. At Cincinnati, Mr. Fuller had started the investigation there on filtration work and I helped Mr. Ellms the principal assistant to Mr. Fuller preparing solutions for that investigation, and also did analytical work for a period of one month after the work had started.

Q. And what other experience have you had as a chemist, as a water analyist?

A. I have had no other experience as a water analyist with the exception of the regular analyses at school. I
2246 made a few analyses of water there.

Q. Didn't you have some experience here in water analyses?

A. Yes sir. Outside of this investigation I mean.

Q. By whom were you employed as a water analyist here?

A. I have been employed on this investigation by Dr. Teichmann, City Chemist.

Q. When did you first go to work for Dr. Teichmann?

A. Went to work for Dr. Teichmann on November 26, 1900.

Q. How long did you work at that time?

A. I worked until January 8th as I remember, 1901.

Q. Then did you work any other time on these waters?

A. No sir, not until I was called back here from Pittsburg in 1901, September 6th about.

Q. Then how long did you work?

A. I worked until January the following year, January 8th or 9th.

Q. Did you work any other period than these two mentioned?

A. Not on these rivers, not on the river water at this point.

Q. Well, in what capacity were you employed in January and February 1900, to January 1902?

A. As analytical chemist under Dr. Teichmann.

Q. Now, what work did you do, where did you do it and what was the work performed upon, what samples and where?

A. I performed the work on various samples from points
2247 of collection from Lake Michigan, down on the Illinois
River to the City of St. Louis, Intake, etc., and also during that period I made one trip up the river to determine the amount of oxygen dissolved—dissolved oxygen in various waters.

Q. Now what particular portion of the work in the City Chemist's office did you perform?

A. While I was at the City Chemist's office in 1900 I made at various times all the determinations that were made with the exception of the ammonias as during that period the work was divided up amongst the different assistants and in that way I managed to perform the different determinations, or I managed to perform for certain periods, all the analyses.

Q. Mr. Goetz worked there at the same time, same period of time, did he not, that you did?

A. Yes, sir.

Q. Now, were any entries made of the data obtained as the result of the analyses of these waters?

A. Entries were made daily in record books which were properly ruled up for that purpose by the different analysts.

Q. Now, did you have anything to do with the transcribing of the notes in those entry books, onto any large sheets?

A. As I said before, we came here in February, Mr. Goetz and myself came here in February, 1900, and worked on these
various tests until October, 1900, when the investigation
2248 ceased and during the period October, 1900, to December,
1900, we were engaged in transcribing records and during that period we had a corps of four or five other assistants and they assisted in making additions and divisions to obtain the

proper daily record which was transcribed onto the official sheets, and their work was either checked by myself or Mr. Goetz—by Mr. Goetz or myself.

Q. The work of these assistants was all performed under your and Mr. Goetz immediate supervision?

A. Yes, sir.

Q. Now, have you got there in front of you the analytical sheets upon which this data was transcribed from the books?

A. Yes, sir.

Q. Now, after that was transcribed onto these sheets, was it checked by anyone?

A. Yes, sir; it was checked; that is while we were there it was checked either by Mr. Goetz or myself.

Q. Now, in what manner did you check that, just describe it?

A. Why, these books, these daily record books contained the records of analyses as put down by the chemists. Now, most of those chemists took no part in making the transcriptions, so it was necessary for us to check up their work and see that it was transcribed onto these official sheets correctly.
2249 Now, we were assisted by four men who made the necessary additions to obtain these results and we always saw that their work was thoroughly gone over and checked.

Q. That is the additions that they made?

A. Yes, sir. These men were not experienced chemists, although they could do clerical work accurately, very accurately, although it is necessary to check them, as I said before.

Q. Well, then, after the work was put onto those sheets was it again checked?

A. Yes, sir; it was called off, that is the daily official result as recorded in the daily record book was transcribed onto these sheets and checked by either Mr. Goetz or myself, so that these figures on the sheets represent the figure as recorded in the book, in the daily record book.

Q. Well, then, all of the sheets during the two periods of time which you mention that you were employed there were checked and the correctness tested by yourself and Mr. Getz?

A. That is while I was there?

Q. That is what I say, during the period of time that you were there?

A. Yes, sir.

Q. Now, can you testify as to whether or not those sheets
are correctly made from the data that was obtained from
2250 the analyses of these water samples?

A. Those sheets were correctly made as far as we know, up until the time we left the City Chemist's office.

Q. Now, can you describe the method that you used there in the determination of solids?

A. In making the solids determination there were two different determinations to be made, that is, we found the soluble solids, the solids in solution and the suspended solids. In order to find the dissolved solids we first filtered the sample perfectly clear through filters that had been previously washed and one hundred cubic centimeters of that filtrate were put into a platinum dish which had been thoroughly dried and weighed before the water was put into it and then it was put onto a water bath and the contents were evaporated to dryness and it was afterwards put into a bath which holds the temperature constantly at 100 degrees, or within a few degrees of 100.

Q. Of what, heat?

A. One hundred degrees centigrade, boiling point, so that all excess moisture was driven off. It was kept so for about a period of one hour and then it was put into a dessicator and cooled out of contact with the air. Then it was again weighed. I might say that in that dish there is a calcium chloride to extract the moisture from any air that is in there. Did I say that
it had been weighed? Well, it was weighed then, and
2251 then the difference in these weighings represents the
amount of dissolved solids. To get the total solids we go through the same operation only the water is not filtered. That is, you take 100 cubic centimeters of the water, evaporate it to dryness in a platinum dish, weigh it afterwards and subtract, and the result represents the total solids. To get the suspended solids we deduct the dissolved solids from the total solids.

Q. Now, what process did you follow there for the determination of the nitrites?

A. Well, it was only necessary that those determinations should be made. They were made by different chemists and the order was of no consequence, in which they were made, except you might say this, that the nitrites, free ammonias and nitrates, were the most important determination, and they should be made immediately on receiving the sample.

Q. Then, in the matter of obtaining the solids there in suspension, or the total solids, is a matter that would not be particularly affected by the time in which it was made?

A. No, sir.

Q. In other words, it could be made last as well as first?

A. Well, it would not be well to allow that period to be too great. It is necessary to make the tests as soon as possible after receiving the sample.

2252 CROSS-EXAMINATION, by Mr. Johns.

Q. The process of determining these various things in the laboratory is substantially the same or exactly the same, as described here by Dr. Keiser?

A. The regular standard methods of water analysis as followed by all water chemists.

Q. Now, you made some trips up the river, you say, to determine the dissolved oxygen?

A. Yes, sir.

Q. Is that the same thing as oxygen consumed, in some tables?

A. No, sir.

Q. What is it?

A. Oxygen consumed means the amount of oxygen consumed in oxidizing carbonaceous organic matter in the water. Oxygen dissolved in the water means the actual amount of oxygen dissolved by the water. I might add that fish breathe the oxygen out of the water just as we do out of the air and that dissolved oxygen is necessary in the water for the life of fish. It has nothing to do with oxygen consumed.

Q. Well, now, how did you determine the oxygen dissolved?

A. Oxygen dissolved in water is determined by means of
2253 Wenkler's method.

Q. Well, I am no wiser now than before, what is the method?

A. Those methods are rather hard to repeat off-hand and before going through an analysis of that kind it would be necessary to refer to notes in order that you would get the various quantities correctly, but I can give you the general method.

Q. Well, give me the general method?

A. Wenkler's method of determining dissolved oxygen consists in adding a quantity of sodium hydrate to the water, and also a quantity of manganous sulphate. As I say, these are not official figures, the strength of these solutions I could not give.

When these two re-agents are added to a given quantity of water, to a measured quantity of water, which is determined beforehand, there is a certain reaction which takes place between the sodium hydrate and manganous sulphate and manganous hydrate is formed which is easily oxidized and takes up oxygen from the water, takes up all that there is present and forms a manganic hydrate. Now, after that manganic hydrate is thoroughly precipitated, which can be judged by looking at it or observing it, a certain quantity of hydrochloric acid, concentrated hydrochloric acid is added, and this manganic hydrate is broken down to the manganous
2254 chloride again and the oxygen that had been taken up is liberated. After that oxygen is liberated, or before, I might say, there had been a re-agent called potassium iodide added. That acid and the oxygen which is liberated by the breaking down of the manganic hydrate acts upon the potassium iodide and liberates the iodine and from the amount of iodine liberated and by mathematical calculation you can tell how much oxygen there was dissolved originally in that sample.

Q. How do you estimate the iodine liberated?

A. The iodine liberated is estimated by titration, with sodium thiosulphate. Now, as I said before, going through that determination, it would be necessary for me to refer to notes.

Q. As to the quantity?

A. Yes, sir.

Q. Well, I don't care about that?

A. That is the general method, that is the Wenkler method.

Q. Now, I still do not understand how you arrive at the oxygen consumed, whether by building up other re-agents and making the comparison—

A. Well, we have been talking about dissolved oxygen, you remember?

Q. That is what I meant, dissolved oxygen, I beg your
2255 pardon. I do not understand, I do not get into my head,
how you determine the amount of oxygen consumed?

A. Well, as I said before, that oxygen liberates an equivalent quantity of iodine in that process, and although we have no direct method of getting at the oxygen we have a direct method of getting at the iodine.

Q. That is the way you determine the oxygen dissolved?

A. Yes, sir.

Q. By measuring this iodine?

A. Yes, sir.

Q. If I understood you, Mr. Miller, the results of the determination of the various analyses were set down in books by each analyst?

A. Yes, sir.

Q. And then those were copied off on the daily sheets, were copied onto daily sheets?

A. Yes, sir.

Q. And from those daily sheets another table of weekly averages was made?

A. Well, that weekly average was made on the daily sheet.

Q. But then it was copied off onto another tabel afterwards?

A. Yes, sir; that is during the period of 1900. That was
done during the period of 1901, while we were there, that
2256 was not done for the reason that we were rushed with
work and we were employed by the day.

Q. And afterwards you made up for 1901 those weekly averages?

A. Yes, sir.

Q. And in the manner in which you have described?

A. Yes, sir.

Q. Now, while you and Mr. Goetz worked there, do I understand you that you two gentlemen made up all those weekly averages?

A. Yes, sir.

Q. When you came to a table of daily results which some other person had added up and divided, did you, if you were handling the table, add up again the same results, to see if it was correct?

A. Yes, sir.

Q. And in each instance, as to each result?

A. Yes, sir. That is while we were there we saw that there was a thorough check on all the transcriptions and weekly averages that had been made up until the time that we left.

Q. Well, I am asking you, when you took the tables, daily results, upon which the weekly averages had been inserted
2257 by some one else, of daily results?

A. Yes, sir.

Q. In the same manner substantially as in that sheet before you?

A. Yes, sir.

Q. And then after that was done, they were transcribed onto another table?

A. Yes, sir; during the period of 1900 and also during the period of 1901.

Q. Now, you two gentlemen, if I understand you, did all of that addition to determine weekly averages?

A. To determine weekly averages, yes, sir. As I say, now I have a sheet before me which we did not do, which was made after we left there; but while we were there up until the time we left, we saw that those weekly averages were thoroughly checked.

Q. And then you say you saw that they were correctly transcribed?

A. Yes, sir. A. N. MILLER.

2258 JOSEPH F. SONDAG called as a witness on behalf of the complainant, being first duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION, by Attorney-General Crow.

Q. What is your name?

A. Joseph F. Sondag.

Q. Where do you reside and what is your occupation?

A. I reside at 6806 Virginia avenue, this city.

Q. What is your business?

A. Well, I am a druggist by trade, but since October 1, 1901, I have been employed in the City Chemist's office as a clerk.

Q. Well, you are an assistant at the distillation table also?

A. Yes, sir.

Q. You took part in the analyses of the waters brought in from the Mississippi and Illinois Rivers?

A. No, sir; not the Illinois.

Q. Nothing but the Mississippi River water?

A. Only the Mississippi.

Q. What period of time now did you take part in these examinations?

2259 A. Since October 1, 1901.

Q. 1901?

A. Yes, sir.

Q. Last April?

A. Yes, sir.

Q. And then you have been there ever since?

A. Before this time I never had anything to do with this investigation.

Q. Now, what did you have to do with these analyses since April, 1901?

A. I made the distillations for the ammonias.

Q. Now, did you work under the direction of Dr. Teichmann?

A. Yes, sir.

Q. Did you make any entries in the books regarding the data for ammonia?

A. Yes, sir.

Q. Were the entries made by you in the original books?

A. Yes, sir.

Q. Did you do any transcribing of notes containing results of the analyses of water from the books in which the original entries were made on to the analytical sheets?

A. Yes, sir; I have done all that work since October 1, 1901.

Q. Well, are these sheets here that you have in front of

2260 you, those that you transcribed?

A. Yes, sir.

Q. Now, what period of time do they cover, from April, 1902, up to January, 1903?

A. I entered the records from October 1, 1901, up to—

Q. October 1, 1901?

A. Yes, sir; you see I entered all those up, to the last record—and the last record I made was July 31, 1902.

Q. Well, are those sheets there?

A. This is part of them, this is some of them.

Q. Where are the rest of them?

A. Some of them are down stairs, I guess.

Q. Now, did you transcribe anything on to any of these sheets from the original entry books, other than those things which you yourself put into the original entry books?

A. Yes, sir.

Q. Now, when you transcribed such data that you had not made in the original entry books, did you check up the original entry books to see that they were correct?

A. Yes, you know they would generally enter the readings, they would enter the number of the sample, where they were from, and then the readings, before thy would make the determination and the readings of the burette after the determination and they would put down the result, while I
2261 would take all these figures off.

Q. Now, in the original entry books there is nothing to be added but the reading for ammonia, is there?

A. That is all. Well, there is a determination made, you know, of parts per million.

Q. Well, is that entered in the original entry books, too?

A. Yes, sir.

Q. That would have to be added up?

A. Yes, sir.

Q. Did you do that?

A. Yes, sir.

Q. When you made these analytical sheets did you compare them with the books?

A. I copied them off the books onto the sheets, you know.

Q. And then did you add up the entries on the analytical sheets to see that they corresponded with the totals that were contained in the books?

A. Yes, sir—well, under the ammonia, all the adding I did in the ammonias was the final figures, of final determinations. The reading of the burette of parts per million is the only figure that is entered up on the sheets.

Q. Well, did you compare the work after you had got it done on the sheets with the original entries in the book?

2262 A. Yes, sir.

Q. Well, did you find them to be correct or incorrect?

A. Correct.

Q. Now, have you got the sheets there for the whole period of 1902, October 1, 1901, on up to the time you quit work?

A. They are not all right here, no.

Q. Where are they?

A. Part of them are down stairs, I guess. (Dr. Teichmann hands witness certain tables.)

Q. Did you get those sheets?

A. Yes, sir; I got them here.

Q. Well, then, you have all the sheets there, have you?

A. Yes, sir.

Q. And you are able to testify that those sheets were correctly made from the original entries as to the result of the analyses?

A. Yes, sir.

CROSS-EXAMINATION, by Mr. Johns.

Q. Do I understand you to say that all the sheets which are presented here, of daily results were made by you?

A. Since October 1st.

Q. October 1st, 1901?

A. Yes, sir.

2263 Q. Everyone of them?

A. Yes, sir.

Q. And transcribed by you from the books?

A. Yes, sir; onto these sheets.

Q. In making those sheets you didn't add up in the book the determinations for parts per million, but took them as correct in the original book?

A. I went over all the figures, I also checked them up myself, figured all the readings. I would take the reading of the burette before determination, say, for instance, on chlorides, and after determination, and the deduction is the result. I checked all that over.

Q. You checked all that over?

A. Yes, sir.

Q. For each determination?

A. Yes, sir.

Q. For each day?

A. Yes, sir.

Q. Of each sample?

A. Yes, sir.

Q. Then checked that parts per million?

A. Yes, sir.

Q. And found that that was correct?

A. Yes, sir.

2264 Q. Then you copied those parts per million under the proper columns in these sheets now before you?

A. Yes, sir.

Q. And that you think was correctly done?

A. Yes, sir.

Q. Did you make any sheets of weekly averages afterwards?

A. No, sir; I only figured the weekly average onto the sheets, the same as this.

Q. Now, are these figures of weekly averages there your figures?

A. Yes, sir; except two months, October and November of 1901.

Q. All the others are yours?

A. All the others since then are mine.

Q. Without assistance, did you do it individually?

A. Yes sir. Miller and Goetz did the work for these two months. They would compare them with books, one would take the books of the different readings and compare them with my figures. After they would get that all checked off then they would make weekly averages.

Q. But only for those two months?

A. Only for those two months, because they quit there 2265 about December 8, 1901, and since then after that, why we only took samples from the Chain of Rocks. Since then everything that was entered on the sheets was done by me.

JOS. F. SONDAG.

2266 **THOMAS A. BUCKLAND** resumed the stand for further direct examination, by Attorney-General Crow, and testified as follows:

Q. Mr. Buckland, what part of the analytical work of this investigation did you do?

A. Well, you are referring to the time of 1901?

Q. You testified about what you did before?

A. Yes, sir.

Q. I am referring to the time in 1901, after the close of the first original investigation.

A. That was the second original investigation.

Q. Well, the second; after the close of that period of time?

A. Well, I made all the analytical determinations.

Q. Well, what waters did you work on, what rivers?

A. Well, the Mississippi principally, I think. We had a few samples from Grafton and other places.

Q. Well, out of the Illinois or the Mississippi?

A. Yes, I think there were some from both the Illinois and Mississippi, some few, I don't remember the number, that is on the record.

2267 Q. Well, what determinations did you make from these samples and during what period of time were they, just state the dates?

A. Well, from the time that the large investigation—

Q. Well, when was that?

A. Well, I am not able to state the exact date.

Q. Well, just as near as you can, some time after 1901?

A. After the samples, after the large number of samples ceased coming—

Q. The early fall or in the winter?

A. In the winter, yes, sir.

Q. At what time of the year?

A. I think it was about December.

Q. What year?

A. 1901.

Q. Now, from that time on until January, 1903, did you make determinations?

A. Yes, sir.

Q. For what?

A. For ammonia, nitrites, nitrates, chlorine, alkalinity and oxygen consumed. I did not, however, make all the determinations on all the samples.

Q. Who recorded the results of that?

A. Well, with the exception of the ammonia results I recorded the results myself in the small books which were 2268 provided for the purpose.

Q. Who transcribed that on to these analytical sheets?

A. Mr. Sondag, I think.

Q. Now, do you recognize that as any of the work that you did as the result of that analysis (handing witness large sheet)?

A. Well, these were not copied on here by me, my results were entered into the small book.

Q. Well, then, you don't know whether that is correct or not?

A. No, sir. I have no doubt it is, but as I did not copy it on the sheets I cannot state that it is.

Q. Well, do you know from your recollection, as to whether or not you find high free ammonias in December, 1901, in the Illinois River at Grafton?

A. Yes, sir; I found the ammonias quite high.

Q. Do you know what was the maximum amount you found and the date of it?

A. I cannot remember the date. It was somewhere in the neighborhood of one part per million.

Q. That would be 1.?

A. Yes, sir, 1.

MR. JOHNS: One whole number?

2269 A. One whole number.

Q. Well, have you any recollection as to how the ammonias run, whether high or low during the subsequent months, for the samples taken at the Intake?

A. They were rather high, according to my recollection.

CROSS-EXAMINATION, by Mr. Johns.

Q. What caused the ammonia to run high in the Illinois River at that time?

A. Well, I am not prepared to state what made it run high.

I can state just what was found in it. I presume it was from pollution in the Illinois River from farther up.

Q. Do you know the state of the ammonias in the Mississippi at that time?

A. According to my recollection they were lower, the free ammonia was lower.

Q. I am asking you, do you remember the state of the Mississippi as to the ammonia on that same day?

A. No, sir.

Q. Do you remember the state of the Missouri as to ammonia on the same date?

A. No, sir.

2270 Q. Do you know whether the Mississippi was at that time as to ammonia, higher or lower than a fair average?

A. No, sir; I am not able to state.

Q. Do you know whether the Missouri at that time was higher or lower than a fair average?

A. No, sir.

Q. But you do recollect, you think, that the ammonia at the intake tower was high, ran high?

A. About that time, yes, sir.

Q. Yes, about that time?

A. Yes, sir.

Q. But, from what cause you don't pretend to state?

A. No, sir.

THOS. A. BUCKLAND.

Adjourned until 10 a. m., Monday, March 23, 1903.

2271 Met pursuant to adjournment at the same place at ten a. m., March 23, 1903. And thereupon an adjournment was taken by consent until ten a. m., March 24, 1903.

Met pursuant to adjournment at the same place at ten a. m., March 24. And thereupon an adjournment was taken by consent until ten a. m., March 25, 1903.

Met pursuant to adjournment at the same place at ten a. m., March 25, 1903. And thereupon an adjournment was taken by consent until ten a. m., March 26, 1903.

Met pursuant to adjournment at the same place at ten a. m., March 26, 1903. And thereupon an adjournment was taken by consent until March 27, 1903.

Met pursuant to adjournment at the same place at ten a. m., March 27, 1903. And thereupon an adjournment was taken by consent until March 28, 1903.

Met pursuant to adjournment at the same place at ten a. m., March 28, 1903. And thereupon an adjournment was taken by consent until Monday, March 30, 1903, at ten a. m.

2272 Southern Hotel, St. Louis, Missouri. 10:00 a. m., Monday, March 30, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel as before, representing the respective parties.

DR. WILLIAM C. TEICHMANN, resumed the stand for cross-examination, by Mr. Johns, and testified as follows:

Q. Dr. Teichmann, what is your idea or reason for calculating the volume of the Illinois River and its flow per minute of cubic feet, or per second of cubic feet, to place it at the extremest low water that you could find data for?

A. The low water stages are the most important in my opinion, in calculating the effect of the sewage on the Illinois River, because of the lower volume of water producing a lower ratio of dilution.

Q. Why not, if you wanted to strike a fair average of the ratio of dilution, select a mean stage of water?

A. Because a mean stage would be a theoretical condition, whereas, the low stage would be calculating on the basis of an actual condition as it occurred. In other words, the low stage found at a certain time would be liable to return again
2273 and then the condtions would be such as to produce a ratio of dilution much lower than the average would be, and we should then, as I have said, have an actual condition to base our calculations on for future determinations.

Q. Then you take the position that you cannot ascertain the mean stage of the Illinois River?

A. Yes, sir, the mean stage can be ascertained.

Q. Well, if it can be and has been, why not take it instead of the lowest stage?

A. Well, because, as I said, the lower the stage of the Illinois River is, the smaller will be the dilution of the sewage in the river.

Q. The idea was to calculate the smallest amount possible of dilution for the purposes of calculation of the dilution of the river then?

A. Yes.

Q. Well, a low stage of water might continue for a day or a week or ten minutes, might it not?

A. Yes.

Q. The very lowest stage?

A. Yes.

Q. And the very lowest stage is extremely rare and a very unusual thing, is it not?

2274 A. Well, that depends upon the weather conditions very much.

Q. Precisely. But the very lowest stage of the river is the thing which occurs less frequently than an average or a mean stage of the river, is it not?

A. Yes, sir.

Q. Now, where did you get your figures for the low stage of the Illinois?

A. I got those from a report published by Lyman E. Cooley, formerly chief engineer of the Chicago Drainage Canal.

Q. Made when?

A. In the year 1890.

Q. In 1890?

A. Yes.

Q. Have you any data as to the stage of the Illinois River at any time from 1890, to 1899?

A. Yes, sir.

Q. Have you it with you?

A. Yes, sir.

Q. From what reports did you get it?

A. I got those records from reports published by the Illinois State Board of Health up to 1899.

Q. In which the stage of the Illinois River was given at various times?

2275 A. Yes, sir, by Civil Engineer Harman.

Q. Well, why did you not take some time nearer to the opening of this canal than 1890, as the basis for your data?

A. Well, I thought that the lowest stage on record would be exactly the stage to take because it might possibly recur again—this lowest stage, and the lower the stage of the river of course the smaller will be the amount of water for dilution of the sewage in the river.

Q. And the worse then the amounts of pollution shown on the charts?

A. Yes, sir.

Q. Now, if you will take a piece of paper and a pencil, I want you to make a calculation for me.

A. Yes, sir.

Q. In your testimony of March 17th, you have the lowest stage at Wilmington, on the Kankakee, 25,200 feet per minute. On the Des Plaines 256 feet per minute—

A. 256 feet per minute?

Q. Yes?

MR. WOERNER: Do you mean per minute?

MR. JOHNS: That is what the record says.

Q. And at another time you have for the Des Plaines, 339 cubic feet per minute.

GENERAL CROW: That must be per second, isn't it, doctor?

2276 THE WITNESS: Yes, I will have to look up my report to see what I testified to, because I took those data from the report. It is more likely to be per second, though.

Q. MR. JOHNS: In the Fox River, 31,339 feet per minute; the Mason River 15,000 cubic feet and the Canal at La-Salle 37,900 cubic feet. How many cubic feet per minute is that in all those rivers?

A. 110,034 cubic feet.

Q. How many cubic feet per second would that be?

A. 18,339.

Q. Now, all those rivers named are above Utica, are they not?

A. Well, I presume so; I don't know, but I think you are right.

Q. Then where do you get your basis of 600 cubic feet of water, upon which you calculate the basis of dilution and pollution?

A. Well, I got that from the figures as they were presented by Mr. Cooley, in his report, and I thought I had quoted them correctly, that is, figuring on the volume of water coming at the lowest stage on record there, from those rivers, and I calculated that out and my figures—the figures of Mr. Cooley agree with the figures produced by Civil Engineer Harman for the Illinois State Board of Health in his report; he finds that same volume,—600 cubic feet.

2277 Q. Answer the question and we will get along more rapidly. Assuming that the data as given you there are the figures from your testimony of March 17, the volume of flow was three times as much—yes, was thirty times as much as you gave—was it not?

A. Well, Mr. Johns, the question is whether my testimony on that day conveyed that idea. Of course I am not sure about that just now, but certainly the figures that I presented there would lead to the conclusion that the flow was considerably less than 18,339.

Q. Well now, how do you happen to assume the sewage of Chicago at 400 cubic feet per second?

A. 400 cubic feet per second?

Q. Yes.

A. Well, figuring on the amount of sewage coming from the Illinois and Michigan Canal, it is simply that the flow per minute is converted into seconds; they would have to take sixty times that; that would give you a certain figure per minute, and that would be the flow from that sewage.

Q. If you have any data or know any way in which you can figure that the sewage of Chicago is 400 cubic feet per second, state now what it is and how you arrive at that conclusion?

A. Well, that was at that time from the Illinois and Michigan Canal—

2278 Q. Based on what theory?

A. Well, based on the theory that there is 60 times—figuring on 36,000 per minute of flow.

Q. Of flow?

A. Yes.

Q. Assuming that the discharge from the Illinois and Michigan Canal was 36,000 per minute, and that 60 per cent of that flow was Lake Michigan water, 40 per cent of it then you say would be sewage?

A. Yes.

Q. From Chicago?

A. Yes sir.

Q. What is 40 per cent of 36,000?

A. That would be simply two-fifths—40 per cent would be 14,400.

Q. Assuming that that is Chicago sewage per minute, how many feet is that per second?

A. That would be 2400.

Q. 2400?

A. No, 240.

Q. Then were did you get your figures of 400?

A. Well, you must take the total volume of the sewage mixed with the water as it leaves the canal.

2279 Q. That is precisely what I am doing, and assuming that 60 per cent of the flow,—36,000 feet, is Lake Michigan water, dilution, and 40 per cent is sewage, as you say, then your statement of 400 feet per second for Chicago sewage, is incorrect, is it not?

A. No, I don't think so, because the sewage as it leaves the canal is supposed to be the sewage mixed with the lake water there. It is diluted sewage; you can't base the calculation on the sewage there, because it is mixed with the water and leaves the canal together; that is what is understood by the sewage leaving the Illinois and Michigan Canal. It is of course the sewage mixed with the water there.

Q. Well, you say at the ratio of 40 per cent sewage to 60 per cent Lake Michigan water,—so that your assumption of 400 feet was incorrect by 140 feet, was it not?

A. No sir, not the way I construe it, and the way Mr. Cooley and Mr. Harman construe it in their reports. They calculated on the total volume leaving the canal and entering the Desplaines River, or rather at LaSalle and call it all sewage.

Q. Answer this question: If the flow from the Illinois and Michigan Canal is 36,000 feet per minute, and if 40 per cent of that is Chicago sewage; then assuming that state of facts, without any argument with reference to it, your assumption of 400 cubic feet per minute of Chicago sewage is a mistake, is it not?

2280 A. No, I can't admit that, because the mixture there is still sewage; it is a sewage mixture—

Q. I beg your pardon. You are now on the stand as an expert, and I have a right to assume to you any question that I see fit to propound, in the way of legitimate cross-examination, and you are bound by the facts which I state. Being now bound by the facts which I state in that question, is not your assumption of 400 cubic feet wrong?

A. No sir.

MR. WOERNER: We object to the question on the ground that it is apparent that the witness cannot answer the question "Yes" or "No" without a further explanation, as to what he means by sewage.

MR. JEFFRIES: And which explanation he has already given.

Q. MR. JOHNS: Assuming that the volume per second of the Illinois River above Utica is over 18,000 feet, and that the sewage of Chicago is 400 feet per second, your rate of dilution of 1 to 5 is also incorrect, is it not?

A. Well, based upon your premise.

Q. Now then, assuming that the volume of the Illinois River above Utica before the opening of the Drainage Canal was in round numbers 18,000 feet, and that the sewage of Chicago was 400 cubic feet, per second; what is the ratio of dilution?

2281 A. The ratio of dilution would simply be their subtraction—400 there, and 18,000; that would be of course a very large ratio.

Q. Yes, well, what is it?

A. Forty-five.

Q. One to forty-five.

A. Yes.

Q. Well, that is a very considerable dilution, is it not?

A. Yes sir.

Q. Now do you know that in this calculation that you have made here of the stage of the Illinois River above Utica, you have left out a number of rivers—several?

A. Well, those rivers were left out because in the opinion of Mr. Cooley, their stages were such that they were practically dry during that season of drouth, so that Cooley omitted them from his calculations.

Q. Your entire argument upon the question of the dilution of sewage is based upon an opinion of Mr. Cooley, given in 1890?

A. Principally, yes, and also upon an opinion, in figuring out those stages and averages, in an opinion presented by Mr. Harman, the Civil Engineer for the Illinois State Board of health, published in 1901.

Q. Do you know anything as to the annual average stage of the Illinois River above Utica?

2282 A. Well, I couldn't tell you off-hand. I have looked over those publications, and am somewhat familiar with those stages, but I could not give you the exact figures off-hand.

Q. What do you define sewage to be?

A. Well, sewage ordinarily is defined as the liquid contents of the sewers, but this definition would have to be modified some because you cannot call it strictly liquid contents. It has solid matter in the contents of the sewers, so that you define it as the contents of the sewers.

Q. Sewage, as you use it, is the discharge of matter from cities through tubes into some place of exit?

A. Yes sir.

Q. Including all kinds of discharges?

A. Yes sir, various kinds of sewage.

Q. Do you know what the discharge of the sewers of Chicago was into places in which it was discharged before December, 1900?

A. Repeat that question.

Q. Do you know what was the discharge of sewage in Chicago in December, 1899?

A. That would have to be calculated with the water supply of Chicago. I calculated out that the water supply is equal to the amount of sewage every day. That is a general assumption that is based upon calculations of various engineers and it is usually resorted to. 2283

Q. And at how much per head, per day, that is per individual per day?

A. I would make it for the city of Chicago 42,000,000 cubic feet per day.

Q. Why do you make it that?

A. Well, based upon the water supply of the city of Chicago.

Q. Do you assume that there is pumped annually into the water surface of Chicago, 42,000,000 cubic feet per day of water?

A. What's that?

Q. (Question repeated)?

A. Yes, I base it on the water supply.

Q. You assume that there are 42,000,000 cubic feet of water pumped into the surface mains of the city of Chicago per day?

A. Yes sir.

Q. And then you assume that all that water becomes sewage?

A. No, I estimate the amount, the bulk of the amount of sewage which the city of Chicago produces.

Q. How do you know what that is?

A. Equal to the water supply.

Q. That is in determining the amount of Chicago sewage, you say that if there is pumped for the use of the city into its mains, 42,000,000 cubic feet of water per day, the sewage of the city of Chicago is 42,000,000 cubic feet? 228

A. Yes sir.

Q. Without any kind of deduction for any other use than the discharge into the sewers?

A. Well, that is an approximation, of course. The figure may not be absolutely correct, but it is an approximation that is accepted by all engineers, and practically all text-books on engineering. In figuring the volume of sewage produced every day, you base it on the water supply.

Q. And that is purely an assumption without any data to substantiate it at all, isn't it? It is a scientific argument?

A. Well, that's a scientific argument, though that is the basis upon which investigators carry on their investigations, engineers.

Q. By whom, for instance?

A. Well now, I cannot quote any particular one just now, but it is usually recorded in various text-books.

Q. By whomsoever it is created as a standard, it leaves out of the calculation the use of water for steam, for drinking purposes for animals and man, and for all purposes for which it is used, in which it does not afterwards escape bodily into the sewers?

2285 A. It is the daily consumption of the water; that is what it is based upon, of the city water supply.

Q. You don't understand my question. That estimation leaves out of consideration entirely the water used for steam and drinking purposes, or for any other purposes in which it does not escape into the sewers in the form of water?

A. No sir. It isn't to be understood that way. It is to be understood upon the consumption of water in the city, by the city water supply. That is, this data, as it is calculated by the engineers of the water supplies.

Q. If you will pay attention to my question. We will assume that the water supply of the city of Chicago is 42,000,000 cubic feet of water per day?

A. Yes sir.

Q. Then you assume that the sewage of the city of Chicago is 42,000,000 cubic feet per day?

A. Yes sir.

Q. That assumption excludes all the purposes for which water is used in the city of Chicago, except such purposes to which it is put as would return it in the form of water to the sewers, whether consumed by steam, for drinking purposes by man and animals, that is destroyed absolutely in manufacturing, as water, and disappears as water entirely. It excludes that amount of water, whatever it is, doesn't it?

2286 A. No, I don't think so. I think it is entirely the official consumption as recorded by the data of the engineers.

Q. But if the water is converted into steam it doesn't return into the sewers, does it?

A. No.

Q. And if the water is consumed and drunk by animal or man, it doesn't return to the sewer again as water, does it?

A. No sir, not necessarily.

Q. If it is destroyed in the purposes of some manufactory and its identity and character is so lost that doesn't again return to the sewer as water, does it?

A. No sir.

Q. Then the whole assumption excludes from use all water in the city of Chicago which doesn't return it to the sewers again as water?

A. I cannot agree to that.

Q. Now then, assuming that it is 42,000,000 cubic feet per day, how many cubic feet per minute is that?

A. Well, I would simply have to make a calculation of that —291,666 cubic feet per minute.

Q. Now where did you get your estimation of 400 cubic feet per minute for the sewage of Chicago?

2287 A. Well, that is the Illinois and Michigan Canal at that time. The total amount of the sewage of Chicago was not pumped into the canal at that time. Only a part of it.

Q. If the total amount was not pumped in, what would you say?

A. Well, that depends on the average that we take. I calculated on 36,000.

Q. Cubic feet per minute?

A. Yes sir.

Q. And that was the water pumped at the Bridgeport pumping works?

A. Yes sir.

Q. Now what is the effect of chlorine in water?

A. You mean chemically?

Q. Yes?

A. Well, the effect of chlorine is simply that it adds so much sodium chloride, the form in which chlorine is usually prevalent in the water.

Q. Well, it is a pollution, isn't it?

A. Well, a pollution only—you mean of organic origin?

Q. I don't care—of any kind of origin. I am asking you now the effect of chlorine in water?

2288 A. If you take absolutely pure water, aqua pura—it shouldn't have any chlorine, and adding chlorine to it, would be adding impurity to it.

Q. If you should take a potable water, how much chlorine would render it suspicious?

A. Well the chlorine as such might be comparatively high and yet that water would be potable.

Q. How high?

A. Its potability would depend upon the amount of organic matter present in the water in conjunction with the chlorine.

Q. Well, could you determine a standard beyond which water would be unpotable, with reference to chlorine alone?

A. Yes, the sodium chloride present in the water may be of such a large amount, of this chemical, that it would be injurious to the health.

Q. Well now, what amount would that be, parts per million?

A. Well, that would have to run very high. It would run perhaps in the thousands.

Q. Well, if you know, what is the per cent of chlorine alone in water, which makes it unpotable, tell me?

A. I couldn't tell you that limit from that standpoint, of its medical properties. It might be medical water. It might be good for certain diseases and contain very high chlorine. And then again, ordinarily such water would have such a salty character that it would be unpotable.

2289 Q. How much chlorine in water would make it unpotable to the average good, healthy Missourian?

A. I think, of course it is an approximation, it is very hard to tell, because a high amount of chlorine may be palatable to the stomach of one individual and it may not be palatable to the other. It is very hard to draw the limit there. There might be a thousand parts of chlorine in that water and yet people might be able to drink that water, and others again, would reject it; it wouldn't agree with them.

Q. I have asked you a plain, simple question. What amount of chlorine in water would make it unpotable to a resident of Missouri? If you know, answer it, and if you don't say so.

A. Well I claim that there may be as much as 500 parts chlorine in that water and yet it may be potable.

Q. If there is any standard, state it, for chlorine in potable water?

A. No standard would be recognized that would condemn water solely on its contents of chlorine.

Q. Now, when in water you find chlorine, it is a certain chemical constituent, isn't it?

A. Yes sir.

Q. Although it might be developed chemically from different sources, its effect upon the water is the same, it is chlorine, isn't it?

2290 A. Well, that depends whether it is present in conjunction with organic matter or not.

Q. I am talking simply and alone of chlorine, as a separate and distinct element of pollution in water, when it becomes what chemists recognize as chlorine, then it is a chemical constituent, which is a pollution, is it not, no matter where it comes from?

A. I wouldn't define it as a pollution.

Q. For instance, is there a difference chemically between the thing termed chlorine in water, when it comes from dissolved salt, and when it comes from a dissolved manure heap?

A. Certainly, there is a great difference.

Q. Now the thing itself is called chlorine?

A. I mean in its importance as an ingredient to the water.

Q. In itself, considered alone as a constituent in the water, isn't it the same when you find it, whether it comes from dissolving salt, or from a dissolving manure heap, chemically?

A. If you leave out of consideration everything else and simply look to the chlorine, why certainly, it is all the same. It it identified the same way and it is present.

Q. Now is it or is it not an element of pollution in water without reference to its source?

A. Soley as such it is not.

2291 Q. In no respect a matter of pollution?

A. Well, that depends upon what you define as pollution.

Q. Well, I will come to that in a moment. I am going to find out what is pollution pretty soon. As an element of pollution in water of itself, you think it cannot be called a polluting matter or a polluting substance?

A. Well, I would say that it may, if entering pure water, that it may add impurity to the water, but what is generally considered as pollution, I cannot class it with that.

Q. You cannot class it with that?

A. No sir.

Q. What is pollution in water, at any rate?

A. The general definition of pollution in water, is understood to be pollution principally by organic matter.

Q. And you do not call salts and minerals organic matter of course?

A. No sir.

Q. So that when you find chlorine in water, you cannot tell, considered by itself, and separate from all other things, whether it comes from organic matter or mineral matter, can you?

A. No sir, not by itself.

Q. What is the character of albuminoid in water? Is it one of the pollutions?

2292 A. Yes, I would call albuminoid ammonia, it is generally termed, having a number of organic compounds, that we obtain by certain analytical processes.

Q. Is it an element of pollution in water?

A. Yes.

Q. It is an evidence that in that water there must have been some organic substance?

A. Yes sir.

Q. When you find albuminoid ammonia in water, you conclude that there have been organic substances in the water which have become decomposed?

A. Yes sir.

Q. Now whether those organic substances are fecal discharges or the result of dissolution of plants, you cannot tell?

A. Yes, it may be either one.

Q. Or it might be both?

A. Yes. It might be a source of pollution from both, of animal and vegetable origin.

Q. At what time, if from vegetable origin, would albuminoid ammonia be the highest in the Mississippi River?

A. I don't understand the question.

Q. At what season of the year, if albuminoid ammonia was to be attributed to the decomposition of fecal matter, would it be the highest in the Mississippi River?

2293 A. Well, it would be during the summer months.

Q. June, July and August?

A. Yes, during the warm season decomposition proceeds more rapidly; fermentative processes are more active during the warm season than they are during the cold season.

Q. That would apply also to the Illinois River and Missouri River, would it?

A. It would apply very well to all rivers.

Q. And to all waters?

A. Yes sir.

Q. Wouldn't it be higher in the waters of the Illinois if they were attributable to organic substances, vegetable substances, rather,—in September, October and November?

A. Yes, as a result of the decomposition having taken place during the summer months, that is possible.

Q. Of vegetable matter?

A. Yes sir.

Q. Now when you find albuminoid ammonia for instance in water at Grafton, in the Illinois River, you cannot tell whether it is the result of the decomposition of fecal or organic matter or animal matter, can you?

A. You mean the Illinois River at Grafton?

Q. Yes.

A. We have to take into consideration there the general 2294 analytical results.

Q. I am not asking you to take anything into consideration except the albuminoid ammonia alone.

A. Repeat that question.

Q. When you find albuminoid ammonia in water in the Illinois River at Grafton, can you tell whether it comes from decomposition of animal organic matter or vegetable organic matter?

A. In a measure I will be able to distinguish approximately whether this albuminoid ammonia may be more of animal origin or of vegetable origin.

Q. You mean you do that from the consideration of the ammonia alone.

A. By comparing the analytical results for the albuminoid ammonia obtained from the sample analyzed of the filtered water and the sample analyzed from the unfiltered water, and also by comparing results for the organic matter as estimated by the oxygen consumed process. Also on filtered and unfiltered samples, and also taking into consideration the residue on evaporation and the total solids test. In finding out whether the residue on evaporation found in the suspension, that is in the suspended matter of the original sample, is high or low, and how it compared with the residue on evaporation found from the estimate of the total solids in the filtered sample. We take 2295 all these things in general together and that enables us in a measure to say approximately and form an opinion as to whether the albuminoid ammonia there may be of animal origin principally, or of vegetable origin. An exactly correct estimation in quantity may not be possible. It is an approximation, but in general we can draw some conclusions from these comparisons.

Q. Now take another thing about which we have been talking here, the nitrites for instance. You found nitrites in the Illinois River at Grafton. Can you tell whether they are from the decomposition of vegetables or animal organic matter taken by themselves?

A. That I cannot distinguish, not as such, no.

Q. Your theory is that the Illinois and Michigan Canal was in a way, a septic tank?

A. Yes sir.

Q. And that therefore the waters discharged from it into the Illinois River at Joliet were in a better condition chemically than the waters discharged into it by the drainage canal?

A. Yes sir.

Q. Did you ever make any chemical analyses of the waters of the Illinois River at Joliet before the opening of the Drainage Canal?

A. No sir.

2296 Q. Did you ever have anybody do that?

A. No sir.

Q. So as to what was the condition of the Illinois River at Joliet consequent upon the discharge of the water of the Chicago River through the Illinois and Michigan Canal prior to the opening of the Drainage Canal, you do not pretend to know?

A. Well as I have obtained some information from available data, published by reliable authority.

Q. By yourself or in an investigation made under your direction?

A. Not from my own personal analytical examination, no sir.

Q. Did you ever make any analyses of the waters of the Desplaines river at any point before the opening of the Drainage Canal?

A. No sir.

Q. So that you have no personal knowledge in any way of its condition chemically either above or below the place where the Drainage Canal flows into it?

A. Well, whatever information I was able to obtain from published data of responsible investigators, I have.

Q. From your own personal investigation?

A. Not from my own personal analyses of the waters.

2297 Q. Now if a septic tank is good at one place, it ought to be good at another place in the course of decomposition, ought it not, in the purification of water?

A. Yes sir.

Q. Whatever state of oxidation, up to purification, with a septic tank intervening, is to hasten the process of purification?

A. Repeat that question.

Q. Whatever state of purification has been reached, a septic tank would be beneficial and hasten the ultimate purification of the water, wouldn't it?

A. Well, after a certain water had already passed the stages that are represented in a septic tank, then after it has run through a septic tank again, that same water would hardly be benefited by the septic tank because the action of the nitrifying cycle produced by the aerobic bacteria follows the action of the anaerobic bacteria in the tank as far as that sewage is concerned, of course, and it would not be any benefit.

Q. If there were a series of septic tanks through which the same water flowed, each septic tank would of itself aid in the purification of the waters, wouldn't it?

2298 A. Well, if there were a balance of water leaving one tank which had not gotten the initial processes of purification, of course that water or sewage would be benefited by passing through the second tank, etc.

Q. In the upper septic tank, if, when the water left, there were found free ammonia and albuminoid ammonia, and nitrites, the passage of that same water through another septic tank would help the processes of purification, wouldn't it?

A. Well, it has been established that in these septic tanks the aerobic bacteria are present to a limited degree, and these aerobic bacteria by being present in subsequent tanks may to a small degree continue these processes of purification and produce a purified product, that is, as far as they are able to do so in that tank. The number of aerobic bacteria from investigations made, show that the number is very small but they are admittedly present in these tanks.

Q. Well, in the Illinois and Michigan Canal, there was some current of water? The water flowed through that canal, didn't it?

A. Yes.

Q. Do you know how rapidly?

A. I couldn't tell just now. I haven't got the data at hand.

Q. Have you any idea how rapidly?

A. The current is exceedingly slow and it depends very much
upon the amount of sewage pumped into the canal and
2299 how long it is permitted to be in the canal. It varies
greatly.

Q. If 36,000 cubic feet per minute pumped in, and 36,000 cubic feet per minute discharged, there must have been a current in the Illinois and Michigan Canal?

A. Yes sir, at that time.

Q. And if that was the average state and condition of the Illinois and Michigan Canal, it must have had somewhat of a current?

A. Yes sir.

Q. Now suppose that below where the Illinois and Michigan Canal discharged into the Illinois River, there was a stretch of river of say three miles, in which the current was very slow, scarcely perceptible, would that operate as a septic tank?

A. Three miles per hour?

Q. A stretch three miles long of the river?

A. Yes sir, it would.

Q. If there was another stretch of 23 miles, that would also operate as a septic tank?

A. Yes sir.

Q. And in any investigation of the Illinois River that you have made, a long and continued series of septic tanks would have been very beneficial, wouldn't they, to the purification?

2300 A. In a measure it would.

Q. Do you know anything about the grades and descents of the Illinois River?

A. Oh, I have a slight knowledge of the same, a study of reports written by responsible authorities.

Q. But only taken from authorities? You made no surveys yourself?

A. No sir.

Q. Do you know that upon the Illinois River there are a large number of bayous of lakes, adjoining the banks of the Illinois River, which are spring fed?

A. Yes sir.

Q. And which in low water discharges their water into the Illinois River?

A. Yes sir.

A. And which in high water are completely overflowed?

A. Yes sir.

Q. Would they operate in any way as septic tanks?

A. Yes sir, they could.

Q. Do you know as a matter of fact whether they do or not?

A. Well, not from my own personal study.

Q. How many cross-sections of the Illinois River, did you ever take in the course of this investigation?

2301 A. Well, we took cross-sections in 1901, in October and November, we took various cross-sections in the Illinois River.

Q. Did you take any in March of 1901?

A. No sir.

Q. Do you recall how many cross-sections you took in 1901, and where they were?

A. Yes, I took cross-sections at Joliet and took cross-sections at Peoria, at Wesley, between Peoria and Pekin, and took cross-sections at Pekin.

Q. How many did you take altogether?

A. Well, for the Illinois River there were four or five; I couldn't tell just now. I believe five, it may be four, but I am not sure.

MR. TODD: At what point, doctor?

A. At Joliet and then at points below Peoria and Pekin.

Q. MR. JOHNS: In taking cross-sections how many samples did you take?

A. We took one at Kingston, Illinois, which is eight miles below Pekin.

Q. In making the cross-sections of the Illinois River, how many samples did you take?

A. Well the cross-sections taken at Pekin and Peoria represented three sections across the river; that is, we took 2302 the center of the river and then the right and left shore coming down the river.

Q. Only taking three samples for a cross-section?

A. Yes sir, right there.

Q. Now have you presented anywhere the result of the analyses of these cross-sections?

A. No sir, they have not been presented as yet.

Q. There is no chart or table of these cross-sections in your testimony?

A. Well, thus far they have not been testified to.

Q. Have you referred in your testimony thus far, to any chart or table in which the result of the analyses of these cross-sections was made?

A. I believe in stating the amount of work that was done in the beginning of my testimony, I mentioned that I had taken cross-sections at these points.

Q. I asked you if you had stated anywhere the results of the analyses of the samples taken in these cross-sections?

A. No sir.

Q. Do you know how in any way of the stages of the Missouri, Mississippi and the Illinois Rivers from August, 1899 to January 22,1900?

A. Yes sir.

Q. Were they high or low?

2303 A. You mean from August, 1899, to January, 1900?

Q. Yes.

A. The stages of the rivers at what points?

Q. Any point?

A. They were comparatively low.

Q. Can you state what was the average stage of the river in feet as indicated upon the guages during that period?

A. I cannot tell without consulting data.

Q. Well, have you introduced any evidence or have you spoken about or referred to such data here in the course of your testimony?

A. Yes sir.

Q. Have you with you, or presented here the chart 1?

A. Yes sir.

Q. Or table 1?

A. Yes sir.

Q. I would like to see it.

A. Do you mean the chart or the table?

Q. I would like to see the table, but I would like to have both.

A. (Handing paper to counsel) That is the table of the data for 1899, compared with the Illinois and Mississippi Rivers at Grafton.

2304 Q. Now in your table, the one intitled on the left-hand side: "Location, Illinois River above Grafton; Mississippi River above Grafton," and below the table the words "Above table gives the average results of samples between September 6th, 1899, and January 17, 1900." You may state whether or not you have a table of the daily results of these analyses at those points during that time.

A. There were no daily samples collected during that period?

Q. Have you a table of the results of the analyses of such samples as were taken?

A. Yes, I have them all on record, on record sheets.

Q. Have you presented in any table that you have produced here, while you were testifying, such results as to each sample taken at those places during that time?

A. To my recollection, such record has not been presented, but I have them ready though—

MR. JOHNS: We would like to have that, General Crow.

GENERAL CROW: At what point, Grafton?

MR. JOHNS: I want the table showing the results of the analyses of each sample at that place at this time. We don't understand that table has ever been given.

Q. How many samples did you take from that time, September 6th, 1899, to January 17th, 1900?

A. Well, I don't recollect just now; there were quite a 2305 number; I believe there were some 19 samples from each one of those points at the mouth of the Illinois River. I will have to look that up.

PROF. KEISER: There were eighteen.

THE WITNESS: There were eighteen samples taken.

MR. JOHNS: Have you the dates upon which they were taken and the places from which they were taken?

A. Yes, I have them all on the record sheet.

Q. From what source did you obtain the statement that in round numbers there were only 800,000 population of Chicago which discharged its sewage into the Illinois and Michigan Canal?

A. To my recollection, I didn't state that 800,000 population discharged into the Illinois and Michigan Canal, perhaps you mean the Drainage Canal.

Q. I am going to ask you about that afterwards. From what source then did you obtain the information that only 800,000 people discharged sewage into the Drainage Canal?

A. Well, that information I obtained from statistics obtained from Mr. Benezette Williams, Civil Engineer.

Q. And the basis of 800,000 population is on Williams' statement or report?

A. Why, both his statement in the testimony here, as well as his report.

GENERAL CROW: Let me ask the witness a question. 2306 Now are you testifying here that Benezette Williams in his testimony here stated that only 800,000 of the Chicago population drained into the Drainage Canal?

A. No, I drew the conclusion from Mr. Benezette Williams

statement that at times, not all the time, only 800,000 population of the City of Chicago, were draining their sewage into the south branch of the Chicago River which sewage, when the weather was clear and there was no heavy rainfall, at such times when the sewage in the North Branch and in the South Fork of the South Branch was stagnated. At such times I said directly at the rate of 250,000 cubic feet per minute, the rate of flow passing through the Chicago River, that is the south branch of the Chicago River into the Drainage Canal. I said at that time the districts of Chicago that drained into the south branch of the Chicago River and directly into the canal through the south branch, I say that this district represented a population of 800,000 and this estimate at such times, I said, not all times, I very distinctly specified that at such times, that the figure was 800,000 population according to data presented by Mr. Benezette Williams. I then also stated that at times when there were heavy rain-falls and storm water coming down the North Branch and coming down the South Fork, that then at such times the drainage of sewage into the Drainage Canal was vastly
2307 larger, vastly increased, and that evidently at that time a much larger population was draining sewage directly into the Drainage Canal.

MR. JOHNS: I must remind you once more, doctor, you are here to answer questions and not at this time to indulge in discussion.

A. I beg pardon, I just wanted to explain my statement.

Q. Well, we will get that into the record, and that question asked by me, and the question asked by Mr. Crow, and the answers to those questions were all that was expected.

Q. Now you were in chicago in September, 1900?

A. Yes sir.

Q. You say that the Drainage Canal was practically closed during that month?

A. It was closed a number of days in the month of September.

Q. Entirely closed?

A. During the day time, yes sir. There were repairs at the dams there, and the regulations in the rivers, with improvements made in the Des Plaines river that necessitated, as I was told, the closing of the Bear Trap dam.

Q. I am asking you whether you know or whether this is something that was told you by somebody?

A. No, I was there myself.

Q. Did you see the Drainage Canal closed, so that no 2308 water from it flowed into the Des Plaines River?

A. Yes sir.

Q. In September, 1900?

A. Yes sir, I saw that myself at the Bear Trap dam.

Q. How often did you see that during September?

A. I saw that on three different days.

Q. Have you any memoranda by which you can tell what days they were?

A. I believe I could follow it up from some notes which I took at that time, and designate the days. I cannot just now.

Q. You haven't them with you?

A. No sir.

Q. Now you stated that there were fish killed there, dead fish in the Des Plaines River and the Illinois River at Joliet. Did you ever see any such thing?

A. No I didn't see any fish coming over dead, but it was reported to me by one of my water collectors and one of my assistants, who was up there after I was up there, that they had seen these dead fish coming over there.

Q. Who were they?

A. George Ottens, one of the water collectors, and Alexander Miller, a chemist who recently testified.

Q. What you know about it is what has been told you by somebody?

2309 A. Yes sir.

Q. You don't pretend that you have any personal knowledge of it?

A. No sir, they saw that. They went there after I had left.

Q. From what source did you get the information that only 47 per cent of the population of Peoria discharged its sewage into the Illinois River?

A. Well now, that I found in a report published by Mr. Harman Civil Engineer, in the Illinois State Board of Health Report of 1900.

Q. You don't know that by any personal examination whatever?

A. No sir.

Q. Do you know that at Peoria there are a number of large distilleries?

A. Yes sir.

Q. And very large glucose works?

A. Yes sir.

Q. And that there are a great many other manufactories in the city of Peoria?

A. Yes sir.

Q. Do you know that in these distilleries a very large number of cattle are fed?

Yes sir.

2310 Q. And that the sewage from this city of Peoria, in proportion to its population is enormously large?

A. Yes, it is quite large.

Q. And very much disproportioned to the amount of the water supply as discharged from its sewers into the river?

A. Well, that I don't admit.

Q. Well, do you know that pollution in an enormous amount is dumped bodily into the Illinois River at Peoria, not through sewers at all, but just bodily into the river?

A. I know that quite an amount of sewage and refuse matter is dumped into the Illinois River at Peoria, between Peoria and Pekin.

Q. Very much disproportioned to its population?

A. That I do not admit. That is, its disproportion to the population.

Q. I want to know whether it is so or not?

A. Every large city that dumps its sewage into running waters has more or less of such refuse.

Q. But in proportion to its population, 56,000 say, the amount of solid matter dumped into the river not coming in through the sewers at all, is very largely out of proportion, very largely in excess of the population?

A. Well, if we draw approximate comparisons with a great many other cities that have similar manufacturing
2311 industries, I don't consider it very much out of proportion.

Q. But I am taking the suppositious cities upon which you chemists proceed, that the suppositious amount of water per day per individual. You know that the solid matter and sewage of the city of Peoria is very largely in excess of that supposition you made?

A. I don't think it is largely in excess.

Q. Will you say that it is not?

A. I don't think it is. It is not; that is my opinion.

Q. In your opinion is Peoria an average of cities of its size as far as the pollution of its water course is concerned?

A. Do you mean whether it is an average size of city?

Q. No. So far as the pollution gets into its water course is concerned, is it about the same as the average city of its size, or in other words has it the same averages as other cities of its size?

A. There may be cities that have no manufacturing industries of that kind and naturally the amount of refuse from such manufacturing establishments would be very small; but there are a great many cities that have in proportion to their population equally large industries, and it would not be justifiable for me to say that this refuse from sewage from the city of Peoria is out of all proportion in comparison with the population. 2312

Q. Well, have you any personal knowledge about it, is what I am trying to get at?

A. Yes, I have been in Peoria several times and studied these conditions myself.

Q. Did you ever see floating down the Illinois River islands of discharged animal matter, combined with straw, and find them sixteen and eighteen miles below Pekin, 25 or 30 miles below Peoria?

A. I haven't seen such but I have heard of so-called floating islands coming down the river there and being recognized by parties in the towns below Peoria, between Peoria and Beardstown.

Q. Now that is a very unusual state of affairs, isn't it?

A. I have seen some of those so-called little islands myself. I remember now, in the trips I made down that river on such occasions.

Q. Have you ever seen them going over the Copperas Creek dam?

A. No sir.

Q. Have you ever been in the estuary of the Illinois River called Spring Lake, fourteen miles below Pekin?

A. No sir.

Q. You never saw them in that?

A. No sir.

2313 Q. Now as to the actual character and amount of sewage of Peoria, you know nothing practically, of your own observation?

A. Well I have testified as to certain facts concerning the sewage of Peoria, and there are certain conditions of that sewage and certain conditions of the pollution of the Illinois River by sewage and manufacturing refuse in the city of Peoria that I am familiar with.

Q. If the sewage of Peoria will purify itself, if the dilution which it receives from the Illinois River, in a run of from 25 to 50 miles down the river, why will not the sewage of Chicago discharged at Lockport, purify itself in a run from Lockport to Peoria?

A. First of all, the sewage of Peoria cannot purify itself by such a run of from 25 to 30 miles under the conditions prevailing in the Illinois River. That is, the water of the Illinois River as it reaches Peoria not being sufficiently pure.

Q. That is to say that the waters of the Illinois River, when it receives the pollution of Peoria, is not in such a condition as to aid materially in reducing and purifying the Peoria sewage in addition to the burden which it already carries?

A. The water in the Illinois River as it reaches Peoria and passes down is confined to the current in the Illinois River.

Q. There is no water outside of the current?

2314 A. Oh yes, there is, but it is the current of the Illinois River that carries the water of the Illinois River down that river. The sewage from Peoria is discharged into the River near the shore. There is a different speed of the river in the channel from the speed along the shore. The character of the shore is proved to be from my personal observation, it is such and the chemical analyses demonstrate that fact, it is such that the sewage from Peoria—I speak now of the sewage as it enters the Illinois River from the sewers, does not reach the channel right away. It remains along the shore and since it has been established that the velocity of the river along the shore is always slower and different from the channel itself and there being quite a number of impediments there, the river makes certain curves between Peoria and Pekin, there is a considerable slackening of the speed of the river along the shore and this sewage from Peoria has a considerable time to perform certain initial purification processes along its route whereas in the channel the current is faster and this sewage from Peoria when it reaches the channel finally has remained for some time along the shore and has undergone certain processes of initial purification. The chemical analyses of cross-sections show that.

Q. It has been in the septic tank adjoining the current in the channel of the Illinois River?

2315 A. In a measure we can call that a septic tank.

Q. Now, if the waters of the Illinois River were potable when the sewage of Peoria was deposited in them, and if the waters of the Illinois River were of the same volume as they are now with the drainage canal open, would the sewage of Peoria purify itself in 25 or 30 or 50 miles?

A. Under the circumstances as I have described them and provided that the water of the Illinois River as it reaches Peoria would be pure, would be potable water, which it is not. and which according to all chemical records, it is not—

Q. Excuse me. Pay attention to my question. If the waters of the Illinois River were of the same volume that they are now that the Drainage Canal is open and were potable when they reached Peoria, and then received the sewage of Peoria, would they purify themselves in a run of from 25 to 50 miles?

MR. JEFFRIES: I object to that question and submit the witness was about to fairly answer that question.

MR. JOHNS: Answer the question Yes or No.

MR. JEFFRIES: He was fairly answering the question.

MR. DRENNAN: Let him answer it; I think he was going to do it; let him answer the question separately.

Q. (Question repeated)?

MR. JEFFRIES: We interpose an objection to the 2316 question because it is assuming a fact that is not proven and is not true.

MR. DRENNAN: It is asked with the understanding, and we assume that to be a fact, and whether it is a fact or not is a matter of dispute.

THE COMMISSIONER: Answer the question.

A. If that water, the Illinois River water, as it reached Peoria, would be pure, from the analytical data obtained, from the examination of samples of water collected between Peoria and Grafton, the conditions as described by me prevailing in the Illinois River between Peoria and Kingston, and through the lower towns there, these analytical data would demonstrate that chemically the effect of the pollution of the Illinois River by the Peoria sewage would not be noticeable.

MR. DRENNAN: Within that distance, he specified, or beyond that distance?

A. I previously said it would take from 25 to 50 miles for that sewage to disappear in the channel of the river, not to be noticeable in the channel of the river, the effect of it.

Q. (Question repeated.)

MR. DRENNAN: Answer yes or no.

A. I have answered it.

MR. JOHNS: Let me ask him a question. You are to as- 2317 sume that the waters of the Illinois River at Peoria are potable, and of the same volume as when the Drainage Canal waters flowed at that point, and at that point they receive the sewage of Peoria, would not those waters purify themselves so as to be again potable in a run of 25 or 50 miles, and I would like you to answer yes or no.

GENERAL CROW: If you can so answer it.

A. Whether that sewage would be purified or not, absolutely purified or not, that is a question I cannot answer, because, as I said, the water in the channel shows a different character from the water along the shore, and samples taken from the channel from 25 to 50 miles below Peoria do not show any more, chemically, the effect of the discharge of sewage of Peoria into the river. That don't preclude that the Peoria sewage may still be, partly, in a partly decomposed state along the shore.

not in the channel, and may still necessitate further purification before it could have disappeared, from the analytical results.

Q. Do you understand that you are testifying here as an expert?

A. Yes, sir.

Q. Do you understand that a lawyer has a right to put a supposititious question to you and that he is entitled to an answer to it?

2318 MR. JEFFRIES: I object to the question.

THE WITNESS: Well, that is not for me to determine.

MR JOHNS: You don't know that you have to answer the question?

A. Well, I have answered the question.

Q. I am asking you now if you understand your position as a witness here?

GENERAL CROW: I object to the question.

MR. JOHNS: Do you understand as an expert witness that an examining lawyer has a right to put to you a suppositious state of facts, and he has a right to require you to answer them?

GENERAL CROW: I object, for the reason that the question and even the answer as given does not tend to prove or disprove any issue in this case, and further that an attorney has no right whatever to instruct the witness as to his duties on the witness stand.

MR. JOHNS: I think in the absence of a Court an attorney has.

GENERAL CROW: That is a matter of opinion.

MR. JOHNS: Answer the question.

Q. (Question repeated.)

A. As I have stated before, a chemical analysis of the water taken from the channel 25 to 50 miles below, would 2319 not show any more the presence of the sewage from the city of Peoria, but that would not preclude the sewage from the city of Peoria still being in the river along the shore, undergoing its natural processes of gradual purification.

Q. Do you understand that as an expert witness upon the stand you are required to answer such supposititious questions as are put to you by an attorney?

A. Well, I am perfectly willing to answer the question if I am requested to do so by some authority. I have endeavored to give all the information that I possess on that subject embodied in the question.

Q. Assuming that the waters of the Illinois River when they reach Peoria, are potable, and of the same volume as when the Illinois Drainage Canal is discharged into them, and that at that point they receive the sewage of Peoria, would those waters become potable again in a run of from 25 to 50 miles? Answer that question.

A. I don't think they would; that is, potable in general.

Q. Would they become potable in a run of 75 miles under the same circumstances supposed in the previous question?

A. In a run of 75 miles?

Q. (Question repeated.)

A. That would depend very much upon the character of the sewage of the city of Peoria.

2320 Q. Knowing the sewage of the city of Peoria as you do, as intimately as you have become acquainted with it by chemical analyses, would it purify itself in 75 miles under the circumstances supposed in the second preceding question?

A. That would depend upon the character of the sewage as such. Depend very much upon whether it would contain pathogenic bacteria or not.

Q. You made a statement on March 17th, that the sewage entering the Illinois River from the city of Peoria, after running from 25 to 50 miles, would purify itself so as to remove the polluting effect of the Peoria sewage on the Illinois River?

A. I said chemically.

Q. Is it true or not that if the waters of the Illinois River were potable before they came to Peoria, that the sewage entering the Illinois River from the city of Peoria, would, after running from 25 to 50 miles, purify itself, so as to remove the polluting effect of the Peoria sewage?

A. I said chemically, yes. I didn't say that at that time, but it was understood, and if I had been asked the question I would have said so at that time, that a chemical examination of the samples of water taken at a point below Peoria, and taking into consideration the general conditions of the river, I would say that that sewage disappears from the channel, that is, the

chemical result would not show its presence in the
2321 channel.

Q. 25 to 50 miles below Peoria, do you think it would show its presence along the sides of the channel?

A. The cross-sections that we have taken from the Illinois River below Peoria show chemically a difference between the water running along the shore and running in the channel.

Q. Answer this question. I have just as much time as you have. Does it show in the Illinois River on the sides, or would it show, and not in the channel 25 to 50 miles below Peoria?

A. At that distance?

Q. Yes?

A. That I couldn't tell, because I haven't made any examination of samples from that point.

Q. And you haven't produced the cross-sections to show it here, yet, have you?

A. The chemical researches demonstrate—

Q. Answer the question?

A. (Continued)—that sewage can remain on the shore for a long time before it goes down the river.

Q. You haven't produced the cross-section analyses of the cross-sections which show any such results here, have you?

2322 A. I have not. I have not been requested to do so.

Adjourned until 2:00 p. m., same day, March 30, 1903.

2323 Southern Hotel, St. Louis, Missouri, 2: p. m., Monday, March 30, 1903. Continuation after recess.

Present, the Commissioner and same counsel representing the respective parties.

DR. WILLIAM C. TEICHMANN, resumed the stand for further cross-examination, by Mr. Johns, and testified as follows:

Q. Were the samples of water which you took from the Illinois River taken all within the channel?

A. Yes, sir; the orders issued to the collectors were that they should always take them from the channel.

Q. When you took samples at the Chain of Rocks, on the Missouri shore, how far was that sample taken from the Intake?

A. That sample was taken as close to the Missouri shore as was necessary to get a characteristic sample of the Missouri River water as it hugged the Missouri shore.

Q. Your theory is that the Missouri River water at St. Louis coming down six or seven miles, is not mixed with the Mississippi River water to any great extent?

A. Well, that part of the River which runs close to the Missouri shore is composed principally of Missouri River water.

2324 Q. Now, the Missouri River comes into the Mississippi pretty nearly at right angles, does it not?

A. Well, that depends upon the volume of water coming down the Missouri River.

Q. In the mean stage of the Missouri River, its general geographical formation at its mouth, isn't it true that the current of the Missouri comes into the Mississippi at nearly right angles?

A. No, sir, that has not been my observation at such times when I was up there at the mouth.

Q. Well, if a man should look at a map, an accurate map of the Missouri where it enters the Mississippi, he would find that it comes in there at pretty close to right angles, would he not?

A. Well, you see the pressure of the volume of water coming down the Mississippi River will naturally produce a curve there; it would not turn down in such a way as to enable an angle to be formed.

Q. When the current of the Missouri River strikes the current of the Mississippi River, is it, or is it not about at right angles?

A. No, sir—no, it is not at right angles, because the pressure from the Mississippi River water will always produce a curve there.

2325 Q. Well, I will get to the deflection after a while. But run a line two miles up the current of the Missouri River and a line in the current of the Mississippi River at their junction—at the junction of the two, what would the angle be?

A. Well, that would be a different proposition.

Q. Well, that is the proposition that you are confronting now.

A. Yes, sir; that would produce an angle.

Q. Produce pretty close to a right angle, wouldn't it?

A. Yes, sir.

Q. Now, then, your theory is that when the two conflicting currents meet, the Mississippi overcomes the Missouri and turns it down the Missouri bank?

A. That depends upon the volume of water in each river. If the Mississippi is higher, it will naturally crowd the Missouri River current closer towards the Missouri shore. If the Missouri River is higher it will crowd the Mississippi River closer to the Illinois shore.

Q. Well, when there are equal stages of water, and in an average condition, your theory is that the current of the Mississippi overcomes the current of the Missouri and turns it down the Missouri shore, towards St. Louis?

A. No, not exactly; it don't turn it over to the shore so
that the Mississippi River would prevail. The two cur-
2326 rents will run alongside of each other, each river hugging
one shore—the Missouri hugging the Missouri shore, and
the Mississippi River hugging the Illinois shore. Now, it will
depend entirely upon the volume of water in each of those cur-
rents which will prevail in the channel—of the channel water.

Q. Well, when the stages of the river are equal, the fact is that the current of the Mississippi overcomes the current of the Missouri and turns it down at right angles, and runs it along the Missouri shore?

A. Well, what was the question in that connection?

Q. Well, that is the question. Is that the fact?

A. That they run alongside of each other on such occasions?

Q. Yes.

A. Yes, that can happen.

Q. Well, it does happen, does it not?

A. Yes, sir.

Q. But at the same time there is more or less a mixture of each of the rivers on the Missouri shore at St. Louis, at the Chain of Rocks?

A. Sometimes this mixture which may be found in the channel may crowd over toward the Missouri shore somewhat, but still our analytical data show that samples taken close to the Missouri shore will always be prevailingly Missouri River water—if close to the Missouri shore.

2327 Q. Now, the Illinois River comes into the Mississippi at a very slight angle, does it not?

A. The Illinois and the Mississippi?

Q. Yes.

A. Well, before they meet there is a long narrow strip of land that divides them, and when they meet they run almost parallel; that is, they come togeher slowly, this way (indicating).

Q. The Illinois River water keeps close to the Illinois shore?

A. Yes, sir, it is entirely a different situation than that at the mouth of the Missouri.

Q. Yes, the Illinois River keeps close to the Illinois shore, and the Mississippi River in its natural channel, closer to the Missouri shore?

A. Yes.

Q. How far is it from the Missouri shore to the place where you actually took the samples at the Chain of Rocks on the Missouri shore?

A. You mean how far from the Missouri shore to the—

Q. Place where you actually took the samples?

A. Well, that might have been 500 feet; it might have been 1,000 feet. It was left very much to the judgment of the collector who was to get the water from the particular current of the river as it flowed along there. When he was 2328 to get a sample of water from the Missouri shore, he was supposed to get Missouri River water, and when he was to get a sample from the Illinois shore, he was to get a sample of the mixture of the Mississippi and the Illinois Rivers as they ran along the shore of Illinois.

Q. There was then, as to the Missouri shore, no fixed and certain place at which the sample was taken?

A. No, sir; it depended upon the current entirely.

Q. And it was left to the judgment of the man who took the sample as to where he should take it?

A. Yes, sir.

Q. So that a sample one day might have been taken 300 feet from the Missouri bank, and the next day 1,000 feet from the Missouri bank?

A. Yes, sir, if the current would run that way; he was instructed to get samples accordingly.

Q. Is the current of the Missouri at the Chain of Rocks on the Missouri shore constant and regular?

A. Yes, sir.

Q. And flows along from day to day in about the same place?

A. Well, it varies somewhat in volume and in the width of the current at that place, but there is always some Missouri River water running close to the Missouri shore. Our analytical data show that. 2329

Q. So, if you took a sample of Missouri shore water, and upon the same day made a cross-section of the Mississippi and took one at the Intake and one at the Illinois shore, and you did the same thing the next day, you couldn't tell to save your life whether the sample on the Missouri shore was taken at or very near the place it was taken the day preceding, could you?

A. Well, we could tell from the comparison with the Bellefontaine samples, whether it was Missouri River water or not, that he got at the Missouri shore.

Q. Yes, after analyzation—but could you tell when the sample came into your office, or did you have any certainty of its being from comparatively or substantially the same place on the Missouri shore that it was taken the day before?

A. Well, for the most part of the year the Missouri River sample would always show more sediment and we could tell at a glance from the amount of sediment in the sample whether it was taken close to the shore or not, because the Missouri River always has a sediment.

Q. When you got a sample of Missouri River water on two succeeding days, could you tell whether they were taken from substantially the same place, or whether they might have been taken at a distance of five or six hundred feet from each other?

2330 A. Well, the chemist that would get those samples day after day would pretty soon be able to see those differences if there were any, and he could tell at a glance that must be water coming from the Missouri shore, because of its heavier sediment—heavier as compared with the Illinois shore.

Q. I am not asking you as to the amount of sediment, nor the analyzing, but from the mere fact that the sample was presented at your office on two successive days, purporting to come from the Missouri shore, could you tell whether they were taken within 500 feet of each other or not?

A. Well, sometimes I could.

Q. In what way?

A. Well, because the Missouri River current would come down the Missouri shore, and the Mississippi and Illinois mixture would come along the Illinois shore. Now, we could tell from the stages of the rivers in looking over the weather maps, we could see which river was higher, whether there had been a change in the stage of the river over night, and that would give us a line on the proximity of the Missouri River toward the shore.

Q. You could tell by the analyzing of a sample as to whether it was Missouri River water or not—largely? Whether it was a large per cent. Missouri River water?

A. Yes, sir.

2331 Q. Could you tell by the analyzing of a sample whether it was taken within six hundred feet of the sample of the day before which you analyzed?

A. Yes, I could by comparing it with the Missouri River sample taken at Fort Bellefontaine.

Q. And you could tell whether it was Missouri River water or not?

A. Yes, by comparing those two samples.

Q. But could you tell by the analysis whether it was taken within three hundred feet of the Missouri shore line or whether it was taken from about nine hundred feet from the Missouri shore line?

A. Well, not from the analytical data alone.

Q. Well, now, how far is it from the Chain of Rocks to the place where you took the water from the Illinois shore?

A. Well, that varied. It might have been 75 yards—

Q. From the Chain of Rocks—from the Intake at the Chain of Rocks?

A. Oh, you mean from the Intake?

Q. Yes.

A. Yes, even from the Intake. Of course the stage of the River would have a great deal to do with the width of the river at that point. Sometimes the water would be high of course, and the Illinois and Mississippi River mixture would 2332 prevail of course, considerably if it—if a large volume of water came down the Mississippi. It wasn't necessary then for the collector to go very close to the Illinois shore.

Q. Now, from any place on the side of the river designated as the Illinois shore, where you took samples each day?

A. Well, originally I went out and took the collectors out there and told them just about in this neighborhood here (indicating) you ought to take the samples, but you have got to follow your own judgment very much in connection with the stages of the river. Just see that you get the sample that is most characteristic of the water running along that shore.

Q. It was not an endeavor then to take water at any particular and certain point on the Illinois shore, but it was an endeavor to leave it to the judgment of the collector to select the place in which he would get water characteristic of the Illinois shore?

A. Well, he was originally instructed to get it at certain points selected by me, and to always try to get them as close to that point as possible.

Q. Now, was that instruction followed?

A. Yes, sir.

Q. Was the sample from the Illinois shore then taken substantially at the same place each time?

2333 A. Oh, no, I can't say that exactly from the same place, but about in that neighborhood there. You see the samples were taken from a skiff, and the skiff floats while the samples are taken, and it cannot be a fixed point. Simply the instructions can only designate "In this neighborhood, right around here, as close to this place now where I am today, you ought to collect samples hereafter."

Q. How close were you to the Illinois shore when you told the man this was to be the place that you wanted to take the Illinois shore sample?

A. Well, that day, I was about 75 yards I think—I remember.

Q. From the Illinois shore?

A. Yes, sir.

Q. And opposite the Chain of Rocks?

A. Yes, sir.

Q. Now, do you suppose for a moment that the water at that point, any of it, ever got into the Intake Tower?

A. When I took the sample on that—or when I designated those points on the certain days, I believe the Missouri River at that time on that day prevailed at the Intake, but I am not quite sure about that; I would have to look up the data.

Q. Well, I will have to ask you the question again. Do you suppose that any of the water which you took at the place which is designated as the Illinois shore, ever got into the Intake? 2334

A. Yes, it got into the Intake quite frequently.

Q. How did it do it?

A. Well, when the Missouri River was low, and the larger volume of the Mississippi River water coming down the Illinois shore, would push the Missouri River toward the Missouri shore, and beyond the Intake, which is 1,500 feet distant from the Missouri shore line, and on such days, the Mississippi and Illinois mixture water would get into the Intake.

Q. Now, let us see if we can understand each other. The water taken at the place called the Missouri shore at the Chain of Rocks, and the Intake at the Chain of Rocks, and the Illinois shore at the Chain of Rocks were supposed to a cross-section of the Mississippi?

A. Yes.

Q. And the point on the Illinois shore was opposite the Chain of Rocks?

A. Yes, sir.

Q. Is that correct?

A. Now, what is the question?

Q. The point on the Illinois shore opposite the Chain of Rocks, and the point at the Intake Tower and the point which you designate as the Missouri shore, constituted a cross-section of the Mississippi River? 2335

A. They were to constitute a cross-section as near as possible.

Q. Then the point designated as the Illinois shore was opposite the Chain of Rocks and near the Illinois shore?

A. Yes, sir.

Q. Now, the question is, did any drop of the water from that point designated as the Chain of Rocks, as the Illinois shore, ever get into the Intake, and if so, how?

A. Of course, from that collection point on such a day the water that would flow along the Illinois shore would only get into the Intake, if out in the channel, upon the edge of which channel the Intake Tower is located. If in that channel, Mississippi River water would prevail, then that Mississippi River water would go into the Intake.

Q. That assumes that the water on the Missouri side of the Mississippi channel is the same as the water on the Illinois shore outside of the Mississippi channel?

A. No, sir; because the line of demarkation between the Missouri River current and between the Mississippi River current on such days might have been between the Missouri shore and the Intake, so that the Intake was getting Mississippi River water, while beyond the line of demarkation between the
2336 two currents the Missouri shore was getting Missouri River water, the Intake being located 1500 feet from the Missouri shore on the edge of the channel.

Q. If the Intake is on the Missouri side of the Mississippi channel, and the point designated as the Illinois shore is on the Illinois shore side of the Mississippi channel, then all your calculations assume that the water between the Intake and the Illinois shore points is precisely the same as the Illinois shore points, is it not?

A. You say that the water was taken between the Intake Tower and the Illinois shore—

Q. Is precisely the same?

A. Between?

Q. Yes, all your calculations are based on that assumption?

A. I know, yes, but that depends again upon the percentage of mixture of the two rivers in the channel.

Q. That is precisely what I am getting at.

A. You see the Intake Tower being located on the western edge of the channel, there might be a different water in the channel then 20 or 30 feet east of the Intake Tower, and still a different kind of water chemically, running along the Illinois shore.

Q. Well, why do you in determining the percentage of Illinois water, of impurities from the Illinois River at the
2337 Intake, use as one of the elements of the calculation the water on the Illinois shore?

A. Because the samples taken from the Illinois shore were such samples as would be most characteristic of the water running along that shore.

Q. Well, the water at the Illinois shore at the point, at the Chain of Rocks, and at the point from which you took it, never did get ito the Intake, did it?

A. Now, how is that question, please?

Q. The water at the point where you attempted to take, at the Illinois shore —

A. Yes.

Q. That water never did get into the Intake, did it?

A. It could not on such days because the point of collection was to be far enough away from the Intake so that it should not be water that was going into the Intake, but should be water that was passing along the Illinois shore.

Q. If you took a sample of water on the Illinois shore opposite the Intake, the water at that point in order to get into the Intake of the St. Louis Waterworks, would have to turn a direct right angle and travel across the stream, wouldn't it?

A. Yes, sir.

Q. Now, did that ever occur?

A. Not to my knowledge.

2338 Q. Then when you assume in calculating the per cent. of pollution, nitrites, nitrates, free ammonia, albuminoid ammonia, or anything, upon the basis of such pollution at the point known as the Illinois shore, the Intake and the Missouri shore, you never did get it right, did you?

A. I can't draw that conclusion at all, from my statements.

Q. If none of the water at the point where you took it, could by any possibility, get into the Intake Tower, then all your entire basis of calculation was wrong, wasn't it?

A. I said that the instructions to the collectors were such that he should take a sample of the water running along the Illinois shore and not that water that was going into the Intake, because he was to take a separate sample at the Intake to find out the character of the water that was going into the Intake.

Q. Well, your idea of taking water at the Illinois shore was to get the condition of the water at the point where you took the sample, was it not?

A. Yes, sir.

Q. Now, if that point was a direct line, and immediately opposite the Intake Tower, the condition of that water never was represented at the Intake Tower at all, was it?

A. No, sir; the character of the water taken from the Intake Tower was represented in another sample taken
2339 right at the Intake tower where the water flows in there.

Q. But the water which was taken at the point called the Illinois shore, opposite the Chain of Rocks, was never the water which entered into your calculations as to the mixture of the Mississippi and the Illinois at the Intake Tower, was it?

A. Oh, it entered into the calculations when I made certain calculations to estimate the percentage of the mixture of the waters at the Intake Tower.

Q. The figures derived from the analyses of the water on the Illinois shore entered into your calculations as to the character of the water at the Intake Tower, did they not?

A. No, sir; it could not, because it was a different water. It was not water going into the Intake Tower unless the Mississippi River should be so high that it would push the Missouri River toward the Missouri shore and prevail in the narrow channel, and thus get into the Intake.

Q. Supposing a case—take a piece of paper—suppose the nitrites at the point known as the Illinois shore were .007, and the nitrites at the Intake Tower were .005, and the nitrites at the point known as the Missouri shore were .003—what percentage of the waters of the Mississippi River enter the Intake?

2340 A. Well, now, I don't base the calculation in my testimony on the nitrites as found on those three shores—at those three points.

Q. Well, I am asking you to do it now?

A. Because I consider the margins so very small there that the data would be approximations, whereas, if I would take the total solids found I might get larger variations and consequently better results. I mean results—get more detailed percentages.

Q. I am not anxious at all now about the results. That is one of the least of my troubles. The question is if the nitrites were as supposed there, you being bound by the supposition, wise or foolish, what was the per cent. of Mississippi River water, as indicated by nitrites, going into the Intake Tower?

A. Well, I would say that the water going into the Intake is a medium there, between the water at the Illinois shore and the Missouri shore, but I don't calculate any per centages on that basis.

Q. Can you calculate a percentage on that basis?

A. Yes, I think it can be done.

Q. Take your chart 8, for instance, and tell me whether or
not you base your calculation as to the per cent. of chlo-
2341 rine at the Intake Tower upon the 23rd day of January,
upon the data which that table or chart shows?

A. Yes, based upon the chlorines there I made an approximate estimate there, and an approximate average of the percentages as found at the Missouri shore, Illinois shore and the Intake Tower.

Q. At the Chain of Rocks?

A. At the Chain of Rocks, yes.

Q. Now, the chlorine is not very different from nitrites in their ability to turn a right angle and come across from the Illinois shore to the Intake Tower, are they?

A. Well, that depends very much upon the general relation of the various chemical ingredients there. I would not say that they run parallel, the chlorines and the nitrites.

Q. Now, but I am asking about the ability of the chlorines to turn a right angle at the point called the Illinois shore, and run into the Intake Tower?

A. Well, now, that is hard to tell. My observations do not enable me to say so.

Q. Well, don't you know of course that it is a physical impossibility; that they couldn't do it?

A. Well, I have said, to my knowledge, I didn't know. I don't want to assert anything I don't know.

2342 Q. Well, theoretically now, chemically considered, do the waters at the point called the Illinois shore turn a right angle and make a straight shoot for the Intake Tower?

A. No, sir; as I said before, I said there is no—I have never seen from my own observation any right angle there.

Q. Now, what point up the Mississippi River do you think that it would be fair to select in order to get a sample of Mississippi River water which actually intermingled with the Missouri and went into the Intake Tower?

A. I consider one mile above the mouth of the Missouri River in the Mississippi as a proper point.

Q. Proper point?

A. Yes, sir.

Q. Well, then your calculations as to the pollution of the waters of St. Louis having been based entirely on the samples taken at the Illinois shore, are upon a false basis, are they not?

MR. WOERNER: I object to the question on the ground that it assumes that the witness has stated that the water on the Illinois shore at that point passes into the Intake, whereas, the testimony of the witness has been that samples were taken on the Missouri shore so as to get the characteristic Missouri water, and on the Illinois shore so as to get the characteristic Illinois water, and comparing the same with the water taken from the Intake, to be able to ascertain how much of a 2343 mixture of those two waters passes into the Intake.

Q. Well, answer the question.

A. What is the question?

Q. (Question repeated.)

A. Well, I have taken for comparison—

Q. No, answer the question; they are or they are not on a false basis?

MR. WOERNER: One moment. I further object to the question on the ground that it assumes that the witness bases his calculations solely upon the water taken from the Illinois shore, whereas, such is not the case. I don't think your question is fair.

MR. JOHNS: Well, I am responsible for that. You needn't worry about it.

Q. Answer the question?

A. Now, do you refer to this approximation of chlorines at the Intake Tower, or do you refer to my general percentages of total solids, as found in the Missouri River and the Mississippi above the mouth of the Missouri, and the Intake. There are two different kinds of estimates that I have made there?

Q. (Question repeated.)

A. I cannot say that they are on a false basis because they have not been compared in such a way.

Q. Where did you obtain the data upon which you base
2344 the calculation made as to the percentage of Mississippi
River water and the Missouri River water entering the Intake Tower?

A. One sample was taken from the Missouri River at Fort Bellefontaine; another sample taken from the Mississippi River from the channel of the Mississippi River one mile above the mouth of the Missouri at a point designated as Hartford in the analytical records, and on the charts; the third sample was taken from the collection point at the Intake Tower; that is the water as it flows into the Intake Tower was sampled, and the samples from these three points were compared. The residue on evaporation was selected as affording the widest range in figures, and therefore the closest approximate estimate of percentages of mixtures at the Intake.

Q. Well, in that calculation you have no reference to the Illinois shore, at all—at the point called the Illinois shore?

A. No, I have taken the channel water.

Q. From the Mississippi?

A. From the Mississippi one mile above the mouth of the Missouri.

Q. Now, what per cent. of that water was water from the Illinois River you don't pretend to know, do you?

A. How do you mean?

Q. What per cent. or what proportion of the water taken
2345 in the channel of the Mississippi River at Hartford was
of the entire water, in the Mississippi River at that point you don't pretend to know?

A. Well, I only know that it was the water that was running in the channel; the water that was coming down.

Q. Well, there wasn't any of it Illinois River water—do you know?

A. Well, the analysis of the channel water showed that there is Illinois River water in that mixture that runs in the channel.

Q. I am asking you as a matter of fact, do you know whether any water taken at Hartford in the channel of the Mississippi River is a mixture of the Illinois river water with the waters of the Mississippi, above its mouth?

A. Yes.

Q. How do you know it?

A. From analytical data that I have.

Q. Do you know it in any other way than that?

A. Well, at times of personal inspection of those points I know that those samples were taken from the channel.

Q. Yes, but how do you know that those samples contained any Illinois River water by inspection?

A. Well, by inspection alone I could not ascertain that chemically that water was a mixture, it required the 2346 chemical analysis subsequently made to determine that Illinois River water was contained in the mixture running in the channel.

Q. If the nitrites on any given day at Hartford in the channel of the Mississippi were .004 parts per million, what percentage of that was Illinois River water?

A. That I could not tell off hand. I could study the analytical data and the original figures, and draw deductions therefrom.

Q. Are your figures based then upon the assumption that the waters of the Illinois River and the Mississippi River at Hartford are thoroughly mixed?

A. I am of the opinion that the chemical analyses prove that the water running in the channel between Grafton and the mouth of the Missouri, is a mixture of Mississippi water above the mouth of the Illinois River, and Illinois River water; that after they meet they mix; the analytical results demonstrate that.

Q. But the waters of the Mississippi and the Missouri do not?

A. The waters of the Mississippi and the Missouri also mix. The analyses of samples taken from the Mississippi River channel after the two rivers meet demonstrate that.

Q. That they do mix?

A. Yes, sir.

Q. Well, are the waters of the Mississippi River in the
2347 channel at Hartford a complete mixture of the waters of
the Mississippi above Grafton, and of the waters of the Illinois River as they come in at Grafton?

A. It would be impossible to say complete, but the mixture is proven by the chemical analyses of samples from the channel.

Q. It is proven that there is some mixture?

A. Yes, sir.

Q. So far as mere matter of mixture is concerned?

A. Varying more or less from day to day.

Q. Well, now, are they mixed more at Hartford than they are at the Chain of Rocks?

A. Now, you mean to say that the Illinois River and the Mississippi River water there are better mixed at Hartford than they are at the Chain of Rocks?

Q. Yes?

A. Well, that would be difficult to establish because the water in the channel at the Chain of Rocks also contains the Missouri River water, and that would be the mixture of three rivers and it would be difficult to estimate.

Q. Are the waters of the Mississippi River above Grafton, and the waters of the Illinois River as they come into the Mississippi at Grafton, better mixed at Hartford with each other than they are at the Chain of Rocks?

2348 A. Well, that is a question that cannot be answered. I couldn't say so.

Q. Then on what theory did you take a sample at the point called the Illinois shore?

A. On the Illinois shore?

Q. Yes, opposite the Chain of Rocks?

A. Opposite the Chain of Rocks?

Q. Yes.

A. Because there is always a current running along the Illinois shore that is distinguishable in a chemical analysis from the current running along the Missouri shore and the channel water, the three are always different at the Chain of Rocks.

Q. And the sample taken at the Illinois shore is more representative of the Illinois River water, is it?

A. The sample taken from the Illinois shore demonstrates by its chemical character that it is a mixture of the Illinois River and the Mississippi River.

Q. Does it demonstrate that there is more of the Illinois River water in the mixture at the Chain of Rocks, than there is of the Mississippi?

A. Well, that would necessitate a very close study of the analytical data, it varies. The amount of mixture of those two rivers for each will vary constantly.

2349 Q. Was the object in taking the sample at the point called the Illinois shore opposite the chain of rocks, to get as good a representative of the Illinois River water as possible?

A. No, sir. The object was to get as good a sample as possible of the water running along the Illinois shore, because the analyses show that it differed from the water going into the Intake and from the water running along the Missouri shore.

Q. And it also showed that the water of the Illinois River predominated on the Illinois shore at a point opposite the Chain of Rocks, at which you took the sample?

A. Well, that, strictly speaking, would be impossible to say, but the Illinois River predominates on the Illinois shore; it is a mixture that runs along that shore of the Mississippi and the Illinois, and the water taken from the Illinois shore shows in its chemical results greater pollution and more impurities than the Mississippi River above the mouth of the Illinois River, so consequently the mixture of the Mississippi River and the Illinois River which takes place in the channel between Grafton and the mouth of the Missouri, that mixture continues and increased pollution continues to show in the water running along the Illinois shore at all times.

Q. And it shows also, doesn't it, that at a point opposite 2350 Chain of Rocks the characteristics chemically of the Illinois River predominate over the characteristics of the Mississippi River above Grafton?

A. I couldn't say predominates, but that pollution of the Mississippi River below the Illinois River shows its effect in increased figures of the characteristic ingredients of sewage found in the water at the Illinois shore, Chain of Rocks, as compared with the water found in the Mississippi River before it meets the Illinois. The effect of the pollution of the Mississippi River by the Illinois, can always be traced down to the point of collection in the Mississippi River from the Illinois shore at the Chain of Rocks.

Q. The per cent. of pollution in the water at the point called the Illinois shore, opposite the Chain of Rocks, is higher than the per cent. of the pollution of the Mississippi River above Grafton?

A. Yes sir.

Q. The per cent. of pollution of the Mississippi River at Hartford in the channel is greater than the per cent. of pollution of the Missouri River at Bellefontaine?

A. Yes, sir.

Q. The per cent. of pollution at the Intake Tower is higher than the pollution shown in the Missouri River at Bellefontaine?

2351 A. At such times when the Mississippi River and the Illinois River mixture enters the Intake Tower, at such times, which frequently occurs, the water going into the Intake is more polluted than the water found in the Missouri River at Bellefontaine, but whenever the Missouri River is very high and it crowds the Mississippi River, the Illinois River mixture towards the Illinois shore, so that the Missouri prevails in the channel, then the water that flows from the channel into the Intake Tower is prevailingly Missouri River water, and the analytical results will show at such times that the water that goes into the Intake is chemically just like the water running along the Missouri shore and just like the water found in the sample taken at Bellefontaine, Missouri River. Then the three are alike. When the Missouri River prevails in the channel, Missouri River water goes into the Intake, but when the Missouri River is lower than the Mississippi and Illinois mixture and the latter prevails in the channel, the Intake Tower being located 1500 feet from the shore on the edge of that channel the

Intake Tower then gets the Mississippi and Illinois River mixtures, and the analytical results show that the water that goes into the intake then is more impure and more polluted than the water found on the Missouri shore in the Missouri River current, and found at Bellefontaine in the Missouri River.

2352 Q. If you find by analyses that the water going into the Intake Tower has a higher per cent. of pollution than the water of the Missouri River at Bellefontaine, your chemical conclusion is that the water going into the Intake Tower is very largely Mississippi River water?

A. Yes, sir.

Q. And your conclusion is based not upon any ability to observe by the currents, which river it is, but solely and entirely from the chemical analyses?

A. Yes sir.

Q. And is based not upon any personal observation of your own, but soley and entirely upon the chemical analyses?

A. Yes sir.

Q. Where did you get the data for the curve described upon chart 8?

A. Those data were obtained from analytical results which were calculated from chemical analyses of samples of water collected from January 23rd, until October 2nd, 1900, from the Missouri shore, the Chain of Rocks—from the Intake Tower at the Chain of Rocks, and from the Illinois shore at the Chain of Rocks.

Q. If you were going to make a table showing the relation between the respective quantities of Missouri and Mississippi River water pumped, why did you not take your data from 2353 Bellefontaine, the Mississippi River above Grafton, and the Illinois at Grafton?

A. Because the question as to the chemical character of the water going into the Intake could best be answered by taking a sample from the channel at Hartford, representing the Mississippi River water just before it meets the Missouri River.

Q. If that is the case, why did you take a sample of water at the Chain of Rocks and on the Illinois shore for comparison?

A. Because I considered that the most important question was in calculating out the daily results as we can see them from the chemical analyses, that we had better take the Missouri

River before it meets the Mississippi and the Mississippi before it meets the Missouri, so as to get the accurate character of those rivers, and since they each flow down the Mississippi River, each one hugging the shore, the Missouri the Missouri, and the Illinois and Mississippi mixture hugging the Illinois shore, that we would get the data that would best show the effect of the mixture of those rivers, taking those points.

Q. You took the data on the Illinois shore in that chart to determine what?

A. This chart was only to determine a general average for the whole period. Total residue on evaporation and 2354 chlorine and nitrites by comparison, but as regards the most accurate data in the table, I considered it largely a range of figures between the Missouri River sample and the Mississippi River sample above the mouth of the Missouri, as affording a more accurate and detailed estimate. The ranges are very wide there, the figures on total solids, and afford a very good estimation of those percentages. For the daily percentages, for the daily approximations, this estimate based at the Chain of Rocks would do, but between the two I would consider the percentage estimations from the samples taken in the Missouri River and the Mississippi above the mouth of the Missouri and the Intake, as more conclusive, particularly because they show the daily variations better.

Q. Then why, in order to determine the respective quantities of Missouri and Mississippi River water pumped, did you take a sample from the Illinois shore when you knew it was a physical impossibility for that water to be pumped at all?

A. Well, that is to show the character of the current running down the Mississippi River at the Chain of Rocks.

Q. It shows the character of the current on the Illinois shore, doesn't it?

A. Yes sir.

Q. And the character of the current at the Intake?

2355 A. Yes sir.

Q. Which is across the channel of the Mississippi from the point known as the Illinois shore?

A. Yes sir.

Q. And the character of the indefinite place known or styled the Missouri shore?

A. Yes sir.

Q. If no drop of the water taken at the Illinois shore as represented by the blue line on that chart ever entered the Intake tower, then that blue line is not a fair representation of the character of the Mississippi River water which was pumped into the Intake, is it?

A. Well, in order to get a percentage there, I also take the current of the Missouri River as it runs along the Missouri shore, and taking these two figures and taking the result of the analyses as found at the Intake, that would allow a fair approximation like this.

Q. Have you a chart, or did you ever exhibit a chart of the residue upon evaporation or the chlorine?

A. Yes sir.

Q. And the nitrites at Bellefontaine, Hartford and the Illinois River above Grafton.

A. No sir.

2356 Q. For what purpose was that chart 8 presented then?

A. This chart 8 was principally presented to show an approximate average for the entire period from January until October, 1900, of the residue on evaporation as found at those three points, the Illinois shore, the Missouri shore and the Intake at the Chain of Rocks, and also for the chlorines.

Q. Was it taken for the purpose of showing that the water at the Intake was in its chemical characteristics intermediate as to the Missouri River water, and the water of the Mississippi?

A. Well, it was to show whatever result might be ascertained by the chemical analyses of any mixture if there was any, and the conclusions from the results as found by these analyses demonstrated certain facts there that showed that there must be mixtures going on of the two rivers in the channel, which water goes into the Intake tower.

Q. And that is on the supposition that the water at the point on the Illinois shore opposite the Chain of Rocks, in its condition is taken, and enters the Intake?

A. Well, that water as it runs along the Illinois shore has certain chemical characteristics. It may be that when the water running along the Illinois shore, that is, the Mississippi and

Illinois River mixture is very high, it may be that the water prevailing then in the channel because of the crowding
2357 of this larger volume of the Mississippi and Illinois River mixture, the crowding of the Missouri towards the Missouri shore, may go on to such an extent as to prevail in the channel, and the samples then taken from the channel at the Intake may show the same chemical results such as are found from the samples running along the Illinois shore, so, while that sample of the water that was taken from a certain point on the Illinois shore would not go into the Intake, yet the current predominated, the current of the Illinois shore water predominated in the channel on that day, would give that other sample that is collected at the Intake the same chemical character as the sample would have, running along the Illinois shore, which would demonstrate that at such a time there is a larger percentage of Illinois and Mississippi River mixture going into the Intake.

MR. JOHNS: I now move that the answer be stricken out as not responsive to the question.

Q. Was that chart taken and made for the purpose of showing that the water at the Intake Tower was intermediate in its quality, as between the Missouri River and the water on the Illinois shore?

A. It was simply made for to show certain analytical resuluts.

Q. (Question repeated)?

A. In so far that the study of the analytical data proved that, yes.

2358 Q. Now take your chart No. 9, where did you get your data as to typhoid fever?

A. The data as to typhoid fever were obtained from the Health Department, the Health Commissioner's office of St. Louis.

Q. Out of what kind of a book or paper?

A. These data were obtained by one of my assistants and received by him from an official in the Health Commissioner's office who tabulates that.

Q. Do you know whether they were taken from reports, printed reports, or from records written?

A. My instructions were to take them from the official reports.

Q. Does the lower, very irregular curve upon this chart represent the percentage of Mississippi River water pumped into the Intake?

A. Yes sir.

Q. What do you mean there by percentage of Mississippi River water?

A. That is, I had the percentage of mixture of water of the Missouri River and the Mississippi above the mouth of the Missouri and the water going into the Intake. I had the percentages calculated from the total residue on evaporation, so-called total solids, and whatever the percentage of Mississippi River water, as compared with the percentage of Missouri River water so found, is represented on this chart here in the bottom curve. 2359

Q. That bottom curve then represents a supposed percentage of Mississippi River water, based on calculations of the Mississippi above Grafton?

A. No sir, I beg your pardon, the Mississippi above the mouth of the Missouri at Hartford.

Q. And the Missouri at what point?

A. Bellefontaine.

Q. Finding certain chemical constituents prevailing or existing in these two rivers at those points, you made a curve representing what you estimated to be the percentage of Mississippi River water, which is the lower curve on chart 9?

A. Yes sir.

Q. Now why did you not also make an estimate as to typhoid fever based upon the percentage of Missouri River water at the same time?

A. Well, because when I gave the percentage of Mississippi River water here, the remaining percentage or balance—supposing I gave, I will say—I have twenty per cent of Mississippi River water; that means that the remaining 80 per cent is Missouri River water. Thus you will see in these summer months the Missouri River water prevail largely, that the percentage of the Mississippi River water goes down to the zero point, which means that the Missouri River water prevailed entirely at the Intake at that time. 2360

Q. Can you explain why the typhoid fever in St. Louis did not visibly increase from the 20th of March to the 14th of August.

GENERAL CROW: In what year? 1900?

MR. JOHNS: Yes.

THE WITNESS: I will have to go back to the river stages of the Illinois and Mississippi Rivers above the mouth of the Illinois, to answer that question. During the months of February, 1900, after the opening of the Drainage Canal on January 17th, the Mississippi River above the mouth of the Illinois River was low. The data presented every day in my testimony there, reading the stages of the river, showed the Mississippi to be very low. At that time evidently, the volume of Mississippi River water which met the Illinois River was low, so that there was much more Illinois River water in that mixture coming down in February than there was after the rise of the upper Mississippi River above the mouth of the Illinois River in March, which I also showed. I showed a very marked rise of the Mississippi River water above the mouth of the Illinois,
2361 so that the Mississippi River water coming down in
March there—the Mississippi River water evidently had a much larger portion of Mississippi River water than Illinois River water and the Illinois River water being represented in a very small percentage of that time because of the larger volume of upper Mississippi water coming down. That water was entirely different in its chemical character from the water coming down in February. In February the upper Mississippi above the mouth of the Illinois was low. The water then represented in the mixture at the Intake—I want to say that evidently there was a larger percentage of Illinois River water, of that mixture going into the intake, in February and being represented by a high percentage, one day as high as 100 per cent, going down again and then going up again, in February up to 90 per cent; there was more Illinois River in that mixture; that was followed by a rise in typhoid for the month of March.

Q. Now why did the typhoid fall and the percentage of cases fall when the Mississippi River was at 100 per cent on the 27th, or in the middle of April?

A. Because then at that time the Mississippi River water had a different character than the Mississippi River water coming down in February, and it had a larger percentage of upper Mississippi River water and a smaller percentage of
2362 Illinois River water.

Q. So that the chart doesn't contain anything about the Illinois River, but simply assumes that when the typhoid fever is bad, the Illinois River water prevails.

A. From the stages of the river as officially recorded by the Weather Bureau, it is evident that the first big rise in February was due to the Mississippi River at that time, a rise in typhoid followed, a period when there was very much more Illinois River water in that mixture than there was subsequently when the second great rise or percentage of Mississippi river water came. The second great rise represented largely upper Mississippi River water above the mouth of the Illinois and the proportion being much larger than that of the Illinois River at that time, the Illinois River water was of necessity represented by a smaller percentage. That was not followed by typhoid in St. Louis, and that is what the map is to indicate.

Q. And that is what the map was made to show?

A. Well, the stages are not represented on this map, but if the stages would be on this chart they would show that.

Q. Now do you know the particulars or history of any case of typhoid fever in the city of St. Louis, prior to January 23rd, 1900?

A. Yes sir.

2363 Q. What one?

A. Well, you mean an incidental case?

Q. Any case of typhoid fever prior to 1900, in the city of St. Louis, the history of it and the ascribed cause of the disease?

A. I am not a physician, so of course I have no experience in that direction.

Q. Do you know the cause of any one or more cases of typhoid fever after 1900 in the city of St. Louis?

A. Well, I have given the matter considerable study.

Q. Answer the question. Do you know the cause of any one or more cases of typhoid fever in the city of St. Louis after 1900?

A. Well I have not treated any cases because I am not a physician.

Q. You either know or you do not. Which is it?

A. Well I am familiar with the history of quite a number of cases.

Q. Now for example, give me the history of one case?

A. Well, I cannot recall any particular one just now.

Q. Well, give me the history of three?

A. I cannot recollect, because these cases as I studied them were simply from information that I have received by coming in direct contact with physicians who treated the 2564 cases of typhoid fever, and from the study of reports and the study of books that were written on that subject.

Q. Do you know of a single case of typhoid fever in the city of St. Louis, in which you could tell the reason or the manner of the getting into his system of the typhoid bacillus. I mean now of your own personal knowledge?

A. Well, I have instituted an investigation to ascertain from the official data of reported cases of typhoid fever, and a personal inspection of every case during one year by inspectors who were instructed by me to examine the cases. I have ascertained that a large majority of cases of typhoid fever in St. Louis reported during one year after the opening of the canal, that these cases all correspond with the fact that the patient had been drinking city water during that period.

Q. That you got from the reports of inspectors employed by you?

A. From the official reports of the physicians when they reported their cases to the health department.

Q. Do the official reports of the city of St. Louis made by the physicians, state the cause of the disease?

A. Yes sir.

Q. And you say you have inspected those reports and find that in the majority of cases reported, that they have been drinking St. Louis water?

2365 A. They have been drinking water from the city water supply.

Q. Does it say anything about whether they had been drinking milk?

A. Yes, in some instances.

Q. How many people in the city of St. Louis get their water from the city water supply?

A. Well, I cannot give you an accurate figure just now as to that question, but by far the larger majority of the population have the city water supply.

Q. Three-quarters?

A. Well, I wouldn't say because I haven't got the accurate figures.

Q. One-half?

A. I would say the larger majority as I have been told by the officials of the water department, but I haven't got accurate figures.

Q. Personally you know nothing in regard to it?

A. No, I have no data on hand just now.

Q. How many cess-pools are there in the city of St. Louis?

A. Well, I don't believe that there is a record establishing just how many there are.

Q. How many wells are there in the city of St. Louis?

2366 A. The number of wells in the city of St. Louis, about four years ago, when I gave particular attention to that question probably amounted to from 3500 to 4000.

Q. Not more than that?

A. No sir. There are quite a number of cisterns in addition to that, so that we usually say there are 7000 cisterns and wells in the city of St. Louis.

Q. What proportion of those typhoid fever cases were suffered by people who took water from wells or cisterns?

A. It was ascertained in this special investigation, that of the 1160 or 1180 cases reported in 1900, of typhoid, three-fourths of these patients did not drink any well water or cistern water, but only drank water from the city supply.

Q. From the city water supply?

A. Yes sir. The others admitted that they drank well water, but frequently would also drink water from the water supply besides.

Q. In addition?

A. Yes, but those that drank nothing but city water amounted to 800 and something out of 1160 or 1180 cases examined.

Q. Where can that data be found?

A. I have a record of those data. They are all kept on file in my office.

2367 Q. Are they in any published reports, volume reports of officers here?

A. No sir.

Q. They never accompanied the reports of the message of the mayor of the city?

A. No sir, they never have been published.

CROSS-EXAMINATION,

By Mr. Todd.

Q. Doctor in these 1180 cases of typhoid that you have spoken about, were those 1180 cases of deaths?

A. No sir. Cases reported by the physicians of St. Louis, officially to the Health Department.

Q. Was that in 1900?

A. Yes sir.

Q. What was the number of cases reported in 1899?

A. Well, I haven't got that figure here right now; I couldn't tell you exactly. I had the official data, but not knowing that this would come up I haven't got the official data with me.

Q. What were the number of deaths from typhoid in 1900?

A. They were above 100, but I couldn't tell you just now; I haven't got the data here.

Q. Above 100?

2368 Q. Were there as many as 125?

A. It may be, but I am not quite sure. I cannot command the figures at this moment.

Q. It was less than 150 as you recollect it, was it?

A. I think it was, but I am not prepared to say for sure.

Q. Is there any other period in the history of St. Louis, when there were 1180 cases of typhoid previous to 1900?

A. Do you mean to say when there was less than that?

Q. More than that?

A. Yes sir.

Q. When was that, doctor?

A. To my knowledge, in 1892 or 1893, I am not certain just now.

Q. What was the number of patients sick with typhoid in 1892 or 1893?

A. It was a high figure, but I cannot recollect just now how much it was. It was several thousand.

Q. To what was that epidemic attributed?

A. That epidemic was attributed to my knowledge, to pollution of the Mississippi River from sewage in the Harlem Creek, which is a creek that discharges into the Mississippi River somewhere near the northern boundary line of the city.

Q. Was that epidemic of 1892 and 1893 preceded by cases of typhoid in the neighborhood of Harlem Creek?

2369 A. That I don't know at this moment.

Q. Do you know whether there had been typhoid among the inhabitants whose feces or urine were discharged into this creek and whether that of itself would cause typhoid to develop?

A. I am not prepared to answer that question. I cannot say. I am not positive.

Q. How many deaths occurred in 1892 and 1893 from typhoid?

A. I couldn't tell you at this moment; I haven't got the figures at hand.

Q. Was that epidemic general throughout the city?

A. That I couldn't tell.

Q. After 1892, when did you have typhoid in St. Louis?

A. Well, there has been typhoid all along every year, the statistics will show some typhoid.

Q. Attributed to what cause?

A. Well, that is a matter that I cannot answer.

Q. Did you ever give it any consideration?

A. I studied the typhoid situation in St. Louis somewhat, as far as the estimation of the cause of the epidemic of 1892 or 1893 was concerned, and I gave the question of typhoid some study after the opening of the Drainage Canal, but I did not go into any researches prior to that time.

2370 Q. Have you any idea what the number of cases reported in 1893 was?

A. Well, to my knowledge it was several thousand.

Q. In 1894, the year after the epidemic that you spoke of?

A. I couldn't tell you at this moment.

Q. Can you give me your best judgement upon it, doctor?

A. I cannot right now. A glance at the official data would enable me to answer that question at once.

Q. How is that official data prepared, doctor?

A. By the statistics obtained by the Health Department of St. Louis.

Q. Are those statistics obtained by the Health Department previous to 1900, based upon the number of cases, or upon the number of deaths?

A. I know that the statistics have been based upon both, from the number of cases and the number of deaths, and I have an official certificate from the secretary of the Board of Health certifying the official figures as taken from the official records for those periods.

Q. How long have you been connected with the Board of Health of St. Louis, doctor?

A. I haven't got it at hand just now.

Q. (Questiôn repeated)?

A. Ten years.

2371 Q. During the time that you have been connected with the Board of health of St. Louis, has there ever been a letter sent out to the physicians in the city, asking them to report typhoid cases coming under their immediate care?

A. Yes sir.

Q. When?

A. There was one issued in the fall of 1900, and another one issued in the fall of 1901.

Q. Previous to the one issued in the fall of 1900, do you know of any letter having been sent out to the physicians in St. Louis during your term in connection with the Health Department of the City of St. Louis?

A. There wasn't exactly a letter sent out, but I remember as long as I have been connected with the health department that the Health Commissioner has frequently requested physicians through the press and in official reports, to report the number of cases of typhoid more promptly.

Q. But in 1900, there was a special letter sent to all physicians, wasn't there?

A. Yes sir, there was a circular letter issued by the Health Commissioner, calling the attention of physicians to the fact that the law required them to report all cases of typhoid and all deaths from typhoid promptly.

Were there responses to that letter generally?

2372 A. Well, this way, the attention of the physicians was called to the requirement of reporting the cases. Now whether they reported them more regularly after that I couldn't tell.

Q. You got a great many replies to that letter, didn't you?

A. No, there were no replies necessary.

Q. I mean reports?

A. Well, it happened to be that these circular letters were issued just at a time that typhoid had gone up in St. Louis, the number of deaths had increased and the number of cases had increased, and naturally at that time, whether or not there had been a circular issued at that time—I presume that the number of cases reported would have increased.

Q. Well, that letter stimulated the doctors in reporting cases of typhoid, didn't it?

A. Well, it called their attention to the violation of the law in not reporting those cases.

Q. Was there any penalty attached to the violation of that law?

A. I don't know what the penalty is, but I know that physicians can be compelled to report those cases.

Q. Do you know whether there is a penalty attached to the law compelling physicians to report typhoid cases, or other epidemics?

2373 A. I cannot tell you just at this moment.

Q. Well assuming that there is a penalty attached for the violation of that law, do you know that there is any case previous to 1900 where the law has been invoked against any physician for not reporting a case of typhoid in the city of St. Louis?

A. I don't know.

Q. At the time that letter was sent out the question of opening the Drainage Canal was being agitated in the public press of St. Louis, wasn't it?

A. Yes sir.

Q. And the Health Department of the city of St. Louis?

A. Yes, there was considerable discussion. An investigation was going on at that time of the analysis of the samples, etc., and that attracted considerable attention.

Q. For seven years previous to the sending out of that letter, do you know of any publicity such as was given in 1900, as having been given to the health condition of the city of St. Louis by the public press or by the Board of Health?

A. Yes sir.

Q. For the securing of data on typhoid?

A. Yes, I remember that when the typhoid epidemic of 1892 or 1893 came, it was discussed very much. 2374

Q. That was eight years previous?

A. Yes sir.

Q. I mean seven years previous?

A. Yes, there was some discussion; there always is in connection with the discussion of the water supply and the warnings issued by the Health Department against the use of the city water, and the necessity of boiling it, etc.

Q. Your observation has been that the people pay little attention to boiling the water in the city of St. Louis, hasn't it?

A. Well, I think they pay a great deal more attention to it since 1900, than they did prior to that.

Q. I mean the people, the plain people, as Mr. Bryan speaks of them?

A. Well, I think that the entire inhabitants of St. Louis have been so fully warned against the character of the water that they today largely are only drinking boiled water or well filtered water. This number is much larger than prior to the opening of the drainage canal.

Q. Now your physicians pay more attention to the enforcement of that law than they did prior to 1900?

A. Well, that I couldn't tell. It is my impression though, that they pay considerable attention to the typhoid situation in St. Louis. 2375

'Q. Are you acquainted or have you the means of knowing what the mortality is in typhoid cases?

A. Well, the mortality of typhoid cases is recorded in the official records of the Health Department.

Q. I mean what is the general percentage, not to be accurate?

A. Well, the precentage is usually calculated on the ratio of the population per 100,000 inhabitants; that is the custom of every investigator.

Q. I am not saying—in any case of typhoid, what is the rate of mortality?

A. That I couldn't tell you. I haven't studied that question.

Q. Now previous to 1900, and the opening of the Drainage Canal in 1899, was there any typhoid in the city of St. Louis?

A. Yes sir.

Q. How many cases, doctor?

A. Well, I would have to consult the official data to tell you.

Q. What is your judgment upon the matter?

A. Well, I have looked over this data, and I have looked over a great many other data, but I cannot tell you the exact figures

Q. Give me approximately what your best judgment is?

2376 A. You mean of the number of cases?

Q. Yes, the year previous to the opening of the Canal?

A. Well, the number of cases showed a very low ratio between 1895, after the removal of the Intake to the Chain of Rocks, above the St. Louis sewers, and the Harlem Creek, showed a reduction of typhoid.

Q. I want the number, not the ratio?

A. I couldn't tell you the exact number now.

GENERAL CROW: What year?

MR. TODD: 1899. Were there 500 cases of typhoid in the city of St. Louis, in 1899?

A. There were more cases in 1899 than 500; that is, during the entire year. Typhoid was very low, but during one month they went up some.

Q. To what was that increase attributable?

A. That increase in typhoid was in November, 1899.

Q. The Drainage Canal had not been opened then?

A. That I couldn't tell.

Q. Didn't you give that any consideration?

A. I gave it some thought, and I have some views on the subject.

Q. Could you favor us with your views?

A. I haven't got anything. I haven't come to a definite conclusion as to the result of the investigation that I had
2377 carried on at that time, and am not prepared to make a statement.

Q. Will you be able to secure for me the statistics showing the number of typhoid cases in the city of St. Louis in the years 1897, 1898 and 1899?

A. Yes sir.

ATTORNEY GENERAL CROW: That is already in the record. You will find it in Dr. Ravold's testimony.

MR. TODD: I missed that.

Q. Assuming that the statements made by Dr. Ravold correctly state the number of typhoid cases in 1899 and 1898, in your investigations have you tried to ascertain what the causes were for that typhoid?

MR. WOERNER: That has been given too, Mr. Todd.

MR. TODD: I am asking him.

THE WITNESS: Well, I have attempted to investigate the matter, but I finally concluded that I might as well leave it to the chief of the bacteriological investigation, Dr. Ravold, who took up the matter and carried it on.

Q. Doctor, what do you know about typhoid fever?

A. Well, what my—

Q. Excuse me for asking the question, but does your professional calling include the treatment of typhoid, as a part of your profession?

A. No sir, I am a chemist and not a physician.

2378 Q. And all that you know about typhoid is what is known as book knowledge instead of actual experience, isn't it?

A. Well, information that I have carefully obtained by personal contact with people familiar with it.

Q. It is hearsay evidence, hearsay information isn't it?

A. And from the study of reports and books and statistics.

Q. Well, as I say, it is hearsay, isn't it; you have never treated typhoid, have you?

A. No, I have not. I am not a physician.

Q. Well, in drawing your conclusions as to the cause of typhoid, your experience has not been such in actual contact with typhoid fever, as to make you an expert upon the disease of typhoid, has it?

A. Not upon the medical treatment of typhoid. I cannot express an opinion on that, or pass judgment.

Q. Can you say now as an expert that the 1180 cases of typhoid in the city of St. Louis, or any portion of them, was attributed to the opening of the Sanitary Canal in 1900?

A. Do you mean in the city of Chicago?

Q. I mean in the city of St. Louis.

(Question repeated)

A. From a careful study—

Q. No, just repeat my question. It admits of Yes or No?

GENERAL CROW: Answer him and make your explanation.

2379 MR. TODD: I don't want to shut off anything.

Q. (Question repeated).

MR.TODD: My question is, can you say as an expert that is true?

A. Well, I can say this; from the study of the question in connection with this entire investigation, and from a great many scientific facts that have come to my knowledge, and from the testimony as it was presented here by Dr. Ravold, and from a comparison of the statistics of typhoid in the city of St. Louis, with the analytical results as obtained from the chemical investigation conducted since the opening of the Drainage Canal, on the waters between Chicago and St. Louis, I can say that it is my opinion that the character of the water coming down from the Drainage Canal, the Des Plaines River, the Illinois River and down the Mississippi River into the Intake Tower is such that all sewage polluted—that it is possible from what I know about the connection of typhoid epidemics, with the chemical character of water, that I am prepared to say that it is not unlikely that typhoid in St. Louis might come from the sewage polluted water which reaches the St. Louis intake from the Drainage Canal.

MR. TODD: Now I move to strike out the answer as not responsive to the question.

Q. Are you an expert on typhoid? Can you answer that "Yes" or "No?"

2380 A. If you construe it as connected with the medical features of typhoid, I would say "No."

Q. I don't want to construe it, doctor; I want you to construe it, and I will follow up your construction. Now do you consider yourself an expert on typhoid?

A. Well, I will interpret your question in the way I said just now, and say No.

Q. Do you know the symptoms of typhoid?

A. Well, I have had typhoid myself three months, some years ago and I recall the symptoms which were diagnosed as those of typhoid at that time.

Q. Were you attended by a docter?

A. Yes sir.

Q. Did you diagnosticate your own case, or did you get the doctor to do it for you?

GENERAL CROW: I object on the ground that the witness has already said he wasan't qualified to testify in that way.

THE WITNESS: I was then eighteen years old and I took a great interest in the matter.

MR. TODD: Then going back to your other answer that you are not an expert on typhoid; can you as an expert in chemistry attribute any part of the 1180 cases in 1900, to the opening of the Drainage Canal?

A. Indirectly, yes; in connection with my statements.

2381 Q. Do you consider it a cause or an incident?

A. You mean what?

Q. The 1180 cases of typhoid in 1900, and the opening ot the Drainage Canal?

A. I consider it in a measure as very striking that with the increase of the pollution of our water supply, and the increased pollution of the Des Plaines River from the Drainage

Canal and the Illinois River and the Mississippi down to the intake in the year 1900, I consider it very striking that there was corresponding with that increase in pollution in the month of March, 1900, an increase in typhoid of 1300 per cent over the average of the five preceding years for the number of cases in St. Louis. That typhoid epidemic followed a pollution of the water supply, as traced up the Mississippi; then up the Illinois, up the Des Plaines River to the Drainage Canal, was followed by the pollution so high as was never before experienced in St. Louis; that is, no previous water analyses ever showed such high pollution, such sewage polluted water as went into the intake tower and went through the reservoir, and came from the taps of the hydrants in February, 1900.

Q. A person not a chemist nor an expert on typhoid could draw the same conclusions, couldn't he, doctor?

A. If he would give the matter as careful study as I have tried to do I think he could. 2382

Q. In making your study, didn't you consider it essential to find out the cause of the typhoid existing in St. Louis during the four or five years previous to the opening of the drainage channel?

A. Well, in a measure I have done that by ascertaining whether or not the typhoid cases, the high typhoid cases, and the increase in 1900, was due to the drinking of well and cistern water in St. Louis, or was due principally to water coming from the hydrants, as it was established by this special investigation I referred to today.

Q. During the five years previous to 1900, was the water supply of St. Louis, as found in these hydrants, good, potable water?

A. No sir.

Q. Did it require boiling?

A. Yes sir.

Q. Did it require filtration?

A. It should have been filtered, yes.

Q. Now do you compare potable water or drinking water as being bad or worse?

A. I do compare the analytical results in 1899, prior to the opening of the canal. I compare those results with those

of 1900, 1901 and 1902, after the opening of the canal, and
2383 the water has become worse in its chemical character since the opening of the Drainage Canal.

Q. But before that it wasn't drinkable, was it?

A. Frequent warnings were issued by the Health Department and myself to boil the water or filter it well before drinking it.

Q. Why were those instructions given, doctor?

A. Because the water was not found to be potable.

Q. Would the water as it existed today, if filtered or boiled be as good as the water that existed prior to 1900, if boiled or filtered?

A. Presumably it would.

Q. For how long a period of time has the health department of St. Louis advised the citizens not to drink the water of St. Louis?

A. Oh, that has been done since 1893, since I assumed charge of the office of City Chemist and analyzed the water.

Q. What was the character of the pollution of the water in St. Louis prior to the opening of the Sanitary District?

A. The water as proved to be prior to the opening of the Drainage Canal, was polluted.

Q. With what?

A. The analytical results showed pollution in a measure from sewage and in a measure of vegetable origin.

2384 Where did the sewage come from that got into the water of St. Louis?

A. In my opinion, as a result of my investigation in 1899, I found that the Missouri River and the Mississippi River above the mouth of the Illinois, were of much better sanitary quality than the Illinois River at the mouth of the Illinois, and I found at that time that the Illinois River polluted the Mississippi River after meeting the Mississippi River and that this pollution extended along the line or along the route of the Mississippi River as it came down and passed the intake, or at times when the Missouri River was low, it would go into the intake.

Q. At that time was the Missouri River water potable water?

A. Yes sir.

Q. And is Missouri River water now potable water?

A. Yes sir.

GENERAL CROW: Are you speaking chemically and bacteriologically, or chemically alone?

MR. TODD: I would like to ask him a question on that line, Mr. Crow, if you don't object.

Q. Doctor, you have given no attention to the study of bacteriology?

A. I have, some, yes.

2385 Q. You don't class as an expert on bacteriology, do you?

A. Well, bacteriology as connected with the chemistry of water, I have given considerable study.

Q. Then in your testimony, you testified in this case as a bacteriological chemical expert?

A. I testified as a chemical expert who is supposed to make himself familiar with all the bacteriological features connected with the chemistry of water.

Q. Now, with that understanding, did you regard the waters of the Missouri River as being potable waters chemically and bacteriologically prior to the opening of the Drainage Canal?

A. Well, chemically I am prepared to answer that question "Yes;" but bacteriologically I am not prepared to answer the question.

Q. Why, doctor?

A. Because I have not given the strictly bacteriological feature of that water any special study; that is, I studied the bacteriology of the water, as far as it is connected with certain chemical changes going on in the water, for instance the action of the an-aerobic and the aerobic bacteria. It is my duty to inform myself on that point, but I have not made investigations strictly on the bacteriology of water, such as determining and making the counts and the determinations of the presence of pathogenic bacteria, etc.

2386 Q Have you had anyone doing that for you, under your direction, in connection with the city health department?

A. No sir.

Q. Was that done prior to the opening of the Drainage Canal?

A. Yes sir.

Q. And by the health department?

A. Yes sir, and under the direction and supervision of Dr. Amand Ravold.

Q. And he has testified to the condition of the water here, hasn't he?

A. Yes sir.

Q. I was not present myself.

A. Yes sir.

Q. Was the water of the Mississippi River prior to the opening of the drainage canal potable chemically?

A. Do you mean the Mississippi River after—

Q. Above the intake?

A. That is after it met the Illinois River?

Q. Yes. I understand the Illinois River meets the Mississippi River about 20 miles above the intake; is that right?

A. How is that?

Q. The Illinois River empties into the Mississippi about 20 miles above the intake; is that correct?

A. No, it is 34 miles.

2387 I am speaking now above the intake.

MR. WOERNER: And below the mouth.

MR. TODD: I mean within five miles above the intake of the St. Louis water supply.

A. That is, above the mouth of the Missouri?

Q. Yes?

A. That water was not potable.

Q. Now what proportion of the year did the water of the Mississippi within five miles above the intake of the city of St. Louis, enter the intake?

A. At what time?

Q. During the year, what proportion of the year did the citizens of St. Louis drink Mississippi water prior to 1900?

A. Well, that cannot be estimated according to a particular season or time of the year. The amounts of Missouri and Mississippi River water coming down the channel and prevailing in the channel and then going into the Intake all these years varies considerably, varies daily, and it is very difficult to generalize there, but approximately, taking the whole year together

I am prepared to say that about seventy-five per cent. that is the daily quantity of water going into the Intake there would be Missouri River water, and about 25 per cent. would be Mississippi River water.

Q. That is, during the year?

2388 A. That is during the entire year, but it may vary so much, that on one day it might be a very high percentage of one river and the next day turn right around and show probably a difference of fifty per cent. just according to the stage of the river and the volume of water coming down from the big watersheds the three big watersheds, the Illinois, Missouri and Mississippi.

Q. About seventy-five per cent. of the time?

A. Yes, if you take the whole time together.

Q. Would be Mississippi River water?

A. No, woud be Missouri.

Q. Seventy-five per cent. Missouri River water?

A. Yes, sir.

Q. And twenty-five per cent. Mississippi water?

A. Yes, sir.

Q. Does that continue for any period of time?

A. No, as I said, it varies from day to day; it is simply a yearly approximation.

Q. You would have a period of nine months where you drank nothing but Missouri water?

A. I said this wouldn't apply to nine consecutive months which would be three-quarters of the year. I said that daily for the whole year it would amount to—

2389 MR. WOERNER: Say no, doctor, and be done with it.

Q. MR. TODD: Was 25 per cent. of the Mississippi water sufficient to contaminate and pollute 75 per cent of the Missouri water that entered the intake?

A. You couldn't draw that comparison, that contamination, because it is an approximation.

Q. Well, would the amount of water entering the Intake, the Mississippi water, be sufficient to keep the water supply of St. Louis in a polluted condition?

A. The fact that whole days during this period when the percentage of Missouri River water going into the Intake is 100 per cent., and that soon after I will say, within a week afterwards or two weeks afterwards there might be 100 per cent. of Mississippi water going into the Intake, that no such comparison could be drawn; you couldn't get any results from it because it varies too frequently in the percentage.

Q. The results at the City Chemist's office would answer my question, and that is is the water polluted the year around?

A. Yes, sir.

Q. By the Mississippi River water?

A. It is considerably polluted always when the percentage of Mississippi River water, as estimated from the residue on
evaporation of those two rivers, the Missouri and the Mis-
2390 sissippi, and then at the Intake, whenever that percent-
age is high, of course the pollution of the water is increased, and whenever the Missouri River water prevails at the Intake Tower, in other words, when nothing but Missouri River water goes in, the water at times, may be considered potable. That is, it isn't all the time so bad that I cannot call it potable, but it is not potable at such times when water like that running along the Illinois shore, down the Mississippi, when that gets into the Intake.

Q. Those days when the water supply of St. Louis is potable are exceptions instead of the rule, aren't they?

A. No, sir; they are not exceptions to the rule because—

Q. I am talking now of previous to 1900. Was the water supply of St. Louis potable all the time or was it polluted?

A. As I have stated in my testimony in direct examination, prior to January, 1900, the water supply of St. Louis as coming from the water going into the Intake was potable at times. I said in my conclusions there were great variations, and at some times the water would be a good drinkable water, the water would be potable, and at other times it would be very bad, polluted, as I said.

Q. What I want to get at is, what is the proportion of time that it was polluted to the time it was potable?

A. That I could not estimate for that period because I
2391 did not make daily examinations at that time. I did not
take daily samples during 1899, prior to the opening of the canal.

Q. Now, above Grafton, was the water of the Mississippi River prior to 1900, potable?

A. The water of the Mississippi above Grafton, yes, it was.

Q. Now, what is the volume of water that empties into the Mississippi River from the Missouri in its normal condition?

A. That I couldn't tell you off-hand. I would have to refer to the figures and consult the data.

Q. How far south of the Missouri River does the water of the Missouri hug the shore of Missouri, and retain its identity?

A. Well, I have never analyzed any water south of the Chain of Rocks, so I cannot tell from analyses.

Q. Have you ever made observations of it from the Eads Bridge?

A. I have made observations from the Merchant's Bridge, and in looking up the river, just for that particular purpose, and I cannot deny that it is noticeable that the water running along the Missouri shore was much heavier in sediment, it had more clay and silt in it than the water running along the Illinois shore.

Q. Did you ever observe it at the Eads Bridge?

A. I cannot recollect it, no, sir.

2392 Q. Have you ever observed it on the banks of the river in front of the city?

A. No, sir, but I have noticed it from the harbor boat and from boats going up the river.

Q. Is it discernible?

A. There is a channel, you see, where the mixture takes place, and that is an intermediate stage between the two. There is not a strict line of demarkation there.

Q. Is the current of the Mississippi River found in the current of the Missouri?

A. That depends upon the stages of the river.

Q. Well, in normal stages?

A. At times it may, and at times it may not; the current varies very much, because the Mississippi is fed there by three watersheds, the Missouri, the upper Mississippi and the Illinois, and the constantly varying stages, and the constantly varying quantity of rain-fall in these river flows, which changes the velocity of the current very much in the Mississippi.

Q. Well, does the normal condition in the Missouri river prevail the greater part of the year?

A. No, I don't think so because the flood volume coming down the Missouri River in the spring time is very large and produces variations in the stages of the river.

2393 Q. Well, is the Missouri higher a greater part of the year?

A. It is usually higher during the spring and summer months.

Q. How about the Mississippi, is its condition normal during a greater part of the year?

A. Well, the Mississippi River stages are also affected by the quantity of rain fall in these two big watersheds, and the varying volume of water coming down these watersheds.

Q. And the Illinois is it a swift running river or slow?

A. It is prevailingly a slow river, sluggish current.

Q. How does it compare with the Missouri and the Mississippi?

A. Its current is supposed to be slower, and the results of examinations as published demonstrate that.

Q. How does the volume of the water of the Illinois compare with the volume of the Mississippi at the place where the Illinois empties into the Mississippi?

A. Well, that varies greatly. The volume of water coming down the Illinois River sometimes may amount to 1200 cubic feet, and then it may amount—

GENERAL CROW: Per second or per minute?

A. Per second.

MR. TODD: 1200 cubic feet per second?

A. Yes, and then it may be 112,000 cubic feet per second;

2394 then the volume of the Mississippi River above Grafton can also vary enormously.

Q. Does the volume of the Mississippi ever go down to 1200 cubic feet per second?

A. I don't think so from what I have studied about it.

Q. Does the volume of the Mississippi ever go down to as much as 300,000 cubic feet per second at Grafton?

A. I couldn't tell you at this moment. I would have to consult data.

Q. When the Mississippi River coming down below Grafton, and the waters of the Illinois coming in contact with the waters of the Mississippi, the Mississippi current is always swifter than that of the Illinois, isn't it?

A. Yes, as a rule.

Q. The Illinois River comes in on the Illinois shore, and the swifter current of the Mississippi bears the water of the Illinois onto the Illinois shore, doesn't it as it comes down?

A. It does that somewhat, but there are a great many curves there bewteen Grafton and the mouth of the Missouri produced by dikes extending from the Missouri shore far into the river, cross-sectioned and extending from the Illinois shore far into the river, so that there is a narrow channel there, running right around those curves, and this channel, of course, has
a different velocity than the water that is kept at the
2395 dikes, and the water that almost stagnates in times of
low water stages in the summer, in the corners of those
dikes, and that produces different conditions. The channel there, will be quite a mixture. Now, of course, if the Mississippi River is very high above the mouth of the Illinois—it could be very high in a day and the Illinois very low, why then the water prevailing in the channel between Grafton and the mouth of the Missouri might be principally Mississippi River water.

Q. But the point I make is, the Illinois River water retains its identity how far from its mouth coming south along the Illinois shore?

A. Yes, the Illinois River water as it runs along the Illinois shore, is stopped by those dikes, and it is kept in the corners of the dikes, and only a part of that water is gradually, when the upper rivers rise, swept out, and gets into that narrow channel, so that the identity of the Illinois River as such, would, in my opinion, be lost before it reaches the Intake of St. Louis. From the mixture we can trace many curves.

Q. Have you made a cross-section of the Mississippi River above Grafton?

A. No, sir.

Q. Have you made a cross-section of the Mississippi River below Grafton?

2396 A. Yes, sir.

Q. In how many places?

A. Alton and Hartford.

Q. Only two?

A. I have taken cross-sections there of twelve samples across the Mississippi River one mile above Alton and Hartford.

Q. You don't get my point. How many samples did you take on a line intersecting the Mississippi River below Grafton, which is called a cross-section?

A. Twelve.

Q. Twelve right across?

A. Right across, yes, sir.

Q. At one time?

A. Yes, sir.

WILLIAM C. TEICHMANN.

Adjourned until 10:00 a. m., Tuesday, March 31, 1903.

2397 Southern Hotel, St. Louis, Missouri. 10:00 a. m., Tuesday, March 31st, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

DR. WILLIAM C. TEICHMANN resumed the stand for further cross-examination, by Mr. Todd, and testified as follows:

Dr. Teichmann, you stated, I believe, at the conclusion of the testimony yesterday, that you took samples below Grafton, Illinois, on the Mississippi River?

A. Yes, sir.

Q. That is what is known as a cross-section, is it not?

A. Yes, sir.

Q. And that you took twelve samples between two points at one time, across the Mississippi River below Grafton?

A. Well, I took cross-sections at three points.

Q. I am taking just one point at a time.

A. Yes.

Q. The first point?

A. The first point is Alton.

2398 Q. Was Alton?

A. Yes, sir.

Q. That is from Alton to West Alton?

A. Yes, right across the river there.

Q. Now, you took twelve samples at that point?

A. Yes.

Q. How many days did you take twelve samples?

A. Cross-sections were taken on—now let me see—I am not quite sure whether it is two or three times that I took those cross-sections.

Q. Were they all in one day or at different days?

A. Different days, yes.

Q. How far apart, between the taking of those samples at that point?

A. Well, they were equally divided, so that they would practically cover the entire width of the river at those points.

Q. What was the duration of time between the taking of the samples between Alton and West Alton, on the line of the cross-section?

A. Well, they were taken by the two men in one boat.

Q. No, you don't get the idea, doctor. You took twelve samples to-day?

A. Yes, sir.

2399 Q. Now, did you take twelve samples tomorrow, and twelve samples the day before? You said you took them on three occasions.

A. No, there was a longer interval between those three days. It is some time since I looked at those charts—

Q. Can you approximate it?

A. I couldn't tell you off-hand. I have the data in the other room. I can get them in a few minutes.

Q. I would like to have you get that data, doctor.

A. Yes, I will get them.

(Upon returning to Court room, witness stated that the charts had been returned to his office by mistake, but that he had telephoned for them.)

THE WITNESS: I was mistaken in regard to those cross-sections at Alton and Hartford. For one month these cross-sections were taken daily for five points at Hartford and Alton, but the cross-sections taken at the Chain of Rocks—those were taken at a dozen points across the river. I confounded those. I would rather wait until I get those charts.

MR. TODD: Well, I will resume the cross-examinaton on that point when you get the charts. I will take up another matter.

Q. When was it that you examined—that you made the examination of the Desplaines River above Lockport, before the waters of the Drainage Canal emptied into it?

2400 A. There were no examinations made in our laboratory of any waters from the Desplaines River prior to the opening of the Drainage Canal. They began on March 3rd, 1900.

Q. At what point in the Desplaines River did you take samples?

A. Do you mean in the Desplaines River?

Q. Above Lockport?

A. Above Lockport?

Q. Yes?

A. Well, that was in the Desplaines River some distance up the Desplaines River above the junction of the Canal and the Desplaines River—the Drainage Canal and the Desplaines River.

Q. That was before the waters of the Sanitary Canal emptied into the Desplaines River?

A. Yes, the Desplaines River water was analyzed—

Q. That is all; I just want that question.

A. (continuing)—in 1901.

Q. How many samples were taken at that point?

A. Well, there were—let's see—from the Desplaines River above the Bear Trap Dam daily samples were taken in October and November, 1901.

Q. You analyzed those samples, did you, doctor?

A. Well, I—

2401 Q. Or caused them to be analyzed under your direction?

A. Yes, I superintended the analyses.

Q. From the analyses what conclusion did you draw as to the potability of the waters of the Desplaines?

A. I stated in my testimony that I considered that water potable water.

Q. And was that opinion arrived at from the analyses of the water in that river at that point?

A. Yes, sir, for those two months.

Q. What is the volume of the Desplaines River?

A. You mean—

Q. In water?

A. Just before it reaches the Drainage Canal?

Q. At the point where you took your samples?

A. Well, the volume there varies very much according to the statement of the Chief Engineer, Mr. Randolph, of the Drainage Canal.

Q. About the time that these samples were taken, doctor, is what I am interested in?

A. Well, that I couldn't tell you at this moment; I would have to look up the data.

Q. Was it high water or low water in the river at that time, do you know?

A. I cannot recollect at this moment; I knew it at the time.

2402 Q. And you say that that water was potable?

A. Yes, sir.

Q. You mean by that, good drinking water?

A. Yes, sir.

Q. Do you know what towns empty their sewage into the Desplaines River?

A. I do not know at this moment.

Q. Do you know that the sewage of Riverside, of about 5000 inhabitants, empty their sewage into the Desplaines River above that point, and the village of La Grange?

A. I know that some towns drain their sewers into those rivers—into that river.

Q. Do you know that the waters of the Desplaines River have been condemned by the Board of Health of the City of Chicago as being contaminated, and that ice men are prohibited from selling the ice from that river?

A. No, sir; I don't know that fact.

Q. If those facts should appear to you, that the village of Riverside, located within ten miles, and La Grange, and Maywood, and other suburban towns were draining their sewage into that stream, would you still call that a potable water?

MR. JEFFRIES: We object to the question because the question does not state the population of the towns mentioned, as draining their sewage into the Desplaines River.

2403 Q. Just answer the question.

A. I drew my conclusions from the analytical data that we received from the analyses of those samples from the Desplaines River in October and November, 1901, and I feel justified in stating that from those analytical results I must consider the water of the Desplaines River for those two months, at least, of our examination, as a potable water, just at the point before the Drainage Canal discharges its waters into the Desplaines.

MR. JEFFRIES: You haven't answered the question, doctor.

THE WITNESS: Would you please repeat the question and I will answer the question.

MR. TODD: The reporter will read you my question.

(Question read.)

A. I could only base an opinion on the analyses of the samples taken from that river.

Q. Then if the sewage of these different places that I have indicated, does empty into the Desplaines River, and did empty at the time that you made your examination, purification of that sewage had been completed at the point that you made the examination. Is that correct?

A. Yes, sir; if the facts are such; provided, however, that the volume of water was sufficient, and the Desplaines River at times can discharge as much as 600,000 cubic feet of water per minute. 2404

Q. Well, assuming the volume of water that was there at the time that you took the samples out of the Desplaines River, can be ascertained, and I assume that it can—you could give me the data on that couldn't you?

A. Yes, sir.

Q. And assuming also that the sewage from these points above there was emptied into that River, before that sewage got to the point that you took your samples, it had been purified, and the water had been rendered potable according to your analyses, is that correct?

A. Yes, my analyses established the fact that during those two months the water taken from the Desplaines River was potable before it reached the Drainage Canal.

Q. The condition of purification in the Desplaines is not different from the condition obtaining in the Illinois, is it?

A. Well, it depends very much upon local conditions. They may change the conclusions very much. No conclusions can be based absolutely on certain facts without taking into consideration the general conditions; the volume of water and the character of the sewage, and the population of the towns draining their sewage into the river.

Q. Well, I mean the principles of purification will apply to the Desplaines River the same as to any other river, would they not?

2405 A. Well, if the conditions were alike, of course.

Q. Well, that is the principles, depending upon conditions?

A. Yes, but the general—a general assumption nowadays is that local conditions have to be taken into consideration in determining a question of purification.

Q. What is your opinion, doctor, as to the effect of running water upon sewage? Does it purify itself or not?

A. That depends very much upon the conditions prevailing in those running waters, and the volume of water, the character of the sewage; the question would come into consideration whether or not pathogenic germs are contained in that sewage, and various other questions that all would have to be considered before a general opinion coud be formed in each case.

Q. Have you given the subject sufficient consideration to be able to enunciate a principle applicable to the purification of streams sewage contaminated?

A. No, sir; not absolutely.

Q. Do you know whether sewage contaminated streams will purify themselves within a given distance?

A. That is a question which again cannot be defined per se. It would require a careful consideration of local conditions; the volume of water, the character of the water into which the sewage is discharged, the character of the sewage, as I said before—whether pathogenic germs are contained in the sewage, etc. 2406

Q. Suppose we eliminate, doctor, the bacteriological from the chemical and address yourself to the chemical; what do you mean by the character of the water?

A. The character of the water is determined by chemical analyses looking for characteristic ingredients of pollution, whether of animal or vegetable origin..

Q. What do you mean by the volume of the water?

A. The volume of the water is important in so far that the current will be greatly accelerated in the running river by a larger volume of water, and the sewage will be carried down the river much faster and go a longer distance.

Q. What is your opinion as to whether the sewage of a population of 500,000 inhabitants, being emptied into a river the size of the Mississippi at St. Paul and Minneapolis—at what distance would the waters of the Mississippi purify themselves, and become potable, after receiving the sewage of St. Paul and Minneapolis?

A. I have not made any analyses of the waters between St. Paul and the mouth of the Illinois River, excepting a few miles in the Mississippi above the mouth of the Illinois, so that I am not prepared to make a statement answering that question.

2407 Q. Have you any opinion as to whether the Mississippi River, after receiving the sewage of St. Paul and Minneapolis, subsequently purifies itself?

A. No, sir.

Q. Do you know whether the Mississippi River purifies itself from the sewage pollution of St. Paul and Minneapolis?

A. Well, that is a matter that I have not investigated, except that I know that the Mississippi River water at the mouth of the Illinois, is a comparatively much purer water than the water found in the Illinois River at the mouth of the Illinois.

Q. Read my question, please?

(Question read.)

MR. TODD: I move to strike out the previous answer as not responsive, and ask to have the question read again and an answer that is responsive, given.

THE WITNESS: Will you please read the question again?

Q. (Question read.)

MR. TODD: That can be answered yes or no, doctor. The question is, do you know?

MR. JEFFRIES: We object to the question for the reason that it neither tends to prove or disprove any material issue

involved in this controversy and for the further reason that the fact as to whether or not the waters of the Mississippi River would purify themselves from their polluted state caused
2408 by the sewage discharges at St. Paul, by the time the City of St. Louis is reached, has no bearing upon this controversy, and wouldn't justify or excuse the defendant, Sanitary District of Chicago, in discharging its sewage into the Desplaines River, thereby polluting the natural streams foreign to its own watershed.

Q. (Question repeated.)

A. I cannot answer that question.

Q. MR. TODD: Do you know?

MR. JEFFRIES: Give your opinion, doctor, as an expert?

A. Well, I don't know.

Q. MR. TODD: That is what I mean.

A. Yes.

Q. What effect upon the waters of the Mississippi would the sewage from McGregor, Prairie du Chien, and Dubuque have in addition to the sewage from St. Paul and Minneapolis?

MR. JEFFRIES: We object to the question for the same reason embodied in the objection to the question that refers to the sewage from St. Paul.

Q. MR. TODD: Do you know?

A. I do not know, because I am not familiar with the conditions prevailing in any of those Mississippi River cities.

Q. Is it an established principle that sewage contaminated water receiving a discharge of additional sewage, retards
2409 the purification of the last discharge of sewage?

A. That again depends upon the relative proportion—

Q. Is it a principle?

A. Well, it cannot be answered, I say it depends upon the comparative proportions of the amount of sewage and the character of the waters.

Q. As a general principle, is that true?

A. It may be true in one case, and may not be true in another case. It depends upon local conditions.

MR. JEFFRIES: He is asking you about a general principle, doctor.

A. Well, I cannot accept a general principle, when there are instances pro and con.

MR. JEFFRIES: Well, can you state the principle and then give the exceptions afterwards?

A. I don't know which would be the exception in that case.

Q. MR. TODD: Then you have no knowledge upon which you can establish a general principle applicable to that condition, have you?

A. I base my opinion—

Q. No. Answer my question?

A. (continuing)—on the facts as I find them in the particular case.

2410 MR. TODD: I move to strike out the answer and ask to have the last question read.

Q. (Question read.)

A. To what condition?

Q. A condition that where a river is sewage polluted by a city above and running down past another city has had additional sewage emptied into it, would the condition of the water when it arrives at the latter place, retard the purification of the sewage from the latter city?

A. That question can only be answered by taking into consideration the local conditions at the points involved.

Q. Doctor, my question is, have you any knowledge?

A. Certainly I have some knowledge on that point.

Q. Based upon a general principle that sewage contaminated water from cities above, receiving an additional discharge of sewage from cities below, that the water of the river so contaminated at the time of the additional discharge, will retard the purification of the stream?

A. Yes, sir.

Q. You say you have knowledge?

A. Yes, sir.

Q. What is the general principle; does it or does it not retard the purification?

2411 A. No general principle could be formed there.

Q. Then there is no general principle applicable to a condition of that character?

A. No; theoretically not. It all depends upon the practical investigations—

Q. That is all I want, doctor. You have answered my question.

A. Yes.

Q. Now, assume that the Mississippi River at St. Paul and Minneapolis receives the sewage discharge from the population of those two cities, and that it constantly receives the discharge of sewage from the cities lying along its banks below St. Paul and Minneapolis, the cities of Dubuque, Clinton and Quincy—do you know whether the river will purify itself from the sewage discharge of these cities below St. Paul and Minneapolis, on account of having been impregnated with the sewage of St. Paul and Minneapolis?

A. I don't know, because I have not made any investigations on that line at those points.

Q. Assume that the sewage of St. Paul and Minneapolis did not empty into the Mississippi River, but that the sewage of the cities below Minneapolis and St. Paul emptied into the Mississippi River, would the fact that that sewage entered pure water, purify itself quicker than it would if it entered
2412 sewage contaminated water from St. Paul and Minneapolis?

A. I could only answer that question after an investigation of the conditions prevailing in the rivers at those cities.

Q. You have no knewledge then, as to the general effect of conditions such as I have assumed, have you?

A. Not as far as the sewage from those cities is concerned, that you have mentioned just now.

Q. Then with the addition of the sewage of Burlington, Keokuk, Rock Island, Moline and Davenport entering the Mississippi River and all of the cities and villages lying tributary to the Mississippi emptying their sewage into the Mississippi, have you any knowledge as to whether the river purifies itself or not of that sewage?

A. I have no knowledge, because I have not investigated that problem for those cities.

Q. Is there any principle established by science that holds the doctrine that the river does not purify itself of that sewage?

A. You mean to say that the sewage from those cities—

Q. Yes. Is there any principle established by chemical science that holds that the river would not purify itself of that sewage that it has received?

A. I don't know of any as applied to those conditions prevailing in the Msisissippi River above the mouth of the Illinois.

2413 Q. What is the condition of the waters of the Mississippi River above Grafton, as to whether it is potable or not?

A. While I consider the Mississippi River a few miles, from three to five miles above the mouth of the Illinois River as polluted I do not consider it as badly a polluted river as compared with the Illinois River.

MR. TODD: I move to strike out the answer as not responsive to my question and ask to have the question re-read.

Q. (Question repeated.)

A. You ask whether it is potable or not?

Q. Yes?

A. At certain times that water is potable.

Q. What's that?

A. At certain times during the year the water of the Mississippi River above the mouth of the Illinois, from three to five miles above the mouth of the Illinois, that water is potable, at other times it is not potable; it varies according to the amount of impurities.

Q. What were the periods of variation during the year?

A. During the summer months the analyses of samples shows for the Mississippi River a few miles above Grafton, shows low impurities.

Q. (Question repeated.)

I mean that the water was potable or was not potable?

2414 A. During the summer months the water found at the points from three to five miles in the Mississippi above the mouth of the Illinois River was potable.

Q. What months were those? Give the months?

A. That is principally during the summer months.

Q. Name the months, doctor?

A. Well, I would have to consult the data to be accurate, to say exactly which months, but during the warmer period of the year the water from that river is always better than it is during the winter months.

Q. How many months in this climate do you consider summer months?

A. June, July, August, and in St. Louis, very often we have summer weather prevailing through the month of September.

Q. Then for those four months you consider the water as potable?

A. I do.

Q. Above Grafton?

A. Yes, sir.

Q. How do you explain the potability of the waters during those four months when you take into consideration that the sewage of all the cities along the Mississippi River from St. Paul to Grafton, is emptied into that stream at different points, according to their location?

2415 A. During the warmer months of the year the purification processes in the rivers are greatly accelerated. They are performed more rapidly than during the winter months.

Q. The rivers are at the lowest stages during those months, aren't they?

A. Not always. After the spring months, after the usual rise in the rivers, what you call the spring rise of the rivers is very high water, consequently larger volumes of water coming down the river.

Q. What are those rises attributed to, doctor?

A. Well, to the spring freshets, and the melting of the snow in the mountains, and sometimes the rain-falls are very heavy in the spring.

Q. Do the rises continue during the summer months?

A. No, but we have what you call a June rise, for instance.

Q. Well, when you have the June rise, do you have potable water in the river above Grafton?

A. The analyses show a gradual reduction of the impurities.

Q. I didn't ask for analyses. I asked you if you had potable water—we are laymen and the word "potable" means a lot to us.

A. The potability increases and decreases gradually; it don't come all of a sudden.

Q. Well, when the water rises at that stage which you
2416 denominate as potable, is it at the rise of the river caused
from the spring, or is it at that stage of its decline?

A. The potability increases in the spring slightly with the warmer weather.

Q. Is that accompanied by the increase in the volume of the water, or by a decrease in the volume of the water of the Mississippi?

A. Well, during the summer months—not always; it depends upon the weather conditions. Sometimes there are heavy rain-falls in June and we have had heavy rain-falls in July. It is difficult to draw a conclusion.

Q. Does a heavy rainfall in July affect the potability of the water?

A. Well, the potability of the water, as I said, depends very largely upon the weather conditions, the temperatures. In warmer weather the oxidation is more rapid.

Q. Assuming that the temperature is normal for the summer, would the fall of rain affect the potability of the water of the Mississippi River at Grafton?

A. The rain-falls act very peculiarly upon the chemical conditions of the rivers. While the chlorines will be diluted by a larger volume of water, the ammonias are frequently shown to rise.

Q. Stick to the word potability, doctor. We understand 2417 that. If we have learned what potable waters mean, from your testimony, based upon these different chemical ingredients, stick to the word "potable."

Now, does the rain-fall in July affect the potability of the water in the Mississippi river above Graften?

A. That depends upon the conditions, whether the water is cold or warm.

Q. Assume that the temperature is warm?

A. Certainly, warm temperature will assist materially in purifying.

Q. And the water remains potable?

A. Well, it assists in making it potable, in warmer weather.

Q. Is it not a fact that if the rains covering the watershed of the Mississippi River above Grafton, that it washes down into the river the drainage of the farms and the stables and flushes out the creeks, and the sewers of the cities, and throws more impurities into the river, thereby creating a greater contamination; isn't that true?

A. Such a condition may prevail in the Mississippi. It depends entirely on the circumstances at those places where these impurities get into the river, and it depends upon whether it is pollution of vegetable or animal origin, which materially affects the question of potability of water.

2418 Q. Well, wouldn't that be accelerated, the pollution of animal origin, to have a heavy rain-fall along the tributaries of the upper Mississippi?

A. If there are accessions of organic matter of animal origin, they will certainly be swept down much faster by a rapid current caused by an increased volume of water.

Q. And wouldn't that disturb the potability of the water at Grafton, even in warm temperature?

A. That would again depend upon the character of the pollution and depend upon the kind of water that such organic matter is discharged into. Again the local conditions will have to be considered.

Q. Then, if the waters of the Mississippi River for four months during the summer are potable, isn't the conclusion irresistible that a running stream the size of the Mississippi River will purify itself from all impurities, and from all sewage that has been discharged into it above Grafton?

A. Such a conclusion would not be justifiable unless based on a careful study of all local conditions; the character of the pollution of that water; the amount of sewage coming or being discharged from all of these cities into the river; what the distances are, etc., of the towns to the point at the mouth, the volume of water, the weather conditions—everything would go into consideration. No hard and fast rule could be evolved from such a theoretical question.

2419 Q. Doctor, if the waters at Grafton were chemically decided to be potable, is not the conclusion irresistible that the sewage, however magnified or increased in the upper Mississippi has been purified by the time it got to Grafton?

A. It would demonstrate that the pollution of the Mississippi River above Grafton is of such a character that it doesn't affect the potability of the water of the Mississippi at the mouth of the Illinois.

Q. And how is that question of potability arrived at aside from the theory that running water purifies itself in a certain distance if the analyses of the water demonstrate beyond question that the waters at Grafton are potable?

A. It is possible that such purification may take place, but it is necessary for various conditions all to co-operate to being favorable to such a result being obtained.

Q. Do not all conditions operate favorably, and do not the waters sewage contaminated become purified when such results at Grafton obtain?

A. I wouldn't say so, because I am not familiar with the conditions which I consider necessary for consideration to determine that question, the conditions in the Mississippi River above Grafton existing at the mouth.

2420 Q. Well, doctor, if those conditions do not obtain, what effect do those conditions have in deciding whether a stream polluted by sewage purifies itself, when your chemical analyses at Grafton demonstrate the potability of the water?

MR. JEFFRIES: I object to the question, because it is an argument to the witness.

A. All the conditions that I have mentioned as being required in the consideration of the question as presented by you, all those conditions will have to be considered before anybody could answer that question in the direct manner that you desire.

Q. Doctor, you understand that the sewage of St. Paul and Minneapolis empties into the Mississippi River, don't you?

A. I don't know whether it does; I presume though from your statement that it does.

Q. You understand that the sewage of McGregor, Prairie du Chein, Dubuque, Clinton, Keokuk, Moline, Rock Island and Davenport, empty into the Mississippi River, don't you?

A. Well, I presume so from your statement; I don't know personally.

Q. Assuming that they do, and also assuming that the chemical analyses are correct, that the waters at Grafton are purified and are potable, what weight have those conditions that you speak of, upon the results which you obtained by your analyses at Grafton?

2421 MR. JEFFRIES: I object to the latter part of that question for the reason that it does not contain the number of population that those cities have.

Q. (Question repeated)?

A. I cannot answer that question, because I am not familiar with the conditions in the Mississippi River valley above a point five miles above the mouth of the Illinois.

Q. Have you a theory in regard to those conditions you speak of?

A. I have no theory that I would apply to every case.

Q. Well, a theory of the conditions that exist along the Mississippi above Grafton?

A. No, I have no theory because I have not investigated the conditions prevailing in that river except by analyses five miles above the mouth of the Illinois.

Q. Well, when you made analyses above Grafton, you were confronted by the condition, not a theory, aren't you?

A. Yes sir.

Q. And the condition—with due apologies to Grover—that you find there, is that the water is potable, is it not?

A. Yes, at certain times of the year the water is potable.

Q. I mean during four months?

A. Yes sir.

2422 Q. Now, assuming that the sewage from the cities that I have mentioned and their population as given in the census are correct, and empties into the Mississippi, aren't you drawn from the condition you find, to the irresistible conclusion that the Mississippi River purifies itself of all that sewage before it gets to Grafton?

A. I don't know the conditions prevailing in that valley and I don't know the population of the towns, and I don't know the character of the sewage, and I don't know the character of that organic matter that is found in that water except by analyses from three to five miles above the mouth of the Illinois, so that I cannot answer that question conscientiously.

Q. Assuming that your chemical analyses are correct?

A. Yes sir.

Q. Can you conceive of any conditions existing above Grafton, along the Mississippi River, that would change the conditions which you draw from your conclusions, as to the potability of the water at Grafton?

A. I cannot answer that question as I said before.

Q. Why?

A. Because I am not familiar with those various conditions that I have stated, which I must study before I would be able to form a conclusion as to whether the Mississippi River is polluted before it reaches the mouth of the Illinois, by
2423 sewage from those cities. I don't know whether I can express an opinion.

Q. Have you any faith yourself in the conclusions which you derive from the chemical analyses above Grafton?

A. Yes, I am compelled to draw the conclusion from the analysis as I found it; how I find that water three to five miles above the mouth of the Illinois, in the Mississippi.

Q. And your conclusion is based upon the chemical analyses of the water at that point?

A. Yes sir.

Q. Can you conceive of any conditions existing above Grafton along the Mississippi River, that would make you draw a different conclusion from what you have, from the analyses that you made of the waters of the Mississippi above Grafton?

A. There are various possibilities, but I cannot draw any deductions from possibilities, where I am unfamiliar with the facts, upon which alone I could base a conclusion. Whether the Mississippi River when it reaches Grafton is polluted or not and what kind of pollution it might be I can only say. I found the water to be such as my analyses show, three and five miles above the mouth of the Illinois.

Q. Assume, doctor, that there was a population of 10,000,000 people emptying its sewage into the Mississippi from St. Paul down to Davenport, and your chemical analyses
2424 above Grafton showed you certain results which you have testified to here, would that condition make you draw any different inference from those analyses than you draw at present?

A. If this sewage from 10,000,000 people would all be discharged into the Mississippi River from one city, it is not likely that the sewage would ever purify itself in that river, and it is not likely that the water would be found in such a condition as I found it chemically from analyses of the samples taken three and five miles above the mouth.

Q. Assume that your analyses are correct.

A. Yes sir.

Q. And assume that 10,000,000 did discharge their sewage into the upper Mississippi, would the fact that they discharged their sewage into the upper Mississipp make you draw any different conclusion from your analyses, than you have drawn?

A. Well, I couldn't draw but one conclusion from the analyses, and that would be as I already stated, that the chemical character of that water is such, just as the analytical data enabled me to state.

Q. Then your conclusion as to the potability of the water above Grafton, does not depend upon the conditions that may or may not exist in the upper waters of the Mississippi, does it?

A. It must depend upon the conditions there which I am familiar with.

2425 Q. Don't your conclusions depend upon the analytical data of the waters above?

A. My conclusion that the water is potable or not potable in the Mississippi at the mouth of the Illinois, my conclusion is based on the analytical data. Whether or not that Mississippi River water, before it reaches that point, was polluted, and how it was polluted and where it was polluted don't come into consideration in my conclusion there. I only base the conclusion on the Mississippi River at the mouth of the Illinois.

Q. That is my question.

A. Yes sir.

Q. That your conclusion is arrived at from the analyses of the waters of the Mississippi at Grafton?

A. Yes sir.

Q. And the conditions that exist along the Mississippi River above Grafton, up to St. Paul, whether there are 10,000,000 people discharge their sewage into the Mississippi or not, wouldn't make you change your conclusions, would they?

A. It could not, because the conclusion is not based on those conditions.

Q. Then your conclusion from the analyses is, that the Mississippi River water at Grafton has become purified and potable during the months you have enumerated, is that right?

2426 A. I say it is potable at certain times.

Q. During the four months?

A. Yes sir.

Q. The water can only become potable by being purified, is that correct?

A. It may be potable without having been impure.

Q. But assume that it is impure; it would have to become purified before it would become potable, wouldn't it?

A. It must be in a certain chemical condition to enable the condition that is potable.

Q. Well, assume that it is in the chemical condition at the time you denominate it as potable, and previous to that point it was sewage contaminated, doesn't the conclusion of potability carry with it, the idea of purification for water of the character of that described?

A. No, water may be potable, and yet may not be pure.

Q. Can sewage contaminated water be pure?

A. A sewage contaminated water, no sir.

Q. Then if sewage contaminated water becomes what is known as potable, doesn't the condition of potability carry the idea of purification?

A. It doesn't carry the idea of complete purification, it only carries the idea of a purification to a degree.

2427 Establishing the water potable. That is permissible to be allowed for use for drinking purposes; that is potability.

Q. I understood you to say that the only chemically pure water was the laboratory water?

A. Yes sir.

Q. We are not talking about that water.

A. No sir.

Q. Now if the water of the Mississippi River at Grafton is potable, doesn't it convey to your mind as a chemist, that sewage discharged into that water at Minneapolis and St. Paul and all the cities nursing the banks of the Mississippi River, has become purified to the degree of potability by the time it gets to Grafton, the point where you made your examination?

A. Stating as I have done, that I am not familiar with the conditions, whatever pollution there might have taken place in that Mississippi River above the mouth of the Illinois River; whatever pollution has taken place, it has been rendered sufficiently harmless by the time that water reaches the mouth of the Illinois as to render that water potable during certain times of the year, as I have stated.

Q. That is the question I was after.

A. Yes sir.

Q. During the other eight months of the year, doctor, are the waters of the Mississippi River potable?

2428 A. They are more or less. That may depend upon certain conditions as found by the chemical analyses.

Q. Well, are they more or are they less?

A. I don't think that the impurities found during the other months of the year in the water taken from the Mississippi River a few miles above the mouth of the Illinois—I say I don't think that the impurities found at that time would very much affect the potability. There might be a slight increase in the impurities, and yet our analyses demonstrate that from a liberal standpoint, that water coming from the Mississippi River and subsequently mixing with the Illinois River, that it is on the whole potable water.

Q. I am speaking above Grafton.

A. Above Grafton; that's what I mean. I say that some parties might say that the water in the Mississippi River above Grafton is not potable.

Q. I want to know what you think.

A. My opinion is that practically throughout the year it is permissible as good drinking water.

Q. Doctor, assume that Grafton was a large city, and you were placed in charge of the water supply of that city as a scientific man, would you advise the citizens of Grafton to use the waters of the Mississippi River above the entrance of the Illinois River for drinking purposes during those eight

2429 months without boiling and without filtering, and denominate it a potable water?

A. I would consider that water from the Mississippi River potable.

Q. And would you so advise?

A. Yes sir.

Q. Then what did you mean in the beginning of this examination this morning, in stating that during the summer months, June, July, August and September, that the water in the Mississippi River above Grafton, was potable for that period?

A. Potable in the opinion and from the standards of all authorities that I know and that I recognize as authorities, but for the remaining months it may be that some parties would say, "Well, this water would not pass," but I would consider it as I said, from my standpoint, the liberal standpoint, I would consider that water potable throughout the year.

Q. Doctor, in giving your opinions here upon questions that are presented, are you giving us your personal information based upon your personal knowledge, or are you giving us the opinion of other men who have expressed themselves either in writing or in reports upon the subject matter of your testimony?

A. I am giving you first of all, wherever I can, my own
2430 personal judgment derived from either direct analytical work, and direct personal observations of conditions and direct personal study of various conditions prevailing at points where the information is necessary, and also from the study as is required of other chemists, the study of the literature published on the subjects, involved in the study of such questions.

Q. What literature have you consulted in regard to the potability of the waters of the Mississippi above Grafton, limiting it to the four months during the summer and excluding the other eight. Can you name the literature?

A. I have seen the standards formulated as regards the potability of waters when they have a certain amount of ingredients.

Q. I am speaking of the water, doctor, at Grafton, above the entrance of the Illinois River into the Mississippi?

A. I know of no literature that expresses a direct opinion on the potability of the Mississippi above the mouth of the Illinois. I mean general standards.

Q. Then when you testified that for the four summer months the water was potable, namely, June, July, August and September, as against the other eight, you were testifying and giving your individual opinion, were you, or the opinion of someone else?

2431 A. When I stated that I considered the water potable, absolutely for those four months, I meant that the amount of chemical ingredients found in the samples of water there are within the limits set by sanitarians and chemists as the limits of what would be potable and non-potable water. It comes within all those limits of responsible authorities. For the remaining months there might be a difference of opinion. Some sanitarians might say as I have stated in my standard that I have published, such a book or such a report, I would consider these limits beyond, I would consider the quantity of these ingredients beyond those limits, but there are only a few of those. On the whole I think that sanitarians will agree with me, with my personal opinion, that practically throughout the year the Mississippi River at points three and five miles above the mouth of the Illinois, is potable.

Q. Doctor, you stated that you were a specialist on bacteriology and chemistry. Do you know of any bacteriologist that holds to the doctrine, that any running stream, sewage polluted, is potable water?

A. First of all, I didn't state that I was a bacteriologist. I said I was a chemist and that—

Q. You employed bacteriology in your work?

A. I consider it my duty to familiarize myself with much of bacteriology as is a part of the chemistry of water.

2432 Q. And in your investigation and in order to equip yourself as a chemist, you deemed it necessary to qualify yourself to a certain extent in bacteriology.

Q. Now do you know any bacteriologist of any recognized standing that adheres to the doctrine that a stream or river sewage polluted is potable water?

A. There are scientists—

Q. No, I am talking about bacteriology.

A. Yes, there are scientists that maintain the opposite views.

Q. Who are they, doctor?

A. Well, there are a number of them. They are principally German investigators.

Q. Do you know any that have given the question of running streams any consideration that hold that view?

A. That running water purifies itself?

Q. No, that streams sewage polluted by cities nursing their banks, are potable water?

A. Yes, there are some.

Q. Well, who are they?

A. Well, I cannot think of any just at this moment.

Q. Do you adopt their views?

A. No sir.

2433 Q. Are you opposed to their views?

A. I think that the weight of the evidence from the other side in opposition to those views is so strong, that from a careful study of those views, I would accept the views of those that are opposed to the views that you quote as correct.

Q. That is, that the bacteriologists who hold that sewage polluted streams are not potable water, the views of those learned men, meet with the approval of your judgment, is that right?

A. Yes sir.

Q. Now supplementing your investigations as a chemist, with the views of bacteriologists that hold that running streams sewage contaminated, are not potable, do you still adhere to the opinion as a chemist and bacteriologist that the waters of the Mississippi River are potable during a greater part of the year?

A. Why my chemical analyses demonstrates the potability of the Mississippi River water at the mouth of the Illinois.

Q. Doctor, when you are in doubt as a chemist, you remove that doubt, do you, if possible by the aid of bacteriology, if it will remove it?

A. Well, I take into consideration a bacteriologist's views.

Q. And if those views create a condition or supplement a
2434 condition that chemistry fails to disclose, you combine the
two and draw a conclusion, do you not?

A. That depends upon the question involved. If it is one of chemical importance I disregard it.

Q. Take the question of running streams, sewage polluted, you say you accept the views of the bacteriologist that running streams, sewage polluted are not potable? Am I correct in that statement?

A. As applied to the great majority of cases investigated.

Q. Do you make the upper Mississippi an exception to the rule?

A. I cannot make it an exception to the rule, but as long as I am not familiar with the conditions prevailing there, I have no right to apply the rule, any rule, to the conditions existing in that river.

Q. Aside from the Illinois River and the Mississippi River from Grafton, do you apply that rule to any other river or rivers in the world, of the bacteriologists?

A. From a study of conditions of some of the river waters which I have analyzed, I have formed conclusions, taking into consideration the results of bacteriological investigations as well as chemical investigations.

Q. And did you arrive at the potability of the water?

A. Yes sir.

2435 Q. From chemistry or bacteriology?

A. Well, principally from chemistry, but I found that bacteriology supplemented in a measure, the chemical results, so that a conclusion could be formed taking into consideration the bacteriological views.

Q. Now, doctor, if a stream was disclosed to be chemically pure and bacteriologically infected, which conclusion would you follow, a chemical test or a bacteriological test, in arriving at the potability of the water?

A. You say if the water would be chemically pure, and bacteriologically—

Q. Yes, I mean chemically potable. I am not using, when I say "pure" the laboratory purity; I am using purity as defined by you as to potable water?

A. That is confined to the chemical feature of it?

Q. Yes?

A. And adding thereto—

Q. The bacteriological view. If a stream was discovered to be chemically potable, by the aid of chemistry and bacteriology, and contaminated by the aid of bacteriology, what would be your view as to the potability of that stream as a scientific man who has made researches into both fields of learning?

A. It might be bacteriologically impure.

2436 Q. That is an argument?

A. Well, no researches have shown that may be the case.

Q. Now what are your conclusions as a scientific man from the situation such as presented to you by the question, as to whether waters are potable or not?

A. The chemical conditions are usually such in a polluted river that they bear out the bacteriological conditions, and the bacteriological conditions may bear out the chemical conditions, of a sewage polluted river. They usually go together—both pollutions.

Q. I want to ask you a question, doctor, in order to be fair. Are the conditions which I have given in the hypothetical question I propounded to you an unfair hypothesis and inconsistent with the conditions that might exist?

A. Well, there is no limit to the possibilities of the conditions existing.

Q. Well, are they inconsistent, I mean?

A. Well, it is not to my knowledge, that I know, where such conditions exist as you mention.

Q. Then the question is a fair assumption?

A. Well, it is a hypothetical question.

Q. It is a fair assumption; it has nothing that is contradictory in itself, has it?

A. That may be possible.

2437 Q. Now if a condition of that character presented itself to you where a stream was chemically potable and bacteriologically contaminated, what would be your opinion, Dr. Teichmann's opinion as to the potability of the water?

A. If such a condition should exist—I don't know of any—if it should exist, that water would certainly from a general hygenic standpoint, not be considered potable, because the bacteriological pollution would certainly stamp it as unpotable, as not potable.

Q. Then if you accept the authorities in bacteriology that all sewage contaminated streams are not potable, and your analyses disclose the potability of the stream, how can you arrive at the conclusion that a running stream, sewage contaminated becomes potable?

A. The potability there from a general hygienic standpoint—the question of potability will depend upon both the chemical and bacteriological conditions as found.

Q. But assuming that the authorities that address themselves to your intelligence with approval, hold to the doctrine that sewage contaminated streams are not potable, notwithstanding that chemical analyses disclose the potability of the stream. How can you reconcile your position that a running stream such as the Mississippi River above Grafton is potable during the year?

2438 A. The analytical results from the water as I have studied them, the water of the Mississippi River found a few miles above the mouth of the Illinois, allow of no other conclusions than that the water is potable.

Q. Then you eliminate from your conclusion all considerations of the opinion of experts on bacteriology which you adopt in arriving at that conclusion, don't you?

A. I do not, because the study of bacteriological reports on the water from that point, do not justify me in forming a general conclusion from a general hygienic standpoint, a conclusion that the water found in the Mississippi River above the mouth of the Illinois is unpotable. There is no bacteriological evidence to show that it is unpotable from a general hygienic standpoint in conjunction with the chemical potability found.

Q. Then the principle as held by the bacteriologists whose opinions you say you approve is not attainable when applied to the Mississippi River above Grafton as to the non-potability of running streams sewage contaminated?

A. I do not draw that conclusion from my statement.

Q. Isn't that a fact?

A. I cannot draw such conclusions because I haven't made any statement wherein such a conclusion was given.

Q. You approve of the opinions of experts and bacteri-
2439 ologists that hold that all sewage contaminated streams are not potable, don't you?

A. I said that the potability of the water as determined by careful investigation chemically and bacteriologically show that, that from a general hygienic standpoint we can only determine the potability by taking into consideration both factors, chemically and bacteriologically.

Q. Isn't there a class of learned bacteriologists who hold to the view that sewage contaminated rivers are not potable?

A. Yes sir.

Q. Did you not state, doctor, that you adopted those views?

A. I said that the weight of the investigations—

Q. I want to get at what you think, not the weight?

A. The weight of the opinions is favorable to that side, which considers sewage contamination of waters a serious problem.

Q. Well, in adjudicating the opinions of different men and arriving at a conclusion as to the weight of evidence, do you Dr. Teichmann, adopt the principle of those men who hold that sewage contaminated streams are not potable?

A. I do adopt it for all causes where general conditions as I have repeatedly mentioned today, are favorable to the application of such a rule, but they are not favorable to every case.

2440 I do not accept it as a hard and fast rule for every possible case, disregarding entirely the various conditions that should come into consideration.

Q. Do you know of any reason or condition that exempted the Mississippi River from Grafton to St. Paul from being within that rule, if so, what are they?

A. No sir.

Q. Why not?

A. It is possible that the rule may be applicable to the Mississippi River above Grafton, providing that the conditions prevail that will justify its application.

Q. Do you know whether those conditions prevail or not?

A. I don't know, as I said before.

Q. Then if you don't know, why do you make the Mississippi River an exception to that rule that you have accepted?

A. I don't make it an exception. I don't form an opinion.

Q. Does the Mississippi River come within the rule?

A. That is what I cannot tell unless I make an examination of the conditions necessary to form an opinion.

Q. And then not knowing whether the conditions obtain or not in the Mississippi, and being unable to express an opinion as to whether the Mississippi River is an exception to the rule or within the rule, how do you come to the conclusion that the waters of the Mississippi are potable unless you eliminate from your opinion all consideration of bacteriology?

2441 A. The question in this case is not involved, "What are the conditions in the Mississippi above the mouth of the Illinois miles and miles away." I only base an opinion on the conditions as I find them three and five miles above the mouth of the Illinois.

Q. Are you testifying as an expert upon the facts that only apply to this case, doctor?

A. I am testifying to the facts as I found them at the mouth of the Illinois River. What the conditions are hundreds of miles above the mouth of the Illinois on the Mississippi I am not considering. I only ascertained the character of the Mississippi River water three and five miles above the mouth of the Illinois. Is it good or bad? And I find it potable, and I have so expressed it. What it might have been miles and miles above the mouth of the Illinois, is immaterial to my mind in considering the questions involved in the investigation that I conducted these years.

Q. As far as the effect upon this case one way or the other, you don't take that into consideration, do you doctor?

A. Well, it is a question of cause and effect. I find the effect there at the mouth of the Illinois River.

Q. Get my question. As far as the effect it might have upon the determiation of this law suit, you don't take that into consideration in giving your opinion, do you?

2442 A. No. I am only to find out what the character of the water is, of the Mississippi before it meets the Illinois. What it has been miles and hundreds of miles above the mouth of the Illinois, is immaterial in determining the question, "How is the water at the mouth of the Illinois?"

Q. Then as far as your opinion goes to the potability of the water at the mouth of the Illinois, you haven't taken into consideration the bacteriological view of the situation have you?

A. Yes sir, I have.

Q. And have you given it any consideration, any weight, in arriving at that conclusion?

A. Yes sir, I have.

Q. And in view of the fact that you are unable to state what the conditions of the Mississippi River are above Grafton bacteriologically, whether it is the exception or within the general rule, that all sewage contaminated waters are not potable, still you adhere to the opinion that you take into consideration the bacteriological view as well as the chemical, and arrive at the conclusion that the water is potable?

A. Yes, I have examined both conditions chemically and bacteriologically and thereupon formed a conclusion that the
water of the Mississippi is potable, three and five miles
2443 above the mouth of the Illinois.

ADJOURNED until 2:00 P. M. same day, March 31, 1903.

2444 Southern Hotel, St. Louis, Missouri. 2:00 P. M., Tuesday, March 31, 1903. Continuation after recess. Present, the Commissioner, and same counsel representing the respective parties.

DR. WILLIAM C. TEICHMMANN,

resumed the stand for further cross-examination by Mr. Todd and testified as follows:

Q. When did you personally make a bacteriological examination of the waters of the Mississippi at the point indicated in your last answer?

A. I did not make a personal analytical examination. What I meant was that I examined reports—

Q. Well, that is all I want, doctor.

A. Yes.

Q. Did you personally make a bacteriological examination of the waters of the Mississippi three or four miles above Grafton?

A. No sir.

Q. Then upon your personal knowledge, you don't know whether the waters at that point were bacteriologically pure or
not, do you.
2445 A. Well, if you mean personal knowledge based on original analytical researches, I would say "No."

Q. That is what I mean, what you, yourself know?

A. Well, based upon original researches, analytically, I would say "No."

Q. Then what information you have as to the bacteriological condition is based upon what other people have told you and not upon what you yourself know from personal analytical researches, is that correct?

A. From what has been reported by bacteriologists who made examinations at that point.

Q. Now excluding the opinions of everybody and basing your opinion upon your personal knowledge, can you say that the waters of the Mississippi River three miles above Grafton are potable, bacteriologically and chemically?

A. Not if based upon personal analytical investigation of my own.

Q. That is all I want, is your own knowledge.

A. Yes.

Q. So that when you testify as to the potability of those waters, your answer is based upon your personal researches as a chemist?

A. Yes sir, and upon the study of reports.

2446 Q. As a chemist—and you have no personal knowledge from personal investigation as to the bacteriological conditions that prevail at that point, have you?

A. Not as far as personal analytical researches is concerned.

Q. Now, if the information that comes to you second-hand is inaccurate, or not properly founded, your opinion based upon hearsay would not be an opinion that you would put a great deal of credence in, would it?

A. If the bacteriological information that I base the final conclusion on is erroneous, I would certainly modify my views accordingly.

Q. Have you any opinion of bacteriological experts, whose opinion you deem worthy of belief, that hold that the waters of the Mississippi above Grafton are potable waters?

A. The information that I have—

Q. No—opinion of bacteriologists, of accepted standing, whose opinion you adopt, that hold that the waters of the Mississippi above Grafton, are potable?

A. Well, I have the analytical report—

Q. I want the opinion?

A. Of a scientist from which I draw my conclusions—

Q. Now doctor, I didn't ask for reports; I ask you have you any opinion or do you know of any opinion of any bacteriologist who holds that the waters of the Mississippi
2447 above Grafton are potable, and whose opinion you accept?

A. Well, that opinion is embodied in the analytical report as I studied it, from which I draw that conclusion.

Q. I am not asking you for reports. I want the conclusions of a bacteriologist who has made the analytical investigation, who concludes from his analytical investigations that the waters of the Mississippi are potable, and whose opinion you approve.

A. Well, I have no definite conclusion to that effect, because I formed my own opinion from the study of analytical data.

Q. Then you know of no bacteriologists whose views you accept that hold that the waters of the Mississippi are potable above Grafton?

A. No, I form my own opinion from the data.

Q. I didn't ask you about your opinion, doctor?

A. Well, I answer that question "No."

Q. You do not?

A. No.

Q. And notwithstanding that fact and the fact that you personally have never made a bacteriological survey of the waters of the Mississippi above Grafton, you still hold to the opinion that the waters of the Mississippi are potable?

A. From the study of analytical data of the bacteriol-
2448 ogical investigations—

Q. Can't you answer that Yes or No?

A. (Continuing)—I feel justified in answering that question Yes.

Q. Then is it not a fact, doctor, that bacteriologists have condemned the waters of the Mississippi above Grafton?

A. Not to my knowledge.

Q. Is it not a fact that Dr. Ravold, the bacteriologist, a recognized authority in St. Louis upon bacteriology, condemned the waters of the Mississippi as not being potable?

A. Not to my knowledge.

Q. Didn't you hear his testimony here?

A. I heard some of his testimony, but I didn't hear him testify to that fact, that is, in general conclusion.

Q. Assuming that he did so testify, would that have any effect upon your conclusion as to the potability of the waters of the Mississippi at Grafton?

A. I would base my final conclusion on the study of analytical data that have been obtained from bacteriological investigation of the water at that point.

Q. Then you would not regard the opinion of a man who has given this question a great deal of study, as having any weight upon you in arriving at a conclusion as to the potability of the waters of the Mississippi, bacteriologically?

2449 A. I woud give considerable weight to the conclusions of a bacteriologist upon certain analytical data that he is investigating or from which he is drawing his final conclusions, but I would not accept his conclusions unless I would have convinced myself by a personal study of those very analytical data whether in my opinion, when judging the general potability of a water, whether his conclusion would conform with my final conclusion, from a general hygienic standpoint.

Q. Have you given any personal consideration to the bacteriological examinations of the waters of the Mississippi River above Grafton?

A. I have studied the analytical data which were at hand.

Q. Above Grafton?

A. At the point several miles above Grafton.

Q. And were those analytical data sufficient to enable you to pass upon the potability of the waters of the Mississippi for twelve months in the year?

A. These—

Q. Answer the question, doctor, Yes or No?

A. These data were sufficient to my mind—

Q. Yes?

A. To enable a general conclusion from a hygienic standpoint—

Q. To enable you to pass upon the potability of the water of the Mississippi above Grafton for a period of one year?

2450 A. Yes sir.

Q. Covering what period of time were the samples taken from which the data to which you refer were made?

A. They were taken from September, 1899, until October, 1900.

Q. Every day?

A. No sir.

Q. Every week?

A. For about eight months, the samples were collected every day.

Q. And did you make the examination?

A. No sir.

Q. Are you qualified to make examinations bacteriologically?

A. Well, not in general.

Q. Just answer it Yes or No, doctor?

A. Well, no; I say no.

Q. Do you know anything about the reliability of the data except what you get from hearsay?

A. Well it is a matter of personal judgment.

Q. Well, a man could go down there and look at the water, couldn't he, and have a personal judgment as to whether it is bacteriologically free from sewage or not, couldn't he?

A. No sir.

2451 Q. He could not?

A. No sir.

Q. If he has no personal knowledge of the analyses, what is the difference between his position in passing judgment and if he is not competent to examine bacteriologically, what is the difference between passing a judgment in that way—than it would be to have somebody tell him that the waters are not impure, and for him to form an opinion from what somebody told him?

A. Well, he must be able to judge whether the analytical data obtained by personal analytical investigation by another man, whether they have the character of reliability, so that in studying these data that he can himself form an opinion on the data collected by others.

Q. Is there anything in the data itself that shows whether it is reliable or not?

A. Well, it is again a matter of personal judgment.

Q. Is there anything in a personal judgment that will enable a man to tell whether the data is reliable or not, if he is unable to make the analyses himself?

A. Well, he can go very much by the opinion, and the character, and the education and the experience of the man who collected the data.

2452 Q. Then you are adopting the opinion of the man who collected the data instead of the data itself, are you not, doctor?

A. As far as the methods of collecting is concerned, yes sir.

Q. As far as the integrity of the data as derived from analyses bacterially speaking, you have got to rely upon the man who made it?

A. Yes sir.

Q. So that it comes right down to the point that you have got to accept the judgment of some other man before you can pass a judgment yourself, isn't that right?

A. In a measure, yes.

Q. Well, isn't that in a full measure?

A. Well, he won't form an opinion blindly; he will examine those data and from the general course pursued in obtaining those data, together with the personal opinion that he has of the reliability of that man as a scientist, to conform to the opinion.

Q. Well that would leave it to the man's judgment, wouldn't it?

A. Yes, that altogether would make up the judgment.

2453 Q. And all that you have got when you get through with what you have stated, is the judgment of the man himself who made the data?

A. As far as the data themselves are concerned, yes sir.

Q. If I should hand you some data and you did not know the man who made it, could you tell whether the data was correct or not, by the data itself?

A. Well, I may not know him personally, but I may know of him.

Q. No, I don't tell you who made the data. I give you the data made by an unknown, all that you have before you is the data itself, can you look at the data and tell whether that data is to be relied upon or not?

A. I could not, because it would be unfair. The data may be entirely wrong; they may not have been honestly collected, etc.

Q. Then you have got to rely upon the honesty, the ability and the carefulness and experience of the man who collects the data before you can predicate an opinion upon his judgment?

A. Yes sir, I should.

Q. And all that you have that is anyways tangible to base your opinion on is the judgment of the man whose judgment you respect; is that right?

A. Yes sir.

2454 Q. If that man is wrong in his conclusions and analyses, you are wrong in your conclusions, are you not?

A. Not in all cases. He may draw different conclusions from the very data than I would draw—

Q. And by the data to which you are speaking—was that the data that Dr. Ravold introduced in evidence here in connection with his testimony?

A. Yes sir.

Q. Do you draw different conclusions from those of Dr. Ravold?

A. As far as I know, I have drawn certain conclusions from those data which are my own conclusions.

Q. And if Dr. Ravold draws the conclusion from those data that all streams sewage polluted are not potable water or that the Mississippi River, which is sewage polluted, is not a potable water, you disagree with him in his conclusions?

A. I do not disagree with him as far as the application in many cases may be concerned.

Q. I am speaking of this particular case?

A. Well not in general, as I said this morning, I do not draw a hard and fast rule as to this question; it all depends upon local conditions surrounding, in bringing about these questions; they have to be taken into consideration.

2455 Q. Then I say, if Dr. Ravold, up at Grafton, should draw the conclusions from the analytical data which you have inspected, that running water in the Mississippi River which is sewage polluted, is not a potable water during twelve months of the year, you differ with him?

A. If Dr. Ravold meant to apply that to every case analytically—

Q. No, I mean at Grafton.

A. At Grafton as compared with the chemical results, I have already stated that from a general hygienic standpoint, I would consider the Mississippi River water potable.

Q. Doctor, I didn't ask you what you considered?

A. I never considered it alone.

Q. I ask you if Dr. Ravold drew the conclusion that the waters of the Mississippi River were not potable, from the data that you say you have inspected and analyzed, do you differ with him as to his conclusions? Can't you answer that Yes or No?

A. Well, that depends upon the point to which he applies this conclusion.

Q. At Grafton; at the point where the samples were taken, at Grafton?

A. I formed my conclusions—

Q. I didn't ask you that doctor. Do you understand my question?

2456 A. Yes sir, I do.

Q. Then, can't you answer it?

A. I am begining to answer it.

Q. The question is whether if Dr. Ravold drew a conclusion from the data that you say that you have inspected—

A. Yes, I have.

Q. Up there at Grafton, that the water of the Mississippi was not potable, do you differ with him in his conclusions from that data?

A. According to my opinion that the water is potable at Grafton, I do.

Q. You do?

A. Yes sir, I do, viewed from a general hygienic standpoint.

Q. You differ with him then as to his conclusions based upon that data as to the potability of the water?

A. I would from a general hygienic standpoint.

Q. Yes, that is all I wanted to get there. Now doctor, how does that condition of potability bacterially, and chemically obtain four miles above Grafton in the Mississippi River—what is the cause of it, and to what is that condition attributable?

A. That I could only say by an investigation of the character of the Mississippi River during its entire route from 2457 the point where it starts, down to the mouth of the Illinois, which investigation I have not made.

Q. Well, if it should appear that the sewage of St.Paul and Minneapolis and all the other cities above Grafton empty their sewage into the Mississippi River, and that that sewage came from a great many thousands of people, how could you explain the potability of the water at Grafton during the entire year, if those facts, which are assumed, are facts?

A. I would not express an opinion except by my personal investigation of the analytical data that might be presented to me from reliable chemical authorities on the character of that water above a point from where I took the samples.

Q. Well, assuming that this sewage goes into the water?

A. It would still be impossible to answer that question without taking into consideration—

Q. Can you give any explanation from a scientific standpoint why it is that you find the water above Grafton potable during the year?

A. I have not during that investigation given that question any consideration because I did not feel called upon to answer the question.

Q. Why?

A. The question was not involved in the investigation 2458 as outlined by the authorities for whom I carried on this investigation. I was only to ascertain the character of the Mississippi River water a few miles above the mouth of the Illinois River. That was all.

Q. So that you are unable to give an opinion or to express a reason why the sewage contaminated waters of the Mississippi are purified and rendered potable during the entire year, when it reached three miles above Grafton?

A. It would be unfair for me to give an opinion on that question without personal investigation and study of analytical data.

Q. You have no opinion then as to how this condition above Grafton is obtained?

A. Nobody could form a fair opinion.

Q. I am not speaking of anybody doctor, I am asking for Dr. Teichmann's opinion?

A. Well, I have no opinion.

Q. You have no opinion?

A. On that subject.

Q. And the situation that presents itself of the potability of the water above Grafton, is a condition that you have no explanation in your mind to offen for?

A. I didn't study it and therefore have no opinion to express.

2459 Q. Have you any ideas on the subject, doctor, as to why that water is potable for the year around, above, Grafton?

A. I would not form any ideas without a thorough investigation.

Q. Does the theory that running waters purify themselves of sewage contamination, running over the course from St. Paul down to Grafton, appeal to your judgment as an experienced man upon water-courses?

A. I could not express an opinion without previous investigation.

Q. Now doctor, have you examined—what is the condition of the waters of the Missouri River above its mouth, as to potability?

A. I consider the water potable at Fort Bellefontaine, the station in the Missouri river where we collected samples of water.

Q. Where is Fort Bellefontaine, doctor?

A. Bellefontaine is five miles above the mouth of the Missouri.

Q. Is that water potable all the year around?

A. More or less potable all the year around?

Q. Is it more or is it less?

A. That varies according to the seasons.

2460 Q. Now when you use the word potable, do you compare the word "potable" as "potable," "less potable" and "least potable" or do you classify it as "potable" or not "potable?"

A. In general I would classify it as potable or not potable; but the potable water may differ very much in its degree of potability. One water may be much better than another water and both may be potable.

Q. During a year how many months of the year are the waters of the Missouri potable and how many months of the year are the waters of the Missouri not potable?

A. I would consider the water found at Fort Bellefontaine station potable throughout the year.

Q. Throughout the year?

A. As I said, to a varying degree.

Q. Are you acquainted with the cities that empty their sewage into the Missouri River above Bellefontaine?

A. Somewhat, yes sir.

Q. Will you name to me the cities that empty their sewage into the Missouri River?

A. You mean all the cities that empty their sewage into the Missouri River?

Q. Yes?

2461 A. I could not give you that list, because there are a great many. It is a very long river.

Q. Well, beginning at Sioux City, that empties its sewage into the Missouri, does it not?

A. I believe it does.

Q. Omaha empties its sewage?

A. Yes sir.

Q. Omaha has large packing industries there, has it not?

A. Yes sir.

Q. And large distilling interests in Omaha?

A. Yes sir.

Q. And across the river from Omaha is the town of Council Bluffs, which is quite a manufacturing town, is it not?

A. I understand it is.

Q. They empty their sewage into the Missouri River do they not?

A. I believe they do, yes sir.

Q. And coming down a little bit further, is the town of St. Joseph or St. Joe; that empties the sewage into the Missouri River, does it not?

A. Yes sir.

Q. And Leavenworth, Kansas, quite a large city, empties its sewage into the Missouri?

A. Yes sir.

2462 Q. And Atchison also, and Kansas City?

A. Yes.

Q. That is a city of considerable size, is it not?

A. Yes.

Q. Great industries in the packing business, and slaughtering business there?

A. Yes sir.

Q. It has distilleries too?

A. Yes sir.

Q. And other manufacturing institutions, and the sewage of that city empties into the Missouri?

A. Yes sir.

Q. And then the towns that lie along both sides of the River in Kansas—

MR. JEFFRIES: I object to all the questions and move that they, together with the answers thereto be stricken out as far as the same refer to the emptying of the sewage of the various cities into the Missouri River, for the reason that the same is incompetent and irrelevant, and has no bearing upon the controversy here involved, and for the further reason that those towns situated upon the Missouri River discharge their sewage into a natural water flow, and flow into the water shed tributary to the Missouri River, while the question here involved, is that the sewage from Chicago is carried over 2463 from one watershed into another from the Chicago River or Lake Michigan rather, into the watershed of the Illinois River and thence into the Mississippi.

Q. And then the towns that lie along both sides of the river in Kansas, and the tributaries of the Missouri, empty their sewage into the Missouri River, do they not?

A. Yes, some do.

Q. And the sewage of Jefferson City, the pride of Missouri, empties its sewage into the Missouri River, does it not?

A. Yes sir.

Q. Now, doctor, are there any other cities that you know that I have not enumerated that empty their sewage into the Missouri River?

A. Yes sir, I think you have ommitted Herman, Missouri and St. Charles, Missouri.

Q. Doctor can you explain to me why the Missouri River at Bellefontaine is potable when all these cities and towns that have been mentioned here empty their sewage into the Missouri River?

A. First of all it depends very much upon the amount of sewage which these cities discharge into the Missouri River. It depends furthermore upon the volume of water in the Missouri River. It depends also upon the velocity of the flow.
2464 It depends also upon the general conditions of the course of the Missouri River; it depends largely upon what accessions of soil in the form of clay and silt the Missouri River takes up along its winding course, with innumerable curves and bends, drags along into the river, and what effect sedimentation of this enormous quantity of soil which is by the erosions of the land carried into the water will have on the sanitary character of that water.

Q. Doctor, does a stream running east and west purify itself any better than a stream running north and south?

A. I do not see any difference there.

Q. What conditions obtain in the Missouri River for its purification that do not obtain in the Mississippi River above Grafton?

A. The Mississippi above Grafton I am not familiar with except at a point from three to five miles above the mouth of the Illinois, so I could not make a comparison there.

MR. JEFFRIES: We object to the question for the reason that it is incompetent, irrelevant, and has no bearing upon the case.

Q. MR. TODD: What conditions obtain in the Missouri River that do not obtain in the Illinois River?

A. There are various conditions. The volume of water in the Missouri River is generally larger. The course that the Missouri river takes is one of a great many bends and 2465 curves, much more so than the Illinois River does. The quantity of suspended matter as found by the analyses of the waters from the two rivers is much larger in the Missouri River than it is in the Illinois River. There are, as I have already said, enormous accessions of soil swept along the course of the river from the shores of the river into the Missouri River. This is not the case in the Illinois River.

Q. What effect has suspended matter in water upon the purification of sewage pollution?

A. That depends very much upon the character of the suspened matter.

Q. Does clay in suspension act as a purifier?

A. Heavy sediments of clay will produce at such points along the river where the velocity is slow along the shores of the river and not in the channel, will produce—particularly if there are many bends and curves, considerable sedimentation along the banks. The Missouri River is a river that is very poorly regulated; it is a river whose banks often over-flow.

Q. What do you mean by poorly regulated, doctor?

A. Well, I mean by the Government; it is a river that is practically being abandoned, and there is considerable overflow at times of high water and this overflow will cover vast areas of land sometimes.

Q. Does that help the purification?

A. Yes sir, it does.

2466 Q. In what way?

A. Because sedimentation according to the accepted axiom of modern science will assist materially in purification.

Q. What is the area of the land overflowed by the Missouri River that you take into consideration as affecting this purification by the process of sedimentation?

A. I cannot give you any accurate data on that point.

Q. Can you approximate it?

A. No sir.

Q. Where, along the Missouri River do those conditions prevail?

A. They prevail from my own observation along the Missouri River between Kansas City and St. Louis.

Q. The entire course?

A. Well I haven't examined the entire course, but at such points where I examined it I personally convinced myself of it.

Q. And to what extent, how far from the thread of the stream does the river overflow?

A. Well, that varies greatly.

Q. Well, approximately as you observe it?

A. I have seen at places along the route of the Missouri River, I have seen as much as 40 or 50 acres overflowed 2467 on one side of the stream.

Q. Have you ever seen as much as ten square miles overflowed?

A. Not to my recollection.

Q. Between Kansas City and St. Louis?

A. It might have been more than ten square miles that I have seen, but I couldn't say positively that it was that much.

Q. Well, how many acres do you think it was?

MR. JEFFRIES: Forty or fifty acres at many places.

MR. TODD: Forty or fifty acres that you saw overflowed, would that assist to any material extent in the purification of the Missouri River?

A. Since these conditions prevail all along the route between Kansas City and St. Louis, from information that I have I should think it would have a considerable effect.

Q. Do you consider that a great effect in the purification of the Missouri River—these sedimentation beds operated by the overflow of the banks?

A. Yes sir.

Q. In what way doctor, does that obtain. Just describe how that is effected?

A. Simply that these periods of rises, causes the water when it overflows like that on its banks, the velocity is reduced considerably. At some places these points of sedi- 2468 mentation are covered with water that stagnates for some time, and the natural processes of sedimentation there will drag down to the bottom of those sedimentation beds, a great deal of organic matter and this organic matter will undergo nitrifying processes of purification more rapidly because of nitrifying organisms, so-called bacteria, that perform this oxidation work in the soil.

Q. Is there anything that you regard as beneficial in the purification of the Missouri River in these overflow places for sedimentation?

A. I consider them beneficial.

Q. Is there anything else more beneficial for the purification of that stream than that?

A. There may be additional benefits from the general chemical character of that stream between Kansas City and St. Louis.

Q. Has it got a general chemical character peculiar to itself?

A. It has a character of great stability.

Q. Is that a chemical characteristic,—stability?

A. Yes I should define it as such.

Q. What do you mean by stability, doctor?

A. Stability, in contradistinction from instability, would
2469 be that the processes of purification have reached the
stage where the final product of the nitrifying cycle, that is, the oxidation of the free ammonia to nitrites, and nitrites to nitrates, has reached a stage so that it is largely completed, as is always evidenced in the Missouri River between those points that I have mentioned, by low nitrites, and uniformly low nitrites between Kansas City and St. Louis and comparatively high nitrates.

Q. Doctor, do you know how far below Sioux City, after the discharge of the sewage from Sioux City, the water becomes purified and potable?

A. No sir.

Q. Do you know how far below Omaha, and Council Bluffs the water becomes purified and potable after the sewage has been emptied into it?

MR. JEFFRIES: I object to all questions of that character for the reason that they are incompetent and irrelevant and have no bearing on the issues in the case.

MR. TODD: How far below Council Bluffs and Omaha, do the waters of the Missouri become purified and potable after the sewage is emptied into it at those places. Do you know?

A. As regards the point of purification; that question could not be answered.

Q. Why, doctor?

2470 A. Because the conditions are such in the river that while the water in the channel below Omaha might show certain chemical improvements after the sewage of Omaha has been discharged into the river, the water running along the shore line wouldn't show that to that extent.

Q. Why?

A. Because it is a well known fact that the sewage as it is discharged into the rivers, in most of the cities, is discharged on the shore, right from the shore. It flows along the shore where there is supposed to be a current of less velocity than the current in the channel, and this sewage may appear in this shore water, the shore current, whereas the channel current is entirely different water.

Q. It ultimately gets into the channel, doesn't it?

A. Until at high stages of the river when flood water comes down. It is a matter of course that the flood water will sweep out and push out the organic matter that has been in a more quiescent state along the shore and sweep it out into the channel and that will bring higher results again.

Q. Wouldn't the serpentine course of the Missouri River serve to get the sewage into the channel?

A. Well now, it has been demonstrated by careful investigation—

2471 Q. I want to know what you think, doctor, not anybody else.

A. Well, not necessarily, no sir.

Q. It would not?

A. No sir, my observations—

Q. Wouldn't that be purified twenty miles down from Omaha?

A. That would be impossible for me to say because of the facts that I have mentioned.

Q. What are they?

A. The conditions that the sewage may run along the shore current and take some time before flood water may sweep out the sewage and flush it into the channel. As long as that stream of flood water wouldn't come, the channel water may show an entirely different chemical character than the shore water.

Q. Well, if it remains along the shore, say for a week, wouldn't the process of purification take place?

A. That is hard to tell; it might take months.

Q. As a kind of septic tank?

A. It might take months.

Q. Months?

A. Yes sir.

Q. Wouldn't all the impurities be destroyed before a month?

A. No sir, not necessarily; it would depend upon the character of the sewage very much, that would be discharged 2472 into the river.

Q. If the sewage should be placed into the channel would it take any longer to purify it in the channel than it would along the shore on the banks?

A. Sometimes it would and sometimes it wouldn't. It depends upon the conditions.

Q. Why, and what conditions?

A. Because it would depend somewhat upon the character of the water and it would depend upon the velocity of the stream, and it would depend upon the character of the sewage being flushed from the shore into the channel.

Q. Well, assuming that the same condition of water exists in the channel as exists along the shore, and assuming that the same sewage that was placed along the shore was placed along the channel, would the fact that the sewage entering the channel serve to purify it any quicker?

A. It is not likely—

Q. Than it would along the shore?

A. It is not likely that such a condition would prevail.

Q. Assume that it does prevail.

A. All investigations show that it does not.

Q. What?

A. All investigations and researches by scientists show 2473 that such a condition does not prevail.

Q. We will assume that it did prevail.

A. Well, what then, if I may ask.

Q. Would the sewage purify quicker in the channel than it would along the shore?

A. No sir, it would not.

Q. And what are the conditions along the shore that prevents the purification of sewage, that do not exist in the channel?

A. I say that the conditions along the shore are usually, not always more favorable to a gradual purification of the sewage, than they are in the channel.

Q. Then, if the sewage of Omaha entered the channel in any way, it would take how long for it to purify?

A. That is a difficult matter to determine.

Q. Would it take thirty days?

A. I couldn't say.

Q. Well, if it takes thirty days along the shore, and the conditions along the shore are more favorable for its purification than in the channel, it would take longer in the channel wouldn't it, than it would along the shore?

A. I couldn't say.

Q. Why, doctor?

2474 A. Because there are so many conditions to be considered that I cannot determine that point.

Q. Well if the conditions were the same, wouldn't the sewage in the channel take longer than along the shore?

A. It would take longer for the sewage in the channel to purify than it would if it remained in a quiescent state on the overflowed banks along the shore.

Q. What conditions exist in the channel of the Missouri River that would facilitate the purification of the sewage?

A. The conditions in the channel of the Missouri River are such that usually when the sewage of the cities is flushed into it into the channel, that it has previously undergone a certain stage of preliminary purification along the shores in the sediment of the banks which are overflowed at those points in this poorly regulated river.

Q. Do you know that as a fact, doctor, or as a theory?

A. Well, the general character of the river proves that.

Q. Do you know that statement to be a fact or a theory?

A. That conclusion is justifiable from the chemical character.

Q. I didn't ask you about whether the conclusion was justifiable or not. Do you personally know that statement to be a fact or theory, of your own knowledge?

A. I have a right to assume it as a fact.

2475 Q. You can answer it as many times as you want to, but you are going to answer that question if it takes all afternoon. *Do you know of your own knowledge* whether that statement is a fact or a theory?

A. That is from my own knowledge, from a careful study of conditions.

Q. Is it a fact or is it a theory?

A. I consider it a fact.

Q. Do you know that it is a fact?

A. I have a right to take it for a fact from the investigation.

MR. TODD: I move to strike out all his reasons that are not responsive to the question.

Q. Do you know that as a fact or a theory?

A. My experience justifies me in saying that I do know.

MR. TODD: I move to strike out the answer as not responsive.

Q. Do you know of your own knowledge?

A. As I said, I do know.

Q. That it is a fact or a theory?

A. As I said I do know that it is a fact.

Q. What are the places along the Missouri River at Kansas City or Council Bluffs, that you have personally investigated to accertain that fact?

2476 A. The analytical data would suffice.

Q. I didn't ask you about the data. I asked you about the place, the locality.

A. I have obtained it from the analytical data from those points.

Q. Were you ever on the ground, doctor?

A. Yes sir.

Q. Did you see the sewage of the city?

A. At what points do you ask me, where from?

Q. Have you seen the sewage of Omaha and Council Bluffs when it entered the Missouri?

A. No sir.

Q. Then can you state at that point that it is a fact or a theory?

A. At that point I could state it is a theory.

Q. At Kansas City, have you witnessed the sewage as it empties in the Missouri River?

A. I have been in Kansas City and investigated the conditions there, but I haven't seen the sewers myself, no sir.

Q. Well, then is it a fact or a theory as pertaining to Kansas City?

A. It is a theory justifiable from analytical data obtained.

MR. TODD: I move to strike out the latter part of the 2477 answer as not responsive.

MR. JEFFRIES: The witness has a right to explain when he answers in a passing way.

MR. TODD: I don't deny his right to explain. I simply want to reserve my rights in the record.

Q. As to Kansas City, have you any personal knowledge based upon observation as to how the sewage enters the Missouri River?

A. No sir.

Q. Now don't you see by answering "No" how easy we get along. As to Leavenworth, Kansas and St. Joseph, have you any personal knowledge as to how the sewage enters the Missouri?

A. No sir.

Q. Now what place along the Missouri River have you any personal knowledge as to how the sewage enters the river?

A. I haven't seen those sewer outlets with my own eyes.

Q. Then the statement that you made in regard to how the sewage enters the river and remains along the banks instead of entering the channel is a theory and not a fact personally known to you?

A. If you define it as personally known to me, I say that it is a theory.

2478 Q. Now if the theory, instead of being that the sewage was along the bank, should be a theory that the sewage enters the channel, how long would it take that sewage to become purified?

A. That again would be difficult to answer because it would depend upon the various conditions and the various circumstances that would have to be taken into consideration.

Q. What conditions and what circumstances would you take into consideration in order to answer that question scientifically?

A. First of all, the character of the sewage, the character of the manufacturing refuse going into the sewage—

Q. What do you mean by the character of the sewage?

A. The character, because the sewage may vary very much.

Q.. What do you mean by the character of the sewage?

A. Well I mean different characters. There are all kinds of material in the sewage, that justify and lead to the distinction of sewage of various kinds.

Q. What are the different kinds of sewage?

A. There is the sewage of fecal discharges; there is the sewage from the manufacturing establishments, from factories and slaughterhouses, from gas works, which is all discharged in that way and embodied in sewage. There are the washings from the kitchen, there is the dirt and dust in the street
2479 that is swept into the sewers by street sprinkling, or heavy
rainfalls, etc., that will give a varying character to the sewage constantly.

Q. Well, the character of sewage such as you find would obtain at Kansas City, Missouri, wouldn't it?

A. Well, I presume that the conditions would differ somewhat there.

Q. In what respects?

A. Well, because they are different cities.

Q. The fecal discharge would be the same, wouldn't it?

A. Well, I don't think it would.

Q. In what way would it differ from other cities?

A. Because much or a considerable percentage of the sewage of Kansas City don't go into the sewers at all.

Q. How about Omaha?

A. At Omaha again it depends upon how much sewage goes into the sewers.

Q. Well whether it is much or little, it has the same characteristics, hasn't it?

A. Well, it may if the same conditions prevail in both cities.

Q. What do you mean by the same conditions, doctor?

A. Well, one city may have a great many more slaughter houses, a great many more manufacturing establishments

2480 of one kind than the other. One city may have thousands of cess-pools and the other city may not, where the sewage is detained.

Q. But that relates to quantity, not to quality, doesn't it?

A. Well, but the quantity has a great deal to do with the effect that the sewage pollution will have on the water of the river.

Q. Well, assume that the quantity of one city is of a given amount, take Omaha and Council Bluffs, and that sewage is poured into the channel. How long would it take that sewage to purify itself in the channel?

A. That is very difficult to say.

Q. Have you any opinion upon it based upon scientific data?

A. Not as regards the city of Omaha.

Q. Have you any opinion in regard to Kansas City based upon scientific data?

A. No sir.

Q. Have you in regard to St. Joseph or Leavenworth, based upon scientific data?

A. No sir.

Q. Have you any opinion in regard to any of the cities located upon the Missouri River based upon scientific information?

2481 A. Well, what kind of information?

Q. As to how long it will require sewage to be purified that is emptied into the channel?

A. No, sir.

Q. And can you give any reason why this sewage becomes purified and the water rendered potable when it gets to Bellefontaine?

A. Yes, I have a reason why the water at the point of Bellefontaine is potable, based upon investigations I made of the Missouri River.

Q. What are those reasons, doctor?

MR. JEFFRIES: I object to the question because it is a repetition.

A. The great length of the river, its many curves and bends, its many sedimentation beds along its course, and the long time water takes to flow all this distance from Kansas City.

Q. What length of time, doctor?

A. According to the volume of water and the stages of the river.

Q. Give us some approximate idea in days?

A. There would have to be made a distinction between the velocity of the channel of the river, near the channel, and the velocity along the shores where the water frequently is
2482 impeded by flowing over the banks, and it almost stagnates, and that water requires flood water from the upper valley to flush it out and send it down the river.

Q. What is the distance from Omaha and Council Bluffs to Kansas City?

A. From Omaha and Council Bluffs by river?

Q. In going from Council Bluffs to Kansas City?

A. I have the data right here, I can tell you in a moment.

Q. I would like to have that in the record.

A. The distance from St. Louis to Omaha by the water line of the Missouri River is 676 miles; from St. Louis to Omaha.

Q. How much to Kansas City doctor?

A. From St. Louis to Kansas City it is 403 miles.

Q. How far is it from Omaha to Kansas City?

A. The distance from St. Louis to Omaha being 676 miles, and the distance from St. Louis to Kansas City being 403 miles, would make the distance 273 miles between Omaha and Kansas City.

Q. What is the character of the sewage, doctor, that empties into the Missouri River at Kansas City?

A. The character of the sewage entering the Missouri River at Kansas City is that of the city, a sewage very high in percentage of refuse matter from slaughterhouses and rendering establishments, and it contains 60 per cent. of the
2483 sewage of Kansas City as discharged into the river. This sewage of course includes the fecal matter—it includes

all the dirt in the streets as swept into the sewers from rainfall or from street sprinkling.

Q. How about the slaughterhouses, doctor?

A. I say that the high percentage comes from the slaughterhouses.

Q. How many slaughterhouses are there in Kansas City?

A. That I don't know. There are a very large number.

Q. It is a vast amount of sewage, isn't it, that enters the river at Kansas City from slaughterhouses and other manufactories?

A. There is considerable sewage entering from that source, yes, sir.

Q. What is the character of that sewage as to bacteria?

A. That I am not prepared to state. I could not say so.

Q. Is the refuse of the slaughterhouses more pregnant with bacteria than the fecal discharge?

A. From a general standpoint, I think not.

Q. Does that sewage from Kansas City purify itself in the Missouri in going 400 miles?

MR. JEFFRIES: I object to the question because it is immaterial and irrelevant.

2484 A. The chemical analyses of samples of water taken at Fort Bellefontaine show that whatever water pollution—

Q. Can you answer that, yes or no, doctor?

A. I am answering it, but it requires an explanation.

Q. Answer it first and explain afterwards?

Q. (Question repeated.)

A. Whenever sewage pollution has taken place from the sewage of Kansas City, that sewage pollution has to such an extent disappeared that when the water reaches Fort Bellefontaine, after a run of 403 miles, that water is potable at Fort Bellefontaine.

Q. What is the velocity of the waters of the Missouri, the main velocity between Kansas City and St. Louis?

A. Well, I couldn't tell you what the amount of the velocity is; I haven't got the data with me.

Q. Is the current in the Missouri River swifter than the current in the Illinois?

A. That depends upon the river stage, the volume of water.

Q. Well, at a normal stage?

MR. JEFFRIES: I object because it is immaterial.

THE WITNESS: At a normal stage the water in the channel?

Q. MR. TODD: I mean the normal stage in the Missouri and the normal stage in the Illinois.

A. Well, it is my opinion that it is slightly swifter.

2485 Q. In what?

A. And on such occasions when the Missouri River is high, but when the Missouri River is low of course the current is sluggish and slow.

Q. But when the Missouri River is low and the Illinois River is low, how do the velocities of those two streams compare?

A. I think they would be about alike.

Q. Isn't it a fact, doctor, that the velocity of the current of the Missouri River is much swifter than that of the Illinois?

A. Well, at low stages I should think they would be more alike.

Q. I mean at similar stages?

A., At similar stages I think that the Missouri River is for a larger time higher, and that the velocity exceeds as I said already, that of the Illinois River, of the channel always of the channel, not the shore water.

Q. I am speaking of the channel of the Illinois and Missouri. How swift is the current in the channel of the Missouri River?

A. Do you mean the average?

Q. Yes, the average?

A. The average would be three miles, from three to
2486 three and one-half miles.

Q. Per hour?

A. Yes, sir.

Q. What is the average current in the Illinois River?

A. Well, that depends very much upon the back water at the mouth of the Illinois.

Q. Well, under normal conditions, under similar conditions with the Missouri?

A. There are times when the upper Mississippi River is very high, and the volume of water coming down is so large that the velocity of the current in the Illinois River for more than 50 miles upward is greatly impeded, so that it is almost difficult to form an average there.

Q. For how long a period does that exist?

A. It may be.two miles and it may be more.

Q. I mean in time; how much time during the year does that condition exist in the Illinois?

A. Well—

Q. Approximately, six months in the year?

A. I couldn't tell you.

Q. Three months?

A. I haven't made any measurements of the Illinois River.

Q. Well, what is the velocity of the current of the Illinois
2487 River?

A. Well, I have been at times on the Illinois River, when the current was one mile; and then again when it was declared to be two miles an hour, but not from my own measurements or investigation.

Q. Do you know of it ever being over two miles an hour?

MR. JEFFRIES: I object, because the witness has already said he didn't know.

A. I think so.

Q. MR. TODD: How much faster than two miles an hour have you known the current to be?

A. Well, at times, at high water, I have known that it was three miles an hour.

Q. In times of high water in the Missouri how fast is the current?

A. The current can go up at high water, to three and a half miles and possibly four miles.

Q. Four miles an hour?

A. Yes, sir.

Q. When the current in the Missouri is four miles an hour and the sewage of Kansas City entering into the Missouri river, will that sewage purify itself before it reaches St. Louis?

MR. JEFFRIES: I object to the question because it is immaterial and doesn't tend to prove any issue in the case

2488 and because it assumes a fact which has not been proven in the evidence.

A. It is hard to tell; it depends entirely upon the conditions.

Q. Will the sewage from slaughterhouses purify itself in running streams, purify itself in four days, doctor?

A. That is a question that would require a test to be made and investigations would have to be made to establish that.

Q. Have you made tests sufficient to answer that question?

A. No, sir.

Q. Then how can you state that the waters of the Missouri River all the time are potable, in view of the fact that when the current of the river is four miles an hour, and it is only 403 miles from Kansas City to St. Louis, which at that rate would be four days for the sewage to get from Kansas City to St. Louis that the water is potable?

A. I can only form the conclusion that the water is potable, from the chemical analyses performed upon the water taken from the Missouri River at Fort Bellefontaine, and the water was potable.

Q. Have you ever analyzed waters taken from the river at Bellefontaine when the current of the river was four miles an hour?

2489 A. Yes, sir; very likely.

Q. Have you?

A. Well, I have the data to find out on which days when samples were taken, such was the case, but I haven't got it at hand just now. I could ascertain that fact. Very likely that did occur because we analyzed samples taken from Fort Bellefontaine daily from January until October, 1900.

Q. Then, if your analytical data is correct, does it not justify the conclusion that the sewage would purify itself in running waters in four days?

A. Not as such.

Q. Why, doctor?

A. Because it all depends upon the varying conditions and the circumstances prevailing along the route of such river which must be considered in determining the question whether or not sewage running such a distance will purify itself.

Q. If your analytical data is correct, wouldn't it justify the conclusion that when the current of the river is four miles an hour that it will purify itself in running a distance of 403 miles?

A. My data wouldn't enable such a conclusion.

Q. Would your data enable you to draw any conclusion as to how long or how far it would require in order to purify its original stream?

2490 A. No, sir.

Q. It might be a less time than four days that the sewage would purify itself in running waters, might it not?

A. Not usually with the conditions as they prevail in the various rivers.

Q. In the Missouri River I am speaking about now?

A. I cannot draw the conclusion that sewage will purify itself in four days running.

Q. Why, doctor?

A. Because it cannot be ascertained whether it came down in four days.

Q. How long would it take water to come from Kansas City to St. Louis, running at the rate of four miles an hour?

A. I can only make an estimate of the current in the channel.

Q. Well, in the current?

A. The regular channel, how long it would take channel water to come down at that rate?

Q. That's what I mean?

A. Well, four days as you say.

Q. Now, if this sewage should get into the channel, is there any reason or any law known to you which would preclude that sewage from coming along with the rest of the channel water down the river to St. Louis?

A. If the quantity of sewage was very large when it
2491 would get into the channel, and the current very swift,
the chances are it would be carried a very long distance before having undergone sufficient oxidizing processes to call it potable.

Q. What quantity of sewage would you think would be necessary to carry it 400 miles in the channel?

A. Well, the sewage itself in being carried that far, if it is in the channel entirely, it will take much longer to purify it.

Q. Does the quantity of sewage in the channel have anything to do with its purification?

A. Yes, very much so.

Q. In what way, doctor?

A. Because the more sewage you discharge into the channel the more will that sewage prevail in the channel and the natural processes of purification will be so much slower. There is so much more material to decompose, to disintegrate, to disorganize, and to render soluble, and to prepare in the proper form and in the proper condition for the aerobic bacteria to finish the processes of purification.

Q. Well, now, if the sewage goes into the channel at Kansas City, in any large quantities from the slaughterhouses there, wouldn't it be completely destroyed by the time that it got to St. Louis, if it only took four days for it to go?

2492 A. It would depend very much upon the quantity of the sewage that would go into the river. It would depend upon the weather conditions, whether it was warm weather, that would facilitate the processes of oxidation, etc., and there would be a great many circumstances that would go into consideration to determine whether that sewage after running four days at four miles an hour would purify itself. It would depend very much upon the various circumstances.

MR. JEFFRIES: I move to strike out all the testimony in reference to the water in the Missouri River, which has been introduced for the reason that it is immaterial and has no bearing upon the issues in the case, and I move to strike it out for all purposes except as to the effect it might have upon the competency of the witness.

MR. TODD: What character of sewage will purify itself most rapidly, slaughterhouse sewage, that is the refuse from slaughterhouses, or what is known as household sewage?

A. Household sewage varies.

Q. I mean—

A. If you mean fecal matter—

Q. Yes, fecal matter.

A. You mean fecal matter?

Q. Yes, and the urine?

2493 A. The slaughterhouses refuse is more apt to deposit itself and disappear in the sludge at the bottom of the river. The fecal matter, however, is more apt to remain in the floating part of the water, and then the fecal matter, I mean principally the fecal matter in solution, that is the urine, which forms a very large component part of this matter; that of course being in solution would show a different character than the refuse from slaughterhouses.

Q. Now, doctor, returning to the original question, which one will purify or oxidize more quickly, that from the slaughterhouse or from the household, including fecal discharge?

A. That is difficult to determine, which will purify itself quicker.

Q. Which would oxidize and disappear?

A. I couldn't tell you.

Q. Haven't you, as a chemist, given that question any consideration?

A. I have endeavored to obtain all the information I could possibly get on that subject.

Q. I am not asking you what other people have told you. I cannot cross-examine those other gentlemen you are talking about. I have got to address myself to you, doctor?

A. Yes, sir.

Q. Have you, Dr. Teichmann, investigated that phase 2494 of the question so as to be able to give a scientific answer?

A. I haven't made any special researches to determine whether the fecal matter or slaughter sewage will be decomposed more rapidly.

Q. What are the principal constituents of slaughterhouse sewage?

MR. JEFFRIES: If you know?

A. Well, such refuse—

MR. TODD: Well, do you know, doctor?

A. Yes, sir.

Q. What are they?

A. Such refuse as are usually thrown away.

Q. Well, chemically speaking?

A. Well, organic matter.

Q. What kind of matter?

A. Organic matter of animal origin.

Q. Well, how are they chemically spoken of, doctor?

A. Well, they are compounds, composed of carbon, nitrogen, hydrogen and oxygen.

Q. Well, aren't all elements nearly composed of carbon, oxygen, hydrogen and nitrogen?

A. Those are the elements, yes, sir.

Q. Isn't nearly everything in nature composed of one or more of those elements?

A. They are very abundant in nature.

2495 Q. I was taught that in chemistry?

A. Yes, they are very abundant in nature.

Q. Now, is that the best answer that you can give to my question as a scientific man, that the chemical characteristics of the sewage of slaughterhouses are composed of hydrogen, nitrogen, oxygen and carbon?

A. Compounds principally.

Q. What compounds?

A. Well, what we call organic compounds.

Q. Well, the organic compounds are divided into what?

A. Into innumerable classes.

Q. Name them—you needn't scare us now, we can stand a little more of it. Just give me the names.

A. Well, say albuminous compounds.

Q. What other compounds?

A. Well, various others.

Q. Well, can you name them?

A. Then other elements would come into consideration.

Q. Let us stick to the compounds, doctor, just name them.

A. I think albuminous compounds cover them principally.

Q. Is that the best answer you can give to the question?

A. Yes, sir.

Q. What are the chief things in household sewage?

2496 A. Now, do you mean simply the washings from the sinks?

Q. The chemical constituents?

A. Or do you mean the fecal matter?

Q. Everything—all?

A. Well, various compounds of organic character.

Q. What are they, doctor? Just name them?

A. Well, the urine—

Q. Well, let us take the urine, what are the chemical compounds of the urine?

A. There are a great many compounds represented in urine.

Q. Well, what are they?

A. Well, sodium chloride is one.

Q. Well, what are the others?

A. There are several others.

Q. Just name them?

A. Uric acid, urea.

Q. What others?

A. There are several other organic compounds.

Q. Can you recall them now?

A. You might include some other salts that appear in the urine sometimes.

Q. Is that all that you can name?

A. Well, I think it is sufficient.

Q. Well, what are in the feces?

2497 A. The feces are also composed of organic compounds principally.

Q. What are they?

A. Formed from the elements that I have already mentioned, carbon, nitrogen, hydrogen and oxygen, together with other compounds represented and coming from other elements.

Q. To be specific, what chemical elements or compounds are in the feces different from those four compounds of nitrogen, hydrogen, oxygen and carbon?

THE WITNESS: Now, Mr. Todd, I have anwsered a great many of these questions and I have passed an examination on the elementary principles of chemistry, when I graduated from the university. As I testified, I have been an instructor of chemistry in a medical college of St. Louis. I am supposed to know a great many things that are necesary for any man, a chemist, to pass an examinaton, and to furthermore act as an instructor. I think that after having answered questions like that officially, that I am entitled to the privilege of refusing to answer further questions that I have answered a long time ago when I qualified myself as a chemist.

Q. Doctor, in the question that I asked you that you object to answering, all you have to say is, "I decline to answer." And there will be no argument between us. You understand I
2498 mean no discourtesy by the questions that I ask you. I
have in view questions that I want to ask you. I ask you these questions for the purpose of basing the other questions which I have in view to ask you.

THE WITNESS: I understand your motive as not at all being personal; but when I am asked questions, "What are the chemical constituents of urine," and I answer that question, and it goes on, "What are the chemical constituents of feces and such things," it is practically interrogating me on knowledge that every chemist ought to possess. It is fundamental knowledge. I think I will have to be excused from answering that question. I have given my reasons.

Q. Mr. TODD: The Supreme Court takes no judicial notice of chemistry or the chemical constituents of feces, except as testified to under oath by a competent chemist, and I want to get this in the record.

Q. Is it not a fact that the most important element that enters into this investigation is the feces and urine of animal or man?

MR. JEFFRIES: I object because it is an argument with the witness. You can ask him all the questions you please, but when you ask him as to his judgment upon this litigation, it is arguing the question with him.

2499 Q. MR. TODD: Is it not a fact that in the contamination of streams the most important elements entering into the question of pollution are the elements which are known as feces, or urine of man or animal?

A. I have answered that question, in so far as stating what the number of elements are that form the compounds that causes that.

Q. You don't get my question.

A. What is called the formation of feces. That ought to be sufficient.

MR. TODD: I object to the witness passing upon the competency of my question.

Q. (Question repeated.)

A. Yes, I have answered that question.

Q. Now, what are the chief compounds in feces? Answer that?

A. Now, I will answer that in one general answer—carbonaceous and nitrogenous compounds.

Q. Are those general compounds divided into individual compounds?

A. They are represented by a number of organic compounds, yes.

Q. What are those compuonds?

A. The chief compounds are carbonaceous and nitrogenous compounds.

2500 Q. I mean, doctor, have they any other name?

A. Of various kinds. It shouldn't be necessary to answer a question in detail as if—

Q. What are the names of those compounds?

A. Now, as I said before, when I answered the previous question—

MR. JEFFRIES: Go ahead and answer that question.

A. I refuse to answer that question.

THE COMMISSIONER: Doctor, the Commissioner cannot compel you to answer, but there are processes by which you could be compelled to answer. It is a fair question. It will be better for you to answer it.

A. I have already answered that question intelligently, and that ought to be sufficient.

MR. TODD: Do you want to pass upon the questions that are asked you as to whether you will answer them or not, doctor?

MR. JEFFRIES: That is an objectionable question, and I will permit him to answer without objection.

A. I will refuse to answer the question, as I said before.

MR. TODD: Do you refuse to answer any further questions in regard to the component elements or chemical elements of feces?

A. No, when they are embodied in general terms sufficient to answer questions, I shall not refuse.

2501 Q. Do you refuse to answer the questions that pertain particularly to the component elements?

A. I have mentioned the component elements represented by the compounds classed in the way I have mentioned.

Q. (Queston repeated.) Is that the only answer you will give to that quetsion, doctor?

A. Yes, sir.

Q. And you refuse to go into further details?

A. No, not exactly; it depends upon the nature of the question.

Q. The question is to name the important compounds in feces?

MR. JEFFRIES: As many as you can.

A. I named those.

Q. MR. TODD: And is the answer that you made, the only answer that can be made by a chemist to that question?

A. I consider that answer a sufficient reply to the query made.

Q. Have these compounds any names different from the names you have given?

A. Certainly.

Q. What are they?

MR. JEFFRIES: Name them.

A. No, I won't name them; I refuse.

Q. MR. TODD: You refuse to answer that question, do you?

2502 A. Because I have answered that question already.

Q. Is that the best answer you will give to that question and the only one?

A. Yes, sir.

Q. Doctor, from the known composition of slaughterhouse sewage and household sewage, which in your opinion will oxidize, or purify itself more rapidly?

A. It is difficult to determine.

Q. Have you any opinion upon the question?

A. No, sir.

Q. In your examination at Fort Bellefontaine, did you find albuminoid ammonia in the waters of the Missouri River?

A. Yes, sir.

Q. Was it high or low?

A. It varied considerably according to the data received.

Q. What was it mostly, high or low?

A. The albuminoid ammonia in comparison with the free ammonia was considerably high.

Q. What does that indicate, doctor?

A. That indicates contamination of organic matter.

Q. Does it indicate anything else?

A. That could only be determined by taking into consideration other chemical ingredients found in the water.

Q. Does it indicate anything of itself?

2503 A. That depends upon whether the albuminoid ammonia was found in suspension or solution.

Q. If in suspension, there was more than in solution, what does that indicate of itself?

A. If there was more in suspension than there was in solution, it would indicate organic matter due to the contamination of vegetable origin.

Q. Why not animal origin, doctor?

A. Because the organic contamination of animal origin is more represented in the albuminoid ammonia in solution.

Q. Why?

A. Because the organic matter of animal origin that is found in solution in the albuminoid ammonia will represent to a large extent the pollution of animal origin in soluble forms.

Q. If the albuminoid ammonia is in solution instead ot suspension to a high degree, what would that indicate?

A. Well, that will enable the conclusion that the origin ot the organic matter may be more from animal sources.

Q. In what condition would you find the albuminoid ammonia from the sewage of slaughterhouses, in suspension or solution?

A. Well in both, very likely.

Q. Which would prevail the more largely?

A. In suspension.

2504 Q. In what condition did you find the albuminoid ammonia in the Mississippi River at Bellefontaine?

A. You mean in the Missouri River?

Q. Yes, I mean in the Missouri River?

A. I found considerable high albuminoid ammonia.

Q. Was it in suspension or in solution?

A. Partly in suspension and partly in solution.

Q. Which more?

A. At times the albuminoid ammonia in suspension would be larger than the albuminoid ammonia in solution, and at other times the reverse would show.

Q. If that is true, how would you distinguish between the albuminoid ammonia of vegetable and animal origin?

A. The distinction could be made from that point of view, that the organic matter in suspension is very largely composed of such matter as is of vegetable origin.

WILLIAM C. TEICHMANN.

Adjourned until ten a. m., Wednesday, April 1, 1903.

2505 Southern Hotel, St. Louis, Missouri, 10:00 a.. m., Wednesday, April 1st, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

DR. WILLIAM C. TEICHMANN, resumed the stand for further cross-examination, by Mr. Todd, and testified as follows:

Q. Doctor, is the albuminoid ammonia found at Bellefontaine, Missouri, in solution or suspension?

A. It varies. For a larger part of the time the albuminoid ammonia in the water from that point appears to be in suspension and the smaller part in solution, but there are times when the albuminoid ammonia in suspension is less than the albuminoid ammonia in solution.

Q. What is albuminoid ammonia, doctor?

A. Now Mr. Todd, I would like to make a statement regarding—

Q. Just answer my question, doctor, and at the conclusion you may make any statement you desire.

A. I beg your pardon; what is the question?

Q. What is albuminoid ammonia?

2506 A. Albuminoid ammonia is the product of a distillation process with a chemical called potassium permanganate; it is the ammonia that is received as the distillate from the distillation of the sample of water with this chemical—potassium permanganate.

Q. What is the origin of albuminoid ammonia?

A. Organic matter.

Q. Is that organic matter from animal or vegetable origin?

A. It may be from animal and it may be from vegetable origin.

Q. When albuminoid ammonia is found in water, whether in suspension or in solution, is there any marked characteristic of the albuminoid ammonia so found that enables a chemist to determine whether it is from vegetable or from animal origin?

A. A number of responsible chemists endeavord—

Q. Well, just give me your opinion, doctor. I don't want the chemists; I can't cross-examine them.

A. Well, it is the custom to make a distinction there in the manner in which the ammonia distills over in the distillation apparatus, and in the amount of what we call oxygen consumed found, that is, organic matter estimated by the so-called Kugel oxygen consumed process.

Q. I will put the question in another way, doctor. Is albuminoid ammonia which is derived from animal origin
2507 identical with the albuminoid ammonia which is derived
from vegetable origin?

A. Well, since what we call albuminoid ammonia is a product of distillation, the distillate itself would not enable a distinction unless other points are considered in determining whether it may be of vegetable or animal origin.

Q. Then albuminoid ammonia derived from vegetable is the same ammonia that is derived from animal?

A. Well, as a product of the distillation it is the same.

Q. There are no identifying characteristics of albuminoid ammonia when it is found, that will enable the chemist to say whether that ammonia came from vegetable or animal origin, is there?

A. Not if he bases his opinion solely on the product of distillation.

Q. I am talking about albuminoid ammonia, now as such.

A. Yes sir.

Q. Distinct from everything else.

A. Now, Mr. Todd, I would like to make a statement regarding my refusal yesterday to answer a question—

MR. TODD: I submit that the proper time for that is on rebuttal.

THE WITNESS: (Continuing) I was under a mental strain at that time and had become very nervous owing to

2508 two days cross-examination and somewhat irritated, and therefore refused to answer a question. I realize that the question was justifiable since it was connected with fundamental principles involved in this investigation and litigation, so that I wish to say that I have reconsidered my refusal and am willing to answer that question as it is my duty to do so.

Q. Now, doctor, when you find albuminoid ammonia in water, the albuminoid ammonia may be attributable to vegetable or animal matter origin?

A. Yes sir.

Q. And is there anything in the albuminoid ammonia itself that will enable the chemist to ascertain whether it came from animal or vegetable origin?

A. No sir, not in the analytical product, itself.

Q. In the Missouri River you found albuminoid ammonia in solution and in suspension?

A. Yes sir.

Q. In different degrees?

A. Yes sir.

Q. When albuminoid ammonia is found in suspension, does that indicate whether it is of animal or vegetable origin?

A. Well, that could not be determined from the analytical product itself.

2509 Q. If albuminoid ammonia was in solution, would that indicate whether it was from vegetable or animal origin?

A. Not if determined as found from the analytical product itself.

Q. When you find albuminoid ammonia in solution and in suspension, does that indicate whether the albuminoid ammonia is from animal or vegetable origin?

A. Not if viewed from the analytical product itself.

Q. In the process of purification albuminoid ammonia, whether in suspension or solution, changes to free ammonia does it not?

A. Well, what we call free ammonia there, is also the analytical product received from the distillation process, without the addition of the permanganate solution; when we add permanganate solution to the water and distill it, then we get albuminoid ammonia, so they just classify two kinds of ammonia,—we call the first free ammonia, but it is not free ammonia as such.

Q. Well, albuminoid ammonia is nothing more than albuminoid substances found in the water, is it not?

A. Well, it is supposed to represent what is in the water as organic matter either of vegetable or animal origin.

Q. Known as albumen?

A. Yes sir.

Q. Or related to it?

2510 A. Yes sir.

Q. Then when this albumen which we denominate albuminoid ammonia becomes disintegrated by bacteria, or oxidation, it gives what is known as free ammonia, does it not?

A. Yes—well, carbonate of ammonia, by the action of the bacteria in the water, carbonate or chloride of ammonia is supposed to be formed there.

Q. But the basis of the free ammonia is the albuminoid ammonia or the albumen in the water?

A. Yes sir.

Q. Then when the free ammonia by similar process of oxidation or bacteria, is broken up, it results in what is known as nitrites?

A. Yes sir.

Q. And the nitrites by a similar process, change into what is known as nitrates?

A. The final product of the cycle of nitrification.

Q. Nitrates?

A. Yes sir.

Q. So that in the beginning is what is known as albuminoid ammonia or albumen in the process of fermentation or purification?

A. Yes, probably carbonate of ammonia and chloride of ammonia, but including of course these albuminous compounds.

2511 Q. Now albuminoid ammonia is present in the sewage from slaughter-houses and fecal discharges from man and animal, is it not?

A. Yes sir.

Q. It is also found in the decomposition of vegetable matter?

A. Yes sir.

Q. It manifests itself—pollution from vegetable or animal matter manifests itself in water in what is known as albuminoid ammonia?

A. That is—well it manifests itself in the analysis of the water as albuminoid ammonia, yes sir, representing that organic matter.

Q. Albuminoid ammonia evidences the presence of vegetable or animal pollution?

A. Yes sir.

Q. Albuminoid ammonia appears in suspension or in solution in waters does it not?

A. Yes sir.

Q. When it appears in suspension what does that indicate, vegetable or animal origin?

A. Well since most of the albuminoid ammonia of animal origin is generally supposed to be contained in solution the conclusion is drawn that much of the vegetable organic
2512 matter in the waters being insoluble, this latter would be represented in the suspended matter, and the general conclusion is that in suspended matter, when there is high suspended matter present, that this suspended matter is largely of a vegetable character, but not altogether. There may also be a solid matter of animal origin in that water and found in suspension.

Q. Doctor, as a chemist, do you enunciate that as a principle, of chemistry, which you yourself, by your analytical investigations have established,—that albuminoid ammonias in suspension indicate vegetable origin and albuminoid ammonias in solution indicate animal origin?

A. I said that they may be present in both; not altogether, in one.

Q. If they are present in each class, suspension or solution, how are you able to differentiate between albuminoid ammonia which is of vegetable origin and the albuminoid ammonia which is of animal origin?

A. Because I take into consideration the oxygen consumed results, the oxygen consumed results enable in a measure an opinion as to the vegetable or animal origin, or whether the vegetable or animal matter prevails in that albuminoid ammonia.

Q. Doctor, is chemistry an exact science

A. It is supposed to ascertain facts only, and therefore is an exact science.

2513 Q. It is generally accepted among scholars as an exact science, is it not?

A. Yes sir.

Q. Almost on a par with mathematics, in its exactness?

A. Yes sir.

Q. Is there anything in chemistry and has there been an established principle that albuminoid ammonia when found in suspension or in solution in running waters, that it can be accurately and definitely ascertained whether that albuminoid ammonia originates from animal or vegetable origin?

A. Some of the greatest authorities are willing to draw conclusions by comparing the albuminoid ammonia results analytically, and the oxygen consumed results analytically, are willing to form conclusions—general conclusions, as to the prevailing character of that albuminoid ammonia, whether it is of animal or vegetable origin. Such authorities as Leffman, for instance, Leffman and Beam, and Professor Drown, in a measure, lay a certain stress on this distinction to be made in judging whether it is of vegetable or animal origin.

Q. Does he hold that albuminoid ammonia of vegetable origin is found in suspension rather than in solution?

A. Leffman and Beam hold that when certain observations are made as to the way in which the ammonia distills over from the original flask in which the water is contained,
2514 into the tubes, that when this ammonia organic matter
comes over—I mean organic matter is found to be high, according to the oxygen consumed process of the Kulel method by which organic matter is determined, that would indicate vegetable origin. If the organic matter however, as ascertained by oxygen consumed power, is low, with the high albuminoid ammonia, he ventures to say that it indicates animal origin.

Q. By indicating, do you mean demonstrating?

A. Yes, I construe that—

Q. Is it a chemical demonstration?

A. Yes sir, according to his own statement in his book on "Examination of Waters."

Q. Do you as a chemist enunciate the principle that albuminoid ammonia in suspension demonstrates the vegetable origin of the albuminoid ammonia?

A. Not if viewed from the analytical product of the albuminoid ammonia in the distillation process itself. Only by comparing the results with those obtained from the oxygen consumed test as Professor Leffman advises in his book, in which he draws these conclusions.

Q. (Question repeated)?

A. As I said, not if viewed from the sole analytical product of albuminoid ammonia as received by distillation.
2515 Only, I said, could we look for vegetable origin in the oxygen consumed power as obtained by the so-called Kulel oxygen consumed process by comparing the results, could we look for vegetable origin there, if the results justified it.

Q. Then albuminoid ammonia in suspension does not demonstrate whether it is of vegetable or animal origin in itself, does it?

A. Not if you take the albuminoid ammonia analytically, the result by itself.

Q. By itself?

A. You could not tell, no sir.

Q. And does the albuminoid ammonia in solution demonstrate its animal or vegetable origin?

A. In a measure only, if the general analytical result and the oxygen consumed results are taken into consideration. It is by comparing the general analytical results, estimation of other characteristic ingredients of sewage, that one would be justified in drawing a definite conclusion.

Q. Are not the vegetable substances mostly in solution?

A. Well, that cannot be determined. There are vegetable matters in solution and vegetable matters in suspension; vegetable matters that are indissoluble in water, that will remain in this suspended matter accordingly; whereas, there are
2516 other vegetable matters that may by chemical process be partly converted into soluble compounds which would be represented in the ammonia in solution.

Q. What are the substances of vegetable origin which yield albuminoid ammonia?

A. Well, there are multitudes—plants, leaves from the trees, wood. The plants that are connected with the soil that is washed into the rivers.

Q. The chemical compounds, doctor, I mean, what are the chemical compounds?

A. The chemical compounds, well, that depends upon the vegetable matter itself. There may be a great many of them. For instance the different vegetable plants, different vegetable growths will all have different chemical constituents.

Q. Does albuminoid ammonia from animal origin appear in solution and in suspension in water?

A. Yes, it may.

Q. Does albuminoid ammonia from vegetable origin appear in suspension and in solution in water?

A. Yes sir.

Q. Now will you tell me how you can ascertain and differentiate the origin of albuminoid ammonia as to whether it is vegetable or animal origin when found in water in suspension or solution?

2517 A. As I said, professor Leffman—

Q. I would prefer doctor, to have Professor Teichman. I can't cross-examine Professor Leffman.

A. Well, I take the result of the distillation for albuminoid ammonia and I watch the distillation process in itself to notice whether the ammonia comes over rapidly or whether it comes over slowly. I then take the oxygen consumed results and see whether they are high or low as compared with the albuminoid ammonia results. If the albuminoid ammonia found is low—well, that in itself would show low albuminoid ammonias. If the albuminoid ammonia is high, and the oyygen consumed is low, that would indicate in accordance with the opinions of authorities that the conclusion is justified that the albuminoid ammonia is prevailingly—not altogether—but prevailingly of ammonia origin.

Q. Have you ever analyzed the waters of swamps?

A. Yes sir.

Q. Is the albuminoid ammonia high or low in the waters of swamps?

A. The albuminoid ammonia may be high.

Q. And if the albuminoid ammonia is high, what does it indicate?

A. It indicates pollution by organic matter.

2518 Q. Of vegetable or animal origin?

A. If the result of the analysis of that same water for oxygen consumed is taken into consideration and also the result obtained for nitrites and chlorines—if all the other results show low figures, and only the albuminoid ammonia figure shows high, the albuminoid ammonia can in such a case be ascribed to vegetable origin. Professor Drown, one of the leading authorities, enunciates that opinion in his famous report to the State Board of Health of Massachussets.

Q. Can you tell from the presence of nitrites whether the nitrites come from vegetable or animal origin?

A. I would only take the general results of the entire analysis and certain local conditions as they are prevailing at the point where the sample is taken. After considering all these circumstances, the nitrites would form part of the basis from which the conclusion may be drawn that this water may be of sewage origin.

Q. That is, if you knew independent of chemistry that the water was sewage contaminated from the sewage of man or animal, then the nitrites appearing there, you would draw the conclusion that they came from animal rather than vegetable origin, is that correct?

A. Yes sir.

2519 Q. If you didn't know the origin, but only had the nitrites to go upon, could you tell whether it was of vegetable or animal origin?

A. No sir, not if I took the nitrite results by themselves, I could not do it.

Q. It is impossible then to ascertain from nitrites per se, whether they come from vegetable or animal origin?

A. Yes sir, you are right there.

Q. In free ammonia, if you don't know the origin, is it possible to tell whether it comes from animal or vegetable origin?

A. That depends upon the general analytical results.

Q. Give me an example, doctor, wherein you can tell whether free ammonia comes from vegetable or from animal origin, in the absence of any knowledge outside of chemistry?

A. When the general analysis shows certain corresponding conditions, I will say high nitrites, and high chlorines—

Q. I am asking about free ammonia, doctor. I will get to that later.

A. (Continuing)—and high free ammonia, when those three go together, the general rule is to consider the pollution there of sewage origin. High nitrites, high chlorines, and high ammonias going together indicate sewage pollution.
2520 That is, it has been established as an axiom of sanitary science by the investigations conducted under Professor Down for the Massachusetts State Board of Health.

MR. TODD: I move to strike out the answer as not responsive, and ask to have the question read again.

MR. JEFFRIES: I think he gave you the example that you called for.

Q. (Question read).

MR. TODD: I withdraw my motion to strike out. I had another question in mind.

Q. Can you tell by the presence of free ammonia in itself, whether it is of animal or vegetable origin?

A. No sir.

Q. Can you tell of nitrites in itself, whether it is of vegetable or animal origin?

A. No sir.

Q. Can you tell of nitrates in itself, whether it comes from vegetable or animal origin?

A. No sir.

Q. Nitrates come from nitrites?

A. Yes sir.

Q. Nitrites from free ammonia?

A. Yes sir.

2521 Q. Free ammonia from albuminoid ammonia?

A. Well, yes, you may consider it that in your interpretation.

Q. Then in order to ascertain whether the nitrites, nitrates and free ammonias are of vegetable or animal origin, you must ascertain first as to whether or not the albuminoid ammonia is of vegetable or animal origin, mustn't you?

A. No sir, not if you take the nitrites and the chlorines and the free ammonias together, it is not necessary then to determine whether the albuminoid ammonia is of vegetable or animal origin.

Q. What does high chlorines in a river indicate, doctor?

A. High chlorines in a river by themselves, you mean?

Q. Yes.

A. They may indicate sewage pollution and they may indicate the passing of the river through a deposit of salt in the geological structure.

Q. So that it is uncertain, is it not, what it indicates?

A. Yes sir for chlorines alone.

Q. Chlorines alone?

A. Yes sir.

Q. Chlorine is the only element entering into water from sewage that does not change its form, is it not?

A. Well there are constantly chemical changes going on; 2522 salts are being formed in the rivers.

Q. I know, but chlorine does not ever loop into something else like nitrites into nitrates, does it?

A. No, not in that form, because the chlorine there is supposed to be present in the form of sodium chloride and that is a salt in itself, which is fixed.

Q. Fixed?

A. Yes sir.

Q. Now in Kansas City there is a great amount of sodium chloride going into the Missouri River, isn't there?

A. Yes sir.

Q. There is a great amount at Council Bluffs and Omaha, and Leavenworth, Kansas, and all the towns that empty their sewage into the Missouri River, this sodium chloride is coming into the river from the sewage, is it not?

A. Well, I would make a distinction there, between high chlorines coming from the Kaw River or the Kansas River—

Q. I understand that.

MR. WOERNER: Wait a minute. Just finish your sentence.

A. (Continuing) You see I distinguish there between the chlorines found in the Missouri River above Kansas City, and above the junction of the Kansas, or Kaw River with the Missouri and the chlorines below.

MR. TODD: I move to strike out the answer, and ask to
2523 have the original question read.

Q. My question, doctor, is this. Does the sewage from all the cities upon the Missouri River entering into the Missouri River carry with it sodium chlorides?

A. Yes sir.

Q. That is the point I make.

A. Yes, they do.

Q. And in addition to that you have testified about the Kaw River?

A. Yes sir.

Q. Can you as a chemist, distinguish the sodium chloride which comes from sewage from the sodium chloride which comes from the salt beds of the Kaw River as you have testified?

A. No sir, not chemically, no sir.

Q. Did you take into consideration in drawing your conclusions as to the conditions of the Missouri River, as to its potability, the sodium chloride which entered that river from the sewage of all the cities along it?

A. In a measure, yes.

Q. In what measure, doctor?

A. Well, there is a certain amount of chlorine found in the Missouri River above the mouth of the Kaw River, that is true the analyses show that, and also a certain amount of chlorine is found in the Missouri River after the Kaw River emp-
2524 ties into the Missouri River.

Q. And when it got to Bellefontaine, were you able to state what percentage of the chlorine which you there found, came from sewage, and what percentage came from the Kaw River?

A. No sir.

Q. Whether the percentage from the sewage was larger than the percentage that came from the Kaw, are you able to ascertain chemically?

A. No sir.

Q. So that the presence of chlorine which you discovered by your analyses in the waters at Bellefontaine, you cannot state whether the greater proportion came from sewage or not, can you?

A. The conclusion is justified there that since the chlorines are uniformly—the average chlorines uniformly higher between Kansas City and Bellefontaine, than they are between Omaha and Kansas City, the conclusion is justifiable that since as much as 100 parts per million or five and six times as much chlorine is found in the Kaw River, that the Kaw River certainly is responsible for the high chlorines prevailing between Kansas City and Bellefontaine as compared with the chlorines between Omaha and Kansas City.

Q. Where does the Kaw River enter the Missouri River, 2525 above or below Kansas City?

A. It is practically between Kansas City, Missouri and Kansas City, Kansas. It enters the Missouri River above Kansas City, Missouri.

Q. What is the size of the Kaw River, doctor?

A. Well, I could not tell you.

Q. What is the volume of water?

A. I have no data at hand just now.

Q. Compared to the waters of the Missouri?

A. I have no data at hand just now to answer that.

Q. Have you ever had any data at hand?

A. No sir.

Q. Then if the size of the Kaw River was smaller than the Missouri River in comparison with the Missouri River, would not the high chlorines in the Kaw River go down when it reached the Missouri?

A. Yes sir, it would—they would.

Q. Wouldn't it have but little effect upon the Missouri if the Kaw River was comparatively a small creek or stream?

MR. WOERNER: In what respect?

MR. TODD: In comparison with the Missouri River.

MR. WOERNER: You mean as to chlorines?

MR. TODD: As to chlorines?

A. The analyses that I have made of the Kaw River and 2526 the Missouri River at the same time show a remarkable reduction in the chlorines, as compared with the Missouri and the Kaw after the two rivers meet. That is the Kaw River chlorines showing 100 parts per million. The Missouri River, after the Kaw river discharges into the Missouri, the Missouri River may show not more than 24 parts per million of chlorine.

MR. WOERNER: And how much above the Kaw?

A. And above the Kaw it might show 16. That would show an increase in the chlorines of the Missouri River resulting evidently from the mixing of the two rivers.

Q. MR. TODD: How far below the entrance of the Kaw into the Missouri were your samples taken?

A. Now they were taken several miles below Kansas City, Missouri.

Q. Several miles below?

A. Several miles. I cannot think of the exact number just now. It is in the record.

Q. You had your samples taken in the Kaw River?

A. Yes sir

Q. The size and volume of the water in the Kaw River you don't know?

A. No sir.

Q. And never did know?

A. No sir.

2527 Q. Then the next place that you took samples was below Kansas City?

A. Yes sir.

Q. And you instituted a comparison between the Kaw River and that point below Kansas City, did you?

A. Yes sir.

Q. That point below Kansas City had received the sewage of Kansas City in addition to the volume of water from the Kaw River, had it not?

A. Yes sir.

Q. Did you take a sample above Kansas City?

A. Yes sir.

Q. In the Missouri River?

A. Yes sir.

Q. How far above Kansas City was the sample taken?

A. It was taken half a mile above the waterworks of Kansas City.

Q. How far is that from the Kaw River?

A. Well, that I cannot tell you exactly.

Q. Well, approximately, doctor?

A. I think it is several miles.

Q. In your opinion at that point above Kansas City, do you believe that the waters of the Kaw River had completely mixed with the waters of the Mississippi?

2528 A. You mean the Missouri?

Q. The Missouri.

A. Well, that I couldn't say because I haven't made any observation to that effect.

Q. Do you know whether the samples taken above Kansas City were taken nearer the shore where the Kaw river enters the Missouri River or in the channel or nearer the opposite bank?

A. The waters were collected by my collector and the orders were for him to collect all the samples, to take the samples from the channel.

Q. Do you know whether that was done?

A. Well, I think it was; I considered the collector reliable, and that he did so.

Q. Has there any evidence been introduced on the record on that point, doctor; I don't know I am asking for information.

A. I don't think that question has been asked the respective collectors, but the collector himself has testified that he collected the samples and where he collected them.

Q. Now doctor, if that sample was taken—The Kaw River enters the Missouri from the North shore, dosen't it?

A. The Kaw enters it coming from the west.

Q. If that sample was taken two or three miles below the Kaw River near the west shore of the Missouri River, it would be mostly Kaw River water, wouldn't it? 2529

A. Well, that would depend upon the volume of the Kaw River on those days as compared with the volume of the Missouri River.

Q. Would the Kaw River waters commingle completely with the Missouri River three miles below its entrance into the Missouri River at the point where the sample was taken?

A. That I couldn't tell. I haven't made any observations of that kind.

Q. Where was this sample taken between the mouth of the Kaw River and Kansas City, Missouri. I want to localize that place, doctor?

A. Well now the samples to my knowledge were collected only above Kansas City, Missouri.

Q. Let me ask you a question there. Was the sample that was taken above Kansas City, Missouri taken below the mouth of the Kaw River?

A. No sir, above the mouth of the Kaw River.

Q. Above the mouth?

A. Yes, a half mile above the waterworks which are located above the Kaw River and above Kansas City, Kansas.

Q. Above Kansas City Kansas?

A. Yes sir.

2530 Q. I had it wrong; I thought it was below the mouth.

A. No sir.

Q. Now you took a sample in the Kaw River before it empties into the Missouri?

A. Yes sir.

Q. You took a sample in the Missouri River above the point where the Kaw River enters the Missouri?

A. Yes, and above Kansas City, Kansas and the waterworks.

Q. That is the one I mean. The one above Kansas City, Kansas, is above the entrance of the Kaw River into the Missouri.

A. Excluding all the sewage from Kansas City, Kansas, and Kansas City, Missouri and excluding the Kaw River.

Q. Let me get those points located, doctor. That's what I want to get; then we will get at the other.

A. Yes sir.

Q. The Kaw River is above Kansas City, Missouri?

A. Yes sir.

Q. And is below Kansas City, Kansas?

A. Yes sir.

Q. And its confluence with the Missouri River is between those two cities?

A. Practically, yes sir.

2531 Now one sample was taken in the Kaw River above Kansas City, Kansas, in the Kaw River, the only sample?

A. Yes sir.

Q. Now did you take a sample above Kansas City, Missouri and below the entrance of the Kaw River in the Missouri River?

A. No sir.

Q. Then you took a sample below Kansas City, Missouri?

A. Yes three samples altogether.

Q. Now the sample that you took above the Kaw River in the Missouri River; does that show high chlorines?

A. It showed on the day of collection, one day it showed 16 parts per million.

MR. WOERNER: Is that the highest?

A. No, it showed higher yet on another occassion.

Q. MR. TODD: On the day that sample was taken, was the sample taken in the Kaw?

A. Well, it couldn't have been taken on that same day; it is either on the preceding or the following day if not on the same day. I couldn't recall at this moment.

Q. The sample taken in the Kaw showed high chlorines, didn't it?

A. Yes, on one day 100 parts per million of chlorine.

Q. Now after the Kaw River entered the Missouri and before it reached the sewage of Kansas City, Missouri,
2532 you didn't take a sample at that point then, did you?

A. Yes, that was the only sample taken in the Kaw River, it was taken at Argentine, Kansas.

Q. No, in the Missouri before the sewage of Kansas City, Missouri entered the Missouri River, you didn't take a sample above Kansas City and below the mouth of the Kaw?

A. No, I did not.

Q. Now if the Kaw is a small stream in comparison with the Missouri River, the waters of the Kaw becoming commingled with the waters of the Missouri, the chlorine would be reduced considerably, wouldn't it?

A. Yes the analytical results of those days showed that.

Q. Then if that be true, the sewage from Kansas City, immediately below Kansas City at the point that you took the next sample would add considerably to the chlorine of the Missouri River, wouldn't it?

A. If the Missouri River would be low on that date of collection, naturally the quantity of chlorine coming from the Kaw River would have a smaller volume of water to mix with and the chlorines would show high at the point below Kansas City, but if the volume of water was large and the stage of the river high, was very high, the stage of the Missouri on the day that
the samples was taken, the quantity of chlorine coming
2533 from the Kaw river on that day would mix with so much
water that the result would show low, and the chlorine
does that

Q. How about the chlorine that comes from the sewage of Kansas City?

A. That would apply in the same way as the chlorines coming from the sewage.

Q. What fraction of increased chlorines below Kansas City, is due to the Kaw River and what became of the sewage of Kansas City, on those days that samples were taken?

A. On those days that samples were taken, one day showed the chlorines above Kansas City to be, I believe, 16. I have not got the data at hand just now. I am speaking from memory I am not positive that I am correct.

Q. I would just as soon have the proportions, doctor, as the actual data.

A. And the Missouri River below Kansas City showed 24 parts per million of chlorine, which showed an increase of one-third in the chlorine, from 16 parts per million, to 24 parts per million.

Q. That one third increase is due to what, the Kaw River, or the sewage of Kansas City?

A. Well since on that day the Kaw River showed very high chlorines, I don't know whether it was 80 parts per million
or 100 parts per million on that day, the conclusion could
2334 be drawn that so much chlorine coming from the Kaw
river into the Missouri River would affect the quantity of
the chlorine found in the Missouri River below Kansas City.

Q. Suppose that the Kaw River only emptied about 200 cubic feet of water per second into the Missouri River; would that conclusion be justified?

A. That would depend upon the volume of water in the Missouri River; the relative proportion of the dilution there.

Q. Then, in order to draw that conclusion, isn't it necessary to know the volume of water in the Kaw River as well as the volume of water in the Missouri River?

A. It would certainly enable definite conclusions.

Q. In the absence of the volume of water in the Kaw River, and the volume of water in the Missouri River, is the conclusion based upon proper facts?

MR. WOERNER: There wouldn't be any river under those circumstances.

MR. TODD: In the absence of the known volume in the Missouri and the known volume in the Kaw, can you draw a conclusion, and are you justified in drawing a conclusion such as you have?

A. Yes, I think I am, because if there is such a tremendous
2535 amount of chlorine found in the Kaw River there, and the Kaw River empties into the Missouri River, the chlorine has got to show in the Missouri River, and it is a natural conclusion to be drawn, that the chlorines found in the Missouri River must increase as the result of the discharge of water from the Kaw River showing such enormous quantities of chlorine as on the two days when samples were collected from the Kaw, 80 parts per million of chlorine per million on one day and 100 parts per million on another day.

Q. Doctor, in the absence of the known volume of the Missouri and of the Kaw, do you take into consideration the sewage contamination from Kansas City, Missouri, and Kansas City, Kansas, as to the chlorines?

A. Well, I did not in this case.

Q. Wouldn't it have been fair to have done that?

A. I admit that a definite conclusion could have been drawn if the quantity of chlorine coming from the sewage into the river could have been ascertained, but that was an impossibility, and on the other hand, the Kaw River showing such tremendously high chlorines, I considered it a natural conclusion that there must be some effect of the high chlorines in the Kaw on the increase in the Missouri River.

Q. Then drawing your conclusions you eliminate the

2536 volume of water in the Kaw, the volume of water in the Missouri and the sewage of Kansas City?

A. As I said, I based conclusions that I drew on the high chlorines in the Kaw River which had to go somewhere, and to show their effect on the Missouri River.

Q. Did you eliminate those three elements that I speak of in arriving at your conclusion?

A. I say that more accurate conclusions could have been drawn if all those facts could have been ascertained, and in conjunction with the fact of those high chlorines in the Kaw River, should have been taken into consideration

Q. My question is, did you eliminate those three essential facts from your opinion or conclusion; did you not?

A. Yes sir.

Q. In order to ascertain whether the chlorines below Kansas City are there from the Kaw River, wouldn't it be absolutely necessary to know the volume of the Kaw, the volume of the Missouri and the amount of sewage discharged from Kansas City?

MR. WOERNER: One moment, Mr. Todd, if you will permit the interruption.

MR. TODD: Surely.

MR. WOERNER: I would like you to say, when you say 2537 it is necessary to know, just whether you mean the precise quantities of water in each or whether the witness could make a determination from his general knowledge of the water in those two streams.

MR. TODD: I will ask him if he has any general knowledge.

MR. WOERNER: I wish you would.

MR. TODD: I have already asked him and he said he had not.

MR. WOERNER: That is the point I am getting at. What I am getting at is this. When you say you know what the volume of the water is in the Kaw River, the witness interprets that as understanding it: Do you know the amount of cubic feet going in there, but I understand he is not absolutely without knowledge as to the volume of water in the Kaw river or in the Missouri River.

MR. TODD: I will find that out.

MR. WOERNER: I wish you would.

MR. TODD: Doctor, do you know the volume of water in the Kaw River.

MR. WOERNER: Did you ever see it?

A. Yes, sir; I saw it.

MR. WOERNER: Why don't you say so?

MR. TODD: Do you know the volume of water that enters the Missouri River at the mouth of the Kaw?

A. No, sir; I do not.

2538 Q. Do you know the volume of water in the Missouri River above Kansas City, Missouri?

A. Yes, sir.

Q. What is the volume of water?

A. Well, the volume of water varies considerably, it may be 100,000 cubic feet and it may be 600,000 cubic feet per minute. It just depends upon the conditions in the upper Missouri River valley, which is a very long valley.

Q. You have no accurate data as to the Kaw?

A. No, sir; I have not.

Q. Have you any accurate data as to the volume of sewage that enters the Missouri River from Kansas City, Missouri and Kansas City, Kansas?

A. No, sir; except that I have ascertained from the city engineer of the City of Kansas, that only 60 per cent. of the population drains sewage into the river directly.

MR. JEFFRIES: You said the City of Kansas.

A. I mean Kansas City, Missouri.

Q. MR. TODD: Do you have any accurate knowledge as to the volume of that sewage based upon that percentage?

A. No, sir; not just at hand, but it could be estimated, based on the water supply.

Q. Have you knowledge sufficient so that you could take that amount of sewage into consideration in order to ascertain the percentage of chlorine pollution in the Missouri below Kansas City? 2539

A. No, sir; I cannot.

Q. In order to draw a conclusion as to whether the chlorine below Kansas City, comes from the sewage of Kansas City Missouri, and Kansas City, Kansas, or from the Kaw River, isn't it important to know the volume of the Kaw and the amount of sewage discharged into the Missouri from Kansas City, Missouri, and Kansas City, Kansas.

A. It would enable an absolutely accurate estimation.

Q. Your conclusion, then, is not accurate, is it?

A. Well, I consider it an approximation.

Q. Well, doesn't a conclusion that you could call approximate, in the absence of those two elements that I have spoken of —it isn't a conclusion that you would call approximate, is it, doctor, in the absence of those two elements that I have spoken of—the Kaw and the sewage from Kansas City?

A. I would call it only an approximation because of the natural conclusion that the Kaw River having so much chlorine, the chlorine in the Missouri River must be increased somewhat.

Q. Well, if the Kaw River was only a river of two or three hundred cubic feet per second, emptying into the Mis-
2540 souri, the volume as you have indicated, wouldn't that dilute the Kaw River so much as to make a great reduction in the chlorines of the Kaw as manifested in the Missouri River?

MR. WOERNER: You mean, wouldn't it dilute—

A. The chlorines in the Missouri?

MR. TODD: No, the chlorines in the Kaw, flowing into the Missouri would be reduced by dilution?

A. Yes, sir.

Q. Enormously, wouldn't it?

A. Yes. Those very analyses that I presented show that they are reduced from 100 in the Kaw to 24 parts per million in the Missouri, which is an enormous dilution.

Q. Can you state what proportion of the increase of chlorines below Kansas City is due to the Kaw water, and what to the Kansas City sewage?

A. No, sir; I cannot.

Q. Do you know whether 90 per cent. of it is due to sewage or not?

A. I don't know.

Q. Now, if you don't know what proportion is due to sewage in your analyses at Bellefontaine, can you ascertain there what proportion of the chlorine is due to sewage contamination and what to the Kaw River?

A. As I already said, that since the Kaw River showed 2541 chlorines varying from 80 to 100 parts per million on two particular days, and since these chlorines go into the Missouri River, if the Missouri River is not high the ratio of dilution would be small of that chlorine in the Missouri River and the Missouri River chlorines between Kansas City and Bellefontaine, would show an increase. The lower the Missouri River would be, the higher would be the increase in chlorines from the Kaw River chlorines. The higher the Missouri River would be of course, the lower the chlorines would be. Now, on those few days that samples were collected from the Kaw River and the Missouri River at Kansas City, the Missouri River was high and the dilution was great so that the increase was only one-third, no matter where that increase came from, the increase was very small but the conclusion could be drawn from the conditions prevailing in the Missouri River at times of low stage when the high chlorines of the Kaw river wouldn't find much water in the Missouri River for dilution, so that the chlorines of the Kaw River must of necessity then, affect the chlorines of the Missouri River and show high, and they showed very high at times at Bellefontaine. They showed as high as 35 and 36 parts per million.

Q. Wouldn't the same condtions obtain if the sewage discharge of Kansas City into the Missouri River when it 2542 was low, would be evidenced by high chlorines, and when high, by low chlorines?

A. Yes, it would depend upon the stage of the river and the volume of the water.

Q. Why is it, in your conclusions, doctor, you do not take into consideration the sewage of Kansas City?

A. Because such high chlorines as found in the Kaw River and that water discharging into the Missouri River, those chlorines must go somewhere. They are in the water and just according to the stage of the Missouri River they must increase the chlorines of the Missouri River proportionately. As I said, it may be that the Missouri River is so high that the dilution of the chlorines of the Kaw River in the Missouri is so great that the effect may be very slight if noticeable at all. It depends upon the volume of water coming down the Missouri River.

Q. Doctor, why didn't you take into consideration the sewage from Kansas City, in your conclusions in regard to chlorines?

A. I have no available data. I couldn't obtain them and it would have necessitated an investigation which I couldn't undertake at that time, and then seeing or noticing the high chlorines in the Kaw River and calculating on a natural increase of chlorines, and in a degree depending upon the Missouri River stages, I calculated that some effect of the Kaw River
2543 chlorines must be estimated for the Missouri River, varying more or less, according to the stage of the Missouri River.

Q. Your inability to get the data of Kansas City, do you consider that a justification for the elimination of the sewage of Kansas City from your consideration?

A. Not at all times.

Q. At any time, at any one time?

A. There may be occasions when the stages of the river enable a dilution that neither the chlorines of the Kaw River, nor the chlorines from the sewage of Kansas City will show any effect there on the Missouri River.

Q. When was that period that you have just spoken of?

A. The period when we took the samples and during the time when the Missouri River was high.

Q. And was that a time such as you have indicated when the Kaw River and the sewage of Kansas City had no effect upon the Missouri?

A. No, not such a very high stage, but a high stage to account for the tremendous dilution of the Kaw River chlorines in the Missouri River.

Q. That is, an exceptional condition rather than a general condition, of the Missouri River, isn't it?

A. Well, that I couldn't tell off-hand, without studying
2544 the stages of the Missouri River very carefully.

Q. But in none of your investigations have you taken into consideration the sewage discharge of Kansas City, have you?

A. I have not in calculating the chlorines for the Missouri River.

Q. I am talking about the chlorines.

A. Yes, not in connection with the chlorines.

Q. And was it because you did not deem that essential for your consideration, that you didn't take it into consideration?

MR. WOERNER: Let the question be repeated, digest it and then answer it.

Q. (Question repeated.)

A. I would have preferred a careful scientific investigation of the amount of chlorines going into the Missouri River, but since on the two occasions that samples were taken from the Kaw River, the Kaw River showed such enormously high chlorines and the Kaw River below Kansas City showed an increase notwithstanding the fact that the Missouri River was very high, producing great dilution of the Kaw River chlorine, I consider the conclusion in that instance as an approximaion of the character of the chlorines in the Missouri River as sufficient.

2545 MR. JEFFRIES: I object to the question and answer and move that both be stricken out, because it is incompetent, irrelevant and doesn't tend to prove any issue involved in this case.

MR. TODD: I move to strike out of his answer all in regard to the Kaw, which is not responsive to my question.

Q. And was it because you did not deem that essential for your consideraton, that you did not take it into consideration, the sewage discharge of Kansas City?

A. It was because I couldn't obtain the data.

Q. And not being able to obtain the data, you eliminated it entirely from your consideration, didn't you, doctor?

A. I relied upon the condition of the Kaw River as found to justify an approximate conclusion.

Q. And eliminated the sewage from Kansas City from any consideration?

A. Yes, sir.

Q. Can you tell me what proportion—you made an examination of samples below Kansas City, did you not?

A. Yes, sir.

Q. From that examination what proportion of the increase of chlorines was attributable to the Kaw River and what to Kansas City, do you know?

MR. JEFFRIES: Object to the question for the reason 2546 that he has already said that he didn't take into consideration the sewage discharge from Kansas City.

Q. MR. TODD: Do you know? That can be answered yes or no, doctor?

A. Well, I have already testified that I attributed—

Q. (Question repeated.)

A. At low stages of the Missouri River the Kaw River chlorines will affect the Missouri River chlorines—

MR. WOERNER: How do you know it, that it all didn't come from Kansas City instead of from the Kaw River?

A. Well, I made no investigations and that's why I couldn't tell.

Q. MR. TODD: Then you don't know?

A. For those two samples that were collected on those two days—

MR. TODD: Then you don't know what proportions of the chlorines below Kansas City came from Kansas City and what came from the Kaw River, do you?

A. Not from any investigation of the Kansas City sewage.

Q. Do you know from any investigation the proportion of the increase of chlorines below Kansas City that is due to the Kaw River water and what is due to Kansas City sewage?

A. How much of each I have not estimated.

2547 Q. Do you know? Not what you have estimated?

A. Well, I couldn't know from any original data except that I can draw an approximate conclusion for low water stages.

Q. Independent of conclusions, do you know what fraction of the increase of chlorines below Kansas City is due to the Kaw River and what to the Kansas City sewage?

A. As applied to the analyses made of certain samples? Do you mean it that way?

Q. Yes. Or from any other information that you have got; do you know?

A. Well, as applied to the conditions prevailing on those days that those samples were collected, I couldn't tell.

Q. And you have no other source of information except the samples that were taken upon those days, have you?

A. No direct information.

Q. Now, the chlorines that you found at Bellefontaine, you are unable to say what proportion of those comes from Kansas City sewage and what proportion comes from the Kaw River, are you?

A. I feel justified when the Missouri River is low, and I find high chlorines at Fort Bellefontaine, that those chlorines can come from the Kaw River chlorines largely, if not altogether.

2548 Q. Can you say whether the chlorines that you found at Bellefontaine, that 90 per cent. of it doesn't come from the sewage of Kansas City?

A. At low stages of the river I think that it does not.

Q. I am not asking you about the stages.

A. That 90 per cent. does not. It depends upon the conditions of the river.

Q. Have you ever made any analytical data for the purposes of ascertaining the proportions of chlorines that emanate from the sewage of Kansas City and from any other sources of information, are you able to state that 90 per cent. of chlorine in the river at Bellefontaine does not come from the sewage of Kansas City?

A. I couldn't say that because the quantities of chlorines vary almost daily at Fort Bellefontaine and no conclusion would be possible on the basis as you direct the question to me.

Q. Assuming that 90 per cent. of the chlorines found at Bellefontaine comes from the Kansas City sewage would that have any effect upon the potability of the waters of the Missouri?

A. Not unless corresponding high nitrites and correspondingly high free ammonias would be shown.

2549 Q. If correspondingly high nitrites and correspondingly high free ammonias were shown, and the albuminoid ammonias you were not able to ascertain whether they were from animal or vegetable origin, could you tell?

A. And how much chlorine would be in that calculation?

Q. The amount which you found by your analyses. Would you denominate that water potable?

A. If the nitrites were high and the chlorines were high and the ammonias were high and I was personally convinced that the chlorines were due to sewage and not from the Kaw River, I would say according to the axiom of sanitary science that the water was not potable. The mere analytical facts of high nitrites and high chlorines and high free ammonias and the high chlorines being proven to come from sewage pollution, that in itself, those three things together would condemn that water as not being potable, certainly.

Q. Can you, doctor, say that the scientific fact that the albuminoid ammonia found in suspension or in solution demonstrates without a doubt that its origin is animal and not vegetable?

A. If not corresponding with the high chlorines and the high nitrites and the high free ammonias it could not be shown that the high albuminoid ammonia is due to animal pollution.

2550 Q. Can it be shown that it is due to vegetable pollution?

A. In many instances, it can be shown, yes.

Q. And in many instances it cannot be shown, is true, too, isn't it, doctor?

A. Well, the point is this, that all instances that I have familiarized myself with by the study of analytical investigations not only of my own, but of other people; they have all justified the conclusion that the high albuminoid ammonia found in itself with further ingredients of pollution being low, is usually of vegetable origin. As I said before today, Professor Drown has practically established that as an axiom of sanitary science in judging water. He thinks less of the albuminoid determination than of any other in figuring sewage pollution.

MR. TODD: I move to strike out all that he states about what other professors have stated, as not being responsive to my question.

Q. The slaughterhouses of Kansas City empty a great part of the sewage which turns into albuminoid ammonia, doesn't it, doctor?

A. Yes, sir.

Q. That is sewage from animal and man emptied into the Missouri River above Fort Bellefontaine, isn't it?

A. Yes.

2551 Q. Now, can you, as an analytical chemist, differentiate in percentages the amount of albuminoid ammonia in suspension or in solution that is attributable to animal origin and to vegetable origin?

A. The animal origin is only existing for the high albuminoid ammonia as accompanied by high nitrites and high chlorines and high free ammonias—they go together to characterize water as sewage polluted.

MR. TODD: I move to strike out the answer as not responsive and ask to have the question re-read.

Q. (Question repeated.)

A. In percentages, no, sir.

Q. You cannot tell whether the albuminoid ammonia found in the Missouri River, whether 50 per cent. is attributable to vegetable or animal origin, can you, doctor?

A. No, not by my calculation, getting it down to such figures.

Q. Then if the albuminoid ammonia should be of animal origin and accompanied by high nitrites and nitrates and free ammonia and high chlorines, the water wouldn't be potable, would it?

A. It would not if accompanied by those high other ingredients you mention.

Q. If the high albuminoid ammonia came from vegetable origin there is nothing that would render it impossible to 2552 be accompanied by high nitrites, nitrates and free ammonia, is there?

A. The water collected from the station at Bellefontaine—

Q. (Question repeated.)

A. I want to exemplify it.

MR. TODD: Answer it first and exemplify it afterwards.

Q. (Question repeated.)

A. It wouldn't be possible if high chlorines were going with it.

Q. I didn't ask about the chlorines, doctor.

A. Well, in order to determine the potability, chlorines would have to be taken into account.

Q. Well, if the chlorines came from the Kaw River, they could be high and yet that condition could exist, couldn't it?

A. You mean what condition?

Q. That is, you could have albuminoid ammonia in suspension or solution accompanied by high nitrites, nitrates and free ammonia, could you not, if it was of vegetable origin?

A. If it were of vegetable origin?

Q. Yes, could that condition obtain?

A. Hardly, at Fort Bellefontaine.

Q. Anywhere?

A. Some places, yes.

Q. It could obtain in the Illinois River, couldn't it?

2553 A. Yes.

Q. But it couldn't obtain in the Missouri River?

A. Well, it could obtain in the Missouri River, but it doesn't obtain at Fort Bellefontaine where we took our samples.

Q. I am speaking of it as a principle, doctor, as applicable to any place.

A. You cannot apply that to all places, that principle.

Q. Hypothetically I am speaking, doctor.

MR. WOERNER: When you put in the Missouri River, that eliminates the hypotheses.

A. Not even hypothetically.

Q. MR. TODD: Then that condition couldn't obtain in the Missouri River?

A. Not with the conditions prevailing in the Missouri River.

Q. That is, you couldn't have high ammonia in solution and in suspension in the Missouri River from vegetable origin?

A. Yes, you could have that.

Q. Then could you have high nitrites?

A. I never found high nitrites in the Missouri River. There are no high nitrites in the Missouri River.

2554 Q. The nitrates?

A. The nitrates are high.

Q. The nitrates are the second stage to nitrites, aren't they?

A. It shows that the process of oxidation of the water and purification has reached a permanent stage; that is, it is completed and gives the water a character of stability.

Q. And you could have free ammonia?

A. Yes, sir.

Q. If you have high albuminoid ammonia in suspension or solution, that condition obtains in the Missouri River, doesn't it?

A. High ammonia?

Q. High albuminoid ammonia?

A. And what else?

Q. And high free ammonia?

A. Yes, sir.

Q. Now, the free ammonia, when the processes of disintegration takes place turns into nitrites, doesn't it?

A. Yes, sir.

Q. And the nitrites carry on in the nitrates?

A. Yes, sir.

2555 Q. What is the reason, doctor, that when you have free albuminoid ammonia, and free ammonia and nitrates, high nitrates, that you don't have high nitrites?

A. That shows that the processes of purification, for part of the pollution, has reached the stage where it has been completed and the high nitrates demonstrate that, and the low nitrites demonstrate that, because if the nitrites were high this process of purification would still be going on for pollution of a certain kind.

Q. What do the nitrites come from, doctor?

A. They come from nitrogeneous matter in the water, and the oxygen.

Q. Known as what?

A. Well, as nitrites.

Q. No, I mean the nitrogenous matter in the water is known as what?

A. Well, the organic matter.

Q. Free ammonia?

A. Carbonate of ammonia, yes.

Q. That is what is known as free ammonia?

A. Yes, sir.

Q. Now, the free ammonia is constantly undergoing a change in water, isn't it?

A. Yes, sir, they are.

Q. And that is forming nitrites?

2556 A. Yes, sir.

Q. And the nitrates are formed from the changes from nitrites to nitrates?

A. Yes, sir.

Q. Now, if you have got free ammonia in large quantities, I mean chemically speaking, and the changes are going on with that free ammonia, that changes to nitrites, doesn't it?

A. Yes, sir.

Q. Do the nitrites change to nitrates quicker than the free ammonia to nitrites?

A. Well, that couldn't be established.

Q. It could not be established?

A. No. I know of no investigations that have resulted in figuring the ratio of time there.

Q. If you have high ammonia and high nitrates, musn't there be an intermediate stage of high nitrites?

A. No, sir, not necessarily, the analytical results of many investigations show that high nitrites are not there; it isn't necessary.

Q. Well, they have been there sometime haven't they?

A. Sure, but they have been converted into the final product in the cycle of nitrification to nitrates, so that the pollution has been disposed of. It has resulted in converting the various
ingredients which are characteristic of the pollution into
2557 the final produce of nitrates.

Q. So that when you find free albuminoid ammonia and free ammonia and nitrates, the conclusion chemically speaking will justify that the nitrites have changed to nitrates more rapidly than the free ammonia to nitrites, isn't it?

A. Not at all, because the free ammonia may come from various sources.

Q. Whatever sources it comes from, it is there?

A. Yes, it is there. It is eventually converted afterwards according to the changes going on in that river.

Q. Now if you find in a river, albuminoid ammonia, I mean free ammonia, high free ammonia, high nitrates, low nitrites and high chlorines, wouldn't it be potable water?

A. That would depend upon the relative proportions of the ammonias and the chlorines, and the sources of the chlorines, but low nitrites in itself would demonstrate a character of stability in that water with the process of nitrification as being completed, and as giving the water a certain stability, less liable to changes and when that is found frequently as ascertained by daily analyses of samples, the conclusion is justifiable that the water is potable.

Q. Suppose that you didn't know the source of the chlorines and that condition obtained; wouldn't it be potable?

2558 A. I would still take into consideration the nitrites, the most important ingredient, because the potability of the water depends very much upon its stability or instability, that is, whether the fermentative changes that the organic matter undergoes, whether those fermentative changes have reached the stage that they are completed, which is demonstrated by the low nitrites and the high nitrates which is the case at that point.

Q. The nitrites whether high or low do not indicate whether they are from animal or vegetable?

A. Taken by themselves, they do not.

Q. Now if you have got high albuminoid ammonia, free ammonia, low nitrites, high chlorines and you don't know what the source of that chlorine is, would you say the water was potable or not?

A. I would base my judgment upon the conditions prevailing and the source of that high chlorine.

Q. No. But supposing I came to you and presented you with a sample of water and asked you for an expert opinion. The water is in a bottle. I refuse to tell you where I got the water from, but wanted to know whether the water was potable or not, and that the sample upon analysis disclosed albuminoid ammonia, high free ammonia, low nitrites, high nitrates and high chlorines?

2559 A. And low nitrites?

Q. Low nitrites.

A. I would say this is an exceptional condition—

Q. Wait until I finish my question. That would be what was disclosed by the water that I brought you. I would then ask you is that water a potable water or not, and ask you to answer me Yes or No? Could you answer it?

A. I would refuse to answer that question Yes, until I had ascertained why it was that the exceptional condition presents itself of water having low nitrites, high nitrates and high chlorines. That would demonstrate that the chlorine is due to some source of pollution not sewage pollution, and it would be necessary to ascertain where this high chlorine comes from, that can go together with low nitrites and high nitrates, because the pollution has been removed, of that water, to a very large extent as shown by the low nitrites and the high nitrates. The pollution would still be there because the presence of nitrites would show that the fermentative changes were still going on. Very low nitrites together with very high nitrates with the processes of purification to a large extent, to the largest extent of that pollution, had been completed, and the high chlorines would have to be investigated because it would be an exceptional condition. Where does the high chlorine come from?

2560 Q. Then if I refused that information to you, you would be unable to give me an opinion as to whether the water that was present in the sample was potable or not; is that correct?

A. I would refuse to do so with that information.

ADJOURNED until 2:15 P. M., Wednesday, April 1st, 1903.

2561 Southern Hotel, St. Louis, Missouri. 2:15 P. M., Wednesday, April 1st, 1903. Continuation after recess. Present, the Commissioner and same counsel representing the respective parties.

DR. WILLIAM C. TEICHMANN,

Resumed the stand for further cross-examination by Mr. Todd, and testified as follows:

Q. Doctor, are the waters of the Missouri River at Fort Bellefontaine what is known as stable waters?

A. Yes sir.

Q. What is the meaning of stability as applied to a river?

A. The words—or rather the term "stable" is applied to a river where the fermentative changes and the nitrification changes which the impurities in the river undergo, are more of a uniform character, and are going on in a manner that they do not change rapidly, and where analytical results show by low nitrites and uniformly low nitrites that the cycle of purification has reached a stage where a large portion of the impurities have been converted into nitrates,—the final product of the cycle of nitrification.

Q. In your examination of the waters of the Missouri at Fort Bellefontaine, what did you find as to the presence
2562 of albuminoid ammonia?

A. I found the albuminoid ammonia quite high.

Q. As to free ammonia?

A. I found the free ammonia as a rule, which I conisder low, but at times I found a slight increase in the free ammonia, where I would say that the free ammonia was there in a considerable quantity.

Q. As to nitrites?

A. The nitrites I found uniformly very low for a river—frequently absent.

Q. And nitrates?

A. Nitrates I found at times quite high, and at other times not so high—as a variation.

Q. And chlorines?

A. Chlorines I found high; sometimes as high as 46 parts per million.

Q. Was the Missouri River a polluted stream based upon your chemical analyses?

A. You mean at Fort Bellefontaine?

Q. At Fort Bellefontaine?

A. Yes sir.

Q. And to what extent was it a polluted stream, doctor?

A. Well, whenever it would show the presence of free ammonia, and albuminoid ammonia and nitrites—further-
2563 more when the oxygen consumed test would show organic
matter present—the opinion is justified that the water was polluted.

MR. JEFFRIES: Now he asked you to what extent doctor. Why don't you say to what extent?

A. To what extent?

MR. JEFFRIES: Yes?

A. Well, that is variable. You could not define it. That is, you could call it a polluted stream. I would not call it a very polluted stream.

Q. MR. TODD: To what do you attribute the pollution?

A. Well, that depends upon the seasons and depends upon the times when the sample is analyzed.

Q. My question is to what do you attribute the pollution?

A. I attribute it to organic matter of vegetable origin, and organic matter of animal origin,—the degree of each varying.

Q. Are you able to state from your analyses the extent of pollution attributable to vegetable origin and to animal origin?

A. I would say that during the summer months—

Q. Doctor, you don't get my question. Read my question. (Question read.)

A. Approximately, yes.

Q. To what extent was the stream polluted by pollution due to animal origin?

2564 A. At what time of the year, because that varies according to the seasons and the weather?

Q. Well at any time of the year during which you made the examinations?

A. Well, there are changes produced resulting in variations that make it difficult there to answer that question directly.

Q. Were there times when the pollution was greater from animal origin than from vegetable origin as disclosed by your analyses?

A. Applying the same principle in determining the vegetable origin of the organic matter, I would also say that whenever the albuminoid ammonia in solution runs very high with the organic matter—as estimated by the oxygen consumed process, high and the nitrites, although uniformly low, would still show their presence by a figure showing that there was still fermentative changes going on at that time,—at such times I would say that the pollution could be of animal origin.

Q. At those times was the river potable?

A. At such times it was not potable.

Q. During what periods of the year, or how much of the year did conditions such as you have described obtain, in the Missouri River at Fort Bellefontaine?

A. Well they would appear during the winter months.

2565 Q. And during the winter months beginning with what month, doctor?

A. Well, there is a gradual increase in the impurities of every river during the fall months and also of the Missouri River, that is when the colder weather sets in the processes of purification in the rivers are retarded. The plant life is greatly inhibited by the cold weather, and the absorption of impurities by the plants is of course proportionately decreased. Furthermore the bacteriological purification going on in the river of the organic matter also lessens with colder weather, and with the approach of cold weather in the fall gradually there is an increase of the impurities taking place.

Q. And are those winter months—Of those winter months how many do you estimate are contained in the period that you described in the preceding answer?

A. Well, there is a transitory period in the fall and in the spring months that depends upon the special weather conditions at that time, whether there is a warm fall or not. If there is a warm fall of course then retardation of the purification and oxidation processes sets in later; as long as the warm weather prevails, so long will the purification processes be hastened by this condition.

Q. How many months are considered as winter months in this climate?

2566 A. Well, as absolutely winter months, I would consider from three to four months. We may have winter weather for three months, and we may have winter weather for four months.

Q. Well then, during those four months, this condition of pollution that you have described as being attributable to animal origin, obtains in the Missouri River?

A. Yes sir, the only way that we have of differentiating between vegetable and animal origin,—that very principle applied would demonstrate animal origin during those winter months.

Q. And during that time are the waters of the Missouri potable?

A. No sir.

Q. Then when you stated in your testimony yesterday that the Missouri River was potable throughout the year, you eliminated from your consideration the four winter months during which animal contamination existed in the Missouri?

A. I am very glad you brought that matter up, because if I said throughout, I did not mean to say that; what I meant to say, was prevailed during the year, in taking the larger part of the year when I think the water is potable, but for those four months I do not consider it potable.

Q. Those four months or three months, as the case may be, you can ascertain chemically that the waters of the
2567 Missouri River are not potable?

A. Yes sir.

Q. As to the other eight or nine months of the year when you claim that the water is potable, that condition you ascertained by chemical analyses?

A. Yes sir.

Q. Have you ever supplemented your chemical analyses by any bacterial investigation?

A. Yes sir.

Q. Are the waters of the Missouri River bacterially pure?

A. No sir.

Q. Are not the bacilli coli communis prevalent in the Missouri River in large quantities throughout the year, as evidenced by the bacteriological examinations and the tables that have been introduced in evidence?

A. I consider them smaller during those summer months than in the winter months.

Q. Well, smaller is a relative term.

A. Which deductions I have drawn from bacteriological reports that I have seen.

Q. And do you consider the presence of these bacteria in the quantities in which they appear, as evidenced by the tables that have been introduced here, in evidence, as being in
2568 such insufficient quantities as to not affect the potability of the waters of the Missouri?

A. As compared with the chemical analyses indicating during the summer months very little, if any, sewage pollution of the water at Bellefontaine, the high counts,—the total counts of bacteria could not, in my opinion be ascribed to the prevalence of such bacteria as are found in sewage because the water as it is found there at Bellefontaine does not appear to be sewage polluted during the summer months.

Q. Whenever the bacillus coli communis is found in water, what does the presence of that bacteria indicate?

A. The presence of that bacteria may indicate either sewage pollution if corroborated by chemical analyses, or may indicate fecal discharges of fish.

Q. Are there many fish in the Missouri River?

A. Yes sir.

Q. And do you attribute the presence of these coli bacilli to fish in connection with your chemical analyses?

A. Well, since investigations have determined that fish have in their fecal discharge the colon bacillus, and if the chemical analysis does not demonstrate sewage pollution of the water the conclusion may be reached that sewage not being identified as present by the chemical analyses, the presence of the bacilli coli communis may be ascribed to the fecal discharges of fish. 2569

Q. Doctor, has it been scientifically ascertained how the coli communis bacilli get into fish?

A. That is a question that would not come into consideration there in ascribing the presence of the coli communis to the fecal discharges of the fish, since it has been proven by scientific researches, that the bacillus coli communis is present in the fecal discharge of fish.

Q. And has it been proven that that bacilli is present in fish in streams other than sewage contaminated?

A. Well, it is some time ago since I have studied data and reports on such investigations, and at this moment I cannot remember that, but it is very likely that since I based my conclusions at that time on a careful study of that question some time ago, that such investigations have been made.

Q. Then the presence of this bacterium has been scientifically demonstrated to be in the fecal discharge of fish?

A. Yes sir.

Q. And if, bacterially speaking, the coli communis is discovered in water, and that water is well stocked with fish, its presence there could be as scientifically accounted for as coming from the fecal discharge of fish as from sewage pollution, could it not?

A. Yes sir.

2570 Q. And there is no way of telling from a scientific standpoint whether this coli is the result of the fecal discharge of fish or of sewage, is there?

A. The investigations so far as I have been able to inform myself, have not reached that stage yet where that point could be settled.

Q. Well, there is no mark or no peculiar attributes of these coli bacilli that marks it then as emanating from the fecal discharge of fish as different from the fecal discharge of animal or man, is there?

A. Not to my knowledge.

Q. Do you know of any bacteriologist who has made a careful bacterial analysis of the waters of the Missouri, that holds to the view that the Missouri River is a potable stream?

A. No sir, I do not know of any, at this moment.

Q. Do you know of any who hold that it is not a potable stream?

A. If there are any I am not familiar with their researches.

Q. Are you acquainted with the conclusions drawn by Dr. Ravold from the bacteriological examination which he made of the waters of the Missouri River as to whether or not it is potable?

A. Yes sir.

2571 Q. In getting your information as to the bacterial conditions of the Missouri River, what data have you consulted?

A. Dr. Ravold's data.

Q. The data that you consulted was the data that was compiled under the direction of Dr. Ravold, and which has been introduced here in evidence?

A. Yes sir.

Q. Outside of that data have you made any independent investigations on the line of bacteria in the Missouri River?

A. No sir.

Q. Do you agree with Dr. Ravold's conclusions?

MR. JEFFRIES: I would suggest that that is a repetition.

MR. TODD: I mean as to the Mississippi River, but not as to the Missouri.

MR. JEFFRIES: I thought you included both rivers at the time.

MR. TODD: No, I took them one at a time, because I couldn't carry both of them.

Q. Do you agree with Dr. Ravold's conclusions that the waters of the Missouri are not potable?

A. I will answer that question if the conclusions of Dr. Ravold are read to me so that I can compare his views with my views.

2572 MR. WOERNER: I object to the question that is asked on the ground that it is incompetent, immaterial and irrelevant, and would suggest that the doctor be asked as to the facts and what his conclusions are, and then whether they agree or not with some other witness, is a question for the Court.

Q. MR. TODD: From the data as compiled by Dr. Ravold, in regard to bacteria in the Missouri River, what conclusion do you draw from that data as to the potability of the Missouri River?

A. I consider the Missouri River potable during those eight or nine months that I have specified, as representing the warm season of the year—potable at Fort Bellefontaine.

Q. That is what I am speaking about, doctor.

A. Yes.

Q. What do the analytical data which you consulted, show as to the presence of bacteria during the other months in the Missouri River at Fort Bellefontaine?

A. Well now, to be accurate I would have to look over the tables presented by Dr. Ravold, because it is some time ago that I studied that table, and I formed a general conclusion at that time but, as to answering this question specifically, I would have to glance over the table again.

Q. You cannot give a general answer to the question?

A. No, it is some time ago since I studied that table and
2573 there were varying conditions there that necessitate a
close scrutiny of the data before forming an opinion.

Q. Do you know of any authorities that hold that sewage polluted streams are potable, bacterially?

MR. JEFFRIES: That is a repetition Mr. Todd.

A. Well that question cannot be answered, because the potability depends upon the chemical as well as the bacteriological conditions of the water.

Q. Can a bacteriologist pass judgment upon the potability of a stream?

A. Yes, he can in some instances. There are exceptions where water may be chemically pure and yet contain typhoid fever germs, as has been demonstrated by investigators, and that water of course would not be potable; but those are exceptions.

Q. Do you know of any bacteriologist who has discovered the germs of typhoid fever in running waters?

A. I know of some investigations where the typhoid bacillus was identified in the sediment found on the filter of a river water from a city water supply.

Q. Do you know of anyone who has discovered the bacillus of typhoid in running water?

A. If accepted under such conditions, that is, that the typhoid bacillus was identified in the sediment remaining on
2574 the filter when filtering a polluted river water, yes.

Q. I am not asking, doctor, about the discovery of typhoid germs on filters from water mains in cities. I want to know if you know of anyone who has discovered the germs of typhoid in running waters of rivers?

A. There have been investigations recorded in which it was claimed that this bacillus had been found, but the overwhelming evidence is to the effect that,—as far as I have been able to get the evidence from a vast amount of literature, that I have read, on the subject,—the overwhelming evidence is that the typhoid bacillus has not as yet been identified in running waters.

Q. Is the Missouri River a sewage polluted stream?

A. That depends upon what point—

Q. At any point from its source to its mouth, eliminating Bellefontaine.

A. Eliminating Bellefontaine?

Q. Yes.

A. Yes, at various points it is sewage polluted, wherever the sewage enters the river from cities along the line.

Q. Do you know of any standard authority upon the subject of running waters sewage polluted that holds to the potability of that water in such a stream?

2575 A. You mean potability of the Missouri River water?

Q. Yes. I will make it applicable to the Missouri.

A. No, as far as the Missouri River is concerned.

Q. Do you know of any scientific man who has investigated the waters of the Missouri that holds to the doctrine that it is potable, aside from yourself?

A. Well, if I understood the testimony of Professor Keiser, correctly, Professor Keiser testified to that effect.

Q. He didn't touch on the bacteriology of it, did he?

A. Well, you are speaking of potability. You did not specify bacteriologically.

Q. Yes, but as applying it as to bacteriology. I am examining you now as a bacteriological expert.

A. Well, bacteriologically, I mean to say from a bacteriological standpoint alone, a running river should not be judged as to its potability. The chemical conditions should be taken into consideration.

Q. Do you know of any other authority on bacteriology that holds that the Missouri River is potable—is a potable stream aside from yourself?

A. Bacteriologically?

Q. Yes?

A. No, I cannot recall any to my mind just now.

2576 Q. Doctor, how do you account for the Missouri River being a stable river with the presence of albuminoid ammonia, and nitrates and chlorine present there in the quantities that you have indicated?

A. Because first of all, the free ammonias are comparatively low during the larger part of the year, and secondly the nitrites are low, they are frequently absent, and the nitrites high, and the free ammonias not being high at such times, justifies the conclusion taking into consideration also that during frequent periods of the year when the river is low, that the high chlorines may be attributable to the Kaw River. Taking all these facts into consideration, the stability of the river is established by the remarkable uniformity of these impurities throughout long periods. They don't fluctuate so much, the impurities, they do not change so much. There is a stability established there by the uniformity of the nitrites from being uniformly low, to only being present in traces, or being absent entirely. The nitrates being uniformly high and the free ammonia being uniformly low, and the chlorines as I said, during just such periods of low stages of the river, when they are high, being atributable to accessions from the Kaw River.

Q. If you assume that the presence of cholrine was not due to the Kaw River, but to the sewage contamination of
2577 Kansas City, would that change your conclusions as to its stability?

A. No sir, not unless all the conditions as I described, that had to be taken into consideration when you judge the potability of that water. Not unless all the conditions would point to sewage contamination.

Q. Well, assume that all the conditions that you found existed and that you are mistaken about your deductions in regard to the Kaw River, but that the chlorines are attributed to the sewage of Kansas City, and the other cities along the banks of the Missouri, would that change your opinion as to the stability of the Missouri River at Bellefontaine?

A. But that would be a strictly theoretical condition which I never found to exist during my investigation.

Q. Assume that it exists?

A. Well, that would be strictly a hypothetical question.

Q. Consider it as a hypothetical question.

A. Not based upon any actual conditions found during many investigations and many samples collected and analyzed from the river.

Q. You don't object, do you doctor, to the elimination of the Kaw River from your answer?

A. I said from a hypothetical point of view.

Q. I am putting it as strictly hypothetical as I know how, 2578 and assuming that the conditions existed there as you found them by your analyses and that the high chlorines that you found there were attributed to the sewage discharge of Kansas City, what would be your conclusions as to the stability of the Missouri River at Fort Bellefontaine?

A. Even if those high chlorines would be—now this a theoretical problem.

Q. I so stated it.

A. Even if those high chlorines you mention there, were due to the sewage from Kansas City, after a run of 403 miles, even then it would be very difficult to ascribe such character to the water as you hypothetically present to me, as due to sewage pollution from Kansas City.

Q. Why, doctor?

A. For various reasons.

Q. Give the reasons?

A. First of all the distances from Kansas City to St. Louis would be 403 miles by water.

Q. Yes.

A. Only 60 per cent of the Kassas City sewage would go into the Missouri River. The Missouri River during its winding course with many curves, and as proven by the length of that river, 403 miles, where the air-line is much shorter, a great deal shorter, as proven, the character of the river not being 2579 regulated, that is, there being no dams or anything, the river overflowing frequently during its course, carrying a great deal of sewage over vast places there adjoining the river, and at a low stage of the river, as the river falls, much of this sewage never coming down the river, being left there in a condition of fermentation, on that soil, previously overflowed. It would be impossible to claim that any Kansas City sewage reached St. Louis or reached Bellefontaine.

Q. Then the conclusion is irresistable that the sewage of Kansas City has become purified before it reaches Bellefontaine in going a distance of 403 miles?

A. At certain times, when all of such conditions would prevail, as I describe, I would say yes.

Q. Isn't it at all times true, doctor, that when in high water it is deposited on the overflowed land and at low water stages it is left along the banks in its serpertine course towards Bellefontaine, so that under these conditions, the Missouri River that takes the sewage of Kansas City, has become pure, or has purified itself in going 400 miles? Is that true?

A. There may be exceptions because these conditions may not prevail throughout the year.

Q. Well, can you give me any reason for the exceptions, doctor?

(Question withdrawn).

2580 Q. Can you answer the question Yes or No and then give the exceptions?

A. Repeat the question.

Q. (Question repeated)?

A. Well, since you specify in that question when the sewage with the overflow of the water would be deposited on the land, on the soil and retained there after the fall of the river again, a considerable time having elapsed during all of this deposit of the sewage there, I could answer your question Yes, with such conditions prevailing.

Q. Are there any exceptions to that rule, doctor, that the Missouri River purifies itself in going 400 miles?

A. Well that I am not prepared to say because I found that during the winter months, the cooler weather retarding the processes of oxidation and mineralization of the organic matter in the Missouri River, I say that the chemical results of the analyses of samples showing at Fort Bellefontaine the same pollution of the water, I am not prepared to answer that question.

Q. The distance that the stream would purify itself from Kansas City, would depend upon the velocity of the current, wouldn't it?

A. Well, other conditions too.

2581 Q. Other conditions being equal?

A. The condition of the river itself, that is, in enabling the overflow over large banks.

Q. Well, it is a uniform rule, is it not, that the waters in the Missouri, with the higher stage of water, the swifter the current?

A. In the channel, yes.

Q. The lower the stage of the water the slower the current?

A. Yes sir.

Q. The high stage of water and the swift current is overcome by the sedimentation that takes place along the overflowed portion of the Missouri River in assisting purification; isn't that true?

A. Yes sir.

Q. Now if the current at low stages was decreased in velocity, purification would take place in going a lesser distance, wouldn't it?

A. Well now, the course of the river between Kansas City and St. Louis is so long that this principle cannot be applied to the entire route; it may vary along the route considerably.

Q. But if the sewage gets into the river that has a slow current, it will become purified in going a shorter distance than it would in going a longer distance with a swifter current, wouldn't it?

2582 A. That depends so very much upon the different conditions there prevailing in the river that you cannot apply that rule to every case; that is the way it seems to me.

Q. I am speaking of the Missouri River doctor, when the river is within its banks and the current is not as swift as it is at high stages, the time that it takes for purification may be the same, but the distance the water travels may be not so great isin't that true?

A. Compared with what?

Q. With its high stages?

A. Repeat the question.

Q. It takes a certain period of time for the purification of that sewage, doesn't it?

A. Well, a certain time. I couldn't say. It takes time, but how much time would be hard to tell.

Q. Well, we will assume a certain time. Does it take any longer time when the river is high than when the river is low?

A. Does it take any longer time when the river is high?

Q. Than when it is low, for the processes of fermentation and purification to take place?

A. It may and it may not, because the overflow from the high stage may be so frequent, you understand, and the progress of the sewage may be so impeded that it might take
2583 a longer time, and it might be the reverse for a river of such a length, for such a long distance, with such an immense number of bends and curves, it would be almost difficult to answer that question, to say Yes. I understand it now, Mr. Todd.

Q. The time would be nearer together, that it would require for the purification, than would be the element known as the distance that the stream might run, wouldn't it?

A. I couldn't say so because the distance is too long; it is impossible to draw any such deduction from such a river so peculiar as that river is in its course between Kansas City and St. Louis.

Q. Is the Missouri River a peculiar river?

A. Yes sir.

Q. Kind of like God's chosen people.

A. Not exactly, but it has a big waterway. The largest waterway in this country, very much neglected in regard to regulation and in regard to dams, etc.

Q. You have stated that once before, doctor.

A. Yes sir.

Q. Do you know how far above Bellefontaine the river purifies itself of the sewage of Kansas City?

A. I cannot tell.

Q. Does the figure that you have given that 60 per cent of the sewage of Kansas City empties into the Missouri
2584 River, convey to your mind any idea of the volume of the sewage that enters that river?

A. Calculations could be made to that effect.

Q. Have you in mind now any idea of the volume of the sewage?

A. Well, as I say, it could be calculated by comparing it with the water supply of Kansas City as is done in a great many other cities, and then calculated on sixty per cent of that figure.

Q. Does that 60 per cent include the sewage from the packing houses and stock yards of Kansas City, do you know?

A. Yes, the sewage out-fall into the river as estimated by the city engineer and given to me personally.

MR. WOERNER: Do you know whether that includes the packing houses, or is that in the other 40 per cent?

A. Yes, it included the sewage of Kansas City.

Q. You said sixty per cent of it?

A. Sixty per cent of the population.

MR. TODD: Repeat my question.

(Question repeated)

A. Mr. Todd, I will withdraw that last answer.

Q. Do you know of your own knowledge anything about the sewage of Kansas City?

A. Yes sir.

2585 Q. State what you know about the sewage of Kansas City?

A. I know it from the official statement of the city engineer of Kansas City, made to me in December, 1902, that sixty per cent of the population of Kansas City, Missouri, the sewage of sixty per cent of the population drains directly into the Missouri River.

Q. Are there any stock yards in Kansas City, doctor?

A. I couldn't tell from my own observation.

Q. If there are any, do you know whether the sewage from the cattle in the stock yards is included in the sixty per cent of population?

A. Well that, I have no information about.

Q. Do you know where the slaughter houses in Kansas City, Missouri are located?

A. I don't know of any being located in Kansas City Missouri, because my understanding is that they are located in Kansas City, Kansas.

Q. Do you know whether the sewage from the slaughter-houses in Kansas City, Kansas, drains into the Missouri River or not?

A. I don't recollect at this moment; I really cannot remember.

Q. Doctor, do you know where Kansas City, Kansas is located?

2586 A. Yes sir.

Q. How far is that from Kansas City, Missouri?

A. Why, it is right across the Kaw River.

Q. Assuming that the slaughter houses and packing houses are located at Kansas City, Kansas, on the Kaw River, and that these packing houses, their sewage is emptied into the Kaw River; would that offer any explanation as to the chlorines that are found in the Kaw River?

A. The explanation can easily be given by the fact that the samples taken from the Kaw River were taken way above Kansas City, Kansas, so that no sewage from Kansas City, Kansas, could come into consideration there.

Q. The sewage of Kansas City, Kansas?

A. I understand it is Argentine, Kansas where the Kaw river samples were taken.

Q. It empties into the Missouri or into the Kaw River and ultimately gets into the Missouri River below the confluence of the Kaw with the Missouri, doesen't it?

A. Yes, if it is discharged into that river.

Q. And the sewage of Kansas City enters the Missouri at Kansas City, doesn't it?

A. Sixty per cent of the sewage.

Q. Doctor have you any personal knowledge of how much sewage enters at Kansas City, except what you have been told?

2587 A. Well, that is information I have from the city engineer of Kansas City, who ought to know.

Q. Do you know to what extent he has investigated the sewage question at Kansas City?

A. Yes, he told me that he had investigated it for years and is thoroughly familiar with the conditions.

Q. You have no knowledge of the sewage conditions there, except as were told to you by the city engineer, have you?

A. No sir, that is all.

A. And as to whether his statement of 60 per cent of the population is true or false, true or incorrect, you have no means of knowing, have you?

A. He made the impression upon me of being a trustworthy man.

Q. I am not asking you to pass upon his credibility. Have you personally verified any statement that he made to you?

A. No sir, I have not.

Q. As to what the amount is of 60 per cent of the population, you have no idea, have you?

A. Well now, I took a few notes at that time and I would have to look up those notes to answer that question.

Q. 'Did that 60 per cent include the manufacturing districts of Kansas City, or did it exclude the manufacturing districts of Kansas City?

2588 A. You mean now, Kansas City, Missouri?

Q. Yes, Missouri?

A. Well that I cannot remember just now. We had quite a long conference on the subject and I took notes of the most important facts, but I haven't got those notes with me at this moment.

WILLIAM C. TEICHMANN.

Adjourned until 10:00 a. m. Thursday, April 2nd, 1903.

2589 Southern Hotel, St. Louis, Missouri, 10:00 A. M., Thursday, April 2nd, 1903.

Continuation pursuant to adjournment. Present the Commissioner and the same counsel as before.

DR. WILLIAM C. TEICHMANN,

Resumed the stand for further cross-examination by Mr .Todd and testified as follows:—

Q. Doctor, in your analyses of the waters at Bellefontaine, was the presence of albuminiod ammonia and free ammonia evidence of pollution in the waters at that point?

A. Yes sir, that is, if the free and albuminoid ammonias were high.

Q. Were they high?

A. Well, they varied considerably. Sometimes the albuminoid ammonia would be what I would consider quite high, and the free ammonia would be low at that time, and then again the free ammonia would be a little higher, and the albuminoid ammonia would be lower.

Q. How long, doctor, does it take nitrites by the process of oxidation, to become nitrates?

A. It would be impossible to tell as to this process tak-
2590 ing place in running rivers, but from samples of water
that have been collected and left standing in laboratories, and from day to day the water analyzed for nitrites, and nitrates, some chemists have estimated the number of days it would take for the oxidation of the nitrites to nitrates in that bottle of water owing to the evident presence of aerobic bacteria in the water.

Q. Would the time depend upon the number of the bacteria in that water?

A. Evidently, because the aerobic bacteria are the ones that produce this oxidation of the nitrites to the nitrates.

Q. If the waters contained large quantities of bacteria such as you have described, the time for changing the nitrites to nitrates would be lessened, would it not?

A. Yes sir.

Q. Do you know of any rule that would apply to conditions such as are contained in the question just answered?

A. No sir, not in regard to the running waters, only in regard to laboratory experiments.

Q. Well, I mean in laboratory experiments, doctor.

A. Well, these laboratory experiments simply in each case would establish the fact that the nitrites found present in the respective samples of water on the first day, disappear after a number of days.

2591 Q. About how many days?

A. (Continuing)—and the nitrites increase show that they had been converted into nitrates.

Q. How many days would that take, doctor?

A. Well, that would depend very much upon the amount of nitrites present and the quantity of aerobic bacteria performing this oxidation process.

Q. Suppose that there would be a great number of aerobic bacteria present in the water and the nitrites were not in a large quantity, how long would it take?

A. This process would be a very rapid one. It might take 24 hours and it might take 48 hours for a—well a small amount of nitrites to disappear.

Q. If the aerobic bacteria were present in the running waters in great numbers, that would have a tendency to decrease the nitrites even in the water, would it not?

A. Yes sir.

Q. And when that water is placed in the laboratory, the action would be a great deal faster on that same water than it would while in the running stream, would it not?

A. Well, that could not be determined, because you can't bring in comparative results of the time required for oxidation action in the running water itself. You only have the
2592 laboratory samples there and have no river samples to compare with them.

Q. But by analogy, bacteria will work faster in still water than in running water, will they not?

A. Well the bacteria—it depends very much upon the number of bacteria present.

Q. Assuming the same number to a cubic volume of water in a running stream and in a vessel, would not the bacteria have better opportunities for working in still water than in running water that is constantly changing?

A. Well that would again depend upon the weather conditions at that time, for instance—

Q. Well, under the same conditions of temperature?

A. The same conditions of temperature—well they would be much more active during the warmer season of the year than they would in the winter season.

Q. Well I am speaking of the samples of water now in the laborotory—the laboratory tests?

A. There may be cases where that may be true.

Q. Well, do you know, doctor? Have you any definite information on the subject as to whether the an-aerobic bacteria—

A. Now you mean aerobic or an-aerobic?

Q. Aerobic bacteria in a given quantity of water in a given amount of nitrites, in a running water and in the
2593 water that is in the vessel, whether the bacteria will convert the nitrites to nitrates any faster in the bottle than it would in the river under the same temperature?

A. Well that would depend very much upon the quantity of dissolved oxygen present in the sample of water closed up in the bottle, because when that supply of dissolved oxygen is exhausted,—which dissolved oxygen is necessary for the life of the aerobic bacteria, and which dissolved oxygen is apparently used to oxidize the nitrites to nitrates by adding one atom of oxygen to the nitrites, and converting it into nitrates, when that supply is exhausted, why then the action ceases, and the aerobic bacteria would probably die, because they need the oxygen to live.

Q. In the laboratory test do you cut off the supply of the oxygen?

A. Well, the question is this, that it is the oxygen that is dissolved in the water which furnishes the supply for this bacterial action and bacterial life—

Q. Does that same condition obtain in the waters of the river?

A. Yes sir.

Q. So that if a sample of water was taken out of the river today, would the nitrites in that sample operate more speedily. I mean would the bacteria in that sample operate more speedily than they would in the river under similar conditions? 2594

A. Well, if the supply of dissolved oxygen would be larger in the sample in the bottle, in comparison with an equal quantity of water in the river and if the number of bacteria—aerobic bacteria would be larger in the bottle, of course the action would be much more rapid.

Q. Can you tell whether in the sample of water taken out of the river there would be any more bacteria in the sample than in the water of the river?

A. No, at the time when the sample would be taken and very soon afterwards naturally the proportionate quantity would be the same because the sample was taken from that river, but there are very rapid changes going on in the sample of water immediately after the collection, and—

Q. What changes are those, doctor?

A. Well, the aerobic bacteria will continue their action of oxidation constantly, that is, from the moment that the sample is taken and the sample as it gets to the laboratory.

Q. On the nitrites?

A. Yes sir. That is one of the reasons why the nitrites are first tested in the sample of water, because of the rapid oxidation.

Q. Does the oxidation process go on as swiftly for albu-
2595 minoid ammonia as for the nitrites?

A. No sir, it does not. That is—

Q. Does it go on as swiftly for the free ammonia as for the nitrites?

A. No sir, not as swiftly, but it does go on.

Q. Does the presence of clay or silt retard or facilitate the action of microbes upon nitrites?

A. Well this clay usually contains a large number of bacteria that perform this nitrifying process. They are found in the soil and this soil is washed into the rivers, and would get into the sample of water collected, and the bacterial action there by the laws of nature in oxidizing the nitrites would be materially facilitated by the nitrifying bacteria or these oxidizing aerobic bacteria in the soil there.

Q. So that the presence of clay and silt is evidence of a greater number of these bacteria that possess the nitrifying effect upon the nitrites?

A. Yes sir, the conclusion is justifiable that they are there in great numbers.

Q. Now doctor, the waters of the Missouri River—how do the waters of the Missouri River compare with the waters of
the Mississippi as to the presence of these bacteria, an-
2596 aerobic I believe you call them, wasn't it?

A. No, aerobic; those that live in the presence of oxygen.

Q. Aerobic bacteria.

A. The anaerobic bacteria, that is—

A. Well I have got it now. How do the waters of the Missouri compare with the waters of the Mississippi in the presence of aerobic bacteria?

A. Well the larger amount of sediment usually found,—not always, but,—well, prevailingly, found during the year in the Missouri River as compared with the Mississippi River would show that there are more nitrifying or so-called oxidizing aerobic bacteria in the Missouri River water and that of course would accelerate the oxidizing action in that water,—in the Missouri River water as compared with the Mississippi.

Q. Now the aerobic bacteria oxidizes the nitrates in water.

A. The nitrites.

Q. The nitrites in water much more rapidly than they do the albuminoid ammonia or the free ammonia, do they?

A. Well the analytical results by which this question was investigated from laboratory experiments shows throughout,—these various investigations of the kind have been made for instance by Mason, of Troy, New York—they show in the analytical results of water of one sample collected day after day from the same original sample that the changing of the am-
2597 monia into nitrites was slow, that is the reduction per day
of ammonia in quantity as estimated by analyses was very small, whereas, the reduction of nitrites was large and that small amounts of nitrites would as I said, disappear in a period of from 24 hours to 48 hours.

Q. Now when the samples were taken at Fort Bellefontaine, how long a period intervened between the taking of those samples and the analysis for nitrites?

A. These samples were collected about ten or eleven o'clock in the morning; they arrived at the laboratory regularly at half past one o'clock, or two o'clock if the train would be late. The nitrites were determined immediately upon the arrival ot the samples so that the period intervening between the time of the collection and the time of the analysis for nitrites constituted from three to four hours.

Q. During those three or four hours, could you tell to what extent the oxidation of the nitrites had taken place by the action of the aerobic bacteria?

A. No sir, because that would have necessitated comparative tests on the spot, or rather at the place of the collection, and then comparative tests very soon afterwards.

Q. So no test was made at the place of collection, was there?

A. Not for nitrites.

2598 Q. Was any test made that would enable you to speak
definitely as to how long it would take the nitrites in the Missouri water at the time of collection to be converted to nitrates?

A. You mean to nitrites or nitrates?

Q. The nitrites to be converted to nitrates?

A. The nitrates, oh yes. No sir, the samples were packed in ice and the low temperature would have retarded the oxidation action to such an extent that I would consider the changes that might have taken place in that direction during those few hours so insignificant that they could be overlooked in the result.

Q. But you made no effort to definitely ascertain whether that conclusion was justified or not, did you?

A. Well, I base this conclusion on the fact that if this water is kept at low temperatures this oxidation process is very slow and so slow that it would not affect materially the analytical result.

Q. Did you make any test between waters taken at the same time,—one sample kept at a low temperature and the other kept at the normal temperature of the weather at the time of taking, to ascertain what changes if any, took place between the time of taking and the time of analysis in order to ascertain the effect of temperature upon the waters? 2599

A. Not for samples collected at Fort Bellefontaine.

Q. Then if you made no test or analysis to determine that fact the statement that no changes of any appreciable amount took place because of the fact that the samples were packed in ice, is a mere assumption, is it not?

A. As applied to this particular case it is an assumption, but based upon comparative investigations of samples from other points—

Q. Under similar conditions?

A. Well, I won't say that they were absolutely similar, but conditions corresponding in a general way.

Q. With the presence of clay and silt such as is found in the Missouri River?

A. Well I don't recollect at this instant, whether those samples upon which these experiments were made contained as much sediment as the samples usually contain that come from Fort Bellefontaine.

Q. Did the samples that you speak of as giving you a criterion to base your judgment upon, have as many aerobic bacteria in them as is found in the waters of the Missouri at Fort Bellefontaine?

A. Well, that I could not tell because the quantities of these bacteria cannot be estimated.

2600 Q. Cannot a bacteriologist estimate the quantity of those bacteria?

A. No sir, not to my knowledge. That is, the absolute distinction between the quantities of these bacteria from those rivers to my knowledge, has not been made, but approximate estimates of the amounts have been made from septic tanks as to the total approximate number of an-aerobic bacteria and aerobic bacteria present in that tank, but to my knowledge no such experiments have been made as regards this water here.

Q. Has bacterial science developed to such an extent as to enable the bacteriologist to ascertain accurately the number of these bacteria in a given sample of water?

A. Not what I would call a result of absolutely correct figures. They are approximations which are derived from the method of bacterial counts in large numbers.

Q. Do you know whether any such investigation for the purpose of ascertaining the quantity of bacteria known as aerobic was made of the waters of the Missouri River at Bellefontaine, which you examined?

A. No sir.

Q. Can you state, doctor, as a positive fact, that the low nitrites which you found in the waters of the Missouri at Fort Bellefontaine are not attributable directly to the action of these bacteria from the time of the taking of the sample
2601 up to the time of the analysis?

A. If such a reduction of nitrites to nitrates, or rather oxidation, to be absolutely scientific, if oxidation of nitrites to nitrates took place in those samples while they were in transit from the station at Fort Bellefontaine to the laboratory it would be so inappreciable that it could be disregarded because of the fact that the samples were packed in ice and kept at a very low temperature from the time that they were collected until the time that the chemist would take the sample—open the bottle and make his nitrite tests.

Q. How do you know that, doctor, as a scientific fact, as applicable to the waters of the Missouri?

A. Because the comparative tests that I have made on several occasions of the samples that were packed in ice and sent from certain points to St. Louis, and samples taken from those same places that were not packed in ice and taken to St. Louis and analyzed, and samples that were analyzed for nitrites very soon,—probably ten minutes after they were taken from the place of collection and analyzed on a boat. From comparative tests that I have thus made there I have come to the conclusion that the oxidation of nitrites is inappreciable for six hours at times, and at other times at eight hours, if the samples were properly packed in ice.

2602 Q. Were those samples of water that you made that experiment upon, identical with the waters of the Missouri?

A. No, sir; they were Mississippi River samples.

Q. Did the water contain the same number of aerobic bacteria that the waters of the Missouri contain?

A. There were no bacteriological approximations made on the number of aerobic bacteria from those samples.

Q. Then if the process of oxidation upon nitrates depends upon the quantity of aerobic bacteria and you made no investigations to ascertain that fact, how can you assert that oxidation did not take place between the time of taking the samples in the Missouri River at Fort Bellefontaine, and the analysis in the laboratory of the city chemist?

A. Because if samples taken at a point and packed in ice, and not tested for nitrites until eight hours after the samples were collected, and they show no appreciable difference in the quantity of nitrites as compared with the sample analyzed practically on the spot of collection—I don't say spot of collection because the samples were taken from the Mississippi River, and on the harbor boat there were appliances enabling us to make direct tests for nitrites, right on the spot there, I say, if there was no appreciable difference there in the nitrite results, a sample of water packed in ice, collected from Fort Belle-
2603 fontaine and analyzed three hours after its collection
would not show much or any appreciable change in the nitrite results, because the nitrite results did not show it in the other sample for such a long distance. Now, even if the number of aerobic bacteria would have been considerably less—grant that—that they were less in the sample collected from the Mississippi River and not analyzed until eight hours afterwards, it would stand to reason that even the lesser number would pro-

duce the same result within a period of eight hours, because it is a much longer period than three hours, and the changes of the nitrites to nitrates will progress faster according to the time until eventually the supply of dissolved oxygen is exhausted, when their action ceases.

Q. Doesn't the test that you have just given only prove the absence of aerobic bacteria in the waters that you made the test with, and does not warrant the conclusion that you draw from it?

A. No, sir.

Q. If you were going to make the test to find out whether there was no aerobic bacteria operating upon the nitrites, wouldn't the test that you have just indicated demonstrate that fact?

A. I said that the changes were inappreciable. There must be some aerobic bacteria—must have been present in those samples taken from the Mississippi River. 2604

Q. And the test that you made showed the presence of a very small quantity of aerobic bacteria because of the fact that the nitrites were not appreciably oxidized, doesn't it?

A. That conclusion would only follow if the sediment in that water taken from the Mississippi River was very small, but I have not got the data at hand now, I don't remember exactly how much less a sediment or how much less a suspended matter in the form of sediment was present in those Mississippi River samples on that day, or whether there may have been more present than in samples of the Missouri River; although I will say that at times the Missouri River has more sediment than the Mississippi River at any time.

Q. Can you, doctor, institute a proper comparison between the waters of the Missouri and the waters of the Mississippi?

A. Yes, sir.

Q. And can you draw an accurate conclusion as to the effect of aerobic bacteria upon nitrites in the Missouri from an investigaton in the Mississippi?

A. There are—

Q. Now answer my question, doctor. I am going to insist upon a definite answer and an explanation afterwards.

A. Yes, sir, I can.

2605 Q. You can?

A. Yes, sir.

Q. You made no investigation in any of your analyses for the presence of aerobic bacteria in the waters of the Mississippi, did you?

A. No, sir.

Q. The oxidation of nitrites depends upon the presence of these bacteria, does it not?

A. Yes, sir.

Q. If this bacterium is present in large quantities, oxidation will be facilitated, will it not?

A. Provided, that there is also a large quantity of dissolved oxygen present in that water.

Q. Is there any reason why there would not be as large a quantity of dissolved oxygen in the waters of the Missouri as in the waters of the Mississippi?

A. There may at times be more disolved oxygen found in one river than there is in the other—either one.

Q. Did you make an examination of the waters of the Mississippi River to find out whether the quantity of dissolved oxygen was the same, more or less, in the Missouri than in the Mississippi?

A. Yes, sir.

2606 Q. In connection with the analyses of these samples?

A. I had such tests made by my assistants.

Q. Did you take that into consideration in arriving at the conclusion as to the oxidation of nitrites in the Missouri River from the time of taking, to the laboratory?

A. I examined the analytical—

Q. No. Did you take it into consideration, doctor, in giving your opinion?

A. I did.

Q. What was the difference between the oxidation in the Missouri and the oxidation in the Mississippi at the time these samples were taken?

A. Now, I will have to look up the data; it is some time ago that those data were prepared.

Q. Was it more or less in the Missouri than in the Mississippi?

A. I will have to look up the data. I haven't it at hand here, though.

Q. Was it the same in the Missouri as in the Mississippi?

A. Well, now, there are only a few occasions when those tests were made, and I really do not recollect the exact figures at this moment, but I have them ready.

Q. Was the difference marked enough to change the
2607 character of the waters of the Missouri from the waters
of the Mississippi?

A. That I am not prepared to say until I have looked at the data again; I haven't got them at hand, and haven't looked at them for some time.

Q. Then, doctor, if you made no comparison between the aerobic bacteria of the Missouri and the aerobic bacteria of the Mississippi and the clay and silt of the Missouri facilitates oxidation of nitrites, can you state as a positive ascertained scientific fact that the nitrites in the Missouri River at the time of taking the sample, do not become oxidized by the actions of these microbes to a large extent from the time of the taking of the waters to the time that they reached the laboratory?

A. Yes, sir.

Q. You can?

A. Yes, sir.

Q. What is the time?

A. The difference would be inappreciable, because—

Q. How do you arrive at that time, doctor, as to the particular waters of the Missouri River in the absence of having made any test upon that water?

A. Because I consider three hours for the transfer of those
samples, provided, that the samples were packed in ice
2608 and kept on ice from the time of their collection to the
time of their analysis, I consider any change that may
take place so inappreciable that it can be disregarded in the chemical results in drawing conclusions from the chemical results of the analyses of that sample at the laboratory.

Q. Can you give me any reason based upon your scientific examinations of the waters of the Missouri, why one hour would not be more nearly the exact time than three for ascertaining that conclusion?

A. I am convinced that three hours wouldn't make a material difference so as to in any way affect the result of the analyses and affect the conclusions to be drawn from the result.

Q. Do you know what the difference would be in nitrites upon the waters in the Missouri River analyzed at the time of taking and analyzed four hours afterwards at the laboratory?

A. I don't know at this moment.

Q. Have you ever made an examinaton of the waters of the Missouri River at Fort Bellefontaine at the time they were taken out of the river?

A. No, sir, not at Fort Bellefontaine.

Q. That's what I am speaking about.

A. I have taken samples and analyzed them at the mouth of the Missouri which I had just recollected.

2609 Q. Now, as you have made no examination, doctor, of the waters at Fort Bellefontaine at the time they were taken out of the river to compare with the samples analyzed three or four hours afterwards—are you able to state as a scientific fact what the effect of the aerobic bacteria upon that water is from the time of leaving the stream until the time it gets to the laboratory?

A. The conclusion would be justified—

Q. I am not asking for the conclusion, doctor?

A. The effect is unappreciable.

Q. (Question repeated.)

A. Yes, sir.

Q. You are?

A. Yes, sir.

Q. Is that result attained by the analyses of the waters of the Missouri at Fort Bellefontaine?

A. You mean the analyses of the samples taken at Fort Bellefontaine in the laboratory?

Q. No, at Fort Bellefontaine?

A. You mean the analyses made at the point of collection?

Q. Yes?

A. No, sir.

2610 Q. Is the conclusion arrived at by the analyses of waters in every way similar to the waters of the Missouri River at Fort Bellefontaine?

A. It is a conclusion arrived at from a number of analyses of waters made sufficient to justify the conclusion that the effect of oxidation in transit between Fort Bellefontaine and the laboratory would be unappreciable.

MR. TODD: I move to strike out the answer and ask for a specific answer to my question.

(Question repeated.)

A. I cannot tell at this moment because I haven't got the data at hand upon which I base these conclusions, for comparison, to say whether the samples were similar in chemical character. It may have been that the conditions prevailing at Fort Bellefontaine—I cannot tell that.

Q. You cannot tell?

A. No, sir.

Q. Doctor, can you institute a comparison between similar waters?

A. Yes, sir.

Q. Can things of dissimilarity be compared?

A. Well, now—

Q. As an example, can you compare a horse and a cow?

A. There is a tautology in that question.

2611 Q. Can you, in chemistry, compare or draw a comparison between dissimilar quantities in chemistry any more than you can draw a comparison between dissimilar animals?

A. Well, I won't say in regard to animals, but in regard to chemistry I would answer that question yes.

Q. Can you institute a comparison between the waters of the Missouri River and the waters of the Mississippi as far as the oxidation of nitrites are concerned in the absence of any knowledge upon the number or quantity of the aerobic bacteria in that water?

A. Yes, sir.

Q. It can be done, can it?

A. Yes, sir.

Q. Does the quantity of aerobic bacteria have anything to do with the comparison?

A. Not directly.

Q. Does it indirectly?

A. As far as—

Q. Answer yes or no. You stated not directly. Now does it indirectly?

(Question repeated), of the waters of the Missouri, and the waters of the Mississippi?

A. A comparison taken from what standpoint?

Q. For the oxidation of nitrites?

2612 A. No, sir.

Q. Then, if the quantity of bacteria has nothing to do with the oxidation of nitrites directly or indirectly, what effect upon the nitrites do the bacteria have?

A. It is a question of cause and effect. The effect is established by analytical results. "What is that water," "what kind of water is it?" Then if the causes of the condition found in that water are taken into consideration; the causes, for instance, why the low nitrites are found, or the high nitrates, then in considering the cause of that condition found as the effect, the action of the aerobic bacteria would come into consideration as an explanation for the cause of that effect.

Q. The effect in water analyses is just as essential as the cause, isn't it?

A. Certainly, the effect is based upon the cause.

Q. And the cause plays a considerable part in the analyses, doesn't it?

A. No, sir. You look for the effect only. You want to establish the character of that water; you want to say "What kind of water is this?" You say, "What is the analytical result?" That is the effect.

Q. You say in your analyses you look for cause, didn't you, throughout this investigation?

2613 A. I looked for causes so far as the water is concerned, on the route between Chicago and St. Louis.

Q. But as far as the Missouri River is concerned, you didn't look for causes?

A. No, sir. You mean Fort Bellefontaine samples?

Q. Fort Bellefontaine?

A. As regards Fort Bellefontaine samples I only looked for the condition of the water at Fort Bellenfontaine.

Q. And didn't look for the causes?

A. No, sir.

Q. And that is the reason in the analyses of the waters of the Missouri River that you eliminated the consideration of the sewage pollution coming from Kansas City, Missouri, and Kansas City, Kansas, is it because you didn't care to—because you went at the effect? Answer that question, doctor, yes or no?

A. The effect would be the only fact that came into consideration in this investigation.

Q. And it doesn't make any difference whether the causes which established that effect was sewage contamination from Kansas City, Missouri, and the stock yards pollution from Kansas City, Kansas. All you were looking at was the effect at Fort Bellefontaine, is that right?

2614 A. Since for certain months I established the fact, in certain periods of the year, I established the fact that the water found at Bellefontaine was chemically good and potable water, and the conclusions that I have drawn from the conditions of that water as I found it were based upon the conditions prevailing during that period, a consideration of any cause there, was immaterial, unnecessary, because all that was necessary to establish was the sanitary character of the water at Fort Bellefontaine.

MR. TODD: I move to strike out the answer and ask to have a specific answer to my question.

(Question repeated.)

A. Well, I don't admit sewage pollution at Fort Bellefontaine from Kansas City or the stock yards.

MR. TODD: I move to strike out the answer and ask to have a specific answer to my question.

A. Well, the question is based—

Q. My question is clear cut and put in decisive language, doctor, and I would like to have you answer it, based on your testimony.

A. It involves the existence of sewage pollution at Fort Bellefontaine and Kansas City, which I do not admit.

MR. TODD: I move to strike out the answer and ask to have a specific answer to my question.

2615 Q. (Question repeated.)

A. It would make a difference if I establish pollution of the water as due to sewage from Kansas City and refuse from the stock yards because that would involve a question that required consideraion as to the point of a pollution of streams.

Q. Do you consider that as an answer to my question, doctor?

A. As I say, I cannot answer the question in any other way.

Q. Now, do you consider that last answer an answer to my question?

A. Yes, sir.

Q. Were you looking after the causes in your analyses of the waters at Fort Bellefontaine?

MR. WOERNER: The causes of what?

MR. TODD: Or for simply the effects, whatever those effects might be?

A. During that period—

Q. Answer my question, doctor?

A. I did partly during that period when the investigation showed pollution of the Missouri River at Fort Bellefontaine, I considered it my duty to ascertain what this pollution may be ascribed to.

2616 Q. Then your answer to my previous question that you were looking for effect and didn't take into consideraion the causes, you wish to modify, do you?

A. That is to be applied to that period when I found that water good and potable; then it was unnecessary to look for any cause, but during that period of the investigation when I would find the Missouri River water polluted I made an effort to ascertain the causes of that pollution.

Q. Then when you stated that in your investigations at Fort Bellefontaine you were only looking for the effects and had nothing to do with the cause, you didn't exactly state your condition, did you?

A. I understood the question to apply to that period of the investigation which was discussed when we found the water good and potable.

Q. So, then, as long as you found the water good, you didn't look for any causes?

A. No, sir.

Q. And as you found the water good nearly all the year there was no necessity for looking for any causes, was there?

MR. WOERNER: We object to the question, because it is impossible to tell what causes are referred to in the question. What is meant by the word "causes?" I am sure I don't understand it.

2617 MR. TODD: The causes of purification.

A. When you speak of causes—

Q. I want this all in the record. I am willing once in a while to let it go, but I want to have it all in the record, doctor?

A. All right.

Q. Now, when you found the water pure or good, that is the word you used—at Fort Bellefontaine, you didn't look for the causes that created that good condition of the waters, did you?

A. No, sir.

Q. You were mindful all the time in your investigation that the sewage of Kansas City, Missouri, and Kansas City, Kansas, and the other towns located upon the Missouri River, was emptying into the Missouri River, were you not?

A. Yes, sir.

Q. And as long as you found the water good, you didn't look for the causes that purified the water from the sewage contaminations of the cities above, did you?

A. No, sir.

Q. Are you able to state what made the waters good with the knowledge that there was sewage pollution at Kansas City and at other points?

A. Nobody could state that—that is impossible.

2618 Q. Then that is a matter outside of the realm of scientific research, is it?

A. No, sir.

Q. Then if nobody could tell what caused that, can you name anybody who could?

A. No, sir.

Q. Then, if nobody knows what causes, scientific men have not been able up to the present time to give an explanation of that condition of purification, have they?

A. They can give an explanation from studying the general conditions prevailing in the Missouri River between Kansas City and Bellefontaine.

Q. Then, what did you mean, doctor, by stating that no one could tell the causes of purification?

A. Because scientific researches have not been made to the extent of analytical survey of the entire route from innumerable points between Kansas City and St. Louis, and therefore an opinion may be formed on the queston of what becomes of the Kansas City sewage, would be based upon the general conditions prevailing in that river between Kansas City and St. Louis as described in my testimony previously, from which general conclusions could be drawn as to what may become of the Kansas City sewage.

Q. It is problematical, is it?

2619 A. Yes, sir.

Q. No scientifically ascertained results at present have been achieved?

A. It is problematical, yes, sir.

Q. But it isn't problematical what becomes of the sewage of Chicago, is it, doctor?

A. The conditions—

Q. Answer the question, doctor?

A. The Chicago sewage is entirely different.

Q. Has the light of scientific truth shone more clearly upon the chemical and bacteriological mind, in regard to the Chicago sewage than that of the Kansas City sewage?

A. The conditions of the two rivers are so materially different. The quantity of sewage coming from Kansas City being discharged into the river is so materially different from the sewage being discharged from Chicago into the Desplaines River, the conditions of the Desplaines River and the Illinois River vary so much from the conditions prevailing in the Missouri River. The distance between Chicago and St. Louis for the sewage to run, 357 miles, and the distance from Kansas City to St. Louis, 403 miles.

Q. Making how many miles difference?

A. Forty-six miles.

2620 Q. Doctor, have you any personal knowledge of the quantity of sewage from Kansas City that empties into the Missouri River?

A. I haven't got the data at hand.

Q. I mean personal knowledge.

A. I have calculated the amount of sewage discharging into the Missouri River on the same principle, and at the same ratio that the sewage from Chicago is calculated on.

Q. We will get at the sewage of Chicago before we get through, doctor. I want to know if you have got any personal knowledge of the amount of sewage from Kansas City, Missouri, and Kansas City, Kansas, as to the quantity, that enters the Missouri River?

A. Yes, sir.

Q. Have you been there and investigated it?

A. I have been there.

Q. Have you seen where the sewage empties into the Missouri River?

A. That is not necessary.

Q. I am not asking you what is necessary. Have you seen it?

A. No, sir.

Q. Do you know how much sewage enters the Missouri River from the Kansas City stock yards and the packing houses?

A. I formed a computation upon recognized tables that are usually used.

MR. TODD: I move to strike out the answer as not responsive. 2621

Q. Do you know? You can answer yes or no.

MR. JEFFRIES: I submit the witness has stated how he knows.

Q. MR. TODD: If he has answered the question—I submit to counsel that is the proper way to answer a question, yes or no. It is a question if he knows.

A. I don't know at this moment, because I haven't got the data at hand upon which I can base the customary calculations.

Q. Have you ever been in Kansas City, Kansas, where the slaughterhouses and packing pens and cattle-sheds are located?

A. I have been in Kansas City, Missouri.

Q. I am asking you about Kansas City, Kansas.

A. Not in Kansas City, Kansas.

Q. Do you know anything about the quantity of sewage from those slaughterhouses in Kansas City, Kansas?

A. I did know it, and I can re-calculate it again if I have the tables here.

Q. Based upon your personal knowledge?

A. I consider that personal knowledge.

Q. Do you consider what somebody else has told you as being personal knewledge?

A. No, sir; but personal investigation.

Q. I am not asking about personal investigation. I want to know about your personal knowledge.

2622 A. I consider that personal knowledge.

Q. You consider, then, what somebody else has told you as personal knowledge?

A. This is not what somebody else has told me.

This is my own personal information.

Q. Do you know how much sewage comes from the slaughterhouses?

A. That is impossible to know unless one examines the respecitive slaughterhouses and makes personal estimations and personal investigations on the spot.

Q. That you have not done, have you?

A. That is not customarily done.

Q. I am not asking you about the custom; I want to know what you have done?

A. I haven't done it, no, sir.

Q. Then you don't know as a matter of fact what the quantity of sewage that enters the Missouri River at Kansas City, Kansas, or Kansas City, Missouri, do you?

A. I can ascertain it by customary computation.

Q. Have you in your mind now, doctor, any definite amount of sewage that enters the Missouri River at those points?

A. Not at this moment. This data I have prepared some time ago. I haven't got them at hand now. I cannot recall them at this moment; it is impossible to do that.

2623 Q. In giving your answers to questions that have preceded, have you taken into consideration by any definite assumption the amount of sewage entering the Missouri River from those two points, based upon personal knowledge?

A. That depends upon what you consider personal knowledge.

Q. I mean personal knowledge that everybody considers personal knowledge. Knowledge that you have obtained by your personal observation?

A. Yes, sir.

Q. And yet you cannot state that you have a personal knowledge of the sewage of Kansas City, Missouri, as you have never been in the town?

A. This personal knowledge is obtained in the customary way by customary calculation.

Q. Do you know the size of the slaughterhouses in Kansas City, Missouri?

A. No, sir.

Q. Do you know the number of cattle that are slaughtered there per day?

A. I couldn't tell you at this moment.

Q. I mean Kansas City, Kansas.

A. I had those data but I haven't got them at hand and I haven't got them in my memory at this moment.

2624 Q. Have you ever figured it out in tons, the amount of sewage that enters the Missouri at Kansas City, Kansas, and Kansas City, Missouri?

A. I have estimated it in volume, yes, sir.

Q. Have you estimated it as to Kansas City, Kansas?

A. Yes, sir.

Q. What is the purpose of making that estimation, doctor?

A. The purpose of that estimation was to ascertain how much sewage enters the Missouri River, in accordance with the customary estimation, from Kansas City, Missouri, and Kansas City, Kansas.

Q. What did you want to know that for, doctor?

A. To find out how much sewage these cities discharged into the Missouri River.

Q. After you found that out, what use did you make of it?

A. Well, I studied the conditions of the Missouri River and I utilized the data in the customary way such conditions are studied.

Q. When you made your analyses below Kansas City, Missouri, for the ascertaining of chlorine in the Missouri River, why didn't you take into consideration the volume of sewage that you have testified to having at one time estimated in considering the chlorine test at that point?

A. I didn't consider the chlorines; I considered the sewage
2625 as such.

Q. My question is, why didn't you take into consideration in ascertaining the source that chlorine came from, the sewage of Kansas City, Kansas, and Kansas City, Missouri, when you made the test below Kansas City?

A. Because it is difficult to estimate from the volume of sewage discharged into that river the quantity of chlorine.

Q. Is it any more difficult, doctor, to estimate the quantity of chlorine below Kansas City, that enters that river from the sewage of Kansas City, Missouri, and Kansas City, Kansas, than it is to estimate the amount of chlorine that comes from the Kaw river population of Kansas City?

A. That is a different proposition. The chlorine in the Kansas or Kaw River is estimated and analytically by taking a sample right from the river and analyzing it, the quantity of chlorine, to find out how much chlorine is contained in the sewage discharged from the city of Kansas City, is extremely difficult, because there are a number of sewers there and the water has to be taken out of the sewers there and tested, and then you have to approximate, which may not be sufficiently reliable to be used as data, establishing how much chlorine there is in sewage coming from all these sewers.

Q. Was it because of the difficulty in ascertaining those facts that made you eliminate the sewage from Kansas
2626 City, Missouri, and Kansas City, Kansas, in ascertaining the chlorine below Kansas City and attributing it to the Kaw River?

A. I didn't eliminate the sewage of Kansas City in passing an opinion on the chlorines, as compared in the Kaw River and found below Kansas City.

Q. How much of the chlorine that you discovered in your analyses below Kansas City, was attributable to the sewage from Kansas City, Kansas, and Kansas City, Missouri?

A. That is a question which I yesterday answered, that I couldn't tell because I hadn't made investigations as to the quantity of chlorine to be found in the sewage discharge from various out-falls, into the Missouri River, because of the extreme difficulty in ascertaining the amount of chlorine there.

Q. Can you say now from your investigations that 80 per cent. of the chlorines found below Kansas City, is not directly attributable to the sewage from those two places?

A. I couldn't say from any investigation made, but I don't think that it is likely.

Q. Have you an opinion as to what amount of it is attributable to the Kaw River?

A. Well, that depends upon the volume of water in the Missouri River at Kansas City.

Q. What's that?

2627 A. It would vary much; it depends upon the volume of water in the Missouri.

Q. Then taking the chlorine at Bellefontaine can you state how much of that chlorine is attributable to the sewage pollution of the Missouri River from Kansas City, Missouri, and Kansas City, Kansas.

A. When the Missouri River is low at Kansas City, I would attribute a considerable portion of the chlorines found at Bellefontaine to the Kaw River.

MR. TODD: I move to strike out the answer and ask to have a specific answer to my question.

(Question repeated.)

A. I couldn't tell in accurate figures.

Q. Is there anything in connection with the chlorine itself that will enable you to tell whether it is mineral pollution as evidenced by the discharge of the Kaw, or sewage pollution as evidenced by the sewage of Kansas City, Kansas, and Kansas City, Missouri?

A. Yes, sir.

Q. What is it, doctor?

A. As I explained yesterday.

Q. Just explain it today.

A. The fact that the analytical results of the water at
2628 Fort Bellefontaine do not show correspondingly high free
ammonia and chlorines and nitrites together.

Q. Doctor, I suggest you don't understand my question.

MR. WOERNER: Yes he does. He is getting that all right. Go ahead, doctor.

A. (Continuing) And that the nitrites are uniformly low is no justification to ascribe that pollution or rather to ascribe the high chlorines to sewage pollution.

MR. WOERNER: Let him answer that question without interruption. You interrupt him.

MR. TODD: I am satisfied he is not answering the question. I am satisfied he doesn't understand my question.

Q. (Question repeated.) The question is, is there anything in the chlorine itself?

A. No, sir.

Q. Then the only reason that you attribute the presence of chlorine at Bellefontaine to the Kaw River and not to sewage is based upon considerations aside from the chlorine itself?

A. No, sir. Now, I can explain if you want me to.

Q. You have answered my question, doctor, and if you want to explain you may.

MR. JEFFRIES: Go ahead and explain.

A. In determining that question it is necessary to take into consideration the general analytical results as found from
2629 the analyses of the samples at Fort Bellefontaine. If
the chlorine is due to sewage pollution there should be high nitrites; high free ammonias, and high organic matter would show in the results. If the nitrites are low and the free ammonias low, as it usually is in the Missouri River, this high chlorine cannot be attributed to sewage pollution; it must come from mineral matter. It must come from salt.

Q. Then the determination of the sources of the chlorine must be had from outside considerations, aside from the chlorine itself, is that right?

MR. JEFFRIES: The witness answered that very same question an hour ago.

MR. TODD: He answered another question in which the answer to that question is found, but not that question.

THE WITNESS: I don't understand the queston.

Q. (Question repeated.)

A. Yes, in such a case.

Q. And that determination is largely based on low nitrites, high free ammonia—low free ammonia and what else?

A. And low nitrites.

Q. Anything else?

A. And high chlorines.

2630 Q. How about albuminoid ammonia, doctor?

A. I believe I stated that albuminoid ammonia would come into consideration as organic matter.

Q. High or low albuminoid ammonia?

A. Either high or low. If the free ammonia were low and the nitrites were low, that is the most essential point involved there.

Q. Did you find high albuminoid ammonia in the Missouri River?

A. I found at times comparatively high albuminoid ammonia, yes.

Q. Didn't that condition obtain nearly all the year?

A. No, sir.

Q. What part of the year for the albuminoid ammonia?

A. Well, now, to be accurate I would have to refresh my memory from the data there.

Q. Will you make a mental note of that and at two o'clock be prepared to give me in a short answer the period that high albuminoid ammonia was in the water?

A. Yes, sir, I will.

Q. How about the free ammonia, doctor?

A. Well, the free ammonia for the major part of the year is very low; is very low in the Missouri River for the major part of the year.

2631 Q. Do you know how much of the time?

A. The larger part of the year I would consider it low.

Q. And the nitrites are low all the time?

A. Yes, they are either very low or absent entirely.

Q. Now, if the chlorines were attributed to sewage pollution and not to the Kaw river, what conclusion would you arrive at on that hypothesis?

A. Well, conclusion as to what?

Q. As to the potability of the water?

A. In determining the potability of the water, I would take into consideration general analytical results.

Q. Well, assume that the general analytical results show albuminoid ammonia, free ammonia, low nitrites, chlorines in the amount that you found it, but that the chlorines were attributable to sewage pollution, and that there was no river Kaw there?

A. Well, if it would be an established fact that the chlorine was due to sewage pollution, why that water in itself would be unpotable, because of its sewage origin, and if the chlorines were identified as coming from sewage pollution, the presence of the other ingredients going with it would of themselves form a part of that conclusion, because the fact is then established as such, that the chlorine is due to sewage pollution. If that fact is established.

2632 Q. Would the volume of the Kaw River, if its volume was shown to be very small in comparison with the volume of the Missouri River, change your conclusions if the presence of chlorine in the Missouri River at Fort Bellefontaine was attributable to the Kaw, if the volume of the Missouri River would be very high?

A. You mean extremely high?

Q. Yes?

A. And the volume of the Kaw River would be very small?

Q. No, that isn't what I mean, doctor. I understand that the conditions that would make the Kaw River high would make the Missouri River at that point high, and the conditions that would make the Misouri River low, would make the Kaw River low, as they come practically from the same watersheds.

A. But then sometimes the Kaw River may be high because it comes from an entirely different direction and drains 300 miles and a great many tributaries besides.

Q. Assuming that it should appear that the volume of the Kaw River throughout the year was very small in comparison with the Missouri River throughout the year, would that fact change your conclusion that the chlorine in the Missouri was attributed to the Kaw and not to sewage pollution?

A. If such conditions as you describe just now would prevail at the time of considering that question, the immense dilution of the chlorines, first in the Kaw, and then again in the Missouri River, would practically wipe out the effect of the addition from the Kaw River as far as the effect upon the Missouri. 2633

MR. WOERNER: You mean by that it wouldn't be noticeable in the Missouri?

A. It wouldn't be noticeable if these conditions would prevail that Mr. Todd describes, at the time of the consideration of the question.

MR. TODD: Now, doctor, when you made the nitrate test —

A. Do you mean the nitrate or the nitrite?

Q. The nitrite test. Was the nitrite test made on the water directly or after filtration. Do you understand my question? Was it made upon the waters of the Missouri River before filtration or after filtration?

A. Well, the laboratory test included the clarification by Aluminum hydrate.

Q. Did you run it through a filter before making the nitrite test?

A. No sir; it was clarified by adding alum.

Q. That is, the water in the natural state from the Missouri was clarified by adding alum?

A. Yes sir, that is necessary because a clear solution of 2634 the sample must be obtained in order to make the Griess-Warrington nitrite test.

Q. After the addition of alum was the water filtered?

A. Yes, of course.

Q. And after the filtering the tests were made?

A. Yes sir.

Q. Doctor, you stated that you were never in Kansas City, Kansas, didn't you?

A. Yes sir.

Q. That's what I understood you to say?

A. Yes sir.

ADJOURNED until 2:00 P. M., same day, Thursday, April 2, 1903.

2635 Southern Hotel, St. Louis, Missouri. 2:00 P. M., Thursday, April 2nd, 1903. Continuation after recess. Present, the Commissioner and same counsel as before, representing the respective parties.

DR. WILLIAM C. TEICHMANN,

Resumed the stand for further cross-examination by Mr. Todd and testified as follows:

Q. Before taking up that other topic, doctor, I want to ask you one or two questions. How long have you known that the waters of the Missouri were potable?

A. Since 1899.

Q. You have always been an advocate of using Missouri River for consumption in the city, have you not, since you have been city chemist?

A. Yes sir, but used under certain circumstances connected with the—

Q. You have agitated the use of Missouri River water have you not?

A. In preference to that of the Mississippi at the present intake.

Q. At the present intake?

2636 A. Yes sir.

Q. When did you first entertain those views in regard to the Missouri River water as being the best water to be used in the city of St. Louis?

A. In 1899.

Q. Previous to that time did you have any views on the subject?

A. No sir, not on the Missouri River as a preferable source for our water supply.

Q. When did you first become connected with the city as City Chemist,—what year?

A. In 1893.

Q. At the time that you became City Chemist, did you know of the contemplated building of the drainage canal of the Sanitary District?

A. Yes sir.

Q. When did you first learn of that contemplated improvement?

A. Well, that had been on visits to the city of Chicago previous to 1893.

Q. Did you read anything about the building of that canal in the newspapers of St. Louis, at the time that the bills were passed in the legislature of Illinois at Springfield?

A. Well, that is prior to 1890, isn't it?

2637 Q. Yes, 1889?

A. 1889—no sir, not at that time.

Q. And from 1889 on to 1893 or 1894, was anything said about the canal and its construction, in the papers of St. Louis, that you know of?

A. Yes sir, the matter was discussed in the year 1893 to some extent.

Q. It was a matter of general knowledge then in St. Louis that this improvement was being made in Chicago, was it?

A. Yes, it came up before the Board of Health in the form of discussion of a resolution introduced in the year 1893.

Q. And who introduced the resolution, doctor?

A. I believe the Health Commissioner of St. Louis at that time, Dr. George Homan.

Q. Have you a copy of that resolution?

A. I have it not on hand just now, but it is published in the annual report of the Health Department for that year. I could produce it.

Q. Could you state in the absence of the resolution,—which I would like to have you produce,—the contents in substance of what that resolution was?

A. Now, as far as I can recollect it—this is quite a long time ago, there were several resolutions. One resolution was that in view of the construction of the drainage canal
2638 at that time going on in Chicago—

Q. That was in 1893, was it?

A. Yes—a national board of experts should investigate that question as far as it would affect the water supply of St. Louis and questions in general pertaining to sewage pollution. The Board of Health recommended in the resolution either that Representative Barthold of St. Louis in Congress, should introduce a measure asking for such an investigation, or that such a measure had already been introduced by Mr. Barthold, and was supported by this resolution. The other resolution was calling upon the City Chemist to perform some analyses of samples of water,—he was to collect them from the mouth of the Illinois, down to the city of St. Louis at that time, from the Mississippi River and the Illinois River.

Q. Were these resolutions passed?

A. Yes, sir.

Q. And was that all the action that was taken at that time?

A. Well now, I don't recollect whether the recommendation of the Board of Health made to the Mayor of St. Louis, for an injunction suit in the Federal Courts against the construction of the drainage canal, whether that was the result of the analyses that I made of the water or whether it preceded this investigation. I cannot recollect at this time, because it is nearly ten years ago.

2639 MR. JEFFRIES: We object to the question and move that the above question and answer be stricken out because it is immaterial and not responsive to the issues involved in this case.

Q. MR. TODD: Can you secure for me the copies of those resolutions and the recommendations of the President of the Board of Health to the Mayor?

A. Yes sir.

Q. And will you do so and produce them here?

A. Yes sir. I can furnish you with a copy of the annual report in which the proceedings of the Board of Health are printed, and these resolutions are verbally copied.

Q. And do you know whether the recommendations in regard to an injunction, that was communicated to the Mayor of the City was ever presented to the city council here or not?

A. Well that I don't know, because it was presented to the Mayor of St. Louis and what became of it after that I could not tell you, I do not know.

Q. Did you make a cross-section of the waters of the Mississippi River above Grafton?

A. No sir.

Q. Did you make a cross-section of the waters of the Illinois River before the same entered into the Mississippi river at Grafton?

A. No sir, not at Grafton.

2640 Q. Did you make a cross-section of the Mississippi River below Grafton?

A. Yes sir.

Q. Where, doctor?

A. At Alton and at Hartford.

Q. How far is Alton below Grafton?

A. Alton below Grafton? I will have to look that up *exactly*. *I have it in the record here.* Alton is located sixteen miles below Grafton.

Q. How many samples were taken at Alton in that cross-section, doctor?

A. Five.

Q. Where were the samples taken?

A. That is, whenever a cross-section was taken,—five cross-sections, five points were selected in a line across the river.

Q. At the same time.

A. And the samples taken at that point, the number of days when these cross-sections were taken cover about a month,—every day.

Q. There were five samples taken crossing the river each day for about a month?

A. Yes sir.

Q. And where were the samples taken from?

A. There were collectors in a skiff who would row across 2641 the river in as straight a line as possible, and the samples were taken then in the customary way, from the river, direct from the skiff.

Q. I mean, how far apart, doctor, that is what I want to get at?

A. Well that I don't know exactly, but the distances were evenly divided in the five parts—into five parts in accordance with the samples.

Q. Then where were the next samples taken?

A. At Hartford in the Mississippi, one mile above the mouth of the Missouri.

Q. And how many samples were taken there, doctor?

A. Also five samples in the same manner and form.

Q. For what period of time?

A. For about a month.

Q. And were the samples that were taken at Alton taken during the same months and days that the samples that were taken at Hartford—

A. Practically; there were a few samples taken at one point I believe, which the record will show. I don't remember it just this moment.

Q. No, but did they cover the same period of time in both places, the same months?

A. Yes sir.

2642 Q. What month was it, doctor, that these examinations were made at Alton?

A. In the month of November.

Q. What year?

A. 1901.

Q. And the same in November, 1901 at Hartford?

A. Yes sir.

Q. Did you make any cross-sections in November, 1901, at any other place except Alton and Hartford?

A. Yes sir.

Q. Where, doctor?

A. At the chain of rocks, that is St. Louis Waterworks, in the Mississippi River.

Q. How many did you make there?

A. On five different days from November 25th to November 30th.

Q. How many samples did you take?

A. Twelve samples were taken across the river.

Q. November 25th to November 30th, twelve samples were taken across the River at the Chain of Rocks?

A. Yes sir.

Q. Were any more samples taken at that time in cross-sections except at Alton, Hartford and Chain of Rocks?

2643 A. Yes sir, there were some cross-sections taken from the Illinois River.

Q. Where were the cross-sections taken, from the Illinois River, doctor?

A. They were taken at points between Peoria and Pekin and at Pekin.

Q. How many samples were taken at Peoria—I mean in November?

A. I will have to look up the record sheet to tell you.

Q. How many samples were taken at Pekin in a cross-section?

A. I cannot recollect this moment; I have the sheet here, though.

Q. Were any samples taken at the mouth of the Illinois River?

A. For cross-section?

Q. Yes?

A. No sir.

Q. Were any samples taken at the mouth of the Missouri River in November for cross-sections?

A. Not from the mouth but at Fort Bellefontaine, two cross-sections were taken.

Q. Where was the first one taken?

A. At Fort Bellefontaine, on November 29th.

Q. How many samples were taken there?

A. Eight samples were taken across the river.

2644 Q. And where were the next samples taken—that was when?

A. On November 29th.

Q. And were any taken at any other place?

A. Then again on the following day, on November 30th, another cross-section was taken at Fort Bellefontaine.

Q. Any other place except Fort Bellefontaine that samples were taken in cross-sections?

A. In the Missouri River?

Q. Yes.

A. None.

Q. In deciding on the different waters of the different rivers that were found at the Chain of Rocks that investigation is confined to the period of November 25th to November 30th, is it not?

A. As far as the cross-sections are concerned.

Q. The cross-sections.

A. Yes sir.

Q. Now Alton is how far below Grafton?

A. Sixteen miles.

Q. And Hartford is how far below Alton?

A. 14 miles—no, excuse me—yes, fourteen miles, yes sir.

Q. And Hartford is how far from the Chain of Rocks?

A. Nine miles.

Q. If you made no cross-sections of the Illinois River—
2645 or how far is Pekin from Grafton?

A. I couldn't tell you exactly at this moment, I haven't got the figure.

Q. Approximately, doctor, if you can,—100 miles?

A. It must be more than that, the distance between Peoria and Grafton is 157 miles—between Peoria and Grafton.

Q. Well Pekin is about fifteen or twenty miles from—

A. Yes sir, I cannot recollect whether it is fifteen or twenty.

Q. Well, we will assume that it is 25, for the sake of what I want to illustrate.

MR. JOHNS: It is about fourteen miles by river.

MR. TODD: Fourteen miles by river. Then Pekin would be about 140 miles from Grafton?

A. Yes, according to that estimate.

Q. On November 5th these samples were taken at Pekin, were they? I mean between November 25th and 30th, were samples taken at Pekin.

A. You mean those cross-sections?

Q. Yes.

A. Well, I couldn't tell you at this moment; I would have to look up the sheets.

Q. I wish you would ascertain that if you have got the information.

2646 A. I have the sheets or the table here. I have here the analytical record sheet specifying on what days those cross-sections in the Illinois River were taken, and how many at each point on the respective days.

Q. Well, I want Pekin doctor; that will do me for my question. I want the date.

A. At Pekin Bridge?

Q. Yes?

A. There were taken on November 12th, 16th, 19th, 23rd and 26th, in 1901, two samples on each day from the Illinois River at Pekin Bridge.

Q. Two samples?

A. Yes. The cross-section taken was as follows: Two samples were taken from the river going down the stream right and left—

Q. That is all I want. Just two samples. Now in order to ascertain between the 25th and 30th of November, at the Chain of Rocks, the component constituents of the waters of the Mississippi as to whether the water there was Missouri, Mississippi or Illinois water, you would be confined to the data from the period between November 29th and 30th, would you not, as those are the only two days that the cross-sections were made in the Missouri River?

2647 A. Well if the conclusions to be derived from the analytical data would depend upon the cross-section—

Q. Well, doesn't the conclusion which you arrive at depend upon the cross-sections?

A. That depends upon conclusions in what respect, because I—

Q. As to the character of the waters at the Chain of Rocks in the Mississippi River?

A. Not altogether.

Q. Then what was the purpose of taking twelve samples of water across the Mississippi River at the Chain of Rocks, between the period of November 25th and November 30, daily?

A. I said that it was not dependent altogether upon those cross-sections, but the cross-sections of course gave me certain information that I wanted to obtain from the cross-sections in order to obtain facts that the cross-sections would reveal to me.

Q. Well, when the cross-sections failed to reveal the facts that you were looking for, would you go anywheres else for those facts?

A. Yes sir.

Q. Where would you go?

A. Well, I would take all the analytical data that I could
obtain, on that question and consider them from a general
2648 standpoint as every chemist would.

Q. What facts were you looking for, doctor, that were not revealed to you by the cross-sections?

A. You mean what facts I was looking for in taking the cross-sections?

Q. No. You stated that if the cross-sections did not reveal the facts that you were looking for, you went elsewhere to find the facts?

A. Yes sir.

Q. Now what facts were you looking for that the cross-sections did not reveal?

A. I was looking for a large number of facts in connection with nitrites and chlorides for which the cross-sections were taken.

Q. And what were you trying to prove by cross-sections—that these waters mixed and went into the Intake?

A. Yes sir.

Q. And if these cross-sections did not reveal that fact then you went elsewhere to find that fact to prove that they mixed and went into the Intake, did you?

A. Well, I said in connection with the general analytical result, I would take the result of the cross-sections and consider them.

Q. But you would not consider them by themselves, would you?

2649 A. Not in determining that question entirely. I would take into consideration the total solids, which total solids were not estimated in these cross-sections that I looked for.

Q. If this cross-section made at the chain of rocks, at Hartford, and Alton, at Bellefontaine and at Pekin, did not prove conclusively to your mind that the waters of the Illinois River entered the intake of the City of St. Louis, did you go anywheres else for any facts in order to establish that fact?

A. Well, in reviewing the analytical results from these cross-sections my views were strengthened as to the currents coming down the Mississippi River, at the intake.

Q. Then before you made these cross-sections—

A. No, at the chain of rocks, I want to say.

Q. Then before you made these cross-sections, you had views that the waters of the Illinois entered the Intake tower of the city of St. Louis, did you not?

A. Yes sir.

Q. And these cross-sections were made to confirm that view?

A. Yes sir, as far as nitrites and chlorines could confirm that view, because I only took cross-sections for that purpose.

Q. And if it failed to prove that fact conclusively, where else did you go for evidence to prove that fact?

2650 A. Well, these conclusions that I drew were to my mind sufficiently definite to dispense with a further investigation of that problem. I had settled in my mind the question that I wanted to have answered by the general analyses, and in a measure as far as it can be done, by the estimation of nitrites and chlorides, substantiated by these nitrites and chlorides.

Q. Did the cross-sections which you have stated were taken —did those cross-sections establish independently the fact that the Illinois river went into the Chicago Intake?

A. You mean the St. Louis intake, yes sir.

Q. Independent of anything else?

A. I beg your pardon. You mean St. Louis intake, because you asked for the Chicago intake.

Q. The St. Louis intake?

A. No sir, I had formed an opinion on that question prior to the taking of the cross-sections, but I wanted to see what the cross-sections would reveal in substantiating from the standpoint of the chlorides and nitrites, the opinion that I had formed on that question.

Q. So that when you started in upon this line of investigation you already had an opinion in regard to the waters of the Illinois mixing—going into the St. Louis intake?

A. Yes at that time, in November, 1901.

2651 Q. 1901?

A. I had an opinion.

Q. Now in the investigations that you made at those times to substantiate your previous opinion, did you consider any dates except the 29th and 30th of November, in connection with these cross-sections?

A. Well, in looking over the analytical results I considered these data as I had obtained them from the collection and analyses of those samples.

Q. Well now, in the Missouri River you only took two cross-sections on November 29th and 30th?

A. Yes sir.

Q. Wouldn't it be fair to limit your investigations in the cross-sections at the chain of rocks in ascertaining the St. Louis water, to November 29th and 30th?

A. No sir, that wasn't necessary, because I had practically formed an opinion as to that question prior to the taking of those cross-sections. The cross-section at—

Q. Then if you had that opinion already formed, what was the use of going to all this trouble in making cross-sections at these different points?

A. Simply if possible to corroborate and substantiate my opinions previously formed on the previous investigation.

2652 Q. Doctor, during the month of November, 1900, were any samples taken at Grafton, in the Illinois River?

A. Well, I will have to look up my data; I am not quite sure. We took samples regularly every day in 1900, from January 23rd, until October 11th, at Grafton, and subsequently some additional samples were taken, but I could not tell you at this moment whether they were taken daily or taken semi-weekly or tri-weekly, but there were some taken for the remainder of that year at Grafton.

Q. Well, were they taken in November?

A. Well I would have to look up my data. I have the sheets here. I can tell you in a minute.

Q. I wish you would?

A. After the termination of that investigation of daily collection of samples for that second period, from January 23, until October 11th, after the termination of that period of these daily collections at Grafton, samples were taken at Grafton on October 15th, October 16th, October 24th and October 30th. Now I haven't got any additional data on hand to tell whether any collections were made in November, 1900.

Q. What is your best judgment about it, doctor?

A. Well there are so many data here, of 8,000 analyses, that I cannot recollect at this moment, but it is my impression that no additional samples were taken in the year 1900 at 2653 Grafton, Illinois, after October 30th, but I am not positive about it. The next samples taken were in 1901.

Q. Were there any samples taken in the Mississippi River above Grafton during November, 1901?

A. Not if there were no samples taken from the Illinois River because the samples were usually taken from both points together, on like days.

Q. Have you got the data with you so that you could tell what the chemical analyses showed of the sample that was taken nearest the Illinois shore at Alton in the cross-section?

A. Yes sir.

Q. On November 29th?

A. Yes, November 29th.

Q. The sample nearest to the Illinois shore?

A. Yes, that is at Alton, for nitrites .010; for the chlorides it was 9. These figures represent parts per million.

Q. Yes.

A. And as regards nitrites, of course nitrogen in the form of nitrites.

Q. Now what was the sample next to the Illinois shore at Hartford on that same day, November 29th?

A. For nitrites .009; for chlorides 7.3.

Q. Were those two samples Illinois River water?

2654 A. I beg your pardon?

Q. Were those two samples that you have just spoken of as being nearest to the Illinois shore at Alton and nearest to the Illinois shore at Hartford, Illinois river water?

A. Well that I could not tell without consulting the data for Grafton, Illinois, and the samples.

Q. You didn't have any data for Grafton, Illinois, on that day, doctor, November 29th?

A. Yes, for 1900. You are now comparing the cross-sections taken in November, 1901.

Q. Yes, that is the time I mean—

A. And then you want me to look up the analytical data for November, 1901.

Q. On the 29th of November, 1901 at Grafton, you stated there were no samples taken?

A. No sir, 1900. You said 1900, and I—

Q. Well did you take any samples?

A. I was very careful to listen. That is why I said that the long investigation conducted from January 23rd, 1900 until October 11, 1900 was continued for a few samples at Grafton up to October.

Q. Well, let us go back and get that right. State whether any samples were taken at Grafton on the 29th of November, 1901.

A. Yes sir, that was the investigation of 1901.

2655 Q. I am right about the dates of the cross-sections at Alton, Hartford, Chain of Rocks and Fort Bellefontaine, —were taken in November, 1901?

A. Yes sir.

Q. And at Pekin?

A. Yes sir.

Q. Now at Grafton, in November, 1901—

A. Yes sir. You want the results for which date?

Q. No, I want the number of samples taken.

A. In 1901?

Q. At Grafton in the Illinois River?

A. They were taken from October 4th, 1901, daily until December 19th, 1901.

Q. Now will you look at November 29th and tell me whether those two samples that you have given me in regard to nitrogen and chlorines was Illinois River water?

A. The analytical results compared from the Illinois River at Grafton during that period, and the analytical results received from the analyses of the samples at Alton show a reduction of nitrites there at Alton.

Q. Give me the nitrites on November 29th, 1901, at Grafton.

A. They were .04.,

Q. Now the chlorines?

2656 A. The chlorines 19.5.

Q. Were any samples taken in the Mississippi River above Grafton on that day?

A. Yes sir.

Q. How many?

A. There were daily samples taken at the point in the Mississippi River above Grafton, from, I believe October 4th, 1901, until December 14th, 1901. To be sure, I will have to look up the sheet. (After referring to tables.) That is correct, from October 4th until December 14th, 1901.

Q. Now take the sample of water on November 29th, 1901, that was taken in the Mississippi River on that date, and the sample of water that was taken nearest to the Missouri shore at Alton and nearest to the Missouri shore at Hartford and tell me whether that was Mississippi River water or not, at those points?

A. On November 29th, the sample collected from the point in the Mississippi River several miles above the mouth of the Illinois, showed no nitrites and showed chlorines three parts per million. The sample collected in the cross-section at Alton on November 29th—

Q. Next to the Illinois shore?

A. No, next to the Missouri shore, you are asking.

Q. Missouri shore.

2657 A. Next to the Missouri shore showed no nitrites and showed chlorines four parts per million.

Q. What is your conclusion as to that sample of water at the point, where that sample was taken, as to whether it was Mississippi River water or not?

A. My conclusion would be that that—well now, whether that was Mississippi River water or not, I would have to compare additional data, for instance, compare the ammonias and compare total solids to get an absolutely correct estimate, and also the nitrates, but since only—

Q. Well, did you make a table of ammonias and total solids in order to ascertain that fact?

A. Well not for those points.

Q. Well I mean at that very point on that day?

A. No sir, I did not, but as far as the nitrites and the chlorines are concerned, it would show a remarkable resemblance between the water found in the Mississippi River above Grafton and the water found at the point opposite Alton in the Mississippi River close to the Missouri shore,—a remarkable resemblance.

Q. Now will you take that same day at the same relative position to the Missouri shore at Hartford?

A. Yes sir. At Hartford there were nitrites found, that is nitrogen in the form of nitrites .004, at the point closest to 2658 the Missouri shore, and chlorides six parts per million.

Q. And what does that show, doctor?

A. That shows a slight increase in nitrites at Hartford on the Missouri shore and a smaller amount of chlorides found on the Missouri shore—No, no—a reduction of chlorines—

Q. A reduction of chlorines?

A. Yes sir, from six parts per million to four parts per million.

Q. And what would you conclude as to whether that was Mississippi River water or not at Hartford?

A. The cross-section showed at this point, at Hartford, what it showed for Alton, that as you go across the river from the Missouri shore to the Illinois shore, an increase in nitrites and chlorines, as you go across the river in the cross-section.

Q. I am speaking of that sample taken at Hartford there next to the Missouri shore; doesn't that show again that that is Mississippi River water, if the analysis shows anything?

A. Well, as compared with the water running down the Illinois shore at those points where the nitrites are much higher and the chlorines higher, it would show that there is still a difference between those two currents there running along each shore, but it would show that while the sample taken from the point at Alton, as regards nitrites and chlorines is re- 2659 markably similar to the sample found in the Mississippi River above the mouth of the Illinois at Grafton; that there is a slight increase in nitrites and in chlorines in the samples taken from the Missouri shore at Hartford.

Q. Well what does it show as to the character of the water?

A. Well, it shows that while the samples taken at Hartford there from the Illinois shore show higher nitrites—

Q. No, I mean as to its being the water of the Mississippi River?

A. Well, there are still two currents there at Hartford, but that the Mississippi River water presumably running along the Missouri shore had been slightly polluted, that is, the increase in nitrites and chlorines although small, yet would signify or indicate some increase there in these impurities.

Q. Wouldn't that difference be found in two samples taken at the same place in the Mississippi River twenty minutes apart?

A. Well, how do you mean, twenty minutes apart?

Q. That is, you take a sample now in a certain place in the Mississippi above Grafton, and in twenty minutes you take another sample of water wouldn't that variation in the water at the same time and place be likely?

A. Well, I haven't any data to base a conclusion on that question.

2660 Q. Are the waters of the Mississippi River uniform at all times of the day?

A. What part of the Mississippi do you refer to?

Q. Above Grafton?

A. You mean whether it is uniform—

Q. As to nitrites and chlorines?

A. You mean that day?

Q. Yes?

A. Well, that I could not say because I didn't take two samples on one day from that point.

Q. Well, don't samples in all rivers that you have investigated, vary each day?

A. Well, from some points the sample shows a uniformity in some results, that is, in some ingredients, uniformity going on for days and weeks, sometimes, and then again it may not show the uniformity in other results for that time.

Q. Now, doctor, upon the day, the 29th of November, when you got down to the Missouri River, wouldn't the Missouri River itself press the waters of the Mississippi towards the Illinois shore by the time it got to the Chain of Rock?

A. Well, it will always push the water somewhat toward the Illinois shore, because of the manner in which it comes down the Missouri River and during the larger part of the year this volume being quite large, it would press the Mississippi
2661 River somewhat toward the Illinois shore; that is correct.

Q. And when it does that, the water that enters the Intake would be the Mississippi River water or the Missouri River water mixed with the Mississippi River water, would it not?

A. Well, it follows that if the pressure is very great and the volume of the Missouri River water—I mean if the volume of the Missouri River water is very large, and the volume of the Mississippi River not so large, that the pressure of the volume of water would be to push the Mississippi so close to the Illinois shore that on such days nothing but Missouri River water would enter the intake at the edge of the channel in the Mississippi—the intake of the water works.

Q. And at other times nothing but Mississippi River water would enter?

A. The condition might be the reverse, and then the intake being located fifteen hundred feet from the Missouri shore would receive at that time nothing but Mississippi River water as it comes down the river.

Q. Just above the intake, doctor, do you know whether it is true or not that there has been a sand-bar formed in the Mississippi River?

A. Yes sir.

2662 Q. And does the water that strikes that sand-bar go over toward the Missouri shore, or over toward the Illinois shore?

A. Now it can happen—I have been at that point frequently and investigated its condition—it can happen that the sandbar at a very low stage of the river is affected in that respect.

Q. In what respect, doctor?

A. That the water would sweep around that sand-bar, and I have seen considerable of an angle, and be pushed over toward the Missouri shore. I guess that is what you refer to?

Q. And keep the Missouri River towards the Missouri shore?

A. Yes, push it a little more toward the Missouri shore because this water at an angle, it would come around that sand-bar with considerable pressure and would press the Missouri closer toward the Missouri shore.

Q. At these times, would the water in the Intake be from the Missouri or the Mississippi?

A. At such times it would be from the Mississippi, because you are speaking now of the crowding of the Missouri River towards the Missouri shore by the Mississippi River current.

Q. Have you from your analyses been able to ascertain at what point below the discharge of the Illinois river into the Mississippi the waters of the Illinois and the Mississippi become commingled?

2663 A. Well, that depends upon what you define as commingling there.

Q. That is, thoroughly mixed with each other, so as to partake of the identity altogether of itself?

A. In the channel there is a considerable of a mixture, varying constantly almost from day to day.

Q. Does the Illinois river preserve its identity near the shore up to the time it reaches the chain of rocks?

A. The Missouri River?

Q. The Illinois, along the Illinois shore?

A. Well, the analytical results of samples taken at Hartford and Alton in the Mississippi River, as compared with the analytical results of samples taken at the Illinois shore opposite the intake, always show by comparison somewhat less impurities in the sample of the Illinois shore, at chain of rocks, than the samples at the Illinois shore, at Hartford and Alton. That would show some mixing effect of the Mississippi and Illinois Rivers at the point on the Illinois shore if the sample was taken opposite the intake.

Q. • Did the water next to the Illinois shore at the chain of rocks show less nitrites than the water at Hartford next to the Illinois shore? It does, doesn't it?

A. I cannot recollect from the analytical data whether
2664 they always do, but they practically do during the year.

Q. And the waters next to the Illinois shore at Hartford show less nitrites than at Alton, don't they?

A. Well, at Alton and Hartford those nitrites run pretty much alike; there is sometimes a slight reduction in nitrites,—very slight,—found in the samples taken at Hartford as compared with the samples taken at Alton.

Q. But there never is an increase in nitrites in the samples next to the Illinois shore over those at Alton, is there?

A. Well, sometimes there is a very slight increase shown, but as a rule they are pretty much alike.

Q. Have you made any calculations on the percentages of decrease in nitrites of the waters of the Illinois from Grafton down to Alton, in going that distance?

A. No, but there is invariably a decrease noticeable in the analytical results of the nitrites found at Alton as compared with the samples taken from the Illinois River at Grafton.

Q. And do you attribute that to the mixing of the Mississippi River or to the natural fermentative changes that take place in the water?

A. I think that it may be due to either cause. It is difficult to determine to which cause in all those instances, it would be due to; it may be due to either.

2665 Q. And the same thing of the Chain of Rocks?

A. You mean for the sample found at the Illinois shore?

Q. Yes, the Illinois shore?

A. Yes sir.

Q. If that is true, that it may be due to the fermentative changes the Illinois River would retain its identity along the Illinois shore down as far as the Chain of Rocks, wouldn't it?

A. Well, it cannot retain its indentity since the reduction in the nitrites and the reduction in other ingredients found in that water is noticeable.

Q. I mean its identity subject to the natural loss of purification in going that distance?

A. Well, it cannot have the same identity because it differs somewhat in its analytical character, the water from the Illinois shore at the Chain of Rocks as compared with the water of the Illinois River at Grafton.

Q. Have you made an analysis of the waters of the Illinois River for a distance of 39 miles immediately above its mouth to Grafton?

A. Do you mean at a point 39 miles above Grafton in the Illinois River?

Q. Yes?

A. No sir.

2666 Q. You don't know how much the varying changes would be for the samples taken 39 miles above Grafton on the Illinois River, to Grafton, do you?

A. No sir.

Q. Do you know whether it would be any greater, any greater change than is evidenced by your analyses from Grafton to the Chain of Rocks, along the Illinois shore?

A. I don't think the change would be so great in the Illinois River from the point 39 miles, as you state.

Q. That is the distance I think from Grafton to the Chain of Rocks?

A. As the change would be from Grafton to the chain ot rocks.

Q. On what do you base that, doctor? Have you made any experiments of it?

A. Because of the fact that the Mississippi River connects with the Illinois River at Grafton, and that the Missouri River connects with the Mississippi River at the mouth of the Missouri.

Q. Is that the only reason you have for believing to the contrary?

A. Well, that would change the conditions materially and bring about a different situation than exists in the Illinois river between the point 39 miles above Grafton and Grafton.

2667 Q. Do you know what percentage of Mississippi water and the Illinois River water is in the channel of the Mississippi River at Alton?

A. No sir.

Q. Have you any way of ascertaining that fact?

A. I think that the same principle applied—

Q. I ask you if you have any way of ascertaining it?

A. Yes, there is a way, there would be a way.

Q. Why didn't you ascertain that fact, doctor, in your investigation, if it was possible, so as to give the percentage of water from the Illinois, and water from the Mississippi, that is found in the channel of the Mississippi River at Alton?

A. Because the analytical data revealed to me certain chemical conditions found in the samples taken from the channel of the Mississippi between the mouth of the Illinois and the mouth of the Missouri, that I feel justified in drawing conclusions as to the mixture from a general review of the analytical data of the samples taken from the Mississippi River above the mouth of the Illinois at Grafton, and from the Illinois river above the mouth of the Illinois, and from Alton. By comparing the general analytical data I formed the opinion that there is some mixture taking place in the channel.

Q. But the amount of that mixture you did not ascertain?

2668 A. No, I thought approximations would suffice for the purposes of my investigation.

Q. And the same condition obtained at Hartford, did it. You made no investigation to ascertain the amount of Mississippi water and Illinois River water that constituted the channel of, the Misissippi at Hartford, did you?

A. You mean the Illinois and Mississippi compared?

Q. The Illinois and Mississippi at Hartford?

A. No sir.

Q. And when you got down to the Chain of Rocks, were you able to say how much Missouri River water, how much Mississippi River water and how much Illinois River water was in the channel of the Mississippi at the Chain of Rocks?

A. Well, I could by approximations form a conclusion as to the relative mixtures there prevailing at the chain of rocks.

Q. But as a matter of analyses were you able to do it?

A. Well, by studying the analytical data.

Q. Well, did you do it, doctor, is what I want to get at?

A. Yes sir.

Q. Now tell me how many parts in the channel of the Mississippi River at the Chain of Rocks was Missouri River 2669 water; how many parts Illinois River water, and how many parts Mississippi river water, if you did it?

A. That would depend entirely upon the study of the analytical data of certain days, and the analytical data reaching as far up as the mouth of the Illinois river.

Q. We will assume that you made that study. Now give me your conclusions?

A. Well, I can give only a general conclusion because these percentages, I won't call it percentages,—these approximations would vary from day to day.

Q. Wouldn't it be guess-work to try to do it?

A. No, it is based upon a study of the analytical data.

Q. Could you take a gallon of that water in the channel of the Mississippi River at the Chain of Rocks and tell how much of that water was Missouri River water, how much Illinois River water and how much Mississippi River water?

A. No sir, not that way.

Q. Could you anyway?

A. I could by a careful study of the analytical data obtained from the analyses of samples taken in the Illinois river a few miles above Grafton, above its mouth, samples analyzed as collected from points in the Mississippi River at Alton and Grafton, from the analytical data obtained from samples, also samples in the Missouri River.

2670 Q. Doctor, have you done that?

A. Yes sir.

Q. Well, will you tell me what are the parts of those three rivers making up the channel of the Mississippi River at the Chain of Rocks?

A. It is impossible to make these approximations without carefully studying for every case.

Q. You haven't done it then?

A. I carefully studied these analytical data. I have done so yes sir.

Q. Can you give me the result of your investigation?

A. No sir, I haven't those data at hand. I have done it though, taking the analytical figures.

Q. Have you testified to it in this examination?

A. No sir, I have not.

Q. Are you able to tell me the exact proportions of this water in the channel of the Mississippi River at the Chain of Rocks?

A. This would also include, as I stated, a separate estimation of the character of the Illinois River, as you say.

Q. At Hartford do the waters of the Mississippi contain as much mixture of the Illinois River water on the Missouri side as on the Illinois side?

A. Evidently not from the analytical data.

2671 Q. What proportion of the waters at Hartford near the Missouri shore, is Mississippi river water, and what proportion is Illinois River water?

A. You mean at Hartford?

Q. At Hartford, yes sir?

A. Well, that would depend upon a careful study of the analytical data of the two rivers before they meet.

Q. Do you know now, doctor?

A. Well, I cannot give you any exact figure without taking the special analytical data and going over them carefully and then making calculations.

Q. That is taking the analytical data and drawing conclusions from them, that satisfy your own mind as to the quantity?

A. As to the approximate quantities.

Q. Approximate quantities?

A. They are all approximations.

Q. All this is an approximation, isn't it?

A. As applied to what?

Q. To the different waters in the channel of the Mississippi River at the Chain of Rocks?

A. Yes sir.

Q. How much of the year do the waters of the Missis-
2672 sippi river and the waters of the Missouri River enter the intake at the Chain of Rocks?

A. The variations are so great there from day to day, that a general deduction as to how many days during the year or for how long a period the mixture of the Missouri and the Mississippi enters the intake, is difficult, unless we apply chemical results as found in the analyses of waters collected from the Mississippi River at Hartford; from the Missouri River at Bellefontaine and from the Mississippi River as it enters the Intake.

Q. Are you able to give it to me now; have you compiled that data?

A. Yes, I have for a period covering every day from January 23rd, until October 12th, I believe, 1900.

Q. Has that been testified to?

A. Yes sir.

Q. And did that contain the Mississippi river and Missouri River water all the time?

A. Well, those data, the table was presented; they demonstrated that there were days when, as based upon the estimation of the residue upon evaporation, called also total solids, as found in the samples of water taken from the Mississippi at Hartford, from the Missouri at Bellefontaine, and from the Mississippi as it goes into the intake; these estima-
2673 tions showed that as based upon the residue upon evap-

oration, approximately on some days, evidently only Mississippi River water went into the Intake, and at other days only Missouri River water went into the intake; then for the major part of the year there was a mixture of the two rivers going into the Intake, with varying percentages. At one time in that mixture the Missouri River would prevail and at other times the Mississippi River would prevail.

Q. Doctor, going up to Chicago, will you state what are the important chemical constituents of the Chicago sewage as discharged at Bridgeport into the canal?

A. The important chemical constituents of the sewage as is discharged from Bridgeport into the canal?

Q. That is at Robey Street, where the canal enters the Chicago river?

A. The principal constituents of the sewage going into the canal there would be classified as carbonaceous organic matter, and nitrogenous organic matter. There will be phosphate salts, there will be sulphate salts, and there would be tissues of various kinds of animal origin; there would be a number of organic compounds that are usually found in sewage, in the fecal matter. There would be refuse from manufacturing establishments which drain into the south fork of the south branch of the
267b Chicago River; there would be refuse from the gas factories located at that point, in addition to multifold other constituents of sewage of a minor importance as represented in the quantity of the sewage.

Q. Which, if any of these substances that you have described are in themselves, harmful?

A. Do you mean harmful to health?

Q. Yes, to health?

A. If that sewage as it is constituted when it enters the Illinois and Michigan Canal—well that would depend very much upon the quantities of various of these ingredients found, or present in that sewage.

Q. To what ingredients do you refer?

A. Well those that I have principally mentioned.

Q. Then the presence of all of those ingredients in what quantities would be harmful to health?

A. Well, it would be rather difficult to estimate the harmfulness of that sewage. It wouldn't be confined to those ingredients that I have mentioned. There might be in the sewage pathogenic bacteria, which in themselves would be harmful to health.

Q. Can you name any of the substances in the sewage that is discharged into the drainage canal at Robey street which are in themselves harmful to health, whether in large or small quantities?

2675 A. Well, the analyses of the samples taken from the drainage canal at Robey street, show certain chemical conditions—the chemical analysis I am referring to now, showed certain chemical conditions of that sewage, which if confined to the chemical conclusions would not justify me in saying if anybody would drink that water in the drainage canal at Robey street after that sewage would have entered it, that it would be injurious to his health as far as the chemical constituents are concerned, but that leaves out of the question all the bacteriological character of that sewage.

Q. Will you give me the names of any of the substances that are found in that sewage that are harmful to health as it enters the canal at Robey street in Chicago?

A. As far as the chemical character—that is, setting aside the bacteriological character—is concerned, the analytical results would not show the presence in the water from the drainage canal, would not show the presence of chemicals as revealed by the analyses of samples that were taken during this investigation, would not reveal that anybody who would drink that sewage laden water would be injured by chemical substances. It left out of the question of course, the bacteriological consideration.

Q. I want you to testify now, doctor, as a chemist?

2676 A. Yes, I say chemically.

Q. After a while I will examine you as a bacteriologist.

A. Yes, sir. There is a question of the potability of that water. It may not show any chemical ingredient that would injure anybody that drinks that water. You can drink sewage, what you call pure sewage, although impure, and there may be no pathogenic bacteria in that sewage and it may not do you any harm.

Q. Well, is there anything, any substances in the sewage discharged into the drainage canal at Robey street that are dangerous to health as ascertained by you as a chemist?

A. The chemical analyses alone, not considering the bacteriological analyses?

Q. I have asked you to leave out the bacteriology.

A. The chemical analyses alone would not reveal that.

Q. Do your chemical analyses reveal anything in the discharge of the Chicago sewage into the drainage canal as being harmful to health?

A. It did not reveal anything directly, but general conclusions as to the potability of that water would result in a different opinion.

Q. Do your chemical analyses of the waters, of the sewage that was discharged into the drainage canal at Robey street in the city of Chicago, reveal to you any substances that were dangerous to public health? 2677

A. No, sir; not as such, chemically.

Q. What are the real dangerous elements in sewage to public health?

A. Well, there may be refuse. Chemically there may be refuses from manufacturing establishments that in their chemical character would constitute a direct danger to health, and there may be a bacteriological character of the sewage that may be such as to render it dangerous to health.

Q. What are the refuses from manufacturing businesses that are dangerous to health, that you mentioned in the first part of your previous answer?

A. That would depend very much upon the quantity of water with which these refuses would be mixed. There might be chemical factories, manufacturing various kinds of chemicals that in themselves would be poisonous unless greatly diluted. That is refuses there that would be cast into the river, might be refuses from gas factories, and may be so much of it would be discharged into such a little quantity of water that it would be insufficiently diluted and that would apply to a great many manufacturing establishments. It might apply to tanneries, too, and such things.

Q. In your investigations of the waters of the Illinois from

Lockport to the St. Louis intake, did you discover any of 2678 these elements such as you have last described, in the waters entering the St. Louis Intake, from the Mississippi River?

A. No, sir; I did not.

Q. What did you say were the other dangerous elements in sewage outside of the chemical products of manufactories?

A. It would be the pathogenic bacteria.

Q. Did you discover as a bacteriologist, any pathogenic bacteria in the sewage of the drainage canal at Robey street?

A. Not from my own investigation; that is from my own analytical investigations. Those I didn't make.

Q. Have you examined the tables that have been prepared on bacteria, and introduced here in evidence?

A. Yes, sir.

Q. Did you draw any conclusions from those tables?

A. Yes, sir.

Q. From those tables, do you know whether or not they disclosed any pathogenic bacteria as being present in the sewage at Robey street in the drainage canal?

A. Yes, sir.

Q. Was there any pathogenic bacteria in that sewage?

A. Yes, sir.

Q. What were they?

A. There was the coli communis found.

2679 Q. Was the coli communis a pathogenic bacteria?

A. The coli communis being an important factor in some diseases—

Q. My question, doctor, is, is it a pathogenic bacteria?

A. I consider it in a measure a pathogenic bacteria.

Q. In what measure?

A. In so far that it may be harmful in water to some people; to some individuals, and it may be harmless in water taken by other people.

Q. Does the coli communis become harmful when taken internally?

A. Some intestinal diseases are ascribed to the presence of coli communis.

Q. Are not the bacteria of coli communis found in the intestinal tract of almost every man?

A. There is abundant evidence that they are found in the intestinal tracts of many individuals.

Q. Is it not true as being universally found in the intestinal tract of man, whether healthy or unhealthy?

A. Well, in a great many.

Q. Then, how does it become pathogenic from being taken into the system?

A. That depends upon the individuality. What I would call the physical or physiological individuality of the person drinking such water. 2680

Q. Is it not a fact, doctor, and recognized by bacteriologists everywhere that the bacilli coli communis is non-pathogenic?

A. There are some authorities that will call it non-pathogenic, because in many individuals it is harmless, and then again there are others that call the coli communis pathogenic because it is harmful to others.

Q. Is it not a fact, doctor, that the only way that coli communis becomes harmful is when it is inoculated into the blood or into a cut, and not harmful when it is taken into the alimentary canal?

A. Well, some authorities assume that standpoint.

Q. What are the characteristics of the coli communis bacilli?

A. In what respect do you mean, in what characteristics?

Q. How is it distinguished from other bacteria?

A. Well, by methods of bacteriological examination.

Q. What are those methods?

A. I am not familiar with those methods because I am not an expert bacteriologist.

Q. You do not call yourself then an expert bacteriologist to-day, do you?

2681 A. No, sir; I never did.

Q. Then I have been mistaken, doctor. What kind of sewage, doctor, undergoes final oxidation the more rapidly, excreta products or undigested matter?

MR. JEFFRIES: Do I understand you have got three propositions there?

MR. TODD: No, the excreta products and the undigested matter.

A. That is very difficult to ascertain, if possible at all.

Q. Do you know anything about the relative time it requires for the final oxidation of these two classes, excreta products and undigested matter?

A. No, sir; because the relative presence in sewage of these various ingredients of the sewage, and taken together with the multifold kinds of sewage existing, and constantly varying make it impossible to determine that question.

Q. Do you know what proportion of the sewage of Chicago is composed of undigested products, and what proportion is composed of excreta products?

A. No, sir; it is impossible to ascertain.

Q. Take an example such as meat before digested, and meat after digested, which would take longer to oxidize?

A. Where?

Q. In the sewage?

2682 A. Which would take longer to oxidize?

Q. Yes?

A. I couldn't tell you, because that is difficult to determine.

Q. The meat before digestion or the product of meats after digestion, which is known as feces, and the urine?

A. Well, the feces would be in a state of initial fermentation which the raw meat would not be. The raw meat would very likely take longer, but I haven't made any investigations on that question and therefore cannot answer it from a scientific point of view.

Q. In the Chicago sewage, did you discover any sewage except feces and urine?

A. Well, now, in the Chicago sewage —

Q. At Robey street?

A. Then you mean practically in the water?

Q. In the water of the drainage canal; I will take the drainage canal as a starting point?

A. I only looked for certain chemical ingredients, indicating sewage pollution, as is customary in analyzing those waters taken from the drainage canal at Robey street.

Q. Were you able to ascertain from the sewage in the drainage canal, the presence of slaughterhouse sewage?

A. The chemical data obtained from the analyses would 2683 not enable a determination as to whether or not that sewage was of fecal matter or of refuse from slaughterhouses or how much of each there was represented in that sewage.

Q. What sewage would oxidize more rapidly, that from slaughterhouses or the fecal and urine discharge of man?

A. I couldn't tell you, because I have made no special researches in that line.

Q. What amount of sewage did you calculate was discharged into the drainage canal from Chicago?

A. I have stated that at times, the population of 800,000 people would drain sewage directly into the south branch of the Chicago River and the drainage canal being fed by the waters from the Chicago River, or rather from the water passing through the south branch of the Chicago River from the lake, I stated that at times the population of 800,000 Chicago people would drain sewage directly into the south branch of the Chicago River and thus directly into the drainage canal at times.

Q. How do you calculate the quantity of sewage of Chicago, doctor?

A. I compare the quantity of sewage as it is customary with engineers, with the water supply of the city.

Q. Then if a city consumes 100,000 gallons of water a day, would you figure the sewage at 100,000 gallons of sewage a day?

2684 A. Well—

Q. I simply use that to ascertain whether that is the principle?

A. Yes, that is the figure used for computation customarily.

Q. Doctor, is there any sewage, any elements of danger to public health, aside from the fecal discharge of man, or the urine of man, in sewage?

A. Yes, I said that there might be—

Q. Aside from the chemical productions of factories?

A. Well, it depends, if that sewage is free from chemical poisons that may have been introduced into it with the water from other sources than from chemical manufacturing—

Q. That's what I mean, eliminating the chemical manufacturing.

A. That would only be by willful pollution of an individual source, the introduction of chemical poisons.

Q. Aside from the contamination of the stream by artificial means, such as putting poison into it or something of that kind, the chief danger lies from the excreta of man, doesn't it?

A. The excreta of man and the discharges from manufacturing establishments as I specified.

Q. Aside from the discharges of manufactories?

A. There is no additional source of danger to be looked for.

2685 Q. Do you know what the average urine and fecal discharge of man is?

A. Well, that varies considerably according to the man.

Q. As an average, I mean. Dr. Ravold, I believe, testified on that point, that there was 43 ounces of fecal and urine discharged from the average person a day.

A. Well, I would accept that figure, too.

Q. That is approximately, is it?

A. Yes, sir.

Q. Now, in the sewage of a city what proportion of fecal and urine do you calculate in connection with water examination?

A. Well, that I couldn't tell you at this moment. I have studied that question and have some data, but I haven't got them at hand, and I would have to refresh my memory from those to be able to answer that question.

Q. Well, that is a proper subject of investigation, isn't it?

A. Yes, sir; it is.

Q. If there are 100,000 gallons of water consumed by a city a day of 5,000 people, the proportion of urine and feces discharged by those people, into 100,000 gallons of water is a proper subject of inquiry isn't it?

A. Yes, sir.

Q. And that enters into the question of dilution?

2686 A. Yes, it is an important matter whether the solid fecal matter or the liquid impurities represented by the urine, whether one or the other prevails and what the relative proportions are. It comes into consideration as to the average time required for proper oxidation of this sewage.

Q. And if the people in a city consume 60 or 70 gallons of water a day per capita, it is not exactly fair to say that for every man there is sixty gallons of sewage, without any mixing of it, is it?

A. Well, a town that would only consume so much water would have entirely different conditions of sewage disposal. The relative computation usually applied by engineers in estimating relative proportions of sewage in water supply, the relative computation would not be applicable.

Q. Do you recall the Commision of Hydraulic Engineers appointed by the City of St. Louis in 1902?

A. Yes, sir.

Q. On page 12 of the report on the water supply of the City of St. Louis, appears the following: "From investigations made upon the water systems of cities where the quantity of water used is measured, it appears that in large cities the average volumes needed for domestic, public and manufacturing purposes are respectively about 30 gallons, 5 gallons and 25 galons per day, for each inhabitant, and that any supply in excess of 60 gallons a day per capita goes to under-
2687 ground leakage or to unnecessary waste." Do you approve of that statement as to the quantity of water?

A. Well, that I couldn't do unless I had compared it with various statements of responsible engineers that have expressed an opinion on that subject.

Q. I mean from your own ideas and experience as a city chemist, do you regard sixty gallons of water as too large a consumption of water for the average man, woman and child, for a large city?

A. I cannot answer that question unless I have studied some data that I have to compare with those data in order to form a conclusion as to the accuracy of those data.

Q. What would be your idea of the amount of water that each party used in a large city, per capita?

MR. JEFFRIES: I object to the question for the reason that the witness has not qualified himself as an engineer expert on water supply. That is, as to the quantity of water to be supplied to each individual from the water system.

Q. MR. TODD: Can you answer the question, doctor?

A. As to the quantity of water which should be provided per individual, the larger the quantity of water of course the better for the sanitary conditions of the city. That is the way I would answer that question.

2688 Q. What is the extent of organic pollution from the Peoria distilleries and glucose works, doctor?

MR. JEFFRIES: If you know.

MR. TODD: Do you know?

A. I haven't made an accurate scientific estimate of that so I couldn't answer that question.

Q. Don't you deem that important to be ascertained, in order to arrive at a correct conclusion as to the contamination of the Illinois River below Peoria?

A. As far as the analytical results of the examination of samples of water taken from points in Illinois above Peoria, near Peoria and below Peoria are concerned, that question indirectly came into consideration.

Q. To what extent did you take them into consideration, doctor?

A. That the character of the pollution of the Illinois River from the distilleries and glucose factories at Peoria and Pekin required attention because the personal local investigation that I made at those points and the analytical results showed some connection with the analytical results of the refuse discharged into the Illinois River from the distilleries and glucose factories.

Q. Have you any idea as to the amount of that sewage
2689 as to volume and weight?

A. No, sir; not as to volume and weight.

Q. What amount in tons does it pollute the Illinois River at Peoria?

A. There is some pollution of the Illinois River at Peoria and Pekin from those discharges.

Q. In your investigation, doctor, of the sewage conditions at Peoria, did you make any?

A. I gave this pollution which is mentioned, some consideration, yes, sir.

Q. Did you ascertain it to be the fact that there is no city in the United States that flows as much sewage as the city of Peoria according to the population?

A. Now, Mr. Todd, do you mean that there is no city in the United States that produces more sewage in proportion to its population than Peoria?

Q. Yes, sir?

A. I haven't found that to be the case in my investigation of the sewage of the cities.

Q. Do you know anything about it, doctor?

A. I have given the matter of the sewage production and sewage disposal considerable study.

Q. Do you know about the Peoria sewage and the extent of it?

A. Yes, sir.

2690 Q. Do you know how many cattle are fed there every day?

A. Well, I have collected those data, but I haven't got them at hand and I would have to refresh my memory to give you an exact figure.

Q. Do you know how much of the products of the distillery and the glucose company is thrown into the Illinois River every day in tons?

A. I have some estimates and figures on that question, but I haven't got it at hand now, and I cannot recollect them.

Q. What is the composition of this polluting material in the sewage of Peoria?

A. Well, it is the same composition that other sewages show.

Q. Well, take the distilleries; what are the compositions of the sewage from the distilleries of Peoria?

A. Well, that is a certain swill of organic matter that is cast off as refuse.

Q. What is its nature, doctor?

A. Well, it is what we call a grain swill.

Q. What is the chemical composition of it?

A. Well, that I couldn't tell you off hand. I have studied that problem and have collected data on the subject, but I haven't got it at hand just now. It is organic compounds.

Q. What is the effect of this material in oxidation?

A. This material will in the course of time undergo certain changes, chemical changes, and will disappear in the 2691 run of the river into which it is discharged.

Q. Will it oxidize more slowly or more rapidly than household sewage?

A. Well, that I couldn't tell. I haven't made any investigation of that point, that question.

Q. Is its destruction rapid or non-rapid?

A. Well, that is the disappearance of this refuse from the distilleries has been established to my mind in certain cases, where analyses were made at points where that swill is introduced into the river and at points below after the swill had run a certain distance. I now distinguish the swill from the distilleries from other sewage such as household and fecal matter.

Q. Does it oxidize more rapidly than fecal matter and household sewage?

A. That I could not tell; but I have noticed in analyses that the disappearance of that swill was noticeable in running rivers.

Q. Where, for instance, doctor? Give me an example of where that swill disappears and the sewage from the distillery disappears in running rivers?

A. At Peoria, and at Pekin.

2692 Q. Do you know of any other place in the United States except on the Illinois River where that condition prevails?

A. Now, I have made no analyses of any waters where the proportion of so much of that swill in proportion to the population was discharged into the river, so I couldn't draw any comparisons in that respect. It is only my experience in drawing conclusions from the analytical data obtained from the examination of samples of water in the Illinois River.

Q. If it disappears rapidly, does it disappear more rapidly than household sewage?

A. That I couldn't tell.

Q. How do you distinguish it from the household sewage, doctor, in these tests?

A. Well, the analytical results would show in these tests after a river into which the swill had been discharged had run certain distances, that the effect of the introduction of that swill disappeared, and the physical character of the water, that is, by appearance, would demonstrate that, because this swill is very much noticeable in the water by the eye, at those places where it is discharged directly in such quantities as happens at Peoria and Pekin.

Q. Do you assert that as a fact that this sewage from the distilleries is detectible by the eye?

2693 A. At places where the discharge is in such large quantities as in the Illinois River at Peoria and Pekin, my own eyes have shown me this swill and refuse from the distilleries.

Q. How far from the place of discharge did you see this, doctor?

A. Well, I have seen it a number of miles down the Illinois River on trips of personal inspection that I made.

WILLIAM C. TEICHMANN.

Adjourned until 10:00 a. m., Friday, April 3, 1903.

2694 Southern Hotel, St. Louis, Missouri. 10:00 a. m., Friday, April 3rd, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

DR. WILLIAM C. TEICHMANN resumed the stand for further cross-examination by Mr. Todd and testified as follows:

Q. Doctor, Teichmann, I hold in my hand the 17th Annual Report of the Health Commissioners of St. Louis. Will you state whether this is an authorized published copy of the proceedings of the Health Commissioner of the City of St. Louis?

A. It is the annual report of the Health Commissioner of St. Louis for the fiscal year 1893-1894, beginning with April 1st, 1893, and ending April 1st, 1894.

Q. I would like to have you identify certain parts of this report. On page 11 of this report there are two topics discussed: "Public Water Supplies," and "Illinois River Pollutions."

A. Yes, in the introductory report of the Health Commissioner.

2695 Q. That is correctly reported in this book, is it not?

A. Yes, sir; official publication.

MR. TODD: I offer page 11 of this report for identification.

MR. JEFFRIES: You don't offer it as evidence yet?

MR. TODD: No, I offer it for identification.

MR. JEFFRIES: I want to object to it when you introduce it.

MR. TODD: No, I simply offer it for identification.

THE COMMISSIONER: Let me suggest you had better give me a copy.

MR. WOERNER: You won't have to identify it; we will admit the identity of the book.

MR. TODD: That is all right then.

MR. JEFFRIES: Of course we won't admit its relevancy or its competency.

MR. TODD: I would suggest that all this that has gone before be stricken out, and just let me ask the question. I would like to have you identify the 17th annual report of the Health Commissioner of St. Louis.

MR. JEFFRIES: If it will serve your purpose we will admit that that is what it is.

MR. TODD: Counsel admits that this is the 17th annual report of the Health Commissioner of the City of St. Louis.

MR. JEFFRIES: We will make that admission for you
2696 at any time you want, Mr. Todd, as far as the admission is concerned.

Q. MR. TODD: Doctor, in 1893, did you make any analyses of the waters of the Illinois River?

A. Yes, sir.

Q. By what authority did you make these analyses?

A. By order of the St. Louis Board of Health.

Q. To what extent did you make analyses of the Illinois River?

A. I started with the collection of three samples on October 11th, 1893, from the Illinois River.

Q. At what points, doctor?

A. I believe it is three, five and seven miles above the mouth of the Illinois.

Q. How often were these samples taken?

A. Just on that one occasion we only had those three samples at these three points.

Q. On the Illinois River?

A. Yes, on the Illinois River.

Q. Three, five and seven miles above the mouth of the Illinois River?

A. Yes, sir; it is my impression. I will look up the analytical sheet here to be certain. (After referring to sheet): Excuse me, it was one, three and five miles above Grafton in the Illinois River.

2697 And when were those analyses made, doctor?

A. The samples were collected on October 11th, and on my arrival at St. Louis on October 12th, the samples were analyzed.

Q. Did you take any other samples of water in the Illinois River after that?

A. Not until September, 1899.

Q. In September, 1899, how many samples did you take of the waters of the Illinois River?

A. Well, I would have to look up the record. That was part of the investigation conducted prior to the opening of the Drainage Canal, and there were nineteen samples collected from the Illinois River during the months of September, October, November, December and part of January from the Illinois River.

Q. At what points, doctor?

A. That was points three and five miles above the mouth of the Illinois. That has been testified to in my report.

Q. I understand that. Now, in the examinations that you made of the water samples taken in 1893, what was the condition of the waters of the Illinois River?

A. The condition of the water of the Illinois River as demonstrated by the analytical results showed the presence of
organic matter as evidenced by free and albuminoid am-
2698 monia; the presence of nitrites to some extent and the
presence of high chlorines, proved contamination of the
Illinois River at the mouth.

Q. By sewage pollution?

A. Well, since only one set of samples were taken on that day, and I thought that a longer series of collections should be made, I did not pass any definite conclusions at that time on the character of that pollution, whether it was of sewage or vegetable origin at that time, and in my report to the Board of Health I stated that a more extensive investigation would be necessary.

Q. In 1899, when you made your examinations what conclusion did you arrive at as to whether the waters of the Illinois were sewage polluted or not at Grafton?

A. Well, I did draw the conclusion from the large number of samples collected and analyzed from the mouth of the Illinois at that time, that there was considerable pollution of the water.

Q. From what source—sewage?

A. Now, you refer to 1899?

Q. 1899; yes?

A. 1899. I stated at that time that the pollution found in 1899 was of a character indicating sewage pollution of the Illinois River.

2699 Q. Can you refer me to the part of the report which you made at that time in regard to the sewage pollutions of the Illinois River?

A. Yes, there were no samples collected after this investigation of 1899 prior to the opening of the canal at any point in the Illinois River above the mouth.

Q. That is what I mean, doctor, just at the mouth prior to the opening of the canal?

A. Yes, I have those conclusions here. One of the conclusions was the Illinois River at its mouth was badly polluted during the entire period of investigation, from September, 1899, until the middle of January, 1900.

Q. Before the opening of the canal?

A. Yes, sir.

Q. That refers—

A. Or rather, there were a few samples collected there after the opening of the drainage canal but at that time it was impossible for the drainage canal to have reached the mouth, so that is why I am justified in stating that those samples all refer to the time before any pollution from the drainage canal could have reached the mouth.

Q. Have arrived, yes. And in that investigation, did it demonstrate conclusively the character of the pollution,
2700 as to whether it was sewage or vegetable?

A. Well, my opinion was that it was sewage pollution.

Q. Sewage pollution?

A. Yes, sir.

Q. Now, from that investigation are you able to go back and review the data of 1899 and state whether the analyses at that time showed sewage or vegetable pollution?

A. Well, owing to the fact that in 1893 I had no data at hand to form an opinion of the character of the Illinois River water above the mouth, I refrained from stating at that time, in 1893, what the pollution found at the mouth of the Illinois River might be ascribed to, but in 1899, while I had no analytical data based upon original analyses of my own of the water of the Illinois further above the mouth than three miles and five miles, I consulted analytical data published by Professor Long of the State Board of Health of Illinois, and Professor Palmer, who performed a series of chemical investigations also of the Illinois River, and based upon the analytical data of Professor Long and Professor Palmer, I formed some opinion as to the nature of the pollution found at the mouth of the Illinois.

Q. In 1893?

A. In 1899. I mean that was in 1899.

Q. I am going back to 1893, doctor.

2701 A. In 1893 I refrained from drawing any conclusion as to the pollution found at the source, or the mouth, of the Illinois, because I had no data.

Q. But the character of the pollution is what I am asking you, not the source.

A. Well, I thought that it was just one sporadic analytical survey there, that would not justify a definite conclusion, and in my report I asked for an additional investigation—for means to carry on an investigation on a very large and exhaustive scale to determine that very question, where that pollution came from.

Q. In the examinations that you made in 1893, what did you find the albuminoid ammonia, high or low?

A. I found high albuminoid ammonia.

Q. In suspension or solution?

A. Well, I did not determine at that time the albuminoid ammonia in suspension or solution.

Q. How was the free ammonia, doctor, in that examination?

A. Free ammonia was comparatively low.

Q. And nitrites?

A. Nitrites were quite high in the Illinois at that time; the nitrites were quite high; I would not say high, but quite high, the intermediate between low and high.

Q. And the chlorines?

2702 A. The chlorines were very high.

Q. Now, from your experience and analyses as a chemist, what does high albuminoid ammonia, low free ammonia, high nitrites, and high chlorines indicate when found in water?

A. Well, they indicate pollution, but they make it uncertain what the source of that pollution might be, unless one has evidence, or has formed definite conclusions based upon some investigations, what the source of the high chlorines may be and whether or not the general character of the river from which these samples are taken indicates sewage or vegetable origin of pollution.

Q. What in the examinations of 1899 did you find the albuminoid ammonia, the free ammonia, the nitrites and the chlorines to be?

A. I found them at times quite high and at times again high, throughout; that is for 1899.

Q. Now, for albuminoid ammonia; how did you find albuminoid ammonia?

A. The albuminoid ammonia I found comparatively high in 1899.

Q. In suspension or solution?

A. I found it high in solution.

Q. And how in suspension?

2703 A. In suspension I didn't find it as high throughout as I did in solution.

Q. But it was high in suspension, was it not?

A. Well, at times it was high after heavy rainfalls in the

Illinois River valley, both of the ammonias would go up, and of course the albuminoid ammonia would go up with the free ammonia and show high figures.

Q. No, I mean in suspension and solution.

A. Yes, the albuminoid ammonia in suspension would show an increase as well as in solution after the rain-falls.

Q. In 1899 you found then the albuminoid ammonia high, both in solution and in suspension?

A. Well, at times I would always find the albuminoid ammonia in solution high throughout, but the albuminoid ammonia in suspension, I would very often find less than the albuminoid ammonia in solution, but sometimes higher.

Q. That is not what I mean, doctor. You don't get my idea. You found the albuminoid ammonia in suspension as compared with the albuminoid ammonia in solution lower than the albuminoid in solution?

A. Yes, sir.

Q. But the albuminoid ammonia that you found in suspension was high, too—a high degree wasn't it?

A. Sometimes, yes.

2704 Q. Aside from being compared with that in suspension?

A. Sometimes it would be high but for most of the time the albuminoid ammonia in solution would be higher.

Q. Yes, woud be higher?

A. Yes.

Q. But I mean without comparing it with the albuminoid ammonia in solution, just taking it in suspension, wasn't it always high?

A. No, sir; it would be comparatively low sometimes.

Q. Now, how about the albuminoid?

A. You see the total solids would show lower results, that is the water would not be so turbid, and there would be less matter in suspension present, and accordingly less albuminoid ammonia in suspension, because the albuminoid ammonia there would only represent the albuminoid ammonia in the suspended matter—principally of vegetable character then.

Q. How was the free ammonia?

A. In 1899?

Q. Yes.

A. Well, free ammonia—

MR. WOERNER: Are you talking about this one sample now?

MR. TODD: No, the series of samples; the investigation of 1899.

A. During 1899 I found sometimes the free ammonia low
2705 in the Illinois River and then again I would find it high.

Q. And the nitrites?

A. The nitrites the same way, I would find them low at times and then again quite high.

Q. And the chlorines?

A. The chlorines I found pretty high in 1899.

Q. From that analyses you concluded that the Illinois River as it enters the Mississippi was a sewage contaminated stream, did you not, and the waters were not potable?

A. I did, taking into consideration the reports of Professor Long and Professor Palmer, as to the condition of the entire Illinois River valley.

Q. Yes, taking into consideration all the information that you had at hand, you concluded that in 1899 the Illinois River was a sewage polluted stream, did you not?

A. Yes, sir.

Q. And was not potable water?

A. Yes.

Q. After the waters of the Drainage Canal leave the Bear Trap Dam at Lockport, do you know into what it empties, after going over the watershed of the Desplaines River?

A. Well, it empties at Lockport into the Desplaines River.

Q. And from the Desplaines River is there any lake through which the Desplaines River runs?

2706 A. Well, I understand that there are larger basins through which the Desplaines River runs there, that are termed by some people, lakes.

Q. Are you acquainted with what is known as Lake Joliet, immediately south of Joliet, along the line of the Desplaines River about eight miles from Brandon Road?

A. No, sir; I have not been there.

Q. Have you read anything of it, or have you any knowledge about the existence of Lake Joliet?

A. I have read something about it.

Q. Now, when the sewage waters of the Desplaines River run into Lake Joliet, what effect would that have upon the purification and oxidation of that sewage?

A. Well, that would depend upon the character of that lake. If it were a lake where there is no flow of water at all, that would practically be in a quiescent state, as far as motion towards one direction is concerned, because absolutely quiescent would not be proper to assume, because the water conditions and the winds will produce motion there; but what I mean, motion of flow in one direction—if that would not be the case, if it would be what we usually call the quiescent state it would enable the oxidation processes somewhat by sedimentation of the suspended matter and the sewage at the bottom of the lake, but if this lake were simply a large basin in the course 2707 of the river, and there would be a current through that lake, of course this sedimentation would not take place to that extent, and the faster that current would be passing through that lake, of course the less sedimentation there would be and the stage of the water would have to be taken into consideration also, at low stage of course the current would be less. There would be more sedimentation taking place than there would at the rapid flow of the current.

Q. If Lake Joliet was two or three miles in length and from one-half mile to a mile in width, with a kind of a peat bottom bogs, and the waters passing through would disseminate themselves throughout the lake and would only leave a slow current through the lake, would not that act as a sediment basin for the waters of the Desplaines River?

A. It would somewhat, and the slower that current would be the more sedimentation would take place, and the faster the current would be the less sedimentation.

Q. A great proportion of the sewage going through a lake of that character would have a tendency to be deposited on the bottom of this lake or morass, as it were?

A. Yes, sir.

Q. And fermentative changes would operate in a lake of that character, would it not?

A. Yes, sir.

2708 Q. Now, if it should appear, doctor, that before getting to Lake Joliet there was considerable—quite a number of acres of land over which the waters of the Desplaines flowed, sedimentation would take place under those conditions the same as it would in the lake, would it not?

A. Yes, if the current were very slow, and these low-lands would retain any of the sewage that had been during the overflow deposited on the banks. If such conditions would prevail these fermentative changes would be facilitated somewhat.

Q. While the waters were over the land would sedimentation be the only method of purification?

A. Well, since sedimentation would be one of the material forces of nature, that would bring about various stages of what we call purification.

A. And in Lake Joliet, where the sewage laden waters of the Desplaines River enter, wouldn't that lake operate as a septic tank to some degree?

A. It would if the ordinary conditions that are requisite for a septic tank would prevail there, as I said, slow flow and an abundance of an-aerobic bacteria to perform the initial process of purification.

Q. What current would you call a slow current, doctor, through a lake of that character?

A. Well, I would consider a slow current a current that 2709 would perhaps have one-eighth or one-fourth of a mile flow per hour.

Q. If the current should be as high as half a mile an hour what effect would that have?

A. That would have some effect in facilitating sedimentation.

Q. Now, after the waters left Lake Joliet and on their way down to the Illinois River, if it should appear that thousands of acres of land were inundated, low-lands, over which this water in its course traversed, what effect would that have upon the purification of the sewage laden waters of the Desplaines River?

A. It would have some effect in distributing the sewage over vast fields there, during the overflow, and if the sewage would have some time there to remain in a quiescent state some fermentative changes would take place in the ordinary process of purification.

Q. And if after traversing over these many acres of land that were inundated, it finally empties into the Illionis River where it continuously overflows the banks of the stream in high water, would not that condition of purification obtain constantly?

Q. It would be facilitated whenever conditions of inundation of large areas of land would prevail.

2710 Q. Do you know what the conditions are through which the Desplaines River runs from Joliet to LaSalle, on the Illinois?

A. Well, I am familiar with the conditions somewhat.

Q. Have you any idea of the number of acres of low land between those points that the sewage laden waters of the drainage canal runs over in arriving at LaSalle?

A. No, sir; I have no data to that effect.

Q. Have you any idea or any information of any kind in regard to those conditions?

A. I have nothing definite in that direction.

Q. Don't you think that in order to properly consider this question intelligently, that data of that character is essential?

A. No, sir.

Q. Is it not as essential to know in the Illinois River as in the Missouri?

A. It is a matter of analytical investigation as far as the character of that water is concerned, in considering the question of sewage pollution of those rivers, and if the analytical results show high figures at various points along the route that the river is traversing, it would be the most important information, and if found consecutively along the entire route it
2711 would justify general conclusions as to the character of that water chemically.

Q. Wouldn't it be essential, doctor, as essential in ascertaining the origin of contamination as to whether from vegetable or animal, to know these conditions obtaining in the Illinois River between LaSalle and Lockport?

A. It is not necessary when the analytical data from the samples taken along the route demonstrate high pollution, because the object of the analytical investigation is only to ascertain the character of that water as it flows along that route.

Q. Have you not repeatedly stated in your examination, doctor, that the analytical data, in the absence of knowledge as to the source from whence pollution came, was not sufficient to enable you to determine whether it was sewage or animal pollution?

A. The source, yes, of the pollution as estimated in the analyses of the samples.

Q. And have you not stated that large areas of overflowed land eliminated sewage contaminaton from waters?

A. I said that it may do so under certain conditions.

Q. And is it not necessary to ascertain whether those conditions exist or not before drawing a conclusion as to whether the elimination or the presence of the chemical constituents of the water are attributable to animal or vegetable
2712 origin?

A. If the analytical results uniformly show high impurities along the route of a river, there are various questions that come into consideration, such as the original source of that pollution, the relative proportion of pollution that might come from tributaries, the relative proportion of pollution that might come from large cities that discharge their sewage into that river. Those questions of primary importance would be considered and in explanation of the origin of the pollution if the chemical analyses enable an approximate distinction between vegetable and animal origin of the organic matter, it would be sufficient to form final conclusions on the character of that water as it traverses the route of the river.

Q. Did you ascertain all those conditions that you have enumerated?

A. In application to what investigation do you mean?

Q. The Illinois river?

A. Illinois river, you mean after the opening of the Drainage Canal?

Q. Yes?

A. Yes, sir.

Q. What tributaries of the Illinois River did you investigate for sewage pollutions?

A. I investigated practically all the tributaries that may
2713 come into consideration in determining that question.

Q. What tributaries did you investigate, doctor?

A. I investigated the Kankakee, the Sangamon, the Fox River, and several others.

Q. What are they?

A. Well, they are tributaries of the Illinois River.

Q. Well, just name the rivers—all the rivers that you investigated?

A. I would have to refer to my data to look that up.

Q. Well, will you please refer to it?

A. Yes, sir. The Kankakee, the Fox, River, the Big Vermillion, the Sangamon and the Spoon, that's all.

Q. Did you examine the Mazon?

A. Yes, sir, the Mazon. I overlooked that.

Q. The Macoupin creek?

A. I think at the time of the consideration of this problem of the tributaries of the Illinois, that I did consider Macoupin creek.

Q. The Mackinaw?

A. No, I don't recollect at this instant.

Q. The Quiver?

A. I think I did, yes, sir; the Quiver.

Q. What examinations of the sewage did you make of these different streams, doctor?

2714 A. I didn't make any analytical investigations of my own, because I found analytical data published by responsible authorities, by Professor Long and Professor Palmer, that could be taken as a fair criterion for the character of these rivers, and also a report published by Lyman E. Cooley in 1890, entitled "The Lakes and Gulf Waterway, as Related to the Chicago Sanitary Problem."

Q. What effect would it have upon the waters of the Illinois River when it enters at LaSalle—are you familiar with the conditions of the water at LaSalle?

A. I am from an examination of samples taken at that point.

Q. I mean the condition of the River Desplaines there, doctor?

A. Not from my own personal observation on the spot. I have not been there.

Q. Have you information as to the effect that there is a large stagnant pool in excess of a mile, right under the hill at LaSalle, along LaSalle, where the waters of the Illinois river—

A. I understand that is the case, yes, sir.

Q. What effect does that have upon the waters of the Illinois river as to purification?

2715 A. Well, if the Illinois river there would stop its flow completely and enable sedimentation by the stagnant condition of the river there, fermentative changes producing initial purification would certainly be facilitated.

Q. Have you any idea, doctor, how many thousands of acres of land in the form of marshes are along the course of the Illinois river?

A. No, sir.

Q. Have you ever tried to ascertain that data?

A. I have. I have studied all the reports that are published that came to my notice and that I can find on the subject.

Q. Are you aware that there are many thousands of acres of land that is inundated by the Desplaines and the Illinois rivers before the waters get to Peoria?

A. I understand that inundations take place at times of overflow.

Q. Well, during those times, would the same conditions of purification and sedimentation take place in these overflowed lands, as would take place along the shore of the Missouri river?

A. They would if all conditions were alike in both rivers.

Q. What conditions, doctor?

2716 A. Well, first of all the chemical character of that water carrying the sewage. The quantity of the sewage in that water in proportion to the quantity of water with which it is mixed, the weather conditions and several other conditions as I have explained them before, which would facilitate the fermentative initial purification process.

Q. During these times of overflow that would have a tendency to purify the waters wouldn't it to a considerable extent, depending upon the amount of territory that is overflowed?

A. The sewage would be distributed over large areas of land like that during the overflow. If that sewage would have a considerable time to remain in a more or less quiescent state on those lands, it stands to reason that it would undergo fermentative changes of initial purification. That part of the sewage, however, that would remain in the channel, that part of the sewage would not be similarly affected.

Q. Wouldn't the water become impregnated with vegetable contamination in going over the overflowed marshes of Illinois?

A. Certainly, that part of the water that would overflow those large areas of land, that would be impregnated with vegetable matter.

Q. And what it would lose in sewage pollution, it would gain from vegetable pollution to a certain amount, wouldn't it?

A. Yes, if that land had vegetation, it would necessarily receive accessions from that source.

Q. And vegetable pollution would manifest itself in the
2717 presence of albuminoid ammonia, wouldn't it?

A. Yes, and also in the color of the water, and sometimes as found in the odor of the water.

Q. Now when the water gets to Peoria, do you know whether it flows through Lake Peoria before arriving at Peoria, or after it leaves Peoria—do you know where Lake Peoria is located?

A. Yes sir.

Q. Where?

A. Lake Peoria is located above.

Q. Now when the waters pass into Lake Peoria after coming the distance from Chicago over vast swamps or marshes along its route, through different lakes, and stagnant pools, Lake Peoria would continue the fermentative changes and oxidations of that sewage water, wouldn't it, if any remained?

A. More or less, yes, dependent upon the size of that lake, dependent upon the question whether there is a flow in that lake, any current carrying the water through the lake rapidly and so forth.

Q. Did you make any investigations to ascertain the dimensions of Lake Peoria?

A. No sir.

Q. How large a lake is Lake Peoria?

A. Well, I couldn't tell you now, I only know that it
2718 varies very much in its size, and I haven't got any data at hand just now as to the size of that lake at those various times.

Q. Have you any information?

A. I have some information about that so-called lake.

Q. About how large is it, doctor?

A. Well I couldn't tell you at this moment; it is some time since I have studied that data.

Q. How swift is the current through Lake Peoria?

A. I couldn't tell you at this moment; I have no data at hand.

Q. Do you know the source of the Kankakee River?

A. No.

Q. Have you ever heard of the Kankakee Marshes of Illinois?

A. I know of those marshes from the literature published on the subject.

Q. If it should appear that those marshes drain into the Kankakee river, would not the Kankakee river carry into the Illinois large quantities of pollution due to vegetable origin?

A. Yes, at times of very high water in the Kankakee they would.

Q. Didn't you deem it necessary in arriving at your conclusions above Peoria, to ascertain the length, breadth, depth and current in Lake Peoria?

2719 A. Well, I did inform myself on that subject a lon
time ago; it is several years ago that I investigated that problem and I have been compelled to remember a great deal of data so I cannot just now summon to my memory those data, but the data—at the time of the investigation, I knew what the dimensions of that lake usually and at high water and low water were.

Q. Don't you deem it a matter of considerable importance to know the number of acres of land in the form of marshes that the waters of the Illinois commingle with and overflow before arriving at Peoria?

A. Yes sir.

Q. Did you ascertain that information?

A. I tried to obtain all the information from available data published.

Q. Well, did you get any specific information in regard to the number of acres along the Illinois river that was overflowing marshes, or farms lands?

A. No sir, except that there are general conditions which I familiarized myself with from the literature published on the subject.

Q. Is Copperas Creek located above or below Peoria?

JUDGE JOHNS: Copperas Creek is about 25 miles below Peoria?

MR. TODD: The dam at Henry is located above Peoria, isn't it?

2720 A. Yes sir.

Q. Doesn't that dam create a stagnant pool of water in the Illinois river?

A. At times the flow is very much retarded at that dam as well as at the other four principal dams which are located in the Illinois river, yes sir.

Q. The retarding of the flow of water at those places serves to elevate the water and back it up-stream, doesn't it?

A. Yes sir.

Q. And overflow the banks of the river?

A. Yes sir.

Q. And on each side of the river at those places the land is low, isn't it?

A. Yes sir.

Q. And thousands of acres of land is inundated by virture of those dams?

A. Yes sir.

Q. Doesn't that condition act as a septic tank for the waters of the Illinois when it is backed up there and held by those dams?

A. In a measure it would, yes.

Q. Did you in your examinations endeavor to ascertain in what measure and to what extent purification would take
2721 place at those points?

A. Yes sir.

Q. And were you able to tell?

A. I think I was able to judge from the analytical results of the samples taken along the route, what effect the dams would have in the ordinary purification processes of the sewage in the water, yes.

Q. And did it have a beneficial effect?

A. I think that at times during the year some effect is due to those dams in purifying these waters of the Illinois river to some extent.

Q. In what seasons of the year is that effect more marked, in winter or summer?

A. Well, that effect would be prevalent during the low water stages of the year, after the overflow had taken place, carrying the sewage laden water over those fields; that is at the low water stage that part of the sewage that would remain on those fields would not be swept back into the river and of course the low water stages then would facilitate the purification processes.

Q. The low water stages of the Illinois river are mainly in the summer months, are they not?

A. Well sometimes, if the season is dry and if the rainfall is low.

2722 Q. Well it never is as high in the summer as it is in the spring.

A. It is usually high, during the spring freshets, yes.

Q. The spring freshet is when the snows in the watershed of the Illinois and its tributaries begin to melt and come down the river in the shape of water?

A. Yes sir.

Q. During those times there is greater dilution to this sewage water than in the summer, isn't there?

A. Dilution of the chlorines, yes.

Q. And dilution of the sewage?

A. Well, the analytical results of many investigators demonstrate that the freshet doesn't result in the decrease of ammonia for instance. The ammonias go up after a freshet, because a freshet will sweep out the ammonia which is prevalent in the sediment at the bottom of the river, where, during the low stages these fermentative changes are going on, then that sludge is swept out and my investigations show that while the chlorine will be lowered and the dilution evidently reduces the figures of chlorine materially after the freshet, the ammonias go up.

Q. Isn't the presence of ammonias in freshets due largely to the manure of cattle, and the farm houses and stables 2723 that are being washed down into the creeks and tributaries of the river throughout a great expanse of country and emptying directly into the Illinois river?

A. To a certain extent, yes, but they are also due to the sewage that may have been in that river before these freshets come, and due to the ammonias themselves prevalent at the bottom of the river where the fermentative changes in the sludge at the bottom of the river are going on and the ammonias is produced; then they may be due to the ammonia in the rain water, and may be due to the ammonia in the snow that melts and particularly to snow that has fallen in the neighborhood of cities, which is apt to contain free ammonia. I speak now of free ammonia and also rain-water. Rainwater may add free ammonia to river water in heavy rain-falls, spring freshets.

Q. In the country, doctor, where a great many cattle are being fattened for the markets along the sides of creeks for watering purposes, and a heavy rain comes up generally through the country, doesn't that wash down the refuse of those cattle on the different farms covering great expanses of territory?

A. You mean through the tributaries?

Q. Through the tributaries which ultimately empty into the river and cause it to rise; doesn't that account for the presence of ammonia?

2724 A. Yes, some, but not much, because this manure undergoes initial processes to some extent, before it reaches those brooks and tributaries, for the same reason that it is to a large extent surface drainage, and the soil there acts as a filter, and the nitrifying bacteria in the soil will naturally assist very much in the purification processes of manure from farms and from the cattle yards of farms, etc. So that when that water reaches the rivers, when the water that drains through this soil first reaches these branches of the rivers, it is in an advanced state of purification. It don't show such high ammonia because ammonia is always the preliminary state of purification, the first product.

Q. Does the high dilution have any effect upon the sewage in water?

A. High dilution has a great effect on the chlorines, in reducing the chlorines in water.

Q. Has it an effect upon anything else in the water except on the chlorines?

A. Well, it may have some effect on the nitrates and nitrites in reducing their quantity.

Q. Does it have any effect in lessening the quantity of albuminoid ammonia, high dilution ?

A. Well now, in some instances it may and in some instances it may not, because if the water that enters the
2725 river there and dilutes the albuminoid ammonia; if that water is of good character naturally the albuminoid ammonia will have been reduced in total quantity because it is diluted, but if that water contains albuminoid ammonia of vegetable origin, as is frequently the case, after a freshet, why then the albuminoid ammonia may go up very high.

Q. In arriving at a conclusion from chemical analyses of the waters above Peoria, does the current of the river cut any figure in the conclusions drawn?

A. Yes sir.

Q. During high water, there is increased dilution with a correspondingly increased current, with a correspondingly greater area of territory inundated, is that true?

A. Yes sir.

Q. Do all those elements enter into and are they essential facts to be known in drawing a conclusion as to the cause of the pollution of the waters above Peoria?

A. They may be of value, but not essential in drawing a conclusion as to the sanitary character of that water as it flows in the river.

Q. If you only had the analyses to go by and knew nothing of the conditions before mentioned, such as the area of territory inundated, the volume of dilution or the rate of the current, would you be able to draw definite conclusions
2726 from those analyses as to the source of the pollution?

A. I would. I haven't taken into consideration all those conditions.

Q. Would you be able to draw a definite conclusion from the analyses in the absence of any knowledge upon those conditions?

A. Now a conclusion as to what?

Q. As to the condition of the water and the source of its contamination, whether vegetable or animal?

A. Yes, as far as that is concerned.

Q. Take the chlorines, could you tell to what the high chlorines would be attributed in the Illinois river if you didn't know the source from which it was derived except by the analyses that were made of the waters?

A. These high chlorines and the high ammonias and the high organic matter in general found there, if accompanied by high nitrites, would suffice to enable the conclusion that the chlorine there was due to sewage pollution.

Q. Are the conditions of the Illinois any different from the conditions of the Missouri?

A. Yes sir.

Q. High chlorines in the Missouri River without knowing the source whence they come, I believe you stated yesterday or the day before, that you were unable to state whether they were from animal or mineral origin, by the analyses
2727 themselves.

A. That was with the hypothetical question, if the chlorines were high and if the nitrites were high, but only in case the general analyses point to certain conditions like they prevail in the Illinois River, with the high organic matter, high nitrites, high free ammonias, and chlorines going with that, since high ammonias and high organic matter and high nitrites would hardly go together unless there was high chlorines, indicating sewage pollution, the conclusion is justified that it is immaterial to determine the source of the chlorines in such a case. When you form an opinion of the sanitary character of the water, you take into consideration the general analytical results. You compare figures for the principal ingredients of pollution and from that comparison you form a general conclusion.

Q. Can you tell by the chlorines whether in the Illinois River they come from vegetable or animal origin?

A. Well, that would be impossible for anybody to determine as to the chlorine itself.

Q. As chlorine can you tell whether the chlorine comes from mineral or vegetable or animal origin, from the chlorine itself?

A. No sir.

Q. Can you have high albuminoid ammonia and free ammonia?

2728 A. Do you mean high or low free ammonia there?

Q. High free ammonia and high albuminoid ammonia and high nitrites from vegetable origin?

A. It is not likely.

Q. Can you have it, doctor?

A. Well, it may be possible but from the examinations I made of those rivers—

Q. I am not speaking of your examinations, doctor; I am speaking now as an abstract proposition. Can those conditions obtain in water from vegetable origin?

A. I think it does in exceptional cases, but not as a rule.

Q. Can those conditions obtain in water from animal origin?

A. Not unless they were accompanied by correspondingly high chlorines.

Q. Could those conditions obtain from vegetable origin and the high chlorines were directly attributable to salt beds?

A. Well now, what conditions do you refer to?

Q. High albuminoid ammonia, high free ammonia and high nitrites, and that the chlorine was directly attributable to mineral origin, to salt beds?

A. What would be the question then?

Q. Can you have those conditions such as is presupposed in the previous question, from vegetable contamination?

2729 A. The high chlorines would render that improbable.

Q. If they came from mineral origin?

A. No—wait a moment. If it had been determined that the chlorines came from mineral sources—

MR. WOERNER: That is what he said.

A. That then the high ammonia and high nitrites and high albuminoid ammonia might be due to vegetable origin. Is that the question?

Q. That is the question.

A. Yes, then it may be from vegetable origin if the nitrites are high, correspondingly high to the albuminoid ammonia and the free ammonia correspondingly high.

Q. Could you have low nitrites and high free ammonia and high albuminoid ammonia under the same conditions from vegetable origin, attributable to salt beds?

A. Yes, they may be of vegetable origin with high free ammonias and low nitrites, but high free ammonia.

Q. Could you have high albuminoid ammonia, low free ammonia and high nitrites with chlorine attributable to mineral origin from vegetable sources?

A. Well that is a case that would hardly occur. It may be possible, but—

Q. That is what I want to know. Could those conditions obtain?

2730 A. It would be a very rare occurrence, because in the relation of those compounds with the albuminoid ammonias high and the nitrites high, the free ammonia ought to be high because the free ammonia there is an intermediate product of the fermentative changes going on and it is not likely that there would be high albuminoid ammonia and high nitrites unless the albuminoid ammonia were high with it.

Q. Couldn't you have such a condition, is what I am asking. Is such a condition possible?

A. This is now a hypothetical question.

Q. Now are such conditions possible?

A. Well, I don't know of any from my analytical investigations.

Q. Could you have those conditions possible from animal contamination, attributing the chlorine to animal origin?

A. With the condition of high free ammonia or low free ammonia?

Q. High?

A. Those conditions that you mentioned just now, though, included low free ammonias; that is just why I said it was doubtful.

Q. I mean including high free ammonia, high albuminoid ammonia and high nitrites, with the chlorines attributable to

salt beds, could you have that condition as being derived
2731 from vegetable origin?

A. Yes, provided that the chlorine is proven to have come from salt beds.

Q. That is what I stated.

A. That may be possible in some instances but it would be an exception to the rule. It would require certain conditions that are not often found.

Q. Now when you made your analyses above Peoria, what were the conditions of the free ammonia?

A. I found the free ammonia high.

Q. What were the conditions of the albuminoid ammonia?

A. The albuminoid ammonia I found sometimes high, but at times I found them so low that they were lower than the free ammonia, which was a very bad sign.

Q. And the nitrites?

A. I found the nitrites high. Now, how far up above Peoria do you mean?

Q. At the point above Peoria that you took the samples.

A. You don't mean the entire route?

Q. No, I mean at the point above Peoria.

A. I found the nitrites high at Peoria, three miles above Peoria.

Q. And the albuminoid ammonia?

A. The albuminoid ammonia I would sometimes find
2732 quite high and sometimes find low, as compared with a
uniform high free ammonia.

Q. And when you found low albuminoid ammonia and high free ammonia, what did that indicate?

A. Low albuminoid ammonia I said, and high free ammonia.

Q. Yes?

A. If it corresponded with high nitrites and comparatively high chlorines, it indicated sewage pollution beyond a doubt.

Q. Low albuminoid ammonia and free ammonia indicated that the albuminoid ammonia had been oxidized, didn't it, and converted into free ammonia?

A. No, it showed a character of the free ammonia justifying the conclusion that it was of animal origin; that is generally assumed. That is the conclusion that is usually drawn by all sanitary chemists, that when the free ammonia is higher than the albuminoid ammonia and it comes with high nitrites and high chlorines, that is a positive indication of the prevailing animal origin of that sewage.

Q. At what point above Peoria, did you take the samples aside from the three mile point above Peoria?

A. That depends upon the time of the investigation.

Q. Any one time, doctor?

A. At one time there were samples taken at LaSalle.

2733 Q. How far is LaSalle above Peoria?

A. I couldn't tell you at this moment; I would have to look that up. I haven't got the table of those distances at hand just at this moment.

Q. Give it to me approximately, doctor. I won't bind you to your answer. Is it fifty miles?

A. Well I wouldn't say because I cannot recollect at this moment.

Q. We will pass that doctor. Did you figure or estimate the percentage of purification from Lockport to LaSalle of the waters of the sanitary canal?

A. No sir, not percentage figures.

Q. Do you know how much the sewage of the sanitary canal purifies itself by the time it gets to LaSalle, after leaving the Bear Trap Dam at Lockport?

A. The fermentative changes of the initial processes of purification of the sewage—

Q. The question is doctor, do you know?

A. I haven't made a percentage calculation of that but I know—

Q. Did you make any kind of a calculation that would enable a layman to understand how much of that sewage has been eliminated from the waters of the Drainage Canal by the time it got to LaSalle?

2734 A. That would be impossible to determine in any other way than in approximations obtained from the careful study of the analytical data because the question of elimination of sewage would practically mean the completion of the ordinary chemical purification processes, and that is almost impossible to determine in this case. The analytical data have to be compared as obtained from samples collected at points say at the drainage canal at Lockport, from the Desplaines River at LaSalle and from a comparative study of those data the conclusion is to be drawn, and the only possible conclusion that can be drawn, as to what general degree of purification may have taken place, and what changes that sewage may have undergone in transit between those two points.

Q. Did you figure out from your data those changes?

A. As I said, it was impossible to figure those data in percentages; nobody could do that.

Q. Then the effect of purification in the elimination of Chicago sewage in going from Lockport to LaSalle is an impossible calculation, is it?

A. The percentage calculation as you indicate would be impossible to perform by anybody.

Q. Is there any way of ascertaining how much sewage contamination is added to the Illinois river from other
2735 sources than the drainage canal between Lockport and LaSalle?

A. In general, yes.

Q. Did you ascertain that fact?

A. I did.

Q. How much; what percentage of sewage was added to the Desplaines and Illinois rivers before they had got to LaSalle, from sources outside of the drainage canal and the Illinois and Michigan Canal?

A. That would be difficult to estimate unless the various conditions would be taken into consideration. The analytical data obtained from the examination of the samples along that route, would give information that would enable some conclusions as to the effect of the sewage of the drainage canal on that river.

Q. Were these analytical data to which you referred quantitative?

A. Yes sir.

Q. Would they tell the quantity of sewage that was added, of the percentage of sewage in a given sample of water?

A. It would demonstrate the effect of any sewage that was

added to the waters after the drainage canal sewage was discharged into the Desplaines River. That would depend upon the places where the samples were taken; that is whether the sample was taken from the Desplaines river before the drain-
2736 age canal meets it, and the sample taken from the drainage canal before it meets the Desplaines river; then a sample after the drainage canal meets the Desplaines river; then a sample taken after the sewage of, I will say Joliet for instance, has been discharged into the river and a sample taken after that sewage has been discharged.

Q. Would that sample indicate the volume of sewage discharged from Joliet into the Canal?

A. Well, that would be impossible to determine; nobody could do that.

Q. And has that been done?

A. Not to my knowledge.

Q. Do you know how much sewage from LaSalle is discharged into the Illinois River?

A. The sewage of LaSalle would be inappreciable.

Q. That isn't what I am asking you. Do you know how much in volume?

A. I cannot recall the figure at this time, but I did study that problem.

Q. Do you know how much in volume was discharged into the Illinois River from the Sangamon?

A. Do you mean to say how much water or how much sewage?

Q. How much sewage—water isn't contaminating in itself, is it, unless it has sewage pollution?

2737 A. No. At low stages of the Sangamon River coming from that river would be inappreciable, and hardly have an effect upon the general chemical character of the Illinois River.

Q. But you don't know the amount?

A. No, but I studied analytical data obtained from analyses of the Sangamon river before it meets the Illinois river and after the two rivers have joined and from this analytical data I am justified in concluding that at certain times the effect of that sewage on the sanitary character of the Illinois river would be inappreciable.

Q. Would that be true of the Kankakee River?

A. It would be true under like conditions, yes sir.

Q. Well, does the Kankakee river contaminate the waters of the Illinois?

A. I think it does some, and at times a little, but there is always some contamination there.

Q. Always some, but is it enough to affect the potability of the stream in itself?

A. No sir, because the analyses received from those tributaries showed that those tributaries are in a much better sanitary condition than the Illinois river.

Q. Assuming that the Drainage Canal did not empty into the Illinois river, would the sewage contamination from the Kankakee and the Fox river and the Sangamon, and these 2738 other rivers contaminate the waters of the Illinois so as to render the water not potable?

A. If the chemical analyses of the water from those tributaries would demonstrate considerable sewage pollution the waters from those rivers would of necessity increase the pollution already present in the Illinois river and that would depend upon the volume of water coming down those tributaries, whether it was high stage or low stage. During times of drought, the effect of those low stages, the effect of those rivers will be very little, and the chemical analyses of those waters from the tributaries showing that they are of much better quality, although not pure, yet only polluted to a very limited degree, and this pollution by low chlorines demonstrating that there is only a little, and in such cases, if any pollution of animal origin could be deduced from those figures as obtained, I say that a pollution from those rivers would be at times so immaterial that it wouldn't affect the general sanitary character of the Illinois river injuriously, if the Illinois river had run some distance after receiving the waters from the tributaries.

Q. Do the chemical analyses of those rivers emptying into the Illinois river demonstrate the conditions that you have related?

A. They demonstrate that at times those conditions that 2739 I mentioned prevail.

Q. Then if you would eliminate from the Illinois river the sewage contamination from the sanitary district, these rivers with that minimum amount of sewage as disclosed by the chemical analyses would not render the waters of that river non-potable, would they?

A. At times, yes.

Q. At what times would these rivers pollute the waters of the Illinois, so as to make the waters of the Illinois unpotable?

A. Well, they could do so when the stages of the rivers by its tributaries would be high, because that would sweep out whatever accretions of pollution there might have been on the banks, that it would increase the ammonias. It would sweep out the deposited sludge in those rivers and that would enter the rivers. Now this would depend very much upon the character of that pollution, whether of vegetable or animal origin. I speak of pollution in general, not specifying sewage pollution.

Q. But by the time it got below Peoria, all that contamination would disappear, wouldn't it, on account of its small quantity?

A. Well, the general analytical results from those rivers, demonstrate that the pollution from those tributaries would in a measure disappear during the run of the Illinois river.

2740 Q. Now what effect would the sewage from Lockport have upon the Illinois river if the sewage of Chicago was cut off from it; wouldn't that disappear? I don't mean Lockport, I mean Joliet. Wouldn't that disappear long before it reached Grafton, the amount being so inconsiderable from Joliet?

A. I think that the Joliet sewage before it would reach the mouth of the Illinois, would be purified to an extent that the effect of the original pollution would be of a character that while the water at the mouth of the Illinois would not be pure, yet it would be in a much better condition than the water at the mouth is, because of the sewage of the drainage canal entering the Desplaines river.

Q. I am eliminating the drainage canal, doctor. I am taking conditions that are based upon the elimination of the sewage of Chicago?

A. Yes sir.

Q. Now that would be true of LaSalle and the towns located along the river there, you said LaSalle sewage was inconsiderable.

A. Yes sir.

Q. And I believe you also stated here the other day that the sewage from Peoria would be purified by the time that it got to the mouth of the Illinois river at Grafton, didn't you,
2741 if the Chicago sewage was eliminated?

A. I didn't say that. I said that if the water of the Illinois river when it reached the city of Peoria, would be pure, then I said it would be true that the sewage of the city of Peoria would chemically have undergone changes by the time it reached Grafton, to the effect that it would not be noticeable in the analytical results found in the water at Grafton, chemically speaking.

Q. I am talking chemically. You qualified the other day first you said, as a bacteriological expert and disqualified yesterday, so I want to confine you to chemistry.

A. I didn't qualify as an expert bacteriologist at any time of my testimony.

Q. I say as I understood you, not as you understood yourself. I am responsible for that, not you.

A. Yes sir.

Q. Now, eliminating the sewage of Chicago from the Illinois river, the sewage of Peoria entering that river would be not chemically discernible when it got to Grafton would it?

A. The effects of that pollution would not be chemically discernible at Grafton.

Q. Now, doctor, if your statements are properly based on investigation and if you properly state the conditions of
2742 the Illinois river and its tributaries as to pollution, will you explain to me how it was in 1899, before the opening of the Drainage Canal you reported to the Board of Health of the City of St. Louis that the waters of the Illinois river at Grafton were contaminated and not in a potable condition, as evidenced here by the report on file?

A. Because I found the water of the Illinois river above Peoria badly polluted.

Q. In 1899, before the sanitary district channel was opened you made analyses under the direction of the Board of Health and the samples that were made were 19, taken three and five miles above Grafton, and from those analyses you reported the contamination of the Illinois River?

A. Yes sir.

Q. Now my question is, if the sewages of those cities purified themselves and the tributaries of this river, the Illinois river, do not pollute the Illinois river at Grafton, chemically speaking; how is it that your analyses in 1899, before the opening of the drainage canal brought you to the conclusion of denominating that water a polluted water and not potable water?

A. Because my chemical analyses of the samples taken in the Illinois river a few miles above Grafton, demonstrated the polluted character of that river at that point, and my in-
2743 vestigation of analytical data furnished by Professor Long and Professor Palmer, also showed that the Illinois river was badly polluted a few miles above Peoria. The explanation would easily be found in the conclusions that I drew that the Illinois river was in 1899 a badly polluted stream throughout.

Q. Then if your conclusions are correct that the Illinois river was a badly polluted stream in 1899 throughout, why is it then that you conclude that the sewage of the cities along the banks and its tributaries do not contaminate the waters of that river at Grafton?

A. Because the Illinois river was badly polluted before it reached Peoria, before it passes those towns.

MR. TODD: I move to strike out the answer.

A. And simply assumes its bad character again.

Q. (Question repeated)?

A. The Illinois river could be badly polluted and yet any pollution from the tributaries and from the towns along the Illinois river could be so inappreciable that it would not materially affect the character of that river. The river in its entire course was polluted in 1899.

Q. The sewage of Chicago previous to the opening of the drainage canal did not enter the Illinois river, did it, or the Desplaines river?

2744 A. Yes sir, it did.

Q. Haven't you testified that when the sewage from the Illinois and Michigan Canal was pumped into the Desplaines river, that it had been operated upon by conditions such as a septic tank would give, and that the sewage had almost disappeared?

A. Yes, I said that the preliminary stage of purification had been greatly facilitated by the conditions prevailing in the Chicago river and in the Illinois and Michigan Canal, but I never claimed that it wasn't sewage any more when it was discharged from the Illinois and Michigan Canal into the Desplaines River and the Illinois river at LaSalle, why that is still sewage as long as it is not purified in its entirety, and has reached the final stage of nitrates.

Q. Do you hold now to the view that the pollution evidenced by your examinations in 1899, at Grafton, were attributable directly to this discharge into the Illinois and Michigan Canal by the pumping works at Bridgeport, Chicago?

A. It is my conclusion that the Illinois river was polluted by the sewage from the Illinois and Michigan Canal to some extent in 1899, certainly, and the analytical data shows that.

Q. And it manifested itself at Grafton?

A. It manifested itself at Grafton by the bad condition that the water was found to be in at Gratfon.

ADJOURNED until 2:00 P. M., Friday, April 3, 1903.

2745 Southern Hotel, St. Louis, Missouri, 2:00 P. M., Friday, April 3rd, 1903. Continuation after recess. Present, the Commissioner and same counsel as before, representing the respective parties.

DR. WILLIAM C. TEICHMANN,

Resumed the stand for further cross-examination by Mr. Todd and testified as follows:—

Q. Doctor, previous to the opening of the Drainage Canal, what amoant of sewage entered the Desplaines river through the Illinois and Michigan Canal?

A. The amount in volume could not be estimated in any possible way, with the conditions prevailing at that place, but analytical data that are at hand on the chemical character of the water in the Illinois and Michigan Canal, prior to the opening of the drainage canal would show considerable sewage present in the canal.

Q. Are you correct in your statement that the amount of sewage emptying into the Illinois and Michigan Canal could not be estimated. Isn't the contrary true?

A. Well, the volume of sewage could not very well be
1746 estimated, but the chemical analyses can show the presence of characteristic ingredients of sewage pollution that would enable an estimate of the degree of pollution of the water in the Illinois and Michigan Canal with the sewage.

Q. Isn't it a fact that just the converse is true, that the chemical analyses did not disclose the amount of sewage, but the operation of the pumps at Bridgeport would show the exact amount of sewage that was pumped into the Illinois and Michigan Canal?

A. Well the conditions as they are in—

Q. Just answer my question doctor?

A. Well, in order to do that I would have to explain the conditions there—

Q. Answer it first and explain afterwards.

A. The conditions are such at the canal that practically the sewage in the south fork of the Chicago river is pumped into the Illinois and Michigan Canal at Bridgeport.

Q. And very many gallons a day?

A. Yes sir, it varies.

Q. And an accurate count has been kept and published of the number of gallons pumped at Bridgeport every day
2747 into the Illinois and Michigan Canal, is that not true?

A. Yes sir.

Q. And does not the amount that is pumped each day indicate the amount of sewage that enters the Illinois and Michigan Canal?

A. Yes sir, the sewage as it is discharged from the south fork of the south branch of the Chicago River.

Q. What was that amount in gallons, doctor, or cubic feet?

A. Well the amount varies, considerably; sometimes it may be 10,000 or 12,000 cubic feet per minute and other times it may be 20,000 and 30,000 and as much as 40,000 cubic feet per minute.

Q. How does the amount of sewage pumped in the Illinois and Michigan Canal compare with the amount of sewage from Kansas City, Missouri at that time?

A. Well that I could not tell off-hand without making computations on the volume of sewage discharged from Kansas City into the Missouri River.

Q. What would be your opinion as to whether it would be more or less?

A. Well, that I could not tell off-hand without—

Q. You have no information on the subject?

A. Well, I could form an opinion from conclusions made with customary computations of the relative figures of water supply and sewage of Kansas City.

2748 Q. At present you have no idea as to the volume of the sewage?

A. Well, I could not form an opinion off-hand.

Q. Can you give any explanation, doctor, as to why the sewage of Kansas City, or the sewage contaminated waters from Kansas City entering the Missouri River are purified by the time they get to Fort Bellefontaine, and that this sewage emptying into the Illinois and Michigan Canal undergoing fermentative processes such as would prevail in the Illinois and Michigan Canal, is not completely purified by the time it gets to Grafton, in the Illinois River, previous to the opening of the Drainage Canal?

A. Well, that is a rather sweeping question to ask, because a comparison between the two would have to be based upon like conditions prevailing at both places, which is not the case.

Q. So that the conditions of the Missouri River from Kansas City to Fort Bellefontaine are so entirely different from the Illinois River from Lockport to Grafton, that no comparison can be made?

A. The conditions are so different as to render a comparison difficult. I don't say it is impossible after carefully computing all the data that are at hand, and on the relative proportion of sewage to water supply, and the character of the sewage of the two places, and the water with which the sewage is mixed at the two places. 2749

Q. What is your opinion based upon, your knowledge of the conditions prevailing in the Illinois River prior to the opening of the drainage canal, based upon your knowledge of the influences of a septic tank upon sewage, and conditions prevailing in the Illinois and Michigan Canal, from Bridgeport to where the same empties into the Des Plaines River, as to whether that sewage becomes purified in entering the Illinois River before it reaches Grafton or not, prior to the opening of the Drainage Canal?

A. Well that is a very long question. I would like to have it re-read to me slowly.

Q. (Question read).

A. The conditions prevailing in the south fork of the south branch of the Chicago River which is principally the feeder of the Illinois and Michigan Canal; furthermore the conditions prevailing in the Illinois and Michigan Canal are such during the major part of the year that the preliminary fermentative processes of purification of sewage are facilitated in that river as well as in the Illinois and Michigan canal; yet the sewage, although in its ordinary course of purification, partly purified in its preliminary stage, yet this sewage requires considerable additional purification, the ordinary chemical processes obtaining in this purification process, that it will require 2750 considerable time before the effects of this pollution on the Illinois River, could disappear.

Q. Well, assuming all that, will it disappear by the time it gets to Grafton?

A. It is my opinion that it does not.

Q. Does that volume of sewage unoxidized, equal the amount of sewage when it gets to Peoria that is discharged into the Illinois River by the city of Peoria?

A. The chemical analyses of samples of water taken at those points are the only data that could be used in determining that question.

Q. Did you ever take any samples of the Illinois River at Peoria before the opening of the Drainage Canal?

A. No sir, I did not.

Q. Then if you did not take any samples, how are you able to express an opinion that it does not?

A. Because there are data of responsible investigators at hand showing the chemical character of the Illinois River at Peoria, that enable conclusions.

Q. Why is it that the sewage from Chicago prior to the opening of the Drainage Canal would not purify itself in running 350 odd miles when the sewage from Peoria does in going less than 150 miles?

2751 A. First of all, I don't concede that the sewage from Peoria purifies itself from a general hygienic standpoint during that distance.

Q. Do you assert as a scientific fact that it does not purify itself?

A. I only assert that the effects of the pollution of the Illinois River from sewage of Peoria—the effects are not discernible in the chemical analyses as far as chemistry is concerned, from the samples collected at Grafton, several miles above the mouth of the Illinois—as far as chemistry is concerned.

Q. If that is true doctor, what you have just stated, can you determine whether the sewage which you found at Grafton is Chicago sewage or sewage from Peoria?

A. The fact that the—

Q. Answer my question doctor, Yes or No.

(Question read).

A. I can draw the conclusion from analytical data—

MR. TODD: Wait a minute. I move to strike out the answer and ask for a specific answer to my question.

A. Well, the answer—

MR. JEFFRIES: Read the question again.

Q. (Question read.)

2752 A. It can only be ascertained what the effect of the discharge of Peoria sewage into the Illinois River is on the sanitary character of the Illinois River; that is the only thing that can be ascertained.

MR. TODD: I move to strike out the answer and ask for a specific answer to my question.

(Question read) My question is, can you determine?

A. The conclusion is justified that since the chemical analyses of the samples of water taken at a point a few miles above Peoria, the chemical character shows certain conditions of the Illinois River at that point, that after the introduction of the Peoria sewage into the Illinois River, before the Illinois River reaches Grafton, the chemical character of the water at Grafton is of a certain character, comparing that character with the character found in the water above Peoria, the conclusion is justified that the effect of the Peoria sewage on the Illinois River has disappeared, and the general pollution of the Illinois River as established above Peoria continues in a measure to the mouth.

MR. TODD: I move to strike out the answer and ask for a specific answer to my question.

A. Well that is the only way that question can be answered.

Q. Read the question. (Question read). Now can you determine by your analyses at Grafton—if what you stated before is true,—Chicago as distinct from Peoria sewage?

2753 A. That could not be done. Nobody could do that.

Q. And that includes yourself, does it?

A. Yes sir.

Q. You made examinations of the waters above Peoria, did you not, doctor?

A. Yes sir.

Q. Suppose that the sewage of Peoria did not empty into the Illinois River, would the conditions that you found above Peoria of sewage, become better in going as far as Grafton?

A. Well that question would be hard to answer because it would depend upon various conditions that have to be taken into consideration.

Q. Doctor, have you any prejudice against answering a question of that kind?

A. No sir.

Q. Is there any reason that suggests itself to your mind, why you cannot answer that question as to whether the sewage above Peoria in the water, if the Peoria sewage was eliminated would not become purified or improved by the time it got to Grafton, going 139 miles, I believe?

A. Since there is no such condition as you state, prevailing in the Illinois River, I could not base any conclusions on actual conditions there.

Q. I asume these conditions to be true, and you being 2754 an expert I desire to have you address yourself to the assumed conditions. If Peoria did not empty any sewage into the Illinois River, would the condition of the water as you find it from chemical analyses above Peoria be improved by the time that water got down to Grafton—chemically speaking?

A. Well that is a strictly hypothetical problem.

Q. Yes sir, have you any opinion upon it?

A. Hypothetically I would then say that since the Illinois River showed such high pollution during its route from La Salle to Peoria, and this high pollution being found throughout all our investigations, that while the absence of sewage from Peoria might reduce that figure, it is my opinion now, hypothetically,—that the pollution of the Illinois River without the addition of the pollution from Peoria would prevail to a sufficient extent to still render that water as found a few miles above the mouth of the Illinois, unpotable.

Q. Would it be to such an extent, to the same degree under those conditions as it would if supplemented by the sewage of Peoria?

A. Well, I have already answered that question; that I said that while there might be less of pollution noticable at the mouth of the Illinois River, in the absence of pollution from Peoria, that still the pollution of the upper Illinois, be- 2755 fore it reaches Peoria being uniformly high, as found throughout all our investigations, this pollution would still prevail to a certain extent at the mouth of the Illinois, rendering the water of the Illinois River at its mouth unpotable.

MR. WOERNER: Now what he asked you was whether it would be just the same or not; that is what he asked you. Now answer that Yes or No.

A. Well that is impossible to say. I said there might be less pollution, but the character of the Illinois River before it reaches Peoria being such a bad pollution, its character in a measure would continue down to the mouth of the Illinois, but hypothetically—

MR. TODD: If the pollution above Peoria was eliminated would the waters at Grafton be purified of the sewage of Peoria by the time it arrived at Grafton?

A. As I have already testified, if the Illinois River water before it reached Peoria would be pure chemically, the effect of the pollution of Peoria sewage in the Illinois River would not be discernible at Grafton.

Q. In 1899, prior to the opening of the Drainage Canal you stated in your report to the Board of Health, that the waters of the Illinois River were polluted and non-potable; is that correct, doctor?

A. Yes sir.

2756 Q. To what did you attribute—

A. One moment, I did not exactly say non-potable, but I said that they were polluted; the water was polluted.

Q. Well, were they potable at that time?

A. Well, this investigation only covered a few months and during that time the character of the Illinois River water varied considerably at the mouth; that is, there were some samples taken there from the Illinois River at Grafton in 1899 that showed low results for some ingredients of pollution, whereas on other days of those nineteen collections the Illinois River water was badly polluted at Grafton, Illinois.

Q. Well, from the examinations and the sources of information that you had at hand, you concluded did you not, that the Illinois River was a polluted stream, prior to the opening of the drainage canal?

A. Yes sir.

Q. Now to what was that pollution attributable?

A. I attributed that pollution to sewage pollution from the Illinois and Michigan Canal.

Q. To anything else?

A. Well, nobody could draw that sweeping conclusion that it would not be attributable to anything else, because the pollution might be caused at that time in the tributaries—if the tributaries contributed some pollution to the river,—
2757 particularly to those rivers.

Q. Well, did the tributaries contribute any pollution to the rivers?

A. That I did not investigate for 1899; I had no data to that effect.

Q. Well, what is your opinion now as an expert as to whether the tributaries at the present time contribute any pollution to the Illinois River?

A. Well, that would depend upon the stages of the tributaries. As I have testified before, when the stages of the tributaries are low, the pollution from those tributaries is inappreciable.

Q. Well, when they are high, is it appreciable at Grafton?

A. It may be possible that at times, when the tributaries are very high and they sweep out considerable pollution that has accumulated in the course of the tributaries, they sweep it out; that that pollution may have some influence in increasing the pollution found at Grafton, but I testified before, that the low chlorines in those tributaries prevailingly show and the chemical analyses of the tributaries as performed by Professors Long and Palmer, show that the character of the pollution from those tributaries is of a different kind than the prevailingly—than the pollution coming straight down the Illinois River.

Q. Do you know, doctor, whether the sewage unconverted,
2758 that emptied into the Des Plaines River from the Illinois and Michigan Canal exceeded in volume and in quantity all the other sewage from the tributaries and from the cities along the banks of the Illinois River between Lockport and Grafton?

A. Well that would require a careful—

Q. The question is, do you know?

A. Estimation of the volumes of flow of all the tributaries; the volume of flow in the Illinois River—

MR. WOERNER: Just say Yes or No, whether you know it or not, doctor?

A. No, not off-hand.

Q. MR. TODD: Have you ever investigated to find out whether the amount of sewage unoxidized that emptied into the Des Plaines river from the Illinois and Michigan Canal was greater or less than the sewage of the Illinois River derived from all its tributaries and the cities lying upon its banks?

A. That is impossible for anybody to estimate. You speak of unoxidized sewage, the sewage—

Q. I am speaking of the sewage that enters the Des Plaines river from the Illinois and Michigan Canal.

A. Well, the sewage that enters the Des Plaines River—well, that is where it crosses the Des Plaines River at Joliet, you mean?

Q. Yes, as it comes out of the Illinois and Michigan Canal?

2759 A. Well, you know the Illinois and Michigan Canal
crosses the Des Plaines River in Joliet and then runs straight from the Des Plaines river down to La Salle, where it empties into the Illinois River.

Q. Yes, I am including that.

A. Now which point do you mean?

Q. Both points.

A. Both points?

Q. Taking the sewage, that is—sewage unoxidized when it enters the Des Plaines river or the Illinois River. Do you know whether that amount of Chicago sewage, when it entered the Des Plaines and Illinois Rivers exceeded in volume the entire sewage of all the other cities and sections of the country that drain into the Illinois River?

A. At very low stages——

Q. Do you know, I ask?

A. Well, to—

Q. Whether it is greater or smaller?

A. To say that, accurate estimations would have to be made for certain periods.

Q. Well for a year, say, do you know?

A. No, I mean for certain times, at low water stages, very low water stages, on record, I think that that sewage coming
from the Illinois and Michigan Canal would be larger than
2760 from the tributaries and from those small cities along
the route.

Q. Has the stage of water anything to do with the volume of sewage?

A. Well, in measuring or in estimating whether the quantities of sewage there in those rivers, you have got to take the volume of water into consideration because they mix.

Q. If a pound of fecal discharged is placed in 100 gallons of water, would you have any more sewage out of 100 gallons than you would if a pound was placed in 50 gallons of water?

A. Well, the chemical analyses would show a different analytical result and consequently a difference in the chemical character of those two sewages there after being mixed with so much water.

Q. Then the chemical analyses would show more sewage in 100 barrels of water than it would in 50 barrels of water, would it?

A. Well, it would show a larger volume of sewage polluting water, that is all.

Q: I am not talking about volume of sewage polluted water doctor. I am talking about the sewage that pollutes the water. Have you got the distinction?

A. Yes sir, if you take—

Q. Now do you know whether the quantity of sewage that pollutes water, that enters the Des Plaines and Illinois 2761 rivers from the Illinois and Michigan Canal, was greater or less than the amount of sewage entering into and polluting the waters of the Illinois from its tributaries and the cities nestling along its banks?

A. That depends upon the stages of the river.

Q. Would the stages of the river indicate whether you know it or not?

A. The stages of the river would have to be taken into consideration in determining that point.

Q. If the river was two feet above its normal stage, would you know?

A. It would simply mean——

Q. Answer my question, doctor?

A. It would simply mean so much more dilution of that sewage.

Q. But would you know if it were two feet above, or two feet below datum?

A. The chemical analysis would give me some information in that respect.

Q. I am not speaking about chemical analyses; I want to know if your knowledge of the subject depends upon the height or the depth of the water in the river?

A. It depends above all upon the chemical analyses of that water; the character of the water.

2762 Q. Is there any connection between the volume of the water and the source of your information in regard to that matter?

A. Well, if I want to draw any conclusions—

Q. I don't want any conclusions; I want to know whether you know or not?

A. Well, such a question could not be answered without taking into consideration the volume of the water into which the sewage is discharged.

Q. Then you assert as a positive fact that unless you know the volume of water, you can't tell whether a thousand pounds of sewage polluting substance enter the water at the Illinois River from the Illinois and Michigan Canal, or whether 500 pounds enter it from its tributaries, and cities outside of that source of pollution?

A. It would certainly require the consideration of the volume of water in that river.

Q. Doctor, isn't it a fact that volume of water hasn't a thing to do with it?

A. It has a great deal to do with it.

Q. Isn't it a fact that the effect of sewage upon water depends upon the amount of sewage in the water?

A. Certainly, and the amount of the water into which it is discharged.

2763 Q. Isn't it a fact that 100 pounds of sewage contaminating substance entering a thousand gallons of water has no effect upon whether it is 100 pounds or not?

A. Well, if we analyzed the original sewage and analyzed the mixture of the sewage in the water, you will get entirely different results, which shows to you that the water, that the volume of water with which that sewage is mixed is an important factor.

Q. Does it effect the amount of sewage discharged from the city of Chicage whether the Drainage Board discharged 200,000 cubic feet of water over Bear Trap Dam or a million cubic feet of water over the Bear Trap Dam?

A. Yes sir, it is an important factor.

Q. Does it effect the volume of sewage? Doesn't it only go to the dilution of the sewage?

A. Well, but with so much water different chemical conditions are produced.

Q. I am not talking about chemical conditions now, doctor.

A. According to the quantity of water added to it.

Q. Doesn't that sewage exist before the chemist attempts to make his analysis?

A. But he cannot take that sewage out of the water there and separate it again after it was once mixed with the water.

2764 Q. That is true, but he can control the amount of water that goes into the sewage, can't he?

A. Well how do you mean, whether he can control that amount of water that goes into the sewage?

Q. Suppose that the city water department instead of using 60 gallons of water a day only used 10; that ten gallons would be polluted with the same amount of sewage that the 60 gallons would be polluted with, wouldn't it?

A. The 60 gallons of water would produce an entirely different mixture than ten gallons would.

Q. That is true, but it would not increase the sewage that enters into the mixtare, would it?

A. No, but in estimating the effect of the sewage there, you will get a different analytical result.

Q. I am not asking for analytical results or effects. Do you know whether the amount of sewage—eliminating the water, —of the organic matter that composes sewage—I withdraw that question and will ask you one more.

Q. What is sewage?

A. Sewage is usually defined as the liquid contents of sewers, but since the contents of sewers are largely composed of solid matter,—suspended matter, as we call it too, that would have to be included.

Q. Can you ascertain the solids in sewage?

A. Yes sir.

2765 Can you eliminate the water and ascertain the solids in sewage?

A. Well, there are certain chemical processes that have to be observed there in order to determine the solids.

Q. Are those chemical processes in the solids?

A. Well all these chemical processes that determine the solids.

Q. Suppose that you take a pint of sewage and evaporate it down to the solids, and then add a pint of water to that product that you have would that put it back in the same condition it was when you first started?

A. No sir, it would not.

Q. What would be lost?

A. There would be lost some matter that had escaped during the process of evaporation.

Q. Can the matter be collected and weighed?

A. No, that is not done.

Q. Can it be done?

A. Well a great many things are possible that are not done.

Q. Can a chemist do it, is what I want to know, doctor; or is that beyond the scope of chemistry?

A. Well, that is never done.

Q. Can it be done?

2766 A. Well, you can determine that in a different method, by a method—

Q. Can it be done, doctor?

A. By distillation processes.

Q. Is there any reason why you cannot answer that question?

A. Well, it is never done.

Q. Can it be done.

A. Well so I presume it cannot be done.

Q. Then it cannot be done,—that is, to ascertain what the weight of the substances that disappear from sewage by evaporation, is that true?

A. Well, the way you construe it, yes sir.

Q. Now doctor, if that cannot be done, is there any way of ascertaining the quantity of sewage in 100 gallons of water as to quantity?

A. Well, this is estimated by certain chemical methods, and the quantity is determined according to the analytical results obtained.

Q. Suppose that the fecal discharge of man consisting of urine and feces, should be weighed, and five pounds of urine and feces should be placed in 100 gallons of water, and five pounds placed in 50 gallons of water; is there any way in chemistry to ascertain the amount of the feces and urine that has been placed in those two solutions?

2767 A. Yes sir, by chemical analysis.

Q. Chemical analysis?

A. Yes sir.

Q. Then if that is true, can you not ascertain the amount in pounds, or rather the quantitative amount of sewage polluting substance that enters into water?

A. Well that is done based upon chemical investigations.

Q. The amount of sewage producing substances that contaminate water does not depend upon the quantity of water does it?

A. Well, the analytical results would not be accurate unless the quantity of water there would be taken into consideration.

Q. If the water is increased, it does not lessen the amount of sewage polluting substance that enters it, does it?

A. Well, the analytical results would differ accordingly, according to the quantity of water that that sewage was dissolved in.

Q. If you can ascertain that five pounds of fecal and urine discharge is placed in 50 gallons of water, would it change that five pounds by putting 50 gallons more of water into the fifty that it already contained?

A. The chemical results would vary considerably.

Q. But would the quantity in solution vary?

A. The quantity in solution would show different results.

2768 Q. Would it be more or less than five pounds if you added 50 gallons of water?

A. Well, if you dilute it somewhat, the chemical results would show of course a smaller percentage—

Q. But would the amount increase or decrease by adding water?

A. The chlorines would show reduction by dilution.

Q. Would the amount increase or decrease by adding water, doctor?

A. Well, the amount itself—

Q. Would there be any more than five pounds of it, if you added fifty gallons more of water?

A. If you added like amounts to like volumes of water, the amount added to the two volumes of water is alike, certainly.

Q. But if you add 50 gallons of water with five pounds of feces and urine in solution, would the fact that you added 50 gallons of water increase or decrease the five pounds of feces and urine in the water?

A. Well, you added five pounds to it; that is five pounds larger then. After you add it to the water there is something new created; you have then a sewage polluted water, because much of that sewage immediately dissolves into the water.

Q. But wouldn't you have your five pounds of feces and
2760 urine in that 100 gallons of water?

A. It would show that originally five pounds of that matter had been added to that water.

Q. Then if you add 50 gallons more of water to that quantity wouldn't you still have your five pounds of urine and fecal discharge?

A. Well, those five pounds are immediately partly dissolved in the water and you have entirely different conditions then.

Q. But the five pounds would be there, wouldn't it?

A. No, you couldn't say that, because there is no more five pounds of sewage there then; the five pounds of sewage are partly immediately distributed or dissolved in the water.

Q. What has become of it?

A. It is dissolved.

Q. Well, it is there, isn't it?

A. It is dissolved, though; it is not there any more.

Q. You believe in the doctrine of the indestructibility of matter, do you not?

A. Yes, sir; it is one of the laws of nature.

Q. Well, that is there, isn't it—the five pounds?

A. Yes, sir; in that way.

Q. Now, could you, as a chemist, ascertain whether it was five pounds or twenty pounds in that water?

A. You mean after the chemical analysis?

2770 Q. No, after it has been mixed—five pounds of urine and
feeal discharge mixed with 50 gallons of water?

A. And I wouldn't know how much you had added, and you would want me to determine—

Q. No, we have first got 50 gallons of water. We put five pounds of fecal and urine discharge in that water—

A. Yes, sir.

Q. Now, could you by any process known to chemistry, analyze that water and state that five pounds of fecal and urine discharge has been put in there?

A. No, sir; I could not; I could only determine that sewage had been added to that, and the chemical analysis would show a percentage of sewage ingredients somewhat corresponding to the original quantity of sewage added to that water and dissolved in it partly, and partly not.

Q. Now, if we add 50 gallons more of water—pure water—to that water with the five pounds in it, would that make more or less than five pounds of polluting fecal and urine discharge in the water?

A. Well, it would show in the chemical results afterwards which are estimated. Estimated according to the quantity of water for certain chemical ingredients, it will show a reduction, for instance, of the chlorines. For instance, you have 2771 added so much water to that, it would reduce the chlorines.

Q. Doctor, do you understand my question?

A. I think I do.

Q. You really think you do?

A. Yes, sir.

Q. And you are not trying to evade it in any way, are you?

A. No, sir; I consider this a very serious matter, Mr. Todd. I am in duty bound to give an honest opinion, and I would attribute—

Q. Well, then, if you understand my question, doctor, will you tell me whether the addition of water increases or decreases the quantity of the polluting substances in that water?

A. It doesn't increase or decrease the quantity introduced into that water.

Q. That is my question, doctor?

A. Well, that it don't do.

Q. That is all I want to know.

A. But in chemical analysis, of course —

Q. I am not asking about chemical analysis.

A. The quantity of water added to the sewage is of some importance in determining the resuts.

Q. That is all I am asking you about, is that proposition

2772 Q. Now, having ascertained that fact, that the addition of water does not increase or decrease the quantity of this polluting substance in water; that is correct, isn't it?

A. Oh, no; you said upon sewage, or sewage as such—

Q. The quantity of the polluting substance of sewage?

A. Well, the polluting substances are the chemical ingredients that are in that sewage, according to chemistry.

Q. The polluting chemical ingredients of sewage in the form of substances?

A. Well, those will show in the analytical results according to the quantity of water—

Q. Wait, doctor, until I get my question. There is in sewage what is known as a polluting substance, is there not?

A. Yes, sir.

Q. The water that is in sewage in itself is not polluted, is it?

A. How is that question?

Q. The water that enters into sewage is not in itself polluted, is it?

A. Well, it may be pure water and it may be polluted water.

Q. Well, pure water added to sewage is not polluting, is it?

A. No, sir.

Q. Now, if 100 gallons of pure water is added to a gallon of sewage, there still is a gallon of sewage in that 100 gallons of water, is there not? 2773

A. Well, the moment that you put it into the water, the physical and chemical action takes place immediately and brings about a condition that that—

Q. There is so much more sewage then, is it not?

A. Well, it is diluted sewage, then.

Q. Diluted sewage?

A. Yes, sir.

Q. Well, I am speaking of sewage. You speak of diluted sewage as a tangible way of expressing it, is that true?

A. Well, that depends upon where this sewage is taken.

Q. Then, if at the controlling works at Lockport 300,000 feet of sewage diluted water was allowed to go over the Bear

Trap Dam, there would be 300,000 cubic feet of sewage enter into the Desplaines river, wouldn't there?

A. No, that would be 300,000 cubic feet of sewage diluted water, because that is a mixture of the sewage and water.

Q. Now, what is there in that water as it passes the Bear Trap Dam that is known as sewage?

A. The chemical analyses reveal that certain characteristic ingredients of sewage are to be found in that water, which justify the conclusion that sewage has been mixed with the water.

Q. Now, whatever sewage is defined to mean, is something tangible, isn't it? 2774

A. Do you mean tangible in its application?

Q. It is an entity, it is something tangible; it is a material?

A. Yes, sir.

Q. Now, call it what you want to and give to it any name that you please, will you tell me whether you know whether the sewage that entered the Desplaines river from Chicago prior to the opening of the Illinois and Michigan Canal was greater or less than the sewage from all of the tributaries of the Illinois river and the cities that were built upon its banks from Lockport to Grafton?

A. At times of low water stage—

Q. Doctor, I asked you if you knew? We have gone over the water business and that would only go over it again.

A. I am ready to answer that question.

Q. (Question repeated.)

A. At times of low stage of the Illinois river it was.

Q. Do you know?

A. Yes, at times of low river stages it was.

Q. It was what, greater or less?

A. Greater.

Q. The Chicago sewage was greater than all the rest or all the rest was greater than the Chicago sewage?

2775 A. The sewage discharged from the Illinois and Michigan Canal in its effects, as shown by the chemical analyses and applied to low water stages was greater at such times than the sewage from the tributaries and the towns.

Q. How much greater, doctor?

A. Well, I couldn't give the exact figures, because I would have to consult the original data, and compute the figures from those original data. I gave an approximation which leads me to that conclusion.

Q. Have you ever made a calculation?

A. I have made such calculations, yes, sir.

Q. When did you make them?

A. I made those calculations several years ago in preparing my report on the investigations in questions here.

Q. How much sewage did you give to the city of Peoria when you made that calculation?

A. I cannot recollect at this moment; I haven't got all those data fresh in my memory; it is several years ago since I computed them.

Q. How much sewage did you give to Chicago?

A. The sewage from the city of Chicago at that time I figured hypothetically from publications by authorities who had expressed opinions on the quantity of sewage from Chicago.

2776 Q. What do you mean by hypothetically?

A. Well, because it has never been estimated by engineers with the proper engineering methods applied, how much Chicago sewage is discharged through the Illinois and Michigan canal; that is scientific engineering calculations have not to my knowledge been made, or to my knowledge examined. I failed to find any such, although I looked for them very hard.

Q. Was any sewage emptied into the Illinois and Michigan canal except through the pumps at Bridgeport that you know of?

MR. JEFFRIES: If you know?

A. That I couldn't tell at this moment. I am not sure whether any adjacent towns on that canal did.

MR. TODD: I am talking about Chicago.

A. You are speaking of the Illinois and Michigan Canal now.

Q. I asked you if any sewage from Chicago entered the Illinois and Michigan Canal except at the pumping works at Bridgeport?

A. To my knowledge at this moment, only at Bridgeport.

Q. And hasn't data been kept of the number of gallons, the number of cubic feet that has been pumped every twenty-four hours for the last twenty years at the Bridgeport pumping works?

A. Yes, but that is not what I consider sufficient engineering data as to how much sewage of the city of Chicago 2777 enters the Illinois and Michigan Canal, because this sewage, the sewage of the city of Chicago, is discharged into a waterway, into the Chicago river and the speed of that river varies. The varying stages of the river cause varying conditions, sometimes the river stagnates and keeps that sewage in there for a long time before it reaches the pumps at Bridgeport, and then again, during storm water times, the flood water sweeps that sewage much faster and quicker, from the south fork principally, into the Illinois and Michigan canal; so that there are different conditions. Therefore it is not possible to say how much direct sewage goes into that canal. I will admit, or rather it is a matter of course that there are daily estimations made of the quantity of sewage pumped from the south fork of the south branch of the Chicago river into the Illinois and Michigan Canal.

Q. Is it not a fact that the sewage from the Chicago river enters the Illinois and Michigan Canal—that not a drop of the sewage from the Chicago River enters the Illinois and Michigan Canal except what is pumped in there?

A. Yes, sir; and that is my impression.

Q. And that sewage that is pumped in there comes from freshets in a more polluted condition or, if stagnation has been allowed to take place in the Chicago river, in a less polluted condition, but the amount of sewage always equals the 2778 amount that is pumped in from the Bridgeport Pumping Works?

A. The amount of sewage polluted water from the Chicago river, yes.

Q. From the Chicago River?

A. From the south branch of the Chicago river, to be correct.

Q. Now, from that amount in cubic feet, did you say that exceeds the sewage polluted water that comes from Springfield, Illinois, from Ottawa, from Peoria, from Pekin, from Beardstown, Virginia City and all the cities lying on the tributaries of the Illinois river, which empty into the Illinois?

A. At times of very low river stages, yes.

Q. And can you state how much in excess of the sewage of these different places that sewage amounts to?

A. I couldn't say at this moment, because I would have to compute accurate data there which will take me some time to calculate. I would have to get all the original figures.

Q. Have you ever made any personal investigation as to the amount of sewage from Springfield, Illinois that enters the tributary that leads into the Illinois river. Have you ever made an estimate?

A. The analyses from the Sangamon river suffices to demonstrate —

2779 Q. You can go on and I will move to strike out your answer as not responsive to the question.

A. Repeat the question?

Q. (Question repeated.)

A. I made an estimate as to the effect of that sewage on the Sangamon river.

Q. Have you made any estimate as to the cause of that effect?

A. It wasn't necessary.

Q. Have you made any estimate as to the cause of that effect, is my question?

A. No, it wasn't necessary.

Q. Whether it was necessary or not, is another matter. Have you made any estimate as to the amount of sewage draining into the Illinois river from Joliet, Illinois?

A. Yes, sir.

Q. How did you make that estimate, doctor?

A. I based that estimate on the water supply of the city of Joliet.

Q. Did you make any estimate at Pekin?

A. Yes, sir.

Q. How did you make that estimate?

A. I made that estimate from chemical analyses of samples of the water taken above and below Pekin.

2780 Q. When?

A. I made that several years ago during other investigations.

Q. Since or before the opening of the drainage canal?

A. I made that before and after the opening of the drainage canal.

Q. And did you arrive at the quantity of sewage that entered from that place?

A. I made some allowance there for the conditions prevailing in every small town like Pekin, that much of the sewage does not, or is not discharged into the river by the sewerage system, but goes into the surface soil through cess-pools and outhouses.

Q. What percentage did you base that on?

A. I don't remember now; it is some time ago since I computed those figures and I haven't got that in my memory just now.

Q. How do you figure out the quantity of sewage from Peoria?

A. The quantity of sewage from Peoria, I base that on the water supply.

Q. Did that water supply apply to the distilleries?

A. Well, that was to include all the sewage from the city of Peoria.

Q. Do you know how many tons of sewage or refuse is drained into the Illinois river every day by the distilleries
2781 of Peoria?

A. Well, directly, I don't know.

Q. Have you any idea?

A. Well the chemical analyses of samples taken above Peoria and between Peoria and Pekin, at such places where the distilleries run their swill into the Illinois river, because many of them run it directly into the Illinois river, and the chemical analyses made from the points where that swill is discharged directly into the river, enabled indirectly an estimation of the effect of the pollution of the Illinois River from the distillery swill.

MR. TODD: I move to strike out the answer and ask that the question be re-read.

Q. (Question repeated).

A. I cannot give an accurate figure directly, as to the quantity in tons.

Q. Prior to the opening of the drainage canal the Illinois river was a polluted stream, wasn't it?

A. Yes sir.

Q. When this report was made in 1893, that you have stated, and your report was made to the Board of Health, it was after that report was made that the Intake was placed at the Chain of Rocks, in the Mississippi River, wasn't it?

2782 A. Yes, in 1895 the intake was placed— No, the waterworks were removed, but whether or not the intake was in the course of construction in 1894—this report was made in December, 1893,—that I don't know, but my impression is that it was contemplated, if not in the course of construction.

Q. When the Intake of the St. Louis water supply was located at Bissell's point, there was an epidemic of typhoid in the city of St. Louis, wasn't there, caused by some creek right above Bissel's Point?

A. Yes sir, right above Bissell's point.

Q. That epidemic was attributed to that contaminated creek, wasn't it?

A. Yes sir.

Q. Then when the waterworks were changed out to the Chain of Rocks, did they have another epidemic?

A. To my knowledge there was no epidemic of that force after that.

Q. No, but they had a good sized epidemic for a few months there didn't they, in 1899?

A. In 1899, in November, there was somewhat of an epidemic.

Q. How many cases of typhoid were there in the month of November, 1899?

A. I will tell you that in a moment; I have the official figures here. There were 482 cases reported in November, 1899, of typhoid. 2783

Q. Do you know whether in any one month in any year previous to that one, that number of typhoid fever cases were reported?

A. Do you mean since the removal of the Intake?

Q. Before, at the time of the epidemic previous to that.

A. You mean in 1892.

Q. Yes.

A. You understand that the number of cases reported in 1892—

Q. Was 1180?

A. During that month was higher—

Q. During the year.

A. Now you are comparing November, 1899, with no previous month in the year.

Q. Yes. 480 cases.

A. 482 cases were reported in November, 1899.

Q. Now in the records of the Board of Health Department of the City of St. Louis, is there any month previous to that when as large a number of cases has been reported in one month?

A. Yes, in the year 1892, during that epidemic, ascribed to the Harlem Creek pollution, above the old intake—

Q. What month was that in?

A. Well, I haven't got the data for that at hand now, but it is my impression that it was a fall month; whether it was October or November.

2784 Q. How many cases were reported in either of those two months?

A. They were considerably higher than those in November, 1899; I don't know the exact figures; I haven't got those.

MR. JEFFRIES: Doctor, haven't you got the tables back for 1895?

A. No, I have only got the statistics for the period following the removal of the intake to the Chain of Rocks, above Harlem Creek.

MR. TODD: Haven't you the tables showing the month in which these 1180 cases of typhoid were?

A. Dr. Ravold presented that table, I believe, as an exhibit, but I haven't got it.

Q. Well, 482 cases in one month, makes quite a respectable showing for typhoid, doesn't it doctor?

A. Yes sir.

Q. What was the cause of that typhoid?

A. Well, the true cause for that typhoid has never been ascertained except that it has been ascribed to the polluted water supply.

Q. No reason then has been able to be found for explaining the presence of typhoid at that time in St. Louis?

A. Not to my knowledge.

Q. And that was before the opening of the drainage canal?

2785 A. Yes sir.

Q. Since the opening of the drainage canal have you had as many as 482 cases of typhoid in St. Louis in any one month?

A. No sir.

Q. Then the conditions in the public health of the city of St. Louis since the opening of the drainage canal has never reached the point in typhoid that occurred for any one month, in 1899, is that correct?

A. Based upon—

Q. Can you answer that Yes or No, if it is true?

A. If based upon the estimate of one month, you are right.

Q. Now doctor, there is just a little matter that I want to pay you a compliment on at the conclusion of my cross-examination, by having you tell me all that you know about the Kaw River and the sources from whence you get your information as to it running through a salt country?

A. Yes sir.

Q. From what data do you get the information that the Kaw River goes through a salt country?

2786 A. (Reading) "Mineral resources of the United States. Calendar year 1887. United States Geological Survey." A tabular presentation of Salt Deposits in the United States, published in this government publication under the title: "Useful Minerals of the United States, a partial list of ores, minerals and mineral substances of industrial importance arranged alphabetically by states and territories, edited by Albert Williams, Jr." This gives the useful mineral deposits for every state where such are found, and names the minerals as well as the quantities where the deposits have been found. It will be seen here on page 732 in the column, "Mineralogical Name," "Halite, common salt, brines and rock salt." It states there "Extensive deposits in Central part of State; Ossowatomie, Miomee county, several wells; near Hamlin, Brown County, springs; Valley of Fall River, Greenwood county; Mound City, Linn County, brine in wells; Marmiton, brine in wells; Emporia, Lynn County, Valleys of Fall and of Verdigris rivers, salt springs; State Salt Springs and other salt marshes in the belt of country crossing Republican, Solomon and Saline valleys, 80 by 35 miles; rock salt south of Great Bend of Arkansaw River, in beds six to twenty-eight inches deep Salt industries at Solomon City, Saline County; Junction City, Davis County; rock salt at Anthony (75 feet thick) Harper County; many borings at Hutchinson 250 feet thick, and Ellsworth, 140 feet thick; Lyons 250 feet thick, Kingman 200 feet thick; of considerable economic importance and remarkably pure." 2787

Now several tributaries of the Kaw River as well as the Kaw River itself, the Kaw River being 300 miles long, drain through several of these counties which are mentioned here as having salt deposits.

Q. Any other source of information on that subject, doctor, except what you have just read?

A. Well, I have discussed this problem with—

Q. I mean from literature first?

A. No, not from literature, no sir.

Q. Doctor, turn to page 622 of that same report.

A. Yes sir.

Q. Is anything said there about salt deposits?

A. Yes, it states there under the heading of "Kansas" what new discoveries of salt deposits have been made during the year 1887 for Kansas.

Q. Will you read that into the record please, doctor. You took that into consideration in regard to the Kaw River, didn't you?

A. No. While it was interesting to see that additional salt deposits had been discovered in Kansas, during 1887, the tabular statement of the mineral resources of useful minerals contained information of all sources of salt deposits in Kansas. 2788

Q. Then if you didn't take that into consideration, why I don't want it. If you didn't regard that at all as shedding any light upon the Kaw River.

A. Well, it did not, because it mentions the discovery of deposits there in counties that were not drained by tributaries of the Kaw or of the Kaw itself.

Q. Doctor, will you state briefly, what the chemical constituents of potable waters as found in rivers, are?

A. Do you mean the natural solids that are in the water, or do you mean impurities that would be permissible and the degree of impurities?

Q. Yes, that's it.

A. You mean the permissible impurities?

Q. Yes?

A. The definition of what is potable water should include a certain arrangement of the degree of impurities taken singly as compared with the general character of a water and the source of a pollution, or the character of the pollution, if the pollution of water should be permissible, and the water be allowed to be considered potable. Now do you want that chemically and bacteriologically, or do you only want it chemically?

2789 Q. I would have to cross-examine you for a couple of days if you go into bacteriology. I want to get through. As to bacteriology I have disregarded you. I am treating you now as a chemist, doctor, and chemically is what I want.

A. You see, the entire potability of water would depend upon both the chemical and bacteriological character of the water, but chemically I would consider water potable if it would be free from nitrites; would be free from free ammonia and albuminoid ammonia, and accordingly it would be free from albuminoid ammonia; it would not show organic matter in the analyses. However, since nature does not furnish such an ideally potable water to a multitude of communities, a liberal allowance must be made by communities for the presence of impurities such as nitrites, free ammonia, albuminoid ammonia and organic matter, as evidenced by the free and albuminoid ammonias. A trace of nitrites and low free ammonia and low albuminoid ammonia, with a comparatively low chlorine, or if the chlorine could be traced to sources not of a polluted character, such a water would be permissible.

Q. Have you completed the answer, doctor?

A. Yes sir.

Q. What proportion of albuminoid ammonia is permissible in potable water?

2790 A. Well, that would depend upon the corresponding amounts of chlorine and nitrites found in the water.

Q. What proportion of albuminoid ammonia, nitrite, chlorines and free ammonia is permissible in what is known as potable water of rivers.

A. Now there again a liberal allowance would have to be made for the conditions forcing a community to accept a water that would not be unpotable if it would have certain relative proportions of these ingredients, proving that whatever pollution formerly existed in that water, if any, that this pollution had been sufficiently removed so as to give that water a character of stability in its chemical ingredients as found present to a limited degree.

Q. Then if you could make a community take the water whether it contained these substances in a high or low degree, that would decide its potability?

A. Well, not entirely because the question would also have to be considered of the bacteriological character of the water before its degree of potability could be determined.

Q. Just eliminate the bacteriology part and stick to chemistry?

A. Yes, from a chemical standpoint alone.

Q. From a chemical standpoint alone, what?

A. I think that a liberal allowance could be made there if 2791 a general conclusion was justifiable, that the potability as accepted by the chemical character of that water would not affect public health injuriously.

Q. And that is the most concise answer you can give as to what is potable water in rivers?

A. Well, analytical limits as to the amount of impurities to be permitted in such water are frequently formulated, but while such limits could be applicable to conditions prevailing in the only possible water supply of a community at one place, they may be different at another place, so that such a limit might be severe in such an instance, and if the general effect on the public health of that community would not be injured by that construction of that so-called standard, such a standard of potability could be adopted in that particular case.

Q. Then the standard of potable water—then the moral to be drawn from what potable water is "Give the people what they think they want" is the test isn't it?

A. If it is not injurious to the public health.

Q. And as far as the chemist is concerned, he cuts very little figure in the determination of what is potable water unless the people accept his views on the subject, is that right, doctor?

A. No. I would say it would depend upon the effect
2792 upon the general public health that the practical application of that standard would have.

Q. So, after all, the people are the judges as to what is potable water or not, and it depends upon the caprices of the people to a large extent?

A. It depends upon public health statistics.

Q. And if the people can stand the water, why it is potable?

A. If the public health statistics show that the water doesn't have any injurious effect on the public health, such water can be considered permissible.

Q. Doctor, have you ever formed an opinion as to whether the waters at New Orleans after receiving the sewage discharge of the entire Mississippi Valley, is sewage polluted or not, or potable?

A. I have not given the analytical data obtained by other investigators on the chemical character of the Mississippi River water at that point any study.

MR. WOERNER: Why don't you say Yes, doctor, and be done with it?

A. I won't say that, I haven't studied the data, but I am not able to answer that question now, positively or negatively.

Q. That's what he asked you, whether you knew.

A. I don't know.

WILLIAM C. TEICHMANN.

ADJOURNED until 10:00 A. M. Saturday, April 4, 1903.

2793 Southern Hotel, St. Louis, Missouri. 10:00 A. M., Saturday, April 4, 1903. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

DR. WILLIAM C. TEICHMANN,

Resumed the stand for re-direct-examination by Mr. Jeffries, and testified as follows:—

Q. Doctor state whether or not the fact can be ascertained that the Kaw River runs through saline regions or salt laden soil, from the analyses of the water, by judging from the high number of chlorines found in the water?

A. Yes sir.

MR. TODD: I object to the question on the ground that it is not re-direct of anything that has taken place, and has been covered in chief.

Q. Now what information have you aside from literature and geological reports, that leads you to believe that the Kaw River runs through salt laden territory?

MR. TODD: I object to that for the same reason as is expressed in the former objection.

Q. Go ahead.

2794 A. The results of chemical analyses made of samples of water collected from the Kaw river.

Q. What were those results?

MR. TODD: I object to that question on the ground that in his direct-examination he has already given the results.

MR. JEFFRIES: If that is true, I will withdraw the question, because I was not here when he was examined.

Q. You answered that, did you doctor?

A. Yes sir, the analytical results have been read.

MR. JEFFRIES: I withdraw the question.

Q. Doctor, assuming that the waters of the Illinois River have been condemned as unpotable; assuming that the important tributaries of the river have likewise been condemned as unpotable, and assuming the fact that the effect of the waters of the Illinois river on the Mississippi at their junction or at any point below their junction did not render the Mississippi river water unpotable prior to the opening of the canal; what effect has the opening of the canal, carrying the Chicago sewage into the Illinois river had from your chemical analyses upon the Mississippi River water?

MR. TODD: I object to that question on the ground that it assumes that the waters were condemned without stating by whom or what method the condemnation has been made, and for the further reason that it is not re-direct examination.

2795 ATTORNEY GENERAL HAMLIN: And for the further reason that this witness has testified to the facts in the case and he is now asked an opinion not based upon the facts that he has testified to.

MR. JEFFRIES: Go ahead and answer, doctor?

A. Do you refer to the drainage canal?

Q. I refer to the Mississippi River water and the effect that the drainage canal has had upon it since the opening?

A. Now would you read that question please, over again.

Q. (Question read)?

A. A polluting effect.

Q. State whether it rendered it unpotable or not?

A. It rendered it unpotable.

RE-CROSS-EXAMINATION.

By Mr. Todd.

Q. Doctor, if water is unpotable, will the addition of additional sewage render it more unpotable?

A. Yes sir.

Q. Then if the waters of the Illinois and its tributaries had been condemned as being unpotable before the entrance of the drainage canal into the Illinois river, after that event took place, the water would be more unpotable, would it?

A. Well the increased pollution would of course have an 2796 increased effect on the public health of such community that would use that water for a water supply, and in that respect I would say that it is more unpotable.

Q. That is, if it is unpotable before the addition, it would be more unpotable to a degree?

A. Yes, as judged by its effect on the public health of the community that would use that water as a water supply.

Q. And if the people thought that they wanted to use that water and did use it, it would be potable for all practical purposes, would it not?

A. You mean after the increased pollution. Yes sir.

RE-DIRECT-EXAMINATION,

By Mr. Woerner.

Q. Doctor, do you mean to say that it is your idea that the potability of water depends upon the opinion of the people that are drinking it?

A. No sir.

Q. Now then, I wish you would explain what you meant by the answer to the last question that was asked you by Mr. Todd?

A. Well, will you read that question—not the last one, but the one preceding the last one?

Q. (Question read as follows:) "And if the people thought that they wanted to use that water and did use it, it would be potable for all practical purposes, would it 2797 not?"

A. The potability of the water could only be judged by its effect on the public health.

Q. How do you determine whether it is potable or not?

A. I determine it by the chemical analyses and a general consideration of the analysis from a chemical and bacteriological standpoint.

Q. Well now, isn't that the only way to ascertain whether it is potable or not?

A. Well that is a theoretical way. The practical way would be to judge its effect upon the public health.

Q. But the idea of the people that are drinking it ha nothing to do with that?

MR. TODD: I object to the question as leading.

A. No sir.

BY MR. TODD:

Q. Has the people's judgment anything to do with the potability of water?

A. Well the experience of the people in drinking the water may enable them to form an opinion.

Q. People who are used to drinking a certain water become accustomed to its use, do they not?

A. Somewhat, yes sir.

2798 Q. And people who are not accustomed to drinking that character of water, when they drink it, it affects them injuriously, does it not?

A. The experiences of some communities show that the strangers are more susceptible to the water than the inhabitants of the city that drink that water.

Q. Well water that would be potable in St. Louis would not be potable to the people of some other city, would it, until they got used to it?

A. Well to some degree, the people from the other cities if they would visit the city where that water is not good, they would be more susceptible to it.

Q. And its use and becoming adapted to the use of water—that decides in a large measure its potability, does it not?

A. In a measure; it might be taken into consideration.

Q. And in the case of St. Louis the people become immune to the water that they drink?

A. To a certain extent they become accustomed to the water and their susceptibility as to diseases from polluted water may be lessened, but the susceptibility is not removed.

Q. Can a chemist, without knowledge of local conditions from analyses, pass upon the potability of water in streams?

A. No sir.

WILLIAM C. TEICHMANN.

2799 PROF. EDWARD H. KEISER,

Resumed the stand for further direct-examination by Mr. Jeffries, and testified as follows:—

Q. Professor Keiser, I will ask you if you have made an examination from data furnished you by the Board of Health of the City of St. Louis, of the condition of the water supply of St. Louis, and subsequent and prior to and after the opening of the Chicago Drainage canal?

A. Yes sir.

Q. Will you state briefly the result of your examination?

MR. JOHNS: I object to the result of the examination as incompetent and not being founded on sufficiently recognized data.

Q. MR. JEFFRIES: State where you got the data?

A. I obtained the data from the Water Commissioner of St. Louis, Mr. Edward Flad, and from the office of the City Chemist, Dr. Teichmann. I received it from Dr. Teichman, also some data from my own laboratory, the Washington University chemical laboratory.

Q. Now you may state the result of your examination?

MR. JOHNS: I still object on the same grounds as before stated and on the further ground that such comparisons are not competent evidence, as the data if in existence, are the 2800 only evidence, and the comparison is a matter of law, and not of fact. It is a matter for the Court.

Q. MR. JEFFRIES: Have you got the data?

A. Yes, I have some of them here and the other data are in the room below.

MR. JEFFRIES: If you insist on all of the data Mr. Johns, we can burden this record with it. It will take time to get it all in.

MR. JOHNS: You can take your own course. I simply object at this time.

THE WITNESS: They are all in the building; the tables are all here.

Q. MR. JEFFRIES: Well, go ahead; state the result of your examination and we will get the data afterwards.

A. In the first place, I have tabulated all the analyses that were made of the waters of St. Louis prior to the opening of the Chicago Drainage Canal, and I find that the records go back to the year 1894. In the first place there are reported seventeen analyses of water from the distributing well. These analyses were made from May 2, 1893 to January 24th, 1894. They are reported in the Mayor's message,—the Mayor of St. Louis, annual message for 1894, page 418, and here are these analyses taken out of the Mayor's message for 1894 (Exhibiting sheets of paper). The average results as here printed for the 2801 condition of the water supplied to St. Louis are as follows:

Free ammonia—this is the average of the seventeen analyses—Free ammonia .046.

Nitrites—that means parts per million of nitrogen—Nitrites .003 parts per million.

Albuminoid ammonia 1.033 and nitrates .38 parts per million.

Then we have in the same report seventeen analyses of water from the settling basins made from April 14th, 1893 to January 24th, 1894, and they gave the following average results:

Free ammonia,	.019,
Nitrites,	.002,
Albuminoid ammonia,	.411,
Nitrates,	.44.

Then a series of twenty-one analyses were made at intervals from December 15, 1892 to April 20th, 1894 in the chemical laboratory of Washington University. They gave the following average results. These are the originals, the twenty-one analyses. Now the average at the bottom is as follows:

Free ammonia,	.048,
Nitrites,	.005,
Albuminoid ammonia,	.310,
Nitrates,	.38.

2802

In addition to these results twenty-six analyses were made by the city chemist of the intake water at intervals from September 9th, 1899, to January 22nd, 1900. The average values—

MR. JOHNS: Wait a minute. I object to the statement as to the results of these analyses because, it has already been introduced in evidence in this case.

A. (Continuing) The average values for these analyses are as follows:

Free ammonia,	.063,
Nitrites,	.002,
Albuminoid ammonia,	.552,
Nitrates,	.39.

Comparing these averages obtained in different years we see that there was but very slight change in the character of the water supplied to St. Louis. The free ammonia ranged between—

Q. MR. WOERNER: What year are you talking about?

A. Supplied to St. Louis previous to the opening of the drainage canal.

The free ammonia ranged between .019 and .063 parts per million. The nitrites varied from .002 to .005; the albuminoid ammonia from .310 to 1.033, and the nitrates were practically constant. 2803 The maximum value for free ammonia before the water of the Drainage Canal reached St. Louis was .138 on January 21st, 1900, and for nitrites the maximum value was .01 on the same day.

These analyses that are recorded prior to the opening of the canal show that the water was comparatively stable, and that it was not an unwholesome water compared with its present condition.

Q. Now give the condition of the water after the opening of the canal?

A. On January 17th, 1900, the Drainage Canal was opened. The water must have reached St. Louis about the beginning of February, 1900, and the effect of that opening on the St. Louis water is clearly seen in the results of the analyses made daily during the month of February—twenty-eight daily analyses of intake water made by the City Chemist gave the following average values?

MR. JOHNS: I object now to the recitation here of the results and conclusions from analyses made after the opening of the Drainage Canal, first because they have twice been introduced in evidence here and are already in the record, and second because the conclusions are not competent evidence in this case.

Q. MR. JEFFRIES: Go ahead doctor?

A.

Free ammonia,	.217,
Nitrites,	.013,
Albuminoid ammonia,	.676,
Nitrates,	.6.

2804

The impurities tend to increase during March as is shown by the following value for thirty-one daily analyses in March, 1900:

Free ammonia,	.348,
Nitrites,	.014,

Albuminoid ammonia, 1.202,
Nitrates, .8.

The average results for April, 1900, were free ammonia .186,
nitrites, .020
albuminoid ammonia, 1.036,
nitrates, .6.

A portion of this great increase in free ammonia and nitrites noticed in February and March, 1900, may have been due to the fact that in the winter months, impurities usually are found to run higher than in spring and summer, but the increase in the months of February and March, 1900 was very much greater than had been observed in any previous analyses, and further the water from this time on was found to have been permanently changed. Subsequent analyses show that in 2805 the spring and summer months, following, the water did not return to its former condition, but had been permanently polluted; thus the monthly averages for April, May and June, and for each following month until June, 1901, are as follows: And I have here a table. Shall I read this off, this table?

MR. JEFFRIES: It is too long, isn't it? It can be copied into the record.

(Said table is in words and figures as follows:)

		Free Am.	Nitrites.	Alb. Am.	Nitrates.	Chlorine.
April,	1900,	.186	.020	1.036	.6	9.
May,	"	.094	.011	1.190	.5	10.
June,	"	.070	.004	1.148	.3	11.
July,	"	.127	.004	1.350	.3	10.
August,	"	.101	.005	.810	.4	12.
Sept.	"	.093	.004	.818	.7	15.
Oct.	"	.118	.006	.898	.6	9.
Nov.,	"	.098	.007	.705	.6	10.
Dec.,	"	.105	.011	.289	.4	17.
Jan.,	1901,	.144	.009	.396	.8	19.
Feby.,	"	.121	.007	.296	.7	19.
March,	"	.310	.013	1.455	1.3	11.
April,	"	.191	.016	1.034	1.1	6.
May,	"	.088	.002	.506	.4	9.
June,	"	.105	.002	1.161	.5	10.

2807 A. (Continuing) The average results for this table, are as follows:

Free ammonia,	.150,
Nitrites,	.009,
Albuminoid ammonia,	.880,
Nitrates,	.6.

Comparing this now with the average result before the opening of the canal, namely, free ammonia, .063,

Nitrites,	.002,
Albuminoid ammonia,	.552, and
Nitrates,	.39,

we see that there has been a very decided increase in each of these forms of nitrogen and that the chemical analyses show a permanent pollution of the water.

According to generally accepted standards of potability, a water having .150 parts of nitrogen as free ammonia, and .009 parts of nitrogen as nitrites, would be condemned as unsanitary.

Q. Now give us the sanitary condition of the Missouri River water before and after the opening of the Drainage Canal?

MR. JOHNS: I move to exclude the entire answer of the witness to the last interrogatory, as argumentative.

2808 A. In looking over the statistics of the Health Department of the City of St. Louis, I found eleven analyses of water of the Missouri River taken at a point above the mouth of the stream, are on record in the Health Department of the city of St. Louis.

MR. JOHNS: I object to the announcing of the results of those analyses, and the average of them, on the ground that it is all of record as testified by the witness.

A. The average results of these analyses were:

Free ammonia,	.080,
Nitrites,	.001,
Albuminoid ammonia,	.657,
Nitrates,	.4.

And the average values of eight analyses made in the chemical laboratory of Washington University of Missouri River water taken at Fort Bellefontaine, Missouri, from January 23rd to January 31st, 1900, are as follows:

Free ammonia,	.134,
Nitrites,	.008,
Albuminoid ammonia,	.342,
Nitrates,	.39.

The average of all these recorded analyses of Missouri River water prior to February 1st, 1900, are as follows:

	Free ammonia,	.107,
2809	Nitrites,	.0045,
	Albuminoid ammonia,	.499,
	Nitrates,	.39.

After February 1st, 1900, daily analyses of Missouri River water were made by the City Chemist until October 10th, 1900, and also during the period October 1st, 1901 to November 30th, 1901.

MR. JOHNS: I object to the announcement of the average values of the results of the chemical analyses during the periods named by the witness because they have been twice testified to already and are of record and it is merely a matter of computation.

MR. JEFFRIES: Go ahead?

A.	Free ammonia,	.142,
	Nitrites,	.007,
	Albuminoid ammonia,	1.203,
	Nitrates,	.5.

And for the second period the averages are:

Free ammonia,	.069,
Nitrites,	.003,
Albuminoid ammonia,	.631,
Nitrates,	.55,

Now the averages of both of these series are as follows:

2810	Free ammonia,	.105,
	Nitrites,	.005,
	Albuminoid ammonia,	.917,
	Nitrates,	.5.

Comparing these averages now, with the averages of analyses before February 1st, 1900, namely:

Free ammonia,	.107,
Nitrites,	.0045
Albuminoid ammonia,	.499,
Nitrates	.39,

We see that there is but a slight difference in the average condition of the Missouri during these two periods. In other words, the Missouri River during the period of September 2nd, 1899, to November, 1901, has undergone no permanent change in its sanitary character. The same fact is shown by comparing the average results obtained by the City Chemist on September 2nd to December 4th, 1899, with the average results obtained by him in October and November, 1901. Those analyses in the form of an average give

Free ammonia,	.080,
Nitrites,	.001,
Albuminiod ammonia,	.657,
Nitrates,	.4.

In the later period, which was two years later, but at the 2811 same time of the year we find

Free ammonia,	.069,
Nitrites,	.003,
Albuminoid ammonia,	.631,
Nitrates,	.55,

We see from these that while St. Louis water had undergone a marked deterioration, the Missouri River water had remained unchanged. It is true that in the winter months the impurities in this river are higher than in the summer. This is true of all streams, but we see that in the fall of 1901 the water had again returned to its former condition. These results show then, that the increase of impurities in the St. Louis water, did not come from the Missouri River.

MR. JOHNS: I move to strike out the entire answer as an argument.

Q. MR. JEFFRIES: Those are conclusions arrived at based upon the data which you have given, are they not?

A. They are.

Q. Now give us the sanitary condition of the Mississippi River before and after the opening of the drainage canal?

A. There are recorded in the health department of the City of St. Louis, analyses made by the city chemist, seventeen analyses of the Mississippi River collected at Hartford, Illinois, a point about one mile above the mouth of the Missouri River. These samples were collected at intervals between Au-

2812 gust 3rd, 1899, and December 4th, 1899. The average results of these analyses are as follows:

MR. JOHNS: I object to any statement of the average results taken from these analyses, because the analyses are not proven and the persons who made the analyses are not produced as witnesses and are not subject to cross-examination.

A. The average results are as follows:

Free ammonia,	.107,
Nitrites,	.004,
Albuminoid ammonia,	.622,
Nitrates,	.5.

These were all made before the opening of the drainage canal. After the opening daily analyses were made from January 23rd, 1900 to October 10th, 1900, upon samples taken at Hartford. The average values for these analyses are as follows:

Free ammonia,	.275,
Nitrites,	.018,
Albuminoid ammonia,	.613,
Nitrates,	.7.

Daily analyses were also made from October 1st, to November 30th, 1901, and the averages obtained were:

Free ammonia,	.062,
Nitrites,	.011,
Albuminoid ammonia,	.368,
Nitrates,	.54.

2813 Averaging both series that were made subsequent to the opening of the drainage canal we get:

Free ammonia,	.236,
Nitrites,	.017,
Albuminoid ammonia,	.568,
Nitrates,	.67.

Comparing these results with the average condition of the Mississippi River at the same point before the opening of the Canal, namely:

Free ammonia,	.107,
Nitrites,	.004,
Albuminoid ammonia,	.622,
Nitrates,	.5,

we see that there has been a permanent increase of the pollution of the water. The water of the Mississippi like that of the St. Louis intake has been very materially inferior in sanitary quality since February, 1900, and further, these analyses show that since the St. Louis water is a mixture of the water of the Missouri and the Mississippi the increased impurities of the St. Louis water must have come from the Mississippi river and not from the Missouri river.

MR. JOHNS: I move to strike out the latter part of the answer as an argument.

2814 Q. MR. JEFFRIES: Now give the condition of the Mississippi River above the mouth of the Illinois River?

A. It having been shown by the previous analyses that the Mississippi River is a carrier of the impurities to the St. Louis intake, it is now of importance to determine how these impurities find their way into the Mississippi. The question arises: Do these impurities come down the main stream of the river or from the Illinois River. Eighteen samples of water were taken from the Mississippi River at a point above the mouth of the Illinois river. These samples were collected at intervals between September 6, 1899, and January 17th, 1900. The average values of the analyses made by the city chemist are as follows:

Free ammonia,	.069,
Nitrites,	.002,
Albuminoid ammonia,	.503,
Nitrates	.3,
Chlorines,	6.0.

Daily analyses of the water from this point were also made from January 23rd, 1900 to October 10th, 1900. The averages obtained are as follows:

Free ammonia,	.138,
Nitrites,	.008,
Albuminoid ammonia,	.587,
Nitrates,	.46,
2815 Chlorines,	5.0.

Daily analyses were again made from October 1st, to November 30th, 1901, and the averages obtained were:

Free ammonia,	.057,
Nitrites,	.001,

Albuminoid ammonia,	.348,
Nitrates,	.1,
Chlorines,	4.3.

Comparing these with the results as given, we see that the Mississippi River above the mouth of the Illinois, while higher in impurities in the winter months, returned in the fall of 1901 to a condition very similar to that which it was in 1899. The amounts of free ammonia and nitrites are relatively low in this stream and it is very similar in sanitary character to the Missouri River above its mouth. Plainly then, the upper Mississipi is not the source of the impurities that pollute St. Louis water.

Q. Now, professor, give the results of the analyses of the Illinois River made three miles above Grafton.

A. Nineteen samples of the water of the Illinois River from a point three miles above Grafton were collected and analyzed by the City Chemist at intervals between September 6th, 1899 and January 17th, 1900. That was before the opening of the canal. The average values found are as follows:

2816 Free ammonia,	.215,
Nitrites,	.012,
Albuminoid ammonia,	.553,
Nitrates,	.8,
Chlorine,	25.0.

These results show that at this time the water was badly polluted and not fit for drinking according to accepted standards. From January 23rd to October 10th, 1900, daily analyses were made of water from the same point, and again in October and November, 1901. The averages for the first series are as follows:

Free ammonia,	.272,
Nitrites,	.032,
Albuminoid ammonia,	.509,
Nitrates,	.96,
Chlorine,	13.0.

For the second series:

Free ammonia,	.110,
Nitrites,	.043,
Albuminoid ammonia,	.373,

Nitrates,	1.71,
Chlorine,	21.6.

The average values for both series of analyses are as follows:

2817	Free ammonia,	.239,
	Nitrites,	.034,
	Albuminoid ammonia,	.482,
	Nitrates,	1.11,
	Chlorine,	14.7.

We see from these that for the ten months since the opening of the drainage canal there was an increase in free ammonia of nearly 27 per cent and of nitrites 167 per cent. We can only conclude from these figures that after the canal was opened there was a much larger quantity of sewage undergoing putrefactive changes, than before in 1901, although the proportion of free ammonia had fallen somewhat, the nitrites had gone up to .043 parts per million, an increase of 258 per cent over what they were before the opening of the drainage canal. The Illinois River is thus shown to be the stream which, with its high free ammonia and nitrites, contaminates the Mississippi, and the Illinois River at its mouth is found to be in a much more polluted condition since January 23rd, 1900, than it was prior to that time. It is therefore the Illinois River that has caused the permanent increase in the impurities of the St. Louis water. The analyses have shown that both the Missouri River and the Mississippi River above the Illinois have undergone no permanent change but the Illinois River has been rendered more impure as a result of the opening of the
2818 drainage canal.

MR. JOHNS: I move to exclude the answer as an argument.

MR. JEFFRIES: Now can you give the condition of the Illinois river at the points above Peoria?

MR. JOHNS: I object to the question because the matters inquired of have already been placed in evidence twice and the conclusions drawn have also been placed in evidence twice.

A. There were no analyses of the water of the Illinois river at points above Grafton made by the city chemist before the opening of the canal, but from January 23rd, 1900, to October

10th the same year, daily samples were taken at a point three miles above Peoria, and occassional samples at Joliet and at Lockport. Samples were also taken from the Illinois and Michigan Canal and from Lake Michigan. These analyses show that as we ascend the river from Grafton to Chicago, the water becomes steadily more and more impure. This fact is clearly shown by the average values obtained from the Illinois: Thus, the average values from samples taken three miles above Grafton, are as follows:

Free ammonia,	.239,
Nitrites,	.034,
Albuminoid ammonia,	.482,
Nitrates	1.11,
Chlorine,	14.7.

2819 The average values for samples taken three miles above Peoria are as follows:

Free ammonia,	.468,
Nitrites	.095,
Albuminoid ammonia,	.284,
Nitrates,	1.48,
Chlorine,	19.4,

And the average values from samples taken at Joliet in 1901 are as follows:

Free ammonia,	2.732,
Nitrites,	.057,
Albuminoid ammonia,	.452,
Nitrates,	.22,
Chlorine,	23.9,

and the averages of samples taken from the Illinois and Michigan Canal, are as follows:

Free ammonia,	13.250,
Nitrites,	.009,
Nitrates,	None,
Chlorine,	150.0.

The averages from the drainage canal, Lockport, Bear Trap Dam are as follows:

Free ammonia,	1.585,
Nitrites,	.026,
2820 Nitrates,	.15,
Chlorine,	15.0.

Now for the sake of comparison, the averages of the water from Lake Michigan are as follows:

Free ammonia,	.043,
Nitrites,	.005,
Nitrates,	.15,
Chlorine,	6.0,

Q. MR. JEFFRIES: Now what conclusions do those results show or lead you to?

MR. JOHNS: I object to the answer and move to strike it out as an argument.

Q. (Question repeated)?

MR. JOHNS: I object to the question as the conclusions have already been testified to and are not at any rate, competent evidence.

A. We see that the entire Illinois river is in a highly polluted condition. The figures obtained at Joliet and those for the Illinois and Michigan and Drainage Canals are such as would have been obtained from sewage in its early stages of decomposition. Lake Michigan has .043 parts of free ammonia and .005 parts of nitrites. Now by the admixture with the sewage in the Chicago River, we find that when it reaches the drainage canal the free ammonia has increased to 1.585
2821 and nitrites to .026 parts per million. The Illinois and Michigan Canal is still more highly charged with sewage and gives 13.250 parts of free ammonia. These two canals carry sewage into the Illinois River by dilution with the water of the river, we find free ammonia .468 at a point three miles above Peoria. The nitrites, however at this point are higher, namely .095. Going down then to Grafton we find that the free ammonia has fallen to .239, and the nitrites to .034, but this is still far from being in a condition fit for drinking. We see that the oxidation and self-purification processes become very slow as the concentration of the sewage is diminished, and for the same reason we find these impurities in the water of the Mississippi and in the water of the St. Louis waterworks.

MR. JOHNS: I move to exclude the answer as an argument.

CROSS-EXAMINATION, BY MR. JOHNS.

Q. By whom were the seventeen analyses from the distributing well made in the period ranging from May 2nd, 1893, to January 4th, 1894?

A. They were made by the Water Department of the City of St. Louis, Mr. M. L. Holman, water commissioner.

Q. Where did you obtain these figures?

2822 A. I obtained these figures from the annual report of the Mayor of St. Louis for 1894, page 418.

Q. You know nothing whatever as to the time of the analyses of any of these samples prior to January, 1900, with reference to their being taken from the water?

A. Yes, the dates are all stated for those in that report from the Mayor's message of 1894, and also these others that are recorded below. The date when the samples were taken is always indicatd.

Q. When was the sample of May 2nd, 1893 taken, and how long after it was taken was it analyzed?

A. Well, it was taken May 2nd, 1893, and it was analyzed in a short time after that, in a very short time after that.

Q. Have you any knowledge of that fact?

A. None except what is stated in the report of the water commissioner.

Q. Do you know as to any one of the samples in the paper I have in my hand marked "Appendix I" Annual Report of the Water Commissioner for the year ending 1894, M. L. Holman, what time of the day, or any one of the days mentioned in the first paragraph of this table, that the sample was taken, from what point and what time elapsed from the taking of the sample until this analysis was completed?

A. They were taken at the St. Louis intake but I don't 2823 know what time elapsed after the taking until they were analyzed.

Q. Do you regard the St. Louis intake as the same thing as the distributing well?

A. No sir, but the water is very much the same.

Q. Well, the samples upon this paper to which I have referred, and which I have described in a previous question, and which you have inclosed in pencil marks, are from the distributing well and samples from the clear wells, are they not?

A. Yes sir.

Q. As to any of these samples in the paper described in group D and group C, can you tell at what time they were taken from either the distributing wells or from the clear wells and how long a time elapsed until they were analyzed after they were taken?

A. No sir.

Q. Do you know personally anything in refrence to the manner in which those samples were kept for the purposes or plan by which they were analyzed?

A. Yes sir.

Q. I mean, do you personally know anything about it?

A. No, except what I have read in that report. The method of the analyses is there described.

Q. Your knowledge then in reference to it, is derived 2824 from the report?

A. Yes sir.

Q. And your knowledge as to that is derived from the printed copy of the report?

A. Yes sir.

Q. Now when you were reading off these results, why did you not state the amount of oxygen consumed?

A. Simply to make the report concise and not to over burden the report with the table of figures.

Q. Do you know whether as to those samples of May 2nd, 1893 to January 24th, 1894, in group D, and from April 14th, 1893 to January 24th, 1894 in group C, there was determined the amount of solids in suspension?

A. There was a statement there of solid matter, of total solids.

Q. Why didn't you state that in giving these figures?

A. I don't know.

Q. Were you instructed not to?

A. Oh, I misunderstood you. What is the question?

Q. Why did you not state them in giving these figures?

A. The solids, simply because it would throw very little light upon the sanitary condition of the water.

Q. Was there any statement made of the solids in solution?

A. No sir, I made no statement of that.

2825 Q. Was there any statement in the report of solids in solution?

A. I don't remember, but we can see by looking at that.

Q. Whether there was or not, do you regard the question of solids in solution as having anything to do with the potability or unpotability of the water?

A. Very little. Very little information can be derived from that as to the sanitary character of the water.

Q. Were there any statements in the report of chlorines?

A. No sir.

Q. And therefore as to those results obtained from the examination of the report, you made no statement as to the chlorines?

A. No sir.

Q. Would you be able to give an opinion as to the sanitary condition of the water without a knowledge of the chlorine?

A. Yes sir.

Q. In your opinion chlorine does not enter into the proper consideration of the potability of water?

A. Not of the St. Louis water.

Q. I am asking about water in general.

A. Oh yes.

Q. In order to determine the potability of water there should be taken into consideration the chlorines, shouldn't 2826 there?

A. Yes sir.

Q. Also the oxygen consumed?

A. The oxygen consumed is not always taken into consideration.

Q. Shouldn't it be properly taken into consideration in the fair opinion as to the potability of water?

A. It assists in forming an opinion.

Q. Well then, it should be taken into consideration shouldn't it?

A. At times I think it is valuable to do it, and at other times it isn't of very great importance.

Q. Abstractly without refrence to the matter now under investigation, is it necessary to take into consideration that subject?

A. It is advisable at times to do it.

Q. At what times?

A. When you know very little about the natural history of the water. It is very desirable then to get all the data that one can in regard to the water before passing judgment on it.

Q. And do you make a distinction between oxygen consumed and oxygen consuming power of water?

A. Those terms mean the same.

2827 Q. Do you make any distinction between dissolved oxygen and oxygen consumed?

A. Yes sir.

Q. Is it necessary in a fair consideration of the potability of water eliminating now any consideration of this case, to know the amount of oxygen dissolved?

A. It isn't usually done.

Q. Is it necessary?

A. It is not very necessary.

Q. Is it necessary at all?

A. I don't think so.

Q. Was the oxygen dissolved stated in the report from which you took these or drew these conclusions?

A. I don't remember that it was.

Q. Can you form an opinion on the potability of a sample of water which has, only so far as your information is concerned, the following elements: Free ammonia .046; nitrites .003; albuminoid ammonia 1.033 and nitrates .38, and if so, what is that opinion?

A. Yes sir, I should say that water was not unsanitary.

Q. Is it potable water?

A. Yes, drinkable water.

Q. Is there a distinction between potable water and drinkable water?

2828 A. I think not; I think they mean the same.

Q. Do you know anything in regard to the samples taken from the clear wells from April 14th, 1893 to January 24th, 1894 as to the time when they were taken and the time elapsing before they were analyzed?

A. No sir.

Q. Do you know anything with reference to the series of nine samples from December 17th, 1892, to April 20th, 1894, in the chemical laboratory at Washington University as to the time when the samples were taken?

A. Yes.

Q. The place from which they were taken and the time elapsing from being taken until analyzed?

A. Yes sir.

Q. State what you know in reference to it personally?

A. I have here a table giving the individual analyses of the samples taken from December 15th, 1892 to April 20th, 1894, stating the exact date upon which these samples were taken and giving in addition to the averages here, giving the actual results obtained, not only for these statements but also for the solids, the total solids and chlorine, and stating whether they were filtered, or unfiltered, and this part of the report if you would like to see it.

MR. JOHNS: I move to strike out the answer as not responsive to the question.

2829 Q. Referring to the former question, have you any personal knowledge as to the taking of the samples in that question mentioned?

A. No, sir.

Q. Nor as to their analyses?

A. No, sir.

Q. Have you any personal knowledge as to the samples taken from September 9th, 1899, to January 22nd, 1900, in the office of the City Chemist, of the intake water?

A. I have no personal knowledge of those.

Q. From what source did you draw the conclusions that you have given as to that water?

A. I have taken the figures from the tables furnished by the city chemist and drawn up these averages.

Q. As to those 26 samples, how did you obtain the averages mentioned?

A. I obtained the average for free ammonia by adding together all the recorded values for free ammonia found in those 26 samples and then dividing the whole number by 26.

Q. And the same process as to the nitrites?

A. Yes, sir.

Q. And as to the albuminoid ammonia and nitrates?

A. Yes, sir.

Q. Taken in the abstract without reference to anything
2830 and—taken in the abstract without reference to anything
than the elements of pollution stated by you, to-wit, free ammonia .063, nitrites .002, albuminoid ammonia .552; nitrates .39. Are those figures sufficient to warrant you in a conclusion as to the potability of that water?

A. I think so.

Q. What is your conclusion as to that?

A. It is potable water.

Q. If I remember correctly, after January 17th, 1900, you were engaged regularly and continuously in the analysis of specimens of the waters under investigation in this case?

A. Yes, sir.

Q. You obtained the averages which you have given this morning by the use of the process of adding up the results as to each sample and dividing it by the number of samples?

A. Yes, sir.

Q. Do you consider a water having the following constituents potable, namely:

Free ammonia,	.217
Nitrites,	.013
Albuminoid ammonia,	.676
Nitrates,	.6 ?

A. No, sir.

Q. On what account?

2831 A. Because the free ammonia there has gone beyond .2
and the nitrites are up in the second decimal place, whereas, potable water shouldn't have free ammonia very much above .1 and in fact, if the nitrites are measurable at all, we usually condemn the water; but we see here in the figures you have given us .013. That is very high nitrites.

Q. I don't want an argument at all; I asked you in what respect?

A. On account of the very high free ammonia and the very high nitrites.

Q. Do you consider the albuminoid ammonia?

A. Of very little value in determining the character of these waters.

Q. Are they of any value in determining a sample of water without reference to this case or a history of the water?

A. Of a little value.

Q. Was the water analyzed as taken from the intake during the month of February, 1900, an absolutely unpotable water, unfit for human consumption?

A. Yes, I should condemn that water as unfit for drinking purposes.

Q. Would it of a certainty, poison inhabitants and animals, people and animals having partaken of it and render it unfit for manufacturing and agricultural purposes?

2832 A. It would not necessarily make it unfit for agricultural and manufacturing purposes, but it would probably cause disease if used for drinking purposes; perhaps not in persons of robust constitution, but very probably in persons of weak constitution, or children. Persons that are weak would probably suffer.

MR. JOHNS: I move to strike out the answer as not responsive and ask the reporter to read it again, and request that an answer directly be made.

Q. (Question repeated.)

A. Not with certainty, I would say.

Q. From what places were the samples mentioned as taken in April, 1900, to June, 1901, on page 3 taken?

A. These samples were taken at the St. Louis Intake, or the Intake of the St. Louis Waterworks.

Q. Would water containing the following ingredients, namely:

Free ammonia,	.150
Nitrites,	.009
Albuminoid amomnia,	.880
Nitrates,	.6

of a certainty be unfit for human consumption?

A. Not with certainty.

Q. Would such water of certainty produce disease in either animals or human beings?

2833 A. It will probably produce disease.

Q. Upon what account?

A. On account of the large amount of sewage matters in it, as indicated by the proportions of free ammonias and nitrites.

Q. That would be because of the presence of germs in that sewage, bacilli?

A. I suppose so.

Q. If there were no pathogenic germs in that sewage, could you tell anything about the probability of its producing disease?

MR. JEFFRIES: I object to the question because the witness is not qualified as a bacteriologist?

A. I don't know.

Q. MR. JOHNS: Well, a chemist considered of himself, is not supposed to know anything about bacteriology.

A. No, sir.

Q. It is the bacteria in the sewage which produce disease, isn't it?

A. I don't know.

Q. The chemical constituents named here in the proportion in which they were named in the former question, would not produce disease, if the water was used for drinking?

A. They might.

Q. Considered of themselves now, and solely as chemical
2834 constituents?

A. These figures that the chemist obtains show that there are in the water nitrogenous materials and nitrogenous materials are of animal or vegetable origin and they furnish the food for the growth and development of disease germs.

Q. I am asking you to exclude anything from your mind and from your consideration except the mere fact that the waters contain the constituents named in the former question and eliminate from your mind any other consideration in that and answer this quesion: Would such chemical constituents produce disease in a human being if such water was used for drinking purposes?

A. These constituents which we have, are not in the water as such, they are chemical compounds that have been gotten out of the water by chemical transformations. For instance, we report chlorines so many parts per million. We don't mean by that that the chlorine is there as chlorine. We report free ammonia so many parts per million. We don't mean that it is there free as ammonia; it is there in combination as ammonium carbonate, or ammonium chloride and when we say albuminoid ammonia, we simply mean ammonia that has been evolved by acting chemically upon this water, freed albuminous substances in the water.

MR. JOHNS: I am very much obliged to you for the lec-
2835 ture, and I move to strike out the answer as irresponsive
and ask that the question be re-read and I demand a direct
answer to the question.

MR. JEFFRIES: I submit that the witness has answered the question in an intelligent way and directly.

MR. WOERNER: Without a lecture.

Q. (Question repeated.)

A. I don't know.

Q. MR. JOHNS: Do you know anything personally as to the 11 analyses of water taken from the Missouri river above its mouth from September 2nd, 1899, to December 4th, 1899?

A. No, sir.

Q. Do you know what time elapsed from the taking of those samples until their analysis, the season of the year in which they were taken or the point in the river at which they were taken?

A. Only in so far as they are recorded on the sheets that I have examined.

Q. On the sheets that you examined were the solids in solution and in suspension given for those samples?

A. Yes, sir.

Q. Was the oxygen consumed given?

A. Yes, sir.

Q. The chlorines given?

2836 A. Yes, sir.

Q. Why did you not give the averages as to those?

A. Because it would have lengthened this statement very much and because those values are of less importance in judging of the sanitary character of the water.

Q. Are they of any importance as to the Missouri river?

A. The chlorine is of no importance, and the solids in suspension and in solution are of no importance, or of very little importance in arriving at a knowledge of the sanitary character of the water.

Q. Why is the chlorine not of any importance?

A. For the reason that the Missouri river water is highly charged with chlorides which is of mineral origin.

Q. Have you any personal knowledge as to that, as to the mineral origin of it?

A. Only in so far as the analyses show this water comes from the Kaw river.

Q. Have you any personal knowledge as to the Kaw river?

A. No, sir.

Q. What those results show to you as a chemist, independent of the consideration of this case, from such results as you have given, could you say whether that water was potable or unpotable?

2837 A. Yes, these results enable me to form an opinion of the sanitary character of this water.

Q. Well, what is that opinion?

A. That it is a fair drinking water, not above suspicion, but still it is drinkable.

Q. And you come to that conclusion without reference to the solids in solution or suspension, or the chlorine or oxygen consumed?

A. Yes, sir.

Q. And from those four items alone, you are enabled to form that opinion as an impartial chemist?

A. Yes, sir.

Q. In the examinations made by you of eight samples, did you determine the amount of solids in solution and suspension and the chlorines and oxygen consumed?

A. Yes, we determined the total solids—excuse me—we determined all of those but we didn't determine the solids in solution. We determined the total solids and the chlorine and the oxygen consumed.

Q. That is, in your data you determined the total solids?

A. Yes, sir; the total solids include those in suspension and those dissolved.

Q. And because they were not necessary to a consideration of the potability of the water you omitted them from this statement?

2838 A. Yes, sir; and because they would have cumbered this report with an unnecessarily large amount of figures and made it difficult to compare the same in these forms of nitrogen in every case.

Q. Which was the stronger consideration in your mind, the incumbering of the record, or the in-utility of the omitted elements in the making of the table?

A. The in-utility of the omitted elements?

Q. Referring to the sanitary condition of the Mississippi river between August 3rd, 1899, and December 4th, 1899, having free ammonia .107; nitrites .004; albuminoid ammonia .622, nitrates .5; is that water potable?

A. I should say that was unsanitary water and water that had reached the limit. It shows so much impurity in that water that it ought not be used for drinking purposes.

Q. Would you consider water, having the following parts, namely: Free ammonia .107, nitrites .004, albuminoid ammonia .622 and nitrates .5 a potable water?

A. No, sir.

Q. Now, that was the average condition of the Mississippi river as given in your tables, before the opening of the canal?

A. Yes, at a point above where it mixes with the Missouri.

2839 Q. Would you consider water having the following constituents free ammonia .069, nitrites .002, albuminoid ammonia .503, nitrates .3 a potable water?

A. Yes.

Q. Why, in putting in the average values for the Mississippi river above the mouth of the Illinois, did you put in the chlorine 6.0 when you have omitted it in all other tables and estimates made here?

A. Because, afterwards I found that I could get the chlorine for comparison in the Illinois river with the Mississippi.

Q. Well, you could have got the chlorine in the Missouri for comparison with the Illinois, couldn't you?

A. Yes, sir.

Q. And the chlorine from the Missouri for comparison with the Mississippi also?

A. Yes, sir.

Q. But you did not?

A. It wouldn't have helped us any.

Q. But it does help in the case of the Mississippi?

A. Yes, I think it does.

Q. Very little?

A. Yes, sir.

Q. Now, why does it help in one case and not in another?

2840 A. Because where a stream is contaminated with salt, rock salt, of course, the chlorine is no indication of sewage pollution, but where you have a stream that is not contaminated in that way a high chlorine indicates sewage, because all food matters contain a good deal of salt. Salt is used for seasoning food and we find it therefore in large quantities in sewage.

Q. Now, you assume in defense of the Missouri river, that its chlorines are entirely from mineral deposits in the river in Kansas?

A. No, sir; not entirely.

Q. Well, very largely?

A. Yes. There is so much there that the chlorine is no longer of service to us in judging of the amount of pollution in the water.

Q. You wouldn't admit that any portion of the chlorine in the Missouri river showed the presence of sewage in the Missouri river?

A. Yes, sir.

Q. What portion do you think in the Missouri shows the presence of sewage?

A. I couldn't say; I don't know.

Q. You have no idea?

A. No idea.

2841 Q. As a chemist and without reference to this question, if you had been called upon to analyze a sample of Missouri river water not knowing that it was Missouri river water and not knowing that you were a chemist of the City of St. Louis, would you have said considering the high chlorine in that sample that it was potable water?

A. I would have been inclined from the high chlorines to condemn that water as unpotable.

Q. The average values which you have stated here in all instances are taken or obtained in the usual way by the addition of the results of all samples taken and dividing by the number of samples?

A. Yes, sir.

Q. Have you done this work yourself, of obtaining these averages?

A. Yes, sir.

Q. These are the results of your own personal examinations, and the evidence introduced here, the tables introduced?

A. Most of them. In a few cases like this large table, in the beginning I have taken the averages that were made by the city chemist and published by him in the report of the three hydraulic experts that were appointed by the mayor of St. Louis to investigate the water supply.

Q. What samples or which table is that?

A. That is the table on page 3.

2842 MR. WOERNER: You had better have the record state that.

A. They were taken from the report on the water supply for the City of St. Louis by the Commission of Hydraulic Engineers in 1902. These are the monthly averages of themselves and I didn't figure out those. I took them as here published.

MR. JOHNS: If a consideration of the chlorines in the Missouri was not necessary to you as a chemist in determining the potability of the Missouri river water, why do they become necessary to you as a chemist in the determination of the potability of the waters in the Illinois river?

A. Because chlorine is generally used as one of the means of judging the potability of water.

Q. And yet you omitted it in the Missouri river samples?

A. Yes, sir.

Q. And the Missouri river conclusions?

A. Yes, sir; because the local history—if we had known that the Illinois river was fed by streams that carried large quantities of salt we shouldn't have been able to use the chlorine there.

MR. JOHNS: When these tables were made up with reference to a consideration of the circumstances of a particular case, they were not made up with reference to the consideration of the potability or unpotability of the water itself?

A. They were simple averages drawn from the recorded 2843 analyses in the possession of the Health Department of the City Chemist's office of St. Louis and the Washington University.

Q. Were they made up with reference to the consideration of the facts in this particular case, or were they made up by you as an impartial expert simply to draw conclusions with reference to the potability of the water?

A. They were drawn up by me in an impartial way for the purpose of satisfying myself as to what the conditions of the waters were at those stated times.

Q. But you took no consideraion of the chlorine in one river and you did in the other two. Did that arise from an impartiality in your mind, do you think?

A. Well, it seemed to me there was no use in putting the chlorine in, in the case of the Missouri river because it wouldn't help us any; it would simply cumber the report to put that in; it was of no value.

RE-DIRECT EXAMINATION, by Mr. Woerner.

Q. Professor, I want to ask you this question. You say that you did not consider the chlorine as an element in determining the potability of the water of the Missouri river because you attributed that chlorine to mineral origin and not to vegetable or animal?

A. Yes, sir.

2844 Q. Now, isn't it a fact, independent of any knowledge as to the origin of the chlorine, that the water contains high chlorine and low ammonias and low nitrates or an absence of nitrates, that it shows that the chlorines are not attributable to animal or vegetable origin, but must be attributed to mineral origin?

A. Yes, sir.

Q. And you found those conditions present in Missouri waters?

A. I did.

Q. And that did not apply to any of the other streams?

A. No, sir.

Q. So that if you knew nothing about the chlorine in the Missouri, coming from the Kaw river or from any other mineral source, you would have still come to the conclusion that they were attributable only to mineral salt sources?

A. Yes, if the ammonias are low. If the ammonias and nitrites are law, and if we find all forms of nitrogen low, low nitrites and low nitrates, then find high chlorine, the water is no longer contaminated and it may show that the water was at one time contaminated, but the forms of nitrogen have been removed and while the mineral matters may be high, the chlorine might be high, it would in all probability come from salt layers or salt springs.

2845 Q. And if the chlorine could be attributable to animal or vegetable origin, then you would say as a chemist that the nitrites and the free ammonias must be correspondingly high?

A. Yes, sir.

Q. And if they are not, it shows that they did not come from sewage pollution?

A. Yes, sir.

Q. And that is the condition of the Missouri river?

A. Yes, sir.

Adjourned until 2:00 p. m. same day, Saturday, April 4, 1903.

2846 Southern Hotel, St. Louis, Missouri. 2:00 p. m., Saturday, April 4, 1903. Continuation after recess.

Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWARD H. KEISER resumed the stand for further re-direct examination, by Mr. Jeffries, and testified as follows:

Q. Professor, I will ask you to state what that piece of paper is (handing same to witness).

A. These are the printed results of chemical analyses of the water taken from the distributing well and the settling basins of the St. Louis Waterworks, in the year 1893. This paper is from the Annual Report of the Water Commissioner for the year ending April, 1894—M. L. Holman, Water Commissioner.

Q. And is the same paper that you testified concerning in your answer to questions propounded by Mr. Johns this forenoon?

A. Yes, sir.

Q. I will ask you if you have a copy of that report in full?

A. I have.

2847 Q. And that is one of the pages taken from the official report?

A. Yes, sir.

Q. Now, this morning you said something about the report containing the system used in making the experiments or the examinations or analyses of the water?

A. Yes, sir.

Q. Is that contained in the report?

A. Yes, sir; the methods used in arriving at these figures are described in the pages succeeding this in the same report.

Q. Can you get a copy of the pages containing the report?

A. Yes, sir. I simply removed one page from it. The other pages follow this, and I have those.

Q. Now, what do you say with reference to the system used in ascertaining those results, as to its being a proper system to follow in the examination of water?

MR. JOHNS: I object to the question as not re-direct examination and as incompetent—that it is a subject upon which it is incompetent to express an opinion.

A. I have read the methods described in this report and they are the usual standard methods used in analyzing water.

Q. Now, will you get a copy of the page containing those methods and bring it down here Monday morning?

A. I will. I have the rest of this that contains it. It is 2848 a bulky volume. I can bring it—the other pages, or bring the whole of it. I will bring the whole of it.

Q. Will you bring the book from which those pages are taken?

A. Yes, sir.

MR. JEFFRIES: Now, I will offer this page in evidence as complainant's Exhibit No. 36, with the privilege, Monday morning of introducing that page from the book or report of the Mayor for the year, in connection with the pages of the book as containing the system or plan used in arriving at these results.

Said paper received in evidence and marked as requested.

MR. JOHNS: I object to the paper with the proposed addition, as it is not a public record and not such a publication in any event as becomes competent evidence.

Q. MR. JEFFRIES: I will ask you to examine those two papers and state what they are?

A. The first of these two gives the results of twenty-one analyses of samples of water—of the St. Louis water, made from December 15th, 1892, to April 20th, 1894, in the chemical laboratory of Washington University.

Q. What kind of water was it?

A. That was the tap water—or the St. Louis drinking water.

2849 MR. WOERNER: Well, were you familiar with those yourself?

MR. JEFFRIES: Who made this tabulated statement?

A. These were made by my predecessor, who was professor of chemistry in the Washington University at that time. His name was Dr. Charles Sanger, now professor of chemistry at Harvard University.

Q. And was a record kept of the examinations—kept there in that laboratory?

A. In the laboratory record book.

Q. And that is copied from the record book, is it?

A. This is copied from the record book.

MR. JEFFRIES: Now, I offer this record in evidence as complainant's Exhibit 37, with the privilege of respondents to examine the original book from which it was copied, on Monday morning.

MR. JOHNS: We object to the admissibility of the exhibit as evidence because it is not such a matter of evidence as can be identified or proved by comparison, and that the record from which it was copied is not a public record.

Said document received in evidence and marked as requested.

Q. MR. JEFFRIES: Is it possible to get the original record and leave it in this case?

MR. JOHNS: Don't misunderstand me, gentlemen; I am 2850 not objecting to it because it is a copy. I have not said so. If the original paper was here I should object to it in the same way.

MR. WOERNER: Let the record show then that the objection is not based on the ground that it is a copy.

MR. JOHNS: The objection is not that it is a copy of some entries in that book, but is that the entries in the book, and the book itself, is not such record as is admissible under the rules of evidence, in any legal controversy.

Q. MR. JEFFRIES: This tabulated statement as contained on that sheet and as contained in the original record in the laboratory of the Washington University were made by your predecessor, you say?

A. Yes, sir.

Q. And represent the analyses of water taken from the tap?

A. From the tap.

Q. In the laboratory of Washington University—hydrant water of St. Louis.

Q. And the record is kept in your laboratory by the Board of Trustees of the University, and under their direction?

A. It belongs to the university; it is a university record.

Q. Now, I will ask you to examine this sheet and state what it is, and what it represents?

2851 A. This sheet contains the results of daily analyses of water from the Missouri river at Fort Bellefontaine, the samples having been taken from January 23rd, 1900, to February 1st, 1900. They were made under my direction in the chemical laboratory of Washington University.

Q. And from water taken where?

A. From water taken in the Missouri River at Fort Bellefontaine.

Q. Is this a copy of the record contained in the laboratory?

A. No, this is the original record.

Q. This is the original record?

A. These were made under the direction of the City

Q. Which side it was on?

A. Yes, and the velocity of the wind varied probably from about 5 to 12 miles an hour.

Q. Now can you give the names of the men that you selected and who were actively engaged in taking these observations from Chicago to St. Louis?

A. C. V. Mersereau, and T. F. Reed were the assistant engineers from Chicago to Peoria, and J. E. Gibson and F.
2880 J. Brown from Peoria to Grafton. They are all connected with the St. Louis water department, and were detailed for these observations.

Q. Is that all of them?

A. That was all except the boatmen, etcetera, that were hired and had no part in the technical observations that we made.

Q. Now then, from these men that you have just named, you got this data with reference to the flow of the river along these particular places?

A. Yes, from Chicago to Grafton.

Q. State whether or not the work was done continuously from day to day with the exception of suspending the work during the night, and as you stated a moment ago?

A. There was no interruption through more than a night and the hours of early morning and late afternoon, except one day where a very severe storm on the upper Illinois prevented a prosecution of the work there; that day was the 24th of March.

Q. You stated, I believe, Professor, that these floats were made under your personal supervision?

A. Yes sir.

Q. As a civil engineer?

A. Yes sir.

Q. State if you know from your personal observation in following these floats down the Mississippi River from Grafton to the Intake, which side of the river they seemed to fol-
2881 low or what particular point in the river did they follow?

A. The floats were placed in the lower end of the Illinois River in such a way that they spread across the river; one in the center, one about half way from this one to the right bank, and one about half way from the center one to the left bank.

Q. That was in the Illinois River?

A. That was in the mouth of the Illinois river. As they flowed into the Mississippi River they moved closer and closer to the Illinois shore of the Mississippi River and in a general way from the Illinois river to below the mouth of the Missouri they were more or less close to the Illinois shore. Sometimes, in the extreme, getting to the middle of the Mississippi River, but most of the time being within three or four hundred feet of the Illinois shore. At about two miles above the waterworks intake for instance, the floats were quite close to the Illinois shore; perhaps about 50 feet from it, but from this point on down to the waterworks intake the floats rapidly left the Illinois shore, reaching the middle of the Mississippi River and finally passing the waterworks intake between the Intake and the Missouri shore.

Q. All of them?

A. Yes sir, and perhaps—and somewhat closer to the Missouri shore than to the intake. The distance from the
2882 Missouri shore to the waterworks intake is about 1500
feet and from that I judge that the floats passed the intake about 700 feet from the Missouri shore.

MR. JEFFRIES: We are through with the witness now with the exception that we may want to introduce one of the floats when it gets here.

CROSS-EXAMINATION BY JUDGE JOHNS.

Q. Does the stage of the water in the drainage canal above Lockport remain pretty constant?

A. I understand so.

Q. The stage of the water in the Desplaines River is very fluctuating, is it not?

A. Yes sir.

Q. Are there any gauges indicating the stage of the water in the Desplaines river?

A. Yes sir.

Q. Where?

A. I saw one at Lockport, just below the Bear Trap Dam, when I was at Lockport, after these observations were taken, in an attempt to get the readings of the gauge for that month. I understand there are gauges at Joliet, but I did not personally see them there.

Q. Do you know anything about the stage of the Desplaines River when the floats were put in there? 2883

A. Gauges were read by these engineers as they passed them, wherever they saw them, but beyond that I know nothing about it. I have been unable to get such readings.

Q. Have these gauge readings been furnished to you by the observers?

A. They are in the field note books which I neglected to bring this morning.

Q. They are not in your notes from which you have been refreshing your memory?

A. No sir.

Q. So as to the time that these floats were in the Desplaines River, you have no knowledge now of the stage of the river?

A. No exact knowledge, no sir.

Q. Do you know as a matter of fact whether the river was high or low?

A. It was high.

Q. Now there are gauges at various places upon the Illinois River?

A. Yes sir.

Q. Do you know at what places?

A. There are gauges at all the locks; there are also gauges of which I have records, at Peoria, Beardstown and Grafton.

Q. And at various locks?

2884 A. Yes and I am confident there are others, but I don't know definitely about them.

Q. Now what was the stage of the Illinois River from the time that the floats were placed in it until the end of the experiment?

A. In general, the Illinois River was high.

Q. Was it very high?

A. Yes sir.

Q. The bottom lands and the overflowed land along the Illinois River was very extensive, was it not?

A. Yes sir.

Q. The river was sometimes four or five miles wide in very high water?

A. It may be.

Q. From water line to water-line?

A. Yes sir.

Q. Varying of course with reference to the proximity of the high land to the river?

A. Yes sir.

Q. But at times during this experiment the river was out of its banks and overflowing the bottom lands, was it?

A. A great many of them.

Q. Well, the ordinary banks of the river at all places were overflowed with water?

A. Yes.

Q. The water extending out into the bottoms?

A. Yes sir.

2885 Q. Now in the Desplaines River how many floats were put in at one time?

A. I believe five; one had been lost in the drainage canal.

Q. Were they put in at the same place and at the same time?

A. Yes sir.

Q. So that you had floating down the Desplaines River under observation at the same time, five different floats?

A. Through a portion of it, but from time to time the floats were lost so that before reaching the mouth of the Desplaines river I believe that one or two more had been lost.

Q. When you placed them in the Desplaines river what was the plan upon which they were placed?

A. The plan was to distribute them across the channel portion of the river, to place them abreast of each other opposite a certain point, to distribute them across the channel of the river.

Q. By channel you mean that part which is the swiftest moving of the water?

A. Yes sir, as near as could be judged.

Q. Now did you have in the Desplaines river floats of different lengths?

A. Yes sir.

Q. One, two and three feet?

A. Yes sir.

2886 Q. And you continued that also in the Illinois River?

A. Yes sir.

Q. Where were the longer floats placed, in the center or on the sides of the channel?

A. As a rule the longer ones were placed in the deeper water.

Q. In the center of the channel?

A. Yes sir.

Q. Well, whether or not—was that your instructions for the Desplaines?

A. I believe in the oral instructions I spoke of that matter to those engineers before I sent them out, but nothing in regard to that occurred in the written instructions.

Q. Is there anything in regard to placing the floats and the length of the floats in your field notes from your engineers?

A. The numbers to identify the floats are given in each case,—yes; so that it can be told where the floats of different depths were put with reference to each other and with reference to the shore in a general way.

Q. Do you know whether after those floats were placed in the water on a cross-section of the river they separated wider than when placed—or whether the tendency was to come together toward the middle of the channel?

A. I understand that the general tendency was towards separation although there was nothing very marked to be observed in that connection.

2887 The stage of river throughout our observations in the Desplaines and the Illinois being in a condition of overflow, caused them to rather seek the banks.

Q. The current outward?

A. Yes sir.

Q. During that time was it found they were aground?

A. Quite often.

Q. And when that was done they were released and taken back to some deeper point?

A. Taken back.

Q. Did those floats in the Desplaines river keep abreast of each other if they were floating rapidly?

A. That would depend largely on the wind, sir, whether they would keep abreast of each other or not. In general they would keep abreast of each other.

Q. Which one would advance more rapidly?

A. That would depend whether the wind was more up-stream or more down-stream. In general the wind was (more than otherwise) up-stream or had a component up-stream, which would affect the shorter float more and hold it back.

Q. Have a greater effect on the shorter float?

A. Yes sir.

Q. The float having the shorter chain from the visible part to the gauge below—what do you term the lower part of the float, having the flanges?

2888 A. Well, it has no distinct name. I generally speak of it as the vanes of the float.

Q. Would the direction of the wind have a considerable effect upon the direction in which the floats went down the river?

A. I couldn't say. It would considerably affect it would have an effect and of course the amount of it would depend upon the velocity of the wind as well as other things, but mainly upon that. The effect would be small compared with the effect of the current of course, but it would have an effect, a certain effect.

Q. You had no way of determining how much of an effect it had in varying the course of the float?

A. No experimental way. Of course it was generally noticed that during a half a day or a day's run, that the floats would work toward the leeward side of the river. If the wind is across stream during a number of hours' run, greater or less, depending upon the velocity of the wind, the floats in general will be influenced in the direction of the wind to an extent.

Q. The visible floating part was it rigid or would it revolve and swing in the water?

A. It was rigid as far as—it was not a pliable thing, but you see the chain would allow the upper part to move as though on an axis, perfectly well. That is to say, I suppose the question refers to that metal flag that was upon it?

Q. I am asking you first as to the float, the body of the
2889 float itself; was it attached to the chain by a swivel or in any way so that it could by itself revolve?

A. No sir, there was no swivel. The chain was linked so that the link permitted a horizontal movement.

Q. The flag above the float was how high?

A. The top of it was about twelve inches above the top of the cone.

Q. And the top of the cone was above the water how much?

A. Above the water level about four inches.

Q. So that the top of the flag would be about sixteen inches from the surface of the water?

A. Yes sir.

Q. How large was this flag?

A. Four inches square.

Q. Of what material?

A. Sheet iron.

Q. On what kind of a staff?

A. Stiff wire.

Q. Ordinary wire?

A. Yes sir.

Q. Was it fixed firmly to the staff or would this flag revolve?

A. No sir, it was fixed firmly to the staff.

Q. I don't know that I understand you. Was the flag a square piece of metal?

2890 A. Yes sir.

Q. Four inches square?

A. Yes sir.

Q. And painted?

A. And painted a color and with a number to identify the float.

Q. Now were the observations of your engineers kept with reference to the numbers of those floats?

A. Yes sir.

Q. And the field notes were mentioned by number?

A. Yes sir.

Q. When a float went aground, what was done with it?

A. It was pulled out and put in the channel either opposite the point where it went aground if it was not too far back, but if it were too far in the rear of the general group of floats, it was simply pulled out and carried ahead and put in with the group in the channel.

Q. Now did they differ very considerably in the distances which they would travel in a given time?

A. Yes, quite considerably.

Q. On what account?

A. Well on various acounts; partly on account of the different depths of the vanes; partly on account of some of them in the same group being deflected toward the shore and others
continuing in the channel, and partly because of driftwood
2891 that would interfere with them sometimes, and other similar reasons.

Q. Is it not a fact as a general observation that the floats nearest the center of the channel traveled most rapidly?

A. Yes sir.

Q. And the floats nearer the shore were much slower?

A. Yes sir.

Q. So that the fact is that the center of the channel, the current of the river, wherever it may be, moves according to these observations much more rapidly than the water does on the side?

A. Yes, there is a very distinct difference.

Q. Could you tell how much difference from the observations and reports which were made to you as to the current in the center of the channel of the Illinois River and at the sides?

A. No sir. It is a very noticable difference in all hydraulic observations of the kind, but it is a very variable difference at different portions of the river, depending on a great number of things.

Q. Your statement that the entire time from Lockport to the Intake, or to Grafton, rather, was nine days and three minutes?

A. Yes sir.

Q. Would that be for the center of the channel?

A. That would be—that time is the aggregate time which
is determined by the time occupied from the putting in of
2892 the floats in the current abreast of each other, and fairly
close together, to the time when the leading of these floats reached the point at which work was suspended for that day.

Q. So that whenever you have mentioned a time here that the float was taken out, it was the time of the arrival of the most advanced float at that point?

A. Yes sir.

Q. Then the total time of 9 days and three minutes, is the fastest time that these floats made down the Illinois River?

A. Yes sir.

Q. Could you tell or had you any knowledge of how rapidly the current flowed if at all, at the side of the banks of the Illinois River?

A. Well, I know nothing definite about that except for one portion between Peoria and Pekin, where I was obliged, or where I did start a party and was obliged to take a trip in order to find a boat, when I simply observed a very slow current at the side of the banks of the stream; how slow I couldn't say. I haven't any doubt it was less than a foot a second and very much less.

Q. Less than a foot a second?

A. Yes sir. It was observed from along the line, and is nothing definite at all.

2893 Q. So that all your observation has determined is the quickest time of the most swiftly flowing water from Lockport to Grafton?

A. Under conditions existing at the time the observations were made, yes sir.

Q. Now isn't it true that the current of the Illinois River at the time of these observations was very much swifter in its channel than at the ordinary stage of the river?

A. I suppose it is.

Q. Is it not true that it is very much swifter than at the low stage of the river?

A. Undoubtedly.

Q. Now all you know from these experiments as to the time for the flow of water is at a very high stage of the Illinois River and the fastest time that the floats could make?

A. I would say as to all except the last phrase. As an engineer I could not agree that it is the fastest time that the floats could make under any stage of the river.

Q. I didn't intend that you should gather that meaning from my question. It is the fastest time that the floats under the observation of yourself and your assistants, did make from Lockport?

A. Yes, it is the minimum time over the course covered.

Q. Do you know whether there had been all over the valley of the Illinois, very heavy rain-falls immediately preceding this experiment?

A. I understand that is the case, yes.

2894 Q. Did you select this time for the experiment with reference to that fact?

A. About a week before entering upon this work I was told that these facts were very desirable in connection with the investigation and suit, and I was asked to make experiments as speedily as possible and did so. I had not the information of the desire to have them until a few days before they were entered upon.

Q. Now what was the stage of the Mississippi River at the time you followed the floats from Grafton to the Intake?

A. In an approximate way the Mississippi River was at about half stage, half its flood stage.

Q. The guage readings were about 24 feet here, were they not?

A. Nearly, yes,— between 23 and 24 at the time the observations were made from Grafton.

Q. What do you understand by a guage?

A. A gauge is a staff or other appliance on a river bank placed there for the purpose of indicating the stage of water in the river.

Q. We have been using the term here in a little different sense. When we say that the river is 24 feet on the gauge; that means 24 feet above what point?

A. It doesn't always mean the same thing, sir. It means that it is simply 24 feet above the zero reading of that 2895 gauge. Now the zero reading may be low water and may not.

It is generally the desire, and is certainly better to have the zero mean extreme low water reading, but it isn't always the case on gauges.

Q. Is it the case at St. Louis?

A. The lowest water known at St. Louis was 2.5 feet below the zero of the St. Louis gauge.

Q. Now when you say that the Mississippi River was at about half stage, do you mean to say that the Mississippi River at St. Louis rises to a height on the gauge of 48 feet?

A. No sir. I said that was the approximate condition for this reason; while the St. Louis gauge read 23.3 the highest water we have had here was 41.4 feet, less than double, while at Grafton the gauge reading on that same day was 16 feet and the highest water known there was 37.8, and more than double; so that it is the local condition, the width of the channel and other such things that control; so that I cannot state precisely whether the river is half height, or two-thirds height, or six-tenths height, or what not.

Q. Now what part of the river, of the channel of the river does the water flow most swiftly in,—the center is the place I presume?

A. In a straight piece of river. If it is curved, it is swifter toward the concave bank and sometimes very close to the
2896 concave bank.

Q. And sometimes right up against the concave bank?

A. Well, not exactly, but very close to it.

Q. Now commencing at the surface, is the water flowing on the surface more rapid than it is two feet below? Or more slow?

A. In general it is more slowly. If there is wind down stream sometimes the surface has a maximum velocity under the influence of the wind, but usually the maximum velocity is at the depth, where there is no wind, at the depth of one-fifth or one-sixth below the surface, or somewhere in that vicinity. It is not the same for all streams but that is the general fact.

Q. When you say one-fifth or one-sixth, you mean one-fifth or one-sixth of tthe perpendicular depth from the surface?

A. Yes sir.

Q. Not from the bottom?

A. No sir, from the surface.

Q. Water below that point, the swifter flowing, of course, flows more slowly?

A. Yes sir.

Q. And in the channel most slowly at the bottom?

A. Yes sir.

Q. Have you any means of determining, as an engineer, assuming the flow of the water at its swiftest point to be, say six feet a second, what would be the flow of the water at the 2897 bottom if its perpendicular depth was twenty feet, or any other depth?

A. No sir, there is no way of determining that. It depends not merely on the slope of the river itself, but on the general direction and character of the river, whether it is comparatively straight, or very crooked. That would depend particularly upon the character of the bottom, whether it is mud, sand, rock or gravel, or very rough or very smooth; there is no way to do it.

Q. Whether it is clogged with obstructions or free from them?

A. Yes sir.

Q. Now the longest chain you used on the float in the Illinois River was three or four feet?

A. Three feet.

Q. And the shortest was one foot?

A. Yes sir.

Q. Where was the longest float placed,—near the center of the river; was that your instruction?

A. That was the general intention, but that was left a good deal to the discretion of the engineers that were observing it. It was a point of such minor importance that I didn't consider it worth while to issue any special instructions on the point. For instance, any delay that might be caused by acceding 2898 to such requirements would more than compensate for securing it.

Q. Your object was to obtain the approximate length of time it would take a float to travel from Lockport to the Chain of Rocks?

A. Yes, or really from the Chicago River.

Q. What kind of a day was it when you followed them on the Mississippi River?

A. The floats were started at 6:56 in the morning and passed the intake at six minutes after six in the evening.

Q. As to the character of the day?

A. The day was somewhat cloudy and somewhat windy. Enough to cause that part of the float sometimes to be entirely out of water and sometimes entirely submerged.

Q. And the flag sometimes submerged?

A. No sir, simply the buoy part. The flag and above the wire staff was practically always out of water. There was a jumping of the float—an apparent jumping of the float of about eight inches. That would give an idea of the conditions perhaps.

Q. What was the direction of the wind that day?

A. I judged from the way it seemed to vary with reference to our course, that it was practically from the southeast all day.

Q. These floats hugged the Illinois shore down to a point
2899 a mile or two above the entrance of the Missouri River?

A. No sir, below the entrance of the Missouri River to two miles above the waterworks intake.

Q. Two miles above the waterworks intake?

A. Yes, they were never more than half way across above Alton.

Q. Then above the intake they started across the river?

A. Yes sir.

Q. All of them?

A. Yes, there were only two then. We started with three but a chain parted and one was lost below Alton. I think from Alton down there were only two.

Q. How far out from the bank on the Illinois shore were those floats when they started toward the Missouri?

A. About two miles above the intake both floats were about 50 feet from the Illinois shore. That is, this two mile point was between the mouth of the Missouri and the intake.

Q. How long were the chains to these two floats?

A. One was six feet and the other four.

Q. Did they travel together?

A. No sir.

Q. How much did they separate?

A. Do you mean with reference to the shore or with reference to the speed?

2900 Q. With reference to each other first?

A. Will you allow me to read the field-notes?

Q. Read them and refresh your recollection, if you see fit.

A. I recollect very plainly their action with reference to each other, as far as the distance from the shore is concerned, but how far one was ahead of the other I don't remember. (Witness reads notes) I am wrong in what I just said, sir. The floats were about 50 feet from the Illinois shore at a point where the Missouri River enters the Mississippi. A mile below this point both floats were three or four hundred feet from the Illinois shore. Two miles below this point the red No. 5, which is the six foot float, was 200 feet from the Illinois shore and the four foot float was 400 feet or thereabouts, from the Illinois shore. In passing the upper end of Chouteau's slough, still nearer the waterworks intake, the four foot float was 600 feet or thereabouts from the Illinois shore and the six foot float was about 100 feet in the rear and about 100 feet from the Illinois shore, and just below that the six foot float kept moving still further toward the left, and was about to pass at what is called by river men, the chutes, that is the pasage to the eastward of the island opposite the intake, and was pulled out of the water and put in again opposite, the four foot float which had not been
disturbed, and about 60 feet to the left of it. That is, 60
2901 feet toward the Illinois shore from the four foot float.
That is below the Madison Point light; and still the six foot float kept working off toward the left and moving toward those chutes (as they are called), behind the islands, to the east of them and was pulled out again and put in abreast of the four foot float about sixty feet toward the Missouri shore,—at this time, from it. From that time on they both kep on very closely together, the six foot float however, lagging behind, but with reference to the shore they seemed to keep, or work, toward each other and crossed opposite the intake at about the same distance from the shore. That is to say, the red was disturbed twice,—the six foot float was disturbed twice between Alton and the waterworks intake. The four foot float was not touched.

Q. Now the six foot float was taken out of the water and moved over toward the Illinois shore?

A. Moved away from the Illinois shore, because it seemed to be that if it had gone behind the islands, to the easward of the islands, it would have been lost to us.

Q. Then it was moved over toward the right?

A. Toward the right, yes sir.

Q. I understood you to say it was moved over towards the left?

2902 A. No, I said it had moved over near the Illinois shore, and placed the first time about 60 feet to the left of the four foot float.

Q. And that would be 60 feet nearer the Illinois shore?

A. This four foot one was farther from the Illinois shore than it (the six foot float) was when it was taken out.

Q. Now what are these things which you term chutes?

A. It is simply a high water channel behind the islands. At low water there is practically no flow and there is no channel there and when the water of the Mississippi rises it of course leaves its channel and flows on through this back channel on the Illinois shore.

Q. It was about to go into some one of these things when it was removed,—the six foot float?

A. Yes. So I placed no special import upon the action of that red float, the six foot float, because it was disturbed, it was taken out.

Q. Did it travel more slowly than the other one?

A. It did after it was put in the last time, near the waterworks intake, about a mile above the waterworks intake. For the first mile it moved more slowly. There were times when one would move more slowly than another, depending upon the circumstances, or the wind and the depth, probably, mainly.

Q. And the velocity of the current at the place where it was?

A. Yes, really, but affected by wind and depth.

2903 Q. When you say that the floats were close to the shore at a point where the Missouri River enters the Mississippi, you mean the north shore of the Missouri River, or the center of the river, or what do you mean?

A. I mean that the floats passed the mouth of the Missouri River, at the Missouri River point as it is called on the river, at about fifty feet from the Illinois shore, of the Mississippi River, that is, the left bank of the Mississippi River.

Q. The Missouri River was also a very high stage of water at that time?

A. The Missouri River at that time was at about a half stage.

Q. Well, at about the same stage as the Mississippi?

A. Yes sir.

Q. Twenty or twenty-five feet on the gauge?

A. This will give the indication. At the lowest gauge I could get on the Missouri on this date, the reading was 15 and one-half. This is at Hermann. The high water is 35.6, indicating very much the same thing as the stage of the Mississippi.

Q. Is there a water gauge at Fort Bellefontaine?

A. I think there is, but I didn't get the gauge. I have no reading for that, no sir.

Q. Was the Missouri River where it enters the Mississippi very wide at this stage?

2904 A. Yes sir.

Q. How wide would you say?

A. Well, at almost any stage not deducting the area occupied by the numerous islands, it is between three-quarters and a mile wide, probably, but part of this is taken up of course by islands.

Q. And the confluence of the two rivers produces strange effects in the currents there, doesn't it? For instance, did the floats circle any in the meeting of those waters?

A. No sir.

Q. They kept along steadily?

A. Very steadily. They were apparently so close to the Illinois shore that they were not affected at all directly, by the inflow of the Missouri River.

Q. And kept that position for a mile or two?

A. Well, from that point they began gradually and very slowly, but gradually, to leave the Illinois shore, or from that vicinity.

Q. Do you know whether there were dikes in the river along the Illinois shore opposite the mouth of the Missouri River and below that down towards St. Louis?

A. I don't know of any.

Q. You know nothing whatever as to the number or contion or position of dikes opposite the Mississippi River and on the Illinois shore practically to the chain of rocks?

2905 A. I cannot speak authoritatively on that point at all. I don't know of any such.

Q. And whether there are any or not you don't know?

A. No sir.

Q. If there were such dikes, would that effect the direction or velocity of the current for such a stage as you have described?

A. To an extent. The Mississippi dikes are always built for low water effects, and at this stage I can hardly see how such dikes would have any effect if they existed there, other than to retard the velocity of the floats, because the floats would be passing directly over them if they were there.

Q. Now how far above the intake itself did these floats pass in going over toward the Missouri shore?

A. It was a gradual movement entirely.

Q. Well, with reference to the current of the Mississippi River the intake is about on the edge of the Mississippi channel is it not?

A. Yes sir.

Q. How far with reference to the direction of the current above the intake, did these floats pass the intake itself?

A. I can explain that better perhaps by showing the platted course of these floats.

2906 Q. Well, if you can answer my question you may.

A. Well, I estimate that at about one-third of a mile.

Q. Now then, did they go clear over to the Missouri shore?

A. No sir.

Q. Did they pass the intake itself on the west side?

A. Yes sir.

Q. And between that and the shore?

A. Yes sir.

Q. Where did you take them out of the water?

A. Immediately below, as soon as I could get them after timing them as they passed.

Q. And both of the floats went over there?

A. Yes, one of them as I have stated, however, being removed and put in again, which destroys any significance that may be attached to it.

Q. How far is it from the mouth of the Missouri River to the chain of rocks?

A. I guess I will have to scale that off of the chart.

Q. Have you a general idea how far it is?

A. I should think five or six miles; that's my recollection of it.

Q. Five or six miles, you think?

A. Yes, that's my recollection as near as I can give it.

2907 Q. Now when these floats started across the river for the Illinois shore, how far were they north of the intake?

A. Up-stream from the intake?

Q. Yes, up-stream?

A. They were opposite the mouth of the Missouri. They were actually opposite the Missouri River point which is a point between the Missouri and the Mississippi as they come together.

Q. Well, that is the southern point.

A. It is the northern point, on the north side of the Missouri River.

Q. Of the Missouri River?

A. Yes.

Q. They were opposite the north side of the Missouri River when they started to move across the river?

A. Well, I don't know that they started immediately there. They were at that point, opposite the Missouri River point, when they were about 50 feet from the Illinois shore.

Q. Now they started to move away from the Illinois shore when they were about opposite what is known as the Missouri River Point.

A. I don't know that they started then. The first thing that I noticed was about a half a mile below that, or opposite really the mouth of the Missouri River. They were not so close to the shore, not so close to the Illinois shore as they were opposite the Missouri River point.

2908 Q. And when they were a mile below this Missouri River point they were 300 feet or so from the Illinois shore. Now did they continue to go in about a direct line across the Mississippi River?

A. Oh, no sir. From that point on down for some distance, the four foot float kept on at about the same distance from the Illinois shore, and the six foot float moved off toward it.

Q. Well, for how great a distance was that in feet or miles or fraction of miles?

A. Well in another mile or two the four foot float was somewhat farther from the Illinois shore, perhaps 600 feet and the six foot float was still closer to the Illinois shore or about 100 feet from it perhaps.

Q. How far below the mouth of the Missouri River?

A. My recollection is about three miles.

Q. About three miles?

A. That is just at Chouteau's slough. I can get that exactly if you care to have it.

Q. Well, in general terms it is about three miles below the real mouth of the Missouri when the six foot float was closer again to the Illinois shore?

A. Yes sir.

Q. And the four foot float was about 600 feet from the shore?

A. Yes sir.

2909 Q. How wide is the Mississippi River at that point between its normal banks?

A. I think it is about three-quarters of a mile. It appears to be narrower somewhere in that vicinity.

Q. Then the floats three miles below the mouth of the Missouri were not near the center of the channel?

A. No sir, not near the center of the river. I don't know where the channel is.

Q. Not near the center of the river?

A. No sir.

Q. Can you tell accurately the distance from Chouteau's slough to the intake?

A. I can in a moment.

Q. Will you please?

A. (Witness examines map). I have platted there the course of the floats as indicated by the notes. There is the Mississippi River (indicating). Here is the Missouri and there is the Missouri River point which I have described, and the black line shows the course of the float which was not interrupted, and the red line shows the course of the six foot float which was taken out and put in as indicated there.

Q. MR. WOERNER: And also shows the interruptions?

A. Shows the interruptions and shows everything just as it occurred. Here is the intake and here is where they crossed. 2910

JUDGE SPRINGER: What does this mean?

A. That is a sand-bar.

Q. Was it out of the water?

A. It was really an island. There were trees and the water was overflowing it. This is the chutes I referred to a moment ago. This is where the red one was heading for, and I didn't want to lose any so I simply took it out of the water.

Q. JUDGE JOHNS: Can you tell accurately the distance from Chouteau's slough to the intake?

A. It is practically four miles from Chouteau's slough to the intake by the course followed by the float.

Q. Now below the point where the six foot float was about to go into Chouteau's slough, there is a sand-bar or island?

A. Yes sir.

Q. In low or medium stage, it is quite a large island, isn't it?

A. Yes sir.

Q. And the general current of the river goes around to the left of the island as you go down the river?

A. Yes sir.

Q. And that is the general current at what time?

A. It certainly must be at low water when there is practically no flow here, and the course of these floats indicated it to be the case at medium stage.

2911 Q. If this red float had not been interrupted it would have gone down through Chouteau's chute, wouldn't it?

A. Through this chute as the river men call it. Probably it would. I was afraid of it.

Q. And if it had done so, it might have gone below and to the left as you go down the river, of three other islands or two other islands between that and the chain of rocks?

A. To the right, do you mean?

Q. Yes.

A. I think so; I presume so.

Q. Now may be you and I don't agree as to which is right—

A. I beg pardon, I made a mistake.

Q. To the left?

A. Yes sir.

Q. To the left as one is going down the stream?

A. Yes sir.

Q. That float might have gone to the left of three islands between Chouteau's slough and the intake if it hadn't been interrupted?

A. Yes sir.

Q. And at that time there was a decided current that way?

A. Yes sir.

Q. And in order to prevent its going that way you took it out of the water and replaced it in the main channel of the Mississippi?

2912 A. Yes sir.

ADJOURNED until 2:15 P. M., May 5th, 1903, to meet at the City Counselor's Office, in the City Hall.

City Hall, St. Louis, Missouri.

2913 2:15 P. M., Tuesday, May 5th, 1903.

Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

J. L. VAN ORNUM,

Resumed the stand for further cross-examination by Judge Johns, and testified as follows:

Q. What is the general direction of the Mississippi River from Chouteau's slough to the Chain of Rocks?

A. It is very crooked in that vicinity. Its flow at Chouteau's slough, as I recollect it, is about southwest, and from that direction there is a gradual curve, until at the Chain of Rocks I believe the Mississippi River flows nearly south.

Q. Its general direction is southwest from below Chouteau's slough to the Chain of Rocks, or is it west of south?

A. It is certainly west of south. I think the average direction might be considered something west of south.

Q. A southeast wind then would be blowing almost at right angles to the direction of the current?

A. I don't think at right angles, but very close to it. In connection with the map and in considering in my own 2914 mind that aspect of the case, I had arrows put in to indicate the direction of the wind, which would indicate on the map the relation to the direction of the flow at different portions of the river, all the way from the Missouri River down to where the floats were, to the Illinois shore, and to the waterworks intake, and as a resume and result of that I think it is fair to say that the average component of the wind which would affect a float in direction in right angles to the average direction of the current would be about 6-10 of the effect of wind if it were blowing exactly across the stream all the way.

Q. Well, is the general direction of the southeasterly winds across the Mississippi River from Chouteau's slough to the chain of rocks, an angle of about 60 degrees?

A. It might be. I can get at it quite closely if it is worth while by referring to that same map if you wish it.

Q. What is your opinion?

A. Well, I haven't looked into that so that I can't give a very close idea about that. I presume that would be a fair estimate.

Q. Now of all these observations of which you have testified, you personally conducted none except from Grafton to the chain of rocks?

A. No sir.

Q. You didn't assist in the making of the experiments, 2915 nor did you conduct those which were commenced at the highway bridge at Peoria?

A. Well, I conducted that to this extent: I started everything and did personally start the floats, but at that point left it to the charge of the assistants.

Q. So that all your knowledge or information of the floats and their speed and rapidity and the various happenings to them come to you from reports made by your employes?

A. Yes sir.

Q. As to the entire Illinois River above Grafton?

A. Yes sir.

CROSS-EXAMINATION,

By Mr. Todd.

Q. Professor, when the floats were first put in the drainage canal, you stated they were lost or taken out?

A. During the succeeding night, yes.

Q. How do you know they were taken out?

A. I know because I was told by Mr. Mersereau who was in immediate charge of that part, that when he was going forward the next morning, there were some of the floats that he had allowed to run all night—he found them in the possession of I think someone on the bank of the canal who had pulled them out and who was there with them at the time.

2916 Q. Those were floats that were lost in the canal proper?

A. Those were floats which were interrupted. No sir, I would not say they were lost.

Q. I mean interrupted.

A. Yes sir.

Q. You recovered those, did you?

A. Yes sir.

Q. The reason I ask you this is, there was no interference on the part of the Sanitary District, in these experiments that you could find, was there?

A. No sir.

Q. Did you make any investigation as to the volume of water coming down the Illinois River at the time this experiment was made?

A. No sir.

Q. Are you acquainted with the conditions that obtain in the Illinois River under normal conditions?

A. To an extent; simply from observation of the fact at different times when I have seen the river under different conditions of flow.

Q. How do the conditions that would be denominated normal compare with the conditions that existed at the time that this experiment, or these experiments were made?

A. At the time these experiments were made the river was much higher than the average condition of the river. In fact,
it was overflowing the low lands. The necessary accom-
2917 paniment of that fact is that the current was swifter, and
there was drift-wood running.

Q. Now, professor—

A. If that's all you wish, I have nothing more to say, sir.

Q. Do you know how high the river was above the normal flow at the time this experiment was made?

A. I could tell you that sir, if you could tell me what the height of it is at normal flow. I hardly know what to place as that condition.

Q. You are not acquainted then with the Illinois River sufficiently to know what the normal flow of the river would be in the absence of flood waters?

A. Would that mean the total flow for a year for instance, divided by the number of days in the year?

Q. No, the ordinary stages of the river?

A. I think through all the lower portion of the river that is entirely controlled by the locks and dams.

Q. Then an evidence of the conditions of the water would obtain in ascertaining the height of water that was above the four different dams in the Illinois River, wouldn't it?

A. I suppose so, yes sir.

Q. How high was the water above the crest of the dam at Henry at the time this experiment was made?

A. That I don't know; I have been unable to get those
2918 records.

Q. And at Copperas creek?

A. I don't know that.

Q. And La Grange?

A. I don't know.

Q. And at Kampsville?

A. I don't know.

Q. Did you have any opinion at that time in regard to the height of the water above the crest of the dams at those four places?

A. I think that can readily be deduced when the observers who passed those points testify, because they had orders to read such gauges; and if we can tell the gauge readings at ordinary stages at those points, we can readily get those facts. I don't know them.

Q. If the water was six to ten feet above the crest of the dams at those four different places at the time you made the experiment, that would indicate, wouldn't it, that there were flood waters in the Illinois River?

A. Yes sir.

Q. And is it not a fact that at the time this experiment was made there was a great amount of flood water in the Illinois River?

A. Yes sir.

Q. The river had overflowed its banks from LaSalle, practically to Grafton, hadn't it?

2919 A. I couldn't say certainly; I think so, through the larger part of that distance, certainly. At Peoria, for instance, the river was practicaly confined to its channel, to the old channel because the banks are high in that vicinity.

Q. That was not true at Peoria, was it, doctor?

A. Well, it was a trifle wider on the Peoria side.

Q. Which is below Peoria, just before you get to Peoria?

A. Between Peoria and Pekin it had widened a trifle.

Q No; just immediately below Peoria, wasn't the water, or didn't the water overflow its banks, right bank, to an extent of several miles?

A. I don't know how far.

Q. Did you go down from Peoria to Pekin?

A. Yes sir.

Q. Do you remember the sanitary district that was mapped out just below Peoria that the dikes had broken away and the waters had extended over that vast territory?

A. I don't know about the sanitary district you speak of, but the lands below Peoria, between Peoria and Pekin, were overflowed for wide distances. I don't know the distance, but a mile or two perhaps.

Q. At the time you made these observations, the waters in the Illinois river were what you call high, were they not?

A. Yes sir.

2920 Q. Do you know how long that condition obtains in the Illinois River; that stage of water?

A. No sir, it is of variable quantity, and of course a variable length of time.

Q. Your experiments then were based upon conditions most favorable to a swift current?

A. I wouldn't say most favorable.

Q. What conditions could you define as being superior to the conditions that you found at that point at that time?

A. A condition, or actual stage of water as indicated by gauge readings, where the water is rising rather than falling, as it was when our observations were taken. That is to say, it is a well known fact that when rivers are rising the discharge is greater and the velocities are greater at the same elevation of the river, or at the same flood stage, than they are when that same stage is reached on the falling river. Our observations were all of them occurring at a time when the river had fallen; it had passed its crest, or highest water had occurred shortly before the observations were undertaken, and so as a general principle, I can say that the length of time occupied and recorded here is probably greater than it would have been if the observations could have been made when the river was at the same stage, but still rising.

Q. What was the height of the river from which you estimated the fall, at the time you made the observations? 2921

A. The fall was not estimated.

Q. You said it was a falling river?

A. Yes, I say that for the reason that the gauge readings at Peoria for instance, or at any other of the places which I have records of, indicated that the crest of the flood passed before the observations were made; that is to say, at Peoria, when we began on the afternoon of the 14th.

Q. Of what month?

A. March, 1903.

Q. What was the gauge reading on the 14th?

A. The gauge reading was 19.1 feet. Now on the 12th the gauge reading was 19.4 and there had been a rise, a continuous rise from the 7th up to the 12th, and I felt confident that if the floats had passed Peoria for instance, anywhere between the 7th and the 12th, instead of on the 14th or later, the velocities would have been found to have been greater, and following down these charts, the charts indicate more or less all the way down the river that if maximum velocities are desired, they could have been obtained a few days before the observations were taken, with almost a certainity of securing greater velocities than were observed during these observations.

Q. How much lower was the river at the time you made these observations than the maximum height?

A. Well, I can only give an average reply to that. Perhaps I could give it for specific cases and specific places. 2922 It is variable all along, it would probably range from practically nothing to a foot less than the maximum.

Q. Then this experiment that you conducted was made during a stage of the river which ran from nothing to one foot below its maximum flood?

A. During this month?

Q. Yes, during this month?

A. Yes sir.

Q. The time calculated was calculated upon the channel flow?

A. As near as I could get it. It was calculated, as I said this morning, on the actual time covered by the floats as observed.

Q. What was the proportion of water in the channel, to the water in the Illinois River outside of the channel?

A. I don't know.

Q. You made no calculation upon that?

A. No sir.

Q. Have you any judgment upon it?

A. Only the roughest. It is a very variable quantity. In places the water was entirely confined to the channel and in other places it was spread for probably miles wide, with a very slow flow. I should hesitate to give a guess and it would be nothing but a guess, at the proportion in the channel and 2923 the proportion at the side. If I were obliged to, I might guess it 90 per cent of it in the section between the natural banks of the river on an average.

Q. That is an average of 90 per cent is in the channel?

A. I think that would be fair.

Q. How did the water along the overflowed banks compare in velocity of current with that in the channel?

A. Very much slower.

Q. Can you give any figures that would convey an idea more clearly than the adjectives which you used to express it?

A. No sir, I cannot.

Q. Was the water in the basins beyond the banks of the river, or rather did the water in the basins of the overflowed land have any perceptible current?

A. As far as I saw it, it was barely perceptible.

Q. It was practically in a stagnant, slow condition, was it not?

A. As far as I saw it.

Q. And how much land was overflowed?

A. I don't know, sir.

Q. By the river, that you observed?

A. I only observed it at this time between Peoria and Pekin, and then only causually. Apparently the width varied from nothing at Peoria and nothing at Pekin where the bluffs extend to the river, to somewhere between a mile and two 2924 miles between the two cities, and the depth changed, say from a few inches to perhaps a few feet, as indicated by grass still rising through the water, and bushes in most places, and things like that.

Q. Did you observe the width of the channel at Lake Peoria?

A. Only as I saw it from the Peoria Highway bridge.

Q. Could you see the width of the stream at that point?

A. I could see that it was very wide.

Q. Approximately how wide?

A. Well, I would hesitate to give an estimate unless I had seen it across the stream, which I did not.

Q. From your observations in this experiment, are you able to tell what the velocity of the current would be if the Illinois River was contained within its banks?

A. No sir.

Q. The condition that you found in the Illinois river, does that condition obtain the year round?

A. No sir.

Q. What period of the year does that condition obtain in the Illinois River?

A. I don't know.

Q. Have you any idea about it?

A. Only the most vague.

Q. Does it obtain for a period of six weeks during the 2925 year?

A. I don't suppose it will average that much. I speak without definite knowledge.

Q. Would it obtain for three weeks, professor?

A. I have no idea, when you get to that point.

Q. Then you wouldn't put it above six weeks, would you?

A. Not as a guess, no sir.

Q. Then the experiments that you made would apply to the Illinois River for a period not to exceed six weeks throughout the year, would it?

A. I presume so.

Q. Do you know or have you any information in regard to the volume of water that you found in the Illinois River at the time you made the experiments, as compared with the volume of water that would be in the Illinois River, if the Illinois River was contained within its banks?

A. I have been unable to get such facts.

Q. That information is obtainable, is it not?

A. I don't think so.

Q. Is it beyond the scope of engineers to make those calculations?

A. No sir, but I think they have never been made.

Q. That's what I mean. It is possible to find that out, isn't it?

A. It is.

Q. By engineering skill?

A. Yes sir.

2926 Q. You mean when you say it has never been done, that you don't know of it having been done?

A. I don't know of it being done, nor have I been able to find that it has, after inquiry.

Q. Now, as to the gauge readings that you collected along the Illinois River; what are those gauge readings based upon; what is the data from which they are taken?

A. It is wholly an arbitrary thing.

Q. Beginning at what?

A. At no definite point for the zero reading, unless or except in certain instances—it is the endeavor of course, at gauges at locks and dams, to put the zero of the gauge below the lock, at the level of the mitre sill, or of the gauge above the lock at the elevation of the upper gate or top of the upper gates, but there is no regular and definite place to put the zero of gauges universally used.

Q. Take it at Peoria; you read I believe, the gauge reading there as 19.1 feet?

A. 19.1 feet above, yes sir.

Q. What does that mean?

A. That means that the record that day was 19.1 feet vertically above the zero of that particular gauge.

Q. What does the zero signify at Peoria?

A. Nothing in particular. The way to interpret that 2927 reading would probably be by stating that the low water reading for Peoria is 2.6 on the same gauge, and that at high water the reading (I suppose from that—I can explain) the highest water previously of record is 21.9 feet.

Q. When was that?

A. I don't know, sir.

Q. And the 19.1 feet was the difference between the low water gauge as you gave it on the 19th, showing the height of water above the low water reading?

A. We would subtract 2.6 from 19.1 to get the height above the low water reading, yes.

Q. Is there any way of ascertaining the velocity of the current if the height of the gauge reading is reduced instead of 19 or 18 feet above the zero, suppose it was 10 feet above zero?

A. Is there a way of computing the velocity of that current?

Q. Yes, in your experiments?

A. It would be exceedingly crude and liable to a very considerable percentage of inaccuracy. There are ways of attempting to arrive at such a thing, but it is very likely to be wide of the facts.

Q. Then your experiment only serves to prove the velocity of the current at a time and under conditions that existed in the Illinois River at the time that the experiment was made?

A. Yes sir.

2928 Q. It doesn't show what the velocity of the current would be at other stages of the year, when the water in the Illinois River is considerably lower than it was at the time that you made the experiment, does it?

A. No sir, it would not furnish proof of such velocity at any other stage.

Q. From Grafton to the Chain of Rocks, at the time that you made this experiment, what was the stage of the water in the Mississippi River?

A. Do you mean the gauge reading, or about?

Q. The gauge reading?

A. The gauge at Grafton read 16 feet; the gauge at St. Louis 23.4.

Q. What does that mean, professor?

A. That means that the water in the river at those respective places was at the height above the zero point of the gauges which is given.

Q. Now what does the zero point mean in the Mississippi River?

A. That can best be indicated by giving the lowest water reading at Grafton on the same gauge, which is minus .3 feet, with the corresponding high water reading.

Q. Right there, professor. Minus .3 feet; does that mean the bottom of the river?

2929 A. No sir, that means the surface of the river at the lowest water that has been observed there.

Q. And do you know how far below that surface was the bottom of the river at that point?

A. I don't know at the present moment. That would be told from the depth of the water of course.

Q. We had these once before and I was trying to get it straightened out. That is the reason I am asking these questions.

Q. Now if the stage of the river that you have read at Grafton at the time that this experiment was made—it was how much?

A. 16 feet.

Q. If it was 16 feet, was that a normal or an abnormal flow in the Mississippi River?

A. That was certainly greater than the average flow.

Q. It was what is known as high water?

A. Yes sir.

Q. Coming down the Mississippi to the point—may I have that chart you exhibited this morning—coming down from the mouth of the Missouri River, down to the Mississippi River, to where a sand-bar appears in the Mississippi River, is that sand-bar under water or above water?

A. When the observations were made?

Q. When the observations were made?

A. It is, I suppose, entirely under water, with bushes and trees growing upon it, of course above the water surface.

2930 Q. Do the bushes and trees grow entirely over the sand-bar or do they only grow on a part of the sand-bar?

A. As far as I know they cover it. I won't be positive of the covering of the whole of it.

Q. Does the water of the Mississippi flow over that sand-bar the greater part of the year, do you know?

A. I think not.

Q. Does the water of the Mississippi pass to the left of that sand-bar during the entire year?

A. I don't know of my own knowledge. I understand that at low water stages, very little, if any, passes to the left of the sand-bar.

Q. Do you know what proportion of the year the Mississippi is at low water stage?

A. It varies with the year. For instance last year there was no what might be called low water stage, and the year before there was a great number of weeks when it was.

Q. Is there any channel to the left of the sand-bar that we are talking about, in the Mississippi River?

A. Yes sir.

Q. Do you know what the depth of that channel is, professor?

A. No sir.

Q. Have you any idea as to its depth?

A. Not at the present time. I believe that the upper end
2931 of that channel has been closed by a jetty, which would
cause it to fill and would obstruct the low water flow through it. These depths we see here were the depths at the date this map was made and before such jetty was put in.

Q. Doesn't the sand-bar project considerably west of the line of vegetation?

A. I don't think so very much.

Q. The three islands south of the sand-bar are about how large, Professor?

A. They were submerged when my observations were taken, and I have not been in that vicinity during low water recently so that I could answer at all. There are changes since that map was made, to a greater or less extent, how much I don't know, in the size of the islands.

Q. East of the intake, do you know whether the island forms the bank of the river or whether there is a channel around that island in the river on the Illinois shore?

A. I believe there is a channel between that island and the Illinois shore, through which the waters, in high water stages, make their way. I understand there is practically no flow there during low water stages.

Q. Professor, after you left Joliet some of the floats were lost again, were they not?

A. From Joliet to Grafton?

Q. Below Joliet?

2932 A. Yes, there were.

Q. How did they become lost?

A. Mostly from flowing into the woods from the side channels, which are full at high water, and getting away.

Q. What did that indicate as to the current?

A. It indicated that the waters of the river separated wherever there was an opportunity to, and the current is more or less dissipated.

Q. And the water went over and submerged the lands?

A. Yes sir.

Q. Do you know whether the men operating under you kept the velocity or made a memorandum of the velocity of these floats through what is known as Lake Joliet?

A. They did.

Q. What was the velocity?

A. Well, they made the velocity experiments in this way; they noted the time of passage through but not the velocity as it may be expressed in feet per second, for instance.

Q. Have you the data showing the time that these floats entered Lake Joliet and the time that they emerged from Lake Joliet?

A. Not in that way. I do not know; and from the records I have, I cannot identify the upper end of Lake Joliet. The time from Rome to Peoria, if that is at all indicative—

2933 Q. No, Lake Joliet is immediately below Joliet.

A. No, I have not; I cannot give that. I can give the time from Bear Trap Dam, in the aggregate, to Joliet.

Q. Well, from Joliet, where is the next point?

A. Morris is the next. We will locate a point 24 miles.

Q. They did not make any data in regard to this point of which you speak?

A. They undoubtedly did, and I imagine the engineer who was in local charge, can give you those facts.

Q. Did they make any data of Lake Peoria from the time that the floats entered Lake Peoria?

A. I think that can be arrived at in the same way. All I could give was the time from Rome to the Peoria bridge.

RE-DIRECT-EXAMINATION BY MR. JEFFRIES.

Q. Professor, I would like to have you take this chart or map and explain what it is?

A. This is simply a tracing I had made to show the point at, or figures of time of the flow from really the Chicago River to the St. Louis waterworks intake, embodying graphically what was given in the figures this morning. That is to say, the towns are given along the river and the distances of those towns from Lockport, successively all the way down, and the aggregate time at which each of those towns was reached. Say for in-
2934 stance, here we have Ŭtica, a distance of 62 miles from Lockport. The aggregate time of flow from Lockport to Utica being 29 hours and 51 minutes, and so for all the rest, and the time is given in the notes here of passage through the drainage canal.

Q. This was prepared by yourself, was it?

A. Yes sir.

Q. Upon the figures made by the men you had to make these observations?

A. Yes sir.

Q. As to the velocity of the Illinois River during the month of March, 1903?

A. Yes sir, and the figures, for instance, were taken from tables furnished me by the different United States engineering offices. I don't know how correct they are.

MR. JEFFRIES: Mr. Commissioner, I would like to have you mark that paper Complainant's Exhibit No. 40. I offer it in evidence.

Said map marked Complainant's Exhibit No. 40.

2935 RE-CROSS-EXAMINATION BY JUDGE JOHNS.

Q. The distances marked on that chart are the distances by river?

A. As well as I could get at them, yes sir.

MR. TODD: And this is at the stage of water you have testified to in your testimony?

A. The times given there correspond with the stage of water existing during the observations, yes sir.

MR. TODD: I object to the map for the same reason that I objected to the data from which the copy was compiled, namely, that it was based upon hearsay and not the personal investigations of the witness.

RE-DIRECT-EXAMINATION BY MR. JEFFRIES.

Q. I will ask you, professor, if it is not a fact if you know, that the water would spread out over a considerable portion of low land near Peoria, even in low water of the Illinois River?

A. I have never been there at such a time, so I don't know.

Q. Professor, I will ask you if you ascertained the water stages of the Illinois River from Chicago to St. Louis or various points along the river and the canal?

A. Those were read at the time the parties passed such
2936 gauges but only at such times as they were passing them.

Q. Did you make any effort to obtain the water gauges of the canal and Desplaines river?

A. I made a very extended effort to get the gauge readings of the upper Illinois and the Desplaines river, all above Peoria, of at least a dozen or fifteen different sources of information that I thought might give them to me and found that the Chicago Drainage Canal controls all such readings. I then wrote to Chief Engineer, Mr. Randolph and he replied very courteously that after consultation with the legal advisers, he must refuse them.

Q. When was that that you made this effort to get these readings?

A. I have been continuously making this attempt since these observations were begun, and have in every case asked for such readings during the month of March, 1903.

Q. Then it was during the month of March, 1903?

A. I made the request to cover the month of March, 1903, and have been up to last week trying to get them.

RE-CROSS-EXAMINATION BY MR. TODD.

Q. Did you get a letter from Mr. Randolph in regard to the gauge readings?

A. Yes sir.

2937 Q. Have you got that letter with you?

A. I have.

Q. Will you produce it?

A. Shall I read it?

MR. TODD: I would like to have it read into the record.

GENERAL CROW: Let me see it before you read it into the record. We may not want it read into the record.

(Witness hands letter to General Crow.)

GENERAL CROW: There is no objection to reading that letter.

MR. TODD: Read it into the record.

THE WITNESS: (Reading) "Chicago, April 27, 1903, J. L. Van Orum, Esq., Professor of Civil Engineering, Washington University, St. Louis. Dear Sir. I have yours of the 25th instant, *in re* gauge readings in the Desplaines and Illinois Rivers. I hope that in what I am about to say, you will acquit me of any discourteous intention, and believe me, when I assure you that in time of peace, that everything I could do to serve you would be done. After advising with our attorney I must decline to furnish any facts bearing upon the St. Louis situation which would aid said city in preparing its case against the district. All physical facts possessed by us which have any bearing upon the questions at issue, will be presented when the State of Illinois and the Sanitary District present its case. Yours very truly, Isham Randolph, Chief Engineer."

2938 MR. TODD: You said, Professor, that all the gauge readings you found were under the control of the Sanitary District or something to that effect, did you not?

A. Yes, every source of possible information which I approached, either referred me to someone else, who in turn referred me, or referrrd me directly, to the Sanitary District as controlling those gauge readings and taking them.

Q. And to what points did you have reference?

A. I asked particularly for gauge readings at or near Lockport or Peoria, preferably Lockport, and at or in the vicinity of Ottawa and LaSalle, so that I could divide the river, you see, into approximately equal distances all the way down from the upper end to the lower.

Q. And the answer that you got was the authority for the conclusion that you gave, that all gauge readings were under the control—or putting it the way you did—of the Sanitary District?

A. Yes sir, it was the inference from the replies that I received.

Q. Do you know whether any of the parties to whom you spoke, had any authority to speak for the Sanitary District?

A. I know definitely of only one such case. That was the man who appeared to be in control of the Bear Trap Dam at Lockport.

2939 Q. I mean outside of the District's property.

A. No sir, I do not. No employe as far as I know, of the Drainage Canal told me that such readings were taken by the drainage canal people. There was, for instance the City Engineer of Joliet, who told me that if the readings were taken at Joliet by any one, it was done by the drainage canal people, and other similar replies were made.

Q. Was the same said at Peoria?

A. I have the Peoria readings; I didn't need them.

Q. And at other points below Joliet?

A. Yes, similar replies were sent in those cases.

RE-DIRECT-EXAMINATION BY MR. JEFFRIES.

Q. Professor, identify that chart and state what it is?

A. That is a graphic representation of the gauge reading of the Mississippi River at Keokuk and Grafton, and at St. Louis during the month of March, 1903, and at Hermann, Missouri, for the Missouri River for the same time.

Q. Did you prepare that?

A. Yes sir.

Q. From what?

A. I prepared that from figures furnished to me in most cases by the Weather Bureau, and in one case by the figures furnished directly by the gauge reader.

2940 Q. Which case was it?

A. That at Keokuk.

Q. That was directly by the gauge reader?

A. Yes sir.

MR. JEFFRIES: Now we offer this chart as complainant's Exhibit No. 41 and ask to have it marked by the Commissioner.

Chart marked by the Commissioner "Complainant's Exhibit 41, Frank S. Bright, Commissioner."

2941 JUDGE JOHNS: We object to the chart as not competent evidence and not prepared from any data which has been verified and known to be correct.

MR. JEFFRIES: I will ask you to identify this chart and state what it is?

A. This is a chart prepared by me showing the gauge readings in the Illinois river during the month of March, 1903, at Peoria, Beardstown and Grafton, Illinois. This was prepared by a table furnished by the Weather Bureau also.

Q. What do the figures on the lower margin of the chart or map represent?

A. The day of the month and the figures at the side in ink represent the gauge readings.

Q. In feet?

A. In feet, yes sir.

MR. JEFFRIES: I will offer that chart in evidence and ask to have it marked Complainant's Exhibit No. 42.

MR. TODD: I object to it for the same reason as was given in the objection to Exhibit No. 41.

Chart marked by the Commissioner "Complainant's Exhibit No. 42, Frank S. Bright, Commissioner."

2942 MR. JEFFRIES: You have the original data from which that chart was made, in your possession, have you?

A. Yes sir.

Q. Professor, state whether or not the wind, taking it as it blew, on the day that you observed, and the observation of the velocity of the current of the Mississippi made from Grafton to the intake at the Chain of Rocks, would be sufficient to throw the floats on the west side of the Intake and explain fully, whether or not?

A. The wind as it existed during these observations, in its effect upon the float, was not sufficient to drive it or carry it to the westward of the intake, supposing of course that without wind it would have gone to the eastward of the intake. I say it is very evidently the case in the first place (and it must be said that the wind does have an effect upon the float) because it reaches the exposed portion of the float; and the amount of that effect is a matter for computation, depending upon the circumstances existing.

Q. Mathematical computation?

A. Yes. Do you wish me to go into the details of this computation?

Q. Yes, I think you ought to explain the system.

A. Authorities, whose authority is entirely reliable for deriving the principle, state that the effect of any fluid upon 2943 a body, varies in its effect upon that body as the area of exposed surface, and particularly as to the square of the velocity of the moving fluid, and also particularly as to the density of the fluid. Now I consider in this case we have a situation like this: the wind affecting the upper portion and opposing that effect of the wind the resistance of the fluid in which the lower portion of the float is suspended; and there will be a sidewise movement until the resistance offered by the water, equals the pressure exerted by the wind.

Now the average velocity of the wind at the water surface, from the time the floats were 50 feet from the Illinois shore, to the time they passed the intake tower, is estimated at eight miles an hour. Of course this estimate was made and recorded in my field notes before any such computation was made. The area of surface exposed to the wind, is the area of that buoy part of the float above the rim, and of the flag and its wire stand extending above it. The area of the vertical projection of that cone in which the flag rests—the part above the horizontal rim, is 16 square inches, and the best and most authoritative experiments on the effect of wind upon a conical surface, indicate that the equivalent area of a plain surface, which would offer equal resistance, is 38/100 to the projection of the conical surface, or 38/100 of the sixteen square inches which I have just mentioned.

38/100 of these sixteen square inches gives us practically six square inches, as the equivalent plain area of surface 2944 exposed to the wind in the conical portion of the buoy part, and to that the area of the flag wire and of the flag itself as it is wrapped around with wire, would add about one square inch, or make seven square inches in all as the equivalent area exposed to the wind pressure. Now if that vane portion of the float, floated with one of those vanes at right angles to the current, the area would be 144 square inches, but I have considered the worst condition, where one of those vanes is at an angle of 45 degrees, with the direction of the wind, offering the least resistance, and in that case the area of the vanes exposed to the current is 122 square inches. The chain which is also exposed to the current would add eight square inches, as near as may be, to these 122 square inches, or giving a total of 130 square inches surface exposing itself to the resistance of the water. Reynault, Ganot and other physicists, who have measured and observed very accurately the density of air as compared to that of water, state that at zero degrees centigrade, or just above, for water, so that it isn't freezing, and at a barometer pressure of 660 millimeters, water is 773 times as dense as air. That is to say a cubic foot of water will weigh 773 times as much in a vacuum as a cubic foot of air. Now to arrive at the definite effect of the wind, and to determine how much this wind would drive or influence the float in a certain direction, we can say that the weight of 2945 water, 773, as I have just given, times that of air, of exposed surface, 130 square inches as just given, times the velocity of movement, which is at present unknown, and which we wish to find, is equal to a weight of the equivalent unit of air, or unity, times the exposed area of the surface of seven square inches, times square of the velocity of the wind, or 8 miles an hour squared, which is 64. Seeking for the unknown velocity of water, which would offer an equivalent resistance, we find that this velocity is 0.066 miles per hour. Now as I stated this afternoon, in trying to arrive at the effect of the wind, I found that the average direction of the wind with reference to the direction of the current was such that the effect of the wind was .6 what the effect of the wind would have been at the same velocity if it had blown constantly, directly at right angles to the direction of flow in the river. So, multiplying this by the .6, we get, wouldn't we, .04 miles per hour as the equivalent velocity of the water in the direction which would carry the float sidewise at right angles to the direction of the stream. Now how long was this influence exerted. I have taken it as being exerted all the way down the river from a point opposite the Missouri River point when the floats were about 50 feet from the Illinois shore, to the time they passed the intake, which was practically 100 minutes, so multiplying this .04 miles per hour by the 100 minutes, and dividing by 60; multiply this result by 5280, which is the number of feet in a mile, to reduce the effect of the wind to feet, I found that on this basis the effect of the wind was to move the floats toward the Missouri River shore about 350 feet. That is to say, in all probability if there had been no wind whatever that day the float would have passed about 350 feet nearer the intake than it did, about 350 feet further from the Missouri shore than it did actually pass. 2946

Q. You testified, I believe, this morning, it passed about 700 feet?

A. About 700 feet from the Missouri shore, yes.

Q. And that the intake was about 1500 feet from the Missouri shore?

A. Yes.

Q. Then, from your calculation the wind was not sufficient to throw the floats on the Missouri side, and between the Intake and the Missouri shore?

A. No sir.

Q. Then, if there had been no wind, according to your calculations, where would the floats have gone?

A. This four foot float which is exhibited, would probably have passed about 450 feet to the westward of the Intake instead of 800 as it did.

Q. Now the system that you have used in these calculations is one that is generally adopted by civil engineers in estimating these matters, is it not? 2947

A. It is the most authoritative method that there is; the most reliable one, and practically the only one I know of, of any reliability, the only one that would be used.

Q. Examine this, Professor, and state what it is?

A. This is the float we called White No. 5, on which I wrote my name, at the time it was used in the Mississippi River, as being the one passing (without being touched in its course from above Alton to the St. Louis waterworks intake) as I have stated, about 800 feet westward of the intake before it was taken out.

Q. Now this is one of the floats that was used in this experiment, was it, concerning the velocity of the water from Chicago to St. Louis?

A. Yes sir, this is the identical one which was used from Grafton to St. Louis, and the others were entirely similar, the only difference being in the length of the chain.

MR. JEFFRIES: We offer this float in evidence as complainant's Exhibit 43.

Float marked by the Commissioner "Complainant's Exhibit 43. Frank S. Bright, Commissioner."

2948 RE-CROSS-EXAMINATION BY MR. TODD.

Q. At the time, Professor, that these calculations were made, what was the condition of the waves?

A. I don't apprehend the question I am afraid. The calculation was made after the return from the observations.

Q. I mean the data from which these calculations were made; what was the character of the water—was it smooth as a looking-glass?

A. No sir.

Q. Or was it wavy?

A. It was wavy.

Q. How high were the waves?

A. The force of the wind and consequently the height of the waves was reduced toward evening. It was the highest that day during the middle of the day and the waves then were such that at times we could see probably half way from the extreme rim of the buoy to the lower point of the buoy part of the float, and at times the buoy was submerged to a point about half way from that horizontal rim to the upper point of the—

Q. At any time during the—

A. There was an apparent movement of the water so as part of the time to expose the buoy down to about here (indicating on exhibit 43.)

Q. Probably about like that (indicating)?

2949 A. No, a little bit under the surface of the water.

Q. Did you make any calculations in the problem that you have given us, of the time that that surface of the buoy—the under surface, was exposed to the wind?

A. No sir, I assumed that inasmuch as a part of the time some of the lower portion was exposed to the wind, and during other protions of the time not even the full portion above that rim was exposed to the wind that the fluctuations balanced each other and that the average condition could be considered, where all of that portion below the horizontal rim was entirely exposed to the water, and the portion above the horizontal rim entirely exposed to the wind—during all the time—it was an average.

Q. When the buoy would go over the crest of a wave and turn up, it would present a perpendicular surface for the wind to strike, would it not?

A. Conditions were not enough to turn it perceptibly to the wind. The waves were very short and choppy and really the up and down effect was the only effect noticeable in the float. There was no tipping effect—the waves were small and it was so that it really bobbed up and down without tipping appreciably.

Q. So that it didn't take that motion?

A. Not to any appreciable extent.

Q. Were you able to calculate, or were you able to determine whether the under surface of the buoy was inclined so as to give a perpendicular surface for the wind to strike at 2950 any time or any number of times?

A. I didn't attempt to calculate that sir, because I know from watching the float that such a condition did not exist.

Q. Did you make a calculation based upon the effect of the wind when it bobbed up out of the water and struck the lower surface as well as the upper surface?

A. No, that condition of things which existed was generalized in this way, as though the calculation was made upon the assumption that the average condition and the fair condition on which to make this calculation is that everything below that horizontal rim is not exposed to the wind at all, but only to the water and everything above that horizontal rim is exposed to the wind only, and while that condition did not exist much of the time, exactly, still the position of the float and of the buoy part of it—particularly with reference to the water surface, was such that that was an average condition—that condition on which the computation was made, is the average condition that existed.

Q. Well, assuming that the wind struck the lower part of the buoy as often as the buoy was up out of the water, what do the authorities hold as to the effect of the wind striking an incline towards the water, such as is indicated upon this buoy?

A. I know of no investigations of that.

2951 GENERAL CROW: That condition did not obtain either, did it, in this experiment?

A. It obtained occasionally. That is to say, the rim was above the water surface sometimes, so that the wind would reach the lower cone, and I suppose the attorney's question refers more or less to the effect of imprisonment of the wind between the water surface and the surface of the cone; but that condition was only momentary and the situation varied from that as I have said, to the condition where the buoy was not only buried to the horizontal rim, but buried enough to, as far as we can tell, balance the effect.

MR. TODD: How did you calculate the velocity of the wind?

A. Simply from being obliged for a great many years to arive at that from observation only.

Q. Did you have any instrument?

A. No sir.

Q. Did you ever use any instruments in the calculation of the velocity of the wind?

A. Yes sir.

Q. Was it from instrument observations that you say you were compelled to make the velocity of winds that enable you to form an opinion as to the velocity of this wind?

A. That helped, of course, and I have also, where I was obliged to make such estimates, as often as I could, compared them to nearby readings of wind velocities, so as to per-
2952 fect myself as far as I could, in this kind of thing.

Q. Was this a steady gale of eight miles an hour, or did it come in gusts?

A. Well, as far as I know, all winds come in gusts more or less. As "steady" is generally used with reference to winds, however, this might be considered as a steady wind, and yet, of course—

Q. And then the velocity of the wind is merely a guess?

A. It is an estimate.

RE-DIRECT EXAMINATION, by General Crow.

Q. It is not a guess in any sense; it is simply the opinion of an expert, isn't it, based on wide experience in determining the velocity of wind without instruments?

A. I think that may be said.

Q. You have had a good deal of experience of that kind, haven't you?

A. Yes sir.

Q. Go back to the proposition that he diverted from when I started to examine you. The top of that float; the conical portion of the top you started to say, was submerged equally as much under the water as the lower conical portion was lifted above it by the action of the waves?

2953 A. Yes sir.

Q. And thus you say you thought it would be fair enough to consider that in the calculations?

A. Yes, there was that consecutive condition, one following the other.

Q. The cone itself—the float was built for the purpose of keeping it from tilting, wasn't it?

A. Yes sir.

Q. So as to make it stay erect.

A. Those dimensions given it were determined for that purpose.

Q. Now, the action of waves and the action of wind were both calculated upon in the building of that float?

A. Yes sir.

Q. And it was built under your direction?

A. Yes sir.

Q. And is such a float as is built and operated by civil engineers when they desire to test the flow of a stream?

A. Very frequently, yes sir.

MR. TODD: Just one question, Professor. In your calculations, did you calculate the effect of the wind on the water itself in diverting the current?

A. No sir.

Q. Does the wind have any effect upon the current in 2954 diverting it?

A. It does at the surface.

Q. How far below the surface does that extend?

A. It depends upon the velocity of the wind. There is probably no effect whatever—no appreciable effect—no effect that could be expressed in figures comparable to this 350 feet for instance.

GENERAL CROW: For measurement, you mean?

A. That can be measured or definitely stated, at a depth of four feet at which this vane portion was carried.

MR. TODD: In your calculations does the effect extend as far as six inches below the surface?

A. I think it would, yes sir.

Q. And would that effect upon the current six inches below the surface add any effect to the wind as upon the buoy? Do you get my idea?

A. Yes sir. I think it would have a very slight effect indeed in tending to move the buoy sidewise.

Q. Was that taken into consideration in—

A. No sir, it would be an exceedingly small percentage of the total as given.

GENERAL CROW: Would it be appreciable in measurements sufficient to affect the result as to whether it would pass inside of the intake?

A. Oh no; no sir.

2955 RE-CROSS EXAMINATION, by Judge Springer.

Q. Where were you, Professor, when you made these observations—where were you?

A. I was in a steam launch in the vicinity of the floats all the time.

Q. How did you get the measurements as to the relative distances from the shore of these lines?

A. By estimation.

Q. Estimation?

A. Yes sir.

Q. What do you mean by estimation; by your eye you mean?

A. Yes, by eye and experience in that class of work a great many years.

Q. You were on a steam launch; you had a pencil and this map before you and you observed and you marked this line about where you supposed it would be if a tape line were put upon it?

A. Why, that isn't precisely it. I noted in my field note book the distance from shore at certain consecutive points and when I reached my office I plotted that line with reference to these records.

Q. Well, the line is simply the result of the field notes which you made?

A. Yes sir.

2956 Q. Therefore the field notes were your estimates as to what the distance was?

A. Yes.

Q. From shore?

A. Yes sir.

Q. And you based that entirely upon your vision—what you saw?

A. Yes sir.

Q. You had no actual measurements?

A. No actual location or measurements.

Q. Did you make more than one experiment between Alton and the intake as to the velocity of this float?

A. No sir.

Q. You did not?

A. No sir.

Q. Why did you not make another estimate in order to test the correctness of your calculations?

A. Well, because no launch was furnished me and I wasn't asked to take the time for it, sir.

MR. JEFFRIES: It wasn't necessary?

A. I didn't see any necessity for it.

JUDGE JOHNS: Professor, the vertical projection of the white part of this float is how many square inches?

A. Sixteen.

2957 Q. Sixteen square inches. Then the white part of this float offers as a resistance to the wind, sixteen square inches of surface?

A. No, that doesn't follow, because it has—

Q. Well, if the top of the float had been a vertical plane of sheet iron or tin, it would have had an exposure of sixteen square inches, would it not?

A. Yes sir.

Q. Now the wind was blowing in a general direction from the southeast?

A. Yes sir.

Q. That would make the waves moving across the current of the river in a northwesterly direction?

A. Yes.

Q. The force of the waves, whatever it might have been, would be to crowd the float northwesterly?

A. Yes sir.

Q. And therefore towards the Missouri shore?

A. Yes sir. J. L. VAN ORNUM.

2958 C. V. MERSEREAU,

Recalled as a witness in behalf of the complainant, having been first duly sworn by the Commissioner, was examined in chief by Mr. Jeffries, and testified as follows:

Q. What is your name?

A. C. V. Mersereau.

Q. You have testified in this case before, haven't you?

A. I have.

Q. Are you employed in the water department of the city of St. Louis?

A. I am.

Q. I will ask you if at any time in the past few months you have made any observations of the velocity of the water in the Chicago drainage canal and the Desplaines River?

A. I have.

Q. State when it was and how you made them and under whose direction?

A. It was under the direction of Professor Van Ornum. The observations were begun on March 15th, 1903, and ended on March 26th.

Q. Now then, what waters did you take observations of?

A. Through the drainage canal from the Western Street bridge to the Bear Trap Dam at Lockport. From the bridge at Morris, Illinois, to a point about seven miles above Henry.
2959 From Chillicothe to Peoria.

Q. Now I will ask you what kind of an instrument you used in taking these observations?

A. For part of the work we used floats similar to the one exhibited here.

Q. Complainant's Exhibit 43?

A. Yes sir.

Q. They were furnished you by professor Van Ornum?

A. Yes sir.

Q. Well now, you state part of the time you used this kind of floats—what kind did you use in addition?

A. We used a float that was made of a white pine picket, about one and one-eighth of an inch square, on the bottom of which were nailed two pieces of tin, bent at right angles, so as to resemble those floats.

Q. Well now, you started in in the canal, did you?

A. Yes sir.

Q. Did you take water gauges along the route?

A. I read no water gauges in the drainage canal at all until after I reached Lockport. At Lockport I read both gauges. The gauge in one corner of the basin showing the stage of water in the canal.

Q. Do you know what that was?

A. Yes sir.

2960 Q. What was it?

A. (Witness refers to book).

Q. You are refreshing your memory now from your field notes?

A. From the field notes. It is recorded in the notes. About nine o'clock on March 16th the water gauge of the Bear Trap Dam at Lockport was 4.4 feet. Allow me to change that time. That was at 6:00 a. m. on March 16th, the gauge on the Bear Trap Dam read 4.4 feet.

Q. Above or below?

A. They read it as plus reading, meaning that the water—that the depth of the water going over the Bear Trap Dam was 4.4 feet. The gauge in the corner of the basin read minus 2.3 feet.

Q. Now in these field notes, what did you keep? Just state briefly what was kept in those field notes?

A. Kept the time that the float was dropped into the water and its approximate position also.

Q. Now that was on all the floats that were put in?

A. That was on all the floats that were put in. Also the time that any floats were picked out of the water, and anything that happened to the float, and the time of passing any marked object.

Q. Well now, would you note the time that the float was deposited in the water again after it had been picked out?

2961 A. Yes sir, the time when a float was picked out of the water, the approximate distance behind any other float was taken, and when it was deposited in the water, it was generally deposited opposite a float, and the time noted.

Q. And the number of the float opposite which this float was re-deposited was always noted, was it?

A. Yes sir.

Q. Do you know when you first started your floats?

A. Yes sir.

Q. You may state that.

A. On March 15th, at 10:19 a. m. dropped white float No. 3 off from Western Street bridge, about 95 feet north of the center of the draw pier.

Q. How many floats did you have there?

A. Shall I read the numbers?

Q. Yes, give the numbers of the floats?

A. Mr. Reed dropped green float at the same time, 75 feet south of the center draw pier, so there were two floats.

Q. Two floats?

A. Put in at that time, yes.

Q. Now then, how did they run and where did they lead you to?

A. I followed the floats that day all day long, until approximately six o'clock that night.

2962 Q. Until six o'clock?

A. Yes, do you want the exact time?

Q. Yes, I want the exact time and the distances?

A. At 6:18 p. m. white float No. 3 passed what is known as the Chicago Terminal bridge.

Q. Now, how long had it run?

A. That had run from 10:19 to 6:18, that would be practically nine—

Q. Between 10:19 in the morning to 6:18 in the evening?

A. Yes, that was the last reading that I took that evening. The float continued in the canal all night and ran—it was picked out of the canal by some laborers at a stone quarry at about half-past nine the next morning.

Q. Now then,what did you do with it when you found it, take it back?

A. I took it back, yes sir.

Q. Back where?

A. Back to the bridge where I made the reading at 6:18.

Q. Where you made the reading at 6:18 in the evening?

A. Yes sir.

Q. Well, what did you do then?

A. I dropped it in the water— no, allow me to change that. I put the white float back in the water at the place

that it had been picked out, and followed it on to Lockport that day. It was placed in the water at 11:48 on the
2963 morning of the 16th. It was taken out of the water at 6:31, about 100 feet east of the north gate tower at Lockport.

Q. At Lockport?

A. Yes sir.

Q. Now then, what became of the other float?

A. The other float—

Q. Did you keep time on it?

A. I did for some time, until the white float was running so far ahead of the green float that I couldn't take time on both of them.

Q. On the first night?

A. On the first night.

Q. You kept time on it?

A. I kept time on it.

Q. You did?

A. Yes sir.

Q. Well now, give us the time that that one—

A. Well, I kept time as long as I could on it. I will tell you that. (Referring to book.) At half-past three the green float was approximately 2,000 feet behind the white float, and from that time on I have no definite readings. At the times that I read the white float passing the bridge, it was too dark to have seen the green float more than 1,000 feet up
2964 stream, and so it was useless to take that.

Q. Well now, go right on through with it?

A. Go right on with the white float?

Q. Yes.

A. The white float was picked out at the Lockport dam at 6:31 p. m., and was taken back to the Chicago Terminal bridge and dropped from the bridge at 8:30 p. m. Here is the record. 8:30 p. m., No. 2, white, dropped into the canal from the C. T. Railroad bridge at south side of draw pier and five feet from it.

Q. That is where you went back?

A. Yes sir.

Q. Is that where you went back?

A. Yes sir.

Q. Going over again?

A. Yes sir.

Q. Now then, that was where you were going back over the same route again?

A. Yes sir.

Q. To that float which had been picked out by those quarrymen?

A. Yes sir.

Q. Now then, carry that from there?

2965 A. The next morning I didn't find the float until 11:57, and that was the first reading that I made on it. It was then approximately two miles above the St. Stephen Street bridge. From there I followed the float down to the quarry where I had put it in.

Q. On the day before?

A. The day before. It was picked out at 3:34 in the afternoon opposite the same point that I had taken the time in starting the float the day before.

Q. Well now, go right on.

A. Well, I picked it out at that point, so that completes—

Q. That completes that section?

A. The record as far as the drainage canal is concerned.

Q. Now then, have you got the field notes of the exact time that it took the float to go through the canal?

A. Why, I haven't got it worked out here.

Q. But you have not given it here in your testimony?

A. No, I worked it out and gave it to Professor Van Ornum.

Q. Now then, take the second section; that statement that you gave—

GENERAL CROW: Let him state the time it went in and the time it went out.

A. The time is broken and it had to be computed from the time that I gave.

2966 Q. MR. JEFFRIES: You stated a moment ago that you started in at a certain place, at a certain time?

A. Yes sir.

Q. And that you took readings of the time about six o'clock in the evening?

A. Yes sir.

Q. Then you let the float go on that night?

A. Yes sir.

Q. And it was picked up by some laborers the next morning, before you reached it?

A. Yes sir.

Q. And that you came back after that and ran that space over again?

A. Yes sir.

Q. And computed the time from the time it was put in to the time it was taken out?

A. Yes sir.

Q. Now take the second section; and commence at the time you put the floats in. Now this second section commences where the first section left off, doesn't it?

A. No sir.

Q. There was another man in between you?

A. There was another man in between.

Q. All right.

A. On March 20th, at 8:40 a. m., white float No. 4 passed
2967 under bridge near middle pier at Morris, Illinois.

Q. That is where you started anew on your second section; is that correct?

A. Yes sir.

Q. That is where you started on your second section?

A. Yes sir. Do you want any of the time in or not?

Q. Yes, if you have them, go ahead.

A. Well the readings are in the books, taken on an average of about every three minutes.

Q. Oh well, I don't want that.

A. The floats were run all day.

Q. And taken out in the evening?

A. They were picked up at 4:24, the float passed under the Marseilles wagon bridge—No, I will have to stop a minute there; that is not right.

Q. Just give where they were picked up that evening?

A. Well, there is a break in there on account of the dam. At 3:50 picked up float No. 4 about one-quarter of a mile above the State dam at Marseilles, Illinois.

Q. That was the green float?

A. That was the white float.

Q. The white float?

A. Yes sir. The float was started again at 4:17 and passed over the State dam where the float was lost. That
2968 was about five minutes from there to the bridge. Then the next morning we started again at 7:30 a. m. I will have to change that time. The gauge was read at 7:50 a. m.

Q. What was the gauge then?

A. 98 feet—the gauge above the State dam at Marseilles.

Q. Go ahead.

A. The floats were dropped off from the bridge at Marseilles at 9:05 and 9:09. They were taken out at 11:30 a. m. at the bridge at Ottawa, at the wagon bridge. The gauge on the wagon bridge in Ottawa is 80.6 or 90.6. The first figure was indistinct and we couldn't make out what it was. The zero and the 6 was plain. The float was started again at the wagon bridge at 1:25 p. m. At 5:12 No. 4 float passed the wagon bridge at Utica, Illinois. Picked out float for the night.

Q. At that place?

A. At that place, yes sir. At 6:55 a. m. March 22nd, float passed the wagon bridge at Utica, Illinois. That was starting again the next morning at the point where we left off the night before. At 11:28 passed Peru wagon bridge. Gauge reading on the bridge, 14.75. At 1:38 p. m. passed Spring Valley wagon bridge. Well, the float was taken out of the water at 5:35 that evening—

Q. Where?

A. Opposite the town of Depue.

2969 Q. Now is that as far as you went on that section?

A. No sir, that was that night.

Q. Now the next morning where did you begin and when?

A. At 6:30 the next morning.

Q. Did you deposit it in the same place?

A. We deposited it opposite the same place and at 10:59 the float passed the elevator at Hennepin, and the floats were run the rest of the day until 5:20 that evening when they were picked out opposite the point about seven miles above Henry.

Q. And that was the end of that section?

A. That was the end of that section. I left Mr. Reed to—

Q. What time was it picked out now at Henry, or seven miles above Henry?

A. At 5:20 p. m.

Q. Now then, the parties that took the observations below that point started in from that place?

A. Started in at that point and took it down to Chillicothe.

Q. And that is where you commenced anew again?

A. And that is where I commenced again.

C. V. MERSEREAU.

ADJOURNED until 10:00 a. m. May 6th at City Counselor's office, City Hall, St. Louis.

2970 City Hall, St. Louis, Missouri. Continuation pursuant to adjournment, 10:00 a. m., Wednesday, May 6th, 1903.

Present, the Commissioner and same counsel representing the respective parties.

C. V. MERSEREAU resumed the stand for further direct examination, by Mr. Jeffries, and testified as follows:

Q. Now, we had concluded the second section of the observations that you were testifying about yesterday afternoon, had we not, Mr. Mersereau?

A. Yes, sir.

Q. Now, commence at the third section and give the place of starting, the time and follow that through to the end of the section.

A. On March 21st, we started at the grain elevator at Chillicothe, at 5:56 a. m.

Q. At when?

A. 5:56 a. m. And then all of that day.

Q. When did you reach the end of the section?

A. Reached the end of the section at 6:43 on the 23rd.

2971 Q. Now during that time you hadn't run during the night?

A. No sir, a part of the time I had run a double set of floats.

Q. Well now, when you would remove the floats from the water at night, you would put them back in at the same place the next morning?

A. Yes sir.

Q. That is, at the place where you removed it?

A. Yes sir.

Q. Noting the time of the removal and the time of the re-deposit?

A. Yes sir.

Q. Now, how long did it take for you to get through that section?

A. 29 hours and 59 minutes.

Q. Now take the third section; did you get any of the gauges during that section?

A. That is the third section, sir.

Q. This is the third section—did you get any of the gauges on that third section?

A. No sir, there were no gauges on that section.

Q. Now take the fourth section?

A. I only had the three sections.

Q. You only had the three sections?

A. Yes sir.

2972 Q. Now then, on your third section you started your float where the party above you had left off?

A. No, I started ahead of the party.

Q. You started ahead of him and he came down to where you started?

A. Yes.

Q. Now then, where did you stop—right where another party had started?

A. Yes sir. Yes, on the third section I stopped at Peoria, highway bridge, where Mr. Van Ornum had started a party about two weeks previous.

Q. About two weeks previous?

A. About that—ten days or two weeks, yes sir.

Q. Do you know who it was that he started there?

A. Mr. Gibson and Mr. Brown.

Q. Now you used these same floats that you started with, did you?

A. Not on the third section. On the third section I had none of those floats.

Q. You had some new ones?

A. I had temporary floats that I had made.

Q. You turned all of this information—all of these field notes over to Mr. Van Ornum, did you?

A. Yes sir, the day following my return from Peoria.

2973
CROSS-EXAMINATION,
By Judge Johns.

Q. Where did you commence your work?

A. Sunday, March 15th.

Q. At what place?

A. Western Street bridge.

Q. How far did you personally follow the floats, or superintend the work of following?

A. Why, I followed the floats personally that day and the next day. During the night one of the floats was running through the drainage canal and nobody followed it.

Q. Where did you quit the following day, on the 16th?

A. On the 15th I got down as far as the C. & C. T. bridge. The float ran that night and was picked out the next morning at about the county line, near where the tablet is in the side of the canal. That morning I started that float again at that point and took it down as far as Lockport; got down there late in the evening. I then took it back to the C. & C. T. bridge where I was the night before and dropped it off from the bridge and allowed it to run all night. In the morning I went below it and walked up the canal until I met it, and then followed the float down until it came to the point, where it had been picked out the day before, where I started the other float.

Q. Now did you follow the floats personally any other place?

2974 A. Yes sir. All the records that I have here were made by my following the float.

Q. Well, did you follow floats from Lockport down to Peoria?

A. No, it was divided into three sections from there.

Q. What section did you take up?

A. I took from Morris down to about seven miles above Henry, and then from Chillicothe down to Peoria.

Q. How far is it from Morris to the place where you left off?

A. Well, that would be a matter of guess work. I could tell—

Q. What day did you commence at Morris?

A. I will have to look and see, sir. (Witness refers to notebook). March 20th.

Q. And you followed the floats how many days then, yourself?

A. I followed it March 20th, March 21st, March 22nd and March 23rd. That was between Morris and a point about seven miles above Henry.

Q. How many hours and minutes for that distance?

A. In the neighborhood of 33 hours.

Q. When you stopped running the floats at a certain place, you timed the taking out by the arrival of the first float there?

A. Yes sir.

Q. On each occasion that you took them out?

2975 A. Yes sir.

Q. The time you gave is the time that the first float arrived at the place?

A. Yes sir.

Q. How many floats did you conduct down the river?

A. It varied. In some places I had five; in other places I only had one.

Q. For what reason?

A. It depended upon the width of the river and the wind and state of the water.

Q. Could you not run five when the wind was running high?

A. When the wind was running high it was almost impossible to attend the five.

Q. Would they be blown over onto the banks?

A. No sir, but the trouble was handling the boat and getting around.

Q. Keeping track of so many floats on account of the difficulties with the boat?

A. Yes sir.

Q. When the wind was high you then ran only one float?

A. I always tried to have in two floats, with the exception of one day, and that day the wind was quite high, and I only ran one float.

Q. Where was that?

A. Just below Ottawa down—well say the afternoon of
2976 the day that we were running from Ottawa down to the
next point—Utica I think it was.

Q. Did you put that float in the middle of the river,—in the middle of the current?

A. It was in the middle of the current a part of the time. I would put a float in the river and try to put it where I thought the point of maximum flow was. Whenever that float appeared to be working too much to one side I would go out and drop another float opposite to the first one and then let them both run from there and see which was running the fastest and then take up the one that was lagging behind.

Q. The object being to keep the float traveling as fast as you could discover current to make them travel?

A. Yes sir.

Q. And you were looking for fast time down the river?

A. I was looking for the actual time that it took the float to go.

Q. And the fastest current?

A. Well, I was taking the fastest float.

Q. And if the float began to get slow you put in another one opposite and ran it?

A. Yes sir.

Q. Now in going down the canal did you have a boat?

A. I did not.

2977 Q. You went along the shore?

A. Yes sir.

Q. Did you have any companions or assistants?

A. During the forenoon of the first day Mr. Reed was with me.

Q. Who is Mr. Reed?

A. Mr. Reed, the man who took the second section. There were two of us left St. Louis, and were supposed to work together, but I found that the time that had been allowed me would not allow us to do the work together, so I sent him down to begin at Lockport and go on down until I overtook him.

Q. Now when he started at Lockport, did he take a boat?

A. He did, yes sir.

Q. What—a launch or a row-boat?

A. A small row-boat.

Q. How many oarsmen did he have?

A. He had one oarsman.

Q. Do you know who he was?

A. I think the name is given in the book here; I would not be sure of that.

Q. Have you a name that you think is the name of the person?

A. I will look and see, sir. (Witness refers to book). Yes sir. George Garver.

Q. Where did he live?

2978 A. He lived at Joliet.

Q. Did he go with Mr. Reed any great distance?

A. He went with him to Morris.

Q. Now when you were on the Illinois River, what kind of a boat did you have?

A. I had a row-boat.

Q. How many oarsmen did you have?

A. I had one.

Q. Where did you get him?

A. I had one on part of the work. I couldn't get an oarsman and I did my own rowing at that time. Mr. Reed was in the boat with me.

Q. Now where did you get a boatman?

A. I hired a boatman at Chillicothe.

Q. Who was he?

A. Harry Wilkie.

Q. Did he live at Chillicothe?

A. Yes sir.

Q. How far did he go with you?

A. Down to Peoria.

Q. To Peoria?

A. Yes sir.

Q. Now did you do any work below Peoria yourself?

A. No sir, I had nothing whatever to do with it.

2979 Q. You quit at the Peoria highway bridge?

A. Yes sir, the lower bridge.

Q. The lower bridge?

A. Yes, the one about the middle of the town.

Q. And at a point where some other parties had previously started floats?

A. Yes sir.

Q. About two weeks before?

A. Well, approximately that.

Q. Do you know exactly the day when the party started at Peoria?

A. I do not, but I think it was the same day that I started at Chicago.

Q. At Chicago?

A. Yes sir.

Q. Do you know who that party was that started at Peoria?

A. There were two men, Mr. Gibson and Mr. Brown, from the Water Department, that went up there with Professor Van Ornum.

Q. Well, while you were on it, the Illinois River was quite high I believe?

A. Yes sir.

Q. How many gauges did you read and where were they?

A. In the drainage canal I read two gauges; one was the gauge on the Bear Trap Dam; the other was the gauge in the corner of the basin. I think the next gauge that I got was
2980 the gauge at Morris, on March 20th, at 8:40, the gauge at Morris was 91.25.

Q. Were they the only ones you saw?

A. No sir, the next one that I read was on the same day at the Seneca railroad bridge; the gauge was 95.0.

Q. What does that mean, 95.0 feet?

A. No sir, I think that those gauges are set with reference to the datum plane of the drainage canal and the reading on them decreases as you go down the river.

Q. What do you understand that that reading 91.25, meant?

A. Well, I don't know definitely what it means, but my idea of the matter is that that is 8.75 feet below the datum plane of the Chicago drainage canal. It was the difference between 91.25 and 100, which would be 8.75. Now those gauges I know nothing about definitely.

Q. What kind of a looking thing was this gauge?

A. Most of them were a board painted with figures on them, fastened to the piers of the bridges.

Q. Marked off into feet and tenths of feet?

A. Yes sir.

Q. Well, when you read 91.25, was that the surface of the water upon that board?

A. The surface of the water on the board.

Q. And the exact significance of those figures you do not
2981 understand?

A. No sir.

Q. Did you read any other gauges?

A. Yes sir. At the Seneca wagon bridge the gauge read 95.5.

Q. What kind of a gauge. Was that also a board nailed to the pier?

A. Yes sir.

Q. And that was the reading at the surface of the water?

A. Yes sir.

Q. And you do not understand the significance of that?

A. No sir, more than as I have stated, that I suppose those gauges were set with reference to some definite plane used by the drainage people, and that the zero of those gauges would correspond with that plane, and that the difference in reading would give the fall of the river.

JUDGE SPRINGER: That would be below the level of Lake Michigan, you mean?

A. No, I don't say that. The zero of that plane may be an arbitrary point. These figures are merely for comparison of the readings at the different points.

JUDGE JOHNS: Did you read any other gauge?

A. Yes sir. No— I had the reading of the gauge about a quarter of a mile above the dam at Marseilles; that was given to me by the gauge reader that morning, but I didn't read the gauge myself.

2982 Q. What was the gauge as given to you?

A. 98 feet.

Q. 98 even?

A. 98 even, yes sir.

Q. And the significance of that you don't understand?

A. No sir.

Q. Except as you suppose it is from some arbitrary datum?

A. My instructions were to read the gauges and I read the gauges without going into further details.

Q. At what other place did you read a gauge?

A. At the Ottawa bridge. There the "10" figure on the gauge was indistinct, and it was either 80.6 or 90.6. The zero and 6 were plain, but the third figure I couldn't make out.

Q. And at what other place did you read a gauge?

A. At the LaSalle bridge the reading there was 81 feet.

Q. 81 even?

A. Yes sir.

Q. And at what other place?

A. I think that is the last gauge—No, there must be one more. I will have to hunt through the book to find that. (Witness refers to book). The gauge on the Peru highway bridge was 14.75. Now this gauge appeared to be a gauge set from a different datum, and I took it to be a government gauge.

Q. Was it a board or an iron rod?

2983 A. I would not be sure about that, sir.

Q. Do you understand that to be 14.75 feet above zero of that gauge?

A. Yes sir.

Q. Well, if you read any others, tell me where they were and what the reading was?

A. I think that was the last gauge reading that I have—that is, that I read. I have a gauge reading that was made at Henry by the gauge reader.

Q. Well, you have already given that have you not?

A. No sir.

Q. Well, give me the gauge at those various places, and the date?

A. On March 24th, the gauge readers—well, it was the lock tender at Henry,—gave me the reading of the gauge at 11.8 feet at 7:00 A. M. He gave me the high water of the Thursday or Friday before that, at 13.4 feet.

Q. Now, did you get any other gauge readings at any time?

A. I think not.

Q. What time did you start from Chillicothe and at what point did you start?

A. I started at 5:56 on the morning of March 21st. The float crossed the road line at Chillicothe about 300 feet from the east bank. No. 1 was in the middle of the channel. 2984 The channel was approximately 1,000 feet wide, and at 6:05 that same float passed the grain elevator at the lower end of the town. And that 6:05 is the time that should be used as the party coming down with the other float took his time at that elevator.

Q. When did you arrive at Peoria?

A. Two days later.

Q. How far did you travel the first day?

A. The first day we got down nearly opposite Mossville.

Q. What time did you take the float out at Mossville?

A. At 5:50.

Q. Of the same day that you started from Chillicothe?

A. Yes sir.

Q. Now when did you start the next day?

A. I started at 6:40 A. M.

Q. And when did you arrive at Peoria?

A. 6:43. That only shows in that time about twelve hours, but as an actual fact the float covered a time in there of about nineteen hours. I was anxious to get through that day— I would put my floats in, and I started the first float on the range that I had the night before. I just went down-stream some distance, and got into a range and put in another set of floats and let them go on down, and I waited there or went back and

met the other floats and took them out when they reached that range so that the total time that it took the float to go from Mossville down to the highway bridge at Peoria, is
2985 somewhere in the neighborhood of 19 hours.

Q. Could you give me from your data the exact time?

A. Yes sir, 29 hours and 59 minutes.

Q. From Mossville to Peoria bridge?

A. No sir, from Chillicothe.

Q. From Chillicothe to Peoria Bridge?

A. Yes sir.

Q. Now that was through a part of the Illinois River called Peoria Lake, was it not?

A. Yes sir.

Q. The progress of the floats even in this high water through Peoria Lake was very slow?

A. Yes sir.

Q. Do you know whether you kept your floats in such current as actually existed in Peoria Lake?

A. I don't quite catch your meaning. They must have been in the actual current to have made that time. As to whether the float could have been put through that lake in quicker time that than, I can't say definitely.

Q. At that time Peoria Lake was a very wide body of water to have a river running through it?

A. Yes sir.

Q. Well, did you endeavor in Peoria Lake, so far as your observations would allow you, to keep the float in the fast-
2986 est current you could find?

A. No, not entirely. On the upper part of that lake, or, not the upper part,—the part below the upper highway bridge, there was a time in there when the wind was very high, and it was not any too safe to be out with a light boat, and for that reason I didn't spread as many floats out as I otherwise would. I always had two, and part of the time four floats going through there.

Q. Did any one float along uninterruptedly from Mossville to Peoria?

A. I should say not. I could tell by looking through the records, but without doing that I should say no, for one reason. Well, I can answer right off-hand that they did not, because the way I was doing the work one float couldn't possibly go through; there was only twelve hours between starting and finishing.

Q. Now in making sub-sections from Chillicothe to Peoria, did you make more than one?

A. Oh, yes.

Q. How many times did you go ahead of floats that were in the water and start others on some range line?

A. Nine sections.

2981 Q. That is, you put in floats at nine different places and allowed them to run free, and waited for the floats up the river, to come to that range line.

A. What I did was, in the morning I put in a set of floats. I would then drop down about a mile or a half a mile and put in another set of floats. It took the first set of floats 57 minutes to get down to the range where I had started the second set of floats. I followed those floats for a while and dropped down and put in some more on a range. The second set of floats were in the water one hour, fifty-five and a half minutes. The third set were in two hours and 45 minutes, and the next set 3 hours and 28 minutes.

Q. That would be the fourth?

A. Yes sir, the fourth.

Q. What about the fifth?

A. The fifth were in 2 hours and 8 minutes.

Q. The sixth?

A. Three hours and 38 minutes.

Q. The seventh?

A. One hour and 26 minutes.

Q. The eighth?

A. 53 minutes.

Q. And the ninth?

A. 34 minutes. That is the 9th instead of the 10th.

2988

CROSS-EXAMINATION,

By Judge Springer.

Q. Did you note the movement of the floats in upper Peoria Lake, opposite the city of Peoria?

A. Yes sir.

Q. Have you a record of the movement there?

A. Yes sir.

Q. Will you refer to it please?

A. I have the record here.

Q. State if you please what time the float entered the upper part of Lake Peoria?

A. What do you mean by the upper part of Lake Peoria?

Q. The place called the Narrows, above the City of Peoria?

A. You mean there by the Narrows, the point where the upper highway bridge is, or do you mean the Narrows farther up, just below Spring Bay?

Q. I mean the narrows above Peoria, where the river below them widens out into what is called Lake Peoria.

A. Well, I hardly know how to locate the point. I will tell you. I am not very familiar with only going over it, and if I understand it, Peoria Lake runs away up the river above Peoria. Now just below Spring Bay, the town of Spring Bay, is what you call the Narrows, up there. The lake widens out and a number of points go out into the Lake, but I think it is quite wide until it gets down to where the highway bridge
2989 is across, about three miles above the city of Peoria, and if you mean that point, I can give it to you definitely, or if you mean the Spring Bay Narrows, I can give that definitely.

Q. Well, I desire to learn the velocity of the float in Peoria Lake, if you have a note of that, so as to indicate the velocity at that place?

A. I will have to work it out for you definitely; that is, the time here is not continual, on account of putting in and taking out the floats; I would have to add the different times in order to give it to you.

Q. Did you notice a material increase or decrease in the velocity of the float while it was in Peoria Lake?

A. There was a very decided difference in the velocity of the floats in going through the narrows or through the lake.

Q. How does the velocity in the lake compare with the ordinary velocity of the river?

A. I cannot answer that definitely, because I have never figured it out. These record books were turned over to Professor Van Ornum, when I came back from doing the work, and they have not been in my possession until yesterday.

Q. Then you did not note the velocity of the float in the upper lake harbor?

A. There are two ways of answering that. I did not note
2990 the definite velocity that the floats were making, but there is data enough in the notes to figure out that velocity.

Q. That you have not done?

A. No sir.

Q. If you have an opportunity during recess today, I wish you would figure that out in your notes and be able to state it after adjournment today. You can do that, can you?

A. Yes sir, but in doing that you will have to understand that it is done in making an approximate distance. For instance, I can simply say that it is approximately three miles from the upper highway bridge, to the highway bridge in the middle of the town and on that basis I can figure it, or I can give you the definite time between those two points and you can get the correct distances and figure it.

Q. That will be sufficient.

CROSS-EXAMINATION,

By Mr. Todd.

Q. At any time that these floats were going down the river, what was the character of the wind; was it high or low?

A. All the way from nothing to 24 miles an hour.

Q. When the wind was 24 miles an hour, how often would you take the floats out of the water?

A. We took them out of the water and turned in.

Q. That is, you didn't continue the experiments?

2991 A. Yes sir, we had to quit.

Q. Well, when the wind was ten miles an hour?

A. We continued.

Q. And how often did you take the floats out of the water then?

A. As often as was necessary.

Q. And how often did that appear to be necessary?

A. Well, sometimes the floats—I can show the records here, where the floats were taken out of the water, once on an average of every five minutes; that is, one float; that is where I was running five floats.

Q. What was the cause of taking it out?

A. As a rule the cause was that the current is not or was not following the channel of the river, the country was overflowed, and there was a tendency of the float to leave the river and go out across the point, so that you had to be continually taking up a float that was on the inside and taking them out and putting them on the other end of the line.

Q. Was that generally in the direction the wind was blowing, or the opposite direction?

A. Why the wind cut very little figure in that I think, with the exception of the past part of the day that we quit above Henry, about 7 miles above Henry. On that day the wind was very high and there was a very heavy swell and the float
2992 showed a tendency to work with the wind. Now I didn't realize that the wind was so high that day.

Q. How high was the wind that day?

I think that I estimated it at about 15 to 20 miles an hour late in the day, and I have forgotten now whether it was that day, or the day following that the signal service in Chicago registered it 24 miles an hour.

Q. When the wind was high enough to create waves, would the waves have any tendency, or rather any effect on the floats?

A. Very little. The floats ran quite steady. There would be some rocking of the floats, but I think that on an average you might say that it had very little effect on the velocity. The only reason for my saying that is, that I had two kinds of floats. One of them was simply a picket like they use in buiding a picket fence, about 1 1-8 inches square, and on the bottom of it were two sheets of tin that were 10x16 inches and bent at right angles. They were nailed on the different sides of the stock so that it gave practically the same effect to the float as the float that is exhibited here, but it had no cone or buoy at the top, so that the only surface that the wind could act upon was from four to six inches of the picket, 1 1-8 inches square, and a little piece of wire may be, six inches long, which is not a great deal larger than a pin, and a little piece of wrapping cloth, say four by six inches.

2993 Q. At any time that the wind was blowing did you ever remove the floats out of the river when they had gone towards the side of the stream from whence the wind was coming?

A. I couldn't say definitely that I did. On the piece of river just below Ottawa, there is quite a bluff along there, and part of the time the wind was blowing away from the bluff and part of the time it was blowing toward the bluff, depending on the direction of the river, and the floats appeared to want to follow the bluff all the time, notwithstanding that the wind part of the time was blowing away from it. Now I found the same thing in the drainage canal. That owing to the rock piled up on one side of the drainage canal, that the tendency of the float was to go in the direction the wind came from, as though the wind came over the bluff and created a suction.

Q. The tendency, you say of the float was to go in the direction that the wind came from?

A. Yes, in those cases that I speak of.

Q. And did you attribute that tendency to the wind?

A. Well, in the drainage canal I didn't know what else to attribute it to, but in the river below Ottawa, it might have been the wind, or it might have been an under-tow in the river. The wind driving the surface of the water in one way and the water flowing back and taking the float in the opposite direction.

2994 Q. You are not able then, to arrive at any definite conclusion as to the effect of the wind upon the floats in the drainage canal?

A. In going through the drainage canal the wind was not high, it was a light breeze.

Q. Did you find any other explanation as to why the floats went in the opposite direction to the wind, except what you have given?

A. No sir.

RE-DIRECT-EXAMINATION,

By Mr. Jeffries.

Q. The real reason why the float went in the opposite direction from the wind was what? State whether or not it wasn't the current that carried it,—the current of the river?

A. You ask me to state it definitely, and I cannot do it. The tendency of the float was gradually to work one way or the other. Now in the majority of cases, I think you can say it was the current, but at times they may act a little erratic. They may appear to be erratic.

Q. Now wouldn't the fact that the river rises, have a tendency to swell the current and throw it to one side?

A. I think you will find that would be different with different rivers.

2995 Q. You mean they go down stream if there was no current?

A. The current would take them down stream.

Q. I want you to give me again where you started the first section and where you ended?

A. From the Western Street bridge to the Bear Trap Dam at Lockport, within 100 feet of the Bear Trap Dam.

Q. You mean the Western Avenue Bridge instead of the Western Street bridge?

A. Yes sir.

Q. Where did you commence on the second section?

A. At Morris, Illinois.

Q. Where did you go to?

A. To a point seven miles above Henry.

Q. Now where was the third section?

A. From Chillicothe to Peoria.

JUDGE SPRINGER: State where in Peoria you ended?

A. The highway bridge, about the center of the town.

ADJOURNED until 2:30 P. M., same day, Wednesday, May 6th, 1903, at City Hall, St. Louis.

2996 City Hall, St. Louis, Missouri, 2:30 P. M., Wednesday, May 6th, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

C. V. MERSEREAU,

resumed the stand for further cross-examination by Judge Springer, and testified as follows:

Q. This morning Judge Johns asked you to state the length of the last division of the Illinois River in which you made your experiments. You could not state it at that time. Have you since obtained that data?

A. Yes sir, I can give you that in just a moment (witness refers to book). It is approximately 24 miles.

Q. Approximately 24—that is, between what points?

A. That is between Chillicothe and Peoria.

Q. Now, I requested you this morning to furnish the data from which you estimated the velocity of the flow in Lake Peoria. Have you obtained that data?

A. Yes sir.

2997 Q. Will you please give it?

A. The total time of the float in going from the upper bridge at Peoria to the bridge at the central part of the town, which is approximately three miles, was five hours and 49 minutes, which would make one mile in about one hour and 56 minutes. It was practically one mile every two hours.

Q. One mile every two hours?

A. Practically, yes sir.

Q. What is your opinion as to what would be the velocity of the flow in Lake Peoria at an ordinary stage of water?

MR. JEFFRIES: Do you ask him that as an expert or as a layman?

JUDGE SPRINGER: I am asking him for his opinion. That would be an opinion as an expert.

MR. JEFFRIES: Objected to, as the witness is not qualified as an expert on that subject, so as to give his opinion at an ordinary stage of the water.

JUDGE SPRINGER: Now, will you answer the question?

MR. JEFFRIES: I object to the question for the further reason that the witness has not stated that he has seen the water at an ordinary stage, or at any other stage than at the time the observations were taken.

JUDGE SPRINGER: Let the objection be noted. I will ask another question.

Q. Did you observe the width of the Lake opposite the city of Peoria?

2998 A. I did.

Q. How does it compare with the ordinary width of the river above the lake?

A. I never saw the river at an ordinary stage.

Q. How?

A. I never saw the river at an ordinary stage, but at the upper part of the lake there is no question but what it is considerably wider than it would be at an ordinary stage. In other words, the river was out of its banks.

Q. You could see where the banks were however, could you not, the ordinary banks?

A. In some places you could, yes sir, from the trees and bushes along the banks.

Q. Now you can answer that question I asked you before—what is your opinion as to what would be the velocity of the flow in Lake Peoria at an ordinary stage of water?

MR. JEFFRIES: I will interpose a further objection to that, that the witness has not qualified himself as being acquainted with the various flows of water, except in this particular instance, when the measurements were made by him.

JUDGE SPRINGER: Well, in view of the objection I will withdraw the question.

Q. Did you observe the character of the water between the Des Plaines river,—the mouth of the Des Plaines River
2999 and the end of the last division in which you made examinations as to its turbidity?

A. I was not on any portion of the Des Plaines River.

Q. Well, this is on the Des Plaines River after it had received the sewage of Chicago, or the drainage canal, opposite Joliet, for instance, all the way down from Joliet to Peoria, did you observe the character of the water as to turbidity?

A. In a general way, yes sir, the water was a little turbid.

Q. How?

A. The water was a little turbid.

Q. A little turbid?

A. Yes sir.

Q. Did you see any indication of the presence of the water of Lake Michigan?

A. I think that the water in the river was more turbid than the water in the canal,—if that will answer your question.

Q. Yes. It was more turbid in the river than in the canal?

A. Yes.

Q. Did you notice the condition of the streams that were emptying into the Illinois River,—the Kankakee for instance, and the Fox River?

A. Only in a general way. Let's see, the Fox River comes in at Ottawa?

Q. Yes.

A. I think the water that was coming in from the Fox
3000 River was rilier than the water in the Illinois.

Q. More turbid you mean?

A. Yes, more turbid.

Q. How about the Kankakee River; that comes in.

A. I didn't see that point.

Q. What was the stage of the water in the tributaries, that is, the Kankakee and the Fox Rivers, so far as you noticed or observed, was it a high stage of water or low?

A. Why, I couldn't answer that question because I did not go up on the Fox River at all. I only saw the river as I came by it.

Q. Well, you saw the confluence of the two streams, of that stream with the Illinois River?

A. Yes sir.

Q. Well, what was the appearance of the water there, low stage or high stage?

A. Well, of course the stage of water at the mouth would agree with the stage of water in the Illinois River, and with a low stage it would back up in the stream so that I would have no means of judging the height of the water in that stream at all.

Q. You could tell whether it was backing up from the Illinois or whether it was crowding from the Illinois?

A. Perhaps I could if I went over and watched it to make
3001 that determination. I could tell whether the current was
flowing in very strong or whether it was dead water.
Did you observe that?

A. I did not.

C. V. MERSEREAU.

3002 **FRANK J. BROWN,**

called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Mr. Jeffries, and testified as follows:

Q. State your name?

A. Frank J. Brown.

Q. You have testified in this case before, haven't you?

A. Yes sir.

Q. Where do you live?

A. 2754 Lawton Avenue.

Q. You are still engaged in the water works department, are you?

A. Yes sir.

Q. Here at St. Louis?

A. Yes sir.

Q. Did you do any work on the Illinois River last March, —this last March?

A. Yes sir, I did.

Q. What was the character of the work?

A. It was to ascertain the velocity of the current of the Illinois River from—I started at Peoria, Illinois, and came down as far as Naples.

Q. You had one section then?

A.Yes sir.

3003 Q. And obtained the velocity from Peoria to Naples?

A. Yes sir.

Q. Now at what point at Peoria did you start?

A. Opposite the lower highway bridge.

Q. That is the bridge that is opposite the main part of the city?

A. Opposite the main part of the city of Peoria, yes sir.

Q. Did anybody else take the distance,—or rather time the velocity above that?

A. Yes sir, I understand Mr. Mersereau or Mr. Reed was there above that point.

Q. What did you do with the field notes that you made during that period?

A. I returned them to Professor Van Ornum of the Washington University.

Q. Professor Van Ornum?

A. Yes sir.

Q. Now can you state the time that it required the floats to come from Peoria?

A. Yes sir, the total distance was 71 hours and 40 minutes.

Q. Between what places?

A. From Peoria, Illinois to Naples, Illinois.

Q. What kind of floats did you use? Those that were furnished you by Professor Van Ornum?

3004 A. Yes sir, I had six floats, one, two and three feet submerged.

Q. One, two and three feet submerged?

A. Yes sir.

Q. You made a continuous run, did you, night and day?

A. No sir.

Q. Well now state what you did with refrence to stopping, or rather, removing the floats from the water and re-depositing them the next day?

A. Well, I started the floats at 3:15 at Peoria, Illinois, March 14th, and arrived at Pekin, Illinois at 7:45 that day.

Q. What did you do—

A. I took them out of the water at the highway bridge at Pekin and took them over to the hotel until the next morning and then took them out the next morning and put them in the water at the same point that I took them out the night before, and started them down the river.

Q. Now state whether you put them in the current of the river or on the side?

A. Yes sir, in the current, as near as I could possibly place them.

Q. What day did you finish your observations?

A. March 21st.

Q. March 21st?

A. Yes sir.

3005 CROSS-EXAMINATION, BY JUDGE JOHNS.

Q. Did you put the floats in at any stated distance from each other at Peoria?

A. Yes sir, I started them about fifty feet apart, probably, about that, I guess, yes sir.

Q. In going from Peoria to Pekin, did you have to take them out of the water because they grounded?

A. Some of them, yes.

Q. How many times?

A. Why, I don't know. There was several times I had to go to shore; I had to take them out.

Q. On the right bank of the river going down?

A. Well, partly. Not altogether on the right bank;—partly on the left. Partly on the right bank, and partly on the left, yes sir.

Q. Which was the most?

A. I think it was on the right bank, that was the most, if I remember it.

Q. The river from Peoria to Pekin is quite tortuous?

A. Yes it curves around.

Q. At Pekin did you put them in at this same distance,—about fifty feet apart?

A. Yes, just about that.

3006 Which float traveled the most rapidly—what ones?

A. Why, I think that the one-foot submerged floats made a little the best time in my experience.

Q. Made the better time?

A. Yes sir.

Q. Which was the slowest?

A. Well, the three-foot was the slowest, except in case of high winds up-stream, and if anything they would fall behind, but in the ordinary current or wind, the red floats made the best time.

Q. If the wind was high, and blowing up-stream?

A. The three foot floats made the best time.

Q. Would travel the most rapidly?

A. Yes sir.

Q. Did you take any guage readings along the route?

A. Yes sir.

Q. Where did you read guages?

A. At Peoria, where I started, and at Pekin, at the Copperas Creek dams—the State Locks, as they call it; at Havana, Government locks and Beardstown, and at Meredosia.

Q. Have you the guage readings for those various places?

A. Yes sir.

Q. Give them please?

A. The guage at Peoria, at the starting place, was 19.

3007 Q. Do you understand that was 19 feet above zero?

A. Yes sir.

Q. Well, go on and give the guages at the different places respectively, and the day of the month on which you read them?

A. That was March 14th.

MR. JEFFRIES: You say that guage at Peoria was March 14th?

A. Yes sir. Guage on bridge at highway—highway bridge at Pekin, Illinois, Sunday, March 15th, was 13.6. The guage at the State Locks, same day, at 6:35 p. m., was 17.5.

Q. JUDGE JOHNS: Is that the Copperas Creek dam?

A. Copperas Creek dam, yes sir. And I also took the readings at the Copperas Creek dam the next morning, sir, when I started out at 7:27 and it was 17.5. At Havana, Illinois, March 17th, at 4:20 P. M., the gauge at the highway bridge was 16.9. On March 19th at 6:15 P. M., the gauge at Beardstown, Illinois, was 16.10. At Meredosia, March 21st, at 8:40 the guage was 17 feet, nine and one-half.

MR. JEFFRIES: 8:40 in the evening or morning?

A. 8:40 A. M. And on March 20th, the government locks, at 2:02 P. M.,—there is two guages there, called the upper guage and the lower guage of the Government Locks.

JUDGE JOHNS: At La Grange?

A. Yes, just below the boat landing at La Grange, about a mile. It was 24.50 at the upper end of the locks, and the
3008 lower end was 24.25. That is all the guage readings I have.

Q. How many hours and minutes from Peoria to Naples?

A. 71 hours and 40 minutes.

Q. When you took out the floats each time at the place where you stopped, you took out the first one that arrived?

A. Yes sir.

Q. You endeavored to keep the floats in the current of the river as much as possible?

A. Yes sir.

Q. And in the most rapid current?

A. Out in the current as near as it was possible, just as direct in the current as we could get them.

Q. When a float went astray and got out of the current, or went aground, you took it out and put it in the current, opposite where you took it out?

A. Yes sir.

Q. Did you have a boatman?

A. Yes sir.

Q. How many?

A. One.

Q. Who was he?

A. His name was Henry Clay.

Q. Where did Henry live?

A. At Peoria, Illinois.

Q. Can you give his street number and address?

3009 A. Foot of Bridge Street, was his Post Office address, Peoria, Illinois.

CROSS-EXAMINATION, BY MR. TODD.

Q. You said something about the floats, in regard to their situation depending upon the wind, whether the wind was upstream or not—what was the statement?

A. What was the statement?

Q. Yes?

A. Well, I said with a very high wind blowing up stream the three foot submerged float made a little the best time. At least I think so according to my observation.

Q. The three foot submerged float?

A. Yes, in a high wind.

Q. How high a wind did you have?

A. Well, 25 miles an hour,—twenty or twenty-five miles an hour.

Q. Did you have wind 25 miles an hour?

A. Well, I didn't have anything with me to measure it, but I think at one time it was fully that much, yes sir.

Q. Well, any wind under 25 miles an hour wouldn't effect the floats, would it?

A. Yes, it would not necessarily have to be that strong;

twenty-five miles it would have some effect upon it, blowing directly up stream. 3010

Q. Have you ever had any experience in a wind of 25 miles an hour?

A. No sir, none whatever, except the cyclone in St. Louis, that's all.

Q. Do you know what the speed of that was?

A. About eighty five.

A. How did you arrive at that conclusion that the wind was 25 miles an hour?

A. Because it was a very strong gale,—a very strong wind.

Q. And it might have been 50 miles an hour as far as your observation goes?

A. No, it wasn't that—no I don't think so.

Q. Well, have you any experience in regard to the velocity of wind?

A. No sir. I told you that before—none whatever.

Q. Well then, how did you fix 25 miles an hour there?

A. That is my observation of the matter; what I thought about it.

Q. Well, if you had no experience in that line, was there anything that would enable you to draw that conclusion?

A. Well, I think—

Q. Except a pure guess?

A. That's all, just a pure guess, as I had nothing to measure it by, whatever.

3011 Q. Now would those conditions obtain in a lighter gale than the one which you spoke of?

A. Well I said when the wind blowed strong,—I would say ten miles, that is an ordinary gale, the white float would make a little the best time; that is my idea.

Q. That then, doesn't obtain only in these heavy gales?

A. Any ordinary gale.

Q. Any ordinary gale?

A. Yes sir, it is a pretty strong wind when it is blowing directly up-stream.

Q. How did this wind affect the floats?

A. Well, I don't know; I couldn't answer that question, how it affected them.

Q. I mean, what appearance did it have on the floats at eight or ten miles an hour say?

A. The only way I could answer that question,—the one foot submerged float didn't make as good time as the others. I noticed that it dropped behind considerably; that is all I could tell you.

Q. Most of these floats were floats with conical tops, with a flag, weren't they?

A. Yes sir.

Q. When the wind was down stream, what effect did it have on them?

3012 A. Well, in my experience on the river, there was a very little wind blowing directly down stream, but when it did blow down stream, it was very light.

Q. Well, the wind you speak of, didn't blow down stream all the time, did it?

A. Oh no, just only came up once or twice.

Q. Did the wind blow across stream?

A. Yes sir.

Q. What effect did it have when it blew across stream?

A. I couldn't answer that question.

Q. Would it affect the six foot float as much as it would the four float?

A. No sir, whenever the wind was across stream, an ordinary breeze—

Q. Well, a ten mile an hour breeze?

A. Across stream it would not effect it at all, I don't think. Not so much as I could notice it.

Q. It was only wind which was blowing up-stream that would affect them?

A. I noticed that the white one would make better time.

Q. When it was blowing up-stream, was the white float exposed anymore to the wind than the deep one?

A. I don't know what was the cause of it. The others dropped behind a little bit.

Q. That was merely a coincidence then?

3013 Well, the coincidence happened every time it blowed.

Q. When the wind blew up stream, why the floats didn't go down as fast?

A. I don't know, about as fast—

Q. I mean, the two floats didn't go down the stream with uniform regularity?

A. One didn't go quite as fast as the other.

Q. But at other times they would go with uniform regularity?

A. Yes sir.

Q. And when the wind was blowing as a gale, ten or fifteen miles an hour did you take the floats out of the water at any time?

A. No sir.

Q. Did you take the floats out of the water at any time in making these different experiments?

A. No sir, except when they would get grounded on shore or something of that kind.

Q. How?

A. They would drop way behind and go to one shore or the other; I would have to take them out. That is the only times.

Q. When they would get out of the channel you would take them out and put them back in the channel?

A. If they would get too near the shore or get aground, yes sir.

Q. Did that happen frequently?

3014 A. Well, from Peoria down to Havana I had some trouble with them, but it didn't seem to bother me so much after that.

Q. What seemed to be the cause of it?

A. Well, I don't know, unless it would be the wind blowing from the bank, driving them over that way.

Q. The wind blowing from the bank?

A. I noticed, which way the wind was blowing, the floats always go that way.

Q. The floats would always go with the wind?

A. Yes sir, across the stream.

Q. Across the stream?

A. Yes sir.

Q. And the wind had a perceptible influence on the floats?

A. It seemed that way, in going across, yes sir.

Q. Now when the wind would come up at a ten mile an hour gale, how far would the floats go before they would strike the shore?

A. Oh, it would sometimes be a couple of hours.

Q. And then would they go across sooner than that?

A. Oh, I think that if they were out in the current, ordinarily they would go two or three hours without running ashore.

Q. How many times did you take up the floats from Peoria to Havana, and put them in the current?

3015 A. Took them up—I had six of them you know, and sometimes the six of them would run nearest to the shore and run aground, and I would take one up—occasionaly it would get caught in the drift-wood.

Q. But the wind did have a perceptible effect upon the floats?

A. I noticed it, in going across, yes sir.

RE-DIRECT-EXAMINATION, BY MR. JEFFRIES.

Q. When you took one of these floats out of the drift-wood, or its place of lodgment, you took it back to the channel and relocated it in the channel where?

A. Right opposite the float—

Q. That was running on?

A. That was running on, yes, sir.

Q. Not opposite the place where you took it up from then?

A. No, sir.

Q. You stated in answer to Mr. Johns a moment ago, you put it in opposite the place where you took it up.

A. No, sir; I placed it opposite the float that was in the current.

FRANK J. BROWN.

3016 JOSEPH E. GIBSON, called as a witness in behalf of the complainant, being first duly sworn, was examined in chief by Mr. Woerner, and testified as follows:

Q. State your name?

A. Joseph E. Gibson.

Q. Where do you reside?

A. 2753 Lafayette avenue, St. Louis.

Q. What is your business?

A. I am employed in the water and construction departments.

Q. How long have you been in that employ?

A. Fourteen years.

Q. Did you make any observations in March last of this year, in order to ascertain the rapidity of the current of the Illinois river?

A. Yes, sir.

Q. State what you did and when you did it and the manner in which you did it?

A. I started from Naples, Illinois.

Q. You started from Naples, Illinois, and went up where?

A. No, sir; I started from Naples and went down to Grafton.

Q. Do you know who the man was immediately above you, who made the observations of the river above the place where you began?

3017 A. Yes, sir.

Q. What was his name?

A. Mr. Brown.

Q. What one took up the observations after you left at Grafton; who was that?

A. Professor Van Ornum.

Q. Now, just state in detail the manner and method and time in which you made these observations and what the result thereof was?

A. I was 30 hours and 37 minutes from Naples to Grafton; that was the total time of my time consumed in making the trip.

Q. That was the aggregate time of what?

A. From Naples to Grafton, from the time the floats were in the water.

Q. You made experiments with floats, did you?

A. Yes, sir.

Q. Like the gentlemen who have testified heretofore?

A. Yes, metal floats, submerged floats—three foot chains, a foot and a half and a foot—the length of the chains.

Q. Did you follow the floats in a skiff?

A. Yes, sir.

Q. Anybody with you?

A. Yes, I had a skiff man.

Q. Where did you hire him?

3018 A. In Naples.

Q. Did he go with you the whole way?

A. Yes, sir.

Q. Did you travel during the day time only?

A. Sir?

Q. Did you travel only during the day time?

A. During the day time only, yes, sir.

Q. What did you do at night?

A. Well—

Q. Stay on the bank?

A. If we could get a good comfortable place to stay all night, we stayed all night.

Q. Well, you ceased to do anything at night?

A. We didn't do anything at night at all.

Q. Then you started in the morning at the same place?

A. The same place we took the floats out.

Q. Go on and tell what you did and what the result of it was, just as near as you know how.

A. Do you want those gauge readings, etc.?

Q. No, sir; not yet.

Q. Just state how you did it from point to point?

A. Well, I started from Naples with three floats, and from Naples to Bedford I was 7 hours and 50 minutes. That was on March 18th, and from March 19th, from Bedford, opposite the government light to three miles below Kampsville, there 3019 is where I took the floats out for the night. That is, the distance or time approximately was 9 hours and 40 minutes, and that was the time consumed between those two points. On the 20th I started the floats opposite the government light three miles below Kampsville, the same point I just referred to and took them out opposite the government light, about nine miles above Grafton. That was 9 hours and 5 minutes consumed in that run. On the 21st I started the floats opposite the government light 9 miles above Grafton to a little island opposite Grafton. There is where I took the floats out. The time was 4 hours and 2 minutes.

Q. Making an aggregate for the entire distance covered by you of how much?

A. Thirty hours and 37 minutes.

Q. Did you have all the floats when you stopped?

A. Yes, three. I started with three and finished with three.

CROSS-EXAMINATION, by Judge Johns.

Q. State where you took the gauge readings when you took them, and the readings.

A. I will have to go through my note-book and get those out. At 9:45—

Q. A. m. or p. m.?

3020 A. 9:45 a. m. That was the day they started, on March 18th. The gauge reading equals 18 feet 2½ inches. This is in inches. Gauge on draw-bridge opposite Valley City, Wabash draw-bridge. On March 19th, arrived at 9:35 a. m. Arrived at Chicago & Alton draw-bridge. Gauge reading equals 16 feet 6 inches.

Q. Was the gauge in feet and tenths?

A. The government gauges are all in tenths, but those railroad gauges are not.

Q. Where did you read a government gauge?

A. At the government locks at Kampsville. I will get to that in a minute. I forget the name. The government locks at Kampsville. That is the only government gauge I read. March 19th, 3:07 p. m. Arrived at government locks on right bank—that is at Kampsville. The reading equals 24.7.

Q. Was that gauge above or below the locks?

A. It is above the dam.

Q. Did you read any gauge below the dam?

A. No, sir; there is only one gauge there.

Q. Was the dam at Kampsville visible?

A. No, sir; I asked the keeper there in regard to that and he said there was about 11 feet of water over the dam. Saturday, March 21st, 10:11 a. m. Arrived at Grafton and the gauge reading there was 17.0. That is the only gauge readings I have.

3021 Q. Which one of your floats traveled the most rapidly?

A. Well, that is pretty hard to say; I could not distinguish much difference in them.

Q. What kind of weather were you having on the first day you were out?

A. We had a very nice day the first day. It was clear. The weather was clear.

Q. You didn't run into any 25 mile an hour gale?

A. No, sir.

Q. Did you keep a record of the journeyings of each one of your floats?

A. Yes, sir.

Q. Have you them numbered?

A. Yes, sir.

Q. When you arrived at the place where you took out the floats, you took out the one that arrived there first, didn't you?

A. Yes, sir.

Q. And kept the time for that?

A. Yes, sir.

Q. You kept the floats as much as you could, in the current of the river?

A. Yes, sir.

Q. Did your floats ground sometimes and run into the drifts?

3022 A. Well, sometimes they would drift out on the edge of the bank.

Q. And when they did, you would take them out and put them in the current opposite where you took them out, as closely as you could?

A. Yes, sir.

Q. Do you know which one of your floats drifted out the most?

A. No, sir; I couldn't say that.

Q. Did you have a compass?

A. No, sir.

Q. Did you keep the direction of the wind?

A. No, sir.

Q. You made no notes, field notes of anything except the time you put in the floats and took them out?

A. I took field notes of the wind and the usual direction with reference to the bank, up or down or partly from the right or left bank.

Q. Without regard to the points of the compass?

A. Yes, sir.

Q. Which was the prevailing wind, up the river or down the river?

A. Mostly up-stream.

Q. Well, from what general direction was the wind on the first day, say?

3023 A. Well, up-stream mostly, from the right bank, I think my note-book showed.

Q. That means the right bank of the river as you were going down stream?

A. Yes, sir.

Q. Now, the second day, what was the direction of the wind?

A. Partly from the right bank, I think. I have that next day.

Q. And the third day?

A. The third day was almost due up-stream. We had a severe wind that day, too.

Q. A higher wind?

A. Yes, sir.

Q. Now, which one of your floats went the most rapidly that day?

A. Well, they all kept pretty close together. I couldn't tell much difference.

Q. You couldn't tell any difference?

A. No, sir.

Q. Did they seem to drift off toward the bank in the direction in which the wind was blowing?

A. Well, I think it had a kind of a tendency to draw them over at times.

Q. The river was very high, wasn't it?

A. Yes, sir.

3024 Q. Out all over the bottoms?

A. Yes, sir.

Q. When there was considerable wind, there were waves in the current of the Illinois River?

A. Very rough, yes, sir.

Q. Sometimes quite rough?

A. Yes, sir.

Q. If the wind was from a general direction south, it would either blow up stream or at an angle across stream?

A. Yes, sir.

Q. When the waves struck these floats, it seemed to knock them over in the direction which the waves ran, didn't it, a little?

A. Yes, that had a tendency to work that way somewhat.

Q. There was a visible effect of that character?

A. Yes, sir.

RE-DIRECT EXAMINATION, by Mr. Woerner.

Q. Are you able to state whether or not, when the wind blows up-stream, it affects the floats to any extent?

A. When the wind is due up-stream?

Q. When the wind blows up-stream, and the floats are floating down-stream, whether the floats would be retarded more than they would be if the wind wasn't blowing?

A. I don't think it would have much effect on them, no,
3025 sir; not the wind I encountered.

Q. You do not think that that would have much effect on the floats at all, then?

A. No, sir.

JOS. E. GIBSON.

3026 THOMAS F. REED called as a witness in behalf of the
complainant, being first duly sworn, was examined in chief, by Mr. Woerner, and testified as follows:

Q. What is your name?

A. Thomas F. Reed.

Q. You live in St. Louis?

A. Yes, sir.

Q. What is your occupation?

A. Rod man in the water department.

Q. How long have you been in the water department?

A. A little over thirteen years.

Q. Mr. Reed, did you take part in any observations, the object of which was to determine the velocity of the flow of the Illinois River last March?

A. I did; yes, sir.

Q. State first, in a general way, what portion of the river you covered?

A. I covered from Lockport to Morris.

Q. The whole of it?

A. The whole of it; yes, sir.

Q. Any other portions of the river?

A. And from seven miles above Henry to Chillicothe.

3027 Q. Any others?

A. No, sir; that's all.

Q. Those two portions then, were assigned to you?

A. Yes, sir.

Q. Now, you started at Lockport, you say?

A. At Lockport, yes, sir; at the Bear Trap Dam at Lockport.

Q. Now, just state in detail what you did and the manner and method in which you proceeded and the dates, and the result of your observation?

A. I started two floats at the Bear Trap Dam on the 16th of March, and one of them started down the river all right, and the other I couldn't keep track of, so I just followed the one at that time, that is, on the 16th, and I followed it as far as Joliet and took in the float the night of the 16th, just below the McDonnough Street Bridge in Joliet. On the morning of the 17th, I started at the point I left off the night before, with two floats, and it was very foggy, and I lost track of the two floats, and I got out of the skiff and walked down as far as the Brandon Street Bridge, and that was the last I seen of the floats. I sent the boatman back to look after the floats, and I went back to Joliet to have two more made.

Q. You did what?

A. I went back to have two more new floats made. I only had one. I knew it was the only chance I would have to get any floats to finish the trip. And I started again. I will have 3028 to look at my notes to see what time I started.

Q. Those are the notes that you made at the time?

A. Yes, sir; I have the notes in the book here. That is the only way I can explain. I have the original notes here in the note book.

Q. You can tell by refreshing your memory from the notes then. Before we go on, Mr. Reed, I wish you would state how long it took you from the place where you started down to Joliet, as you have stated?

A. Down to Joliet or to Morris, do you mean? From Lockport to Joliet it took me 2 hours and 15 minutes the first day.

Q. Is that from the place you started?

A. Yes, from the place I started at the Bear Trap Dam.

Q. That took you how long?

A. Two hours and 15 minutes, where I took in the floats for the evening.

Q. That is Joliet?

A. Yes, sir; that is Joliet.

Q. Now, go on further?

A. On the next day from Joliet to about two miles and a half above Millsdale, it took me 3 hours and 35 minutes; that is, from the time I started to make the run over again after losing the floats.

Q. Those are the new floats?

A. The new floats, yes, sir.

3029 Q. What date was that?

A. The 17th of the month. It took me 3 hours thirty-five and a half minutes to go two miles and a half about, above Millsdale. I took in the floats in the evening. I started from Millsdale the next morning and it took me three hours and six minutes to get to Smith's farm. I had a very bad boat and the water was very rough and I couldn't handle the floats, so I took the floats in and stopped there, and the weather was very bad all day and I just took the floats in for the day. The waves were very high and I had a very bad boat. It was a very dangerous part of the river and the boatman was afraid to make the trip.

Q. You needn't state the reasons why. Just state what you did.

A. I took the floats in that evening. From Smith's farm the next morning, to Morris, it took me 9 hours and 24 minutes to get to Morris, from where I left off the morning before, 9 hours and 24 minutes. The total number of hours it took me to get from Lockport to Morris, is 18 hours twenty minutes and a half.

Q. You have got down to Morris now?

A. Yes, sir.

Q. Now, that is where you stopped that part of your trip?

A. That is where I stopped my part of the trip.

3030 Q. Now, then, who took it up from that point where you quit on the way down immediately below you?

A. From that point to seven miles above Henry, Mr. Mersereau and I made the trip. From Morris to seven miles above Henry, Mr. Mersereau and I made the trip.

Q. Then the part you have narrated, you went yourself?

A. Yes, from Lockport to Morris.

Q. And from Morris down, you and Mr. Mersereau together made the trip?

A. Yes, sir; together. I recorded—

Q. Now, continue with just what you and he did together, as briefly as possible?

A. Well—

Q. That portion of it which you and Mr. Mersereau did?

A. I was just looking over these notes here, the part I did.

Q. You can give us the aggregate time it took the floats, can you?

A. No, sir; I cannot.

Q. Well, then, where did you go on again after that?

A. From seven miles above Henry to Chillicothe.

Q. Now, when did you start from the point seven miles above Henry?

A. On the 25th of the month.

Q. Now, go on and narrate that part of it.

A. It took me 10 hours and 25 minutes from the point
3031 about seven miles above Henry to about two miles below
Henry. Now, I will have to look up the time on the 26th, from Henry on down. I haven't had a chance to look up these notes. I haven't had any time to look them up and this is the first I have seen of the book since I turned it in. It took me 11 hours 18 minutes and a half to make the trip from two miles below Henry to Chillicothe.

Q. You mean by that, that it took the float that long?

A. It took the floats that long, 11 hours 18 minutes and a half.

Q. Well, is that where you left off?

A. That's where I left off, at Chillicothe, yes, sir.

Q. What day or dates did that cover?

A. This is on the 26th of the month, the 26th of March.

CROSS-EXAMINATION, by Judge Johns.

Q. Did you have a boatman or an oarsman at Lockport?

A. Yes, sir.

Q. Who was he?

A. Why, he was a boatman that I picked up—a river man whose name was Garver. I haven't his address.

Q. Does he live in Joliet or Lockport?

A. Yes, I think he lives in Joliet.

3032 Q. James Garver?

A. George Garver was his name.

Q. What happened to your float that you lost at Lockport?

A. Why, I put the float in on each side of the dam and one float went down the river all right, and the other cut around the mouth of the Desplaines river and got in the brush there in the willows and of course I started on down after the float that was in the channel of the river and just let the other one go, it was speeding pretty fast and I was afraid I would lose it, and it was in the channel of the river, in the current of the river, so I just let the other one go and paid no attention to it at all.

Q. How far did you put in the one you lost above the dam or right at the dam?

A. Just above the dam in the canal, I put one on each side of the dam.

Q. One below the dam and one above?

A. No, sir, not one below and one above; both of them were above; both went over the dam at the same time on each side of the dam of the canal.

Q. Which one got lost?

A. The one that I started on the—

Q. The right bank of the canal or the left?

A. It was on the right bank of the canal.

3033 Q. How far did you observe that float?

A. Well, I didn't see it a very few minutes after it started. I struck right down after the float that was in the channel of the river.

Q. This one that was lost, did it go across the Desplaines river?

A. It went across the Desplaines river and came on down as far as the bridge. It went across the Desplaines river; then

I picked this float up and I started with it again later on, after the float got down as far as the bridge. The first float, I timed it at the bridge, and I went back and picked up the other one.

Q. Where did you find it?

A. I found it in the river going down the river. It had gotten tangled up in the willows. I took it out just above the bridge and started it in at the bridge again, and that was the last I seen it. I took it up after I started it from the dam. The other float I started down the river; I started it after that and took the time of this float; then I went back and picked up this float that was tangled in the willows between the bridge and the mouth of the Desplaines River, picked it up and started it again at the bridge.

Q. When you got to this first float, was it stopped or floating?

3034 A. Yes, sir; it was in a lot of brush.

Q. How far from the dam?

A. I didn't make a memorandum of that and I couldn't tell you exactly. It was between the dam and the bridge.

Q. Well, how far is that?

A. Well, an eighth of a mile.

Q. When you went back and put it back in the river again, and floated it down to the bridge?

A. Well, I will look up my notes and read the notes to you.

Q. Well, cannot you recollect independently of your notes what happened to your float after you picked it up?

A. After I picked it up I started it again at the bridge and that was the last I seen of it. I lit down after the other float and didn't pay no attention to it at all. I just let it go.

Q. You lost it entirely that time?

A. Lost it entirely, yes, sir.

Q. When you had the floats made at Joliet, what kind were they?

A. They were the same we started with. I just got one of the old floats and had it as a pattern and had two made just exactly like it.

Q. Tin floats?

A. Tin floats, yes, sir.

3035 Q. With submerged veins underneath?

A. Yes, sir.

Q. Of the same thickness and size?

A. Yes, sir; duplicate floats.

Q. You didn't use a picket, a fence picket, weighted?

A. I did not, on the first trip that I made, no, sir. On the first division I made I didn't use a picket, no, sir.

Q. Did you read any gauges?

A. I did; yes, sir.

Q. Where?

A. I met the gauges at the different bridges and any gauge that I passed, I read—on the bridges.

Q. Now, give me the names of the places where you read the gauges and the time of day and the gauge readings, and the date of the month.

A. It will take me some time to look that up. Ninth Street Bridge at Lockport at 3:00 p. m., the gauge on the bridge read 16.7 feet. At ten o'clock a. m. on the 18th of the month. This is at the mouth of Jackson Creek, I read the gauge 81.55.

Q. Did you know what that 81.55 signified?

A. No, sir; I did not; just as the gauge read I recorded it in the book. About three miles below Millsdale, time 12:12. This is past Charles Smith's wagon bridge in the Desplaines river, about three miles below Millsdale. Gauge at bridge, west
side tree, registered 81.1. On the 19th of the month, the
3036 gauge on the Elgin, Joliet and Eastern Railroad bridge
at 9:41 registered 87.7. That is all the gauge readings
I have on the first part of the trip, unless I have passed over some of them there. Now, do you want me to give you the readings from Henry on down to Chillicothe?

Q. Yes.

A. On the 25th of the month I didn't get any gauge readings on the 25th of March. I read the gauge on the Lacon wagon bridge at 10:44.

Q. Is that the hour of the day or what?

A. That is at 10:44 a. m.

Q. Now, what was the gauge reading?

A. The gauge reading was 18.7 feet.

Q. Did you have a boatman on this last trip down to Chillicothe?

A. Yes, sir.

Q. Who was he?

A. His name was Krafft.

Q. What is his first name?

A. I think it was George; I ain't certain (refers to book). His name was Nick Krafft.

Q. Where did he reside?

A. On a farm about seven miles above Henry.

Q. How many hours and minutes were you on this last trip?

A. 11 hours, 18 minutes and a half.

3037 Q. Now, the river was very high, wasn't it?

A. The river was very high; yes, sir.

Q. Which one of your floats traveled the most rapidly?

A. Well, I changed the floats off and on. I would start a certain number of floats in the morning, and as they would lag back I would pick up the hind float and put it up opposite the head float, as they drove into shore, you know, the ones that lagged back. I tried to keep two or three floats in the river all the time the latter part of the trip.

Q. Which one of your floats traveled the most rapidly, the one with the greater or less submergence?

A. Well, I don't know. I couldn't say.

Q. What caused the floats to move out of the channel?

A. The wind. The high wind all the time; every day we were out; the wind would drive them right into the shore, right along.

Q. What direction was the wind from?

A. Generally across stream, up-stream part of the way.

Q. Well, across stream probably in a southerly direction, going in a northerly direction?

A. I couldn't tell you; I don't know. I couldn't tell you exactly the dates or the direction of the wind; I just made notes across stream or up-stream.

Q. The wind would blow the floats in the direction the wind was blowing?

A. No sir, not necessarily.

3038 Q. Well, towards that shore?

A. Towards the shore, yes.

Q. Towards the shore in the direction in which the wind was blowing?

A. Yes sir.

Q. When you were on the second section that you were working upon the river was very wide wasn't it?

A. Yes sir, very wide from bluff to bluff.

Q. And the dams were all submerged with water?

A. Yes sir.

Q. The wind had a free sweep?

A. Yes sir.

Q. The water was sometimes quite rough?

A. Yes sir, all the time.

Q. The waves ran a foot high, did they?

A. Yes and more.

Q. More than a foot high?

A. Yes sir.

Q. Now the floats would drive in the direction in which the waves knocked them?

A. Well, I tried my best to follow the current of the river and I supposed I was in the current of the river.

Q. Well, when the floats drive—when you had to take them out, they had drifted in the direction in which the waves were running?

3039 A. Yes sir.

THOMAS F. REED.

ADJOURNED to the Southern Hotel until Thursday morning, at ten o'clock, May 7th, 1903.

3040 Southern Hotel, St. Louis, Missouri. 10:30 a. m., Thursday, May 7th, 1903.

Parties met pursuant to adjournment.

Present: The Commissioner and same counsel representing the respective parties.

No witnesses being present an adjournment was taken to Southern Hotel, St. Louis, until Friday, May 8, 1903, at 10:00 a. m.

3041 Southern Hotel, St. Louis, Missouri. 10:00 a. m., Friday, May 8, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

No witnesses being present, an adjournment was taken until 2:00 p. m. same day.

2:00 p. m., Friday, May 8, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

L. B. ENGLISH,

Called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Mr. Jeffries, and testified as follows:

Q. State your name?

A. L. B. English.

Q. Where do you live, Mr. English?

A. 4339 Finney Avenue, City of St. Louis.

Q. You are a law clerk in the City Counselor's office of St. Louis, are you? 3042

A. Yes sir.

Q. I will ask you if you have done anything with reference to the collection of typhoid death rates in various cities along the Mississippi river to the north of St. Louis in the last two or three months?

A. Yes sir.

Q. If so, when, and state the number of places that you have examined.

A. Minneapolis, St. Paul, Dubuque, Iowa, Des Moines, Iowa, Keokuk, Burlington, Hannibal, Quincy and Fort Madison, Iowa.

Q. Now when was this done?

A. (Witness refers to book.) Commencing on the 6th of April and extending over a period up to and including April 15th, this year.

Q. Where did you go first?

A. Minneapolis, Minnesota.

Q. State the character of your examination of the records at Minneapolis?

A. I examined the records to determine the deaths per month and year from typhoid fever, and the total number of deaths.

MR. TODD: I object on the ground that the records are the best evidence, and on the additional ground that anything that he might say is mere hearsay and is not competent.

MR. JEFFRIES: Go ahead Mr. English?

3043 A. To ascertain the deaths from typhoid fever and the total number of deaths from all causes. I have got those by the month, beginning with January 1, 1893, up to and including December, 1902.

Q. You examined those records in the office of the Board of Health, did you?

A. The Health Commissioner, yes sir.

Q. In the city of Minneapolis?

A. In the city of Minneapolis.

Q. Now will you state what you found from those records?

MR. TODD: I object to the question on the ground that the records are the best evidence, and it is incompetent for this witness to testify about what the records disclose.

A. Do you want me to state them by the month?

Q. MR. JEFFRIES: First state the time of this particular examination in Minneapolis, if you have it.

MR. TODD: In order to save time, will it be understood that this objection goes to all of this? Then we won't need to interrupt?

GENERAL CROW: Yes sir. That will be understood to apply to all this class of testimony.

A. Monday, April 6th.

MR. JEFFRIES: Now go ahead and tell what you found in this record.

GENERAL CROW: That is, of this year, 1903?

3044 A. This is the examination of this year, 1903. In the year 1893—which form will be the best for the stenographer—

MR. JEFFRIES: Give the number of cases of typhoid by month, and the totals for the year, each year?

A. You don't want the cases; you want the deaths?

Q. No, I don't care anything about the cases.

A. (Witness refers to paper.)

THE COMMISSIONER: Is this one that is certified to?

A. No sir, this is not one that is certified to. This is one that I made the extracts myself. Year 1893, January, 4 deaths from typhoid from total causes—

MR. JEFFRIES: Well, you needn't put the total in; there is no use of putting that in the record.

A. You just want the typhoid?

Q. Yes, if they want it on the cross, they can put it in.

A. February, 2 deaths from typhid.
March, 4,
April, 3,
May, 6,
June, 4,
July, 16,
August, 19,
September, 27,
October, 22,
November, 18,
December, 9.

3045 Total deaths from typhoid fever for the year 1893, 134.

Year 1894:
January, 3 deaths from typhoid fever.
February, 2,
March, 9,
April, 3,
May, 1,
June, 2,
July, 7,
August, 27,
September, 13,
October, 18,
November, 10,
December, 6,
Total, 107.

Year 1895:

	January,	4 deaths from typhoid fever.
	February,	1,
	March,	2,
	April,	3,
	May,	2,
	June,	3,
	July,	9,
	August,	17,
	September,	12,
3046	October,	16,
	November,	13,
	December,	6,
	Total,	88.

Year 1896:

	January,	6 deaths from typhoid fever.
	February,	4,
	March,	6,
	April,	4,
	May,	6,
	June,	4,
	July,	4,
	August,	7,
	September,	7,
	October,	6,
	November,	4,
	December,	2,
	Total,	60.

Year 1897:

	January,	2 deaths from typhoid fever.
	February,	6,
	March,	35,
	April,	26,
	May,	15,
	June,	14,
3047	July,	12,
	August,	8,
	September,	9,

October,	7 deaths from typhoid.
November,	10,
December,	8,
Total,	148.

Year 1898:

January,	7 deaths from typhoid.
February,	4,
March,	8,
April,	6,
May,	1,
June,	5,
July,	10,
August,	8,
September,	16,
October,	10,
November,	6,
December,	5,
Total,	86.

Year 1899:

January,	3 deaths from typhoid.
February,	3,
March,	2,
3048 April,	3,
May,	5,
June,	5,
July,	6,
August,	10,
September,	10,
October,	12,
November,	5,
December,	7,
Total,	71.

Year 1900:

January,	1 death from typhoid.
February,	2,
March,	none,
April,	3,
May,	1,

	June,	1 death from typhoid.
	July,	none,
	August,	1,
	September,	1,
	October,	1,
	November,	1,
	December	2,
	Total,	13.

Year 1901:

3049	January,	5 deaths from typhoid,
	February,	4,
	March,	25,
	April,	25,
	May,	11,
	June,	5,
	July,	5,
	August,	8,
	September,	11,
	October,	8,
	November,	10,
	December,	4,
	Total,	121.

Year 1902:

	January,	3 deaths from typhoid
	February,	2,
	March,	8,
	April,	8,
	May,	5,
	June,	4,
	July,	1,
	August,	8,
	September,	9,
	October,	4,
3050	November,	10,
	December,	4,
	Total,	66.

That is all for Minneapolis.

Q. Now you got that from the records in the Board of Health Department of Minneapolis?

A. Yes sir.

Q. You saw the records personally and examined them and made the copies?

A. Personally and made the extracts myself.

Q. Made the extracts?

A. Yes, read them to the stenographer and afterwards compared them.

Q. Now then, just refer to St. Paul.

A. (Witness refers to paper).

Q. That was made what day,—the following day?

A. Yes sir, the following day.

Q. Which would be what date?

A. That would be April 7th.

Q. 1903?

A. Yes sir.

Q. Now commencing from 1893 to 1902?

A. 1893—January, 3 deaths from typhoid,
February, 2,
March, 1,
3051 April, none,
May, 2,
June, 3,
July, 1,
August, 11,
September, 8,
October, 9,
November, 5,
December, 6,
Total, 51.

Year 1894:
January, none,
February, 1,
March, 1,
April, 1,
May, None,
June, 2,
July, 2,
August, 4,

September, 6. deaths from typhoid.
October, 5,
November, 6,
December, 4,
Total, 32.

Year 1895:
3052 January, 3 deaths from typhoid,
February, 5,
March, 3,
April, 1,
May, 1,
June, 3,
July, 4,
August, 5,
September, 2,
October, 8,
November, 1,
December, 2,
Total, 38.

Year 1896:
January, 7 deaths from typhoid,
February, 6,
March, 3,
April, 3,
May, 1,
June, 1,
July, none,
August, 5,
September, none,
October, 4,
November, 5,
3053 December, 2,
Total, 37.

Year 1897:
January, no deaths from typhoid,
February, 2,
March, 2,
April, 2,

May,	1 death from typhoid.
June,	1,
July,	none,
August,	1,
September,	3,
October,	3,
November,	6,
December,	1,
Total,	22.

Year 1898:

January,	7 deaths from typhoid,
February,	none,
March,	1,
April,	3,
May,	6,
June,	4,
July,	none,
August,	6,
3054 September,	9,
October,	none,
November,	4,
December,	3,
Total,	43.

Year 1899:

January,	2 deaths from typhoid,
February,	1,
March,	none,
April,	1,
May,	1,
June,	1,
July,	1,
August,	3,
September,	4,
October,	4,
November,	5,
December,	2,
Total,	30.

Year 1900:
January, 2 deaths from typhoid,
February, 3,
March, none,
April, 1,
May, 2,
3055 June, 2,
July, 4,
August, 4,
September, 6,
October, 7,
November, 1,
December, 4,
Total, 36.

1901:
January, 4,
February, 2,
March, 2,
April, none,
May, 2,
June, 1,
July, none,
August, 2,
September, 4,
October, 3,
November, 2,
December, 2,
Total, 24.

Year 1902:
January, 2 deaths from typhoid,
February, none,
3056 March, 2,
April, 1,
May, 1,
June, none,
July, none,
August, 2,
September, 5,

October, 4 deaths from typhoid.
November, none,
December, 1,
Total, 18.

That is all for St. Paul.

Q. Now did you go to Prairie due Chien?

A. I went to Prairie du Chien, but the records were incomplete, and they had only been taking them since the state law was passed, requiring the clerk of the city to make them, and he had only been making them for a short time.

Q. How large a place is it?

A. 3,500.

Q. Did you go to Dubuque.

A. Yes sir.

Q. Give us Dubupue?

A. January, 1893—

JUDGE SPRINGER: Is this Dubuque, Iowa?

A. Dubuque, Iowa, yes sir. Year 1893:

3057 January, deaths from typhoid fever, none,
February, 2,
March, none,
April, none,
May, 1,
June, none,
July, 1,
August, none,
September, 1,
October, 3,
November, 1,
December, none,
Total, 9.

Year 1894:

January, deaths from typhoid fever none,
February, none,
March, 1,
April, 1,
May, none,
June, 1,

July, 1 death from typhoid.
August, 1,
September, none,
October, none,
November, 1,
3058 December, 1,
Total, 7.

Year 1895:
January,—deaths from typhoid fever, none,
February, 1,
March, none,
April, none,
May, none,
June, none,
July, 1,
August, 3,
September, 2,
October, 3,
November, 2,
December, 2;
Total, 14.

Year 1896:
January, 1 death from typhoid fever,
February, none,
March, none,
April, none,
May, none,
June, none,
July, none,
August, 2,
3059 September, 3,
October, none,
November, 2,
December, none,
Total, 8.

Year 1897:
January, deaths from typhoid fever none,
February, 2,

March,	none,
April,	none,
May,	2,
June,	none,
July,	1,
August,	none,
September,	2,
October,	5,
November,	none,
December,	1,
Total,	13.

Year 1898:

January,	1 death from typhoid fever,
February,	2,
March,	none,
April,	1,
May,	2,
3060 June,	1,
July,	2,
August,	none,
September,	none,
October,	3,
November,	1,
December,	none,
Total,	13.

Year 1899:

January,	1 death from typhoid fever,
February,	none,
March,	1,
April,	1,
May,	none,
June,	1,
July,	1,
August,	3,
September,	none,
October,	4,
November,	2,
December,	1,
Total,	15.

Year 1900:
January, 1 death from typhoid fever,
February, none,
3061 March, none,
April, 1,
May, 1,
June, none,
July, none,
August, none,
September, 1,
October, 1,
November, 1,
December, 4,
Total, 10,

Year 1901:
January, 2 deaths from typhoid fever,
February, 1,
March, none,
April, none,
May, 1,
June, none,
July, 1,
August, 1,
September, 1,
October, 3,
November, 1,
December, 2,
Total, 13.

Year 1902:
3062 January, 2 deaths from typhoid fever,
February, 1,
March, 2,
April, 1,
May, 1,
June, 3,
July, 2,
August, 1,
September, 3,

October, 2 deaths from typhoid fever,
November, 3,
December, 2,
Total, 23.

That is all, except three months in 1903. Do you want those?

Q. Yes, you can give it to me.

A. 1903, January, 2 deaths from typhoid fever;
February, none,
March, 1,
Total for the three months, 3.

Q. Now where is the next place?

A. Des Moines, Iowa.

Q. Now give us Des Moines.

A. 1893:
January, no deaths from typhoid fever,
3063 February, none,
March, 2,
April, none,
May, 1,
June, 1,
July, 2,
August, none,
September, 3,
October, 4,
November, 4,
December, 5,.
Total, 22.

Year 1894:
January, 2 deaths from typhoid fever,
February, none,
March, none,
April, 1,
May, 2,
June, 1,
July, 2,
August, 4,
September, 2,
October, 6,

November, 4 deaths from typhoid fever,
December, 5,
Total, 29.

Year 1895:

January, 2 deaths from typhoid fever,
3064 February, none,
March, none,
April, 2,
May, 2,
June, 1,
July, none,
August, 5,
September, 4,
October, 5,
November, 7,
December, 2,
Total, 30.

Year 1896:

January, 1 death from typhoid fever,
February, 1,
March, 3,
April, none,
May, 1,
June, 2,
July, 1,
August, 2,
September, 1,
October, 2,
3065 November, none,
December, none,
Total, 14.

Year 1897:

January, 1 death from typhoid fever,
February, none,
March, none,
April, none,
May, none,
June, 1,

July,	none,
August,	3 deaths from typhoid fever,
September,	5,
October,	3,
November,	5,
December,	2,
Total,	20.

Year 1898:

January,	1 death from tphoiyd fever,
February,	none,
March,	none,
April,	none,
May,	none,
June,	none,
July,	none,
3066 August,	3,
September,	6,
October,	2,
November,	3,
December,	2,
Total,	17,

Year 1899:

January,	no deaths from typhoid fever,
February,	1,
March,	1,
April,	none,
May,	1,
June,	none,
July,	none,
August,	2,
September,	5,
October,	none,
November,	1,
December,	2,
Total,	13.

Year 1900:

January,	no deaths from typhoid fever,
February,	1,

March, none,
April, none,
3067 May, 1 death from typhoid fever,
June, none,
July, none,
August, none,
September, 2,
October, 1,
November, 1,
December, 1,
Total, 7,

Year 1901:
January, 2 deaths from typhoid fever,
February, none,
March, 1,
April, none,
May, none,
June, none,
July, 2,
August, 2,
September, 4,
October, 4,
November, 5,
December, 2,
Total, 22.

Year 1902:
January, no deaths from typhoid fever,
3068 February, none,
March, 1,
April, 2,
May, 2,
June, none,
July, 1,
August, 5,
September, 5,
October, 1,
November, 1,
December, 3,
Total, 21.

Year 1903:

January, 1 death from typhoid,
February, 1,
March, 1.

That is all for Des Moines.

Q. Now from there you went to Burlington, or somewhere else?

A. To Burlington. 1893. January, no deaths from typhoid fever.

February, 1,
March, 1,
3069 April, 1,
May, none,
June, none,
July, none,
August, 1,
September, 1,
October, 2,
November, none,
December, 2,
Total, 9.

Year 1894:

January, 1 death from typhoid fever ,
February, 1,
March, none,
April, 1,
May, none,
June, none,
July, 1,
August, none,
September, 1,
October, 1,
November, 2,
December, 2,
Total, 10.

Year 1895:

January, 3 deaths from typhoid fever,
3070 February, 2,

March, none,
April, none,
May, 3 deaths from typhoid fever,
June, none,
July, none,
August, none,
September, none,
October, none,
November, none,
December, none,
Total, 8.

Year 1896:

January no deaths from typhoid fever,
February, 1,
March, none,
April, 1,
May, 1,
June, none,
July, 3,
August, 3,
September, 2,
October, 1,
November, 1,
December, none,
Total, 13.

3071 Year 1897:

January, no deaths from typhoid fever,
February, none,
March, none,
April, none,
May, none,
June, none,
July, none,
August, 1,
September, none,
October, 1,
November, none,
December, 1,
Total, 3.

Year 1898:

	January,	no deaths from typhoid fever,
	February,	1,
	March,	none,
	April,	none,
	May,	none,
	June,	1,
	July,	none,
	August,	none,
	September,	1,
	October,	none,
3072	November,	none,
	December,	1,
	Total,	4.

Year 1899:

January,	1 death from typhoid fever,
February,	1,
March,	2,
April,	1,
May,	none,
June,	none,
July,	none,
August,	none,
September,	1,
October,	none,
November,	1,
December,	1,
Total,	8.

Year 1900:

	January,	1 death from typhoid fever,
	February,	4,
	March,	2,
	April,	2,
	May,	none,
	June,	none,
	July,	none,
3073	August,	none,
	September,	1,

October, none,
November, 1 death from typhoid fever,
December, 2,
Total, 13.

Year 1901:
January no deaths from typhoid fever,
February, 1,
March, none,
April, 3,
May, none,
June, 1,
July, none,
August, none,
September, 2,
October, none,
November, 1,
December, 2,
Total, 10.

Year 1902:
January, 1 death from typhoid fever,
February, none,
March, 1,
April, 2,
3074 May, 1,
June, none,
July, 2,
August, 4,
September, none,
October, 1,
November, none,
December, none,
Total, 12.

Year 1903:
January, no deaths from typhoid fever,
February, 1,
March, 2,
Total, 3.

From there I went to Fort Madison. The records had only been kept a very short time and they commenced with the year 1900. I will not give each month when they had none. I will give each month when they had them. There are only four in the year, but if you gentlemen prefer, I can read them the other way.

Q. Just give what you have got there.

A. March 28th, 1900, 1 death from typhoid fever,
September 10, 1 death from typhoid fever,
September 30, 1 death from typhoid fever,
October 7th, 1 death.

Q. That is for what year?

3075 A. That is for the year 1900. In 1901 no deaths from typhoid fever.

Q. That is, there were none reported?

A. The law in Iowa is that all deaths must be reported to the city clerk, and he keeps a record of them, and it was from this record I got this. They have no deaths from typhoid fever.

Q. No record of any deaths, you mean?

A. Yes, that is the record showed none.

Q. That is what I was trying to bring out.

A. January 1st to March 31, 1903, no deaths from typhoid.

Q. Now that is all you found in your examination of the records at Fort Madison?

A. Yes, there had been no records kept before that time. From there I went to Keokuk, Iowa.

Year 1893:

January, no deaths from typhoid fever,

February,	none,
March,	none,
April,	none,
May,	3,
June,	none,
July,	1,
August,	none,
September,	none,
3076 October,	3,
November,	1,
December,	none,
Total,	8.

Year 1894:

January, 1 death from typhoid fever,
February, none,
March, 1,
April, none,
May, 1,
June, none,
July, none,
August, 1,
September, 5,
October, 3,
November, 1,
December, none,
Total, 13.

Year 1895:

January, no deaths from typhoid fever,
February, 1,
March, none,
April, none,
May, none,
June, none,
3077 July, none,
August, none,
September, 1,
October, none,
November, none,
December, none,
Total 2.

Year 1896:

January, no deaths from typhoid fever.
February, none,
March, none,
April, none,
May, 1,
June, none,
July, none,
August, 2,
September, none,

October, none,
November, none,
December, none,
Total, 3.

Year 1897:

January, 1 death from typhoid fever,
February, 1,
March, none,
April, none,
3078 May, none,
June, 1,
July, none,
August, 1,
September, 2,
October, none,
November, 1,
December, none,
Total, 7.

Year 1898:

January, 2 deaths from typhoid fever,
February, 1,
March, 1,
April, none,
May, 1,
June, 1,
July, 1,
August, 1,
September, none,
November none,
December, 1,
Total, 9.

Year 1899:

January, no deaths from typhoid fever,
February, none,
3079 March, none,
April, none,
May, none,
June, 1,

July, 2 deaths from typhoid fever,
August, 1,
September, 1,
October, 4,
November, none,
December, none,
Total, 9.

Year 1900:

January, no deaths from typhoid fever,
February, 1,
March, 1,
April, none,
May, none,
June, none,
July, none,
August, 4,
September, 2,
October, 1,
November, 1,
December, none,
Total, 10,

3080 Year 1901:

January, 2 deaths from typhoid fever,
February, none,
March, none,
April, none,
May, none,
June, none,
July, none,
August, 1,
September, none,
October, 1,
November, none,
December, none,
Total, 4.

Year 1902:

January, 1 death from typhoid fever,
February, none,

	March,	1 death from typhoid fever,
	April,	1,
	May,	none,
	June,	none,
	July,	1,
	August,	none,
	September,	2,
	October,	1,
	November,	1,
3081	December,	none,
	Total,	8.

Year 1903:

January, one death from typhoid fever.

February, no deaths. That is all I have for 1903.

Q. Now you collected those figures from the—

A. Records myself, yes sir.

Q. You collected them directly from the records?

A. Yes sir.

Q. Now the next place you went was Quincy, was it?

A. No, Hannibal—no, it was Quincy, yes sir.

Q. You made the same character of examination at Quincy As you did at the other points?

A. Yes sir.

Q. Now you may state that.

A. 1893, January, one death from typhoid fever.

	February,	1,
	March,	none,
	April,	1,
	May,	none,
	June,	none,
	July,	1,
	August,	1,
	September,	7,
3082	October,	5,
	November,	1,
	December,	3,
	Total,	23.

Year 1894:

January,	5 deaths from typhoid fever,
February,	3,
March,	2,
April,	1,
May,	none,
June,	2,
July,	1,
August,	1,
September,	1,
October,	1,
November,	4,
December,	7,
Total,	28.

Year 1895:

January,	6 deaths from typhoid fever,
February,	3,
March,	none,
April,	none,
May,	1,
June,	1,
3083 July,	1,
August,	none,
September,	3,
October,	4,
November,	4,
December,	2,
Total,	25.

Year 1896:

January,	2 deaths from typhoid fever,
February,	1,
March,	1,
April,	1,
May,	1,
June,	3,
July,	none,
August,	1,
September,	4,

October, none,
November, none,
December, none,
Total, 14.

Year 1897:

January, no deaths from typhoid fever,
February, 2,
March, 1,
3084 April, 1,
May, 1,
June, none,
July, 1,
August, 2,
September, 1,
October, 1,
November, 2,
December, 1,
Total, 13.

Year 1898:

January, no deaths from typhoid fever,
February, none,
March, 1,
April, 1,
May, none,
June, 2,
July, none,
August, none,
September, 1,
October, 1,
November, none,
December, 1,
Total, 7.

3085 Year 1899:

January, no deaths from typhoid fever,
February, none,
March, 1,
April, 2,
May, none,

June,	none,
July,	1 death from typhoid fever,
August,	1,
September,	none,
October,	none,
November,	none,
December,	1,
Total,	6.
Year 1900:	
January,	1 death from typhoid fever,
February,	none,
March,	1,
April,	none,
May,	none,
June,	1,
July,	none,
August,	2,
September,	1,
3086 October,	4,
November,	none,
December,	none,
Total,	10.
Year 1901:	
January,	1 death from typhoid fever,
February,	1,
March,	2,
April,	2,
May,	none,
June,	none,
July,	none,
August,	1,
September,	1,
October,	3,
November,	1,
December,	2,
Total,	14.

Year 1902:
January, 6 deaths from typhoid fever,
February, 5,
March, 2,
April, none,
May, 1,
June, 2,
3087 July, none,
August, none,
September, none,
October, none,
November, none,
December, 1,
Total, 17.

Year 1903:
January one death from typhoid fever,
February, 2,
March, 1,

Q. Now the next point was Hannibal?

A. Hannibal, yes sir.

Year 1893:
January one death from typhoid fever,
February, none,
March, none,
April, none,
May, none,
June, none,
July, none,
August, 2,
September, 1,
October, none,
November, 3,
3088 December, none,
Total, 7.

Year 1894:
January no deaths from typhoid fever,
February, none,
March, none,

April,	none,
May,	none,
June,	1 death from typhoid fever,
July,	none,
August,	none,
September,	1,
October,	2,
November,	2,
December,	none,
Total,	6.
Year 1895:	
January	no deaths from typhoid fever,
February,	none,
March,	1,
April,	none,
May,	none,
June,	none,
July,	1,
August,	1,
3089 September,	1,
October,	none,
November,	2,
December,	none,
Total,	6.
Year 1896:	
January	no deaths from typhoid fever,
February,	none,
March,	none,
April,	none,
May,	none,
June,	1,
July,	1,
August,	3,
September,	3,
October,	none,
November,	1,
December,	none,
Total,	9.

Year 1897:
January no deaths from typhoid fever,
February, none,
March, none,
April, none,
May, none,
3090 June, none,
July, 2,
August, none,
September, 3,
November, 2,
December, none,
Total, 7.

Year 1898:
January, 1 death from typhoid fever,
February, none,
March, 1,
April, none,
May, 1,
June, 1,
July, 1,
August, none,
September, 3,
October, none,
November, none,
December, none,
Total, 8.

Year 1899:
January no deaths from typhoid fever,
February, 1,
March, none,
3091 April, none,
May, none,
June, none,
July, 1,
August, 1,
September, 1,
October, 1,

November, none,
December, none,
Total, 5.

Year 1900:

January, 1 death from typhoid fever,
February, none,
March, none,
April, none,
May, none,
June, none,
July, none,
August, none,
September, 2,
October, none,
November, none,
December, none,
Total, 3.

Year 1901:

3092 January no deaths from typhoid fever,
February, none,
March, none,
April, none,
May, 1,
June, none,
July, none,
August, 1,
September, 1,
October, none,
November, 1,
December, none,
Total, 4.

Year 1902:

In January no deaths from typhoid fever,
February, none,
March, none,
April, none,
May, none,
June, none.

That is as far as the records at Hannibal show.

3093

CROSS-EXAMINATION,

By Judge Johns.

Q. In what one of these towns and how many of them did you find the records kept in regular form and tabulated?

A. You mean that were tabulated in printed form, or the records themselves tabulated?

Q. Their records themselves kept in tabulated form.

A. In all cities with the exception of Fort Madison, and I think Fort Madison was the only one,—they were kept under certain headings, running across the top of a large book. They gave the cause of death and age and the birth-place and death place, the burial place and all those sort of things. Is that what I understand you mean?

Q. Yes.

A. All with the exception of Fort Madison.

Q. That you found in all these stations you have named except Fort Madison?

A. Yes, except Fort Madison.

Q. In each one of those towns where you found these records, did they have persons, were there persons and clerks as custodians of those records?

A. Yes, in every case.

Q. In each case did the city or municipality have a seal in the custody of the clerk?

3094 A. I am unable to say that.

Q. You know that they had in some of those places?

A. In some places that I took in, two or three places, the records were kept by the City Clerk who had the seal of the city in charge. In other places, larger places, they were kept by the Health Commissioner. Only in one instance do I know of him having a seal.

Q. But in all these places except Fort Madison they were in the custody of some officer appointed for the purpose, keeping the records?

A. Yes sir.

CROSS-EXAMINATION,

By Judge Springer.

Q. Did you examine the records at Davenport, Iowa?

A. No sir.

Q. Or at Rock Island?

A. No sir.

Q. Isn't Rock Island a large city?

A. Yes sir.

Q. Why did you miss that place?

A. I was given a list of certain cities. I got them from that and I took only the ones from the list I was given.

Q. You did not examine the records at Galena, Illinois, 3095 either?

A. No sir.

Q. Did you take any account of the population of the various towns to which you have referred,—or cities?

A. Yes, in each instance I did; that is, the poulation at the time I took the records; that is the census of 1900.

Q. You didn't note the census of the previous years?

A. No sir, I did not.

Q. Have you those figures?

A. I have them in my desk at my office. I made some notations in my memorandum book and some on the copies themselves. Sometimes I would jot them down in my book and sometimes in another memoranda, and sometimes on the original memoranda that I made.

Q. Did you find upon these records any statement as to the number of cases of typhoid fever that were treated?

A. I found in one or two places, but they told me they were not accurate, that it depended on the physician. That they depended upon the physicians to report them and as a rule they were not sufficiently accurate to make any complete record from.

Q. Did the law require in these localities that deaths should all be recorded, and the cause of the death?

A. Yes sir.

3096 Q. And you took not only the typhoid death rate, but also the death rate of other diseases?

A. The total number, yes sir, in every instance. I have the figures here on that.

CROSS-EXAMINATION,

By Mr. Todd.

Q. All you have testified to, you got simply from the inspection of the records at the different places you have indicated?

A. Copying them from the record, yes sir.

Q. What place was there where the records showed the typhoid cases?

A. I recollect one instance,—Minneapolis.

Q. What other places?

A. I think that was the only one.

Q. And with whom did you have this conversation?

A. I think his name was P. M. Hall, Health Commissioner.

Q. And was this the same record that you took the statistics of death out of?

A. No sir.

Q. Did they have separate records for the cases of typhoid from the deaths from typhoid?

A. They were not separate records. He had them printed. The only record of typhoid cases, the only list of typhoid cases I saw was in the printed record, a printed report which 3097 was entirely separate. That is, it was a different table entirely from the table of typhoid deaths and total deaths.

Q. Was it from the printed report you got these figures you have testified to here in Minneapolis?

A. In Minneapolis, yes.

Q. Then you didn't go to the public records?

A. Yes I saw the public records and looked at them.

Q. Are the public records printed?

A. No sir. That is, they are in the Annual Report; the records are embodied in the report in the Health Department.

Q. Did you get your figures out of the annual report or from the public records themselves from which the annual report was made?

A. In this instance?

Q. I mean Minneapolis?

A. I got them from the printed annual reports.

Q. Did you compare the printed annual reports with the records in the Health Department of the place where these records are kept?

A. In the first year, and I was going over it in that way to see as far as I could, to ascertain whether it was accurate for one year. I was assured by the Health Commissioner they were.

Q. The question is did you make a comparison upon the
3098 printed report with the records themselves?

A. In 1893 I did, the other years not.

Q. Now were the public records that were consulted in regard to the cases of typhoid fever, kept in the same way the records were kept?

A. I didn't see any official record of them kept. The only table that I saw of them was in these printed annual reports.

CROSS-EXAMINATION,

By Judge Springer.

Q. You may state if you please, as to the cases of the cities to which you have referred. Have you the certificate of the clerk as to the correctness of these figures?

A. Yes sir. The City of Des Moines, Iowa; the City of Burlington, Iowa; the City of Minneapolis; the City of Dubuque.

Q. Just read one of those certificates so as to put it in the record.

A. (Reading) Burlington, Iowa, April 14th, 1903. State of Iowa, Des Moines County. I, Edward S. Johnson, Assistant City Clerk, City of Burlington, Iowa, on oath depose and say that the attached lists of deaths from typhoid fever and other causes is a true and correct copy from the original death records of the City of Burlington, Iowa, to the best of my knowledge and belief. Edward S. Johnson, Assistant Clerk. Subscribed and
3099 sworn to by said Edward S. Johnson, before me this 14th
day of April, 1903. F. P. Bulger, City Clerk." The one in Minneapolis differed a little from that. It is a certificate of the Health Commissioner, he being the custodian instead of the clerk.

LEE B. ENGLISH.

ADJOURNED until Saturday, May 9th, 1903, at 10:00 A. M,—Southern Hotel, St. Louis.

3100 Southern Hotel, St. Louis, Missouri. 10:00 A. M., Saturday, May 9th, 1903. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

Whereupon an adjournment was taken until 10:00 A. M., Monday, May 11th, 1903, at Southern Hotel, St. Louis.

3101 Southern Hotel, St. Louis, Mo. 10:00 A. M., Monday, May 11th, 1903. Parties met pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

J. L. VAN ORNUM,

Re-called for further direct-examination by Mr. Woerner, testified as follows:—

Q. Professor, you have been sworn the time you testified before in this case, have you not?

A. Yes sir.

Q. Have you taken any samples of the water of the Mississippi and Illinois Rivers and tributaries recently for the purposes of examination?

A. I have taken samples of the waters of the Mississippi and Missouri Rivers for such examination.

Q. Now Professor, I wish you would state what you did and when, and the purpose?

A. On the 10th and 12th of April samples of water were taken at sections noted on this sheet (referring to map), one section being just above the confluence of the Missouri and Mississippi in the Mississippi river; another above the
3102 same confluence in the Missouri River; another section in the Mississippi River below the confluence of these two rivers, and a fourth one about 1,000 feet above the waterworks intake, above the St. Louis waterworks intake in the Mississippi River. These samples were taken for the purpose of sending to Mr. George C. Whipple, at Brooklyn for turbidity examination, and duplicates of each sample were retained in St. Louis, those duplicates being in the boxes in the room now. For distinguishing the samples there was tied at the time of taking, a tag about the neck of each bottle, on that tag being

a capital letter to distinguish the section as noted here (referring to map), section I being close to the intake, and section C also in the Mississippi River below the confluence of the Mississippi and Missouri, section M in the Mississippi above the mouth of the Missouri, and section B in the Missouri River above the confluence.

Q. Now professor, these were all cross-sections, were they, —these four?

A. These were all cross-sections, locations being kept on each cross-section from 1 t› the highest number. No. 1 always being towards the right bank of the river.

Q. You mean towards the Missouri shore?

A. Toward the Missouri shore.

Q. I wish you would state the number of cross-sections, respectively for each of these examinations—the number
3103 of samples taken from each cross-section?

A. The number of samples taken from each cross-section are indicated on this same sheet. There were three points on the section B in the Missouri River, and there was one sample taken at a ten foot depth, at each of these three points.

Q. How many times?

A. Once. No sample was taken but the once.

Q. One day you mean?

A. No, I mean there was one sample taken from each depth at each point, and that sample was large enough so that a duplicate bottle could be filled from the same sample. Above the mouth of the Missouri river in the Mississippi or at section M there are eight located points across the stream and one sample was taken at each of these points at a depth of ten feet below the surface; also at section C there are eight located points, and there were three samples taken at each of these points; one sample is marked after the section letter C, and after the point number 1, 2 or whatever it may be. The small "a" designates six inches below the surface, the small "b" means in every case ten feet below the surface and the small "c" on the tag means 30 feet below the surface (which was the length of the line) or else the bottom, if it was encountered at a less depth than 30 feet, and practically the same facts should govern the section I, which is above, St. Louis

3104 waterworks intake, where there are, however, twelve located points with three samples taken at each point, unless the bottom was encountered at the ten foot level or sooner, which was the case, I believe, in three instances, but in every case the small letter "a" on the tag following the section letter and the location number or figure (the small letter "a") indicates six inches below surface as the depth at which the sample was taken, "b" indicates ten feet and "c" either bottom or 30 feet if the bottom was deeper than 30 feet.

Q. Now what is the method of taking the sample from the river?

A. The sample was taken with an apparatus sent by Mr. Whipple which consisted of a stand in which a bottle was placed. This stand was weighted so as to cause the bottle and all to sink. There was a cord fastened to the stand by which it was lowered to the required depth, and there was also a spring connection with a short cord connection to the cork so that by a slight jerk the cork could be pulled from the neck of the bottle after the bottle was lowered to the required distance.

Q. Permitting the water to get into it?

A. Permitting the water to go into it.

Q. Now what was done with these bottles after they were brought to the surface; what did you do with them?

A. Sampling the bottle, after it was brought to the surface—was done by first introducing a thermometer immediately in the bottle to get the temperatures, which are also noted

3105 on the tags. Then the water was immediately after shaken,if there was any sedimentation at all apparent,was poured, half of it or whatever was necessary, to fill one bottle, into a bottle like these here. Another half of it or thereabouts was poured into another bottle. Half of these bottles were sent to Brooklyn to Mr. Whipple, and the other half are here.

Q. This map that you have in your hand is a correct indication of these locations and the number of points from which samples were taken at each location, is it?

A. It is, yes sir.

Q. It shows the current or the direction of the river, of the flow of the respective rivers in so far as it may be indicated on the map?

A. Yes sir; it shows in short everything to connect the tags with each bottle, and with the exact position of each sample as it was taken.

Q. Well now, I will ask you what the red line upon that map along the thread of the stream indicates?

A. That red line as near as may be indicates what may be called the channel line or the deepest water throughout the length of the Mississippi River as shown on this sheet. In some cases it is not quite true, for instance, below the jetty
near the waterworks intake there is deeper water behind
3106 it than there is where a steamship could travel, but it is
the deep water, and in general, practically the route that a steamship would follow,—(of deep draught) in trying to find the deepest water for navigation purposes.

Q. And that varies from one side to another in accordance with the windings and meanderings of the stream, doesn't it?

A. Yes sir.

MR. WOERNER: We will offer this map in evidence.

Said map received in evidence and marked Complainant's Exhibit 44.

MR. TODD: Is this the same map that you testified to the other day?

A. It is the identical print, yes sir.

MR. TODD: I object to the introduction of the map, in regard to what the map itself indicates, on the ground that it is not a correct condition that exists in the Mississippi River today, as the map was made in 1880, and has been stated by the witness in the other examination as not being correct as of today.

THE WITNESS: That was the latest and most authentic map that is obtainable.

MR. TODD: And I object on the further ground that the red line indicating the channel is placed upon the map by the witness and there is not sufficient evidence in the record to justify that that is the channel today, as indicated by the red line.

3107 JUDGE SPRINGER: Was the red line now appearing
upon this map showing the channel of the river, put

there by you recently or was it put there by the government when this map was made, in 1880?

A. It was not put there by the government; it was put there in Mr. Whipple's office, as I understand, and I have examined it and believe it to be as near as may be the channel line of the river.

Q. You didn't state before what examination you have made for the purpose of ascertaining that. What did you make?

A. I simply compared the line with the depth of soundings indicated on each side, those soundings being government soundings.

Q. Then you base your line upon the government soundings of 1880,—1879 or 1880?

A. I am not sure of the date, but whatever date is given there is the date of the soundings on which I based that line.

Q. Then your ascertainment of the channel is based upon soundings marked upon this map at the time it was made by the government officials?

A. Yes sir.

JUDGE SPRINGER: We object to it as not showing the channel at the present time.

MR. TODD: I want to make a further objection. I object to the note that is placed on this map at the north- 3108 west corner, and signed J. L. Van Ornum, as being no part of the map.

CROSS-EXAMINATION,

By Judge Johns.

Q. Under whose direction were these samples taken?

A. Under mine.

Q. Who took the samples at Section B?

A. Well, there was a party, each doing his own part in the getting of those samples, all under my personal direction.

Q. Who were the persons taking samples at Section B?

A. I want to answer the question; I don't know quite how. There was one man letting down the sampling apparatus; there was another man ready with the thermometer; another man ready with the bottles, another man marking the tags. I was in the boat looking after everything and also supervising the location.

Q. In what kind of a boat were you?

A. I am not sure whether it was a gasoline or naphtha launch; it was a power launch.

Q. It was a steam launch, or naphtha launch?

A. Yes.

Q. Now were each of these samples at each of these sections taken from this same boat by this same party?

A. Yes sir.

3109 Q. Where were the first samples taken?

A. At Section I, near the intake.

Q. Then you proceeded up the river?

A. Yes sir.

Q. Were all these samples taken on the 11th of April?

A. None of them on the 11th. Part were taken on the 10th of April and part on the 12th (referring to notes).

Q. Take section I, for instance; what is the distance between the various stations numbered from 1 to 12?

A. Four hundred feet.

Q. What is the distance of section 1 from the Missouri shore—of Station I?

A. My recollection is, about 300 feet—I will soon see (referring to book) 300 feet from the Missouri shore.

Q. How was that distance ascertained?

A. By sextant angle taken between transit placed on shore, (which was there to indicate when the launch was on the cross line) and the intake tower.

Q. When you took samples at station 1, at Section I, for instance, was the boat anchored and stationary?

A. No sir.

Q. How many samples did you take at Station 1 in Section I?

A. Three.

Q. At what depth?

A. Six inches, ten feet and I am not positive whether the
3110 lowest was 30 feet now—the tag will show, either 30
feet or one foot above bottom.

Q. Were those samples taken from three separate stands at separate times, or from one stand arranged to hold three bottles?

A. Neither. The boat was propelled just above the section at practically the right position and allowed to slowly float down and just before reaching the section the sampling apparatus was lowered, and on reaching the section the cork was pulled and the bottle allowed to fill at one certain depth; then after the sample was poured into the bottles for further use the boat was propelled back to the same location again and the same sampling apparatus lowered to a different depth, so the samples were taken successively.

Q. And was that on each numbered station at each one of these sections?

A. Yes sir.

Q. Is this the identical map that you had in testifying the other day in regard to following the floats?

A. As far as the printed portion of it is concerned, it is.

MR. WOERNER: You don't mean it is the same map, but a similar map?

A. Yes, it is another one similar; it is not the same sheet of course.

3111 JUDGE JOHNS: But it is identically the same as to the print of it?

A. Yes sir.

Q. Will you tell me what is the direction of the flow of the current of the Mississippi River from the place on this map marked Section I to and above the line marked 38 degrees and 47 minutes, across the map?

A. The flow is in the opposite direction. It is from that line 38 degrees and 47 minutes towards section 1.

Q. What is the direction by the points of the compass?

A. In a general way, southward.

Q. Well, is it exactly south, west of south or east of south?

A. In general it is some west of south.

Q. Are these cross lines running lengthwise of this sheet exactly north and south?

A. They are supposed to be; they are intended to be.

Q. They are intended to be north and south?

A. Yes sir.

Q. What were the names of the persons engaged in this taking of samples, other than the yourself?

A. M. F. Levy, H. Schantl, E. Sessinghaus, Robert Schmidt, P. R. Goodwin, and then in some positions and at different times there were changes. The second day some of the men in some positions were not the same as on the first
3112 day. For instance, the second day there was an S. Jones.
That names, as far as I recollect, the men who were with me.

Q. And are they all residents of St. Louis?

A. Yes sir.

Q. When were these samples taken upon the first day, shipped to Mr. Whipple?

A. I was told and I left instructions for them to be shipped to Mr. Whipple the next day and was told that those instructions were carried out, on my return to the city.

Q. When were the samples, taken on the second day, shipped to Whipple?

A. They were delivered to the express company on the day after taking.

Q. Duplicate samples are here, are these bottles now in the room?

A. Yes sir.

Q. What was done with them?

A. They were stored in the chemical laboratory of Washington University.

Q. Are they now here in the room in the same conditon in which they were stored?

A. Yes sir.

Q. In whose custody and charge were they at the chemical laboratory of the City of St. Louis ?

A. Dr. Keiser's.

3113 Q. How many samples altogether, did you take?

A. Sixty-eight.

Q. And then divided each of the 68 into two samples?

A. Yes sir.

Q. At what sections were the samples first taken?

A. At section I, near the intake; then proceeding up the river to section M; these were all that could be taken that day.

Q. Is that section M across the Mississippi?

A. Yes sir.

Q. How far above the confluence of the Missouri is that?

A. Oh, about half a mile above the point of confluence.

Q. And the other sections at C and B were taken two days afterwards?

A. Yes sir.

Q. Is the place here on the left hand side of the river above the line 38 degrees 47 minutes, and to the left of the large island marked on the plat where the word "sand" is printed known as Chouteau's chute?

A. No sir, Chouteau's Slough is this, indicating on Exhibit 44, and these are called simply "the chutes," popularly, along the river.

Q. Was it at one of these places I have designated, where the word "sand" is, that you took out one of the floats and placed it back in the river, to which you testified the other day?

A. Somewhere along there. It was, I think about a 3114 half a mile to the northeast, as I recollect it.

Q. But that was to prevent the bottle from going down the chute at the left of the island, through which the line marked 38 degrees and 47 minutes runs?

A. To prevent that float—

Q. Going down that chute?

A. Yes sir.

Q. If the float had gone down that chute, it probably would never have gotten anywhere near the intake?

A. Probably not.

Q. What is the distance between the lines marked on this map as a square, one geographical mile. Has each one of these squares a reference to a square mile?

A. Yes sir. Exactly it refers to one minute of arc, which is approximately a geopraphical mile in latitude.

CROSS-EXAMINATION,

By Mr. Todd.

Q. Professor, was this map made at low or high stage of water?

A. According to the notes placed upon the sheet by the Mississippi River Commission, the stage of water was comparatively low, varying evidently from four feet above to ten feet above the low water stage.

Q. What was the stage of the Mississippi at the time you made or collected these samples?

3115 A. It was higher.

Q. How much higher?

A. I couldn't say precisely. My impression is that the stage of water was 15 and 20 feet above the low water stage. I can determine that if desired.

Q. Was the channel of the Mississippi which is indicated upon this map in red the channel of the Mississippi at the time you took the samples?

A. I could not definitely state. There was every appearance of it being approximately or fairly closely in the position shown there.

Q. What effect does high water have upon the channel of a river?

A. It changes the deepest portion if the river. The channel at high water is very often more or less different from the location of the channel at low water.

Q. How are the currents of a river affected by high water?

A. In general they are increased.

Q. As to direction?

A. They are not the same in certain places as far as direction is concerned.

Q. High water has a tendency to change the currents in a river, doesn't it?

A. It does, especially where the channel passes from one side of the river to the other. Where the channel is in
3116 concave banks, on a certain side of the river, due to that concavity, the channel at high water remains the same or practically the same, but where the channel must make a cross-

ing, that is, pass from one side to the other—from that concave bank to a concave bank on the other side—then the position or crossing of that channel is frequently more or less changed from low water to high water.

Q. Now, between sections C and I of stages of water that existed at the time this map was made, the channel is illustrated here by a red line in considerable of a curve?

A. Yes sir.

Q. At high water such as existed at the time you took these samples, would the direction of the curve correspond to the direction of the red line indicative of the channel?

A. In some points I think it would; in others probably not.

Q. Why would it in high water, follow that line of channel?

A. At a certain point here, for instance, in a concave bank, whether the river is high or low, there would be no difference essentially between the direction of the current or the position of the deepest water between the high and low water, but the point which is below section C between it and the concave bank I just described, I suspect there would be a different direction of the current and possibly a different deepest channel location at high water.

3117 Q. If the water in the Mississippi River at the point indicated upon the map nearest to 38 degrees and 48 minutes should be 18 feet above the conditions that existed at the time this map was made, wouldn't the water flow in the course of the least resistance and come down over that island?

A. There would be a portion of the water pass over the island.

Q. Wouldn't the greater portion of the water come down to the east of the channel?

A. Do you mean by channel that same red line?

Q. The same red line, if the water was up eighteen feet?

A. There would be more to the east than west of the red line in that same bend, yes.

Q. Then the red line which indicates the channel doesn't necessarily indicate the direction of the current at high stages of water, does it?

A. Not precisely, nor does it indicate an equal division or quantity on one side or the other necessarily, ever.

Q. The water flows in the course of the least resistance, doesn't it?

A. Yes sir.

Q. The higher the elevation of water the greater number of obstacles are submerged which retards its flow?

A. Yes sir.

Q. And when those obstacles are submerged the water flows right over them unimpeded?

3118 A. It flows over them, but the obstacles still have a greater or less influence.

Q. That is true, no doubt, but the water at that high stage flowing over them would not necessarily follow in the confines of this channel at the low water mark?

A. No sir.

Q. Now is there anything upon this map that indicates the direction of the currents at the stage of water that you found at the time you made your experiments?

A. Only in a general way.

Q. Is that general enough to establish a scientific fact in regard to the currents?

A. It depends upon the scientific fact that it is desired to establish.

Q. The direction of the current?

A. Certain scientific facts which depend on the direction of a current to a great extent, would be proved by the sheet as submitted. Others that require specific direction in each position (or other point in that river,) would not be established by it.

Q. Did you calculate a cross section of the river at the time you made these examinations, in order to ascertain the volume?

A. No sir.

3119 Q. And without making that calculation, is it possible to accurately determine the course of the current as affecting the great volume of water in the Mississippi at either of these points?

A. It would be possible to say the direction of the current without making a calculation for volume.

Q. As to volume?

A. Yes sir.

Q. In what way could that be ascertained, doctor, as to what direction the greater volume of the water passing down the Mississippi River, would pass a given cross-section?

A. I did not understand the question last asked to be involved in the question previous. It would be necessary to have a determination for volume by parts at each section, to determine just where the greater volume of the flow passes. The direction of the current at any point would be determined by observing floats and taking the direction of them at any point.

Q. Did you make any calculation of the rate of the current at any one of the twelve points where you took samples?

A. No sir.

Q. The rate of the current at these points would be necessary to know in order to figure the volume of water passing a given point, wouldn't it? 3120

A. Yes sir.

Q. And that you did not ascertain?

A. No sir.

Q. Does the surface current in any one place indicate the current beneath the surface or near the bottom?

A. In direction or strength?

Q. In direction?

A. They usually are practically the same; not necessarily so.

Q. At what point in the river does the current flow the most rapidly, the top or the bottom?

A. It is more rapid at the top than at the bottom.

Q. Is there any law applicable to the rate of current in water.

A. Only in a general way. Each river seems to have its own special law. There are variations between different rivers, in trying to express the relations of flow at different points, or depths.

Q. Is there any mathematical rule established that applies to the velocity of running waters between the top and bottom, other points being given?

MR. WOERNER: I object to the question on the ground that the whole field now gone into in this examination has been gone into before with this same witness by the same counsel.

3121 MR. TODD: I want to state that the line of my examination is based upon the introduction of this map, where the depth of the river has been indicated upon it, and the curve has been indicated, and it is for the purposes of ascertaining the effect of that red line upon this map that I made this examination.

THE WITNESS: There is a formula which is not necessarily constant,—of a different magnitude for different rivers. There is no formula that will apply strictly to different streams and give correct results. There is a different ratio that applies everywhere.

Q. Do you know, doctor, where the channel of the Mississippi River changes?

A. Yes sir.

Q. Do you know how often those changes take place?

A. No sir.

Q. It is a fact that in the Mississippi River the channel of today might not be the channel six months' hence, isn't it?

A. It is.

MR. JEFFRIES: I object to that as incompetent and immaterial.

MR. TODD: Do you know whether the channel indicated here by the red line on this map is the true channel of the Mississippi River today?

A. I don't know.

3122 Q. Have you any scientific knowledge on the subject?

A. Of what is the true channel today in the river?

Q. Yes?

A. No sir.

Q. All that you know about the channel of the river as pertaining to this map is gathered from the soundings indicated upon this map which appear here in small letters within the channel of the river, is it not?

A. Precisely.

Q. And as to whether or not that channel has changed from 1879 and 1880(I wish you would look at that map so as to see that I am accurate about it) you are not able to state?

A. In general, the channel as far as observation will indicate, is the same as shown there, but precisely whether it is true or not, I don't know.

Q. What do you mean by observation, doctor?

A. By riding up and down the river and noticing where the channel of the river is indicated.

Q. Is that possible, is it possible to ascertain the channel by ocular observation?

A. In a general way, it is, fairly closely.

Q. Is there any way specific enough to enable one to form an opinion?

A. An approximate opinion; not a precise opinion.

3123 Q. Well, that opinion should not be entitled to very much weight, should it?

A. It depends upon what is to be proved by it, sir.

Q. In proving the channel of the river?

A. Well, it depends upon what knowledge of that channel is desired for. For instance, if it is wanted for—

Q. Do you think then, it is sufficient to prove the channel of the river for the purposes of this case?

MR. JEFFRIES: Object to the question as argumentative.

THE WITNESS: I think (for the case that Mr. Whipple is here to follow with) it will be to show that channel shown there.

Q. If it is true, doctor, why did you refer to this map in establishing the channel and why didn't you establish the channel by occular observation for that purpose?

A. Because the soundings which are shown there are better evidence than simply ocular observation.

Q. You didn't see this river in 1889?

A. No sir. It was in 1889 when the soundings were made.

Q. You didn't see the river at that time?

A. No sir.

Q. And you have seen the river within the last two or three months?

A. Yes sir.

3124 Q. And by ocular observation you determined where the channel was?

A. By ocular observation, I say nothing indicated that the channel was noticeably different from the channel as indicated there.

Q. At the time you went up the channel did you have this map before you to observe or check up this map by ocular observation?

A. On the first trip up the river this spring, I had a map like that; not that identical sheet—

MR. WOERNER: Let him finish.

MR. TODD: I thought you had finished.

THE WITNESS: That's all.

MR. TODD: If I interrupt you doctor, on your examination indicate it. I don't intend to. When you went up the river and had the map did you make any investigation with a view to checking up the channel?

A. No, nothing instrumental.

Q. I mean ocular. We are talking about ocular observations now. I assume you got no instrumental.

A. I simply observed its direction, the swiftness of the current and the direction of it, and such general facts as that which would indicate or locate very plainly what I said,—that the channel is near the concave bank on that side and
3125 near the concave bank on this side. Now ocular observation wouldn't permit me to definitely know where that crossing occurs between parallels 38 degrees and 47 minutes and 38 degrees and 48 minutes, whether that crossing is precisely right or not or whether it might not vary a hundred feet or two hundred feet or perhaps three hundred feet from the position shown there, but as far as the channel is concerned, in the concave banks, I think there is little doubt but that anyone would know definitely that the channel was practically the same at high water as at low, and practically at the same distance from the banks as indicated.

Q. If this channel should be 700 feet east of the point indicated here in the concave banks would that serve the purpose for the channel, Professor Whipples' channel, which you indicated a few minutes ago?

A. Hardly.

Q. Were there any necessity for establishing a channel at the point indicated by this red line, in order to meet the requirments of the channel you have indicated that Professor Whipple wanted?

A. No sir, there was no necessity of establishing a channel at any points to meet any requirements. The channel was established for the purpose of interpreting, if there was any way, instead of showing certain effects upon certain results ot 3126 Mr. Whipple, and certain channel depths if such results were shown.

Q. The word "channel" of a river conveys a definite locality in regard to the river, doesn't it?

Q. It does, but it is not always used in the same sense.

Q. What is your idea, Professor, of the meaning of channel?

A. I am using channel today, as meaning entirely, the deepest portion of the cross-section.

Q. Assuming now the deepest portion of the cross-section as meaning that in reference to my question, when I use the word "channel," then the channel of the river does not depend upon any use for which that channel is to be employed, does it?

A. No sir.

Q. Now is it possible to ascertain the deepest point of a cross-section by occular demonstration?

A. No sir.

Q. And that is all the information outside of this map that you employed in order to ascertain the present channel in the Mississippi River?

A. That's all except my general knowledge of where channels are to be expected from the outlines of the banks; for instance, that the channel is closest to the concave bank almost invariably, practically invariably.

3127 Q. Is there a rule which will enable you to locate the channel in the river if you have got the equation of the curve of its banks?

A. At other points except the crossings I can locate such channel fairly closely. Not exactly.

Q. Now in this point indicated here which we will call the concave bank, is it possible if you know the equation of that curve to locate the channel?

A. Not precisely.

Q. Even approximately?

A. Approximately we could, because we know that the channel is on this side of the concave bank rather than on the opposite side of the stream, always.

Q. Doesn't that depend upon the volume of water in the stream?

A. Not to any considerable extent, not usually.

Q. Does it depend upon the rapidity of the current?

A. No sir.

Q. Did you figure out what the character of that curved bank was?

A. No sir.

Q. Do you say now, professor that the red line indicates the channel of the river at that point for the year 1903?

A. I say again that I don't know whether it does or not precisely, but I believe that it is a fairly good representation of the position of that channel as it exists now. 3128

Q. Upon what do you base that opinion, that it is a fairly good representation?

A. On the fact that as far as appearance is concerned, the general outline of the bank is the same as it was at the time that topography was taken, and upon the fact that the bank is still a concave bank. That something like the same concavity appears there and upon the fact that apparently the swiftest water is nearest to that bank, and on the fact that unless there are variations in the regimen of the river, which would probably be indicated to ocular demonstration, on the ground that no such violent change would occur as to really throw the channel noticeably different from its general location as indicated there.

Q. Did you make any observations as to the relative speed of the current at that point?

A. No instrumental observations, no sir.

Q. Could you make observations with the eye relatively?

A. Only in a very general way.

Q. Is that specific enough, or is that general observation specific enough to enable you to come to any kind of an accurate conclusion?

MR. WOERNER: Object to the question on the ground that it has been asked and answered a number of times.

3129 A. An approximate or pretty close estimate can be determined. for instance, at the stage of water that existed at the time of passing these several points of the river, there was driftwood floating in the river, and this so-called drift-wood concentrates in the channel as our river men know thoroughly and they have to look out for it when they are piloting steam ships. Further, that an indication on this point of other things of a similar character, for instance, where there is the swiftest water, and any breeze. If the breeze is up-stream at all, the waves are higher or deeper where the water is swifter. Further that the indication of this speedier current in this same concave bank and other things like that not very definite or precise, but which together give a pretty thorough impression and pretty thorough knowledge of where the deep water and swift current occur, or rather the swift current and consequently the deep water occur.

Q. Now, professor, at the St. Louis intake—will you indicate the point on this map for me please?

A. (Indicating point on map) here.

Q. How far east of the St. Louis intake is the red line indicated upon this map approximately?

A. Approximately 400 feet.

Q. Professor, at the west of the in-let tower indicated 3130 on this map, there is a dike. Does that dike project above the water?

A. No sir, only at points in extreme low water.

Q. How far was the crest of the river from the crest of the dike at the time you made or took these samples?

A. I cannot answer that exactly. My impression is that it is about 15 and 20 feet above the top of the dike.

Q. When these samples were taken and shipped, were they packed in ice?

A. No sir.

Q. Nothing was done with them except to ship them in the condition they were put in the bottles?

A. Yes sir, only to prevent breaking.

Q. That's what I mean?

A. Nothing except to prevent breakage and get them safely in Brooklyn.

RE-DIRECT-EXAMINATION, BY MR. WOERNER.

Q. What you have testified to with respect to taking the samples and the places, you know of your own knowledge by observation?

A. I do, yes sir.

Q. You were there and saw the whole thing?

3131 A. Yes sir.

Q. You also are able to say what the depth of the river was at the places indicated at these cross-sections, or rather where the current was at that place?

A. Only at such points as had a depth of less than 30 feet.

Q. Well the red line on the map corresponded so far as you are able to say with what you observed at those points?

MR. TODD: I object to the question as leading.

MR. WOERNER: As to the channel?

A. Yes sir.

Q. So far, therefore, as at the place where the red line occurs, the place where you made these cross-sections it does indicate the channel?

MR. TODD: I object to that on the ground that is is leading, and that counsel is testifying, not being under oath.

A. In the same general way that I believe it indicates the channel at other points. The length of the line was not enough to instrumentally determine those depths.

RE-CROSS-EXAMINATION, BY MR. TODD:

Q. Professor, at the time that you made the soundings did you have this map with you?

3132 A. No sir.

Q. Did you make any memoranda or note-book of the depth at which these soundings were taken?

A. Do you mean these samples?

Q. I mean the samples, yes.

A. Yes, they were all indicated on the tags on the bottles as noted in the note on the northwest corner (refering to the map)

Q. At section B in the Missouri River you took three samples, did you, across the river?

A. Yes sir.

Q. And how many samples at each place?

A. One.

Q. How deep did you take the samples at each place?

A. Ten feet.

Q. Did you take all the samples at a depth of ten feet?

A. Yes.

Q. Professor, will you explain to me if the river was 14 or 18 feet above its normal condition at the time these were taken, how you are able to state in answer to the question of Mr. Woerner that the depth of water you took corresponded to the depth indicated on this map?

MR. WOERNER: I object to the question on the ground that there was no such answer given or question asked.

3133 THE WITNESS: That is just what I was going to state.

MR. TODD: Will you explain to me what you intended to convey by your answer to the question in regard to the channel and your observations there?

A. My answer was intended to convey the idea that the same fact which led me to consider the red line as in general indicating the channel, in answer to your question, that I last gave, are the observations when we were taking these samples in the cross section.

Q. And have no reference then to the soundings indicated upon this map in regard to the locality of the channel, did it?

A. Do you mean by that the correctness of those depths as shown by my own samples?

Q. Your own soundings?

A. It had nothing to do with that.

Q. So then, as far as your soundings are concerned, or putting down the bottles for the purpose of getting the samples, that gave you no indication as to the channel by measurement, did it?

A. In point of fact it did not, because the depths (except in a few places of the river), were greater than the length of the water line.

Q. And you made no comparison between the depths of

your soundings, using the word in the sense of going down
3134 after the water to compare with the depth of soundings
indicated upon this map?

A. No sir.

CROSS-EXAMINATION BY JUDGE SPRINGER.

Q. Did I understand you to say that the object of taking these samples was for the purpose of determining the turbidity of the water at the different places where the samples were taken?

A. I believe I said so, yes; that is my recollection.

Q. Is that the only object for which they were to be used?

A. I am not positive about that. That was the main purpose?

Q. I understood that to be your statement. That is the reason why I regarded it for the special purpose and not the general analyses of the water in the river?

A. I have no definite knowledge of what use they were put to other than that. Or whether—

Q. If they were taken and should be used, for other purposes I should desire to ask some further questions of this witness, but at present I have no further questions to ask.

MR. WOERNER: That is not a part of his testimony, what was done with it.

MR. JEFFRIES: We will offer in evidence three boxes
as complainant's Exhibit No. 45, A, B, C, and to be re-
3135 ferred to hereafter as Van Ornum's Exhibits.

THE COMMISSIONER: I will mark them Complainant's Exhibit No. 45, A, B, C.

J. L. VAN ORNUM.

3136 GEORGE CHANDLER WHIPPLE,

called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Mr. Woerner and testified as follows:

Q. State your name in full?

A. George Chandler Whipple.

Q. Where do you reside?

A. In Brooklyn, New York.

Q. What is your occupation?

A. My official title is that of biologist and director of Mount Prospect Laboratory of the department of water supply, gas and electricity of the city of New York.

Q. How long have you been in that position?

A. Since 1897, except that when I began at that time I was employed by the city of Brooklyn, and since then there has been a consolidation with New York City, but the position has been practically unchanged.

Q. State what education you have had and what positions you have held with respect to science on the subject of waters and bacteriology and other scientific positions you may have held?

A. Well, I graduated from the Massachusetts Institute of Technology in 1889 in a course of civil engineering. During the summer vacation previous to my graduation I was inspector of tenement houses in the City of Boston; after graduation I was employed for several months by Mr. Desmond Fitzgerald, Superintendent of the Boston Waterworks, on some experiments upon the filtration of water through a sponge. In the fall of that year a biological laboratory was established by the Boston Water Department and I was placed in charge of that work with the title of biologist. The work of the laboratory consisted in keeping a supervision of all the sources of supply of the city of Boston, and in addition to the inspection of the sources we made microscopical examinations, physical examinations, bacteriological examinations and occasional chemical analyses of the various sources of supplies. In connection with that work I had to make tests of the sewage disposal system at South Framingham, which was located upon the watershed, also the sewage disposal system of Natick, Massachusetts. I also made frequent tests of the sand filter at Pegan Brook in Natick, Massachusetts. 3137

I also made an inspection trip which covered all of the large water supplies of Massachusetts for the purpose of comparing the waters of the City of Boston with those of the cities tested. I also made frequent trips to the Lawrence experimental station, conducted by the Massachusetts State Board of Health for

the purpose of observing their experiments. For three years an experimental filter plant was carried on near our
3138 laboratory and I had charge of all the biological examinations made in connection with these experiments. During the eight years with which I was connected with that laboratory, I made numerous experiments on the growth of microscopic organisms and upon the temperatures of large bodies of water, especially in regard to the so-called stagnation phenomenon.

In that connection I assisted in designing an instrument called the thermophone, for obtaining the temperature of water at the bottom of a reservoir. From 1893 to 1896 I also had charge of a biological laboratory under the direction of the waterworks of Lynn, Massachussets, where similar tests were made.

In 1896 I spent four months with Professor Albert R. Leeds at Hoboken, New Jersey and assisted him in studying the character of the water at Brooklyn, New York, which at that time was affected with a bad odor.

In 1897 I established the laboratory known as the Mount Prospect laboratory in connection with the Brooklyn Water Department. I had charge of its equipment and planned the work. The scope of this laboratory was extended after the annexation of Brooklyn to the City of New York, and the analyses of water which included, chemical, physical, microscopical and bacteriological tests were extended to cover the borough of Queens as well as the borough of Brooklyn. In January, the 1st of the present year, the scope of the laboratory was still
3139 further extended and now covers all of the water supplies of New York City. In connection with my work I have occasion to visit all the watersheds and keep a lookout on the presence of typhoid fever in the city and in general to watch the sanitary condition of the water supply in connection with my work. I have had to investigate a number of local epidemics of typhoid fever.

Early in the present year a commission was appointed to study the future supply of water for New York City, this Commission being known as The Commission on Additional Water Supply. All sanitary investigations involved in that problem have been placed in my hands, and we now have a temporary laboratory at Poughkeepsie, New York and at Katonah, New York. We are making a careful study of all sources of water supply that are available for the city of New York, and this includes practically all the waters of the eastern part of New York State. We are making special studies of all streams which drain into the Hudson River, as well as of the Hudson River itself. In all we have about 50 men employed in this investigation at the present time.

In connection with my regular work in the laboratory I have recently made a test of the electro zone process of purifying water and am now preparing designs for a sand filter designed to filter 15,000,000 gallons of water on the Croton water-
3140 shed.

MR. TODD: Per day?

A. 15,000,000 gallons of water per day. In connection with the work of additional supply. I am now making a test of the sand filter at Poughkeepsie, New York and am carrying on experiments of the sedimentation of water of the Hudson river at Poughkeepsie, and am studying the question of how far the sea water runs up the Hudson River under different conditions. In addition to the regular work connected with my position, I have a considerable private practice as a sanitary expert and during the past six years have examined samples of water from nearly every state east of the Mississippi River, also some from Cuba and from Egypt and from India. I have had a long series of samples from Little Falls, New Jersey, Watertown, New York, Oswego, New York, Birmingham, Alabama, from the Red River, Louisiana, from the Delaware River at Trenton, from York, Pennsylvania, from the Susquehannah River at Binghampton, New York and the Wabash at Vincennes, Indiana, and elsewhere.

I have also made a report upon the electro-lytic method of water purification for the United States War Department.

I am also consulting chemist for the water department in Binghampton, New York and have recently completed a test of a mechanical filter which filters water at the rate of 6,000,-
3141 000 per day, and have had practical charge of the operation of that filter during the past year.

I have recently investigated an epidemic of typhoid fever at Waterville, Maine, where there were more than 250 cases, and this investigation was also extended to the towns of Fairfield, Maine, Winslow, Maine, and Benton, Maine.

MR. WOERNER: What is the population of Fairfield, Maine?

A. As I recollect it, it is about 1,000, but the population of Waterville is 10,000.

I am also employed as Sanitary Expert for the Kennebec water district.

I have published some sixty or seventy scientific pamphlets on various subjects relating to water and sanitary matters and am the author of a book on the miscroscopy of drinking water.

Q. What is the full title of that book?

A. That is the full title,—the Microscopy of Drinking Water.

Q. Is your name identified with that?

A. Yes, the Microscopy of Drinking Water by George Chandler Whipple, published by John Wiley & Sons in 1899 I think it was.

Q. Let me interrupt you there a moment, professor. Without laying you open to the criticism of immodesty, I want to ask you if that book is not considered one of the most recent and best authorities on that subject?

3142 A. I have frequently seen it referred to as such, and it is used as a text-book in the Institute of Technology of Boston, but the University of Minnesota—

MR. TODD: You will admit it is such without argument.

A. Yes, I suppose so. I am also engaged in the preparation of a work on hygienic analysis and another on water supply in general.

JUDGE SPRINGER: Not published?

A. No sir, not published. I have made a good many experiments associated with the methods of water analyses and devised the so-called silica standard for the measurement of the turbidity of water which has been practically accepted by the United States Geological survey.

I also devised the scheme for tabulating the results of odor determinations which has also been generally accepted, or which was accepted by the American Public Health Association.

I am a member of the American Society of Civil Engineers and the American Chemical Society, the American Microscopical Society and the Society of American Bacteriologists, and the American Public Health Association of which I am secretary of the laboratory section, also the Society of Chemical Industry.

3143 Of the American Limnological Commission, and I am a fellow in the Royal Microscopical Society of London.

I am also secretary of the Committee on Standard Methods of Water Analyses of the American Public Health Association.

Perhaps that is enough.

MR. WOERNER: Well now professor, engaging in these various matters to which you have testified, and having kept abreast of your profession, especially in the writing of those works, were you required to study all the scientific facts and acquire all the scientific knowledge relating to diseases bred and borne along by water and the various ways of avoiding the same and in thoroughly familiarizing yourself with the various microscopical organisms in water and of matters relating to the sanitary conditions of water?

MR. TODD: I object to the question as leading?

A. Yes. The nature of my official work has required that I keep myself informed upon the matters which you mentioned.

Q. And have you done so or not?

A. Yes, to the best of my ability.

ADJOURNED until 2:00 P. M. same day May 11, 1903.

3144 Southern Hotel, St. Louis, Missouri. 2:00 P. M., Monday, May 11th, 1903. Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

GEORGE C. WHIPPLE,

Resumed the stand for further direct-examination by Mr. Woerner, and testified as follows:

Q. Professor Whipple, have you had any occasion to make microscopic examinations of samples of the waters of the Illinois, Mississippi and Missouri Rivers?

A. Yes sir.

Q. And if so, state when?

A. In October and November, 1901 I made microscopic examinations from, I think it was 136 samples taken—some from Lake Michigan, some from the Chicago Drainage Canal, some from the Illinois River, some from the tributaries of the Illinois; some from the Mississippi River above Grafton, some from the Mississippi River at Alton; some from the Missouri River at Bellefontaine; some from the Mississippi River at the chain of rocks, and at the Illinois shore opposite the chain of rocks; some from the settling basins of the St. Louis waterworks.

Q. Now from whom and how did you obtain these samples?

3145 A. I understood that these samples were taken by different collectors under the direction of Dr. Ravold, and it is my impression that he has already testified to sending these samples to me, some of them were taken by Dr. Ravold's brother, and I understand that he has testified to sending them to me. I have a list giving the names of the different samples and the name of the collector, which I can read if necessary.

Q. Well, where did you receive the samples?

A. When?

Q. Where?

A. At mount Prospect laboratory in Brooklyn.

Q. How were they sent to you?

A. They came in two-quart bottles.

Q. I mean what was the method of transportation, if you know?

A. By express.

Q. Were these bottles labeled or marked in any way?

A. Yes, they were marked so as to identify their source; they were marked with the name of the collector and the date and hour at which he collected them, the temperature of the sample was also recorded as well as the temperature of the air at the time at which the sample was taken.

Q. In what condition were these samples received by you?

A. They seemed to be in good condition for the purpose of microscopic examination. The bottles came sealed and in every case the seal was unbroken.

3146 MR. TODD: I move to strike out that part of the answer where he employs the words "good condition."

MR. WOERNER: Well, state what you mean by the term "good condition," professor?

A. Well, I mean that the bottle was unbroken, and the sample was received apparently in the condition in which it was packed.

Q. Did you make any examination of these samples?

A. Yes sir, I examined them—all of them microscopically and of some of them I determined the turbidity and color.

Q. State for what purpose you examined them?

A. I examined them microscopically in order to determine the number and character of the microscopic organisms present, and I examined some of them for turbidity in order to find the amount of suspended matter present.

Q. Now before going into the results of your examination, professor, I want to ask you what are microscopic organisms and how do they differ from bacteria?

A. Strictly speaking, all very minute organisms my be called microscopic organisms, but all water analysts have come to understand by the term "microscopic organisms" those minute forms of life which are too small to be readily identified without the use of a miscroscope, but which are large enough so that they do not need to be studied by artificial cultures as we study 3147 bacteria. For example, the microscopic organisms belong some of them, to the plant kingdom and some of them to the animal kingdom, although among these low forms of life it is somewhat difficult to draw the distinction between animals and plants.

Q. Bacteria, are they all of vegetable—are they vegetable matter?

A. Bacteria can be said to belong to the plant kingdom, or vegetable kingdom is a better term.

Q. Now, what changes, if any, would be likely to occur with respect to these organisms in the water which you received, while it was in transit?

A. Well, some of the organisms found might die out during the period of transit; others of them might possibly develop during transit, while others still would probably remain unchanged. They would not increase in number and neither would they disintegrate to such an extent as to be unrecognizable.

Q. Now, professor, can you state what the result of your examination and investigation was?

A. Well, do I understand you would like to have the detailed results?

Q. Yes.

A. I have tabulated the results of the observations and the microscopical examinations which I made, and I have with me these tables which contain the results.

3148 Q. Well, can you refresh your memory by looking at those tables?

A. (Witness refers to tables). I have here a table——

MR. JEFFRIES: Are those duplicates?

A. Duplicates, yes, sir. I have here a table which I have marked table zero, which gives the results of the microscopic examinations made from samples of water said to be collected from Lake Michigan, five of these samples being labeled as coming from the Lake View crib, three as coming from the Carter Harrison crib and two as coming from the Four Mile crib. At the top of the table is a line giving the number of the sample, and I may explain that the samples as they were received, were given a serial number, and that these numbers in this line refer to those serial numbers. Beneath the line giving the number of the sample, is a line giving the locality from which the sample was collected, and beneath that a line giving the depth in feet at which the samples were collected, and beneath that a line giving the date of collection. Then in vertical columns I have placed at the left the name of the group of organisms found in the sample. In the second vertical column are the names of the genera found, and in the succeeding columns are the numbers of those genera which were found expressed in terms of standard units of organisms per cubic centimeter. Shall I go on and explain this further?

3149 JUDGE SPRINGER: You might explain the bottom line there?

A. Near the bottom there are two lines, one giving the total microscopic organisms, which numbers are the summation of the numbers given in the vertical columns, and then the last line giving the amount of amorphous matter which represents the amount of matter without form, simply, you might say, dirt, almost. Matter which is not recognizable as an organism; also expressed in terms of standard units per cubic centimeter. And I may say that this term "standard unit per cubic centimeter" is designed to show the relative bulk of these organisms present. In some cases one standard unit corresponds with one organism. A standard unit as it is used is a unit of superficial area equal to 400 square microns, one micron being equal to 1-1000 of a millimeter. The advantage of using this unit of a standard unit instead of numbers is that the organisms differ in size and it is our intention in these analyses to express as far as possible the relative bulk of the different organisms present, in order that one may be compared with another.

MR. WOERNER: Professor, in all of the tables which you are about to testify to, you use the same standard and measure, do you not?

A. Precisely.

Q. So that this applies to all of your tables?

3150 A. Yes, sir.

Q. Now, Professor, what do the results of your investigation as appearing upon this tabulated statement to which you have referred, indicate to your mind?

A. Well, I can answer your question by giving you the general results as shown by these figures.

Q. We want the general results first.

A. The most abundant organisms present in Lake Michigan during the period covered by these examinations were synedra and tabellaria, which belong to the plant kingdom, known as the diatomyceae, or to use a shorter expression, they are known as diatomes. There were other diatomes which were constantly present, namely, asterionella,cyclotella and nitzschia, fragilaria, and a few others which were noted on most of the occasions when samples were collected, namely, melosira and stephanodiscus. Other diatomes were found occasionally. In the group known as the chlorophyceae or to use a more popular expression, the green algae, the most constant form present was dictyosphaerium, and a number of other green algae were present at times. Among the cyanophyceas the most constant form

was the coelosphaerium. I might say that the popular name for this class of cyanophyceae is blue-green algae, as distinguished from the green algae in the class previously mentioned. The microcyztis and oscillaria and aphanizomonon were present on many occasions. The protozoa, which may be in gen-
3151 eral considered as belonging to the animal kingdom—
were not as abundant as the plant forms above enumerated. The most constant form among the protozoa was dinobryon, which was present on nearly every occasion. The other forms were less numerous. The rotifera, or the rotiferas which also belong to the animal kingdom were practically absent during the period covered by the examinations. The total numbers of microscopic organisms expressed in the usual forms of standard units per cubic centimeter varied from 576 to 1656. It will be noticed by a comparison of samples Nos. 32 and 33, the first two columns—the first of which was collected at a depth of five feet at the Lake View crib, and the second at a depth of 25 feet—it will be noticed that the organisms were somewhat more abundant at the surface in the former sample than in the latter and this is in accordance with what is generally observed in lakes, that microscopic organisms of these classes are generally more abundant near the surface than at greater depths. Speaking broadly, there is a general agreement among the samples, examinations of which are recorded on this sheet, showing that during this period these organisms were fairly well distributed through the lake at the points covered by the samples.

Q. This sheet relates entirely to Lake Michigan water, does it?

A. Yes, sir.

3152 Q. That is the one marked zero?

A. Yes, sir.

Q. Now take up the next one, doctor?

A. The next sheet?

Q. Yes?

A. Shall I go ahead and describe the second sheet as I did the first?

JUDGE SPRINGER: I think you had better give each sheet a number so that you can identify them.

MR. JEFFRIES: We want you to give the general description of the sheet as you have it.

MR. WOERNER: First describe the sheet and state what it is?

A. This sheet that I now present is known as plate No. 1, and it contains the results of examinations of samples said to be collected from the Chicago Drainage Canal, the first four of which were marked Paulina Street and the last six marked Bear Trap Dam, Lockport. The general arrangement of the sheet is similar to that of sheet number zero.

Q. Well, do you want to go on and explain that now or later on?

A. Just as you wish.

Q. Well, go on and show what the sheet indicates. These sheets, I understand, were made by yourself, were they not?

A. Those sheets were personally prepared and copied 3153 from my original records. It will be seen from the results shown upon this plate No. 1, that synedra and tabellaria were constantly present in the waters in the samples, and that asterionella and cyclotella and nitzschia were likewise constantly present; also that the melosira were present on a number of occasions; that the coelospharium among the blue-green algae was present on most of the occasions, likewise certain forms of organisms not so commonly present in Lake Michigan, namely, clandothrix, which belongs to the class termed schizomycetes and fungi and monas, which belongs to the group of protozoa. Vorticella of the same group were somewhat more constantly present in these samples than in those on the first sheet. The total numbers of organisms varied from 644 to 2750 standard units per cubic centimeter. The amorphous matter was more abundant than in the samples collected from Lake Michigan.

Q. Now, that is the sheet referring to samples taken in the drainage canal, is it?

A. Yes, sir; the Chicago Drainage Canal, except that I might say that I understand that the samples at Paulina street were taken really in the Chicago River before the drainage canal begins.

Q. Yes, and the others were taken from the drainage canal itself?

A. Yes, the others were taken at the Bear Trap Dam at Lockport.

3154 Q. Now, is that all that you wish to say about that?

A. Yes, sir.

Q. Now, professor, passing down the river, what is the next station the samples of which you examined and investigated?

A. The Desplaines river at Lockport, Illinois. This is plate No. 2, and contains results of six samples said to be collected from the Desplaines river at Lockport, Illinois, above the entrance of the Chicago Drainage Canal. It will be seen from this sheet that the organisms in general were much less numerous than in Lake Michigan or in the Chicago Drainage Canal. On one occasion, namely, on November 26th, 1520 cyclotella were found, but with this exception no organisms were abundant. The total numbers of organisms varied from 24 to 126, excepting on the date mentioned, when there were 2316. I should say on that same date that asterionella were present to the extent of 680 standard units per cubic centimeter.

Q. Now, with respect to all of these sheets, professor, the number of these organisms that were found are correctly stated by the sheet although you are not reading them—

A. Yes, sir.

Q. At this time; they are correctly stated on the sheet opposite the respective names?

A. Yes, sir.

Q. What is the next point from which you examined the samples?

3155 A. Plate No. 3 contains the results of examinations from the various tributaries of the Illinois river, and these tributaries are enumerated at the top of the page in the vertical columns. There was one sample from each tributary except in the case of the Sangamon river where there were six. It will be seen that these tributaries vary considerably in the number of microscopic organisms found. For instance, the total numbers of the microscopic organisms varied from 20 to 11,296. It will be noticed that the synedra and tabellaria, which were so commonly present in the Lake Michigan water and in the water from the Chicago Drainage Canal are here only sparingly found. The cyclotella were not found in a good many samples from a good many of the tributaries, but were found in large numbers, I may say in extraordinarily large numbers in the samples from

Crane Creek, No. 110, and in large numbers, though smaller than Crane Creek, in Apple Creek and McKee Creek, and the Sangamon River and the Spoon River. There were none of the chlorophyceae present in large numbers, nor the cyanophyceae or the schizomycetes or fungi. The anthophysa, one of the protozoa was quite commonly present in the tributaries as well as the monas and the trachelomonas. Trachelocerea was present frequently in the Sangamon river and in one or two other places.

Q. Now, that is the chart refering to the samples taken from the tributaries, and numbered?

3156 A. Plate 3.

Q. Now, professor, what is the next point from which you examined samples?

A. Plate No. 4, samples received from the Illinois river three miles above Peoria. This sheet represents the results of six examinations. The most important facts to be noted are the presence of synedra and tabellaria, cyclotella, dictyesphaerium and coelosphaerium. The total numbers of organisms varied from 300 to 816 standard units per cubic centimeter.

Q. This table like the others shows the number of these organisms, respectively, of each kind, together with the dates upon which you found them?

A. Yes, sir; the dates being taken from the tags which accompanied the samples.

Q. In case no organisms of any of these particular genus appear, did you incorporate the name in the table together with the statement that there were none of such, or did you omit the name altogether?

A. I omitted the name from the table.

Q. Now, professor, passing on to the next point down the river from what point did you next examine samples?

A. From the Illinois river at Beardstown.

Q. Identify the chart for that?

A. These results being recorded on plate No. 5, and this 3157 sheet gives the results of five examinations at this point. It will be seen from this sheet that the most prominent organisms were cyclotella, synedra, tabellaria, anthrophysa and monas. The total number of microscopic organisms varied from 350 to 3376 standard units per cubic centimeter.

Q. Now, will you please pass on to the next point?

A. And this is plate No. 6, which represents the results of samples collected from the Illinois river at Grafton, Illinois, there being seven such analyses reported. It will be seen from this sheet that the most prominent organism was the cyclotella, which was constantly present, but which varied in numbers from 4 to 23,200 standard units per cubic centimeter. Synedra and tabellaria were also prominent, as was also dictyosphaerium and scenedesmus. The total numbers of organisms varied from 54 to 23,876 standard units per cubic centimeter.

Plate No. 7 represents the results of seven examinations from samples from the Mississippi river collected above Grafton.

Q. How far above Grafton—I see the prior one was at Grafton; is that right?

A. I can tell by consulting my book.

Q. Oh, this is Mississippi river above Grafton now?

A. Yes, this is Mississippi river above Grafton. Do you want me to locate it more definitely?

3158 Q. No, that will do. The distinction is that the prior chart illustrated samples taken in the Illinois river at Grafton, and this is one in the Mississippi River above Grafton.

A. The distinction being that the samples in the Illinois river were taken from the Illinois river above its junction with the Mississippi and the Mississippi samples were taken above the point where the Illinois river enters.

It will be seen from plate No. 7, that the two most prominent organisms present were melosira and cyclotella. Asterionella were also present on most of the occasions and stephanodiscus were present on all occasions. The navicula were also present in five out of seven samples; the protococcus was present in all samples but one, and in the sample collected October 23rd scenedesmus was present to the extent of 1,000 standard units per cubic centimeter. On the same date clathrocystis was present to the extent of 1800 standard units per cubic centimeter. Microcystis was present in five out of seven samples and actinoprys was present in all of the samples. Monas was present in five out of the seven samples. The total numbers of organisms varied from 2000 to 15,380 standard units per cubic centimeter.

Q. What is the next point?

A. Plate No. 8 contains the results of six samples collected from the Mississippi river at Alton, Illinois. It will be 3159 seen that melosira and cyclotella were the most prominent organisms. They were present on all occasions in comparatively large numbers. Stephanodiscus was also present on all occasions. Asterionella was present in four out of the six samples. Navicula was present in four out of the six samples; synedra was present in three out of six samples, and tabellaria in two out of the six samples. Dictyosphaerium was present in five out of the six samples and so also was protococcus, while scenedesmus was present in all of the samples. Actinophrys was present in four out of six samples, and monas was present in five out of six samples. The total numbers of organisms varied from 2560 to 12,036 standard units per cubic centimeter.

JUDGE SPRINGER: Does it state at the top of that where it was taken, at Alton, whether it was above the city or below the city? Does it state on that sheet?

A. It doesn't state on that sheet. The samples sent to me were said to be taken from the Mississippi river at Alton. I learned from Dr. Ravold that they were taken from midstream, I think, a short distance above the city. I think that Dr. Ravold has put in evidence the location of samples that he sent to me. I understand so.

MR. WOERNER: Go on to the next point?

A. Plate No. 9 shows the results of five examinations of 3160 samples collected from the Missouri River at Fort Bellefontaine. It will be seen that the organisms in the Missouri river were far less numerous than in the Mississippi river. Cyclotella was found in small numbers on two occasions. Melosira in small numbers on three occasions. Stephanodiscus on one occasion. Asterionella and tabellaria which were observed in Lake Michigan and in the samples from the Illinois river and the Mississippi river at Alton were not found at this point. Synedra were found.

MR. JEFFRIES: Were they found in the Mississippi river above Grafton?

A. Well, I think some of those that I have enumerated were, but I think perhaps not all. Synedra were found in small numbers on three occasions. Protococcus was found in four out of five samples and monas in four out of five samples. The total numbers of organisms varied from 80 to 190 standard units per cubic centimeter.

Q. MR. WOERNER: Now, what was the next point?

A. Table No. 10 represents the results of examinations of seven samples collected from the Mississippi river—

Q. From the Mississippi river?

A. From the Mississippi river at a point near the Illinois shore opposite the intake.

3161 It will be seen from this table that the most prominent organisms were the melosira and cyclotella and stephanodiscus, these organisms being present in all of the samples. Asterionella were found in four out of the seven samples; synedra were found in five out of seven samples and tabellaria in four out of the seven samples. Nitzschia in five out of the seven samples and navicula in four out of the seven samples. Dictyosphaerium was found in four out of the seven samples. Pediastrum in six out of the seven samples. Protococcus in six out of the seven samples. Scenedesmus in six out of the seven samples,—actinophrys in five out of the seven samples, and monas in five out of the seven samples —

MR. TODD: Isn't that four?

A. Monas in four out of the seven samples. I read a mark which was apparently in the number, and which is not part of the table.

MR. WOERNER: Monas should be four instead of five?

A. Yes, monas should be four. There is a little bit of a thread that looked like "1." The total number of organisms varied from 1588 to 8344 standard units per cubic centimeter.

Q. What is the next point?

A. Plate No. 11 represents the results of seven examinations of samples collected at the Intake of the waterworks at the Chain of Rocks.

3162 It will be seen from this table that the most prominent organisms were melosira, which was present on all occasions; cyclotella which was present on five out of the seven samples; stephanodiscus was present in six out of the seven samples; asterionella present in three out of the seven samples; protococcus present in five out of the seven samples and scenedesmus present in four out of the seven samples. Synedra were present in three out of the seven samples, and the total numbers of microscopic organisms varied from 310 to 1880, standard units per cubic centimeter.

Q. Now, you made no others of the Mississippi river, did you?

A. No, sir—I beg your pardon; I made two other series, shown in plates 13 and 14.

Q. But they were not in the Mississippi, were they?

A. They were in the Mississippi river, both of them, and represented cross-sections.

Q. Well, just keep the order in which you made the examinations and pass on to the next?

A. To the next serial number?

Q. Yes?

A. Table No. 12 represents the results of two examinations from samples collected in the settling basins of the St. Louis Waterworks at the Chain of Rocks.

It will be seen that cyclotella were present in both of these
samples; asterionella were present in both of the samples;
3163 tabellaria was present in one sample; stephanodiscus was
present in one sample; dictyosphaerium present in both
and protococcus present in both samples. The total number of organisms in one sample being 380 and in the other 480 standard units per cubic centimeter.

Q. Is that the last one?

A. Plate No. 13 represents the results of 12 samples collected from the Mississippi river in a cross-section just above Alton on November 12th, 1901. The result showed the presence of melosira, stephanodiscus and dictyosphaerium in all of the samples; asterionella was present in all but one; cyclotella in all but one; synedra were not present in the first five samples, but were present in the remaining seven. Tabellaria was not present in the first four. It was present in the next two. It was absent from the next two and was present in the last four.

MR. TODD: Doctor, were these samples taken at the same time right across the river?

A. I understand that the information in regard to the collection of these samples has already been put in evidence by Dr. Ravold and I understand from him that they were taken on the same day, on November 12th, at equal distances apart and that the numbers ran from 1 to 12, beginning with the Mis-

3164 souri shore and running towards the Illinois shore. That is, the left hand side of the sheet represents the Missouri shore and the right hand side of the sheet represents the Illinois shore.

The protococcus was present in all of the samples but two; scenedesmus in all of the samples but one. I may have stated that. Actinophrys was present in all of the samples but two, namely, Nos. 2 and 12. The other organisms are of lesser importance. Perhaps I need not enumerate them at all.

MR. WOERNER: But they are all given on the sheets?

A. They are all given on the sheets. I might say that the total numbers varied from 1464 in sample No. 12 to 3408 in sample No. 1.

MR. TODD: 12 is near the Illinois shore, isn't it?

A. Yes, sir; and I stated in the foot-note the fact which you asked, that the samples were taken at approximately equal distances across the river. The cross-section number, that is the number of the sample in the cross-section as distinguished in the serial number given in the first line is at the Missouri shore and cross-section No. 12, if I may be permitted the correction there, that line to 12 is at the Illinois shore.

Plate No. 14 gives the results of microscopic examinations of samples collected from the Mississippi River at a cross-section just above the Chain of Rocks, on November 10th, 1901. The arrangement of these samples in the cross-sections from 1 to 11 being the same as in the previous sheet, namely,
3165 from the Missouri shore towards the Illinois shore.

These examinations show that melosira was present in all the samples; cyclotella was present in all but one, namely, in No. 2, that is it was missing from No. 2. Stephanodiscus was present in all the samples excepting No. 1. Protococcus was present in all samples except No. 1; synedra was present in samples Nos. 1, 2, 4, 7, 9, 10 and 11. Tabellaria was present in Nos. 1, 7, 8, 10 and 11. Dictyosphaerium was present in Nos. 8 to 11, and pediastrum in Nos. 7 to 11. Scenedesmus was present in No. 4 and in Nos. 7 to 11. Actinophrys was present in samples Nos. 8 to 11. The total numbers of organisms varied from 230 in sample No. 1 to 2628 in sample No. 10.

Q. Are those all the charts which you have, or tables?

A. Yes, sir.

MR. WOERNER: We now offer these tables or charts in evidence as complainant's exhibits, they being numbered from zero to 14, being 15 charts altogether.

THE COMMISSIONER: We will mark them complainant's Exhibits No. 46, with sub-numbers 1 to 15, inclusive.

Q. MR. WOERNER: Now, professor, what is a diatome and how does it differ from other microscopic organisms?

A. A diatome is a unicellular plant and perhaps its most important difference from other unicellular plants is the
3166 fact that its cell wall is so impregnated with silica that
it is practically an indestructible thing. That is, a diatome might be described as a little plant cell made of glass. The living matter lies within this silicious cell and after the death of the cell the walls of the cell remain just as they appear during life. In fact, they may be considered as fossil remains of a plant, and there are in existence today geological deposits which are composed almost entirely of diatomacious cells.

Q. Are they considered more hardy and more likely to survive the voyage from Lake Michigan down the various water courses, to the intake at St. Louis, than the other microscopic organisms or not?

A. Yes, sir; these cells being indestructible, or practically so, could be identified after a long passage through a river, and this cell wall being a strong protection to the cell offers more favorable resistance than many of the microscopic plants, such for example, as the blue-green algae or the green algae even.

Q. Where are these diatomes most likely to be found?

A. Diatomes are likely to be found in almost any kind of fresh water, but there are thousands of species of diatomes, and the particular diatomes with which we are concerned in those examinations, namely, asterionella, synedra, melosira, cyclotella, stephanodiscus and the others mentioned, are
3167 more commonly found in ponds and lakes and such bodies
of water, than they are elsewhere.

Q. Then you think they would not be found to any extent in the waters of running streams unless they came from elsewhere?

MR. TODD: I object to the question as being leading.

A. These organisms just enumerated, or these diatomes just enumerated are not as likely to be found in the waters of running streams, unless these streams are fed from lakes or ponds, or similar bodies of water.

Q. MR. WOERNER: Would they or would they not be found in running streams such as we find between Lake Michigan and the City of St. Louis, unless they came from other sources?

MR. TODD: I object to the question on the ground that it is leading.

A. Experience has shown that these organisms would not be likely to be found in the streams tributary to the Illinois River, except in so far as these streams are fed by lakes or ponds.

MR. TODD: I move to strike out the answer for the reason that what experience shows is not competent and that the answer is not responsive to the question.

MR. WOERNER: Professor, from your examination of these waters and the diatomes found in them by yourself, to what do you attribute their presence in the Illinois and the Mississippi rivers and the drainage canal?

3168 MR. TODD: What waters do you have reference to, Mr. Woerner?

MR. WOERNER: The waters I have reference to are the waters of the drainage canal, the Desplaines river, the Illinois river and the Mississippi river and also of Lake Michigan.

JUDGE SPRINGER: Mississippi river, at what point? There are four or five points that you have for the Mississippi above Grafton and at Chain of Rocks?

MR. JEFFRIES: At all points.

JUDGE SPRINGER: At all points.

MR. WOERNER: Well, I have asked him the question. Let him answer.

A. It is my opinion that the diatomes in the Illinois river above the point where it enters the Mississippi river at Grafton, came partly from Lake Michigan and partly from the tributaries of the Illinois river; that the waters of the Mississippi river from the various points below Grafton came partly from the upper Mississippi, from Lake Michigan and from the tributaries of the Illinois river. My answer being understood as to refer to the diatomes as a class, and without reference to particular genera or species.

Q. Are you able or not to say from your examinations and your knowledge upon this subject, whether any particular species of these diatomes or micro-organisms came from Lake Michigan, or not?

3169 A. There were certain diatomes found during my examinations which appeared to be characteristic of Lake Michigan and Lake Michigan alone. I would like to change that. Lake Michigan and nowhere else, excepting the streams below, to which the water from Lake Michigan had access.

Q. Can you say whether or not any of these micro-organisms which were peculiar to Lake Michigan, were found in the Mississippi river at the Intake and if so, state which ones they were and how they got there?

A. There was an organism which I will describe as synedra pulchella variety sub prolongata, which was found at the Intake of the waterworks at the Chain of Rocks, and which was found also in the water of Lake Michigan, but was not found in the water of the Missouri river, or the water of the upper Mississippi river, or in any of the tributaries of the Illinois river unless we consider the Chicago Drainage Canal as being a tributary.

Q. What do you mean by upper Mississippi river—beginning at what point?

A. When I use the term "upper Mississippi" in that last sentence I refer to that portion of the Mississippi river above the point where the Illinois river enters it at Grafton.

Q. Now, professor, have you tabulated the results of your examinations to show the average numbers of diatomes at the various places where you collected the samples? 3170

A. Yes, but I have not two copies of that. I have simply the copy which represents the results of my original figures which I can read.

Q. Yes, just read them.

A. (Witness refers to table.)

Q. Now, state what this table is and read it so that it will get into the record.

A. This table represents the averages of all the examinations made at each point to be enumerated, and for the entire period covered by the observations. The figures given being averages across the sheets horizontally—of the plates—of the sheets already presented in evidence in so far as they relate to the diatomes, or to the most important diatomes.

Q. Well, read that so it will get into the record as testimony.

A. I will read first this column of the list of samples and then read them out serially—the numbers of the samples—

Q. Whichever way you think is the most lucid.

A. Well, I will read the first column, which gives the location of the samples, and which corresponds to the titles of the sheets already presented. This is Lake Michigan, the first line; the second line is drainage canal at Lockport, and the third is the Desplaines river at Lockport; the next is all the
3171 tributaries of the Illinois River averaged together, the
Illinois river above Peoria; Illinois river at Beardstown, Illinois River at Grafton; Mississippi river above Grafton; Mississippi river at Alton; Missouri river at Bellefontaine, the Mississippi river near the Illinois shore opposite the Chain of Rocks, the Intake of the St. Louis Waterworks, and the settling basin of the St. Louis Waterworks. The table is as follows:

	Synedra........	Tabellaria........	Melosira........	Cyclotella........	Asterionella....	Stephanodiscus.
0. Lake Michigan...........	577	236	13	38	25	8
1. Dr. Canal—Lockport	270	236	13	30	22	2
2. Desplaines—Lockport ...	2	2	1	264	113	9
3. All tributaries Ill. R.....	17	3	2	709	13	1
4. Ill. R. above Peoria......	126	62	8	48	10	3
5. Ill. R. at Beardstown....	95	19	0	784	31	0
6. Ill. R. at Grafton........	90	46	8	4468	41	3
7. Miss. R. Grafton........	1	0-	2400-	1372	569	307
8. Miss. R. at Alton........	19	16	1741	2534	124	174
9. Mo. River	5	0	22	16	0	6
10. Miss., Ill. shore	51	21	1380	1957	396	192
11. Intake	16	0	403	443	40	93
12. Settling Basin	0	12	0	256	68	10

3172 MR. JEFFRIES: Now I wish you would state in general terms, professor, what that table shows?

A. It contains the average results of the number of most important diatomes present at the various places between Lake Michigan and the settling basin of the St. Louis waterworks where samples were collected.

Q. It gives the location of the samples?

A. It gives the location of the samples and the average numbers of the most important diatomes for each of these locations throughout the entire period covered by this investigation.

Q. Does it give the names of the diatomes?

A. It gives the names of the diatomes and the average number of each for each place.

Q. What significant features do you notice in connection with this table and the respective diatomes, if any?

A. I notice that certain diatomes are especially characteristic of certain waters. In all cases these are not necessarily found only in these waters, but that they are in point of numbers—

Q. Now state what they are and why you think it is significant?

A. Well, take first the synedra. The average number of synedra found in Lake Michigan, was 577 standard units 3173 per cubic centimeter. The average number of synedra found in the Illinois River at Grafton was 90. When I say 90 I mean in every case standard units per cubic centimeter. The average number found in the Mississippi River above Grafton was 1; the average number found in the Missouri River at Bellefontaine was 5; the average number found in the intake of the St. Louis waterworks was 16; the average number found in the Mississippi River at the Illinois shore opposite the chain of rocks, was 51; while there were none found in the settling basin of the waterworks.

Q. Now what conclusion do you draw from that?

A. I should draw this conclusion, that the 16 synedra which were found in the intake of the St. Louis waterworks, came not from the Missouri River, nor from the Mississippi River at a point above Grafton, but rather from the Illinois River at Grafton, and if we consider that there were 577 synedra in Lake Michigan, with only an average of 17 per cubic centimeter in all the tributaries of the Illinois River, I should conclude that the chances were that the 16 organisms found at the intake of the St. Louis waterworks, or most of them, came from Lake Michigan.

Q. Now with respect to some of these other diatomes, did you notice anything of consequence with reference to them?

A. That is considered tabellaria; there were 236 tabellaria per cubic centimeter on an average, in the water of Lake Michigan.

3174 Well now, the average in the tributaries of the Illinois was about 3.

The average in the Illinois River at Grafton was 46. There were none found in the Mississippi River just above Grafton.

There were none found in the Missouri River.

There were 21 found in the Mississippi River near the Illinois shore opposite the chain of rocks.

There were none found in the intake of the waterworks but there were 12 found in the settling basin of the St. Louis waterworks.

Q. Now what conclusion would you draw from that?

A. This conclusion, that in all probability the tabellaria found in the settling basin of the St. Louis waterworks, and at a point in the Mississippi River near the Illinois shore, came not from the Missouri River or from the Mississippi River at a point above Grafton, but from Lake Michigan by means of the Illinois River and not from any of the tributaries of the Illinois.

Q. Did you make any other comparative tables from the samples of those different classes of diatomes?

A. I have more on the same table that I haven't explained.

Q. Go ahead.

A. Let us consider the melosira, which is an organism.

3175 The average number of melosira was 13 at Lake Michigan, 2 in the tributaries of the Illinois River, 8 in the Illinois River at Grafton, 24 in the Mississippi River above Grafton; 22 in the Missouri River at Bellefontaine; 1380 in the Mississippi River near the Illinois shore at chain of rocks, and 403 in the intake of the St. Louis waterworks at the chain of rocks.

Q. Any others?

A. Shall I go on as I did in the other organisms?

Q. Yes, go through all of those.

A. The conclusion from these figures being that for the most part the melosira found at the intake of the St. Louis waterworks and at the Mississippi River near the Illinois shore were derived not from the Illinois River or from Lake Michigan or from any of the tributaries of the Illinois, but rather from the Mississippi River above Grafton.

Q. Go right down the line with all those long names?

A. Now consider the cyclotella; there were 38 in Lake Michigan. 700 on an average in the tributaries of the Illinois River, 4468 in the Illinois River at Grafton.

1372 in the Mississippi River above Grafton,

16 in the Missouri River at Bellefontaine,

1957 near the Illinois shore opposite chain of rocks,

443 at the Intake of the waterworks of St. Louis at the chain of rocks.

3176 The conclusion being that these cyclotella found at the intake of the St. Louis Waterworks at the chain of rocks, came for the most part, not from the Missouri River, but from the Mississippi River and the Illinois River, and only to a slight extent from Lake Michigan. The cyclotella found in the Illinois River at Grafton being derived not from Lake Michigan, but from one or more of the tributaries.

Q. Do you mean the cyclotella?

A. Yes, of the Illinois River. Now consider the asterionella. There were 25 in Lake Michigan,

There were 13 on an average in the tributaries of the Illinois River.

There were 41 on an average in the Illinois River at Grafton.

There were 569 in the Mississippi River above Grafton;

There were none in the Missouri River;

There were 396 in the Illinois shore, opposite the chain of rocks.

There were 40 at the intake of the St. Louis waterworks at the chain of rocks.

The conclusion being that for the most part the asterionella found at the intake of the St. Louis waterworks and at the Missouri shore or at the Illinois shore opposite the chain of rocks were derived not at all from the Missouri River, but chiefly from the Mississippi River above Grafton, but in
3177 part from the Illinois River and its tributaries and Lake Michigan.

Now the stephanodiscus. It was found to the extent of 8 per cubic centimeter in Lake Michigan and the average of 1 in the tributaries of the Illinois River;

3 in the Illinois River at Grafton,

307 in the Mississippi River above Grafton.

6 in the Missouri River at Bellefontaine,

192 in the Mississippi River at the Illinois shore opposite the chain of rocks,

93 in the intake of the St. Louis waterworks.

From which I conclude that of the stephanodiscus—of that the majority of the stephanodiscus found at the intake of the St. Louis waterworks, and at the Illinois shore opposite the chain of rocks, were derived not so much from the Missouri River or the Illinois River, as from the Mississippi River above Grafton.

Q. Now professor, do the synedra found in the tributaries of the Illinois differ from those found in Lake Michigan? If so, how do they differ?

A. The synedra found in Lake Michigan belong to the species pulchella and variety sub prolongata, while the synedra found in the tributaries of the Illinois River were either the synedra lonslotta, or the synedra pulchella variety curta.

3178 Q. Are they easily distinguishable?

A. The synedra pulchella are very easily distinguishable from the snyedra lonslotta, because of the different shape, while the synedra pulchella, variety sub prolongata differ from the synedra pulchella variety curta in their size; the subprolongata being in round numbers, twice as large as the variety curta. All three of these forms of synedra are very easily distinguishable under the powers of the microscope used in the examination.

Q. Would this enable you to distinguish which came from Lake Michigan and which came from other sources when they were taken from the waters at the Intake?

A. Yes sir.

Q. And you did so?

A. Yes sir.

Q. Now those that were taken from the intake, did you find the species that you say was found in Lake Michigan only; I mean that originates in Lake Michigan only?

A. I found both. I found the synedra pulchella variety sub prolongata at the intake of the St. Louis waterworks; I think on November 12th if I recollect the date correctly.

Q. To what did you attribute their origin, that is, where they originally came from?

A. So far as all of my examinations show, I should say that they came from Lake Michigan.

3179 Q. Did you make a chart of the comparative number of these different diatomes in various sections?

A. I made charts of those which were most prominent; I did not of all.

Q. Have you those charts with you?

A. Yes sir.

Q. You made those charts from your own examinations, did you?

A. Yes sir.

Q. Now these charts depict graphically the results of your investigations, do they?

A. Yes sir.

Q. I wish you would explain the various charts beginning nearest to Lake Michigan, or in Lake Michigan as the case may be; explain what the charts are and what they indicate and what your numbers say and what you mean to illustrate by them?

A. I present first this diagram No. 1, which gives the results of the determinations of synedra pulchella, per cubic centimeter, at the various places between Lake Michigan and the intake of the St. Louis waterworks at the chain of rocks.

The upper section of the chart shows the number of synedra pulchella at different days in Lake Michigan, The second section of the chart shows the number at the Chicago Drainage Canal at Lockport.

The next section shows the number in the Illinois River above Peoria.

3180 The next section shows the number in the Illinois River at Beardstown.

The next section shows the number in the Illinois River at Grafton.

The next section shows the number in the Mississippi River at Alton.

The next section shows the number in the Mississippi River opposite the chain of rocks,

While the last one shows the number in the Mississippi River at the intake of the St. Louis waterworks.

It would be noticed that I did not include in this diagram the numbers in the Mississippi River above Grafton, or the numbers in the Missouri River at Bellefontaine, for the reason that in the first case the numbers do not exceed 8 per cubic centimeter, or in the second case 10 per cubic centimeter, numbers which would be so low that it would be scarcely seen upon the scale used.

This diagram shows in a general way the decrease of the synedra pulchella between Lake Michigan and the Intake of the waterworks at St. Louis, at chain of rocks.

Q. That is chart No. 1?

A. Yes sir, that is chart No. 1.

Q. What does the next chart or diagram show?

A. The next diagram is known as diagram No. 2, and is
3181 drawn by the same plan as the preceding, and shows the numbers of tabellaria fanistrata at the points enumerated on the different sections.

The first section or upper section shows the number in Lake Michigan.

The second section shows the number in the Chicago Drainage Canal at Lockport,

The next section in the Illinois River above Peoria,

The next section in the Illinois River at Beardstown, and the next section in the Illinois River at Grafton, the next section in the Illinois River at Alton, the next section in the Mississippi River, Illinois shore, at chain of rocks,

and the next section at the intake of the St. Louis waterworks where there was none,

and the next in the settling basin at the chain of Rocks.

During this *period there is noted at the top* of this diagram—I state that during this period no tabellaria fanistrata was found in the Mississippi River above Grafton, or in the Missouri River at Bellefontaine.

This diagram shows in a general way the decrease in the number of tabellaria fanistrata between Lake Mich-
3182 igan and the settling basin at the chain of rocks.

Q. What is that line drawn down the center of the chart?

A. That serves to separate the month of October from the month of November. The vertical line drawn down the center of the diagram serves to separate the observations made during the month of October, from those made during the month of November. The observations which were made by me beginning on October 15th and continuing from that through November.

The next diagram, being diagram No. 3, shows the number of standard units of microscopic organisms actually discharged with the pollution by the various towns between Lake Michigan and noted at the bottom of the diagram, and states that the organisms included in the above are:

Cladothrix,
Beggiatoa,
Anthrophysa,
Bussasia,
Ciliata,
Euglena,
Monas,
Trachelomonas,
Vorticella,
Trachelocerea,
Paramacium,
Pleuromona,

3183 These are arranged to show the numbers of the organisms mentioned in the preceding list that I had covered by examinations. The observations during October being to the left of the central line and those for November being to the right.

The upper section shows the number found in Lake Michigan; the next section those found in the Chicago drainage canal at Lockport;

The next section shows those found in the Illinois river above Peoria.

The next section shows those found in the Illinois River at Beardstown.

The next section shows those found in the Illinois River at Grafton.

The next section shows those found in the Mississippi River just above Grafton.

The next section shows those found in the Mississippi River at Alton.

The next section shows those found in the Missouri River at Bellefontaine.

The next section shows those found in the Mississippi River at the Illinois shore opposite the chain of rocks,

the next section those in the intake of the St. Louis waterworks.

This diagram shows that the organisms were very few
3184 in Lake Michigan, and that they were quite numerous in
the Chicago drainage Canal and the Illinois River and that they were entirely absent from the Mississippi River above Grafton, and from the Missouri River at Bellefontaine, and that they were found in the Illinois River or rather in the Mississippi River at the Illinois shore opposite the chain of rocks and at the intake of the St. Louis waterworks.

The next diagram shows the number of melosira granulata at various points in the Mississippi River.

The upper section showing the number in the Mississippi River above Grafton;

The next section showing the number in the Mississippi River at Alton,

The next section showing the number in the Mississippi River, Illinois shore, opposite chain of rocks, and the next section showing the number in the intake of the St. Louis waterworks at the chain of rocks.

And the note at the bottom states that during this period the number of melosira granulata in the Illinois River at Grafton did not exceed 24 per cubic centimeter, standard units, and in the Missouri River at Bellefontaine, they did not exceed 60 per cubic centimeter, the quantity being so low they would scarcely appear on this sheet.

3185 The results indicate that during the period covered by the investigation there was a gradual decrease in the number in the Mississippi river at Grafton, and that this decrease was also noted at Alton in the Mississippi River and at the Illinois shore opposite the chain of rocks, and also at the intake of the waterworks at the chain of rocks.

The next number is diagram No. 5 and shows the number of cyclotella operculata at various points in the Mississippi River and at the Illinois River at Grafton.

The upper section shows the number in the Mississippi River above Grafton;

The next section in the Illinois River at Grafton;

The next section in the Mississippi River at Alton;

The next section in the Mississippi River, Illinois shore, opposite chain of rocks;

And the last section in the Mississippi River at the intake of the St. Louis waterworks,

And the note states that during this period the cyclotella operculata did not exceed 60 per cubic centimeter in the Missouri River at Bellefontaine, but the results indicate that during the latter part of November there was an enormous increase in the cyclotella operculata in the Illinois River at Grafton, the numbers being so great it could not be shown upon the scale of this diagram; and that this increase was also
3186 noted at Alton, at the Illinois shore, chain of rocks, and at the intake of the St. Louis waterworks.

The next diagram, No. 6 shows the results of the examinations made of samples collected at twelve points in the cross-section across the Mississippi River above Alton.

It shows the results of the microscopic organisms and it also shows the results of certain turbidity and color observations which I have not yet put in the testimony.

The upper line shows the turbidity of the water at the different stations expressed in terms of the silica standard.

MR. TODD: I suggest in order that these charts may be more intelligible, that there has been no evidence introduced as the Professor says, in regard to some of them.

MR. WOERNER: I will ask him about that as soon as he gets through.

THE WITNESS: (Answer continued) The second section shows the color of the water at the different stations expressed in terms of the platinum cobalt standard.

The next section shows the number of microscopic organisms characteristic of the Mississippi River, indicated by lines of different character, the full line referring to the total organisms; the melosira being expressed by the dash line, the cyclotella by the dotted line, and the stephanodiscus by
3187 the dot-dash line.

The last section on the sheet shows the microscopic organisms characteristic of Lake Michigan. The synedra expressed by the full line and the tabellaria expressed by the dash-line.

The results show that the turbidity was fairly constant across the stream, but that it was lower on the eastern shore than on the western.

Q. What is the number of that chart?

A. No. 6.

JUDGE SPRINGER: Lower on the Illinois shore?

A. Yes. These diagrams being based just as the tables were, with the numbers of the Missouri shore on the left of the diagram, and the numbers of the Illinois shore on the right of the diagram.

3188 Q. Explain what turbidity means?

A. The turbidity of the water means its opacity to light, or its opacity or opposition to the passage of the rays of light and is a measure of the suspended matter present. Observations of turbidity are frequently made instead of determinations of suspended matter because of the much greater convenience of the method.

The diagram shows that there was in general a gradual decrease of color from the Missouri shore towards the Illinois shore, and that the color was particularly low near the Illinois shore. The diagram also shows that the melosira, which as has previously been offered in testimony, were especially characteristic of the waters of the Mississippi River above Grafton,—decrease generally from the Missouri shore towards the Illinois shore, while the cyclotella, which were found in both the Illinois River and the Mississippi River, but were more abundant in the Mississippi River at the time when the cross section was made, were fairly constant across the river excepting near the Illinois shore, while the stephanodiscus were nearly uniform across the stream, but showed a slight tendency to decrease towards the Illinois shore.

The synedra, which were charactertistic of Lake Michigan, were not present in samples 1 to 5, and were most abundant in sample 7; while tabellaria, which also was especially characteristic of Lake Michigan, were not found in 3189 samples 1 to 4, or in samples 7 and 8, but were found in the other samples.

This last diagram is No. 7 and it shows the results of the observations of the samples taken in the cross section of the Mississippi River about one mile above the chain of rocks and it shows the turbidity of the water at each station; the color at each station and there is a line showing the comparative abundance of melosira, cyclotella and stephanodiscus organisms which at that time were especially characteristic of the Mississippi River above Grafton, and a line showing the synedra and tabellaria organisms which at that time were especially characteristic of Lake Michigan. These samples were collected on November 10th, 1901. These are the turbidity observations shown on this diagram and indicate a progressive decrease from the Missouri shore towards the Illinois shore, while the color progressively increases from the Missouri shore towards the Illinois shore. The lines at the bottom of the diagram show the progressive increase in the melosira, cyclotella and stephanodiscus, speaking in a general way, from the Missouri shore towards the Illinois shore, while the same is practically true of the synedra, an organism especially characteristic of Lake Michigan. The tabellaria, which was characteristic of Lake Michigan, was not found west of station 7. It will be noticed however, that

all of these organisms which were characteristic of Mis-
3190 sissippi river water, were found at station 1, and that the synedra, which was characteristic of the water of Lake Michigan, was also found at stations 1, 2, 3 and 4.

MR. WOERNER: We offer the diagrams in evidence as exhibits to the testimony of Professor Whipple, as Complainant's Exhibit No. 47—sub-numbers 1 to 7 inclusive. So marked by the Commissioner.

MR. WOERNER: Professor, in regard to the tests of color, you made them yourself?

A. I made those tests personally.

Q. And the result was as you have stated, and as indicated on the diagram from which you have given this testimony?

A. Yes sir.

Q. I will ask you, professor, whether you are able to form an opinion from your examinations and the results thereof, as depicted on these diagrams, as to the relative amount of water that enters the intake—as to the relative amount of water coming from the Illinois and the Missouri Rivers—I will ask you first whether the relative amounts of waters from these streams are capable of being determined from these data?

A. Yes sir, I think that they are.

Q. Did you make any calculations in that respect?

A. Yes sir, I made calculations from the table of averages which has been submitted, and I made those determinations from this table of averages.

3191 MR. JEFFRIES: Averages of what?

A. Averages of the relative numbers of melosira, cyclotella, asterionella and stephanodiscus present in the intake of the St. Louis waterworks, in the Missouri River at Bellefontaine, and in the Mississippi River at Alton.

Q. And the Illinois River at any point?

A. As I understood his question it referred to the proportion of Mississippi River water and Missouri River water.

MR. WOERNER: By the Mississippi, you mean the waters of the Mississippi and also those that enter from the Illinois?

A. Yes sir.

Q. You include that in the Mississippi, do you?

A. Yes sir.

Q. State in a general way what you did, and what the results of your calculations were?

A. I assume for the purpose of this calculation, that the samples which were collected at the Missouri River at Bellefontaine, represented the character of the water in the Missouri River, and that the samples which were collected in the Mississippi River at Alton represented the character of the Mississippi River just above the point, or above the point where the Missouri River enters the Mississippi, and I compared the average results of these various organisms enumerated, with the average results of similar organisms found in the water at the intake of St. Louis waterworks.

3192 Q. Now, one moment; are you for the present leaving out of consideration the turbidity of the water, or is that entering into your calculations

A. In this calculation I am considering only the average results of the melosira, the cyclotella and the asterionella, and the stephanodiscus, which were found in the places mentioned.

Q. Now what were your conclusions?

A. I concluded that on an average 32 per cent of the water which entered the Intake of the St. Louis waterworks was considered as Mississippi River water, and that 68 per cent of the water was Missouri River water.

Q. Is that result arrived at by calculation or by guess work?

A. By mathematical calculation.

JUDGE SPRINGER: As to what?

A. By mathematical calculation based on the relative abundance of the four organisms enumerated in the Missouri River, in the Mississippi River at Alton, and at the intake of the St. Louis waterworks.

MR. WOERNER: Did you make any calculations of the relative percentages of the waters of these two streams based on the turbidity and color of the water?

A. I did, but I have not my figures at hand at this mom-ment. I can put that in.

3193 Q. Now, Professor, what tests did you make with respect to the turbidity and color of the water in the respective streams?

A. I made turbidity observations and observations of color in the samples taken from the two cross sections, one at Alton just above Alton, and the other one mile above the chain of rocks.

Q. What was your purpose in doing that?

A. *To find the relative turbidity of the water across the* stream at the different points, and the relative color across the stream at the different points.

JUDGE SPRINGER: When was this, November, 1901?

A. Yes, the first section was taken on November 10th, and the second November 12.

MR. WOERNER: Well, what results did you obtain?

A. I can read these results from the original records which I have here and with your permission I will read them as to columns. If we consider first the section across the Mississippi river above Alton taken on November 12, we have the following list of turbidity expressed in terms of silica standard:

No. of Sample.	Turbidity.	Color.
1.	18	34
2.	14	32
3.	14	33
4.	12	33
5.	13	29
6.	15	25
7.	15	25
8.	14	26
9.	16	24
10.	11	23
11.	12	23
12.	12	21

3194

That is all of that section.

Q. At what point is that?

A. At a point one mile above Alton.

JUDGE SPRINGER: What is your explanation of these figures as to turbidity and color?

A. When I say that the turbidity of a sample is 18, it means that that sample is just as turbid as it would be if it contained 18 parts per million of what we call the silica standard, or 18 parts per million of finely divided silica, which is prepared according to a definite formula.

Q. Passing from technicalities, what is the common explanation of this turbidity?

A. The turbidity?

Q. Yes, passing from your technical terms, what do you say it is?

A. I have already stated in the record that the turbidity is the opaqueness of the water, as you hold it to the light.

3195 Q. The relative opaqueness then would be arrived at by what?

A. The relative opaqueness would be arrived at by the turbidity, and the higher the number the greater the turbidity, or the greater the opaqueness.

Q. What are the limits of your numbers?

MR. WOERNER: What the judge means is what do you take as a standard?

A. The unit of turbidity, or water which contains one part in a million of this silica standard.

MR. WOERNER: So you mean parts per million?

A. When I say it is 18 it is equivalent in turbidity to a solution prepared by adding 18 parts of turbidity.

JUDGE SPRINGER: Per million?

A. Per million, by weight.

JUDGE SPRINGER: How about color; how do you explain that?

A. The color is measured by comparing the sample of water after removing the suspended matter, with arbitrary standards, which are varied in color by the addition of different amounts of platinic chloride, and when I say that the color of the water is 34, it means that the color is as dark as an artificial solution which contains 34 parts per million of this platinum salt.

Judge SPRINGER: The lower the numbers the brighter they become?

3196 A. The higher the number the more colored the water is.

Q. What is your unit?

A. The unit being one part in a million of this platinum salt.

MR. WOERNER: Now this sample was taken at what point?

A. I have given you one cross section; I have not given you the second.

Q. Where is this cross-section?

A. The one that I have read is one mile above Alton. The second cross section was taken one mile above the chain of rocks and consisted of eleven samples numbered from 1 to 11, from the Misouri shore to the Illinois shore, and I will read the turbidity and color just as before:

No. of sample	Turbidity.	Color.
1.	2200	18
2.	1700	19
3.	1560	18
4.	1140	22
5.	800	24
6.	430	26
7.	190	29
8.	140	34
9.	110	37
10.	35	43
11.	18	48

3197 MR. WOERNER: Now Professor, I want to ask you when these samples were taken and from whom you received these?

A. The samples of this cross-section just mentiond were collected on November 10th.

Q. What year?

A. Of 1901, by Dr. Ravold's brother, Edward, I think his name is. I have it marked "Ed."

G. C. WHIPPLE.

ADJOURNED until Tuesday, May 12th, 1903, at 10:00 A. M. Southern Hotel, St. Louis.

Southern Hotel, St. Louis, Missouri.

3198 10:00 A. M., Tuesday, May 12, 1903.

Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

GEORGE CHANDLER WHIPPLE,

Resumed the stand for futher

DIRECT-EXAMINATION,

By Mr. Jeffries.

Q. Mr. Whipple, state whether you received some samples of water from Professor Van Ornum during the month of March, 1903?

A. Not during the month of March.

Q. Month of April?

A. But during the month of April I did.

Q. Now state where you receiver those samples and how you received them?

A. They were received at my laboratory in Brooklyn, some on April 14th, and some on April 16th.

Q. Do you know how many samples you received?

A. I received sixty-eight.

Q. Who did you receive them from?

A. From Professor Van Ornum.

3199 Q. Do you know what they were?

A. They were marked in the following method, or a method which Professor Van Ornum has already mentioned in his testimony. Shall I give the method again?

Q. Yes, give the method again.

A. I received eight samples with tags upon which there was a capital "M." This capital M was followed by a serial number from 1 to 8, and this number was followed in each case by the small letter "b." I also received—

Q. Now what did they represent?

A. I received a letter from Professor Van Ornum in which he stated that the capital letter M referred to a cross-section about one-quarter of a mile above the mouth of the Missouri River, across the Mississippi River, and that the serial numbers from 1 to 8 represented stations in that cross section, beginning with the Missouri shore and running across to the Illinois shore, and stating further that the samples were spaced 200 feet apart, and also that the letter "b" meant that the sample was collected at a depth of 10 feet below the surface. Upon each tag there were also figures indicating the temperature of the water in degrees Fahrenheit.

Q. Now did you receive any other samples?

A. On the same date I received other samples marked with a capital letter I, and with serial numbers running from 1 to 12. These serial numbers being followed by small letters,
3200 either a, b or c, and the tag also included the temperature of the water. In three instances, namely, the samples marked with the serial numbers, 10, 11 and 12, bottles were received which bore the small letters b and c, and in Professor Van Orum's letter he stated that at that station the water was not over ten feet deep and consequently the b sample also represented the bottom as nearly as possible.

JUDGE JOHNS: You didn't give us the number, Professor, of I.

A. The number of the samples?

Q. Yes?

A. I thought I did,—from 1 to 12.

Q. No, but the number of bottles?

A. Thirty-three.

Q. Marked "I"?

A. 33 bottles marked "I."

Q. MR. JEFFRIES: Now that was a cross section of what?

A. According to the letter which I received from Professor Van Ornum, the capital letter "I" referred to a cross section of the Mississippi River above the intake of the water works at the chain of rocks. The serial numbers from 1 to 12 represented the stations across the river from the Missouri shore towards the Illinois shore,—the samples of the stations being 400 feet apart.

The small letter "a" meant that the sample was taken
3201 at the surface or near the surface.

The small letter "b" indicated that the sample was collected at a depth of 10 feet, and the small letter "c" that the sample was collected at or near the bottom of the stream.

Q. Now is that all the samples you received?

A. That was all that I received on April 14th.

Q. Now when did you receive the next?

A. On April 16th, I received three samples which were marked with the capital letter B and which had serial numbers from 1 to 3. In each case the serial number was followed by the small letter "b" and in each case was recorded the temperature of the water.

The letter which I received from Professor Van Ornum stated that series B, or that the samples marked with a capital letter B represented a cross section of the Missouri River just above its mouth. Serial number 1 being near the south shore; number 2 being in mid-stream and number 3 being near the north shore.

I also received 24 samples which were marked with a capital letter C, and which were followed by numerals from 1 to 8, or serial numbers from 1 to 8, and which had after the serial numbers, small letters, either, a, b or c. The tags also bore the temperature of the water.

Q. Now what did the a, b and c represent?

A. The small letter "a," according to Professor Van Ornum's letter, represented a sample of water at or just below the surface of the stream. Small "b" represented the water at a depth of ten feet; small "c" represented the water at the bottom, but at stations 1, 2, 3, 4, 5 and 7, the small letter "c" was folowed by the figures 30 feet, and according to Professor Van Ornum's letter these "c" samples which were followed by the figures 30 feet, were taken not at the bottom, but at a depth of 30 feet and I understand that the reason for this was that the cord attached to the sampling apparatus did not permit of his collecting samples at a depth greater than 30 feet. 3202

I understand from his letter that the samples which were marked with a capital C were collected across the Mississippi River below the point where the Missouri River enters it, and that the serial numbers run from 1 near the Missouri shore, to 8 near the Illinois shore, and that the stations were 200 feet apart. In his letter he further stated that sample No. 1 was taken at a distance of about 800 feet from the Missouri shore.

Q. Now that cross section was taken where?

A. Across the Mississippi River below the point where the Missouri River enters.

Q. Now you made an examination of those samples, did you?

A. I examined all of these samples for turbidity.

Q. What was the character of bottle that they came in, and state whether or not the water was properly bottled to 3203 make an examination for turbidity?

A. The samples were received in glass bottles, which held approximately one quart, and the bottles had cork stoppers. The bottles were nearly full in every case, and there was sufficient water in each to make the determination for turbidity.

Q. Now you made that determination?

A. Yes sir.

Q. Have you the results of the determination?

A. Yes sir.

Q. Will you give them?

A. I can call them off, I think easier.

Q. Now in calling them off, state the particular cross section to which the explanation applies?

A. The first list will give the results in cross section M which was in the Mississippi River just above the mouth of the Missouri River, the exact location having been testified to by Professor Van Ornum. Sample marked M 1 b, the M being a capital letter, the "b" being a small letter, had a turbidity of 127.

Q. Now in ascertaining the turbidity of those samples, you used the same unit or standard of measure as testified to yesterday with reference to obtaining the turbidity of the water?

A. Yes sir.

3204 MR. WOERNER: When you say one hundred and twenty-seven do you mean one hundred and twenty-seven or one and twenty-seven hundredths?

A. One hundred and twenty-seven.

JUDGE SPRINGER: Parts per million?

A. And when I say 127 I mean that the water was as turbid as it would be if it contained 127 parts per million by weight of the specially prepared silica used in measuring turbidity according to this method.

MR. JEFFRIES: And that silica is what?

A. The silica is prepared from diatomacious earth and is carefully washed and ground before used for preparing the standards.

Q. Now then, go ahead and give your results?

A. To repeat: Sample M 1 b had a turbidity of 127—

Q. Now then, what end of the cross section was that on or which side of the river?

A. On the Missouri side.

Sample M 2 b, turbidity 152,
Sample M 3 b, turbidity 147,
Sample M 4 b, turbidity 135,
Sample M 5 b, turbidity 175,
Sample M 6 b, turbidity 100,
3205 Sample M 7 b, turbidity 100,
Sample M 8 b, turbidity 80.

Q. Now those samples, according to that explanation were taken at ten feet beneath the surface of the water?

A. Yes sir. Will you have the next one?

Q. Yes?

A. The next series were section B, which was taken across the Missouri River, the serial numbers running from the south shore to the north shore:

Sample B 1 b, had a turbidity of 1400,
Sample B 2 b, had a turbidity of 1540,
Sample B 3 b, had a turbidity of 1540.

That is all in that section.

JUDGE SPRINGER: Where is that section?

A. That is across the Missouri River just above its mouth.

The next section is series C, which represents a cross section of the Mississippi River below the point where the Missouri River enters.

Sample C 1 a had a turbidity of 1680,
Sample C 1 b had a turbidity of 1480,
Sample C 1 c 30 feet, had a turbidity of 1500.
Sample C 2 a had a turbidity of 1280,
Sample C 2 b had a turbidity of 1520,
Sample C 2 c 30 feet had a turbidity of 1420,
3206 Sample C 3 a had a turbidity of 800,

Sample C 3 b had a turbidity of 700,
Sample C 3 c 30 feet had a turbidity of 760,
Sample C 4 a had a turbidity of 690,
Sample C 4 b had a turbidity of 720,
Sample C 4 c, 30 feet had a turbidity of 740,
Sample C 5 a had a turbidity of 720,
Sample C 5 b had a turbidity of 730,
Sample C 5 c, 30 feet, had a turbidity of 780,
Sample C 6 a had a turbidity of 420,
Sample C 6 b had a turbidity of 550,
Sample C 6 c had a turbidity of 560,
Sample C 7 a had a turbidity of 315,
Sample C 7 b had a turbidity of 270,
Sample C 7 c, 30 feet, had a turbidity of 290,
Sample C 8 a had a turbidity of 245,
Sample C 8 b had a turbidity of 240,
Sample C 8 c had a turbidity of 240,

That is all of that series.

The next series is series I, which represents a cross section of the Mississippi River above the intake of the St. Louis waterworks.

Sample I 1 a had a turbidity of 1500,
Sample I 1 b had a turbidity of 1200,
Sample I 1 c had a turbidity of 1120,
3207 Sample I 2 a had a turbidity of 1020,
Sample I 2 b had a turbidity of 1160,
Sample I 2 c had a turbidity of 1120,
Sample I 3 a had a turbidity of 750,
Sample I 3 b had a turbidity of 720,
Sample I 3 c had a turbidity of 880,
Sample I 4 a had a turbidity of 250,
Sample I 4 b had a turbidity of 160,
Sample I 4 c had a turbidity of 380,
Sample I 5 a had a turbidity of 158,
Sample I 5 b had a turbidity of 157,
Sample I 5 c had a turbidity of 142,
Sample I 6 a had a turbidity of 95,
Sample I 6 b had a turbidity of 110,

Sample I 6 c had a turbidity of 100,
Sample I 7 a had a turbidity of 95,
Sample I 7 b had a turbidity of 95,
Sample I 7 c had a turbidity of 100,
Sample I 8 a had a turbidity of 100,
Sample I 8 b had a turbidity of 100,
Sample I 8 c had a turbidity of 110,
Sample I 9 a had turbidity of 85,
Sample I 9 b had a turbidity of 100,
Sample I 9 c had a turbidity of 105,
3208 Sample I 10 a had a turbidity of 100,

Sample I 10 b-c—both letters being on the tag,—had a turbidity of 110.

Sample I 11 a had a turbidity of 100,
Sample I 11 b-c had a turbidity of 97,
Sample I 12 a had a turbidity of 95,
Sample I 12 b-c had a turbidity of 90.

That is all of that.

MR. JEFFRIES: From what shore of the Mississippi River do these cross sections commence, as far as the numbers are concerned?

A. The cross-sections in the Mississippi River begin nearest the Misouri shore and run across towards the Illinois shore.

Q. From 1?

A. From 1 serially up to the highest number.

Q. Can you examine some of the bottles contained in complainant's Exhibit 45, and state in detail the character of your observations with reference to the turbidity of this water?

A. Do you want me to exhibit each sample?

Q. I don't know as it is necessary to exhibit each sample, but enough of them to get in this record a practical demonstration of it.

A. (Witness exhibits 12 bottles of water from Complainant's Exhibit 45).

3209 Q. Now what have you before you, Professor?

A. I see twelve samples, marked with the capital letter I, all with the small letter "b" and with serial numbers running from 1 to 12, excepting that the last three samples have the b-c.

Q. Now they were taken from complainant's Exhibit 45 were they?

A. Yes sir.

Q. Now the letters, numbers and the figures represent respectively the location, depth and temperature of the water from which the samples were taken, do they not?

A. The capital letter represents the location of the section, the serial numbers the station in that section beginning with the Missouri shore and running towards the Illinois shore, and the small letter representing the depth—the letter "b" representing the depth of 10 feet and the other figures the temperature.

Q. Is the temperature regular or irregular on all of the samples, comparatively speaking?

A. It is comparatively regular between slight limits.

Q. Now then explain in detail from these bottles of water the manner of your observation, with the view to obtaining the turbidity of the water?

A. Do you mean you want to know how I obtained the turbidity?

Q. Yes?

3210 A. We have in the laboratory an instrument known as the turbidimeter,—it consists of a tube of glass which is placed inside of a metal tube, and both of which are placed over a standard candle. It is so arranged that one can look down vertically through the tube and see the candle, and in the operation of measuring the turbidity, the apparatus is carried into a dark room in order to prevent the influence of daylight. With the glass tube held over the candle, the sample, after thoroughly shaking, is poured into the glass tube until the flame of the candle ceases to be visible. The tube is graduated in figures which represent the turbidity according to the silica standard, and this graduation is made by first calibrating the tube, using the standard preparation of silica. When the calibration has been made the figures on the tube are permanent, and the work is done once for all. For instance, if we pour into the tube some of our silica standard which contains 100 parts per million of silica, we will find that the candle flame will disappear at a certain point. This point is marked on the tube as 100. If later on a sample of water is poured into the tube and the flame of the candle disappears at this mark, we say that this sample also has a turbidity of 100. That is the method used in making these observations.

Q. Now I notice in comparing sample 1 with serial number 12 a difference in the coloring of the contents of the bottles. Explain the difference in the turbidity of those waters, without reference to the percentage of turbidity or anything of that kind? 3211

A. When you say that you observe a difference in the coloring appearance I assume that you mean a difference in the color as viewed by the eye, but I would like to offer a word of explanation, that when we speak of the color of water technically we refer not to the suspended matter present, but rather to the stain which the water has, and which is due to substances in solution. Therefore, the apparent color as you use the term or as I understand that you use the term, refers to turbidity and not to the true color as I used the term yesterday in my testimony.

Q. What I wanted to know was for you to explain the comparative difference between the two samples from the standpoint of coloration as viewed by the naked eye, in the ordinary acceptation of the term,—color, without reference to the science of chemistry or any other scientific examination of water?

A. Sample No. 1 is very much more turbid than sample No. 12.

GENERAL HAMLIN: As I understand your question, Mr. Jeffries, you want to know what causes that?

MR. JEFFRIES: Well, I am going to get to that.

Q. Now then, what causes this obvious difference between the coloring of the two waters, as viewed by the naked eye, speaking from the standpoint of a layman? 3212

A. Well, the presence of matter in suspension.

Q. Now does the coloring of which we now speak have anything to do with the color and odor of water from a sanitary scientific standpoint?

A. The turbidities in all of these samples are so great that the true color, using the term in its technical sense, could not be observed. There is no necessary relation between the turbidity of these samples and any odor which you might have of sanitary significanse.

Q. Now while we have these samples before us, I will ask you to explain so as to get it into the record, and state whether or not this degree of turbidity commencing on the Missouri shore, decreases continuously as you approach the Illinois shore, as viewed by the naked eye—from an occular observation?

A. Comparing these samples as they stand before me, it is evident that there is a rather sudden decrease in the turbidity of the water from the Missouri shore towards the Illinois shore in the first four or five bottles, and that from there on, towards the Illinois shore the difference in turbidity are comparatively small.

GENERAL HAMLIN: Is the first station 200 feet from the Missouri shore?

3213 A. I am unable to state exactly, but if I recall, Professor Van Ornum introduced evidence yesterday upon that point.

MR. WOERNER: Yes, he gave all those distances.

THE WITNESS: My recollection is that the first sample was taken about 150 feet from the Missouri shore and that succeeding samples were taken at intervals of 400 feet in this cross-section.

MR. JEFFRIES: It would make no particular difference though, as to the exact location, so that they were taken at regular intervals clear across the stream commencing at a certain point on the Missouri shore and crossing to a certain point on the Illinois shore?

A. It undoubtedly makes a difference where the samples were collected in a cross section.

Q. But a difference as to the particular point of beginning, so that it was on the Missouri shore?

A. If it was reasonably near the Missouri shore, from a general standpoint, the difference would be slight.

Q. Mr. Whipple, I will ask you if you have prepared diagrams showing graphically these cross sections of the rivers, 3217 A. the next diagram which I have here represents the results of turbidity observations made at section C, which was a section across the Mississippi River at a point about one mile below the mouth of the Missouri River. This diagram is drawn in a similar manner to the preceding. The figures at the left of the diagram indicating turbidities according to the silica standard. The figures at the foot of the vertical columns representing stations in the cross section, station No. 1 being toward the Missouri shore and station No. 8 toward the Illinois shore. Station No. 1 itself being approximately 800 feet from the Missouri shore and the other stations being about 200 feet apart, the exact locations having been given in the testimony already by Professor Van Ornum.

Q. Now the numbers in the left hand margin represent the same thing that is represented by the same numbers or by like numbers on the exhibit which has been introduced?

A. The same as in the table already introduced, yes sir.

MR. JEFFRIES: Now we offer in evidence this diagram showing the cross sections of the Mississippi River at a point about one mile below the mouth of the Missouri River known as cross-section C, and to be known as complainant's Exhibit 49.

Q. Now you have the third diagram which you prepared from this water which was furnished you?

A. Yes sir.

Q. Now describe this third diagram?

3218 A. This diagram which I hold in my hand represents the results of turbidity observations made at Section M, being a cross section of the Mississippi River at a point about a quarter of a mile above the mouth of the Missouri River. The diagram is constructed as the previous two diagrams. The figures at the left of the diagram representing the turbidity according to the silica standard, the figures at the foot of the vertical column representing the stations in the cross-section, No. 1 being toward the Missouri shore, No. 8 being toward the Illinois shore, and the stations being about 200 feet apart. The exact locations of the stations having already been placed in evidence by Professor Van Ornum.

MR. JEFFRIES: Now we offer in evidence this diagram showing the cross-sections of the Mississippi River at a point a quarter of a mile above the mouth of the Missouri River, giving the turbidity of the water, to be known as complainant's Exhibit No. 50. G. C. WHIPPLE.

ADJOURNED until 2:00 P. M. same day, Tuesday, May 12th, 1903.

3219 Southern Hotel, St. Louis, Missouri. 2:00 P. M., Tuesday, May 12th, 1903. Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

MR. TODD: As to the necessity of further evidence identifying these water analyses charts, as testified to by Professor Teichmann and Messrs. Miller and Goetz and other witnesses, we will waive the necessity for any further identification of the same and will consider whether we will require the same to be admitted in evidence or not at some future time. The charts shall be subject to use by either party and will be in the custody of the Commissioner.

MR. JEFFRIES: We offer for identification the charts of water analyses referred to by witnesses Tichmann, Miller, Goetz and others, containing 117 pages, to be known as complainant's Exhibit 1 for identification.

CARL UNGAR,

Called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Mr. Woerner, and testified as follows:

Q. State your name?

A. Carl Ungar.

3220 Q. Where do you reside?

A. St. Louis, Missouri.

Q. What is your business?

A. Attorney at law.

Q. Mr. Ungar, have you had occassion to make any investigations as to the typhoid statistics of any towns in the Illinois River valley lately?

A. I did.

Q. State when and what towns?

A. I left St. Louis by the instruction of the City Law Department,—on or about—the date is not very essential is it, Mr. Woerner?

Q. Not at all.

A. On or about April 7th I visited the following cities and towns.

Q. Now Mr. Unger, suppose you take them up seriatim?

A. Just as I traveled and give each town?

Q. Yes?

A. At the first place I visited was Springfield, Illinois. Do you wish to know the result there?

Q. Yes.

A. The records at Springfield were in very poor shape; I could only get three years, 1900, 1901 and 1903. My instructions were to get—

3221 Q. State what you did; never mind instructions?

A. I found that in 1900, according to the report of the Health Commissioner of the City of Springfield, there were 20 deaths form typhoid fever in that year. In 1901 there were ten; in 1902 there were 8; in 1903 there were 11, for those three months of 1903, for the first three months of the year 1903.

From Springfield I went to Bloomington. In Bloomington I found complete reports. Here is a tabulated statement; shall I read this off This I took by months first and then tabulated this for the benefit of Dr. Fuller, so that he could have them in comprehensive shape.

Q. Do I understand that you tabulated the deaths from typhoid?

A. I took the fatal cases of typhoid fever on the books of the city of Bloomington.

Q. From the official records?

A. Yes, from the official records.

Q. Give us the result of your investigations by months, and the totals by years.

A. In 1893 there were 12 deaths from typhoid fever,

1894	14
1895	15
1896	9
1897	10
1898	10

3222 In the year 1899 there were 9 deaths from typhoid fever.
1900 15
1901 9
1902 15

Q. Now Mr. Ungar, these deaths by the year, you tabulated also according to the months, did you?

A. I did.

Q. And does this paper correctly represent that tabulation?

A. It is a correct copy from their books.

Q. Of the deaths for each month?

A. Of each month. I might state here, with your permission, I was in doubt about the typhoid malaria, some are registered as typhoid malaria, and there were others disguised as ulceration of the bowels, etc., so that by taking a few typhoid malaria, they balanced, of those that were disguised. That is as near as anybody could by leaving out some and putting in others.

Q. Just give us a skeleton of what you did. This table represents the result of your investigation?

A. I went through ten years of reports.

Q. Does this table represent the result of your investigation?

A. I have so stated. Yes.

The table referred to by the witness is as follows:

3223

	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
Jany	2	1	0	0	0	2	0	1	2	2
Feby	0	0	2	0	0	1	1	1	1	0
Mch	1	2	3	1	0	1	0	0	1	1
April	1	0	1	1	0	0	0	4	0	0
May	0	0	0	0	0	0	0	0	0	0
June	0	1	0	0	1	0	1	0	0	1
July	0	1	1	0	0	1	0	1	0	2
Aug	0	1	1	2	4	2	1	3	0	0
Sept	2	1	0	0	3	1	2	1	0	1
Oct	3	3	3	3	0	0	0	2	3	1
Nov	1	3	4	0	1	1	1	2	2	3
Dec	2	1	0	2	1	1	3	0	0	4
Totals .	12	14	15	9	10	10	9	15	9	15

3224 Q. What was the next town you went to Mr. Ungar?

A. The next one was Peoria. Do you want me to make another statement except what you ask me?

Q. No sir.

A. I made some memoranda for Dr. Fuller as to the source of water.

Q. What was the town?

A. Peoria, 1893, there were 16 deaths, and in 40 or 45 cases no diseases were reported during that year.

Q. You mean the cause of the death was not given in the records?

A. Yes, and in 1894 there were ten deaths, and in 77 cases during the year 1894 no diseases was reported.

Q. You mean no cause of death was given?

A. Yes sir. In 1895 there were 36 deaths and in nine cases during the year no cause of death was reported, and in

1896 there were	13 deaths,
1897	18
1898	18
1899	12
1900	23
1901	15
1902	18

That's all I have got for Peoria, Illinois.

Q. Now what was the next town you went to?

3225 A. I will take them as I get hold of them here. The next one I have here is the city of Ottawa, Illinois:

in 1893 there were	2 deaths,
1994	5
1895	2
1896	2
1897	4
1898	4
1899	3
1900	3
1901	5
1902	2

Q. Now in this town as in the others, you also tabulated the deaths by months?

A. By months, yes sir.

Q. And these deaths appear by months as indicated on the sheet that you have in your hand?

A. Yes sir.

The paper referred to by witness, is as follows:

3226 Deaths from typhoid in City of Ottawa, Illinois.

	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
Jany	0	1	1	0	0	2	0	0	0	0
Feby	0	1	0	0	1	1	0	0	0	0
Mch	0	0	0	1	1	0	0	0	0	0
April	0	0	0	0	0	0	0	0	0	0
May	0	1	0	0	0	0	0	0	0	1
June	0	0	0	0	1	1	0	0	0	0
July	0	0	0	0	0	0	0	0	1	0
Aug	0	1	0	0	0	0	1	0	0	0
Sept	0	1	0	0	1	0	0	1	0	1
Oct.	1	0	1	0	0	0	1	2	1	0
Nov	0	0	0	0	0	0	1	0	3	0
Dec	1	0	0	1	0	0	0	0	0	0
Totals .	2	5	2	2	4	4	3	3	5	2

HOWARD W. FARNSWORTH,
City Clerk.

3227 Q. What is the next town?

A. We have Decatur, Illinois. These I copied from the books of Mr. Pennywell, as City Clerk. Here is the official letterhead:

In 1893 there were 5 deaths,
1894 7
1895 2
1896 no record.
1897 2
1898 5
1899 7
1900 11
1901 5
1902 4

Q. You also tabulated these deaths monthly?

A. Yes, monthly, from the books.

Q. And that appears also as per that sheet?

A. Yes, sir.

Paper referred to by witness is as follows:

3228 Decatur, Illinois.

	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
Jan'y ...	1	0	0	...	0	2	0	0	0	0
Feb'y ...	0	2	0	...	0	0	0	0	0	0
M'ch ...	1	1	0	...	0	0	1	2	0	0
Ap'l	0	0	0	...	0	0	0	0	0	1
May	0	0	0	...	0	0	1	0	0	0
June	0	0	0	...	0	0	0	0	0	0
July	0	0	0	...	0	1	0	0	0	0
Aug.	1	2	0	...	0	1	1	1	2	1
Sept. ...	0	0	0	...	0	1	3	3	0	0
Oct.	1	1	0	...	0	0	0	1	0	0
Nov.	1	1	2	...	1	0	1	1	3	1
Dec.	0	0	0	...	1	0	0	3	0	1
Totals.	5	7	2	...	2	5	7	11	5	4

No record for 1896.

3229 Q. What is the next town?

A. Joliet, Illinois. In 1893 there were 12 deaths,

1894	14
1895	15
1896	12
1897	12
1898	15
1899	5
1900	13
1901	13
1902	21

Q. Did you also tabulate those deaths monthly, as per that sheet?

A. I took them monthly as per this sheet. There is a note on this paper: "Population. Water supply obtained through wells. No water pumped direct from the river."

Paper referred to is as follows:

3230 Deaths from typhoid fever, Joliet, Ill., April 22, 1903.

	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
Jan'y ...	0	2	1	2	0	1	2	0	2	1
Feb'y ...	0	0	0	0	0	2	0	0	0	4
M'ch ...	0	0	2	0	1	0	0	0	3	1
Ap'l	1	0	4	0	0	0	0	1	0	0
May	2	1	0	0	0	1	0	0	0	1
June ...	0	0	0	0	0	1	1	1	0	1
July	2	0	0	0	0	0	0	0	0	2
Aug.	0	0	0	2	1	1	1	1	1	3
Sept. ...	3	6	0	4	1	1	0	2	6	1
Oct.	1	4	3	1	4	5	0	3	0	1
Nov.	3	1	3	2	3	2	0	0	1	2
Dec.	0	0	2	1	2	1	1	5	0	4
Totals.	12	14	15	12	12	15	5	13	13	21

REMARKS:

Population, 1900, 29,353,
1890, 23,264,

Water supply obtained through wells, no water pumped direct from river (Des Plaines).

3231 Q. What was the next town?

A. Pekin, Illinois. I found the reports very incomplete. Dr. Millman gave me all the help he could. 1900 is the first one I have got. In 1900 there were two deaths; in 1901 there was one death and in 1902 two deaths. It has a population of 8,400. The records for 1902 are in very bad shape. In 1902 the total number of deaths was 102, from all causes. I put that down as a comparative statement. Here I have Elgin, Illinois. In 1893 there were eight deaths, in 1894 there were 3 deaths, and in 1895 there were 5 deaths, and in 1896 there were 14 deaths. In 1897, during this year, not one case of typhoid fever was reported. In 1898 there were four deaths and in 1899 there were five death; in 1900 there were 15 deaths and in 1901, 15, and in 1902, 8 deaths.

Q. You also tabulated those for Pekin, Illinois, monthly, according to the sheet you have?

A. Yes, sir.

The paper referring to Pekin, Illinois, is as follows:

3232 Pekin, Illinois.

1903.

Jan. 0
Feb. 0
M'ch. 0
1902—total 2 deaths,
1901—total 1 death,
1900—total 2 deaths.
1902 total number of deaths 102.
Population: 1900—8420
1890—6347

Records up to 1902 in very bad shape.

Q. You also tabulated those for Elgin monthly, according to the sheet you have?

A. Yes, but in this case I had to go through a pile of stubs they had, and I bought the young lady a box of candy for helping me.

The paper referred to is as follows:

3233 Elgin, Illinois.

	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
Jan'y ...	1	1	0	0	0	0	0	0	0	2
Feb'y ..	0	0	0	5	0	0	0	1	0	2
M'ch ...	0	0	0	2	0	0	0	0	1	0
Ap'l	3	0	1	2	0	1	0	1	1	1
May	0	0	0	0	0	0	0	2	0	0
June ...	0	1	0	0	0	0	0	0	0	0
July	1	0	0	2	0	0	0	0	1	0
Aug.	1	0	0	0	0	0	3	1	2	1
Sept. ...	0	0	1	2	0	0	0	5	5	0
Oct.	0	1	2	1	0	3	1	3	2	1
Nov.	2	0	0	0	0	0	1	2	1	0
Dec.	0	0	1	0	0	0	0	[illegible]	2	1
Totals.	8	3	5	14	0	4	5	15	15	8

During 1897 not *one* case of typhoid fever reported.

3234 Q. Give us the next town?

A. Aurora, Illinois. They hadn't any records worth speaking of, but the Health Commissioner, McDonald, furnished me the following information from his records:

In 1893 there were 6 deaths,
" 1894 " 12 "
" 1895 " 19 "
" 1896 " 10 "
" 1897 " 5 "
" 1898 " 10 "
" 1899 " 4 "
" 1900 " 17 "
" 1901 " 11 "
" 1902 " 7 "

In the year 1895, there were 105 cases of typhoid fever reported, of which 19 were fatal. He explained to me the reason, if you gentlemen want to know. This is not tabulated by months except in a few instances. I couldn't get it.

I had a report from Havana, Illinois. I couldn't get them tabulated by the month; I took what I could get by the year:

In 1893 there were 3 deaths,
" 1894 " 7 "
" 1895 " 2 "
" 1896 " 5 "
Then there is no report until
In 1901 there was 1 death,
" 1902 " were 2 "

Q. Any other towns?

A. I am expecting a report from Jacksonville, where I
found the courthouse closed when I was there. I sent
3235 the county clerk his fee for writing it up for me, but it
has not arrived. That's all I have got.

Q. Now, Mr. Ungar, can you tell us what the water supply is of these respective towns?

A. Some of those I cannot give you very explicitly, because I sent the maps to the doctor at New York. I don't see it here.

(Question withdrawn.)

Q. Did you make these examinations of the records yourself, Mr. Ungar?

A. Invariably, with the exception of Ottawa, where I didn't find the clerk in, but he certified to it.

Q. Where is that certification?

A. Here (referring to the Ottawa paper.)

Q. In every other case you made the examination yourself?

A. Yes, sir.

Q. When you say it is certified, what do you mean?

A. Signed by the clerk and sent to me by the clerk. I went to LaSalle, but I don't see any report here.

Q. Now, Mr. Ungar, so far as the other towns are concerned, you examined the records yourself?

A. Yes, sir.

Q. You say that the result of your investigations as to LaSalle appears as per the sheet which you sent to George W. Fuller in New York?

A. Yes, Jacksonville and LaSalle are the two reports which are missing yet.

3236 JUDGE SPRINGER: We are perfectly willing that Jacksonville and LaSalle should be put into the record at this point without recalling the witness; the same as if he had testified to them.

MR. WOERNER: Mr. Ungar, are you able to state the population of these towns according to the census?

A. I thought I had the book, the Health Commissioner's report. That's where I got them. I can state them approximately.

CROSS-EXAMINATION, by Judge Johns.

Q. Did you make up some statistics from typhoid fever, typhoid malaria and typhus fever at Bloomington and strike an average?

A. There was one place; I think it was Elgin, where I noticed they had ulceration of the bowels, malignant ulceration of the bowels, etc., and I asked a doctor about it. There were some months where there were suspiciously few typhoid fever cases. Of course this was hearsay evidence I am giving you now, but you asked for it.

Q. I asked you if you made up in these tables from Bloomington some cases of typhoid fever which do not appear on the records in Bloomington, as typhoid fever?

A. No, sir; but I took some typhoid malaria, and a few, one or two, which were marked typhoid malaria, being in doubt whether the were typhoid or not.

Q. And you added them in as typhoid deaths?

3237 A. Yes, sir; typhoid malaria. I found two cases of intestinal ulceration. You see in the whole year 1897 there wasn't a single report.

Q. Did you add those two cases in as typhoid fever?

A. No, sir, but I made a memorandum here if you notice.

Q. Well, in what town did you add in some cases which were not reported as typhoid fever, among the number of deaths, and how many did you add in?

A. I was in doubt in several towns whether typhoid malaria was typhoid fever.

Q. Well, when you were in doubt as to whether it was a death from typhoid fever or not, what did you do with the case?

A. I left them out; I didn't report them.

MR. JEFFRIES: For instance, you took all the cases of typhoid malaria?

A. No, I didn't take all of them. I might have taken in a town one or two before I got to thinking about it. Wherever I saw typhoid I put it down. Where I was writing I had to write them very quickly. I couldn't stay very long, and when I saw tphoid, I put it down, but in some of the other towns I scrutinized it closely and I found that perhaps during the year, one, two or three were typhoid malaria, and when my attention was called to it I left them out. I want to qualify that statement I made before. In the city of Elgin, where I made the little memorandum there. It says "Intestinal ulceration." I asked one of the doctors if that couldn't possibly be typhoid. He said it might be disguised typhoid. In one whole year there wasn't a single case reported. That's the reason I investigated that closer than anything else.

CARL UNGAR.

Adjourned until 10:00 a. m., following day, May 13, 1903.

3238 Southern Hotel, St. Louis, Missouri. 10:00 a. m., Wednesday, May 13, 1903.

Parties met pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

WILLIAM H. GETZ,

Re-called for further examination in behalf of the complainant, testified as follows:

DIRECT EXAMINATION, By Mr. Jeffries.

Q. What is your full name?

A. William H. Getz.

Q. You have been sworn in this case before, have you Mr. Getz?

A. I have.

Q. I will ask you to look at these several sheets of paper and state what they are.

A. This is a table of percentages of the Missouri and Mississippi river water at the intake of the St. Louis waterworks. These calculations are based upon the daily estimation of total solids in samples collected at Bellefontaine, the intake and at Hartford, covering a period from January 23rd to October 11, 1900.

3239 Q. Who prepared them?

A. Those were prepared by Mr. Miller and myself.

Q. Personally?

A. Yes sir.

Q. From what did you prepare them?

A. These were prepared from the daily estimations of the total solids in the water from the samples at those three points.

Q. And from the tabulated sheets which were identified by you and Mr. Miller during your former examination?

A. Yes sir, these figures were taken from those sheets.

Q. Now what do those tables show?

GENERAL HAMLIN: That is objected to. Are these the Teichmann tables?

MR. JEFFRIES: Yes sir.

GENERAL HAMLIN: And they have not been introduced?

MR. JEFFRIES: It is for you people to say whether they are to be introduced in evidence, they have been identified and offered as complainant's Exhibit 1 for identification.

GENERAL HAMLIN: All right.

Q. MR. JEFFRIES: What do they show?

A. Well, from these results of the total solids we figured the percentage of water from each river which entered the intake for every day during this period.

Q. Now I will ask you to state the column on the sheets which shows the percentage of the respective waters that
3240 enter the intake?

MR. TODD: Does that show the Missouri and Mississippi?

MR. JEFFRIES: Yes sir.

MR. TODD: It is confined to those two rivers?

MR. JEFFRIES: Yes.

THE WITNESS: Take these columns in order on the sheet—

Q. What does the first column represent?

A. The first column gives the date on which the sample was collected.

Q. What does the second column represent?

A. The second column gives the total solids in the sample collected at Fort Bellefontaine on each day.

Q. On the respective days?

A. Yes sir.

Q. And the third column?

A. Gives the same results for the intake.

Q. What do you mean by the intake?

A. Of the samples taken at the intake tower of the St. Louis waterworks.

Q. And the fourth column?

A. Is of the Mississippi river at Hartford.

Q. And the fifth column?

A. The fifth column is merely a combination of the first and third and gives the difference between the total solids at Bellefontaine and at Hartford.

3241 Q. Now what does the sixth column mean?

A. The sixth column gives the difference between the total solids at the intake and at Hartford. These were used for figuring the percentages.

Q. Now what does the seventh column represent?

A. The seventh column is the percentage of Missouri river water at the intake on that day—on each particular day.

And the eighth column is the percentage of Mississippi river water at the intake.

Q. What do the pencil marks and the figures on the right hand margin represent?

A. The pencil marks are merely averages of these daily percentages for the different months.

Q. Those pencil marks are on the right hand margin and at the side of the eighth column?

A. Yes sir.

Q. The right hand side of the eighth column?

A. Yes sir.

MR. JEFFRIES: Now we offer these sheets in evidence, which table, as testified to by the witness, is in words and figures as follows:

(Table will be found in testimony of this witness given May 30, 1903.)

3242 GENERAL HAMLIN: As I understand, this witness is testifying to percentages based upon certain tables. Now that is right, isn't it Mr. Getz?

A. Yes sir.

Q. I say these tables are based upon certain tables?

A. They are taken from the same results that appear in these tables.

Q. I know, but how do you make the calculation?

A. From the records of the total solids results for those different days.

Q. Well then those all appear in some table?

A. They all appear in some table, yes.

Q. What tables are they?

A. It is that large number of tables, sheets and charts, etc., that were in here yesterday.

Q. Well those were tables simply on the question of the mixing of the waters?

A. This table is. Those tables cover the total results.

GENERAL HAMLIN: These calculations you have introduced now, and that he is testifying about, are simply upon the question of the per cent of the different river waters that is to be found at the intake?

MR. JEFFRIES: No, it gives the amount of total solids, and from the amount of total solids he deducts the percentage of the water of the two rivers going into the intake.

3243 GENERAL HAMLIN: What is your purpose in introducing that?

MR. JEFFRIES: For the purpose of showing the mixture of the water.

GENERAL HAMLIN: Now then, there ought to be in the record that portion of these tables upon which these calculations were made.

MR. JEFFRIES: Those table are with the Commissioner.

CROSS EXAMINATION, By Judge Johns.

Q. On the table from which table was prepared, are there any statements as to the stages of the Mississippi or the Missouri river, or the gauge?

A. My recollection is that there were, yes sir.

Q. Why did you not put those stages in?

A. No sir, on the charts that were made, the gauges were put, but there were no numerical figures put on the sheets that these were taken from.

Q. Where were the stages of the river or the gauge at the time this table was made? Were they before you for the purposes of assisting in this calculation in any way?

A. I don't think so; there was no need of them.

Q. And there was no necessity of them for the purpose of calculating these percentages?

A. No sir.

3244 Q. So when this table of percentages shows that on the 7th of February that the percentage of Mississippi river water in the intake was 100 and the percentage of the Missouri river was zero, there is no intimation as to the state of the gauge of the two rivers at that time?

A. Nothing on that table, no sir.

Q. Was there anything of that kind upon any table from which you made a calculation?

A. It was put on the charts, but not in the tables.

Q. In what charts?

A. On those charts that have been exhibited, I believe—the charts that were made covering these periods—the charts made of the weekly averages.

Q. You testified to the tables containing the results of the chemical analyses of water?

A. Yes sir.

Q. Made at the St. Louis laboratory?

A. Yes sir.

Q. Were there on those tables any statements as to the gauge of the river?

A. No sir.

Q. Then to what charts do you refer?

A. Those curves as we call them, the curves that were plotted from those tables; they were plotted in colored inks on cross sections.

3245 Q. And the state of the river as shown by the gauges was on none of those charts?

A. It was on one of those simply as being interesting to know in that connection, but there were no deductions drawn in this table from the gauge of the river.

Q. Did you prepare a chart on which there was a statement of the gauge of the river in connection with any curves that have been testified to here?

A. My recollection is that we did, yes sir.

Q. Well, as it is not on any chart which we have so far introduced in evidence, I would like to have you produce that one.

A. (No answer.)

Q. How does it happen that in Febraary, 1900, you have here only 16 days?

A. Those were the only samples available during that month.

Q. And the only ones analyzed during the month?

A. The only ones that were analyzed for that particular determination.

Q. There were others analyzed for other determinations?

A. I don't know whether there were or not.

Q. Do you know whether or not on each and every one of these tables that you and Mr. Miller have identified, there was for each day in each month in which an examination of water by chemistry was made, a determniation of solids?

A. There was occasional times when samples could not be
3246 collected on account of the ice in the river, or for some
such reason as that. There was an occasional sample that was broken, I believe. Of course in that case there was no record.

Q. Do you know now whether in February there were samples analyzed from the 17th to the 28th inclusive?

A. I don't remember those dates. The table there shows the dates on which those samples were analyzed.

Q. Were there times when the determination was not made for solids when chemical determinations were made for other elements?

A. I think the total solids were always determined.

Q. Do you know whether or not the tables in which you figured up an average for February, there was a determination of solids from the 16th to the 28th of February, 1900?

A. There was if it is shown on the table, yes.

Q. It is not shown on this table. Do you know whether there was on the table from which this was prepared?

A. That includes everything shown on the tables from which it was prepared.

Q. Take the month of July, 1900, in which it appears that the average of the percentage of Mississippi river water at the intake averaged 7.73; do you know anything about the stage of the Mississippi and the Missouri river relatively at that time?

A. I don't personally at present know. We did, I think,
3247 collect the records of the stages of the rivers; but these
calculations do not depend in any way on the stage of the river.

MR. JEFFRIES: They may, however, have some effect on the results?

A. They do affect these results; but there was no use made of them in the calculations.

GENERAL HAMLIN: You have offered the table. I object on the part of the state of Illinois for the reason that the table is not relevant testimony unless the complainant offers to follow it up with proof of the rain-fall, or conditions that might have obtained, or did obtain on the lower Illinois river, on the Mississippi or the Missouri rivers at the time these calculations and analyses were made.

GENERAL CROW: In reply to that, the State of Missouri suggests that that objection is to go to the credibility of the testimony and not as to its relevancy or competency, but that at the proper time we will offer such statistics on the question of rain-fall and water gauges in the Missouri, Mississippi and Illinois rivers, as we think proper to offer.

CROSS-EXAMINATION, By Mr. Todd.

Q. Mr. Getz, where was the data from which these percentages were figured, taken from?

A. Well, I explained all that before. It was taken from 3248 the original note-books first and collected on to these charts or on the tables, and then it was taken from there for this special purpose. It is one of the determinations that were made on all these samples, and they were taken and repeated here on this table and the percentages were calculated from those. This table is strictly the chemical results.

Q. Were these figures taken from the tables that have been marked here as complainant's Exhibit 1 for identification?

A. They were.

Q. Who took these figures off of those tables?

A. Mr. Miller and myself.

Q. What part of this table did you take off, of these sheets known as complainant's Exhibit 1 for identification?

A. Well, as to which particular numbers I took I could not testify; we worked together on that.

Q. Did you ever compare the data that appears here upon this paper, with the data on Exhibit 1 for identification to ascertain whether the same were correct?

A. We compared our work, our copy of the table which we made. I didn't sit down to the typewriter and write the table, but the copy of the table which we made in our own writing was compared with the chart—with the sheets.

Q. And was this typewritten copy compared with the copy that was in your own writing?

3249 A. Not by me it wasn't.

Q. Do you know by whom?

A. I don't know who did that.

Q. Are you able to say that the data upon this table which has been offered in evidence, contained the same data that is in Exhibit 1 for identification?

A. Well, I can't answer for any clerical mistakes that might have been made in copying that. I didn't take the typewritten work and check it with the table I made out, but the table from which this was copied has been checked with those sheets.

Q. Did you check the table from which this table was copied, with the sheets?

A. I did, yes.

Q. And found it correct?

A. And found it correct.

CROSS-EXAMINATION, By Judge Johns.

Q. When you made these figures as to solids, you took them for the Missouri river at Bellefontaine?

A. Yes sir.

Q. And for the Mississippi river at Hartford?

A. Yes sir.

Q. Did you make the calculation for total solids or for solids in suspension or solids in solution?

3250 A. Total solids.

MR. TODD: How were these percentages calculated?

A. Well, there is always considerable variation or nearly always considerable variation in the total solids as found in the Missouri river at Bellefontaine, and those found in the Mississippi river at Hartford, and the total solids at the Intake of the St. Louis waterworks was found to lie between those two, or approximately the same as either one of them, and by taking the difference in the total solids in the two rivers at those places, and interpolating the value of the total solids found at the Intake, we find the percentage of the two rivers, which is represented by the mixture.

CROSS-EXAMINATION, By Judge Springer.

Q. I see from this table that you have presented, that the proportion of waters from the Mississippi river for the month of January, 1900, in the St. Louis Intake is put down at 25.75?

A. That 25.75 represents the average for all the samples we had during that month. It is simply an average for these separate days during the month of January, 1900.

Q. What does this number, then, represent?

A. That represents the average of the daily samples, which
would be considered as the average amount of Mississippi
3251 river water entering the Intake during that period, about
seven or eight days.

Q. Now this average amount of water from the Mississippi river that entered the Intake during those days in January, which are here noted, simply means an average which you have reached by estimating the total solids which you found in the waters of the two rivers, one at Bellefontaine, and the other at Hartford?

A. That is the average of those daily percentages, yes.

Q. The average as ascertained by the total solids?

A. By the total solids, yes. It simply consists in adding up the percentages for that number of days and dividing by the number of days.

Q. Now, if during that time there should have been a considerable rain-fall above Bellefontaine in the Missouri river, with no corresponding rain-fall at Alton or up the Missis- river, without any appreciable or perceptible increase of the volume of the water, there would have been a great increase in the total solids, would there not?

A. You mean no increase in the Mississippi and considerable increase in the Missouri?

Q. Yes, suppose that there was no perceptible increase really in the volume of water, but an increase in the total solids would appear, from a rain-fall above—

3252 A. Yes sir.

Q. There would have been a difference in the total solids?

A. Yes.

Q. Then the correctness of this map so far as determining the quantity of water which flowed into the intake from the respective streams would depend, then, to some degree upon the conditions of the weather along the line of the respective streams above the place where the samples were taken?

A. That is all taken into account in the samples themselves, as they are collected. We made no deductions on that account.

Q. You made no deductions on that account?

A. It doesn't influence our results, although it influences them before we get the sample.

Q. It influences the quantity of total solids, but would not to a corresponding degree influence the quantity of water; is that right?

A. That is possible.

Q. Then the condition of the weather would have something to do with the quantity of water, irrespective of the question of solids, is that right?

A. Well, I don't know that the weather would have anything to do with it.

Q. The rain-fall?

A. Well, they draw a certain amount of water through the St. Louis intake—

3253 Q. You don't seem to understand—I mean that the percentage of solids would be determined in a great measure upon the condition of the immediately preceding rain-fall in the respective rivers?

A. Yes sir.

Q. Whereas the volume of water might not itself be materially different?

A. Yes sir.

Q. Then, if there was then, a the time of this first determination, a larger stage of water in the Missouri river than is normal and a lower one in the Mississippi than normal, the question of the gauge of the two streams would have considerable to do with determining the amount of the water that actually went in from each stream, to the intake?

A. It does affect it, yes sir.

Q. So that to make this calculation accurate, it should have been taken into consideration—both these other factors, should it not?

A. No sir, the accuracy of the table does not depend upon it at all.

Q. For the accuracy of the table of percentages, it is not, but the actual amount of water that went into the intake would be determined in a great measure by these other factors, would it not?

3254 A. Well, the water goes into the intake of a certain quality. We know that it is a mixture usually of these two rivers. Now we can determine by taking a sample of water of those two rivers exactly just which one appears in the mixture. Now rain-falls and such things would affect that mixture the percentages.

Q. Without affecting the quantity of water?

A. But that is all taken account of in the analysis itself.

Q. I understand this analysis is based upon the actual quantity of solids which you found in the samples of water examined. Those solids were fixed quantities so far as you are concerned?

A. Yes sir.

Q. And they were variable only as the weather might vary, but you were not running with the weather, you were taking the samples as you found them, is that right?

A. Taking them as we found them, yes sir.

Q. If the weather and the stages of the river were the same at both these places, would not the averages for each period always be the same?

A. I don't know.

Q. What?

A. I don't think you could bring about exactly identical conditions.

Q. Well I am not asking whether you can do it or not,
3255 I am supposing that it was so. Suppose that you assume that the stage of the rivers—of both rivers, was the same during a given period of time covered by these tables, and that

the rain-fall was the same during all this period; then would not your averages for each period be the same for total solids?

A. If all the conditions affecting those were the same, the conditions would be the same.

Q. The fact that at one time during one month for instance the average would be 25.75 and the next month would be 40.67, and for another month 60.29, and so on,—they are variations which can only be explained from the different stages of the river and the different conditions of the weather along the line of the rivers above the place where the samples were taken?

A. Yes sir.

RE-DIRECT EXAMINATION, By Mr. Jeffries.

Q. Now Mr. Getz, along the line of the questions propounded to you by Judge Springer, state what effect the fact of a flood in the Missouri river and a comparatively low water stage in the Mississippi river would have with reference to the correctness of arriving at the proportionate amounts or relative amounts of the two waters going into the intake?

A. It would have absolutely no effect.

3256 Q. Then the variation referred to by Judge Springer refers simply to the amounts of the respective waters that go into the Intake by means of the change in volume of water of the respective rivers, and not with reference to the correctness of your determinations?

A. Yes sir.

Q. It doesn't interfere with the correctness of the determinations?

A. No sir, it has no effect. We have the three samples. One of them is a mixture of the other two. Now we don't care how the mud got into either one of them; it is there. As to whether it is due from heavy rain-fall or there has been a drought, and so on, that has nothing to do with it. We have the two rivers before they get to the intake; before they are mixed, and then we have the mixture, after they come together, which is entirely independent of any conditions which produce those different amounts of total solids.

3257 GEORGE C. WHIPPLE,

Re-called for further direct examination by Mr. Jeffries, testified as follows:

Q. Mr. Whipple, have you visited the Chain of Rocks and made yourself personally familiar with that portion of the waterworks plant of the city of St. Louis which is located at that point?

A. Yes sir.

Q. What is the approximate distance from the Missouri shore to the Intake tower of the St. Louis waterworks?

A. About 1,500 feet.

Q. What is the position of the Intake tower at the Chain of Rocks with reference to the channel of the Mississippi river?

A. The Intake tower of the St. Louis waterworks at the Chain of Rocks is located a few hundred feet to the west of the channel of the Mississippi river at that point.

GENERAL CROW: Do you mean to say it is only a few hundred feet west of the channel of the Mississippi river—the Intake?

A. Yes sir.

MR. JEFFRIES: Do you mean the channel or the center of the channel?

A. That would depend upon just the definition of the term "channel." When I used that word in that sentence, I meant the center of the channel of the river, that is, the central thread of the main channel of the stream. 3258

Q. What is the approximate distance from the Intake tower at the Chain of Rocks to the mouth of the Missouri river?

A. About six miles.

Q. State the general features of the Mississippi river with regard to the curves and directions of flow, between the mouth of the Missouri and the Intake tower at the Chain of Rocks?

A. From personal observation I know that the Mississippi river before it reaches the Intake tower of the waterworks, curves to the westward, but I cannot describe that curve in detail without referring to the Government chart, or to some chart upon which that curve is shown. If that chart can be shown to me I could explain it more in detail.

Q. Now in that connection I want to ask you what are the general features of the river with regard to curves and directions of flow between the mouth of the Missouri river and the Intake tower at the Chain of rocks, which you can explain from the chart?

A. Kindly read that once more?

Q. What are the general features of the Mississippi river with regard to the curves and direction of flow between the mouth of the Missouri river and the Intake tower at the Chain of Rocks?

A. The chart is right here.

3259 Q. I say you can explain it from the chart.

A. Yes sir. From this chart, which shows a section of the Mississippi river and which has been offered as complainant's Exhibit No. 44, I find that the Mississippi river just above the point where the Missouri river enters it, is flowing in a direction slightly west of south. Further, that the direction of the eastern bank of the stream continues to be the same down to the lower part of the mouth of the Missouri river. At about that point the Mississippi river—

GENERAL HAMLIN: Will you allow me to suggest that when you can, when you speak about "that point," that you locate the point.

MR. WOERNER: He said about the lower point of the mouth of the Missouri.

A. (Continuing.) At the lower point of the mouth of the Missouri, the Mississippi river, which there contains both the waters of the upper Mississippi river and the Missouri river, turns to the westward and flows in a southwest direction. About one mile below the lower point where the Missouri river enters, the river flows for a short distance almost westward. During the next mile of flow, the right bank of the river has a direction slightly north of west. Below this point there is a second bend in the river, and the direction of the right bank becomes somewhat south of west, and then this curvature continues, gradually increasing, towards a southerly direction until at a point about a mile and a half—about two

3260

miles I would say above the Intake of the Chain of Rocks, the western bank of the stream has a direction which is generally north and south. For that mile of the stream just above the Intake of the waterworks the direction of the right bank of the stream is somewhat west of south. Going back to the lower point of the mouth of the Missouri river I find that the left bank of the stream is practically parallel with the right bank, for about 1½ miles. Below that point the left bank of the stream is a southwest direction and barring a slight indentation about a half mile below this point, that is, a southwesterly direction, that is a generally southwesterly direction, continues to a point opposite the intake of the St. Louis waterworks. At a point about 1½ miles below the lowest point of the mouth of the Missouri river, the river broadens and does not contract again to the distance just found at the lowest point of the mouth of the Missouri river before it reaches the Intake of the waterworks at the Chain of Rocks.

Q. Now, Mr. Whipple, from your general knowledge of stream flows, what is the effect of those curves upon the mixing of the Mississippi and Missouri river waters?

A. From my general knowledge of the subject of rivers and the effect of curves upon the currents of those rivers, it is 3261 my opinion that this curve which I have described, in the Mississippi river between the mouth of the Missouri river and the Intake of the St. Louis waterworks would tend to allow, or would increase, or would be favorable to the mixture of the waters which come down the Mississippi river and the Missouri river.

Q. At what points now would that mixture take place the most rapidly?

Question withdrawn.

Q. Independent of sanitary conditions, what are the general characteristic features of the Missouri river water and the Mississippi river water at the mouth of the former, or at the mouth of the Missouri?

A. *Judged from the samples of water which I have received from the Missouri river at Bellefontaine—I will not say from Bellefontaine, but from the section shown upon the chart which I have before me, from section B, and from section M in

the Mississippi river upon this chart, I should say that the water in the Missouri river is much more muddy than the water in the Mississippi river; that is, that it contains very much larger amounts of suspended matter, and by referring to the analyses which I have made I can show that by figures as well as by this general statement. For example, the average turbidity of the three samples collected at section B on
3262 April 12, 1903, was 1493 parts per million. This average figure being the numerical average of the turbidity observations which I have already placed in evidence. The average of results of the turbidity observations made upon the samples collected on April 10, 1903, was 127 parts per million.

MR. TODD: Where was that, doctor?

A. At section M.

MR. JEFFRIES: That was across what river?

A. Section M being a cross-section across the Mississippi river just above the point where the Missouri river enters the Mississippi.

These figures bear out the general statement which I made, that the water in the Missouri river is much more muddy and contains more suspended matter than the water in the Mississippi river. From observations which I made upon the samples collected during the months of October and November, 1901, in the Missouri river at Bellefontaine, and in the Mississippi river at Alton, I found the same general fact to be true, and from an inspection of the analyses made under the direction of the city chemist and which have been recorded upon certain sheets and placed in evidence as complainant's Exhibit 1 for identification, and consisting of 117 sheets, I found that this also bore out my statement in regard to the greater amount of suspended matter in the water of the Missouri river than in that of
3263 the Mississippi river above the mouth of the Missouri.

From observations which I made upon the color of samples of water from the Missouri river at Bellefontaine, and from the Mississippi river at Alton during the months of October and November, 1901, I found that the water of the Mississippi river at Alton was more highly colored than the water of the Missouri river at Bellefontaine, and in using this term color, I refer not to any substances in suspension, but rather to substances in solution.

From an inspection of the sheets which contain the results of chemical analysis of the samples of water from the Missouri river above its mouth and from the Mississippi river at points above the mouth of the Missouri, I have observed that the amount of chlorine in the Missouri river was generally higher than the amount of chlorine in the Mississippi river above the mouth of the Missouri.

From the same sheets I also observed that ordinarily the amount of alkalinity in the Missouri river at Bellefontaine, was higher than the alkalinity in the waters of the Mississippi river above the mouth of the Missouri.

Q. Assuming that the Mississippi water above the mouth of the Missouri contains certain forms of vegetable life which can be distinctly identified by well defined characteristics, and further assuming that the Missouri river water at that
3264 time contained no such species of vegetable life, and that
those forms of life are present in water drawn through the Intake tower at the Chain of Rocks, I will ask you to state what that shows as to the presence of Mississippi water in the Intake tower?

A. If I should find the organisms which you mention in the water of the Mississippi river above the mouth of the Missouri, and if at the same time these organisms were absent from the water of the Missouri river itself, and if at the same time I should find them in the water of the Intake tower of the St. Louis waterworks at the Chain of Rocks; it is my judgment that these organisms found at the Intake tower of the St. Louis waterworks came from the water of the Mississippi river above the mouth of the Missouri river and that they were borne thither by the water of the Mississippi river above the mouth of the Missouri.

Q. Assuming that at times the water of the Mississippi river above the Missouri contains very little mud, and that the water of the Missouri river at the same time is highly charged with mud, and further assuming that the water taken through the intake tower at the Chain of Rocks, contains an amount of mud intermediate in quantity between those of the two rivers before they unite, state what in your opinion that shows with regard to the mixing of the waters of the two rivers?

3265 GENERAL HAMLIN: That is objected to on the ground that it does not assume all of the facts testified to and appearing in the record, and all the conditions necessary to be assumed before an expert can answer such a question.

THE WITNESS: Under the assumptions just made, it would be my opinion that the water found at the intake tower of the St. Louis waterworks, at the Chain of Rocks, was not entirely water derived from the Missouri river nor water entirely derived from the Mississippi river above the mouth of the Missouri, but was a mixture of the two waters.

MR. JEFFRIES: Mr. Whipple, I hand you a table containing a transcript of the quantities of the total solid matter in the Missouri river at Bellefontaine, and the Mississippi river at Hartford, and the water at the Intake, which is a table read in evidence by the witness Getz, and ask you to explain the table, and state whether or not the results as to the quantity of water of the respective rivers entering the Intake at the Chain of Rocks, are determined by that table?

GENERAL HAMLIN: That is objected to on the ground that this witness is an expert; that he did not make the table, and did not make the table from which deductions in the table now in the expert's hands were made.

MR. JEFFRIES: It is not introduced for the purpose of showing that the total number of solids is correct.

3266 MR. TODD: I also object to it on the ground that the table speaks for itself. That the question is answered by the table itself.

THE WITNESS: I find that this table which you show me contains eight columns of typewritten figures; in the first column there is a series of dates beginning with January 24, 1900, and extending to October 10, 1900.

In the second column there is a series of figures under the caption "Bellefontaine," which, from the heading at the top of the table, I infer to represent the total solids in the samples collected at Bellefontaine on the respective dates.

In the third column I find a series of figures which I understand from the general heading of the table to represent the total solids in the samples collected at the intake of the St. Louis waterworks on the respective dates, and in the next column I find a series of figures which I understand represent the same information upon samples taken from the Mississippi river at Hartford.

In the fifth column is a series of figures which I understand from the caption, gives the results obtained by subtracting the figures in the fourth column from those in the first column.

In the sixth column is a series of figures which I understand is obtained by subtracting the figures in the fourth column from those in the third column.

3267 In the seventh column is a table of figures which I understand gives the percentage of Missouri water in the intake of the St. Louis waterworks, presumably calculated from the figures in the previous columns.

In the last column there is a series of typewritten figures giving the percentage of Mississippi River water at the intake of the St. Louis waterworks also calculated from the figures in the previous column.

(Question repeated)

A. In looking over this table I find that in general the total solids found in the samples at the intake were intermediate in amount between those found in the Mississippi River at Hartford and in the Missouri River at Bellefontaine, and it is my opinion that it is possible from the figures given to calculate approximately the relative amounts of the water of the Missouri River and of the Mississippi River above the mouth of the Missouri present in the water at the intake of the St. Louis waterworks. I understand that the percentages obtained in the last two columns, were obtained from the information given in the previous columns. Does that sufficiently answer your question, Mr. Jeffries?

Q. Yes.

GENERAL HAMLIN: Before you ask another question, I move to exclude the answer to that question for the reason that the witness does not undertake to say that he made the

3268 table or that he made the table from which this table was made, or that he has himself examined the samples or made any analyses of the waters at the points mentioned, and his answer is simply to bolster up a table made by someone else and not by him.

MR. JEFFRIES: Assuming that the table before you contains the correct number of total solids in the waters of the two rivers, state the degree of reliability of the percentage of the waters of the two rivers calculated from these total solids that would enter the intake at the chain of rocks?

GENERAL HAMLIN: That is objected to upon the ground that the reliability of this table does not depend upon any expert knowledge that this witness has, nor from any actual knowledge he has derived from the original tables from which this table is made.

THE WITNESS: It is my opinion that if the figures given in this table represent the total solids in the water of the Mississippi River at Hartford and the water of the Missouri River at Bellefontaine, and the water of the intake of the St. Louis waterworks at the chain of rocks, if these figures are accurate representations of the total solids in the samples collected, and if the samples collected fairly represent the waters of the streams at the points named, then the calculations made by using these figures in obtaining the percentage of water of the Missouri River and of the Mississippi River above the mouth of the
3269 Missouri, in the water of the intake of the St. Louis waterworks, are reliable.

GENERAL HAMLIN: I move to exclude that answer for the reasons that are apparent in the answer given by the witness.

ADJOURNED until 2:00 P. M. same day, May 13, 1903.

3270 Southern Hotel, St. Louis, Missouri. 2:00 p. m., Wednesday, May 13th, 1903. Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

GEORGE C. WHIPPLE resumed the stand for further direct examination, by Mr. Jeffries, and testified as follows:

Q. Mr. Whipple, state whether or not you made any calculations of the percentage of the waters of the two rivers, to-wit, the Missouri and the Mississippi, entering the Intake at the Chain of Rocks, from the samples of water that were furnished you, and about which you testified previously in this case; if so, state what those perentages are?

A. I made no such calculation of the percentage of the Mississippi River water in the Intake at the Chain of Rocks, but I made calculations showing the percentage of Mississippi River water at stations 4 and 5 on cross-section I, the results of which were submitted the day before yesterday, and shown on complainant's Exhibit 44, or rather the location of which is shown on complainant's Exhibit 44.

3271 Q. Where is cross section "I"?

A. Cross section I was located as shown by the diagram mentioned before, about one-quarter of a mile above the Intake Tower of the St. Louis Waterworks at the Chain of Rocks, and from this diagram it is apparent that the inlet tower of the Chain of Rocks—that the distance of the inlet tower of the Chain of Rocks from the Missouri shore, is the same distance as from the Missouri shore to some point in the cross section, between stations 4 and 5. In making the calculation to obtain the percentage of Mississippi river water at point 4 in the cross section I, I assumed that the turbidity of the Missouri river was represented by the average of the turbidity observations in the three samples collected at cross-section B, cross-section B being shown on the diagram before me. I found that the average of the three turbidity observations mentioned were 1493. I assume further that the turbidity of the water in the Mississippi river was represented by the average of the turbidity observations made upon samples collected at cross secton M as shown on the map at a point about a quarter of a mile above the mouth of the Missouri river. I assume further that the turbidity of the water at point 4 in section I was represented by the average of the turbidity observations made upon the three samples collected at different depths at that point. This average turbidity was found to be 263.

3272 These figures showed that the average turbidity of the water at point 4 in secion I, was intermediate between the figures showing the turbidity of the water of the Missouri River at section B, and the turbidity of the water of the Mississippi river water at section M.

GENERAL HAMLIN: Did you give the turbidity of the water of section M?

A. I thought I did. The average of the turbidity observations made at section M was 127.

MR. JEFFRIES: Go ahead with your answer.

A. Using these three average figures for the turbidities of sections B and M and the point 4 in section I, I calculated that the percentage of Mississippi river water at point 4 in section I, was 90 per cent.

I made a similar calculation to find the per cent. of Mississippi river water at point 5 in section I, using the same average turbidities for section B and section M, and using for the average turbidity of the water at section I, the average of the turbidity observations made at three different depths, that is the average turbidity at point 5, section I, being 152. From these three figures I calculated that the percentage of Mississippi river water at the point 5 in section I was about 97 per cent.

Q. Now, state those per cents again so that we can get 3273 them clearly in the record, of points 4 and 5 of the respective waters?

A. My calculation showed that the percentage of Mississippi river water which was present at point 4 in section I, was about 90 per cent., and that the percentage of the Mississippi river water at point 5 in the same section, is about 97 per cent.

Q. Now, those were calculations of the percentage of the two rivers that appear in the Mississippi at that point at that time?

A. Yes, sir.

Q. When were those samples gathered?

A. The samples at section B were collected on April 12th, 1903; the samples at section I were collected on April 10th, 1903, and the samples in section M were collected on April 10th, 1903.

Q. Now, Mr. Whipple, assuming that when the waters of the two rivers, the Mississippi and the Missouri, unite or connect at their junction, that there is no mingling of the waters with each other as they flow down the stream; what would be the character of the water as shown in the cross section across the Mississippi river at the Chain of Rocks or at a point a short distance above the Chain of Rocks, or at a point in the river as shown by section I, on complainant's Exhibit 44?

A. On the assumption to which you have referred I should expect to find under those conditions, that in crossing the river from the Missouri shore to the Mississippi shore, there would be a sharp line of demarkation separating the water of the Missouri river on the west shore from the water of the Mississippi river on the east shore, and that the position of this line would be determined by the relative volumes of these two streams, the Mississippi river and the Missouri river, and the cross section of the river at that point. 3274

Q. Have any of your examinations or analyses of these waters indicated such results?

A. No examinations which I have made, have shown that such a sharp line of demarkation existed, and that can be illustrated by referring to certain exhibits which have already been presented.

Q. What physical exhibit would you refer to?

A. It was shown by the samples of water collected at twelve points on the section I, numbered from 1 to 12, beginning on the Missouri shore, and which have all been exhibited in this room. The fact is also shown by a certain diagram which has been presented, illustrating the turbidity of the water at this section.

Q. Mr. Whipple, which one of the ingredients mentioned by you this morning, permits the portion of the amount of the two river waters, at the Chain of Rocks, to be determined the most accurately, and why? 3275

A. In comparing the general character of the waters of the Missouri river and the Mississippi river above the mouth of the Missouri this morning, I referred to the presence of suspended matter in the two waters, to the presence of chlorine, to the presence of alkalinity, to the turbidity, to the color and to the total solids. Of these various parts of the analysis of water, it is my opinion that the relative percentages of the waters of the Mississippi river and the Missouri river at the Intake at the Chain of Rocks, can be most reliably determined from the total solids, for the reason that the differences between the total solids of the two rivers is ordinarily fully as great as shown by the other parts of the analysis and for the reason that this determination is in general somewhat more accurate than the others. The determination can be made, for instance, by a comparison of the chlorines in the waters of the two streams, but there is not as great a difference—greater relative difference between the chlorines in the water of the Missouri river and the Mississippi river than is ordinarily found in the case of the total solids. The same is true for the alkalinity and the same is true for the color.

Q. Are you familiar with the published reports showing the population and natural residents upon the watershed of the Missouri river, of the upper Mississippi above the Chain
3276 of Rocks, and of the upper Illinois river, and their tributaries?

A. Yes, sir; I am familiar with certain reports showing those facts and with the reports of the United States census for 1900, which give those facts.

Q. When considering cities having a population of 25,000 or more according to the census of 1890, what percentage of increase to the population naturally resident upon the watershed of the Mississippi, at the Chain of Rocks, is caused by the Sanitary District of Chicago diverting its sewage into the Illinois river and becoming thereby tributary to the Mississippi?

GENERAL HAMLIN: That is objected to on the ground that it is not a proper basis of estimation upon which to base a proper conclusion as to this subject matter by an expert, and the further objection that the testimony is not relevant to the issue in hearing, made by the bill and answer.

THE WITNESS: Speaking generally the population is about double.

MR. JEFFRIES: Now, what do you mean by the word "double" when you used it in connection with your answer to the previous question?

A. I mean that there is a certain population naturally tributary or situated upon the watershed of the Missouri river and the Mississippi river above the Intake, and the Illi-
3277 nois river, exclusive of the population of Chicago, and that if we add to this natural population upon these three watersheds, that would more than double that population.

Q. That is by considering cities having over 25,000 inhabitants?

A. On the assumption mentioned in your question as I understand it, considering only cities which have a population of 25,000 and over.

Q. Considering cities having a population of 4,000 or over, how large a percentage of increase in population tributary to the Mississippi above the Intake Tower of the St. Louis Waterworks at the Chain of Rocks, is caused by the Chicago Drainage Canal discharging the sewage of Chicago into the Mississippi river by means of the canal and the Illinois river?

GENERAL HAMLIN: That is objected to on the ground that it is not based upon a proper estimation that is resident upon the Mississippi and its tributaries above the Chain of Rocks.

THE WITNESS: This percentage of increase is about 63 per cent.

Q. MR. JEFFRIES: What do you mean by 63 per cent?

A. I mean to say that if you consider the population of cities which have more than 4,000 population, situated upon the watersheds of the Missouri river, the Mississippi River
3278 and the Illinois river above the Chain of Rocks, but not including the population of Chicago, and if we add to this population the population of Chicago, we should increase the populations as mentioned, by about 63 per cent.

Q. As a general proposition is it customary for sanitarians to consider that the amount of sewage pollution in a stream may be approximately estimated by taking the sum of the population of the towns on its watersheds having a population of 4,000 residents or over, and if so, why?

MR: TODD: I object to the question on the ground that what is customary among sanitarians does not bind the defendants in this case.

THE WITNESS: There is such a custom among sanitarians. There is this custom among sanitarians, that when it is desired to determine the amount of pollution, sewage pollution which exists in a stream at any point, at any certain point, to consider the population dwelling upon the watershed above that point in cities which have 4,000 or more inhabitants, and for this general reason we take it the country over. It has been found that in general, communities which have more than 4,000 inhabitants, are ordinarily supplied with such public improvements as public water supplies and sewerage systems, while in general those communities which have less than 4,000 people are not ordinarily so supplied. It is recognized that this is an arbitrary dividing line but for practical scientific
3279 purposes, it is believed to be a reliable method of estimating the pollution of a stream, or the relative pollution of different streams.

MR. TODD: I move to strike out the answer on the ground that we are dealing with facts and not with customs.

MR. JEFFRIES: What mode or means did you adopt as a sanitary expert in making those calculations?

A. I have adopted the same means.

Q. What is the distance by river from the mouth of the Missouri to the mouth of the Illinois?

A. I think it is about 23 miles.

Q. I will ask you if it is possible by reason of analytical results to determine the amount of mixing of the Illinois and Mississippi waters during their flow from Grafton to Hartford, and if you have made any such determination, to state your results?

A. I believe that it is possible by analytical means, to determine the percentage of Illinois River water which is present in the water of the Mississippi river at Hartford, for example. I have also made such a calculation in order to determine the percentage of Illinois River water at Alton as well as at Hartford. I made these calculations from the analyses shown upon the sheets which I hold in my hand and which form a part of complainant's Exhibit 1 for identification.

3280 Upon this first sheet there are given the results of the determinations of nitrites. In five samples of water collected daily from October 30th, 1901, to November 29th, 1901, at five points in a cross section of the Mississippi River at Alton, and these points being marked, A, B, C, D and E.

Sample A being taken at the Missouri shore.

Sample E being taken at the Illinois shore, and the other points intermediate between them.

The same sheet also shows the results of the determinations of chlorides, at the same points and on the same dates.

This other sheet which I hold in my hand gives the results of chemical analyses among which I find the determinations of chlorines, made upon samples collected in the Illinois River at Grafton daily, between October 30th, and November the 29th, 1901.

The sheet also gives determinations of the nitrites from the same samples. From this next sheet I gather the results of chemical analyses of samples collected in the Mississippi River at Grafton, among which I find determinations for the amount of chlorine upon daily samples collected between October 29th and November 29th, 1901, and also the determination of nitrites for the same samples.

3281 From the determinations mentioned, I have obtained the following average figures for the period mentioned: At the cross section at Alton, Station A, contained 5.2 parts of chlorine, and .002 parts of nitrite.

Station B contained 6.8 parts of chlorine, and .005 parts of nitrites.

Station C contained 8.7 parts of chlorine and .009 parts of nitrites.

Station D contained 9.7 parts of chlorine and .0105 parts of nitrites.

Station E contained 10 parts of chlorine and .0115 parts of nitrites.

JUDGE JOHNS: Those are the averages for that time?

A. Those are the average figures at the five points mentioned.

GENERAL HAMLIN: Now for the purpose of making a motion here I should like to ask the witness a question. Professor, you are using certain tables there. Are those tables made by you?

A. These tables, complainant's Exhibit 1 for identification?

Q. Yes?

A. No sir.

Q. Then you are giving results from tables that you have not made?

A. Yes sir.

MR. JEFFRIES: The witness stated that they were sheets taken from complainant's Exhibit 1 for identification.

GENERAL HAMLIN: I move to exclude the answer as to the results obtained, as they are not expert's state-
3282 ments, but are statements of a fact determined from tables not made by the witness.

THE WITNESS: I have averaged the figures given upon the table which shows the determinations of the nitrites and chlorines, at five stations, at a cross section at Hartford, and from those I obtained the following results:

At station A the chlorine was 6.8 parts per million, and the nitrites .006.

At station B the chlorine was 7.1 and the nitrites .006.

At station C the chlorine was 8 parts per million, and the nitrites were .008.

At station D the chlorine was 8.8 parts and the nitrites .009.

At station E. the chlorine was 9.1 parts and the nitrites .010.

I found—I have not at hand at this moment the averages obtained for the Illinois River at Grafton, or the Mississippi River at Grafton, which averages were used in the calculations now to be described, but I can produce these averages later.

From these average figures, I have calculated the percentage of the Illinois river water at the five points in the cross-section of the Mississippi River at Alton, and obtained
3283 the following results:

At station A I obtained 7.8 per cent of Illinois River water.

At station B I obtained 7.7.

At station C 29.3 per cent.

At station D 35.4 per cent.

At station E 37.2 per cent.

While at Hartford I obtained the following percentage figures for the per cent of the Illinois River water at the different points:

At station A	17.17
B	19.5
C	25.
D	29.8
E	31.7

I have also plotted these results on a diagram which I have and which I submit (Hands paper to counsel).

Q. What is this?

A. This is a diagram which shows graphically the results, the average amounts of nifrites and chlorines at the cross-sections at Alton and Hartford, across the Mississippi river, for the period from October 30 to November 4th, from the period of October 30th to November 29th, in the case of the Alton cross section and from November 4th to November 30th, in the case of the Hartford cross section.

3284 It also gives in the lower portion of the diagram, a graphical illustration of the per cent of the Illinois River water at the two cross-sections.

Q. Who prepared that?

A. This a blue print which was made from a tracing, the tracing being made from an original which I personally prepared.

Q. That is an exact copy of the original which you prepared?

A. This is an exact copy of my original.

Q. And a correct copy?

A. Yes sir.

GENERAL HAMLIN: Now I want to enter this motion to exclude this answer on the ground that this testimony is based upon data, analyses and tables not prepared by the witness who has testified upon this point as an expert. This answer is simply the results obtained from data or tables or analyses not made by him and is not expert testimony.

MR. JEFFRIES: From what did you prepare the chart?

A. From the average figures showing nitrites and chlorines at the various points in the two cross sections, which average figures I obtained from the sheets giving daily analyses and which sheets have been placed in evidence and form a part of
complainant's Exhibit 1 for identification, and from the
3285 figures which I obtained, using these average results to
show the percentage of the Illinois River water at the various points in the two cross-sections.

MR. JEFFRIES: Now we offer this diagram in evidence as complainant's Exhibit 51. Received and marked by the Commissioner.

GENERAL HAMLIN: I object to the diagram for the reason given in the motion to exclude the answer to the former question.

MR. JEFFRIES: Are you personally familiar with the present condition of the Chicago River and its several branches and forks?

A. Yes, I have personally inspected the territory you mentioned, and I am familiar with reports and maps, etc., which show the general situation of the places you mention.

Q. Mr. Whipple, assuming that at a certain time lake Michigan water contained an organism called synedra pulchella sub prolongata variety, and that this plant is not contained at corresponding times in any of the branches tributary to the Illinois river nor in the upper Mississippi water at Grafton, nor in the Missouri river water, and further assuming that this plant was found at a corresponding time in the water at the intake tower at St. Louis, what in your opinion does that show?

MR. TODD: I object to the question on the ground that the assumptions have not been established in the evidence, especially as to the Missouri river.

3286 THE WITNESS: It would show that this synedra pulchella variety sub prolongata was not derived from the water of the Missouri River or from the water of the Mississippi river above Grafton, or from the tributaries of the Illinois River, but that it came from Lake Michigan and was borne thither by the water from Lake Michigan.

Q. The correct name of that organism is what? I do not know that I have got it exactly right.

A. Synedra pulchella variety sub prolongata.

Q. Assuming that the Lake Michigan water contained at a certain time a certain organism known as tabellaria, and that this plant is not contained at a corresponding time in any of the branches tributary to the Illinois River, nor in the upper Mississippi River at Grafton, nor in the Missouri River water, and further assuming that this plant was found at a corresponding time in the water coming from the settling basins of the St. Louis Waterworks at the chain of rocks, what does this show?

A. It would show that the tabellaria found in the settling basins of the waterworks at the chain of rocks, did not come from the water of the Missouri river nor from the water of the Mississippi river above Grafton, nor from the water of the tributaries of the Illinois river, but did come from the water of Lake Michigan and was borne to the settling basins above mentioned, by the waters of Lake Michigan.

3287 Q. What in your opinion is the duration of life of the germ of typhoid fever in natural water?

A. When the germs of typhoid fever are put into natural waters they will continue to live for several months, though in gradually decreasing numbers.

Q. Assuming that the sewage and lake water passing from the Chicago River into the drainage canal, reaches the Mississippi river at the chain of rocks in ten and one-half days, will the typhoid fever germs coming from the sewers in Chicago, survive the passage through the Chicago River, the Chicago Drainage Canal, the Des Plaines River and the Illinois river, to St. Louis?

GENERAL HAMLIN: I object to that question upon the ground that this assumption is based upon a condition which does not exist, namely, that the water is in a natural condition in the Chicago River and in the Drainage Canal and below Peoria, after the sewage of Peoria has entered into the river.

A. From what I know about the life of the typhoid fever bacillus in the water, and from my knowledge of the conditions which exist between the Chicago drainage canal and the intake of the waterworks of St. Louis at the chain of rocks, it is my opinion that if typhoid fever germs exist in the sewage of Chicago, they will survive the passage down the Chicago Drainage canal and to the intake tower of the St. Louis waterworks at the chain of rocks under existing conditions.

3288 GENERAL HAMLIN: I move to exclude the answer on the ground,—or rather so much of the answer on the ground that it is not responsive to the question and on the ground that the witness has not yet shown any personal knowledge, by anything shown in the answer as being responsive to the question, and anything responsive is not based upon any evidence that he has yet given, on the question of typhoid fever germs.

3289 Q. You testified here a moment ago that you were personally acquainted with the conditions of the Chicago River and the Drainage Canal, did you not?

A. Yes sir.

Q. State those conditions, Mr. Whipple, as you saw them?

A. Do you mean to give the entire situation?

Q. Yes.

A. About one month ago I made a personal inspection of the Chicago River and the Chicago drainage canal and Des Plaines River, as far as Joliet. I saw the point where the Chicago River naturally drains into Lake Michigan; I saw the north branch of the Chicago River, the south branch of the Chicago River, the south fork of the south branch, and what I believe is called the west fork of the south branch of the Chicago River. I saw the point where the Chicago Drainage canal begins; I saw the beginning of the old Illinois and Michigan canal; I saw the terminus of the Chicago Drainage Canal at Lockport, and inspected the Bear Trap Dam at that point; I saw the Illinois and Michigan Canal at that point—at Lockport, and noted the place where it could discharge into the Des Plaines River, and I saw the Des Plaines River at Joliet and the dam at that place.

Q. Now then, from your personal observation to which you

have just testified, and assuming that the sewage and
3290 lake water passing from the Chicago River into the drainage canal, reaches the Mississippi at the chain of rocks, in ten and one half days, will typhoid fever germs, coming from the sewers in Chicago, survive the passage through the Chicago Drainage Canal, the Des Plaines river and Illinois River to St. Louis?

GENERAL HAMLIN: That is objected to upon the ground that the witness has not yet shown that he has made any examination upon which an opinion could be based, by the witness, and the further objection that as an expert he has not yet been asked the facts touching this question, that are in the record, upon which that is all material facts upon which he can base an opinion as an expert, such as an opinion should be based upon.

MR. TODD: I object to it on the ground that the assumption of time does not include the height of water in the Des Plaines and Illinois Rivers at the time,—the time of ten and one-half days.

A. It is my belief that they will.

GENERAL HAMLIN: I move to exclude the answer for the reasons given in the objection to the question.

Q. MR. JEFFRIES: Assuming that at times of flood conditions in the Illinois River, the period of passage of Chicago sewage to the chain of rocks at St. Louis is eight days,—is it, or is it not true that that would enable a greater percentage of the typhoid fever germs to survive the passage to the chain of rocks at St. Louis?

3291 GENERAL HAMLIN: The same objection as made to the former question.

A. Under the conditions assumed it is my judgment that a great proportion of typhoid fever germs would reach the intake of the St. Louis water works from the Chicago drainage canal when the time of transit was 8 days than when the time of transit was 10½ days.

GENERAL HAMLIN: I move to exclude the answer of the witness on the same grounds as previously stated.

MR. JEFFRIES: Q. From your general knowledge of typhoid fever epidemics state whether there are cases on record where such epidemics have occurred where the evidence shows the typhoid fever germs considered to have caused the epidemic remained in the water for at least 10½ days prior to the entrance of the water into the service pipes of the community where the epidemic prevailed?

MR. TODD: I object to the question on the ground that he has not shown that he has any knowledge on the subject of typhoid.

MR. JEFFRIES: Q. State whether or not you have any such knowledge?

Question withdrawn.

Q. Go ahead and answer the question.

(Last question read).

GENERAL HAMLIN: That is objected to on the same ground that the question does not disclose the kind of 3292 water referred to nor the conditions, and if admissible at all as a fact and not as an expert question, the record would be the best evidence,—the record showing such a condition.

MR. JEFFRIES: Go ahead and state. I will state the question again. From your general knowledge of typhoid fever epidemics, state whether there are cases on record where such epidemics have occurred, where the evidence shows that typhoid fever germs considered to have caused the epidemic remained in natural water for at least ten and one-half days prior to the entrance of the water into the service pipes of the community where the epidemic prevailed?

MR. TODD: The same objection to that question as to the other question.

A. I believe there are such cases on record.

MR. TODD: I move to strike out the answer as not responsive to the question as I believe it was asked.

Q. State the cases that are on record of this character?

MR. TODD: I object to the question on the ground that the records are the best evidence, if there are any such records.

A. The epidemic which occurred at Detroit, Michigan, and the epidemic which occured at Lawrence, Massachusetts.

JUDGE SPRINGER: What year was that?

A. I don't recollect the year.

MR. TODD: I move to strike out the answer as not being
3293 competent evidence.

MR. JEFFRIES: From your knowledge of existing conditions of the Chicago Drainage Canal as you have just testified, and of the several connecting water courses between that canal and the intake tower of the St. Louis waterworks at the chain of rocks, is it, or is it not your opinion that there exists any efficient work of artificial construction which continually insures the prevention of typhoid fever germs which may enter the Chicago drainage canal, from reaching the intake of the St. Louis waterworks at the chain of rocks?

GENERAL HAMLIN: That is objected to upon the ground that the witness has given no such personal knowledge, information or examination of the waters upon which he can base an answer as such a witness, and if asked as an expert, the question does not include the facts testified to in this case in this, that it does not show the amount of water discharged into the drainage canal from Lake Michigan nor the amount of water at an average season of the year discharged into the Illinois river through its tributaries and does not include the waters of the Mississippi above Grafton, and does not include the waters of the Missouri river.

MR. TODD: I object to the question as to its form.

A. It is my opinion that no such work of artificial construction exists as to bring about the result mentioned.

3294 Q. Assuming that between January 17th, 1900, and December 31st, 1902, as compared with the period from 1895 to 1899, inclusive, there had been no increase on an average in the number of deaths from typhoid fever in those cities situated upon the Missouri river, upon the Mississippi river above Grafton, and upon the Illinois river and its branches, exclusive of the Chicago Drainage Canal, and further assuming that the typhoid fever death rate in the City of St. Louis had increased about 54 per cent on an average during this period, over the previous period mentioned, and further assuming that there was no substantial change in the manner of treatment of the water supply of St. Louis, and assuming further that since January 17th, 1900, a large part of the sewage of Chicago has been passed through the drainage canal and thence into the Des Plaines River, the Illinois River, the Mississippi River, and into the intake, and assuming further that some of the water of the Mississippi river would contain a certain amount of Illinois river water at the intake of the waterworks at the chain of rocks;—state what if anything, in your opinion the Chicago sewage from the drainage canal had to do with the increased typhoid death rate in St. Louis?

GENERAL HAMLIN: That is objected to upon the ground that the question itself discloses that the facts attempted to be stated are not stated with any sufficient degree of 3295 certainty and the further objection that the question is not based upon all of the material testimony introduced in evidence, as appears of record in this case so far.

MR. TODD: I object to it on the ground that the time, namely, two years prior to December, 1900, is not a fair assumption of the typhoid conditions which existed in 1899 in the City of St. Louis, and for the further reason that there is no evidence to show that the Illinois river water enters the intake of the St. Louis waterworks.

GENERAL HAMLIN: I would like to add a still further objection, that the record introduced in this case shows the deaths from typhoid fever in St. Louis from 1890, instead of 1895.

MR. TODD: I want to add to my objection in there, that there is no evidence to show that the sewage of Chicago enters the intake at the chain of rocks, or that the sewage that did enter, if it did enter, was Chicago sewage.

MR. JEFFRIES: Go ahead and answer the question, Mr. Whipple?

A. Under the assumption which you have mentioned, and if the conditions named are those which obtained, it is my judgment that the sewage of Chicago was the most probable cause of the increase of typhoid fever in the City of St. Louis which you mentioned.

Q. From your knowledge of existing conditions in the 3296 Chicago Drainage Canal, and of the several connecting water courses between that canal and the intake tower of the St. Louis waterworks at the chain of rocks, is it or is it not your opinion that there exists any reliable and efficient natural agencies which can continuously insure the prevention of typhoid fever germs which may enter the Chicago Drainage Canal, from reaching the intake of the St. Louis Waterworks at the chain of rocks?

A. It is my opinion that no such natural agencies exist.

Q. Assuming that 106 barrels containing 40 gallons each of the culture of bacillus prodigiosus, each cubic centimeter of the culture solution containing about one thousand million prodigiosus germs were emptied into the Chicago Drainage Canal at Lemont, and further assuming that at the time of this experiment this germ was absent in Lake Michigan water and the Illinois river water, and its tributaries; in the Mississippi river above Grafton, and in the Missouri river water, and assuming that soon afterwards some colonies of bacillus prodigiosus on several occasions were found in samples of water taken from the intake tower at the chain of rocks; what in your opinion does this show?

MR. TODD: I object to that question as it does not contain the facts as proven.

3297 MR. JOHNS: I object further on the ground that the assumption of one thousand million is at least one hundred times too small.

MR. JEFFRIES: 1,000 million per cubic centimeter.

JUDGE JOHNS: Oh, all right.

JUDGE SPRINGER: I object on the ground that the evidence on which this is based, of Dr. Ravold, did not show that several colonies were found there, but that only three distinct bacteria were found at that place.

A. Under the conditions mentioned in your question, it is my opinion that the finding of colonies of bacillus prodigiosus at the intake of the waterworks at the chain of rocks, if they were found at such a time after the introduction of the culture of prodigiosus into the Chicago Drainage Canal at Lemont, as was consistent with the time required for water to pass from the one place to the other, and if this bacillus was absent during this period from the water of the Missouri river, or from the water of the Mississippi River above Grafton, or from the water of the tributaries of the Illinois river, or from the water of Lake Michigan, it is my opinion that the origin of the bacilli found, was the culture which was introduced into the Chicago Drainage Canal.

Q. As a general proposition what is the evidence as to the relative life history of typhoid fever germs and prodigiosus germs in natural water—as a general proposition?

3298 A. To judge from experiments which I have made and from what I generally know of the subject, it is my judgment that the longevity of the two germs in natural waters is not greatly different.

Q. Assuming that the number of deaths from typhoid fever in the city of Chicago from 1895 to 1902, inclusive, have been as follows:

1895	518
1896	751
1897	437
1898	636
1899	442
1900	337
1901	509
1902	801

State from your general sanitary knowledge, the relation which exists between the dejecta of those persons dying of typhoid fever in Chicago, and the mixture of sewage and lake water entering the Chicago Drainage canal?

GENERAL HAMLIN: That is objected to on the ground that there is no proof in the record that the dejecta of typhoid fever patients has been discharged into the Lake or the sewers of Chicago.

MR. TODD: I object on the ground that there is no evi-
3299 dence to show that prior to 1900 any of the dejecta of typhoid patients entered the drainage canal, as the canal, was not opened until 1900, and the evidence prior to that time was incompetent.

A. From my general sanitary knowledge, it is my judgment that the dejecta of typhoid fever patients would enter the sewage of Chicago—

GENERAL HAMLIN: That would or does, did you say?

A. That do, I say, enter the sewers of Chicago, and that under the assumptions mentioned, that the sewage of Chicago enters the Chicago Drainage Canal, or has entered the Chicago Drainage Canal since its opening, since January 17th, 1900, it is my judgment that the dejecta from the typhoid fever patients of Chicago enters via the sewers of Chicago, the Chicago Drainage Canal, or the Chicago River, and the Chicago Drainage canal.

G. C. WHIPPLE.

ADJOURNED until 10:00 A. M., to following day, May 14th, 1903.

RECORD

The State of Missouri

vs.

The State of Illinois

and

Sanitary District of Chicago

VOL. 3

72

S.6

IN THE

Supreme Court of the United States

THE STATE OF MISSOURI
vs.
THE STATE OF ILLINOIS
and
THE SANITARY DISTRICT OF CHICAGO.

Original,
Docket No.

Before
FRANK S. BRIGHT,
Commissioner of the Supreme Court of the United States.

VOLUME 3.

A—126½

VOLUME 3.

Southern Hotel, St. Louis, Missouri.
3300 10:00 A. M., Thursday, May 14th, 1903.
Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

THE COMMISSIONER: It appearing that two of the sheets in complainant's Exhibit No. 1 for identification were inserted by mistake, they are, with consent of the defendants, withdrawn from this exhibit, and said exhibit No. 1 for identification consists of 117 pages instead of 119 pages.

GEORGE C. WHIPPLE,

Resumed the stand for further direct-examination by Attorney General Crow, and testified as follows:

GENERAL HAMLIN: Are you through with the witness, Mr. Jeffries?

GENERAL CROW: The witness wishes to put in something that he did not have with him yesterday.

Q. Go ahead Mr. Whipple, and make the corrections or additions to your testimony that you wish to.

A. In my testimony yesterday, I did not have at hand the average amount of chlorine in the water of the Illinois river above Grafton for the period between October 30, and November 29, 1901, which I used in calculating the percentage of Illinois River water at various points in a cross-section of the Mississippi River at Alton. Upon consulting my notes I find that the average figure which I used was 20.3,—this figure being an average of the results of daily chlorine determinations given upon one of the sheets in complainant's Exhibit No. 1 for identification. Neither did I have the figure for the average chlorine in the water of the Mississippi River above Grafton for the same period, and upon consulting my notes I find that the figure which I used was 3.9 parts per million of chlorines. This figure being an average of daily determinations of chlorine 3301 given upon one of the sheets in complainant's Exhibit No. 1 for identification.

GENERAL CROW: Is that all the additions you wish to make?

A. Yes sir.

GENERAL HAMLIN: I move to exclude that answer or statement. Before I do that, though, I will ask a question.

Q. These sheets that you referred to Mr. Whipple, are the sheets that were prepared by Mr. Teichmann as you understand it?

A. I don't know who prepared the sheets.

Q. Do you know who made the figures that are in the sheets and who made the analyses shown by the sheets?

A. Not from personal knowledge, no sir.

3302 Q. Do you from any information that you have?

A. I have heard the testimony of Mr. Getz yesterday, and from that testimony I understood that these sheets were prepared by him and Mr. Miller, but I don't know that from personal knowledge.

Q. The original sheets, the sheets for identification?

A. I am speaking of the sheets in complainant's Exhibit No. 1 for identification.

Q. Well, those are not the tables that were testified to yesterday by Mr. Getz, are they?

A. I think he referred to those tables in his testimony.

Q. Yes, but the tables that he had were tables that were prepared by him and Miller from the sheets, as I understand, that you are referring to. I want to see if I am right about that.

A. From these sheets.

GENERAL HAMLIN: Isn't that a fact, Mr. Jeffries?

MR. JEFFRIES: No, this testimony that he is giving now has nothing to do with those smaller sheets that Mr. Getz testified to. It is simply drawn from the contents of those larger sheets contained in complainant's Exhibit 1 for identification.

GENERAL HAMLIN: That is the way I understand it.

GENERAL CROW: Those made under the direction of the men that have heretofore testified in this case—or made by the men.

GENERAL HAMLIN: You understand that those sheets are the results of examinations made by Teichmann and Keiser?

3303 A. That is what I understand—under the direction of Dr. Teichmann.

GENERAL HAMLIN: Now I move to exclude this statement or answer on the ground that it is a mere calculation testified to by this witness based upon tables that were not prepared by him and are not the subject of expert testimony.

GENERAL CROW: The answer to the motion to strike out is that these matters have been introduced in evidence, identified and the contents sworn to and proven by the men who did the work personally.

I want to ask another question or two of Mr. Whipple before we close the examination in chief.

Q. Mr. Whipple, assuming that since January 17th, 1900, a larger amount of the sewage of Chicago has entered the Desplaines and Illinois Rivers via the Chicago Drainage Canal, than was previously the case, and assuming that water of the Illinois river containing such sewage, enters the Mississippi River and passes to the intake of the St. Louis water works at the chain of rocks, what in your opinion, is the relative safety of the St. Louis water supply at the chain of rocks in the Mississippi River before and after January 17th, 1900, with reference to its use for drinking purposes?

GENERAL HAMLIN: That is objected to upon the ground that the proofs so far offered by the complainant fails to show the facts assumed in the question. 3304

A. Upon the assumptions named in the question it is my judgment that since January 17th, 1900, the water at the intake of the St. Louis waterworks, has been relatively less safe for drinking purposes than prior to that time.

GENERAL HAMLIN: I move to exclude that answer for the reason that the facts assumed in the question are not the facts as testified to by the complainant's witnesses and the records, so far.

Q. GENERAL CROW: Mr. Whipple, what, in your opinion, is the most dangerous kind of pollution of public water supplies derived from rivers, lakes, ponds or reservoirs, with reference to the safety of these waters for drinking purposes?

A. It is my judgment that the most dangerous kinds of pollution of such water supplies, are the dejecta and urine of human beings, such as are commonly found in the sewerage systems of cities and towns.

CROSS-EXAMINATION, by General Hamlin.

Q. Mr. Whipple, I was not here when you gave the major part of your testimony. As I understand, you have qualified as a chemist and bacteriologist, have you not?

A. Yes sir.

3305 Q. Of how manys years experience?

A. Fourteen.

Q. During that time you have been located at Brooklyn, New York?

A. Part of that time I have.

Q. How long at Brooklyn?

A. Since 1897.

Q. And before that time where?

A. Before that time at Boston.

Q. Now how many analyses of the waters of the Mississippi River above Grafton, have you made?

A. I would want to refer to that sheet that I submitted.

Q. You can refer to anything you choose.

A. May I see that sheet before I answer?

Q. Yes, get anything you want.

A. You said the Mississippi River above Grafton?

Q. Yes.

A. Seven.

Q. And when did you make them?

A. Between the dates of October 16th and November 26th, 1901.

Q. Where did you receive those samples?

A. At my laboratory in Brooklyn, New York.

Q. Have you made any other analyses except those that you have now mentioned, of the waters of the Mississippi

3306 River above Grafton?

A. A number of years ago I made certain physicial tests of the water of the Mississippi at Minneapolis.

Q. (Question repeated). I am speaking of analyses. Have you or have you not?

A. I ordinarily include under the general head of water analyses, such physical tests as that of the determination of color and turbidity.

Q. Speaking from a scientific standpoint, is that correct, that those are included under the head of analysis?

A. I consider such to be the case.

Q . So that you did, some years ago, make some, what you term physical tests, at Minneapolis?

A. Yes sir.

Q. How many years ago was that—to the best of your recollection?

A. Three or four years ago.

Q. Who assisted you in making those tests in Minneapolis, anyone living there?

A. No one, no sir.

Q. Was that on the occasion of some convention that was held there?

A. Yes sir.

3307 Q. Are you acquainted with Mr. P. M. Hall, of Minneapolis, who was Commissioner of Health, for the several past years?

A. I don't remember him, no sir.

Q. Do you know the name of the City Chemist at that time?

A. I don't remember it.

Q. You did know probably at that time, did you not?

A. My impression is that I met him, but I went to the—well I am unable to say.

Q. Did you make any test for sediment at that time?

A. No sir.

Q. For ammonia?

A. No sir.

Q. Chlorides?

A. No sir.

Q. Organic matter?

A. No sir, excepting as the organic matter may be included in the color of the water.

Q. Nitrates or nitrites?

A. No sir.

Q. Or total solids?

A. No sir.

Q. What was the condition of the samples that you received in October and November, 1901, at your laboratory when they came there?

3308 A. The samples were received in bottles which had cork stoppers and which were sealed. Is that what you mean by condition?

Q. Well, whatever you mean by condition. You are a better judge of that than I am.

A. Well, I will stop there.

Q. All right. Well, did you make a chemical analysis ot those samples?

A. No sir.

Q. Did you make a bacteriological examination, or whatever you may term it?

A. No sir.

Q. None whatever?

A. No sir.

Q. How many samples, if any, did you receive from the Illinois River, yourself, above Grafton, and when?

A. I received seven samples from the Illinois River at Grafton between the dates of October 16th and November 26th, 1901. I received five samples from the Illinois River at Beardstown—

Q. No, you are not answering my question. I would like to have you limit your answers to the questions. Read the question.

(Question read).

A. Well, those samples that I have mentioned are all above Grafton.

3309 Q. Well I mean immediately above Grafton; I don't mean any other point.

A. I received seven samples from the Illinois River at Grafton between the dates of October 16th and November 26th, 1901.

Q. From whom did you receive them?

A. From one or more collectors working under the direction of Dr. Ravold.

Q. Now what condition were they in when you received them?

A. The samples were received in glass bottles which had cork stoppers, and these bottles were sealed when received.

Q. Did you make any chemical analysis of those waters?

A. No sir.

Q. Any bacteriological examination?

A. No sir.

Q. Were those all of the samples above Grafton at the mouth of the Illinois, that you ever personally examined?

A. Yes, if you mean immediately above Grafton.

Q. I do. And the ones that you have testified that you received above Grafton on the Mississippi, are the only ones that you have personally examined?

A. Immediately above?

Q. Yes, immediately above?

A. Yes sir.

3310 Q. Now you say you received some samples further up the river—the Illinois River?

A. Yes sir.

Q. What place?

A. I received some from the Illinois River at Beardstown.

Q. When?

A. In the month of November, 1901.

Q. Who sent you those?

A. One or more collectors who worked under the direction of Dr. Ravold.

Q. Who is Dr. Ravold?

A. He is a physician who resides in St. Louis.

Q. What connection has he with this case, as you understand it?

A. I understood that at the time, when these samples were sent to me he was the consulting bacteriologist of the St. Louis Health Department.

Q. You understood that these samples that you received from the Illinois River and the Mississippi River above Grafton, were received for the purpose of your making an examination so as to enable you to be a witness in this case, did you not?

A. I think nothing was said definitely about my being a witness in this case at that time.

Q. Answer the question. Read the question. (Question read).

A. No sir.

3311 Q. Didn't you expect at that time to be a witness in this case?

A. I didn't consider the matter at that time.

Q. Didn't you have reason to believe in your own mind that you would be called upon to testify in this case?

MR. JEFFRIES: Objected to as incompetent and irrelevant.

GENERAL CROW: We object to it for the further reason that it does not matter what he had reason to believe so far as this case is concerned.

A. I did not.

GENERAL HAMLIN: When did you first know that you would be called as a witness?

A. I don't remember.

Q. About when?

A. Well, within a year.

Q. That is rather indefinite, Mr. Whipple, couldn't you locate it nearer than that?

A. Perhaps I may say within half a year; I don't remember just when.

Q. How many samples did you receive and from whom and when, of the waters of the Missouri River above its mouth?

A. I received five sample between the dates of October 16th and November 21st, 1901, from sample collectors who worked under the direction of Dr. Ravold, and who collected the samples at Fort Bellefontaine.

3312 Q. Did you make any chemical analysis of those samples?

A. No sir.

Q. Did you make any bacteriological examination?

A. No sir.

Q. You regard yourself, and you are regarded, are you not, in your judgment, as an authority on the chemical analysis of waters and the bacteriological examinations of waters?

A. Yes sir.

Q. Now when did you next receive, if you did receive, any samples from the Missouri River?

A. The next samples which I received from the Missouri River were those which were collected by Professor Van Ornum on April 12th, 1903?

Q. What year?

A. 1903,—the present year.

Q. And how many samples did you receive?

A. Three.

Q. Are those the samples that you received Mr. Whipple taken at different depths of the water in the Missouri?

A. Which samples do you refer to, the last three?

Q. Yes?

A. They were all taken at a depth of ten feet.

Q. Did you make any chemical analysis of those samples?

A. No sir.

Q. Any bacteriological examination of them?

3313 A. No sir.

Q. Did you receive, and if so, when, any samples of the Mississippi River water taken above the mouth of the Missouri —immediately above the mouth of the Missouri?

A. I received the samples already mentioned and in addition eight samples collected in a cross section known as section M, and which were collected by Professor Van Ornum on April 10, 1903.

Q. Who is Professor Van Ornum?

A. I understand that he is Professor of civil engineering in the Washington University of this city.

Q. And has testified as a witness for complainant?

A. Yes sir.

Q. Did you make any chemical or bacteriological examination of those samples?

A. I did not.

Q. Does that cover all the samples that you have ever received from that point?

A. Yes sir.

Q. Now, if you received any samples of the waters of the Mississippi River above that point and between that point and the Mississippi River just below Grafton, state when and where?

A. I received six samples of water from the Mississippi River at Alton, Illinois, which were collected between October 16th and November 21st, 1901.

3314 Q. That was in 1901?

A. I am not quite through with the answer.

Q. All right. Any time that I interrupt, you stop me and straighten it out.

A. And also twelve samples of the water of the Mississippi River above Alton, collected on November 12th, 1901.

Q. That is all, is it?

A. Yes sir.

Q. Now did you make any chemical analyses or bacteriological examination of those waters—of the samples, I should say?

A. I did not.

Q. Now if you received any samples of water from any point below the mouth of the Missouri, you may state when and where?

A. I received seven samples of the water of the Mississippi River at the Illinois shore opposite the chain of rocks, which were collected between October 15th and November 29th, 1901.

Q. Who did you receive them from—while you are stating that?

A. From collectors who were working under the direction of Dr. Ravold.

I also received eleven samples from the Mississippi River just above the chain of rocks, collected on November 10, 1901.

Also seven samples of water from the Mississippi River at the intake of the St. Louis water works, at the chain of rocks which were collected between October 15th, and November 3315 29th, 1901.

I also received twenty-four samples from the Mississippi River at a cross section which has already been described as series C, just below the mouth of the Missouri River, which samples were collected by Professor Van Ornum, on April 12, 1903.

I also received 33 samples of water from a cross-section of the Mississippi River which has been described as series I, just above the intake of the St. Louis waterworks, which samples were collected by Professor Van Ornum on April 10th, 1903. Those are all the samples.

Q. Who located that cross section I?

A. I understand that Professor Van Ornum did.

Q. And it is not at the intake, is it?

A. No sir.

Q. How far above it?

A. I think about a quarter of a mile.

Q. Don't you think it would have been a fairer test to have located that cross section at the intake?

A. That would depend upon what kind of a test is meant.

Q. Well I am speaking of the tests that you made?

A. I don't think it would be a much fairer test.

Q. Well you think it would be somewhat fairer, don't you?

A. Practically not.

3316 Q. Practically not?

A. Yes.

Q. Now these samples that you have mentioned, did you make any chemical analysis of these samples?

A. No sir.

Q. Nor any bacteriological examination?

A. No sir.

Q. Now I think you have given all the samples that you have received, have you not?

A. No sir.

Q. Well now, if any others, when and where,—in the Mississippi, the Missouri or the Illinois?

A. That is all I received from the Missouri River or the Mississippi River, but I received other samples from the Illinois river.

Q. Well, let us have them and when and from whom, and where?

A. I received six samples from the Illinois River at a point three miles above Peoria, which were collected between October 16th, and November 21st, 1901 and which were sent to me by collectors who worked under the direction of Dr. Ravold.

Q. Did you make any chemical analysis of those samples?

A. I did not.

Q. Not any bacteriological examination?

A. No sir.

Q. Now go right on?

3317 A. I received no other samples in any of the three rivers which you have named.

Q. Now you have given them all?

A. Those are all of the samples which I received from the Missouri river or the Mississippi River or the Illinois river.

Q. Yes? You received some samples from the tributaries of the Illinois?

A. Yes sir.

Q. Well now, I will ask you the general question as to the samples that you have received from the tributaries of the Illinois; did you make any chemical anlaysis or bacteriological examination?

A. No sir.

Q. Have you stated all now?

A. I have stated all the samples that I received from the three rivers you named, but I have not stated what samples I received from the tributaries.

Q. But you have stated on all that you did, you didn't make either any chemical or bacteriological examination of them?

A. Yes sir. I made no chemical or bacteriological examinations of any samples mentioned.

Q. Did you receive any samples from the Drainage Canal?

A. Yes sir. I received six samples from the Chicago Drainage Canal at the Bear Trap Dam at Lockport, which were collected between the dates of October 17th and November 3318 26th, 1901.

Q. Did you make any chemical analysis or bacteriological examination of those samples?

A. No sir.

Q. Any others on the drainage canal?

A. I received four samples which were marked, Paulina Street, and which are included in this sheet marked Chicago Drainage Canal, but I understand that these were collected from the Chicago river just before it enters the Chicago Drainage Canal. These four samples were collected between November 8th and November 30th, 1901, and were received from collectors who worked under the direction of Dr. Ravold.

Q. Have you received any other samples from the drainage canal or the Chicago River?

A. No sir.

Q. Any from Lake Michigan?

A. Yes.

Q. Where?

A. I received five samples from the Lake View crib, between the dates of November 4th, and November 22nd, 1901.

I received three samples from the Carter Harrison crib between the dates of November 6th and November 15th, 1901, and two samples from the Four Mile crib on November 20th and November 27th, respectively, 1901.

3319 Q. Is that all?

A. All of which samples were received from collectors who worked under the direction of Dr. Ravold.

That is all from Lake Michigan.

Q. Now did you make any chemical analysis or bacteriological examination of those samples?

A. I did not.

Q. What examination did you make?

A. Of the last samples mentioned, or all?

Q. All?

A. I made microscopical examinations of all of the samples mentioned, except those samples which were collected by Professor Van Ornum.

Q. I don't know whether that includes the three samples that you got from the Missouri river or not. Does it?

A. It does not include the three samples collected in the Missouri River on April 12th, which were collected by Professor Van Ornum.

MR. WOERNER: What year?

A. 1903.

GENERAL HAMLIN: Now why didn't you make chemical examinations of these samples and bacteriological?

A. Because I wasn't asked to do so.

Q. You could have made these examinations very easily, could you not? 3320

A. Yes sir.

Q. Now there are two kinds of vegetable growth that you mentioned that you found in the waters of Lake Michigan that you did not find in the Missouri River. (See if I state this correctly) and the Mississippi River above Grafton, and the tributaries of the Illinois; is that right?

A. I don't think I made that statement.

Q. Then just state it, without hunting up your testimony. I want to get started right on it.

A. I stated that there were two microscopic organisms,—vegetable plants, if you choose—

Q. Perhaps you had better name them right there?

A. Synedra and tabellaria, which were especially characteristic of Lake Michigan water, but not of the waters of the Missouri River or the Mississippi River above Grafton or the tributaries of the Illinois river.

Q. Right there now, Mr. Whipple, do I understand you to mean that those two do not exist in the waters of the Mississippi above Grafton,—those micro-organisms?

A. No sir.

Q. You don't mean that?

A. No sir, I don't mean that.

Q. Then they might be found, so far as you know, in the
3321 Mississippi River above the mouth of the Illinois?

A. They certainly might.

Q. And do you mean to say that they cannot be found or do not exist in the waters of the Missouri River?

A. No sir.

Q. Do you mean to be understood as saying that they do not exist nor cannot be found, in the tributaries of the Illinois?

A. No sir.

Q. Where do you generally find these micro-organisms especially?

A. You refer to these two?

Q. Yes, I refer to those two?

A. They are usually found in the waters of lakes, ponds or reservoirs.

Q. Now do you know how many lakes, if any, are situated on the Illinois River between Lockport and Grafton?

A. I don't know.

Q. You have no knowledge on that point, have you?

A. No personal knowledge, no sir.

Q .And you have no knowledge of whether or not there are any lakes or ponds that connect with the Mississippi River above Grafton?

A. No personal knowledge that I can recall at the moment.

Q. If there were lakes on the Illinois River between Lock-

3322 port and Grafton that connect with the Illinois River, you would expect to find those micro-organisms, wouldn't you?

A. They might be found there.

Q. Well, wouldn't it be reasonable to suppose that they would be found there?

A. At times, yes sir.

Q. And the same is true of the Missouri River and of the Mississippi river, isn't it, under the same conditions?

A. Yes sir.

Q. Now how much experience have you had as a chemist?

A. I have had charge of Mt. Prospect laboratory in the Brooklyn Water Department since 1897.

Q. Isn't that considered one of the principal laboatories in the country?

A. Yes sir.

Q. And how much experience have you had as a bacteriologist?

A. I have had charge of the laboratory mentioned and I have carried on bacteriological examinations in Boston from 1889 to 1897, and I have carried them on since that time up to the present date.

Q. Have you ever made any examinations of the waters of the Mississippi River below St. Louis?

A. No sir.

Q. Never examined it at New Orleans?

3323 A. Not to my recollection.

Q. Mr. Whipple, how familiar are you with the waterworks system of St. Louis?

A. I have seen the plant at chain of rocks, I have seen the pumping station at Baden; I have ridden along the conduit connecting the two. I have seen from the train the settling basins at Bissell's Point.

Q. Do you know how many settling basins they have here?

A. There are two plants.

Q. You don't know the number?

A. No sir.

GENERAL HAMLIN: How many are there General Crow?

GENERAL CROW: I really can't say; there are six I believe. There are six at the upper works and two at Bissell's point.

THE WITNESS: There are four at Bissell's Point and six at the chain of rocks.

GENERAL HAMLIN: That would make ten altogether?

A. Yes, counting each particular tank as a basin.

Q. What is the purposeof settling basins, for what purpose are they used?

A. To get rid of the mud.

Q. Any other purpose?

A. To get rid of the suspended mater in the water also.

3324 Q. What effect does it have upon the water itself?

A. What effect does it have?

Q. Yes, the use of settling basins.

A. It makes the water clearer.

Q. Anything else?

A. It makes the water freer from suspended matter.

Q. Does it purify the water?

A. Yes, to some extent, by the removal of matter in suspension.

Q. What do you consider the principal elements in the purification of water?

A. The removal of those substances which would render water impure.

Q. Has dilution anything to do with it?

A. If the water is diluted with another water which is purer than it is, it makes that first water purer.

Q. Has sedimentation anything to do with it?

A. With purification?

Q. Yes.

A. Yes, sedimentation ordinarily makes the water purer.

Q. Are dilution and sedimentation regarded by scientists and sanitarians as the two important elements in the purification of water?

A. They are regarded as two important elements.

3325 Q. Aren't they regarded by the authorities on the subject of sanitation and purification of water, as the principal elements?

A. No sir, I wouldn't say the principal elements.

Q. Would you say they were regarded as important elements?

A. In certain cases they are regarded as important elements.

Q. In most cities that use means for purification, aren' settling basins used extensively?

A. Yes, in cases where the original water contains larg amounts of suspended matter which would settle out during th process of sedimentation.

Q. What do you mean by natural water?

A. Any water found in nature.

Q. Is that the sense you used it in when the questions wer asked you yesterday as an expert?

A. I don't remember the particular question to which yo refer.

Q. You were asked some questions regarding sewage being discharged into natural water?

A. Yes, I meant in that sense. That is the sense in whic I intended it.

Q. And that is the sense in which you have used the ter during your entire examination is it, by the complainant?

A. Yes sir.

Q. Who prepared the expert questions which were aske you yesterday. Did you prepare any of them?

3326 GENERAL CROW: I don't like to object to that, but will say for your information without calling on the wi ness for it, that myself, Mr. Fuller, Mr. Whipple and the othe gentlemen jointly got those questions up.

GENERAL HAMLIN: I don't regard it as improper at a for Mr. Whipple to have perpared the questions.

GENERAL CROW: I don't regard it improper for anyo to have prepared the questions.

GENERAL HAMLIN: Nor I; only I want the fact.

GENERAL CROW: You have the facts now. It can g into the record as my statement. If you insist on the witne answering it I will not object, but I do not think it is right, wit all due respect to you.

GENERAL HAMLIN: I think it is proper, General,—not impugning any motive of Mr. Whipple's which I expressly deny, because Mr. Whipple in his testimony has been fair on the basis on which he has given it, but as to the character of the questions submitted to him, that's all.

Q. I will ask you if you prepared them?

A. I didn't prepare them all.

Q. Did you prepare those that refer to the typhoid fever?

A. I may have assisted, but I don't think I prepared them all.

Q. You did prepare some of them.

A. Some of them I did not prepare.

3327 Q. You did prepare some of them?

A. Some of them I did not prepare.

Q. And some you did, did you?

A. In some of them I assisted.

Q. Did you prepare any of them yourself absolutely, all of them or any one entire question?

A. I don't think I did.

Q. When you testified to the per cent of chlorine found in the Mississippi above Grafton—you did testify to that, didn't you?

A. Not expressed in percentage.

Q. I thought you gave the percentage there?

A. Not the percentage of the chlorine.

Q. What was it?

A. I used an average figure in my testimony taken from the sheets of complainant's exhibit 1 for identification which gave the amount of chlorine in parts per million.

Q. And you took the average, did you?

A. Yes sir.

Q. And then you took the average of chlorine in the Illinois River above Grafton, as I remember it?

A. Yes sir.

Q. And then you took the average chlorine at what point below Grafton?

3328 A. At five points in the cross section of the Mississippi River at Alton and Hartford.

Q. Now for what purpose did you use that, for the purpose of showing the mixing of the waters of the Illinois and the Mississippi?

A. Yes sir.

Q. Why didn't you adopt the same plan of using the solids instead of the chlorines?

A. Because there were no determinations of the total solids on those sheets.

Q. There were not?

A. No sir.

Q. There was no determination of solids in the Illinois River above Grafton?

A. There were such determinations there.

Q. Why—but none above Grafton in the Mississippi?

A. There were such determinations there.

Q. Why couldn't you use that?

A. Because there were no corresponding determinations at the five points in the two cross-sections at Alton and Hartford?

A. There were no determination of solids at all for those points.

A. No sir.

Q. On those tables?

3329 A. No sir, not upon the tables which I referred to.

GENERAL CROW: The solids were not determined in the cross-sections.

GENERAL HAMLIN: Wasn't there a determination of the solids at Alton and Hartford?

GEGNERAL CROW: Not in the cross sections.

GENERAL HAMLIN: I don't mean the cross section. My recollection is from Teichmann's testimony, that's all. Do yor know Mr. Whipple?

A. I don't recollect.

Q. Well, if there had been determinations of solids at those points wouldn't it have been a better and more correct test than to use the chlorines?

A. Yes, if there had been a greater difference between the total solids in the Illinois River at Grafton and the Mississippi

River above Grafton than was the case with the chlorines.

Q. Well do you select the greatest difference as the best test, without regard to anything else?

A. Well, that is one of the reasons for selecting these, but the accuracy of the determination should also be considered in picking out the ones which should give the best results.

Q. You stated yesterday, I think, to Mr. Jeffries, that the best test, that is, the most reliable test, is the test made with the solids?

3330 A. I consider it to be such for the particular case which is being discussed. I wouldn't lay that down as a universal proposition.

Q. Well, do you consider that one standard of tests is to be adopted at one place and another standard at another place, and another standard at another, where you are dealing with the same waters and the same rivers practically, at the same points or nearly so?

A. It might be so.

Q. How would you consider that?

A. It would depend upon each individual case.

Q. Well the individual case here is the condition of the water at the intake of St. Louis, isn't it?

A. The individual case which was discussed yesterday where I made the statement that the total solids was the best test, was the case where we compared the waters of the Mississippi river and those of the Missouri river with the water of the intake at the chain of rocks.

Q. Don't you think, Mr. Whipple, it would be a fairer test, if you had sufficient data, to employ the same tests from the Mississippi river at Grafton, the Illinois at Grafton and the river between Grafton and the mouth of the Missouri, and the mouth of the Missouri to the intake?

A. It would depend upon what those data showed.

3331 Q. Please answer this question by yes or no.

GENERAL CROW: I desire to interpose an objection to counsel asking a question and instructing the witness what to answer, and submit the witness has a right to answer the question in any manner he sees proper, that is responsive to the question.

A. The question is not sufficiently intelligible for me to answer Yes or No.

Q. GENERAL HAMLIN: Doesn't the question embrace "that if you had sufficient data?"

A. The question is still sufficiently unintelligible for me to answer "Yes" or "No."

Q. Do you say as an expert that that question is not sufficiently intelligible to you as such an expert, that you can answer "Yes" or "No," and then make such explanation hereafter as you choose to make?

A. The question is sufficiently not intelligible for me to answer Yes or No?

Q. Can you answer Yes or No to that question?

A. Not without explanation.

Q. How far below the mouth of the Illinois river at Grafton do you say that there is any mixing of the Illinois with the Mississippi River?

A. I believe that such a mixing of the Illinois River with the waters of the Mississippi was evident at Alton.

3332 Q. How far is that from Grafton?

A. I don't recollect; I should have to look it up in some references.

GENERAL HAMLIN: Does anybody know here?

GENERAL CROW: Somewhere from twelve to eighteen miles, I think about sixteen miles.

Q. Assuming that it is fifteen miles, you may state if you know, the condition of the banks, the right and left bank between Grafton and Alton.

GENERAL CROW: The condition with reference to what, General?

GENERAL HAMLIN: I mean how the banks are with reference to the river?

A. I have never seen the river in that region, but from my recollection of the charts I believe the banks to be very nearly parallel with each other and very nearly in a straight line, barring slight irregularities. I am speaking now in very general terms and I should want to consult the chart before giving it in detail.

Q. You are not prepared to say then whether there are any curves in these banks between Grafton and Alton, or not?

A. My recollection is that there are no important curves.

Q. You say that you think there is a mixing of the waters of the Illinois and Mississippi at Alton?

A. I think that the Illinois river water mixes with the water of the Mississippi by the time it reaches Alton, to
3333 some extent.

Q. To some extent?

A. To some extent, yes sir.

Q. And that you understand to be about fifteen miles away from where the rivers unite?

A. As I said, I don't recollect exactly, but in a general way I believe that is about the fact.

Q. How far is it from the mouth of the Missouri River to the St. Louis intake?

A. I think it is about six miles.

Q. In your examination you stated: "From my general knowledge of the subject of rivers and the effect of curves on the currents of these rivers, it is my opinion that this curve which I have described (referring to a curve on the map or chart which you had in front of you) in the Mississippi river, between the mouth of the Missouri river and the intake of the St. Louis waterworks would tend to allow or would increase, or would be favorable to the mixture of the waters which come down the Mississippi river and the Missouri river." Now which one of those statements do you wish to adopt, "Would tend to allow, or would increase, or would be favorable?"

A. I think they are all applicable.

Q. That they mean the same?

A. No sir, I don't think they mean the same, but I think
3334 they are all applicable.

Q. Then you wish to stand by all of them?

A. Yes sir.

Q. Now at what point would that mixture you speak of, take place the most rapidly?

A. I should say in that part of the curve where the central thread of the main channel crosses from the position near the left bank to a position near the right bank.

Q. Where is that point?

A. I should have to refer to that map to give that.

Q. Locate it if possible, with reference to the mouth of the Missouri river by distance.

GENERAL CROW: Do you want to add that to your question?

GENERAL HAMLIN: That is proper to add to that question.

A. When I used the word "point" I did not mean a geometrical point; I meant a place.

Q. Well, where is that place?

A. That place is from one to two and a half miles below the southern point of the mouth of the Misouri river.

Q. How wide is the river at that point or place?

A. At the place where that region, or where that place begins, the Mississippi river is something more than a quarter of a mile wide.

Q. Now at this point that you speak of, as you go towards St. Louis, doesn't the left bank bear to the east and south?

3335 A. No sir, not to the east and south.

Q. What direction does it?

A. To the southwest approximately.

Q. How far before it turns towards the east and south?

A. A considerable distance below the city of St. Louis.

Q. You have no actual knowledge in regard to the currents at the different stages of the water, nor any actual knowledge of the mixing of these waters from any personal observation to any extent, and you are simply stating, or rather you are arriving at your conclusions from the curves alone, are you not?

A. I think I stated that my answer was based upon my general knowledge of the currents in rivers which had curves, and my knowledge of these curves as obtained from this Government chart.

Q. But you have no actual knowledge from any observations covering any considerable length of time as to currents, volume of water, and the mixing of the waters of the Missouri and Mississippi, other than your general knowledge of rivers and what this government chart shows with reference to the curves?

A. Not from any personal observations of the currents in the rivers, covering any considerable length of time.

Q. How far is it from Lockport by the Illinois River, to Peoria?

3336 **A. I don't recollect. I should have to consult some memoranda.**

Q. (Question repeated)?

A. About 130 miles.

Q. How far from Peoria to Grafton?

A. 161 miles.

Q. How far from Grafton to the mouth of the Missouri, if you know?

A. I think it is about 23 miles.

Q. And how far from the mouth of the Missouri to the intake?

A. About six miles.

Q. How far from Peoria to Beardstown?

A. About 74 miles.

Q. In the statements of the population made by you in your examination in chief, did you state the population of the watershed of the Illinois river?

A. Not the total population, no sir.

Q. What did you state in regard to the watershed of the Illinois river in regard to population?

A. I will look it up in the testimony.

Q. I will ask another question while that is being looked up in the testimony. The population when discussed and considered by scientists, you say is limited to the population 3337 of cities and villages of 4,000 and upwards?

A. No sir, I wouldn't say it was limited to that.

Q. Didn't you say that was the figure that scientists adopted?

A. They sometimes adopt it, yes sir.

Q. Didn't you make the statement that scientists used that arbitrary figure as the one upon which they based their research, and upon which they would arrive at any given conclusion, where population becomes an element to be considered?

A. That is one upon which they reach a conclusion, but it is not the only one. I don't think I conveyed that impression.

Q. Isn't it true that among all authors upon sanitary questions, that the population of the watershed instead of being based upon populations of 4,000 and above is based on what is known as the urban population; that is contiguous to the stream or the watershed and the rural population of the watershed?

A. It is not true that all authors use the amount of urban population and the amount of rural population instead of the population of cities which have more than 4,000 inhabitants.

Q. Don't you think that where the pollution of a stream is involved, that the rural population is an element that should be considered on the question of the discharge of sewage into that stream?

3338 A. I think that should be considered, yes sir.

Q. Do you know what the rural population of the Illinois watershed is?

A. Not from my recollection.

ADJOURNED until 2:00 P. M. same day, Thursday, May 14th, 1903.

3339 Southern Hotel, St. Louis, Missouri, 2:00 P. M., Thursday, May 14, 1903. Parties met pursuant to adjournment. Present the Commissioner and same counsel representing the respective parties.

GEORGE C. WHIPPLE,

resumed the stand for further cross-examination by General Hamlin, and testified as follows:

Q. Do you know what the rural population of the Illinois watershed is?

A. I find from the report of Jacob A. Harman, included in a report of the Illinois State Board of Health, on sanitary investigations of the Illinois river and its tributaries, 1901, on page 119, that the total rural population of the Illinois River drainage basin in the year 1900 was 893,723.

Q. That is outside of Chicago?

A. Yes sir, that does not include Chicago, but only the natural drainage area of the Illinois river.

Q. And only the rural population?

A. And what he has called the rural population.

Q. Do you know what the urban population is, outside 3340 of Chicago, in the same drainage basin?

A. In the same report and on the same page to which I have referred, I find it stated that the urban population for the same region for 1900 was 617,664.

Q. Do you know how many creeks, rivers and tributaries there are to the Illinois river, having their watershed drain into the Illinois river?

A. I don't remember exactly, but I can tell by consulting a map of the stream.

Q. I will ask you if it is not a fact that the creeks, rivers and tributaries of the Illinois river, having their watershed drain into the Illinois river, is not about 25,000 miles?

A. Do I understand you to mean that the watersheds of the various rivers, creeks and streams have a total watershed of about 25,000 miles?

Q. No, has 25,000 miles of creeks, rivers and tributaries, draining portions of Indiana, Wisconsin and a large part of Illinois, into the Illinois River, which empties into the Mississippi near Grafton?

A. Unless we include the Chicago drainage canal as a tributary—

Q. No, I am not including that. Exclusive of the Chicago River, the Illinois and Michigan Canal and the Chicago Drainage Canal.

3341 A. Kindly repeat the question again.

Q. I will ask you if exclusive of the Chicago River and the Illinois and Michigan Canal and the Sanitary District Canal, if there are not about fifty creeks, rivers and tributaries to the Illinois River having their watershed drain into the Illinois River, making about 25,000 miles of creek, river and tributary draining portions of Indiana, Wisconsin and a large part of Illinois, into the Illinois River, which empties into the Mississippi River near Grafton?

A. I think that statement is approximately correct, but I find on page 120 of Mr. Harman's report, to which I have alluded, that the area of the watershed of the Desplaines river, the Kankakee river, the Fox river, the Vermillion river, the Mackinaw river, the Spoon river, the Sangamon river, Crooked Creek, McKee's Creek, Macoupin Creek, and a number of small tributaries not mentioned by name, that the sum of these drainage areas equals 27,914 square miles, and I have a memorandum made from the eleventh United States census which states that the drainage area of the Illinois river was 29,013 square miles, and another memorandum taken from the report of the chief of the Weather Bureau, from 1896 to 1897, which states that the drainage area of the Illinois river was 29,150 square miles.

Q. In my question I was not referring to the area or 3342 number of square miles but to the number of miles of the Illinois river and its tributaries, exclusive of the Illinois and Michigan Canal, the Chicago River and the Drainage Canal?

A. Do you mean the number of lineal miles up and down the streams?

Q. Yes sir?

MR. JEFFRIES: The first question, as I understood it, did not include the Illinois river, but only its tributaries and their tributaries?

GENERAL HAMLIN: No, I mean the Illinois River—to 25,000 miles of Illinois River and its tributaries, exclusive of the Chicago River, the Illinois and Michigan Canal and the Drainage Canal—if there is not that many miles of creek and river?

A. I have no personal knowledge of that fact.

Q. You don't know then?

A. I don't know that there are 25,000 lineal miles of river.

Q. In the statement from which you have read in your answer to the former question, did you include the Kankakee River?

A. In speaking of the drainage area in square miles?

Q. Yes, you had it there on a slip of typewritten paper in which you gave the list of tributaries.

A. I understand that that is included.

Q. Did you give the Kankakee?

A. No sir, there was no reference to the Kankakee river
3343 on this typewritten piece that I have here.

Q. Did you intend to include the Kankakee in your statement that you made in the answer to the former question?

A. When I read from this typewritten paper that the drainage area as taken from the Eleventh census of the United States was 29,013 square miles, I understand that that does include the area of the Kankakee river.

Q. And its tributaries?

A. Yes sir.

Q. You don't know that that is true from your own knowledge, or from any examination that you have made?

A. From the statement that that was the watershed of the Illinois River and inasmuch as the Kankakee river drains into the Illinois River, I assume that that is included.

Q. Do you know where the source of the Kankakee River is—in what state?

A. I guess I will have to refer to that map. (Witness refers to map).

Q. (Question repeated)?

A. In the state of Indiana.

Q. Do you know how many tributaries it has?

A. I don't know exactly, but upon the map which accompanies, or which forms a part of the report of the State Board of Health—of the Illinois State Board of Health on the sanitary investigation of the Illinois Rivers and tributaries for
3344 1901, I find depicted about twenty of those tributaries.

Q. Of the Kankakee?

A. Of the Kankakee river.

Q. How many tributaries are there to the Illinois River, exclusive of the Illinois and Michigan Canal, the Drainage Canal and Chicago River, in number, if you know?

A. I can't state exactly the number of tributaries which flow into the Illinois River, but on the map of the Illinois river and of the Illinois and Michigan Canal—

Q. I have excluded that.

A. I know, but I am simply naming the title of the map.

Q. Well, that wouldn't answer my question.

A. But on a map of the Illinois River and of the Illinois and Michigan Canal, reduced from maps showing surveys of Lieutenant Colonel J. H. Wilson, in 1867, under the direction of Captain C. J. Lydecker, of the corps of engineers, I have counted more than 50 tributaries which flow into the Illinois River.

Q. Is there anything that shows the number of miles now of those tributaries, including the Illinois, exclusive of the Chicago River, the Drainage Canal and the Illinois and Michigan Canal?

A. There is nothing upon this map which shows the lengths of those tributaries.

Q. Then as to whether there is 25,000 miles in length of
3345 them, you don't know, from either anything that you know personally or from any maps or reports that you have access to; is that what you mean to say now?

A. I don't know it from any personal knowledge, or from any maps or reports which I have seen.

Q. And you don't know the rural or urban population comprised within the territory of the Illinöis River and the tributaries about which I have just asked you, first, of your own personal knowledge, or from any investigation that you have personally made?

A. I don't know the rural population dwelling upon the Illinois river, and its tributaries, exclusive of the Chicago Drainage Canal, from personal knowledge, as I have never counted the inhabitants. I know them simply from the report to which I have referred, namely, that of Mr. Jacob A. Harman, in which he states that the rural population upon that watershed is 893,723.

Q. That report does not undertake to give the urban and rural population of all the tributaries of the Illinois River, does it, outside of the Chicago River, Illinois and Michigan Canal and Drainage Canal?

A. When you say this report, do you mean this particular table in this report?

Q. I mean that report that you have referred to?

3346 A. You mean the report of Mr. Harman of this—

Q. Yes sir.

A. I think it does not.

Q. Well, it is impossible for you to say, is it not, how much sewage is discharged into the Illinois River and its tributaries, outside of the Illinois and Michigan Canal, the Drainage Canal and the Chicago River?

A. It is impossible for me to say.

Q. It is impossible for you to say, is it not, how much water reaches the Illinois River from its tributaries, exclusive of the Drainage Canal, the Illinois and Michigan Canal, and the Chicago River?

A. It is impossible for me to say exactly, but it would be possible to obtain an approximate idea by comparing the relative drainage areas of the tributaries of the Illinois River, with the drainage area of the Illinois river above some point in that river, as for example, at Peoria, Illinois, where there are data on record which give the discharge of the stream of the Illinois river at that point.

Q. What do you say about Grafton?

A. Well, what about Grafton?

Q. As to the same plan to be pursued at Grafton, whether you could tell or not?

A. As to whether I am able to state, do you ask me
3347 whether I am able to state—whether I can state the discharge of the Illinois River at Grafton—the amount of water discharged?

Q. The amount of water carried into the Illinois River from its tributaries?

A. I am unable to state that exactly, but I can make an approximate calculation of the amount of water there discharged by comparing the drainage area of the Illinois River above Grafton, with the drainage area of the Illinois River above some point such as Peoria, where data in regard to the discharge of water are known, and where the drainage area of the Illinois river above the point is known, making due allowance for any flow of water that might enter from the Chicago Drainage Canal.

Q. Well, you haven't made these calculations at all, have you Mr. Whipple?

A. (Witness refers to charts).

Q. Just answer the question whether you have or not, first.

A. I have personally made one or two such calculations.

Q. You have not made any such calculations that you would say would be reliable, covering a period of six months or a year, have you?

A. I have not made such calculation personally—

Q. Well, that answers the question.

3348 THE WITNESS: I haven't finished my answer.

Q. Well, I don't care to go into it unless you want to go into it. You can put that in on re-direct. My idea is to limit the inquiry.

GENERAL CROW: I suggest that you have no right to shut the witness off in his answer.

GENERAL HAMLIN: I will insert the word "personally" there in that question.

Q. (Question read as follows:) You have not personally made any such calculation that you would say would be reliable, covering a period of six months or a year, have you?

A. No sir, but I have personally directed the preparation of certain memoranda, from which such calculations can be made.

Q. From what period?

A. From a period from August, 1899, to October, 1900, inclusive.

Q. You have no means of telling with any degree of certainty, the amount of sewage discharged into the Illinois River exclusive of the Chicago River, the Illinois and Michigan Canal, and the drainage district, have you?

A. No sir.

Q. When you speak then of the typhoid bacillus reaching the intake at the city of St. Louis, if such a thing should 3349 occur, you have no means of knowing or saying where such typhoid bacillus would come from, have you?

A. I couldn't say definitely.

Q. You couldn't say with any certainty, could you?

A. I couldn't say certainly, without comparing the population which drains into the Chicago Drainage Canal, and thence into the—I will say the sewered population which drains into the Chicago Drainage Canal and thence into the Illinois River, with the rest of the sewered population on the watershed of the Illinois River and its tributaries, and the Mississippi river above the Illinois River and the Missouri river.

Q. Well, Mr. Whipple, you are an expert are you, on typhoid fever germs?

A. Yes sir.

Q. Now as such an expert, if typhoid fever germs were discharged into the Mississippi river at Alton, or the Missouri river at St. Charles, on the Missouri River; wouldn't they more likely reach the intake than if discharged into the stream say 300 miles away—the streams that compose the Mississippi River before it reaches the Intake?

A. That would depend upon a series of conditions, among which would be included the number and character of the typhoid bacilli discharged; the distance of the point of discharge from the intake of the St. Louis Waterworks, along the water courses; the manner in which the several streams mentioned become mixed before the water reached the intake of the St. Louis waterworks, and the character of the water into which the typhoid fever bacilli were discharged.

Q. Assuming the conditions of the various streams of water about which you have testified, would a typhoid bacillus discharged in the water at Alton or St. Charles, be more likely to reach the intake at St. Louis, than it would if discharged into any one of these streams 350 miles away?

GENERAL CROW: Now we object to the question for this reason, that it does not state the conditions under which the bacilli are supposed to enter the water at either place, neither as to time nor manner, nor does it state any conditions with reference to the location of the St. Louis waterworks so far as distance is concerned, from the same.

MR. JEFFRIES: Nor does the assumption state the condition of the respective waters about which the assumption is made.

THE WITNESS: Now read my answer to the next to the last question, if it is proper.

GENERAL HAMLIN: I don't see how you could do that. You are an expert; the question is plain.

GENERAL CROW: Well, he has a right to do that if he wants to. You have no objection to him looking at the answer, have you?

3351 GENERAL HAMLIN: No, that is no way for a man who is competent, to do. If it was in a Court, it would not be permitted.

GENERAL CROW: Yes, I think it would. I don't know of any rule of law what would exclude it.

GENERAL HAMLIN: I have no objection, if he wants to look at it.

THE WITNESS: Well, never mind. Leave that out. You might read the last question again.

Q. (Last question read)?

A. I have not testified to enough of the conditions mentioned to enable me to answer the question.

Q. GENERAL HAMLIN: Assuming the conditions of the various streams composing the Mississippi river at the intake at St. Louis, as you understand them, would a typhoid bacillus discharged into the Missouri River at St. Charles, Missouri, or at Alton on the Mississippi River, more likely reach the intake at St. Louis than a typhoid bacillus discharged in the water of any of these streams 350 miles away from the intake?

A. Now I would like to have that question read again, to refresh my memory.

Q. (Question read).

A. In so far as the question of distance alone, is concerned a typhoid fever bacillus would reach the intake of the St. Louis Waterworks from St. Charles, Missouri, or from Alton, Illinois more easily than a typhoid bacillus of equal vitality in-
3352 troduced at a distance of 350 miles from the intake of
the St. Louis Waterworks; but whether or not a typhoid bacillus discharged at St. Charles or at Alton would actually reach the intake of the St. Louis waterworks more easily than a typhoid bacillus of similar vitality, discharged at a distance of 350 miles from the intake, would depend among other things upon the degree of mixing of the waters into which the bacilli were discharged, before they reached the intake of the St. Louis waterworks, and to some extent perhaps, upon the character of

the water into which the bacillus which was introduced at a distance of 350 miles from the intake of the St. Louis waterworks, was introduced.

MR. TODD: What was the last part of that answer?

(Answer read).

THE WITNESS: Just wait a minute; perhaps I have not finished my answer.

GENERAL HAMLIN: Go ahead, you can have all the time you want, as far as that is concerned.

THE WITNESS: Just read the first part of that answer again.

(Answer read.)

A. (continuing) And it would depend still further upon the velocities of the streams into which the bacilli were discharged at the three points mentioned.

Can I change the first part of that answer some?

3353 GENERAL CROW: Yes, change it to suit yourself?

GENERAL HAMLIN: Let the answer stand as originally given, though, and give the new asnwer.

GENERAL CROW: No, he has a right to answer this question as he pleases.

GENERAL HAMLIN: Oh, he has to give another answer.

GENERAL CROW: But he has to sign his testimony. You don't undertake to say that if a man wants to correct his answer, that he can't do it.

GENERAL HAMLIN: No, the point is this; that the answer stands, but if he makes a correction, both the answer and the correction should be shown.

GENERAL CROW: No, I don't understand that. If he doesn't want a thing to go in as an answer, he don't have to put it in. In other words, he don't have to put in anything that he does not want to put in.

GENERAL HAMLIN: We don't put anything into his mouth.

GENERAL CROW: But when he wants to change the answer; he can do so.

GENERAL HAMLIN: When you put the testimony in before the Court, you are right, of course, but where you have no power of objection and no power of passing upon a question, then the record must show what actually takes place. That is the rule.

GENERAL CROW: (To witness) I don't suppose you care whether it goes in or goes out?

3354 THE WITNESS: As long as I get my answer in, I don't care. I was simply going to say in the first part of the question that which I did reserve to the last part.

GENERAL CROW: Well, just start in and answer it again, if you want to.

THE WITNESS: Do you mean that I should start and answer the question all over again?

GENERAL CROW. If you wish to, perhaps that would be better, to get it connected.

THE WITNESS: Read the question again.

Q. (Question read).

THE WITNESS: Will you read my original answer?

(Answer read).

THE WITNESS: I guess I will let that stand.

Q. GENERAL HAMLIN: If it depended on velocity, the one nearest the intake would reach the intake first, wouldn't it?

A. Provided the velocities of the streams were such that the one which was nearest the intake got the shortest time of transit.

Q. Well, Alton is nearer the intake than a point 350 miles away, isn't it?

A. In so far as that flow is concerned, as I understand it.

Q. Well, that disposes of velocity. Now so far as the vitality is concerned, do you want to be understood that a typhoid bacillus with equal vitality at Alton, and starting on his journey to the intake, with one of equal vitality 350 miles away, that one would be as liable to reach the intake as the other, and still maintain their vitality? 3355

A. Now will you read that question again?

Q. (Question read).

A. I do not understand that question.

Q. Well, it is plain.

A. I don't think it is. Will you kindly read it again?

Q. (Question read).

A. If, by vitality, you mean the ability to resist external conditions, that would depend upon the relative character of the water into which the bacillus was introduced at Alton, and the water into which the bacillus was introduced at a distance of 350 miles, and the time required for the bacillus to travel from Alton to the intake of the water works, as compared with the time required for the bacillus to travel from a point 350 miles away to the intake of the waterworks.

Q. That is your answer?

A. That is my answer.

Q. What is the area of the watershed of the Mississippi river above Grafton, the Missouri river and the Illinois river exclusive of the Illinois and Michigan Canal, the drainage canal and the Chicago river?

3356 A. From the memorandum which I have I read that according to the Eleventh census of the United States, the drainage area of the Missouri river was about 527,000 square miles, while the drainage area of the Missouri river according to the report of the Chief of the Weather Bureau for 1896 and 1897, was about 527,150 square miles; that the drainage area of the Mississippi river above Grafton, according to the Eleventh United States census was about 143,512 square miles, while according to the report of the Chief of the Weather Bureau for 1896 and 1897, it was about 126,750 square miles, while the drainage area of the Illinois river, exclusive of the Chicago drainage Canal and the Illinois and Michigan Canal—that's the way you worded it isn't it?

Q. Yes, and the Chicago River?

A. Was, according to the Eleventh United States census about 29,013 square miles, while according to the report of the chief of the Weather Bureau for 1896 and 1897, it was about 29,150 square miles.

Q. Making a total of how much, exclusive of the Chicago River, the Illinois and Michigan Canal and the Drainage Canal?

A. Making a total for the three watersheds of the three rivers mentioned, and excluding the canals named, of 699,525 square miles, according to the figures of the Eleventh United

States Census, and 693,050, according to the Chief of the Weathe Bureau for 1896 and 1897.

3357 Q. What is the urban population of this drainage area, exclusive of the Illinois and Michigan Canal, the drainage canal and the Chicago River?

A. When you state "this drainage area," do you mean th total population of the three?

Q. Yes, the urban population?

A. You mean the sum of the three?

Q. Yes?

A. If, by urban population we include the population onl of those towns and villages and cities which contain more tha 4,000 inhabitants, I find on page 27 of the report on the wate supply of the City of St. Louis, by the Commission of Hydrauli Engineers, dated 1902, that the aggregate urban population o the three watersheds mentioned in the last question was, according to the United States Census of 1900, 2,694,738.

Q. Now, if to that you add the rural population in thi basin that is contiguous to those watersheds or the streams tha connect with those various rivers, exclusive of the Illinois an Michigan Canal, the drainage canal and the Chicago river, wha do you find it to be?

A. Read me that question.

Q. (Question repeated).

A. I will have to have the question repeated again.

Q. (Question repeated)?

3358 A. I am unable to state because I don't know what th rural population referred to is.

Q. I will get you to state if it is not a fact that in this are of these three rivers that you have mentioned, that is within thes drainage basins, exclusive of the Chicago River, the Illinois an Michigan Canal and the Drainage District, if the population, according to the United States census, was over 12,000,000?

A. Read me that question.

Q. (Question read).

A. I don't know, as I haven't made any estimate of such population.

Q. Have you tried to ascertain as to this population o these drainage basins about which you have just been asked, exclusive of the Chicago river, the drainage canal and the Illinois and Michigan Canal?

A. Repeat the question.

Q. (Question repeated)?

A. I have not tried to estimate the total population. Repeat the question.

Q. (Question repeated)?

A. I have not tried to ascertain it.

Q. You do know that the Platte is a tributary of the Missouri River, don't you?

3359 A. Yes.

Q. And that Denver is located there?

A. Yes sir.

Q. Do you know where the towns of Bismarck, Pierre, Sioux City, St. Joe, Kansas City and Jefferson City are? They are all on the Missouri River, aren't they?

A. I guess you will have to name that list again.

Q. Bismarck, Pierre, Sioux City, St. Joe, Omaha, Kansas City and Jefferson City?

A. Do you mean Kansas City, Kansas, or Kansas City, Missouri?

Q. Both?

A. Is that the list?

Q. Yes.

A. (No answer).

Q. Well, you know that Minneapolis, St. Paul, LaCrosse, Galena, Rock Island—

A. Shall I answer the other question?

Q. I don't care to take up time with it. Those are prominent towns on the Missouri river.

GENERAL CROW: We will admit they are there of course.

GENERAL HAMLIN: Minneapolis, St. Paul, LaCrosse, Galena, Rock Island, Davenport, Burlington, Quincy and Keokuk, are on the Mississippi river above Grafton, are they not?

A. Yes sir.

Q. While on the Missouri River and its tributaries, there

3360 is an innumerable number of towns ranging from 500 to 4,000 people are there not?

A. I have no doubt there are towns ranging from 400 to 5,000 people, but I wouldn't say they are innumerable.

Q. You don't know?

A. (No answer).

Q. Now assuming that the population of these three drainage basins of the Illinois River, of the Missouri River and of the Mississippi river above Grafton, exclusive of the Illinois and Michigan Canal, the drainage canal and the Chicago river is, according to the United States census of 1900, over 12,000,000, what would be the proportion that the population of the sanitary district of Chicago and the towns tributary to the Illinois and Michigan Canal above Lockport and the Drainage Canal, bear to such population?

GENERAL CROW: Now do you mean included in the drainage area of the Chicago Canal?

GENERAL HAMLIN: No sir.

THE WITNESS: Repeat the question.

GENERAL CROW: You do not mean, included?

GENERAL HAMLIN: No, I am talking about the population.

Q. (Question repeated)?

GENERAL CROW: You said population in the drainage area of the drainage canal.

3361 THE WITNESS: You may want to include that, but perhaps we had better have the question read again.

GENERAL HAMLIN: I will change that, to the population of the Sanitary District of Chicago.

Q. (Question read as amended).

A. It would be about 13.6 per cent if we assume that the total population of the Sanitary District is 1,639,456, according to the United States census, which figure I am reading from some memorandum prepared by Mr. Benezette Williams.

Q. Assuming that based upon the population given in the former question, that the sewage discharge from the population into the Missouri river, from the basin of the Missouri river, and of the population of the basin of the Mississippi river above

Grafton, and of the population in the basin of the Ilinois river, exclusive of the Illinois and Michigan Canal and the Drainage Canal above the Bear Trap Dam, and the Sanitary District, what would be the percent of sewage discharged by the sanitary district, the Illinois and Michigan Canal above the Bear Trap Dam and the Drainage Canal, as compared with the sewage discharged into the Missouri river from the population of the Missouri river basin, and the population of the Mississippi river from the Mississippi river basin above Grafton, and the population of the basin of the Illinois river, exclusive of the Illinois and Michigan Canal, the Drainage Canal and the Chicago River?

3362 A. Read that question.

GENERAL CROW: Now we want to interpose an objection to that question for the reason that it is unfair in this; that he institutes a comparison between the sewered urban population and rural unsewered population, without making any allowances for the difference in the sewage matter that might pass into the Missouri, the upper Mississippi and the Illinois, or to the effect that might be produced on the waters of the said streams.

A. Read that question.

Q. (Question repeated).

A. Now will I answer the question?

GENERAL HAMLIN: Yes.

A. If we assume there are 12,000,000 inhabitants living upon the watershed of the Missouri river and the Mississippi river above Grafton, and the Illinois above Grafton, exclusive of the population living within the Chicago Sanitary District, and if we assume that there are living within the Chicago sanitary district 1,639,456 inhabitants, and if we assume that the amount of sewage from each individual is the same as the amount of sewage from every other individual upon the three watersheds mentioned, and within the sanitary water district, and if we assume further that all the sewage of all these individuals mentioned as living upon the three watersheds, and within the
3363 Sanitary District, empties into the streams mentioned, the
amount of sewage contributed by the inhabitants of the sanitary water district of Chicago would be about 13.6 per cent of the amount of sewage contributed by the 12,000,000 popula-

tion dwelling upon the three watersheds mentioned, exclusive of the Chicago Sanitary District.

Q. Do you know how much sewage actually enters the Illinois river outside of the Sanitary District or of the Missouri river, or of the Mississippi river above Grafton?

A. Will you read that again?

(Question repeated).

A. I don't know exactly, but I know there are upon the watersheds of the Missouri River about 63 cities, towns and villages which had a population of 4,000 and over according to the United States census for 1900, and which had an aggregate population of about 1,090,832 according to that census, and there are upon the watershed of the Mississippi river, above the mouth of the Missouri, about 74 cities, towns and villages, which had populations of 4,000 and over according to the United States census of 1900, and which had an aggregate population of 1,219,645 and that according to the same census there are upon the watershed of the Illinois river, exclusive of the sanitary District, about 30 cities, towns and villages having a population of 4,000 and over and which have an aggregate population of about
3364 384,261, and I know that speaking generally for the United States, cities, towns and villages which have populations of 4,000 and over are liable, ordinarily to have sewerage systems and that cities, towns and villages which have less than 4,000 population are ordinarily not so liable to have sewerage systems and public water supplies, and that therefore, the population included in cities of such size, located upon the watersheds of the Missouri river and the Mississippi river and the Illinois river as above mentioned, afford a reasonable basis for comparing the relative amounts of sewage discharged into the Missouri river, the Mississippi river and the Illinois river as above mentioned?

Q. How far, according to the authenticated cases of the contamination of water that has produced typhoid fever, has been the distance from the point or place where typhoid fever was contracted by water contamination?

A. I will have to refresh my memory on that.

Q. Can't you give from recollection substantially?

A. I can give a general idea from my recollection, without going into details. Will you read the question again?

Q. (Question repeated).

A. To the best of my recollection, and in the absence of my notes, it is my opinion that this distance has been as great
at times as 50 or 60 miles.

3365 Q. Do you know of any well authenticated case in the
books where it has been beyond sixty miles?

A. No sir, unless some of the cases which I have in mind should be somewhat more.

Q. Isn't it true that the majority of cases that have been reported in this country and in Europe, are less than thirty miles?

A. Yes, I should say that the majority of the well recognized epidemics caused by water borne typhoid fever bacillus were due to infection less than thirty miles distant.

Q. Did you give the amount of typhoid fever cases in St. Louis in 1901 and 1902?

A. No sir, but I think that the numbers of such cases were mentioned in an assumption included in a question which was asked me.

Q. Suppose in 1902 that the number of reported cases of typhoid fever in St. Louis was 1112, and the number of deaths was 222, and that the same year, at St. Charles, Missouri, a distance of 35 miles—St. Charles then having a population of 7982—and the sewage of St. Charles, including that of two or more hospitals, and the public schools, as well as the population of the city, and that for the year 1902, typhoid fever was epidemic in St. Charles, and assuming further that the sewage thus dis-
charged from St. Charles, was carried down the Missouri
3366 river to the Mississippi river, and from there to the intake
of the St. Louis waterworks, traveling that distance in that
way. To what then, would you attribute the increase of typhoid fever cases and deaths in St. Louis, for the year 1902?

A. I should say that the facts assumed, without considering other cases of typhoid fever that might exist upon the watersheds of the Missouri river and the Mississippi river above Grafton, and the Illinois river and the Chicago Sanitary District and without considering the time when typhoid fever was assumed to be epidemic in St. Charles, and the time when the assumed increase of typhoid fever in the City of St. Louis, and without considering the relative flows of the streams mentioned, and the amount of sewage discharged into the different streams, and the amount of sewage discharged by the Chicago Sanitary District and the manner in which the waters of the three streams mentioned were mixed, before reaching the intake of the St. Louis waterworks, and without considering possible local causes for the assumed increase in the typhoid in the City of St. Louis, the assumption made is insufficient for me to answer the question.

G. C. WHIPPLE.

ADJOURNED until 10:00 A. M. following day, Friday, May 15, 1903.

3367 Southern Hotel, St. Louis, Missouri. 10:00 A. M., Friday, May 15th, 1903. Parties met pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

GEORGE C. WHIPPLE,

Resumed the stand for further cross-examination by Attorney-General Hamlin, and testified as follows:

Q. Mr. Whipple, assuming that St. Charles, Missouri is located on the left bank of the Missouri River twenty miles above its mouth, where it empties into the Mississippi river, and that the mouth of the Missouri river is situated six miles above the intake and assuming further that prior to the first day of February, 1903, that the City of St. Charles was supplied with Missouri River water from a pumping plant having two settling basins, and an intake into the river located on the river front, and assuming for the year 1902, that the city of St. Charles had four public sewers, ranging from three or four blocks in length to eight blocks in length, draining the business district and portions of the more populous residence territory, besides, there being many private sewers from hotels and business houses leading into the river, and that on Main Street, which is parallel with and one block from the river there are five hotels and one or two livery stables, all of these having sewers draining into the river, and that there is a public hospital 3368

located four blocks from the river which has a sewer leading into the river, said hospital accommodating in the year 1902, twenty patients; and that on Madison Street in the city of St. Charles, one block down stream from the former sewer, is a sewer ten inches in diameter, which receives the sewage from one of the public schools of the city, where 250 pupils attend. In addition to the sewage from this school this sewer also receives other sewage from buildings located on or above Madison Street for a distance of four blocks from the river; that on Clark Street in said city is a sewer leading up the same from the river a distance of seven blocks to the Benton School, which school had in attendance in the year 1902, sixty pupils; there also being a very considerable number of residences, also connected with this sewer; also that in the year 1902, the sewage from the Convent of the Sacred Heart, having about 100 inmates, and also the sewage from the private schools maintained by the Catholics for day pupils, which have an attendance of about 250. In addition to this there are a number of public buildings connected with this sewer from the private schools maintained by the Catholics and that altogether about 70 per cent of the sewage pro-
3369 duced in the City of St. Charles is drained by means of public sewers, directly into the Missouri River, and that the streets of St. Charles, which are at right angles to the river, having steep slopes, and the surface drainage runs repeatedly into the river and washes the streets thoroughly at each down-pour of rain, and assuming further that the city of St. Charles has four cemeteries located in the southwest portion of the city; that these cemeteries are on broken ground about 100 feet above the level of the Missouri river; that the natural drainage of these cemeteries is through a number of ravines which ultimately gather into one large ravine leading into the Missouri River and finding an outlet about 300 yards below the present intake of the waterworks at St. Charles; and assuming further that St. Charles had a population of 7,982 in the year 1902, and assuming further that the number of deaths from typhoid fever in the city of St. Charles was 18 for the year 1902, as follows:

4 in the month of January,
1 in February,

3 in March,
3 in April,
1 in May,
1 in July,
1 in August,
1 in September,
3370 1 in November,
2 in December;

Assuming further that the sewage mentioned and the drainage from the four cemeteries mentioned passing into the Missouri River, thence to its mouth; thence from its mouth down the Mississippi River to the intake; and assuming further that the sewage discharged from the sanitary district of Chicago into the Drainage Canal, passing down the Drainage Canal over the Bear Trap Dam, thence into the Des Plaines and Illinois Rivers, and assuming further that at the Narrows on the Illinois River above Peoria, that a chemical analysis of the water and a bacteriological examination of the water at this point in the year 1902, showed substantially no pathogenic germs; then, eliminating all other conditions or causes that might have produced typhoid fever in the city of St. Louis in the year 1902, and comparing the situation at St. Charles, Missouri as stated in this question, and the condition of the water at the Narrows above Peoria, then in your opinion, considering these conditions alone and apart from any other consideration, if you were called upon to decide as an expert, as to these two causes alone, which, in your judgment, would be the cause of the existence or increase of the typhoid fever in the city of St. Louis in the year 1902?

A. If we consider only the conditions which are assumed 3371 to exist at St. Charles, and compare these with the assumed fact that at the Narrows on the Illinois River above Peoria, the chemical analysis of the water and the bacteriological examination of the water shows substantially no pathogenic germs, and if we eliminate all other conditions or causes that might have produced typhoid fever in the city of St. Louis in the year 1902, I should be unable to decide as to the assumed increase in the amount of typhoid fever in St. Louis for the year 1902, for this reason, among others: that simply because the chemical analysis of the water and the bacteriological examination of the water shows substantially no pathogenic germs, it does not follow that that water so examined, did not contain them.

JUDGE JOHNS: We reserve the right on the part of the State of Illinois, to further cross-examination.

MR. WOERNER: All right.

CROSS-EXAMINATION, By Mr. Todd.

Q. How is the presence of sewage in water determined?

A. The best way to determine it is to actually find out whether or not sewage enters the water.

Q. Well in the absence of that information can water be taken from a river and by any process known to science, can it be determined whether that water is sewage polluted or not?

A. Just read that question again.

3372 Q. (Question read.)

A. In answer to that I will say that some water can be and some water cannot be.

Q. What water can be and what water cannot be?

A. If water is much polluted with sewage that fact can be ascertained by scientific methods; if it is but very slightly polluted with sewage, it cannot always be determined by scientific methods.

Q. What degree of pollution would you denominate "much polluted" as contained in your former answer?

A. I am unable to state that in general terms.

Q. Have you any idea on the subject?

A. I have not a definite idea.

Q. Do you have any idea of the ratio of pollution of pure water to sewage that would be included in the answer "much polluted?"

A. I have not a definite idea because it would depend not alone on the amount of pollution, but also on the character of the water which was polluted.

Q. What do you mean by the character of the water that was polluted?

A. I mean the character of the water as shown by those qualities which might be used in determining the possible pollution of the water.

3373 Q. What are those qualities which enable you to determine the possible pollution of the water, in water?

A. There are no qualities in the water which, taken alone, would enable me to determine the possible pollution of the water, but among the qualities which I should naturally consider in forming an opinion as to the possible pollution of the water would be the amount of organic matter as shown by the albuminoid ammonia—

Q. As shown by what?

A. The albuminoid ammonia, and the character of the organic matter with reference to its decomposition as shown by the free ammonia, the nitrites, the nitrates, the amount of chlorine in the water and the hardness of the water; the total solids, the suspended solids and the color of the water, meaning by that the organic matter in solution which exhibits itself as a vegetable stain; the number of bacteria in the water and the presence of certain particular species of bacteria such for example as the bacillus coli communis.

Q. Is that all, doctor?

A. No, not quite. Let's see. I am still thinking.

Also the possible presence of certain microscopic organisms commonly associated with sewage pollution—just read that answer please.

(Answer read.)

3374 A. (Continuing.) As a matter of punctuation, I do not wish it to be understood that I include the chlorine as one of the qualities which would indicate the decomposition.

Q. Is that completed?

A. Yes sir.

Q. Are these the qualities to which you referred in the former answer, in water, what would enable you to determine whether water is much polluted or not by sewage?

A. Yes sir.

Q. In the absence of knowledge that sewage entered the waters, can the fact that the water is sewage polluted be ascerained from the different elements that you have enumerated ere in your previous answer?

A. Just read that question again.

Q. (Question read.)

A. I believe that at times it can be, and that at other times t cannot be?

Q. What are the times that it can be and what are the times hat it cannot be?

A. I believe that it can be when the amount of sewage pollu-ion is considerable, and that it cannot be when the amount of ewage pollution is very slight.

Q. The word "considerable" as you use it, is a relative term, is it not?

375 A. Yes sir.

Q. Now what proportion of sewage, to the volume of vater into which the sewage enters, is necessary to arrive at the lignity of "considerable" as you use it?

A. I am unable to state, as that depends upon the character f the sewage and the character of the water into which this ewage is discharged.

Q. Now take the character of the water into which the ewage is discharged; what kind of water do you have refer-nce to?

A. I don't understand what you mean by "what kind of vater."

Q. What do you mean by "that it depends upon the char-cter of the water into which the sewage is discharged"—what lo you mean by the word "character" as used in your answer?

A. I mean its character with respect to the qualities enu-nerated as being those which I should consider in endeavoring o determine whether the water was or was not polluted with ewage.

Q. What is the character with reference to the qualities nuemerated to which you refer in that previous answer?

A. I mean that if the qualities of one water more nearly esemble the qualities of a certain sewage than the same quali-ies of another water, it would be more difficult to ascertain vhether the former water were polluted with that sewage than in the case of the latter.

3376 Q. In other words, to see if I understand you, it would be a question of whether the water polluted the sewage or the sewage polluted the water under those conditions; is that right?

A. It would be—just read the question again.

Q. (Question read.)

A. It would be a case of comparing the water with the sewage.

Q. Under the state of facts that you have enumerated in your previous answer, wouldn't it also involve a comparison of the sewage with the water?

A. We should compare the water with the sewage and the sewage with the water.

Q. Then what would be the character of the water necessary to enable you to ascertain when sewage empties into that water, whether it is sewage polluted or not?

A. Just read that once more.

Q. (Question read.)

A. The character of the water will have to be different from that of the sewage, but just how different I am unable to state,—or I will say, to what extent it is different I am unable to state.

Q. In what manner is it possible to express that difference between the water and the sewage in a scientific way?

A. It is possible to express that difference by a determination of the qualities which I have enumerated.

3377 Q. It is necessary to determine the presence of organic matter in the form of albuminoid ammonia, or organic matter in the form of decomposition known as free ammonia, nitrites, nitrates, hardness of the water, total solids, solids in solution, the presence of bacillus coli communis, in the water, before the sewage enters into it, in order to ascertain whether that water would become sewage polluted or not?

A. Just read the first part of it again.

Q. (Question read.) By the presence of sewage, being added?

A. It is not always necessary to determine all of the qualities that you have enumerated.

Q. Assume that you determine the absence of all these qualities in water before the sewage enters into the water, what proportion, then, of the water, with the absence of these elements and sewage that would enable you to determine the presence of sewage in water of that character?

A. Now will you just read that again?

Q. (Question read.)

A. If you mean by that question the proportion of sewage in a water free from those qualities mentioned, as shown by the amounts of those qualities, after mixture of the sewage with the water, I could not tell the proportion unless I knew the character of the sewage and the changes which might have occurred between the time when the sewage was added to the
3378 water and the time when the analysis was made.

Q. What about the character of the sewage, would you want to know, in order to ascertain that fact?

A. I should want to know one or more of the qualities which have been enumerated.

Q. Before the sewage enters the water?

A. Yes sir.

Q. How would those facts be ascertained?

A. By making analyses.

Q. Then, in order to ascertain the presence of sewage in water of the character that we have been talking about, with these elements eliminated, is it necessary to make a chemical analysis of the sewage before it enters that water, in order to ascertain the proportion of the sewage to the water into which it enters, in order to ascertain its presence?

A. In order to ascertain the proportion of the particular sewage mentioned, it would be necessary to make some sort of an analysis.

Q. Then, in the absence of any analysis having been made of the sewage before it enters the water, is it possible to ascertain the presence of the sewage in the water into which it empties?

A. Just read that again, please.

Q. (Question read.)

3379 A. It might be possible to ascertain its presence, but not its exact proportion.

Q. At what proportion of sewage to water, is it impossible to detect the presence of sewage in water?

A. I am unable to state, as it depends upon the character of the sewage and the character of the water.

Q. Take the waters of Lake Michigan and the sewage of Chicago: what proportion of the water of Lake Michigan would be necessary to mix with the sewage of Chicago and the sanitary district in order to enable you to ascertain the presence of sewage in a mixture of that character?

A. Once more please.

Q. (Question read.)

A. I am unable to state.

Q. Do you know the character of the sewage of the Sanitary District before it mingles with the water of Lake Michigan?

A. I know certain characteristics of it from published analyses.

Q. Are those characteristics sufficient to meet the requirements of your previous answer, in regard to the condition of sewage before it enters the waters of the kind that we have been talking about?

A. Yes, so far as they alone are concerned.

3380 Q. Do you know the character of the water of Lake Michigan as free from the sewage of Chicago and the Sanitary District?

A. I know certain characteristics of the water of Lake Michigan as used in the water supply of the city of Chicago.

Q. That is impregnated with sewage, is it not? Do you know?

A. I know that it has been stated that at times such is the case.

Q. Well, do you know the character of the waters of Lake Michigan when freed from any sewage pollution from Chicago?

A. Only from analyses of such portions of Lake Michigan as are used for the water supply of the city of Chicago.

Q. And do you know whether that is free from sewage contamination or not?

A. I couldn't state definitely.

Q. Are you able to state from your knowledge of the sewge of Chicago before it commingles with the waters of Lake lichigan at what proportion of water to sewage you would be ble to ascertain the presence of sewage in that water?

A. No sir.

Q. Your experience as a scientist has not enabled you to nake that kind of a determination, has it?

A. It has not enabled me to determine that point exactly.

Q. Do you know of any scientist of established standing, r admitted standing that has been able to solve that proposiion?

A. I do not know of any such scientist who has really been able to solve it. ;381

Q. Then the line between much polluted water and lightly polluted water has never been scientifically defined as o the ratio of sewage to water, or dilution, has it?

A. It is my opinion that it has not been truly defined, and hat it cannot be truly defined.

Q. Now in the absence of any knowledge that sewage eners water, or the character of the water when the sewage entered t, a scientist is able to ascertain the presence of sewage in that vater with the absence of that knowledge isn't he?

A. If a scientist did not know that the sewage entered the vater, and if he didn't know the character of the water before he sewage entered it, the question of whether he could determine the probable presence of sewage in that water, would depend in part, upon the original character of the water and the haracter of the results shown by his analysis.

Q. But if he didn't know the character of the water; then could he ascertain it, in your judgment?

A. That would depend upon the results of his analysis.

Q. If he didn't know the character of the water into which the sewage entered, or the character of the sewage that entered the water, in fact didn't know that any sewage entered the water at all, what would have to be the results of the analyses in order to demonstrate the presence of sewage in the water?

3382 A. I should be unable to state in definite terms.

Q. Do you know?

A. Not in definite terms, no sir.

Q. Do you know in indefinite terms or in any terms. Ar you able to answer the question, Mr. Whipple?

A. Yes, I will answer it. If I didn't know the characte of the water originally or the character of the sewage; if obtained from my analysis, results which approached those i character which would ordinarily be obtained by the analysi of sewage I should be able to form a fairly reliable opinion a to the presence of sewage in the water.

Q. What are the results which are obtained by the analysi of sewage, to which you would compare the results from th analysis of the water in order to draw that conclusion?

A. Do you mean the character or the amount?

Q. I mean the character and the amount and all the el ments that would enable you to form an accurate judgment, scientific judgment.

A. Read that question again.

Q. (Question repeated.)

A. I should compare the qualities which have been alread enumerated.

Q What are they?

3383 A. In so far as I could obtain them.

Q. What are those qualities?

A. Namely, the amount of organic matter as shown by th albuminod ammonia, the character of the organic matter a indicated by the free ammonia, the nitrites and the nitrates; th amount of total solid matter, the matter in suspension, the chl rine, the hardness, the prevalence of certain particular specie of bacteria such for example as the bacillus coli, the number o bacteria, the color, the presence of certain microscopic orga isms, etc.

Q. To which one of these elements would you attach th greatest importance in ascertaining the presence of sewage i water?

A. That would depend upon circumstances.

Q. What circumstances?

A. It would depend upon the character of the water int which the sewage was discharged.

Q. Suppose you didn't know that. You take the wat fter these things have occurred, and analyze it, and you find hese elements in it. You know nothing about the source of he water. To which one of these elements would you attach he greatest significance as evidencing the presence of sewage?

A. If you will excuse me, I didn't quite finish my answer
384 to the previous question.

Q. You may go ahead Mr. Whipple; I didn't mean to nterrupt you.

(Answer to the previous question read to the witness.)

A. (Continued.) And upon the time that might have lapsed between the collection of the sewage and its analysis.

Q. (Last question read to the witness.)

MR. TODD: My question refers to an analysis made of ater itself, without any knowledge of what took place miles bove, as to the character of the water into which the sewage mptied and the character of the sewage which emptied into he water, but the analysis shows the presence or absence of hese elements which you have enumerated.

Now my question is to which one of these elements do you ttach the greater significance in order to demonstrate the presence of sewage pollution in the water thus analyzed?

A. There is no one element to which I should attach speial prominence.

Q. Suppose some of these elements were absent, could you onclude sewage pollution?

A. I might be able to conclude the presence of sewage polution, but my judgment would be to that extent, or to the existence of the pollution, less reliable.

Q. What significance has the presence of albuminoid amonia in water as to determining the presence of sewage or not.

3385 A. It serves as a measure of the amount of undecomposed organic matter present, but taken by itself, it cannot be used to determine the amount of sewage pollution present.

Q. The presence of sewage pollution was my question—not the amount.

A. That's what I mean.

Q. You said the amount.

A. I meant the presence.

Q. What is albuminoid ammonia?

A. There is no such substance.

Q. What?

A. There is no such substance.

Q. There is no such substance as albuminoid ammonia?

A. No sir.

Q. Then when you used the words "organic matter" know by the name of albuminoid ammonia, you were referring to substance that did not exist, were you?

A. I do not think I used the expression "organic matt known by the name of albuminoid ammonia."

Q. You used the words "albuminoid ammonia," didn you?

A. Yes sir.

Q. What did you mean by it if no such substance exist

A. It is simply a form of expression for describing th amount of organic matter present.

3386 Q. It is merely, then, an expression that has a quant tative meaning as applicable to something else, and ha no meaning in itself, has it?

A. It is a form of expression for the substance, and is n the name of the substance itself.

Q. Do chemists employ terms that have no significance?

A. I should say not.

Q. Chemistry is an exact science, isn't it?

A. Fairly so.

Q. And albuminoid ammonia is not a name that attach to any particular element known in chemistry, is it?

A. No sir.

Q. If you take the white of an egg and allow it to decon pose, isn't the product of decomposition known as albumino ammonia in chemistry?

A. Not as we use the term in water analysis.

Q. You use different terms in chemistry for elements whe you analyze water, from what you use when you analyze oth elements and substances?

A. We sometimes do.

Q. Is this word "albuminoid ammonia" a trick word of e profession?

A. No sir, I shouldn't call it a trick word.

Q. Isn't albuminoid ammonia a chemical element the same as nitrites and nitrates? 87

A. Not as we understand it in water analysis.

Q. Is there any such thing as free ammonia in water anal-is?

A. We have that expression.

Q. Does that expression mean anything?

A. I think it does.

Q. What does it mean?

A. If the water is said to contain free ammonia, we mean at the water contains ammonium compounds which are such upon boiling the water the ammonia will be driven off in such way that its amount can be determined.

Q. Well, that is a name given to a chemical substance, is not, free ammonia?

A. Ammonia is.

Q. Free ammonia?

A. It stands for the ammonium compounds present, as I ave described.

Q. Is there any difference between the use of the term free mmonia, to water, in defining an element, than in using the ords "albuminoid ammonia" in defining the element?

A. Neither of them are the names of substances actually xisting in the water, but rather they stand for substances ex-sting in the water.

Q. They stand for substances existing in the water?

388 A. Yes sir.

Q. And are used synonymously with the substances them-elves, are they not?

A. Practically so, for practical purposes in water analysis.

Q. What are nitrites, are they a substance, or the name for substance?

A. It is both.

Q. What are nitrates?

A. They are also a substance which may exist in water.

Q. From what source do you get what is known as fr ammonia in water?

A. Sometimes from organic matter from decomposition; a other times by the reduction of nitrites or nitrates.

Q. By what?

A. From nitrites and nitrates.

Q. Can you get free ammonia by the reduction of nitrit and nitrates?

A. You can get the nitrogen of the ammonia.

Q. Can you get free ammonia. Can you answer that question, Mr. Whipple?

A. Oh yes.

Q. What is your answer?

A. You can get the nitrogen of free ammonia as the expression is used, in water analysis.

3389 Q. You can get free ammonia from nitrates and nitrites

A. I said you could get the nitrogen of free ammonia, a the term is used in water analysis, from the nitrites and nitrate

Q. My question is, can you get free ammonia from nitrite and nitrates. Do you know?

A. You can, if there are no compounds in the water whicl would unite with the free ammonia, to form ammonium compounds.

Q. Is it not a fact that when you get nitrates, the proces of purification has been completed, and what is known as th nitrogen cycle has been perfected?

A. If we start with organic matter as represented by albuminoid ammonia, and if— Repeat the question.

Q. (Question read.)

A. And if this decomposition progresses, we may get al of the nitrogen compounds into the form of nitrates.

Q. From what is albuminoid ammonia derived, from animal or vegetable origin?

A. The substance for which the term albuminoid ammoni stands, may be derived either from animal or vegetable matter. In fact, it may be animal or vegetable matter.

Q. When you find the presence of albuminoid ammonia ir water does the science of chemistry enable you to ascertai

whether that albuminoid ammonia comes from animal or
390 from vegetable origin?

A. No sir.

Q. That is a chemical impossibility, is it not?

A. With our present methods of determination or analysis, ith the substances represented by the term of albuminoid am- ionia, it may be derived from or may be either animal or vege- able matter.

Q. And is it not a fact, Mr. Whipple, that it is beyond the ale of chemical science to ascertain whether the presence of lbuminoid ammonia in water is derived from animal or from egetable origin?

A. From any methods of chemical analysis with which I m familiar, it is impossible to tell whether the substance rep- esented by the term albuminoid ammonia, is derived from ani- nal or vegetable matter.

Q. Then, if that fact remains in doubt, the presence of ree ammonia which is derived from albuminoid ammonia by he operation of the an-aerobic bacteria upon it, is also in doubt, s it, as to its origin?

A. Repeat the question.

Q. (Question repeated)?

.Q. As to whether vegetable or animal?

A. Repeat the question.

(Question repeated.)

A. The origin of the free ammonia which may be present,
391 whether from vegetable or animal matter, can not be definitely determined, although if the amount of free am- nonia is high compared to the amount of albuminoid ammonia ound, there is, to some extent, more reason to expect that it ame from animal matter, using the terms free ammonia and al- uminoid ammonia as standing for the substances.

Q. Would that be a scientific fact, a scientific demonstra- ion?

A. I shouldn't say that it rises to the dignity of a scien- ific demonstration.

Q. It would be a guess, wouldn't it?

A. No sir, I shouldn't call it a guess.

Q. Anything that falls below the dignity of a scientifi demonstration, you would characterise it how, as a scientist?

A. I might use the term "estimate."

Q. It is merely an estimate which doesn't arise to the dig nity of a scientific demonstration, is it?

A. That is probably a fair statement.

Q. And it is as liable to be wrong as it is to be right, i it not?

A. No sir, I would say it would be more likely to be rig than it would be to be wrong, but I couldn't say how much mor

Q. Well, would it be sufficient for you, as a scientist to pu
yourself on record as saying that you could tell by th
3392 quantity of free ammonia in the water, whether it cam
from animal or vegetable origin?

A. No sir.

Q. You understand we are dealing here with scientifi facts and in my questions that's what I want to keep in ev dence.

(No answer.)

Q. Now that which is true of free ammonia is true nitrites and nitrates, is it not, as to the origin, whether anima or vegetable?

A. Not in the same sense, because nitrates may come fro substances of mineral character.

Q. Nitrates coming from substances of mineral characte

A. I say they might.

Q. In water, what do they come from?

A. They might there.

Q. Is it not a fact that when free ammonia becomes oxidiz by the operation of these bacteria, so-called, that it is convert into what is known as nitrites, and the nitrites in turn whe operated upon by the same kind of bacteria, known, I believ as an-aearobic, the nitrites are converted into what is known nitrates?

A. It is a fact that the substances which you describe
free ammonia, that the nitrogen of that substance may b
3393 come changed to nitrites, and afterwards to nitrates und
the influence of certain bacteria.

Q. Then if you found nitrates in the water analysis, these itrates may come not only from animal and vegetable, but also rom mineral origin?

A. They might.

Q. Then when they come from mineral, does that come from ewage of any kind?

A. Not unless the sewage contains minerals from which hey came.

Q. But generally it doesn't contain mineral matter does , except chlorine?

A. Sewage contains mineral matter besides chlorine.

Q. Well, if these nitrates should come from mineral, would ou say that they came from mineral sewage, or from mineral utside of the sewage?

A. I couldn't say definitely without knowing whether any f the sewage entered the water, or whether the water in any ay came into contact with minerals which would give up nirates.

Q. But the minerals do not come from the vegetables?

394 A. Speaking popularly, minerals do not come from vegetables, but in so far as nitrates represent mineral matter, these might be derived under the action of bacteria, from egetable matter.

ADJOURNED until 2:15 P. M. same day, Friday, May 15, 903.

395 Southern Hotel, St. Louis, Missouri. 2:15 P. M., Friday, May 15th, 1903. Parties met pursuant to adjournment.

Present, the Commissioner and same council representing he respective parties.

GEORGE C. WHIPPLE,

esumed the stand for further cross-examination by Mr. Todd, nd testified as follows:

Q. Mr. Whipple, if nitrates are found in the chemical analyses of water, does their presence there indicate from what ource they have their origin, whether vegetable, animal or nineral?

A. No, sir; not simply because they are found there.

Q. Does the presence of albuminoid ammonia, free ammonia, nitrates and nitrites of themselves, whether in large or small quantities, determine the presence of sewage pollution?

A. Not necessarily.

Q. You stated among these different elements in the analysis of water, hardness of water; that term—what do you mean by that chemically speaking?

A. It is a term which we use in the chemistry of water to
3396 define the amount of those substances present which will
decompose soap, and is represented chiefly by the carbonates and sulphates, nitrates, chlorides, etc., of calcium and magnesium.

Q. The hardness of water is an attribute which is derived chiefly from mineral origin, is it not?

A. Yes, sir.

Q. It is not derived from sewage pollution when the sewage is from the fecal and urine discharge of man, is it?

A. It might be to some extent.

Q. Well, to an extent so limited that you would not consider it, would you?

A. I should usually consider it.

Q. To what extent would you consider it?

A. I could not express that in definite terms, but I might say that that would be a smaller fact to be considered than most of the other elements which I have mentioned.

Q. Of itself would it decide sewage pollution?

A. Certainly not.

Q. Have you ever examined the waters of the springs in the Ohio valley?

A. No, sir; not personally.

Q. Nearly all spring water is what is known as hard water, is it not?

A. Speaking in general terms I should say yes, but I
3397 know of some localities where the spring water is con-
sidered soft.

Q. Where there are rock deposits—mineral deposits?

A. For example, lime deposits.

Q. In limestone regions the water is what is known as hard water, is it not?

A. Yes, sir.

Q. Now, total solids and solids in suspension, those solids may come from what sources?

A. They may be of mineral origin or of animal or vegetable origin.

Q. Is there anything in the attributes pertaining to the solids themselves which would indicate their origin?

A. That would depend upon the character of the solids rather than the amount of the solids.

Q. That is what I mean; is there anything in the solids in suspension or solution that would enable you to determine scientifically—when I use the word "scientifically" I mean within the scope that you have qualified as an expert—

A. Perhaps you had better read it again; I think I get your meaning—

Q. (Question read)—the source from whence the solids are derived?

A. Well, that would depend upon what I found to be the character of the solids—of the suspended solids, or of the total solids. 3398

Q. Well, in the analyses that you have made in connection with this investigation, was anything disclosed as to the character of the solids in solution or the solids in suspension?

A. To which analysis do you refer?

Q. The one—take complainant's Exhibit 1 for identification.

A. I guess I will have to look at it, I don't know just what that was.

Q. Well, while we are waiting for that I will ask you another question. Do you recall whether any of the characteristics such as you would want to know, were disclosed in those analyses?

A. Yes, sir; for instance, if we consider the total solids which would naturally include the hardness and the chlorines, etc., I should want to know—

Q. You don't get my question, Mr. Whipple. My question is, did the analyses which you have before you, complainant's Exhibit 1 for identification, disclose the character and nature of solids in suspension and solids in solution aside from quantity?

A. Yes, sir; there were certain facts shown on this tabl which would give me a certain idea as to the nature of the soli matter—of the total solids and the suspended solids.

Q. Will you indicate what characteristics, aside from quantity, are disclosed by those tables as to the characteristic
3399 of the solids in suspension and the solids in solution?

A. If we consider this sample, on the first line of thi sheet numbered 5785, I see that the total solids, or the tota residue on evaporation, as it is called here, is 2070. Now fro my general knowledge, I know that in those total solids would b included the chlorines, which is stated as 17½ parts per millio and the alkalinity which is stated as 120 parts per million, an there are figures given for the nitrogen as albuminoid ammoni free ammonia, nitrites, nitrates, etc., all of which would necessarily be included under the head of total solids.

Q. So, then, under the head of total solids, there is chlorine, albuminoid ammonia, nitrites, nitrates and free ammonia

A. I mean that those substances which you mentione would be included in those total solids.

Q. Are the proportions of those substances given in th total solids?

A. Not in the figure which represents the total solids; don't know as I quite catch you; I am trying to understand you question.

Q. The point is, do the elements which you find there o the table—albuminoid ammonia, chlorine, nitrites, nitrates an free ammonia, are they the component parts of the total solid in a given sample of water?

3400 A. They form a part of the total solids, but the sum o these elements named, does not necessarily equal the tot sum.

Q. Now, from the table and analyses that you have befor you, are you able to tell whether that sample of water wa sewage polluted or not, or whether those elements are derive from animal or from vegetable origin?

A. I am not able to tell either of those things from the figures, as I find them right here, considering nothing else, tha these figures.

Q. That is what I want to get at. Now, what other el ments would you consider in connection with those analyses in order to determine whether the chlorine, albuminoid ammonia, free ammonia, nitrites and nitrates, were derived from animal or vegetable origin, as indicated in those tables marked Complainant's Exhibit 1 for identification?

A. I should want to have more information—more practical information in regard to the source of this sample and the place from which it was derived.

Q. Does that table indicate where that sample was taken?

A. It is taken at Fort Bellefontaine, in the Missouri river.

Q. That gives the locality of the sample, as to place and the river from whence it was taken?

3401 A. Yes, sir.

Q. Now, what else would you want to know?

A. I should like to know the character of the watershed from which this sample of water was derived, with reference to the existing pollutions.

Q. Is that the answer?

A. Yes, that is the answer.

Q. Then if you did not know the character of the watershed you could draw no conclusion from that, as to whether it was sewage polluted or not, could you?

A. I don't think I could from this particular sample; I think the analysis is of such a character that it would be difficult to tell from analysis itself, whether or not this water were sewage polluted.

Q. Assume, Mr. Whipple, that the sewage of Kansas City, Kansas, and the sewage of Kansas City, Missouri, and the sewage from slaughterhouses and cattle sheds located at those two places, emptied into the Missouri river about 400 miles above this point, would that enable you to draw any conclusion as to whether that water was sewage polluted or not?

A. Now, if you will read that once more; there are one or two points there—

Q. (Question read.)

A. Those facts would indicate that this water might per-
3402 haps be sewage polluted, except in so far as the effects of the pollution which you have mentioned, may not have been interfered with by processes of sedimentation, etc., between

the point of pollution and the point where this sample was collected. I should have to balance a number of different conditions in order to arrive at such a result.

Q. If it should appear that several thousand acres of lan upon the Missouri was overflowed or inundated, and the water of the Missouri passed over those lands, and that the river wa serpentine in its course—winding, would that information added to the assumptions about the Kansas Cities, shed any light upo the conclusion to be derived from that examination?

A. Just read that question.

Q. (Question read.)

A. The added information which you mention would enabl one to make a better judgment of the probability of this wate showing the effects of pollution at the point where the sampl was taken, but even this information would not be sufficient t give an absolute opinion on this matter without considerin such questions as dilution, sedimentation, etc., which I mentioned.

Q. Would not the overflow of this land aid sedimentation

A. In so far as by the overflow of the land the water wa
allowed to come to a position of quiescence, it might ai
3403 sedimentation; but on the other hand, during the proces
of overflowing, the land, it might add to the water sediment derived by overflowing the land, and thus make the wate more turbid, or contain more suspended matter than before.

Q. Well, what would be your opinion as an expert, as t whether the sewage from Kansas City would purify itself i going 400 miles, to Fort Bellefontaine, the point where tha sample was taken?

A. Just read that question.

Q. (Question read.)

A. That would depend upon the amount of dilution whic the sample—which the sewage received, the amount of sedimentation which took place in the stream; the action of microscopi organisms and bacteria upon the sewage, etc., and when I spea of this as a process of purification—and when I speak for example of dilution as being a process of purification, I woul not imply that it was a change which was brought about in th matter of the sewage, but rather that an equal volume of wate contained less of the sewage matter than before, assuming of course, that the water used in dilution was purer than the sewage.

Q. Are you acquainted with the character and volume of the sewage of Kansas City, Missouri, and Kansas City, Kansas?

A. I am not acquainted with its character, and I am not
3404 acquainted with its volume, except in so far as in general
that may be indicated by the population of the city.

Q. Are you acquainted with the character of the population and the sewage of the cities that empty into the Missouri river above Kansas City?

A. I am acquainted with the number of inhabitants in the cities of over 4,000 inhabitants in the territory you mention, but I am not personally acquainted with the character of the sewage.

Q. Would you call the water of the Missouri river above Kansas City a potable water?

A. I have not the means for answering your question, for in the first place I have no analytical data concerning the water of the Missouri river above Kansas City; and furthermore the term "potable" does not have to me a definite and well defined meaning.

Q. A pure water, then?

A. To a lesser extent the same is true of that term.

Q. A sewage polluted water?

A. How was that phrase there—

Q. Do you consider the water of the Missouri above Kansas City a sewage polluted water?

A. In so far as the sewage of the cities dwelling upon the
water shed of the river above that point enters the river,
3405 I should consider it as a sewage polluted water.

Q. Suitable for drinking purposes?

A. That I am unable to state from the facts which I have at hand.

Q. You stated in a previous answer—I don't know that I quote you right, but if I don't, you correct me—that whether the Missouri river purified itself of the sewage of Kansas City, would depend upon the amount of pollution, sedimentation, and the action of bacteria, before it got to Fort Bellefontaine. Does that correctly state what you meant?

A. Perhaps you had better read that again.

Q. (Question read.)

A. What I meant was whether certain elements of the sewage as it entered the stream at Kansas City—was it?

Q. Kansas City, Kansas, and Kansas City, Missouri?

A.—actually reached the Fort Bellefontaine, would depen among other things upon the dilution—what was that quesio again?

Q. (Question read.)

A. (Continuing) whether it reached Fort Bellefontaine i quantities sufficient to be detected, or to have any effect upo the water when used for drinking purposes, depended upo dilution, sedimentation. the action of bacteria—I would sa the possible action of bacteria and microscopic organisms 3406 or other such natural agencies and I understand that yo are barring out any artificial actions which might be introduced?

Q. Yes. What would be the amount of dilution necessar to meet the requirements of your answer—what proportion o water to sewage?

A. That would depend upon the character and the amoun of the sewage and also perhaps upon the relative effect of som of the other agencies mentioned, including, for example, th time of transit of the water from the one place to the other. What was that answer?

(Answer read.)

THE WITNESS: Will you read that question again?

Q. (Question read.)

A. Well, I don't know that I need to add anything furthe to that.

Q. Do you know what the amount of dilution of the sewag of Kansas City is, when it enters the Missouri river at Kansa City?

A. No, sir; I don't know the exact amounts of dilution, because I don't know the volume of the sewage and I don't kno the volume of the stream at that point.

Q. Do you know the amount of sedimentation that take place?

A. I don't know the actual amount of sedimentation whic

takes place, but speaking broadly, I know that the Mis-
3407 souri river is a comparatively rapidly flowing stream;
I know that its flow varies at times, and it would be my
udgment that at times sedimentation might occur; at certain
imes and places sedimentation might occur, to some extent, and
t other times the sediment deposited might be taken again into
uspension and carried down stream; therefore I am unable to
tate the combined effect of sedimentation, and what would be
he opposite, the condition which you might term the scouring
f the stream, or the removal of the sediment.

Q. Do you know the rate of the current of the Missouri iver?

A. I have in some notes which I think I can find, some ap-roximate figures.

Q. Approximately four miles an hour, is it not?

A. I don't recollect exactly. I should rather refer to my otes.

Q. I wish you would.

GENERAL CROW: You mean in the mean stage of water, r average?

MR. TODD: Yes.

GENERAL CROW: That is a pretty fast current, isn't it?

MR. TODD: That is what Dr. Teichmann testified to, I hink.

THE WITNESS: I have here some notes which state that
he mean velocity expressed in feet per second, of the Missouri
river from Plattsmouth, Nebraska, to the Mississippi
3408 river, the time of average flow is about four and one-half.

GENERAL CROW: Four and one-half feet per second?

A. Yes, sir; four and one-half feet per second. Under hat we may term an ordinary low flow, though not a minimum low perhaps, it is about 2.7 feet per second, while under an rdinary high flow, though perhaps not under extreme condi-ions, about 6.5 feet per second.

MR. TODD: Is that figured out into miles?

A. No, sir; it is not.

GENERAL CROW: That only makes it three and one-uarter miles, at an average stage—it wouldn't make that; it ould make about three miles.

THE WITNESS: One foot per second is equal to abou .68 of a mile per hour—do you want me to find that for you

MR. TODD: No, I think I have what it will approximat

Q. If it should take seven days from Kansas City to For Bellefontaine, for the water to come that distance, what is your opinion as to whether the sewage from Kansas City, Missouri and Kansas City, Kansas, purifies itself by the time it gets there?

A. I could not give a general answer to that as applied to the sewage as a whole, because certain things might affec certain elements of the sewage, and not affect the other elements.

3409 Q. Have you any opinion as to whether the water of the Missouri river at Fort Bellefontaine, is sewage polluted or not?

A. In so far as the population of the watershed on the Missouri river above that point is concerned, or in so far as the sewage of that population is concerned, I believe it to be sewage polluted water to the extent mentioned.

Q. To what extent?

A. In so far as the amount of sewage from the populatio dwelling upon the watershed enters the water of the Missour river, and in so far as the ingredients of this sewage are no destroyed or diluted or otherwise removed from the water o the river before it reaches Bellefontaine.

Q. Then it is your opinion that all the sewage that i eliminated does not exist when the waters get to Fort Bellefontaine, is it?

A. Why, if the sewage is really eliminated from the water it does not get to Bellefontaine.

Q. That is a kind of an axiom, isn't it?

A. I suppose that you may call an axiom—that is, to illustrate: If you put a thing into water and take it out again, i isn't there.

Q. And do you know how much of the sewage that enter the water at Kansas City is taken out or eliminated chemi-
3410 cally or in any other way, by the time it gets to Fort Bellefontaine?

A. I don't know exactly, but I don't think that is a subjec of exact determination, and I don't think that the sewage as a whole can be subjected to such a determination. As I explained before, what might occur to one constituent of the sewage might not occur to another constituent of the sewage.

Q. You stated that the color of the water was one of the elements among the numerous elements that you have enumerated. To what is color due, to vegetable or animal origin, in the term that you used it?

A. Speaking broadly, the color of the water which shows itself as a brownish stain, is due to vegetable matter in solution.

Q. Then that color does not indicate sewage pollution, does it?

A. No, sir.

Q. You spoke of the presence of the bacilli coli communis; what does that indicate—sewage origin?

A. I could not state definitely that it does indicate sewage origin. It is believed by many scientists today that this organism may be found in waters where pollution may be remote. This organism is a common inhabitant of the human intestine, present in large numbers in ordinary sewage, and this organism is found so often and in such quantities in waters which are 3411 known to be sewage polluted and which is found so rarely or in such small quantities in waters which are presumably not polluted, that most bacteriologists are agreed that the test for the presence of this organism is a most important one to be considered in determining whether or not the water is sewage polluted.

Q. What do you hold as a scientist, upon that question, and as a bacteriologist, aside from what those people hold that you have referred to?

A. I hold that if this organism is constantly present, or is very often present in a water, and if this organism is present in such numbers that we can readily determine its presence by analyzing one cubic centimeter or less of the water, it is probable that this is an indication of contamination by fecal matter. I do not believe that the test is an absolute test, but I consider it a valuable one to be interpreted in connection with the rest of the analysis.

Q. Where is this bacilli coli communis found?

A. It is found most commonly in the intestines of man and certain animals.

Q. What animals?

A. For example, the cow, the horse, the pig, and I think birds, and speaking generally, in warm blooded animals.

Q. Suppose that a stream contained a great number of fish, like the Illinois river, and this organism or bacteria coli communis was found in the fecal matter of fish, would the 3412 presence of the bacillus coli communis in such a water be any evidence of sewage pollution?

A. Just read the question again.

Q. (Question read.)

A. It is my judgment that the presence of the fish, even though the bacillus coli communis might be found in their intestines, would not materially influence the interpretation to be made from the results of the coli test of the water.

Q. Why?

A. Because it has been my experience that the intestines of fish do not ordinarily contain this bacillus, and that if this bacillus is found there, it is a case where the bacillus has been derived from the water, and I base my judgment upon considerable personal work which I have done in that direction.

Q. If the bacillus coli communis was found in fish in the Missouri river, would you disregard its presence there in the fish in considering the coli communis in order to ascertain sewage pollution?

A. So far as the presence of the bacillus coli communis in the intestines of a fish influences the presence of the coli communis in the water.

Q. Have you finished that?

A. Yes, sir.

Q. Read my question. (Question read.)
You would disregard it, or regard it?

3413 A. I meant that I would disregard its presence in the intestines of the fish so far as any interpretation were made from the presence of the coli communis in the water.

Q. Have you personally investigated this quesion of coli communis in fish?

A. Yes, sir.

Q. To what extent?

A. I can't give you a definite answer, but I can remember a number of years ago that I spent several weeks in investigating the contents of the stomach and intestines of a number of different kinds of fish with respect to the presence of this bacillus coli communis, and I came to the conclusion that this organism did not live in the intestines of the fish as it lives in the intestines of a warm blooded animal, as for example, a cow, but that the occasions when I did find it were so rare that I was safe in concluding that they came from the water in which the fish were found.

Q. About how many fish did you examine?

A. I can't say definitely, but certainly two or three dozen.

Q. Did you examine any fish of the carp variety?

A. No, sir; I did not examine any carp.

Q. Were the fish you examined fresh water or salt water fish?

A. Fresh water fish.

3414 Q. What fish were they?

A. I don't know that I can tell you exactly, but I remember perch and pickerel and hornpout and a lot of smaller fish, and I remember those fish that we call pumpkin seeds in New England; some of the common fish which were found in our New England ponds.

Q. Now, are there any micro organisms, such as you have described, in the tables, submitted, found in the intestinal discharge of man, in the feces or the urine?

A. I have never found any microscopic organisms in the urine of man, but I have found the remains—if you can call them remains—or the cell walls of diatomes, for example, in the feces of man, and I attribute their presence there to the fact that they have taken these organisms into their stomach, and that these cell walls being of comparatively indestructible character, were not injured in passing through the intestinal tract.

Q. But was there anything in connection with these microorganisms to identify them as having passed through the alimentary canal of man?

A. There was not.

Q. And when they had made this passage, were they alive or dead?

A. I cannot remember exactly, but I imagine that the or-
3415 ganisms themselves were dead, although I cannot say.

Q. What organisms—what micro-organisms found in water demonstrate sewage pollution from the fecal discharge of man?

A. I don't know of any that absolutely demonstrate its presence, but there are certain microscopic organisms or micro-organisms which are so often associated with sewage, that in a very general way they do serve as an index of the presence of sewage, but I wish to be understood as saying that they indicate it only in a very general way.

Q. So general that you could not assert that a stream was sewage polluted because these organisms were found in the stream?

A. No, sir; I could not assert it from their presence there, barring all other considerations.

Q. Now, Mr. Whipple, we have gone through all the elements which you have indicated that the analyses would show. Are any of these elements taken separately or combined, that demonstrate their origin to come from the fecal discharge of man or the urine discharge of man, if found in waters?

A. Just read that once more.

Q. (Question read.)

A. There are none of the elements which you have mentioned taken singly, that would demonstrate that fact.

Q. Or taken collectively?

3416 A. And even when taken collectively, they are not always
able to demonstrate their origin as coming from the urine or feces of man, but taken collectively and making comparisons with what we know of their character and amount in sewage, we are sometimes able to judge as to whether or not a water may be polluted with sewage which presumably contains the dejecta and urine of man.

Q. Is that an assumption or a scientific demonstration?

A. I wouldn't consider it as a scientific demonstration, but I would regard it as more than an assumption; I would regard it as a fair estimate of the conditions.

Q. Does the words "fair estimate" in the sense you use it, rise to the dignity of a scientific demonstration?

A. No, sir; I wouldn't call it a straight scientific demonstration, but I would consider it what you may call a reasonably correct judgment.

Q. And that judgment that you define as reasonably correct judgment, is liable to be mistaken, is it not?

A. Yes, like all human judgments.

Q. And differs from a scientific demonstration in the fact that the scientific demonstration is not liable to be mistaken; is that right?

A. That depends upon just how straight an interpretation you wish to give to a scientific demonstration.

3417 Q. Well, isn't a scientific demonstration, in the way that you use it as a scientist—not the way that I use it, because I know nothing about science—an accurate determination of a fact, and without any elements of doubt connected with it?

A. Considering that it brings about an accurate and infallible result, I say that my reasonably correct judgment is not as high as an absolutely infallible result.

Q. Is an estimation, in the sense you use it, a scientific determination of a fact in regard to stream pollution?

A. Perhaps, in the straight sense, in which you may mean.

Q. I want to know what you mean, if you will excuse me for suggesting it, as you are testifying and I am merely asking.

A. Perhaps not in the strictest possible sense, but I believe what you may call a scientific estimate may often be considered as giving us reasonably correct results.

Q. That is true in the absence of science, when the judgment of a man of ordinary common sense attempts to give an opinion upon a state of facts, is it not?

A. The accuracy of the judgment will depend upon the basis upon which that judgment is founded, and upon the character of the person who makes the judgment; his experience on the subject upon which the judgment is made, and such general conditions as that.

3418 Q. Then is this proposition true, that where science is unable to enter a demonstration, the judgment of a scientist can form an estimate which is reliable?

A. No, sir; I wouldn't say that was true as a general proposition.

Q. Is the science which you bring, by virtue of experience, to fortify your opinions in this case, any less accurate than the science of engineering, that constructs a bridge, or of the surveyor that plots a piece of ground?

A. I don't think I can answer that question by yes or no, because the science includes so many—because the two sciences assume so many facts. For example, there are certain determinations in chemistry which can be made with great accuracy and with as small limits of error as certain determinations made by the engineer or the surveyor, while there are other parts of the science where the limits of accuracy may not be as great, just as I concede may be the case the other way around.

Q. Then when scientists get to that point where they cannot demonstrate by analyses, they can merely approximate the truth by an opinion or an assumption, is that right?

A. No, sir; I don't think that is right. When they get to a point where they cannot make an absolute determination, they obtain the best available data which they can get, and make the best scientific judgment which they can from this data. They do not abandon all data and simply make a guess.

3419 Q. You wouldn't call that judgment scientific, though, would you?

A. I would call it a judgment based on scientific facts. To that extent it would be a scientific judgment, perhaps.

Q. Now, in the bacillus of typhoid, how many of these organisms are discharged by one typhoid patient?

A. I couldn't say definitely, although I have at times seen figures which pretend to give the numbers of typhoid bacilli found in the feces and dejecta of typhoid patients and in the urine discharged by a typhoid patient, and I have myself made determinations of the number of typhoid bacilli in the urine of a typhoid patient, where I found a number of thousands of such bacilli to a cubic centimeter, but I cannot give the exact figures either from memory or from notes.

Q. Well, as a general statement, isn't it true that the numbers are enormous?

A. They are certainly enormous.

Q. And the number of these organisms from the discharge of one patient, would be sufficient to create an epidemic, wouldn't it, if the waters of that stream were drunk?

A. Under certain conditions.

Q. By the cities?

A. Under certain conditions.

Q. What conditions?

3420 A. That would involve a considerable series of conditions, among which you may consider the vitality of the organisms originally, the rate at which they might die out in the water, the relation of the number of organisms to the amount of water into which they enter; the amount of sedimentation which might occur in the water between the times when they enter the water and the times when that sewage reached the people who drank the water, and if sedimentation occurred, the chances of these organisms being again carried into the water and thence borne to the places where the people drank the water, the possible influence of the microscopic organisms, the possible influence of sunlight and such conditions.

Q. So it depends upon numerous conditions?

A. It depends upon numerous conditions, yes ,sir.

Q. Do you know how long the bacillus of typhoid will live in sewage contaminated water running in a river?

A. I don't know definitely.

Q. Do you know of any scientist who knows or who has asserted it as a fact?

A. I don't know of any scientist who actually knows. I know the bacillus of typhoid fever will live in sewage polluted water, but scientists have made laboratory experiments to determine that fact and they have arrived at certain conclusions. Do you wish me to enumerate any further?

3421 Q. That is an answer to my question, and is as far as I care to have you go. Do you consider conditions in the laboratory, where experiments have been made, similar to conditions that exist in a running stream, sewage polluted?

A. No, sir; I do not.

Q. Do you know whether there has ever been a test of typhoid germs in sewage polluted water made in the laboratory?

A. Yes, sir.

Q. You know how long they would live in that water, subject to sunlight and air and motion, do you?

A. I do not recall the experiments made to determine the longevity of the typhoid bacillus by laboratory experiments in water, where the question of motion was taken into account, but I know of experiments which have been made in sewage polluted waters where the questions of sunlight and air were taken into account. In fact, I know of a number of such experiments which have been made and the longevity was found to vary from a period of some weeks to a period of some months. I cannot at this moment give the exact results reached by those observers. I have also made experiments on the subject myself.

Q. Were those experiments conducted in the laboratory, similiar to conditions that exist in running streams?

GENERAL CROW: Which do you refer to; the ones he made himself?

3422 MR. TODD: Yes, and the ones you have testified about?

A. No, sir; the conditions were not the same as would exist in running streams in all respects.

Q. Do you know of anyone who has ever discovered the germs of typhoid in running waters?

A. I know people who have claimed to have discovered the germ of typhoid in running waters, but I am unable to state whether they actually did discover that germ in running waters or not. In the earlier stages of bacteriology when species were not studied as carefully as they are today, certain results were obtained and put forth by bacteriologists, which would hardly be credited in the present state of the science, and yet there are on record cases where apparently the results indicate that the typhoid fever germ was discovered.

Q. What is the name of that test that has been recently discovered for the germs or bacteria?

A. I don't know just what test you refer to.

GENERAL CROW: Do you mean the physician's test, the Widal test?

MR. TODD: Yes. Has anyone discovered the germs of typhoid in running waters since the discovery of the Widal test?

A. I am not exactly sure, but I think that one or two such discoveries are said to have been made.

3423 Q. Do you know who they were or anything about it?

A. I don't know anything definite, but it is my impression that Dr. Wesbrook of the University of Minnesota, who is the bacteriologist for the State Board of Health of Minnesota, found an organism which appeared to be a typhoid bacillus, and if I am not mistaken that organism did give the proper test with the Widal reaction, but I cannot confidently state that this is the case.

Q. Has any scientific investigation been made as to the rate this typhoid bacillus dies out in running waters, running sewage polluted water?

A. Experiments have been made to show the rate at which they will die out in water, under laboratory conditions.

Q. But I mean in the natural conditions of rivers?

A. I know of no experiments that have been made in the rivers themselves. I don't see how it is possible in the present state of bacteriology for reliable experiments of that character to be made.

Q. You stated that it would depend upon the rate they died out and the amount of water dilution and sedimentation. What did you mean by the amount of water dilution?

A. What would depend?

Q. Whether the discharge of a typhoid patient in the river, that the bacteria in it would be sufficient to cause an epidemic among people who drank the water of that river, and your
3424 answer, as I remember it was, that it would depend upon the rate they died out, the amount of water in dilution, sedimentation and one or two other matters?

A. Yes sir.

Q. Now in regard to that, what did you mean by the amount of water in dilution?

A. I meant this, that if a certain number of typhoid fever bacilli were put into a certain amount of water and mixed throughout it, and if again, the same number of bacilli were put into a larger quantity of water and thoroughly distributed throughout it; then disregarding all other things, an equal volume of the large quantity of water would contain fewer bacilli of typhoid fever than the small quantity.

GENERAL CROW: Do you mean to say exactly that thing? Now would it contain fewer, or might it contain fewer?

A. I am assuming they would be all equally distributed.

GENERAL CROW: That is what I am getting at. Is that a possible condition, as a matter of information I want to know?

A. I am not stating that as a condition which would occur; I am stating it as a condition which might.

Q. He is asking you the practical question, the effect of dilution; that's the reason I offered the suggestion that I did. Pardon the interruption. I thought you would want a practical answer.

3425 MR. TODD: I want the facts. What is the effect of dilution upon the typhoid bacteria?

A. If we assume that different typhoid bacilli are separated from each other, and that they will be distributed in the water, the effect of dilution is to spread further these organisms from each other, assuming of course a thorough mixture of the water, as I understand you to mean.

Q. Are they separated or are they in clusters when they are discharged through the urine or through the feces?

A. I think that both conditions would prevail.

Q. Is it not a fact that the urine carries more of these organisms than the feces of a typhoid patient?

A. I don't recollect; that would depend upon whether you include the amount of urine, or whether you measure them and compare the number in a cubic centimeter in the one, with the number in a cubic centimeter of another.

Q. By that comparison?

A. I think it would further depend on the stage of the disease. I can conceive that at a certain stage of the disease they might be more numerous in the feces than in the urine, and at the other stage I can conceive that the reverse might be true.

Q. Well, when they get into the water they separate, do they not?

A. I have no doubt that many of them do. I suppose it 3426 is also true, that like other bacteria, many of them remain together in what you call groups, using that word in a broad sense, or may be held together by some force, substance perhaps, so that as a matter of fact they may occur both singly and in groups.

Q. · Do they increase and multiply while in the water?

A. I believe that the best scientific information which we have on that point, leaves us to suppose that after leaving the human system they do not ordinarily multiply in the water.

Q. Are you acquainted with the conditions of the Illinois River between Lockport and Grafton, the physical conditions of the river?

A. I have seen the river between Lockport and Joliet, and I have examined maps and profiles and read reports describing the conditions between Joliet and Grafton; I have never personally seen the river between Joliet and Grafton.

Q. Would the presence of lakes in the river act as settling basins for the purification of the sewage discharged from the drainage canal at Lockport?

A. If such lakes were present on the Illinois river, and if in such lakes the water therein should become more quiescent, than in that of other portions of the stream—Did you speak of typhoid fever bacillus?

Q. Yes. I am speaking of the sewage.

3427 (Question repeated).

A. (Continued) The suspended matter of the sewage, the suspended portions of the sewage might tend to settle more rapidly than in the swifter portions of the stream, but whether this could be called an actual—did you use the expression "purification of the sewage"?

GENERAL CROW: He used the expression "sedimentation and sewage."

A. (Continued) Purification of the water which contained the sewage would depend in part upon what happened to the suspended matter after it had settled, and whether or not the suspended matter was afterwards carried into the stream again, to Grafton.

Q. Is that the end of the answer?

A. Yes sir.

Q. What is your opinion as to whether the suspended matter would settle or not?

A. From what I have learned from reading various reports which describe the conditions of the Illinois River between Lockport and Grafton, it is my opinion that at times such sedimentation may take place.

Q. At what times?

A. At such times as the velocity of the water in the stream was low.

3428 Q. Is it your understanding that the velocity of the Illinois river throughout the year from Chicago to the intake is between eight and ten and a half days?

A. From what I have read concerning the velocities of the stream, I should not place those as the limits for the year.

Q. That is practically the maximum, isn't it, as those rates were taken at practically high flood waters of the river?

A. You mean the maximum rate?

Q. The maximum rates of flow.

A. I should say they were nearer the maximum than they were of the minimum certainly.

Q. When the rate of flow attained that velocity, would you take into consideration the volume of water that spreads out over the surrounding country, overflowing the banks of the Illinois, as sedimentation basins?

A. If we assume that these rates represent conditions approaching the maximum, I should not, speaking generally consider that expansions of the stream which might be due to overflowing the banks, would act continuously as sedimentation basins for any considerable period.

Q. It would add considerable to the dilution of the sewage wouldn't it?

A. The mere fact that the water over-spread the banks would not increase the dilution. It is simply a case of the
volume of the water with reference to the amount of
3429 sewage which affects the dilution.

Q. Assuming that the drainage canal discharged 250,000 cubic feet of water a minute through the Bear Trap Dam, and that the volume of water passing a given point, say Peoria, was 1,000,000 cubic feet a minute, under normal conditions (this is purely hypothetical because I haven't the data), and under flood tide conditions, it would be 3,000,000 cubic feet. Wouldn't the flood conditions add greatly to the dilution of the sewage from the drainage canal?

A. They would add to the dilution. They would increase the dilution of the sewage.

Q. And increasing the dilution of the sewage, wouldn't the sewage be disseminated through the water which overflowed the banks of the Illinois river? That would happen, wouldn't it?

A. A part of the sewage might be carried into the water which overflowed the banks if they overflowed the banks under the conditions which you suppose.

Q. The current in the overflowed sections of the country wouldn't be as swift as it would be in the main channel, would it?

A. Probably not.

Q. And sedimentation would take place there, wouldn't it?

3430 A. That would depend not upon the relative current as much as upon the absolute current.

Q. Well, sedimentation takes place in any kind of a current more or less, doesn't it?

A. I wouldn't say that, no sir.

Q. Now where the river is down to its normal conditions, are you acquainted with the conditions that exist in regard to the dams across the Illinois River?

A. I don't know just what you mean by "in regard" to the condition, unless you mean the average condition.

Q. An average condition?

A. I know that there are some dams across the Illinois river at several places.

Q. Do you know how many—there are four. You know what those dams are there for do you not?

A. I think so.

Q. They are there for the purpose of assisting navigation by raising the water and backing it back up stream. Now when the water in the Illinois river is at normal, and is backed up by these dams, would not the backing of the water up above the dams act as settling basins?

A. If in this water above the dams, the velocities were reduced to such a degree that sedimentation of suspended matter could take place.

Q. What velocity would that be?

3431 A. That depends partly upon the character of the suspended matter and partly upon the velocity of the suspended matter. (Witness referring to book).

Q. Did you write the book?

A. I didn't write this one.

Q. Have you any independent judgment on the point, outside of any authority?

GENERAL CROW: Let him answer the question you asked him.

A. If you ask whether I made any experiments on the subject to determine that fact. I have not.

MR. TODD: Well, have you any judgment yourself as an expert on that proposition?

A. Yes sir.

Q. What is your individual judgment upon the subject as to the speed of a current that would be necessary in order to permit sedimentation?

A. My judgment is that if the velocity is reduced say from a quarter to one-third, or perhaps to a half a foot per second, sedimentation of suspended matter of a certain character might occur. If the suspended matter were coarser, it would settle with greater velocities. I can imagine suspended matter so fine that it would not settle even at those velocities named.

3432 Q. Suppose that the current was a mile in two hours, would sedimentation take place?

A. I think it would, sedimentation of substances of a certain character.

Q. Is there any fixed rule or rate of current when sedimentation might take place?

A. I don't think our knowledge of the subject has reached the point where we can give any strict rule. Properly, I will say that it depends upon the character of the suspended matter and the temperature, and upon a series of conditions, all of which would have to be taken into consideration in formulating such a rule.

Q. If these four dams in the Illinois river in normal conditions, back up the water for a considerable distance above, they would assist sedimentation wouldn't they, considerably?

A. I should say, if I understand your meaning. I think they would allow sedimentation to take place under more favorable conditions than if they were not there to just the extent to which they reduced the velocity of the stream.

Q. And is there a fixed rule as to the amount of sedimentation that will take place at a given velocity?

A. I don't think there is any such fixed rule.

Q. Then it is purely a matter of reasoning, isn't it?

A. No I don't consider it purely a matter of reasoning.
3433 Experiments have been made on the subject, but I don't
think that experiments have been sufficiently numerous or have been made under such sufficiently different characters so that we are enabled to formulate our knowledge in precise statements.

Q. Do you know what the conditions are which obtain in the Illinois river in regard to sedimentation, whether it is the same as in any other river or not, or different?

A. Of course we understand that the laws governing sedimentation of suspended matter would apply to the Illinois river the same as they would apply to other streams, and I know from reports that sedimentation actually is said to take place in the Illinois river at certain places.

Q. Now when you get to Lake Peoria, which is a lake of considerable size where the velocity throughout the channel is one mile in two hours, at the maximum, practically maximum height. Would that facilitate sedimentation?

A. I think that a velocity of one mile in two hours would allow sedimentation of a certain size or kind of suspended matter to take place.

Q. Now by the time that the sewage of Chicago got to Peoria, do you know whether that sewage would be purified or eliminated from the waters or not?

3434 A. Under the conditions which exist, it is my judgment
that the proportions of the sewage, of all parts of the sewage of the city of Chicago would not be eliminated by the time that it reached Peoria.

Q. What part would be,—fifty per cent, seventy-five per cent, or are you able to state?

A. I am unable to state definitely.

Q. Upon what do you base that, doctor, that opinion? Upon what do you base your opinion that the sewage of Chicago is not eliminated by the time it gets to Peoria?

A. I said parts of the sewage, and when I said parts I did not mean a half or a quarter or an eighth or a sixteenth. I meant parts of the sewage, understanding that sewage is not a single substance, but it is composed of various ingredients.

Q. Upon what do you base that opinion?

A. Perhaps I can illustrate that better by example. If we take chlorine, for instance, which is a constituent of sewage, that chlorine would not be affected by sedimentation, for instance, but practically only by dilution, and to that extent the sewage of Chicago would not be eliminated by the time it reached Peoria, but simply reduced in amount by the dilution it might receive.

Q. Well, do you know that from any analytical data, that that is true?

3435 A. I know that there is a certain amount of chlorine in the sewage of the Chicago Drainage Canal, but I cannot recall the amount at this moment.

Q. Let me ask you a question, if I may interrupt you. Do you regard chlorine as an evidence of sewage pollution?

A. Under certain conditions I do.

Q. What conditions?

A. When the chlorine of a water known to be polluted with sewage, is compared with what may be called the normal chlorine in the natural waters, from the region which the water, to which the sewage was added—I do not know whether I am making myself clear or not.

Q. Do you regard chlorine in the Missouri river as an evidence of sewage pollution?

A. From what I know of the existing conditions on the watershed of the Missouri river and from the fact that there are certain salt deposits, there are said to be certain salt deposits on portions of that water-shed, and from analyses which I have seen showing the indication of such salt deposits, or the effect of such salt deposits on the water of the Kaw river, it is my opinion that the chlorine in the Missouri River, in its low reaches, cannot be used as an index of pollution, although part of it may be derived from sewage pollution, because the effect of the chlorine from the salt deposits, would simply mask any chlorine from sewage pollution, and in that 3436 particular case the chlorine could not be used to determine whether or not the water was sewage polluted.

Q. When did you first learn that the Kaw River had salt deposits in it; when was that first brought to your attention?

A. I received a report on the subject a number of years ago. I have the report here somewhere; I can get the date for you if you would like to have it.

Q. I don't care about the date.

A. I have known it as a matter of general knowledge—

Q. How large a river is the Kaw in volume of water?

A. I cannot recall at this moment.

Q. Well, do you know that the Kaw River, is a river from 2000 feet per minute, to 20,000 per minute—cubic feet, is that true?

A. I couldn't tell without consulting some notes.

Q. Well, I will pass by the Kaw.

(No answer).

Q. Is it your opinion, and I believe you stated that the increase in typhoid in the city of St. Louis, is due to the sewage from the drainage canal, from 1900, 1901, and 1902?

A. I think that I stated that under certain conditions which were assumed, the most probable cause of the increased typhoid in the city of St. Louis during that period was due to the sewage of Chicago, meaning by that that was the easi- 3437 est explanation of the increase under the conditions which were assumed.

Q. Does an easy explanation always explain, Mr. Whipple?

A. It doesn't always explain.

Q. Assuming that in the month of November, 1899, there were 482 cases of typhoid and 36 deaths, and in December 116 cases and 37 deaths, and that the number of cases of typhoid for those two months exceeded the number of cases of typhoid in St. Louis for any two months since 1892, and exceeds the number of cases for any similar two months since 1899, and assuming that the number of cases along the towns of the upper Mississippi and the Illinois towns outside of Chicago and outside of the Missouri river towns, was 201 for the year. Do you know of any explanation that will explain the cause of this typhoid epidemic?

GENERAL CROW: I object to it for the reason that it assumes first an impossible condition of affairs, and secondly a condition of affairs that did not exist. First because the number of deaths in the two months attempted to be classified of November and December, 1899, with other periods, is wrong, according to the official returns of the City of St. Louis, and secondly, because the question as to whether or not the witness can explain the cause of the deaths by typhoid in 1899,
has nothing whatever to do with the question as to wheth-
3438 er or not the Chicago sewage has increased the pollution
of the water supply of St. Louis, and for the further reason that it assumes only a period of two months for a test of the City of St. Louis, while assuming a series of years for the entire remainder of the water-shed, which renders it completely unfair, even as a hypothetical question.

A. On the assumptions named, without considering other facts or assumptions, which among other things might include the amount of typhoid fever on the water-shed of the Missouri river and without knowing the time and place where the typhoid fever referred to as existing upon the water-shed of the upper Mississippi and the Illinois river occurred, and other facts of that nature, I cannot form an opinion as to the subject.

Q. If you knew the places where the typhoid existed that made up the 201 cases to which I referred, on the Illinois and Mississippi Rivers, would that assist you in any way in solving this problem?

A. It would be an assistance, yes sir. But it might not be sufficient to enable me to solve the problem.

Q. Well, I will add that to the question. At Centralia, 30 deaths from typhoid fever in 1899.

Dubuque 15. I will state that those are memoranda that I made from the testimony offered in the case. Des Moines 13—

GENERAL CROW: These figures are for the entire
3439 year of 1899.

MR. TODD: Yes and are as follows:

Burlington	8
Minneapolis	71
Keokuk	9
Quincy	6
Hannibal	5
Bloomington	9
Peoria	12
Ottawa	3
Decatur	7
Joliet	5
Elgin	5
Aurora	4

GENERAL CROW: These are towns in Illinois exclusive of Chicago?

MR. TODD: Yes, exclusive of Chicago.

THE WITNESS: That makes 202.

MR. TODD: I have it 201. here. With that additional assumption, does that enable you to offer any explanation?

A. With the addition of that data alone, it would not. There would still be things that I should desire to consider before expressing an opinion.

Q. What other elements would you like to consider?

3440 A. I should like to consider the character and the amount of typhoid fever that existed upon these same watersheds for previous years. The amount of typhoid fever which existed upon the Missouri river water-sheds for previous years and for this year.

Q. Have you heard, or did you hear the testimony here in regard to the typhoid fever at those different places during the previous years?

GENERAL CROW: Did you finish your answer, Mr. Whipple?

A. I said among other things. I didn't name them all. I don't know as I should have named them all.

MR. TODD: I didn't mean to interrupt you.

A. No, I didn't hear the testimony to which you refer, but I have seen some of the figures which I think were introduced.

Q. Well, would those figures help you to solve this problem if you had them?

A. I think they alone, in addition to what you have already stated, and disregarding the questions relating to the flow of the streams at that time, to the possible influence of local causes of the epidemic, that I should still be unable to decide, without studying the question still further. I wouldn't stop with those facts alone.

Q. What local causes could create an epidemic of typhoid such as this in the city of St. Louis, as you know the physical conditions of the city?

3441 GENERAL CROW: Your question assumes the fact that he did not state as I understand him. Your question assumes that he stated that the local cause could create such an epidemic as you call it, in December, 1899. I didn't understand him to say that local causes would do that. He said that was one of the factors we might consider, as I understood him. I want to understand the matter as we go along, that's all.

MR. TODD: What local conditions would you want to know?

A. In deciding or endeavoring to find out the cause of the increase, which you assume to be considerable, and which I believe, if I remember correctly, was the case, I should wish to know among other things, if any changes had occurred in the water supply system of the city, compared with previous years, to naturally investigate questions concerning the milk and other foods, although the apparently high increase would hardly be due to such milk or food, though I do not say that it absolutely could not be.

Q. Assume in addition to that that the Health physician, or that the Board of Health were unable to discover any local conditions which accounted for that typhoid?

A. If we should wipe out the influence of foods or such
other local conditions as might cause it, and assuming that
3442 no local conditions did cause it, I think that I should nat-
urally infer that an epidemic was in some way due to an
infected condition of the water supply of the city, but how or
where that water supply became infected, I don't think I should
be able to say definitely from the conditions thus far assumed.

Q. Assume that no rational explanation has been able to be made for the cause of this epidemic in 1899, which is the more rational explanation for the subsequent epidemics of 1901 and 1902, the unknown cause that led to this epidemic or the opening of the drainage canal in 1900?

GENERAL CROW: I object for the reason that the record in this case does not disclose that there is no explanation offered for the increase in typhoid in this city in November, 1899 and December of the same year.

MR. TODD: I base it upon the testimony of Dr. Teichmann.

GENERAL CROW: That is not all the evidence in the case, however.

MR. TODD: I didn't hear Dr. Ravold make any explanation of that. He may have, but I didn't hear it.

A. I don't believe that it is possible to make a fair comparison between a cause which is unknown and which may perhaps have acted on one particular occasion, and as to which we do not know, whether it can or cannot occur again, 3443 with the Drainage Canal through which is delivered part of the sewage of the City of Chicago, as the cause of the increase in the number of deaths from typhoid fever in St. Louis, during the years 1900, 1901 and 1902, as compared with several years previous.

Q. You cannot state as an established fact that the opening of the canal at Lockport is the cause of the increase in typhoid in St. Louis, can you?

A. I cannot state it as an established fact absolutely, and conclusively proven.

Q. What effect does the sewage of Peoria have upon the water supply of St. Louis?

A. That would depend upon a considerable series of conditions.

Q. Well, assuming all the conditions you know to exist, can you give me an answer to the question without the assumptions?

A. Not without the assumptions, no sir.

Q. Do you know whether the sewage of Peoria purifies itself in 25 miles or 50?

A. I don't know that it does.

Q. Would you say that it did or did not?

GENERAL CROW: I object to the form of the question, for the reason that it assumes a fact not proven, or admitted; that is, that the sewage would have purified itself by the
3444 mere distance that it goes with water.

Q. Can you answer the question, Mr. Whipple?

A. Yes sir. Just read it again.

Q. (Question read).

A. If you mean by purification, the fact that the water into which the sewage of Peoria is discharged becomes free from all the constituents of that sewage; if you put the time within 25 or 50 miles, or if you mean that the water into which the sewage of Peoria is discharged—perhaps you will have to read that answer—

(Answer read) as follows: "If you mean by purification the fact that the water into which the sewage of Peoria is discharged, becomes free from all the constituents of that sewage,"

A. (Continuing) I should say that it did not.

Q. Would it purify itself by the time that it got to the St. Louis intake?

A. If you mean by purification of the sewage the fact that all of the elements of the sewage were absolutely removed from the water I should say that it did not, but in connection with both of these answers, I wish it to be understood that the factors of dilution, etc., must be taken into consideration.

Q. Is chlorine in water injurious to health?

A. No sir, not unless you get an excessive quantity of
3445 it, and it would probably be impossible to get enough to injure one as I understand your question.

Q. In order to make water dangerous to public health, there must be some pathogenic germ in it, must there not?

A. I should say it must contain something which would affect the human system, and that that something would ordinarily be a pathogenic germ, rather than any form of poison, or anything of that sort.

G. C. WHIPPLE.

ADJOURNED until 10:00 A. M., following morning, Saturday, May 16th, 1903.

Southern Hotel, St. Louis, Missouri.

3446 10:00 A. M., Saturday, May 16, 1903.

Parties met pursuant to adjournment, present, the Commissioner and same counsel representing the respective parties.

GEORGE C. WHIPPLE,

Resumed the stand for cross-examination by Judge Johns, and testified as follows:

Q. In order to determine the general character of a water by microscopical examination, the samples taken and examined ought to be at different times and quite numerous, ought they not?

A. The more frequently the samples are taken, and the more samples that are taken, the more reliable would be our knowledge in regard to the character of the microscopic organisms present.

Q. They ought also to be taken at different seasons of the year, ought they not?

A. They ought if you desired to know the character of the water at different seasons of the year.

Q. To know the general character of the water for an entire year, samples should be taken frequently at different seasons of he year, should they not?

3447 A. If you wanted to know the character of the microscopic organisms in the water for the entire year and the changes which might take place in the number of microscopic organisms present at different seasons, the samples should be taken at different times of the year, and the more frequently hese samples were taken the better would be our general knowledge—the more reliable would be our knowledge in regard to the eneral character of the water with respect to microscopic oranisms.

Q. Take one set of samples in a cross section of the Illinois iver and examine them microscopically, you wouldn't learn nything except as to the condition of the river at that time?

A. Just read that question again.

Q. (Quesion read).

A. We would learn the condition of the water at the point where the samples were collected at that time.

Q. And that determination would not apply to the condition of the river, a month previous, or a month subsequent to those samples?

A. It might not.

Q. So that as to the condition of any of the water of any running stream, one set of samples taken at a selected time, would give no reliable information?

A. That would give reliable information as to the character of the water of that stream at that time.

Q. And at the very point where the samples were taken?

3448 A. At the point where the sample was taken.

Q. And at no other time, or at no other point?

A. No sir, so far as those samples alone, were concerned, and in the absence of any one from which we know that those waters remained constant in character through a period of time.

Q. In taking a sample of water as these have been taken in this case, all that the bottle contains is the water that comes in from its top at an aperture less than an inch in diameter?

A. Yes sir, I think the aperture was something approximately what you state.

Q. And there might be at a distance of two feet or any other distance in the water at the same instant, an entirely different condition of affairs?

A. Such a condition might exist, but it would not naturally exist in the water of the running stream where the water is reasonably well mixed up or in the water of the lake where the water is stirred up by winds, etc.

Q. Have you examined the data of the chemical and bacteriological examinations of samples of water of the Illinois River taken at Pekin Bridge, fourteen miles below Peoria?

A. Just read that again.

Q. (Question read).

3449 A. I have seen some analyses of that nature from samples collected at that point, yes.

Q. Did you notice the startling difference between the samples taken on the right bank and those on the left, as to the chemical and bacteriological elements?

A. I don't recollect at this moment.

Q. Samples are taken in a cross section of a river upon the theory that the average state of the entire number of samples is a correct representation of the condition of the river at that point at that time?

A. They are taken in a cross section in order that more reliable information could be had of the character of the water passing that cross section than could be obtained from a single sample,—

Q. And more reliable information as to the condition of the water at that point at that time?

A. At the point where the samples were taken at that time.

Q. Have you traveled up the Illinois river at all?

A. No sir.

Q. Did you make a physical examination—

A. No sir, excepting that I have seen the—no sir, using the word "Illinois River," I will say I have not.

Q. Have you traveled up the Mississippi river with a view of determining its physical surroundings and conditions?

A. No sir.

3450 Q. Nor up the Missouri river?

A. No sir.

Q. Or did you know about the character of the waters of any one of these streams, from such examinations as you have made of samples furnished you and from an examination of the tabulated results of examinations bacteriological and chemical, which have been shown you here, as introduced in this case?

A. Just read that question.

Q. (Question read).

A. I have seen the Mississippi river water between St. Louis and the Chain of Rocks and I know of the character of the water from examinations which I have made, and from the results of physical, chemical and bacteriological examinations which have been made by others, some of which have been submitted in evidence, and I have seen other published results of chemical and bacteriological analyses in the Illinois river, for instance, which so far as I know, may not have been presented here in evidence.

Q. And in making up an opinion as to the condition of these rivers, you have assumed that these results which you have seen as tabulated or published, were correct?

A. I was told that they were correct, yes sir.

Q. Is it a fact that if two chemists make an examination of waters from the same point, taken at the same time, they will differ in their results?

3451 A. That might happen.

Q. Does it not generally happen that they differ slightly?

A. As a rule they would differ slightly.

Q. Two chemists of equal experience, having equal opportunities for examination and material for examination will differ as to the results of the examination of the same water taken at the same point at the same time?

A. There might be differences within slight limits, yes sir.

Q. In the matter of nitrites for instance, a very slight difference might make a very material difference in a judgment as to the quality of the water?

A. No sir, I would not say that.

Q. What is the extreme limit for the potability of water so far as your information goes, as to the amount of nitrites in it, the water being considered independent of any physical surroundings?

A. I cannot express an opinion upon that point, as the term "potability" does not convey to my mind a well defined and definite meaning.

Q. There is no such thing as a well defined and definite standard for the potability of water, considered independently of its physical history, is there?

A. I do not consider that there is, because I do not con-
3452 sider that the term "potable" has a well defined and de-
finite meaning, and if that is the case we cannot have a definitely recognized standard regarding it.

Q. We have been going along here in ignorance, perhaps, on the assumption that potability meant a condition of water in which it was not deleterious to health to drink. Is there any such standard as that?

A. With regard to the presence of nitrites?

Q. Any chemical constituent?

A. I do not consider that there is a well defined standard regarding what I may term the safety of water with respect to its use for drinking purposes, excepting that of the absence of substances which might render the water unsafe.

Q. Do micro-organisms such as you have named in your testimony here, have any office in the purification of waters?

A. It is my opinion that it is a practically unknown subject as to whether or not the presence of microscopic organisms would render a water which once was unsafe, safer for use than if they were not present. It is my opinion that there may perhaps be some influences which certain microscopic organisms exert upon bacteria which might tend in that direction, but I do not believe that the information of that characer is very definite.

Q. So that the presence of a greater or less quantity of any kind of micro-organisms such as you have named, is not indicative that the water is undergoing a process of purification?
3453

A. I do not consider that it is indicative of that, no sir.

Q. Do you know whether the classes of micro-organisms which you have named,— diatomaceae, chlorophyceae and protozoa, have any separate or distinct offices in regard to the purification of water; that is to say, do the diatomaceae for instance, perform some office in the purification of water, different from that of the protozoa?

A. I do not believe that our knowledge on the subject is very definite, but it is conceivable that diatomes may exist with different relations to bacteria which may be present in the water than some of the protozoa, for instance, or some of the blue green algae.

Q. Have any of these classes of micro-organisms or the groups of micro-organisms, motility?

A. Some of them do have, yes sir.

Q. Which have?

A. I couldn't answer that by separating them into definite groups, and say that one group has while the other does not, because there are differences within the groups, but taking the proposition on an ordinary basis, the diatomes are not considered to be motile, the blue green algae are not considered to be motile, as a rule.

3454 Q. Do they belong to the diatomes?

A. No sir, they belong to the cyanophyceae. The chlorophyceae are, most of them, non-motile, while many of the protozoa are motile.

Q. Any one of these groups of micro-organisms might encounter such a condition of water as would exterminate them, might they not, from that water?

A. Any one of those groups might encounter conditions which might exterminate them so far as their life were concerned, but I have already testified that the cell walls of the diatomes are practically indestructible in water.

Q. Well, the organism lived inside of the cells, did it not? The life principle of that micro-organism is inside the cell?

A. The diatome is a plant, and the living matter of the plant lies to a considerable extent, I might say, practically within the cell wall.

Q. Well, it is open so that the water in which it lives or exists has an influence upon it?

A. There are believed to be openings between the exterior of the cell and the interior of the cell.

Q. Could a diatome then, thus fortified with a glass sell, be subjected to the influence of some water that would kill it?

A. I think that they can, so far as the life of the plant is concerned.

3455 Q. Now diatomes are found most generally in ponds and lakes?

A. The diatomes are found in all surface waters, to a more or less extent. There are certain diatomes which are found more generally in ponds and lakes, than in running streams, for example, except in so far as the waters of those streams are fed by the waters of ponds or lakes.

Q. The synedra are such diatomes as are found principally in ponds and lakes?

A. There are a great many kinds, a great many species of synedra.

Q. Well, the synedra pulchella, variety sub prolongata is found in ponds and lakes, is it not?

A. The synedra pulchella variety sub prolongata is more commonly found in ponds—in the waters of ponds and lakes than in the waters of streams, except is so far as those streams might be fed by lakes which contain them. I mean, the natural habitat of the organism is in ponds and lakes.

Q. Is that also true of tabellaria?

A. Yes sir, that is true of tabellaria. I will say, of some species of tabellaria.

Q. If the variety of synedra which you have mentioned, and the tabellaria could be required to pass through twenty miles of what has been called pure sewage, they would not be likely to survive the journey?

A. I think it might survive the journey, yes sir.

3456 Q. Have you any knowledge as to whether it actually will, from personal observations or experiments?

A. I have examined samples of sewage in other cities where I have found this organism and where, so far as could be told by looking at it through the microscope, the plant was in a living state.

Q. But that could not be determined with any certainity, I suppose, by microscopical examination?

A. I could not tell with certainty whether or not the organism—or the living princple of the plant was still alive.

Q. Did you ever examine any synedra or tabellaria that you knew to a reasonable certainty as a scientific man, had passed through ten miles of pure sewage?

A. I have examined samples of sewage in which I found these organisms, in the city of Boston,— the samples of sewage being taken from near the out-fall of the sewage, at Moon Island, and it is my impression that they must have traveled, I should say eight or ten miles at least, in the sewers of the city, but I cannot tell at the present moment just how far they did travel.

Q. Or whether they were dead or alive when you examined them—that the principle of life was in them?

A. To all appearances, as I examined them under the microscope they were alive, but I could not say definitely from that simple ocular inspection of them.

3457 Q. Assume that the Illinois river has upon both banks from Joliet to Grafton, or from La Salle to Grafton, large numbers of ponds and lakes, many of which are fed by springs, overflowing in time of high water, and acting as feeders to the Illinois river in time of low water, having their low water outlet into the Illinois river, could the synedra and the tabellaria, of which you speak, exist in such ponds and lakes?

A. Yes sir, they could exist there.

Q. Is there any geographical limitation to the existence of the synedra?

A. Do you mean with reference to latitude and longitude?

Q. Yes sir?

A. It is my opinion that these organisms are well distributed geographically.

Q. And that the State of Illinois is within their geographical distribution?

A. Oh, I should say that they might occur there, yes sir.

Q. Is that true also of the tabellaria?

A. Yes sir.

Q. Assuming that synedra and tabellaria of the kind you mention, exist in the waters of Lake Michigan, and also in lakes and ponds which are tributary to and discharge their waters into the Illinois River below Lockport, and these same organisms were found in the intake of the St. Louis waterworks,
3458 and that these organisms coming from Lake Michigan, have to pass through 24 miles of sewage of the drainage canal, being found in the St. Louis intake,—to which source would you prefer to attribute them?

A. In order to answer that question I should have to know the numbers of the organisms in Lake Michigan, as compared with the numbers assumed to exist in the assumed lakes along the Illniois river, and the relative volumes of water from Lake Michigan as compared with the volumes of water delivered from those so-called lakes.

Q. Assume that the number of synedra and tabellaria per cubic centimeter in the waters of Lake Michigan and the waters of the Illinois river lakes, and tributary streams were exactly equal; that in all physical respects the organisms from both sources had equal vitality, and started from their habitat on a journey to the St. Louis intake, and that the ones from lake Michigan had to pass through the drainage canal and they were found in the St. Louis intake, and eliminate all other considerations than these mentioned, to which source would you prefer to attribute them?

A. In order to answer I should have to know further the relative amounts of water coming from Lake Michigan and from the lakes and tributaries which you have assumed.

Q. Well, the relative amount of water now discharged
3459 from the Drainage Canal into the Illinois River, is greater
than is naturally in the Illinois River. Assuming that one more thing, which I concede to you, to which source would you prefer to attribute the tabellaria and the synedra in the St. Louis intake?

A. If we have a certain volume of water contributed by the tributaries of the Illinois river, and the assumed lakes which contain a certain number of these organisms, I will say, assumed to contain a certain number of these organisms, and if we have a greater volume of water from the Chicago Drainage Canal, which contains per cubic centimeter, as I understand it—

Q. Yes.

A.—an equal number of these organisms, then if we assume a thorough mixing of the waters, it would be my judgment that the organisms found in the resulting water would be more likely to come from lake Michigan than from the other sources named, and would be more likely to—in proportion to their volumes, and the volumes of the tributaries and lakes, as against the volume of the drainage canal, and I would like to explain it still further by saying that these organisms—that it would be my judgment that these organisms would come from both sources, but that more of them would come from the water which was greatest in volume, provided that the two waters contained an equal number per cubic centimeter.

Q. Then all other considerations being equal, you don't

3460 think that the fact that the supposed organisms traveled through 22 or 24 miles of sewage, of any consequence?

A. Practically not in this case, or in the case of these two organisms so far as they refer to any examinations that have been made, for the reason that in the examinations which I have made, I have not attempted to differentiate between a live synedra and a synedra not capable of developing.

Q. The synedra are not naturally and orginally inhabitants of running streams, are they?

A. You refer to this particular variety?

Q. Yes, the kind you mentioned?

A. The synedra pulchella variety sub prolongata, are not, so far as my experience has shown, naturally found in the waters of running streams except in so far as these streams are fed by ponds or lakes.

Q. But if they are found in the waters of running streams, they are fed by ponds and lakes, you attribute their origin to the ponds and lakes, do you not?

A. From my experience, that would be the most probable origin in those cases.

Q. So that when these organisms get into a running stream, polluted with sewage, they are out of their natural element?

A. They are out of the habitat in which they are most likely to develop.

3461 Q. Now take any volume or number you please of the variety of synedra of which you have spoken, and start them toward a given point 150 miles distant, in an element in which they do not originate, and in which they are not likely to develop; start an equal number in equal condition, with like history, 60 miles from the same destination, which ones would you prefer to say would arrive at the given point, traveling in the same media and in the same direction?

A. I don't think I fully understand your assumption; but if you mean that we have a stream of water flowing from say the point A to the point C, and if there was no change in the volume of that stream of water as it flows from the point A to the point C, and if we consider a certain number of these organisms at the point A and let them travel to the point C, and we start an equal number at a point B, below the point A and t them travel to the point C, it is my opinion that all of the rganisms would reach the point C, except in so far as they ight be broken up in transit, or might settle out on the way.

I have stated that in the microscopical examinations which have made, I have not taken into account the actual life of e synedra and tabellaria present; I have simply ascertained e number of the cells of the organisms regardless of whether they were—you may say dead or alive.

462 Q. Which ones would be most likely to arrive at the given point alive in the case supposed?

A. That would depend upon the character of the water and pon the conditions which affect the life and death of this or- anism, which conditions I do not believe it is possible to de- ne definitely in the present state of our knowledge.

Q. Take an equal number of synedra of the kind you have entioned, at two different points, traveling in precisely the me amount of water, at the same time, one point 150 miles rom the destination, another point 60 miles from the destina- on, the water in which they are traveling not being the kind of ater in which they originated, which set of synedra would be ost likely to arrive at the destination alive?

A. Just read that question.

Q. (Question read)?

A. So far as their arriving alive is concerned, I am unable state from anything mentioned in the assumptions, and from ck of better knowledge on the subject of the life and death of e organisms, and as to the numbers which might arrive from e one place or the other, that would depend, among other hings, on the amount of sedimentation between the first and the econd places, and the point of destination.

3463 Q. Eliminating all considerations except those embraced in the preceding question, and considering only the relative distances which the two sets of organisms traveled, do you or do you not know which would be most likely to rrive at the destination?

A. I don't think it can be stated without further assump- ions than those that you have made, as there are so many fac- ors which have to enter the problem.

Q. I have a right to state conditions to you as an expe and I state only such conditions as are in the second precedi question, and upon these assumptions, do you or do you n know which ones would arrive at the destination?

A. Will you please state the conditions again?

ATTORNEY GENERAL CROW: Allow me to suggest th you have the right to answer the question in your own way. you cannot answer it, as he puts it, just say so.

JUDGE JOHNS: And you can make any answer you plea

A. Please state the conditions again; perhaps I did n understand them all.

(Question read).

A. Well, I cannot answer your question without maki further assumptions in regard to the conditions.

Q. The question requires you to answer without regard any other assumptions?

A. Well then, without regard to any other assumptions cannot answer your question.

Q. Do you think then that the distance traveled by syned
of the kind you have mentioned, in water in which th
3464 do not originate, and which is not favorable to their d
velopment, makes no difference in the probability of th
arriving at a given point?

A. So far as distance alone is concerned, and disregardi absolutely everything else, I don't think it would make mu difference whether they started ten miles from a certain pla or twenty miles from a certain place, but of course there wou be conditions which would naturally exist, which would te to influence their arrival.

Q. Are you familiar with the bacillus prodigiosus?

A. Yes sir.

Q. How many varieties of bacillus prodigiosus are ther

A. I could not say.

Q. Do you know whether there are three, four or five?

A. I have examined several different cultures of bacill prodigiosus, which, while they agreed in their main points resemblance, had slight differences from each other in cultur in the laboratory, but to what extent these differences were d their being different varities, or different kinds, I am not ble to state.

Q. Do you believe that 100,000 million of bacillus prodigious could be concentrated in one cubic centimeter of water and ve?

A. I believe that they can be concentrated into such a volume of water, but to what extent they would live there,
465 I don't know.

Q. Do you think that one thousand million bacillus proigiosus by special culture, could be concentrated in one cubic entimeter of water and exist for two days alive?

A. I don't know.

Q. A bacillus may be transported by any means in which here is water involved, may it not, from one point to another?

A. A bacillus may be carried by water from one point to he other provided nothing happens to it on the passage.

Q. It might be taken from the river by pump and thrown long the decks of a steamer traveling up the river, in the prosss of washing the decks, and go out in the river five or ten miles bove where it was taken from, might it not?

A. I supose it might.

Q. Any bacillus existing in water might be taken up stream y boats or aquatic animals or in any way in which water was ansported, above where it was taken out of the stream might not?

A. You mean that a bacillus might be taken in a portion f water and put into a boat and carried up stream?

Q. Yes?

A. And then put down in the water again?

Q. Yes?

A. If conditions were favorable, yes sir.

466 Q. They might be taken from one point in the water by acquatic animals,—ducks, geese, or any acquatic animal, nd transported up the stream a very considerable distance, ight they not?

MR. JEFFRIES: What bacillus are you talking about ow?

JUDGE JOHNS: I am talking about bacilli in general.

A. I think that a bacillus, speaking in general, as I unde stand your question, might under certain conditions, becon attached to a duck for example, and if the duck might trav up stream the baellus might get away from the duck and into the water, yes sir.

Q. Yes,—it might be taken up in a duck or through a pum and travel up stream and be used for the purpose of washing th decks of a boat, and returned to the water again alive, three four miles or ten miles from where it was taken out?

A. I think it might, yes sir.

Q. That principle would apply as well to Prodigiosus well as to any other bacillus would it?

A. So far as my knowledge goes, yes.

Q. Then the fact that the baellus prodigiosus, one colo of them, was found three miles up stream from the place which it was put into the river, wouldn't have any very spec significance?

A. Significance as to what?

Q. As to the fact as to whether it was naturally an inhab tant of that river?

3467 A. If we—perhaps you had better read that again,

Q. (Question read).

A. So far as that fact alone is concerned, it would simp show that the water at that point at that time contained th bacillus.

Q. Assume that the bacillus prodogiosus could not of its go up stream, and that it was put in a stream at a certain poi and was not naturally an inhabitant of that water, and that it w found three miles above the place where it was put in, would be possible, by any of the means mentioned in the previous qu tions, to transport it thus far by the stream?

A. I didn't get all of that; please read that question.

Q. (Question read).

A. Do you mean would it be possible to have the bacil transported up stream, by boat, for example?

Q. Yes, or ducks, or any other thing by which the wat of the river in the place where the bacillus was put into t water was removed up stream and deposited again in the strea

A. If I understand your question correctly, it is my opinion that if a bacillus were taken out from the place where it was put in and carried up by a boat three miles, and then put into the water—

MR. WOERNER: It would be there?

A. It would be there.

3468 JUDGE JOHNS: Would there be any reason why it might not as well be there under those circumstances, as inherent to the organism itself, that is to say, is it of such a character that it would not bear such transportation?

A. I think it would bear the transportation probably—perhaps you had better read the first part of that question again.

Q. (Question and answer read).

A. Under the circumstances which you have mentioned.

Q. Do the bacilli which are found in running waters, and are afterwards in the course of experiments, put into bottles of sterilized water and hung out in the sun, live as long as they would in the natural condition of the water in which they existed?

A. Will you read that question again?

Q. (Question read).

A. I have no definite means of knowing.

Q. You have no opinion on that subject?

A. I have no definite opinion, as it would depend upon very many conditions, and the effect of these different conditions being, I may say, comparatively unknown.

Q. Suppose bacilli, naturally inhabitants of running waters which are turbid to some extent, should be removed from their natural place of abode, developed by special culture, put in bottles of sterilized water, and hung out in the sun, would
3469 that be a fair means of determining how long they live
in their natural waters?

A. I dont' think it would enable us to tell how long they would live in their natural waters, no sir.

Q. Such an experiment would only prove how long they did live under the circumstances in which they were experimented upon?

A. Yes, just the results would be available in so far as—

Q. So that an experiment of that kind proves nothing as to the life of any particular bacillus in its natural situation?

A. It does not enable us to give a definite opinion as to that point.

Q. If the bacillus prodigiosus under special culture was used in such experiments in sterilized water, in a bottle, in the city of St. Louis, and exposed to the sun for any number of hours, each one of the succeeding days, and lived fifteen days, you could not determine from that how long it would live in its natural waters, undisturbed?

A. Not from that alone, but of course balancing up the conditions as well as possible, conditions in the laboratory experiment, if I may call it that, with the conditions in nature, it might enable us to form—it might guide us in our opinion as to how long it would live in nature, but it could not definitely determine that.

Q. The conditions of the laboratory experiment in which
3470 the bacillus is produced by artificial culture, and exposed
to the sun in a bottle, in water to which it is in nature totally unaccustomed, could not very well be balanced with the natural conditions, could it?

A. It could not be balanced so as to obtain a definite result no sir.

Q. Now if the bacillus prodigosus, as many as could be contained, of specially prepared culture, were put into a forty gallon wiskey barrel, first throughly sterilized, and dumped into the Illinois river at or near its mouth, in August, 1900, do you know whether that bacillus thus introduced into that water would live continuously and become native to that water?

A. It is my opinion from what I know of the nature of the bacillus prodigiosus, that it would in all probability live in continually decreasing numbers, in the water in which it was placed, but just how rapidly the numbers would decrease I don't know. or just how long it would live, I don't know.

Q. Now if the bacillus prodigiosus was afterwards, in quantities of 107 barrels of water, containing 1,000 million to the cubic centimeter, were afterwards in November of the succeeding year, put into the waters of the Illinois drainage canal, 357

or 360 miles from St. Louis and 23 days afterwards, one of them was found in the tap at the City Chemist's office
3471 in St. Louis, would you know to which plant of bacillus prodigiosus to attribute that colony which was found—just read that question again.

Q. (Question read).

A. That would depend upon the number of factors—

Q. Assume that bacillus prodigiosus were put into the waters of the Illinois river in August, 1900, one barrel of them, and afterwards—

A. What point in the Illinois river do you mean?

Q. At or near its mouth, or in the Mississippi river at or near the mouth of the Illinois river, and that in November of the succeeding year 107 barrels of it containing 1,000 million of these organisms to the cubic centimeter were put into the drainage canal at or near Lockport, and afterwards a colony of this bacillus was found in the intake of the St. Louis Waterworks and another at some other point in the city, of St. Louis, to which colony of the bacillus thus planted, eliminating all other considerations whatever, would you attribute the ones found at the intake and in the water taps of the city of St. Louis?

A. The question cannot be answered without taking into consideration other considerations, other facts. I should naturally assume, or I think it would be more reasonable to expect that it came from the second dose, if I may use that ex-
3472 pression, than from the first, but this would involve questions in regard to the life of the bacillus, the flow of the streams, sedimentation and such factors.

Q. Taking into consideration all that you know of the physical conditions, and the surroundings of the Illinois Drainage Canal and the Illinois river and the character of the bacillus, and the Mississippi river and the intake, and the location of St. Louis on the Mississippi river, and assume that some bacillus were put in near the mouth of the Illinois river in August, 1900, and in November, 1901, 107 barrels of them were put in near Lockport in the drainage canal, and that they were afterwards found at the intake and in taps of the City Waterworks, here, could you tell with any kind of certainity to which dose of the bacillus put in these waters, those found were to be attributed?

A. It is my judgment that if those found came from either one dose or the other, that they came from the second dose rather than from the first.

Q. Could you tell it with any kind of certainty?

A. I think with reasonable certainty, yes sir.

Q. Notwithstanding that one traveled 350 odd miles and the other was placed in the water at a distance of less than forty miles from the intake?

A. Yes, I think so still.

3473 Q. Is that reduced to a moral certainty in your mind?

A. Yes sir.

Q. Why?

A. It is my opinion that between August, 1900, and November, 1901, if I have the dates correct, that all of the water in the stream of the Illinois river and the Mississippi river between the points where the first dose was added and the intake of the St. Louis waterworks, would have passed down stream, and it is my opinion that many of the prodigiosus would have died out in that time by natural decrease in the water, and I don't believe that even that interval—well, just stop right there, that is enough.

3474 Q. That is a matter of opinion, not a matter of actual knowledge from any experiments or in any way in which that fact could be ascertained?

A. It is a matter of opinion. It is based upon facts which are shown to be reliable and sufficient to enable me to take that position.

Q. There is no way known to the science of chemistry and bacteriology or microscopy, by which the fact could be certainly ascertained, is there?

A. Perhaps not to a mathematical certainty, but I believe it to be established beyond a reasonable doubt.

Q. As a matter of inference from given facts?

A. As a matter of judgment from facts I believe to be reliable.

Q. Now the mixing of waters of two rivers must depen upon circumstances or volume, and of the relative height of the two rivers at the moment of mixing?

A. These factors enter into the question of mixing, yes sir.

Q. The waters of the Missouri and Mississippi river for instance, do not at all times and at all seasons of the year mix equally?

A. At what point?

Q. At any given point equally with other seasons of the year and other stages of the river.

GENERAL CROW: You mean by the last phrase, other seasons of the year. 3475

JUDGE JOHNS: It is supposed that forty-five miles below the mouth of the Missouri there was a certain per cent of the Missouri river water determined by algebra, and a certain per cent of the Mississippi river water found in the waters at that point, in March. Would that be any indication of the per cent of the same water at the same point, in September?

GENERAL CROW: Of the same year?

JUDGE JOHNS: Of the same year?

A. If you consider the question of percentage mixture I would say that the percentage of mixture of the two waters would not be the same at all times.

Q. If the Mississippi river by gauge readings immediately above its confluence with the Missouri were five feet below a gauge similarly placed in the Missouri river, the waters of the Missouri and Mississippi would mix more rapidly below the confluence of the two than if they were at an equal gauge, would they not?

A. I cannot answer that without considering some particular point at which you wish to consider the mixture.

Q. Well, take it at the chain of rocks?

A. Well, if you consider the water at the chain of rocks, I should say that the water of the Mississippi river would not be as well represented there as the water of the Missouri river relative to other times when the gauge reading of 3476 the Missouri river was equal to that of the Mississippi river, assuming that the volume of the stream varied substantially as the gauge reading.

Q. Well, as a matter of fact the mixing of the waters of the——the percentage of the waters of the two rivers are not the same at any one point, at any given point, are they?

A. You do not mean at any one time, you mean at all times?

Q. Yes sir.

A. As a rule, if we consider a certain point, below the point of mixture, they would not be the same at all times, on account of natural variations in the flows of the two streams, and questions concerning their currents, etc.

Q. So that when it is determined that upon a certain day the percentage of Mississippi river water and the percentage of Missouri river water, bear certain relative proportions to each other, that determination would not apply to any certainity, with any other day or with any other time, would it?

A. It would not necessarily apply to any time, no sir; it would simply apply to that one time.

Q. Now you have testified here to volumes of water, to percentages of volume of water of the Missouri river and the Mississippi river at the intake, based upon total solids?

3477 A. Yes sir.

Q. And also upon the chlorine as to the Illinois and the Mississippi?

A. Yes sir.

Q. Do you mean to say from the total solids and the percentage of total solids entering the intake upon the day upon which you made the calculations, that the percentage of actual water was the same, or do you simply mean to say that the percentage of water carried a certain percentage of the solids in solution?

A. Carried a certain percentage of the solids in solution and to represent relatively the volumes of the water as far as the solids represented the samples.

Q. So that when you say of the Illinois river and the Mississippi river for instance, that there was a certain per cent of the volume of water at the Mississippi river below the Illinois based on a consideration of chlorine, you simply meant to say that in the waters of the two rivers considering that the chlorines remained constant, the chlorines in the mixed water represented a certain per cent of the chlorine in the Illinois and the chlorine in the Mississippi?

A. Yes, and to the extent which the samples represented, you may calculate the percentages of the two river waters.

Q. As to the volumes of the two waters?

A. So far as the samples are representative.

3478 Q. The question is, are the samples representative of anything more than a percentage of the mixture of chlorine, for instance?

A. I think if the determinations for the chlorine represent fairly the waters from which the samples are taken, that the calculation will give us the limits of accuracy governed by the sample and the determinations of percentages of the two waters.

Q. Suppose that the chlorines in the Illinois River at Grafton were 24 parts per million and that the chlorine in the Mississippi upon the same day above Grafton, were 4 parts per million; what would be the per cent of the chlorine, if the two waters mixed?

A. I couldn't tell without knowing the relative volumes of the two waters.

Q. In any determinations which you have made of the percentages of water entering the intake, based upon solids as to the Mississippi and the Missouri, or upon the chlorines as to the Mississippi and the Illinois, did you take into consideration the relative volumes of the waters of the two streams?

A. That practically is taken into consideration in the formulae used in obtaining that. We would take it into consideration absolutely, but relatively in one case we say that the volume
of the water is X, an unknown quantity—I will not say
3479 an unknown quantity, but an unknown percentage of
water, and in the other case, it is 100 minus X for the
Illinois, so to that extent we take into consideration the volume.

Q. Well, that is the theoretical volume. When you made a determination there, based upon the chlorine of the waters of the Illinois and the Mississippi, what were the relative percentages?

A. Do you want me to read them absolutely?

Q. Yes, if you please?

A. I made these calculations at five points in the cross-section of the Mississippi river at Alton, which were lettered from A to E, beginning from the Missouri shore and running towards the Illinois shore, and I found that the per centage of Illinois river water varied from 7.8 per cent at point A, to 37.2 per cent at point E.

Q. Now as to the Mississippi?

A. And that the percentages of the Mississipi river water at the same points varied from 92.2 to 62.8 from the point A to the point E.

Q. In the Mississippi?

A. In the Mississippi river at the cross section at Alton.

Q. Well, what per cent of Illinois river water and Mississippi river water mixed, did you conclude existed at the point taken for calculating the per cent?

3480 A. Do you mean what per cent mixed throughout the entire cross-section?

Q. Yes, below the confluence of the two rivers. If I understand you, in order to arrive at a determination of the percentage of the waters of the two rivers, you considered the chlorine at the cross section at Alton and consider the chlorine at the cross section at Grafton?

A. Yes sir.

Q. And then did you not also consider the percentage of the waters mixed at some point still further below?

A. I also found the percentages at which they were supposed to be mixed at Hartford on the Mississippi river.

Q. Now when you got through with that determination, what was the relative per cent of the waters of the Illinois and Mississippi based upon the chlorine as the basis of calculation in the mixed waters?

A. Do I understand you to mean considering all the samples in one cross-section and all the other samples in the other cross section and then considering them as a whole, then to find the percentage of Illinois river water which might exist at any point?

Q. Below, yes.

A. Well I made a calculation similar to this. The cross

section included 5 points in the stream, one point taken in
3481 the middle of the stream, which was called point C, two
points taken, near the edges of the stream, which were points A and E, and two points taken intermediate between the center and the extreme, which were points B and D. I do not recall exactly the cross section of the river at this point, but for the sake of making an approximate comparison, I assume, if you wish to obtain an average of the percentage of Illinois river water at that cross-section, that the points at the sides of the stream should be given only half way, half of the way to those intermediate, of the intermediate points, inasmuch as the intermediate points may be considered to represent a greater width of the stream than the side points. I believe in the absence of information as to the cross section, that that is a fair assumption upon which to work and make an average with such allownace, and I found that the per cent which the Illinois river, which the water of the Illinois river would be of all the water in the stream at that point, was 19 per cent, while making a similar calculation from the figures obtained at Hartford, I found that it was 19.7 per cent which was a practical check, the one upon the other, within what I believe to be the limits of accuracy of the determination in samples.

Q. In speaking in round numbers the Illinois river was as to its waters, to the Mississippi river as to its waters, as 20 to 80, or as twenty parts in a hundred.

3482 A. Speaking in approximate terms, such was found to be the case from these calculations.

GENERAL CROW: At what time was that?

A. This was in the month of November, practically the month of November, 1901.

Q. That was low water stage.

(No answer.)

JUDGE JOHNS: Do you mean to say that at that time the percentage of actual water contributed by the Illinois river and the Mississippi river to the actual water of Hartford, was 20 and 80 parts respectively in a hundred?

A. That was what was shown by those figures and I compared those figures with certain data which I obtained from the river stages at that time, and I believe these figures to be approximately near the truth. I haven't the data to make an exact comparison, but I believe they were within reasonable bounds.

Q. I don't want you to be accurate, but do you mean to say that those figures thus obtained, approximately, substantially represent the actual amounts of the waters of the two rivers at Hartford at that time, or do you mean to say that they represent practically the amounts of chlorine in the two waters, contributed to that point?

A. I mean practically the amounts of the water of the river.

3483 Q. The actual water in volume?

A. Yes, substantially.

ADJOURNED until 2:00 p. m. same day, May 16, 1903.

3484 Southern Hotel, St. Louis, Missouri. 2:00 p. m., Saturday, May 16th, 1903. Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

GEORGE C. WHIPPLE

resumed the stand for cross-examination by Judge Springer, and testified as follows:

Q. Mr. Whipple, what importance do you attach to the numerical results of a single bacteriological examination of a sample of water in so far as it may be important in considering the sanitary conditions of the water?

A. That would depend in part upon the result obtained. If the number of bacteria found was extremely low, it might indicate a comparatively good sanitary condition; if they were extremely high, it might indicate a comparatively bad sanitary condition. If they were intermediate, between what may be called very high or very low, I would not be able to draw any conclusion from that alone.

Q. In order to reach a correct conclusion as to the sanitary condition of a given water, it would not be necessary to obtain

the number of samples, or to make a number of examina-
3485 tions of those samples, both bacteriologically and chemically?

A. The larger the number of samples and the more complete the examination made, the more—the better judgment we could make of the sanitary condition of the water or the sample analyzed.

Q. Can microscopical examinations of water be depended upon to determine the pathogenic qualities of drinking water?

A. No sir.

Q. Are the common microscopical organisms found in water the cause of disease?

A. They are not so far as I know.

Q. Does their presence indicate pollution?

A. Not definitely, but as I have already testified, there are certain forms of microscopic organisms which are so commonly found in waters known to be polluted, that to some extent their presence in water is indicative of pollution.

Q. To what extent?

A. To a slight extent.

Q. To a slight extent?

A. Well, I may add to a very slight extent.

Q. Where the chemical examination of water may determine the amount of organic matter contained in a sample, does it determine the nature of the water?

A. It does not definitely determine the nature of the or-
3486 ganic matter in the water.

Q. It does not?

A. No sir, not definitely.

Q. Are not microscopic organisms very susceptible to changed conditions of temperature, pressure and of light?

A. Some of them are, yes sir.

Q. What ones?

A. Well, if you take for example the microscopic organism known as uroglena. If that organism is subjected to unusual pressure, as it sometimes is, in the water pipes of a distribution system, that micro-organism may be broken up. I have seen some organisms go to pieces apparently under the influence of sunlight and if we take some of the delicate forms of microscopic organisms they will go to pieces under the influence of high temperature, for example.

Q. Is that all?

A. I think I have answered the whole question.

Q. Well, I asked you if you were through?

A. I think so.

Q. In order that an analysis or a bacterial examination of a given sample of water should be of real value, ought not the analysis or examination be made at the time the sample is taken from the water?

A. In order to obtain the most accurate result, the bac-
3487 teriological examination of the sample should be begun
at the time, or I may say, immediately after the time
when the sample is collected, but the character of the water
would, to a considerable extent, influence this fact. Waters of
some character could be allowed to stand longer than others
without having the result of the bacteriological examination interfered with by standing.

Q. What would be the character of the water to which you desire to direct attention that would influence the result?

A. I simply mean this: that if you have a water which contains comparatively little food upon which the bacteria might thrive, such for example as we might have in well water, that water might be allowed to stand longer before the bacteriological examination was made, than say a water which was rich in organic matter, without having the result of the bacteriological examination seriously interfered with.

Q. Assuming that the water to be analyzed or examined came from the Illinois river during the months of October and November, what would you say as to the time that water should be examined after taken from the stream?

A. I should say that such water as you mention should be examined immediately after the sample was collected, or within a few hours of the time of its collection. I don't think I could give you a maximum limit beyond which the results would be absolutely worthless.

3488 Q. What was the time which elapsed between the time of the taking of the samples of water to which you have referred and of which you made microscopic examinations, and the time which you made those examinations in New York?

A. If my recollection serves me correctly it was about three days in some cases and about four days in others, and if I am not mistaken, four days was the longest time that elapsed between the time of collection marked on the tag, and the time when I made the examination. I can look this matter up; I can go into it further—

Q. That is sufficiently accurate for my purpose. Is it your opinion that that time was not too great to affect the results which you found by your examinations?

A. It might affect certain results which I found; it probably would not affect others.

Q. What results would it affect?

A. It might affect for example certain of the protozoa which might develop in the sample between the time of collection and the time when the examination was made. It also might affect such organisms as some of the blue green algae, which might conceivably disintegrate between the time the sample was collected and the time the examination was made.

Q. Would it affect your determinations in any other way?

A. Well, there are other microscopic organisms which 3489 were present, such for example as the diatomes, where of course I did not make a distinction between living forms and the cells which might contain matter not in a living stage and because the conditions surrounding the samples between the time when they were collected and when they were examined would probably not admit of the growth of these diatomes, nor would they admit of the—or be likely to admit of the destruction of these cells which have silicious walls. I do not believe that the results regarding those organisms would be interfered with by the standing of the sample, or by the lapse of this time.

Q. Were those samples received in ice or in the natural conditions in which they were collected?

A. They were not received in ice.

Q. Would not the shaking of the bottle incident to railway travel, tend to the breaking up of the organisms?

A. It might tend to break up some of the more delicate forms; it would not tend to break up the cell walls of the diatomes.

Q. Is it your opinion that substantially the same results would have been obtained from those samples of water, if you had examined them immediately upon their being taken from the water, that you did obtain by the examinations made four days afterwards?

A. I would say "Yes," so far as the diatomes are concerned, but perhaps not so far as some of the more delicate forms are concerned. 3490

Q. What would be the more delicate forms?

A. Well, some of the protozoa, such for example as dinyobryon and some of the blue green algae, as for example anabena.

Q. What would have been the probable difference, and what would it have indicated from a scientific standpoint?

A. In the case of the anabena it is possible that while not necessarily probable, that if this organism had been present in the sample when collected, it would show smaller numbers after standing for a number of days, while in the case of the protozoa in monas, it is quite possible and perhaps probable that the sample originally collected might show fewer organisms in number than after standing.

Q. Would this change the result of your determinations materially?

A. That would depend from what standpoint we judged the determinations. If you mean from strictly a sanitary standpoint I should say that it would not, because, as I have said these microscopic organisms are not a definite indication of the sanitary quality of the water.

Q. Did you test any of those waters for the purpose of determining the presense of pathogenic germs?

A. No sir.

3491 Q. In your examination of the bottles from the rivers to which our attention has been called in this investigation and Lake Michigan, you stated that there were two microscopic organisms which you discovered in Lake Michigan, which you did not find in the waters of the Mississippi and the Missouri Rivers. Do you mean to have us infer that those genera were not present in those waters?

A. In the first place I did not make a statement exactly as you have told it. I think that I stated that there were two organisms which I called synedra pulchella variety sub prolongata, and tabellaria, which were especially characteristic of those two waters, but I think I stated that only with regard to the synedra pulchella variety sub prolongata, that that organism was not found anywhere else than in the water of Lake Michigan, or the waters with which lake Michigan might have been afterwards mixed.

Q. Do you mean by that that that variety of micro-organism was not found by you or has not been found by other experts other than in Lake Michigan?

A. It was not found by me in waters other than those of lake Michigan, and the waters with which Lake Michigan water might become mixed, nor so far as I know has it been found by other experts in the other waters mentioned.

Q. Are not the microscopic organisms which you found in lake Michigan, found in all parts of the world, and under 3492 a great variety of climatic conditions?

A. I believe they are, speaking generally.

Q. These organisms have received I believe I understood you to say, a vast amount of investigation by scientists?

A. I think they have received a great deal of attention.

Q. Are the laws governing their distribution in determining the places at which they may be found, understood at this time by scientists?

A. They are certainly not fully understood. I think we are beginning to understand something concerning these laws.

Q. May not a certain genus of the varieties to which you have referred, grow vigorously in one pond or place, and be absent from a neighboring pond where the conditions are equally as favorable for its existence?

A. Yes, so far as we know those conditions, I can recall such cases.

Q. Does it not often happen that a certain genus of the species to which you have referred may suddenly appear in a pond, lake or water in which it has never been before seen?

A. They certainly do suddenly appear in waters where apparently they have not before been seen, but just how far back observation has extended in regard to the previous history of that water, or just how far observations of a scientific
character have been made concerning that water,
3493 would have to be taken into account in comparing their
presence today with their presence of former days.

Q. Might not an examination of a sample of water in the Missouri river or in the Mississippi river above Grafton taken today, show the presence of the two genera which you failed to find in the samples found in Lake Michigan?

A. Well I didn't catch that.

Q. (Question read).

A. They might.

Q. I believe you stated that there were only three places at which samples of water were taken which were forwarded to you for examination at the mouth of the Missouri river, is that correct?

A. I stated that there were three samples sent to me from the mouth of the Missouri river, collected in a cross section by Professor Van Ornum. These were sent to me for examination but I did not make a microscopical examination of them; I simply determined the turbidity of those three samples.

Q. And from what examinations did you ascertain that there were no genera of the two species to which we have referred, found?

A. From the microscopical examinations of samples which were sent to me during the months of October and November, 1901.

Q. How many of such samples did you receive?

3494 A. I should have to look at that sheet in order to refresh my memory. (After referring to chart) I received five samples which I analyzed, but I might add that I received two broken bottles marked as having contained samples from the Missouri River. As the bottles were broken when I received them of course they contained no water.

Q. Did you ascertain from the five samples that you examined where and when they were taken?

A. The tags which were attached to the bottles stated that the samples were collected from the Missouri river at Fort Bellefontaine, and the dates of the samples were given. Shall I read the dates?

Q. Yes, read the dates?

A. They were collected respectively on October 16th, November 1st and November 13th, November 14th and November 21st, 1901.

Q. Well, when were the other samples taken from the water, about which you have testified, in Chicago,—those taken in Chicago, the Lake Michigan water only?

A. The samples which were collected from Lake Michigan were collected between November 4th and November 29th, 1901 I think it is, I can hardly read these figures.

Q. Have you the dates at which they were collected. You say between November 4th and November 29th?

A. Yes, I have them all here.

Q. Let me have them please. November 4th was the first.

3495 A. There were two samples collected from the Lake View crib on November 4th,

1 sample from Carter Harrison crib on November 6th,
1 sample from the Carter Harrison crib on November 8,
1 sample from the Lake View crib on November 13th,
1 from the Carter Harrison crib on November 15th,
1 from the Four-Mile crib on November 20th,
1 from the Lake View crib on November 22nd,
1 from the Four Mile crib on November 27th,
1 from the Lake view crib on November 29th.

Q. Why were these samples taken in October and Nomember.

A. Which samples do you mean?

Q. That you have examined?

A. All of them?

Q. Well those to which you have just referred. I believe they were all taken in October and November, were they not?

A. All the samples which I examined microscopically were collected I think in October and November. I will read the entire list right through, if you wish.

Q. No, I don't want any more. But I ask why your examinations were confined to those two months?

A. Why were they?

Q. Yes?

A. I simply examined the samples that were sent to me;
3496 I can't tell why the samples were collected in October and
November rather than at any other time.

Q. You were certainly not asked to examine any other than these?

A. I simply examined the samples that were sent to me to be examined.

Q. Do you know of any special reason why the samples which you examined should have been sent from those months, rather than from other months?

A. I do not; I know at that time that they were making a general investigation of the waters; I don't know why they were made during those two months rather than at any other time.

Q. If additional samples of water have been taken at other times during the year 1901 and examined microscopically, to ascertain the presence of the micro organisms to which you have referred, is it not probable that those other samples of water would have disclosed—taken at Bellefontaine or in the Mississippi river above Grafton, would have disclosed the presence of the two genera which you stated were not found at those places?

A. I can't say that it is probable that they would, but they certainly might have disclosed it.

Q. They might have done so?

A. Might have done so, yes sir.

3497 Q. In your examination day before yesterday I believe
it was you cited two instances in which typhoid fever
germs had existed for ten days previous to their introduction to the water supply from which an epidemic had originated. Will you please state the distances which were traveled by the germs before they reached the water supplies which they entered?

A. I can't tell you exactly, but in the case of Lawrence, which I mentioned, it was supposed that the typhoid bacilli traveled from Lowell down the Merrimac River; thence into the water supply system and through the reservior into the—perhaps I had better say through the reservior into the water supply system a distance which was somewhere near 20 miles, I can't say exactly. I have frequently covered the distance. I am speaking quite from recollection.

Q. And in the other case?

A. The other case was that of Detroit, where, if my recollection serves me, the distance traveled was some fifty or sixty miles,—again speaking from recollection.

Q. Is there any other recorded instance in the books where the typhoid fever germs that were supposed to have produced an epidemic were carried a geater distance by water than those were carried in the Detroit case?

A. I think I have heard of greater distances, but I am unable to rêcall at the present moment. I mentioned the distance of fifty or sixty miles the other day because I felt quite 3498 sure that it had been carried at least that. I think it has been carried a greater distance, but I am less confident of the greater distance.

Q. Would not the fact of the distance traveled, or to be traveled by pathogenic germs, such for instance as typhoid fever germs, be a material and important factor in determining the presence of these germs at a point remote from their introduction into the water?

A. I think it would be an important factor in so far as it affected the time required for the bacilli to travel through water from a point where they might be introduced, to another point below; I don't think it is any question of linear distance, so much as it is time of transit.

Q. Are there no other elements to be considered than the time of transit?

A. Indeed there are.

Q. What are those elements?

A. There are a great many elements to be considered.

Q. Name some, will you please?

A. For example, the so-called vitality of the organisms, the rate at which they die out in water; the rapidity of the current in which they flow; with reference to possible sedimentation; the possible phenomena that they might settle to the bottom of the stream and again be taken from the bottom of the

stream and carried down; the question of the tempera-
3499 ture of the water might influence their vitality; the character of the water might to some extent. Those are some of the elements which would enter into the question.

Q. Has the fact been determined among scientists as to whether pathogenic germs multiply in water?

A. I cannot say that the fact has been absolutely determined, but I think it is the concensus of the opinion of scientists that such a pathogenic germ as typhoid fever for example, does not develop in water, but on the contrary, dies out. Perhaps I had better say, continues to live in water in constantly decreasing numbers, but—well, I think that is enough.

Q. If the pathogenic germs, such as typhoid fever germs for instance, multiply in water the same as the ordinary water bacteria, would it not soon happen that all the streams of the country would be so impregnated with those germs as to render the use of their water impossible?

A. If typhoid fever bacilli should multiply in water as do ordinary water bacteria, and if they should retain their same pathogenicity, it would seriously affect all of the surface water supplies where they multiplied, most certainly.

Q. There would certainly be no surface waters that would be safe to use as drinking water?

A. Probably there would not be.

3500 Q. Then we may reasonably conclude that the pathogenic germs such as typhoid germs, for instance, do not multiply in the water?

A. I think it is the concensus of opinion that the pathogenic germs like typhoid fever, as I say, do not multiply in water.

Q. Then the number of such germs found in water must be ascertained by the presence of the dejecta both solid and liquid, of human beings?

A. The number of such germs would not be ascertained in that way.

Q. How?

A. The number of such germs would not be ascertained in that way.

Q. Well, I will strike out the word "ascertained" and say accounted for then, their presence can only be accounted for by considering the dejecta of a human being, is that right?

A. Their presence is best accounted for by considering the probable presence of the dejecta and urine of human beings, which contain such bacilli.

Q. So that when any of these pathogenic germs are destroyed in transitu they reduce of course the possibility of transmission of disease in proportion to the number destroyed in transitu?

A. I think that is a fair proposition.

Q. Have scientists or authors upon the subject ascertained by any experiments today, the probable duration of pathogenic germs such as typhoid fever in running water? 3501

A. I don't think they have, excepting by means of laboratory experiments which naturally cannot be made under the same conditions as actually exist in running waters.

Q. Would laboratory experiments be more favorable to their existance or less favorable to their existence, than the natural water?

A. It is my opinion, speaking generally, that a laboratory experiment would be less favorable than the natural conditions.

Q. Less favorable to existence?

A. Less favorable to their longevity. Of course it must be considered that conditions alter cases; but I am speaking in very general terms, and I think you understand me in that way.

Q. Are you familiar with a work known as Micro-organisms in Water, by Percy and G. C. Frankland?

A. Yes sir.

Q. Is that a recognized authority on this subject?

A. It was at the time it was issued, and I think that it still today is considered a recognized authority, many portions of it. Of course it is understood that bacteriology has advanced considerably since that time, and I would not want to say that every statement in that book was well recognized today. Speaking generally, however, I would say that it is called an authoritative work. 3502

Q. This is the edition of 1894 that I have before me.

A. I don't know of any more recent issue.

Q. On page 294 of that book I find that the results obtained by Krans with un-sterlized waters are given in detail and in this statement the typhoid bacilli are shown to have either disappeared or at any rate to have been no longer demonstrable when the water bacteria began to assert themselves. Have you made any examinations upon that subject or upon those conditions?

A. You mean with reference to the presence of typhoid bacilli in sterilized water?

Q. No, in un-sterilized water, and the presence of the ordinary river bacteria,—water bacteria,—will they disappear in proportion of those numbers, or increase in proportion of those numbers?

A. I don't think that that can be stated because the identification of the presence of typhoid bacillus in the presence of common water bacteria is an extremely difficult thing, and it is in most instances impossible to determine the presence of a typhoid fever bacillus in the presence of a lot of common water bacteria. I know that to be true from experiments which I have made.

Q. Well at the place to which I called your attention, there is a table which refers to water taken from the Munich 3503 water supply, the river Mangfa—you are familiar with that river I presume, in which the number of typhoid bacilli found in a cubic centimeter of water as given on the first day as 57,960,

And on the second day	50,400
On the third day	15,680
On the fifth day	9,000

And on the seventh day none. There were two other samples of water taken at the same place

A. Is that sterilized water?

Q. No, unsterilized water. There were two other samples taken besides that in refrence to typhoid fever bacillus found in the water and there are three statements here in regard to the number of water bacteria found in a cubic centimeter of the same water, and it appears from those that on the first day there were none;second day none; third day none; fifth day 80; seventh day 288,000; ninth day 400,000; 20th day 970,000; these tables showing when the ordinary water bacteria began to appear the typhoid bacilli disappeared. Does that accord with the investigations which you have made upon this subject, if you have made any?

A. I should say from those results that if the common water bacteria increased as you mentioned, it was no wonder that the man didn't find typhoid bacilli in the samples at the end of seven, nine or ten days; in the presence of such numbers
3504 of common water bacteria I don't believe it is a bacteriological possibility to demonstrate the presence of the typhoid fever bacilli.

Q. He seems to have done so.

A. Apparently, from those figures I should question whether the results that he actually obtained would stand the test of the bacteriology of the present day.

Q. This subject has been very carefully considered, I presume, by scientists, the subject of the vitality of micro-organisms and pathogenic germs especially?

A. It certainly has, and the poverty of our results on the subject shows the difficulties which have been encountered in obtaining such results.

Q. Have you ever examined the investigations made in reference to the waters of the Spree, which supplies the city of Berlin, with water?

A. I believe I have seen examinations of some kind from the waters of that river; I don't recall just at present though, what they were.

Q. Well, you understood that until recently the water supply of the city of Berlin passed into the city from the river Spree, and I find in the book to which I have called your attention, a statement as to the conditions of the water before it entered the city and at a few miles below the city, after
3505 it had passed through the city, and obtained its sewage. I find it stated here that at Sacrow, which is the end of a small lake a few miles below the city, the water had resumed its normal condition before it entered the city. Have you had occasion to examine the conditions under which that purification took place?

A. I think I remember reading about the case. I am not able to recall at the present moment just the conditions, but I think you mean that the water above the city contained a certain number of bacteria, and that immediately below the city, below the entrance of the sewers, the number of bacteria was much higher, and then again further down the stream, below that lake, I think which you mentioned, or extension of the river—

Q. Havre Lake?

A. The numbers again were as low as they were above the city. I think I remember reading that fact.

Q. This lake into which the water of the Spree entered is called Havre Lake, and is several miles in length, as stated in the books, and at the end of that lake, which was only a few miles—a very few, less than ten, from the city, the water had resumed its normal purity. This was attributable in that case to the sedimentation of the bacteria in the lake. I will now ask you, after having made this suggestion, whether you
3506 have considered the question of sedimentation in the Peoria Lake, and in the other lakes in the Illinois river, and especially in the dams across that river at various points to which your attention has been called in determining whether it were possible for typhoid bacteria to be carried from the Chicago river by way of the drainage canal into the St. Louis Intake?

A. Yes, I considered the question of sedimentation in those expansions of the river to which you refer, the Illinois river, and it is my opinion that under certain conditions sedimentation of bacteria might certainly occur in those places.

Q. If for the short distance to which I have referred there was an entire disappearance of bacterial conditions, or in other words that the bacterial conditions had reached their normal condition, would it not be much more probable that such conditions would maintain in reference to the bacteria found in the Chicago River and the Drainage Canal in reaching the St. Louis intake?

A. I don't quite catch that question.

Q. (Question read).

A. The question is not just clear to me; I don't know just what you mean by the normal conditions.

Q. I mean the condition of the water before it entered the city, in reference to the Spree.

3507 A. I thought you were referring to the water of the Illinois river and Lake Michigan.

Q. Well I mean if in this distance in the Spree, the water had reached its normal condition bacterially speaking, in so short a distance by means of sedimentation and other purifying conditions, how much more likely it would be, or wouldn't it be much more likely for the water to reach its normal condition in coming the distance from the Chicago River to the St. Louis intake?

MR. JEFFRIES: Now you are assuming that it was in its normal condition at the time it started?

JUDGE SPRINGER: No, I am assuming simply that it reached the condition that it was below the city, as it was before it entered the city, and if it did that in that case, why wouldn't it do it in this case in a much more marked degree, as marked as the distance was in this case, and the distance in the latter case?

A. I think there were so many conditions that come in there that it could not be answered definitely. I can conceive that after passing through all these expansions of the river to which you have referred, the number of bacteria below them might be even lower than the number of bacteria above, but I don't think that could be definitely stated without having
3508 further knowledge in regard to the conditions that exist
at that place there, and comparing them with conditions which exist on the—

Q. Would the presence of 300,000 cubic feet of water of Lake Michigan, in diluting the sewage of Chicago, and the waters of the Illinois River, have anything to do with bacterial conditions that might appear in the Illinois River at Grafton?

A. The more the sewage of the Chicago river was diluted—I would say, the sewage of Chicago, and the Chicago river was diluted with the water from Lake Michigan, the smaller would be the number of bacteria in the water after this dilution.

Q. And the less likely would that bacteria be to produce injurious results?

A. Well, I could not say that dilution is destructive of bacteria.

Q. The probability of removing its presence?

A. The greater the dilution the less the probability would be of finding the typhoid fever bacillus, for example in a glass of water, but dilution,—mere dilution of the bacteria so far as the dilution alone is concerned, is not destructive of bacteria.

Q. But the amount of dilution increases the chances of pollution at a given point, does it not?

A. You mean decreases? Would decrease the amount
3509 of pollution?

A. The greater the amount of dilution of a polluted water, the less danger there would be from drinking this water, so far as dilution alone, is concerned.

Q. Yes, that is what I meant. I want to call your attention to an experiment in reference to the waters of the river Limmat which flows out of Lake Zurich. It is stated in the work to which I called your attention, that the average number of micro organisms in the water of Lake Zurich was from 100 to 200 per cubic centimeter. The river Limmat flows out of the lake. A sample collected below Zurich, after it had passed through the city and before it receives its drainage, showed that already in its flow through Zurich it has become more or less contaminated. The increase in the number of bacteria is however, very much more marked below the point of the sewage outfall, and after the rain or snow, has fallen, the numbers show a decided increase, and this is specially exhibited so this author states, in the experiments of January 28th, and 30th and February 15th and 16th, and other experiments being particularly instructive in this respect, as many as 24,000 micro-organisms being found at Extringingen in one cubic centimeter of water; at Dietikon, after a flow of ten kilometers, which I understand to be six miles, the bacterial condition of the water approaches very often to that of the river before the introduction
3510 of the sewage.

In view of that instance noted in this work, and assuming that the conditions stated there are true, is it not very highly probable that the waters of the Illinois river at the Narrows, above Peoria, a distance of over 100 miles from Chicago, would have obtained a bacteriological condition which those waters had before the reception of the Chicago sewage?

MR. JEFFRIES: That is objected to for the reason that the question does not state similar conditions as applicable to both places.

A. Now if you will just read that question.

Q. (Question read).

A. It is my opinion that without knowing more about the conditions which actually existed where those experiments were made, the results obtained would not be of any material value in judging as to what would be the bacteriological conditions at Peoria, but the experiments made, seem to be in line with what is generally known in regard to the decrease in the total number of bacteria in streams below points where they become polluted, and it is quite conceivable that the conditions in the Illinois river between the Chicago drainage canal and Peoria are such that the total numbers of bacteria in the Illinois River at that point might be as low, or even lower than the numbers
of bacteria in the waters of Lake Michigan before it re-
3511 ceived the sewage of Chicago, but I would add to that
that when we speak of the bacteriological condition we must consider not only the number present, but also the character of those bacteria.

Q. If the number of ordinary water bacteria decreased during this interval of time, and distance, would not the pathogenic germs decrease in like proportion?

A. The probability is that pathogenic germs would decrease, but whether or not they would decrease exactly in proportion to the water bacteria is a thing which I cannot state.

Q. Isn't it true as a bacteriological fact, that they would decrease more rapidly by reason of the presence of the water bacteria?

A. I don't know that that can be stated exactly, in natural waters, and that result appears from experimental work to be at times in the laboratory, but whether or not that actually occurs in natural bodies of water, where conditions are very different from what they are in a flask, for example in a laboratory, I am unable to state definitely.

Q. If pathogenic germs do not multiply in water, and if ordinary water bacteria do multiply in water, is it not probable that there would be a greater decrease in the number of
the pathogenic germs during an interval of time, and
3512 space through which the water traveled, than there would
be in the number of water bacteria?

A. It is conceivable that there might be but that would depend upon the character of the water bacteria and the conditions of the water. Water bacteria are not all the time multiplying in water; they are sometimes dying, and they might die and certain forms of the water bacteria might die at even a greater rate than typhoid bacilli under certain conditions.

Q. Have you ever made any experiments to determine the effect of the temperature upon pathogenic germs, and of water bacteria as to their respective longevity?

A. You mean as to how temperature effects the longevity of typhoid bacillus as compared with the longevity of water bacteria?

Q. Yes?

A. I don't know that I ever made any direct comparative experiments, but it is my general impression from experiments which have been made, that at most temperatures water bacteria would live longer in water than the typhoid bacilli, but of course that all depends upon the character of the water bacteria and the character of the water, the temperature and other considerations. I have made a good many experiments covering both phases of the subject, but perhaps never any particular one set to bring out just that one point.

3513 Q. All other conditions being equal, except the condition that the pathogenic germs do not multiply in water, and the fact that the water bacteria do, would not the probability be greater for reducing the number of pathogenic germs, as compared with the number of ordinary water bacteria during the transit of a given number of miles in a stream of running water?

A. If we neglect all other conditions, such as sedimentation, etc., etc., and consider only the fact that typhoid bacilli do not multiply in water, while water bacteria do multiply under the conditions assumed, why then is it probable that the typhoid bacilli would not linger in water as long as the bacilli which multiplied there, but as a natural practice it would not do to neglect all such other considerations in studying a problem of that character.

Q. I am only asking your opinion upon the conditions suggested; of course there might be other conditions.

A. I have given my opinion under those conditions.

Q. Are you familiar with a stream in Scotland known as the River Dee?

A. Yes sir, I have heard of it; I never saw it.

Q. The stream upon which the city of Aberdeen is situated. The book to which I called your attention, by Percy and G. C. Frankland, on pages 100, 101 and 102, referred to
3514 experiments made by one of the authors by bacteriological examinations of the waters of that river in July, 1892. I will not read the results of this as stated here, but call your attention to the fact which is here stated, among other things, that the water in the river on reaching Invercannie, which is the mouth of the river or near the mouth, exhibited just about the same number of micro-organisms as it did at the first point mentioned, and that the total number of miles of the river's flow, which were examined bacteriologically, was a little upwards of forty miles; that the distance was upwards of forty miles, and during this time, this work states that there were as many as four different sources of pollution entering the river, and that after each one the river reached its normal condition, and came out at the end comparatively, bacterially pure, as stated by this writer, the river thus affords a most perfect example of the repeated pollution and repeated restoration of a stream to a state of comparative bacterial purity.

In view of these facts which have been ascertained by an acknowledged authority on the subject of bacteriology, is it not highly probable that the waters of the Illinois river in passing from Joliet to the Narrows above Peoria, a distance of over 100 miles, were rendered bacterially or comparatively bacterially pure by reason of the sedimentation, oxidation and
3515 other causes tending to the purification of running waters?

MR. JEFFRIES: That question is objected to for the reason that the hypotheses mentioned are not the same in both cases and that the hypothetical statements do not disclose the full conditions of the various streams polluting the river Dee or that the application to be given them is the same, so that whatever answer might be made to the question could not apply with equal force in both instances.

A. It is my opinion that the conditions which exist in the River Dee, have not been described with sufficient completeness as to the amount of dilution received, in the course of the streams, the amount of sedimentation etc., which might take place, to enable a fair comparison to be made between the River Dee and the Illinois River.

Q. Doesn't the mere fact that this River Dee received pollution at four different places in the stream and that it purified itself four times during forty miles, tend to show that other streams will purify themselves in traveling a given distance?

A. It will tend to show that other streams would act in the same manner where the conditions were the same, and I may add that the result which you have described as having been obtained in the river Dee agree generally with many results
which I have observed in other streams. It is a general
3516 fact that if a stream is polluted at a certain point and
the water of that stream contained a certain number of the bacteria below that point of pollution, that a decrease in the number of bacteria is often noticed down stream due to a variety of causes.

Q. If typhoid fever should exist at the same time in cities on the banks of a given stream of water, which of the cities—the up-stream or the down-stream cities, would be in the most unfavorable condition so far as being affected by the presence of dejecta from typhoid fever patients in those streams?

A. That would depend upon the amount of the typhoid fever dejecta, discharged into the stream at various points and it would be influenced by question of dilution and sedimentation and a number of such factors. I fear, however, I don't fully understand your question.

Q. Well you have comprehended it; that is what I wanted to know. If there was an epidemic of typhoid fever in the City of St. Louis, for instance, and the dejecta of typhoid patients were cast into the Mississippi river, what effect would you conclude would be produced upon the persons living in the cities below St. Louis, which derive their water supply from the Mississippi River?

A. Well, that would depend upon the extent of the epidemic in St. Louis and upon the amount of dilution which the
dejecta might receive in the river and upon the location of
3517 the cities down stream which might receive that water, and
upon the time required for the water to pass from St.

Louis to the other city and upon the rate of dying out of the typhoid bacilli; upon the sedimentation and upon factors of that sort.

Q. Assuming that the cities on the Missouri and Mississippi rivers in the year 1890, were visited by a typhoid epidemic, of more or less extent, and the sewage of the respective cities was emptied into the Mississippi and Missouri rivers, would the pollution and the danger from the presence of typhoid bacilli increase as you passed down the streams?

MR. JEFFRIES: The question is objected to for the reason that it does not give the approximate location of the various cities, and whether it means that the danger would increase before it would arrive at certain cities, or after it had passed by certain cities, so that any answer that might be given would be indefinite and not applicable to any given state of facts.

Q. (Question read).

A. Speaking very generally, the danger of contracting typhoid fever by drinking the water of those streams would decrease down the stream.

Q. Would decrease or increase?

A. Would decrease down the stream, but in this we should
have to consider the relative amount of dilution which
3518 took place down the stream and such factors as the dying
out of the bacilli and sedimentation and other factors,
of which I have already spoken in previous answers.

Q. Then there might be conditions of sedimentation which would cause a decrease of the danger, or in the number of pathogenic germs?

A. I can conceive that if in passing down the stream the typhoid fever bacilli settled to the bottom of the stream, and if no other influences ever came about to lift them again into the water, and carry them down stream, that so far as those bacilli that would settle out, were concerned, the danger down stream would be decreased.

Q. Would be decreased?

A. Yes sir, if the bacilli settled out of the water, at a certain place, and remained there from that time on, there would be no danger from that particular bacillus down stream.

Q. Then the danger of contamination of the lower river would be lessened in proportion as the pathogenic germs were eliminated by the sedimentation and other causes to which you have referred?

A. The danger from drinking the water in the stream further down the river is certainly lessened in proportion as typhoid fever germs are actually eliminated from the water.

3519 Q. Well assume that there had been no typhoid cases in the upper city, then how would you account for the condition in the last city upon the stream?

A. What condition do you mean?

Q. As to typhoid, how would you account for the presence of the typhoid germs if there had been no typhoid cases in the towns above, how would you account for the typhoid germs in the lower river?

A. If it were true that there had been no cases of typhoid on those portions of the river above a certain point, and if it could be shown that the water at that point contained typhoid bacilli, and it must be understood that the methods of bacteriology do not admit of that to be shown, while the presence of the typhoid bacillus at that point could not fairly be considered as coming from the stream above.

Q. Some other cause then would have to be found for its presence?

A. If they were really present in the water at that point, they must have gotten in, in some way, but that is a condition which I may say is almost impossible.

Q. What condition is impossible?

A. The condition that typhoid fever exists at a certain point on the stream without their having been put into the stream either at that point or above that point. It is simply the practical proposition that if we find them there, they must have been put there.

3520 Q. They must have come from some place.

A. Yes, they must have come from some place.

Q. In the United States census for 1890, there is contained some data for cities of 50,000 inhabitants and upwards, for the year 1890, in reference to the deaths from typhoid fever per 10,000 living persons in certain cities. At Denver, Colorado, for instance, population 106,000 in round numbers, there were 21.7 deaths per 10,000 living persons;

In St. Paul there were 6.9 deaths per 10,000, with a population of 133,000;

In Minneapolis, with a population of 164,000, there were 5.7 deaths per 10,000 persons;

In Memphis, with a population of 64,000, there were 5.1 deaths per 10,000 persons;

In Omaha, with a population of 140,000, there were 4.5 deaths per 10,000.

MR. JEFFRIES: What year is that for?

THE WITNESS: 1890.

JUDGE SPRINGER: 1890; United States census for 1890.

Q. (Continuing) In Kansas City, with a population of 132,000, there were 4 deaths per 10,000 persons;

In St. Louis, with a population of 451,000, there were 3.2 deaths in 10,000;

In New Orleans, with a population of 242,000, there were
3521 1.9 deaths per 10,000.

Of these cities, Denver received its water supply from the North Platte river, a river which empties into the Missouri near Omaha; St. Paul receives its water supply from lakes near that city, and Minneapolis from the Mississippi river; Memphis receives its water supply from artesian wells; Kansas City from the Missouri river and St. Louis from the Mississippi river, and New Orleans from the Mississippi river, and Omaha from the Missouri river. All of these cities, I believe, have sewerage systems emptying into the Missouri and Mississippi rivers, except Denver, which receives its supply from the North Platte river, which empties into the Missouri. How do you account for the fact that the death rate of New Orleans, which was 1.9 per 10,000 persons, was less than it was in any of the up-stream cities to which I have referred?

A. I cannot account for it without considering a series of conditions, many of which are quite unknown to me. I can conceive it possible that in so far as the typhoid fever existed in these various cities, and in so far as that sewage from typhoid fever patients drained into these streams, and in so far as typhoid fever bacilli may have reached the water supplies of

the cities further down on those streams, that those cases of typhoid fever in the upper cities may have had some influence upon the lower, but the amount of the influence, I could not
3522 state. I do not know all the conditions which exist with regard to the decrease in the typhoid fever bacilli at the different places, or the relative effects of the sewages of the different cities on the streams below. In short, the problem is too big a one to be solved without knowing many more conditions than anything that I have at hand at this moment aside from these figures.

Q. Assuming the facts to be as stated in this data, taken from the census of 1890, is it not apparent that the sewage from typhoid patients which carried typhoid bacilli into the Missouri and Mississippi rivers, was so diluted by the waters of the two rivers, and the bacteria therein so far destroyed by sedimentation and oxidation, and by being lost on the banks and bottoms of the rivers, that they did not reach the lower Mississippi in quantities to increase the ordinary conditions which would otherwise have existed.

A. I have no doubt that starting with Denver and the Missouri river and St. Paul on the Mississippi river, and continuing down the two streams, both before and after their junction, that in so far as the bacilli—typhoid fever bacilli in the sewage of those cities were concerned, there was an increasing dilution; there may have been sedimentation; there was no doubt a dying out of the typhoid fever bacilli. On the other hand some of the bacilli which settled may have been again carried into suspension and borne a distance, pos-
3523 sibly to be again settled; possibly to be again carried on, and I should judge from these figures, that the water which was being used by the people of New Orleans, for example, was less dangerous from the standpoint of typhoid fever, than the water which was being used by the city of Memphis, for example, assuming that there were no local conditions or no other conditions to account for the difference in the typhoid fever rate. In short, the death rate from the typhoid fever in the two cities for a certain period offers a fair index for the comparison of the danger of the two water supplies for the period, irrespective of other causes which might account for some of the cases, aside from the water.

Q. In estimating the drainage area of a river or of the rivers in question here, why do you limit the population along the rivers or in the watershed to cities and towns of 4,000 inhabitants and over?

A. Did you say why?

Q. Yes?

A. Just read the question again.

Q. (Question read.)

A. I assume that you ask the question as to why we often consider only cities which have more than 4,000 population on a certain drainage area, when considering the effect of population with reference to its influence on the water supply, and to that I would say that we do not always limit it to that, 3524 but that it is my judgment that considering the population in such a way offers us on the whole a better means for comparing the effect of the population upon one watershed with the effect of the population upon another watershed, for example, than by considering the total population; for the reason that speaking generally, throughout the country, communities which have more than 4,000 population are more often supplied with such public improvements as a sewerage system and public water supply, than are those which have less than 4,000. I recognize that this is an arbitrary division, but it is one which taken broadly all over the country seems to be a fair one.

Q. At what seasons of the year is there the greatest pollution in running streams, in the dry season or the rainy season; in high floods or low floods?

A. That depends upon what you mean, just how you would define pollution, and upon the character of the stream and upon the time when the polluting matters and substances might enter the stream.

Q. I refer to those kinds of pollution which render a given river unsuitable as a water supply for a city or town; in view of that fact, when is the time of the greatest pollution of the waters of such a stream?

A. It depends in part upon the constancy of the pollution. If there is a sewer, for instance, running constantly into a 3525 stream, the relative proportion of the sewage to the flow of the stream would be less in time, of low flood than at times of high flood; but on the other hand, there may be streams where at times of high flood the pollution is greater than at times of low flood.

Q. Do not scientists universally recognize as a fact that the greatest pollution in streams of water is at times when the flood is the greatest, or the flow of the water is the greatest?

A. No, sir; I should not think that was universally recognized as a fact.

Q. It is not?

A. I should not think it is universally recognized as a fact, no, sir.

Q. What do you regard as the fact?

A. I don't think that any broad fact like that can be established.

Q. When the spring floods come into a river, and the washings from the small tributary streams are brought into the main channel, and the farms and barn-yards, and feeding pens are washed, and the sewage accumulating in the small villages, where they have no drainage system, is washed into the stream, as is usual—is not the pollution greater at such times than at any other season of the year, especially when the water is at a normal stage?

3526 A. In so far as that kind of pollution is concerned, and in so far as that kind of polluting matter is washed into the streams by the villages, I believe that is true; that, however, is not the only kind of pollution which may pollute a stream, and therefore I should want to consider that fact before assuming to draw any general conclusion. As I stated, I do not think any general conclusion can be drawn as to the relative pollution of streams at different seasons. It depends upon conditions in the different streams.

Q. Well, the conditions in most of the streams are so similar that in times of high water, when the spring rains come in, the sewers are flushed and fields washed out; isn't that the time of greatest pollution in a river?

A. At such times there might be a greater amount of polluting matter washed into the streams, but on the other hand at such times the volume of water is usually large, and dilution greater so that the result might not be different from what would occur under normal conditions; with the constant pollution of the stream by a sewer, for instance.

Q. Well, there would be some increase then by reason of all these conditions, taking place, to which I have referred?

A. No doubt there would be in some instances, but I can conceive of cases where there would not, and as I said, it must be decided according to the case in question.

3527 Q. Then in so far as the spring floods would increase the sewage in a given stream, if it would increase it to that extent should not the fact of the possible pollution of streams by reason of smaller towns than those having 4,000, and the rural districts, be taken into consideration in determining the population of a given area or given stream of water?

A. It might be desirable to consider those conditions, but they should also be considered in connection with questions of pollution, etc.

Q. Is there any means of determining bacteriologically or chemically the presence or absence of pathogenic germs in running water?

A. I don't believe that there is any practical method by which pathogenic germs can be determined in water, either chemically or bacteriologically.

MR. JEFFRIES: What do you mean by that, Judge, in river water running water—natural water?

JUDGE SPRINGER: Yes I mean in waters taken from the streams.

THE WITNESS: That is what I understood; the natural water.

Q. Natural water taken from the river?

A. Yes, sir.

Q. Couldn't that water be used for peritoneal injections into animals for the purpose of determining the presence of pathogenic germs, and would not such investigations determine to some extent the presence of pathogenic germs in natural water? 3528

A. To some extent it might determine the presence of germs in water which were pathogenic to the animals experimented with, but there may be micro-organisms pathogenic—there may be bacteria pathogenic to certain animals which would not be pathogenic to human beings, and to that extent the results of the determination would be of less value.

Q. Then if I understand you correctly you are of the opinion that it cannot be determined with certainty whether there are typhoid germs in natural running water?

A. I believe it to be a fair statement to say that in ordinary natural running waters, there is no practical method by which the presence of the typhoid fever bacillus can be determined. I do not think that it is absolutely impossible to do so, but there is no practical every-day method for doing it.

Q. If it is impracticable to ascertain the absence of pathogenic germs in the natural water, it would be equally impractical to ascertain their presence in the same water?

A. I consider the two propositions as practically one. The germ may be there and you might fail to find it; and it might not be there when you failed to find it.

Q. It does not depend upon whether you find it or not, but whether you can ascertain its presence by any chemical 3529 or bacteriological means, or any other means?

A. I stated that I do not consider that there is a practical method by which the presence or the absence of the typhoid fever bacilli can be ascertained in natural waters by chemical or bacteriological means.

G. C. WHIPPLE.

Adjourned until 10:00 a. m., Monday, May 18th, 1903, at Southern Hotel.

3530 Southern Hotel, St. Louis, Missouri. 10:00 a. m., Monday, May 18th, 1903. Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

GEORGE C. WHIPPLE

resumed the stand for re-direct examination by Attorney-General Crow, and testified as follows:

Q. Speaking as an expert, do you or do you not consider that the liquid leaving the Chicago drainage canal at Lockport is polluted?

JUDGE JOHNS: Objected to as not re-direct examination on any point made in the cross-examination.

A. I certainly believe it to be polluted.

JUDGE SPRINGER: What is the answer?

A. I believe it to be polluted.

GENERAL CROW: Assuming that the volume of flow of the liquid leaving the Chicago Drainage canal is 300,000 cubic feet per minute, and further assuming that at times the natural flow of the Illinois river just above Peoria is as low as 40,000 cubic feet per minute, state the percentage of diluted sew-
3531 age in the Illinois river just above Peoria, under these conditions?

JUDGE JOHNS: Objected to for the same reason as above.

JUDGE SPRINGER: I object further for the reason that it leaves out of the assumptions that should be presented to the witness the question of what amount of this sewage, if any, would be lost or absorbed or disappear in its transit from the drainage canal to Peoria.

MR. TODD: I object to it on the ground that the assumption of 40,000 cubic feet per minute at Peoria has not been established by the evidence, and it concludes a fact that has not been put in evidence.

A. If we consider that the liquid which leaves the Chicago drainage canal at Lockport to be polluted sewage and to be flowing at the rate of 300,000 cubic feet per minute, and if to that is added 40,000 cubic feet per minute of diluting water, the sum of these two amounts would be 340,000 cubic feet per minute, and of this sum about 88 per cent would be the diluted sewage.

Q. Is it or is it not possible for you to state whether the contamination of the water supply of Chicago at the intake cribs of said city, is at times appreciable?

JUDGE JOHNS: I object for the same reasons as to the first question.

MR. TODD: I object to the question on the ground that
3532 the witness has not shown that he is in possession of sufficient facts upon which to predicate an opinion, and on the further ground that appreciable is a relative term that does not have any bearing upon the investigation here.

GENERAL CROW: Go ahead.

A. I believe that at times the pollution is appreciable.

MR. TODD: I move to strike out the answer as not responsive.

Q. Now I will ask you this question: Assuming that an epidemic of Asiatic cholera should occur in the city of Chicago, under existing conditions, is it possible that the germs of that disease might find their way into the intake tower of the St. Louis waterworks at the Chain of Rocks?

JUDGE JOHNS: Objected to on the part of the State of Illinois for the same reason as to the first question.

MR. TODD: I object to it on the ground that the witness has not qualified as an expert on Asiatic cholera, and as far as the evidence goes has not shown that he has any knowledge of Asiatic cholera which would enable him to express an opinion such as is asked.

A. Just read that.

(Question read.)

A. Under the assumptions made, I believe that it is possible that those germs might find their way to the intake of the St. Louis waterworks.

3533 Q. Why?

A. Because I do not believe that there are any existing artificial or natural agencies which would at all times insure the prevention of these germs reaching the intake.

Q. MR. JEFFRIES: Mr. Whipple, you stated substantially that the banks of the Mississippi river from Grafton to the mouth of the Missouri are straight, and form what is known as a straight reach. Now I will ask you if you know whether the channel of the river between the points stated, changes from side to side, and if so, how many times, and what effect do they have on the mixing of the waters of the Illinois and the Mississippi rivers?

A. I believe that I stated that the—

MR. TODD: Wait, just read that question.

(Question read.)

JUDGE JOHNS: Objected to by the State of Illinois for the reason given in the objection to the first question.

JUDGE SPRINGER: The Sanitary District makes the same objection to this question as to the other questions asked of the witness this morning.

MR. TODD: Further, that this matter was not gone into in chief and is not a proper subject for re-direct examination.

A. Shall I answer?

MR. JEFFRIES: Yes.

A. I believe that I have stated that the banks of the river
3534 between the points mentioned, were practically straight,
barring certain sinuousities—I forget just the expression which I used. Now I know that the channel does change from side to side a number of times during that reach of the river, as I recall it, some five or six times, passing from a position near the right bank to a position near the left bank—I haven't answered the latter part of your question.

As to the effect which this changing channel would have on the mixing of the water, I believe that it would tend to assist the mixing of the Illinois river water with the water of the Mississippi river, and that a greater mixture would naturally occur than if the channel formed a perfectly straight line during that reach.

Q. You have stated that the Mississippi river had two sharp bends in it between the mouth of the Missouri river and the Chain of Rocks intake tower of the St. Louis waterworks; now I will ask you to say what in your opinion is the effect of the mixing of the Mississippi and the Illinois waters during their flow from the mouth of the Missouri to the Chain of Rocks of the St. Louis waterworks?

A. I believe that just as these bends would tend to increase the mixing or the commingling of the waters of the Mississippi river with the waters of the Missouri river, so it would also
tend to mix the waters of the Illinois river with the waters
3535 of the Mississippi river, and with those of the Missouri
river.

Q. Speaking as an expert, are you able to state whether or not it is possible for the Illinois river water at all times to flow from Grafton to the Chain of Rocks, and by the Chain of Rocks without some of it reaching the intake tower of the St. Louis waterworks?

JUDGE JOHNS: Objected to for the same reasons as above mentioned, to the first question.

A. I don't think that it is possible.

Q. Possible to what?

A. For the water of the Illinois river to pass down by the intake of the St. Louis waterworks at all times without some of the water of the Illinois river reaching the point in the river where the intake of the St. Louis waterworks is located.

Q. Assuming that the minimum stream flow of the Mississippi river at the Chain of Rocks is at times as low as 40,000 cubic feet per second, and assuming that the flow of the Chicago drainage canal is increased in the future from 5,000 cubic feet per second to 10,000 cubic feet per second, state what in your opinion would be the effect of such increase upon the amount of infectious material which may reach the Chain of Rocks, intake tower of the St. Louis waterworks?

MR. TODD: I object to the question on the ground that the facts assumed in the question have not been proven and for the further reason it is not re-direct examination. 3536

A. Shall I answer?

MR. JEFFRIES: Yes.

A. It is my opinion that under the increased conditions of flow there would be a material increase in the liability of infectious material to reach the intake tower of the St. Louis waterworks from the Chicago Drainage Canal.

Q. Under the conditions of relative flow of Mississippi river water and of the Chicago Drainage Canal, as stated in the last question, what effect will that produce regarding the mixing of the Illinois water with that of the Mississippi and Missouri water?

MR. TODD: I object to the question for the same reasons stated in the last objection.

A. I should say that it would tend to increase the proportion of Illinois river water which would become mixed with the water of the Mississippi river.

Q. Having the analyses of three samples of water, as follows: Total residue on evaporation, 170; dissolved residue, 138; suspended, 32; nitrogen as ammonia total, unfiltered, 156; filtered blank—

A. Pardon me just a minute. Albuminoid ammonia, did you say 156?

Q. Yes, .156.

3537 MR. TODD: You didn't say albuminoid ammonia; nitrogen as ammonia.

MR. JEFFRIES: That is nitrogen as ammonia; total, unfiltered, .156; filtered, blank; free ammonia, .040; albuminoid, total, .116; dissolved, blank; suspended, blank. As nitrites, .002; nitrates, .12; oxygen consumed, unfiltered, 2.2; filtered, 1.6; chlorine, 6.0; alkalinity, 117.0.

The second sample, total residue on evaporation, 321; dissolved, blank; suspended, blank; totals blank; loss on ignition, dissolved, blank and suspended blank. Nitrogen as ammonia, total, unfiltered, .754; filtered, .634—

A. What is that filtered?

Q. Yes, filtered nitrogen as ammonia. Free ammonia, .278; totals, albuminoid, .476; dissolved, .356; suspended, .120; as nitrites, .06; and nitrates, .9; oxygen consumed, unfiltered, 7.2; filtered, 6.7; chlorines, 16.0; alkalinity, 151.

Sample 3.—Residue on evaporation, totals, 305; dissolved, 273; suspended, 30; loss on ignition, total, 130; dissolved, 100; suspended, 30; nitrogen as ammonia, total unfiltered, .346; filtered, blank; as free ammonia, .092, totals, .254; that is total albuminoid, .254; dissolved albuminoid, blank; suspended, blank; as nitrites, .047; nitrates, .45; oxygen consumed, unfiltered, 5.1; filtered, 4.4; chlorine, 26; alkalinity, 162, all of which are assumed to represent mixtures of pure water and diluted sewage from the same city. Will you state solely from the standpoint of the water analyst, how they rank in regard to dilution of the sewage? 3538

JUDGE JOHNS: Objected to as not proper re-direct examination.

A. Now I wish you would read once more, if you will, the results for the nitrogen.

MR. JEFFRIES: Just read the whole question.

(Question read.)

A. If these three samples are supposed to represent different mixtures of a pure water and sewage, I should think that, so far as dilution alone is concerned, that sample No. 1 contained the least sewage, and that sample No. 2 contained more than sample 1, but less than sample 3, and that sample No. 3 contained the most. Speaking solely with respect to dilution.

Q. On the same basis what would you say was the approximate relative dilution of sewage in the three samples?

A. Speaking of dilution alone, I should consider the chlorines given in the three analyses as giving the best index of the degree of dilution, and I should say that the dilutions of sewage varied approximately according to the figures which represent the chlorines, which were 6 in the first sample, 16 in the second and 26 in the third. That would not be an exact ratio, but it
would be, for practical purposes it would give us the de-
3539 sired result.

Q. If informed that the first sample represents Chicago water from the tap at 2421 Dearborn Street Chicago, and that the second and third samples represent water taken from points on the Illinois river, would your general conclusions be changed?

MR. TODD: I object to the assumption on the ground that the facts contained in the assumptions have not been proven.

A. Since I was interpreting the results purely from the standpoint of the water analyst, why under the assumptions named in the previous question, it would make no difference where the samples came from.

Q. If water of the character of sample No. 1, that is known to have produced typhoid in the city of Chicago, and samples 2 and 3 are mixtures of this water, and the diluted sewage of Chicago, what do you say as to the probability, considering dilution alone, of these latter samples producing typhoid fever if used for domestic and drinking purposes?

MR. TODD: I object to the question on the grounds that there has been no proof offered in this case to sustain the assumption that waters or samples of waters have been known to produce typhoid fever in the city of Chicago as indicated in the hypothesis, and on the other ground that there is no evidence in the record establishing the facts upon which this hypothetical question is based.

JUDGE JOHNS: The State of Illinois objects for the

3540 same reason as to the first question propounded to the witness this morning.

A. I do not understand what samples you mean by having produced typhoid fever in the city of Chicago. I cannot compare samples 2 and 3 with samples from the city of Chicago which I do not know anything about.

Q. Well, if water of the character of sample No. 1.

A. Oh, of sample No. 1.

MR. TODD: Is it sample No. 1 that produced typhoid fever in Chicago?

MR. JEFFRIES: Yes, that's it.

MR. TODD: I also further object on the ground that no evidence has been offered in the case to substantiate the assumption that sample No. 1 at 2421 Dearborn Street in the city of Chicago has ever been the cause of typhoid fever.

A. Why, if water of the character of sample No. 1 has been the cause of typhoid fever, and if this sample be compared with samples Nos. 2 and 3, which, according to the analyses and the previous assumptions indicate a less degree of dilution with the sewage, it would be my opinion that there would be more chances of samples 2 and 3 causing typhoid fever than sample No. 1, so far as dilution is concerned.

Q. In your opinion, is the water of the Mississippi river below the mouth of the Illinois and above the St. Louis 3541 waterworks intake at Chain of Rocks, less valuable for drinking purposes now than before the emptying of the drainage canal waters mixed with Chicago sewage, into the Illinois river?

A. Read that again.

(Question read.)

JUDGE SPRINGER: You mean before January 17, 1900, do you?

MR. JEFFRIES: Well, before the opening of the drainage canal, January 17, 1900, yes.

MR. TODD: I object to the question on the ground that the value of the water of the Mississippi below the Illinois and above the intake, prior to the opening of the drainage canal has not been offered in evidence in this case; and for the further reason that the witness has not shown himself qualified from any facts, to pass upon the relative value of the waters of the Mississippi river prior to the opening of the canal, and since the opening of the drainage canal, and for the further reason that the value of water for drinking purposes is an unscientific term that expresses nothing.

JUDGE JOHNS: The State of Illinois objects to the question for the reason given in the objection to the first question.

A. Just read that question again.

Q. (Question read.)

A. It is my judgment that it is less valuable.

3542 RE-CROSS-EXAMINATION, By Judge Johns.

Q. What experience have you as to the direction and flow of currents of streams?

A. In general?

Q. Yes.

A. I know about them from many personal observations and from many studies of literature on the subject.

Q. Suppose that the current of a stream in its deepest part runs close to a precipitous curved bank of a river at the rate of three miles an hour, when it comes to a point where the river is again straightened, would the current go across the river or follow around the bank?

A. Do I understand you to assume a condition where there is a curve followed by a straight reach, if I may use that expression?

Q. Yes.

A. And where the current at the curve is near a precipitous bank?

Q. Yes.

A. It might follow along the straight reach, and on the other hand it might be deflected to some extent across the stream again.

Q. Well, it might do either one of the two things, follow
3543 along the bank in a straight reach, or go across?

A. It is possible—there would, without doubt, be a slight deflection that would be the natural condition.

Q. Is there any certain law about it?

A. That depends something upon the varying cross-section of the stream, so far as any general law is concerned, there would tend to be a slight deflection of the current across the stream again.

Q. Well would the main body of water in the channel follow the bank or go across the stream?

A. Of course the water would be kept between the two banks. If the main current of the channel tended to cross the stream, and if the cross-section of the stream were such as to allow it, there might be a slight tendency for a considerable part of the volume of the water to cross the stream. Perhaps I don't exactly understand your question.

Q. Assuming only and solely that the current of a stream in its deepest part, flowing at the rate of three miles an hour, is immediately adjoining a precipitous bank in a curve, and that below the curve there is a straight reach of the river, where would the current of the river go, immediately down the straight bank of the stream, or across it?

A. Well, on a uniform cross-section, I believe it would tend to re-cross to some extent. I do not believe that it would keep exactly to a straight line along a straight reach under the assumed conditions of a uniform cross-section. 3544

Q. Have you any more familiarity with the character of the Mississippi on this 18th day of May than you had on the 16th of the same month, as to its curves and bends and reaches between here and Grafton?

A. Well, practically not.

Q. You never have been on the Mississippi river between here and Grafton, have you?

A. Not between the Chain of Rocks and Grafton.

Q. Not between the Chain of Rocks and Grafton?

A. No sir.

Q. Where did you derive your knowledge of the banks and curves and reaches of the Mississippi river between the Chain of Rocks and Grafton?

A. From several maps, among them the Government charts, the charts of the Mississippi river commission.

Q. Of what date?

A. I don't recollect the date.

Q. The same charts which you examined in reference to the cross-sections in your examination in chief—cross-sections for turbidity?

A. Yes, that was one of the charts; I examined several others; it required several sections of charts to cover the entire distance.

3545 Q. Do you know whether they were of the same date or not?

A. I don't recollect.

Q. You don't know whether any of those charts were within the last five years, do you?

A. I don't think they were within the last five years.

Q. Do you know whether any of them were in the last ten years?

A. I don't think they were. I know not to what extent they have been revised, but I think they were made along in the eighties.

Q. Do you know whether those charts represent the condition of the banks and the curves of the Mississippi river in January, 1900?

A. Not exactly, but I believe that, speaking generally, they so represent them. I have no doubt that there have been slight changes.

Q. What reason have you to believe that, speaking generally, they represent them; do you not know that the currents of the Mississippi river and the banks change constantly, and with great rapidity, and with great frequency?

A. I understand that they do change from time to time; sometimes rather suddenly.

Q. What is the cause of it?

A. Due to the variations in the flow of the stream, due
3546 perhaps to the cutting away of some of the banks.

Q. Cutting away of the bank would be because of the sudden change in the current, would it not, and channel?

A. It might be a change in the direction of the current or in the amount of the current, amount of flow; the change would also be due to the deposition of sediment perhaps.

Q. Your knowledge, then, of the probability of the waters of the Illinois river reaching the intake of the St. Louis waterworks at Chain of Rocks, is derived from an examination of Government charts made some time in the years from 1870 to 1880, and not from any later data so far as you now know, and from no personal observation or knowledge of your own?

A. My knowledge is not derived from a personal inspection of the river, in that reach, but from various maps and charts, among them the Government charts which were made on dates which I do not just recollect, but not very far, I believe from the dates you mention.

Q. Assuming that the volume of the Illinois river at Peoria before the opening of the drainage canal, given you, namely, 40,000 feet per minute—is the volume at the lowest known water, the lowest known stage of the river at any time within the last 25 years, would you think that assumption fair, upon which to make a calculation of the percentage of dilution?

A. It would be fair with reference to that particular time.

3547 Q. Assuming that at all times since that data was given, the volume of the Illinois river has been greater and that it has at Peoria at some times been as much as 2,000,000 feet per second, would you be able to form any opinion as to the percentage of dilution at any other time than the exceptional time given you in this supposititious question?

A. Why no, I could form simply an opinion of the dilution at the time when the figures were given.

Q. Assume that below the Peoria Narrows, and between there and Grafton, at the mouth of the Illinois, there is a very much greater dilution of the waters of the Illinois river from its tributaries than above Peoria, would your conclusion as to the possibility of the waters in the Illinois river above Peoria reaching Grafton in the state in which they were above Peoria, be in anywise changed?

A. Why, I should want to know the relative amount to which the water was diluted below Grafton, in so far as dilution was concerned.

JUDGE SPRINGER: You mean below Grafton or below Peoria?

A. Below Peoria, between Peoria and Grafton, as compared with the dilution above, and that would affect simply the question so far as the dilution was concerned; that would not influence other factors which might influence the water, in its passage in the Illinois river.

3548 Q. Well, sewage may be rendered harmless by proper dilution, may it not, that is harmless to health?

A. I would not say that in such plain terms, no sir, so far as that alone is concerned, you understand.

Q. If a cubic foot of sewage is diluted with 300,000 cubic feet of good water, the danger of disease from that sewage thus diluted would be either nothing or very small, would it not?

A. That would depend upon the character of the sewage. The danger would be certainly very much less than that from the sewage itself.

Q. If sewage was diluted in the proportion of one foot of sewage to 45 feet of pure water, or good water, that amount is above the ordinary requirements of sanitarians, as to dilution, is it not?

A. One cubic foot of sewage diluted with 45 cubic feet of pure water?

Q. Yes?

A. No sir, I shouldn't call it above the requirements.

Q. What are the requirements of scientists as to the dilution of sewage with good water so that the water might become potable?

A. I know of no exact requirements, and furthermore, the
word "potable" as I have previously said, in testimony,
3549 does not convey, to my mind, a definite meaning.

Q. Have you any word which expresses your idea of water which it is safe to drink, other than the word "potable"?

A. I just use the word "safety."

Q. You prefer to use the word "safety"?

A. I prefer the word "safety" meaning safety from danger of contracting disease from drinking water.

Q. Can water which is polluted with sewage, be diluted to such an extent that it is safe to drink it?

A. It can be diluted to such an extent that the chance of contracting disease by drinking the water is very remote. I don't think that simply by dilution alone you can absolutely say that it can be rendered safe at all times.

Q. Then the greater the dilution the less the chances of harm?

A. That is certainly true, as far as dilution goes.

Q. Assuming that the city of Chicago had for fifteen years prior to 1900, discharged into the Illinois and Michigan canal substantially the same amount of sewage that has been discharged by the drainage canal into the Illinois river since 1900, with a dilution of only 40,000 feet per minute, would you think that that sewage had, during that fifteen years, reached the intake at St. Louis?

3550 MR. JEFFRIES: The question is objected to for the reason that it does not contain an hypothesis stating or showing that the sewage was carried through the old Illinois and Michigan canal in the same length of time as through the present Chicago drainage canal.

A. Read the question once more.

Q. (Question read.)

MR. JEFFRIES: I object for the further reason that the question does not assume that the sewage matter thus discharged was practically the same when it entered into the Illinois and Michigan canal as it is when it enters the Chicago drainage canal today.

A. So far as dilution is concerned, or rather, in so far as your assumption takes into account only dilution, I could not give a definite reply to that. Perhaps you had better read that question again. I think I have answered it.

Q. (Question read.)

A. Do I understand that you assume any other conditions than dilution? Do I understand that you wish me to take into account any other conditions than dilution?

Q. No sir, only the conditions stated in the question?

A. Read my answer again.

(Answer read.)

Q. Well, go ahead?

A. That wasn't what I meant. In so far as dilution is

3551 concerned, without considering other factors, I believe it might be possible—how do you express that first part of it?

Q. I just want to know whether if it goes into 40,000 feet of dilution in the Illinois river it is just as likely to reach the intake as with 300,000 feet of dilution?

A. I understand that you made no comparison; I understood you to ask if it did?

Q. Yes sir.

A. And I believe that so far as dilution goes, it might.

Q. Well, if the waters of the Illinois river, to which are added 300,000 feet of water from Lake Michigan, certainly reach, in your opinion, the intake at St. Louis, why wouldn't the waters of the Illinois to which were added 40,000 feet, as certainly reach the intake at St. Louis?

A. I think that so far as dilution alone is concerned they might as certainly reach, so far as dilution is concerned.

Q. But if for 15 years prior to 1900, substantially the same amount of sewage discharged into the Illinois river from Chicago, diluted with 40,000 feet of water as is discharged since 1900, diluted with 300,000 cubic feet of water, then the danger of disease in St. Louis from the sewage of Chicago, diluted with 40,000 feet of water, would be more than seven times as great as if diluted by 300,000 feet of water, would it not?

3552 MR. JEFFRIES: I object to that question for the same reasons stated in my objection to the previous question.

A. In so far as dilution itself is concerned, that would practically be the case, so far as dilution itself is concerned; dilution is a good thing.

3553 Q. When was Asiatic cholera in Chicago?

A. I don't know.

Q. Do you know whether there ever was any there?

A. No sir.

Q. You are not aware that there was Asiatic cholera in Chicago or so-called Asiatic cholera in 1847, and that there has been none since?

A. I don't know that.

Q. Is Asiatic cholera, considering the latitude and longitude of Chicago, at all likely to occur there?

A. As far as the latitude and longitude go I think it might occur there, yes.

Q. Independent, then, of latitude and longitude, taking into consideration any other element, is it likely to occur in Chicago?

A. So far as the latitude and longitude are concerned, I think it might occur there.

Q. Now with all the other conditions added do you think it likely to occur?

MR. JEFFRIES: What other conditions?

JUDGE JOHNS: I don't know.

A. That would depend upon other conditions; it is quite conceivable that cholera might occur in the city of Chicago.

3554 Q. On the doctrine of probability, if there is any such thing, is it probable that Asiatic cholera would ever occur in the city of Chicago as an epidemic?

A. I think that would depend wholly upon circumstances. I think if any of our health officials in most of our cities, particularly the sea-coast cities, did their duty, this country ought not to be visited by cholera, but I cannot say and no one can say when cholera might not occur in this country.

Q. Could the Asiatic cholera occur in Sitka, Alaska?

A. I could not definitely say that it would not, but I don't think it would be likely to occur in such a northern situation as that.

Q. Could it occur in Vancouver, British Columbia?

A. I think it might occur there.

Q. Asiatic cholera has somewhat of a geographic limit owing to climate, has it not?

A. I think it is more likely to occur in warm climates and temperate climates, than in extreme northern climates, but I cannot draw any line, and I don't believe scientists could draw any definite line of why or where, or just how far north it could not or can occur.

Q. When you say that the pollutions in the Illinois river are sometimes appreciable, at the intake and at the Chain of Rocks, to what extent do you mean appreciable?

A. I mean that if the Illinois river is polluted that that

pollution may reach the intake at the chain of rocks, but
3555 I cannot state the extent to which it would reach the Chain of rocks, or when it would.

Q. Can you say whether it would at all times?

A. I cannot say whether it would at all times.

Q. Can you designate the season at which it would be appreciable?

A. I cannot definitely, because it depends upon a number of conditions with reference to the flow of the streams, with reference to the amount of pollution; with reference to mixing and sedimentation and all those factors which we have discussed.

Q. At what season of the year is typhoid fever the most prevalent?

A. As a rule it comes in the latter part of the summer and early fall. Speaking of it generally without regard to exceptional epidemics.

Q. In a general way it comes in the early fall?

A. Yes, in this hemisphere, and in the other hemisphere it is the other way around.

Q. Could you tell or do you know whether the pollution in the Illinois river was appreciable at the intake of the St. Louis waterworks in the fall of 1902?

A. I couldn't say definitely.

Q. Or any other year?

3556 A. I cannot say definitely that it was, but I see no reason why it might not be at times.

Q. Do you mean by appreciable, simply capable of being perceived by scientific examination?

A. No sir, I mean appreciable from a practical standpoint that it may have an effect upon the health of the people who drink the water.

Q. Do you mean to say that it does as a matter of fact have an effect upon the health of the people?

A. I cannot say absolutely that it does, but I believe that possibility certainly exists.

Q. It is a possibility that it might?

A. I believe that it is.

Q. Do you believe that the waters of the Missouri riv have an appreciable effect upon the character of the water at the St. Louis intake?

A. I cannot say absolutely that they do, but I believe that they may.

Q. Do you not know that they absolutely do have an appreciable effect upon the character of the water at the St. Louis intake?

A. I couldn't say that they absolutely do.

Q. To what do you attribute the extraordinary amount of matter in suspension in the waters of the intake, the Missouri the Mississippi, or the Illinois?

3557 A. I believe that it comes largely from the Missouri river.

Q. If typhoid fever germs were discharged into the Missouri river, the Mississippi river and the Illinois river at such times that the waters into which they were discharged would reach the chain of rocks simultaneously, and in consequence thereof, typhoid fever ensued in the City of St. Louis, to what would you attribute the typhoid fever?

MR. JEFFRIES: That is, I understand that they all reach the intake at the same time?

JUDGE JOHNS: Yes, all go in the same date.

A. If there were typhoid fever germs reaching the intake on a certain date from the Missouri river, and if there were others reached the intake from the Mississippi river and others reached it at the same time from the Illinois river, and if these germs caused typhoid fever in the city of St. Louis, I couldn't say exactly which one of the three or whether all of them caused the typhoid fever, and I couldn't tell the relative number of cases which each one caused without knowing more about the number of germs that came from each one.

Q. If under the conditions supposed in the former question the typhoid germs from the Missouri river traveled 40 miles, and the typhoid germs from the Mississippi 100 miles and the typhoid germs from the Illinois 350 miles, which set of 3558 germs would be most likely to cause the typhoid fever, supposed in the former question?

MR. JEFFRIES: That is still supposing that they all reached there at the same time?

A. Yes, you couldn't tell from those figures alone, in so far as those distances affect the time required for the germs to travel, and in so far as that time alone affected the germs, you would naturally expect a greater effect from the nearer one, but that would have to be taken into consideration with many other factors.

Q. Suppose that the time of transmission to St. Louis was proportionate to the distance named in the former question; to which one would you attribute the typhoid fever in St. Louis?

MR. JEFFRIES: Proportionate to the distance did you say?

JUDGE JOHNS: Yes.

A. So far as that fact alone, disregarding everything else, you might naturally expect—disregarding the numbers and those other factors and considering the question of time, why that those nearest might be considered as having the greatest effect, but in making a true comparison you would have to compare all factors; you couldn't compare that alone.

Q. In you answer to the questions propounded this morning, as to samples 1, 2 and 3, did you suppose an equal amount of pollution in the water in each event?

3559 A. I don't understand what you mean by that. I assumed that those were different mixtures, or that those were a mixture of a certain water in a certain sewage, in different proportions.

Q. From what question propounded to you did you arriv at that assumption?

A. That is what I understood the question was, one of the questions asked by Mr. Jeffries, I think it was.

Q. What would be the effect upon your judgment as to samples 1, 2 and 3, if they were equally diluted with pure water?

A. To what extent?

Q. As to the percentage of sewage in it.

A. I don't understand what you mean.

MR. JEFFRIES: I think he means if the same amount of sewage was in each sample.

JUDGE JOHNS: What did you understand the assump tions were in the questions propounded to you by Mr. Jeffries, as to samples 1, 2 and 3?

A. I understood that these three samples represented three different mixtures of sewage and water. In one there was such a pollution—these three different mixtures, and I was asked to state which in my opinion showed the greatest pollution; in other words to state what the relative mixtures were, as to whether one contained a larger proportion of the sewage than the other.

3560 Q. You were answering as to whether one was more largely diluted with pure water than the other?

A. Yes, the pure water in question.

Q. On that basis, did you explain that sample 1 had the most dilution?

A. Yes, sir; more than the other two.

Q. And sample 3 less dilution than sample 2?

A. Sample 3 was less diluted than 2, they were in the order 1, 2 and 3.

Q. Did you assume as to those matters that the same amount of sewage existed in each sample in weight or volume, and of the same character?

A. No, sir; that was a practical question. That was practically what was supposed to be determined by comparing analyses as to which had the greater amount of sewage?

Q. Did you assume that each sample contained an equal amount of water, or that each sample was of equal volume or weight?

A. I supposed we were comparing equal volumes. These results were expressed in parts per million by weight.

Q. The results of the chemical analyses of the samples were expressed in parts per million?

A. Yes, sir.

Q. You understand, that is, from equal volumes of the samples submitted?

3561 A. Yes, expressed in terms of equal weight, which means practically the same thing.

Q. Your opinion is then, that there was greater dilution in sample 1 than in sample 2?

A. Yes, sir.

Q. And greater dilution in sample 2 than in sample 3?

A. Yes, sir.

Q. Do you know at what point in the river samples 2 and 3 were taken?

A. I don't know where they were taken. I think in one question he assumed that they were taken at certain points.

MR. JEFFRIES: The assumption was that they were taken in the Illinois river.

JUDGE JOHNS: Do you care to tell me where, Mr. Jeffries?

MR. JEFFRIES: I don't know.

THE WITNESS: As I understand, this was an assumption.

JUDGE JOHNS: You don't know whether sample 2 is taken at all; is anything more than a supposition, as taken above or below Peoria?

A. I consider these three analyses as a supposition, but in one question he assumed that sample No. 2 was taken at or above Peoria; I have forgotten which. I understand that it is an assumption.

Q. You have no knowledge as to whether the other two samples are anything more than a supposition?

3562 A. I couldn't say whether they are anything more than a supposition from the question.

Q. Did you select these supposed chemical analyses of three supposed samples, and give them to the attorneys for the State of Missouri for the purposes of this supposition?

A. No, sir.

Q. Do you know who did?

A. I thought I saw Mr. Fuller and Mr. Jeffries looking over the record together; I don't know which one of them picked them out. I don't know really whether they picked them out or not. I saw them looking over the records.

Q. Do you know whether they were looking at the record in this case?

A. It looked like one of the sheets of complainant's Exhibit 1 for identification.

Q. But whether or not it was, you don't know now?

A. I did not definitely examine the paper with that idea.

Q. Suppose sample No. 2 was taken above Peoria and represented fairly the quality of the water at that point at a given time? By the time that water reached Grafton it would be vastly changed, would it not, if nothing in the way of pollution were added to it?

A. I should suppose that it would be changed, under existing conditions.

3563 Q. The process of nitrification would have changed the constituents of that sewage very largely by the time it reached Grafton, if it was taken above Peoria?

A. It might change it.

Q. Would it not as a matter of fact, actually change it?

A. It practically would have changed it to some extent, yes.

Q. Wouldn't it have changed it to a very considerable extent?

A. I couldn't say to how considerable an extent.

Q. Would it have changed it for the better or for the worse?

A. Speaking in broad terms, I suppose somewhat for the better.

Q. If sample No. 3 was taken below Peoria and represented correctly the condition of the water in the Illinois river at the time it was taken, its character also would have changed in its journey down the river to Grafton, would it not?

A. I presume it would have, yes.

Q. And for the better as far as the safety of the water for drinking purposes is concerned?

A. I couldn't say—you were speaking about nitrification; I couldn't say that without knowing the conditions.

Q. I am speaking now of nitrification?

A. As far as nitrification is concerned, it would become better water, using that word "better" in a very general sense.

3564 Q. If after the arrival of these two conditions of water thus improved, they were added at Grafton to the Mississippi river in the proportion of 1 to 7, at the time they reached the Missouri river, the intake at the chain of rocks, they would be still more changed, wouldn't they?

A. You mean as far as nitrification is concerned, or in all conditions?

Q. Yes?

A. They would be changed as far as nitrification is concerned probably. I suppose that process might keep on in the Mississippi river to some extent.

Q. They would also be very vastly changed by dilution, would they not, and mixture with the Mississippi river water?

A. They would be changed by dilution, yes.

Q. And the character of the water into which they were injected at Grafton by the Illinois river, would be very vastly modified by influence with the water of the Mississippi river?

A. After the mixture of the water of the Mississippi river the resulting water would no doubt be quite different from that in the Illinois river.

Q. Are either one of these samples positively bad and unsafe for drinking purposes?

A. I couldn't say from these analyses. I could not definitely say from these analyses. 3565

Q. Would either one of these analyses, existing in water which is used for drinking purposes, produce disease?

A. I couldn't say from these analyses.

Q. Would either one of them produce typhoid fever?

A. I couldn't say from these analyses.

RE-CROSS-EXAMINATION, by Mr. Todd.

Q. Mr. Whipple, you answered in reply to the question, if the liquids leaving the Chicago Drainage Canal at Lockport were polluted, and you answered Yes.

A. Yes, sir.

Q. What was the proportion of pollution?

A. I couldn't say that definitely.

Q. Polluted in what way?

A. Polluted by the sewage of Chicago.

Q. How do you know that it was polluted with the sewage of Chicago?

A. I have seen the Chicago river entering the Chicago Drainage Canal and I have seen some of the sewers of Chicago entering the Chicago river, and I believe it to be polluted with the sewage of Chicago.

Q. I am speaking of your own knowledge, now, Mr. 3566 Whipple, and if in my questions you will confine yourself to your personal knowledge we will get along much faster.

A. Yes, sir.

Q. Do you know what proportion of dilution the sewage of Chicago bears to the 300,000 cubic feet per minute that passes over the Bear Trap Dam?

A. I couldn't tell you exactly, but I know what the limit dilution prescribed by law is.

Q. What are they?

A. 20,000 cubic feet per minute of lake water to the sewage of each 100,000 inhabitants of the Sanitary District of Chicago.

JUDGE SPRINGER: Isn't that per second instead of per minute?

A. Per minute.

Q. That would make a difference then of sixty times, if it is per minute?

A. Yes, sir.

MR. TODD: And when you stated that you based it upon your knowledge of the conditions as enunciated in the law?

A. I have read the law, yes, sir.

Q. Now, in the 300,000 cubic feet of water that is passing over the Bear Trap Dam at present, what proportion of that is sewage, and what proportion of it is Lake Michigan water?

A. I couldn't say exactly, for I don't know the exact 3567 volume of the sewage which enters the canal.

Q. Have you any knowledge of the amount of sewage that enters the drainage canal, as distinct from lake water?

A. I believe it to be true that the sewage of approximately a million and a half people enters the Chicago drainage canal. I cannot give you the exact figures, but I believe that to be true.

Q. What is the amount of sewage known as feces and urine that is ejected from each individual in a period of twenty-four hours?

A. Speaking generally the amount of urine is about a quart and a half, more or less. I do not recollect at this moment, the exact amount of feces.

Q. In ounces, how many would you say?

A. I don't remember.

Q. Where you stated 88 per cent. in your answer, will you tell me what that 88 per cent. meant; I don't recall it right now, and I simply want to get it for a question that I want to ask you?

A. In the question to which you refer, I think it was stated that the flow from the Chicago Drainage Canal was 300,000 cubic feet per minute, and it was assumed that the minimum of that flow at Peoria was 40,000 cubic feet per minute; that 3568 is the minumum total of 340,000 cubic feet per minute, and I meant that 300,000 cubic feet per minute coming from the drainage canal was about 88 per cent. of this total.

Q. Of the total of what?

A. Of the combined flow.

Q. At Peoria?

A. At this point, Peoria, under the conditions assumed.

Q. What proportion of that 88 per cent. is sewage, and what proportion is lake Michigan water?

A. I couldn't tell you exactly, but if we assume—

Q. I don't want any assumptions; I want actual knowledge.

A. I was going to give you or to express an answer, giving you as good a result as I could.

Q. Have you any accurate data on the question?

MR. JEFFRIES: Let the witness answer. Go back to your answer to the other question that you started on and finish it.

A. (Continuing) If the 300,000 cubic feet per minute flowing from the Chicago drainage canal receives the sewage of Chicago, according to the dilution prescribed by law, then the combined flow at Peoria, obtained by adding 300,000 cubic feet per minute from the canal and 100,000 cubic feet per minute representing the flow of the stream, we should find that the mixture contained the sewage of Chicago approximately to the amount of 23,000 cubic feet per minute for each 100,000 3569 inhabitants; that is by dilution the ratio was increased from 20,000 cubic feet per minute for each 100,000 inhabitants, to 23,000 cubic feet per minute. I do not think I can express my answer in any closer terms than that.

MR. TODD: Have you finished?

A. Yes, sir.

MR. TODD: I move to strike out the answer as not responsive to my question.

Q. What proportion of that 88 per cent. is sewage and what proportion is Lake Michigan water?

A. I couldn't tell you the exact proportions of Lake Michigan sewage in the water, no, sir.

Q. Can you give me any actual personal knowledge free from any assumptions that you might make?

A. No, sir; I cannot; unless I allow a fair quantity of sewage for each inhabitant of the City of Chicago.

Q. Do you know what the fecal and urine discharge per capita is in the City of Chicago?

A. Not definitely, but such calculations can be made.

Q. Do you know of your own knowledge, independent of any assumptions, what the fecal and urine discharge per capita is in the City of Chicago?

A. Not such that I could express it mathematically.

Q. Now, in the samples known as 1, 2 and 3 that you
3570 have testified about; did those samples indicate sewage
pollution?

A. I couldn't say definitely from these samples without regard to anything else.

Q. What other elements would you have to know as to whether those samples are sewage polluted without assuming that they are sewage polluted?

A. I should want to know the character of the water, the character of the so-called pure water, with which the sewage was supposed to be mixed. As I stated the other day—

Q. May I ask you to let my question be read to you, as I see you do not understand it?

A. Yes, sir.

Q. (Question repeated.)

A. I need no other elements, but I should naturally desire to know something about the bacteria present, to note the abundance of bacillus coli, the color of the water, the odor of the water may be of some assistance also, etc., but then, with these additional quantities I might not be able to tell whether these were or were not sewage polluted, if I didn't know certain other things.

Q. Then if those samples in themselves did not indicate sewage contamination, how are you able to institute a comparison between those samples in regard to the diluted sewage contained in each?

3571 A. Because they were assumed to be a mixture of pure water and sewage, and I was simply asked to compare one with the others.

Q. What is sewage chemically speaking?

A. Do you mean as shown by the elements of water analyses?

Q. (Question repeated.)

A. It consists of organic and mineral matter in water, some of which may be in solution, and some of which may be in suspension; some of the organic matter may be lifeless and some of it may contain or be made up of living organisms.

Q. Is sewage made up of what is known as hydrogenous compounds?

A. Partly.

Q. What are the hydrogenous compounds of the sewage of man?

A. In the compounds are contained, hydrogen, nitrogen, oxygen and carbon perhaps.

Q. Have they any names?

A. A great many names.

Q. What are they?

A. The urea, for instance. Then we have the marsh gas and many other very complex compounds, cellulose, and a great many such substances, I cannot name them all at this moment.

Q. How does the sewage from man differ from the sewage of slaughterhouses?

A. I couldn't say exactly from a chemical standpoint.

3572 Q. Which sewage will purify itself or oxidize quicker, the sewage discharge of man or the sewage discharge of slaughterhouses in water?

A. I couldn't say exactly, using the word "purification" in a general sense.

Q. Using it in a chemical sense, could you say?

A. In the sense of destruction of organic matter do I understand?

Q. Yes?

A. I couldn't say exactly.

Q. If three samples of water, such as you have testified to, should be presented to you and your analyses should disclose ingredients such as have been assumed to exist in these three separate samples and your opinion was asked as to whether those samples were sewage polluted or not, what answer would you make?

A. I could not be able to tell definitely from these. I could give some idea possibly as to the relative probability, but I could not give what I would consider a definite answer from these analyses.

Q. Could you give any scientific opinion based upon these analyses alone?

A. Based upon any one of these analyses alone, without considering anything else than the figures here shown,
3573 and without knowing the source from which they came,
I couldn't state definitely that these were samples of sewage pollution if I knew absolutely nothing about them aside from these figures.

Q. Is there anything in either one of those samples which would indicate that if a person took into his system water similar, chemically similar to either one of those samples, that he would contract typhoid fever?

A. No, sir.

Q. Is there anything connected with the analyses of these three samples that would indicate typhoid fever?

A. No, sir.

Q. What experience have you had with Asiatic cholera?

A. I have studied the organism in the laboratory. I have had no practical experience with the disease.

Q. Have you ever seen a case of Asiatic cholera?

A. No, sir.

Q. Do you know how long the germ of Asiatic cholera would live in running waters?

A. I don't know definitely, no, sir.

Q. Assume that there should be an epidemic of smallpox in Chicago, under existing conditions, is it possible that the germs of that disease would find their way to the intake of the water tower of St. Louis?

3574 A. I don't know anything about the germs of smallpox;
I cannot answer your question, but so far as scientific

evidence goes, I know of no reason for believing that smallpox is transmitted by water, even though the germ of smallpox may not be known to science.

Q. The same would be true of scarlet fever, wouldn't it?

A. Practically so, although some scientists claim they know more about the germ of scarlet fever than they do about the germ of smallpox, but practically true as far as being a water borne germ, yes.

Q. Is it a fact that the germ of smallpox has been discovered?

A. I know that a scientist has recently claimed that he has discovered the cause of smallpox; I don't think that has generally been accepted by scientists, although it may be true.

Q. When chlorine is found in water in the proportion of 6, 16 and 26 as indicated in the samples 1. 2 and 3, are the samples containing the largest amount of chlorine, the 6, 16 or 26?

A. Well, the one which contains the 26; the sample which contains the 26 parts of chlorine contains the largest amount, larger than those which contain 16 or 6.

Q. That is the way that quantity or amount of chlorine is expressed in that way, is it?

A. Expressed in parts per million.

Q. Is sample No. 3 the one that contains 26?

3575 A. Yes, according to my memoranda.

Q. When the assumption was made that sample No. 1 would cause typhoid fever in Chicago, was there anything in the sample indicated that such a condition would obtain?

A. No, sir.

Q. Then the conclusion in the assumption that samples 2 and 3 would cause more typhoid than No. 1 is purely an assumption based upon no scientific knowledge in connection with the three samples, collectively or separately, is it?

A. It was an assumption that sample No. 1 was the cause of typhoid fever. It is a further assumption that this was a mixture of pure water and sewage. It is a reasonable assumption that the typhoid fever was caused by that portion of the sample which was sewage and not that portion which was pure water, and in such a case, it is reasonable or it may be reasonable to infer that samples 2 and 3 would be more likely to cause typhoid fever because of containing a larger proportion of sewage than the first one.

Q. Do samples numbered 2 and 3 contain more sewage than No. 1 as evidenced by the analysis that is before you?

A. On the given assumptions that these three samples were all mixtures of pure water and sewage.

Q. Well, independent of any assumption, taking the samples as they appear.

3576 MR. JEFFRIES: Let the witness answer the question.

MR. TODD: I thought he was through.

A. I had finished.

(Question repeated.)

A. Independent of any assumption, I could not say from samples 2 and 3 that they contained sewage.

Q. In the hypothetical question put to you the words "less valuable as drinking water" were employed, to which you remember I objected?

A. Yes, sir.

Q. What scientific significance, do the words "less valuable" have in regard to drinking water?

A. I use "less valuable" speaking from a sanitary standpoint; of course water may be less valuable for other reasons, but the question of sanitary value, the sanitary condition of the water enters into the value of that water for drinking purposes.

Q. Assume that the water at Grafton, in 1899, prior to the opening of the drainage canal was condemned by the city health department of the city of St. Louis, after examination and analysis by the city chemist as being not potable and not fit for use, would the entrance of the drainage canal into that water, render that water less valuable for drinking purposes?

A. I think it would.

3577 Q. Then what value would you attach to water for drinking purposes if it was condemned as non-potable water and dangerous to the public heath prior to the opening of the drainage canal?

A. I would say that it was less valuable. It is a case of relative conditions.

Q. What value would you attach to a water which had been condemned as being sewage polluted?

A. That would depend upon how much it was sewage polluted.

Q. Polluted to the extent that the City Physician of St. Louis after chemical analysis of the waters, denominated it unfit for drinking purposes, and dangerous to public health, what value would you attribute to water of that character?

A. If it were true that it were absolutely unfit for drinking purposes I should consider that from a sanitary standpoint it had a very low value.

Q. Would you give to that kind of water any value as drinking water?

A. Yes, if I couldn't get any other.

Q. Assuming that the city of St. Louis is so situated that it could get other water, and that the water of Grafton in the Illinois river by the analyses of the city chemist in 1899 was condemned and pronounced dangerous to the public health of the city of St. Louis, what value would you give to that water?

3578 A. If it were really dangerous to health I should give it a low value.

Q. How low would you put that value?

A. That would depend upon how much it was polluted; I couldn't state that in mathematical terms.

Q. As a sanitarian, would you give any value to water for drinking purposes, which has been by the analyses condemned as dangerous to public health?

A. If I knew that every glass of water which was take from that source—I shouldn't give that glass of water any sanitary value. and a larger number of glasses of water that would be necessary to be drunk in order to produce the disease why the more value it would have.

Q. How many glasses of water at the present time of the city water supply, is drunk before disease is produced?

A. I couldn't say.

Q. What value do you give to the present water of the City of St. Louis?

A. I cannot express that in definite terms. I think that the water certainly has a value.

Q. Suppose that public statistics should show that less

than one person in over 500 is sick in the city of St. Louis and less than 1 in 2,000 gets typhoid fever a year, and during the year 600,000 people drink on an average a pint of water
3579 a day, what value would you give to the water of St. Louis?

A. The range that you have stated, is so wide that it would be pretty difficult to give an exact opinion.

Q. What is the par value of drinking water in per centage, according to the use of the word "value" in the hypothetical question that you answered, of Mr. Jeffries?

A. I don't think that can be stated in definite terms, I should think that the par value would be water which would have from a sanitary standpoint no injurious effect on the public health.

Q. Do you know whether the water that entered the St. Louis intake prior to 1900 was such a water as to have no effect upon the public health?

A. I couldn't say that it did not have an effect upon the public health.

Q. Assuming that bulletins from the board of health, almost daily and monthly throughout the year, advised the citizens to boil the water, what would your opinion be as to the value of the water of St. Louis, prior to the opening of the drainage canal, as it affected the public health?

A. I don't think I could say just from the bulletins. It would depend upon who made the bulletins and what grounds he had for making them.

Q. Assume that he made examinations according to the established line of chemical analyses, and according to the
3580 methods used in exhibit 1 for identification, and arrived at the conclusion that the water was dangerous to public health, and requested that the water be boiled, what value as a sanitarian would you give to that water?

A. I don't think I could judge from that fact alone.

Q. Assume that since the opening of the drainage canal, the public health office by the same method of analyses has advised that the water be boiled before consumption, what value would you give to the water now?

A. As a sanitarian I couldn't give a value to the water simply from public bulletins concerning the water.

Q. What are the conditions of the water today as differing from the water prior to 1900, at the St. Louis intake?

A. As I understand it—

Q. From your actual knowledge, then, independent of public bulletins?

A. As I understand it, there is a greater possibility today of the water supply of the city of St. Louis at the intake being polluted than there was before January 17th, 1900, by reason of the discharge of the sewage of Chicago through the Chicago Drainage Canal.

Q. Has that probability been scientifically demonstrated?

A. I believe so, within the bounds of scientific judgment. It has not been chemically demonstrated.

3581 Q. Has it been chemically demonstrated?

A. I have no information that leads me to believe that it has been chemically demonstrated, excepting that I understand that certain results of the analyses in general show slight increases in the organic matter, etc., indicating of itself, but not proved.

Q. Do these indications rise to the dignity of proof?

A. No sir, I do not consider that they do.

Q. Has the demonstration scientifically been made that the waters that enter the intake tower today, are more injurious to public health than they were prior to 1900?

A. I don't believe it has been chemically or scientifically proved, but I believe that scientific judgment leads us to believe that such is the case.

Q. When scientific demonstration fails to establish a fact then the so-called scientific judgment does not differ from the judgment of a man who is not scientifically advised, drawing his inference from the same conclusion?

A. Where an absolute scientific demonstration is impossible the next best thing to my mind is a scientific judgment.

Q. Well, can a judgment be scientific when the facts upon which that judgment is predicated, are incapable of scientific demonstration?

A. No sir.

ADJOURNED until 2:00 P. M. same day, May 18, 1903.

3582 Southern Hotel, St. Louis, Missouri. 2:30 P. M., Monday, May 18th, 1903. Parties met pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

GEORGE C. WHIPPLE,

resumed the stand for further re-cross-examination by Judge Springer, and testified as follows:

Q. Mr. Whipple, calling your attention to the question put to you this morning by General Crow, and your answer thereto, in reference to the possibility of germs of Asiatic cholera coming from the City of Chicago to the City of St. Louis, or to the St. Louis intake, did you take into consideration any facts in regard to the longevity of such germs?

A. I didn't take any facts, especially in mind, when I spoke, but I believe from what I know of the subject that the germ of cholera will continue to live in water for a considerable period, though probably like the germ of typhoid fever, in diminishing numbers.

Q. In diminishing numbers?

A. In diminishing numbers as time goes on.

3583 Q. Is it not the opinion of scientists, and do not bacteriological examinations of water show that the bacillus of Asiatic cholera is of very short duration?

A. I would not say that that is the generally accepted opinion. If I were comparing the two germs, typhoid and Asiatic cholera bacillus I should say that from what I know, that it was quite possible that the germ of Asiatic cholera might not be as hardy as the germ of typhoid fever, but I do not believe one can say that it will not live for a considerable period in water. In fact I believe that it will.

Q. Do you know of any instance where a microscopical examination of natural water has revealed the fact that the germ of Asiatic cholera survived as long as ten days in unsterilized water?

A. I do not recollect at this moment; I know that there have been experiments made upon that subject, but I do not remember just how long they did survive.

Q. You cannot point then to any instance recorded in authentic works, upon this subject, in which bacterial examinations have shown a longevity of Asiatic cholera germs equal to ten days?

A. I don't think of any special experiments at this time, that shows that, no sir.

Q. Doesn't the effect of sunlight upon these Asiatic cholera germs tend to reduce their virulence and longevity in a very marked manner?

3584 A. I should say, speaking in general, that sunlight would tend to reduce the longevity, but I cannot say quite as much as to the virulence, but it is possible that it might act in the same way with virulence. also as a rule. Speaking in general terms, sunlight is inimical to bacterial life.

Q. Does not the virulence of the germ of Asiatic cholera decrease very rapidly in un-sterilized water, and in sunshine?

A. I am inclined to think that the virulence would decrease, but how rapidly, I cannot say.

Q. Do you know of instances where peritoneal injections of the Asiatic cholera germs in lower animals would produce an injurious result?

A. I think so.

Q. After the length of three or four days from the time of culture?

A. I don't recollect any special experiments, where the time interval was taken into consideration. I have read more or less on the subject, but I do not recall at this moment, just the point that you speak of.

Q. If it should appear from investigations that have already been had or those which you should make hereafter, that the germs of Asiatic cholera do not survive in unsterilized water for a greater period than five days or ten days, you may put the limit if you please, then your answer this morn-
3585 ing that they might get here would be a mistake, would
it not?

A. If it could be proven to me that such germs would not live in natural waters under conditions existing, my conclusion might be changed, but just as in the case of typhoid fever, I am not sure at all that the conditions existing in a laboratory experiment would be comparable to those which would exist in running streams.

Q. And if the conditions in a laboratory experiment were kept as nearly equal as possible to those which would prevail in the running water, and if under those conditions the examination should show a vitality of less than ten days and a constantly decreasing virulence during those days, what would you say then as to the probability of the germs of Asiatic cholera coming from Chicago into the St. Louis intake, and if they should come, as to the probable virulence they would have?

A. In so far as the results of certain experiments were conclusive in showing that the cholera germ could not live in natural waters, I should lessen my opinion as to the probability of their surviving from Chicago to St. Louis, but I question whether or not it would be possible. I question whether or not it would be possible in a laboratory, to duplicate the conditions.

Q. Is that your answer?

A. I think I have answered the question.

3586 Q. Isn't it the object of all these examinations in a laboratory to duplicate the conditions which exist naturally, as nearly as possible in order to reach a result that is of some value?

A. I think it is. In the absence of our ability to exactly duplicate the conditions, we do the best thing we can to duplicate them; in so far as we are successful, these results may be considered as having value.

Q. In so far then as you can duplicate any one of these in a laboratory experiment, duplicate the conditions which exist in the natural water, in so far are your conclusions of value?

A. Yes sir, and of course we must also duplicate the conditions in regard to the organisms themselves used in experiments and those which were introduced in the water.

Q. And that therefore, the further you depart in your laboratory experiment from the conditions which prevail in the natural water, the further removed are your experiments from any practical utility?

A. Yes sir.

G. C. WHIPPLE.

Adjourned until 10 A. M. Tuesday, May 19, 1903.

Southern Hotel, St. Louis, Missouri.
3587 10:00 A. M., Tuesday, May 19, 1903.
Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

WILLIAM THOMPSON SEDGWICK,

called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Attorney General Crow, and testified as follows:

Q. Please give the stenographers your name, address and occupation.

A. William Thompson Sedgwick; residence, Boston Massachusetts.

Q. Professor, where were you educated?

A. I was graduated at Sheffield Scientific School at Yale in 1877; studied for the greater part of two years in the Yale Medical School; taught physiological chemistry at Yale for one year; became fellow, assistant, and associate of Johns Hopkins University, Baltimore; proceeded to Boston in 1883, and have since that time been assistant professor, associate professor, and professor in the Massachusetts Institute of Technology,
3588 In Boston. I received the degree of Doctor of Philosophy
at Johns Hopkins in 1881. I am not a physician. I have studied in a medical school but I have no medical degree. Shall I give some of my positions?

Q. Yes sir.

A. I served as biologist to the State Board of Health of Massachusetts from 1888 to 1896; I am a member of the American Academy of Arts and Sciences; Massachusetts Association Boards of Health; New England Waterworks Association; Society of American Bacteriologists; American Society of Naturalists; American Public Health Association; Member of the Advisory Board of the Hygienic Laboratory of the United States Public Health and Marine Hospital Service; Past President of the American Society of Naturalists; and of the Society of American Bacteriologists. I may say that I have been employed by various cities and towns as an expert in water supply or

sewage disposal, especially by Burlington, Vermont, Pittsburg, Pennsylvania, and possibly one or two more that I do not now remember. Yes, Lowell, Massachusetts. I am the author of a text book on General Biology, and of a treatise on the Principles of Sanitary Science and the Public Health published last year. I have made numerous reports and investigations of epidemics of typhoid fever for the State Board of Health of Massachusetts, a report on typhoid fever in Pittsburg in 1898, and have published numerous papers on water supply, water purification, sewage purification and so on besides a paper on typhoid
3589 fever in Chicago, published in 1892, with Mr. Allen Hazen, the well known engineer. I trust that that is sufficient.

Q. You are a biologist?

A. Yes sir.

Q. What does that term imply scientifically?

A. It implies work upon living things, which may be anything, from man to microbes. It is a very general term and of course I do not pretend to be an expert in all its departments.

Q. You are now Professor of Biology in the Boston Institute?

A. Yes sir.

Q. Massachusetts institute of technology?

A. Yes sir.

Q. You are an epidemiologist?

A. Yes sir.

Q. What does that term imply?

A. That implies a study of—or ought to imply and does imply I hope, an expert knowledge of epidemics, their origin, their characteristics, their scope, and everything else relating to them.

Q. Well have you made that branch of sanitary science, as related to the American cities and towns, and the American public, a study?

A. I have sir. It so happened that in my work for the State Board of Health of Massachusetts, I was confronted in
3590 1890 with one of the most serious epidemics of typhoid fever that we have ever had in this country, at Lowell, Massachusetts, and acting partly for the Water Board of Lowell, and partly for the State Board of Health of Massachusetts, or

jointly I should rather say for the two, I made a very careful study of that epidemic that gave me a certain reputation; which led me to be called in for the purpose of investigation of other epidemics, and as just at that time my attention was drawn to the great epidemic of typhoid fever in Chicago which threatened the welfare of the people who should visit the World's Fair, I made an investigation of the facts in that case, and together with Mr. Hazen, published the paper that I have already referred to.

Q. You are also a bacteriologist, are you?

A. Yes sir.

Q. You have had practical experience in that?

A. I have taught bacteriology and have had practical experience in that line.

Q. Did you ever analyze any of the waters of Lake Michigan?

A. No sir,—or, I think I did once or twice, but not to any great extent.

Q. Bacteriologically you have analyzed the waters of other towns and cities?

A. Of some other towns and cities.

3591 Q. Mention some of them?

A. Especially of Lowell and—

Q. Duluth?

A. Duluth, Pittsburg—no, not Pittsburg, Duluth; Newburyport, Massachusetts; Holyoke, Massachusetts, and Burlington, Vermont. Possibly some others, but mainly Massachusetts cities and towns.

Q. In the preparation of the paper you mentioned, on typhoid fever in Chicago, in 1892, did you have occasion to investigate the physical conditions and sanitary conditions of the City of Chicago with reference to water supply, sewerage and sewer out-falls at that time?

A. In a general way I did. I was visiting the World's Fair—I was visiting the Exposition when it was being got ready for the next year, having charge of the installation of certain exhibits there, and I spent quite a little time in going about the city and familiarizing myself with the local conditions.

Q. Well state generally what you found with reference to the sanitary condition of that city, as to the water supply and as to the sewage and its relation to the water supply and the effect thereof on the health from the standpoint of typhoid fever.

A. I came to the conclusion, mainly from a study of the
3592 typhoid fever statistics and the general arrangements of
sewerage and water supply, that the water supply of the City of Chicago at that time was seriously polluted with sewage,—so seriously that the city was then suffering from one of the worst epidemics that ever afflicted any American city and that this pollution was derived from typhoid cases in the city of Chicago which contributed their sewage to the sewers of the city, and that those emptied their sewage either into the Chicago river or into the lake, and in that way gave occasion for the germs of the disease to get into the "cribs," or the intakes of the water supply.

Q. Did you or did you not have occasion at that time to investigate the physical condition and the sanitary condition of the Chicago River and its branches?

A. I made no very thorough investigation; I simply walked along the river at various points and noticed its condition, which was obvious to the eyes and nose.

Q. And was that condition polluted or un-polluted at that time?

A. It was grossly polluted.

Q. Now what is the source and character of the Chicago city water supply?

A. The public water supply of the City of Chicago is and
for many years has been derived from Lake Michigan
3593 through a series of intakes called "cribs," which lie at
different distances from the shore.

Q. In front of the city?

A. Along the lake front; and which were supposed originally to obtain pure water from the lake, but which as the population has increased, have naturally received more and more contamination from the sewage of the city itself.

Q. What becomes of that portion of the Chicago city water supply which is used for domestic purposes?

A. That is of course passed through the houses of the people and through the bodies of some of them, and poured into the sewers, more or less polluted.

MR. TODD: Read that question.

(Question read).

MR. TODD: Is that now, or in previous times?

GENERAL CROW: You can consider it in either way; as it is meant to cover both periods of time, both in the past and now I suppose that it results the same.

Q. Did you finish answering the question?

A. Possibly not, as it has been interrupted.

GENERAL CROW: Read the answer.

(Answer read).

Q. Now are the Chicago sewers built on the separate or
3594 combined plan; that is, do street washings, rain-falls and
surface water enter the sewers?

A. They are built, I believe upon the combined plan.

Q. Now what is the effect of that on the flow and speed of flow in the sewers themselves?

A. It means of course that street washings and storm water find their way into the sewers, and greatly accelerate the flow in the sewers, at the same time diluting the sewage somewhat.

Q. And what is the effect of that as to the time-factor of removing the sewage as it comes from the house connections into the place where the out-falls of the sewers empty?

A. Well, of course the effect during the year, or broadly speaking, is that it very much accelerates the flow and shortens the time spent in the sewers.

Q. Then in a city where the sewers are built on a separate plan, and storm waters and the street washings and surface waters are cared for otherwise than directly through the sewers, would the sewage matter pass from the house connections as rapidly to the sewer out-falls as in a city where the sewers are used on the combined plan?

A. No sir, not on the average. Of course during storms—

Q. Other conditions being equal?

A. Yes, other conditions being equal.

Q. What else besides domestic waste, including urine and
3595 fecal matter, enters the Chicago sewers?

A. As I have just said, of course street washings would find their way in, and any material that human beings are likely to add to sewers might find their way thither; the washings of stables, the discharge of waste of breweries, of manufacturing industries, of bake-shops, butcher-shops; the material from hospitals;—any or all of the filthy material of a population which seeks to get rid of it, and which material is not carried off in any other way, as garbage or any other material.

Q. How much sewage matter do you estimate is discharged daily into the Chicago sewers?

A. I have not made any careful estimate of that, but I should say several hundred tons.

Q. Into what are the contents of the Chicago sewers discharged?

A. Into what?

Q. Yes sir?

A. They are discharged partly into the Chicago river and partly into the Lake itself.

Q. Do you know what proportion of the population of Chicago and the Sanitary District discharges sewage into Lake Michigan roughly estimated?

A. I think it is something over a quarter of a million of inhabitants.

3596 Q. Into Lake Michigan?

A. Into Lake Michigan.

Q. Now where does the remainder of the sewage of that population discharge?

A. That is discharged into the Chicago River, and from that into the drainage canal.

Q. What is the effect in general terms, of the discharge of sewage of the population sewering into Lake Michigan, upon the character of Lake Michigan water both in the vicinity of the mouth of the Chicago River and the intake cribs of the municipal water system?

JUDGE SPRINGER: Is that question relating to the present time or to the time when Professor Hazen made his investigation?

GENERAL CROW: It relates to the present time; what is the effect; not what was the effect, is the terms of the question.

A. It tends to pollute those waters.

Q. Are you acquainted, generally speaking, with the conditions prevailing in the Chicago River, Chicago Drainage Canal, and the water courses through which the Chicago sewage flows, from Lockport to the Mississippi river, and also those general features on the upper Mississippi and Missouri rivers which affect the sanitary quality of the St. Louis water supply, and the waters of the Mississippi River below the mouth of the Illinois, that are or may be used by the inhabitants of the State of Missouri for drinking purposes?

3597 A. Yes sir.

Q. Now Mr. Sedgwick, speaking as an expert of water supplies, do you recognize any difference between the pollution of water and infection of water? If so, state what it is?

A. I do recognize a difference between mere pollution and infection,—or what I might call infectious pollution,—somewhat as follows: I understand by pollution alone, a condition in which a water contains organic matters, or even filth, free from the germs of specific diseases; and I understand by infected water or an infectious pollution of water, or an infectious contamination of water, a condition in which, either with the same or more, or less pollution the germs of specific diseases are present; so that a water may be polluted, from my point of view, but not infected, or it may be infected and yet to the ordinary eye not polluted.

Q. Then do you recognize the difference between the effect of pollution in water that will produce an obnoxious condition of the same and the effect of pollution of water that will produce danger to health?

A. I do, decidedly. And the water may be so polluted as to be unattractive or objectionable otherwise than from the disease-producing standpoint.

Q. Well, is water that is polluted by infectious pollution a dangerous water?

3598 A. I don't think I got the question?

Q. Is water contaminated by infectious pollution a dangerous water?

A. Yes sir.

Q. Professor, I will ask you to state whether or not dilution will destroy or eliminate infectious pollution or matter in waters?

A. No sir. Mere dilution, I understand?

Q. Yes.

A. Mere dilution.

Q. Now Professor, on the basis of dilution alone, do you consider that the sewage from the Chicago Sanitary District as it reaches the Illinois river above Peoria, is at all times rendered pure and safe for domestic use?

A. No sir.

Q. Will running water absolutely purify itself so as to be free from pathogenic bacteria that may have been placed therein?

A. That is a large question, sir. I shall have to answer that in a somewhat lengthy way, I am afraid.

In this whole matter of self-purification of streams we have today very different ideas from what we had twenty or thirty years ago. In trying to answer the question specifically and closely—if I tried to answer it specifically and closely,
3599 I should have to say that running water under some conditions might conceivably, very largely, and possibly even altogether, purify itself from infectious germs, but those conditions would have to be very unusual and so unusual as to be practically theoretical, or virtually theoretical. It was formerly believed by experts that running water readily purifies itself. That belief has been altogether abandoned. Acting upon that belief, which was the best state of our knowledge twenty or thirty years ago, numerous cities and towns of the United States put in waterworks which should derive water from streams into which sewage had been poured at points above. That was the best art of the time, and engineers, chemists and sanitarians agreed about it. In the city of Pittsburgh, for example, which I have especially studied,—into the city of Pitssburgh, the water supply was introduced from the Allegheny river, with the confident belief that such sewage as might find its way into that river at points above would be effectually removed before the citizens had ac-

cess—before the water came to the citizens. That belief has been found to be erroneous. Pittsburgh suffers today with typhoid fever perhaps more than any other city of the United States,—certainly excessively. The cities on the lakes,—Niagara Falls, Buffalo, Cleveland, Detroit, Chicago, Milwaukee,
3600 Duluth, take water supplies subject, or exposed to contamination by sewage, and are today, one after another, considering at any rate the possibility of abandoning such supplies, because of the failure of the self-purification of sewage. Nevertheless, there is a large measure of self-purification of streams. There is at times, in certain streams, especially, a large measure of self purification. The subject is a complex and difficult one, and the tendency of opinion, the growth of opinion, has been to increase our distrust in the efficiency,—the efficacy of self-purification of water or sewage.

I don't know that I need to add very much to that.

Q. Well, you have written on that question in your book—

JUDGE JOHNS: I move to exclude so much of the foregoing answer as relates to the inferences and conditions named in the answer commencing with Pittsburgh and ending with Duluth, as not material to this inquiry.

Q. GENERAL CROW: You have written something on that question in your book?

A. Yes sir. Three or four years ago in studying this subject carefully, I arrived at a conclusion which I stated in a book published a year ago, before I had any expectation of any connection with this case, which gives substantially the same point of view that I have stated, but which I should be glad to read if it is proper.

3601 Q. If it is your own statement, you can read it of course, the same as you would state it.

JUDGE JOHNS: I move to exclude the answer as not responsive to the question and at any rate immaterial to any issue in this case.

Q. (Question read).

MR. TODD: I object to the question in so far as it requests the witness to read from a book published by him, on the ground that the subject about which it is supposed he is about to read is immaterial to this inquiry, and amounts only to a matter of opinion.

GENERAL CROW: Go ahead, Professor.

A. "Today we realize that this theory of purification is only half true, and that such self-purification is only partial and absolutely unreliable." (Witness reads further from book): (Principles of Sanitary Science and Public Health, Macmillian.)

"By a curious reversal of scientific opinion, we now hold that it is precisely running water which is least likely to purify itself, while stagnant or standing water, formerly looked upon with dread and suspcion, is now in much favor. The old theory was in vogue long enough to enable us to make a wonderful series of experiments, and on a stupendous scale; experiments in which whole cities confidingly used for years, sewage polluted waters, often with sad results, but results of lasting instruction to mankind. Never again so long as civilization
3602 endures, will intelligent communities acting under expert advice, repeat these sad experiments."

JUDGE JOHNS: I move to exclude the reading as immaterial and as not competent evidence.

MR. TODD: I move to exclude the answer on the ground that the facts from which this opinion is expressed in the book, have not been set forth by any statement made by the witness.

Q. GENERAL CROW: State whether or not sewage flowing directly from the out-falls of the city sewer, will effect the value for drinking purposes of a running stream of water?

A. That is flowing into the stream, of course?

Q. Yes sir.

A. Certainly; it lowers that value of course.

Q. State whether or not the sewage from a district as large as the Sanitary District of Chicago would affect the value for drinking purposes of a stream as large as the Drainage Canal and as large as the drainage canal and the Desplaines River and Illinois Rivers combined, and if so, in what manner?

A. Yes sir, the mere introduction of sewage into a stream at once creates suspicion as to the—at once throws suspicion upon the character of that stream, and unless it can be shown that that sewage has been effectually removed by purification, the value of that stream is distinctly lowered.

Q. Please state your opinion as an expert on water sup-
3603 plies for cities and towns as to whether or not the waters of the Mississippi River west of the center of the main channel of said river below the mouth of the Illnois River and down to the intake tower of the St. Louis Waterworks at the chain of rocks, is less valuable for drinking purposes and more liable to carry water-borne diseases such as typhoid fever and cholera, now than it was before the sewage from the Sanitary District of Chicago was run into the Drainage Canal and through it into the Illinois river?

JUDGE SPRINGER: I object to the question for the reason that it does not indicate whether the time fixed was the time at which the present drainage canal was opened, or whether it relates to the time previous to that when a certain amount of sewage of Chicago was dumped into the Drainage Canal.

GENERAL CROW: I refer to the drainage canal as distinguished from the Illinois and Michigan Canal.

JUDGE SPRINGER: I simply want to know what the dividing line is.

GENERAL CROW: I want to know whether or not you are going to require that all the way through this case we put the name of the drainage canal technically, into the record?

JUDGE SPRINGER: I want the witness to understand as to the time at which this line is drawn.

THE WITNESS: I understand it to refer to today, sir.

3604 JUDGE SPRINGER: I mean the time fixed by the question was since the opening of the drainage canal.

THE WITNESS: The time fixed by the question was since the opening of the drainage canal.

GENERAL CROW: It covers the period from the 17th of January 1900, to the present time.

JUDGE SPRINGER: That is all right; I simply want to know whether—

GENERAL CROW: Do you enter an objection here because I do not put in the technical name of the drainage canal?

JUDGE SPRINGER: No, I withdraw my objection now that you have stated what you mean—that you mean the drainage canal.

GENERAL CROW: I mean the Chicago Drainage Canal. If I had meant the Illinois and Michigan Canal I would have said so.

A. I consider it decidely less valuable.

Q. State whether or not the increase of the volume of water in a stream will increase the speed of the current?

A. Ordinarily it will.

Q. State if you know what is the increase in the volume of water in the Ilinois river by reason of the flowing of the waters of the drainage canal into said river,—in a general way?

A. About 5,000 cubic feet per second.

Q. Well, relative to the quantity of water in the Illinois river, do you know what proportion the added volume
3605 from the drainage canal would bear to the waters of the Illinois?

A. At the period of lowest flow it might perhaps, be as high as five-sixths; with the ordinary flow it would of course be less than that. I have only general knowledge of the hydraulics of the river.

Q. State whether or not an increase in the speed of the current of the Illinois river by reason of the added volume of the water of the drainage canal would effect the amount of sedimentation that might otherwise occur in the Illinois river, and if it does affect it, how and in what manner?

A. The addition of such a volume of liquid as passes through the drainage canal must materially,—must often materially, quicken the flow of the Illinois river; it must therefore hinder effective sedimentation, and thus by shortening the time required for infectious germs to pass through the river, and by interfering with their detention, aggravate the danger of their arrival at the mouth of the river. I should like to say right here, that the time allowed in all these matters is very important, so that any quickening of the flow is a grave consideration. It is not so much distance as time which is the basis of self-purification of streams.

Q. What effect, if any, Professor, would the increase in the speed of the current of the Illinois river have upon the

3606 time within which sewage from Joliet, Peoria and other towns on the Illinois river might be removed into the waters of the Mississipi, as compared with the conditions that existed and the time it might have taken before the added volume of water from the drainage canal was poured into the waters of the Illinois?

A. I will ask you to read that.

Q. (Question read).

A. It would shorten the time.

Q. For what reason?

A. Because by increasing the flow, by quickening the flow, sewage or infectious pollution from Peoria and the lower points might arrive more quickly at the mouth of the Illinois, and mingle with the waters of the Mississippi.

Q. Professor, if water is made more clear and less turbid than it was before by an added volume of water being placed therein will such bacteria as typhoid have more or less of a tendency to go down to the bottom of the stream than they had prior to the water being rendered less turbid?

A. The clearer the water, the other things being equal, the clearer the water, the slower the rate of sedimentation. The more turbid the water, the more rapid and the more effective the sedimentation, so that the addition of clear water to turbid water, as a rule, tends to postpone and delay sedimentation.

3607 Q. Professor, if an increase be made in the speed of the current of the Ilinois river by the addition of the water of the Drainage Canal, would that increase in said current, have any effect in increasing or diminishing the typhoid and liability to typhoid and other water-borne diseases on the part of the inhabitants of the State of Missouri using the waters of the Mississippi river for drinking purposes, below the mouth of the Illinois river?

A. I believe that it would have an effect, and that it would increase the typhoid.

Q. Professor, does the sewage from the cities and towns, speaking from the standpoint of an expert on water supply, pollute and render unfit for drinking purposes the waters of a running stream, for the purposes of domestic use?

A. Speaking generally it does.

Q. Professor, are settling basins recognized at the present time and have they been recognized at any time as an efficient and adequate means for the purification of sewage to be discharged in a drinking water stream?

A. Do you mean settling basins alone?

Q. Yes, considering nothing else?

A. No sir.

Q. What, Professor, in your judgment, becomes of the deposited matters in the bed of a running stream?

3608 A. The deposited matters or the matters deposited in the bed of a running stream may lie there for some time, or they may be swept out by an increase in the rate of flow of the stream. If they lie there for some time, they may be more or less modified by chemical and bacterial action. If they are returned to the stream by an increase in its velocity they may be re-deposited at lower points or borne on into some other body of water.

Q. Professor, what do you say as to the longevity of the germs of typhoid fever, as a general proposition in connection with sewage polluted water?

A. Here also, our ideas have undergone some change of late years. My ideas have undergone some change. Broadly speaking, the tendency has been to come to the belief, or has been to show or to indicate, a greater and greater longevity. Laboratory experiments have sometimes indicated a short and sometimes a longer longevity. Practical experience has tended to make us believe in a greater longevity than that formerly entertained, and having reference to the conditions in the stream, the various conditions in streams, my belief is that in a sewage polluted stream the typhoid germs might live in gradually diminishing numbers for weeks or months, or even years.

3609 Q. Professor, assuming that the numbers of bacilli coli communis in the waters of the Illinois river at Grafton are at intervals no greater than the numbers contained in it before the opening of the drainage canal, do you consider for that reason that the water is at all times no more dangerous for drinking purposes than formerly?

A. I do not. I consider that even if the number of colon bacilli as shown by occasional tests, is no higher today or were no higher today than before the opening of the drainage canal, the mere fact of the addition of a vast population contributing sewage to the Illinois river, constitutes and must always constitute, an added menace to the health of persons using the water of the Illinois river at its mouth or below. And I may add that I have this opinion or I will say, for the reason, that bacteriological examinations obviously can not be made at every moment, or I will say at all times or at all seasons or hours of the day; and are at best not absolute guides as to the sanitary condition of the water. There might be times and seasons when materials would flow by, escaping analysis, and pass on to do harm to the people below.

Q. Professor, assuming that the germs of typhoid fever coming from the sewers of Chicago and passing by way of the drainage canal to Lake Peoria, might be in large numbers deposited in the bed of Lake Peoria for the period of a
3610 month, say; do you consider that typhoid germs would be entirely destroyed at the end of that time?

A. In that deposit?

Q. Yes?

A. No sir.

Q. Professor, assuming that typhoid fever germs coming from Chicago sewage are deposited in large numbers in the lakes and slack water portions of the Illinois river above Peoria, do you or do you not consider that flood conditions such as would scour the deposits from the bed of the stream, would cause the water leaving Lake Peoria, to contain at times more infectious and dangerous pollution than are at present in the diluted sewage entering the Des Plaines River at the Bear Trap Dam at the foot of the drainage canal?

A. I think at times it might.

Q. Why?

A. Because, if accumulations of typhoid germs were formed in the lakes or slack water basins of the river, these might, especially in the case of a large amount of typhoid fever in Chicago, result in the storage there of a vast number of germs, and the sudden flood, might sweep out these accumulations and actually bring it about that sometimes more typhoid fever germs should be flowing in that stream than in the drainage canal itself.

3611 Q. Has the removal of deposits of sewage matter from the bed of streams resulted in causing typhoid epidemics?

A. I know of one excellent instance in a stream, and I think there have been some in lakes; some cases of that sort in lakes, or sluggish bodies of water. The best example, undoubtedly, that we have of such an effect in a stream, and it happens to be one that was combined with the slack water lake, so that we have the double demonstration in one case, is the well known instance of typhoid fever in Detroit, resulting from the dredging of the Black River at Port Huron, which caused the carriage of detached sediment down St. Clair river, through the St. Clair Lake and into the intake of the Detroit waterworks. I think that was in 1892 if I remember right. That is probably the most striking case we have on record. It was very thoroughly investigated, and I am familiar with the data upon which the conclusions were based, and in my opinion it is a well established case, and it is the best that I know.

Q. In which a typhoid epidemic resulted from the removal of sewage deposits from the bed of a stream?

A. Yes sir.

Q. Professor, do you consider that the water of the Illinois River since the opening of the drainage canal and now, as it enters the Mississippi river, is one which may be used with safety for drinking purposes?

3612 A. No sir, I do not.

Q. Now, Professor, assuming that the only pollution of the Illinois river was that contributed to it by the Chicago Sanitary District, and having in mind the large amount of typhoid fever in said district, do you or do you not consider the effects of the time interval, dilution and sedimentation occurring between Chicago and Grafton, would be such as to render the water as it enters the Mississippi at all times free from liability of producing water-borne diseases in those who drink it?

A. Emphatically not.

Q. Why?

A. For the reason that such processes of self-purification, including sedimentation and dilution, as would take place in the Illinois river and above, to Chicago, would be, in my judgment, inadequate to insure at all times and seasons a complete removal of infectious material.

Q. Have you had any personal experience which would lead you to believe that infected water coming from the Illinois river and entering the Mississippi might become mixed with the latter in such a way as to menace the health of the inhabitants of the Missouri shore of the Mississippi river, using the Mississippi river waters for drinking purposes, at points below on the Missouri shore?

A. I think that I have had a very instructive piece of per-
3613 sonal experience bearing upon that question. In the
autumn of 1890, I was called in, as I have already stated, to investigate an epidemic of typhoid fever in the City of Lowell, Massachusetts, and after preliminary studies I was led to the conclusion that the epidemic in question was caused or had been caused, by typhoid fever infection of a small and sluggish stream,—or I might say a small and often sluggish stream,—entering the Merrimac river, a larger and much swifter stream, almost at right angles; and that such infection and water of the smaller stream had mingled with the water of the larger stream, so that at a point about three miles below the entrance of the smaller into the larger, and on the opposite side of the river, where the city of Lowell had the intake pipe of its waterworks, the infectious material arrived, and from that point was borne into the water supply, producing an epidemic of upwards of 1,000 cases of typhoid fever.

Q. Compared with the volume of water or size of the stream of the Ilinois to that of the Mississippi, what was the relative proportion to that of the Stony Brook Stream and the Merrimac River?

A. The Stony Brook Stream was much smaller in proportion to the Merrimac river than the Illinois river is to the Mississippi River. And I may add to my previous statement, that

it was possible in this case, owing to the waste of a wool
3614 scouring mill, which was upon the smaller stream, to detect for some distance below the water of the smaller stream running parallel with the larger one, but after the distance of, say a half a mile, it was no longer possible to detect the parallelism, or rather, it was no longer possible to detect the water of the smaller stream by the eye, and the two waters seemed to have become remarkably well mingled. I may further add that there was a bend below the point of exit of the small stream, so that the water of the larger stream went, so to speak, against the water of the smaller stream as it turned.

Q. From what distance up Stony Brook did this infection in the water come?

A. A very short distance.

Q. What distance down the Merrimac river did it flow in the water?

A. As I have said, as nearly as could be determined, it entered the Lowell waterworks, and produced an epidemic, three miles and a half below, but there was also reason to believe that it reached Lawrence, nine miles farther on, and began an epidemic there, which afterwards rose to extraordinary proportions, owing as I believe, partly to this infection, and partly to the very much larger infection from the city of Lowell which, I have said, is 9 miles above the intake of the Lawrence
3615 water works.

Q. You made a personal investigation and examination of the water supply and the surroundings at the time, did you?

A. I made a very thorough personal investigation of the whole subject at that time?

Q. Now, Professor, assuming such mixture as was referred to in the question asking whether or not you had any personal experience which would lead you to believe that infected water coming from the Illinois river and entering the Mississippi would become mixed with the latter so as to menace the health, of the inhabitants of the Missouri shore, using the Mississippi river water; do you or do you not consider it probable that infectious pollution would at times enter the intake of the St. Louis Waterworks at Chain of Rocks?

A. I do.

Q. Professor, have you made any study of the typhoid fever statistics of the City of St. Louis, and if so, during what period and with what result?

A. Yes. I have made a rather careful study of the typhoid fever statistics of the City of St. Louis, and with this general result: During a period of fifteen years prior to January 1st, 1900, the typhoid fever death rate in St. Louis has not in general been above that of some cities provided with water supplies considered pure, and of good repute. During the period following the removal of the intake from the lower point
3616 to the chain of rocks, the typhoid fever death rate of St.
Louis was rather remarkably good, by which I mean that it was lower than it had been, and lower for example than the death rate of the city of Boston for that same period. Beginning with the first of January, 1900, there has been a marked annual increase in the typhoid fever death rate of the City of St. Louis, so that it has during that period not only been higher than during the previous period of five years, but also higher than at any time in its own history since 1885, and very much higher than the death rate in the city of Boston, with which previously it compared very favorably. If I may give figures, I may say that the increase in typhoid fever deaths in the city of St. Louis since January 1st, 1900 as compared with the preceding fifteen years, and excluding one year,—1892,—when there was a great epidemic in St. Louis, an epidemic which was thoroughly investigated by Dr. Ravold,—has been about 26 per cent; while the increase since January 1st, 1900 in the annual mortality from typhoid fever as compared with the preceding five years, I think it was, at any rate as compared with the period between the removal of the intake to the chain of rocks, has been 73 per cent.

Q. Are you familiar with the water supply of the City of Boston, and the death rate there?

3617 A. Fairly so, yes sir.

Q. In your opinion as an expert on water supplies for cities is the water supply of Boston and the death rate there reasonably normal?

A. I consider the water supply of Boston a fair supply, I should even say a good supply. It is undergoing a period of transformation, but it ranks among the water supplies of the country as a good water supply. The typhoid fever rate of Boston is, however, higher than that of New York or London, which are about the best that we know; so that previous to January 1st, 1900, we shall say, fairly, I think, that the typhoid death rate of St. Louis, like that of Boston, was below that of most cities, possibly of all cities, certainly most cities having polluted water supplies.

Q. Of similar size?

A. And of similar size. I may add that among the biggest cities of the United States, New York has the lowest death rate from typhoid fever. Boston and St. Louis, as I have said, ran very close together until January 1st, 1900, since which time Boston has gone lower and St. Louis has increased. Philadelphia shows a much higher death rate than Boston and St. Louis if you cover a period of years, while Chicago has the worst record of all in respect to typhoid fever, and has long had. I am speaking now of long periods, not for any one year in particular,
3618 but taking long periods.

Q. Do you know the cause of the high typhoid rate in the city of Philadelphia?

JUDGE JOHNS: I object to the question as immaterial.

A. I don't know of my own knowledge, but as an expert familiar with statistics and sanitary conditions in Philadelphia, I have no doubt that the prevailing opinion among sanitarians is correct, and that it is mainly the pollution of the public water supply.

Q. Now Professor, assuming that the only pollution upon the water-shed of the Mississippi and its tributaries, above the intake of the St. Louis waterworks, was that derived from the sanitary district of Chicago, and having in mind the large amount of typhoid fever in Chicago, do you or do you not believe that infection and dangerous pollution might find its way into the water supply of the city of St. Louis?

A. May I ask you if you mean may or might, under existing conditions?

Q. Yes might under existing conditions?

A. Yes sir, I believe that it might.

Q. Now, Professor, assuming that there was no typhoid fever pollution of the waters upon the water-shed of the Mississippi river or its tributaries above the intake of the St. Louis waterworks, other than that derived from the sanitary
3619 district of Chicago, do you or do you not believe that typhoid fever germs from said district are liable to find their way into the water supply of the city of St. Louis through the intake at the chain of rocks?

A. I believe that they are liable to find their way into the intake.

Q. Why?

A. For the reason that typhoid fever having been frequently very abundant in the city of Chicago, I must start with the assumption that a very large number of typhoid germs find their way into the sewage of the city, pass through the sewers and on into the drainage canal, and subject to local conditions may, in diminished numbers, pass out of the Illinois river, mingle with the waters of the Mississippi, pass over to the other side and find their way to the intake at the chain of rocks.

Q. Now Professor, assuming that 108 barrels containing 40 gallons each of culture of the bacillus prodigiosus each cubic centimeter of the culture solution containing 1,000 million prodigiosus germs, were emptied into the Chicago drainage canal at Lemont, and further assuming that at the time of this experiment this culture was absent in Lake Michigan water and in the Illinois river and its tributaries, in the Mississippi river above Grafton, and in the Missouri river water, and further as-
3620 suming that one or more colonies of bacillus prodigiosus on several occasions were found in samples of water taken from the intake tower at the chain of rocks, what in your opinion does this show?

A. This interesting and valuable experiment, as I regard it, seems to me to show that typhoid fever germs might pass from the drainage canal, through the Illinois river and the Desplaines river, and be carried alive to the intake of the waterworks at the chain of rocks, and there enter the water supply of the city, very likely producing typhoid fever at St. Louis.

Q. Assuming that an epidemic of Asiatic cholera should occur in the city of Chicago, is it possible that the germs of that disease might find their way into the intake tower of the St. Louis waterworks at the chain of rocks, from the city of Chicago?

A. I consider it possible that they might.

ADJOURNED until 2:00 P. M., same day, Tuesday, May 19th, 1903.

Southern Hotel, St. Louis, Missouri.
3621 2:00 P. M., Tuesday, May 19, 1903.
Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

WILLIAM THOMPSON SEDGWICK,

Resumed the stand for further direct-examination by Attorney General Crow, and testified as follows:

Q. Professor, what knowledge have you of typhoid fever epidemics having been conveyed by water through the water supplies of cities and towns?

A. I have a rather extensive knowledge on that subject, General.

Q. Well, just state generally?

A. Setting aside epidemics derived from wells, which I presume you don't care to go into.

Q. No sir.

A. The most celebrated and important epidemic in this country was certainly,—up to a very recent time,—one which happened at the little mining town of Plymouth, Pennsylvania, in 1885. On the watershed of that town they had built four storage reservoirs and on the bank of the stream which supplied the uppermost of those reservoirs, a case of typhoid fever appeared in the early spring of 1885. The reservoirs had all 3622 been drawn very low owing to a cold spell which they had had, and on the arrival of the spring thaw, 1200 cases of typhoid fever broke out in this little town of 8,000 inhabitants. These were traced,—and it is believed by sanitarians, were correctly traced,—to the occurrence of one case of typhoid fever on the bank of the uppermost reservoir, followed by the washing during the thaw, of the dejecta of that patient, and in the lo state of the reservoirs, its rapid transmission to the people of th town. It was a dramatic and terrible event. I will make th just as short as I can because if I did not, I should take all th afternoon. That was in 1885. In 1890, came the Lowell epidemi of which I have spoken, investigated by myself. That was fo lowed close after—I will say instead, very soon after, by worse one in Lawrence, nine miles below. This was traced t the infection which I referred to, which began upon Stony Brook and of course the Lawrence case was caused largely by the typhoid fever germs in the sewage of Lowell, the larger city abo it,—nine miles distant—

Q. What was the extent of the epidemics in the two towns

A. In Lowell I investigated personally, or had investigated some 550 cases, but from the number of deaths and fro the cases we knew, and so on, we estimated there were a thousand of them.

3623 MR. TODD: That was in Lowell alone?

A. That was in Lowell alone. In Lawrence, just belo there were several hundred cases,—and a larger incidence in proportion to the population.

Two years after, in 1892, I investigated a very interestin epidemic on the same river, in the city of Newburyport, which i at the mouth of the Merrimac river. The Newburyport epidemi was a small one, for Newburyport was a small city. The Newburyport people supposed that they were drinking a spring water, but surreptitiously the superintendent of the waterworks ha connected the mains with the Merrimac, and the people wer really getting, as he himself admitted, for some two or thre months, Merrimac river water, and this was particularly instructive because for the first two months, we will say, of the tim that they got that Merrimac water, there was no typhoid in Newburyport. On going up the river I found that the reason for th was that they had been drinking simple filth,—good straigh sewage, uninfected apparently; but unluckily for them a littl epidemic broke out in Lowell after they had been drinking fro the river for a while there in Newburyport, and some sevent

cases appeared there (in Lowell),—a larger number than they had had since the big epidemic. We found that the result of those cases in Lowell was perfectly obvious in Lawrence, although the water had had to travel nine miles and pass
3624 through a storage reservoir where it had been detained for at least a week, and that it was proportionately almost as much marked, perhaps just as much, in the number of the details. Now in Newburyport, the distance from Newburyport being, as I remember it, about,—I think it is 25 miles; I have forgotten just how that is—

MR. FULLER: Newburyport to Lowell; I think it is more than that.

THE WITNESS: I have forgotten what the distance is.

GENERAL CROW: Approximately, anyway?

A. It is 20 or 30 miles; I have forgotten just how far. When they got this water which had been infected,—when they not only drank sewage but infected sewage—when they not only drank filth but drank the germs of disease, this epidemic occurred in Newburyport, and it was one of the saddest cases I ever investigated, because the people supposed that they were drinking spring water, and they were drinking this infected sewage. That was in 1892. But it was small. In Newburyport there were eight deaths; but it was a very instructive epidemic as showing how things may be carried in running water.

The Rivers Pollution Commissioners of Great Britain, in a report published by them in 1874, state that there is no river in the United Kingdom long enough to purify itself from any
3625 sewage admitted to it, even at its source. That stands as one of the axioms of sanitary science today; those Rivers Pollution Commissioners in 1874, I think it was, made that statement, that there is no river in the United Kingdom,—I think they said,—long enough to purify itself of any sewage introduced into it—introduced at its source, and of course some of the rivers of the United Kingdom are very long.

Now that (the Newburyport epidemic) was in 1892-3. About that same time I was sent by the State Board of Health of Massachusetts to watch the epidemic in Windsor, Vermont. Windsor, as you may know is a pretty summer resort to which William

M. Evarts and other lawyers,—have resorted for years. Their water supply was derived from a dammed up brook, but they had an epidemic of typhoid fever there which was attributed by the State Board of Vermont, to one case of typhoid fever on the watershed above—not very far above, a mile perhaps, and that case was a very severe and dramatic one; the town was in mourning, and the affair was a very sad one. I did not make a lengthy investigation of that, but it is one of the well known cases.

As I have already said; in 1898, I think it was, I made a special study of typhoid fever in Pittsburgh. Acting on advice of one of the most eminent engineers of the time, Pittsburgh intro-
duced a water supply a number of years ago,—twenty or
3626 thirty years ago, drawn from the Allegheny river, mainly,
and partly from the Monongahela. Now the Allegheny is a swift stream with only remote pollutions. There is no near pollution that amounts to much, if anything,—but the remote pollutions from Oil City, etc., and as a result of the careful study of that epidemic prolonged for some weeks—not of that epidemic but of the study of cases of typhoid fever in Pittsburgh, it resulted in the recommending of the filtration plant for the city of Pittsburgh, for the reason that in my judgment infectious materials might be brought to cities which had no filtration plant, from points as distant as Oil City, or even more remote,—113 miles or more. I reported that in 1898, and am on record as having said that in 1898.

Q. What was the character of that epidemic there at the time?

A. It was a serious one, something like the Chicago conditions, where they had a large amount all the time,—and an excessive amount frequently.

Q. Was it traced to the water supply?

A. It was by me, and by the citizens. It was generally attributed to the water supply. They got me out there to see if they were probably right about it; as far as I know they generally accepted my conclusions.

Another very serious epidemic due to pollution on the water-
shed, of the public water supply, was that at New Haven,
3627 Connecticut, about three years ago. The city of New
Haven, Connecticut, gets a part of its water supply from

a certain inhabited water-shed—not very thickly inhabited,—but under conditions similar to those in Pittsburgh, Pennsylvania. They had drawn their reservoirs down low owing to a freeze-up, and in the spring, in March, the thaw came and then followed a big rain—tremendous, with the result that, as it turned out afterwards, some feces were washed from a house on the watershed where there had been a very few cases of typhoid fever—if I remember right, there were two or three only,—washed down into one or the other large storage reservoir, which, however, as I have said was very low. The result, was that the water was shot through that pretty fast, and this stuff came quietly to the citizens, and they had 470 cases of typhoid fever in the spring—not in the fall, when typhoid fever cases in communities generally occur. Now I am familiar with the conditions there because as I said this morning, I am a Yale man, and it so happened that at this time there was a big rain. I was in Hartford, which is only thirty-six miles away, and found the water in the taps there muddy from the sudden washing that had come down the watershed. It was the same rain of course—

Q. Were those cases on the watershed traced as the origin of this epidemic?

A. Yes, these cases on the watershed were traced by Dr. 3628 Smith, dean of the Yale Medical School, who proved, as far as we can prove anything of this kind, that this was the probable cause of the epidemic, and it was generally received as such by the experts and by the public.

Then another epidemic that you have heard of—that everyone has heard of almost, is the recent epidemic in Ithaca, New York, where we have every reason to believe that the conditions were quite similar to those at Plymouth, Pennsylvania, and New Haven, Connecticut. I visited Ithaca a week ago. I was giving a lecture in Buffalo on the protection of municipal water supplies by filtration, and took pains to visit Ithaca and confer with Dr. Soper, the expert who is making the investigation there. I also talked with the Cornell professor of Engineering, and with Professor Williams who is expected to testify in this case, and I think, pretty thoroughly informed myself on that subject. I won't go into details, but it is a matter of feces on a water-shed, and a heavy rain and a slight freshet—slight or heavy, I don't remember which, and the quick carriage of pollution to the citizens below.

Q. How far up the watershed was it?

A. I am not sure about that.

Q. What was the extent of the epidemic?

A. It was a very serious epidemic. Ithaca had a thou-
3629 sand cases, as reported by my friend, Professor Jordan of
Chicago,—and with a considerable death rate.

Those are a few of the epidemics. I might speak of Hamburg, Germany, in 1892, when the water supply of Hamburg got polluted with the germ of Asiatic cholera, and of the fact that the citizens of London are only protected against pollution and infection on the watershed by their filters, as shown by the fact that when one of their filters droke down in 1866 they had a big epidemic of Asiatic cholera.

I might speak of the breaking down of the Berlin (Germany) filters which caused a small epidemic of typhoid fever; of the Altona filters which caused a small epidemic of cholera;—but it is a matter universally admitted among sanitarians that running water, uncared for and unprotected by special processes of filtration or prolonged and very thorough storage, is liable, if from an infected watershed, to convey the germs of disease.

I will spare you any further illustrations.

Q. I will ask you professor, what you know if anything, concerning water-borne epidemics of typhoid fever on the Great Lakes, and especially at Niagara Falls?

A. I have given some attention, as I said this morning, to typhoid fever in Chicago and I have also to the condition of af-
fairs at Detroit, Cleveland, Buffalo and Niagara Falls, and
3630 I found in Buffalo, rather to my surprise, a prevailing feel-
ing among medical men that the time was at hand when Buffalo had got to purify her water because of the pollutions put into the lake at Cleveland and higher points. I found that at Niagara Falls they were suffering severly from typhoid fever which the physicians there, who were present at my lecture, freely expressed themselves as believing to be derived from the sewage of Buffalo which had run down the Niagara river,—Buf-

falo and higher points. I think it is a great question whether the big lakes,—or rather the people who are using the big lakes have not got to give up the use of them after a while. A while ago Professor Jordan reported practically to that effect for Chicago, and Detroit certainly stands in great danger from pollutions at Port Huron and possibly other points, and Cleveland, I have been told—though I am not sure of this, is seriously thinking of giving up its tunnels and going into filtration, because the water that comes down from above is polluted, and the whole question of the extent of pollution of water supplies and the life of the typhoid germ—typhoid and other disease germs in water, is today a very seriously debated question; and as I said this morning the growth of opinion is more and more towards the idea that it won't do to trust to self-purification, provided you have got upon your watershed a heavy or extensive pollution.

3631 I may say right here, and in this connection we might as well be done with this once for all:—We used to think that running water, when it got thoroughly aerated purified itself, especially if it came from long distances. That was the theory on which Pittsburgh put in its water-works. That was the theory upon which Lowell took the obviously sewage polluted water of the Merrimac, and used it for water supply purposes. It was one of the commonest things that chemists and sanitarians believed, and they had reason to believe at that time, that running from—at even modern distances, water would so purify itself as to be safe; but Pittsburgh and Lowell and Lawrence, and so far as I know, nearly all—perhaps all—of the cities that have trusted to that, have been typhoid ridden, and today, as I reported at Pittsburgh, the distance of 100 miles or even more remote points, infection coming from Oil City, 113 miles or even more remote points may produce typhoid fever. It is not today so much of a question of distance; it is the question of giving time for the germs to settle out and to die out, and it is dilution and time of quiescence, particularly quiescence. It is simply a question of time. You have got to eliminate all idea of distance from these things and bring in the question of time largely, and that is what I have stated in my treatise on Sanitary Science and Public Health, written two or three years

ago. It is nothing that I have got up for this case or any-
3632 thing of that kind; it is a fact that is borne in upon me by long experience, and I believe that in that respect I stand entirely square with the sanitarians of the world. At any rate I hold that opinion myself.

Q. Professor, would the amount of infectious pollution affect the question of time needed, or the degree of danger?

A. It affects the degree of danger. It would not affect the time; that is the time for each individual microbe; of course that is its own individual problem. One microbe coming down from Chicago and resting quietly in the slack water of the Illinois, if it lay there long enough, would probably die out—I would say, must certainly die out if it lay there long enough. Of course, someone might not agree with me on that, but I think so; but of course if a million came down the chances that some might be carried on by a little freshet or something of that kind before they had died out,—for they don't all die at the same time—would be greatly enhanced, and other things being equal, the larger the infection the more serious the danger.

Q. Professor, do you know whether or not the flowing of the waters of the Niagara river over the falls tends to or does eliminate the disease bearing germs in that water?

A. I don't know how it is as a matter of fact, but the organic matter which was formerly supposed to be so oxidized by running in an open stream and which was the basis of
3633 self purification of streams, has been repeatedly analyzed by Professor Leeds and said to be exactly the same after it has gone down the falls, and been thoroughly aerated, as it was before; and I believe that allowing for the time, the germs would be just the same below as above. When I said Niagara Falls I mean the city of Niagara Falls, the town of Niagara Falls, where typhoid is rampant today, and it is rampant, as I believe because they are drinking the sewage of Buffalo, which has come bounding down that river and has been splendidly aerated and has had a chance to purify itself, but it has not purified itself because the time is short; and the reason that Buffalo gets along fairly well with typhoid is in my opinion because the germs put in at Detroit and Cleveland and all along up the lakes have partly sedimented out; partly died out in

Lake Erie en route, in the flowing water or at the bottom; and they have typhoid at Buffalo or will have it, Lake Erie being a shallow lake, because although Lake Erie distributes the pollution very much and gives a good chance for purification it is still shallow; and they are thoroughly scared today, and are talking seriously of going in for filtration, although they are so far away from Cleveland.

Q. Have you any reason as an expert, to believe that the aeration the bacilli might receive flowing down the Niagara River and proceeding over the falls, would cause their death?

A. No sir; on the contrary, I believe they would be more 3634 likely to survive if there was plenty of oxygen present.

Q. Now professor, considering your personal knowledge as an expert of typhoid fever conditions in the Sanitary District of Chicago and existing conditions in said district as to sewers and the out-falls thereof, and the amount of sewage, and all existing conditions of the Desplaines, the Illinois, Mississippi and Missouri rivers, and all conditions existing in the water-sheds of said streams, and the tributaries thereof and all existing conditions as to whether the water supply of the City of St. Louis and the general sanitary conditions existing in the city of St. Louis, would you or not, beyond a reasonable doubt, attribute the principal portion of the increase of typhoid fever in St. Louis since the opening of the drainage canal to the infected sewage of the Sanitary District of Chicago?

MR. TODD: I object to that question on the ground that it does not contain all the conditions pertaining to the typhoid fever along the water-sheds of the Missouri, Mississippi and Illinois Rivers and their tributaries.

Q. (Question read).

MR. TODD: I want to add to my objection that while it contains existing conditions, it does not include the sanitary conditions as regards typhoid.

MR. DRENNAN: Now I want to make an objection. I object as the testimony of the witness does not disclose that he is familiar with the sanitary conditions of all the cities 3635 and villages above St. Louis on these rivers and their tributaries, and the question does not embrace the fact as to such conditions.

GENERAL CROW: Well, I will qualify him on that.

Q. You have a general knowledge of the existing conditions of the water sheds of these rivers I have mentioned?

MR. TODD: I object to that question on the ground that it is leading.

DR. DRENNAN: My objection was in regard to sanitary conditions, General Crow.

GENERAL CROW: Well if he has knowledge of the general conditions he knows the sanitary conditions.

Q. Well, put it that way, so as to meet the fastidious taste of you gentlemen. Have you a general knowledge from reading and literature, of the general sanitary conditions existing on the water-sheds of these rivers?

A. I think I may say that I have a general knowledge as to the sanitary conditions in regard to typhoid fever. I don't know that I have much knowledge in regard to consumption and a lot of other things.

Q. That is what we are talking about—typhoid fever?

A. That is what I meant—typhoid fever. Well, I should state that I have a general knowledge of the sanitary conditions.

3636 GENERAL CROW: Now read that previous question. (Previous question read).

A. After a careful consideration of the subject I can say that in my opinion beyond a reasonable doubt, the principal portion of the increase of typhoid fever in St. Louis, since January 1st, 1900, of the principal annual increase, since January 1st, 1900, has been due to the pollution of the water supply of St. Louis by the sewage of the Sanitary District of Chicago.

Q. I will ask you to state, professor, if you did not say this morning in answer to one of my questions that from 1895 to 1899 the typhoid rate was substantially normal in the city of St. Louis, comparing favorably with similar cities, of like situations, and of similar size, as to the typhoid rate only?

A. From 1895 to 1899 both inclusive, during those five years, yes; that was what I did say.

JUDGE JOHNS: 1895 to 1899 is five years.

A. Yes, it is five years.

GENERAL CROW: And your answer is what?

A. My answer is that I did say substantially that—just read that question again.

(Question and answer read).

A. (Continuing) Although I should like to add that 3637 the word "normal" here must be taken in a general, rather than an advanced sanitary sense, for I believe that both Boston and St. Louis are capable of further improvement in this direction and both are higher than New York and London.

Q. I will ask you to state if you know, Professor, how the typhoid rate compares in St. Louis City from 1895 to 1899 inclusive, with the rate from typhoid fever in Lowell after the introduction of the ground filter water supply, and in Lawrence after the introduction of the first class filtration plant?

A. In 1895 to 1899 it compared favorably with the typhoid death rate of those cities.

Q. Is there any appreciable substantial difference?

A. I should think not. I don't remember off hand, just what they were.

Q. Have you any experience, Professor, in investigating typhoid fever epidemics caused by seriously infected water in running streams that would cause you to believe any running stream can absolutely be relied upon at all times to remove disease bearing germs such as the typhoid bacillus?

A. No sir, not if the pollution was at all serious or extensive.

Q. Professor, do you or not consider that the Illinois River water containing the mixed sewage and canal water 3638 from the Chicago Drainage District since the opening of the drainage canal has rendered less safe and wholesome now than before the opening of the canal, for drinking purposes on the part of the inhabitants of Missouri, the water of the Mississippi river below the mouth of the Illinois river?

A. Now will you kindly read that again?

Q. (Question read).

A. This question opens up a number of subsidiary questions, and I shall, be unable to answer it without some little consideration of these questions.

As I understand it, the question really is whether the mixing of the sewage of the Chicago river in the Chicago river, with lake water, and the pouring of that mixture down the Illinois does or does not enhance the danger of infection on the part of the people of the Missouri shore?

Q. That is the interpretation that I meant you should put on the question.

A. Yes. Now in the first place we have got to consider the matter of dilution. The addition of an amount of lake water which will yield 5,000 cubic feet a second at Lockport, passing out of the canal does, on the face of it, add to the sewage a water purer than that sewage. The sewage is therefore to some extent diluted, unquestionably diluted, and that is shown by the improved condition of the Chicago river. Anybody
3639 who is familiar with the old conditions can see that the Chicago River is cleaner and fresher than it was before. At the same time it must be borne in mind that the water which is thus used for purposes of dilution is not itself the unpolluted water of Lake Michigan. It is drawn chiefly from the mouth of the Chicago river and vicinity, and the Lake Michigan water in that vicinity and at that mouth has long been known to be infected, more or less. The problem then resolves itself into this, in part: Does the dilution of a presumably, of an often infected sewage, by a presumably often infected water, contribute to the purity of the Illinois river? But that is not all. The Chicago River was formerly a sluggish stream. Today it is much less so, and those infectious materials that were formerly put into the Chicago river are today carried with comparative swiftness down the drainage canal and into the Desplaines and Illinois rivers. We have further, then, to consider whether sewage, as described above, carried quickly, and in considerable volume, into the Illinois river, does or does not render that river safer than before. My own belief based upon those considerations which I have already outlined in regard to time as a purifying factor is that it is at least very doubtful whether the pouring of the sewage of Chicago, diluted as described, into the Illinois river does at any time improve that river. Looking at it still more closely and considering the larger amount of sewage now delivered, the opportun-
3640 ities for sedimentation; the susceptibility of the Illinois

river to freshets, large and small, and in view of the changed conditions brought about by the introduction of this fresher sewage with a larger volume of water, I am inclined to believe that,—and further, in view of the frequent extensive pollution of the sewage of Chicago by the germs of typhoid fever,—

Q. You mean infection, don't you?

A. Infection of typhoid fever, I should say—I am inclined to believe that the pouring of the sewage diluted as described, into the Illinois river, has not at any time improved it from a sanitary point of view—from the point of view of the health of the people who may use that water on the Missouri shore. I may say that undoubtedly at times it may have improved its appearance, and may seem to have improved its quality; but taking it through the year at all times, at all seasons, I am inclined to doubt exceedingly such improvement,—any such improvement at any time.

Q. Would any amount of dilution eliminate infectious pollution completely?

A. No sir, mere dilution does not eliminate infection; does not destroy it. Dilution may eliminate it from one particle of water by pushing it into another particle, but it does not eliminate it from the stream.

3641 Q. Now professor, I will get you to state whether or not in your opinion the liability to contract typhoid fever or other water-borne diseases on the part of the inhabitants of Missouri, using the Mississippi river water for drinking purposes below the mouth of the Illinois river, by reason of the sewage from the Drainage Canal, infecting the water of the Illinois river, is constant, immediate and continuous under all existing conditions, upon the Mississippi, the Desplaines, the Illinois and the Missouri river, and the tributaries of said streams and all existing conditions upon the water-sheds of said rivers and the tributaries thereof, and the drainage canal of the Sanitary District of Chicago?

A. I believe that the danger is practically constant,—by which I mean that it can never be known at what moment infectious material may arrive from the sewers of Chicago. I do not suppose that such material is arriving every minute, or

every hour, but I believe that the danger is constant, because
we never can know when it may come. I believe that it is immediate,—in
the sense that it is urgent and serious; and I believe
that it is impending, from the fact that it is, as it were,
hanging over the citizens of Missouri on the shores of the Mississippi
all the time. I can't help looking at the thing in this
way:—It is as if there were now located on the water-shed
of the Mississippi, since the opening of the drainage
3642 canal, a big additional city, a city notorious for its typhoid
death rate, or for its typhoid epidemics, I would
say, and,—yes, for its high death rate too, from typhoid fever;
and as if the placing of that city virtually upon the Mississippi
water-shed had introduced a new element into the life and welfare
of the people on the river below. It is no trifling matter to
take on a city of that size and add its sewage to an already
sewage-polluted stream. The danger line may by that addition
be reached sooner—must in the nature of things be reached
sooner, by those who use the water, and it is for that reason
that I do regard the danger as impending, immediate and aggravated,
as well as continuous.

Q. Professor, has it been your observation that in cases where typhoid-infected sewage was delivered into streams containing dams and ponds, that such dams and ponds have proved efficacious at all times in preventing the infection from reaching communities using the stream as a source of water supply below?

A. No sir, the truth appears to be this. Again, it is a
question of sedimentation and time. Dams undoubtedly so far
as they produce slack water or quiescence, favor purification and
the disappearance of disease germs for the time being, but if
the sediment or sludge is allowed to remain in the stream and
not removed artificially, or taken out and put off out of
3643 a position of danger, the chances are good, and experience
shows, that in freshets it may be returned to the
stream, again become a part of it, travel with it and produce
trouble below. That was the case for example, at Newburyport,
below the sewers of Lowell and the Lawrence dam, and that dam
at that time, as I remember it,—I am not perfectly sure about
this,—was allowing no water to go over it; it may have been

a slight stream, but it was in August, and at that season of the year the water very seldom goes over the dam. Part of it goes through the mills. The Merrimac is often a series of mill ponds, a series of quiet lakes in which sedimentation goes on nicely and the water shows great purification at such times, but just as soon as a thunder shower or anything comes, sufficient to upset the stream, it begins to rise and scouring takes place and trouble may ensue, as happened in the case of Newburyport,—although in that case I do not remember whether there was any such shower; but it is a general principle that dams are useful; they are helps, but they are not sufficient to rely upon for purification; they alone are not sufficient, and the only way in which they could be made efficient would be to have them made high enough to hold the water back and then carefully clean out the stuff and get rid of it, but even that would not do in case of water supplies because of the very act of stirring up things, —and you may get something from this as you did in the case of Detroit in the epidemic which occurred there. The only safeguard is to keep the germs quiet in the sediment
3644 at the bottom so long that they shall have entirely died out. We hardly ever know when that is. It is a very weak reed to lean upon.

Q. At Lawrence there is a big waterpower, supplying immense amounts of machinery with power to run, is there not?

A. Yes sir.

Q. How far backwards toward Lowell and up the stream does the dam affect and slack the water?

A. At times the water reaches back almost to the Lowell sewers.

Q. And how far would that be?

A. It would be nearly nine miles, and in the dam above Lowell, which furnishes the power to Lowell—it reaches back almost to the town of Nashua, New Hampshire, sixteen miles. The Merrimac river in the summer, is a series of mill-ponds, slack water like that, the water used for mill power. I am very sure that the Lowell mill-pond in summer is about sixteen miles long. I remember very well the lesson I had there. I thought that that would be a time when the water would be of the worst quality. That was twelve or thirteen or fourteen years ago.

We didn't know as much about it as we do today,—we don't know as much about it today as we wish we did,—and I expected to get a very bad water from those ponds which received
3645 so much sewage from above. On the contrary I found it very good, but in Lowell and in Lawrence we have always got our epidemics,—or have generally got our epidemics,—in the time of freshets, when the freshets come down the river and scour it out. That is the time when we get into trouble. We do not have a high typhoid rate in summer when the dams are effective and sedimentation is going on, we get it in the spring when the pollution is great and the scouring is also great.

Q. You speak now as to the time when you usually got your epidemics—

A. Let me add,—And also in the autumn, or after the autumn rains.

Q. Well, you speak now of the time when you generally get your epidemics following a rise of the river, and you refer do you not to the period anterior to the date of securing better water supply for both Lowell and Lawrence?

A. Oh, certainly. Lowell and Lawrence stand now, almost with the best rank in the world,—a very high rank at any rate,—since they had this terrible lesson of the epidemics of 1890 and 1891. Lawrence immediately set to work and put in an intermittent sand filter, and Lowell went to work and put in driven wells. Both are now among the cities having entirely reasonable death rates from typhoid fever.

3646 Q. Professor, I will get you to state what in your opinion as a general proposition will be the future increase in the population of the Sanitary District of Chicago, as compared with the remainder of the water-sheds of the Desplaines, Illinois, Mississippi and Missouri rivers, and their tributaries?

JUDGE JOHNS: That is objected to as not a question that can be propounded to a sanitary expert, as there is no qualification shown here for an opinion on the increase of population in a certain territory.

GENERAL CROW: Go ahead and answer the question.

A. My opinion is that the rate of growth in the Chicago Sanitary District is likely much to exceed, and the total growth is likely greatly to surpass, that upon the other places mentioned. I should expect it to be at least ten times as great. I will add to this answer,—basing an opinion upon pages 119 and 121 of the "Illinois State Board of Health report for 1901, sanitary investigation of the Illinois River and tributaries,"—I should even be willing to make this figure very much larger, as the increase in rural population given there is less than one per cent; that in urban popuation outside the sanitary district of Chicago is 28.2 per cent, and that of the City of Chicago is 54.4 per cent:

Q. Speaking generally, professor, how does the urban population increase in this country as compared to the rural
3647 population?

A. It is increasing very much faster. I will add a little to that if you please. It is increasing very much faster I said. Now it is one of the most striking facts with which sanitarians have to deal, that villages are growing into towns; towns into cities; water supplies and sewerage systems are being introduced and in consequence of this growth, problems of water supply and sewage disposal are almost everywhere becoming common and pressing. This condition of things is bound to increase. In the older cities it has already led to serious investigation and litigation, with long and varied attempts at remedial legislation, and I cannot help feeling that with the impending growth of cities and towns in the Mississippi valley, it is a question of the gravest sanitary consequence what becomes of the sewage of the cities and towns in that valley,—in or near that valley,—and also how their water courses may be kept from pollution and the dangers of infection.

Q. Now Professor assuming that Chicago sewage now ordinarily reaches St. Louis intake tower at the chain of rocks in a period varying from about one to three weeks, and averaging about two weeks, and further assuming that Chicago increased in population to 5,000,000 people, and dilutes its sewage in the drainage canal in the same proportion as at present, what significance will those future conditions of Chi-
3648 cago bear to the sanitary character of the water flowing in the Mississippi river along the Missouri shore, and especially at the chain of rocks intake tower?

A. Let me have that question again?

Q. (Question read).

JUDGE SPRINGER: On behalf of the sanitary district, I object to this question on the ground that its answer will not be responsive to any of the issues in this case. We are not trying a case that may happen when Chicago has 5,000,000 inhabitants. It may never occur in the world.

MR. TODD: I want to make an objection that the facts assumed in that question as to the rate, has not been established by the evidence, as to average or minimum or maximum.

GENERAL CROW: I didn't put any time on that question.

MR. TODD: You said one week to three weeks, with an average of two.

A. That seems to me one of the most interesting, and one of the most serious features in this whole case, as I understand it. Any material growth in the population of Chicago, accompanied by a corresponding dilution of its sewage to that which it now has, must obviously quicken the stream flowing in the Illinois, and have an effect in bringing infectious materials more rapidly and more quickly to the people of Missouri.
3649 I cannot help looking at it in this way. It is as if Chicago should be gradually moved towards St. Louis, as if the distance between the two cities should be diminished, and as if potentially Chicago should become a nearer neighbor, from a sanitary point of view, of St. Louis and the vicinity. The larger Chicago gets of course the nearer it practically comes. Now as I have repeatedly said, one of the great elements in this matter of sewage purification is time, and anything that would hasten the delivery of infectious materials at the chain of rocks, other things being equal, would add very seriously in my judgment to the dangers pertaining to an infected drinking water in St. Louis. I should go even further. I should say that it was of interest not only to St. Louis and Missouri, but to Illinois herself, and to the cities and towns that are bound to grow up in the valley below, and that if Asiatic cholera or any other infectious disease the germs of which are carried by water, should appear in a city five times as big as the present, or having a population of 5,000,000, it would be a very much magnified menace to the welfare of the inhabitants

of the Mississippi valley. I should say this even if Chicago should purify her water supply and reduce her typhoid fever, because epidemics sometimes come even upon communities having a good water supply, and the mere existence of this 3650 large number of human beings pouring their sewage down the Mississippi valley, no matter how good their general sanitary condition might be, would be a very serious item in the welfare of the inhabitants in the future; that under existing conditions, with typhoid fever abundant, and excessive, in amount in Chicago, any material increase of population; any added flow of sewage which would give us a shorter time in the slack water portions of the river, in my opinion would be a very important and very serious menace to the people of the Mississippi valley.

MR. TODD: Read the first part of that answer.

(First portion of answer read, as follows): That seems to me one of the most interesting and one of the most serious features in this whole case as I understand it.—

MR. TODD: I move to strike that sentence out as not responsive.

THE WITNESS: Just read that answer.

(Answer read).

THE WITNESS: The mere presence of pollution— I mean by that uninfected sewage. That is supposing Chicago had reduced her typhoid rate, she would still pour her sewage down the valley, and that sewage by merely favoring the longevity or growth of germs which got in from Peoria or anywhere else, would be an added menace to cities with water supplies, even if she did not send typhoid fever germs down; sending the filth alone down, is serious.

3651 MR. TODD: I would suggest that that last clause be subjoined to his answer and my objection follow that, —because now it comes right in the middle of that answer. I moved to strike out the first part of his answer.

Q. Professor, I will ask you this question: Do you or not consider that the Illinois river water polluted and infected by the sewage from the Chicago Sanitary District, since the opening of the drainage canal, has rendered less safe the water supply of the city of St. Louis as drawn at the intake tower at the chain of rocks, and on what do you base your opinion?

MR. TODD: I object to the question on the ground that it has been asked before and answered.

GENERAL CROW: No, the other question was generally as to the waters below.

Q. (Question repeated).

A. I do consider it less safe for the reason that I believe that the germs of typhoid fever may and do find their way through the intake at the chain of rocks, into the water supply of the city of St. Louis.

Q. Professor, assuming that the population of the Chicago Sanitary District covers about 3,000,000 people and that the flow through the drainage canal reaches 600,000 cubic feet a minute, what in your opinion would be the effect on the water of the Illinois river as compared with that water at its
3652 mouth as found during the past three years?

A. I believe that it would be less pure and less wholesome.

Q. What would you say as to the relative amount of infectious material and pollution in the river under those changed conditions?

A. I should expect under those conditions,—doubling the flow through the Drainage Canal,—with the conditions which I have already referred to at length above, would prevail to a greater or less extent, and that the danger of infection would be enhanced or increased. The danger of infection would be increased.

Q. Now Professor, assuming that the population of the Chicago Sanitary District is increased to 5,000,000 of people and that the flow through the drainage canal reaches 1,000,000 cubic feet per minute, what in your opinion would be the effect on the water of the Illinois river at its mouth as compared with the water at that point as found during the past three years?

A. I believe that the water would be less pure, less wholesome and more infectious and less suitable for drinking purposes for the reasons already given.

Q. Now professor, what do you say as to the general proposition regarding the mixing of the Illinois and upper Missis-

sippi river water, during their flow from Grafton to the
3653 chain of rocks intake tower of the St. Louis waterworks?

A. I believe that a mixture takes place at times, such that the water of the Illinois river may find its way to the intake of the St. Louis waterworks at the chain of rocks.

Q. Now professor, I will ask you this question: Assuming that the Chicago sewage from 1,500,000 people living in the Sanitary District and City of Chicago, should be discharged into the Chicago drainage canal and carried through the canal into the Des Plaines river and thence into the Illinois river, Chicago being situated 358 miles from the St. Louis intake, and assuming that a typhoid fever epidemic of extraordinary proportions should become prevalent among the residents of the sanitary district of Chicago, at a time when the sewage from said district is being so discharged into the canal, what immediate and impending danger would exist, and what effect would it have on the people of St. Louis and those people living on the Missouri side of the Mississippi river below Grafton who used the waters of the Mississippi river for drinking purposes?

A. I believe that an epidemic of the kind described under the circumstances mentioned, would under existing conditions be likely to produce an epidemic of large proportions among those so using the water.

3654 Q. Well, would it cause any immediate danger?

A. As to the immediate danger, I think perhaps I have already dwelt upon that sufficiently, but there can be no question that if such an epidemic should appear, the citizens of St. Louis and the Missouri shores, would have a right to regard themselves as in a critically dangerous condition, as far as their water supplies were concerned.

Q. Now, professor, assuming the same conditions as in the last question you have been answering, and assume that instead of an extraordinary typhoid fever epidemic prevailing in the Sanitary District of Chicago a cholera epidemic should prevail in the sanitary district of Chicago, a severe cholera epidemic should prevail in the Sanitary District, would the danger be imminent, impending and immediate to the people of Missouri below Grafton who use the waters of the Mississippi for drinking purposes, as far down as the chain of rocks?

A. I think that it would, sir, for the simple reason that they could never be sure, under existing conditions, that some of the germs of that disease might not find their way into their water supplies from the sewage of Chicago.

Q. Now, Professor, looking forward into the future and
considering not this general relation alone, but those that are
to follow and considering the relation of the filth and infection
of the sewage of the Chicago Sanitary District to the
3655 water of the Mississippi river as it flows along the Mis-
souri shore; considering the effect in hastening the filth
and sewage from the cities on the Illinois river below the mouth
of the drainage canal, and assuming that dilution is maintained
in the same proportions as that which now exists caused by the
added volume of water from the canal into the Illinois river,
I will ask you to state your views as an expert on public health
matters regarding the above mentioned conditions, considered
as a broad, practical proposition?

A. I have already perhaps covered part of the ground
which would be a proper answer to this question, but there are
some other considerations that I think ought to be taken into
account and some of them are these: We are finding it in-
creasingly difficult to get unpolluted water for drinking pur-
poses. Our fathers did not feel it necessary to filter or to store
or to treat the waters as we often find it necessary to do today.
Our children will, if foresight is worth anything, be obliged to
filter as we have to do today and a great deal more perfectly.
With the increased use of water and the increased development
of populations and industries, the production of by products and
trades wastes and agricultural drainage and all sorts of things
upon the watersheds, pure water will become very scarce, and
cities and towns will probably be driven first to filter their water
as they are now doing in some places, and in the second
3656 place very likely, to filter it twice. Then will come a time
when the rivers will get so sewage polluted that mere fil-
tration will not suffice. It may be that at that time, all the
cities will unite in declining to put sewage into the water courses,
but whether they do or not, it will be increasingly difficult to
secure good water and to get rid of the sewage. Now I hold that
we have no business to hasten the arrival of these days of

trouble. We have, perhaps, troubles enough of our own, but at the same time we ought to use every endeavor and I believe it is the opinion of sanitarians in general that cities ought to use every endeavor, first, to preserve the purity of their own water supply; secondly, preserve the purity of the water supplies of their neighbors. In England many of the water courses are so small that cities and towns are obliged to treat their sewage, and if the population of cities like Chicago and St. Louis goes on growing, I look forward to the time when we shall be in straits,—and that time is perhaps not so very far distant for some cities,—when we shall be in straits for decent water; when it will be possible for us to secure a good water supply only at great expense and difficulty. The cities of the Mississippi valley are using and must use very largely the water courses in that valley. Some of them are suffering already from polluted water supplies. They will be obliged
3657 very soon to spend large sums in purifying their water.

Every ton of filth or refuse; every infectious disease germ added to their streams increases that difficulty and means expense and outlay for those cities. I think the question of what will happen if Chicago grows very much larger and continues to pour its refuse and disease germs upon the Mississippi valley, is not an academic question; it is a practical, burning question, and it is going to become more so as time goes on.

MR. TODD: I move to strike out the answer as not responsive to the question and contains matter that is not relative to the inquiry made, and the pleadings of this case.

MR. DRENNAN: I object to the question and move to strike out the answer on the ground that the question and answer are too remote and indefinite.

GENERAL CROW: Now Professor, I will get you to state if you have any knowledge on the subject from which you can give an opinion as to whether or not the stream flow in this country will increase?

A. I have only a very general knowledge, but a very definite impression, and that is, following the results of experience, —that we may expect that stream flows in general will not increase, but rather decrease as time goes on.

Q. Has that been the experience in other countries?

3658 A. That has been the experience more particularly in the older portions of this country.

Q. What particular sections of the country do you refer to?

A. I am thinking most particularly of the water-shed of the Connecticut at this moment.

Q. Have you made any observations?

A. No sir, no study of it.

Q. Have you any knowledge that would enable you to state an opinion as to whether or not the dry weather flow of the streams in this country is diminishing?

A. No sir I have not. I haven't done very much in that line.

WILLIAM T. SEDGWICK,

ADJOURNED until 10:00 A. M., Wednesday, May 20th, 1903.

3659 Southern Hotel, St. Louis Missouri. 10:00 A. M., Wednesday, May 20, 1903. Parties met pursuant to adjournment.

Present, the Commissioner and the same counsel representing the respective parties.

WILLIAM THOMPSON SEDGWICK,

resumed the stand for further direct-examination by Attorney General Crow, and testified as follows:—

GENERAL CROW: Now we have some typhoid fever statistics here that we want to offer. I suppose you gentlemen will not require us to read them into the record. We can present them to you and you can inspect them.

MR. JEFFRIES: Complainant offers in evidence certicate of the City Clerk and ex-officio Secretary of the Board of Health of the City of St. Charles, showing the number of deaths from typhoid fever in St. Charles, Missouri, from July 1st, 1899 to January 1st, 1903.

GENERAL HAMLIN: Mr. Jeffries, have you a copy of them?

MR. JEFFRIES: No sir, I have not.

GENERAL HAMLIN: We can have a copy made, can't we?

MR. JEFFRIES: Certainly.

GENERAL CROW: Just make the offer and let them 3660 have the right to object to any part of it, or all of it.

GENERAL HAMLIN: Of course, strictly speaking, you could not offer them now, but you can let them be offered without any objection as to the time when they are offered, but subject to any objection that we might make in regard to the substance matter or the correctness of them.

GENERAL CROW: That is all right, and we will have copies of them made and furnished to you.

GENERAL HAMLIN: I think General, they ought to go into the record at the close of this man's testimony.

GENERAL CROW: Well, we want to insert them in the record at this place when the record is finally written up, but if we put some of them in the record now, and have to change some of them, why we will have to change the record, and by furnishing the original to the stenographer, he don't have to write it in until he gets it.

MR. JEFFRIES: We offer in evidence, certificate of the Clerk of the District, Court, and the custodian of the mortuary records of the city of Davenport, Iowa, showing the typhoid deaths in that city by months from 1893 to 1902, inclusive;

Also certificate of the clerk of the county Court, and custodian of the mortuary records in the County of Rock Island showing the number of typhoid deaths in the city of Rock Island, Illinois by months for the years 1893 to 1902, inclusive.

3661 And including the months of January and February, 1903.

Also certificate-certified copy—of the City Clerk of the City of Moline, in the State of Illinois, and the custodian of mortuary records of that city, showing typhoid deaths by years for the years 1893 to May 16th, 1903, inclusive.

Also a statement and certificate of the clerk of the County Court of Jo Davies County, Illinois, showing the number of deaths from typhoid fever in the city of Galena, Illinois for the years 1893 to 1903, inclusive.

Also certificate from the City Clerk of the City of Warsaw, Illinois, certifying to a copy of the typhoid death rate in that city for the year 1902, containing the statement that the record contained no deaths for previous years.

Also certified copy of the mortuary records on typhoid fever of Kansas City, Missouri, from 1893 to 1902, inclusive certified to by the Clerk of the Board of Health of Kansas City, Missouri; also certified copy of record of deaths from typhoid fever in the City of St. Joseph, Missouri, certified to by the Clerk of the Board of Health of the City of St. Joseph, Missouri.

Also certified copy of the record showing typhoid deaths at Council Bluffs, Iowa, from January, 1893, to April 30th, 1903, inclusive, shown by the certificate of the City Clerk of Council Bluffs, Iowa.

3662 Also certified copy of typhoid death record of Lincoln, Nebraska, for the years 1893 to 1902, inclusive, as certified to by the Health Officer of said City.

Also certified copy of typhoid death record of the City of Omaha, Nebraska, for the years 1893 to 1902, inclusive, as certified to by the Commisioner of Health of said City.

Also a certificate from the Commissioner of Health of the City of Chicago, showing deaths from typhoid fever in Chicago from 1890 to 1902, inclusive.

3663 GENERAL CROW: I will ask you this question: Referring now to the question asked you on page 17 and 18 and your answers thereto, in your testimony taken yesterday afternoon, do you say now that the water of the Mississippi is rendered less safe by the reason of the water of the Illinois, of the Chicago Canal emptying into it, now than it was before the opening of said canal, from the standpoint of the health of the persons on the Missouri shore on the Mississippi river below the mouth of the Illinois who may use or wish to use the waters of the Mississippi for drinking purposes?

A. Yes sir, I should say that in my opinion it is decidedly less safe in spite of the fact that at times, as I have said, it may look better or seem better, and the whole burden, I think of my testimony would be to state what I believe to be true, that the quickening of a stream by the addition of a volume of other water, especially under conditions such as prevail on the Illinois, is a very serious menace to the people of the regions below who use that water. It is my opinion that in spite of the addition of the so-called "pure lake water;" in spite of the greater dilution resulting from that, the water of the Mississip-

pi river is constantly and beyond all reasonable doubt rendered more dangerous to the public health and to the citizens who use it, because of that addition, and under all the circum-
3664 stances which exist on the Illinois and Mississippi rivers.

Q. Now professor, in describing several epidemics yesterday, due to infected water, you did not state exactly and in detail the precise sources of contamination. Will you now do so if you can?

A. The precise sources?

Q. Yes sir?

A. I think that in the case of Plymouth I did briefly state that the dejecta of a single person who was ill with typhoid fever, and who lived on the bank of the stream supplying the reservoirs, were washed into the stream and delivered to the citizens below, causing one of the most serious epidemics that we have ever known. I did not state, I think, the conditions in the case of the great Lowell epidemic of 1890 and 1891. Those I investigated personally, and briefly described. They were as follows:—

About three and a half miles above the intake of the Lowell waterworks, and on the other side of the Merrimac river there is, as I have stated, a small stream. It is more than a brook; it is a large brook, a stream called Stony Brook. Upon this brook are certain factories, and connected with those factories are certain out houses, some of them over-hanging the stream. At one of these in particular, I found that a man named James Larkin had been in the habit of defaecating, while he was a workman in the foundry nearby. He became infected
3665 with typhoid fever and spent the greater part of several
days, while trying to work,—as he was a poor fellow,—in this overhanging privy. The dejecta fell from him—the excreta fell from him into the brook, and proceeded, as I believed, directly into the Merrimac, and crossing over the river reached the intake of the Lowell waterworks. This was the principal cause, in my judgment, of the great Lowell epidemic, and of the relatively more severe Lawrence epidemic which followed. There were other cases at the time, and these contributed more or less to the epidemic, but this was the principal case. This man's brother was also ill. His feces also went

into the stream from a wool-scouring factory near by, as did those of two of three girls, but the principal person in my judgment, was this one.

In the case of the New Haven epidemic, a family living upon the watershed had typhoid fever. I think there were two or three cases in the family. Their dejecta were thrown out on the ground near by, and in the thaw which I described yesterday, were washed into the stream.

Q. How far from the stream were they?

A. I don't remember just how far; I think they were quite a little distance, perhaps fifty feet or something like that.

Q. Was that in the winter season?

A. The typhoid was in the late winter, and the thaw
3666 came along, as I remember it, in March, very much as it
did in the Plymouth case. This was washed into the reservoir which was ordinarily used—well, it was a regular storage reservoir of the city of New Haven.

Q. But it went first into the stream?

A. It went first into the stream.

Q. And then how far down the stream?

A. I don't remember; but it was only two or there miles,—something like that,—and from the stream into the reservoir, where it underwent probably a very slight sedimentation, and storage and then passed on to the citizens.

Q. How many cases were there?

A. There were 470 cases or thereabouts, at that time from that single infection.

Q. That was the only known cause of that infection?

A. That was the only known cause, and was reported by the State Board of Health of Connecticut, to be the explanatory cause of that?

In the case of Windsor, Vermont, according to the expert employed by the State Board of Health of Vermont, whose results were adopted by that Board as sound, the infection came from a privy about a mile from a storage reservoir, a small storage reservoir—and were supposed to have been washed from
the privy into a very small stream,—a mere thread of a
3667 stream—

Q. Well, how was that washed,—by natural causes?

A. That was washed by rains, by common rains, yes, in the spring; it was at the time of the breaking up of the winter snows and was in the freshet time.—From this thread of a stream down into a larger brook, and then into the reservoir, where it was stored for a while, probably not very long, however, and then distributed to the citizens. I myself saw that privy and the local conditions, so that I can speak with some familiarity of that.

Q. How far was it from the privy vault over to the gully or place—was there water in this little stream when you saw it?

A. Yes, there was some water in the stream, and the privy was perhaps 500 feet,—the privy was only about 100 feet from the begining of the small stream, and the wash occurred right across a barnyard into that stream, which practically drained the barnyard, the small stream possibly 500 or 1,000 feet long, ran into a larger stream which went to make up the distance to the reservoir, perhaps a mile or thereabouts.

At Ithaca, New York, in the recent epidemic it is believed,—it is I think I may say, established, that the epidemic proceeded from pollution upon the water-shed of Six Mile Creek. Whether that came from a camp of Italians working on that creek and upon a new reservoir, or whether it came from other
3668 workmen upon that water-shed is not yet absolutely clear, but everyone is agreed that the epidemic came from fecal matters deposited upon the water-shed and washed into the water supply. These are the cases, I think, that I chiefly mentioned yesterday. If I go into others, I shall have to go into pollutions by more than one or two people. Do you care for any more of those?

Q. Well, it doesn't cut any figure about the number of people that caused the pollution.

A. In the Newburyport epidemic to which I referred yesterday, the pollution was, I believe, derived from the regular typhoid fever in the city of Lowell which at that time was excessive; the city of Lowell was full—yes, full of typhoid fever as the phrase went,— and a little larger epidemic than usual arose. The germs of it were carried down past Lawrence to Newburyport, and showed their effect in Lawrence and in Newburyport.

In an epidemic which I did not mention yesterday, but which

I may mention today, at Zurich, Switzerland, the typhoid fever which visited that city about 1885, was attributed to disturbance of sediment near an intake pipe and a defective filter, by which latter the city was supposed to be protected. A break had come in their intake pipe without their knowledge; their filter was imperfect; it had long been believed to be that, and the disturbance of some sediment near the intake pipe was followed by
an epidemic of typhoid fever in Zurich which has been
3669 attributed by sanitarians generally to that cause—that
source.

In a case which occured in Catherham, England in 1879, a pollution by one workman infected the water supply so that several hundred cases of typhoid fever appeared at a place in which it never had been before; that pollution taking place near the source, in a well which they were digging for additional water supply. The presence of workmen upon a watershed is a constant menace to the purity of water supply, and in addition to the population which may pollute the water, is recognized as a very serious menace. I have known within my own experience, of two cases of that kind where the temporary addition of bodies of workmen to a water-shed typhoid fever having appeared among these workmen, was regarded as a distinct and very serious danger to the communities using the water below. Two of these were within my own experience.

In the building of the great reservoir at present, of the Metropolitan Water Supply at Boston, extraordinary pains are taken with the workmen on the water-shed to see that they shall not pollute the supply, and in general, whenever any filth or fecal matter or sewage or drainage pollution or contamination or anything of that sort is added to a water-shed
in such a way that it may find access to the streams,—I
3670 will say readily find access to the streams,—it is every-
where regarded as a serious threat to the health of the
people below, who use that water.

I don't know that I need to take up your time with any more cases.

Q. Professor, will you state in general terms if you can, the relative efficiency of urban and rural population in the pollution and infection of running streams?

A. As a general proposition the urban population is very much more dangerous, very much more efficient in the pollution of waters than a rural population. It would probably be fair to say,—to put it in figures, that the urban is at least ten times as dangerous, and the reason for this is that urban populations are more often sewered, and when not sewered are more often upon streams, while the rural population is very often remote from streams, almost always without sewers, and even if the same infection occurs in a rural family as in an urban family, the chances of keeping that infection within the family and on the place, are far greater than they are in the case of an urban population. It is an obvious, general proposition that the rural population is of comparatively little importance in this respect. It is the urban population that we have chiefly to consider in the question of water supply, and sewage disposal. A farm house for instance, will have its own privy pit; its own sink
3671 drain, and even if heavy rains come, these are not readily washed into streams, except in unusual cases, as in some of those that I have mentioned.

Q. Now, professor, can you tell me anything about how much urban sewage producing population has been added to the drainage area tributary to the watershed of the Mississippi river, as it flows to the intake tower of the St. Louis waterworks, by the opening of the drainage canal?

A. Did you ask how much urban population?

Q. Yes that is by the opening of the canal, which has been brought about by cutting through the natural divide between the watershed of Lake Michigan and the Illinois River?

A. I find that it is about 63 per cent.

JUDGE JOHNS: 63 per cent of the entire urban population is added by the City of Chicago?

A. Yes sir. 63 per cent has been added to the amount above the St. Louis intake.

GENERAL CROW: Can you tell me the amount of urban population on the water-shed of the Mississippi river and its tributaries; the Illinois, Mississippi, Missouri and Des Plaines, and their tributaries, exclusive of the Sanitary District of Chicago above the intake of the St. Louis waterworks, on the
3672 basis of cities and towns of 4,000 inhabitants and more, ex-

cluding the sanitary district of Chicago from such water-shed?

A. Just read that question.

Q. (Question read)?

A. Exclusive of the sanitary district?

GENERAL CROW: Now you had better just read that again. Read a little louder; those gentlemen talking there I didn't just exactly catch it.

(Question read).

GENERAL CROW: Well, now, exclusive of the Sanitary District of Chicago, of the population of the water-shed of Lake Michigan; that is, I don't want you to consider that population on the Lake Michigan water-shed at all.

A. I make it 2,695,782. Understanding by urban population towns and cities having 4,000 and more.

Q. Have you those figures so that you could give the water-sheds of the different rivers?

A. Yes sir.

Q. Please put it in the record in that shape also?

A. According to the 1900 census the urban population defined as cities or towns having more than 4,000 population would be as follows:

Missouri river, 1,090,832,

Upper Mississippi River, by which I understand the Mis-
3673 sissippi river above the mouth of the Illinois.

Q. Above the mouth of the Missouri you mean, don't you—yes, you are correct in that; it is above the mouth of the Illinois.

A. The upper Mississippi River above the mouth of the Illinois I don't know whether that is so or not. Wait a minute. I think that's right, yes sir.

Q. Well, it is really above the mouth of the Missouri, exclusive of the Illinois.

A. That's what I understand, yes sir.

Q. It is the same proposition stated another way.

A. It is 1,219,645.

JUDGE JOHNS: The upper Mississippi?

A. The Mississippi above the Illinois. The Illinois is 385,305. All those added together make the sum I gave you a moment ago.

GENERAL CROW: Professor, I believe you did not state in connection with your description of the typhoid epidemics in Lawrence and Lowell, the period of time required for water containing typhoid germs, to pass from the Lowell sewers to the Lawrence water consumers. Do you know this period? If so, state it?

A. The mouth of the Lowell sewers is about nine miles above the intake of the Lawrence waterworks. From
3674 that point the water was pumped to the reservior of the city of Lawrence, and in that reservoir it was kept for a period varying from one to a little more than two weeks. If we add to this one to two weeks, the time spent in flowing the nine miles, and through the pumps which I suppose, or which I know from observation, would be a short time, we may say that the period was sometimes probably as long as fourteen days or more, and this amount of storage proved to be some protection undoubtedly to the people of Lawrence, but an inadequate protection because they suffered relatively more from typhoid fever than the people of Lowell did, although they were not so near the sewers of Lowell. I may add that the difference between the Lowell and Lawrence reservoirs was very striking and interesting. The Lowell reservoir was so arranged that the water passed in and out almost immediately, and the number of bacteria in the Lowell water was sometimes quite high, because of this absence of adequate storage. In Lawrence the storage was longer and was an undoubted protection of a certain sort,—a certain imperfect sort,—to the people of Lawrence, but it did not protect them adequately or perfectly.

Q. If there was any difference in the degree of infection between Lawrence and Lowell, state what it was and the reason for it if you can?

A. The difference in infection was of course, immense.
3675 Lowell received the germs from the little Stony Brook and Lawrence received those same germs, or what Lowell had not taken out, and in addition, later, the typhoid germs from upwards of 1,000 cases of typhoid fever in Lowell, and as I say the storage was a certain protection, but in spite of that the mortality rate was far higher, or considerably higher, in Lawrence than it was in Lowell.

Q. Do you know of any instance, where settling basins holding suspected water for longer periods than this one at Lawrence, have failed to protect the people using such water, from typhoid fever, and if so, what are they?

A. There are well known cases. Covington, Kentucky and New Albany, Indiana, deserve mention. At Covington, Kentucky, the water of the Ohio River, more or less polluted on the stream above, is kept at times as long as thirty-two days, and yet Covington suffers severly from typhoid fever, apparently due to infected water. At New Albany, Indiana, on the same stream, the storage is about a month in the sedimentation basin, as in the case of Covington, but typhoid fever is high in New Albany, showing that the storage for a period even as long as a month cannot be depended upon to entirely remove the typhoid germs.

Q. Well, professor, going back to your statement yesterday, as to typhoid existing quite excessively at Niagara Falls, I will ask you to state if you know, to what cause that is
3676 attributed?

A. I meant to have stated yesterday, and I think I did briefly state that it was attributed by every one who was familiar with the facts, to the sewage of Buffalo, although that sewage has passed down one of the most favorable,—or rather has passed down a stream, one of the most favorable in the world, perhaps, for dilution, aeration, oxidation, self-purification and similar processes.

Q. Is the volume of water in the Niagara River at this place, large or small?

A. Enormous, very large. They have a filter at Niagara Falls, but it is admitted that it is not perfect. It is admitted in fact that it is anything but perfect. There are times when they do not use it at all, and at such times the people suffer severely from typhoid fever. A leading physician of Niagara Falls himself told me of the remarkable prevalence of the disease there. I regard the case of Niagara Falls as it is today, one of the most instructive we have. The sewage is well diluted, well aerated, and that for a considerable distance; the distance, as I recall it, between the sewers of Buffalo and the intake at Niagara Falls, is about, about, I should suppose, eighteen miles, but I am not sure about that. It may be only fifteen.

Q. Isn't it more than that?

3677 A. I do not know. I should suppose that was about it. It may be. I have not been along the river there. I have ridden back and forth on the train, and as I remember the distance, I should suppose it was fully fifteen to eighteen miles, it may be more.

Q. Now do you know whether or not it is a fact that Niagara is considered to have the highest typhoid death rate of any city on this continent?

A. I don't know about that. It is a new matter to me, the Niagara matter. I have never made any study of it.

Q. Do you know whether or not the rate is high?

A. No, I do not. I only know that it is very high. I could look it up if you want me to do it. I have not done so. If I could send for a paper down stairs, I could settle it.

Q. You can do that a little later.

A. Yes sir.

MR. JEFFRIES: I have one question I want to ask you Professor, and that's all.

3678 Q. Assuming that the following cities are situated on the water-shed of the Missouri River; that the sewage of said cities is discharged directly or indirectly into the Missouri River as hereafter indicated, and that the respective population, according to the census of 1900, and the distance from St. Louis, as well as the number of deaths from typhoid fever in each city for the years given, is as follows:

St. Charles, Missouri; population 7, 982; 47 miles from St. Louis.

Deaths from typhoid fever:

1899,	22,
1900,	5,
1901,	6,
1902,	14.

Kansas City, Missouri; population 163,752; 403 miles from St. Louis.

Typhoid fever deaths:

1893,	59,
1894,	37,
1895,	34,

1896,	29,
1897,	38,
1898,	49,

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1899,	52,
1900,	49,
1901,	58,
1902,	58.

St. Joseph, Missouri; population 102,000; 501 miles from St. Louis.

Typhoid deaths:

1892,	29,
1893,	20,
1894,	22,
1895,	31,
1896	19,
1897,	13,
1898,	19,
1899,	37,
1900,	20,
1901,	12,
1902,	13.

Omaha, Nebraska; population 102,552; 676 miles from St. Louis. Typhoid deaths:

1893.	22,
1894,	40,
1895,	29,
1896,	18,

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1897,	22,
1898,	32,
1899,	26,
1900,	24,
1901,	23,
1902,	22.

Council Bluffs, Iowa; population 25,802; 676 miles from St. Louis. Typhoid deaths:

1893,	5,
1894,	7,

1895,	6,
1896,	8,
1897,	8,
1898,	6,
1899,	11,
1900,	6,
1901,	6,
1902,	8.

Lincoln, Nebraska; population 40,169; 745 miles from St. Louis. (All of these distances are by water); typhoid deaths:

1893,	33,
1894,	21,
1895,	23,
1896,	15,
1897,	14,
1898,	12,
1899,	13,
1900,	4,
1901,	13,
1902,	10.

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That the sewers of all the cities just named discharge their sewage directly into the Missouri River, except Lincoln, Nebraska, which discharges into the Platte River, and thence into the Missouri River.

Also assuming that the following cities are situated on the water-shed of the Misissippi River; that the sewage of said cities is discharged directly or indirectly into the Mississippi River above Grafton, Illinois; that their respective population according to the census of 1900, their distances from St. Louis by water and the number of deaths in each city from typhoid fever for the years named, are as follows:

Quincy, Illinois; population 36,000; 148 miles from St. Louis. Typhoid deaths:

1893,	21,
1894,	28,
1895,	25,
1896,	13,
1897,	13,

1898,	7,
1899,	6,

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1900,	10,
1901,	14,
1902,	17.

Keokuk, Iowa, population 14,041; 185 miles from St. Louis; typhoid deaths:

1893,	8,
1894,	13,
1895,	2,
1896,	3,
1897,	7,
1898,	9,
1899,	9,
1900,	10,
1901,	4,
1902,	8.

Burlington, Iowa; population, 23,201; 225 miles from St. Louis. Typhoid deaths:

1893,	8,
1894,	10,
1895,	8,
1896,	13,
1897,	3,
1898,	4,
1899,	8,
1900,	13,
3683 1901,	12,
1902,	11.

Rock Island, Illinois; population, 35,300; 310 miles from St Louis; typhoid deaths:

1893,	15,
1894,	13,
1895,	3,
1896,	13,
1897,	no record,
1898,	no record,
1899,	10,

1900,	14,
1901,	28,
1902,	5.

Davenport, Iowa; population, 35,254; 310 miles from St. Louis; typhoid deaths:

1893,	5,
1894,	6,
1895,	4,
1896,	3,
1897,	5,
1898,	2,
1899,	12,
1900,	14,
1901,	11,
1902,	11.

3684 Moline, Illinois; population, 7,987; 313 miles from St. Louis; typhoid deaths:

1893,	7,
1894,	9,
1895,	8,
1896,	11,
1897,	3,
1898,	5,
1899,	20,
1900,	22,
1901,	16,
1902,	7.

Des Moines, Iowa; population, 62,139; 387 miles from St. Louis; typhoid deaths:

1893,	22,
1894,	29,
1895,	30,
1896,	14,
1897,	20,
1898,	17,
1899,	13,
1900,	7,
1901,	22,
1902,	21.

Minneapolis, Minnesota; population, 102,718; 707 miles from St. Louis. Typhoid deaths: 3685

1893,	134,
1894,	107,
1895,	88,
1896,	60,
1897,	148,
1898,	86,
1899,	71,
1900,	13,
1901,	121,
1902,	66.

St. Paul, Minnesota; population 163,055; 694 miles from St. Louis; typhoid deaths:

1893,	51,
1894,	32,
1895,	38,
1896,	37,
1897,	22,
1898,	43,
1899,	30,
1900,	30,
1901,	24,
1902,	18.

Assuming that all the sewage from said cities entered directly into the Mississippi river except from Des Moines, 3686 which is discharged first into the Des Moines River and from thence into the Mississippi river about two miles below Keokuk, Iowa.

Assuming further that the following cities are situated on the watershed of the Illinois river, that their sewage flows directly or indirectly into the Illinois river; that they are situated above St. Louis and their population according to the census of 1900 and their typhoid fever deaths for the years named, are as follows:

Peoria, Illinois, population 56,000; 198 miles above St. Louis; typhoid deaths:

1896,	13,
1897,	18,

1898, 18,
1899, 12,
1900, 23,
1901, 15,
1902, 18.

Springfield, Illinois; population, 34,159; 191 miles from St. Louis; typhoid deaths 1900, 20;

1901, 10,
1902, 8.

Bloomington, Illinois population 23,286; 238 miles from St. Louis; typhoid deaths:

3687 1893, 12,
1894, 14,
1895, 15,
1896, 9,
1897, 10,
1898, 10,
1899, 9,
1900, 15,
1901, 9,
1902, 15.

Ottawa, Illinois, population, 10,588; 282 miles from St. Louis; typhoid deaths:

1893, 2,
1894, 5,
1895, 2,
1896, 2,
1897, 4,
1898, 4,
1899, 3,
1900, 3,
1901, 5,
1902, 2.

Decatur, Illinois; population, 20,754; 246 miles from St. Louis; typhoid deaths:

1893, 5,
3688 1894, 7,
1895, 2,
1896, no record,

1897,	2,
1898,	5,
1899,	7,
1900,	11,
1901,	5,
1902,	4.

Joliet, Illinois; population, 29,000; 322 miles from St. Louis; typhoid deaths:

1893,	12,
1894,	14,
1895,	no record,
1896,	12,
1897,	12,
1898,	15,
1899,	13,
1900,	13,
1901,	13,
1902,	21.

Pekin, Illinois; population, 6,420; 188 miles from St. Louis typhoid deaths:

	1900,	2,
	1901,	1,
3689	1902,	2.

Elgin, Illinois; population, 22,433; 348 miles from St Louis; typhoid deaths:

1893,	5,
1894,	3,
1895,	5,
1896,	14,
1897,	no record,
1898,	4,
1899,	5,
1900,	15,
1901,	15,
1902,	8.

Aurora, Illinois: population, 24,147; 328 miles from S Louis; typhoid deaths:

1893,	6,
1894,	12,

1895,	19,
1896,	10,
1897,	5,
1898,	10,
1899,	4,
1900,	17,
1901,	11,
1902,	2.

3690 Havana, Illinois; population and distance not given; typhoid deaths:

1893,	3,
1894,	7,
1895,	2,
1896,	5,
1897, 1898 and 1899 not given; no record;	
1900 not given,	
1901,	1,
1902,	2.

Assuming that the total number of deaths from typhoid fever occurring in the City of St. Charles, Missouri, Kansas City, Missouri, St. Joseph, Missouri, Omaha and Lincoln, Nebraska, Council Bluffs, Iowa, on the Missouri watershed, Quincy, Illinois, Keokuk, Burlington and Davenport, Iowa, Rock Island and Moline, Illinois; Des Moines, Iowa, Minneapolis and St. Paul, Minnestota, on the Mississippi river watershed above Grafton, and Peoria, Bloomington, Ottawa, Decatur, Joliet, Elgin and Aurora, Illinois, on the Illinois River watershed, was for the years 1897 to 1902, inclusive, as follows:

1897, total deaths,	369,
1898, total deaths,	357,
1899, total deaths,	385,
1900, total deaths,	338,
1901, total deaths,	442,
3691 1902, total deaths,	365.

Assuming that the total number of deaths from typhoid fever on said watersheds in all other towns and cities of 4,000 population and over have not increased for said years in any greater or different proportion than in the cities above mentioned in detail.

Assuming that the three rivers mentioned run through alluvial soil principally and the Illinois river enters the Mississippi at Grafton, 29 miles above the Chain of Rocks, Intake Tower of the St. Louis Waterworks; that the Missouri river enters the Mississippi river twenty-three miles below Grafton and six miles above the Intake Tower of the St. Louis Waterworks, located on the Missouri side of and in the channel of the Mississippi river about fifteen hundred feet from the Missouri shore.

Assuming that the City of St. Louis obtains its water from the Mississippi at the Intake Tower of the St. Louis Waterworks, by which it supplies its citizens, about 600,000 in number, with water for drinking and domestic purposes, and that no substantial change in the method of taking said water, or treatment thereof has occurred since January 17th, 1900.

Assuming that the sewage of 1,500,000 inhabitants of Chicago has since January 17th, 1900, been discharged into the Chicago Drainage Canal at Lockport, 291 miles above Grafton,
and that the sewage polluted water from said city and
3692 canal has continually since said day proceeded into the
Desplaines river at Lockport, and that the Desplaines enters into and is tributary to the Illinois river forming a continuous water course from Chicago to the Missouri shore of the Mississippi river and to St. Louis.

Assuming that in the years 1895 to 1902, inclusive, the number of deaths in Chicago from typhoid fever was as follows:

1895,	518,
1896,	751,
1897,	437,
1898,	636,
1899,	442,
1900,	336,
1901,	509,
1902,	801.

And assuming that in St. Louis for the years of 1900, 1901 and 1902, and to this day the percentage of annual typhoid fever mortality to total mortality, has increased about 73 per cent. over and above that of the years 1895, 1896, 1897, 1898 and 1899, and that the typhoid deaths in all towns and cities of over 4,000 inhabitants were about the same per population as those above given on the watersheds of said three rivers during said 3693 time, and that on the ordinary basis of computing sanitary population by taking the aggregate population of all towns and cities of 4,000 or over on the watersheds named, there was a population as follows:

on the Missouri watershed	1,090,832,
on the Mississippi river above Grafton,	1,219,645,
on the Illinois river, exclusive of the Sanitary District of Chicago	385,305,

State what, in your opinion, the sewage from 1,500,000 people of Chicago, discharged into the Drainage Canal, had to do with the increased death rate from typhoid fever in St. Louis as above stated.

Adjourned until 2:00 p. m., same day, Wednesday, May 21, 1903.

3694 Southern Hotel, St. Louis, Missouri. 2:00 P. M., Wednesday, May 21, 1903. Parties met pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

WILLIAM THOMPSON SEDGWICK,

resumed the stand for further direct-examination by Attorney-General Crow, and testified as follows:

Q. (Previous question, asked just before adjournment this forenoon, repeated).

JUDGE JOHNS: We object to that question upon the ground that the assumptions of fact in the supposing part of the question are not in accordance with the evidence already introduced, and not in accordance with the facts as will be hereafter shown and not in accordance with the facts as testified to by Dr. Teichmann, a witness for the complainant.

GENERAL CROW: Is that all the objection, gentlemen? Have you any objection, Mr. Todd?

MR. TODD: Well I join in the objection which Judge Johns made, that part of the assumptions made are not in accordance with the evidence.

A. After having carefully considered the question and the
assumptions which it contains, and in view of my studies
3695 of the typhoid fever statistics of the city of St. Louis to
which I referred in my testimony of yesterday, as stated
at that time, I believe that beyond all reasonable doubt, the principal factor of the annual increase of typhoid-fever mortality of the city of St. Louis since January 1st, 1900—

MR. JEFFRIES: Since January 17th, 1900?

A. No, since January 1st, 1900,—has been due to the pollution of the water supply of the City of St. Louis by the unpurified sewage of the sanitary district of Chicago.

Q. GENERAL CROW: What method of ascertaining that percentage did you use in fixing the increase in typhoid fever in St. Louis?

A. As referred to in my testimony of yesterday?

Q. As referred to in your answer just now and in your testimony yesterday?

A. Just read that question.

Q. (Question read).

A. I used the method known as that of "mortality percentages" in which the typhoid fever mortality is compared with the total mortality of any given district. This method is a common one among sanitarians and students of vital statistics, and is regarded as on the whole the most accurate, inasmuch as it takes no account of the population, always a dubious,—
or usually a dubious,—and uncertain factor, while the
3696 number of deaths is always, or is usually, more readily de-
termined and also more accurate. It is the same method
which I employed in my study of the typhoid fever statistics of the City of Chicago in 1892, and have often employed in my investigations.

Q. Can you state what percentage of increase you discovered from your investigations?

A. As I have already said, the increase in the annual typhoid fever mortality as measured on this basis, has been for the three years, 1900, 1901 and 1902,—let me start that again. Just strike that out.

As I have already said, measured upon this basis, the increase in the typhoid fever mortality during the years 1901, 1902 and 1903, as compared with that during the years 1895, 1896, 1897, 1898 and 1899, was 73 per cent,—

Q. Where at—the location—in St. Louis?

A. In the city of St. Louis, yes sir.

MR. JEFFRIES: Professor, assuming the same state of facts as embraced in the last hypothetical question propounded to you, and considering in addition thereto also the rural population of the water-sheds of the rivers mentioned therein, what way, if any, would it affect or modify your answer to that question?

A. My answer to that question in that case would not be materially modified, for the reason that, as I stated this
3697 morning, the wastes of rural life are, speaking broadly, usually disposed of satisfactorily from a sanitary point of view, upon the areas within which they arise. Occasionally, of course, a rural contamination may produce an epidemic of typhoid fever, but such cases are infrequent and exceptional.

Q. GENERAL CROW: On what class of water-sheds do rural populations usually make the most trouble, where the water-shed is limited or where it is wide in area?

A. The rural population is always of most serious consequence when it is within some constricted, steep-sided watershed, and located near a reservoir or a water course which passes quickly, and without much opportunity for purification, to the consumers of the water below. For example, the Plymouth epidemic that I spoke of this morning; the New Haven epidemic, and the Windsor epidemic, and I dare say others that I mentioned, were of this sort. The Ithaca epidemic also, and those which caused the epidemics at Lowell and Lawrence.

Q. Professor, assuming the fact that the waters of the Chicago Drainage Canal, taken from points in Lake Michigan, at or near the mouth of the Chicago River, were to be conveyed from Lockport to Grafton on the Mississippi river, through a canal or closed conduit so built as to maintain the same velocity of flow provided in the present canal built as far as Lockport, and further assuming the contents of this canal or conduit receive none of the Chicago sewage except such portion as now

3698 reaches Lake Michigan directly, and without entering the Chicago river; do you or do you not consider that the assumed conditions above mentioned would constitute a menace or danger to the inhabitants of the State of Missouri and especially of the city of St. Louis, drinking the Mississippi river water in its raw condition?

JUDGE JOHNS: I object to the question because it is not founded on any fact proven or proposed to be proven in this case, and upon a supposition as to the existance of a state of facts which does not now exist and never can, and which it is not proposed shall ever exist.

THE WITNESS: This does not read right, General.

GENERAL HAMLIN: I don't know whether he has got it right, there, but it was taken down right.

THE WITNESS: It says sewage of the Chicago Drainage Canal.

GENERAL CROW: Just read that again.

(Question read).

MR. TODD: I want to add an objection to the question on the ground that the quantity of water is not stated in the assumption, whether it would be small or large.

JUDGE JOHNS: I desire to add to my former objection that there is no evidence here in this case on which to base the assumption that drainage of Chicago now goes into Lake Michigan, or if there is such evidence, what quantity or amount
3699 there is of such drainage.

GENERAL CROW: Just add in that question there, in order to meet any possible objection of Mr. Todd's,—although I said the waters of the canal; say, "the waters of the drainage canal to the extent of 300,000 cubic feet per minute." Just put that in at the front of the question.

A. As I understand this question, it virtually seeks to discover whether the conveyance of water from the Lake Front of Chicago, and from a population which I have already testified has been estimated at more than a quarter of a million of people now draining directly into Lake Michigan, might be conveyed at the rate of 300,000 cubic feet a minute, through an elongated conduit reaching from Chicago to the mouth of the Illinois River.

In answer to the question I can say, and I will say that in view of all the facts and assumptions, I believe that the arrival of this water—I would rather say that the discharge of the volume of water mentioned, derived as indicated,—would in my judgment be a source of danger to persons using the water for drinking purposes on the Missouri shore and at the City of St. Louis.

MR. TODD: I move to strike the answer out on the ground that the question does not assume that this water empties into the Mississippi river, as he has assumed it in his answer.

3700 GENERAL CROW: Add "into the Mississippi river" in there. Now read the question.

(Question read as revised).

MR. TODD: Then I withdraw my motion.

Q. GENERAL CROW: Professor, will you state whether or not it is within the bounds of human possibility for any competent expert to say that in a period of low water in the Missouri river such as is likely to occur at next Christmas time, a thaw on the Illinois watershed might not endanger the lives of people using the waters of the Mississippi below the mouth of the Illinois, on the Missouri shore and at the City of St. Louis by sending to them in that water, the unpurified sewage of the Sanitary District of Chicago?

A. Suspended sewage?

Q. Yes, suspended sewage—or unpurified sewage.

A. Just read the question.

Q. (Question read).

MR. TODD: I object to the question on the ground that it is not competent for this expert to pass judgment upon the ability of some other expert, because no question can be conceived which is without the bounds of expert opinion.

GENERAL CROW: Go ahead Mr. Sedgwick.

A. I don't believe that it is.

Q. Why?

3701 A. Because in my opinion no competent expert either can or will say that any means exist at present by which such unpurified sewage can be warded off from the people on the Missouri shore and the citizens of St. Louis under those conditions.

CROSS-EXAMINATION BY GENERAL HAMLIN.

Q. Professor, Sedgwick, I believe you stated you resided at Boston?

A. Yes sir.

Q. Connected with what school?

A. The Institute of Technology.

Q. As a teacher?

A. As a teacher.

Q. Of what subject?

A. General Biology, Sanitary Science and Public Health, the history of inductive sciences; bacteriology of water and sewage, municipal sanitation, etc.

Q. Have you ever been employed by any municipality in establishing a system of waterworks or rendering opinions in regard to the same?

A. Yes sir.

Q. You have?

A. I think so, yes sir.

3702 Q. To what extent?

A. Well, not to any great extent in establishing a system of waterworks.

Q. But you are familiar with that subject, are you not?

A. Fairly familiar. I think I am very familiar with waterworks, but not so much the establishment or construction.

Q. No, but with the systems?

A. Yes, I think I am quite familiar with those.

Q. You have given that matter some study, have you not?

A. Yes sir.

Q. What system of purification from your study and experience, do you recommend?

A. It depends very much upon circumstances.

Q. Well, take where the water supply is taken from running streams?

A. I should recommend filtration in some cases and storage in others.

Q. What do you mean by storage?

A. The accumulation of water in great reservoirs so that it may be kept for some time before it is used.

Q. Without any treatment of it?

A. Without any treatment of it.

Q. Mere storage?

A. Mere storage.

3703 Q. How large size reservoirs?

A. The larger the better.

Q. Well I know, but take a city like St. Louis for instance?

A. I shouldn't recommend storage for St. Louis, probably. That would have to have filtration.

Q. That would be your judgment, filtration?

A. That would be my judgment.

Q. Filtration?

A. Yes sir.

Q. Now the last question that you answered, as I understand it, was the elimination of all the sewage of Chicago except such as might be carried into Lake Michigan and then discharged from Lake Michigan into the Drainage Canal and thence into the Desplaines River and thence by a conduit into the Mississippi river?

A. Yes sir.

Q. And that you would consider a menace and danger to the water supply of St. Louis?

A. I should.

Q. I didn't hear all of your testimony but I have looked over some of it, but as I understand it, as an expert and scientist and sanitarian, you are of the opinion that there is more or less pollution in all running streams?

3704 A. Pollution as distinct from infection, yes.

Q. And where sewage is carried into running streams, then there is infection?

A. Then there is usually infection.

Q. And that in your judgment exists in the streams to which you have testified in this case, and from the examinations and observations that you have made?

A. Such for instance as the Mississippi and the Illinois?

Q. And the Missouri?

A. Yes sir.

Q. Do you know how much population St. Louis had in 1900?

A. Yes sir.

Q. Will you state it please?

A. 575,200.

Q. Now how much sewage, if the sewage of St. Louis were discharged into the Mississippi river, according to the estimates that sanitarians use, how much sewage would be discharged into the Mississippi River from St. Louis, assuming that they do discharge their sewage into the Mississippi water?

A. That depends largely upon the consumption of water. I do not at the moment know just what that is.

Q. We will take the consumption of water that is generally used in cities; I don't know whether that varies or not.

A. Unfortunately that varies from 50 gallons up to 500
3705 per capita per day, but perhaps it might do for your purpose to say 200 gallons a head, and just multiply this number by 200.

Q. I think perhaps that is high; say 150 gallons?

A. I mean taking that amount of sewage—

Q. Yes, I know what you mean, 150 gallons to the head.

A. Yes sir.

Q. Now do you know the number of towns within a distance of 350 miles below St. Louis on the Mississippi side?

A. No sir.

Q. On the Mississippi on the Missouri side?

A. No sir, I do not.

Q. Well, if the cities or towns below St. Louis on the Missouri side of the Mississippi river, should take their water supply from the Mississippi River, they would be affected by the sewage of St. Louis, would they not?

A. If they took it unpurified, yes.

Q. I say, unpurified.

A. You say on the Mississippi side?

Q. I mean on the Missouri side. They would, would they not?

A. They would unless the dilution was so great that the sewage of St. Louis was lost in the volume. I should suppose that they would be affected.

Q. You do not attach much importance to dilution alone, do you?

3706 Q. Do you?

A. Very great.

Q. You do?

A. Yes sir.

Q. Well, take the town of St. Genevieve, that is near by; that would, according to your idea of the effect that the sewage of Chicago would have, necessarily this sewage of St. Louis would affect a town within a distance of 100 miles, wouldn't it?

A. It seems to me that is simply a question of self-purification and time and dilution.

Q. It would be the same proposition?

A. The same proposition exactly.

Q. As you would have in Chicago?

A. Yes, certainly. The same factors would hold there.

Q. I mean the same factors, but whether the same results would follow, you do not undertake to say?

A. No sir.

Q. To what extent have you studied the amount of sewage discharged into the Missouri river?

A. Only in a general way by considering the number and position of the cities above.

Q. Well, it is a large amount of sewage that is discharged into the Missouri river isn't it?

3707 A. It is.

Q. And in the Mississippi above the mouth of the Illinois, isn't there?

A. Also, yes sir.

Q. Then, according to your statement in regard to this conduit, I will ask you this, if it is not true in your opinion as an expert that if you were to eliminate all of the sewage from Chicago and take the Illinois, with the sanitary district out, and its tributaries, and the Mississippi and its tributaries, and the Missouri, and combine those waters as they are combined above St. Louis, that you would have a badly polluted stream?

A. I should say unhesitatingly that the water is and would be under such circumstances a polluted water.

Q. And that the chances are that it would be dangerous to the people of the city of St. Louis and the towns below?

A. Certainly.

Q. And you believe that the best process of making this water a potable water here, would be by filtration?

A. Well, I haven't given any study to that subject particularly, but broadly speaking—

Q. That is your judgment?

A. That is my judgment at the present moment, yes.

3708 Q. Well, then, so far as the purification of the water of St. Louis is concerned at present, and rendering it fit for domestic use here, for drinking purposes, the expense of doing that would be the same, whether the sewage of the sanitary district was in it or not, wouldn't it?

A. The probable cost of doing it at present, owing to the conditions on the various rivers and at Chicago would, I should suppose not be materially affected by the addition of the sewage of Chicago to the Mississippi River as those rivers are and as that sewage is today.

CROSS-EXAMINATION BY JUDGE JOHNS.

Q. In your study of sanitary questions, have you considered the chemistry of waters and the chemical analysis of it?

A. Only in a general way. I am not a chemist, but I am somewhat familiar with it.

Q. Do you regard yourself as a bacteriologist?

A. Yes sir.

Q. Do you consider the chemical examination of water as of any importance in determining its condition for drinking?

A. Yes I do under some circumstances.

Q. Do you under all circumstances?

A. No sir.

3709 Q. Can you determine from the chemical examination of water, so far as you know, the source of the pollution of the water, if the chemical examination reveals that it is polluted?

A. No sir, not as I understand the question.

Q. Does the chemical examination of water enable one to determine whether or not the water is polluted?

A. Sometimes it does and sometimes it does not. If the water is grossly polluted, no great skill is required. If it is only slightly polluted it might require a very high skill, or such skill might even be altogether unavailing.

Q. Have you examined the evidence here with reference to the chemical constituents in the Missouri river?

A. Not closely at all; I have looked over some of it.

Q. From what you know in a general way of the condition of the waters of the Missouri river, would a chemical analysis determine whether they are polluted?

A. Do you mean sewage polluted?

Q. I am using a general term.

A. I should think that at times it might and at times it might not.

Q. You think then that a chemical analysis of the waters of the Missouri river taken from daily samples for one year, might determine that at some times it is polluted, and at other times that you couldn't tell whether it was polluted?

A. Yes, that is it exactly. It would of course depend 3710 upon where the samples were taken from, largely.

Q. From your general knowledge of the waters of the Mississippi river, is it possible by a chemical examination, to determine whether they are polllted?

A. I should make the same answer as before, that at times it would be and at times it might not be.

Q. Could it be determined by chemical analysis, whether the waters of the Missouri or the Mississippi were infected?

A. No sir—by chemical analysis?

Q. Yes, by chemical analysis?

A. No sir.

Q. Have you studied bacteriology?

A. Yes sir.

Q. And have practiced the examination of waters for bacteria?

A. Yes sir.

Q. And in your office of teacher are continually doing so?

A. More or less. Less of late years. I used to do a good deal of it.

Q. Do you regard yourself as a bacteriologist?

A. Yes sir.

Q. Can you determine from a bacteriological examinatio of running water whether it is polluted?

A. Sometimes I can—polluted you say; not infected?

Q. Yes, polluted?

A. Sometimes I can and sometimes I cannot.

3711 Q. Are you familiar with the bacteriological examinatio of the Missouri river which has been given in evidenc here?

A. In a general way only.

Q. Can you determine from your examination of the evidence as to the bacteriological examination of the waters of th Missouri, whether the Missouri is a polluted stream?

A. From that alone you mean?

Q. Yes?

A. I suppose I could, but I very much prefer to do it i other ways. I could at times, I say, but when common sens comes in I like to use that.

Q. Can you determine from a bacteriological examinatio of the waters of the Mississippi as shown by the evidence in thi case, whether the Mississippi waters are polluted?

A. I will make the same answer; sometimes I might an sometimes I might not; sometimes I could and sometimes I coul not.

Q. Could you determine from the joint consideration of th chemical analysis and the bacteriological examination of th waters of the Missouri as shown in evidence here, whether suc waters were polluted?

A. A joint examination would be perferable to the indivi ual and separate examinations, but I should have to make th same answer—sometimes I could and sometimes I cou not.

3712 Q. And the same answer as to the waters of the Missi sippi?

A. The same as to the Mississippi.

Q. Then a chemical analysis and bacteriological examin tion of the waters of the Missouri and the Mississippi rivers, a not of themselves sufficient to determine the qualtities of t waters at all times for drinking purposes?

A. I should not consider them as competent at all times.

Q. Do you believe in the purification of water by its flowing in streams?

A. I believe in a purification of it, in a certain purification of it, or rather an uncertain purification of it.

Q. Do you believe that the waters of running streams, sewage polluted, purify themselves by the flowing of the streams?

A. To a large extent and under favorable circumstances, yes.

Q. Would the rapidity of the flow have anything to do with the degree of purification?

A. I think so, sir. As I have repeatedly said on direct-examination, it is the time-factor which comes in, and that would be profoundly modified by the rapidity of the flow.

Q. If in any given river there were numerous reaches where the flow of the water was extremely sluggish, would such reaches contribute to the purification of the waters as they passed through?

A. Of the flowing water?

Q. Of the flowing water?

3713 A. For the time during which the sluggish movement persisted, undoubtedly, yes.

Q. If the flow of waters in streams was checked by occasional dams, would that instrumentalily contribute to the purification of the water?

A. Yes sir.

Q. If the reaches of a river were in great numbers, of a sluggish current and in such a river there were dams which retarded the flow of the current, would these reaches and dams contribute to the purification of the water by any other means than sedimentation?

A. I think so, sir, they certainly would.

Q. In what other ways?

A. By detaining the germs present, and thus favoring their dying out if they lay there long enough to die out. The mere detention, apart from the sedimentation, would be a factor, in this same time-factor I have so often spoken of.

Q. If near a given river there were numbers of small lakes or ponds which filled up during the over-flow or high water of the river and which contributed to the flowing stream of the river when the water subsided, what effect would they have upon the purification of the stream?

A. Accepting the conditions given, they would contribute to the purification of the stream.

3714 Q. In the proportion in which the supposed lakes and ponds afterwards contributed to the current of the stream?

A. In a general way, yes.

Q. Wouldn't they also contribute to its purification in the time of floods by the lack of current or of flow over the surface which afterwards contained the pond, because the water there is sluggish?

A. It certainly would contribute to the purification of that part of the water which was over the lakes, but whether it would contribute to the stream as a whole during such periods—well, that factor would contribute undoubtedly to the stream as a whole. Whether the stream as a whole would really be purer or not depends on other things.

Q. If there was a flood in the Illinois river, in which the waters overflowed the banks and spread out in the bottoms, which continued for four weeks, and in the bottoms there is no perceptible current of the river and the waters in the bottoms when the river subsided flowed back again into the river, they would by standing upon the bottoms, be considerably purified, would they not?

A. Those portions which stood upon the bottoms would certainly be purified somewhat.

Q. Wouldn't it be purified so far as the sewage is concerned, very considerably? 3715

A. The water would, yes. The bottoms would not.

Q. Are you familiar with the general physical characteristics of the Illinois River?

A. I am, yes.

Q. By what means?

A. Studying from maps, and talking with men who have been up there.

Q. Not from any personal examination?

A. No sir.

Q. Do you know then that the bottom lands or overflowed lands of the Illinois river are very considerable?

A. I have understood so, yes sir.

Q. Do you know that in its overflowed stages, the Illinois River, when confined within its banks, is a sluggish stream?

A. In a general way, yes. I know that there are several dams and at times much so-called slack water.

3716 Q. JUDGE JOHNS: Do you know also that independent of the dams that in reaches of the river which are not affected by the back water of the dams, there is in ordinary stages of the Illinois river, in a great many places, and for long distances, a very slight fall?

A. Yes sir, I understand that.

Q. Do all of these things aid in the purification of the waters of the Illinois river?

A. They certainly do, sir, under ordinary conditions.

Q. Have you any opinion as to the amount of dilution of sewage polluted water which will make it reasonably safe for drinking purposes?

A. Well sir—oh, the dilution—the amount of dilution?

Q. Yes?

A. Merely?

Q. Yes?

A. I should say that no amount of dilution,—mere dilution—well now, I won't say that, because, of course—erase my answer please. The amount of dilution that would make it reasonably safe? That is a pretty hard proposition. I don't think that I can answer that except to say that a very large dilution is required to make it reasonably safe.

Q. If to one gallon of sewage from the City of Chicago there was added 100 gallons of good water, would that 3717 water be reasonably safe for drinking purposes?

A. No sir.

Q. If there was added to that one gallon of sewage 200 gallons of water would it be reasonably safe?

A. I find it very difficult to take the term "reasonably" in this question. I should not consider it safe. I hardly know what to call reasonably safe.

Q. Do you consider that there are any degrees of safety for drinking purposes of sewage polluted water?

A. Yes sir, as a practical proposition I have an opinion on that matter.

Q. What is it?

A. It is this, that as far as possible, all sewage should be kept out of drinking water, but I should be unwilling to take the ground that one microbe in the Mississippi River or one spoonful of sewage in the Mississippi River at Minneapolis, would make it impracticable for drinking purposes—or unfit for drinking purposes, at New Orleans. There are degrees of danger undoubtedly, but I don't feel able to define those degrees.

Q. Do you think that one gallon of sewage at Alton would pollute the waters of the Mississippi River at the Intake tower so as to make them unsafe for drinking?

A. It might, if it was typhoid infected.

Q. It might?

3718 A. It might. I don't say that it would; it might.

Q. Do you think that one gallon of sewage at St. Charles put into the Missouri river, and infected with typhoid germs would render the waters at St. Louis unsafe for drinking purposes?

A. It might.

Q. Would you as a general proposition, knowing that one gallon of sewage from St. Charles, infected with typhoid germs had been put into the Missouri River, pronounce the waters o the Missouri at the intake tower, unsuitable for drinking purposes, or unsafe?

A. Do you mean without purification—oh, at the intak tower. Yes, I shouldn't want to drink it and I shouldn't recommend it to others to drink if I could help it.

Q. Well then, you would consider it unsafe?

A. I should consider it unsafe, yes sir, as a general proposition, provided of course that I didn't know when that gallo was coming along. If it was put in last year and I was to g there now, it would be a different thing, but assuming—

Q. Assuming that you knew a gallon of sewage, infected with typhoid germs, was put into the water, into the channel of the Missouri river at St. Charles, at a certain time, and that you knew when that water would reach the intake tower, you
3719 would consider the water at the intake tower at the time of the arrival of this water from the Missouri, as unsafe for drinking purposes, would you?

A. As a general proposition, yes sir.

Q. Would you say the same thing as to the same amount of infected sewage at Kansas City?

A. Kansas City is—I forget how many miles away?

GENERAL CROW: Between four and five hundred miles.

A. Yes, between four and five hundred miles. Well sir, I should not want to drink the water at that time when it was expected here; but I should not be willing as a sanitarian, to say that that was unsafe for drinking.

Q. Then you are a little more particular as to yourself than as to the community in general?

A. No, but others are not as particular as I am.

Q. Well, having an equal regard for others, as for yourself, you would say that the gallon of sewage put into the waters of the Missouri at Kansas City, was unsafe, would you not, at the intake of St. Louis?

A. Assuming that the water was to be taken at the intake at the time that the arrival of that polluted water might be expected, yes sir.

Q. If a gallon of sewage were put into the Missouri river at Omaha, Nebraska, and you knew when that water would
3720 arrive at the intake tower at St. Louis, would you consider that water unsafe for drinking purposes if the sewage were typhoid infected?

A. I don't know how far that is. It is farther away,—it is six or seven hundred miles.

Q. 676 miles?

A. Of course it is hard to draw the line in cases of this kind, as it is always in sanitary matters, and if that were to come only once, I do not suppose that I should fail to consider the water arriving ordinarily as unfit for drinking purposes—I am not answering the question. Erase my answer and give me the question.

Q. (Question repeated).

A. A good deal would depend on the flow of the Missouri at that time; if it were in flood I should probably not consider that unsafe.

Q. If the Missouri was at its ordinary stage?

A. If it was polluted, I understand—

Q. If the Missouri river as you have heard of it and know it, was at its ordinary stage, would you consider that water dangerous?

A. I don't know whether I should or not, I should have to think that over. There comes a time in all questions of this kind when it is a very difficult matter to decide, and I don't
3721 know just where I should draw the line between water that I should drink with a gallon of sewage, and water I should not. I should want chemical and bacterial analyses of the water and I should want to know the conditions more than I now do,—the conditions of purification, **en route**, and a lot of things which are not included in that question.

Q. Taking your knowledge of the Missouri river, whatever it may be, and assuming that a gallon of sewage was put in that river at Omaha, Nebraska, when the river was at its ordinary stage, and that the waters in which the sewage was injected, typhoid infected sewage, arrived at the St. Louis intake; would you consider that water unsafe for drinking purposes?

A. I should like to look up the flow of the Missouri, which I do not recall now. (Witness refers to papers).

Am I obliged to answer the question?

Q. Yes, that is what you are here for?

A. I think I should consider that unsafe.

Q. If, it the year 1901 there were 13 deaths from typhoid fever at Lincoln, Nebraska; 58 in Kansas City; 6 in Omaha, 12 in St. Joseph, and 5 in St. Charles, and the typhoid bacilli in each of these cases, went by some means into the waters of the Missouri river, and some of them arrived at the intake in St. Louis, to which one of the six towns would you prefer to ascribe the bacilli arriving at the intake?

3722 A. I guess I will have to ask to have that question repeated, so I can get the number of cases, which I did not begin to take down.

Q. (Question repeated).

GENERAL CROW: That refers exclusively to typhoid rates in this city?

JUDGE JOHNS: No sir, it means everything that this witness knows.

GENERAL CROW: I simply want to understand the question myself. We have put in the record all the typhoid statistics that we have been able to gather; now we put in the rate here in St. Louis and in Chicago; now you come along and you assume that there are so many cases in a certain number of towns, and then you assume that some of those bacilli will reach the intake tower.

JUDGE JOHNS: The bacilli arriving at the intake tower.

GENERAL CROW: You ask him which one he would say would arrive there first; is that it?

JUDGE JOHNS: Now I have the right to assume to this expert, General Crow, any question that I see fit.

GENERAL CROW: Well, I have a right too, as opposing counsel, to ask you a straight plain question to understand your proposition; there is no doubt about that.

JUDGE JOHNS: I have the right to say that the question must stand upon its own interpretation.

3723 GENERAL CROW: Read the question once more.

(Question read.)

GENERAL CROW: I want to interpose an objection on the ground that the question, considering the testimony heretofore introduced regarding the typhoid death rate in the entire water-shed tributary to the intake tower of the St. Louis waterworks, so far as complainant has been able to gather the same, and considering the testimony in chief of the witness, it is entirely unintelligible, and for that reason it should not be asked.

A. The question asks to which of these I would ascribe it. As a scientific man—or, I should like to ask if I am obliged to assign them to anyone—

Q. No sir, you are not obliged to do anything you don't want to.

A. I have had to do some things I didn't want to do, already.

GENERAL CROW: You can give whatever answer you please. It is your answer and you are responsible for it, that's all.

JUDGE JOHNS: It is my question and your answer; we have joint proprietorship in the result.

A. Then erase anything that I may have said in answer, as it was only a question in regard to the bearing—

In answering this question I should have to say in the first place that I should not have any preference in the matter,
3724 except such as came from study of the facts laid down, and a weighing of the probabilities as to the origin of each of these—as to the part played by each of these. Other things equal, the nearer the infection, the greater the probability of derivation from that source. The question, however, is a very complicated one, inasmuch as it assumes a large number of cases in the upper regions of the river, and a small number at St. Charles, 47 miles away, as I believe. I should expect, as a result of the consideration of all the circumstances, that I should be entirely unable to assert any preference in the matter or to determine from which of these places the bacilli had come.

Q. From which place is it more likely they would come?

A. Those that were to be found—assuming that some were found?

Q. Yes sir.

A. These were cases or deaths?

Q. Deaths?

A. I think you stated cases, did you not?

Q. No, I think I stated deaths.

A. I think they would be more likely to have come from Kansas City.

Q. Why?

A. Because that would mean 580 cases in Kansas City,
3725 and 50 cases in St. Charles, in round numbers, assuming a mortality of ten per cent, and the likelihood of one getting into the intake at the Chain of Rocks, would, I believe, be

greater, all things considered, from 580 cases at that distance, than from 50 cases at the other distance, or from these other numbers at their respective distances. It is a matter, however, almost entirely of guess work.

Q. Do you guess that the chances would be as 5 to 58 in the above supposed question, with reference to Kansas City and St. Charles?

A. No, I took into consideration the distance of Kansas City and the dilution and other factors, en route. I shouldn't make that figure—

Q. In what proportion would you calculate the probabilities as to Kansas City with 58 deaths, and St. Charles with five deaths, as to the arrival of the bacilli from those cases of typhoid fever in the Missouri river, at the intake?

A. I should not expect to be able to calculate it with any precision, but I should like to look up the distance from Kansas City—

GENERAL CROW: It is 406 or 407 miles.

JUDGE JOHNS: Kansas City is 403 miles—taken from your assumed question—

GENERAL CROW: 408.

THE WITNESS: Now if you will read the question again.

3726 (Question and answer read.)

A. (Continuing.) Finding this distance to be 403 miles, I should be still less willing to make the calculation, believing it would be of very little value.

Q. Are you not extremely uncertain as to whether the bacilli in the supposed case at Kansas City, would arrive at the intake at all?

A. In a supposed case?

Q. Yes in a supposed case.

GENERAL CROW: In the supposed case.

JUDGE JOHNS: Well, I said in the supposed case of 58 deaths.

A. I thought you meant in the case of typhoid fever, supposing there were 58 deaths there.

Q. Yes sir.

GENERAL CROW: Now, are you talking about St. Charles or Kansas City.

JUDGE JOHNS: Kansas City.

A. Kansas City. I think I am not extremely uncertain. I could not say positively that they would arrive, any of them.

Q. Could you say positively that none would arrive?

A. No sir, I could not.

Q. Then you don't know whether they would or not?

A. No, I do not.

Q. Have you an opinion as to whether they would or not?

3727 A. Yes, I have.

Q. What is your opinion?

A. I believe they would.

Q. How far is the longest distance, either in reported cases or in your own personal experience, in which it is either known or supposed that typhoid bacilli have been transported by running waters, and caused infection in some water supply?

MR. JEFFRIES: Do you mean how long in distance or in time?

Q. How long in distance?

A. Known or supposed—I think the greatest distance known, that I now recall, is that of the Detroit epidemic, in which it was well established—apparently well established—that the infection was conveyed for about 57 miles. The assumed and supposed distances, however, are very much more than that. For example, at Pittsburgh, I myself supposed and assumed that typhoid fever germs might have come as I said in by report, from Oil City, which was 113 miles, or even, as I remarked, from points much more remote. That is, there are cases on record where the sewage of towns above, apparently influences the typhoid death rate of towns below, and where no epidemic has ever happened or been traced conclusively fastening the one upon the other.

Q. Do you place any limit upon the distance a typhoid bacillus may travel in water and live, and at the end of the 3728 journey be virulent?

A. Not if the rate of travel is fast enough.

Q. Well, take into consideration now all that you know or have heard in reference to the transporting by running waters, the typhoid bacilli, would you be willing to place a limit to the distance which those bacilli might travel, and at the end of their journey, be of sufficient strength and vitality to communicate typhoid fever to people who drank the water?

A. In the present state of the subject I should not be willing to set any limit, but the real problem would be not so much the distance as the time. If the stream were a quiet, sluggish stream, the distance, or limit which I should perhaps be willing to fix provisionally, might, in a certain case, be very much shorter than it would in a swift stream.

The Allegheny river was a swift stream; those 113 miles were covered quickly. It was a stream with a great deal of scour, so that if those deposits occurred—it was a babbling stream most of the way, scouring the stones, and while I was willing to believe that the typhoid fever in that case came as far as 113 miles, in another case with a slow stream I would not be willing to suppose that they had gone 50 miles.

Q. With reference to the Allegheny river, you expressed 3729 an opinion that typhoid bacilli might have come from Oil City. On what did you base that opinion?

A. On the rate of flow of the river, largely, and on my knowledge of the life history of the typhoid bacillus.

Q. Now is there any such thing as accurate and certain knowledge as to the life history of the typhoid bacillus?

A. Oh yes.

Q. In running water?

A. Yes sir, I think there is.

Q. Well now, what is that accurate knowledge?

A. Well, accurate,—I suppose that perhaps we should not agree on the word "accurate," but in saying "Yes," I meant by accurate, within certain limits there is accuracy. I know for example, that they may live to pass from Lowell to Lawrence—nine miles. That was as clearly proved as any proposition in nature that is not mathematical—in fact I don't know but it was a mathematical problem.

Q. Taking the Lowell and Lawrence case, your conclusion was that the waters of Stony Brook—the waters of the Merrimac River, were polluted by a single case of typhoid fever, was it not?

A. No, there was one principal case upon which I laid the greatest amount of the blame, but I mentioned the brother of
that case, and then there were others. There were all told
3730 about forty cases in North Chelmsford, which is a little
town on Stony Brook. Not all of them, however, contaminated the brook, so far as I could discover.

Q. How many did you discover that contaminated the brook?

A. I think I found about eight or ten—it seems to me, it was; some worked in the wool scouring factory, and that before they went to bed, in the early stages of the epidemic, I think there were three women who worked there, who clearly contaminated the brook, and as I remember it, there were three or four others, so that all told, I think there were somewhere between half a dozen and a dozen who contaminated the brook so far as I could discover. Others may have done so of course.

Q. Well, your examination of the cases at Lowell and Lawrence, excluded every other possible consideration of source of contamination than that which you discovered?

A. I tried to, yes.

Q. You didn't consider that it was possible that typhoid infected urine or dejecta might have been put in the reservoir or waterworks of either one of the places?

A. No sir.

GENERAL CROW: Read the last two questions and the answers. I don't think that the witness understood your second question.

3731 THE WITNESS: I think I understood that. You meant
maliciously put in?

Q. Yes, or any way.

GENERAL CROW: I don't understand your question.

THE WITNESS: I should like to modify my answer.

GENERAL CROW: I want to know whether or not you want that answer from the witness; if you do, I want to be able to ask him a question on re-direct examination.

JUDGE JOHNS: I am satisfied with the witness' answer.

GENERAL CROW: Very well.

THE WITNESS: I should like to—where I said "I tried to," I should like to add, "and I believe I did."

JUDGE JOHNS: So that there was no other possible source for the contagion in the Merrimac river, or of the infection of the Merrimac river, or the epidemic of typhoid at either Lowell and Lawrence, than those which you discovered and to which you attribute the two epidemics?

A. No other source for the excess. Of course Lowell and Lawrence had always been typhoid-ridden cities, because they drank the polluted water of the Merrimac river, but I think the epidemic, meaning by that the rise above the ordinary—I believe that of that there was no other source.

Q. You would not consider it possible that in the waters of Stony Brook, or the Merrimac River, or the reservoirs or wells, or whatever they have at Lowell and Lawrence, there 3732 might have been injected typhoid bacilli by some malicious person?

A. Yes, it is possible.

Q. Then if it is possible, the Lowell and Lawrence cases do not afford an accurate knowledge of the life history of bacilli do they?

A. The Lawrence end would— No, but assuming that he did the same thing at Lawrence, no sir, that would not, under those circumstances. WILLIAM T. SEDGWICK.

Adjourned until 10:00 A. M., Thursday, May 21, 1903.

3733 Southern Hotel, St. Louis, Missouri. 10:00 a. m., Thursday, May 21, 1903. Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

WILLIAM THOMPSON SEDGWICK resumed the stand for further cross examination by Judge Johns, and testified as follows:

THE WITNESS: Before we begin, Judge Johns, may I ask to have the last question and my answer read to me? I have not seen any report of it, and I had an impression that it was not perfectly clearly answered.

JUDGE JOHNS: It is not. I was just going to call your attention to it. I think we understood it at the time, but it does no appear so on the paper.

THE WITNESS: If I may just strike out the word "but"—

JUDGE JOHNS: No, excuse me. You may modify it. We want the record to stand. You may explain your answer if you see fit.

GENERAL CROW: Wait a minute. Just let me ask you a question, Professor.

Q. Is that your answer correctly reported?

A. I think it probably is; yes, sir.

3734 Q. Well, then you may just add any explanation to it that you wish.

A. I simply wish to make it perfectly clear, that a malicious infection of the Lowell reservoir would not have invalidated my conclusion in regard to the Lawrence epidemic.

JUDGE JOHNS: Now, from Lowell to Lawrence is nine miles?

A. Yes, sir.

Q. Along the Merrimac river?

A. Along the Merrimac river.

Q. That community is thickly populated—there is a very dense population between Lowell and Lawrence?

A. Oh, yes—it depends upon what you mean by dense.

Q. Well, more populated than the rural districts of Missouri, for instance?

A. Possibly; but it is a rural district on the whole.

Q. People live along the banks of the river?

A. More or less.

Q. And are as subject there to disease as anywhere else?

A. I suppose so; in rural communities.

Q. Yes. And as subject to typhoid fever as anywhere else?

A. As anywhere else in rural communities, yes, sir.

Q. Now, is it within the limit of probabilities that persons living near the Merrimac river between Lowell and Lawrence might have had typhoid fever?

3735 A. Yes, sir.

Q. And that their dejecta might either be thrown into the river or washed in?

A. Yes, sir.

Q. So that it is within the limit of probabilities that the contagion of Lawrence might as well have been from something occurring along the banks of the river as from the contagion of Lowell?

A. No, sir; because Lowell is a city of 80,000 people and was full of typhoid fever, while we, after careful inquiry, learned of no cases along the line between the two—

Q. Were there no cases, absolutely, between the two towns near or on the banks of the Merrimac river?

A. I don't know.

Q. It is possible that there might have been?

A. It is.

Q. Having the great epidemic in Lowell would add very strongly to the probability of there having been cases between Lowell and Lawrence?

A. Not at the same time of the epidemic in Lowell. If the people along the banks had got the typhoid from Lowell it would have come later.

Q. Yes, owing to the period of incubation?

A. Yes, sir.

3736 Q. How long after the epidemic in Lowell was the disease in Lawrence so marked?

A. As I recall it, the largest number of deaths in Lowell was in November—

Q. Of what year?

A. Of 1890, and in Lawrence, in January of 1891.

Q. When did you examine the facts as to Lowell?

A. About the first of January—between Christmas and January 1st, and aftewards:

Q. Had the disease in Lowell then subsided?

A. No, sir. It was subsiding, but it had not subsided.

Q. You arrived on the ground, then, after the greatest degree of mortality?

A. Yes, sir; that is the greatest degree of mortality at Lowell.

Q. How long had the disease been in epidemic form in Lowell when you arrived, two months?

A. Something like that.

Q. The examination which you made there was by inquiry among physicians?

A. In Lowell, you mean?

Q. Yes, sir?

A. It was in a variety of ways, partly by inquiring among
physicians, partly by a study of the cases reported to the
3737 Board of Health, partly by personal visitation of the sick
people in their own houses,—house to house visitation,
as we call it.

Q. How long after the dejecta of these two people on Stony Brook, was it that you examined the facts as to Lowell?

A. There were more than two people of course, on Stony Brook.

Q. But the two conspicuous ones, the two brothers?

A. The two principal ones, how long after, do you mean, was it—

Q. Yes, after their dejecta was cast out upon the ground, until you made the examination?

A. I don't recall exactly. It was perhaps somewhere between two and three months.

Q. How did you ascertain that their dejecta was thrown upon the ground?

A. It wasn't thrown on the ground; it was thrown into the stream.

Q. Well, how did you ascertain that it was thrown into the stream?

A. By finding—by talking with their families, and with the operatives with whom they worked in the machine shop, or foundry, and with the officers, the employers of these men in the foundry.

3738 Q. Then your information upon the subject was what
lawyers call hearsay?

A. I don't know what lawyers may call it; it is the usual method of investigation in such cases.

Q. Of course as to the facts you have no personal knowledge?

A. None other than I have stated, but in all these epidemies the investigation is done after the fact.

Q. Yes?

A. It is necessarily so, because the cases have occurred long—and sometimes a long time before, and the investigator arrives on the scene after the trouble has begun.

Q. Of course the investigator makes the best investigation possible under the circumstances?

A. He should do that certainly.

Q. And he draws his conclusions not from personal observation of the facts which he afterwards reports, but from a belief in the existence of those facts as reported to him?

A. I should say that he draws his conclusions from facts which he himslef ascertains to be true to the best of his knowledge and belief.

Q. Well, in ascertaining, for instance, that the fact was that the dejecta of the two brothers on Stony Brook were thrown into the brook, you relied upon the statements of persons who purported to know that fact?

3739 A. I did; yes, sir; and also upon the obvious fact that the man was said by the physician,—one of these men was much more important than the other,—that this one man was said by his physician to be suffering from typhoid fever, while he was working in the factory or machine shop; that he told his physician that he spent a good deal of the day in this privy; and that his fellow workmen told me that they saw him going to the privy constantly.

Q. And relying upon these statements you believed them to be true?

A. I did, yes.

Q. And therefore reported that the dejecta of the man through the privies and otherwise, went into the Merrimac river and Stony Brook?

A. Yes, sir.

Q. You then ascribed the contagion in Lowell entirely and solely to the dejecta of people ill of typhoid fever on the Merrimac or Stony Brook, above Lowell?

A. I ascribed the increase of typhoid fever in Lowell during the so-called epidemic chiefly to that source.

Q. To what did you ascribe the regular and ordinary stage of typhoid fever in Lowell?

A. I ascribed that largely to the steady use or regular use by the inhabitants of that sewage polluted water coming
3740 down the river from towns and cities above, which poured their sewage into it.

Q. Now, typhoid fever may exist almost any season of the year, in any given community?

A. Yes, sir.

Q. It is more generally prevalent in the fall and early winter than other times?

A. Broadly speaking, that is true.

Q. But any condition which may produce it may exist at any time of the year?

A. It might.

Q. And frequently does?

A. And frequently does.

Q. Did you learn how these two brothers contracted typhoid fever?

A. That was not clearly shown.

Q. Did you investigate with reference to it?

A. I did; it was supposed that they had got it in Lowell.

Q. So, in regard to Lowell and Lawrence you came to the conclusion, and so reported, that the cause of the increase of typhoid fever in the two cities, was the infection of Stony Brook and the Merrimac river, from people whose dejecta had been put into them?

3741 A. I reported that in my opinion the principal part of that increase which was regarded as the epidemic, was due to that source.

Q. While you did not take into consideration at all the possibility, owing to the prevalence of typhoid fever in Lowell, and about there,—that the disease might be communicated and continued and spread by any other means than by water infection?

A. Yes, sir; I took into consideration various circumstances and after having taken into consideration all the circumstances. I came to the conclusion already mentioned.

Q. That that was the principal one?

A. That that was the principal one.

Q. Did you come to the conclusion that that was the sole one?

A. No, sir; I think not; I did not—change that. I did not.

Q. What kind of a disease is typhoid fever, contagious, infectious, or what other term do you apply to it?

A. It is commonly called an infectious disease.

Q. It can be contracted in other ways than by the drinking of infected water?

A. Yes, sir.

Q. Is it possible that the bacillus of typhoid fever might be in the air?

A. It is possible.

Q. Is it probable that it is?

3742 A. Only to a limited extent and under peculiar circumstances.

Q. What are the peculiar circumstances?

A. The peculiar circumstances are these: If typhoid material by which I mean the material containing typhoid fever germs, is dried up, pulverized and blown into the air, it is possible that those germs may find their way into the mouths of persons who shall from that source contract the disease.

Q. Well, the material in which typhoid germs are, may be dried up, pulverized and blown away when exposed to the influence of the sun and air?

A. Yes, sir; may be.

Q. And then typhoid fever could be contracted by breathing the air in which there were those germs?

A. It is believel that it has sometimes been so contracted, but such cases are rare, and we don't ordinarily attribute—sanitarians I will say, do not ordinarily attribute any great amount of typhoid fever to this source.

Q. Now, the germs of typhoid fever may be carried about on the wings and feet of flies, may they not?

A. Yes, sir.

Q. And typhoid dejecta exposed as food or prey to these animals, or these flies, would be resorted to, and any human dejecta is infested with flies?

A. Often so, yes.

3743 Q. And they might and they frequently do carry the infection of typhoid fever to persons whose water supply is pure?

A. They may and they probably do to a certain extent, but in my opinion only to a much smaller extent than some other vehicle, such as water or milk.

Q. How does the typhoid germ get into milk?

A. In a variety of ways.

Q. It does not come through the animal, the cow?

A. It is not believed to come through the animal; broadly speaking it enters milk in the form of dirt,—dirty hands, dirty utensils, dirty water, dirty milk-men.

Q. Did you investigate the character of the milk supply of Lowell?

A. I did, with great care.

Q. With great care?

A. And found that I could not account for the epidemic reasonably on that ground.

Q. Did you find that the milk supply was absolutely excluded as the cause?

A. Broadly speaking, yes.

Q. Did you find that it was impossible that the typhoid fever in Lowell should have come from the milk supply?

A. I did.

Q. That you learned also by the examination of persons
3744 or the firm's engaged in the business of supplying milk to
Lowell, and from the health officers?

A. I learned it by a careful consideraton of the milk supply of Lowell; by a study of the vital statistics of Lowell during the epidemic, by actual inquiry at the houses of victims as to the source of their supply, and by bringing together all of these facts and focusing them upon the general character of the epidemic.

Q. And by assuming that the facts learned by this inquiry were true?

A. Yes, sir.

Q. Well, if there was in any city an epidemic of typhoid fever, could you tell by the characteristics of the disease itself, independent of other physical and local considerations, whether it was occasioned by milk or infected water?

A. You mean by the condition of the patient?

Q. Yes?

A. No, sir; I could not.

Q. Could anyone?

A. I don't believe that anyone could.

Q. When you made an examination of the water supply at Pittsburgh, did you go to Oil City?

A. No, sir—Yes, I did; but not further than to pass through.

Q. You made no examination as to the conditions in Oil
3745 City from which, or to which you thought it probable
that typhoid in Pittsburgh, was to be attributed?

A. I made no personal examination of conditions in Oil City.

Q. Do you know whether there was in Oil City an ordinance of the city, requiring that all dejecta and urine of typhoid people should be destroyed?

A. I do not. I do not now recall that there was any such ordinance.

Q. Do you know whether there was any such—

A. May I fix that answer? I do not now recall that I had any knowledge of any such ordinance.

Q. Do you know whether or not there is any such ordinance in the City of Chicago, for instance?

A. I do not.

Q. When you made the examination in Pittsburgh, was there then an epidemic of typhoid fever in Pittsburgh?

A. Yes, sir. Was there, did you say?

Q. Yes, at the time?

A. Read the question, please?

Q. (Question repeated.)

A. There was no great epidemic; there was a considerable number of cases, and typhoid fever in Pittsburgh, had long been high, so that one might say there was a continuous epi-
demic, but there was no such great increase in the number
3746 of cases over the ordinary, as there was for example, in
Lowell.

Q. Had there been previous to that a very great increase of typhoid in Oil City?

A. I don't remember.

Q. Do you know whether previous to that and during the continuance of the high rate of typhoid fever in Pittsburgh, there was an excess of typhoid fever in Oil City?

A. I cannot remember.

Q. Do you now remember whether you investigated with reference to that?

A. Let's see. I think I did.

Q. Believing now that you did, or thinking that you did, do you now remember whether there was such an excess there?

A. No, I do not.

Q. In reporting upon the condition of affairs at Pittsburgh, and the remedy to be applied, did you exclude all considerations except the existence of the Allegheny river, and the flourishing towns above Pittsburgh?

A. I did.

Q. And without knowing whether there was typhoid fever in any one of those towns, or an excessive rate of typhoid fever in any one of those towns, you ascribed the typhoid fever in Pittsburgh, to the infection of the Allegheny river from towns above it?

3747 A. I do not remember whether there was any above or not; whether I based my conclusion upon that partly or not; but in any case even supposing there had been an excess up there I should have come to the same conclusion, because they were pouring regularly a certain amount of sewage into the stream.

Q. Then all that is necessary to make the waters of a running stream unsafe, as to typhoid fever, is the fact that the sewage of populous places above, is poured into the river?

A. Broadly speaking, yes.

Q. Without regard to the fact as to whether there is or had been typhoid fever in any of the populous places above, where the sewage was poured into the river?

A. Yes sir.—Read that question.

Q. (Question repeated).

A. Yes, in taking this thing as an ordinary proposition, and taking the question as a broad one, we may always assume that sooner or later there will be in the sewage of a populous city or town, germs of typhoid fever.

Q. When was the epidemic of typhoid fever or the great increase of typhoid fever in Detroit?

A. I forget the exact date; I think it was 1892 or 1893.

Q. You did not personally examine the situation there?

A. No sir.

Q. Your knowledge of that case is taken from books and 3748 publications with reference to it?

A. And from conversations with persons personally familiar with the circumstances.

Q. And accepting these statements made by these persons who were personally familiar with it, and the statements in books and papers which you have read, as true?

A. Yes, certainly.

Q. To what point above Detroit was this infection ascribed?

A. Port Huron.

Q. Is that on the same side of the river as Detroit?

A. I think it is; I am not very familiar with the topography there.

Q. And how far away?

A. I think it is about 57 miles; I don't remember accurately.

Q. But in the neighborhood of fifty or sixty miles?

A. I think so.

Q. Are you familiar with the St. Clair River?

A. No sir.

Q. Have you ever been upon it?

A. No sir.

Q. Ever fish in the St. Clair Flats?

A. Never.

Q. Are you aware that the St. Clair river is a passageway for the water of three Great Lakes on their way to Lake Erie?

3749 A. Yes sir.

Q. And that it is a very swift stream?

A. I have understood so, yes.

Q. That on each side of it there is a very flat country full of marshes?

A. I don't know about that.

Q. That in these marshes and dwelling about them there is a large population of fishermen?

A. I have no knowledge of that.

Q. That the St. Clair flats is dotted with club houses, the resort of all classes of people during certain seasons of the year?

A. No sir, only a very general knowledge. It seems to me that something of that kind was referred to in the paper which described the epidemic.

Q. *And didn't the papers which described the epidemic,* and the persons to whom you talked, exclude all these considerations from the determination as to the cause of typhoid fever in Detroit?

A. I understand that they did.

Q. Then they took the most easily ascertained, and most prominent possible cause and ascribed to it and it alone, the entire increase in sickness?

A. I presume they did; that would be good sense.

Q. What other place have you personally examined–
3750 at what other place where there has been an increase
of typhoid fever, or an epidemic of it, have you made personal examinations?

A. Other than Lowell?

Q. Other than Lowell and Lawrence.

A. Lowell, Lawrence and Pittsburgh?

Q. And Pittsburgh?

A. Chicago, Newburyport, Massachusetts; Windsor, Vermont; Ithaca, New York; Marlborough, Massachusetts; Provincetown, Massachusetts; Bondsville, Massachusetts; Springfield, Massachusetts. Those are all that I recall at the moment. There are several other places which I could name if I could send on and get–

Q. How long a time did you use in investigating typhoid fever in Chicago?

A. How long was I in Chicago?

Q. Yes, investigating the question of typhoid fever?

A. Oh, perhaps a week.

Q. What kind of an investigation did you make there?

A. I made very little investigation in Chicago, excepting to study the general situation; but I secured documentary evidence–the reports of the Board of Health, and compared the typhoid fever death rate in Chicago with that in other cities. I also inquired into the water supply and milk supply, and other possible factors, and then, bringing the results all together arrived at my conclusion jointly with Mr. Hazen, 3751 who was able to put some of the facts into my possession.

Q. You arrived at the conclusion that the excessive rate of typhoid fever in Chicago was due to the fact that its sewage at that time was largely poured into the Lake and into the Chicago River?

A. I attributed the excess—the abnormally high death rate from typhoid fever in Chicago, after excluding as well as I could, other considerations, to the infection of the water supply of the city of Chicago by the sewage of the city of Chicago.

Q. Has there been in your knowledge a time when the City of Chicago had what might be called an average rate of typhoid fever?

A. No sir; on the contrary, I discovered that typhoid fever had nearly always been very high in Chicago.

Q. At times when it was lower than the general average, of a series of years, to what did you ascribe the typhoid fever in Chicago?

A. Partly at least to other factors than water pollution.

Q. What other?

A. The ordinary factors which contribute to cause a certain moderate amount of typhoid fever in cities generally.

Q. What are they?

3752 A. These are occasional pollutions—occasional limited pollutions of milk supply; occasional limited pollutions of food supply; occasional limited pollutions of the air, and occasional or constant limited pollutions of the water.

Q. To all of these—

A. As well perhaps—no, I will stop there.

Q. To all of these any time when the rate was below the average —

A. Excuse me, may I add one clause there?

Q. Yes sir.

A. And to similar minor factors.

Q. Well, when the average rate of sickness in Chicago, or when the sickness in Chicago from typhoid fever was less than an average of the rate for Chicago for a number of years, you didn't attribute that solely and entirely to the infection of the water supply?

A. Read that question please.

Q. (Question read).

A. That amount, do you mean?

Q. Yes?

A. No sir.

Q. When it rose above the average and far exceeded it, you attributed it to the water supply?

A. As a rule, and as a general proposition, yes.

Q. In Chicago, did the excessive rate of illness from ty-
3753 phoid fever arise suddenly, or did it it ascend gradually
from an average?

A. It was a very irregular—erase that please. The curve or line of typhoid fever in Chicago has been a very irregular one, always high, as compared with cities having a very low, or as compared with most cities having purer water supplies, but occasionally rising rapidly to much higher points.

Q. When it did rise rapidly to much higher points, to what did you ascribe the rapidity of the increase?

A. I do not now remember to what I may have ascribed it in each individual case, but generally speaking and as I remember I was able to—or I was led to believe that these rapid and unusual rises were due to the washing out of sediment from the Chicago river into the lake, and a contamination of the water supplies,—an unusual contamination of the water supplies by such dislodged sediment or other fecal materials—other polluting materials, rapidly conveyed to the intakes.

Q. Did you compare the statistics, or examine the statistics as to the rain-fall in Chicago and find that such rain-fall was coincident with—or that the increase of typhoid fever actually followed a violent rain-fall, and a sudden rise in the Chicago River?

A. As I remember it, it did so in some cases, and enough to confirm us in the general belief.

Q. Now at Newburyport, Windsor, Marlsborough, Pro-
3754 vincetown, Bondsville and Springfield, you made such ex-
aminations after the disease was most prevalent, as you
have described in these other places?

A. As a rule, yes sir. Sometimes the examination was made while the disease was still going on.

Q. Did you make bacteriological examinations of the waters of the Merrimac River at the time of the epidemic in Lowell?

A. As I remember it, I did.

Q. Did you make bacteriological examinations of the waters of the Merrimac between Lowell and Lawrence?

A. I don't think I did at that particular time.

Q. Have you ever done so?

A. I would like to add to that. I don't think I did. I don't remember. Have I ever, did you say?

Q. Yes, have you ever?

A. Between Lowell and Lawrence?

Q. Yes sir?

A. Yes, I have made examinations.

Q. When.

A. Well I don't remember. Along about that time. It may have been a year later. I was constantly engaged in work at a laboratory in Lawrence, and we frequently took samples up the river and I might even have made at that time, or had them made by my assistants.

3755 Q. You have no distinct recollection now as to a particular instance?

A. No. In a general way we were keeping watch of the river.

Q. Did you make bacteriological examinations of the waters of Stony Brook?

A. I think I did, yes sir.

Q. Frequently?

A. Yes, at that time rather frequently, if I remember rightly.

Q. Did you discover any pathogenic germs in the water?

A. No sir.

Q. Did you ever in your bacteriological examinations of water, discover pathogenic germs in running water?

A. This question is difficult to answer on account of the word "pathogenic." If we understand by the word "pathogenic" capable under all conditions, or under any conditions—

I beg pardon, I will change that—If we understand by the word "pathogenic," capable of producing disease at any time, nearly all germs are probably pathogenic,—Excuse me, I want to change that to "some time."—Capable of producing disease at some time,—nearly all bacteria might be called pathogenic. If you mean by pathogenic germs, those of the well defined infectious diseases, then I did not discover any.

Q. And never did in any bacteriological examination which you ever made?

3756 A. Of a stream?

Q. Of the waters of a running stream?

A. And never did under those circumstances.

Q. Now you have been asked here as to water-borne—

A. Excuse me one moment. Will you kindly read my answer about pathogenic. I want to get that just straight.

(Question and answer read).

Q. Of course you mean by that, Professor, in samples of running water which you have examined?

A. Certainly.

Q. You have spoken here of water-borne diseases, what did you mean?

A. By this term we generally understand diseases which are capable of being transmitted by water, which are capable of being conveyed from one person to another, from one community to another, by means of water as a vehicle.

Q. What are those diseases?

A. What?

Q. What are the names of those diseases?

A. Some of them are typhoid fever, Asiatic cholera,—or two of them I will say are typhoid fever and Asiatic cholera. As to others it is probable that some may be conveyed in this way, but the evidence is far less clear than it is in regard to these two diseases.

3757 Q. These are the only two diseases which you regard as water-borne diseases, from a clear preponderance of the evidence?

A. I should rather say these are the two diseases in which the evidence is so clear and unmistakable that there can be no shadow of doubt in regard to the conclusions drawn.

Q. Well, Asiatic cholera is an infectious disease?

A. Yes sir.

Q. And may be communicated by the air or by any of the other means by which typhoid fever may be communicated, may it not?

A. It is so believed, yes sir.

Q. And Asiatic cholera in the City of Chicago is of very rare occurrence, is it not?

A. Fortunately so, today. Formerly, however it prevailed very seriously in Chicago.

Q. Once?

A. I don't remember how many times.

Q. Do you remember whether it was ever serious at all. or existed at all, except in 1848 or 1847?

A. I don't recall, but I am under the impression that it was pretty serious there.

Q. Now the danger of Asiatic cholera in the water supply of St. Louis, coming from Chicago, is extremely remote, is it not?

3758 A. Let us have that question.

Q. (Question repeated).

A. No sir, I should not say that; I should say that inasmuch as Asiatic cholera is by no means an exterminated disease, it might turn up in a population like that of Chicago at almost any time, and that the danger to the citizens of St. Louis under the existing conditions, would be grave.

Q. But it would depend entirely upon the existence of Asiatic cholera in some other place than the City of St. Louis and above its water supply?

A. I don't understand the question.

Q. Danger in St. Louis would depend entirely upon the existence of Asiatic cholera in some one of the streams from which St. Louis derives its water supply?

A. Not wholly. There would be danger of conveyance by train, and in articles of merchandise, but I should think that the most omnipresent, the most serious danger, would be from the water supply.

Q. The danger by train and by the handling of merchandise infected, must then be added to the possible cause of typhoid fever anywhere?

A. I thought you were speaking of Asiatic cholera.

Q. Asiatic cholera and typhoid fever anywhere?

A. Repeat the question.

3759 Q. (Question repeated).

A. Yes sir.

Q. If a person in San Francisco, whose hands were infected by typhoid fever germs,—they might arrive I presume in St. Louis, and spread the disease here?

A. Yes, sir, that is a possibility.

Q. Or if he carried such germs in his clothes?

A. Yes sir.

Q. Or if some person engaged in packing goods in San Francisco should have typhoid infection on his hands, might it not be communicated to people in St. Louis or New York?

A. Yes sir.

Q. Or London?

A. Yes sir.

Q. Or St. Petersburg?

A. Yes sir.

Q. Or Moscow?

A. Yes sir.

Q. Or Karthoum, by way of Moscow and Nijni Novgorod?

A. Yes sir.

Q. As far as that?

A. I think so, if he didn't wash his hands en-route.

Q. If he didn't free himself from the infection, he might convey it around the world?

3760 A. I see no reason why not.

Q. And out of their habitat and away from anything in which they are known to essentially support themselves, these germs would live?

A. Not indefinitely.

Q. Well, in a trip around the world?

A. Oh, a long time.

Q. In a trip around the world, say sixty days?

A. I believe that they might.

Q. That would be true also of the germs of Asiatic cholera?

A. I understood that you were speaking of typhoid fever.

Q. I was, but I am asking you now as to Asiatic cholera.

A. I should be unwilling to say that Asiatic cholera might not also be conveyed around the world under certain circumstances in other things than in water.

Q. Say in clothes of persons traveling or in merchandise that went around the world?

A. Yes, and a great deal would depend of course upon the time and conditions to which the germs were subjected, but in the present state of our knowledge I see no reason why they might not be transmitted even as far as that in those ways and under favorable conditions of course.

Q. In other words it is not an impossibility?

A. I do not regard it as an impossibility.

3761 Q. Would you regard it as a probability, of a person traveling with ordinary speed around the world, that he might arrive at his departure point with the same bacilli of typhoid upon him as he started with?

A. No sir, I should expect that he would leave some en route.

Q. Would he arrive with some of them?

A. Oh, I don't know about that; he might and he might not.

Q. He might and he might not; it is very uncertain?

A. Very uncertain. The chances are that he would not. If he was a respectable person and traveling around the world he would probably take a bath and change his clothes.

Q. And strike a sleeping-car porter.

A. And he wouldn't carry them any such distance.

Q. Are the bacilli coli communis common in the waters of Massachusetts?

A. Yes—in the waters of Massachusetts, did you say?

Q. The running waters of Massachusetts?

A. That is a very difficult proposition to answer, because the running waters of Massachusetts vary very much. They are common in the sewage polluted waters of Massachusetts, or some of them.

Q. Most of the running waters in Massachusetts are sewage polluted are they not?

A. No sir, oh no; we have a great many running brooks that are quite unpolluted.

3762 Q. Is there any geographical limitation to the existence of coli communis in sewage polluted waters?

A. Geographical?

Q. Yes.

A. Not so far as I am aware.

Q. So far as you know, wherever there is sewage polluted water there may be the colon bacillus.

A. Wherever there is a sewage polluted water, there either may be now or may have been the colon bacillus.

Q. Is it a pathogenic germ?

A. The colon bacillus?

Q. Yes?

A. Not in the sense in which I define pathogenic, although it is put down in some of the books as capable of producing disease, and no doubt under certain circumstances is capable of producing disease. By that I mean it is not the cause of a well-defined, specific disease, or is not recognized as the cause of a well defined, specific disease.

Q. Is it the cause of ill-defined and general diseases?

A. Not to my knowledge.

Q. Why then is it a menace to the city of St. Louis?

GENERAL CROW: I object to the question for the reason that it assumes that the witness has testified that the colon bacillus is a menace to the city of St. Louis.

3763 JUDGE JOHNS: Yes he has, at least I have so understood him. Are the bacilli coli communis a standing menace or floating menace, or any other kind of a menace to the city of St. Louis?

A. I do not regard them so in themselves, inasmuch as every citizen of St. Louis has millions of them in his alimentary canal.

Q. Did you intend to be understood as testifying that the bacilli coli communis were dangerous to the health of the city when found in the waters supplied to the inhabitants of the city for drinking purposes?

A. Not in themselves.

Q. In what connection or relation would they be in order to become of themselves a menace?

A. They would have to be capable of producing disease.

Q. And as to whether or not they are, you are not certain?

A. I have already stated that I do not believe that they produce any specific well-defined disease, or any general and ill-defined disease.

Q. So that we may acquit the coli communis of being a pathogenic germ?

A. For practical purposes, yes.

Q. Would you acquit them in the Illinois River of being pathogenic?

3764 A. For practical purposes, yes.

Q. You have testified here about certain percents, if I understood you, of typhoid fever, based upon urban population in cities or towns of 4,000 or more inhabitants, have you?

A. The percents were not based upon urban population. I have testified to certain percentage mortalities of typhoid fever in St. Louis, in their probable relation to typhoid fever in such communities as you describe.

Q. What is the process of calculation by which you arrived at such percentages.

A. The typhoid fever mortality?

Q. Yes sir.

A. By comparing the total number of deaths from typhoid fever with the total mortality from typhoid fever, or rather with the total mortality from all diseases; or, in other words, typhoid deaths to total deaths.

Q. Do you mean to say that the typhoid deaths of the city of St. Louis since the year 1900, considered annually are about 73 per cent increased over the deaths from the same disease before?

A. Not exactly that. What I did say was this: that the increase in the average percentage mortality from typhoid fever in St. Louis, reckoned annually since January 1st, 1900, was about 73 per cent above the average percentage mortality
3765 during the previous five years.

Q. Now how did you arrive at that calculation and conclusion? I want to know the process by which you arrived at your conclusion of 73 per cent?

A. Certainly. I shall be very glad to explain that. I arrived at it in this way. In the annual reports of the Board of Health of this city will be found a table giving the total number of deaths for the number of years indicated excepting one or two which are not yet in the report, and also giving the number of typhoid fever deaths in another column, as here for instance (referring to Board of Health Report). The total annual mortality is shown in one column, and the total annual number of typhoid fever deaths in another column. If now we figure the percentage which the typhoid fever deaths were of the total number of deaths, we obtain what is known as the percentage mortality of typhoid fever for each year.

Q. That is to say as to the year 1891, the total deaths being 9530 and the deaths from typhoid being 165, the percentage mortality is as 165 to the other figure, 9530?

A. Yes sir, exactly; that is right, sir.

Q. Then you took the annual deaths for five years and the deaths from typhoid fever for five years prior to 1900, added each together and divided by 5 to find the average?

A. No, I first computed the percentage mortality for each
3766 of the five years in the way already described, and for
each of the three years following January 1st, 1900, in the same way. Added the five together and divided by 5; added the three together and divided by 3, and compared the result obtained in one case with that obtained in the other case, finding that the sum obtained in the last case, namely since January 1st, 1900, was 73 per cent higher than that obtained in the first case.

Q. As a matter of mathematics if you had added together the number of deaths in St. Louis from all causes for five years prior and the number of deaths from typhoid fever for five years prior to 1900, and then divided those sums by 5 and then added together the total number of deaths for the three years, succeeding, and including 1900, from all causes, and the total number of deaths from typhoid fever for the same period, you would have arrived at the same result, 73 per cent.

A. I don't know.

Q. Is there a rule or practice or custom among scientists of arriving at the mortality percentage in the way you have just described?

A. Is it a custom?

Q. Yes?

A. Yes sir.

Q. Is that a matter of convenience, or is it an arbitrary rule?

3767 A. There are various ways of getting at the relative efficiency of any particular disease as a death agent. The quickest way, undoubtedly, is to compare the total number of deaths from that disease, with the population ascertained or estimated. This is what is known as the "death rate" from that disease, but as I stated in my direct examination this usually involves,—and always excepting in the census year,—a consideration of population which is estimated rather than ascertained, and even based on the amount of population, is always a more or less uncertain factor. On the other hand I believe, and it is generally held, I think, that inasmuch as the total number of deaths is ascertained in most cities with considerable precision, and the deaths from any specific disease are also ascertained with similar precision, that a truer way of ascertaining the real facts is by the method which I have described as that of mortality percentages. This however, is not absolutely exact, because the reports of physicians cannot be absolutely relied upon and the recording of the deaths cannot be absolutely relied upon. It is a choice between two methods, and on the whole I prefer this one and have usually employed it.

Q. The calculation of a mortality percentage upon the basis of an urban population of 5,000 or more is an arbitrary rule or custom among sanitarians, isn't it?

A. Mortality percentages would not be computed upon
3768 the basis of population.

Q. At all?

A. At all.

Q. Well, the computation of percentages as to deaths or as to typhoid fever, based on population, only urban population, and in excess of 4,000, is an arbitrary rule, is it?

A. I do not exactly understand the question. If you mean is the assumption of 4,000 as a basis of urban population for the purposes of sanitary comparison, I should say that it is somewhat so. The basis varies. The United States census for example, classifies urban population as cities and towns of 8,000 and more, and in different sections of the country, the definition of urban population may vary somewhat, but the estimate of 4,000 as a basis for the estimate of urban population is probably a pretty fair basis.

Q. At any rate, it is an arbitrary basis?

A. More or less so.

Q. Now are you aware that on the Illinois river, the Mississippi and the Missouri, there is a very large population residing actually upon the banks, and actually upon the water, engaged in fishing largely, sometimes in agricultural pursuits, and all of whose sewage goes directly and without any intermediation whatever, into the rivers?

A. I have no doubt that that is essentially the case
3769 although I should hesitate to say "a very large" population as compared with urban communities. I should say rather, a considerable number of people.

Q. I was not instituting a comparison with either urban or other rural populations, but that a very large number of people do live upon the banks of these rivers, exist because of these rivers, and have all of their household sewage cast directly into the river?

A. I have no doubt of that fact.

Q. And you have no doubt either that among such a population, there may be, and probably is, a great deal of typhoid fever?

A. I have no doubt that there is a considerable amount of typhoid fever.

Q. Have you any doubt that the typhoid fever among such a population, on the basis of population, is very largely in excess of the rate among urban population along the same rivers?

A. That is a question that I should find it hard to answer. I should suppose that it might be greater in some cases and less in others. It would be hard to make a general statement to that question.

Q. Assume on the Illinois river 5,000 people living upon its banks directly and upon the water in house-boats, and if you place 200,000 people in what you call the urban population, wouldn't the percent of deaths from typhoid fever among

3770 those 5,000 calculated on the basis of 5,000, be very much larger than among the 200,000 urban population calculated upon the basis of 200,000?

A. That would depend entirely upon the conditions in which the 200,000 were living. If they were living in well ordered cities with good water supplies, probably I should expect, or I would say, that the amount of typhoid fever among those on the river would be larger, but if the urban population were affected, or supplied with bad water, and were living in unwholesome conditions, I do not believe the rate would be very different.

Q. That is to say, if the urban population upon the Illinois river obtained its water supplies in as crude and raw state as what we will call the river population for convenience, the per cent of mortality would be about equal between them?

A. Speaking of mortality percentages, I should expect a little higher fatality among the river population, because of the lack of medical care and the lack of proper feeding and so on and so forth, but this would be fatality rather than mortality, as we speak technically of those subjects.

Q. Wouldn't the percent of typhoid fever deaths, in this assumed river population, to that population be larger than the same per cent of the assumed urban population, having the same water supply?

A. I should expect that it would be somewhat.

3771 Q. Now in calculating these things about which you testified yesterday or the day before, you excluded all of this river population?

A. I don't understand the question.

Q. In calculating upon the basis of urban population, you excluded all of this river population from your percentages?

A. I didn't calculate any percentages on urban population. I did not calculate any percentages of typhoid fever; what I did say was that the addition of Chicago to the urban population upon the river above St. Louis, was an addition of about 63 per cent—; as far as I am aware, I didn't make any statement about the percentage of mortality in any urban population except St. Louis.

Q. Well, that was the percent to which I referred. I will say frankly I didn't have it very clear in my mind. Now, in calculating that percent, you excluded all the rural population in arriving at the per cent of population which the city of Chicago or the Drainage District bore to the total urban population. You excluded all the river population and all the rural population?

A. I simply took the facts as given in the census. The method of taking the census I am not familiar with in this part of the country. Whether they counted this river population that is floating about, into cities at the time they came
3772 around to take the census or not, I don't know; but I suppose quite a lot of them would be counted in, that would be loafing in the city, and a little later they would be out of the cities, and if they happened to be in the cities at the time the census was taken I suppose they would be counted in the urban population very largely.

Q Well, suppose that we assume that the census taken in Illinois and Missouri from precisely the same rule and precisely under the same regulations as in New York or Massachusetts, then this river population would be excluded in the computation of the urban population, wouldn't it?

A. No sir, I don't see that. It seems to me that this river population as I understand it, is a movable population, and on any one day there a lot of the men who on another day appeared on the river, might be in town, and they might give their living place or lodging house as one of the boarding houses or lodging houses along the river where they frequently stopped. I should think a lot of them might get counted as a matter of urban population. Of course a lot of them would not, but I do not think we can take all the men who are working on the river and living in houses for this purpose part of the year and so on, and exclude them from the urban population. I think we can take quite a percentage of them, but I don't know what that percentage would be.

3773 Q. But you don't know whether actually anything like that is done or not?

A. I don't know anything about it.

Q. That is a mere surmise?

A. That is a mere surmise,—No, it is not a mere surmise. It seems to me it is common sense.

Q. That assumes, doesn't it, that this river population has not sense enough to tell where it does live?

A. That is true, no doubt; if it is the same kind we have around the wharves in Boston.

Q. Now doesn't the rural population, so-called, contribute very largely to the pollution of streams in whose water-sheds they reside?

A. To the pollution, yes, using that word as distinct from infection.

Q. If some person of the rural population, who happened to have an infectious disease, he might contribute to the infection of the river, might he not?

A. He might, yes, under certain circumstances, but as a rule he would not. As I stated on my direct testimony, that is to say, taking the rural population by and large, broadly speaking, taking the whole amount of rural population, such a case would be comparatively unlikely, to infect streams. It might of course happen.

3774 Q. That is, comparatively unlikely in reference to persons in the city having drainage?

A. Yes sir.

Q. Would he be just as likely to contribute to the infection of the stream as a person living in some city or town who had not access to sewage?

A. Not quite, because in un-sewered cities and towns the system of removal of night soil from cess-pools and the like, often leads to the deposit of these things, or this thing,—or infectious materials, I will say,—leads to the deposit of infectious materials in such a way that a large quantity of the material is washed into the stream. The point is that in the rural population you have got units which are sufficient unto themselves, lead their own lives, and their wastes are usually safely disposed of on their own property. Take an un-sewered town on the other hand and after a time there comes a period when things have got to be got out of that town, or often this is the case at any rate, and these infectious materials or pollutions are removed in large masses at one time carried off away from the town, and very likely deposited somewhere where they get washed into the water courses.

Q. Do you think that process prevails in the villages and towns along the Illinois and Mississippi and Missouri Rivers, having a population of less than 4,000 inhabitants?

3775 A. I don,t know about that. I think it might in some cases.

Q. As to the population and the people living on the banks of the Missouri and Mississippi above Grafton, and the entire Illinois, that is purely a theory?

A. It is a fact as I have seen it in my experience.

Q. On these rivers in this country?

A. No sir.

Q. Then as to these rivers in this country at this time, that is purely a theory, isn't it?

A. Why, I don't know that it is purely a theory. It seems to me that it is a likelihood in many cases, or in some cases at any rate, though of course the conditions may be different here and it may not be anywhere near as true here as it is in my own experience.

Q. Isn't it a fact in sanitary science, that the pollution of rivers by what we term the rural population, is a very large factor in the consideration of the amount and degree and kind of population?

A. Of pollution, yes.

Q. But scientifically, considering infections, you do not take it into account?

A. Not so much, because in the rural population, infection to begin with, is less common, and in the second place, owing to the time factor which is apt to come in, in the partial 8776 purification of the pollutions, the infectious materials may be destroyed.

Q. Do you know whether the mortality percentage as to the rural, not the urban population along the Illinois river, from typhoid fever, is greatest in the urban or in the rural population?

A. I have no knowledge of those facts.

Q. And no means by which you can arrive at an opinion upon that point?

A. Yes, I have made studies of this question in general, and I believe that in strictly rural communities on the whole, taken in a large way, the death rate from typhoid fever is much lower than it is in cities and towns unless these be in an unusually good santiary condition. Whether that applies to this particular area or not I cannot say, but I believe that it does.

Q. On what basis do you arrive at that belief?

A. By having made computations of the rural population of Massachusetts with the urban population, defining rural and urban in my own way. Taking as I said strictly rural communities and strictly urban communities.

Q. What is a strictly rural community?

A. By strictly rural community, as I use the term I mean a farming town without any little manufacturing end to it, or any river running through it upon which there is traffic, 3777 or anything of that kind. I mean a strictly farming community.

Q. Then when you say a strictly rural population, you do not mean all the population on the watershed of a river which is in communities of less than 4,000?

A. Decidely not, for the purposes of this discussion.

Q. We will take an unscientific and common rural population, meaning by that a population not in a village or city of 4,000 inhabitants or more, including in rural population, or rather that is not included in cities of 4,000 inhabitants or more. Does not such a population enter very largely into the consideration of all sanitary questions in regard to the pollution of rivers?

A. It certainly does.

Q. Doesn't it certainly also enter very largely into the consideration of the infection of rivers?

A. Yes sir.

Q. In arriving at the conclusion that the city of Chicago added 63 per cent to the urban population of the watershed of the Missisippi, not excluding the rural population as I have defined it in the preceding question, and all the rural population where it was not in a village or city of 4,000 inhabitants or over?

A. Yes sir.

Q. Have you any means of determining what percent the rural population of the Illinois river watershed, adds to 3778 the population of the watershed of the Mississippi river?

A. I think I have. I don't know that I can lay my hands on it at this moment, but I think the data for such a comparison exists.

Q. Have you now in your mind approximately what that per cent is?

A. No, I have not.

Q. You have no definite idea of the time in which the typhoid bacilli do actually live in the waters of running streams, have you?

A. Oh yes, I think I have very definite ideas.

Q. Have you arrived at that idea from the investigations which you have made and your studies upon that subject?

A. Yes sir.

Q. Did you ever trace a typhoid bacillus by its effects from the place and time of its origin until it ceased to exist in any given case?

A. I do not understand what you mean by origin?

Q. Well, from the time they were thrown into the running water?

A. Until they ceased to exist there in that running water?

Q. Yes?

A. Yes, I think we have a certain amount of evidence of this sort.

Q. I am asking of your personal experience.

3779 A. Repeat the question.

Q. (Question repeated)?

A. Yes, I think I have. I think for example from the Newburyport epidemic I obtained a certain amount of evidence as to the time the bacilli in question remained in the flowing stream. On the other hand I do not of course know how long they may have remained in the sediment at the bottom of that stream.

Q. What was your evidence in the Newburyport case?

A. My evidence was of this character, I traced a small epidemic in Newburyport to a larger epidemic in Lowell, and I knew by the history of the disease in Lowell and in Newburyport, when I had a right to assume that the germs in the flowing water had gone by. Still, I must confess, I do not know how long they remained in the sediment of the river, if any were deposited.

Q. How long was the time in the Newburyport case during which the typhoid bacillus, in your opinion existed in the river or flowing stream?

A. As I recall the case the river appeared to have been infected from this source for about a month, but that of course doesn't mean that any one bacillus necessarily was a month in passing down the flowing stream. It may have been that
fresh infections occurred in Lowell, or it may have been
3780 that some that had come early and had been sedimented
or deposited on the bottom of the river at first, afterwards
came down, but the epidemic as I remember it, lasted about one month, the period of infection, so that the stream was infected during that period.

Q. And perhaps continuously from the sewage of Lowell?

A. There was reason to believe that it was constantly more or less infected from the sewage of Lowell.

Q. How much time elapsed from the flow of water from the sewers in Lowell to the intake or whatever it may be at Newburyport?

A. I did not determine.

Q. What is the distance?

A. I should say about 30 miles, but it is very likely 35 or 40.

Q. Is the Merrimac a rapid stream?

A. In places it is rapid.

Q. Interrupted by dams?

A. There is one dam between Lowell and Lawrence.

Q. And a sluice way around that time?

A. And there is I say, another element there, the stream is a tidal stream at Newburyport.

Q. Is it at Lowell?

A. No. sir.

3781 Q. Is it a tidal stream far above Newburyport?

A. Yes sir, quite a little distance.

Q. And with the receding tide the current would be accelerated in that part?

A. Yes sir.

Q. Well, what is your best judgment as to the time that it took the typhoid bacilli injected into the river from the sewer of Lowell to reach the intake at Newburyport?

A. The epidemic as I remembered was in August, and that was probably a period of low water in the river, in which case the Lawrence dam practically made a lake or pond, reaching back nearly to the Lowell sewers, I think I made an estimate at the time but I do not remember now what it was. I should suppose that in view of the season of the year and the probable condition of the stream, it might have been several days.

Q. Well, two or three?

A. I should say not less than three probably.

Q. Nor more than five?

A. I shouldn't suppose it would be more than five or six, but I really don't know.

Q. Then assuming that there was no other cause for the contagion or infection at Newburyport, than the infection of the river by the sewage of Lowell, you conclude that the typhoid bacillus in that particular case, actually did live in the 3782 waters of the Merrimac river for the time necessary for its transmission from the sewers at Lowell to the intake at Newburyport?

A. I have no doubt of that fact and I so reported my conclusions in reporting upon the epidemic.

Q. Now have you any other evidence upon the question as to the time that the typhoid bacillus may exist in running waters?

A. Do you mean myself personally?

Q. Yes, personally?

A. I think I have already spoken on my direct examination of the effect of the Lawrence reservoir in holding back the germs very materially in the great epidemic, where the period was considerably longer. The germs came down nine miles and were pumped presumably into the service reservoir of the city of Lawrence, and by comparing the time elapsing between the corresponding periods of the two epidemics in Lowell and Lawrence, and knowing the custom of the water department in holding the water in the reservoir, I have estimated that they may have lived in the water for between one and three weeks.

Q. And covering a distance of how many miles?

A. In that case the distance was only perhaps ten miles.

I don't mean to say that this is the only evidence that I have in this direction. From my studies at Pittsburg I was led to 3783 conclude that the germs of typhoid fever might live in running water for some days, at any rate, and come from a very much greater distance than was the case in Lawrence or Newburyport, but as I have said the element here is time, not distance I believe, mainly.

Q. Assume that a person willfully and with malice aforethought cast the germs of typhoid fever into the river with the knowledge that such typhoid germs would produce the death of some unknown person if he drank of that water and that such death under the law would be murder, and that the person charged with throwing the bacilli into the river, was charged with that consequent murder and that he must be shown to be guilty beyond reasonable doubt, if you were on the jury would you have convicted that man on the evidence you have adduced here?

MR. JEFFRIES: That charge is not in the petition, but it is very apropos of the case.

GENERAL CROW: I want to interpose an objection to it. Not but what I want the question answered, but for the reason that is so wholly foreign to any action that a man who would have intelligence enough to handle typhoid bacilli, would be guilty of, that it renders the question thoroughly inpracticable, and for the further reason that there has not been and will not be and cannot be introduced in evidence by the re- 3784 spondents any proof of the assumed fact, or in any manner tending to prove directly or indirectly any such state of facts.

JUDGE JOHNS: In reply to which I beg to say that it seems to me that it is pertinent upon the witness' understanding of the words "reasonable doubt."

Q. (Question repeated).

A. I do not understand what you mean by the evidence I have adduced here.

Q. Such as you have given here in your examination in chief, and your cross-examination as to your personal knowledge of the existence of typhoid bacilli in the waters of a supposititious running stream?

A. I cannot say what I should do under such circumstances of course, because so much would depend upon a lot of causes that are not here introduced. If the man were crazy I do not suppose I should convict him. If he set out to murder a community and succeeded in doing it, if he were a bacteriologist who knew of these things, I probably should. I don't see that I can say without knowing a good deal about the man and the conditions and everything else.

Q. Could you say whether you would or not without knowing a good deal more about what is a reasonable doubt?

A. Oh, I don't think that would trouble me so much.

Q. What is a reasonable doubt?

3785 GENERAL CROW: I object to the question for the reason that it calls for a legal opinion from the witness and he has not qualified as a legal expert.

JUDGE JOHNS: The witness has used the term "beyond reasonable doubt" on several occassions and very empatically. I want to know what that reasonable doubt is.

A. I have no objection to telling what I understand by the expression, "beyond a reasonable doubt." I mean by that an assurance of accuracy such as shall persuade me of the truth.

Q. Do you understand that a reasonable doubt is one which must rise solely from a consideration of the evidence adduced and which excludes every other reasonable hypothesis than the one of guilt, from the evidence as adduced?

GENERAL CROW: I object to that for the reason that the legal assumption that the gentleman makes is entirely wrong, unless he qualifies it by stating that a reasonable doubt is to be drawn from circumstances alone; and for the further reason that the witness has not qualified as a legal expert and has already given his opinion as to what he thinks would convince him beyond a reasonable doubt, and any further explanation from him is mere play upon words.

THE WITNESS: As I understand the question, that is my understanding of the conditions required,—I will say, if I understand the question right.

JUDGE JOHNS: And on that understanding of the 3786 term "reasonable doubt" in the case supposed just previously would you convict a man of murder, assuming him sane?

A. I cannot say what I should do under particular circumstances which might arise, but certainly if anyone maliciously threw typhoid fever germs into a stream in the expectation that they would kill people below, and if they did kill people below, I should convict him of murder.

Q. That is, if the particular typhoid fever germs which he threw into the river were shown by the evidence beyond a reasonable doubt to have produced it?

A. If the evidence was conclusive, that is the act had produced the deaths of innocent persons, if the act was knowing and intelligent, and if he knew that his act was of such a character as would be likely to produce the deaths of such persons, and if he were sane, I should.

Q. I am considering you as a scientific man, selected upon a jury, and you have the right to take into consideration all that your occupation and avocations in life leads you to know as a matter of common experience. You know as a matter of common experience in your profession and business, that you couldn't identify the bacilli at all, don't you?

A. I should hardly say that. You mean from streams?

Q. Yes, in this particular case supposed.

A. In this particular case I shouldn't expect to detect the germs, no. 3787

Q. You know as a matter of common experience, that the bacilli that killed this supposititious man, he might have received from any other of a dozen different sources?

A. Theoretically, yes.

Q. And practically?

A. Well, I should want to be sure that he couldn't have received them from other sources.

Q. Assuming that he might have received them from other sources, and that you as a juror, knew it, would you then convict the man of murder?

A. I should if the connection between his act and the result supposed or asumed, were so clear as to time, as to character, and as to every other probable condition, as to leave me in no reasonable doubt.

Q. I think that would be right, but you wouldn't arrive at a reasonable doubt about it when you considered you couldn't identify the bacilli causing death, were the bacilli thrown into the water by the defendant?

A. No, sir, I should not. That wouldn't stop me. I hold in a case of this kind, it is not necessary to discover the bacillus; it is sufficient to get the facts of epidemics and connect them as is done constantly in sanitary science and I think might be applied legally in a case of this kind.

3788 Q. In a case of this kind you wouldn't exclude every reasonable possibility from your mind, of the derivation of a death-dealing bacillus from some other source?

A. Certainly, that would be my first step. I should begin by making sure there was no epidemic above the point or at the point or below the point, and above the city or the man which would account for his death reasonably.

Q. Would you also consider that there was no isolated case, any infection from washing infected hands in the river and any other of a thousand ways in which the bacilli might be put in the river?

A. I should certainly consider those conditions and weigh them most carefully, but I shouldn't allow them any undue weight, and if this man had done this thing at that time I should feel persuaded beyond a reasonable doubt that he should be hanged.

ADJOURNED until 2:00 P. M. same day, May 21, 1903.

3789 Southern Hotel, St. Louis, Missouri. 2:00 P. M. Thursday, May 21, 1903. Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

WILLIAM THOMPSON SEDGWICK,

resumed the stand for further cross-examination by Judge Johns, and testified as follows:—

THE WITNESS: Before we begin, Judge, I should like to give you the exact dates of the Newburyport case. I have been looking it up and I find that I was wrong about the season of the year. It was not August, but mid-winter, and the cases appeared in Lowell, the supposed causative cases appeared in

Lowell in December, 1892, and reached Lawrence and Newburyport in January, 1893. I confused it with another epidemic, but in that season also the probabilities are that the river was low, although the conditions must have been different, of course, to those which would have existed in August, but still so far as any of my remarks go—I don't know that there would be any material change to make in them.

Q. Did you ever know of a case or cases of typhoid fever which were certainly traceable to typhoid bacilli which 3790 had existed for any length of time in the sediment of a running stream?

A. Will you read the question?

Q. (Question read).

A. I mentioned in my direct evidence the well known epidemic in Zurich, Switzerland, which was regarded by those who investigated it, as clearly traced to the stirring of the sediment near a broken intake pipe; and I also mentioned further the Detroit case, which to the best of my judgment and belief was conclusively traced to the stirring of sediment in the Black River near the St. Clair River.

Q. I am talking of your personal knowledge.

A. My personal knowledge. Read the question again.

Q. (Question repeated).

A. I don't think I have in my own personal experience.

Q. Your opinion as to the question, as to whether typhoid bacilli do exist in the sediment of running streams, is derived from your readings of cases in scientific books?

A. It is derived partly from my reading and partly from my general biological and bacteriological acquaintance with the typhoid bacillus, and with bacteria in general, in as much as my own studies have led me to the point of view, or points of view, which would strengthen and support the deductions drawn from my readings.

3791 Q. Well, it is an opinion, founded upon reading and study of bacteria from which you have drawn the deduction that they may live in the sediment of a running stream?

A. Well, sir, I think I may say I draw that deduction from a variety of data, largely, no doubt, from my acquaintance with literature on the subject, largely, in part from my own experiments; in part from consideration of what would be likely to go on under such circumstances, but especially from considering epidemics reported upon by others in which the investigations seemed to have been well made, and in which the results practically agreed with those of laboratory experiments and general bacteriological and biological knowledge.

Q. Do you know whether in the Zurich instance the bacillus of typhoid fever was actually discovered in the sediment which was disturbed at Zurich?

A. I don't think it is stated in the reports. My impression is that it was not. I should like to add: That, however, was at a time when our knowledge of the typhoid bacillus was less good than it is today, and while it is not readily discoverable today, it would not follow that it was not present then, as it might or not be today under similiar circumstances.

Q. Do you know of any instance either in your personal experience or as recounted or recited in books or publications, of the typhoid bacillus having been actually discovered in
3792 the sediment of a running stream?

A. I think I have read of some cases in which it was believed that it had been discovered in sediments .

Q. In what book and who was the author of it?

A. I don't remember now, and I am not even sure that such was the case.

Q. I presume that other bacilli have been discovered in great numbers in the sediments of running streams?

A. Yes, sir.

Q. And very frequently?

A. And very frequently.

Q. And without much difficulty?

A. With great ease.

Q. And because other bacilli do live, you reason that the typhoid bacilli may live or do live in the sediments of running streams?

A. I reason partly by analogy; partly from the general behavior of bacteria in organic materials, and partly from the epidemiological evidence that I have referred to.

Q. What epidemiological evidence have you that they exist in the sediments of running streams other than the Zurich instance, if that should be one?

A. And the Detroit instance. Do you care to accept that?

Q. Yes, and the Detroit—other than these two?

3793 A. Other than these two. May I have the question?

Q. (Question read.)

A. I think we have a great deal of evidence. The fact that freshets, especially the beginnings of freshets are very apt to cause epidemics of typhoid fever in communities using the water derived from such freshets, and without the contemporaneous occurrence of epidemics which would explain such increase in typhoid fever in those communities existing on the streams above, indicates very clearly that heaps of material at the mouths of sewers or in running streams when stirred up, may and do cause epidemics of typhoid fever.

Q. Would not the same course of reasoning under the same circumstances apply also as to the bacilli of typhoid fever upon the surface and banks of the streams in which freshets occur?

A. Yes, that is well known that washing in of materials from banks of streams, has, as I have stated, produced some of our worst epidemics.

Q. Having the two causes then, in the case of a freshet, the possible existence of bacteria in the sediment of the stream and the possible existence of the same bacteria on the banks, and about the immediate water drainage of the stream—surface drainage of the stream, do you prefer to attribute epidemics of typhoid fever to the sediment rather than to the surface washings?

3794 A. I should attribute them in an uncertain proportion to both and as a particularly exceptional case, like that of New Haven and several others that I have mentioned, the washing in of the stuff from the watersheds has produced disasters; but if the sediment in question was derived from a city or town constantly suffering from typhoid fever, I should expect that the stirring of the sediment thus accounted for, or thus arising, would be the major factor in the case. It would depend of course upon many intermediate conditions; but looking at it broadly and without specific and precise knowledge of each individual pollution, either of the watershed or of the water of the stream, I should say that the sediment deposited by a large urban population constantly suffering from typhoid fever, would be more likely to produce serious results below than the washing in of occasional pollutions of the watershed.

Q. Is there any positive knowledge, as distinguished from theory or deductions, as to the existence of typhoid germs in the sediment of running streams?

A. Just read that please.

Q. (Question read.)

A. Well, sir; I don't know any branch of knowledge more positive than rigid deductions, and I should say that the deductions drawn from the epidemics, like that of Detroit and at Zurich, are just as positive knowledge as we ever get in
3795 our ordinary scientific work in sanitary science, and that
they were not dependent upon theory.

Q. Well, that might be true as to sanitary science. Do you know of a single instance in which the bacteria of typhoid fever have been found,—discovered and identified, in the sediment of running streams?

A. I do not recall any such cases.

Q. Was it the former belief that the typhoid bacillus had very short longevity?

A. Opinion on that subject has varied greatly. In the early days it was supposed that the typhoid germ spent a part of its life in manure heaps and places of that kind, and had a considerable longevity outside of the human body, possibly even a requisite portion of its life history. Precisely as the *Trichina* has to go through the pig before we can get it, the old theory was that typhoid has to go through a dung-heap before a man could get it. That, however, was before the days of bacteriology and when germs were talked about only in a loose and indefinite way. Then there came a time when the typhoid was discovered and worked upon in laboratories and at first the experiments did show a short longevity, but as time has gone on, the opinion has, I think, grown among bacteriologists—it certainly has in my mind,—that those earlier experiments upon the germs
3796 were based upon laboratory conditions,—unnatural con-
ditions, and that under perhaps slightly different conditions, in mud or in manure, or in the earth, the typhoid germ might live very much longer than we had at first believed.

Q. Do bacteriologists now unanimously agree to that proposition?

A. I cannot speak of course, for bacteriologists in general, but I think I should be able to answer that question; they differ among themselves like other men.

Q. I presume that there are in the science of bacteriology schools of theories, as in medicine?

A. After a fashion, yes.

Q. And they are at war among themselves as much as doctors?

A. More or less, yes, sir.

Q. On nearly every theory of bacteriology?

A. Well, no, sir.

Q. And its usefulness?

A. No, I think they are remarkably harmonious on the principal theories. As I said in my qualifications, I have been president of the Society of American Bacteriologists, and a more peaceable company I never presided over.

Q. But they at the same time differ among themselves as to these—what may now be called modern theories?

3797 A. I don't think so, sir. Bacteriology is a rather restricted science. There are of course differences of opinion, but on the broad lines of bacteriology, and the behavior of germs in nature and in man, I think there is a remarkable unanimity.

Q. Do you know of any difference in opinion as to the pathogenic properties of coli communis among bacteriologists?

A. There have been wide differences of opinion.

Q. Do those differences still exist?

A. I do not think they do, except in the way of the definition of the term "pathogenic" which I referred to this morning.

Q. Do you know of any persons who differ with you—bacteriologists—upon the question as to the longevity of the typhoid bacillus in running water?

A. Oh, I should hardly expect that any bacteriologist would agree with me precisely, but I don't know of anyone who in my opinion would differ from me materially on that; it might be less, or more, but I think all bacteriologists are agreed that the life of the typhoid germ in water and mud and those things is uncertain and may be longer than we know.

Q. Did you ever hear any bacteriologist say that the typhoid bacillus would live in a journey of 400 miles in running water?

A. I don't know that I ever did; no, sir.

3798 Q. Did you ever hear one assert that it would live in a journey of 300 miles?

A. I don't think I ever heard a bacteriologist make any such assertions because they would be fool assertions. He doesn't know whether they would live in such a journey or not unless he knows more about the conditions,—it depends upon what kind of a journey it is and under what conditions of stream and all that sort of thing. As I have said over and over again, it is not so much the *distance,* it is the *time* that comes in, and bacteriologists don't go around making assertions of that sort, at least, the good ones don't.

Q. Do you now assert that a typhoid bacillus turned into the Illinois river from the drainage canal having its derivation in Chicago, does live in a journey down the Illinois river and the Mississippi to the Intake Tower at St. Louis?

A. I am ready to assert my conviction—my positive conviction that typhoid bacilli may and do live to make that journey.

Q. Based on what evidence?

A. Based on the whole chain of evidence which I have in my possession regarding the sanitary history of Chicago, the character of the water used to dilute the sewage of the City of Chicago, the character of the Illinois river, especially as to being subject to floods, and the character of the Mississippi river into which the Illinois empties, and with which in my
3799 opinion the Illinois freely mixes, so that such germs may be carried alive and virulent, from the people of Chicago to the Intake Tower of the St. Louis Waterworks, and further upon the vital statistics of the City of St. Louis as I have studied and compared them with the vital statistics of other communities.

Q. That belief is in direct opposition to all known experience and all knowledge as to the existence and the time of existence of typhoid germs in running streams, is it not?

A. I don't think so, sir.

Q. Well, if it is not in direct opposition, isn't it a very large and remarkable extension of the theories derived from such things as are now known to science?

A. I think I may say that it is an extension, but I am not ready to say that it is a very large or very remarkable extension, all things taken into consideration. If we bear in mind this same question of time, to which we have so constantly referred,—the evidence introduced here that the time required for the transmission of particles of water or sediment from Chicago to St. Louis, and all the other evidence that has been brought in, I don't think that it can be regarded as either very large or very remarkably extended.

Q. Suppose that a certain identified quantity of water
3800 should require in its transmission from the outlet of the
Sanitary District canal into the Illinois river, to Grafton, five weeks, would you say that the typhoid bacillus might live in that given body of water?

A. I should say that in such an identified body of sewage or water—or I suppose it would have to begin as sewage?

Q. Yes.

A. Things might happen which would cause the ready survival of the germs for that length of time, either in the moving water or in the sediment just below the moving water.

Q. Would you say the same thing if the time required were five months?

A. I should say the same thing.

Q. Would you say the same thing if the time required were one year?

A. In that case I should want to know a good deal about the sediment and the particular conditions that prevailed during that year. I can conceive of conditions which might destroy the germ en route during that time or even before that time, but I can as readily conceive of other conditions which might prolong its life, for example, the pouring of a large quantity of acid from manufacturing wastes down the canal during that year might conceivably destroy the typhoid germs in the water,
and in the sediment. On the other hand, the pouring down
3801 of an unusual amount of organic matters from the stock
yards, or from some other place, might so enrich the water as to sustain the life of the germs, perhaps even leading to a greater duration of life than that that you have stated. The fact

is that the conditions which have got to be considered in a case of this kind are so many that it is impossible to make categorical answers which will have any real value, unless all of the conditions can be assumed, and that is impossible.

Q. Then you have no explicit opinion as to the given time of one year?

A. I think the chances are good that for the greater part, the germs would have died out, but I should be afraid that some might be still alive if they came in Chicago sewage, under the conditions existing on the Illinois river; I should expect that some might still be alive—a small percentage.

Q. Would you expect that under the conditions existing on the Illinois river, that typhoid bacilli turned loose into the Illinois river at the termination of the drainage canal, would live for a period of fifteen months?

A. I should not expect very much about it; I should say that in regard to the periods beyond a few weeks or months, that in general the mortality among the bacteria—among the typhoid bacteria would be heavy; but that I should never feel certain, personally, I should never feel certain, even after
3802 one or two years, or possibly longer, that some of those were not still living there.

Q. But that is more a personal belief than a generally accepted doctrine or dogma, if I may term it so, of bacteriology?

A. I don't think that the subject has ever been investigated or studied sufficiently so that we have any "dogmas" or "doctrines" of that sort. The ordinary times given in the books are shorter than those that I have mentioned, undoubtedly, but they are given largely upon laboratory experiments, and when we come to epidemiological evidence, that has forced us thus far to prolong the time and when we take the thing in a large and broad way, and look at it biologically, I as a biologist and sanitarian can see no reason why these little fellows may not under some circumstances have their lives very extensively prolonged.

Q. And indefinitely prolonged?

A. At the present state of our knowledge indefinitely prolonged. Of course I mean in diminishing numbers, and with a small percentage left.

Q. And with decreasing vitality and virulence, as to the survivor?

A. On that ground we may, I think, fairly suppose that there is a diminishing virulence; but there again, we are very much in the dark, as we are in a good many of the finer
3803 points of bacteriology and medicine, and while I think it is probably true that under these circumstances the virulence is diminished, there is no evidence which would lead us to suppose that it would be lost or that it might not be regained pretty quickly when these possible remaining bacteria were reintroduced into the human system and had a chance to multiply.

Q. The place where typhoid bacilli thrive and multiply is in the human body, is it not?

A. The best place, yes. They thrive also in our laboratories, in our cultures under certain conditions.

Q. Yes, under favorable conditions for that purpose?

A. Under favorable conditions for that purpose, and it is possible that they may multiply in nature under unusual circumstances, e. g. tropical countries, with conditions in nature resembling those which we have in our laboratories; that is, rich food, proper temperature and everything is just right.

Q. But nothing is known as to that?

A. Nothing is known as to their so multiplying in nature, no, sir, outside of laboratories.

Q. The generally accepted theory of the most modern bacteriologists is that they do not multiply in running streams?

A. That is the general acceptation, yes, sir.

Q. Do you know any bacteria which removed from the place in which, and the medium in which it naturally thrives, and naturally exists, that positively does exist in an unnatural
3804 and unfriendly medium, for three months in nature, as distinguished from the laboratory?

A. Let us have that, please?

Q. (Question read.)

A. I don't know that I can give any positive proof of such a case, but it is commonly supposed that Asiatic cholera lives in the polluted water butts of the city of Calcutta the year around, and I think the same thing was found, or believed to be found in Egypt. There is a good deal also of indirect evidence, but valuable evidence, tending to show that diphtheria sputum and tuberculosis sputum may live outside of man and outside of the laboratory for a long time,—as long, I should say readily, as three months, and I am under the impression that in some diseases, such as smallpox and scarlet fever, there are plenty of cases on record in which the infectious material and therefore the germ, has been kept in clothing in chests and things of that sort, and when taken out even a year later, has infected human beings. I think it would be easy to collect evidence on that head, showing that germs may live outside the human body and outside of the laboratory in the environments of man for very long periods of time.

Q. If such evidence was collected as to any other one bacillus than typhoid fever, would that evidence tend to prove in your mind the same fact as to the typhoid bacillus?

3805 A. It would tend to prove it, though it would not of course necessarily establish it; but owing to the close resemblance of these various germs, biologically, a fact of that kind established in one or more other diseases would be certain presumptive evidence in favor of similar facts in regard to this disease.

Q. Are you familiar with the bacillus prodigiosus?

A. Fairly so.

Q. Do you know whether there are any varieties of that bacillus?

A. The subject of bacteriology is in such condition that it is a little difficult to answer that question directly. There are what some bacteriologists believe to be varieties, and other bacteriologists hold them to be distinct species. Following the analogy of higher forms, we should expect varieties, but on the whole I think we may say that prodigiosus as we have it in our laboratories, and as we use it is a very well defined species with no troublesome varieties turning up.

Q. On a plate in special culture it develops a red color, does it?

A. Yes, sir.

Q. And that is a peculiarity of the bacillus prodigiosus?

3806 A. Well a great many bacteria produce color, but this one produces a large amount of a peculiar color.

Q. By which it is readily identified?

A. Not by that alone but which helps very much in identifying it.

Q. Is that the distinguishing characteristic of it?

A. No, sir; that is not the distinguishing characteristic of it.

Q. What is the distinguishing appearance?

A. That, taken together with a lot of other characteristics, as to its general behavior toward gelatine and this, that and the other material.

Q. Do you know whether the bacillus prodigiosus exists in the waters of the St. Lawrence River?

A. I do not.

Q. Do you know whether it exists in Lake Erie?

A. No, I do not.

Q. Do you know whether it exists in the Columbia river?

A. I do not.

Q. Do you know whether it exists in Lake Michigan?

A. I do not.

Q. Do you know whether it exists in the Missouri river?

A. In this, and in all previous cases, I may say I do not know whether it exists, but that in my experience it is not 3807 found ordinarily, so that while I don't know whether it exists in those places or not, I should be very much surprised to find that it did exist there, unless exceptionally and rarely.

Q. Does it exist in the Mississippi river?

A. I should make the same answer as before.

Q. And the Illinois river?

A. Again the same.

Q. If it did not exist in the waters of the Missouri, the Mississippi or the Illinois, but was injected into such waters, do you know whether it would live and multiply?

A. I don't know of my own knowledge, but I should suppose that it would not.

Q. For what reason?

A. For the reason that, judging by analogy, it is not at home in our American waters, and in my experience has not been found to multiply in the waters with which I have dealt; with which I have experimented.

Q. Have you ever found it in natural waters in the United States?

A. Never.

Q. You have experimented with it from special cultures?

A. Yes sir. I have found forms that superficially resembled it, and rarely forms that came very near it, but which did not finally answer all of the tests but those forms were more common, in my experience, in deep wells than they were
3807 in running waters.

Q. Is it different in its vitality from other bacilli?

A. Each bacillus has within its bounds, its own vitality, so to speak; but broadly speaking, it is supposed to be a bacillus and fall into the same group with the other bacilli.

Q. It lives upon something, I presume, in its natural media?

A. In its natural media?

Q. Yes?

A. Yes, it was originally discovered upon starchy foods, cold bread, cold potato and things of that kind, and it derived its name, as you may have been told, from the fact that it appeared upon the communion bread in churches,—hence the name *prodigiosus*—miraculous; but that was in Europe.

Q. Can you count, or do you estimate the number of bacilli of a given kind, derived from special culture in a cubic centimeter of water?

A. May I have the question?

Q. (Question repeated).

A. In a sense, we count them, but it is such a peculiar method of counting that it comes closer to an estimate than it does to the ordinary count. We cannot pick them out, one, two three, and count them; but as you know and have been told, no doubt, we cultivate them in a jelly, make them multiply and then count the products of their multiplication which are
3809 isolated in spots; those spots being colonies. We count
their products,their descendants,so to speak, the nations or colonies which spring from them; and thus indirectly we count them.

Q. Without any knowledge or ability to ascertain how many individuals there are in any special colony?

A. Oh, quite so; absolutely—well, not without the ability, either; we can estimate the number in a particular colony, but we don't ordinarily. We can take off that colony and make a fresh plant of that and then estimate from the colony which we produce, how many there were in that colony, just as we do from a cubic centimeter of water; but that we never do, except for scientific purposes.

Q. Can you conceive of a thousand million of bacillus prodigiosus in a cubic centimeter of water?

A. I have been in the habit of doing that sir, for twenty years,—with great ease.

Q. That is easy to conceive, but very hard to understand I suppose?

A. Yes, it is—well it is not easy to conceive unless one has thought about it quite a little. I always spend quite a time in lecturing to my students in trying to get them to conceive what a cubic millimeter is even, and use illustrations—such as a granule of granulated sugar, and tell them the number that would have to be corded up in that space, in order to try to give
3810 them some idea of what millions and hundreds of millions mean.

Q. At best, all that can be said in regard to the number of bacilli of any given kind in a cubic centimeter of water, is that it is an estimate which you assume to be approximately correct?

A. Which is an approximate estimate.

MR. TODD: One or two millions doesn't make very much difference?

A. Not very much in some cases.

JUDGE JOHNS: Two or three hundred millions wouldn't make very much difference?

A. Well, it depends upon what you are after,—what you are using them for. If you simply want to make cheese, for instance, or rather, make butter, two or three hundred millions of the butter bacteria are a great advantage; if you are putting sewage in water, two or three hundred millions of typhoid germs would make a great difference.

Q. Would be awful?

A. Would make a great difference.

Q. Do you think that a medium especially prepared for the purpose and containing a thousand million of bacillus prodigiosus to the cubic centimeter, could be transported from St. Louis to Lockport by freight and the bacillus live?

3811 A. That would depend something on how long it took, I should think—Oh, you said transported by freight, and I suppose that means what? Three or four days?

Q. Oh no, 24 hours.

A. Freight trains move at different rates in different parts of the country.

Q. These were hurried.

A. I should expect, under those conditions, a slight diminution in the number—that is in 24 hours.

Q. You think they would be reduced how many millions in that time?

A. Beg pardon?

Q. How many millions do you think they would be reduced in that time?

A. Twenty-four hours?

Q. Yes sir?

A. A great deal would depend upon the culture which was used; upon the food material present. If a thousand million for example, were put in fresh food material and started on that journey, you might have ten times that number when you got there, but if you had, on the other hand, an exhausted food material, if I may use that term, when they started, then I should expect that the mortality would be rather heavy; they might fall off in numbers ten per cent.

3812 Q. If the commissary supply was not exhausted, was bounteously prepared and abundantly supplied, you think they would be able to survive?

A. I think they would, undoubtedly, and increase.

Q. And of course that is a matter of opinion rather than of any scientific knowledge.

A. Except that in a general way we know that bacteria put into abundantly rich food ordinarily grow; put into exhausted food materials, ordinarily begin to die.

Q. I presume bacteria can be transported by artificial means up a stream?

A. Yes sir.

Q. On the bottoms of boats?

A. Yes.,

Q. In buckets or any other way in which water is transported up stream?

A. Certainly, sir.

Q. So that to find bacteria of a particular kind two or three miles above the place where they were injected into the Mississippi River would not be a very remarkable thing of itself, would it?

A. Is this the Mississippi river?

Q. Yes, and the Illinois?

A. Well, I should want to know the conditions under
3813 which they were thrown in; how many were thrown in,
etc. In the Mississippi river as I saw it not long since, flowing under a south wind and with a tremendous current, whitecaps and all that, I should not expect that the bottom of a boat would carry many up stream. Of course a bucket on the boat might, but in general, the finding of them above the place in which they were put would be a surprising and a rather unusual thing, undoubtedly, provided they did not exist in that stream before.

Q. If they were put in in large enough numbers to permeate the stream, stock the stream pretty well, would it be very surprising if they were taken up the stream by boats for instance in the process of washing the decks of the boat, by pumping water from the river?

A. Then certainly, it would not be very surprising.

Q. Well, it would not be very surprising if they were conveyed up in any way in which water is ordinarily conveyed up stream?

A. If they were in that water, and the water was carried up, I should expect them to come up with it.

Q. I am desired by Judge Springer to submit to you the following questions:

Assuming that the waters and sewage coming from the drainage canal of the sanitary district of Chicago should be
wholly diverted into another channel so that none of
3814 such waters could enter into the Mississippi river or into
the intake of the St. Louis waterworks, and that the only waters that could enter such intake would come from the Missouri and Mississippi rivers, and the Illinois river, excluding the

water and sewage from said drainage canal; what is your opinion as to whether such waters would be suitable and safe for drinking and other domestic purposes in their natural condition or in the condition in which they entered the St. Louis intake?

GENERAL CROW: I object to that question for the reason that so far as respondent is concerned, it is immaterial what the character of the water supply of the City of St. Louis was prior to the time that the Chicago Sanitary District added its sewage mixed with the Chicago canal water, to that of the Mississippi, by sending it by way of the Illinois and the Desplaines river, and therefore the question asked, and the answer has no relevancy and could have no relevancy to the point at issue in this case which is, and only is, as to whether or not the mixture of the lake water with the Chicago sewage, into the Mississippi river has made less safe the water of the Mississippi river for the primary uses of the inhabitants of Missouri.

A. What is the question please?

Q. (Question repeated).

A. My opinion is that such waters would not be suitable and safe for drinking purposes in their natural state, or as 3815 they enter the intake tower of the St. Louis waterworks.

Q. In your opinion is it practicable by any of the known and recognized systems of water purification, for the waters which now enter the intake of the St. Louis Waterworks, to be so treated as to become suitable for drinking and other purposes, and as a safe water supply for the City of St. Louis?

GENERAL CROW: The same objection as last above made, with the addition that the citizens of the State of Missouri including the citizens of the City of St. Louis are entitled to the use of the waters of the Mississippi river in their ancient and accustomed flow and in their primary state, without filtration or other processes to purify the same which may have been made necessary by pollution infected by disease, put into the stream by the Sanitary District of Chicago or anyone else, and for that reason the question and any answer given to it is wholly foreign to any issue in this case.

A. Now will you read the question?

Q. (Question read).

A. Certainly; in my opinion it is perfectly possible and practicable that such water—that the waters described should be— what was that question?

Q. Question read).

A. Now erase what I began to say and I will begin again. In my judgment it is entirely possible and practicable

3816 to so treat the waters referred to in this question, that they shall be suitable and safe for drinking purposes on the part of the citizens of St. Louis.

Now kindly read the question and answer and see if I have got it straight.

(Question and answer read).

Q. JUDGE JOHNS: Do you know whether the present system of supplying water to the City of St. Louis is now substantially the same as it was prior to January 17th, 1900?

A. I do not know of my own knowledge, but I have taken pains to satisfy myself that it is substantially the same.

Q. And is it insufficient and in-efficacious?

A. For adequate purification?

Q. Yes?

A. In my judgment it is insufficient for adequate purification.

Q. And was prior to January 17th, 1900?

A. And was prior to January 1st, 1900.

3817

CROSS-EXAMINATION,

By Mr. Todd.

Q. Professor, in taking the death rate of typhoid fever in the city as a basis of calculation, why is that done in preference to taking the number of typhoid cases?

A. Oh it is a matter of taste largely. The old records were based mainly on that process.

Q. Does the death rate of typhoid indicate the number of cases?

A. Not with precision;—approximately, yes; we say for instance that for one death there were probably ten or more cases, the percentage of mortality or fatality it is better to call it, varying anywhere from twelve to eight. There are always therefore a very much larger number of cases than of deaths.

Q. In the treatment of typhoid, the number of deaths depends largely upon the treatment, doesn't it?

A. No sir, I don't believe it does—if by treatment you mean medical treatment?

Q. I mean medical treatment, medicine and attention.

A. If you allow nursing and caring and feeding, those things as a part of the treatment, as you certainly would of course, you ought to, as opposed to drugs, I should say yes.

3818 Q. Did I understand you to say that you were opposed to drugs, or "as opposed to drugs"?

A. Nursing and care as opposed to drugs.

Q. A death rate of 25 cases of typhoid fever in a town doesn't indicate the danger that the town lying immediately below on the same stream, would be subjected to, by the typhoid cases that are in the town, where the deaths occurred, does it?

A. That alone—

GENERAL CROW: Read the question again; I didn't quite catch it.

(Question repeated).

GENERAL CROW: Do you mean 25 deaths? You said 25 cases.

MR. TODD: Yes, 25 deaths.

THE WITNESS: That alone would not be a proper measure of the danger. Much would depend upon whether the town was isolated or not and whether the town below took its drinking water in such a way as to get the germs, and a lot of conditions.

Q. Have you ever estimated the quantity of fecal, and urine discharged per day from a typhoid fever patient?

A. No sir, I have not.

Q. Or the number of germs of typhoid that would be discharged by a typhoid patient in 24 hours?

A. I have not myself.

Q. Have you any opinion on the subject?

3819 A. Results have been obtained; investigations have been made and results obtained by various observers, and the general result is that the number of microbes discharged in a day from a normal human being is very large, enormous, and that in cases of typhoid fever, the probable discharge is also very large.

Q. You have given consideration to the question of typhoid in the city of St. Louis for the years prior to 1890, have you not?

A. Yes, I went back farther than that.

Q. In your testimony you used the expression that the rate of mortality in the city of St. Louis was normal.

A. Of typhoid fever?

Q. Of typhoid fever, but not in the legal sense,—I believe you used an expression of that character did you not?

A. I don't remember whether I did or not.

Q. I mean legal in the legal, not in the sanitary sense.

A. I may have used something of that sort; I don't remember using the word "legal" but I dare say I did. I did not intend however, to attach to it any special significance.

Q. For the purposes of my question I want to locate the point. What do you mean by normal as used in the connection in which you used it, professor?

A. I mean by a normal typhoid fever death rate, a death
rate which places a city or town having it, in the ranks of
3820 cities and towns having good water supplies and good
general sanitary arrangements and conditions, other good
sanitary arrangements and conditions.

Q. If it should appear that there were 788 cases of typhoid in the city of St. Louis in 1893, would that be a normal rate, while there would be only 215 deaths.

A. As a matter of fact, in 1893, if I remember right, the number was large, and was apparently connected with the great epidemic of 1892. I should like to consult my charts.

Q. The figures I give were taken from Dr. Ravold's chart.

A. I don't remember what he gives, but I have the facts right here and I will see in half a minute. In 1893 there were only 215 deaths.

Q. And 788 cases?

A. I don't know about the number of cases.

Q. (Question repeated)?

A. That would not be a normal number of cases; it would be too small. The presumable number of cases from that number of deaths, would be nearer 1500 to 2000, and all that means is that the physicians did not report the cases, as often hap-

pens in epidemics of typhoid fever. They fail to report the cases as they should do, and only the more careful physicians
3821 doing that, the upshot is we seem to get a tremendous fatality, when as a matter of fact it is about normal. But that number of deaths in that year was higher than St. Louis has had since 1884, or at least the mortality percentage was higher. I don't know about the number of deaths.

Q. In 1899 if it should appear that there were 130 deaths and 908 cases of typhoid, would that be normal?

A. That would come nearer.

Q. In a sanitary sense?

A. That would come practically down to normal. That would be for a big city of this character, I should say, a very good showing in respect to typhoid fever, but here again the number of cases is rather small for the number of deaths.

Q. What would be the normal death rate from a sanitary standpoint for typhoid in a city of the population of St. Louis?

A. About that which St. Louis had in 1895 to 1899 inclusive, although it might be lower than that under the most favorable circumstances, but as I have already stated, that was below the typhoid mortality percentage at Boston during those years.

Q. Professor, to what do you attribute the presence of typhoid, from 1895 to 1900 inclusive, in the city of St. Louis, the five years?

A. I attribute the typhoid fever in St. Louis during the
3822 period mentioned, from 1895 to 1899 inclusive, to a variety of causes, each of which probably played its proportionate part in the making up of the total. For example, I have no doubt that the water may have contributed something to the net result; milk something, oysters something, secondary infection,—by which we mean contagion, practically, dirty hands and that sort of thing, from person to person,—and also infected foods, other than milk and oysters, such as watercress, celery and unwashed fruits, flies and the numerous factors, each of which goes to keep up in all of the cities of the world a small but rather constant amount of typhoid fever.

Q. In regard to oysters, professor, how is typhoid fever transmitted through oysters?

A. In regard to oysters the method of transmission is as follows: The oysters are frequently grown or placed for a time in sewage polluted streams, and as the act of raking up,—"tonging" as they call it,—tonging the oysters to get them up with tongs, causing the valves or shells of the oysters to close suddenly, they are very apt to include within the shells a certain amount of the water in which they may have been lying, and if that water is sewage polluted, or rather if it is infected,—typhoid infected,—an oyster may carry between its shut valves a mouthful or more of the so-called juice of the oyster, which is really sea water or in this case diluted sewage which 3823 may in some cases, and has been proved in some cases to, convey the disease.

Q. Do you know of anyone who has ever discovered the germ of typhoid in an oyster?

A. I think that some English and French bacteriologists have done so or claim to have done so.

Q. Can you give me the name of any such?

A. I can not give you the name, and I don't know that I could with certainty give you the name of the book in which the results were put down, but there are two or three well known books on infectious diseases in shell-fish, and I think it is mentioned in one of those two or three.

Q. Do you know whether any of those books—

GENERAL CROW: Do you know of any recent case of prominence where it is supposed to have occurred? Where they found the bacillus. I mean where it is supposed to have occurred, the Vanderbilt case?

A. The number of epidemics—or the number of cases of typhoid fever, which are attributed to the bacillus is quite considerable.

MR. TODD: Is that among the poorer class or the richer class?

A. Well, sir, the late Governor of Massachusetts, Roger Wolcott, was supposed to have died from that source, and 3824 Mr. Cornelius Vanderbilt, who has been ill with typhoid fever lately, was supposed to have got it from that source, and it is general in this country among well to do classes, that is true; but in Italy, in Naples, typhoid fever is said to be very common among the poorer people who buy there fish and oysters and cheaper sorts of food and eat them raw.

Q. Do you know whether in these books to which you have made reference whether the scientists who made them, claim to have found the bacillus of typhoid in an oyster?

A. I am under the impression that one or two of them have done that. I cannot state positively.

Q. In regard to Wolcott and Vanderbilt. Do you know whether they ate celery with their oysters or not?

A. I presume they did. Personally I have never felt entirely satisfied that the case was made out. It is easy to say one got it from eating oysters. That saves a lot of trouble and you don't have to make investigations, and people jump to conclusions in medicine,—as they do in bacteriology.

Q. A kind of a leap-frog game, is it professor, when they can't find the cause, to attribute the cause the most easily secured as the explanation of the typhoid?

A. That may have been true or may be true in isolated cases, but we have on record one phenomenal epidemic in which the thing was proved as clearly as ever anything is proved.
3825 A lot of students of Wesleyan University, contracted typhoid fever from eating oysters which had been placed upon a bed in the Quinnippiac River at New Haven Connecticut, and so located that the sewer from the house of the owner of the oysters, emptied right over the oyster bed, while his daughter was sick from typhoid fever in the house and the germs from her unquestionably must have infected the oysters.

Q. That being true, do you know or have you made any investigation of the number of oysters that are consumed in St. Louis, or have been consumed in St. Louis for the last five years?

A. I have not.

Q. Are you prepared to state that the typhoid in St. Louis is not due to over-indulgence in these bi-valves?

A. I am.

Q. If you don't know the source of the oysters, whether they were sewage polluted or not, and the number of oysters that were consumed here by the people and whether those oysters were infected, how can you attribute any other cause to the typhoid since 1900?

A. The increased typhoid you mean?

Q. Yes.

A. This seems to me a very simple matter.

Q. For the years 1900, 1901 and 1902?

3826 A. This seems to me a very simple matter. Three years stated in the question at stake, 1900, 1901 and 1902. Repeat the question.

Q. (Question repeated).

A. Well, I have no doubt that some typhoid infected oysters may have been eaten in St. Louis during those years and may have caused cases of typhoid fever. The amount of increase in the disease, considering the size of the city would mean such a vast change in the habits of the people or in the condition of the oyster supply of the United States, that in my judgment it would be unreasonable to attribute the rise in question to any such source, particularly as oyster epidemics are not frequent, and are local, while the rise in typhoid fever in St. Louis has been persistent. It would be unreasonable and opposed to all our knowledge of sanitary science to look for the increase chiefly in infected oysters.

Q. Is it not a fact, professor, that the demand for oysters has increased at an enormous rate throughout the country within five or six years over what it was the previous five years?

A. I think not. I think the demand has fallen off a good deal. After the great oyster scare of 1894, when this epidemic which I have described took place, the oyster men of Boston almost had to go out of business for many months, and 3827 every now and then today they have to take, not only in Boston, but in other places, Baltimore and Washington—they have to take pains to announce that they get their oysters from a particularly pure source of supply, so that I don't believe that the consumption of oysters has increased inordinately or out of proportion, or much out of proportion to the increase of population.

Q. If statistics should show that the increase be as I stated in my former question, would that have any effect upon your former judgment?

A. It would have an effect, but assuming, as I suppose to be the case that some at least of the oysters of St. Louis come from the east, and knowing the general state of feeling among the oyster men, and the pains they are taking, and the influence that Boards of Health are bringing to bear upon them to improve their oyster-layings and the like, if a considerable increase in the consumption should be shown, as I daresay may be, owing to the prosperous times we have today, that would not materially alter my position.

Q. Wouldn't the fact that the growth of population bordering upon the rivers, and the longevity of the typhoid bacillus emptying into it, or into the ocean where these oyster beds are located, wouldn't this increase have a tendency to spread
3828 into the directions where the oyster-beds are, as for example, take the Mississippi river with all its tributaries, entering in at the delta and spreading all over the southern part of Louisiana, Mississippi and Alabama, wouldn't that carry this contagion into the oyster beds in that part of the country, beyond the reach of local boards of health. Would you assume that would be the danger line in accordance with the views expresed by you in your testimony in regard to the longevity of the typhoid bacillus?

A. I think it is unquestionably true that the growth of population and the other conditions that you have referred to, do have a certain tendency in that direction, for it is generally admitted today that we have got to be extremely careful in the future and at the present in regard to this matter of oysters, but the growth of population and the additional amount of sewage entering the rivers and harbors, would not in my judgment produce any such sudden or marked increase in the typhoid fever of St. Louis, as has actually taken place.

Q. Assume, Professor, that in 1899, in November and December, that the number of reported cases in November in St. Louis was 480 and in December, I think it was 352 cases, for the year 1899, prior to the opening of the drainage canal, and for those two months in 1899 the number of reported cases in the city of St. Louis has never been equaled by any two sub-
3829 sequent months from 1899 up to the present, wouldn't it be reasonable to suppose that the increase in typhoid for 1900, was largely due to the cause that led to this epidemic in the months of November and December, thereby raising the number of deaths of 1900 from 130 in 1899 to 168 in 1900?

A. The difficulty with this question is as I have already stated. The number of reported cases is a very uncertain measure of the amount of typhoid fever in any city in which the reporting is not very well done, and we have evidence that this is a city of that kind. Therefore the question makes certain assumptions which I personally doubt the truth of. I do not mean that I doubt the material truth.

Q. Let me make an assumption in addition to the question. Assuming that in 1899 the Board of Health of St. Louis, sent out a letter requesting all physicians to return all cases of typhoid and a special effort was made to secure the data, and the same in 1900 and 1901

A. I am sorry to say that wouldn't materially modify my answer thus far, because physicians are notoriously not obedient to the Boards of Health which request them to do these things. Inasmuch therefore as the question makes assumptions which in my judgment are at least questionable, and probably, judging by the deaths, at variance with the facts, I am unwilling to draw any conclusions from those assumptions.

3830 Q. What additional facts that were included in this question do you have to state that the increase in 1893 resulted from an overreaching of 1892's epidemic, if you so stated?

A. I believe I did so state.

Q. (Question repeated).

A. It was not additional facts that I found out, but different facts. I had the deaths for the year and if I remember right, by months, and I ought to have in order to answer this question intelligently, the deaths by the months rather than the cases by months. However, I want to get at and tell the entire truth in this matter and all that I know and believe, and I may say frankly that I do believe that a part of the rise in 1900, was due to the same causes which operated at the end of 1899.

Q. That's what I was trying to get at.

A. Exactly.

Q. In a city the size of St. Louis, how many deaths from typhoid fever would there have to be to characterize the situation as epidemic?

A. That is almost an impossible question to answer. There is nothing more confusing than the terms "epidemic," "endemic," "outbreak" and the like, as applied to typhoid fever. In many cities and towns in which I have been investigating what I considered epidemics the local officials would try to 3831 hush up the use of that term, declaring that somebody would be scared away from the town, and they would refer to the thing as an out-break, or avoid calling it anything at all.

Q. My question applies to you as a sanitarian.

GENERAL CROW: He is answering it.

MR. TODD: If there is any reason that can be had.

A. And I should be unable to state any precise answer to your question. I should be unable to give a limit to the word "epidemic." In answering your last question or two, in which you use the term "epidemic" I hesitated to fall in with the question because of that use, but I thought that the word was so difficult to define anyway that it was not worth while to stick at that point. Now as a matter of fact it is questionable whether the amount of typhoid fever at the end of 1899, in a city of this size, and considering the season of the year, is entitled to be called an epidemic, but it was somewhat above the ordinary.

Q. Well, substitute for "epidemic" a "large increase." I am not captious about words.

A. Exactly, neither am I.

Q. I am after ideas.

A. We are a unit on that.

Q. In a city the size of St. Louis, would you regard an increase in the total number of deaths of fifteen or twenty 3832 as a large increase for the year?

A. That would depend upon the total mortality somewhat, assuming that mortality from typhoid in the sense you employ the term. If the total mortality were smaller than usual, or larger than usual, such a number of deaths might be excessive.

Q. (Qustion repeated).

A. Then, what is meant by large increase, is that it?

Q. Yes?

A. I should consider an increase such as I have actually found for the period since the drainage canal was opened, 73 per cent a large increase.

Q. If in 1900 you attributed a part of the mortality to conditions that existed in 1899, would you consider 38 death by typhoid in a city of the size of St. Louis a large increase?

A. Other things equal I should consider it a considerable increase because it means three or four hundred cases. It must be remembered that small things in typhoid fever count for a good deal, and a small increase may be indicative of a serious situation. The number of deaths from typhoid fever for instance in 1899 was 131, according to this (referring to board of health report) and that is not a large number of deaths from ty- good deal, and a small increase may be indicated of a serious phoid for a city of this size? If therefore, we have an increase the next year of 38 deaths, 38 is a pretty large percentage of 131,
and it seems to me that means a very serious state of
3833 affairs. We are dealing here with small numbers now.

Q. Suppose in 1890 there should be 277 deaths?

A. You mean 1900?

Q. 1890.

A. There were not, there were only 140.

Q. This chart has 277 deaths.

A. I don't know anything about that chart. Here is the table of the Board of Health.

Q. This has been introduced in evidence and marked Complainant's Exhibit No. 22.

A. In 1890, the number was not so very high according to this, 140. It must be a blunder on that chart according to the books. I go according to the report of the Board of Health.

Q. Assume, professor, that this chart is correct and there were 277 deaths in 1890. This chart has been verified and introduced in evidence by the City Bacteriologist of St. Louis.

GENERAL CROW: I beg your pardon; the city of St. Louis didn't have any bacteriologist. It was Dr. Ravold.

MR. TODD: Then by Dr Ravold.

GENERAL CROW: He wasn't city bacteriologist.

A. Everybody is subject to error. He probably made a mistake and got the wrong year.

3834 Q. But assuming that this is correct and that table there is a typographical or clerical error, because this has been sworn to and that has not. What would you attribute the high death rate in 1890 to?

A. I cannot answer that question. That would be a puzzler.

Q. What's that?

A. I don't believe I should be able to answer that question. I don't know. I would have to give it up.

Q. Do you know from what months those statistics are made up?

A. This (referring to board of health report).

Q. Yes.

A. No sir, I do not. They are published I believe by the Board of Health, and are such as I have usually in my studying.

Q. (Question repeated).

A. I will say that I cannot answer that question.

Q. If the total number of deaths in 1890 was 277 and the total number of deaths in 1891 was 160, and in 1892 was 488, caused by the sewer at Bissell's Point wouldn't you attribute the high death rate of 1890, to the cause of the high increase of 1892?

A. If I understand the question I think that I probably should, because if it had been found out that said water supply was contaminated from one of these sources in 1892, so
3835 much so as to make an epidemic, or as to have made an epidemic, I should be very much inclined to attribute a large number of deaths only two years before, to the same cause. That is, if I had found out unexpectedly a new and dangerous cause, I should expect to find that cause had probably been operating for the past two years, particularly if it was a clear case like that.

Q. Those causes operate to increase rather than reduce, do they not professor?

A. What causes?

Q. Of epidemics?

A. Sometimes to increase and sometimes to decrease.

Q. If the cause of the epidemic in 1890, wherein there were 277 deaths, was the same cause in 1892, wouldn't the increased number of typhoid cases in St. Louis in 1890, serve to contaminate the water supply more excessively, and thereby increase the number of deaths rather than reduce them in 1891?

A. I should expect that it would, yes.

Q. Then if the number of deaths in 1891 fell to 160 as against 277, in 1890, would you attribute the large number of deaths in 1890, to the cause which operated the epidemic in 1892?

A. I don't think I am quite clear on that.

Q. (Question repeated)?

A. Oh, I might or I might not. The causes of epidemics
3836 are intermittent oftentimes, and not continuous, and the
mere fact that the number had fallen between times would not be conclusive as to whether the same causes were or were not operative, but I cannot concede without further investigation, the assumption that there was an epidemic in 1890.

Q. I did not use the word "epidemic" for 1890 or for 1892.

A. I thought you did.

Q. I am wary of that word "epidemic." It was for 1890.

A. Well then I will put it in this way, but my own statistics show that there was no marked increase in 1890. 1890 and 1891 having had almost exactly the same amount of typhoid fever measured by mortality percentages and neither year being very different from the previous eight or ten years, so that all these assumptions and conclusions and deductions and inferences do not seem to me to have any value.

Q. Assuming that 277 for the year of 1890, is correct, and 160 deaths for 1891 is correct, as plotted on complainant's Exhibit No. 22, then what would you say?

A. In regard to?

Q. To the cause of the large increase in typhoid deaths in 1890?

A. From the conditions included, or rather from the facts
assumed and the conditions included, I should be unable to
3837 state because we have no knowledge of what had been
going on during 1890, and as I have already said, I think that assumption is probably contrary to the facts.

Q. Assuming that the assumption is in acordance with the facts?

A. Then I should still be unable to state.

Q. Then assuming that the assumption is in accordance with the facts of conditions in regard to deaths in 1890, the number of deaths in 1890 exceeded the number in 1900, 1901, 1902, didn't it?

A. On this exhibit it does.

Q. For each year?

A. For each year, yes sir. The annual number of deaths. But as I say, I am unwilling to accept this without further investigation because either there is a mistake in the reports of the Board of Health or else there is a mistake here.

Q. Do you consider an increase of 20 deaths in a city the size of St. Louis, which brings the total number of deaths up to 222, as being a normal increase in typhoid?

A. I must understand by normal increase that which would come from the growth of population alone, and in my judgment an increase of 20 deaths or about 200 cases in a city of this size would be abnormal and deplorable. Cities of the size and character of St. Louis should be diminishing their death rate rather than increasing it, and speaking generally all over the
3838 world they are doing so. Boston for example, with which I have compared St. Louis, has on the whole for many years been reducing its death rate, although there have been times when it has raised for a short period, the death rate from typhoid fever. I should therefore regard an increase of 20 deaths, under all the circumstances, as an abnormal and as I have said, a deplorable increase.

Q. Would you consider the mortality percentage on 10,601 cases, 198 deaths from typhoid fever, above the normal in a city the size of St. Louis?

A. I should, because that means 2000 cases, or rather very nearly 200 deaths to two thousand cases, and a mortality percentage higher than St. Louis has had at any time with the exception of 1892, 1893 and 1894,—since 1883, and also because it is very, much higher, in fact it is double the mortality percentage of New York and London, or very nearly so, as well as perhaps one-third higher than that of Boston at the same time.

Q. In a city of this size do you give any credit to the increase of typhoid fever which is contracted by citizens, outside of St. Louis and other places?

A. Certainly. That is one of the sources other than polluted water which I might have included in my list of flies, oysters, celery, milk and the like, and to that list I should

3839 like to add ice as one possibility, especially if it is made
from polluted water like that flowing in the Mississippi
river.

GENERAL CROW: Do you mean natural ice or artificial ice?

A. Either, it depends upon what the ice is made from. If it is made from Mississippi water and is not distilled or purified, it might be one element, although I believe a small element, in the production of typhoid fever. If it were natural ice cut on a polluted stream, I believe that might be one element, although a very small element, in the cause of typhoid fever.

Q. My question refers to people or citizens who have contracted the disease in other cities and other towns?

A. And die here?

Q. Yes, wouldn't that amount to quite a large percentage in this increase in death rate?

A. It would probably not amount to a large percentage of the increase, because people went away before 1900 and contracted typhoid fever very much as they do today. We may allow of course that there is more travel every year, but there is no sign of any such effect in New York City or London or Boston. St. Louis stands alone in that respect if that cause is the principal factor here. After a very careful consideration of all the circumstances and making due allowances for probable propor-
tion of persons dying in this way, coming and dying in the
3840 hospitals here and contracting the disease at summer re-
sorts and coming in and adding their name to the death
record, I see no reason to suppose that any unusual or extraordinary change has taken place since January 1st, 1900, and I may say further that I have taken some pains to inquire in regard to the hospital cases, and found no marked increase.

MR. JEFFRIES: Hospitals where?

A. The hospitals here in St. Louis.

WILLIAM T. SEDGWICK.

ADJOURNED until 10:00 A. M., Friday, May 22, 1903.

3841 Southern Hotel, St. Louis, Missouri. 10:00 A. M., Friday, May 22, 1903. Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

WILLIAM THOMPSON SEDGWICK,

resumed the stand for further cross-examination by Mr. Todd, and testified as follows:

Q. In addition to oysters conveying typhoid fever, you stated that celery might do so. In what manner, professor?

A. It is held by sanitarians that almost any form of uncooked food may under unusual circumstances, become a vehicle for typhoid fever. Among such uncooked foods celery and lettuce have often been mentioned, because these are sometimes manured with liquid or solid fertilizer which may have been contaminated with the infection of typhoid fever. As a matter of fact, however, there is no case on record in which it is clearly, quite clearly and satisfactorily established, so far as I am aware, that either of these vegetables has been the carrier of typhoid fever. I know of one case in which the evidence seemed
3842 tolerably clear in regard to celery, but this is the only case
with which I am familiar, and sanitarians generally do not allow any considerable importance to these or other vegetables as carriers of this particular disease. They rather look upon elements of this sort as going to make up that small amount of typhoid fever to which I have referred as the "normal" amount in civilized cities and towns, the word "normal" in this case being defined as I have already defined it, and perhaps rather unwisely used for a disease which ought not to exist at all in civilized communities. The true "normal" would be zero, for as someone has said, for every case of typhoid fever somebody ought to be hanged.

Q. In your last answer, professor, you gave what the views of sanitarians were, without mentioning who the sanitarians to whom you referred were. Do you adopt the views yourself which you have expressed as the views of sanitarians?

A. I ought perhaps to have said that these are my opinions, strongly held, and I believe are in entire accord with the general body of opinion of competent sanitarians generally and everywhere.

Q. In regard to the last expression in your previous answer; do you approve of that saying?

A. In the present state of civilization I consider it an extreme statement, because a great many cases of typhoid
3843 fever cases are caused by simple ignorance, and none, so far as I know, by malice.

Q. Do typhoid fever germs appear in the breath of patients?

A. I don't believe that they appear floating in the expired air, but if a patient should cough and a small particle of sputum should fly off in the breath, that particle might contain the germs of typhoid fever.

Q. Typhoid fever may be contracted from kissing, may it not?

A. It is held that it may be.

Q. Do you hold it?

A. Yes, I hold it.

Q. Are there any other ways by which typhoid may be contracted, than the ones which you have enumerated?

A. I have no doubt that there are.

Q. Are you acquainted with the number of wells in the city of St. Louis?

A. I have made some inquiries upon that subject.

Q. And what information have you been able to receive?

A. That there is a large number of wells.

Q. About how many?

A. I should have to refer to my notes, but my impression is at least two or three thousand.

Q. Do you know whether these wells are located in the neighborhood of outhouses?

3844 A. I don't know, but I have no doubt that some of them are.

Q. If the majority of these wells are located where there are privy vaults, and the inhabitants of the houses where these wells are situated use the water from those wells for drinking purposes, is there any way of estimating what effect those wells so situated, would have upon the typhoid increase in the city of St. Louis?

A. May I have that question please?

Q. (Question read).

A. I think there is.

Q. In what way, professor?

A. I think that any expert by a consideration of all the circumstances so far as he could learn them, and making careful inquiries as to changes in the custom of the people before and after a given time, would be in a position to say positively whether any such increase was due to any such cause—whether any considerable part of such increase, I will say even any inconsiderable part, was due to such cause.

Q. Do you know whether such a thorough investigation as you have indicated has been made of these wells for the years 1900, 1901 and 1902, in the city of St. Louis?

A. I think so.

Q. By whom?

3845 A. By myself. I have ascertained the number of wells. I have considered the question whether such number was materially changed before and after. I have used my general knowledge of American communities and their behavior in regard to wells and water supplies. I have taken into account the typhoid fever and the characteristics of the population as nearly as I could ascertain them by inquiry and observation, and I have come to the conclusion that there is no reason to suppose that any material change in the habits of the people in regard to the use of such wells or well waters since the time mentioned has occured, and that therefore that element may be entirely excluded as of consequence in causing any portion of the increase. I might even go further and say that as between wells taken in a general and large way, and including a certain number of polluted wells, and a city water supply, not above suspicion, it is by no means clear in my mind that the use of such wells would at any time increase the typhoid fever rate over and above the use of a water supply which was not entirely pure. I therefore exclude altogether the wells of the City of St. Louis as producing any important part of the increase in typhoid fever since January 1st, 1900.

Q. Do you consider that the information which you have is sufficient to establish your conclusions beyond all reasonable doubt?

3846 A. I do.

Q. How many wells in the city of St. Louis have you investigated personally, that privies drain into?

A. None.

Q. How many privies in the neighborhood of those wells, within these three years, have received the excreta of typhoid patients?

A. I don't know.

Q. How many people living in the houses where these wells are located and drinking the well water, have contracted typhoid fever from them if you know?

A. I have no means of knowing.

Q. And in the absence of knowledge upon those three propositions, do you claim as an expert sanitarian that your conclusions in answer to my former question were established beyond a reasonable doubt?

A. I do.

Q. I believe that you stated in one instance, of an epidemic that the same was caused from the excreta of one typhoid patient on the side of a hill. If a typhoid patient or several should discharge their urine and feces in a privy vault adjacent to a well in the City of St. Louis, and the people should drink the water from the well, is it possible for the water of the well to be contaminated by the infected fecal and urine discharge from
3847 the typhoid patients?

A. That depends altogether upon circumstanmes. If the material of the earth through which those infectious materials must pass, be of the right sort for purification *en route;* or if they be impervious to the passage of such materials; then no infection would arrive in the well. If on the other hand, cracks or fissures existed so that there was a free communication between well and privy, it is possible that typhoid fever might arise as suggested. The well water theory, however, has in my judgment been seriously overworked, and I am on record in my book entitled "The Principles of Sanitary Science and the Public Health," as stating that in my judgment the public belief in the dangers of well waters has been greatly exaggerated. In my epidemiological experience, which is now quite extensive, I but very seldom have had occassion to attribute to infected wells epidemics of typhoid fever. I may say that I have never seen an epidemic of any size derived from such source. The most famous epidemic on record in which a contaminated well was the cause of the trouble, was that at Caterham, in 1879, when the dejecta of one workman digging in a well, from which the water went quickly to the people, did apparently cause a serious and extensive epidemic, but the well water theory is in my opinion,—in the popular form of it at least,—based largely upon insufficient evidence.

3848 I know from my experiments for the State Board of Health of Massachusetts upon the purifying power of earthy materials, that as a rule the passage of infectious materials through open soil, removes all traces of infection. If the soil is not open; if it is impervious, obviously nothing can pass. The only cases in my judgment, in which privies are dangerous to wells, are those in which the soil is either very open, or cracked or fissured in some way.

In view of all these facts, and further, in view of the fact that no material or essential change, so far as I can discover, has taken place in the habits of the people of St. Louis since January 1st, 1900, I should exclude altogether the wells as any element in the increase which has taken place since that time. They may have contributed to keep up the usual amount of typhoid fever in St. Louis. No doubt a few of them have, but to look to them as in any sense, or in any degree, a reasonable explanation or a reasonable source of the increase,—the large increase,—of typhoid fever, the steady and continued increase since January 1st, 1900, would in my judgment, be a serious blunder.

MR. TODD: Just read my question.

(Question read).

MR. TODD: I move to strike out all of the answer that is not responsive to my question.

3849 GENERAL CROW: Complainant submits that the answer is entirely and directly responsive to the question asked by the gentleman, and answered in a manner exactly as the witness has a right to answer.

MR. TODD: If conditions existed in any of the wells of St. Louis where fissures appeared, permitting the contamination of privies to enter the wells, such as you have indicated in part of your answer, have you investigated to ascertain whether that condition obtains or not?

A. I have not.

Q. If that condition should obtain, would you say then as a sanitarian, that the water of that well would not spread the contagion of typhoid?

A. Am I to understand that you assume a typhoid infected privy near a fissure, or communicating with fissures leading to a well?

Q. Yes.

A. That in my opinion would be a serious menace to the health of the people drinking that water.

Q. Do you know whether in the three thousand wells or more in the City of St. Louis, that condition obtains in one or more wells?

A. I do not.

Q. Can that fact be ascertained in any way except a personal investigation of all the wells?

3850 A. It cannot even be ascertained in that way, for it would require the taking up of the earth about every well and in the process of digging, fissures might be filled up by the workmen, which fissures had previously existed. It is an impractical proposition, and the facts are, in my judgment, beyond the power of human discovery, broadly speaking. It might of course in some cases be found, but a personal inspection alone would probably not disclose it in a single instance, unless by some rare good fortune.

Q. If the theory of well contamination has been overworked, would you as a sanitarian, permit wells to be built in the neighborhood of privies, the waters of which wells are used for drinking purposes?

A. I should certainly not recommend such procedure, because while safety may, and in my judgment does, ordinarily follow it, the water of said wells would almost inevitably contain a more or less purified sewage, and for mere aesthetic reasons quite apart from all dangers of infection, I should not recommend such a course; and moreover, one can never know when a fissure may be formed or under what circumstances it

may have originally existed, so that while I believe, as I have said, that the well water theory of the causation of typhoid fever has been unduly pressed, I do not believe that well
3851 waters are entirely free from either suspicion or danger.

Q. You do admit, do you not, professor, that conditions may exist *whereby the water of a well may be contaminated, as* well as infected?

A. Certainly, sir.

Q. If that condition should exist in St. Louis, and there can be no evidence, or practically so, to disprove that assumption, and water from that well should be drunk by people visiting the household where such a condition exists, notwithstanding the fact that the parties or party who drank the water at this house, also drank the water from the water supply of the City of St. Louis, and contracted typhoid fever; is there any way known to science to prove from which cause the typhoid fever was contracted,—the well water, or the drinking water from the St. Louis water supply,—during the years 1900, 1901 and 1902?

A. Not by an examination of the patient alone; but under certain circumstances, it might be possible to establish it with a high degree of probability. If, for instance, at the time when the patient contracted the disease, as shown by the subsequent history of typhoid fever in St. Louis, few people were coming down with that disease throughout the city at large; and, further, if it could be shown that at that same time there was an outbreak of typhoid fever among persons regularly or ordinarily using the water of that well, then an
3852 epidemiologist would be justified in concluding that the patient had probably contracted the disease from the well water, and not from the city water. In the absence of some such evidence as this, however, it would be impossible to tell, as it often is in single or sporadic cases of typhoid fever, exactly where the patient contracted the disease.

Q. Suppose that there should be a number of such wells answering like conditions as are pre-supposed in the former questions, and during the year 1900, in the City of St. Louis there should be 1213 cases of typhoid; 1901, 1101 cases of typhoid, and 1902, 1112 cases of typhoid; then with like conditions prevailing at each of the places where a number of wells are located, such as is assumed in the previous questions, would it be possible for you, in the absence of a personal investigation of the water of these wells, to ascertain whether these cases of typhoid fever for these different years as I have numbered them, came *from these wells*, or a *large* part of them, came from the wells, or from the drinking water of St. Louis, or from other causes?

GENERAL CROW: Read that question.

THE WITNESS: Perhaps we had better have the previous question read.

MR. TODD: Read the previous question.

(Two previous questions and answers read.)

3853 A. Now, what do "these cases" refer to, to the total?

Q. These cases for the three years before mentioned.

A. It depends upon what you mean by personal investigaiton. If by that term you mean that I must go personally and endeavor to seek out such limited outbreaks and discover whether they form a large part of the total number of cases, then I do not consider it necessary. If on the other hand you mean merely to ask would it be necessary for me to take into consideration the possibility that such local outbreaks have occurred, or that in my studies of the vital statistics of St. Louis I should make inquiries of competent persons, familiar with local conditions, sufficient to satisfy myself in regard to the actual facts so far as known, then I may say that I do regard it as necessary, and as a matter of fact I have in my studies, taken into consideration precisely such conditions. I have satisfied myself as an expert, by careful inquiries, and by a study of the local conditions, that no serious or numerous outbreaks of this kind have occurred, or any which would justify me in coming to any different conclusion to that which I have come, namely that wells—polluted and infected wells—as an appreciable factor of the increased typhoid fever mortality in St. Louis, must be excluded.

Q. By personal investigation I mean such an investigation made by yourself or some competent, reliable person who
3854 is able by competent evidence to establish the existence or non-existence of the facts assumed in the hypothetical

questions put to you. With that definition, have you in that manner satisfied yourself as an expert, of existing conditions in regard to wells?

A. Just read that question and also the previous question.

(Two previous questions read.)

A. I have.

Q. I believe you stated that you made no personal investigation?

A. I made no personal investigation of individual wells.

Q. In St. Louis?

A. In St. Louis.

Q. From what person or persons who have investigated the conditions of these 3,000 wells in the City of St. Louis and have submitted the results of their investigation to you, that you have been able to be satisfied of the actual conditions of those wells, as they existed during the last three years?

A. I have not satisfied myself in that particular way, but in a different way. I have examined the approximate location of the places of death of persons dying of typhoid fever in St. Louis and from my general knowledge of typhoid fever outbreaks, based upon experience and my general training as 3855 an expert, I have satisfied myself conclusively that no such outbreaks have in fact happened during the period mentioned, of such magnitude as to make any perceptible impression upon the increased death rate in St. Louis during the years mentioned.

GENERAL CROW: I beg your pardon. Do you mean death rate generally, or death rate of typhoid fever?

A. Death rate by typhoid fever, of course.

Q. MR. TODD: What locations or approximate locations of places of death or persons dying of typhoid fever in the City of St. Louis have you investigated and give the location of those localities?

A. I have investigated the distribution of the deaths by years, by months and by districts throughout the city and I find that the characteristics of typhoid fever in St. Louis are precisely such as might be expected and have in fact been experienced in epidemics—the causation of epidemics or other appearances of typhoid fever,—due to an infected water supply. In

the rare instances in which epidemics or outbreaks have been traced to wells, the deaths are numerous within a short time, bunched together, so to speak, both in time and in space. I find nothing of this kind in the City of St. Louis during the years mentioned, which would lead me in any degree to modify
3856 the opinions already expressed as to the source of the increase of typhoid fever.

GENERAL CROW: Allow me to suggest that instead of the years mentioned, that you interpolate into that answer, the precise years.

MR. TODD: It is understood that you mean the years 1900, 1901 and 1902..

A. It is understood that the years mentioned are the years 1900, 1901 and 1902.

Q. What districts throughout the city have you investigated for typhoid fever?

A. The so-called sanitary districts.

Q. How are they designated?

A. By numbers.

Q. Can you give the numbers?

A. I can. There are seven.

Q. Are those seven districts co-extensive with the city limits of St. Louis or are there other districts in St. Louis aside from those seven?

A. I shall have to get a map for that. (After referring to map). They cover the city of St. Louis for sanitary purposes, and form the basis of the statistics which have been so often referred to.

Q. Do you know, Professor, whether the city of St. Louis is divided up into sanitary districts?

3857 A. I understand that it is.

Q. And how many sanitary districts are in the city of St. Louis?

A. Do you mean in the legal city,—in the municipality?

Q. Yes?

A. I don't know, but I supposed that the seven districts were co-extensive with the city boundaries, but whether they are or not, they are the districts upon which the statistics have been founded all through, and they are practically at least, taken together, the same thing as the city of St. Louis.

Q. That is, that the statistics of typhoid cases, and deaths, —especially the deaths that have been talked about here in evidence, are compiled from these seven districts?

A. That is the case.

Q. Have you investigated all those seven districts?

A. I have.

Q. How are those districts designated, by numerals or by some other means?

GENERAL CROW: He has already said they are numbered.

THE WITNESS: Yes sir.

Q. Take district No. 1, how many wells are located in District No. 1?

A. I have that information, on another paper which I do not seem to have here. If it is important I can send down 3858 and get that; it is downstairs.

Q. Yes, I would like to have it.

A. (Witness procures papers referred to). Of course I cannot undertake to say precisely, but the number I have today is 492.

Q. District No. 2?

A. 1073.

Q. District No. 3?

A. 101.

Q. District No. 4?

A. 1058.

Q. District No. 5?

A. 300

Q. District No. 6?

A. 311.

Q. And District No. 7?

A. 1877.

Q. How many deaths from typhoid fever were in district No. 1?

GENERAL CROW: What year?

MR. TODD: For the year 1900, if you have the figures.

A. I cannot of course guarantee the absolute correctness of these, but these were compiled from the official records by officials, and as I have them here, there were 19. This is for the year 1900; you asked for 1900?

Q. Yes, 1900?

3859 A. 19.

Q. And 1901?

A. Same number.

Q. And 1902?

A. 26.

Q. District No. 2—1900?

A. 14.

Q. For 1901?

A. 1901 for the second district, 27.

Q. And 1902?

A. 21.

Q. District No. 3?

A. 28 for 1900; 30 for 1901 and 36 for 1902.

Q. No 4?

A. 24 for 1900, 27 for 1901; 34 for 1902.

Q. No. 5?

A. 18 for 1900; 18 for 1901; 23 for 1902.

Q. No. 6?

A. 42 for 1900, 46 for 1901; 57 for 1902.

Q. No 7?

A. 23 for 1900, 30 for 1901; 25 for 1902.

3860 Q. Now as to the physical conditions and sanitary conditions in these wells, in any of these districts, has anyone reported to you an investigation to ascertain their physical and sanitary conditions?

A. No.

Q. Assuming that in these different districts where the typhoid was high in comparison with the other districts, that there existed a number of infected wells, wouldn't that condition account for the typhoid in the city of St. Louis?

GENERAL CROW: For what period of time?

MR. TODD: For 1900, 1901 and 1902.

A. It might, if one were justified in making such an assumption and excluding from the same assumption the possibility of the occurrence of infected wells in other districts. Any such assumption unless it covers the whole city, is a gratuitous one, and such wells are no more likely to occur in one place than in another. Besides there is in no case in these districts any such excess as would lead to the expectation or to the supposition that any such infected wells had existed and inasmuch therefore, as the assumption is so to speak, entirely in the air, and does not include all the conditions which any assumption of this kind must include, I do not think that the larger numbers of typhoid deaths in certain districts can reasonably be accounted for in this way.

3861 Q. But assume that an infected well exists out of this great number of wells in the city of St. Louis, in the absence of any personal investigation of all these wells by a man competent to pass upon their sanitary condition, you wouldn't consider as a gratuitous assumption, would you?

A. Repeat the question.

Q. (Question repeated)?

A. No sir.

Q. If such a well should exist and be connected with a dairy where the water from the well was used in diluting milk, could not that spread the disease of typhoid throughout the city if the milk was delivered to different houses and consumed by the people?

A. If the route of the dairyman covered the whole city or any considerable part of it, and the conditions were as you have stated, it is possible that an infection might be spread from such a source; but any milk epidemic produced in this fashion if of appreciable size, is usually easy to discover and there are none of the ear marks of any such epidemic so far as I have been able to discover, about the typhoid fever deaths in the City of St. Louis during the years 1900, 1901 and 1902.

Q. Do you use the word "epidemic" in the sense that you defined it yesterday as applicable to conditions existing
3862 in St. Louis during 1900, 1901 and 1902?

A. I do not remember exactly how I used it yesterday.

Q. You gave a definition of an epidemic in connection with a question that I used in which I employed the term.

A. I was under the impression that I rather avoided defining the word "epidemic" for, as I then stated, it is a debatable term. The word means "upon the people," and I believe that the typhoid fever in St. Louis during this period, during the years 1900, 1901 and 1902, would justify the use of that expression. At the same time I like to reserve the use of the term rather for such violent and brief explosions of the disease as occurred, for example, in St. Louis in 1892 and in Chicago in 1891. At the same time I should not hesitate to employ this term for the entire three years of the period mentioned, especially as the disease has been gradually increasing during that time and it may hereafter appear that worse conditions are to follow. I have, however, in my direct testimony, and I think nearly always, referred to the condition as an increase of 73 per cent. rather than an epidemic; and for the reasons mentioned.

Q. If the wells in St. Louis were typhoid contaminated to a sufficient extent to account for the increase of typhoid, how would it be possible to ascertain and demonstrate that fact, Professor?

A. I think that would be a comparatively easy matter. 3863 For in that case, inasmuch as it is absolutely inconceivable from a sanitary standpoint, that any very large number of wells should be so infected, the vital statistics must then show a large number of cases and deaths in restricted or special localities, a much larger number than have hitherto occurred in such localities, and so localized in time as to pass like a wave over even the locality in question. I believe that any competent epidemiologist would readily discover such a condition if it existed, by its results.

Q. Assuming that a household consisting of a family, had a visitor from some other city who had the typhoid fever, contracted elsewhere than in St. Louis, and the discharge of this person found its way into a well, and that the water in that well became typhoid infected, and assume that the water supply to that family should suddenly be cut off, and the question for decision would be, is that water usable. Is there any way known to science whereby it could be decided whether that water was usable or not?

A. For drinking purposes?

MR. TODD: Yes, sir.

Q. (Question repeated.) Aside from the knowledge contained in the assumption that it was infected?

A. Not with absolute certainty.

Q. What do you mean by absolute certainty, Professor,
3864 in the answer to the preceding question?

A. I mean not with accuracy. One might by chemical and bacteriological analyses gain a good deal of information. He might arrive at a high degree of probability, but our methods of chemistry and bacteriology are not so perfect but that there would remain a possibility that something had been overlooked, something had escaped observation. Samples would have to be taken as the whole well cannot be examined. One would have to take what we call for lack of a better word, a "typical" sample, but there again we have only approximate information. No sample can be absolutely typical of all parts of anything when that thing is made up of heterogeneous material. We, however, analyze these samples by processes which are open to human fallibility and which are at best only approximate, so that although we may arrive at a high degree of probability and might believe that the water was usable for drinking purposes, I cannot as a sanitarian, state that the water would be or is absolutely and indubitably free from any possibility of infection; and as long as I could not state that,—under the assumption of a previous infection, a known infection,—I should be unable to arrive at what I call an absolute certainty.

Q. Then the only proof of the infection of that water would be its effect upon the people using it, wouldn't it?

3865 A. If one obtained a positive result,—if he were fortunate enough to discover the typhoid bacillus, or a large number of colon bacilli, or other organisms characteristic of polluted water, he would have some evidence of its unfitness. If, however, chemical analysis revealed similar evidences of pollution, which might possibly be accompanied by infection, then such positive results would not require the occurrence of disease in the person using the water in order to answer the question and enable an expert to come to an opinion; but in the absence of such results, at the other end of the scale, if one found the analyses fairly satisfactory, or even very satisfactory, chemically and biologically, there would still remain an element of doubt which would prevent the expert from affirming an absolute certainty.

Q. Has the germ of typhoid ever been found in running water?

A. That is a disputed question. Some bacteriologists think that they have discovered it in running waters. Others feel that while they may have discovered something very closely related to it, yet that they have not sufficiently established the fact that they did discover the real germ of typhoid fever, so that I am unable to answer that question point-blank, with "Yes" or "No." I have never discovered it in running water, and although one of my assistants at one time, thought that he
3866 had discovered it in the tap water of a city, which water
was sewage polluted, that was a number of years ago when our methods were not as keen as they are today, and I have never felt entirely satisfied that he had the real and only germ of typhoid fever. The matter is a very difficult one at best, but at the same time some observers, especially some foreign observers, do believe that they have discovered the typhoid bacillus in running waters, and if I am not mistaken, in the sediment deposited from sewage polluted waters, and it is possible that they are right. I do not wish to set my opinion against theirs. I simply state my own, the fact that I have never found it, and that it has been found very rarely, if ever.

Q. If the well should be typhoid polluted, does that mean that the water in that well is capable, if taken into the human system, of causing typhoid, that water or parts of it?

A. That also is a very difficult question to answer. If the infection is sufficiently extensive, or if the well is small in proportion to the amount of infection,—which would come to the same thing; if, furthermore, time be given for agitation or distribution by the ordinary processes of diffusion in quiet bodies of water, or if the well be stirred up by pumping or by a bucket, or fish, such as are often kept in a well in the country,—and the stirring up of the sediment by fishes must always be borne in mind in a sewage polluted stream, and the possi-
3867 bility of a return of the infection to the supernatant water
by such agitation of sediments which have become partially typhoid infected; then it is possible that a very considerable portion of the water,—I don't mean every atom or every mollicule, but every glass or pitcher-full of the water, if you choose,—may become infected, and certainly no one would be rash enough to say that the typhoid pollution or infection of

a well will leave any part of it safe to drink, until such infection has been effectually removed.

Q. But you can conceive of conditions where people drinking of that well, some of them would be affected with typhoid and others not?

A. That, sir, is the ordinary experience in all kinds of epidemics. There we have to bring in the matter of vital resistance. Out of 50 people drinking water from an infected source, from a public supply or well, or taking milk or celery or any other infected food material, some may be immune by virtue of previous attacks of typhoid fever, and some may be in such buoyant or robust health as to be able to deal successfully with the infectious material, so that it is a common experience to find, it is a universal experience to find, that only a portion of the persons exposed to infection do actually succumb to the disease.
3868 I look upon it somewhat in the manner of a battle. A regiment may be exposed to a similar fire, but not every man is hit, and some are hit worse than others.

Q. If it is impossible, chemically and bacterially to ascertain whether a well is typhoid infected or not and everybody using this water is not susceptible to being infected by the water, and the possibility or probability that some of these wells in St. Louis, or a great number of them are infected, could not the typhoid condition in St. Louis for the last three years, in excess of what you have denominated a normal condition, from celery, oysters and matters of that character be attributable to those wells?

A. Decidedly not, because there is absolutely no reason to the best of my knowledge and belief, to suppose that any different condition prevails on the whole in the wells of the City of St. Louis since January 1st, 1900, to that which had prevailed there for years before, and I should regard it as absolutely impossible and absurd to attribute the excess of typhoid fever which has appeared in St. Louis since January 1st, 1900, to any such source.

Q. In examining the statistics of typhoid offered here in evidence, I find in the city of Lincoln, Nebraska, for the year 1900, 4 deaths.

1901, 13 deaths,
3869 1902, 2 deaths.

In the city of Kansas City, for 1900, 49 deaths,
1901 58 deaths,
1902, 58 deaths.

In Quincy, Illinois, for 1900, 10 deaths.
1901, 14 deaths,
1902, 17 deaths,

In the City of Des Moines, Iowa, for 1900, 7 deaths,
1901, 22 deaths,
1902, 21 deaths.

In the City of Minneapolis for 1900, 13 deaths,
1901, 121 deaths,
1902, 66 deaths.

In those different cities which I have mentioned, the deaths from typhoid fever indicate a gradual rise from 1900 to 1901, to 1902, with few exceptions. From your investigation and consideration of the typhoid fever in these different locations, have you any opinion to express as to what is the cause of this apparent increase for these years, in these different cities?

MR. JEFFRIES: I object to the question because it doesn't call the witness' attention to the falling off of the cases in other cities during the same period on the same watershed.

GENERAL CROW: I object to the question on the fur-
3870 ther ground that the increase in the cities named is wholly immaterial in this case.

MR. TODD: In explanation of Attorney-General Crow's objection, I will state that in view of the fact that the witness has expressed an opinion as to the cause of the increase of the typhoid in St. Louis, as a sanitarian, I ask these questions to see how extensive his knowledge is upon questions of a like character arising in other places.

GENERAL CROW: In reply to the explanation of the objection by respondent's counsel, complainant states that the asking of the witness' opinion as to typhoid epidemics in other places, certainly cannot test the accuracy of his opinion in this case, for the reason that counsel for respondent has by a long and continuous, not to say wearying cross-examination, tested fully the knowledge of the witness as to the condition of affairs in St. Louis.

MR. JEFFRIES: And I object to the question further for the reason that the witness is not informed in the assumption or in the question the distance or number of miles that the respective cities are located from St. Louis?

MR. TODD: In reply to that objection I submit that in the longest hypothetical question in the record propounded by Mr. Jeffries all these distances were assumed and have been given
to the witness, and I do not care to incumber the record by
3871 repeating what is already supposed to be in evidence.

A. Having made no investigations of the sanitary conditions and causes of the typhoid fever in any of the cities mentioned, I am unable to give any reason for the facts stated. I may, however, say that in the case of Minneapolis, the large number of deaths in 1901, namely 121, must obviously have been due to some special epidemic inasmuch as the deaths in 1900 were only 13 and fell off in 1902 to 66. Here we see no such steady rise as is found in St. Louis, and the remarkable condition of 1901 appears to have been temporary and passing, while that of St. Louis appears to be thus far at least, permanent, and steadily growing worse.

In the case of Des Moines, Iowa, the numbers given are not materially different from the number of deaths in the immediately preceding years, and in my judgment do not constitute any such remarkable difference from the years preceding, as do the deaths in St. Louis since 1900 compared with those during the five years immediately preceding. I may make the same statement in regard to Lincoln, Nebraska, where, although the number of deaths in 1900 was only four, it is obvious from a comparison of this number, with those which occurred in the years immediately before and afterwards that the typhoid fever mortality in those particular years was unusually low and the rise which came from this abnormally low period to the two following years made the number of deaths in those years
3872 only about the same as in the previous three years, a condition of things totally different to that in St. Louis.

In the case of Kansas City, so far as I have the figures before me, there has been some rise, and I am unable to account for this without having made any investigation. It is apparently not very large and may be due simply to the rapid increase in population.

Adjourned until 2:00 p. m., Friday, May 22, 1903.

3873 Southern Hotel, St. Louis, Missouri. 2:00 p. m., Friday, May 22nd, 1903. Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

WILLIAM THOMPSON SEDGWICK, resumed the stand for further cross-examination, by Mr. Todd, and testified as follows:

THE WITNESS: If you will read my answer (just before adjournment) I think I said that the same state of facts applied to Quincy.

(Answer read.)

THE WITNESS: That is all right.

MR. TODD: Professor, in the hypothetical question put to you by Mr. Jeffries, and the tabulation of typhoids from each of the cities located on the water-shed of the Missouri, Mississippi and Illinois river, exclusive of the sanitary district of Chicago, would you regard the excreta of the typhoids that appeared in each one of those several cities, if emptied into the river, upon which those cities are located, alone sufficient to make unsafe, the water supply of St. Louis? By that I
3874 mean any one city as distinct from all the cities?

A. I should certainly regard the rapid and practically continuous pouring of typhoid excreta from such a number of cases as appears to have occurred in any of these cities, as contributing to make the water supply of the city of St. Louis unsafe; but inasmuch as this is purely a theoretical question, and as a matter of fact such a condition does not, and in the nature of the case, cannot exist; and furthermore, keeping in mind the partial purification of the water supply of St. Louis after it has been taken from the river at the chain of rocks; I cannot say whether I should or should not under real conditions, so regard the water.

Q. Assume that in 1897 the total number of deaths from typhoid fever as tabulated in the hypothetical question put to

you by Mr. Jeffries, for the cities lying along the water-sheds of the Missouri, Mississippi and Illinois Rivers, were 374, and for 1898 were 375, and for 1899 were 387, and that the excreta from these typhoids which have been tabulated as the ones who died, as well as those who survived, entered the different tributaries,—the different rivers above the St. Louis Intake, would the excreta of this number of typhoids, including those who died as well as those who survived, be sufficient to render unsafe and dangerous the water supply of St. Louis for those three
3875 years, as it comes into the intake tower?

A. I have no doubt that the number of typhoid fever deaths and cases existing during the three years mentioned, upon the water-shed above the intake of the St. Louis waterworks, which numbers would indicate perhaps between three and four thousand cases, annually, would render the water supply of the City of St. Louis, if taken at the chain of rocks and delivered to the citizens, unpurified, somewhat unsafe and somewhat dangerous, but it must be borne in mind that many of these deaths occurred at very remote points. It must be remembered furthermore that at no one time was there anything like any such number of cases as three or four thousand, and that for some periods the number of cases and deaths upon this immense watershed must have been comparatively very small, so that there may have easily been times during those years, or any one of them, when the water was neither unsafe nor dangerous. Putting all the facts together, then I should say that inasmuch as at no time was there any very large number of cases or deaths upon the said water-shed, exclusive of the sanitary district of Chicago, so far as I am aware, and inasmuch further, as the water taken from the intake tower at the chain of rocks was considerably purified by sedimentation before its delivery to the people of the city, the danger at any one time could not have been very great. In point of fact the statistics show
3876 that during those years typhoid fever in St. Louis was, for St. Louis, remarkably low, and the water probably better than for many years previous, excepting the years 1895 and 1896, when the conditions of the intake were similar to those which prevailed during the three years under consideration.

Please read that answer.

(Answer read).

MR. TODD: Is that your answer, Professor?

A. Yes sir.

Q. What element in this question involved anything connected with the sanitary district of Chicago?

GENERAL CROW: I object to that for the reason that it is wholly immaterial as to whether or not the witness can so interpret the question of counsel as to make it relevant to the defense of the respondents in this case.

MR. TODD: Read the question.

(Question read).

GENERAL CROW: You refer now, Mr. Todd to your question?

MR. TODD: To my question, yes.

A. I am not sure that any element in the question required reference to the Sanitary District of Chicago. My only idea in referring to it was to make it perfectly clear to which part of the watershed I referred in my answer.

3877 Q. The data from which these summaries for 1898, 1899 and 1900 are made,—have you had an opportunity to look over them?

A. I have; most of them at any rate.

Q. From that data is it not a fact that there was typhoid fever in some of these places during nearly every month of the year?

A. I think it is, in a general way, yes.

Q. Do you hold as a sanitarian that where the excreta of persons suffering from typhoid is thrown into a running stream that cities below, located upon that stream below the place where the excreta was received, and taking their water supply from the stream, that that water supply is not unsafe and dangerous, whether the distance is 50 miles or 800 miles?

A. Will you read the question?

Q. (Question repeated).

A. As I have already repeatedly said, it is not after all so much a matter of distance, as to time, and speaking broadly, I do hold that the pouring in of raw sewage materials into a drinking water stream, is likely to render the water below unsafe for drinking purposes. There may be however times when such water could be used with safety, owing to the so-called self-purification en route, by dilution, sedimentation and the time-factor. The trouble is that no one never knows when such factors shall have had their perfect work. Days or weeks may go by when the water may be consumed without danger, 3878 and then owing to a change of conditions or circumstances, such as a stirring of the sediment or a quickening of the flow, a stream that was previously safe for a while may become a source of the greatest danger for an uncertain period.

Q. Assume, Professor, that you occupied the position in St. Louis as a sanitary engineer, and you were acquainted with all the conditions in regard to typhoid for the years 1897, 1898, and 1899 on the watershed, as have been proven here in evidence, and as have been included in the different hypothetical questions, both the one put to you by Mr. Jeffries, and the ones that I have presented to you; would you be able, from your experience as a sanitarian, as well as a scientific man, to state what times under conditions existing in St. Louis, as they did during those three years, in regard to its water supply, when it would be safe for the citizens to use the water that comes from the intake and when it would not be safe, as explained in your previous answer?

A. Just read that question.

Q. (Question repeated).

A. No, I should not be able to state the times when it would or would not be safe under the conditions assumed.

Q. That being the case, would you as a sanitarian, recommend to the citizens of St. Louis to use that water at any time during those periods, and recommend the same as being 3879 a safe drinking water?

GENERAL CROW: Complainant objects for the reason that it is wholly immaterial to any issue in this case as to what the witness might have recommended under the assumed conditions, because complainant was and is entitled to the use of the waters of the Mississippi river on the Missouri side, for drinking and all primary and domestic purposes, free from pollution by the Sanitary District of Chicago or any one else, and the question as to whether the water supply of St. Louis is such as would be recommended by a sanitarian as reasonably safe for use prior to the 17th of January, 1900, is wholly immaterial in this case.

Q. (Question read).

A. I should probably not have recommended it for drinking purposes, or as a safe drinking water at any time during that period without treatment and purification, inasmuch as one would never know—could never know, assuming that typhoid bacilli once found access to the river above in these large numbers—could never know with any precision or certainty that these would have been effectually removed. Especially is this true with a water-shed of this character, upon which a rain, limited as to the area upon which it falls, might seriously affect the problem and inasmuch further, as the stirring of sediments
3880 by steamers or by fishermen might at any time
convert what would otherwise be a well purified, flowing stream, into one laden with danger.

Q. Professor, do you know whether the Health Department of the City of St. Louis has ever examined any of the wells located in the city of St. Louis, for the purposes of ascertaining their sanitary condition?

A. I do not know, but even if they had I should not feel certain as to the results of such examination, because in the present state of the art, as I stated this morning, it is often impossible to tell by ordinary methods of examination whether a well is or is not safe for drinking purposes.

Q. In the hypothetical question put to you by Mr. Jeffries, in which no facts in regard to typhoid were assumed for the city of Alton, between Grafton and the St. Louis intake, if the facts should disclose a considerable amount of typhoid fever at Alton would that fact have any effect upon the answer that you gave?

A. May I ask what year?

Q. For the periods included in the question.

MR. JEFFRIES: Included in what question?

MR. TODD: Mr. Jeffries' question?

A. Now read that again.

Q. (Question read).

A. It might, although Alton is on the other side of the river, and considerably nearer St. Louis than the mouth 3881 of the Illinois, but as a matter of fact this question is purely hypothetical because no such facts can be disclosed. I have myself visited Alton in order to make good the blank in our record which unfortunately existed, and in order to avoid any possible blunder in this direction and I not only found no such excess, but every indication of a low death rate from typhoid fever.

Q. What did you find at Alton, Professor, in regard to typhoid?

A. I found that for the year 1903 thus far, there had been only three deaths, I think it was, from typhoid fever, in a city of 15,000 people, as recorded by the city clerk. For the year 1901 there was no record at all; for the year 1900, no record at all, and having been informed by the newly appointed City Clerk that I should get all the facts, if there were any, at Edwardsville, I took pains to visit Edwardsville and myself examined the county records but found nothing material in addition to what I had already discovered, or failed to discover, in Alton. The fact is, the Alton records are miserable in the extreme from any standpoint of sanitary science,—or were previous to January 1st, 1902, for a number of years. One of the ridiculous things that came out was that in the year 1900, I think it was, in a city of 15,000 people, only three persons had died from all 3882 causes,—a state of affairs which shows the absolute worthlessness of the records. It is perhaps the most remarkable death rate that I ever heard of.

Q. Professor, if the excreta of typhoid fever should be placed in a privy vault, how long would it have to remain there before it would lose its infection?

A. No man knows.

Q. It might be days, weeks or years, might it not?

A. I believe so.

Q. Do you believe in the theory of what is known as septic tanks?

A. I believe in a septic tank, but I know of no one "theory" of that tank.

Q. Would a privy vault operate as a septic tank for the purification and destruction of pathogenic germs?

A. Ordinarily a privy vault does not closely resemble a septic tank because it is a mass of tolerably solid material, while a septic tank is essentially standing or stagnant sewage. That is to say something very much more dilute. At the same time, some privy vaults are undoubtedly septic tanks, but as to septic tanks, while I believe that pathogenic germs are relatively quickly destroyed, we are not yet in possession of sufficient evidence to enable us to speak with entire precision
3883 on that head. I do believe that under some circumstances the typhoid excreta in a septic privy vault might be disinfected and under slightly different conditions, might not; but the ordinary privy vault is not in my judgment, a good septic tank.

Q. And if the contents of such a vault should be placed where the same should get into a stream it would contaminate that stream both by way of pollution and infection, would it not, if the contents came from typhoid patients?

A. Read that please.

Q. (Question read).

A. It would, unless as stated in the previous question, the pathogenic germs might have died out.

Q. When you made your investigations in regard to typhoid in the city of Chicago, was that investigation made under the authority or by the direction of anybody?

A. No.

Q. It was an individual investigation?

A. A labor of love,—purely a labor of love. I was informed that typhoid fever was excessive in amount in the city of Chicago not long before the opening of the World's Fair, and realizing what it meant to the whole country, not to mention visitors from other countries, to have Chicago in the midst of so great a typhoid epidemic as that from which it was then suffering, I deemed it my duty to collect the facts and publish them.

3884 Q. In your investigations, to what did you attribute the conditions of typhoid in the City of Chicago?

GENERAL CROW: Have you got that report, professor?

A. Yes.

GENERAL CROW: You might refresh your memory?

A. Chiefly to the pollution and infection of the water supply, although of course, the usual factors of secondary infection, milk and the like, were also considered. We,—for Mr. Allen Hazen was with me in the investigation,—found in the reports of the State Board of Health of Illinois and in those of the Chicago department of health, as well as in certain documents published by associations of citizens such statements as drew our attention at once to the water supply, and further studies led us to believe that this was indeed the principal cause of typhoid fever in Chicago.

I should be glad to read in support of this position if it is proper to do so—

MR. TODD: I don't care to do that. I just wanted to ask you a preliminary question—

GENERAL CROW: You can put that in the record if you want to.

MR. TODD: Well, I object to it—Just read my question.

(Question read).

MR. TODD: Now that doesn't call for the report.

3885 GENERAL CROW: It is not his report; it is somebody else's.

MR. TODD: Do you consider that the question that I asked called for your report, Professor?

GENERAL CROW: It called for what he based it on.

MR. TODD: Read my question.

(Question read).

GENERAL CROW: You can finish your answer to the other question and then answer the last one.

THE WITNESS: Well, I will answer the last one first.

I do not consider that it calls for the whole of my report, but I am glad to be able to show briefly what the condition was at that time, in order to justify my conclusion that the epidemic was due to the pollution of the water supply.

MR. TODD: Q. Now that is all that I want for the purposes of my question. If you are desirous of putting your report in, why it is a matter that you have a perfect right to do; but it is a matter that I did not request and do not call for it.

THE WITNESS: I should like very much to put it in.

GENERAL CROW: In reply to the suggestion of respondent's counsel, the complainant states that the respondent has no right to dictate the answer for the witness, and that if the witness wishes to put something into the record which respondent thinks should not go in, he can move to strike it out.

MR. JEFFRIES: And I would make the further suggestion that the records from which the witness desires 3886 to read, state conditions as they existed at that time, and as he found them, and speak for themselves with more force than if stated by the witness from memory today, because it has been ten years since the incident occurred.

MR. TODD: I want to state in objecting to the introduction of the report, that the answer that the witness gave, namely, his conclusion, in regard to the condition there, was all that was intended and all that the question implied.

JUDGE JOHNS: I object on the part of the State of Illinois because the proposed reading is not in any sense or way pertinent to the question nor an answer to it.

THE WITNESS: Just read my answer there.

(Answer read).

THE WITNESS: (Continuing). If it will save the time of counsel, I can introduce the entire report, but if that is not proper nor timely, I should be glad to read some extracts from it.

MR. TODD: I made no request for any extracts from the report, and if the witness reads any extracts he does it voluntarily.

THE WITNESS: Certainly, in justification of my position at that time.

MR. TODD: As my question did not call for any facts upon which the conclusion was based—

3887 THE WITNESS: That is true, but to justify myself I should be glad to present some of the facts.

JUDGE JOHNS: To justify yourself about what?

A. About my conclusion.

Q. What conclusion?

A. That the water supply was the cause of the typhoid fever.

MR. JEFFRIES: And involves a question which was put to the witness by Mr. Todd originally.

JUDGE JOHNS: Your conclusion then or your conclusion to which you have testified now?

ATTORNEY GENERAL CROW: His conclusion then.

JUDGE JOHNS: Well, I am asking the witness.

A. You mean my conclusion in 1892.

GENERAL CROW: I am aware that you are asking the witness, but I have a right to suggest.

THE WITNESS: My conclusion in 1892, yes.

JUDGE JOHNS: Your conclusion in 1892?

A. Yes sir.

Q. What has your conclusion in 1892 to do with your conclusion in 1903?

GENERAL CROW: Your co-counsel asked that question, and the record shows it.

MR. TODD: That is correct; I wanted an answer on that
question for another question that I want to predicate it
3888 on. But I don't consider that because I asked the wit-
ness for a conclusion and he happens to have written a
book on the subject that the book should go in the evidence. I have no power to keep it out, except by motion to exclude, that is all; but it has no relevancy to the question which I had intended to follow it up with.

ATTORNEY GENERAL CROW: I suggest that the witness go ahead and read what he wants to, and you can cut it out afterwards.

THE WITNESS: I should like to change the word "justify" there to—where I said—what is the previous question?

(Question read as follows:) In your investigation, to what did you attribute the conditions of typhoid in the city of Chicago?

MR. TODD: Wait a minute; I would like to modify that question.

GENERAL CROW: I object. You can ask additional questions but let the record stand as it is.

MR. TODD: I want to change that question from "conditions" to "causes."

THE WITNESS: So that it will now read?

(Question read as follows:) In your investigations, to what did you attribute the causes of typhoid in the City of Chicago?

A. We attributed the cause of typhoid fever in the city
3889 of Chicago at that time to a pollution of the water supply
by sewage which according to the best information we

could obtain was from time to time washed out of the sewers and the Chicago river into the intake cribs, especially by floods and freshets, having found that the records of a number of years described a very remarkable and most unsanitary state of affairs, especially in the Chicago river. We did not ourselves make any further investigation than a study of the vital statistics and an examination of the local conditions. We did, however, find a remarkable series of records or statements in the reports of the Department of Health of the city and of the State Board of Health of Illinois, one or two of which seem to me to be germane to this case, and especially instructive under the conditions upon the Illinois river since the construction of the drainage canal—

MR. TODD: Now I object to the witness giving any facts which he believes germane to this case, as he is called as an expert to answer questions and not to give th [illegible] any bearing on this case one way or the other, as he may decide.

THE WITNESS: (Continuing). On page 16 of our report, we record the following statements in regard to the sanitary history of Chicago and the emptying of the Chicago river after freshets. It is taken from a report of the Citizens'
3890 Association upon the Main Drainage and Water Supply of Chicago, 1885.—

MR. TODD: Wait just a second, Professor; I want to get some objections in here. I object to the witness reading from any report of the Citizens' Association as the same is not legal evidence, and for the reason that it is not responsive to my question, but is injecting statements into the record that are not responsive and not competent as evidence.

THE WITNESS: (Continuing, reads from book.) "The "Sanitary history of Chicago is a history of makeshifts and "expedients. In the great rain of August 2nd, of this year— "1885—the contents of both branches of the Chicago river, with "the sewage accumulation of many weeks in the south fork, the "contents of slips, and the washings from several hundred miles "of low grade sewers, were in a few hours incontinently belched "into the lake. At every considerable freshet in the Desplaines "and in the north branch, or several times in an average sea-

"son, a similar obnoxious flood, differing little in degree, is "turned into the lake water. The ejection of such volumes of "sewage into the lake at irregular intervals, is a matter for "most serious consideration, in connection with the water supply. That it sometimes reaches the crib under favoring conditions of wind and current is a matter of direct observation "and evidence from city hydrants. * * *

3891 "That raw, unoxidized sewage occasionally and not "rarely contaminates our drinking water, does not admit of serious question. On Wednesday, August the 5th the "river discharge was obserbed in an unbroken stream to and "around the crib." There is much more of the same material but I think I have read enough to show that we had good reason to believe that it was the flushing of this great mass of accumulated sediment which was largely responsibe for the contamination of the water supply, especially as there was abundant evidence of a cumulative character in the official reports of the State Board of Health of Illinois and of the City Department of Health of Chicago and as, furthermore, we ourselves on one or two occasions saw the dark sewage material flowing out from the river toward one of the cribs, which we believed it might easily reach. We were loth to come to this conclusion because at that time we believed in the efficiency of the lake as a storage basin and purifying place, an opinion which was justified by the general opinion of sanitarians, and we had to fortify ourselves at that time by all the evidence that we could get, in order to come to that conclusion.

MR. TODD: I move to strike out all of the evidence as taken from this report as not responsive to the question.

Q. Did you ever find anybody that differed with the con-
3892 clusion that you arrived at, that the typhoid of Chicago was caused by the polluted water supply of the city.

A. We did, indeed.

Q. Who did you find, Professor?

A. The newspapers for the first few days after we published our report, referred to us as "jealous Bostonians" and men who did not know anything about it, affirming that the water supply of Chicago was "pure and unadulterated," and that "Lake Michigan is the most magnificent water supply in the world."

Q. (Question repeated).

A. I think my answer is responsive. They further quoted, if I remember right, some of the city officials who made similar statements.

Q. When was this report made, Professor?

A. I don't remember the exact date. Yes, it was read before the American Statistical Association on the 22nd of January, 1892.

Q. Did you know at that time that the Hering Commission had made a report upon the condition of the water supply of Chicago?

A. If I did, I have forgotten it.

Q. Did you know that a bill had already passed the legislature for the building of the drainage canal?

3893 A. I am not sure whether we did or not. I suppose we did. We certainly did before the paper was published, because it is referred to here with some satisfaction.

Q. Well, the bill I believe, was passed in 1889.

A. Then we probably knew.

Q. Assuming that the water supply of Chicago was contaminated by the sewage emptying into the lake, and this sewage was what caused the prevalence of typhoid fever in Chicago, would the elimination of all that sewage from Lake Michigan cause, in your judgment, a reduction of typhoid in the City of Chicago?

A. I should certainly expect it to do so.

Q. Do you regard the lake water at Chicago, if the sewage of the sanitary district, including Evanston on the north and Calumet on the south, as well as the city of Chicago, is eliminated from the lake, as contaminated water?

A. I never have until recently. Someone I believe, has lately suggested,—an engineer of some repute,—that possibly it is, from the sewage of Milwaukee, or the shores of Lake Michigan, at other places than those mentioned.

Q. My question is, do you. I cannot cross-examine these other people. I want to know if you do, you are a sanitary expert.

(Question repeated). And dangerous to the public health
3894 of the City of Chicago for drinking purposes?

A. I should certainly not consider it a seriously contaminated water, and certainly not very dangerous to the public health, but in view of the fact that steamers are constantly passing in and out of the mouth of the Chicago River, and in view of the fact that the Lake apparently is used by numerous fishermen and pleasure seekers, and in view of what I suppose to be the fact that in times of extraordinary rainfall the Chicago River may, even today have its current reversed for a time, I cannot say that I should consider the water of Lake Michigan within four miles of the shore, on the lake front of Chicago, as a perfectly wholesome and suitable material for drinking purposes, under the conditions assumed.

Q. Assuming that the river will not reverse its course when a gravity flow of 600,000 feet is passing the Bear Trap Dam, by the largest kind of a rainfall, eliminating that factor, what would you say?

A. Then, certainly the danger would be very much diminished, the present danger would be very much diminished, but would, I believe, still exist in some degree. The requirements of a pure water supply are steadily rising, and keeping in mind how great a city Chicago is likely to become in the near future, and keeping in mind also the increased use which will be made of the water on the lake front for commercial and pleasure purposes, I cannot escape the conviction that the 3895 water, even at the Four Mile Crib, would not be under the conditions assumed, entirely proper for drinking purposes, or likely to remain so.

Q. Do you know of any large city in the country whose water supply rises to the perfect standard fixed by sanitarians?

A. I do not.

Q. Do you know of any city in the country that will have a better water supply than the city of Chicago when the sewage of the Sanitary District is completely eliminated from Lake Michigan?

A. Yes, I think so. I think that the water supply of New York is better than that of Chicago would be under those circumstances, or would be likely to be later on. I think that the water supply of Boston is another example.

Q. Any other?

A. I think that the water supply of Philadelphia, if the filters now under construction and others which are contemplated are carried to completion, and are rightly constructed and rightly managed, will be such a case.

Q. What effect in your judgment as a sanitarian will the elimination of the sewage of Chicago have upon typhoid conditions in that city?

A. You mean the elimination by completing the sewers 3896 and bringing all that can be so brought into the drainage canal?

Q. Yes, and I will state that the system when completed, will be a complete elimination of the sewage of Chicago.

A. That ought to be followed by a material reduction in the typhoid fever death rate, and I should expect that it would be.

Q. As the reduction of typhoid takes place, the danger from the sewage of Chicago going into the lake will be thereby decreased, will it not?

A. Yes sir.

Q. And the elimination by that process will tend gradually to purify and improve the water conditions of Chicago, will it not?

A. I believe so; so far as that element is concerned.

Q. And that in turn will eliminate to a large extent the pollution and infection of the Illinois river, will it not?

A. The infection, not the pollution.

Q. I mean the infection.

A. The infection, yes, it ought to do so. But yet even it the rate is lowered it will not necessarily do so. The quantity of material put in will depend not upon the rate, but upon the total number of cases of course.

Q. I am speaking of the infection.

A. Exactly; but if the rate fell off one-half, and the 3897 total number of cases continued the same by the growth of the city, or by any other means, then the quantity put in would remain the same, the quantity of typhoid material put in would remain the same.

Q. But that is what is known as a gratuitous assumption, is it not? Under the conditions that I have assumed for the lake water?

A. I don't think so sir. I assume that Chicago is going to be one of the greatest cities of the world, and although I assume also, under the conditions mentioned, that the tyhoid fever death rate will fall off very largely, yet the total amount of typhoid material thrown into the drainage canal may even get bigger than it is at present.

Q. Do you believe that the growth of Chicago in population will be co-extensive with the increase of typhoid, with pure drinking water?

A. I don't understand the question.

Q. That the typhoid conditions with pure drinking water in Chicago will increase at the same rate that the population increases?

A. I should hope not. No man can tell, of course. I should hope and I look confidently for a material reduction in the death rate of typhoid cases and typhoid mortality per 100,000 of population, when the sewage is taken out of the lake 3898 altogether, but there will always be some typhoid probably in a city of that kind, and whether with an increase of the city in numbers, the total amount of typhoid infection going down the drainage canal will be as great as it was before, no man knows. I hope that it will not be. I should suppose that it ought not to be.

Q. Aside from the drinking water as a source of contamination, are there any other precautions that a city can take to prevent the presence of typhoid?

A. There are many other precautions. The matter of disinfectants, for example, of the excreta under the careful supervision of the Board of Health, with free disinfectants furnished to the poor, and with sanitary police to make sure that such disinfection actually takes place in the houses of both rich and poor; the careful isolation of cases as far as practicable, so that walking cases and the like, shall not distribute their excreta throughout the city; a better inspection of milk farms, so that cases of typhoid fever arising on the milk farms shall be shut out from the dairy yards and barns and the utensils which the milkman uses; the careful supervision of the oyster supply; the careful examination of the ice supply as to its origin, with pains taken that such ice as comes into the city shall be cut from proper sources, not exposed to sewage pollution, nor from sewage polluted streams of lakes. There are many pre-

cautions which could be taken to diminish the existence of
3899 typhoid fever in a city over and above that of pure water
supply.

Q. An anti-kissing society would be a good thing too, wouldn't it?

A. I think that it might restrict the spread of various diseases, though I have no great expectation that any such will be formed.

Q. Was the Chicago river at the time you made your investigations up there, and drew the conclusions that the sewage ot Chicago contaminated the lake, did it have any element or attribute of what is known as a septic tank?

A. I think it had in places, many of the elements and attributes of septic tanks a good deal of the time. It resembled very closely septic tanks in that it was essentially a mass of liquid sewage with a scum on the top, fermenting and purtrifying, as a septic tank should do.

Q. What is your opinion as to whether the conditions that obtained in the river at that time would destroy the presence of the bacteria of typhoid?

A. As I recall the river, and as I have refreshed my memory of it by reading my report today, or parts of it, I should say that some parts of the Chicago river at times were undoubtedly in such a condition as to be likely to abreviate life of pathogenic germs. I may add, however, that our knowledge of the life
of pathogenic germs in septic sewage is not as extensive
3900 as I wish it were, but so far as it goes, it points towards
their destruction under some circumstances in such
sewage.

Q. When the sewage of Chicago is diverted from the lake and the number of typhoids in Chicago are reduced, in your opinion, would the sewage discharged through the drainage canal in coming out into the Illinois river, spreading over the bottomlands and mingling with the vegetation there, would those conditions have a tendency to purify and eliminate the infection from the Chicago sewage?

A. There can be no question that such conditions as are mentioned near the end of the question, would have a tendency to remove from the flowing liquid the infectious germs referred

to and in so far to purify such flowing liquid. As to the first part of the question, the removal of the sewage from the lake into which it now goes and its turning down the drainage canal, other factors come in which must be carefully considered. As now is, the sewage going into the lake enters a large body of comparatively deep, cool and quiet water, in which the conditions for sedimentation and the detention of the typhoid bacilli upon the bottom are favorable. It is a grave question whether, after the sewage now thus going into the lake, and there undergoing more or less purification is gathered into intercepting and
3901 other sewers and sent rapidly down the drainage canal,
unpurified in any way, it may not actually bring it about, that more typhoid germs shall arrive in the Illinois valley than now arrive there. I have not, however, taken into consideration thus far the probable diminution in the typhoid fever death rate in the City of Chicago. If this diminution results, as I hope that it may, in a smaller quantity of typhoid fever excreta, this will be an immense gain; but if the city should grow, it may happen, as I have already indicated, that an amount of typhoid excreta may still be turned down the drainage canal, as great as that flowing through it today, or even greater, and if this should happen, there would be no sanitary advantages from the conditions assumed, but rather a disadvantage, especially if the rate of flow in the drainage canal should be increased.

Q. Professor, has the origin of the typhoid germ ever been located?

A. I think so, sir. Yes sir. It is found in various parts of the human body, especially in the spleen and in the alimentary canal.

Q. Does it have its origin in those locations of the human anatomy?

A. If I understand what you mean by "origin," I think I may say that it does. The origin of species is something
3902 which Darwin wrestled with a good many years ago, and
precisely where the first microbe, or the first man come from is still uncertain, but speaking of the origin of typhoid germs, for sanitary considerations, I think I may say that it is essentially as already stated.

Q. Is the typhoid germ found in any other animal than man?

A. I believe that there are so-called cases of typhoid fever in some of the lower animals, but these are, to say the least, uncertain, and I cannot say that the existence of such well defined germs has ever been made out. We therefore look to the human subject as the source of pollutions of water, sewage and the like, rather than to any of the lower animals.

Q. Will the sewage which enters the Illinois river at Peoria purify itself within 25 or 50 miles, in your judgment?

A. To a certain extent, yes, but not to such an extent that I should consider the stream in which it is poured fit for drinking purposes.

Q. In a hypothetical question, the last one that was put to you by General Crow, that if a conduit connected with Lake Michigan at the mouth of the Chicago river transmitted a volume of water equal to 300,000 cubic feet per minute to Grafton and emptied the same into the Mississippi river, whether that amount of Lake Michigan water would endanger the water supply at the St. Louis intake. 3903

GENERAL CROW: You have not all the facts that I assumed. I assumed also that the conduit contained all the sewage of Chicago emptying into Lake Michigan.

MR. TODD: That is what I was going to add to that. And, adding the suggestion that General Crow just made, did you assume in that question the sewage that now empties into Lake Michigan as distinct from the sewage which empties into the Chicago river, a limited sewage contamination, to that which entered lake Michigan?

A. That was my understanding of the question. Assuming that only water of Lake Michigan, at the mouth of the Chicago river and its vicinity—I think the question ran like that.

Q. Have you ever made an analysis of the waters of Lake Michigan at that point?

A. No sir.

Q. Would the analysis of the water at that point made by any method now known to science, assist you in coming to the conclusion that you did?

A. Analyses are always valuable aids, but even if I had, as was the fact, no analyses, I should have to come as I did come, to the conclusion simply upon the fact that the sewage of somewhat more than a quarter of a million of people, as I under-

stand, is now going into the lake not very far from that
3904 point, and that the water of the lake is now being taken
into the Chicago river, thus drawing upon these not very remote points of sewage discharge, and also sucking in the inevitable contaminations which the lake front in any big city must receive from steamboats and fishermen, and so on.

Q. Are you acquainted with the lake front in Chicago?

A. Fairly well, but not very well.

Q. Do you understand that on the North Side of the City there are fishermen?

A. No, as I remember the North Side, it is the beautiful residential portion.

Q. And on the south side from 12th street south to 53rd is occupied by the Illinois Central Railway tracks?

A. I am aware of that, and it may not be a fact today; but certainly not many years ago when I was there, the whole shore just outside of the tracks was lined with fishermen, so that every post had a man sitting on its top with a fishing pole in his hand. That may have all been done away with. I haven't been there very lately, but it was a remarkable fact, because I have made some investigations of the exposure of drinking waters to the doings of fishermen, and once traced an epidemic of typhoid fever in Haverhill, Massachusetts, to the probable infection of
the water supply at the intake or reservoir by fishermen
3905 who were out in a boat in that vicinity.

Q. What proportion of dilution would such a volume of water entering the Mississippi at Grafton, bear to the Mississippi River?

A. Dilution of sewage, do you mean?

Q. Yes?

A. I don't know, I should say that the dilution would be enormous from Chicago.

Q. In that hypothetical question, taking 300,000 cubic feet of water?

A. Exactly, as I say I should think that the dilution of the sewage at two ends of the Sanitary District, whatever they are, would under that condition be enormous.

Q. And mixing with the Mississippi river at Grafton?

A. It would be still further increased?

Q. And that condition in your opinion would render the water supply of St. Louis dangerous and unsafe?

A. Without some form of purification.

Q. Under the present conditions, I mean?

A. Under the present conditions, that is, at the intake you mean?

Q. Yes sir.

3906 A. Yes sir.

Q. And would that be more dangerous than the water supply of St. Louis was prior to the opening of the drainage canal?

GENERAL CROW: I object to the question because it is wholly immaterial.

A. I cannot say as to that. I have already testified, I think, to the fact that I did not regard the Mississippi water previous to the opening of the drainage canal as it arrived at the chain of rocks, as suitable for a modern city, but as to less or more I cannot say without a very careful investigation.

Q. Professor, in the question that I asked you in some previous part of my cross-examination, I assumed that the number of typhoid cases in St. Louis for the month of November was 480, and for the month of December 350, and I find the facts to be 482 in November and 116 in December. If the questions had been correctly stated according to those figures, would it make any difference in your answers?

A. No sir, that would probably have made no difference in my answers.

WILLIAM T. SEDGWICK.

ADJOURNED until 10:00 A. M., Saturday, May 23, 1903.

3907 Southern Hotel, St. Louis, Missouri. 10:00 a. m., Saturday, May 23rd, 1903.

Parties met pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

WILLIAM THOMPSON SEDGWICK

resumed the stand for re-direct examination by Attorney General Crow and testified as follows:

Q. Professor, in your previous testimony you used the term "normal typhoid," is that an accurate expression and will you please define to me what you mean by that term as used in your testimony?

A. I have used the word "normal" typhoid and, although I perhaps explained it sufficiently for passing purposes, I want to be careful not to give an impression that this is a common term, or a safe term for use in this kind of work. In thinking the matter over since, I am inclined to prefer the word "residual" typhoid, to normal, meaning by that that the amount of typhoid which remains in any community after deducting any particular element under consideration and especially any larger important element—

3908 Q. Element of what?

A. Element of the causation of the fever itself, or what contributed to it. I had in mind what contributed to it.

Q. That's what I supposed, but you didn't state that.

A. I am simply trying to arrive at a good scientific statement of the case for use hereafter if need be. The word "normal," as applied to a disease being objectionable, and I should say, for example, that in the city of Chicago, after deducting the typhoid fever which might be reasonably attributed to infected water, if it should appear that the amount then remaining in the city was fairly comparable with the amounts remaining in cities having good water supplies, such remnant or remainder might well be called the residual, rather than the normal typhoid, and I should say the same thing of St. Louis or New York or Boston or any other city. It is simply that I wish to place myself straight on the use of a term which I do not altogether like, the more I think of it.

Q. Now Professor, in your cross-examination you dealt somewhat with the question of number of cases of typhoid. fever in the watershed tributary to the intake tower at St. Louis, and those cases in the Sanitary District of Chicago. Have you any figures that would enable you to give me the total amount of cases as reported from which the complainant has submitted typhoid statistics on the water-shed tributary
3909 to the intake tower of the St. Louis waterworks for the years 1897, 1898 and 1899?

A. Yes sir.

Q. What are the towns?

A. Those that I happen to have before me are St. Charles—

Q. Well, never mind. You needn't name the towns. It will just take up time. If you have the number of cases, give *them.*

A. You mean the number of deaths.

Q. The number of deaths as given by the statistical reports that were put in on that territory.

A. These are all in the record and have been referred to repeatedly, I think, by counsel on both sides and are in round numbers for the years 1897, 1898 and 1899, something like 1,100 deaths.

MR. TODD: Is that for the three years?

A. That is for the three years, yes sir. This would mean say about 11,100 cases for the three years under consideration.

GENERAL CROW. Now have you any statistics which would show the number of deaths from typhoid fever in the Sanitary District of Chicago for those three years, 1897, 1898 and 1899?

A. Do you mean that for the same years, 1897, 1898 and 1899?

Q. Yes, that's what I mean?

A. In the city of Chicago during the same years, 1897,
3910 1898 and 1899, the total number of deaths reported was
1,515, which would mean about 15,100 cases.

Q. Now have you any statistics that would give the number of deaths in the water-sheds tributary to the Missouri river, as reported by the statistics for that territory submitted by complainants heretofore during the years 1900, 1901 and 1902?

A. I have, and these amount, according to the figures I have before me, to 1,144 deaths.

Q. How many cases would that amount to?

A. About 11,400 cases.

Q. Now have you any figures which would give the deaths, by typhoid fever from the Sanitary District of Chicago for 1900, 1901 and 1902?

A. The total deaths for the period of 1900, 1901 and 1902, in Chicago was 1647, which would amount to about 16,400 cases.

Q. Now, Professor, in your cross-examination, one of the first questions that was asked you was with reference to whether it wold cost any more to filter the water supply of St. Louis after the opening of the drainage canal and now, under present conditions, and those that existed then, than it would have cost before, and I want to ask you what you have to say about that proposition now, considering your answer as given then, and the state of facts as they exist?

A. The question, as I remember it, was in regard to puri-
3911 fication by filtration and my answer was, that the cost
would probably not be materially increased by the addition of the pollution and infection derived by the city of Chicago or the opening of the drainage canal. On reflection, however, I realize that I did not take into consideration with sufficient care the fact that aside from the masses of filth that might be washed down on certain occasions, such as freshet periods and which would add somewhat to the cost of the cleaning of the filter and caring for the same,—a cost which might or might not be a material increase in the conduct of those filters according to the importance attached to the word "material",—there is and would be the necessity for a much keener watch of the filters in regard to protection of operation, so that it might make a difference for example between the employment of a low-salaried man and a high-salaried man as resident manager of the works. The fact is that in all our big cities using water filters, although at first it was thought that almost anyone could manage them, and low-priced men were often put in charge, experience is rapidly teaching us that the best men are none too good to supervise filters and safe guard the citizens against the incoming of the germs of infectious diseases. The volume of water passing through is so large that possibilities of damage, by frost, to the filtering material, and the possibility of channels working
through the filters, and various other factors are making
3912 it every day more and more clear that we have got to have
able and experienced and high priced men in charge of these things, so that even at present I do think there would be a material increase of cost in the probable management of such filters because of the added pollution and infection from the city of Chicago. This is more particularly the case at present be-

cause there either is now or lately has been in the city of Chicago, a typhoid fever epidemic, the number of deaths in the year 1902 having been larger than at any time since the great epidemic of 1890, 1891 and 1892. The actual occurrence of such an epidemic at the present time, or very lately would of necessity be a source of the greatest solicitude on the part of anyone operating filters in St. Louis during or shortly after any such epidemic and it would be necessary to employ extraordinary care in operation and superivision of such filters even at the present time because of the epidemical condition of typhoid fever in Chicago in 1902. Furthermore, inasmuch as Chicago has repeatedly suffered from outbreaks of the disease which can be fairly called, and have been called, epidemics, the present operation of filters in the hands of any competent person would require extraordinary and constant attention and skill; and such things are costly.

Q. Well, can you state whether or not there might in the future rise a condition by reason of the increase in popu-
3913 lation of Chicago to say, three or four million people that a single filtration would not suffice?

A. I think I have already intimated in some part of my testimony,—I have already expressed in some part of my testimony, an opinion to that effect and in consideration of the already large amount of typhoid fever in the Sanitary District or City of Chicago, and in view also of the rapid increase of population in that city I should expect that such cost of maintenance and operation of filters as has been just referred to might steadily increase until it might even become necessary to resort to double filtration. Looking still further into the future, there might even come a time when at low periods of flow, the oxygen in the river should disappear altogether for brief periods and septic conditions should rise and new difficulties in filtration be introduced, not necessarily by the typhoid fever alone, but by the presence of mere filth which should so corrupt the stream as to render the water unfit for drinking purposes under any consideration. This, of course, would probably be a very long time in the future, but it is entirely within the bounds of possibility. Many a stream that was once bright and pure has been converted into an open sewer, a stinking nuisance, not only unfit for drinking purposes, but a source of obnoxious odors and the like; as for

instance happened in the Blackstone River in the state of
3914 Massachusetts, which was formerly a bright, pretty
stream, but which has been so defiled by the sewage of the city of Worcester, that between Worcester and the town next below,—Millbury by name,—it is simply an open sewer; or as has happened, I suppose, in the little stream in St. Louis known as Des Peres, which anyone can see is now practically an open sewer, but which was presumably a few years ago a decent stream. It seems to me that it is precisely these long looks into the future that we have got to take in cases of this kind. The population on the Missouri and the Mississippi is rapidly growing, the defiling of the rivers is increasing and likely to increase because of this growth, and the addition of a vast population like that of Chicago, discharging its filth into the Illinois River, a tributary of the Mississippi, and contributing to that general deterioration of the river is bound to go on unless some steps are taken to correct it, is a matter, it seems to me, of grave consequence and likely to add a heavy financial burden to any city using its water. I may say still further in regard to the Blackstone, the history of which is very interesting in this connection and important, that while the Blackstone river is furnished with various dams which were formerly sources of water power, these are gradually filling up and although at times the water flowing over them is very clear, at flood times it is black and dirty and
the river, flushing itself to a certain extent, removes these
3915 impurities and puts them further down, but has thus far
failed to come anywhere near purifying itself in the upper reaches, and is of course not used as drinking water below. The stream has been turned from a respectable river, into a most objectionable and abominable open sewer between Worcester and Millbury. Bearing in mind furthermore, that the dry water flow, the low water flow of the Mississippi river at St. Louis is something like 40,000 or 42,000 cubic feet a second; and that Chicago is already pouring down 5,000 cubic feet a second of mixed water and sewage; and that the drainage canal is built in places for the carriage of at least 10,000 cubic feet a second, it seems to me fair to inquire what will be the effect of that mixture of 10,000 feet a second of water and sewage with the Mississippi river, which at times is only flowing 40,000 or 42,000 cubic feet

a second in volume at St. Louis. Here we come it seems to me, near to the danger line. It is not at all inconveivable that all things considered, when 10,000 cubic feet a second are poured down, and are more readily charged at Chicago with mere pollution,—quite aside from typhoid fever,—the presence of this material in the Mississippi, itself growing more polluted meanwhile may bring about or help to bring about at certain seasons of the year a condition approaching that of a septic tank, when the oxygen will begin to fall off in the water and that
3916 water will begin to degenerate into a condition of dilute
sewage. All these large and general propositions, it seems to me, have got to be kept in mind. I think they involve added cost today, and I think they will involve a very greatly increased cost in the near future, and they may even amount within fifty or a hundred years to such a pollution of the Mississippi river in dry weather times, low water times, as to make it an impossible source for any modern civilized city; for it is fair to suppose that cities in the meantime will not relax their sanitary requirements as to water supply, these having long been steadily rising, so that even double filtration in time may not suffice. In regard to the probable number of cases of typhoid fever in Chicago during the last three years, as compared with the number in the cities on the rest of the watershed during the same period, and in regard to the number in the cities on the watershed before the opening of the drainage canal above the intake of the chain of rocks, I am deeply impressed with the fact that while I have been able to learn of only about 11,000 cases in the cities on the watershed during each of the three year periods referred to, before and after.

Q. During each or during the total?

A. During each of the three year periods,—above the chain of rocks and exclusive of the sanitary district of Chicago;—I find that there must have been about 16,000 cases in
3917 Chicago during the period of three years since the open-
ing of the drainage canal; so that it appears that the opening of the drainage canal has more than doubled the probable number of typhoid fever cases in the urban communities on the watershed above the intake at St. Louis. Moreover, al-

though Chicago is some 358 miles distant from the city of Louis, some of the cities on the Missouri and Mississippi wat sheds are even farther away, many of them, perhaps, fartl away. When I consider all of these facts taken together, I c not escape the conclusion that the opening of the drainage ca was a very grave addition to the sanitary and financial burd of the people of the State of Missouri using the Mississippi ri below Grafton.

MR. TODD: In behalf of the Sanitary District of Chica I move to strike out the answer as not responsive and as i proper on re-direct examination.

GENERAL CROW: Professor, in your cross-examinati reference has been made to the dams I believe, in the Illin river, to their probable effect on the flow of the stream w reference to the effect of currents and sedimentation and t general proposition of the result of dams on the disappearar of infected sewage in running water, and I will ask you to st from your knowledge of the general subject what in general
the effect of the dams in running streams on the dis
3918 pearance of infectious matters in the waters, which ki
of infectious matters may convey water-borne diseas

A. The general effect of dams is of course hold back the water and to produce slack water basi especially when the dams are high enough to che the flow entirely or essentially, and any checking the flow and slowing down of the stream, other thi being equal, favors sedimentation and the disappearar from the supernatant waters of the infectious material. T sanitary significance of this is, as I have already stated, e tremely interesting and important. The carrying down of t germs of infectious diseases and the longer or shorter detenti of them in the sediment, in the first place removes them from t moving water, or tends to remove them, and in the second pla by detaining them gives them an opportunity to die out, more less. These factors of sedimentation and storage are, in n judgment the principal factors in the so-called self-purification streams; on the other hand it must be carefully kept in mi that streams are subject to scouring more or less frequently a that the disappearance of infectious materials is not necessar

their destruction. It is even possible to conceive of such conditions in the bottom of a stream or pond as shall favor the longevity of germs, but broadly speaking, generally speaking,
3919 sedimentation and storage, as favored by dams, are temporarily at least of much value to the water from which they disappear. Again, broadly speaking and keeping in mind the conditions in this case, I think we must be very careful not to assume too readily that such sedimentation and storage or such disappearance of bacilli or other microbes, is necessarily or even occasionally equivalent to a continuous or uninterrupted purification of the stream. A considerable increase in the flow of such a stream as the Illinois river must tend to favor the return to the supernatant stream or lake or pond of some of the materials which it had previously deposited. The same thing may happen with wind currents. It is a well known fact that Lake Erie for example is so readily disturbed by winds as to bring up sand and sediment from the bottom, and interfere with the use of the water at Buffalo for drinking purposes. It is a well known fact that shallow ponds and lakes are particularly susceptible to disturbance by currents produced by winds. In my judgment one can never know when some of the deposited material may be returned to the flowing stream, nor how long it may stay there. The problem is by no means a small one, and while there is undoubtedly a high value in sedimentation and storage of infectious materials, and a tendency toward their permanent removal, either mechanically or by death, I do not
3920 feel that the processes referred to, are trustworthy means of sewage purification under such conditions as exist in the Illinois river.

Q. Now the term "standard of dilution for reasonable safety," has been used somewhat by those asking questions in the cross-examination. I will ask you to state if in sanitary science of water supplies there is any standard of dilution for reasonable safety that is recognized and adopted, for drinking purposes?

A. I never heard of it.

Q. Now I believe you stated in your cross-examination that typhoid bacilli have been rarely found and identified in running water?

A. I think I did. Very rarely.

Q. Are there other bacilli that are transported by water and convey what you call water-borne diseases, that are also, very seldom found, yet generally recognized as a source of drinking, water-borne diseases?

A. Yes sir.

Q. What are they?

A. The cholera germ for example, the Asiatic cholera germ.

Q. Any others?

A. And the supposed germs of diarrhea, dysintery—

Q. Any that convey animal diseases?

3921 A. Yes, glanders. While I do not know whether glanders has been found in the water, still glanders is supposed to be conveyed to horses, from one horse to another by water.

Q. How about anthrax?

A. I think that anthrax has been supposed to be conveyed by water.

Q. How about hog cholera germs?

A. One moment. In regard to anthrax. There is every reason to suppose it might be so conveyed, because it is one of the hardest germs to kill of all that we have. It is a spore bearing germ, and when it so to speak, goes to seed, those seeds are very enduring; they are very tough, resisting heat and long periods of keeping, without destruction, and I should think that there might be no question that these would live a very long time in water, although whether they have actually been found in running water I do not recall. I think they have. But in all this matter of finding specific disease germs in water one needs to know who has found them, because some bacteriologists are more readily persuaded of their presence than others.

Q. Well, isn't there a record of the anthrax bacilli having been found in the Illinois river by the State Board of Health of Illinois?

A. I dare say, but I don't know.

Q. What about the hog cholera bacilli, are they conveyed 3922 by water?

A. These animal diseases I am not thoroughly posted upon but my impression is that any of them may be conveyed by water and that hog cholera is often conveyed in that way. I do not wish to give that however, as my positive opinion, because I do not recollect.

Q. Now as to the result of typhoid fever, and Asiatic cholera in persons, the bacilli being so hard to obtain from the water, in what manner must the conveyance of that disease therefore be judged by?

A. I don't quite understand the question.

Q. By what must you judge the conveyance of these waterborne diseases, typhoid fever and Asiatic cholera if you are unable as a rule to find the bacilli in the water?

A. One must judge by the effects which the water produces upon those who use it.

Q. You judge by the results?

A. By the results. That is the one final standard we have in sanitary science today and it is the best standard because, after all that is the point at issue. If a community drinks sewage polluted water and it can be clearly shown that there is a connection between the use of such water and the typhoid history of that community, we have far better evidence than any chemical or bacteriological evidence can possibly be, in the present state of these various sciences? 3923

Q. You said something in your cross-examination, about having studied the life history of typhoid bacilli during the Lowell and Lawrence epidemic, now I will ask you if that experience furnished you the only knowledge you have on the question of longevity and life of the typhoid bacilli?

A. No, I did not intend to say that by any means. Those were laboratory studies and of course at that particular time, such epidemiological evidence as I could get. A little later came the Newburyport instance, which was very instructive as to the longevity of typhoid bacilli, and since that time by observing the work of others, and by studying other epidemics I have considerably extended my acquaintance with the subject.

Q. Now you were cross-examined with reference to the Lowell and Lawrence epidemics, as to whether or not there couldn't be some causes on the watershed adjacent to the water supply of Lowell and Lawrence and Newburyport that might have contributed to the cause of those epidemics. I will ask you to state what examinatoin if any, you made of those watersheds at that time to determine that question?

A. I started out from Lowell and went up the bank of the river to North Chelmsford, inquiring along on one side, (there were no houses at all on the other side) and in walking
3924 along I asked the physicians who lived nearby if they had seen any typhoid or heard of any around there, and did not find any between Lowell and North Chelmsford. I also made careful inquiries above North Chelmsford, not only along the banks but in the cities discharging sewage into the river, to see if there had been any epidemic above, which would explain the facts, for they were always pouring in sewage above, and Lowell for a long time, had had considerable typhoid, but nothing unusual could be discovered at any of the points, urban or rural, upon the river as far as I went. Of course I didn't go all over the Merrimac water-shed which is a very large affair, but I went far enough to satisfy myself that no unusual condition had existed nearby or in any of the big cities, or in any place where the sewage would not be subjected to more or less sedimentation and storage and dilution. Then when the Lawrence epidemic appeared, I did not myself go along the river, but I sent one of my assistants, a trusty fellow, to see if he could find anything between Lowell and Lawrence, and especially as the Lawrence epidemic came in later than we at first had expectd, for we were not then aware of the full value of storage and sedimentation as we are today, at least I was not, and having expected the Lawrence epidemic a little sooner than it came I sent him to Lawrence to see if any people had been taken sick along the shore from the Lowell sewage, that would go along
3925 there, but he didn't find anybody, besides, if we had found one or two cases, this would not have accountd for the facts in the Lawrence epidemic because the Lawrence epidemic was more severe, proportionately to the population, than the Lowell epidemic and the water supply was guarded by a reservoir, so that the simplest explanation of the law of parsimony would have been, even if we had found a few cases up there, that it was 500 to 1000 cases at Lowell, which was producing the epidemic, rather than the few cases along the shore. I went along the shore more to find out whether the people got it from Lowell

rather than whether they were giving it to Lawrence, but we didn't find anything at all.

Q. Now you have said in your cross-examination I believe, that the epidemic at Newburyport in proportion to the population was more severe than either Lawrence or Lowell?

A. I don't remember that I said that.

Q. Was it or was it not?

A. I do not recall, I shouldn't have said that it was.

Q. I thought you did.

A. I can easily tell by looking it up.

Q. You can look it up at noon or some other time.

A. I think I can tell in a minute by figuring.

Q. Well, go on, you can do that later.

A. All right.

3926 Q. Now I will ask you if you meant to state in your cross-examination that the typhoid fever at Pittsburg, was caused by the typhoid fever epidemic at Oil City, Pennsylvania?

A. The typhoid fever that existed, did you say?

Q. Yes?

A. No sir, I had no evidence of any epidemic at Oil City, or at Johnstown, which was another of the urban communities on that watershed; nor did I find any "epidemic," using that word in the sense of explosion and a large number or unusual number of cases for a short time,—in Pittsburg. The condition in Pittsburg was rather more like that in St. Louis today, a large amount of typhoid fever, rather than what I should call an epidemic, though as I said yesterday, some people might call it an epidemic in either case, Pittsburgh or here, and I came to the conclusion that the state of affairs, whatever it was called, in respect to Pittsburgh was due, not to any epidemic in Oil City, any special epidemic, or in Johnstown, or in any other community upon the watershed,—because I couldn't find in any of these any such unusual occurrence of typhoid fever,—but rather that the regular and steady occurrence of typhoid fever in many places on the watershed had each contributed its proportional share to the making up of the total in Pittsburg; and as the case at Pittsburg is interesting, it seems to me, and important in this

case, I should like to read twenty lines or so from my pub-
3927 lished report as to just what I did find and report at that
time.

JUDGE JOHNS: I object to the answer so far as Pittsburg is concerned, because the subject was gone into in chief and cross-examined upon, and is not a proper subject of re-direct examination, and I object to the reading of anything upon this re-examination upon that subject, and the extract proposed to be read, whatever it may be, as neither relevant nor competent evidence, and as not pertinent upon a re-examination of the witness as to the condition of affairs found in Pittsburgh, as narrated in his testimony.

MR. TODD: I join in the same objection in behalf of the Sanitary District.

A. (Reading) "The life of the typhoid germs in water while
"it has never been satisfactorily determined is without question
"capable of extending over a considerably greater period than
"that required for the water of the Allegheny to pass, even from
"remote points on the water-shed, to the intake of the Pittsburgh
"waterworks, so that there seems to be no escape from the con-
"clusion that typhoid fever infection introduced even at remote
"points, may and even must be delivered to the citizens of Pitts-
"burgh in an active and virulent condition. Oil city is distant
"from Pittsburgh 113 miles, but such is the peculiar character
"of the river and such the character of the watershed,
3928 "that infection introduced at much more remote points
"than Oil City may in my opinion be actively dangerous
"to the health of Pittsburgh." This is from my report to the Filtration Committee of the City of Pittsburgh, published in January, 1899.

JUDGE JOHNS: I move to strike out the extracts so read as irrelevant and incompetent.

GENERAL CROW: Now, something was said in your cross-examination about your not having considered in estimating the pollution of the waters tributary to the intake tower of St. Louis waterworks, the number of fishermen along the Illinois river and other streams. Now I will get you to state if you know whether or not it is a fact or if you know in what degree the people living upon the banks of, or adjacent to running streams in rural communities, pollute such streams and infect them?

A. I have no personal knowledge of the actual conditions on the watershed above St. Louis in this particular,—

Q. I mean running streams generally.

A. I was going on to say,—but speaking from such knowledge as I have I may say that it would depend a good deal upon the streams broadly speaking, since upon streams passing through large, uninhabited districts, there must be large stretches in the river in which no pollution at all would take place. On the other hand, in agricultural communities,
3929 the use of the banks and the occupancy of house-boats and
the presence of fishermen would undoubtedly contribute its natural quota, whatever that might be, to the pollution and even the infection of the stream; but inasmuch as the shores of streams are always small in extent in comparison with the watersheds which they drain I should suppose that this factor would not be a large element in the pollution or infection produced by such a rural population. In the case of rivers passing through cities, and apart from the sewage pollution from sewers, owing to the larger number of people on the banks of the stream, and to boats and the like, there must be a considerable pollution; but broadly speaking and proportionately speaking I should not expect that the river pollution by persons upon or near the river itself, would be of much consequence in proportion to those remote from such streams,either in rural districts or in cities, respectively; that is, there would be more of course where cities border on a river, but that I should suppose would bear some such proportion to the people in the city, as the people on the rivers in the country would bear to the people on the rural watershed. Of course any such estimate is all guess work, I really do not know much about it. Nobody does.

Q. Well, as a matter of fact do you know whether the
3930 agricultural people, people living on the farms in the
watershed, and away from the banks do, or do not pollute the running streams to any degree?

A. I have already said, broadly speaking, that they take care of their own wastes upon their own farms.

Q. You said in your cross-examination in answer to a question asked you that you thought perhaps the typhoid increase in December, 1899, did reach over into 1900. I will ask you to state if you know how far into 1900 you think that reached, if you have any idea as to how far it reached?

A. I think that question is very easily answered.

Q. Will you please answer it?

A. Because while in 1900 there were 19 deaths from typhoid fever, which was a larger number than had happened in January for several years, at least, in February the number of deaths was only five, which was a smaller number than in 1897, 1898 or 1899. This in my judgment, shows that the little outbreak at the end of 1899, whatever it may have been due to, had spent itself, while the occurrence of 16 deaths in March, 1900, has been attributed, and I believe properly attributed, by Dr. Ravold, to the opening of the drainage canal on January 17th. At least a part of that increase may have come and probably did come from that source. On the other hand the deaths in the next month fell off again to four, which was lower than during the two previous years, so that it is not easy to be absolutely sure that the number 16 did really come to any great extent from the
3931 first arrival of the material held in the drainage canal. I may add that it is only by taking these things in a large way and for considerable periods that any safe conclusion can, in my judgment, be drawn.

Q. Professor, after sewage which is infected with bacilli of waterborne diseases is placed in running water, is there any absolute safety in using that water afterwards for drinking purposes within a month's time?

JUDGE JOHNS: I object to that question as not re-direct examination, the subject having been gone into in chief extensively.

A. Broadly speaking, I do not think that there is.

ADJOURNED until 2:00 P. M., same day.

Southern Hotel, St. Louis, Missouri.
3932 2:00 P. M., Saturday, May 23rd, 1903.
Parties met pursuant to adjournment.

Present the Commissioner and same counsel representing the respective parties.

WILLIAM THOMPSON SEDGWICK,

resumed the stand for further re-direct examination by Attorney General Crow, and testified as follows:

THE WITNESS: I have been looking over what I said this morning, or parts of it, and I find that in answering the next question to the last I contradicted myself and I desire to put myself right on the matter.

(Question and answer referred to, repeated as follows:)

"Q. You said in your cross-examination in answer to a question asked you, that you thought perhaps the typhoid increase in December, 1899, did reach over into 1900; I will ask you to state if you know, how far into 1900 you think that reached, if you have any idea as to how far it reached?

A. I think that question is very easily answered, because while in 1900, there were 19 deaths from typhoid fever,
3933 which was a larger number than had happened in January
for several years at least, in February the number of deaths was only 5, which was a smaller number than in 1897, 1898,or 1899. This in my judgment shows that the little outbreak, whatever it may have been due to, had spent itself and the occurrence of 16 deaths in March, 1900, has been attributed, and I believe, properly attributed, by Dr. Ravold to the opening of the drainage canal on January 17th. At least a part of that increase may have come and probaly did come from that source. On the other hand the deaths in the next month fell off again to four, which was lower than during the two previous years, so that it is not easy to be absolutely sure that the number 16, did really come to any great extent, from the first arrival of the material held in the drainage canal. I may add that it is only by taking these things in a large way and for considerable periods that any safe conclusion can, in my judgment be drawn."

THE WITNESS: Now I should like to have the greater part of the answer stand as it is. Will one of you read it while I alter it?

JUDGE JOHNS: Suppose you make an answer now, and leave that answer stand.

A. Very well; I will make an entirely new answer.

(Question and answer repeated).

3934 A. In answer to the question I may say—

GENERAL CROW: Professor, excuse me. Let the record show that being as the gentleman wants your other answer to stay in there, that counsel do not want that answer changed, that you now want to correct your former answer by making this answer. That makes it connected.

A. I do not quite understand.

GENERAL CROW: The gentlemen object to your altering your former answer and taking it out of the record.

A. I did not intend to do that.

GENERAL CROW: Let your answer show the reason for giving a new answer, so that the record will explain itself without any interpretation.

A. Well I supposed that the stenographers had already taken down my statement that it was self-contradictory which would be a sufficient reason for changing it, and now I was going to change it into a form which would not be self-contradictory. What I intended to say was this, that there is evidence that the out-break at the end of 1899 reached over into 1900, as is seen in the fact that there were nineteen deaths in the month of January in the City of St. Louis from typhoid fever, a larger number than had occurred in that month for several years previous. On the other hand it is very clear that the out-break referred to had spent itself in February for the number of
3935 deaths from typhoid fever in St. Louis in February, was
lower than in any of the three years preceding; the number rises again, however, in March, being sixteen, a number larger than for several years before in that month, and it might be thought by some epidemiologists, in fact I should myself have suspected, if I had no other explanation of the fact that these sixteen deaths meant a recrudesence of the previous outbreak. Fortunately, however, we have a simpler explanation in the fact that the Chicago Drainage Canal was opened on January 17th, 1900, and it is in evidence, I believe that not long after a mass

of black and dirty water arrived at the intake of the St. Louis waterworks, which was believed to have come directly from the Chicago drainage canal. In view of this evidence I regard the excess in March, or at any rate, the larger part of it, as due not to a recrudesence of the outbreak at the end of 1899, but to the pollution of the St. Louis water supply by material arriving from Chicago. This conclusion was reached, I believe, or a similar conclusion by Dr. Ravold, who, as it seems to me, very properly attributed the greater part of the excess in this month to the cause described.

MR. TODD: I want to enter an objection to this witness testifying to the conclusions expressed by another witness
3936 in the case, as being plainly incompetent.

THE WITNESS: I should like to continue. Read the last part of my other answer.

(Answer to former question read to witness).

A. In April on the other hand, the number was again low, which goes to show that the cause which operated, or the cause of the deaths in March, was apparently absent, or at least very slight. In matters of this kind we must take the statistics in a broad way, and cover considerable periods of time if we wish to be absolutely sure.

MR. JEFFRIES: Professor in a question put to you by Mr. Johns on cross-examination, he stated as an assumed fact that the population along the banks of the Illinois river produced a larger number of typhoid cases than populations not upon the river, whether they be urban or both, and that the typhoid dejecta would more readily find its way directly into the Illinois river coming from the population along the banks of the river, and the towns situated upon the banks of the river. Now state in your opinion, what effect the increased flow of water in the river coming through the canal at the Bear Trap Dam would have on hastening this typhoid dejecta to the mouth of the Illinois river and into the Mississippi river?

MR. TODD: I object to the question upon the ground that
3937 the preamble is not a part of the question itself, and that the question has already been answered on direct-examination and is not a proper matter to go into again on re-direct examination.

A. You mean the increased flow from the drainage canal?

MR. JEFFRIES: Yes, hastening the typhoid dejecta at any time after they opened the canal.

A. It would obviously move it forward more rapidly and quicken somewhat its delivery into the Mississippi river and the time of its arrival at the intake of the St. Louis water works.

Q. Assuming that the water supply of the City of St. Louis has been treated in the same manner since 1895, what in your opinion, was the sanitary condition of the water supply of that city after treatment, for the years 1895, 1896 and 1897, based on the typhoid fever death rate of the city for those years?

JUDGE JOHNS: I object to the question on the ground that it is not a subject of re-direct examination.

MR. TODD: I make the same objection.

A. If I understand the question, it is, what was the sanitary condition of the water supply of St. Louis during the years 1895, 1896, 1897, 1898 and 1899?

MR. JEFFRIES: Yes.

3938 MR. TODD: I want to object because the question does not assume all the typhoid conditions that existed during those years along the watershed of the Illinois river, the Mississippi river and the Missouri river.

A. My answer is that judging partly by my knowledge of the method of sedimentation employed, but chiefly by the typhoid fever death rate in St. Louis during those years, that the sanitary condition of the water supply as actually delivered to the citizens during those years, was good.

MR. JEFFRIES: What is your opinion as to the sanitary condition of the St. Louis water supply based on the typhoid fever death rate of the city since January 1st, 1900, which includes the three years that the Chicago drainage canal has been opened, assuming that there has been no change in the treatment of the water supply of St. Louis.

MR. TODD: I object to that question in behalf of the Sanitary District, on the ground that it is not re-direct examination.

JUDGE JOHNS: The State of Illinois joins in the objection.

A. Using precisely the same line of reasoning as before, and assuming that there has been no change in the method of treating the water, which I believe to be the fact, that there has beeen no essential change in the treating of the water, the 3939 typhoid fever death rate of the city of St. Louis for the years 1900, 1901 and 1902, is of such a character as in the absence of any evidence of any other factors of its increase, than the change produced in the water supply at the chain of rocks by the opening of the Chicago drainage canal, as to place the said water supply under the gravest suspicion of contamination, to tend to remove it from the class of cities having good water supplies, and to place it in or near the class having polluted water supplies. This is particularly the case in 1901 and 1902, both of which years showed a considerably higher mortality percentage from typhoid fever than the year 1900, and one of which, namely, the typhoid fever record for 1902, belongs clearly in the class of polluted water supplies. I may add that one of the most serious phases of the situation is the fact that the annual increase since the opening of the drainage canal in typhoid fever mortality in St. Louis has been steady, an increase which has as yet shown no signs of cessation.

RE-CROSS-EXAMINATION,

By Judge Johns.

Q. Since your answer to Mr. Hamlin, stating that the expense of filtration of the waters of the St. Louis supply would be probably the same, whether the waters of the Illinois river were added or not, you have been giving that question 3940 considerable thought, have you?

A. Some, yes sir.

Q. You think now that owing to the polluted condition of the water coming from the Illinois river an extremely careful and scientific filtration here would be more expensive because of that condition in the Illinois river?

A. No sir, an extremely careful and well supervised filtration would be expensive anywhere, but what I meant to convey was that in view of the infection that I believe comes from that source, we should have to have here a more careful and expensive system than we would have had to have without it.

Q. While it is evident to your mind that at any time in the last ten years the water supply of St. Louis ought to have been filtered?

A. Broadly speaking I should say "Yes," although as I have just answered a question of Mr. Jeffries, there perhaps have been times when the city did get on remarkably well without it, but I think that it ought to have been filtered even then.

Q. If they ought to have a filter it ought to be managed with great care by good men in any event ought it not?

A. It certainly ought.

Q. If it ought to be conducted by good men with great care under any circumstances, why ought it be conducted by better men with greater care, on account of the Illinois river?

3941 A. Simply because the added danger should require the best care possible, and greater care than would have been required with none of that river.

Q. With typhoid germs coming down the Missouri and the Mississippi river in greater or less amounts and in varying amounts at different times, ought not the keeper of the St. Louis filters, if there were such, to be vigilant and competent at all times?

A. Certainly, but there are degrees in this thing, and inasmuch as they got along very well without such supervision, they might, as our cities are managed in the United States, very likely have somebody who was not thoroughly up to the mark. It is a practical consideration, and if they should have such a person they would get into trouble more than they did formerly.

Q. But assuming it their duty to have good men, exercising great care at all times, if they happen to have bad men exercising small care at some times, that would be their neglect and not the fault of the Illinois river, would it?

A. It certainly would be their fault if they had bad men exercising small care at any time, but that is not the question it seems to me—

Q. Excuse me, it is my question.

A. Well, as I understand—

MR. JEFFRIES: I submit the witness has a right to answer the question. 3942

A. The problem, however, would be more difficult of solution inasmuch as it is one of the fundamental precepts of water purification that a city should obtain the purest raw water possible. It is not merely a matter of skill. It is partly a matter which is outside of skill. Accidents may happen and the best laid filters may occasionally go wrong, even under the best supervision, but of course the best paid manager and the best built filters will be more likely to exclude danger than a worse one.

Q. JUDGE JONES: Assuming that the waters in the Illinois river, which enter the intake at St. Louis, speaking broadly and in a general sense, are as 1 to 16, of all of the water which enters the St. Louis intake and that they do enter the St. Louis intake in a polluted condition. What proportion of the great expense incurred in filtration, should be attributed to the Illinois river?

A. I should find it very difficult to say, but as I said this morning, of course the fact is that a much larger amount than that—

(Question repeated.)

A. I should suppose that would be a matter for a jury to determine, rather than for a sanitary expert.

Q. Well, if you have any opinion as to what proportion
3943 of that expense should be attributed to the waters of the Illinois, state your opinion?

A. I haven't any, at least I haven't anything worth stating in figures.

Q. Assuming that the waters of the Missouri river are sixty per cent, speaking in broad general terms, of the waters which generally enter the intake at St. Louis, and that they are polluted with typhoid germs, and that the waters of the Mississippi river above Grafton are 34 per cent of the remaining 100, and that they are polluted with typhoid germs, and that the waters of the Illinois river are six per cent of the entire 100 and that they are also polluted with typhoid germs, what proportion of the great increased expense of the filterting out of these germs shold be attributed to the Illinois river?

A. I should be unable to answer that question, because it is not merely the removal of typhoid as stated this morning, it

is partly the mere introduction of added filth, and while the mud which came from one river might be more abundant than that from another, the manufacturing waste that came from say the Illinois, might be more serious than that that came from the Missouri or the Mississippi. It is a very complex problem, and when it came down to the actual question of damages, I should think that it would require very serious investiga-
3944 tion. I mean the proposition that it would be an added expense.

Q. If the typhoid germs and the germs of other water-borne diseases were common in the water supply of any city, ought not there be always great care and all the devices known to sanitary science, exercised and used?

A. Certainly.

Q. In the filtering of the waters of that city?

A. I think so sir, yes, undoubtedly.

Q. If the filtration plant of the city of St. Louis was built with a view of excluding from its water supply the germs of water-borne diseases, would it have to be any better or more complex because the supposed mass of water-borne germs was greater or less?

A. I think it would. The larger the number in the river, and the greater the amount of organic matter the more perfect should be the construction of the filter; that is to say, for a water containing a rather low number of pathogenic germs, a more rapid rate, for instance might be used than anyone would dare to use if the water is more heavily contaminated. The filtering bed of sand, if it were a slow-sand filter, ought to be made deeper in case of a river which is rich in infection than in one which is poor in infection. I think it would really practically add to the difficulty of construction and operation.

3945 Q. Then your theory is, that if there are a small number of germs in the water, they are less likely to get through a given filter than if there are a large number of germs thrown into the same filter?

A. Other things equal, yes, and if some should get through from a small number applied, if anything happened to the filter in its ordinary operation, or even if it was working normally, and some had slipped by, the chances of more getting by,—a dangerous number getting by,—from a large dose than a small dose, I think is admitted by all filtration students.

Q. Well if you were endeavoring to exclude by filtration germs from water, your endeavor would be to exclude as far as possible all germs?

A. Certainly all disease germs.

Q. And you wouldn't want to take any chances on that?

A. Certainly not; that is what filters are built for, but we have to take chances; that is to say, even in the best filters there are occasional times when for some unexplained cause there is evidence that a few may get through; no filter is perfect, I think we may say, for very long periods of time, but the number that pass in a well constructed filter, a thoroughly constructed filter, thoroughly up to date and well operated, is extremely small.

3946 On the other hand in inadequate filters and filters that are not well attended to, we have reason to believe that it is largely this factor of safety which is to be taken into account, and the difficulty of operating the filter is universally increased, so it is held by all filtration experts I think, although I do not pretend to be a filtration engineer,—is held to be increased by any marked deterioration in the quality of the water.

Q. In a pure water for a water supply, such a water as being intended for a water supply, would be termed by a sanitarian, pure, there ought not to be bacteria of any kind, disease-bearing or non-disease-bearing, except in very small number?

A. Except in small numbers, and only such as escape from the filter.

Q. Is it necessary to make a different construction of a filter with reference to pathogenic germs than it is for non-pathogenic germs?

A. I don't think anyone ever made a filter for non-pathogenic germs, and I shouldn't suppose that it was, broadly speaking, no.

Q. Now if the Missouri river has twice as many germs in number, bacilli in number, as the Illinois river and Mississippi river combined at the intake, then it would be necessary in filtering against the entrance of those germs to have very great care taken of the waters from the Missouri river, wouldn't it?

3947 A. Assuming that they came in an equal quantity of water, yes, and assuming that all were equally polluted of course.

GENERAL CROW: There is one factor in there that both of you didn't mention. Are you talking of pathogenic or non-pathogenic germs?

A. I understood this to be non-pathogenic.

JUDGE JOHNS: Yes, non-pathogenic germs is what I was talking about.

MR. JEFFRIES: I object to the question as being immaterial.

JUDGE JOHNS: If the Missouri river contains more germs of all kinds than the combined waters of the Mississippi and the Illinois at a given time, and ten times as much of solids in solution and suspension, as the combined waters of the Illinois and the Mississippi at the same time at the intake of the St. Louis waterworks, would it be necessary to filter that water with reference to the Missouri river or with reference to the Mississippi river or with reference to the Illinois river?

A. Well, I don't think that the man in charge would work with reference to either river. He has got to have filters constructed and arranged for all possible waters that may come down. I can conceive of times when it might be more difficult to purify the Missouri than the mixed Mississippi and Illinois, and I can conceive of other times when it might be more difficult to purify the Mississippi and the Illinois than the Missouri, 3948 but in building and operating filters we have got to look at the thing as from year to year and there would be certain seasons, as I testified this morning, when the content of Illinois water in the Mississippi might rise as high as 12 per cent, and at times I suppose, in the near future may rise as high as 25 per cent. Now at a time like that the Missouri must be a comparatively small portion of the whole, because if the Illinois alone is 12 per cent—no, that doesn't necessarily follow, of course it might be or it might not, but at any rate it would be a small per cent, and the thing is apt to be sometimes one way and sometimes another, and you cannot run filters on hypothetical questions.

Q. Well, you can construct filters with reference to conditions, can't you?

A. You have got to construct them with reference to conditions.

Q. Well the conditions being assumed that the Missouri river as to all kinds of bacteria combined and all kinds of solids in suspension and solids in solution, much worse than the combined waters of the Mississippi and the Illinois arriving at the intake of the waters leading to the filter, it would be necessary in the preparation of that filter, to recognize the condition of the Missouri river, wouldn't it, and arrange the filter to filter the waters of the Missouri combined with the other two?

3949 A. Certainly, if that were the fact and if that were the whole fact, but I don't understand that it is.

Q. I am assuming the questions and am responsible for them. If that were the fact then in constructing the filter you would construct it with reference to the very large predominance of the Missouri water requiring filtration, wouldn't you?

A. Certainly if that were the fact and it was so all the time.

Q. So that if that were the fact and it would not be very necessary to provide at a large and great expense, against the filtration of Illinois water in a filter which must be arranged the same, whatever water is to be filtered?

A. Well, if I understand the assumption, and I want to be sure that I do—

Q. (Question repeated.)

A. In reviewing the question I observe that one of the conditions is the combined bacteria of the Missouri river and these might be clearly non-pathogenic for the most part, so that reference would have to be had to the kinds of bacteria delivered by the respective rivers. If the assumption covers that point, then I should answer the question in the affirmative, but practically I believe that the filter would have to be built under local conditions with reference to each of the waters, because at some sea-

sons far more of one is got than of another, and I still cling
3950 to my original statement that the purer the water which
is to be filtered the easier and safer is the process of filtration.

Q. Do you believe because you cannot find pathogenic germs in the water of a running stream that if you attempted to filter such waters, the pathogenic germs would slip through easier than any other time?

A. No, I don't think so, broadly speaking. Some might but I don't think so as a general proposition.

Q. Suppose that a filter was constructed which would at all times and under any circumstances, filter successfully the waters of the Missouri river, wouldn't that filter at all times and under all circumstances filter with equal success, the waters of the Illinois?

GENERAL CROW: I object because it is wholly immaterial for the purposes of this case, and for the reason that the city of St. Louis is not bound to filter its water supply, nor is any other inhabitant of the State of Missouri, to prevent hostile, contagious diseases, by reason of the water being polluted by the respondent.

A. I don't know. I should have to know more about the chemical composition of the waters of the two rivers, at different seasons and times. I should suppose that from a manufacturing city like Chicago, and a place like Peoria, a good deal of manufacturing wastes would come down, and it might even
3951 happen that a water polluted with acid sewage should
issue from the mouth of the Illinois River. Not being sufficiently familiar with the general character of the waters to form an opinion, I should be unable to answer that question. It has been found for example at Worcester, where they are purifying their sewage in order to keep it out of the Blackstone River, to which I referred this morning, that the filtration which they employ has to be of a peculiar kind because of the presence of wastes from the wire works, which make the sewage acid. Now if the material from the stock yards and from the factories of Chicago happened to be of a kind which interfered with filtration as ordinarily conducted, or made it difficult, I can easily

conceive that a filter might have to be differently built than it would if it had just to filter the Missouri River water.

Q. Assuming that the waters of the Missouri River are polluted with acids from Kansas City and other cities upon its banks, having their sewers drained into the Missouri river and that a suppositititious filter erected at St. Louis successfully filtered that water, thus polluted with acid, would not the same filter also successfully filter the waters of the Illinois?

GENERAL CROW: I object to the question because the question as to whether or not a filter that would filter the Missouri River water would also filter the Illinois river water is wholly immaterial and does not tend to prove or disprove
3952 any issue in this case, and for the further reason that the question assumes and asks for an opinion of the witness without stating whether or not the Illinois river and the Missouri river are equally polluted, while the evidence in the case clearly shows that the Illinois river is the more polluted of the two streams.

A. I should have to answer as before, that I don't know because the two waters might or might not be the same in other respects, even if they were the same in respect to acidity, but I do not think that anybody could tell in advance whether a filter that would purify one of them would not also purify the other.

Q. If you as a sanitarian were giving advice as to the kind of a filter that should be used at this point to filter the waters for St. Louis, would you go to Kansas City to determine the kind of sewage which was thrown into the Missouri river from that point?

A. I think I probably should. As a matter of fact of course, I probably shouldn't be put in charge of such an enterprise. It is a little out of my line, but if I were I should certainly go up each stream and see what was put in, for fear that in low water in that particular stream I might get a heavy dose of something that I wasn't aware of at other times. I should depend mainly, however, no doubt, on chemical analyses ex-
3953 tending through years, chemical and bacterial analyses.

Q. Suppose that the chemical analyses of the waters of the Missouri show that it is a polluted stream, you couldn't tell from the chemical analyses what the pollution was?

A. Not what the origin of the pollution was, but one could tell the present state of pollution as to certain points.

Q. You couldn't tell what was the character of the pollution from the chemical analyses?

A. Sometimes we could, but very often not.

Q. More frequently you could not, than that you could?

A. I should say so.

Q. If the bacteriological examination of the waters of the Missouri also showed that it was a sewage polluted stream, you couldn't tell from the bacteriological examination what the character of the sewage pollution was, could you?

A. Not with absolute certainty.

Q. Then that would be equally true of the Mississippi?

A. Yes sir.

Q. And equally true of the Illinois?

A. Yes sir.

Q. If the chemical analyses of the waters of the Missouri river showed that it contained vastly greater amounts of solids in suspension, and in solution, and vastly greater amounts of some chemical constituents injurious of themselves, than 3954 either the Mississippi or the Illinois, and the filter erected here successfully filtered the waters of the Missouri, wouldn't that filter as successfully filter the waters of the Illinois, confining your answer to the consideration of the facts assumed in the question?

GENERAL CROW: The complainant objects for the reason that no defense in this case with reference to pollution and infection of the water supply of the State of Missouri below the mouth of the Illinois, that a filter which would reasonably and safely filter the Missouri river water, would safely filter the water of the Illinois river, is made, and for the further reason that the question doesn't state what kind of matter is supposed to pollute the Missouri river or the Illinois river.

A. Do I understand that the chemical constituents injurious in themselves, are also in the other waters?

JUDGE JOHNS: No, you are not to understand anything more than that the waters of the Illinois, and the chemical constituents of the waters of the Missouri as stated.

(Question repeated.)

A. I couldn't say.

Q. What is your best opinion on that question?

A. I should decline to give an opinion on the conditions stated.

Q. In your remarks upon re-examination this morning, 3955 upon the considerations of the future, did you take into consideration the prospective enormous increase in population of all the other places upon the water-sheds of the Illinois, the Missouri and the Mississippi, or did you consider only the prospective and possible prospective increase in population in Chicago?

A. I intended to take it in all through the valley of the Mississippi and Missouri and Illinois, as well as in the Sanitary District.

Q. Do you conceive that in the future, there might be an increase in the population of the urban cities; that is, the cities having a population of 4,000 and over on the watersheds of the Missouri and the Mississippi and Illinois other than Chicago, in proportion to the increase in Chicago?

A. Approximately I should say, except that Chicago has naturally grown faster and no man can tell whether she is going to outstrip the other cities or not; but I intended to allow a very rapid growth to all the other cities as well as to Chicago.

Q. Do you know whether or not the total increase in population of Chicago upon the basis of the census of 1890 and the census of 1900 is equal to or greater than the total increase in population of all the other cities in the watersheds of the three rivers combined?

A. I do not.

Q. If the population along the banks of the Mississippi 3956 in the cities should increase as you anticipate, and excluding the population of the city of Chicago and its consequent sewage, there might in the future come a time at very low water, when the Mississippi would be almost a river of dilute sewage, might there not?

A. I intended to include that idea in my remarks, yes.

Q. If there was such an increase as I have described, along the banks of the Missouri, this Missouri might at some time in the future become at very low water, simply a stream of dilute sewage?

A. Certainly.

Q. In which case it would be necessary for St. Louis to get its water from the Merrimac, or resort to double filtration?

A. No man can say, but something would have to be done, something serious.

Q. Do you not anticipate that at some time in the future all these things will be changed, and these communities will destroy their sewage at their point of origin?

A. I have often wondered about that and tried to imagine what was likely to happen. As I think I intimated in some part of my testimony, that has been the general line of human progress in the most civilized communities. In England, for example, they are paying more and more attention to the purification of the sewage before they put it into streams, and similar
3957 processes are going on today in the older communities of this country.

Q. If these Utopian ideas in the event of the enormous increase in population should prove to be realities, do you not think then some other inhabitant of Utopia might not also conceive that the sewage would be destroyed?

A. I think such a supposition is not difficult, nor unreasonable.

Q. Do you know that in 1900, when the drainage canal was opened that the waters of the Illinois River were very high?

A. Yes, I was told that it was.

Q. And a very high stage of water?

A. I understood that it was high; I don't remember just how high.

Q. You have been told that after the waters of the drainage canal were poured into the Illinois river in January, 1900, there was an appearance of black water at the intake of the St. Louis waterworks?

A. I have been told and I think I read it also in the evidence in this case.

Q. Did you know anything at the same time with reference to the stage of the Mississippi or the Missouri?

A. I understood that at that time the Missouri was low, or at any rate, that the conditions were such that the mixed Illinois and Mississippi found ready access to the intake.

3958 Q. Did you understand that the Mississippi was high?

A. I understood that the thaw did not extend at that time to the Mississippi, but I do not remember about the height of the water.

Q. You know that for fifteen years prior to 1900 the city of Chicago had been pumping into the Illinois and Michigan Canal the sewage of the City of Chicago from sustantially the same area as it is now pouring in from the drainage canal?

A. I know that there were pumps at Bridgeport, and that when they did not break down, which happened pretty often, they were operated, and that they did lift a large amount of sewage into the Illinois and Michigan Canal.

Q. Well speaking in a broad and general way—

GENERAL CROW: Let the witness finish.

JUDGE JOHNS: I beg your pardon, I thought you had finished.

A. But one of the reasons why typhoid fever was so abundant in Chicago in 1891 and 1892, as nearly as I could discover was that the Bridgeport pumps had been supposed to be out of order a good deal of the time, and there are frequent statements to that effect in the report of the Health Department of the City of Chicago and in the report of the Board of Health of the State, so I have always regarded the Bridgeport pumps as an uncertain element in the matter, but undoubtedly at times they did lift considerable sewage into the Illinois and Michigan Canal. 3959

Q. Did you know the purpose of putting the pumps at Bridgeport was to pump the sewage of the city of Chicago into the Illinois and Michigan Canal from substantially the same area as is now drained by the Sanitary Canal?

A. I have understood so.

Q. What would be the difference in time in your judgment between the flow of water in the Illinois river before 1900, in January and after that time, with reference to the arrival of the waters at its mouth at Grafton?

A. I haven't made any special study of that point, but I should suppose that it would have made a difference of a day or two or something like that. That, however, is largely guess work?

Q. Assuming that the sewage from the city of Chicago poured into the Illinois and Michigan Canal, thence into the Illinois River, would have two more days of time in arriving at the mouth of the river at Grafton, would that two days' time so immensely purify the water that it would be inocuous?

A. I shouldn't expect that, assuming the quantities of sewage to be the same.

Q. Would it be so immensely purified in that lapse of two days as to remove 30 per cent of its dangerous qualities?

A. Assuming that the dangerous qualities were equal in
3960 the two I shouldn't expect that.

Q. Assuming that the dangerous qualities were equal before 1900 and after 1900, would you assume that the lapse of two days' time would remove ten per cent of the danger?

A. I shouldn't make any such assumption because it would be contrary to the facts; that is to say, there would be times when it would be slower in getting here than some time since January 17th, 1900. But there would be other times, when owing to floods it might get here quicker, and I do not think that any accurate comparison can be drawn except on averages for long periods, and I haven't the data to make any such things.

Q. Assuming that all other conditions as to floods, speaking in broad and general terms, were the same before 1900 as after, do you think that the lapse of two days in time would rob the sewage of Chicago of ten per cent of its danger?

GENERAL CROW: I want to interpose a formal objection. I object to this examination because it is wholly foreign to any re-direct examination, because there was nothing said in re-direct examination about the Illinois and Michigan Canal.

A. I don't think that a difference of two days would make any very great difference in the degree of purification under the conditions assumed, or existing, because the two days would be so small a portion of the whole period that if for instance the sewage came down in ten days, two days more would not

3961 make any difference,—certainly would not make very much difference,—in the life of the germs.

Q. Confining your answer to the lapse only of two days' time, you think it wouldn't make much difference?

A. A difference of two days I understood you.

Q. Yes.

A. Much practical difference I mean. Of course there would be more purification in a longer period.

Q. Which one of two individuals, one on the Lake front in Chicago and one on the Illinois River below Joliet, immediately casting dejecta, one into the waters of Lake Michigan and the other into the waters of the Illinois would be most dangerous to the health of the city of St. Louis, if both were typhoid infected persons?

A. Excuse me, before leaving that other subject, I thought you were going on with, I want to say something about the conditions in the Illinois and Michigan Canal.

JUDGE JONES: I have no doubt General Crow will afford you the opportunity.

GENERAL CROW: No sir, I will not. If the Illinois and Michigan Canal were sufficient, they never would have built this one.

Q. (Question repeated.)

3962 A. That means of course at the present time, today.

Q. Under the same existing conditions.

A. I think, other things equal, the one at Joliet.

Q. Assuming that there is what was termed here in your cross-examination a river population of 3,000 people on the Illinois river and its banks between Joliet and Grafton, why isn't their household sewage precisely as injurious to St. Louis as the sewage of the same number of people fishing on the lake front in Chicago, to Chicago?

A. I think it is as dangerous to St. Louis as that is to Chicago. Repeat the question.

Q. (Question repeated.)

A. Largely because St. Louis treats its water and removes a very considerable portion of the microbes by sedimentation, while Chicago takes water unfiltered or un-treated, at the cribs, and I can easily conceive of conditions in which the sewage of the 3,000 people on the lake front might do more harm to the citizens of Chicago than the same amount of sewage from similar persons on the shores of the Illinois to those of St. Louis.

Q. Assuming the conditions of the previous question, why isn't the household sewage of the river population on the Illinois river as dangerous to the waters of the intake tower at St. Louis as the dejecta of the supposed 3,000 fishermen on the lake front of Chicago, is to Chicago?

3963 A. I am not prepared to say that it wouldn't be.

Q. Did you want to be understood this morning as saying that what I have termed river population on the Illinois river, did not cast its sewage into the Illinois river directly?

A. No sir, not if I remember right. I have never denied or failed to believe that there must be a lot of people along the shores of the river, who threw things into the river. I think what I said was that these bore a similar relation to the people behind on the land, as the people on the rivers bore to the people in the cities.

Q. Did you want to be understood this morning as saying that the typhoid deaths or the deaths from typhoid fever, according to the evidence introduced in this case, was double after the opening of the drainage canal to what it was before the drainage canal was opened.

A. In Chicago?

Q. In the Illinois valley?

A. No indeed, I did not so intend to state. What I did intend to say—at least not unless Chicago be considered a part of the Illinois valley. What I did mean to state was this: That for the three years preceding the opening of the drainage canal the total of typhoid fever deaths in or on the watershed above the intake of the St. Louis waterworks, in urban communities, so far as we have been able to discover them, was about 3964 1,100; while owing to the addition of Chicago—the very great addition of Chicago to the watershed on January 17, 1900—the deaths upon the watershed above the intake of the St. Louis waterworks for the three following years was a similar sum (1,100) plus, if I remember right, 1,647. That is to say, this sum (1647) shows the increment in typhoid fever deaths and presumable infection upon the general watershed of the Mississippi River above the Chain of Rocks since January 1, 1900.

Q. Considering that there is substantially the same amount of sewage now coming down the Illinois river, as there was prior to January, 1900, and substantially the same population, urban and rural, on the Illinois river now as before the opening of the drainage canal, using the waters of the Illinois river in substantially the same way and in substantially the same quantities during a period of three years prior to·the opening of the drainage canal and three years after, on your theories as to the increase of typhoid fever, which period should have the greater death rate from typhoid fever, the one for the three years before the opening of the drainage canal or for the three years afterward?

GENERAL CROW: I object to the question because it is ambiguous and it assumes that there was the same amount came down before the opening of the canal as comes now, and for the further reason that it is an assumption that cannot be made applicable to this case under any circumstances.

A. I should say the three years after.

Q. Why?

A. Because, (1) assuming that the same amount of sewage from the same population was pumped in in the old way, through the old Illinois and Michigan canal, it was really a very different sort of sewage. The conditions then existing on the Chicago river were totally different to those that exist today. At that time the Chicago river was a kind of sedimentation basin, and it not infrequently ran in the opposite direction to that which it now takes. It was for the most part a putrescent stream, resembling more or less what we sometimes call a septic tank. And also (2) because in certain places, owing to these facts, there were opportunities for the dying out of typhoid fever germs in that river or its branches, but thirdly, and perhaps chiefly, because the sediment deposited, as I have indicated, was from time to time belched out into the lake as I have said, so that the Chicago water supply was often worse infected than it is today, indicating that the typhoid germs which now very likely

come down to St. Louis, at that time, if alive, went on into the lake much more freely and more readily polluted the water supply of the city of Chicago. To sum up, because the conditions in the Chicago river were so different from those which exist there today, that it is not, in my judgment, diffcult to
3966 explain the facts. I have, of course, thought a great deal about this question, and have endeavored to give it the fairest possible consideration. It is a perfectly natural question which you have asked me, and one that occurred to me long ago, and I have met it to my own satisfaction, studying all the conditions and remembering all the circumstances, and I may say that I believe that the period since the opening of the drainage canal would be far more likely to be the one showing high typhoid fever in St. Louis largely because the typhoid germs formerly held back in the Chicago river, where they either died or were washed out into the lake by heavy rains from time to time, have, since January 17, 1900, for the most part, been sent down the Illinois river, and, although many of them no doubt have disappeared en route, at least for the time being, they have in greater or smaller numbers, nevertheless, survived at other times, and even at some times have reached the intake tower of the St. Louis waterworks and caused typhoid in St. Louis.

Q. Assuming the conditions in the second preceding question, during which period, the three years before or the three years after the opening of the drainage canal, ought the death rate from typhoid fever on the Illinois river below Joliet and to Grafton be the greater?

GENERAL CROW: Complainant objects for the reason, first that the examination could not under any possible
3967 construction be interpreted as being re-cross-examination, and secondly for the reason that it is wholly immaterial and does not tend to prove or disprove any issue in this case, as to whether typhoid fever, under assumed conditions is greater or less on the Illinois river, because the evidence in this case so far has failed to disclose that anyone used the Illinois river water for drinking purposes—of the towns or cities on its banks.

MR. JEFFRIES: And for the further reason that no town or city on the Illinois river is using the water of the Illinois river for its water supply or for drinking purposes.

Q. (Question repeated.)

A. I don't know of any facts which would enable me to answer this question.

JUDGE JOHNS: What was the average flow of the water in the Illinois and Michigan canal for fifteen years prior to January, 1900?

A. I don't know.

Q. What has been the average flow of the waters in the drainage canal since the 17th of January, 1900, per mile?

A. I don't know that. I only know that the amount supposed to be poured down is five thousand cubic feet per second, but what the actual amount poured down has been I don't know.

3965 Q. What was the average rate of flow per mile of the waters in the Illinois and Michigan canal for fifteen years prior to 1900?

A. I don't know.

Q. What is the average rate of flow of the waters in the drainage canal since its opening?

A. I don't know.

RE-CROSS-EXAMINATION, By Mr. Todd.

Q. Professor, in the question put to you by Mr. Jeffries, I believe it was the second, in regard to the years 1895, 1896, 1897, 1898 and 1899, based upon the typhoid conditions in the city of St. Louis, you stated that the water supply from a sanitary point, was good; what did you mean by the word "good" in that sense?

A. I meant that it must have been of such quality as to have probably produced little or no typhoid fever.

Q. Is the word in the sense you used it, safe and drinkable, the word "good"?

A. I should have considered it so in view of the facts.

Q. And you took into consideration all the facts in connection with typhoid for those years, did you?

A. I did. WILLIAM T. SEDGWICK.

ADJOURNED until Monday, 10:00 a. m., May 25, 1903.

3969 Southern Hotel, St. Louis, Missouri. 10:00 A. M., Monday, May 25th, 1903. Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

GARDNER STEWART WILLIAMS,

called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Attorney General Crow, and testified as follows:

Q. Will you please state your name, address and occupation?

A. Gardner Stewart Williams. Ithaca, New York; present occupation Consulting Water Supply and Hydraulic Engineer and professor of experimental hydraulics in the Cornell University.

Q. You gave your residence, did you?

A. I gave my residence, yes.

Q. How long have you been at Cornell University?

A. Since the fall of 1898.

Q. Where were you educated, professor?

A. In the primary grammar and high schools in the state of Michigan, and in the engineering department of the University of Michigan, where I took my degree in 1889. In 1899 I took the advanced degree—

3970 Q. Degree of what?

A. Took the degree of bachelor of science in civil engineering in 1889, and in 1899, the advanced degree of civil engineer, which was awarded to me as a result of my experience and studies in connection with water supplies, particularly from a sanitary standpoint, and the diseases likely—and in relation to the diseases likely to be communicated by them, and upon investigations upon the flow of water. I may say that the results of some of these investigations which were presented to the American Society of Civil Engineers during the past two years, recently received the Normal medal, awarded by that society.

Q. Now, Professor, what experience have you had as an expert on water supplies?

A. I began my experience as a water supply engineer in connection with the construction of the waterworks at Bismarck, North Dakota, where I had charge of the work of getting the intake into the Missouri River; I was then in charge of the construction of the waterworks at Greenville, Michigan, and afterwards at Owasso, Michigan, and in 1893 became the Civil Engineer to the Board of Water Commissioners of the City of Detroit, in which position I had responsible charge of the design and construction of all the engineering work that was done in connection with the plant of the city of Detroit, which was then supplying between 275,000 and 300,000 people, and had a 3971 distribution system of between four and five hundred miles, until the fall of 1898. During that time I was engaged as consulting engineer in connection with numerous other plants and prepared plans and specifications, and had supervision of the construction of works at several other places and since that time have prepared plans and supervised the construction of extensive additions to the waterworks plant at Ithaca, New York.

Q. Well, you are now the consulting engineer, are you, for the water system at Ithaca, New York?

A. I am now consulting engineer of the Ithaca Waterworks Company.

Q. Now you have made the study of water supplies one of your principal occupations, have you, in the last ten years?

A. I have.

Q. Have you anything in the way of an experimental station at Cornell University, that enables you to study flow and action of water on the beds of streams, etc.?

A. The hydraulic laboratory of Cornell University, which has been under my direct charge since the fall of 1898, is by far the most extensive and most noted hydraulic experimental station in the world, and it represents an outlay there of some $50,000, which, were it not for the natural advantages of the location would have cost certainly two or three hundred 3972 thousand dollars. During the time that I have had charge of that laboratory, extensive experiments have been carried on, on the flow of water in open channels, and over dams; part of them for the United States Board of Engineers on Deep Waterways; part of them for the City of New York in connection with their investigations regarding the Croton water supply; part of them in connection with the New York State Canal survey, and we are now engaged upon an extensive series of experiments for the hydrographic department of the United States Geological Survey. In addition to this I may say that a number of less important investigations have been carried on directly as a result of inquiries set on foot by the laboratory itself. During this time I have also been engaged in investigations of the flow of the water at Holyoke, Massachusetts, and at Sault Ste. Marie, Michigan, and in investigations on the discharge of St. Mary's River at Sault Ste. Marie, Michigan. I might also say that during my connection with the Detroit Waterworks, I had occasion to make an extended series of investigations upon the flow in the American Channel of the Detroit river, and have on numerous occasions investigated problems involving stream flow generally.

Q. Generally speaking then, you have a practically equipped channel and streams of water, etc., there at Cornell, with which these hydraulic experiments were made?

3973 A. I have. We were able to produce on the actual scale on which they exist, a very large number of the structures which are met with in the ordinary streams of the United States.

Q. And the apparatus and the streams you have there, and the dams, etc., are used in connection with the instruction which is given to the students under your charge in hydraulic engineering?

A. Both in connection with instruction, and in the line of original investigation, independent of questions of instruction.

Q. Now have you had any experience in the study of epidemics?

A. I have.

Q. Of disease epidemics?

A. As a water supply engineer, I have naturally been interested in any of those and all of those diseases which are influenced by the quality of the water supplies. I have made investigations of typhoid epidemics at Detroit, Michigan, Saginaw, Michigan, Charlevoix, Michigan, Ithaca, New York, and have made an extensive study of the information published in regard to epidemics of water-borne diseases both in this country and abroad.

Q. Then you have made epidemiology another branch of your studies in connection with water supplies?

3974 A. I have to a very considerable extent.

Q. Now, Professor Williams, are you acquainted with the quality of the water supplies of the cities on the Great Lakes of this country?

A. I am.

Q. Did you obtain that information from your own personal observation largely?

A. In a great many cases, very largely.

Q. How does the water supply of Chicago compare with those of the other cities on the Great Lakes?

JUDGE JOHNS: I object because the comparison is not competent or relevant evidence.

A. The water supply of Chicago viewed from a sanitary standpoint is certainly the worst of any supply furnished to a large city on the Great Lakes; in fact, I doubt if there is a supply of any of the smaller towns that has such a continuous reputation for infection.

Q. Explain if you can, the conditions which affect the water supply of Chicago?

A. The water supply of Chicago is drawn from Lake Michigan, through a number of intakes located at various distances from the shore of the lake, which lake has received for a number of years to a large extent, the sewage of the city of Chicago.

This sewage has generally not been discharged directly in-
3975 to the Lake, but into the Chicago river, which in times of
flood has delivered its contents into Lake Michigan with the result that the bottom of the Lake in the vicinity of the outlet of Chicago river and in fact very extensively along the lake shore both ways therefrom, has become covered with accumulations of sewage matter which in times of storm are stirred up and carried out in the lake to the intake cribs. The intakes of the city have been moved to greater distances from shore, but such changes have only afforded temporary relief, and the supply still stands as a seriously infected one.

Q. You have stated that the water supply of Chicago is infected by the sewage of the city. What composes the sewage of Chicago?

A. The sewerage system of Chicago is what is known generally as the combined system; that is, it receives not only the household sewage, but the washings from the streets and all forms of filth from a great city, and so that the sewage is made up of both sorts. The discharges from something like one and three-quarters of a million of people go into the sewers of Chicago, and although a portion of that has recently been diverted by means of the Chicago Drainage Canal, into the Illinois river, there is still being delivered into Lake Michigan the sewage from about one-quarter of a million people.

Q. Professor, can you estimate the amount of human 3976 feces discharged daily into the Chicago sewers?

A. Yes, the amount of human feces daily delivered into the sewers of Chicago is in the neighborhood of 4400 cubic feet. This is considering the fecal matter alone, leaving out other impurities and filth.

Q. Does that relate to the fecal matters as they are suspended in the liquids or water and the urine, or does it relate to the solid substances,—those measurements?

A. That means the solid human feces.

Q. Aside from any liquid mixture?

A. Aside from any liquid mixture.

Q. In tons what would that be?

A. Somewhere in the neighborhood of about 150 tons.

Q. That is every 24 hours?

A. That is every 24 hours.

Q. How does that compare with the suspended solid matters at Lockport?

A. It amounts to something more than 50 per cent of the suspended matter of Lockport, as appears from analyses there.

Q. That is, this 150 tons of human feces amounts to more than fifty per cent—

A. Amounts to more than 50 per cent of the total suspended matters.

Q. You have stated Professor, in your testimony that 3977 a portion of the sewage of Chicago is still delivered into Lake Michigan. What is done with the remainder?

A. The remainder is delivered into the Chicago river and its branches, and from there carried through the Chicago Drainage Canal into the Des Plaines river and thence into the Illinois river and on down that river into the Mississippi.

Q. You have said that the remainder of the sewage of Chicago is mixed with water from Lake Michigan and discharged through the drainage canal into the Des Plaines and Illinois rivers. What can you say as to the quality of the water of Lake Michigan used for this mixture, as compared with that pumped through the intake of the Chicago Waterworks?

A. The water used to dilute this sewage as it is drawn through the drainage canal, is taken from Lake Michigan, near the mouth of Chicago river, and therefore from immediately over these large beds of sewage deposits, which have been found by investigators to be from one to four feet deep in some cases. The condition of Lake Michigan along the docks is such that even today one can hardly fail to see that it is an impure supply. A few years ago, when I was engaged in Chicago in work along the docks, the odors arising from the water even at a considerable distance from the mouth of the Chicago river, were highly offensive, and the suspended matter in the water was such
3978 as to cause light colored substances, dropped into it, to
disappear within a few feet of the surface, whereas in the pure lake Michigan water such as you meet at Mackinaw, such substances can be seen at depths of 20 feet or more. This water becomes clearer as you go from shore, and at the intakes is certainly very much better than that which would be found along the shore, where it is being constantly agitated by the passage of boats, which stir up the deposits on the bottom, and put them in such a condition that they may be readily drawn into the mouth of the Chicago river when the current happens to lead that way. Moreover, the bottom of the Chicago river is also covered with similar deposits and these also are stirred up and carried with the mixing water into the drainage canal.

It therefore is evident that the water taken from along the lake front anywhere in Chicago, will be very much worse from a sanitary standpoint than that taken several miles from shore where the water is very much deeper, and between which places there has been an extensive opportunity for the disappearance of polluting matter.

Q. Assuming then, as you have stated, that the water supplied through the intakes of the Chicago Waterworks, is the principal cause or one of the principal causes, of the high typhoid death rate in Chicago, would not the water used to dilute
the sewage of Chicago and sent into the canal be likely
3979 to carry typhoid infection into the Illinois River water?

A. It certainly would.

Q. Now, Professor, assuming that this water drawn from Lake Michigan at the mouth of the Chicago river, or along the lake front, were delivered un-mixed, with sewage, into a conduit of such capacity and description as to deliver the said water without other mixture, into the Mississippi river at Grafton in the same length of time as the mixed sewage and water is now delivered, would you consider the delivery of such water under such circumstances a menace and danger to the people of Missouri living along the shore of the Mississippi river below the mouth of the Illinois, who might use the waters of the Mississippi river for drinking purposes?

JUDGE JOHNS: The question is objected to as asking for an opinion and not as to the fact, and because further the supposed facts are not relevant to any issue in this case.

A. Speaking generally, I should consider that the discharge of such an infected water as that which would flow into such a conduit from Lake Michigan, near the mouth of the Chicago river, or along the lake front of Chicago, into the Mississippi river, likely to convey disease infection into the Mississippi river at Grafton, and therefore be a menace to the health of people using the water of the Mississippi river below that
point for drinking purposes.

3980 Q. Do you consider the mixture of water and sewage
discharged into the DesPlaines river at Lockport of such
a character as to be safe for use for drinking purposes?

A. Most emphatically I do not.

Q. How is the character of this liquid discharged into the DesPlaines river at Lockport, changed by the time it reaches Grafton on the Mississippi river?

A. It is changed by the dilution with the waters reaching the DesPlaines and the Illinois rivers from other sources, by the effects of sedimentation along the line of the stream and by the action of the vegetation along the same.

Q. What are the physical characteristics of the DesPlaines and the Illinois rivers below Lockport?

A. Below Lockport the DesPlaines river has a rapid fall to Joliet where the slope becomes materially less and lower velocities follow, and the stream then passes on into the Illinois, which is a stream of moderate slope in its upper reaches—

Q. Well, slope where, in the bed of the stream?

A. That is the slope of the water surface from point to point; but as it gets down towards LaSalle, it reaches very flat country where the river partakes quite essentially at times of the nature of an estuary rather than of a river; that is, it is affected extensively by the height of water in the Mississippi. It leaves its banks at a stage a little over
3981 ten feet above ordinary low water, and overflows large areas and flows into bayous, which temporarily store these flood waters and return them to the stream. It is a stream that has wide variations in the amount of its discharge, and the height of the water. For purposes of improving navigation, numerous dams have been constructed across the stream, which being intended solely to store water in times of drouth are not to be considered of the nature of such dams as are built for power purposes, but are in general quite low structures which in times of flood are practically drowned out. The difference in the height of the water surfaces measured from the crests of the dams, in what would be the upper and lower pools, that is the water on the upper side of the dams and that on the lower side, is frequently less than one-half a foot; in fact sometimes as low as two-tenths of a foot, so that in time of high water or even at what might be called moderate stages, boats are able to go over the tops of the dams, rather than having to go through the locks, so that in cases of flood these dams are rather to be looked upon as an obstruction in the bottom of the stream than as dams proper. That is, they partake of the nature and are what are known as submerged weirs under those conditions.

Q. And they were built presumably for the purpose of aiding navigation only?

3982 A. Yes, that is the purpose for which they have been put there and of course as such are only needed in times of low water, as when the water is high, it is sufficient for navigation purposes without the assistance of the dams.

Q. Now, referring, Professor, to the velocity of flow in the so-called lakes near Joliet in the Illinois river, and Peoria, and a portion of the Illinois river where slack water is found, above several dams which exist upon the stream, state whether or not in your opinion, the matter suspended in the water as it flows through the sections of the river referred to, will be deposited at any time upon the bottom?

A. There is no question that under the conditions which exist in those localities where the current is slow, there would be a very extensive deposit of the suspended material in the water, upon the bottom of the stream, at such times as the flow through those portions is low and of a uniform character.

Q. In the event of deposits occurring from the material suspended in the flowing water, explain, please, the process of deposition?

A. As depositions occur in flowing water the heavier materials naturally are deposited first, but it is perhaps a notable phenomena that in a stream of flowing water the pressures existing in the different *layers* of water, if you 3983 may call them so, vary inversely as the velocity. That is, the higher the velocity the less the pressure which the water flowing along is able to exert upon the water adjacent to it. The velocity in streams is ordinarily quite uniform for some distance below the surface so that it is easily possible for the suspended matters to disappear from the surface of the stream and get into the lower layers, but as they approach the bottom the change of velocity becomes much more rapid and hence the increase of pressure from point to point becomes more marked, so that as they approach the bottom of the stream they meet a high resistance in the force of their deposition which results in the accumulation along the bottom of the stream of a layer of water thus highly charged with the suspended matter. In fact when viewed by the eye this may often appear to be an actual deposit lying on the bottom, but as fishermen have frequently observed, if a fish darts through this material, a cloud of dust seemingly is raised in the water. That fish does not go through the deposits on the bottom but through the highly saturated water which lies next to and near to the bottom. Obviously as the pressure varies from top to bottom, a particle in order to settle to the bottom must be of sufficient weight to overcome the difference of pressure from layer to layer .

Q. Of the water?

3984 A. The difference of pressure of the water from layer to layer as it passes downward. Consequently the lighter particles in the water will be the last to be deposited, and we may say that generally speaking the bacteria which are of very nearly the same specific gravity as that of the water itself, will only be borne to the bottom when entangled with the heavier suspended matter, which is finding its way to the bed of the stream. In other words, the mud will be deposited first and the lighter particles, the vegetable and animal particles, later, if at all.

Q. Then, Professor, it would follow, as a result of your statement, in your opinion, that the bacteria contained in the water would be less likely to be deposited than would the inert mineral matter?

A. There is no question about that being the fact.

Q. Would this same thing be true of the very finest kind of clay particles in water?

A. The very fine clay particles would be likely to be carried in suspension for a long time in a stream having an appreciable velocity. They are, however, heavier than the bacteria.

Q. Professor, what effect would the occurrence of higher water in the Desplaines and the Illinois river have upon the deposit of sedimentary material in the bed of the stream?

3985 A. Any condition which tended to change what is called the regimen of flow, that is, which causes a change in the velocities from the bottom to the top of the stream, will cause changes in the amount of deposition, and will also frequently lead to what is known as scouring. It is particularly likely to stir up the suspended matter in the layer of water next to the bottom which is in a very unstable condition, and to distribute that material which in the quiet portions of the stream would be largely made up of the vegetable and animal life in the water, back into the stream.

Q. What evidence is there that this scour you mentioned takes place in the stream?

A. First and probably the most valuable evidence, is the ocular evidence that in times of flood the water in the stream becomes more turbid than that of the water flowing over the surface of the ground into it. That it is an observed fact that rivers dig out again in times of flood the channels which they have previously filled up during low water stages, and if this were not so the rivers would ultimately fill themselves up. And in the case of the Illinois river, the observations of the United States Engineers who have had charge of the improvement of that river, show that there has been no extensive silting up or filling of the channels of the stream, either natural or
3986 artificial. In fact, Mr. Jordan states in a paper which he has recently published that he was remarkably struck with the fact that there was no apparent deposit on the bottom resembling such deposits as would be expected from sewage polluted matter in stagnant waters.

JUDGE JOHNS: I move to exclude the answer, or portion of the answer which pertains to the statements of the United States Engineers and Professor Jordan, as none of those gentlemen are present for cross-examination, and as their statements are not evidence in this case.

MR. TODD: I join in the same objection in behalf of the Sanitary District.

GENERAL CROW: What effect would the presence of the existing dams have upon this scouring action?

A. The effect of dams upon the scour and upon the sediment along the bottom of a stream is very interesting. The currents set up behind the dam tend to cause a rolling over of the particles of the suspended matter in the water, very much as snow drifting against a fence will roll and toss and hence there follows a sorting of the materials, so that behind such dams there will be found accumulations of well-washed, coarse sand and gravel, while the finer particles that formerly existed in deposits of this material have been carried over the dam and sent on down the stream. It is not infrequently the case
3987 that these deposits of sand will be found arranged very much as snowdrifts appear against a tight board fence. This phenomena has been practically made use of in the washing of sands for mechanical purposes, and in fact in the washing

of gold from sands in the old placer mines where the plan was to form a series of dams with blocks nailed across the sluice box, behind which the heavier particles were caught, while the finer and less heavy particles were carried over the blocks and ran to waste at the bottom of the sluice-way. On the down stream side of the dam the water is diverted to the bottom of the stream, so that a very high velocity follows or results in the lower layers of the stream itself, which increases to a very great extent the amount of scouring that would have occurred in these localities had there been any dam present, so that we may say that the dams, except in periods of very low water, are to be regarded as more likely to cause or to assist in the transportation of the suspended matters in the river water than to retard them.

Q. Is it necessary to have a condition of flood waters to take up the suspended matter and move it down from behind the dam?

A. Not at all. In fact, a very small change in the stage of the river at low water time, would make a very decided difference in the transportation of sedimentary matter; even so small a change as might be almost imperceptible on the gauges,—may be accompanied by a considerable disturbance of the matter along the bottom of the stream by reason of the inflow of
3988 water from the surrounding territories, through the ground and into the bed of the stream itself. It is to be borne in mind that in the case of surface streams a large percentage of the water which they carry comes to them not in the visible tributaries over the surface, but rather beneath the surface, and is delivered to them through their banks and through the bottom, so that in the event of even a mild rain-fall which might show itself only in a very limited rise of height of the river, there may be brought to it considerable amounts of water from the surrounding country, delivered in through the bottom, the currents of which would cause considerable disturbance in the very light matter which overlies the sedimentary deposits on the bed of the stream, and which might indeed, and frequently does disturb even the heavier matters that exist along the bottom.

Q. Would the passage of boats have any effect upon the deposits in the bed of the stream, and if so, when?

A. The passage of boats would have a very decided effect in stirring up the deposits along the bed of the stream. This would be not only so in the case of low water, but also in the case of high water. In the first place the churning of the water from the wheels of the boats causes very many eddying currents to reach down into the stream and beyond that, the passage of the boat itself, independent of the disturbance by
3989 the wheels causes changes in the direction of flow in the
water of the stream, such as to lead to considerable re-suspension of the matter deposited on the bottom. During my investigations of the flow of the St. Mary's river I had opportunity to observe the extent to which these variations in the velocity of the stream were felt. There was at that time a channel about 2600 of 2800 feet wide, and through the major part of its extent, the depth was 50 to 56 feet, running down to about twenty feet at the sides. We observed that when a steamer drawing from 14 to 17 feet passed through that channel, the velocities in the stream were disarranged and disturbed for a distance of as much as 100 feet each way from the steamer, and extending clear to the bottom, and that this disturbance continued for sometimes as much as a half an hour after the passage of the steamer, before the water was able again to rearrange itself in the conditions of its normal regimen. All these disturbances change the conditions of velocity and pressure in the different layers of the stream, even at times rendering the pressures sufficiently greater near the bottom to force the material in suspension there into the upper layers of the water. It is also observed that even a boat stationary in a stream causes disturbances of flow which lead to the scouring at the bottom beneath it and at its sides, so that the effect of boats in the
3990 Illinois river cannot fail to be a very important factor
in the disturbance of the sedimentary deposits that may be formed along the bottom both in high and low water.

Q. In what manner did you measure the change of velocity in the flow of the St. Mary's river?

A. The observations were made by means of current-meters.

Q. Well, are they the instruments used by hydraulic engineers for the purpose of determining the speed of the flow and the change of flow in streams?

A. It is the odinary apparatus used for such purposes by hydraulic engineers generally, particularly by the engineers of the United States Government in their investigations of the flow of water in streams, and the measurements of flow in streams.

Q. You mentioned that the passage of boats would cause a change in the velocity. What effect has the change in velocity of a stream as to scouring?

A. Any change of velocity increasing the velocity of flow in the vicinity of the bottom, will lead to scour, or to picking up of particles from the highly loaded layer of water next to the bottom. This becomes more effective when these currents are in the nature of eddies, when they tend to bore or cut into the material on the bottom of the stream. In the case of the formation of eddies, as frequently occurs, when
3991 boats pass at rapid rates through water-ways, or when
they are propelled by wheels of any sort, the disturbance at the bottom is very great and may frequently be observed by the clouds of sediment which are brought up at the stern of the boat, or in the vicinity of its driving wheel.

Q. Does the displacement of water cause a change in the flow of it?

A. Certainly. If water is displaced it has to go somewhere, and if a boat is moving through it, the water has to pass from in front of the boat around and behind it; consequently there are considerable changes in the distribution of the velocities through a stream which I previously explained.

Q. Does a change of the flow of the water diminish or increase the velocity or change it?

A. The velocity must necessarily be increased in the case of still water or water flowing in the opposite direction to that in which the boat is moving, consequently there is a likelihood of scour taking place in that portion of the water which is directly below the boat at any given time.

Q. Professor, what portions of the sedimentary deposits would be first picked up by the water in times of flood?

A. The particles which would be first picked up in times of flood would be those in the layers of water over-lying the bed of the stream, or in other words, those which were last laid

down. The lighter particles of the suspended matter in
3992 the water and the lighter particles of the matter lying
actually on the bed of the stream.

Q. Now, you have spoken of disturbances caused by boats. Might winds cause any similar disturbances or effects?

A. Winds are very likely to cause similar disturbances. In fact, most always do. It has been observed on the Great Lakes, particularly Lake Erie, that after heavy winds, the waters of the lake are charged with greatly increased numbers of bacteria, such as are found in the bottom of the lake and as are not ordinarily found in the water near the top. I have also myself observed that winds have a very decided effect in stirring up the bottoms of ordinarily quiescent bodies of water, even when the depths are very considerable.

MR. TODD: I move to strike out that part of the answer which begins with the words "it has been observed," as not based upon any personal knowledge of the witness, and is therefore not competent.

GENERAL CROW: Now, Professor, you stated that in times of flood or in case of the disturbance of the waters, that the lighter particles would be picked up first in a scouring process, or in a process of removal of sedimentary matter, then what would you say as to the relative transmission during such periods of disturbance of the water, of bacteria and ordinary particles of mineral matter?

A. I should say that the bacteria at such times would be
3993 much more likely to be re-suspended, and when re-suspended, would be carried much farther than would the particles of mineral matter. The latter being heavier would sooner redeposit on the bed of the stream.

Q. Mr. Williams, what would become of the bacteria thus stirred up?

A. In the case of the Illinois river?

Q. Yes, and in streams?

A. They would be carried on down stream. They might be in part redeposited some place in the course of the flow, but some of them would undoubtedly be carried for very long distances in the water and in the case of the Illinois river would be discharged into the Mississippi river.

Q. Do you consider, Mr. Williams, that germs of typhoid fever coming from the sewers of Chicago and passing by way of the drainage canal into the Desplaines and Illinois rivers, that might be deposited in the bed of these streams and remain there for considerable periods, would be entirely destroyed?

A. That of course would depend upon the length of time which the bacteria might remain deposited in the bed of the stream, but under such conditions as existed upon the Desplaines and Illinois rivers, receiving the sewage of the city of Chicago, I see no reason to believe that germs deposited in the bottom of the stream would be destroyed under existing circumstances.

3994 Q. Mr. Williams, do you consider it possible that the water of the Illinois river in times of flood might contain as a result of a scouring action upon the deposits in the bed of the stream more infectious and dangerous material than that ordinarily present in the diluted sewage entering the Desplaines river at the Bear Trap Dam at the foot of the Drainage Canal?

A. It seems entirely possible that as a result of the scouring action set up upon the bottoms of the slack water portions of the Illinois river, the water in times of flood might be more heavily charged with polluted and infectious matter than is the dilute sewage delivered into the Desplaines river at the Bear Trap Dam.

Q. How much of a rise of water would you consider necessary to produce a scouring of the sedimentary deposits in the Illinois river?

A. If water were just flowing over the tops of the dams I should consider that a rise of half a foot would be sufficient to set up an appreciable scour and in many places on the stream a rise of very much less than this would undoubtedly change the conditions of equilibrium along the bottom and cause the re-suspension of previously deposited matter.

Q. Why?

A. Because as already explained a change in the quantity of water flowing down stream is accompanied by a change in the arrangement of the velocities in the stream and hence
3995 by a change in the pressures existing throughout, all of which tended to disturb the equilibruim of the water and

the material suspended in it and also of the material lying on the bottom adjacent to the flowing water, which would therefore be picked up from time to time and re-distributed throughout the body of the stream. In addition to this the increase of depth would cause a much larger quantity of water to be delivered over the dams, and the effects of the scour below the dams would become much more extensive than previously existed.

Q. Mr. Williams, have you made any estimate of the length of time required for the passage of water under existing conditions from the Bear Trap Dam at Lockport to the mouth of the Illinois River?

A. I have, and it appears that we may expect the water to travel this distance under the different conditions existing in the stream in from one to three weeks, speaking generally.

Q. Have you made any estimate as to the number of days in the year 1900, say, in which the water coming over the Bear Trap Dam at Lockport would reach the mouth of the Illinois river within say, fifteen days or less time?

A. I estimate that in 1900, during something over three hundred days, water would have flowed from the Bear Trap Dam to the mouth of the Illinois River in less than 15 days.

3996 Q. Mr. Williams, what effect upon the quality of the water in the Mississippi River at Grafton, Illinois, has a discharge into it of the Illinois river, after the latter river has received the mixture of Chicago sewage and water at Lockport?

A. It tends to increase the pollution and infection of the water of the Mississippi river and render it less safe for use for drinking and general household purposes below the mouth of the Illinois river.

Q. Mr. Williams, when the Mississippi River is in flood and the flow in the Illinois River not above normal do you consider it possible for the two waters to become so mixed as to affect the quality of the water upon the Missouri shore of the Mississippi river?

A. I do.

Q. Please explain how this mixing would take place.

A. That brings us back to the question again of the dis-

tribution of velocities and the distribution of pressure. I have already said that the swifter flowing water transmits less pressure to the water adjacent to it, and consequently the Illinois river entering the Mississippi at a lower velocity than the Mississippi itself is flowing, the waters of the Illinois would be drawn, or forced,as you may choose, to mingle with the Mississippi River, just as we are enabled to pump water by means of the jet pump, where we deliver a jet of water through a channel
at high velocity and that entrains with it slower moving
3997 water at its side and carries it out of the place where
it originally was. We may perhaps place this in more popular language by saying that the swifter moving stream, exerts a suction upon the water of the slower moving stream, which leads to the dissemination and mixing of the latter throughout the volume of the former.

Q. Mr. Williams, would the mixture occur when the Illinois river was in flood and the Mississippi river low?

A. Yes, to a more considerable extent than would occur in the other case.

Q. Why?

A. By reason of the velocity of the Illinois river, the momentum of the particles delivered into the Mississippi would be such as to carry them well out into the stream. In fact it is observed that when the Illinois river is in flood, the waters do pass well out into the main stream of the river.

Q. Of the Mississippi river?

A. Of the Mississippi river, and that an extensive mixing is ocularly evident.

. MR. TODD: I move to strike out the latter part of the answer beginning with "it is observable" as not based upon any personal knowledge of the witness.

A. I may add that I have frequently observed this phenomenon at my old home where the Cass, Shiawassee and the
Tittabawassee rivers unite to form the Saginaw. The
3998 Tittabawassee is a highly muddy stream, while the other
two are rather dark colored and in times of flood I have often observed as I have been boating on the river that when the Tittabawassee was high, her current was disseminated widely through the river. In fact, reaching clear across to the oppo-

site shore a very short distance below the mouth of the other stream.

MR. TODD: I also move to strike out the latter part of the answer as the same furnishes no parallel to the conditions existing between the Illinois and the Mississippi rivers in this case.

ADJOURNED until 2:00 P. M. same day.

3999 Southern Hotel, St. Louis, Missouri. 2:00 P. M., Monday, May 25, 1903. Parties met pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

GARDNER STEWART WILLIAMS,

resumed the stand for further direct examination by Attorney General Crow and testified as follows:

Q. Now, Professor, what effect would the backing up of the water in the Illinois river by higher water in the Mississippi river, have upon the mixing of the waters of the Illinois and the Mississippi?

A. The backing up of the Mississippi water into the Illinois River would have the effect of producing a quite thorough mixture of the waters of the Illinois and so much of the Mississippi as backed up into the stream, and as the flow or effect of this water which had been stored in the Illinois, considering it as an estuary, as it came out of the Illinois, would have the same effect as a flood rising in the Illinois itself, and producing an effect of additional scour on the bottom of the
stream, and carrying the water into the Mississippi, which
4000 then being flowing rapidly, would have the mixed water
more generally disseminated throughout the main current than would be the case with the rising river.

Q. Mr. Williams, are you prepared to state positively that at times the waters of the Illinois river reach the intake of the St. Louis waterworks at the chain of rocks?

A. I am.

Q. Mr. Williams, supposing all disease germs and infectious matter in the diluted sewage of Chicago as it passes Lockport, should be rendered or become inocuous, at and from that point, would you then consider the discharge of the waters of the drainage canal into the Illinois River in any way dangerous to the health of the people of Missouri using the water of the Mississippi river for drinking purposes, below the mouth of the Illinois River?

A. Even under such circumstances I should consider that the discharge into the Illinois river of the quantity of water now delivered through the Chicago Drainage Canal, would be a menace to the health of the people of Missouri using the water of the Mississippi river below the mouth of the Illinois, for drinking purposes, for the reason that this quantity of water added to the stream during the low water periods tends to materially decrease the time required for the flow of the water from various points along the Illinois river, where pollu-
4001 tion and infection may be and are added to the stream,
and thereby increase the liability of such pollution and infection reaching the Mississippi river in condition to do injury and harm to the citizens of Missouri who may be using the water.

Q. Mr. Williams, what do you estimate, if you have made any estimates at all, to be the length of time required for the water to travel from Lockport to the intake tower of the St. Louis waterworks, at the chain of rocks?

A. I have made quite careful estimates of the time probably required for water to travel from Lockport to the intake tower of the St. Louis waterworks, and it is my conclusion that under the conditions existing since the opening of the drainage canal that such water during something over 300 days in the year would reach the intakes of the St. Louis waterworks in from nine to fifteen days of the time that it left the Bear Trap Dam; that a portion of the infection contributed, or of the water added to the Illinois River at the Bear Trap Dam, flowing in the less rapid portions of the stream might be delayed considerably beyond this time, but that it is quite certain that a considerable amount of the mixed water and sewage of Chicago would reach the Mississippi river at the chain of rocks within the period which I have mentioned, during, as I have stated, over 300 days in the year. In fact it appears that since

the opening of the drainage canal, during from 60 to 90
4002 days in the year—

Q. Each year?

A. Each year, the water of the Chicago Drainage Canal would probably arrive in the Mississippi river at the Chain of rocks within ten days of the time that it passed over or through the Bear Trap dam.

Q. Now Mr. Williams, in making this estimate you used the proper methods that are used by hydraulic engineers in estimating the flow of streams?

A. I did, to the best of my ability.

MR. TODD: I object to that question on the ground that it is leading.

GENERAL CROW: Anything else?

MR. TODD: That's all.

Q. GENERAL CROW: Now Mr. Williams, considering the suspended matters in the diluted sewage at Lockport, the quantities of water flowing in the drainage canal and in the Desplaines and the Illinois Rivers, and the Mississippi river, I will ask you to state if you have been able to find the probable average dilution and probable range of dilution of the suspended matter in the water of the Mississippi river flowing past the chain of rocks?

A. I have made computations upon such a basis, and find
that during about seven months in the year, the dilution
4003 of the suspended matters in the diluted Chicago sewage
delivered into the Desplaines river at the Bear Trap Dam, when the said sewage and water reaches the Mississippi river at the chain of rocks, would be from one-half to one part per million, and that in the case of very low water in the Mississippi River the dilution might be reduced so that the suspended matter would represent a dilution of only one and three-fourths parts per million.

Q. By range of dilution of suspended matter in the water of the Mississippi, flowing past the chain of rocks, you mean the amount of dilution in proportion to the volume of the water in the Mississippi river at the chain of rocks?

MR. TODD: I object to that on the ground that it is leading.

A. I mean that the ratio of the amount of suspended matter delivered into the Desplaines river from the Chicago drainage canal at Lockport, and the quantity of water flowing in the Mississippi river, is as from five-tenths to one part of the suspended matter, to one million parts of the water of the Mississippi river, and that in time of low water this ratio may be one and three-fourths parts of the suspended matter to one million parts of the water of the Mississippi river.

Q. Now, Professor, I will get you to state whether or not this suspended matter refers to the sewage in the liquid form and in the form of feces or does it refer to the solid matter in the sewage, excluding any liquid substances or matters that might be in the sewage from the drainage canal?

4004 A. This is based upon the solids which are in suspension in the sewage at the Bear Trap Dam, and has no bearing upon any substances which may be in solution and therefore not appearing as solids in suspension, in the analyses of the water.

Q. Mr. Williams, do you know of any case where a similarly diluted mixture of suspended solids from sewage matter has produced typhoid fever?

A. I do, at Detroit, in 1892.

Q. Will you please briefly describe the circumstances of that epidemic and the conditions involved in it, and which led up to it. If you have personal knowledge of those facts, please state that.

A. I have personal knowledge of the facts in question, inasmuch as I investigated the outbreak of typhoid fever in Detroit which followed the occurrence to which I have reference.

The water supply of the city of Detroit is drawn from the American Channel of the Detroit River, at the head of the river or at the foot of Lake St. Clair. Detroit river as you know, is one of the links in the connecting waters between the upper lakes, Huron, Michigan and Superior, and the lower lakes, Erie and Ontario, and is the natural outlet of the upper Great Lakes to the sea. The water from Lake Huron enters the St. Clair river and flows through it a distance of about 35 miles, to the delta of the St. Clair river, when it

4005 discharges into Lake St. Clair. Lake St. Clair is nearly circular in form, being 24 miles wide and including its delta, about 24 miles in length, measured in the direction of flow. The water supply of Detroit is taken practically from the lake, or from the river a few hundred feet below the point where it takes its origin in Lake St. Clair.

In the year 1890, the number of deaths in the city of Detroit from typhoid fever, were 39; in the year 1892 the number of deaths from typhoid fever in the city of Detroit, were 209. This remarkable increase was such as to cause Detroit for that year to take rank among those cities which have had the highest death rates from typhoid fever in America,—there are but one or two of our large cities that have had death rates notably higher than this; one of them being Chicago. An examination of the records showed that this epidemic begun in June, during which month there were 38 deaths by typhoid fever. As the Civil Engineer to the Board of Water Commissioners of Detroit, it was very natural that my attention should be called to this condition of affairs, as many people attributed the cause of the epidemic to the water supply and I started to ascertain, if it were possible, where such a remarkable infection could have come from so suddenly and so unexpectedly. After an extended investigation I found that the epidemic was undoubtedly caused as a result of improvements to the channel of Black River which flows into St.
4006 Clair river near its head, at Port Huron, a distance of about 57 miles from the intake of the Detroit Waterworks. I found that Black River which was a sluggish stream, having ordinarily no current whatever, and only in times of heavy rains a perceptible current, had been for years receiving the sewage from the city of Port Huron, through the center of which it flows. In order to improve the harbor of Port Huron, which was virtually the lower portion of Black River, the United States Government had caused the river to be dredged during the early months of 1892, and in the process of that dredging, had removed deposits from near the mouths of the sewers, which ranged in depth from a foot to seven or eight feet, and, according to the testimony of some of those who lived along the banks, to as much as ten feet in depth. This material was

loaded upon scows and transported out into the St. Clair river, where it was discharged or dumped into the stream, at a point as I have already stated, about 57 miles above the intake of the Detroit Waterworks. I found upon further investigation that this work had been begun during 1891, and that conditions were such that this particularly highly infectious deposit of material was reached right at the beginning of the operations in 1892, so that this fully explained the sudden out-break of typhoid fever in Detroit, it having been carried through the
4007 water of the St.Clair River, and through Lake St. Clair, to
the intakes of the Detroit waterworks, and thence distributed to the consumers throughout the city, with the result above mentioned.

MR. TODD: I move in behalf of the Sanitary District to exclude all of that part of the answer beginning with the expression "from the examination of the records" as being based upon hearsay and not personal knowledge, and the conclusions made by the witness from the facts as stated, as not being competent evidence in the case.

Q. Mr. Williams, do you know the amount of material that was dumped into the St. Clair river at that place?

A. I do.

Q. Professor Williams, do you know the depth of the St. Clair river at the place where this dumping was done?

A. St. Clair river at the point where this material was dumped was about 1800 feet wide, and from 30 to 36 feet deep.

Q. Mr. Williams, if I understand you the St. Clair river flows into St. Clair Lake, is that correct?

A. That is correct.

Q. Now what did you say was the size of St. Clair Lake?

A. About 24 miles wide and 24 miles long, including the delta at the head of it.

Q. Now Mr. Williams, do you know aside from the delta
4008 portion of the lake, what is the average depth of St.
Clair Lake?

A. About sixteen feet at that stage of water.

Q. Now Mr. Williams, do you know whether or not the current in the St. Clair lake is perceptible to the human eye?

A. It is not. The St. Clair river, while quite a swift flowing stream, discharges into Lake St. Clair over a delta which spreads out for about 130 degrees, has ten distinct mouths, and the distance between the extreme mouths measured along the arc of the delta is about 20 miles. This delta portion is quite shallow in places; sometimes not more than a foot deep, other times running down in the channels to a depth of 15 or 16 feet. It is covered in the shallower portions and often in the channels, with a very heavy vegetable growth, and reeds growing up out of the water in a great many places. It is one of the most remarkable fishing grounds, I may state incidentally, that there is along the Great Lakes.

Q. What is the character of the water of Lake St. Clair as to whether it is muddy or clear?

A. The water of Lake St. Clair is a clear water under ordinary conditions, and except in times of storm when the winds churn it up, it is an entirely satisfactory water for drinking purposes without anything in the nature of treatment or clarification.

4009 Q. Mr. Williams, have you any knowledge as to the speed of flow from the St. Clair River in the lake and through the lake and into the Detroit River, if there is any such flow?

A. Yes, the velocities in the St. Clair river range from about three and three-fourths miles per hour down to about 1.8 miles per hour. In the delta portions, the highest velocities that have been measured, which are in the main channels there, are a little less than one-quarter of a mile per hour; that is one mile in four hours.

Q. How much is in the delta?

A. There is about seven miles of delta.

Q. Now what about the velocity in the lake?

A. In the lake the velocity ranges from about .06 of a mile per hour—that is one mile in about 16 or 17 hours, to about one-twelfth of a mile per hour; that is one mile in twelve hours.

JUDGE JOHNS: When you get through with the testimony in regard to Lake St. Clair I want to move to exclude all the testimony, descriptive of Lake St. Clair, and its waters, as irrelevant and incompetent both.

Q. GENERAL CROW: Mr. Williams, I will get you to state if you know what was the length of time in the case you have mentioned, that probably elapsed between the discharge or dumping of the matter, and the distribution of the 4010 water into which said material was dumped, to the consumers of water in the city of Detroit?

JUDGE JOHNS: The question is objected to as assuming a fact not proved, namely that this matter discharged into Lake St. Clair was distributed to the citizens of Detroit; and also on the ground that there is no proof that the waters into which the matter was dumped, was distributed to the citizens of Detroit.

MR. TODD: I object in behalf of the sanitary district on the ground that there is no legal evidence in this case showing that any matter of any kind was dumped, as included in the question, and that the witness has shown no personal knowledge of the existence of such fact, except based upon hearsay.

A. The time elapsing between the deposit of the infectious matter at Port Huron and the arrival of the water into which it was so discharged, and the delivery of the same to the consumers in the city of Detroit, would be the time required for the water to flow from the point in the St. Clair river, where the material was discharged, to the intakes of the Detroit waterworks, and to be distributed through the distribution system of the Detroit Waterworks to the consumers in the said city, and that time I have estimated quite carefully, and find that in all probability it may not have been less than eight days, and that it undoubtedly would have arrived there in 12 to 14 4011 days. I think that ten days is a fair estimate of the time required for the most rapid travel of the water from the vicinity of Black River in Port Huron to the water system, or to the intakes of the Detroit waterworks.

JUDGE JOHNS: I move to exclude that answer as not based upon any evidence yet submitted in this case, and as not based upon the knowledge of the witness.

MR. TODD: I join in the same motion, and for the additional reason that the witness has not shown that he knew when this matter was deposited, of his own personal knowledge, if any such matter was in fact deposited.

Q. Now Mr. Williams, do you know what is the ordinary period of incubation for typhoid fever, after one has taken into the intestinal canal the typhoid bacillus?

A. According to the best evidence which we have it appears that the disease may incubate in as short a time as seven days, or that it may require in the neighborhood of four weeks, but that probably about 75 per cent of the cases will incubate in from ten to fifteen days of the time infection is taken, and I have concluded that twelve days is a reasonable and proper period of incubation to be allowed in the study of typhoid epidemics.

MR. TODD: I object to the answer on behalf of the Sanitary District, on the ground that the witness has not 4012 shown any qualifications that will enable him to answer this question.

GENERAL CROW: Now Mr. Williams, considering the relation of the St. Clair river, St. Clair Lake, the Detroit River and the Detroit waterworks, the location thereof, the speed of flow as you have described the same in the St. Clair River, and down the Detroit River, and the time when the material from the bed of the Black River in front of Port Huron was dumped into River St. Clair, I will get you to state if you know whether or not the typhoid epidemic you have mentioned in 1892, appeared in the city of Detroit within a reasonable period of incubation thereafter, or after the water from the point where the material above mentioned was dumped into the St. Clair river, may have reached or should have reached the consumers in Detroit?

MR. TODD: I object to the question on the ground that the facts assumed in the question have not been established.

GENERAL CROW: I have not assumed any facts.

MR. TODD: You assumed the dumping in.

GENERAL CROW: No I didn't. I said considering the facts.

Q. (Question repeated).

MR. TODD: I object to the question on the ground that there is no evidence that the witness has shown that he has a personal knowledge of any material having been dumped into St. Clair River as stated in the question, and that that fact has not been established by any competent evidence.

4013 A. I found that making the allowances already stated for the time required for the infection to come from the point at Port Huron where this material was discharged into the St. Clair river to the consumers of water in the city of Detroit, and allowing the average period of incubation for typhoid fever, and allowing the ordinary time to elapse between the taking down of the patient and the occurrence of death in the event of death occurring, that the sum of such times agreed within 24 hours with the time which had elapsed from the deposit of the dredged material from Black river into the St. Clair river, and the time when there were in a single day in Detroit four deaths from typhoid fever, there having been only one in the preceding twenty-four days.

MR. TODD: I move to strike out the answer because the witness has not shown that he is in possession of facts of personal knowledge sufficient to make the answer that he has made.

JUDGE JOHNS: I move to strike out all the witness' testimony in which there is a description of the river St. Clair, Lake St. Clair and the Detroit River, as irrelevant and incompetent testimony.

GENERAL CROW: Now, Mr. Williams, you say that this water coming into the intake of the Detroit waterworks had passed through Lake St. Clair a distance of some seventeen miles, and at the latter end of its journey,—now wasn't 4014 it probable that it might have flowed through this Lake St. Clair in a direct line at considerable velocity and thereby have reached the intakes of the Detroit Waterworks in a much shorter time than you have mentioned?

A. That would have been impossible from the formation and form of the delta, and also from the fact that there is at no place in Lake St. Clair, or was no place in Lake St. Clair any perceptible current through it, but that the water flowing into it was distributed throughout its whole upper end and must therefore have passed by very slow stages, through the lake and out of the outlet at the lower end.

Q. What was the estimate, if you know, of the discharge or volume of water by the St. Clair river at the time of this epidemic of 1892?

A. The discharge of the St. Clair river varies from 180,000 to 200,000 cubic feet per second, and at the time of this epidemic was at about the lower figure, which by way of comparison

I may remark, is about the discharge of the Mississippi river at St. Louis at ordinary stages, that being the discharge of the upper lakes, except such as is taken through the Chicago Drainage Canal.

Q. How is that?

A. I say that discharge represents the discharge of the upper lakes, except such as is taken through the Chicago Drainage Canal.

4015 Q. You mean the discharge of the upper lakes into the sea?

A. Yes, the discharge of the upper lakes into the sea.

Q. Now are you familiar with what is termed slack water?

A. Yes sir.

Q. Well, do you know whether or not the water of Lake St. Clair could be termed slack water?

A. I think it may be termed considerably more than slack water, as it is unless affected by winds, frequently to all intents and purposes, with no wind to disturb it, a quiescent water. It would be impossible to observe any motion of floats put upon its surface, except as they were blown about by the wind. It is nearly as quiescent water as the water of Lake Michigan is, so far as regular currents are concerned, or anything in the nature of flow. As compared with the slack water supposed to exist behind various dams on the Illinois river the velocity in Lake St. Clair is not one-quarter that which exists in the slack water places along the Illinois River.

Q. Mr. Williams, you stated that the intake at Detroit waterworks was located on the American side of the Detroit river, how does the discharge of this channel compare with that through the Canadian Channel if you know?

A. From discharge measurements which I made upon the Detroit River while I was connected with the Detroit

4016 Waterworks—I also made an extended survey of portions of Lake St. Clair above the mouth of the Detroit River, so that I am personally familiar with the conditions that existed, and I frequently passed through the channels connecting Lake St. Clair with the St. Clair river, and up the St. Clair River to Port Huron, so that I am personally acquainted with the conditions that exist along that stream and throughout Lake

St. Clair,—I found the quantity of water discharging through the American channel of the Detroit river, from which the Detroit waterworks takes its supply, was about one-third of the total quantity which is delivered through the river.

Q. Then considering that fact would or would not the Canadian Channel be a more direct outlet for a larger portion of the water of Lake St. Clair that came into the Detroit River?

A. The Canadian channel undoubtedly took the larger portion of the water flowing into Lake St. Clair and still does so, and it is in a more direct line with the main mouth of the St. Clair delta, in fact more than half of the mouth of the St. Clair delta, discharging in such a way as to indicate that the water transmitted would be more likely to pass down the Canadian channel than down the American channel.

Q. Mr. Williams; was the effect of the infection of the water of the St. Clair river and the Detroit river in 1892, felt in any other cities along the St. Clair and Detroit Rivers other
4017 than the city of Detroit?

JUDGE JOHNS: I object to it as irrelevant and incompetent.

A. The presence of infectious matter in the water of the Detroit River was indicated by a largely increased prevalence of typhoid fever in all the towns along the St. Clair and Detroit rivers which had public water supplies taken from the Detroit and St. Clair rivers.

Q. I will get you to state if you know, what was the dilution of the matter taken from the Black river and dumped into the St. Clair river in 1892, and what was the character of that material which was removed, if you know, from the Black River at Port Huron?

JUDGE JOHNS: Objected to as incompetent and irrelevant.

A. Estimating the quantity of dilution from the discharge of the St. Clair river as determined by the readings of the gauges maintained by the United States corps of engineers along said stream at the time when the work at Port Huron was in progress, and by the number of cubic yards of dredged material as shown by the books of the inspector who had charge of that dredging, now on file in the office of the engineer corps of Detroit, which I have personally inspected and examined, I find that during the month of April, 1892, the ratio of the volume of dredged material discharged per day into the St. Clair River at Port Huron, 4018 to the volume of water flowing in the said river for twenty-four hours, based upon the above data, ranged from a ratio of .55 of a part of dredged material to 1,000,000 parts of water, to 1.1 of dredged material, to 1,000,000 parts of water.

MR. TODD: I want to object to the question on the grounds that I have stated in the objections to the other questions.

Q. (Question repeated.)

A. The materials dredged were composed of deposits of silt and sediment apparently coming from the sewers of Port Huron near the mouths of which it lay, having been protected from disturbances there by the piers of a bridge near by, and according to the statements in the book of the inspector who had charge of the dredging, which I have personally examined, amounting to about seven feet in depth, and below that the material was a clay—colored by the sediment, and in some places mixed with sand.

MR. TODD: I move to strike out the answer for the reason that the records as contained in the books of the inspector are not evidence of themselves, not competent and the fact that the witness examined the records doesn't make them competent for him to testify to, and for the further reason that the witness has not shown that he has such knowledge of the facts as to make his evidence competent upon the questions he is testifying.

4019 JUDGE JOHNS: I join in the objection, and object further that the witness has stated no facts as to the amount of materials dredged which would enable anyone to verify his conclusions.

GENERAL CROW: Q. What, Professor, do you state to be the range of dilution of the sewage matter of Chicago, from the Sanitary District of Chicago, in the waters of the Mississippi river flowing past the chain of rocks?

A. At ordinary stages, from .5 of a part of suspended matter to 1 part of suspended matter in one million parts of water.

Q. How does the dilution in the Detroit case you have mentioned, in the St. Clair river, compare with the usual dilution of the sewage of the Sanitary District at Lockport and also at the Chain of Rocks in the Mississippi river?

JUDGE JOHNS: Object to the question as incompetent.

A. The suspended matters in the sewage and water at Lockport, are something over twenty times as great as I have estimated the suspended matter in the St. Clair river, due to the dredged material at Port Huron, to have been at the time the dredged material was dumped into it, and the suspended matters estimated in the Mississippi River at the Chain of Rocks as coming from the Chicago Drainage Canal, are practically in substantially the same proportion to the quantity of water flowing as those existing in a stream of substantially the same size, in the case of the Detroit typhoid epidemic.

4020 Q. The dilution you mentioned in the Detroit case, was that in Lake St. Clair or St. Clair river?

A. That is estimated upon the discharge of the St. Clair River at Port Huron, the United States gauging station.

Q. Mr. Williams, you have stated heretofore in your examination that there had been dredging done at the mouth of the Black river previous to the spring of 1892, which caused the epidemic in Detroit which you have described. Did that dredging produce any effect upon the amount of typhoid fever in Detroit?

JUDGE JOHNS: Objected to as immaterial and irrelevant.

A. Following the dredging of the bar at the mouth of Black River and the lower portion of Black river in 1891, there was a very decided increase in the typhoid fever deaths in Detroit for the fall months of 1891, which to my mind was undoubtedly very largely due to the said dredging.

Q. Mr. Williams, if you know will you please state for how long a period of time the deposits of sewage which you have mentioned, had been accumulating in the waters and on the bottom of the Black River at Port Huron prior to their removal as detailed by you in 1892?

JUDGE JOHNS: Objected to as incompetent and irrelevant.

A. Those deposits had been accumulating for a number of years.

GENERAL CROW: I will ask you this question. How

4021 do you know that sewage matter was deposited in the Black River in front of Port Huron?

A. I know from personal interviews with the City Engineer of Port Huron that the sewers discharging into the Black river at this point have been constructed and in use for a considerable number of years before he became City Engineer of Port Huron, which was previous to 1892.

Q. I will get you to state if you know whether or not Port Huron had sewers in 1892, and where they discharged?

JUDGE JOHNS: I object to the question as incompetent and immaterial.

A. Port Huron had sewers in 1892, and they did discharge into the Black River.

GENERAL CROW: I will get you to state if you know whether or not there had been typhoid fever in Port Huron preceding the time of the dredging above mentioned in the Black River?

JUDGE JOHNS: Objected to as immaterial.

A. There had been typhoid fever in Port Huron during September and October, 1891, as shown by the records of the State Board of Health of Michigan, which facts have been communicated to me by the secretary thereof.

MR. TODD: I move to strike out the answer as not competent and not relevant.

GENERAL CROW: I will get you to state whether or 4022 not you made any examination to discover whether or not there was any typhoid fever in the territory tributary to the waters of the St. Clair River in the period you have mentioned in 1892 or prior thereto, that might have conveyed infection to the waters and thus been the source of the infection of the water supply of Detroit?

JUDGE JOHNS: I object to it as incompetent and irrelevant.

A. The presence and extent of typhoid fever in the various cities, towns and villages upon the watershed of the St. Clair River, Lake St. Clair and the Detroit River above the intakes of the Detroit waterworks, and of that portion of the shores of Lake Huron adjacent to the head of St. Clair River, was carefully examined into—

Q. By whom?

A. By myself with the cordial assistance of the State Board of Health of Michigan, the Provincial Board of Health of Ontario and by means of special communications to the health officers and physicians in the several localities, and after a most searching investigation and inquiries from private citizens and others familiar with the facts extant, or existing at the time of the epidemic in Detroit, and previous thereto, I was unable to find any source of infection that could in any way account for even
4023 a small portion of the outbreak of typhoid which I have described as occurring in Detroit in the spring or in June of 1892.

GARDNER S. WILLIAMS.

ADJOURNED until 10:00 A. M., Tuesday, May 26, 1903.

4024 Southern Hotel, St. Louis, Missouri, 10:00 a. m. Tuesday, May 26, 1903.

Parties met pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

GARDNER STEWART WILLIAMS

resumed the stand for further direct-examination by Attorney-General Crow and testified as follows:

Q. Mr. Williams, I will ask you if you can state the time when this dredging and dumping was done in the Black and the St. Clair rivers, in 1892?

A. The time when it was done?

Q. Yes?

A. It began April 16th, 1892, and the work continued all through the year, but the dredging of the particularly infectious matter ended in a comparatively short time, a matter of a few weeks.

Q. I will get you to state if you know the amount of material that was dredged out of the Black River and dumped into the St. Clair river at the point you have mentioned?

MR. TODD: The same objection to that question that I
4025 made to the others, namely, because the witness has already testified to the effect, or I mean the testimony of

the witness heretofore given, shows that he has no personal knowledge of the facts about which he is called upon to testify.

JUDGE JOHNS: I object on the part of the State of Illinois to all the testimony with reference to the history of the epidemic at Detroit, as irrelevant and incompetent.

A. The note-book of the inspector who had charge of the dredging in Black River in 1892, as the representative of the United States Board of Engineers on that work, shows on April 16th 327 cubic yards of material dredged and dumped; that there was no further work until the 20th when 548 cubic yards were dredged and dumped; on the 21st, 442 cubic yards,

On the 22nd, the same,
On the 23rd, the same,
No work on the 24th, apparently,
On the 25th, 442 cubic yards,
On the 26th, the same,
On the 27th, 557,
On the 28th, 548,
On the 29th, 442,
On the 30th, 663,

and continuing through the month of May in similar quantities.

MR. TODD: I move to strike out the answer on the 4026 ground that the note-book of the inspector is not competent evidence in this case, and besides, the witness has not shown that he has a personal knowledge of these excavations, as shown in the supposed note-book of the inspector.

Q. GENERAL CROW: Mr. Williams, I will get you to state if you know how this amount of dredged material raised from the Black River and dumped into the St. Clair river, would compare in quantity with the solid fecal matter coming through the out-falls of the Chicago sewers, now, and into the drainage canal every 24 hours?

MR. TODD: The same objection to that question as to the preceding.

JUDGE JOHNS: And the further objection that the comparison is not competent evidence, and the witness has no personal knowledge of the amount of sewage coming from Chicago, as stated in the question.

A. The quantity of the dredged material dumped into the St. Clair river at Port Huron daily in 1892, varies in amount from two to five times the amount of human fecal matter that is delivered by the sewers of Chicago into the Chicago River and thence into the drainage canal each day. I mean by that, that the total amount of dredged matter composed of the sedimentary accumulations from the sewage of Port Huron, which had been accumulating for a number of years, and the material
4027 which was originally part of the bottom, and which was
taken up by the dredges in this work and delivered, mixed with the other material, into the St. Clair river, daily, taken altogether, is in amount from twice to five times the amount of human feces only, which are delivered daily through the sewers of that portion of Chicago discharging its sewage ultimately into the drainage canal.

MR. TODD: I move to strike out the answer for the same reason assigned in the previous motion.

JUDGE JOHNS: I object to the answer for the reason that the year 1892, as to the sewage of Chicago, is not material to any issue in this case.

Q. GENERAL CROW: Mr. Williams, you have stated that you investigated to try and discover if there were any causes for the Detroit typhoid epidemic of 1892, upon the watershed of the Detroit waterworks, other than the pollution of the St. Clair River by dredged sewage deposits from Port Huron. Now I will ask you to state whether or not you made any investigation in the city of Detroit, to determine whether or not any local causes might have existed at or prior to the time of the epidemic that might have produced the same?

A. I did make a most thorough investigation of all possible conditions existing in Detroit, previous to the outbreak and during the existence of the epidemic to ascertain whether
4028 it were possible that the cause of the epidemic might lie
in any such condition, and after the most careful investigation which it was possible for me to make, which included conversations with physicians who treated cases during this epidemic, the studies of rain-fall, general precipitation and temperature of the distribution of the cases throughout the city, with

relation to possible infection from previous cases, and a consideration of all other suggested sources of typhoid infection—it was impossible for me to find any cause which could explain or begin to explain such an outbreak of typhoid as occurred in the month of June, 1892.

MR. TODD: I move to strike out the answer as being incompetent and not responsive.

Q. GENERAL CROW: The cause you refer to, is a local cause, is it?

A. I didn't understand the question.

Q. You stated that you were unable to find any cause for it. You have reference to a local cause?

A. Any local cause, yes sir, or any cause other than the dredging of Black River at Port Huron, and the discharge of the dredged matter into the St. Clair River.

MR. TODD: I move to strike out the answer for the same reason as heretofore stated.

4029 Q. Mr. Williams, do you know whether or not there has been any dredging done in the Black River or St. Clair River, and Lake St. Clair since 1892?

A. There has been considerable dredging done in the Black River, or some dredging done in Black River and considerable in St. Clair River, and in Lake St. Clair, since 1892.

Q. What has been the effect, if any, upon the record of typhoid fever, of this dredging, in the city of Detroit?

A. The years in which dredging has been done in the waters above the intake of the Detroit waterworks, between there and the foot of Lake Huron, have uniformly been years of high typhoid in the city of Detroit; said typhoid making its appearance generally some weeks after the beginning of the dredging, and the excess disappearing shortly after the discontinuance of the dredging, up to the time when the 21-foot channel through Lake St. Clair was completed, at which time the conditions previously existing in that lake were materially changed by providing a channel through the lake leading into the Canadian channel, through which a considerable quantity of the water of the St. Clair River flowed directly.

Q. Was or was not the effect of the channel to divert more water to the Canadian side than had previously flowed there?

A. The effect was to divert more water.

Q. Mr. Williams, do you know of any other instance
4030 where the disturbance and discharge of deposits of sediment from sewers into a running stream, has caused typhoid fever among the users of the water of such a stream?

A. I do.

Q. Please state the circumstances if you know them, in that instance?

JUDGE JOHNS: In order to save the necessity of objections to each question and answer as propounded, the State of Illinois now objects to all testimony to be elicited from this witness with regard to investigations either by himself or other persons, of the cause of typhoid fever, and in any other place than in St. Louis, arising from infection of the waters at the intake at St. Louis, caused by the inflow of drainage from the drainage canal in Chicago, and insists that such testimony is neither competent nor relevant, and desires that this objection shall stand to all such testimony from this witness.

MR. TODD: I wanted to make a motion at the conclusion of the Detroit investigation. I don't know whether you have finished that yet or not.

GENERAL CROW: Yes, we have concluded that.

MR. TODD: On behalf of the Sanitary District I move to exclude all of the evidence in regard to the conditions as testified to by the witness as existing in Detroit and Port Huron in the year 1892.

4031 GENERAL CROW: Please state the circumstances, if you know them, in that instance?

A. The circumstances were these: The main sewer of the town or city of Crookston, in Minnesota, became damaged, so that it failed to discharge the material delivered into it. Temporary repairs—

Q. What was the result of that failure to discharge?

A. This of course led to the accumulation in the sewer of deposits of sewage matter, and to afford a temporary relief, a small connection was made around the break which carried off a portion of the liquid matter of the sewage and discharged it into the Red Lake River, which was the stream into which the

sewage of Crookston was regularly discharged. In the fall
1893, this sewer was repaired, and on November 17th, the sewe
age system of Crookston was flushed of the accumulations whi
had gathered during several months preceding. Typhoid fev
to the extent of about 60 cases had existed in Crookston
October and November, 1893. At the time of the flushing
these sewers, and the consequent delivery of the sedimenta
accumulations from the sewers into the Red Lake River, the riv
was frozen over. The town of Grand Forks, North Dakota,
located about 60 miles by river, below Crookston, on the R
Lake River, or on the Red River. In November, 1893, the
were recorded in Grand Forks, two cases of typhoid fev
4032 and no deaths, and for months preceding, there had be
a very small amount of typhoid fever present or prevale
in Grand Forks.

In December, following the flushing of the sewers at Crook
ton, on November 17th, there were reported 230 cases of typho
fever in Grand Forks, and four deaths.

In January there were reported 712 cases and 52 death
In February, 231 cases and 27 deaths,
In March 46 cases and 11 deaths,
In April, 26 cases and 2 deaths,
In May, 1 case and no death,

showing, apparently, that the epidemic had expended itself b
the close of the month of April, and this appears to include i
the neighborhood of 1,200 cases and nearly 100 deaths, as
result of the flushing of the sewers at Crookston, some sixty mile
up-stream from Grand Forks, which was taking its water su
ply from the river into which these sewage deposits were di
charged.

I may further add that during the following months th
typhoid cases and deaths remained at what might be considere
the ordinary amount prevalent in Grand Forks, namely in Jun
3 cases and no deaths,

July, 2 cases and 1 death,

August, 4 cases, no deaths, these months from June t
4033 August being in 1894.

MR. TODD: On behalf of the Sanitary District of Chi cago, I move to strike out the answer for the reason that the witness has not shown that he had personal knowledge of the facts concerning which he has testified.

Q. GENERAL CROW: I will get you to state, Mr. Williams, if you know whether or not Grand Forks, took its water supply from the river into which the sewage of Crookston was emptied?

A. Grand Forks was taking its water supply, and is still, from the river into which this sewage deposit was discharged.

Q. Mr. Williams, what evidence is there to you, as an expert, or what would be your opinion as an expert, on the facts connected with the Detroit typhoid epidemic, which would bear upon the subject of the mixing of currents of water in flowing streams?

A. The conditions which existed at the time of the discharge of the dredged material from Black River into the St. Clair River, and subsequently thereto, afford very excellent evidence of the thorough mixing of the currents of water in a flowing stream. The St. Clair River is about 30 miles in length from the point where the dredged matter was deposited, to the inlet or head of the delta. It is a moderately straight stream, and of comparatively uniform depth, consequently its flow is
not subjected to nearly as much disturbance as is the water
4034 of the Mississippi River in the course of its flow from
Grafton, the mouth of the Illinois River, to the Chain of Rocks, a distance of approximately the same length, or about 29 miles, yet, although the material dredged from Black River was dumped intermittantly from scows, at a single point in the stream, which was at that point about 1,800 feet wide, and from 30 to 35 feet deep, and was discharging at that time a quantity of water about equal to that which the Mississippi River discharges or delivers past St. Louis in its ordinary stages, nevertheless, by the action of the currents of the river itself, following the well known laws of the flow of water, this material seems to have become so thoroughly mixed with the water in all parts of the St. Clair River, that by the time it reached the head of the delta it was delivered into all parts of Lake St. Clair.

MR. TODD: I move to strike out the answer for the reason that has been given in similar motions, in regard to the Detroit River.

Q. GENERAL CROW: What resemblance, if any, is there between Lake St. Clair and a settling or storage basin for water?

A. Lake St. Clair might be, and has been regarded as an ideal settling basin. When the Detroit waterworks was located at its present situation, a report was made upon the probable quality of water so obtained, by a commission of engineers,
4035 composed of members of the United States Engineer
Corps, and in which they pointed out that in Lake St. Clair, the city of Detroit was provided with a vast sedimentation basin which would add materially to the purity of the water drawn from the river at the point where it was proposed to take it.

MR. TODD: I move to strike out the answer on the ground that if the report was competent evidence of the facts, stated, it would be the best evidence.

Q. GENERAL CROW: Do you know who made this report?

A. My impression is that it was made by General Weitzel, General Comstock and General Greene.

Q. Who were they?

A. They were engineers in the service of the United States, members of the United States Engineer Corps, and General Weitzel and General Comstock both had charge of the improvements of navigation and surveys of the Great Lakes.

Q. Do you know about the date when that report was made by these men?

A. That report was made about 1868 or 1870.

Q. From your knowledge of the facts with reference to the deposits of sewage matter in the Black River at Port Huron, how long, in your opinion, did the infection remain in the sedimentary deposits in front of Port Huron?

MR. TODD: I object to the question for the reasons here-
4036 tofore stated.

A. In consideration of the fact that the most recent known cases of typhoid fever preceding the time of the dredging in the spring of 1892, at Port Huron, were those reported in

September and October, 1891, to the Michigan State Board of Health, and in view of the fact that inquiries of the Board ot Health of Port Huron and of the health officer of said city, and of leading physicians there, failed to establish the existence of typhoid fever in Port Huron subsequent to that time and previous to the beginning of the dredging in the spring of 1892, I am entirely satisfied that some of the infection in the sewage matter dredged in the spring of 1892, had remained or lived in that material for three or four months at least, and I think it entirely probable that much of it had lived a very much longer time.

MR. TODD: I move to strike out the answer in behalf of the Sanitary District, for the reason that the witness has not shown that he has any personal knowledge of any sewage having been dumped into the St. Clair river, and is therefore not qualified to pass an opinion.

Q. GENERAL CROW: From your knowledge of the facts in this matter with reference to the Detroit epidemic and the dumping of the dredged material from the Black River into the St. Clair River, how long, in your opinion, did the typhoid 4037 germs or bacilli live in the water of the St. Clair River, Lake St. Clair and the Detroit River?

MR. TODD: I object to that question for the reasons heretofore stated.

A. The typhoid germs delivered into the St. Clair river at Port Huron must have lived a sufficient length of time to have traveled to Detroit, to have passed through the distribution system of the city and to have been delivered to the consumers, and such time could not, in my opinion, have been less than eight or nine days, and in a great many cases, must have been as much as twelve or fifteen days, or more.

MR. TODD: I move to strike out the answer for the same reasons as heretofore stated.

Q. GENERAL CROW: I will get you to state from your knowledge of conditions as they exist at Detroit, in Lake St. Clair and the St. Clair and the Detroit Rivers at the time mentioned heretofore, if in your opinion these typhoid germs may have lived along the banks of the streams, and on the bottoms of the rivers and lakes, for any considerable time?

MR. TODD: I object to the question for the reasons heretofore stated.

A. From the increase of typhoid fever in Detroit in the early months of 1892, January, February, March and 4038 April as compared with the typhoid prevalent during the corresponding months of previous years, following, as those increases do, the rise of water and increased discharge of the St. Clair river, and corresponding to no discoverable increase of infection from other sources, and being as an examination of the individual cases show, due in the main to infection of the water supply, I am convinced that they were very largely caused by the stirring up of the material on the bottom and sides of the St. Clair river and Lake St. Clair, and at the head of the Detroit River itself, which had come there as a result of the dredging of moderately infected material at the mouth of Black River during the fall of 1891, and had remained on the bottom or in the layer of water adjacent to the bottom during the intervening period.

MR. TODD: I move to strike out the answer for the reason that there is no evidence to show that there was ever any typhoid germs at the bottom of the St. Clair river, and for the reasons mentioned in my previous objection.

Q. Mr. Williams, how does the typhoid infection usually get into the water of streams?

A. Through the sewage discharged into those streams.

Q. Mr. Williams, do you consider it safe in your opinion to permit the discharge of human sewage in the streams of 4039 water which may thereafter be used as a source of water supply, taking this question in its broad outlines?

A. As a broad general proposition, most emphatically I do not.

Q. Mr. Williams, in your opinion will typhoid fever germs discharged from the sewage of Chicago reach, and have they reached, and will they continue to do so, the intake of the St. Louis waterworks at the Chain of Rocks under the conditions of flow in the streams and the drainage canal, uniting the sewers of the Sanitary District of Chicago to the said intake above mentioned?

A. It is my opinion, based upon my knowledge of the transmission of typhoid fever through water, and the conditions which I have found upon investigation to exist along the drainage canal and streams which unite the sewers of Chicago to the intake of the St. Louis waterworks at the Chain of Rocks, and the conditions which have existed in Chicago and in St. Louis prior to and since the opening of the Chicago drainage canal, that typhoid infection or typhoid germs have at times come from Chicago to the intake of the St. Louis waterworks; that they may and will continue at times to do so under the conditions which exist and which may be expected to exist in the streams aforesaid.

Q. Mr. Williams, speaking as a general proposition, what in your judgment and opinion as a water supply engineer
4040 and expert is the best criterion of the sanitary quality of a water supply?

A. The best criterion of the sanitary quality of a water supply that is being used by a community for domestic purposes, is the presence or absence among the users of such supply, of water-borne diseases, of which in this country, typhoid fever is at present the most important.

Q. You have stated in your answer that it depended upon the absence or presence of typhoid fever. I will get you to state in your opinion as an expert, whether the abundance of or the number of cases of typhoid fever or deaths, could have any effect in your judgment, as to the quality of the water supply?

A. The number of cases and the number of deaths from typhoid fever in a community using the water supply under consideration, I should consider the most important evidence to be adduced as bearing upon the sanitary quality of that supply, and if such a number of cases and deaths in proportion to the population supplied with the water in question were above the corresponding number of cases and deaths usually occurring in communities known to have pure or high-grade water supplies, unless it could be shown that such increase was due to sources of infection other than the water supply, I should regard as the best of evidence that the water supply was infected.

4041 Q. Mr. Williams, are you familiar with the typhoid statistics of the city of St. Louis for the past eight or ten years?

A. I am.

Q. Mr. Williams, what would you say of the quality of the St. Louis water as delivered through the waterworks plant to consumers, in the city of St. Louis from 1895 to 1899, inclusive, as judged from the typhoid fever in this city and elsewhere?

A. I should say that the evidence afforded by the typhoid fever statistics of St. Louis for the period mentioned indicates that while the water supply of St. Louis at this time was not ideal, it nevertheless, would compare favorably with that of a very large number of our American cities, and that generally speaking it would entitle the St. Louis water supply to rank with about the second class of American water supplies as water supply experts usually consider them.

Q. Mr. Williams, taking the typhoid fever statistics of the city of St. Louis, as an index of the quality of water supply, what in your opinion has been the character of the water supply of the city of St. Louis since the 17th of January, 1900?

A. Considering the evidence of the typhoid statistics of the city of St. Louis since the beginning of 1900, it appears that up to near the end of January the water supply of St. Louis during the year 1900 must have been about as good as form-
4042 erly, but that about that time there appears to have been
a considerable infection of the supply which has continued to increase from time to time since, with the result that the typhoid statistics show the probable infection of the supply during the year 1902, to have been nearly twice as great as existed on the average from 1895 to 1899 inclusive, and that the rank of the water supply of St. Louis has materially dropped judged by the standard of sanitary purity.

Q. Mr. Williams, have you examined the records of typhoid fever in the cities on the Mississippi, the Illinois and the Missouri rivers outside of the Sanitary District of the city of Chicago?

A. I have so far as they have been presented in connection with this case.

Q. I will get you to state if, in your opinion as an expert you have found anything in those statistics mentioned in you last answer that would account for the large increase of typhoi fever in St. Louis since the 17th of January, 1900?

A. I have not.

Q. I will get you to state if you know when the drainage canal was opened?

A. About the middle of January, 1900. Accurately, January 17th, 1900, I believe.

4043 Q. I will get you to state what, in your opinion as an expert, the discharge of the sewage of the city of Chicago through the drainage canal since January 17th, 1900, has had to do, if anything, with the increase in typhoid fever in the city of St. Louis since January 17th, 1900?

A. Basing my opinion upon the facts brought to light in an extended examination of the conditions which seem to me likely to bear upon the questions involved, it is my judgment that to the discharge of sewage by the sanitary District of Chicago, into the Mississippi River, by means of the Chicago Drainage Canal, the Desplaines and the Illinois Rivers, is attributable, the major part of the increase in typhoid fever, revealed by the typhoid statistics of the city of St. Louis since the beginning of 1900, as compared with the period from 1895 to 1899 inclusive.

Q. Mr. Williams, speaking as an expert on water supply, in your opinion, is the absence of such impurities as can be detected ordinarily by chemical analyses of the water, an indication of the absence of disease-producing infection in such water?

A. It certainly is not.

Q. Now you state that it is not an indication. Is it any evidence whatever to an expert, that a chemical analysis does not dislose the presence of disease producing infection in the water?

4044 A. The fact that the chemical analysis fails to show the presence of disease producing infection, is no evidence to an expert that such infection may not exist in the water in question.

Q. I will get you to state, Mr. Williams, if the chemical analysis is one of the aids that water experts use in determining the quality of water supply?

A. It is. An expert in determining the quality of a water supply avails himself of all the information which he can possibly obtain concerning that supply, and a chemical analysis is a valuable aid in that it may show the presence of substances which would be inimical to the health of persons using the water, but nevertheless should it fail to show the presence of such substances, it would not be safe to assume that they might not be and were not present in the water to a sufficient degree to cause very serious results, if that water were used for drinking purposes.

ADJOURNED until 2:00 P. M. same day.

Southern Hotel, St. Louis, Missouri.
4045 2:00 P. M., Tuesday, May 26, 1903.
Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

GARDNER STEWART WILLIAMS,

resumed the stand for further direct-examination by Attorney General Crow and testified as follows:

Q. Mr. Williams, I will get you to state your opinion as an expert, where chemical analyses disclose impurities in water, is that an indication that the water may probably be polluted with a disease producing infection?

A. When the results of a chemical analysis of a water indicate the presence therein of substances which frequently do have their source in sewage, as a water supply expert I should consider that as highly important testimony as to the probability or possibility of the water containing at times matters which would be deleterious to the health of those who use the water, and in such a case I should make every effort to ascertain positively that such substances did not come from sewage contamination before recommending the water for use as a public supply.

In other words, we may sum up the value of chemical
4046 analyses about as follows: That if it fails to show anything of a deleterious character, it is not to be accepted as evidence of purity: If it does show the presence of substances which are recognized as connected with infectious material, then

it is to be regarded as a valuable indication of the possibility of contamination.

Q. Mr. Williams, you have stated that you do not consider the absence of such impurities in water as are ordinarily detected by chemical analysis, as a sure indication that the water is free of disease producing infection. Now, I will ask you what is your reason for holding that view?

A. My reason for holding to the view that the failure to appear in a chemical analysis of water, on the part of any or all of those substances which are recognized as connected with pollution, is not to be taken as an evidence of purity, is that the infectious quality of the water is dependent not upon its chemical constitutents, but upon the presence therein, generally speaking, of living organisms, which are of such minute character, and may be so few in number, that they are entirely beyond the range of chemical analysis to detect and yet may be there in sufficient quantities to cause very serious results, in the event of such water being used for drinking purposes. This fact was excellently brought out by a series of analyses made of the water of the River Dee, in Scotland, where in bacterial analyses,
4047 simultaneously made, showed the bacterial content of the
water to contain thousands of organisms in a cubic centimeter of water while the chemical analysis was entirely unable to detect the presence of these added microbes.

I may also state as another example, that at the time of the epidemic referred to in the City of Detriot, analyses of the water of the Detriot river were made—

Q. What year?

A. In 1892. Analyses of the water of Detriot River were made by competent and experienced chemists, who were accustomed to making analyses of that water, and therefore thoroughly familiar with its ordinary characteristics, and they expressed themselves as entirely unable to detect in that water any indication of pollution, although the records of the city were showing that a tremendous epidemic of typhoid fever was then existing, due to that water.

JUDGE JOHNS: I move to strike out all of the foregoing answer which refers to the River Dee and to the Detriot epidemic, as not competent, and as an argument in support of the theory on which the answer is based.

MR. TODD: I make the motion in behalf of the Sanitary District, to strike it out on the ground that it is mere hearsay evidence, and not based upon any legal proof of the facts
4048 established in this case.

Q. GENERAL CROW: I will get you to state whether or not you had personal knowledge of the character of the water of the Detroit river which came into the intake tower from Lake St. Clair and the St. Clair river in 1892, as to whether or not it was clear or turbid; that is, its appearance

A. The appearance—

Q. Well, did you have that knowledge?

A. I had that knowledge, as a resident of Detroit, and drinking the water every day.

Q. Well, what was the appearance of the water?

A. The appearance of the water was as usual; that is, there was nothing in it to attract the attention of one who was ordinarily drinking the water. No apparent turbidity that anybody noticed or remarked, or that I noticed or remarked, although I may say that I suffered from one of the most severe attacks of diarrhoea at that time that I ever had in my life, and that nearly all of the men in the office with me were similarly affected, said diarrhoea being undoubtedly due to the infection of the water at that time.

Q. Well, was the water supply of Detroit at that time clear or muddy? That is what I meant?

A. It was clear.

Q. What are the ordinary characteristics of the water
4049 supply of Detriot as to its being muddy or clear?

A. It is a clear supply; very clear.

Q. Well, it is clear lake water, isn't it?

A. Clear lake water; except in rare instances it shows practically no turbidity.

Q. Mr. Williams, would you, as a water supply expert, give me an opinion as to what value you place upon the results of chemical, microscopical and bacterial analyses of water as determining its purity or impurity, for the purpose of drinking water and general primary purposes?

A. I consider that whenever chemical, microscopical or bacterial analysis of the water indicates the presence therein of substances which are known to be related to infectious matter, then it is proper to give to the evidence of those analyses, great weight in estimating the quality of that water and the expert should not recommend such water for use, speaking generally, until he is satisfied that the source of such organisms or such constituents or impurities, is such as to be unlikely to affect the sanitary quality of the water. On the other hand, it is not necessary for the expert to depend, or to require either a chemical or microscopical or bacteriological analysis of water to determine its pollution, if it is possible for him to see polluting matter flowing into it.

Q. Mr. Williams, assuming that the numbers of bacilli coli
communis in the waters of the Illinois River at Grafton are
4050 at intervals, no greater than the numbers contained in it
before the opening of the drainage canal, do you as an expert on water supplies, for cities and towns, consider for that reason that the said water is at all times no more dangerous for drinking purposes than before the opening of the drainage canal on January 17th, 1900?

A. Most certainly I do not.

Q. Mr. Williams, I will ask you as an expert on water supplies for cities and towns, passing your opinion upon the subject broadly, in your judgment, is there any present or impending or future danger to the people of the State of Missouri, using the waters of the Mississippi River below the mouth of the Illinois for drinking purposes, which danger would be due to the discharge of the mixed sewage of the Sanitary District of Chicago and the waters of the drainage canal, into the Illinois river, other than the infection with typhoid fever germs, of the waters of the Mississippi river?

A. In the history of water-borne diseases in America, while typhoid fever plays an important part, it comes far short of playing the entire part. Not only Asiatic cholera, but a large number of our common American diseases are undoubtedly transmitted through the water. Among those germs which have been found to have a considerable length of existence in water, are

the germs of diphtheria, tetanus and anthrax, as well as
4051 a considerable number of germs which are derived from
the diseases of the lower animals.

The germ of anthrax for instance, is capable of producing very serious disease in both man and beast, and there have already occurred in the city of St. Louis cases of anthrax one of which has been traced apparently to the water supply, and the germ of anthrax is reported to have been already found in the waters of the Illinois river. Anthrax is primarily a disease of the lower animals, and in France, where it has been especially prevalent, in some provinces it has been no uncommon thing for ten per cent of the sheep to be destroyed by it in a single year. A peculiarity of anthrax is the remarkable length of life of its spores, or seeds,—whichever you may choose to call them,—in water, they having been known to exist in it not only for months, but for years, and are practically indestructible. Should anthrax be present among cattle which are daily slaughtered in the Chicago Stock Yards, and from them be transmitted by the discharges from the nostrils, mouths or bowels of those cattle, into the sewers of Chicago, there would be no question that the germs of anthrax might easily find a lodging in the people of Missouri with extremely fatal results. The germs of anthrax may not only be taken into the human system and produce disease, by passing into the intestinal tract, but it is also
4052 susceptible of producing disease as a result of inoculation, so that a person bathing in water in which there were present germs of anthrax, if he had on his body any abrasions of the skin, would be particularly liable to receive an infection from anthrax, which might very probably end fatally. It is not an uncommon thing for anthrax to be communicated to those who are handling the skins of animals and who may become scarred or bruised in the course of their occupation.

The germ of anthrax being practically indestructible under ordinary conditions, is frequently conveyed in hides and skins, and in the refuse from leather manufacturing esablishments might easily get into the sewage of the city of Chicago as well as by way of the Stock Yards.

The people of the Stae of Missouri resident in the counties

bordering upon the Mississippi River are largely engaged in stock raising, and in times of drouth, the Mississippi river is practically the only source of water for the stock so raised, and it has come to my knowledge that in such times, this water is carted for many miles from the shores of the Mississippi river to be used by both stock and the human inhabitants of the country adjacent. Should the sewage of Chicago become infected with germs of anthrax, and should those germs be transmitted as they undoubtedly would be, into the waters of the Missisippi,
4053 if the Chicago Drainage Canal continues to discharge the sewage of Chicago into the Desplaines and Illinois rivers, at such times there would be great danger of the occurrence of an epidemic of anthrax not only among the human inhabitants of the State of Missouri, but also among the lower animals using the water. Anthrax is recognized as one of the worst of water-borne diseases with which we have to contend, for the reason that when once it becomes established in a community, it may attack both man and beast, and its eradication can only be accomplished by the absolute destruction of the bodies of animals so infected. It is able to live for long periods of time in the earth, and may thereby be communicated long after the death of the primarily infected animal to other animals grazing over the surface.

I may add further that the disease known commonly as glanders, is also transmitted through water, and that it is not an uncommon disease among the stock of this country at the present time, and the discharge of the sewage of Chicago which is at any time liable to be contaminated by glanders, into the Illinois river, is another source of danger to the inhabitants of Missouri. In fact, as we look into the future and see the probable growth of Chicago both in industries and in population, and the added probability of infection of its sewage due to the more general spread of infectious disease, it seems to
4054 me that the danger impending over the citizens of Missouri as a result of the discharge of the sewage of Chicago through the drainage canal into the waters of the Illinois river, is a most fearful menace to the health and welfare, not only of the citizens of Missouri, but of the citizens of other cities below the mouth of the Illinois river, leaving entirely out of consideration the question of typhoid fever.

MR. TODD: I want to object to the question as to its form and second, I move to strike out the answer as being based largely upon information or upon hearsay evidence and as being incompetent, irrelevant and immaterial.

Q. GENERAL CROW: Mr. Williams, are you acquainted with the disease commonly known as hog cholera?

A. Somewhat.

Q. Has that disease any similarity to typhoid fever in human beings?

A. It is the nearest prototype of typhoid fever that is known among the lower animals. The germ of hog cholera is evidently very closely related to the germ of typhoid fever, and it has been suggested that one germ is but a modification of the other, brought about by reason of its peculiar surroundings.

Q. Will you state if you know whether or not the bacilli of hog cholera can be conveyed by water?

4055 A. The bacilli of hog cholera are conveyed by water in the same manner as the bacilli of typhoid fever are, and as the coli communis is transmitted through water, the three germs appearing to be very closely related.

Q. I will get you to state if you have any knowledge on the subject, what your opinion would be considering the conditions, as to whether or not the cholera bacilli of hogs might be transmitted through the canal and the waterways connecting the Mississippi River below the mouth of the Illinois?

A. There is no question in my mind but that they might be and very probably would be so transmitted.

Q. Have you any knowledge as to the longevity of the hog cholera bacilli?

A. That has not been accurately determined, so far as I know, but there is every evidence that it may exist for considerable periods, for several weeks.

Q. Mr. Williams, considering your knowledge of the Illinois river, the drainage canal and the Desplaines river and the Mississippi river below the mouth of the Illinois at Grafton, the conditions of said rivers; the beds of the streams, the flow of the streams, and the velocities, the volume of water, and all other existing conditions so far as you know the same, as an expert

on the flow of streams, and the action of waters in scour-
4056 ing the beds of streams, and the depositing of material in the beds of streams, as a result of the action of the waters and the flow thereof in the streams, I will get you to state whether or not in your judgment, mud, silt and sewage matter under existing conditions may or may not be removed from the bed of the Illinois river, the drainage canal and the Desplaines river and deposited in and upon the bed of the Mississippi river?

A. From my knowledge of the points raised in the question and my general familiarity with the flow of water in streams, and the accompanying phenomena, I would say that there is no doubt that such deposits as are mentioned in the question may be, have been and will be carried from the drainage canal or Desplaines River and the Illinois river, into the Mississippi River and there deposited to remain for a greater or less time upon the bed and sides of such river.

Q. Mr. Williams, will you please state whether or not in your opinion the volume of water added to the Desplaines and the Illinois Rivers by the opening of the drainage canal in January, 1900, would increase the amount of mud and sewage and silt that might be removed from the canal, the Desplaines and the Illinois rivers and deposited in and upon the bed of the Mississippi River?

A. It would unquestionably increase the quantity of such
4057 material so delivered.

Q. Why?

A. Because it has very greatly increased the velocity of flow at low stages of the river, and has therefore prevented to a considerable extent the deposit of the material which otherwise would have found its place upon the bottom of the stream, and has caused it to continue in suspension for a longer time and therefore to have reached the Mississippi river more promptly and more surely than it would otherwise have done.

Q. Mr. Williams, have you been to the chain of rocks water station of the St. Louis waterworks?

A. I have.

Q. Have you examined the location there with reference to the river and the intake tower and the general condition of the flow of the stream and direction?

A. I have.

Q. Did you or did you not examine the Missouri bank of the Mississippi river some distance above the pumping station and above the intake tower?

A. To some extent I did.

Q. Do you know whether or not there is any of what is commonly called riprapping on the Missouri shore above the intake tower of the St. Louis waterworks?

A. I observed that for a considerable distance above the
4058 intake tower of the St. Louis waterworks the bank of the
river has been riprapped, evidently to prevent the cutting
of that bank by the current which was impinging upon it from
the bend in the river above, and had undoubtedly scoured away
considerable portions in times previous to the construction of the
said riprap.

Q. Mr. Williams, assuming that an epidemic of Asiatic cholera should occur in the city of Chicago under existing conditions of sewerage in said city and existing conditions in and upon the drainage canal, the Desplaines and the Illinois and the Mississippi river, and the existing conditions with reference to the intake tower of the St. Louis waterworks, and the storage and distribution of the water from the chain of rocks to the consumers in the city of St. Louis; I will ask you as an expert on water supplies for cities and towns, is it possible or probable that the germs of that disease might find their way into the intake tower of the St. Louis waterworks at the chain of rocks and thence to the consumer?

A. In the event of an epidemic of Asiatic cholera in Chicago
under the conditions now existing in the waters between Chicago
and the chain of rocks, through which the sewage of Chicago
now flows, there is not only a possibiliy but probability and
almost a certainty that the germs of the disease would be com-
municated or transmitted to the water supply of the city
4059 of St. Louis and the consumers thereof.

Q. Now Mr. Williams, what effect, if any, would the conveyance of Asiatic cholera germs have under those circumstances upon the people of the city of St. Louis?

A. It would undoubtedly lead to an outbreak of Asiatic cholera in the city of St. Louis.

Q. Now Mr. Williams, I will get you to state whether or not in your opinion as an expert on water supplies for cities and towns, if it is within the bounds of human possibility for any competent expert upon the subject of water supplies for cities and towns to say that in a period of low water in the Missouri river, such as is likely at times to occur, and a thaw occurring at such times, on the Illinois watershed, that the lives of the people of Missouri below Grafton, Illinois, using the waters of the Mississippi river for drinking purposes and the lives of the people of the city of St. Louis using said water for said purposes, might not be endangered by having carried to them through the drainage canal from the outfalls of the sewers of the sanitary district of Chicago down the Desplaines, the Illinois and the Mississippi rivers, the infected sewage of the sanitary district of Chicago?

MR. TODD: I object to the question on the ground that this witness has not qualified as an expert on experts, as the field of expert testimony is unlimited. 4060

A. If, with the knowledge of the existence of the conditions at Chicago and along the drainage canal, the Desplaines river and the Mississippi river, that are now known to me to exist,—

Q. You had better state the proposition in a different way. People might interpret that question differently.

JUDGE JOHNS: I suggest that the witness has a right to answer it as he sees fit.

A. (Continued) an expert should state that it is impossible for infectious matter discharged by the sewers of Chicago to reach the Missouri shore of the Mississippi river, and the intake of the St. Louis waterworks at the chain of rocks and to be a source of danger to the citizens of Missouri, residing on the Missouri shore of the Mississippi river and using the water therefrom for drinking purposes below the mouth of the Illinois river, and the citizens of St. Louis using the water supply drawn through the intake at the chain of rocks, I should say that he had thereby shown such lack of knowledge of the history of water-borne diseases, and the life and phenomena connected with their transmission and infection, as well as of the laws of flow of water in open channels, as to totally disqualify him as an expert upon the sanitary value or quality of a public water supply.

MR. TODD: I move to strike out the answer as it is not the 4061 prerogative of this witness to pass judgment upon the evidence of experts if any may be called upon to give testimony upon such hyphothetical question as is included in the question, but it is the prerogative of the Supreme Court of the United States; and for the further reason that the witness has shown a lack of knowledge in regard to experts.

GENERAL CROW: Mr. Williams, as an expert on water supplies for cities and towns considering your personal knowledge of the typhoid fever conditions in the Sanitary District of Chicago, and the existing conditions in said district as to sewers, and the out-falls thereof, and the amount of sewage, and all the existing conditions of the drainage canal, the Desplaines, and the Illinois, and the Mississippi, and Missouri rivers, and the water-sheds of said streams, and all the conditions existing in said water-sheds, and the existing conditions as to the water supply of the city of St. Louis and the location of the intake tower of the St. Louis waterworks in the channel of the Mississippi river 1500 feet from the Missouri shore, and the general sanitary conditions existing now in the city of St. Louis, would you or would you not from all the knowledge that you possess, as an expert on water supplies, beyond reasonable doubt, attribute the principal portion of the increase of typhoid fever in St. Louis, Missouri since January 17th, 1900, the date of the opening of the drainage canal, to the infected sewage of 4062 the Sanitary District of Chicago?

A. I would.

Q. Now Mr. Williams, what is the most common method of sewage becoming infected with typhoid bacilli from cities and towns that have sewers, if you know?

A. By the discharge into those sewers of the dejecta of typhoid fever patients, or of those into whose intestinal tracts the typhoid fever germ has entered.

Q. Now, Mr. Williams, as an expert on water supplies, I will get you to state what in your opinion is the most dangerous source of disease producing infection in public water supplies of towns and cities in this country?

A. The sewage of large communities.

Q. Now Mr. Williams, as an expert on water supplies, I will ask you if you have ever had any experience in investigating typhoid epidemics caused by seriously infected water in running streams or lakes, that would cause you to believe any stream can be absolutely relied upon at all times to remove disease bearing germs such as typhoid bacilli, which may have been placed therein?

A. I have not.

Q. Now Mr. Williams, looking forward into the future and considering not this generation alone, but those that are to follow, and considering the relation of the filth and infection 4063 of the Chicago sewage to the water of the Mississippi river as it flows along the Missouri shore, I will ask you to state your views as an expert on public health matters, regarding the above mentioned conditions, considered as a broad, practical proposition?

A. With regard to the effect on future generations of the discharge of Chicago sewage into the Illinois river and thence into the Mississippi river, and its effect upon the water of the Mississippi river, I would say that there is no question in my mind, but that the problem before future generations is one of far more difficult solution than that which we face in the present. A careful study of the relations existing between the flow of the rivers which contribute to the water flowing past the chain of rocks, and the prevalence of water-borne diseases in the city of St. Louis among those of her citizens who are users of the public water supply, has led me to the conclusion that at the present time the remarkable immunity from serious typhoid infection which the citizens of St. Louis have thus far experienced, although they have been using water which is unquestionably at the time of its entering the intake considerably polluted, is due very largely to the character and amount of water contributed by the Missouri river. I long ago learned to appreciate 4064 the importance, from a sanitary standpoint, of Missouri river mud. As the Missouri river enters the Mississippi river, the amount of silt in suspension in its water amounts often times to over 1200 parts in a million. A large portion of this

silt is of such a nature as to be quite readily deposited as the water approaches a state of approximate quiescence, and such a vast quantity of depositing mineral matter mixed thoroughly throughout the water of the settling basins of the St. Louis waterworks cannot fail, and analyses show that it has not failed, to remove a very considerable percentage of the bacteria which are daily brought into those settling basins in the water as it comes from the Mississippi river. Laying aside the question for the moment, of the possible increase of infectious matter in the water supply through the intake at the chain of rocks, due to the increased growth of the city of Chicago and the other populations upon the drainage area of the rivers which contribute to the St. Louis water supply, it is to be borne in mind that as time goes on, the history of the Missouri river will become the history of every other stream upon whose borders the hand of man has rested, and that while the total quantity of water which that stream will deliver from year to year, will remain about the same as now, the quantity of water which will be delivered in times of drouth will be decidedly less than heretofore, and that larger and larger portions of the discharge will be concen-
4065 trated in a few floods. The result of this upon the waters
mingling to form the supply of St. Louis, will be that in the future the Missouri river will show a greater diminution in the percentage which it represents of the flow past the city, than will the waters derived from those other two streams upon which the hand of man has already rested for so long a time, that comparatively small changes are to be anticipated in the future in the quantities of their low water run-offs. It will therefore follow that the amount of silt that will be furnished by the Missouri river will be less and less sufficient to remove from the mixed water the numbers of disease germs which even now exist there, leaving alone the possibility, the probability and the certainty that the numbers of those germs will vastly increase as time goes on. It therefore seems quite clear to me that any added pollution to the waters of the Illinois or the Mississippi river will have from year to year a greater and greater effect upon the healthfulness and quality of the water which will be delivered, under circumstances similar to those now existing in the treat-

ment of the water delivered to the citizens of St. Louis by their waterworks system, and when we consider that in the city of Chicago there is now a population representing above one-third of the total urban population upon the watersheds tributary to the Mississippi river at St. Louis, and probably repre-
4066 senting more than one-sixth of all the population resident upon those watersheds, and that now no city in this portion of the United States, if indeed in any portion of it, has shown such remarkable and rapid growth both in population and in industries as Chicago, there can be no question that in the future the menace to the health of St. Louis arising from the discharge into the Illinois river of the sewage of the Chicago Sanitary District, will be a much more tremendous and impending danger to the citizens of Missouri living along the Mississippi river below the mouth of the Illinois than exists at the present time, grave though the present condition be.

Q. Mr. Williams, I will get you to state whether or not you have considered the question of the relative amount of the sewage producing population in the water-shed tributary to the intake tower of the St. Louis waterworks, as compared with the sewage producing population of the Sanitary District of Chicago?

4067 A. Understanding you to mean by sewage producing population that population which contributes its dejecta through established sewer systems, or discharges it in such a way that it may rapidly find access to the streams tributary to the Illinois, Mississippi and Missouri rivers, above the chain of rocks; I would say that I have considered the subject and from a long personal observation of the extent to which sewerage systems are ordinarily utilized in communities of various sizes, and the extent to which liability exists of infectious matter from rural communities finding its way into the streams of running water, and considering the fact which has already been established by testimony presented in this case, that in the Sanitary District of Chicago a very large portion of those resident therein, are connected to and use the sewers which are discharging into the Chicago river, and thence into the Chicago Drainage Canal,—I would say that there is no doubt in my mind that the population of the City of Chicago is today contributing considerably more than half of the entire sewage pollution which reaches the streams upon the water-sheds tributary to the Mississippi river above the chain of rocks.

Q. Mr. Williams, considering all the towns and cities on the watersheds tributary to the waters of the Mississippi, below the mouth of the Illinois, and above the intake of the St. Louis waterworks, which said towns may have 4,000 population
4068 or over, as urban population, I will get you to state
whether or not you know what percent of urban sewage producing population has been added to the water-shed tributary to the intake of the St. Louis Waterworks by the opening of the drainage canal on the 17th of January, 1900, and the deposition into said canal of the sewage of the Sanitary District of Chicago?

A. I find upon examination of the populations in cities of 4,000 inhabitants or more, resident upon the water-shed of the Mississippi river and its tributaries above the chain of rocks, exclusive of those residing in the Sanitary District of Chicago, and a comparison with the population of the said Sanitary District, contributing its sewage to the Chicago Drainage Canal, that when the said Chicago drainage canal was opened in January, 1900, there was added to the population previously existing in cities of 4,000 inhabitants or more, upon the water-shed of the Mississippi River above the chain of rocks, a number of urban inhabitants amounting to over sixty per cent of those already there, and a number of sewage contributing inhabitants sufficient to more than double the number previously existing.

GARDNER S. WILLIAMS.

ADJOURNED until 10:00 A. M. Wednesday, May 27, 1903.

4069 Southern Hotel, St. Louis, Missouri. 10:00 A. M., Wednesday, May 27th, 1903. Parties met pursuant to adjournment. Present the Commissioner and same counsel representing the respective parties.

GARDNER STEWART WILLIAMS

resumed the stand for further direct-examination by Attorney-General Crow, and testified as follows:

Q. Mr. Williams, you stated in your testimony yesterday that it was your opinion that the flow of water in low water stages in the Missouri River would lessen as the years increased; what reason have you for making that statement?

A. The history of practically all the streams in the country upon which the population has increased, and where the forests have been cut off in the progress of development, has shown that such denudation of the forest areas has the effect of increasing the flood flows and decreasing the low flows for the reason that the forests naturally act somewhat in the nature of reservoirs and store up at times of freshet or heavy rainfall, or times of melting snow, a considerable portion of water, which when the forests are removed, is immediately contributed to the streams, and therefore increases the floods. This water when stored up by the forests is gradually leeched out of them during the dryer periods, thereby continuing to maintain, 4070 or tending to maintain the stage of the river more constant than would exist if such forest tracts were not there; and as there is no question that along the head waters of the Missouri river there will be a considerable increase in population; that there will be a considerable removal of timber from the forested lands in that region, and that furthermore there is likely to be a considerable diversion of the waters of the Missouri River, particularly in time of drouth, for irrigation purposes, it is quite certain that the flow of that stream at low water periods will decrease to a considerable extent in the future. On the other hand, with the other tributaries, particularly the Illinois, it does not appear that the increase of population will make very much difference in the temporary retention of water upon that watershed, especially as the flow contributed by the sanitary district is a very large percent, in fact, three or four times, even five times as much as the natural low water flow of the stream, and the upper Mississippi has been so generally populated that it is not to be anticipated that any very great further change in the low water flow will be brought about there, as the cutting off of timber along its head waters has already reached an extent which is so great that the future is not likely to change the conditions very much, whence in view of all this, I conclude, as stated 4071 yesterday, that the proportion of water to the entire water which flows past the city of St. Louis, that will be contributed by the Missouri River in times of drouth, will be relatively less than it has been in the past, and furthermore, the amount of sedimentary matter carried by the Missouri river itself will be reduced by reason of the reduction of flow in its upper tributaries, and consequently its effect in producing precipitation of the bacteria in the mixed water will be decreased in even greater proportion than the decrease of percentage of Missouri River water at the St. Louis intake.

Q. Mr. Williams, are you acquainted with the appearance of the surface of the waters of the St. Clair river, as to whether or not they flow smoothly or roughly in their course?

A. I am, having traveled over the river on numerous occasions in boats,—I have observed the flow of the stream, and it may be described as being a swift but placid flow, there being very little evidence of eddies or disturbances in the regimen apparent on its surface.

Q. Mr. Williams, you live now at Ithaca, New York?

A. Yes sir.

Q. I will get you to state whether or not there has been any typhoid fever epidemic at Ithaca recently?

4072 JUDGE JOHNS: The defendant, State of Illinois, objects to all statements as to the supposed epidemic at Ithaca, New York, as irrelevant and incompetent.

A. There has been a very remarkable and interesting epidemic of typhoid at Ithaca during the past four or five months—four months.

Q. When did that typhoid epidemic begin, and what was the extent of it?

A. The epidemic condition apparently made its first appearance about the 16th of January—

Q. Of what year?

A. Of 1903; when half a dozen or more cases of typhoid put in their appearance, without there having been any previous indication of an excess of typhoid in the community. It has been estimated that between 1,000 and 1,200 cases of typhoid have occurred in Ithaca as a result of this outbreak, and there have been in the neighborhood of sixty or seventy deaths from that cause since the middle of January.

Q. What is the population of Ithaca?

A. The population of Ithaca is about between eleven and twelve thousand, with probably 3,000 students and those who are brought there with them, temporarily, added.

Q. Students of what?

A. Students in Cornell University, which is one of the
4073 principal colleges in the State of New York.

Q. Was this disease spread among the university students?

A. It was to a very considerable extent; in fact about half the deaths having occurred among students.

Q. Does the whole town of Ithaca and the Cornell University use the water from the same supply?

A. The water supply of Ithaca is derived from you might say, four sources. Cornell University has a water supply of its own taken from Fall Creek, a stream having a drainage area of about 115 square miles. This water is used upon the university campus and is delivered to those students resident upon the campus, which composes the majority of women students of the university who are quartered in the dormitories on the campus, and probably 150 to 200 of the male students who live in fraternity houses located upon the campus, and therefore receive the water supply of the university. This supply is not delivered to any localities off from the university campus itself, and the large majority of students, something in the neighborhood of 75 per cent, reside in the town itself. The town outside of the University, has as I have already stated, practically three water supplies; the oldest being that from ordinary wells, deep or shallow, which are still used to a considerable extent in many por-
4074 tions of the city, and exclusively in some portions. The
public supply, so-called, which is furnished by a corporation known as the Ithaca Water Works Company, is obtained from two streams, one of them known as Buttermilk Creek, which has a small drainage area of somewhere near 15 square miles, perhaps, and a part from a stream known as Six Mile Creek, which has a drainage area of about 50 square miles. The water obtained from Buttermilk Creek is mixed with that of Six Mile Creek, and delivered to certain portions of the city. The mix-

ture so delivered being varied in proportion to ingredients, in certain localities.

Another locality of the city, which is especially occupied by student boarding houses, and where perhaps nearly half of the students who reside outside of the limits of the campus are domiciled, is supplied with the Six Mile Creek water alone.

The epidemic broke out practically all over town, excepting upon the campus, and in those portions where well water was used exclusively, and the distribution of the cases, the ages of the persons having the disease, and all other phenomena connected with the epidemic indicated to anyone familiar with such conditions, that it was an outbreak due to water-borne infection.

In addition to that, examinations of the milk supply and
4075 other possible sources of original infection were made by
the local Board of Health, which established the fact to the satisfaction, I think of all concerned,—certainly to my own,—that the epidemic was beyond question primarily due to an infection of the water supply of either Buttermilk Creek or Six Mile Creek, or both.

A further examination of the conditions proved what had been well known to many of us, that there was no reason to suppose that the water supplies of any of the streams, either Fall Creek, Six Mile Creek or Buttermilk Creek, might not at any time become seriously infected with the typhoid germs, or with any other of the ordinary water-borne diseases, and I may incidentally state, that as Consulting Engineer of the Ithaca Waterworks Company, I had informed them that they would in the nature of things, be compelled probably within five years, to install a filter plant for the purification of the water, which they were supplying to the city, and plans had already been begun and pretty thoroughly arranged for the construction of a filtration plant, as soon as the financial resources of the Company would permit of the expenditure.

An examination as to the specific cause of the outbreak showed that it was possible that it might have come from several sources, and that quite probably part of the typhoid existing in
the city did come from various sources upon the water-
4076 shed, but the most probable source of the bulk of the in-
fection lay in the fecal discharges of a gang of workmen

who were employed by one of the railroads in the construction of some culverts across one of the tributaries of Six Mile Creek, some five or six miles above the intake of the waterworks, which discharges were delivered upon the ground or in a shallow trench, near the bank of the stream, and which discharges, it has been ascertained were infected by those of typhoid-fever patients, that disease having appeared among the workmen there employed, and which discharges by reason of a considerable thaw occurring about the first of January, were washed into the stream, a portion of the bank slumping away, or caving into the water, and the infection thereby being carried down the stream to the intakes of the waterworks and thence distributed to the consumers. It is quite interesting also, in connection with this epidemic to see that there were probably continued re-infections of the water supply following successive freshets, showing apparently that this material originally washed in, in the early January freshet, was in part deposited along the sides and bottom of the stream, and then picked up by a succeeding freshet, to be washed on down and re-infect the supply at a later date.

I may also say that the infectious matter which caused this outbreak was delivered upon the banks of the stream 4077 during the summer and autumn months, and had undoubtedly lain in the fecal deposits for a number of weeks before finding its entrance into the stream.

In giving this explanation, as I have already said, I do not wish to be understood as eliminating the possibility or probability of other infections having reached the waters of the stream in a moderate degree, but this seems to be the most probable, and in fact the only source of infection sufficient to explain the remarkably severe and sudden character of the outbreak.

Q. Are you acquainted with the appearance of the water supply from the portions of the town of Ithaca served with water from the drainage area of the two creeks, Six Mile and Buttermilk, as to whether or not it was turbid or clear at the time the outbreak occurred?

A. At the time of the outbreak, or at the time when the infection must have first been received, the water was quite

parently that the infection was mild, and it was traced
4081 immediately to the water, and the water authorities
therefore decided that a scarcity of water was preferable to an impure supply, and refused to permit the intake into the lake to be opened any further, except in case of a fire, and the fever died out in the course of a comparatively short time The disease was prevalent perhaps for two months and then disappeared, and since that time there has been no recurrence, the supply having been restricted to the wells until the additional supply was put in, in 1898, when it was drawn from the sands along the shores of Lake Michigan and a most excellent water has been since obtained.

JUDGE JOHNS: I move to exclude the answers of the witness as to the disease in Ithaca, New York, and in Charlevoix, Michigan, as incompetent and irrelevant testimony.

CROSS-EXAMINATION BY JUDGE JOHNS.

Q. What degree did you receive from the University of Michigan in 1889?

A. Bachelor of Science in Civil Engineering.

Q. After how many years of study in Michigan University?

A. I had been there about four years and a half.

Q. Did you commence the practice of civil engineering immediately after your graduation?

A. I had been engaged upon civil engineering for two years before I graduated, during portions of my time.

4082 Q. The question is, did you commence to practice immediately after your graduation?

A. I continued to practice immediately after my graduation.

Q. Where did you first practice civil engineering after your graduation?

A. At Detroit.

Q. How long did you continue there?

A. About a month.

Q. Where did you then go?

A. To Owasso.

Q. How long were you there?

A. About five or six months.

Q. When did you commence your experience as a water supply engineer at Bismarck, North Dakota?

A. In July, 1887.

Q. When at Greenville, Michigan?

A. June, 1888.

Q. When did you become Civil Engineer to the Board of Water Commissioners of Detroit?

A. February, 1893.

Q. Were you in Detroit in 1891?

A. I was.

Q. What were you doing then?

A. I was superintendent of erection for the Russel 4083 Wheel and Foundry Company, a manufacturing concern doing a general structural iron business in the city of Detroit.

Q. When did you cease that employment?

A. In February, 1893.

Q. You continued with this company from 1891 to 1893?

A. From 1890 to 1893.

Q. You weren't in the employ of the city of Detroit in 1891 or 1892?

A. No sir, not directly.

Q. Has the business of civil engineer departments or branches?

A. It has, certainly.

Q. What department or branch of civil engineering did you follow and practice from 1889 to 1893?

A. What you might call structural engineering.

Q. The drawing of plans and specifications, and having charge of the erection of structures?

A. Yes sir.

Q. When did you investigate the epidemic of typhoid fever which appeared in Detroit in 1892?

A. From 1895 to the present time.

Q. At the time of this epidemic you made no kind of investigation of it?

A. No sir.

4084 Q. And were not then practicing that branch of civil engineering which pertains to the erection of water supply system?

A. I was not.

Q. Can you remember when you commenced to investigate the epidemic at Detroit in 1895, what time?

A. Some time in the fall.

Q. At whose request or by what authority did you make that investigation?

A. By the authority vested in myself as Civil Engineer to the Board of Water Commissioners who was, by the act of the Board creating the office, especially at all times, to make it his study and care that the water supply furnished to the citizens of Detroit and the methods of furnishing it, should be the best that was possible under the circumstances.

Q. What did you do in investigating the epidemic at Detroit in 1895?

A. I first personally searched through the records of the local Board of Health, to ascertain whether there had been an epidemic and if so, what its proportions were and what its peculiarities. I examined all the typhoid records of the city of Detroit from the date of the establishment of the local Board of Health and made transcripts therefrom, of the history as recorded in the mortuary records of all the cases of typhoid which
had occurred in the city, or that had been buried from the
4085 city, within the time preceding the beginning of my in-
vestigations, and such investigations I was able to continue until about the close of 1899.

Q. What else did you do?

A. I also examined into the prevalence of typhoid fever throughout the cities and towns upon the watershed tributary to the city of Detroit; examined into the prevalence of typhoid fever throughout the State of Michigan and throughout the country in general and set forth in the reports of the Boards of Health concerned, as I was able to obtain information, and from special inquiry in special localities. I proceeded to examine personally as far as possible for sources of possible pollution from the city of Detroit and inaugurated a system of survey of the Detroit river to ascertain whether it would be possible that the infection might have come from the tributaries adjacent to the city of Detroit, and in fact proceeded to go through all the ordinary processes that any epidemiologist has to go through in making an investigation in regard to an epidemic of any sort.

Q. You were not at that time an epidemiologist, were you?

A. I had made at that time a very careful study of the literature of typhoid fever epidemics that was ordinarily accessible, or that I could make specially accessible to myself, and I considered myself abundantly competent to examine into
4086 and pass judgment upon the probable causes of an epidemic of typhoid fever if such causes should become apparent to me.

Q. What do you call the watershed of the waters tributary to and furnishing water to Detroit?

A. I limited that watershed to those portions of the entire watershed of the upper Great Lakes which drained naturally into the Detroit River above the intakes of the Detroit Waterworks, into Lake St. Clair, into St. Clair River, and into portions of Lake Huron immediately adjacent to the head of St. Clair River. I did not of course attempt to include the cities of Chicago or Milwaukee, or the upper shores of Lake Huron or Lake Superior, but I embraced all that territory which I had then reason to believe could possibly have contributed to the infection, and I am still of the opinion that I covered sufficient ground to exclude the probability of any great degree of infection coming from beyond those limits.

Q. How many miles from the intake of the Detroit Waterworks did your investigation cover?

A. In certain directions, a matter of two or three hundred miles.

Q. In the direction of the Detroit River, Lake St. Clair, St. Clair river and Lake Huron?

A. Upwards of a hundred miles.

Q. Along both shores or banks of Lake Huron?

4087 A. Yes sir.

Q. Why did you not go further?

A. Because I regarded it as quite improbable that typhoid fever infection contributed by any of the communities tributary to the shores of Lake Huron above the mouth of the St. Clair

River, those communities being in general small and very few, and they not discharging sewage into the lake anyway, could possibly contribute a sufficient amount of contamination to mix itself with the water of such a body as Lake Huron and thereby produce any such serious infection as evidently had existed in the Detroit water supply at the time I had under consideration.

Q. When you commenced this investigation in 1895, had you discovered from the literature in reference to typhoid fever, that no case of typhoid fever had in that literature been attributed to infection at a greater distance than thirty miles?

A. So far as I recall I had no knowledge of a case where the infection was attributed to a travel of more than thirty miles in a water supply.

Q. Had you any personal knowledge of any distance to which might be attributed typhoid infection traveling by water, in 1895?

A. Well, if you mean by personal knowledge an actual pursuance of the infection, I certainly had not. If you mean by
4088 personal knowledge such knowledge as a person obtains by
a study of treatises on typhoid fever, and the reports of published and well substantiated epidemics, I had knowledge.

Q. Independent of what you learned with reference to typhoid fever in publications in 1895, you had no knowledge of the transmission of typhoid germs in running water, had you?

A. I had knowledge of the transmission of typhoid infection through water at that time.

Q. The question is confined as to your knowledge as to the transmission of typhoid germs in running water.

A. I cannot recall whether the water in question was running water or not. My impression would be that there very likely was a current in it.

Q. Where was this?

A. It was in Kentucky.

Q. That you had personally investigated?

A. The case was that of my brother who got typhoid fever from drinking out of a marshy body of water which was infected by the discharges of his fellow workmen, and he was brought home and I helped to nurse him through the attack.

Q. You made no personal investigation of the locality?

A. I did not.

Q. Then you had in 1895, no knowledge derived from your personal investigation as to the transmission of typhoid 4089 germs in running water?

A. I think I had as much personal knowledge of the transmission of germs of typhoid in running water as anybody else could possibly be said to have, if you restrict the personal knowledge to the actual observation of the transmission of the specific germs.

Q. You had in 1895, derived from your own personal investigation of the conditions and circumstances any personal knowledge as to the transmission of typhoid fever germs in running water?

A. Understanding you to mean by personal knowledge actual observation of the transmission of the specific infection through running water, I have not, nor has anybody else at the present time.

Q. Understanding my question to mean precisely what it says, I will ask the reporter to read it to you and ask you for an answer.

GENERAL CROW: I would suggest that the witness has answered the question and has a right to answer it in his own way, and interpret the question in his own manner, unless counsel explains the question to him and shows he doesn't understand the question.

(Question repeated.)

A. I think my answer covers the question as I understand it.

Q. JUDGE JOHNS: Had you up to 1895, personally in-4090 vestigated any of the facts and conditions by which you afterwards arrived at the conclusion that the disease of typhoid fever was caused by the transmission of typhoid germs in running water?

A. Up to the middle of 1895, I had not.

Q. Then when you commenced the investigation in 1895, as to the cause of typhoid fever in Detroit, in 1892, it was a new branch of civil engineering to you, or water engineering and supplies?

A. I think it may be so considered.

Q. Where did you learn that the harbor of Port Huron had been dredged?

A. Where?

Q. Yes?

A. At a meeting of the Detroit Engineering Society, held at the Hotel St. Claire in Detroit, was the first I knew.

Q. At what time?

A. I think it was some time in 1896, or possibly 1897.

Q. The first that you learned or knew of the fact that the Harbor of Port Huron and the mouth of the Black River had been dredged by the government was in 1896 or 1897?

A. I will correct my former answer; it occurs to me that information did come to me in a letter from the City Engineer of Port Huron previous to the information which I received at the meeting of the Detroit Engineering Society.

4091 Q. How long before?

A. A matter of two weeks, or probably not more than three or four.

Q. So that the first you knew that the harbor of Port Huron had been dredged was in 1896 or 1897?

A. Yes sir.

Q. Which year was it to the best of your recollection, 1896, or 1897?

A. I am unable to state positively, but I think it was late in the fall, possibly in December, 1896.

Q. You ascertained the number of cases of typhoid fever, and the deaths consequent in 1892, in Detroit from the mortuary records, did you, of Detroit?

A. I had no means of ascertaining the number of cases, because there was no record thereof kept. I did ascertain however the number of deaths from the mortuary records of the Board of Health of the City of Detroit.

Q. Were they recorded by days or months?

A. They were recorded consecutively as the certificates were issued. The record gave the date of the issuance of the certificate and the date of the death.

Q. Were those records in tabulated form?

A. They were in the ordinary mortuary record book, in which the deaths from all diseases and from all causes appeared, as I said, in the regular sequence of the issuance of the death certificates. 4092

Q. Then the mortuary records of Detroit are made up not from the deaths reported, but from the death certificates issued?

A. They are either posted from the death certificates or the entry in the mortuary record is made at the same time that the certificate is issued. I think that both methods of procedure have been followed at different times during the keeping of the records.

Q. Then all that you know positively as to the number of deaths in Detroit is derived from an inspection of the records?

A. And also from the published reports of the Local Board of Health and from the published reports of the Michigan State Board of Health and from occasional personal knowledge of deaths from typhoid in Detroit which came under my observation while a resident there.

Q. Those cases which came under your personal observation were reported were they not, and became a part of some of these reports?

A. They were reported, certainly.

Q. Did you go to Port Huron in 1896, to investigate the dredging done there in 1892 and 1891?

A. No sir.

4093 Q. Did you ascertain in Port Huron the number of cases of typhoid fever or deaths from typhoid fever in 1890, or in the preceding year?

A. As I remember the matter now, there were no records available in 1890, or during the preceding years.

Q. Were there any records available in 1891 at Port Huron as to the deaths from typhoid fever?

A. The records in 1891 I believe, were obtained from the Michigan State Board of Health.

Q. How the Michigan State Board of Health obtained it, you do not know?

A. They obtained it from the report of the Health Officer or person in Port Huron reporting the appearance of typhoid to them.

Q. Whether that report was correct or not you do not know?

A. I certainly do not.

Q. Do you know how many cases of typhoid fever there had been in Port Huron in 1891, prior to November?

A. My recollection is there had been two cases reported.

Q. Do you know how many cases had been reported in 1890, during the entire year?

A. I do not. My impression is, there had been none reported.

Q. Do you know as to 1889 or any preceding year?

A. I do not.

4094 Q. So that when you commenced these investigations you didn't know even by the records, of a greater number than two deaths from typhoid fever in Port Huron for any time preceding 1891?

A. When I began this investigation I didn't know of any deaths in Port Huron from typhoid fever.

Q. And you do not know of any now, do you?

A. I was not personally acquainted with any persons who died from typhoid fever in Port Huron.

Q. Do you know from the records, and if so, from what records, of the existence of typhoid fever in Port Huron prior to November, 1891, with the exception of the two cases which you recollect?

A. I do not.

Q. So that absolutely, you never did know and do not now know whether there were more than two cases of typhoid fever in Port Huron.

GENERAL CROW: Two deaths.

JUDGE JOHNS: Two deaths from typhoid fever in Port Huron prior to November, 1891?

A. I do not.

Q. Do you know from the records or in any other way of a case of typhoid fever in Port Huron prior to November, 1891, and if so, how many do you know of, irrespective of deaths?

A. My recollection is that I know of two.

4095 Q. These are the same two you have mentioned.

A. They are.

Q. Were those cases of deaths or merely sickness?

A. I cannot positively recollect, but my impression is they were cases, not deaths.

Q. How large a town was Port Huron in 1891?

A. I haven't the exact figures. I should say it was somewhere in the neighborhood of nine or ten thousand.

Q. You have no statement from the census of 1890?

A. I have a statement from the census of 1890, for the entire county, but I haven't for Port Huron separately, here.

Q. What was the population of the county of Port Huron in 1890?

A. The population of St. Clair county in which Port Huron is situated, was about 51,000 in 1890.

Q. How large a territory did the county of St. Clair embrace?

A. Oh, pretty nearly 700 square miles.

Q. How many other villages and towns are there in the county?

A. There are several others. I am not prepared to say at this moment just how many. Possibly I have sufficient information here so that I can give you an idea, but I haven't it in mind. No I am not able to state at the present moment.

4096 Q. Do you know of any other town in St. Clair county having a population of 4,000 or over?

A. My impression is there was not at that time.

Q. Are there any cities or towns of a population of over 4,000 above Port Huron, on the eastern side of the southern peninsula of Michigan?

A. Several.

Q. What are they?

A. Do you mean upon the borders of the lake, or do you mean to take the eastern half of the State of Michigan?

Q. Upon the borders of lake.

A. Bay City and West Bay City would be, I think, the next ones, and I guess the next one you would come to would be Alpena.

Q. Alpena is quite up at the northern end of the peninsula?

A. Well, it is pretty well up. I would say it is four-fifths of the way.

Q. What are the populations of those various towns?

A. Bay City and West Bay City together—

GENERAL CROW: At that time, Judge?

JUDGE JOHNS: Yes, what were the populations in 1890?

A. A population of somewhere around 40,000.

Q. That is, Bay City and West Bay City?

A. Yes, sir; the towns are there together.

Q. Are those two towns situated upon a river?

4097 A. Situated about three miles above the mouth of the Saginaw river; yes, sir.

Q. The Saginaw drains into Lake Huron or the St. Clair river?

A. Saginaw river drains into Saginaw Bay, which is an arm of Lake Huron.

Q. Are there any villages or towns below Port Huron and between that and Detroit, on the shores of Lake St. Clair or the banks of the Detroit or St. Clair rivers?

A. There are.

Q. What are they?

A. St. Clair.

Q. Having a population of how much in 1890?

A. I do not remember exactely, but I should say 2500 or 2800, somewhere along there.

Q. Any other?

A. Marine City, which I think is not quite so large, and Algonac, which is nothing more than a village.

Q. Are there any cities on the Canadian side of the Detroit river?

A. Above the Detroit intake?

Q. Yes?

A. No, sir.

Q. On Lake St. Clair?

4098 A. No, sir.

Q. On the St. Clair river?

A. I think there are no cities; there are a few villages.

Q. Having a population of over 4,000 any of them?

A. I think not.

Q. Now, Lake St. Clair is about 24 miles in width and length?

A. Yes, including in the length the length of the delta, which is properly a part of the lake.

Q. And that delta is the delta of the St. Clair river?

A. Yes, sir.

Q. A very large part of Lake St. Clair is very shallow, isn't it?

A. Why, the delta portion which perhaps amounts to one-fourth of its area is quite shallow, but the bulk of the lake is of fairly good depth. The depth runs as high as 20 feet in some places, and for a stretch of ten or twelve miles there is a depth of over 16 feet, continuously, I think, in both directions.

Q. For what distance in width is there a depth of from ten to twenty-five feet?

A. If I said twenty-five feet, it was a mistake.

Q. I am assuming 25 feet.

A. I cannot give a specific answer without measuring a chart of the lake, but in general it represents probably
4099 half of its area.

Q. Now, through Lake St. Clair there is a well defined channel in which boats travel?

A. There is at the present time.

Q. Was there in 1890?

A. No, sir.

Q. Was there no channel marked by buoys in Lake St. Clair in 1890?

A. Not through the entire lake. There were channels marked by buoys across certain bars occurring in the lake, those bars being at the outlet of the lake.

Q. Do you know whether in 1890, boats traveled up and down Lake St. Clair in their passage from one river to the other, and followed a well defined course?

A. They did.

Q. And always practically the same course?

A. No.

Q. If a boat were passing from Lake Huron into Lake Erie, it would pass through St. Clair river?

A. Yes, sir.

Q. Lake St. Clair?

A. Yes, sir.

Q. And the Detroit river?

A. Yes, sir.

4100 Q. If it were a large boat, carrying a large amont of freight, wouldn't it travel in a certain well known and ascertained course through Lake St. Clair?

A. It would at the present time.

Q. Would it in 1890?

A. It would not necessarily have done so.

Q. How much of the space in width east and west was there in Lake St. Clair from the delta of the St. Clair river to the mouth of the Detroit river in which a boat of large carrying capacity could safely travel?

A. Eighteen or twenty miles, I guess.

Q. Wide?

A. Yes, sir.

Q. Are you quite certain about that?

A. It depends a little on what you call a boat of large capacity. Such boats as some which are upon the lakes now couldn't have traveled around there anywhere; that is, through the entire length of the lake, but many such boats as ordinarily pass up the lake might have traveled over a very large portion of the lake with entire safety if they so desired.

Q. Are there flats or marshes in St. Clair lake on the Canadian side?

A. On the Canadian side of the delta, just as there are on the American side of it and all through it.

4101 Q. On both sides of the lake, the American and the Canadian there are considerable marshes?

A. In the upper portion of the lake.

Q. Where the water is quite shallow?

A. Oh, the depth varies from one to ten feet perhaps.

Q. The lake has upon it in the proper seasons and especially during the summer, a very large number of men who gain their livelihood by fishing, hasn't it?

A. There is considerable fishing in the delta at the upper end of the lake and very little, if any, at the lower end or below the middle of it, in fact, below a third of the way down.

Q. On the flats of Lake St. Clair there are a number of club houses and summer resorts?

A. The flats of Lake St. Clair are the delta of the St. Clair river, and there are a number of summer resorts there.

Q. In fact, a number of club houses?

A. Yes, sir.

Q. It is quite a place of resort for the people of Detroit and the surrounding country during the seasons when such resorts are used and open?

A. Yes, sir.

Q. And a large number of people are there daily?

A. Well, it depends upon what you call a large number.
4102 If you should compare it to the population of Detroit I should say it wasn't a very large number, or even if you were to compare it to the population of Port Huron, I wouldn't say it was a large number.

Q. There are three or four thousand people up there in the summer every day?

A. I question it. I doubt it. I am quite sure it is not ordinarily the case that any such number of people are there.

Q. During the summer seasons aren't the flats of Lake St. Clair, its marshes, frequented by from two to three thousand people daily, at the resorts and in the club houses and in the occupation of fishing?

A. That is a larger number than I should estimate were there.

Q. Well, there is a considerable number?

A. There is a considerable number there, yes.

Q. And the considerable number varies from day to day as to the individuals?

A. Yes, sir; usually.

Q. So that there is a considerable number of constantly changing population upon Lake St. Clair during the summer seasons?

A. Yes, or upon the upper portion of Lake St. Clair. That is, upon the delta of the St. Clair river.

Q. And the dejecta of these people goes directly from all those people directly into the water, doesn't it?

4103 A. I think that that is generally the case. In fact, I know of no other deposition of it.

Q. Now, as you go from Detroit toward Lake Huron you pass through, first, the Detroit river?

A. Yes, sir; a portion of it.

Q. How far is it from Detroit to the head of the Detroit river in Lake St. Clair?

A. You mean from Detroit, or from the intake of the Detroit Waterworks?

Q. Well, from the intake of the Detroit Waterworks?

A. Oh, you would be in Lake St. Clair in going a mile above the Detroit Waterworks. In fact, I think in going half a mile.

Q. You would probably be in Lake St. Clair?

A. Yes, sir.

Q. Then you travel across Lake St. Clair how far going to St. Clair river?

A. Oh, about 24 miles across.

Q. How far would you travel by St. Clair river until you came to Port-Huron the point opposite the mouth of the Black river in the St. Clair river?

A. That is about 23 miles.

Q. When you are in the channel of the St. Clair river, how far are you from the harbor—

A. Excuse me; I wish to correct that statement. It is a little over 30 miles. 4104

Q. When you are in the channel of the St. Clair river, how far are you from the landing place of boats in Port Huron?

A. In Port Huron, the channel practically extends almost all the way across the river, so that you might say you are either at the landing place or fifteen hundred feet away from it.

Q. Now, the St. Clair river is the outlet of Lake Huron, Lake Michigan, Lake Superior and all their bays and estuaries, on the travel of the waters of those three lakes to the sea?

A. At the present time it is the outlet of practically all of them, except the Chicago river.

Q. At Port Huron, how wide is the St. Clair river?

A. Oh, it is about eighteen hundred feet, or fifteen or sixteen, or perhaps two thousand feet wide there in places. It varies somewhat.

Q. Is it confined there by precipitous banks, or does it spread out in marshes on either side?

A. I should hardly consider that either description suited the case. The land, while not high, has a well defined border, and the variation of the stage of the river is quite limited.

Q. The St. Clair river is not subject to very great variations upon the gauge, is it? 4105

A. No more than the Great Lakes.

Q. And that variation upon the Great Lakes is how much?

A. About six feet.

Q. The variation at different times from extreme low water to extreme high water, is a variation of about six feet?

A. I believe so; about that. I believe such variations have been recorded.

Q. Those variations in the St. Clair river are not sudden and violent?

A. No, sir.

Q. But are very gradual?

A. Quite gradual.

Q. And if not observed by some physical object as a gauge for instance, would be imperceptible?

A. Yes, just as it would be in any stream. I don't see how a person looking at the surface of a stream could possibly tell whether it was high or low, if he wasn't familiar with the stream previously or had objects of reference.

Q. You think if you approached a stream to which you were a stranger that you couldn't tell by observation of its surface, whether it was high or low?

A. It would depend very much upon the character of the stream. I think it would be very difficult for a person to
4106 approach the St. Clair river and tell whether it was high or low without having some object to refer the surface to.

Q. Have you a sufficient knowledge of the Illinois river to know, whether if you had seen it for the first time, you could tell from the surface whether it was high or low?

A. I think I could in certain localities.

Q. Are you familiar with the data or measurements of discharge and velocity by which the cubic feet per second of the flow of the St. Clair river is ascertained?

A. I am.

Q. Where did you obtain this data?

A. From conversations with the men who were carrying on the work who have been intimate acquaintances of mine for a number of years, and from the reading of their reports and the examination of the data of the discharges, in their offices.

Q. And you state that discharge to be how much?

A. It varies from 180,000 cubic feet per second up to 200,000, according to the best information we have in our possession at the present time.

Q. Do you state that as the average, and do you understand that as the average flow or discharge?

A. The average flow is somewhere in the neighborhood of 200,000 cubic feet per second. I have not examined to ascertain what the probable low water or probable high water flow 4107 would be, but through such stages as have been observed, the discharges vary between the limits stated.

Q. If the discharge of the St. Clair river was 180,000 cubic feet per second, you may state whether or not the discharge in 24 hours would be 25,920,000 feet, or whether it would be a very much larger number?

A. It would be considerably larger.

Q. What is the amount of discharge, if you have made the calculation, for 24 hours?

A. About 15,000 million.

GENERAL CROW: Cubic feet?

A. Yes.

JUDGE JOHNS: Are you familiar with the discharge or volume of the Mississippi river at St. Louis per second?

A. I have information which enables me to state the approximate discharge of the Mississippi river at St. Louis under certain conditions, at least.

Q. Well, state what the discharge is, and what the conditions are.

A. At ordinary stages, that is, those which exist during the greater portion of the year, the discharge is between 180,000 and 200,000 cubic feet per second.

Q. Where did you obtain that data?

A. From the reports of the Mississippi river commission 4108 and of the United States Corps of Engineers.

Q. What would you call an ordinary stage of the river?

A. The stage which exists through the greater portion of the year.

Q. How many feet upon the gauge would be marked at an ordinary stage of the river?

A. I am not prepared to say at the present moment, without looking up the gauge records. I will answer that question for you after I have had an opportunity to examine them.

Q. Did you make any investigation of the reports of the

Mississippi River Commission, from which you arrived at the discharge in the Mississippi river of 180,000 feet per second, or did you assume that was correct?

A. I found recorded gaugings of the river which indicated a discharge in the neighborhood of that amount.

Q. Did you find reports which indicated a very much less amount at times?

A. I did.

Q. Did you find reports which indicated a very much greater amount at times?

A. I did. I found reports which indicated discharges of less than half this quantity, and which indicated discharges of more than twice this quantity.

Q. For how many times in the year did you find from
4109 investigation of the reports of the Mississippi River Commission that the discharge of the Mississippi river was substantially 180,000 cubic feet per second?

A. Oh, in some years the discharge of the Mississippi river has varied between 180,000 and 200,000 cubic feet per second, for pretty nearly half the year.

Q. In what year?

A. I am not prepared to state at the present moment.

Q. What seasons of the year?

A. The seasons of medium stage.

Q. Fall, winter, spring or summer?

A. Sometimes in the fall and sometimes along in the winter, and sometimes in the late summer. The high stage is ordinarily May and June.

Q. Can you name any day in any year or any month in any year, in which the discharge of the Mississippi river was 180,000 cubic feet per second?

A. I don't know that I can name any day, month, time or week when the discharge of the Mississippi was exactly 180,000 cubic feet per second.

Q. Well, substantially 180,000 cubic feet per second.

A. That is at St. Louis of course?

Q. At St. Louis, yes?

A. August 5th, 1881, the gauging of the Mississippi river
4110 at St. Louis shows 179,000 cubic feet per second.

Q. Do you find any in 1900?

A. I do not. I haven't with me the reports of the gaugings for 1900.

Q. Did you investigate the reports of the gaugings for 1900?

A. If there were any published I investigated them. I am not sure there were any as late as that.

Q. As 1901?

A. The same answer would apply to 1901.

Q. And also for 1902?

A. I am quite sure I did not investigate any for 1902.

Adjourned until 2:30 p. m., same day, Wednesday, May 27, 1903.

4111 Southern Hotel, St. Louis, Missouri. 2:30 p. m., Wednesday, May 27, 1903. Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

GARDNER STEWART WILLIAMS resumed the stand for further cross-examination, by Judge Johns, and testified as follows:

THE WITNESS: If I may, I would like to make a correction as to my testimony this morning in regard to the population of Port Huron. I find the population to have been about 18,000.

JUDGE JOHNS: In 1890, according to the census?

A. I believe that is taken from the United States Census, although I will not be positive, because I also took information from the state census of 1894, and it may have been from either source, though I think it more probably from the United States census.

Q. Does the city of Port Huron have a sewerage system which discharges itself into either the Black river or Lake St. Clair?

4112 A. The city of Port Huron has had for a number of years a sewerage system, the discharge being into the Black river.

Q. Did it have such sewerage system in 1901 and 1902?

A. It did.

Q. What amount, in cubic feet, would there be in Port

Huron for one year, of fecal and urinal discharge into the sewers?

A. I will be unable to answer that question, because I am not informed of even approximately the number of persons who use the sewers of Port Huron, and therefore it would be impossible for me to make an estimate in answer to the question.

Q. Had you in 1890 or 1891 or 1892, sufficient familiarity with the city of Port Huron to make a guess as to the number of people whose sewage was discharged into the sewers of Port Huron?

A. I think not.

Q. Then as to the volume or amount of such discharges, you have no kind of an idea?

A. No, sir; except that there were such discharges.

Q. Suppose that we assume, for the matter of convenience that 9,000 of the people of Port Huron, discharged their household sewage into the sewers, would you think that was a large or a small estimate?

A. I should be inclined to think that for 1890, that was a large estimate. 4113

Q. Would you say, in your best opinion, that it would be fair to estimate that 5,000 people discharged their household sewage into the sewers of Port Huron in 1890, and 1891?

A. I think it is possible that that number of persons may have discharged sewage into the sewers of Port Huron in those years—wait a minute, let me have that quesion.

(Queston repeated.)

A. That is all right. That is as I understood the question.

Q. If such assumption is fair, what amount in cubic feet would you estimate there was, of dejecta and urinal discharges from those 5,000 people, making the estimate upon some basis which engineers or sanitarians assume?

A. I will have to do a little figuring on that. I cannot say off-hand. Is this per year?

Q. Yes, in the first instance?

A. Oh, between 6,000 and 7,000 cubic feet. That is of the solid matter.

Q. Solid matter?

A. Yes.

Q. How many cubic yards would that be?

A. Oh, about 230 to 250, or less than one-half the amount, or about one-half of the amount that was usually dredged in a day during the dredging of the Black river in 1892.

4114 Q. Then one-sixth of that 230 or 250 cubic yards would be fairly attributable to the months of April and May in 1892, with reference to the time when dredging was done there?

A. I should expect that the same proportion,—that is, it would be fair to make division of the amount that I have computed by "6" to get the probable delivery in the two months of the year in quesion.

Q. Or, substantially, in round numbers, 40 cubic yards in the two months?

A. Just about that substantially, yes, sir.

Q. I call your attention to your testimony of May 26 on the second page (handing witness record) and ask you to tell me how many cubic yards were dredged out of the mouth of the Black river and the harbor of Port Huron during the month of April, according to the figures you have given there; that is, assuming an equal amont for May as in April, as you have given it?

A. The number of cubic yards dredged out of the Black river during the month of April—

GENERAL CROW: Dredged what—what material?

A. Of material of all sources dredged out of the Black river in the month of April, 1892, was about 5300 yards roughly —5295 yards, I believe.

Q. That would be 10,600 yards substantially in round numbers in April and May, of dredged material?

4115 A. I think it would be considerably more than that, as they dredged practically all of May, while they only dredged half of April.

Q. I am asking you on the basis of your testimony yesterday, assuming a similar amount for May.

A. I said, continuing in similar quantities, meaning similar quantities per day or per week; that is what I meant by the testimony.

Q. You appear to have obtained these figures from a book from which you read; what is that book?

A. That is a note-book of my own into which I made transcripts of the record of the inspector, or such parts of it as I desired for my information.

Q. In that book you transcribed the figures of some United States officer from some book kept by him?

A. Yes, sir.

Q. And correctly transcribed the number of yards dredged with the date?

A. To the best of my belief I did.

Q. And you are refreshing your recollection and testifying from memoranda made by you in 1896 or 1897?

A. I think this memoranda was made in 1898.

Q. In 1898?

A. Or, it may have been as early as 1897.

4116 Q. Which memorandum was copied from some memoranda made by some United States officer at some other time?

A. Yes, during the period of the dredging in question.

Q. Whether those memoranda from which you copied, were memoranda made in the proper official discharge of the duties of such officer you do not pretend to say?

A. The inspector who had charge of the work informed me that they were his daily records of the work done, from which he made up his official reports.

Q. And you assumed that to be correct?

A. I assumed that to be correct. I see no reason for doubting it.

Q. Of the assumed 10,600 yards of material dredged from the harbor of Port Huron, some forty-odd cubic yards might possibly be a fair estimate of the amount of solids in the household sewage coming from the bodies of persons using the sewers of Port Huron?

A. I would say that I think that 40 cubic yards of about 15,000 yards would be a correct statement of the case, or an approximately correct statement of the case.

Q. Well, assuming that the sewage discharge of the kind spoken of—household sewage, in solids, was 230 to 250 cubic yards per year, you would have a fair estimate, you think, of the solids in cubic yards, for the city of Port Huron during 4117 the year?

A. I think it is a reasonable estimate.

Q. Now, what do you estimate to be—

A. Beg pardon. That is, I think it is a reasonable estimate for the fecal discharge.

Q. Yes, for fecal and urinal discharges?

A. Yes, sir.

Q. Now, what do you estimate to be the fecal and urinal discharges of the people of Chicago, using the sewers of Chicago, which are emptied into the drainage canal, for one year?

A. About 4400 cubic feet per day.

Q. For how many inhabitants?

A. I didn't include the urinal matter in that estimate. Nor did I endeavor to be accurate in the amount of urinal matter in the estimate in regard to Port Huron.

Q. Well, you understood that as to Port Huron, the urine was included in the estimate?

A. I understood that was included in the question.

MR. JEFFRIES: Just let the witness explain his answer.

THE WITNESS: I was just going to say that owing to the extreme difficulty of estimating accurately the solids in urine, I did not attempt to make any accurate, positive estimate thereof, and used virtually the same figures that I did in estimating the discharge in Chicago.

4118 Q. JUDGE JOHNS: What do you estimate to be in cubic yards, the fecal and urinal discharge of the people of Chicago who use the sewers of Chicago, which flow into the Drainage Canal for one year?

A. About 60,000.

Q. Cubic yards?

A. Yes, sir.

Q. For one year?

A. Yes, sir.

Q. That would be about 5,000 yards for one month, would it?

A. Yes, sir.

Q. Or 10,000 yards for two months?

A. Yes, sir.

Q. Well, then, such solid discharges into the sewers of Chicago from the bodies of the inhabitants, which sewers enter into the canal are not five times as much as the entire amount dredged at Port Huron?

GENERAL CROW: For what period, judge?

JUDGE JOHNS: For any period, five minutes or five years.

A. No, sir; they are not.

Q. Give me the exact number of cubic feet of flow in the St. Clair river and the Mississippi river, assuming 180,000 cubic feet per second, your answer this morning being about 1500 millions.

4119 A. I haven't the figures that I made. I can make them over again for you. Do you ask for it per day?

Q. Yes, first per day?

A. Well, that is what you desire now?

Q. Yes, sir?

A. 15,552 million.

Q. And for sixty days, being the months of April and May in 1892, how many cubic feet would that be?

A. Sixty days?

Q. Yes, sir?

A. 933,120,000,000.

Q. That is 933,120,000,000?

A. Yes, sir; if you use that notation.

Q. If such a body of water were regularly and continuously polluted one part in one million, how many cubic feet of pollution would have to be put into the water each day to make one part?

A. On that assumption, 15,552 cubic feet.

Q. That is to say, in order to regularly, systematically and scientifically pollute the body of water flowing past Port Huron in the St. Clair river, for one day of 24 hours, there would have to be 15,552 cubic feet of polluted matter to make one part in a million of pollution?

A. That is correct, sir.

4120 Q. Now, assuming that it was fair to say that there were 15,000 cubic feet of solids dredged out of the harbor of Port Huron and the mouth of the Black river in the months of April and May, 1892, that entire solid matter would not pollute that body of water if regularly and continously put in in equal quantities and in constant, flowing succession or volume, for much more than one day would it, on the basis of one part per million?

A. Understanding the phrase of the question on the basis of one part per million to mean to the extent of one part per million, which I judge is what you mean—

Q. Yes, sir?

A. It would not, but it is to be remembered that the quantity of material dredged from Black river and discharged into the St. Clair river at Port Huron in 1892, was not 15,000 cubic feet during the months of April and May, but 15,000 cubic yards which is 27 times as much as has been assumed in the quesion.

Q. Then if 15,000 cubic yards were regularly and systematically in a constant and regular flow, put into the waters of the St. Clair river at Port Huron, such discharge would not pollute the water of St. Clair river for more than 27 days, would it?

A. It would pollute it as long as it were put in.

Q. At the point at which it was inserted, would it pollute
4121 it there for more than 27 days?

A. Understanding your question to mean, would it pollute it at the rate of one part per million?

Q. Yes?

A. I would say that such pollution would last for 27 days.

Q. What per cent. of pollution of 933,120,000,000 cubic feet of water is 40 cubic yards of solid material, stated in parts per million?

A. About 108-10,000.

Q. 108-10,000, of one per cent.?

A. 108-10,000, of one part per million.

Q. Do you want to be understood as saying on the basis of these figures, that if there was the dejecta of two typhoid patients put in some time about the first of April, 1892, in 40 cubic yards of solid sewage, from the bodies of people, in 933,120,000,000 cubic feet of water which would travel 57 miles, that that dejecta would pollute the entire body of water during any considerable portion of that time, or any portion of it?

GENERAL CROW: Complainant objects to a question of that kind for the reason that the witness did not state that, according to the official record, there were only two cases prior to Aprii, 1892, and that the question therefore is based upon an assumption of facts that has no existence in the record
4122 and there is no evidence tending to show that.

Q. (Question repeated)?

A. Considering the fact that the number of bacteria found in the excrement of typhoid patients has been on the average about 200,000 million per day, and that if these patients were sick with typhoid fever and recovered, they would each have been discharging that excrement so charged with infection, for a period of 60 days, and considering that there were assumed to be two patients, we find that there would have been probably discharged into the sewers of Port Huron, and from there possibly into Black River and the material dredged therefrom, 24 million million bacteria, which would have been sufficient to have put about 27 bacteria into every cubic foot of water discharged under the conditions assumed, and it therefore seems to me possible that the infection might have been so distributed.

Q. Does it therefore seem to you probable?

A. I think it is within the realm of probability, assuming that there is no error in the arithmetical computations upon which I based my former answer.

Q. In 1892, in March, April and May, how many cubic feet of water were pumped into the Detroit waterworks, assuming 7 and one-half gallons to a cubic foot?

A. During March, April and May?

4123 Q. Yes, the average per day.

A. You only want the approximate figures?

Q. Certainly.

A. The average for that time per day, you say?

Q. Yes sir.

A. About 4,600,000 I think,—say four and one-half million.

Q. Cubic feet?

A. Cubic feet, yes sir.

Q. Then assuming that the volume of water in the St. Clair river passing Port Huron in a day was 15,552 million, what per cent of it was pumped into the Detroit Waterworks?

A. Three-hundredths of one per cent I think.

Q. Twenty-seven bacteria or typhoid bacillus to a cubic foot of water would be about four individual, separated bacteria roughly speaking, to a gallon.

A. Yes.

Q. Assuming that the number of bacteria you have mentioned, namely, 27 to a cubic foot of water, was equally distributed throughout the entire volume of water flowing out of the St. Clair River into the Lake St. Clair, and there from through the Detroit River to the intake at Detroit, do you want to be understood as saying that those four bacteria in a gallon of water traveling 57 miles would live and be virulent?

A. I see no reason why some of them might not live and
4124 be virulent.

Q. Do you see any reason, based on any prior knowledge, why they should? I am not asking you for details of any specific case, but on any knowledge that you have now, of the state of the science or art prior to May, 1892, do you see any reason why they should?

A. Yes, I do. In 1888, experiments showed that in ordinary potable waters the germs had been found alive after two weeks, and it would not take them two weeks to come from Port Huron to Detroit under the circumstances assumed.

Q. That was in laboratory experiments?

A. That was a case of ordinary potable water.

Q. In a laboratory experiment?

A. It was a laboratory experiment, certainly; but the relation of laboratory experiments to the conditions existing in nature seems to me to be very much like the relation of the life of beasts in captivity and their life while in nature, and I can see no reason to expect that the longevity of these germs in the laboratory would be any greater unless provided with special food to prolong life, than would be the case in the natural waters.

Q. With the state of the science or art as it existed and is known to you now, in 1892, do you know of any reason why
this supposed number of bacteria,—four to a gallon,
4125 should live in running water for a distance of 57 miles?

A. I certainly know of no reason why they should not.

Q. Do you know of any reason why they should in running water?

A. Any more than that it is the law of nature for living organisms to exist until some cause sets about to cause their destruction or death.

Q. Does being cast into an unnatural medium create, in your mind, any reason why they should die in that medium?

A. Reasoning by analogy, bearing in mind that ordinary vegetables live for very long periods in what may be termed unnatural media, I see no reason to suppose that they would necessarily die under the circumstances you suggest.

Q. If an ordinary vegetable removed from the garden was cast into water and set afloat, would it live?

A. Some of them would for a considerable time. I don't think many of them would die within a couple of weeks.

Q. Would an ordinary water plant, having its medium or natural habitat in running water, if cast into coal oil, live?

A. I am unable to say, as I never heard of the experiment being tried.

Q. Do you know when these two people died of typhoid fever, in Port Huron?

A. I don't know that they died.

Q. You have heard that they died?

4126 A. No sir.

Q. Do you know then whether these two cases of which you have heard, recovered?

A. I do not.

Q. Do you know whether the discharges from their bodies were cast into the sewers of Port Huron?

A. I do not.

Q. Do you know whether the discharges from their bodies were destroyed?

A. I do not.

Q. Or disinfected?

A. I do not.

Q. Then not knowing whether there was any typhoid dejecta in all the mass of stuff taken from the harbor of Port Huron and the mouth of the Black River, do you still wish to be understood as saying that a typhoid epidemic in Detroit was created by the dredging of the harbor of Port Huron and the mouth of the Black River?

A. Considering the fact that in a population of 18,000 souls, many of whom were railroad employes, passing back and forth from one place to another, and exposed to the liability of becoming infected with typhoid; knowing full well that even in cases of epidemics when an especial effort is made to get a report of all the cases, that statistics show that rarely 4127 are more than sixty per cent of those cases obtained; having in mind also the possibility of the existence and passage through the intestinal tract of man of the typhoid organisms in its vital state, without causing therein any inconvenience or disease to the patient; having in mind the existence of so-called cases of walking typhoid; having in mind too, the fact that prior to 1897 there was no rigid requirement in force as to the registration of vital statistics, or the reporting of cases of typhoid in the State of Michigan,—it seems to me far less reasonable to assume that there were no other cases in Port Huron than those of which I received information during the time under consideration, than it is to assume that the infection from those cases reached the sewers of Port Huron and ultimately the people of Detroit.

JUDGE JOHNS: I move to strike out the answer as wholly irresponsive to the question.

Q. Without stating what you may have in your mind, do you wish to be understood as a sanitary expert, epidemiologist and sanitary engineer that under the facts and figures elicted by your cross-examination, you are still of the opinion that typhoid fever resulted from the dredging of the harbor of Port Huron, and the mouth of the Black River in 1892?

A. I wish to be understood as saying that it is my belief that the typhoid fever in 1892 was very largely caused 4128 by the dredging of Black river in Port Huron during the same year.

Q. Is the Detroit case regarded as a classic in sanitary science?

A. I couldn't say.

Q. Are you responsible for the story going about in scientific sanitary circles concerning the epidemic in Detroit and its origin?

A. I don't know what story is going about in scientific circles concerning that epidemic. I investigated that epidemic and the results of my investigation have been given here.

Q. Did you make a report which got into print, of your investigation?

A. In an address which I delivered before a sanitary convention held under the auspices of the Michigan State Board of Health, in Detroit, I enumerated or outlined the essential facts concerning this epidemic and my conclusions in regard thereto, and afterwards repeated those statements before another assemblage.

Q. Did those statements get into print?

A. The Michigan State Board of Health published the remarks which I made at that time before the Sanitary Convention as an appendix to the report of the State Board of Health.

Q. Assuming that 5,000 cubic feet of human discharge are put into the sanitary canal or drainage canal in Chicago
4129 in one month and was there diluted with 300,000 cubic feet of water per minute as it continuously flowed into the sanitary canal and then traveled 357 miles, partly down the Illinois river, and in the Mississippi River to the intake, and by the time it arrived at the intake, was thoroughly mixed with the waters of the Mississippi river at the intake, arriving continuously during the month and being diluted so that during the month it was contained in 933,120,000,000 cubic feet of water, during the same month, do you think that that sewage would pollute the intake waters at St. Louis?

A. You mean the water at the intake or in the intake?

Q. Yes?

A. Understanding the word "pollute" to mean the addition to water of filth and infectious matter or both, whether in large or small degree, I do.

Q. Assuming that stated in the form of a solid mass, the dejecta and urine of a human being put into the sanitary canal at Chicago amounted in a month to 5,000 cubic feet, and that it was diluted with 300,000 cubic feet per minute, each minute of the month, of water, and that it traveled 357 miles to the intake at St. Louis, receiving in 317 of those miles the dilution of the tributaries of the Illinois river and receiving at the mouth of the Illinois river the dilution of the Mississippi river

and that when it arrived at the intake in the regular course
4130 of arrival during the month, it had been mixed with and
constituted a part of 933,120,000,000 cubic feet of water; do you wish to be understood as saying that if during that month in Chicago there were 75 deaths from typhoid fever whose dejecta were put into the water during that month that those bacilli in that dejecta would have a poisonous effect or any deleterious effect upon the waters at the intake at St. Louis?

A. I do, to whatever extent they might arrive there.

Q. Do you want to be understood as saying that they might arrive?

A. I do.

Q. Considering all that you know, or that can be learned of sanitary science, and considering also the fact that with the exception of the Detroit case no bacilli of typhoid fever have been supposed to travel over 30 miles in running water, on what do you found that conclusion?

GENERAL CROW: The complainant wants to interpose an objection to that question because it assumes facts that are at war with the evidence in this case, for they witness that the witness' own testimony, uncontradicted, shows that the bacilli have traveled a distance of 60 miles in the Crookston case in Minnesota.

MR. JEFFRIES: And the complainant makes the further objection that the question is ambiguous.

A. I base that conclusion upon my knowledge of the life
4131 of the typhoid germ in water as determined experimentally; upon my knowledge of its transmission in the epidemic of Detroit, and epidemics other than Detroit; upon my knowledge of the conditions affecting the water supply of St. Louis previous to the opening of the Chicago Drainage Canal; upon my knowledge of the conditions existing in and about Chicago previous to that time; upon my knowledge of the conditions existing in and about St. Louis since the opening of the said drainage canal, and the conditions existing in and about Chicago since the opening of the said drainage canal, whence it appears clearly to my mind, that there has as yet been found no other explanation sufficient to account for the increase now

amounting to about 100 per cent in the number of annual typhoid deaths in the city of St. Louis, as compared with the annual number recorded during the five years previous to the opening of the drainage canal, other than that the said infection has been received from Chicago through the drainage canal, the Illinois river and the Mississippi River, and that therefore if much may come, it must necessarily follow that little may also come.

Q. How did you calculate the percent of increase of deaths from typhoid fever in St. Louis?

A. I said 100 per cent increase in the annual number of deaths, that is, irrespective of population, which is com-
4132 puted as follows: The average number of deaths annually from typhoid fever recorded in the city of St. Louis from 1895 to 1899 inclusive was 112, and the number recorded during the year 1902, from the same cause, in the same city, was 222, which is substantially an increase of 100 per cent.

Q. Where is Crookston, Minnesota?

A. It is up in the Northwestern part or a little north of the central portion of the western half of Minnesota, pretty well over toward the line.

Q. How far from St. Paul?

A. I couldn't say at the present moment.

Q. Were you ever in Crookston?

A. No sir.

Q. Where did you get your information about Crookston?

A. In published reports.

Q. What published reports?

A. Published reports of the epidemic at Grand Forks.

Q. In what publication is this set out?

A. In the Engineering News for one, and I believe it is also referred to in some of the Health Reports of Dakota.

Q. Of Dakota?

A. I won't be positive in regard to that. I have seen it referred to in some of the health reports.

Q. Is Crookston in Minnesota or Dakota?

4133 A. Crookston is in Minnesota.

Q. And Grand Forks is where?

A. North Dakota.

Q. Did it appear in the reports of the State Board of Health of Dakota?

A. I couldn't say.

Q. Did it appear in the reports of the State Board of Health of Minnesota?

A. I couldn't say.

Q. Do you remember where you did see the report of this thing?

A. I saw it in the Engineering News and I also have seen it referred to elsewhere, but I cannot recall where.

Q. When did you see it in the Engineering News?

A. I think it came to my attention along somewhere in 1897 or 1898, I think probably in 1898.

Q. Do you know when it was published in the Engineering News?

A. In 1893 or 1894.

Q. Is the Engineering News a weekly paper or monthly paper?

A. It is published weekly now and I believe it was at that time.

Q. Where?

A. New York.

4134 Q. Who was the author of the publication in the Engineering News?

A. The City Engineer of Grand Forks.

Q. Have you a copy of the Engineering News from which you derived that information?

A. I have at my home.

Q. You made no personal investigation of the epidemic at Grand Forks?

A. Further than to talk about it with my friend, Professor Vaughan who was one of those who investigated the cause, concerning it.

Q. You did not as a matter of fact, yourself, make any kind of a personal investigation of the locality where it occurred?

A. I never was in Grand Forks or Crookston, or along Red River; if that is an answer to your question.

Q. Is it Red River or Red Lake River?

A. Red Lake River into which the sewage was discharged.

Q. So that all you know about Crookston is, what you saw in some periodicals, the Engineering News, preferably, and what a gentleman named Vaughan told you?

A. And what I am quite sure I saw in regard to it in another reference, which, however, I am free to state was

4135 not an original description of the epidemic.

Q. Had there been typhoid fever in Crookston?

A. It was so stated.

Q. How many cases?

A. I believe the report says there had been about sixty cases.

Q. Is that where the typhoid epidemic of which we are talking, originated?

A. That is the supposition.

Q. The cause of it?

A. The cause of it.

Q. The deaths occurring in Grand Forks of which we have been talking?

A. Yes sir.

Q. Do you know of that sixty supposed cases, how many of them occurred in any one month?

A. I do not. The statement is that they occurred during the months of October and November, I believe, as I remember the report.

Q. How many deaths were there from those sixty cases?

A. I don't know that. I have never seen it stated, but it is my impression that if there were any deaths they were rather few, although at the present moment I have no definite knowledge on the subject.

4136 Q. How large a place is Crookston?

A. At the present time I couldn't say positively, but my impression would be that it has probably somewhere between three and six thousand inhabitants.

Q. How many population did it have according to the census of 1890?

A. I couldn't say.

Q. Have you ever seen any statement of the amount of population at Crookston, at the time that the sewer became broken there or clogged?

A. I don't recall whether I have or not.

Q. Do you know what proportion of the people of Crookston have their household sewage emptied into the sewers?

A. I do not.

Q. Do you know whether any one of the supposed sixty cases, had their dejecta thrown into the sewer?

A. I do not.

Q. Do you know whether the city in any part has sewers?

A. It was so stated in the report of the outbreak.

Q. Whether that report is true, you do not know?

A. No more than I know that such reports are generally true or false, according to the intrinsic evidence of reliability which they bear.

4137 Q. What kind of a river is Red Lake River?

A. Red Lake River is a river about 200 miles long, has a considerable fall and moderately rapid velocity.

Q. Has it any known rate of discharge in cubic feet per second?

A. When it is at a low water stage, its discharge has been shown to be or calculated to be 988 cubic feet per second, or thereabouts.

Q. And Grand Forks was sixty miles from it, from Crookston?

A. I believe so, about that.

Q. Is the lake between Crookston and Grand Forks?

A. I am not aware that there is.

Q. Do you know whether there is a lake or a pond there called Red Lake?

A. There is such a lake or pond somewhere near the head waters of the stream.

Q. Whether Crookston is above that lake or below it on the stream, as the current flows you do not know?

A. My impression is that it is below.

Q. Do you know whether there were any cases of typhoid fever in Crookston the year prior to 1893, or in 1892?

A. I do not.

Q. Do you know whether there were any cases of typhoid fever there in January, February or March of 1893?

4138 A. I do not.

Q. Do you know whether there were any typhoid cases there in April, May or June, 1893?

A. I do not.

Q. Do you know whether there were any typhoid cases there in July, August or September?

A. I don't know positively, but considering the fact that there are reported to have been in October and November, 60 cases—

GENERAL CROW: What year?

A. In October and November, 1893, it would be remarkably strange, and almost a single instance of the kind in the history of typhoid fever, if there were not cases of typhoid fever there during July, August and September preceding.

JUDGE JOHNS: Have you any idea where the contagion came from that caused the supposed cases in Crookston?

A. I have not.

Q. Or whether that was a water-borne infection or not?

A. I have not.

Q. Would it be safe to assume that the infection which caused the disease in Crookston was water-borne?

A. I shouldn't wish to make that assumption absolutely without further knowledge of the conditions existing there.

Q. If it should happen that the infection in Crookston
4139 was a water-borne disease and infection, would it be fair
to assume that the infection went down the river from there to Grand Forks?

A. If the infection at Crookston came from an infection transmitted by the water of Red Lake River, it would be fair to assume that the infection would continue and probably did continue on down the river to Grand Forks, and I think that it is highly probable that such was the case, in view of the fact that the amount of typhoid fever prevalent in Grand Forks during the early and middle parts of 1893, was in excess of that which has been prevalent there since 1894, after which time the water supply has been filtered and therefore a reasonably pure supply, and it would seem quite clear therefore, that the excess previously existing was due to the infection of the water and might either have come from above Crookston, or come from disease existing in Crookston, the infection being discharged in limited quantities into the stream at that place.

Q. Does Crookston take its water supply from Red Lake River?

A. I don't know.

Q. Does Grand Forks take its water supply from Red Lake River?

A. It takes its supply from the river. I am under the impression that Grand Forks is at a junction of Red Lake
4140 and Red River, and I am uncertain whether the intake is in one or the other, but I understand that it is in the same place that it was previous to the outbreak of typhoid in 1894.

Q. Do you know where the intake of the waterworks in Grand Forks, if there be such a thing, is with reference to the mouth of Red Lake River?

A. I do not.

Q. You could not tell whether it is below or above the mouth of Red River?

A. I am not able to say at the present moment.

Q. Now how large a stream is Red River, which flows past Grand Forks?

A. I believe it is in its upper reaches a smaller stream than Red Lake River; that is, that Red Lake River is the larger stream.

Q. It is designated as Red River below Grand Forks?

A. I believe so.

Q. Now how much of the Red River is above Grand Forks in miles?

A. I couldn't say.

Q. Do you know whether in 1893, in September, October and November there was any typhoid fever above Red River?

A. I do not.

4141 Q. Do you know whether there were any towns or populous communities above Grand Forks on the Red River in Dakota?

A. I do not, but my impression is that there are not.

Q. That is an impression and not any actual knowledge at this time I suppose,—any positive knowledge?

A. General knowledge of the map of Minnesota, that's all. I may of course be mistaken.

Q. Does the Red River run mainly above Grand Forks in Minnesota or Dakota?

A. Pretty nearly the border.

Q. Is it a boundary stream between the two states?

A. A portion of it is I believe. That is my impression at the present moment.

Q. This occurrence in Grand Forks was before you were employed by the Board of Water Commissioners or the officials of Detroit, wasn't it?

A. No sir.

Q. Before you investigated the occurrence at Port Huron?

A. Yes sir.

Q. When did you make a careful investigation by books or written authorities of any kind first, of the state of affairs at Crookston and Grand Forks?

4142 A. In either 1897 or 1898, and I am not sure—it is barley possible I can give you the date. (Referring to memorandum book). I conclude from the entry in my notebook that it was in 1898.

Q. That you first became aware of it?

A. Yes sir.

Q. And your entire research and investigation in reference to it has been reading an article in the Engineering News, and some other indirect reference to the case in some other publication of which you cannot now state the name, and a conversation with a man named Vaughan, your friend?

A. My knowledge of the epidemic at Grand Forks which I have described, is based upon a description of the said epidemic which appeared in the Engineering News, and in which statement or description the authority of the City Engineer of Grand Forks was given as being the person responsible for the information, and from a conversation with my friend, Prof. Victor C. Vaughan, himself an eminent bacteriologist, analyst and I may say epidemiologist, who had been called in to advise in connection with the discovery of the cause of the outbreak and who gave me considerable information in regard to it, and I think indeed, that it was he who first called my attention to it, and I may add that I have also seen or heard reference to it elsewhere.

Q. And you did not hear from your friend professor
4143 Vaughan in reference to it until in 1898?

A. My impression is that I first heard of it in 1898. It is barely possible that I may have heard of it late in 1897, or sometime, even in 1899. I am prepared however, to state positively that I had at that time come to the conclusion which I still hold and should still hold, irrespective of any evidence that there may be on the subject in the Grand Forks epidemic; that the infection which caused the outbreak of typhoid fever in Detroit in 1892, came from the dredging in Port Huron.

JUDGE JOHNS: I move to strike out the answer, or that part which commences with the words "I am prepared."

GARDNER S. WILLIAMS.

ADJOURNED until 10:00 A. M., Thursday, May 28, 1903.

4144 Southern Hotel, St. Louis, Missouri. 10:00 a. m., Thursday, May 28, 1903.

Parties met pursuant to adjournment. Present the Commissioner and same counsel representing the respective parties.

GARDNER STEWART WILLIAMS

resumed the stand for further cross-examination by Judge Johns and testified as follows:

Q. Charlevoix is on the shores of Lake Michigan, is it not?

A. It lies between Lake Michigan and Round and Pine Lakes; practically on the shores of all three. Substantially you might say, generally speaking, it is on the shore of Lake Michigan.

Q. There is an outlet from Round Lake into Lake Michigan which has been dredged out?

A. Yes, that has been improved, to create a harbor. It was the natural outlet of Pine Lake.

Q. And Pine Lake has its outlet into Round Lake?

A. Yes sir.

Q. And above Pine Lake and extending up into the woods in Michigan, is a stream?

A. There are small streams flowing into Pine Lake; none
4145 of them very large. Boyne River is the largest.

Q. There is above Charlevoix, extending northeasterly up through the State of Michigan for about sixty miles, a chain of lakes which are connected with and have their outlet through Pine Lake, into Round Lake and Lake Michigan?

A. There is a considerable chain of lakes up in there; I think your statements are substantially correct.

Q. How large is Round Lake?

A. Round Lake is about a half or three-quarters of a mile in diameter perhaps.

Q. Have you visited Charlevoix?

A. Oh, yes; several times.

Q. How large a town is it?

A. Oh, it is hardly a town. It is a village, may be—I couldn't recall the figures on population, but I should say it might be 1200 to 2000, somewhere along in there; perhaps more.

Q. And in summer it is quite a popular resort?

A. Yes.

Q. The sewage from various hotels and boarding houses goes into Round Lake and thence out into Lake Michigan?

A. In some cases it goes into Round Lake. There are one or two sewers I think, that drain into Pine Lake. Those hotels and boarding houses, if they have sewers at all, have private sewers, or had up until quite recently. I think they have
4146 recently constructed a system of sewers up there.

Q. By boat it is about how many hours from Chicago?

A. I couldn't say. It is practically almost the full length of Lake Michigan; that is, when you get to Charlevoix you are almost up to the Straits.

Q. Well, you are about forty miles below the Straits?

A. Yes, something of that sort.

Q. It is quite a resort for people of Chicago?

A. Yes, quite a large number of people from Chicago and from Indiana. It is quite near Petoskey and Bay View which are generally full of summer resorters.

Q. Do you know whether there was any typhoid fever in Charlevoix the year that the United States boat came into Round Lake?

A. Previous to the coming of the boat, you mean?

Q. At the time of the coming in of the boat?

A. I know that typhoid fever had been practically unknown in the village up to that time. That was the first time that they had ever had any typhoid fever, that had attracted any attention from the physicians themselves.

Q. Well, had there been, in Charlevoix, typhoid fever prior to the coming in of this revenue cutter?

A. Not to my knowledge, and my knowledge would indicate that there had not been.

4147 Q. Whether there had been or not, as a matter of actual fact, you don't know?

A. I am not prepared to state positively.

Q. Now when was it this boat sailed into the harbor, of Round Lake, or steamed in?

A. My recollection is that it was either in July or August.

Q. Of what year?

A. Of 1897, I think. My testimony on this has been given wholly from memory, as my notes are at my home.

Q. Were you there at the time?

A. I was not.

Q. How long after the arrival of the boat were you in Charlevoix?

A. I was there the next spring.

Q. And in this case as in the other cases to which you have testified, you derived your information by inquiries of physicians and other people in the locality who are assumed to know the general condition of affairs?

A. I did, that being the usual method of investigation in such cases, it being impossible for a man to forestall an epidemic and be on the ground at the time that it occurs.

Q. How long was this United States Boat in Round Lake?

A. I think she was in there two or three days, but I am not certain as to that. She was there some little time.

4148 Q. Who was the man who had typhoid fever on board the boat?

A. I did not learn his name.

Q. Was he a seaman, an officer, or a passenger?

A. I could not state, but presumably he was one of the crew. In fact I think that statement was made to me, that he was one of the crew.

Q. Was the typhoid fever prevalent upon the boat or was this a single case?

A. It was a single case.

Q. The boat was in Round Lake?

A. Yes sir.

Q. And the dejecta of the typhoid fever patient was cast into the lake from the boat?

A. Presumably, as that is where the dejecta from boats goes—into the water in which the boat is.

Q. As a matter of fact do you know, or have you ever heard whether the excretions of this typhoid patient were destroyed on board the boat, or disinfected?

A. I never heard that they were or were not.

Q. Did you ever inquire about that?

A. I don't know that I ever did, inasmuch as I never met anyone whom I would consider competent to answer the question.

Q. Do you know what the practice and the rule of the United States Navy is with regard to the dejecta of men 4149 sick on board their boats in running streams, as to the destruction of the dejecta or its disinfection, if the man has some infectious disease?

A. I do not, but I should imagine that if they knew the man had that disease they would probably attempt to disinfect so far as the facilities at their hands would permit.

Q. Do you suppose that an officer of the United States Navy would allow the dejecta of a typhoid patient to be cast into the waters of a community which took its water supply from those waters?

A. I haven't any doubt of it.

Q. What?

A. I haven't any doubt that they would.

Q. What do you base that on?

A. Well, from my knowledge of the United States Naval officers, and their knowledge of these subjects generally; they know no more about them than the ordinary people, and it is only comparatively few people after all who today would think anything about that propostition and who would think of the seriousness of it.

Q. Don't you know as a matter of fact now, that the United States Naval officers—all of them, are taught the nature of infectious diseases, and the way in which not only to avoid them,
but to treat them and prevent them, and disinfect its sew-
4150 age on board their boats, as a matter of general instruc-
tion at the Naval Academy?

A. I should imagine that they would be so taught, but I don't know it.

Q. Well, do you presume the contrary?

A. I presume that the instructions so received are not sunk very deeply into their minds, so that in the average case they would not be likely to take especial precautions, unless it was called to their attention that the case in hand was a particularly dangerous one.

Q. Then your presumption is that an officer having a duty imposed upon him by the regulations of his office, and his oath as an officer, would wilfully and recklessly disregard his duty?

A. I don't presume anything of the kind.

Q. Now you never spoke to anyone in Charlevoix, to inquire whether the dejecta of this man went into this Round Lake or not?

A. Knowing the usage on board ships, of the disposal of dejecta, that is uniformly existent and knowing that the practice was to discharge dejecta from boats into Round Lake, I saw no reason to question the probable fact that the dejecta were discharged into Round Lake.

Q. And not knowing the usage on board United States
4151 boats in regard to the dejecta of people having infectious
or contagious diseases, you presumed for the purposes of the investigation, that the United States officer allowed that stuff to be cast into the water?

A. I certainly did, and I think it was a just presumption.

Q. Did you ever examine, as a sanitary expert, on water supplies, the regulations of the Navy of the United States, and of the Naval Department, with regard to this subject?

A. I never did.

Q. But, going to Charlevoix, and hearing that about seven or eight months before there had been a man on board a United

States steamer in that harbor who was said to be sick with typhoid fever, you attributed the increase of typhoid fever in Charlevoix to the excreta of that man?

A. Yes, and I think I was fully justified in so doing, considering all the other circumstances with which I was at that time familiar.

Q. At the same time you didn't know whether there was typhoid fever on Pine Lake, any estuary of Pine Lake, or in Charlevoix, one or more cases?

A. I found there was no evidence of there being one or more cases in any of those places, other than the one in question.

4152 Q. Round Lake and the channel leading from Round Lake out into the main lake is the harbor for pleasure craft in the summer?

A. More or less.

Q. And for steam launches which ply along that coast?

A. Yes sir.

Q. And for local boat lines?

A. Yes sir.

Q. And each day during the summer, two or three boats from various places along the shores of Lake Michigan come into Charlevoix, into Round Lake, do they not?

A. I think so, fully that number.

Q. And do you know whether there was typhoid fever on any of those boats?

A. Do I know whether there was?

Q. Yes?

A. I do not.

Q. Nor if any of the people who came from Chicago or elsewhere to Charlevoix, had typhoid fever, walking cases?

A. I think it is quite possible that people coming from Chicago might have had walking cases.

Q. And also it might be possible that some fellow slipped in there from Milwaukee, with a walking case?

A. Oh yes, it might be possible that some fellow slipped in.

4153 Q. Might possibly have come in from as far as Ann Arbor?

A. Yes, or any other place. In fact there were various ways in which typhoid fever might have gotten into that water. It evidently was in the water, and that was the most obvious way in which it could have gotten in, and while I do not pretend to say that that was the cause of this outbreak, it strikes me that it was presumably the cause, while I don't know particularly; but as long as it was satisfactorily established that it was the water that caused it, I didn't proceed to scrape the country with a fine-tooth comb to see that all other possible sources were eliminated.

Q. But you did finally conclude that the waters of Charlevoix at the intake of their waterworks, there—that the water was polluted?

A. Yes sir.

Q. Or infected?

A. Yes, I think there was no doubt about that, and I should have come to that conclulsion if there had been no typhoid epidemic and if there had been no case of typhoid on the boat, knowing the conditions that existed around there.

Q. So that the existence of the single case on board the boat was not anything more than an indication of the fact that it was very possible and perhaps very probable that the water supply of Charlevoix was infected?

4154 A. It was what I considered pretty good evidence, or highly probable, or rendered it highly probable, that the water supply of Charlevoix was infected; that in fact the dejecta of that patient, independent of other sources of infection which may have existed, caused the infection.

Q. Have you made any estimate of the amount of water which might be contained in the basin of Lake St. Clair at an ordinary stage of the water?

A. No, I have not.

Q. Have you any opinion upon that subject?

A. Not off-hand, nor that I am prepared to give at a moment's notice.

Q. Well, could you give me now a general estimate of the amount of water in that lake at an ordinary stage, considering it a basin with a radius of 12 miles and a possible average depth of seven feet?

A. Of course it is possible to compute the volume of water that would be contained in a basin of a radius of twelve miles, and an average depth of seven feet, but as that does not approximate to the conditions of Lake St. Clair at all—

Q. In what respect does it differ from the conditions of Lake St. Clair?

A. Well, because considered as a basin, I think 24 miles in diameter would be considered nearer—

4155 Q. I said radius.

A. I beg your pardon, I misunderstood it; at least I had diameter in mind. Do you wish me to make the computation?

Q. No, just—

A. It is just simply a mathematical computation, that is all it would be.

Q. Now as much water must come into Lake St. Clair every day from the St. Clair river, as goes out through the Detroit River in order to maintain the stage of water, must it not?

A. Oh, generally speaking, yes. Of course there are a few small tributaries that bring in some additional quantities, but we neglect that in the present case as it is a very small matter.

Q. Well, if that quantity is 15,552,000,000 cubic feet each 24 hours, then there is considerable water flowing into Lake St. Clair and considerable flowing out?

A. Yes sir.

Q. And, while there may not be visibly upon the surface of that lake a current, yet there must be a very considerable activity of the waters of that lake in order to receive and discharge that much water each 24 hours?

A. It depends upon what you would call considerable activity. The lake is by no means stagnant.

Q. Well, there is some way that the water goes into and 4156 gets out of that lake?

A. Yes, and passes through with velocity.

Q. And that passage through of that water with velocity constitutes a current, does it not?

A. Why, I don't know that you would be warranted in saying that it was what would be dignified as a current, because by currents we ordinarily understand streams of water flowing within somewhat narrow bounds. We speak for instance of the current of a river, as distinguished from the water close to its banks, and so there is undoubtedly a motion throughout pretty nearly the whole of the lake in the general direction of its length.

Q. Is the Gulf stream in the Atlantic Ocean a current?

A. I think so.

Q. And all these other currents in these great oceans are currents?

A. They are. They are currents properly speaking, flowing between well defined banks.

Q. Yet on the surface of the ocean, all along the coast of the United States and clear across to England, and past England up to Norway, there is no perceptible current can be seen, is there?

A. There can if you are stationary, and should put in a float.

4157 Q. Well, did you ever try to put a float into Lake St. Clair?

A. Oh, I have seen things floating about in Lake St. Clair—Yes, I have put in floats, a large number of them; in fact—well, we ran, I think in the neighborhood of two or three thousand floats in Lake St. Clair, or tried to. Some of them ran and some of them did not.

Q. Some of them moved along and some of them didn't. Those that moved along were perhaps carried by some kind of a movement of the water?

A. Yes, those that moved along went down into the outlet where the lake was narrow, and where the lake of course had velocity.

Q. Have you any idea how long it would take a float, the air being calm, to go from the delta of the St. Clair across to the mouth of the Detroit River, on Lake St. Clair?

A. Oh, seven, eight, ten or twelve days.

Q. Did you ever try that experiment?

A. I never sent one clear across the lake, no sir.

Q. Did you ever know anybody who did?

A. No sir.

Q. Do you know whether, if one was put in at some one of the numerous mouths in the delta of the St. Clair, it would go across the lake?

A. I do not. I think it would be very likely to be washed
4158 ashore.

Q. The river St. Clair I presume, has a current?

A. Quite a decided one.

Q. How long in time do you think it would take the current, or take a body of water to flow from the mouth of the river from the head of the river at Detroit, to the Detroit waterworks intake?

A. Oh, a matter of a few hours, one, two or three perhaps.

Q. Two or three hours?

A. It depends upon what you call the head of the Detroit river. It is rather hard to locate Detroit river—it is properly a strait; the lake narrows and the river starts, and there is a current in there of perhaps something less than a mile an hour for some little distance above the waterworks.

Q. You have no definite knowledge then as to the time of the passage of water from St. Clair river through Lake St. Clair to the Detroit River?

A. I think I have quite a definite knowledge.

Q. And how did you acquire it?

A. Based upon the area of the lake, a cross section of the lake through which the water has to flow, and the quantity of water flowing in, and the quantity of water flowing out, and the distribution of the water as it enters the lake, which is such as to insure a quite uniform distribution of the current
4159 throughout the entire lake—the distribution of velocity perhaps I had better say.

Q. Suppose that the St. Clair river should be turned in some other direction and no water from it was supplied to Lake St. Clair, how long would it take the Detroit River to drain that lake?

A. I couldn't say.

Q. Well, what do you think about it?

A. At the present moment I haven't any idea.

Q. Would it take three days?

A. I couldn't say.

Q. Would it take three weeks?

A. I wouldn't want to say at the present moment. I could figure it out for you and give you some sort of a guess at it, but to give you a pure, off-hand statement—

Q. Have you been up the Illinois river at a time of ordinary stage of water?

A. I have not.

Q. At any time or any stage of water?

A. Not in the vicinity of the river, no sir.

Q. Do you know how many dams there are on the Illinois river below Joliet?

A. I believe there are five.

Q. Four government and one state dam?

4160 A. Yes. I don't know whether the Henry dam is called a government dam; it was built by the state.

Q. You never saw those dams in the stage of low water?

A. No, nor any other stage.

Q. Do you want to be understood as stating that the water in the lower pools of any or all of those dams is never more than two-tenths of a foot or a half a foot below the crest of the dam?

A. I never so stated.

Q. I understand that you did so state.

A. I didn't understand that I did so state. If the record shows that I so stated, the stenographers either misunderstood me or I mis-spoke. The statement I intended to make was quite different from that.

Q. (Mr. Johns reading from foregoing testimony of this witness.) "The difference in the height of the water surface measured from the crests of the dams in what would be the upper and lower pools, that is, the water on the upper side of the dams and that on the lower side, is frequently less than half a foot, in fact sometimes as low as two-tenths of a foot."

A. That says "frequently;" it doesn't say all the time.

Q. Is it not true as a matter of fact that the difference between the height of the water on the lower and upper sides of the dam is for more than six months in the year any-

4161 where from two feet to seven, and that but little water flows over the crest of the dam, like a veil, a thin veil of water?

A. That I think is the case.

Q. Well, the dam in such an event would create a very considerable basin above it, would it not?

A. Yes, basins are created by those dams to a considerable extent.

Q. If a given dam on the Illinois river had a perpendicular height of eight feet above the pool below, in extreme low water, it would back the water up the river a considerable distance, would it not?

A. Yes sir.

Q. Are you familiar with the surface flow in various stretches of the Illinois River, for instance, do you know the fall of the Illinois river from Ottawa to Lacon?

A. I am not certain that I have any information on the fall of that particular reach.

Q. Have you any knowledge of the fall of the Illinois river from Morris to Peoria?

A. Yes, approximately.

Q. What is it?

A. Fifty or sixty feet, something of that sort I believe.

Q. Fifty or sixty feet?

A. Wait a minute. (Witness refers to memoranda.) Yes, somewhere around those figures.

4162 Q. Have you any knowledge of the fall of the river from Peoria to Copperas Creek dam?

A. Yes.

Q. What is it?

A. Why, between two and four feet, I guess.

Q. And what is that distance?

A. Somewhere around thirty miles.

Q. Is that a large or a small grade?

A. That is low, very.

Q. A very low grade?

A. Yes sir.

Q. That entire reach of river would be almost a sedimentation tank, would it not?

A. At certain stages.

Q. At a stage of the river when the distance from the crest of Copperas Creek dam to the surface of the pool below, is six feet, the effect of Copperas Creek dam would be to retard the flow of water above Peoria, would it not?

A. Yes, I should say it would.

Q. Does the slope of the Illinois River water change in degree from low to high water?

A. It probably does to some extent.

Q. If for instance the gauge at Henry at the dam read 6 feet, and the gauge at Copperas Creek read 6 feet, and at
4163 some other time the gauge at Henry read 18 feet and the
gauge at Copperas Creek read 18 feet, would there be a difference in the slope of the river?

A. My answer is "No." That is of course confining it to the length between those points, which I judge is what you meant.

Q. Yes. If the height from the crest of the dam at Copperas Creek for instance, to the pool below, at a time when the water ran over the crest of the Copperas Creek dam, in a very shallow stream, say six feet, Copperas Creek dam would be something more than a submereged weir, would it not?

A. Certainly. I wouldn't call it a submerged weir unless the water in the lower pool was above the crest of the dam.

Q. So that the fact when the water flows over Copperas Creek dam, and there is a perceptible flow from the pool above to the pool below, the dam ceases to be a submerged weir?

A. No sir, that statement is not correct.

Q. Well, at what distance would the dam cease to be a submerged weir when there was a perceptible flow in that water over the crest of the dam to the pool below?

A. Well, the dam becomes a submerged weir when the surface of the water in the lower pool rises above the crest of the dam, independent of where the water in the upper pool may be, generally speaking.

Q. When the water at the crest of any given dam on the
4164 Illinois River, flows over the dam from the crest, a distance of two feet to the surface of the pool below, is that dam then a submerged weir?

A. Well, let me be perfectly clear in what you mean. I would like to explain this to you without having it go into the record.

Q. (Question read.)

A. The dam would not be a submerged weir so long as the water in the lower pool was not at a higher level than the crest of the dam.

Q. When a dam ceases to be a submerged weir and is actually an effectual instrument in retarding the flow of the water above it, it aids in sedimentation, does it not?

A. Not necessarily, and very frequently not.

Q. Do you think that the resistance of dams to the flow of the water in the bottom of the stream causes a kind of a pressure to be exerted on the waters in the bottom of the stream and forces them up over the dam?

A. Waters go up over the dam from the bottom of the stream and from all parts of it.

Q. Take Copperas Creek dam for instance, if the water is flowing over its crest at a depth of one foot, is that water so flowing over it from the middle and bottom currents of the stream, or is it simply the top layer of the water slipping over? 4165

A. It is taken from the entire depth of the stream, from top to bottom.

Q. And do you say that the resistance of the dam to the lower current of the stream in such a supposed case tends to force up the impurities settled in the bottom and force them over the dam?

A. I say that the disturbance set up by the obstruction by the dam in causing changes of direction in the flow of the currents, stirs up particles on the bottom and tends to carry them over the dam. That is an observed fact.

Q. How far back from the dam would such a state of affairs exist?

A. Oh, on that head it would only extend for a comparatively short distance—a few times the height of the dam perhaps.

Q. Well, if the height of the dam was seven feet, it would extend back perhaps 21 feet?

A. Oh yes, I would be willing to say probably 20 to 30. It might extend back fifty feet. I shouldn't expect it would be very perceptible beyond that.

Q. Now the passage of boats upon rivers has the effect to very considerably disturb the waters of that stream?

A. Yes sir, in any stream.

4166 Q. If there was a continuous disturbance of the waters of the Illinois river for instance, along its entire course, similar to a disturbance caused by the passage of one stern-wheel steamer, it would be very beneficial to the purification of that water, would it not?

A. I fail to see why.

Q. Well, why would it not?

A. I don't see any reason why it would.

Q. If the waters of the stream were in a continual state of agitation, and that agitation being as violent as that created by the passage of a stern-wheel steamer up the Illinois, would that contribute materially to the purification of that stream?

A. I think not. Bacterial examinations for instance of the Niagara river above and below the falls, and down through the rapids, have shown no change in the bacterial contents of the water at all, and I doubt if any stirring up by the boats would accomplish anywhere near the result that the flow over the Niagara Falls, and the stirring up afterwards, would produce.

Q. We have been taught that time is an enormous factor in this matter. If the waters of the Illinois river were continually agitated for thirteen days, or during the passage of a given body of water through it, for thirteen days, would it add to the purification of the water?

4167 A. I am unable to say. My opinion of the value of aeration, which I judge is the point that you are working at—

Q. Yes sir.

A. Is, that it has been greatly overestimated. Such experiments as we have, bearing upon it now, tend to indicate that.

Q. Have you any definite idea derived from your personal experience or your readings, in whatever way, as to the length of time that a typhoid bacillus might live in the sedimentation of the Illinois River?

A. I have not.

Q. Whether it would live fifteen minutes or fifteen days, you don't know?

A. I am quite sure it would live more than fifteen days.

Q. How do you get at that?

A. Oh, by my knowledge of the apparent life of it in similar situations elsewhere.

Q. Have you, or has any other scientist any kind of positive knowledge as to the length of time that any given lot of typhoid bacilli lived in sedimentation. Now I mean, of positive knowledge?

A. You mean actual experimental knowledge?

Q. Yes, anything more than suppositions.

A. I am unable to cite a case of specific experiment, and at the present moment do not recall one.

4168 Q. How do you arrive at the conclusion that for over 300 days in a year the water would flow from Bear Trap Dam to the mouth of the Illinois river, in fifteen days?

A. By an examination of the gaugings of the stream, and the corresponding water stages.

Q. That is to say, if you knew what the gauge of the stream was at Bear Trap Dam and the gauge of the stream at Grafton, was, you could tell by the fluctuations of the gauge as to when a similar stage of the river existed at Grafton as had previously existed at Bear Trap Dam?

A. Let me see; I didn't quite follow the last part of that question. I think I understand it, but I don't wish to mislead you. Will you read the question?

Q. (Question read.)

MR. JEFFRIES: I object to the question because it is ambiguous and it is impossible for the witness to answer.

A. I would like to have you re-word that a little bit, Judge. I think I understand the question, and I think you intend to be entirely fair in asking it, and I want to answer it fairly, and squarely. I have no desire to evade it at all.

Q. How do you arrive at a conclusion that the flow of water from Bear Trap Dam to Grafton, in fifteen days, by an estimation of the gauges?

4169 A. Well, by taking into consideration the gauge heights at various points down the stream, and the discharges which have been measured at those points or at other points under corresponding conditions of gauges; taking all that information into consideration and comparing it with such other information that I may have as to the time that it requires for the passage of water from one point to another under corresponding or similar conditions.

Q. In order to arrive at that determination, you would have to have the stages of the various gauges along the river for one element?

A. Some of them, yes.

Q. The velocity of the current?

A. At some points.

Q. The amount of discharge at some points?

A. It practically simmers down to the question of velocity in a particular case; that is the question of discharge is only involved—

Q. Well, it is involved in the calculation, is it not, of time?

A. No.

Q. Well, what other elements than those named, would you have to consider in order to determine the time of the passage of a given body of water from Bear Trap Dam to Grafton?

A. The time that it actually took under some condi-
4170 tion of gauges and velocity for water to pass from point
to point along the stream.

Q. But if you did not know the time which it actually took and were endeavoring to find out what the time actually was by some kind of a scientific calculation, what other elements than I have named, would you have to consider?

A. I should then have to consider the discharge and the cross-section of the stream.

Q. At various points?

A. At various points, which would be a wise thing to do in any case.

Q. Would you consider the influence upon this time, of the tributaries of the Illinois river, and their inflow?

A. Most certainly.

Q. You certainly would consider the stage of the water?

A. Yes sir, the condition of the tributaries, would, however, be very largely indicated by the stage of water on the different gauges at different points.

Q. Is there any mathematical formula or any stated rule among engineers by which this calculation is made?

A. Oh, engineers have different methods of making such calculations. I have found, however, that a formula is about the last thing that a man wants to tie up to when dealing with natural laws.

4171 Q. If you knew the gauges of the rivers at various points, the velocity of discharge, and knew also the fact that some floats had gone down from the Bear Trap Dam to Grafton in about ten days, would you take all those things into consideration in arriving at the conclusion as to the time a given body of water would take to go from the Bear Trap Dam to Grafton?

A. I should certainly, and any other information that might bear on the physics of the river.

Q. Of such data you have no personal knowledge?

A. I have made no personal observations of those phenomena in this particular case.

Q. In making your estimate you have resorted to such information as has been afforded you here in the way of publications and the evidence in this case?

A. Yes sir.

Q. And assumed the information in the publications to be correct?

A. Yes sir, which I think was a justifiable assumption considering the sources of the information.

Q. If the water in the Illinois river at a given period stood at eighteen feet upon the gauge, which is considered quite high water, and at another given period had stood at two feet upon the gauge throughout the entire river, what difference in time would there be in the flow of the water from
4172 the Bear Trap Dam to Grafton?

MR. JEFFRIES: Now do you mean all the gauges at two feet and all the gauges at 18 feet?

JUDGE JOHNS: Yes, a uniform stage of the river, high and low water.

MR. JEFFRIES: Well, 18 feet might be high water at some place and might be low water at some other place. It seems to me that question is an impossible one and ambiguous.

JUDGE JOHNS: Well, put it in the record.

MR. JEFFRIES: I object to the question because it is ambiguous and impossible to answer, for the reason that the Illinois river is so situated that an 18 foot gauging might at a certain place be low water, and at other places be high water, and that two feet at certain places might be high water, and at other places low water, so that there can be no comparison made from the question.

A. Understanding by the 18-foot stage, that the river would be eighteen feet above ordinary low water mark, or standard low water mark, if such gauges were along the river as under those conditions, would indicate properly that rise, which of course would not apply to the gauges at the lower side of the dams; for instance, if it should be 18 feet on the upper side of
the dams it would be much more than that on the lower
4173 side, and understanding that your two foot gauge would
represent what river men explain as the river stage—
that's what you mean by the question, is it?

Q. Yes.

A. I would say for the two feet stage of the river the time would be something over twice as long for the water traveling that distance, or from about twice to about three times.

Q. Assuming an ordinary stage of water in the Illinois river, an average stage of water in the Illinois River, and assuming a stage throughout the entire river of 18 feet above the ordinary, which would be extremely high water in the Illinois river, what would be the difference in time of the flow of the water from Bear Trap Dam to Grafton?

MR. JEFFRIES: I object to the question because there are three assumptions included in it, average stage, 18-foot stage and high water stage, having reference to the same condition of affairs.

JUDGE JOHNS: Assuming an ordinary stage, that is to say an average stage?

MR. JEFFRIES: I object to the question for the further reasons that the conditions of the Illinois river are such that it never goes at certain places to 18 feet above high water mark, therefore it is not a practical question as far as the merits of this case are concerned, and as far as any answer that the witness might give would be applicable to the case.

A. Well, if I understand your question, you wish to in-
4174 quire what I would consider the difference in time?

Q. I simply changed the question to assume two different stages, the high water stage and the average stage.

A. That is, you mean the question to cover the high water stage and the average stage?

MR. JEFFRIES: As represented by the figures you gave,—eighteen feet?

JUDGE JOHNS: Yes.

A. At the average stage it would take the water a little less than twice as long, something less than twice as long, to travel over the distance as it would in the case of the flood.

Q. So that if floats were run over the Bear Trap Dam to Grafton in the Illinois river at a stage of high water in ten days and a half, at a stage of low water, they might take twenty days in traveling the same distance?

A. The question was based on mean water?

Q. In the stage of mean water?

A. No, I shouldn't expect that it would take quite as long as that in the swifter parts of the current; I should say possibly sixteen or seventeen or eighteen days.

Q. Would an addition of six or seven days in the flow of a stream like the Illinois be a considerable time factor in its purification?

4175 A. I think it would, yes sir.

Q. A chemical analysis doesn't determine the presence of bacteria in water, does it?

A. No sir.

Q. The chemical constituents of water, such as free ammonia, albuminoid ammonia, nitrogen in nitrites and nitrates, and chlorine, detected by chemical analyses may possibly determine the question of the pollution of that water?

A. I shouldn't want to say that it would determine it. It might.

Q. If these elements were so high that a chemist might come to the conclusion that the water was polluted, he couldn't tell whether the water was infected or not, could he?

A. Not by his chemical analyses.

Q. A bacteriological examination never has determined whether water was infected, has it?

A. There are cases on record where it has.

Q. Where?

A. There are some reported in the "Report of the Sanitary Investigation of the Illinois River and its Tributaries, prior to and after the opening of the Drainage Canal," which was published at Springfield, Illinois, by Phillips Brothers, State Printers, in 1901, on page 93, paragraph 18. "Tetanus bacilli were found at Morris, Henry, and Spoon River, Havana. Anthrax bacilli were found twice at Havana, Illinois River. Of the pathogenic bacteria the bac. coli communis was found 4176 55 times, bac. lactis aeorogenes 16 times, bac. enteritidis 10 times, proteus vulgaris 40 times; proteus mirabilis 3 times; bac. pyocyaneus 2 times; bac. tenani 3 times, staphyloccus pyogenes aureaus 3 times, bac. anthracis 2 times. Respectfully submitted, F. Robert Zeit; Gustav Futterer."

Q. Of how many samples of water, do you know?

A. I do not.

Q. Bacteriological examinations have never detected the presence of typhoid germs in running water, have they?

A. There are cases on record where the typhoid germ has been reported to have been found in running water.

Q. In this country?

A. Yes sir.

Q. Where?

A. In the experimental station of the Massachusetts State Board of Health, at Lawrence, Massachusetts.

Q. In the runnig water of streams?

A. In the tap water as supplied from the running water.

Q. Are you quite sure of that?

A. That statement is on record.

Q. In the report of the Massachusetts State Board of Health?

A. Yes sir.

Q. Does a bacteriological examination as a rule determine whether water is infected?

4177 A. Not absolutely; in fact generally not.

Q. Sanitary Engineers and experts upon the quality of water assume that if there are populous communities having their sewage and drainage thrown into running streams, that the streams are infected?

A. That is an ordinary assumption and a very justifiable one.

Q. Do you consider in looking into the future, that the Missouri river, in its watershed, will never be densely populated?

A. It depends a little bit upon what you mean by densely populated. Oh, certainly I anticipate a very marked increase in population in the Missouri River valley and its tributaries.

Q. As well as the valley of the Mississippi river?

A. Yes sir.

Q. And the valley of the Illinois?

A. Yes sir, and I might add that there is a probability of greater growth on the Mississippi and the Missouri, than there is in the valley of the Illinois exclusive of the upper end,—Chicago.

Q. So that the amount of sewage pollution in each of these rivers, the Mississippi and the Missouri is likely to increase much in the future?

A. I think so.

Q. And the Missouri is therefore in the future a menace

4178 to St. Louis?

A. I don't know that the river is.

Q. The waters of the river?

A. It would depend upon what is done with them.

Q. In their natural state, considering the future, the untreated waters of the Missouri river will be necessarily a menace to the inhabitants of St. Louis as the waters came into the intake, would they not?

MR. JEFFRIES: I object to the question because in their natural state they could not under any possibility be a menace to the city of St. Louis.

A. I shouldn't think that the waters of the Missouri river in their natural state, either in the present, past or future, would be a menace, but if you mean with the growth of population upon the Missouri watershed it would contribute additional infection to the Missouri river and cause it to become less healthful and less safe as a water supply, I am perfectly frank to answer yes.

Q. And that answer would apply also to the waters of the Mississippi river?

A. Yes sir.

Q. Could you expect that in the distant future in a stage of very low water, that the waters of the Missouri river would become substantially a stream of liquefied sewage, or a stream of liquid sewage? 4179

A. I can hardly conceive that in the Missouri river.

Q. Could you conceive that as to the Mississippi?

A. A little more readily.

Q. Depending entirely upon the supposed and anticipated increase of the sewage, in the pollution of each of those streams?

A. No, not entirely upon that.

Q. Upon what other considerations?

A. Upon the decrease of the flow of the streams themselves for one.

Q. Well, from the decrease of the flow and the increase in the population, the waters of both of these rivers would be dangerous to the inhabitants of the State of Missouri, on her banks?

A. For ordinary domestic purposes, you mean?

Q. Yes.

A. Yes.

Q. Are there other persons, sanitary engineers, expert in water supplies in this country, who are as familiar with the subject as yourself?

A. I think there are not very many.

Q. About how many?

MR. JEFFRIES: I object to the question as being incompetent, irrelevant and immaterial. 4180

A. At the present moment I do not think of any whose judgment I would take in preference to my own, or whose judgment I would advise a client to take in preference to my own.

Q. If it could be imagined that some gentleman who had the experience and qualifications equal to your own, and had made the same amount of examination and study of the conditions embraced in this entire case, should come to an opposite conclusion to yours, would you consider that that person exhibited an ignorance of the conditions and of the subject which would make his opinion of no account?

A. That would be the conclusion I would have to draw from the evidence in the case.

Q. Assuming a certain number of cases of typhoid fever at St. Charles, Missouri, and an equal number of cases at Kansas City, Missouri and consequent typhoid fever in St. Louis, to which place would you attribute the typhoid fever in St. Louis, St. Charles or Kansas City?

A. Both.

Q. Assuming typhoid fever in St. Charles, Missouri and an equal number of cases at Omaha, and typhoid fever in St. Louis, to which would you attribute the typhoid in St. Louis?

A. Well I would say, to be perfectly fair to both yourself and to me, that in answering the former question I assumed you to mean that the typhoid occurred in St. Louis at a 4181 proper time after the appearance of the other to permit of the connection.

Q. Yes sir.

A. Yes sir, I should attribute it to both.

MR. JEFFRIES: And also that there is typhoid fever at no other place, just those two places?

JUDGE JOHNS: I am assuming these conditions.

MR. JEFFRIES: Eliminating all other conditions?

JUDGE JOHNS: Assuming typhoid fever at St. Charles, Missouri, and an equal number of cases at some place near the head waters of the Missouri river—

A. Helena, Montana for instance?

Q. At some place near the head waters of the Missouri river, Helena, Montana, for instance, and that the waters from Helena came down infected and joined the waters of the Mississippi, with the same infection, and the two bodies of water thus infected, arrived at the St. Louis intake, to which one would you attribute the consequent typhoid fever in St. Louis, Helena or St. Charles?

A. On the hypothesis stated I should attribute it to both.

Q. Take out of the hypothesis that the waters coming from Helena were infected, but assume the dejecta of typhoid patients in Helena, cast into the Missouri River, and that body of water into which it was cast, coming down to St. Charles, and there joined by water infected with an equal number of cases
4182 of typhoid fever in St. Charles, and typhoid fever in St. Louis consequent, to which place would you attribute the typhoid fever in St. Louis?

A. I would still be inclined to think that both might be responsible for it.

Q. Considering 50 cases of typhoid fever at Helena, Montana, and no other possible source in the Missouri River of infection of its waters, from typhoid at that time, and that the waters from Helena, Montana arrived in the Mississippi river at the Chain of Rocks, and that in a proper time after that there occurred in St. Louis an increase in typhoid fever, would you attribute that to the infection of the river at Helena?

MR. JEFFRIES: Object to that question on the ground that it does not eliminate the local conditions; that is the conditions up the Mississippi or the Illinois.

A. On the hypothesis stated, I should not want to attribute a very large part or more than a very small part of the increase of typhoid fever in St. Louis to the typhoid fever cases at Helena.

Q. Can you conceive of any distance in a running stream in which typhoid fever bacilli might not live in the waters of that stream?

A. The life of the typhoid bacilli in streams, is rather a question of time and distance, and as a general proposition
4183 I would say that it is my present opinion that there is no stream of water on the surface of the earth flowing in natural channels, that is long enough to warrant the absolute assurance that a typhoid germ might not live from one end of it to the other.

Q. So if there were typhoid germs cast into the waters of the

Mississippi river at St. Paul and no other possible source of infection of those waters, do you believe that those typhoid germs might arrive at New Orleans and infect the water supply of the city of New Orleans?

A. I think it is possible to a certain degree; that is, I think it is possible that some of them might arrive. I do not want to be understood as saying they would all arrive.

Q. Are not all of such suppositions very vast extensions of any kind of knowledge upon that subject?

A. I think not.

Q. Do you know, in your experience or learning, of any instance in which even by the process of reasoning of scientists in water supply, or bacteriology, or chemistry, or of sanitary engineering, where they have determined to their own satisfaction that the typhoid bacillus has lived in running streams for a distance of over 150 miles?

A. Yes sir.

Q. What instance?

4184 A. The instance of the pollution of the St. Louis supply by the drainage of the city of Chicago for one.

Q. Any other?

A. The pollution of some of the supplies on the Merrimac River, I believe are traced to distances as great as that. The pollution of the Connecticut river similarly, and on the Hudson river.

Q. Infectious?

A. Yes, infections.

Q. Name an instance in which an infection has been traced in the Merrimac River a distance of 150 miles.

A. The typhoid along the lower river towns on the Merrimac river has been shown to follow in regular sequence the typhoid in the upper river towns for a number of years consecutively, indicating that pollution travels down the river from town to town and through practically the whole length of the stream.

Q. Is there any instance with reference to the Merrimac River in which the infection of a town 150 miles from another town, on the course of that stream, has been traced to the upper town?

A. I think that you may fairly say that that is the case.

Q. Now what other instance?

A. As I say, there are similar instances in connection with
4185 the Hudson river, that I have in mind at the present moment.

Q. Have you in mind an instance in which it has been assumed or stated by sanitary engineers, that the infection of water in the Hudson river at a given point was caused by a similar infection of the water of the Hudson river 150 miles above?

A. I am not prepared to make a specific statement of that kind; that is a specific citation of the instance, but a statement was made to me not very long ago, that such was the case, by a gentleman who had made some investigations along those lines.

Q. Some recorded instance?

A. Yes I believe so.

Q. What one?

A. I think it was in the case of the sewage from Schenactady and some of the lower Hudson river towns.

Q. Can you state the lower towns?

A. No, I cannot at the present moment, because I didn't inquire into the thing particularly; it came up in a casual conversation.

Q. Did the gentleman who gave you the information make any publication of the investigations?

A. I believe not. I think he is in the employ of the State of New York, making the investigations, at present, and
4186 probably will publish it within the present year.

Q. Did you ever hear of an instance where the pollution of one water supply, or infection, was caused by the infection of a water three hundred miles above?

A. Yes sir.

Q. In what instance?

A. In the case of Chicago and St. Louis that we are considering at the present time.

Q. Any other?

A. Your question was 300 miles?

Q. Yes.

A. I will say no to that question.

Q. Did you ever hear of or know of an instance in which the infection of a water supply was attributed to an infection 250 miles above the place where the infection was found to exist except in the case now under investigation, and if so where and how did you hear of it?

A. I do not recall of having heard of any such case at the present moment; that is, any such specific case.

Q. Did you ever learn of a case in which the infection of a water supply at a given point was attributed to similar infection 200 miles above the infected place except the one under investigation at present?

A. I think, generally speaking, that I have.

4187 Q. In what instance, and what place?

A. Cincinnati and Pittsburg, which it turns out are considerably further apart than that.

Q. How far is Cincinnati from Pittsburg?

A. Somewhere around 300 miles I believe.

Q. Has it been asserted by sanitary engineers or any kind of scientific men that the waters of Pittsburg infect the waters at the intake at Cincinnati?

A. I think I have seen such a statement, on what would be considered the authority of some kind of a scientific man, or some kind of scientific men.

Q. Who was the man and what kind of a scientific school did he belong to, what profession?

A. My impression is that it was the Board of Sanitary Engineers who were considering the water supply of Cincinnati. I think so, but as I am speaking from memory on that, I won't be positive about it.

CROSS-EXAMINATION,

By Mr. Todd.

Q. Professor, will you state in detail how you estimated the rate of flow for 300 days in the Illinois river and the methods that you employed?

A. By an examination of the gauge heights at various 4188 points along down the river, to ascertain what the river stages were for certain periods in the year, and comparing those gauge heights with the discharges at various places and the corresponding velocities at those places, and making use of all the information that I was able to gather on the subject.

Q. Any other elements that you took ino consideration?

A. The profile of the river, the cross-section and the data that I could gather at the present time, about the river. I do not pretend to say that my examination has been exhaustive, and may not be subject to some revision, but according to the best information that I possess now, those results that I gave are correct, I think.

Q. Where did you get the information from?

A. I got the information from the reports of the United States Engineering Corps, the records of the gauge heights along the river as published by them, from the various surveys of which I have the maps and profiles, and the maps of the geological survey and some reports of the Chicago Drainage Canal and various other things. I took into consideration everything I could get hold of on the subject in the limited time that was at my disposal.

Q. After you got that information, what mathematical formula did you apply to it?

A. None whatever. I do not tie up to mathematical formulae; I have been experimenting in hydraulics too long to make any such break as that. 4189

Q. Well, you applied mathematics to the information?

A. Of course you have to apply mathematics to it.

Q. What rules in mathematics?

A. Well, the simple rules of addition, multiplication, division and substraction.

Q. What I wanted to get at were the facts upon which you base your calculation that would enable a civil engineer or a water engineer to verify it.

A. I think they would, yes sir.

Q. If possible?

A. Yes sir.

Q. And from what you have given me, and the sources from whence the information was derived, that could be done?

A. Yes sir. Of course I may say that in such a case you may expect a personal equation in the conclusions that a man would arrive at.

Q. In figuring the time at Detroit, from the time that the infected matter dredged from the Black river was deposited into the St. Clair river, and from the time there were in a single day in Detroit four deaths from typhoid fever, there having been only one in the preceding 24 days, as contained in
4190 the answer that you gave in your direct examination
for the time required for the infection to come from the point at Port Huron in the St. Clair river, to the consumers of water in the city of Detroit; the date of those four deaths was the time that you calculated back from in arriving at the time it took the infection to reach Detroit, was it?

A. No sir.

Q. What part did the four deaths in Detroit have upon the estimate?

A. They had no part at all in that. I started at the other end of the problem entirely.

Q. You started with the date of the infectious material being deposited?

A. Yes sir.

Q. And calculated up to the four deaths?

A. Yes sir.

Q. And that the period from the deposit of infectious material to the four deaths occurring corresponded within 24 hours you stated, of the time allowance for incubation?

A. For the transmission, incubation and death.

Q. How long had those patients been sick with typhoid fever?

A. I couldn't say.

Q. How long after a person contracts typhoid fever before
4191 they pass the danger point?

A. That's rather hard to say.

Q. A person may have typhoid fever and it may run over two months?

A. Oh yes.

Q. And at the end of the two months die?

A. Yes, may die at the end of six months.

Q. And may die before the end of three or four days after contracting it?

A. No sir, I think there are no cases on record of a man dying of typhoid fever as quickly as that; at least none has come to my attention.

Q. You wouldn't say that it was not possible?

A. I wouldn't say that it was not possible, but it is highly improbable.

Q. Well, not knowing how long these four patients had been down with typhoid fever before they died, how did you make your conclusions as to the time of incubation, between the deposit and their death, as being an accurate judgment?

A. Well, having made a study of the statistics of some thousands of typhoid cases, and determining therefrom the ordinary average period elapsing from the time of infection to the time of death; or from the time of taking down to the time of death, and finding the average period in a very large number of cases of typhoid, I felt warranted in assuming
4192 and applying that period to the cases in question.

Q. Regardless of knowing whether those patients had been sick for two or three months prior to death or not?

A. Certainly, yes.

Q. Assuming, if as a matter of fact they had been sick for two or three months before death, would your knowledge gained from other statistical investigations affect your judgment in applying it to the cases under consideration? By that I mean that your conclusion was based upon a general principle as I understand it, deduced from your investigations of typhoid fever other than the four deaths in question?

A. Yes, it was to a large extent. I consider that the four deaths were highly corroborative of the conclusion I arrived at from another course of reasoning.

Q. Assuming it is not an improbability or an impossibility—

A. It certainly is not an impossibility.

Q. That the date of the four deaths under consideration had occurred after an illness of say two or three months duration, would that make any difference in your conclusions?

A. I think I can safely eliminate those four deaths, without vitiating my conclusions or causing me to change my views in the matter.

Q. In your studies as a Sanitary Engineer and an epidemiologist, have you added anything new and unknown to the science of epidemiology, and to that of sanitary engineer-
4193 ing and water supply?

MR. JEFFRIES: I object to the question because there can be nothing new added to a science.

A. I have certainly extended the amount of information available to persons engaged in those subjects.

Q. Have you enunciated and demostrated any new principles?

A. I don't know that I have.

Q. Have you been the pioneer in any new departure of investigation in these sciences?

A. I should hardly want to claim that I have.

Q. Has this science of epidemiology and sanitary engineering as to water supply been exhausted?

A. I rather think not.

Q. Do you know of anyone in this country or elsewhere that has made more extensive investigations than yourself?

GENERAL CROW: You mean into those two general subjects?

MR. TODD: I am talking about these two subjects.

A. Sanitary engineering and epidemiology?

Q. Yes?

A. Oh, yes I think so. I think there are such persons.

Q. If such a person, in consideration of these facts should draw different conclusions from those which you have drawn would you consider their conclusions unworthy of ac-
4194 ceptation?

A. Unless they were possessed of other facts which are not now known to me, I would certainly consider they had made a mistake.

Q. Do you consider that in your investigation of the conditions existing between Chicago and St. Louis, on the watershed of the Mississippi river above the intake, that you are in possession of all the facts possible and necessary in this investigation, and sufficient to establish the certainty of your conclusions?

A. Yes sir.

Q. Then if the one who has made greater investigations, and had broader experience in these sciences than you have, and I believe you concede there are some who have done it, and should be acquainted with all the facts with which you have been acquainted, should draw different conclusions would you consider these conclusions were unwarranted and unworthy of acceptation?

A. Unless he had different information to that which I had I would so consider it.

Q. Can you conceive of any different information that could be obtained that would change your conclusions?

GENERAL CROW: Do you mean different information in the development of the science, or local conditions?

MR. TODD: I mean in the development of the science or
4195 local conditions.

A. No, I cannot.

Q. Do you consider your conclusions in this case then as infallible?

A. No sir.

ADJOURNED until 2:00 P. M., same day.

Southern Hotel, St. Louis, Missouri.
4196 2:00 P. M., Thursday, May 28th, 1903.
Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

GARDNER STEWART WILLIAMS,

resumed the stand for further cross-examination by Mr. Todd and testified as follows:

Q. Professor, have you studied the typhoid conditions existing on the watershed of the Mississippi, the Illinois and Missouri rivers for the years 1896, 1897, 1898 and 1899?

A. To a considerable extent, yes.

Q. If, during those years there existed upon the watersheds typhoid fever that resulted in the death of from 300 to 375 people annually, from all the towns and cities situated upon the river, emptying their sewage into the Illinois, Mississippi and Missouri rivers, would the excreta from that number of typhoid patients be sufficient in your judgment to render the water supply of St. Louis unsafe and dangerous for domestic use?

A. The presence of such cases would undoubtedly render
4197 the water supply of S. Louis unsafe and dangerous for
domestic use, for even though the water was treated by what we know to be and what analysis has shown was an efficient method of treatment, the typhoid fever death rate and number of cases of death in St. Louis apparently traced to water infection is greater than should exist attributable to a good water supply.

Q. With your experience as a sanitarian or sanitary engineer and epidemiologist, if during those years you should have occupied the position of sanitary engineer of the water supply of St. Louis, and the same system of water supply existed, then in the city of St. Louis, as exists today, and you were in possession of the history of typhoid along the valley of the Illinois river and the Mississippi river and the Missouri river, and their tributaries, would you as a sanitarian and epidemiologist, recommend the water that was suppiled to the citizens of St. Louis as a safe and drinkable water?

A. I should certainly not have recommended it as a safe water.

Q. Would you have recommended it as a drinkable water?

A. I shouldn't have advised the people to drink it without further treatment.

Q. What treatment?

A. Why, boiling, filtration, or some treatment that would
be sure of certainly reducing the possibility of infection
4198 from it.

Q. Would the treatment that you recommend then, such as boiling, be a safe treatment to use now?

A. It certainly would add very much to the safety of the water if the water were boiled now. I would consider it would be a safe water.

Q. Is there any way known to sanitary science or epidemiology which can tell or demonstrate that the increased typhoid in St. Louis in 1900, 1901 and 1902, did not come from any one of the cities whose sewage emptied into the Mississippi river above the intake on the Mississippi?

MR. JEFFRIES: That is excluding Illinois?

MR. TODD: No, including everything.

A. There is no method that I am aware of that would enable one to demonstrate that no part of the infection came from any one of the cities in question.

Q. Is there any way to show that all of it did not come from any one of the cities tributary to the waters of the intake?

GENERAL CROW: You mean the increase or the typhoid?

Q. MR. TODD: All the typhoid.

A. I think it would be entirely possible to show that.

Q. Outside of making assumptions that are not scientifically established?

A. Yes, I think so. That might be scientifically established.
4199 I am not prepared to say that the necessary evidence can be adduced at the present moment, that it is in shape to produce.

Q. What do you mean by that last expression, Professor?

A. I mean just simply this, that I think it would be entirely possible to prove infections in the cases of some of these instances which came from such specific sources, as to prevent and preclude the possibility of all of the cases having come from any one source.

Q. I mean from the cases that are produced by water-borne diseases?

A. By water-borne infection?

Q. That's what I mean.

A. Well, I wasn't restricting it to water-borne infection in answering the question.

Q. In my question, I confined myself to the typhoids in St. Louis that came from the drinking water, from the water supply of St. Louis; not isolated cases that have been contracted by families or individuals in some other town or some other locality than St. Louis, which is easy to demonstrate.

4200 Q. (Previous question read)—which have been contracted from the drinking water of St. Louis?

A. I think that can be shown with an accuracy sufficient to meet the requirements of science.

Q. I don't know what the requirements of science are because that is a variable, mercurial term from my standpoint; but can that fact be demonstrated as a logical proposition?

A. I think it certainly can, as a logical proposition.

Q. If in the year 1896 there were 60 deaths in Minneapolis, 1897, 148 deaths; 1898, 86 deaths; 1899, 71 deaths, and Minneapolis is 707 miles from St. Louis, and in Kansas City, which is only 403 miles, for 1896 there were 29 deaths; 1897, 38 deaths; 1898, 49 deaths, 1899, 52 deaths, and assuming that there were no other cases of typhoid fever reported on the water-shed tributary to the water supply of St. Louis, understanding by that the Illinois, Mississippi and Missouri Rivers—

A. Let me suggest right there, do you mean reported or existing?

Q. Reported or existing.

A. All right.

Q. And there was in St. Louis for those years, 106 deaths for 1896; 125 for 1897; 95 for 1898 and 130 for 1899, and that the typhoid condition was assumed to be attributable to the water supply of the city; is there any way known to the science that has to do with water supply, whether it is termed
4201 sanitarian or epidemiologist, that can demonstrate whether this contagion came from Minneapolis in its entirety, or whether it came from Kansas City in its entirety, or whether it is a combination of both, assuming that the times of the typhoids in St. Louis and in these other two places are not in conflict with the theory of typhoid?

A. As borne from those places?

Q. Yes.

GENERAL CROW: What other place did you name besides Minneapolis?

MR. TODD: Kansas City and St. Louis. I eliminated the others in the hypothetical question.

A. There is no means by which it would be possible to determine how much came from either one or that it did not come from both.

Q. Is there any way to show that it did not all come from one or the other?

A. I think that might be fairly shown.

Q. In what way, except by assumptions?

A. By the actual history of the water, and the conditions of stream flow, and so on, and the statistics of the outbreaks themselves,—all three considered.

Q. Assuming that there was no existent history that would exclude either one or the other of these places, as being
4202 the cause of the typhoid in St. Louis?

A. I judge from this question that you misunderstood my answer to the last, or else I misunderstood your question in answering it. The answer that I intended to give to the last was that I thought it was possible to establish the fact that it came from both sources; not that it came from either one.

Q. Is it possible to establish the fact that it came from either one of the sources?

A. No sir, I think not, under the conditions assumed.

Q. It might be possible that it should come from one source and not from the other, might it not?

A. I should regard it as very doubtful that that would be the case under actual conditions.

GENERAL CROW: Under assumed conditions.

A. I mean under assumed conditions, yes.

Q. MR. TODD: I mean under assumed conditions.

A. Well, along with those conditions one is necessarily compelled to assume the laws of nature to be in force and acting, and so on. We cannot consider a susupension of them in answering a question of that kind, and I intend to confine myself strictly to your assumptions so far as they cover the case.

Q. If conditions existing between Minneapolis and St. Louis were such as to be the cause of the typhoid in St. Louis, and similar conditions existing between Kansas City and
4203 St. Louis were such as to have Kansas City the cause, and these two conditions existing in Minneapolis and Kansas City existed at the same time, is there any way known to science of waters than can demonstrate whether the cause of the typhoid fever in St. Louis came from Kansas City, and not from Minneapolis, or from Minneapolis and not from Kansas City?

A. Not to my knowledge. That was the answer that I intended to give to the question before.

Q. Notwithstanding the fact that conditions of that kind might exist as to those two places, isn't it possible that the contagion could come exclusively from Kansas City, or from Minneapolis, without receiving any effect of contamination from the other city, whichever the case may be?

A. I should think not.

Q. But there is no way of proving the affirmative or the negative of the proposition, is there?

A. I think it would be impossible to make an absolute proof either in the affirmative or the negative.

Q. Now, if added to those conditions in the hypothetical questions where the two cities were supposed, all the conditions which actually exist along the watershed of the Mississippi river above the intake, is it possible then to say which one of
those cities contributed the largest amount of the typhoid
4204 existing in St. Louis for the years 1900, 1901 and 1902?

GENERAL CROW: You mean the Mississippi or the Mississippi and tributaries?

Q. MR. TODD: When I use the term waters of the Mississippi at the intake, I include the tributaries, the Illinois, the Mississippi and the Missouri.

A. You are basing the thing now on the conditions as they actually exist?

Q. As they actually exist?

A. I think not.

Q. Is there any way of scientifically demonstrating the proportionate share of the increase in typhoid fever in St. Louis, from any of those cities, without assuming something?

A. It seems to me that it may be demonstrated without an assumption.

Q. What proportion did Minneapolis contribute to the increased typhoid fever in St. Louis in 1900?

A. I couldn't say.

Q. Can you say what proportion any of the cities contributed outside of Chicago?

A. I doubt it, I think not.

Q. Can you show what Chicago contributed without assuming anything?

A. Not the absolute quantity.

Q. Any more than you could for Minneapolis?

4205 A. I think so.

Q. Any more than you could for Kansas City?

A. Any more than for Kansas City—I think so.

Q. Any more than you can for any one of the number of cities the typhoid statistics of which have been introduced in evidence here?

A. I think so.

Q. Is there a different rule applied by epidemiologists and sanitarians to the city of Chicago than would be applied to all or any of the other cities lying tributary to the water supply of St. Louis?

A. There is not; but different facts are in our possession in regard to the city of Chicago from those which exist in regard to the other cities on the watershed.

Q. If different facts are in your possession in regard to the city of Chicago, from what you have in regard to Kansas City, Minneapolis and these other cities, how are you able to draw a conclusion in regard to the typhoid conditions existing in these other cities, such as you have done in your testimony?

A. I don't see any difficulty in doing that. If a man has different facts in regard to two different things, he certainly would draw two different conclusions in regard to them.

Q. Do you regard that you have the facts as elaborately in regard to all of the other cities as you have in regard

4206 to Chicago?

A. Not quite, but sufficiently so for all practical purposes I think.

Q. What do you mean by practical purposes?

A. Those purposes for which a practical man would use such facts.

Q. Is a sanitarian and an epidemiologist a practical man?

A. I should hope so.

Q. Is that word "practical" man, and scientist, synonimous?

A. Not necessarily.

Q. As applied to water?

A. Not necessarily.

Q. What facts have you about Chicago that you have not about Peoria?

A. The fact that at a certain time its sewage was added to the waters which supplied St. Louis with its water supply, for one thing.

Q. At that time was the sewage of Peoria being added to the water supply of St. Louis?

A. Yes sir, I think so.

GENERAL CROW: You say, was it being added; it was already coming into it.

THE WITNESS: I understood Mr. Todd to be asking a fair question.

4207 MR. TODD: I am not trying to play on this at all.

GENERAL CROW: I know you were not; that is the reason I suggested it.

THE WITNESS: I understand Mr. Todd to be conducting a straightforward examination here, and I am endeavoring to answer his questions fairly and squarely.

Q. MR. TODD: Previous to the opening of the drainage canal, what was the difference in the volume of sewage from Chicago entering the Des Plaines River from what empties into the Des Plaines river now, since its opening?

A. I am not prepared at the present moment to give explicit figures.

Q. You have testified as to the number of cubic feet of fecal discharge entering the drainage canal every 24 hours, from the sanitary district, have you not, Professor?

A. I think not.

Q. What was the 4400 cubic feet that you testified about; what did that represent?

A. That represented the solids in the fecal matter discharged into the sewers of Chicago, which are tributary to the Chicago river and the drainage canal.

Q. And which enters the drainage canal?

A. I didn't say that it entered the drainage canal.

Q. Well, do you know whether it does or not?

4208 A. Some of it does undoubtedly.

Q. Do you know what proportion of it does?

A. No.

Q. Do you know whether the same territory that empties into the Chicago River, the 4400 cubic feet of solid fecal matter, is any different today from what that same territory was prior to the opening of the drainage canal?

A. I couldn't say at the present moment positively.

Q. Do you know how much, or what proportion of that 4400 cubic feet was pumped into the Illinois and Michigan canal at the Bridgeport Pumping works prior to January 17th, 1900?

A. No.

Q. Do you know whether all of it was pumped from the Bridgeport Pumping works into the Illinois and Michigan Canal prior to the opening of the drainage canal?

A. I am very sure that it was not.

Q. Do you know?

A. Yes, I think I can say that I know.

Q. How much of it was?

A. I don't know how much of it was.

Q. Do you know whether 80 per cent of it was?

A. I do not.

Q. Do you know that 80 per cent of it was not?

A. I do not.

4209 Do you know whether 90 per cent was?

A. I do not.

Q. Have you any judgment on the matter based upon any accurate knowledge?

A. I don't know that I have at the present moment.

Q. Then in giving an opinion in regard to the contamination of the water supply of St. Louis as being infected by the sewage of Chicago, as to an approximate amount of that infection, and not being able to give the same information in regard to the other cities, don't you as an expert deem it necessary to know those facts in order to be able to make your conclusions in regard to the infection from Chicago proportionately increasing the typhoid in St. Louis?

A. Those facts in regard to the other cities, you mean?

Q. No, in regard to the amount of that solid matter being pumped into the Illinois River and Des Plaines through the Illinois and Michigan Canal via the Bridgeport pumping works, prior to the opening of the canal?

A. I don't see how that influences the case any more than knowing the actual amount of infection that may have come from any other source, that was continuous, before the opening of the drainage canal.

Q. Do you know the amount of infection that came from any other one source before the opening of the drainage canal?

4210 A. Oh no.

Q Since the opening of the drainage canal, you stated that there was a sediment on the bottom of the Chicago river. How much of a sediment is there upon the bottom of the Chicago river at present?

A. I couldn't say.

Q. Have you any idea?

A. Oh, I think it would vary in different places. I wouldn't be surprised if you might find some feet of it in some places.

Q. From the mouth of the Chicago river to Robey Street, where the Canal enters the Chicago river, what sediment such as you have described in the first part of your examination in chief, would you say was on the bottom of the Chicago river?

A. I think that sediment that has been accumulating there for a number of years is still there, and additional sediment that is drawn in from the lake itself, is probably there.

Q. Suppose that there was no such sediment, would that have any effect upon your conclusions?

A. I doubt it.

Q. Do you know of anything in addition existing in Chicago that if it was different from what you assume exists there would have any effect upon your conclusions?

A. Oh yes.

4211 Q. Did you consider the sediment on the bottom of the Chicago river as an important factor in this examination?

A. Not as a continually important factor; I think it was an important factor at the opening of the canal.

Q. Well, as of today?

A. Oh, it has its importance, but it is not paramount.

Q. What importance has it?

A. Why, simply the importance that it is likely from time to time to be disturbed and carried on down into the Illinois river and into the Mississippi, and carry with it infection.

Q. When was it that you were in Chicago and examined the Lake front?

A. That was in 1892.

Q. Do you know whether the Lake front in Chicago today is the same as it was in 1892?

A. I know that it is quite materially different in some respects.

Q. In what way?

A. Oh well, the conditions there have been considerably improved.

Q. When you were in Chicago the Lake Front, so-called, was immediately beyond the tracks of the Illinois Central railroad, was it not?

4212 A. That was the portion with which I was most familiar.

Q. Well, do you understand now that the Lake Front has been extended several thousand feet beyond that point, and they are filling in what is known as Grant Park?

A. No, by the term Lake Front, I referred to the—

Q. I mean from 12th Street to Randolph.

A. In using the term "Lake front" I was not confining it to any specific narrow location. I was speaking of that portion of Chicago which borders upon the lake.

Q. The entire lake front?

A. Yes, substantially that.

Q. And did the conditions which you found and testified to obtain along the entire lake front for the municipality of Chicago?

A. Oh, I can't say that they did along the entire lake front.

Q. Those conditions obtained mostly near the mouth of the Chicago river, did they not?

A. That is the worst portion, nevertheless, along the entire lake front there are more or less accumulations of matter that has apparently come out of the Chicago river, or there are undoubtedly—I won't say that there are positively, because I have not measured any, such accumulations that have been borne there by the effect of waves, and winds, and currents which set back

and forth along the shore, so that an examination of the
4213 bottom of the lake would undoubtedly reveal quite extensive pollution of it for long distances beyond the narrow limits that one would first expect to find that pollution in.

Q. How deep is the Chicago river, if you know?

A. My recollection is that it is somewhere around sixteen or eighteen feet possibly.

Q. If it should appear that the Chicago river from the entrance to Robey Street was of a depth of 26 feet in the channel, with the exception of the tunnels, and that condition has been created within the last three years, would that have any effect upon your conclusions in regard to the effect of sedimentation in the Chicago river?

A. I think not, for that is about the condition that I should have anticipated would have resulted there.

Q. What effect did the sewage pumped into the Illinois and Michigan Canal prior to the opening of the drainage canal, have upon the water supply of St. Louis?

A. I don't know.

Q. How much of the typhoid in St. Louis, would you attribute to the discharge of Chicago sewage through the Illinois and Michigan canal prior to the opening of the Sanitary District?

A. I couldn't say.

Q. Can you now state how much of the increase in ty-
4214 phoid fever in St. Louis is due to the sewage discharged through the drainage canal?

A. I think it is safe to state that the major part of it is.

Q. By major part, what do you mean?

A. Well, considerably more than half.

Q. How many cases of typhoid in St. Louis for 1900, was the excess over 1899?

A. I can't say at the present moment; I can look the matter up and tell you.

Q. If there were 130 deaths in St. Louis in 1899, and 168 deaths in 1900,—if those were the figures?

A. You are speaking of deaths now?

Q. Deaths.

A. All right.

Q. Is there any way of ascertaining the number of cases, and the excess,—increase?

A. Not absolutely.

Q. What would you say approximately?

A. I would say approximately that the cases probably increased to about the same extent, the same proportion as the deaths, as a general proposition.

Q. Suppose that the number of cases as testified to upon the chart that is offered by Dr. Ravold, in 1900, was 1213 cases,
and in 1901 was 1101 cases, and 1902, was 1112 cases,—
4215 which would be the most scientific way to consider the
question of typhoid, increase in deaths, or the decrease
in cases?

A. The increase in deaths.

Q. What?

A. The increase in deaths, certainly.

Q. Why do you say that the deaths are the better criterion than the cases, if you have the deaths and the cases?

A. Because a man never dies but once, and if he dies, under the laws of the United States generally, a record of his death is bound to be made somewhere; whereas, a man may be sick of the typhoid and no record of it appear; so that records of cases are always deficient. As a matter of fact, it is rarely that you get more than 60 per cent of the cases, and the percentage varies considerably from year to year.

Q. But if, as in the case of St. Louis the deaths are reported by the doctors, and the cases were reported by the doctors, you have relied upon the doctors' diagnostication of the cases?

A. I am not questioning the diagnoses in either case; I am questioning the report.

Q. The report?

A. Yes, I say that a man having a case of typhoid might not report it, and in fact it shows that they don't report it, to
a very large extent.

4216 Q. A man frequently has been accused of dying of ty-
phoid when as a matter of fact he didn't have it, hasn't
he?

A. Oh, certainly, and so there have been other cases where he died of other causes and they thought he had typhoid.

Q. So it leaves the whole situation in doubt, doesn't it?

A. To a moderate extent; but considering these things from a broad, practical standpoint, those things will balance up in a period of years; those things might vary considerably in a week's time, but in a year, the record will come out about right.

Q. The only true science then is not the medical but the epidemiological science?

A. I don't know on what grounds you have come to that conclusion.

Q. If the cases reported and testified to as being accurate are not to be relied upon, how are the deaths that are reported and testified to, to be relied upon?

A. Well, the simple reason, as I stated before, that if a man dies, he never dies but once, and some record of that is bound to get—or some statement of that is bound to appear upon the record books; but a man may have typhoid fever and never be treated at all. He wouldn't report the case himself, because he wouldn't know that he had it, and the facts prove that where-
as the mortality from typhoid fever where cases are
4217 looked after and reported, to a large extent, is only about
one in seventeen while taking the ordinary statistics the
ratio is about one to ten; that is ten cases to one death, whereas, properly it is seventeen cases to one death.

Q. If a man has typhoid and does not know it, why should the epidemiologist assume the fact that he has it when there is no evidence?

A. The epidemiologist does not assume the fact that he has it.

Q. Then we haven't anything to do with the man who has typhoid and doesn't know it, have we, in this investigation?

A. I don't see how we can get him in here as a specific basis of computation.

Q. Well, we will just leave him out and take what we have got then.

A. Yes, that is best.

Q. Assume as a fact that in the city of St. Louis in 1897, there were 433 cases of typhoid; in 1898,—426 cases of typhoid; in 1899, 908 cases of typhoid; in 1900, 1213 cases of typhoid; in 1901, 1101 cases of typhoid; in 1902, 1112 cases of typhoid, as testified to by Dr. Ravold, and as illustrated by the chart that has been offered in evidence, and assume that those figures are true, would the fact that 160 deaths occured in 1900, as 4218 against 198 in 1901, be evidence that typhoid had increased in the city of St. Louis, when the facts are that the number of cases decreased?

A. I should never base conclusions in a typhoid epidemic upon the number of cases which were reported, for reasons already stated, and there is no question that an increase from 160 deaths to 198 deaths shows an increase of typhoid in the city.

Q. Don't the number of deaths from typhoid largely depend upon the unskillful attention that the patient receives, whether from doctor or from nursing?

A. It depends somewhat upon that, and also upon the amount and intensity of the infection that he has, I should judge.

Q. Well, don't it depend largely on the number of deaths in cases of well defined typhoid—doesn't the number of deaths in that number of cases depend upon the skill of the physician; the enviroments, the attention and the nursing that the patients receive?

A. There is no question but the mortality in typhoid is affected by the skill of the physician, the care of the nursing and attendants and so on; but the history of typhoid in the United States shows by the decrease in deaths from it as time goes on, that we are acquiring continually greater and greater skill in the handling of the disease, and the assumption is, and 4219 it is well borne out by the facts, that we are able to handle it better than before, and considering those facts, I should say that the probability was that less people die of typhoid fever, —or would have died of typhoid fever, out of the same number of cases in 1901, than would have died of it in 1900.

Q. Now if we assume that the number of cases, as is illustrated upon the chart that is already in evidence, is true, and that those cases started in 1896 with 291; 1897, 433; 1898, 426; 1899, 908; 1900, 1213; 1901, 1101; 1902 1112, would you say, as an expert sanitarian, that the typhoid conditions existing in St. Louis for 1900 and 1901 and 1902, were attributed to the drainage Canal of Chicago and not to the same causes which created the uniform increase in typhoid fever from 1896 up to 1899?

A. Assuming that these figures given are correct, which I judge to be the case,—as representing the number of cases of typhoid fever which were reported, but which I absolutely deny to represent the number of cases that existed in St. Louis during any of the years in question—

Q. Well, just assume the facts in my question as true.

GENERAL CROW: He is answering it. Go ahead with your answer.

4220 A. (Continuing) I consider that the records of cases in the city of St. Louis in regard to typhoid, proved nothing except that all the cases were not reported in the earlier years, and are not reported now.

Q. Suppose that this number of cases reported, had all died, and what is here assumed as the number of cases was assumed as the number of deaths, then what conclusion would you arrive at?

A. I would say that St. Louis was getting into Chicago's class.

Q. Well just eliminate Chicago for a second and confine ourselves to the conditions in St. Louis.

A. All right. Now give me the straight question.

Q. Regardless of Chicago's class—

A. Without modification, just give me your straight question in a few words now.

Q. Assume that the number of cases—

A. Cases or deaths?

Q. The number of cases as I have given them to you, from 1896 to 1902, were deaths, to what would you attribute the gradual increase in typhoid fever in the city of St. Louis from 1896 to 1902?

A. To gradually increased infection from somewhere.

Q. Where?

4221 A. I don't know. I would have to investigate the matter to see. Inasmuch as the condition assumed is contrary to the fact, I have not taken the trouble to investigate it.

Q. Would the fact that the number of cases, instead of being typhoid cases, were typhoid deaths, change the conditions to you?

A. Change the conditions of what, Mr. Todd?

Q. As to the cause?

A. If I were confronted with such a record of deaths as this in the city of St. Louis, it would very materially change my view as to the cause of the increase, temporarily, at least. I might ultimately come to the same conclusion, but with those statistics before me I do not consider the case at all comparable with the one that I have been investigating at first sight.

Q. Assuming that these figures which show the number of cases—that all the cases died, and this represented the total number of typhoids in St. Louis—

A. You want mortality percentage of 100 in this case—everybody died?

Q. Yes sir.

A. All right.

Q. Would that change the condition?

A. Well, I think the answer to the last question was substantially the answer to this. If I were confronted with that condition of affairs in St. Louis I should certainly make a further investigation as to the cause of such conditions existing. 4222

Q. Suppose that this number of cases none of them died, and by the best scientific knowledge of today, these cases were tested in the laboratories and ascertained to be typhoid fever, and included all the typhoid in the city of St. Louis, to what would you attribute, knowing all the conditions that existed during those seven years, as you do, to what would you attribute the gradual increase in the number of cases, from 1896 to 1902?

A. I couldn't say without making a study of the conditions with such facts in view, these facts being contrary to those existing, have not been considered in my investigation of this case.

Q. Do you deny and have you any facts upon which to base that denial, that the number of cases as assumed in my question, is not a true condition in the city of St. Louis?

A. As assumed in your last question?

Q. Yes?

A. I certainly do deny it.

GENERAL CROW: True representation of all the cases you mean?

MR. TODD: True representation of all the cases.

4223 A. I certainly do deny that it is a true representation of the conditions in St. Louis.

Q. Upon what facts do you base that denial?

A. Upon the fact that any such mortality as is indicated by the record for instance of 1896, where you have 291 cases and 106 deaths, is so preposterous, from the standpoint of all knowledge and history of typhoid, that it is simply absurd to advance or consider any such proposition.

Q. In your consideration of this question did you take into consideration the sewage from Peoria?

A. I did.

Q. What is the amount of sewage that enters the Illinois river from Peoria?

A. I don't know.

Q. Do you know how many cattle are fed at Peoria?

A. I don't recall at the present moment.

Q. Have you any idea of the number?

A. Oh, it is a very large number.

Q. How many would you say?

A. Oh, I could only make a guess. I know that Peoria is a place where cattle are very extensively fed, and it probably compares—

Q. Have you investigated the character of the sewage that comes into the Illinois river from Peoria?

A. Not particularly.

4224 Q. Do you know the difference between the sewage from distilleries and that from slaughter houses?

A. Why, there is some difference.

Q. Do you know whether there is any difference between the sewage from distilleries and the sewage from glucose factories?

A. Oh, there certainly is.

Q. Do you know whether there is any acids discharged into the river from a large glucose factory?

A. There would be likely to be.

Q. Do you know in what quantities?

A. I do not.

Q. Do you know whether any acids would be discharged into a river from distilleries?

A. It would be likely.

Q. What effect would the discharge of acids into a stream the size of the Illinois, from large distilleries at Peoria, and glucose factories at Peoria, have upon the life of the typhoid bacillus?

A. Oh, that would depend very much upon the alkalinity of the water in the first place. Under some conditions it might tend to prolong it, under other conditions it might tend to decrease the life of the bacillus.

Q. Have you ever made any experiments under those
4225 assumed conditions?

A. What are the assumed conditions please?

Q. Such as you have stated?

A. I have assumed no conditions.

MR. TODD: Read that last question and answer.

(Question and answer read). Those are the assumed conditions.

A. Not personally.

Q. Do you know of anybody who has?

A. The life of typhoid fever bacilli in alkaline and salt waters has been experimented upon and compared with its life in slightly acidic waters—

Q. Do you know of anybody who has made experiments with the typhoid bacillus in water impregnated with the sewage discharged from a distillery or glucose factory?

A. I am not aware of anyone who has done so, at the present moment.

Q. Do you know whether that discharge would tend to increase or decrease the life of the typhoid bacillus?

A. I am not able to say postively, it might do either.

Q. Then if you are not able to say whether it would or it would not, can you say whether or not a typhoid bacillus on his journey from Chicago to St. Louis coming in contact with the sewage laden water at Peoria from the distilleries and gluclose factories, would be able to live the journey?

4226 A. I cannot say whether a specific typhoid bacillus would or would not be able to live under the circumstances assumed.

Q. Can you say whether a whole tourist excursion of those bacilli would live or not?

A. I think it is entirely probable that some of them might squeeze through.

Q. Upon what do you base your doctrine of probability in the absence of any specific knowledge as to whether the individual bacillus would live in a medium of that character?

A. The fact which is very evident to my mind, that certain typhoid bacilli or some typhoid bacilli started from Chicago have lived, passed through the Illinois river and infected the water supply of St. Louis, and produced typhoid in those who have used it.

Q. Do you know of anyone that has ever been able to prove that the typhoid bacillus that left Chicago ever arrived in St. Louis?

A. I think we have pretty nearly proved it in this case.

Q. Well, eliminate "we" do you consider that you have proved it?

A. I don't know that I want to say that by my own individual self I have proved it, but I think it has been proven.

Q. Well nobody knows any more about this subject than you do, do they?

4227 A. Well, I don't think that anybody knows very much more.

Q. And do you know it all?

A. Oh no.

Q. Do you know whether before the typhoid bacillus that leaves Chicago can get into the intake tower at St. Louis, it must pass by Peoria, must it not?

A. It must pass somewhere in that neighborhood, certainly.

Q. Do you know how many distilleries empty their filth and sewage into the Illinois river at Peoria?

A. No, I do not, but I don't imagine that the number is any greater than formerly emptied there.

Q. How many emptied there formerly, if you know?

A. I don't know; but I don't imagine that it was very many less than do now.

Q. Well, does that give you any idea as to the amount—the fact that no more empty into the Illinois river now than did formerly?

A. No, but I don't see that it is of any importance whether there are one, one hundred or one thousand in that case.

Q. Do you know the character of the sewage that comes from a distillery?

A. Moderately, I have some knowledge of it.

Q. Do you know how long a typhoid bacillus will live in that kind of sewage?

4228 A. I shouldn't expect it to live a great while.

Q. Do you know what the character of the sewage that comes from a glucose factory is?

A. Oh, I have a moderate idea of it.

Q. Will a typhoid bacillus live in that medium any length of time?

A. I couldn't say.

Q. Can you say whether they would or would not live based upon any scientific knowledge, in a medium the size of the Illinois River at Peoria, receiving the discharge from the four distilleries there and the large glucose factory?

A. I certainly could, because they evidently do.

Q. Or the number of distilleries there—

MR. JEFFRIES: We object to the question for the reason that the comparison before and after the opening of the canal cannot be properly made so far as the fact of the sewage from these distilleries and glucose factories is concerned, because of the increased volume of water coming down the Illinois river by means of the opening of the canal.

MR. TODD: In reply to the objection I will state that my question does not include the subject of your objection.

Q. Have you ever been able to identify any bacillus of typhoid found in the Mississippi river above the intake as being indigineous to Chicago and not coming from the other

4229 towns located upon the watershed of the Mississippi river, above its intake, the Missouri and Illinois?

A. Certainly not, and it would be absolutely impossible to do so any more than it would be possible to determine from what source a potato came that you might find floating in the river.

Q. Would the fact that you found a potato floating in the river prove that it came from Chicago?

A. Certainly not.

Q. If you are not scientifically able to state that the sewage conditions existing in the Illinois river at Peoria, do not kill the germs of typhoid, or do not aid in its longevity, and a condition existing below Peoria on the Mississippi river, where other typhoid germs may come from other places, how are you able to state that the typhoid germ will pass through the sewage polluted Illinois river at Peoria?

MR. JEFFRIES: We object to the question for the reason that Chicago is not responsible for the distilleries at Peoria, and so far as this record is concerned, there is nothing to show that they contribute anything to the maintenance of the distilleries at Peoria, which kills off the germs, if they do so.

MR. TODD: In reply I will state this is not a case against Chicago, but a case against the State of Illinois.

4230 GENERAL CROW: Well, we could show the same thing in regard to Illinois; that they did not build the distilleries.

Q. (Question read).

A. Because it is entirely possible that the typhoid germ might pass through the sewage polluted Illinois river at Peoria without coming in contact with the sewage from the distilleries and glucose factories that you have been discussing, if such exist.

Q. Do you know that to be a fact?

A. Oh, I think there is no question about it.

Q. Or, is it a matter of reasoning?

A. It is a fact.

Q. Can you demonstrate it scientifically?

A. I think so.

Q. When did you first begin the investigation of the germ known as anthrax?

A. Sometime in 1895.

Q. And the germ of tetanus?

A. About the same time.

Q. Have you ever known of anybody catching lockjaw from drinking the germs of tetanus?

A. No sir.

Q. Is it contended that people get it by taking it in through the alimentary canal?

4231 A. I believe not.

Q. So that it doesn't make any difference whether that germ goes through the drainage canal or not?

A. I think it does.

Q. Would it have any effect upon the health of a man who drank it?

A. I don't know that it would. It might or it might not.

Q. What is your opinion about it?

A. It would depend upon the condition of his intestines.

Q. Well, assuming that the ordinary citizen of St. Louis has a normal intestinal tract the same as other people, what is your opinion about the effect of the germ of tetanus?

A. I think it is possible that he might get lockjaw from taking it internally, even though his intestines were all right. For instance, he might have a raw place in his throat, due to a cold or something of that sort.

Q. Is there anything beyond the bounds of possibility in the sanitary science or epidemiology?

A. I think there is, for instance that the typhoid fever germs contributed by the Chicago Drainage Canal should all die before getting to the St. Louis intake.

Q. Anything else except that?

A. Oh, there may be others.

Q. Assuming that there should be typhoid fever in New
4232 Orleans, and two months before one case of typhoid fever
appeared upon a steamer in Lake Itasca, the source of the Mississippi river and there were no other cases of typhoid fever between that point and New Orleans—

A. And no other source of infection I suppose you mean?

Q. Yes. Would you attribute the cases in New Orleans to the cases in Lake Itasca?

A. I am afraid I would have to. These things do not generate of themselves.

Q. Has that been demonstrated?

A. Well, there are several who have tried very hard to demonstrate that they did, and they have slipped up on it, given it up.

Q. Were they epidemiologists?

A. I think so. I think they would be ranked as such. Pasteur was one of them, at least.

Q. Now, in regard to this anthrax occurring in Chicago. Did you ever hear of a case of anthrax in the City of Chicago?

A. I don't know that I have. No, I am free to say that I have not heard of a case coming from the City of Chicago.

Q. If a case of anthrox should appear 200 miles south of St. Louis on the Missouri side, and the cause was drinking Mississippi river water, would you attribute that to the sewage of the Chicago drainage Canal?

A. Not necessarily.

4233 Q. Do you regard the sewage of Chicago as a greater menace to the inhabitants of Missouri than the sewage discharged by the City of St. Louis into the Mississippi—

A. Certainly.

Q. Than to those lying south of St. Louis?

A. Yes, I think I do because if Chicago were not around, St. Louis wouldn't have so much typhoid, inasmuch as Chicago increases apparently the typhoid in St. Louis, she therefore makes the sewage of St. Louis so much more of a menace, and I think is to be charged with quite a bit of the account on that view of the case.

Q. Assuming that Chicago sewage should be cut off, what would you say about the condition of the Mississippi river on the Missouri side to the people in Missouri drinking the waters of the Mississippi after it had received the sewage discharge of St. Louis?

A. I should say it would be unfit water for them to drink.

Q. Is there any more liability of anthrax occurring in Chicago than in St. Louis?

A. I don't know that there is.

Q. Is there any more danger of hog cholera occurring in Chicago than in St. Louis?

A. I don't know that there is.

Q. You spoke of hog cholera appearing in the stock yards
4234 of Chicago?

A. Yes, sir.

Q. Are you acquainted with the conditions at the stock yards?

A. Only to a moderate extent, but if there are live hogs there, it is entirely probable that hog cholera may be present, and I imagine that there are live hogs there most of the time.

Q. Do you know whether or not every hog is inspected before it is admitted to the Chicago Stock Yards?

A. No, sir; but inspection cannot determine the presence or absence of hog cholera absolutely, any more than inspection can determine the presence of typhoid in a person coming down with it.

Q. Do you know that in the treatment of the hog, how much of that residue gets into the drainage system of Chicago?

A. I know that it is a very small portion.

Q. Did you when you dipped into the future, anticipate a cholera of hogs along the Missouri shore as due to Chicago?

A. It is entirely possible to get it.

Q. Isn't it more possible that if they did get cholera along the southern border of Missouri south of St. Louis along the Mississippi that it should come from St. Louis more likely than from Chicago?

A. It is entirely possible that it should come from there. Yes, I think it would be more likely that it came from there. I should look in St. Louis for the source of infection before
4235 I looked in Chicago.

Q. When you looked into the future and saw an impending calamity of cholera, did you really believe that such a thing was possible?

A. I certainly did and certainly do.

Q. Of Asiatic cholera.

A. Of Asiatic cholera. I see no reason why an epidemic of Asiatic cholera might not be brought into the United States almost at any time, and if so brought, I think Chicago is in a position where she is particularly likely to get it.

Q. More so than St. Louis?

A. Yes; vastly.

Q. With a World's Fair coming on and with people from all of the Orient coming here, do you think that Chicago is more likely to get it?

A. That is only next year, and they all pass through Chicago anyway.

Q. You believe then that Chicago is more likely to get Asiatic cholera than St. Louis?

A. I do, yes; in the event of its coming to this country at all.

Q. Now, in regard to anthrax, the case you spoke of appeared here in St. Louis. Do you know whether that was due to the water of the Mississippi?

A. I think so; it has been attributed to the water.

4236 Q. Who attributed it to the water?

A. The man who had the case.

Q. Who had the case?

A. A physician here in town.

Q. What is his name?

A. A. Ravold.

Q. Did you say that Dr. Ravold attributed that to the drinking water as a certainty?

A. Dr. Ravold attributed it to the water as being the most probable source.

Q. What water?

A. The water which was used for domestic purposes in the City of St. Louis and which came from the public system.

Q. Is that the only case of anthrax that has been found here?

A. I think not.

Q. What other case has ever been found here?

A. I have been informed there have been other cases, but I haven't any specific information on the subject.

Q. The case of anthrax to which you referred; do you know the history of it?

A. I have been told something of the history of it.

Q. That was the case where the woman was scrubbing the floor and got a piece of slate in her hand, wasn't it?

4237 A. No, sir.

Q. What were the facts?

A. I believe she was scrubbing a sink and got a piece of slate in her hand.

Q. Any other facts in the history that you know connected with it?

A. It was proved to be a case of anthrax. Inquiries were made to ascertain the source, and it was impossible to ascertain that there had been anything in the neighborhood of the sink that might have communicated the germ; at least it was not ascertained that there had been, other than the water, and knowing that bacillus had already been found in the waters of the Illinois river, it is at least a moderately justifiable assumption to say that it may have come from the water, and in fact very probably did.

Q. Would you assert from the history of the case as you got it, that the water is the only explanation?

A. No, sir; not for a minute.

Q. But the man who discovered it, gave it that explanation?

A. I think, as I understand it, he was unable to explain it for a considerable time, and at last concluded that the water was the most probable explanation.

Q. Was it attributed to the water of the Illinois river?

4238 A. I couldn't say, not specifically.

Q. When you look into the future do you expect to see an anthrax epidemic in Missouri?

A. I shouldn't be surprised, understanding that there has been an epidemic of it in Missouri in the past few years.

Q. How long ago was it?

A. I couldn't say exactly, a matter of a few years.

Q. As much as five years?

A. It may have been. I am not certain. My impression is it was two or three years ago. It may have been four or five.

Q. Was that before or since the opening of the drainage canal?

A. I couldn't say; I didn't inquire.

Q. Well, if it was prevalent here prior to the opening of the drainage canal and the germ of anthrax is indestructible, would you as a scientist who dips into the future, attribute a subsequent epidemic to any contagion that might come from Chicago?

A. I shouldn't be inclined to attribute an epidemic of anthrax to Chicago upon its first appearance, but knowing the intimate relations which exist between Missouri, or between Chicago and St. Louis, I could readily conceive that the anthrax beginning in Missouri might travel to Chicago, infect the
Chicago sewage and come back to Missouri with redoubled
4239 force as a result, and that such is quite probable, and that
the existence of such a possibility is an added menace to
the health of the people of the State of Missouri.

Q. Suppose these cattle that you spoke of should also be shipped to Kansas City, Kansas, on the Kaw river, wouldn't they come down to Missouri?

GENERAL CROW: Do you mean cattle or anthrax?

MR. TODD: I mean anthrax?

A. I should think that possibly they might and in fact probably they might.

Q. Now, if some of these cattle with this disease should be shipped to Kansas City, Kansas, and to Chicago and anthrax should break out on the shores of Missouri, would you as an epidemiologist be able to tell whether it came from Chicago, or whether it came from Kansas City, Kansas, or not?

A. Not without considerable more knowledge of the facts than your question implies, and I doubt if even with the knowledge that I could get, it would be possible to separate the thing, in any practical case.

Q. How many epidemics have you personally investigated?

A. Four or five.

Q. Is there any school which graduates a student with the degree of epidemiology?

A. Not in this country, at least, that I am aware of.

4240 Q. I mean in this country?

A. Not that I am aware of.

RE-DIRECT EXAMINATION, by General Crow.

Q. I believe you stated in answer to Judge Johns' question that you only found recorded in the official records two cases of typhoid fever in the year 1891 in Port Huron?

A. I did so state.

Q. Now, do you know whether they kept any official records, or made any official reports prior to 1891, in Port Huron?

A. They made no regular reports in Port Huron prior to 1893, I think.

Q. Well, then, the two cases in 1891 were not officially reported?

A. Well, they seem to have been accidentally reported by somebody.

Q. By whom?

A. I think they were reported to the State Board of Health, although I am not positive as to that, as I got the statistics at that time from both the State Board of Health and from the local Board of Health of Port Huron, and from among those statistics I was able to locate the two cases in question.

Q. Well, the city records of Port Huron, do they disclose
4241 any official recording of mortality from typhoid fever,
prior to 1891, or during 1891?

A. Well, I am not able to state positively at the present time, my impression is that in general there were not established satisfactory records in Port Huron previous to the latter part of 1892.

Q. Well, speaking generally from your information, do you know or have you any reason to believe that there were other cases in 1891 and prior to 1891, for several years, of typhoid fever in Port Huron?

A. Yes, there was no doubt about it. For instance, the report of the State Board of Health of Michigan for 1890, page 219, relates, or rather shows that four cases of typhoid occurring elsewhere in the State of Michigan were attributed by the health officers there to an original infection in Port Huron, which of course would indicate that there must have been typhoid in Port Huron at that time, and the report for 1891 (page 237) reports that the cause of 9 cases and 2 deaths of typhoid in Sanilac county, which is the next county to St. Clair county in which Port Huron is situated, is reported by the health officers of the respective communities, as being traced to an unreported outbreak of typhoid in Port Huron: And again in the report of the State Board of Health of Michigan in 1892, page 252, there
are reported 50 cases and 26 deaths throughout the state
4242 traced, on the authority of the health officers who re-
ported these cases, to the State Board, to another unreported outbreak in Port Huron; and on page 268 of the Report of State Board of Health of Michigan, for 1893, there are reported from Port Huron 22 cases and 2 deaths of typhoid, and in the same year there are reported five cases and two deaths as being traced to Port Huron as the source of the infection. So that if in all the reports from the state there were in 1893, 5 cases and two deaths traced to Port Huron, and 22 cases and 2 deaths reported in Port Huron at that time, it seems to me

at least fair to assume that there being nine cases and 2 deaths traced to Port Huron in 1891, there must have been probably more typhoid there at that time than there was in 1893, and similarly again in 1892, fifty cases and 26 deaths were traced to Port Huron—I may say incidentally that the records at Port Huron show a large number of cases of typhoid in Port Huron during 1892, there being as many I think as 193 in one month, and bearing in mind, moreover, that the typhoid fever was in Michigan at this time very common and an ordinarily prevalent disease, and the character of the population of Port Huron, the situation of the town and also the testimony which had been given me by the health officer at Port Huron, that typhoid fever was a common disease and prevalent very nearly all the time there during the years preceding 1897, when
4243 I made inquiries of him, I think there is no question whatever, no doubt whatever, that there was a large amount of typhoid prevalent in Port Huron in 1891, and in the early part of 1892, and for years previous and years following that time.

Q. Mr. Williams, I will get you to state, if you can, as to the least time, about what the least time, you think under the conditions as they ordinarily exist, that water would flow from the point where the material dredged from the Black river in front of Port Huron was dumped into river St. Clair down to the intake of the Detroit Waterworks in the year 1892?

JUDGE JOHNS: Object to the question as not proper on re-direct examination.

A. Somewhere in the neighborhood of eight days.

Q. GENERAL CROW: Mr. Williams, I will get you to state if you have considered at all the effect of the Illinois and Michigan Canal, the sewage as pumped into it by the pumps at Bridgeport prior to the year 1900, say in 1899 and prior thereto, and its influence, if any, upon the water supply at the intake tower in the City of St. Louis?

A. I think it is entirely possible that the water passing through the Illinois and Michigan canal may have contributed somewhat to the typhoid in St. Louis, but it very evidently did not contribute very largely to that because the typhoid in St. Louis was not excessive during those years, and more-
4244 over that amount of water passing into the Illinois and Michigan Canal at Bridgeport was not sufficient to take

care of anywhere nearly the sewage of Chicago. In times of freshet the current of the river was turned toward the lake, and very large quantities of sewage material were washed out into the lake to the serious pollution of the water supply of Chicago, the washings having the effect of forcing the people of Chicago to extend their intakes in an endeavor to get beyond them, and ultimately to build the drainage canal, in order to prevent a recurrence of such discharges of filth into the lake, which was their water spply.

Q. Do you know whether some of the sewage yet of the sanitary district goes into the Illinois and Michigan Canal?

A. My impression is that some of it does.

Q. Mr. Williams, you have no accurate knowledge as to the fall from Morris to Peoria?

A. Except as I got it from profiles, and published data, supposed to be authoritative. Well, the elevation of the crest of the Copperas Creek dam is given as 149 below the dam and the elevation of the Marseilles dam is given as 101, which would cause 48 feet there substantially. I was speaking of the river level, of course.

Q. Now, Mr. Williams, in answer to the question of Mr.
4245 Todd in which he assumed that Minneapolis and Kansas City were rivaling each other to convey typhoid in the same space of time to the citizens of St. Louis, he asked you whether or not it was possible to tell provided all other things were equal and no other source of infection were open, whether the typhoid came from one city or the other. Now, I will ask you to state if there is any way to tell when typhoid germs have been once placed in the water, when and where they will convey that disease to persons drinking that water?

A. Not absolutely and specifically. You can be pretty sure they would be likely to convey it to any persons when they drink the water, within a period of time through which they may live. As that period is yet indeterminate it is impossible to state whether they will or will not at certain places. While we can be pretty sure that at certain other places they will convey infection.

Q. Now, in answering a question in your cross-examination, you gave several things that you would consider in determining

whether or not the Chicago sewage, if it was infected with typhoid germs, would be likely to infect the water coming into the intake tower at St. Louis Waterworks; now, I will ask you to state if you would consider the time factor, that is the time within which it would take water bearing infected sewage to flow, an important item in making up your judgment
4246 on the question?

A. I certainly should.

Q. Well, how much importance would you give to that factor of time?

A. Well, it is hard to state any percentage, but I should consider it as one of the most important factors to consider. In fact, next to the fact that infection was put in, I think I should consider the time it took to get somewhere else.

Q. Mr. Todd asked you a question today as to whether or not if there were any additional facts that might come to your knowledge as to the prevalence of typhoid fever in the cities from which the complainant has introduced reports, from the watershed tributary to the intake of the St. Louis Waterworks, if these facts might or might not affect the conclusion you would arrive at, and I think you stated in a general way that perhaps they might not affect your judgment materially. Now, I will ask you if you meant to convey by that answer the impression that no facts that might come to your knowledge bearing upon the subject of typhoid infection in water, would not affect the conclusion you would arrive at?

A. I will say in answer to that question I had in mind the difference of the significance of the words "might" and "could," the questioner using the word "could." What I meant
4247 to imply, or what I meant to convey by my answer was that it didn't seem to me possible that any facts could be adduced which had not already been considered, that would have a sufficiently important bearing upon the question to change my opinion upon the general proposition. I did not mean of course that my opinions were not subject to modification as additional facts might be brought out.

Q. I will ask you Mr. Williams, if in your examination of the typhoid statistics whether or not you found the increase in typhoid fever in St. Louis had been continuous and regular since the 17th of January, 1900, generally speaking?

A. I found that it has been regular and continuous, and that up to the very last date at which we have a record, it shows itself continuing and increasing.

Q. Now, in studying from the standpoint of an epidemiologist, the effect of disease in a community, what effect would the continuous rise in the mortality rate for certain diseases in the city have upon the opinion of a man in figuring out as to whether it came from a local cause or came from a cause that existed theretofore when conditions had not changed, except in the one respect to which the increase in death has been attributed?

A. Any one in studying the conditions of nature, is compelled to look for a cause for every effect, and if it were found that certain diseases were increasing the natural inference and proper assumption would be that there was a continuing and increasing cause for the existence of that disease, and if it should prove upon investigation that at a certain time this increase began, we should look at that time for the beginning of the cause which was leading to the increase. 4248

RE-CROSS-EXAMINATION, by Mr. Todd.

Q. In your investigations in regard to increase, did you take into account the number of cases or the number of deaths?

A. The number of deaths.

Q. If the number of deaths should show an increase and the number of cases a decrease, or normal for 1901 and 1902, what would you say?

A. I would say as I have stated already, that I consider the death record decidedly more reliable than the record of cases and therefore I very seldom gave to the cases any great amount of consideration in investigations of this kind, and I think in fact, my usage is in accordance with all others who investigate these subjects for the reasons which I have already stated.

Q. If you should find that the cases had been accurately diagnosticated, would that change your views any?

A. No, sir; it is not a question of diagnosis at all; it is a question of report and a question of ascertaining the cases.

4249 Q. Suppose it should appear that the cases reported were the correct number of cases existing, and the cases reported were correct diagnostications of the cases, would that affect you any, or would you still adhere to the death standard?

A. I should consider that in all human probability, that the death standard would be the safer one to rely upon. If it were absolutely proved that the other were the case, that is, that the number of cases represented all the cases, and that the probability of a correct diagnosis was the same as in the case of deaths, I should then give the record of cases an equal weight with the record of deaths.

GARDNER S. WILLIAMS.

MR. JEFFRIES: Now we formally offer, at the conclusion of this witness' testimony a certified copy of the typhoid fever deaths for the various years previously stated, at Kansas City, Missouri; St. Charles, Missouri; Council Bluffs, Iowa; St. Joseph, Missouri; Lincoln, Nebraska; Omaha, Nebraska; Chicago, Illinois; Davenport, Iowa; Moline, Illinois; Rock Island, Illinois; Galena, Illinois, and Warsaw, Illinois.

MR. TODD: I object to the documents as incompetent.

THE COMMISSIONER: On suggestion of the Attorney-General of Missouri, complainant's Exhibit No. 22 was withdrawn, for correction, defendants' counsel consenting thereto.

The documents above offered, are in words and figures as follows, to-wit:

4250

ROCK ISLAND, ILLINOIS.

Year....	Jan.....	Feb.....	Mar.....	Apr.....	May.....	June....	July.....	Aug.....	Sept....	Oct.....	Nov.....	Dec.....	Total 12 months.
1893	0	3	1	1	1	1	1	1	4	0	0	2	15
1894	0	0	3	0	1	1	0	0	3	0	3	2	13
1895	2	0	1	0	0	0	0	0	0	0	0	0	3
1896	0	0	2	1	0	2	6	2	0	0	0	0	13
1897	0	0	0	0	0	0	0	0	0	0	0	0	0
1898	0	0	0	0	0	0	0	0	0	0	0	0	0
1899	0	0	0	0	0	1	4	2	0	0	0	3	10
1900	4	1	3	0	0	1	0	0	2	0	1	2	14
1901	8	6	9	0	3	1	0	0	0	0	1	0	28
1902	1	0	0	0	0	0	0	1	0	1	1	1	5
1903	0	1											

State of Illinois, } ss.
County of Rock Island. }

I, Henry B. Hubbard, Clerk of the County Court of the County and State aforesaid, and Custodian of Mortuary records of the said County of Rock Island, do hereby certify that the foregoing is a true copy of the deaths from typhoid fever in the city of Rock Island for the years and months therein given 4251 as shown by the original death records. I further certify that said records are important public records and cannot be removed from my office.

Witness my hand and official seal this 11th day of May, 1903.

(Seal) (Signed) Henry B. Hubbard,
Clerk County Court.

4252

GALENA, ILLINOIS.

Year....	Jan.....	Feb.....	Mar.....	Apr.....	May.....	June....	July....	Aug....	Sept....	Oct.....	Nov.....	Dec.....	Total 12 months.
1893	0	0	0	0	0	0	0	0	0	0	0	0	0
1894	0	0	0	0	0	0	0	0	0	0	0	0	0
1895	0	0	0	0	0	0	0	0	0	0	0	0	0
1896	0	0	0	0	0	0	0	0	0	0	0	0	0
1897	0	0	0	0	0	0	0	0	0	0	0	0	0
1898	0	0	0	0	0	0	0	0	0	0	0	0	0
1899	0	0	0	0	0	0	0	0	0	0	0	0	0
1900	0	0	0	0	0	0	0	0	0	0	0	0	0
1901	0	0	0	0	0	0	0	0	0	0	0	0	0
1902	0	0	0	0	0	0	0	0	0	0	1	1	2
1903	0	0	0	0									

State of Illinois, } ss.
Jo Daviess County. }

I, Jasper C. Williams, Clerk of the County Court and County Clerk of Jo Daviess County, State of Illinois, and Custodian of the Mortuary Records of said County, do hereby certify that the foregoing is a true copy of the record of deaths from

typhoid fever occurring in the City of Galena, County and
4253 State aforesaid, for the years and months therein given,
as shown by the original death records.

I further certify that said records are important public records and cannot be removed from my office.

WITNESS my hand and official seal, this 13th day of May, 1903.

(SEAL)

(Signed) Jasper C. Williams,
Clerk.
By W. Barner,
Deputy.

4254

STATEMENT OF DEATHS CAUSED BY TYPHOID FEVER IN THE CITY OF MOLINE, ILLINOIS.

Total number of deaths for	1893, 218.	Caused by typhoid fever,	7
do	1894, 224.	do.	9
do.	1895, 237.	do.	8
do.	1896, 230.	do.	11
do.	1897, 204.	do.	3
do.	1898, 217.	do.	5
do.	1899, 338.	do.	20
do.	1900, 324.	do.	22
do.	1901, 323.	do.	16
do.	1902, 235.	do.	7
do. from Jan. 1st, 1903, to	May 16th, ’03, 71.	do.	1

State of Illinois. }
County of Rock Island } ss.
City of Moline. }

I, Chas. G. Carlson, City Clerk of the City of Moline, State of Illinois, do hereby certify that I am the custodian of the mortuary records of the City of Moline, in the State of Illinois,
and that the above statement is a true copy of the said
4255 records, showing deaths from typhoid fever for the years
therein mentioned.

I further certify that the said mortuary records are in daily use and are of public importance and cannot be removed from office.

(SEAL)

(Signed) Chas G. Carlson,
City Clerk.

4256 DAVENPORT, IOWA.

Year....	Jan....	Feb....	Mar....	Apr....	May....	June....	July....	Aug....	Sept....	Oct....	Nov....	Dec....	Total 12 months.
1893	0	1	0	0	0	0	0	0	2	0	1	1	5
1894	0	1	0	0	0	0	0	3	0	0	1	1	6
1895	0	0	1	1	1	0	0	0	0	1	0	0	4
1896	0	1	0	1	0	0	0	0	0	0	1	0	3
1897	0	0	0	0	1	0	0	2	0	1	0	1	5
1898	0	1	0	0	0	0	0	0	0	0	0	1	2
1899	1	1	1	0	1	0	0	1	1	2	1	3	12
1900	3	1	1	2	0	1	2	0	1	1	0	2	14
1901	1	1	1	1	2	2	0	0	0	1	1	1	11
1902	0	2	1	1	1	0	1	2	0	2	0	1	11
1903	No returns for 1903.												

State of Iowa }
} ss.
County of Scott }

I, W. G. Noth, Clerk of the District Court within and for the County of Scott and State of Iowa, and Custodian of the Mortuary Records of said County, do hereby certify that the foregoing is a true copy of the record of deaths from typhoid fever occurring in the City of Davenport, in the State and County aforesaid, for the years therein given as shown by the original death records. 4257

I further certify, that said records are important public records and cannot be removed from my office.

Witness my hand and official seal this 12th day of May, 1903.

(SEAL)

(Signed) W. G. Noth,
Clerk of the District..

4258

DEPARTMENT OF HEALTH.

Arthur R. Reynolds, M. D.,
Commissioner.

Chicago, March 12th, 1903.

DEATHS FROM TYPHOID FEVER IN CHICAGO,1890-1902.

1898	1008
1891	1997
1892	1489
1893	670
1894	491
1895	518
1896	751
1897	437
1898	636
1899	442
1900	337
1901	509
1902	801

I hereby certify that the foregoing is a true copy of the records of this Department, of deaths from Typhoid Fever, from January 1st, 1890, to December 31st, 1902.

(SEAL)

(Signed) Arthur R. Reynolds, M. D.,
Commissioner of Health.

4259 Tabulated list of deaths from typhoid fever in the city of Omaha, Nebraska, for the years 1893 to 1903.

Year.	*Deaths reported.*
1893	22
1894	40
1895	29
1896	18
1897	22
1898	32
1899	26
1900	24
1901	23
1902	20

State of .... }
} ss.
County of ....}

I, J. B. Ralph, M. D., of the City of Omaha, State of Neb., do hereby certify that I am the custodian of the mortuary list of the city of Omaha, and that the hereto attached statement is a true and direct copy of the lists of deaths from typhoid fever within said city from the original death records of said city, for the years and months therein stated, and that the original records are of public importance, and cannot be removed from my office. 4260

Given under my hand and official seal this May 11, 1903.

(Signed) J. B. Ralph, M. D.,
Commissioner Health.

(SEAL).

4261 Tabulated List of Deaths from Typhoid Fever in the City of Lincoln, Nebraska, for the years 1893 to 1903.

Year	*Deaths Reported.*
1893	33
1894	21
1895	23
1896	15
1897	14
1898	12
1899	13
1900	4
1901	13
1902	10
Total,	158

State of Nebraska }
} ss.
County of Lancaster }

I, William C. Rhode, of the City of Lincoln, State of Nebraska, do hereby certify that I am the custodian of the mortuary list of the City of Lincoln, and that the hereto attached statement is a true and direct copy of the lists of deaths from typhoid fever within said city from the original death 4262 records of said City, for the years and months therein stated, and that the original records are of public importance, and cannot be removed from my office.

Given under my hand and official seal, this 11th day of May, 1903.

(Signed) William C. Rhode,
Health Officer.

(SEAL).

4263

Warsaw, Illinois. Copy of the Mortuary records.

Time.	No. of deaths.	Typhoid fever.	All other causes.
January, 1902,	2	none	
February, 1902,	2	none	
March, 1902,	5	none	
April, 1902,	none	none	
May, 1902,	1	none	
June, 1902,	none	none	
July, 1902,	5	none	
August, 1902,	2	none	
September, 1902,	6	1	
October, 1902,	none	none	
Nov., 1902,	3	none	
December, 1902,	2	none	
January, 1903,	6	none	
February, 1903,	2	none	
March, 1903,	3	none	
April, 1903,	5	none	
May, 1903,	1	none	

The record contains no statistics previous to the above dates.

4264

State of Illinois. }
County of Hancock. } ss.

I, Amos H. Wathen, of the city of Warsaw, State of Illinois, do hereby certify that I am the custodian of the mortuary list of the city of Warsaw, and that the hereto attached statement is a true and direct copy of the lists of deaths from typhoid fever within said City from the original death records of said City for the years and months therein stated, and that the original records are of public importance, and cannot be removed from my office.

Given under my hand and official seal this 12th day of May, 1903.

(Signed) Amos H. Wathen,
City Clerk.

(SEAL).

4265

State of Missouri. }
} ss.
City of St. Charles. }

DEATHS CAUSED BY TYPHOID FEVER.

From July 1st, 1898, to July 1st, 1899:

January, 1899,	7 deaths,
February, 1899,	5 deaths,
March, 1899,	5 deaths,
April, 1899,	1 death.

Total—18 deaths.

From July 1st, 1899 to July 1st, 1900:

July, 1899,	1 death,
October, 1899,	1 death,
November, 1899,	1 death,
December, 1899,	1 death,
January, 1900,	1 death,
March, 1900,	1 death,
April, 1900,	1 death.

Total—7 deaths.

From July 1st, 1900 to July 1st, 1901:

July, 1900,	1 death,
November, 1900,	1 death,
January, 1901,	1 death.

Total—3 deaths.

4266 From July 1st, 1901, to July 1st, 1902:

March, 1901,	1 death,
October, 1901,	1 death,
November, 1901,	2 deaths,
December, 1901,	1 death,
January, 1902,	3 deaths,
February, 1902,	1 death,
March, 1902,	3 deaths,
April, 1902,	2 deaths,
June, 1902,	1 death.

Total—15 deaths.

From July 1st, 1902, to January 1st, 1903:

July, 1902,	1 death,
August, 1902,	1 death,
September, 1902,	1 death,
November, 1902,	1 death.

Total—4 deaths.

State of Missouri, }
} ss.
City of St. Charles. }

I, H.C. Sandforth,City Clerk and Ex-Officio Secretary of the Board of Health of the City of St. Charles, Missouri do hereby certify that the above and foregoing statement is a true 4267 and correct statement, by months, of the deaths from Typhoid Fever within said city from July 1st, 1898, to January 1st, 1903, as the same appears in the "Permanent Record of Deaths" in my office. I further certify that said "Permanent Record of Deaths" is a record in my office that cannot be taken therefrom, and that the City of St. Charles kept no record of deaths prior to July 1st, 1898.

In witness whereof, I have hereunto set my hand and affixed the seal of the City of St. Charles, Mo., this 9th day of May, 1903.

(Signed) H. C. Sandforth,
City Clerk and Ex-Officio Secretary
of the Board of Health of the City
of St. Charles, Missouri.

(SEAL)

4268

State of Missouri }
County of Jackson. } ss.

I, E. W. Davis, Clerk of the Board of Health, of the City of Kansas City, State of Missouri, do hereby certify that I am the custodian of the mortuary list of the City of Kansas City, and that the hereto attached statement is a true and direct copy of the lists of deaths from typhoid fever within said City from the original death records of said City, for the years and months therein stated, and that the original records are of public importance, and cannot be removed from my office.

Given under my hand and official seal this 9th day of May, 1903.

(Signed) E. W. Davis,
Clerk of Board of Health.

(SEAL).

4269 TYPHOID DEATHS IN KANSAS CITY, MISSOURI, from January 1, 1893, to January 1, 1903.

1893.		1894.	
January,	5	January,	2
February,	1	February,	1
March,	0	March,	1
April,	2	April,	0
May,	5	May,	0
June,	17	June,	5
July,	12	July,	1
August,	4	August,	13
September,	3	September,	6
October,	1	October,	3
November,	6	November,	4
December,	1	December,	1
Total,	59	Total,	37

4270

1895.		1896.	
January, 1895,	1	January,	2
February,	0	February,	2
March,	1	March,	1
April,	0	April,	4
May,	1	May,	1
June,	1	June,	0
July,	4	July,	4
August,	3	August,	6
September,	8	September,	3
October,	11	October,	2
November,	1	November,	2
December,	3	December,	2
	—		—
Total,	34	Total,	29

1897.		1898.	
January,	0	January,	6
February,	1	February,	2
March,	1	March,	3
April,	5	April,	1
May,	2	May,	1
June,	6	June,	4
July,	1	July,	8
August,	4	August,	7
September,	5	September,	6
October,	7	October,	4
November,	2	November,	6
December,	4	December,	1
	—		—
Total,	38	Total,	49

1899.		1900.	
January,	3	January,	0
February,	1	February,	4
March,	1	March,	2
April,	4	April,	3
May,	0	May,	0
June,	3	June,	2

1899.		1900.	
July,	2	July,	4
August,	11	August,	15
September,	11	September,	5
October,	5	October,	9
November,	7	November,	2
December,	4	December,	3
	—		—
Total,	52	Total,	49

4272

1901.		1902.	
January,	1	January,	7
February,	1	February,	4
March,	3	March,	3
April,	1	April,	2
May,	2	May,	2
June,	4	June,	3
July,	5	July,	3
August,	8	August,	6
September,	9	September,	8
October,	3	October,	3
November,	6	November,	10
December,	15	December,	7
	—		—
Total,	58	Total,	58

4273 State of Iowa, } ss.
Pottawattamie County. }

I, N. C. Phillips, City Clerk of the City of Council Bluffs, Iowa, do hereby certify that the attached statement of the number of deaths from Typhoid Fever in this city, from Jan. 1st, 1893, to April 30th, 1903, inclusive, is a true and correct copy of the records as the same remain of file in my office, said records being of public importance and in daily use and cannot be removed from my office.

Witness my hand and seal of the City of Council Bluffs this Eleventh day of May, 1903.

(Signed) N. C. Phillips,
City Clerk.

(SEAL).

4274

	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903
Jan.	0	0	0	0	0	1	1	1	0	1	0
Feb.	0	2	3	0	0	0	0	2	1	0	0
Mch.	0	0	0	0	0	1	0	0	0	1	1
Apr.	0	0	0	0	1	0	0	0	0	0	1
May	0	0	2	1	1	1	1	0	0	1	.
June	0	0	0	1	1	0	0	0	0	0	.
July	0	0	0	1	0	1	0	0	0	0	.
Aug.	3	1	0	3	0	1	0	3	0	0	.
Sept.	0	2	1	0	2	1	1	2	1	1	.
Oct.	2	1	0	1	1	0	1	0	2	0	.
Nov.	0	1	0	0	1	0	4	3	1	4	.
Dec.	0	0	0	1	1	0	0	0	1	0	.
Total	5	7	6	8	8	6	8	11	6	8	2

Grand total for ten years........................75.

4275

REPORT OF DEATHS FROM TYPHOID FEVER,
St. Joseph, Mo.

	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
Jan.	1	1	0	1	0	0	1	2	1	0	2
Feb.	2	0	1	1	0	1	2	1	1	0	1
Mch.	1	0	2	1	1	1	1	2	1	1	1
Apr.	0	2	3	0	0	0	0	2	1	0	0
May	1	2	1	0	2	1	1	1	0	1	1
June	0	4	0	0	1	2	2	2	2	0	0
July	1	3	1	4	0	2	1	2	0	2	1
Aug.	4	2	4	4	5	3	0	3	1	2	3
Sept.	3	1	4	5	4	4	4	5	2	1	2
Oct.	6	1	1	5	1	1	1	6	9	3	1
Nov.	2	2	5	9	2	0	3	8	2	1	0
Dec.	8	2	0	1	3	0	3	3	0	1	1
Total	29	20	22	31	19	15	19	37	20	12	13

Complete total ....237.

W. G. Crandell,
President Board Health.

(SEAL).

Will H. Hartigan,
Clerk Board of Health.

4276 State of Misouri.
County of Buchanan. } ss.

I hereby certify that I, Will H. Hartigan, have been duly qualified and sworn as Custodian of the Mortuary Statistics of the city of St. Joseph, which are open for public purposes, and cannot be removed from this office.

Witness my hand and the seal of the Board of Health this 11th day of May, 1903.

(Signed) Will H. Hartigan,
Clerk Board of Health.

(SEAL).

State of Missouri,
County of Buchanan. } ss.

I, Will H. Hartigan, of the city of St. Joseph, State of Missouri, do hereby certify that I am the custodian of the Mortuary list of the City of St. Joseph and that the hereto attached statement is a true and direct copy of the lists of deaths from typhoid fever within said city from the original death records of said city, for the years and months therein stated, and that the original records are of public importance, and cannot be removed from my office.

4277 Given under my hand and official seal this 9th day of May, 1903.

(Signed) Will H. Hartigan.

Adjourned until 10 A. M., Friday, May 29, 1903.

4278 Southern Hotel, St. Louis, Missouri. 10:00 a. m., Friday, May 29, 1903.

Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

GEORGE W. FULLER,

called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Attorney-General Crow, and testified as follows:

Q. Please give the stenographers your full name and address.

A. George W. Fuller, New York City.

Q. Mr. Fuller, please give me your occupation also, will you?

A. Sanitary expert.

Q. You are now engaged in that business?

A. Yes sir.

Q. Where were you professionally educated?

A. At the Massachusetts Institute of Technology in Boston, and the University of Berlin, Germany.

Q. Have you received an education as a bacteriologist?

A. Yes, I may say that I have, although that is not the particular branch of sanitary work which I gave the most attention to while at the Institute of Technology. That was the principal topic which I studied at Berlin, both at the 4279 hygienic institute and in the private laboratory of the engineer in charge of the filter plant of the Berlin waterworks.

Q. Have you been educated in chemistry?

A. Yes sir, it was from that department which I graduated at the Institute of Technology in Boston.

Q. You are also a practical constructor and engineer in the construction of water plants?

A. In regard to the necessity and advisability of treating water supplies by artificial processes, I would say that I have given that matter special attention, and with regard also to plans and specifications. I am not in the constructing business; not in the contracting line, nor do I ordinarily supervise construction.

Q. After your graduation from the Institute of Technology in Boston, did you have charge of any institution connected with the line of work for which you were educated?

A. Yes sir, after returning from Europe the first time that I was abroad, that is directly after my graduation from the Institute of Technology, I spent five years in the service of the State Board of Health of Massachusetts and the greater portion of that time I was stationed at Lawrence, where they have an experimental plant conducted with a view to finding the best ways of purifying sewage and water. I was for the 4280 greater portion of my stay the officer in immediate charge of that station.

Q. Well, as the officer in charge of that station you were engaged then for five years in experimenting with water and the influence of sewage upon water?

A. Yes sir.

Q. Now where did you go to from that point?

A. I spent four years, after leaving Lawrence, in the valley of the Ohio river, at the cities of Louisville and Cincinnati, being engaged in studying the best means of purifying the polluted Ohio river water as found at those cities.

Q. You were engaged upon that work professionally?

A. Yes, I was in charge of quite extensive studies and investigations. I suppose at those two places there was a hundred and fifty thousand dollars spent under my immediate charge, finding out the character of the Ohio river water at those two cities, and the best means of purifying it. By that I mean the cheapest way of accomplishing a practical and satisfactory result.

Q. Was a record kept of those results?

A. Yes sir, and they have been published in full.

Q. In what other places and cities in this country have you investigated water supplies?

A. Well for the past four years I have been in private 4281 practice, and have made investigations I suppose in upwards of twenty-five or thirty different cities, among which are a number of the larger ones in this country. I might mention the city of Washington, as one of these places where I was connected professionally, as a member of the special commission appointed by the United States Senate Committe of the District of Columbia, which committee had in charge the ways and means for treating in the best manner, the sewage polluted Potomac river water, which is the source of supply for Washington City.

Do you want me to enumerate?

Q. Yes, you might mention two or three more, if you feel like it.

A. I will mention Springfield, Massachusetts; New Haven, Connecticut; Oswego, New York; Meadville, Pennsylvania; York, Pennsylvania; Columbia, Pennsylvania. The group of cities lying directly west of New York, furnished by affiliated groups of water companies with their public water supply, that is, Paterson, Passaic, Jersey City, Hoboken, etc. I have also made examinations in a number of places throughout the Southern country, down in Mexico also, on the western coast at Manzonillo.

Q. All of these examinations were made in the capacity of a water supply expert?

A. Yes sir.

Q. Are you a member of any sanitary and scientific organization in this country? 4282

A. Yes sir. I am a member of the American Society of Civil Engineers; the American Chemical Society; the Society of American Bacteriologists; the American Public Health Association; the American Waterworks Association—

Q. Are you a member of the American Society of Naturalists?

A. Yes sir.

Q. In connection with your membership in the American Public Health Association, I will ask you if you had any special work relating to water supplies for cities and towns?

A. I have given that matter quite a little attention in that connection, having been for a number of years Chairman of the Committee on the Pollution of Public Water Supplies, and also chairman of another committee having to do with the question of standard methods of water analyses.

Q. Mr. Fuller, speaking broadly and generally, are you familiar with the principal facts in this record in this case, and the essential facts from a sanitary standpoint, as associated with the quality of the St. Louis water supply?

A. Yes sir, I am.

Q. Mr. Fuller, will you please state whether or not you know the general features of the system of waterworks in the city of St. Louis as regards the source of supply and the treatment of the water, artificially, in recent years, and if you know these general features please state them. 4283

A. I am familiar with the general features regarding the source and the method of treatment of the water supply of St. Louis.

The Mississippi river for many years has been the source of supply. Some thirty years ago or more, the municipal water department established an intake at Bissell's Point, near the present Merchant's Bridge. At that place there were provided four settling basins, each having a capacity of about 15 million gallons. The water from the river was pumped to these basins, in which it was settled, that is, partially clarified, and partially purified, and then the water leaving those basins was pumped into the distributing mains conveying the water to the citizens of St. Louis. Those works continued in service until the autumn of 1894. For some ten years preceding that time, attention had been given to the question of locating a new point of intake. This matter I think, was first looked into about 1885 or 1886. For several years following that, as soon as the enabling acts were passed, construction was carried on for the completion of the works, as they now exist at the Chain of Rocks. The object of moving the intake from Bissell's Point to the chain of rocks some eight miles or so, up-stream, from Bissell's Point, 4284 and some six miles below the mouth of the Missouri, was with the view to avoiding all possibility of sewage pollution of the Mississippi water at Bissell's Point, due to the inhabitants of St. Louis, in the Northern district, and in which district the population had increased rapidly since the time that the Bissell's Point plant was constructed.

At the chain of rocks there is a tunnel constructed through the solid rock, extending out from the Missouri shore some 1500 feet, and terminating in an intake tower located on the Missouri side of the main channel of the river; the water entering this intake tower flows by gravity through the tunnel, which connects with a suction well 100 yards or so distant from the shore. From this suction well the water is pumped by the low lift pumps situated in the station adjoining the suction well, to a series of six settling basins. These basins are each about 660 feet long, 400 feet wide, and have an average depth of water of about 15 feet when full. Their capacity is about 29 million gallons each. The river water in passing through these settling basins is clarified to a considerable degree, as there is left in the form of deposit a large amount of the mud obtained from the raw river water. There is also removed a considerable portion of the bacteria, including those of infectious diseases if such are present in the raw water.

4285 From these settling basins at the chain of rocks, the water flows by gravity through a masonry conduit leading to the old waterworks plant at Bissell's Point, where a portion of the water is taken by the pumps in the original station, and delivered to the consumers. A part of the water, however, since 1897, has been taken from this conduit say about half way between the Chain of Rocks and Bissell's Point, at a point called Baden. At Baden there is what is known as the high service pumping station where there is pumped a considerable portion of the water going to the high service districts, the hilly portions of the city of St. Louis.

Q. For this time and for years you have been engaged in no other business professionally, except that of examining and advising about the water supplies for cities and towns?

A. No sir; none except that and the allied line of sewage disposal.

Q. Mr. Fuller, do you know from what period of time the water has been taken from the intake tower in the channel of the Mississippi river at the chain of rocks, and do you know whether or not the treatment has been essentially changed from the period of time at which the water was begun to be taken from the channel of the Mississippi river at the chain of rocks?

A. The water supplied to the city of St. Louis by the municipal water department has been taken from the chain of 4286 rocks since the late autumn of 1894, and from that date to the present time there has been no essential change in the method of treatment of the raw water taken as the source of supply, treated and delivered to the citizens of St. Louis.

Q. I will get you to state if you know who owns the water plant which supplies the city of St. Louis with water?

A. It is owned by the municipality.

Q. Mr. Fuller, I will get you to state as a sanitary and water supply expert, what you consider to be the best index to the sanitary character of a public water supply?

A. As a general proposition it is my judgment that the best index to the sanitary character of a public water supply is the mortality record from water-borne diseases in the community using the water supply in question, and especially the mortality statistics of typhoid fever.

Q. Mr. Fuller, I will get you to state why the mortality statistics of typhoid fever are a better index in your judgment, to the character of a water supply in a community, than those of other water-borne diseases?

A. It is my experience that the typhoid fever mortality statistics are preferable to those of other water-borne diseases for a number of reasons, of which the principal ones, are the wide-spread nature and distribution of typhoid fever, its abundance in those communities having supplied to them sew-
4287 age polluted waters; the well defined character of the
disease, taking everything into consideration, and also the substantially large percentage of deaths to those who have the cases, that is, the percentage of deaths to cases is larger than in some other instances. If Asiatic cholera should become established in this country I dare say that that might serve as an index to the sanitary character of water, substantially as well.

Q. Mr. Fuller, do you know how many people generally speaking, sicken and die of typhoid fever each year in the United States?

A. Some years ago I gave that matter careful consideration. Generally speaking I would place the number of typhoid deaths on a very conservative basis, as at from 25 to 30 thousand annually in this country. As to the number of cases occurring in this country annually, of typhoid fever, I would place the figure at more than a quarter of a million.

Q. Mr. Fuller, what in your judgment was the sanitary character of the municipal water supply of St. Louis, after having passed through the settling basins as delivered to the consumers, during the years 1895 to 1899, inclusive, and upon what do you base your conclusion?

A. It is my judgment that the water supplied to the citizens

of St. Louis by the municipal water department during the years 1895 to 1899 inclusive was what might be called a good sanitary water. I base that judgment upon this fact:
4288 during the period mentioned, the typhoid fever mortality statistics showed as low a rate approximately speaking, as in the case of quite a number of other American cities having a pure or very nearly pure water supply.

Q. Mr. Fuller, what treatment was given to the raw river water after its entrance into the intake tower at the chain of rocks and before its entrance into the service pipes of the consumers, in the city of St. Louis during the period from 1895 to 1899, inclusive, and how if at all, did that treatment affect the sanitary character of the water?

A. The treatment at that time, that is from 1895 to 1899 inclusive, consisted of settling the water in the basins at the chain of rocks, which process I have already outlined in its general features. The result of this settling was to improve the water to a considerable degree as regards the elimination both of mud and of bacteria, including those of a pathogenic nature when such were present in the raw river water.

I will add another thing, and say that there was substantially no change in the period for sedimentation during the years in question.

Q. I will get you to state Mr. Fuller, whether or not the term "pathogenic bacteria" is used by you to include waterborne bacteria that might convey infectious diseases such as cholera and typhoid?

4289 A. Yes sir.

Q. Mr. Fuller, what in your judgment was the sanitary character of the raw Mississippi river water as it entered the chain of rocks intake tower, St. Louis waterworks, during the years 1895 to 1899, inclusive?

A. It is my judgment that the raw Mississippi river water entering the intake tower during the period 1895 to 1899 inclusive, was a much less safe water from a sanitary standpoint than was the water after it had been treated in the settling basins, and delivered to the consumers. This was due of course to the elimination of bacteria of an injurious nature, by the process of sedimentation, and in which process the injurious bacteria subside—fall to the bottom of the basin and from time to time are removed from the basin and thus prevented from passing on with the water delivered to the consumers.

Q. How are the deposits made in the settling basins of the St. Louis waterworks removed, by the action of the water or by artificial means?

A. They are removed by artificial means; that is to say, once or more each year, the basins are emptied, and the mud is flushed by the aid of water, into channels, which conduct the mud to a sewer leading from the end of the basins to the river, and down below, a considerable distance below the
4290 intake tower.

Q. Mr. Fuller, referring to the sanitary character of the raw river water as it entered the chain of rocks intake tower during the years 1895 to 1899 inclusive, how would you classify that water as a city water supply?

A. I would classify it in its sanitary character, as a suspicious water, meaning by that not distinctly a good water, but one in which there was a liability of danger from time to time to those who drink it in its raw condition.

Q. Mr. Fuller, I will get you to state if you know how the typhoid fever statistics in the city of St. Louis for the period since January, 1900, compare with those of the five preceding years, and if so, state the comparison?

JUDGE JOHNS: I object to the question as the statistics themselves are the best evidence, and a comparison by the witness is not competent.

A. During the period from 1895 to the end of the year 1902, the number of deaths from typhoid fever each year was as follows:

	1895	106,
	1896	107,
	1897	125,
	1898	95
	1899	130,
	1900	168,
4291	1901	197,
	1902	222.

Averaging the number of deaths from typhoid fever during the five years, 1895 to 1899, inclusive, gives 112 deaths per annum from typhoid fever. The average annual deaths from typhoid fever during the three years beginning with January, 1900, is 196, showing an increase in round numbers in the number of deaths, of about 80 per cent.

Taking into consideration the differences in population, that is, the increase in population during that period, and expressing the typhoid fever deaths with reference to the number per 100,000 of population living, there has been an increase during the past three years on an average, of about 60 per cent over the annual typhoid fever death rate per 100,000 population living, for the five years 1895 to 1899 inclusive.

Comparing the number of deaths from typhoid fever during these eight years, with reference to the total number of deaths from all causes, occurring in the city of St. Louis, and obtaining the percentage mortality from typhoid fever, the percentage increase for the last three years on an average as compared with the average percentage of mortality from typhoid fever during the five preceding years, is 73 per cent.

I will further state that the average number of deaths from
typhoid fever in St. Louis during the first five years
4292 under consideration was about 20.4 per 1000,000 population living, and that this rate during the past three years, on an average, was about 32.3 on the same basis; that is, the average number of deaths per annum per 100,000 population living.

Q. Mr. Fuller, I will get you to state if in your judgment the three methods of investigating and comparing typhoid fever statistics afford, when considered together, a proper and reasonable basis upon which to base conclusions with reference to typhoid fever statistics of the city?

A. In my judgment that is true, for the reason that each throws light upon the matter, but the data regarding the two last methods of comparison taken together, are the fairest and best way.

Q. Now Mr. Fuller, I will get you to state speaking broadly, what in round numbers, considering all of these methods, and all of the facts, you consider the increase of typhoid in St. Louis to be, in the periods mentioned in the former question?

A. I should say in round numbers there has been an increase during the second period under consideration of about sixty to seventy per cent above the average rate in the earlier period mentioned.

Q. Mr. Fuller, I will ask you if you know how the typhoid fever statistics of the city of St. Louis for the period 4293 covered by the first five months of each year since 1895 to 1899 inclusive, compare with the first five months of the three years since January, 1900, if so, state what that comparison is?

A. The number of deaths from typhoid fever in St. Louis during the first five months of the years 1895 to 1899, show sums or amounts very much less than during the first five months of each of the years following 1899; that is, 1900, 1901, 1902 and 1903. This is particularly true of the present year, 1903.

Q. Do you know, Mr. Fuller, the mortality from typhoid fever for the five months of the year 1903 by months?

A. In January, 1903, there were 15 deaths,
In February, 1903, 15 deaths,
In March, 20 deaths,
In April, 17 deaths, and
In May up to date 18 deaths.

Q. These statistics are for the city of St. Louis are they Mr. Fuller?

A. City of St. Louis.

Q. Mr. Fuller, are you enabled by any methods of judgment of typhoid statistics, that you have mentioned, and from your general knowledge to say whether or not these figures for the year 1903 indicate an increase or a decrease of the typhoid fever in this city?

4294 A. They clearly indicate an increase in typhoid fever in this city.

Q. Mr. Fuller, I will get you to state if you know whether or not from the facts in your possession and the statistics that you have stated and are aware of, if typhoid fever shows any signs of abating in this city?

A. The record of the number of deaths from typhoid fever in the city of St. Louis by months, shows a continuance of these comparatively high figures to an unusual degree, showing that for this season of the year there is an unusual prevalence of this disease in this city.

Q. Mr. Fuller, I will get you to state to what cause you ascribe the increased mortality from typhoid fever in the city of St. Louis since January, 1900, and why?

A. I ascribe it to an increased amount of infection in the public water supply, and predicate this opinion upon the practically uniform distribution of the homes or residences in which the typhoid deaths have occurred in the city of St. Louis, and the further fact that a careful examination of the several other possible sources of typhoid fever shows that no substantial portion of this increase may be explained in that way.

Q. Mr. Fuller, what in your judgment has been the sanitary character of the public water supply of St. Louis 4295 after passing through the settling basins as delivered to the water consumers since January, 1900?

A. I consider that the sanitary character of the public water supply delivered to the consumers in the city of St. Louis has been less safe than it was formerly.

Q. Mr. Fuller, I will get you to state if, in your judgment, the water supply of St. Louis, as delivered to the consumers, after passing through the settling basins since January, 1900, can any longer be classed as a good water?

A. It is my judgment that it cannot be classed as a good water.

Q. Mr. Fuller, what has been the treatment of the raw river water after it leaves the chain of rocks, intake tower, and prior to its reaching the consumers in the city of St. Louis during the period since January, 1900, as compared with the five preceding years?

A. The treatment has been essentially the same.

Q. Mr. Fuller, what in your judgment has been the sanitary character of the raw Mississippi river water as it enters the chain of rocks intake tower, since January, 1900, and how does it compare with that of the five preceding years?

A. I consider that the sanitary character of the raw Mississippi river water entering the intake tower of the St. Louis

waterworks since January, 1900, has been distinctly and
4296 decidedly less safe than during the five preceding years.

Q. Mr. Fuller, generally speaking, what is the principal source of dangerous impurities in public water supplies in their raw condition?

A. Sewage pollution.

Q. Mr. Fuller, I will ask you if you are familiar with the relative amounts of typhoid fever prevailing on the area naturally tributary to the Mississippi river above the chain of rocks, for the five years preceding, and the three years since January, 1900, and what do you say as to the relation between the conditions in the sanitary character of the raw Mississippi river water at the chain of rocks intake tower and the prevalence of typhoid fever within the natural limits of the Mississippi watershed above St. Louis; that is, exclusive of the Chicago Sanitary District?

A. I am generally familiar with the typhoid fever statistics in the larger centers of population upon the Mississippi watershed, above the chain of rocks, intake tower of the St. Louis waterworks, and excluding the Chicago sanitary district during the periods mentioned in the question. During these periods there have been at quite a number of points, some variation in the amount of typhoid fever prevailing in different years. Taking the typhoid fever statistics upon this water-shed area
as stated, as a whole, but excluding the Sanitary Dis-
4297 trict of Chicago, based upon the average number of deaths
from typhoid fever per year, it is my judgment, viewing the matter as a general proposition, that there has not occurred on the natural area of the Mississippi watershed above St. Louis any increase in the number of deaths sufficient to explain to any material degree the less safe condition of the Mississippi river water as taken from the intake tower of the St. Louis waterworks, during the last period, as compared with the period 1895 to 1899.

Q. I will get you to state, Mr. Fuller, if you know of any cause that renders the water, if it is, less safe—that renders it so at the intake, at the chain of rocks now, and within the last three years, than prior to January, 1900?

A. In my judgment, it is the Chicago Drainage canal discharging sewage and drainage containing filth and infection, from the city of Chicago, which makes the water in its raw condition at the intake tower, chain of Rocks, St. Louis waterworks, less safe than it was preceding January, 1900.

Q. Mr. Fuller, when was the Chicago Drainage Canal opened?

A. January 17th, 1900.

Q. Mr. Fuller, will you please state briefly if you know, the object sought, and the means of accomplishing it, by the drainage canal, in relation to sanitation in the Chicago Sanitary District.

4298 MR. DRENNAN: I object to the question as not a proper subject matter for this witness.

GENERAL CROW: Is that all the objection?

MR. DRENNAN: Yes, the objection is one of substance.

A. The object primarily was to prevent the sewage from Chicago and the Sanitary District from reaching and polluting the municipal water supply of the city of Chicago. In carrying out this object there was provided a means for removing the sewage and drainage through the Chicago river by reversing its flow and having the sewage enter the Chicago drainage canal thus diverting it into the Mississippi valley. This method of removal so far as it relates to Chicago, involved dilution with the lake water to a degree which would prevent ordinarily a putrifaction of the sewage within the limits of the sanitary district. Incidentally of course, this method of disposing of the sewage meant an improvement and betterment of the sanitary conditions prevailing in the Chicago River and its several branches and forks.

Q. Mr. Fuller, I will get you to state if you know how many deaths from typhoid fever have occurred since January, 1900 in the city of Chicago, and what has been the disposition of the infectious discharges of the persons sick with this disease?

A. There have been about 1647 deaths from typhoid fever

4299 in Chicago since January, 1900, and the infectious discharges from the persons sick and dying of typhoid fever have to a very large degree been disposed of by their passage through the sewers to the Chicago river and the Chicago drainage canal.

Q. Mr. Fuller, I will get you to state whether or not you have made an estimate of the approximate number of persons sewering into the Mississippi river and its tributaries, exclusive of the Sanitary District of Chicago. If so, what figures have you obtained and upon what basis as to the separating of the rural from the sewage contributing population?

A. I have looked into this matter and in round numbers place the figure for those people who sewer directly into the Mississippi and its branches and tributaries above the St. Louis waterworks and exclusive of the Sanitary District, at about 2,700,000. This figure is based upon a separation, on an average of the sewage contributing population from the rural population by taking towns of 4,000 and over as representing those who have sewerage systems and contribute sewage directly to the water courses. Some of the towns of more than 4,000 population are undoubtedly not provided fully with sewerage facilities. On the other hand there are quite a number of towns of less than 4,000 population which in a limited measure do have waterworks, and do have some sewerage. Looking at this question as a practical proposition, it is my judgment that the
4300 amount of the sewage-contributing population in towns
of less than 4,000 inhabitants no more than off-sets in the aggregate the amount of population in the cities larger than 4,000 inhabitants which do not have sewers. It is a fact well known among practical waterworks and sewerage people that the number of miles of water mains in a town ordinarily exceeds to a considerable degree the number of miles of sewer lines. In making this statement as to the number of people in the aggregate sewering into the Mississippi river above the chain of rocks intake, I include of course, the Missouri river and the Illinois river, exclusive of the Chicago Sanitary District, as well as the upper Mississippi.

Q. Mr. Fuller, why did you draw a line at the towns of 4,000 inhabitants for the separation of population contributing pollution directly, from those which contribute indirectly?

A. Well, that matter I took up pretty thoroughly in the last answer I gave, and will state that the basis as described in my last answer is the result of my experience and I think that on the whole it is a reasonable and fair method due to its compensation of the two factors; first the amount of population in the cities above 4,000 which do not sewer directly into the river and secondly the population of some towns of less than 4,000 which do contribute sewage directly to the water courses.

4301 Q. Mr. Fuller, what would you estimate to be the percentage of increase in population sewering into the Mississippi river valley above St. Louis, due to the Chicago Drainage Canal bringing sewage of Chicago into the Mississippi river watershed?

A. In round numbers I estimate an increase of 60 per cent.

Q. Mr. Fuller, please state if you know, what course the diluted sewage follows, after the contents of the drainage canal, containing the filth and infection of the Chicago Sanitary district, after it flows from the Bear Trap Dam at Lockport and into the Desplaines river?

A. The contents of the Chicago drainage canal after entering the Desplaines river below the Bear Trap Dam at Lockport, flows along the course of the Desplaines River, which river joins the Kankakee and the two form the Illinois river. The contents of the drainage canal thence flow throughout the entire length of the Illinois river and enter the Mississippi at Grafton, which is distant about 291 miles from Lockport.

Q. Mr. Fuller, how long a time do you estimate is required for the Chicago sewage to flow this distance of 291 miles from Lockport to Grafton?

A. I place the figures ordinarily at from ten to twenty-five days. That range of course depends on the velocity
4302 of flow of water in the river.

Q. What would you estimate the average to be in time to make the flow from Lockport to Grafton?

A. It is my opinion that the average time required for the flow from Lockport to Grafton is about 15 to 18 days. In this connection I would further state that there are portions of the stream mainly the upper portions, which flow more rapidly than the lower portions, and some water presumably reaches Grafton quicker than indicated by the average above mentioned.

Q. Mr. Fuller, what in your judgment is the period of time which typhoid fever germs may and do continue to live in sewage polluted waters such as are found in streams, reservoirs and the like?

A. I consider that they may and do continue to live for weeks and months under those conditions.

Q. Mr. Fuller, what do you say as to the longevity of the germs of Asiatic cholera under the conditions mentioned in your last question?

A. The life history of the germs of Asiatic cholera under the conditions mentioned is less accurately known than in the case of the typhoid fever germs. Generally speaking, however
it is my opinion that there is not any very great difference
4303 in the life history of the germs of the two diseases, under
the conditions stated in the question.

Q. Mr. Fuller, in your judgment, what is the influence or effect upon the sewage discharged into the Desplaines river at Lockport, of the dilution which under existing conditions takes place in the Illinois river, viewing this question from the standpoint of a hygienic or sanitary character of the Illinois river water, as it enters the Mississippi river at Grafton?

A. The dilution of the Chicago sewage, as it flows from Lockport to Grafton, by the waters of the Illinois river and tributaries, is a very variable proposition. At times the dilution of the contents of the Chicago drainage canal by the flow of the Illinois river and its tributaries, is very considerable. At other times the volume of flow of the Chicago drainage canal exceeds the flow of the Illinois river, this being true particularly in its upper reaches. There consequently results at times a dilution of the Chicago sewage by the waters of the Illinois river, and other times a dilution of the Illinois river by the contents of the Chicago drainage canal. Dilution at best does not destroy disease germs or infectious matter. Its effect is to minimize the danger to those who may drink of the water so diluted. One
effect of the dilution existing in the Illinois river at low
4304 stages is to bring to Grafton more quickly than would
otherwise be the case, injurious matter entering the Illinois river at points along the route of its flow, and also entering the Illinois river from cities and towns located upon the tributaries to that river.

Q. Mr. Fuller, in your judgment, what is the significance of the ponds and of the dams and of the slack water stretches which are found on the Illinois river, regarding the hygienic or sanitary character of the diluted Chicago sewage flowing from Lockport to Grafton?

A. The most significant feature of these so-called lakes, dams and slack water stretches is the low velocity of flow of the water, at times of low stages of the Illinois river. There are a good many days in the course of a year when these velocities at the places above referred to are so low that deposition takes place to a considerable degree, of the bacteria and other matters suspended in the water, and which to a large degree are derived from the contents of the Chicago Drainage Canal. The deposition of these bacteria including those of infectious diseases like typhoid fever, does not mean their permanent elimination and removal from the flowing water. The reason of this is that as they reach the bottom and lie upon the bed of the stream they are disturbed from time to time, due to changes in velocity of stream flow, such as caused by
4305 moderate rains, or by the passage of boats or the action
of the wind and the like. The resulting disturbances cause the bacteria to leave the bed of the stream in which they may rest for some time, bringing about a return of those bacteria to the flowing water. In this way the germs of disease may pass from the Chicago drainage canal at Lockport to the mouth of the Illinois river at Grafton.

Q. Mr. Fuller, is it or is it not your opinion that typhoid fever germs disappearing from the flowing stream and becoming deposited in the bed, are able to live there for weeks or months?

A. I think that they are able to live for weeks and months.

Q. Mr. Fuller, I will get you to state if in your judgment it is possible, that the water of the Illinois river as it flows into the Mississippi may sometimes be richer in typhoid fever germs derived from the sanitary district of Chicago and coming through the drainage canal, than was that portion of the water drawn from the drainage canal when it flowed over the Bear Trap Dam?

A. In my judgment such a condition of affairs at times is not only possible but probable.

Q. Why?

A. Such a condition of affairs may arise and at times probably does arise through the disturbances of the sediment
4306 lying upon the bed of the stream in places, which sediment may and undoubtedly at times does contain relatively large numbers of typhoid fever germs. As these typhoid fever germs are returned to the flowing stream from their position in the bed of the river there is effected an accumulated result, whereby at times at least the waters of the Illinois river flowing to Grafton, may discharge the concentrated essence of the infection of Chicago sewage, by taking in the manner above described, portions of the infection coming from many days' flow of the drainage canal into the Illinois river.

Q. Mr. Fuller, I will get you to state if you know of any cases excepting storage reservoirs connected with public water supplies, in which sedimentation is employed for the purification of sewage or sewage polluted water without any provision having been made for the removal of the sedimented materials, so that these shall not find their way back to the flowing stream?

A. I know of no such instance, and it is obvious that if means are not provided for the removal of sedimented materials from time to time under proper conditions so that they will not re-enter the water as it leaves those basins, then the object and purpose of the settling basins largely fails.

ADJOURNED until 2:00 P. M., same day.

Southern Hotel, St. Louis, Missouri.
4307 2:00 P. M., Friday, May 29th, 1903.
Parties met pursuant to adjournment.

Present the Commissioner and same counsel representing the respective parties.

GEORGE W. FULLER,

resumed the stand for further direct-examination by Attorney General Crow, and testified as follows:

Q. Mr. Fuller, do you or do you not consider that all existing circumstances and conditions from Lockport to Grafton taken separately or together, are sufficient to prevent at all times the pollution and infection coming from the Chicago Sanitary District and entering the Mississippi valley at Lockport, from reaching the Mississippi river at Grafton?

A. I believe that those conditions are not sufficient to prevent at all times infected materials coming through the Chicago drainage canal and entering the Mississippi valley at Lockport, from reaching the Mississippi river at Grafton.

Q. Mr. Fuller, do you know how far it is from Grafton to the Chain of Rocks, water tower?

A. About 29 miles.

Q. Do you know how long a time is required for the Mississippi river to flow from Grafton to the chain of rocks?

A. It is a fraction of one day.

4308 Q. That is in the ordinary stage of water?

A. Yes sir.

Q. Mr. Fuller, is it or is it not possible, in your judgment, for the Illinois river water entering at Grafton the Mississippi River, which in turn is joined with the Missouri river six miles above the chain of rocks, to flow past the chain of rocks without some of the Illinois river water ordinarily entering the intake tower of the St. Louis waterworks?

A. I don't believe that it is possible for the Illinois river water to flow by the chain of rocks without some of it ordinarily entering the chain of rocks intake tower of the St. Louis waterworks.

Q. Mr. Fuller, in view of all the facts and conditions as you know them, do you or do you not consider that the sewage of the Chicago Sanitary District pollutes and infects the water of the Mississippi river along the Missouri shore, and especially at the chain of rocks intake tower of the St. Louis waterworks, to such an extent that it makes the Mississippi river water less safe for drinking and domestic purposes than it was before the opening of the drainage canal?

JUDGE JOHNS: I object to the question as requiring the witness to determine what is to be ascertained by the United States Supreme Court on the trial.

4309 A. It is my judgment that it does.

Q. Mr. Fuller, assuming that during the three years before and the three years after the opening of the Chicago drainage canal, the total number of typhoid fever deaths so far as can be learned, was about the same on the water-shed of the Mississippi river above the intake tower of the St. Louis waterworks at the chain of rocks, exclusive of the Sanitary District of Chicago, and that there were 337, 509 and 801 typhoid deaths in 1900, 1901 and 1902, respectively, making a total of 1,647 typhoid deaths for these three years in the city of Chicago, since the opening of said canal; state whether or not the said deaths in Chicago have in your judgment, had any influence on the typhoid fever mortality of the city of St. Louis, and if so, what?

JUDGE JOHNS: I object to that question for the same reason as to the foregoing question.

A. It is my judgment that under the conditions assumed in the question, the typhoid infection coming from Chicago and passing through the drainage canal by way of the Desplanes and the Illinois rivers to the Mississippi river and to the intake tower at the chain of rocks, of the St. Louis waterworks, did have an influence upon the typhoid fever death rate in the city of St. Louis, and that it is the cause of the principal portion of the increase during the past three years.

4310 Q. Mr. Fuller, assuming that the population of the sanitary district of Chicago grows larger, and that the amount of Lake Michigan water and of the sewage sent down the drainage canal and on into the Mississippi river under conditions corresponding in method of procedure to those which prevail today on the Desplaines and Illinois rivers, thereby increasing the amount of infected sewage entering the Mississippi watershed, what effect could such future growth of population in Chicago, and such future increase in added pollution to the Mississippi river waters, reasonably be expected to have upon the sanitary quality of the water of the Mississippi river in its raw condition, arriving on the shores of the State of Missouri below the mouth of the Illinois river and especially at the intake of the St. Louis waterworks at the chain of rocks?

A. Under the conditions assumed in the question it is my opinion that the water in the Mississippi river along the Missouri shore, especially at the chain of rocks, intake tower St.

Louis waterworks, in its raw condition, would be rendered less safe than at the present time, due to the increased amount of infection entering the Mississippi watershed, from Chicago and to the shorter interval of time required for the passage of that sewage from Chicago to the points considered, on the Missouri shore of the Mississippi river.

Q. Mr. Fuller, what effect, if any, in your judgment
4311 would the increasing amount of sewage from the sanitary
district, coming through the drainage canal into the Illinois river in future, caused by the growth of population in the sanitary district of Chicago, have upon the Illinois river and the Mississippi river at low water stages?

A. It would make it a much less safe water generally speaking, than at the present time, and it is quite possible that looking far enough into the future, that this amount of pollution would become sufficient to exceed the oxygen and to make it in many ways resemble an open sewer, that is to say, it will be a stagnant pool, resembling sewage rather than a live, natural water containing atmospheric oxygen.

Q. Mr. Fuller, I will get you to state if in your judgment the increased sewage coming into the Illinois river by way of the drainage canal and thence into the Mississippi, now, and in the future, would add any difficulties, or increase any cause to the problem of filtering or otherwise purifying the water of, and furnishing with safe water, the City of St. Louis?

A. In my judgment the increased amount of infection coming into the Mississippi river from the city of Chicago's sewage at the present time makes an added responsibility as regards the treatment of that water, to make it perfectly safe and wholesome as supplied to the citizens of St. Louis. Such treat-
4312 ment of the water would involve, I think at the present
time, more responsibility, and in a financial way, it would be shown by the greater expense of supervision of a filtration plant, and the added cost of supplies used in connection with the operation of filtration works, especially at times of low water. It would also mean that such filtration works, if adopted, would be operated from time to time, if not regularly, at lower rates of filtration than if this increased infection were absent. The significance of this is that by reducing the rate of filtration, that a

larger plant would be required, and hence a more expensive installation for filtration works, to purify the same quantity of water than in the instance of water without this added infectious matter.

Looking some distance into the future and considering the various centers of population naturally tributary to the Mississippi river at St. Louis, the Missouri and Illinois rivers, but excluding the Chicago Sanitary District, it is certain that there will ultimately come a time when single filtration can hardly be expected to produce a satisfactory quality of water with its source at the Chain of Rocks, intake tower. When that time will come it is difficult to state specifically, as it will depend upon the rate of growth of population in the communities situated upon the watershed of the Mississippi, Illinois and Missouri
4313 rivers, exclusive of the Sanitary District of Chicago.

Whatever the rate of growth may be in the communities situated upon the watershed of the Mississippi river above St. Louis, independent of the city of Chicago, it is certain that the added infection of the Mississippi water at the St. Louis intake due to the Chicago sewage, will hasten the day when single filtration at St. Louis will prove unsatisfactory, and when it will be necessary to give attention either to double filtration or to other methods, involving increased expense and increased responsibility.

CROSS-EXAMINATION by Judge Johns.

Q. Your opinions are all based on the assumption that the waters of the Illinois river are so polluted with the waters of the drainage canal as that they cannot purify themselves of infectious matter by the time they reach the intake at St. Louis, if they ever do?

A. That is true, but with the idea that that degree of purification can take place at certain times, not at all times.

Q. Are there any times in the Illinois river, or in the flow of the water from Bear Trap Dam to the intake at St. Louis, when that water would free itself of infection if any infection
4314 existed in it?

A. There may be and may not be; I don't know.

Q. Is there any season of the year in which it might happen?

A. I doubt it.

Q. Is there any rate of flow in which it might happen?

A. I doubt it.

Q. Is there any stage in which it might happen?

A. I doubt it.

Q. Well then, there is no time in which you do not doubt the purification of the waters of the Illinois before they arrive at the St. Louis intake?

A. Yes sir, that is right. The question of absolute removal at all times is the point that I have been giving most consideration to.

Q. You believe that infectious matter flowing from sewers in Chicago into the drainage canal will certainly arrive at the St. Louis intake at times?

A. At times, I certainly do.

Q. And in order to provide against that contingency some means of filtration or of the purification of the water should be adopted at St. Louis?

A. In order to get those particular germs out?

Q. Yes sir.

A. Yes.

4315 Q. If the city of St. Louis received its water supply only from the Missouri, it ought to be filtered, ought it not?

A. I think that would be desirable. It is not necessary in order to get a reasonably good water, as has been shown by the typhoid statistics and experience during 1895 to 1899.

Q. To have had a water supply which would meet the views of sanitary engineers at this time, the waters of the intake at St. Louis, if consisting only of Missouri water, ought always to have been treated by other means than sedimentation?

A. In order to get a thoroughly satisfactory water, without liability of possible pollution from time to time, that is true, but it is also true that before 1900, they got a reasonably good water without filtration but with the sedimentation.

Q. To what was the typhoid fever in St. Louis then attributable?

A. That is due to a variety of causes, such as may be classed in this way: There is a residual number of typhoid deaths in American cities which are not ordinarily eliminated even with a pure water supply and they are still found in a group of cities like Lowell and Lawrence, Massachusetts, and Albany, New York, which are now provided with good water supplies.

Q. If the waters at the St. Louis intake consisted entirely of Mississippi river water, without an admixture of the Illinois river water, it ought always to have been filtered, ought 4316 it not?

A. My reply would be the same as I have already given with regard to the Missouri water. I am of course referring now to the Mississippi exclusive of the Illinois in connectoin with the Chicago Sanitary District.

Q. So that if the Illinois river and the city of Chicago did not exist and the problem before the people of St. Louis now was what to do with their water, you think it ought to be treated?

A. In order to get a thoroughly satisfactory water, but as I have said, sedimentation from 1895 to 1899 gave them a reasonably good hygienic water.

Q. Did sedimentation from 1885 to 1895 give them a reasonably good water?

A. In my opinion I would hardly call that a reasonably good water at all times.

Q. Did sedimentation exist here before 1885?

A. Yes sir.

Q. For how many years?

A. Since about 1870, I should say.

Q. Do you know whether or not sedimentation from 1870 to 1885 gave the city of St. Louis reasonably good water?

4317 A. Judging from a sanitary standpoint I should be inclined somewhat to doubt that. I haven't those figures clearly in mind at the moment, as to typhoid fever statistics during the period which you mention, and prior to 1895.

Q. Now the opinions of sanitary engineers in their business have been constantly changing, and as you think constantly advancing for the last thirty years?

A. Well, I won't say within thirty years, although to a degree that may be so. It is more particularly so since the germ theory of disease became recognized.

Q. When was that generally recognized first?

A. Well, from fifteen to eighteen years ago, I should say. That period would apply not to the sanitary engineers as a profession, but to those who had traveled abroad and who were better posted with experiences in Europe.

Q. When did the germ theory of disease become generally recognized in the United States among sanitary engineers so far as you know?

A. It was in the late eighties. I couldn't state that specifically. They have been learning all the while, and are still learning.

Q. And except to continue to learn?

A. Very likely; I hope so.

Q. So that in twenty years from now all present theories 4318 will be abandoned?

A. I have no reason to suppose that.

Q. Well, looking into the future don't you think that present theories might be abandoned?

A. I have no reason to believe that the fundamental principles upon which sanitary engineering is based, are apt to change to any essential degree. In applying those principles with a view of securing thoroughly satisfactory water supplies, as to quality in different places, we would have to recognize the individuality of local conditions in adapting the application of those principles to practice.

Q. Looking into the future, it might be possible that the practice of filtration would have to be abandoned, might it not, and sewage destroyed at its origin?

A. There is a possibility that that may be a condition in the future.

Q. Looking into the future it is possible in low water that the Missouri river might become a stream of liquid sewage?

A. Well, that would be a long way off, as to its being liquid sewage; it would be very highly sewage polluted no doubt.

Q. Looking into the future, no matter how distant, it is possible that the Mississippi river might become either a stream of liquid sewage, or a highly polluted water at times of 4319 low water?

A. Yes sir.

Q. And that the Illinois river might become a stench to the nostrils of the people?

A. It is possible it might be so, yes.

Q. In which case quadruple filtration might be necessary if the city of St. Louis persisted in taking its water from these rivers?

A. There is a possibility of that, but as I have stated, it is also possible that other types of purification may be required in connection with filtration. Also as stated in my examination in chief, the city of Chicago's sewage will very much hasten that day, whenever it may come.

JUDGE JOHNS: I move to strike out the latter part of the answer as not responsive to the question.

Q. You believe that typhoid bacilli entering the drainage canal at Chicago not only may be, but are transmitted to the intake at St. Louis?

A. I do.

Q. And that belief exceeds by more than 210 miles any distance in which it is either known or supposed heretofore that typhoid bacilli have traveled in running water and lived?

A. No sir, those are not my views in the matter. It is a question of time interval, not of distance, which is the 4320 controlling factor in this proposition.

Q. The question of distance then doesn't enter into it at all?

A. So far as it reduces the time interval it does.

Q. Given sufficient distance and sufficient time, typhoid bacilli might disappear, or would disappear from running water, would they?

A. You mean that proposition independent of dilution?

Q. Yes.

A. And just the natural dying out?

Q. Yes sir.

A. There would be a very large reduction ultimately. Whether typhoid fever germs would be eliminated, wiped off the face of the earth in that way, it seems to me is very doubtful.

Q. Given a stream of water of 300,000 cubic feet a minute, into which the sewage of Chicago was poured, would there be any length of time, or any distance which would free that stream of typhoid infection?

A. By looking at it practically, I think it is very doubtful. Of course I am not considering any distances which are absolutely impossible.

Q. If a stream of water of 300,000 cubic feet per minute, into which was poured the sewage of Chicago, was started in a tortuous course of a small river at Bear Trap Dam, and received no dilution on the way, do you think it would purify itself by the time it reached New Orleans?

4321 A. I do not believe it would be absolutely freed of infection. There would be a very great reduction though, in the number of typhoid germs present.

Q. You do not believe that there is any length of time or any conceivable distance for a stream of sewage to travel and in which time it will absolutely purify itself of infection?

A. Taking that as an absolute proposition, I think it is very doubtful.

Q. Do you believe that if the sewage of Chicago was poured into the Mississippi river at St. Paul, it would purify itself by the time it got to St. Louis?

A. It would to a large degree, but I don't think it would be absolutely purified.

Q. If poured into the Mississippi river at St. Paul would it be dangerous to the people taking water at St. Louis at the intake?

A. It would in the sense that the liability of trouble would always exist to my thought.

Q. So that there is absolutely no such thing as the purification of a stream of running water into which infection is poured from sewage?

A. Absolutely speaking, I think that is a very doubtful proposition.

4322 Q. And if it was doubtful whether it would purify itself under any length of time or any distance, or any amount of dilution, the water ought to be filtered before used in human consumption?

A. In order to be absolutely safe, I think that that is true.

Q. Do you recognize degrees in the safety of water for drinking purposes, as for instance, safe, safer and safest?

A. I use them, yes sir, as a matter of convenience, but not as a fixed, prescribed means of nomenclature.

Q. If there were typhoid bacilli in the Missouri river and the water supply of St. Louis was taken from the Missouri river only, there ought to be filtration or some treatment of that water?

A. I should advise it.

Q. If there were typhoid bacilli in the waters of the Mississippi and the Missouri and the water supply of St. Louis was taken from those two streams, without the intermixture of the Illinois river water, it still ought to be filtered?

A. In my judgment that is correct.

Q. What proportion of the entire body of water passing the Chain of Rocks is Illinois river water?

A. That is a very variable and somewhat uncertain proposition when expressed in precise terms. It no doubt is quite an appreciable quantity at all times, but at times of low 4323 water in the Missouri and at times of high water in the Illinois, it must be a very distinct and decided proportion.

Q. Have you any idea of the average proportion?

A. No, I don't think that I would express any figure off hand.

Q. Would you say that it was as much on an average as one-twenty-fifth of the entire body of water that passes the intake?

A. I should think that very likely it would be more than that.

Q. One-twentieth?

A. Well, it is somewhere around that vicinity. I haven't any definite statement to make on that proposition.

Q. Now is there any peculiar arrangement of modern filters by which there can be provision made for filtering out infectious matter as distinguished from polluting matter?

A. In a certain sense, there is not.

Q. If you were going to build a filter with reference to the waters of the Missouri river, assuming that the Missouri river was not infected, but was polluted, would you build it any differently or on any different plan than if you were building the filter against the Missouri river waters, assuming that they were both infected and polluted?

A. I don't think there would be any material change re-
4324 garding a certain unit portion of it, but as the pollution
and infection increased there would be a larger area required in order satisfactorily to purify the infected water.

Q. If you were providing a filter now against Missouri river water only, would you make it larger and more elaborate because of its present condition of infection?

A. Not under the present conditions, no sir.

Q. If you were providing a filter against the Mississippi river water only, without reference to the Illinois river, would you make it larger or more expensive because of its present state of contamination?

A. Not to any material degree so far as its construction is concerned. At the present time it would be a question of the cost of operation principally.

Q. If you were providing for a filter against Missouri and Mississippi river water without an admixture of the Illinois river water, and to supply a certain amount of filtered water, would you make it larger or more expensive because of the union of these two waters, the Illinois being excluded?

A. Excluding the Illinois, I would not.

Q. Would you make it larger and more expensive in its construction if the Illinois river were also included, at the intake at St. Louis?

A. The way that would probably come about in prac-
4325 tice is that there would be no very marked difference in
the size of the first installation; but the reserve portion of that first installation would serve for a shorter period of years, due to the presence of the Illinois river water and its pollution, than would be the case without that water.

Q. That is due to the supposed increased pollution of the Illinois river water?

A. To existing pollution of the Illinois river water.

Q. Of the existing pollution of the Illinois river water?

A. Yes sir.

Q. Well, if you are going to manage a filter, you ought to have pretty good men to do it, oughtn't you?

A. That is true as a general proposition, yes sir.

Q. And when you are going to filter the water for any purpose you ought to do it the best you know how, having regard to the health of the people who are to drink it?

A. Well, there is a good deal in that, but ordinarily a water which can be easily handled by filtration, and where the possibility of a slight deterioration in the quality is not a serious matter, it is very seldom in practice that the expense of the organization would be so great, as it would be in the instance where the unfiltered water is of such a character that serious harm might result from a slight deterioration, or from a serious marked deterioration for a short period.

4326 Q. The operation of filtration of water in any way now known is purely mechanical, is it not?

A. In what sense do you use the word "mechanical" if I may ask?

Q. I mean that the actual act of the filtering of the water does not depend upon the deftness or skill of any human being around the works?

A. It depends in the case of these southern and western waters very much upon the skill with which the coagulant is adjusted, in order to secure proper results.

Q. In the filtration of waters now, is it necessary to always add coagulants?

A. It is at this city as a practical proposition.

Q. For cities?

A. For the water supply of this city at St. Louis intake tower, or the Missouri river, that is true.

Q. The adding of a coagulant, alum for instance, is necessary?

A. It is imperative in order to get results here at a practicable cost.

Q. There is required some skill and judgment in the man who manipulates the coagulant?

A. Some skill, yes sir.

Q. And some judgment?

A. And some judgment.

Q. Well, would it require any more skill and judgment to 4327 add the coagulant to the filtration of the combined waters of the Mississippi and the Missouri, excluding the Illinois?

A. Yes sir, very much more, because they are entirely different waters in character; one is muddy water and the other is a water with a vegetable stain.

Q. Would it require any greater judgment to filter a mixture—an equal mixture of the waters of the Missouri and the Mississippi, excluding the Illinois, than to filter the waters of the Mississippi, so far as the coagulant is concerned?

MR. JEFFRIES: Do I understand that to mean an equal mixture at all times?

JUDGE JOHNS: Oh, any time.

A. I think it would.

Q. And require still more sense to filter the waters of the three rivers combined, as they are now, than to filter the waters of either the Mississippi or the Missouri, or the two combined?

A. I think so, yes.

Q. The additional expense therefore, would be for the paying of the increased amount to the men who had sense enough to do it?

A. And to the members of his staff who would take that responsibility in detail, through the 24 hours of each day 4328 and each day in the week and each day in the year.

Q. What system of filtration do you recommend?

A. It depends altogether upon local conditions.

Q. What system of filtration would you recommend here at St. Louis?

A. I endorsed a project involving the use of the mechanical filters following sedimentation of the river water, and then coagulation and supplementary subsidence, there being three steps; the first, plain sedimentation; the second, coagulation and supplementary subsidence; and the third, mechanical filtration.

Q. Do you recommend, then, that this mechanical filtration should be by gravity or by pressure?

A. By gravity.

4329 CROSS-EXAMINATION, By Mr. Todd.

Q. Mr. Fuller, in the operation of a filter plant such as you have described, for the filtration of the waters of the Illinois, the waters of the Missouri and the Mississippi, exclusive of the waters of the Illinois, sufficient to meet the demands of the citizens of St. Louis, how many men would be required to operate such a plant?

A. I doubt whether I could tell you that very accurately off-hand. It is a matter that has been reported upon, with the cost of the same, after having been given careful consideration. If it is essential I will try and figure it out for you.

Q. Assume in round numbers that 20 men could operate such a plant for the filtration of the waters of the Mississippi and Missouri river to meet the demands of the citizens of St. Louis, in the employment of those men would you require the services of less able men to conduct a filter of that character than you would if the filter filtered in addition to the waters of the Missouri and the Mississippi, the waters of the Illinois?

A. I won't place it on the basis of the ability, but I will say their experience, unless you mean by ability, practical capacity, I will say then that there should be more experienced and more able men operating the filters here at St. Louis
4330 should the Illinois river water, containing its infection, become a factor.

Q. How many of those 20 men would be required to possess that high degree of skill necessary to conduct the plant operating for that purpose?

A. I suppose somewhere from four to six, speaking off hand now. There would be the man in charge of the plant and the members of his staff, who would be on each of the three watches per day. That is my general view of that matter.

Q. Now the man at the head of the plant, the executive officer of the plant, if I may call him such, would have to be a man of just as skilled abilities and intelligence to operate that plant for the filtration of the waters of the Mississippi and the Missouri as he would have to be if the Illinois river was added, wouldn't he?

A. No, I hardly think so.

Q. Would you recommend in the conduct of a plant such as we have described, the employment of a man to superintend a filter plant of the character we have described, when the waters to be filtered consisted of those of the Mississippi and the Missouri, less skilled and able than when the waters of the Illinois were added?

A. Well, a less experienced man would serve the purpose in managing the plant where the Illinois river was ex-
4331 cluded, and this pollution which it carries.

Q. Do you regard experience as the chief element in the qualification of such a man?

A. I would regard experience in conjunction with natural ability and good sense, assuming that the man in charge would have those. I think that is imperative.

Q. Have you any idea as to what the difference in cost would be in the employment of a man of sufficient skill to operate a plant under the former supposition than under the latter?

A. This is the man in charge, and the present time you are considering?

Q. I am talking about the present time now, and later we will dip into the future?

A. I should think it would be several thousand dollars, but I wouldn't want to state that specifically. I don't know the amount of talent which is available in this section.

Q. What would be the cost or amount to operate such a plant as that filtering the waters of the Mississippi and the Missouri rivers?

A. I am afraid I cannot dictate the terms of compensation for those men.

Q. Have you any idea about it?

A. I should think between the limits of $2,500 and $5,000 a year; I don't know exactly.

4332 Q. Aren't there men of sufficient skill to operate a plant of that kind, filtering the waters of the three combined rivers, that could be secured for less than $5,000 a year?

A. I wouldn't want the responsibility of what they would do in the line of managing the plant, without knowing about them.

Q. Do you know of any man in the United States today that operates a filter such as would be operated here, in filtering the waters of the Illinois, Mississippi and Missouri rivers?

A. I am not personally acquainted with such a man.

Q. Do you know of any conditions existing in the United States or elsewhere, similar to those existing in St. Louis, and would exist if a filtering plant was established, such as you have indicated, to filter the combined waters of those three rivers?

A. I do not know of anything exactly parallel, no sir.

Q. Then, if there is no such parallel to be found, where will the experience come from that will enable a man of that kind to be secured, having the ability to perform the work?

A. It will be necessary to get a man who has had the advantage of the experience in the development of the science and art of water filtration as it stands today.

Q. Now, securing such a man, would you say that such a man could be secured for $5,000 a year?

4333 A. I really don't know.

Q. Assuming that such a man could be secured who possessed the requisite ability to conduct a plant of that character, wouldn't that man be able to direct the administration of that plant with subordinates not quite so experienced as himself?

A. I don't know, I am sure. There is a possibility of it, but I really don't know.

Q. Then you have no knowledge based upon experience, that would enable you to state as a business man and expert, as to what the added cost of operating such a plant would be if the waters of the Illinois were added to the waters of the Mississippi rivers, have you?

A. Now you are considering not only the question of the executive management, but the cost of the station and all the supplies, and everything in connection with the plant?

Q. We are first taking the management, the man part of the concern.

A. That is, the executive head.

Q. The executive head.

A. Why, it would amount to several thousand dollars a year; I cannot place a close figure on that; it is appreciable and distinct in my opinion.

Q. Is this a matter that rests in opinion, or is it a matter that can be suitably demonstrated or measured in dollars and cents? 4334

A. It can be, approximately in dollars and cents, but I have not considered it in detail to give any more close figures than I have already stated.

Q. What in general would be the added expense of such a plant, covering the waters of the Illinois, the Mississippi and Missouri, over a plant filtering the waters of the Mississippi and the Missouri?

A. Still considering the executive head?

Q. Taking the whole matter, and we will separate it afterwards.

A. That is under present conditions?

Q. Yes, under present conditions.

A. I haven't made any close figures on that. I should think it would amount to quite a number of thousand dollars each year.

Q. Well, how many?

A. It is a mere guess which I would give; perhaps $20,000 or $25,000 for an off-hand opinion.

Q. Do you feel that you are competent to pass an opinion on the proposition?

A. If I were asked to figure it out in detail and make such a report, I think I am competent.

Q. I mean at present, Mr. Fuller?

4335 A. I can give you an off-hand opinion, as I am doing.

Q. Do you attach much value to that opinion?

A. As a general guide to the truth, I do.

Q. Is that opinion made from any knowledge of the details of expense of operating a plant?

A. Yes sir.

Q. What would be the added figure of the help of such a plant operating for the filtration of the waters of the Mississippi and Missouri, and the same plant with the Illinois added?

A. I have already stated that to be several thousand dollars. I cannot prescribe salaries.

Q. How do you arrive at several thousand dollars?

A. On the basis that it takes more experienced men to operate a filter plant where the quality of water is more dangerous, and where there are added supplies and responsibility, in the management.

Q. Would it require skilled men to operate a plant to filter the waters of the Missouri and the Mississippi?

A. It would require skilled men, yes.

Q. Would you recommend a less skilled man for the filtration of those waters than you would if the Illinois was added?

A. Yes, that is, experience and skill, combining the two.

Q. Yes.

A. Yes sir.

4336 Q. Under present conditions, what percentage of Illinois river water enters the St. Louis intake throughout the year?

A. I don't know accurately on an average. It varies very much no doubt.

Q. Have you any idea?

A. Do you mean for the average?

Q. An average per cent assuming that the waters at the intake represent 100 per cent and the 100 per cent is made up of Missouri river water, Mississippi river water and Illinois river water, what the average per cent throughout the year is of Illinois river water?

A. I couldn't tell you that very accurately.

Q. Then wouldn't the additional cost of a plant of that kind depend very largely upon the percentage of Illinois river that enters into the mixture of Missouri and Mississippi River water entering the intake?

A. As a practical proposition it would not depend upon the average per cent, but the maximum percentage of the amount of Illinois river water, highly polluted, which might from time to time reach the intake.

Q. Do you know as a matter of fact whether the conditions do not exist at the St. Louis intake, wherein the waters of the Missouri and the Mississippi are more infectious at times than the water from the Illinois?

4337 A. I do not know accurately about that. I think there may be some day in the course of a year when that might be possible.

Q. Do you think it is possible there are days during the course of a year when the water supply of St. Louis comes exclusively from the Missouri river and not from the Mississippi and Illinois?

A. No, I don't think that.

Q. Do you think there are days in the year when the waters at the intake come from the Missouri and Mississippi and not the Illinois?

A. No, I think there is some Illinois river water at all times.

Q. At all times?

A. Yes sir.

Q. When the Mississippi is low and the Illinois is low and the Missouri river high, would that condition obtain?

A. Yes, but of course there are times when the Illinois would be small in percentage with the Missouri high and the Mississippi and Illinois low.

Q. Do you know how often during the year the percentages of Missouri river water and Mississippi river water are greatly in excess of the Illinois river water, taking it at the St. Louis intake?

4338 A. A good many days, I presume, when the Missouri and the Mississippi are larger than the Illinois.

Q. Don't you think that the general average for the year would show a smaller per centage of Illinois river water than the Missouri and the Mississippi river water combined in the St. Louis intake?

A. Yes sir, a smaller percentage of Illinois.

Q. If it is true as an average, what additional skill would be required to operate a plant where the percentage of Illinois river water was much smaller than that from the Missouri and Mississippi?

A. To guard against danger arising on those occasions when a considerable amount of infection comes from the Illinois river water, and such as would produce a dangerous water at the intake of the St. Louis waterworks, independent of the infection and danger which might possibly come from the Missouri and Mississippi water.

Q. Is there anything known to sanitary science or any method known to sanitary science when those times can be accurately ascertained?

A. Not definitely, and that is the very reason why skill and experience are required, in the operation of that plant, to a greater degree with the Illinois river water, than without it.

4339 Q. Aren't there times and can't you conceive of times when the sewage discharge from Kansas City would be a great menace to the public health of the city of St. Louis?

A. Are you looking into the future now, sir?

Q. Either the present or the future?

A. I can conceive of such a condition taking the water in its raw condition.

Q. When such a time should arrive and such a time might arrive, might it not at no great distant future?

A. There is a possibility of it.

Q. If there should be an epidemic break out in Kansas City, wouldn't that be a menace to the water supply of St. Louis?

A. To a certain degree it would.

Q. Do you know how long it takes the sewage from Kansas City to come to the intake of the St. Louis water supply?

A. I have made estimates on all those things. I can get them if you wish to know.

Q. I would like to have an estimate on that if you can get it.

A. Under the average conditions it would be in the neighborhood of a week.

Q. Assuming that in Kansas City there should be an epidemic of typhoid fever, and the filter system such as you would construct for the filtration of the Missouri and Mississippi 4340 river waters was operated by a less skillful crew than would be established there when the combined waters of the Illinois and Mississippi rivers would be filtered, would the filters be a protection to the public health of the city of St. Louis under those conditions so operated?

A. I should hope so. I think they would.

Q. Then if the crew that you have mentioned would be able to compete with the epidemic at Kansas City within seven days journey from the waterworks of St. Louis, why couldn't that same crew protect the city water supply when filtering the waters of the Illinois?

A. It is possible that they might, but there would be the added danger from the Illinois water in that is intermittently flushing out large accumulations of sediment making the water here much more dangerous than it would in connection with the Kansas City epidemic.

Q. When you look into the future, you have no pessimistic views about the growth of Kansas City, have you?

A. No sir.

Q. With its near proximity to St. Louis in point of time, and the possibilities of it getting a typhoid contagion, isn't it a danger and a menace, present and impending to the water supply of the city of St. Louis?

A. As a general proposition I think it is.

Q. Would the closing of the drainage canal and the shut-
4341 ting off of its sewage preclude the future pending and impending dangers to the water system of St. Louis as it is at present established and preclude the probability of typhoid fever infection, or the danger from typhoid fever infection?

GENERAL CROW: Object to the question because it is wholly immaterial in this case as not tending to prove or disprove any issue that may be involved herein.

A. It would render much more distant the day when serious trouble would result from the use of the water taken from the present intake tower and treated in the manner as it is treated at the present time and as it was treated during the period of 1895 to 1899, and when the typhoid fever death rate in the city of St. Louis was such as to enable that water so delivered to the citizens of St. Louis, to be fairly called a good sanitary water.

Q. In considering the present, do you consider the waters of the Missouri river as a safe and usable water?

A. In a raw condition?

Q. In their present condition, in their raw condition?

A. No sir, I do not consider that the water in the Missouri river at the present time a fairly safe water.

Q. With the treatment that it receives with the water system existing here in St. Louis, would you pronounce it as safe and usable water?

MR. JEFRIES: At the present time or prior to 1899?

4342 Q. At the present time? It has been admitted here that the conditions of today have existed for ten years.

A. I shouldn't say so in absolute terms, but practically speaking and based on the experiences from 1895 to 1899, I would say that it would be reasonably safe.

Q. And based on the experience prior to that time?

A. Well, that I couldn't state.

Q. Would you consider a water such as the Missouri, with a town located within seven days of its water supply, where the number of typhoid deaths such as existed in Kansas City from 1893 to 1899, a safe water, after it has been subjected to the conditions existing here in St. Louis?

A. I don't think it would be absolutely safe, but practically speaking I think it would be reasonably safe, as judged by what was the actual experience in this city from 1895 to 1899. I don't know the conditions prior to 1895, at least I haven't them in mind.

Q. Do you consider a filter plant such as we have talked about, absolutely safe?

A. Practically speaking I do, but there is no such thing as an absolutely germ proof filter on a large scale, though.

Q. Then if there is no such thing as absolutely pure,

4343 we will eliminate that term and apply a practical term.

Would you consider the waters of the Missouri with the typhoid conditions existing from 1893 to 1899 along the watershed of the Missouri river as safe a water for drinking purposes, as treated by the St. Louis water system, assuming that the same conditions existed then as exist now?

A. That is, typhoid at Kansas City, and the settling of the water at the chain of rocks intake tower?

Q. Also Council Bluffs, and Omaha, Lincoln, Nebraska and the other towns?

A. I should say that the water would not be absolutely safe water after having been treated in the chain of rocks settling basins. But from a practical experience, under the conditions such as did obtain, I think it would be still a reasonably good water, a reasonably safe water.

Q. Eliminating the question of absolute purity, would you consider the waters of the Missouri, after that period, so treated, as a safe drinking water for the people of St. Louis?

A. I should say reasonably safe, as I have said in each instance, based on practical experience where they had not only the sewage and typhoid infection of the Missouri river towns which you have mentioned, but also of the upper Mississippi during the period from 1895 to 1899.

4344 Q. Assuming that you occupied the position of sanitary engineer in St. Louis, that there was no typhoid fever in the city and that a plant such as the plant now installed here was just established, and conditions existed along the Missouri river such as you are acquainted with as having been proven here, and the water supply for the city was to be taken from the Missouri river, would you as such sanitary engineer, recommend the water so treated, as a safe water for drinking purposes?

A. I should probably recommend that they adopt filtration in connection with it, but if those funds were not available, and I was asked if sedimentation without filtration wouldn't do for that water, and whether it wouldn't be reasonably safe or good decent water, as water supplies go in this country, I should say "Yes." That is my general view.

Q. Assuming that same question, with the water here being taken from the Missouri and the Mississippi river and all the conditions from 1893 to 1899 that existed upon the watershed of the Mississippi above Grafton, and the Missouri river, existed, excluding the Illinois, up to 1899, would you then pronounce the water so treated, as a safe water?

A. I should still think it would be a reasonably safe water, yes sir; not absolutely but reasonably so.

4345 Q. Well, we will eliminate the absolutely, as I believe you have stated there was no absolutely pure water used by cities, did you not?

A. I stated that there are no filters which are absolutely germ proof at all times.

Q. Yes, that's what I mean at all times.

A. There is a comparative degree which always obtains there.

Q. Assuming that the water supply came from the Missouri, the Mississippi and the Illinois, excluding the sewage that comes from the drainage canal under similar conditions, as contained in the previous two questions, what would you say then as to the water being safe and usable?

A. I should still think it would be safe and usable with the sedimentation which takes place in the manner similar to that actually provided at the chain of rocks.

Q. During the years prior to 1899, do you consider that the sewage pumped into the Illinois and Michigan Canal by the Bridgeport Pumping Works and thence entering the Desplaines river, as an infected sewage?

A. I think that the sewage pumped into the Illinois and Michigan Canal prior to 1899, contained infection, in a considerable proportion. A large proportion I may say, of the infection coming from the Chicago sewage remained on the Chicago side of the Bridgeport pumping station, where it was
4346 present with the sediment which remained undelivered by
the pumps into that canal.

GENERAL CROW: Remained where?

A. Remained undelivered through the pumps, that is, in the Chicago river. I also believe that the contents of the Chicago canal pumped into the Illinois and Michigan Canal were in such a state of advanced decomposition that the proportion of typhoid fever germs originally present in that liquid was comparatively small, particularly as the contents of that canal flowed into the Desplaines river.

Q. When any sewage is pumped into the Illinois and Michigan canal and then emptied into the Desplaines river, do you hold that it was free from any infectious germs dangerous to the city of St. Louis?

A. Not absolutely, no.

Q. In what degree?

A. I can measure that practically only in connection with all of the existing infection during the period from 1895 to 1899 which reached the chain of rocks intake tower of the St. Louis water works, meaning by that all of the infection coming from the Missouri, the upper Mississippi, from the Illinois and including such portion as came from the Illinois and Michigan Canal. Taking all those together there resulted a water polluted to a certain degree of course, at the intake tower of the St. 4347 Louis waterworks, but which degree of pollution was not such but that the sedimentation protected the citizens of St. Louis from any serious trouble from typhoid so far as the public water was concerned.

Q. If a considerable portion of that sewage was infected and once got into the Desplaines river, the typhoid infection would lie there in the sediment for a considerable portion of time wouldn't it?

A. It might, but I don't think that infection would get into the Desplaines river to any large degree because of this septic action, which, owing to the very nature of the process means a very tremendous growth of certain kinds of bacteria, the action of which is known to have a destructive influence upon the germs of typhoid fever.

Q. If in the watershed exclusive of Chicago, of the Illinois, Mississippi and Missouri rivers for the year 1897, there should be 374 deaths from typhoid fever and as high as 148 in the city of Minneapolis, will you explain why, with this typhoid condition existing for that year, that the St. Louis water supply was not menaced?

A. In its raw condition it was to a certain degree. It was not absolutely free from infection and the liability of infection, but that degree of infection was not such but that the sedimentation which the city waterworks provided could protect 4348 reasonably the water consumers in the city of St. Louis.

Q. How long would it take typhoid infected water, placed in a sediment basin to settle, so as to make the water safe?

A. With a water which is very seriously infected with typhoid matter, I think it is extremely doubtful if not certain, that it would never be entirely freed from that infection by sedimentation.

Q. Do you know how many typhoid bacilli are contained in the dejecta of one typhoid patient during the period of 24 hours?

A. No sir, I haven't any recollection of any such information.

Q. Assuming that there are two hundred thousand millions of typhoid bacilli discharged from a typhoid patient in 24 hours, and that there were in the watershed of the Missouri river, figuring that for every death there were ten cases, 3,740 cases, and that the average life of a typhoid case would be about fourteen days, if that number of bacteria as counted, represented by carrying out the calculation, was dumped into the watershed of the Mississippi river above its intake, including by that the Mississippi, the Missouri and the Illinois during the period of a year, and distributed as the time shows, wouldn't that be enough microbes, parasites or germs, as the case may be, to pollute the water of the Mississippi?

A. It would pollute it somewhat, no doubt; it would be
4349 bound to.

Q. How long would that water thus polluted, placed in a sediment basin, be, before it would become pure, safe and usable?

A. I don't think anyone can answer that very specifically, but it would be a very much longer period than almost anyone would be inclined to think, and I base that opinion on the fact that sedimentation basins holding thirty days' supply, are not able, uniformly, to protect water consumers in instances where the waters entering such settling basins are sewage polluted and infected. There would be a very large removal, though it would not be an absolute removal.

Q. Do you know how long water that is placed in sediment basins of St. Louis, remains there before being taken out?

A. It is a question of several days.

Q. Is it not a fact that the settling basins in St. Louis are emptied every three days or less?

A. For what purpose, sir?

Q. For consumption?

A. That was their style of operation in the early years, but not at present.

Q. How long does the water stand today in the settling basins from the time it is pumped into the settling basins to the time it is given to the consumer?

A. That is a very variable matter, depending upon the
4350 rate of consumption, but taking the average consumption we will say, for the year, there are approximately 65,000,000 gallons of water used here in St. Louis on an average, per day. Those six basins at the chain of rocks hold 174,000,000 gallons, so that there would be between two and three days storage or period of sedimentation in those basins provided none of them were out of service for cleaning.

Q. In those sediment basins are the waters in a perfectly quiescent state for a period of three days at a time?

A. No.

Q. Two days?

A. It never gets absolutely quiescent. That is impossible in large bodies of water.

Q. There is always great turmoil in those settling basins, isn't there?

A. There is some movement to the water.

Q. How much of a movement would you calculate?

A. I should think it would be less than a foot per minute as I remember it. I am speaking off hand.

Q. How much would that be in miles per hour?

A. It would be a great deal less than one-third of a mile per day.

Q. One mile in three hours?

A. It would be less than that.

4351 Q. Would it be as much as one mile in four hours?

A. It is less than that a good deal, at the chain of rocks.

Q. During the time that the waters are in the settling basins, is that water quiescent so as to have complete sedimentation?

A. It approaches quiescence, but it doesn't reach it. Sedimentation takes place to a large degree, but it is very seldom that all the matters in suspension are entirely eliminated.

Q. And if that water should have a few million typhoid bacteria in it, the time that it is in the settling basin wouldn't be sufficient to eliminate them, would it?

A. Not if all those typhoid fever germs we are talking about up the several rivers continued to live and reach the intake tower of the St. Louis waterworks.

Q. Is there anyway of ascertaining how long they will live?

A. An opinion can be formed on the period which some of them may live.

Q. Can an opinion be formed except it is based on a theory?

A. Yes, I think it can.

Q. Has it ever been demonstrated how long a typhoid germ will live in running water, except based upon assumptions; I mean, water running in a river? Suppose it was possible 4352 to pick out 50 typhoid germs and put them into a running river, has anyone ever been able to say how long those germs would live?

A. Not from laboratory experiments; but it is possible by actual information as to the pollution of the water supply of one city on a large river, by the sewage of another large city, some distance above the first mentioned one, to demonstrate that. There are quite a number of instances available as to that practical information which may be obtained.

Q. But it is not a scientific demonstration, is it?

A. I should consider it so, because it is a truthful one.

Q. It is as infallible, is it, and as accurately demonstrated as twice two is four?

A. I think it is, that some typhoid fever germs will pass a long distance in running water from the sewers of one city to the water taps of the city below, the city below taking its water of course, from the same river into which the sewers of the upper city discharge.

Q. Now when the water in settling basins is exhausted from one of the settling basins, how is it replenished?

A. Do you refer to St. Louis?

Q. In St. Louis mean?

A. The old method of operating.

Q. How is that?

4353 A. The water is drawn off to a certain level and then it is turned on again, allowed to settle, and drawn again. It is a series of filling, allowing to stand in as quiet a condition as can be obtained, and then drawn off again.

Q. How much of the water is drawn off before it is replenished?

A. This, you understand, is in the old days.

Q. I am speaking of the conditions in St. Louis today.

A. They are not worked that way today.

Q. How are they worked?

A. On the continuous displacement plan.

Q. What plan is that?

A. All of those basins which are not out of service for cleaning are kept full of water. The water is turned into those basins at one end and there are siphons at the other end, and the water having traveled the length of that basin is siphoned over into the next basin, and thence traveling through the length of that, and so on.

Q. At those points where the siphon draws out and discharges there is quite a commotion, isn't there?

A. The velocity is higher than it is throughout the entire width of the basin, but I wouldn't call it a commotion.

Q. Isn't there a commotion or disturbance sufficient to arouse the sleeping typhoid germs that may be in the sediment, to action and thereby get into the water supply of St. Louis? 4354

GENERAL CROW: I object because we haven't proven that they go to sleep.

A. Those siphons take the water, I think, some ten feet from the bottom, and I should doubt whether there would be any material disturbance of the sediment, particularly in those basins through which the water last passes before it reaches the city.

Q. How long would a typhoid germ that got into a settling basin and got into the sedimentation of the basin, live there?

A. A good long while in all probability, some of them would.

Q. And if the water is slightly typhoid infected, it would be liable to accumulate a great number of these little creatures or vegetables during the course of six months, wouldn't it?

A. You mean in the sediment of the basin?

Q. In the sediment?

A. There very likely would be a good many in the sediment, yes.

Q. And they are the last to settle down to rest in the sediment of the water?

A. No sir, the clay is the last to go; in fact all the clay as is well known doesn't go down usually in this water.

4355 Q. The microbes are heavier than the clay?

A. They are larger than the clay particles.

Q. And these basins are exposed to the winds, aren't they?

A. Yes sir.

Q. And with such a wind phenomena as we have had during the last two or three weeks, passing over these basins, wouldn't it have a tendency to stir it at the bottom?

A. There is a tendency in that direction. I don't think there will be a great deal of the sediment brought up but there would be some, though.

Q. And if the waves upon those basins caused by a severe gale or wind, should turn up the sediment in the bottom of these basins, where these typhoid organisms have gathered, that water would be liable to be carried into the intake, wouldn't it?

A. You mean into the outlet?

Q. I mean into the outlet and distributed to the people of the city?

A. It would provided the churning action of the wind were to get that sediment in there.

Q. Would the churning action of the wind be less liable to affect that condition in the sediment basin of St. Louis than it would upon the Illinois river?

A. The basins here are deeper, but if all things were
4356 the same, of coarse nature is going to work the same in
both waters, but the basins of St. Louis are deeper than
are the slack water stretches on the Illinois.

Q. Well, a good strong wind over those settling basins, down here near the Merchant's Bridge would create a great deal of disturbance in the surface of the water, wouldn't it?

A. Yes sir.

Q. And that disturbance would be communicated to the bottom, wouldn't it?

A. It would in a measure, but those basins are still deeper than those at the chain of rocks.

Q. Have they got some at the chain of rocks that are not as deep as those at Bissell's Point?

A. Yes sir.

Q. Well, those at the chain of rocks are not as deep as the ones at Bissell's Point, is that right?

A. Yes sir.

Q. Well, the conditions there would be greater for disturbances from wind than it would be in the other basins, wouldn't it?

A. Theoretically that is so, yes, from very heavy winds. There would be some difference, no doubt.

Q. Now do you think that the water in those basins has three whole days in which to settle?

A. No, I have said it was less than that under the most
4357 favorable conditions.

Q. Would it be about an average of a day and a half?

A. That would be a fair general figure, yes.

Q. You do not consider, as a sanitary expert, that a day and a half to settle in basins where they are gradually taken off and leveled by siphons, as being a sufficient time to eliminate any considerable number of typhoid germs, do you?

A. It will do very well as far as sedimentation alone is concerned, and it undoubtedly does eliminate a very large number. In fact, in practice here it is true that there is a very material reduction.

Q. If the settling basins of St. Louis subjected to a day and a half sedimentation on an average, creates such good results in regard to bacteria and infected germs, why wouldn't the lakes upon the Illinois river, Lake Joliet and Lake Peoria, and the back water of the different dams in the river, effect the same results?

A. They would, provided all the conditions were the same. Nature would work the same in the two instances. There is a great deal of elimination from the flowing stream of typhoid germs and other bacteria, as the water of the Illinois river passes through those basins, but it is not removed as it is in the case of the chain of rocks settling basins. At the chain of rocks
settling basins the sediment is removed by draining the
4358 the basins and washing them out, flushing them out. On

the Illinois river the typhoid germs and other bacteria which leave the flowing water and go to the bottom and lie upon the bed of the streams are subsequently flushed out by conditions which naturally occur on that bed and are returned to the flowing water and pass down toward the mouth; and some of them, many of them, doubtless do reach the mouth of the stream.

Q. How do you know that, Mr. Fuller?

A. It is a matter of common sense from the changing stages which occur in that river, the slope of the river and the various physical conditions which obtain there.

Q. Have you ever found common sense making a mistake?

A. I think it is the best guide I know of to go by.

Q. When these germs sink to the bottom of the lake and the sedimentation of the sewage pollution of the water settles down with them, do you know whether any chemical action takes place down at the bottom where these microbes are?

A. I presume that there is quite a little chemical action going on there.

Q. Do the an-aerobic bacteria have any effect upon the destruction of the bacillus of typhoid?

A. It does under septic conditions, such as would obtain in a septic tank or in the Illinois and Michigan Canal, but
4359 in the bed of the stream, of the Illinois river where such septic action does not ordinarily, if ever, obtain, I do not think that they would effect the life very materially of the typhoid fever germ.

Q. In this back water of the dam, do you know how far above the dam this water is raised, and extends up the river?

A. Well sir, I have studied that carefully. As my memory serves me, some of them would go back forty or fifty miles, but I will look it up if you wish?

Q. No, just the fact that you knew is all I want. When the water is not at flood tide in the Illinois river, do you know how swift the current is through these back-water basins?

A. I have studied that carefully, yes sir.

Q. What is the rate?

A. It gets down to less than a half a mile per hour.

Q. During those times sedimentation can take place, can it not, and does?

A. Yes, to a considerable degree.

Q. And the bacteria of typhoid would go to the bed of the river, wouldn't they?

A. Yes, if they settled, certainly.

Q. They would settle, wouldn't they?

A. A great many of them would settle, yes.

4360 Q. Do you know of any reason why they wouldn't practically, I mean?

A. There would be a very small percentage of them which would not, due to the action of passing boats and wind and those little things, as in all probability occur in the stretches of slack water many miles long, and where the velocity uniformly is very low.

Q. When these settling basins extend over surrounding country where vegetation and grass are plenty, these organisms would get out among the grass, wouldn't they?

A. Some of them would.

Q. And when they got out there, would a freshet drive them back into the center of the stream?

A. That is possible.

Q. Isn't the possibility that they would not, more than they would?

A. I think more of them would not go back than would.

GEORGE W. FULLER.

ADJOURNED until 10:00 A. M., Saturday, May 30, 1903.

4361 Southern Hotel, St. Louis, Missouri. 10:00 A. M., Saturday, May 30, 1903. Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

GEORGE W. FULLER,

resumed the stand for further cross-examination by Mr. Todd and testified as follows:—

Q. Do you know what proportion or what percentage of the bacteria in the St. Louis settling basins are eliminated by the sedimentation processes that take place there

A. The percentage removal as a general proposition is quite variable and as an average I presume it would be in the neighborhood of 75.

Q. Do you know whether the consumption of water in St. Louis is greater in winter than in summer, or vice versa?

A. As a general proposition there are seasonal fluctuations in the quantity of water used. In the summer, owing to warm weather and the amount of water used for sprinkling lawns, there is a high consumption, and in very cold weather in winter there is high consumption because people leave
4362 their faucets open. In the spring and autum, as a general proposition, the quantity supplied throughout the city is somewhat less than those two extremes of summer and winter.

Q. Well, as a general proposition, isn't it a fact that the amount of water consumed in the city of St. Louis in the summer months is far in excess of that for the cold months, or the winter months, on account of sprinkling the lawns, and washing the streets, and bathing purposes, etc?

A. It is somewhat in excess I should say.

Q. And during those months the time of sedimentation in the settling basins would be less than for the other months would it not?

A. It would be somewhat less, but its effects may be very small because, after a period of sedimentation in those basins for a day or a day and a half, the further removal during one or two hours, or three or four hours beyond that period, is comparatively small.

Q. Are you acquainted with the conditions that obtain in what is known as Lake Joliet, as to current?

A. I have looked those matters up as a general proposition, yes sir.

Q. Do you know what the character of the bottom of Lake Joliet is?

A. I haven't personally examined it, no sir.

4363 Q. Would the character of the bottom of a stream have any effect upon the question of sedimentation in the bottom?

A. You mean so far as removal of sediment from the flowing waters is concerned?

Q. Yes, would the bottom have any effect upon the sediment in connection with freshets?

A. So far as the nature of that bottom is concerned, I shouldn't like to say it was anything of a factor, that is, so far as its composition is concerned.

Q. If the bottom of the stream should be a sandy or rocky bottom, or a peat-bog, would the sediment be removed as rapidly from a peat-bog as it would from a sandy or rocky bottom in times of freshet?

A. It would be the velocity of flow of the water at times of freshet which would be the controlling factor, and not the composition of the material forming that bottom.

Q. If in a lake with a bottom of sand or rock, a certain flow of water should pass, would that flow be as likely to remove the sediment if the bottom of that lake, was a peatbog?

A. I don't think practically speaking, there would be any very great difference one way or the other.

Q. Where the bottom is a kind of a vegetable growth, or
a peat-bog growth, and the bacteria settled in that bottom,
4364 wouldn't it be harder to remove that bacteria with the
same current than it would if it was a hard bottom or a
sandy bottom?

A. It might be very difficult to remove those bacteria which were actually lodged, and attached directly to the grass and vegetable matter, but as to those which are simply lying loosely upon the bottom, it is my opinion that that would not be an essential factor.

Q. Do you know what the current is through Lake Joliet?

A. It gets down to a fraction of a mile at times.

Q. Do you know how rapid it gets at times?

A. It must be quite rapid at times; very rapid.

Q. By quite rapid, how would you express that in miles—

A. I presume several miles per hour.

Q. Now is a current of several miles per hour a sufficient current to scour out a lake when that current passes through the center from its inlet to its outlet?

A. I should think that it would remove a considerable portion of them. All of these questions of the degree of removal are the functions of the velocity. One set of conditions with a flow of three miles per hour would remove sediment but to a less degree than a velocity of four miles per hour. It is a question of detail as to degree, fitting velocity with the character of the material to be removed. 4365

Q. Now if the sewage of Chicago, passing through Lake Joliet when the current was only a mile, a mile and a quarter or a mile and half an hour, considerable deposit would take place, and elimination of the germs would be effected in the transmission through that lake, would it not?

A. There would probably be some considerable removal of those germs from the flowing stream.

Q. And part of the germs that entered would be scattered and disseminated over that part of the lake which is not adjacent to the current, wouldn't they?

A. That is possible.

Q. Now, after it passes Lake Joliet, the first dam that it would reach, the upper pool of which extends for several miles or more, would aid in the process of purification by means of sedimentation, would it not?

A. There would be a removal of germs at times when the velocity of flow was small, and such velocities at times do occur, in my judgment.

Q. Do you know whether those times are the greater part or the lesser part of the year?

A. I presume that they would aggregate upwards of half a year. I am not speaking now accurately, but in general terms.

4366 Q. And when these back water pools spread out over the country, overflowing the land, the germs that settled along the shores and on the overflowed land, would be less likely to be disturbed by freshets than that just deposited in the bed of the stream, would it not?

A. I presume that the velocity may be somewhat less there, but I think there are undoubtedly conditions which obtain on these overflowed portions, which would enable some of those germs lying in the sediments on the overflowed banks, to be returned to the stream.

Q. And those conditions would obtain in regard to all the dams along the Illinois river, would they not? What is true of one would be true of them all?

A. Conditions being the same, that is true, there would be at times a sedimentation or removal from the flowing stream; they would become deposited upon the bed, and following would come the scouring velocities and pick up and move them on. As a general proposition that is true.

Q. And during these times, when the germs are in a state of sedimentation, destruction and death would be prevalent among the germs, would it not?

A. To a certain degree there would be a dying out among those germs.

4367 Q. Is there any way of ascertaining how much or how many or what percentage of those germs would live, and what would not?

A. No ready means that I know of. I know that some do not die out within the period of time intervening between the ordinary successions of flood stages and the disturbances which would bring about a removal of the germs from the sediment, and a return of the germs lying in the bed of the stream to the flowing water.

Q. And when the water from Chicago gets to Lake Peoria, do you know what the current of Lake Peoria is?

A. No sir, I am unable to state that from my memoranda that I have at hand.

Q. Do you know whether the current at Lake Peoria even at high stages of water, exceeds two miles an hour?

A. I should not expect it would exceed it under all ordinary high stage conditions.

Q. Assuming that the current in Lake Peoria at the time that Professor Van Ornum made the float test was six-tenths of a mile per hour, would that current be sufficient to scour out the lake?

A. That velocity would not make a complete removal, but there would be disturbances probably, boats and wind actions, and such things, which would make a considerable removal of sediments, but not complete.

Q. Assuming that at the time that that experiment was

4368 made, that showed six-tenths of a mile an hour, that the water was at high stage, almost its maximum at Peoria, can you conceive of a freshet under normal conditions creating a greater current in Lake Peoria than existed there under the high stages of water at the time that that experiment was made?

A. Not any very material increase beyond that point, but of course it is to be borne in mind that in these reaches of quite considerable width, if the water overflows the banks, that the velocities do not advance according to the stages; that is, velocities in the main stream do not increase proportionately to the increase of the river heights, as shown on the river guages.

Q. Now you speak of disturbances by boats. Have you any idea of the number of boats that run up the Illinois river from Peoria?

A. No. I don't imagine there are a great many.

Q. If it should appear that not one boat in three weeks or six weeks went up the river above Peoria, would you attribute very much importance to the disturbances which that boat would create?

A. No sir. So far as boats are concerned, that is one of several factors. It is the end result which I was considering; that is the information which is available showing that those deposits are not permanent and accumulative. 4369

Q. If the sedimentation in Lake Peoria is constantly going on and the current at maximum stages of the river, or high flood of the river, is only six-tenths of a mile per hour would you consider that a scouring was possible to take place in Lake Peoria?

A. I should consider that bacteria would be removed from the sediment of the stream under the existing conditions, taking all of those together, collectively, on this basis. There is suspended matter at times coming into the stream above Lake Peoria; that sediment passes through the lake. If that sediment is not deposited, it indicates to my thought very clearly, that the conditions are such that bacteria may be removed,—upon comparing now the hydraulic subsiding value of the particles of a mineral nature suspended in that water, with that of the bacteria which at low velocities of flow may become and do become deposited upon the bed.

Q. The velocity of the current would decrease as you went away from the channel of the lake, would it not?

A. I should expect it would decrease somewhat.

Q. And the water entering the lake at the intake would be distributed over the surface of the lake, would it not?

A. In a general way that is true.

4370 Q. And that water which gets in the lake outside of the channel would have better opportunities for sedimentation than that which is immediately in the channel would it not, because of its quiescent state?

A. Well, there is no such thing as a thoroughly quiescent state, so far as velocity of flow is concerned. The conditions would be very favorable, but we also have to take into consideration this fact, that sedimentation and also scour are affected by changes in velocity and changes in condition within certain limits independent of the absolute flows.

Q. There is no quiescent state in the settling basins of St. Louis, is there?

A. Not absolute quiescence, no sir.

Q. Now when this water gets to Peoria, after passing the dams above Peoria, and the lakes above Peoria, considerable elimination of its infection and polluted matter is accomplished, is it not?

A. On an average that would be true. I presume ordinarily that is true, but there are times when I think that that is not so.

Q. Do you know how long a germ of typhoid fever would exist in polluted water such as would come from the distilleries and glucose factories of Peoria?

A. I should think some might live for several weeks or months.

4371 Q. Do you know, is my question. Not what you think.

A. I know of places where water has been polluted with refuse similar to that, and I know that that does not kill the typhoid fever germs.

Q. Have you ever made any laboratory experiments to ascertain whether in sewage of that kind typhoid fever germs would exist?

A. I have not.

Q. Have you analyzed the sewage that comes from the glucose factory at Peoria?

A. No sir.

Q. Have you any idea as to the volume of sewage that is emptied into the Illinois river from those factories and distilleries?

A. I know that the volume cannot be a very material one, for in examining the analytical evidence I have been unable to detect that that is a controlling, or, I might say, a general or dominating factor, taking this entire proposition of the disposal of the Chicago sewage as it comes down through the Illinois river.

Q. If you were called upon to pass upon the condition of the water of the Mississippi river at present in the absence of any knowledge or effect of that water, would you be able as a sanitary engineer to tell whether it was safe or
4372 usable or not?

A. You are speaking now independent of typhoid fever statistics, which is the best—

Q. I am speaking independently of the results.

A. Why I should say that the amount of sewage pollution in the Mississippi river at the chain of rocks intake tower considering that water in its raw condition, is such that it would not be thoroughly safe.

Q. How would you ascertain that fact?

A. I would consider it with reference to the amount of pollution entering the streams above.

Q. Suppose that you did not know the amount of pollution entering the streams above?

A. Well, I think it is very essential for any sanitary engineer or sanitary expert to ascertain that information and it would be a very reckless proposition for anyone to make a definite statement in the absence of such information.

Q. Is there any way that a sanitary engineer can ascertain from the water itself whether it is a safe and usable, or a dangerous water?

A. He can get considerable assistance through the tests made for the presence of intestinal bacteria. If in examining it at very frequent intervals in large quantities such water, so

that he will get information representing both the flow
4373 and the element of time, day by day, at different cross sections, and he finds that intestinal bacteria are absent—

Q. What bacteria do you mean?

A. Colon bacillus—if that is absent in that water, or if it is necessary to test very large volumes of that water in order to get a positive result, he would be able to get considerable assistance in forming a judgment in a practical way, regarding the pollution of that water.

Q. Does the coli bacillus come from fish?

A. Why in my judgment that is not very much of a practical proposition in these streams out here. I base that on my experience that in mountain streams where fish are very abundant, there does not seem to be anything in the fecal discharges of fish to distort to any very serious degree the practical results to be derived from the colon bacillus tests which I described. I do recognize, however that there is evidence on record that some fish do contain the colon bacillus. Personally I am not posted on that. I go on my own practical experience with mountain streams, where I know that fish predominate and where the coli is shown to be uniformly absent.

Q. If it should appear that the fish that infest the Illinois River did discharge the colon bacillus into the waters through their intestines, and that the stream itself is impregnated with fish to a large extent, would the presence of
4374 the coli bacillus be any evidence to you of sewage pollution?

A. If I satisfied myself that there were no opportunities for sewage to enter that stream, and still found that the colon bacilli were present in relatively large numbers, why I certainly would consider that to be a factor, and would want to investigate what the chances are of large numbers of colon coming from fish.

Q. Does it require an expert man who has devoted any great considerable time to the study of water to draw a conclusion where he knows that sewage enters water, and where he knows that the people drinking that water become sick?

A. It does not require a great deal of technical training to ascertain whether sewage enters water, but it does require skill and judgment and good practical common sense to know whether there is going to be serious danger resulting among those persons who drink of that water at various places.

Q. Can you tell whether there will be danger to the people drinking that water before the danger has manifested itself in sickness and typhoid fever, by the examination of the water itself?

A. It is possible to form judgment as to the liability of there arising from sewage pollution the liability of serious danger coming to those people who drink of the water, and forecast that in advance of the vital statistics among the
4375 people consuming such water.

Q. Well, that is not an accurate, scientific demonstration is it; it is mere guess, isn't it?

A. No sir, that is an aid which a practical man can use in interpreting existing conditions as they are found in nature.

Q. In regard to the typhoid germ living in the sediment of streams, do you know of anyone that has ever discovered a typhoid germ in the sediment of a stream, a running stream?

A. It has been found in the sediment of lakes, and we know it exists beyond all doubt in the sediment of running streams.

Q. Has it ever been demonstrated by bacteriologists that typhoid germs have lived in the sediment of a running stream?

A. It has been demonstrated that they have lived for a long time in the sediment of lakes, and I do not consider that there is any weakness in the process of reasoning by which one steps from a lake to a river, provided of course that each of those waters are live waters, and not subjected to septic action.

Q. By whom has it been ascertained that the typhoid germ has been found to live in the sediment of a running stream or a lake?

A. There are observers over in Switzerland who made such examinations with a positive result, showing the presence of typhoid germs in the sediment of Lake Geneva, I think also Lake Zurich.

4376 How long after the germs were put into the sediment was it before they were discovered?

A. I don't know in the case of the particular germ which they found, but they were found considerably more than a mile from the shore, or from the outlet of any sewers.

Q. Isn't the length of time that a typhoid bacillus will live in a sediment, more a matter of assumption than a matter of demonstrated proof?

A. I consider that it is a very clean cut demonstrated fact, that typhoid fever germs may, do and have continued to live in the sediments of running waters.

Q. For what length of time?

A. I should say for a month or more, possibly in cases for years.

Q. Who has demonstrated that it ever lived a year?

A. I think that the conditions existing in the moist soil in many rural places in this country where typhoid fever prevails from time to time, are proof that typhoid fever germs in the presence of moisture can live for such a term. If that were not so, then there would be an elimination absolutely, of typhoid fever through the rural districts of this and all other countries.

Q. Are those the facts upon which you claim that the life of the typhoid bacillus for a year has been scientifically
4377 demonstrated?

A. That is one of the principal factors to which as a scientific man, I give great credence in showing that typhoid fever germs are not eliminated absolutely within that period of time.

Q. By that same process of reasoning, couldn't you have credence that it would live a thousand years as well as a year?

A. Well I am not familiar with vital statistics for such a period of time.

Q. Are you familiar with the vital statistics for a year?

A. In many places I am.

Q. Where is any one place that you have personally investigated and have demonstrated that a typhoid germ has lived for one year, whether in laboratories, or elsewhere?

A. Why, my common knowledge of the existing conditions in many country towns, satisfies me beyond all doubt as a scientific man, that those germs have lived for at least a year.

Q. Is your common knowledge superior to scientific demonstration?

A. In a great many instances it is vastly superior to it.

Q. What do you mean by common knowledge, Mr. Fuller?

A. I mean that information which leads one to the truth in explaining phenomena as they exist in nature.

Q. Is that a matter that can be scientifically demonstrated?

A. Science can do no more than show the truth.

4378 Q. Well, has science ever demonstrated what your common knowledge has proclaimed as the truth?

A. I should put science and common knowledge in the instance of which we are speaking, in the same class.

Q. Do you know of any specific instance where you have personally investigated and established beyond all reasonable doubt that a typhoid germ has lived for one year?

A. I am satisfied that beyond all reasonable doubt those typhoid fever germs which cause typhoid fever to prevail in isolated rural communities in many places in New England with which I am familiar and where I spent my boyhood days, that these germs most unquestionably did live in some instances for at least a year.

Q. Do you regard that answer as an answer to my question, —as a scientific answer to my question?

A. As a practical proposition I say that that answer is responsive to that question, because science can do no more than explain the truth; science aids in that, and that is the purpose of science, to find out the reason why.

Q. What in your answer to my previous question contains elements of a scientific demonstration?

A. A scientific demonstration, as I understand the expression, means the use of procedures which ascertain the truth and I am satisfied that in the answer which I gave those conditions which I considered and mentioned, do lead me to the truth. 4379

Q. From that scientific investigation, as you denominate it, in answer to my question, was it scientifically demonstrated that the typhoid germ in the places and localities which you indicated, only lived one year or lived a period in excess of one year?

A. I presume that some of them did live more than one year. I think that that is a fair and correct assumption.

Q. How many years would you say that the typhoid fever germ in the instance that you have given has scientifically been demonstrated to have lived?

A. I will say several years. I will not go into details beyond that. I think unquestionably they live several years.

Q. By "several" do you mean three or two?

A. In that general vicinity, two or three, as compared with, well, say 100.

Q. Do you know of any other scientific man that holds that a typhoid germ lives as long as three years?

A. In the soil, you mean, and where moisture prevails?

Q. Where it has been discharged from the bowels of man?

A. Yes, sir; I think that there are people who hold that view, particularly that group of scientists who may be classified as epidemiologists. If that were not so, then the
4380 transmission of infectious diseases cannot be explained.

Q. Name me one man by name who holds that a typhoid germ will live three years?

A. I think I am safe in stating Professor Sedgwick.

Q. Anybody else but Professor Sedgwick?

A. No doubt there are a good many.

Q. That you can name, I mean?

A. I have not personally conversed with a great many people on the subject. I think that there are, unquestionably, others though.

Q. Well, name me anyone who has exploited that longevity for a typhoid bacillus, in any work?

A. I don't recall at the moment.

Q. You have made a study of bacteriology, have you not, Mr. Fuller?

A. I have given a good deal of study to it, several years ago.

Q. Have you ever discovered in the waters of the United States the prodigiosus bacillus?

A. I think that that was found in the Ohio river at Cincinnati on one occasion, in the course of over a year's investigation, involving practically daily examinations of the water of the Ohio river.

Q. Where one bacillus of a peculiar bacteria is discov-

4381 ered, as a scientist, you would not hold that that was an isolated case, would you, but that there were others existing in the same water, would you not?

A. There is a possibility of that, but it is a fact that the bacillus prodigiosus is very, very rarely found in American waters, according to the information now available, and it is a very easy germ to discover. It is one which is given to beginners in their class work, and if it were found very abundantly or very frequently, I am sure that that would be very widely known among bacteriologists.

Q. Will a typhoid germ live a year in water?

A. Some, out of a large number, put in water, I have no doubt will live a year.

Q. If a typhoid germ should be deposited in Lake Itasca, from the excreta of an Indian up in that neighborhood, and that typhoid germ floating down the Mississippi should enter the intake at New Orleans, and get into the system of a creole, would that creole be likely to take typhoid fever?

A. I think there is a decided possibility in that direction, and if there were enough of those individual instances of one germ coming down from Lake Itasca to the New Orleans intake, there would surely trouble result to the person drinking that water in its raw condition, and in which were present germs coming from Lake Itasca.

4382 RE-DIRECT EXAMINATION, by General Crow.

Q. Mr. Fuller, you were asked on your cross-examination about whether or not you had any knowledge as to typhoid bacilli being traced through the out-falls of the sewers of a city, into running streams conveying typhoid to persons using the water in cities below upon that same stream, into which the sewers emptied. I will get you to state if on any of our western rivers you have had any experience that would lead you to that conclusion?

A. Yes, in the instance of the sewage polluted Ohio river water, which is taken as the source of supply for the city of Louisville. Considerable typhoid fever prevails in the city of Louisville. After the water supply is drawn from that river it is passed through the settling basins, holding some five or six

days' supply, and in which sedimentation takes place. The sewage coming into the Ohio river is almost entirely confined to points at and above Cincinnati, which is distant about 150 miles by river. At times of very low flow in the river the velocity is such that the period of time for some of those germs to pass from Cincinnati to Louisville from the sewers of the city of Cincinnati to the taps of the citizens of Louisville, is more than one month. I consider that that is a very
4383 reliable demonstration that typhoid fever germs are not absolutely removed from sewage polluted waters, in which that pollution takes place one month before the water is used for domestic consumption.

I will further state that in the instance of the waterworks plant in the city of Covington, Kentucky, the source of this water supply is the Ohio river. There are provided sedimentation basins holding approximately thirty days' supply. It has been found that year after year the citizens of Covington using the Ohio river water coming from those basins are not protected from typhoid fever.

As to the pollution which exists in the Ohio river at Cincinnati, I consider that there is no room for doubt, but that a portion of the pollution existing in the Ohio river at Cincinnati is due to the sewage coming from the cities and towns located in Allegheny county, Pennsylvania, including its two principal cities, Pittsburg and Allegheny. This distance is between 450 and 500 miles.

Making this statement clearer, I will further say that in my judgment were all sewage pollution of the Ohio river and its tributaries between Pittsburg and Cincinnati eliminated, I consider that the Pittsburg sewage would unquestionably make its influence felt in the hygienic character of the river water at Cincinnati.

Q. Mr. Fuller, I will ask you if you have any facts or
4384 information bearing upon the question as to whether or not in Lake Peoria and other slack water places on the Illinois river, deposits of sediment have appreciably accumulated upon the bed of the stream?

A. There is documentary evidence to that effect, and there is also practical observation as to the amount of scouring which must take place. As to the former I will state that it is on record in reports of the Chief of Engineers of the United States Army, that the engineers in charge of the Illinois river, find that where channels are dredged in that river, they are nearly permanent. "Channels dredged twenty years ago are but little deteriorated, and it is surprising to find that there has been no deterioration in depth in the pools created by the Henry and Copperas Creek dams after from fifteen to twenty-eight years' use."

Q. Where is the Copperas Creek dam with reference to Lake Peoria?

JUDGE JOHNS: It is about 27 miles below Lake Peoria.

GENERAL CROW: And where is the Henry dam?

JUDGE JOHNS: That is above.

THE WITNESS: That is above. That last statement as to channels is a quotation from Major Marshall in the report of the Chief of Engineers, United States Army, 1895, page 2716.

4385 The same gentleman is quoted in the report of the Chief of Engineers of the United States Army, 1898, page 2436, as follows:

"The dams (meaning in the Illinois river) have no appreciable effect above mid-stage of the river when currents are the strongest, so that all lighter sediment is swept away as well now as before constructing the dams. That there has been no appreciable change felt in the pools of the Illinois river is a fact that has been so often remarked upon by steamboat men and persons interested in the use of the river since the construction of the first dam at Henry, thirty years ago."

JUDGE JOHNS: I move to strike out portions of the answer which are read from the reports named in the answer, as not competent evidence.

GENERAL CROW: Now, Mr. Fuller, I will ask you from all the information you have of every kind, as to whether or not it is your judgment that any great amount of sediment does accumulate and remain upon the bed of the stream of the Illinois river, for any great length of time?

A. In my judgment not.

RE-CROSS-EXAMINATION, by Judge Johns.

Q. What towns are on the Ohio River shore on either side between Louisville and Cincinnati?

4386 A. The Ohio river between Louisville and Cincinnati has situated upon it no towns of any considerable size below the towns of Aurora and Lawrenceburg, at the mouth of the Miami river which is some 20 or 25 miles below Cincinnati. About 50 miles above Louisville there is the little town of Madison which some years ago was quite prosperous when the cooperage business was being carried on there; a town I suppose of some 6,000 people; but when I lived in Louisville, I know there was no public sewerage system of any consequence and I doubt whether there were any sewers other than through private drains, which are used in towns of that size, so that for a distance of about 125 miles on the Ohio river above Louisville, we may say practically speaking, that there is no sewage entering the river.

Q. How many communities, of you will dignify them as towns, are there upon the banks of the Ohio upon either side between Louisville and Cincinnati?

A. Within what distance from the river?

Q. Well, upon the banks of the river?

A. There are very few as I remember. I have been frequently up and down that river on a steamboat, and the boats have a good deal of trouble, according to my observation and experience, in finding their landing places. There are not many habitations on the Ohio river between those two cities

4387 which could contribute in any appreciable degree, sewage to the waters of that stream.

Q. Has the Ohio river a considerable river population, by that meaning people who live in boats upon the river and upon the shores of the river as fishermen and otherwise, between Louisville and Cincinnati?

A. There are some people living in house-boats on the river.

Q. Are there tributaries of the Ohio between Louisville and Cincinnati, on either side?

A. The only river of any importance entering the Ohio between Louisville and the mouth of the Miami 25 miles below

Cincinnati, is the Kentucky river. The mouth of that river is distant from Louisville I should say 50 or 60 miles.

Q. Are there any small tributaries of the Ohio between Cincinnati and Louisville other than the Kentucky river.

A. There are some small creeks, but so far as I recall, there is no opportunity for any material amount of sewage pollution to enter the Ohio from those creeks. I looked into that matter several years ago, when I spent three years in studying the quality of the water and its improvement at Louisville, and I recall that there is nothing nearer to Louisville, where direct sewage enters the stream than the town of Frankfort, some 90 miles distant by water, and having a partial sewerage system. That town has a population, as I recall, of some 12,000 or 14,000 people. 4388

Q. Covington, Kentucky, is opposite Cincinnati on the Ohio river?

A. Yes, sir.

Q. And the conditions which obtain in Cincinnati, you think, exist also in Covington?

A. In what respect, sir?

Q. As to typhoid fever and the causes?

A. There isn't so much typhoid fever in Covington as there is in Cincinnati?

Q. In proportion to population?

A. In proportion to population, there isn't so much.

Q. But still, Covington is not free from typhoid fever, you think, from its water supply?

A. That is my judgment, I am sure.

Q. The reports of the United States Engineers from which you have read, are reports as to channels dredged in the Illinois river?

A. I so understand.

Q. They are not reports as to conditions obtaining on either side of those dredged channels?

A. There is a statement on page 2716 in the report of the Chief of Engineers of the United States Army, for the year 1895, containing a quotation from Major Marshall to the effect "that the State of Illinois controls and collects tolls over 90 miles of this river and has never completed this part of the improvement by dredging the pools above its dams." 4389

I will say further that the general information available upon that matter indicates that there isn't any material silting up of the pools away from any dredged channels.

GENERAL CROW: I will get you to state, Mr. Fuller, what would be the effect upon any stream and upon the Illinois river, if there was constant accumulation and no scouring out of the material of any kind that might be deposited on the bed thereof?

A. There wouldn't be any river bed there.

GEORGE W. FULLER.

4390 WILLIAM H. GETZ, recalled as a witness in behalf of complainant, was examined in chief by Attorney-General Crow and testified as follows:

Q. Now, what table is that you have, Mr. Getz?

A. This is the same table which I presented before, showing the percentage of mixtures of the Mississippi and the Missouri rivers at the intake of the St. Louis Waterworks.

Q. Now, have you examined that table and made any correction on that?

A. I have gone over this table, yes, sir; very carefully from the original charts and checked all the calculations.

Q. That was offered before?

A. Yes, sir.

Q. Now, you can just state how you verified those amounts and made those corrections.

A. I took the sheets on which these results were tabulated.

Q. The original results?

A. Yes, sir; the original sheets, and checked or transferred all those numbers to this table, and then the calculations which followed.

Q. This purports to be a table of percentages of Missouri and Mississippi river waters at the intake of the St. Louis
4391 Waterworks, calculated from daily estimates of total solids from samples collected at Bellefontaine, intake and Hartford?

A. Yes, sir.

Q. Now, can you state whether or not that table is correct now as made from examinations and analyses of the water?

A. I think there is no reason to doubt it.

JUDGE JOHNS: The per cent. of Mississippi river water there is obtained how?

A. The difference of amounts of total solids in the Mississippi river and in the Missouri river, at the points where these samples are taken, is found, and also the the difference between the total solids at the intake and those at Hartford on the Mississippi river.

Q. Then how do you obtain the per cent.?

A. The per cent. would be, or the percentage of Missouri river water, for instance, would be the total difference divided into the difference between the intake and Hartford.

Q. The per cent. of Mississippi river water is obtained there, by calculating it between what two figures in the columns of this table?

A. The final resuts for the percentage of Mississippi river is taken from the column headed Bellefontaine minus Hartford, and the column headed Intake minus Hartford.

4392 Q. Now, in the first line of the first page "Bellefontaine minus Hartford" is 300. "Intake minus Hartford 220," and that calculation arrives at the conclusion that 220 is 73 per cent. of 300?

A. Yes, sir.

Q. And therefore there is 73 per cent. of Missouri river water and 27 per cent. of Mississippi river water at the intake, on the 24th day of January, 1900?

A. Yes, sir.

Q. Is that correct?

A. Yes, sir.

The table above referred to by the witness is in words and figures as follows, to-wit:

4393 PERCENTAGES OF MISSOURI AND MISSISSIPPI RIVER WATER AT THE INTAKE OF THE ST. LOUIS WATERWORKS.

Calculations based upon the daily estimation of total solids in samples collected at Bellefontaine, Intake and Hartford, January 23rd to October 11, 1900.

Date. 1900.	Bellefontaine.	Intake.	Hartford.	Bellefontaine minus Hartford.
Jan. 24	800	720	500	300
25	740	670	580	160

Date. 1900.	Bellefontaine.	Intake.	Hartford.	Bellefontaine minus Hartford.
26	770	685	380	390
27	710	670	390	320
28	690	670	460	230
29	720	570	400	320
30,	700	590	340	360
31,	640	580	370	270
Feb. 1,	....	....	....	....
2,	535	450	330	205
3,	500	450	380	120
4,	540	490	410	130
5,	470	460	320	150
6,	....	....	....	....
7,	1540	400	400	1140
8,	....	....	....	....
9,	1500	1290	1230	270
10,	1160	1430	1680	520
4394				
11,	1400	1570	1550	....
12,	1050	1120	1200	150
13,	1020	1220	1590	570
14,	770	920	1430	660
15,	500	600	1300	800
16,	500	540	2325	1825
Mar. 4,	690	640	450	240
8,	3430	2940	1130	2300
9,	2435	1900	1180	1255
10,	2520	2040	1060	1460
11,	2860	3050	1060	....
12,	3410	2340	1115	2295
13,	3940	3180	1420	2520
14,	3810	3380	1485	2325
15,	4050	3180	1310	2740
17,	3590	2680	1210	2290
18,	3430	2380	1240	2190
19,	....	....	....	....
20,	2370	1600	1250	1120

Date. 1900.	Bellefontaine.	Intake.	Hartford.	Bellefontaine minus Hartford.
Mar. 21,	2010	1890	1420	590
22,	2375	1205	1091	1284
23,	1575	891	806	769
4395				
24.	1470	678	830	....
25,	1233	728	765	....
26,	1142	640	631	511
27,	1363	528	670	....
28,	1142	554	647	....
29,	928	627	439	489
31,	1010	590	600	....
Apr. 1,	1180	590	510	670
2,	1280	870	460	820
3,	1400	880	480	920
4,	1510	860	480	1030
5,	1540	935	455	1085
6,	1530	1200	480	1050
7,	1570	1595	630	....
8,	1785	1220	545	1240
9,	1875	1235	545	1330
10,	1735	1300	480	1255
11,	1675	1150	500	1175
12,	1860	1085	455	1405
13,	1965	1240	450	1515
14,	2955	2110	415	2540
15,	3402	3542	376	....
4396				
16,	1861	2048	....	....
17,	3604	1842	401	3203
18,	2395	1807	424	1871
19,	2410	1488	410	2000
20,	2384	1309	425	1959
21,	2300	1611	458	1848
22,	4374	1342	520	3854
23,	1987	1657	493	1494
24,	1755	1354	615	1140

Date. 1900.	Bellefontaine.	Intake.	Hartford.	Bellefontaine minus Hartford.
Apr. 25,	1938	1488	1444	494
26,	1514	1375	469	1045
28,	2000	1455	521	1479
29,	1730	1310	440	1290
30,	1438	1240	458	980
May 1,	1655	1245	455	1200
2,	1665	1260	420	1245
3,	1845	1435	445	1400
4,	2287	1535	380	1887
5,	2600	1485	415	2185
6,	2880	1685	1235	1645
7,	2110	1485	510	1600
8,	1951	1449	1091	860
9,	1913	1390	545	1368
4397				
10,	2013	1300	555	1458
11,	1696	1202	491	1205
12,	1885	1258	448	1437
13,	2198	1884	453	1745
14,	3563	2147	410	3153
15,	3010	2120	420	2590
16,	2380	1960	415	1965
17,	2495	1930	450	2045
18,	2335	2050	405	2430
19,	2615	2390	545	2070
20,	2160	1945	505	1655
21,	2340	1985	490	1850
22,	2280	2033	540	1740
23,	2358	2032	565	1793
24,	2136	2007	526	1610
25,	2204	1917	515	1689
26,	2283	1834	457	1826
27,	2120	1805	502	1618
28,	1743	1918	440	1303
29,	2225	2122	420	1805
30,	3480	2255	390	2090
31,	2290	2290	435	1855

4398

Date. 1900.	Bellefontaine.	Intake.	Hartford.	Bellefontaine minus Hartford.
June 1,	2200	2090	410	1790
2,	2580	2005	390	2190
3,	2280	2180	335	1945
4,	2170	2285	430	1740
5,	2455	2155	460	1995
6,	2360	2105	435	1925
7,	2355	1950	410	1945
8,	2375	1825	390	1985
9,	2405	2010	380	2145
10,	2475	1935	330	2145
11,	1950	1858	340	1610
12,	2015	2030	425	....
13,	2515	2215	595	1920
14,	4315	3955	320	3995
15,	3538	3730	375	....
16,	2562	2935	335	....
17,	2326	2656	324	....
18,	2545	2412	340	2205
19,	2183	2280	345	....
20,	2179	2080	335	1844
21,	2210	2105	305	1905
22,	3258	3055	315	2943
4399				
23,	3683	3910	363	....
24,	3205	4184	453	....
25,	3506	3892	471	....
26,	3330	3553	....	....
27,	3170	3155	470	2700
28,	3325	2870	455	2870
29,	2760	2805	405	....
30,	2685	2805	280	....
July 1,	2440	2770	380	....
2,	2515	2867	345	....
3,	2115	2800	325	....
4,	2782	2873	330	....
5,	3945	3000	330	3615

Date. 1900.	Bellefontaine.	Intake.	Hartford.	Bellefontaine minus Hartford.
July 6,	3400	4175	331	....
7,	3125	3193	364	....
8,	3060	3234	867	....
9,	3435	3490	343	....
10,	3822	3400	330	3492
11,	2690	2855	320	....
12,	2430	2655	540	....
13,	2175	2415	310	....
14,	1970	2210	290	....
4400				
15,	1450	2100	270	....
16,	2435	2315	280	2155
17,	2575	2405	415	2160
18,	2360	1880	310	2050
19,	2415	2300	327	2088
20,	2293	2050	610	1683
21,	2020	1800	370	1650
22,	1895	2132	380	....
23,	2780	2760	344	2436
24,	3885	3210	310	3575
25,	4580	3420	335	4245
26,	3791	3277	408	3383
27,	3157	2500	480	2677
28,	2730	2371	450	2280
29,	....	....	....	....
30,	2310	1995	408	1902
31,	2061	1972	512	1549
Aug. 1,	2127	1792	522	1605
2,	1725	1807	495	1230
3,	1975	1693	455	1520
4,	1812	1630	382	1430
5,	1622	1339	340	1282
4401				
6,	1530	1393	315	1215
7,	1530	1045	302	1228
8,	1294	1069	305	989
9,	1242	1008	305	937

Date. 1900.	Bellefontaine.	Intake.	Hartford.	Bellefontaine minus Hartford.
Aug. 10,	1226	990	289	937
11,	1220	970	240	980
12,	1082	935	280	802
13,	1060	890	292	768
14,	1110	904	300	810
15,	1000	860	270	730
16,	1053	860	284	769
17,	1120	835	260	860
18,	960	830	260	700
19,	1343	1061	283	1060
20,	1482	1306	318	1164
21,	1785	1305	405	1380
22,	1845	1525	665	1180
23,	1760	1445	685	1075
24,	1610	1470	688	922
25,	1556	1320	584	972
26,	1570	1365	535	1035
27,	1410	1358	538	872

4402

Date. 1900.	Bellefontaine.	Intake.	Hartford.	Bellefontaine minus Hartford.
Aug. 28,	1595	1422	445	1150
29,	1565	1371	420	1145
30,	1686	1259	395	1291
31,	1881	1125	375	1506
Sept. 1,	1376	1315	430	946
2,	1460	1450	420	1040
3,	1610	1414	445	1165
4,	....	....	...	....
5,	1930	1489	365	1565
6,	1600	1545	370	1230
8,	1635	1436	354	1281
9,	1570	1308	352	1218
10,	1430	1240	340	1090
11,	....	....	...	....
12,	1492	1033	359	1143
13,	1305	1048	340	965
14,	1213	931	348	865
15,	1110	896	298	812

Date. 1900.	Bellefontaine.	Intake.	Hartford.	Bellefontaine minus Hartford.
Sep. 16,	1270	....	345	....
18,	1230	853	300	930
19,	1210	864	340	870
20,	1428	970	311	1117
4403				
21,	2200	1380	315	1885
22,	3230	1900	313	2917
23,	2985	1920	327	2658
24,	3116	1980	330	2786
25,	2558	1836	360	2198
26,	2365	1640	320	3045
27,	1970	1500	580	1390
28,	1870	1325	350	1520
29,	1785	1330	605	1180
30,	1840	1373	400	1440
Oct. 1,	1847	1357	444	1403
2,	1990	1320	365	1625
3,	2960	1990	448	2512
4,	2920	1332	455	2465
5,	2677	2036	394	2283
6,	2480	1895	376	2104
7,	3095	1937	370	2725
8,	2578	1878	351	2227
9,	2605	2095	355	2250
10,	2807	2165	370	2437

4404 SECTION NO. 2 of table.

PERCENTAGES OF MISSOURI AND MISSIPPI RIVER WATER AT THE INTAKE OF THE ST. LOUIS WATER WORKS. CALCULATIONS BASED UPON THE DAILY ESTIMATION OF TOTAL SOLIDS IN SAMPLES COLLECTED AT BELLEFONTAINE, INTAKE AND HARTFORD, January 23 to October 11, 1900:

Date. 1900.	Intake minus Hartford.	Percentage Mo. River.	Percentage Miss. River.
Jan. 24,	220	73	27
25,	90	56	44

Date. 1900.		Intake minus Hartford.	Percentage Mo. River.		Percentage Miss. River.	
	26,	305	78	73.12	22	26.88
	27,	280	87		13	
	28,	210	91		9	
	29,	170	53		47	
	30,	250	69		31	
	31,	210	78		22	
Feb.	1,	....	..		..	
	2,	120	58		42	
	3,	70	58		42	
	4,	80	62		38	
	5,	140	93		7	
	6,	....	..		..	
	7,	....	..		100	
	8,	....	..		..	
	9,	60	22		78	
4405						
	10,	200	38		62	
	11,	....	0	54.77	100	45.23
	12,	80	53		47	
	13,	370	65		35	
	14,	510	77		23	
	15,	700	88		12	
	16,	1785	92		2	
Mar.	4,	190	79		21	
	8,	1810	79		21	
	9,	720	57		43	
	10,	980	67		33	
	11,	....	100		0	
	12,	1225	53		47	
	13,	1760	70		30	
	14,	1895	81		19	
	15,	1870	68		32	
	17,	1410	62		38	
	18,	1140	52		48	
	20,	350	31		69	
	21,	470	80		20	
	22,	114	9		91	
	23	85	11		89	

4406

Date. 1900.		Intake minus Hartford.	Percentage Mo. River.	Percentage Miss. River.
			42.68	37.32
Mar.	24,	....	..	100
	25,	....	..	100
	26,	9	2	98
	27,	....	..	100
	28,	....	..	100
	29,	188	38	62
	31,	....	0	100
Apr.	1,	80	12	88
	2,	410	50	50
	3,	400	44	56
	4,	380	37	63
	5,	480	44	56
	6,	720	68	32
	7,	....	100	0
	8,	675	55	45
	9,	690	52	48
	10,	820	65	35
	11,	650	55	45
	12,	630	45	55
	13,	790	52	48
	14,	1695	67	33
			58.41	41.59
4407				
Apr.	15,	....	100	0
	16,	....	100	0
	17,	1441	45	55
	18,	1383	70	30
	19,	1078	54	46
	20,	884	45	55
	21,	1153	63	37
	22,	822	21	79
	23,	1154	78	22
	24,	739	65	35
	25,	44	9	91

Date. 1900.		Intake minus Hartford.	Percentage Mo. River.		Percentage Miss. River.	
Apr.	26,	906	87		13	
	28,	934	63		37	
	29,	870	68		32	
	30,	782	80		20	
May	1,	790	66		34	
	2,	840	67		33	
	3,	990	71		29	
	4,	1155	61		39	
	5,	1070	49		51	
	6,	430	26		74	
	7,	955	60		40	
	8,	358	42	72.00	58	28.00
4408						
	9,	845	62		38	
	10,	745	51		49	
	11,	717	59		41	
	12,	810	56		44	
	13,	1431	82		18	
	14,	1737	55		45	
	15,	1700	66		34	
	16,	1545	79		21	
	17,	1480	72		28	
	18,	1645	68		32	
	19,	1845	90		10	
	20,	1440	87		13	
	21,	1495	81		19	
	22,	1493	86		14	
	23,	1467	82		18	
	24,	1481	92		8	
	25,	1402	83		17	
	26,	1377	75		25	
	27,	1303	81		19	
	28,	1478	100		0	
	29,	1702	94		6	
	30,	1865	89		11	
	31,	1855	100		0	

4409

Date. 1900.		Intake minus Hartford.	Percentage Mo. River.	Percentage Miss. River.
June	1,	1680	94	6
	2,	1615	74	26
	3,	1845	95	5
	4,	....	100	0
	5,	1695	85	15
	6,	1670	86	14
	7,	1540	79	21
	8,	1433	72	28
	9,	1630	81	19
	10,	1605	75	25
	11,	1515	94	6
	12,	....	100	0
	13,	1620	84	16
	14,	3635	91	9
	15,	....	100	0
	16,	....	100	0
	17,	....	100	0
	18,	2072	94	6
	19,	....	100	0
	20,	1670	91	9
4410				
			92.17	7.83
	21,	1795	94	6
	22,	2740	93	7
	23,	....	100	0
	24,	....	100	0
	25,	....	100	0
	26,	....	100	0
	27,	2685	99	1
	28,	2415	84	16
	29,	....	100	0
	30,	....	100	0
July	1,	....	100	0
	2,	....	100	0
	3,	....	100	0
	4,	....	100	0

Date. 1900.		Intake minus Hartford.	Percentage Mo. River.	Percentage Miss. River.
July	5,	2670	74	26
	6,	....	100	0
	7,	....	100	0
	8,	....	100	0
	9,	....	100	0
	10,	3070	88	12
	11,	....	100	0
	12,	....	100	0
	13,	....	100	0
	14,	....	100	0
4411				
	15,	....	100	0
	16,	2035	94	6
			72.27	7.73
	17,	1990	92	8
	18,	1570	77	23
	19,	1973	95	5
	20,	1440	86	14
	21,	1430	87	13
	22,	....	100	0
	23,	2416	99	1
	24,	2900	81	19
	25,	3085	73	27
	26,	2869	85	15
	27,	2020	76	24
	28,	1921	84	16
	29,	....	..	..
	30,	1587	83	17
	31,	1460	94	6
Aug.	1,	1270	79	21
	2,	1312	100	0
	3,	1238	82	18
	4,	1248	87	13
	5,	999	78	22
	6,	1078	89	11
4412				
	7,	743	61	39
	8,	764	77	23

Date. 1900.		Intake minus Hartford.	Percentage Mo. River.	Percentage Miss. River.
Aug.	9.	703	75	25
	10,	701	75	25
	11,	730	75	25
	12,	655	81	19
	13,	598	78	22
	14,	604	75	25
	15,	576	75	25
	16,	590	81	19
	17,	575	67	33
			77.23	22.77
	18,	630	90	10
	19,	778	73	27
	20,	988	85	15
	21,	900	65	35
	22,	860	73	27
	23,	760	71	29
	24,	782	85	15
	25,	736	76	24
	26,	830	80	20
	27,	820	94	6
	28,	977,	85	15
	29,	951	83	17
4413				
	30,	864	67	33
	31,	475	32	68
Sept.	1,	885	94	6
	2,	1030	99	1
	3,	969	82	18
	4,	....	..	..
	5,	1124	72	28
	6,	1175	96	4
	8,	1082	84	16
	9,	956	78	22
	10,	900	83	17
	11,	....	..	..
	12,	674	60	40
	13,	708	73	27

Date. 1900.		Intake minus Hartford.	Percentage Mo. River.	Percentage Miss. River.
Sept.	14,	583	67	33
	15,	598	74	26
	16,	....	..	..
	17,	570	67	33
			70.35	29.65
	18,	553	60	40
	19,	524	60	40
	20,	659	59	41
	21,	1065	57	43
	22,	1597	54	46
4414				
Sept.	23,	1593	60	40
	24,	1650	59	41
	25,	1476	67	33
	26,	1320	65	35
	27,	920	66	34
	28,	975	64	36
	29,	725	61	39
	30,	975	68	32
Oct.	1,	913	65	35
	2,	965	59	41
	3,	1542	61	39
	4,	877	36	64
	5,	1642	72	28
			64.2	35.8
	6,	1519	72	28
	7,	1567	58	42
	8,	1527	68	32
	9,	1740	77	23
	10,	1791	74	26

End of table.

ADJOURNED to Southern Hotel, St. Louis, Mo., June 1, 1903, at 10 A. M.

Southern Hotel, St. Louis, Missouri.
4415 10:00 A. M., June 1, 1903.
Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

No witnesses being present, an adjournment was taken until 10:00 A. M., June 2, 1903.

Southern Hotel, St. Louis, Missouri.
10:00 A. M., June 2, 1903.

Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

No witnesses being present, an adjournment was taken until 10:00 A. M., June 3, 1903.

Southern Hotel, St. Louis, Missouri.
4416 10:00 A. M., June 3, 1903.

Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

No witnesses being present, an adjournment was taken until 10:00 A. M., June 4, 1903.

Southern Hotel, St. Louis, Missouri.
10:00 A. M., June 4, 1903.

Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

No witnesses being present, an adjournment was taken until 10:00 A. M., June 15th, 1903.

10:00 A. M., June 15, 1903.
Southern Hotel, St. Louis, Missouri.

Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

No witnesses being present, by consent a further adjournment was taken until June 22nd, 1903, at 10:00 A. M.

Southern Hotel, St. Louis, Missouri.
4417 10:00 A. M., Monday, June 22, 1903.

Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

HIRAM R. MILLS,

called as a witness in behalf of the complainant, being first duly sworn, by the Commissioner, was examined in chief by Attorney General Crow, and testified as follows:

Q. Please give the stenographer your name, occupation and residence?

A. Hiram R. Mills.

Q. Give him your address please?

A. Soldiers' Home, Grand Rapids, Michigan.

Q. What is your occupation?

A. Physician.

Q. How long have you been practicing medicine?

A. Thirty-five years.

Q. Where have you resided nearly all the time?

A. Port Huron.

Q. Michigan?

A. Michigan.

4418 Q. That is your home at this time, is it?

A. No sir, my home now is at the Soldiers' Home, Grand Rapids.

Q. When did you leave Port Huron?

A. The 25th of April.

Q. What year?

A. Last.

Q. 1903?

A. 1903.

Q. You were a practicing physician in Port Huron?

A. Yes sir.

Q. In 1888, 1889, 1890, 1891 and 1892?

A. Yes sir.

Q. Now what stream is Port Huron on?

A. It is on the St. Clair River.

Q. Now what stream empties into the St. Clair River at that point?

A. Black River divides Port Huron into two parts and empties into the St. Clair river.

Q. With reference to the size of the town on either side of the Black River, how is it, equally or unequally divided?

4419 A. There is not a great deal of difference.

Q. What is the present size of Port Huron in population?

A. About 21,000.

Q. What was it in 1890, 1891 and 1892?

A. Oh, probably about 15,000 or 16,000.

Q. Was Port Huron sewered, or any portion of it in 1890, 1891 and 1892?

A. I know some of it was, but I don't know exactly what portion of it was. I know a large portion of it was.

Q. On both sides of the river?

A. Yes sir.

Q. What is the topography of the ground upon which Port Huron stands, on either side of the river? Just describe it.

A. On the north side it is higher than it is on the south side, some, I think, perhaps not a great deal of difference, and it is pretty well elevated above the river and the north side, is quite sandy. The south side is more clay.

Q. If there is any natural drainage to the town there, state what it is?

A. The natural drainage for the greater part of the town is into Black River.

4420 Q. Now do you know whether or not in 1889, 1890 and 1891, in January and February and March, of 1892, there were any typhoid cases?

A. Yes sir, there was.

Q. In Port Huron?

A. There has been typhoid fever there off and on every year since I have been there, more or less cases.

Q. How long have you been there?

A. Thirty-three years. I have been there 33 years in December next.

Q. Do you know of any cases in the summer and autumn of 1891 in Port Huron?

A. Yes sir.

Q. How many cases did you have personal knowledge of?

A. I have just made a little memorandum of some of the typhoid cases. (referring to paper.) In 1891 there were four cases I looked up.

Q. Four cases or four deaths?

A. Four cases.

Q. That were under your personal knowledge?

A. Yes sir.

4421 Q. What months in 1891 were they?

A. Well, I thought I had that arranged. Here is one in August and September, 1891; one in October, 1891. I could have that arranged—

Q. Oh, never mind.

A. I thought I had that.

Q. When were the other ones?

A. 1891 there was one in April and May in 1891.

Q. Were there any cases in 1890?

A. Yes sir. Four in 1890, and in 1891 four. Let's see. I will have to look at that again.

Q. What months were they?

A. There is one in June and July.

Q. MR. TODD: What year?

A. 1890, and one in October and November—just October, that's all, and then one in September and October and another in October and November. I guess that is the four.

Q. GENERAL CROW: Did you have any in January, February or March, 1892?

A. I didn't have any record of 1892. In fact, I don't know that I looked particularly for 1892.

4422 Q. Where do the sewers of Port Huron empty into?

A. The sewers of Port Huron empty into the Black River largely, almost entirely.

Q. Have they been emptying in there a long time?

A. Yes sir.

Q. Do you know whether or not Black River has ever been dredged by the Federal Government?

A. Yes sir, it has.

Q. What year?

A. In 1891 and I think it continued into 1892.

Q. With reference to the outfall, that is the emptying point of the sewers, where was this dredging done?

A. That was done past those points and above and below.

Q. You mean at the point—

A. At those points and above and below, dredged from the mouth of the river up to Railroad Bridge; the river was dredged from the mouth of Black River to the Fiber Works.

Q. Fiber Works?

A. Yes sir, that was above the dredging.

CROSS-EXAMINATION,

4423 By Judge Johns.

Q. In 1890, 1891 and 1892 was there a Board of Health in Port Huron?

A. There was a Board of Health, but it was not in very active running order.

Q. Were you a member of it?

A. No sir.

Q. Did they have there statistics of the deaths and causes of deaths, kept in an official record?

A. At that time?

Q. Yes.

A. No sir.

Q. Did they in 1892?

A. No sir; the deaths and births were collected by the Supervisors twice a year.

Q. Was a record kept of them then, as collected by the supervisors?

A. Yes, I don't know what became of them. I have never seen them. As a matter of fact I suppose they were kept. I knew that was the law.

Q. Were they recorded in tabulated statements?

4424 A. No sir, I don't know anything about it.

Q. Or did the supervisors simply go after and collect the statistics?

A. Yes sir.

Q. And make a minute of it in their proceedings?

A. I don't think they made any minute of it in their proceedings. They had blanks furnished by the State, and there was some disposition made of those blanks. There ought to be a copy in the County Clerk's office.

Q. Do you know whether there is one or not?

A. I do not.

Q. These cases in 1890, the first one in June and July; what was the case?

A. You mean the name of the person?

Q. Yes?

A. Let's see, I couldn't say—oh, the first one was in 1890. Let's see; there were four in 1890—I just ran over this hurriedly (referring to memorandum) There is Otis Scott, corner Broad and Ontario Street, in 1890, June and July.

Q. Did you attend him personally?

4425 A. Yes sir.

Q. Did he live or die?

A. He died—did he live? He lived.

Q. Where is this place in Port Huron?

A. Where is it?

Q. Yes?

A. Why, it is not far from the—it is on Ontario, right near the Ontario Street sewer.

Q. Is the house connected with the sewers, or was it then?

A. I think it was at that time.

Q. Are you quite sure about that?

A. Why, I don't know that I could say positively, but that is my impression. I understood that at the time it was connected with the sewers, but I couldn't say positively that it was, because I didn't make the examination to trace it up and see.

Q. And did you cause the dejecta from this patient to be thrown into the sewer?

A. I told the nurse as to what to do with the dejecta; she was to use disinfectants and put it into the closet. I think

4426 their closet was connected with the sewer.

Q. Now then, before it was put into the sewer, it was disinfected,—at least you ordered it to be?

A. I ordered it.

Q. Whether it was or not you don't know?

A. Whether it was or not, I couldn't say.

Q. It was disinfected by what means, or what process?

A. To use carbolic acid or copperas, and sometimes put into boiling hot water.

Q. It would be received into some vessel and then disinfected, either by boiling or putting in some disinfectant?

A. Those were the instructions, yes.

Q. Whether that was done or not you don't know?

A. I couldn't say.

Q. You paid no attention to that?

A. Well, I wouldn't be there every time to see whether it was done or not.

Q. The second one was in October—who was that person?

A. Let's see; that was in 1890 that we are on?

Q. Yes sir.

A. Mrs. Bunce, Lepear Avenue.

4427 Q. At what number on Lepear Avenue?

A. Well, it was near 9th Street; it is almost directly opposite 9th Street on Lepear Avenue; it would be 800 and about the last number in the block.

Q. Was there a sewer on Lepear Avenue?

A. Yes sir.

Q. Was this house connected with the sewer?

A. I don't know whether it was at that time or not.

Q. Did you also give instructions there for the disinfecting of that dejecta?

A. I always give instructions to that effect.

Q. Do you know in that case whether it was disinfected or not?

A. I do not.

Q. And whether or not the dejecta went into the sewer or not, you don't know?

A. I could not say positively that it did.

Q. The next was in October,—September and October?

A. Of 1890?

Q. Yes sir.

A. That was Fred Gooding; that is the name, Ontario
4428 Street near Pine Grove Avenue.

Q. Was that house connected with the sewer?

A. I think it was; I am not sure about that either.

Q. You are not certain that that house was connected with the sewer?

A. No sir.

Q. Well, you gave orders there to have the sewage disinfected,—the dejecta disinfected?

A. Always.

Q. Do you know whether it was or not in that case?

A. I do not.

Q. Do you know whether the dejecta from that patient, whether disinfected or not, went into the sewer?

A. I couldn't say positively that it did.

Q. Now the next was in October and November?

A. Another in 1890?

Q. 1890?

A. Massmore on Lepear Avenue. That was connected with the sewer at that time.

Q. That was connected with the sewer?

A. Yes sir.

4429 Q. You gave the usual orders to have the dejecta disinfected?

A. Yes sir.

Q. Do you know whether it was done?

A. I suppose it was, but I don't know.

Q. Do you know whether dejecta, whether disinfected or not, went into the sewer?

A. I don't know that it did, but I suppose it did.

Q. You had no positive knowledge on that?

A. No sir; the nurses were instructed to do it, and I suppose they did.

Q. Now in 1891 there was a case in August and September; who was that?

A. In 1891—August—Mrs. John Folkers, Miller Street, 1209.

Q. Was that house connected with the sewer?

A. I don't know. There was a sewer right in front of the house on Miller Street.

GENERAL CROW: What location do you say that was?

A. Miller Street.

Q. Near what?

A. Between 12th and 13th,—near 12th,—1209, that's what it is; that would be between 12th and 13th. No sewer there.

4430 Q. JUDGE JOHNS: Was there any sewer on that street for that house?

A. No sir.

Q. What became of the dejecta of that patient?

A. It was thrown into the closet and the closet drained into the little stream there, the Indian Creek, or the stream that ran down into Indian Creek.

Q. Through the sand?

A. No, that is the clay.

Q. It is clay?

A. Yes sir.

Q. This dejecta then, from this closet percolated through the clay?

A. Through the outside; they didn't have the deep outhouse vault; it was one of those surface vaults.

Q. It might be washed out by flood or something of that kind?

A. Yes sir.

Q. Now as to that case, was there such a condition of rainfall as to flood this out-house?

A. Yes, there was the location—at any time there was a 4431 heavy rain, there would be a certain amount of the sewage from this vault, or this outhouse, which would go into the Indian Creek, and that went into Black River.

Q. Now you gave the usual orders there to have the sewage disinfected?

A. Yes sir.

Q. Was it done?

A. I don't think it was.

Q. Why do you not think so?

A. Why, it was that class of people that would not be apt to do it if you did tell them to.

Q. Did you have a nurse there?

A. Yes, one of the daughters; they were German people,—working people, and they didn't think it was necessary, very likely.

Q. But do you have any positive knowledge in regard to it, doctor?

A. In reference to what?

Q. In reference to disinfecting the sewage or the dejecta of this patient?

A. No sir, I have not.

Q. Do you know?

4432 A. I don't know whether they attempted it or not; I told them to do it; I gave them the instructions; now whether they did it or not, I can't say.

Q. Now, you have absolutely no knowledge on that point?

A. No sir.

Q. You have no knowledge either positively, as to whether the dejecta of that patient, disinfected or not, went into the vault or into the out-house?

A. Well, personally, no sir.

Q. That is a surmise?

A. That would be a natural inference without any personal knowledge.

Q. Now you had another in October?

A. In October, 1891?

Q. Yes sir.

A. Well, that is another of the same family; they lived on Quay Street; that is right on the bank of Black River.

Q. Was it connected with a sewer in this house?

A. No sir.

Q. Where was the outhouse?

4433 A. The outhouse was practically on the dock over the edge of the river.

Q. Do you know whether that dejecta was disinfected or not?

A. I do not.

Q. Did you give orders to have it disinfected?

A. Yes sir.

Q. Did you have another in 1891?

A. I think that was all there was.

Q. In April and May?

A. April and May—Yes, I have it here, in 1891, was it?

Q. Yes?

A. April and May, John McFadgen, Court Street; that is between Seventh and Eighth, in that old Stevens house,—That is connected with the sewer I think.

Q. Was it connected with the sewer in 1891?

A. I think it was. I think there was a sewer on Court Street at that time.

Q. Are you quite sure about that?

A. I don't know, sir; I never traced it.

4434 Q. Whether there was a sewer or not, do you know whether this house was connected with a sewer, so that the—

A. I know they had the regular closet in the house, and I would infer that it was connected with the sewer.

Q. Did you give the usual orders there to have the sewage or dejecta disinfected?

A. Yes sir.

Q. Do you know whether it was done?

A. No sir.

Q. Have no knowledge upon that point?

A. No sir.

Q. Now in 1890 and 1891, did the city of Port Huron take its water supply from any public source; was there a public waterworks there?

A. In 1890 and 1891?

Q. Yes?

A. Yes, the waterworks were in before that.

Q. Where did they obtain their supply?

A. From the St. Clair River.

Q. Above or below the mouth of Black River?

A. Above.

4435 Q. Take any one of these cases in 1890, and can you tell whether they received their water supply in the houses from the public water supply of Port Huron?

A. I think they all did, because I know that wells are very scarce. It is very seldom—I don't know when I have seen a well in ten years.

Q. Well now, name one of the four cases in 1890, in which you know now that they received their water supply from the public waterworks?

A. Well there is—in 1890?

Q. Yes sir.

A. Otis Scott.

Q. Was the water of Port Huron filtered?

A. No sir.

Q. It came direct from the St. Clair River?

A. Yes sir.

Q. Is it a tolerably good water supply?

A. It is counted one of the best in the world, but—there was contamination there; that is where we got our fever from.

Q. What is the reason?

4436 A. The upper part of the city extended quite a distance above the intake pipe, and the intake pipe at that time was just on the bank of the river, flush with the dock, and only about five feet below the surface, and contaminated water was constantly coming down from that upper part of the city.

Q. Into the St. Clair River?

A. Into the St. Clair, from the cases that occurred along the eastern slope of the city.

Q. Now do you know whether or not these people in 1890, this man Scott, for instance, and his family, did they drink the water from the public water supply?

A. Yes sir.

Q. Without any kind of treatment?

A. Without any filtering; I think they did. I don't think they had a filter.

Q. Are you quite positive about that?

A. Yes sir.

Q. They didn't filter it?

A. No sir.

Q. Now, you know that of your personal knowledge, as to this particular case?

4437 A. Well, I have been in that house enough to know it as much as I would in my own house.

Q. Did you attribute this case of typhoid fever to the contamination of the water supply of Port Huron?

A. That is the only way I could get it at that time, up to that date, we had been getting it from that source.

Q. And that is the theory upon which you—

A. Yes, that is the theory.

Q. —base your conclusion?

A. And from the wells that had been used way back in years before in the outskirts.

Q. Take another case in 1890 now, in which the person sick received water from the public water supply of Port Huron?

A. Fred Gooding, October 4th to November 1st. Ontario Street near Pine Grove. They received their water from the waterworks.

Q. Any other person in either the family of Gooding, or the other man?

A. Any other member of the family?

Q. Yes, having typhoid fever?

A. No.

Q. Only one in each family?

A. Yes, at that time.

4438 Q. Now you think that Gooding also drank the water from the public water supply of Port Huron?

A. I know he drank water from the public supply.

Q. Can you name another case in 1890, in which the water was taken into the house where the case existed, from the public water supply?

A. Yes, I know this Bunce family didn't have any well. I know their water came from the public supply. They lived just across the street from me.

Q. And you attributed that case to the contamination of the water supply?

A. Well, possibly; you can't tell. These people sometimes go outside the city and get contaminated water elsewhere. You can't swear that they got it from that water, but it is a waterborne disease, and ordinarily it is through the milk or water.

Q. Now whether it was in any one of these cases in 1890 or 1891, directly and decidedly attributed to the water supply—the public water supply of Port Huron, you don't know?

A. It is mere theory; it could not be demonstrated.

Q. Well, in 1891, can you give me the names of the people 4439 who received their water supply—who were sick from typhoid fever,—who received their water supply from the public waterworks?

A. In 1891?

Q. Yes?

A. Let me see now. That is true, I think, both of the Folkers on Miller Street and Quay Street. I think they took their water from the public supply. They didn't have wells; they had to have water from the public supply.

Q. Whether they contracted typhoid fever from the water supply or some other source, you don't know?

A. I couldn't say whether they had been out in the country taking contaminated water out there, or where they got it, only the chances were they could get it in either of those places.

Q. How far from the mouth of Black River is this place called the Fiber Works?

A. About a mile, three-quarters of a mile to a mile.

Q. How many sewers of the city empty into the Black River above the Fiber Works?

A. None.

4440 Q. None at all?

A. No.

Q. Was dredging done in Black River up to the Fiber Works?

A. Yes sir.

Q. In what year?

A. In 1891 and 1892. They commenced in 1891; whether they completed and got clear through to the Fiber Works in 1891, I am not sure, but they finished their job in 1892 I think.

Q. Was this done under Government supervision?

A. Yes sir.

Q. Was there a harbor in Port Huron up as far as the Fiber Works in 1890?

A. Well, up to the Iron Bridge; that is right adjoining the Fiber Works.

Q. For lake boats?

A. Lake boats could go up there, that is, if they could get water enough. Shallow draught boats could go up there any time, but after they dredged it, then they could take up boats of deeper draught.

Q. Which side of the river were these cases, north or south side?

4441 A. Let me see. They were about equally divided, just about. I don't know that one side had a preponderance over the other. I don't think it did.

Q. Did the waterworks system extend on both sides of the river?

A. Yes sir.

Q. And very generally through the town?

A. Yes sir.

Q. How many people do you suppose—how many houses in Port Huron use the water supply—the public water supply?

A. Oh, you could almost say 99 per cent,—90 per cent anyway.

Q. That is very unusual, is it not?

A. I don't know that it is.

Q. In a small town?

A. Well, I don't think it is less than that in Port Huron.

Q. When were the waterworks installed in Port Huron?

A. In 1872.

Q. Were there any wells in Port Huron?

A. There were up to that time.

Q. Were there any afterwards?

A. Well, they disappeared after that, gradually.

4442 Q. So that the water was taken very generally and largely from the public waterworks?

A. Yes sir.

Q. Now have you any idea of the months in 1890, when dredging was done in Black River?

A. What months?

Q. Yes?

A. In 1890?

Q. Yes?

A. I don't think it was done at all in 1890.

Q. Was there any in 1891?

A. I think it commenced—well, I couldn't say whether they commenced in May, June or July. It was some time in the summer months.

Q. In 1890?

A. In 1891.

Q. Was that dredging done in Black River in 1891?

A. It was begun in 1891, and I think it was not entirely completed in 1891,—I think there was some dredging done in 1892; that is my recollection.

Q. What time in 1892 was dredging done?

4443 A. It would be from the—probably the first part of the summer.

Q. Have you a distinct recollection of the time?

A. No sir.

Q. Either in 1891 or 1892, when the dredging was done?

A. The exact time as to day or month, no sir.

Q. You have a general recollection that there was dredging done there both years?

A. Yes sir.

Q. And in the summer months?

A. Yes sir.

Q. Well now, if there was any disinfected—or infected dejecta from typhoid fever patients in the matter dredged, of course you do not pretend to know certainly?

A. No, not as to positive knowledge. We had a theory amongst ourselves, that is all.

Q. How far out into the St. Clair River was this dredged material taken before it was dumped?

A. It was taken and dumped over the shallow places, over the tunnel, or in the deep places, where the tunnel came near
breaking through, and that would be about perhaps two-
4444 thirds of the way across from the American side, along
the line of the tunnel.

Q. The tunnel under the St. Clair River?

A. Yes sir.

Q. Was it there in 1890?

A. Yes sir.

Q. And this dredging was done to aid in the preservation of that tunnel?

A. No sir.

Q. But it was because—

A. Incidentally it was left there for that purpose.

Q. Yes, for that purpose?

A. Yes sir.

Q. And incidentally the dredged matter was used to cover the tunnel?

A. Yes sir.

Q. Was it put in any one particular place, or was it distributed across the river?

A. Well, there was one locality where there was quite a little stretch of it that the tunnel came pretty near the surface of the bottom of the river, and that was put in there. 4445 That is what I was told.

Q. What side of the river would that be on?

A. It would be over on the Canadian side, I think. I think it would be in Canadian water.

Q. It is your impression that the major part of this dredged matter was deposited over in Canadian water?

A. Why, it would look like that. I don't know exactly where the line runs; whether it was in the center or whether there was any special arrangement about it, but I think it was nearer the Canadian side than the American side.

Q. How far above Lake St. Clair?

A. Oh, it is about 30 miles, may be more than that. It is 28 miles from Marine City; it may be about thirty-five or forty miles.

Q. By river?

A. By river.

Q. From the place where this dredged matter was deposited, to St. Clair Lake, it would be about 25 to 30 miles?

A. Yes, it would be all of that.

Q. The St. Clair river is a wide and rapidly flowing 4446 stream, is it not?

A. Yes sir.

Q. And St. Clair Lake is in places very shallow?

A. Yes sir.

Q. In fact the larger part of the Lake is quite shallow, is it not?

A. It is a shallow lake, yes sir.

Q. And where there is a current, it is about the center of the lake, flowing through the lake?

A. The current is along the channel in the lake.

Q. And there is considerable current there?

A. Something of a current; I don't know how much. It broadens out so that the current is very much reduced after it leaves the canal. It goes through the ship canal you know.

Q. Where is the ship canal?

A. The ship canal connects the St. Clair River with the lake up at Star Island.

Q. Is it a canal or is it a channel dredged?

A. Just a channel dredged.

Q. And then at the other side of the lake the river is

4447 called Detroit River, is it?

A. Yes, on the south of the lake, after you go down St. Clair River to lake St. Clair, then through Lake St. Clair to Detroit river.

Q. Now is there a canal or channel dredged in the Detroit River?

A. No sir, I don't think there is. Of course they may have to keep their channel open with dredging. I don't know about that.

Q. Now was St. Clair Lake also dredged to make a channel?

A. Not the whole length.

Q. How much dredging was done to make a channel in St. Clair Lake?

A. I don't know.

Q. Of course you are quite familiar with Lake St. Clair?

A. Oh, I am somewhat familiar with it, yes sir.

Q. And while the current is not so swift as in St. Clair River, there is yet considerable current through Lake St. Clair?

A. Yes sir.

4448 Q. The current of Detroit River is also swift, is it not?

A. Yes sir.

Q. And in order to maintain a channel in the Detroit River there was some dredging done there by the Government?

A. I don't know how much; I don't know where or anything about it.

Q. You don't know as to that?

A. No.

Q. How far from what you would call the mouth of the St. Clair River, across the lake to where the Detroit River may be said to commence is it?

A. It is about twenty miles I think, fifteen or twenty.

Q. Fifteen to twenty miles?

A. Yes sir.

Q. Now there is an enormous quantity of water that flows down the St. Clair River?

A. Yes sir.

Q. And the river is not subject to great floods?

A. No sir, no floods.

Q. Does it vary sometimes in its depth?

A. Oh just with the wind, that's all.

4449 A. It is a strait, that's what it is.

Q. A strait between the two lakes, Huron and Ontario?

A. Huron and Lake Erie.

Q. Erie I meant to say.

A. Yes sir.

Q. Now of course it maintains its level, and in order to do that there must be a very considerable current through it?

A. Yes sir.

Q. Do you know the volume of water, or the flow of that river per cubic foot per minute?

A. No sir.

Q. Do you know whether it is 180,000 or more than that per minute or per second?

A. No sir, I don't know anything about it.

Q. You never studied that matter at all?

A. No sir.

Q. But at any rate whatever the amount of water that goes into Lake St. Clair from the St. Clair river, it is discharged through the lake into the Detroit River?

A. Yes sir.

4450 Q. How far is it from Port Huron to Detroit by river?

A. Oh, about 65 miles.

Q. How far from Port Huron to the intake of the Detroit waterworks?

A. I don't know.

Q. What is the speed of the current in St. Clair River?

A. It varies. At the foot of the lake it is about six miles an hour, and as you get down, it is probably three miles.

Q. In the lake, about three?

A. In the lake St. Clair?

Q. Yes.

A. I don't know whether it is that or not, in Lake St. Clair, it is mere guess work.

Q. Where is it six miles per hour?

A. At the rapids, up at Port Huron, I think it is that at times.

Q. And below the rapids you think it is about three miles per hour?

A. Probably.

Q. Do you know the speed of the current of the Detroit River?

4451 A. No sir, I don't know that.

Q. How does the speed of the current of the Detroit River compare with the speed of the current of the St. Clair River?

A. I don't think it is quite as strong, or rapid.

Q. Is the Detroit a wider river?

A. Perhaps it is a little, but not very much; they are about the same. As you get down towards Lake Erie it is a little wider.

Q. By boat, an ordinary lake boat from Port Huron to Detroit is how long? How many hours?

A. Coming down about—you leave Port Huron about seven and you are in Detroit at noon—five hours.

Q. And up the stream from Detroit?

A. It is about the same, a little more. It may be about four and one-half hours down and five up; I think that would be nearer.

Q. Now on the St. Clair river there is considerable agricultural population on both sides?

A. Yes sir.

Q. Having its natural drainage into St. Clair River?

A. Yes sir.

4452 Q. And Lake St. Clair; there is an agricultural population also?

A. Well, it is where we never see it. It is stretched out so wide. I suppose there are farms along the lake. I presume there are.

Q. Now on Lake St. Clair there are a number of summer resorts and club houses?

A. Yes, on this canal.

Q. Quite a number of those?

A. Yes sir.

Q. So that in summer Lake St. Clair is a kind of a resort?

A. Yes, it is a great resort, fishing, duck hunting, boating and clubs.

Q. Large numbers of people resort there during the fishing and hunting season?

A. Yes sir.

Q. The hunting season commences in March?

A. I don't know.

Q. And the hunting and fishing season continues until after late in November?

A. I don't know a thing about it.

4453 Q. In addition to the people who make that place a resort in summer, there is a large fishing industry on St. Clair River and Lake St. Clair?

A. Well, not much fishing done, except by hand, in Lake St. Clair. At the flats. The fishing industry is up in Lake Huron.

Q. Are there any people fishing with nets in Lake St. Clair and the Detroit River below?

A. I don't think so, possibly; I don't know.

Q. How many people would you say resorted at Lake St. Clair and the St. Clair River in the summer?

A. As resorters?

Q. Yes?

A. I have no idea; it would be in the thousands.

Q. Every day?

A. Probably.

Q. Of course varying with the season?

A. Yes sir.

Q. And varying with the times of the season, would it?

A. Yes sir.

Q. So that any day during that time, in the summer, 4454 there might have been from two to three or four or five thousand people on Lake St. Clair?

A. I don't know that there would be that number on any one day, but it would be hundreds and perhaps more.

Q. These people might as well have had typhoid fever as anybody else?

A. Just as well.

Q. Especially coming from Detroit?

A. Especially if they had been exposed to it.

Q. Detroit has been rather notorious for typhoid fever for many years, has it not?

A. I don't know any particular notoriety in that line.

Q. More than the average?

A. They have had quite a number of cases, and so on down along the river and at Port Huron.

Q. Down along the St. Clair River they have had typhoid fever?

A. Yes sir.

Q. About as regularly as any place else?

A. Yes sir.

Q. Both above and below Port Huron?

A. Yes sir.

4455 Q. And on both sides?

A. Yes sir.

Q. Take the cases of typhoid fever in 1890 were the people who had it engaged in occupations which took them away from home, from their houses I mean?

A. No sir, they were not.

Q. Were any of them engaged in any business?

A. Just wait a moment. They were all home people.

Q. Well, were they engaged in occupations during the day which took them locally away from home, about the city?

A. No, I don't think that there was anything in that line. They belonged right there in the city and consumed the city water and city food. I don't think they were out on the road in any way.

Q. No, but were they people who having houses at one place, would have offices or places of employment at some other place in the city?

A. No sir.

Q. Did they have no occupation whatever?

A. No, there is one of these men that would be at home constantly; he was a driver; he had work down town. He
4456 lived right close to the saw mill and his horses he kept close by there, and he lived right there.

Q. What was he, a teamster?

A. Teamster.

Q. He worked about the city?

A. No he was working about the mill and delivering lumber all over the city.

Q. Now if he took a drink of water during the day at any time, he might have gotten it then at some other place than the water supply of his house?

A. But he would get the same city water wherever he went.

Q. But he might have got it at some other place than his house?

A. I don't care whose house, it would be public water from the waterworks.

Q. Take any of the cases in 1890, were they people at leisure and didn't work about, or who didn't have any employment for a livelihood?

A. Not that I have quoted here, no sir; they were home people tending to business at home, and had no business anywhere else.

4457 Q. That is, they had business in the city of Port Huron?

A. That is what I mean, around the city.

Q. They didn't remain constantly at their houses and drink constantly of the water at their houses?

A. That is right. They did.

Q. And that would be true also of the people in 1891?

A. That is largely true of the people in 1891; I don't know of an exception.

Q. So that any one of them may have contracted typhoid fever from some drinking water derived from some other place than his particular residence?

A. He may have got contaminated water at some other place except his residence, yes sir.

CROSS-EXAMINATION BY MR. TODD.

Q. Doctor, in these eight cases that you have enumerated, four you specified for 1890, and three for 1891?

A. You want the fourth?

Q. Yes, you have seven?

A. Let's see, 1891 has four.

Q. Those you have given.

4458 A. And 1890 has four; just the one that is lacking?

Q. Well, you gave the one in October, one in September and October and one in October and November?

A. In 1890 or 1891?

Q. 1890?

A. Now there is one more wanted in 1890?

Q. In 1890. You gave Scott, Gooding and Massmore, I believe it was.

A. 1890 did you say or 1891?

Q. 1890?

A. Fred Gooding, have you got him?

Q. Fred Gooding.

A. And then here is Mrs. Bunce in 1890.

Q. Yes, that is in October.

A. That is in October; then Massmore in October; have you got that?

Q. Yes.

A. Now isn't that all of 1890,—and Otis Scott?

Q. That makes four.

A. That makes four.

4459 Q. Now in 1891, August and September, John Folkers.

A. H. Mayer in 1891, April and May,—Gillett Street between 12th and 13th.

Q. I have got John McFadgen.

A. He was a railroad man, that is, he was superintendent of the Grand Trunk business in Port Huron.

Q. That is Mayer?

A. No, McFadgen.

Q. What about Mayer?

A. Mayer was a clerk in one of the stores; he clerked at a grocery store.

Q. Among these eight people, did any of them result fatally?

A. Yes sir, Mrs. Bunce and Mr. McFadgen.

Q. Those were the only two?

A. Those were the only two out of that list.

Q. Of these eight patients, how many were attended by a trained nurse?

A. I don't remember.

Q. Were the nurses that had charge of these patients, the
majority of them, typhoid fever trained nurses, or just
4460 nurses within the family?

A. No, most of them were just their own people. For instance, Mrs. Bunce,—her daughter attended to her.

Q. You left directions with the nurses in all these cases for the disinfecting of the dejecta?

A. For disinfection of the dejecta.

Q. For disinfection of the dejecta?

A. Yes sir.

Q. You also left directions with them as to how to attend the patients?

A. Yes sir.

Q. And you found that in matters that came directly under your observation, these nurses carried out your instructions did you not?

A. Yes sir.

Q. And there is no reason for you to assume that they did not carry out your instructions?

A. No sir, I have no reasons to believe that they did not.

Q. In regard to disinfecting the dejecta?

A. The only thing is I know that oftentimes they got care-
less about those things, but that is outside of my knowl-
4461 edge. I don't know whether they did it or not.

Q. Now above Port Huron are there any towns?

A. No sir, not in the neighborhood of Port Huron at all.

Q. Are there any sewers emptying into the Black River above the intake?

A. You mean St. Clair River above the intake pipe?

Q. Yes?

A. Yes sir.

Q. How many?

GENERAL CROW: That is at that time?

MR. TODD: At that time I am speaking of?

A. There has been right along, for years; there has been trouble. As I said a minute ago, we had our water contaminated from sources above the intake pipe.

Q. Was there any place above the intake pipe, exclusive of the sewage of Port Huron, where typhoid infected dejecta could get into the St. Clair River?

A. Any place above the intake pipe?

Q. Yes, exclusive of the sewage from Port Huron?

4462 A. Well yes, there was what is called McNeil Creek. I think that was in existence at that time, but it has been filled up since. McNeil Creek drained quite a territory in that part of the city.

Q. That is just part of the city?

A. That is part of the city, but none beyond the city.

Q. Well, that is what I want to get at?

A. No, none.

Q. What is your theory in regard to the cause of the typhoid that infected the water?

A. You mean any particular epidemic?

Q. No, in these cases?

A. In general?

Q. Yes?

A. Why, the theory that our medical society has had there always has been that we had contaminated water, or contaminated milk.

Q. Well, you can only get contaminated milk by putting contaminated water in it?

4463 A. Yes, that would be one source, but if there are cases of typhoid fever at the dairy, and they get to handling your pails, or perhaps they wash the milk pails with contaminated water. You could have contaminated milk through that source.

Q. What I want to get at doctor, is this; there had to be a beginning of the typhoid in these years, in order to contaminate the water which created the continuance of the typhoid?

A. Certainly.

Q. Now what was the theory of how this original contamination began or did they have any?

A. Why there is no case without a case ahead of it.

Q. How?

A. We never have a case of typhoid fever without a case ahead of it. It comes from somewhere, some person has brought it to a certain locality.

Q. But that wasn't discovered, I mean in this particular instance?

A. No.

Q. So that any contamination from typhoid at Port Huron must originate in Port Huron and get into the water supply of Port Huron. There is no place above there that it could get in?

4464 A. Yes, they might come by rail. You might get cases of typhoid fever into Port Huron in a great many ways.

Q. I know; I am not speaking of that, about its being imported in, I mean it must be within the city limits, the confines of Port Huron, getting into the water supply and drinking it, because there are not any cities above Port Huron?

A. No, there is no city above. It must come from the town itself, any contamination of the water there.

RE-DIRECT-EXAMINATION BY GENERAL CROW.

Q. Doctor, you are not an expert on stream flows and the volume of its flow?

A. No sir.

Q. What you said about the rapidity of the current of Lake St. Clair and the St. Clair River is mere—

A. Guess work; I don't know a thing about it.

Q. —guess work?

A. Yes sir.

Q. How long has typhoid fever existed to your knowledge, in Port Huron?

A. It has been there ever since I have been there.

4465 Q. How long has that been?

A. I have been there 33 years.

Q. Thirty-three years?

A. Yes, 32 years last December.

Q. Doctor, I will ask you if in your judgment as a physician, the disinfectants that are applied to stools of typhoid fever affected patients always destroy all of the bacilli, entirely?

A. No sir.

RE-CROSS-EXAMINATION BY MR. TODD.

Q. I believe you stated that you gave instructions to use hot boiling water?

A. Yes sir.

Q. Will that kill the typhoid bacillus?

A. If it is done thoroughly, it will.

Q. By "thoroughly" what do you mean, doctor?

A. I mean that if they pretend to use boiling water, sometimes before they get through with it, it is put in, perhaps a cold vessel, and the dejecta is cold, and the whole business is not as hot as required to kill the germs. If boiled long enough.

4466 Q. When hot water is not employed, what disinfectant did you use?

A. Carbolic acid and copperas.

Q. Well, will carbolic acid destroy the germs of typhoid fever?

A. I think it will kill it at the time.

Q. That doesn't require to be heated does it?

A. No.

Q. If your instructions were carried out, what reason have you to assume that it would not kill all of the germs?

A. Well, the question was, as ordinarily used, would it? I think that is the question.

Q. Let me change my question then. What do you understand the meaning to be "as ordinarily used"?

A. Well, in ordinary practice it is used thoroughly sometimes, and sometimes not. That is the point.

Q. But if it is used in the manner in which you prescribed it to be used—

A. Why, then it did kill them—it ought to destroy the germs.

Q. And wherever it was, you don't know that it was used in that method?

A. No.

4467 Q. By GENERAL CROW: Your experience as a physician, however, leads you to believe it was not used as it should be?

A. That they did it with a great deal of carelessness.

HIRAM R. MILLS.

4463 **CHARLES B. STOCKWELL,**

called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Attorney-General Crow and testified as follows:

Q. Give the stenographer your full name, occupation and address?

A. Physician and surgeon. My name is Charles B. Stockwell. Address, Port Huron, Michigan.

Q. How long have you lived in Port Huron?

A. Fifty-one years.

Q. Fifty-one years?

A. Yes sir.

Q. How long have you practiced medicine?

A. Twenty-four years—23 call it. I don't know as it is quite 24.

Q. Were you practicing medicine in Port Huron in 1892?

A. I was.

Q. Do you know whether or not there was any typhoid fever cases in Port Huron in 1892?

A. There was.

Q. Of your personal knowledge, do you know how many there were? 4469

A. From personal knowledge I have a record of three.

Q. What months of 1892 was that?

A. February, March and April. One of these cases extended into May, beginning in April—April 3rd.

Q. Do you know whether or not any of the houses in which these patients were sick, had a connection with the drainage, directly or indirectly, into the Black River?

A. In two of these cases. In one case I know there was direct connection with the Black River by private sewer, and in another one there was direct connection with the St. Clair river, but not direct connection either—I believe it was through one of the sewers—I don't remember.

Q. It was a sewer, was it?

A. Yes, it emptied in near the waterworks which has already been spoken of. The other one, the house was located on the border of Indian Creek, which emptied into the Black River; whether there was a sewer there or not, I can't tell.

CROSS-EXAMINATION, By Judge Johns.

Q. In one case there was sewage directly into the Black
4470 River by private sewer, was there?

A. Yes sir, by private sewer.

Q. Now was this case personally attended by you?

A. Yes sir.

Q. Was the sewage disinfected?

A. It was not that I remember. It was simply turned into the hopper.

Q. Did you give instructions to have it disinfected?

A. I don't—I did not that I remember.

Q. Was that your practice or custom?

A. At that time it was, where it could be easily flushed right into the sewer. I wouldn't say that I would do it now.

Q. You don't remember as to that one case having sewage into the Black River, whether you caused the sewage to be disinfected or not?

A. I am quite certain not. I had the case after it had been running for a week, but as far as I remember, I didn't say anything in particular about disinfecting.

Q. But the particular case having indirectly a connection by sewerage with the St. Clair River, where was it in the
4471 city of Port Huron?

A. Just at the lower border, or southern border of the Park, which is within 200 feet of the river.

Q. Of the St. Clair River?

A. Of the St. Clair River.

Q. And was there a public sewer leading from that house to the St. Clair River?

A. Yes sir.

Q. Below the intake or above?

A. Below the intake.

Q. How far would the mouth of the sewer in the St. Clair River be above the Indian River?

A. Above the Black River you mean?

Q. Above the Black River?

A. It would be I should think, a little over half a mile.

Q. The current of the St. Clair River would carry that sewage, if deposited from the sewer, past the mouth of Black River?

A. It would, except at this point there was an eddy, and I have no personal knowledge though, but there were
4472 experiments that were carried on to find whether any of that sewage could get into the water supply. I know experiments were made, but I have no personal knowledge, so I say nothing about it.

Q. As to the result of the experiment?

A. As to the result of the experiment, no. I know the water was carried up pretty close to that intake pipe.

Q. Now the other two cases, the second case in 1892—where was it?

A. The other one was on Court Street, the one that was on the bank of Indian Creek.

Q. Where was the dejecta of that patient deposited?

A. By the way, that was not my patient originally. I saw it two or three times. The patient that my father attended—who is now dead—he was unable to attend a few times so I looked after the patient for him.

Q. Where were the discharges from that patient deposited?

A. That I am not quite certain about. He had charge of that.

Q. As to whether it was disinfected, do you know?

A. I knew nothing about that, because I was simply asked to go in and see how the patient was doing.

4473 Q. Whether the discharges of that patient went into out houses or into Indian Creek, you are not certain about?

A. I would not be certain. I know it was on the bank of the stream, but what was done with it, I don't know.

Q. Now the third case in 1892, where was it? You gave one near the St. Clair River.

A. Oh yes, the other was within 200 feet of Black River, just above what is called Seventh Street Bridge.

Q. Is that above or below the fiber works?

A. That would be below the fiber works.

Q. Was there sewer connection with the house in which that case existed?

A. It was connected with a private sewer.

Q. To the Black River?

A. Yes, emptied right into Black River.

Q. Now do you know whether the discharges of that patient were disinfected?

A. I think they were not, I don't remember of ever telling them. They were just simply taken immediately to the closet and flushed out.

Q. What time in 1892 was the first case?

4474 A. That would be February 6th.

GENERAL CROW: Which case was that?

A. February 6th was the one on the bank of Indian Creek. February 10th I was called to see the case on the bank of Black River, near Black River; but that had gone on a week before I was called.

Q. JUDGE JOHNS: And the third case?

A. The third case began April 3rd. That was up near the waterworks, at the lower end of the park.

Q. None later than that?

A. None later.

Q. I have used the term here with the former witnesses and with yourself, of "dejecta." Do you understand that to mean also the urinary discharge?

A. Yes sir.

Q. In a general way?

A. Yes sir.

Q. There was no Board of Health in Port Huron at that time.

A. I think so, but it could hardly be dignified by that name I guess.

Q. It wasn't in very good order?

A. Not at all, no. Really, as far as I remember, very little work was done in fact. 4475

Q. Such statistics as were gathered with reference to deaths and the causes of them, were gathered by the supervisors, as Mr. Mills testified?

A. I think so. As I remember, they were never gathered at all. The only thing I know the Board of Health doing at that time was to collect cards upon which physicians wrote the kind of cases they were treating. I think that is all that was done.

Q. And no public record made of that?

A. Not that I know of. I have never been able to get trace of any.

Q. Do you understand, doctor, that a person having typhoid fever may have typhoid fever germs in his system for a very considerable time after he is apparently cured and healed?

A. I am sure I know nothing about it.

Q. You don't know as to that?

A. No.

Q. You don't know whether the typhoid bacillus is found in the discharges of human beings for months and years after recovery from typhoid fever?

A. No. I am ignorant regarding that.

4476 CROSS-EXAMINATION, by Mr. Todd.

Q. Doctor, were these the only cases you had in 1892?

A. Yes, in those months. All I was asked to look up was for February, March and April, so that is all that I have made a record of. I think there are other cases that I have had.

Q. But these are all that you recollect now, for 1892?

A. These are the only ones, because those are the only ones that I looked up for those three months.

Q. Typhoid fever was not prevalent in Port Huron at this time, was it?

A. Yes, it was prevalent there.

Q. Well, no more than ordinarily is the case in any town of 15,000 or 16,000 inhabitants, is it?

A. Yes, it was more prevalent at that time. I remember that distinctly, that anyhow, that is my impression, that it was much more prevalent.

Q. But these three cases are all the cases you know of?

A. Yes sir.

CHARLES B. STOCKWELL.

4477 **OLIVER STEWART,**

called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Attorney-General Crow and testified as follows:

Q. Please give the stenographer your name, occupation and address?

A. Oliver Stewart, physician; Port Huron, Michigan.

Q. How long have you lived in Port Huron?

A. Sixteen years.

Q. How long have you been practicing medicine?

A. That same length of time.

Q. You were practicing medicine there in 1889, 1890 and 1891?

A. I was.

Q. Do you know whether or not there was any typhoid fever cases in 1889, 1890 and 1891 in the early months of 1889, 1890 and 1891 in Port Huron.

A. I do.

Q. Of your personal knowledge, how many cases do you know of during those years?

A. Well, I will have to refer to the notes for that, to get the exact number. (Witness refers to memorandum.) In 1889, I had five cases—In August I had three cases—

4478 Q. August, 1889?

A. In August, 1889; I had one in September and I had one that ran through between October and November. It was partly in those two months.

Q. Now what did you have in 1890?

A. I had five cases in 1890. I had four in one house, in September running into October, in 1890, and I had one case on 9th Street between Howard street and Pine.

MR. TODD: What month?

A. That month—well that year, it was in September. That case on 9th Street was in September, 1890.

Q. GENERAL CROW: How many cases did you have, doctor, in 1891?

A. I had four. I had one in September that ran into October, then in October I had three other cases, one of them being a tramp at the hospital.

Q. You had five, you say in 1891?

A. I meant to say four.

Q. Now did any of these patients, or the houses in which they were located, have any sewer connection?

A. Let's see. One I know did, but I am not positive that
4479 any of the rest—yes, there is two. Now just wait a minute. That last one I am not so sure about that. I fancy that that one did, but when I think of it, I cannot say positively that that one did have any sewer connection. I think Mr. Rogers would probably be able to settle that.

Q. Well, give us the location?

A. It was over at the end of Pleasant Street. That was in 1891.

Q. Now, where are the other cases located?

A. In 1891?

Q. Yes.

A. Then there was one on 13th Street, 13th and Miller Streets.

Q. Right close to Indian Creek?

A. Well, the waterfall, there is a little swail runs down from that place and drains into Indian Creek. I don't think there were any sewers there at that time.

Q. Well, where were the other two located?

A. Well, the one that I mentioned was at the corner of Lepear Avenue and 12th Street, and the other was at the hospital, the tramp. Well, I didn't get him there. I had him
4480 sent there as soon as I was called.

Q. Is that connected with the sewer?

A. I believe the hospital was connected with the sewer at that time.

Q. How many physicians were there at that time—1889, 1890 and 1891, practicing in Port Huron, just approximately?

A. You mean the regular—

Q. Yes.

A. I think there was about twenty, as near as I can remember, at that time. I am speaking of just the regular physicians.

Q. Well, other physicians besides yourself had cases of typhoid fever?

A. Oh yes.

Q. You know as a matter of fact then, of your own knowledge, that there were other cases of typhoid fever in Port Huron besides what you attended?

A. Yes sir, I know that I saw some that other physicians attended.

CROSS-EXAMINATION, by Judge Johns.

Q. Who were these people in 1889; can you give the names?

A. Yes, one was a Mistress Joiner, a wench, poor, very poor.

4481 GENERAL CROW: What did you say, a wench?

A. Yes, a colored woman.

Q. JUDGE JOHNS: Did she have sewerage connection with her house?

A. I don't know. I don't think so; that was on 11th and Miller. I don't know about the sewers at that time there.

Q. What month was that?

A. That was in August, 1889.

Q. What was the name of another one in 1889?

A. I had one case, Gilbert Rogers and wife. They lived not just on the corner, but the next house, I guess, to the corner, of Gillette and 11th.

Q. Were they well conditioned people?

A. Not particularly, no. That house I am pretty sure was not connected with a sewer. They had water. They got their water from a hydrant.

Q. Did you give orders to have the discharges of Mistress Joiner disinfected?

A. Yes, I mentioned it to her, but the neighbors used to go in and give her a drink of water occasionally. I would contrive
to call around once or twice a day. I fixed those a
4482 number of times, so that I know some of those stools
were disinfected, but others I haven't the slightest idea—
I don't think they were.

Q. Now in the case of Rogers and his wife—

A. His sister took care of them and I gave them the tablets and told them what to do with them. That is as far as my—

Q. But what they did, you don't know?

A. Yes, what they did I don't know.

Q. Now then, the other two in 1889?

A. In the case of Spade, I think that was done. His wife took care of him. She was a careful German woman, and had instructions to do it, and told me she did do it. I don't know any further than that.

Q. Now the fifth one?

A. Proctor. He had a man nurse, he was not a trained nurse. By the way, I might say that at the time we had this epidemic of typhoid fever in Port Huron, I don't think there was more than one—possibly two—I don't know whether there were any trained nurses in Port Huron. In looking over my cases I only know of one that had a trained nurse, and that was imported from Detroit.

4483 Q. In 1889, this person Proctor?

A. Yes sir, this old man said that he did too; he said that he used the tablets, but I don't know whether he did or not. He was a failure as a nurse.

Q. Did the man Proctor die?

A. He did not.

Q. In 1890, who were some of them?

A. I had one girl, a particularly strong girl. Her name was Correy. I don't know that I could say just what the girl died of. We held a post mortem on another patient and it resulted that he had thrombosis of the medulla—the other patient had, and she had practically the same symptoms. This girl was on 9th Street. Her sister took care of her; was very assiduous, and they were in very medium circumstances.

Q. And you left the material to disinfect the discharges?

A. That was a standing thing with me. It was a thing that I had impressed upon me by one of my professors and I always did it.

Q. Now the other four or any one of the other four—let me ask you, Miss Correy, when was her sickness?

A. That was in September of 1890.

Q. Now another one?

4484 A. Now these four cases that I had in one family were three boys and one girl. I think the eldest one was about eighteen, and they went from that down. They were all just about alike. There wasn't very much difference. One of them was sick longer than the others with some stomach trouble, but they were practically the same.

Q. Did their discharges go into the sewer or was it disinfected?

A. Those discharges went into a closet and the instructions were left, but I don't know—probably, I think they were carried out. I know some of them were because I saw the water that they told me they put that in when the stools were made, because there was so many there. I was there a great deal of the time and I was there sometimes when those bowels moved.

Q. You think their practice was to disinfect?

A. I think it was.

Q. That constitutes the five cases in 1890. Now in 1891, four cases, who were they?

A. One was a boy about 19, on 13th and Miller Streets. The same instructions were given there. I think they
4485 were carried out. His mother took care of him, and she was both industrious and faithful.

Q. And it would be your best judgment that the discharges from that patient were disinfected?

A. I think most of them were.

Q. And the other three?

A. This one, the girl on the corner of Lepear Avenue and 11th Street, I am very certain was, because her mother took care of her. They were a very intelligent family and I believe they followed instructions.

Q. Now then this third case?

A. That one, her mother took care of her and I think I can say the same thing for her.

Q. And the fourth one?

A. That was the tramp in the hospital. That hospital—probably you gentlemen may get the wrong idea of that hospital. I have seen at that time, or either that year or before, I have seen the matron of that hospital doing her washing in the hall and chickens going through there, so I have not the slightest idea whether that was done or not. She had instructions to do it, but I haven't any idea about it. That is a dirty thing to
4486 say about our hospital, but it is the fact just the same.

Q. Whether the sewage discharges were disinfected at the hospital you don't know?

A. I don't believe they were. They may have been. I don't believe it though.

Q. What time in 1891 was this case at the hospital?

A. In October.

Q. Do you know the history of that case—where the man contracted the fever?

A. I haven't the slighest idea. He had been running around the country and struck a friend there and was taken sick at his place.

Q. And removed to the hospital?

A. And as soon as I was called, I sent him to the hospital. I think there were others that had more cases. I am sure there was there.

CROSS-EXAMINATION BY MR. TODD.

Q. Doctor, in regard to any other cases of typhoid that you know of as existing there, except those which came under your personal supervision, you got from hearsay, from the doctors who attended them?

A. Yes, or got them in discussing them in the societies.

4487 Q. Was it not the general practice among the doctors in Port Huron to prescribe that the excreta of patients should be treated in the manner that you have described?

A. It is only fair to say that that wasn't done nearly so much then as it is now. I couldn't say postively much about that. I know some did not and I know some did. I am speaking now of what they told me.

Q. That is what I mean?

A. Some of them told me that they always did and some did not.

Q. I suppose that among these 22 physicians that are practicing in the regular school there are all grades of doctors?

A. Yes sir.

GENERAL CROW: You are speaking of thirteen years ago now?

MR. TODD: That is what I am speaking about now. They had the same grades then that they have now?

A. Yes sir.

Q. And among the typhoid cases that would be treated, they would be treated mostly by the best class of doctors, either originally, or called in subsequently?

A. That was a good deal so, yes, but there were some men there that were not strictly regular, and they had some
4488 cases. At least they said so. I couldn't swear to that.

Q. You speak of "regular;" what do you mean by that?

A. I mean any man graduated from a distinctly recognized medical college.

Q. And do you apply that to eclectics, allopaths and homeopaths, or strictly to one of the schools?

A. Well we don't, as a rule, among physicians, we don't recognize eclectics or homeopaths as regular men,—not as a rule. There are some doctors who are graduated in homeopathy, but they get to reading after they get out, and they don't use it now. That man, I wouldn't want to say that he was irregular, because he is honest in his convictions, and he uses the regular books and says he practices regular medicine and I have no reason to doubt him, but a straight homeopathist, I shouldn't class him a regular physician.

Q. And how would you class them?

A. Well, I really think that a homeopath—that there are some honest men, even among the homeopathists. I think the trouble was with the men—I can hardly think of a man with good judgment—now this is my own opinion—I can't understand a man with good judgment, embracing that sort of a thing.

4489 Q. How many homeopathists are in the practice in Port Huron?

A. Well I only know—I can only think of two just now. Dr. Lewis graduated as one, but he said is was a matter of expense a good deal. Says he doesn't use it and doesn't practice it now. I think there are only two besides him.

Q. And did you count those two in the regular school?

A. No.

Q. Do you know how many public, well regulated and well governed hospitals in the country that are open to the two schools of medicine,—homeopathy and allopathy?

A. I didn't know that any of the hospitals excluded homeopathists.

Q. I mean where departments are set aside for them, where the treatment is given in one department, allopathy, and the other is eclectic?

A. Really, I don't know. At Ann Arbor there are some few chairs of homeopathy; I don't know how many. I don't know about that.

Q. If an examination of those statistics should show to you that the percentage of cures in the homeopathic wards
4490 excelled those in the allopathic wards, would that have any effect upon your judgment as to homeopathy and the people following it?

A. I don't think it would. I would question the diagnosis probably.

Q. If in the Cook County Hospital in Chicago, which is one of the largest in the country, it was acknowledged by the allopathic school, that the homeopathic made the best showing in their treatment of typhoid fever patients in the hospital, would that have any effect upon you—and the records showed it,—as to whether—

A. Now I would still question the diagnosis a good many times.

Q. How do you diagnose typhoid fever, doctor?

A. Well, by the symptoms.

Q. What are the symptoms of typhoid fever?

A. Well, coated tongue; feeling of lassitude; tired and lack of ambition; loss of appetite; possibly in the first stages, of constipation and a general bad feeling. Nothing very definite.

Q. Are those the symptoms that in the first stages you would diagnose a case of typhoid fever from?

A. I might be able. There are other things that simu-
4491 late those things very closely.

Q. What different diagnosis would the so-called grippe have from the diagnosis that you have just given for typhoid fever?

A. Much quicker. A grippe case is quicker and the symptoms are not the same. You generally have a high fever quicker than you do in typhoid. You have a more intense aching. The symptoms are more acute altogether.

Q. Is epi-taxis an indication of typhoid fever?

A. It is one of the symptoms in some cases.

Q. Are there any rashes break out on the stomach as an indication of typhoid fever?

A. We almost invariably have some of that.

Q. How long has a typhoid fever case to be in existence in a patient before you can ascertain definitely that the patient has typhoid fever?

A. It is very difficult to determine definitely when it started. It depends—some of them, the diagnosis can be made positively earlier—I am speaking from the symptoms now—can be made much earlier than they can in others.

Q. Are the symptoms that you have related the symptoms that are relied upon by the advanced thought and knowledge of the regular physicians?

4492 A. They have to be.

Q. Isn't the blood test the accepted test now among physicians for diagnosing typhoid fever?

A. No sir, not positively.

Q. And has not that test been developed within the last two years for the purpose of ascertaining the presence of the bacteria of typhosus in the blood, and has it not been pronounced the only real, true test for typhoid fever?

A. In a great many cases the typhoid bacillus cannot be demonstrated in the blood.

Q. Do you consider the typhoid fever bacillus a consequence or a cause of typhoid fever?

A. I think typhoid fever is a consequence of an infection of the typhoid bacillus.

Q. Now in disinfecting the excreta of a typhoid patient, what disinfectant did you employ?

A. Bichloride of mercury.

Q. Among these cases that you have given us an account of, how many would you say the excreta of which emptied into the sewers?

A. Well, sir, I believe there is only two, the tramp and

4493 one other.

Q. What is your opinion as to the effect of bichloride of mercury upon the germs of typhoid fever, as to whether it destroys them or not?

A. I believe in a strong solution, say about one per cent solution, I believe it would kill the germs. Now I want to qualify that. Now, I don't know postively that that is the case. In my opinion it will do it.

OLIVER STEWART.

ADJOURNED until 2:30 P. M. same day, Saturday, June 22, 1903.

4494 Southern Hotel, St. Louis, Missouri. 2:30 P. M., Saturday, June 22, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

FRANK F. ROGERS,

called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Attorney General Crow and testified as follows:—

Q. Give the stenographer your name, occupation and address.

A. Frank F. Rogers; civil engineer. Port Huron, Michigan.

Q. How long have you lived in Port Huron?

A. Since June, 1890.

Q. How long have you followed the business of civil engineer?

A. Twenty years.

Q. Twenty years?

A. Yes sir.

Q. Are you familiar with the location of Port Huron?

A. Yes sir.

Q. What is its topographical situation there with reference to the Black River and the St. Clair River?

A. Well, Port Huron is situated on the west bank of the 4495 St. Clair River and is intersected by the Black River which flows through the city in a southeasterly direction, dividing it into nearly equal halves so far as population is concerned, and there is a limited area of territory adjacent to St. Clair River which slopes direct to the river, not exceeding five or six hundred feet in width. I think the most part of the rest of the topography of the city drains gradually to Black River from each side of Black River. There was one stream flowing into Black River, called Indian Creek, which flowed through the south half of the town in a northeasterly direction and emptied into Black river at a point approximately half a mile from the outlet of Black River.

Q. That was a small stream?

A. A small stream known as Indian Creek, although it had well defined banks. It is not shown on the map. It had well defined banks, and in some portions it had bottom lands a couple of hundred feet in width. In other places less than that and quite a little area of territory tributary to that sloped directly to it. The highest part of the city is about 20 feet to 25 feet above St. Clair river, and the main business street of the town which is fairly up on the highlands, running north and south, inter-
4496 secting Black river, is from 12 to 20 feet above the water in St. Clair River, both ways sloping towards Black river.

Q. Now what is the character of the Black River. Is it a rapid or sluggish stream?

A. It is a very sluggish stream in most seasons of the year, having no perceptible current except during the spring freshets or excessive rainfall.

Q. What is the character of the bottom of the stream; is it mud and silt or gravel?

A. Well the native soil is sand and clay, having a little gravel and a good deal of silt is washed into it from above.

Q. Now do you know where the water intake of the city was situated in 1890?

A. Yes sir.

Q. And in 1891 and 1892?

A. Yes, sir.

Q. Whereabouts with refrence to the town, and in what streams?

A. It was on the north side of Black river, on the west side of St. Clair river, on the east side of what we call Pine Grove Park. It would be a little over a mile north of the mouth of Black River measured along the shore of St. Clair river.

4497 Q. Now which way does the St. Clair River flow there?

A. It flows in a southerly direction.

Q. In a southerly direction?

A. Yes sir, nearly south.

Q. Now at that point where the intake was, where was the intake situated in the center of the stream, or was it situated close to the shore?

A. It was situated close to the shore. There is a dock extending out from the bank perhaps fifty feet—that is just a guess, but I am very familiar with the location as near as I could estimate it without measuring it, and the intake was just at the edge of the dock.

Q. Now was there any out-fall for the city sewers up the river above that intake?

A. There were no city sewers there. There was a sewer from Block I shops—no, pardon me, sir, what we call the Grant Locomotive Shops, which discharge sewage of a considerable population at times. The city was always given to understand that it was not used as a regular sewer for feces, but I know it was used for urine, and I am suspicious that it was used in other cases at times.

4498 Q. And that was above?

A. Yes, that was even above anything that shows here (referring to blueprint). It was perhaps half a mile above the waterworks.

Q. Now the territory that lies north of the point where the intake is, the surface of that territory would naturally drain by washings of rain,—would that be into the river?

A. Well, north of these shops?

Q. No, not north of the shops, but north of the intake?

A. Well, there would be only a limited portion of it. The banks are quite high, right up to the river here, without any decided slope to St. Clair river from the waterworks north, until we get up to where a creek known as McNeil Creek used to enter St. Clair River, and then the natural flow is along that creek bed.

Q. And thence into the river?

A. And thence into the river in a southeasterly direction.

Q. Now are you familiar with the condition of the water front there?

A. Yes sir.

Q. Were you in 1890?

A. Yes sir.

4499 Q. Do you know whether or not there was any deposits of sewage from the city of Port Huron, into the Black River in front of and adjacent to the wharves and docks there in 1890, 1891 and 1892?

A. Yes sir.

Q. Do you know whether or not that was ever removed?

A. In Black River?

Q. In Black River, yes?

A. Do you mean deposits on the banks?

Q. No, in the river?

A. Why, it was removed by dredging.

Q. When?

A. In 1892, partly. I think there was a little dredging done in the fall in 1891, or the fall of 1891. The principal dredging was done in 1892.

Q. Who did it,—the government?

A. The United States Government.

Q. What was the object of it?

A. Why, as I understand it, the appropriations were secured through the influence of local congressmen for the benefit of shipping facilities along the stream, and also on account of making a winter harbor for vessels. 4500

Q. Was that the object of it there at Port Huron?

A. Yes sir.

Q. Was there much of this sewage and debris removed from the bottom of the river?

A. Well, the channel was deepened at that time from the neighborhood of twelve feet to sixteen feet and to the width of 100 feet in the central portion of the river.

Q. Do you know where this material was dumped?

A. It was dumped in St. Clair River.

Q. Were there any sewers in the town of Port Huron in 1890, 1891 and 1892?

A. Yes, there were about ten miles—well, in 1892 there were more than that. In 1891 there were approximately ten miles and two miles were added in 1892.

Q. Where did these sewers empty?

A. There were two sewers—

Q. Well, generally they emptied into Black River?

A. Into Black River, yes sir, all of those sewers that I speak of.

4501 CROSS-EXAMINATION BY JUDGE JOHNS.

Q. How far from the mouth of Black River is the point known as the Fiber Works or Iron Bridge?

A. Well, approximately a mile and three-quarters, measured around the river.

Q. How far up the stream did the Government dredge?

A. They dredged to Washington Avenue, which is just the north boundary of the Fiber Works property.

Q. A channel 100 feet wide?

A. The channel was dredged 100 feet wide—not to that point as I remember, but to a point above Suffern Street, and fifty feet wide from there above. That took it through the built up portion of the city.

Q. Now the dredging was to deepen the channel of the river from an average of about twelve feet to an average of about sixteen feet?

A. Yes sir, that is to the best of my knowledge of its previous depth, that is I know it in places.

Q. How many sewers empty into the Black River east of Suffern Street?

A. Well, there is one empties in at Suffern Street, but 4502 there has been some built since that time; but at that time all of the sewers emptied into Black River at and below Suffern Street.

Q. How many were there?

A. There were six large sewers, not counting some private sewers that I haven't any record of.

Q. In 1890, what proportion of the public of Port Huron emptied their household sewage into the sewers?

A. Well, that would be a mere guess. At that time the best residence sections of the city were accomodated with sewers and outside of that the sewers were scarce. I would think it would be less than one-quarter.

Q. Of the total inhabitants?

A. Yes sir, I would say less than one-quarter.

Q. And the larger part of that from what you would call the better residence portion of the town?

A. And the business.

Q. And the business portion?

A. Which of course, includes some of the poorer residents.

Q. The principal part of the dredging was done in 1892?

A. The principal part.

Q. What part, if any, was done in 1891; how much, would
4503 you say?

A. Well, I have no definite knowledge as to what was done in 1891. I think there was a little done near the outlet of the river in 1891. I have not so distinct a recollection of that as of the other. I was in charge of street work along the river and that year we had quite a serious epidemic and there was more or less talk about it, and it is fixed on my mind more than what happened previous.

Q. What time in 1892 did the dredging commence in the Black River?

A. It began in April.

Q. How long did it continue?

A. Why it continued through the summer season; I don't know just when they quit.

Q. Was it continuous or carried on at intervals?

A. Well, it was I think, practically continuous. I haven't any recollection of any cessation of the work.

Q. What was done with the dredged material?

A. It was dumped into St. Clair River.

Q. Loaded onto scows?

A. Loaded onto scows and taken out into the river and dumped from the bottom of the scows.

4504 Q. Could you state what month the dredging commenced?

A. It commenced in April.

Q. What time in April?

A. I couldn't give it to you sir; I haven't looked it up recently.

Q. Nor when it ended, you couldn't tell?

A. No, I couldn't tell you.

Q. Is the Black River a navigable stream for lake boats without dredging?

A. Well I suppose it was at an early day, but it would not be for lake traffic of today.

Q. The ordinary lake boats of today or of 1890, couldn't go very far up the Black River, I suppose?

A. Oh no, not without this dredging.

Q. And it is an extremely sluggish stream?

A. Very sluggish indeed.

Q. Are there manufactories along the banks in Port Huron?

A. Well, the most important manufactory is the Fiber Works referred to. There is a ship yard—are you asking this at that time, in 1891?

Q. Yes, in 1890 and 1891?

A. Well, the most important at that time was the Fiber
4505 Works. In fact, it is the only manufactory of very much
importance that was then right on the banks of the river.

Q. What did it deposit in the river; what kind of refuse material?

A. Why, it deposited—the water that comes from their process of manufacturing paper pulp,—it is mixed with a large amount of acid I suppose. I don't know very much about the chemical contents.

Q. Well, it makes a yellowish looking fluid?

A. Well I have seen it. It never attracted my attention as being particularly yellowish. It is dirty.

Q. Is it discharged in considerable quantities?

A. Why, quite large quantities. I don't know exactly what their water consumption is.

Q. Well, there are no fish in Black River from the mouth up to that Fiber factory, are there?

A. Well, there are such fish as German carp, they seem to be able to live in it, and some catfish.

Q. But the ordinary lake fish do not live in it?

A. No, they don't seem to like the waters.

Q. Where is the strip which drains into the St. Clair River, naturally?

4506 A. Well, the principal part of the strip that I refer to is south of Black River and commencing just east of Military Street there was low land in what was the Pere Marquette Railroad Yards here, which is perhaps seven or eight feet above the water in St. Clair river as compared with an elevation of fifteen or twenty feet on the Main business street.

Q. And how long is that strip which drains into the St. Clair River?

A. Oh, there is half a mile there on that side of the river.

Q. Six or seven hundred feet wide?

A. In some places. Less in others. That would be about the widest part.

Q. Average five hundred feet?

A. Why, perhaps, between four and five hundred feet would be a fair average.

Q. That was taken up by railroads?

A. Principally by railroads, railroad warehouses and elevators and things of that kind.

Q. Was it at that time, in 1890 and 1891?

A. Yes sir.

4507 Q. And did no part of the surface of the ground above the Black River inside the city limits and north of the Black River drain into the St. Clair River?

A. Yes, in a natural state, there was a small strip of land that—well it drained to the east and to the south. I presume that the streets laid out as they are, more of it reaches Black River than directly into the St. Clair, but in a natural state there is a little strip of land until we get up to near the waterworks, where there is not much of any slope toward the lake, but for half a mile or a little more there is a general incline in a southeasterly direction.

Q. So that part of the surface waters—

A. Would go to St. Clair and part to the Black River.

Q. Where were the sewers in Port Huron in 1891?

A. There was a sewer on Huron Avenue, that is from Black River north to Park Street.

Q. What would that distance be, about?

A. About one-quarter of a mile. There was another sewer emptying into Black River at the same bridge on the south side on the main business street, extending a little south, then west to an alley, between Military and Sixth Streets, and thence south, being a total length of somewhat over half a mile.

4508 There was a sewer on 7th Street emptying into Black River at Seventh Street Bridge and extending south, well between a half and three-quarters of a mile, or nearly three-quarters of a mile. There was also another sewer in there right beside this one which extended a little south, then westerly on Lapear Avenue to Ninth Street, and south to Division Street, about a mile in length. There was a sewer emptying into Black River at the mouth of what formerly was Indian Creek, extending in a westerly direction to 10th Street up the Creek bed; thence west on Miller street to 12th street; thence south to Griswold street, being somewhat over a mile in length. There was another sewer emptying in at Suffern Street extending easterly on Suffern Street to 10th Street; thence north on 10th Street to the limits between what used to be called Fort Gratiot and Fort Huron. That was somewhat over a mile in length, and there were two sewers—well, there was one sewer with branches, yes, two sewers with branches emptying directly into St. Clair river. There were three—

Q. How long were they?

A. Well, the total length of those sewers—I haven't the total length of all the branches, but they would aggregate two or three miles perhaps.

4509 Q. Or three?

A. Perhaps, or three.

Q. What character of sewers were they, tile or constructed of brick?

A. All of the sewers that I am referring to as emptying into Black River were brick sewers.

Q. And those emptying into the St. Clair?

A. There was one brick sewer with one brick branch; the others were tile.

Q. What was the population of Port Huron in 1890?

A. Why, I don't know definitely, but it was somewhere between fifteen and twenty thousand I suppose,—probably seventeen or eighteen thousand.

Q. As the sewers existed in 1890 and 1891, what proportion of the population did they actually reach, what fraction of the population did they actually reach?

A. Well, practically all of the main sewers were constructed after the building of the two long sewers that were built in 1891. There were a number of branches that had to be built afterwards to reach the whole population. Of course they immediately only reached the population that was adjacent
4510 to them. I would estimate roughly, if all of the buildings were connected at that time, that could have been connected, perhaps fifty per cent.

Q. Fifty per cent of the population?

A. Yes sir.

Q. In 1890 and 1891?

A. Yes, I am talking of 1890 and 1891.

Q. Now, of the people who could have been connected, what per cent were not?

A. Well, that is very difficult to tell.

Q. What is your best opinion about it?

A. Well, I would state, in my opinion probably not more than twenty-five per cent of the total, but I don't think not to exceed 25 per cent of the whole population could have been having sewer connections.

Q. Now your two principal sewers were built in 1891?

A. That is the two longest sewers.

Q. They were the main sewers, into which branches led?

A. Yes, we would call them now the main sewers, although all the business section of the city is sewered into the sewers which were previously built.

Q. What time in 1891 were these two principal sewers
4511 constructed?

A. Oh, the construction began in May and wasn't finished until winter set in.

Q. So that those two main sewers were not used in 1891 probably at all?

A. Only a few odd houses that took advantage of them.

Q. And in 1892 some more people probably connected with them?

A. Yes, sir.

Q. Now, then, these branches were constructed as necessities of the city required, after 1892?

A. Constructed very rapidly after 1892.

Q. Do you know whether the city authorities kept a record of the sewer connections in the city of Port Huron?

A. Well, they did after I got the thing started there in 1891, but previous to that there was no record.

Q. When did you get started there as engineer?

A. I began in May, 1891.

Q. There was no record of sewer connections prior to that?

A. No, there was no record in the office.

Q. Did you make a record of the sewer connections which existed prior to that, after you established the record?

4512 A. I never made a record of all of the connections that were established after that. I made a map showing the location of all of the sewers, and I never got at a record of every house that was connected with the old sewers during my term

Q. Now, since 1891, has there been a record, say after 1892 of the sewer connections made in 1892?

A. The permits were required to be taken out as the connections were made and a record kept of them.

Q. Have you any idea of the number of yards of material that was taken out of the Black river by dredging?

A. I have not.

Q. Did you have occasion to examine the dredged material to see of what it was composed?

A. Why, only as I saw it passing through the river there and through the bridges. There were two bridges that I was frequently crossing there. I had public work going on on each side of the river and I would frequently have to wait when the bridges were swung and I could see the scows passing out.

Q. It was sand and silt from the bottom of the river?

A. And clay.

Q. And seemed to be largely earthy material?

4513 A. Yes, it was earthy material and such refuse as had accumulated in the river above it.

Q. When the Black river is in flood, does it wash itself out some?

A. Well, there is some times in the spring a good current there for a day or two and other springs it is not very perceptible.

Q. When there is a good current, does the Black river wash out?

A. Like any other river working under a good current, I suppose there is about the same scour that there would be with any stream. It would not be different from other streams under those conditions.

Q. So that the ordinary sewage deposits in Black river at times of flood would be washed out considerably?

A. Why, to some extent.

Q. The soil about or in Port Huron, you say is sand mainly?

A. Sand and clay.

Q. Is it a kind of a mixture, or is it free?

A. No, it is separate. There are sections of the city which are all sand to a depth of ten or fifteen feet, and other sections solid clay, where if you dig a sewage trench it will stand in a vertical wall like stone. 4514

Q. How much of the city is built upon this clay formation?

A. Well, there is not much of the clay formation on the north side of the river, and perhaps about one-half of the south side of the river might be—well, I guess that is a large estimate. I don't think there is half on the south side that could be called clay soil.

CROSS-EXAMINATION, by Mr. Todd.

Q. Did you ever make any soundings of the river to ascertain how much of the deposit above its natural bed was created by the sewage discharge into the Black river?

A. No, sir.

Q. Have you any idea or any opinion on the subject?

A. Not definite.

Q. Do you know whether there would be as much as a foot?

A. I wouldn't desire to put it in any given units. It is a matter I have no definite knowledge of.

Q. When did the dredging first begin?

A. Do you mean in 1891?

Q. In 1891, I mean when they first began dredging on 4515 that river, the United States Government?

A. Well, I don't know. I think there had been dredging previous to that time; that is, at former times I think, but I don't know when.

Q. Well, at this particular period?

A. Well, as I said, I think that there was some dredging done in the fall of 1891, or late in 1891; how much, I don't remember.

Q. And then the dredging ceased for a while, did it?

A. It ceased during the winter, and was resumed the following spring.

Q. Now, where was this deposit from the dredges spilled?

A. In St. Clair river.

Q. Where,—above or below the mouth of the Black river?

A. Below the mouth of the Black river.

Q. How far below, approximately?

A. I suppose a mile or a mile and a half perhaps, or a little more.

Q. Now, when it began in the spring of 1891, are you able to tell what months the dredging proceeded in 1891?

A. It began in April and continued during the season. 4516 It may have been stopped at brief intervals, but not very long. I would have no means of knowing just what days or just what weeks dredging was going on, but so far as I know, it was going on continuously, but there may have been interruptions.

Q. How long had those sewers been in operation prior to 1891?

A. Oh, the early sewers there were built in the early seventies.

Q. About how many?

A. Well, the two first ones through the business part of the town perhaps a mile of sewers there were built in the early seventies and the others followed along, all except these two main sewers which were built in 1891, were built previous to my going to Port Huron.

Q. Was all the sewage material dropped into the St. Clair river at the point about a mile below the mouth?

A. Oh, I wouldn't say that all of it was. Of course there may have been some variation in that. I saw scows dumping there, but it was none of my business and I didn't pay definite attention to it, and it was rumored that it was over the tunnel.

4517 Q. You have no definite information as to what percentage of sediment was excavated, and what percentage of clay and natural soil was taken from the bed of the river?

A. No, sir; I wouldn't attempt to put that into percentages at all.

Q. Was the water of the Black river a clear water?

A. Clear water?

Q. Yes?

A. No, it is not a clear water; it is a dark colored water.

Q. Does it differ from that in the St. Clair river?

A. Very materially.

Q. To what is the color attributed?

A. Well, the river is of a dark color as far up as I know it, and I know it nearly to its source. The source is in mucky swamps in the northern part of the Huron peninsula and above, where it is not polluted with city refuse, etc., I presume it gets its dark color from those mucky swamps. Of course through the city of Port Huron it has an added pollution.

Q. Are there any towns above on the Black river, above Port Huron?

A. There is the little town of Croswell up there, about between 25 and 30 miles, on Black river.

4518 Q. What is the population of it?

A. Oh, 1,000 or 1,200.

Q. That is the only town of any size?

A. They have no regular sewerage system.

Q. How far from the mouth of the river,—the Black river, is the last sewer or was it, in 1891?

A. You mean how far above the mouth of the last sewer emptying into the river?

Q. Yes.

A. In 1891, it was at Suffern street, a little over a mile.

Q. Which one of the sewers emptied the greatest amount of sewage into the Black river?

A. Previous to 1891?

Q. Yes, those nearest its mouth?

A. Well, those nearest its mouth, the sewers that were emptying the refuse all emptied in at the two main bridges there, —one crossed the river at Military street and the other at Seventh street. These were fairly large good sized brick sewers emptying into it previous to that time.

Q. Above Seventh street how many sewers previous to 1890, were emptying their refuse into the river?

4519 A. Previous to 1890, there were no sewers proper, except some private sewers along the banks.

Q. Well, those private sewers above Seventh street did not empty enough material so as to create a sediment in the bottom of the river above that point, did they?

A. Why, they created some sediment of course; there is no sewer but what would do its proportion probably.

Q. Well, it would be a rather small proportion,would it not?

A. Well, it would not be large that would come from a residence or business place.

Q. Was the river dredged in 1890, in the latter part, as far up as Seventh street?

A. In 1890?

Q. In the latter part of 1890?

A. I don't know that there was any dredging done in 1890.

Q. The latter part of 1891?

A. I haven't any recollection of any dredging being.done that fall above Military street. There may have been some done above that, however.

Q. Where is Military street?

4520 A. Military street on the south side, Huron avenue on the north.

Q. The amount of sediment between Military street and Seventh street, based upon the capacity of the different sewers, and their age, would be greater from the mouth to Huron street than it would be from Huron street to Seventh, would it not?

A. Well, the distance is twice as great, and of course—

Q. I mean the amount by feet above the natural bottom of the stream?

A. Would it be greater below than above?

Q. Yes?

A. Well, it is hard to tell. I don't know just how far that sewage, or how much of it would pass below the bridge that emptied in here, but considering everything, I would think the space between the two bridges would be as foul as any space of the same length of the river.

Q. I am speaking of the sediment on the bottom of the stream.

A. Well, the foulness of the stream would approximately measure the sediment.

4521 Q. They couldn't dredge the foulness, but in dredging the sediment, in your opinion would there be the same number of inches of sediment on the bottom of the stream from Huron street to the mouth as there would be between Huron street and Seventh street?

A. Why, I have no definite knowledge of that, Mr. Todd. It might vary somewhat.

Q. If in the latter part of 1891 they had dredged up to Huron street, then when the dredging was resumed in the spring, the amount of sediment from Huron street to Seventh street was dredged out first, was it not?

A. Sir?

Q. I say, then in the spring they dredged from Huron street to Seventh street?

A. I don't know. I think there was a little moving back and forwards there, and I have no data as to just how that dredging proceeded. It is all a matter of record in the Government office, and I have never attempted to get it or keep track of it.

Q. From Seventh street up to the Fiber Mills, that section of the river was never polluted by sewage discharged 4522 into the river to any great extent, was it, in 1891?

A. Not as compared with the section below.

FRANK F. ROGERS.

MR. TODD: In behalf of the Sanitary District, and I am joined by the State of Illinois, I move to exclude the evidence of Charles B. Stockwell, Hiram R. Mills, Oliver Stewart and Frank F. Rogers, for the reason that the evidence is incompetent, irrelevant and immaterial.

Adjourned until Saturday, June 27th, 1903, at Southern Hotel, 10:00 a. m.

4523 Southern Hotel, St. Louis, Missouri. 10 a. m., Saturday, June 27th, 1903. Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

E. J. HAYNES, called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Attorney-General Crow, and testified as follows:

Q. Just give the stenographer your name, address and your ocupation?

A. E. J. Haynes, Detroit, United States Engineers Office, Detroit. And my occupation I suppose would be—you may term it United States Inspector.

Q. Are you in the employ of the government?

A. Yes, sir.

Q. How long have you been?

A. About fourteen years.

Q. What line of service have you been in during those years?

A. I have been in the same line for the entire time, first as laborer and then, since 1891, as inspector.

4524 Q. Now, when you say "inspector," what do you mean by that term? Just tell us what you do?

A. Why, according to the civil service rules, an inspector is a man who takes charge of dredging.

Q. Dredging where?

A. On the rivers or lakes. It is a term given to just a branch of the employ, as near as I can say.

Q. Well, what is your duty as inspector; what do you do?

A. The inspector takes charge of any dredging that they might put him in charge of. He keeps track of the amount of material dug, the positions it is dug in, and makes a weekly or monthly report as the case may be, to the United States Engineer's office in charge of the work.

Q. Do you know whether or not there was any dredging done in the fall of 1891 and the spring of 1892 in the Black river and in front of Port Huron, Michigan?

A. Yes, sir; there was work done there in the fall of 1891 and the spring of 1892.

Q. Were you connected with that work?

A. I was.

Q. When did you begin the work in 1891?

A. That would be about November,—about the first of November.

Q. How long did you work there that fall?

4525 A. I went away on Thanksgiving Day of that year, I couldn't say whether the 25th—somewhere between the 25th and 27th of November.

Q. Now, what was the character of the work you did there in November, 1891?

A. It was deepening of the river somewhere between the mouth and Tenth street.

Q. In Port Huron?

A. In Port Huron.

Q. Well, the river was deepened by being dredged?

A. By being dredged, and the material removed taken down St. Clair river and dumped.

Q. Whereabouts in the St. Clair river was the material dumped?

A. Why, it was as near as possible over the St. Clair tunnel.

Q. What do you mean by the St. Clair tunnel?

A. The St. Clair tunnel is a tunnel running from Port Huron to Sarnia, under the St. Clair river.

Q. On the Canada side?

A. On the Canada side.

Q. Is it a railroad tunnel?

A. Yes, the Grand Trunk, I believe, built the tunnel.

Q. Was that in the channel of the St. Clair river?

A. Yes, sir. The material was principally dumped on the Canadian side of the St. Clair river, that being the deeper part.

4526 Q. The deeper part?

A. The deeper part of the river. It was done for the purpose of raising the bed of river, to protect the tunnel from leaking.

Q. Now, was there any work done in the spring of 1892, dredging at Port Huron in the Black river?

A. Yes, sir.

Q. What was it and how long did it last?

A. I couldn't say just how long it lasted. I went there about the middle of April. I was there for something like two or three months.

Q. Did you have charge of that work as inspector?

A. I did during May of 1892.

Q. Well, you were there in April, 1892?

A. Yes, sir.

Q. What was done? The Black river was dredged, was it?

A. Yes, sir; the material was dredged out of the Black river between Military and Tenth streets.

Q. In Port Huron?

A. In Port Huron.

Q. And where was that material taken?

A. To the same place in the St. Clair River.

Q. Dumped in the St. Clair river?

A. All material while I was there was dumped into the
4527 St. Clair river.

Q. Do you know how much was taken out in April, 1892?

A. About 5300 yards.

Q. The Federal Government did this dredging both times?

A. Yes, sir.

Q. You were employed, I believe you said, by the Federal Government?

A. Yes, sir.

Q. This dredging was done with the ordinary government dredging boats?

A. It was done by contract.

Q. Under the supervision of government employes?

A. Under the supervision of government employes.

Q. Well, it was done with an ordinary dredging boat?

A. Yes, sir.

CROSS-EXAMINATION, by Judge Johns.

Q. Were you an inspector in 1891?

A. Yes, sir.

Q. When did you first become an inspector?

A. I first drew my pay as inspector in the spring of 1891.

Q. Were you inspector upon the work of dredging in the harbor of Port Huron in 1891?

4528 A. Yes, sir.

Q. Were you the sole inspector?

A. No, sir.

Q. How many others were there?

A. I know of one more, and I couldn't say whether there was two or not.

Q. Who was the other?

A. H. Kallman, Jr.

Q. Where did he live?

A. At that time he was living in Port Huron.

Q. Where does he now live?

A. I couldn't say.

Q. Is he in the government employ still?

A. No, sir.

Q. When did you last hear of him?

A. That would be about two years ago. At that time he was in New York, somewhere in the city of New York; I couldn't say where.

Q. His first name, if you know?

A. Herman.

Q. Herman Kallman?

A. Herman Kallman, Jr. He has a father, now in Detroit.

Q. Is the harbor of Port Huron distinct from the Black river?

4529 A. Why, Port Huron is situated directly on the St. Clair river. There is no harbor any more than just the straight river front.

Q. That is the river front of the St. Clair river?

A. Yes, sir.

Q. There is no such thing as a harbor in the Black river?

A. The only harbor in the Black river would be for the purpose of boats running in there for the purpose of discharging cargo. It is a straight creek, and it is probably 200 to 250 feet wide.

Q. Did boats run into Black river and up as far as Tenth street to discharge cargoes in 1891?

A. Yes, sir.

Q. Where is Military street with reference to Tenth street,—up the river or down the Black river?

A. Military street is down the river from Tenth street.

Q. How far from what would be known as the mouth of Black river is Tenth street?

A. Between half and three-quarters of a mile.

Q. Do you know a place there called the fiber works?

A. Yes, sir.

Q. Where with reference to the fiber works, is Tenth street?

A. Down the river.

4530 Q. How far?

A. I should think it was about half way between the mouth of Black river—Tenth street is about half way between the mouth of Black river and the fiber works.

Q. Was there any dredging done up as far as the fiber works?

A. No, sir; not in my time.

Q. Neither in the fall of 1891, nor the spring of 1892?

A. No, sir.

Q. Was there any dredging done in the fall of 1891 above Tenth street?

A. I couldn't swear that there was or was not; I don't think there was.

Q. Was there any dredging done in the spring of 1892 above Military street?

A. Yes, sir.

Q. How far above?

A. The latter part of May, 1892, the river was dredged in front of what is called Haynes' Lumber dock, that is about—it is just about two blocks above Tenth street.

Q. This dredging was for the purpose of making a channel in the Black river, was it?

A. Yes, sir.

Q. How wide a channel?

4531 A. It would be about 100 to 150 feet.

Q. How much earth was taken out in depth?

A. The cutting in some cases would be four feet; not over that.

Q. Not over that?

A. No.

Q. And the average for the entire distance up to Tenth street—

A. About two feet.

Q. Of what did this dredged material consist?

A. The river bed proper was blue clay, and some sediment, and very little sand.

Q. What proportion of the dredged material taken out in the fall of 1891 was blue clay?

A. That would be impossible to say.

Q. What is your best judgment about it?

A. There would not be over one-third of it.

Q. How much of it would be sand?

A. The rest of the dredging would be mixed entirely with a black muck, or it is a wash from the marshes up above, and I shouldn't think—probably one-sixth of the entire remaining material would be sand.

Q. One-sixth of the remaining two-thirds?

A. Yes, sir.

4532 Q. The Black river is how long, do you know?

A. The Black river runs up the country, and it is now navigable up above the fiber works, but the river itself must be about ten or eleven miles, I should think. I don't know.

Q. It drains, and it has its origin in some marshes and swamps?

A. Yes, sir.

Q. Away from Port Huron?

A. Yes, sir.

Q. And this sediment which is in its bottom is the wash from those swamps and marshes?

A. Partly, yes, sir.

Q. From the mouth up to the fiber works is how far?

A. I should think it was something over a mile.

Q. So the Black river is navigable for about a mile?

A. About a mile and a half.

Q. How much dredged material was taken out in the fall of 1891?

A. I couldn't say that.

Q. When did the dredging commence in the fall of 1891?

A. It had been going on through the entire summer, the greater part of it. I wasn't there.

Q. Was there any dredging done except in the Black river?

4533 A. Yes, sir.

Q. Where?

A. In St. Clair river.

Q. How much of it was done in the St. Clair river?

A. Well, there was one dredge working there nearly the whole entire season as I understand it. I am not certain of it.

Q. In the fall of 1891?

A. Yes, sir; during the season of 1891.

Q. Was there any dredging in front of Port Huron and in the St. Clair river?

A. Yes, sir. There was one contract covered the deepening of what they called the Middle Grounds, gravel washed from the rapids of the St. Clair river, and the other contract we were just speaking of was a contract in the Black river for deepening of the river.

Q. Where was the material dumped from the Middle Grounds, or from the St. Clair river?

A. Over the St. Clair tunnel.

Q. In the same place as the—

A. As near as possible; yes, sir.

Q. —dumping from the Black river?

A. Yes, sir.

Q. Which was the larger contract?

4534 A. I couldn't say for certain. I think both contracts were the same price, $10,000.00.

Q. Was there a specified amount of work for the St. Clair river in what you call the Middle Grounds?

A. There was $10,000 appropriated—I say $10,000, I am not sure of the amount, and the contractor agreed to remove the material for a certain amount per yard, and he removed material enough to use the entire amount of money.

Q. Until the appropriation was exhausted?

A. Yes, sir; until the appropriation was exhausted.

Q. Where is this Middle Grounds with reference to the mouth of the Black river?

A. Directly below it; on the American side.

Q. On the American side below the mouth of the Black river?

A. Yes, sir.

Q. In the St. Clair river?

A. Yes, sir.

Q. Now, do you know how much dredged material was taken out of the Middle Grounds in the fall of 1891?

A. No, sir.

Q. Do you know how much was taken out in the spring of 1892 from the Middle Grounds?

A. No, sir.

4535 Q. Do you know how much was taken out of the St. Clair river in the fall of 1891?

A. No, sir.

Q. You think there was 5300 yards taken out of the Black river in the spring of 1892?

A. 5300.

Q. I mean 5300 yards?

A. Black river—yes, sir; that was in April, 1892.

Q. At what time did you say 5300 yards were taken out?

A. That was taken out in April, 1892.

Q. Where did you obtain these figures of 5300 yards?

A. United States Engineer Office, Detroit, Old Post Office Building.

Q. When?

A. Last Tuesday.

Q. Why, did you not obtain the figures for the dredging in the Black river in the fall of 1891?

A. I wasn't led to believe that they were wanted.

Q. At whose request did you obtain these figures?

A. Gardner S. Williams.

Q. Where did you meet him?

A. I never met him. I have heard from him at different times.

Q. Do you know whether he is the Gardner S. Williams 4536 who testified in this case as an expert?

A. I should think he was; yes, sir.

Q. When did you hear from him with reference to it?

A. About the 16th of June.

Q. Of this present year?

A. Yes, sir.

Q. From what place did he communicate with you?

A. Ithica, New York.

Q. You investigated this record at the request of Mr. Williams?

A. Yes, sir.

Q. How wide is the St. Clair river at Port Huron?

A. In the navigable bed?

Q. No, the entire width from shore to shore?

A. About 250 feet, perhaps 300.

Q. The entire width of the river?

A. Yes, sir.

Q. 250 feet?

A. Or 300.

GENERAL CROW: Black river you are talking about?

JUDGE JOHNS: No, the St. Clair river.

A. Oh, the St. Clair river, about three-quarters of a mile.

Q. Is it quite swift at that point?

4537 A. It is towards the Canadian shore; towards the American shore there is an eddy that causes gravel to settle upon the American side.

Q. The current is more swift on the Canadian side?

A. Yes, sir.

Q. And it was on the Canadian side that this dredged material was dumped?

A. Yes, sir; on the Canadian side.

Q. This dumping, I presume, was from scows?

A. Yes, sir.

Q. And was carried on during the fall of 1891, as the scows were loaded?

A. Yes, sir.

Q. It was not dumped in one body, but only by the scow loads?

A. Scow loads, about 150 yards or something like that in a scow.

Q. About how much?

A. 100 to probably 150 yards; I don't know just how much it was.

Q. And in the spring of 1892, was the dumping conducted in the same way?

A. Yes, sir.

Q. Now, the St. Clair river runs into Lake St. Clair?

A. Yes, sir.

Q. And opposite Port Huron the deepest part of the St.
4538 Clair river is on the Canadian side?

A. Yes, sir.

Q. This dumping was not to protect the tunnel from being struck by passing boats, but to prevent its leaking?

A. Yes, to prevent its surface wearing down; it was rather thin over the Canadian side I understood.

Q. From what part of the Black river was this 5300 yards obtained, in the spring of 1892 between Tenth and Military streets?

A. Between Seventh and Military streets.

Q. Between Seventh and Military streets?

A. Yes, sir. Well, no, it would be below Tenth street. It would be between Tenth and Military streets.

Q. Between Tenth and Military streets?

A. Yes, sir.

Q. How far from the mouth of Black river is Tenth street?

A. Well, it would be something over half a mile. I don't know exactly, what it was. There are ten streets .

Q. Is First street on the river front, and then do they run back up the Black river by number?

A. The first street I remember is Sixth street, so there would be six blocks back—six ordinary street blocks.

Q. Is Black river lined with docks on each side from its
4539 mouth to Tenth street?

A. On the north side it is. On the south side it is nearly all the way.

Q. What is the character of these docks, piling and platforms?

A. Piling and platforms always.

Q. And water running under the piling?

A. Yes.

Q. Or through the piling between the piles. There are no walled docks there?

A. No, sir.

Q. Nor are the piles planked to the bottom of the river?

A. There may be some dikes built that way. I don't remember of any.

Q. Well, is it one continuous dock on the north side or is it separate docks with slips?

A. They would be continuous docks. There are no slips as I remember it.

Q. A continuous line of piling with planks on top, constituting a dock for half a mile there?

A. Yes, sir.

Q. And on the south side of the river an occasional dock?

A. On the south side there are docks all the way from the 4540 mouth of the river to Seventh street.

Q. Was there in 1892?

A. Yes, sir. That is when I was giving it.

Q. You are talking of 1892?

A. Yes, sir.

Q. How far from the mouth of Black river across St. Clair river was it to the place where this dredged material was dumped?

A. From Black river to where the material was dumped?

Q. From the mouth of the St. Clair river; from the river front of St. Clair river?

A. It was not over a mile and a half I don't think.

Q. Now, was this dredged material all dumped in one place or was it dumped along the line of the top of this tunnel?

A. Dumped along the line of the top of the tunnel.

Q. For what distance from the Canadian shore?

A. Well, the object was to dump it in the deep water over the tunnel.

Q. Would it extend along the tunnel as far as a quarter of a mile?

A. It would.

Q. So that the dredged material was deposited along the line of this tunnel for a distance of about a quarter of a mile, you would say?

A. Yes, sir.

4541 CROSS-EXAMINATION, by Mr. Todd.

Q. In 1891, what months was dredging done in?

A. Oh, I wouldn't say for certain what months the work was done in, but I know there was some done in November. I went from the Clinton river up there.

Q. Was there any done in December?

A. I came home sick Thanksgiving Day of November. I could not say.

Q. Do you know whether there was any done in December?

A. No, I don't know.

Q. Any in January, 1892?

A. No, sir.

Q. There was none done in January?

A. No, sir; the season was closed. I am not certain, but I believe the season was closed in November, 1891.

Q. So, then, if that statement is correct, there was no dredging done in December of 1891, and January, February and March and up to the middle of April, 1892?

A. No, sir.

Q. How was this dredging measured, by scow measurement or place measurement?

A. Scow measurement.

Q. Did you have anything to do with any soundings upon the river?

4542 A. Upon the Black river?

Q. Yes.

A. No, sir.

Q. What other characteristics did you find in the soil excavated from the bottom of Black river, except the sediments which came from the woods and swamps, the clay and the sand, if any?

A. Why, the material gave off rather an offensive odor at all times. There was a sediment from all the causes I suppose that ordinarily occur in such a creek, where the sewage and such things were dumped into the river.

Q. What was the current of the river—the Black river?

A. During the summer months there was no current. In the spring there was a freshet which took the ice and everything out of it.

Q. Was the same character of soil excavated between Sixth street and the river found above Sixth street and the point where the dredging ceased, above Sixth street?

A. As I remember it; yes, sir.

Q. Did you observe any difference in the character of the dredging?

A. No, sir.

Q. The same characteristics prevailed from the mouth of the river up to the point where you ceased to dredge?

4543 A. There was very little change, if any. I couldn't recall any just now.

RE-DIRECT EXAMINATION, by General Crow.

Q. This dredging was done immediately in front of the city of Port Huron?

A. Yes, sir.

GENERAL CROW: That's all.

E. J. HAYNES.

4544 Southern Hotel, St. Louis, Missouri. 1:15 p. m., Saturday, June 27th, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

WILLIAM C. TEICHMANN, recalled for further direct examination by Attorney-General Crow, testified as follows:

Q. Now, Doctor Teichmann, what are these charts here that you have?

A. These are nineteen charts which were prepared under my direction and supervision by Mr. Alexander Miller and William H. Getz.

Q. These charts are the same ones you used in your testimony and referred to in your testimony?

A. Yes, sir.

Q. Your testimony in chief?

A. Yes, sir. They are the ones referred to in my testimony as charts numbered 1, 2, 3, and so on to chart No. 19.

4545 Q. They are made from the analyses made under your direction in this case?

A. Yes, sir.

Q. That you have heretofore testified about?

A. They were made entirely from the analytical data which I collected from the analyses of samples of water made in the city chemist's office during the years 1900 and 1901.

GENERAL CROW: We will just offer these charts in evidence, Mr. Commissioner.

Said charts received in evidence and marked by the Commissioner "Complainant's Exhibits 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69 and 70. Frank S. Bright, Commissioner."

WILLIAM C. TEICHMANN.

No cross-examination.

All these exhibits will be found bound in volume of Complainant's Exhibits.

4546 WILLIAM T. SEDGWICK recalled in behalf of the complainant, was examined in chief by Attorney-General Crow, and testified as follows:

Q. Mr. Sedgwick, when you were on the stand before, you testified as to the pollution of certain streams which you then named which had come under your personal observation, which pollution was caused by sewage being discharged thereinto. Now, I will ask you if you know of any other streams besides those that you testified to that you have investigated, whose waters have been polluted with the sewage of towns and cities and thereby rendered unhealthful?

A. Yes, sir.

Q. What other stream is it that you have investigated and found the waters polluted?

A. At that time I recalled indistinctly and not with sufficient knowledge to enable me to testify in regard to it, the facts relating to the pollution of the Potomac river and the effect of this pollution upon the typhoid fever conditions in the city of Washington, D. C. Since that time I have visited Washington and made a careful examination of the typhoid fever statistics on file in the office of the Department of Health, and in particular, have inquired into a very serious and extensive infection of the river which took place at Cumberland,
4547 Maryland, in 1890. I have also visited Cumberland and have made inquiries from some of the physicians and I have secured by correspondence from one of the physicians who at the time of the epidemic wrote about it, and has been much

quoted in regard to it, and I find that in December, 1889, and more particularly in January, February, March and April, 1890, there was in the town, or city I suppose it is—in the city ot Cumberland, a very extensive epidemic of typhoid fever, the effect of which was at the time, by a competent investigator, asserted to be plainly discoverable in an increase of the typhoid fever cases in Washington. I have recently reviewed the records in Washington and obtained from physicians on the spot at the time, in Cumberland, the facts so far as they could give them to me in that city; and I believe that this epidemic and its consequences constitute one of the most important examples on record of the transmission of typhoid fever germs over long distances.

JUDGE JOHNS: I object on the part of the State of Illinois to any recitation of the facts learned by the witness from other sources than his own personal observation, and from records, because the facts, if they exist, are capable of better proof than a recitation by the witness of things he has learned from other people, and the records are the best evidence of the facts which he purports to state, as existing or as shown
4548 by such records, and I move to strike out all of the foregoing answer which pertains to the supposed epidemic of typhoid fever in the city of Cumberland, Maryland, and the supposed consequent epidemic in Washington.

MR.TODD: The Sanitary District Joins in the same objection and motion.

Q. ATTORNEY-GENERAL CROW: Professor, did you ascertain that there was an epidemic of typhoid in 1889 and 1890 in the city of Cumberland, Maryland?

A. I did.

Q. Do you know about how many cases there were?

A. There appear to have been in January, 1890, eighteen deaths; in February, 27; in March 39; in April 8; and in May 5; and there was also one death in December, but this was that of an imported case.

Q. In 1889 or 1890?

A. In December, 1889.

Q. And the other months, were they in 1889 or 1890?

A. In 1890; those that I gave you. That is to say by some the epidemic was thought to have begun in December, 1889, but

the deaths began, properly speaking, in January, 1890. There were therefore, all told, in the epidemic in Cumberland, 98 deaths from typhoid fever, and although it has been re-
4549 peatedly stated in sanitary discussions and pamphlets
relating to the water supply of Washington, that there were 485 reported cases of typhoid fever in Cumberland—

Q. In Cumberland or in Washington?

A. In Cumberland at this time, and in this epidemic—the number of deaths indicates that there must have been actually nearly double that amount. An effect of this epidemic appears to have become marked in Washington in March, 1890, when the total number of deaths from typhoid fever was 19, and to have extended through August, the number of deaths per month having been:

March,	19
April,	11
May,	13
June,	33
July,	36
August,	28

and after August no effect of the epidemic can be traced in the deaths from typhoid fever in Washington.

This case is a particularly interesting one and has been repeatedly referred to in public meetings and conferences and hearings before Congressional and other committees and the like, in Washington, but has not hitherto found its way to any considerable extent into the books upon the subject. I re-
4550 gard it, however, as perhaps on the whole, as I have already intimated, a most instructive example of the transmission of typhoid germs in a polluted stream over a long distance, because Cumberland is about 175 miles from Washington by the river, and because the river is of such a character as to offer a good example of a stream neither very swift nor very slow, but having occasional areas of what might be called slack water; these succeeded by steeper portions, and therefore affording good opportunities for a certain amount of so-called self-purification en route.

The epidemic moreover in Cumberland, having been a very extensive one, must have afforded a heavy infection of the stream, although it is a fact that at that time the city of Cumberland was not at all thoroughly sewered. It is however peculiarly arranged with respect to the water courses flowing past or through it. It is at the junction of that portion of the river which comes down from the Allegheny mountains, and another portion which comes from the West Virginia hills, and in 1890 there was (and there still is) a large number of privies overhanging the streams, which consist of the Potomac on the south and two small runs emptying into the Potomac near the intake of the waterworks, and a creek known as Wills Creek. The two runs and the creek receive directly a large amount of fecal matter from the privies referred to and so striking was this arrangement, that Doctor Kober who made 4551 the first investigation of the epidemic, published a plate showing these unsanitary conditions and this plate has been repeatedly copied. I should like to introduce that if it is competent evidence.

GENERAL CROW: You may offer it.

THE WITNESS: And I will offer a copy of it which appears in the report of the Commissioners of the District of Columbia for 1895, opposite page 1337.

One other fact of great importance I think should be mentioned. Between October 4th, 1889 and March 18th, 1890, the sedimentation basin in Washington and the distributing reservoir also appear to have been out of service so that during this period the water of the Potomac was delivered to the citizens of Washington without purification of any kind, a fact which no doubt added to the severity of the outbreak in Washington.

MR. TODD: I move to strike out the answer for the same reasons that are stated in the last objection made to the last preceding question, and the motion.

JUDGE JOHNS: And the State of Illinois joins in the motion.

Q. GENERAL CROW: When did the typhoid break out in Washington, what month,—do you know?

4552 A. The typhoid deaths—the excess of typhoid deaths—Washington has long had an excessive death rate from typhoid fever. This has been repeatedly attributed in part by competent experts to the use in that City of the Potomac River water for drinking purposes; but, during and from March, 1890, through August of the same year, this excess reached extraordinary proportions; so much so that if the typhoid deaths in these months are compared with the average monthly typhoid mortality for the five years previous to 1890, and for the five years after 1890, it appears that this excess amounted to about one hundred per cent. That is to say, in addition to the ordinarily excessive typhoid of Washington, there was apparently, owing to this epidemic in Cumberland, Md., a further excess of about one hundred per cent. So clear was this connection regarded or held to be by local authorities, that when a case of Asiatic cholera was reported to have appeared in Cumberland, Md., in 1894, grave anxiety was felt by these experts in Washington. Fortunately, however, the case proved to be something else than Asiatic cholera.

The question will naturally be asked, How long does it take for water to flow from Cumberland to Washington, and this time has been variously estimated; but is given by Capt. Gaillard, of the U. S. Engineers, in Senate Document No. 94, 55th Congress, second session, as from four to seven days from
Cumberland to the intake, and by one of the officials of the
4553 U. S. Geological Survey, as from two to four days.

It is interesting to note in connection with the epidemic in Washington in 1890, which followed that in Cumberland, Md. in the same year, that the excess of deaths of typhoid fever in Washington is not clearly marked until about two months after the outbreak in Cumberland. That is to say, while there were eighteen deaths in Cumberland in January, 1890, no marked excess appears in Washington until March. Furthermore, while the epidemic in Cumberland ended in May, that in Washington was continued vigorously during July, and even to some extent during August. Whether this delay in the instance of deaths in Washington is or is not due to the temporary deposit of the germs in the bed of the stream from which they were afterwards returned from the flowing water and delivered in Washington it is impossible to say positively, but it is difficult to resist the feeling that this may have been the case. It is certainly a remarkable and interesting fact. We know, to

be sure, that persons who have had typhoid fever continue, even after recovering, often for considerable periods, to discharge germs from the body, and it may have been that a part at least of the tardier appearance of the disease in Washington and its continuance after the epidemic in Cumberland had ceased, was due to this cause; but it may also have been due to the thorough infection of the river—of the bed of the stream, which was not entirely washed out for sometime after the epidemic
was over, in part also, the later appearance is also un-
4554 doubtedly due to the passage of the water through the
settling basin and distributing reservoir, which were in operation after March 18th.

MR. TODD: I move to strike out the answer and all the recitations and conclusions cited by the witness in regard to other experts, as being incompetent and not proper evidence.

JUDGE JOHNS: State of Illinois joins in that objection and motion.

Q. GENERAL CROW: How large a town is Cumberland, Md.?

A. Its population at that time is said to have been twelve thousand.

Q. What is its size now?

A. I think it is nearer twenty thousand today.

Q. Did they have at that time, 1890, a system of water works in Cumberland?

A. Yes sir. And the epidemic in Cumberland is supposed to have been caused, and in my judgment was caused by an infection of their own water supply by a case of typhoid fever happening just above the intake of their water works, which was placed in a very objectionable position in the Potomac river.

Q. The source of their water supply is the same stream as that of the City of Washington, the Potomac River.

A. The Potomac river. It is the South branch of the Potomac River.

Q. The number of cases in Washington was how many, did you say in 1890?

4555 A. I gave only deaths, not cases.

Q. Well, deaths?

A. The number of deaths during this epidemic was 140, if I remember right.

Q. During the period of a few months?

A. Yes, 140 deaths during the period of six months.

Q. How many cases would that indicate in the City of Washington?

A. About 1400.

Q. Do you know the population of Washington City at that time?

A. (Referring to memorandum) 250,000.

Q. Do you know anything about the present supply, and the supply for the last few years, of water for the City of Washington, as to whether or not it has been considered suitable and safe for drinking purposes?

JUDGE JOHNS: Objected to as irrelevant and incompetent.

A. Yes, the problem of the water supply of the City of Washington has been a matter of very grave concern to the citizens of that city, and ought to be to the citizens of the whole country, as it is a very much visited city, and as I have already said, it has long been high in typhoid fever. It has been attributed, in my judgment and with reason, in large part 4556 to the use of the polluted water of the Potomac River. So much so has that been the case that numerous reports and meetings and conferences have been held on the subject, and there is probably no water supply in the country that has been more thoroughly discussed in which public opinion has crystallized more fully than in the case of the water supply of the City of Washington. It was recognized that the Potomac is a polluted stream, although there are very few sewered towns upon it, but there are these overhanging privies and the like and it is anything but a good supply. Steps, however, are being taken at the present time to adequately purify it.

Q. In what manner?

A. By an extension of the system of sedimentation and filtration.

Q. What kind of filtration?

A. They are going to use partly the slow sand filters, and when the water is very turbid and clayey, the rapid mechanical filters.

Q. Is that the Alton filter, the rapid mechanical filter?

A. That is the Alton method.

Q. So that they will have a combination of the two methods of filtration there in Washington City?

A. They will have. The contracts have just been let.

4557 Q. Do you know how the distance from Cumberland to Washington by river compares with the length of the River Thames in the United Kingdom?

A. The Thames is 209 miles long, and is, I believe, the longest river in the United Kingdom, and this epidemic seems to confirm in a very remarkable way that statement of the Rivers Pollution Commission of Great Britain, to which I have referred in my previous testimony, where they said that there was no river in the world that was long enough to purify itself of any sewage introduced into it even at its source.

Q. This record you have here, is that an official report of the Commissioners?

A. This is the official annual report of the Commissioners of the District of Columbia so far as the Department of Health is concerned.

Q. For what year?

A. 1895.

Q. 1895?

A. Yes sir. In 1895 there was another serious epidemic in Washington, which was carefully investigated, but it was not directly connected, so far as I am aware, with the event of typhoid fever in Cumberland.

Q. Now, you have visited the City of Cumberland, have you?

A. I have.

4558 Q. And visited Washington City?

A. I have.

Q. And observed the Potomac River?

A. Yes sir.

Q. And you are familiar with the conditions there?

A. I have been familiar with the conditions in Washington in a general way for a good while, but I have never visited Cumberland till recently. Nor was I familiar, except in a general way, with the Potomac River.

Q. Now, from your knowledge of the situation, and of the conditions that prevailed in 1889 and 1890 in the City of Cumberland, Md., and the City of Washington, the conditions of the Potomac River, and the water supply of the two towns, of the sewage and human deffication of the stream of the Potomac River, I will get you to state whether or not, in your judgment, the epidemic of typhoid fever in 1889 and 1890 in the City of Washington was caused by the placing of sewage infected with typhoid bacilli in the waters of the Potomac River at the City of Cumberland, Md.?

A. I should hardly call the excess of typhoid fever in Washington in 1890 an epidemic, although that term might perhaps very well be applied to it. It was rather an extraordinary and unusual excess of typhoid fever, and, in my judgment, this excess was and is directly traceable to the great epi- 4559 demic of typhoid fever occurring shortly before, and during a portion of the same period in the City of Cumberland, Md.,—germs from that epidemic having apparently passed down the river into the water supply of the City of Washington alive and virulent. Of course there must have been a considerable removal of germs en route, else the outbreak in Washington would have been far more severe.

Q. What was the percentage increase in the death rate in 1890 in the City of Washington as compared with previous periods of similar extent?

A. I have already stated that, for this period, the increase of typhoid fever mortality over and above the average mortality for the same period during the five years preceding and during the five years afterwards was about 100 per cent. I don't know what the effect was upon the general death rate, and owing to the fact that the Washington Board of Health keeps its records by calendar years, their records are somewhat obscure, by the fact that a portion of this epidemic on their records appears in 1889 and a portion in 1890, but the consequence of that is that although these two years in their records appear to be the same, this is for the reasons indicated, that they are reckoned by the calendar year, not by the fiscal year. If the figures are examined in the way in which I have stated, and studied as I have studied them, the results are those that

I have already given. It remains, however, a fact that
4560 even upon their own showing, the two years, 1889 and
1890, were exceedingly high in typhoid fever mortality.

CROSS EXAMINATION.

By Judge Johns.

Q. When did you make the examination of the excess of typhoid fever in Washington?

A. It was immediately after I left St. Louis on my last visit, and about the first of June.

Q. Of the present year?

A. Of the present year, yes sir.

Q. And after you had finished your testimony given here in May?

A. Yes sir.

Q. Were you then in the employ of the State of Missouri as an expert?

A. Yes, sir, I was.

Q. Were you instructed by the State of Missouri through its Attorney General to make this investigation in Washington?

A. I suggested to the Attorney General that it would be wise for me to go and make this investigation and he then instructed me to do so.

Q. Are you still in the employ of the State of Missouri as an expert in this case?

A. Yes, sir.

4561 Q. And expect to be in such employ until the close of the testimony in this case?

A. Until further notice, at any rate, yes sir.

Q. You are now acting for and in behalf of the State of Missouri in an advisory capacity in this lawsuit as an expert?

A. I understand that I am, yes sir.

Q. From what point in the Potomac River does Washington receive its water supply?

A. At a point called Great Falls.

Q. How far from the Capitol building is that?

A. I don't think that I could answer that question, but it is about four and one-half miles from Washington.

Q. Up the river?

A. (Referring to memorandum) 14 miles above Washington.

Q. That information you derive from some report from which you are now refreshing your memory?

A. Yes sir.

Q. Outside of that report, do you know as to the fact?

A. Yes sir.

Q. From what report are you refreshing your memory?

A. This is a report of an investigation of the feasibility and propriety of filtering the water supply of Washington, D. C, with detailed estimates of the cost of the work required, by Col. A. M. Miller, of the U. S. Engineers, who has recently had charge of the water supply of Washington. 4562

Q. Do the tides run up the Potomac River past Washington?

A. I understand the tide is felt above Washington, or at and near Washington, but that salt water does not run up above Washington; but I have no especial knowledge on that point.

Q. Do you know whether the tides are felt at the intake of the Washington water works?

A. I understand that they are not. This is above?

Q. Above the influence of the tides?

A. Yes, sir, so I understand.

Q. Do you know what the tidal rise is at Washington?

A. I do not.

Q. What kind of water supply, or water system, had the City of Washington in 1890 and 1891?

A. What kind of supply?

Q. Yes, was it taken from the river and passed through sedimentation tanks?

A. In general it was taken from the river and carried through a sedimentation basin where it was allowed to sediment to a certain extent; then it was lifted to a distributing reservoir, and from there sent direct to the citizens; but at times the sedimentation basin was not employed and at those times the water was sent directly to the distributing reservoir. On this one occasion to which I refer, as I understand it, both sedimentation basin and distributing reservoir were out of service. 4563

Q. And the water pumped virtually from the Potomac River into the mains in the City of Washington?

A. I suppose it was, yes sir.

Q. From whom did you obtain that information?

A. That is stated in a letter of Capt. D. D. Gaillard, U. S. Engineers—in a letter dated February 24th, 1898, and addressed to Dr. Geo. M. Kober, the well known sanitary expert who first studied the Cumberland epidemic and who first pointed out its probable connection with Washington.

Q. What other experts have studied the epidemic about Cumberland and the consequent increase of typhoid at Washington in 1890 and 1891?

A. So far as I know, no one has studied it thoroughly excepting Dr. Kober, and, if I may be permitted to say so, myself.

Q. What other experts had grave apprehensions as to Asiatic cholera when it was discovered that there was a case of Asiatic cholera in Cumberland?

A. My authority for the statement which I have made in that connection is Dr. J. J. Kinyoun, an eminent bacteriologist connected until recently with the U. S. Marine Hospital Service, and is found in a discussion by Dr. Kinyoun of the question of water supply for the District of Columbia published in Document 183, Fifty-fifth Congress, Second Session, page 25.

4564 Q. House or Senate document?

A. Senate document.

Q. Well, now, in addition to this gentleman, what other experts had grave anxiety about it?

A. Excuse me, may I just—

Q. I am only asking you for names.

A. I should like, however, to give this one instance here.

Q. Well, I object to it. I am asking you now only for names.

A. Dr. Kinyoun said—

Q. I object to the reading of anything that Dr. Kinyoun said from the book in possession of the witness, and to the witness reading here anything which is not responsive to the question, the question being only as to the name of the experts.

A. I don't care to insist at all.

Q. What other experts now had grave anxiety about Asiatic cholera than the one you have named?

A. He is the only one that I know of who had such anxiety, but as I know that he was associated with other sanitarians of note, I have no doubt that the matter was talked over by them at the time.

Q. Did you talk with Dr. Kinyoun yourself in this visit to Washington?

A. No, sir, I did not.

Q. Your information as to his grave anxiety arises from reading something that he got in print?

A. It does.

4565 Q. Then because he did that you infer that other sanitarians had like grave anxiety with reference to it?

A. I do.

Q. Now, before what committee of Congress was this epidemic in Cumberland discussed?

A. It was not discussed so far as I know before any committee.

Q. By what committee was it investigated?

A. Nor was it investigated. It has been referred to in numerous discussions and conferences, as for example—

Q. I am asking you now only for committees of Congress.

A. Exactly, that is what I am after.

Q. And I object to any statement as to any other thing under the present question than committees appointed.

A. Senate Document 183, already referred to, and which shows that the Senate committee on the District of Columbia—possibly the whole committee on the District of Columbia, in a letter from its clerk dated February 21st, 1898, accepted an invitation from the Medical Society of the District of Columbia to attend a meeting of that society on the following Wednesday; and further on in this document it appears that the Cumberland epidemic and its possible effects on the City of Washington were at that time discussed by Dr. Kober. Of course I cannot say that the committee was present, but I infer that it was. 4566

Q. Was this a somewhat protracted meeting of the

Health or Medical Socity of Washington as appears from that document?

A. The document simply recites a report of the committee of the Medical Society on the water supply and sewage disposal of the District of Columbia and the discussion thereon, and does not bear evidence as to how protracted the discussion may or may not have been.

Q. Nor any evidence as to whether the Senate committee for the District of Columbia was present?

A. No, sir.

Q. How many cases—

A. Excuse me one moment. This is one example, and I think that there has been others of the same sort, but I don't happen to have them with me.

Q. That is examples of times when committees of Congress took some interest in this matter.

A. Yes, I think so.

Q. Now, whether any committee of Congress actually investigated the typhoid epidemic in Cumberland you are not prepared to state?

A. I am not prepared to state.

Q. Now, how many cases do you say were reported of typhoid fever in Washington in December of 1889 and the first seven months of 1890?

567 A. In Washington?

Q. Yes, sir.

A. I don't think I said how many were reported in December of 1889, but I can give them however. But I suppose ou meant deaths and not cases.

Q. No, I mean cases.

A. I don't know, no.

Q. How many cases were reported in the first seven onths of 1890?

A. I have not paid any attention to the number of reported cases in Washington, but only to the deaths.

Q. Have you stated in your examination in chief that there ere reported, or assumed to be, about 458 cases?

A. No, sir, that was in Cumberland, 485.

Q. 485 cases?

A. Yes, sir.

Q. Now, from what source did you obtain that information of 485 cases in Cumberland?

A. That rests, both in Dr. Kober's reports and in my own case, upon the authority of Dr. W. W. Wiley, of Cumberland. The health records of Cumberland are exceedingly defective. I have endeavored to obtain officially the necessary data, but was unable to do so, and both for the cases and for the deaths in Cumberland I am dependent, as Dr. Kober was, upon Dr. Wiley, the local physician.

4568 Q. Was this Dr. Wiley a resident of Cumberland during this epidemic of 1890?

A. Yes, sir, he was.

Q. He reported there were 485 cases, did he?

A. He has written to me that there were 485 reported cases.

Q. Reported cases?

A. Reported cases.

Q. You prefer not to believe that?

A. Yes, I believe that there were 485 reported cases.

Q. But you also believe that there were a great many other cases, namely: about 1000?

A. I also believe that there must have been upwards of about 1000 cases in Cumberland, judging by the deaths.

Q. And that is upon the theory that there are about ten cases of typhoid fever to one death?

A. It is upon the experience of mankind that there are at least ten cases to one death.

Q. If it should be authoritatively reported that there were 500 cases of typhoid fever only in a given locality and that there were 125 deaths, would you believe it?

A. Not without making a further examination of the facts, or by personal inquiry into them, because this would be so remarkable a fatality as to excite the gravest suspicion.

Q. If a report does not conform to what you call the ex-
4569 perience of mankind in reference to the ratio of deaths
to cases in typhoid fever, you don't believe the report?

A. I don't believe the report as a rule, because we have so many instances in which physicians fail to report their cases and because, furthermore, there are many cases which never come to the knowledge of physicians, walking cases and the like.

Q. Suppose it was reported by what you would deem competent authority that there actually was not another case than 500, the excess in cases of the exact number of five hundred in any given locality, and that there were actually only 125 deaths from typhoid fever, you would not believe the report?

A. Not without looking into it somewhat to see. It is possible of course that in a very severe epidemic the fatality should be unusually high, but such a statement as that would call for some explanation.

Q. As it would not conform to your belief in reference to the ratio of deaths to the cases of typhoid fever, you would want further evidence than the report?

A. I should. It would be on the face of it entirely out of harmony with the sum of human experience and medical knowledge in these matters, and I should therefore expect that whoever made such a report should give some reason for the extraordinary fatality.

4570 Q. How many miles long is the Potomac River?

A. I don't think I can answer that question.

Q. How many branches has it which are designated by the name of Potomac?

A. As I understand it, it is generally called the Potomac above Cumberland, on the south side, but that a better description of the river would be to say that it was formed at Cumberland by two principle sets of tributaries, one from the south and one from the north.

Q. Is either one of those tributaries designated upon the maps as the Potomac?

A. I rather think that the southerly one is, but I am not sure about that.

Q. What is the other one named upon the maps?

A. The other one, the principal one, is Will's Creek.

Q. In its entire extent, what is the area of the valley of the Potomac?

A. I have no personal knowledge of this, but referring to Col. Miller, of the U. S. Engineers, the drainage area above the intake figures 11043 square miles.

Q. What is the population of that drainage area?

A. Col. Miller gives it at 44 1-2 sq. miles.

Q. 44 1-2 of population to the square mile?

A. Yes, estimated for 1900.

Q. That is quite a thickly populated country then?

4571 A. Yes sir.

Q. Are there towns and cities upon the Potomac above Washington and below Cumberland?

A. There are a number.

Q. How many?

A. Well, I don't know how many, but in 1890 none of these, as I understand it, were sewered. The principal ones were Harper's Ferry, Hagerstown, Frederick, Winchester and a number of others that I don't remember.

Q. I didn't ask you about the sewerage, I was asking you about the number of towns.

A. I don't know what the number of towns is. It is considerable.

Q. Are there towns upon either of the branches of the Potomac River above Cumberland.

A. There are.

Q. How many upon the South Branch?

A. I don't know, but there are two which are commonly referred to as Piedmont and Keyser.

Q. What upon the north branch?

A. I think there are a few upon the north branch. The north branch is comparatively small.

Q. The valley of the Potomac is a very rich, agricultural country is it not?

A. It is.

4572 Q. And is for an agricultural country thickly populated?

A. I should say so, yes.

Q. And has upon it a large amount of domestic animals?

A. Yes sir.

Q. And is much in its agricultural characteristics a gardening country, is it not?

A. I should hardly say that it is an agricultural country certainly.

Q. Well, isn't the principal industry raising vegetables for the market?

A. I am unable to say.

Q. Now, in 1889, was typhoid fever in any one of these towns, save Cumberland?

A. *Not so far as I have been able to learn.*

Q. You haven't heard of any?

A. I have inquired and have not learned of any.

Q. What kind of inquiries did you make about it?

A. In Washington, talking with the health officials, who are fairly familiar with the condition of the water sheds, and in Cumberland with physicians.

Q. With what health official in Washington have you talked while engaged in this investigation?

A. Dr. Woodward, Chairman of the Board of Health.

Q. Was he in Washington during this period of 1889 and 1890?

A. I think he was, although I am not sure.

4573 Q. With what other person have you talked upon the subject?

A. No one else in Washington, except some of the people in the office, whom I didn't know, but in Cumberland with the doctors that I referred to.

Q. With what doctors in Cumberland?

A. I talked with Dr. Johnston, Dr. Speer and I corresponded with Dr. Wiley.

Q. When were you in Cumberland? ?

A. As I have said, about June 1st. I have not the means here of saying the exact date.

Q. How long were you there?

A. Half a day.

Q. You arrived there on some morning train and left on some noon train?

A. The other way around. I arrived at noon and left at night.

Q. With what other person than Dr. Wiley did you talk in Cumberland?

A. Dr. Johnston and Dr. Speers.

Q. Did you examine during that half day the records of—

A. I tried to, but there were not any except since 1900.

Q. There were no health records in Cumberland prior to 1900?

A. I could find none in the health office. I was very much dissappointed.

4574 Q. Do you know whether there was typhoid fever in any of the towns on any of the tributaries above Cumberland on the Potomac River?

A. At that time?

Q. Yes?

A. Not so far as I could learn.

Q. You haven't heard of any?

A. I haven't heard of any.

Q. What are the tributaries of the Potomac River below Cumberland, Md. and to Washington?

A. I think the principal tributaries are the Shenandoah and the Monocacy, although there are others, such as the Antietam creek and very likely some smaller ones that I do not know about.

Q. Does the Shenandoah river drain the Shenandoah valley?

A. Yes, sir.

Q. That is a very thickly populated agricultural region?

A. It is a rich, fine agricultural country. I shouldn't say very thickly populated. I have driven up through there. I should say that it was not very thickly populated.

Q. Not very thickly populated as an agricultural region?

A. That depends upon one's standard of course. As compared with New England in many places I should say not.

Q. There is no agricultural country in New England to speak of. I am speaking now of agricultural country.

4575 A. Speaking of it from the standpoint of southern Illinois and Indiana I would say that it was rather thickly populated.

Q. And the Shenandoah valley has its drainage, its surface drainage into the Shenandoah river?

A. Yes, sir.

Q. Thence into the Potomac?

A. Thence into the Potomac.

Q. Do you know the drainage area of the Shenandoah valley or of the Shenandoah river?

A. No, sir; I do not.

Q. Do you know the drainage area of the Monocacy?

A. No, sir.

Q. Is the valley of the Monocacy an agricultural region?

A. I am not familiar with that. I don't know.

Q. Was there any typhoid in this period and prior to it in the valley of that river?

A. I don't know of any, but I have no doubt there were some few cases.

Q. Having learned from reports of conferences that there was considerable typhoid fever at Cumberland at one time, and subsequently a remarkable increase of typhoid fever in Washington, and not knowing as to typhoid fever any place else, you conclude that the typhoid fever in Washington is attributable to Cumberland?

4576 A. I do.

Q. Your entire knowledge of it has been gained and acquired since about the first of June and since that time?

A. My definite knowledge of it has been acquired since that time, as I have stated, because although I had an indistinct recollection of the facts I did not have them sufficiently in mind or in hand to enable me to speak of the matter upon my previous examination with any confidence. I therefore requested the privilege of going and looking up the matter as I believed it to be interesting and important.

Q. Can you tell me why the cases in January, 1890, in Cumberland didn't show any effect, if they ever had any, in Washington in February?

A. I cannot. There was a slight increase in Washington in January, but it was so slight that I didn't feel it fair to attribute it with any strong presumption or probability to the cases in Cumberland. At the same time—

Q. At what time in the year is the Potomac river at Cumberland in flood?

A. Allow me to finish my answer.

Q. Excuse me.

A. At the same time it is entirely possible that this slight excess in January was due to the cases in Cumberland.

Q. At what time is the Potomac river in flood at Cumberland?

A. I have not learned with any great degree of accuracy 4577 of the flood periods of the Potomac river, or at least beyond the statement of Capt. Gaillard that its flow is very marked, varying from a minimum at Great Falls of about 1063 feet per second to between four and five hundred thousand during the great freshet in June, 1889.

Q. In June, 1889, there was a freshet in the Potomac river, was there, according to the statement of Capt. Gaillard?

A. Yes, there was.

Q. At which time the river flow was about four or five hundred thousand cubic feet per second?

A. Yes, that was June, 1889.

Q. And do you know when there was another flood after that?

A. I do not.

Q. Whether there was any in 1890?

A. No, I do not.

Q. Or in the winter of 1889 and 1890?

A. I do not; but of course it was fair to suppose that with the breaking up of snow on the Virginia mountains and the Alleghenies there must have been the usual spring floods. I have not undertaken to connect closely the typhoid in Washington with the typhoid in Cumberland, believing that no such close connection could be traced to that, but that only a broad and general connection was discoverable.

Q. Do you think that the typhoid fever in Cumberland of 4578 January of 1890 was a contributing cause to the typhoid fever in Washington in March?

A. I do decidedly.

Q. For what reason?

A. Because, as I have already stated, beginning with March there was a continued excess in Washington which, in my judgment, corresponds well with a correspondingly continued excess in Cumberland.

Q. I am asking you only of the month of January. Do you believe that the typhoid fever which occurred in Cumberland in January, 1890, contributed to the typhoid fever in Washington in March of the same year?

A. I certainly do.

Q. On what theory?

A. For the reason that we have good reason to believe that germs of that disease were deposited in the Potomac water at Cumberland. We know that this water travels down the river and is in part at least used for drinking purposes by the people of Washington. We find an otherwise inexplicable excess in typhoid fever in Washington at a time following, when such increase would reasonably be unexpected.

Q. All the water in the Potomac river at Cumberland had flowed past the City of Washington in the Potomac, long before this epidemic or increase of typhoid fever in Washington, that is to say, the water infected, if it was infected, by typhoid 4579 fever in January at Cumberland had flowed past the City of Washington a very considerable time before allowing for the period of incubation, had it not?

A. I should suppose that it must have in a large part. Perhaps entirely.

Q. Then, if the typhoid fever in Cumberland in January contributed to the typhoid fever in Washington in March, the germs must have been deposited somewhere in the meantime?

A. That seemed to me a very decidedly suggestive fact, but I think we should bear in mind that in January it is possible that the stream was tightly frozen and that sedimentation took place to an unusual extent for a time. The so-called self-purification going on.

Q. Is the Potomac river ever frozen between Cumberland and Washington?

A. I have no personal knowledge of it, but I don't see how it can be otherwise. There are many quiet ponds in the stream between Cumberland and Harper's Ferry which I should suppose would freeze over readily, as Cumberland is in the mountains.

Q. Is the Potomac river ever frozen over in those places where there is a current?

A. If the current is not too swift, I should suppose it must have, and certainly the current would be slow in the places that I have spoken of.

4580 Q. Of course, there is no way of determining as an actual fact whether any typhoid fever germs were deposited in any of the sluggish places in the Potomac river?

A. No, sir.

Q. Nor, whether they were washed out so as to contribute to the typhoid fever in Washington in March?

A. No, sir. We can only infer from the end result, what may have happened.

Q. And the belief that typhoid fever in Cumberland was the cause of typhoid fever is based upon the theory that typhoid fever germs live in water and are transported by water and retain their virulence?

A. That certainly is the theory, sir.

Q. And that theory in this case must be applied to a distance of how many miles between Cumberland and Washington?

A. The distance from Washington to Cumberland by river is about 175 miles, but I fancy that that includes the acqueduct and settling basins.

Q. From the intake to Washington?

A. Yes, I believe so.

Q. So that the distance from Cumberland, say, to the intake at Washington is possibly 165 miles?

A. Well, about 160 miles perhaps.

4581 Q. 160 miles?

A. 160 to 165.

CROSS-EXAMINATION, by Mr. Todd.

Q. What was the sewerage system in vogue at Cumberland in 1890, Professor?

A. There was no regular system of sewerage, but there were some short private sewers, and according to the best information I can obtain, privies overhanging the streams then as they now do, and draining into the runs, which contributed to the river; to some extent also night soil was emptied near the stream according to a statement made by one of the physicians, and the banks being quite steep in that neighborhood, no doubt a good deal of the excrement found its way into the stream, but I think there was no regular system of sewers.

Q. What percentage of the sewage at Cumberland found its way into the Potomac river?

A. That would be impossible for me to answer, or for anyone to answer.

Q. What proportion of the population of Cumberland resided immediately on the banks of the Potomac river and Wills creek and the two little runs?

A. I can't say accurately, but I should suppose perhaps 4582 one-third to one-half.

Q. How far does the town of Cumberland extend back from the Potomac river?

A. Today it extends perhaps an average of one-third to one-half miles.

Q. To what extent along the river does the City reach?

A. That is also difficult to answer because it extends from the Chesapeake and Ohio Canal to Wills Creek and also to the little runs in another valley and to the Potomac in the third, but I should say, without speaking accurately, it was about a mile.

Q. At the town of Cumberland are the banks of the river high or low?

A. On Wills creek the banks are tolerably high. On the runs they are low, and also on the Potomac.

Q. On the Potomac do the houses front on the river, or are they situated so that the rear is on the river?

A. As I remember it, there were comparatively few houses upon the Potomac, and I should say that they for the most part fronted on the river, their backs often reaching to little runs to which I have referred.

Q. How many privys did you observe that overhung the banks of the Potomac?

4583 A. I did not see any on the banks of the Potomac proper, but I did not go very far up that stream.

Q. How many did you observe on the banks of the creek overhanging the banks of the creek when you were there?

A. I think I counted about thirty or forty, and, as far as I could see up the stream, they were still in evidence, but I did not go up to count them.

Q. Do you know what system is in vogue for the receiving of the fecal discharge in connection with the residences that are located along the creek and along the Potomac?

A. At that time?

Q. Yes.

A. As near as I could learn, there were a good many box privys and some private vaults, the usual arrangements of rural or semi-rural communities, but these privys and private vaults to a great extent emptied upon the banks of the stream. I have here a definite statement upon this from a physician, Dr. H. V. Miller, of Cumberland, who says that the entire outlet for waste material here is the Potomac river. The closets are cleaned and refuse deposited on soil drained into the dump, direct into the river, while many closets and sewers open direct into streams which flow into the river.

4584 Q. Have you any information as to the number of typhoid cases or deaths that occurred in the houses where the privys overhung the stream?

A. No, sir, I have not.

Q. Have you any information as to the number of typhoid deaths that were in houses that used private vaults?

A. No, sir.

Q. When the fecal discharge of a typhoid patient is deposited into a private vault, how long under those conditions in your judgment would the bacteria of typhoid live?

A. This is a difficult question, but in my judgment some of them might live for weeks or months, or even years.

Q. Have you any information as to how often the privy vaults and box privys were cleaned and the refuse dumped into the Potomac?

A. I have not.

Q. In order to form an accurate conclusion as to the effect of the typhoid fever in Cumberland, wouldn't it be necessary to ascertain that fact?

A. I think not under the then existing circumstances. There was in Cumberland a very extensive epidemic of typhoid fever. During a part of that period the water of the Potomac
at Washington was apparently pumped very directly to
4585 the people. A remarkable excess of typhoïd fever ap-
peared soon after in Washington, which excess continued
over a number of months, corresponding well to the duration of the excess in Cumberland; and, although some of the germs in Cumberland doubtless lived beyond the period of the Washington epidemic, the ordinary processes of purification of the

water supply in Washington were such that no unusual effects were discoverable from them. It should be remembered, however, that typhoid fever is almost always excessive in Washington, and I believe that this regular excess is in a large part due and long has been due to a limited number of cases occurring in Cumberland, so that a small infection surviving or proceeding from box privys emptying into the river after this period would, in my judgment, keep up the usual excess of typhoid in Washington. It might not materially add to it.

Q. Have you any information as to how often the privy vaults of Cumberland were cleaned or renovated?

A. No, sir.

Q. Have you any information as to whether the fecal discharge from typhoid patients in Cumberland was treated by the application of any antiseptic?

A. I have not.

Q. If it should appear that under the direction of the doctors such antiseptic precautions had been taken, would not you deem it necessary to ascertain that fact in order to draw a 4586 correct conclusion as to the effect of the sewage of Cumberland upon the Potomac River?

A. No, sir. I should not, broadly speaking, because it is well known that any such general order for such disinfection, or any such practice of disinfection, is always only partially obeyed, and I should rather believe that the moderate character of the excess in Washington, which I have hesitated to call an epidemic, was in part due very likely to some such disinfection. If there had not been some means of destroying these germs in part at the start or en route, in my judgment the effect in Washington would have been much greater than it was; and the very fact that it was great, but not appalling, seems to me to fit in admirably with all the known circumstances and conditions at Cumberland on the river and in Washington.

Q. If the facts should appear that a disinfectant was employed and that these privy vaults where the typhoid fever feces or excrements was emptied, were not cleaned or renovated oftener than six months, would that fact be necessary to ascertain as shedding any light upon the infection which the Potomac river received from this typhoid condition at Cumberland?

A. I think that the ascertaining of such a fact would be interesting and vauable, but I do not consider it as in any way
indispensable to the present inquiry, because in this case
4587 particularly, so many privys overhanging the creek and
the runs must, with the abundance of typhoid fever in
Cumberland, have delivered uninfected feces to the river, that any such inquiry would be somewhat academic rather than practical in my judgment.

Q. Then you do not regard as essential the establishment of the fact as to whether the fecal discharge of typhoid patients had been treated to an antiseptic or not, or whether the houses whose night soil was emptied into the river were inhabitated by typhoid cases or not in arriving at your conclusion as to the pollution of the Potomac river?

A. I certainly do not in the present case, because even if there had been a general order by the municipality to disinfect, I am sufficiently familiar with the small effect of any such order to have learned to disregard it, and, besides, in the present instance there is no reason to suppose any such order was given, or even in part obeyed.

Q. Do you know as a matter of fact whether such an order was given?

A. I do not.

Q. Do you know as a matter of fact whether it is a practice of physicians in Cumberland to disinfect the fecal discharge or the exhumentia of typhoid patients?

A. I do not, but I have no doubt that it was the custom
among the best physicians in Cumberland to advise the
4588 families having the typhoid patients to do such disinfecting.

Q. Do you know whether the privys that received the exhumentia of the typhoid patients were emptied into the Potomac river or not?

A. I do not.

Q. Then, in the absence of any knowledge with regard to that fact whether the sewage was or was not emptied into the Potomac river, how are you able to predicate an opinion that it was?

A. I do not remember that I have predicated that, but I have no doubt that the practice of the people which appears to have been of that sort was to a greater or less extent at any rate continued even during and after the epidemic; but in any event many mild cases must have contributed germs to privys which were emptied as usual, the patients and their friends themselves not knowing that this disease had been in the family. Cases of this kind are very common in all grave epidemics.

Q. Is it not a fact that in attributing the increase of typhoid fever in the City of Washington you predicated that increase upon the assumption that some of the exhumentia of the typhoid patients in Cumberland did find its way into the Potomac River?

4589 A. Certainly.

Q. And do you as a matter of fact know whether it did or not?

A. I think I may say that I do.

Q. How do you know it except by inference?

A. I think I may say that I know it because to begin with a large amount of the excreta of typhoid patients must have gone into the river before the people themselves were aware that the typhoid epidemic was in their midst. Many of them were in the habit of using the overhanging privys already referred to and it is inconceivable that, with an epidemic of the extent of that which prevailed in Cumberland in January, 1890, a considerable amount of such material should not have found its way into the river even before the people were aware of the fact. Later, when they had become aware of the fact, necessity and custom, combined with such ignorance of these matters, as often prevails in the lower classes of the community would have caused them to continue to use their ordinary means of sewage disposal, so that I think I may say that I know that typhoid excreta must have found access to the river.

Q. If you know that to be a fact, is that knowledge based upon any personal investigation made by you at that time?

A. Not at that time in Cumberland.

4590 Q. I am speaking about Cumberland. Is that knowledge based upon the knowledge of anyone who made a personal investigation of the conditions at that time?

A. I think I may say that it is, inasmuch as I base my opinion partly upon the investigation made at that time by Dr. Kober of Washington, and Dr. Wiley, a physician of Cumberland.

Q. Professor, when you state that you know, do you use the word "know" synonomously with the word "opinion?"

A. No, sir. I mean by the use of the word "know" that I have a knowledge of the facts in this instance such as I have of many of the scientific facts which I hold, based partly upon my own experience and partly upon the investigations of others, and partly upon general principles.

Q. Do you know whether during this period that the typhoid conditions in Washington existed as you have related them, whether there was any typhoid fever at Harper's Ferry or not?

A. I have not learned of any.

Q. If there should have been 15 or 20 cases of typhoid fever at Harper's Ferry, would that in your judgment be enough typhoid fever to be attributed to account for the increase in Washington?

A. I should need in that case to know whether Harper's Ferry had had a similar outbreak before, and, if so, what 4591 the effect of that had been upon the typhoid rate in Washington. I should also wish to know if these 15 cases were contemporaneous, so as to cause a comparatively heavy infection of the river. I should further wish to know whether the privys at Harper's Ferry overhung the river, and therefore am unable to answer that question off-hand.

Q. Did you take any steps to ascertain whether those conditions existed at Harper's Ferry at this time and at this period?

A. Only by way of general inquiries in Washington and Cumberland.

Q. Did you make any inquiries from anybody at Harper's Ferry who would be most likely to know of the conditions there?

A. I did not.

Q. In order to ascertain those conditions you would deem it necessary to find out the facts from someone who was in possession of them, would you not, as to Harper's Ferry?

A. Well, as to an epidemic?

Q. Yes.

A. Certainly, if I had reason to suppose that there was an epidemic in Harper's Ferry I should want to go there and find out about it; but in this case, having a great epidemic at Cumberland, and being unable to learn of any at Harper's Ferry, I didn't think it necessary to visit Harper's Ferry. 4592

Q. Did you make any inquiry specially as to whether there was any typhoid fever at Harper's Ferry or not from anyone that lived at Harper's Ferry?

A. I did not.

Q. Did you make any special inquiries from anybody who had visited Harper's Ferry who was not a resident there to ascertain that fact?

A. No, I made no inquiries except of the health authorities in Washington and in Cumberland.

Q. Would the health authorities in Washington and Cumberland know the conditions at Harper's Ferry?

A. I think they would, because they were acquainted with this epidemic and knew its importance and interest.

Q. Do you know whether he made any investigation at Harper's Ferry to ascertain the conditions that existed there at this time?

A. I do not.

Q. And whether typhoid fever existed at Harper's Ferry at this time or not you have no knowledge, Professor?

A. I have no personal knowledge.

Q. You can conceive of conditions in Harper's Ferry that would account for the increased typhoid cases in Washington, could you not? 4593

A. I could, although it would be comparatively difficult, because Harper's Ferry was at that time, and it is now I dare say, very much smaller than Cumberland.

Q. You are acquainted with the typhoid epidemic that occurred at Ithaca, New York?

A. In a general way.

Q. Do you recall now how many cases of typhoid were there?

A. About a thousand, I should think.

Q. And that thousand cases was attributable to some laboring men up on a creek, was it not?

A. I believe so.

Q. If that condition should obtain at Ithaca from a camp of laboring men, a like condition could obtain in Washington from any infected town between Washington and Cumberland, could it not?

A. No, sir. It does not seem to me that the cases are parallel, because Six Mile Creek at Ithaca is a small stream, and the Potomac is a large one, and a good deal of the time Washington was protected by this sedimentation basin to a certain extent, and Ithaca was not. It seems to me that the cases are so different as not to be closely comparable.

4594 Q. Do you know how many cases of typhoid existed between Cumberland and Washington along the watershed of the Potomac?

A. I do not.

Q. Did you make any investigation to ascertain the number?

A. No, sir. I had no reason to suppose that there was any unusual number. Of course there are always cases along a stream of that sort, and, as I have already said, there has long been typhoid in Washington, which, I have no doubt, is due in a large part to such pollution; but this was an unusual and extraordinary phenomenon.

Q. You made no investigation to ascertain the number of typhoids between Cumberland and Washington, did you?

A. I did not.

Q. And the reason that you didn't do it was because you didn't deem it essential?

A. That's it exactly.

Q. And whether there were a great number of typhoids there or not you are not prepared to say, are you?

A. I am not prepared to say positively, but if there had been I am sure that I should have heard of it.

Q. If you made no effort to ascertain it, how would you have heard it?

A. Because Dr. Kober who investigated the thing at the time would have been in my judgment sure to mention the fact, as he is a careful man. 4595

Q. Then, the fact that no one mentioned it to you is the only ground that you have for believing that there was no considerable amount of typhoid fever within that stretch of 170 miles?

A. Not exactly that no one mentioned it to me, but that no record of it appears in the report of the investigation at that time.

Q. You made no effort to ascertain that fact, did you?

A. No, I did not; I didn't deem it necessary.

WILLIAM T. SEDGWICK.

Adjourned until July 2nd, A. D. 1903, at the Waldorf-Astoria, New York City, at 10:00 a. m.

4596 The Waldorf-Astoria, New York City, July 2nd, 1903, at

10:00 A. M. Parties met pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

Whereupon an adjournment was taken until following day at same place, 10:00 A. M.

4597 The Waldorf-Astoria, New York City, 10:00 A. M., Friday, July 3rd, 1903. Parties met pursuant to adjournment. Present, The Commissioner, Attorney General Crow,
Attorney General Hamlin,
Judge Springer,
Mr. Todd.

ALLEN HAZEN,

called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Attorney General Crow and testified as follows:

Q. Give the stenographer your name, residence and occupation, please?

A. Allen Hazen; residence, New York City. Occupation Civil Engineer.

Q. How long have you resided in New York City?

A. Six years.

Q. Where did you reside prior to that time?

A. I was born in Vermont and resided there until 1888; then lived in Massachusetts with the exception of a part of the

year in Chicago, in 1893. Massachusetts was my legal
4598 residence until 1896 or 1897.

Q. Now where were you educated?

A. I was educated in the public schools of Hartford, Vermont, at the New Hampshire State College at Hanover, and at Thayer School of Civil Engineering, Hanover; at the Massachusetts Institute of Technology, and afterwards for one term at the Technical School at Dresden, Germany.

Q. Now have you studied any branch of science other than civil engineering in your preparation for professional work?

A. I studied chemistry—particularly the chemistry of water supplies, and had the title of chemist at Lawrence.

Q. Have you studied water supplies at any particular places, any particular schools, if so what?

A. No sir, my education was mainly general, and the knowledge that I have of water supplies has been secured in other ways.

Q. Now were you ever at the Lawrence Experiment Station of the Massachusetts State Board of Health?

A. Yes sir, I was at the station in direct charge of the work from the time of my leaving the Institute of Technology in Boston until February, 1893.

Q. Now what was the character of the work at that Lawrence Experiment Station?

4599 A. Investigations were made as to methods of purifying sewage and water and also investigations of problems,—particularly sanitary problems connected with water supplies and sewage disposal.

Q. Was that an institution supported by the Commonwealth of Massachusetts?

A. Yes sir.

Q. Under the control of the State Government?

A. Yes sir.

Q. Is it still in existence?

A. Yes sir.

Q. Now have you ever studied the question of water supplies and sewage disposal on the continent of Europe?

A. Yes sir.

Q. Where?

A. My first visit to Europe was the summer of 1890. In 1894 I spent nearly the entire year in Europe and visited water supply and sewage works of the larger part of the large European cities, and in 1896 again visited a few of them.

Q. Now have you had charge of any investigations in this country as to the disposal of sewage and drinking waters?

A. I was at the World's Columbian Exposition at Chicago in 1893, in charge of the sewage disposal plant; and also 4600 had charge of the inspection of the drinking waters used on the World's Fair Grounds.

Q. Now have you practiced your profession of Sanitary Engineer or civil engineer in any other city in this country than New York City?

A. I was of the firm of Noyes and Hazen in Boston for the years 1895 and 1896. Mr. Noyes then died, and shortly after I came to New York.

Q. What was the business of that firm?

A. Civil Engineering.

Q. Did you make any specialty of water supply and sewage disposal?

A. Yes sir.

Q. Now during your experience as a sanitary and civil engineer you have had various professional engagements, I suppose, in different parts of the country?

A. Yes sir.

Q. Did you have an engagement at Albany, New York?

A. Yes sir.

Q. What was the nature and character of that engagement?

A. I advised regarding the water, particularly with reference to their supply and the means of improving it, and afterwards acted as their engineer for constructing the works.

4601 Q. What was the occasion for your service there at Albany?

A. The death rate in the city was high, and the cause of the high death rate was the sewage polluted condition of the water, and the works built were a filtration plant to purify the water.

Q. Now, have you had any professional engagement at Ithaca, New York?

A. Yes sir, I am engaged there now, building a filter plant.

Q. What is the occasion for that?

A. There was a typhoid epidemic in the winter due to the use of the Six Mile Creek water.

Q. Now have you had any engagement at the State Lunatic Hospital at Harrisburg, Pennsylvania?

A. I built a filtration plant for that institution, yes sir.

Q. For the purpose of purifying the water supply?

A. Yes sir.

Q. Now have you had an engagement at West Superior, Wisconsin?

A. Yes sir, I have built a filter plant there.

Q. What was the occasion of that?

A. The water contained iron, and it was to remove the iron.

Q. Have you had one at Watertown, New York?

A. Yes, I am designing a filter plant which it is hoped to build within a year, if the money is available. 4602

Q. For what purpose?

A. For purifying the water. It received some sewage above the intake.

Q. Have you had a professional engagement as to the water supply at Yonkers?

A. Yes sir, I am engaged in building a filter plant at Yonkers at the present time.

Q. Have you had an engagement at Pittsburg, Pennsylvania?

A. Yes sir.

Q. What was the character of that?

A. I advised the city government as to the character of their water supply and the best means of supplying the city with pure and wholesome water, and afterwards made plans for a filter plant for the city.

Q. Do you know the occasion for the purification of the water supply of Pittsburgh?

A. The water supply was unsatisfactory because it was sewage polluted and caused typhoid fever among the users.

Q. Have you had any engagement at Providence, R. I.?

A. Yes sir, I have advised in regard to filter plant—several plans for filter plants for that city.

Q. What was the occasion of the installing of a filter plant there?

4603 A. The Pawtucket River above the intake is polluted by sewage and wastes from mills and was unwholesome because of that.

Q. Have you had any professional engagement at Washington City, D. C.?

A. Yes sir.

Q. What was the character of that, and the object of that?

A. I have had two such engagements at Washington. First I was a member of a commission composed of Messrs. Hering, Fuller and myself, which reported to the Senate Committee on the District of Columbia, upon the water supply and the means of improving it, and more recently I was engaged by the Engineer Corps of Washington with reference to the plans for the work, and afterwards was engaged to and did make plans for the filters for the city of Washington.

Q. Do you know whether those works are now under construction?

A. Contracts have been let and construction has been commenced.

Q. What was the occasion, of the desire for the purification of the water at Washington?

A. Partly that it was not wholesome because of the sewage pollution which it received.

Q. Have you had any professional engagement at Chester, Pennsylvania?

4604 A. Yes sir, I advised the city in an action which it brought against the water company to compel it to furnish pure and wholesome water.

Q. What, if anything, occasioned the impurity of the water at Chester?

A. Principally the sewage of Philadelphia, which was quite enough.

Q. What stream is that?

A. Delaware.

Q. Have you had any engagement at Trenton, New Jersey?

A. Yes sir, I have advised the city with reference to the quality of its water supply and the means of improving it. The works there have not been carried out as yet.

Q. What is the source of the Trenton, New Jersey supply?

A. It is taken from the Delaware River. The principal reason for wishing to make other arrangements, was the pollution by the sewage of Easton and other cities above.

Q. Have you had any professional engagement with reference to the water supply at Toledo, Ohio?

A. Yes sir.

Q. What was that and the character of it?

A. I was a member of a commission composed of Mr. Benzenberg, Mr. Clark and myself, to investigate the waterworks and make recommendations for the improvement of it, or
4605 for a new supply.

Q. What was the occasion of desiring to change the supply at Toledo?

A. The water is both muddy and polluted. It is polluted by the sewage of numerous cities and towns up the river.

Q. What is the source of the supply?

A. The Maumee river.

Q. Did you have an engagement at Grand Rapids, Michigan?

A. Yes, I was a member of the commission, composed of Mr. Gray and myself, to examine the water works, and report on means for improving them, or substitution of other supply.

Q. Did you have an engagement in Lancaster, Pennsylvania?

A. Yes, I advised with reference to the supply there, and a method of improving or changing the supply.

Q. Did you have one at Millbury, Massachusetts?

A. Yes sir.

Q. What was the character of that?

A. I advised the town of Millbury in a suit which it brought against the City of Worcester to compel it to purify its sewage so that it would not pollute the Blackstone River.

Q. What was the occasion of that pollution, did you say?

A. The river was polluted by the sewage of the city of Worcester.

4606 Q. Do you know whether or not at the time of this litigation and the time of your advice, there was sewage purification works in operation at Millbury?

A. Worcester had established a sewage purification plant as it had been required to do as a result of the action which Millbury had brought against it. Prior to that time its purification plant was only partial. Since that time the Court has compelled a greatly extended and improved character of the plant, so that the stream has been much more satisfactory than it had been prior to that time.

GENERAL HAMLIN: I move to strike out everything in that answer regarding the suits and complaints and results of suits at Millbury.

Q. GENERAL CROW: Mr. Hazen, have you ever advised in a professional capacity, the Ohio State Board of Health, if so, with reference to what?

A. I acted as consulting engineer for the Ohio State Board of Health for a few years, and advised them in regard to a number of special problems and also made a general and preliminary report on the question of stream pollution in the State of Ohio.

GENERAL HAMLIN: When was that?

4607 A. I think in 1898 and 1899; I wouldn't be perfectly sure without consulting my records—1897 and 1898, I think.

Q. GENERAL CROW: Did you visit Chicago in 1891?

A. Yes sir.

Q. Did you have any occasion to become familiar with the general conditions from a standard sanitary standpoint of that city at that time?

A. I was much interested in the question and I met several officers and others interested in the matter and saw something of the waterworks and sewage disposal at that time.

Q. And did you become generally familiar with the conditions that then obtained?

A. In a general way, yes.

Q. Did you do any work with Professor Sedgwick on the question of typhoid fever in Chicago?

A. Yes sir.

Q. What was it?

A. After that visit I secured additional data and worked them up with Professor Sedgwick and wrote a paper, jointly with him upon the typhoid fever in Chicago, which was published.

Q. Was that with reference to the water supply?

A. Yes sir.

Q. That was in 1892, was it?

A. That was in 1892?

4608 Q. Later did you make another investigation of your own of the drinking waters of Chicago, and publish it in 1894?

A. Yes sir, that was a report which I made on the drinking water used in Jackson Park during the World's Fair period. I also wrote a paper jointly with Professor Reynolds, who was then and I understand is now, Health Commissioner of Chicago, upon the water supply of Chicago, which was presented to a meeting of the American Public Health Association held in Chicago in 1893.

Q. Did you ever have occasion to examine sewer plans and water intakes of Chicago?

A. I did.

Q. Did you ever make any maps showing the location of sewer outlets and water intakes for different periods?

A. I did.

Q. What time was that?

A. I do not now remember the precise periods, but I made maps showing the position of the intakes and sewer outlets for several periods, which maps were also arranged to show the typhoid death rates, which were observed with those conditions.

Q. Have you ever visited the Chicago River and the North and South branches thereof?

A. Yes sir, I saw them frequently during 1893 and since that time I have observed the Chicago River itself frequently when I have been there—when I have been in 4609 Chicago. The branches less frequently.

Q. Were you ever at Joliet?

A. Yes sir.

Q. Have you observed the Canal and the river at that point?

A. Yes sir.

Q. Have you been at LaSalle, Illinois?

A. Yes sir, I was at LaSalle in 1893. I examined the waterworks at that time.

Q. You saw the Illinois river?

A. Yes sir.

Q. And the canal?

A. Yes sir.

Q. Which canal?

A. I think it is the Illinois and Michigan Canal—it is the old one.

Q. Did you make any analyses of the Illinois and Michigan Canal water at that time?

A. I did, yes sir.

Q. Have you been in Chicago since 1893?

A. Yes sir, at intervals.

Q. What was the last period of your visit there?

A. I think my last visit to Chicago was January, 1902.

4610 Q. Have you looked at plans for various parts of the sewerage work in the city of Chicago?

A. I have.

Q. Have you ever been through any portion of the sewers while they were in course of construction there?

A. I went through part of the large sewer building, I think in 39th Street.

Q. Have you ever noticed the condition of the Chicago River before and since the opening of what is known as the Drainage Canal?

A. Yes, I noticed it often.

Q. When did you first visit the St. Louis Waterworks?

A. In the summer of 1896.

Q. Were you a member of the Commission to report on improvement of the water supply of St. Louis?

A. Yes sir.

Q. If so, when?

A. I was a member of such commission, composed of Messrs. Williams, Wisner and myself. We were appointed in 1901 and reported early in 1902.

Q. What Williams was that?

A. Benezette Williams.

Q. Of Chicago?

A. Yes sir.

4611 Q. Did you examine the waterworks system, pumping station, settling basins, conduits, reservoirs, and so forth?

A. I did.

Q. Did you examine the intake and the river above the same, up as far as the confluence of the Missouri and Mississippi?

A. I did.

Q. Did you go as far as Grafton and the mouth of the Illinois River?

A. I did.

Q. Did you visit any places on the upper rivers?

A. Yes sir, I visited many places.

Q. Did you investigate any of the sources of pollution above the intake tower upon the two rivers?

A. Yes sir.

Q. Did you make any diagrams and tables of the populations polluting the rivers and their tributaries?

A. Yes sir. I made tables of the populations of the towns on the banks of the various tributaries and of their distances, from the best data that I could get—their populations by the census of 1900, and those matters were plotted in my office.

Q. What records and data did you use in making these diagrams and tables?

A. The data of the census office, and for the maps and distances the census report of 1880 on water power, was 4612 very useful. In addition I had the maps of the geological survey as far as they were available, and various other sources of information.

Q. Did you use whatever Federal Government records that were accessible to you?

A. I did, yes.

Q. Did you secure any data as to typhoid deaths in St. Louis on this investigation?

A. Yes, I got the deaths as reported at the health office. I made no detailed investigation of the methods of securing and recording that data.

Q. At that time did you study the relation of the Chicago sewage to the St. Louis water supply?

A. I did.

Q. And you formed an opinion thereon as a result of these investigations?

A. I did.

Q. That was in the year 1901?

A. In the year 1901.

Q. Since that time, 1901, you have been familiar in a general way with the conditions in St. Louis?

A. Yes sir.

Q. You have paid some attention to the record of typhoid 4613 fever deaths in the city of St. Louis since that date?

A. Yes sir.

Q. Mr. Hazen, I will ask you what has been the effect if any, in your opinion, of the discharge of the waters of the Chicago Drainage Canal, carrying the sewage of the Chicago Sanitary District, into the Desplaines River under conditions existing since January 19th, 1900, upon the water of the Mississippi River along the Missouri shore, and particularly as drawn from the intake tower of the waterworks at the chain of rocks, with reference to its use for drinking and domestic purposes?

GENERAL HAMLIN: That is objected to on the ground that sufficient facts are not stated in the question upon which to base an expert opinion, and no sufficient facts have been testified to by the witness as to the conditions known by him as a matter of fact.

MR. TODD: In behalf of the Sanitary District I join in the same objection.

GENERAL CROW: You may answer the question.

A. I believe that the quality of the water is seriously damaged by this discharge.

GENERAL HAMLIN: I move that the answer be stricken out for the reasons given in the objection to the question.

MR. TODD: The Sanitary District joins in the same motion.

Q. GENERAL CROW: I believe you stated that you 4614 are now and have been since 1901, familiar with the conditions of the water supply at St. Louis city, and from 1893 to the present time familiar with the conditions of the water supply at Chicago, the Drainage Canal and the course it pursues?

A. Yes sir.

Q. You are familiar with the source or the beginning of the Chicago canal, where it commences?

A. Yes,—well, not in detail.

Q. Well, you know where it begins?

A. Yes sir.

Q. You know its distance?

A. I don't recollect the number of miles.

Q. You know where its outlet is?

A. Substantially, yes sir.

Q. At what point is that outlet?

A. The outlet is into the Desplaines river at some point above Joliet; I don't remember precisely.

Q. Do you know what the Desplaines River empties into?

A. Into the Illinois River.

Q. And what the Illinois River empties into?

A. Into the Mississippi River.

Q. At what point?

A. At Grafton.

4615 Q. Do you know the distance from Grafton—or from the St. Louis intake, to the city of Chicago?

A. It is approximately 360 miles.

Q. That is by the water route is it?

A. By the water route, yes.

Q. That is via the Canal, the Desplaines, the Illinois and the Mississippi Rivers?

A. Yes sir.

Q. Now are you familiar with the stream flow in the canal and the Desplaines and the Illinois and Mississippi Rivers in a general way?

A. In a general way, yes sir.

Q. Are you familiar in a general way with the stream flow and velocity of the Missouri and Mississippi Rivers both?

A. Yes sir.

Q. You have made yourself familiar in this investigation of 1901 as to the points of pollution of those rivers above the intake of the St. Louis waterworks?

A. Yes sir.

Q. Were you familiar with the conditions that existed as to the St. Louis water supply prior to 1901?

A. Only by records and by a visit in 1896.

Q. In a general way do you know about the time of flow, 4616 what it would be from the city of Chicago through the canal, the Desplaines River, the Illinois and the Mississippi Rivers, to the intake of the waterworks at St. Louis?

A. I have seen estimates of that. I have no data of my own to compute it.

Q. Now this opinion that you have given as to the effect of the Chicago Drainage Canal upon the waters of the Mississippi River at the intake; what was that based upon?

GENERAL HAMLIN: That is objected to on the ground that the witness cannot give the reasons in direct examination, for an opinion either as an expert or as a witness testifying to facts within his own knowledge.

MR. TODD: I object to it on the ground that it is improper to cross-examine the witness about an opinion that has heretofore been expressed.

Q. GENERAL CROW: Answer the question.

A. It was based upon the facts that the sewage entering the water courses above the intake, was nearly doubled by this discharge; that the distance from Chicago to St. Louis is very considerably less than the average distance of the other points of pollution, from the St. Louis intake; that the mixing of the waters in the channel of the Mississippi is such that the amount of sewage received at the intake is a large part of what it would be if the mixing were complete, and that the times of 4617 passage from the point of pollution to the intake were not sufficient to allow the complete destruction of the injurious and polluting matters discharged.

Q. I will get you to state if you know of your own knowledge, whether or not the waters of the Mississippi and the Missouri and the Illinois rivers commingle at the intake of the St. Louis waterworks?

A. They do.

Q. I will get you to state whether or not you know of your own knowledge, if the waters of the Illinois river or some portion thereof, pass into the intake of the St. Louis waterworks?

A. Yes sir.

Q. Now in view of these matters, I want to repeat the same question I put to you before. Now I will just repeat the same question. What has been the effect, if any, in your opinion, of the discharge of the waters in the Chicago Drainage Canal, carrying the sewage of the Chicago Sanitary District, into the Desplaines river under the conditions existing since January 19, 1900, upon the water of the Mississippi River along the Missouri shore, and particularly as drawn from the intake tower of the St. Louis waterworks at the chain of rocks, with reference to its use for drinking and domestic purposes?

4618 GENERAL HAMLIN: That is objected to upon the ground that the witness has not stated sufficient facts within his own knowledge upon which he can base an opinion. Second, the facts so far as he has stated them, are not true; third, that the question does not embrace a hypothetical statement of facts shown in the record, upon which the witness could base an opinion.

JUDGE SPRINGER: The Sanitary District makes the same objection.

Q. GENERAL CROW: Answer the question, Mr. Hazen.

A. It seriously injures the quality of the water.

CROSS-EXAMINATION,

By General Hamlin.

Q. Mr. Hazen, you have been engaged as a civil engineer in the establishing of filtration plants for how many years?

A. Eight years.

Q. During that time how many plants have you personally and under your direction, installed?

A. Six or seven.

Q. And at what points?

A. The Queens County Water Company—

Q. Name the places?

A. At Far Rockaway, and neighboring towns. The
4619 Rumson Improvement Company is at Red Bank, New Jersey; a plant for the Pennsylvania State Lunatic Hospital at Harrisburg; a plant for the city of Albany; a plant for the Superior Water, Light & Power Company at Superior, Wisconsin; a plant approaching completion at Ithaca; a plant under

construction at Yonkers. I have made designs for several others which I have not myself built. Shall I include them?

Q. How many others, you say?

A. I made plans for the Washington filters, which are building; for the filters at Nyack, N. Y., which were built; and for Pittsburgh, which are not building. That is all I think of now.

Q. When you were in St. Louis as a member of the Commission composed of Mr. Williams, Mr. Wisner and yourself, was that for the purpose of making investigations to establish a filtration plant?

A. Not for that purpose. The question was how best to supply the city of St. Louis with clear and wholesome water.

Q. You were never there for the purpose then of making plans or agreeing among yourselves on the best system of filtration?

A. Not for the purpose of making plans, no sir.

Q. Were you there for the purpose of discussing and determining the question of filtration?

4620 A. Well, that was a part of the main question.

Q. And did you report on that question?

A. Yes sir.

Q. And was that report a unanimous report?

A. No sir, a divided report.

Q. Now, in what way was it divided?

A. Messrs. Williams and Wisner reported for a gravity supply.

Q. From what place?

A. From the Merrimac River.

Q. And what was your report?

A. I recommended the continuance of the Mississippi water with filtration.

Q. With filtration?

A. Yes sir.

Q. At that time the intake was established at the chain of rocks, where it is now, as you understand it, wasn't it?

A. Yes sir.

Q. And you recommended a continuance of that same supply but with filtration?

A. I did.

Q. Did you make any estimate of the cost of filtration?

A. I did.

4621 Q. Do you remember what that was?

A. Not precisely. I could give you an approximate idea of it. It was about $2,000,000 for a filtration plant proper, and Seven or Eight Hundred Thousand dollars for auxilary works, which would be necessary in connection with it. It was something under $3,000,000 for the whole project as required by the present requirements of the city.

Q. Your business mainly then has been in the making of designs and constructing filtration plants, has it not?

A. In a large part, yes.

Q. That is the department of your work upon which you are able to speak advisedly in your opinion, are you not?

A. Yes sir.

Q. Have you ever made any chemical analyses of the water at St. Louis?

A. No sir.

Q. Have you ever made any bacteriological examination of it?

A. No sir.

Q. That is not a department of your work, or has not been, has it?

A. No sir; I have made in years gone by, chemical analyses.

Q. Yes, you did as a student?

A. Something after that, yes sir.

4622 Q. Not as a practical chemist with a view of giving opinions on chemical analyses?

A. To some extent, yes sir, it was.

Q. Well, you wouldn't want to say that you were an expert on that question?

A. Yes sir.

Q. You would?

A. Yes, on the chemical analyses.

Q. But you have made none in this case?

A. No sir.

Q. Now you spoke of three, I think on three different occasions where you were employed to advise in certain suits that were brought by a city against a water company. Do you now remember how many times you have been so employed?

A. No sir, I do not; the list was not nearly complete.

Q. You only gave a few?

A. Yes sir.

Q. In all of the cases that you have mentioned, where you have advised the installment of filtration plants upon the subject of pollution at those places mainly, you have taken the opinions of others, have you not?

A. The opinions of others upon what point?

Q. On the question of water pollution itself?

4623 A. No sir, I have not.

Q. Do you mean to say that you have made a personal examination in each case?

A. Usually, yes sir.

Q. And had not examinations been made by others and reports, upon which you acted and based your opinion on largely?

A. No sir, not generally.

Q. Well, hasn't that been the case in many cases?

A. I don't remember of such a case. I think there may have been, but I don't remember it now. Generally I have been asked to report on the extent and nature of the pollution, and the character of the supply, and have used my own methods for securing the data and have used my own judgment on that point.

Q. Has that been fortified by the opinions and investigations of others?

A. Oftentimes.

Q. Yes, largely so, but I am not speaking about your ability; I am speaking about the fact.

A. Well, as far as my own conclusions are concerned, they have been based on my own investigations, but of course other people's opinions and other reports would no doubt influence my superiors largely, but in my own personal reports I have depended principally upon my own investigations.

4624 Q. Now you take the pollution at St. Louis; you made no chemical analyses of the waters at St. Louis?

A. No sir, it was not necessary.

Q. Well, you did not, that is your opinion, that it was not necessary?

A. Yes sir.

Q. Nor did you make any bacteriological examination?

A. No sir.

Q. So, based upon either of those, you have no knowledge at all other than what you got from some other source, have you?

A. No sir.

Q. And you did take from other sources there, did you?

A. I had analyses from other sources. The deductions to be drawn from those were entirely my own.

Q. That is true upon any other proposition; you draw your deductions based upon something?

A. Yes sir.

Q. Now isn't that true largely now, Mr. Hazen where you have installed filtration plants, most anywhere?

A. That I have depended upon the conclusions of others?

Q. To a large extent?

A. No sir.

Q. You have not depended on them?

A. On analyses?

4625 Q. Yes, and bacteriological examinations and reports?

A. Not to any large extent.

Q. Take in the Ohio case, now, did you have a report of the State Board of Health?

A. Yes sir.

Q. Showing the conditions as they found them?

A. Yes.

Q. And you drew deductions from those reports, did you not?

A. From those reports and the other facts in the cases.

Q. But your main business was to install filtration plants?

A. No sir. In that case not at all.

Q. Well in many cases it was?

A. Yes.

Q. And you drew the designs, made the plans and estimated the cost?

A. Yes.

Q. Now in the majority of cases that you have given, isn't that true, that that has been your main business, to draw the plans and estimate the cost?

A. I don't think in a majority; in a large number of cases.

Q. It has been in a large number of cases?

A. Yes.

Q. And have you superintended the work?

A. Yes sir.

4626 Q. In most of the cases that you have mentioned did you superintend the work?

A. In most of them unless I have mentioned otherwise.

Q. Then you have a practical knowledge as well as a professional knowledge of the construction—of the actual construction of this kind of work?

A. Yes sir.

Q. And that is your main business, is it not?

A. It is a large part of my business.

Q. Have you ever traveled over the drainage canal and down the Illinois river and the Mississippi, to St. Louis?

A. Not over the whole distance, no sir.

Q. You have been as far as Joliet and LaSalle?

A. Yes sir.

Q. Not any further?

A. Not in that direction.

Q. Well, that is not a great ways down the Illinois River, is it?

A. It is something like 100 miles up to LaSalle, as I remember it.

Q. Well, that is not a great ways if that distance is true?

A. No sir, it is something like one-fourth.

4627 Q. You are not certain that that is the correct distance to LaSalle?

A. Oh no, that is just my general recollection.

Q. You don't know as a matter of fact?

A. I have a record of it; I haven't it in my mind just now.

Q. You are of the opinion then, as I believe you stated in your report, that there should be filtration at St. Louis?

A. Yes sir.

Q. The Mississippi River at St. Louis is composed of what streams; that is, what main streams?

A. In the immediate neighborhood are the Mississippi and the Missouri and the Illinois enters the Mississippi on the other side a little further up.

Q. It would not cost any more to establish a filtration plant, if one was necessary, if the Mississippi did not receive the waters of either the Missouri or of the Illinois, would it?

A. If the Mississippi did not receive the waters of either the Missouri or the Illinois?

Q. Yes, or the Illinois?

A. I think it would, because the character of the water of the upper Mississippi is very different.

Q. I am not speaking about water; I am assuming now that filtration is necessary?

4628 A. It is necessary for me to state this please. The water—

GENERAL HAMLIN: Question withdrawn.

GENERAL CROW: Just put your answer in the record.

GENERAL HAMLIN: Oh no, he can't put an answer in when I withdraw the question.

GENERAL CROW: He has a right to put his answer in the record.

GENERAL HAMLIN: I am running this side of the case.

GENERAL CROW: Let him finish his answer.

GENERAL HAMLIN: Just answer this question and then you can put in anything you like—

GENERAL CROW: Let's put it in right here. This is the place it belongs.

GENERAL HAMLIN: He can answer all the questions he has a mind to after he answers this one—

THE WITNESS: The water of the upper Mississippi is different physically from the water of the Missouri, and I have not said—

GENERAL HAMLIN: I knew what you were going to say. That is why I was going to change the question. Put it in.

A. (Continuing) I have not studied the kind of plant which would be necessary for the Mississippi water above the

Missouri, but I think it would be very different from the
4629 plant required for the Missouri river water. Whether it would cost more or less, I don't now know.

Q. Now you understand the Missouri river water to be rather muddy?

A. It is very muddy.

Q. A very muddy stream?

A. Yes sir.

Q. Well then, would it cost any more to establish filtration plants, suppose that you eliminate the Illinois River and put in the Missouri and the Mississippi river?

A. It would make no substantial difference.

CROSS-EXAMINATION,

By Mr. Todd.

Q. When did you first examine the sewage system of St. Louis?

A. The sewerage system?

Q. Yes?

GENERAL CROW: I didn't ask him anything about that, and he didn't testify to that. It was waterworks system.

MR. TODD: I understood that the question was that he had examined the sewerage system and water systems of St. Louis.

GENERAL CROW: I didn't mention that. I meant of Chicago.

4630 Q. MR. TODD: When did you first become acquainted with the water system of St. Louis?

A. In 1896.

Q. What was the purpose that led you to the investigation of the water supply of St. Louis in 1896?

A. I was in the city for a day or two, on some business, and having time, and having met the engineer of the works, I looked them over.

Q. When did you next give the water supply of St. Louis consideration?

A. In July, 1901, upon my appointment upon a commission for that purpose.

Q. In 1896, what in your opinion was the condition of the water supply of St. Louis?

A. I didn't investigate it at that time in a way to enable me to have an opinion of its quality.

Q. In 1896 did you consider the waters of the Mississippi above the intake as a safe and potable water?

A. I didn't know much-about it.

Q. In 1901 you made a more careful examination, did you?

A. Yes sir.

Q. Will you state what examination you made, in detail?

A. I visited the various pumping stations, intakes, reservoirs, conduits; examined the plans of them on file in the
4631 municipal offices; and I went on the city boat up the river and noticed particularly the conditions of flow and mixing, where the Missouri comes into the Mississippi, and where the Illinois comes into the Mississippi, and the channel. I visited a number of places up the Mississippi and Missouri rivers. That was incidental to other studies however, and not for this direct purpose. I went over the watershed, using the maps and the census reports as I have stated; found the names of all the considerable cities and towns on the watersheds, and their populations by the census of 1900, and got the distances that they were above the St. Louis intake, by the best obtainable data, using the United States census report of 1880 and figures from Government engineers, and where I couldn't get direct data from map measurements. For the chemical and biological character of the water, I examined all the old records, which were very full at St. Louis, and the records of Mr. Teichmann and others were also put at my disposal for studying that question.

JUDGE SPRINGER: That was in 1901?

A. 1901.

Q. MR. TODD: Did you examine the waters of the Missouri river?

A. Only as I saw it going into the Mississippi—wait
4632 a minute; that is not correct. I examined the plants of the waterworks at Kansas City, Kansas; Kansas City, Missouri, St. Joseph and Omaha, to find out the character of the Missouri water and the methods which were necessary to treat it and the results which could be secured by those methods.

Q. In your examination of the Omaha waterworks, did you ascertain whether the sewage from the city of Omaha and Council Bluffs entered into the Missouri river?

A. I assumed that it did; I didn't ascertain it at that time.

Q. Did you examine it as to whether the sewage of Kansas City, Kansas, Kansas City, Missouri,—emptied into the Missouri river?

A. I assume that it did. I examined some sewers in that case.

Q. Did you examine as to whether Jefferson City emptied its sewage into the Missouri river?

A. I assumed that all of the cities on the watershed sewered into the water courses.

Q. And what effect did you assume this sewage to have upon the water—the quality of the water of the Missouri river, before it emptied into the Mississippi?

A. It injured its quality.

4633 Q. Did you consider it a safe and potable water?

A. No, sir.

Q. Do you consider it so now?

A. No, sir.

Q. A safe and potable water?

A. No, sir.

Q. If the Illinois river could be dammed at its mouth and a channel cut whereby it should empty below the intake tower of the City of St. Louis, would you consider the water of the Missouri and Mississippi which entered the intake tower at St. Louis, a safe and potable drinking water?

GENERAL CROW: Complainant objects for the reason that the character of the water of the Missouri and the Mississippi, as to whether it is safe and potable, is wholly immaterial to this inquiry.

A. No, sir.

Q. MR. TODD: Assuming that a channel cut from the Illinois river should empty into the Ohio at Cairo, thus eliminating entirely the Illinois river water from the Mississippi between Cairo and Grafton, would you consider the water of the Mississippi at Cairo a safe and potable drinking water?

GENERAL CROW: Complainant objects for the reason

that the character of the water of the Mississippi and the
4634 Missouri aside from the Illinois, is wholly immaterial in
this inquiry?

A. No, sir.

Q. Mr. Hazen, if you were to venture an opinion as to the character of the Mississippi river water above Cairo, would you consider that its character was made unwholesome and unpotable by the addition of the sewage discharged into the Mississippi river by the cities of St. Louis,—and the cities in Missouri emptying their sewage into the Mississippi river, as well as the cities on the Missouri, emptying their sewage into the Missouri river?

GENERAL CROW: Complainant objects to that question for the reason that it is wholly immaterial in this inquiry as to what effect sewer outfalls of cities of the Mississippi and the Missouri may have in their effect upon the water of the Missouri and Mississippi rivers.

A. I think that the discharge renders the waters less wholesome and less potable. I cannot say that it renders it unwholesome and unpotable because it may be that it would be unwholesome and unpotable without them.

Q. In my hypothetical question I am assuming that the waters of the Illinois are eliminated by this supposed channel.

A. Yes.

Q. Now, consider the addition to the waters of the Mis-
4635 souri and the Mississippi, of the sewage discharged by
the towns in Missouri into the Mississippi, as making that water an unsafe and unwholesome water for drinking purposes, without being treated.

GENERAL CROW: Complainant objects to this question for the reason that the effect of the sewage of the Missouri river towns and the Mississippi river towns entering into the rivers, making the waters of the Missouri and the Mississippi rivers unwholesome, is immaterial to this inquiry.

A. As I understand it, this quesiton is substantially the same as the last one, and my answer would be the same.

Q. MR. TODD: What do you mean by the comparative term "less wholesome" and "less safe" as a sanitary engineer?

A. I mean that they would produce, or might produce, more sickness and more deaths among those who used the water.

Q. Assume that the waters of the Mississippi above its confluence with the Missouri and the Missouri above Kansas City, Missouri, were non-polluted streams, and assume that the sewage discharged into those rivers by the cities in Missouri such as Kansas City, Missouri, Jefferson City, St. Charles, St. Louis and the other smaller towns that empty their sewage into those rivers, would you consider the water of the Mississippi river above Cairo a safe and potable water?

4636 GENERAL CROW: Complainant objects for the reason that the effect of the sewage of the towns mentioned in the question in the waters of the Mississippi and Missouri river is wholly immaterial in this inquiry.

A. I should not, off-hand. It is a question that I have not studied in detail.

Q. You know the population of Kansas City?

A. Approximately.

Q. You know the population of St. Louis?

A. Yes.

Q. You know approximately the population of the cities in Missouri that empty their sewage into the Missouri and Mississippi rivers, do you not?

A. I have looked them up and listed them.

Q. What further facts would you need to be put in possession of in order to form an opinion as to whether that water was a good, safe, drinking water under the conditions pre-supposed in the previous question?

A. A good safe drinking water is a relative term.

Q. I would like to modify that question—a good safe drinking water in the language employed by sanitary experts?

A. A good safe drinking water is a relative term. There are waters polluted so slightly or so remotely that notwithstanding the fact of pollution, they are reasonably good waters.
4637 The amount of dilution and the period of time between the point of pollution and the point where the water is used are matters which have to be considered. In some cases I have studied these matters in detail and have formed judgments upon them. In this hypothetical question which you put to me, I give you my impression, but I have not made computations concerning it as I certainly should do if the question was presented to me for a professional opinion.

Q. Would you consider the water of the Mississippi river above Cairo under the conditions existing in the hypothetical question, but with the additional information as to the rate of current and time of flow in the Missouri river, and the Mississippi river, a reasonably safe drinking water after it had received the addition of the sewage from these different cities?

GENERAL CROW: The cities in Missouri?

MR. TODD: Cities in Missouri.

GENERAL CROW: Complainant objects to the question for the reason that the effect of the towns and cities on the Missouri and Mississippi rivers is immaterial to this question, the question being on the pollution of the Illinois river, and its effect upon the water supply of St. Louis.

A. I think not.

Q. MR. TODD: Will you explain to what extent it
4638 would not be a reasonably safe drinking water, and what
do you mean by that term?

A. There are some waters that are so polluted that they cause death of more than one person from typhoid fever for each thousand people living, and seem to cause—although the evidence is less conclusive, but it is very good—and seem to cause the death of four or five people altogether per annum, per thousand living, and water that does that is about as bad a water as is used anywhere in this country at this time. Waters that are less polluted than that produce smaller amounts of sickness and death. The question comes as to where to draw the line. It may be a question whether even almost the best waters that we have are absolutely free from suspicion of causing sickness and death, but when a water causes so little that it cannot be certainly traced, and measured, we class it as a good water, and the point at which that line is drawn is not and cannot be a sharp line. It is going down. A water that classed as good twenty years ago is classed as bad now, and a water that satisfies us today probably will not satisfy the most exacting people a generation hence.

Q. Mr. Hazen, assume that in the southeast corner of the State of Missouri a company was about to establish a large city, and conditions existing along the Mississippi river above that point were such as are contained in the hypothetical ques-

4639 tion, and you should be selected as the sanitary engineer to look out for its water supply; knowing the conditions such as I have assumed them in the hypothetical question, and before you could ascertain whether this water was going to kill anybody or not, what would you say as to whether the waters of the Mississippi under those conditions, would be a safe drinking water for the future inhabitants of this supposed city, without being artificially treated?

GENERAL CROW: Complainant objects to that question for the reason that the inquiry is not as to the effect of the sewage of towns in Missouri upon the Missouri river and Mississippi river, but upon the effect of the sewage of Chicago by way of the Illinois river into the waters of the Mississippi river, and therefore the matter inquired about is wholly immaterial.

A. I think not.

Q. That is, you wouldn't consider that water a safe drinking water?

A. No, sir.

Q. Assume that the Illinois river should be diverted to Cairo in the manner I have indicated, and knowing all the conditions that obtain upon the upper watershed of the Mississippi and the Missouri rivers as they do today, and the water system in St. Louis as it now exists, would you consider that
4640 water a safe drinking water for the people of St. Louis?

GENERAL CROW: The complainant enters the same objection to this question as to the question immediately preceding.

Q. MR. TODD: Treated the way it is today?

A. I think I have already answered that question.

Q. I don't think so. You have answered one similar, but not exactly the same.

A. It is assuming that all the conditions upon the upper water shed are the same, except that the drainage canal is out?

Q. Oh, no, the waters of the Illinois river.

GENERAL CROW: The waters of the Illinois river were out of the other question too.

A. I should not.

Q. Then the cities bordering upon the Illinois river, and the conditions that obtained prior to January 17th, 1900, would not make the water supply of St. Louis a safe and usable water supply under existing conditions, in your judgment, would it?

GENERAL CROW: Complainant objects to that question for the same reasons given above.

A. No.

Q. MR. TODD: You have stated that you made an investigation in connection with Professor Sedgwick in regard to the conditions of typhoid in the city of Chicago in the year 1892? 4641

A. Yes, is.

Q. Your conclusion at that time was to the effect that the cause of typhoid in the city of Chicago resulted from the sewage that entered Lake Michigan and got into the water supply of the city?

A. Yes, sir.

Q. Had anyone else arrived at that conclusion before you and Professor Sedgwick did, that you know?

A. I presume so.

Q. You were aware of the fact that the Legislature of Illinois had passed what is known as the Sanitary District Act in 1889, based upon the fact that the sewage entering Lake Michigan was the cause of the contamination and infection of the water supply of Chicago, and that the canal was built for the purpose of diverting that sewage from Lake Michigan?

A. Yes, sir.

Q. You said you were acquainted with the intercepting sewer systems of the city of Chicago?

A. At present or then?

Q. At present?

A. In a general way, yes.

Q. What are the purposes of the intercepting sewer system that you investigated there the last time you were there?

4642 A. To keep the sewage of Chicago from entering the lake, and diverting it to the drainage canal.

Q. How extensive is that sewerage system?

A. It is very extensive. Portions of it were already in service, and a large part discharging through this 39th Street sewer was to be diverted soon. I don't think that has yet gone into effect, and there were still some districts of the city, not the most densely populated ones,—that were entirely outside of the district served by the sewers now under construction or immediately contemplated.

Q. Have you ever investigated the waters of Lake Michigan?

A. Yes.

Q. Are the waters of Lake Michigan a safe and potable water, exclusive of the sewage of Chicago and of the outlying territory immediately north and south of Chicago that empties into Lake Michigan?

A. That is, would it be if that sewage was excluded?

Q. Yes, would it be?

A. Yes, sir.

Q. You traced the cause of the typhoid in Chicago to the sewage contaminated water that entered the intake and thence came back into the water supply of the city, did you?

A. Yes, sir.

4643 Q. Assuming that the Calumet district on the south and Evanston upon the north should be added to the Sanitary District of Chicago, and the sewerage system of Evanston should be diverted from going into Lake Michigan, but was directed through the Lawrence Avenue conduit to the North Branch channel that is in contemplation of improvement, and into the Chicago river; and the Calumet district on the south should be diverted from Lake Michigan into the drainage canal by way of the Sag; what effect in your opinion would that system of sewerage have upon the water supply of the City of Chicago?

A. It would improve it.

Q. When the entire sewage from the population from Evanston on the North to the Indiana line on the south is diverted from Lake Michigan, will not the waters of Lake Michigan become a safe and potable water?

A. They will if you go out far enough.

Q. How far would you consider it necessary to go?

A. I could not give you an estimate off-hand.

Q. How far from shore are the intakes of the water supply of Chicago?

A. At the present time I think the nearest ones are about two miles, and the principal ones are four or five miles.

Q. Would you consider that a safe distance from shore?

4644 A. Not necessarily.

Q. Would you consider it an unsafe distance from shore with the sewage from the city being diverted?

A. With the sewage diverted?

Q. I am speaking of conditions when the sewage was diverted from Lake Michigan?

A. I couldn't say that off-hand. You would still have a source of pollution from your shipping, and possible overflows which occur on even the best designed system of sewers sometimes, and I don't think the water in shore for those reasons would be altogether safe.

Q. Assuming that you are in error in regard to the possibilities of an overflow from the present sewerage system of Chicago when fully developed, going back into the lake, which I am informed to be a fact, that such a condition can never obtain when the sewerage system is completed, would that change your opinion as to the potable condition of the waters at the present intakes?

A. It would improve the condition, but you still have youi shipping to contend with. I don't think the water directly in the city would be safe. How far you would have to go out I cannot say.

Q. What effect would you attribute to the shipping as a

4645 source of contamination of the water supply of Chicago?

A. It is an element, I could not say how important an element; in many cases, in waters of rivers and lakes, the pollution from shipping has been found from investigation to be quite an important element.

Q. How far are the intakes of the City of Chicago located from the line of ships that enter the Chicago river?

A. I could not say.

Q. Most of the sewage discharged by the ships would enter the Chicago river as a matter of fact would it not?

A. That discharged by the ships when they were in port would do so, yes, sir.

Q. And the amount of sewage discharged by ships leaving port would amount to a very small amount, would it not?

A. It would amount to something.

Q. Would it be enough to be a menace to the water supply of Chicago?

A. I think it might be.

Q. In what way?

A. Polluting it.

Q. Could you tell how the ships leaving the Chicago Harbor would contaminate the water supply at the 12th Street crib, or at the Hyde Park crib, and the South Chicago intake?

A. The shipping up and down the lake from other en-
4646 trances than the Chicago river—from the Calumet river—
pleasure boats, etc., and when the wind is in a certain direction, it will carry pollution discharged at one point in comparatively concentrated condition in whichever way the wind is blowing; so that I don't think the fact, if it was a fact, that no ship went very near the intake, would necessarily assure you from pollution in that respect.

Q. But that pollution would be infinitesimal, would it not?

A. No, sir; it would be more than that.

Q. Would it amount to one 100th of one per cent. of the pollution?

GENERAL CROW: Pollution of what?

MR. TODD: I mean, would it amount to one hundredth of one per cent. of the total pollution?

A. I think it would.

Q. How would you treat the waters of Lake Michigan, and as a sanitary engineer, how would you advise that the water should be treated if the only source of contamination should be from the shipping interests of Chicago and you should have a proposition of that kind presented to you?

GENERAL CROW: Complainant objects for the reason,
first, that it is not part of the problem for the witness to
4647 furnish the sanitary district of Chicago an opinion for
the purification of its water supply without employment by the sanitary district in that capacity. Second, it is wholly immaterial for this inquiry as to what method Chicago should pursue for the purpose of purifying its water supply.

MR. TODD: In reply to that, I will state that I am not asking him the question to get his idea as to what Chicago would do, as I am not authorized to secure information for Chicago, but to test his ability as a scientific and sanitary engineer upon problems of that character about which he has qualified in his direct examination.

A. I cannot tell what my solution of that problem would be. I should have to study the problem in detail before I could decide. It may be that no treatment would be necessary if the intake could be placed far enough from the shore to give satisfactory water without treatment; and it may be that it would be cheaper to take water at some convenient place and treat it.

Q. If the sewage of Chicago should be diverted in the manner that it will be when the intercepting sewers are completed, what in your judgment will be the effect upon the typhoid conditions in Chicago?

4648 GENERAL CROW: Complainant objects to that question for the reason that the issue here is not what effect the opening of the drainage canal and the out-fall of the sewers of Chicago into the drainage canal would have upon the water supply of the City of Chicago, but the question is as to what effect that sewage disposal would have upon the waters of the Mississippi river at the intake tower of the St. Louis Waterworks, and, therefore, the question is immaterial.

MR. TODD: Just answer the question.

A. That is as to the effect of the completion of the intercepting sewers on the typhoid death rate?

Q. In Chicago.

A. I think it will reduce it.

A. Will it not reduce the typhoid death rate to the minimum as caused by the water borne by disease of typhoid when the sewage is diverted?

A. I don't know.

Q. Have you any opinion on the subject?

A. Not a decided one.

Q. So the infected sewage of Chicago will be greatly lessened when those conditions obtain, will it not?

A. So far as typhoid infection is concerned it will be.

4649 Q. You have given the subject of the drainage canal and the sewage conditions in Chicago, considerable thought and study, have you not?

A. Considerable, yes, sir.

Q. Where does the Drainage Canal enter the Chicago river?

A. Where does the Chicago river enter the Drainage Canal?

Q. Either.

A. At Lockport.

Q. Where does the Chicago river and the Drainage Canal meet?

A. I don't remember the name of the place.

Q. Do you know how far from the Chicago river—how long the Drainage Canal is?

A. No, sir.

Q. Do you know the width of the Drainage Canal?

A. I don't remember it now, sir.

Q. Do you know its depth?

A. No, sir.

Q. Do you know its capacity?

A. No, sir.

Q. What effect does dilution have upon sewage?

A. It dilutes it.

4650 Q. Is that the only answer that you can give to my question as a sanitary engineer?

A. In what way do you wish to know what effect?

Q. What effect as a scientific engineer does dilution have upon sewers?

A. It has many effects.

Q. What are they?

A. It distributes the sewage matter through a larger volume of water. That is the first and most important effect. The word dilution expresses that.

Q. And what are the other effects besides dilution?

A. If the water which is used for the dilution is aerated it furnishes more oxygen in proportion to the matters requiring oxygen and so changes more or less radically, according to the character of the changes which take place in the oxidation and fermentation of the sewage.

Q. What percentage of sewage to water would be necessary to obtain the conditions that you have mentioned in your last answer?

A. I do not recollect that I specified any conditions which I could define that way. Please read my answer.

(Answer read.)

Q. That is aeration and oxidation?

A. Do you wish to know what percentage of dilution 4651 would be necessary so that oxygen would be always present?

Q. Yes.

A. If that is the question, the ratio which controls is the ratio between the amount of polluting matter and the amount of oxygen in the diluting water, and that depends upon the concentration of the sewage and upon the degree of aeration of the water used to dilute. Both of those ratios are variable and the resulting ratio varies widely in different cases.

Q. Can those ratios be expressed in percentages?

A. In particular cases, not in general.

Q. Take the conditions obtaining in Chicago?

A. And what do you wish?

Q. Take the conditions of the sewage in Chicago with that of the waters in Lake Michigan?

A. I don't see that your question is in shape that I can give you an intelligent answer. If this will help you, I will say that, from my observation of the water flowing out of the Chicago river as I have seen it in the last few years, it has looked to me as if there was dilution sufficient to give an excess of oxygen, and, I do not doubt that that is the case.

Q. Now, you stated that a sufficient amount of oxygen would meet the case; what do you mean by that?

4652 A. Sufficient oxygen to oxidize those matters in the sewage which require oxygen for their destruction?

Q. And what matters in sewage require oxygen for their destruction?

A. The organic matters, the undigested portion of the food in the excrement matters from the urine, and all the matters that go to the makeup of sewage so far as they are oxidizable, but some of them are so stable that they do not readily oxidize and of course don't take up oxygen under those conditions.

Q. When they take up oxygen what chemical compounds result?

A. Carbonic acid and water.

Q. Any other?

A. Yes, the nitrogen in particular goes to the form of nitrates, and there are others, but those are the most important ones.

Q. What quantity of oxygen is necessary to oxidize a given quantity of these organic compounds in water and what time is necessary for complete oxidation to take place?

A. Well, the amount of oxygen depends upon the character of the water that you have to deal with and the time required is very variable. Some of the matters in water are capable of oxidation in twenty-four hours or even less, while others will gradually oxidize for a period of six months or a year, or
longer, I don't know that there is any limit to that. In the
4653 case of peaty matters, the oxidation is so slow that a
month's storage in reservoir hardly produces an appreciable effect, but if you hold it six months or a year you get a very appreciable purification.

Q. What is necessary to aerate water?

A. To get oxygen into it?

Q. How can oxygen be gotten into water?

A. In various ways.

Q. What are they?

A. One way is to throw the water up into the air, let it fall through the air; one way is to pump the air into the water through pipes and let it bubble up through it. The way that is commonest is to let the water absorb oxygen from the air as it always will when the water is not saturated.

Q. In your examination of the sewage conditions of Chicago and the Drainage Canal what did you find to be the ratio between the sewage and the volume of water that entered the Drainage Canal?

A. This is the Drainage Canal and you are not referring to the time prior to the opening of the Drainage Canal?

Q. Since the opening of the Drainage Canal.

A. I have not investigated that; I told you that, sir, from
4654 my observation it was my impression that the oxygen was
in excess.

Q. The analyses which have been made would show that I suppose?

A. Certainly.

Adjourned until two o'clock p. m., same day.

4655 Waldorf-Astoria, New York City, 2 p. m., June 2, 1903.
Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

ALLEN HAZEN resumed the stand for further cross-examination, by Mr. Todd, and testified as follows:

Q. Mr. Hazen, an increased dilution of water to the sewage of Chicago would lessen and mitigate its danger would it not?

A. Not to St. Louis.

Q. Not to St. Louis?

A. No, sir.

Q. Then the amount of dilution of Chicago sewage would have no effect in mitigating the danger to St. Louis, would it?

A. Yes, it would have some effect, not in the direction of mitigating the danger, however.

Q. What is there in sewage that you regard as dangerous?

A. The matters which cause damage which we know most about are the bacteria. I don't know absolutely that there are not other organized forms than bacteria in sewage which may cause damage.

4656 Q. What bacteria do you have specially in mind as being dangerous?

A. The typhoid bacteria are the best known and best studied, but there is every reason to believe that there are other kinds which are also harmful.

Q. Have you ever given the subject of typhoid bacteria any special study?

A. I have given their life history, their relations to water supply and disease study. I have never studied them in the laboratory with a microscope.

Q. What explanation have you for the fact that the typhoid bacillus has never been found in the waters of the Desplaines, the Illinois and the Mississippi rivers?

A. It is a very difficult matter to find them. The amount of water that can be examined effectively for them is extremely small. An infinitesmal proportion of the amount of water flowing and failure to find in the small samples which can be examined is not evidence that it is not present.

Q. And the failure to find is not evidence that it is present, is it?

A. No, sir.

Q. What are the processes by which sewage becomes purified?

A. Well, I should have to prite a book on that subject. I don't think I could cover it then. It is a very long question.

4657 Q. Well, without going into the details, would sedimentation have any effect upon the purification of sewage?

A. It would remove some of the objectionable matters from it and put them upon the bottom of the stream. Considering the question as a whole I should not call that purification.

Q. What would you call it?

A. I should call it sedimentation, the separating of a part of the impurities. From the standpoint of the water alone, it is purification, but considering the whole subject it is not.

Q. Does aeration tend to purify sewage polluted waters?

A. Yes, sir.

Q. In your investigation of the question of the effect of sewage from Chicago on St. Louis, did you ascertain what facilities existed between Chicago and St. Louis for the aeration of the sewage in the waters?

A. No, sir; any more than my general knowledge of the conditions, and I assume as I believe to be the fact that oxygen is in excess throughout.

Q. Do you know how far it is from the Chicago river to the end of the canal?

A. No, sir; I do not.

Q. Do you know by what means the waters of the canal empty into the Desplaines river?

A. It is controlled by a bear-trap dam, of which I have 4658 some figures.

Q. Do you know whether the conditions that obtain at the bear-trap dam are such conditions as would tend to greatly increase the aeration and oxidation of the waters?

A. Why, I should think they might be, I don't know certainly.

Q. You have never seen the conditions that obtain when the waters pass over the bear-trap dam down the declivity into the—

A. I never have.

Q. And you don't know what the effect of that waterfall is upon the waters of the canal, do you?

A. No, sir.

Q. After the waters leave the controlling works at Lockport, do you know how far they flow before they enter the Illinois river?

A. No, sir.

Q. Do you know what the natural conditions are that obtain along the Desplaines river?

A. In what respect?

Q. Do you know whether there are any lakes?

A. No, sir.

Q. If there should appear to be lakes, where the current in the lakes is very slow, would that have any effect upon the purification of the water?

4659 A. Such places would require more time for the passage of the water and so would afford facilities for purification.

Q. That would tend greatly to increase sedimentation, would it not?

A. It would tend to increase sedimentation.

Q. And when the pollution in the water was settled on the bottom of the lakes the amount of sedimentation that did settle would be eliminated from the water as it passed off, would it not?

A. For the time being.

Q. Now, have you ever investigated the conditions that obtain in what is known as Lake Joliet?

A. No, sir.

Q. Do you know whether there is such a thing as scouring that takes place in Lake Joliet?

A. No, sir.

Q. Have you passed Lake Joliet, which is immediately below the city of Joliet—did you follow the course of the Desplaines river as far as LaSalle?

A. On the railroad; not otherwise.

Q. Well, your observation from the train is very limited, is it not?

A. Very limited, yes.

Q. From LaSalle down did you observe the conditions of
4660 the river?

A. I did not.

Q. Do you know how many dams are located in the Illinois river from LaSalle to Grafton?

A. I have seen records of it; I don't know it from personal knowledge.

Q. Do you know what the effect of those dams is upon the waters of the Illinois river?

A. I have some idea.

Q. What is it?

A. To retard its flow somewhat.

Q. How far from the dams is the effect of those dams experienced by the waters of the Illinois river up stream?

A. I could not say, sir.

Q. If it should run up from twenty-five to fifty miles, that would increase sedimentation, would it not?

A. It would when it operated that far, yes, sir.

Q. How long would this sewage have to lie on the bed ot that river in order to be made non-injurious?

A. I do not know, sir. In the Millbury case we were confronted by the proposition, backed up by very eminent experts, that the trouble that our people were experiencing was due to sewage mud which had been deposited prior to a time
4661 some years before, and that was the cause and the sole cause of the trouble.

Q. Do you know from personal knowledge and observation whether or not the conditions obtained along the stream that you have just spoken of here are similar to the conditions that obtain in the Illinois river?

A. To some extent they are similar in that there are a series of dams and places where the flow was slower, and it was in this place where this mud accumulated that remained, and would give rise to trouble after long periods.

Q. Have you any knowledge as to whether the Illinois river is a river that is scoured by freshets or high water?

A. I believe it is.

Q. Upon what do you base your belief?

A. Upon my recollection of the valley; my knowledge of its watershed, and the amount of water which must flow down in time of flood.

Q. What would be the best way to ascertain accurately that fact?

A. Get testimony of residents I presume.

Q. Wouldn't soundings made upon the river before the freshets and after the freshets be the best means of ascertaining that fact?

A. I misunderstood your previous question. I thought your question referred to the freshets.

4662 Q. No, I am speaking of the disturbance of the sedimentation along the bottom of the Illinois river?

A. Well, then my previous answer is not correct, and I would like to have you, if you will, put the question again and I will answer with reference to that.

Q. Would not soundings made upon the river before the freshets and after the freshets be the best means of ascertaining that fact, as affecting the bottom of the rivers where sediment has been deposited?

A. No, sir; I don't think that sounding would be the best way.

Q. Then you believe that the best way and the most accurate way of ascertaining whether the Illinois river is affected by scouring is asking the inhabitants along the river, is that right?

A. I should rather have the judgment of one who understood the subject, who studied the floods.

Q. In what?

A. Who understood the subject, and who watched the flow of the river in floods. I think that would be more conclusive than the judgment of the people who lived along the banks. I thought your first quesion was directed toward the fact of there being such floods and the local evidence should certainly be sufficient to establish that fact.

4663 Q. Supposing that there are floods along the Illinois river, what would be the best means of ascertaining whether the bottom of the river where sedimentation has taken place has been disturbed by these floods?

A. I think that could be told by inspection by an expert. The deposits made in that way would be very light and would often be of such thickness that they would not certainly be shown by soundings, which are at most rough approximations, and I should not rely entirely upon soundings to establish that point. I think it would be possible to see if the current was such that it would stir up and carry away such deposits by inspection.

Q. Have you any opinion as to what amount of deposit has been made in the Illinois river above the dams?

A. No, sir.

Q. Have you any means of ascertaining—is there any means of ascertaining by inspection of the river whether there is a foot or six feet of deposit of sediment on the bottom of that stream above the dams?

A. If there was any such amount as that it could be measured if suitable observations had been instituted for it. I know nothing about whether such observations have been made or not.

Q. What kind of observations do you mean, ocular?

4664 A. If it was to such a great depth as that, it could be best established by sounding.

Q. But, as to whether the deposits are distributed by the freshets, so-called, from the Illinois River, have you any positive knowledge as to whether that is done or not?

A. No, sir, only my knowledge as to what happens generally in rivers.

Q. Do you understand what period of the year the Illinois River flows between its natural banks?

A. No, sir.

Q. Have you any idea how many acres of land in the valley of the Illinois is overflowed throughout the year by the Illinois River?

A. No, sir.

Q. If it should appear that it would be in excess of five hundred thousand acres of land inundated outside of its banks, would that fact suggest to you the possibilities of greater sedimentation and less disturbance by flood than would take place if the river was within its natural channel?

A. The sedimentation undoubtedly would be much greater in that portion of the stream outside its banks where the water was shallow and the current was slower. The scour might or might not be less.

Q. But that you don't know?

4665 A. No, sir.

Q. Did you examine the waters of the Illinois prior to the opening of the Drainage Canal in 1900?—the waters of the Illinois prior to the opening of the Drainage Canal in 1900 above Peoria?

A. Not of the river, I examined some samples from La-Salle from the Canal which I think came from the river some distance above.

Q. Do you know how far Peoria is from La Salle?

A. I don't recollect, no, sir.

Q. Are you acquainted with the size and dimensions of what is known as Lake Peoria, immediately above Peoria?

A. No, sir.

Q. Do you know what the condition of the water immediately above Peoria was prior to the opening of the Drainage Canal?

A. No, sir.

Q. Do you know what its condition is since?

A. No, sir.

Q. Do you know whether the water of the Illinois River above Peoria is less polluted today than it was prior to the opening of the Drainage Canal?

A. No, sir.

Q. What effect does sewage of Peoria have upon the Illinois River?

4666 A. I assume that it pollutes it.

Q. Have you any idea as to the amount of sewage discharged from Peoria into the Illinois River?

A. I have an idea as given by the Census Report of the size of Peoria.

Q. Do you know what factories and industries are located at Peoria?

A. I understand that the distilling business is conducted there and that large numbers of cattle or hogs are fed there, and that a great deal of the refuse is put into the river.

Q. Do you know how many distilleries are located at Peoria?

A. No, sir.

Q. Do you know of any other factories?

A. No, sir.

Q. Are you acquainted with what is known as the Glucose Sugar Refinery factory which is located there, whose refuse goes into the Illinois River?

A. No, sir.

Q. Have you any idea of the number of cattle that are fed along the banks of the Illinois River by the distilleries?

A. No, sir.

Q. Do you know what the ratio of Chicago sewage bears to the sewage of Peoria, immediately below Peoria at Pekin in the waters of the Illinois River?

4667 A. The proportion of Chicago sewage, do you mean the whole of the sewage or that part which is left?

Q. The proportion of the sewage that reaches Peoria from Chicago, the ratio of the sewage that enters the Illinois River at Peoria?

A. Why, I should say that the ratio of the sewage was in proportion to the respective populations.

Q. Have you any knowledge as to how much of the sewage of Chicago has been eliminated from the waters of the Illinois by the time it gets to Peoria?

A. No, sir.

Q. Then, in the absence of that knowledge, would the proposition that you have enunciated that the ratio depends upon the relative population of those two cities still stand?

A. The proportion of sewage, I think it would, sir; if you mean to distinguish between sewage and some constituent part of sewage, it would not, but if you refer to the amount of sewage in the water, I think it does.

Q. Would the amount of sewage at Peoria be as great in the Illinois River as the amount of sewage that passes over the bear-trap dam?

A. No, sir.

Q. Have you any idea as to what percentage of the sewage of Chicago has been eliminated from the waters of the 4668 Illinois River by the time it gets to Peoria?

A. I don't think that any part of the sewage has been eliminated, but some of the constituents of the sewage have been eliminated.

Q. What is the difference between sewage and its constituent parts?

A. Sewage is composed of its constituent parts.

Q. Then, if you eliminate some of its constituent parts, you eliminate some of the sewage, do you not?

A. You change it.

Q. But you eliminate it, do you not?

A. No, sir, I shouldn't say so; you change it then; you modify it.

Q. When it becomes modified, does it still retain its characteristic of sewage?

A. Not necessarily always, no sir.

Q. That which has not become oxidized and destroyed still remains as sewage, does it not?

A. No sir, not necessarily. To my mind it is a question of dilution. When it is concentrated it is sewage; when it is diluted beyond a certain point it is polluted water. There is not a sharp line, it is an entirely arbitrary division.

Q. Would the pollution—employ that term—of the waters at the bear-trap dam be as great as the waters of the Illinois?

4669 A. I don't know, sir.

Q. The pollution at Peoria would be less would it not, than the pollution at the Bear Trap Dam?

A. I don't know, sir.

Q. You don't know?

A. The pollution—I do not if I understand your question correctly, sir.

Q. I am employing the word "pollution" with the significance attached to it that you described in one of your previous answers.

A. Yes.

Q. Now the question is, is the water that passes over the Bear trap dam more polluted than the water is by the time it reaches Peoria?

A. I presume it is.

Q. Is it less polluted at Peoria than it is at the Bear Trap dam?

A. I presume it is.

Q. If it is less polluted, to what do you attribute the lessening of the pollution of the waters of the Illinois at Peoria?

A. In the first place to dilution. In the second place, at times to sedimentation. In the third place to the destruction of a number of the organic matters by oxidation in the
4670 water, and in the fourth place to the death of a portion of the bacteria.

Q. Do you know whether the water of the Illinois River, before it takes on the sewage of Peoria, is more polluted than the water of the Illinois river is after it has taken on the pollution of Peoria?

A. Do I know if the water above Peoria is more polluted?

Q. Yes, than the water below Peoria?

A. No sir; I should suppose it would be the other way.

Q. That is, it would be more polluted below Peoria than it would be above Peoria?

A. I should certainly think so.

Q. Do you know whether the amount of polluting material in the water above Peoria is as great as the amount of polluting material that is added to the water by the sewage discharged at Peoria?

A. Do you refer to the organic matters in gross, or to the germs which are likely to cause disease, because there is a very important distinction there. These wastes from Peoria probably contain enormous quantities of organic matter which make a perfectly tremendous show upon your chemical analyses, but which from a sanitary standpoint are of no significance whatever.

Q. Well, we will take it from the organic matter first.

4671 A. Then sir, I don't know as to the ratios of those substances that you mention.

Q. Then we will take it as to its infected matter.

A. I should suppose that the amount of infected matter brought from Chicago would be very largely in excess of the amount added by Peoria.

Q. Is that opinion based upon any accurate knowledge, either chemically or bacteriologically?

A. It is based upon my experience with streams in general, under the conditions as I understand and assume them to be.

Q. Is it based upon any personal knowledge in regard to the conditions that obtain at Peoria itself?

A. No, sir.

Q. It is an assumption then, based upon experience in other matters and in other cases?

A. Yes sir.

Q. Do you know what the conditions of the waters of the Illinois River is at Grafton?

A. When?

Q. Since the opening of the drainage canal?

A. It is very variable.

Q. As to whether it is infected with infectious matter or polluted with organic matter?

A. I regard it as quite certain that it is certainly, 4672 beyond a reasonable doubt.

Q. How do you prove that proposition?

A. I don't prove it.

Q. It is a proposition that it is not necessary to prove. You admit it. Is that the way you come to it?

A. No sir, I would like to prove it if I could. The proof would necessarily be somewhat indirect and circumstantial.

Q. It is susceptible of demonstration?

A. I think it may be.

Q. Has it ever been?

A. Perhaps not absolutely demonstrated. The increased death rate in St. Louis since the opening of the canal is a very strong indication of it.

Q. But eliminating St. Louis for the time being, is it susceptible of demonstration at Grafton?

A. Well, sir, I don't know about the certainty,—about the possibilities of that.

Q. Well, do you know whether or not the waters of the Illinois River at Grafton has been proven to be infectious and polluted?

A. I believe it has.

Q. In order to prove it infectious what is necessary to be established?

A. The best available proof is the increased death rate 4673 among those who use it.

Q. Do you know of anyone who uses the waters of the Illinois River at Grafton, or immediately above Grafton?

A. No.

Q. If it should appear to you that a great number of people fishing on the Illinois river, living in flat boats along the Illinois River,—a floating population of several thousand, was using this water for drinking purposes, and that typhoid fever was a thing almost unknown among those people, would that have any effect in your judgment?

A. It would be an interesting consideration and I should consider it.

Q. If you saw these people drinking and knew that these people drank that water and you knew that these people did not have typhoid fever as a consequence of drinking that water, would you not draw the conclusion from that fact that the water was not infected?

A. If there were a sufficient number of people; if the evidence was clear and conclusive on the point that they drank the water and that they drank it straight, and that they did not have typhoid fever, it would be a very important piece of evidence.

Q. Suppose that the evidence should show that the cities 4674 along the Illinois River, where great numbers of people were engaged in the fishing industry and that these people should contend that the water of the Illinois River was better water today than it was prior to the opening of the drainage canal; that they drank the water and experienced no deleterious effects from it, would not that be strong evidence to your mind as a sanitary engineer that that was not infected water?

A. It would not. That is an entirely different proposition from the one which you put to me. The men who use the water as you say, would measure the character of the water by its appearance and the addition of the clear, colorless lake Michigan water unquestionably improves the appearance of that water very much. The fact that a number of people would testify that they drank it and did not have typhoid fever would be valueless in the absence of the complete record about which you spoke, because even with the most polluted waters, the large majority of the people drinking such water escape, while only a small minority contract the disease and suffer. A majority of people will take the germs and dispose of them and be no worse for it.

Q. Then the fact that a large number of people living in flat-boats along the Illinois River drinking the water; a great number of people going out and fishing upon the rivers
4675 and drinking the waters for weeks at a time, and that
the typhoid conditions decreased instead of increased among that class of people since the opening of the drainage canal, would be no evidence then, to you as to whether the water was infected or non-infected?

A. To make the evidence of value it is necessary to have a definite population and to get the statistics of sickness and death for that population. To show that a large number of people used the water and did not suffer from it is utterly inadequate.

Q. There are other causes that may give typhoid fever except the drinking water, are there not?

A. Yes sir.

Q. Now if it should appear that these other causes, such as oysters, celery and matters of that kind, and people traveling, were not present, would not the absence of any other cause be a strong evidence or circumstance that this water was not infected?

A. I don't see how the absence of the other circumstances would make the case clearer.

Q. Then, assuming that you eliminate St. Louis and disregard the evidence of the people who use the water along this river, how can you determine whether or not the water of the Illinois at Grafton is an infected or non-infected water?
4676 GENERAL CROW: Complainant objects to the question for the reason that it states a proposition that is absolutely impossible for this witness to base an opinion on, for the reason that a man must have some information about a subject before he can offer an opinion.

Q. MR. TODD: Answer the question.

A. If we eliminated the evidence in this particular case, there might be no proof. We could still form an opinion and back it up on very good grounds, that the water would be injurious, because of the large proportion of sewage which it contains, and the fact that the time required for the sewage to reach that point is insufficient to allow complete destruction of the deleterious matters contained in it.

Q. But as far as any scientific chemical or bacteriological examination of the waters at Grafton is concerned, have you any definite knowledge or personal knowledge as to its condition at that point?

A. The chemical analyses can never show infection of a water; they can only show pollution and infection can be sometimes inferred from the pollution. The bacterial examinations may possibly show the presence of infectious material. As a matter of fact the difficulty of finding it, even when it is known to be present, is so great that it is very seldom found
4677 even where there is the best reason to believe that it is present and present in serious amounts.

Q. Then the way you ascertain a conclusion that a water is infected is by its use and effect upon the inhabitants of the people who use it?

A. If that evidence is available it is about the best usually. If it is not available, we have to resort to indirect methods, methods which have been established by experience in other cases, and which when reasonably applied are reliable.

Q. How long does it take the sewage of Chicago to go to the intake at St. Louis at an average flow of water?

A. Somewhere in the neighborhood of two weeks?

Q. How do you ascertain that fact?

A. I have been told that by people who have studied the matter.

Q. You have no personal knowledge on the subject?

A. No sir.

Q. You don't know whether that is correct or not, except as you have faith in the person who told you?

A. That's all.

Q. Do you know how long it takes the water from Kansas City to get to the intake tower at the chain of rocks?

A. It would depend upon the water stage.

Q. Do you know how far it is from Kansas City?

4678 A. I don't recollect it now.

Q. It is about 400 miles, and the time as has been testified to is in the neighborhood of four or five days?

A. That seems reasonable.

Q. If you should have in Kansas City, 490 cases of typhoid fever there in a year, within four days journey of St. Louis, could you tell whether the death rate in St. Louis was attributable to the pollution from Chicago, which takes at normal times, two weeks, or whether it came from the pollution of Kansas City?

A. I think they would both be contributors.

Q. Could you determine which one would be the more generous contributor?

A. In point of time Kansas City would be nearer; in point of population Chicago would be much greater. I should think probably the extra population of Chicago would more than off-set the extra time, but that is a matter which from the nature of the case could not be determined with precision.

Q. The nearer the water supply is to the source of contagion, the greater the danger is it not?

A. When measured in time, yes sir.

Q. If it should appear that along the watershed of the Illinois, the Mississippi and Missouri Rivers, for the year 1900, there should be in the neighborhood of 3500 cases of typhoid fever and in the city of Chicago there should be in the neighborhood of 3300 cases of typhoid fever, figuring the deaths and the cases at the ratio of one to ten; ten cases for every one death, to what would you attribute the increase of typhoid fever in the city of St. Louis,—to Chicago or to the other town? 4679

A. That is the increase?

Q. The increase?

A. I should attribute it to Chicago, because Chicago is a new element in the situation in the year which you mention.

Q. That being the case, if it should appear that in Kansas City, the increase for the year 1900 and 1901 was a gradual increase, and if it should appear that in Quincy, Illinois, they had a similar general increase, and in the city of Minneapolis there should be an increase from 13 in 1900 to 121 in 1902, deaths, what theory could you give as accounting for the increase in other places not being affected by the city of Chicago?

A. It would be impossible for me to explain such matters off-hand without knowing about the conditions present. If it should be shown that there was a general increase in typhoid over the Mississippi valley co-incident with the increase in St. Louis, it would tend to show that the pollution from the cities up the valley contributed more to the increase in St.
4680 Louis, and the addition of the Chicago sewage less, than I should suppose under opposite conditions.

Q. Have you given the question of the increase of typhoid fever for the years 1900 and 1901 in other cities outside of St. Louis, any consideration?

A. No sir.

Q. Do you know what effect the Spanish-American War had upon the increase of typhoid fever in this country, the soldiers returning from the typhoid laden camps throughout the south and Cuba?

A. I understood that in some parts of the country cases were brought home in that way. That has not come under my observation anywhere, however.

Q. Do you know what position St. Louis occupied during those years, the three years I have mentioned, as to being a central point for returning soldiers from these wars, to separate and go to their homes?

A. No sir.

Q. If it should appear that a great number of soldiers from these infected camps passed through the city of St. Louis during these years, would not that account in a large measure for the increase of typhoid fever there, as well as in other places similarly affected?

4681 A. If a large part of the cases and deaths were among such returned soldiers, it certainly would; otherwise I don't see that that would be an element in the case.

Q. Would you regard an increase of thirty deaths in a city of the size of St. Louis, as something enormous, or of the nature of an epidemic?

A. Let's see; thirty deaths; that represents 500,000–people.

GENERAL CROW: You mean in a year?

MR. TODD: For a year I mean?

A. That is a substantial increase.

Q. If the total deaths in St. Louis was 168, would you call that a condition of epidemic—for a year?

A. I would leave that to the doctors.

Q. That fact has no significance then to you, as a sanitary engineer?

A. Yes sir, the fact of the increase has significance, but whether it is called an epidemic or not is something which I should not attempt to say. Very different rules are followed about that. If that happened in Germany it would be called an epidemic without question, but in my American practice I doubt if it would be commonly so called.

Q. What do you regard as the most important fact, the number of people who die from typhoid fever, or the number of people who have the cases?

4682 A. If you can find out the number of people that have the cases accurately I think that is best, but under American conditions that number can very seldom be determined accurately or even approximately, and under our condition of registration the record of deaths is much more reliable.

Q. If it should appear that in the city of St. Louis in 1900, 1901 and 1902, the death rate was a gradual increase, and the number of cases was a gradual decrease, what conclusion would you form from that condition?

A. I should think there was a new kind of germs of more active kind, that were getting into the water.

Q. If the evidence sworn to in this case should show that in 1900 there were 168 deaths, and 1213 cases, and in 1901, 198 deaths and 1101 cases, and in 1902, 222 deaths and 1112 cases, would you state from that data that typhoid fever in St. Louis was on the increase for those years, or on the decrease, assuming that the man who swore to these figures was connected with the Health Department of the City of St. Louis?

A. From my knowledge generally of the way such records are kept, I should give the record of deaths much greater weight

than the record of cases, because while the deaths are not always reported, the percentage of deaths not reported is comparatively small, while reporting cases, even under the most stringent laws in this country is very irregular, a large
4683 part of the cases never are reported.

Q. Do you know in what proportion of deaths reported as typhoid fever that there was a regular diagnostication of the cases by the doctor?

A. I have no idea.

Q. It is not an easy matter for an ordinary practitioner to diagnosticate a case of typhoid fever is it Mr. Hazen?

A. I understand there is doubt sometimes.

Q. Then is the question of death any more accurate as to the causes of death than the number of typhoid cases reported as being typhoids?

A. Yes, I think it is. It does not turn on the diagnosis by the doctor; it turns on the fact of the completeness of the returns. A man has a mild case of typhoid fever and his doctor doesn't report it; the health board never hears of it at all. If he dies they are more apt to hear of it.

Q. But assuming that in the city of St. Louis for these three years, particular effort was made by the health department in sending out letters to all the practicing physicians to report the cases of typhoid fever and the deaths, and these tables that I have given were the results obtained, accepting these results as true, would you say that the deaths indicated an increase or the number of cases indicated a decrease?

A. I could not accept that record as true.

4684 GENERAL HAMLIN: He says to accept it.

A. Because the ratio of cases to deaths is such that it would indicate a clumsiness on the part of the St. Louis doctors, if it is true; I could not believe so; it is outside of the range of conditions that I can assnue.

Q. But assuming that the St. Louis doctors as a class are as good as the doctors in any other cities in regard to diagnosing deaths as well as diagnosing cases that do not die, and assuming that these facts are true as testified to, would you as a sanitary engineer say that the deaths illustrated an increase in typhoid fever, or that the cases demonstrated a decrease in typhoid fever?

A. I don't think that either statement would be correct without qualifying it by notice of the other.

Q. Mr. Hazen why do you want to qualify the question when the assumption is assumed to be true?

A. Because if the deaths increased and the cases decreased in a city, and the record was absolutely correct, it would not be wholly true to say either that the disease was on the increase or the decrease, because, measured by different standards, each assumed in this case to be correct, the results are different.

Q. You recognize the fact that different doctors of different degree of talent have greater or less success in the treatment of typhoid cases, do you not? 4685

A. I presume so.

Q. Some doctors, by virture of their experience and skill lose very few of the cases of typhoid which they treat. You recognize that fact, do you not?

A. I presume that there is a difference in skill, yes sir.

Q. And there are other doctors that kill nearly every one they treat, depending upon their skill or lack of skill?

A. Yes, or lack of skill.

Q. But the question of how a case terminates, has nothing to do with the case itself, has it?

A. I think that it has, because I think it has to do with the severity of the attack, because sometimes the cases are all mild and sometimes they are all severe, and I think that if the cases become more severe without increasing in numbers, so that a larger proportion of them are fatal, that that may fairly be called an increase in the typhoid conditions.

Q. A mild case of typhoid fever will infect a water supply as greatly as a severe case, will it not?

A. I don't know about that. I don't think the data show.

Q. That has been testified here by people who have assumed to know?

A. I wouldn't dispute it, but I don't know it.

4686 Q. Now, assuming Mr. Hazen, that in the city of St. Louis, the true situation was in 1900 that out of the total number of typhoid fever cases,—there were 1213— 168 people died; in 1901 there were 1101 cases, and 198 people died. For those two years would you say that typhoid fever in the city of St. Louis was on the increase or on the decrease?

A. I should say it was on the increase.

Q. In other words, the more people that die and the less number of cases, would be indicative of an increase in typhoid fever, and if few people died, and more cases prevailed, it would be on the decrease?

A. That would in general be my conclusion, but I think a full accurate statement of that would include data upon both points.

Q. Do you reason that way Mr. Hazen, upon any other line of thought or business in which you have any connection?

A. Reason in what way?

Q. The same kind of reasoning that you apply in answer to my last question, about the increase and decrease of typhoid fever?

A. I endeavor to use my best reasoning power on all the problems that I consider.

Q. Before the opening of the drainage canal did you consider the waters at St. Louis as dangerous for drinking purposes?

4687 A. I did not consider it at that time, but I should so consider it.

Q. You would consider it?

A. Yes.

Q. If a water is a dangerous drinking water, how can that water be seriously injured by the addition of more pollution?

A. I endeavored to explain that to you this morning, by stating that there were different degrees of infection; that they range from nothing up to a certain figure, which represents not the worst water that could exist, but the worst water that is practically met under American conditions, and if a water was of such a character as to cause one death unnecessarily, I should regard it as dangerous or bad water, but if it became more polluted it might cause two deaths or five deaths in place of one, and so it would become worse.

Q. In the construction of filters is there any additional cost for a filter for the filtering of bacteria?

A. There may be.

Q. Aside from the filtering of mud?

A. There often is additional expense. In the case of St. Louis there would not be materially.

Q. As the water of Chicago becomes less contaminated
with sewage from the city, by diverting the sewage into
4688 the Desplaines river, and the public health of the city
becomes improved, the infectious material entering into
that river will gradually become diminished, will it not?

A. I expect it will.

Q. And in proportion to its diminishing, in just such a proportion does the danger of that water in the Illinois River decrease to those using it?

A. So far as typhoid fever is concerned, that proposition is to a large extent reasonable, but as I said this morning, from the best data that I can get, where there is one death from typhoid fever, there are several deaths from other diseases shown by the general death rate which come from the preponderance of the diseases there. I would put it in this way: when a city has a bad water supply and does away with it, and gets a good one, the general death rate falls. That has happened repeatedly; has happened so closely to the time that the new water supply has been introduced that there can be no reasonable doubt that that is a fact. Our information in regard to typhoid fever and the germs of it, is more specific than in regard to these other things. Whether they react in the same way or not I don't know, so that the proposition that you raise, it seems to me is speculative and beyond the range of what can be settled by the existing data.

4689 Q. This whole subject is speculative, is it not?

A. To some extent, yes sir.

Q. The question of the effect of Chicago sewage upon St. Louis is speculative, is it not?

A. To some extent.

Q. Now in the mixing of the waters of the Mississippi and Illinois, Mr. Hazen, how did you ascertain that fact?

A. I saw it.

Q. Is that a thing that is susceptible of demonstration by the naked eye?

A. Yes sir.

Q. Where did the mixing first begin?

A. At the mouth of the Illinois river.

Q. When the mixing begins at the mouth of the Illinois river, by the time it gets to the mouth of the Missouri river, is that mixing complete?

A. I don't think it is absolutely complete. It is approximately so; more so at low water than at high water.

Q. Is the water on the Missouri shore of the Mississippi river—in the Mississippi river for several hundred feet from the shore, and when beyond that point becomes slightly mixed with Illinois River water, and the Illinois River water preserving its identity on the Illinois shore?

A. No sir. I investigated that point much more at
4690 length with reference to the mixing of the Missouri and
Mississippi river waters. I can give you figures on that if you like.

Q. The Missouri River water entering the Mississippi, does that commingle and mix before it reaches the St. Louis intake?

A. It does.

Q. What proportion of the Mississippi River water that mixes with the Missouri River water, is Illinois river water?

A. I cannot give you that proportion; it is variable with the flows.

Q. Is it susceptible of demonstration?

A. Yes sir.

Q. That in a gallon of the water at the intake, what part of that gallon is Missouri River water what part is Mississippi River and what part is Illinois river water?

A. Yes, it can be substantially demonstrated; not precisely.

Q. In what way, Mr. Hazen?

A. The best way is by a consideration of the constituents of the different waters. I made those computations for the Missouri and Mississippi, not attempting to separate the Mississippi and the Illinois, and we find this condition: The water
of the Missouri carries a great deal more suspended mat-
4691 ter than the water of the Mississippi. It also carries a
great deal more chlorine. Taking analyses at the same

times of waters of the Missouri a little distance up and of the Mississippi a little distance up and analyses of the water taken at the same time from the chain of rocks, it is possible to compute with considerable accuracy the proportions of the Missouri and Mississippi river waters in the intake at that time. The determinations of chlorines and suspended matter proved to be the most useful for making that computation in this particular case, but other constituents of the water could be taken for the determination and perhaps in the case of the Illinois river it would be better to use something else.

Q. What proportion of Missouri River water and Mississippi water enters the intake?

A. About thirty per cent Mississippi River water, and 70 per cent Missouri river.

Q. Of that thirty per cent, how much of that 30 per cent would you call Illinois River water?

A. That I could not say.

Q. Do you think it would be an average of five per cent?

A. I could not tell.

Q. Do you think it averaged anything?

A. Yes, it does.

4692 Q. How do you know it?

A. Because it mixes with the Mississippi and the Mississippi mixes with the Missouri.

Q. Does it completely mix on the west side of the Mississippi?

A. Oh yes.

Q. Did you follow that fact down?

A. I didn't follow it down because I regarded it so obvious that it was unnecessary to follow it up.

Q. You assumed that is the fact, did you?

A. Yes sir.

Q. You didn't demonstrate it?

A. I can see it.

Q. And you regard ocular evidence as all sufficient for that purpose?

A. I do.

Q. And of this thirty per cent, would you believe that five per cent of the water was Illinois River water?

A. That could be computed, but I have not made the computation, and I would not attempt to venture a guess.

Q. Do you know how much of the year that percentage obtains of the Mississippi river water entering the intake?

A. The annual average as nearly as I could get at it,—
I expect that the Mississippi river water runs up to seventy
4693 or eighty per cent in the early spring, and down to
ten or fifteen per cent in the July rise in the Missouri.
It probably varies from year to year—constantly varies.

Q. You are acquainted with the way the St. Louis intake is situated, are you not?

A. Yes sir.

Q. What effect does the dike between the intake and the shore have upon throwing the water of the Missouri river out towards the Intake?

A. Oh, I don't know that it has a very material effect. I presume it has more effect at low water than at higher stages.

Q. At the higher stages of water wouldn't that have the effect of throwing the water towards the intake, striking against it?

A. I shouldn't think nearly as much effect in high stages, as at low stages.

Q. Well, would there be any time that it didn't have any effect, more or less?

A. Oh, perhaps not; I don't know about that.

CROSS-EXAMINATION, by Judge Springer.

Q. You stated that you had given an opinion as to the proper treatment of the water supply of the city of Washington?

A. Yes sir.

4694 Q. What did you find to be the condition of the water supply of that city so far as application to the water supply of Washington from a sanitary standpoint is concerned?

A. I don't think I quite get your idea.

Q. What did you find to be the condition of the water in the Potomac River with reference to its use as a water supply for the city of Washington?

A. Why, it is a somewhat polluted water, and objectionable.

Q. Was it so far polluted that you gave it as your opinion that the path of safety lay through filtration?

A. Yes sir.

Q. What kind of a system did you recommend?

A. We recommended a combined system consisting in the first place of the treatment of the water with a small amount of coagulent at times of flood only; that part of the treatment was to be omitted whenever the turbidity of the raw water was such as not to require it. The water was then to be settled, and after settling was to be filtered through sand filters. I think that is substantially correct.

Q. Is that the system which is being carried out now?

A. It has been adopted as to the filters. The provision for applying the coagulent has never been officially adopted.

4695 Q. What is your general method for treating the waters of our American rivers before being introduced into a city or town as a water supply?

A. Well, there are different treatments that are used for different waters. There is a great deal of variation in that respect.

Q. Is there a general idea that runs through the whole?

A. Yes sir.

Q. What is that general idea?

A. To take out the deleterious substances; but those substances are so different in different cases, different in kind and different in amount, that the means adopted for removing them are quite varied.

Q. Where those deleterious properties are the result of ordinary sewage pollution from the sewage of cities and towns in the river districts, what is your system?

A. And that only?

Q. Yes?

A. To filter the water through sand as is done in Europe, where the conditions are favorable for that. We are limited somewhat by the local conditions that we can get.

Q. What did you find were the general conditions so far as water supply at St. Louis was concerned, at the time you made the examination in 1901?

4696 A. The St. Louis water is extremely turbid in addition to its sewage pollution, and in addition to the yellow color which it gets from the upper Mississippi. That yellow generally is not a serious factor at St. Louis, but it occasionally is when the upper Mississippi is in flood and the Missouri is low.

Q. What importance do you attach to that pollution in our rivers which comes from flood tides and the washing of the rural districts as distinguished from the sewage from cities?

A. That is an element in the problem, but the most dangerous pollution is that from the cities.

Q. Is not the pollution that comes from the annual rise of the rivers where rural districts are washed out and farms and breeding lands and the small villages are washed out, a very important question in polluting the streams in this country?

A. It is an important element. There are saving features, if it comes at a time when the flood is greatest; if that amount of pollution was put into the river at a low water flow it would be most disastrous.

Q. The large amount of dilution then which accompanies this flood tide period tends to remove a portion of the danger?

A. Yes, sir.

Q. From pollution?

A. Yes, sir.

4697 Q. But do you not take into consideration in prescribing a means of treating the waters for a city or town, both these elements of pollution, the flood tide element, and also the continuous pollution from the sewers of cities?

A. A water purification plant has to be designed to meet all the conditions that can be reasonably anticipated.

Q. Now, when you passed upon the question of a water supply for St. Louis, what elements did you take into consideration in regard to the condition of the water at the chain of rocks?

A. I considered particularly the removal of the three matters which I mentioned, the mud, which comes largely from the Missouri, the color which comes largely from the upper Mississippi, and the sewage pollution which comes from all of them.

Q. Well, didn't this system which you recommended, contemplate the meeting of all of these conditions and overcoming them?

A. As far as possible, yes, sir.

Q. What was that system?

A. It was a system of settling the water first, to remove the grosser matters; then coagulate it; then settle it again and then taking it to mechanical filters and then to clear water reservoirs; then to the pumping stations in the city. 4698

Q. What did you estimate then would be the condition of the water after passing through this process and entering the city supply?

A. I considered that it would be a satisfactory supply.

Q. Is it your opinion that the waters of our navigable rivers generally require similar treatment for the purpose of making them suitable for domestic uses?

GENERAL CROW: Complainant objects to that question because the experience in general of the witness is not at issue in this case.

A. With some modifications that is generally true. The details of the treatment recommended would be very different for different kinds of water.

Q. Isn't it true that in all cases where you have been consulted in regard to water supplies of cities, that you have recommended some kind of artificial treatment before the use of the water from our streams?

A. So far as the large rivers are concerned, that is true, but it is not true with reference to smaller streams and lakes.

Q. I confined my question to the rivers. It would not be true of course where there is no pollution. When you took into consideraton the various conditions at St. Louis to be overcome, did you take into consideration the fact that the supply of water at the intake came from the three rivers, the Missouri, the Mississippi and Illinois rivers? 4699

A. I did.

Q. Were you aware of the fact at that time that the drainage canal had been opened and the sewage of Chicago was emptied into the Desplaines river?

A. Yes, sir.

Q. You took that into consideration?

A. Yes, sir.

Q. Having that fact in your mind, and the large amount of matter in suspension in the Missouri river, and the turbidity of the upper Mississippi, you reached the conclusion that a wholesome, safe water supply could be obtained for that city by the use of the system which you have described?

A. Yes, sir.

Q. What did you say the cost of that would be according to your judgment?

A. The cost of construction, including the auxiliaries was something under $3,000,000. I have not got the exact figures. Of course the operating cost would be in addition to that.

Q. Would the cost be reduced somewhat if you could eliminate the water that comes into the Desplaines river from the drainage canal?

4700 A. Not materially.

Q. Assuming that the dilution produced by waters from Lake Michigan, caused the waters of the Illinois river to appear to be freer from matter in suspension, in other words, clearer, would that element add anything to the use of the stream for farm purposes and the culture of fish and the supply of those uses and domestic purposes other than drinking water?

GENERAL CROW: Complainant objects to that for the reason that the question as to whether or not farms on the Illinois river might be benefited by the flow of the lake water into the Illinois river, is not at issue in this case, and the further objection that the witness is not competent to pass upon that question; nor has he any knowledge as to fish culture or agriculture.

JUDGE SPRINGER: I was simply asking his opinion of the water for domestic uses.

Q. (Question read.)

A. That is a question that I have not considered at all. I don't know that I could answer it off-hand.

Q. What was it that suggested to your eye at the St. Louis intake, that Illinois river water was present?

4701 A. There is an intermediate step in the reasoning. I could see the twist in the current where the Illinois river came into the Mississippi, which showed me that the Illinois and Mississippi waters became mixed before they got down to the mouth of the Missouri.

Q. What was it?

A. And the proportions which I gave were the mixture of the Missouri with the mixture of the Mississippi and Illinois river waters, as it was above, taking the samples opposite Alton.

Q. What was the peculiarity that caused you to discover the presence of the Illinois river water?

A. At Alton, say?

Q. At any place.

A. There is no peculiarity of the water. It could not be followed as the mud of the Missouri could be followed. It was simply that I could see the current twisting in such a way that it involved a mixing of the water, as I know by experience with water myself.

Q. Could you discover any difference in the color of the water of the Illinois river there as compared with the Mississippi and Missouri?

A. Where they come together the Illinois river water has a low color and the Mississippi water is yellow, and at the time of your inquiry I had overlooked that fact. For a little way be-
low you could see nearly colorless water on the Illinois
4702 side, but it only went down a short distance and went
across, so that no difference was perceptible.

Q. Where it came in from the Mississippi river it was much lighter in color?

A. Not so much difference in clearness, but the Illinois was nearly white and the Mississippi was quite yellow.

Q. What was the cause of that difference in color?

A. The peaty matter in the Mississippi river water.

Q. And the freedom from turbidity in the Illinois river?

A. The turbidity was about the same as I remember it.

Q. The turbidity as relates to color?

A. The turbidity and color are separate. All water can be either colored or turbid, the two things are entirely distinct and anyone using one term does not imply the other.

Q. I thought turbidity related to coloring matter in the water and not to matter in suspension.

A. Turbidity relates to matter in suspension, coloring matter to matter in solution.

Q. The coloring matter given by mud, for instance, is not
turbidity, and turbidity, according to Professor Sedg-
4703 wick's definition, was that coloring matter that came from
cattle, glucose, as already defined, for instance—

A. I didn't hear Professor Sedgwick's testimony, but knowing him very well, I should confidently expect that he would testify to the very reverse of that.

Q. But still you could see the difference?

A. Yes, sir.

Q. And that difference was more pleasing to the eye than the coloring matter that you saw coming from the other?

A. It was; it was a nicer looking water.

Q. Then so far as farming purposes along the line of the river below St. Louis are concerned, this Illinois river water would not materially deteriorate the conditions?

A. I should think that, as it tended to increase the pollution of the river, it would tend to be objectionable. I presume that it would not be large in its influence below St. Louis.

Q. Especially for watering stock and cattle?

A. I presume so. I have not studied the transmission of diseases of cattle and pigs. I have understood that they were carried by water, and that they were factors in such cases, but I have not studied that and do not attempt to testify as to it.

4704 RE-DIRECT EXAMINATION, by General Crow.

Q. Mr. Hazen, counsel on the other side was asking you as to the effect of dilution and infection in sewage in water; I will ask you if any amount of dilution alone will remove typhoid bacilli from water?

A. It will not remove it; it may reduce it in amount to so small a quantity that for practical purposes we would be willing to overlook it.

Q. Well, does it reduce the amount of bacilli?

A. No, sir; not in the absolute; it simply reduces the proportion.

Q. It minimizes the danger of receiving it?

A. Yes, sir.

Q. Mr. Hazen, the question was asked you if a good deal of your work had not been with reference to putting in filter plants. I will ask you if you have not been engaged in purely chemical work also, with reference to water supplies at various times?

A. That was at Lawrence, before I went to Chicago.

Q. Well, it was during your professional career?

A. Yes, sir.

Q. What was the character of that employment there,
4705 and what was your title?

A. My title was Chemist in charge of the station.

Q. Now, what was that station called?

A. The Lawrence Experiment Station.

Q. Experiment on what?

A. I described that this morning. It was on the purification of the sewage and water and at first I did considerable chemical work, but afterwards there were other questions coming into the scope and I had charge of all of it, and another man was assigned to help me on the chemical work and I didn't follow that as much personally.

Q. Well, for five years you did have charge of very important chemical work at that station in the state of Massachusetts?

A. Yes, sir.

Q. And at Chicago did you ever have charge of chemical work?

A. Yes, sir; I had charge of chemical work frequently, but the difference is, I always got someone else to do it for me. I have not attended to it personally.

Q. Well, you were the chemist at the Exposition in Chicago?

A. In that department, yes, sir.

Q. Water supply?

A. Yes, sir.

4706 Q. Now, I will ask you if you have been in your professional career, if you have been consulted, and have you not advised at different places, towns and cities, as to the mere disposal of sewage without reference to the supply of water?

A. I have, yes, sir.

Q. Where and when?

A. Altoona, Pa., works for the purification of a part of the city sewage were built under my general direction and I advised them with reference to sewage for other parts of the city, and Vassar College, the firm of Noyes and Hazen, of which I was a member, designed and built the sewage disposal plant.

I was also employed by Plainfield, N. J., and by Spencer, Mass., in relation to the construction of purification works.

Q. Sewage purification works?

A. Yes, sir; and I have advised in regard to some other cases. There was one at Waterville, Me., and one at Gloversville.

Q. Are you generally familiar with the methods of sewage disposal, aside from water supply, that was practiced on the continent of Europe ten years ago and up to this time and in England?

A. I was quite familiar with them back in 1894. I have spent a great deal of time investigating the most important plants since that time, a great deal has happened in sewage disposal which I have not followed in detail. 4707

Q. Now, does aeration destroy typhoid germs?

A. No, sir.

Q. I will get you to state whether or not you were familiar with, at the time of the investigation in 1901 of the St. Louis water supply and your report thereon, the chemical and bacteriological data that was under the control of and accessible to the city authorities of that city at that time?

A. I was familiar with that data.

Q. Did you examine it?

A. Yes, sir.

Q. Who had compiled that data?

A. Mr. Teichmann, the city chemist, had compiled his observations and Dr. Ravold also had made some compilations and in addition to that there were some records of very considerable interest and value which had been obtained in the water department itself by a chemist whom they had formerly employed.

Q. All of those matters were taken into consideration by you in your report?

A. Yes, sir.

Q. Those same things were considered in your opinion which you have expressed today?

A. Yes, sir.

Q. There was something asked you this morning as to whether or not you knew the size and general characteristics of the Chicago Drainage Canal. I will ask you to 4708 state if you ever made an investigation as to the width and depth of that canal and the relative flow of water and the speed thereof, so far as the same is of record?

A. I had those figures and have studied them at various times, but I did not have the figures accurately in mind and could not state them off-hand.

Q. Have you ever made any investigation so far as the official government records disclose, of the slopes and basins of these rivers under consideration, in Illinois, and Mississippi and Missouri and the stream flows thereof?

A. I have had such data. I have made plottings of various matters in my office for the purpose of study.

Q. Have you considered all those matters that you have gone through in former years in making up the opinions which you have expressed here today?

A. I have.

Q. Mr. Hazen, considering all other things equally, will the amount of pollution of water which is to be filtered affect in any manner, if so, in what manner, the quality of the water to be furnished after the filtration, assuming of course in that question a modern filtering plant?

4709 A. The operation of filtration does not absolutely eliminate the objectionable matters in the water. It reduces them very largely, reduces them often to such small amounts that we are content to neglect them, but as the removal is not complete, if the amount of pollution of the raw water is increased, it does increase in some measure the danger from the use of the filtered water, and it is for that reason that in locating filter plants—an effort is always made to get a raw water that has as little pollution as possible.

Q. Considering the danger to the St. Louis water supply as coming from the Illinois river, assuming that said river carries infected sewage of the City of Chicago. would that danger be gauged entirely by the average amount of Illinois river water going into the intake every day in the year, or would it be influenced by the amount that might go in there ten or twenty days in the year at flood times, when the Missouri river was low and the Illinois and Mississippi high?

A. Well, that is a very difficult matter to determine. The effect of the water obviously would be very variable upon the water taken at the intake, and the flood washing out the channel and coming down perhaps when the larger rivers were not in flood might result in pollution at the intake, which would represent more damage to the water than the ordinary pollution for months.

4710 Q. Have you ever observed the Illinois river when it was turbid and muddy in appearance?

A. No, sir; I believe not.

Q. Do you know whether or not it does carry suspended matter?

A. I have had records which show that it does at times.

Q. What would that indicate with reference to the question of scouring?

A. That it did scour.

Q. As a sanitary engineer, Mr. Hazen, is the proposition of putting in water filter plants only one of the different lines of mechanics that go to make up the practice of your profession?

A. That is all, sir; it is an important one.

ALLEN HAZEN.

Adjourned to the office of Commissioner Frank S. Bright, 1413 G. St., N. W., Washington, D. C., Monday, July 6th, 1903, 10 a. m.

4711 The Commissioner's Office, 1413 G. street, N. W., Washington, D. C. 10:00 a. m., Monday, July 6th, 1903. Parties met pursuant to adjournment.

Present, the Commissioner, Attorney-General Crow, Mr. Todd.

DR. W. W. WILEY, called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Attorney-General Crow, and testified as follows:

Q. Doctor, will you please give your name and occupation to the stenographer?

A. W. W. Wiley; physician.

Q. Residence, please?

A. Cumberland, Maryland.

Q. Doctor, how long have you lived in Cumberland?

A. About thirty years.

Q. About thirty years?

A. Yes, sir.

Q. How long have you been practicing medicine, doctor?

4712 A. About that same length of time.

Q. Have you been practicing in Cumberland all this time?

A. Yes, sir.

Q. Are you still engaged in business there?

A. Yes, sir; in regular practice.

Q. How large a city is Cumberland?

A. It is about 20,500, sir.

Q. About 20,500?

A. Yes, sir.

Q. Where is it located?

A. In Allegheny county, on the north branch of the Potomac river.

Q. Now, doctor, do you know how far from this city it is by rail and river to Cumberland?

A. By rail it is 153 miles; by river it is about 204. By canal—do you want that?

Q. Why, yes?

A. 184 miles.

Q. What canal is that?

A. Chesapeake & Ohio.

Q. That runs in a pretty straight line, does it?

A. Yes, sir; zigzag.

Q. Where is the terminus of that canal this way?

A. Georgetown.

4713 Q. And Cumberland the other terminus?

A. Yes, sir.

Q. Now, doctor, is there a sewer system in Cumberland at this time?

A. At this time, yes, sir. It has been established pretty thoroughly.

Q. Now, do you remember the typhoid epidemic in 1889 and 1890, in the city of Cumberland?

A. Yes, sir; it commenced in December, 1889.

Q. Do you remember what month it began—you say in December?

A. In December, 1889, near the middle of the month, about the 10th.

Q. What first attracted your attention to it, doctor?

A. It first struck my attention when called in consultation to see a young man sick of it.

Q. Sick with typhoid fever?

A. Yes, sir.

Q. Did it continue for any length of time?

A. Continued up to the following June.

Q. That would be June, 1890?

A. Yes, sir.

Q. Did it increase in severity?

A. It did, sir; there were only about, as far as I could personally learn, the one case, but afterwards I learned of
4714 four cases in December. In the early part of January they cropped up, and February more than in January, and more in March, and then it dropped off in April and May.

Q. And did it increase again after that?

A. No, sir; we had a few cases.

Q. It gradually diminished?

A. Yes, sir.

Q. Now, doctor, do you know whether or not there was any health record kept by the city government at that time at Cumberland?

A. Not by the city government, no, sir.

Q. Now, do you know of your own knowledge anything about how many cases there were there?

A. There were at least 485 cases reported by the physicians society.

MR. TODD: I move to strike out the answer as to what is reported by the physicians, as being incompetent testimony.

Q. Have you any personal knowledge of that?

A. Yes, sir; a good many.

Q. Now, do you know whether or not there was a great many cases of your own personal knowledge aside from what the physicians reported?

A. Yes, sir.

Q. About how many cases do you think you have personal knowledge of? 4715

A. Well, I should say about,—to be within the limits,—270.

Q. That is that you attended and had knowledge of—in consultation with?

A. Yes, sir; had consultation with.

Q. Was that fever pretty well scattered over the town?

A. It was, sir.

Q. Now, at that time, doctor, was there any sewerage connection with the Potomac river directly or indirectly from the houses of the town?

A. Indirectly there were, sir; there were private sewers running into small streams there and they emptied into the Potomac river.

Q. Well, now, just describe that location there so that we can get it in the record, with reference to those running streams that ran into the Potomac?

A. The town is pretty evenly divided in half by Wills creek, that runs north and south and divides it east and west.

Q. What does Wills creek empty into?

A. Into the Potomac river. It commences up in Pennsylvania.

Q. Is there any other creek there, doctor?

A. We don't call them creeks; we call them streams. Yes, there is a stream known as Sulphur Run that comes down Fayette street on the west side and joins with one coming 4716 down Green street, and they together empty into the Potomac. At that time it was above our intake,—above the waterworks about 175 feet above the intake, where the pipe runs out into the river.

Q. There was water in these small streams, was there?

A. Yes, in December, January, February, March and April there was water in them all the time, sir.

Q. Now, do you know whether or not any of these houses had direct sewer connection with Wills creek and this other small creek called Sulphur Run?

A. I do, sir.

Q. Have you personal knowledge of that?

A. Yes, sir.

Q. Do you know whether or not any of the houses in which the people were ill with typhoid fever in 1889 and 1890, had direct sewer connection with either Wills creek or Sulphur Run?

A. Yes, sir; I have.

Q. Can you name some of the people?

A. Yes, sir; Mr. Daniel Arun, cashier Second National Bank.

Q. You attended him, did you?

A. No, sir; I didn't attend him, only in consultation.

Q. Anybody else?

A. Sinclair had two cases.

Q. Did you attend them?

4717 A. No, sir; not directly.

Q. Their houses were connected with the sewers?

A. Yes, sir.

Q. Now, you attended a great many cases there, did you, yourself?

A. I did, sir.

Q. Doctor, at that time did the physicians generally, or did they not generally order the disinfection of the stools of patients, and the urine?

MR. TODD: I object to the question as being incompetent.

A. Yes, sir; they did all that was in their power, they did. Of course in private practice you can't carry it out rigidly; you can't enforce it.

Q. Where it is attempted to be done it does not result in the destruction of all the germs anyway, does it?

A. No, sir; it does not.

Q. Now, these streams, Sulphur Run and Wills creek empty immediatey into the Potomac?

A. Yes, sir; both of them.

CROSS-EXAMINATION, by Mr. Todd.

Q. This epidemic of which you speak occurred between December and June, of 1889 and 1890?

A. Yes, sir.

4718 Q. During that period what system of sewerage was in vogue?

A. We had no general system; it was private; it was individual sewers running into this run, for instance, or into Wills creek, or into a place called Millrix, or directly into the canal.

Q. Was the system of taking care of the household sewage a system commonly known as privy vaults and privies?

A. A good many, sir; a good many of course had closets in the house.

Q. And what proportion of the population had their closets in their houses?

A. In their houses at that time?

Q. Yes.

A. I don't suppose sir, over twenty per cent. had them in their houses at that time. A good many more have now, sir.

Q. The other eighty per cent. used what is known as privy vaults?

A. That is it, sir.

Q. What connections existed between the privy vaults and the Potomac river ?

A. Many of these privies were built right over the edge of these streams, and it was carried directly into the river.

Q. About how many privies were built over the edge of these streams at that time, doctor?

4719 A. Well, I couldn't say, sir. You see there were several streams there, and as I say, there were about eighty per cent.—well, I should suppose there must have been a quarter of them at least flowed into the streams, and may be a little over that, sir; altogether nearly a third connected with the streams direct.

Q. In the city of Cumberland of 20,500—did that population obtain there in that period?

A. No, sir; it was about 12,000.

Q. Of the 12,000 there were about 3,600 people adjacent to the streams?

A. Yes, sir; just about, all these different streams—just about, yes, sir.

Q. Do you know how many people had typhoid fever that occupied houses whose privies overlooked these different streams?

A. No, I couldn't answer that; no, sir.

Q. What part of the city was the epidemic most prevalent in, that along the banks of the river, or away from it?

A. No, sir; away from it.

Q. The wealthier people of the city lived along the banks of the Potomac, did they not, and the rivers?

A. No, sir; no they don't live on the banks; they live out at Washington street; live away from it, on the west side.

Q. Now, what was the class of people that lived along the
4720 banks, the laboring classes?

A. Mechanics and so forth.

Q. Was it there that the typhoid fever cases were the most numerous?

A. No, I can't say it was sir, for instance there is Decatur Street which is pretty far removed from any one of these streams and it had more on it than any street, I think, in town.

Q. And what was the character of the sewers on Decatur Street?

A. Most of those were private, in the yards, and so forth, some few had sewers.

Q. And the household sewage was deposited in privy vaults?

A. Yes, sir.

Q. And there it remained until the period came around when it was removed.

A. Yes sir, but let me tell you, those people on Decatur Street almost nearly all used river water at that time.

Q. You say they did use river water?

A. Yes, sir.

Q. In the treatment of these 270 cases that came under your observation what did you prescribe for the disinfection of the sewage of these patients?

A. You see we didn't have at that time what we have now. A great many of us used bi-chloride of mercury; chloride of lime, carbonate of lime, carbolic acid, bi-chloride of lime,
4721 carbonate of lime—that is carbolic acid.

Q. Those are the disinfectants that were used during that epidemic?

A. Yes, sir.

Q. What directions were given for its use?

A. Well, they were all told to use it before it was emptied into the closets—to use it plentifully on the stool, because we thought the germs were in the stool only, and that is what we used; and then a good deal I have used in the closet itself.

Q. And do you know whether or not this was used?

A. In the different houses?

Q. Yes.

A. O yes.

Q. Was this disinfectant used generally there among the doctors?

A. Many of the more prominent doctors, yes sir.

Q. Now out of the number of cases that you claim were reported something in the aggregate of over 400—270 of those cases came under your personal knowledge and observation?

A. Yes sir.

4722 Q. And these that came under your personal knowledge and observation, was the excrement of those patients treated in accordance with your directions?

A. No sir, many of them were neglected.

Q. And do you know of any that were neglected that emptied directly into the Potomac river and not into privy valuts?

A. Yes, many of them.

Q. How many?

A. I suppose at least half, sir, when you come down to it.

Q. Half?

A. Yes, because you cannot stay there and watch, many of them would not have trained nurses.

Q. Did you ascertain what the cause of the typhoid epidemic was at Cumberland?

A. Well, we had the Secretary of the Board of Health up there for a long time, and we had Prof. Tomery.

Q. No, I asked you if you ascertained the cause?

A. No sir, I don't know sir, only from these gentlemen, and the fact that the people that drank this water seemed to get typhoid fever, and then when the river was abandoned, you might say, almost entirely—well it was abandoned for drinking water, why the typhoid gradually died out.

Q. What town is located above?

A. The nearest town on that river is Keyser, 29 miles.

4723 Q. Was there any typhoid fever in Keyser?

A. There were said to be two or three cases there at that time.

Q. And that was already within the heart of it?

A. Yes sir.

Q. You made no investigation of it?

A. No sir.

Q. What sort of a water system did they have in Cumberland?

A. Holly.

Q. At that time?

A. The Holly water system.

Q. Where was the water secured?

A. From the Potomac, pumped direct and forced to the city; no filtration, just direct.

Q. Of the 270 cases that you treated or had personal knowledge of, doctor, what became of the fecal discharges of those patients?

A. Why, many of them were put into the vault in the yard; many of them were on the surface, and a good many were dumped into the closet in the house, and many of them in the sewer.

Q. What percentage of it would go into the river directly?

A. All over the town?

Q. No, I mean of these patients—that would go directly from the house into the sewer—the houses that had sewer connection?

4724 A. Oh, I should say sir, that 70 per cent., if not beyond.

Q. Now that seventy per cent.; what class of people would that represent?

A. Why, the rich and the poor.

Q. Did the poorer people have the houses connected with private sewers?

A. Not many of them, but they were the classes that were over these streams, on the edges of the streams.

Q. I mean the people that had their houses connected with private sewers?

A. Oh, there would not be seventy per cent. of these, sir;

I mean at least seventy per cent. of the people that were sick, their closets in some way or another connected with these streams that led into the river. You see, as I say up to that time we had no general system of sewerage at all. Since then it has been pretty well sewered?

Q. Did you make any investigation of the typhoid condition except what you found in Cumberland?

A. No sir.

Q. What occurred below Cumberland?

A. Well, I communicated there with a doctor at Hancock. That is a place sixty miles below Cumberland, and soon after we had our epidemic in Cumberland they began to have cases at Hancock, but I never heard the number; but they had 4725 quite a number of cases at Hancock and accused us of communicating it to them.

Q. What proportion of the typhoid fever cases used the private vaults?

A. That would be hard for me to tell exactly, sir, how many typhoid fever patients used the private valuts?

Q. Yes.

A. I couldn't tell exactly that, sir.

Q. Is there any more difficulty in telling the number of patients that had typhoid fever that used the privy vaults than the percentage of typhoid excreta emptied into the Cumberland, the Potomac and the other two rivers or streams?

A. I say they all must have, excepting the one street, Decatur street is the only street that I know of in town, where the sewers could not reach the river—the only street, and that at the present time has no system of sewers, and as I say, out of the 485 cases there, if I could tell exactly how many cases occurred on Decatur street, I could tell you about what the percentage would be.

Q. Exclusive of those cases that occurred in houses where the privies overhung the river, how long would it take sewage to get from the other houses into the river?

A. Why with the water running that way, it would take 4726 a very few hours, sir.

Q. They had waterworks, did they?

A. Yes, all those that had these private sewers had water connections.

RE-DIRECT EXAMINATION, by General Crow.

Q. Doctor, was the intake at that time below the place where some of these creeks into which sewers ran, emptied into the Potomac?

A. Yes sir, only about 175 feet, I guess, below.

RE-CROSS EXAMINATION, by Mr. Todd.

Q. Where was the intake of the water supply of Cumberland located at that time?

A. Why, it went right out into the river from the water works. The water works was directly on the edge of the river and it went right out.

Q. How much of the city was built above the water works?

A. Let's see, at that time about one-third.

Q. And was the water works located below the creeks or small streams that divided the city?

A. No, it was below the stream that as I say, comes
4727 down Fayette and Green Streets and then the creek communicates with it. You see there is a dam along there forming a basin.

Q. The sewage of Cumberland, a part of Cumberland itself, entered the water above the intake?

A. Yes sir.

Q. And the water itself that got into the intake was contaminated and polluted by the sewage discharged from Cumberland itself?

A. Yes sir, and those streams above it unite and form one stream and did come in about 175 feet above the water works.

Q. Now then—

A. They carried that pipe up along the bank, 1,500 feet further up so as to be on that stream.

Q. About what proportion of the population drained into the river above the intake?

A. At that time?

Q. Yes.

A. About one-third of the population.

Q. How large a river is the Potomac at Cumberland?

A. It is about 300 yards wide, sir.

Q. How deep?

A. Well, the deepest place is about 29 feet.

4728 Q. Is it navigable?

A. No sir, only canal boats.

Q. And at the time that this epidemic began in December, was it at a high or low stage?

A. Well, about middle then, sir.

Q Had the winter set in?

A. Well, the river don't generally rise; it freezes over you see in December, and breaks up then about the latter part of March.

Q. Well, during December, when it freezes—the Potomac rises in the mountains, does it not?

A. Yes sir.

Q. And the streams that feed the Potomac, when they become frozen in the winter, the Potomac falls, does it not?

A. No sir, I could not say it does; it keeps up pretty well about the same.

Q. It keeps up pretty well?

A. Yes sir.

Q. Have you any idea about the volume of water that would pass a given point at a given time at this period of the year in the Potomac?

A. No sir; I have heard that given in the trial of the city of Cumberland against the Pulp Paper Mill Company. That was tried, I think, three times.

4729 Q. But you have no recollection of that?

A. No sir.

Signature waived. F. S. B. Com'r.

Adjourned until 2 o'clock p. m. same day, Monday, July 6, 1903, at Office of Weather Bureau, Washington, D. C.

4730 2:00 p. m., Monday, July 6th, 1903.
Weather Bureau, Washington, D. C.

Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

WILLIAM B. STOCKMAN,

called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Attorney-General Crow and testified as follows:

Q. Will you please give the stenographer your name, residence and occupation?

A. William B. Stockman, District forecaster United States Weather Bureau; residence, Washington, D. C.

Q. How long have you been in the Weather Bureau service?

A. Over twenty-five years.

Q. What district are you superintendent of?

A. I am in charge of the division of meteriological records.

Q. Does that division have charge of the rain precipitation over the area covered by the watershed of the Illinois, Missouri and Mississippi rivers above the city of St. Louis?

4731 A. It has a record of the precipitation throughout the country—has charge of it.

Q. Now I show you here two charts marked "United States Department of Agriculture, Weather Bureau." Can you identify those; if so, tell me what they are?

A. Rain precipitation; they represent the mean annual rainfall of the various places mentioned or indicated.

Q. Are they copies of the official record?

A. They are copies.

Q. Now do you know anything about that map that I show you?

A. That is simply indicating the stations to be selected in the various river districts.

Q. That red line does not include the watershed?

A. Well, that is supposed to as I understand it; that was given me to extract the data for.

GENERAL CROW: Mr. Todd, examine those. I want to offer them in evidence if there is no objection to them. The books are right here, but I thought we could offer copies of them. Is there any objection to the form of the testimony?

MR. TODD: I won't object to the form; I simply object to the materiality.

Q. GENERAL CROW: Now begin here at Chicago, Illinois, and these places, what do these figures out on the side here

represent? Just explain the chart so that the Court will
4732 understand what is meant by it?

A. Suppose I go to Chicago and show you just exactly what it does mean, from the figures.

Q. All right.

A. (Witness refers to book). Each entry here represents the total amount of precipitation in that month and year; that is 1871, January, February, and so on. That means the total amount of precipitation for the twelve months of the year, and so on all through the length of the record.

Q. These figures at the side here then in this column (indicating) represent the average of the years since 1871?

A. Well no, that chart is only brought down to and including the year 1895. We are now working on one which will bring them up to 1903.

Q. And that is as far as these figures go then?

A. Yes, that is as far as they go.

Q. You have the figures though in that shape from 1895 to 1903?

A. Oh yes, they are all here, yes sir.

Q. All we want to get out of this is to get the date when each one of these stations began; I suppose that marks the time when you began the record?

A. Yes sir.

4733 Q. Now will you take the record and give the stenographer the dates when Chicago began, and Ottawa?

A. At Chicago; this is the record up to and including the year 1895, beginning January, 1871.

Q. And the figures here represent the mean average for those years inclusive?

A. It represents the mean average from 1871 to 1895 inclusive. Those are our regular stations, they are called voluntary—Springfield, Illinois—

Q. You haven't the record then for Ottawa?

A. Oh yes, we have but not in these books; these are the books for our regular weather bureau stations.

Q. That is the average annual fall?

A. Yes, you see that is the mean of taking these 25 years, the sum of them.

Q. The mean annual rainfall?

A. The mean annual rainfall. Duluth is from January, 1871 to 1895, inclusive. These books are arranged alphabetically; at least the dating of them are alphabetical. Davenport is the same. Now Dubuque will be from 1874 to 1895. Des Moines is from 1879 to 1895.

Bismark is from 1875 to 1895.

Cheyenne is from 1871 to 1895.

4734 Concordia is from 1886 to 1895,

Denver is from 1871 to 1895,

Kansas City is from July, 1889, to December, 1895,

Hannibal, Missouri, is from May, 1892, to December, 1895,

Havre, Montana, is from—including Fort Assinibon from 1880 to 1891, and Havre the remaining four years,

Helena is from April, 1880 to 1895,

Keokuk is from July, 1871, to 1895.

Q. That is your official stations?

A. Yes, those are our regular stations. Did I give you Huron, South Dakota?

Q. No sir.

A. Huron, South Dakota, is from July, 1881 to 1895,

LaCrosse is from November, 1872 to 1895.

Q. Do you make proportionately that many observations over the entire country, as many as in this district?

A. That is about the proportion. I think it is more in the eastern part of the country.

Miles City is from October, 1891 to 1895.

Lincoln, Nebraska, is a broken record, but it is a very complete one from 1885. You see the months are missing in through there (indicating on book).

4735 Lander, Wyoming, is from January, 1888 to 1895, with a broken record; an estimated record in June and July, 1891.

North Platte is from October, 1874 to 1895,

Omaha is from 1871 to 1895,

Pierre, South Dakota, is from July, 1891 to 1895,

Springfield, Missouri—there is a straight record from October 1887 to 1895.

Springfield, Illinois, is from July, 1879 to 1895, Sioux City is a very clear record from 1883. November and December of 1888, and January, February and March in 1889 missing.

St. Louis is from 1871 to 1895.

Q. Is the precipitation heavier in these valleys than it is in the east?

A. Well, not as a rule. Rapid City is from February, 1881, to May, 1883, inclusive, and from January, 1883 to 1895.

St. Paul is from 1871 to 1895,

Topeka is from June, 1887 to 1895,

Valentine is from September, 1885, excepting January and February, 1893.

Williston is combined with Fort Buford, which runs from February, 1879 to 1895, and November, 1893, not considered.

Yankton is from April, 1873 to 1895. That is all of the
4736 voluntaries.

Ottawa is from March, 1856, to November, 1870, excepting January, 1857; October, 1860; June and July, 1863; and January, May, 1865; November, 1867; November and December, 1868; January and September, 1869; December, 1870; October, 1868; October, November and December, and a straight record from October, 1886.

Peoria is from December, 1855, to December, 1874, and perhaps June. It goes right on excepting—oh yes, that is complete to 1895.

Beardstown is a broken record from April, 1885, excepting October, November and December, 1888; January, February and March, 1889, and in the years 1898, 1899, 1900 and 1901, but we don't want to run that far.

Q. There is no annual amount put in here (referring to chart). Is it figured up there?

A. At Beardstown?

Q. Yes sir.

A. Well it is such a broken record, I guess that is why they didn't use it. I can give you the mean from 1890 to 1896, the complete years, if that will answer. It was 38.03.

Q. Now have you got the figures for those places from
4737 1895 to 1903?

A. Yes sir.

Q. But you have simply got the figures for each year?

A. Yes, amount each year.

Q. Well, could you get that and just read that into the record, just the amount? Now, I will tell you; we will save a lot of time in this matter for ourselves, and you can have it done at your leisure, too, if you will just have copied into these sheets here the amounts of the rainfall for the years 1895 to 1903 for these stations.

A. That is pretty considerable of a task. If the annual values will answer as well, we can do that.

Q. The annual, just as you have it here?

A. Yes, just as it is there.

Q. Well, that will do just as well.

A. Well, if it will—it is only one-thirteenth of the work.

Q. And you can just mail it to Mr. Bright here in this city.

A. Very well, sir.

Q. Now you don't know whether that represents accurately the watershed or not?

A. No, I do not. If you wish any data from any other of the stations that you think—

Q. No. I just want the watershed of these three rivers; 4738 there are no other stations in the three watersheds?

A. I don't know; I haven't looked that up.

Q. Well, if there are, will you please insert them in here?

A. Well, I don't know anything about watersheds.

Q. I think from the looks of it, it does cover it, it comes up to the divide, Lewiston is over the divide.

A. Well, I will just make up the annual values from 1896.

THE COMMISSIONER: Do you want these charts identified in any way?

GENERAL CROW: Yes, you put your mark on them and identify them.

THE WITNESS: Or you may take those and just give me a list of the stations. That is all I care for. Now if you will call those off to me, I will put them down.

THE COMMISSIONER: (Reading from chart):

Chicago, Illinois,
Ottawa,
Peoria,

Beardstown,
Springfield,
St. Louis,
Duluth,
St. Paul,
LaCrosse,
4739 Dubuque,
Davenport,
Keokuk,
Des Moines,
Hannibal,
Havre,
Williston,
Helena,
Miles City,
Bismark,
Pierre,
Huron,
Rapid City,
Yankton,
Valentine,
Lander,
Cheyenne,
North Platte,
Sioux City,
Omaha,
Lincoln,
Denver,
Concordia,
Topeka,
4740 Kansas City,
Columbia,
Springfield, Missouri.

Charts are marked by the Commissioner "Complainant's Exhibits 71 and 72."

THE WITNESS: Now would you like these data certified to?

GENERAL CROW: Yes, you can certify them if you will.

Certified charts marked "Complainant's Exhibit 73." Frank S. Bright, Commissioner.

CROSS-EXAMINATION, by Mr. Todd.

Q. Mr. Stockman, in getting these averages for the periods that you have indicated, are the averages taken by months or by years?

A. We take the total for the months, the amount for the months of the year; and for the annual, we take the annual data.

Q. And these figures that represent, take for instance, Chicago, 34.76, what does that mean?

A. The mean annual precipitation at Chicago.

Q. In what measurement?

A. In inches.

Q. And that is true all through?

A. That is true throughout. We use the same method and the same measurement. The monthly values appear in these books you see (indicating the records).

4741 Q. Yes, that is all I wanted to find out.

Signature waived.

Adjourned to the Commissioner's office, 1413 G Street, N. W., Washington, D. C., until 3 p. m. same day, Monday, July 6th, 1903.

4742 3:00 P. M., Monday, July 6th, 1903.

Office of the Commissioner, 1413 G. Street, N. W., Washington, D. C.

Parties met pursuant to adjounrment.

Present, the Commissioner and same counsel representing the respective parties.

WILLIAM C. WOODWARD,

called as a witness in behalf of the complainant, being first duly sworn by the Commissioner, was examined in chief by Attorney-General Crow and testified as follows:

Q. Doctor, will you please give the stenographer your name, address and occupation?

A. William C. Woodward, 508 I Street, Washington, D. C. I am health officer of the District of Columbia.

Q. How long have you lived in the District of Columbia?

A. My entire life, since 1867.

Q. How long have you been Health Officer of this city?

A. Since August 1st, 1894.

Q. The office of Health Officer of this city is created by what statutes?

A. By an Act of Congress passed some time in 1878.

4743 Q. What are the duties, generally speaking, of the Health Officer of the District of Columbia?

A. They are to execute and enforce all laws relating to public health, and to keep a full and correct record of vital statistics and to perform such other duties as may be assigned by the Commissioners of the District.

Q. The keeping of the records of the vital statistics includes records of marriages, births, deaths and diseases of different kinds?

A. It includes now the records of births, deaths, and the various sources of diseases; we do not now keep records of marriages.

Q. Do you keep a detailed history of the individual cases in different diseases?

A. Yes, sir.

Q. How long has that record been kept?

A. The detailed history of the individual cases has been kept for various lengths of time in various diseases. Of course it will depend somewhat upon what you mean by detailed history.

Q. Well, for instance typhoid fever, water and the milk and the diet?

A. Well, typhoid fever has been reportable in the District of Columbia since about February, 1902, and ever since that time we have been keeping a detailed history of the cases as to milk, water supply, diet, etc. 4744

Q. Now before you became Health Officer, were you connected with the Health Department?

A. I was for about a year before I became Health Officer, Coroner for the District, and for six months prior to that time I was physician to the poor in the health office.

Q. Prior to the date you last mentioned, you practiced medicine in this District?

A. For about six months prior to that I was physician in charge of the emergency hospital, and prior to that time I had practiced medicine since about 1892.

Q. Of what school are you a graduate?

A. University of Georgetown in this city.

Q. Are you the official custodian of the vital statistics as recorded in the District of Columbia under the Act of Congress?

A. Yes sir.

Q. The records of your office are the only official records of the vital statistics?

A. Yes sir.

(Counsel for Complainant hands papers to counsel for
4745 defendants).

GENERAL CROW: Any objection to the form of it?

MR. TODD: No, I don't object to the form. I object to the competency.

Q. GENERAL CROW: Now, doctor, I show you here what purports to be a statement showing the number of deaths from typhoid fever, typhoid malarial fever, malarial fever and diarrheal diseases, occurring in the District of Columbia during each month from January, 1885, to December, 1895, inclusive. I will ask you if that was made from records in your office?

A. Yes sir.

Q. Is it a correct copy?

A. To the best of my knowledge and belief it is.

Q. That is your signature attached to the certificate?

A. Yes sir.

Q. And the official seal of the District of Columbia?

A. Yes sir.

Q. And the official seal of your office?

A. Yes sir.

GENERAL CROW: Now I offer that in evidence.

Said document received in evidence and marked by the Commissioner Complainant's Exhibit 74.

MR. TODD: I object to it on the ground of its incompetency.

Q. GENERAL CROW: Now, doctor, in your capacity
4746 as Health Officer you have also had charge of the records
or record of vital statistics from 1895 on up to 1902?

A. Yes sir.

Q. Have you got the records of the deaths—the typhoid fever cases and the deaths for the year 1902?

A. I have the record of deaths, but I have not the record of cases with me. That is an original table, I cannot leave that with you.

GENERAL CROW: Now, Mr. Todd, this is an original record in his office there, and the only way I can get it into the record is to copy it in.

MR. TODD: Just read it in.

Q. GENERAL CROW: I will ask you, doctor, to just begin at 1895 and read those figures.

A. Do you want them by months?

Q. Yes, by months, and the totals, just as you have it there.

A. The total you see covers ten year periods; that won't give it.

Q. Well, just read it by months.

A. We can put in the totals afterwards. This is by calendar years, January, 1895, to 1903.

Q. That gives cases or deaths?

A. These are deaths.

Q. All deaths?

4747 A. Yes sir.

January, 1895, 0 deaths,
1896, 9 deaths,
1897, 13,
1898, 8,
1899, 10,
1900, 17,
1901, 7,
1902, 19.
February, 1895, 0 deaths,
1896, 8,
1897, 4,
1898, 4,
1899, 4,
1900, 6,
1901, 2,
1902, 8.
March, 1895, 0 deaths,
1896, 3,
1897, 4,

March, 1898, 2,
1899, 7,
1900, 8,
1901, 8,
1902, 12.
4748 April, 1895, 1 death,
1896, 3,
1897, 4,
1898, 9,
1899, 6,
1900, 10,
1901, 2,
1902, 9.
May, 1895, 2 deaths,
1896, 4,
1897 6,
1898, 6,
1899, 3,
1900, 5,
1901, 4,
1902, 13.
June, 1895, 1 death,
1896, 7,
1897, 9,
1898, 20,
1899, 6,
1900, 12,
1901, 10,
1902, 9.
4749 July, 1895, 12 deaths,
1896, 8,
1897, 10,
1898, 24,
1899, 9,
1900, 20,
1901, 16,
1902, 21.
August, 1895, 27 deaths,
1896, 15,

August, 1897, 16,
1898, 22,
1899, 38,
1900, 41,
1901, 33,
1902, 39.
September, 1895, 56 deaths,
1896, 25,
1897, 18,
1898, 22,
1899, 30,
1900, 29,
1901, 28,
1902, 25.
4750 October, 1895, 53 deaths,
1896, 25,
1897, 10,
1898, 28,
1899, 28,
1900, 25,
1901, 21,
1902, 32.
November, 1895, 24 deaths,
1896, 18,
1897, 9,
1898, 21,
1899, 27,
1900, 28,
1901, 22,
1902, 19.
December, 1895, 20 deaths,
1896, 16,
1897, 18,
1898, 16,
1899, 26,
1900, 17,
1901, 16,
1902, 20.

4751 Do you wish the totals?

Q. Well, have you got the totals?

A. Yes, totals for each year:

1895,	201,
1896,	141,
1897,	121,
1898,	182,
1899,	194,
1900,	218,
1901,	169,
1902,	226.

Q. Have you got the rates per thousand?

A. Rates per ten thousand. These are for population, rates per 10,000:

1895,	7.49,
1896,	5.17,
1897,	4.39,
1898,	6.56,
1899,	6.97,
1900,	7.83,
1901,	6.06,
1902,	7.99.

Q. Now, Doctor Woodward, as health officer of this city have you had occasion to investigate the water supply of the city at various times?

4752 A. I have made personal inquiries into its condition, but I never investigated the watershed, nor personally made bacteriological nor chemical analyses, though I am familiar with the work that has been done along both lines.

Q. You are familiar with the aqueduct that you have here?

A. Yes, sir.

Q. And the water plant in general?

A. Yes.

Q. You are familiar with the general sanitary conditions in the city?

A. Yes, sir.

Q. And with the typhoid rate?

A. Yes, sir.

Q. Now, I will ask you what in your opinion is the principal cause of typhoid fever in this city?

A. My own opinion, after a very careful consideration of the entire subject is that the chief cause of our typhoid fever is our Potomac river water.

Q. Have there been any steps taken to remedy that?

A. Yes, sir.

Q. What steps?

A. The Federal Government now has in course of construction a filter plant to filter the entire public water supply of the District of Columbia.

4753 Q. What kind of a filter plant?

A. By means of slow sand filtration.

Q. Was that by Act of Congress?

A. Yes, sir.

Q. What kind of pollution in your opinion, is it that renders bad the Potomac river water at this point?

A. Human excreta, I think.

Q. And sewage pollution?

A. Yes, sir.

CROSS-EXAMINATION, by Mr. Todd.

Q. Dr. Woodward, you don't hold yourself out as an expert on typhoid fever, do you?

A. No, sir.

Q. You don't hold yourself out as an expert on causes of epidemics, do you?

A. No, sir. I will cover all those questions by saying that I don't hold myself out as an expert on anything.

Q. And when you give an opinion in regard to the causes of typhoid fever in the city of Washington, is that an opinion of an expert upon the subjects to which you testify, or simply the opinion of a layman, so-called, as distinguished from an expert?

4754 A. I will have to leave it to others to determine whether I am an expert or not. I don't hold myself out in any case. I have carefully studied the subject of typhoid fever in the District of Columbia since 1894. I have especially closely studied the subject of water supply here and elsewhere, and as the result of that study, covering a period of nearly nine years, I have expressed that opinion.

Q. Then you do express an opinion as an expert upon the subject concerning which you have expressed the opinion?

A. That, as I say, I have expressed the opinion, and I stated my experience. I will leave it to the Court to determine whether I am an expert or not.

Q. Now, in your conclusions or opinion that the cause of typhoid fever is from the Potomac river water, is that the only cause of the typhoid fever in the city of Washington?

A. Absolutely not.

Q. Washington is a peculiar city in this, that it is visited by people from every other city and country in the world, is it not?

A. Well, that of course applies to all cities more or less. We have a considerable number of visitors, of course.

Q. Well, you have more people visiting here from different cities, than almost any other city, by virtue of the fact that 4755 it is the capital of the country, don't you?

A. We have, I presume, more pleasure seekers and sight seers of that class, but when it comes to business,—along the line of business I presume commercial cities have a larger percentage of visitors than we have, though I know nothing of it, of course; I have never investigated the subject.

Q. Do you regard the water of the Potomac as the sole cause of the typhoid fever in the city of Washington?

A. No, sir.

Q. What other causes do you consider as contributing to the typhoid fever?

A. In the first place we have of course the direct infection of one patient from another, as in the case of nurses.

In the second place we have a great number of persons who are infected through milk.

In the third place we have a certain number,—possibly we have never discovered them,—I say possibly, who are infected through oysters and vegetables eaten raw.

In the fourth place we have persons visiting here from other cities, or persons who are returning from summer resorts who are residents here, who develop the disease, and then finally, we have the class of persons who develop it from drinking water, either well water or Potomac river water, as against one 4756 of those classes,—that is the class of persons who contract the disease elsewhere, and develop it here, and the opposite. Of course the persons who contract it here and develop it elsewhere will probably even it up.

Q. Have you any statistics showing the number of persons who contracted it here and developed it elsewhere.

A. Absolutely none.

Q. How, then, are you able to offset one against the other?

A. I don't offset them in actual figures. But we know that if persons living here develop typhoid fever, that the persons who come here for brief stays are liable, and in the natural course of events do contract typhoid fever. We know that our citizens go to other places and develop it, and come home with it, and there is no reason to believe that the situation is different with respect to other persons who may come here and go home.

Q. What percentage of the total typhoids in Washington city would you attribute to the water of the Potomac?

A. Speaking from memory, as to the result of the investigation of a large number of cases that we had last year, I should say from sixty to seventy per cent., and possibly more, and that is from memory, but we carefully investigated it, and that is my best recollection.

Q. And the other thirty or forty per cent. you attribute 4757 to the causes as you have indicated in your previous answer?

A. Yes, sir.

Q. In the investigation that you conducted, that disclosed the sixty or seventy per cent., what did you do in order to arrive at that conclusion?

A. Each case of typhoid fever is investigated by an inspector, who visits the premises for that purpose. He gets the history as nearly as may be of the onset of the case, and the history of the patient prior to its onset as to absence from the city, as to water supply and general food supply, and as to exposure to other cases. Then if we can find any reasonable cause to attribute the case to, or any definite cause, it is so attributed. When it comes to attributing cases to our Potomac river, we have done so only, you may say, as a last resort. A man who is using a milk supply in common with hundreds of others; a man who has not left the city, and a man who has not used well water or spring water, has presumably gotten his typhoid from the great source of the disease, and that is from the water he drinks,—the Potomac river water. It is not of course an absolute demonstration, but you cannot make absolute demonstrations in cases of that kind.

Q. It is speculative largely, is it not?

4758 A. I would rather have you define the term "specuative" I should say—

Q. Not being an expert, but a lawyer, I am absolutely unable to.

A. Well, I should say then that it was a demonstration, not beyond a reasonable doubt, but by a preponderance of the evidence.

Q. Were you able to tell whether those cases that you said came from the Potomac water did not as a matter of fact come from eating oysters?

A. Only by the statements of the patients, that they had not used oysters.

Q. Then you have to rely upon the statements of the patients?

A. Absolutely, in medicine.

Q. And are those statements made at the beginnig or at the close of their cases?

A. They are made as soon as practicable after the reports of the cases. In the investigation last year, that varied very widely. Some of those statements were made promptly and others were made, you might say, some time after the recovery, because the cases came in so rapidly we could not keep up with them, so I could not make a general answer to that question.

4759 Q. Do you know whether they were interrogated, the majority of them, in the beginning or in the convalescing stage of the typhoid?

A. I should say that probably—and you will have to allow me to correct the statement, that it is the patients, because sometimes it is by those in attendance upon the patients—I should say that probably in the majority of cases it was some time after the beginning of the cases.

Q. Do you know how many of those patients were delirious at the time that these statements were made?

A. I think I can safely say none.

Q. Does not the typhoid patient become delirious after three or four days of the disease?

A. Not in the majority of the cases.

Q. You regard then a man with typhoid fever after three or four days duration of the disease, in the majority of cases, as having a mind not in a state of delirium?

A. In the majority of cases?

Q. Yes.

A. I so regard them. I might add that the investigation was made by a medical man, as bearing on the question that the interrogations were not made to a patient in a state of delirium.

4760 Q. It is sometimes rather difficult to ascertain whether a patient is delirious or not, isn't it, unless you are with him a good while?

A. No, I think not. It has not been my experience.

Q. Have you ever had typhoid fever yourself, doctor?

A. No, sir.

Q. Now, in arriving at this percentage that came from the Potomac river water in the city of Washington, would you say that that percentage is accurate?

A. I testified before that that was merely from the best of my recollection, so that I could not say that that was accurate.

Q. Now, in the statement that you read I notice that the totals in the first column of figures—what does that total mean?

A. Those are the totals that I read (referring to paper).

Q. Didn't you read those in?

A. No, that includes three years that were in the other table, so I read from 1895 down. Those are the totals that I read (indicating). The totals that I read represent the total number of reported deaths from typhoid fever during the years indicated.

Q. 1893, 1894 to 1900?

A. Yes, sir.

Q. What is considered as an epidemic of typhoid fever; what death rate?

4761 A. I would be unwilling to define the term "epidemic." The term has no definite meaning, and it is impossible to state what an epidemic is.

Q. In this table marked Exhibit No. 73, you have what is known as typho malaria and typhoid fever. What is the difference between typhoid fever and typho malaria?

A. I regard a case of typho-malarial fever as a case of typhoid fever, in which the physician has made a mistake at the beginning and called it malarial fever, and he seeks the best way to get out of the hole. We classify them separately because some people regard them as different diseases, and we furnish our statistics to people and let them use them as they see fit, but I have expressed my opinion.

Q. You give the people what you think they want, then?

A. We give it to them and they can call it typhoid fever, or typho malarial fever, as a distinct disease.

Q. But is there a distinction as a matter of fact between typhoid fever, typho malaria and malarial fever?

A. There is a very marked distinction between malarial fever and the other diseases, unless you regard the typho malarial fever as typhoid fever. When it comes to typho malaria and typhoid fever, the best authorities today I believe, regard them as the same disease.

4762 GENERAL CROW: In other words, they don't recognize typho-malaria at all?

A. No, sir.

MR. TODD: In the study of these statistics how does the public health of the city of Washington compare with other cities of similar size, with regard to typhoid fever?

A. The typhoid death rate is high, according to the United States census figures, which I have recently gone over for a purpose other than this,—the present inquiry—there were about two large cities that excelled it in the typhoid fever death rate. One was Pittsburg, and the other Atlanta.

Q. How did Philadelphia compare wiih it?

A. Philadelphia was below. These were United States census figures and may or may not be correct.

Q. These tables merely show the deaths from typhoid fever?

A. Yes, sir.

Q. The number of cases are not tabulated in these?

A. No, and it has been only since February 1st, I think it was, sometime in 1902, that the cases have been reportable.

Q. What is considered a normal death rate from typhoid for 10,000 inhabitants?

A. It would be hard to fix a normal death rate from a
specific disease of that kind. I should say that the death
4763 rate should run down certainly not above ten.

Q. I notice that from 1893 to 1902, according to this table submitted here, that the rate per 10,000 of population under that heading is a figure for 1893 of 7.43; what does that mean?

A. That is,—I should have said one instead of ten. In that case it was 100,000, I was figuring on. That means that out of every 10,000 people in the city for one year that number died from typhoid fever.

Q. Then a normal death rate would be one in 10,000 people?

A. I could not say a normal death rate. There is no normal death rate for typhoid fever. We should have none, but I should say that it should not exceed that; but that would not be normal. We should have none.

Q. Do you know of any city on the American continent where the death rate from typhoid fever is one in 10,000?

A. I would not undertake now to recall the death rates of the various cities. I could not answer that question without reference to the statistics.

Q. The water of the Potomac is a polluted water, is it not?

A. I so regard it.

Q. And where does it get its pollution from?

A. The pollution of course varies in its nature and varies
in its origin. You get part of the pollution from the
4764 bottom of the stream, part from the banks and part from
the drainage, from the habitations that border on the
stream.

Q. The stream runs through a very thickly settled country, does it not?

A. It cannot be regarded as thickly settled.

Q. Are there any cities lying on its shores?

A. There are some small hamlets from place to place, and then within a distance of 152 miles up there are nine communities, the largest of which, according to the latest United States census has a population of 17,128; the smallest of which has a population of 824.

Q. Are there any streams that empty into the Potomac?

A. Quite a number.

Q. Are there any cities or towns located upon those tributaries?

A. Yes, small places that border on them. This includes the two branches, the Shenandoah and the Potomac proper. The Shenandoah is an independent stream, and yet it comes in at Harper's Ferry as quite a large branch, as big as the Potomac I think, and the statement I made includes both branches. The distance as given, of 152 miles represents the distance above the Great Falls. We get no water for our water supply below that point, so they measure the distance above Great Falls.

4765 Q. What do you mean by Great Falls, a place right near Washington, here?

A. Yes, 15 miles up about, up the river there is what we call the Great Falls. Our dam is across the river there.

RE-DIRECT EXAMINATION, by General Crow.

Q. Do you know, doctor, the number of cases in this city in 1902, of typhoid fever—do you recollect them?

A. I don't recollect them. I looked them up this morning, but made no note of them.

Q. Do you know the approximate number?

A. To the best of my recollection, it was about 1500 or 1600.

Q. Doctor, will you please give me the names of those nine towns on the watershed above your intake, and their population and distances from this city?

A. Distance from Great Falls?

Q. Yes, from your intake?

A. Harper's Ferry, West Virginia, 44 miles; population, 896;

Shepardstown, West Virginia, 54 miles; population, 1184;
Charlestown, West Virginia, 54 miles; population, 2392;
4766 Williamsport, Maryland, 75 miles; population, 1472;
Front Royal, Virginia, 84 miles; population, 1005;
Hancock, Maryland, 84 miles; population, 824;
Cumberland, Maryland, 127 miles; population 17,128;
Keyser, West Virginia, 147 miles; population, 2536;

Piedmont, West Virginia, 152 miles; population, 2115;

The measurements are taken from the annual report of George H. Elliott, Colonel, Corps of Enginers United States Army, in charge of the Washington aqueduct by appendix B B B of the annual report of the Chief Engineers for 1894. That is, the distances were taken from that and the population figures are taken from the last annual report of the census office.

Q. Doctor, do you know whether or not any of those towns have sewers that have outfalls into the Potomac river?

A. I don't know about that.

Q. They are in the drainage shed of the river, however?

A. Yes, sir.

GENERAL CROW: Now, Mr. Todd, I want to introduce some photographs taken of the intake tower, St. Louis, and our settling basins, and I want to introduce some maps of statistics, and I want to have Dr. Ravold fix that map that he has,
4767 and then have that man Goetz come over from Pittsburg, Pennsylvania, and I will have to get him to come here or have Mr. Bright go there and have him sign his testimony; and then there are some weather maps I want to put in; but I am perfectly willing to offer all that at Chicago or some time later. There is no more expert testimony that I want to put in and no more facts that will interfere in that way, and with that understanding I am willing to close my side of the case.

Signature of Goetz subsequently waived.

THE COMMISSIONER: The chief, except as indicated, is closed this 6th day of July, A. D. 1903.

ADJOURNED.

4768 10:00 a. m., Friday, July 10, 1903. Southern Hotel, St. Louis, Missouri.

Present: The Commissioner, Judge W. C. Johns, representing the State of Illinois; Mr. James Todd, representing the Sanitary District of Chicago; Messrs. Crow and Jeffries, representing the complainant.

The Commissioner announced that he was now ready to hear defendants' case, complainant having agreed to waive notice, and thereupon defendants announced that there were no witnesses present, and by consent an adjournment was taken to July 13, 1903, on board the Illinois Fish Commission Boat, "Illinois" at the foot of Vine Street, St. Louis, Missouri.

10:00 a. m., Monday, July 13, 1903. On board the steamer "Illinois," continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

Whereupon the following evidence was offered in behalf of the defendants, to wit:

4769 AUGUST JOHNSON,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION, By Mr. Todd.

Q. What is your name?

A. August Johnson.

Q. Where do you live?

A. Where I live now?

Q. Yes.

A. In Burnesville, Missouri.

Q. Did you live at 407 Espensthieh Street?

A. I never lived there, but I always had my mail delivered there.

Q. Where did you live in St. Louis.

A. I lived South of River Des Peres, in the southern part of the city limits.

Q. Did you have anything to do with taking samples of water?

A. Yes, sir.

Q. For whom did you take these samples?

A. I think it was for the Sanitary District of Chicago.

Q. Where was this water taken from?

A. Opposite Jefferson Barracks.

4770 Q. In the Mississippi River?

A. Yes sir.

Q. When?

A. 1899 and 1900.

MR. JEFFRIES: We move to strike out all the witness' testimony with reference to samples taken at Jefferson Barracks from the Mississippi River, for the reason that it is irrelevant and does not tend to prove any issue in the case.

Q. MR. TODD: Did you receive instructions as to how to take the water?

A. I had instructions from the certificate—on the back of the certificate was all the instructions that I had.

Q. From whom did you get these instructions?

A. Well, the instructions, as I said before; I only had instructions on the back of the certificate, I was appointed by Dr. Palmer of the University of Illinois.

Q. I will ask you to examine these cards and state whether the cards are in your handwriting and made by you?

A. Yes sir, I made all them. They are all in my handwriting.

Q. The instructions which you had are printed on the back of these cards, are they?

A. Yes sir.

4771 Q. Did you follow out these instructions?

A. As closely as I possibly could, yes sir.

Q. Now, after you took the water, according to the instructions, what did you do with it?

A. After I took the water I sealed the bottles, packed them in ice and shipped them to the University of Illinois, the University of Chicago, at Chicago, Illinois, and to the Health Department of Chicago.

Q. To whom did you send them to the University of Illinois?

A. Dr. Palmer.

Q. To whom to the University of Chicago?

A. Professor E. O. Jordan.

Q. And to whom to the city of Chicago?

A. To the laboratory at Chicago.

Q. Dr Reyonlds?

A. No, there was no address, only Health Department, City of Chicago, No. 11, City Hall, I don't recollect the number, anyhow to Health Department City of Chicago.

Q. After you had sealed the bottle of water did you place a tag similar to the one that I hand you, upon all the water that you shipped to Prof. Palmer at Champaign, Illinois, of the University of Illinois, Prof. E. O. Jordan of the University of Chicago, and the Health Department of the City of Chicago?

A. Yes sir, they were all shipped alike; all samples were collected at the same time and all treated alike in the shipment.

Q. You numbered the samples, did you?

A. I numbered them, yes sir.

4772 Q. You placed the date on the ticket?

A. Yes sir.

Q. You placed your name upon the ticket?

A. Yes sir.

Q. You placed the height of the water?

A. Yes sir.

Q. The temperature of the water?

A. Yes sir.

Q. The direction of the wind?

A. Yes sir.

Q. The temperature of the air?

A. Yes sir.

Q. And noted about whether it rained or not?

A. Yes sir, I noted that.

Q. By what express company were all these samples shipped?

A. The Pacific Express Company.

Q. Just describe in your own way how you collected the water from the river?

A. Well, the way I collected it was to remove the stoppers, and I held the bottles a certain distance under the water to let it run in, and then I would take it out of the water, put stoppers on and they were taken to the shore where they could be sealed; sealed and packed in ice and forwarded to the different parties.

4773 Q. Where did you get the bottles from?

A. The bottles were sent to me from the University of Illinois, University of Chicago and the Health Department of Chicago.

Q. Did you have any apparatus for handling the bottles?

A. No sir.

Q. What part of the Mississippi River did you take the samples from?

A. From the west side, center and east of center, as near as I could judge the distance.

Q. You took how many samples at a time?

A. At three points across the river.

Q. You began taking samples when?

A. As near as I can recollect in August, 1899, first week of August, somewhere in there.

Q. Before that time you took samples did you not?

A. Before that time I only assisted.

Q. Whom did you assist?

A. Emil Appel.

Q. How long did you assist him?

A. I believe it was something like two months, six or eight weeks, I don't remember exactly how long.

Q. And was the water that you and Emil Appel collected treated in the same manner that it was treated after you began taking it?

A. In the same manner, yes sir.

4774 Q. You saw the water shipped at that time?

A. I did not see it shipped. I never saw it put on, because I never stayed long enough to go on the train, but I seen it put up.

Q. When did you cease taking water?

A. I believe in September or October, 1900, I don't know the date exactly now, I can't recollect that.

Q. The cards that you sent to Chicago show the dates?

A. They give the dates, they show the dates, yes.

MR. TODD: Mr. Commissioner, I will ask to have this card marked for identification as "Sanitary District of Chicago's Exhibit 1 for identification."

Said card is so marked by the Commissioner.

CROSS-EXAMINATION, By Mr. Jeffries.

Q. When did you say you took these samples?

A. In 1899 and 1900.

Q. What part of the year did you commence?

A. As near as I recollect it was the beginning of August, the first week in August I think.

Q. Now how often did you take the samples?

A. Sometimes once every week and other times, there was once during the winter I took them three times a week,
4775 during the winter of 1900, I believe it was.

Q. Did these bottles have cork stoppers?

A. They had glass stoppers.

Q. And after you had collected the samples you sealed the bottle?

A. I sealed the bottle, yes sir, as soon as I took the sample.

Q. Do you know whether or not those bottles had been sterilized before you received them?

A. I don't know anything about that; they were sent to me, and that's all I know.

Q. Now in taking these samples, you pulled the cork out or stopper out before you put the bottle in the water?

A. Well sometimes, and sometimes not; there was times that I put it in the water and there was times, too, in the winter that the moisture of the air would freeze the cork so you had to take them out before you put them under water, otherwise I couldn't take them out at all.

Q. Now did you remove the corks after you got out on the river in the boat or before you went out?

A. I removed the corks after I got out in the boat.

Q. Now when did you cork them?

A. As soon as I got them out of the river I put the cork right on; as soon as I got them out I put the cork on, as soon as I possibly could.

4776 Q. Now after you had sealed the bottles, what did you do with them?

A. Packed them in ice and expressed them to the different departments as I said before.

Q. That's all you did with them?

A. That's all I had to do was to get them, pack them in ice and forward them to the different departments; that's all I had to do with them.

Q. You put the bottles in a box and then ice around them?

A. Well, there was two different ways, there was a small bottle which I put in a larger vessel, and packed with ice, then I packed ice in an outside can as much as I could pack in; the large bottle I simply put in there; there was no ice used.

Q. What was the size of the small bottles?

A. I believe it was supposed to be a four ounce bottle, I think.

Q. What was the size of the large bottles?

A. It was supposed to be a gallon bottle; that's what is marked on the card; of course I don't know what they are.

Q. How often did you collect samples in 1900?

A. Once a week. No, in 1900, there was sometimes once a week and sometimes three times a week as near as I can recollect. 4777

Q. Now you collected them in the same manner?

A. In the same manner.

Q. And made the same disposition of them?

A. Yes sir.

Q. As those that were collected in 1899?

A. Yes sir.

RE-DIRECT EXAMINATION, By Mr. Todd.

Q. You attached a tag to the bottles when you sealed them?

A. Yes I made out a certificate of shipment; of course I don't remember now what it was; whatever the certificate says.

AUGUST JOHNSON.

4778 Monday, July 13, 1903.

HENRY ATKINS,

(Mitchell's Point on Mississippi River.)

called as a witness in behalf of the defendants, being first duly sworn by the commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Henry Atkins.

Q. Where do you live, Mr. Atkins?

A. Mitchell, Postoffice, Illinois.

Q. How far do you live from the Mississippi River?

A. About 150 yards I guess.

Q. Mr. Atkins were you employed by the Sanitary District of Chicago to take samples of water from the Mississippi and Missouri Rivers?

A. Not of the Missouri, but of the Mississippi.

Q. At what point?

A. Chain of Rocks, down there.

Q. When were you first employed?

A. May 25, 1900— or 1899.

Q. And when did you cease to take samples of water?

A. October 4th, 1900.

Q. Have you taken any samples since October 4, 1900?

A. No sir.

4779 Q. For whom did you take this water?

A. Chicago Sanitary District.

Q. I will ask you to look at a card, sample number 2528, and ask you if, upon that card, the instructions printed on the back are the instructions which you followed in the taking of water?

A. I took the samples the same as those people told me to take them at the time.

Q. Well, the instructions on the back?

A. That's the way I filled the bottles.

Q. And is that in your handwriting, the card?

A. Yes sir.

Q. After you had taken the water from the Mississippi river, what did you do with it?

A. Took it over to Mitchell's and shipped to Chicago.

Q. Did you seal it?

A. Sealed it up first and put the tags on and shipped it up to Chicago and Urbana. I shipped one to Palmer, one to Prof. Jordan and one to the Sanitary District.

Q. On the tags that you sent attached to each sample, did you place the sample number upon it?

A. Yes sir.

Q. The time that it was taken?

A. Yes sir.

Q. Your name as the Collector?

4780 A. Yes sir.

Q. The height of the water?

A. Yes sir.

Q. The temperature of the water?

A. Yes sir.

Q. Direction of the wind?

A. Yes sir.

Q. Temperature of the air?

A. Yes sir.

Q. The absence of or occurrence of rains?

A. Yes sir.

Q. I will show you a tag for sample No. 2,528 and ask you if that was the same kind of a tag with its proper notation that were placed on each one of the samples which you collected and sent to Prof. Jordan of the Chicago University, Prof. Palmer of the University of Illinois at Urbana and the Health Department of the City of Chicago?

A. This is the same kind.

Q. With the proper notations?

A. Yes sir.

Q. What parts of the river did you take the water from?

A. First at 400 feet off the Missouri shore, the first sample; the second sample was at the tower, in the tower, and the third sample was in the main channel; fourth sample 400

4781 feet off the Illinois shore.

Q. Were these samples all taken the same day? Or at the same time?

A. You mean each sample taken the same day?

Q. Yes, cross-section?

A. Yes, all taken the same day.

Q. How often did you take these samples when you first began?

A. Once a week when I first began.

Q. When did you begin to take them oftener than once a week?

A. July, 1900.

Q. How often did you take them then?

A. Three times a week then.

Q. How long did this continue, three times a week?

A. A little over three months up to the 4th day of October.

Q. Did you take any samples after that?

A. No sir.

Q. Where did you get the bottles from that you took the samples in?

A. Mitchell, Illinois; they were shipped from Chicago and Urbana down to Mitchell.

Q. To you?

A. Yes sir.

4782 Q. What kind of bottles were these?

A. Some were gallon bottles and some were half-pint bottles.

Q. What kind of stoppers did you have?

A. Glass stoppers.

Q. Were the stoppers in the bottles when you got them?

A. Yes sir, unless I would find one broken.

Q. When would you remove the stoppers.

A. When I would fill the bottle with water, rinse it out and then refill it.

Q. How would you fill the bottle?

A. Take and remove the stopper and stick them down in the water and rinse them and observe the instructions they told me to, and fill them up again and set them back in their places.

Q. After the bottles were filled and the stoppers replaced, what did you do with the bottles?

A. Put the seal on them.

Q. Where were you when you put the seal on, on the river or on the shore?

A. Sometimes I put them on in the river and sometimes on the shore.

Q. After you placed the seal on the bottle did you attach the tag?

A. I put the tag on them.

Q. And each tag contains the notations that you have 4783 testified to in your previous answers?

A. Yes sir.

Q. After the bottles were sealed and tagged, what did you do with the bottles?

A. Took them over to Mitchell and shipped them by express to the places,—Urbana and Chicago.

Q. How did you prepare them for shipment?

A. Put them in their cases and had boxes with stuff around them packed them up in the boxes, so they wouldn't break, and the bacterial bottles, the small bottles I packed them in ice; that was my instructions.

Q. After you had packed the small bottles in ice, and the large bottles in excelsior, where did you take them to be shipped to Chicago?

A. Took them over to Mitchell station.

Q. By what express company did you ship them to Chicago?

A. Went by the Pacific; the other one, I don't know what it was, sometimes they went by the C. & A., which is the American, I believe, but the Pacific, most of them. The Wabash took some of them.

Q. You shipped them by one or the other of the express companies?

A. Yes sir.

4784 Q. I show you a bunch of tags and ask if they are in your handwriting?

A. That's my handwriting.

Q. They all have "H. Atkins" on them, is that your name?

A. That's my handwriting, yes sir.

MR. TODD: Mr. Commissioner, I will ask to have tag sample No. 2,528 marked Sanitary District of Chicago's Exhibit No. 2 for identification.

Said card so marked by the Commissioner.

CROSS-EXAMINATION, By Mr. Jeffries.

Q. Mr. Atkins, where were you living at the time these samples were collected?

A. At the same place I live now, Chouteau Island.

Q. How far is that from the Chain of Rocks?

A. About a mile and half I should judge.

Q. What time of the day was it that you collected the samples?

A. I collected some in the morning, that is the first I collected, I collected in the morning, before dinner.

Q. Did you collect any in the afternoon?

A. Yes sir, generally about 2:00 p. m.

Q. How soon after you collected them before you shipped them?

4785 A. Before I got them over to Mitchell you mean?

Q. Yes.

A. Oh, it would be about four hours before I would get over there with them.

Q. Occasionally miss a train and hold them over until the next day?

A. Never held them over that I know of.

Q. In not one single instance?

A. There might have been one time; that's all I know. On special collection, Dr. Palmer was down there at one time, and we missed. Missed one time when this man from Urbana was here.

Q. You can remember no other time?

A. Two times is all I recollect on account of special collections.

Q. How about on the regular collections?

A. Didn't miss any time.

Q. That is you don't remember that you did?

A. No sir, I don't remember; there is only the two times that I recollect.

Q. Where did you get these bottles that you used in your collections?

A. Up at Mitchell, Illinois.

Q. Who did you get them from there?

A. They come from Chicago and Urbana; they shipped them there.

4786 Q. Were they shipped every day?

A. No sir.

Q. How often were they shipped?

A. Once a week up to July, 1900.

Q. Shipped direct to you?

A. Shipped to Mitchell, Illinois, to me, yes sir.

Q. Where did you keep them?

A. I went over and got them that day and filled them that same day; I came over in the morning and got the bottles and filled them the same evening and brought them back. On the first collection, once a week.

Q. How about those where you collected three times a week.

A. Well, I got them—always had sample bottles on hand all the time; took the bottles over and brung another set back with me.

Q. They shipped one set at a time, did they to you?

A. When three times a week they had lots of bottles down here then; they had three or four sets always; couple of sets on hand. There would always be a box at the depot waiting for me and I would get the set when I would go over there.

Q. Now what I want to know did you keep those extra sets at your house or did you leave them at the depot?

A. Sometimes over at the depot and sometimes I had some at the house.

4787 Q. Were the glass stoppers in them when you got them?

A. Yes sir.

Q. Did anybody besides yourself have access to them?

A. No sir.

Q. Where did you keep them?

A. In my house there, in a room.

Q. Did you keep them under lock and key?

A. No sir.

Q. Then anybody could have access to them if they had been there?

A. Yes, they could, if they wanted to; I mean when I was filling the bottles, is what I had reference to.

Q. Do know whether those stoppers were removed while you had them there in your house?

A. Why nobody bothered them that I know of.

Q. Now after you went out in the river to collect these samples, you took two kinds of bottles, didn't you?

A. Yes, large bottle and small bottle; gallon bottle and a half pint bottle.

Q. Did you always take the sample at the same place?

A. As near as I could; couldn't always get steady.

Q. You say you rinsed the bottles?

A. Yes sir; that was my instructions, to rinse them out.

4788 Q. Did you rinse both the large and small bottles?

A. Yes sir.

Q. In order to rinse the bottle, how deep under the surface of the water did you go?

A. About that deep I would hold my hand down (indicating).

Q. About how many inches?

A. About four or five possibly.

Q. Then after the water got into the bottle you would take it out and rinse it?

A. Yes sir.

Q. Then what would you do?

A. Put it back under the water again and fill it.

Q. Where was the bottle when the cork was first taken out of the bottle?

A. Why, I had my hands above the water.

Q. And you put the cork back in the bottle to rinse it?

A. No, I took and rinsed it out and put it down again and took it up and put the stopper in it; they wouldn't allow me to hold the stopper in my hand at all; they made me keep it away from the bottle; not touch the stopper.

Q. In other words, they didn't want you to put the fleshy part of your hand against that part of the stopper that goes into the bottle?

A. Yes sir, that's it.

4789 Q. How deep under the surface of the water did you hold the bottle when you collected the sample that you shipped?

A. Five or six inches, something like that; about that deep down (indicating).

Q. Did you ever collect any with a machine of any kind?

A. No; I made a patent of my own there towards the last; I made a wooden holder and held the bottle in that.

Q. You say you only collected once a week or three times a week?

A. Once a week up to July, 1900; oh, I missed some collections; I couldn't collect every time. I missed sometimes when the river was froze over or ice running.

Q. Now from July, 1900, you collected three samples?

A. After July, 1900, I collected three samples, three times each week.

Q. Three times each week?

A. Three times each week.

HENRY ATKINS.

4790 Alton, Illinois, July 13, 1903.

F. M. CALHOUN,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. You may state your name, occupation and place of residence?

A. F. M. Calhoun, fisherman, place of residence, city of Alton, State of Illinois.

Q. Were you ever in the employ of the State of Illinois, in taking samples of water, and if so when and at what place?

A. Yes sir. I have been employed by the State Board of Health, in taking samples out of the Illinois river at its mouth, and the Mississippi also.

Q. At what place?

A. Above Grafton.

Q. On what river?

A. The Illinois river, about two miles above Grafton, and the Mississippi river samples was gathered about a half a mile above the town, across on the other side of the channel of the Mississippi.

Q. Were the samples taken in the Mississippi river, taken above or below the mouth of the Illinois river?

4791 A. It was taken above the mouth of the Illinois; that is, it was taken from where the Illinois water couldn't possibly reach the Mississippi water at that place. When it was high, so there was some show of it mixing, why I would go further up.

Q. How many samples did you take each time in the Illinois river?

A. I would take two.

Q. At what points in the Illinois River?

A. About two miles above Grafton, or, well, I will explain it a little plainer. It was in case the Mississippi were higher than the Illinois, I would have to go higher than a certain point. Of course I aimed to get the water clear all the time—the two waters being unmixed, is what I have reference to.

Q. How many bottles and what kinds or sizes did you use each time that you took a sample?

A. Well, I couldn't exactly say. The large sample was a gallon bottle, and I think the small sample was about a four ounce bottle.

Q. Did you use these two sizes of bottles for samples of both the Illinois and Mississippi river water?

A. Yes sir.

4792 Q. State as nearly as you can when you commenced taking samples in each river and how long you continued taking them each time and how many times a week you took them?

A. Well sir, that would be hard for me to tell. I think that I could tell positively. I have a memorandum of it, I think of all of it.

Q. Give your best recollection as to the time when you commenced, and in order to refresh your recollection I hand you a bundle of tickets, which you may examine?

A. Yes sir. I recognize the tickets. 1899, July the 17th. Of course they refresh my memory so I think it was about that time I commenced.

Q. I will ask you to examine the last one of the bundle of tickets and state whether the date upon that is about the time you closed the first taking of water?

A. Well, I could say this. I recognize taking that, but whether that was the last I couldn't tell. I could tell on my book exact.

Q. Do you remember whether you took samples in the early fall of the year 1899?

A. Yes sir.

Q. Do you remember whether you took samples also in the year 1900?

A. Yes sir.

Q. At what time in the year?

4793 A. As for remembering it; I didn't try. I kept an account of it on the book; I didn't try to keep it in my mind.

Q. Examine the tickets which I now hand you, numbered 318 and dated February 15th, 1900, and state whether or not that is a ticket made by you?

A. Yes sir, I recognize my signature on it.

Q. Did you commence taking samples about that time 1900?

A. Yes sir, I remember commencing about that time.

Q. Examine the ticket I now hand you marked in the corner 616 and dated September 24th, 1900, and state whether or not that is also in your handwriting?

A. Yes sir, that is the ticket.

Q. Do you remember whether that was the last of the samples you took in 1900?

A. I couldn't say, but from what I wrote on there, it must have been.

Q. During the period covered by these tickets, did you take samples of water in each river, the Illinois and the Mississippi?

A. Not all the time. I would take the Illinois water by itself sometimes, just one sample, and not the Mississippi.

Q. How frequently during the time that you took samples did you take them? That is how many times a week or a day? 4794

A. Why, sometimes, I would take them once a week, and it varied from that to five times a week.

Q. Describe particularly the manner in which you took the samples?

A. I took them according to the directions on those cards as near as I could.

Q. Did you use any machinery to take it?

A. No sir.

Q. Always by hand?

A. Yes sir.

Q. After the bottles were filled, describe particularly what you did to each of them, each sample?

A. I sealed them according to those directions, very particular, and stamped them with the number I had; I had a stamp with a number on it. It was No. 12 upside-down, is what my stamp was, so it was just as good as if it had been right side up. I have the stamp yet in my possession; I can produce it.

Q. To whom did you send these samples?

A. Mr. J. H. Long, Chicago.

Q. By what means?

A. By express.

4795 Q. How soon after they were taken?

A. Just as soon as convenient to ship them, as near as I could.

Q. How soon after the taking were they shipped?

A. Well, it would vary from an hour, an hour and a half to the time they would be shipped.

Q. How were the smaller bottles packed?

A. Packed in a small can with cotton around it; the can sealed, put in a large can and ice packed around the smaller can.

Q. How was the larger bottle packed?

A. The larger bottle was packed in a box with excelsior around it, and the glass stoppers was tied up tight and sealed.

Q. What did you put upon the bottle? Did you put any tag or card upon the bottle?

A. Yes sir.

Q. Describe it?

A. It was the tag like those, put in an envelope, sealed and directed to Mr. Long, and tied on the neck of the large bottle; that's where I alwys tied the tag.

Q. Was there any tag put upon the smaller bottles?

A. No sir.

Q. Now in what did you put in these envelopes?

4796 A. One of those blanks filled out.

Q. I hand you an envelope for identification, upon which I have put in pencil the letters "J. H. L.," and ask you to state whether that envelope is similar to the ones used by you?

A. Yes sir. That's the same envelope I always used.

Q. The same kind?

A. Yes sir.

Q. Exactly?

A. Yes sir.

Q. Now did you put in such an envelope a card or letter similar to the one which I hand you which is marked 315?

A. Yes sir.

Q. And was the envelope then sealed?

A. Yes sir.

Q. I hand you now for identification a bundle of such cards, together with three pieces—or rather four pieces of white paper and ask you to state whether the writing upon those and each of them, is yours?

A. Yes sir, I am satisfied all those cards I have seen before.

Q. Are those the cards which you put into the envelopes and forwarded to Prof. Long?

A. Yes sir.

4797 Q. And the envelopes in which these were enclosed were attached to the bottles in each instance?

A. Yes sir.

Q. Now I hand you another bundle of cards and you may state whether or not they are in your handwriting.

A. Yes sir.

JUDGE JOHNS: Mr. Commissioner, I will ask you to mark this "Exhibit No. 1 for the State of Illinois, for identification." (Cards enclosed in an envelope, sealed and marked by the Commissioner as requested).

Q. Now were these cards which I now hand the Commissioner and ask him to mark "Exhibit No. 2 for the State of Illinois for identification," all made by you? (Cards enclosed in an envelope, sealed and so marked by the Commissioner).

A. Yes sir.

Q. And were they each put in an envelope and attached to a bottle?

A. Yes sir.

Q. I hand you now a third bundle of cards and ask you to state whether or not those cards are in your handwriting?

A. Yes sir.

Q. Did you take samples of water during the time covered by the dates upon these cards?

A. Yes sir.

Q. I now hand the Commissioner a third bundle of cards and ask him to mark them "Exhibit No. 3 for the State of Illinois, for identification," and ask the witness to state 4798 whether they are all in his handwriting? (Cards enclosed in an envelope, sealed and marked by the Commissioner as requested.)

A. Yes sir.

Q. Were those cards put in envelopes which were attached to bottles containing samples of water?

A. Yes sir.

Q. Did you take samples of water at three different periods, commencing in 1899 and ending in 1901? I mean by that at three different times?

A. Yes sir. I took that many.

Q. How long have you lived at Grafton?

A. I lived there ten years and a few months.

Q. Did you live in the village?

A. Yes sir.

Q. What was your business during that time?

A. Fishing.

Q. By what means, nets or lines?

A. Nets.

Q. Was that your regular occupation?

A. Yes sir.

Q. For how many years prior to the 17th day of January, 1900, did you pursue the business of fishing in the Illinois river?

A. Some every year for eight years.

4799 Q. Did you during those years engage in putting up ice, or assist anyone in putting up ice?

A. Yes sir.

Q. For how many years?

A. Prior to 1900 do you mean?

Q. Yes, prior to 1900?

A. Every year that the ice was fit to put up during that time. There was some years during that time we had no ice fit to put up.

Q. What do you mean by "fit?"

A. It didn't get heavy enough; thick enough.

Q. Did you engage in fishing after January, 1900? And if so for how long a time at Grafton, in the Illinois river?

A. For two years.

Q. Were you aware of the opening of the drainage canal?

A. Yes sir.

Q. What was the condition of the water in the Illinois river before the opening of the drainage canal, as a general thing?

A. Take this time of year, low water, it was very stagnant, down, twelve or fourteen miles, where I was used to going, and not a very good current in it and therefore it was in bad shape. Of course in cold weather it was—the water 4800 was in better condition, of course. After the canal was opened, why it never got so stagnant, as it did heretofore. We had more or less current all the time. Of course it would take some time to explain what I mean.

Q. Go on; that's what we want to know.

A. We could fish it different before you turned it in, than we could afterwards, because the current interfered in part of our way of fishing. Of course we all consider it was better by having a good current.

MR. JEFFRIES: We object to what the witness says as to what they all considered and move that it be stricken out.

Q. JUDGE JOHNS: Go on. Mr. Calhoun?

A. Why I don't know as I have anything more to say.

Q. At which time was the water clearer?

A. Well, after we would get settled weather, without raises, after the canal was turned in, it woud get very clear, different from what it used to be before it was turned in; it would depend upon the rainy weather and raises and falls. Before it was turned in, why take it when it got low, there would be a green scum form over it, and you couldn't tell whether it was very clear or not; with the current we had but very little of that afterwards.

Q. Did you use the water for drinking purposes?

A. Yes sir, part of the time.

4801 Q. Do you know whether the fishermen living upon the river in your vicinity use the water of the Illinois river for drinking purposes?

MR. JEFFRIES: Objected to as incompetent, irrevelant and immaterial, as not tending to prove any issue in this case and not competent of this witness.

A. Yes sir.

Q. At which time was it best for drinking purposes?

MR. JEFFRIES: We object to the question for the reason that the witness is not qualified as being capable of testifying from a sanitary standpoint as to whether the water was suitable for drinking purposes at any time.

A. Well it was better in cold weather, of course.

Q. With reference to the opening of the drainage canal, was it—which was the better condition for drinking purposes?

A. Well of course twice a year it was just as good as any time, but of course it wasn't so good before the Canal was turned in, when that green scum was on it. Of course we overcome that some when we was compelled to drink it during that time by sinking a jug down under the surface of the water and got it in that way.

Q. Is it your opinion that it was better for drinking purposes after the canal was opened?

4802 MR. JEFFRIES: We object to the question for the reason that the witness is not qualified as an expert on the sanitary condition of the water, nor as an epidemiologist, and for the further reason that any opinion that the witness himself might have, would be irrelevant and incompetent and without weight.

A. I couldn't say as to that; we drank it before and afterwards just the same.

Q. With reference to the ice which you put up and assisted in putting up, at which time was it clearer, before or after the opening of the drainage canal?

A. Well, that is a question hard to answer. It would depend on the condition the river was in, when she froze up and the ice was made. Of course it is hard to answer on that account. It might have froze up muddy afterwards, when the canal was turned in, it would be bad looking ice, and it might have done that before; I couldn't say.

Q. As a general rule, at which period was the ice more clear, before or after the opening of the drainage canal?

A. I couldn't say.

Q. Was there at any time before or after the opening of the drainage canal a disagreeable odor in the water at Grafton?

A. No sir, not any more than it always had, that I could say.

4803 Q. When the river was frozen over, was there a disagreeable odor in the water under the ice, either before or after the opening of the drainage canal?

A. No sir; I didn't see no difference.

Q. Are there ice houses at Grafton in which you assisted in putting up ice?

A. Yes sir.

Q. Both before and after the opening of the canal?

A. Yes sir.

Q. Did you ever have occasion to examine the draining, or drains from the ice houses?

A. Yes sir, some.

Q. Could you tell whether there was any odor from the drains or water running from the ice houses?

A. Why there is more or less of an order from an ice house at any time as near as I can tell; I have examined them of course.

Q. Could you tell any difference in the odor, whether there was a greater odor after the opening of the canal?

A. No sir.

Q. Than before?

A. No sir.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Where did you get the bottles that you used in taking these samples of water?

4804 A. They were shipped to me from Chicago.

Q. Do you know who shipped them?

A. Yes sir, I think I do.

Q. Who was it?

A. Mr. J. H. Long.

Q. How many did he ship at a time?

A. Well, they varied; they come sometimes two of them, and I think as high as 20 of them; it varied between that.

Q. They were shipped direct to you?

A. Yes sir.

Q. What did you do with them?

A. I taken care of them and used them as I was ordered to do.

Q. Took care of them in what way; where did you keep them?

A. I kept them locked up in a small building that I had.

Q. Nobody else got in there?

A. No sir.

Q. Now when you went out in the river to take these samples, you first rinsed the bottle before you took the sample, did you?

A. No sir.

Q. Did you use some kind of an instrument in getting them?

A. No sir.

Q. Now state how it was done?

A. Well, I would take the bottle in the left hand and a hold of the stopper with this hand, put it under the water and
take the stopper out; when the bottle filled, I put the stop-
4805 per back again.

Q. How deep under the surface of the water did you get the bottle?

A. I suppose they got about a foot under the water is about as far as I could get them.

Q. And you took it up, corked it, sealed it, packed it and shipped it?

A. Yes sir.

Q. What time of the day would you generally take the sample?

A. Along about four o'clock in the afternoon.

Q. You would start out and get the sample in the Illinois river, then you would carry those samples along with you to the Mississippi river and then you would take all those samples and bring them back and ship them?

A. Yes sir.

Q. Now how long would that take you?

A. You mean the whole trip from the time I would start?

Q. Yes.

A. It would depend on the wind I had to pull against.

Q. Well about how long, approximate it, about how was the average?

A. About two hours.

4806 Q. Then after you packed them you put them right on the train and expressed them through?

A. Yes sir.

Q. How many times did you miss getting the samples on the train the day that you intended to get them on?

A. I don't remember of ever making a failure.

Q. You say, I understood you to say that about the only difference in the water of the Illinois river before and after the opening of the canal so far as appearance is concerned, is that prior to the opening there was a green scum on the water in places while that is not true now; there is no scum now?

A. No sir, the current keeps it carried off.

Q. Well that is your testimony that that was the only difference in the water so far as appearance was concerned?

A. Yes sir, about the only difference.

Q. Now this green scum never forms on running water does it?

A. No sir, not like we have on dead water.

Q. So that the real difference is that there is a running current now when before at times, there was no current?

A. Yes sir.

Q. Since the opening of the canal has the water in the Illinois river ever got so low that there was no current?

A. No sir, but then that don't always make the dead water.

4807 We had a sixty mile current up the other way this year. She was dead the other way. It depends on the Mississippi, or controls it to a certain extent, but it doesn't control it now so much as it used to.

Q. You are speaking now of the back water from the Mississippi river, aren't you?

A. Yes sir.

Q. Now if the back water from the Mississippi stood in the Illinois river long enough, a green scum would form would it not?

A. Yes sir, likely it would, in hot weather.

Q. How far up the Illinois river have you been?

A. Above Hardin a little ways, about twenty-two or three miles further up the river.

Q. Then you don't know of your personal knowledge that there was 60 miles of back water?

A. Well, of course there is lot of things we don't know. Steamboat people on the Bald Eagle told me personally it backed up sixty miles.

Q. But you don't know it personally?

A. No sir.

Q. You are not acquainted with the Illinois river then above its mouth very far?

A. No sir, I am not.

4808 Q. Well, did that green scum form on the waters of the Illinois river when there was no back water from the Mississippi?

A. No sir.

Q. Neither before or after the opening of the canal?

A. No sir.

Q. You say it did not?

A. Yes sir, I said it did not.

Q. Do you know whether or not the rains have any effect on the appearance of the water with reference to its being clear?

A. Why, if it rained too much, made it muddy, it wouldn't be clear. If the rain was far enough up that the muddy water would settle before it got down to where I was, it would cause a current and wash the scum off.

Q. What's your idea of a drinking water?

A. What do you mean?

Q. Why a water suitable for drinking purposes, clear water?

A. Why, good clear, pure water.

Q. Any water that was clear and cool, you would pronounce good drinking water, wouldn't you?

A. If it had no stench to it.

Q. And that's your idea of water when you say you have been drinking the Illinois river water, that is you drink it because it is clear?

A. Yes, sir; because I think it is about as good as any, about as good as well water.

4809 Q. Well, do you drink it at any and all times of the year now?

A. Yes, sir.

Q. Regardless of its appearance?

A. Yes, sir.

Q. Well, it isn't always clear now?

A. No.

Q. There is much more of a current now as I understood you, than there was prior to the opening of the canal?

A. Yes, sir.

Q. About how much more of a current?

A. Well, there is considerable more. It is hard to answer that question that way.

Q. Do you know whether or not that current is caused by an increased flow of water from the Sangamon river or from other rivers?

A. Well,—

Q. Or do you know what causes it?

A. Yes, sir; I think I do.

Q. Well, what is it?

A. Why, I think it is caused from the canal, a certain amount of it.

Q. What canal?

A. The Chicago Drainage Canal; if you want to know why I know it, I can explain to you why I think I know it.

4810 Q. You can explain it to us if you want to?

A. Why, if it was caused by rains; it would be muddy, more rilier, muddier—not so clear.

Q. Then I understand you to say that the volume of wa coming down the Illinois river now at all times of the year is far in excess of what it previously was or was prior to the opening of the canal?

A. Yes, sir.

Q. Now, there is no back water in the mouth of the Illinois river except when the Mississippi river is high, is that true?

A. Yes, sir.

Q. At ordinary stages it runs out regularly and down the Mississippi?

A. Yes, sir.

Q. A distinct rapid current?

A. Yes, sir.

Q. Flowing out?

A. Yes, sir; a fair current.

Q. Fair current.

A. Yes, sir; it controls it more or less.

Q. Depending on the stage of the Mississippi river?

A. The Mississippi and Illinois.

Q. Now, this ice that you cut, how far up the Illinois river did you go to cut the ice? 4811

A. Why, we cut it right in the mouth of the river; it depends on what you call the mouth of the river there.

Q. In the channel of the river?

A. Not exactly, no.

Q. Was it from the back water from the Mississippi?

A. No, sir.

Q. Where was that ice disposed of or consumed?

A. In Grafton.

Q. How large a place is Grafton?

A. Why, I think its about six or seven hundred.

Q. How long have you been fishing?

A. Eleven years.

Q. Right there at Grafton?

A. No, sir; I spent a year here.

F. M. CALHOUN.

4812 Alton, Illinois, July 13th, 1903.

GUST BAILEY, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. You may state your name, residence and occupation?

A. Well, my occupation at present is fisherman except when I was collecting water; I am what you might call a day laborer.

Q. Residence?

A. East Alton.

Q. Were you ever engaged in taking samples of water for the State of Illinois?

A. Yes, sir.

Q. Do you remember when you commenced and when you finished?

A. Not exactly; I have got a record of it all, but I lost it in this high water.

Q. Were you engaged in taking samples of water more than one season?

A. Yes, sir; I commenced in the fall at first, and the next spring I collected eight samples, and then they stopped.

Q. In what year did you commence?

A. Well, I disremember by year, but I had a record of it, I depended on that. It would show on my cards if you
4813 have them there.

Q. I hand you some cards, one of which is numbered 644 and dated October 10th, 1901, and ask you to examine them and state whether or not the cards are in your handwriting?

A. Yes, sir, it is.

Q. Examine all of them and state whether they are all in your handwriting?

A. Yes, sir.

JUDGE JOHNS: I now hand the Commissioner the cards examined by the witness and ask that they be placed in an envelope and marked Exhibit 4 for the State of Illinois, for identification.

(Cards inclosed and marked by the Commissioner, as requested.)

Q. Where did you take the samples of water?

A. At the mouth of the Missouri, about 100 yards above the dividing waters.

Q. Of what rivers?

A. The Missouri river and the Mississippi.

Q. Were they taken with reference to getting the water of the Mississippi or the Missouri river?

A. Missouri river water is the water I collected.

Q. How frequently did you take samples during the time you were engaged in that business?

A. The first week I taken it three times a week, and along towards the last they put me to four—four collections a week, or it could have been five; I am not positive.

4814 Q. At how many points in the Missouri river, did you take samples each day—each time?

A. About the same point as near as I could hit it.

Q. Where was that point?

A. It was right across the Mississippi from where I lived, at what they call the Mobile Island, it is called the Mobile Island at the mouth.

Q. Where was this point with reference to the current of the Missouri river?

A. Why, I collected the water in the channel in the main current, or at least where the boats ran.

Q. Describe particularly the manner in which you took the samples each time, and the kind of bottle in which it was?

A. I took it in the way I was directed on the card, as strictly as I possibly could.

Q. How many bottles did you have each time?

A. Two. One bottle contained about a gallon of water, and the smaller one about a pint or half a pint.

Q. At what depth did you take the sample?

A. About a foot below the surface of the water.

Q. When the bottles were filled, what did you do with them?

4815 A. I attached the stoppers in as directed and lifted them out of the water.

Q. Did you then place any mark or any tag upon the bottle?

A. Yes, sir; after I sealed them.

Q. How did you seal the bottles?

A. With sealing wax; I placed a rubber cloth over; wrapped the neck well with a rubber string, and put the seal on top of the bottle, placed the little bottle in a can packed with cotton; I also sealed this little can in three places. I took the large bottle, wrapped it also, tied it with a string, wrapped the string forked over the top of the bottle and sealed the string fast to the top. That held the tag.

Q. Did you have any number upon your seal?

A. Yes, sir; J. H. Long, that was all the mark that was on my seal.

Q. Did you also take the temperature of the water?

A. Yes, sir; as you will find there on the cards. And of the air also; stormy or calm; raises or falls.

Q. In the river?

A. In the river. Or standing.

Q. Did you place upon these cards these various items correctly each time?

A. Yes, sir.

4816 Q. And as they are now do they correctly state the temperature of the air and water?

A. Yes, sir; according to thermometer that they gave me.

Q. When you had written upon the card what did you do with it?

A. I placed it in this envelope sealed to the bottle and sealed the tag up—the envelope I called them.

Q. I hand you now an envelope marked John H. Long, on which I have placed in pencil, the initials, "J. H. L." and ask you to state whether or not the envelopes which you used were exactly similar to that?

A. Mine was not cut open, this was left open and I put the tag inside there and sealed it.

Q. After the card was placed in the envelope and sealed, what did you do with the envelope?

A. Why it was simply fastened on the large bottle before I placed the card in the envelope. Sealed fast, understand. Tied and sealed.

Q. Was the string which tied the envelope to the bottle also sealed?

A. Yes, sir; fast to the bottle.

Q. After the bottles had been sealed, what did you do with them?

A. I placed the little bottle in this can as I stated, before, in the cotton, the can of cotton. I placed this can in another can, and packed around it with cracked ice. This 4817 can was sealed in three places. I placed the larger bottles inside of a box in excelsior; we packed it well. That's the bottle that this card was on.

Q. Then what did you do with the box?

A. I carried it to the Adams Express office, in Alton.

Q. How long a time from the time you took the samples until the box that the sample was in—

A. Reached the express office?

Q. Yes, arrived at the express office?

A. Oh, about two hours.

Q. To whom was the box addressed?

A. J. H. Long, Chicago.

Q. Was the course of business in taking each sample the same as you have described?

A. Each sample, you mean, collected the same way?

Q. Yes.

A. Yes, sir.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How long did you engage or were you engaged in collecting these samples?

A. Well, sir, as I stated before, I couldn't call it to memory, but it was from the time I commenced until just a while before Christmas. 4818

Q. You say you collected from three to five samples a week?

A. Yes, sir; it might not have been only four. The dates will show on my cards.

Q. Did you collect the same number each week?

A. No, sir; I collected only three collections the first three weeks and then they added another collection on to that, I forget.

Q. You simply collected them as they ordered?

A. Yes, sir; I collected as they ordered.

Q. Did you rinse the bottles out?

A. No, sir; I just filled them as they was sent to me.

Q. Weren't you instructed to first rinse the bottles out before you filled them?

A. No, sir.

Q. Don't you know that the card on which your instructions were written, and which was attached by seal to each bottle, after the sample was taken, specified in the instructions to you, that the bottle should be first rinsed.

A. No, sir; I think they did that themselves, and for us not to meddle with them.

Q. Did you put the bottle under the water before you removed the stopper?

A. Yes, sir.

4819 Q. What kind of a machine or instrument did you use in gathering the samples?

A. My hands.

Q. How deep under the surface of the water did you go to take the samples?

A. About one foot, about to my elbow (indicating).

Q. You sent no samples to any other person than to J. H. Long?

A. No, sir.

Q. How long have you been a fisherman?

A. Been fishing three years this time.

GUST BAILEY.

Adjourned to the same place at nine a. m., July 14, 1903.

4820 Alton, Illinois, July 14, 1903. Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

GEORGE BROOKS, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. George Brooks.

Q. Where do you live?

A. I live in Alton.

Q. Mr. Brooks, did you collect water for the Sanitary District of Chicago?

A. I did.

Q. When did you begin the collection of water?

A. I didn't keep no dates, but the first I collected was, I commenced in November for the state, the University at Urbana.

4821 Q. What year was that?

A. I couldn't tell you what year it was. If you will let me make a statement I can show you what year it was.

Q. Did you take samples in 1899?

A. Yes, sir; according to that card I did.

Q. Did you take samples in 1900?

A. Yes, sir.

Q. Did you take any samples last year, 1901?

A. Last year, I don't think I did. I quit taking samples a year ago last October, I think it was, when I quit. I took a few samples after that for Prof. Reynolds; I believe I took four samples after that for Prof. Reynolds, after the Chicago people stopped; that was a year ago last October, I think. I didn't keep no dates at all; I guess the card shows the dates.

Q. Where did you take samples from?

A. I took them up here at the new waterworks, about a mile above Alton, except two or three times I couldn't get up there on account of the heavy ice; and then I took here at the old waterworks, I couldn't get up there with a skiff at that time; there was no way of getting them.

Q. What other place did you take water from?

A. I took water at Wood river, down here about six miles.

Q. Where else?

A. Took it down below the mouth of the Missouri; I was
4822 with Prof. Reynolds at that time right along, at the time
we took it below the mouth.

Q. Where else did you take them?

A. No other place.

Q. Then you took it in three places?

A. You mean down there and up here?

Q. Yes.

A. Yes, sir; but that wasn't regular you know, but whenever Prof. Reynolds would come in here and want me to go I would go with him, but one time he sent in here and I went down there another man and myself, and we took water for him.

Q. Where was it that you took regularly?

A. Up here at the new waterworks; that was my regular place.

Q. When you took water down below Alton, that was special takings?

A. That was special, yes.

Q. How many samples of water would you take across the river at one time?

A. I took water in five different places in crossing the river.

Q. For how long a period did you take it?

A. I commenced in November taking regular and I kept
that up—that was for the state alone; that was kept up
4823 until last June. I took five bottles in five different places
in crossing the river. Well, then, the next June I received

these boxes from Chicago, two sets of boxes from there and one from Urbana, and I took them until the next June would be one year, and then the following October, that would be about eighteen months that I took water for Chicago and the State combined.

Q. *In taking water, just describe how you took it; what* you took it in?

A. I used to go up to the waterworks and I would go out as near as I could calculate 100 feet from the shore and anchor; then I had a rigging that I put this bottle in and fastened it in there and then I would sink it down about a foot under water, and take the water, and then I would put that bottle away, and then I would go one-fourth of the distance as near as I could calculate and do the same thing, and then I would go to the center of the river and do the same thing; and then one-fourth the distance from the other shore, and then I would go 100 feet from the other shore and take the last sample; that was my instructions.

Q. What kind of an affair was this rigging that you speak of?

A. It was a piece of board with a little box right down at the bottom of it, and this piece of board was about five or six feet long; this little box was big enough to receive the bottle would fit in there nicely, and then I would tie a string 4824 around the neck of it and then I could plunge it right down under the water and take it that way. I done that in cold weather you know; I couldn't stand it to hold it with my hands in the ice water, was the trouble. It was all right in warm weather, but this rigging, I could use it any time.

Q. Now after you took the water, what did you do with it?

A. I brought it down here and fixed it for shipping, and labeled it.

Q. The bottles that you took the water in, where did you get them from?

A. Why, the express company delivered them to me.

Q. And who sent them to you by express?

A. Chicago and the State.

Q. By the state, do you mean the University of Illinois, Prof. Palmer?

A. Yes sir.

Q. When these bottles arrived, did they have glass stoppers in them.

A. Yes sir.

Q. When did you remove the glass stoppers?

A. Just at the time that I was going to submerge them under *the water.*

4825 Q. And when did you replace them?

A. Instantly as soon as the bottle was filled.

Q. And then, after collecting one series of samples on a given day, you brought the samples to shore?

A. Yes, sir.

Q. And sealed them?

A. Yes, sir.

Q. And placed the tag upon them?

A. Yes, sir; and the small bottles; I also had ice for the small bottles.

Q. Did you do this to all the samples that you collected?

A. I did, sir.

Q. I will show you a card which is sample No. 2222, and ask you if that was the kind of a tag that you placed on all the water samples which you collected?

A. Yes, sir.

Q. That tag is in your handwriting, is it not?

A. Yes, sir; it is.

Q. On these tags you marked the number of the samples, the date of taking?

A. Yes, sir.

Q. The place where the samples were taken?

A. Yes, sir.

Q. Your own name?

A. Yes, sir.

4826 Q. The height of water, temperature of water. direction of wind, temperature of air, and whether it rained or not, did you?

A. Yes sir.

Q. And these tags were placed on all the samples which you took?

A. Yes sir.

Q. Now after you had sealed and labeled the samples, how did you prepare them for shipment?

A. Why I packed them in what we called excelsior; I packed them in that as hard as they could be; and the small bottle of course which was in the can I had to put ice in there; I filled the can full around the bottle.

Q. How large was the big bottle and how large was the small bottle?

A. Well I don't know; them large bottles I think, looked like they might hold a gallon.

Q. And the small bottles?

A. Well the small bottles, they looked like they would hold a pint.

Q. The small bottle was packed in ice and the large bottle and small bottle were put in a box.

A. Yes sir.

4827 Q. To whom did you express these samples?

A. I expressed one sample to the City Hall, Chicago, and the other one to the University in Chicago, that is, one box, you know, and the other one went up here to Urbana, to the state.

Q. Do you know whether the box sent to the University of Illinois at Urbana, was sent to Prof Palmer?

A. Yes sir, it was.

Q. And the one to the University of Chicago to Prof Jordan?

A. Well, his name wasn't mentioned.

Q. And the other to the Health Department of the City of Chicago?

A. Yes sir.

Q. What express Companies did you send these three different samples by?

A. Well, it was United States Express.

Q. How long after they were collected and sealed and packed was it, before you sent them off by express?

A. Well, sometimes it might be two hours before they would go and sometimes it wouldn't be that long. If we could catch the early train in the evening, why they went sooner.

Q. You got them all off the day that you collected them, did you?

A. Yes sir.

4828 MR. TODD: Mr. Commissioner, I ask to have the tag, sample No. 2222, which has been exhibited and identified by this witness, marked "Sanitary District of Chicago's Exhibit No. 3 for identification."

Said card so marked by the Commissioner.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Where did you say you lived?

A. Alton.

Q. Over on the east side?

A. East side.

Q. How long have you lived in Alton?

A. I lived in Alton since 1874.

Q. What is your business or occupation?

A. Well I followed fishing about 15 years.

Q. What are you doing now?

A. Running a skiff ferry and building skiffs.

Q. What kind of an instrument was this that you used in collecting these samples of water?

A. It was a small box nailed onto a board about five foot long.

Q. You put the bottle in the box and submerged it?

A. Yes sir.

4829 Q. When did you pull the cork out?

A. Just before I submerged it; right at the top of the water.

Q. When did you put the cork in again?

A. Just as soon as possible after the bottle was raised out of the water.

Q. Where did you say you took these samples?

A. I gathered them in five different places in crossing the river.

Q. What river?

A. The Mississippi.

Q. Where?

A. Up here at the new waterworks, about a mile.

Q. You mean a mile above Alton?

A. Yes sir.

Q. You generally got the samples out on the train the same day that they were gathered?

A. Yes sir.

Q. How many times did you miss the train?

A. I don't recollect of missing it any time.

Q. You say it was about two hours after the samples were gathered until you got them to the express office ready for shipment?

A. Yes, generally about that time.

Q. Sometimes longer than that?

4830 A. It might have been; sometimes it was a little longer.

Q. You took two kinds of samples, didn't you, a small bottle and a large bottle?

A. Yes sir.

Q. Always packed both bottles in ice?

A. Not the big bottles I didn't; the little one that was in the can.

RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. On the back of these cards were the instructions?

A. Yes sir.

Q. Did you follow these instructions?

A. As near as I could.

GEORGE BROOKS.

4831 Alton, Illinois, July 14, 1903.

JAMES MATHEWS,

called as a witness in behalf of the defendants, being first duly sworn, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. James Mathews.

Q. Where do you live Mr. Mathews?

A. I live on Little's Island, just above the bridge.

Q. That is in the Missouri River?

A. Yes sir.

Q. Did you take samples of water for the Sanitary District and the State University of Illinois and the University of Chicago?

A. Yes sir.

Q. What years did you take the water?

A. 1899 and 1900, according to them cards, I must have run into 1901, but I didn't know it; I supposed it was over before I come to 1901, I didn't keep no dates.

Q. I show you a card to refresh your recollection No. 9746 and ask you if that is in your handwriting?

A. Yes sir.

4832 Q. And the date was put on there correctly by you, was it?

A. 1901, yes.

Q. Look through that bunch of cards and see if all the dates are not 1901, that you collected samples and made the cards?

A. Yes sir, they are all dated 1901 that I see here.

Q. When you first began to take water in 1899, where did you collect from?

A. Fort Bellefontaine bridge.

Q. And at what other points?

A. That's all the point.

Q. How many places?

A. One place, the main channel.

Q. Of what river?

A. The Missouri.

Q. Did you ever collect any water in any other river but the Missouri river?

A. No sir.

Q. Is that place where you collected water known as Fort Bellefontaine, or near there?

A. It's fort Bellefontaine on the other side, and West Alton on this side; I shipped from West Alton.

Q. West Alton is on the Missouri river?

A. Its the closest town on this side to the bridge, West Alton is.

4833 MR. JEFFRIES: That is you mean the bridge at Bellefontaine?

A. Yes sir.

Q. Mr. TODD: See if I understand you. You collected the water from the Missouri river between Fort Bellefontaine on one side of the river and at a point known as the bridge?

A. Yes sir.

Q. And shipped the water from West Alton?

A. Yes sir.

Q. What did you collect the water in?

A. I collected it in what is called three sample boxes; it was a large bottle and two small ones in each case.

Q. How often?

A. Once a week.

Q. During these periods that you collected water, did you collect it oftener than once a week at any time?

A. No sir, I never did, excepting a year ago last winter I collected six days and took it to St. Louis.

Q. Who were you collecting for then?

A. Prof. Palmer; there was a chemist in St. Louis used some of it and part went to Chicago.

Q. Where would you get the bottles from that you used?

A. They were shipped to West Alton, Missouri.

4834 Q. Did the bottles have stoppers in them?

A. Yes sir.

Q. What kind of stoppers?

A. Glass.

Q. Who shipped them to you?

A. Well they were shipped from three places, one from Urbana, one from City Hall, and one from the University.

Q. City Hall in Chicago, you mean?

A. Yes sir.

Q. Describe how you filled the bottles?

A. Well I had a rigging to put them in, I expect about that long (indicating). One for the large bottle and one for the small bottles and they fit in there.

Q. What was this rigging made out of?

A. Iron or steel; I don't know which.

Q. Where did you get this rigging from?

A. From Prof. Irons.

Q. Of the University of Chicago?

A. I think he is from Urbana; I ain't sure; I think he is from St. Louis.

Q. Now just describe how you worked it?

A. Well I would fasten the bottles in, submerge it and draw the stopper and then shove it in and shut it again
4835 and take it out.

Q. You did that with all the samples you collected?

A. Well, I got to pouring off air space; I was told to; I forget who it was told me, there should be an air space, but I loosened the cork up enough to let the air space out and placed it back.

Q. And that is a process which you employed in collecting all the samples which you collected?

A. Well, that was in collecting for this five and a half weeks, which I took to St. Louis over a year ago last winter. I didn't have this machine during that sixteen months or fourteen months that I made collections.

Q. How did you collect the water before you got the machine?

A. In warm weather I rolled my sleeves up and went down above my elbows and removed the cork while it was down there and put it back when it was full and let the air space out and put it back.

Q. In cold weather what did you do?

A. In cold weather I had a rigging similar to what Brooks described there, in fact I took a patent off of his, I couldn't stand that ice water in cold weather.

Q. Now when you filed the bottles, when did you insert the stopper?

A. Right away.

4836 Q. After you got the bottles filled and stopped up, stare what you did with them?

A. I went ashore and packed them.

Q. How did you pack them?

A. I had excelsior; packed them in excelsior the large bottle; would leave a space and put some ice on top of the excelsior; the small bottles I put in the can and filled the can with ice, and filled it with cotton and then filled the box all around with all the ice it would hold.

Q. Did you seal the bottles?

A. Yes sir.

Q. After you sealed them what did you do?

A. Well then I packed them right away after I sealed them.

Q. Did you attach any tag to them?

A. Yes sir.

Q. I show you a tag which is a tag for sample No. 2613, and ask you if you placed a tag similar to that tag upon all the samples of water which you collected and shipped, making the proper memorandum upon it?

A. Yes, if I didn't make no mistake once in a while of a figure; I don't think I did.

Q. Did all the tags contain instructions written on the back?

A. Yes sir.

4837 Q. Did you follow these instructions?

A. As near as I could.

Q. Did the tag which you attached to the bottle contain the sample number, the date, place taken, your name, height of water, temperature of water, direction of wind, temperature of air, absence or occurrence of rain, with direction, upon the back?

A. Yes sir.

Q. After these samples had been prepared in the manner that you have indicated, where did you take them, and to whom did you express them?

A. I took them to West Alton and expressed them to these three places, one to each place.

Q. The University of Illinois?

A. Yes sir.

Q. Chicago University and the Health Department of the City of Chicago?

A. Yes sir.

Q. Do you know whether Prof. Palmer was the one that you sent them to at the University of Illinois?

A. I believe his name was on one envelope; I ain't sure.

Q. Whose name was on the ones for the University of Chicago, Prof. Jordan?

4838 A. Well now I couldn't say; Jordan was one of them.

Q. What express company did you send them out by?

A. Well, I couldn't say; the train used to leave at eight o'clock in the evening and I couldn't say the express company.

Q. What express companies do you have in West Alton?

A. Well there is just a depot there and the express office, and there is four or five roads, I believe runs along there and I don't know which one handled the samples.

Q. You took them to the general express office and sent them on their journey?

A. At West Alton, yes sir.

Q. And what road or what express company they went by you don't recall?

A. No sir.

MR. TODD: Mr. Commissioner, I ask to have card of sample No. 2613 marked "Sanitary District of Chicago's exhibit No. 4 for identification."

Received and so marked.

CROSS-EXAMINATION.

By Mr. Jeffries.

Q. What is your occupation?

A. Fisherman.

Q. How long have you been engaged in that business?

4839 A. 19 years.

Q. Where did you get the bottles that you filled?

A. At West Alton.

Q. Were they expressed to you?

A. Yes sir.

Q. Large boxes of them, were there?

A. No they was about that long and that deep and that wide (indicating).

Q. How many samples each week did you take?

A. I made collections once a week for each sample box.

Q. You say you put the bottle down in the water, pulled the stopper and let the bottle fill; then drew the bottle from the water, pulled the stopper out and let enough water run out to form an air space?

A. Yes sir.

Q. And then you put the stopper back in the bottle?

A. Yes sir.

Q. How long after the samples had been taken before they were shipped?

A. Well it would be I expect three hours, from the time they were collected until they were shipped.

Q. Where did you take them to seal them and pack them?

A. Back to the shore; I live right on the river.

4840 Q. Did you rinse the bottles out before you filled them?

A. I did do that, but I didn't continue it all through.

Q. Why didn't you continue it?

A. Well, it was in the right cold weather; the bottle would freeze with a glare of ice all over it, particles of ice like needles was in the water.

Q. So when there was cold weather on, you didn't rinse the bottles?

A. Not the severest weather.

Q. But you did rinse the bottles in warm weather; hot weather?

A. Yes sir.

Q. Now state how you rinsed the bottles?

A. Well I would get it down and submerge the cork under the water, let a little in shake it around and pour it out; and put the cork in again and put it down and get my water.

JAMES MATHEWS.

4841 Grafton, Illinois, July 14, 1903.

V. J. SCHUMACHER,

called as a witness in behalf of the defendants, being first duly sworn, by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. V. J. Schumacher.

Q. Where do you live?

A. Grafton, Illinois.

Q. What is your business?

A. Pilot.

Q. On what rivers?

A. Illinois and Mississippi.

Q. How long have you been a pilot?

A. Six years.

Q. What did you do before you became a pilot?

A. I was an engineer,—steamboat engineer, or mate either one, half of the time one and half of the time the other.

Q. For how long?

A. For fourteen years.

Q. Upon what rivers?

A. Mississippi and Illinois, mostly on the Illinois river.

4842 Q. How long have you been acquainted with the waters of the Illinois River?

A. 32 years.

Q. From what points?

A. From St. Louis to La Salle, Illinois.

Q. During that time about how many trips have you made up and down the Illinois river?

A. Lord! I couldn't say; that's a hard one. Of course I couldn't give you the exact number of trips, because it was too much. I have been in the excursion business and been up and down the river every year, but I couldn't give you the exact number of times.

Q. Have you been on the Illinois river continuously during that period?

A. Yes sir.

Q. Prior to January, 1900, were you acquainted with the waters of the Illinois river?

A. Yes sir.

Q. What was the condition of the water of the Illinois river from La Salle to Grafton prior to January 17th, 1900, the date of the opening of the drainage canal?

MR. JEFFRIES: We object for the reason that it is incompetent and immaterial.

4843 A. Well, of course I can't give you the exact date, but then during the time since that before the drainage canal went in there the water was green; the water from, well, we will say from Beardstown up it stunk; we couldn't drink the water; it would foam the boilers; but now we can go along and drink the water; we pump the water and use it on excursion boats; before we could not.

Q. Before the opening of the canal what was the color of the water, if you know?

A. Before the opening of the canal we had a green scum on the river;—it smelled bad, it wasn't fit to drink; we would have to get water from the shore; but since the drainage canal we don't have to do that.

Q. Before the opening of the drainage canal, do you know what effect the water of the Illinois river had upon the fish that lived in the water?

A. Yes sir.

Q. What was it?

A. Before the drainage canal came in, we would find dead fish floating in the river; tons of them floating in the river above these dams; since the opening of the canal we have had better water and better fish.

4844 MR. JEFFRIES: I move to strike out all the testimony of the witness to the effect that the water in the Illinois river is better since the opening of the canal than it was prior to the opening, for the reason that the witness has not qualified as an expert upon the sanitary condition of the water for domestic use.

Q. Where was it in the Illinois river that these dead fish were found?

A. Down at Copperas Creek dam; also at the dam below Beardstown, right below Beardstown.

Q. Where else?

A. Also at Campsville; we found them up there every time we would go through there; the boys would make remarks about it on board the boat, about the fish there.

Q. How far down the river would that condition prevail?

A. Well, they would be laying along the shore; after they would pass over the dam they would lay along the shore; but nothing floating; there was no floaters; there would be no current them days to drive the fish along and consequently the fish would drift out to the bank.

Q. At that time how far up the river did you find the green scum?

A. We would find it plumb to La Salle.

Q. And where did that green scum cease to appear down the river?

4845 A. Well, it would generally go down about to Alton before it would begin to vanish, to spread out and go over all parts of the water of the river.

Q. How would the water at Grafton compare with the water at Beardstown and at Pekin?

A. I don't know as it would be much difference in the water at the two places; of course further down the river the water would naturally become more pure on account of the current in the river.

Q. What effect did you observe the sewage from Peoria, and the distilleries and cattle sheds at that place, have upon the waters of the Illinois river, and the glucose factory there?

A. Why, those distilleries would have great piles of stuff in the river; it would lay there, and a steamboat would come up and throw great mounds of it up in the river; and the water would stink; we don't see that any more.

Q. How would the water above Peoria compare with the water below Peoria?

A. Well, the water was better above Peoria always; it was some better than it was below, because it was stiller up there, because this sewage business couldn't go up the river and consequently it didn't have this bad green smell and look to it that it had below Peoria always, but we find we have a good deal better water in the channel now than we had before.

4846. Q. Before the opening of the drainage canal did the people living upon the Illinois river drink the waters of the Illinois river to any considerable extent?

A. We never drank it at all; we would dig holes along the bank or the shore or sink pumps down and get the water that way.

Q. Since the opening of the drainage canal and the admission of Lake Michigan water into the Illinois river, what has been the effect of that water upon the water of the Illinois river?

A. They don't drink—

MR. JEFFRIES: Just wait a minute. The question is objected to because the witness has not sufficiently qualified himself to be able to distinguish the difference between good water and bad water for domestic purposes, or drinking purposes, and for the reason that the witness has not qualified himself as a person able to give an opinion as to the sanitary or unsanitary condition of water, and for the further reason that various persons might drink water, believing from its appearance that it was reasonably wholesome, while in fact it contained more impurities than water less clear.

MR. TODD: In reply to the objection I wish to state that this witness is not offered as an expert chemist, bacteriologist or epidemiologist, but merely as a layman who has lived and
worked upon the Illinois river for the last fifteen years
4847 or more and has had ample opportunity of observing the
waters of the Illinois river before and since the opening
of the drainage canal, and in law we are entitled to have his opinion in regard to the water and other conditions pertaining to the water not as a scientific expert but as a layman.

MR. JEFFRIES: We move to strike out the argument of counsel interposed as an explanation of the testimony of this witness.

(Question repeated) In your opinion as a layman and a man who has observed the conditions along the river?

A. The water has been better since.

Q. In what way better?

A. Better to drink and better to use in every way in the river.

Q. Has the green scum disappeared from the water?

A. Not entirely; to a certain extent, more than it ever was before.

Q. Has the odor of the water disappeared?

A. Yes, sir.

Q. Has the water become more clear than heretofore?

A. Yes, sir.

Q. What has been your observation as to the condition of the water above Peoria before it takes on the sewage of the city of Peoria, since the opening of the drainage canal, as to whether
it is a better water than it was before the opening of
4848 the drainage canal?

A. Now, I can only say from last year; I haven't been up there this year, and last year from July on to late in the fall when we left there, we used the water; before we didn't, from above Peoria up and below Peoria we didn't use no water until we got to Beardstown.

Q. How does the water at Grafton—what is the condition of the water at Grafton at the present time?

A. Well, I believe the water is better than it was before; in fact, we have more water and more current in the river than we had before.

Q. How does the water at Grafton compare with the water at Pekin, immediately below Peoria?

A. Well, there is a good deal of difference in that; it is like a man taking a drink of river and taking a drink of spring water; like where there had been rotten fish or somebody had been laying in it. I wouldn't want to drink the water there. Here we drink the water all the time when we are out in a skiff or such places, when we put ice in it to cool it.

Q. Do you know how many people or approximately how many people live along the Illinois river from LaSalle to Grafton in fish boats or flat boats?

A. No, sir, I do not; there is too many of them.

4849 Q. Have you any idea of the number of people engaged in the fishing industry along the Illinois river, who live upon the river and drink the water of the Illinois river?

A. No, sir, I do not; there is too many of them.

Q. What do you mean by too many of them?

A. Why, there is more than I could tell you. What I mean by that is that there is so many fishermen that live upon the river in cabin boats that I couldn't tell you and tell you the exact number or the amount that is there.

Q. Does it run up in the thousands?

A. Well, it gets pretty close to it I believe, yes, sir.

Q. Have you learned of any sickness that has been attributed to the waters of the Illinois river since the opening of the drainage canal among people living upon the river and drinking the water?

MR. JEFFRIES: We object to the question for the reason that the witness has not qualified himself as being acquainted with the people along the Illinois river, nor has he qualified himself as a witness on the question as to whether or not such persons were affected with diseases caused by bad water, or by some other cause.

A. No, sir; I have not.

4850 CROSS-EXAMINATION, by Mr. Jeffries.

Q. How long did you say you have lived on the Illinois river?

A. I have been on the river since I was twelve years old.

Q. How old are you?

A. 36 years old.

Q. Then you have known the river 24 years?

A. Yes, sir; I have known this river longer than that; 25 years I have been on this river—24 years, that's right.

Q. The first service that you did on the river in the way of steamboating was either as mate or engineer?

A. No, sir; the first service I done in steamboating was firing; I served a year at that.

Q. You served a year at that you say?

A. Yes, sir.

Q. Then you went from that to engineer and mate?

A. Yes, sir.

Q. And then to Pilot?

A. Yes, sir.

Q. I understood you to say that prior to the opening of the canal there was a green scum formed on the Illinois river?

A. That was before the canal was opened?

Q. Yes.

A. Yes, sir.

4851 Q. To what extent did that scum form and what seasons of the year?

A. Well, during the summer seasons or late in the fall until the ice would drive it out.

Q. What was the extent of it?

A. From bank to bank.

Q. All up and down the river?

A. Yes, sir.

Q. Would that green scum freeze up in the winter time?

A. Why, yes, sir; it would to a certain extent; not as bad as it would be in the fall, but where it would be in the eddy, where they would cut ice, there would form that green scum in the water.

Q. You don't know what caused that green scum?

A. No, sir, I do not, unless it would be from the filth in the river, from the water,—there not being no current in the river.

Q. Now, if there had been a current to any great extent, the probabilities are that there would have been no scum?

A. Well, sir, we have a current now, and we have a little scum now.

Q. But there has been no scum to any great extent?

A. No, sir, not to any great extent.

4852 Q. So, then, even though there is a current, the impurities are still in the water, unless the current has taken it out, or else the pure water from the lake has carried it out; isn't that true?

A. I hardly understand what you mean by that.

Q. (Question read). I mean by that, the impurities in the water that formed this scum where there is no current. Now, the impurities in that water are still there, unless the current has taken them out; now isn't that true?

A. The impurities would still be in there unless the current has taken them out, is that what you mean?

Q. Yes?

A. Well, of course, I expect that is right, that the impurities would still be in there, but if it was not for this dead water there would be no scum. We understand that. This scum comes from behind these islands and in these dead pockets where there is no current.

Q. Now, there is no other additional volume of water coming down the Illinois river since the opening of the canal than that which comes through the canal, that was not coming down the river prior to the opening of the canal?

A. Oh, yes; we have the same waters coming into the river today that came in before the canal came in.

Q. That's what I understand exactly, but you have no
4853 other waters?

A. No, sir.

Q. Other than the canal?

A. Other than the canal.

Q. Then as you understand it, the opening of the canal and the water from Lake Michigan coming through the canal, is the cause of the additional volume of water in the Illinois river and the current that now exists in that river?

A. Yes, sir. Of course it's not altogether the amount of water that is there now because we have had a swell in the river.

Q. That was due to local showers, local rains up the river?

A. Yes, sir.

Q. Now, when you say that the water is better now than it was prior to the opening of the canal, you simply mean that first there was no scum on the water, second that the water is clearer than it was prior to the opening of the canal, and that it has no bad odor or anything of that kind?

A. I don't mean that the river had no scum on it at all; it had the scum on it, and it has a little scum on it now, but not as bad as it was before the opening.

Q. Now, state your reasons for saying that the water in the Illinois river is better since the opening of the canal
4854 than it was before the opening of the canal?

A. Before the opening of the canal we had no current in the river to purify the water. We would carry water in buckets and tubs for to supply our boats with to drink. Since we had the current in the river, we dip the water from the river and drink it, by putting ice in it to cool it off.

Q. Now, the fact then that there is a current in the river, is the principal reason for your saying that the water is better now than it was prior to the opening of the canal?

A. The reason why I say that is that the current purifies the water; where there is no current there must be stagnated water; that's the reason why I put it that way.

RE-DIRECT EXAMINATION, by Mr. Todd.

Q. You are not attempting to give the reasons—

MR. JEFFRIES: I will have to object to that as being leading.

Q. You are not attempting to give the reasons why the water since the opening of the canal is better than it was before; but you are simply stating what in your opinion is a fact, are you not?

MR. JEFFRIES: I object for the reason that it is leading.

A. Yes, sir.

4855 Q. What is the main fact that makes you say that the
water is better in the Illinois river today than it was before the opening of the drainage canal?

A. You mean, why do I say this?

Q. Yes.

A. The reason why I say this, is because the water is better and I know that it is better from using it, and the hundreds and hundreds of people that we carried on the steamboats, using the water and not kicking against the water.

RE-CROSS-EXAMINATION, by Mr. Jeffries.

Q. That's all you know about the water in the Illinois river?

A. Yes, sir.

V. J. SCHUMACHER.

4856 Grafton, Illinois, July 14, 1903.

B. F. ROBINSON, called as a witness in behalf of the defendants, after being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. B. F. Robinson.

Q. Where do you live, Mr. Robinson?

A. At Grafton, Illinois.

Q. Mr. Robinson, did you take water for the Sanitary District?

A. Yes, sir.

Q. When did you take it, what years?

A. Well, I don't remember—1900—1899, 1900 and 1901.

Q. For whom did you take water?

A. Well, I commenced for the Chicago Health Department and for the University of Chicago, and also for Dr. Palmer for the University at Urbana.

Q. Of Illinois?

A. Yes, sir.

Q. Where did you take samples of water from?

A. From the Illinois and the Mississippi.

4857 Q. The water that you took in the Illinois was taken at what point?

A. About two miles from here.

Q. Above the mouth?

A. No, sir; not that far, about a half a mile above the mouth.

Q. Of the Illinois?

A. Yes, sir.

Q. How many samples of the water of the Illinois did you take at a time?

A. There was times I took more than others; but I don't remember exactly the number. I took for bacteria and a chemical sample at each place.

Q. How many samples did you take across the Illinois river in one day?

A. I never took them that way; I don't remember exactly how many times, but I don't think we took them that way over a dozen times, if that. I never took them that way only when one of the parties was with me. I just had orders to take a certain amount. They just sent so many bottles.

Q. How—where did you take samples on the Mississippi river?

A. That was out just above what they call Little Island—I don't know the other name for it.

4858 Q. It is above the mouth of the Illinois river on the Mississippi river, is it not?

A. No, sir.

Q. Where would it be?

A. Right out here, right out in this direction (indicating).

Q. Below the mouth of the Illinois river?

A. Yes, sir.

Q. Were these samples which you took in the Mississippi river, Mississippi river water?

A. Yes, sir.

Q. Were any of the samples that you took in the Mississippi river Illinois river water?

A. No, sir; I don't think it was.

Q. You took water from the Mississippi river unmixed with Illinois river water?

A. Yes, sir.

Q. And you took water from the Illinois river unmixed with Mississippi river water?

A. Yes, sir; so far as I know.

Q. Now, after you had taken these samples of Mississippi river water and Illinois river water, what did you do with them?

A. I brought them down home and I put the directions on them where I got them; stated the time; and iced them and took them to the depot.

4859 Q. Now, where did you get the bottles from that you filled with water from the Illinois and Mississippi river?

A. I got some from the health department of Chicago, some from the University of Chicago and some from the University at Urbana.

Q. When these bottles came to you were they corked up with a glass stopper?

A. Yes, sir.

Q. Now, just explain how you filled the bottles with water from the Illinois river and from the Mississippi river?

A. I would just take them by the neck hold the stopper and shove them down.

Q. How deep under the water would you fill the bottles?

A. Just as far as I could reach, down to the elbow.

Q. When would you place the stopper in the bottle?

A. Just the minute I raised it up.

Q. And after you placed the stopper in the bottles you took them to shore where you sealed them, tagged them and expressed them to the University of Chicago, the Health Department of the City of Chicago and the University of Illinois?

A. Yes, sir.

Q. The tags which you placed upon each bottle of water which you collected, did you place the sample number, the 4860 date of collection, the hour of collection, the place of collection, with your name on the cards, the gauge of water, the temperature of the water, direction of the wind, temperature of the air, notation about rain—

A. No, very little I noticed of that.

Q. And did the cards contain the instructions for collecting and sending the sample for analysis printed on the back?

A. .Yes, sir.

Q. I show you a card, sample No. 2618, and ask you to state whether that card is in your handwriting?

A. Yes, sir.

Q. And whether you placed a similar card with proper memorandum, upon each sample of water collected by you and sent to these different parties.

A. Yes, sir.

Q. Did you follow the instructions on the back of the card?

A. Yes, sir; as near as I could.

Q. How did you pack the samples for shipping?

A. They were packed in gallon bottles; the small sample was put in a small can, and that was covered; then the can put inside of a gallon bucket with ice around it; that was my instructions. They were placed in cases of course, or boxes.

4861 Q. And were shipped from Grafton?

A. Yes, sir.

Q. By what express company?

A. Adams.

MR. TODD: Mr. Commissioner, I will ask to have this card sample No. 2618, as testified to by the witness, marked "Sanitary District of Chicago's Exhibit No. 5 for identification."

Said document so marked by the Commissioner.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. What is your business?

A. At present I am a clerk, and a carpenter.

Q. What were you doing at the time you took these samples?

A. I was doing a little fishing, and after that was just after odd jobs, whatever I could find to do.

Q. How often in each week would you take these samples?

A. Well, I couldn't say.

Q. Well, about?

A. During the test I took every day.

Q. What do you mean by the test?

A. That is when they were going through the three months test.

4862 Q. Now, after that how many times did you take them each week, after the test?

A. Well, I quit there; I didn't send any more.

Q. Well, before that?

A. Before that I don't remember; I couldn't say. I haven't kept no record of it; I had no orders to that effect; I would just get my orders you know, to send so much water and I would go and get it, and that was all there was of it; I kept no record of it. Of course I could if I had just thought of it.

Q. Now, after these samples of water were collected, how long would it take, or be before you got them to the express office?

A. Well, I had no regular time; it just depended on the weather.

Q. Two hours?

A. Oh, yes, two hours and sometimes longer.

Q. Sometimes four hours?

A. Yes, sir.

Q. Now, did you get them sometimes to the depot too late to get them out that day?

A. No, sir; I don't think they got there once but what they went on time; if they did, I didn't know anything about it, because I always got them there before the train left.

Q. What time did the train leave?

A. 5:35.

4863 Q. What time did you get the sample?

A. Well, I aimed to get them right after dinner; but if it was bad weather, sometimes I would get them before dinner, but as a general thing I would try to get them as late as I could in the afternoon.

Q. What kind of an instrment did you use?

A. With my hands.

Q. How deep under the surface of the water did you go to get the sample of water?

A. I aimed to reach as far as my elbow.

Q. About a foot?

A. Yes, sir.

Q. Did you uncork the bottle after you put it under the water?

A. No, sir; I pulled the stopper and put the bottle in.

Q. Then you got some water from the surface?

A. I didn't suppose I did by having the air in there; I didn't suppose I did, but that was my instructions.

Q. Did you rinse the bottles?

A. Yes, sir.

Q. According to the instructions?

A. Yes, sir.

Q. When did you cork the bottles?

4864 A. Just the moment I raised it up.

Q. Out of the water?

A. Yes, sir.

B. F. ROBINSON.

4865 Grafton, Illinois, July 14, 1903.

JAMES M. ALLEN, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. You may state your name, residence and occupation?

A. James M. Allen; residence, Grafton, Illinois; retired miller.

Q. What official position do you occupy in Grafton?

A. I am chairman or president of the Town Council.

Q. What is the geographical position of Grafton with reference to the Illinois and the Mississippi rivers?

A. We were formerly located on the Mississippi river, but since the Government has built dikes between Calhoun county and the island opposite, we are now located on the Illinois river, and are so, in fact, in low water.

Q. Calhoun is a county of Illinois located between the Mississippi and Illinois rivers?

A. Yes, sir.

Q. How far from Grafton to the southern point of Calhoun county?

A. Two miles.

Q. So that formerly, the mouth of the Illinois river was two miles or more above Grafton?

4866 A. Yes, sir.

Q. How long have you lived in Grafton?

A. 56 years.

Q. What has been your business and occupation in Grafton since you arrived at man's estate?

A. Miller, flour milling.

Q. Are you in a general way—were you in a general way, acquainted with the waters of the Illinois river prior to the opening of the drainage canal?

A. Yes, sir.

Q. What was the condition of the water at that time in this vicinity?

A. Well, at times in low water, it was almost stagnant.

Q. Was there any perceptible odor about the water when it was stagnant?

A. At times, yes, sir.

Q. Was the water used for drinking purposes to any extent?

A. Not when we could help it.

Q. What was the appearance of the water as to color, or its being muddy?

A. Frequently it was covered with a green scum.

Q. Since the opening of the drainage canal, what has been the condition of the water?

4867 A. At the times when I have seen it, it has been better, but whether it has always been better, I couldn't say.

MR. JEFFRIES: We object to any testimony from this witness upon the character of the water for domestic or drinking purposes, for the reason that he has not qualified as being possessed of sufficient scientific knowledge to express an opinion or belief as to the sanitary condition of water; for the further reason that experience shows that various people will insist upon drinking certain water known to be diseased and infected, with no other excuse than that the water is clear water, and for that reason the testimony of this witness as a layman is immaterial, irrelevant and incompetent.

It is agreed that the above and foregoing objection shall apply to all testimony of all witnesses whose testimony is taken upon the Illinois river, who are not experts, and that this objection shall be treated and considered as applying to all such testimony, without its being further stated. (F. S. B., Com'r.)

Q. Better in what respect?

A. Well, it was purer, and looked better.

Q. Has Grafton a public water supply?

A. No, sir.

Q. From what source do the people obtain water at Grafton?

A. Wells and springs.

4868 Q. Does any portion of the population obtain water for domestic purposes from the river?

A. I think not.

Q. The water—you may state what water is next the shore on the Mississippi river at Grafton, Illinois river water or Mississippi river water?

A. As a usual thing it is Illinois river water; there are times, though, when the Mississippi river predominates.

Q. When is that?

A. Any time when there is a raise in the river, especially if the Mississippi is higher, the current comes through to this shore, and we get Mississippi water, frequently backing up the Illinois river for some miles.

Q. Do you know whether there is a population in and about Grafton engaged in the business of fishing?

A. Yes, sir.

Q. Do you know whether in their fishing operations they use or drink the water of the Illinois river since the opening of the drainage canal?

A. I suppose they must to a certain extent.

MR. JEFFRIES: That question is objected to as being irrelevant, and not tending to prove or disprove any issue in the case.

4869 Q. JUDGE JOHNS: Since the opening of the drainage canal in January, 1900, has there been any stagnant water or water having a green scum upon it, in the Illinois river near this point?

A. Well, I think there has.

Q. At what season?

A. That would be I think in 1901, along the summer months, the fall months.

Q. What kind of a season as to rainfall was the summer of 1901?

A. It was unusually dry.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Why do you say the water of the Illinois river is better since the opening of the Chicago drainage canal than it was prior to it?

A. For the reason that there has been a larger body of water in it and the current has been stronger.

Q. How much stronger has the current been?

A. I could hardly say.

Q. Well, approximate it?

A. Well, I should say perhaps a mile an hour.

4870 Q. You speak, then, from the standpoint that water will purify itself in a running stream?

A. I have always believed that, yes, sir.

Q. And your testimony in this respect is based upon the theory that the water is void of the green scum now?

A. Well, it has a better appearance, and isn't sluggish, and there isn't as much of that scum on the surface as it formerly had.

Q. Are you acquainted with the Illinois river from its source to its mouth?

A. No, sir.

Q. Did I understand you to say that the people of Grafton did not use the water from the Illinois river?

A. No, sir.

Q. Where do they get their water supply?

A. From wells and springs.

Q. And they cut their ice from the Mississippi?

A. Well, they cut their ice from the river and if you call it the Mississippi it is the Mississippi, and if you call it the Illinois, it is the Illinois, usually in winter time when we cut ice it is Illinois ice, from the Illinois water.

Q. When you speak of the water from the Illinois river being better now than prior to the opening of the canal, 4871 you speak simply from your observation of that water?

A. Yes, sir.

Q. Rather than from its use by you?

A. Yes, sir.

Q. You don't use it?

A. Very little.

RE-DIRECT EXAMINATION, by Judge Johns.

Q. What is the population of Grafton?

A. 988.

J. M. ALLEN.

4872 Grafton, Ill., July 14, 1903.

WESLEY PARK, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Wesley Park.

Q. Where do you live?

A. Grafton.

Q. How long have you lived in Grafton?

A. Fourteen years.

Q. What is your business?

A. Practicing physician and surgeon—practice of medicine and surgery.

Q. How long have you been engaged in that business?

A. About 43 years.

Q. Are you acquainted with the Illinois river?

A. Yes, sir.

Q. How much of the Illinois river are you acquainted with?

A. Well, practically between Grafton and Hardin, but not much above Hardin.

Q. How far is that from here?

A. About 30 miles by river.

4873 Q. Were you acquainted with the Illinois river before the opening of the drainage canal on January 17, 1900?

A. Yes, sir.

Q. Have you seen the waters of the Illinois river since that time?

A. Yes, sir.

Q. Were you acquainted with the waters of the Illinois river above Grafton before the opening of the drainage canal as far up as Beardstown and Peoria?

A. As far up as Hardin; not up as far as Beardstown.

Q. Was the water of the Illinois river at Grafton before the opening of the drainage canal, better or worse than the water at Hardin?

A. Better or worse than the water at Hardin?

Q. Yes.

A. I didn't notice any difference in the water at Grafton and Hardin, prior to the opening of the canal.

Q. Since the opening of the drainage canal, has the condition of the water of the Illinois river at Grafton been better or worse than it was before the opening of the drainage canal?

A. Why, I think it is better, purer, clearer, and greater current.

Q. What was the condition of the water of the Illinois river at Grafton before the opening of the drainage canal?

4874 A. It was at other times sluggish, more than it is now; more or less green scum or polluted, whatever it is; more or less moss covered the water prior to the opening of the canal; the current wasn't as swift; the water was more sluggish, more of an impure character.

Q. Since the opening of the canal what is the condition of the water?

A. We have a greater volume, stronger current, clearer, and purer water, is my observation.

Q. In your practice as a physician, have you had anything to do with the fishermen who live in Grafton and whose occupation takes them upon the Illinois river?

MR. JEFFRIES: We object to the question; in addition to the objection urged in reference to the testimony of Mr. Allen, for the reason that it is incompetent and immaterial, and does not prove or tend to prove any issue in this case, and does not prove or tend to prove that the disease laden water coming from Chicago has been purified, and does not prove or tend to prove that the water is in better condition since the opening of the canal than prior to its opening, and does not prove or tend to prove the sanitary condition of the water of the Illinois river.

A. Yes, sir.

4875 Q. What is the population of Grafton?

A. I think between eight and nine hundred; I am not sure about that.

Q. How many doctors are there at present in the city of Grafton?

A. Two.

Q. Have you had any typhoid fever cases among the fishermen and men who live upon the Illinois river, and who pursue their calling upon the Illinois river, since the opening of the drainage canal in 1900?

MR. JEFFRIES: We object to the question for the reason that it assumes that fishermen living on the Illinois river use the water of the river for domestic and drinking purposes.

A. I can't call to mind now any case of typhoid fever among the fishermen in the last three or four years; I can't call to mind any.

Q. Among the sicknesses that you have attended during the last three years, have you attributed as a cause of the sickness the waters of the Illinois river?

A. No, I don't know of any what you call—I don't know of any cases that I have had that I could attribute to zymotic causes; that is of a typhoid character that could be caused by drinking Illinois river water; we have sometimes cases
4876 that we call typho-malarial fever, which is a misnomer; it is simply a continued fever from miasmatic causes; not from a zymotic cause.

Q. How many fishermen do you know who live in Grafton, that are engaged in the fishing business at this point and up the Illinois river?

A. Well, between this and Hardin I certainly know fifty; I think I do; I couldn't tell without counting them; but that is the best of my judgment.

Q. Doctor, from your observation and knowledge of the waters of the Illinois river, what is your opinion as to whether or not the waters of the Illinois river at Grafton are better or worse now than they were before the opening of the drainage canal?

MR. JEFFRIES: That's objected to for the same reason as stated in the objection to Mr. Allen's testimony, for the reason that the witness is testifying as a layman and not as an expert.

A. Well, from a knowledge based upon appearances and a use of the water, I would say that the waters are much better than they were before the canal was opened, and I mean by that its appearance, it has a purer appearance.

4877 CROSS-EXAMINATION, by Mr. Jeffries.

Q. Doctor, what is the difference between what we call the ordinary typhoid fever and typho-malaria?

A. Typhoid fever is what is called a zymotic disease and is a blood poison; it comes from a decay of animal matter. Malarial fever comes from a decay of vegetable matter—miasmatic or malaria, which means bad air, you understand. Now, then chills and fever is a malarial fever or a miasmatic fever. We have a continued form of that sometimes instead of intermittent fever; that we call typho-malarial fever. Typho means like typhoid, that is the grade becomes low and continuous. You understand that chills and fever comes every day or every other day.

Q. Then, as I understand you there is no resemblance so far as the materiality of the disease is concerned?

A. No, sir. It is really a misnomer; there is really no such thing as typho-malarial fever, but physicians have got in the habit of calling it that and it is very often spoken of as such in medical works and medical journals, but the fact is that it is a misnomer; that is all; simply a continued form of malarial fever.

Q. When you say that the water in the Illinois river is better now than it was prior to the opening of the canal
4878 you simply mean by its appearance, do you not?

A. Yes, sir; simply from its appearance and its use; what I have known of its use.

Q. Does there any green scum form on it now?

A. No, sir; I haven't noticed it.

Q. Why does it not?

A. Because the current is swifter.

Q. How much swifter, doctor?

A. Well, it is said now that the current is about six miles an hour; I don't think it used to be six feet an hour thirty years ago—at that time I used to cross over to Hardin and go back and forth in the same track where the canoe had parted the scum, hours before.

Q. Now, what was the condition the year prior to the opening of the canal, the same?

A. Yes, sir.

Q. Right up to the time of the opening of the canal?

A. There is no scum over it now.

Q. Yes, but I mean that condition you have just stated, with reference to the scum being opened by the skiff or canoe obtained some thirty years back and right up to the date of the opening of the canal covered that series of years?

A. Well, so far as I recollect it, more or less.

4879 Q. What, if you know, caused this increase in the volume of water and this increased flow of the current in the Illinois river? What was the cause of it, if you know?

A. My idea is gained from my knowledge of their having opened the canal; throwing the water from Lake Michigan into the canal.

Q. The people here that live in Grafton, get their water from wells and springs, do they?

A. Yes, sir.

RE-DIRECT EXAMINATION, by Mr. Todd.

Q. Do you pump the water out of the river into a tank?

A. No, sir. Mr. Meisenberg has a pump that he elevates the water into a tank and I pipe from his tank some five or six hundred feet to my residence. I have used that water for a number of years, five or six years perhaps; water pumped out of the river, elevated into the tank and then piped from the tank to my house.

Q. Is that water used for domestic purposes?

A. No, sir; more for stock; just for that. I never have used it only for washing purposes and for stock; I don't use it as a beverage, or for cooking; never had occasion to.

Q. Does that water have any injurious effect upon stock?

A. No, sir. I could add that a family living close to me, use it for domestic purposes.

4880 RE-CROSS-EXAMINATION, by Mr. Jeffries.

Q. How large is that tank?

A. Oh, I suppose it holds a thousand or twelve hundred gallons.

Q. The water is pumped into the tank and then allowed to settle, is it not?

A. Well, yes. During the hot weather we run one or two tanks full a day; pump it in for our use; use it for lawn purposes, sprinkling lawns, etc.

Q. Now was that pump and tank in operation prior to the opening of the canal?

A. I can't answer that.

Q. Well, the canal was opened in January, 1900, now you stated a moment ago that this tank and pump had been in operation about five years?

A. I think that is correct; I think it was up prior to the opening of the canal.

Q. Now, the water in that tank is put to the same use now as it was when it was built?

A. Yes, sir.

Q. And no other use?

A. No, sir.

WESLEY PARK, M. D.

4881 Grafton, Illinois, July 14, 1903.

E. MEYSENBURG,

called as a witness in behalf of the defendants, being first duly sworn, by the Commissioner, was examined in chief by Mr. Todd and testified as follows:.

Q. What is your name?

A. E. Meysenburg.

Q. Where do you live?

A. In Grafton.

Q. How long have you lived in Grafton?

A. Since 1867.

Q. What is your business?

A. I am doing a little banking and merchandising business here.

Q. What is the name of the bank with which you are connected?

A. Grafton Bank.

Q. Who is the president of it?

A. I am the sole proprietor.

Q. Are you acquainted with the waters of the Illinois river at Grafton?

A. To a certain extent, yes sir.

Q. To what extent, Mr. Meysenburg?

4882 A. Well, I have always been fond of the river; keep a boat of my own and have always spent considerable time on the river, fishing, hunting, and so forth. I live right on the bank of the river, what is virtually now the Illinois, since this dike has been extended down here.

Q. How far up the river from Grafton are you familiar with the Illinois river?

A. I would say fourteen miles.

Q. Were you acquainted with the waters of the Illinois river prior to the opening of the drainage canal in January, 1900?

A. Yes, sir.

Q. Have you seen and been on the waters of the Illinois river since the opening of the drainage canal?

A. A good many times.

Q. What is your opinion as to the condition of the water and the quality of the water now, as compared with what it was before the opening of the drainage canal?

MR. JEFFRIES: That is objected to—the former objection holds good.

A. I consider it much improved.

Q. In what way?

A. It is not stagnant water, as it was previous to the opening of the canal.

Q. How about its appearance?

4883 A. To my mind it looks much better.

Q. Have you used water of the Illinois river for domestic purposes since the opening of the drainage canal?

A. I have since this high water; my well and cistern were flooded during this high water and I used water out of my elevated tank during that time.

Q. Where did this water come from?

A. Well, from a well that is fed by the river.

Q. How long have you used that water?

A. I think it was June 11th when the water flooded my well; I have used it up to the present time, but had my well cleaned out today.

Q. Has your family used it?

A. To a certain extent, yes, sir.

Q. Have you experienced any deleterious effects from the use of the water?

A. There has been nobody sick at my house.

Q. Prior to the opening of the drainage canal what was the appearance of the water in the Illinois river?

A. It frequently looked like a stagnant pool; no current.

Q. Any scum on the top of it?

A. Oh, yes.

Q. Describe it.

4884 A. Well such as would form on a pond that had no current in it.

Q. Is there a current now in the Illinois river?

A. A decided current.

Q. Are you acquainted with the fishing industry at Grafton as it is carried on in the Illinois river?

A. Yes sir.

Q. Have you any knowledge as to the amount of fish that is shipped from Grafton, that are taken out of the Illinois river?

A. Well, Mr. Todd, I could only make a guess at that; at times there are many fish shipped from here; I have known as high as twelve tons shipped in one night; last week I was told that in one day there were fifteen thousand pounds shipped in one evening. Fishing is a queer business. The fish sometimes run for a week or two and then again the catch is very small; but the fishing industry is quite an item here.

Q. The Illinois river is quite a prolific fishing ground is it not?

A. Yes sir.

CROSS-EXAMINATION.

By Mr. Jeffries.

Q. This well that you said was fed from the river, how was it fed?

A. By I suppose seepage, from the river; it is close to 4885 the river as many wells here are.

Q. Then it occupied the position relatively speaking, of a living well?

A. Yes sir—if I understand you by a living well, is—

Q. Fed from some source under the ground?

A. Yes, fed from some source under the ground.

Q. Now do you know the character of the soil where that well has been dug?

A. Yes sir.

Q. What is it?

A. I went down; I bored down 26 feet before I dug the well, with the intention of having a bored well. I discovered that that wouldn't work. I then dug a well, about three years ago. The first six feet of this well is loam. We then struck about a foot of gravel. Below the gravel we struck a dark mucky soil such as you find a good deal in these bottoms. Below that we struck gravel again and some sand. We went down to the rock and we then got a good flow of water from the river.

Q. That is from the solid rock?

A. Close to the solid rock; it caved in on the river side and gave us plenty of water; the pressure from the river side was sufficient to cave it in and give us quite a chuck of it, which convinces me that it is river water filtered through the soil.

4886 Q. Now it is from this well that you have been using water since the 11th day of last June?

A. As near as I can remember, Mr. Jeffries, yes sir.

Q. You didn't go out into the river and dip the water up and use that water?

A. No sir.

Q. You don't use the water in that way?

A. No sir, never.

Q. Now when you say that the water in the Illinois river is better since the opening of the canal than prior to the opening you base your opinion solely upon the fact that the water is clearer, is that it, and free from the scum?

A. Partly that, Mr. Jeffries, and partly from the fact that I believe running water is better than water that is stagnant.

Q. That is true, is it, regardless of whether the water that is running has been polluted by animal matter or not?

A. Now you are propounding a very difficult question.

Q. Now you answered the question; I want to see how far you are going to go on that opinion?

A. My opinion is that swift running water, polluted 200 miles above where it is to be used, is good water to use.

4887 Q. Regardless of the volume of the water or the extent of the pollution.

A. Now you are going too far, you might get all pollution and then you would get nothing but pollution but where it is mixed with water that is fit to use as in this case, my opinion is, that it is decidedly better than it was then.

Q. When it is based on what you have testified to?

A. Yes sir, my opinion, if it is worth anything.

Q. Where is your house located with reference to the Illinois river?

A. Immediately on the bank.

Q. Now as I understand it, the Illinois River flows almost due south before it empties into the Mississippi river?

A. No sir, it flows due east.

Q. The Illinois river flows due east?

A. Into the Mississippi, yes.

Q. Now the government built a dike up the river from your house how far?

A. The government built a dike connecting Calhoun Point with the Island opposite Grafton.

Q. Now Calhoun point was formerly at the mouth of the Illinois river?

A. Yes sir, Calhoun divides the Illinois and the Missis-
4888 sippi rivers; it is a peninsula really between the two rivers.

Q. So since the building of this dike, connecting Calhoun Point with the Island which lies in the Mississippi river, or which at that time was in the Mississippi immediately to the west of Grafton, it moved the mouth of the Illinois river from its former position down to Grafton, is that correct?

A. Yes sir.

Q. Now is there any water at any time of the year flowing over this dike connecting Calhoun Point with the island?

A. Yes sir.

Q. Is there any time at which water does not flow over that dike?

A. Yes sir.

Q. What seasons of the year?

A. During low water the Mississippi is confined to its own channel, reaching to the warehouse at Grafton, where we are.

Q. From the lower end of the island?

A. Yes sir, this dike comes down here and ends just about opposite here.

E. MEYSENBURG.

4889 Grafton, Illinois, July 14, 1903.

JOSEPH SPANLE,

called as a witness in behalf of the defendants, being first duly sworn by the commissioner, was examined in chief by Judge Johns and testified as follows:—

Q. What is your name?

A. Joseph Spanle.

Q. What is your occupation?

A. Fisherman.

Q. How long have you been a fisherman?

A. Ever since 1851.

Q. Where do you live?

A. I live here at Grafton at the present time.

Q. Did you fish any in the Illinois river before January, 1900?

A. Yes sir.

Q. For how many years?

A. Ever since 1857.

Q. What was the kind of water in the Illinois river before the drainage canal was opened?

A. Well, I couldn't say much about it either way, but sometimes the water got too low.

Q. Did it smell sometimes?

A. Well, it didn't smell much, but it got kind of still; there was no current in it those days.

4890 Q. Did it have a green scum on it in the summer?

Objected to as leading.

A. Yes sir, lots of it sometimes.

Q. Was it good to drink?

A. No sir, it was no good to drink that time; that is in the part of the year when it was low. In high water we used to drink it, when the water was cold.

Q. What color was it?

A. Well, it was a natural color; I couldn't see no difference in the color much; that is in fact I never took notice of the color much either.

Q. Did you fish with nets before the drainage canal was opened?

A. Yes sir. We used to fish with seins and trammel nets, too.

Q. What got on your nets before the drainage canal was opened?

A. What got on it?

Q. Yes, moss and slime?

A. Yes moss and slime got on it three or four years ago I guess; some little moss yet, that comes once in a while, but that current washes it off more.

Q. Do you drink the water since the canal was opened?

Objected to as leading.

A. No sir. I haven't. In the winter time, when it was cold enough to drink. Yes.

4891 Q. Is the water lighter colored now than it was before the drainage canal was opened?

Objected to as leading.

A. It looks more clear now than it was.

Q. You are a German and do not speak English very well?

A. Well, I used to come from France. They used to call me a Frenchman; the state used to belong to France where I came from but now the Germans took it away from France.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. There isn't much more current in that river now than there was before the opening of the canal, is there?

A. Yes, there is a good deal more current, yes sir.

Q. You live here in Grafton?

A. Yes sir.

Q. Have you got a well at your residence?

A. Oh yes sir, I have got a big well too.

Q. Is it a living well or a cistern?

A. A well and cistern both.

Q. You have got both?

A. I got both, yes sir.

Q. You don't use the water from the river then?

4892 A. No sir, I don't use the river water at all when I am home, but when I am out I do use it sometimes.

Q. Not very often though?

A. Not without I have to.

JOSEPH SPANLE.

4893 Grafton, Ill., July 14, 1903.

DANIEL HEATH,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. Daniel Heath, residence, Grafton; occupation, fisherman.

Q. How long have you been a fisherman?

A. Twenty-odd years, I don't know exactly, 25 years probably.

Q. Did you fish in the Illinois river before the opening of the drainage canal?

A. Yes sir.

Q. For how many years?

A. Well, twenty-odd years, twenty-five years ago I fished there; ever since I lived in Grafton.

Q. Have you fished there continuously during that time?

A. Yes sir, every year.

Q. What was the condition of the water of the Illinois river before the opening of the drainage canal?

4894 A. After the spring freshets in the summer time, there was no current in there, the river was dead.

Q. What was the color of the water?

A. Well I don't know as I could say there was much difference in the color of it; it used to have a green scum on it just like a pond in the summer time.

Q. Did you drink it before the opening of the drainage canal?

A. Yes sir, we used to drink it in the cool weather, the summer and fall.

Q. What effect did it have upon your nets before the opening of the drainage canal?

A. Well there used to be a kind of a scum gather on them; *it would hang down in tassels.*

Q. Did the water have a smell?

A. Yes sir, in the summer time when it was stagnated it would smell.

Q. What has been the condition of the water since the opening of the drainage canal?

A. Well we have always had a current in there and the water always seemed to be purer because the current was in there; it kept the banks washed off, the current you know.

Q. Do you drink it now?

4895 A. Yes sir, in the spring and fall and winter. Not in hot weather we don't; not now; the weather is a little too warm.

Q. Are you acquainted with the fishermen in the lower part of the Illinois river?

A. Yes sir, I am acquainted with a good many of them.

Q. For what distance up the river?

A. Well I have been up as far as Campsville; I knew a lot of them a good many years ago; I have lost track of some of them; I know some up the river.

Q. Since the opening of the drainage canal how about the moss upon your nets?

A. Well there has been but very little moss; the nets used to be loaded with moss and we couldn't hardly pull them in the skiff at times; we hardly ever see it any more.

Q. How about the slime that hung down in tassels?

A. It is not so bad any more.

Q. Do you know of any cases of typhoid fever among the fishermen along the Illinois river since the opening of the drainage canal?

A. No sir, I don't remember of a fisherman having typhoid fever.

Q. Do you ever engage in cutting ice on the Illinois river?

A. Yes sir, I cut ice nearly every winter for a week or so here at the mouth.

4896 Q. Would the ice that you cut be of Illinois river water?
A. Yes sir.

Q. Is there any difference in the appearance of the ice since the opening of the drainage canal?

A. I couldn't say whether there is or not; I couldn't distinguish any difference.

Q. Does it seem to you to be about the same since as before the opening of the drainage canal?

A. Yes sir, it looks that way to me.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Your opinion is based altogether on the appearance of the water?

A. Yes sir.

Q. And of the ice?

A. Yes sir. In the winter the water is generally clear and I couldn't tell any difference.

Q. Did you fish in this scum, in under the scum that formed on the river?

A. Yes sir, we have fished under there, but it used to be when the water would get low and dead and stagnated, we could not fish under there, because the current wouldn't hold our nets up but we can fish in there now any time. There is always a current in there and it keeps our nets straight; 4897 the kind of nets we fish with are a little different from what they fish with up the river; we have to have a little current to hold the net out; the nets we fish with are called a buffalo net; a set net; it takes no stake to hold them out now; we always have a current along there and it holds the net out straight.

Q. There is a great deal more current then now than there was formerly?

A. Oh yes, yes sir.

Q. Is that true as far up as you have gone?

A. Yes sir, we always have a current in there now,—only when the Mississippi is the highest and backs it up—we have a current in there. If the Mississippi rises rapidly it backs that river up at the mouth.

Q. You say you live here in Grafton?

A. Yes sir.

Q. You have a cistern at your house?

A. No sir.

Q. A living well?

A. No sir.

Q. Where do you get your water?

A. We get the water out of a well but I haven't any myself.

4898 Q. And you don't use the river water?

A. Only when I am on the river working.

DANIEL L. HEATH.

4899 Grafton, Ill., July 14, 1903.

GEORGE SEIK,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. My name is George Seik; Grafton, Illinois; my occupation is a fisherman.

Q. How many years have you been a fisherman?

A. Been a fisherman since 1892.

Q. During that time have you fished in the Illinois river?

A. Yes sir, I have fished in the Illinois river every spring.

Q. What was the condition of the water in the Illinois river before January of 1900?

A. Of course I couldn't make no dates; prior to any year; but prior to the drainage canal I could.

Q. Well, that is the time.

A. The water in the summer time was a good deal like a pond; the current would leave it, and a green scum would come over it a good deal like a pond; of course when we had a heavy raise, there would be a good deal of current in the river.

4900 Q. Did the water smell?

Objected to as leading.

A. Yes sir.

Q. What kind of an odor?

A. Why it smelled like stagnated water in the summer time; the water never smelled in the spring of the year, but when it had this green scum on it it smelled like a stagnated pond; can't tell just exactly the odor.

Q. What was its color?

A. Well the water had a kind of a milky color, as near as I can tell.

Q. Did you use it to drink before the drainage canal was opened?

A. Yes sir, in the spring and fall we drank it right along, and in the summer time we wasn't in the Illinois very much in the hot weather and if we should happen to be there and had no water, we would drink it then, but not as much as we did in the spring and fall.

Q. How did the water act upon the nets before the opening of the drainage canal?

A. Why, I don't know as it acted any different before than it does after.

Q. As to slime and moss on the net?

A. Why, in the fall of the year there would be moss on the nets.

4901 Q. Since the opening of the drainage canal, what has been the condition of the water?

A. Why, since the opening of the drainage canal there has been more current in the river than there was before, and therefore I think the water is purer than it was before.

Q. Is it better to drink?

A. Why, I don't know that it is any better to drink; the water tastes cool, and it must undoubtedly be better to drink because there is more current in the river; it is a purer water, is what I mean by it; it is a pure water.

Q. How about the moss upon the nets since the opening of the drainage canal?

A. Why, since the opening of the drainage canal I haven't fished any more in the Illinois river in the fall of the year. So I can't say whether the moss is as bad or not.

Q. Is the water in the Illinois river a different color since the opening of the drainage canal?

A. Well, I haven't paid much attention to the color of the water, but the color of the water is different; it raises and when the river falls, you know, it makes a difference in the water, now whether it is the drainage canal or not I don't know.

Q. But it is a different color?

A. Oh, it differs in color, yes, sir, as it raises—as the river raises it muddies up and as the river falls it clears up 4902 some, but whether that is the fault of the canal or not I don't know about that.

Q. Have you engaged in cutting ice in the Illinois river?

A. No, sir.

Q. How far up the river are you acquainted with the fishermen?

A. Why, I have fished from 12 mile Island down—twelve miles up the Illinois river.

Q. About how many fishermen do you know who fish upon the Illinois river?

A. Why, I don't know, but four or five above here, only from our own place; of course I know all from my own place.

Q. How many altogether?

A. I can't tell the exact number, but twenty or thirty anyhow.

Q. Do you know of any typhoid fever among the fishermen?

A. I do not.

Q. Do you know whether in the last three years there has been any typhoid fever among the fishermen?

A. I do not; I haven't heard of any.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. What is typhoid fever?

A. I don't know what it is; its typhoid pneumonia; I don't know what it is caused from; I have heard of it; it's a bad 4903 cold that settles on the lungs, I think is typhoid pneumonia; I don't know what it is; I am not posted on the disease whatever. As I said, I didn't know of anyone having it.

Q. What do you mean by pure water as testified to by you here a moment ago?

A. Pure water,—a clear running stream I think is pure water.

Q. You live here in Grafton, do you?

A. Yes, sir.

Q. Man of family?

A. Yes, sir.

Q. Have you a well at your house?

A. No, sir.

Q. Do you use well water?

A. We use cistern water most of the time.

Q. Cistern water?

A. Yes, sir.

Q. You don't use the river water?

A. Not all the time; only when I am on the river I use it, in the spring and fall.

Q. You say there is considerably more current in the Illinois river now than there was prior to the opening of the canal?

A. Yes, sir; there is more current; the current lasts longer; more regular current the year around than there was before.

4904 Q. Did you ever have the diarrhea?

A. I have had it some, yes, sir.

Q. How often?

A. I couldn't tell you; it has been so long since I have had it.

Q. You have had it, though?

A. Yes, sir.

Q. Do you know of any other fishermen having it?

A. No, sir.

Q. Never heard them complain?

A. Never heard them complain.

Q. So, when you say pure water you mean clear water?

A. I don't exactly mean clear water.

Q. Clear running water?

A. Yes, sir; I don't exactly mean running water; we are talking about the Illinois.

GEO. SEIK.

4905 Grafton, Illinois, July 14, 1903.

ALBERT FREIMANN, called as a witness in behalf of the defendants, being first duly sworn, was examined in chief, by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. My name is Albert Freimann; I live at Grafton; and follow fishing.

Q. How long have you been a fisherman?

A. Nineteen years.

Q. How many years did you fish in the Illinois river before the opening of the drainage canal?

A. Why, I fished from 1885 to 1900, about 15 years, 1884 it was.

Q. With nets?

A. Yes, sir.

Q. What was the condition of the water in the Illinois river before 1900?

A. Why, when it would get down low it would be kind of stagnant during the summer season.

Q. What was its color?

A. Why, as a general thing when it got down low it was a kind of a dark black; it was clear when there was no raise from head waters.

4906 Q. What kind of a smell, if any, did it have?

A. Why, in that condition it smelled like a pond or an inland lake.

Q. What effect did it have upon the nets?

A. Well, I don't know as it would have much effect on nets, only just from the moss and stuff that growed in there at that time, it would get on them when it floated down the river.

Q. Did you drink it?

A. Yes, sir; we did in cool weather.

Q. Since the opening of the drainage canal, what has been the condition of the water?

A. Why, the water seems to be much purer than it was. More current, I suppose, 'is the reason of it.

Q. Do you drink it since the opening of the drainage canal?

A. During the cool weather, yes, sir.

Q. What is its color, is it lighter or darker than before?

A. Why, it seems like it is a kind of a milky like color.

Q. Do the fishermen on the Illinois river so far as you know, generally drink the water when fishing upon the river?

A. Yes, sir; in cold weather all the fishermen that I know of drinks it.

Q. Do they have typhoid fever?

A. None that I know of.

Q. Have you engaged any in cutting ice?

A. Yes, sir.

4907 Q. Both before and since the opening of the drainage canal?

A. Yes, sir; cut ice every winter that they cut it here, for over twenty years.

Q. If there is any difference in the appearance of the ice before and after the opening of the drainage canal, tell what it is?

A. Why, I don't know as I notice any difference.

Q. Does moss gather on your nets since the opening of the drainage canal?

A. It hasn't as yet.

Q. How far up the Illinois have you fished?

A. Fifteen miles.

Q. How many seasons have you fished up as far as that?

A. Why, I fished part of every season that I have been a fishing.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say the water is clearer now than before the opening of the canal?

A. Well, it isn't exactly the same color as it was; it was a kind of a dark black color before the opening of the canal.

Q. The ice is the same color?

A. Well, I never paid much attention; you know when 4908 you would be on the ice cutting or in the house storing, you wouldn't pay much attention to that. I never examined that thoroughly; I don't know as you could notice any difference in it though.

Q. I understand you to say that before the opening of the canal the water was of a rather dark color?

A. Yes, sir.

Q. Now, what was it since the opening of the drainage canal, a kind of a milky color?

A. Kind of a milky like color; looked like you might take a drop or two of milk and drop it in a glass of clear water, just changed about that much from clear water.

Q. You live here in Grafton?

A. Yes, sir.

Q. Married man?

A. Yes, sir.

Q. Do you have cistern water?

A. No, sir; well water.

Q. Living well water?

A. Yes, sir.

Q. You don't use the water from the river then up at your house?

A. No, sir.

Q. You only use the river water when you are out fishing?

A. Yes, sir.

4909 Q. And that is because you can't get anything else?

A. I could take it with me.

Q. What do you mean by pure water as testified to here by you?

A. Why, water fit to drink, healthy, I suppose, would be pure water.

Q. What do you mean by water that is fit to drink?

A. That there is no sickness created from water that you drink I suppose would be pure.

Q. The fact that there is a current in the river, does that have anything to do with the water being purer now?

A. It seems that since that current has been there it was more pure than it was before.

Q. There was more sickness before than since?

A. It seems that there was more chills and fever it seems like around town than there has been since; outside of that I don't know as there is any more.

Q. What kind of a fever?

A. A kind of an ague fever, I guess.

Q. It wasn't typhoid fever?

A. No, sir; not as I know of.

Q. What you mean by pure water then so far as your testimony is concerned, is clear running water in a stream, 4910 judging from its appearance?

A. Well, I judge it from the drinking qualities.

Q. Then you judge its drinking qualities from the appearance of the water?

A. Yes, sir.

A. FREIMANN.

4911 Grafton, Ill., July 14, 1903.

WILLIAM WRIGHT CRANDELL, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. William Wright Crandall; fisherman; residence, Grafton, Illinois.

Q. How long have you been a fisherman?

A. I have been fishing since 1896.

Q. Since that time have you fished in the Illinois river above Grafton?

A. In the spring of the year only—entirely.

Q. What was the condition of the water of the Illinois river before the opening of the drainage canal in 1900?

A. Why, the water was dead; it was stagnated unless we had a head raise.

Q. In what season of the year was that?

A. Why, it generally come in May and run along from May and June to July and August.

Q. What was its color before the opening of the drainage canal?

4912 A. Why, she was dark.

Q. If it had any odor, what was it?

A. Well, I couldn't just say; it wasn't a very pleasant odor; I couldn't define just how it smelled; it didn't have a pleasant smell by no means.

Q. If you fished with nets before the opening of the drainage canal, how did the water affect the nets as to moss and slime?

A. Well, it affected them pretty badly; it covered them all over; it was mostly slime first; it would come on the net and hang down in pieces that long (indicating) and as thick as your finger, and then the moss would come and cover the nets so heavy you scarcely could lift them.

Q. Was the water good to drink?

Objected to as leading.

A. It wasn't so good then; no, sir, it was not.

Q. Since the opening of the drainage canal?

A. Well, within the last two years; I have fished there now in April, and up to that time the water was pure and reasonably clear, with the exception of the leads that would run into it, you know, and in heavy rains.

Q. How about the moss upon the nets?

A. Well, I haven't fished any in the last two years, to tell how the moss would come; it would generally get off in April and doesn't come until that time; that is in the last year or two.

4913 Q. Has there been an odor to the water since?

A. No, sir, not in the spring of the year there hasn't; now, I couldn't say; I haven't drunk any since in April of that water; I haven't been up there and haven't had any occasion to drink it.

Q. Have you engaged in the cutting of ice on the river?

A. Well, no, sir; I haven't cut any ice in fifteen years there.

Q. Have the fishermen on the Illinois river who drink its waters had typhoid fever?

Objected to as leading.

A. No, sir.

CROSS-EXAMINATION, by Mr. Jeffries.

MR. JEFFRIES: I move to strike out the last question and answer, because it assumes that the fishermen on the Illinois river drink the water from that river.

Q. MR. JEFFRIES: Why, wasn't the water just as good prior to the opening of the canal, as it is now?

A. Well, sir, I believe I can explain that to you. You take a spring or pool, if it hasn't an outlet and a stream to flow to it is impure, and before the drainage canal we had no current in the Illinois river at this time of the year; now we have a current there. We have now the last few years all the year around.

4914 Q. Much of a current?

A. Right good current, yes, sir.

Q. What is the difference in the color of the river?

A. Well, before it was dark and now it is a kind of a clear milky color.

Q. You live here in Grafton?

A. Yes, sir.

Q. Man of family?

A. Yes, sir.

Q. Have you a cistern or a living well at your house?

A. I have neither one at my place.

Q. Do you use well water?

A. Yes, sir.

Q. You don't use the river water at your house?

A. No, sir.

Q. Your family doesn't use it?

A. No, sir.

WILLIAM W. CRANDELL.

4915 Grafton, Illinois, July 14, 1903.

CHARLIE JONES, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. Charlie Jones; I generally fish for a living.

Q. You live in Grafton?

A. Yes, sir.

Q. How long have you been a fisherman?

A. About ten years.

Q. During that time, how much have you fished on the Illinois river?

A. Well, I have fished there more or less every year.

Q. What was the condition of the Illinois river before the opening of the drainage canal?

A. Well, it was generally dead water; stagnated water, you might call it.

Q. What is its condition since?

A. Why, there is generally a good current there and it throws off all of that green scum and things of that kind.

Q. What was its condition as to depositing moss on the nets before the opening of the drainage canal?

4916 A. Well, it generally used to take a net up there before the opening of the drainage canal, there was no current you know, and there was a kind of slime and sediment all over it. Since that there hasn't been so much of it.

Q. What was the color of the water before and after the opening of the drainage canal?

A. Well, I don't remember exactly what color it was.

Q. Which time was it best to drink?

A. Well, generally during cool weather.

Q. Before or after the opening of the drainage canal?

A. Well, we generally always drank it in cool weather—well I don't know as it made much difference.

Q. Have you engaged in putting up ice both before and since the opening of the drainage canal?

A. Yes, sir.

Q. If there was any difference in the appearance or quality of the ice after the opening of the drainage canal as compared with before, tell what it was?

A. Well, you generally take where there is a current there is bound to be purer water; bound to make better ice, better to drink.

Q. Did the water have any smell before the drainage canal?

4917 A. Yes, sir, it had.

Q. Has it had any since?

A. No, sir, none that I have noticed.

Q. Do the fishermen on the Illinois river have typhoid fever?

A. No, sir; none that I know of.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Are you a married man?.

A. Yes, sir.

Q. You live here in Grafton, do you?

A. Yes, sir.

Q. Do you use well or cistern water at your home?

A. We use well water.

Q. You don't use river water?

A. No, sir, I don't know as it comes from the river; not very far from the river, couple of hundred yards, I suppose.

Q. Well, I mean you don't take it out of the river?

A. No, sir.

Q. What did you say was the color of the Illinois river water prior to the opening of the canal?

4918 A. Well, I don't know exactly what the color of it was; I never paid much attention to it.

Q. You don't know what the color was?

A. No, sir; it was kind of milky.

Q. When you speak of the difference between the water in the Illinois river now and what it was prior to the opening of the canal, what do you mean?

A. Well, I should judge it would be better to drink; that is, it would be purer; there was a current to drive that stagnated water off, that slime, and so forth.

Q. From that you base your opinion?

A. Yes, sir.

Q. It is just merely an opinion of yours, is it?

A. Yes, sir.

Q. There is considerable more current now than there was?

A. Yes, sir.

Q. In fact, you said a moment ago there was no current before the opening of the canal?

A. No, there was no current before the opening of the drainage canal; since that there seems to be more current.

CHARLES JONES.

4919 Grafton, Illinois, July 14, 1903.

THOMAS COCKSHOTT,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. Thomas Cockshott; Grafton; fisherman.

Q. How long have you been a fisherman?

A. Been fishing for twenty years.

Q. How much of that time have you fished upon the Illinois river with nets.

A. I fished every season; that is for the season; in the spring; sometimes in the summer; I have fished every season.

Q. What was the condition of the water of the Illinois river before and after the opening of the drainage canal?

A. Well you take it before the drainage canal, after the spring raise it was dead; take it along in the summer season after it got down; it was dead; kind of stagnated; now there is a good deal of current in it and there has been for the last three years.

Q. What was its color before and after the opening of the canal?

4920 A. Well it is a different color; whenever it comes a raise, a dirty color; whenever it comes a raise out of the head waters of these creeks, it is muddy and dirty.

Q. Which time has it been generally clearer, before or after the opening of the drainage canal.

A. Take it when its down; take it when it is low.

A. Well it is clearer now than it was then; there is more the color of lake water in it when there is no raise.

Q. Did you drink it before the opening of the canal?

A. Yes sir.

Q. Did it have any smell?

A. Well in hot weather, when it was warm it was pretty tough to drink. We drank it when it was cool in the spring; but when it turned warm we didn't drink it; we took water with us.

Q. Have you drank it since the opening of the drainage canal.

A. Yes sir.

Q. Is it better to drink now than before the opening?

A. I guess it is; it is clearer.

Q. How about moss upon your nets before the opening of the canal?

A. Well it was worse then than it is now; you see that moss up there was so bad we couldn't fish at all when that river was dead.

4921 Q. Have you engaged in putting up ice?

A. Yes sir.

Q. Can you tell any difference in the color or appearance of the ice before and since the opening of the drainage canal?

A. I believe it is clearer now than it was then—the ice.

Q. Have the fishermen upon the Illinois river had typhoid fever either before or since the opening of the drainage canal?

Objected to as leading.

A. None that I know of.

CROSS-EXAMINATION.

By Mr. Jeffries.

Q. What do you mean by dead water?

A. Why, stagnated, dead water; no current.

Q. That is the way it was before they opened the canal?

A. Yes sir, there is always a current here now with the exception of a raise in the Mississippi when we had the back water.

Q. The difference between the water prior to and since the opening of the canal is that prior to the opening of the canal it was a black color or dark color while now it is a milky or white color?

A. Why you take it when it was down and no raise in it, it looks more like lake water.

Q. Did you ever live on a lake?

A. No sir I never lived on the lake; I never lived no-
4922 where only around here.

Q. Have you ever been on the lake?

A. No sir.

Q. Did you ever see the lake?

A. No, no big lakes.

Q. What lakes did you see?

A. I have seen the lakes around through the timber here.

Q. How large is the biggest lake you ever saw?

A. I saw one across here four or five miles long, when a good stage of water in it.

Q. Is it always that way?

A. A dry season it dries up more or less.

Q. And it resembled the water in those lakes, then did it?

A. Yes, a kind of a clear water that was in these big lakes; you take a kind of blue—

Q. Don't tell what they say, we are talking about what you know now.

A. Well I heard about it, read about it, a blue cast.

Q. You never saw Lake Michigan?

A. No sir.

Q. Are you a man of family?

A. I ain't a married man, no.

Q. You live here in Grafton?

A. Yes sir, I was born and raised here. Right up here close to the mouth of the Illinois river. 4923

Q. You board here in town do you?

A. No sir, I have a mother; my mother and I live together.

Q. Have you a cistern or well at your house?

A. I have a well, no cistern.

Q. You use the water that is consumed at the house then out of this well?

A. Yes sir.

Q. You don't use the river water?

A. Only sometimes to wash in when it is a right dry season; we don't use it to drink.

THOMAS C[illegible]SHOTT.

4924 Grafton, Illinois, July 14, 1903.

MARTIN GILMORE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:—

Q. What is your name, residence and occupation?

A. Martin Gilmore; I live in Grafton; Fisherman.

Q. How long have you been a fisherman?

A. I have been fishing twelve years now; twelve years last March.

Q. How many years have you fished in the Illinois river?

A. I have fished there ever since I have been fishing, that is off and on; fished there every year.

Q. What was the condition of the water of the Illinois river before the opening of the drainage canal and after the opening of the drainage canal?

A. Why before it was opened at certain seasons the water was dead; there was no current in there; it had a scum on it, but since the opening of the canal there is a pretty fair current in there all the time.

Q. Any scum?

A. No, we never see no scum up there now.

4925 Q. What was the color before the opening of the canal and after?

A. Why at times now when the water is down pretty low it is clearer than it used to be; it looks darker. But when there is a raise in it it looks just the same as ever.

Q. What was its smell before and after the opening of the canal?

A. Well before it was opened there was times there that slime and scum that was up in there smelled very bad when the water was dead and had no current in there. We seined up there one year when there was no current and we couldn't seine over three or four hours; when we would catch any fish we would have to come down here and ice them; they would spoil right away; but since that thing is it seems like the fish live better.

Q. Did you drink the water both before and since the opening of the canal?

Objected to as leading.

A. Yes sir.

Q. At which time has it been best to drink?

A. Well the water seems to be more clearer now than it used to be and it is clearer; we never drink it in right hot weather; but we drink it right along when the weather is cool; now we use ice out of it; we use the Illinois ice right along.

4926 Q. Do the fishermen on the Illinois river have typhoid fever?

A. I never heard of it; I never known of but one fisherman to die around here that I can remember, and he was an awful old man.

Q. Have you engaged in putting up ice both before and since the opening of the drainage canal?

A. Yes sir.

Q. Can you tell any difference in the quality or appearance of the ice?

A. It seems to be just the same only the ice is clearer now than it used to be; there ain't the dirt in it; the ice on this side, there ain't as much drug in it as there used to be. It looks clearer.

Q. When you fish now, do you take water with you in which there is ice from the Illinois river?

A. No we generally take water from home when the weather is right hot, and take the Illinois ice and put in the water.

Q. And drink that water as long as it lasts?

A. Yes sir.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You say there is no channel in the river now?

A. No what?

Q. No channel, current?

4927 A. Why yes, there is a good current.

Q. How was it before the opening of the canal?

A. There was times there was no current unless there was a raise out of it; there is always some current now.

Q. When you say the water is better now than it was before they opened the canal, what do you mean?

A. Why I say it is clearer looking.

Q. It isn't stagnant?

A. No it ain't stagnant.

Q. It is running?

A. It is running water now.

MARTIN GILMORE.

4928 Grafton, Illinois, July 14, 1903.

WALTER RICHEY,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Walter Richey.

Q. What is your business?

A. Fisherman.

Q. Where do you live?

A. Grafton.

Q. How long have you lived in Grafton?

A. Twenty-two or three years, 23 years I think.

Q. How long have you been engaged in the fishing business?

A. Fourteen years.

Q. Are you acquainted with the Illinois river?

A. Well I think so; part of it.

Q. What part of it?

A. From here to Twelve Mile Island.

Q. How far is that from here?

A. Twelve miles.

4929 Q. What was the character of the water of the Illinois river before the opening of the drainage canal in January, 1900?

A. Well, there was a slight current and stagnant like a pond most of the time in the summer and fall.

Q. Was there any scum or odor to the water?

A. Yes, sir; a green scum in low water when the current was slack; there was a bad smell to the mud where the water would flow away from the mud it smelled bad.

Q. What effect did the water have on the fish?

A. I don't think fish lived as well then as they do now.

Q. How do you know that?

A. Because if we put fish in a float-box they didn't seem to live as well; there was no current, and it seemed like they were softer, and they didn't live as well in the nets.

Q. Have you observed any change in the waters of the Illinois river since the opening of the drainage canal and if so state in what respect?

A. Well, I think the water is purer, clearer, more pure than it was; it seemed like where there was a current it was more pure than in a pond or a lake. It is a different color; it used to be the water would get kind of green in low water time.

Q. Does that condition obtain now?

A. I think not; I haven't seen it that way in the last couple of years or so.

4930 Q. What in your opinion has been the effect upon the Illinois river of the turning of the waters of Lake Michigan through the drainage canal into the Illinois river?

A. Well, I think the river is in better shape and I think the water is in better shape; it is more purer than it was.

Q. Have you been in the habit of drinking the waters of the Illinois river since the opening of the drainage canal?

MR. JEFFRIES: We object to the question because it is leading and suggestive.

A. Yes, sir; I always drink the water in the cooler season of the year; we always carry water with us in warm weather.

Q. When you carry water with you, do you carry ice?

A. No, sir; we don't.

Q. About how many fishermen fish upon the Illinois river from Grafton?

A. About 30 or 35, I guess; such a number as that.

Q. During the last two years and a half, or since the opening of the drainage canal, do you know of any of the fishermen having contracted typhoid fever from drinking the waters of the Illinois river?

MR. JEFFRIES: We object to the question for the reason that it is incompetent and immaterial, and irrelevant because it does not tend to prove or disprove the material issue in this case.

4931 A. No, sir.

Q. Do you know of any fishermen having had typhoid fever during the last three years?

A. No, sir.

Q. Has the water of the Illinois river which you drank had any effect upon your health?

A. I think not.

Q. Do you know of any fishermen here having died of typhoid fever?

A. No, sir.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Where do you live?

A. In Grafton.

Q. How long have you lived in Grafton?

A. Between 22 and 23 years.

Q. Are you a married man?

A. Yes, sir.

Q. Do you use the water from the Illinois river at your home?

A. No, sir.

Q. What do you use?

A. Use well water, if I am home.

Q. Your family uses well water?

4932 A. Yes, sir; but they use river water when we are on the river; I live on the river part of the time.

Q. What is the difference between the color of the water now and what it was before the opening of the canal?

A. Why, the water is a little muddy now; it is more muddy when it is raised.

Q. A milky color?

A. Yes, sir; it used to have a kind of a green moss on it.

Q. There was no current in it?

A. No, sir.

Q. You don't know whether that green scum was caused by decaying vegetable or animal matter, do you?

A. I don't know anything about that, only I know there was a green scum on the lakes.

Q. On what lake?

A. Lakes in the Illinois bottoms.

Q. Those are small lakes?

A. Yes, sir.

Q. There is no green scum on it now?

A. I think not.

Q. That is on the water in the Illinois river?

A. Yes, sir.

Q. What do you mean by pure water that you spoke about a few moments ago?

4933 A. Why, running water, water that looks purer; I think it is more pure than water with a green scum or that looks kind of green.

Q. That's your reason for saying it is better water?

A. Yes, sir.

WALTER RICHEY.

4934 Grafton, Illinois, July 14, 1903.

R. A. SAWYER, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. R. A. Sawyer.

Q. Where do you live Mr. Sawyer?

A. I live in Grafton, Jersey county, Illinois.

Q. How long have you lived here?

A. I have lived here ten years.

Q. What is your business?

A. Fisherman.

Q. How long have you been a fisherman?

A. I have been a fisherman ever since I have been in Grafton.

Q. Have you ever fished on the Illinois river?

A. Yes, sir; I fished some on the Illinois river; fish there every spring.

Q. Do you know what the condition of the water of the Illinois river was prior to the opening of the drainage canal and what the condition of the water is today?

A. Well, I think I know a little about it; I am not an expert.

Q. Tell me what you know about it?

4935 A. I think the water is in better condition now than it was before the drainage canal was turned in.

Q. State what the conditions were prior to the opening of the drainage canal and what they are today?

A. Well, before it was turned in, it was like a lake or a pond; it was filled with green scum on the water and a moss all over the shores; and the water was really a dark green, and today the water is clearer and purer looking than it was before.

Q. How does the water compare now with what it did then for drinking purposes?

A. I prefer drinking it now better than then as far as I am concerned.

Q. Do you drink the water?

A. I do when I fish in here; I am fishing in the spring of the year.

Q. Have you ever experienced any ill effects from the drinking of the water of the Illinois river since the opening of the drainage canal?

A. No, sir.

Q. What effect has the water upon fish?

A. Well, in my judgment the fish lives better today when we take a fish out of the net, than they did before.

Q. Will you describe the difference in the water, as you see it today from what it was prior to the opening of the drainage canal? 4936

A. Well, as I said before; before the opening of the canal the water was green and it had a scum on it and a moss in the river, and today the water is clearer than it was, more pure looking.

Q. Do you notice any effect upon your nets?

A. Well, the nets don't form a scum on them like they used to; they used to form a scum on the nets and the moss would get onto them; but now we are not bothered so much with that.

Q. Do you know of any fisherman that died of typhoid fever in the last two years and a half?

A. I never knew but one fisherman to die since I have been in Grafton and he died with the heart disease.

Q. How old was he?

A. He was about 65 or 70 years old.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say you live in Grafton?

A. Yes, sir.

Q. Married man?

A. Yes, sir.

Q. Do you use the river water at your house or do you use well water?

A. No, sir; we use well water.

4937 Q. Why do you say the water is purer now than it was before the opening of the canal?

A. Because it looks purer and clearer when you look at it. Before the drainage canal it was a green looking color and today it looks clearer than it did.

Q. You drank the water both before and after, did you?

A. I have when it was cold, yes, sir.

Q. That is the only way that you have of telling that the water is better now in your judgment than it was before the opening of the canal?

A. Yes, sir; that is the only way I can tell.

Q. Any current there now?

A. Yes, sir.

Q. Was there before the opening?

A. At times there was when we would have a raise, a head raise up the Illinois somewhere. But the majority of the time there was no current in the Illinois; it was more like a lake or a pond.

R. A. SAWYER.

4938 Grafton, Illinois, July 14, 1903.

ALBERT LEE, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Albert Lee.

Q. Where do you live, Mr. Lee?

A. I live here in Grafton.

Q. What is your business?

A. Fisherman.

Q. How long have you been a fisherman?

A. About fifteen years.

Q. Fishing on the Illinois river?

A. Yes, sir; part of the time; most of the time I was fishing on the Illinois and part of the time in the Mississippi.

Q. Were you acquainted with the waters of the Illinois before the opening of the drainage canal?

A. Yes, sir.

Q. Are you acquainted with it since the opening of the drainage canal?

A. Yes, sir.

4939 Q. Describe the water before and since the opening of the drainage canal and give your opinion as to what effect the waters of the drainage canal have had upon the Illinois river?

A. Well, before the canal was opened, the water—when the water would get low in the fall of the year, it would get very stagnated, and the water would get a kind of green scum, and it would smell very bad, and when we were seining, up there in the fall of the year, would be nearly impossible to keep our fish alive; couldn't only keep them alive a certain length of time. Well, since, we have always had a pretty fair current in the river and the water has been more clear, that is except when there would be a rise in the river, but other times it would be more clear and it was better water and more pure.

Q. When you are out fishing, do you drink the water?

A. Yes, sir; I have up to the last few days, but when the weather got so warm then we quit drinking it.

Q. Do you use ice now?

A. No, sir; generally take a jug of water with us, and then when we get up to the club house we generally fill the jug there.

Q. Do you know of any fishermen that died from typhoid fever in the last two years?

A. No, sir; I don't know of but one fisherman that has died in the last twelve years and he died with heart disease.

4940 Mr. Veach.

Q. Do the fish live any better now than they did before?

A. Yes, sir, they do.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say there is some current in the river now?

A. Yes, sir.

Q. Much of a current?

A. No, sir, not so very much; it seems to be slackening off a little now.

Q. No green scum on the water?

A. No, sir.

Q. Was there a current on the river before the opening of the canal when this green scum formed?

A. Part of the time the river was like a lake no current scarcely at all; sometimes there wasn't any current at all; it was just like a lake.

Q. Why do you say the water is better now than it was before the opening of the canal?

A. Why there is a current in the river now and there is no scum on the water now and it doesn't smell, and it is better now to drink than it was; then you couldn't drink it at all and the fish wouldn't live in the water either.

Q. And still you fished in it?

4941 A. Yes, sir.

Q. Do you know what caused that green scum?

A. No, sir, I do not.

Q. You don't know whether it was vegetable or animal matter?

A. No, sir, I couldn't say; I know that it had a very bad smell to it.

Q. You are a married man?

A. Yes, sir.

Q. Live here in Grafton?

A. Yes, sir.

Q. Do you use the Illinois river water for drinking purposes at your home?

A. No, sir, not now we don't, but up to a year ago we did.

Q. You use well water now?

A. Yes, sir.

RE-DIRECT EXAMINATION, by Mr. Todd.

Q. What did you mean by saying that the fish didn't live in the water?

A. Well, it seemed like that the water was so foul when you would take them out, and handling them in putting them in a box or float net, just that little time out of the water would kill them.

ALBERT LEE.

4942 Adjourned at 9 p. m., July 14, 1903, to meet at Hardin, Illinois, July 15, at 9 a. m.

RECORD

The State of Missouri
vs.
The State of Illinois
and
Sanitary District of Chicago

VOL. 4

IN THE

Supreme Court of the United States

THE STATE OF MISSOURI
vs.
THE STATE OF ILLINOIS
and
THE SANITARY DISTRICT OF CHICAGO.

Original,
Docket No.

Before
FRANK S. BRIGHT,
Commissioner of the Supreme Court of the United States.

VOLUME 4.

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VOLUME 4.

Hardin, Illinois, July 15, 1903. 10:00 a. m. Met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

CHARLES FLAMM, called as a witness in behalf of the defendants, being first duly sworn, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?
A. Charles Flamm.
Q. What is your business?
A. Insurance; insurance agent.
Q. How long have you been in that business?
A. Ever since last fall.
Q. What did you do before that time?
A. County clerk.
Q. For what county?
A. Calhoun county.
Q. Where do you live?
A. Hardin, the county seat.
Q. How long have you lived in Hardin?
4943 A. Nine years; that is off and on for the last thirty years, but I was gone in Richwood precinct, part of this county for a number of years; otherwise I lived here all the time.
Q. Have you been acquainted with the Illinois river at this point for the last ten years?
A. Yes, sir.
Q. How far is Hardin from the mouth of the Illinois river?
A. I don't know exactly, but I think it is about 41 miles.
Q. What is the population of Hardin?
A. About 500.

Q. Have you been acquainted with the Illinois river since you have lived in Hardin?

A. Yes, sir.

Q. What was the character of the water in the river prior to the opening of the drainage canal?

MR. JEFFRIES: I want it understood that the same objection is urged against the testimony of this witness as the witnesses of yesterday.

MR. TODD: Yes, sir.

A. Why, in my opinion it wasn't as pure as it is now.

Q. Describe the water as it existed prior to the opening of the drainage canal, January, 1900?

A. In my opinion—

4944 Q. I want you to describe the river before the opening of the drainage canal?

A. During the low water the river on the east side here was covered with vegetation, and it looked to me as if the water was very impure.

Q. Was there any scum on the water?

A. There was.

Q. Describe it?

A. It was a greenish scum and when you passed through it with a boat it left a trail; you could notice it for sometime afterwards; that is when the river was rather low; low water; that was during the summer months.

Q. What has been the change, if any, made in the waters of the Illinois at this point by the opening of the drainage canal?

A. It has a better current and this scum no longer appears.

Q. Have you drank the water since the opening of the drainage canal?

A. I have.

Q. Did you ever drink it before?

A. No, sir.

Q. About how many fishermen are engaged in fishing at this point in the river?

Objected to as immaterial.

A. Between twelve and fifteen.

Q. Do you know of anyone who had typhoid fever, or who died from typhoid fever in the last two years at this point?

4945 Objected to as immaterial and not competent evidence.

A. No, sir.

Q. What is your opinion as to whether or not the waters of the Illinois have been improved in their quality, and appearance by the addition of the waters of the drainage canal into the Illinois river since January, 1900?

MR. JEFFRIES: We object to this question for the reason that it calls for an opinion from the witness, who has not qualified himself as being competent to judge or form an opinion as to the sanitary condition of water, and for the further reason that any opinion that the witness might have would be based simply on the appearance of the water and not with reference to its sanitary or unsanitary condition.

A. In my opinion from the appearances, it has improved.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Your opinion is based solely upon the appearance of the water?

A. Yes, sir.

Q. And you say that the water is better since the opening of the canal than it was prior to the opening for the reason that the green scum that formed on the water prior to the opening, while it does not form since the opening, and the creation of the current caused by the opening, is that correct?

4946 A. Yes, sir.

Q. You are not a physician?

A. No, sir.

Q. You don't make it a business of looking after the health of your people?

A. No, sir.

Q. Do you use the river water at your home or do you use well water?

A. We use cistern water.

Q. Hardin has no water system, has it?

A. No, sir; only wells and cisterns.

Q. Only wells?

A. That's all.

CHAS. FLAMM.

4947 Hardin, Illinois, July 15.

EDWARD ATHY, called as a witness in behalf of the defendants, being first duly sworn, by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Edward Athy.

Q. Where do you live?

A. Hardin, Calhoun county, Illinois.

Q. How long have you lived here?

A. In this vicinity, in Hardin about twenty years; I moved here in 1880 on Macoupin Island in 1880.

Q. What is your business?

A. I work at carpenter work and joining, and generally anything I can get to do.

Q. Have you been acquainted with the Illinois river since you have lived in Hardin?

A. Yes, sir.

Q. What was the character of the Illinois river prior to the opening of the drainage canal in 1900?

A. Well, I am only qualified to judge by the appearance; but in my opinion the appearance of the water has improved since the opening of the canal.

4948 Q. Just state what the appearance was?

A. Before that time the water was more inclined to be milky looking and muddy looking, and a scum over the river that was noticeable by every one.

Q. Was there any odor to the water?

A. That I cannot say.

Q. What effect would row-boats have on the water when rowing through it?

A. During the time this scum was over the river, it left a clean furrow over the river. I have crossed the river many a time and could see clear across, or half across.

Q. Since the opening of the drainage canal, what effect have you observed to have taken place in the Illinois river?

A. I have observed a more lively current, a better movement of the water and I have observed less of this scummy looking filth on the top of it than before.

Q. What effect, in your judgment, has the opening of the drainage canal had on the waters of the Illinois river at this point?

A. Well, in my judgment—

MR. JEFFRIES: Objected to as calling for an opinion without the witness having qualified as being competent to testify as to the sanitary condition of the water.

4949 A. Well, my judgment is only from appearances, and the water appearing clearer and cleaner, I should say it was purer.

Q. MR. TODD: Have you noticed any odor in the water since the opening of the drainage canal?

A. No, sir.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Are you on the water a great deal?

A. No, sir; not a great deal.

Q. Your opinion is based solely on the appearance?

A. I am not qualified to judge otherwise; only by appearance.

Q. Do you know why there is no scum on the river now?

A. No, I do not know why, I might testify why I think so.

Q. What is it?

A. I think a better movement of the water carries the scum away.

Q. It did not give it an opportunity to form?

A. No.

Q. You don't know whether the sewage matter from Chicago gets down this far or not?

A. No, sir.

Q. Don't know anything about that?

A. No, sir.

4950 Q. About all that you do know then is that in your opinion the waters have been improved by the increased flow caused by the canal?

A. That is my opinion; that it has been improved by the increased flow.

RE-DIRECT EXAMINATION, by Mr. Todd.

Q. And this improvement is what you see and observe of the water now as different from what it was prior to the opening of the canal?

Objected to for the reason that it is leading and suggestive of the answer desired, and for the further reason that the witness has not properly qualified himself to express an opinion?

A. Yes, sir; that is what I thought about it.

Q. Have you observed in the Ilinois river here anything that would lead you to believe that the sewage from Chicago was present in the waters of the Illinois at this point?

Objected to for the same reason.

A. I have not.

EDWARD ATHY.

4951 Hardin, Illinois, July 15, 1903.

NATHANIEL BULL, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Nathaniel Bull.

Q. Where do you live Mr. Bull?

A. Well, I live in Hardin.

Q. How long have you lived here?

A. Six years. I have lived in Hardin.

Q. How long have you lived in the county?

A. Since 1860.

Q. What is your business?

A. Farmer.

Q. Have you been acquainted with the Illinois river for the last ten or fifteen years?

A. Yes, sir; I have been slightly acquainted with it. Not traveling around on the water, but living along the river.

Q. Have you crossed the river?

A. Well a time or two in the last four or five years, gone on the ferry.

Q. Have you seen the river frequently?

4952 A. Yes, sir.

Q. What was the condition of the river before the opening of the drainage canal as you saw it?

A. Well, it was in a condition just the same as a pond, very near.

Q. Well, how is that?

A. Why, there was a scum over it; you could see if anything had passed through it.

Q. Any odor to it?

A. Well, yes.

Q. Since the opening of the drainage canal, have you observed the waters of the Illinois?

A. Yes, sir, when I traveled along by it.

Q. How does the river compare now with what it did then?

A. Well, I never saw none of that to amount to anything on it since. It appears to have a current.

Q. Have you noticed any odor since?

A. No, not any at all, that ever I noticed.

Q. What is your opinion as to whether the river has improved since the opening of the drainage canal?

A. With a good current in the river, it certainly has improved; taking that away and making the water pure.

MR. JEFFRIES: We move to strike out the question 4953 and answer for the reason that the witness has not qualified himself to testify on that subject.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Your opinion is based solely upon the appearance of the water, is it not?

A. Of course it is based upon the appearance of the water; I ain't traveling now any on the river. I used to travel, but I am getting too old now; since the canal was opened.

Q. Do you know why there is no scum on the water now?

A. Better current, I guess.

Q. You never had the water examined by anyone to see whether it contained any deleterious substances?

A. No, I never had it examined; just by the appearance of the water as I passed along by it.

Q. What is the difference in the current now and what it was before the opening of the canal?

A. Well, there is a big difference; it is a better current now and before it was a pond. You could throw a chunk in and it was pretty near as apt to float up stream as it was down.

Q. Do you drink cistern or well water?

A. I drink well water; two years ago we used the Illinois river water, the dry season; I hauled water from the Illinois river.

4954 Q. That was just during the dry season?

A. Yes, sir.

Q. And when you couldn't get any other water?

A. Yes, when I couldn't get any other water; we don't use river water when we can get well water.

NATHANIEL BULL.

4955 Hardin, Illinois, July 15, 1903.

M. E. FISHER, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd, testified as follows:

Q. What is your name?

A. M. E. Fisher.

Q. What is your business?

A. Merchant.

Q. Where is your place of business?

A. Hardin.

Q. How long have you lived here?

A. About 35 years; all my life.

Q. Are you acquainted with the Illinois river?

A. Yes, sir.

Q. How did you get your acquaintance with the Illinois river?

A. By being on it all my life.

Q. Do you fish?

A. Yes, sir, with a hand line.

Q. Will you describe the physical conditions of the Illinois river before the opening of the drainage canal?

4956 A. Well, so long as it was down low and green grass growing in it and scum all over it, it made a smell.

Q. What phenomena did you observe when a skiff went through?

A. It left a track where the skiff went through the grass and scum.

Q. What changes, if any, have you observed to have taken place since the opening of the drainage canal, in the Illinois river?

A. Well, the river is up higher and clearer and a swifter current; better water.

Q. Did you ever drink the waters of the Illinois river before the opening of the drainage canal?

Objected to as leading.

A. Yes, sir.

Q. Have you drank it since?

A. Yes, sir.

Q. Since the opening of the drainage canal?

A. Yes, sir.

Q. Have you an opinion in regard to whether the water is better or worse since the opening of the drainage canal, in the Illinois river?

A. Yes.

Q. What is that opinion?

4957 MR. JEFFRIES: We object to this witness testifying to an opinion for the reason that he has not qualified to express an opinion as to the sanitary condition of water and can only judge from its appearance regardless of whether it contains substances deleterious to the health or not.

Q. Well, I think if they shut it off, it would be low and slimy like it used to be before they turned it in.

Q. My question goes to your opinion as to its condition today.

A. I think it is in good condition here now.

Q. What is your opinion as to whether it is better or worse since the opening of the canal than it was before?

A. Well, better, the river is clearer and swifter current.

Q. About how many people at this point are engaged in the fishing business?

A. Well, about ten or twelve.

Q. Do you know of any deaths from typhoid fever in this locality?

A. No, sir.

Q. Are you acquainted with all the people in this town?

A. Yes, sir.

Q. Everybody knows each other here and each other's business, do they?

A. Yes, sir.

4958 CROSS-EXAMINATION, by Mr. Jeffries.

Q. You are a man of family, are you not?

A. No, sir.

Q. Single man?

A. Single man.

Q. Do you board?

A. No, I live with my mother.

Q. Do you have a well or cistern at your house?

A. Cistern.

Q. You don't use the river water?

A. No, sir.

Q. There is no water system in this town is there?

A. No, sir.

Q. You made no examination of the water in the Illinois river prior to or since the opening of the canal?

A. No, sir.

Q. So that all you know about the water is what you get from its appearance?

A. Yes, sir.

Q. How much more current is there now than there was prior to the opening?

A. I couldn't say; it looks like double; it has increased it since double.

4959 Q. Very much more?

A. Yes, sir.

Q. You don't know whether the water contains deleterious substances now or not, do you?

A. No, sir.

Q. To what extent do the people in this town use well water or cistern water?

A. Use it altogether, well or cistern water.

M. E. FISHER.

4960 Hardin, Ilinois, July 15, 1903.

ABNER POOR, called as a witness in behalf of the defendants, being first duly sworn, by the Commissioner, was examined in chief by Judge Johns and testified as folows:

Q. What is your name, residence and occupation?

A. Abner Poor; I live here in Hardin, and fish for a living.

Q. How long have you been a fisherman?

A. About 28 years.

Q. How much of that time have you fished in the Illinois river?

A. All the time with the exception that when it would get so low here I couldn't fish here, I would go over to the Mississippi.

Q. Did you fish here in the Illinois river prior to 1885?

A. Yes, sir.

Q. What was the condition of the river then with reference to the stage of water and the character and quality of the water?

A. Well, the river then along in the summer and fall, I don't know what you would call it, but I would call it poison, more poison than water, there was a green scum in it; no current in it nor nothing. You could put a net in the water 4961 and raise it up you know and it would just be hanging in tags.

MR. JEFFRIES: I move to strike out the answer as not being responsive to the question, and as being indefinite, and the witness not being qualified to express an opinion, and the answer shows on its face to have been recklessly given.

Q. JUDGE JOHNS: Were you aware that in 1885 the city of Chicago pumped its sewage into the Illinois and Michigan Canal?

A. No, not in 1885.

Q. And continued that until 1900?

A. No, I don't know anything about that at all.

Q. Prior to the year 1900, at this point did you notice any substantial difference in the character and quality of the Illinois river water?

A. Why, the water is more pure and better now than it was in 1885, at this time of the year it has been in the last two years. I know the water is better now than it was then.

Q. Before 1900, for fifteen years, you may state whether the water in the Illinois river was substantially always in the same condition?

A. About the same, yes.

Q. What was that condition?

A. Well, it was low, no current and most awful dirty and nasty.

Q. From what did the dirt and nastiness come?

4962 A. Well, it just come from the stagnated water, as far as I know; it couldn't come from anything else but the stagnated water, that I know of; it was just like one of these ponds.

Q. That was the condition in low water?

A. Yes, sir.

Q. Before the drainage canal in the winter, what was the condition of the water under the ice when the river was frozen over?

A. Why, if you cut a hole in the ice a kind of a nasty green scum would come up in that hole, and you would pull a net up and it would just be tags hanging all over it.

Q. What kind of stuff composed this black tags?

A. Why, it was filth, is all I could tell you, from the dead water.

Q. Did the fish die under the ice?

A. Yes, lots of them.

Q. Did you drink the water before the drainage canal was opened?

A. I have drank it ever since I have been a fishing; I never pretend to take spring water or well water with me at all.

Q. What was the color of the water before the opening of the drainage canal?

A. Well, it looked something like pond water; kind of a
4963 green scum on it.

Q. How did it smell?

A. Well, I will tell you; I didn't smell it any; as far as that is concerned, only when I would be seining and pulling the seine where it was shallow and this grass growing in it all rotten, it smelled pretty bad there.

Q. Would the fish that you caught live a considerable length of time in live boxes?

A. No sir, they would not.

Q. Since the opening of the drainage canal, what has been the condition of the river?

A. Well the water has been more pure and it tastes better too.

Q. Have you drank it since the opening of the canal?

A. Drank it all the time in the summer; in the winter too when I am on the river.

Q. How about moss and filth in the river?

A. We don't have any more since that.

Q. How about the odor of the water, the smell?

A. Well we don't smell it any more; the current takes off the filth and stuff.

Q. How about grass and weeds in the river now?

A. We don't have any grass and weeds in the river now;
we have a stage of water now that covers those places deep
4964 enough until that grass don't grow. I have seen the
grass from this little Tow Head, the foot of that, clear
to the foot of that Diamond Island up yonder, that you couldn't row a boat through it to save your life; through the grass and moss and stuff.

Q. How much distance is that?

A. Well it is something over a mile and a half. A little fraction over a mile and a half.

Q. Does that condition exist now since the drainage canal was opened?

A. No sir, it does not. It wasn't only this one place but it was everywhere where the water was shallow that it would grow.

Q. This smell that you notice in the water in the summer and under the ice in the winter, was it about the same kind of a smell?

A. Yes sir, it was later on, that is in 1880 and 1885 and along up through there, about one thing all the time in the winter time.

Q. Was it the same kind of a smell, winter and summer?

A. Just about the same; of course it was a little ranker in the summer than it was in the winter.

Q. How far up and down the river have your fishing operations extended?

4965 A. From Twelve Mile Island to Kampsville; I have got nets in the river now within two miles of Kampsville.

Q. How great a distance is that by river?

A. Well, it is about sixteen miles.

Q. Do the fishermen on the Illinois river have typhoid fever?

A. I never knowed one to have it. As a general thing, the fisherman is the hardiest thing there is along the river.

Q. Do the fishermen generally when engaged in their business drink the river water?

A. Yes, the majority of them does; that is I can say that much for the fishermen around here; none of us carries water with us no matter how far we go.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How far is it from here to 12-Mile Island?

A. About eight miles, I guess, or close to it?

Q. How far is it to Kampsville?

A. Well it is about eleven miles by road and about ten by the river.

Q. Then your fishing trips have made you acquainted with the Illinois river for a distance of about 18 or 19 miles?

A. Yes, somewheres along there.

Q. How long did you say you have been fishing?

4966 A. I have been fishing for 28 years, right here.

Q. How old are you?

A. Sixty-one.

Q. You say before the opening of the canal there was a green scum on the water?

A. Yes sir.

Q. Where is that scum now?

A. Well, by gosh, that is more than I can tell you; I ain't been watching it to see where it went.

Q. How much of a current is there in the river now?

A. Well I couldn't tell you how fast the current is running; I know it is more than it was in 1885.

Q. More than it was in 1899 before the canal was opened?

A. Yes sir, of course we have got more.

Q. You don't know anything about the water other than from its appearance?

A. Well I can tell you one thing about it, we had no current at all before that, at this time of the year, when the water was low no current here, and when a skiff would get loose here it was just about as apt to go this way as that way.

Q. Just about as apt to go up stream as down stream?

A. Yes sir, just like this spring when the Mississippi was backing the river up.

Q. Do you live in a boat-house?

A. No sir.

4967 Q. You are a married man?

A. Married man, yes sir; got my own property here in the town; I live here in the town.

Q. You have a cistern or a well at your house?

A. Got a well, yes.

Q. What do you mean when you say the water in the Illinois river is better now than it was prior to the opening of the canal?

A. Why for the simple reason it tastes better now.

Q. Better fishing now than there was then, isn't there?

A. Yes.

Q. The water is deeper and more of it?

A. Yes, and there is one other little thing I would like to tell you about it too; you can take—compared to this canal being let in this river—you could take and dip up a tin cup full of water and let it set and there would be a thousand little worms in it. That is more of it. Just like you get in one of these ponds, and dip it up, like wiggle-tails.

Q. That is not the condition now?

A. No sir.

Q. Do you do anything else besides fish?

A. Nothing at all.

Q. You make that your livelihood?

4968 A. I make my living at fishing.

RE-DIRECT-EXAMINATION,

By Judge Johns.

Q. Before the opening of the drainage canal, how long in the summer would the fish live in live-boxes?

A. Why they wouldn't live 24 hours here.

Q. Since the opening of the canal, how long do they live?

A. Well you can keep them four or five days; I have kept them that long last summer.

Q. Do the fish seem stronger and hardier?

A. They are more livelier and appear better; they have got more life about them than they had before—and there is more of them too.

ABNER POOR.

4969 Hardin, Illinois, July 15, 1903.

DR. P. C. BARRY,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. I reside in Hardin; my name is P. C. Barry; I am a retired practicing physician.

J. How long did you practice medicine in Hardin and vicinity?

A. Over thirty years.

Q. How long since you have retired from the practice?

A. I have retired from active practice; about four or five years; but am still doing office practice; some practice in my office.

Q. When you were in active practice how much of territory along the Illinois river did you cover?

A. Well, I covered sometimes about 30 miles south of Hardin and about fifteen miles north of Hardin.

Q. During that time were you familiar with the character and quality of the water of the Illinois river?

A. I paid no attention to that.

Q. Did you know its general condition?

4970 A. Yes sir, I had an idea of its general condition?

Q. Describe its general condition prior to the opening ot the drainage canal?

A. Well, it seemed to be, in summer time,—well there seemed to be a scum over the river in the summer time and there was no current in the river and even in the best season of the year you could smell it; there was a sort of a stench on it, and the water did not appear to be clear; the water appeared to be muddy.

Q. To what did you attribute that stench?

A. Well I attributed it more to the decayed vegetable matter in the river, and the washings from these creeks along the river.

Q. Was there much vegetation in the river itself?

A. Yes sir, in the river sometimes the water was low; there was some grass that could be seen right over the surface of the water.

Q. Do you know whether in the winter prior to the opening of the drainage canal, when the river was frozen over, there was a smell in the water?

A. I couldn't say.

Q. Since the opening of the drainage canal what has been the general character of the water?

A. Well, it seems to be clearer and purer. In fact
4971 the people consider the water better a good deal than it
has been before that time.

MR. JEFFRIES: I move to strike out the last part of the answer which has reference to what the people consider.

Q. How do you consider the water now as compared with the time before the drainage canal was opened?

A. I consider the water purer and healthier for consumption by the people.

Q. Prior to the opening of the drainage canal, did the people drink the river water?

A. Very little to my knowledge.

Q. Did the fishermen drink it?

A. Not that I know of.

Q. Since the opening of the drainage canal do the people drink the water, and especially the fishermen?

A. Well, I don't know for certain; I have drank the water myself; I don't know about the fishermen. I don't know for certain; there has been water from pumps along the river.

Q. Do you consider that that water is largely river water seeped into the wells?

A. Why yes I consider it all river water of course.

Q. What has been the condition of the people in this community as to typhoid fever?

4972 A. Well to my knowledge we have had no case of typhoid fever here; we have had cases of typho-malarial fever.

Q. Do the fishermen have typhoid fever in this vicinity?

A. Not that I know of.

Q. Have you practiced medicine among them as well as among the people not fishermen?

A. Yes sir.

MR. JEFFRIES: We object to the question and answer for the reason that the witness disqualified himself from testifying in that respect when he said that he had retired from practice about four years ago.

JUDGE JOHNS: From active practice.

Q. While you were in the active practice of medicine, did you practice as much among the fishermen as well as among the people not engaged in that business?

A. Why yes, if they happened to get sick, I generally doctored among them as well as others.

Q. While you were actively in practice were you a man in—or having a considerable proportion of the business in the community?

A. I generally had the largest practice of any physician in Hardin in those days.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How old are you doctor?

A. Sixty-two years old.

4973 Q. Where did you study medicine doctor?

A. I studied partly at the University of Louvain, Belgium, and partly Pope's Medical College, St. Louis.

Q. When was that?

A. That was in 1865 and 1866; during the cholera time in St. Louis, I happened to be there then.

Q. I understood you to say a while ago in answer to a question from Mr. Johns that you knew nothing about the Illinois river except from its appearance; in other words you never made any examination of the water or anything of that kind?

A. No, I didn't make any examination of the water except that I used it; drank the water just when I needed it. No question then about the water, about this germ theory or anything at that time.

Q. How is that?

A. There was no question then about germs or bacilli then, in those days, you know.

Q. That theory has been—

A. Has come up since that time.

Q. There is no water system here in Hardin?

A. No sir.

Q. The people use wells and cisterns?

A. They use wells and cisterns.

4974 Q. What is the difference in the flow of the water now and what it was prior to the opening of the canal, doctor?

A. The current is swifter now, a great deal more so than it was earlier, before 1900.

P. C. BARRY.

4975 Hardin, Illinois, July 15, 1903.

CHARLES H. LAMAR,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. Charles H. Lamar; Hardin, Illinois; editor and publisher of a newspaper.

Q. What is the title of the newspaper?

A. The Calhoun Herald.

Q. How long have you resided in Hardin?

A. Eight years the first of April; going on nine years.

Q. How long have you lived upon or in the vicinity of the Illinois river?

A. My life time, forty years.

Q. Where before Hardin?

A. Three and a half miles north of Hardin, about one mile west of the river.

Q. Have you been familiar with the general character of the Illinois river during your life?

A. I think I have, yes sir.

Q. Have you fished or hunted upon it?

A. Yes sir.

4976 Q. How much?

A. From boyhood; I don't think there has been a year passed but what I have had occasion to fish and swim and hunt around the river.

Q. Prior to the opening of the drainage canal in 1900, what was the general character of the water in the Illinois river?

A. Well, we had less water; not so rapid a current and at times stagnant; in low water it was very much so; considerable vegetation found in the river.

Q. Did it then have an odor in the summer?

A. Yes sir.

Q. To what did you attribute the odor?

A. Well to the grass growing out in the river and to the green scum found upon the water.

Q. Do you know whether in the winter when the river was frozen over, there was an odor to the water under the ice?

A. No sir.

Q. Did you have a general acquaintance with the people residing upon the river prior to the opening of the canal?

A. Yes sir.

Q. Did they use the water for drinking and domestic purposes?

A. Well some did when they couldn't get any other; I know I did in my boyhood days, I lived on the river, a farm there, and we had to use the water.

4977 Q. If you know of any difference in the color of the water, before and since the opening of the drainage canal, describe it?

A. Well I think the water now is clearer; it looks fresher.

Q. Do you know as to the—do you know in a general way as to the quality of the fish, before and since the opening of the canal?

A. Only from my conversation with fishermen, they all informed me—

MR. JEFFRIES: We object to what any fishermen told me.

A. They informed me that the fish was better; remain alive longer.

Q. Do the people along the Illinois river so far as you know, who use this water, have typhoid fever?

A. I don't know of a case of typhoid fever from the using of the water.

Q. Was that so as well before as after the opening of the drainage canal?

A. Well, I can't say; I don't know of any cases of typhoid prior to the opening or since, no.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You have never examined the water have you?

4978 A. No, only in a casual way; by rowing on it or bathing in it.

Q. Well, what you say in reference to it is obtained simply from observation?

A. Yes sir.

Q. Do the people here in town—do they drink well or cistern water?

A. Yes sir.

Q. Use it in their homes?

A. Yes sir.

Q. You do?

A. Yes sir.

Q. So the river water is not used for domestic and drinking purposes?

A. Not by the people of the town, no sir.

CHAS. H. LAMAR.

4979 Hardin, Illinois, July 15, 1903.

G. A. WILLIAMS,

called as a witness in behalf of the defendants being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. State your name, residence and occupation?

A. G. A. Williams; Hardin, Illinois; physician.

Q. How long have you been a practicing physician?

A. I have been practicing about 28 years.

Q. How much of that time at Hardin, or upon the Illinois river?

A. About 22 years at Hardin.

Q. Have you been engaged in the general practice among the people?

A. Yes sir.

Q. Of what school of medicine are you?

A. The regular.

Q. Have you been familiar with the condition of the water of the Illinois river in a general way?

A. Fairly, yes sir.

Q. Prior to January, 1900, what was the condition of the water in the Illinois river, as to current, color and odor?

A. Well it wasn't near as good as it is at the present.

Q. Was the water at times stagnant?

A. Yes sir.

4980 Q. During the summer, did it have an odor?

A. Yes, sir.

Q. To what did you attribute the odor?

A. To the stagnant condition and on account of no current I suppose, and the stagnant condition; the film and the scum that was on the river.

Q. Did the odor arise from decaying vegetation or from sewage?

A. I think it was decaying vegetation and perhaps sewage too.

Q. Since the opening of the drainage canal, what has been the condition of the river as to color, current and odor?

A. Well, it is much better at the present time than it was before it was opened, much improved.

Q. Do the people living upon the river use the water for domestic purposes and drinking?

A. I think they do to some extent.

Q. Prior to the opening of the drainage canal, what was the condition as to typhoid fever among people living along the river?

A. There seemed to be a good deal.

Q. Since the opening of the drainage canal, what has been the condition as to typhoid fever?

A. We don't have any cases, at least, I haven't had any.

4981 Q. Are you now actively practicing medicine?

A. I am.

Q. You may state what has been the character and quality of the ice taken from the Illinois river before and after the opening of the drainage canal?

A. Well, I have noticed that it is clearer and better ice since the opening of the drainage canal than it was previous.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How long have you been practicing, doctor?

A. About 28 years, may be longer.

Q. The people here in Hardin use well and cistern water, don't they, for domestic and drinking purposes?

A. Well, yes, some do.

Q. What do you mean by "some?"

A. Well, I don't suppose all of them do.

Q. You don't know?

A. I don't know.

Q. A few moments ago, doctor, you said there were a great many cases of typhoid fever along here prior to the opening of the canal?

A. Yes, sir.

Q. How many cases?

A. I couldn't tell you, I didn't keep those numbers.

4982 Q. Well, can you name some of them?

A. No, sir; I can't at present; I have forgotten.

Q. Were there as many as a dozen?

A. Well, I guess there were; yes, sir.

Q. Now, in speaking of the number of cases of typhoid fever prior to the opening of the canal, what was the number of years that those cases covered that you have in mind?

A. I can't say that.

Q. Fifteen or twenty years?

A. I guess that would be about the number, fifteen or twenty years.

Q. And you say there have been no cases whatever since the opening of the canal?

A. Well, I haven't had any. Others may have had typhoid cases.

Q. You say you know of others that had it?

A. I suppose that other physicians had it. I never inquired into their cases.

Q. Was it typhoid fever or typho-malaria?

A. I couldn't say as to that. What do you mean by that question?

Q. I say, was it typhoid fever or typho-malaria, these cases that you spoke of years back?

A. Well, there was some of it genuine typhoid and then some other cases of typho-malaria.

4983 Q. You have never made a chemical, nor a bacteriological examination of the water of the Illinois river?

A. No, sir, I never have.

Q. You know nothing then of its qualities except what you get from observation?

A. From observation, yes, sir.

G. A. WILLIAMS, M. D.

4984 Hardin, Illinois, July 15, 1903

CHARLES E. COOKE, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. State your name, residence and occupation?

A. Charles E. Cooke; Hardin, Illinois; I have several occupations, implement dealer, agent for Eagle Packet Company.

Q. How long have you lived in Hardin?

A. About 19 years.

Q. How long have you been the agent of the Eagle Packet Co.?

A. About fourteen years.

Q. Is that a company running a line of boats upon the Illinois river?

A. Yes, sir.

Q. Were you familiar with the general character of the water in the Illinois river prior to January, 1900, when the drainage canal was opened?

A. Yes, sir.

Q. Describe its condition as to quantity, current, color and odor?

A. There is a great deal more water now than then; 4985 much more current; and no odor at all now.

Q. Was there some odor in the summer prior to the opening of the drainage canal?

A. When the wind was from the east it was very bad, very offensive, that is, in low water.

Q. To what did you attribute that odor?

A. Well, I couldn't say, unless to the river itself.

Q. Whether it was from decaying vegetation, grass and weeds in the river, or from sewage, could you tell?

A. It came from the river; that's all I know.

Q. Is there much ice put up in and about Hardin?

A. Not since the dam was put in.

Q. To what dam do you refer?

A. Kampsville.

Q. Do the people here put it up for their own personal use?

A. They do when they get good ice.

Q. So far as you have observed, has there been any difference in the appearance and quality of the ice since the opening of the drainage canal?

A. When we have got good ice, the ice has been much clearer; that is, when the river was low and we could get good thick ice.

Q. Are you acquainted in a general way with the fishermen and other people in this vicinity who live upon the Illinois river?

A. Considerably so, yes, sir.

4986 Q. What has been the condition of health of the people using river water since the opening of the canal?

A. I don't know of any of them being sick; complaining any, only rheumatism, which is always the case on a river.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Your statement that the water is better now than it was before the opening of the canal is based altogether on its appearance?

A. Well, it is much clearer and there is no smell to it; when the water was low it had no current; the water had a very offensive bad smell in low water before the canal came in.

Q. You don't know whether it contains deleterious substances?

A. I don't know anything about that at all.

Q. You are a man of a family?

A. Yes, sir.

Q. Do you use well water or cistern water at your house?

A. We use well water in the summer; cistern water in the winter.

C. E. COOKE.

4987 Hardin, Illinois, July 15, 1903.

M. J. PARKER, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. M. J. Parker.

Q. Where do you live?

A. Hardin, Illinois.

Q. How long have you lived here?

A. I have lived here since 1873, with the exception of five years, I was on my farm in Jersey county.

Q. Did you ever steamboat on the Illinois river?

A. I didn't myself; I run on the Illinois river for four years.

Q. Between what points?

A. From St. Louis, to Montezuma and part of the time as far as Naples.

Q. How far up the river is Montezuma?

A. Well, it is about 32 miles from here, I think; we call it fifty miles to Naples.

Q. What is your present business?

A. I am in the orchard business—farming.

4988 Q. Have you had occasion to be on the Illinois river during the last four or five years?

A. Well, I haven't been steamboating for the last four years; I quit in 1899.

Q. Since 1899 have you been on the Illinois river in any capacity?

A. No, sir; I have just lived on the river; I have been on the river fishing and hunting a good deal; of course I have been on steamboats quite often making the trip between St. Louis and here.

Q. Are you a fisherman?

A. No, sir; only with a rod and reel.

Q. During the winter are you on the river?

A. No, sir.

Q. Do you hunt on the river?

A. Yes, I hunt on the river every season.

Q. Your fishing and hunting is mainly for recreation?

A. Yes, sir.

Q. Have you observed the condition of the Illinois river before the opening of the drainage canal and since the opening of the drainage canal?

A. Yes, sir.

Q. Will you describe the conditions that existed on the Illinois river prior to the opening of the drainage canal, the condition and character of the water?

4989 A. Well, I notice a decided improvement in the conditions.

Q. No, I asked you to describe the conditions that existed before the opening of the canal?

A. Oh, before the opening of the canal it was a very sluggish stream, and it looked like there was an accumulation of moss and grass and the stench was pretty bad at times, especially in warm weather in low water; the water had a kind of a greenish appearance, and very little current.

Q. Was there a scum on the water?

A. Yes, sir.

Q. To what extent?

A. Well, considerable at times; especially when we had a continued drouth, and low water; it would be a good deal more than it would be in the wet season; when the water was coming in from the draw, that is after heavy rains, it would clear it up considerable.

Q. What are the conditions that you observed on the Illinois river today and since the opening of the drainage canal?

A. Well, I consider that there is quite an improvement.

Q. In what way?

A. In the appearance of the water; it looks clearer and purer, and we have got a decidedly better current and it tastes better; it is not so sickly and such a flat, filthy taste.

4990 Q. Have you drank the water of the Illinois river since the opening of the canal?

A. Yes, sir.

Q. How frequently?

A. Not very often; occasionally when I have been on the river, I take a little drink. Early in the year the water is splendid, just splendid, but during this season of the year the water is too warm; take the ice along it makes it very nice.

Q. When you go on your fishing expeditions do you take ice with you?

A. Yes, sir.

Q. What water do you use with the ice?

A. Illinois river water.

Q. Have you ever experienced any deleterious effects from the use of the water?

A. No, sir; I don't think I ever did.

Q. Taking the conditions of the water, as they exist today and comparing those conditions with the conditions that obtained prior to the opening of the drainage canal, what is your opinion as to the effect of the opening of the drainage canal, upon the waters of the Illinois river?

A. Well, there is no comparison generally, prior to the opening of the canal and now; it is a hundred per cent.
4991 improvement, I think.

Q. State in detail how you arrive at that conclusion, and upon what you base your opinion?

A. On the condition of the water and the appearance of it, and the life and the current we have and the tasting of it. Of course, I don't want it understood that I am any expert on this, but then it was in a fearful condition prior to the opening of it, especially in hot weather and at low stage.

Q. Do you observe any odor in the water at present as compared with the odor that existed prior to the opening?

A. Well, no, nothing so bad as it was. Of course vegetable decay in hot weather, you can notice that on any stream, that odor; that kind of a bad smell, and the fish and turtles and many things that die and float around, of course in very warm weather would smell.

Q. Do you know how wide the river is here at Hardin from bank to bank?

A. No, I don't think that I could tell you, but I think it is 400 to 450 yards.

Q. Are you acquainted with nearly all the people that live in Hardin?

A. Yes, sir.

Q. Do you know of anyone having died of typhoid fever in Hardin during the last two or three years?

4992 A. No, No, sir; I don't know that I do; of course while there have been persons died in Hardin, I can't tell you their disease. Now the physicians, of course you understand, would know more about their disease than I did. I haven't heard of any case of typhoid fever, I don't think.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. When you say that the water is better now than it was prior to the opening of the canal, you just judge from its appearance, do you not?

A. Yes, from its appearance and the current and the stage.

Q. You don't know whether there is any deleterious substance in the water now or not?

A. No, sir; I am not scientific enough to explain that.

Q. Well, what has become of the scum and green matter and substances that produced the smell, before the opening of the canal?

A. Well, it has disappeared to a great degree.

Q. Do you know what caused the disappearance?

A. Why, I attribute that to the current and to the stage

of water and the flow which we have now, compared to the river here prior to the opening. It was perfectly stagnant in low water, and just had a green cast all over it, just looked like a pond. There were places and bends in this river that
4993 looked more like a pond than they would a live river; a flowing stream.

Q. You are a man of family?

A. Yes, sir.

Q. Do you use the Illinois river for domestic and drinking purposes?

A. No, sir.

Q. You say you live in the country or right here in Hardin?

A. I live right here in town, Hardin.

Q. From your testimony, then I gather that your idea of pure water is water that looks clear?

A. Well, yes, while I understand that the Missouri river that is never clear is the purest water of the three rivers. I understand that to be true; not knowing, but I have been told that that is the truth. Of course we have fine wells in Hardin and cisterns; we don't use any river water at all, without it flows into our wells here.

Q. What do you mean by flowing into your wells, seeping in?

A. Well, it might seep in, you know.

RE-DIRECT EXAMINATION, by Mr. Todd.

Q. Do you consider water is pure that when you take it, it won't make you sick?

Objected to as immaterial and leading.

4994 A. It will take a long while to answer that question. It would depend on the condition of a man's stomach and how warm it is, and what condition he is in. I have drank the river water when I was very dry, and very warm and it would make me sick at my stomach. I have drank river water again when it didn't affect me a particle, so that it depends on a man's condition I think, more than anything else. I drink very sparingly of river water anywhere out of the river in July or August, without ice. As I stated before, this river water is just as good water as I want, in the winter time and also early spring. It has a good taste and cold and all right of course then. I don't want to make an impression that I consider the Illinois river water absolutely pure, or any other river water so far as that is concerned; I am just comparing it all; the conditions now and prior.

Q. You never had typhoid fever from drinking the water?

A. Never did, no, sir.

M. J. PARKER.

4995 Hardin, Illinois, July 15, 1903.

G. B. CHILDS, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. G. B. Childs; Hardin, Illinois; well, I don't know whether I am called a farmer or what.

Q. How long have you lived in Hardin?

A. I was born here.

Q. Have you lived here all your life?

A. With the exception of my school days and about five years in St. Louis.

Q. Have you become in a general way familiar with the waters of the Illinois river and their condition prior to 1900 when the drainage canal was opened?

A. Yes, sir.

Q. In what manner?

A. Well, by living on it, rowing on it, hunting on it. Living near it, right on the river bank here.

Q. What was the condition of the Illinois river and its water prior to the opening of the drainage canal in 1900 as to quantity, quality, color and taste?

4996 A. Well, I have seen it in the summer during extreme low water when the weeds were growing thickly in it on either side of the channel; it was a greenish cast and full of greenish sediment.

Q. As to its quantity?

A. Well, I have seen it so low that we have had no boats at all on it.

Q. Did it have an odor?

A. Yes, sir.

Q. What kind of an odor?

A. Well, when this moss or grass was on it, it was very offensive; I can hardly describe the odor to you.

Q. To what did you attribute the odor?

A. Nothing but this grass or moss that was in it; I didn't find it otherwise.

Q. Did the people drink it at that time?

A. Well, none about here that I know of.

Q. Do you know whether the fishermen drank it?

A. I can't say as to that, no, sir.

Q. Now, since the opening of the drainage canal, what has been the condition of the river?

A. Well, as far as my observation has gone, it is clearer and the water seems to be better and more volume.

Q. What has been its condition as to grass and sediment?

4997 A. I have seen none since the canal was turned in.

Q. Were you familiar with the ice that was taken out here prior to the opening of the drainage canal?

A. Well, only as I saw them put it up. I put up some before the canal was built, for my own use here at home.

Q. Have you seen ice taken from the river since the opening of the drainage canal?

A. Yes, sir.

Q. Which was the better appearing ice?

A. Well, I don't know as to that; I don't know as I paid any attention to that.

Q. How much in your opinion has the water of the drainage canal raised the Illinois river?

A. Well, I should say here, judging from a bar which you can see the reef of from the boat there, probably five feet.

Q. How wide is the river at this point now?

A. I measured it some years ago; it was 440 yards then.

Q. Do the people drink the water here since the opening of the drainage canal?

A. Well some of them I think do, yes, sir.

Q. What would you say has been the health of the community here since the opening of the drainage canal?

A. Well, I couldn't say that it has been impaired any; or

rather I would think it was benefited; we don't have the
4998 grass and the low water, and we don't have as much malaria.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say you have lived here all your life?

A. Yes, sir; with the exception of my school days and nearly five years in St. Louis.

Q. You are a married man, are you?

A. Yes, sir.

Q. You use cistern or well water at your home?

A. Cistern water.

Q. How long have you been using cistern water?

A. I don't know.

Q. How long have you lived continuously here at Hardin?

A. Up to two years ago, from 1872 up to that time.

Q. In your statement that the water is better now than it was prior to the opening of the canal you judge only from its appearance?

A. Altogether, yes, sir; well, I have drank it being out fishing and taking ice with us.

Q. What is the difference in the flow of the river now and prior to the opening of the Chicago drainage canal?

A. You mean the current?

Q. Yes.

A. Well, we have a more rapid current than we did.

4999 Q. Has there been any time since the opening of the canal in which there was no current?

A. Yes, sir, last spring.

Q. Then the river was lower last spring than it is now?

A. It was higher.

Q. Now, then, when you say it was higher, you simply mean it was higher on account of the backwater of the Mississippi?

A. Yes, sir.

Q. When it was high?

A. Yes, sir.

Q. But aside from the time when the backwater from the Mississippi came up there has been no time that there was not a current since the opening of the canal?

A. Oh, no, sir.

Q. You have never had the water examined chemically or bacteriologically?

A. No, sir.

Q. You don't know what its ingredients are?

A. No, sir.

Q. You don't know whether it contains Chicago sewage or not?

A. No, sir.

GEO. B. CHILD.

5000 Hardin, Illinois, July 15, 1903.

DR. S. FLATT, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. You may state your name, residence and occupation?

A. S. Fatt; residence, Hardin, Illinois; occupation, physician.

Q. How long have you been a practicing physician?

A. Five years.

Q. At what place?

A. Hardin, Illinois.

Q. Have you lived upon the Illinois river prior to coming to Hardin?

A. No, sir; I had not.

Q. Were you familiar with the appearance and condition of the Illinois river prior to January, 1900, when the drainage canal was opened?

A. I was.

Q. Have you fished and hunted upon it?

A. I have.

Q. Describe its condition and appearance as to the color of the water, its quantity, its current and the odor?

A. It was muddier in color, less in quantity; current slower; odor more disagreeable.

5001 Q. To what did you attribute its odor?

A. Well, the odor was due to what is generally termed stagnant water.

Q. Was there much vegetation in the river before the opening of the drainage canal in the bed of the river?

A. I think there was, yes, sir. To my knowledge there was some; there was more prior to the time I came here, so I have been told.

Q. Do you know as to the condition of fish in the Illinois river prior to and since the opening of the canal?

A. In regard to number?

Q. Yes, and their health and strength and activity?

A. Well, there are quite a number more than there have been and the fish all seem to be in good condition.

Q. Did you have occasion to observe the quality and condition of ice taken for domestic use prior to and since the opening of the canal?

A. I think not.

Q. Do you know whether the fishermen on the Illinois river drink the water of the river?

A. Yes, sir, I do.

Q. Prior to the opening of the canal so far as you had an opportunity to know, what was the fact as to the existence of typhoid fever in this community?

5002 A. Well, there has been but little typhoid fever since I came here; I had three cases I think prior to and two since; though one of them was not on this river; one was across towards the Mississippi river.

Q. What in your opinion has been the health of the community since the opening of the drainage canal into the Illinois river?

A. It has been good—exceptionally good.

MR. JEFFRIES: I move to strike out the question and answer for the reason that there is no evidence showing that the people use the water of the Illinois river for drinking and domestic purposes.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You never examined the water in the Illinois river?

A. No, sir.

Q. When you say that the water is better now than it was prior to the opening of the canal you simply judge from its appearance?

A. Yes, sir: I simply judge from the way it appears, from its color; it was not so thick and greenish looking; it is clear and a better smell to it.

Q. The people here in Hardin use wells and cisterns, don't they?

5003 A. Generally, though the last two years; that is two years ago, they used water from the river on account of the drought.

Q. The wells had gone dry?

A. Yes, sir. The people throughout the country generally used river water two years ago.

Q. That was in the dry season of 1901?

A. Yes, sir.

Q. Which continued for several months?

A. Yes, sir.

Q. The wells had all gone dry and it was the only place you could get water?

A. Yes, sir.

Q. What's the difference between the flow of the water now and what it was prior to the opening of the canal?

A. You mean in regard to the current?

Q. Yes?

A. Well, the current is better; the current is three times what it was at that time.

Q. You say you have been practicing medicine five years?

A. Yes, sir.

Q. How old are you?

A. Thirty-one.

DR. S. FLATT.

5004 Hardin, Illinois, July 15, 1903.

GEORGE L. ADERTON,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. You may state your name, residence and occupation?

A. George L. Aderton; occupation—I am county clerk of this county, Calhoun County, Illinois.

Q. And reside in Hardin?

A. Yes sir.

Q. How long have you lived in Hardin, or on the Illinois river?

A. I have lived in Hardin since December 1st, 1894.

Q. Have you been continuously county clerk since that time?

A. No sir, I was sheriff and collector of this town from 1894 until December 1st, 1898.

Q. Have you fished and hunted much or any upon the Illinois river?

A. Well I have never hunted any; I have fished a great deal with rod and line.

Q. Were you prior to the opening of the drainage canal, familiar in a general way with the waters of the Illinois river?

A. Well I never have been scientifically familiar with it.

5005 Q. Were you familiar in a general way with its quantity, color, odor and current? If so, state what its condition was in these respects prior to the opening of the drainage canal?

A. Yes sir; I noticed prior to the opening of the drainage canal the water was sluggish and not so clear as it is at the present time, or after the opening of the drainage canal. There seems to be more current and the water has generally a better and clearer appearance since the opening of the canal.

Q. Prior to the opening of the canal did it have a perceptible odor at times?

A. Why, I never noticed that it had, never to my knowledge have I noticed any odor.

Q. Are you acquainted generally with the people upon the Illinois river living in Calhoun County?

A. Yes sir, I have a pretty tolerably extended acquaintance around here throughout the county, bordering on the Illinois river.

Q. Including the fishermen, are there many people who use the waters of the river since the opening of the drainage canal for domestic purposes?

A. Well, I couldn't say as to that. We haven't used it—you say since the opening of the canal?

Q. Yes.

A. We have used it both before and since, but not for
5006 cooking or anything like; we have had it for laundering and such as that.

Q. Do the people when upon the river engaged in fishing, drink the water?

Objected to as leading and suggestive.

A. Well, I don't know as to that of my own knowledge; I have drank it myself, while out fishing. And I have known others with me, but to make a general statement of it, I couldn't say as to that.

Q. Since the opening of the drainage canal, what has been the general condition of the health of the people along the river as compared with the period before the opening of the canal?

A. Well in our own immediate vicinity here—

MR. JEFFRIES: That is objected to because there is no evidence showing that the people generally use the water for drinking and domestic purposes.

A. I think the general health of the people is about as good now as it was prior to the opening of the canal. I can only speak for our own immediate vicinity here.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Your people use cisterns and wells don't they for their domestic and drinking water?

A. We do, yes sir.

5007 Q. Well, the people generally in the town?

A. I presume they do, yes sir.

Q. Well, don't you know that they do, your neighbors?

A. No sir, I couldn't say that they do; sometimes their cisterns go dry and they have got a good many public wells in town.

Q. Have what?

A. I say I think perhaps that they use more well water than river water, because our town is well supplied with wells, and as to saying positively whether they do or not, I couldn't do it.

Q. Well do you know that they use river water?

A. No sir.

Q. Now what is your opinion about it, as to which they use?

A. Well, I haven't any opinion about it.

Q. Well, what is your information?

A. I am not sufficiently familiar with my neighbors to know what they do; I am not supposed to know that; I only know how it is in my own family.

Q. Are you sufficiently familiar with your neighbors to know when they are sick?

A. Well yes.

Q. To judge of their health?

5008 A. You generally in a town of this size know about who are sick in it. Sickness though of anybody that is seriously ill.

Q. How does the current of the water in the Illinois river now compare with what it was prior to the opening of the canal?

A. Why, prior to the opening of the canal we had no current scarcely.

Q. What have you got now?

A. We have got a good current now.

Q. At all seasons of the year?

A. Yes sir.

Q. Except when the water of the Mississippi backs up!

A. Yes sir, the current runs the wrong way during the high water.

Q. The water from the Illinois river then is not used very extensively for domestic and drinking purposes by the people in this locality?

A. Well sir, I couldn't say outside of the immediate vicinity of Hardin. I don't think that the river water is used for cooking to any great extent.

Q. Or drinking?

A. Well except by the fishermen that are out in the river. Still, there is a good many people that use it occasionally. I am one of them myself.

Q. They do not make a practice of it though?

A. No.

5009 Q. You never had the water in the river examined?

A. No sir.

Q. Either chemically or bacteriologically?

A. No sir.

Q. Either before or after the opening of the canal?

A. No sir.

GEO. L. ADERTON.

5010 Hardin, Illinois, July 15, 1903.

T. J. SELBY,

called as a witness in behalf o fthe defendants being first duly sworn, by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. My name is T. J. Selby; residence Hardin, Illinois; occupation, lawyer.

Q. How long have you lived in Hardin?

A. Since September 16th, 1884.

Q. Were you at one time a member of Congress of the United States?

A. A member of the 57th Congress.

Q. Have you been engaged in the practice of law in Hardin and other counties upon the Illinois river?

A. Yes sir. I commenced practicing here in 1875; I lived then at Jerseyville.

Q. Describe the location of Calhoun County.

A. Calhoun County north and south is about 50 miles in length and at its widest point about 12 or 15 miles in width and lies between the rivers Mississippi and Illinois, at the junction of those rivers.

5011 Q. On which river is Hardin—the county seat?

A. The Illinois river.

Q. How far is it from Hardin to Grafton by river?

A. I would say about 30 miles; I am just guessing at that.

Q. What is the general direction of' Calhoun County—north and south?

A. Yes, a little to the east of north and south, at the lower point.

Q. Were you familiar with the general appearance and condition of the Illinois river along Calhoun county prior to the opening of the drainage canal in January, 1900?

A. Yes sir, somewhat.

Q. What was the condition of its waters as to current, color and the odor?

A. Well at what time of year?

Q. Well at any time; its general condition?

A. Of course in high water time we would have a good current. In the summer season when the water was lowest, there was very little current in the river at this point anyway; it resembled very much a large pond; I have seen it filled with grass, particularly on the eastern side of the river at this point. The color of the water, I am not positive about that. It was not absolutely clear nor yet really muddy so far as my recollection goes.

5012 And as to the odor, sometimes that would be pretty bad in the fall season, perhaps in September, owing to this decaying vegetation being in the river. That was not always the case, however; when the river was high why the conditions would be different. The water then would be muddy and the current stronger and it would sweep away this accumulation of stuff in the river. Our low water period it seems to me is from —I would say from the first of July on into the fall.

Q. What has been its condition since the opening of the drainage canal in the respects mentioned?

A. In respect to grass and vegetable growth which was formerly here is now totally absent, and has been since. 1901 was a very dry year and we had very fair water; such a year as 1901, previous to the opening of the canal, it closed this river up to navigation to the mouth, from this part further up as far as Kampsville dam. Yes, we have had very low water in this river many times; very near wade across it sometimes.

Q. What difference is there in the color of the water since the opening of the drainage canal, or its turbidity?

A. You mean whether it is clearer now than it was before?

Q. Yes.

A. It may be clearer, but I wouldn't be positive about that:

I have not specially inspected the water with a view to ascertaining that. From the general appearance of the river
5013 itself it looks probably clearer, but I have not inspected it for the purpose of ascertaining.

Q. What in your opinion has been the general health of the community since the opening of the drainage canal as compared with the conditions before?

MR. JEFFRIES: We object to the question for the reason that it assumes necessarily that the people in this locality use the water of the Illinois river for drinking and domestic purposes and no such assumption has been shown in evidence.

A. It has been good; I don't know of any time when it has been particularly bad, however.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You say you are not very well acquainted with the appearance of the water either before or after the opening of the canal as I understood it?

A. To answer that question specifically, I don't believe I could because I didn't make an examination. I can only state from general appearances. I have been on the river frequently, crossed it and fished in it and noticed it; drank out of it, before and since the canal—since the opening of the canal. My idea is if there is any difference I would say that it is clearer now than it was at low water times before.

Q. That is simply an ocular observation only?

5014 A. Yes sir, all I know about it is from observation; my opinion is all based on it.

Q. You have had no examination made of the water either before the opening of the canal, or since?

A. No sir, you mean chemically?

Q. Bacteriologically or otherwise?

A. No; I look at it before I drink it. I am no bacteriologist; I don't know of any ill effects from the use of the water or haven't heard of any.

Q. You can't say whether or not it does now or did prior to the opening of the canal contain deleterious substances so far as you personally know?

A. No, if it does, there don't any of us know.

Q. Mr. Selby, your people here in Hardin use cistern or well water for cooking and drinking purposes don't they?

A. They use both well and cistern water.

Q. Of course you don't know how these people living in shanty boats, whether they get it from wells or the river or what?

A. They use it out of the river.

Q. That is your judgment?

A. I have seen them dip it up in buckets. In fact once or twice I have been out hunting and have been caught at their places and got a cup and got a drink myself, out of the river. It has been more than once or twice.

5015 Q. What is the difference in the flow of the water now and prior to the opening of the canal at all seasons of the year? Omitting the back water from the Mississippi river?

A. We have a better stage of water. We have a better current; a stronger current.

Q. How much stronger?

A. Well, a great deal. I don't know what the per cent would be, but I would say considerable. It is sufficient to carry away—we are not bothered any more with this grass and moss and substances like that: We have got a pretty fair current.

T. J. SELBY.

5016 Hardin, Illinois, July 15, 1903.

ELMER E. WILLIAMS,

called as a witness in behalf of the defendants, being first duly sworn, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Elmer E. Williams.

Q. What is your business?

A. Cashier of the Bank of Calhoun County.

Q. How long have you lived in Hardin?

A. Since February, 1899.

Q. Since 1899 have you been familiar with the Illinois River?

A. Yes sir.

Q. What was the condition of the Illinois river from February, 1899, to January, 1900?

A. Well, do you mean take it in the season—in February it was frozen over, as to the summer months?

Q. The summer months?

A. Well in the summer months, we had a swimming club here and at that time we would go swimming down at Rocky bar about a mile below. The water got so foul along in July and August, about August I guess, that we couldn't go in swimming any more.

Q. Just describe the water?

5017 A. Well there would be a green scum on the water and a very foul odor from the water; very turbid. And it was very low too.

Q. Did it have any odor?

A. Yes, a very decided odor.

Q. Did you ever observe the odor?

A. Why yes, we could observe it from where we lived; we live about two blocks from the river and the street runs right down to the river with no buildings south of it; it was very offensive.

Q. What has been the condition of the river since the opening of the drainage canal?

A. Well the next summer, which was in 1900, the lake water had been turned in at that time, and of course that being my first year here I noticed it possibly more than others, that the lake water made a difference in the appearance of the water; there was no green scum formed and there was no perceptible odor like there was the previous year, and that condition has been, I think improving for the better as to the sanitary conditions and clearness of the water and less foul.

Q. What is your opinion as to the effect of the sanitary canal waters upon the waters of the Illinois river at this point?

A. Why I think they have purified it; the drainage canal has purified the water.

5018
CROSS-EXAMINATION,
By Mr. Jeffries.

Q. You are not an expert on the sanitary condition of water?

A. No sir; it is just my general observation, that's all.

Q. You never had this water examined either before or after the opening of the canal?

A. Never did.

Q. How long have you been in the banking business.

A. About twenty-three to twenty-five years.

Q. How long here?

A. Since 1899.

Q. Yours is the only bank in Calhoun County, is it?

A. Yes sir.

Q. Was there a bank here prior to your coming?

A. No, this was the first bank in the county.

Q. Any railroads or telegraph lines through the county?

A. No, there are no railroads and no telegraph lines in the county.

Q. You don't remember the condition of the Illinois river at this point for a longer period than the first year before the opening of the canal?

A. No, not previous to February of 1899; that was when I came here.

Q. You don't use the water of the Illinois river for drinking and domestic purposes do you?

5019 A. No sir.

Q. You use cistern or well water?

A. Cistern water, yes sir. I have drank the Illinois River water though when I was out fishing.

Q. Your neighbors have cisterns or wells?

A. Well yes, but then for drinking purposes they most all use water from the town pumps here. We use cistern water, because in the winter I turn the ice water or snow water into the bank cistern and we use that for drinking purposes at the house, not having any well.

Q. Now you spoke of the water being in better condition since the opening of the canal than prior to its opening? You don't know whether or not the deleterious matter contained in the Chicago sewage comes down this far do you?

A. No, I couldn't state that.

Q. You don't know anything about that?

A. No.

Q. It may or may not so far as you know?

A. No, I do not know.

ELMER E. WILLIAMS.

5020 Hardin, Ill., July 15, 1903.

WILLIAM McNABB,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. William McNabb.

Q. What is your business?

A. Druggist.

Q. How long have you been living in Hardin?

A. About six years.

Q. Were you acquainted with the Illinois river before and since the opening of the drainage canal?

A. Yes sir; been acquainted with the river ever since I come here, about six years.

Q. How did you become acquainted with it?

A. Well by being on the river a good deal.

Q. In what way?

A. In living near, I have been on the river quite a good deal and then lived here since that time.

Q. What were you doing on the river?

A. Why I have been on the river boating and I have been fishing.

5021 Q. Will you describe the character of the waters of the Illinois river prior to the opening of the drainage canal in 1900?

A. The water in 1900 was very low, the stage of the water here, scarcely any current and the condition of the water was not as good as it is now by any means; there was a scum over the river during that year, a green scum.

Q. Do you mean 1900 or 1899? 1900 is the year that the drainage canal was opened on the 17th of January?

A. Well now, I guess that is right; it was before the canal was opened, the season before we had very low water here and in that year there was a green scum over the water.

Q. Was there any odor to the water?

A. Yes, there was.

Q. Since the opening of the drainage canal, have you observed any changes in the Illinois river and if so, what are they?

A. Well we have had a better stage of water, a good current. and we have no scum over the water, and the odor is not—there is scarcely any perceptible odor now.

Q. Is the water any better or worse than it was before the opening of the drainage canal?

A. It is a good deal better.

Q. What leads you to that conclusion?

A. My observation would be about all.

5022 Q. How many druggists in this town?

A. Just one.

Q. Are you the only one?

A. Yes sir.

Q. Do you know whether there has been any typhoid fever in this town since the opening of this canal?

A. I disremember of a case now, since; there perhaps has been but I haven't in mind a case now since the opening of the canal.

Q. Has there been as much malaria in this community since as existed before the opening of the drainage canal?

A. No sir, there has not.

Q. How do you know that?

A. Well, I know from the chill tonics and preparations for that complaint; we haven't sold since the opening of the canal—we haven't sold one-third or perhaps one-fifth as many as we did before.

MR. JEFFRIES: Move that the question and answer be stricken out because it is incompetent, irrelevant and immaterial and does not prove any issue in the case.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You are a married man?

A. No sir.

5023 Q. Do you board or live at home with your parents?

A. I board.

Q. You don't use water from the Illinois river?

A. No sir.

Q. I understood you to say that your opinion as to the water being better now than it was before the opening of the canal was based altogether on your observation of the river?

A. Yes sir.

Q. You never made or had made any examination of the water for sanitary purposes?

A. No sir, I have never made any for sanitary purposes.

Q. You don't know whether the deleterious matter contained in the sewage that comes from Chicago is contained in the water here at Hardin or not do you?

A. No sir—

Q. From personal knowledge?

A. No sir, not from a bacteriological standpoint; I don't know anything about that, I never had anything to do with it; I never examined the water in that way. Only of course from seeing it that I know, and the changes.

Q. In fact you don't know anything about the ingredients of the water?

A. I do not.

5024 Q. It may contain deleterious matter and it may not so far as you know?

A. Yes sir, it may.

RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. Do you know that as a matter of fact chemistry and bacteriology do not prove whether water has deleterious substances in it or not?

MR. JEFFRIES: We object to the question for the reason that the witness has not qualified as a chemist, and disqualified himself as a bacteriologist and has not qualified himself as ever having any practical or laboratory experience as a chemist or bacteriologist, or as an epidemiologist, or a person possessed of sufficient knowledge to offer an opinion upon the result of the experiments and work of men of chemical and bacteriological science, or in the analyses of water from a sanitary standpoint.

Q. (Question repeated.) And that epidemiologists hold that it is not necessary to know the chemical and bacteriological constituents of water in order to pass upon the sanitary character of it.

A. Well, I don't think it proves anything; I think there is a great deal of guess work done about it in fact I know 5025 there is.

RE-CROSS-EXAMINATION, by Mr. Jeffries.

Q. You are not a bacteriologist?

A. No, sir; I have studied bacteriology though.

Q. You are not an epidemiologist?

A. No, sir.

Q. You don't know what it takes to be an epidemiologist?

A. No sir; I don't know the requirements.

Q. You never were connected with any of the water systems of any of the larger cities in the United States?

A. No, sir.

Q. Never made any examination of their water supply?

A. No, sir.

Q. You don't know what the requirements for the best water supplies in the cities of the United States are?

A. No, sir.

Q. You don't know what percentage of the various ingredients deleterious or otherwise would condemn water for supplying a large city with water for domestic and drinking purposes, do you?

MR. TODD: I object to that question because there is no tribunal except a self-constituted individual tribunal authorized to condemn any water used for domestic and drinking pur- 5026 poses?

A. Well, I can't say that I don't know, but I think that that would vary according to the minds of the different chemists, but they may have a standard. If they have any standard of the deleterious ingredients that water should contain; I don't know what it is.

Q. Well, you don't know whether they have any standard or not?

A. No, sir; I don't know that they could have, because I think the opinions of that vary.

Q. You don't know then whether they have or not?

A. No, sir.

Q. In other words, you don't know a thing about it?

A. I don't claim that I know anything about it; I said that in the first place.

WM. McNABB.

5027 Hardin, Illinois, July 15, 1903.

L. M. DAVIS, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. State your name, residence and occupation?

A. L. M. Davis; Hardin, Illinois; my occupation is a general merchant.

Q. How long have you lived in Hardin?

A. Why, since December of 1880. That would be over 23 years.

Q. How long have you lived on or near the Illinois river?

A. Why, ever since 1855, except about five years I was in the army of the United States.

Q. Were you a soldier in the war of the rebellion?

A. Yes, sir.

Q. What was the condition of the Illinois river prior to January, 1900, when the drainage canal was opened?

A. Why, in what respect?

Q. As to quantity of water, current, color of the water, odor and use for domestic purposes?

A. Well, it was less current and to my judgment a great deal more odor and so far as the use of the water for domestic purposes—I know but little about that; I don't know who uses it.

5028 Q. To what did you attribute the odor prior to the opening of the drainage canal?

A. Well, stagnation; the lack of current would be my idea about it.

Q. As to the color of the water, how does it compare with the color since the opening of the drainage canal?

A. Well, I can't say that I see a great deal of difference in the color of the water except in places there would come a kind of a green scum on it; I have seen that along in places where there was no current, and I haven't seen that since the canal has been turned in; haven't noticed it here.

Q. Is there any odor in the water since the opening of the drainage canal?

A. I have never noticed any.

Q. What has been the general health of the community here since the opening of the drainage canal, as compared with the conditions before?

A. Well, I don't hardly know about that, but I am pretty well satisfied that the health has been equally as good as it was prior to the canal coming in.

Q. Did you know the river prior to the opening of the drainage canal, when it was very low?

A. Yes, sir; I have seen it very low.

Q. If you remember of any example of its condition, you
5029 may tell what it was.

A. Well, 12 or 13 years ago the water got so low at this point that boats were unable to get here,—that is steamboats—and I remember of a season prior to that when they got men at a point about I should say 20 or 25 miles north of here to go in with plows and scrapers to make a channel for a boat to go through; that was at Schoolhouse Bar, two miles below the C. & A. bridge.

Q. Do you remember the season of 1901, here as to whether it was a season of rains or of excessive drought?

A. I am not sure about the date; I know we had an excessive drought there a few years ago; I don't remember when it was; we had no rain I think from June to November.

Q. If in that time the waters of the drainage canal had not flowed through the Illinois river, would it have been navigable?

A. I think not, sir, with anything larger than a skiff.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. In your statement that the water is better since the opening of the canal than it was prior to the canal you are simply speaking from observation?

A. Yes, sir; I have never used the water.

5030 Q. You use well or cistern water?

A. Yes, sir; use both.

Q. You don't know then whether it contains deleterious matters or not?

A. Why, no, not from experience.

Q. What is the flow of the river with reference to its current now as compared to what it was prior to the opening of the canal?

A. Why, it is a stronger current, swifter current.

Q. You say they haven't cut any ice here for several years past?

A. No, sir; only along the shores you know.

Q. What they call floating ice?

A. Yes, sir; I guess it would be called that.

Q. The people around here in this locality use well or cistern water, don't they generally?

A. Well, yes, sir, to a great extent.

Q. Almost exclusively outside of the fishermen?

A. Yes, sir; I think so. We have several public wells most always.

Q. A great many of the fishemen have their own wells too, don't they, where they live in their houses?

A. Well, no, I don't know of any. They go to the public 5031 wells; we have five or six there in town.

L. M. DAVIS.

5032 Hardin, Illinois, July 15, 1903.

WILLIAM U. MORTLAND, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. State your name, residence and occupation?

A. William U. Mortland; postmaster; Hardin, Illinois.

Q. How long have you lived in Hardin?

A. Approximately 37 years; I was born and raised here.

Q. Have you during that time become familiar with the waters of the Illinois river, and if so, in what way?

A. I have always lived near the river, within 500 yards more or less, and while I have never made a chemical analysis of the water and practically know nothing about chemistry, all I know is from general observation.

Q. Have you fished and hunted in the waters of the Illinois river?

A. I have fished more or less with a hook and line and have been in bathing frequently.

Q. What was the condition of the water of the Illinois river prior to January, 1900, when the drainage canal was opened?

A. Well, it varied with the years, to the best of my memory
it was something in the nature of a stagnant pool; the
5033 water was covered in summer with a yellow scum, ap-
parently little current, and very strong odor. Of course it varied in different months in the summer; when the weather got warmer it was stronger; the month of August was especially bad.

Q. Was there a great deal of vegetation in the river prior to the opening of the drainage canal?

A. Yes, sir; what we commonly called buffalo grass; I remember some years ago of shooting fish in about the middle of the river in the buffalo grass; the grass was everywhere here.

Q. To what did you attribute the odor in the river prior to the opening of the canal?

A. Well, I don't know as I can say; there was comparatively little current and this buffalo grass doubtless tended to create that smell, and this scum that appeared on the water I presume had something to do with it.

Q. Was that probably from decay of the vegetation?

A. I should judge so.

Q. What has been the condition of the river since the opening of the drainage canal?

A. From general appearances the current is stronger and the water is clearer, and comparatively little if any odor from the water, and a better stage of water generally, and the absence of this buffalo grass; I haven't noticed it at all since that time.

5034 Q. What has been the general health of the community?

A. I know that a few years ago there was more malaria than there is today and than there has been in the last few years, whether that may be attributed to the difference in the condition of the water or not I can't say.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. What do you mean when you say that the water is better now than it was before the opening of the canal?

A. Well, judging from general appearance; the water is clearer now than it was, and judging from the speed of the current.

Q. You don't know whether it contains deleterious matters or not, do you?

A. No, sir; I do not.

Q. You don't use the water, do you?

A. No, sir.

Q. What is the comparison between the water now and what it was prior to the opening of the canal so far as the flow or current of the water is concerned?

A. The current is much swifter now than it was before. I only judge that from the boating that I have done, and the swimming occasionally.

5035 Q. The water flows now with a regular current at all seasons of the year except when the back water from the Mississippi interferes?

A. I presume so, yes, sir.

Q. Was that true prior to the opening of the canal?

A. Yes, sir.

Q. It had a current at all seasons of the year, did it?

A. Yes, sir.

Q. Much of a current?

A. Very little current before; considerable of a current since.

Q. You don't know whether the deleterious matter from the sewage from Chicago reaches this point or not?

A. I do not.

WM. U. MORTLAND.

5036 Hardin, Illinois, July 15, 1903.

JEFFERSON WELCH, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. Jefferson Welch; Hardin, Illinois; fisherman.

Q. How long have you been in the business of a fisherman?

A. Twenty-one years.

Q. How much of that time have you fished in the waters of the Illinois river?

A. Mighty nigh all the time. Of course I get over in the Mississippi sometimes in June or July, but then I fish kind of steady here.

Q. Have you been fishing with nets?

A. All the time with nets.

Q. How many miles above and how many below Hardin have you fished during these years?

A. Well, about 18 miles north, that is up as far as Pearl; that is 18 miles and about that far down the river.

Q. Prior to the opening of the drainage canal, what was the condition of the waters of the Illinois river?

5037 A. Well, it was low in the summer, full of moss and no current.

Q. What effect did the condition of the water have upon the nets?

A. Why it was full of moss, covered with moss; green moss. I would have to take it off with my hands; sometimes let it dry and knock it off.

Q. What was the condition of the fish in the Illinois river prior to the opening of the drainage canal?

A. Well, I don't know; I don't think they were as good as they are now; you see more dead fish along the banks; I haven't in the last few years seen very many dead fish along the banks, like I used to see; that is several years ago.

Q. Since the opening of the drainage canal, what has been the condition of the waters of the Illinois river?

A. It has been more pure, more current, and there was not near as much sickness; wasn't near as much fever and ague along the banks or low-lands as there was before.

Q. What is the condition of the fish in the Illinois river since the opening of the drainage canal?

Objected to as having been answered and as immaterial.

A. I would judge they were better.

Q. Do they live longer now in live-boxes than before the opening of the canal?

Objected to as immaterial.

5038 A. Well, they do if you keep your live-boxes in the current.

Q. As a fisherman do you drink the waters of the Illinois river?

A. Yes, sir.

Q. How is its drinking quality now as compared with before the opening of the canal?

A. Why, it is better now than it was, more cooler, the water drinks better.

Q. Do the fishermen along the Illinois river generally drink its waters while they are fishing?

A. Yes, sir; most generally do.

Q. Do you know of any typhoid fever among the people drinking the Illinois river water since the opening of the drainage canal?

A. No, sir.

Q. Have you been engaged somewhat in assisting in putting up ice?

A. Yes, sir.

Q. State the condition and appearance of the ice both before and after the opening of the drainage canal?

A. Well, I don't know the difference; it seems like to me the ice is more clear than it was before, more solider and more bluer than it was before.

5039 CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say you are a fisherman?

A. Yes, sir.

Q. Don't you know that there has been very little ice put here in the last few years?

A. Oh, we didn't put up none this last year. Of course once in a while we miss here, except if we don't put it up here we put it up on the river somewhere below or above.

Q. What is the difference between the current in the Illinois river now and what it was prior to the opening of the canal?

A. We have more current.

Q. Was there a good current all the time before the opening of the canal?

A. Before the opening of the canal we had a very slack current in the summer time, and of course if we had a head raise, then there was a current.

Q. You have a good current now all the time?

A. Pretty fair current all the time now, yes, sir.

Q. Do you live here in Hardin?

A. Well, I live just a mile and a half north of here.

Q. Do you live in a house or a house-boat?

A. I live in a house.

Q. Have you a well or a cistern?

5040 A. I have both.

Q. And you use well water for domestic purposes?

A. For domestic purposes, yes, sir.

RE-DIRECT EXAMINATION, by Judge Johns.

Q. Is the water from your well the water from the Illinois river which seeps in?

A. No, sir.

JEFFERSON WELCH.

5041 Hardin, Illinois, July 15, 1903.

WILLIAM MORTLAND, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. William Mortland.

Q. What is your business?

A. Farmer and fruit grower.

Q. Where is your place?

A. At Hardin; it is in the corporation here.

Q. Did you ever have any official position in this county?

A. Yes, sir.

Q. What?

A. I was county judge and I was a member of the Legislature in 1881 and 1882.

Q. Have you ever steamboated on the Illinois river?

A. No, sir; I have wood-boated.

Q. How long have you lived in this county?

A. I came here in 1848 and have been here since.

Q. Are you acquainted with the Illinois river?

A. I am around here.

5042 Q. Will you describe the conditions of the Illinois river prior to January, 1900, the opening of the drainage canal and since?

A. I lived on this river and I have seen this grass growing all the way, except about 100 feet of the channel that wasn't covered with grass; I have seen cattle and hogs grazing on it, and I have seen it here when we couldn't get a boat; when we couldn't get our freight loaded and I have seen it with a green scum all over it; it was unhealthy.

Q. What has been the condition of the water of the Illinois river since the opening of the drainage canal in 1900, and what effect in your judgment has the opening of the canal had upon the waters of the Illinois river?

A. Well, it is a good deal healthier here since the canal was opened, and I think the water is much better than it used to be.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Why do you say that the water is better than it used to be?

A. Why, there is not so much sickness here as it used to be and I am satisfied that it is healthier than it used to be.

Q. That is just your opinion, isn't it?

5043 A. Yes, sir; that's just my opinion.

Q. You are not an epidemiologist?

A. No, sir; as I said before, I am a farmer; I am just giving you my opinion.

Q. You have wells and cisterns on your farm?

A. Yes, sir.

Q. You use out of them for domestic and drinking purposes, do you?

A. Yes, sir.

Q. Your neighbors are supplied with wells and cisterns?

A. Yes, sir; some of them.

Q. And those who do not, use the town water?

A. Yes, sir.

Q. The only reason now that you have for believing the water to be better since the opening of the canal than it was prior to the opening of the canal is the fact that there is more current?

A. Yes, sir; there is more current than there used to be and there is no green scum on the water like there used to be and there is not so much malaria as there used to be.

Q. You don't know whether or not the water contains deleterious matter?

A. No, sir.

5044 Q. You don't know anything about the ingredients of the water?

A. No, sir.

WM. MORTLAND.

Adjourned to meet at Kampsville, Illinois, at 9 a. m., July 16, 1903.

5045 9 a. m., Thursday, July 16, 1903.

Parties met pursuant to adjournment.

Present, same as before.

Kampsville, Ill., July 16, 1903.

C. B. BRAKEVILLE, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. C. B. Brakeville; Kampsville, Ill.; I am a fisherman.

Q. How long have you been a fisherman?

A. Well, all my life; I never did anything else much.

Q. At how many places have you fished along the river?

A. Well, I fished at Copperas Creek locks; Havana, Meredosia, Pearl and Kampsville.

Q. Were you familiar with the condition of the Illinois river before the opening of the drainage canal in January, 1900?

A. Yes, sir.

Q. What was its condition with reference to the quantity of water?

A. Well, I don't know. I don't remember.

Q. Was there as much water in the river before the opening of the drainage canal as since?

A. Well, at times, no; not at times.

Q. Did the river sometimes become stagnant?

A. Yes, sir; very bad; it would be all green on top.

5046 Q. Was there an odor in the water?

A. Well, yes, to a certain extent.

Q. What did that come from?

A. Well, I don't know without it was from the water being so dead; that is the only way I can account for it; vegetation.

Q. Was there considerable grass and weeds in the river before the opening of the drainage canal?

A. Well, I don't remember about that; I don't know; I don't remember.

Q. What about the moss and slime upon your nets?

A. Well, yes, there used to be a good deal of slime and moss and such as that.

Q. Since the opening of the drainage canal how has the water been with reference to smell?

A. Well, I have never seen it smell.

Q. How about grass and weeds in the water?

A. Well, I don't know as there is any more than there ever was.

Q. How about the color of the water; is it clearer or less clear than before?

A. Well, to the best of my knowledge, it is clearer than it ever was; it clears up a little quicker.

Q. Do the fishermen as a rule drink the water of the river?

A. Yes, sir; I guess there hasn't been a day in ten years but what I have drank some of the water; every day that I have been on the water.

5047 Q. Are you pretty well acquainted with the fishermen along the river?

A. Well, a good many places, yes, sir.

Q. Do the fishermen have typhoid fever?

Objected to as leading.

A. Well, no, not very bad; you hardly ever see a fisherman sick.

Q. What do you say as to the health since the opening of the drainage canal; is it better or worse than before?

A. Well, I don't know; I never noticed it particular, whether any difference in it or not.

Q. Do you know anything about typhoid fever among the fishermen since the opening of the canal?

A. No, sir; never heard of it.

Q. Is there any difference in the color and quality of the ice, since the opening of the drainage canal, state what it is?

A. Well, there isn't any that I know of, without it is clearer. Clearer ice.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say you live here in Kampsville?

A. Yes, sir.

Q. How old are you?

A. 34 years old.

5048 Q. How long have you been fishing?

A. Well, ever since I can remember anything at all; never did anything else to amount to anything.

Q. Was your father a fisherman?

A. Yes, sir.

Q. Do you live in a boat on the river?

A. I have, yes, sir, all the time; or about all the time.

Q. What is the difference between the current or flow of the river now and what it was prior to the opening of the Chicago Drainage canal?

A. Well, we have a good deal stronger current.

Q. The water in the Illinois river is not clearer at all times and seasons of the year now, since the opening of the canal than it was prior to the opening of the canal?

A. Well, not at all times of the year; when it rains it muddies up but it clears up much quicker than it used to I think.

Q. Whenever a fair sized flood comes, the water gets just as cloudy and muddy now as it did prior to the opening of the canal, does it?

A. Yes, sir; for a short while.

Q. You say there was grass growing in the water prior to the opening of the canal?

A. Well, I don't remember; I don't know; there was grass and moss, that's about all.

5049 Q. What has become of that moss?

A. Well, I don't know; it seems as if it happened every few years; it never was much of a steady thing.

Q. How much of a current is there in the river now?

A. I don't know; I never tested it and I never heard anyone say.

Q. Quite a good current?

A. Pretty fair current, yes, sir.

Q. Now?

A. Yes, sir.

Q. In going down the river this morning, from this point to the dam I noticed the drift flowing down the river, do you know what is the cause of that?

A. Well, it is from the current, that's all I could tell you.

Q. Pretty fast current?

A. Well, yes, sir; there isn't as much right here as after you get away a little piece.

Q. You mean further up the river?

A. Yes, sir.

Q. How far is it from where this boat on which we are taking testimony, down to the dam?

A. Well, it is something like a half a mile.

Q. This current that you speak of continues down on and
5050 over the dam does it not?

A. Yes, sir.

Q. What is the stage of the water in the Illinois river at this point as compared with the ordinary stage of water?

A. Well, it is some lower right now than it has been for several years, that is the last two or three years.

Q. How far up the Ilinois river are you familiar with it?

A. Well, probably up as far as Beardstown.

Q. How far is that?

A. About 60 miles; something like that; I don't know exactly.

Q. There is a good current from Beardstown down the river to this point, is there not?

A. Yes, sir.

Q. How far are you acquainted with the Illinois river from this point down towards its mouth?

A. Well, down as far as Grafton; I have been down there quite often.

Q. Now, there is a good current from here to Grafton, is there not?

A. Well, pretty fair, yes.

Q. Then I take it that if the river is lower now than it has been for several years, two or three years, that there has been a good current in the Illinois river so far as your 5051 acquaintance with that river goes, ever since the opening of the canal?

A. Yes, sir.

Q. Was that true prior to the opening of the canal? Or before it was opened?

A. I didn't understand you.

Q. Was there a continuous current before the opening of the canal?

A. Yes, sir.

Q. How much?

A. I don't know.

Q. Did I understand you to say in your direct examination by Judge Johns, that at times the water became stagnant?

A. Yes, sir; just the same as some little puddle; I have seen it out here when you could see the mark of a skiff for miles through the water.

Q. You say it became just as a puddle?

A. Yes, sir.

Q. Then the water was comparatively still?

A. Yes, sir; the water was still; there wasn't any current above this dam at all.

Q. You don't know whether or not the water in the Illinois river contains certain substances that are injurious to health if used for domestic and drinking purposes, do you?

A. No, I don't know that there is.

5052 Q. Then your only reason for believing that the water is better is because there is some increase in volume and a stronger flow? Is that true?

A. Yes, sir.

Q. You are not a physician?

A. No, sir.

Q. You are out on the river a great deal?

A. Yes, sir; every day and part of the night.

Q. You know comparatively little about the sickness in this town and around the country?

A. Well, I don't know; I never paid much attention to it.

Q. You never paid much attention to it?

A. No, sir.

C. B. BRAKEVILLE.

5053 Kampsville, Illinois, July 16, 1903.

EDWARD HEATON, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. Edward Heaton; Kampsville locks; fisherman.

Q. How long have you been a fisherman?

A. Forty-two years.

Q. At what places on the Illinois river have you fished?

A. I commenced fishing at Chillicothe; fished at Peoria, Beardston, Meredosia, Montezuma, Bedford and Kampsville.

Q. Were you acquainted with the Illinois river at these places before the opening of the drainage canal in January, 1900?

A. Yes, sir.

Q. What was its condition?

A. Well, until from the government locks were put in, until we opened the canal, our low water got very stagnant, dead and bad, and since that, why, we never have had stagnated water.

Q. What was the smell of the water before the opening of the drainage canal?

5054 A. Well in the winter time when we were setting nets, the smell that would come out from the ice we couldn't stand at all; a sort of a gas.

Q. Where did you first observe that?

A. Up at Bedford, and Montezuma; the two towns are right close together.

Q. What effect did it have upon the fish?

A. Well, I won't be positive now about it being 1893, 1894 or 1895, but in one of the years it killed all our catfish.

Q. Did the water have an odor or smell in the summer?

A. Yes, sir; here at the dam anybody could notice it all summer long.

Q. Since the opening of the drainage canal has there been any odor in the water?

A. No, sir.

Q. How about moss and slime on your nets before the opening of the drainage canal?

A. We would have it in low water just the same as we have it now-days.

Q. At which time, before or after the opening of the drainage canal, was the condition of the fish best?

A. At which time of year?

Q. No, whether before or after the opening of the canal?

A. Well, you couldn't notice any difference in the fish.

5055 Q. Did they live longer in the live-boxes before or after?

A. In low water, they wouldn't live at all, before; we didn't have current enough to give them fresh water.

Q. Do they live in the live-boxes now?

A. Middlin' fair.

Q. Have you assisted in the winters before and after the opening of the drainage canal, in putting up ice?

A. Yes, sir.

Q. Is the ice clearer now than before the opening of the drainage canal?

A. Well, we get the ice a good deal clearer in some places, but we have got so much current it gorges together and we don't get as good ice now as we did before when we could catch dead water.

Q. Do you drink the water of the Illinois river?

A. Yes, sir.

Q. Does the water of the Illinois river produce typhoid fever in those who drink it?

A. There is very little typhoid fever that I have ever seen during all the time that I have been on the river.

Q. What is the general condition of the health of the fishermen?

A. Well, you don't find as many sickly fishermen as merchants.

Q. Do the firshermen generally drink the waters of the
5056 Illinois river?

A. Yes, sir.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You live here in Kampsville?

A. Yes sir.

Q. Do you live in a fish-boat?

A. No sir I live in a house.

Q. You live in your own private dwelling?

A. Yes sir.

Q. Have you a well or a cistern at your house?

A. No sir.

Q. Where do you get your water?

A. For the house purposes we get it at the public well.

Q. That is you get your water for domestic purposes at the public well here in Kampsville?

A. Yes sir.

Q. From your examination by Mr. Johns, I understand you are familiar with the river for a considerable distance up the river?

A. Yes sir.

Q. How far; about how many miles?

A. About 160 miles, or 170.

5057 Q. Now the condition that you stated, that the water was in, with reference to its being stagnant and still and void of current, was true with reference to the river prior to the opening of the Chicago drainage canal, from this point to 160 or 170 miles up the river?

A. No I will not say that because I have not been up in that country since the opening—

Q. No prior to the opening, before the opening?

A. Yes sir from this to Henry Lock.

Q. How far is Henry Lock from here, approximately?

A. About 189 miles, somewhere near that.

Q. Now how far up the river from this point are you and have you been familiar since the opening of the canal?

A. Well, not more than ten miles up.

Q. How far down the river from this point have you been acquainted with the river since the opening of the canal and prior to the opening of the canal?

A. Eight or ten miles.

Q. What is the difference so far as the current or flow of the river is concerned, as compared with the time prior to the opening and since the opening?

A. About one-half.

Q. Now as I understand from your testimony in answer to Mr. Johns' questions, there is a good current in the river now?

5058 A. Yes sir.

Q. And prior to the opening of the canal, unless there was a raise in the river or a flood there was no current?

A. None to amount to much, that is.

Q. There is quite a good current here opposite Kampsville, is there not?

A. Yes sir.

Q. Do you know about what is the rate per mile per hour or could you tell?

A. About two miles now.

Q. Right here opposite Kampsville?

A. Yes sir.

Q. How far is Kampsville above the dam known as Kampsville dam?

A. One-half mile.

Q. Does that current or rate of flow continue from this point at Kampsville to the dam?

A. Yes sir.

Q. What is the rate per mile per hour above Kampsville?

A. About the same.

Q. All the way up?

A. Until you get above the back-water of this dam.

Q. It gradually increases as you go up?

A. Yes sir.

Q. There is not very much green scum or moss in the
5059 river now, is there?

A. No sir.

Q. What kind of fish seem to prosper best in the river at this place?

A. German carp.

Q. Do you know, as a fisherman what the German carp feed upon?

A. Yes, sir; all the scavenger stuff they can get.

Q. What do you mean by scavenger stuff?

A. Horse manure, or any kind of manure or anything of that kind.

Q. Filth?

A. Yes sir.

Q. Do they feed on animal matter too?

A. Yes sir.

Q. Do they feed on fish, minnows?

A. No sir, not that I know of; I have never seen any of them feed on them.

Q. You are a very busy man aren't you?

A. I work all the time, yes sir.

Q. You pay no particular attention to the number of cases of sickness in this community?

A. Well, it ain't such a big community but what you can tell when a case of sickness comes up.

Q. You only know what you hear?

A. Well—

Q. And come in contact with?

A. Yes sir.

5060 Q. When you say the water in the Illinois river since the opening of the canal is better than it was prior to the opening of the canal you don't mean to say that it contains less substances and matters, that are harmful when used for domestic or drinking purposes, or that it contains any such matter, but your opinion is based altogether on what you observed from the appearance of the water?

A. No sir, I don't take my opinion that way; only just from what I know and what everybody teaches me, that the swifter the current is the better the water, the purer water.

Q. And that is regardless of whether it has been polluted or not?

A. Well, if polluted, that you say is far enough away in rushing over gravel and sand it is bound to purify it more than if it would lay stagnated.

Q. You don't know those facts that you have been told; you have simply been told that?

A. Well, yes I know it from drinking out of streams.

Q. You don't know that the water does not contain deleterious substances, do you?

A. No sir.

Q. In other words you don't know whether it does or not?

A. No sir.

5061 Q. You don't know whether it contains more or less since the opening of the canal than before the opening of the canal?

A. Well, no; I ain't analyzed it any.

ED. HEATON.

5062 Kampsville, Illinois, July 16, 1903.

JAMES MORAIN,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. State your name, residence and occupation?

A. James Morain; Columbiana, Green County, Illinois. Occupation fisherman.

Q. How long have you been a fisherman?

A. About fifteen years.

Q. At how many different places have you fished upon the Illinois river?

A. Keatches' Landing, about five miles below here, I first commenced.

Q. Have you been familiar with the Illinois river before the opening of the drainage canal in 1900?

A. Yes, sir.

Q. What was its condition then?

A. Well, before it opened this river was like a pond here; filthy stuff and a green scum.

Q. Did it smell?

A. Well, some; some smell especially about nine o'clock
of a morning when there was no draught that the breeze
5063 raises, was felt, there was a smell.

Q. How about the moss and slime and grass upon the nets?

A. The moss and slime was bad; plenty of it, all covered; it took two men to get them out something, that is now bad it was. Of course sometimes you know, it would be worse than when there would be no head raise.

Q. Since the opening of the drainage canal what has been the condition of the river?

A. Why ever since the opening of the canal we have had a much better current; the water has been much better in my opinion since the opening of the canal; that is, it don't smell.

Q. Do you drink the water of the Illinois river?

A. Well I use a well right on the bank of it.

Q. Does the water in the well seep in from the Illinois river?

A. Well sir, I don't know exactly, it is 24 feet deep. You can tell, there seems to be a strong vein in my well; it is mighty good water; it is in the lowest part of the ground; it is in Columbiana.

Q. When you are out upon the river fishing, do you drink the water from the river?

A. Well if it is warm weather we take ice and put in the water and use it; we put ice right in the river water; that is
all the way we have of getting drinking water.

5064 Q. When the water is warm, you take the water from
the river and put ice in it?

A. Yes sir, and when the water is all over the banks, when I live there at home I use the water with ice in it too, for the family. I stay there; it has to get awful high to run me out.

Q. Does the water of the Illinois river when you drink it, produce any disease?

A. No sir; I have lived right here fourteen years and I have never had a chill.

Q. Have you or any of your family had typhoid fever?

A. No sir.

Q. Do the fishermen on the Illinois river who drink its waters have typhoid fever?

Objected to because it assumes that the fishermen on the Illinois river drink the water.

Well sir, not as I know of; I don't know of anyone here that has had typhoid fever at this place.

Q. Have you assisted in putting up ice in the winter on the Illinois river.

A. Yes, I have; not this last winter I didn't.

Q. Since the opening of the drainage canal how is the ice?

A. Well sir, the ice is very nice if the river has no head raise on it; that is it is clear ice. Of course if we have a head-raise you know, there is more muddy water settles in it.

5065

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How large a place is Columbiana?

A. Oh, about five or six or seven families there most of the time.

Q. How far is Columbiana from Kampsville?

A. Just across the river.

Q. How far is Columbiana from Kampsville dam?

A. Well it is one-half a mile as near as you can get at it I guess. It is about 500 yards is all.

Q. Before the Chicago Drainage Canal was opened, I understood you to say there was very little current in the river?

A. We didn't have none; it was just like a pond in low water time.

Q. How is it now?

A. We have a good strong current.

Q. There is a good strong current from Columbiana and Kampsville to the Government dam at Kampsville, one-half a mile below?

A. Yes sir.

Q. There is a good strong current up the river from Columbiana and Kampsville?

A. Yes sir.

Q. It gets much stronger as it goes up?

A. Yes sir, it gets stronger; it was so dead that the nets would not stand up before this drainage came in, in low 5066 water.

Q. What fish thrive best in the Illinois river at this point? What species of fish; name the best fish that thrives, that you find, not the best fish?

A. That thrives the best?

Q. That's it.

A. I believe that the carp fish do.

Q. Do you know what the carp lives on, as a fisherman?

A. Well such as they can gather, the substance in the water, I reckon, and that they gather, floating in it; most anything that they can find floating, bugs and worms and such as that.

Q. Do they live on minnows?

A. No sir, none to amount to anything at all. The third year before the drainage came in our healthiest fish that we had, I think in the waters, died, I don't think that there is any healthier fish in the world than the cuigan. That year; I think it was the third year before the drainage came in, they died

Q. That was when the river was frozen over with ice?

A. Yes sir, but since that; since the drainage came in, it has never killed no fish.

Q. You are not acquainted with the river up any great distance?

A. To Meredosia.

Q. How far is that?

5067 A. That is, Oh I suppose forty miles, forty-five or fifty.

Q. Now since the opening of the canal they have had a good current at all times of the year from here to Meredosia?

A. Yes sir, a man knows it when he pulls it with a skiff.

Q. How was it before the opening of the canal?

A. Why the bigger part of it was a good deal like pulling in a lake.

Q. Or a pond?

A. Yes, or a pond, dead water. We would begin to strike some current then at Graysville, I think; that is the first current we would strike between here and Meredosia.

Q. In your statement that the water is better now than it was before the canal was opened, you judge from the appearance of the water and from the fact that there is a current?

A. Oh yes, the current is much stronger, and the fact is we didn't have none before.

Q. And that is your reason for saying that the water is better?

A. Yes that's my reason.

Q. You don't know whether it contains substances that are poisonous and injurious to the human system do you, when used for domestic purposes?

A. Well, it don't seem to be; I use it right smart during
5068 this last high water, when I used ice in it; I have got a family of six of us.

Q. That is during the high water that you used it?

A. Yes sir, during the high water, and my doctor bill is very little.

Q. Now this well that you speak of is how many feet deep?

A. It is 24 feet.

Q. Did you dig the well?

A. No sir.

Q. You have had occasion to examine it?

A. Oh yes, I have cleaned it out.

Q. What is the character of the soil in the bottom of the well?

A. It is sand, white sand.

Q. How far from the water's edge at low water mark is it?

A. Well at low water mark, it is about 85 yards from the river 50 feet from the slough that comes out right by the side of it, a deep slough.

Q. Now in low water time is there any water in the slough?

A. Yes sir, it never goes down; it turns right in from the river.

Q. It is about fifty feet from this slough?

A. Yes sir; the slough comes in here and the river comes this way the river runs north and south and the slough comes in from the southeast and runs northwest.

JAMES MORAIN.

5069 Kampsville, Illinois, July 16, 1903.

IRA DAVIDSON,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Ira Davidson.

Q. What is your business?

A. Fisherman.

Q. How long have you been a fisherman?

A. About a year and a half.

Q. How long have you lived at Kampsville?

A. Well, Kampsville has been my post office since I lived here a year and a half.

Q. Where did you live before coming here?

A. Lived in St. Louis.

Q. And were you acquainted with the Illinois river before you came here to live?

A. Yes sir.

Q. Where did you get acquainted with the Illinois river?

A. I got acquainted with the Illinois when I was living in Green county prior to going to St. Louis.

Q. When was that?

A. I lived two years in St. Louis.

5070 Q. With the exception of the two years that you lived in St. Louis, you lived here in Kampsville?

A. No sir, I lived in Green county, just across the river here.

Q. How far from the river did you live?

A. I live eight or ten miles from the river but I crossed the river twice a week, every week for about three or four years.

Q. Before 1900, were you acquainted with the condition of the Illinois river?

A. Yes sir.

Q. Will you describe those conditions?

A. Well, before 1900 the condition of the river was low stage of the water and no current practically.

Q. Any scum on the water?

A. Yes sir.

Q. Describe it?

A. Green scum as a usual thing.

Q. What was the color of the water?

A. The water was dark.

Q. What effect did the water have on fish?

A. Well, now I don't know as I can give you a definite answer to that; I wasn't fishing or paying no particular attention to fishing at that time.

5071 Q. What has been the condition of the Illinois river water since the opening of the drainage canal?

A. The water has been clearer, and we haven't had any scum or grass.

Q. Any other differences you have noticed?

A. Well I can't say as there was.

Q. Has there been any odor to the water?

A. None that I have noticed.

Q. How much have you been on the river during the last two years?

A. Eighteen months.

Q. Daily?

A. Yes sir.

Q. Have you drank the waters?

A. Yes sir.

Q. How often?

A. Well as often as half a dozen times a day.

Q. Has it made you sick?

A. Never taken a dose of medicine since I have been here.

MR. JEFFRIES: I move to strike out the question and answer, as being immaterial and irrelevant, and incompetent, and constituting no proof of any material issue.

5072 Q. MR. TODD: About how many fishermen are engaged in fishing at this point?

A. I should judge forty.

Q. Are they in the habit of drinking the water of the Illinois river when out fishing?

A. Yes sir.

Q. Has there been any typhoid fever or sickness in this community during the last eighteen months that you know of?

MR. JEFFRIES: Objected to for the reason that the witness has not qualified himself on the disease of typhoid fever, and has not shown that he is familiar with it, or that he knows the character of the disease, and for the further reason that it is incompetent and not the proper manner of proving the fact sought to be proved.

A. No sir.

Q. What in your opinion— Has the opening of the drainage canal— What in your opinion has the opening of the drainage canal had to do with the Illinois river in regard to the condition of the river as to whether the river water has been made better or worse?

A. Better.

MR. JEFFRIES: Objected to for the reason that the question does not provide for the use to which it is to be put, and upon which the answer is to be based.

5073

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You live here in Kampsville?

A. Yes sir, this is my post office.

Q. You live in a boat-house?

A. No sir.

Q. Do you use cistern or well water or water from the town well?

A. Use water from the well there where we live.

Q. You have a well at your house?

A. Yes sir.

Q. You use that for domestic and drinking purposes?

A. Yes sir.

Q. I understood you to say that prior to the opening of the Chicago drainage canal, in January, 1900, there was very little or no current in the river at this place, and that it looked like a lake or a pond, is that correct?

A. Yes sir.

Q. What is the stage of the river at Kampsville now, as compared with what it has been ordinarily since the opening of the canal in January, 1900?

A. Well, the stage is two foot higher I should judge.

Q. (Question repeated.)

5074 A. Well, it is rather low at the present.

Q. Has it been much lower since the opening of the canal than it is now?

A. Well, year before last, yes sir.

Q. That was in the drought of 1901?

A. Yes sir.

Q. There is a good current in the river now, is there?

A. Yes sir.

Q. A good current in the river here at Kampsville?

A. Yes sir.

Q. That current continues from here to the government dam about one-half a mile below?

A. Yes sir.

Q. And grows stronger as you go up the river away from the dam?

A. The farther from the dam you get the stronger the current.

Q. Do you know what the depth of the water is now that is flowing over this dam?

A. The depth on the dam?

Q. Yes.

A. No sir, I couldn't tell you.

Q. You have seen it have you not?

A. Yes sir.

5075 Q. What is your judgment as to its depth?

A. I wouldn't answer that because I couldn't give you nothing definite about it.

Q. It is considerable isn't it?

A. Yes sir.

Q. Several feet isn't it?

A. Three or more is several isn't it?

Q. Yes.

A. Well it is several feet then.

Q. You don't know whether the water contains any substance that is injurious to health or not?

A. It never injured my health.

Q. Well you don't know whether it contains it, I said?

A. I have never analyzed it; I don't know anything about it.

Q. It never injured your health before the canal was opened did it?

A. I never drank it before the opening of the canal.

Q. You were not fishing then?

A. No sir.

Q. What kind of fish thrive the best in the Illinois river water at this point?

A. I think the carp are thriving the best.

Q. What character of food do the carp live upon as compared with other fish?

A. I have never saw anything they wouldn't eat, yet.

5076

RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. What other fish thrive here besides the carp?

A. Cat, Buffalo, bass, perch.

IRA W. DAVIDSON.

5077 Kampsville, Illinois, July 16, 1903.

W. L. FLATT,

called as a witness in behalf of the defendants, being first duly sworn by the commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. W. L. Flatt.

Q. Where do you live?

A. Columbiana over here.

Q. What is your business?

A. Well, I fish.

Q. How long have you been a fisherman?

A. About ten years I guess.

Q. Are you on the Illinois river most of the time?

A. Yes sir, most of the time.

Q. Are you acquainted with the Illinois river?

A. Yes this part of it.

Q. How long have you been acquainted with the Illinois river?

A. Well, I guess about forty years.

Q. Do you know the condition of the Illinois river before the opening of the drainage canal, January, 1900, and since the opening of the drainage canal?

A. Yes sir.

5078 Q. Will you describe the condition of the water of the Illinois river before the opening of the drainage canal?

A. Well, in low water we have a scum, a good deal more or less upon the water; in low water and hot weather.

Q. What kind of odor did the water have?

A. What kind of a color?

Q. Color?

A. A kind of a green.

Q. Did it have any smell to it?

A. Yes sir.

Q. Was there any dead fish in the water at that time?

A. Yes sir, there was.

Q. How many?

A. Well I couldn't tell you how many, but quite a lot of them though.

Q. Since the opening of the drainage canal what has been the effect upon the waters of the Illinois river,—the turning into the waters of the Illinois river the waters of Lake Michigan?

A. Well it is a more clearer water; the water hasn't been so muddy.

Q. Has the green scum been on the water?

A. No sir.

Q. How about its color?

5079 A. Well it has a clear color more or less; only when it rains.

Q. Has it improved or injured the water?

A. It has improved it I think.

Q. Have you drank the water?

A. Yes sir.

Q. How often?

A. Oh I couldn't say how often; quite a number of times though.

Q. When do you drink the water?

A. Well, when we are out and get dry we have to take a drink of it.

Q. Has it ever made you sick?

A. Not since the canal has been put through.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Did it make you sick before the canal?

A. Yes sir, it did, the ague; I don't know whether the water did it or not.

Q. How old are you?

A. 53.

Q. Do you live here in Kampsville?

A. No sir, in Columbiana.

Q. You live in a residence or a boat house?

A. I live in a residence.

5080 Q. Have you a well at your house?

A. Yes sir.

Q. A living well?

A. Why it is only when the water gets over it, in high water.

Q. You don't know whether the water contains deleterious matter or not do you?

A. No, I don't.

W. L. FLATT.

5081 Kampsville, Illinois, July 16, 1903.

ISAAC STABLER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Isaac Stabler.

Q. Where do you live?

A. I live in Columbiana, Green county.

Q. Is that across the river from Kampsville?

A. Yes sir.

Q. How long have you lived there?

A. I have lived there since the 8th day of last October.

Q. And before that time where did you live?

A. In Montezuma for seven years.

Q. Is that on the Illinois river?

A. Yes sir, right on the bank of the Illinois river.

Q. What is your business?

A. Fisherman.

Q. How long have you been engaged in that business?

A. About 28 years.

Q. During that time you have been acquainted with the Illinois river?

A. Yes sir.

5082 Q. What was the condition of the Illinois river before the opening of the drainage canal in 1900; describe it in your own way?

A. Well as near as I can recollect the water was pretty badly stagnated; about that time that the river, as near as I can recollect in pulling backwards and forwards there was a heavy green scum on the water and since that time I haven't noticed it; since this drainage has been turned in I haven't noticed that scum.

Q. What was the color of the water before the opening of the drainage canal?

A. Well, it was a kind of a green dingy color before the opening of the canal.

Q. Was there any odor connected with it?

A. Yes sir.

Q. What kind of an odor?

A. Well I couldn't hardly tell; but the water was of a bad smell, and it didn't have a good color; I remember that much.

Q. Since the opening of the drainage canal, what has been the effect of the waters of the drainage canal upon the waters of the Illinois?

A. Well I think it gave it a good current, and I think it carried off the filth, and it don't have the green scum that raises on the water, we don't have it now; in fact I think 5083 it made the water more pure than it was before. If we have a freshet here it doesn't take it near as long to clear up as it did before. That is my recollection.

Q. How about the color of the water?

A. Well the color is much better than it was before. The water in fact is more pure than it ever was before.

Q. Is there any odor to the water?

A. No sir, none whatever.

Q. Have you drank the water?

A. Yes sir, drink it yet occasionally.

Q. How does the water taste?

A. Why it tastes a great deal better than it did before as near as I can recollect; it is more clear and pure.

Q. Has the drinking of the water had any deleterious effect upon you?

A. None whatever.

Q. The fishermen generally drink the water?

A. Yes sir, of course when we are out raising we have to drink it; as a general thing the fishermen don't carry water; we drink it right out of the river; sometimes we take water with us, but seldom it is.

Q. Have you had anything to do with making ice in the river?

A. Yes sir, every year.

5084 Q. How does the ice compare that has been made since the opening of the drainage canal, with the ice that was made before the opening of the drainage canal?

MR. JEFFRIES: Objected to as incompetent of this witness. This witness not being qualified to judge.

A. Well I think that our ice is more pure.

Q. In what way?

A. Why, it is more clear; we don't get no moss in the ice since that and we did always before; it was impossible to get it without moss, or a green substance of some kind.

Q. Do you notice any difference in the condition of your nets since the opening of the drainage canal and before the opening of the drainage canal as to deposits?

A. Well yes, quite a difference.

Q. What is it?

A. Well, before the canal was turned in; our nets would all turn green and form a scum all through the meshes of the nets, so you couldn't hardly hold the nets; it was very near impossible to get a stob to hold one. The pressure of the water against the corroding on the nets would pull them always, we couldn't hardly hold one at all.

Q. What has been the condition since the opening of the canal?

A. Well we can place the nets most anywhere we choose
now, and the scum don't pull them any more; we are not
5085 bothered with no substance any more, only in early spring
time, we have leaves of course in spring, early season,
the leaves are bound to run you know, always in the early spring, but that is merely a few days at a time, and after our leaves settle we are bothered no more with anything corroding on the nets.

Q. What in your opinion has been the effect of the waters of the drainage canal upon the waters of the Illinois River.

MR. JEFFRIES: Object to the question as the witness has not qualified to testify in that respect.

A. Well I think it gives it more current, it gives it more power which leads off and carries away faster; I did think at one time that it was a disadvantage, but I don't now, but that was only the rising of the water in the spring, but I see the current now carries the water away a great deal faster than it did before it was turned in. We have a freshet here and when the back water runs up it don't take it but a short time to carry it off, or didn't this spring, and we had extra water this spring. I think it has been a little over four weeks since the water was bad, and now you see where it is; they are planting corn and before that we couldn't do that at all.

Q. What effect has the water had from the drainage canal in purifying the water of the Illinois river?

A. Well I think it has had a great deal of effect.

Q. In what way?

5086 A. Well it carried off all the stagnated water; that is,
it purified it. I think it purified the water simply because we have got a better body of water than we had before, and a stronger current, and the water can't help but be better than it was before because we have more of it.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How old are you?

A. I will soon be 45 years old.

Q. How long did you say you have lived on the Illinois river?

A. I suppose about 22 or 23 years, that is that I have been fishing; somewheres in the neighborhood of it.

Q. How far up the Illinois river are you acquainted with it?

A. As far as Peoria.

Q. How far is that?

A. Well sir, I don't exactly know; I didn't measure the distance and I couldn't tell exactly how far it is.

Q. Well about how far?

A. Well it is I suppose may be 100 miles, may be 110 miles.

Q. How far down the river from Kampsville are you acquainted with the Illinois river?

5087 A. Well I am acquainted to the mouth of it.

Q. What is the difference between the current or flow of the water in the Illinois river from Peoria to Grafton since the opening of the canal as compared with the flow of the water prior to the opening of the Chicago drainage canal?

A. Well I think it is more stronger; it has a stronger current and it carries away faster, if I understand your question right.

Q. Carries what away faster?

A. It carries the water faster.

Q. I understood you to say in your answer to Mr. Todd's questions, that before the canal was opened, the water in the river was stagnant?

A. I did say so.

Q. And still. What I mean is, the water was still?

A. Yes, before, it was dead; before this drainage was turned in it was dead; of course it was stagnant.

Q. How much of a current have you now?

A. Well we have a right smart, more than we had before, but I don't know just exactly the power that a man would drift; the difference in the drifting of the current.

Q. There is a very heavy current?

A. Yes sir, there is a strong current now.

Q. There is a strong current in the Illinois river here
5088 opposite Kampsville, is there not?

A. Yes sir, there is a strong current.

Q. How far is Kampsville above the Government dam?

A. One-half mile, or in the neighborhood of it.

Q. How does the stage of water in the Illinois river today compare with the ordinary stages of that water since January, 1900, the date of the opening of the canal—the month of the opening of the canal?

A. Why we have a better stage than we had before.

Q. I mean, is the stage of the water higher or lower now than it has been for the last two years since the opening of the canal?

A. Well it is a little somewhat higher.

Q. I don't want you to refer to anything that existed before the canal was opened; I am now speaking of conditions that existed exclusively since the opening of the canal?

A. I think it is about the same.

Q. What do you mean by that?

A. Why I think it is about the same as it was.

Q. Was when?

A. Since that canal was turned in; I think it is about the same stage; it may be a little shade higher.

Q. You mean by that that it is a little shade higher now
5089 than it was the month the canal was opened?

A. Yes sir.

Q. Now then, isn't it about as low now as it generally gets, since the opening of the canal?

A. No, it will get somewhat lower yet.

Q. How much lower?

A. Well it will go four feet—three feet anyhow; I will say three feet.

Q. There will always be a current, though?

A. Yes, sir, a good current.

Q. Here at Kampsville?

A. Yes, sir.

Q. Now, as you go up the river from Kampsville, the current grows somewhat stronger?

A. Yes, sir.

Q. Does the current continue from here to the dam?

A. Yes, sir, the current will carry you right over the dam.

Q. You live here in Kampsville, I understand?

A. Columbiana, just across the river.

Q. You live in a residence?

A. I live in a cabin boat on the bank.

Q. What fish or species of fish thrive best in the water here?

A. Carp.

5090 Q. Do you know what carp feed on?

A. Well they feed on anything most; anything in the shape of something to eat.

Q. Do they feed on minnows?

A. Yes sir.

Q. As well as they do on other matters?

A. Well no, not so much; they feed principally on grass; feed in the moss, you know and they go in the mud after mussels, etc.

Q. You don't know whether this water contains deleterious substances or not do you?

A. I don't think it does now.

Q. Well you don't know whether it does or not?

A. Well I have been around it a good deal and I never found anything like that if I understand you right.

Q. Did you ever examine it chemically?

A. No sir, never did that.

Q. You speak simply from observation?

A. Of course there is men that tested it, but I never did.

Q. Of course you are not speaking from what those men said?

A. No. ISAAC STABLER.

5091 Kampsville, Illinois, July 16, 1903.

JOHN M. HIPPLE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. John M. Hipple; I live in Kampsville for the last three years; I am a pilot on the river in the employ of the government.

Q. What is your employment by the government?

A. Pilot in the season time, and in the winter time I look after the fleet, day watchman on the fleet.

Q. What is the fleet?

A. We have three dredges, three steamboats and quarter boats and scows,—barges or scows.

Q. How long have you been in the employment of the government as a pilot?

A. Three years last May.

Q. Did you prior to becoming a pilot, have any other occupation upon the Illinois river?

A. Well I have lived on the river all my life and ferried and fished and steam-boated.

Q. How old are you?

5092 A. I am 38 years old. I was 8 years old when I came to the State of Illinois; I have only been on the river 30 years; I said all my life; ever since I was big enough to work.

Q. While engaged on the Illinois river, have you traveled its entire navigable length considerably?

A. I have traveled to La Salle, Illinois.

Q. Where did you fish in the Illinois river?

A. At Beardstown, that is below there some, below Beardstown.

Q. Have you had opportunity to observe the operations of the government in dredging?

A. Yes sir, I have been with them.

Q. Where have you observed the dredging operations?

A. Well the most of it has been below here, between here and the mouth of the river.

Q. What is the character of the material taken from the Illinois river by the dredge boats?

A. Well in some places down below, we find mostly sand and mussel shells and some places we strike mud, and some places it would be very thin mud and some places stiffer, and gumbo, but the most of it was sand and mussel shells.

Q. Had you anything to do with the dredging operations before the opening of the drainage canal?

A. Yes sir, worked with them one season down there.

Q. At what point?

A. Well you might say between the locks here and the 5093 mouth of the river, or Six Mile Island; Six Mile Island is at the mouth of the river.

Q. What was the character of the material dredged before the opening of the drainage canal?

A. Well I couldn't say as there was much difference; I couldn't say whether there was any difference or not. Of course I saw it and handled the mud, like you saw the boys this morning, and take that away, but the mud was different in so many places.

Q. Does the character of the bottom of the Illinois river vary at different places upon the river?

A. Why yes, at some places it is mud and at some places it is sand, and at some places it is hard mud, what they call gumbo, you can't shovel it, you can't cut it and you can't wash it.

Q. Prior to the opening of the drainage canal, was there in the bottom of the Illinois river a large amount of sediment?

A. Why, there was in places, but not in the channel, but out at one side and behind the island, and where there was slack water, and the river had filled in, there was, but it hadn't filled in in the channel; around the creeks and where the creeks empty it fills in some and changes.

Q. What was the condition of the water on the Illinois river before the opening of the drainage canal?

A. Well at low water it got very filthy and green.

5094 Q. What caused the filth?

A. No current to drive it away, I think.

Q. Was the filth from decayed vegetation or from sewage?

A. Well I think it was from both, but mostly from sewage.

Q. Were you familiar with the stretch of river from Peoria to LaSalle?

A. Yes sir.

Q. What was the condition?

A. Well in low water it was filthy and dirty.

Q. At what part of that stretch of the river did it seem to be more filthy?

A. About the Henry lock; about the Henry dam.

Q. Did the character of the water improve as you got near Peoria and if so in what respect?

A. Well, when we got over the Henry dam it got better, when we got down to Peoria, or down near to Peoria.

Q. Were you familiar with the stretch of river from Peoria to Copperas Creek dam?

A. Yes sir, very.

Q. Prior to the opening of the drainage canal what was the condition of that stretch?

A. Very bad, very bad.

Q. How was it as compared with the stretch of river immediately above Peoria and up to Chillicothe?

5095 A. Well it was a good deal worse down below Peoria than it was above.

Q. On what account?

A. Well I think it was from the sewage from Peoria; no current to drive it away.

Q. Since the opening of the drainage canal, how is the water below Peoria and the Copperas Creek dam?

A. Well, I was over it yesterday and it is a great deal improved; it looks as well as this river down here.

Q. Before the opening of the drainage canal, were you familiar with the stretch of water from the Copperas Creek dam to La Grange dam?

A. Yes sir.

Q. How far is it from Peoria to Copperas?

A. The Government has got it surveyed down here; but the steamboat men call it 30 miles, from Copperas Creek to Peoria.

Q. How far from Copperas Creek dam to LaGrange dam according to the steamboat men?

A. 82 miles.

Q. How far from LeGrange dam to Kampsville dam?

A. 60 miles the steamboat men call it.

Q. Prior to the opening of the drainage canal, what was the condition of the water between Copperas Creek and La Grange?

A. Well it is a good deal better than it was above; after
5096 it went over the dam, it didn't get bad again until it
got down to Beardstown, or near the other lock. Down to the LaGrange lock.

Q. Since the opening of the drainage canal, what is the condition of that stretch of water?

A. Well it seems to be a great deal improved.

Q. Before the opening of the drainage canal, what was the condition of the stretch of water between La Grange and Copperas Creek?

A. Before the opening?

Q. Yes? Between LaGrange and Kampsville?

A. It wasn't near as bad as it was up above Copperas Creek, but it is better now than it was then. The river is in better condition now than it was then.

Q. What was the condition of the water between LaGrange and Kampsville dam prior to the opening of the drainage canal?

A. Well, as I said before, it ain't as bad as it was before; it ain't as bad as it is up above, but it is in a better condition now than it was before.

Q. Prior to the opening of the drainage canal, what was the condition of the water between Kampsville and Grafton?

A. Well, it was in a better condition than it was above.

Q. How is that stretch of water since the opening of the drainage canal?

5097 A. Well, it is improved.

Q. You may state whether the water of the Illinois river, prior to the opening of the drainage canal, improves as it travels from LaSalle to Peoria Lake?

A. Why, yes, it improves.

Q. Since the opening of the drainage canal, you may state whether the water from LaSalle to Peoria Lake improves as it travels?

A. Yes sir.

Q. Prior to the opening of the drainage canal, which water was in the worst condition, that at LaSalle or that immediately below Peoria?

A. That immediately below Peoria.

Q. Which was in the worse condition, the water in Peoria Lake above Peoria, or the water below Peoria?

A. The water below Peoria was the worst; the water above Peoria was the best.

Q. Did the water as it traveled from Peoria to Copperas Creek dam, improve in appearance?

A. No, it seemed like it got worse until after it came over the dam and then it seemed to improve. It had to come to Pekin you know and there it got mixed with a lot more.

Q. At what place between Peoria and Copperas Creek dam was a large amount of sewage and offal added to the water in the river?

5098 MR. JEFFRIES: That is objected to as being incompetent and immaterial and does not tend to prove or disprove any issue in the case.

A. At Pekin.

Q. Before the opening of the drainage canal, did the waters of the Illinois river appear to improve between Copperas Creek and La Grange?

A. Yes sir.

Q. Before the opening of the drainage canal did the water of Illinois River appear to improve between La Grange and Kampsville?

A. Yes, sir.

Q. Before the opening of the drainage canal did the waters of the Illinois river improve between Kampsville and Grafton?

A. Yes sir.

Q. Since the opening of the drainage canal, do the waters of the Illinois river appear to improve between LaSalle and Peoria?

Objected to as leading.

A. Yes sir.

Q. Are the waters in that stretch of river better since the opening of the drainage canal than before?

Objected to as leading and suggesting the answer desired.

A. Yes sir.

5099 Q. Since the opening of the drainage canal, what has been the condition of the waters of the Illinois tween Peoria and Copperas Creek Dam as compared with their condition before the opening of the drainage canal?

A. Well, they are better; navigation is better.

Q. How about the appearance of the water?

A. Well, the water looks better.

Q. Since the opening of the drainage canal, what has been the condition of the waters of the Illinois river between Copperas Creek dam and LaGrange dam?

A. Why they are better, and purer and not so much vegetation and green stuff.

Q. How do the waters between Copperas Creek and LaGrange, since the opening of the drainage canal, compare with the waters between Peoria and Copperas Creek?

A. Well the further down this way the better the water is.

Q. How do the waters of the Illinois river since the opening of the drainage canal, compare with the waters before the opening of the drainage canal between LaGrange and Kampsville dam?

A. Well they are better since the opening of the canal.

Q. Since the opening of the drainage canal, how do the waters below Kampsville dam to Grafton, compare with the waters of the Illinois river before the opening of the drainage canal?

A. Well, it has improved it some; the waters are bet-
5100 ter, but you can't notice it here like you can on the up-
per end.

Q. Since the opening of the drainage canal, you may state whether the waters of the Illinois river gradually and steadily improved from LaSalle to Peoria Lake?

MR. JEFFRIES: Objected to because it is leading and suggestive and because it is misleading.

A. Navigation improved yes sir, wonderfully.

Q. What about the improvement in the condition of the water from LaSalle to Peoria?

A. Well, it looks clearer.

Q. Since the opening of the drainage canal, do the waters of the Illinois river improve between Peoria and Copperas Creek dam, and if not, state why?

MR. JEFFRIES: Objected to as being leading and suggestive.

A. Yes sir, they improve.

Q. What amount of offal and sewage do these waters receive at Pekin?

A. Well sir, you have got me; I don't know.

Q. Is the amount considerable?

A. Yes sir.

Q. Since the opening of the drainage canal, do the waters of the Illinois river improve in condition between Copperas Creek and LaGrange?

A. Yes sir.

5101 Q. And between LaGrange and Kampsville?

A. Yes sir

Q. And between Kampsville and Grafton?

A. Yes sir.

Q. Have you noticed the condition of the ice taken from the Illinois river since and before the opening of the drainage canal at various places?

A. Yes sir.

Q. Which is the clearer ice as a general rule, that taken before the opening of the canal or afterwards?

A. I couldn't say as to that; I couldn't see any difference.

Q. Do you drink the waters of the Illinois river?

A. Yes sir.

Q. How long have you been indulging in that practice?

A. All my life, ever since I was eight years old.

Q. Do the fishermen upon the Illinois river drink its waters?

A. As a rule they do, yes sir.

Q. Among the men now in the employ of the government of the United States upon the dredging fleets, do they drink the waters of the Illinois river?

A. Most of the time, yes sir.

Q. Does it produce typhoid fever among these men?

MR. JEFFRIES: Objected to for the reason that the witness is not qualified to testify upon that point, and whatever he might say in regard to that would in no wise be competent evidence. 5102

A. If any of them ever had typhoid fever, I never heard of it.

Q. In your acquaintance and long experience upon the Illinois river, which class of the community, those living upon and drinking the waters of the river or those living upon land in the hills are the healthier?

MR. JEFFRIES: Objected to as incompetent and immaterial as the witness is not a physician, and therefore unable to testify or make comparison as to the health of the people, or to draw any conclusions as to the cause of such condition of health as may exist.

A. Well, I couldn't say, sir.

Q. What is the use of the dams in the Illinois river?

A. To back the water up over the bars.

MR. JEFFRIES: Objected to as immaterial.

Q. Do these dams retard or stop the flow of the river up to their aprons?

A. Yes sir.

Q. How far does the water of Kampsville dam, back up the waters of the Illinois river?

A. I think they aim for to back it to LaGrange.

Q. What is that distance?

A. Fifty miles.

5103 Q. How far does LaGrange dam back up the water?

A. Oh, I should judge fifty or sixty miles; I don't know just how far it is.

Q. How far does the Copperas Creek dam back up the water?

A. Well I suppose forty or fifty miles; I don't think it backs it up as far as these do.

Q. Does it back it up as far as Peoria?

A. Well, I couldn't say.

Q. How far does Henry dam back up the water?

A. Well I don't know just exactly.

Q. About how far in your judgment?

A. I should judge about forty miles.

Q. What is the effect of high water in the Illinois river upon its channel?

A. It causes the channel to fill up.

Q. Does the flood in the Illinois river wash out the channel and remove whatever sediment there is in it?

A. No sir.

Q. What is the effect of high water in the tributaries of the Illinois river as to the making of deposits and the creating of bars in the Illinois river?

A. The high water is the cause of them filling and forming.

MR. JEFFRIES: We object to the testimony of this witness in this respect for the reason that he has not quali-
5104 fied himself as being able to testify in that regard and especially unable to give an opinion as to whether or not the floods and high waters wash out the deposits in the bed or channel of the river, or as to whether or not the flood caused the deposits to be made in the channel or bed of the river, or as to whether or not the floods or high waters in the tributaries of the Illinois river, create such deposits; the witness having shown none of the necessary qualifications which would authorize that character of testimony.

Q. JUDGE JOHNS: What is the purpose of dredging in the Illinois river?

A. To deepen the channel so steam-boats can run.

Q. At what places is the dredging done?

A. Well, wherever it fills in.

Q. Is it done where bars are formed?

A. Yes sir.

Q. Where do these bars form in the Illinois river, above or below the entrance of the tributaries?

A. Well, it is generally below them.

Q. When the government has dredged a channel through a bar below a tributary of the Illinois river, what do you know with reference to that channel after a flood in the tributary?

A. Well you don't know whether it is there or not until you get in and see.

5105 Q. In your experience in dredging on the Illinois river, what do you find as to the channel below the entrance of tributaries, filling up after high water or flood in the tributary?

A. You mean what kind of sediments, what you get out of there?

Q. As to whether the channel fills up; do you find the channel filled up again?

A. Yes sir, quite often it does; it don't fill up every time a creek comes out.

Q. Do you mean by that every time the high waters of a creek come out?

A. I mean it don't fill up every time a creek comes out.

Q. Well you mean the high waters of a creek?

A. Yes sir.

Q. When you find a channel filled up below the entrance of the tributaries, and after a flood in the tributary, what is the fact as to where the filling matter comes from?

A. Well, that is pretty hard to tell; I couldn't say where it did come from.

Q. To what do you as a government employe attribute the filling up?

MR. JEFFRIES: Objected to for the same reason stated in the previous objection touching the qualifications of this witness to testify on a subject of this character.

5106 A. Well the creeks throws the mud out, it comes down out of the hills, fills the creeks and settles there until they get current enough to carry it away.

Q. In the times of flood, does the Illinois river wash out all the sediment deposited between its banks and carry it away?

MR. JEFFRIES: Objected to as leading.

A. Not always.

Q. In times of flood, what is the effect upon the deposits in the Illinois river, outside of the running channel; are they increased or diminished by the flood?

A. Well it was increased by this year's flood, but as a general thing it is diminished.

Q. Does that depend somewhat upon the character of the flood?

A. Yes sir, here it does.

Q. Does a flood have the effect to increase or decrease the amount of sediment in the back waters or slack waters created at the time of flood?

MR. JEFFRIES: Objected to for the same reason as heretofore stated and because it is leading, the witness being wholly disqualified from testifying on that subject.

A. Yes sir.

Q. You mean by that it increases the amount of sediment?

A. It did this year here.

5107

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Where did you say you lived?

A. Kampsville.

Q. How long have you lived at Kampsville?

A. A little over three years.

Q. Where did you live before you lived at Kampsville?

A. Beardstown?

Q. Were you born and raised at Beardstown?

A. No sir.

Q. How long have you lived at Beardstown?

A. Oh, I was there four or five or six years and I lived down below about six miles; raised down below about six miles.

Q. Below here?

A. Below Beardstown.

Q. What did you say your business was or profession?

A. Pilot.

Q. You are not a civil engineer?

A. No.

Q. How long have you been piloting?

A. About nine years.

Q. You have charge of a fleet here now?

A. No sir, I am on a steamboat now.

Q. In the employ of the government?

A. Yes sir.

5108 Q. How long was you in the dredging business for the government?

A. Well I have been with them going on four years and I go out every season dredging.

Q. And you commenced in 1899?

A. I commenced three years ago last May.

Q. That would be May, 1899, wouldn't it?

A. Well, you can figure it up.

Q. Well I am asking you?

A. I told you.

Q. You told me what?

A. In May.

Q. In what year?

A. Well I said three years ago last May.

Q. Well, what year would that be?

A. I don't know.

Q. You can't tell?

A. I could, yes sir.

Q. Well, I would like you to tell me.

A. Well, I don't think it is important.

MR. JOHNS: Yes, answer the question.

A. No, I wouldn't answer that question.

THE COMMISSIONER: Answer the question.

Q. MR. JEFFRIES: The question may seem foolish to you, but we have to have them answered. I am not trying to humiliate you at all. 5109

A. Well, it looks like it.

MR. JEFFRIES: You are badly mistaken in that; I have no such intention at all.

JUDGE JOHNS: The witness is instructed that he must answer all questions and leave to the Court the propriety of the question; the law requires the witness to answer every question to the best of his ability.

Q. MR. JEFFRIES: What year would that be?

A. Are you waiting on me?

Q. Yes.

A. Well, you needn't to wait on me, I told you when it was.

Q. What year would that be?

A. In 1899.

Q. Then you commenced the service of the government in May, 1899, as I understand it?

A. Yes, sir.

Q. Now, what was the character of your employment when you first commenced working for the government?

A. I was pilot on a dispatch boat.

Q. Was that the name of the boat or the character of the boat?

A. Yes, sir.

Q. Now, explain what you mean by the dispatch boat?

5110 A. What is called the dispatch boat; it carries the mail and provisions and does the chores.

Q. It was a small boat then, was it?

A. Yes, sir.

Q. Did it do any towing?

A. Yes, sir.

Q. Did it do anything in connection with this dredging work?

A. Yes, sir.

Q. Now, what did it do?

A. It helped the other steamboats, removed the dredges and done anything to be done.

Q. It was stationed at the dredge boat, was it?

A. The most of the time.

Q. In fact, all the time except when it would be engaged in some other work?

A. Well, some days we would be here; some days at the fleet, and may be some days up at Beardstown or wherever they were a mind to send us, wherever business called us.

Q. When did you commence the first dredging?

A. Three years ago last May.

Q. Immediately after your employment?

A. Yes, sir.

Q. Do you know whether or not the government had been dredging in the Illinois river prior to that time?

A. Yes, sir.

5111 Q. Could you state where?

A. Why, yes, I could state a good many places.

Q. Name some of them?

A. Devil's Elbow, Sugar Creek, Meredosia, Wilson's Island, Eagle Island and Diamond Island and Herriken Island, Morton's Island, Gilfords, Otter Creek, Twelve Mile Island and Six Mile Island; that's all I can think of now.

Q. Do you know when the dredging was done at Devil's Elbow, approximately, say?

A. No, sir; I couldn't just say the year; I couldn't.

Q. Do you know what that dredging was done for?

A. To deepen the channel for the boats to get through.

Q. Well, at that place they dug out the natural bed, it was not a deposit, was it?

A. In some places they went over it and had to re-dig it out; it might have been a deposit; most of the places it was a natural bed, but in some places it was a deposit.

Q. That applies to nearly all these places?

A. Yes, sir, they pretty near all fill up and they have to re-dig them.

Q. I don't know whether I understand you or you understand me; what I mean this dredging was done in the natural bed, before any deposit was put there, in order to make a deeper channel than had formerly been at any time in the past?

5112 A. Well, around these creeks, where this dredging is done there is a cause; what caused it once, causes it again; a creek comes out and fills it up and if it don't come out any more for four or five years, we don't have to go back there. What caused it once will cause it again.

Q. Now, where was the first place that they commenced dredging after you commenced work for the Government?

A. Mortland's Island.

Q. How long did they work at that place, dredging?

A. Well, I don't just remember just how long they did work there; I should judge a month or five weeks, something like that.

Q. Do you remember the character of the soil or earth that you took out of the river?

A. Why, it was mostly a mixture, or mostly sand; some places it was loose, but most of the places it was sand.

Q. Now where was the next place?

A. Six Mile Island.

Q. Do you remember when that was?

A. It was when I first went to work for them.

Q. Immediately after the Mortland Island work?

A. Yes, sir.

Q. And during that same year?

A. Yes, sir.

Q. Now, was that the same character of soil?

5113 A. No, I think there was more mud down there at Six Mile.

Q. Now, is Six Mile Island above or below Mortland's Island?

A. Below.

Q. From Six Mile Island you went next to what place?

A. From Six Mile I forget whether we moved back up to

Twelve Mile, or whether we moved to Herriken; we worked that over, that country twice that year and twice the next year. We made so many moves, I don't remember.

Q. Now, where is Twelve Mile Island with reference to Six Mile Island?

A. It is six miles this side of Twelve Mile Island.

Q. And the other side of Mortland's?

A. Yes, sir.

Q. And where is Herriken?

A. Herriken is about three miles below here.

Q. Below Kampsville?

A. Yes, sir.

Q. Now, at Herriken there was a great deal of mud there?

A. Yes, sir.

Q. How was it down at Twelve Mile Island?

A. There wasn't a great deal of work there; it was most all sand.

Q. Now, did you do any dredging up the river from Kampsville?

A. Nothing only up at the lock; we went up and dug the mud out of the lock; that is, since I have been working for them.

5114 Q. Yes, I understand. You dragged the mud out of the locks here at Kampsville?

A. No, sir; I never did; I am dragging it out now; when we dug it out before the other man dug it out, and they sent me up to the other lock.

Q. What is the character of the mud that comes out of those locks?

A. It is very thin.

Q. Dark color?

A. Well, it is awful dark; still it is the mud color.

Q. Just the mud color?

A. Yes, sir.

Q. How deep is it?

A. The mud we are digging out now?

Q. Yes.

A. Oh, it varies, some places five or six feet deep. I don't know just exactly, but I judge from the way they bring it up.

Q. Now, what do you do with that mud?

A. Take it out into the river, out of the channel and dump it is about the only thing.

Q. You made the same disposition of all the mud that you took out of the river?

A. Yes, sir; just move it out of the channel.

5115 Q. How deep was the mud at this other lock or dam, up the river from Kampsville, that you cleaned out?

A. Oh, it was four or five feet or more.

Q. What dam was that?

A. LaGrange.

Q. Now, in this work of dredging, your work was entirely in the pilot house, was it?

A. No, sir; I got down when some of the men got involved; I had to go down and give them a start, and show them how to work it, was the only difficulty.

Q. Did you supervise it?

A. Yes, sir.

Q. How much more flow or current is there in the river now along here at Kampsville than there was before the canal at Chicago was opened; I don't mean in exact miles, just approximately?

A. Well, before the canal was opened the water was all green out here; just plumb green like a pond.

Q. There was no current?

A. No, sir; not right above the dam; the further up the more current you get. The water at the lowest here, was practically at a standstill.

Q. How has the current been since the opening of the canal?

A. Why, there has never been no dead water here.

5116 Q. There has always been a good current ?

A. Yes, sir, a fair current when the water was low; it was not a good current, exactly.

Q. When you spoke in your examination in chief in answer to a question from Mr. Johns, you spoke of the water being better now than it was prior to the opening of the canal, you meant from an observation of the water and not from a scientific examination of that water?

A. No, sir; not from scientific; no, sir; I don't know anything about that; I know it is better navigating and it is better to drink and it looks better.

Q. How old are you?

A. 38 years. JOHN M. HIPPLE.

5117 Kampsville, Illinois, July 16, 1903.

C. V. BRAINARD, called as a witness in behalf of the defendants, after being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. C. V. Brainard.

Q. What is your business?

A. Civil Engineer.

Q. Did you have charge of the taking of water above Kampsville Lock for the Sanitary District of Chicago, and the University of Illinois and the University of Chicago?

A. Yes, sir, I did.

Q. What years was water taken?

A. Well, parts of 1900 and part of 1899.

Q. At what points above the lock were samples of water taken, Mr. Brainard?

A. Well, they were taken about four or five feet above the lock, and from two to three hundred feet from the bank, that is, different weeks; they weren't exactly the same place each week, as near as we could get it, though.

Q. How often were samples taken?

A. Once a week.

5118 Q. What instructions did you have in regard to how the samples of water should be taken?

A. The instructions were on the back of the card that was sent and provided that the bottle should be immersed in water before the stopper was taken out and afterwards rinsed out, after a little water allowed to flow in and submerged in the same manner—filled in the same manner and the stopper put in the bottle before the bottle was taken out of the water.

Q. Where did the bottles come from?

A. They came from the different places to which they were sent.

Q. Did they come by express?

A. Yes, sir.

Q. Whom were they expressed to?

A. To me.

Q. Were the corks—were the stoppers in the bottles when they came?

A. They were.

Q. And were not removed until the bottles were filled?

A. They were kept in the bottles until they were filled.

Q. After the bottles were filled, were the bottles sealed?

A. They were.

5119 Q. After they were sealed, was there tags or cards placed on them?

A. There were.

Q. How were the bottles prepared for shipment?

A. One of them was packed in ice, the one that contained the small sample was packed in ice.

Q. And the other?

A. The other was put in a box with excelsior.

Q. And what was done with them after that?

A. They were taken to the express office and shipped to each place?

Q. What express office?

A. They went by the Adams Express Company.

Q. And to whom were they shipped?

A. There was one sample sent to Chicago University, one to the Board of Health of Chicago and one to the University of Illinois.

Q. On these cards which were attached to the different samples of water after they were sealed, was the sample number, the date, the place from which the sample was taken, the hour of taking, with the name, C. V. Brainard, on the card, the height of water, the temperature of water, the direction of wind, temperature of air, all properly indicated upon the cards in the same manner as they are indicated upon the card I show you which is card for sample No. 1242?

A. They were.

5120 Q. And did each card contain instructions for collecting and sending samples of water for analysis, the same as are printed on this card?

A. They did.

MR. TODD: I will ask to have this card marked "Sanitary District Exhibit 6 for identification."

Card is so marked by the Commissioner.

Q. In the collection of these samples were these instructions complied with?

A. They were.

Q. How long have you been connected with the government improvement on the Illinois river?

A. Since February, 1891.

Q. Are you acquainted with the physical conditions of the Illinois river before and since the opening of the drainage canal?

A. Yes, sir.

Q. What was the condition of the water of the Illinois river before the opening of the drainage canal?

A. Well, it was very bad; at low water it got very bad.

Q. In what way?

A. There would always be a greasy sort of a scum on the top of it; it would frequently be green the whole depth of the river.

5121 Q. What kind of an odor did it have, if any?

A. Well, I couldn't describe the odor, but there was always more or less of an odor to it.

Q. What has been its condition since the opening of the drainage canal as compared with the condition that existed before the opening of the canal?

A. It hasn't been as bad since the opening of the canal, as it was at times before.

Q. In what way or manner?

A. There has been more current in the river and there hasn't been that bad look to it; it has always looked clearer and better than it did before.

Q. How about its color?

A. Well, the color has been better; it hasn't had that greenish color that it had before. Before the drainage water was turned in we frequently had grass growing in the river up to the side of the channel where the steamboats kept it worn away; since the water of the drainage canal has been turned in I have seen none of that.

Q. What is your opinion as to whether the water of the drainage canal has improved or injured the waters of the Illinois river?

A. I don't think it has injured it at all; as to the improvement, I—there has been improvement for the time it has been in, over what it was for certain years before.

5122 Q. You live in Kampsville, do you not?

A. Yes, sir.

Q. Have you known of any typhoid fever in Kampsville since the opening of the drainage canal?

MR. JEFFRIES: I object to the question as not the proper way of proving such facts.

A. There has been one case.

Q. Since the opening?

A. Yes, sir.

Q. That was the doctor, was it not?

A. Yes, sir; he had been attending typhoid patients back from the river and we suppose he got it from that.

Q. About how many fishermen are engaged in this vicinity, in the business of fishing?

A. Well, I suppose there is ten or a dozen of them.

Q. Are you acquainted with the Illinois river from its mouth to La Salle?

A. Yes, sir.

Q. Have you any idea of the number of the people who live along the Illinois river in flat-boats or house-boats?

A. I have no idea of the number; I know it is very large, probably several thousand.

Q. They live there with their wives and children, do they not?

A. Yes, sir.

5123 Q. And form a floating population?

A. Yes, sir.

Q. Before the opening of the drainage canal, did you ever observe any dead fish in the Illinois river to any considerable extent?

A. Well, at times there was a number of dead fish; I never paid particular attention to anything of that kind.

Q. Have you seen any since the opening of the drainage canal?

A. Well, I can't say that I have noticed any since the opening of the canal.

Q. How long have you been in the employ of the government at this point?

A. Twelve years and a half.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Did you take these samples of water yourself?

A. No, I didn't. That is, I didn't go out personally and do the work.

Q. You had that done by someone else?

A. Yes, sir.

Q. Then you put all these various data on these cards yourself?

A. Yes, sir.

Q. Did you take the temperature of the water yourself?

5124 A. No, sir; that was taken when they took the samples.

Q. Then as to whether or not the instructions were carried out so far as taking the water is concerned, you can't personally say?

A. I can personally say in a large number of instances because I watched them taking it.

Q. How much stronger is the current in the river now here at Kampsville than it was prior to the opening of the Chicago drainage canal?

A. Well, do you mean above or below the dam?

Q. Well, both, the current generally.

A. Well, it has increased a great deal.

Q. How much stronger is it above the dam?

A. Well, it has increased considerably since. There has been no observation taken to determine that. It is simply by observation,—by looking at it.

Q. You have a cistern or a well at your home?

A. No, we haven't any.

Q. You use water from the town wells?

A. Sometimes we use that and we use it from the river at times; I live down at the locks, right on the bank of the river.

Q. When you say the water is better now than it was before the opening of the canal you simply judge from its appearance?

A. Yes, sir.

5125 Q. Without reference to its sanitary or unsanitary condition or anything of that kind?

A. That I know nothing about because I have made no analysis of it.

RE-DIRECT EXAMINATION, by Mr. Todd.

Q. In using the water where you live at the lock, how long have you used it for domestic purposes?

A. Why, we have used it ever since we have been there.

Q. Has it ever caused sickness in your family, typhoid fever?

A. Well, I don't know whether the water caused it or not, we have all had chills and fever.

Q. Of whom does your family consist?

A. Myself, my wife and three children.

C. V. BRAINARD.

5126 Kampsville, Illinois, July 16, 1903.

FRANK TOZIER, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. Frank Tozier; residence, Kampsville; occupation, steamboat engineer.

Q. How long have you been an engineer on steamboats?

A. For about fifteen or twenty years, all told.

Q. How long have you been a steamboat engineer on the Illinois river?

A. All the steamboating I ever did was on the Illinois river.

Q. As a steamboat engineer have you traveled the entire length of the river from LaSalle to Grafton a good many times?

A. Yes, sir; but not of late years.

Q. Are you now in the employ of the government?

A. Yes, sir.

Q. In what business?

A. As engineer; blacksmith.

Q. Is the government engaged now in dredging the Illinois river at various places?

A. Not at present; only dredging now is just at the mouth of the locks. We have done no dredging last year nor

5127 the forepart of this year.

Q. How long have you been engaged in dredging operations on the Illinois river?

A. I dredged over eight years as a steady work.

Q. At what points upon the river have you dredged?

A. Commence at the upper end of the river from Devil's Elbow and every bar to the mouth of the river.

Q. Where is Devil's Elbow?

A. It is about eight miles this side of Havana, below Havana.

Q. What is the purpose of dredging?

A. To make a channel.

Q. What kind of material or dirt do you get out of the channel of the Illinois river where you dredged?

A. We get clay, sand, clam shells and soft mud.

Q. Have you ever dredged any of these places more than once?

A. Yes, sir.

Q. If so, what ones?

A. I have dredged Devil's Elbow twice, Sugar Creek twice, and all below this lock we have dredged over some of them we have dredged two and sometimes as high as four times.

Q. What causes the channels that you have dredged, to fill up?

A. The creeks.

Q. When the creeks are in flood do they carry out dirt which fills up the channels?

5128 A. Yes, sir.

Q. Where are the bars in the Illinois river with reference to the creeks, above or below the creeks?

A. Below the creeks.

Q. What causes the formation of bars in the Illinois river?

MR. JEFFRIES: Object to the question because it is asking for the opinion of a witness who has not qualified himself properly as being informed so as to testify in a way that his testimony would be competent.

A. I think very nearly the whole cause is the sediment that comes out of the creeks. After each high water there will be a sediment of an inch to two inches; sometimes may be three inches all over the banks, on the flats will be an inch to three and four inches of a sediment, after a long high water. This year there was about three inches.

Q. When there is high water in the Illinois river, does it wash out the sediment or cause more sediment to settle?

A. I think it causes more sediment to settle; there isn't current enough in this river to wash out anything.

MR. JEFFRIES: I object to the question, and move that both it and the answer be stricken out, because the witness has not qualified as being able to testify upon that subject, not having shown a sufficient knowledge upon the flow of the water, the
pressure of the water in a running stream, to remove sedi-
5129 mentation, and that the testimony is incompetent, and
for the foregoing reason, immaterial.

Q. JUDGE JOHNS: Have you ever dredged out a place upon the Illinois river where afterwards you were not able to find the channel again?

A. Yes sir.

Q. Where was that?

MR. JEFFRIES: Objected to as being immaterial.

A. That was at Otter Creek bar; we dredged it out and then moved up on the other bar and then in two or three weeks we had to go back and dredge it again.

Q. What caused that channel to fill up?

MR. JEFFRIES: Objected to for the same reason as stated in a previous objection to testimony of that character from this witness.

A. Otter Creek; a storm came right after we left there, and after the storm we went back there and couldn't find where we had dredged; that was two or three weeks after we left it; I think it was two weeks.

Q. Did that channel fill up because of a flood in Otter Creek?

MR. JEFFRIES: We object to that question as leading; in addition to the objections previously raised as to the competency of the witness to testify on that subject, it being solely an opinion without being based on sufficient scientific 5130 knowledge to be relied upon.

A. Yes sir.

Q. When you have once dredged out a channel in the Illinois river through a bar, what causes the bar to again form in the channel?

MR. JEFFRIES: Objected to for the same reason as heretofore stated.

A. Because there has been a flood in the creeks; I have dredged bars where it was quicksand and came right back.

Q. Do you drink the water of the Illinois river?

A. We do when we are out; not at the present time, but when we are dredging, most of the time we drink the water right out of the river.

Q. Do you use the river water with or without ice?

A. With ice.

Q. Do you use ice when the water is cool?

MR. JEFFRIES: Objected to because it is leading.

A. No sir.

Q. Does the water of the Illinois river give you any disease?

A. No sir.

MR. JEFFRIES: Objected to because it is leading, and because the witness not being a physician would be unable to tell what was the cause of the disease if he had one.

5131 Q. How many boats are there in the fleet of the government now on the Illinois river?

MR. JEFFRIES: Objected to as immaterial?

A. Three barges, three steamers, eight dump-scows; four flats, two quarter-boats and an officer's boat.

Q. How many men are employed upon this fleet?

MR. JEFFRIES: Objected to as immaterial.

Q. When the fleet is all working?

A. We have from 40 to 45 men.

Q. Do these men generally drink the water of the Illinois river?

MR. JEFFRIES: Objected to because it is leading.

A. Yes sir.

Q. So far as you have observed, does it have any bad effect upon them?

MR. JEFFRIES: Objected to for the reason that the witness is not a physician and is not able to observe or to know the effect of water of any kind upon the human system or to know whether a certain disease has been caused from drinking bad water or from some other cause.

A. No, it doesn't; most of them are having good health, the whole thing through. Once in a while there will be one that will have a chill.

5132 Q. What is the condition of the water in the Illinois river now compared with its condition before the opening of the drainage canal in 1900?

A. Well, in 1900, before the opening of that canal, at this time of the year you could find this whole river here as far as you could see covered with a green slime all over it. Whenever the hot weather commenced, it would be covered with that green slime, which we don't have and haven't had for the last two years. May be one of the hot days you may see a little streak of that green right where the channel comes, but very little of it.

Q. What is the quality of the water now as to being fit to drink?

A. The water now with ice in it, I believe would be perfectly healthy right at the present time.

Q. Take it the year around, is the water in the Illinois river now used for drinking purposes?

A. Well, I don't know how that is; take those that don't happen to be out on boats; I suppose that they use well water where they can get it, but I believe it will be fit to drink the year around. After the weather begins to get cold in the fall, we drink it right out of the river; we have no ice at all; we take our water right out of the river.

5133 MR. JEFFRIES: Object to the question for the reason that it is leading and move to strike out the answer except that part where the witness stated he knew nothing about it, for the reason that it is not responsive, and for the reason that the witness is not qualified to form an opinion as contained in the objection to all the testimony of this character, which has heretofore been urged.

Q. What is the purpose of putting dams in the Illinois river?

MR. JEFFRIES: We object to the question because it is immaterial and for the reason that the witness is not qualified as being possessed of sufficient information to know with any degree of accuracy what the reasons for building the dams were.

A. That was to raise the river so boats could run. I can remember the time when the boats, before that Henry dam was put in, couldn't hardly get above there at all without sending men out ahead to shovel it; I have seen it when there wasn't a foot of water in the river at the crossing there on that bar.

Q. Does the dam at Kampsville back up the water in the Illinois river and if so, how far?

A. It will make at Meredosia about six inches of water; a raise of seven feet here will make it about 6 inches at Meredosia.

Q. How far from Kampsville dam to Meredosia by river?

A. It is about 42 miles.

5134 Q. How far is LaGrange dam from Meredosia?

A. About seven miles.

Q. How far does the dam at La Grange back up the water in the Illinois river?

A. Well I couldn't tell you exactly how far that was; I know it was calculated to back clear to Copperas creek lock, but it don't do it.

Q. Do you know the height of the La Grange dam, if so state it?

A. Seven feet.

Q. Do you know how far the Copperas Creek dam backs up the water?

A. Well, the water is just between Henry and Lacon; it backs up, the last showing of it is between Henry and Lacon; that is about four miles above the Henry lock, dam.

Q. How far from Copperas Creek dam to Henry dam?

A. About 70 miles.

Q. Does the dam at Henry back up the water?

A. It backs it, I don't know how it is now; but it used to back plumb to La Salle.

Q. How far from Henry dam to La Salle?

A. About forty miles.

Q. How high is the dam at Copperas Creek?

A. It is supposed to be seven feet, all of them.

Q. Do you mean that all the dams on the Illinois river
5135 are seven feet high?

A. Yes sir, seven feet high.

Q. From what point to what other point do you measure the seven feet?

A. From dead low water.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You say you are an engineer on one of the government boats?

A. Yes sir.

Q. You run the engine on the boat?

A. Yes sir.

Q. How long have you been employed by the government in that capacity?

A. Twenty years; since 1883.

Q. You stated a moment ago in answer to one of Judge Johns questions that the government had done no dredging on the Illinois river for the last year and a half?

A. No sir; unless it is something like what we are doing right now; that we don't call dredging; cleaning up right around locks and the like of that.

Q. Do you remember the date when the last piece of dredging was completed?

A. No, I don't, but it was—

5136 Q. About when?

A. About three years ago when the last piece of dredging was completed.

Q. That would be in June or July, 1900?

A. That would be; we finished down below along in October I think.

Q. 1900?

A. 1900.

Q. Now that is the last that has been done except around the locks?

A. Except cleaning around the locks.

Q. How is the channel of the Illinois river now, compared to what it was in 1900?

A. I can't tell that, because we didn't sound to find out; last year there was a high water, the whole year through, and this year we didn't sound, and so I can't answer that.

Q. Prior to 1900, how many years were there that there was no dredging done, if any?

A. Prior to 1900, we dredged for seven years right straight; about seven years that we dredged every year, and then there come a year that we had no money.

Q. You mean you had no appropriation?

A. We had no money to work on.

5137 Q. Now when you say you had no appropriation, you don't know whether it was because the War Department failed to recommend an appropriation to Congress because it was not needed, or whether it was overlooked, or why it escaped? You have no information on that subject as to what recommendations were made to Congress on the question of appropriation?

A. Well, if I remember right, that year— As a general thing you know, a river and harbor bill is only every two years, and in that year if I remember right, it was vetoed, the bill was—well it was the last year of Cleveland's administration; that is when it was. We had no money at that time.

Q. You are not a hydraulic engineer are you?

A. No sir.

Q. Are you a man of family?

A. Yes sir.

Q. Live here in Kampsville?

A. Yes sir.

Q. Have you a well or cistern at your house?

A. We have a well.

Q. You use that for drinking and domestic purposes?

A. Not at the present time; I would rather take it out of this river than out of the well; I am using out of another well though.

5138 Q. Using it out of the town well?

A. Well, I get it—

Q. Using it out of a neighbor's well?

A. I am using it out of Mr. Rose's well.

Q. A neighbor's well?

A. Yes sir.

Q. Is that a living well or a cistern?

A. Well, he has had his cleaned since this high water.

Q. When you say this high water, you mean this high water this last spring?

A. Yes sir.

Q. The high water from the Illinois river?

A. Yes sir.

Q. Is there any current in the river opposite Kampsville, near where this boat right now stands?

A. In the channel?

Q. Yes.

A. Very little.

Q. How much water is pouring over the dam now?

A. That I couldn't tell you; I haven't been down close enough to see, and I don't know exactly what the gauge is.

Q. Have you been fishing with hook and line here lately?

A. No sir.

Q. Have you seen anybody else fish?

5139 A. Yes sir, I have seen people fishing.

Q. Have you noticed that there is sufficient current here at Kampsville, one-half a mile above the dam to draw the fishing line with two lead sinkers of ordinary size, down the stream?

A. Well I haven't seen anyone fishing here right in the river.

Q. Is there any other dredging outfit belonging to the government on this river other than the one here?

A. No sir, only this one; there is another outfit that belongs to the state.

FRANK TOZIER.

5140 Kampsville, Illinois, July 16, 1903.

VALENTINE TOTZELL,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:—

Q. What is your name?

A. Valentine Totzell.

Q. What is your business?

A. Fisherman.

Q. How long have you been a fisherman?

A. Well I have been a fisherman ever since 1874.

Q. On the Illinois river?

A. Yes sir.

Q. Where do you live?

A. In Kampsville.

Q. Living here all the time?

A. No I used to live at Columbiana, across the river.

Q. Have you been acquainted with the waters of the Illinois river for the last ten years?

A. Yes sir.

Q. Can you describe the waters of the Illinois river prior to the opening of the drainage canal, in 1900?

A. Yes sir.

5141 Q. What was it?

A. Do you want me to answer that?

Q. Yes?

A. Why it was, I considered very stagnated water before the drainage canal was let in; green; I have seen it here one season when the water was green fully six inches deep. If you dipped up a bucket of water, it would be perfectly green.

Q. Did it have any odor in it?

A. There were times that there was a kind of a bad smell coming in kind of puffs like. I suppose it would be from the water.

Q. What has been the effect upon the waters in the Illinois river by the opening of the drainage canal?

A. Well, we have had better water, that is, say six or eight weeks after the canal was let in; we had pretty bad water for about six weeks; the water was colored; at the same time it was cold weather; it was a kind of a coffee color brown; but then six or seven weeks after that it cleared out and we have had good water ever since; we have got a better current now than we generally have.

Q. Has there been any smell to the water?

A. Well no, no smell that I could catch; I drink the water now regular; the time before the ditch was in we couldn't drink it at all; we had to take water with us, seining or raising nets.

5142 Q. What effect has drinking the water of the Illinois river had upon your health?

A. Why it has had no effect that I can see; I have always been hardy since I have been on the river. I had chills 25 or 30 years ago, but I haven't had them since; I don't know as the river had anything to do with that.

Q. What in your opinion has been the effect of turning the drainage canal water into the Illinois river?

A. I think if it had any effect at all it would give us better water.

Q. What do you mean by better water?

A. Why purer water and more of it; we haven't had the stagnated water here since, that we had before, of course.

Q. Before the opening of the drainage canal, what effect did the then Illinois river water have upon the fish nets?

A. Well there was several times when the river was very low; we had no current at all, and it was naturally dead water above the locks here. Three times that I have raised, all the fish in my nets were dead; not a living fish in them, and it would be of course on account of the stagnation of the water, that I laid it to.

Q. What has been the effect of the waters of the Illinois river before the opening of the drainage canal, upon the nets themselves, as to whether there was any scum formed
5143 upon the nets?

A. Well, yes, there was a kind of a slime formed on the nets. If nets weren't fishing you generally found a slime on the nets. If they were fishing good, of course the fish kept the slime off.

Q. What has been the condition since the opening of the drainage canal upon fish in the nets and in live-boxes?

A. Well, they have kept better in live boxes, and you could leave them in nets longer without raising them, and they wouldn't bruise themselves or die with disease as they would before; simply because we have got the current to purify the water more.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You say you live here at Kampsville?

A. Yes sir.

Q. You live in a residence out here in the town?

A. Yes sir.

Q. Have you a well or cistern at your house?

A. No sir I live on a lot where one well supplies the whole business; and I use the water from that well.

Q. You see the water from that well for domestic purposes at home?

A. Yes sir.

5144 Q. When you say the water is better now than it was before the canal was opened, you have reference simply to the water from your observation of it and not an examination that you have made as to what it contained?

A. I can drink it now when I couldn't before; the year around. I could drink it before, but there were times in the year that I could not.

Q. What species of fish thrive best in the waters of the Illinois river here at Kampsville?

A. Well the best to multiply that we have and the most fish that we have is German carp at the present day.

Q. What do they feed on?

A. Well, they feed on everything that I have tried yet. I have not found anything yet they wouldn't feed on. Potatoes, meal, flour, or anything else.

Q. Animal matter—do they feed on animal matter?

A. Yes sir.

Q. How is the current or flow of the river now, as compared with it prior to the opening of the Chicago drainage canal?

A. Well, of course now, the current; before the dam was put in we generally had a current; since the dam was put in we have no current at all in dead low water; now we have a fair current in dead low water, which we didn't have before the ditch came in.

5145 Q. Since the opening of the canal, there has always been a good current in the river here at Kampsville, has there not?

A. Well tolerably fair; we have a strong current when the river is up and a slack current when the river is down. It is lower now than it was any time last year, but I couldn't say how it was the year before.

Q. The people living here in town have their wells and their cisterns that they use water out of, don't they?

A. Yes sir.

V. TOTZELL.

5146 Kampsville, Illinois, July 16, 1903.

O. C. BARTHOLOMEW,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. O. C. Bartholomew.

Q. What is your business?

A. Fisherman.

Q. How many men have you employed in your business?

A. From three to five.

Q. Where is your place of business?

A. Half a mile north of Kampsville.

Q. How many nets do you fish with?

A. About eighty.

Q. How long have you lived in Kampsville?

A. Ten years and one month.

Q. Were you acquainted with the Illinois river during the ten years that you have lived here.

A. Yes sir.

Q. Have you known it before and since the opening of the drainage canal?

5147 A. Yes sir.

Q. What was its condition before the opening of the drainage canal and describe its condition since the opening of the drainage canal and the effects of the drainage canal upon the waters of the Illinois river at this point?

A. Before the opening of the canal here at times or during the summer season, it would be scum on it, and I have seen nothing of that kind since.

Q. Was there any smell connected with the water before the canal was opened?

A. In the winter after a heavy freeze there was.

Q. What effect has the opening of the drainage canal had upon these waters at this point?

A. We have had right smart of a current, and we have had no scum on the water since.

Q. Did you see the scum before?

A. Yes sir.

Q. How extensive?

A. Well, it was heavy; at places next to the shore it would be half an inch or three-quarters deep and extending on out towards the center and be shallower. A boat would make a trail through it of a morning when no wind.

Q. What are the conditions now since the drainage
5148 canal has been opened?

A. Well we have no scum any more; there seems to be a pretty fair current; it appears better.

Q. How about the condition of the water?

A. It also appears better.

Q. What do you mean by better?

A. Well it don't seem to be as stagnant.

Q. Do you ever drink the water?

A. Yes sir.

Q. Since the opening of the canal?

A. Yes sir.

Q. How frequently?

A. Well, it is only through the winter season, when out at work, I drink it then.

Q. Do the fishermen drink the water?

A. Possibly do when out on the water in the winter season.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. All the people around here have wells or cisterns, in town here, do they?

A. Yes sir, I believe so.

Q. They use the water from those wells for domestic purposes and drinking purposes?

5149 A. Yes sir.

Q. They don't use the water from the river for that purpose?

A. As I stated a minute ago, we used it when we was out in the winter time; we did not take any water with us then. Of course these people here in town have wells and use that.

Q. You don't know whether the water contains deleterious matter or not?

A. No sir.

Q. What is the difference between the flow or current of the river now as compared to what it was before the Chicago drainage canal was opened?

A. I don't know what it would average to the mile now, but before, stuff went whichever way the wind was. This is speaking of low water.

Q. In other words there was no current?

A. Apparently there was no current.

Q. Now since the opening of the canal you have a good current?

A. Yes sir, we have a fair current all the time.

Q. Both in high and low water?

A. Yes sir.

Q. There is a current here opposite this place, is there not?

A. Yes sir.

Q. How far is it from here down to the dam?

A. Half a mile.

5150 Q. And the current extends all the way down?

A. Yes sir.

Q. And up the river also?

A. The further up you get the stiffer current you get until you reach the other lock.

Q. How does the stage of the water compare now to what it was last year and the year before?

A. Well it is about the same now as it was last year at this time—well not at this time either, because we had high water last year during July and August.

Q. As a matter of fact isn't the Illinois river lower now than it has been at any time in the last three years?

A. No sir. Two years ago it was lower than it is today.

Q. That was in 1901?

A. Yes sir.

Q. During the drought?

A. Yes sir.

Q. Which lasted for several months?

A. Several months.

O. C. BARTHOLOMEW.

5151 . Kampsville, Illinois, July 16, 1903.

WILLIAM MAPPIN,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:—

Q. What is your name?

A. William Mappin.

Q. What is your business Mr. Mappin?

A. Fisherman.

Q. Where do you live?

A. I live at Kampsville.

Q. How long have you lived here?

A. Well I have lived here about seven years.

Q. Are you acquainted with the river for that time?

A. Yes sir.

Q. What was its condition before the opening of the drainage canal in 1900?

A. You mean about the water, do you?

Q. Yes?

A. Well it was pretty bad.

Q. Describe it?

5152 A. Well at times the water would get down pretty low and there was a right smart scum on it; no current.

Q. Did it have any odor to it?

A. Yes sir.

Q. Did you drink it then?

A. Well, once in a while we did, when we were seining, when the water got down low at times when we were seining, once in a while we would get caught out and have no water and we would take a drink of it.

Q. How about the water now since the opening of the drainage canal?

A. Well, I think the water is purer, better.

Q. In what way?

A. Well, there is not the sediment; we don't have any scum on the river like we did then. Of course it doesn't get down now like it did then. I suppose that is the reason.

Q. Do you drink the water now?

A. No sir.

Q. When you are out on it?

A. No sir; well I have a time or two, here week before last we ran out of water and I took a drink of it.

Q. What in your opinion has been the effect upon the Illinois river, of the opening of the drainage canal?

A. Well I don't know—

5153 Q. As to whether the water is better or worse than it was before?

A. Well, I think the water is better; I don't see why it wouldn't be; we have got a good current in the river; the water has got down now that it only lacks sixteen or eighteen inches I think to being down to what we call low water here.

Q. How long does this period of low water last?

A. Well it don't last very long.

Q. What do you mean by that?

A. Well, I don't think it lasts over a couple of months, or a little bit longer than that. Along in the fall we will get a raise.

Q. Do you have high water the other ten months in the year?

A. Yes we have high water; you might say now the water is getting down pretty low; what we call low water.

CROSS-EXAMINATIIN,
By Mr. Jeffries.

Q. When you say you have high water the remaining ten months in the year, you mean that the water is above low water mark?

A. Oh, yes.

Q. You don't mean that it is overflowed or anything of that kind?

A. Oh, no.

Q. You mean that it is at the ordinary stage?

5154 A. Yes sir.

Q. During the remaining ten months?

A. Yes sir. July and August as a general thing the water gets down about the lowest. September, along in there as a general thing, it gets a raise.

Q. When you say the water is better than it was before the canal was opened, you mean simply from your observation of that water?

A. Yes sir.

Q. And your belief is based altogether upon the fact that there is no more stagnant water and that you have a continuous current through the year?

A. Yes sir.

Q. You live here in town?

A. Yes sir, I live right above here a little ways; I don't live right here in town—well I live here in the town too, inside of the corporation.

Q. Do you live on the river?

A. Yes sir, been on the river all my life.

Q. In a boat on the river?

A. No, it is right up on the bank, some ways from the river.

Q. Prior to the opening of the canal there was very 5155 little current here during certain seasons of the year?

A. There wasn't any at all you might say; the water got down so low here there wasn't any current at all. Whichever way the wind blowed, that was the way the current.

Q. How is it now?

A. Well, it's a pretty good current now.

Q. There is a current right out here in front of town isn't there?

A. Yes sir.

Q. A good current, no stagnant water out there is there?

A. No, I don't see as there is. It is stronger now than it was.

Q. Does that current continue from here down to the dam?

A. That I couldn't say from here, but I suppose it does.

Q. You don't fish down there?

A. No sir, I don't fish down there.

Q. Fish above?

A. Yes sir.

Q. The current gets stronger as you go up above?

A. Yes sir.

WM. MAPPIN.

ADJOURNED until following morning, July 17, 1903, at same place (Kampsville, Ill.) at 8:00 A. M.

Kampsville, Illinois, July 17, 1903.

8:00 A. M., Friday.

5156 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

DR. T. O. HARDESTY,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner was examined in chief by Mr. Johns, and testified as follows:

Q. Doctor, state your name, residence and occupation?

A. T. O. Hardesty; residence Kampsville; occupation physician.

Q. Of what school of medicine are you?

A. Marion Simms, school, St. Louis, Missouri.

Q. How long have you practiced medicine?

A. Since April 1896; that is I graduated in April 1896, and have practiced since.

Q. How long have you lived in Kampsville?

A. Since April, 1896.

Q. Have you been in the general practice of medicine at this point for 7 years?

A. Yes sir.

5157 Q. Covering about what extent of territory?

A. Within a radius on the north of ten miles; on the south nine miles and the west eight miles, and on the east two miles.

Q. What proportion of the population use for domestic purposes the waters of the Illinois river?

A. In this territory, Kampsville?

Q. In this territory?

A. A very small proportion.

Q. Do you know whether the fishermen use it when engaged in their business?

A. In my opinion they do.

MR. JEFFRIES: We object to the witness expressing an opinion, when that question is subject to positive proof.

Q. Have you had any cases of typhoid fever in this community within the last three years or within the last seven years? If so, how many and where?

A. I have had no typcical cases of typhoid fever. You understand, of typical cases?

Q. Yes I understand. Have you had cases of malarial fever?

MR. JEFFRIES: Object to the question as immaterial and as leading.

Q. And typho-malaria?

5158 A. We have every summer a number of cases, roughly speaking, we call them typho-malaria; these cases no doubt are a modified form of typhoid fever.

Q. Where have they been most frequent, among the people using the water of the Illinois river or among those who do not use it?

MR. JEFFRIES: Objected to as leading.

A. The cases that I have had to do with have been practically altogether situated in the hills, back three or four miles from the river; from a mile and a half to four miles back.

Q. Since January, 1900, what has been the general health of this community as compared with the preceding four years?

A. My observation has been that within the last three years there has been less sickness than there has been in the time before that I was practicing here.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How old are you, doctor?

A. I am 33 years old.

Q. Were you born and raised in this town?

A. I was not; I was born and raised in Lincoln county, Missouri.

Q. What did you say your name was?

A. T. O. Hardesty.

5159 Q. You haven't been here then quite six years?

A. Yes sir, I came here on the 28th day of April, 1896.

Q. I thought it was 1897?

A. No sir.

Q. Are you a married man?

A. No sir.

Q. You live here in town?

A. Yes sir.

Q. What is the size of this town?

A. I believe the census gives at about 320.

Q. The people here use well and cistern water for domestic and drinking purposes, do they not?

A. The most of them I presume do; I think do.

Q. As far as your information goes?

A. Yes sir.

Q. What do you mean by a typical case of typhoid fever?

A. We have in our text books given a fever that runs a certain peculiar course, with certain peculiar symptoms, that typhoid fever has; it is not—it does not belong to other diseases, and in this country the fever doesn't run that peculiar type, but we have the predominant symptom of typhoid fever, but they lack this peculiarity of running a given course, which is common to typhoid fevers which you find in the prairies.

5160 Q. How near to the river have any of these cases which you referred to in your examination in chief been?

A. The first case to speak of was one that occurred in town in 1897, the second summer after I was here, and the other cases were from a mile to five miles from the river. They have been in different years along.

Q. Do you know whether the people in this locality along the river use the water of the Illinois river for domestic and drinking purposes?

A. I think the people in town use principally well water, cistern water for domestic purposes, while I have seen those on the river in the government work use water dipped out of the river.

Q. The farmers, what do they use?

A. Mostly spring, living wells.

DR. T. O. HARDESTY.

5161 Kampsville, Illinois, July 17, 1903.

EDWARD DAUGHERTY,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. Edward Daugherty; occupation carpenter; residence Kampsville.

Q. How long have you lived in Kampsville?

A. Twelve years.

Q. How long have you been on or near the Illinois river?

A. Thirty years.

Q. Have you had any occupation which kept you upon the river?

A. I have been employed by the government on the Illinois river since the spring of 1882.

Q. In what capacity?

A. As carpenter and cranesman, on the dredges.

Q. How long have you been connected with the business of dredging the Illinois river?

A. Twenty-one years.

5162 Q. Upon what parts of the Illinois river have you been dredging?

A. From Devil's Elbow to the Six Mile Island.

Q. Is that from about four miles below Havana?

A. Yes sir.

Q. To about six miles above Grafton?

A. Yes sir.

Q. During what season of the year was the dredging operations carried on in the Illinois river?

A. Principally in the fall.

Q. What is the purpose of the dredging?

MR. JEFFRIES: I object to the question for the reason that the witness has not qualified himself as being able to determine the purpose for which the order was made by the government for the dredging.

A. To deepen the channel.

Q. In deepening the channel do you dredge out bars which are formed in the river?

MR. JEFFRIES: Objected to as leading.

A. Yes sir.

Q. Where, as a general rule, do these bars form?

A. Below creeks.

Q. What occasions the formations at such points?

MR. JEFFRIES: Object to the question because the wit-
5163 ness has not qualified as a hydraulic engineer, or sufficiently informed so far as the testimony now shows, to be able to express an opinion on the subject, and whatever he might say would be no more than a guess.

A. The creeks overflowing and throwing out their sediment into the river.

Q. Have you had occasion during your experience to dredge out the same channels in the Illinois river more than once, if so where and how frequently at each place, commencing at the upper portion of the river and proceeding towards Grafton?

A. As far up as I can remember distinctly the first was at the mouth of Sugar Creek. I think we dredged that once after the original dredging; and the next place was down there at Otter Creek; I think we dredged that twice after the original dredging. I don't believe I remember any more places.

Q. Are there other places which you do not remember in which channels have been dredged the second or third time?

MR. JEFFRIES: Objected to as leading and suggestive.

A. Yes sir; we have dredged several places three or four times.

Q. Have these dredgings generally been below the mouths of tributaries of the Illinois river?

MR. JEFFRIES: Objected to as leading and suggestive.

A. Yes sir.

5164 Q. Are you familiar with the Illniois river and have you been upon it in all its various stages from high to very low water?

A. Yes sir.

Q. What is the effect upon the bottom sides of the channel of the Illinois river of floods in the river, as to the deposit of sediment?

A. I haven't noticed any serious results from the sediment.

Q. In times of floods or high water in the Illinois river, is the sediment which has been deposited by the action of the water washed out, or is more sediment deposited?

MR. JEFFRIES: Objected to as leading.

Q. In other words, does the river scour?

A. No sir.

Q. After a flood in the Illinois river, is there more sediment in the bottom and along its banks, or less, than before a flood?

MR. JEFFRIES: We object to the question for the reason that it is suggestive and leading and for the further reason that the witness has not stated that he is acquainted with the question of sedimentation so far as it affects the bed and banks and sides of the Illinois river, and we move to strike out his answer to the previous question to the effect that there is no scour in the Illinois river, for the reason that the witness has not qualified as being competent to testify upon that subject. 5165

A. More sediment every time there is a flood.

Q. Do you drink the waters of the Illinois river?

A. Not at the present time, no sir.

Q. Have you while upon the river in the course of your business in dredging?

A. All the time drink Illinois river water.

Q. In its filtered or unfiltered state?

A. Unfiltered state.

Q. How many men are in the employ of the government here on the Illinois river while dredging operations are being conducted?

A. About 45.

MR. JEFFRIES: Move to strike out the answer and the question as immaterial.

Q. What kind of water do these men drink when engaged in the business of dredging?

A. Illinois river water.

Q. In the course of your experience in dredging upon the Illinois river, how many cases of typhoid fever have you known among these men?

MR. JEFFRIES: Objected to for the reason that the wit-5166 ness has not qualified as a physician and is not a physician, and therefore is unable to know the symptoms of typhoid fever, or to testify in such way as to make the testimony reliable on that subject, and for the further reason that he has not qualified as being acquainted with the extent of sickness in this locality.

A. I was down two months with the typhoid fever myself.

Q. Answer the question first?

A. No sir I don't know of one case among our dredge men.

Q. Have you ever had typhoid fever?

A. Yes sir.

Q. When and where?

A. In Cass County, seven miles and a half east of the Illinois river.

Q. Describe its symptoms and the course of the disease?

MR. JEFFRIES: Objected to as incompetent and immaterial, the witness not being a physician, and able to describe the symptoms of the disease mentioned, other than from the fact that he was told by the physician attending him that he had typhoid fever.

A. Well I couldn't do that accurately; I was only about 15 years old when I had it. I know it left me bald-headed; I had a heavy head of hair, the hair all come off of my head; the skin came all off of my body and feet, hands and everything.

5167 Q. How long did the disease continue?

MR. JEFFRIES: Objected to as immaterial.

A. I wasn't able to be up for about three months after I was taken.

Q. Was a part of that time devoted to recovery from the effects of the disease?

MR. JEFFRIES Objected to as immaterial.

A. Yes sir. I didn't fairly get over it for five years.

Q. Have you seen among the men engaged in the employ of the government, any such disease as that?

MR. JEFFRIES: Objected to as incompetent, for the reason already stated, in connection with the witness testifying on this subject.

A. No sir.

Q. With what part of the Illinois river have you been familiar during your occupation as a dredger? Only from Devil's Elbow down?

A. Yes sir, from Devil's Elbow to Six Mile Island.

Q. Describe the condition of that part of the river before January, 1900 as to the quantity of water, the current and the color and odor of the water.

A. Well, the color of the water was green, stagnated; you take an oar and stir down in the water and it would be ropey; you would find a fine green fiber in it for about two feet
5168 down, and very little current unless we had big head raise up the river.

Q. What was its odor?

A. The odor one winter here when it froze up was terrible bad, after it got broke up in the spring, and the ice got broken so it could get out. That was the only time that I noticed any bad odor.

Q. Did you notice any odor in it in the fall?

MR. JEFFRIES: Objected to as leading and immaterial.

A. No, I didn't, that was after it broke up in the spring; it was froze all winter.

Q. What I mean to ask you is, did you notice year by year, before the opening of the drainage canal an odor in the water as if the vegetation in the river had decayed?

A. No, I didn't pay much attention to that, but it got so bad I couldn't help but notice it; living right on the river all the time I don't notice such things.

Q. Since the opening of the drainage canal, what has been the condition of the river?

A. The river in my estimation has been a good deal healthier.

Q. What with reference to the current?

A. We have better current, more current.

Q. In reference to its quality as a drinking water?

A. It is bound to be better drinking water when we have
5169 a better current in the river; it seems to be more pure.

Q. What is the character of the material dredged from the bottom of the Illinois river?

A. Well that varies. In dredging out a second and third time, it is a soft, mushy mud as near as I could tell you.

Q. Of what are the first dredgings composed?

A. Mussel shells and mud and dirt all mixed up together.

Q. Any sand?

A. Yes sir, quite a lot of sand.

Q. Any clay, and if so what kind, blue or yellow?

A. There ain't any clay in the Illinois river except at two places that I have dredged. I have helped to dredge all the cuts below LaGrange Locks, and down here at the head of Twelve Mile Island. I believe those are the places; I don't remember exactly where those places are. I never jogged my memory with it. About all the clay there is.

Q. Is it—the clay—blue or yellow clay?

A. It is blue up at LaGrange and down here below the clay is yellow.

Q. Is that different from gumbo?

A. Yes sir.

Q. Where do you find gumbo?

A. Find gumbo generally out in the country, back of the
Illinois river and way out sometimes fifteen or twenty
5170 miles, as far as Jacksonville and Springfield.

Q. Do you find gumbo in the bottom of the Illinois river?

A. No sir, I don't believe I ever noticed any.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. When did you first commence the service of the government?

A. In the spring of 1882 I believe,—1881 or 1882.

Q. On a dredge boat?

A. Well I began as a carpenter and then I went on the dredge boat after I started out, and after the return of the fleet I went back as a carpenter.

Q. You kept that work up for how long a time?

A. Well, there was some falls we didn't go out at all; I can't tell exactly how many falls we have been out; we have been out practically every fall when we had money to dredge on.

Q. There has been no dredging in the Illinois river the last year and a half or two years, has there?

A. No sir.

Q. When was the last dredging done?

A. I believe 1901 in the fall we was out; I am not sure now, either 1900 or 1901.

Q. Where was that?

5171 A. That was down below.

Q. At what point?

A. All the way along up, 1899 or 1900, I forget which, I can't tell you positively.

Q. It wasn't so bad in the way of deposits during that season as it had been prior to that time as I understand it?

A. Well, I don't know whether it was or not, I can't tell; I don't know whether that was the time we dredged some of the old cuts out or not, but I think we did.

Q. What was the character of the deposits that you dug out the last season that you worked?

A. Why it was just about the same as we had been digging right along all the time; the same cuts would have the same deposits, there was some sand and some would be mussels. We widened the channel the last dredging, finished up the cut 200 feet wide and of course where you struck a bar it would run 200 feet the same kind of material, whatever it was, sand, clay, mussels or soft stuff, whatever it was.

Q. Or mud?

A. Yes sir.

Q. Now you stated in your direct examination in answer to a question from Judge Johns, if I understood it correctly, that after these shallow places had been dredged out, the matter that was deposited there was mostly mud—those places
5172 that would fill up again?

A. Yes sir.

Q. That was generally true of all the places that you dredged?

A. The second dredging, yes sir, and third, it would be.

Q. Could you explain the character of that mud?

A. How is that?

Q. Can you explain the character of that mud, whether it was thick or thin?

A. Why it would be thin of course, sloppy. Thin mud.

Q. Sloppy?

A. Yes sir.

Q. How deep would it be?

A. Well in some places right close to those creeks, it would be almost level; that is the cut would be filled level with the original bottom of the river.

Q. What do you mean by being filled level with the original bottom of the river?

A. When we would dig down say three feet through this bar; then the creek would come down and fill that three-foot cut up again with the original bottom of the river; that would be the original bottom again, that cut.

Q. Then, as I understand it, you haven't been out on the river dredging these places for some time past?

5173 A. No, we haven't been out for two or three years, I guess with the fleet, that I remember; I don't remember the last time we were out; 1899 or 1900, along there somewhere.

Q. When you say the water is better now than it was before the Chicago drainage canal came into it, you judge altogether from its appearance and not from any examination you made with reference to what it contains?

A. I take my judgment from the look of the water and the current and the condition of the water before and now.

Q. Before the opening of the canal I understood you to say the water was stagnant?

A. Yes sir.

Q. In other words there was no current?

A. No current.

Q. How has it been since the opening of the canal?

A. We have always had a good current, couldn't pull a boat up against it hardly.

Q. How is the current here opposite Kampsville?

A. Oh I suppose we have got about a mile or mile and a half. About a mile as near as I can judge.

Q. An hour?

A. Yes sir.

Q. How far is it from here to the Kampsville dam?

A. It is a little over a quarter.

Q. Isn't it a half?

5174 A. Very near a half from here.

Q. The dam is below here?

A. Yes sir.

Q. The current continues from here to the dam and on over the dam does it not?

A. Yes sir.

Q. How is it above here; does it increase as you go up the river?

A. I don't think it does; as far up as I have been I never noticed any change in it; it is about as swift one place as another.

Q. It is pretty hard to pull a boat up against it?

A. Yes sir, pretty hard to pull a boat.

Q. When this mud and filth is taken up out of the bottom of the river in these places where you have dredged, what is done with it?

A. It is generally taken out and put in behind islands, when it is possible to get behind an island.

Q. If not, you dump in the current?

A. If not, then right up on the bank run the scow right up to the bank just as hard as we could run it, and dump them and leave it up on the bank as near as we can get it.

Q. Never did dump it in the current?

A. Well there would be a little current there certainly; fifteen feet from the bank there is some current.

5175 Q. You remember several times when you were out on this dredging work of employes that worked there having diarrhoea, don't you?

A. Why it seems to me like I remember a case or two of it; nothing serious.

Q. What kind of water do the people use here in this town for domestic and drinking purposes?

A. Well water.

Q. You are a man of family?

A. Yes sir.

Q. You use well water?

A. Yes sir.

EDWARD DAUGHERTY.

5176 **DR. T. O. HARDESTY,**

recalled for further examination by Judge Johns, testified as follows:

Q. Were you ill here at any time, and if so when and with what disease?

A. I was taken sick, I think, the 26th of September and was confined to my bed for eight weeks, about four weeks convalescent. The diagnosis was typhoid fever.

Q. In what year was that?

A. That was in 1902.

Q. Do you know where you contracted that disease?

A. Prior to getting sick I had treated two cases in August —the latter part of July and August, for what we diagnose in this country as typho-malarial fever. The weather was very warm and my opinion was that in drinking the water that I would find at these houses when I would go there, that I contracted the disease from these two patients.

Q. Where were these two cases which you treated?

A. They were five miles south of Kampsville and two miles and a half west of the river.

Q. Did the people having these two cases use the water of the Illinois river for drinking purposes?

A. They did not.

5177 Q. As to the urinary and fecal discharges from your own person during that illness, what became of it?

MR. JEFFRIES: Objected to as irrelevant and immaterial.

A. I think they were just thrown outside.

Q. Into some vault or on the ground?

A. No, on the ground.

Q. Were they disinfected?

A. They were not.

RE-CROSS-EXAMINATION, By Mr. Jeffries.

Q. These patients that you had out in the country, doctor, were they adults?

A. Yes sir.

Q. Male or female?

A. One was male and the other was female.

Q. You don't know whether they had opportunities to drink water away from home or not, during the proper time for incubation?

A. Away from their individual homes?

Q. Yes.

A. I think the gentleman did, the lady did not; he was running a threshing machine.

Q. Where was the threshing machine?

5178 A. Over the hills and country around through here, and where he was taken sick, principally in the hills.

Q. How far did he live from the Illinois river?

A. I would judge from the banks of the Illinois, at least two miles and a half.

Q. Were the two cases in the same family?

A. They were not.

Q. Were they sick at the same time in the same locality?

A. Yes sir, the sickness of one ran right into the other; one was sick and the other about a couple of weeks afterwards, and then they both run about two months and a half.

Q. Were they married people, both of them?

A. The gentleman was a man of family. The lady was in a family but she was a young girl about sixteen.

Q. Had the gentleman been threshing along the bottoms of the Illinois river?

A. He had done some threshing along the bluffs.

Q. Do you know about what time before he was taken?

A. I judge about a month.

Q. You don't say positively that you contracted the fever from drinking the water at one of these houses; that is your opinion, that it might have been?

A. My opinion was that I contracted the disease from one or the other of these two patients.

5179 Q. You practice among the fishermen here?

A. Yes sir.

Q. And the people in general, too, do you?

A. Yes sir.

Q. And were practicing that way at that time?

A. Yes sir.

Q. You are just as likely to have taken a drink at some other place as at either one of those two houses?

A. Yes sir, those two cases were the only cases I had last summer of typhoid fever.

DR. T. O. HARDESTY.

5180 Kampsville, Illinois, July 17, 1903.

DR. FREDERICK W. RUNDE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. Dr. Frederick William Runde; occupation, physician and surgeon; Kampsville, Illinois.

Q. Of what school of medicine are you an adherent?

A. The regular.

Q. How long have you been practicing medicine?

A. Why since 1898; it would be going on five years.

Q. Where have you practiced?

A. I practiced in Denver, Colorado, a year and a half and the balance of the time at this place.

Q. Have you been in Kampsville then a little over four years?

A. It will be four years on the 26th of November.

Q. Were you living at Kampsville before January, 1900, and if so, for how long?

A. Yes, I lived before that time at Kampsville, say a month and a week; say five weeks.

5181 Q. Were you familiar with the waters of the Illinois river prior to the opening of the drainage canal in 1900?

A. Well not particularly except as to the stage of the water.

Q. Have you been engaged in the general practice of medicine here?

A. Yes sir.

Q. How many cases of typhoid fever have you treated in this vicinity?

A. Two cases, one was a case of my own and the other case was in consultation with the other doctor, that was the case of Dr. Hardesty.

Q. Where was the other case that you treated?

A. About three miles south of Kampsville.

Q. How far from the Illinois river?

A. I would judge a mile and a quarter.

Q. Did the person having the fever drink the waters of the Illinois river.

A. No, not to myknowledge.

Q. What has been the condition of the health of the people of this community since the opening of the drainage canal?

A. Why it has been fairly good.

Q. As to malarial diseases, where in your experience have they most prevailed, among the people using the Illinois river water for domestic purposes or away from the river? 5182

MR. JEFFRIES: Object to the question as being entirely leading and suggestive, and assuming that the people who live upon the Illinois river and along its banks use the water of the Illinois river for domestic purposes, when the evidence thus far introduced shows that they do not use it for drinking and domestic purposes, and as being decidedly unfair.

A. As far as my knowledge, why very few drink the water, except those that probably live along the river and can't get anything else, can't get any well water or spring water. As far as the prevalence, there is just as much out in the hills as there is along the river.

Q. Do you conduct any other business?

A. Yes sir.

Q. What is it?

A. Pharmacy.

Q. What is ordinarily known as a drug store?

A. Yes sir.

Q. You may state what in the last two years has been the sale of drugs and medicines in your store which have been used by the people for curing malarial diseases?

MR. JEFFRIES: Objected to as immaterial and as incompetent for the reason that the evidence of this witness shows, as well as the evidence of other witnesses, that the water of 5183 the Illinois river is not used for domestic and drinking purposes.

A. Well I may state that the sales of patent medicines are a great deal less, and especially malarial medicines—anti-malarial, would be more proper.

CROSS-EXAMINATION, By Mr. Jeffries.

Q. Are you a married man?

A. Yes sir.

Q. You use well or cistern water at home?

A. Use well water.

Q. You use well water in the preparation of your prescriptions.

A. Yes sir.

Q. Where did you study medicine?

A. At St. Louis.

Q. At what college?

A. Marion Simms, and also a post-graduate last fall in the medical department of Washington University.

FREDRICK WILLIAM RUNDE, M. D.

5184 Kampsville, Illinois, July 17, 1903.

ALBERT R. ZIMMERMAN,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows.

Q. What is your name, residence and occupation?

A. Albert R. Zimmerman; Kampsville, Calhoun county, Illinois; ship carpenter and calker by trade.

Q. How long have you lived upon or along the Illinois river?

A. I have lived on the Illinois river practically all my life; I am 44 years old and I have been on this river 43 years. We came on the river when I was about a year old, and of course during that time I have been off a little bit, not much, a year or so.

Q. How much of the Illinois river have you been familiar with?

A. Well I will say from Twelve Mile Island to Havana; that is twelve miles from the mouth of the Illinois river; above that I haven't been very much, above Havana.

Q. What was the condition of the Illinois river before January, 1900?

A. The general condition, the stage of the water?

Q. Yes.

5185 A. Well of course the condition has been changed a good many times, but during low water the water was very low and I have noticed a great deal of green stuff and such as that floating in the river; and I can remember when I was a boy and first came on the river; I was probably five or six years old, the river had a great deal of moss; you could almost track a steamboat in it where it ran; now some people may think that is kind of funny, but nevertheless that is a fact, but I presume the high water has taken that out and we don't have any of that any more.

Q. What was the color of the water when the river was at low stage?

A. Well, sometimes it would get pretty green, very green; I have seen it here where it would be green all over, all over the top of the river, but how deep I don't know; but pulling a skiff over the river you could just see the mark of the boat right through the green stuff, moss, or whatever it was, I don't know.

Q. Did you ever notice any odor from the water? If so what kind of an odor?

A. Yes, sir, I have, I noticed it a few years ago, that it was so bad you could scarcely stand it all, up there at LaGrange locks; you take a wind blowing from the north at that lock and you could scarcely stand it at all, and we used to use it for washing purposes, and in fact we used it for drinking purposes, but in got so bad we couldn't even stand the smell of the water in

5186 the house, boiling on the stove; we had to quit it entirely, using it for washing purposes.

Q. Did you drink the waters of the Illinois river before the opening of the canal?

A. We used to drink it very nearly altogether when we was out with the fleet dredging.

Q. Do you know of any cases of typhoid fever among the people drinking the water of the river?

A. Well I never heard of a genuine case of typhoid fever right on the river bank in my life, since I have been on it; I haven't heard of any; all the typhoid fever that ever I heard of I know has been back off of the river.

Q. Since the opening of the drainage canal, what has been the condition of the Illinois river?

A. Well, I find that the river—that we have had a higher stage; we have had more current in the river and as far as speaking about the condition of the water in general whether it has been a benefit or a detriment to the water I couldn't say; I don't see so much of that green stuff in the river, that moss. We have drank the water since that drain has been in and as far as drinking, we can't tell any difference in the taste of it, and we don't find any more sediment in the water than we did before and I presume, take the water in general of the Illinois river,

5187 the Illinois river is today, I believe, is really better than it was before it went in.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say you are a carpenter and skiff builder?

A. Carpenter and caulker.

Q. Where are you at work now?

A. Kampsville.

Q. You don't know whether the water contains deleterious matter or not?

A. Well I never analyzed the water; I can't tell you.

Q. Are you a man of family?

A. Yes sir.

Q. Do you use well or cistern water at home?

A. We use well water at home.

Q. For drinking and domestic purposes?

A. Yes sir.

Q. You say that before the opening of the canal the water in the Illinois river was stagnant?

A. I didn't say it was stagnant; I said the water got very green in low water.

Q. There was no current in it?

A. Well, yes, I never see the river when there was no current in it except when the Mississippi river would back it up.

5188 Q. No current to speak of I mean.

A. Well, yes, it would get so there wasn't very much current in it of course.

Q. You are not on the river every day?

A. I am on the river every day that I am not sick.

Q. What do you do on the river?

A. I am a ship-builder and caulker by trade and I work for the government. I have been working for the government for the last eighteen years on this river. We are working on boats for this Chicago drainage now.

Q. You mean the Chicago drainage canal?

A. For the survey.

Q. Well that's the sanitary district of Chicago?

A. Well I don't know whether it is for the sanitary district or not; it is for the survey; I don't know whether it is the same thing or not.

Q. There is a fairly good current at all times of the year now, is there?

A. Yes we have had a good current in the river for the last two or three years.

ALBERT R. ZIMMERMAN.

5189 Kampsville, Ill., July 17, 1903.

C. V. BRAINARD,

recalled for further examination by Judge Johns, testified as follows:

Q. In your employment by the government, have you been in charge of the dredging operations on the Illinois river?

A. All that has been done in the last twelve years and a half.

Q. Covering how much of the Illinois river?

A. From Copperas Creek lock to the mouth.

Q. Do you accompany the dredge boats at times?

A. Yes sir.

Q. What character of material is dredged from the Illinois river?

A. There is some sand, some clay and some mud.

Q. Where is the dredging done?

A. Well, what do you mean by that?

Q. As to the bars in the Illinois river?

A. As to the location of them you mean?

Q. Yes.

A. Most of the dredging has been done between Kampsville and the mouth of the river, and also between Copperas Creek and Kampsville locks.

Q. What is the purpose of the dredging?

MR. JEFFRIES: Objected to for the same reasons as before suggested in reference to testimony of this character, made by previous witnesses. 5190

A. To deepen the channel.

Q. Is the dredging done largely where bars have formed in order to cut a channel through them?

A. Yes sir.

Q. Where do these bars form, above or below the mouths of the tributaries of the Illinois?

A. The majority of the dredging that has been done is to cut these bars that have been formed for years and have been an obstruction to navigation for probably 20 years and they exist in all points of the river, but the new bars forming are generally below the mouths of the creeks.

Q. What is done with the dredged material?

A. It is deposited to one side in the river.

Q. Do you choose localities if you can, for the depositing of the dredged material?

A. There isn't much choice; we put them in the shortest possible towage that we can get; simply throw it to one side of the river.

Q. Do the channels in the new bars that are formed, sometimes fill up?

A. The dredged channels fill up at times, yes sir.

Q. From what cause?

5191 A. Between Kampsville lock and the mouth of the river it is usually formed by the back water of the Mississippi. There are times at which the creeks pouring out a flood at certain stages of the river will fill up the channel immediately below the mouth of the creeks.

Q. What is the effect upon the sedimentation in the Illinois river of a flood?

A. My experience has been that there is no effect on what has already been deposited.

Q. Does it have the effect to increase the amount of sedimentary matter or material?

A. Well, that I couldn't say. After floods, after high waters we frequently find some of our channels filled up. That is usually in parts of the river that are affected by back water from the Mississippi. This may be caused by two reasons, either that the water that is entering the river from the Mississippi is full of sediment which is deposited when the current is slack, or it may be that the water coming from above in the Illinois river, deposits the sediment into the slack water that is formed from above in the Illinois river, by emptying into the back water of the Mississippi; the deposits may be made in either of the two ways.

5192 Q. Before the opening of the drainage canal in January, 1900, did the Illinois river scour and clean itself in times of high water?

A. I never knew of it doing it.

Q. Since the opening of the drainage canal, does the Illinois river scour and clean itself?

A. No sir, no more than it did before.

Q. Before and since the opening of the drainage canal, if sedimentary matter is deposited in the Illinois river, how is it removed?

A. The only way that it is removed is by dredging it, or some mechanical process; the river doesn't clean itself at all that I have ever been able to find out.

Q. During the high water of this past spring season, which way did the water in the Illinois river flow?

A. At this point it flowed up stream for several days.

Q. Do you know how far that flow up-stream extended?

A. I only know from talking with other parties.

MR. JEFFRIES: Well, we object.

Q. Go on and state it.

MR. JEFFRIES: Objected to as hearsay testimony.

A. I talked with Mr. Worman of the Government survey and he said that he had obtained data that indicated that 5193 the current flowed up-stream above what is known as the Griggsville Bridge, that is about 60 miles from the mouth of the river.

MR. JEFFRIES: We move to strike out the answer because it is hearsay, and the evidence of Mr. Worman can be obtained.

Q. What occasioned this reversing of the current of the Illinois river?

A. The excessive rise in the Mississippi river.

CROSS-EXAMINATION, By Mr. Jeffries.

MR. JEFFRIES: We move to strike out all the evidence of this witness taken today, for the reason that he has not qualified to testify upon the subject about which he was interrogated not having qualified as a hydraulic engineer.

Q. Mr. Brainard, how far is Copperas Creek dam from Kampsville?

A. It is about 106 miles.

Q. Records are kept of all this work, are there not?

A. Yes sir.

Q. And in those records are daily statements of the amount of deposits removed?

A. Yes sir.

Q. The character of the deposit?

A. Yes sir.

Q. And the disposition made of it?

A. Yes sir.

5194 Q. Where are those records?

A. I have a copy of them here in my office and there is a copy in Chicago, in the office of the District Engineer in Chicago.

Q. What is his name?

A. Well really I don't know who it is now; they are just about to make a change; I don't know whether they have made the change or not; Major Willard has been since January, 1900.

Q. Can those records be removed from your office?

A. I don't think they can; a copy of them probably could be obtained.

Q. How deep would the mud accumulate where you have been dredging in these various places?

A. How deep?

Q. The approximate variation?

A. Oh, it might be from a few inches to three or four feet; we finished dredging below the mouth of what is known as Otter Creek below here, one night and moved up half or three-quarters of a mile and began dredging again, and there was a big storm up Otter Creek that night and the next morning we found that there had been a deposit of over a foot in our dredged channel from that storm. Another instance was at French Bar; we dredged from that for about a mile in 1894, and in 1899 we went back to widen the channel; we found that during the high water

of 1899 that in parts of that old channel there had been
5195 from three to four feet of a deposit, and this was caused by back-water from the Mississippi.

Q. Caused by the back-water of the Mississippi river coming up the Illinois river and not having sufficient time to carry the dirt and soil coming from the Illinois river while running out?

A. Yes sir; well, I don't know whether it was caused from the sediment from the Illinois river or whether it was from a sediment out of the water of the Mississippi; that would be impossible to tell which it came from.

Q. It isn't likely that that much deposit would come from back water?

A. Well, I couldn't say that it wasn't likely.

Q. Was the sediment or deposited matter of the same depth over the whole body of the river?

A. No it wasn't, it was simply inside of the dredged channel; outside of the dredged channel it didn't show up so much.

Q. Did it extend over the whole length of the channel that was covered by the back water?

A. No, there was only portions where there were deposits; there was a deposit at French Bar and a deposit along Herriken Island above French Bar.

5196 Q. How long has it been since there has been dredging done in the river?

A. Two years ago this summer.

C. V. BRAINARD.

5197 Kampsville, Illinois, July 17, 1903.

JAMES R. FULLER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. James R. Fuller; Kampsville, Illinois, overseer Illinois river crew.

Q. As such overseer are you in the employ of the government of the United States?

A. I am.

Q. How long have you been in the employ of the government, upon the Illinois river and in what capacity?

A. Thirteen years altogether, clerk and overseer.

Q. What are the duties of overseer?

A. Well I have charge of repairs and construction work and dredging operations under the supervision of the assistant engineer when he is there; when he is not there, why the same duties that he has.

Q. Who has been assistant engineer?

A. W. M. Charles was when I first came on board; C. V. Brainard since.

Q. Over what part of the river have dredging operations
5198 been conducted since you were overseer?

A. As far as I am concerned myself I have never done any dredging above Meredosia; between Meredosia and Six Mile Island.

Q. What has been the purpose of the dredging?

MR. JEFFRIES: Objected to for the same reason as stated in reference to the testimony of the same character from other witnesses.

A. To improve navigation.

Q. Is dredging done through bars that formed in the river?

A. The bars that have principally been in the river and always were in the river, through bars only.

Q. How wide as a general rule have the channels been cut through bars?

A. Two hundred feet I think was the last project; 200 feet wide.

Q. What is done with the dredged material?

A. As far as possible it is dumped along the shore opposite the dredged channel.

Q. What is the character of the material dredged from the bottom of the Illinois river?

A. Sand and mud and some mussel shells.

Q. Where are the bars formed as a general rule, with reference to the mouths of tributaries of the river.

MR. JEFFRIES: Objected to as immaterial and incompetent from this witness.

5199 A. Generally below the mouths of these tributaries.

Q. What causes those formations?

MR. JEFFRIES: Objected to for the same reasons.

A. The flood washes it down from these tributaries; the deposits are washed down by the floods out of those tributaries.

Q. Do the channels cut in these bars ever fill up?

A. Yes sir.

Q. From what cause?

MR. JEFFRIES: Objected to for the same reasons.

A. Freshets out of these tributaries.

Q. Have you occasionally redredged the channels formerly dredged out?

A. We have.

Q. How frequently did that occur?

A. Well just now I only think of two instances.

Q. Where were they?

A. One at French Bar, and one at Six Mile Island, and one at Otter Creek; yes there is four—one at Herriken Island, too.

Q. What is the effect so far as sedimentation is concerned, of a flood in the Illinois river?

A. It would make some deposit along the banks. At the lower end if we have back-water from the Mississippi, it is liable to make deposits in the main channel. 5200

Q. Does it have the effect to lift up and remove sedimentary matter previously deposited, either in the channel or along the banks of the river?

A. I have never seen any effects of it.

Q. In the Illinois river, if sedimentary deposits are made, or occur, what is the only means of removing them?

MR. JEFFRIES: Objected to as immaterial and incompetent.

A. Dredging as a rule; in some form or other.

Q. Did the Illinois river before the opening of the drainage canal, scour or clean itself in times of flood?

MR. JEFFRIES: Objected to as leading and for the reason that the witness has not qualified as a hydraulic engineer or otherwise to know or testify on that subject.

A. Not as I ever saw.

Q. Since the opening of the drainage canal, does the Illinois river scour or clean itself?

MR. JEFFRIES: Objected to for the same reasons.

A. No sir.

Q. In either times of flood or in other stages of water?

MR. JEFFRIES: Objected to as leading.

A. No sir.

Q. Since the opening of the drainage canal, if sedimentary matter occurs in the Illinois river, what is the only means
5201 of removing it?

MR. JEFFRIES: Objected to for the same reasons as before, and for the further reason that the witness has answered it.

A. Dredging.

Q. What is the width of Copperas Creek dam, or length?

A. I do not know.

Q. Well, approximately?

A. Well, I should think it was seven or eight hundred feet, but I don't remember now; I don't know as I ever saw the length of it stated.

Q. What was the condition of the Illinois river water before January, 1900, as to current, general appearance and odor, if any?

A. The current was sluggish, especially in low water, and the river was always muddy. In low water it smelled pretty strong a good deal of the time.

Q. What has been its condition since the opening of the canal?

A. I think the water has been clearer since the opening than it ever was before and there is a good deal more current.

Q. Did the men under you that worked in the dredging operations drink the Illinois river water before the opening of the canal?

A. They did part of the time; occasionally there would
5202 be a spring near where we were working and they would drink that water; otherwise they would drink the river water.

Q. Since the opening of the drainage canal, have they drank the Illinois river water?

MR. JEFFRIES: Objected to as immaterial.

A. Part of the time about the same as they did before; when spring water was convenient they used it; when it wasn't they used river water.

Q. Has there been any typhoid fever among these men to your knowledge?

MR. JEFFRIES: Objected to for the reason that the witness is not a physician and has not qualified as being familiar with that disease or acquainted with the symptoms.

A. Not to my knowledge.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You don't mean to say that in times of high water the river does not cut through these bars and deposits and at places form new channels, do you?

A. Yes, sir, that is what I mean to say.

Q. It doesn't do that?

A. The river don't cut out channels; don't change a channel from itself; it won't cut a channel through these bars.

Q. Then the channel you say never changes, either in
5203 high or low water?

A. Not in my experience; it never changes from the river itself, the current never changes. We change the channel occasionally, dredging; I never saw this river change a channel from the effects of the water.

Q. You are not an engineer?

A. Yes sir, I have studied civil engineering.

Q. Not hydraulic engineering?

A. No sir.

Q. Did you graduate as a civil engineer?

A. No sir.

Q. How long has it been since you have done any dredging?

A. Two years.

Q. Considerable before that?

A. Yes sir, well I worked the season of 1900, 1899, 1897 and 1895, and three months in 1901.

Q. You have never examined the water, have you, in the Illinois river?

A. What do you mean, analyzed it?

Q. Analyzed it to see whether it contained any poison or not?

A. No sir, I never analyzed it.

Q. You don't know anything about it in that respect?

A. No sir.

JAMES R. FULLER.

5204 Continuation at Gravel Point, Illinois, July 17, 1903.

JOHN WEIMER,

called as a witness in behalf of the defendants having first been duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. John Weimer.

Q. Where do you live, Mr. Weimer?

A. Gravel Point.

Q. How far is that from the mouth of the Illinois river?

A. About forty miles.

Q. How long have you lived here?

A. Three months.

Q. What was your business before coming to Gravel Point?

A. I was employed by the government.

Q. In what capacity?

A. As dredge engineer.

Q. How long were you in the employ of the United States government?

A. In the neighborhood of about sixteen years all told.

Q. On what rivers?

A. On the Mississippi and Illinois.

5205 Q. Are you familiar with the Illinois river?

A. Yes sir, to a certain extent I am.

Q. What extent?

A. Well, I think I know the nature of the river pretty well.

Q. Are you familiar with the character of the soil through which the river runs?

A. I am to a big extent.

Q. Do you know how many dams are on the Illinois river?

A. Yes sir.

Q. How many dams are there?

A. Four.

Q. How far up the river are you acquainted?

A. I am acquainted as far as La Salle.

Q. How far down the river are you acquainted?

A. To the mouth of the Illinois.

Q. At what points along the river have you done dredging?

A. Well I have dredged along the river from three miles above Hennepin down to the mouth.

Q. Hennepin is where the Hennepin canal enters the Illinois river is it not?

A. No it is two miles below; Hennepin is below the mouth of the canal.

Q. You are familiar with the character of the Mississippi river are you not?

5206 A. Yes sir, to a big extent.

Q. From what points?

A. From Winona to about twenty miles below St. Louis, I am acquainted to a big extent with the Mississippi river.

Q. How does the Mississippi river and the Illinois river compare as to their channels?

MR. JEFFRIES: Objected to.

A. They don't compare at all, the two rivers.

Why, one will stay stationary in its place and the other moves.

Q. Which one moves?

A. The Mississippi.

Q. And the Illinois stays stationary?

A. Yes sir.

Q. Is it the Mississippi river that scours?

A. Yes sir.

Q. How about the Illinois?

MR. JEFFRIES: Objected to because the witness has not qualified as a hydraulic engineer or qualified upon that subject.

A. In regard to the channel?

Q. Does it scour?

A. No sir.

5207 Q. When sedimentary substances are deposited on the bed of the Illinois river, what effect does high water have upon the beds of the streams and the deposits made upon the bed of the stream of the Illinois river?

MR. JEFFRIES: Objected to for the same reasons as stated in the previous question.

A. That is in reference to the bed of the river?

Q. Yes.

A. I don't see that it has any whatever.

Q. Will high water in the Illinois river scour out the bed of the river?

MR. JEFFRIES: Objected to as leading and suggestive of the answer desired, and for the reason that the witness has not sufficiently qualified himself to testify especially as to the strength and power of the water at the various stages of the river, according to the gauge and flow of the river.

A. No.

Q. Have you had any experience with the Illinois river that justifies you in making that statement?

A. Yes sir.

Q. Relate your experience in that regard?

A. I have sounded the gauge of the water when we dredged, and have sounded it a year or two after we dredged, and found about the same water.

5208 Q. What effect have freshets in the tributaries to the Illinois, upon the Illinois river?

MR. JEFFRIES: Objected to as immaterial and as not a competent question to ask of this witness.

A. They have quite an effect on the Illinois river.

Q. In what way?

A. In washing the soil off the hills and carrying it into the river.

Q. Where is this soil deposited in the river?

A. Principally at the mouth where it strikes a big body of water where it loses the swiftness of the current.

Q. Will that deposit so made by freshets subsequently be removed by high water?

MR. JEFFRIES: Objected to as leading and suggestive and as incompetent of this witness.

A. It might in some cases, but most of the cases it don't on the river.

Q. What cases will it?

MR. JEFFRIES: Objected to for the same reason.

A. It might in a case where the river is very close and a creek comes out into the river, while if there is a big stage a big flat bed, it won't.

5209 Q. In cases where it is removed from the mouth of the tributaries because of the narrowness of the river, what becomes of the deposits so removed?

A. Why I am not able to answer that question for the simple reason that in all the rivers, we have not such experience where it did remove it, but I just said it might remove it where very shallow; it might remove it of its own accord where it is very shallow, but in the twelve years while I was here, we had none of that experience, but yet such might be the case.

Q. How are those bars removed when they are removed?

A. In this river?

Q. Yes?

A. By dredging, we remove them by dredging.

Q. Have you had any experience during the last twelve years upon this river, of instances where you have dredged out a channel and that channel susequently filling up?

A. Yes sir, I have.

Q. Give the instances?

A. We were down here dredging at Twelve Mile Island, right below Macoupin, and we were just about through and we were going to move up the river with the fleet, and a rain came that night up the Macoupin and it come down the Macoupin creek an awful strong current, and it regular flooded; it filled up the channel about a foot.

5210 Q. Any other instance that you can recall?

A. I couldn't think right at this moment.

Q. Do you know when the dams on the Illinois river were built?

A. I know when part of them were built.

Q. Which ones?

A. Why the two lower ones.

Q. What are the names?

A. Kampsville and LaGrange.

Q. Has the river filled up above those dams since they were built, by deposits?

A. Has the river filled up above the dams?

Q. Yes, by sediment outside of the channel which is kept?

A. I don't believe that it has as far as I know of; it might right above the locks; I don't know that it does, but it might be.

MR. JEFFRIES: We object to the statement of the witness as to what it might be.

Q. When matter is deposited on the bed of the Illinois river, do you know of any way by which that deposit can be removed except by dredging?

MR. JEFFRIES: Objected to as leading and suggestive and not a proper question of this witness, the witness not being qualified to express an opinion on that subject.

A. No sir.

Q. Does high water or current change the channel in the Illinois river?

5211 MR. JEFFRIES: Objected to as incompetent of this witness, as calling for an opinion without the witness first having qualified as being capable of forming an opinion or expressing a judgment that would serve any lawful or reasoable purpose.

A. No sir.

Q. What effect does current and volume of water have upon the channel of the Mississippi, if you know?

A. Well, I have seen where the channel would be one time, and after high water it would be altogether removed from there and be another place.

Q. That condition is common on the Mississippi, is it not?

MR. JEFFRIES: Objected to as leading and suggestive.

A. Yes sir.

Q. Have you ever found that condition to exist upon the Illinois?

A. No sir.

Q. What was the character of the water of the Illinois river before the drainage canal was opened?

A. In low water when we didn't have no rains for quite a while it was very stagnated, fearful.

Q. What was its color?

A. It was greenish.

Q. What has been the condition of the Illinois river since the opening of the drainage canal?

5212 A. I consider that it has been a lots better water since we got more current in the river; very better.

Q. In what way is it better now than it was before?

A. I consider it purer now than it was before.

Q. Has it an odor as it had before?

A. At the present?

Q. Yes?

A. No sir.

Q. How many fishermen are engaged in the fishing business at this point?

A. Six or seven families.

Q. Do they live on the river?

A. Along the shore principally.

Q. Do you know of any typhoid fever being among those people?

A. No sir.

MR. JEFFRIES: Objected to as the witness is not a physician and has not qualified as being acquainted with that disease.

Q. Have you drank the water of the Illinois river before and since the opening of the drainage canal?

A. Yes sir; I have used it nearly altogether for twelve years both in summer and winter.

Q. How does it compare for drinking purposes now with what it did before the opening of the canal?

A. It is lots better now.

5213

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You say you live here at Gravel Point?

A. Yes sir.

Q. How long have you lived here?

A. About three months.

Q. Where did you live before you came here?

A. Kampsville.

Q. Did you live in a house-boat there?

A. No sir.

Q. Do you here?

A. No sir.

Q. Did you have a cistern or well down there at Kampsville?

A. We had at the house either a well or a cistern, but I stayed on the river continually more or less.

Q. You are a married man?

A. Yes sir.

Q. Have you a well or a cistern at this place where you live now and have lived for the last three months?

A. I have a well here.

Q. You use the water of the well for domestic and drinking purposes?

A. Yes sir.

5214 Q. Now when was it you said, that you commenced working for the government in dredging business?

A. In the dredging business?

Q. Yes.

A. About fourteen or fifteen years ago, dredging, and I worked before for them, before dredging.

Q. When did you quit?

A. I quit about three months ago.

Q. Where were you dredging when you quit?

A. We were laid up at the time that I quit. We were repairing then.

Q. How long had you been laid up?

A. Last June a year ago or two years ago.

Q. About two years and a half ago, wasn't it?

A. I don't know exactly whether it is two years ago or last June a year ago.

Q. Who were you working under, Mr. Brainard?

A. No, I was under Mr. Long.

Q. You haven't been on the river much since that time excpt around here fishing?

A. Well not in the line of dredging, but I have been on the river more or less; in fact I have been continually on the river.

Q. There is quite a current in the river now?

A. Ordinary current.

5215 Q. What do you mean by an ordinary current?

A. Well, we have had stiffer currents than this already and we have had less current.

Q. How much less?

A. I have seen the current run up stream; you might take the difference.

Q. That was before the canal was opened?

A. No that was this spring.

Q. That was the back water from the Mississippi?

A. Yes sir.

Q. That is the only reason that the water ran up stream?

A. Yes, that's the only reason.

Q. Where did you do your dredging on the Illinois river?

A. I done it along the Illinois river from above Hennepin down to the mouth.

Q. Principally from here to the mouth?

A. Principally from here to the mouth.

Q. How deep a channel would you dig or dredge?

A. That depends on the stage of the water we had in the river. You mean how deep below low water?

Q. Yes, I want to know how much earth you would remove out of the bottom of soil and mud and filth?

A. That depends altogether on the depth we are going
5216 there.

Q. Well, from one to three feet?

A. Well generally a certain depth below low water, whatever it is, sometimes two feet, three feet or four feet.

Q. What was the character of the material taken from the bed of the stream?

A. Very heavy loam and in places in those creeks and stuff, we would get heavy gravel and mussel shells.

Q. And mud?

A. Necessarily heavy mud in it.

Q. Where was the last place that you dredged?

A. I ain't positive whether it was Hennepin or Kampsville; I ain't positive about that, but I know I worked there:

Q. What was the character of the material that you took out at those places, mud?

A. Yes, principally mud.

Q. Now immediately before that where did you do some dredging?

A. Well now, that's pretty hard to tell; if I had my books here; otherwise I couldn't tell off-handed; We dredged so much here and we would move forty or fifty miles and then dredge there, and it is pretty hard to tell in what direction we did go then, but I think it is principally below Kampsville locks; I think that was the principal dredging that we have been doing lately.

5217 Q. There hasn't been as much dredging in the last three years as there was the three years preceding?

A. No sir.

Q. In fact comparatively speaking there has been very little?

A. Very little in the last couple of years.

Q. Now you made a report of all this dredging, didn't you?

A. Yes sir, I kept a record of it.

Q. Did you keep a record of the amount of filth and mud that you took from the bottom of the river?

A. Yes sir.

Q. What did you do with it?

A. The government has got it on file.

Q. Where?

A. My report is kept there at Kampsville.

Q. You made that report daily?

A. Yes sir.

Q. And set down the number of hours worked?

A. Yes sir.

Q. The amount of substance removed?

A. Yes sir.

Q. The character of the substance?

A. Yes sir.

Q. An the disposition that was made of it?

A. Yes sir.

5218 Q. And the depth of the mud where it was taken from?

A. No sir, we took that before we started in with the dredge.

Q. When you took that depth before you commenced to dredge, what did you do with it, make a report?

A. Yes sir.

Q. And is that report at Kampsville?

A. That report is on record either at Kampsville or at Chicago.

Q. When you say that the water is better now than it was before the canal was opened you mean just from its appearance or your observation of it and not from any examination which you made of the water?

A. Well I made my observations by using it.

Q. For drinking purposes?

A. Yes sir, I find it is better now than it was before.

Q. While working on the river?

A. Yes sir.

Q. You are fishing now are you?

A. No sir.

Q. What are you doing?

A. I am doing a little of everything and not much of anything.

5219

RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. Just state in detail what you are doing?

A. Well sir, I am running a store here; I farm, agricultural implements, blacksmith shop, and I will sell most anything a man wants, and buy most anything a man has.

JOHN WEIMER.

5220 Gravel Point, Illinois, July 17, 1903.

THOMAS J. NELSON,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd, and testified as follows:

Q. What is your name?

A. Thomas J. Nelson.

Q. What is your business?

A. Well I have been fishing for a few years and am fishing now.

Q. How long have you been a fisherman?

A. I have been a fisherman for about six years.

Q. What did you do before that time?

A. I farmed here along the river bottoms between here and Kampsville.

Q. During the last six years that you have been a fisherman, have you observed the Illinois river and the waters of the river?

A. Yes sir, noticed it pretty nigh daily.

Q. Before the opening of the drainage canal what was the condition of the water?

A. Well in the fall of the year it was in rather a bad condition; there was a smell to it; it was no current, and green
5221 moss and grass grew in it, a heap more so—there hasn't been any since—to say any, since, and before it was no current.

Q. Was there an odor to the water before the opening of the canal?

A. Well I couldn't say that there was; I didn't use any of it; it was impure, was all you could call it.

Q. What effect has the opening of the drainage canal had upon the waters of the Illinois river?

A. Well it give it a current and the water has become purer, there is more current in it, is all the difference that I can see.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. The only difference then that you can see between the waters of the Illinois river now and prior to the opening of the Chicago drainage canal is that there is a larger volume of water and a better current?

A. Yes sir, there is more water in the river and more current, and it is purer; the current makes it purer so it can run off, is the only difference that I can see in it.

Q. How old are you?

A. I am 63 years old, was the 8th day of last May; was born in 1839.

5222 Q. Have you always lived on the river?

A. I have been on the river here since the fall of 1859, except one year I was in Arkansas; I have been here ever since. I came here thirty days before Abe Lincoln was elected president; wasn't here long enough to vote except for President.

Q. Did you vote for president?

A. In that year?

Q. Yes.

A. No sir; I didn't go to the polls at all, I cut my foot the night before and didn't go.

Q. You say you have been farming on the river for the last fifty years?

A. Yes sir.

Q. You live in a residence here?

A. I live in the first house below here, just a half or a quarter,—the first house below.

Q. Have you a cistern or a well?

A. I have a well.

Q. You use the water from that for drinking or domestic purposes?

A. Yes sir.

Q. So far as the question as to whether or not the water 5223 in the Illinois river contains more deleterious matter now than it did prior to the opening of the canal, you have no information have you?

A. No, I haven't.

Q. You don't know whether the sewage from Chicago gets down here this far or not?

A. No, I couldn't say; of course the water must come here; that is all I could say. It has got to go down stream some place, but this year it went up-stream here.

Q. That was caused by back water from the Mississippi?

A. Yes sir.

Q. And the Mississippi was higher than it has been since 1844?

A. Well, I couldn't say; I know that it is the second time

I have seen the water run up-stream this far since I have been here.

THOMAS J. NELSON.

5224 Gravel Point, Illinois, July 17, 1903.

THOMAS CARTER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Thomas Carter.

Q. Where do you live Mr. Carter?

A. Why I live right down here at Gravel Point.

Q. What is your business?

A. Fishing.

Q. How long have you been a fisherman?

A. I have been fishing for the last forty-five years.

Q. Are you acquainted with the Illinois river before the opening of the drainage canal?

A. Yes sir.

Q. What was the condition of the water of the Illinois river before the canal was opened?

A. Well the late years it was stagnated; low current.

Q. Any green scum on it?

A. Yes sir.

Q. Any smell?

A. Yes sir, in the hot part of the season, July and August.

5225 Q. What effect has the opening of the drainage canal had on the waters of the Illinois at this point?

A. What effect it has?

Q. Yes?

A. Well it has put some current in it; it keeps that green scum off so far.

Q. What else?

A. Why I think the water it purer than it was.

Q. Did you ever drink the water from the Illinois river?

A. Yes sir.

Q. Have you drank it since the opening of the canal?

A. Yes sir.

Q. How often?

A. Well I never drank it much in the summer time; in the winter I do.

Q. How many men are engaged in the fishing business at this point?

A. How many?

Q. Yes?

A. About five.

Q. Any typhoid fever among them?

A. Not as know of; I never heard of any.

5226 CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How long have you lived here?

A. I have been living here about 25 or 30 years.

Q. Been fishing all the time?

A. Yes sir.

Q. Do you live in a boat on the river or in a house?

A. No, I live in a house.

Q. Have you a well or a cistern?

A. I have a well.

Q. You use the water out of that for household and drinking purposes?

A. Yes sir.

Q. When you say the water is better now than it was before the opening of the Chicago drainage canal you mean it has a better current and a larger volume of water?

A. Yes sir.

Q. You don't know whether the water contains more deleterious matter now than it did before the opening of the canal or not, do you?

A. No, I couldn't say.

Q. It is not used much for drinking purposes?

A. No, not very much.

Q. Only when you get out on the river and want a drink
5227 and haven't got anything else?

A. Yes sir.

RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. Do you mean there is a swifter current and a larger volume of the same kind of water that was here before the canal was opened?

A. Yes sir.

Q. No difference in the quality of the water?

MR. JEFFRIES: I object to that as leading.

A. No, I don't know as there is any difference in the color.

Q. Was the water before the canal was opened, as clear as it is now?

MR. JEFFRIES: I object to the question as leading.

A. Except the scum.

Q. What did you mean when you said that the water was better now, than it was before the opening of the canal?

MR. JEFFRIES: Objected to as cross-examining defendant's own witness.

A. I don't know as I said it was any better. I said there was a better current than there was; I don't know as I said the water was any better.

Q. Did you drink the water before the opening of the drainage canal?

5228 A. I have, yes sir.

Q. Have you drank it since?

A. Yes sir.

Q. Which is the better water, the water before the canal was opened, when it was stagnant, or the water now?

A. Well I don't know as I can tell any difference in the taste of it.

Q. It is all damp?

A. Yes sir.

Q. You haven't a very good taste for water anyway, have you?

A. Sometimes yes sir, when I am dry.

his
THOMAS X CARTER.
mark.
F. S. B., Com'r.

5229 Gravel Point, Ill., July 17, 1903.

GEORGE NELSON,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd, and testified as follows:

Q. What is your name?

A. George Nelson.

Q. Are you the son of Mr. Nelson that testified here before?

A. Yes sir, I guess I am.

Q. What is your business?

A. I am a fisherman.

Q. How long have you been a fisherman?

A. I have been fishing for about seven years I guess; six years I think.

Q. You fished here three years before the drainage canal was opened and three years since?

A. Yes sir.

Q. What was the condition of the water of the Illinois river before the opening of the drainage canal?

A. Well it would be—I haven't seen any difference only in the fall of the year.

Q. What difference was that?

5230 A. We have a current now the last three years and water does not get so green and isn't so filthy.

Q. Did you ever drink the water?

A. Yes sir, I have drank it.

Q. Before the opening of the drainage canal?

A. I have drank it both before and since the canal.

Q. What effect has the opening of the drainage canal had on the quality of the water?

A. Well I supose the quality would be the color and such as that wouldn't it?

Q. Yes?

A. A better color and purer water is my estimation of it.

Q. Do you see any green scum upon it now?

MR. JEFFRIES: Objected to as leading.

A. No sir.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Do you live with your father?

A. Yes sir, he lives with me.

Q. He lives with you?

A. Yes sir.

Q. Your family use the water from the well there at home for drinking and household use?

A. Yes sir, we use well water.

5231 Q. You never use the water of the Illinois river except when you are out fishing and haven't got any other drinking water?

A. Yes sir, when I am around home I always drink out of the well but lots of times I am caught out when I have to drink river water you know.

Q. About the only diffrenece as I understand it between the water in the Illinois river now and what it was before the Chicago drainage canal came into it is that there is a larger volume of water, and a better current than there was before?

MR. TODD: I object to the question on the ground that counsel hasn't shown the proper qualifications to testify in this case and besides this question is not proper in form.

A. Well, there is a good deal of difference in the water.

Q. That is the main difference though?

A. Before this water came in it was a regular lake; the water was green.

Q. That's what I meant, exactly, that after the opening of the drainage canal there is a good current?

A. Yes sir, there is a reasonably fair current here ever since it was turned in.

Q. That is about the only difference, isn't it, between the water now and then?

A. Yes sir, that is the main difference.

5232 Q. You don't know whether the Chicago sewage gets down this far or not?

A. No sir, I don't.

RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. Is the only difference that you see in the water that of the volume of the water and the speed of it; aren't there other differences?

A. Why as I stated before, the water was more clear; it wasn't so stagnant for instance; more pure. Of course the current was pure water.

Q. You mean since the opening of the canal?

A. Yes sir.

Q. And before that it was stagnant?

A. Yes sir.

GEORGE NELSON.

5233 Gravel Point, Ill., July 17, 1903.

S. D. THURSTON,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. S. D. Thurston.

Q. Where do you live Mr. Thurston?

A. Calhoun county.

Q. What is your business?

A. Fisherman.

Q. How long have you been a fisherman?

A. Three years steady.

Q. Before that time what did you do?

A. Farmed.

Q. Were you acquainted with the condition of the Illinois river before the opening of the drainage canal?

A. Fairly well, yes sir.

Q. How extensively?

A. Well I have lived along the river most of my life; near it; within two or three miles.

Q. Describe the character of the water of the Illinois river before the opening of the drainage canal?

A. Well it was stagnant in low water; since the dam and 5234 locks were put in, generally none the best before.

Q. Was there any scum on the water?

A. Yes sir, at times.

Q. What kind of scum?

A. Green.

Q. Any odor to the water?

A. Yes sir, in hot weather. Water or mud settling, something, I don't know what, along in the river.

Q. Since the opening of the drainage canal what has been the effect upon the quality of the water in the Illinois river at this point?

A. Why, there is a better current and clearer water, in the winter season anyway. I would say better, in fact.

Q. Do you see any scum on it?

A. No sir, not this low down; I saw it over at Peoria.

Q. Do you drink the water when you are out fishing?

A. I do when it is cold yes sir.

Q. Has there been any sickness among the fishermen in this locality?

A. Not that I know of.

Q. Has there been any cases of typhoid fever here?

A. Not that I know of.

5235
CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You say you have been fishing three years?

A. Yes sir.

Q. Then you were not on the river constantly before the opening of the canal?

A. No sir, not constantly.

Q. And were on it only when you would have occasion to go fishing or go across it?

A. Yes sir, I have lived close to the river though.

Q. Where do you live now?

A. In Calhoun County.

Q. With reference to the river?

A. On the bank of the river.

Q. In a dwelling house or on a boat?

A. Dwelling house.

Q. Do you have a well or a cistern?

A. Well.

Q. You use the water from the well for household and drinking purposes do you?

A. Yes sir.

Q. You don't know whether the sewage gets down here from Chicago or not, do you?

A. No, I couldn't answer that question.

5236 Q. The current is very much stronger now than it was, isn't it?

A. Yes sir, there is more current than there was during low water. There was always current before the dam was put in and since, none.

Q. Until the canal was opened?

A. Yes sir.

Q. You don't drink the water unless you get caught out and have to drink it?

A. Oh, no. S. D. THURSTON.

5237 Continuation at Pearl, Illinois, July 17, 1903.

MARION HESS,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. State your name, residence and occupation?

A. Marion Hess; I live here in Pearl; I fish, farm some along the river.

Q. How long have you fished in the Illinois river?

A. I have fished off and on now for ten or twelve years.

Q. For what distance up and down the river from Pearl have you fished?

A. Fifteen miles anyhow, each way up and down.

Q. What was the condition of the waters of the Illinois river prior to January, 1900, when the drainage canal was opened?

A. Well sir, it was pretty filthy and dead.

Q. What kind of stuff or material was in the water?

A. Well sir, during along July and August it was pretty filthy, green looking water, filthy scum on the water.

Q. How did it affect your nets?

A. Well sir, it would form a scum and slime all over the
5238 nets and as you raised them up the slime and scum dropped off and some stuck on of course; some stuck on and some dropped off.

Q. Did you drink the waters during this time when there was slime and scum in it?

A. No sir, you couldn't drink it; it was too filthy.

Q. Were there times in the fall and spring when there was not slime and scum?

MR. JEFFRIES: Objected to as leading.

A. If there was, it was early in the spring; always formed a scum along in July and August and September, the best I remember now.

Q. When there was not slime and scum upon the waters, did you drink the waters of the Illinois river when fishing?

A. Well yes sir; we drank it along in the spring of the year; it was ordinarily pure then it seemed like; we had high water you see then, and made it a little more purified than along in the summer and fall.

Q. Since January, 1900, what has been the condition of the river?

A. Why it's been, it seems like purer and all right—a good current and seems like the water has been purer and all right.

Q. Since the opening of the drainage canal do you drink the waters of the Illinois river during the season?

MR. JEFFRIES: Objected to as leading.

5239 A. Yes sir, whenever I want a drink of water, during along in the season I take the cup and get me a drink most any time; when I can get no other water you see, it does pretty well.

Q. Do you know of any typhoid fever among the fishermen since the opening of the drainage canal?

A. No sir, I don't know exactly as I do; I couldn't mention any around here.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You live here in Pearl?

A. Yes sir. Live inside the corporation.

Q. On the river?

A. Yes sir, about a quarter.

Q. Do you have a well or a cistern at your home?

A. Have a well.

Q. You use the water from the well for domestic and drinking purposes?

A. Yes sir.

Q. You are a very busy man aren't you?

A. Yes sir I am a working man and work all the time.

Q. You don't pay any particular attention to the sickness in the community?

A. I ain't around so awful much; I am just mentioning 5240 about the neighborhood where I live; around town and around where I live at.

Q. You say you drink the water from the river?

A. Yes sir whenever I am out now I drink the water.

Q. When you can't get any other water?

A. When we haven't any other we do most of the time. When we can't get any we use it, but there was a time along in July and August you couldn't drink the water with scum over it at all; I remember all about them times, and now we take the bailing cup and dip it down and don't get no scum and stuff, and it seems to do for thirst; that is all I can answer for; is all I know anything about the matter.

Q. What is the difference between the current of the river now as far up and down the river as far as you know it?

A. Well, sir we have a current now all the time and in July and August in dead water we had no current at all.

Q. When?

A. Before the canal was turned in.

Q. Is it now?

A. No dead water now at all; I haven't seen any dead water since the canal was opened.

Q. What is the stage of the river now?

A. Well sir, I don't exactly know; I haven't been out. It is ordinarily low water now.

5241 Q. You have a good current in the river now?

A. Yes sir.

Q. There may have been cases of typhoid fever and you not have heard about it

A. Yes sir, there may have been because I don't inquire very much. There hasn't been none lately that I know of. Of course there has been more or less all the time, as far as that goes. But then I don't know what the cause of it is, as far as I know.

MARION HESS.

5242 Pearl, Illinois, July 17, 1903.

E. H. CHANDLER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. E. H. Chandler; my occupation is agent of the Chicago & Alton Railway and United States Express Company.

Q. And your residence?

A. Pearl, Illinois.

Q. Were you engaged to take samples of water at this point from the Illinois river in behalf of the state of Illinois and if so by whom?

A. Yes sir, by Mr. J. H. Long.

Q. When did you make an arrangement with him with reference to it?

A. My recollection of it is; I never kept any record of it in writing, was in the fall of 1899 and 1900, the first arrangement was made in the fall of 1899 as I remember it.

Q. Did you personally take the samples?

A. No sir, I had a boy staying with me by the name of Joseph Lindsey, staying in the office with me, and he took it;
he took the samples all the time; that was the understand-
5243 ing, that I couldn't get away from my office to go and
take the samples personally and he took them in my
name.

Q. How old was Lindsey?

A. He was about 21 years old.

Q. Where is he now?

A. He is in the Philippine Islands.

Q. A soldier of the United States?

A. He is in the Signal Service of the United States, yes sir.

Q. For how long a time in the fall of 1899 did you take samples, or have them taken?

A. Well according to my recollection for about in the neighborhood of two months and a half.

Q. Commencing about what time and ending about what time?

A. Well I don't really remember that it seems to me it was about along in July or August, but I don't remember about that.

Q. Did you see Lindsey take any of the samples?

A. No sir, I never was there and saw him at all.

Q. Did you have any other person taking samples for you?

A. Jonny Rader took samples—several samples after Lindsey quit.

Q. When did Rader take the samples?

5244 A. Rader took the samples after Lindsey, left; he took about six weeks; that is he took the samples six or seven times I think after Lindsey left.

Q. In what year did Rader take the samples?

A. I think in 1900.

Q. How frequently were samples taken?

A. Once a week.

Q. On what day in the week?

A. I think it was on Tuesday or Wednesday; I am not certain which.

Q. Now did you receive instructions from Mr. Long as to the manner of taking these samples and if so, you may state whether the instructions were printed?

A. As I remember it the first time they was not; it was verbal; he came to the depot up there where I was at, and after the first time it was written in a letter.

Q. What were the verbal instructions of Mr. Long?

A. The verbal instructions was to get one of those jars or jugs, whatever it was, or jar or bottle, once a week and the instructions was to get it out near the middle of the river, where the water wasn't adulterated by creeks, and to keep it cool and ship it by express, and notice the thermometer and take the temperature of the water at the time it was taken.

Q. Did you receive instructions from Long to take the temperature of the water and the temperature of the air and the direction of the wind?

5245 A. I don't remember as to the wind, but the temperature of the air and the water, yes sir.

Q. Did you receive instructions from him as to the manner in which the bottles were to be handled and treated?

A. Yes sir, they were to be packed with excelsior shavings, and that was what was in the boxes, and around the jars with ice on them and sealed up, and shipped by express.

Q. How many samples of water did you take each time that you took any?

A. One; we just took one sample at a time.

Q. How many bottles did you have each time you took a sample?

A. One, one to be shipped, sometimes we would have two or three bottles on hand at a time for future use.

Q. Did you have a large bottle and a small bottle?

A. I think there were, yes sir.

Q. Then you had two?

A. The two I think included the one shipment, the way I remember it, while I didn't handle it.

Q. Was one bottle of about a gallon capacity and the other one of about four ounces?

A. I think it was; that is the way I remember it; yes I think it was.

5246 Q. Did you instruct Lindsey how to take the samples?

A. Yes sir, and I think Professor Long also instructed him how to take them.

Q. Do you know whether Professor Long went out upon the river with Lindsey and showed him how to take the samples?

A. I think he did; they went to the river.

Q. Do you know Mr. Jacob Harman who is present here?

A. I think I have met Mr. Harman, I am not positive of it.

Q. Was Mr. Harman with Prof. Long at the time that you were engaged to collect the samples?

A. I have really forgotten, but I think there was a gentleman with him. I think it was, but I wouldn't be quite sure about it.

Q. I hand you now sixteen tickets and a piece of yellow paper and ask you first whether you are acquainted with the handwriting of Lindsey?

A. I believe I would know his handwriting yet; he was with me a year or the matter of that.

Q. When the samples of water were shipped were tickets put upon them?

A. There were tags; the tickets were put into an envelope. They were sent in an envelope.

5247 Q. Examine the sixteen tickets and the piece of paper and state whether the writing on those tickets is in Lindsey's hand?

A. Yes sir, Lindsey wrote them all, every one of them.

Q. I hand you now thirteen other tickets and ask you to state whether those tickets are in the handwriting of Lindsey—fourteen tickets?

A. I think every one of them is in his handwriting.

JUDGE JOHNS: I now hand to the Commissioner the tickets above mentioned, placed in an envelope, and ask him to mark the envelope Exhibit No. 5 for the State of Illinois, to the testimony of the witness E. H. Chandler.

Received and so marked by the Commissioner.

Q. I hand you two tickets, one dated July 21, 1899, and the other September 7, 1899; the first having the number 44 and the second No. 157, and ask you to state if you know in whose handwriting they are?

A. No, I wouldn't say.

Q. I hand you now an envelope addressed in printing to John H. Long, and having written on it at the bottom "from Geo. A. Wiggins, M. D., Milan, Ill.," and on which are also the letters "J. H. L." in lead pencil, and ask you to state whether or not the tickets which have been exhibited, and were used in the marking of the samples of water taken at this point, were enclosed in an envelope similar to that one?

A. Yes sir, I think so, if I remember and tied onto one of
5248 the bottles.

Q. Where did Lindsey take his samples of water?

A. Near the center and below the bridge.

Q. Were the samples taken by Lindsey and afterwards by Rader, taken under your supervision and direction?

A. Yes sir.

Q. After they were taken were those samples packed as directed on the back of the ticket?

A. I think they were; we got ice at the river, every time he would go down there; he would take a chunk of ice at the river and seal them up and bring them up to the depot and take them into the freight room and pack them up again; that is he would take and have some ice along and hammer it up and pack them up good with ice and then seal it up.

Q. How were they forwarded to Chicago?

A. They were forwarded by express, by the United States Express Company.

Q. From the time the water was placed in the bottles in the river, how long a time elapsed until they were sealed, packed and boxed ready for shipment?

A. Well it would be probably 30 minutes.

Q. While in Pearl with whom did Lindsey live or board?

A. He boarded with Mr. John Rader, right close to the
5249 depot.

Q. Is John Rader the same person who afterwards took the samples?

A. Yes sir.

CROSS-EXAMINATION, By Mr. Jeffries.

Q. What business are you in?

A. I am express agent for the United States Express Company and agent for the Chicago & Alton Railway.

Q. Lindsey was there in the office with you?

A. Yes sir.

Q. Working under you?

A. He was learning; he was a student.

Q. You say you didn't personally see him take any of the samples?

A. No sir.

Q. Nor personally see any of the samples taken at any time?

A. Not any one.

Q. Where were the bottles kept, you said you had several on hand?

A. We had sometimes three on hand; kept them there in the office.

E. H. CHANDLER.

5250 Pearl, Illinois, July 17, 1903.

J. RADER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. J. Rader; I am a barber, and live at Pearl, Pike county, Illinois.

Q. Did you know a person named Joseph Lindsey?

A. Yes sir.

Q. Who lived in Pearl?

A. He boarded there about a year; he boarded with me; he was learning telegraph operating from Mr. Chandler.

Q. Did he take samples of water for the State of Illinois in 1899 and 1900?

A. Yes sir.

Q. Were you ever with him when he took samples?

A. No sir.

Q. Did you ever take any samples in his stead when it was his business to take them?

A. Yes sir.

Q. How many do you remember to have taken where it was Lindsey's business to take them?

A. Well it was two or three; I wouldn't be sure which;
5251 he was sick with the measles and I took them while he was sick.

Q. I hand you two tickets, one dated July 21, 1899, and numbered 44, and another dated September 7, 1899, and numbered 157, and ask you to state whether those two tickets are in your handwriting?

A. Yes sir, I wrote that.

Q. Now upon those two days, did you take the samples of water?

A. Yes sir.

Q. I hand you now six tickets, and ask you to state whether or not those six tickets are in your handwriting?

A. Yes sir.

Q. Did you take the samples of water upon the days mentioned on those tickets?

A. Yes sir.

Q. Describe your method of taking the samples and preparing them for shipment?

A. Well sir, I came down here and got a boat, went out to the center of the river; took the two bottles with me, the large one and the small one; took the small one out, and first took my thermometer and took the temperature of the air first, and then the temperature of the water as I was directed to by Mr. Chandler, and then I filled my large bottle, put the top on it and tied the cloth over it and put the rubber around it 5252 and the small one the same way; put the small one in the little bucket, packed it with excelsior and ice.

Q. Did you put the small bottle in a tin can?

A. Little tin can, bucket like.

Q. And did you put that small tin can in a larger one?

A. Yes sir.

Q. And packed the small one with ice inside the larger one?

A. Yes sir. And then I took the large bottle and put it in a box and packed it around with excelsior.

Q. Did you then ship this box so packed, or take this box so packed to the express office and have it shipped?

A. Yes sir.

Q. Did you tie around the neck of the bottle an envelope?

A. Yes sir.

Q. What did you place in the envelopes?

A. The report cards.

Q. Of the kind I have heretofore shown you?

A. Yes sir.

Q. I hand you now an envelope upon which is written at the bottom: "Geo. J. Wiggins, M. D., Milan, Ill.," and on which is written in lead pencil "J. H. L." and ask you to state whether or not that envelope is similar to the ones which you used?

A. Yes sir.

5253 Q. After the packages were—after the bottles were filled and sealed, how long a time elapsed until they were boxed and ready to be shipped?

A. I boxed them there at the river and carried them up home in the buggy and shipped them right away, about an hour from the time I took the water and put them on the train.

JUDGE JOHNS: I now hand the Commissioner eight tickets, and request him to put them in an envelope and mark them State of Illinois Exhibit No. 6, to the testimony of John Rader.

Said documents are so marked by the Commissioner.

CROSS-EXAMINATION, By Mr. Jeffries.

Q. What place in the river did you take these samples?

A. Right here south of here.

Q. This side of the bridge?

A. This side of the bridge.

Q. Out in the channel?

A. Yes sir.

Q. How deep in the channel?

A. As deep down as I could reach with my arm, about sixteen inches.

Q. When did you take the stopper out of the bottle?

A. Not until I went to fill it.

5254 Q. Before or after you submerged the bottle in the water?

A. Just before I put it down into the water; just as I was reaching it over the boat, take the stopper out and let the bottle run full of water and take the bottle up, and then stop it up as quick as I could get to it.

Q. Did you rinse the bottle out?

A. No sir.

Q. Did you take a sample of that water every day?

A. Not every day.

Q. Every week?

A. Every week.

Q. Once a week?

A. Yes sir.

JOHN RADER.

5255 Pearl, Illinois, July 17, 1903.

WESLEY FRISE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. Wesley Frise; city of Pearl; fisherman.

Q. How long have you been a fisherman upon the Illinois river?

A. Well, about twelve years.

Q. How far up and down the river have you fished from this point during that twelve years?

A. To Hennepin. As far up as Hennepin and down to here.

Q. What was the condition of the waters of the Illinois river before the opening of the drainage canal in January, 1900?

A. Well it was pretty bad water stagnated and scummy.

Q. Did it have any smell?

A. Yes sir; it would stink in the summer time when the water got down low it would smell and in the winter time when you would cut a hole in the ice, there would be a regular gas come from the water, and I have cut holes in the ice where dead fish would come right up through the hole, from the gas I guess and stagnated water.

5256 Q. Where upon the river, and in what years do you remember to have found this condition under the ice?

A. Well I remember of two winters its being that way, but I don't remember just how long ago; one was at Hennepin and the other was at Lacon, but that has been, oh, eighteen years ago.

Q. How far above Peoria is Hennepin?

A. Well it must be 60 or 65 miles; I think we call it 45 miles from Peoria to Lacon, and I think it must be 35 miles from there to Hennepin.

Q. Did you fish any in the winter near Pearl prior to the opening of the drainage canal?

A. This is three years I have been to Pearl; this makes the third winter here, last winter. No, I didn't fish any before.

Q. Could you drink the water when you were on the Illinois river before 1900?

A. No sir, I couldn't, with all the scum you would just have to brush it away and then couldn't get nothing.

Q. Did it have a smell in the summer?

A. Yes sir.

Q. Where were you fishing in the years 1897, 1898 and 1899, before you came to Pearl?

A. Beardstown and Frederick.

Q. What was the condition of the waters at those two places during those three years?

A. Well, we had some pretty bad water there.

5257 Q. How far from Beardstown and which way on the river from Beardstown, is Frederick?

A. It is up the river about four miles from Beardstown.

Q. While at Beardstown and Frederick did you cut holes in the ice in winter in order to fish?

A. For awhile yes, we cut holes in the ice there for the nets.

Q. You may state whether or not you found an odor or smell in the water under the ice at Beardstown and Frederick?

A. Yes sir, I have, smell gas when you cut a hole in the ice.

Q. When you were at Beardstown and Frederick did you drink the water of the Illinois river when fishing?

A. No sir, not much, in the winter we would dip up a bucket full and use to wash out of it and caught out putting in nets and caught dry, had to take a drink of it.

Q. Now since the opening of the drainage canal, what has been the condition of the water?

A. Well, I claim it has been pretty fair, good water.

Q. Has it any smell now?

MR. JEFFRIES: Objected to as leading.

A. No sir, I never smell anything.

Q. Do you drink it now since the opening of the canal?

A. Why we do drink it sometimes, yes; I used it a good deal this week and when I have been out up the river I
5258 drink it right along.

Q. How does it compare for drinking, with the water before the drainage canal was opened?

MR. JEFFRIES: Objected to.

A. It is a good deal better; I don't see no scum on it now; it is cooler and clearer.

Q. Do you know of any cases of typhoid fever among the fishermen since the opening of the drainage canal?

A. No sir, I do not; there hasn't been none here that I know of and I haven't heard of any.

CROSS-EXAMINATION, By Mr. Jeffries.

Q. Where did you say you lived?

A. Pearl.

Q. Live on a boat or in a house?

A. Boat.

Q. How long have you lived on a boat?

A. About eight years.

Q. You say the water is better now than it was before the canal was opened, you mean by that that there is more volume and current, more water and more current?

A. Yes sir.

5259 Q. How much more current is there?

A. Well, I don't know just how much more, but there is a good deal more than what there was before.

Q. There is a good strong current isn't there?

A. Yes sir.

Q. At all the times of the year?

A. Yes sir.

Q. You don't know whether the water contains any deleterious substances or not do you?

A. No sir, I don't.

Q. You don't know whether it contains anything that is harmful?

A. No sir.

Q. What fish thrive best in this river?

A. Well the carp I believe does.

Q. Do you know what the carp feed on?

A. Oh they feed on pretty near everything; they will eat most anything. With a trot line they will feed on mussels, crawfish and dough-balls; I have catched them on roasting ears, the grains.

Q. Do they feed on flesh, dead meat?

A. No, I don't believe they do. I never caught any with any.

Q. Did you ever try it?

A. I did with beef and never caught any.

5260 Q. How far up does this good current go?

A. Well I guess it goes all the way up as far as I have been since it started in.

Q. Up as far as Hennepin?

A. Peoria, I have been as far as Peoria since it was turned in.

Q. A good current all the way up to Peoria?

A. Yes sir.

Q. About all you know about this water is that there is a stronger current, more water and better fishing?

A. Yes, and I believe it is better water.

Q. Well you just think so?

A. No I don't think so; I know so.

Q. Why do you know it?

A. Well sir, simply because you don't see this scum along here and this stagnated water and you don't smell this gassy smell any more like you used to.

Q. Don't you know that fish die under the ice in winter time in extremely cold weather on any river?

A. Well I have seen them die right here in the summer time on this river.

Q. Well I mean under the ice?

A. Well not if the water is pure, they won't.

Q. Did you ever live on any other rivers?

A. Yes sir.

5261 Q. What rivers?

A. I lived on the Mississippi, the Big Blue and on the Solomon river.

Q. Were you born on the river?

A. No sir, not exactly.

Q. Was your father a fisherman?

A. No sir.

Q. Where did you live on the Mississippi irver?

A. Hamburg.

Q. Hamburg where?

A. Mississippi, down below Louisiana.

Q. You never saw much ice on the Mississippi river?

A. I seen a lot of it that winter running.

Q. You never saw it frozen over though?

A. Yes, I seen it frozen over.

Q. That winter at Hamburg?

A. Yes sir, and I saw it frozen over several times since.

Q. For a very short time though?

A. Yes sir, not very long.

Q. You have never been up on the Mississippi river?

A. Yes sir, as far as Quincy.

Q. Did you ever live at Quincy?

A. No sir, never lived at Quincy.

5262 I have been there.

Q. In the winter-time?

A. Yes sir, I have been there in the winter time.

Q. Did you ever see the ice frozen over there?

A. Yes sir, I saw it frozen over there one winter.

Q. For how long a time?

A. Oh, I don't know. I wasn't there but just a day.

Q. You don't know then that when the Mississippi river above Quincy freezes over until the ice becomes very thick from eighteen inches to two feet thick and continues frozen for some time, that if you cut a hole in the ice the dead fish will come up?

A. No sir, I don't know that.

WESLEY FRISE.

5263 **Pearl, Illinois, July 17, 1903.**

JOHN WILDT,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. John Wildt, I have been in the fish business for quite a while and I live at Pearl, Illinois.

Q. Are you a buyer and shipper of fish?

A. Yes sir.

Q. How long have you been in that business?

A. I have been in the fish business about 18 or 19 years; not steady though; I was off one time for about two years.

Q. Have you been in that business and buying fish caught in the Illinois river?

A. Yes sir.

Q. For how long a time?

A. Fifteen years with the exception I was away two months and a half last winter and I was away four or five months last summer; not regular I wasn't in the fish business regular last summer.

Q. Have you been a fisherman yourself?

A. Yes sir.

Q. On the Illinois river?

A. Yes sir.

5264 Q. What was the condition of the water of the Illinois river before January, 1900?

A. Why I don't know as I could tell you the exact condition of it. Before January, 1900?

Q. In other words before the opening of the drainage canal?

A. Why we had a very slow river, there was no current, no flow and the water would get very stagnant.

Q. How did it smell?

A. Why, it had a very bad smell, gas like.

Q. In buying and shipping fish, did you use ice in packing them?

A. Yes sir.

Q. From where was the ice obtained?

A. From the Illinois river generally; at times of course I would use ice that was shipped in.

Q. Before the opening of the drainage canal, what was the condition of the ice?

A. Oh, I don't know that you could see very much difference in the ice; I couldn't see any difference in the ice at all; I have cut ice and put it up on the river myself whenever we could get ice in the last twelve or fifteen years, and I notice one particular time, I think it was about 1896 or 1897, some time along there, that we had a real good heavy ice, probably fourteen or fifteen inches; I put up ice at Gravel Point 5265 at that time, and also at this place, and I noticed when cutting ice at that time there was a gassy smell where you would open the ice and the water looked as though there was a dark scum on it, and I would see where you would open a hole the fish would be floating by and they would seem very numb like they were dead, and that ice broke up, if I remember right, in February, along the latter part or middle of February, and there was quantities of fish died, smothered under that ice that winter, and they passed over the dam at Kampsville. I remember that the boys got to catching them there with forks and dip-nets; there where the water run over it left a little open place. They would float out over that and they would catch them and they bought them there for New York, and the Commissioner stopped them; they claimed it was unlawful to do that, and stopped them, and after that ice went out you saw catfish all along the edge of the water where they floated up, we used lines on our nets and raised them with a line.

MR. JEFFRIES: I object to the answer and move it be stricken out for the reason that it is not responsive and for the further reason that it is a well known fact that when the ice is frozen upon a stream to the thickness as described by the witness, and remains for the length of time, a considerable length of time, that the fish in the water will die unless there are air-holes or openings, and that frequently when these 5266 air-holes are frozen it is very disastrous to the fish, and therefore such evidence is incompetent, irrelevant and immaterial; and for the further reason there is no evidence showing that such has been the continued and continuous occurrence during the history of the Illinois river.

Q. What has been the condition of the Illinois river since the opening of the canal?

A. There seems to be more current and the water clears up faster after a rain and after a flood.

Q. Is there an odor in the water now since the opening of the canal?

A. I think the water is more clearer now than it was before the opening of the canal.

MR. JEFFRIES: Move to strike the question and answer out, the answer not being responsive to the question.

Q. Is the water fit to be used for drinking since the opening of the drainage canal?

MR. JEFFRIES: Objected to as the witness has not qualified to testify on that point.

A. I drank some of it the other night; I never drink it unless I have to.

5267 CROSS-EXAMINATION, By Mr. Jeffries.

Q. Where did you say you lived?

A. Pearl.

Q. The people here in Pearl have wells or cisterns?

A. Yes sir.

Q. They don't use the water of the Illinois river?

A. Not without they have to.

Q. It is not considered good water by them?

A. Not in the summer season, no.

Q. Do you know whether or not the freezing of the river in the winter time when the ice is frozen 18 inches or two feet thick and continues for some time until the air holes in the ice are frozen over that it will have a bad effect on the fish in any kind of water?

A. I think that it does, yes sir.

Q. Then you couldn't say that this occurrence that you referred to was caused altogether by the water?

A. No, I think—no I don't think it was caused altogether by the water.

Q. There was no current at certain times before the canal was opened?

A. Very little at times.

Q. And there has always been a good current since?

A. Yes sir.

5268 Q. And that is the only reason that you have for believing it?

A. It shows that it is better; it is cleaner; we don't have so much scum.

Q. You don't know whether it contains deleterious matter or not?

A. I don't know a thing about that.

Q. What has become of that scum and green matter?

A. I supposed it is washed out; I don't know; I don't see it any more; I couldn't tell where it went to.

JOHN WILDT.

[illegible]

5269 Pearl, Illinois, July 17, 1903.

JOSEPH HALL,

called as a witness in behalf of the defendants being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Joseph Hall.

Q. What is your business?

A. Fisherman.

Q. Where do you live.

A. Pearl, Illinois.

Q. How long have you lived here?

A. Three years.

Q. Where did you live before coming here?

A. Frederick, Illinois.

Q. Is that on the Illinois river?

A. Yes sir.

Q. Where is it located?

A. Four miles above Beardstown.

Q. How long have you been fishing on the river?

A. Ever since 1881.

Q. Will you describe or tell in your own way the condition of the waters of the Illinois river before the opening of the drainage canal?

5270 A. I think I can.

Q. Well, do so please?

A. Well, in the summer time, when the water would get down pretty low why the water was pretty bad in the Illinois river; it had a green scum on it; but since that drainage canal we don't see that any more, and the water is more pure; we use the water more or less all the time. The water was better last year than I ever saw it on the Illinois river, and take it in the winter time when the water would get low and froze over, why the water would get stagnant. I have cut holes up there at Beardstown seven years ago this winter that the fish died right in the net and cut a hole in the ice and the water smelled so you couldn't hardly stand it. The water was just like there had been coal oil poured in it.

Q. What has been the condition of the water since the opening of the drainage canal?

A. Well sir, it is better than I have seen it for a good many years on the Illinois river.

Q. In what way is it better?

A. Why it is purer, we don't have that gas and no green scum on the river, and it has more current.

5271 Q. Have you seen ice made since the opening of the drainage canal, on the Illinois?

A. Yes sir, make it myself every winter; I put up ice every winter.

Q. When you cut holes through the ice now, how does the condition compare with what existed prior to the opening of the drainage canal?

A. Well sir, there is a big difference.

Q. Tell it.

A. The water is pure and clear; you can see the bottom in five or six feet of water and the water tastes better.

Q. Any gas?

A. No sir, I have never noticed any gas now.

Q. Any dead fish?

A. No sir, no dead fish, except what has been killed by the fishermen; haven't any been killed that I seen, by bad water.

Q. Do you drink the water?

A. Yes sir.

Q. Have you heard of any cases of typhoid fever of people drinking the water?

A. No sir I have not. We use the water all the time in
5272 the winter time, right in the family.

CROSS-EXAMINATION, By Mr. Jeffries.

Q. You live in a boat house?

A. Yes sir.

Q. How long have you lived in a boat house?

A. I have lived in a boat-house for about eleven years.

Q. The only difference between the water now and what it was before the canal was opened, is that there is a stronger current and a larger volume of water?

A. Yes sir, there is a larger current and the water keeps purer.

Q. That is it looks to be purer?

A. It is; a man can tell it when he drinks it.

Q. How much more water is there now than before?

A. Than before?

Q. I mean before the opening of the canal?

A. It has been averaging about sixteen inches here; from sixteen inches to two feet.

Q. What fish do they catch, or what fish thrives best in this water?

A. Why German carp, I think.

Q. Do you know what they feed on?

5273 A. No, I don't.

Q. Do you know what they don't feed on?

A. No, I don't; they seem to feed on crawfish pretty well; they bite well on that.

Q. There is a good current in the river now at all times, is there?

A. Yes sir, there is a good current.

Q. You don't know whether the water contains deleterious matter or not, do you?

A. No, I don't.

Q. Matter that is harmful to the human system?

A. No.

Q. You never had it analyzed?

A. No sir, I never did.

Q. How long have you been fishing you say?

A. Ever since 1881.

Q. How old are you?

A. Forty-eight the 14th day of last March; I was born in 1855.

J. S. HALL.

5274 Pearl, Illinois, July 17, 1903.

GEORGE HOPPLER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. George Hoppler.

Q. Where do you live?

A. Right here in Pearl.

Q. What is your business?

A. Fisherman.

Q. How long have you been a fisherman?

A. Well ever since I was about 16 years old; I am about forty now; forty-one; that's my business, fishing.

Q. Will you describe the Illinois river before the opening of the drainage canal in your own way as to the conditions of the water and its effects upon fish in winter?

A. The water, take it in July and August, it wasn't any good; it had a green scum on it; and in the winter the water would get so stagnated the fish would die; it wasn't fit to drink nor nothing else.

Q. Did the water have a perfume?

A. Well it smelled awful bad and it would get red; the
5275 last part of it you know, when it gets bad, it turns plumb
red. I fished here one winter when we would go and cut our nets out of the hole and there would be fish come up in the hole dead you know; the water was bad.

Q. Was there any oily substance on the water?

A. Yes, kind of looked like coal oil.

Q. Since the opening of the canal describe how, if anything, the water has changed?

A. Oh yes, the water is better in the winter time; when the river is froze over it is better in the winter time than it was before the canal was turned in.

Q. Do you notice any green scum on the water now?

A. No sir.

Q. Any of that coal oil substance?

A. No sir, I think the water is a good deal better and purer.

Q. Do you have any perfume as you did before?

A. No sir.

Q. Have you drank the waters of the Illinois river?

A. Yes sir.

Q. How often?

A. Every winter.

Q. How many people are engaged in the fishing business at this point?

A. Well there is several; about five fishermen at Pearl here.

5276 Q. How many men do they employ?

A. They are just two you know; two partners is all the party and then there is a good many fishes here during the winter time that farms during the summer time.

Q. How does the water taste today, as compared with the water of the Illinois river prior to the opening of the canal?

A. Why I don't know; I haven't drank any lately; but the water looks a good deal better than it did before the canal came in here.

Q. Since the opening of the canal have you noticed any deleterious substances in the water?

A. No sir.

CROSS-EAMINATION, By Mr. Jeffries.

Q. What do you understand by the word deleterious?

A. Oh, I should think it would be stagnated, ain't it?

Q. Well I am asking you?

A. Well, that's what I take it for.

Q. The water is not stagnated now?

A. No sir.

Q. Was it before the opening of the canal?

A. Yes sir.

Q. At certain seasons of the year there was no current?

A. No current.

5277 Q. How is it now?

A. Well, there is a good current now.

Q. In fact a good current?

A. Yes sir.

Q. At all times?

A. Yes.

Q. Do you live on the river?

A. Yes sir.

Q. On a boat?

A. Yes right up here at the bridge.

Q. How long have you lived on a boat?

A. About ten years.

Q. Do you use the water from the river?

A. Yes in the winter time.

Q. Do you always use it from the river?

A. Yes, in the winter time; it gets warm in the summer time and we have to put ice in it.

Q. About the only difference there is in the water now, material difference is caused by the increased flow and increase in volume since the opening of the canal?

A. I think so.

Q. You don't know whether the sewage from Chicago gets down here or not?

A. No.

5278 Q. How is the stage of the water now compared with what it has been the last three years?

A. Well it is lower now than it has been.

Q. And still you have a good current?

A. Yes sir.

GEO. HOPPLER.

Adjourned at 8 p. m. to meet at Naples, Illinois, July 18, 1903, at 8 a. m.

5279 Naples, Illinois, July 18, 1903, 8:00 A. M.

Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

W. H. WATERS,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:—

Q. What is your name, residence and occupation?

A. W. H. Waters; Naples, Scott County, Illinois; my occupation is fish dealer.

Q. How long have you lived at Naples?

A. Twenty-four years.

Q. How long have you been dealing in fish?

A. On and off all the time.

Q. Have you also engaged in the catching of fish by nets?

A. Yes sir.

Q. As an employer or as an actual worker?

A. Why, both at different times.

Q. Has your business made you familiar with the waters of the Illinois river at this point?

A. Yes sir.

Q. To what extent in miles are you acquainted with the
5280 river above and below this point?

A. As far as my fishing goes, about four miles above and about ten miles below; make it about fourteen miles.

Q. If you have engaged any in putting up ice, from the Illinois river state to what extent and during how many years?

A. I have put up ice out of the river on and off for about eight years; on and off, myself; some years out of the river and some years out of the creeks and lakes.

Q. How far is Naples from Kampsville dam?

A. About 38 miles.

Q. How far is it, from Pearl?

A. That would be about 26; somewhere about 26 miles.

Q. How far from Beardstown, up the river?

A. About 25 miles.

Q. How far from LaGrange dam?

A. About thirteen miles.

Q. What was the condition of the Illinois river before January, 1900, when the drainage canal was opened?

A. Well, we had a very low stage of water at times, and in the summer time a little scum would come on, kind of a green scum; which would last probably for two or three weeks.

Q. Do you know whether the fishermen drank the water at that time?

A. Well, not in the warm weather they didn't, but in the early spring and late fall they did. 5281

Q. Prior to the opening of the drainage canal and since, did you have a general acquaintance with the people of this community and especially with those whose business was upon the river?

MR. JEFFRIES: Objected to as leading.

A. Yes, sir, with a good many of them; quite a good many that made a business of fishing and being on the river.

Q. Prior to the opening of the drainage canal, what was the condition of health among the people whose business kept them upon the river?

A. Well, I don't know; there wasn't very much sickness here; it was generally fair.

Q. How with reference to typhoid fever?

A. Well, there wasn't but a very few cases here to my knowledge.

Q. Since the opening of the drainage canal, what has been the condition of health among the same class of people?

A. Well, about the same; I don't notice much difference; that is right around in this vicinity. Of course I ain't much acquainted outside of that. This is a healthy point though.

Q. How about typhoid fever since the opening of the drainage canal?

A. Well, I haven't heard of any around here.

5282 Q. Prior to the opening of the canal what was the condition of the water in the river in the late summer with reference to smell?

A. Well, sir, I noticed no scent, in particular of it; but I noticed a green scum which lasted about two or three weeks, as I said during the extremely hot weather; the river got much lower than it does now at the same time of the year.

Q. What was the condition of the ice here, taken from the river, before the opening of the drainage canal?

A. Well, that varied, even before the canal went in; it was owing to the condition of the river, or the condition what the river was in when it froze up. If the river was muddy when it froze up the ice would naturally have more or less sediment in it; if the water was clear when it froze up, why, the ice would be more clear.

Q. Since the opening of the drainage canal what has been the condition of the water in the river?

A. Well, sir, it has been clearer and purer up to this spring; purer, I say, so far as I have noticed it has been purer; I haven't analyzed it, you understand; it has been clearer and looks better.

Q. What was the condition this spring, this summer?

A. This summer it has been more riller than I have noticed it for years; more muddier at this point than I have noticed it for years. 5283

Q. Are you able to account for that?

A. No, sir, I am not.

Q. Since the opening of the canal has there been any of this scum upon the river that you have spoken of?

A. No, sir, I haven't noticed any.

Q. If you have taken any ice from the river since the opening of the canal, state its condition?

A. Well, sir, the ice was thin, it would only freeze about six inches; but what we got was good clear, pure ice.

Q. Do you remember before the opening of the canal, occasions through the winter when there was some odor in the water where the river was frozen over that affected the fish, and if so, state what you know with reference to it?

MR. JEFFRIES: Objected to as leading.

A. Well, not to my own knowledge; I stay at the boat a good deal and wasn't out and all I know is what I have heard the fishermen say; the river at this point hardly ever freezes over entirely.

Q. As a fish dealer, did you receive complaints about the scent of the fish or the smell of the fish which you sold to people in the country?

MR. JEFFRIES: Objected to as leading.

A. It was more the fish than it was the smell; they com-
5284 plained more about the taste than they did the smell;
claimed that they tasted like coal tar.

Q. When was that?

A. That was, I think, about seven or eight years ago; I am not sure, about seven or eight years ago.

CROSS-EXAMINATION, by Mr. Jeffries.

A. Do you know that they tasted that way?

A. No, not from my own knowledge.

Q. You live here in Naples, do you?

A. Yes, sir.

Q. How large a place is Naples?

A. It is about 400.

Q. The people have wells and cisterns, don't they, that they use the water out of?

A. Yes, sir; wells mostly, sand-pumps; they are not wells; sand pumps.

Q. You have a well at your house?

A. A pump, yes, sir.

Q. How does the flow of the water compare since the opening of the canal with what it was before the canal was opened?

A. I did not quite understand the meaning. The current?

Q. The current?

A. The current has been very sluggish here this year;
that would be on account of the high water in the Missis-
5285 sippi. The current, though, as a general thing, since
the canal was turned in was a little swifter.

Q. The water from the Mississippi backed up this far this last spring, did it?

A. It didn't get quite this far, no, sir; it got within about seven or eight miles of us, I think.

Q. How long did that last; just a short time wasn't it?

A. About two weeks, I think, about ten days or two weeks.

Q. That had no effect on the water here?

A. Yes, sir; of course we didn't have no back water; but we had very little current here; it naturally would have an effect on it.

Q. Outside, then, of this back water from the Mississippi you have had a splendid current since the opening of the canal?

A. Yes, sir; the water has been all right.

Q. What species of fish thrives best in this water?

A. We haven't got any but what thrive well; carp is more abundant than any other fish.

Q. Do you know what the carp feed upon?

A. Why, some kind of vegetation in the bottom, some feeds on green grass, green hay, wheat or anything where it would be overflowed.

Q. Is the river low or high now compared with seasons to what it has been since the opening of the canal?

5286 A. Well, it is about normal now; that is speaking of it since the opening of the canal?

Q. Yes, altogether.

A. Yes, sir.

Q. You say there has been some typhoid fever here in the last several years?

A. There has been some two or three cases, I presume.

Q. I understood you to say that you had made no examination of the water?

A. No, sir.

Q. And you don't know whether it contains deleterious matter or not?

A. No, sir, I couldn't say as to that.

Q. There has been no ice to any great extent, cut here for several years, has there?

A. No, sir, there has been no big amount. Probably 200 tons a year.

Q. And that is mostly cut from the ponds and lakes?

A. Yes, sir; sometimes we would get it out of the river.

W. H. WATERS.

5287 Naples, Illinois, July 18, 1903.

WALLACE HART, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Wallace Hart.

Q. Where do you live?

A. I live in Naples.

Q. How long have you lived in Naples?

A. Thirty years.

Q. What is your business?

A. Well, I am notary public here now and town clerk; I ain't able to work at anything else.

Q. How old a man are you?

A. 69 years old.

Q. How long have you been familiar with the Illinois river?

A. All my life.

Q. You have been on and off the river most of the time?

A. Yes, sir.

Q. Will you describe the condition and quality of the water of the Illinois river before the opening of the drainage canal in January, 1900?

5288 A. Well, I don't know as I could describe it exactly; I never gave it much thought. I know it was low and almost stagnant; there was a green scum on it and a bad smell in the evening, especially in the evening and at night, from the river to my house is probably just a half a block from the river and I noticed that smell.

Q. Did you see any dead fish in the river?

A. Yes, sir, I saw lots of them floating in the river up above here, along the banks of the river; and I have seen them dead up here, big catfish, where I went to fish with a hook and line.

Q. What has been the effect upon the water of the Illinois river of the opening of the drainage canal?

A. Well, there has been more water in the river and it looked clearer and purer to me and I haven't seen any dead fish, scarcely any since.

Q. Any odor?

A. Well, I haven't noticed any. Come to think about it, I haven't noticed any odor since that canal has been turned in.

Q. How does the clearness of the water at present compare with its clearness before the opening of the drainage canal?

A. Well it is a great deal clearer than it was before.

5289 Q. How many people are engaged in the fishing business at this point?

A. I declare I don't know how many.

Q. Approximately?

A. I think there is ten or twelve.

Q. How many people live at this point in river boats?

A. There is an old gentleman lives down here on the bank, mighty near on the river boat; there is a river boat stops here occasionally.

Q. Is there any typhoid fever in this town?

A. Hardly ever hear of a case of typhoid fever, that is, for the last two or three years.

Q. What is the population of Naples?

A. 480, our last census.

Q. Do you know how far Naples is from the mouth of the Illinois river, or Grafton?

A. Well, I don't know exactly; I think it is about 45 miles.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How long have you lived here?

A. Thirty years.

Q. Been fishing for thirty years?

A. No, sir; I have hardly fished any at all, only with a hook and line.

5290 Q. You haven't been out on the river any?

A. No, sir; I live right up just about two-thirds of a block from the river and go along up the river bank there to home, two and three times a day.

Q. There is a much better current now than there was before the canal was opened, isn't there?

A. Yes, sir; a good deal better.

Q. You have a well or a cistern at your home?

A. Yes, sir; I had an open well, but I filled it up and put in a pump.

Q. What they call a sand pump?

A. Yes, sir.

Q. Do you get the waters you use for household and drinking purposes out of this pump?

A. Yes, sir.

Q. The people generally don't drink the water from the Illinois river, do they?

A. Not those that live anyways back from the river don't; but those that lives right on the river probably do.

Q. Those that live in house-boats?

A. Yes, sir.

Q. That is just a supposition of yours; you don't know it personally?

A. No, sir.

5291 Q. About the only change in the water as far as you know is that there is a larger volume of water and a better current now than before the opening of the canal, and for that reason the water doesn't get stagnant?

A. No, the water doesn't become stagnant like it did before and it don't have that smell to it that it did before.

Q. You don't know what the water contains, in the way of deleterious substances?

A. No, sir.

Q. You don't know whether it contains more now than it did before the opening of the canal?

A. No, sir.

Q. Or whether it contains less?

A. No, sir. WALLACE HART.

5292 Naples, Illinois.

WALTER SURRATT, called as a witness in behalf of the defendants, being first duly sworn, was examined in chief by Mr. Todd and testified as follows;

Q. What is your name?

A. Walter Surratt.

Q. Where do you live?

A. Naples.

Q. How long have you lived here?

A. Twenty years.

Q. What is your business?

A. Fisher.

Q. Have you done anything else but fish?

A. Well, no; I am a practical fisherman.

Q. Were you acquainted with the Illinois river before and since the opening of the canal?

A. Yes, sir.

Q. Describe the condition of the Illinois river before the opening of the drainage canal in 1900?

A. Well, it seemed foul and stagnant, and fish wouldn't live in it, and the water was low and the water wasn't pure at all.

Q. Was there any scum on the water?

5293 A. Yes, sir; during the summer season.

Q. Any odor?

MR. JEFFRIES: Objected to as leading.

A. At places there was odor where there was a kind of an eddy or anything there would be an odor.

Q. Did you ever fish through the ice?

A. Yes, sir.

Q. Describe the condition of the water?

A. Well, before the opening of the canal a kind of a substance would form on the net; it was something like grease, and through the summer season the nets wouldn't last any length of time.

Q. How would you fish through the ice?

A. I don't get to understand what you mean.

Q. Would you cut holes through the ice?

A. Yes, sir.

Q. Would the fish live in the nets under the ice?

A. Yes, sir, some of them lived; part of them would die; they didn't seem to be healthy and lively as they have been; we would lose some fish.

Q. Since the opening of the canal, what has been the effect of the waters from the drainage canal upon the waters of the Illinois river at this point?

A. Well, we have a good current; we haven't had none 5294 of the green scum on the water, and the fish seem to live better; we have more fish in the river in my judgment; it fills up the lakes and I believe that it really helps the lakes in purifying because we don't quite have near the moss in the lakes we had, as well as in the river; we have had grass and stuff growing in the river.

Q. How about the quality of the water?

A. It is more pure than it was.

Q. Have you made ice here in the winter before and since the opening of the canal?

A. Yes, sir.

Q. How does the ice at present compare with that before the opening of the canal?

A. Why, the ice is clear; before it would be dark, and a dark substance in it; at places you would get moss in the ice at low water.

Q. In winter do you have this oily substance on the waters that you had before?

A. No, sir, we don't, because I made a remark to my partner, that we never had such water before.

Q. Did you discover any odor under the ice since the opening of the canal?

5295 A. No, sir, I haven't. I fished down here on Clear Lake last winter where it is fed some by the river and we use the lake water some and never noticed the odor; and years before that we fished there, we couldn't use the water on Clear Lake.

Q. Have you had occasion to observe whether fish would live in live-boxes any better since the opening of the drainage canal than they would before?

MR. JEFFRIES: Objected to as leading and immaterial.

A. Yes, sir, they have. Well, last summer I hadn't a trot line in it; but this year I trot-lined and I keep my fish now from four to five days, and years before that several years ago, we would have to dispose of them every other morning or every morning, and then we would lose half of them, and I haven't had any fish to die on me this year.

Q. Have you fished with nets during the last few years?

A. Yes, sir; all the time.

Q. Are you fishing with nets now?

A. No, sir, not now.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Did you have any fish die here last year?

A. No, sir, I wasn't fishing with no trot-lines last year.

5296 Q. This is just the beginning of the hot season, isn't it?

A. Yes, sir.

Q. So, you don't know whether you are going to have fish die on your hands this year or not?

A. Oh, well, fish commence dying on us long before this—years before.

Q. Now, before the canal was opened, you fished right along, did you, all the time?

A. Yes, sir.

Q. What did you do with the fish?

A. I sold them to the markets here.

Q. You sold them to the markets when you knew they were bad fish?

A. Well, years before, what lived I sold here.

Q. Were the fish in the Illinois river before the opening of the canal condemned by the State Board of Health as unhealthy?

A. I don't know.

Q. Not to your knowledge?

A. I didn't understand —

Q. I want to know if the State Board of Health condemned the fish in the Illinois river before the opening of the canal?

A. Not to my knowledge.

Q. Isn't it a fact that the Illinois Fish Commission would re-stock the river with small fish, minnows?

5297 A. Restock this river?

Q. Yes?

A. I don't see what they would re-stock this river for; they would take the minnows and the fish out of here and restock the lakes and ponds.

Q. Then they took the minnows and fish out of this river and re-stocked lakes and ponds before the opening of the canal?

A. Well, I suppose that they took some out of the river.

Q. Well, don't you know that they did?

A. No, sir, I don't know that they did, I suppose.

Q. You sold your fish on the market before the canal was opened?

A. Yes, sir.

Q. The same market that you sell them in now?

A. Well, I sold them to several markets up and down the river.

Q. Both before and after the opening of the canal?

A. Yes, sir.

Q. About the only difference in the Illinois river now, and before the opening of the canal is that there is a stronger current and a greater volume of water, isn't it?

A. Well, at different periods we have got a better current in here and we don't have the stagnated water that we had before. 5298

Q. In fact, you have a good current all the time now?

A. Yes, sir; we have had a good current for the last two years.

Q. Since the opening of the canal?

A. Since the opening of the canal.

Q. Where do you live?

A. I live here at Naples.

Q. Do you have a pump or a well at your house?

A. No, I use the town pump.

Q. You don't drink the water of the Illinois river unless you have to, do you?

A. Yes, sir—well no, I drink it out when I have been fishing.

Q. How long have you been fishing?

A. Well, I have been fishing ten or fifteen years, I guess.

Q. What has become of that green scum that formed on the river?

A. Well, I suppose that the current has taken it out here and gathered up all that moss and stuff and flowed out.

Q. You don't know whether or not the sewage from Chicago comes down here?

A. No, I have never been up there; but I suppose from the reports in the papers that it comes past here.

Q. It comes past here?

A. The water passes here coming out of Chicago.

5299 Q. Now, you don't know whether the water here contains any deleterious matter or not?

A. Well, you will have to explain what that word means.

Q. It means harmful, or anything unwholesome?

A. No, I don't know as it does; I have used right smart of the river water and I have been healthy; when I would be out fishing I have drank it.

Q. That is the only way you have of judging it?

A. Yes, sir, that is the only way I have of judging it.

Q. You drank it before the opening, didn't you?

A. Yes, sir; I drank it before the opening.

W. W. SURRATT.

5300 Naples, Illinois, July 18th, 1903.

JAMES WATERS, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. State your name, residence and occupation?

A. James Waters; Naples, Illinois; fisher.

Q. How long have you resided at Naples?

A. 23 years.

Q. How long have you been a fisherman?

A. Ever since I was big enough to fish; I was about twelve years old when I first commenced to clean fish on the boats.

Q. How far up and down the river from this point have you fished?

A. Well, sir, I have fished as far up as Browning.

Q. How many miles is that?

A. That is 36 miles.

Q. How far below?

A. About ten miles below.

Q. What was the condition of the Illinois river before the opening of the drainage canal?

A. Why, it seemed like it was kind of stagnated; slime
5301 and scum on the water.

Q. Was there any smell in the water?

A. Yes, sir, it smelled like tar to me.

Q. Before the opening of the drainage canal if there were any times when the river was frozen over, you may tell what occurred with reference to the fish and what was the condition of the water as to smell?

A. Well, I know I and my brother was fishing together for some years before the canal was opened; we was raising nets that winter and the fish would drift down against the leads, and in the leads in the nets would be big catfish and white perch; used to get them and they would be dead, you know, on the ice.

Q. How frequently did that occur?

A. Well, that was two straight winters that I know of.

Q. What years, if you remember?

A. Well, I don't hardly remember; it seems like it has been about six or seven years ago.

Q. Before the opening of the canal, what was the effect of the water upon your nets?

A. It was slime, you know; when you would raise the nets, it would be slime on it and you could hardly get it off; it would block in the meshes of the nets, the slime would.

Q. What was the color of that slime?

A. Well, it was kind of greenish.

5302 Q. Would the nets last as long as since the opening of the canal?

MR. JEFFRIES: Objected to as leading.

A. No, sir, I don't think they would.

Q. Since the opening of the canal what has been the condition of the water?

A. It has been more purified than it was before.

Q. In reference to the smell?

A. Why, it don't smell like it did before; in fact, there is no smell to it. I know I drank some of it here about a month ago.

Q. How about the moss?

A. Well, there is no moss that I can see.

Q. Do the fishermen in this community drink the water of the Illinois—did they before the opening of the canal drink the water of the Illinois river?

A. Not much to my knowledge.

Q. Since the opening of the canal do they drink it?

A. Yes, sir.

Q. Among the people who drank the river water before the opening of the canal, was there typhoid fever?

A. Yes, sir, and a good deal of chills, too.

Q. Since the opening of the canal how about typhoid fever and chills?

5303 A. Well, sir, I don't know of any here in town.

Q. Did you engage in putting up ice before the opening of the canal?

A. Yes, sir.

Q. What was the condition of the ice at that time?

A. Why it seemed more like slimy and dirty looking than what it is now.

Q. Since the opening of the canal have you put up some?

A. Yes, sir; put up some every year.

Q. What was its condition?

A. We put up some as fine ice last winter as we ever had.

Q. Since the opening of the canal has the condition of the ice been generally better than before?

A. Yes, sir; I think so. Better than it was last winter.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Where was this ice cut?

A. Up here in the lake.

Q. What lake?

A. Smith Lake.

Q. How large a lake is that?

A. Oh, it must be a mile and a half or two miles long.

Q. How deep is it?

5304 A. Why, I don't know exactly; it is deeper this year than it generally was, or last winter when we generally put up ice. It was so shallow in there we couldn't put up ice before the canal came in.

Q. Does that lake empty into the river?

A. Yes, sir.

Q. It is stagnant water, is it, still water?

A. Why, yes, it was; I don't know what it is now. I haven't been up there this summer.

Q. It was last winter?

A. Well, I couldn't say that it was.

Q. How long did you say you have been fishing?

A. I have fished all my life, ever since I was big enough to.

Q. How old are you?

A. Thirty-three.

Q. Your father was a fisherman?

A. Yes, sir.

Q. Where do you live?

A. I live here in Naples.

Q. In a house boat?

A. No, sir; I live in a house back from the river one block.

Q. Do you have a pump or well or what?

A. Pump.

Q. Get the water out of the ground?

5305 A. Yes, sir.

Q. You use the water from this pump for household and drinking purposes?

A. Yes, sir.

Q. You never drink the water from the river unless you are out upon it and can't get any other?

A. Oh, no; no, sir.

Q. The people here don't use the water for domestic purposes—the water from the river?

A. No, sir, not that I know of.

Q. Now, before the canal was opened, the fish from the Illinois river had not been condemned by the State Board of Health, had they?

A. I couldn't say whether they had or not.

Q. You sold them in the same market that you sell now, didn't you?

A. Yes, sir.

Q. There were no objections at that time that they were bad fish, that you sold?

A. Why, no, sir; not that I remember.

Q. Now, as a matter of fact there are always more or less dead fish floating in the river in the winter time because they don't decay as rapidly in the winter time as they do in the summer?

5306 A. Well, I have never seen them like that before or since.

Q. That was one particular winter?

A. Two winters.

Q. But it was not a continuous thing every winter before the canal was opened?

A. No, sir.

Q. You have seen some fish dead in the winter time since the canal was opened?

A. I couldn't say as I have.

Q. What fish thrive best in this river?

A. German carp.

Q. Do carp feed on manure—

A. I don't know; most anything, I guess.

Q. You don't know whether this water contains substances that are unwholesome or not?

A. I don't know what you mean by that.

Q. Substances that would be harmful to the health by continuous use of the water for domestic purposes?

A. I don't think it does, because I have used it in the winter time, when I am out fishing, and I have drank it when I was not working, and it has never hurt me.

Q. You just judge altogether by your own experience?

A. Well, I know of other fishermen being out the same way.

5307 Q. There is a much better current now than there was before the opening of the canal?

A. More current, yes, sir.

Q. There is a much better current now than there was before the opening of the canal?

A. Yes, sir, there is more current.

Q. There is no time of the year in which there is no current?

A. Why, no.

Q. Except from back water?

A. Back water; sometimes there is a great deal more you know, than there is at other times.

Q. Now, do you mean more back-water or more current?

A. More current.

JAMES WATERS.

5308 Naples, Illinois, July 18, 1903.

BENJAMIN FRANKLIN ECKLES, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. Well, sir, my name is Benjamin Franklin Eckles; my occupation in my former life has been farming, and it is yet a little.

Q. Where do you live?

A. I live in the corporation of the town of Naples; have for about fifteen years; I used to farm before.

Q. How long have you lived upon the Illinois river?

A. Well, about fifteen years. Part of that fifteen years, four years, I have lived within eight feet of the bank of the river, and that is where I live now.

Q. How long have you lived in this vicinity and in the vicinity of the Illinois river?

A. Well, sir, I call it I lived in the vicinity ever since 1846. I just lived off a little from Naples, but I call it the vicinity of the river.

5309 Q. Have you fished and hunted upon the Illinois river since you have lived in its vicinity?

A. I have never fished any only with a pole, hook and line; I have done a good deal of that.

Q. What was the condition of the Illinois river water, before the opening of the drainage canal?

A. What do you mean, clearness?

Q. Yes, color?

A. Well, I don't know as I could tell you what the condition was. Whenever we had a little rain it was muddy and whenever we had a long dry spell it was clear.

Q. Was there a moss or scum formed in it in low water?

A. Why, yes, there was considerable of that, and even grass; but that was years ago; I have seen grass grow green in the river, but that is a good while ago.

Q. Was there sometimes a smell to the water?

MR. JEFFRIES: Objected to as leading.

A. Yes, sir, there was a smell to the water in warm weather.

Q. Before the opening of the canal, in your fishing excursions, did you drink the water of the river?

A. Well, I don't think I did.

Q. Since the opening of the canal what has been the condition of the water?

A. Well, since the opening of the canal I pronounce the
5310 water clearer, purer, brighter and better, and use it
stronger for all the uses than I did before, a good deal. The last four years I lived on the river and I have used that river water a good deal for all purposes. In right warm weather I don't use it for drinking purposes, but cool weather I do.

Cool weather I use it for drinking purposes, cooking and everything.

Q. How many people in your family?

A. Just myself.

Q. Do you know of other people here who have used the river water since the opening of the canal?

A. Well, I don't know that I do; they have splendid pumps here and it would be more trouble to go down to the river and get the water, more trouble than it would be to pump it at the house.

Q. How deep are the sand pump wells here?

A. Well, they vary a little from twenty to thirty feet on an average mostly.

Q. And of course they are at various distances from the river?

A. Yes, sir.

Q. Have you ever suffered from any disease caused by the drinking of the river water?

MR. JEFFRIES: I object to the question, as the witness has not qualified to determine or to say whether any particular disease comes from drinking the water.

5311 A. Not that I know of, sir; I enjoy very good health for a man of my age.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How old are you?

A. I am 69 years old; going on 70.

Q. You are not a married man?

A. No, sir; I am a widower. I lived to be that old and never enjoyed married life but eight years; been single all my life except eight years.

Q. You do your own cooking?

A. Yes, sir.

Q. You never made fishing your business?

A. No, sir.

Q. You say they have a better current now than they did before the drainage canal was opened?

A. To my knowledge they do; I have crossed the river a good deal in boats, in skiffs, and they beat me down now a great deal worse than they did before.

BENJAMIN F. ECKLES.

5312 Continuation at Meredosia, Illinois,, July 18, 1903.

JOHN CHRISMAN WORKMAN, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd testified as follows:

Q. What is your name?

A. John Chrisman Workman.

Q. Where do you live, Mr. Workman?

A. I live in Meredosia, Morgan county, Illinois.

Q. How long have you lived here?

A. I have lived here eight years the 14th day of last February.

Q. What is your business?

A. I am a fisherman.

Q. How long have you been a fisherman?

A. Well, sir, I have been a fisherman about—I have been working at the business for about 20 years; that is, I haven't been a fisherman myself, but I have been on the river that long.

Q. What kind of a fisherman are you, a net fisherman or rod and line?

A. I am a net fisherman; net and seine.

5313 Q. Will you describe the condition of the Illinois river at this point before the opening of the drainage canal as to the color of the water, character of the water, stagnancy of the water and other characteristics of the water, such as you may have observed?

A. Well, as I said before, that is going to be a hard question to answer; sometimes it is muddy and sometimes it is clear, stagnant, and so on.

Q. Before the opening of the canal I wanted?

A. Well, that is about the best I could give it.

Q. Was there any green scum upon it?

MR. JEFFRIES: Objected to as leading.

A. Well, at times of the year there is green scum upon it. It comes from vegetation as much as anything else.

MR. JEFFRIES: Answer objected to because it is not responsive.

Q. Was there any odor to the water before the opening of the canal?

MR. JEFFRIES: Objected to as leading.

A. At certain times of the year it would smell bad along the river, the same as it does now; it will do that now; it does that along here now sometimes; it is bound to do that whenever the water gets low, more or less.

Q. Have you had low water here since the drainage canal was turned in, in 1900?

5314 A. Yes, sir; we had low water here two years ago; two years ago this fall that the water was so low; it seems to me it was either two or three years ago, the water got so low; that it dried up in those little lakes up here.

Q. That would be before the opening of the drainage canal?

A. That would be in the fall of 1900, wouldn't it?

Q. 1899, wouldn't?

A. This coming fall will be three years since we had low water.

Q. How low was the water then?

A. Well, I couldn't tell just how low it was then; you can tell that by going out on the bridge; they have got the books out here on the bridge. I have forgotten myself; I didn't know that I would ever need to know it.

Q. Do you know whether that was before or since the opening of the drainage canal, January 17th, 1900, that you had that low water?

A. No, I don't know.

Q. Have you observed any smell on the waters of the Illinois river since that low water that you speak of?

MR. JEFFRIES: Objected to as leading.

A. Why, just as I told you a while ago, you know; I told you it would be that way again whenever the water got low, and the water got down off the banks, it is bound to smell, that's all.

5315 Q. Have you had a low water since that low water that you spoke of?

A. No, sir.

Q. Since that low water that you spoke of have you observed any smell?

MR. JEFFRIES: Objected to as leading.

A. Well, of course there is a smell along the river here now; pretty bad, too; but on account of these mussels, though.

Q. I am not speaking about that or a dead horse; I am speaking about the water. You spoke of a smell before the drainage canal.

A. No, I don't think I have.

Q. What in you opinion has been the effect upon the quality of the water in the Illinois river at this point by the opening of the drainage canal in January 17th, 1900?

A. Well, I think it has a tendency to make the water purer, that is, you understand when the water is low; at this time of the year when the water is high, of course it don't do that, because it is bound to be muddy anyway when the water is high, but that is because it comes from the rains, whenever it is muddy, but as far as the canal is concerned, I think it has a tendency to purify the water at this point. That has always been my argument anyway.

5316 CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say you are a fisherman?

A. Yes, sir.

Q. Where did you say you lived?

A. I live right here in town.

Q. Do you live in a house or a boat?

A. I board at the hotel.

Q. Do you have a well or a cistern at your house?

A. We have a well at the hotel where I board. I don't pretend to have a house of my own.

Q. You are not a married man?

A. No, sir.

Q. How long did you say you have been fishing here?

A. I have been fishing ever since I came here, that has been about eight years.

Q. What is the difference between the water now and what it was before the canal was opened?

A. Well, as I told you a little while ago; that is a pretty hard question; it is pretty hard to remember back that far; at a certain time of the year the water is clear and at other times it is muddy.

Q. And that was true before the canal was opened?

A. Yes, sir.

5317 Q. You say the water smells now as well as it did before the canal was opened?

A. I didn't say it did now, I say it would when the water got down low.

Q. It isn't quite low enough yet?

A. No, sir.

Q. You don't know whether the water contains deleterious matter or not?

A. No, sir, I don't.

Q. Do you drink the water?

A. We don't drink it now; we do if it is necessary, but of course we take water with us when we get away.

his
JOHN CHRISTMAN X WORKMAN.
mark
F. S. B., Com'r.

5318 Meredosia, Illinois, July 18, 1903.

JULIAN L. GRAHAM, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Julian L. Graham.

Q. What is your business?

A. Fisherman.

Q. Where do you live, Mr. Graham?

A. Meredosia.

Q. How long have you been a fisherman?

A. About four years, that is engaged actively about four years and previous to that about fifteen.

Q. Married man?

A. Single.

Q. Will you describe the condition of the Illinois river before the opening of the drainage canal in 1900?

A. Yes, sir; in 1900 the water was very foul; very low, and navigation was almost impossible at times; since the opening of the canal it has been different.

Q. Was there any odor connected with the water?

A. At that time, yes, sir.

5319 Q. To what extent?

A. Well, it has been so low and it has been so foul that it was almost impossible to go in bathing.

Q. Was there any scum on the water

A. Yes, sir.

Q. To what extent?

A. Well, it has been to such an extent that a person could hardly pull through it at times with a boat, that is during August at this point here, the scum would get on the oars and pull them down.

Q. Since the opening of the canal have you had any low water?

A. No, sir.

Q. What has been the effect on the waters of the Illinois river at this point, of the opening of the drainage canal?

A. Best in the world.

Q. In what way?

A. For navigation, sanitary considerations and everything else in that line; there has been no smell since, if we have a rise after a couple of days it takes off the vegetable matter; a good stage of water for steamboats; couldn't have been better.

Q. Have you seen any scum on the water since the opening of the drainage canal?

MR. JEFFRIES: Objected to as leading.

A. No, sir.

5320 Q. What has been the effect upon the water itself?

A. Well I believe that it has purified it to a great extent, during both winter and summer.

Q. How has it affected your nets?

A. Not a particle.

Q. Before the opening of the canal, was there any scum upon the nets in these waters?

A. Yes, sir.

Q. How about since the opening of the canal?

A. Well, I don't know as I see very much difference, only it has been an improvement; I don't think I see as much slime and stuff accumulate on the web; I don't believe there are.

Q. About how many people are engaged in the fish business at this place ?

A. Well, I suppose there would be about eighty or ninety, somewhere along there; perhaps more.

Q. Since the opening of the canal do you know of any typhoid fever among the fishermen?

A. No, sir.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How long did you say you have lived here in Meredosia?

A. Lived here since 1873; born and raised here.

5321 Q. Fished all that time?

A. No, sir; for the last four years I have been fishing; I have been in the fishing business 19 years; only the last four years I have been running a seine and fishing.

Q. You are not a married man, are you?

A. Single.

Q. Are you boarding at the same hotel that this other witness is boarding at?

A. Yes, sir.

Q. How far up the river do you fish?

A. Why, about six miles.

Q. How far down?

A. About six.

Q. There is a better current in the river now than there was before the canal was opened?

A. I think so.

Q. You never see any more green scum at all?

A. Not a particle; of course we see the green, but we don't see the scum.

Q. What is it?

A. The scum is the decayed vegetable matter, but the other is the buds of buck-brush floating down; but of course there is other trees, maples and stuff like that, that put it in the water; you get a good current, it passes it through.

5322 Q. That is simply your opinion of the matter?

A. Yes, sir.

Q. What fish thrives the best in this water?

A. Carp.

Q. Do you know what the carp feeds upon?

A. Yes, sir.

Q. State it?

A. They feed upon willow flies, gnats, and of course the parasites in the water and the grasses on the bank the scum and such stuff as that.

Q. And they feed on other things, too, don't they?

A. I suppose they do; I don't know.

Q. Well, we want you to give it?

A. Well, I have forgotten it.

Q. Do they eat manure?

A. I don't know.

Q. Don't you know that they do?

A. I don't know that they do; I think that is their principal food, though.

Q. What kind of manure, all kinds?

A. Any kind and all kinds.

RE-DIRECT EXAMINATION, by Mr. Todd.

Q. Any other fish that thrive here besides carp?

A. Yes, sir.

5323 Q. That flourish here?

A. Yes, sir. Well, the carp of course is the principal fish that thrive. Buffalo thrive, but they can't very well do it; the carp is the only fish that flourish, and the only fish from a financial standpoint, for the fishermen. The others doesn't amount to a continental from a financial standpoint.

Q. The carp is the billy-goat of the water is it?

A. Yes, sir.

JULIAN L. GRAHAM.

5324 Meredosia, Ill., July 18, 1903.

GEORGE S. LEWIS, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows?

Q. What is your name?

A. George S. Lewis.

Q. What is your business?

A. Hotel man.

Q. Where do you live?

A. Up on Main street in Meredosia.

Q. How long have you lived here?

A. Six years last March.

Q. Have you been on the Illinois river since you have been living here?

A. Yes, sir; spent a good deal of my time on the river.

Q. Did you know the character and condition of the water before the opening of the drainage canal in the Illinois river?

A. I was here during the low water; the lowest water we had, I was fishing a good deal that year. There was a good deal of bass fishing next to the bridge here.

5325 Q. When was that?

A. That was 1898 or 1899, I don't know which.

Q. What was the appearance and character of the Illinois river water before the drainage canal was opened?

A. The water was low here and the current was dead; we didn't seem to have much current during the right low water.

Q. Was there any scum on the water?

A. Well I didn't notice—next to the bank there was a scum and it seemed kind of stagnant.

Q. What effect has the opening of the drainage canal had on the water of the Illinois river at this point in your judgment?

A. Well it has made the water clear, and it has made it lower temperature, the water is cooler. I noticed it more in my fish that I use here. My fish are better than they were before. I use a good many fish at the hotel. I find my fish are a good deal better quality than they were before this water was turned in here.

Q. How about the quality of the water itself?

A. Well, you mean the pureness of it?

Q. Yes?

A. Well I judge the water is purer now than it was before this water was turned in; if it wasn't it wouldn't be so much cooler than it is; I noticed it more in the temperature of the water than anything else.

5326 Q. Has there been any typhoid fever here since the opening of the canal that you have heard of?

A. No, I have not heard of any; I don't pay no attention to things of that kind; we have had no sickness of the kind at our place.

Q. Has there been any smell on the water since the opening of the canal?

A. No, I haven't noticed any.

CROSS-EXAMINATION, By Mr. Jeffries.

Q. You say you are not a fisherman?

A. Only a line fisherman; I am on the river a good deal and do a good deal of hook and line fishing.

Q. You say you are in the hotel business?

A. Yes sir.

Q. How long have you been in that business?

A. Six years; six years last March.

Q. Have you a well or cistern?

A. We have a drove well.

Q. And you use the water from that well?

A. Yes sir.

Q. You don't use the water of the Illinois river here?

5327 A. No sir, we never use it. Our waters here are all filtered through the sand. Our wells run all the way from 24 to 36 feet; that far they are bored. They use that water and don't use the river water.

Q. What is the reputation of this river water for drinking and domestic purposes?

A. Well, I don't know as they ever use it here for domestic purposes; not when they have the other water, anyway.

Q. You don't know whether it contains any deleterious substances or not?

A. No sir, I do not.

Q. The fish that were caught here before the canal was opened, were sold on the open market were they not?

A. Yes sir.

Q. They had never been condemned by the State Board of Health?

A. Not that I know of; I couldn't say as to that.

Q. What is the difference between the flow of the water now and what it was prior to the opening of the Chicago drainage canal?

A. Why there is more current in the river.

Q. Considerably more?

A. Yes, considerably more current.

Q. Now you spoke of the water being more clear now than it was before it was opened; what you mean by that was that it had no scum on it, while before it did have?

5328 A. There was some scum on it on account of the water being low and stagnant.

Q. Then remove that scum and the water would be clear, wouldn't it?

A. I don't know that the water was clearer underneath; I never paid much attention to that.

Q. At that time, clearer than it is now, wasn't it?

A. Well I suppose it was; it was more stagnant then; there wasn't much current. All I was going by, it seems purer now than then; I noticed the fish more than anything else.

GEO. S. LEWIS.

5329 Meredosia, Illinois, July 18, 1903.

WILLIAM HAUSER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. William Hauser.

Q. Where do you live Mr. Hauser?

A. Meredosia.

Q. What is your business?

A. Ferry; run this ferry sixteen or seventeen years.

Q. What kind of a ferry?

A. Cable ferry.

Q. That consists of a flatboat, a cable stretched from point to point, that you pull people across with?

A. Yes sir.

Q. You operate it yourself, do you?

A. Yes sir; I have a man that works with me, that helps me.

Q. Will you state the condition of the Illinois river before the opening of the drainage canal at this point?

A. Well before the canal was opened, of course different times, of the year, in the fall of the year that we had a 5330 right smart of stagnant water; but since the canal has come in here our water has been more pure than it was before. And in the fall of the year why lots of times we drink the water when it gets colder and I find that since the canal was in it is better to drink than it was before; I call it a kind of a grit, that makes it taste better than it did before.

Q. Before the canal was opened was there any green scum on the water?

A. Yes sir, especially in the fall of the year.

Q. Has that disappeared?

A. Yes sir.

Q. Have you known of any typhoid fever here since the opening of the canal?

A. No sir. Now before this canal, about three years before this canal was opened up, I took a scythe and mowed the weeds across the river so I could get through with my ferryboat; moss and weeds; some call them water grass; I mowed it with a scythe to get it out of the way so I could get through them all right. Since the canal has been through here I haven't had any trouble with them; I could get through it all right.

CROSS-EXAMINATION, By Mr. Jeffries.

Q. How long have you lived here?

A. I was born and raised here, about 47 years.

5331 Q. When you spoke of mowing the weeds, that was an exceedingly dry season, was it not?

A. It was in the fall of the year when the water would be down. I have seen it here year after year, right along.

Q. But you didn't mow it for two or three years prior to the opening of the canal?

A. I haven't mowed it in the last five years.

Q. In fact you haven't mowed it in the last seven years, you said a moment ago?

A. I am positive I haven't mowed it in the last five years. It might have been six years or seven, but it has been five years anyhow, since I mowed it.

Q. There is more current in the channel now?

A. Oh yes, we have got more current now than we had before.

Q. How much more?

A. A whole lot more current.

WM. HAUSER.

5332 Meredosia, Ill., July 18, 1903.

REV. R. G. LINKER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. R. G. Linker.

Q. What is your business?

A. Minister of the Gospel.

Q. Connected with what church?

A. Evangelical Lutheran.

Q. How long have you lived in Meredosia?

A. I have been a preacher in Meredosia, now six years, lived here five years.

Q. How large is your congregation?

A. Well I suppose we have 65 members; I have two congregations; I have one out in the country besides the one here.

Q. You lived here before the opening of the drainage canal, did you not?

A. Yes sir.

Q. Have you had occasion to observe the water of the Illinois river before and since the opening of the drainage canal?

A. Yes sir, I have.

5333 Q. What was the character of the water of the Illinois river before the water of Lake Michigan was turned into the Illinois river.

A. Well, that is a question I can hardly positively answer; because while I live here I have not watched it, although I might say this, that when the river was low, the water didn't seem to be as good as now.

Q. Did you notice any odor from the water before the opening of the canal?

A. Well as far as that is concerned, I have observed some odor, but I wouldn't be positive about it that it came from the river, because I know when the water was low, before the canal was opened I have observed an odor or rather an offensive smell.

Q. What has been the effect of the opening of the canal in your judgment, upon the water at this point?

A. Well my judgment—that is my opinion?

Q. Yes?

A. That the water has been further better.

Q. Has there been any typhoid fever among the members of your congregation in the last three years?

A. Not that I know of.

Q. Has any body connected with your congregation died with typhoid fever in the last three years?

5334 A. No sir.

CROSS-EXAMINATION, By Mr. Jeffries.

Q. The people in Meredosia drink the water from their wells and cisterns, do they not?

A. We drink water from what we call drive wells, that is, we drive a pipe down until we get to quicksand, to the water, and that is the water we drink.

Q. They don't use the water of the Illinois river for domestic and drinking purposes?

A. Why no.

Q. When you say the water is better now than it was before the canal was opened, you make that statement simply as your judgment from the appearance of the water alone?

A. Yes sir; I make it from observation, from the appearance.

Q. You don't know whether the sewage from Chicago affects the water here or not?

A. In what respect?

Q. Well, in the way of rendering it unwholesome?

A. I don't know anything about that.

Q. You don't know whether the water is more unwholesome now than it was before the opening of the canal, from a sanitary standpoint?

5335 A. Well that, you know we can't tell; we only know by observation that the water is clearer.

Q. Did you ever remove any of the scum from this water?

A. I have never been on the river, never had any occasion to.

Q. You have never been on the river?

A. I have crossed the river on the ferry.

Q. Did you observe the water underneath the scum?

A. No.

Q. You don't know whether it was clear or not?

A. No, because I never examined it; I couldn't give you any testimony on that because I never examined it.

R. G. LINKER.

5336 Meredosia, Illinois, July 18th, 1903.

A. J. LESLIE, called as a witness in behaf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. A. J. Leslie.

Q. What is your business?

A. Dealer in grain.

Q. Where do you live?

A. In Meredosia.

Q. How long have you lived here?

A. Nearly thirty years.

Q. How near to the river do you do business?

A. Here 100 yards.

Q. Have you been on the river here during the last five or ten years?

A. Yes, sir.

Q. How much?

A. Why, I am down to the river or on the river every day.

Q. What was the condition of the river before the opening of the drainage canal?

A. Why, in the summer time in low water there was a green scum all over it; a sluggish current; I suppose you

5337 would call it a green scum.

Q. Any odor to the river?

A. There was, yes.

Q. What kind?

A. Well, that was something that was peculiar to stagnant water; I don't know how you would explain it.

Q. What has been the effect of the opening of the drainage canal on the waters of the Illinois river at this point?

A. Well, I have never noticed any more of that green scum; the water appears to be clearer and purer and a better current, keeps it clearer and the scum don't accumulate.

Q. Has it the same odor that it had before the opening of the drainage canal?

A. I haven't noticed any odor particularly for two or three years.

Q. Have you known of any typhoid fever being in Meredosia since the opening of the drainage canal?

A. I have not.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say there was a green scum formed on the water prior to the opening of the canal?

A. Yes, sir.

5338 Q. Now, after that scum was removed the water would be clear?

A. As to the scum?

Q. Underneath the scum it was clear?

A. No, not so very, on account I suppose it was more stagnant and not as much current; naturally the water is not as clear.

Q. Are you a man of family?

A. Yes, sir.

Q. You live here in Meredosia?

A. Yes, sir.

Q. You have a pump or a well at your house?

A. Pump.

Q. You use the water from that pump for domestic and drinking purposes?

A. Yes, sir.

Q. You don't use the water from the Illinois river for domestic and drinking purposes?

A. No.

Q. They cut the ice that they get in the winter time from Meredosia lake, don't they?

A. Sometimes, and sometimes from the river.

Q. Mostly from the lake?

A. Yes, sir.

5339 Q. You don't know whether the sewage from Chicago comes down here or not?

A. No, sir, I don't know anything about that.

Q. You don't drink the water from the river?

A. No, sir.

Q. The people generally around here don't drink it, do they?

A. No.

A. J. LESLIE.

5340

Meredosia, Illinois, July 18, 1903.

F. A. NEVILLE, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. F. A. Neville.

Q. What is your business?

A. I practice medicine, physician and surgeon.

Q. How long have you been practicing medicine in Meredosia?

A. Sixteen years.

Q. During the time that you have practiced medicine here, have you had occasion to become acquainted with the Illinois river?

A. Yes, sir, some little.

Q. What was the character of the water of the Illinois river prior to the opening of the drainage canal?

A. Well, it would depend a good deal on the season of the year. In the fall the water would become rather stagnant and green of a pea green color and a good deal of organic material in the water and floating.

Q. Was there any current in the water to speak of?

A. Very little.

5341 Q. What in your opinion has been the effect of the opening of the drainage canal and the turning of the water into the Illinois river?

A. I believe it has improved the character of the water.

Q. In what way?

A. Well, the water is more clear and there is less organic material in the water; at least I would judge so from appearances.

Q. In your practice, doctor, does it extend among the fishermen as well as other people?

A. Yes, sir.

Q. About how many men are engaged here in the fishing industry?

A. Well, that is pretty hard to state, but I can say between fifty and a hundred; I couldn't state just exactly the number. There is some over fifty, and I think probably less than 100.

Q. Have you had any typhoid fever cases during the last three years among the fishermen?

A. No, sir.

Q. How many cases of typhoid fever have you had in the last three years, in Meredosia?

A. Not to exceed a half a dozen.

Q. Was any of those cases attributed to the waters of the Illinois river?

5342 MR. JEFFRIES: I object to the question because the witness has not qualified as competent to pass on that question.

A. No, sir.

Q. The cases which you treated, what was done with the excreta?

MR. JEFFRIES: Objected to as immaterial.

A. The excreta was disinfected, and some of it dumped in sink basins and others dug holes; at least that was what I ordered done; I don't know whether the orders were carried out or not.

Q. What is the population of Meredosia?

A. About eight hundred.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You don't use the water of the Illinois river for domestic and drinking purposes, do you?

A. No, sir.

Q. And the people in town don't use it?

A. No, sir.

Q. It is not used for that purpose among any of these patients who were afflicted with typhoid fever that you treated?

A. No, sir, I believe not.

Q. So far as you know?

A. So far as I know, it was not.

5343 Q. When you say the water is clearer, you don't make that statement on any analysis that you have made of the water, but simply from the appearance?

A. That's all.

Q. Then as I understand it you know nothing about the water other than from appearance and the fact that there is a stronger current and a larger volume of water than there was prior to the opening of the canal?

A. Yes, sir, that is all.

F. A. NEVILLE, M. D.

5344 Meredosia, Illinois, July 18, 1903.

S. D. ALLEN, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. S. D. Allen.

Q. Where do you live, Mr. Allen?

A. I live here in Meredosia.

Q. How long have you lived here?

A. About twenty-five years.

Q. What is your business?

A. Pumping here for the Wabash Railway Company.

Q. Pumping what?

A. Water.

Q. Into what?

A. Into the tank.

Q. From where do you pump the water?

A. Out of the Illinois river.

Q. What did you do before you went into the employ of the Wabash Railroad pumping water?

A. I was working here on the bridge before I went pumping water.

Q. When did you begin pumping water, how long ago?

A. About 1896, I think it was.

5345 Q. Before that time how long had you been on the bridge?

A. I had been there about four years.

Q. You are pretty familiar with the Illinois river water then, are you?

A. I suppose I am; I lived here about 25 years and lived about the river all the time.

Q. What was the condition of the Illinois river before the opening of the drainage canal?

A. You mean the water?

Q. The water?

A. At low water it was pretty filthy in my estimation.

Q. What was its appearance?

A. Well, do you want to know what condition the water was in?

Q. Yes.

A. Well, there was a green scum on the river, and there was grass growed all up in the water here and a sediment in the river, that is it went down and left all the filth on the ground outside; that is the water went down and left it, and it was a pretty bad stench here, as soon as the water went down and left it.

Q. How did the water act on the boilers?

A. Well, it was pretty bad on the boilers before the drainage canal.

Q. Well, describe how it acted?

5346 A. Well, the water foamed, for one thing; you understand that. You people, I guess, the foaming business.

Q. What effect has the water of the drainage canal had on the Illinois river at this point?

A. You mean what effect it has had on the health of people?

Q. On the water?

A. It has been a benefit.

Q. In what way?

A. Why, the water has been purer; we have used it for drinking purposes on the bridge right along when it was cold enough to use it.

Q. Is there any odor to it?

A. Not any that I could discern.

Q. Have you seen any of that scum on it since the opening of the canal?

A. No, sir.

Q. What effect has it had on the water for steam making purposes?

A. Well, it has been better.

Q. In what way?

A. Well, it hasn't foamed and it hasn't lined the boiler as bad.

5347 Q. Have you drank the waters of the Illinois river since the opening of the canal?

A. Yes, sir.

Q. How often?

A. Why, we drink it all the time there on the bridge when it is cool enough to drink, every day.

Q. How many of you are there on the bridge?

A. Well, there are three of us; that is I help them part of the time; I ain't there steady all the time, but then I help them part of the time.

Q. Has the drinking of the water of the Illinois river made any of you people sick that you know of?

A. Not that I know of.

Q. Did you ever drink the water before the opening of the canal?

A. Yes, sir.

Q. How does the water since the opening of the canal compare with the water before the opening for drinking purposes?

A. Well, it is better.

Q. In what way?

A. Why, it hasn't got that gas or stench to it that it had before; it is more clear and it is purer, I think.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Are you a man of family?

5348 A. Yes sir.

Q. You live here at Meredosia?

A. I do.

Q. Have you got a well or a pump at your home?

A. I have got a pump, yes sir.

Q. You use the water from the pump for domestic and drinking purposes at home, do you?

A. Yes sir.

Q. You don't use the water from the Illinois river?

A. No sir.

Q. You say the water from the river when put into the boiler foamed?

A. Yes sir.

Q. You don't know that was caused by the water, might it not have been from some other cause?

A. I don't know hardly any other cause it could have been; it never did that before.

Q. How often did it do that?

A. Well, quite frequently before the canal was turned in.

Q. There is a much stronger current now than there was?

A. Yes sir.

Q. In fact before there was no current?

A. Oh well, there was some current of course when the
river was any stage; of course before the canal there
5349 wasn't much current, not near so much as there is now.

Q. You don't know whether the water contains deleterious matter now or not, do you?

A. Well I ain't no expert; I don't know everything: I ain't no analyzer or anything of that kind; I ain't done any of that kind of business.

Q. On account of the increased volume of water and better current, you think the water is better?

A. Yes sir.

Q. Does the water ever foam in your boilers now?

A. No sir.

Q. It never does?

A. No sir.

RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. Is that the only reason you think it is better, because there is a better channel, a better current?

A. Why no, I think it is because the water of Lake Michigan is purer than the water in this river.

RE-CROSS-EXAMINATION,
By Mr. Jeffries.

Q. You don't know what effect the Chicago sewage has on the water though?

5350 A. Well that is just as I told you before; I ain't no analyzer or anything of that kind; I don't know anything about that business.

Q. You are not considering that at all?

A. I do know one thing, that is I believe,—well I know it that the water is better here now than it was before.

S. D. ALLEN.

5351 Meredosia, Illinois, July 18, 1903.

J. P. BAUR,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. J. P. Baur.

Q. What is your business?

A. Well sir, I am a fish culturist in the employ of the United States Fish Commission; but I am at present in charge of the station at this point, of the United States Fish Commission, at Meredosia.

Q. How long have you been employed here in that position?

A. About fourteen years.

Q. What are the duties of that position?

A. Well I look after the collection and loading of the United States Fish Commission cars; that practically would be all. I have charge of the crew here, that is all.

Q. How many men compose the crew?

A. Seven not including myself.

Q. How long have you occupied your present position?

A. Twenty years; that is I have been in the employ of the Commission for twenty years; fourteen years at this town.

5352 Q. Did your duties in your present employment, give you an opportunity to become acquainted with the Illinois river?

A. Yes sir.

Q. To what extent?

A. Up to five or six years ago. I don't know just which, I had charge of the steamer Lotus in making the collection of fish for distribution, for the United States Fish Commission; this boat took its place in the work, but I never had anything to do with this boat (The Illinois).

Q. How much of the river did you become acquainted with?

A. From La Salle to Grafton.

Q. When did you cease your connection with the Lotus and become permanently located at this point?

A. About five or six years ago; I can't remember just now; I would know, but I have my book at home.

Q. How many varieties of fish are found in the Illinois river?

A. Well I couldn't answer that question; I don't believe any man could answer that question but some man who has made it a study all his life.

Q. What variety of fish do you handle for the United States Government?

A. We handle black bass, croppie, channel catfish and
5353 bream. Now those are the fish that we handle for distribution; there is lots of other fish that we handle as a collection, put up in formalin and send to Washington.

Q. What was the condition of the Illinois river before the opening of the drainage canal, between La Salle and Grafton, as you know it?

A. During the summer months the river would get very low and it was a very narrow stream and the water was what I would call bad condition, so much so that you could not drink it even by the use of ice in the water; at least I couldn't.

Q. What was the condition of the water from Peoria to Copperas Creek Dam?

A. Well from Copperas Creek dam for about five miles above it I have gone up that stream in the steamer Lotus and turned up sediment and dead fish—well on several different occasions, and there was a terrible stench and a man could hardly stand the smell, which I supposed of course was from the distilleries or I believe that it was the filth of the distilleries at Pekin and Peoria.

MR. JEFFRIES: I move to strike out that part of the witness' answer in which he undertakes to give the cause of the condition of the water in the river, for the reason that it is not responsive to the question, and for the reason that the witness has not properly qualified to give an opinion on that subject.

5354 Q. Did you know, as a matter of fact that there were distilleries located at Peoria and Pekin, and a glucose sugar refinery at Peoria, which emptied their sewage into the Illinois river?

MR. JEFFRIES: Objected to as immaterial.

A. I knew that there was distilleries at Peoria and Pekin, but I did not know that there was a glucose factory at Pekin or Peoria.

Q. What effect did the water in the Illinois river at low stages, have upon the fish?

A. Well it would only affect fish so far as I know, in ponds; I don't know that it affected the fish below these dams any at all, only during the winter season when the ice was over the water, and after the ice had broken up we would find quite a number of dead fish.

Q. These ponds you speak of are fed by the Illinois river, are they not?

A. When the water is high enough to go back into these ponds.

Q. Did you ever notice any fish dead in these ponds?

A. Thousands of them.

Q. And what became of those fish?

A. They were eaten by birds, the different kinds of waterfowl that we have around this country.

5355 Q. A rise in the river at those times would reach the ponds would it not?

A. If the rise was enough to go over the banks, it would.

Q. Do you remember whether it ever did or not?

A. Oh I remember several times that the water would go up and fill them up and keep the fish from dying.

Q. What would become of the dead fish that would be in those ponds at the time of these rises?

A. Most of these fish that were left in these drying pools are eaten by water fowls before the pond goes dry, and the balance of course would lie there and dry up. If they were large enough, it would create a bad odor around there, and if they were small you would hardly know that there had been any fish at all.

Q. What other places along the Illinois river did you observe similar conditions as existed from Copperas Creek to Peoria?

A. During the winter time I have noticed it at La Grange Locks.

Q. What was the condition of the water above Peoria as compared with that below Peoria during those times?

A. Well during the summer time the water above Peoria—well I couldn't tell you anything about that, above Peoria, because I wasn't very familiar with the water above Peoria, because I was only above there several times and I couldn't
5356 tell you much about that part of the river.

Q. What was the condition at La Grange Lock prior to the opening of the canal?

A. I don't think there was any—that I know of any complaint having been made about any stench around La Grange locks, I never heard of any; I don't know of any. One thing though I may say in favor of it is, that is that the government dredges keep the dam dredged out above the lock.

Q. What was the condition of the water at this point prior to the opening of the drainage canal?

A. During the summer, from the 15th of June to the 15th of August; it was nearly all the time a green scum on the water.

Q. Was there any current in the river at this point?

A. Yes, we always had a current in the river; the channel would perhaps not be over 75 yards wide, and vegetation would grow for 100 yards from the channel bank to the east, to Meredosia.

Q. Would there be any smell emanating from the water at that stage?

A. Well, yes, there would be a smell but I don't know whether you could lay it to the water or to the fish; this is a great point along here for the fishermen to throw off the offal of the fish and it might have been that.

5357 Q. Is that offal thrown into the river at this point?

A. Yes sir.

Q. What has been the effect upon the Illinois river, of the turning of the water of Lake Michigan into the Illinois river, since January, 1900?

A. The water is clearer and we have a three foot, high stage of water from low water mark. During low water, I guess it would have to mean that because in high water we have it very high.

Q. What other effects did you notice?

A. Well not any more than I would drink the water now in the Illinois river today if it had ice in it; I wouldn't have done so previous to the entering of the Chicago river unless it was absolutely necessary to do so.

Q. How about the conditions above the Copperas Creek dam?

A. I don't know anything about that since the canal has been turned in.

Q. Have you observed any green scum upon the water since the drainage canal was turned in?

A. I have noticed a green pod that floats on the water; I don't know the name of it, but it isn't a scum, it is a green pod; it might be taken for a scum in looking at it from a distance, but I know that it is a pod, I don't know what the name of it is.

Q. Pod from what?

5358 A. Why it seems to come from some tree or perhaps grows right in the water; I don't know.

Q. What is your opinion as to whether the water of the Illinois river has been injured or benefited by the opening of the drainage canal at this point?

MR. JEFFRIES: Objected to.

A. In my opinion it has been greatly benefited.

MR. JEFFRIES: The witness has not been qualified to express an opinion.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say these dead fish are found in the lakes and ponds?

A. During the hottest part of the summer.

Q. How about it in the winter time?

A. In the winter time they freeze to the bottom if the ponds are low enough in the summer time for the fish to die in.

Q. If it happens that they are not low enough to freeze to the bottom, these ponds freeze over in the winter time?

A. Yes, just owing to the season we have.

Q. Now, in the spring when the river breaks up, these ponds also break up don't they, by the spring floods?

A. No sir.

5359 Q. The ice doesn't break in the floods?

A. The ice in the ponds does not break up for a considerable time after the ice in the river breaks up, unless the water gets over into these ponds from the river and then it would take several days before the ice would break loose from the bottom.

Q. Now when the ponds don't freeze to the bottom they generally break up with the river?

A. No sir, they don't break up with the river then, from the fact that they will freeze to the bottom along the edges, and perhaps in the center it would lack a foot or two of being frozen to the bottom.

Q. Did the ice in the river kill the fish every winter?

A. No sir, only during a very low stage, and when the ice is very heavy.

Q. And only behind these dams?

A. It seems to be behind the dams, yes sir.

Q. You live here in Meredosia?

A. Yes sir.

Q. Man of family?

A. Yes sir.

Q. You have a pump or well at your house?

A. Yes sir.

Q. And use water for domestic and drinking purposes from the well?

5360 A. Yes sir

Q. The carp is the most bountiful fish in the Illinois river, isn't it?

A. Yes sir.

Q. When you say that the water in the Illniois river is clearer than it was before the Chicago drainage canal was opened, you give that as your opinion, simply from the appearance of the water?

A. Yes from the water being nearly perfectly clear nearly all the time during a fair stage of water.

Q. You don't know that it does or does not contain deleterious matter?

A. No sir.

Q. You don't know whether the sewage from Chicago gets here or not?

A. No I don't know only from what I have read about it and what my opinion would be about it; I don't know it positively.

Q. You are not an expert on that?

A. No sir.

J. R. BAUR.

ADJOURNED until Monday morning, July 20, 1903, at 8:00 A. M.. at La Grange, Illinois.

5361 La Grange Lock, Ill., July 20, 1903.

8:00 A. M.,

Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

JOHN D. KERR,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation.

A. John D. Kerr; Superintendent of La Grange Lock; Illinois river; Versailles, Illinois, is our postoffice. Rural Route No. 1.

Q. How long have you been superintendent of the Lock at LaGrange?

A. Twenty-one years in September.

Q. When was LaGrange Lock built, completed?

A. Well I can't remember the date when.

Q. How much of that time have you been superintendent of the lock?

A. The full time, sir.

Q. How far is La Grange Lock from Kampsville Lock?

A. It is called fifty miles; I don't know by actual measurement.

5362 Q. How far from Meredosia?

A. Six miles is what they call it; these are not actual measurements, gentlemen.

Q. How far is La Grange lock from Beardstown?

A. Twelve miles, or eleven miles.

Q. How far from Browning?

A. I think they call it twelve miles from Browning to Beardstown; I won't be positive, that would be 24 miles from here to Browning; I shouldn't think Browning was over ten miles from Beardstown; I wouldn't be positive about that because I haven't paid much attention to it.

Q. What is the width of La Grange dam between returns?

A. I think it is about 835 feet if I remember right, between the dam abutments, and the abutment on the other side of the river.

Q. Since the opening of the drainage canal how much has the water at La Grange dam been raised in the Illinois river?

A. Well to the best of my knowledge, to the best of my judgment I would say four feet; I couldn't tell you exactly.

Q. At what point is it four feet between the abutments of the dam?

A. On the gauges at the lock; that is guess work though, sir.

Q. Is that amount substantially correct?

A. I should think so.

5363 Q. How many gauges on the locks at La Grange?

A. Two, one above and one below.

Q. What is the difference in the readings of the two gauges?

A. It depends altogether on the stage of the water, sir.

Q. When the water falls over the dam and it is lower below the dam than above, what is the general difference between the upper and lower gauge?

A. Well it depends on the stage of water; at the present time it is 2.8; that is the difference in the reading of the gauges.

Q. Do you mean by that two feet and eight tenths?

A. Yes sir.

Q. Were you familiar with the condition of the water in the Illinois river above and below La Grange dam prior to January, 1900?

A. Yes sir.

Q. What was its condition?

A. Well, we used it for drinking purposes and around the house at that time before the drainage was put in and before the dam was built and we used it for all purposes there for two or three years; we had no other water when the operations first commenced, we had a dry-well then and we didn't think it was the best of water then and we used the river water to drink at that time. 5364

Q. What was its condition as to stagnation?

A. Well, I don't know as there is any—anything any different from any other river I was ever on; of course this river wasn't as big current as there is in some rivers, and it was not as fresh as in other rivers at other times.

Q. Was there a green growth or scum upon the top of the water in low water?

A. Yes sir; what you call water-clover on the river; it growed there. It was just like a regular clover a little three leaf arrangement that grows right on the water; in low water it would be twenty-feet wide, sometimes; and sometimes more.

Q. In times of low water what was the condition of the water as to clearness?

A. Well, it was reasonably clear; it was clear—You could see, I should safely say, a foot or a foot and a half at the dam; you could see the timbers down below.

Q. Since the opening of the drainage canal, what has been the condition of the current in the river?

A. Well the current has been a little over half faster, I should judge. I haven't taken no observations of it, but I should judge that from the appearance of it.

Q. What has become of this clover growth on the river; does it occur now?

5365 MR. JEFFRIES: Objected to as leading.

A. No sir, I haven't seen it.

Q. Have you wells or cisterns at La Grange now and since the opening of the drainage canal?

A. Yes sir.

Q. Do you drink the water of the river since you have had the wells and cisterns?

A. Well no sir; I don't.

Q. What is the condition of the water here since the opening of the drainage canal as to clearness?

A. Well pretty near as clear as it was before, sir.

Q. At times of low water?

A. At times of low water; it has never been real clear since that I have seen it.

Q. Did you observe in the water before the opening of the drainage canal at this point any odor?

MR. JEFFRIES: Objected to as leading.

Q. Or smell?

A. No sir, that is unless it was caused by the drift accumlating; the drift accumulated here one year clear across the river; we had ten acres of it. Dead animals and fish would get in there and they would smell of course; dead fish and things, but we got them out; but as long as they were there we had a very disagreeable odor, but since we got them out; it ain't 5366 there; that was caused by dead animals and things that would be in amongst the drift; as soon as the drift would be removed and the river cleared out, it would be all right; we wouldn't smell it any more.

Q. Since the opening of the drainage canal have you noticed any odor in the water?

A. Yes sir.

Q. Where do you discover it?

A. Anywhere around the locks; when the water was first turned in; it was very disagreeable here for eight or ten days; you could hardly stand it; and in damp weather now you can smell it very distinctly; the wind blowing it just right blows over to my house and I can smell it.

Q. Is that from the open river or from the water in the locks?

MR. JEFFRIES: Objected to as leading.

A. Well I think the most of it is caused where the water flows over the dam, stirs it and the wind blows it; I think that is where most of it comes from.

Q. When the water stands in the locks and the locks are consequently not flushed for some time, does an odor arise from that water?

MR. JEFFRIES: Objected to as leading.

A. Well yes sir, to a certain extent; it forms a kind of an oily substance on the top, and when you open the valve
5367 and the water runs out and stirs it up you can notice it
very distinctly.

Q. Is it different in that respect now, as to the time before the opening of the canal?

A. Yes sir.

Q. What is the condition of the ice taken at this point?

A. Why we use it sir; we fill our ice house right out of the lock; we use it right along.

Q. Is it different in any respect from the appearance of it before the opening of the canal?

A. I don't think there is sir; I have only noticed one bad piece of ice; it had a little streak of something in it; I didn't know what it was and throwed it away, but I have been advised by a physician not to put the ice in the water; put the ice in a vessel and then—put the water in a vessel and then pack the ice around it; that was his adivce to me.

Q. What is the present stage of the river today, as to whether it is—well as compared with any time since the opening of the drainage canal?

A. Well, it is about low water now, very near low water since the drainage canal was put in; within six inches. The lower gauge is 13.70 and the upper one I think it was 16.80, I
think it was, I am pretty sure.

5368 Q. Do you know whether the zeros of the two gauges,
upper and lower are at the same level?

A. Yes sir, they were established that way sir. Our gauge reads from the lower mitre sill.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How long did you say you have lived here?

A. 21 years next September, sir.

Q. How long have you been in the employ of the government?

A. About 27 years.

Q. Ever since the dam and locks were built at this place?

A. I have been superintendent here; I was superintendent during the construction; I was removed here from Memphis, Tennessee I think it was 1872; I was formerly stationed there and then before on the Red River; I was on the Red river first.

Q. You say the water was clearer before the opening of the canal than since?

A. That is my judgment, sir; in fact I know it is.

Q. What is the stage of the water as compared with what it was before the canal was opened?

A. Well I couldn't tell you sir—

Q. Average stage?

A. About four feet; that would be my opinion.

Q. Do you know the depth of water that is flowing over
5369 the dam now?

A. Yes sir; two foot three.

Q. Assuming by that three tenths of a foot?

A. Yes sir, thirty-hundredths.

Q. And the dam is how wide?

A. About 835 feet; I wouldn't be positive about that.

Q. Now how does that compare with ordinary low stages of the water?

A. At low stages I had to keep one foot of water on the dam; I went out there and bored about an inch and a quarter hole, I think it was and set a three-inch board down upon it edge-ways to hold the water back; I never let it get lower than one foot of water on the dam, and if it would go to raise I would take off one of them to make the water run clear over the dam, what we call flash-boards. We have never had to put the flash-boards on since the sewage has been put in.

Q. Those flash-boards are used to hold the water back so that it would run one foot over the dam?

A. Yes sir; that is to make it one foot higher stage above the dam than it would be without. Well not quite that, because there would always be a few inches there.

Q. There has always been a good current since the canal was opened?

A. Yes sir—well I will take that back, when we had the high water in the Mississippi, it kind of slacked it up
5370 and then there wasn't so much current here, there was a current, but not like it was now.

Q. Aside from the water from the Mississippi though, there has always been a much better current?

A. Oh yes, I should think a great deal faster.

Q. Now you say before the opening of the canal the water would smell?

A. No sir, I didn't say that.

Q. It did not smell?

A. No sir.

Q. And since the opening of the canal there has been considerable odor?

A. Yes sir, at times, worse than others; right after the sewage was turned in it was very bad for a while and then it gradually wore off, or we got used to it, one or the other. It hasn't been so bad, but only when the damp, mucky weather comes you can smell it very distinctly.

Q. How is it in the summer time in low water?

A. It is the same in the summer time; we don't get as much of it. One reason I think is because we are using the lock all the time you know, and the water don't stand there. It keeps a going all the time, but whenever the water stays in the lock any length of time, then we can smell it very readily and it has this scum and oily substance; it is a scum like
5371 formerly was on the river; it is a oily substance; I have shown the gentlemen some of it down there that has formed since this boat came through.

Q. You stated a moment ago that when the wind was in the right direction this smell came from over the dam?

A. Well, that is only at times sir, when there is mucky weather.

Q. How is it in extreme warm weather?

A. It is about the same sir; at times you can smell it and then again you can't; it depends on the wind altogether—the direction of the wind; if the wind blows away from it then of course we wouldn't get it on this side of the river; but if the wind is on the shore we get it all.

Q. Do you have a pump or a well that you use at your residence?

A. I have a cistern; I have a well also, but I use altogether cistern water in my family.

Q. You don't use the water from the Illinois river?

A. No; I used water in the Illinois river before the sewage was turned in for several years; my cistern sprung a leak and I had to use the river water; but I haven't used the river water since the drainage was turned in, at all sir.

Q. Why don't you use it?

5372 A. Because I don't think it is healthy; at least I imagine it ain't: I don't know.

Q. How did your physician come to advise you to put the ice around the receptacle containing the water rather than in the water?

A. He was down here a week or ten days ago and it was when I found that bad cake of ice in the ice house and I talked to him and asked him about it, and he said I advise you not to drink that water and he told me to put the ice around the water in the receptacle and cool the water that way.

RE-DIRECT-EXAMINATION,

By Judge Johns.

Q. Who was the physician and where does he live that gave you this advise?

A. Dr. Bly, Beardstown, Illinois; Dr. Bly, Junior; I think his given name is Walter, I ain't certain.

Q. When you speak of the water being clearer before the opening of the drainage canal than after, do you mean at extreme low water?

MR. JEFFRIES: Objected to as leading and suggestive.

A. At all times except when a freshet.

Q. At which time, before or after the opening of the canal after a freshet, did the water clear most rapidly?

5373 A. Why it would clear out after a freshet in a few days; it would run out in a few days; in about seven days we always calculated to get the head waters of the Sangamon.

Q. Does it clear up more rapidly since the opening of the drainage canal than before?

A. No sir.

Q. Does it clear up about as rapidly after a freshet?

A. It doesn't clear up as clear as it did before; it never gets clear; it hasn't been clear since the drainage has been in, sir.

Q. How far is it from here to the mouth of the Sangamon river?

A. The Sangamon is about four miles; the Sangamon comes in right above Browning and has three or four outlets above Beardstown Bay, and a slough and a lot of places it comes in. We also have another creek here that gives us more water than that does; called Crooked Creek. I believe they call it on the map the Des Moines river, something like that.

Q. Crooked creek is on the west side?

A. Yes sir.

Q. The Sangamon river is on the east side?

A. Yes sir.

Q. How far from here to the mouth of Crooked Creek?

A. About six miles. Perhaps seven.

5374 Q. In a low stage, or an average stage of water in the Sangamon river, its mouth is above Browning, is it not?

A. The main mouth of it, yes sir; I think at a low stage of water, it is just about the foot of Hickory Island.

Q. How far is it from La Grange Lock to the main mouth of the Sangamon river?

A. I should judge it was 21 or 22 miles; I wouldn't be positive.

Q. When you say that you get the head waters of the Sangamon in seven days, do you mean that it takes seven days for the water—

A. Oh, no sir; I mean after the flood suspends itself here; it commences to fall here; commences to clear up after that time. We get a Sangamon raise here in 36 hours.

Q. Do you calculate that it takes 36 hours for the water in the Sangamon river to reach here?

MR. JEFFRIES: Objected to as leading.

A. Yes sir, that is what we figure on; somewhere around thirty or thirty-six hours, around there, we call it three days, that's what we figure on.

Q. Thirty-six hours is a day and a half is it not?

A. Well we call it a Sangamon raise, we say, well we will get rid of that in three days; that's the way we talk amongst ourselves here, about 36 hours is what it takes to get here.

5375 Q. What is your age Mr. Kerr?

A. Ffty-three years.

Q. When the Sangamon river or Crooked Creek raises, what is the effect upon the appearance of the water here as to clearness?

A. Crooked Creek will make the water yellow; the Sangamon will make it black.

JOHN D. KERR.

5376 La Grange Locks, Ill., July 20.

BENAJMIN COLE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. My name is Benjamin Cole.

Q. Where do you live?

A. I live at La Grange locks.

Q. How long have you been connected with the locks?

A. I commenced work at the locks here in 1882. That is when I first worked.

Q. What position do you occupy?

A. I do any kind of work; operating in care of canals and other work of navigation, I guess that will cover it.

Q. Were you acquainted with the Illinois river at this point before the opening of the drainage canal in 1900?

A. Yes sir.

Q. What was the character of the water and the river at this point before the opening of the drainage canal?

A. Well sir, we had a very slow current in this river before the canal was turned in and when the water would get
5377 low why of course it would get stagnant.

Q. How far does the La Grange lock back the water up?

A. Well sir, I couldn't say positively, but it was built with the calculation to back it fifty miles; the dam raises the water seven feet four.

THE COMMISSIONER: Is that seven feet four tenths of an inch or of a foot?

A. Of a foot.

Q. MR. TODD: In times of low stage of water, what was the character of the upper pool?

A. Above the dam?

Q. Above the dam?

A. Well sir, the lower the current gets the less water we would have and of course above the dam it would get stagnant; we would have very little current. I have seen it get so low that I would walk across the river on top of the dam, several times, and of course then you know, the river would naturally have a green scum on it; it would be the same as a lake. There would be very little current.

Q. Since the opening of the canal, in January, 1900, what has been the current at this point in comparison with what it was before?

A. Well sir, I have no way of telling only my judgment
5378 would be that we have almost twice the current above the dam that we had before.

Q. When the waters in the locks are not disturbed for a considerable period, what effects do you observe in the shape of odor to the waters here?

MR. JEFFRIES: Objected to as leading and suggestive.

A. Well sir, I never noticed any odor in the water here in the locks; of course when it ain't disturbed there used to be a green scum come in the water in the locks just the same; that is it would be just the same as it would be above the dam you know.

Q. Since the opening of the canal, have you observed the odor that comes from the locks when the water is not disturbed there for several days?

A. I have never noticed any odor in the water in the locks; it is the water that runs over the dam that I noticed the odor in.

Q. When did you notice the odor from the water running over the dam?

A. Well, it was soon after the canal water was turned in.

Q. At the present time do you notice odor in the locks when the water is undisturbed there for a period?

A. No sir, we never noticed anything of that kind only when the water was froze over close to the dam below and close above.

5379 Q. What kind of work do you perform around the lock?

A. Well sir, I do general work; just anything and everything; blacksmithing or carpenter work or anything there is to do; of course I have done submarine work.

Q. What is that?

A. That is going under the water in a diving apparatus.

Q. For what purpose?

A. For working on the valves, repairing.

Q. Did you go under the water before the opening of the canal?

A. Yes sir.

Q. Have you been in it since the opening of the canal?

A. Yes sir.

Q. What kind of an apparatus is it that you use?

A. Well sir, we have got an entire suit for diving purposes and an air-pump to pump the air, with a rubber hose that is fastened on the head.

Q. Can you see out of the apparatus?

A. A very little; you can see when you look straight up; when you look down you can't see anything.

Q. What do you see through?

A. Glass; it has a glass front.

Q. How does the clearness of the water at present compare with its clearness before the opening of the drainage canal?

A. Well it would compare very favorably now as to clearness.

5380 Q. What do you mean by that?

A. Well I think it is fully as clear now as it was before the canal was turned in, and at times clearer. I have seen the water here since the canal was turned in the clearest I have ever seen it.

Q. Have you observed any difference in the temperature of the water?

A. Well in my judgment I have; I would think the water was lots cooler now than it was before; I have seen it in the river when it wasn't fit for a man to go in bathing; but now it is most too cool.

Q. Have you known of any typhoid fever being in this neighborhood along the river, since the opening of the canal?

A. No sir, I haven't noticed any any closer than say two miles and a half and that is along the bluffs; not along the river.

Q. How about the ague and malaria here, do you have it?

A. Well sir, very little; I haven't noticed anybody have ague here for several years.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How long have you lived here?

A. Well sir, I have lived here steadily for sixteen years; I commenced work here in 1882.

5381 Q. Here at the dam, at the locks?

A. Well of course there was no dam in here when I first commenced work.

Q. How old are you?

A. I am 44 years old.

Q. You say you have noticed an odor arising from the river since the opening of the canal?

A. Yes sir.

Q. Have you noticed an odor arising from the river at the dam in the winter time when the water would be frozen up, and yet there would be an opening above and below the dam?

A. Yes sir; it never freezes up against, above and below the dam, but the tighter it gets the more odor we have.

Q. And that you have noticed ever since the opening of the canal?

A. Yes sir.

Q. Do the people around here drink the river water?

A. I couldn't say only for the government outfit here; they drink cistern water and well water.

Q. You don't drink the water from the river?

A. No sir, we don't have no occasion to drink it; we have well water and the well water, you know is colder.

Q. Do you notice an oily scum on the water now, in place of the green scum prior to the opening of the canal?

5382 A. No sir, I don't notice any oily scum on the water here.

Q. Well an oily scum forms here in the locks doesn't it?

A. Well the water gets foul around the locks if it ain't disturbed. In this season of the year there is lots of fishing, and there is more or less dead fish in the water. People throw in many fish that they don't take and it makes the water rather foul around the locks when it ain't disturbed.

Q. Now you noticed no odor on the water before the canal was opened?

A. No sir, I never noticed any.

Q. What is the difference between the current in the river now and what it was prior to January, 1900, when the canal was opened?

A. Well I have no way to tell exactly, but I should judge it was double the current here above the dam; it is from appearance.

Q. That is now and at all seasons of the year?

A . Yes sir.

BENJAMIN COLE.

5383 Continuation at Beardstown, Illinois, July 20, 1903.

G. W. BARNEYCASTLE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. G. W. Barneycastle.

Q. Where do you live Mr. Barneycastle?

A. In Beardstown.

Q. Mr. Barneycastle did you ever take samples of the Illinois river water at this point for the Sanitary District of Chicago, to be sent to the University of Chicago, Professor Jordan and to the Board of Health of the City of Chicago?

A. Yes sir, I did.

Q. What years did you take that water in?

A. Well if I had fetched my book with me—

Q. These cards show correctly, don't they? 1899 and 1900?

A. Yes sir; that looks like my handwriting.

Q. Where did you take the water from?

A. From the Burlington railroad bridge, right in the channel, right on the right hand side of the channel, right on the draw, right down below there; right in the channel where 5834 the water, I should judge would be about twelve feet deep at any time of the year.

Q. How often did you take the water?

A. Once a week.

Q. Did you take it any oftener than that at any one period?

A. No sir, once a week.

Q. How did you take the water?

A. Well, he sent me two glass bottles and I should judge they held a gallon apiece the bottles and I would fill them up and he sent me two little bottles to be packed in ice; I don't know how much they was, probably four ounce bottles; I filled them up and packed them in ice and sent them every time I sent the big bottles.

Q. How did you receive the bottles, which you filled?

A. By express.

Q. Did the bottles have the stoppers in them when they came?

A. Yes sir.

Q. What kind of stoppers?

A. Glass stoppers.

Q. When did you remove the stoppers?

A. Not until I went to fill the bottles.

Q. Just describe how you filled the bottles?

A. Well I would take the bottle and go down to the
5385 water and hold my hand over the top of the bottle until I would run the bottle down underneath, to keep from getting the surface water down there, and let it fill and then pull the bottle up.

Q. When would you put the cork in?

A. Right away as quick as I would get it out I would put the cork in.

Q. Did you rinse the bottles out before filling?

A. Yes sir.

Q. How did you do that?

A. Just run them down in the water and get some water in and shake them and pour it out.

Q. After you put the stopper in the bottles what did you do with the bottles?

A. I put them in the case they were shipped in and packed them with excelsior around them and put the lid right on the box.

Q. Did you do anything else to the bottle except put the cork in?

A. No sir, put a seal on them; sealed it up.

Q. Did you put anything on them besides the seal?

A. Put a piece of leather of some description over it; right over the top of the cork; then put a wire around and put the seal on.

5386 Q. Anything else that you attached to the bottle?

A. No sir, except the card where I shipped it to.

Q. Did you put the card on each sample that you collected?

A. Yes sir, put a card on each one that I shipped.

Q. On the card which you placed on the bottle, did you write the sample number, the date, the hour of taking, the place of taking, your own name, height of water, temperature of water, direction of wind; temperature of air, rain; such as are indicated upon the card which I show you of sample No. 1258?

A. And I always put the time of the last boat passing the draw too; yes sir, that's what I did.

Q. On the back of the card, were there printed instructions for collecting samples of waters similar to the instructions on the back of the card I last showed you?

A. I think it is the same; I haven't got my glasses with me: Yes sir, just the same I think.

Q. Did you attach one of these cards properly filled out in the manner mentioned in the last question, to each sample that you collected?

A. Yes sir, I did.

Q. After collecting the sample what did you do with it?

A. I took them to the Burlington Depot and when it was cold weather put them in the baggage room, so they
5387 wouldn't freeze and burst the bottles, and when it wasn't cold I set them outside until the express train came along and then the express man took them on the express car.

Q. What express company did you send them by?

A. The Adams; that is, I sent one bottle by the Adams, and one went over the B. & O. I believe that was the American Express Company if I ain't mistaken; I won't be sure about that; but they don't have the Adams Express on the B. & O.

Q. To whom did you send these samples?

A. Well I sent one to Dr. Palmer and one to Dr. Jordan, I believe.

Q. Did you send any to the Board of Health in Chicago?

A. Well, there was three samples and I sent two of them to the same man and one to the other.

Q. Two samples you sent to Chicago?

A. Two to Chicago and one to Dr. Palmer.

MR. TODD: Mr Commissioner I will ask to have sample No. 1258 card marked Sanitary District of Chicago Exhibit for identification No. 7.

Said card so marked by the Commissioner.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You say you live here in Beardstown?

A. Yes sir, I live in Beardstown.

5388 Q. When you put the bottle under the water to get these samples you held your hand over the mouth of the bottle until you got it submerged?

A. Yes sir, put my hand over the mouth of the bottle until I got it under the water; that was the instructions I received when I got the contract to collect the water.

Q. How many samples did you take each week?

A. One sample each week.

Q. That is, you took three samples at one time?

A. Yes sir, took three samples at one time; that is I sent the three bottles each week. Every Tuesday morning, sometime between the hour of seven o'clock in the morning and noon; whenever I would just get the time.

Q. How long would it be after the samples were taken before the shipment was made?

A. The same day, the express train went through here at noon every day and they went right off every day on the same train.

Q. When did you re-cork the bottles after you took them out of the water?

A. After I refilled them?

Q. Yes.

A. Right as quick as I could get them out; I had the cork 5389 right there and put it in.

Q. I understood you to say you rinsed the bottles?

A. Yes sir, then I filled them.

Q. Both the small and the large bottles?

A. Yes sir.

Q. And you sent the samples to Prof. Jordan?

A. Yes sir, one of them—no, two of the bottles I sent to Prof. Jordan and one to Dr. Palmer at Urbana.

Q. During that time was you out on the river every day?

A. Yes sir, every day.

G. W. BARNEYCASTLE.

5390 Beardstown, Illinois, July 20, 1903.

DR. GEORGE BLEY,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. George Bley; Beardstown, Illinois, physician.

Q. How long have you been a practicing physician?

A. 22 years.

Q. Of what school of medicine are you?

A. Regular.

Q. How long have you practiced medicine in Beardstown?

A. Twenty-two years.

Q. Have you during that time had a general practice among the people of this vicinity?

A. Yes sir.

Q. How large a town is Beardstown?

A. About 5,000.

Q. Has it a public water supply?

A. Yes sir.

Q. From what source is the water supply obtained?

5391 A. From a six or eight inch well driven ninety feet into the sand about ten or eleven blocks from the river in the back part of town.

Q. Have you been in a general way familiar with the condition of the Illinois river for a number of years?

A. Why to an extent; not chemically; I have never made any analyses or anything of that kind, but just noticing the stage of the river and the water in a general way.

Q. What was the condition of the Illinois river before the opening of the drainage canal as to volume and current and stagnation?

A. Well it was somewhat less than it is now; considerably so I should say; not the current that we have now.

Q. Did a scum form on the river at this point during low water?

A. It did, yes sir.

Q. Was there an odor in the river?

A. I have noticed odors at times, yes.

Q. Have you noticed that odor in the river since the opening of the drainage canal in January, 1900?

A. Well, I wouldn't be sure about that; I would rather think that I have, but I wouldn't be sure; I wouldn't be positive since that date.

5392 Q. What is the condition of the waters at this point since the opening of the drainage canal as compared to its condition prior to that time?

A. Well I would consider that it is better than it was.

Q. Is there or has there been typhoid fever in this vicinity?

A. Yes sir.

Q. Among what class of people has it been, those using the river water for domestic purposes or those using the public water supply?

MR. JEFFRIES: We object to the question for the reason that it is immaterial and for the further reason that it assumes that the people are using and have used the water from the Illinois river for domestic purposes, and there is no proof of any such fact.

A. All classes.

Q. Has there been an increased or decreased amount of typhoid fever since the opening of the drainage canal?

A. Typhoid fever has been increasing here probably for the last ten or fifteen years.

Q. Have you had cases of typhoid fever under your own observation during the last three years?

A. Yes sir.

Q. How many?

A. Well, ten or twenty; may be thirty; I don't know; I
5393 would not say positively; I think though at least thirty.

Q. Do you distinguish between typhoid fever and typho-malaria?

A. Yes sir.

Q. Have your cases been among people who drank from the public water supply or from the Illinois river?

A. Both.

Q. Have you a Board of Health in this town?

A. We have now one member, who is the Health Officer here.

Q. What is done by you in your practice with the dejecta?

A. Disinfected and buried.

Q. Is it both disinfected and buried?

A. Yes sir.

Q. Do you know as to the practice of other physicians here in that respect?

A. I couldn't say positively, no sir, I couldn't but that is my impression; that they do, but that is only surmise though.

Q. Since the opening of the drainage canal has there been this stagnation of the water which you previously observed?

A. No I think not; we have had higher water since.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How does the current or flow of the water compare now to what it was prior to the opening of the canal?

5394 A. It has increased, I should say.

Q. Increased very greatly has it not?

A. No, only during the high water that comes in addition to that; there isn't so much of an increase; it is considerably more though than it was, I would say.

Q. How much of your time do you spend on the river, doctor?

A. Not much now; during the spring months, we have the other part of the river shut out, and our practice across the river down the river and up above here, is a great deal of it done in a launch. I own a launch and we go out a great deal that way; that is about all; when the water gets down in the summer time;—low water time, I am not on the river much because I can go to my work by my buggy, although we do make excursions and trips on the river on the launch all the year round, in the open season—except winter time.

Q. At intervals.

A. Yes sir.

Q. The number of cases of typhoid fever has increased to some extent since the opening of the canal has it not doctor?

A. Yes sir, and before; it has been increasing for a good many years.

Q. Particularly as to the time since the opening of the canal since January, 1900?

5395 A. No, I don't think they have increased any faster since the canal was opened into the river than they did for the last ten or fifteen years.

Q. But there has been a gradual increase?

A. A gradual increase.

Q. The people in this town pretty generally use the water from this public supply, do they not?

A. Yes I think they do, but that is pretty hard to state that definitely, because there is a portion of the town that does not use the public supply; they have wells; perhaps half of them.

Q. What do they use?

A. Well water; pipes driven down into the sand from 20 to 25 or 30 feet.

Q. Do the people use the water from the river to any extent for domestic and drinking purposes?

A. Oh, I think not; possibly these people living along the river in the cabin boats do; but otherwise I don't think it is used at all.

Q. This deep well from which the public supply of water is obtained is located as I understood you to say how many feet from the river bank?

A. Well it is ten or eleven blocks, 300 feet to the block, 3,000 feet possibly from the river.

5396 Q. Do you know the character of the soil through which it is driven?

Q. Sand; the first eighty feet is sand and the next ten feet is gravel; we have about eighty feet of sand here and then [illegible] feet of gravel; then rock. They usually drive right down into that sand or gravel for the city water supply.

Q. When you say the water is better now than it was before the canal was opened, not having made any analyses of the water as you have stated, you judge altogether from the fact that there is an increase in volume and a material increase in flow, and from the appearance of the water do you not?

A. From appearances mostly; it is clearer under the same conditions, than it was before.

Q. You have noticed at times a greasy, oily appearance to the water, haven't you since the opening of the canal?

A. Yes sir, and before.

Q. Where did you study medicine, doctor?

A. Jefferson Medical College, Philadelphia.

Q. How old are you?

A. I am 52.

Q. You are Dr. Bley, Sr., then are you?

A. Yes, I am the elder.

Q. Is Dr. Bley, Jr. your son?

A. Yes sir. It might be well that I make a correction here.
5397 I am the one that signs my name "Junior." My father's
name was George. Prior to his death I signed my name "Junior" and it became rather unhandy after he died, to drop that name "Junior" and I just kept it right up. The Junior now is W. C. Bley, and my name is George.

Q. Was your father a physician?

A. Yes sir. GEORGE BLEY, Jr.

5398 Beardstown, Illinois, July 20, 1903.

L. W. GOODELL,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in Chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. L. W. Goodell; Beardstown, Illinois; I am in the wholesale and retail ice business and I am in the fish business.

Q. How long have you resided in Beardstown?

A. Since 1877.

Q. How long have you been engaged in the business of selling ice and fish?

A. I have been in the ice business myself since 1887 and in the fish business about seven years.

Q. Are you a fisherman or engaged in the business of buying fish from fishermen?

A. We buy fish from fishermen and we run a seine also.

Q. Do you personally engage in the seining?

A. No I don't personally; my partner engages in the seining.

Q. What is your partner's name?

A. George Swan.

5399 Q. What was the condition of the water of the Illinois
river prior to the opening of the drainage canal in January, 1900?

A. Well with reference to volume?

Q. Yes sir and current and appearance.

A. Well the water would get pretty low at times; the current was quite sluggish and the water somewhat riley, dirty looking; not very clear looking.

Q. Did you notice or see here a scum or growth in the water before the opening of the drainage canal?

A. Yes I have noticed a growth, a green growth, a sort of a vegetable, a small vegetable with two or three leaves, a little short root that would form in large masses over the surface of the water.

Q. Did you ever notice any odor or smell in the water prior to the opening of the drainage canal?

A. I don't recall; I don't recollect whether there was any odor to it or not in the summer time; I have noticed it in the winter time when there were holes cut in the ice; there have been times when a great many fish died in the winter time when there was a coating of ice on the water.

Q. To what substance did you attribute this smell; what was it like?

A. Well I don't know; I didn't notice particularly at the time, except this sewage from Peoria and Pekin; I think
5400 it was that partly.

Q. How far from here to Pekin and Peoria?

A. I think it is about 80 miles to Pekin, and about 90 miles to Peoria, probably.

Q. How far to Copperas Creek dam, about?

A. Well, I don't recollect; something like 50 or 60 miles, I believe they call it.

Q. From what water did you get the ice before the opening of the drainage canal?

A. Cut it from the waters of Muscoopin Bay from the arms that project off the river above the C. B. & Q. bridge.

Q. Is that water derived from the Illinois river?

A. Yes. Both from that and from surface water that drains into the bay at the north end of it.

Q. How frequently have you known the fish to die under the ice at this point prior to the opening of the drainage canal?

A. As I recollect it, it was at least two winters that the fishermen complained largely of the fish dying.

Q. How frequently have you noticed an odor coming from the water from under the ice, prior to the opening of the drainage canal?

A. Several times; I wouldn't say exactly how many.

Q. Since the opening of the canal, has there been this
5401 growth or green plant in the water?

MR. JEFFRIES: Objected to as leading.

A. I haven't noticed it in the river.

Q. Since the opening of the drainage canal, have you cut ice and put it up at this point?

MR. JEFFRIES: Objected to as leading.

A. We cut ice this winter and the winter before last.

Q. If there was any odor, you may state—from the water during the last three years?

A. I didn't detect any.

Q. Did the fish die under the ice in the last three years?

MR. JEFFRIES: Objected to as leading.

A. Not to my knowledge.

Q. As compared with the conditions before the opening of the drainage canal, what has been the condition of the ice taken from the Illinois river and its bays and arms here since the opening?

A. I haven't noticed any difference.

Q. As compared with the conditions before the drainage canal was opened, what has been the condition of the water, in a general way since the opening?

A. The water looks clearer.

5402 CROSS-EXAMINATION, By Mr. Jeffries.

Q. How long did you say you had lived here?

A. Since 1877.

Q. And you have been engaged in this same business continuously since that time?

A. I have been in the ice business myself since 1887, my father was in the ice business up to the time of his death, and I took his place.

Q. How long have you been in the fish business?

A. I think it is about seven years.

Q. You don't drink the water from the Illinois river, do you?

A. No, the town here is supplied with water from drive wells.

Q. You don't use the water from the river for domestic and drinking purposes, do you?

A. In the winter time we drink the water from the river when we are cutting ice; I don't use it for my family for any purposes.

Q. Where did you say it was that this ice was cut from?

A. A body of water known as Muscoupin Bay up above the C., B. & Q. bridge.

Q. There is no current through there is there?

A. I don't know as there is a current through there now; there has been until quite recently; there was a current 5403 there when we were cutting ice last winter.

Q. Well, where does the current come from?

A. Well it comes down through Hager's Slough and they overflow all the way through up to the Sangamon River, through the bottoms between here and the Sangamon.

Q. This bay then is fed from these bottoms and streams coming from the hills and the bottoms leading up through the Sangamon river?

A. Yes, the water that comes down through there when the water is sufficiently high; there are times when there is no current whatever and it gets its current from the backwater of the Illinois river.

Q. Now how deep was the water in this slough or in this bay when the ice was being cut?

A. The deepest point was about sixteen feet.

Q. Ranging from sixteen feet to what depth?

A. I think probably there was an average depth of twelve feet.

Q. A kind of a basin then in the bay?

A. Yes, it is a depression; the bay is about a mile and a half long and a half or three-quarters of a mile wide.

Q. Have you noticed an odor on the water before the opening of the canal?

A. Yes, I have at times; I noticed an odor when we cut 5404 a hole through the ice; I noticed an odor there.

Q. Have you noticed any odor since?

A. No, I haven't detected it since; the water has been unusually high at the times we have cut ice, since the introduction of this water from above.

Q. You have noticed an oily, greasy covering on the water since the opening of the canal, have you not?

A. Well, along on the edges I have noticed an oily substance, along close to the shore; I can't say that I have detected any out in the bay or out in the body of the river.

Q. You have made no careful examination of the water?

A. No, I have never made any careful examination of the water.

L. W. GOODELL.

5405 Beardstown, Illinois, July 20, 1903.

H. EHRHARDT,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. My name is H. Ehrhardt.

Q. Where do you reside?

A. Beardstown, Illinois.

Q. How long have you lived here?

A. I have lived here 51 years.

Q. What is your business?

A. I am a physician.

Q. How long have you been practicing medicine?

A. Twenty-six years.

Q. Do you hold any position in the municipal government of the city?

A. Yes sir, I do.

Q. What is it?

A. Health officer.

Q. Are you acquainted with the Illinois river?

A. A portion of it.

5406 Q. What portion?

A. That portion contiguous to Bearstown; in the vicinity of Beardstown, within a radius of ten or fifteen miles above and below Beardstown.

Q. How did you get acquainted with the river, doctor?

A. Why, by almost daily observations.

Q. Have you been on the river much?

A. Yes, quite frequently.

Q. Before the opening of the drainage canal what was the condition of the Illinois river at this point?

A. Before the opening of the drainage canal why the river during low stage was often covered with a vegetable growth; sort of a fungus, grass, and also a scum.

Q. What kind of a current did it have?

A. The current during low stage of water was very sluggish.

Q. Have you observed the condition of the river since the opening of the drainage canal?

A. Yes sir.

Q. What effect, if any, has the opening of the drainage canal had upon the waters of the Illinois river at this point?

A. Well I have noticed so far as external appearances go, the water has had a better appearance; the water is clearer and it has been devoid of that vegetation which was observed before.

5407 Q. What is the character of your practice here doctor?

A. General medicine.

Q. Has typhoid fever in Beardstown been on the increase or decrease since the opening of the drainage canal?

A. I have observed no cases of typhoid fever before or since.

Q. Do you know of any people having died of typhoid fever in the last four or five years, in Beardstown?

A. I do not.

Q. Do you know of any typhoid fever existing in this territory?

A. At present?

Q. Yes?

A. I do not.

Q. Or within the last two or three years?

A. I do not.

Q. How does the health of the people living along the river compare with that of those living in the foot-hills at this point?

A. Well it compares better; the health is better than those living on the foot-hills or in the high lands.

Q. Have you as much malaria in this district or vicinity now as before the opening of the drainage canal in 1900?

MR. JEFFRIES: Objected to as immaterial and leading.

A. I have noticed no difference.

Q. Have you had any cases of typho-malarial fever?

A. Yes sir, I have, so designated.

5408 Q. What is typho-malarial fever?

A. Well I consider typho-malarial fever a malarial fever that, owing to intestinal irritations assumes typhoid character.

CROSS-EXAMINATION, By Mr. Jeffries.

Q. You say from external appearance of the water it is better than it was prior to the opening of the canal?

A. Yes sir.

Q. You know nothing of its internal conditions?

A. Nothing watever.

Q. The water is not used here at Beardstown for domestic and drinking purposes?

A. No sir, not generally; I would like to modify that. It is used, but it is used after it is filtered, understand.

Q. In what way?

A. Beardstown obtains its water supply from deep wells; drive wells, so known. Some call them artesian wells, and that water that supplies those wells, is the river water, but it is filtered through beds of sand and gravel. We know that that is river water, because the water rises to a level in these wells to the same height as the stage of the water in the river.

Q. These wells, then, are driven out in the soil away
5409 from the river, over the town?

A. Yes sir.

Q. The wells are not on the bank, directly on the bank of the river?

A. Some of them are directly on the bank of the river, but they are filtered just the same.

Q. They are scattered out all over the town?

A. All over the town, yes sir. The city supply, what we call the city waterworks, receive their supply from wells put down about ninety feet, while all other people that have open wells—open wells are a thing of the past in this town—they also use drive wells, but they put them down anywhere from twenty to thirty feet. They obtain just as good a supply of water. Now you can put down a drive well right in the center of the river, and by driving it anywhere fifteen or twenty feet into this sub-soil, you can obtain a pure quality of water.

Q. Is the water—from any observation or examination that you have made or information that you have suitable for domestic purposes?

A. I consider it not suitable.

Q. That is the waters of the Illinois river?

A. Before filtration?

Q. Yes?

5410 A. Without filtration I don't consider it suitable for domestic purposes.

Q. You think you have filtration by means of these wells sunk in the sand?

A. Yes sir, I consider our driven wells, the water to be perfectly filtered.

Q. What is the difference between the current of the Illinois river now and since the opening of the canal to what it was prior to the opening of the canal?

A. I think the current is more rapid since the opening of the canal.

Q. You say you have seen this green vegetable grown on the waters of the river at certain seasons of the year?

A. Especially at low stages of the water. In my opinion it was due to the low stage of the water. The less current we have in the river the less chance the vegetation has to flourish.

Q. Have you noticed since the opening of the canal a greasy, oily appearance to the surface of the water?

A. I have not.

Q. Have you been out much on the water recently? Since the opening of the canal?

A. Yes, I have been out on the water quite often.

H. EHRHARDT, M. L.

5411 Beardstown, Illinois, July 20, 1903.

ED. F. HARRIS,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. Ed. F. Harris is my name; residence Beardstown; and am in the fish business, buying fish.

Q. Have you also been a fisherman with nets yourself?

A. Yes sir.

Q. How long were you engaged in fishing?

A. Oh, I have been fishing, that is and buying fish, for the last eighteen or twenty years; about eighteen years.

Q. What amount of territory have you covered?

A. Well, pretty near all the river from Peoria down below Kampsville.

Q. Before the drainage canal was opened, in January, 1900, what was the condition of the Illinois river?

A. Well sir, the water wasn't as clear as it is at the present time; we always had through the month of July and August we always had a green scum on the river and in the winter time we could cut open holes in the ice in the river and there would be a gas smell from it.

Q. Did some material gather on your nets before the
5412 drainage canal was opened?

A. Yes sir. Well, no material only just the mud and moss of the river before that. That is here.

Q. Did you drink the water of the Illinois river before the drainage canal was opened?

MR. JEFFRIES: Objected to as leading.

A. Yes sir, I drank it.

Q. Since the opening of the drainage canal what has been the condition of the water in the river?

A. Well, the water has been very clear, and I think it has been in better shape except winter before last; we had a slime here winter before last, a very little last winter, but otherwise I think it is in better shape than it was before. It clears up a good deal quicker.

Q. Has there been this green scum upon the water since the opening of the canal?

A. Yes sir; see it every summer when the warm weather begins.

Q. On the river?

A. Yes sir.

Q. Since the opening of the canal?

A. Yes sir, but not so much so as before there was so much current as there is now.

5413 Q. Did you notice on the river before the opening of the drainage canal a little three or two-leaf plant that grew on the surface?

MR. JEFFRIES: Objected to as leading.

A. Yes sir; that I think comes out of the lake; I always thought so.

Q. Does it form here on the river since the opening of the canal?

A. It forms very little, very little.

Q. Describe this slime that you found on your nets since the opening of the canal?

A. Well it is a white substance, as near as I could give it, it is where you would boil pigs feet together, gelatine, but it is very hard to get off; it is very near a whitish color; like stone color, you might say.

Q. Does it form in strings and hang down from the nets?

MR. JEFFRIES: Objected to as leading.

A. Yes sir.

Q. As a fish dealer do you use ice considerably?

A. Yes sir.

Q. What has been the condition of the ice?

A. The ice has been good.

Q. Is it better or worse since the opening of the canal?

5414 A. Well I don't think it could be any better than what we have got here; it is as clear as a crystal.

Q. Is the ice taken here from the river or lakes?

A. Taken from the bay above here.

Q. Does it form from river water?

A. Yes sir.

Q. Are you pretty well acquainted with the fishermen in this vicinity?

A. Yes sir.

Q. Have you known whether or not when they are on the river they drink the river water?

A. Well yes, drink it more or less; of course in the summer time they have ice with them, so they use it in that way.

Q. Do you know of any typhoid fever in the last three years among the fishermen?

A. Not that I know of. As a general thing they have got good health.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How long have you lived here?

A. Oh, I have been here thirteen years last November.

Q. In the fish business all the time?

A. Yes sir.

5415 Q. You don't use the water of the Illinois river at your home for domestic and drinking purposes?

A. No sir.

Q. Now what did you say about being out on the river?

A. Why I say we drink it when we are out on the river; if we run out of water when we are seining, and take ice, we dip up some water. Of course in the morning, we usually take a keg of water with us—well water.

Q. You say you notice the green scum forming to some extent since the opening of the canal?

A. Well there has been some scum on the river nearly every summer, during the months of July and August.

Q. Is it an oily, green scum?

A. No, not hardly now; not as much as it used to be.

Q. You don't know whether there is deleterious matter in the water or not?

A. Don't know anything about it, no.

Q. The bay up here is back from the river?

A. Yes sir, the river affords water for the bay.

Q. Backs up in the bay?

A. Yes sir, when the river comes up, when the river is up high, it comes right down through from the other way. In low stage of water though, you can run in and out of the bay at any time with steamboats.

5416 Q. That is at this end?

A. Yes sir.

Q. Unless the river overflows its banks, there is no current in this bay?

A. No, not so the river gets so the water comes from the other way. ED. HARRIS.

5417 Beardstown, Illinois, July 20, 1903.

MARTIN McDONOUGH,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. Martin McDonough, Beardstown, Illinois; Park Hotel.

Q. How long have you lived in Beardstown?

A. All my life; I was born here.

Q. Do you fish and hunt some on the Illinois river?

A. I fish; never hunt.

Q. Do you fish with a rod?

A. Yes sir.

Q. How frequently have you indulged in that sport?

A. Well, during the fishing season several times a week.

Q. What was the condition of the Illinois river before the opening of the drainage canal in January, 1900?

A. Well, when the water got lower than it does now—the water doesn't get as low now, hasn't got as low since; it seems to me as though during the low water period, there was a difference of a foot of water, probably fifteen or eighteen 5418 inches. I noticed in the fall we had a scum on our water that we don't have now.

Q. How about the clearness of the water?

A. Well, I don't see much difference. I don't know very much about that.

Q. What is the condition of the ice, now as compared with the ice before the drainage canal was opened?

A. Well, I don't see any difference; the ice that we use comes off of the bay and that water is usually always clear.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say the water isn't as clear now as it was before the canal was opened?

A. I said that I didn't know very much about that; I don't know as I could say on that.

Q. You are not on the river much?

A. Yes, I am on the river a good deal.

Q. But you didn't observe it?

A. I didn't observe it so much because when we fished you see our fishing is not so much on the river as in the back water, especially since this water has been turned in, it has changed our fishing grounds; we used to get some fishing in the river then, but we don't now. We get it in the back water. It
5419 has driven us in the back waters.

Q. This ice is cut from the bay up here where the water is still and deep?

A. Yes.

Q. During low water there is very little water from the river gets in?

A. No, that's right. Well it is an arm; like that (indicating). Of course it is all river but it is back from the river; there is no current in there.

Q. And it is kept pure by the waters from the banks, by springs and branches running in?

A. I don't know about that.

Q. Well there is water running in it?

A. Well now, it is really part of the river, only the current doesn't get through there, and leaves the water dormant, and it doesn't muddy.

Q. You don't know whether the water contains deleterious matter or not?

A. No, I do not.

Q. You don't use it in any way?

A. No sir. MARTIN McDONOUGH.

5420 **Beardstown, Illinois, July 20, 1903.**

THOMAS K. CONDIT,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. Thomas K. Condit, Beardstown, Illinois. My occupation is cashier of the First National Bank.

Q. How long have you lived in Beardstown?

A. Since 1874.

Q. Have you in a general way been familiar with the condition of the Illinois river water before and since the opening of the drainage canal?

A. I think so, yes sir.

Q. What was its condition before the opening of the canal?

A. Well, during the stage of low water, we had what we regarded as a very bad condition here, very stagnant water, during the months of August, September and October, when the river was low. In fact a greater portion of the time there was a green scum in front of the city here all of the time, and during the season of the fall of 1901, when we had a low stage of water, and that is since the drainage canal was turned in, why my
opinion is that we had a much better condition of the
5421 river than before; that is there was no smell to the river
and no green scum on the water.

Q. Before the opening of the canal, was there an odor here in the water?

A. There was during the summer months; during the latter part of July, August and September.

Q. What kind of an odor was it?

A. Well to me it was—it smelt more like rotten fish than anything else.

Q. Since the opening of the canal has there been any of that odor in the water?

A. Not that I have noticed.

Q. As a banker are you pretty well acquainted with the people in this vicinity?

A. Yes sir.

Q. What was the condition here before and what has it been since as to typhoid fever?

A. Well so far as my knowledge goes, there has been very little of it either before or after. Occasionally we hear of a case, but very seldom.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How long have you lived here?

A. I have lived here since 1874.

5422 Q. Was this odor prior to the opening of the canal very offensive?

A. Well, to people of a very sensitive smell it was; and to others it was not. I live out on Seventh Street and my wife used to complain of it a great deal more than I noticed it; that is, she called my attention to it.

Q. And you have not noticed any such odor since?

A. No sir, I haven't noticed it since 1901.

Q. Have you been on the river a great deal?

A. No sir, not a great deal.

Q. Neither before nor after the opening of the canal?

A. Oh, I am on the river probably during the summer months twenty or thirty times, fishing or boating. There is hardly a day passes that I don't walk out on the wagon bridge, since it was built, in the morning or evening.

Q. You don't use the water for domestic purposes or drinking purposes?

A. No sir, not at all.

Q. The people don't generally use it?

A. Only people living on the river front; we have a great many drive wells here in the town, but the better class of residents use the city water altogether; I don't think there

5423 are now more than ten or fifteen open wells in town.

Q. When you say the water is better now than it was before the canal was opened, you take in consideration the fact that there is a larger volume of water, a much better current and the water seems clearer?

A. Well, I am basing my position on the general conditions; that is as it appears to me.

Q. Well those are the conditions, are they?

A. Yes sir. Of course there is a stronger current, and during the last eighteen months, we have had the higher water all the time, and consequently there has been a greater volume of water passing down the river.

THOMAS K. CONDIT.

5424 Beardstown, Illinois, July 20, 1903.

G. P. HOLLINGSWORTH,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Johns.

Q. What is your name, residence and occupation?

A. G. P. Hollingsworth; fireman on the Burlington out of here, C., B. & Q. Residence, Beardstown.

Q. Did you formerly live at Browning?

A. Yes sir.

Q. What was your business there?

A. I was in the fruit business there; had a fruit farm.

Q. Had you an engagement there to take samples of water for the State of Illinois?

A. An engagement at Browning?

Q. Yes.

A. Yes sir.

Q. With whom was that arrangement made?

A. With Mr. J. A. Harman, and with Dr. J. H. Long.

Q. Under your arrangement with these gentlemen, how frequently did you take samples of water?

A. Well I don't remember just now; I believe it was
5425 every two weeks, as I remember it.

Q. How many samples did you take?

A. Well, I don't remember that either; I didn't keep any account of it; I took samples at two different times and I don't remember just how many I took.

Q. About when did you commence taking samples?

A. Well I believe it was along in the first of June.

Q. Of what year?

A. 1899.

Q. Did you take samples after the opening of the drainage canal in January, 1900?

A. Why, I think I did; I took at two different times; I took one the next year. One was the second year afterwards—the first year after.

Q. Did you take samples in the fall of one year and the summer of the next succeeding year?

A. No sir.

Q. Did you take samples in the fall of one year and the fall of the next succeeding year?

A. I began taking the next year in June—the first year in June and the next year about the same time, I believe; it was a little later when I began to take these samples the second year.

5426 Q. Did you have directions as to the manner of taking these samples?

A. Yes sir.

Q. Were they printed or oral?

A. Printed and oral both.

Q. How many samples did you take each time?

A. Well, I think there were two; two different samples.

Q. Who furnished the vessels?

A. Dr. Long, I believe.

Q. What kind of vessels were they?

A. They were glass bottles; one was a large bottle; I don't know what it contained; and the other was a small bottle, I don't think it contained over half a pint; they were sterilized bottles.

Q. Where is Browning with reference to the Sangamon River?

A. About one mile southwest.

Q. Above or below the mouth?

A. Below the mouth.

Q. At what point in the river did you take the samples?

A. Well, I was instructed to take those samples about 300 feet above the mouth of the Sangamon River as near as I could get them.

Q. With reference to the position of the river and the current, where did you take the samples?

5427 A. Well, I took the samples as near in the center of the stream as I could; there was not much current there.

Q. At what depth in the water did you take them?

A. Why, my instructions were about as far as I could reach from my elbow down.

Q. Describe the manner in which you handled the bottle at the time you took the sample?

A. Which bottle, the large one, or the small one?

Q. Well the large one first?

A. Well, the large one, I removed the cork and held it down about as far as my elbows and filled it; the sterilized bottle I didn't uncork until I had it under the water. I held it under the water; that was my instructions. I aimed to follow instructions as near as I could in that line.

Q. Were you furnished— After the bottle was filled what did you do with it, with reference to the bottle?

A. Why I corked it up and put it back in its case, in the box that it was sent in.

Q. Was any kind of a cover put over the cork?

A. There was a rubber, a piece of rubber I believe put over the cork of the small bottle; none over the large one.

Q. How was the bottle treated after that with reference to tying it up and putting a tag on it?

5428 A. It was sealed with a stamp.

Q. What was your stamp?

A. No. 10.

Q. How did you pack the smaller bottles?

A. The smaller bottle was packed inside of a small can with ice around it; the small can was packed inside of a large can with ice around it also; there was a small piece of cotton in the bottom for the small bottle to sit on so it wouldn't be broken.

Q. Did the small can contain the bottle?

A. Yes sir.

Q. Did you then put that small can in a larger can and put ice in the larger can around the smaller one?

A. I don't know now just how I did do it; let's see. No there was excelsior packed around the smaller can.

Q. How did you pack the small bottle?

A. Packed the small bottle in a small can with ice around it, and with cotton around it and then I packed the small can in a larger can with ice and excelsior around it.

Q. What did you do with the large bottle?

A. I placed it in the box and packed excelsior around it.

Q. Now after the packing, did you put a tag upon it?

A. Yes sir.

5429 Q. Did you make a notation on the card with reference to the time of taking these samples?

A. Yes sir.

Q. I hand you now nine tickets, the first one dated August 3, 1899, and you may state whether or not the handwriting upon those tickets is yours?

A. I guess it is not anybody else's.

Q. The question is are they in your handwriting?

A. Yes sir.

Q. Now with each two bottles of water that you obtained, did you fill out a ticket similar to those exhibited to you, upon which you put the date, your name, the temperature of the water and of the air and then make some remarks about the current or the rain or something, in addition to signing.

A. Why I put them on those, yes sir.

Q. Did you fill out such a ticket with each pair of samples of water that you took?

A. Yes sir.

JUDGE JOHNS: I now hand the Commissioner the tickets and ask to have them marked State of Illinois Exhibit No. 6 for identification to witness G. P. Hollinger's testimony.

So marked by the Commissioner.

Q. Afer this ticket was so filled out you may state whether or not you placed the ticket in an envelope?

5430 A. Yes sir, I did.

Q. I hand you now an envelope upon which is written "Geo. A. Wiggin M. D." Milan, Illinois, and on which is also written in lead pencil "J. H. L." and ask you to state whether you placed these tickets made out by you in such an envelope?

A. Yes sir, I did.

Q. After it was placed in the envelope, what did you do with it?

A. I tied it to the neck of the larger bottle.

Q. Then what did you do with the samples?

A. I took it to the express office to be shipped.

Q. From what place and to what place and to whom was it shipped?

A. Shipped from Browning, Illinois, to Dr. J. H. Long, laboratory, I think it was 2124 Dearborn Street, Chicago, Illinois.

Q. What time in the day did you take the samples?

A. Took the samples about five o'clock in the evening.

Q. How were they shipped, by express or freight?

A. By express.

Q. How long a time elapsed from the time the water entered the bottle until the package was delivered to the express company?

5431 A. Well, about three hours; took the sample about five o'clock and the express company received them about eight o'clock.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You say you personally made these collections?

A. Yes sir.

Q. How do you know that the bottles were sterilized?

A. Why, I don't know only they told me that they were sterilized. Mr. Harman told me they were sterilized when we were up the river.

Q. You don't know personally that they were?

A. No sir, I don't know it personally.

Q. How deep under the water did you go with the bottle in the water?

A. Which bottle?

Q. Either one of them or both?

A. Well I stated I rolled my sleeves up to my elbows and held them down as far as I could, up to my elbows.

Q. About a foot?

A. About a foot.

Q. Did you rinse the bottles?

A. No, I wasn't instructed to rinse the bottles and I didn't.

5432 Q. You collected a sample once every two weeks?

A. As far as I remember, yes; I don't remember much

about the dates because I didn't keep any track of the dates at all; I wouldn't give any dates accurately, because I don't remember.

G. P. HOLLINGSWORTH.

Adjourned at 5 P. M. to meet at Havana, Illinois, at 9 A. M., July 21, 1903.

5433 Havana, Illinois, July 21, 1903. 9:00 A. M.

Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

HAROLD G. HEBERLING,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Harold G. Heberling.

Q. Where do you live Mr. Heberling?

A. I now live in Easton this county, about thirteen miles east of here.

Q. Did you formerly live in Havana?

A. Yes sir.

Q. Did you ever take any water from the Illinois river for the Sanitary District of Chicago?

A. I did, sir.

Q. What years did you take the water?

5434 A. 1899 and 1900 I believe.

Q. At what point?

A. At a point above the mouth of Spoon river and Quiver Lake.

Q. How far is that from Havana?

A. That's about three miles north of here.

Q. Up river?

A. Yes sir.

Q. Did you take it at any other points?

A. I took it a couple of times when the ice was bad, I couldn't get there I took it above the mouth of the Spoon river on the other side.

Q. How often did you take the water?

A. I took it once a week.

Q. What did you take it in?

A. I took it in bottles that looked to be about the size of a quart, and others that looked to be about two ounce bottles—I mean a gallon I should have said.

Q. Where did you get the bottles from?

A. Why they came from the Adams Express Company from the University at Urbana each time; and from Chicago and I forget now where the other one was from; there was three sets of them though I know.

Q. University of Chicago?

5436 A. Yes sir.

Q. Health Department of the City of Chicago?

A. That's right.

Q. What condition were the bottles in when you got them relative to being corcked or uncorcked?

A. I always found them corked, with a rubber cloth over the cork.

Q. What kind of stoppers did the bottles have?

A. Glass stoppers.

Q. After you got the bottles just describe how you filled them?

A. Why I had a device that held one of the large and small bottles with the mouths even at the top and I would reach down and uncork the bottles and let them run full; then cork them under the water and pull them out and put on the cap.

Q. Were the bottles above or below water when you uncorked them?

A. Below water.

Q. After they were corked and the rubber cap placed over the tops of the bottles what did you do with them then?

A. Why I brought them to town here and either set them on the market boat where the expressman could come down and get them, and if he didn't come I carried them myself.

Q. How did you prepare them for shipment?

5437 A. Why they were packed in a case that would just about fit the bottle, with excelsior around them and then ice packed around them; in a receptacle that just fit the bottle, and with ice around that.

Q. Did you place any mark of identification upon each sample?

A. Why I placed the tags where they were to go. Every one had my name on I believe; had to get out the tag and put on my name and about the steamboats, the change in the currents, temperature of the water according to centigrade thermometer and the direction of the wind and the time also that they were taken.

Q. Anything else?

A. In regard to steamboats passing; that was put down.

Q. The date of taking?

A. Yes sir.

Q. Place of taking?

A. Yes sir.

Q. Temperature of the air?

A. Yes, temperature of the air too, that is right.

Q. And the sample number?

A. Yes sir.

Q. I show you a card, sample No. 1111, and ask you if
that card is in your handwriting and if you placed a similar
card to that upon each sample that you collected and ship-
5438 ped, with the proper memorandum, as indicated in your
last answer?

A. Yes sir.

Q. Did each card have the directions for collecting and sending samples of water for analysés printed on the back similar to the direction on the back of the card I just showed you?

A. Yes sir; I didn't notice that, but I know the directions were always there. I did that rinsing out business too.

Q. Describe what you mean by that?

A. Well I immersed it under the water, took out the cork and let in some water, and rinsed it out.

Q. Then filled it up afterwards?

A. Yes sir.

Q. Now after you had filled the bottles, sealed them and tagged them and packed them in the manner that you have testified to, to whom did you ship the samples thus collected?

A. Well I believe it was Palmer at Urbana, and I can't remember the names exactly.

Q. Was it Prof. Jordan of the University of Chicago?

A. Yes sir, that is the man.

Q. Did you ship any to the Health Department of the City of Chicago?

A. Yes sir.

Q. Dr. Reynolds?

5439 A. Yes sir.

Q. By what express company?

A. By the Adams. They were at the American first and then I changed them over to the Adams.

Q. How long an interval would intervene from the time the samples were collected until they were placed on the train for shipment?

A. If I remember right, I would take them between nine and ten o'clock and they would go out sometime about one. If I remember rightly.

Q. Did you follow the instructions on the back of the card for taking the water?

A. Yes sir.

MR. TODD: Mr. Commissioner I ask to have sample card No 1111 marked Sanitary District of Chicago Exhibit 8 for identification.

Said card is so marked by the Commissioner.

CROSS-EXAMINATION.

By Mr. Jeffries.

Q. Where do you live?

A. I live at Easton, this county.

Q. How far is that?

A. Thirteen miles, out on the Central road.

5440 Q. You mean the Illinois Central?

A. The Illinois Central.

Q. Where did you live when those samples were taken?

A. I lived here in Havana.

Q. What was your business then and what is it now?

A. Why I didn't have much of any business then except to fish along the river. I am now a painter and paper hanger.

Q. Did you collect these samples with your hands or did you use some kind of an instrument?

A. I used an instrument, that is to hold the bottles under, I did.

Q. What kind of an instrument?

A. Why an instrument that I could set on the large bottle and the small bottle, with the mouths at the same level; it had a handle to it; held them under the water while they were filled, while it was cold.

Q. When did you take the stopper out?

A. I took the stopper out when I had them under the water about a foot; whatever it said there; I followed the directions.

Q. The stopper from both the large and small bottles were taken out under the water?

A. Yes sir.

5441 Q. When was the stopper returned to the bottles?

A. The stopper was returned to the bottle while it was still under the water, before it was taken out.

Q. And after you had returned the stopper you put the tag on?

A. Well I first rinsed out the bottle; holding the mouth of it barely under the water and let the water run out that was in there.

Q. Then what did you do?

A. Well then I filled her up and corked it up and sealed her up with a rubber, put the lead seal on it, tagged it up, put the bottle inside the tin can and packed ice around it then packed it around with excelsior and took them down to the market boat; or I never packed them in ice until I got down here to the boat, in taking the water.

Q. How many times did you miss getting the samples off on the train the day that you collected them?

A. I don't know that there was any time; I don't remember any.

Q. Don't you know that there were three or four times?

A. Well, there might have been; not my fault though.

Q. You don't mean to say that you got them to the train in time?

A. No, I didn't get them to the train but I got them down 5442 here on the boat. There may have been a time or two that there was one case delayed that didn't get here; I think there was.

Q. You never took them to the express office yourself?

A. A few times.

Q. Whom did you put them in charge of at the boat?

A. Why I would just set them on the boat there and nobody would bother them.

Q. Whose boat was it?

A. Rudolph and Shafer's.

Q. They were already marked, ready for shipment?

A. Yes sir.

Q. Would you send the expressman word?

A. Yes sir, but he knew the day that I collected them on; I didn't send him word every time.

Q. Well you couldn't tell whether he got them that day or not?

A. Yes, I could.

Q. How could you tell?

A. Well I would be down here to the boat and see.

Q. Now as a matter of fact some of those bottles layed there several hours after you put them on the boat, did they not?

A. Well, possibly they did.

Q. Don't you know that they did?

5443 A. No I don't know as I do.

Q. Well, you wouldn't say that they didn't?

A. No sir.

Q. You say you never notified the expressman each day?

A. No sir.

Q. Why didn't you?

A. Why, it was his duty to come down there and get them; he saw me carry the boxes away from his office and down the hill here every day that I got water; he said he would do it; that is all I know.

Q. How far is it from the express office to the boat where you would put these samples?

A. Why it is a little over a block; pretty near two blocks, I guess.

RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. Did you see him come there for the samples?

A. Many a time, yes sir.

Q. Did you ever discover any samples that he failed to call for?

A. No, I don't believe I did.

Q. This expressman was the agent of the Adams Express Company that you sent the samples by?

5444 A. Yes sir. Mr. Barry. Mr. Bill Barry.

H. G. HEBERLING.

5445 Havana, Illinois, July 21, 1903.

O. H. HARPHAM,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. O. H. Harpham; residence Havana; occupation, Postmaster.

Q. How long have you lived in Havana?

A. Fifty-eight years.

Q. Have you been a fisherman or in any way acquainted with the waters of the Illinois?

A. Not a professional fisherman; an amateur with a hook and line; I have been acquainted with the river all my life.

Q. What has been the condition of the Illinois river at this point prior to the opening of the drainage canal in January, 1900?

A. Condition as to what?

Q. Well as to the water, the character of the water and the substances in the water?

A. For a number of years prior to the opening of the drainage canal in low water in the river, the water was very foul; at times extremely so. I have in mind noticing that 5446 large islands of floating manure that came down. Prior to the time that I was appointed postmaster, I was in the hardware business and a number of years ago, how many I couldn't say, there was a large island of floating manure and offal, I thought it was from Peoria, from the distilleries, lodged against the pier of the wagon bridge. My attention was called to it from the fact that at that time I was one of the directors of the Illinois River Bridge Company, and we were fearful that it would injure the bridge and in attempting to remove it, we attempted to do so by blasting it, not having dynamite, we used common blasting powder. We were very unsuccessful in that and finally removed it by prying and knocking off pieces until the current swung it around and took it through. But it was so large it was impossible for it to get between the draw of the bridge.

MR. JEFFRIES: We move to strike out the answer for the reason that it is incompetent, irrelevant and immaterial; one particular and certain occurrence, prior to the opening of the canal and not tending to prove or disprove any issue in the case.

Q. JUDGE JOHNS: Prior to the opening of the canal, were there foreign substances in the water floating here generally, whether at high or low water?

A. Frequently at low water, there was a certain scum on 5447 the river and it was so much in evidence that you could see the wake or track of a boat; that was not always so, but it was occasionally so.

Q. Was there any smell to the water prior to the opening of the drainage canal?

MR. JEFFRIES: Objected to as leading.

A. At times, yes; that is, at low stage, and in warm weather, it was very offensive. I have noticed it up at my place of business and at my house, four or five blocks from the river.

Q. Since the opening of the drainage canal what has been the condition as to that?

A. I have never noticed anything of that kind, and I am on the river every day or two.

Q. Has there been any green scum on the river since the opening of the drainage canal?

A. Well, I think not, what you would call scum, this last month I have been on the river a good deal. I have a little launch; in fact, I have been on it frequently for several years, boatriding, and I noticed up the bend, the river was covered with seeds and the pods from the willows and maples; it was not a scum, when the wind blew from high water off from the bottoms, it would come out in the bend; I think it is noticeable now.

5448 Q. Now, as to the general character of the water since the opening of the canal as compared to what it was before, what would you say?

A. In my opinion the water is in better condition now than it was before. That is at the same stage.

Q. Do you know of any typhoid fever here since the opening of the drainage canal among the people using the water of the river?

A. I have not heard of a single case.

Q. Are you acquainted with the people of this community and know of them in your capacity as postmaster?

A. I think so pretty generally, yes, sir.

Q. Have you here a delivery system or do the people come to the postoffice for their mail?

A. We have no delivery system; they come to the postoffice for their mail.

Q. From what source is the water supply of the city?

A. The city derives its water supply from drive wells; the wells are driven into the sand; I think we have got one about six or seven blocks east of the river. The wells are driven some fifty feet I think, below the surface of the water before they take in water, and in my judgment, the water is not affected by the river a particle.

Q. Has it a sewage system?

A. Only a partial one.

5449 Q. Into what does the sewer empty?

A. The sewer empties into the river. The sewer only reaches up into the business part of the town a little ways, not very extensive.

Q. What proportion of the inhabitants in your judgment, use water from the public water supply?

A. It is hard for me to judge; one-third to one-half, possibly; a great many do not.

Q. From what other sources do the people obtain water for domestic use?

A. Almost invariably from drive wells, from pumps; there are very few open wells.

Q. What is the population of Havana?

A. About 3,400 or 3,500; I have forgotten the census report; I don't remember.

Q. How far is Havana from LaGrange Locks?

A. My impression is 18 miles; I am not positive.

Q. How far from Copperas creek locks?

A. Oh, I was thinking of Copperas creek locks in the first place; it is about 18 miles from Copperas creek locks; LaGrange is below Beardstown; I should think forty or fifty miles from here. They call it forty miles ordinarily to Beardstown, and it is ten or twelve miles below that to the locks.

5450 Q. How far from Peoria?

A. By rail 41 miles. We speak of it as fifty miles by river.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How far is it from here to the mouth of the Illinois river?

A. I couldn't tell you, sir; I have traveled it a great many times, but the distance I don't know.

Q. These sand wells that belong to the town are located seven or eight blocks you say from the river?

A. Yes, sir.

Q. Do you know the character of the soil or earth through which they go from the surface down?

A. Yes, sir. A few feet on the surface is what we call soil and from there to the bottom as far as we have gone, is sand and gravel with occasional streaks of clay here and there. Those streaks of clay are small; sometimes only an inch or two or a foot or two through.

Q. You say about from one-third to a half of the people of the town use water from these public wells?

A. Yes, sir; I think so.

Q. And the remainder of the people use water from private drive wells or ordinary cisterns?

5451 A. I know of no one who uses a cistern; almost invariably use drive wells, or open wells. The large majority are drive wells; now and then you will find an open well; it is so easy to get water with a drive well; it is easier and cheaper than to dig a cistern. You just simply drive a piece of pipe down and make a well.

Q. There don't any of the people of Havana use the water of the Illinois river for domestic and drinking purposes, do they?

A. No, sir.

Q. Do you consider this water good water for domestic and drinking purposes?

A. The river water?

Q. Yes, sir?

A. I think not, sir; I don't consider any open river water, river or pond or anything of that kind, proper water for domestic purposes.

Q. What is the difference in the flow of the water now and what it was before the Chicago drainage canal was turned into the Illinois river?

A. That is a question for an expert, because of the fact that the difference varies with the height of the gauge of the river; in high water it might be one thing and in low water radically another.

Q. What is the comparative difference in the current between then and now, greater or less?

5452 A. It is considerably greater .

O. H. HARPHAM.

5453 Havana, Illinois, July 21, 1903.

GEORGE W. BUNKER, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. My name is George W. Bunker; I am an upholsterer, repairing furniture.

Q. You reside in Havana?

A. Yes, sir.

Q. How long have you lived in Havana?

A. About twenty years.

Q. Have you fished or boated on the Illinois river?

A. I have done some boating, but never fished except with a hook and line. I lived on a boat on the river quite a while; on a cabin-boat.

Q. Were you employed upon steamboats here formerly?

A. I used to be employed, running down to East St. Louis on a steamboat.

Q. What was the condition of the Illinois river here before the opening of the drainage canal here in January, 1900?

A. Well, in low water, the condition of the water was 5454 very bad indeed; in very low water. The water was so impure that they talked a great deal then about blowing out the dam; thought that they would get better water by cutting a waterway out and letting the water pass off quicker.

Q. Was there an odor in the water?

MR. JEFFRIES: Objected to as leading.

A. Yes, sir.

Q. How about foreign substances in the water; was there anything growing or floating in the water?

A. Well, yes, it was very green sometimes in places where the wind didn't blow it away and I have made the remark several times, if it was not for stamboats running up and down this river, people couldn't live on it. Steamboats agitating the water naturally purified it a little, which was very bad indeed. And through the ice it would not do to drink the water at all. I have tried it and I know something about it.

Q. When the river was covered with ice and a hole was cut in, was there an odor from the water?

A. Yes, sir; as a general thing, yes; you could smell it.

Q. What was its effect upon the fish?

A. Well, I don't know; in some places I know there was a good many fish died, but we laid it to the Pekin and Peoria slop or something coming down there that killed them; I don't know what else it was.

5455 Q. Since the opening of the canal what has been the condition of the water?

A. It has been far superior to any water we have had since I have known the river; it has been better water, purer and sweeter. We don't get none of that bad smell now, that we used to have so bad; that is, not to me.

Q. Do you use the river water now yourself?

A. No, sir; I don't use it, no sir; it is a little too muddy of late. There is a lake and the Spoon river right across here sends out a great deal of mud and muddies the water here and I haven't tasted of it, no, sir.

Q. How far above here is Spoon river?

A. Oh, it is a mile perhaps, it comes in here perhaps up the river a quarter of a mile, where it comes in.

Q. Do you know of the existence of any typhoid fever among the people living on the river since the opening of the drainage canal?

A. No, sir; I don't know of any; I don't think there is any at all; there is a good many people living right on the river, and I know there is no typhoid fever.

Q. Before the opening of the drainage canal, what was the condition of the health of the community here with regard to fever and chills?

MR. JEFFRIES: Objected to as immaterial.

5456 A. Well, I will tell you; there was times that we had a good deal of fever and ague—chills, but that seemed to disappear. You don't hear of it now, but very seldom hear of it, a person having the chills here any more, than on the high ground—than on the hills on the high ground.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How long has it been since you were on the river?

A. I am on it now; close by it.

Q. I know, but out on the water?

A. I am out on it a great deal; out in a boat a good many times.

Q. How many times?

A. Oh, I don't know, three or four, may be.

Q. How many times were you on it last summer?

A. Well, I can't tell you; I used to go out fishing occasionally, but I don't know how many times.

Q. Three or four times?

A. Perhaps so, I don't go on the river very much now any way. I used to be on the river on a steamboat.

Q. You haven't been on the river much lately, for the last several years?

A. No, I live here on the river bank; I lived in a cabin boat; I used to be in the water.

5457 Q. Now?

A. Yes, sir; but I am out of the water now; my boat drifted up where it is and I live up there.

Q. Are you a man of family?

A. No, sir.

Q. You "keep batch," do you?

A. Yes, sir.

Q. How long have you "kept batch?"

A. Well, I guess four or five years; that is off and on; part of the time I live at the hotel. If you are speaking about being on the river, I have been down to Beardstown several times and up to Peoria.

Q. The people here in town use well water, don't they?

A. Yes, sir; hydrant water mostly.

Q. Hydrant water, that comes from the city water system?

A. Yes, sir; but there is a few that use drive wells; they use drive wells here down on the bank.

Q. They don't use the water from the river?

A. No, not for drinking purposes as a general thing. Well, they never have very much, except when they get caught out fishing or something of that kind.

Q. When you say the water is better now than it was before the canal was opened, you mean that is so because there is more current and a larger volume of water now?

5458 A. It smells better; it hasn't got that bad offensive smell like it used to have. You would naturally suppose of course that it was the flow of water that remedies that.

Q. You don't know whether that filth is in there now or not?

A. Well, I don't know, sir; I know the water is a little better, that's all I know.

Q. You don't know what it contains?

A. No, sir. No, I don't know that; I know that quick running water generally smells better, and I suppose that is the result of the drainage. We could notice a change for the better a week after the water came in here, as far as that goes.

Q. The current must be much stronger now than it was before the canal was opened?

A. Yes, sir.

Q. Very much stronger?

A. Well, it was a great deal of dead water at some places; it seemed to be no current at all. Low water; we had very low water then.

Q. You don't have that now; there is always a good current, isn't there?

A. There was pretty low water before the canal was turned in.

Q. What I mean, there is no time of the year now that you have dead water?

A. No.

5459 Q. There is always a current?

A. There is always a current.

GEO. W. BUNKER.

5460 Havana, Illinois, July 21, 1903.

C. M. MORRILL, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. C. M. Morrill.

Q. Where do you live?

A. Havana, Ill.

Q. How long have you lived here?

A. It will be ten years in January, next January.

Q. What is your business?

A. Physician and surgeon.

Q. Doctor, are you acquainted with the Illinois river at this point?

A. Yes, sir, quite well.

Q. How extensive has your acquaintance been with the river?

A. Oh, I used to boat a great deal and had considerable interest in the river. I have been around it here considerably; I haven't boated here much, but I did before I came here.

Q. Where did you boat before you came here?

A. On Rock river.

5461 Q. Have you been on the Illinois river since you have been here?

A. Yes, sir. I have been on excursions considerable, and I have been on launches.

Q. Have you observed the Illinois river before the opening of the drainage canal?

A. Yes, sir.

Q. Describe the condition of the Illinois river at this point before the drainage canal was opened?

A. Why, the first two or three years I was here, we had very low water; had no high water; it was a filthy bank all along, as the waters would recede, along in the summer time, and very little current. Scum and filth all along the banks, a good deal of odor from it so you could smell it clear up town sometimes.

Q. Did you observe anything floating down the river?

A. Yes, there used to be, I don't know what it is called—

cakes of filth that came down from Peoria; there was one at the bridge that they had to dynamite out.

Q. What were these cakes composed of?

A. They said they came from the distilleries.

Q. What were they composed of?

A. Well, I couldn't tell you; I didn't examine closely.

Q. Did you see them?

5462 A. I just saw them from the bank, you know; I didn't go on them. There was a large island came here and lodged at the bridge one time and they tried to blow it out.

Q. Did you ever notice any green scum on the water before the opening of the caial?

A. Yes, sir; it was here every summer; it was here at the Chautauqua grounds so they couldn't land hardly, for it, and had to build a floating wharf out in the river before they could land. There was so much filth there and the river was so low.

Q. Have you observed the river since the opening of the canal?

A. Yes, sir.

Q. What in your opinion has been the effect upon the waters at Havana of the opening of the drainage canal?

A. It has made more current; it hasn't been so low during the summer. The water looks purer and cleaner, and the banks have been much better and there is no stench as there was before.

Q. In times of sudden freshets, before the opening of the drainage canal, what would be the effect upon the river at this point?

A. Oh, it would be cleaned out and there was less
5463 malaria in those seasons when we had high water, and less typho-malaria. We have had very little since there has been high water here. The first two or three years the whole town was full of malaria, and all around here.

MR. JEFFRIES: I move to strike out the answer for the reason that it is incompetent and immaterial and does not prove or tend to prove any issue involved in this case.

Q. Since the opening of the drainage canal in 1900, has there been any typhoid fever in the city of Havana?

A. I haven't seen any, real typhoid.

Q. Have you known of anybody dying of typhoid fever here?

A. Not with typhoid, no, sir.

Q. How large a town is Havana?

A. I don't know what they claim, 3500 or something like that.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Was there any typhoid fever before the canal was opened?

A. Why, there was some.

Q. Have there not been some cases since?

A. I haven't seen any, sir; I don't know that there hasn't been any. I have never seen any cases here since.

5464 Q. The water in the Illinois river is not used by the people of this town for domestic and drinking purposes—the town of Havana, is it?

A. Only by the fisherman, I guess; I don't know.

Q. Doctor, have you any personal knowledge of their using it?

A. Why, they tell me they use it; I have seen them drink it; I have seen the boatmen drink it.

Q. When they were out upon the river?

A. Yes, sir; I went up with John Shelte, on his launch; he drank it on the river. They drink it right along out of the river in a cup, or he had a goblet or a beer-glass.

Q. You don't consider this water good water, do you, for domestic purposes, the river water?

A. I don't consider any river water good for domestic purposes, where cities drain in it, unless they get it from the bottom of the river, and I don't know whether it would be then or not. I wouldn't drink any river water; I have, though. I wouldn't unless I had to.

Q. You say you are not an authority on that subject?

A. No, sir.

Q. Then I take it from the statement that you wouldn't drink it unless you had to that you wouldn't recommend this water?

5465 A. No, sir, not for drinking purposes. I have drank it on these excursion boats when they had ice in it. I wouldn't be particularly afraid of it, but I would rather have better water.

Q. What school of medicine do you belong to?

A. Belong to the regular school.

Q. How long have you been practicing?

A. Thirty odd years.

C. M. MORRILL.

5466 Havana, Illinois, July 21, 1903.

L. A. EVERIST, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. L. A. Everist.

Q. Where do you live?

A. Havana.

Q. How long have you lived here?

A. I have lived here all my life, thirty years.

Q. What is your business.

A. Fishing.

Q. How long have been fishing?

A. Never done anything else.

Q. Commenced to fish right after you were born?

A. No, sir. I fished when about fifteen or eighteen years, possibly.

Q. What was the condition of the Illinois river at this point before the opening of the drainage canal?

A. In regard to the stage of waters or—

Q. Everything.

5467 A. Well, the water got very low during this season of the year and the water got very filthy.

Q. How did the filth manifest itself?

A. Well, during the cool season, during the season that the water was cold, it seemed to be more filthy, there was more of that stuff running.

Q. Was there any odor to the water?

A. Yes, sir; during the season when it would be froze up it would smell bad.

Q. In what way?

A. Well, it would smell bad and be filthy so it couldn't be drank or anything.

Q. During the summer in low stages, was there any scum on the water?

A. Yes, sir.

Q. Describe it?

A. A green scum.

Q. What effect would the water have on fish in the winter time?

A. Well, it would kill them if I didn't get in the spring water; the fish on the river would die after it had been froze up for some time.

Q. Did you ever see any fish taken from under the ice?

A. Yes, sir.

5468 Q. Just describe it?

A. Well, after it would be frozen up for some time, the fish would have to go into the spring water or they would die; they would die and float down the river, and get weak—they would swim along the edge of the river and people would pull them out with gigs or forks or something; they would be so weak that they couldn't get out of the way. I have seen them condemned so they wouldn't take them when it would be frozen up at all; all fish around this point.

Q. At what markets would they be condemned?

A. St. Louis and in the east, at New York.

Q. Did you ever fish through the ice here?

A. Yes, sir.

Q. What would be the effect upon cutting a hole in the ice before the opening of the drainage canal?

A. Well, there would be an awful smell and the water would be very filthy.

Q. Did you ever see what is known as Peoria Islands floating down the river?

A. Yes, sir.

Q. What are those islands composed of?

A. Manure.

Q. When and where did you see them?

5469 A. During the flows of the Illinois river and I have seen them all the way from this place to Peoria.

Q. How large would those islands be?

A. Well, they would vary in size all the way from two or three feet to fifty feet, I suppose, square; possibly larger.

Q. Did you ever see any of them here at Havana?

A. Yes, sir.

Q. Where?

A. I saw a large one lodged against the bridge here that I know was blasted loose; and I saw them along the islands and along the shores on both sides of the river.

Q. Since the opening of the canal, what has been the effect upon your nets?

A. Well, since the opening of the canal—in regard to lasting better or—

Q. Yes?

A. Well, we can fish through the summer time and they last better than before. The water is more cool.

Q. How about in the winter time?

A. Well, in the winter time that stuff collects on them just the same.

Q. What stuff do you mean?

A. Why, slime; it is caused from the stills at Pekin and the glucose factory, I suppose.

5470 Q. What is the nature of that slime?

A. Why, it is a slimy substance and will stick to anything it touches; it flows in small pieces, but it collects in large quantities on anything it happens to touch.

Q. Has it a name among the fishermen?

A. Yes, sir; we call it slur-gut among the fishermen.

Q. And did you have that accumulation before the opening of the canal?

A. Yes, sir.

Q. As much as you have it now in winter?

A. Yes, sir.

Q. How are the nets cleaned from the effects of this slur-gut, as you call it?

A. Why, they are shaken and taken out on the bank and whipped with sticks.

Q. What is the color of it?

A. It is a kind of a light color,—white.

Q. How far up the river do you fish and have you fished?

A. Why, I never fished much above Kingston—between here and Kingston is my principal fishing territory.

Q. Do you find this substance on your nets up that far?

A. Yes, sir.

Q. Do you have it on the nets in summer as well as winter?

A. No, sir; not at this point.

5471 Q. Do you have it now in winter in the same quantity as you did before the opening of the drainage canal, or in greater quantity?

MR. JEFFRIES: Objected to as leading.

A. Well, I don't know as there is much difference to speak of.

Q. What in your judgment, has been the effect of the opening of the drainage canal on the water of the Illinois river at this point?

A. Well, it has been higher; the water has been cooler, purer,—I couldn't see why it wouldn't be more pure.

Q. Have any smell to it?

A. Not so much.

Q. The water still has a smell at low stages, has it?

A. During the time that it is frozen up if it is frozen very much it will have a smell; but since the canal was turned in, there is more current and it doesn't freeze so much; don't stay frozen so long.

Q. Have you been up the river from here to Peoria since the opening of the canal?

A. Yes, sir.

Q. How does the water compare as you go towards Peoria?

A. In regard to that there filth?

Q. Yes?

5472 A. In the fall of the year, as the water begins to get cooler, it begins to flow and it is stronger and there is more of it near Peoria than there is near this point.

Q. This slur-gut that you speak of, does it appear more in winter time than in summer?

A. Yes, sir; it can scarcely be noticed in summer.

Q. Have you found a reason for that ?

A. Well, I couldn't say as to that positively; I think it is possibly because the water is warmer and it don't have a tendency to float; it don't have a tendency to float in the warm weather as it would in the cold.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Do you live in a house-boat on the river?

A. No, sir.

Q. Live in a residence?

A. Yes, sir.

Q. Man of family?

A. No, sir.

Q. Do you live at home with your parents?

A. Yes, sir.

Q. You use water from the city water system, do you, for domestic purposes at home?

A. No, sir, we have a well.

5473 Q. Is it a driven well?

A. No, sir, it is an open well.

Q. Living well, then?

A. Yes, sir.

Q. What time of the year do these Peoria islands come down the river?

A. During the spring season.

Q. Are they frozen?

A. At times they are, yes, sir.

Q. Did you see them coming since the canal was opened?

A. Yes, sir.

Q. They come much more rapidly than they did before the opening of the canal, don't they?

A. Yes, sir, they travel a little faster, I guess.

Q. Don't you know that they do?

A. Yes, sir.

Q. Do you know whether any of them come from Chicago or not?

A. No, sir, I couldn't say.

Q. Do you use the water of the Illinois river for domestic purposes?

A. Why, I drink it when I am fishing in the spring.

Q. You don't drink it when you can get anything else to drink, though?

A. No, sir.

5474 Q. What is the difference between the current of the river now and what it was before the canal was opened?

A. We have more current in low water than we did before.

Q. Stronger current?

A. Yes, sir.

Q. Do you notice the oily scum on the river now?

A. Well, slightly; very slight.

Q. Kind of a greasy appearance?

A. It is a mossy appearance.

Q. Do you know that these Peoria Islands come from Peoria?

A. Not positively; I always heard so.

Q. What fish thrive best in this river; what kind of fish?

A. Why, they seem to all thrive.

Q. Which thrives best?

A. I couldn't see much difference; the fish are all thriving well; the carp does the most well.

Q. Isn't the carp the most plentiful at the present time?

A. Yes, sir.

Q. Do you know what the carp feed on?

A. Not altogether, no, sir.

Q. They will feed on most anything, won't they?

A. Yes, sir.

Q. You say this slime and material that accumulates, does it accumulate on your nets in the winter time?

5475 A. Yes, sir.

Q. Did it accumulate on your nets in the summer time before the canal was opened?

A. No, sir.

Q. It accumulated just about as much afterwards as it did before?

A. Just about the same.

L. A. EVERIST.

5476 Havana, Illinois, July 21, 1903.

SAMUEL F. KYLE, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. Samuel F. Kyle; residence, Havana, Macon county, Illinois; occupation, ice business.

Q. How long have you been in the ice business here?

A. About nine or ten years.

Q. Did you take samples of water at this point for the state of Illinois?

A. I did for Mr. J. H. Long, for the state; Prof. J. H. Long of the Northwestern University at Chicago.

Q. During what time did you take the samples?

A. Well, I couldn't give you—the dates are there; I have forgotten; I couldn't give you the dates now without referring to the cards. I took them on the dates ordered by Prof. Long.

Q. Did you receive instructions from Prof. Long as to how to take the samples?

A. I did personally; Prof. Long came here personally and instructed me how to take the samples.

Q. Were there also printed instructions as to the manner in which they should be taken?

5477 A. Yes, sir; on the back of the card.

Q. From what point did you take samples?

A. From the Illinois river above the mouth of the Spoon river and from the Spoon river beyond the influence of the Illinois water.

Q. In what kind of vessels did you take them?

A. In bottles; one bottle I presume—they were a glass bottle with the cork fixed tightly with a rubber seal over it, and a rubber band around it. One bottle I presume would hold a gallon; the other bottle would hold a half pint.

Q. Did you always pursue the same method in taking the samples?

A. I did.

Q. From whom did you receive the bottles?

A. From the express company here, for Mr. Long of Chicago; the American Express Company, I think it was.

Q. Describe the manner in which you took each sample in each bottle?

A. By immersing the bottle about a foot below the surface of the water—that is the small bottle—uncorking it in the water and as the bubbles would come up—of course when the bubbles ceased, I would close it; I knew it was full at that time; seal it with that glass stopper and bring up the rubber close around

it and tie the rubber band around the mouth of the
5478 bottle; that was the smaller bottle and the larger bottle
was done much in the same manner.

Q. How did you seal or cover the larger bottle?

A. It had a glass cork with a rubber cover and a rubber around it; it was just a light rubber that went over the cork and down from the mouth of the bottle so as to prevent the external atmosphere from having any influence on it.

Q. After the bottles were filled and tied up, what did you do with the smaller bottle?

A. Put it in a small can, and that can into a larger one; the small can I suppose was about the size of a quart; the larger one would hold a galon I suppose or two gallons; and it was packed in ice, and a material—I have forgotten the name of the material; it was a wood cutting—

Q. Excelsior.

A. Excelsior, it was covered with excelsior and ice placed around it; outside of the larger can and inside the smaller one, the ice was.

Q. After they were packed in ice what did you do with them?

A. We had a box, I suppose was about six inches by fourteen inches; there was a partition between—wooden partition. This bottle was in one side and the large can in the other packed
with excelsior also, and on top of the excelsior I placed a
5479 little piece of ice also, inside, and carried them to the ex-
press office and shipped them as soon as possible.

Q. At what time in the day did you take the samples?

A. In the morning, about five o'clock in the morning.

Q. From the time the samples were taken, until they were placed in the express office, how long?

A. From a half an hour to an hour, I presume.

Q. Did you have any regular time for taking the samples?

A. I would get these orders from Dr. Long, perhaps an order for four different samples and I would always follow his instructions; they would come a week apart, perhaps two weeks apart, sometimes one week apart, and then perhaps there would be several weeks of an interim, then another order for so many different samples again.

Q. Did you use any cards upon which you wrote the time and place of taking samples?

A. I did.

Q. When you took the samples, did you place upon the card the date when it was taken, the temperature of the water, the temperature of the air and the place of collection?

A. Yes, sir.

Q. When you had so prepared the card what did you do with it?

A. Tied it around the neck of the bottle; attached to the bottle, in the case that was shipped.

5480 Q. Did you place the card in an envelope and tie the envelope to the bottle?

A. Yes, sir; it was a little envelope; put it in the envelope and tied the envelope if I remember distinctly—it had Prof. Long's name printed on it and his address.

Q. I now hand you an envelope on which is written in ink "Geo. A. Wiggin, M. D., Milan, Ill.," and in lead pencil the letters "J. H. L.," and ask you to state whether that envelope is similar to the ones in which you placed the cards?

A. Yes, sir, very much.

Q. Through the hole in the envelope you passed a string and tied it to the neck of the bottle?

A. To the neck of the bottle—to the rubber that was over the neck of the bottle.

Q. I now hand you thirteeen cards and ask you to examine them and state whether those are the cards which you used and put into the envelopes on samples taken from the Illinois river? Here is another card which makes it fourteen.

A. Yes, sir, these are the samples with my notations on them, required by Mr. Long.

Q. I will ask you to examine one numbered 76, and state whether or not you wrote that one?

A. That is not in my handwriting; I think perhaps I carried that to the express office; not having the cards on
5481 hand that morning, understand, that is my impression,
that this card is not in my handwriting, and I think the express agent just wrote that on there at my dictation.

Q. For you?

A. Yes, sir; that would be my impression; the rest of the cards I can say are all in my handwriting.

JUDGE JOHNS: I now hand the Commissioner the cards above referred to and ask him to mark them Exhibit No. 7 for the State of Illinois, to the testimony of S. F. Kyle, for identification.

Said cards are so marked by the Commissioner.

Q. I now hand you forty tickets or cards, and ask you to examine them and state whether or not the writing on them is yours and whether they are the cards which you enclosed in the envelopes and attached to samples collected by you in the Spoon river?

A. Thirty-eight of them are, sir, and I presume the other two are by the agent, as they seem to be in the same handwriting. This I know is my card, because my notations are on there in my handwriting. The other I think is by the agent; 38 of them are in my handwriting.

Q. Are the cards numbered 142 and 156 cards prepared by you or by some person for you?

A. They were prepared by some person for me to the
5482 best of my remembrance; they were prepared for me by
the express agent.

JUDGE JOHNS: I now hand the Commissioner the 40 above mentioned cards and ask him to mark them Exhibit for the State of Illinois No. 8 for identification, to the testimony of S. F. Kyle, Spoon river.

Said cards are so marked by the Commissioner.

Q. What do you say is the difference, if any, between the character of the ice taken at this point, before and after the opening of the drainage canal?

MR. JEFFRIES: We object to the question for the reason that it assumes that ice is cut here and for the further reason that it assumes that the witness knows.

A. Well, our ice that we have taken here, has been the same, because we have taken it out of the bay here, which is outside of the influence of the Illinois river, or out of these lakes, and I have noticed no perceptible difference. Took it out of Seid's Lake up here.

Q. As to the general character of the water and its general condition, before and after the opening of the drainage canal, what do you say?

A. Well, as far as I know the water is better than it was before, that is apparently to me; more current and less stagnation about it. But that's only observation. I have never
5483 made any study of it; but that would be my impression, because I never had noticed this question before the question was brought up; that would be my judgment.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You are a married man, are you?

A. Yes sir.

Q. You don't use the water of the Illinois river for domestic purposes?

A. No, we use hydrant or well water.

Q. Since the opening of the canal you have noticed the oily, greasy substance or coloring on the water, have you not?

A. No, not to my knowledge.

Q. Have you been on the water very much?

A. No, only at ice times; I am not a fisher or hunter, only occasionally at times; perhaps three or four times a year; only at these times you understand that I took these specimens of water; these samples, but I have been about the river on an island up here, but not in the water at all.

Q. How does the current of the Illinois river compare now with what it was prior to the opening of the Chicago drainage canal?

A. I think it is swifter now.

Q. Very much swifter now?

A. Quite a good deal.

5484 Q. You have now a good current at all seasons of the year?

A. Yes sir.

Q. Where is this lake located from which the ice is cut in the winter time?

A. This lake is called Cook Harbor and is located right west of the ice house at the Northwest portion of the city of Havana.

Q. How is that lake fed?

A. Fed by springs, and by the flow of water that comes down from Quiver Creek, it is called.

Q. What portion of the ice is cut from this lake?

A. All of it has been cut there with the exception of one year; one year we cut from the river; that was before the drainage was turned in and year before last we cut from Seid's Lake.

Q. Where is Seid's Lake?

A. About half a mile west and about a mile or mile and a quarter north of Havana.

Q. How far is Seid's lake from the river?

A. About 200 yards, and the mouth of it opens into the river.

Q. Seid's lake is also fed from springs, is it not?

A. No, Seid's lake is fed from Thompson lake, I think, and from the Illinois river; but I think it is fed from Thompson's lake.

5485 Q. Where is Thompson's Lake fed from?

A. It is fed from the river I think and from Thompson's river on the north.

Q. How deep is the water in these three lakes, from which the ice was cut in the winter time?

A. From six to ten feet I should judge.

Q. What did you say was the name of this first lake?

A. Cook's Harbor I think it is called.

Q. Since the opening of the canal, all of the ice has been cut from that lake?

A. From that and Seid's lake.

Q. Where did you say you took these samples from?

A. From the Illinois river above the mouth of Spoon river and from Spoon river.

Q. Where is Spoon river?

A. Spoon river flows into the Illinois river west of Havana.

Q. And above Havana?

A. Above a portion of it, not above the extreme northern line of Havana; above here, but the extreme northern line of Havana is above the mouth of the Spoon river.

Q. Is Spoon river on the opposite side of the Illinois river from Havana?

A. Yes sir.

Q. How large is Spoon river at its mouth?

5486 A. Oh I suppose 100 feet about; 75 to 100 feet about.

Q. Did you personally take each one of these samples?

A. I did.

Q. You have not been on the river much since the opening of the canal other than taking these samples and fishing, or hunting?

A. That's all, either fishing or hunting, once a month or so.

S. F. KYLE.

5487 Havana, Illinois, July 21, 1903.

JOHN McGARVEY,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. John McGarvey.

Q. Where do you live?

A. Havana.

Q. What is your business?

A. Fishing.

Q. How long have you been fishing on the Illinois river?

A. Twenty-six years.

Q. What part of the Illinois river have you fished in?

A. Oh, I have fished in La Salle and Peru and Henry and down as far as Beardstown.

Q. State what the condition of the Illinois river was before the opening of the drainage canal?

A. It was pretty poor; I don't think if the drainage canal hadn't been turned in here we would have had half of the fishing we have got now.

Q. How was the water of the Illinois river before the opening of the canal?

5488 A. Oh, it was dead; kind of rotten and smelled at low water.

Q. Was there any odor on the water?

A. What do you mean?

Q. Smell?

A. Yes there was at low water mark.

Q. How far up did that odor extend, from Havana?

A. Well, it didn't extend any further than from here to Peoria.

Q. Was there any scum on the water?

A. Not very much there wasn't, without it was right low.

Q. As you went from Havana towards Peoria, would the water get better or worse?

MR. JEFFRIES: Objected to as leading.

A. It got worse.

Q. Describe the condition of the water as you would go from Havana to Peoria?

A. Before we would get to Peoria and Pekin it would smell a little worse.

Q. What was the cause of it?

A. The distilleries.

Q. Where?

A. At Pekin and Peoria.

Q. After you passed Peoria, what is the condition of the water?

5489 A. It is better.

Q. How far above Peoria did that condition prevail, the water being better than below?

A. As far up as I ever was along it.

Q. And how far up is that?

A. Well I have been up as far as Ottawa, along the river; I have fished as far up as La Salle and Peru and down to Beardstown and La Grange locks.

Q. What was the condition of the water as you went from Peoria, to Beardstown?

A. Well I couldn't see any difference from here. In the winter season it was pretty near as bad along down there as it was here.

Q. Since the opening of the drainage canal, what has been its effect upon the waters of the Illinois river at this point?

A. I think it has been better.

Q. In what way better?

A. Why the water was more pure; purer than it was before; when the water was low it seemed to be dead like; now there is a current through it, and it is purer too.

Q. Is there any smell to the water?

A. Yes, if you cut a hole through the ice in the winter there is a smell to it.

5490 Q. That is, since the opening of the canal?

A. Well not as bad as it was before.

Q. But you have the smell now?

A. Yes sir, some, but not as bad as it was before that.

Q. In your experience as a fisherman, have you come across a substance known as slurgut.

MR. JEFFRIES: Objected to as leading.

A. Yes sir, I have.

Q. What is this substance so-called by fishermen?

A. Slurgut; that's all the name we ever heard for it; we thought it come from these distilleries above Peoria. There ain't none of it above Peoria.

Q. Is that the name that it is commonly called by fishermen?

A. Yes sir.

Q. Describe what it is and how it affects the nets?

A. Why take it in the fall when the water gets cool; it settles on the nets; it is stringy stuff and just closes up the meshes. You can't lift the net or see through it and nothing will work into the net at all. It is all that two men can do to just move the net out of the water to save their lives. After it is in there 24 hours.

Q. Did that substance appear before the opening of the drainage canal?

A. Yes sir.

5491 Q. And have you had it since?

A. Yes sir, every winter but I don't think it is quite so bad since we got the current in the river.

Q. Did you ever see that substance above Peoria?

A. No sir.

Q. Have you ever seen what are known as Peoria Islands floating down the river?

A. Yes sir, some pretty good sized ones too.

Q. How large?

A. Thirty or forty yards.

Q. In the spring season?

A. I have seen in the spring when the ice broke up; I never counted them—but I seen a good many float over on the island and the bend and around the edge of the river.

Q. Do you remember seeing one that lodged in the river against the bridge?

A. Yes sir.

Q. What are those islands composed of?

A. Well all that I seen was hay and manure.

Q. Do you know where they come from?

A. Not exactly; they all say they come from the still houses at Peoria and Pekin; I never seen them move out.

5492 Q. Did you ever see any above Peoria?

A. No sir.

CROSS-EXAMINATION.

By Mr. Jeffries.

Q. You never fished much above Peoria, did you?

A. Yes sir; I used to live up at Lacon and up to the upper dam.

Q. These Peoria Islands didn't come down in the summer time?

A. No I never seen one in the summer.

Q. Either before or after the opening of the canal?

A. Oh yes sir, they used to come through here in the spring.

Q. But I mean in the summer time?

A. No sir, I never seen them come down here in the summer time.

Q. What do you mean when you say the water is purer?

A. Well it ain't dead; there is a good current through here and it keeps all the trash and everything out.

Q. Where does all that trash go to?

A. Well, it goes down the river or else back, one of the two; I don't know where it goes to.

Q. You say the water smells some now since the opening of the canal?

A. Well if you cut a hole in the ice in the winter you can 5493 smell it a little.

Q. The current is much stronger now than it used to be?

A. Yes sir.

Q. What fish thrive best in these waters?

A. Pretty near every kind I guess. Thrive you mean?

Q. Yes?

A. I don't see no difference.

Q. Which is the most plentiful?

A. Carp.

Q. What do they feed on?

A. They feed on flags and roots and things.

Q. They feed on most anything, don't they?

A. Pretty near.

Q. You live here in town?

A. Yes sir.

Q. Married man?

A. Yes sir.

Q. Do you have a pump at your home?

A. I use from a hydrant.

Q. You don't use the river water?

A. No sir.

Q. You don't use the river water for domestic purposes?

A. Only when it is cold weather we drink it; when it is 5494 cold, in the fall and spring and winter.

Q. You drink it only when you are out on your trips fishing?

A. Yes sir.

Q. You don't drink it when you can get anything else to drink.

A. No sir.

his
JOHN (X) McGARVEY.
mark.

5495 Havana, Illinois, July 21, 1903.

ERNEST O. SPINK,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Ernest O. Spink.

Q. Where do you live?

A. My home is in Chandlerville.

Q. Mr. Spink did you ever take any water for the sanitary district?

A. I did.

Q. From what river did you take the samples?

A. Sangamon river.

Q. When did you take it?

A. Well I couldn't say accurately, but you could tell from the cards, I suppose.

Q. About from what time to what time?

A. It was about from February until October I believe.

Q. And how often did you take it?

A. Once a week.

Q. You got the bottles from where?

A. One came from Chicago and two from Champaign.
5496 I would say, two from Chicago and one from Champaign.

Q. The bottles had glass stoppers in them when they came?

A. Yes sir.

Q. Now when you got the bottles how did you fill them?

A. In the summer time I waded out; I had on long legged rubber boots; I waded out as far as I could and filled them, after keeping the stopper in the bottle until I had them submerged, and then opening the stopper and filling them in that way. In the winter I walked out on the ice and cut a hole in the ice, and filled them the same as I did in the summer by submerging them.

Q. What point on the Sangamon river did you take these samples?

A. It was about 100 yards below the wagon bridge,—well it was on what they call the Mason County road.

Q. At what town?

A. At Chandlerville; about a mile from Chandlerville.

Q. What sized bottles did you use?

A. The large one I should judge would hold about a gallon and the smaller one would hold from three to four ounces.

Q. After you collected the samples what did you do with them?

A. I sealed them there at the river and took them straight to the depot after packing them and shipped them from there.

5497 Q. To whom?

A. Now I don't remember who.

Q. To Prof. Palmer?

A. Prof. Palmer was one.

Q. At Urbana?

A. At Urbana.

Q. Prof. Jordan of the University of Chicago?

A. Prof. Jordan of the University of Chicago.

Q. And the Board of Health of the City of Chicago?

A. And the Board of Health of Chicago.

Q. After you had sealed the bottles, did you pack any of them in ice?

A. The smaller bottles I packed in ice and tin cans; the larger bottles I just packed with excelsior.

Q. Did you place a card on each bottle, identifying the sample?

A. I did.

Q. On the card did you place the number of the sample; the date of taking, the hour of taking from the Sangamon river, with your name, height of water, temperature of water; direction of wind, temperature of air, rain, with the instructions for the taking of the water written on the back?

A. I did.

5498 Q. I show you a card sample No. 1081 and ask you if that card is in your handwriting, and ask you if you placed a card similar to that on each sample that you took, and sent to the three parties heretofore mentioned?

A. I did.

MR. TODD: I will ask the Commissioner to have sample card No. 1081, marked Sanitary District of Chicago No 9 for identification.

Said card is so marked by the Commissioner.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Where did you say you took these samples?

A. Sangamon river.

Q. How far up the Sangamon river?

A. About 100 yards south of the Mason County wagon bridge.

Q. How far from the mouth of the Sangamon river?

A. I have forgotten.

Q. Approximately?

A. I think it is 18 miles from Browning to the mouth of the Sangamon river.

Q. Where did you take the samples to ship them?

A. At the express office and depot at Chandlerville.

5499 Q. How far is Chandlerville from the point where you took the samples?

A. About one mile.

Q. How long after the samples were taken until they were put on the express train?

A. Sometimes it would be a half an hour, and not over three hours.

Q. You took no other samples than those mentioned in your direct-examination?

A. I did not.

Q. And for which cards were attached to the samples at the time?

A. They were.

ERNEST O. SPINK.

5500 Havana, Illinois, July 21, 1903.

RICHARD L. ENGLAND,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. Richard L. England; residence, Havana, Illinois; my occupation is fisherman.

Q. How long have you been a fisherman?

A. Over thirty years.

Q. How long have you been living upon the Illinois river?

A. Over fifty years; I have lived in Havana over fifty years.

Q. Over what portion of the Illinois river have you fished?

A. Well I have fished say twenty miles above here and twenty miles below; about forty miles is the distance.

Q. Are you a fisherman who employs men?

A. Yes sir.

Q. Fish on a large scale?

A. Fish on a large scale.

Q. What was the condition of the Illinois river and its waters prior to the opening of the drainage canal in January, 1900?

5501 A. Well, in our early fishing here; we used to fish altogether with bait nets and seines, and the sediment or settling was so bad that we had to quit that kind of fishing; I don't hardly know how to explain that.

Q. Were there substances growing in the water?

A. No sir, it was substances floating here; the main body of it was corn, the appearance of it; it would fill the nets full that we had to crab it out with a windlass.

Q. Was there—

A. I was going to tell you; the appearance of that when the weather gets cold; there is something that would form on there like cotton; it would collect on the nets, and the meshes were all full like a blanket.

Q. What was the color of this substance?

A. The corn was its natural color, the parts of grains was its natural color and the substance that formed on it was gray.

Q. Was there a smell to the water?

A. When it was froze up; more smell when it was froze up than any other time; we would cut holes in the ice and could hardly stand it over the holes in the winter; we would raise the nets and the fish in the nets would be dead.

Q. Now since the opening of the drainage canal, what has been the condition of the water here?

A. Well, in my opinion it has been a good deal better;
5502 we went back to the same kind of fishing that we did then,
but we had to quit. We don't get near so much of that floating stuff that we did before. The current of course, makes it better too; more current makes the water pure.

Q. To what did you and do you now attribute this floating slime on the water?

A. Well it came from Pekin and Peoria; the sugar refineries, and the distilleries I think is what caused it. That is, from the looks of the sediment, that is the corn and stuff; it naturally came from there. It was not at that time above Peoria; they hadn't the same trouble with it because I was acquainted with all the fishermen there and they claimed that they weren't bothered with it above there.

Q. Are you or have you a considerable acquaintance with the people living upon the river in this vicinity?

A. Yes sir.

Q. What is their condition of health and especially with reference to typhoid fever?

A. Well, the fishermen as a general thing, you hardly ever see one of them or ever hear of one of them having it; I can't hardly mention one that ever had the typhoid fever.

Q. How long do fish live in live-boxes now as compared with the time before the opening of the canal?

A. Well, that is a pretty hard question to answer, but
5503 we have had fish now for a week in the boxes, and usually they would die here when that stuff would come in,
hot weather, in one night. You couldn't keep them at all. You couldn't keep them at all because before we had fish, if we had fish to amount to anything, we had to take them to the mouth of Spoon river and put them in there. We have done it several times.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. The current in the river is much stronger now than it was before the canal was opened?

A. Yes sir.

Q. You say you have fished up the river as far as twenty miles and down the river twenty miles from Havana?

A. About that distance, yes sir.

Q. What do you call this substance that forms on the nets?

A. Got no name for it. We don't know what it is. It is an every year occurrence.

Q. Don't you fishermen have some name for it?

A. A nickname; we call it slur-gut; that is all we have for it. You know of course that is not the proper name. In the heart of all that where it starts to fork, it sprangles out like that (indicating) like your fingers, and when you examine it, right in the center, there is a small bit of corn, probably as short as that (indicating). That is where it starts from 5504 just like hair grows out, and that will float.

Q. You get that substance now don't you, since the canal was opened?

A. Why, some of it last winter, but it is only just a short time. We get rid of it quickly if there is anything in the river. Just a little of it will come down.

Q. You have a well or a pump here in town—are you a man of family?

A. Yes sir.

Q. You don't use the water of the Illinois river for domestic purposes at your home?

A. No sir.

Q. You don't use it under any circumstances, even when you are out fishing, unless you get caught out and haven't anything else?

A. Well, we use it in the winter when the water is cold enough, we don't use any other water.

RICHARD L. ENGLAND.

5505 Havana, Illinois, July 21, 1903

GEORGE E. McHOSE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. George Ephriam McHose; Havana, Ill.

Q. How long have you lived in Havana?

A. I have lived here permanently since 1872.

Q. What is your business?

A. I run a boat livery here.

Q. If you occupy any official position, state what it is and how long you have occupied it?

A. Well, I am Mayor of the city at the present time; I think this is my seventh term.

Q. Were you familiar with the condition of the Illinois river at this point before the opening of the drainage canal?

A. Yes sir.

Q. State its condition at that time?

A. Well it was stagnant and dirty and everything else; dead fish.

Q. Did it have a bar odor?

A. Yes sir.

5506 Q. What was the condition of the river since the opening of the drainage canal?

A. Well the water is in a great deal better condition.

Q. Before the opening of the drainage canal was there a kind of a slime in the water?

MR. JEFFRIES: Objected to as leading.

A. Yes sir.

Q. Since the opening of the canal is that slime in the water?

MR. JEFFRIES: Objected to as leading.

A. Not so much so; there is some.

Q. Do you know of any typhoid fever in this vicinity since the opening of the drainage canal, among the people living on the river?

A. No sir.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Have you fished any lately?

A. Yes sir, with a hook and line.

Q. You never fished with anything else?

A. No sir.

Q. You are a man of family, are you?

A. Did have at one time. I have got one son living.

5507 Q. You don't use the water in the Illinois river for domestic purposes?

A. Nothing only for washing; don't use it for drinking.

Q. You use hydrant water for drinking, do you?

A. Yes sir, we have a cistern.

Q. The current in the river is much more swift than it was before the canal was opened?

A. Yes sir, and more water.

Q. You don't know whether it contains deleterious matter or not?

A. No sir; all I know about it is observation, the fish and turtles and stuff that used to die before the opening.

Q. Well, all that you know is by observation?

A. Yes sir.

Q. If they do die now they are carried away?

A. Well, we don't see them, they don't come around; they don't come to the shore if they do die.

GEO. E. McHOSE.

5508 Havana, Illinois, July 21, 1903.

PHILIP L. DIEFFENBACHER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Philip L. Dieffenbacher.

Q. What is your business?

A. Physician and surgeon.

Q. How long have you been practicing in Havana?

A. Since 1856, about 48 years.

Q. Been in this city all the time?

A. With the exception of three years in the army.

Q. You are acquainted with the river at Havana?

A. Yes sir.

Q. Do you know what the condition of the river was before the opening of the drainage canal?

A. Well before the opening of the drainage canal it got very low and since the dams were put in there is a great deal of deposits along the shore. In some places it extends out 100 feet from the shore.

Q. Was there any scum on the water at low tide?

A. Oh yes.

Q. Any odor?

A. Yes, well there would be a peculiar odor, I can't
5509 describe it.

Q. What in your judgment has been the effect of the opening of the drainage canal upon the Illinois river at this point.

A. It has improved the condition of the water.

Q. Before the opening of the drainage canal did the river have any effect in your judgment upon the public health of the people of Havana?

A. I think it did.

Q. In what way?

MR. JEFFRIES: Object to the question as incompetent, irrelevant and immaterial for the reason that the witness has not properly qualified himself to speak upon that subject and for the further reason it makes no difference what effect the river had on the health of the people of Havana, either prior to or subsequent to the opening of the Chicago drainage canal and for the further reason that the question is not confined to the sanitary condition of the water of the Illinois river when taken into the human system.

A. I think it caused malaria.

Q. Since the opening of the drainage canal has there been any typhoid fever in Havana?

MR. JEFFRIES: Object to the question for the reason
that Havana has a water system as shown by the evi-
5510 dence, and obtains its waters from deep wells and not
from the Illinois river, so that any typhoid fever that might have occurred at Havana, or the absence of its occurrence, cannot be attributed to the use of the Illinois river water.

A. No typical cases.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You have a splendid water system here, haven't you, doctor?

A. Yes sir.

Q. Where do they get their water?

A. We get it from drive wells; I think we have sixteen drive wells probably which render an abundant supply of water.

Q. Do you know the character of soil through which these wells are driven?

A. It is a sandy, gravelly nature, and some streaks of clay or strata of clay.

Q. The people here in Havana don't use the water for domestic purposes?

A. No sir.

Q. You have never made an analysis of the water, have you doctor?

5511 A. No sir.

Q. You don't recommend the water for drinking and domestic purposes?

A. The river water?

Q. Yes.

A. No sir; never has been fit to use.

Q. The current in the river is very much more rapid now than it was before the canal was opened?

A. Yes sir.

Q. Are you on the river much, doctor?

A. Not a great deal; go fishing, that's about all, once or twice a year.

Q. Did you ever notice this odor that arises from the water?

A. I have noticed, yes.

Q. Both before and since the opening of the canal?

A. It don't seem to me there has been very much lately; I don't think I have noticed it this summer at all.

Q. Did you last summer?

A. Well I can't recall to mind whether I did last summer.

PHILIP L. DIEFFENBACHER.

ADJOURNED until Wednesday, July 22nd 1903, at 8 A. M., at Pekin, Illinois.

Pekin, Illniois, July 22, 1903.

5512 8:00 A. M.

Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

C. G. HERGET,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. C. G. Herget; my ocupations are a good many, I will just give one of them; Pekin, Illinois; Manager of the Globe distillery.

Q. Where is the Globe Distillery with reference to the city of Pekin and the Illinois river?

Objected to as immaterial.

A. Located in Pekin, Illinois, about a mile from the court house, in Cincinnati township, about half a mile from the Illinois river.

Q. Is it above or below the city of Pekin, on the Illinois river?

A. Well it is above and still it is below certain parts; I think it is a little below. 5513

Q. What are you engaged in distilling?

Objected to as immaterial.

A. Distilling alcohol, spirits and whiskey, made from grain.

Q. What grain do you use principally?

A. Corn, ninety per cent.; about ninety per cent.

Q. What other grain?

A. Rye and malt. About ten per cent.

Q. Was the Globe Distillery in operation in the years 1900, 1901, 1902 and thus far in 1903?

MR. JEFFRIES: Objected to as immaterial.

A. Yes sir.

Q. In connection with the distillery were cattle fed from the refuse of the distillery?

A. Yes sir.

Q. How are the cattle fed, with reference to the city of Pekin, above or below, so far as the current of the river is concerned?

MR. JEFFRIES: Objected to as immaterial and irrelevant.

A. It would be a little below, but of course they are much higher than the river.

Q. On the river above the current or below on the current?

A. Oh, we are below the city.

5514 Q. After the operation of distillation is completed, if there is any residue, what is it?

A. Slop; it is called slop.

Q. How do you estimate the quantity of slop—by the gallon or by the bushel?

A. By the bushel.

Q. What becomes of the slop?

A. In a bushel of grain there are so many gallons of water; Uncle Sam takes 56 pounds to the bushel on all grains—wait a minute; now there are 45 gallons of water to the bushel mashed, so each thousand bushels of grain represents 45,000 gallons.

Q. Does this product after the distillation of the spirts constitute what you call the slop?

MR. JEFFRIES: Objected to as immaterial.

A. Yes sir.

Q. So that for each thousand bushels of grain used in distilling, there are substantially 45,000 gallons of beer?

MR. JEFFRIES: Objected to as immaterial and leading, and irrelevant.

A. Yes sir.

Q. This beer is then distilled?

MR. JEFFRIES: Objected to as leading and irrelevant.

A. Yes sir.

5515 Q. How much remains of this beer after the process of distillation, in the form of slop?

MR. JEFFRIES: Objected to for the same reasons.

A. In gallons, you want?

Q. Yes.

A. About 40,000 gallons.

Q. What becomes of this slop?

MR. JEFFRIES: Objected to as immaterial.

A. It is stored in tubs and from the tubs it is fed to the cattle through a trough. In connection therewith I guess you want me to say how often we feed it?

Q. Yes.

A. The slop is fed three times a day to the cattle, and divided equally, about three pecks to the steer per day; that is three pecks of slop.

Q. A peck contains about three gallons, doesn't it?

MR. JEFFRIES: Objected to as leading.

A. Well, more than that, isn't it; 45 gallons in the first place to the bushel; it would be 11 gallons to a feed.

Q. About 11 wine gallons to a feed?

A. Yes sir.

Q. Where are the cattle situated, and how are they fed?

MR. JEFFRIES: Objected to as irrelevant and incompetent and not tending to prove or disprove any issue in the case and as wholy foreign to any question under consideration.

5516 A. The barns are located about one-half mile from the river. The construction is entirely wood; with proper ventilation, and sewage connection. We allow three and a half feet to the steer and he has slop three times per day, roughness twice per day, salt twice a day and the barns are thoroughly cleaned with cold water twice per day. The construction of the barns—they are so built with high roofs, with plenty of ventilation for the health of the cattle; they are constructed so that they maintain the best sanitary conditions possible, under a large roof. We feed 4400 head of cattle under one roof.

MR. JEFFRIES: We move to strike out the answer because it is incompetent and irrelevant as before stated and because it is not responsive to the question.

Q. JUDGE JOHNS: What is the material which you call roughness which you feed?

MR. JEFFRIES: Objected to as immaterial and incompetent.

A. What we call roughness is hay; hay or straw or cotton seed hulls—is known as roughness.

Q. When the sheds are washed up, what becomes of the washings?

MR. JEFFRIES: The question is objected to for the reason that it is incompetent, irrelevant and immaterial, not proving any issue involved in the case, it being immaterial so far as the issues of this case are concerned, what the volume or extent of sewage matter or offal from cattle pens at Pekin, into the Illinois river, are, and that such deposits are not and cannot
5517 be under any circumstances a legal or equitable defense
or a justification of the right or privilege to Chicago or the Sanitary District of Chicago to make such deposits or deposits of any character whether sewage or otherwise, into the Chicago Drainage Canal and thence into the Illinois river. And for the further reason that Pekin is situated upon the natural watershed of the Illinois river, and the fact of discharging decomposing matter from distilleries or other sources from cities and places upon the natural watershed of the Illinois river does not and will not either in law or equity, entitle the City of Chicago and the Sanitary District thereof to deposit its sewage, filth and other deposits into a stream carrying said deposits into the Illinois river by means of an artificial canal or waterway, when said deposits naturally belong to and flow into, the basin of a watershed other than that of the Illinois and Mississippi rivers—and for the further reason that there is no evidence showing that the deposits into the Illinois river from the distilleries and cattle sheds of Pekin contain deleterious matter or matter injurious to the public health or to the health of those consuming the water and there is no evidence showing that such substance contains disease germs, or the bacilli of water-borne diseases.

It is hereby stipulated and agreed between counsel that the foregoing objection shall be considered as having been
5518 made to all the testimony as to deposits in the Illinois
river below the Bear trap dam and may be raised at any time in the argument of the case without renewing the objection at the time any witness may testify.

F. S. BRIGHT, Com'r.

Q. (Question read.)

A. They go into the Illinois river.

Q. When the sheds are washed, what matters from the cattle are washed out and flow into the Illinois river?

A. Well the urine and the manure.

Q. Are the cattle fed in stalls or boxes?

A. It is all open barn; 100 to a barn, 50 on each side.

Q. Through troughs?

A. Oh, through troughs, yes sir.

Q. Are the troughs also washed out?

A. Yes sir.

Q. Is the roughness fed in the troughs in which the stock is fed or is it fed in racks?

A. It is fed between the troughs in what are called the hay alleys.

Q. Is the hay alley at times cleaned out?

A. Daily. Twice per day.

Q. Is that done by washings with water, or by shovels and forks?

A. Done by scraper.

5519 Q. What becomes of the matter scraped out of the hay alley?

A. It goes into the sewer.

Q. Is it then carried into the Illinois river?

A. Yes sir.

Q. What kind of an appearance does this refuse from the cattle sheds form in the Illinois river?

A. It forms an island, composed principally of manure, hay straw and refuse.

Q. Are the cattle fed salt, and if so, how much and how often?

A. They are fed twice a day about a quarter of a pound to the steer.

Q. At each feeding?

A. No, per day.

Q. If any of the salt remains, what becomes of it?

A. It would be washed in the sewer.

Q. Stated in wine gallons, what do you estimate is the amount of stuff washed into the Illinois river consisting of remains of slop, urine and fecal discharges, per day, from each steer?

A. In wine gallons, well, there is from eight to ten gallons of urine per day; of course it depends upon whether it is a

steer or bull; you know, and I should judge half of that
5520 amount of manure for each steer, gets into the sewer.

Q. Making about fifteen wine gallons per day for each steer, washed into the sewer?

A. No; that is wrong; I was getting at the urine and manure at that time. It is pretty hard to get the manure in gallons; you might estimate it in pounds, you know.

Q. Now do you mean by that, that there is about eight to ten gallons of urinary discharge per steer per day, and that the fecal discharge would be about half that amount, about four to five gallons?

A. Yes sir.

Q How much water do you use in washing out the stables daily?

A. From five to eight tanks; it depends upon the number of cattle.

Q. Containing how much water?

A. They are 18 foot bottom, and eight foot stave, and eight feet high. Substantially 160,000 gallons per day. But that is on full capacity, you understand.

Q. When the island composed of the offal from the cattle sheds is formed, what becomes of it?

A. Well sir, as a rule when high water comes, we break it and let it float down the river and most of it lodges on farms on the low lands, deposits there and forms part of the farms.
Of course I don't say all of it, but a good part of it does,
5521 so far as my knowledge goes; so far as I know and so far
as I have seen.

Q. The island is cast adrift in the Illinois river and allowed to take is course?

A. Yes sir.

Q. Is this island cast loose more than once per year?

A. About once a year.

Q. Before it goes away is it covered or left exposed to the air?

A. Exposed to the air, uncovered.

Q. Were you feeding cattle continuously during the year 1900?

A. Yes sir.

Q. How many cattle did you feed during the year 1900, in round numbers?

A. About 5,000 head.

Q. For the entire year?

A. Yes sir. That is, that is the total amount fed; it is not 5,000 head each day for twelve months.

Q. As a general thing about how many cattle would be fed daily, in the year 1900?

A. Well in eight months, it will average 4200 head per day and the other four months, about 2300 head. 2300 head is what we call summer capacity.

Q. During what eight months did you feed in 1900 about
5522 4200 head?

A. From October 1st to June 1st; that's the winter months.

Q. And during what period in 1900 did you feed 2300 head?

A. From June 1st to October 1st, or September 30th.

Q. How many cattle did you feed in the year 1901?

A. Well the variations wouldn't be over four or five hundred head. You see our slop capacity is so much and we can't go beyond, so the variation is very small.

Q. Did you feed a larger number during the eight months and a smaller number during the four months?

A. We feed every year about the same as we fed in the year 1900; it may vary from 150 to 200 head.

Q. And in the same proportions as in 1900 as to number?

A. Yes sir.

Q. Are there any other refuse products of a distillery than those you have described?

A. Yes sir.

Q. What are they?

A. Hot water and cold water.

Q. Used for what purposes?

A. For cooking and in the boilers and for cooling purposes.

Q. Do these waters contain any foreign substances?

A. No sir; well I don't know, I haven't analyzed it, but I don't think they do.

5523 Q. Nor any organic matter?

A. No sir.

Q. From what source do you obtain the water used in the distilleries?

A. From drive wells and open wells; what we call second vein water.

Q. At what depth?

A. About eighty feet.

Q. In what kind of strata do you find this water, sand or—

A. Sand and gravel.

Q. Is the water used in washing the sheds obtained from these wells or from the river?

A. From the wells.

Q. How many tons of roughness do you estimate that you feed in a year?

A. We feed about eight pounds per day, per steer.

Q. How many distilleries have been in operation in Pekin during the years 1900, 1901, 1902 and thus far in 1903?

A. Two.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You say the water that you use in boiling and cooking and washing out the distillery is obtained from drive and open wells?

5524 A. Yes sir.

Q. Where do you get the water that is furnished the cattle that you keep on hand?

A. The same place. That is, you know we have tanks with over-flows.

Q. All of the overflow water from those tanks, goes into the cattle troughs?

A. Cattle tubs, or cattle tanks.

Q. So that you don't use the water from the river for any purpose?

A. No sir.

Q. How long has your company been in the distilling business here at Pekin?

A. The Globe Distillery has been in operation since 1893.

Q. Was it operated under any other name prior to that time?

A. Yes sir.

Q. What name?

A. Globe Distilling Company.

Q. How long was it operated as the Globe Distilling Company?

A. Up to July 1st, 1898.

Q. The plant was built in 1893?

A. Yes sir.

Q. And was not in operation prior to that time?

A. No sir.

5525 Q. It was built in 1893 by the Globe Distilling Company and operated by them?

A. Yes sir.

Q. From 1893, to 1898, under that name, Globe Distilling Company?

A. Yes sir.

Q. Then it was sold out to what Company?

A. Standard Distilling and Distributing Company.

Q. Where is the home office of the Standard Distilling and Distributing Company?

A. 27 William Street, New York City.

Q. Does the Standard Distillery and Distributing Company own any other plant in Pekin?

A. No sir.

Q. To what extent was the plant operated from 1893 to 1898? As to its capacity?

A. Well there was 4,000 bushels eight months in the year and 2,000 bushels the remaining four months.

Q. Per day?

A. Per day; yes; that is the winter and summer capacity.

Q. What was the extent of the cattle industry of the firm from 1893 to 1898?

A. You mean the number of head per day?

Q. Yes sir.

5526 A. Just the same as I stated a little while ago; it varies a little, you know.

Q. Then the capacity of the plant and the output of the plant both as to the distilling product and cattle has been about the same from the time the plant was built in 1893 to the present day?

A. Yes sir.

Q. Subject only to slight variation?

A. Yes sir.

Q. Is there any offal or products not used in the distillery that is thrown into the Illinois river aside from what is fed to the cattle?

A. Not to my knowledge.

Q. Describe the manner in which this hay and manure and urine finds its way into the Illinois river?

A. The offal such as urine and manure, and the unused roughness is scraped or washed into the sewer and then flows into the Illinois river, forming an island, and at high water—

Q. I don't care anything about that. Is the mouth of the sewer below the surface of the water at all times, or above it?

A. Above it, all the time, except it has touched the mouth of it; it is an open sewer.

Q. Then this material or product from the distilleries, forms in a heap at the mouth of the sewer?

5527 A. Yes sir.

Q. And while it lays there in the summer time it goes through what is known as the heating or sweat process does it not?

A. Well, I don't know.

Q. You have noticed the steam and sweat in the atmosphere rising from this heap of manure and product, at the mouth of the sewer, have you not?

A. No sir; it doesn't act like other manure; it is entirely different.

Q. Have you ever noticed it closely?

A. Well, I have, but I don't know exactly what months it was; what time.

Q. Do you feed anything except perfectly sound and healthy cattle?

A. That's all we feed.

Q. And you keep them in that condition?

A. Yes sir.

Q. What is the age of the cattle that you feed?

A. About three to four years old; some are older. The steers will average about four years.

Q. Do you use any chemicals of any kind in your distillery?

A. No sir.

5528 Q. All then that you use, and all that the cattle feed upon is the product of grain or hay of some kind, is it not?

A. Yes sir.

Q. Together with the pure water from the sand pumps or wells?

A. Yes sir.

Q. Now you spoke of open wells in your direct-examination; what do you mean by that term?

A. Well a well that is open instead of being a driven well with pipes; it is built open all the way down to the surface of the water and then we insert pipes below that.

Q. With reference to the water supply, is there any difference where the water comes from?

A. No, I think not; you mean the quality?

Q. I mean is it a living well or a cistern?

A. It is a living well.

Q. It gets its water from the sand?

A. Yes. beneath the sand and gravel.

Q. Then, so far as the source of the water is concerned, it is the same both as to the driven wells and the open wells?

A. Yes sir. Same thing.

Q. Pekin has a water system has it not?

A. Yes sir.

Q. Where does it get its supply?

A. From driven wells.

5529 Q. Does it use the water from the Illinois river?

A. No sir.

Q. From your knowledge, state whether the water from the Illinois river is used at Pekin for domestic or drinking purposes?

A. I really don't know.

Q. Do you know of anyone that does use it?

A. I do not.

Q. Are you acquainted with the flow of water in the Illinois river as it now is and as it was before the canal at Chicago was opened?

A. Very slightly.

Q. You have been on the river to some extent, have you not?

A. Oh, once in a while I have been on the river.

Q. The current in the river is much stronger now than it was before the canal was opened?

A. Well, I don't know; I paid no attention to that at all.

C. G. HERGET.

5530 Pekin, Illinois, July 22, 1903.

C. G. MUEHLMANN,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. C. G. Muehlmann.

Q. Where do you live?

A. Pekin, Illinois.

Q. How long have you lived here?

A. Since April, 1900.

Q. What is your business?

A. Physician and surgeon.

Q. Where did you live before?

A. Chicago, Illinois.

Q. Do you hold any official position in Pekin?

A. I do.

Q. What position?

A. Health Commissioner.

Q. What is the source of the water supply of the city of Pekin?

A. Drive wells.

Q. Can you describe them?

5531 A. They are pipes driven into the ground about 150 feet, and from there piped over the city, and the water is piped into a tank; that is where they get their pressure from.

Q. What is the extent of the public sewers of the city?

A. The main sewer is four blocks long, and they have some sewers in four blocks of alleys that connect with the main sewer.

Q. Into what does the sewer empty?

A. Into the Illinois river.

Q. You were not acquainted with the Illinois river before January, 1900?

A. I was sir; I was born and raised here; lived here until 1886 and then went to Chicago.

Q. For what purpose, doctor?

A. In 1886 I went to Chicago and studied pharmacy and graduated in 1889 then clerked in a drug store on the West Side until 1890, and I came back to Pekin, stayed here about a year and a half; went back to Chicago and became proprietor of a drug store there, until 1897 I disposed of it and then studied medicine at the College of Physicians and Surgeons, and graduated April, 1900.

Q. During that time, doctor, were you in Pekin at intervals?

A. I was.

5532 Q. What was the condition of the Illinois river at Pekin before the opening of the drainage canal and what has been the effect upon the Illinois river of the opening of the drainage canal since January, 1900?

A. The water was more sluggish, and there was more green scum and filth on the surface of the water. The current wasn't as swift as it is now, and I think the opening of the canal or the water coming in from Lake Michigan has deepened the channel.

Q. How about the apearance of the water?

A. The water is clearer now than it was at that time.

Q. Did you ever notice the effect upon fish at low stages?

A. I did not.

Q. What has been the condition of typhoid fever in Pekin during the last three years?

MR. JEFFRIES: We object to the question as incompetent, irrelevant and immaterial because there is no evidence showing that the people of Pekin use the water of the Illinois river for domestic and drinking purposes and for the further reason that there has been evidence showing that they do not use it for such purposes and therefore such testimony would constitute no proof of the sanitary condition of the water of the Illinois river at Pekin or elsewhere, prior to or subsequent to the opening of the Chicago drainage canal.

5533 A. You wish the death statistics?

Q. Yes sir.

A. The deaths for 1900 were two; 1901, one; 1902, two; 1903 up to July 1st, one.

Q. Those are the statistics that were furnished by you to the representative of St. Louis who called here, Mr. Ungar?

A. I submitted these to him, yes sir.

Q. Do you know the history of the cases, and where they occurred?

A. I don't know the history of the cases, but they occurred here in the city.

Q. Do you know what part of the city?

A. No sir, I do not.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Can you give the number of deaths from typhoid fever for the years 1897, 1898 and 1899?

A. I can if I refer to my books.

Q. Have you examined them lately?

A. Not since Mr. Ungar was here from St. Louis.

Q. You examined them then?

A. I did.

5534 I gave Mr. Ungar the number of deaths; I think we ran back ten years; but the books were in very poor condition.

Q. You don't know whether you gave him a statement which could be relied upon as authentic prior to 1900?

A. No sir.

Q. Explain, doctor, the system of waterworks here at Pekin?

A. They are drive wells, driven about 150 feet; second vein water I believe is what they call it; sand and gravel; it is then pumped into a tank and from this tank the pressure takes the water all over the city.

Q. State whether or not there is any considerable number of private drive wells in town?

A. There are.

Q. Are there any cisterns?

A. There are.

Q. Any considerable number of them?

A. Most every one has one of their own; that is for rain water.

Q. What is the population of Pekin?

A. Between nine and ten thousand.

Q. The people living in Pekin do not use the water from the Illinois river for drinking and domestic purposes do they?

A. No sir, they do not.

Q. And have not used it so far as you can remember?

5535 A. I do not believe they ever used it.

Q. Have you made an examination, scientifically of the water in the Illinois river for the purpose of ascertaining its sanitary condition?

A. No sir, I have not.

Q. The water in the Illinois river as I understand you, is somewhat clearer now than it was before the canal was opened?

A. Yes sir.

Q. Docter, all clear water is not necessarily free from harmful effects, is it?

A. No sir.

Q. Is all cloudy water, or water of muddy appearance, necessarily disease laden?

A. No sir.

Q. And the current as I understood you, of the Illinois river, is much swifter since the opening of the canal that it was before the canal was opened?

A. I believe so.

Q. You are out on the river a good deal are you?

A. I am, a good deal, hunting and fishing.

Q. Would you recommend the water of the Illinois river for domestic and drinking purposes, in view of its sanitary condition? 5536

A. I would not recommend it for drinking purposes; I would recommend it for domestic purposes.

Q. For washing and cleaning of vegetables that are to be used on the table without cooking?

A. I don't believe that any water ought to be used without cooking.

Q. It wouldn't be necessary to cook the water that comes from these drive wells, would it?

A. For domestic purposes?

Q. For drinking purposes?

A. No sir.

Q. When you speak of any water, you had reference to river water?

A. Yes sir.

C. G. MUEHLMANN, M. D.

5537 Pekin, Illinois, July 22, 1903.

D. H. JANSEN,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. D. H. Jansen.

Q. Where do you live?

A. Pekin, Illinois.

Q. What is your business?

A. I am city engineer and also in the brick and tile business; I manufacture brick and tile and am in the contracting business.

Q. Mr. Jansen, you collected water for the Sanitary District of Chicago in the years 1899 and 1900 to be sent to the University of Illinois—Prof. Palmer; Prof. Jordan of the University of Chicago and the Board of Health of the City of Chicago, from the Illinois river, did you not?

A. Yes sir.

Q. You also collected samples of water for the Illinois State Board of Health, to be sent to Prof. Long?

A. Yes sir.

Q. At what point in the Illinois river did you collect these samples?

A. Part of them were taken about a quarter of a mile below the distilleries at Pekin, and a part of them at Wesley City above the city. 5538

Q. Both for the Sanitary District and for the Illinois State Board of Health at those two points?

A. No, the samples for the Illinois State Board of Health were taken below Pekin.

Q. And for the Sanitary District at those two points?

A. At those two points.

Q. You received bottles with glass stoppers in them, sent to you from these different people by express, did you not?

A. Yes sir.

Q. After you received the bottles just state how you collected the samples?

A. I took the bottles in the cases just as they were sent to me to the boat, and went up or down the river and when I arrived at the point at which I wished to take the sample; I took the cloth off the tops of the bottles; then put the bottles in the water with the stoppers on; pulled the stopper off and filled the bottle with water and rinsed it thoroughly; then I would rinse the bottle; took that water out, put the bottle down in the water again as far as I could reach and when the bottle filled, then put the stopper on under the water; then took the bottle and put the cork on again, tied it on with a tag. Tied it on with a string with the tag attached; and the small bottle we always took enough ice along and placed the small bottles in ice, and then when I arrived at Pekin I would refill them with ice and pack them thoroughly with ice. 5539

Q. After you had the bottles collected and brought into Pekin, how did you prepare them for shipment?

A. I put the large bottle in the case and filled the outside with excelsior; the small bottle I filled up with small broken ice and in that ice we mixed a little excelsior as we found that it held better that way, then we wrote the tags according to directions and had the express wagon come down and take them to the station.

Q. And shiped them to the different parties whose names have been heretofore mentioned?

A. Yes sir.

Q. And on each sample collected for the Sanitary District, did you attach a card with the sample number, the date of collection, time of collection, place of collection, your name, height of water, temperature of water, direction of wind, temperature of air; rain—on the back of which were printed directions for taking and shipping samples of water for analysis; to each one of the samples which were collected and shipped to the different people?

A. Yes sir.

Q. For the Illinois State Board of Health for the samples of water colected and sent by you, did you attach a card 5540 upon which was written, The Illinois State Board of Health, examination of water; place of collection; date of collection; name of collector, temperature of water; temperature of air; upon the back of which was printed directions for collecting and shipping, to J. H. Long, 2421 Dearborn Street, Chicago, at the bottom of it?

A. Yes sir.

Q. I show you a card, sample No. 1514 and ask you if that is the kind of a card with proper filling in that was attached to all the samples sent to the University of Illinois, the University of Chicago and the Board of Health of Chicago?

A. Yes sir.

MR. TODD: I will ask the Commissioner to mark that card Sanitary District of Chicago Exhibit 10 for identification.

Said card received and so marked.

Q. I show you a card on which is written "Illinois State Board of Health" and marked in the upper left hand corner, 408 in lead pencil and ask you if that is a card similar to the one placed on the bottles and sent to Prof. Long?

A. Yes sir.

Q. Are those the cards placed on the bottles sent to Prof. Long?

(Handing witness papers.)

5541 A. They are in my handwriting, yes sir.

MR. TODD: I hand them to the Commissioner and ask him to enclose them in an envelope and mark them State of Illinois Exhibit No. 9, for identification, to the testimony of witness D. H. Jansen.

Said card received and so marked by the Commissioner.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You personally took these samples, did you?

A. Why I personally took some of them and some of them I didn't take.

Q. Who took them for you?

A. Jack Miller took some of them.

Q. You placed your name on all of the cards, or did he do it for you?

A. I placed by name on most of them, but there was a few he put my name on for me, it was all done under my direction for me.

Q. About what portion of the samples did he take for you?

A. Oh, I should say thirty or forty per cent. of them.

Q. Did you see him take them?

A. Take the samples?

Q. Yes.

A. No.

5542 Q. You don't know where he got them then?

A. Why he is a perfectly reliable man and I am pretty certain that he took them where I directed him to take them.

Q. Where did you direct him to take them?

A. A quarter of a mile below the distillery, and up at Wesles City.

Q. What place in the river, near the distillery did you take the samples?

A. Do you want me to designate the place?

Q. Yes.

A. Why it was in the center of the river.

Q. In the channel?

A. Yes in the channel.

Q. Above or below the distillery?

A. Below the distillery.

Q. Which distillery?

A. Well I would say a quarter of a mile below all of them.

Q. Now where did you take the other samples?

A. In the channel of the river at Wesley City.

Q. How far is that from Pekin and in what direction? About how far?

A. Oh, seven miles.

5543 Q. Above or below Pekin?

A. Above Pekin.

Q. You took them from the channel of the Illinois river?

A. Yes sir.

Q. How long after the samples were taken was it before they were shipped?

A. On an average of three hours.

D. H. JANSEN.

5544 Pekin, Illinois, July 22, 1903.

H. G. HERGET,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. H. G. Herget, age 41; manufacturer, Pekin, Illinois.

Q. Were you ever connected here with an establishment for the manufacture of beet sugar?

A. I was.

Q. When was the manufacture of beet sugar commenced in this town?

A. 1900 and 1901.

Q. How long did it continue?

A. Two years and about two months each year.

Q. In a general way, how much beet sugar did you manufacture during those two periods?

A. Several million pounds.

Q. In the process of manufacturing beet sugar, was there any refuse material?

A. Possibly beet pulp; it might be so considered.

5545 Q. What became of this beet pulp?

A. Some of was run through sewers into Dead Lake; some of it was fed to cattle.

Q. Where is Dead Lake?

A. On the southwestern limits of Pekin.

Q. How is it situated with reference to the Illinois river?

A. It is about 1500 feet east.

Q. Is it a bay or estuary of the Illinois river?

A. I hardly think so.

Q. Has it an outlet into the Illinois river?

A. It has.

Q. Do the flood waters of the Illinois go into the lake?

A. When the river is high the water backs into the lake.

Q. When the river is low do waters from the lake flow into the Illinois river?

A. Yes.

Q. In the process of manufacturing beet sugar, do you use any acids.

A. No sir; not to my recollection. I will correct that—a very small percentage of muriatic acid.

Q. Well, what per cent. with reference to what product?

A. It is very infinitesmal.

Q. In these two seasons, how much beet pulp in round numbers by tons did you deposit in Dead Lake?

5546 A. Deducting water, which would evaporate, possibly 6,000 tons.

MR. JEFFRIES: Is that each day?

A. No, total; I get at it in this way, there is a great per cent. of water in pulp; in fact it is nearly all water.

Q. JUDGE JOHNS: State what is the form and consistency of beet pulp?

A. The form of beet pulp as it comes from the diffusion batteries is similar to macaroni, but not hollow; the consistency is like hay; when it is dried it is like hay; it is fibrous.

Q. When it is deposited in Dead Lake is it a solid substance or is it in liquid form?

A. Well, it is more of a gelatinous nature.

Q. Is it composed of the fibers of beets and the water used in the manufacture of it?

A. It is that part of a beet from which the sugar and solids have been extracted.

Q. When floods come in the Illinois river, was this material washed out into the Illinois river?

A. Some of it.

Q. Do you discharge any sewage from the manufacture of sugar into Dead Lake?

A. Water.

5547 Q. Did the water contain any solid substances added to it in the process of making sugar?

A. *Only in infinitesmal quantities.*

Q. What are the substances?

A. Lime and other solids; not required in the manufacture of sugar.

Q. Well if it is not a trade secret, what were they?

A. I couldn't tell you.

Q. How much water did you use and pass through your sugar refinery or manufactory per day?

A. Possibly one million gallons.

Q. Was that also discharged into Dead Lake?

A. It was.

Q. And ran thence into the Illinois river?

MR. JEFFRIES: I object to the question because the witness has stated that the lake was not an estuary for the water of the river.

A. Such as was not evaporated by the sun.

Q. How is the solid matter deposited in Dead Lake, through a sewer?

A. Yes.

Q. Was the water also discharged through the same sewer?

A. It was.

Q. So that mixed with the solid matter during the two months of each year, there was also a million gallons of

5548 water a day?

A. I judge so.

Q. Was there from Dead Lake during the time the sugar was manufactured a stream flowing into the Ilinois river?

A. A very sluggish stream, on account of obstructions.

Q. In consequence of the discharge of this solid matter and a million gallons of water a day, did Dead Lake fill up, or did it empty itself through this stream?

A. It filled up very little, emptied itself partly into the stream, most of the water being taken by evaporation.

Q. By the stream was the solid matter carried out into the river?

MR. JEFFRIES: Objected to as leading.

A. I hardly think so. Excepting what little pulp was carried.

Q. Did the pulp then remain in the lake or did it finally get out into the river?

A. Some of it got into the river and some remained in the lake.

Q. After flood waters, as for instance now, how much of the pulp deposited by your sugar manufactory remains in Dead Lake?

A. Very little, because most of the pulp or a good part of it was dried by the sun.

Q. Well after it was dried by the sun, there was very little matter left, was there not?

A. Fibrous matter.

5549 Q. This fibrous matter, is it of vegetable origin or is it some chemical compound created by the process of manufacturing sugar?

A. I call it vegetable.

Q. After the close of the factory as a beat sugar concern, into what was it converted?

A. Into a glucose factory.

Q. How long has it been running as a glucose factory?

A. Since June, 1901.

Q. Are you connected with the manufacture of glucose here?

A. I am a director of the Corn Products Company.

Q. Have you charge of the manufacture of glucose for the Corn Products Company here?

A. I have not.

Q. State what is the refuse products of the manufacture of glucose here, and where it is deposited and whether it finally gets into the Illinois river?

A. In the modern manufacture of glucose as now practiced in Pekin there is no refuse; as all solids in the corn are recovered; so that all that was running to the lake was water; possibly 2,000,000 to 3,000,000 gallons each 24 hours.

Q. What is the color of that water when it is run into the lake?

A. Clear.

5550 Q. What acids or foreign substances of any kind does it contain?

A. Sulphuric acid.

Q. How much sulphuric acid per thousand gallons of water?

A. A nominal per cent.

Q. Well, one-half of one, or one, or one and a half or ten?

A. I should say it would be a very moderate fraction of one per cent.

Q. Did the water from the glucose factory run into the Illinois river from Dead Lake?

A. It did.

Q. When did the manufacture of glucose commence and when did it end here?

A. It commenced in June, 1901, and with some stoppages, it is still continuing.

Q. Is there any waste product in the manufacture of glucose whatever?

A. None.

Q. Is the process of manufacture of glucose at Pekin different somewhat from the process of manufacture at other places, as for instance at Peoria?

A. The same.

Q. Is there no discharge from a glucose factory of a whitish color, or yellowish color?

A. At times from the feed house, when filter cloths burst,
5551 or tear.

Q. What kind of a discharge is that; of what is it composed?

A. It is apt to consist of a very small per cent. of gluten.

Q. Mixed with water?

A. Yes sir.

Q. How frequently does that occur at Pekin and has it occurred?

A. Rarely.

Q. In the event it does occur what amount of fluid is discharged into Dead Lake and thence into the Illinois river?

A. Only such a small amount as would come through a very small rip in a filter cloth, and on such occasions the repairs are immediately made.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. When did you say you commenced the beet sugar manufacture?

A. In 1899.

Q. Was that a local concern, the local company?

A. Practically.

Q. When they ceased operations as beet sugar manufacturers, did the company sell out to some other company?

A. They did not.

5552 Q. Quit because it was unprofitable or did they quit to manufacture something else?

A. Quit because it was not practicable.

Q. And therefore not profitable, is that true?

A. Well I don't see that that has any bearing on the case, and I don't know whether I want to put that in the record.

Q. I want the question answered.

A. If you do, I will say that we quit because it was not profitable nor practicable.

Q. Now then after that time, were there any other factories of the same character and manufacturing the same product at Pekin or at any other point on the Illinois river that you know of?

A. None other.

Q. And there has been none other since?

A. No sir.

Q. You commenced the manufacture of glucose when?

A. In June, 1901.

Q. And have been manufacturing that product since with the exception of a few intermissions?

A. Yes sir.

Q. How many other glucose factories are there in Pekin?

A. None other.

Q. Do you know how many there are at Peoria?

5553 A. One.

Q. Do you know of any other glucose factory on the Illinois river other than the one at Peoria, and the one with which you are connected here at Pekin?

A. I do not.

Q. What products do they manufacture at your glucose factory?

A. Glucose, grape sugar, corn oil, feed, oil cake and starch.

Q. Now in the manufacture of these products from corn, is there any substance or material or solids from the corn wasted?

A. None.

Q. Do you use any other products than corn?

A. Sulphur and acid.

Q. In the operation of a glucose factory, has there been any improvement in the way of utilizing all the solids of the corn, from year to year?

A. There have been.

Q. In what way?

A. The evaporation of the steeping water.

Q. So that, if any solids escape in the ordinary way of reducing the solids to the desired product, those solids that escape are saved by a process of evaporation, is that true?

A. Yes, unless there should be a temporary leak of some kind.

Q. Now in the use of the sulphur and acids, I understood you to say there was no great amount used?

A. No sir.

5554 Q. A very small, infinitesmal percentage?

A. Yes sir.

Q. Does any of the acid or sulphur escape?

A. Sulphur that is in the water does.

Q. What percentage of the sulphur escapes?

A. A very small percentage.

Q. A very small percentage of the infinitesmal percentage used?

A. A very small percentage as compared with the amount of water.

Q. What percentage as compared with the amount of sulphur used?

A. I could not tell you.

Q. It is not very large?

A. No. Enough to be a good disinfectant, I know.

Q. It is not injurious in any way?

A. On the contrary.

Q. Now as to the acid, what percentage of that escapes?

A. I think none; it being used in conversion.

Q. So that since the company has been manufacturing corn products no refuse has passed from the factory into Dead Lake other than water?

5555 A. Yes, the solids lost in steeping, were carried into Dead Lake until some few months ago, since which time they are being evaporated.

Q. Under the modern process which you have heretofore referred to?

A. Yes.

Q. Where do you get the water that you use in your factory?

A. From the Illinois river for the boilers; pump it from the ground for manufacturing.

Q. You don't drink the waters?

A. Nor the Mississippi.

H. G. HERGET.

5556 Pekin, Illinois, July 22, 1903.

E. W. WILSON,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. E. W. Wilson; I am president of the American Distilling Company, and also of the German American National Bank at Pekin. My residence is Pekin.

Q. What is the name of the distillery which you manage here?

A. The American Distilling Company.

Q. Where is it located with reference to Pekin and the Ilinois river?

A. It is about a mile and a half below the central portion of the city, within the city limits and on the bank of the Illinois river.

Q. What are the products of the distillery?

A. Spirits and alcohol generally.

Q. In the process of distillation here do you have a beer or a mash?

A. Yes sir.

Q. From what kind of grain is it made?

A. Corn principally and some malted barley and rye.

5557 Q. Before you commence to distill, do you have a product called beer?

A. Yes sir. The corn mash is put through a process of fermentation and while it is undergoing that process of fermentation it is called beer.

Q. After the distillation of this beer, and the alcohol is extracted, what is the remainder called?

A. Slop.

Q. In speaking of the quantities of slop, how do you estimate it, by the wine gallon or by the bushel?

A. By the bushel.

Q. What is the quantity which you call a bushel of slop?

A. About forty gallons of beer or mash is equivalent to a bushel of grain is the way we figure it.

Q. In the process of making the fermented beer, how much water do you add to a standard bushel of mashed grain?

A. About forty gallons.

Q. And that amount of the water together with the mashed grain in it is called a bushel?

A. Yes sir.

Q. After the alcohol is extracted, what do you do with the slop?

A. Feed it to cattle.

Q. Where are the cattle located?

5558 A. On the same premises, on the back of the river; in sheds on the distillery premises.

Q. When your distillery is running at full capacity, how many cattle do you feed from the refuse?

A. About 4,000.

Q. Describe particularly the manner of feeding the cattle the slop?

A. Well the cattle are tied in sheds to a trough in which the slop is run; the slop is directly in front of them and they feed from this trough.

Q. How many times a day do you feed the cattle slop?

A. Three times a day.

Q. What quantity do you feed them each time?

A. Oh, about a third of a bushel, or about twelve to fifteen gallons.

Q. If there is any refuse or remainder left from the slop what becomes of it?

A. Why it is run out onto the bank of the river.

Q. Do you feed the cattle any solid food?

A. Yes sir, we feed some hay and cotton-seed hulls; cotton-seed meal at times.

Q. How is that fed to them?

A. It is fed to them dry.

5559 Q. If there is any remainder from the dried food, what becomes of it?

A. Well, I think that is carted away in wagons generally; they use it for bedding the cars.

Q. When your cattle are standing in places tied, is bedding put under them at night?

A. No sir.

Q. How do you keep the sheds clean?

A. The men go in behind the cattle and scrape the excrement into a sewer and it is washed out by water.

Q. Where do the excrement and the water with which it is washed out go?

A. It goes out on the bank?

Q. Does it get into the river?

A. Well I suppose the water does, but most of the excrement would remain in the lowland on the banks of the river.

Q. How many times a day do you clean the sheds?

A. Twice a day.

Q. About how much water do you use in cleaning, in a day?

A. It would be impossible to answer that. It would be sufficient to wash this excrement out; I haven't any idea; probably 50,000 gallons.

Q. Give your best judgment as to the amount of water which you use in cleaning the sheds?

A. Well, I should say 100,000 gallons.

5560 Q. Each day?

A. Yes sir. Well it might be double that amount; I don't know as I could estimate it.

Q. Does the refuse below your distillery on the bank of the Illinois river form a mass of hay and manure?

MR. JEFFRIES: Objected to as leading.

A. Yes.

Q. Do you sometimes call that an island?

A. No.

Q. What becomes of the refuse in times of high water in the Illinois river?

A. Why, there is a large portion of it floats away.

Q. And down the Illinois river?

A. And down the Illinois river.

Q. Do you take any means to break it up and get it into the river when the current is high?

A. No, we never have.

Q. Does it wash away of itself under the influence of current?

A. Yes.

Q. During the years 1900, 1901, 1902 and thus far in 1903, what amount of time has the American Distillery been running?

A. All the time, continuously.

5561 Q. Have you all that time been feeding cattle with slop and hay?

A. Yes sir.

Q. And all that time been throwing the washings of the cattle sheds and manure onto the bank of the Illinois river?

MR. JEFFRIES: Objected to as leading.

A. Yes sir.

Q. What amount of discharge is there as a general thing from one animal fed in the distillery in 24 hours, urine and fecal discharges?

A. There is from 12 to 15 gallons of urine from each animal and from 40 to 50 pounds of excrement.

Q. Now has this urine and excrement been washed out during all these years onto the banks of the Illinois river?

MR. JEFFRIES: Objected to as leading.

A. Yes sir.

Q. If you feed these animals salt, state about how much per day?

A. About a barrel a day.

Q. For use in the distillery?

A. Yes sir.

Q. Do you know whether you feed them as much as a quarter of a pound each, per day?

5562 A. No, I don't think we do.

Q. How many cattle have been fed at the American Distillery in the manner you describe in each of the years, 1900, 1901, 1902 and thus far in 1903?

A. About 6,000 head each year.

Q. How many cattle are you feeding at one time?

A. About 4,000.

Q. Are there any other refuse materials from your distillery than slop?

A. No sir.

Q. Do you use water in the distillery which afterwards escapes into the river aside from that used for the slop and the washing of the stables?

A. Yes, we use some water for cleaning purposes in the distillery, and the water that is used in the boilers.

Q. Is the water used for cooling purposes—does that go into the river afterwards?

A. Yes sir.

Q. How much water is used daily for cooling purposes which afterwards gets into the river?

A. Oh, I should judge 500,000 or 600,000 gallons. A good deal of that water goes through the cattle pens for washing out the sheds, as I said.

5563 Q. How large a mass of stuff accumulates on the bank of the Illinois river at your distillery before it is carried away or washed away by the floods?

A. Well, that's a pretty hard question to answer; there seems to be rather a good current at the place where we dump this on the banks of the river; there was a low spot of land right where our cattle sheds stand and there was a large share of this excrement stayed right in that low land; it has been filled in and hasn't gone to the river at all.

Q. State in a general way, how many tons of solid matter are deposited by your distillery on the banks of the Illinois river, in a month, a day or a year?

A. Well there is about 200,000 pounds of excrement per day.

Q. Do you know a place here called Dead Lake?

A. Yes sir.

Q. Where is that with reference to your distillery?

A. East of our distillery.

Q. Is it a lake which empties its waters into the Illinois river?

MR. JEFFRIES: Objected to as leading.

A. Yes sir.

Q. What factories or institutions here in the city of Pekin discharge their refuse into Dead Lake?

A. The Illinois Sugar Refining Company; the glucose 5564 works.

Q. Is it overflowed by the Illinois river in times of high water?

A. Yes sir.

Q. In times of low water, what is the color of the water in Dead Lake?

A. It is very black.

Q. Does there an odor arise from it?

A. Yes, sir, at times.

Q. Do you know by what that is caused?

A. No, I do not positively. I have an idea.

Q. What is your opinion as to what causes it?

MR. JEFFRIES: We object to the witness giving any opinion on the subject for the reason he hasn't shown proper qualifications.

A. Why, I think it is caused by the steep waters and the action of the acids that they use on the water; but that is my opinion; I don't know.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How long has this American Distilling Company been organized?

A. Since 1892.

Q. Is it the successor of some other company?

A. No, it is a new plant. Prior to that time we operated a
5565 plant just north of that which is now closed and dismantled.

Q. Was it operated under the same names as this one you are now operating under?

A. No, the name was the Hamburg Distilling Company.

Q. Were you connected with that company?

A. Yes sir.

Q. And held office?

A. Yes sir, I was president of that company; it is now dismantled.

Q. The American Company came into existence as the Hamburg Company went out of the business?

A. Yes sir, very shortly after.

Q. How long was the Hamburg Company operated? Approximately?

A. Well, about twenty years.

Q. What was the capacity of the Hamburg Company during that twenty years?

A. About 2,000 bushels per day.

Q. Did it feed cattle also?

A. Yes sir.

Q. What was its capacity for feeding cattle?

A. About 2,000 cattle per annum; well I will change that—about I should judge 3,000 per annum; 2,000 cattle at one time.

Q. Did it feed as much as 3,000 per annum during each
5566 year for the twenty years?

A. Yes sir, I should think that was a fair average.

Q. The home office of the American Distilling Company is here in Pekin, is it?

A. Yes sir.

Q. Is it an Illinois corporation?

A. Yes sir.

Q. Did the offal and manure and drainage from the Hamburg Company deposit in the same place, or practically the same place as that from the present company, the American?

A. Well it was deposited in the same manner, but hardly in the same place.

Q. In the Illinois river—on the banks of the Illinois river?

A. Yes sir, on the banks of the Illinois river.

Q. Is there any waste except the slop that you feed to cattle from the products that you consume in the distillation?

A. No sir.

Q. Do you use any chemicals of any kind?

A. No sir.

Q. Where do you get the water that you use in the distillery?

A. The water that we use in the boilers we pump from the river and the water for cooling purposes is pumped from wells drilled along the bank of the river—the edge of the river.

5567 Q. These wells that you speak of from which you get your water for feeding purposes are driven wells, aren't they?

A. We have one open well and several driven wells.

Q. Now with reference to the source of the water suplying those wells, what is the difference between open and driven wells?

A. I think perhaps it is the same.

Q. An open well is a living well?

A. What do you mean by living well?

Q. Well, it don't depend on rains for its supply like a cistern?

A. No sir, it is supplied by water filtered through the gravel.

Q. Now where do you get the water that you feed your cattle; that you furnish the cattle for drinking purposes?

A. We don't give them much water; we give them the slop.

Q. Well if you give them any it comes from these wells?

A. From the river and from the wells; I don't know how to discriminate between the two.

Q. But you aim to get the water from these wells?

A. Well we use the well water for cooling purposes, because it is cooler; the water that goes to the sheds is overflowed
water; some of it is overflowed after it has done its work
5568 in cooling; some of it has overflowed from the cold stor-
age tank—cold water storage tank.

Q. You feed no cattle that are not healthy and sound?

A. No sir

Q. Do you feed them any deleterious foods of any kind?

A. No sir

A. Nothing but the products of the distillery?

A. That's all; and hay, and at times they are fed some cootton-seed meal.

Q. Does this offal from the cattle get to the river by means of a sewer? In other words, is it conveyed from the cattle by a sewer?

A. Yes sir.

Q. What is the character of that sewer, Mr. Wilson?

A. It is a wooden sewer.

Q. Is the mouth of the sewer below or above the surface of the water in the river?

A. It is above.

Q. I understand you to say that this offal from the cattle does not empty directly into the Illinois river, but that it emptied on a piece of low ground?

A. Yes sir.

Q. How far is the mouth of the sewer from the
5569 bank of the river; from the water's edge, in an ordinary
stage of water?

A. Oh, I should judge it was 100 feet now.

Q. Does the sun strike it before it gets to the water in the river?

A. Yes sir.

Q. It becomes very dry, doesn't it?

A. Yes.

Q. And that is true at all seasons of the year, except during extremely high water?

A. Yes sir.

Q. Is there any other substance or material passing through the sewer from your distillery to the banks of the river other than that which comes from the cattle which you feed in the distillery and the washings from the distillery?

A. No sir; it is built for the special purpose of taking away that offal.

Q. Now that sewer has been constructed for several years?

A. Yes sir.

Q. And has remained in the same place and the discharge from the sewer has been in the same place for the last ten or twelve years, has it not?

A. Not quite; no, we have gradually been filling up and moving it out further each year. I suppose that sewer has been lengthened out probably a couple of hundred feet in the
5570 last ten years.

Q. So that the mouth of the sewer is now about how many feet from the river, did you say?

A. About 200 feet, I should judge.

Q. Well you mean 200 feet from the water's edge?

A. No, I didn't say that. The sewer has been lengthened out probably 200 feet.

Q. The mouth of the sewer is now how many feet from the water's edge at ordinary stage?

A. I should judge 100 feet at this present stage of the water.

Q. You spoke, Mr. Wilson, of there being some acids of some kind discharged from the glucose factory; do you know from your personal knowledge that they do use acids to any considerable extent?

A. No, I do not. E. W. WILSON.

5571 Pekin, Illinois, July 22, 1903.

FRANK MILLER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd, and testified as follows:

Q. What is your name?

A. Frank Miller.

Q. Where do you live, Mr. Miller?

A. I live in Pekin, Illinois.

Q. Mr. Miller, did you take water for Mr. Jansen?

A. Yes sir.

Q. And you took it at the same places that he took it?

A. Yes, at the same place; I took it before he took it.

Q. Did you take water up at Wesley?

A. Yes sir.

Q. And did you take water above Peoria bridge, below the distilleries?

A. Yes sir.

Q. Where are the two places that you took it?

A. At Wesley and Mackinaw here, between Mackinaw and the still house.

Q. When you took the water, did you put any cards on
5572 the samples?

A. Yes sir, I put a card on the bottle, packed it up and took it to the express company.

Q. Did you put a card like that on each bottle? (Showing the witness Sanitary District's Exhibit 9 for identification).

A. On each bottle. I had a little bottle and a big bottle.

Q. How did you put the water in the bottles?

A. Went out with a skiff to the center of the channel; I took the cork out of the botle and put the bottle down that much (indicating) under water and I put the stopper in with the other hand under the water.

Q. Did you take the cork out of the bottle under the water?

A. No I took it out on top of the water.

Q. Did you rinse the bottle?

A. Yes sir.

Q. Did you cork the bottle under the water?

A. Yes sir.

Q. Did you pack the bottles in ice?

A. Yes sir.

Q. And put a card like the one I showed you on each bottle?

A. Yes, on each bottle.

Q. Now where did you ship the samples to?

A. One box I shipped to Champaign by the American Express; one box we shipped that went by the Union Express and one bottle to the University of Chicago that went by the Union Express.

Q. And where did you ship the other box?

A. We shipped three boxes.

5573 Q. Where did you ship the third box?

A. One to the Board of Health of the city of Chicago; one to the State University and one to the University of Chicago.

Q. How long would these bottles be out of the water before they were shipped by the express company?

A. Sometimes two hours; sometimes six hours. I had to go to the train to Wesley.

Q. What years did you collect this water in?

A. I don't know that; two or three years ago; I guess the card shows; yes, three or four years ago.

Q. What was the year?

A. 1899 and 1900.

Q. Who were you collecting these waters for?

A. For Jansen. I made the cards in his name.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. What is your occupation?

A. I keep a boat-yard with skiffs for rent and have lived there for fifteen years; live right on the water.

Q. Are you a married man?

A. No sir, single man.

Q. Where did you take these samples, did you say?

5574 A. At Wesley?

Q. Whereabouts in Wesley?

A. Oh, about 200 yards or 300 yards above Wesley, in the center of the river in the channel.

Q. Where did you take the samples down here at the distillery?

A. Below the distillery, between the distillery and the Mackinaw in the center of the river.

Q. Did you rinse the bottles out?

A. Yes sir.

Q. How did you do that?

A. Set them up straight, reached down with my hand the bottle and rinsed it out; took the water and then I put my hand down under the water four or five or six inches and put the stopper down to it under the water; that is the way I was told and I done it that way.

Q. Who did you say you took the samples for?

A. Jansen.

Q. You said a moment ago that he discharged you, why did he do it?

A. Well he was away working on a bridge and after he got through with the work he didn't have anything to do so he wanted to take the water himself. That's all there is to it.

FRANK MILLER.

5575 Pekin, Illinios, River, July 22, 1903.

WM. J. CONZELMAN,

called as witness in behalf of the defendants, being first duly sworn, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. William J. Conzelman; one of the managers of the Globe Distillery, and also mayor of the town of Pekin, Illinois.

Q. What is the water supply of the city of Pekin.

A. The water supply is obtained by means of drive wells; pumped into a tank or water tower and afterwards distributed about the town.

Q. How extensive are the water pipes distributed through the town?

A. I think about seventeen miles.

Q. What proportion of the inhabitants of Pekin take water from the public supply?

A. About eighty per cent.

Q. Is there a system of sewers in the town?

A. There is; one main sewer extending up First Street about three-eighths of a mile and numerous laterals connecting therewith, constituting a sewer system of about two miles.

5576 Q. What number of inhabitants have connection with the sewer system?

A. About five per cent.

Q. What is the population of the town?

A. Between nine and ten thousand.

Q. How is the remainder of the household sewage in Pekin disposed of?

A. By means of cess-pools.

Q. Is the water supply of Pekin considered good as to the quality of the water?

A. Very good.

Q. What has been the condition in Pekin during the last three years and a half as to typhoid fever?

A. Normal.

Q. Have there been many or few cases?

A. Why, about the general average, I presume about twelve cases a year.

Q. How many cattle are fed yearly in the distillery of which you are manager?

A. About 4,500.

Q. Has the distillery been running continuously since January, 1900?

A. It has.

5577 Q. What is the estimated daily ejected matter from a single animal, urine?

A. That is a rather difficult question to answer.

Q. What is your estimate of it; how many gallons of urine and pounds of manure?

A. Why I think, from hearsay, about eight gallons of one and about half as much of the other.

MR. JEFFRIES: I move that the answer be stricken out because based upon hearsay testimony, and is not the best of evidence.

Q. With what are the animals fed?

A. With slop and rough feed, such as hay and cotton-seed hulls; also some little salt.

Q. About how much salt are they given daily?

A. About a quarter of a pound to each steer; each head of cattle

Q. How is the offal from the cattle disposed of?

A. By means of a slough or sewer into the river.

Q. Is it washed out with water?

A. It is.

Q. Are the cattle bedded down in the Globe Distillery sheds?

A. No sir

Q. Ordinarily, when a steer is put upon distillery food, how long is he kept in the sheds until he is ready for market?

A. The time varies a little. About eight months.

5578 Q. Are any cattle ever fed outside of the sheds of the Globe Distillery?

A. There are occasionally a few that become sore and are turned out into the yard.

Q. How many on an average would you say, during a year?

A. About forty, something like that; forty or fifty.

Q. What becomes of their offal?

A. It accumulates in the yard and is subsequently carried off to the river bank.

Q. After the stuff is carried to the river from the cattle shed, does it form what you call an island?

A. There is an accumulation or mass which we often term an island, yes.

Q. What becomes of this mass?

A. Usually with the high water in the spring it is taken away; and if not we assist by running a boat into it or something, to loosen the matter.

Q. When it is loosened does it float on the current of the river?

A. Yes sir.

Q. How large a mass is detached each year and floated in the Illinois river?

5579 A. A season's accumulation would aggregate a space of about a hundred feet square.

Q. And how deep?

A. About three to four feet.

Q. Is this mass under cover or is it exposed to the air?

A. It is exposed to the air.

Q. Has this condition been continuous at the Globe Distillery during the last three years or not?

A. Yes sir.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How long have you been connected with the business here?

A. Since 1892.

Q. You have fed about the same number of cattle from 1892 to 1900, and from 1900 down to the present day?

A. Yes sir.

Q. And consumed about the same amount of corn?

A. Yes sir.

Q. And manufactured about the same amount of whiskey?

A. Yes sir.

Q. The offal from these cattle and the washings from the distillery are emptied in the same place as they are now emptied and have been since January, 1900?

A. Yes sir.

5580 Q. The sewer through which this offal from the cattle and the washings from the distillery flow, is what is known as an open sewer, is it not?

A. Yes sir.

Q. With its mouth above the surface of the water at its ordinary stages?

A. Yes sir.

Q. Does it empty directly into the river or on the banks of the river?

A. It empties directly into the river.

Q. And accumulates there until there is sufficient current to carry it away?

A. Yes sir.

Q. Do you feed anything in your pens but healthy cows?

A. Nothing but healthy cows.

Q. Now you spoke of certain instances where cattle became sore; in what way would they become sore and be removed from the pens to the yard?

A. Cattle very frequently become foot-sore; their hoofs become inflamed and whenever that condition exists, we take them out into the yard and the contact of the hoof with the earth seems to take out the fever, etc.

Q. There is no eruption of the skin or anything of that kind?

A. No sir.

5581 Q. Do you use any chemicals in your distillery in the manufacture of whiskey from corn?

A. No sir

Q. Where do you get the water that you use in the distillery?

A. From drive wells.

WM. J. CONZELMAN.

5582 Pekin, Illinois, July 22, 1903.

HARRY TAYLOR,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. State your name, residence and occupation?

A. Harry Taylor, residence Pekin, occupation fisherman.

Q. How long have you been a fisherman?

A. Since 1895.

Q. Over what part of the river have you fished?

A. I have fished from Lake Depew to LaGrange dam.

Q. Where is Lake Depew?

A. Well, I should judge it is about twelve miles above Hennepin.

Q. When did you fish at Lake Depew and above Peoria on the Illinois river?

A. I fished at Lake Depew two years ago.

Q. Did you fish at any other point on the Illinois river between there and Peoria?

A. Yes sir, I have fished all the way to Peoria.

Q. Have you fished in the Illinois river above Peoria before the opening of the drainage canal in 1900?

A. Yes sir.

5583 Q. What was the condition of the river above Peoria before the opening of the drainage canal?

A. Well, the water is more pure and clearer now.

Q. Before the opening of the drainage canal; before it was opened, what was the condition of the water in the Illinois river above Peoria?

A. It was good water.

Q. Since the opening of the drainage canal, what has been the condition?

A. It is good water yet.

Q. Is it better or worse than before the opening of the drainage canal—above Peoria?

MR. JEFFRIES: Objected to as leading and suggestive.

A. It is better.

Q. What was the condition of the water in the Illinois river below Peoria before the opening of the drainage canal?

A. Well, to speak it plain, it was rotten.

Q. What kind of material was in it?

A. Why, it is slimy.

Q. Did the slime catch on your nets?

A. Yes sir.

Q. What was the condition of the Illinois river at Pekin before the opening of the drainage canal?

A. At Pekin it was just the same as it was below Peoria.

5584 Q. Was there a smell to the water?

A. Yes sir.

Q. Since the opening of the drainage canal, what has been the condition below Peoria?

A. It has been more pure.

Q. At Pekin is the slime—does the slime now form on the nets as it did before the opening of the drainage canal?

MR. JEFFRIES: Objected to as leading.

A. Yes sir, but not so bad as it was before.

Q. Since the opening of the drainage canal does the slime increase or decrease as you go down the river from here?

A. Why, it decreases.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How old are you?

A. Twenty-seven.

Q. And you have been fishing how many years?

A. Since 1895.

Q. The current in the river is very much stronger now than it was before the canal was opened, is it not?

A. Oh, it is some.

Q. Well, how much, if you know?

A. Well, I don't believe there is a mile.

Q. There is a better curent throughout the year, isn't
5585 there than there was before the canal was opened?

A. Oh, yes, there is some.

Q. You say the water is clearer now than it was before the canal was opened.

A. Yes, below Peoria.

Q. And how is it above Peoria, worse?

A. Better if anything.

Q. Not as clear?

A. Yes sir, clearer, like the water of Lake Michigan; blue like the water of Lake Michigan.

Q. You don't know whether the water contains any deleterious matter or not?

A. On what parts of the river?

Q. Any parts of the river that you are acquainted with?

A. It does below Peoria.

Q. What causes it?

A. Well those sugar houses and one thing and another dumps their offal into it.

Q. Do you know whether the sewage from Chicago comes in the river above Peoria?

A. No, I don't know.

Q. You don't take that into consideration when you say the water is purer; in other words, you don't know what effect that would have on it?

5586 A. Why yes.

Q. You know what effect it would have on it, do you?

A. Yes sir.

Q. What effect does sewage from Chicago have on the water?

A. Yes sir.

Q. Do you undertake to say that you have analyzed the water?

A. No, I never analyzed it.

Q. Then you don't know what it contains, do you?

A. Why, not according to that I don't.

Q. You don't think the offal from nearly 2,000,000 of people would have any effect on the water in the drainage canal, do you?

A. I never seen any of it.

Q. And because you never saw any of it, you don't think that it hurts the water?

A. No, not in my estimation.

Q. That is what you mean by it?

A. Yes sir.

HARRY TAYLOR.

5587 Pekin, Illinois, July 22, 1903.

J. C. LOSCH,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd, and testified as follows:

Q. What is your name?

A. J. C. Losch.

Q. What is your business?

A. Steamboating.

Q. In what capacity?

A. I run a little boat of my own here; have for twelve or fifteen years.

Q. What is the name of it?

A. Steamer Olive A.

Q. How long have you been on the river, Captain?

A. About fifteen years.

Q. What was the condition of the Illinois river at this point before the opening of the drainage canal?

A. Why, in the summer time it was in bad condition.

Q. In what way?

A. By the water being foul.

Q. How did the foulness manifest itself?

5588 A. Well by smelling and killing the fish.

Q. Did you ever see any fish killed?

A. By the water?

Q. By the water?

A. Yes sir.

Q. To what extent and where?

A. Well I have seen them between here and the locks that my steamboat wouldn't have carried them, laying on the shore; been killed probably the night before.

Q. About how many fish would that be?

A. I suppose the boat would carry about ten or fifteen tons.

Q. Would there be that much fish dead there that you saw?

A. Yes sir.

Q. When was that, Captain?

A. It was somewhere along about 1889 or 1891; I can't just exactly tell; but it was along that time; before I bought my big boat.

Q. Were you acquainted with the water above Peoria?

A. I am some.

Q. How did the water above Peoria compare with the water below Peoria before the opening of the drainage canal?

A. Well, it has always been better above Peoria than it has been below.

5589 Q. Since the opening of the drainage canal, what has been its effect upon the waters of the Illinois river?

A. Well, I think they are better.

Q. In what way, Captain?

A. Well, they seem to be purer; there don't seem to be as much smell, nor look as bad.

Q. Have you seen any dead fish to the extent that you saw before the opening of the canal?

A. Nothing like I have saw before.

Q. Is there any smell on the waters now between here and Peoria?

A. Yes sir.

Q. How does it compare with what existed before the opening of the canal?

A. Well it is not as bad; if you will allow me to put in a little word of my own here; years ago every time we went from here to Peoria, every two or three trips, we had to blow out our boilers; we don't have to do that now; the boiler would foam and raise up from the filth and gas between here and Peoria.

Q. By blowing out your boilers, you mean washing your boilers?

A. Wash out the boilers.

Q. How does the river get as you go away from Peoria towards Grafton?

A. Better.

5590 Q. Have you ever seen any of these islands of manure in the Illinois river?

A. Yes sir, I have struck them big enough that if I had hit them fair they would take me down the river, with the little boat.

Q. Where do these islands of manure come from?

A. Peoria, those that I have reference to.

Q. Have you had anything to do with breaking off the manure at the different distilleries?

A. I have.

Q. Tell what it was?

A. Right here at Pekin I had clearing out the distilleries here; the manure would be five or six feet deep and covered probably an acre that I tore out for them; they paid me $25.00 for tearing it out.

Q. Was that the only place you had anything to do with removing the manure?

A. That is the only place I have had to clean it out. The Peoria distilleries paid me for taking it out of the canal above Spring Lake Canal, and the still house here and the Peoria

5591 parties paid me for taking it out of the canal.

Q. How did the manure get into the canal?

A. Floated down from Peoria and got into the canal and stopped up the canal.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. What canal?

A. Spring Lake canal.

Q. You see some dead fish on the river now, don't you?

A. Very few.

Q. Some seasons of the year they are considerable?

A. Not lately.

Q. What is the current of the river now compared to what it was before the canal was opened?

A. Well I think it is a little stronger; the higher the river the stronger the current.

Q. Considerably stronger, isn't it?

A. Well it is not so very much; we haven't got a very strong current at no time here, even during the high water, we haven't got a terrible current, and at low water, as near as I can judge, less than half a mile or a third of a mile an hour. And in high water, I believe about three or four miles an hour.

5592 Q. You have more than a third of a mile now?

A. Well, I don't know; I don't think it would be much more than half a mile an hour now. .

Q. The current is much swifter here opposite Pekin?

A. Much swifter than what?

Q. Than it was before the opening of the canal?

A. Oh yes, the higher the water the swifter the current; it has always been, we have more current during high water than in low water; we have higher current in high water and when it increases up to fourteen or fifteen feet we have more current. I was going to say about the current, between here and Peoria, if the water raises high to between twelve and fifteen feet, we get a terrible current; there is considerable difference in the current between the wide and the narrow places.

Q. When you say the water is purer now than it was before the opening of the drainage canal, you judge by the appearance of the water?

A. Well, yes sir, that is the only way I have of testing the water.

Q. Not having tested it, of course you don't know what it contains?

A. No I don't.

Q. There is considerable smell since the opening of the
5593 canal?

A. No sir, not so much as there was before.

Q. Still there is considerable smell, is there not?

A. Yes sir. J. C. LOSCH.

5594 Whereupon an adjournment was taken until 8:00 A. M., Thursday, July 23rd, 1903, at Peoria, Illinois.

8:00 A. M., Thursday, July 23rd, 1903. Peoria, Illinois. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

No witnesses being present, an adjournment was taken until 2:00 P. M., at Chillicothe, Illinois.

2.00 P. M., Thursday, July 23, 1903. Chillicothe, Illinois. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

5595 Chillicothe, Illinois, July 23, 1903.

JERRY FOLSOM,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. Jerry Folsom, Chillicothe, State of Illinois, and I am a fisherman.

Q. How long have you been a fisherman?

A. Well sir, I fished, not steady, but off and on ever since I was eight years old; big enough to row a skiff, and I am now 56; I have fished off and on for about 47 or 48 years with the exception of about two years I was in the naval service for Uncle Sam.

Q. Over what part of the Illinois river have you fished?

A. I have fished from here clear up to Spring Valley; that has been my fishing grounds, from here to there.

Q. What was the condition of the Illinois river at this point and above before January, 1900, when the drainage canal was opened?

A. Well, I would consider it poor.

Q. In what respect?

A. In winter season when we would cut holes in the ice, it would smell so bad you couldn't hardly stay around the
5596 hole, and the fish would die in the nets, in two or three hours time after they were caught or confined, or after

it was froze up hard, and they tasted of gas and tar until they wasn't fit to market.

Q. Did you cook fish yourself which smelled and tasted that way?

A. Yes sir; you could smell it when you was dressing them; you didn't have to cook them to smell it.

Q. What was the smell; what did it smell like?

A. Like gas or tar; kind of a coal tar or gas smell.

Q. What was the state of the water in the summer time?

A. When the weather got very hot there was a good deal of stuff growed in it; I never had no name for it; but it growed and would get green and had a growth on it, and it smelled bad.

Q. Now since the drainage canal waters have come down here what has been the condition of the river?

A. Well I haven't seen any of that growth, a little green strip comes once in a while but the growth hasn't come here since, and stuff that growed out of it, and I have had no dead fish since that time, nor no gassy fish.

Q. Has there been any smell in the water since the opening of the drainage canal?

MR. JEFFRIES: Objected to as leading.

A. Well nothing like it was; nothing like the gas that I
5597 have seen.

Q. How about the condition of the fish since the opening of the drainage canal?

A. The fishing is good and the fish appear to be healthy; I haven't seen any dead along the shores like there used to be.

Q. Before the opening of the drainage canal, did anything settle in your nets?

MR. JEFFRIES: Objected to as leading.

A. Yes sir.

Q. What kind of looking stuff was it?

A. Well, it was filth of some kind, I couldn't tell what it was, but it was filth anyway and nasty.

Q. Was there a great deal of it?

A. Yes sir, we would find a great deal of it.

Q. Have you had any of that since?

A. No sir, not like that.

Q. Was there ever a time here when the growth in the river obstructed or prevented navigation of the river?

A. From here to the bridge I saw a little tug boat, loaded with stone; that would be seventeen or eighteen years ago—that built the piers of this bridge up here; the little tug boat had to stop sometimes to come over to pass up, and when we went seining we would have to carry shovels along to get the
5598 stuff out of our nets, before we could get out the fish.

Q. How far is it from here to Peoria by river, downstream?

A. It is called eighteen miles, I think.

Q. How far is it from here to the bridge to which you refer?

A. A mile and a quarter from here, is what they called it. Up the stream.

Q. Before the opening of the drainage canal, you may state whether there was in the nets a slimy, whitish looking substance which filled up the meshes of the nets and hung in festoons or strings from the nets?

MR. JEFFRIES: Objected to as leading.

A. No, sir, I never saw any of that here either before nor since, that they filled up the meshes of the nets. The stuff gathers on them, but no such stuff as that, and it don't gather on them that thick. They get what I would call dirty and have to be rinsed off, like they would be if set too long; they gather stuff.

Q. Do you know the kind of slime here which is called slur-gut?

MR. JEFFRIES: Objected to as leading.

A. No, sir.

Q. Have you heard the fishermen from below Peoria talk of the slime called slur-gut?

MR. JEFFRIES: Objected to as leading and hearsay.

5599 A. No, I have never heard of such a name as that up here.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say you live here in Chillicothe?

A. Yes, sir.

Q. How long have you lived in Chillicothe?

A. I have lived here since 1868.

Q. How do they get their water supply for domestic and drinking supply here?

A. They have wells.

Q. What kind of wells?

A. Drove wells, and from what they call the waterworks.

Q. How deep are these wells driven in the ground?

A. Well, sir, I don't know about that.

Q. About how deep?

A. Well, sir, I should judge from thirty to forty feet deep; somewheres from thirty to forty feet deep.

Q. The people here in Chillicothe don't use the water from the Illinois river for domestic or drinking purposes, do they?

A. No, sir.

Q. The current in the river is stronger now than it was before the Chicago drainage canal was opened, is it not?

5600 A. Yes, sir; there is more current than there used to be and the river stays higher.

Q. The fish in the Illinois river before the canal was opened were not condemned by the State Board of Health, were they?

A. I never had any examination of the fish, except when they died in the nets and smelled gassy, I quit fishing.

Q. You noticed the green scum on the water occasionally since the opening of the canal, haven't you?

A. Yes, sir, I have noticed the scum, there is once in a while the green scum, but no growth over it.

Q. A kind of an oily or greasy appearance of the water?

A. Yes, sir, it looks green, and at times it looks kind of greasy, but it has always done that since I have known it, at times.

Q. What is this growth that comes from the scum on the Illinois river?

A. It grows mostly in sluggish places; a slough puts up in the river and up in there it will grow until the river raises from the headlands and causes this stuff to run out.

Q. How does it grow? Heavy bodies?

A. In the first place you will notice this green color on the water, then it begins to grow in a seed, and the seed is green and

round; finally it gets roots on it; well half as long as my
5601 finger; then it gets a leaf on it; it looks something like a
clover leaf; I have seen them so thick along the bank that it ferments and smells horrible.

Q. The dirt and filth gets on the nets to some extent yet, does it not?

A. Oh, there is some; but it is not the kind of stuff that used to gather on them.

Q. Before the opening of the canal did this moss and green scum gather on the nets to a large extent?

A. No, that green stuff never gathered and growed on them, it floats; we had a kind of a moss that growed on them, but it was not this stuff.

Q. What is the character of the scum or of the growth or deposit on the nets since the opening of the canal?

A. This scum?

Q. What is the character of the deposit on the nets?

A. Well, it is a nasty, muddy kind of a stuff; we have to rinse our nets off once in a while; when this stuff gets on them we have to wash them off.

Q. It is a kind of a slimy, black mud?

A. Kind of a black, not slimy, that is to speak of. Of course it is dirty or we wouldn't have to wash the nets off.

Q. What is the difference between the deposit that gathered on the nets before the canal was opened and since the canal was opened?

A. It was a good deal more nastier then than it is now,
5602 more slimy and smelled worse.

JERRY FOLSOM.

5603 Chillicothe, Illinois, July 23, 1903.

BRADLEY B. HAWLEY, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Bradley B. Hawley.

Q. What is your business?

A. Steamboating and boating.

Q. Are you the captain and owner of a steamboat?

A. I am captain of a boat, but I can't say that I am really the sole owner of the boat.

Q. What boat are you the captain of?

A. City of Henry.

Q. How long have you been steamboating on the Illinois river?

A. Steamboating without other boating you mean?

Q. Steamboating and working on the Illinois river?

A. About 43 years.

Q. Are you up and down the river a great deal?

A. Yes, sir; I haven't been off the Illinois river in the summer for 43 years, one whole summer.

5604 Q. Were you acquainted with the Illinois river before the opening of the drainage canal?

A. Yes, sir.

Q. What was the condition of the Illinois river prior to 1900 as to the quality of the water?

A. Well, the quality of the water was always better above Peoria than it was below Peoria, that is a good many miles down; but in low water it was a pretty sluggish current and the water was pretty bad, very bad water.

Q. How was the water before the opening of the canal between Peoria and LaSalle?

A. Well, the water was what we—of course in the spring we didn't notice so much difference, but in the hot weather or low water, and dry times, the water was what we called pretty bad; that is, it moved very slowly in the river.

Q. Was there any odor emanating from the water?

A. Yes, sir; we used to smell it at times, especially in the morning, when we would get up.

Q. Did it have anything on top of the water?

A. Well, there was a good deal of this green stuff, whatever it may be, I don't know just what you would call it,—floating on top of the water.

Q. How was the water below Peoria before the opening of the drainage canal?

5605 A. Well, it was pretty bad.

Q. Do you know what made it bad?

A. Well, what we used to believe, what they used to say, was that it was the sewage from Peoria.

Q. How did the water above Peoria compare with the water below Peoria?

A. The water above Peoria was a good deal better than it was below Peoria at the same time; at that same year.

Q. Do you know where the sewage and polluting matter comes from that comes from Peoria?

A. Well, to give it a real foundation as to where it comes from, all that we noticed of where it comes from is out of those spouts; what we think it comes from. Of course we think it is out of the cattle pens, but then we never went up to see about that; how that was.

Q. Where do these spouts lead to?

A. You mean coming into the river?

Q. Yes.

A. Well, the most we noticed is between the T. P. & O. bridge—even below that, even below the T. P. & O. bridge.

Q. What are located immediately back of these spouts?

A. Why, sugar houses and still houses.

Q. Do you know the number of distilleries in Peoria?

5606 A. No, sir, I do not; I don't know the number of them.

Q. Do you know of any other source of pollution that enters the river at Peoria except that which comes through these spouts from these distilleries?

A. Well, I don't say as I do now; there used to be, the gas works put out a lot of bad water there; but within the last year or so I haven't noticed that.

Q. Do you know where the manure heaps are in Peoria?

A. Why, the manure in the river you mean?

Q. Yes?

A. What we saw was in front of those spouts that runs out that are supposed to be from still houses.

Q. About how many of those spouts are there leading from the still houses?

A. Well, there is some of them there that are not used at the present time. I won't be certain whether it is three or four of them that are not in use now.

Q. Did you ever have anything to do with the removal of these manure heaps?

A. Yes, sir, last summer they hired us to go in there after a feller and kick it out into the river and get the stuff away from the end of the spout.

Q. When was that?

A. I can't say exactly what month it was; it was in the summer after the water went down.

5607 Q. How long ago?

A. This last summer, last season; it was along after the water got low; I remember it was very hot. I remember it was June or July; I just don't remember exactly the month it was; it was hot weather, I remember that.

Q. About how much of that stuff had accumulated at the mouth of those spouts that you removed?

A. Well, we moved stuff that gathered in there, I should judge fully the length of this boat—well it would be nearly as big as this boat would be long, in that neighborhood; that was laying in front of the spouts.

Q. Can you give it in feet?

A. It would be pretty hard to give the exact number of feet; it would be a sort of a long, round mass of stuff together there. It wouldn't be square; it would be round; and most of it would be below the spout.

Q. Would it be as much as a half an acre?

A. Altogether?

Q. Yes?

A. Yes, sir.

Q. What was done with this stuff that you removed?

A. Why, he hired us to kick it out into the river with the wheels of the boat.

Q. Have you been below Peoria lately?

5608 A. Yes, sir—not very lately, but I was down there in April and May.

Q. Have you been below the bridge in Peoria lately?

A. Yes, sir.

Q. How lately?

A. Well, the water after you get down there—say after you get down a mile below the bridge, it begins to get kind of thick and full of something.

Q. What is its color?

A. Well, it is like dirty water; kind of a thick, dirty water.

Q. Any smell to it?

A. Well, I didn't get much of any smell this summer.

Q. Since the opening of the canal, what has been its effect upon the waters of the Illinois river both below Peoria and above Peoria?

A. Why, there is more of a current going than what there was, and the water is what I should call more pure than what it was before; that is, it looks more clear and more pure to me.

Q. How is it below Peoria?

A. Well, it is some stain of this—the same as it was before only it ain't so bad; it don't look so bad to me.

Q. Have you seen the water in Lake Peoria immediately
5609 above Peoria, since the opening of the drainage canal?

A. Yes, sir.

Q. What is the condition of that water?

A. Why, the water looks, as I said, more pure to me, than it was when this green scum settled on it—than it used to be years ago.

Q. How is it as to clearness today?

A. It seems to be—well, the water above Peoria never was very muddy; that is, after it got below this scum that used to float on it in low water. The Peoria lake water never was what you might call bad water, bad looking water, except when this scum was floating over the top; not to my recolection.

Q. Is the water in Lake Peoria as far as Chillicothe, better or worse than it was before the opening of the drainage canal?

A. Well, in my opinion the water is better and clearer than it was before the opening of the Chicago canal.

Q. How far from Peoria can you notice the effects, with the eye, of the sewage from the distilleries and sugar houses that empty into the Illinois river?

A. Below Peoria?

Q. Below Peoria?

A. Well, of course we never took a close observation of that, but you can notice it several miles. thicker water
5610 and a different color.

Q. Did you ever notice any gas bubbles coming up out of the water in front of those distilleries?

A. Oh yes sir, oftentimes, a substance that looked like this stuff that passes out of the cattle pens; it raises up in a great large piece that comes up with those bubbles,—it seems to come from the bottom of the river as far as you can see.

Q. Did you ever cut a hole in the ice before the opening of the drainage canal?

A. Yes, sir.

Q. What was the effect?

A. Well, it smelled bad.

Q. Where did the smell come from?

A. It seemed to come out of the hole, from the river; we undertook to drink the water and we couldn't do it.

Q. When did you do that?

A. I can't tell exactly what year, but in the neighborhood of seven or eight years ago.

Q. Have you done that since the opening of the canal?

Q. No sir, I never laid down there; it don't freeze where we have been laying, as it did that winter; we have been laying around Pekin and Peoria lately.

5611 Q. What business is the steamboat City of Henry engaged in?

A. Boating grain principally from the river towns into Pekin.

Q. Do you know about what the quantity of sewage which empties into the Illinois river from the distilleries and cattle sheds and sugar refineries at Peoria is?

A. No, I don't know the exact amount, because sometimes they are running a good deal more than they are other times; sometimes they trough about eight or ten inches deep and then they shut them off; they ain't running so much; they ain't running regular all the time, them that I have seen.

CROSS-EXAMINATION, By Mr. Jeffries.

Q. Where do you live?

A. I live aboard the boat, but we are more at Peoria than at other points.

Q. You say the current in the Illinois river from Henry to Pekin is very much more swift than it was before the canal was opened?

A. It is, yes sir.

Q. There is a good current all the way down, is there not, from Henry to Pekin, compared to what there was before the canal was opened?

5612 A. Yes sir, there never was much current in the lake; it runs very slow and always did; that is, excepting in high water.

Q. Lake Peoria is not really a lake, it is simply the widening out of the Illinois river is it not?

A. I am calling it just what they call it to me; they call it Peoria Lake.

Q. Well, I am getting down to the actual facts?

A. Well, I am explaining it just as I understand it, just as it was called, and told to me; the way that people generally called it; by name, Peoria Lake.

Q. It is a fact, isn't it, the water of the Illinois river flows into what is known as the head of the lake and out at the foot?

A. That is the way I understand it.

Q. Well you know that to be a fact, don't you?

A. There is no other way for it to get out.

Q. And no other way for water to get in?

A. No sir, excepting from what runs in from the creeks and supplies along the shore, whatever they may be.

Q. How long is that stretch of the Illinois river known by the people as Lake Peoria?

A. Just Peoria lake?

Q. Yes.

A. I never heard any other name for it since I have been

5613 on the river.

Q. No, but how long is it?

A. Well I can't tell you the exact length, only as I understand it from other folks. They call it eighteen miles to Chillicothe, and the lake probably ends down here something like a mile; what I should call the end of it, where it begins to shallow up; what I should suppose would be the end of the lake; what I would call the end of the lake.

Q. Now the lake begins you say, about a mile below Chillicothe?

A. Well, it is what I would call about a mile, that is, I never saw just exactly the end of it showed to me, only as I made my own idea that that would be about the only way, because it begins to look like the river again; it begins to narrow up and get like a river again.

Q. And it ends at Peoria?

A. Yes, sir.

Q. And you say it is eighteen miles by river from Peoria to Chillicothe?

A. That is what the people generally call it by the river or lake, to Peoria, eighteen miles.

Q. Then the lake would be 17 miles long?

A. According to the way they call it at Chillicothe and according to my way of telling about it; I have no other
5614 way of calling it; I have never saw it surveyed or measured in my life.

Q. You have passed down the river through what is known as Lake Peoria several times, have you not?

A. Yes, sir.

Q. Now how wide is the lake?

A. Well, it depends a good deal on the stage of the water, how wide it is; the banks are very low, and in high water it is a good deal wider than it is in low water. The water goes over the banks. I haven't any real way of knowing myself how wide it is.

Q. What was the average width of Lake Peoria at low water stages, before the canal was opened?

A. Well, as I said before—

Q. Give us your opinion, your judgment?

A. Well it wasn't quite as wide as it is since we got the canal in it.

Q. Well, how wide was it?

A. Well, I don't know, it might be a quarter to a half a mile—

Q. I want your opinion?

A. Some places it is wider than it is in other places.

Q. How wide would it be in some places?

A. There is one place down there at Spring Bay that it isn't any wider than the river would be for a little ways.

5615 Q. How wide would that be?

A. Probably in the neighborhood of a thousand feet wide, in what they call Spring Bay narrows.

Q. Spring Bay Narrows is about half way between the two ends of the lake, is it not?

A. Well, no, it looks to be further from the Narrows down to the lower end than it would be from this end to the Narrows.

Q. How much further?

A. Oh, I should judge one or two miles; I have no exact way of telling myself, only as I guess at it.

Q. Now the Narrows at Spring Bay, is about a thousand feet wide at low water time?

A. I should judge it would be about that.

Q. Now is that after the canal was opened or before the canal was opened?

A. Well the lake and the Narrows and the whole business is a little wider now than it was then on account of the sloping bank; that some more water covers each shore than it used to.

Q. Would it be fifty feet wider?

A. No, I don't think it would be, not in low water, excepting it would be caused by rain; caused by the regular sewer, I don't think it would be 50 feet wider.

Q. What do you mean by the regular sewer?

A. Why if it wasn't raining enough to keep it up, but just the natural flow from above.

5616 Q. From above where?

A. From the Northeast, or from Chicago down here; call it the sewer or canal, whatever it is.

Q. Now just below this narrow place in the lake how wide is it from there on down to Peoria?

A. Well as I said before I have no way of telling; it looks to me as if it was three-quarters of a mile wide, that is after you get below the narrows.

Q. And that was before and since the opening of the canal?

A. Well the lake is a little wider now than it was before, because they have got more water; how many feet I couldn't tell you exactly.

Q. Fifty or a hundred feet?

A. No sir, not that much.

Q. How wide is the lake above the Narrows to its head?

A. Well, it varies above the Narrows; it is wider some, in different places.

Q. How wide is it at the widest places?

A. Well, it looks like to me three-quarters of a mile; I have no way of telling exactly, only to guess at it.

Q. How wide is it at the narrowest places above the Narrows?

A. It looks to me as if it would average about three-quarters of a mile wide, until you get pretty well up.

Q. Now that was before the opening of the canal?

5617 A. Well I suppose it would be a little bit wider now than it was then.

Q. What is the average depth of the lake outside of the main channel which runs through it?

A. Well, there is some places where it is a good deal shallower than it is others. There is about, in the lowest time since this canal went in, I should judge it to be about eight or nine feet in the channel, and of course outside of that I couldn't judge; it is pretty shallow.

Q. About how much?

A. Well, it don't run at times. There is low places in it.

Q. Well, what in your opinion would be the average depth outside of the channel?

A. Of course, it would depend on how close to the shore you were and all that.

Q. I mean the average depth all over the whole water?

A. You mean the channel and altogether?

Q. No, outside of the channel.

A. Why I wouldn't suppose there would be over four to five feet of water, without you get close to the shore, if you would get close to the shore there wouldn't be so much.

Q. Some places not six inches?

A. Well, you would have to get pretty close to the shore if it was not over six inches of water.

5618 Q. And varies according to the stages of the water in the river?

A. Yes, sir.

Q. Now the channel or flow of the river comes into this what is known as Peoria Lake at the upper end and runs continuously and well defined clear through the lake?

A. Yes, sir.

Q. To the lower end, just above Peoria?

A. Yes, sir.

Q. Is there any other lake through which the Illinois river runs from Henry to Pekin than Lake Peoria, or what is known as Lake Peoria?

A. No sir, I always heard it called the river and no other name.

Q. And through all that distance from Henry to Pekin, there is a well defined continuous current or channel?

A. Yes, sir.

Q. Before the canal was opened you noticed a green scum on the water and you have also noticed that to some extent since the opening of the canal?

A. I noticed some yesterday in coming down along the shore; between here and Lacon up above.

Q. Before the canal was opened, the water under the scum was just as clear as it is since the opening of the canal, as I understand it? 5619

A. The water was, in what they call the Peoria Lake as far as I know, outside of a raise in the river, generally pretty clear, excepting the scum that would be on the top of the water during—

Q. Low water time?

A. The hot months, yes.

Q. You don't know whether the sewage gets down here or not?

A. Why I know just the same as other folks do, that it does; that it comes here and affects the river, because there is more water than there used to be; the supposition is that it gets here.

RE-DIRECT-EXAMINATION, By Mr. Todd.

Q. Mr. Hawley, what is the effect of the water of the Illinois river in the boilers for generating steam now, as compared with what existed before the opening of the drainage canal?

A. It depends on some where we are working; it depends some on where the boat is working; if the boat is working below Pekin it was a great deal worse then than it is now. Our boiler used to foam from what was supposed to come out of the still houses and sugar houses before that; our boilers used to foam and foam considerable.

5620 Q. How about above Peoria?

A. Well the water in the lake outside of a raise in the river is always pretty clear, but the river water seemed to be more foul. The boilers seemed to act all right with that water above Peoria.

Q. How about now, since the opening of the canal; how does the water from Peoria to Henry act on the boilers?

A. The water in the boilers that you take for steam seems to work better with our boat than it used to all the way along as far as we have been; it don't give what we call foam, or raise the water as much as it used to.

Q. How about below Peoria since the opening of the canal?

A. Well, the water is better than it was; clearer and better than it was; in the boiler it is much better in regard to what we call foaming or raising the water in the boilers.

Q. Does it foam above Peoria?

A. No sir, not in our work.

Q. Have you worked any below Peoria in the last three years?

A. Oh, yes, we was about 160 miles below Peoria in April and May.

Q. Between Peoria and Pekin now, what is the effect of the water in the boilers?

A. We don't have any trouble with the water in the boilers now the water doesn't seem to foam; we haven't had any trouble this summer.

5621 RE-CROSS-EXAMINATION, By Mr. Jeffries.

Q. The water immediately below Henry, down to as far as this point, Chillicothe, would occasionally foam in the boilers before the canal was opened, wouldn't it?

A. Why, we never had any trade from there here; our trade was all below Peoria and Pekin, you know; because there is where we went to unload.

B. HAWLEY.

5622 Chillicothe, Illinois, July 23, 1903.

O. F. THOMAS,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. O. F. Thomas.

Q. What is your business?

A. Physician and surgeon.

Q. How long have you been a physician and surgeon?

A. 25 years last March.

Q. Where do you live?

A. Chillicothe, Illinois.

Q. Doctor, what has been the condition of typhoid fever in the town of Chillicothe during the last three years?

A. I don't know of a case having occurred in the town during that time—yes there was; there was two cases that I know of, two years ago.

Q. Where were those cases?

A. They were on Fourth Street; that is four blocks west of the river.

Q. Did you attend those cases?

A. Yes sir, with Dr. Kelly.

5623 Q. Was the cause of those cases attributed to the river?

A. No sir.

Q. What was done with the dejecta of those cases?

A. They were all treated with bi-chloride of mercury and run into water closets after that.

Q. Have you a sewage system in this city?

A. No sir.

Q. Privy vaults?

A. Yes sir.

Q. What is the condition of the health of this city generally?

A. Well, we consider this a very healthy town and community.

Q. What is the source of the water supply of this city?

A. The city water supply is wells that are sunk alongside of the river right up here at the power house. Near the bank.

Q. How near are the wells to the river?

A. Well I don't know just exactly; I should judge 100 or 200 feet; perhaps it is closer than that.

Q. Do you know the nature and character of the wells?

A. They are driven wells.

Q. Is the water in those wells from the Illinois river?

A. Well, we suppose not; we don't know; I don't I am sure.

5624 CROSS-EXAMINATION, By Mr. Jeffries.

Q. How deep are those wells, doctor?

A. I do not know.

Q. About how deep?

A. I couldn't tell you; I don't know.

Q. How long have you been here?

A. About 48 years; I have lived here all my life practically.

Q. Are they deeper than thirty feet?

A. I think so. I have known a long while ago.

Q. Well in your judgment?

A. Thirty or forty feet.

Q. Do you know the character of the earth in which they are driven?

A. I think it is gravel.

Q. And sand?

A. And sand, yes.

Q. If the water does come into those wells from the river, it is filtered through the sand and gravel is it not?

A. Why yes, if it comes through the sand and gravel it is filtered.

Q. How large is Chillicothe?

A. About 2,500, the two towns together.

5625 Q. What do you mean by the two towns?

A. Chillicothe proper and North Chillicothe.

Q. Are they separate municipalities?

A. Yes sir.

Q. How far apart are they?

A. Oh, they are continuous; one into the other.

Q. Do they have separate postoffices?

A. Yes sir.

Q. Don't they get their water from the same source?

A. Yes sir.

Q. But have separate systems?

A. No, same system; all supplied by this power house down here, from the same well.

Q. The water is pumped from the well into a reservoir?

A. No, into the mains; it is direct pressure.

Q. The people of Chillicothe, or of North Chillicothe, don't use the water from the river for domestic purposes, do they?

A. No sir.

Q. You don't consider the water from the Illinois river good and wholesome for domestic purposes, do you?

A. No sir.

5626 Q. Those two cases of typhoid fever that you spoke of, do you know with any reasonable degree of certainty, the cause?

A. Yes, I had an examination of the milk supply made, and it was attributed to the milk.

Q. You found no typhoid germs in the milk however?

A. Yes, there was.

Q. Did you make the examination yourself?

A. No sir, I had it made in Chicago.

Q. Do you know where the milkman got the water that he used in the dairy or was it from a dairy?

A. Yes it was from a dairy, four miles northwest of town.

Q. On the river?

A. No sir, four miles from the river.

Q. The two patients lived here in town, did they not?

A. Yes sir.

Q. Male or female?

A. One male and one female.

Q. Live in the same family?

A. Yes sir.

Q. Did they have the typhoid fever at the same time?

A. Yes sir.

Q. Do you know whether or not any of the dairyman's family had the typhoid fever?

A. No, they did not.

Q. Did anyone else using the milk have the fever that
5627 you knew of?

A. Not that I knew of.

Q. Did the dairyman supply milk to any other families?

A. A great many of them, yes sir.

Q. In Chillicothe?

A. Yes sir.

RE-DIRECT-EXAMINATION, By Mr. Todd.

Q. Doctor, you said I believe that you had the milk analyzed?

A. Yes sir.

Q. Are you correct in stating that the typhoid bacillus was found in the milk that was analyzed?

A. No sir, not the typhoid bacillus; I don't remember now just what the report was, but the letter that the chemist sent to us was that his opinion was that the milk was the cause of the trouble.

Q. Who was it that made the examination of the milk?

A. I sent it to Chicago hospital; I don't know who made the examination.

Q. Was this a report from a chemist or a bacteriologist?

A. I don't know.

5628 RE-CROSS-EXAMINATION, By Mr. Jeffries.

Q. Doctor, state where you got the milk which you sent to the Chicago Hospital for examination; its condition at the time that you got it and the manner in which it was forwarded and the condition in which it was forwarded to the hospital for examination?

A. I took two clear test-tubes and had the domestic take the milk from the vessel as it was brought to the kitchen and set it to one side, and I sealed them and sent them to Chicago.

Q. Did you pack them in ice or anything?

A. No, it was in the winter; I mailed them.

Q. Did you sterilize the test tubes?

A. I boiled them and the corks also.

O. F. THOMAS, M. D.

5629 Chillicothe, Ill., July 23, 1903.

WILLIAM COLWELL,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and tesified as follows:

Q. What is your name?

A. William Colwell.

Q. Where do you live Mr. Colwell?

A. I live in Chillicothe.

Q. How long have you lived in Chillicothe?

A. I came to Chillicothe in 1847.

Q. What is your business?

A. Well, I have been in the contracting business for the last fifteen years most of the time, bridge building, etc.

Q. Have you constructed any bridges across the Illinois river?

A. Yes sir.

Q. What bridges have you constructed across the Illinois river?

A. I helped in the first place to build the Santa Fe Bridge right here.

Q. At Chillicothe?

A. At Chillicothe; I worked on that and I did trestle 5630 work east of the river; I helped to build trestle work east of the river; then I went to Peoria the next season afterwards and built the Santa Fe Road; I helped to build the upper free bridge at Peoria. I put in the sub-structure, all the foundation and tile work, and the trestle work and so on, on the east side of the river.

Q. Have you been on the river superintending that work yourself?

A. Yes sir.

Q. Have you had anything to do with any steam engines

A. Yes sir, I was running the pile driver and hoisting and so forth, and worked at dredging.

Q. Are you operating a pile driver?

A. Yes sir.

Q. At present?

A. Not at present.

Q. When did you cease?

A. About two years ago.

Q. What part of the Illinois river are you and have you been familiar with during the last ten or fifteen years?

A. All the way from Peru to Beardstown. I helped build a bridge at Beardstown, after the Peoria bridge.

Q. What other stretch of the river are you acquainted with besides the stretch from Peoria to Beardstown? Are you acquainted with the river from Peoria up?

5631 A. From Peoria to Peru.

Q. Will you describe the condition of the Illinois river, from Peru to Beardstown prior to the opening of the drainage canal as you knew it?

A. Well when I first went over the river in the early days, back fifty years ago, the Illinois river was a very nice stream of water; good water; I have drank many a drink out of the Illinois river when I was a young man; but after the towns began to grow and the Michigan Canal was built, they pumped Chicago river into the Michigan Canal at Bridgeport I think and after that the river began to get foul, and it kept on, as the population of the towns, etc., increased in Chicago, it kept on getting more so, for a number of years, until when we built the Santa Fe bridge, the river was very nearly entirely scummed over with a green coating, which looked like some fine vegetation. Well it got—it was so thick sometimes that it was hard work to row a boat through, row a skiff through it. I recollect when we were building the bridge up here and towing stone barges up;.it made quite a hindrance to the towing of barges up some days. That's about all I know about that particular part of it.

Q. How was the odor on the Illinois river prior to the opening of the drainage canal?

5632 A. Well it used to be sometimes, when the wind blew from certain directions, you could smell the river pretty plain.

Q. How was the river at Peoria when you were there, building the bridge at Peoria?

A. Well at the upper bridge it was just about the same as it is here; the upper bridge was just at the foot of the Narrows, it was probably clearer there than where the river was spread out more. The bridge at Peoria is right at the lower end of the Narrows and there is more current and more channel there than most places on the river.

Q. How was the river below the bridge?

A. At Peoria?

Q. Below Peoria?

A. The river there runs right into the lake and spreads out wide and I never noticed anything in particular there different from other places, only when the river would spread out wide there would be a green scum over the water, more so than where it was narrow and more current.

Q. How was the river below Peoria?

A. Late years?

Q. Yes.

A. Well, late years the river between Peoria and Pekin was pretty foul sometimes from the sewage and filth; they claim that it was the filth of the distilleries that made it foul.

5633 Q. How was it at Beardstown?

A. The river was pretty clear at Beardstown. I never could discern any filth any more in the river at Beardstown than we could up here; I never could.

Q. Since the opening of the drainage canal, what has been the effect of the waters of Lake Michigan upon the Illinois river at points where you have observed it, since that time?

A. I think the water is purer than it was then and less odor to it; and I have never seen the river scummed over with the green vegetation since the drainage canal.

Q. At what points along the river do you refer?

A. From here up to the Three I Bridge this side of Peru, this side of Spring Valley. I helped build a bridge at Spring Valley and I also helped build a bridge—the last bridge I helped to build was the Three I bridge, this side of Marquette.

Q. What is the condition of the water at Chillicothe since the opening of the drainage canal?

A. I think it is better than it was before the opening of the drainage canal.

Q. Do you notice any odor from the water now?

A. I haven't noticed any since the drainage canal—to ex-

plain that I will tell you; the water used to be, I used to when I would clean out my boiler, clean it out and fill it up with
5634 fresh water. I would always notice the first day using it after filling it up with fresh water that the steam—every time I would go around the engine I could smell the odor from this water and the odor was quite offensive; I don't know hardly what you would call it; but since the lake water has been turned down here I have never noticed that odor from my engines like I did before.

Q. How long back has it been since the Illinois river was as pure here and clear as it is today?

A. Well, I couldn't hardly tell how many years but it is quite a good many years.

Q. Give your best judgment?

A. My best judgment, it has been twenty-five or thirty years.

Q. How old a man are you?

A. I was 71 years old the 18th day of last June.

Q. Where were you born?

A. I was born in Ross County, Ohio.

Q. How many railroad bridges have you been connected with the construction of across the Illinois river?

A. Two.

Q. How many other kinds of bridges?

A. Three.

5635 CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You live here in this town of Chillicothe?

A. Yes sir.

Q. You have a water system here, haven't you?

A. Yes sir.

Q. Where are those drive wells from whence the city gets its water supply located with reference to the Illinois river?

A. Why right up here on the bank on the first street on the river street two blocks above here.

Q. How far are those wells located from the bank of the Illinois river?

A. 100 feet probably. I am guessing at that; it is in the neighborhood of a hundred feet.

Q. How deep are those wells?

A. I couldn't tell you exactly.

Q. About how deep?

A. About 40 feet below the surface of the river, I think.

Q. That would be about how many feet below the surface of the earth?

A. Oh, probably 55 or 60.

Q. How many wells are there of this character, that are used by the city in securing its water supply?

A. I think there are six,—six 6-inch pipes.

5636 Q. What is the character of the ground or earth through which these wells are driven?

A. Sand and gravel.

Q. And after they are driven, there is a pipe of some kind put down, is there not; or is the pipe driven into the earth in the first place?

A. I think so, yes sir.

Q. Then the wells are encased with an iron tube or pipe?

A. Yes sir.

Q. From the surface of the earth to the full depth?

A. Yes sir.

Q. Aside from these wells that are used by the city in securing its water supply, are there any other wells, either in Chillicothe or North Chillicothe?

A. Yes sir, there are some individual wells.

Q. What is the character of the wells that are used by the individuals, who do not obtain their water from the city supply?

A. Well, the wells are dug down in gravel; dug clear down through the level of the river to the gravel; when they strike the level of the river they strike water as a general thing.

Q. Then these wells that are used by the individuals, known as private wells are living wells, are they not?

A. Living wells?

5637 Q. Yes. In other words, the wells depend not upon the drains, or surface water, but derive the water from the earth beneath?

A. Yes sir.

Q. The same as a spring?

A. Well the water here seems to be on the level with the river out through the gravel and sand all over the prairie; we have a sand prairie here about four miles wide and 7 miles long and pretty much all over that prairie the bottom of the wells are on a level with the river. My father when I was a young man had a well on a farm, a mile from town here and we took a level from the river out there on top of the land, and when we struck water, we wasn't a foot from the level of the river.

Q. The people here in Chillicothe don't use the water from the Illinois river for domestic and drinking purposes?

A. No sir, none that I know of.

Q. Do you use it?

A. No sir.

Q. Do you know the source of the water supply of the farmers and people living in the rural communities along the Illinois river at this point and at points above and below?

A. Well the majority of farmers use well water.

Q. And the remainder use either spring or cistern water?

A. Yes sir.

5638 Q. You say that the Illinois river water has gradually grown worse for several years back?

A. Yes sir.

Q. And particularly so after the opening of the Illinois and Michigan Canal?

A. Yes sir.

Q. Since that time do you know that the sewage from about a million and a half people of Chicago has been coming down through the drainage canal, and if so, what effect would that have upon your opinion as to the water being better now than it was before the opening of the canal?

A. Well I couldn't tell what the amount of sewage from Chicago that comes down here; but the water now appears to be better than it was before the opening of the canal.

Q. You judge from its appearance and not from what it may contain?

A. Well I judge from using it in my engine boiler; the difference in the smell of it and so forth.

Q. That, however, is based upon practical purposes and not domestic and drinking purposes?

A. Well of course it isn't my experience for drinking purposes; I haven't had any; I haven't tried to drink it.

Q. It smells occasionally now, since the opening of the canal does it not?

5639 A. Well I haven't noticed any odor from the river for the last year or so.

Q. The current is much stronger now than it was before the canal was opened, then I suppose?

A. Yes, sir.

WM. COLWELL.

5640 Chillicothe, Illinois, July 23, 1903.

J. E. DALRYMPLE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. J. E. Dalrymple; Chillicothe; fisherman.

Q. How long have you fished upon the Illinois river?

A. Well I have been fishing more or less for about sixteen years.

Q. Over what portions of the river?

A. I fished some at different times from Hennepin to Copperas Creek Locks.

Q. When did you fish below Peoria?

A. Well it was twelve years ago.

Q. How many seasons have you fished below Peoria?

A. I was down there about four years.

Q. What was the condition of the Illinois river below Peoria at that time?

A. Why the river was low down there one time, the water was low.

Q. As to moss or slime in the river, what was its condition?

A. There was lots of slime in that country at that time.

5641 Q. What kind of looking material was it?

A. Why it was a white colored slime; I don't know what you would call it; we used to call it bull-shit down there.

Q. Was there a great deal of it that got into your nets?

A. Yes sir, at places it was very bad.

Q. Now in your fishing above Peoria did you find that same kind of slime?

A. Well we would find it but not so bad.

Q. From Hennepin down to Peoria Lake?

A. No, it wasn't so bad; there was some of it though, all along the river.

Q. Since the opening of the drainage canal above Peoria and at this point, do you find that material on the nets?

A. No, I haven't been bothered with it any the last two or three years.

Q. What was the condition of the Illinois river at this point before the opening of the drainage canal for a number of years?

A. Why we have had low water for several years.

Q. Was there any kind of plant or moss growing in the river?

A. We call it shamrock here; a green stuff that used to grow around on the river and choke up the sloughs.

Q. Describe the leaves and roots of that plant?

5642 A. Well it is a three-leafed plant that had roots growing down into the water; it floated just about whereever the wind blew it.

Q. Did it get into the river here in any great quantity?

A. Well I have seen it pretty bad; we had to fish on the east side of the river with an east wind and on the west side with a west wind.

Q. That is, you had to take where the wind had cleared the river of this stuff?

A. Yes sir.

Q. Before the opening of the drainage canal was there a smell here to the water?

A. In the winter time there world be a pretty bad smell at times.

Q. How was it at the time the river was frozen over?

A. Why it was bad; you could smell it above the town, from the river here; right above here we have a shallows or rapids, that always stays open during the winter.

Q. What effect did it have on the fish?

A. I have seen the fish die in good numbers here.

Q. Did it taint the fish?

MR. JEFFRIES: Objected to as leading.

A. Why there wouldn't nobody buy them from me around town; you couldn't eat them yourself.

5643 Q. What kind of an odor was it?

A. Why, I ate some of the fish and it tasted to me just like tar; I had tar on my tobacco and it tasted just like that. You couldn't tell much difference between the taste of it and the taste of the fish.

Q. Was there a smell in this shamrock that grew in the waters here in the summer?

A. Why yes, if you would pile it up it would heat; the wind would pile it up and it would heat.

Q. And then a smell would come from it?

A. Yes, it would heat. I have saw it six or eight inches deep on this steamboat landing, right here where you have landed, when the wind drove it in.

Q. Did it sometimes prevent boats from running here?

A. Why, these propellers and small tugs, it would choke up and you would have to take a ice hook and pull it out of the propeller wheel.

Q. Since the opening of the drainage canal, what has been the condition of the water above Peoria?

A. Why we have had good water and lots of it.

Q. Is the water purer than before.

MR. JEFFRIES: Objected to as leading.

5644 A. Yes sir.

Q. Is there any of the odor now that there was before the opening of the drainage canal?

A. I haven't noticed it in the last couple of years.

Q. How about the slime here since the opening of the drainage canal, and moss?

A. Why, it don't bother us any more.

Q. Before the opening of the drainage canal, above Peoria, did the fish live in the live-boxes?

A. Why we hardly ever put them in the live boxes in warm weather; they wouldn't keep over night.

Q. How is it since the opening of the drainage canal?

A. Our fish live very good now.

Q. Are you fairly well acquainted with the fishermen along the Illinois river from Copperas creek dam to Hennepin?

A. Why yes, I am acquainted with some of them all the way along.

Q. Do you know of any typhoid fever among them since the opening of the drainage canal?

A. No, I don't know of any such case.

Q. Take the fishermen as a class, in this vicinity, what is the general state of their health?

A. Why it is pretty good; malaria is the only thing that bothers.

5645 Q. Is there more or less malaria among them since the opening of the drainage canal?

A. Well I couldn't say as to that; it ain't bothered me any in the late years.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How old are you?

A. I was 42 years old the first day of last February.

Q. How long have you been fishing?

A. I have been fishing off and on for the last sixteen years.

Q. What did you do before you fished?

A. I used to work on a farm some and I worked at lathing.

Q. Do you live in this town?

A. Yes sir.

Q. You don't live in a house-boat?

A. No sir, I live one block from the river.

Q. Where do you get your water supply for domestic purposes?

A. From the City.

Q. You don't drink water from the river then?

A. Why we don't use it at the house, no.

Q. And you don't drink it only when you are out on a fishing trip and can't get anything else?

5646 A. We don't carry no water in winter season or fall or anything like that; we carry water now. We drink the water at other times.

Q. What do you mean when you say the water is better now than it was before the canal was opened?

A. Why I mean the water is better every way; it is clearer, purer, better to drink; no slime in the nets to bother the fishermen.

Q. What is the character of the slime that forms on the nets in the river here at Chillicothe?

A. Why, there doesn't any form on, particularly lately; we used to have a stuff that formed on the nets here; we ain't been bothered with it lately.

Q. You say you have seen the green scum and vegetable growth on the banks of the river here at the wharf?

A. Yes sir.

Q. There was no current in the river then?

A. Well, not much.

Q. Since the opening of the canal there has been continuously a good current all the time?

A. Yes, there is too much.

Q. What do you mean by too much?

5647 A. Too much for my business.

Q. For the fishing business?

A. For the fishing business.

Q. A greasy oily substance forms on the water now, doesn't it?

A. Why I haven't noticed any.

Q. At no place, at no time since the opening of the canal?

A. I couldn't say as to that; I haven't noticed any in two or three years.

Q. The State Board of Health of Illinois never condemned the fish in the Illinois river, did it?

A. Why, not to my knowledge.

Q. Where are you fishing now?

A. Right here at Chillicothe.

J. E. DALRYMPLE.

5648 Chillicothe, Illinois, July 23, 1903.

SAMUEL HOSSELTON,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. Samuel Hosselton; my main residence is Chillicothe, Illinois; and my occupation was a farmer until I quit. All I do now about is fish when I feel like it.

Q. Are you a net fisherman or do you fish with a pole and line?

A. I fish with a pole and line.

Q. How long have you lived on the Illinois river in this vicinity?

A. Since 1864.

Q. Have you fished in it a good deal during that time with rod and line?

A. Yes sir.

Q. What was its condition in this vicinity before the opening of the drainage canal?

A. Well in low water it was in very bad condition I
thought; there was very little current and the water was
5649 very foul; that is, there was a vegetation growed on the
river and being no current, it would be impossible almost
to get through it at places.

Q. Was there any odor in the water prior to the opening of the drainage canal?

A. Why, nothing more than there is commonly in low water. Of course take stagnant water, there is always more or less odor.

Q. Did you know about its condition in the winter under the ice?

A. Yes sir, in 1893 and 1894, I run this ferry boat, and in the winter of 1893 and 1894, it was very thick ice, and before we got it open—after the ice became unsafe, we had to cut the channel open before the ice went out, and it was a terrible odor that came from under that ice; it killed nearly all the fish that was in this vicinity, that was under the ice.

Q. Since the opening of the drainage canal what has been the condition of the water in the Illinois river?

A. Well in my opinion the water has been purer than it was before.

Q. How about the vegetation in the water?

A. I see nothing more of that only in pools, back water.

Q. Is there any odor in the water now, since the opening
5650 of the drainage canal?

A. Not that I could discover.

CROSS-EXAMINATION,
By Mr. Jeffries.

Q. How long have you lived here in Chillicothe?

A. I have lived here since 1883.

Q. Have you a private well or do you use the public water?

A. I use the public water, but that water is from a well.

Q. You don't use the water from the river?

A. Well I should judge not; they all tell me that the water flows from the west into the river and it shows it along the river where there are springs.

Q. What I mean by that is, you don't go to the river and dip the water up?

A. Oh no; we get our water from the waterworks.

Q. You say you farmed before you moved to Chillicothe?

A. Yes sir.

Q. How far was your farm located from the Illinois river?

A. It is about two miles and a half above, what we call on the Sparland Road; it is a little bit east of north of Chillicothe.

Q. Do you know the character of the water and the source from which it is obtained that is used by the farmers in
5651 the vicinity of Chillicothe?

A. Well I know that most of the farmers get their water from wells.

Q. The same character of water and by practically the same means as the people living in Chillicothe?

A. Yes sir.

Q. Do you know whether they use the water directly from the river or not?

A. The farmers?

Q. Yes.

A. I know they do not.

Q. When you say that the water in the Illinois river is better now than it was before the Chicago Drainage Canal was opened, you have no other means of determining except from observation?

A. That is all.

Q. As to whether it contains deleterious matter, or material from the sewage of Chicago, you have no information?

A. None whatever.

Q. Were you on the river frequently prior to the opening of the canal?

A. Very often.

Q. What was the character of the river with reference to the flow or current?

5652 A. It was with reference to the stage of water.

Q. Well with low stages?

A. There was a very little flow in the river.

Q. Did this green scum form on the waters of the Illinois river before the canal was opened, when the water in the river was at an ordinary stage?

A. As to that I can't state; I was in the state of Florida, for one summer and two winters, at the time they opened the canal.

Q. Well I am speaking before the opening of the canal?

A. Then I didn't understand the question.

Q. (Previous question read)?

A. Yes sir.

Q. Now what was—was there much current in the river at an ordinary stage when this green scum formed on the river?

A. Very little.

Q. With reference to the condition and flow of the river, prior to the opening of the Chicago drainage canal as compared to its condition, flow and current now, since the opening of the canal, at ordinary stages of the water?

A. Well, I consider the flow considerably more and the water I think is purer than it was then.

Q. Do you know of anyone in this vicinity who uses the water for domestic and drinking purposes in their homes?

5653 A. I do not.

Q. What is the reputation of the water of the Illinois river and what has been its reputation with reference to being a wholesome water?

JUDGE JOHNS: Objected to as not cross-examination.

A. I never heard that talked of very much, the wholesome part of it.

Q. Did you ever hear the people discuss the question as to whether it was good water to use for domestic purposes or not?

A. No, I never did; that was because no one used it.

Q. That was because no one used it?

A. Yes.

SAMUEL HOSSELTON.

5654 Chillicothe, Illinois, July 23, 1903.

JOHN DAVIDSON,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. My name is John Davidson; my residence is Chillicothe, and my occupation is a fisherman.

Q. How long have you been a fisherman?

A. Well sir, I have been a fisherman for over forty years; I commenced to putter around a boat when I was 13 years old and I am now 55 years old.

Q. Over what portions of the Illinois river have you fished?

A. From Lacon to Spring Bay. Not much above Lacon and not much below Spring Bay.

Q. How far is Spring Bay from here?

A. About eight miles below here.

Q. What was the condition of the Illinois river in this vicinity before the opening of the drainage canal, in January, 1900?

A. It was in pretty bad shape.

Q. In what way?

A. Why in filth—I don't know what you might call it,—
5655 but filth and the water was not fit to drink, and the fish died in it and the clams, and one summer here the clams all died; the river was floating full of them, thousands and thousands. You could go out here and take up a skiff-load of them and they died; some turtles died. About the next year after the Henry dam was put in; that is when it commenced to get bad.

Q. Was there any plant growing?

A. Well, not much; whenever the water was low, and just natural weeds and there was grass,—river grass and pond lilies here and there along the soft, musty places in the river, always.

Q. Was there any kind of a scum formed on the river?

MR. JEFFRIES: Objected to, as leading.

A. Oh yes; we had to skim it off; sometimes we would have to go three or four miles until we could find a place to sein; where it was blowed off. You had to take the seine out, out above all of it and you couldn't find the fish in it; it would take six or eight men to hoist it out; it formed a kind of a weed on top of the water with a root to it.

Q. What about a smell in the water before?

A. Oh, fearful; above this bridge up here there is a drift in there and this stuff would float down East River; it would be that thick you couldn't row a skiff through it and it would stink terribly.

5656 Q. What was the condition of the fish?

A. Why in the winter, it would freeze hard and every fish would die; and they was gassy and you couldn't eat them at all; you could take them right out of the water and they was gassy, you couldn't eat them at all; just like you had fried them in tar.

Q. As to the condition of the water under the ice, what do you say?

A. Why, it got so that it would be impossible for you to stand near a hole, pretty near, for the smell; if you cut a hole in the ice. You have been on the Chicago River haven't you?

Q. Yes sir, I had a whiff of it.

A. Well, it was just as bad as the Chicago River smelled right under that ice, only it was kind of more gassy, and drink it;—I wouldn't warrant a fellow to live five minutes if he took a drink out of it.

Q. If you caught any fish would they live in the live-boxes?

A. No; now I will tell you a circumstance here so you will know; it froze up here at Crow Creek; it was a spring stream; you could drive a wagon right up to the edge of the spring water. Joe Carle and me seined in there; I seined next to the

mouth of the creek and he seined next below me, and if you would take a fish out of that spring water and put him
5657 back fifty yards from the edge of that ice, he wouldn't live as long as he would out on the land. They crowded in there you know, to get away from this filth, and you would pull the seine in and it would look like you could walk out on them and then we would take dip-nets and dip them out, three or four men, and take the seine in and haul it in again and get as many again; they was all crowded in that place, to get away from that river water. The ice was clear and you could see these big shovel fish floating down under the ice.

Q. Now since the opening of the drainage canal what has been the condition of the water here?

A. Well it has been pretty fair; the water has been up pretty well; the first year the drainage canal was opened, we could seine; and we never had fish die in the live-boxes; we could keep them three or four days and we never could do that before.

Q. How about the smell of the water since the opening of the canal?

A. Oh, it has been pretty fair since the opening of the drainage canal. The first time I have seen any of that scum on the water and then there wasn't a great deal, was last evening, there was no wind and you could see it floating down—not much.

Q. Is the water clearer and cooler than it was before?

MR. JEFFRIES: Objected to as leading.

5658 A. Oh yes, a great deal cooler; it would be so hot it would scald your feet very near; now it is cool and it hasn't been very hot since that drainage was put in.

When they had a pretty good flow of drainage, you know, after a rain in two days it would clear off, and that drainage would clear it up.

Q. Are you pretty well acquainted with the fishermen in this vicinity?

A. Pretty well, yes sir.

Q. Do you know of any typhoid fever among them since the opening of the drainage canal?

A. No—No sir.

CROSS-EXAMINATION, By Mr. Jeffries.

Q. You have lived here practically all your life?

A. Yes sir, I have lived not over six miles from here, all my life—my home.

Q. Before the canal was opened, the water in the river here, at ordinary stages, was comparatively quiet and still, very little current in it?

A. No current at all after that dam was put in here below.

Q. What dam?

5659 A. Copperas Creek dam, the one below there, just like a slough in it; dead water and it would freeze quicker than a pond, just about the same as a pond.

Q. How is the current now compared to what it was before the canal was turned in?

A. Very near just like as if no current at all then. There is an awful current in the river now. You can't hardly row in it here hardly now.

Q. You mean since the opening of the canal?

A. Yes sir.

Q. You spoke of one summer when the fish and clams and turtles died; that was the year after, or the summer after the completion of the Henry Dam?

A. No I think that was two or three summers after that dam was put in; I couldn't tell exactly.

Q. That didn't occur every summer?

A. No that didn't occur every summer.

Q. Nor very frequently?

A. Not very frequently.

Q. Only this one time?

A. Only this one time, and it was right in July, in the summer time.

Q. You say there is some green scum on the river now in the summer time?

5660 A. Yes sir, there is some; there was some yesterday evening, I noticed it.

Q. And there has been some every year since the canal was opened?

A. Oh yes sir, there has been some but not like it was before.

Q. Do you live here in the town of Chillicothe?

A. Yes sir, I live here in town, right up here this side of the power house, in a cabin-boat.

Q. In a cabin boat on the river?

A. It is blocked up now. I blocked it up last winter.

Q. You blocked it up last winter?

A. Yes sir.

Q. It was in the water before that time?

A. Yes sir.

Q. How long have you lived on a cabin-boat?

A. I have lived on a cabin-boat; it is about nine or ten years since I bought this boat.

JOHN DAVIDSON.

5661 Chillicothe, Illinois, July 23, 1903.

A. C. WILKEY,

called as a witness in behalf of the defendants, being first duly sworn, by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. A. C. Wilkey; my occupation is running a boat-yard and my residence is Chillicothe.

Q. Have you ever been a fisherman?

A. Yes sir.

Q. For how long a time did you fish upon the Illinois river?

A. About ten years.

Q. Over what portion of the Illinois river did you fish?

A. From Hennepin to Beardstown.

Q. When did you fish below Peoria?

A. The winter of 1897 and 1898.

Q. What was the condition of the Illinois river below Peoria in those two years that you fished?

A. I wasn't there two years; I was there from one fall to the next spring.

Q. Yes.

A. Why the condition of the water was very bad.

5662 Q. In what way?

A. Well it was covered—it covered our nets with slime, so that we had to take them up every five or six days and wash them out; it would get so heavy it would pull the poles over.

Q. What was the appearance of this slime?

A. Well, it was like snot, that's what it looked like.

Q. Did you fish any below Peoria after the opening of the drainage canal?

A. No sir.

Q. How many seasons did you fish at or near Chillicothe, and from Chillicothe to Hennepin before the opening of the drainage canal?

A. I fished two years at Hennepin and the balance of my fishing was done right here.

Q. What was the condition of the water in this vicinity before the opening of the drainage canal?

A. Well, when the water was very low it was pretty bad and in the winter when the river was froze up it was very bad; that is it wasn't as bad for sediment and stuff in the water as it was for smell.

Q. What made it bad in the summer; was there some growth or plant in the water?

A. Yes, there was what we call shamrock and this long grass that grew on the bottom.

5663 Q. Did this grass and shamrock obstruct the river here at times?

A. Yes sir.

Q. You may tell how; tell an instance of that?

A. The year the bridge was built; it got so thick that it clogged up in the river—well it got so thick that I got stuck with a tug in it; it would gather under the barges so that I couldn't tow them. I was towing stone for the bridge company.

Q. In what business were you engaged that winter that you used the barges?

A. Why I was running tugs for the bridge company; it wasn't in the winter; it was in the summer.

Q. I mean summer. When the river froze over, before the opening of the canal, what was the condition of the water?

A. Well it was gassy, it tasted and smelled gassy.

Q. What was the condition of the fish?

A. So gassy that you couldn't eat them.

Q. Did they die under the water—under the ice?

MR. JEFFRIES: Objected to as leading.

A. Yes sir.

Q. Were you here one summer when the clams died in the river?

MR. JEFFRIES: Objected to as leading and sugges-
5664 tive and assuming the fact.

A. Yes sir.

Q. What year was that?

A. Well I couldn't say; it was some time ago though; it was either 1895 or 1896.

Q. Describe what occurred that year with reference to the animal life in the river?

A. Well the clams was all I noticed that died.

Q. Did they float upon the water; did they come up?

A. Yes, I have seen them come to the top.

Q. Since the opening of the drainage canal, what has been the condition of the river?

A. Well it has been better than it was before, as to smell.

Q. Is there any of that slime such as you noticed before at Peoria, here since the opening of the canal?

MR. JEFFRIES: Objected to as leading.

A. I never noticed any either time—not up here.

Q. Is there any of that shamrock plant in the water here now, since the opening of the canal?

MR. JEFFRIES: Objected to as leading.

A. Yes sir.

Q. To what extent?

A. Well not as bad as it was before.

5665 Q. Does it grow here in the river or come into the river out of the sloughs?

A. It comes out of the sloughs.

Q. Do you know whether that is the same plant that is called water-clover about here, by some?

A. I do not.

Q. Are you fairly well acquainted with the fishermen in this stretch of river here?

A. I know every one of them.

Q. What is their condition as to having typhoid fever since the opening of the drainage canal?

A. I have never known one of them to be sick.

Q. As a class, what is their condition of health generally?

A. Good.

CROSS-EXAMINATION, By Mr. Jeffries.

Q. How long have you lived in Chillicothe?

A. Forty years.

Q. All your life?

A. No sir, I have got fifteen years to go on besides that.

Q. Do you live in a dwelling in town or on the river?

A. I live just a block from the river.

Q. Have you a well or a cistern at your house?

5666 A. I have a well and a cistern both.

Q. And you use the water from the hydrant for washing and drinking purposes both?

A. I use the hydrant water entirely for drinking and the other for washing.

Q. Do you remember the summer that you stated the fish and clams died?

A. Yes sir.

Q. It was the year after the construction of the Henry Dam, was it not?

A. Oh no; it was long since that; it was somewhere between 1894 and 1896; I was running a seine that summer and I don't think of anything that I could place it exactly; somewhere about that time.

Q. Did it ever occur at any other time than that one time to any extent?

A. That is all, except in the winter time, when the fish died.

Q. How many times in the winter time did the fish die?

A. They died every time when the river froze over solid.

Q. And when it was low?

A. Yes sir.

Q. What was the condition of the river prior to the opening of the Chicago canal, as compared with its condition since the opening of the canal, so far as flow and current is concerned?

5667 A. You mean the quantity of water?

Q. The current or flow?

A. The current is considerably more.

Q. Before the canal was opened, there was very little current here, and in this vicinity, at ordinary stages of the water, was there not?

A. Yes sir.

Q. And since the opening of the canal there has been a splendid current?

A. There has been more current.

Q. Very much more, hasn't it?

A. Yes sir.

Q. Do you see any of the green scum on the river now?

A. Yes sir.

Q. Do you smell some odor too?

A. Well, not very much.

A. C. WILKEY.

6:00 P. M. Whereupon an adjournment was taken until 7:30 P. M., same day.

5668 Chillicothe, Ill., July 23, 1903.

Met pursuant to adjournment at 7 P. M. Present, the Commissioner and same counsel.

MARTIN TRUITT,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. Martin Truitt, Chillicothe, Peoria County, Illinois; my occupation is fisherman.

Q. How long have you been a fisherman on the Illinois river?

A. All my life, you might say, for the last 25 years.

Q. Over how much of the river have you fished?

A. I have fished between Chillicothe and Peoria and Chillicothe and Lacon.

Q. Have you been a boatman upon the Illinois river?

A. No, I was never a boatman.

Q. What was the condition of the Illinois river at this point before January, 1900, when the drainage canal was opened?

A. Why I think it was pretty bad; the water was bad, and there used to be green stuff here that you could hardly row a skiff through it, a good many times, and in the winter time if you chopped a hole in the ice, you would have to get away from it on account of the rotten gas coming out; the fish would die; since the canal has been opened, it hasn't been that way 5669 since; I never saw it purer in my life; the fish live better in live-boxes too, now since that.

Q. Have the fishermen on the Illinois river since the opening of the drainage canal, the typhoid fever?

MR. JEFFRIES: Objected to as leading.

A. I don't know; some of them wants the canal opened.

Q. No, you don't understand me. Have the fishermen since the opening of the canal had typhoid fever?

A. No, no.

CROSS-EXAMINATION, By Mr. Jeffries.

Q. You say some of them want the canal opened and some don't?

A. Yes, just a few of them.

Q. Have you always lived here?

A. Yes sir.

Q. Been fishing all your life you say?

A. Yes sir.

Q. Was your father a fisherman?

A. He was a fisherman part of the time; he worked on a fish-boat.

Q. Do you live in a fish-boat?

A. No, I live in a cabin.

Q. Is the cabin a boat?

5670 A. Yes sir.

Q. Is it on the river?

A. No sir, it is up on the bank now.

Q. How far from the bank?

A. Oh, about sixty feet I guess.

Q. It has been in the water?

A. Yes.

Q. How is the current in the river now compared to what it was before the canal was opened?

A. Why there is more current in the river now since the canal was opened.

Q. Was there much current before the canal was opened?

A. No.

Q. How much?

A. I know it wasn't enough to float the green stuff off the river; that green stuff.

Q. That green stuff was mostly decayed vegetable matter wasn't it?

A. No, some of it was stagnant water; that's what I believe about it.

5671 Q. You have noticed the greasy, oily substance on the water since the opening of the canal, haven't you?

A. Why not so much as there was before.

Q. Not as much?

A. Well, there ain't so awful much now.

Q. But you have noticed it?

A. Yes, but not so much.

MARTIN TRUITT.

5672 Chillicothe, Ill., July 23, 1903.

CHARLES F. SCHMIDT,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. Charles F. Schmidt, Chillicothe, and my occupation is fishing, and has been for the last twelve years.

Q. Over what portion of the Illinois river have you fished?

A. Well I have fished from Copperas Creek Lock as far as Hennepin; I haven't fished much above the Henry Lock.

Q. Did you fish below Peoria before the opening of the drainage canal?

A. Yes sir.

Q. How far below?

A. Well I fished down as far as Copperas Creek Lock.

Q. What was the condition of the water in the Illinois river below Peoria before the opening of the drainage canal?

A. Well sir, it was awful bad.

5673 Q. Just tell about it?

A. The slime would gather on the nets so that you couldn't hardly raise one onto the boat. This was below Peoria, right at what they call Coon Hollow Island; that is about three, or four miles and a half above the lock.

Q. What kind of slime was that?

A. Well it was white; puts me in mind of snot a good deal; looks like it. I have had to drag the nets on the bank right out of the water.

Q. Did you fish any below Peoria after the opening of the drainage canal?

A. Well I fished one part of a season. But I never fished no nets that season. I fished a seine that season.

Q. What was the condition of the Illinois river at that time?

A. It was better there then, at the time I was there.

Q. Where did you fish that season?

A. I fished at Kingston; Kingston mines.

Q. How far is that below Pekin?

A. It is fifteen—ten to fifteen miles below Pekin.

Q. Now did you fish in this vicinity, before the opening of the drainage canal?

A. Yes sir.

Q. What was the condition of the Illinois river here and in this neighborhood before the opening of the drainage canal?

5674 A. Well you couldn't keep fish alive very long, that is in the live-boxes, but it wasn't as bad here as it was below Peoria.

Q. Was there any green looking stuff grew in the water here?

MR. JEFFRIES: Objected to as leading.

A. Yes there was some, what we called moss.

Q. How much of that stuff was there which would gather up here in the current of the river?

A. Well there was times it would run thicker than others.

Q. Is it sometimes called shamrock?

MR. JEFFRIES: Objected to as leading.

A. Well I have heard them call it that.

Q. How about a smell in the water here before the opening of the drainage canal?

A. Well in the winter time it was bad; sometimes you couldn't hardly stand it through the ice; you could smell it easy.

Q. What effect did it have upon fish?

A. Why it killed the fish every winter, very near; that is the small fish anyway.

Q. Since the opening of the drainage canal what has been the condition in this vicinity?

A. Why the water has been better in this vicinity to my knowledge; the water never killed no fish that I know 5675 of; well before this drainage was turned in, the fish got so here we couldn't eat them, but since that I haven't heard anything of it.

Q. How about the green substance in the water?

A. Well I haven't seen no green substance to speak of since.

Q. Do the fishermen on the Illinois river so far as you know, since the opening of the drainage canal, have typhoid fever?

MR. JEFFRIES: Objected to as leading.

A. I haven't heard of any, nor seen any either.

CROSS-EXAMINATION, By Mr. Jeffries.

Q. There is some green scum on the water now is there not?

A. Well that green scum now grows in the back water unless the wind happens to blow it out; that is all I have seen this year.

Q. What was your business before you became a fisherman?

A. Well sir, before that I was a common laborer.

Q. Did you live here?

A. No I lived in Peoria.

Q. You were born and raised in Peoria?

A. No sir, I was born and raised in Indiana.

Q. Since the opening of the Chicago drainage canal, and the passage of the sewage from Chicago, mixed with the 5676 lake water there has been a very great increase in the flow or current of the water in the Illinois river at this point and all along the places where you have fished, has there not?

A. Yes sir; more current and more water.

Q. What was the condition of the river with reference to its current before the canal was opened?

A. What was the condition with reference to the current?

Q. Yes.

A. Well it wasn't strong only in high water.

Q. At times and when the river was at an ordinary stage, there was very little current?

A. Very little current in this part of the country; but take the river below Peoria, there was more current always. This on an average was deep water this way.

Q. What is the condition of the river with reference to its current since the opening of the canal?

A. Well it has been swifter.

Q. Very much so?

A. Good deal swifter, only in high water time.

Q. Then it is not so swift out here in high water times?

A. It is just as swift here in high water times; but in high water times as I know it, the water got swifter in high water times than it gets now in high water times.

5677 Q. You have been fishing for how many years?

A. Twelve years.

Q. You have fished every year since then?

A. Yes sir.

Q. Continuously?

A. Yes sir. When I done anything, that's what I done — fished.

CHAS. F. SCHMIDT.

5678 Chillicothe, Illinois, July 23, 1903.

E. N. NELSON,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. E. N. Nelson; Chillicothe, Illinois; fisherman.

Q. How long have you been a fisherman upon the Illinois river?

A. Off and on for twenty years.

Q. Over what part of the river have you fished?

A. Only in the vicinity of Chillicothe, between Lacon and Peoria.

Q. What was the condition of the Illinois river in this vicinity before the opening of the drainage canal in 1900?

A. Well it got very foul in low stage of water in warm weather; it got very foul.

Q. What kind of substance was there in it?

A. Well it was a green vegetation of some kind growing out, during the month of July and August; the water would look green.

Q. In the summer did the water have an odor—a smell?

MR. JEFFRIES: Objected to as leading.

A. Yes sir, it smelled foul and bad; especially when it was stirred up by a boat or anything. 5679

Q. What was its condition in the winter?

A. In the winter when it froze up it would get a kind of a gassy, tarry smell; if you cut a hole in the ice you could hardly stand over it.

Q. What was the effect upon the fish?

A. Why the fish were unmarketable at that time of the year, when the river was frozen over in the winter time; you could hardly stay in the house where they were cooking them and you couldn't eat them at all.

Q. How would they live in the live-boxes?

A. Why they didn't live; they would die in the live-boxes in a very short time.

Q. Since the opening of the drainage canal what has been the condition of the water here?

A. The water has been very good in my estimation; it hasn't been bad at all.

Q. Has there been any odor or smell in the water either in winter or summer since?

A. No sir, not that I have noticed.

Q. How about the fish in the live-boxes?

A. The fish lived in live-boxes first rate last winter; I kept fish in live-boxes for two months and a half.

5680 Q. Are fish shipped from here to the Chicago market alive now?

A. Why in the winter season; not in the summer.

Q. Have the fishermen in this vicinity since the opening of the drainage canal, had typhoid fever?

A. I haven't known of a fisherman having it; I haven't known but one case in Chillicothe, in years and that wasn't a fisherman nor a river man.

MR. JEFFRIES: I object to that question as leading.

CROSS-EXAMINATION, By Mr. Jeffries.

Q. How long have you lived in Chillicothe?

A. My entire life, 33 years.

Q. And you have been fishing on and off for twenty years?

A. For twenty years; ever since I was big enough to ride a lead line.

Q. How far up the river have you fished from Chillicothe?

A. Well not more than eight miles I guess.

Q. And how far down the river from Chillicothe?

A. Peoria.

Q. How far is that?

A. In the neighborhood of twenty miles, I guess.

5681 Q. Are you acquainted with what is known as Peoria Lake?

A. Not a great deal; I haven't fished in there since I was a kid.

Q. You have been down the river to Peoria several times, or a great many times in the last five or six years have you not?

A. No not many times in the last five or six years; about once I think.

Q. Do you know how long Peoria Lake is?

A. No I can't say that I do.

Q. About how long?

A. I can't say that I do.

Q. Do you know where it starts at this end?

A. I think it starts right below the Narrows.

Q. You don't know how wide it is?

A. No I don't know; I couldn't say; I have heard them say it was a mile wide.

Q. Much longer than it is wide?

A. Yes.

Q. Now the river passing Chillicothe, flows through Lake Peoria and on past Peoria, does it not?

A. Yes sir.

Q. Lake Peoria is nothing more than a wide place in the river, is it?

A. That's all.

5682 Q. You say there was some scum on the river before the canal was opened?

A. Yes sir, there used to be a good deal of scum; it used to be very thick at times.

Q. You have seen considerable scum since the opening of the canal?

A. Not in the river; in the back water, at times.

Q. It was of a vegetable character, was it?

A. Yes sir.

Q. Now since the opening of the canal you have seen in the ordinary stages of the river water, a greasy, oily substance on the surface of the water haven't you?

A. No sir, only immediately below the Santa Fe Bridge here, at the time they was painting it; I saw greasy water there.

Q. Before the canal was opened the water was very sluggish?

A. Yes, the current was very slow.

Q. In fact at ordinary stages of the water there was scarcely nothing?

A. Hardly any.

Q. Now since the canal was opened, bringing the sewage of Chicago mixed with lake water, the current is very swift?

A. Yes sir, the current is a good deal swifter than it used to be.

5683 Q. How much swifter?

A. Well, I couldn't say as to that.

Q. Considerably, though, isn't it?

A. Yes sir.

Q. When you say the water is better now than it was before the canal was opened, you speak from observation?

A. Well from my experience on the water, it is clearer, and better looking, and a person can drink it in a pinch now and they couldn't at this time of year before.

Q. You say they can drink it?

A. Yes, I have drank this season and last season both, when I would be on the river.

Q. This moss, or green substance was caused from decayed vegetation, was it not?

A. I understood that is where it came from.

Q. Did it smell like it?

A. It smelled sour and stinking.

E. N. NELSON.

5684 Chillicothe, Illinois, July 23, 1903.

JESSE HORN,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. Jesse Horn; Chillicothe, Illinois; Occupation fisherman.

Q. How long have you fished upon the Illinois river?

A. Oh I have fished off and on for thirteen years.

Q. Over what portions of the river?

A. Between Hennepin and Peoria.

Q. What has been the condition of the Illinois river before the opening of the drainage canal?

A. Well in warm weather it was stagnated water and in cold weather when it was froze up we had plenty of gas under the ice; you couldn't hardly stand it if you cut a hole in the ice; and there used to be a good deal of malarial fever; I have had the malarial fever pretty nearly every year, malarial fever and ague. I missed it this year so far; I don't know whether that is on account of that or not; I belive it is, but as far as knowing, I don't know.

5685 Q. Before the opening of the drainage canal, what was the effect of the water upon the fish.

A. Why, it killed lots of fish, both winter and summer.

Q. Was there any green substance in the water before the opening of the drainage canal?

A. Yes sir.

Q. Describe it?

A. Why some called it clover and some called it shamrock here. Some say it was formed from the grass on the bottom; some say it forms from the willows; I don't know what; they claim that all stagnated water is that way; as far as I know it is.

Q. Since the opening of the drainage canal, what has been the condition of the water?

A. I think purer and clearer. We haven't had no dead fish floating around on the water, because of the water, there hasn't been no dead fish floating.

Q. Has there been any smell to it since the opening of the canal?

A. No sir.

Q. Since the opening of the drainage canal, do you know of any typhoid fever among the fishermen?

A. No sir.
5686 I know of years before that it has though.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. What years before was there typhoid fever?

A. Why every year, as long as I have been around here; it has been about 12 years that I have been here.

Q. How many cases?

A. Oh, several; I couldn't mention just exactly how many cases.

Q. Eight or ten?

A. Well not here, I don't think there was that many.

Q. Five?

A. Yes sir, I believe there was five every year.

Q. Where were those cases?

A. Right here in Chillicothe; not typhoid fever either, it was ague or malaria.

Q. You want to correct your statement then in your answer to Judge John's question when you stated that there was several cases before the canal was opened, of typhoid fever?

A. Well, I didn't mean typhoid fever; I meant the ague or malaria fever, typhoid fever is a different thing; I don't think that typhoid fever is caused from being on the river; I never knew of any fishermen having typhoid fever in my life, and I have known a good many.

5687 Q. Do you know what typhoid fever is?

A. No sir, I ain't no doctor or claim to be, or anything like that; I don't know as I ever knew a fisherman that had typhoid fever; that is, that I knew he had it.

Q. Then as a matter of fact you don't know whether there has been any typhoid fever here or not?

A. Well there has been typhoid fever in town.

Q. How many cases?

A. Why I couldn't answer how many cases; I don't think there was a great many at that.

Q. Fifteen or twenty cases in the last four or five years?

A. No, I don't believe there was.

Q. Ten?

A. No, I would be afraid to say that there was that many; I am not around the town very much; I am on the river pretty nearly all the time.

Q. How many cases could you mention?

A. Well I couldn't mention any, only what I have heard there was typhoid fever in town; that is all I know; I hardly ever am up in town in the evening; once in a week, within a block. I don't know as a matter of fact there is any; only what I hears sometimes, that there is typhoid fever at such and such a place, at Santa Fe or something like that.

Q. Then you don't know whether there has been or has not been typhoid fever in Chillicothe?

5688 A. No sir.

Q. There may have been and may not have been?

A. Yes sir.

Q. How far up the river have you fished?

A. Hennepin.

Q. This vegetable growth or moss or scum that formed on the water before the opening of the canal, and about which you have just testified, is some form of vegetation is it not?

A. Why I am pretty sure that it is, yes.

Q. You say it branches out in leaves like clover?

A. Yes, only smaller.

Q. Since the opening of the canal you have seen green scum on the river have you not?

A. I have seen it on the sloughs, not in the river, only what flows out of the sloughs.

Q. The current in the river is much more rapid since the opening of the canal than it was before the canal was opened?

A. Well, since the canal has been in it has been higher water than it was before.

Q. And therefore more current?

A. And therefore more current.

Q. Considerably more current?

5689 A. Yes sir, in high water, there is more current, the higher water you get the more current there is.

Q. Do you live in a house-boat?

A. No sir.

Q. Do you use the city water for domestic purposes?

A. No sir, I have got a well.

Q. Pump?

A. Yes sir.

Q. Sand pump?

A. No sir.

Q. Drive pump rather?

A. Yes sir; still the city has got good water.

JESSE HORN.

5690 Chillicothe, Illinois, July 23, 1903.

T. H. HARRIS,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. T. H. Harris; Chillicothe, fisherman by occupation.

Q. How long have you been a fisherman on the Illinois river?

A. About ten years.

Q. Over what portion of the river have you fished?

A. Between Peoria and Lacon.

Q. State what you know about the water in the Illinois river before the opening of the dramage canal?

A. Well, it was very bad at times, especially in the winter time along in July and August.

Q. What was the matter with it in July and August?

A. Oh it would get kind of stagnated and a kind of a green color.

Q. Did it have any odor in those months?

A. Well, I don't know that it did.

Q. Was there any growth in the water or upon it?

A. Yes, I have seen what they call duck weed, floating in the river, a lot of it. 5691

Q. Is that weed sometimes called shamrock?

A. Well I never heard it called that; I don't know what the right name is for it; it is known by the fishermen as duckweed I guess.

Q. What was the condition of the water in the winter and its effect upon the fish?

A. Well it was pretty bad on the fish; I have seen the fish rush up into the spring holes as if struggling for life; the mouth of most any creek would be alive with fish; that is where fresh water was coming in.

Q. Was there any smell in the water in the winter?

A. Yes.

Q. How much and what kind?

A. Why it smelled considerable.

Q. Did the fish die under the ice?

A. Yes, I have seen lots of them die under the ice.

Q. What has been its condition since the opening of the drainage canal?

A. Why to my opinion the water is better than it used to be, especially in the winter.

Q. Do the fish die now in the water here?

A. No, I have never seen it since the canal has been turned in.

5692 Q. Is there any what you call duckweed now in the water?

A. I haven't seen any this year yet; it generally grows later in the fall.

Q. Has there been any since the opening of the drainage canal?

A. Yes, there was lots of it last fall.

Q. Where?

A. Why over through the bottoms here, and through Goose Pond; and around through there it was so thick in places you couldn't hardly go through it. It would be up next to the levee where the south wind would drive it up into the timber across the lake.

Q. Have you seen any in between the banks of the river since the opening of the canal?

A. No sir, I haven't.

Q. Have the fishermen upon the Illinois river since the opening of the canal, had typhoid fever?

MR. JEFFRIES: Objected to as leading.

A. Why I haven't heard of a case of it.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. There might have been some of it though?

A. There might have, yes; but I never heard of any of it.

5693 Q. Do you live here in Chillicothe?

A. Yes.

Q. Do you live in a house-boat?

A. No, I live up town on Third Street.

Q. Do you have a drive pump or do you use the water from the town hydrant?

A. From the hydrant and cistern water together.

Q. Where does the water come from that is in the cistern?

A. It comes off the roof when rain falls.

Q. Is it cemented?

A. Yes sir.

Q. You use water from that for household purposes?

A. Yes.

Q. Before the canal was opened, there was very little current in the river, wasn't there?

A. No, there wasn't very much here, no.

Q. Now since the opening of that canal and the flowing of sewage of Chicago mixed with lake water, there has been considerable increase in the current, has there not?

A. Yes.

Q. How much of an increase?

A. Well I couldn't state just how much; but there has been considerable, I know.

5694 Q. You see some dead fish floating in the river now, don't you?

A. No, not unless it is some that have been thrown out of live boxes or something like that.

Q. Aside from the green scum that forms on the water, and the vegetable growth there is practically no difference in the water now from what it was before the canal was opened?

A. Well, I think there is some difference in the channel of the water, but I don't know as there is much of that growth from back water.

Q. Well there is some forms in the back water now, is there not ?

A. To a certain extent, yes.

T. H. HARRIS.

5695 Chillicothe, Ill., July 23, 1903.

L. S. McCULLEY,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. L. S. McCulley, Chillicothe, Illinois, Engineer.

Q. How long have you been an engineer?

A. Somewhere near six years.

Q. Are you a stationary engineer?

A. Yes sir.

Q. Have you been an engineer upon the boats running upon the Illinois river?

MR. JEFFRIES: Objected to as leading.

A. Yes sir.

Q. If you have been an engineer at elevators, you may state where and when?

A. Engineer here at this Turner-Hudnett Company, for four years.

Q. What water did you use in your boilers when you were running boats upon the Illinois river?

A. Illinois river water.

5696 Q. Over what portion of the river have you run as an engineer on boats?

A. From Copperas Creek to Henry and above; Hennepin is as far above as I would get.

Q. Were you an engineer between those points upon boats both before and after the opening of the drainage canal?

A. Yes sir.

Q. How did the water act in your boilers before the opening of the drainage canal, below Peoria?

A. Well it foamed slightly, and at times strong; closer to Peoria stronger than it did below.

Q. What causes water in a boiler to foam?

A. Why, it is pollution.

Q. Below Peoria was there before the opening of the drainage canal, any smell to the steam that escaped from the boiler?

MR. JEFFRIES: Objected to as leading.

A. Yes sir.

Q. Could you describe that smell?

A. Well about the only way that I could describe it would be that it had a real strong odor, decayed matter.

Q. Since the opening of the drainage canal and below Peoria what has been the action of the water in the boilers?

A. It has been quiet and clear—

Q. I am asking you below Peoria?

5697 A. Yes sir.

Q. Has it foamed any below Peoria since the opening of the canal?

MR. JEFFRIES: Objected to as leading.

A. No sir.

Q. Before the opening of the drainage canal, and above Peoria, what has been the action of the water in the boilers?

A. Foaming.

Q. Was there any odor to the steam?

A. Yes sir.

Q. Since the opening of the drainage canal and above Peoria, what has been the action of the water in the boilers?

A. It has been quiet.

Q. Has there been any foaming or odor in it?

A. No sir, no odor any more than comes from natural clear water; of course there is an odor from that.

Q. Since the opening of the drainage canal, which has been the better water for steaming purposes; that below Peoria or that above?

A. Well there has not been much difference; above is the best a little.

Q. Before the opening of the drainage canal, which was the better water for steaming purposes, that below or above Peoria?

A. Above Peoria.

5698 Q. At what places have you been an engineer on boilers on the shore of the Illinois river?

A. At Chillicothe.

Q. In what kind of a building?

A. Elevators.

Q. Were you an engineer here before the opening of the drainage canal?

A. Yes sir.

Q. From what source did you obtain the water for your boilers?

A. From the river.

Q. Before the opening of the drainage canal at this point, what was the action of the water in your boilers?

A. Foaming.

Q. Was there an odor to the steam?

A. Yes sir.

Q. If that odor varied in its strength or amount, at what season of the year was it strongest?

A. In the summer.

Q. Since the opening of the drainage canal, what has been the condition of the waters in the boilers here at the elevator?

A. It has been better, no foaming; not as much lime or scale.

Q. Has there been any odor in the water that you have noticed?

A. No sir.

5699 Q. How about the lime and scale in the boilers before the opening of the drainage canal from the water below Peoria?

A. There was a great deal of it.

Q. And after the opening of the drainage canal and below Peoria?

A. Not as much.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. There is more or less odor to all steam is there not?

A. It depends on the water. There is an odor to steam, yes sir, of course; naturally clear water there is an odor.

Q. The water in your boiler here at the elevator didn't foam very badly did it, prior to the opening of the canal?

A. At times it did, yes sir.

Q. You used the water from the river altogether?

A. Yes sir, excepting some that we put in a tank and run the water from the roof and we washed mostly with that, and soft water.

Q. If the water had foamed very badly, at any time, it would have been an item of very little expense to have driven a well would it not?

A. Well I couldn't tell you that; I am working for the company; it is their look out.

5700 Q. They never suggested anything of that kind to you nor you to them?

A. No sir.

Q. The foam which is created in the boiler, came from decayed vegetable matter did it?

A. To a certain extent.

Q. To a very large extent?

A. It comes more from decayed matter, yes sir, than it does from clear water; clear water don't foam.

Q. I am talking now of the substance in the water which caused the foam and that was decayed vegetable matter was it not?

A. Not altogether.

Q. Well, what was it?

A. Well, the pollution in the water.

Q. The pollution was caused by the decayed vegetable matter in the water, was it not?

A. Partly.

Q. Wasn't it almost solely from that source?

A. No. Stagnant water will make a foam.

Q. Was the water in the Illinois river stagnant at that time?

A. At what time do you speak of?

Q. At the time when it would foam in the boilers?

A. Yes sir.

Q. Both above and below Peoria?

5701 A. Yes sir.

L. S. McCULLEY.

Adjourned until 9:30 A. M., following day, Friday, July 24, 1903, at Lacon, Illinois.

5702 Lacon, Illinois, July 24, 1903. 9:30 A. M.

Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

WILLIAM MANGLE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. William Mangle; Lacon, Illinois; fisherman.

Q. How long have you been a fisherman on the Illinois river?

A. About eighteen or twenty years.

Q. Over what portions of the river have you fished?

A. Between Henry and Chillicothe, all the time.

Q. How far is Lacon from Henry?

A. About seven miles?

Q. How far by river is it from Peoria?

A. 29 miles I think.

Q. How far from La Salle?

A. About forty.

5703 Q. What was the condition of the Illinois river at this point before the opening of the drainage canal in January, 1900?

A. The water was pretty low.

Q. Did it have any matter floating in it or growing in the river?

MR. JEFFRIES: Objected to as leading.

A. Yes, a kind of a moss or green stuff floating in it in low water.

Q. What did you call that stuff?

A. Well we never had any name for it.

Q. Did it have three little leaves?

A. Yes sir.

Q. And a little root an inch or so long?

A. Yes, like a kind of a duck seed.

Q. State what was the condition of that stuff, whether it covered the water and how much there was of it, tell all about it?

A. It would probably be a foot deep along the shore.

Q. Was there any smell in the water in summer?

A. No not in summer to amount to anything.

Q. Did the river freeze over here in the winter?

A. Yes sir.

Q. What was the condition of the water under the ice?

5704 A. It was pretty bad when the water was low—gassy.

Q. When you cut a hole in the ice what occurred as to the stench or smell?

A. A kind of a gas or tar smell.

Q. What effect did it have upon the fish?

A. Well the fish would taste just like it smelled, especially catfish.

Q. Did the fish die under the ice here?

A. Yes, a good many.

Q. How did they live in live boxes?

A. Do you mean—

Q. Before the drainage canal was opened?

A. Well they didn't live long in hot weather; they died fast.

Q. Since the opening of the drainage canal, has there been any of this green plant in the water?

A. Not very much; a kind of a scum.

Q. Is there any smell to the water under the ice here since the opening of the drainage canal?

MR. JEFFRIES: Objected to as leading.

A. No sir.

Q. How is the water here now since the opening of the drainage canal as compared with the water before the opening of the drainage canal, better or worse?

A. Well, the water is better, a good deal and the fish live better. 5705

Q. Prior to the opening of the drainage canal did you drink the water of the Illinois river when fishing?

A. Oh, we drank it in fall, in the cold weather.

Q. Since the opening of the drainage canal do you drink the water?

A. We would in cold weather; not at any other time.

Q. Have the fishermen in this vicinity since the opening of the drainage canal had typhoid fever?

MR. JEFFRIES: Objected to as leading.

A. No sir, not that I know of.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How far up the river did you say you were acquainted with it?

A. Oh, I have fished on it from Henry to Chillicothe; I have been up further than that though.

Q. What is the population of this town?

A. 1200.

Q. What is the name of the town?

A. Lacon.

Q. Have they a system of water works?

A. Yes sir.

Q. Where do they get their water?

5706 A. From wells.

Q. Driven wells?

A. Yes sir.

Q. How deep under the surface of the earth are these wells driven?

A. I don't know how far it is drove, I couldn't tell you.

Q. What is your judgment, 100 feet?

A. No, not over forty feet.

Q. How far is the well located from the river?

A. About 600 yards.

Q. Do you know the character of the soil through which it is driven?

A. Gravel.

Q. And sand?

A. Gravel and sand.

Q. Now, aside from this public well, from which the town gets its supply, there are a number of private driven wells, are there not?

A. No, there is lots of good wells in town, they are not driven though.

Q. They are living wells?

A. Yes sir.

Q. The people living in this town, in Lacon, use the water from these wells for domestic and drinking purposes, do they not?

5707 A. Yes sir.

Q. They don't use the water from the river for domestic and drinking purposes?

A. No sir.

Q. Since the opening of the Chicago drainage canal you have noticed considerable green scum here on the river at Lacon have you not?

A. There is a scum on the water now at present.

Q. It is a different kind of a scum from what it was before the canal was opened, isn't it?

A. Why, it is just a kind of a thin scum instead of them seeds.

Q. Kind of an oily substance?

A. Yes.

Q. Are you a man of family?

A. No sir.

Q. Before the canal was opened. there was very little current in the river, was there?

A. Very little.

Q. At times none?

A. When the water was low there was hardly any current.

Q. Since the opening of the Chicago drainage canal and the running of the water of Lake Michigan mixed with the sewage of Chicago down the Illinois river, the current has
5708 grown very much stronger?

A. Yes sir.

Q. How much stronger?

A. I couldn't say just how much; there is quite a good current, though, all the time.

Q. You say there has been no typhoid fever?

A. Not that I know of.

Q. Do you know that there has not?

A. I don't know; I am not sure.

Q. You know very little about the character of sickness among the people?

A. Very little.

Q. They may have had it and may have not?

A. If there was any around a small town I would be apt to hear about it.

Q. How long have you been fishing?

A. About eighteen years, something like that.

Q. How old are you?

A. Thirty-five.

Q. Is there a good current in the river now since the opening of the canal?

A. Yes sir.

Q. From Henry to Chillicothe?

A. Yes sir.

5709 Q. The scum that formed on the river before the canal was opened, was of a vegetable growth was it not?

A. It seemed to me kind of a seed.

Q. Kind of a water grass or weed?

A. A kind of a little green seed; kind of a little green leaf, it started that way.

Q. It doesn't start that way now?

A. There is hardly any of it now.

Q. Now since the canal was opened, you can smell an odor from the water can't you?

A. Well if a steamboat stirs it up I believe you can smell a kind of a smell to it.

Q. Considerable smell you mean?

A. Kind of a dead smell.

WM. MANGLE.

5710 Lacon, Illinois, July 24, 1903.

JOHN BAUMISTER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. John Baumister, Lacon, Illinois; fishing.

Q. How long have you been a fisherman on the Illinois river?

A. Since 1867.

Q. Over what points have you fished?

A. From above Hennepin down the river as far as Pearl.

Q. When did you fish below Peoria?

A. Well it has been fifteen years ago since I have been below. Didn't do very much fishing below Peoria.

Q. Did you ever run upon the boats?

A. Why yes; we have a little tug of our own. Before they turned that canal in the water used to foam and we had to blow her out every two days, and last year we never had to blow her out once, so the water must be purer.

Q. Before the opening of the drainage canal was there any smell to the steam in the boilers?

A. No I don't know as I ever noticed any smell from the boilers much. The water was bad in the river though; some seven or eight years ago the fish and clams very near all died along here, and we had to hire men to bury the fish along this bank. 5711

Q. Was there a kind of green plant growing in the water here?

A. Yes, what they called duck seed growed awful thick in some places; you couldn't hardly seine through it; there ain't been very much of that lately; very little.

Q. Before the opening of the drainage canal was there a smell in the river water when the river was frozen over?

A. Yes, when it was frozen over a short time the water became gassy and smelled and the fish tasted tarry so we couldn't eat them; frying them in a room you would have to pretty nearly stay out.

Q. Since the opening of the drainage canal has there been any odor under the ice here at Lacon?

MR. JEFFRIES. Objected to as leading.

A. No, I never noticed any myself.

Q. Do the fishermen in this vicinity since the opening ot the drainage canal have typhoid fever here?

MR. JEFFRIES: Objected to as leading.

A. No, I don't know of any.

5712

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How old are you?

A. On the first day of January I will be 60.

Q. How long have you lived here at Lacon?

A. I came here in the fall of 1857.

Q. How long have you been fishing?

A. Since 1867.

Q. How far up the river have you fished?

A. About two or three miles above Hennepin.

Q. How far is Hennepin from here?

A. Twenty-one miles.

Q. How far down the river have you fished?

A. Well the most of the fishing I done, was between here and Peoria; I was down as far as Pearl one summer.

Q. The principal part of your fishing has been done between what points?

A. Between Hennepin and Peoria.

Q. You are a man of a family are you?

A. Yes sir.

Q. Do you live on the river or in a dwelling house?

A. I live in a house.

Q. How far from the river?

A. The first house up here on the bank.

5713 Q. Have you a drive well at your house?

A. No, we have a living well.

Q. Do you use the water from that well for living purposes?

A. Yes sir, and all the neighbors around there; the doctor says it is the best water in town.

Q. The people in your neighborhood and in the town and so far as you know, don't use the water from the river for domestic and drinking purposes do they?

A. Well no, not right around here; take it further up town they have got to use water anyhow from the pump-house; but then it is all well water; it is right at the river there.

Q. How deep is this town's well?

A. One is drove; I don't know, it must be drove eighty feet and the one dug must be forty feet.

Q. Do you know the character of the soil through which this well is dug and the one that is driven?

A. No, I don't know.

Q. Is it sand and gravel?

A. It is gravel quite a ways, but I don't know how far; it must be gravel thirty or forty feet.

Q. How far are these town wells from the river?

A. Well the waterworks well—

Q. How many feet about?

5714 A. Well from the main river about one thousand feet, but from the slough it wouldn't be over a hundred.

Q. The water in this slough here at the town, gets very stagnant, even since the opening of the canal doesn't it?

A. No, not very, this slough water is just the same as the river water; and after the water gets low it becomes a pond, and then there is no more outlet to it and it becomes stagnant.

Q. And forms a scum?

A. Yes sir.

Q. The green scum that formed on the river before the canal was opened, was of a vegetable character was it not?

A. Yes, it was duck seed, that's about all; it made a light green scum; but mostly it was duck-seed.

Q. What is the character of the scum that forms now?

A. Well it would be about the same, but not near as much of it.

Q. Before the canal was opened, when the water was at an ordinary stage, there was very little current in the river was there?

A. Well there was no current to speak of at all.

Q. Since the opening of the Chicago drainage canal there has been a good current at all times in the year?

A. Yes sir.

Q. From Hennepin to Peoria?

5715 A. Yes sir.

JOHN BAUMISTER.

5716 Lacon, Illinois, July 24, 1903.

WILL REED,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. Will Reed; Lacon, Illinois, Marshall County; fisherman principally.

Q. What other occupations have you followed?

A. Firing.

Q. On stationary engines or locomotive engines?

A. On steamboats; steamboat and stationary both.

Q. On what steamboats have you been fireman?

A. The first boat I ever fired on this river was on the Rex.

Q. How much of the time have you been occupied as a fireman on the Illinois river?

A. Well pretty much every summer, more or less.

Q. How far have you traveled up and down the river in that occupation?

A. Well sir, I have traveled from Peoria to La Salle and from Peoria to St. Louis on the Cherokee.
5717 I did make a trip or two on the Bald Eagle.

Q. Did you notice any difference in the quality of the water for steam purposes above and below Peoria?

A. Yes sir.

Q. What was the difference before the opening of the drainage canal?

A. Well sir, from the time you leave Peoria; of course after you get past them still houses down there it is all right. For a ways after you hit them still houses it is bad; that is, it would foam and it was foam up here; it was a kind of a scum raised up in your boiler and made it foam.

Q. How far below Peoria would you notice that foaming in the boiler?

A. Oh, until we got down pretty near to Copperas Creek.

Q. From Copperas Creek down to the mouth of the river was the water better for steaming purposes?

A. It certainly was; we was bothered more with sand in the boilers; the water was mud run; more sandy the water was.

Q. Was there any foaming in the boiler below Copperas Creek dam?

A. Yes, sir, at times.

Q. How was the water below LaGrange dam as compared with the water above Copperas Creek dam?

A. I think it was better above; that is, the quality of the water.

5718 Q. How was the water below Kampsville dam as compared with the water above Copperas Creek?

A. Well, I think it was better; couldn't see much difference in it.

Q. From Kampsville dam down the river, did the water foam in the boilers?

A. More or less, yes; after we got down about Alton there and got down below there.

Q. After you got into the Mississippi?

A. Yes.

Q. In the Illinois river below Kampsville and down to Grafton did the water foam in the boiler?

A. It foamed more or less, yes; there wasn't no big amount of foaming or anything of the kind.

Q. Now, above Peoria and before the opening of the drainage canal how did the water operate in the boilers?

A. It foamed.

Q. Which was the better water for steaming purposes before the opening of the drainage canal—the water in Peoria Lake or the water at Lacon?

A. Why, I think the water at the present time—

Q. No, before the opening of the drainage canal?

A. Oh, it was better here at that time.

5719 Q. Before the opening of the drainage canal, what was the condition of the water at this point as noticed by you as a fisherman?

A. Well, I have seen it pretty bad here at times.

Q. In what way?

A. Well, in scum and one thing and another; seeds are apt to be in the river at any time.

Q. Was there a smell in the water?

A. Yes, sir.

Q. What was it like?

A. Well, it wasn't a very pleasant smell.

Q. What was the condition of the water under the ice in the winter?

A. It was pretty foul.

Q. What effect did it have upon the fish?

A. It killed lots of fish along the river between here and Henry.

Q. Were the fish fit to be cooked?

MR. JEFFRIES: Objected to as leading.

A. No, sir.

Q. After the opening of the drainage canal were you on steamboats as a fireman below Peoria?

A. No, sir.

Q. Since the opening of the drainage canal have you been a fireman on the Illinois river above Peoria?

5720 A. Yes, sir.

Q. What has been the condition of the water for steam purposes above Peoria since the opening of the drainage canal?

A. First rate.

Q. Is there a foaming in the water?

MR. JEFFRIES: Objected to as leading.

A. I haven't had no foaming; every time I was firing I never seen none of it.

Q. Since the opening of the drainage canal, what has been the condition of the water as to odor or smell when the river was frozen over?

A. I didn't find any.

Q. Have the fish died in the water?

A. I haven't seen any.

Q. Before the opening of the drainage canal how did the fish live here in live boxes?

A. Not very good.

Q. How do they flourish in that respect since?

A. Well, from what experience I had, I could hold them four and five days.

Q. Has there been any considerable amount of this green plant that you call duck seed, in the river since the opening of the canal?

A. No, I don't think there has been.

5721 Q. Do the fishermen upon the Illinois river in this vicinity have typhoid fever?

MR. JEFFRIES: Objected to as leading.

A. Why, not that I know of.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How long have you lived here at Lacon?

A. Thirty years; I have lived off and on.

Q. How old are you?

A. Thirty-six years old; I was born in 1867.

Q. You are not an engineer?

A. Why, no; I am not an engineer; I have run an engine, though, at times.

Q. But not on the river?

A. No; that is, I have helped while the man was getting his meals.

Q. Before the canal was opened there was very little current in the river here at Lacon?

A. Very little current; in the spring of the year, yes.

Q. But at times there was very little current?

A. Yes, to amount to anything.

Q. Since the canal was opened, and the Chicago sewage mixed with lake water has been turned into the Illinois 5722 river, there is a good current at all times in the river?

A. We have got a good fair current, yes, sir.

Q. Since the opening of the Chicago drainage canal, you have noticed here at Lacon considerable of the green, oily, greasy scum that forms on the river?

A. Not since the canal was opened, no, sir.

Q. Isn't it a fact that there is a green scum on the river right out here where this boat stands now?

A. It may be, I have never been down to examine it; I am only giving you my opinion of what I know.

Q. Well, you know that that oily green scum does form on the river since the opening of the canal, right here where this boat stands?

A. I don't know; I haven't looked at it.

Q. You do know that it does since the opening of the canal?

A. No, I don't think it has.

Q. I wish you would go out there and look at it and see if you don't see some of it?

(Witness steps out to rail of boat and looks.)

A. There is some there, yes, sir.

Q. It looks kind of like goose grease?

A. No, I don't know whether you woudl call it goose grease or not; it is a kind of a scum; it isn't very bad at that.

Q. It isn't a vegetable growth, is it?

A. I don't know.

5723 Q. It hasn't that appearance?

A. I don't know but it has.

Q. Don't you know that it has not the appearance of vegetable growth?

A. I don't know; I couldn't say that it hasn't or couldn't say that it has.

Q. Was it a vegetable growth prior to the opening of the canal?

A. I don't know as it was; it was not as yellow as that is.

Q. Are you a married man?

A. No, sir.

Q. Do you have a well at your house or do you use the hydrant water?

A. No, sir; I use a cistern. WILLIE REID.

5724 Lacon, Illinois, July 24, 1903.

FRED. MAWBEY, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. Fred. Mawbey; Lacon, Illinois; fisherman.

Q. How long have you fished upon the Illinois river?

A. Twenty-five years or more.

Q. Over how much of the river have you fished?

A. I fished from LaSalle, as far as below Naples.

Q. Did you fish below Peoria before the opening of the drainage canal in 1900?

A. Yes, sir.

Q. At what point?

A. Havana.

Q. Describe the condition of the Illinois river at Havana before the opening of the drainage canal?

A. Why, the conditions were bad; there was a white slime in the water that collected on the nets.

Q. To what extent, what amount of it?

A. Why, lots of it; even if you laid a rope across the 5725 river, the rope would fill up with it; the nets would fill up so that two men could hardly lift them—a net that ought not to weigh over 75 pounds.

Q. What was the condition of the Illinois river in this neighborhood before the opening of the drainage canal?

A. It was bad.

Q. Describe it?

A. Well, through the summer season it would be green in fact from top to bottom and in the winter season, take it above Henry dam, it would take it about eight to ten days to kill every fish in it.

Q. Was there a smell in the water in the summer?

A. Yes, sir.

Q. Was there a smell in the water in the winter?

A. Yes, sir; I have seen it so you would have to cover your face when you went across the bridge at Henry dam.

Q. What effect did that water have upon the taste of such fish as lived?

A. Why, the fish tasted gassy; you couldn't eat them at all, nor you couldn't stay in the house where they were cooked.

Q. Since the opening of the drainage canal, what has been the condition of the river in this vicinity?

A. It has been good.

5726 Q. Has there been any smell or odor in the river here in winter or summer?

A. None whatever that I know of.

Q. Do the fishermen on the Illinois river in this vicinity since the opening of the canal, have typhoid fever?

A. No, sir, not that I know of.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Did they have typhoid fever before the canal was opened?

A. Well, I couldn't say; there was lots of ague, though.

Q. Well, you could come just as near saying as to that question before the opening of the canal as you can since, on the question of typhoid fever?

A. Well, I never seen anybody have any typhoid fever along the river.

Q. Neither before nor after the opening of the canal?

A. No, sir.

Q. Did you ever see them have it in any other place?

A. Yes, sir; I have seen them have it in town.

Q. What town?

A. Lacon.

Q. Very much of it?

A. No, sir.

5727 Q. Since the canal was opened?

A. There was a man died with it here day before yesterday.

Q. How many cases have you had since the canal was opened here?

A. That is the only one that I know of.

Q. You don't remember of any before the canal was opened?

A. No.

Q. You live here in town?

A. Yes, sir.

Q. Do you live on the river or up in town?

A. Right up here on the edge of the river.

Q. Do you live in a house-boat?

A. Yes, sir; it is up on the bank, though.

Q. What was the condition of the current in the Illinois river before the Chicago drainage canal was opened?

A. In low water there wasn't any current to speak of.

Q. What is the condition of the current now, since the opening of the canal?

A. Why, it is good.

Q. At all times?

A. Yes, sir.

Q. This green scum that you speak of as forming on the river prior to the opening of the canal, was mostly in the
5728 dead water, was it not?

A. No, sir, it was in the river; the river was just about the same as dead water; it was dead; there was no current. If it was not for the steamboats running in it, I don't believe you could live on it; they stirred the water up.

Q. It was of a vegetable growth, wasn't it, this scum?

A. Well, no; I have seen the water, you could take a sixteen foot oar and stir it up, put it down and it would come up green. Of course seeds would form on it at times; I have seen them at times from Henry to Lacon, two foot deep.

Q. The low places along the river are grown up with heavy vegetation, are they not?

A. I don't quite understand you.

Q. Why, the banks of the river and the low lands?

A. Yes.

Q. Even out into the water?

A. Yes.

Q. How is it since the opening of the canal?

A. Why, it is better.

Q. There is still vegetation, is there not?

A. Not very much.

Q. There is considerable scum, is there not?

A. No, not much; not unless you go into the slough.

Q. There is some right out here today, isn't there?

5729 A. I didn't look this morning. This river never was any better than it is now.

Q. When you say the water is better since the opening of the canal than it was before, you judge from its appearance?

A. Yes, and the clearness of it.

Q. From its looks?

A. Yes, sir.

FRED. MAWBEY.

5730 Lacon, Illinois, July 24, 1903.

HENRY STOEHRS, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. Henry Stoehrs; Lacon, Illinois; engineer at the woolen mills.

Q. How long have you been an engineer at this point?

A. Twenty years, about.

Q. How much of that time have you obtained water for your boilers from the Illinois river?

A. About twelve years.

Q. Have you been in any other plant than the woolen mills in that twelve years?

A. No, sir.

Q. How far from the river is the engine room of the woolen mills?

A. I should think about a thousand to 1200 feet.

Q. How is the water obtained from the river for the boilers?

A. Pumped.

5731 Q. What was the condition of the water in the Illinois river for steaming purposes, before the opening of the drainage canal?

A. Well, sir, it used to be very slimy, scummy, muddy.

Q. How did that act in the boiler?

A. Well, sir, it didn't act very good in the boilers; it foamed the boilers and we would have to blow them off pretty often.

Q. Was there a smell to the steam when you blew them off?

A. Yes, sir.

Q. What was the condition of the stuff that came out of the boilers when you blew them off?

A. Well, sir, it was a kind of a muddy scum, with an awful smell to it.

Q. Since the opening of the drainage canal?

A. It is better. I don't find that scum in them at all and haven't.

Q. Does the water foam in the boilers?

MR. JEFFRIES: Objected to as leading.

A. No, sir, very little; very little in the boilers.

Q. Is there any odor in the steam now?

A. No, sir.

Q. What is the character of the water that comes off when you blow off the boilers now?

A. Well, sir, it is in very good order; there is very little mud and very little scale.

5732 CROSS-EXAMINATION, by Mr. Jeffries.

Q. Have you lived here in Lacon all the time for twenty years?

A. Twenty years, yes, sir.

Q. What part of the town do you live in now?

A. The north part of the town.

Q. Near the river?

A. About six blocks from the river,

Q. Where do you get the water that you use for domestic purposes at your house?

A. We get it out of the city well here.

Q. How deep is the city well?

A. Why, I did hear, but I can't really—it is about twenty-five or thirty feet.

Q. How far is it located from the river?

A. Well, I think about a thousand feet.

Q. What is the character of the soil through which it runs?

A. Gravel.

Q. And sand?

A. Sand and gravel, yes.

Q. The people living in Lacon don't use the water from the Illinois river for domestic purposes and drinking purposes?

A. No.

5733 Q. Before the canal was opened, the water in the river was very sluggish, was it not?

A. Oh, it was awful.

Q. Scarcely no current?

A. No current.

Q. How is it since the canal was opened?

A. Better.

Q. There is a good current at all times of the year now?

A. Seems to be a good current.

Q. The water foamed in your boilers only in the summer time before the canal was opened?

A. Oh, yes, summer and winter.

Q. How far is your boiler house located from the river?

A. Well, I think about 1200 feet.

Q. There was no occasion for digging a well, was there, or driving one to get water for the boilers?

A. No, sir.

Q. The water in the river was not so bad that you couldn't use it for that purpose?

A. No, sir; I don't think it was.

Q. Do you know whether or not the foaming of the waters was caused from vegetable decay or what?

A. I do not.

5734 Q. The green scum that formed on the river before the canal was opened was of a vegetable character, was it not?

A. Yes.

Q. Since the opening of the canal there has been and is now, today, and at various times, an oily, greasy scum on the river?

A. That is before the canal.

Q. And since?

A. I haven't saw it since.

Q. Isn't there some today right out here near this boat?

A. I haven't saw it.

Q. You haven't noticed it very closely then?

A. No, sir.

Q. You are not on the river very much?

A. Not on the river very much; I am no fisheman.

Q. You don't drink the water from the river, do you?

A. No, not as long as we have got well water, we don't drink river water.

Q. What is the reputation of the water in the Illinois river for drinking and domestic purposes?

A. Well, I have heard and read that it was pretty good during the last two years.

Q. You have heard it condemned also, haven't you?

A. Well, I have.

5735 Q. You don't know of anybody that uses it?

A. No, I don't.

HENRY STOEHRS.

5736 Lacon, Illinois, July 24, 1903.

JOHN FAY, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. John Fay; Lacon, Illinois; fisherman.

Q. How long have you been a fisherman on the Illinois river?

A. Off and on about fifteen years.

Q. Over what points have you fished on the river?

A. Well, fished in the river at Chillicothe and Peoria and down as far as LaGrange.

Q. When did you fish below Peoria?

A. Well, it has been about ten years, I guess.

Q. What was the condition of the Illinois river at LaGrange when you fished there?

A. Well, the water was pretty high when I was at LaGrange; the water was pretty fair then.

Q. Did you fish any at Copperas Creek dam?

A. No, sir.

Q. What was the condition of the Illinois river at this point prior to the opening of the drainage canal?

A. Well, the water was pretty bad, take it in the winter time.

5737 Q. In what respect?

A. Well, it kind of smelled after you cut open the ice; kind of a gassy, tarry smell.

Q. What effect did it have upon the fish?

A. Well, it killed a good many fish in the river; when it didn't kill them they tasted tarry, kind of tarry.

Q. Were the fish themselves tainted, so that they would smell when they were cooked?

A. No, they didn't smell; but they would taste; tasted with a tarry taste.

Q. Now, since the opening of the drainage canal, what has been the condition of the Illinois river in this vicinity?

A. Well, it has been better than what it has been.

Q. Have the fish died here in the water since?

A. No, sir.

Q. Has it had the smell you have described, or any other smell?

A. No, sir.

Q. Has there been much, if any, of that green growth in the water since the opening of the canal?

MR. JEFFRIES: Objected to as leading.

A. No, sir.

Q. As to this green growth in the water how was it before the opening of the drainage canal?

5738 A. Well, there was a good many duck seed on the river before the drainage was opened?

Q. Since the opening of the drainage canal, have the fishermen upon the Illinois river in this vicinity had typhoid fever?

MR. JEFFRIES: Objected to as leading.

A. No, sir.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Did they have typhoid fever before the canal was opened?

A. Not as I know of; I don't know as any fishermen had it.

Q. They may have had it since the opening of the canal?

A. Not as I know of.

Q. How far up and how far down the river from Lacon have you fished?

A. Well, about five miles each way.

Q. How long did you say you had been fishing?

A. About fifteen years, off and on.

Q. You say the fish were not good before the canal was opened?

A. In the winter time they was not good; they had a kind of a tarry taste to them.

Q. You kept right on fishing?

A. No, we pulled up our nets when they got so bad.

5739 Q. What was the condition of the current in the Illinois river before the drainage canal was opened?

A. Well, there is a good deal of difference in the current now; more current in the river than there was then.

Q. What was the condition then?

A. Well, it was pretty dead water then.

Q. No current?

A. No, sir.

Q. What is the condition since the opening of the canal?

A. Well, there is a good current here now; pretty fair.

Q. This green scum that formed on the river before the canal was opened, was of a vegetable nature, was it not?

A. That grows on the water.

Q. You notice some of the green scum yet, do you not?

A. Yes, there is a little green scum.

Q. It is not of the same character now as it was before the canal was opened, is it?

A. No, sir.

Q. It has a kind of an oily appearance now, hasn't it?

A. Yes, there is more oil to it now.

Q. Is there a good current in the river over the whole distance that you have been fishing lately, and since the opening of the drainage canal?

A. Yes, sir.

JOHN FAY.

5740 Lacon, Illinois, July 24, 1903.

WILLIAM V. McKINLEY, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. William V. McKinley; Havana, Illinois; my occupation is engineer.

Q. Have you been an engineer upon boats on the Illinois river?

A. Yes, sir.

Q. For how long a time?

A. Well, I have been a licensed engineer since 1884.

Q. Did you run engines upon the Illinois river before 1884?

A. Yes, sir.

Q. For how long a time?

A. Oh, I suppose five or six years; that is I wasn't first engineer, but I was assistant under my father.

Q. During that time in what service have you been, who have been your employers?

A. I was with my father, I don't know how long; and in 1886 I went ashore; I was on shore for four years, and
5741 in 1891 I went back on the river and I was running from Alton to St. Louis and up this river.

Q. Have you been in the employment of the Illinois State Fish Commission?

A. Yes, sir.

Q. For how long a time?

A. Since 1894; not continually; I was off two years, last year and the year before.

Q. While you were in the employment of the fish commission did you run their boat upon the river?

A. Yes, sir.

Q. What have been the various boats that you have run, by name?

A. I was on the City of Havana, The Josie, The Dick Clyde and the G. M. Sibley, The Iowa, The Belle of Ottawa, The Lotus, The Reindeer, and The Illinois.

Q. How many of those boats have been the boats in the service of the Fish Commissioners of Illinois?

A. Three of them—well the Illinois and Reindeer are practically the same boat with a new hull, under the cabin. This is the Reindeer's cabin with a new hull under it and it is called the Illinois.

Q. During your employment by the fish commission have you traveled the whole length of the Illinois river?
5742 A. As far as navigable with our boats.

Q. Have you at various times been on the bayous, and tributaries and lakes tributary to the Illinois river?

A. Yes, sir.

Q. Do you think that you are familiar with the waters of the Illionis river?

A. Well, I don't know as I could tell it from any other water; that is I could tell it from rain water, but I couldn't go and pick out Illinois river water in a bunch of water.

Q. Do you know the general condition of the river at different times of the year, and all along the river?

A. Yes, sir.

Q. Does the Illinois river scour or clean itself in any of its stretches or reaches, and if so, in what one?

MR. JEFFRIES: I object to the question because it is leading and suggestive and because the witness has not properly qualified himself as a hydraulic engineer or otherwise so as to be sufficiently informed on the subject to give an opinion that could be relied upon or that would be valuable as testimony.

A. Not to any extent, no, sir; not to amount to anything.

Q. Does the river change its channels in any of its stretches?

MR. JEFFRIES: Objected to as leading.

A. No, sir.

(Witness temporarily withdrawn by consent of all parties.)

5743 Lacon, Illinois, July 24, 1903.

J. W. POTTS, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. J. W. Potts; Lacon, Marshall county, Illinois; my occupation is physician.

Q. How long have you been a physician in Lacon and the vicinity?

A. For eleven years or more.

Q. Of what school of medicine are you?

A. Eclectic.

Q. How much has your practice extended up and down the river from this point and among people living on the river?

A. It has extended south to Crow Creek; that's about six miles and north, probably three or four miles.

Q. From what source does Lacon receive its water supply?

A. From the city waterworks, from wells.

Q. How far from the river?

A. Well, that I don't know, probably a thousand feet.

Q. Is there a slough or pond containing Illinois river water nearer to this well than the river?

5744 A. Well, that is a question I can hardly answer; if you call this a slough, it is nearer to the well than the river; but if it is a part of the river,it is not. I don't know where the river begins, nor where it ends, there.

Q. How deep is this well, about?

A. My recollection is that the bottom of the well from the top of the well, it is 39 feet. I was on the city council when they lowered the well; my recollection is that the pipe is 39 feet from the top of the well.

Q. Is it an open well or a driven well—a drove well?

A. It is open for twenty odd feet and then it is driven from there down; pipes.

Q. What proportion of the people of Lacon in your judgment use water from this public supply?

A. Well, fully three-fourths now, and I don't know but more; there are so many public places where they get water.

Q. Is there a sewage system in Lacon, and if so, how extensive?

A. No sewerage system.

Q. How is the domestic sewage disposed of?

A. Dumped in cess-pools, top drainage of course.

Q. Are they cleaned out by mechanical means or just allowed to drain?

A. Why, the most of them are just allowed to drain; the modern cess-pools of course are cleaned out, but they are
5745 not very numerous.

Q. Does this drainage from the cess-pools seep into the Illinois river, or is it absorbed by the earth?

A. Absorbed mostly, I should judge. Underneath is a solid bed of gravel and sand. You go down from four to fifteen feet anywhere in the city and you will strike gravel and the depth of that gravel in the well up here we sink that tube in the neighborhood of twenty feet. That was from the bottom of the well, and that was through gravel all the way down there where the well is.

Q. Has the city a health department in which mortuary statistics are recorded?

A. Not in the city, no, sir.

Q. Are the death certificates reported to the county clerk?

A. Yes, sir.

Q. Do you know of any typhoid fever in this community within the last three years, doctor?

A. No, sir.

Q. Neither among the people along the river nor back from the river?

A. No, sir, not to my personal knowledge.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say about three-fourths of the people use the 5746 water from the public supply?

A. I think so, fully that many.

Q. From what source do the remaining people procure their water?

A. There are some public wells here and then there are cisterns.

Q. This water that you use from these wells, is filtered through the sand and gravel?

A. Yes, sir.

Q. That is the theory upon which they were built?

A. That is the theory, yes, sir; they are sunk from sixty to seventy feet, in the gravel.

Q. None of the people of Lacon and vicinity use the water of the Illinois river for domestic purposes, do they, doctor?

A. Not to my knowledge.

Q. You wouldn't recommend the water of the Illinois river for domestic purposes since the opening of the canal, would you?

A. No, sir; nor at any other time.

J. W. POTTS, M. D.

5747 Lacon, Illinois, July 24, 1903.

S. S. EVERETT, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. E. S. Everett; Lacon, Illinois; physician and surgeon.

Q. How long have you lived in Lacon?

A. Seven years and a half.

Q. Of what school of medicine are you?

A. Regular.

Q. Have you practiced medicine in this vicinity during that time?

A. I practiced in this vicinity for ten years and a half.

Q. Where the remaining years?

A. Across the river at Sparland.

Q. How large a community is Sparland?

A. About 450.

Q. What is its water supply?

A. Quite largely well water; they have no public supply; well water and cistern water, but largely well water over there.

Q. In what county is Sparland?

A. Marshall; same county.

5748 Q. What is the water supply of the people of Lacon?

A. We have a public water supply; the water is taken from deep wells down on the bank of the river and of course besides that, we have wells and cisterns, but our people here in Lacon use well water very little, having this public supply of water; but very largely our better citizens use a filtered suppiy of cistern water?

Q. For drinking purposes?

A. Yes, sir.

Q. Is there a system of public drainage here?

A. No, we have no sewerage system at all; we have an almost ideal natural drainage, however.

Q. Describe it ?

A. The slope—the lay of the land, and the sub-soil is sand and gravel and there is perfect drainage almost to the river; there is no strata of sub-soil to hold the water, to prevent it going downwards and draining back toward the river.

Q. The natural subterranean drainage is towards the river, is it?

A. Yes, sir.

Q. And through a gravelly sub-soil?

A. Yes, sir. The gravel formation is quite deep; you soon strike it below the shallow surface.

5749 Q. How is the household sewage disposed of?

A. Well, cess-pools.

Q. And privy vaults?

A. Privy vaults, yes.

Q. Where are your mortuary statistics recorded?

A. At our county courthouse; the town is the county seat of Marshall county.

Q. Have you known of any typhoid fever in Lacon during the last three years and a half?

MR. JEFFRIES: Objected to as leading.

A. I have.

Q. How many cases?

A. You mean that I have personally treated?

Q. Yes, that you know about?

A. I don't think I have had but four cases in three years.

Q. Where have these cases been?

A. In town.

Q. To what did you attribute them?

A. I think they were imported cases.

Q. The people having contracted the disease elsewhere?

A. Yes, one of them I remember distinctly occurred about
5750 two years ago at this time of the year. A lady from Rock
Island, Illinois. They were having a great deal of typhoid, an epidemic in that city at the time, and she came here to care for her aged mother, and was taken sick in about ten days; that was one very clear case of importation.

Q. What became of the dejecta of the typhoid patients whom you treated?

A. It was disinfected and buried as a rule.

Q. Both as to the urine and the fecal matter?

A. Yes.

Q. What is the condition in this vicinity as to malarial diseases?

A. We have quite a little malaria along the river all the way here; it is not a severe malaria; the types of malaria here are not severe; they are easily treated; it is getting less and less as my judgment serves me; the older physicians tell me about a great deal of malaria they used to have around the country. Our malaria is easily treated.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Have you any means of ascertaining or judging of the other three cases of typhoid fever that you mentioned a few minutes ago?

5751 A. Well, I think they were from the country; imported from the country. They all occurred in the same family. The first case had been in the country visiting some little time, previous to the attack. That is all I could give as to the causation. The hygienic conditions about the home were very good. They used cistern water.

Q. Was there any typhoid fever before the canal was opened prior to three years ago?

A. A little; about the same as now; I don't notice any difference about that.

Q. You say the malarial fever has been growing less and of a milder form for the last two or three years past?

A. Yes, particularly the last two or three years.

Q. And from what the older physicians have told you it is of a much milder form now than formerly?

A. Than formerly, yes, sir.

Q. Do any of the people in Lacon, or the town on the opposite side of the river which you mentioned a few moments ago, use the water of the Illinois river for domestic purposes?

A. No.

Q. Since the opening of the Chicago drainage canal, would you recommend the water for domestic purposes?

A. No; never would.

Q. These wells here in Lacon obtain their supply by
5752 filtration through sand and gravel?

A. Yes, sir.

E. S. EVERETT, M. D.

5753 Henry, Illinois, July 24, 1903.

J. A. McCUNE, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. J. A. McCune.

Q. Where do you live?

A. City of Henry.

Q. Did you take water for the Sanitary District, the University of Chicago and the University of Illinois, in 1899 and 1900?

A. Yes, sir.

Q. Where did you take it?

A. I took it at the dam at the north end of the lock.

Q. Above what dam?

A. The dam at Henry, Illinois.

Q. How often did you take the samples.

A. Once a week.

Q. Where did you get the bottles?

A. Got them from Chicago.

Q. Did the bottles have the stoppers in them when they got here?

5754 A. Yes, sir.

Q. Describe how you got the water after you got the bottles?

A. I put the bottles in a skiff and went out to where I wanted to get the water and took the bottles and put them under water and let them fill and took them out, recorked them and sent the bottles away, sent them to Chicago.

Q. Did you rinse them out?

A. Rinsed it before I commenced to fill it.

Q. Where did you remove the cork from the bottle?

A. In the skiff before I went to fill them.

Q. Well, above or below the water?

A. Below the water; when I filled the bottles to send them away, yes, and re-corked them below the water.

Q. After you had filled the bottles how did you prepare them for shipment?

A. I sealed them, made a statement of the water and sent them to the express office and sent them away.

Q. Where did you ship them?

A. Shipped them to Chicago.

Q. Anywhere else?

A. No, sir.

Q. Did you ship any to Urbana, to Prof. Palmer?

A. Well, I did the second year, yes, sir; a bottle each week.

5755 Q. The first samples taken by you were shipped only to Chicago?

A. Went only to Chicago, yes, sir; that is my recollection; I may be mistaken, but that is my recollection.

Q. The second samples taken by you were shipped to Prof. Palmer at Urbana?

A. Yes, sir, I think so.

Q. Prof. Jordan?

A. And Prof. Jordan.

Q. To the Health Department of the City of Chicago?

A. I suppose they got them; that is, I don't know; I couldn't say; that was as far as we were directed—to Dr. Jordan.

Q. Do you pack any of the samples in ice?

A. Yes, sir.

Q. Which ones, the large or the small samples?

A. The small samples, every week.

Q. After you had prepared the samples for shipment, did you place a card on each sample similar to the card which I now show you which is sample No. 1411?

A. Yes, sir.

Q. Is that card in your handwriting?

A. Yes, sir.

Q. And that kind of cards with the proper notation were filled out by you and sent with each sample?

A. Yes ,sir.

5756 Q. Attached to the sample?

A. Yes, sir.

MR. TODD: I will ask you to have card sample No. 1411 marked Sanitary District Exhibit No. 11 for identification.

Card so marked by the Commissioner.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. At what place in the river did you say you took these samples?

A. At the upper end of the wharf, at the dam.

Q. What dam?

A. The dam across the Illinois river at Henry.

Q. What do they call it?

A. They call it the dam across the Illinois river.

Q. How far above Henry is the dam?

A. Well, it is about probabaly four rods above the north line of the corporation, sir.

Q. How far above the dam did you take the samples?

A. Probably 120 feet.

Q. Did you take them out in the channel?

A. No, sir; took them out right where the water comes around the point of the lock wharf.

Q. How long after these samples were taken before they were shipped?

5757 A. Well, sir, from an hour to an hour and a half, before they were put on the train; I took them generally about time enough to get them to the express office before the express went to the train.

Q. You shipped them over the Rock Island, did you?

A. Yes, sir.

Q. Did you personally take these samples?

A. Yes, sir, every one of them.

J. A. McCUNE.

5758 Henry Illinois, July 24, 1903.

CLYDE BAUTER, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. Clyde Bauter; I live here in Henry; fisherman.

Q. How long have you been a fisherman on the Illinois river?

A. I have been fishing here for the last nine years, I guess; a little longer than that.

Q. Over what territory in the Illinois river have you fished?

A. Well, I fished about three miles below Copperas Creek and clear to Spring Valley.

Q. When did you fish below Copperas Creek?

A. Well, it has been; my brother can tell you more about that; I was sick then and they was doing the fishing down there; he can tell you what time it was.

Q. Did you fish below Copperas Creek enough to become acquainted with the water down there?

A. Well, when we was fishing there the drainage wasn't in at all.

Q. What was the condition of the water down there before the drainage was turned in?

5759 A. Well, it was low; it was in the fall of the year when we were down there; it was low; it was about a three foot and a half fall on that dam down there, or three feet, and the water seemed to be all right then. I couldn't see nothing wrong with it then; it was a little scummy along the banks.

Q. Was there any slime in the nets?

A. Oh, yes, sir; there was slime in the nets; that is in the fall and winter time. They don't slime to amount to anything now.

Q. What was the appearance of this slime below Copperas Creek in the nets?

A. Why, it is a kind of a white stuff; you can't shake it off at all; you have to whip it off with a stick; it is like paste.

Q. What was the appearance of the water at this point before the opening of the drainage canal?

A. Do you mean how the water acts now?

Q. No, before the time the drainage was turned in?

A. Before the drainage was in the nets took the slime up a great deal and the water used to be green and scummy like. I don't think it was as pure as it is now by no means.

Q. What was its condition in the winter when the river was frozen over at this point?

5760 A. Well in the winter time when the water would freeze over, in low water, the water would get gassy, tarry, make the fish taste, and people couldn't eat them; there was no market for them; fish couldn't stay in the back water lakes in low water, before the drainage was in.

Q. Was there a smell under the ice in the winter?

A. Well I don't know whether it is or not; I couldn't say; I never noticed it particularly; I know the water used to get gassy and tarry; I know you couldn't eat the fish at all; that's all I know about that; I never noticed the water smelling.

Q. Have you fished any below Peoria since the opening of the drainage canal?

A. Yes, fished down there two years; I believe, and the water was just as pure as I could see; just as pure as it is now; I couldn't see any difference; only lots of current.

Q. How far below Peoria did you fish?

A. Copperas Creek.

Q. Below or above the locks?

A. Above.

Q. Was the water at Copperas Creek better or worse after the opening of the drainage canal?

A. That's pretty hard to say; I have not been down there for four years now; I couldn't say it was better or worse; but when I was down there the water used to be scummy just like it is up here—scummy and dirty.

5761 Q. I think you misunderstood me. Did you actually fish below Peoria after the drainage canal was turned into the Illinois river, three years ago?

A. Yes sir, I fished down there—the first year it was turned in we fished in Spring Lake, right there above the Copperas Creek, Spring lake and the river. This makes the second year here; and it was only in three years.

Q. What was the condition of the water in the river below Peoria, in the year 1900, three years ago this summer?

A. Well, I couldn't see anything wrong with it then myself; I fished there; I couldn't see nothing wrong. I know there was plenty of current there, that is all.

Q. Now, since the opening of the drainage canal, and at this point, what has been the condition of the water?

A. Well since the drainage canal was opened the first year, the water wasn't as good as it is now; the fish lives good and everything; we wouldn't ask for any better water at all, and the boilers on the boats don't foam or nothing. Four years ago before the drainage was in we was up fishing up above here and we couldn't keep steam on the boiler for foaming water; she would foam over.

Q. How long have you run a boat, operated by steam on the Illinois river?

A. Five years this July 1st.

5762 Q. Did you run a boat operated by steam below Peoria and before the drainage canal was opened?

A. Yes sir.

Q. How did the water act then in the boilers?

A. Just the same; foamed over in the summer time; not in the fall. After the water got cold it wasn't so bad.

Q. Did you run a boat operated by steam below Peoria after the drainage canal was opened?

A. Yes sir; one year, that's all.

Q. How did the water act in the boilers then?

A. Well the first year, if I ain't mistaken, she foamed a little bit, but she don't foam any more.

Q. Since the opening of the drainage canal, have you run a boat in this vicinity operated by steam?

A. Yes sir, run it from Peoria to Spring Valley, as far as we fished.

Q. How does the water act in the boilers now above Peoria?

A. All right; no complaint at all; for the last two years there ain't been no foaming done in the boilers at all.

Q. Are you pretty well acquainted with the fishermen between here and Copperas Creek?

A. Very near all of them I guess. The biggest majority of them I guess.

Q. Do you know of any typhoid fever among them in the last three years?

5763 MR. JEFFRIES: Objected to as leading.

A. No, I don't; I couldn't say nothing about that. Of course I don't think there is anybody that I know of amongst the fishermen that had the typhoid fever in the last three years. I know by golly, I ain't had the chills for a long while.

CROSS-EXAMINATION,
By Mr. Jeffries.

Q. How long did you say you had been fishing?

A. Nine years or more, nine years anyway.

Q. Up here at Henry all the time?

A. No, three years at Henry.

Q. Where were you before you commenced fishing here?

A. Peoria.

Q. Do you live in a dwelling or a house-boat?

A. Dwelling.

Q. Have you a cistern at your house or a well?

A. Two.

Q. Two cisterns?

A. Yes sir.

Q. Do you get your drinking water and water for domestic purposes out of a well?

A. No we use out of the cistern for the house.

Q. Where do the people of Henry get their water supply?

A. Well that's according to what water supply you mean.

5764 Q. Well where do they get the water that they use in their homes?

A. They got them out of cisterns until they got their waterworks.

Q. When did they put up their water system here at Henry?

A. Well they put it up last year; last fall was the first water they used from it.

Q. Explain that water plant; describe it.

A. The building?

Q. No, the whole business?

A. Well it is nothing but a lot of pipes laid in the ground.

Q. Where do they get their water?

A. From a well.

Q. What well?

A. They have got a dug well and two drove-wells, and they get it from a pipe laid in the ground, pumped by a gasoline engine, or a gasoline pump.

Q. How deep are those wells driven?

A. Well I couldn't say; I never heard nor never paid any attention to it.

Q. Where did the people get their water before this water plant was constructed?

A. They got it from the cisterns; the cisterns on the place where they lived; their residence, and they got it from the artificial well here in the park.

5765 Q. They did not use the water, and do not use the water from the Illinois river in their homes?

A. No, not as I know of; I don't believe that they do.

Q. You say you did no fishing below Peoria prior to the opening of the canal?

A. Not only the first year.

Q. And the water in the Illinois river below Peoria, the first year after the opening of the canal was very much worse?

A. Well, it didn't look as good as it does now, the first year.

Q. And it did not look as good as it did before the canal was opened?

A. No.

Q. Were you acquainted with the water above Peoria and along this point, Henry before the Chicago drainage canal was opened?

A. Yes. The water in the summer time was poor; it was awful green, and it wasn't good at all; it stunk.

Q. Now the first year after the opening of the canal, the water at this point and all along the river so far as your knowledge goes, was not so good as it was before the canal was opened?

A. The water when it was low, it wasn't as good as it is now for the last two years.

Q. And was not quite so good as it was before the canal was opened?

5766 A. No; that's right too.

Q. Now, what was the condition of the channel or current of the river from below Peoria to the Henry dam, before the canal was opened?

A. Oh yes, there was plenty of it.

Q. What was the condition of the current?

A. It was pretty swift.

Q. How is it since the canal was opened?

A. Well sir, it is swift.

Q. Very rapid, isn't it?

A. Yes sir, it carries a pretty good stream, about four miles an hour.

Q. You say there was a green scum formed on the water before the canal was opened?

A. Before the drainage was opened, it come up in the summer time, green.

Q. That scum was of a vegetable character, wasn't it?

A. Yes, as near as a fellow could get at it.

Q. There is a considerable scum yet, isn't there?

A. Not in the middle of the river, it isn't; there is on the banks. Of course when the river is falling it is then, but it don't carry clear across.

Q. The water in the Illinois river at this point is not very clear now, is it?

5767 A. Well, I can't see anything wrong with it now; it is a little muddy; it will get muddy any time, I think the rains is what makes it muddy; I don't think the drainage makes it muddy at all.

Q. Now in the winter time and late in the fall, slime forms on the nets yet, doesn't it?

A. Yes it does, but it ain't the same stuff.

Q. Does it form on the nets here at Henry?

A. It does.

Q. How much and what is its character?

A. Well it is a kind of a rotten stuff; it don't hang on like the other did; the other stuff was a kind of a glue.

CLYDE BAUTER.

5768 Henry, Illinois, July 24, 1903.

B. F. FORREST,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. My name is B. F. Forrest; my occupation is physician and surgeon. Residence Henry, Illinois.

Q. How long have you been a physician?

A. Twenty years.

Q. Of what school of medicine are you?

A. The regular school.

Q. How long have you practiced medicine in Henry and vicinity?

A. About thirteen years.

Q. How much of distance above and below Henry have you practiced in the vicinity of the Illinois river.

A. My practice extends in a general way as far north as

Hennepin; I get in Hennepin once in a while, and as far south as Lacon.

Q. If you have occupied any official position in the city of Lacon, you may state when and what position?

A. I occupied the position as Mayor, from 1892 to 1894,
5769 I think it was, or 1895, and from 1898 to 1900, two terms;
I think those are the dates, or near them.

Q. Where does the city of Henry obtain its water supply?

A. Until the present time it has been from cisterns and wells that is in the past, until within the period of the last three months, they have added a city waterworks from which a portion of the people are using. It has been principally from cisterns.

Q. From what source is the water works supplied?

A. From wells—bored wells.

Q. Have you any system of public sewers?

A. No sir.

Q. What becomes of the household sewage?

A. As a rule it is thrown out; some people haul it away in barrels, but the most of it is thrown on the top of the ground, in back yards and alleys, a large portion of it, and privies.

Q. Are there cess-pools here?

A. No sir.

Q. How big is the population?

A. About seventeen hundred.

Q. Do you know of any cases of typhoid fever in this vicinity within the last three years?

A. Yes.

5770 Q. How many and where?

A. I think there are two at the present time that I am attending.

Q. Are they in the city or in the country?

A. In the city.

Q. To what do you attribute these cases?

A. I don't know, other than one of the patients has been away from home, visiting in Indiana, and was taken down with this malady at once after returning, and has had it for three weeks.

Q. Can you account for the other at all?

A. No sir; I inquired particularly as to any source of infection and have learned that they have been using cistern water only and I know of no other method, or no other condition from which she might have been infected.

Q. In the past three years since the opening of the drainage canal, what has been the number of deaths, if any from typhoid fever?

A. None.

Q. What is done with the dejecta of the people, of urinary and fecal matter, of these two typhoid fever cases?

A. They were disinfected and emptied into the vault.

Q. What do you use for a disinfectant?

A. Well I use carbolic acid and lime.

5771 Q. Have you hunted and fished much upon the Illinois river since your residence in Henry?

A. Yes sir, a great deal.

Q. In what way do you fish?

A. I fish with a pole and line and have also been connected with a seining outfit in this way, backing it, knowing what they were doing.

Q. What was the condition of the Illinois river at this point before the opening of the drainage canal?

A. In times of high water, it was good; that is the condition of the water was good, fairly good. In conditions of low water the water was very bad, polluted.

Q. What was its condition when the river was frozen in the winter?

A. After the river would become frozen over, there was a break in the column of ice at the dam; at times the gases that would arise from that break in the dam where it didn't freeze over, it would become very bad; at times so much so that it was very offensive.

Q. What was the effect on the fish?

A. The effect was to kill the fish; if the river remained coated with ice for two or three weeks without a break up, a large number of fish would die.

5772 Q. Were the fish tainted?

A. Yes sir, unfit for food.

Q. Since the opening of the drainage canal, what has been the condition of the water at this point?

A. The water apparently has been better; there has been an absence of this stench, I haven't noticed it as much, not near as much.

Q. As to the fish what would you say?

A. I have heard no complaint; I have known the fishermen have taken them all this season and used them for food.

Q. How far from here to Lockport by river?

A. I don't know.

Q. How far to La Salle?

A. About thirty miles I think.

Q. How far to Peoria?

A. Thirty-three miles.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. This water system has only been put in about a year, hasn't it?

A. No sir, it hasn't only been in operation three months.

Q. What was the character of the water supply before this system was constructed?

5773 A. Why from cisterns and wells.

Q. The water from the river was not used?

A. Not used, except in ice.

Q. The ice is cut from some of the bays?

A. The ice is cut from the river, or the little ponds supplied from the river, back from the river.

Q. Were there any cases of typhoid fever here before the canal was opened?

A. Yes sir.

Q. There was no epidemic or anything of that kind?

A. There never has been. There hasn't been twenty cases of typhoid fever in thirteen years, all told, since I have been river for domestic purposes?

Q. You wouldn't recommend the water of the Illinois river for domestic purposes?

A. No sir.

Q. How is the character of the channel or flow of the river now as compared to what it was before the canal was opened?

A. More current; at times before the drainage canal was put in there was no current, or almost none.

Q. That was when the water became bad?

A. No, not at all times but when it was low it was ordinarily worse; very low; it became stagnant.

B. F. FORREST.

5774 Henry, Illinois, July 24, 1903.

WILL SIEWERS,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. Will Siewers; Henry, Illinois; grocery clerk.

Q. Did you take samples of water here for the State of Illinois?

A. Yes sir.

Q. Do you know who was originally employed here to do that?

A. Why, Mr. Gregory was I guess; but I was working for him.

Q. Did you take the samples of water according to the instructions that were given you?

A. Yes sir.

Q. At what point in the river did you take them?

A. I should judge it was about four or five hundred yards above the dam.

Q. Did you place cards giving the date of the collection, and the temperature of the water and air in an envelope similar to the one I now hand you marked "Geo. A. Wiggins, M. D., Milan, Ill." and on which is written in lead pencil "J. 5775 H. L."?

A. Yes sir, similar to that.

Q. Were you authorized by Mr. Gregory to write his name upon the cards which you made?

A. Yes sir.

Q. I hand you 32 cards and ask you to examine them and state whether those are the cards which you made and placed in the envelopes?

A. All there except those two; those two are not my writing; but that is Mr. Gregory's writing and that is his son's (referring to the two cards).

Q. The card dated June 19, 1900, numbered 424 is in the handwriting of Mr. Gregory?

A. Yes sir.

Q. The card dated December 4th, 1899, is in the handwriting of Mr. Gregory's son?

A. Yes sir.

Q. How often did you take these samples of water?

A. Why, every two weeks I believe.

JUDGE JOHNS: I now hand to the Commissioner the 32 cards referred to and ask that they be marked Exhibit 10, for the State of Illinois, to the witness Will Siewer's testimony, for identification.

Said cards are so marked by the Commissioner.

5776 Q. After the water was taken and sealed and tagged, how long before it was shipped by express?

A. Why it was about an hour before it left here; I would generally take it about 8:30 and the train would leave at 9:30.

Q. Did you each time take two samples, one in a large bottle and one in a small bottle?

A. Yes sir.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Did you take all of this water personally?

A. Yes sir, took it all personally.

Q. No one took any of it for you?

A. Not that I know of.

Q. How deep under the surface of the water did you go?

A. About a foot.

Q. Did you use some kind of an instrument, or your hand?

A. My hand.

Q. What time of day would you generally take them?

A. About 8:30 A. M.

Q. And when would they be shipped?

A. About 9:30.

Q. Except when you failed to get back in time to ship it that day?

5777 A. Well I don't remember of any time that we missed.

WILL SIEWERS.

JUDGE JOHNS: I now offer in evidence the envelope referred to in the examination of the water takers on the Illinois river in behalf of the State of Illinois, marked as indicated in the testimony and ask that it be marked Exhibit No. 11 for the State of Illinois, for identification.

Said card is so marked by the Commissioner.

5778 Henry, Illinois, July 24, 1903.

ELMER MELICK,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. Elmer Melick; Lock tender at the Henry Lock. Henry, Illinois.

Q. How long have you been lock tender at Henry Lock?

A. Since October 1st, 1900.

Q. What was your occupation before that?

A. Three seasons I was with Capt. York on the steamer Peoria; five or six years I was in a grocery store at Henry, here. And I was east about one year.

Q. Upon what portion of the river did the steamer run?

A. From Henry to Peoria and return.

Q. How long then, have you been acquainted with the water of the Illinois river between Henry and Peoria, and at Henry?

A. When I was on the boat I didn't pay much attention to the water; that is any more, we just ran up and down the river, and if it was high or low water we would notice it. Since I have went to work on the locks up here I have noticed 5779 the water more or less.

Q. You did not go to work on the lock until after the opening of the drainage canal?

A. I believe not.

Q. How far from Henry Lock to Lockport, by way of the river?

A. I don't know the exact distance, but I looked at the sheet; we have a tollage sheet and a mileage sheet.

Q. How far from Henry lock to Copperas Creek dam?

A. I think it is 65 miles.

Q. Is Henry a state or a government dam?

A. State dam.

Q. Now what has been the condition of the water in the Illinois river since you have been attending the locks?

A. The water has been lots better than it was before.

Q. In what respect?

A. Before it used to be a bad odor arise from it and since I went to work over there I haven't noticed this odor.

Q. Is the river at this point and on this day lower than the average, or higher?

A. It is higher.

Q. What is the stage of the river here now, today?

A. The lower gauge is 8.9; the upper gauge that gives the water on the dam is 2.4.

Q. Are both these gauges placed on a mitre sill for zero?

5780 A. They are zero I believe.

Q. Is the zero of both gauges upon the same level?

A. No sir, I think not. The upper gauge is just the water as it goes over the dam.

Q. What is the purpose of the upper gauge?

A. To tell the depth of the water that is going over the dam.

Q. So that the gauge shows that there are two feet and four-tenths?

A. Yes sir.

Q. On the crest of the dam now?

A. Yes sir.

Q. Do you know when the flash-boards were taken off this dam?

A. No sir, I couldn't tell.

Q. Were they taken off before you came here as lock tender?

A. Yes sir.

Q. Since you have been here what has been extreme low water mark on the lower gauge?

A. I couldn't give you the exact figures without looking at the gauge book; we have a gauge book at the office.

Q. What is your best recollection about it?

A. Oh, I couldn't say for sure; I think about six feet.

5781 CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How long is the dam across the river?

A. 540 feet I think.

Q. You say the water is now 2.4 deep on top of the dam?

A. Yes sir.

Q. Flowing over the dam?

A. Yes sir.

Q. Is that an ordinary stage or rather low?

A. Well at this time of year; in years gone by, we ought to have about 1.2 on the dam.

Q. Well that was before the canal was opened?

A. Yes sir; when I first went to work in October it was only one foot and two-tenths on the dam, in 1900.

Q. The flash-boards were not used then?

A. No sir.

Q. And have not been used since you have been there?

A. No sir.

Q. You say you don't know anything about the condition of the water before the canal was opened?

A. Not a great deal, no; only the smell and odor.

Q. Where were you working then?

A. In Henry. Part of the time.

5782 Q. What was the condition of the current before the canal was opened?

A. I couldn't say.

Q. What is its condition now, pretty swift?

A. Very swift; the fishermen are all kicking about it, is all I know; they say they can't seine.

Q. Do you notice a green, oily substance forming in the lock now, occasionally?

A. Yes sir, occasionally; very little though.

ELMER MELICK.

5783 WILLIAM McKINLEY,

re-called. Direct-examination continued by Judge Johns.

Q. What was the condition of the water in the Illinois river before the opening of the drainage canal, from Kampsville to the mouth?

A. In dead low water, it was very bad.

Q. In what respect?

A. Well it was stagnant; weeds grew in it; I have seen the weeds grow out from each bank, right to the channel—and moss.

Q. How was it for steam purposes?

A. Well I couldn't tell very much about that because I wasn't in there long enough.

Q. Were you not much below Kampsville dam prior to the opening of the drainage canal on State fish-boats?

A. No sir, not very much.

Q. How was the water after the opening of the drainage canal, below Kampsville locks?

A. Well, it has improved.

Q. In what respect?

A. Well there is more water and running water, and there isn't any moss or any vegetation of any kind.

Q. Since the opening of the drainage canal, have you been below Kampsville upon the State fish-boats?

5784 A. Yes sir.

Q. How has the water been for steaming purposes?

A. It has been all right.

Q. Before the opening of the drainage canal, what was the condition of the water in the Illinois river between Kampsville dam and La Grange dam?

A. Well it was about the same as it was below; there wasn't so much vegetation on account of the dam held the water up; made the water deeper here.

Q. Did the Kampsville dam back water up as far as La Grange dam?

A. Well I heard them say at Meredosia that it raised the water there four inches; or at the lock; that's only what I heard; I don't know anything about that.

MR. JEFFRIES: I move that the answer be stricken out because it is based on hearsay testimony and is therefore not the best evidence.

Q. JUDGE JOHNS: How far is Kampsville dam below La Grange dam by river?

A. Forty-six miles I believe.

Q. Before the opening of the drainage canal, what was the condition of the Illinois river between La Grange dam and Copperas Creek dam?

A. Well it was a kind of a pond like; not much current; stagnant.

5785 Q. How was it for steaming purposes?

A. Well about the same as it always was; we would have to clean the boilers every eight days, we calculated on.

Q. After the opening of the drainage canal, what was the condition of the Illinois river between La Grange and Kampsville dam?

A. It was improved to what it was before.

Q. How was it for steaming purposes?

MR. JEFFRIES: Objected to as leading and suggestive.

A. In what way do you mean?

Q. Between La Grange and Kampsville?

A. For steaming purposes, about the same as river water; you couldn't notice much difference; we had to clean boilers every so often anyway.

Q. After the opening of the drainage canal were the boilers dirtier or cleaner than before the opening of the drainage canal?

A. Well, the water was cleaner than it was before; at least we don't get as much out of the boilers.

Q. Is the water between La Grange and Kampsville dam, since the opening of the drainage canal, better or worse than the water below Kampsville dam?

MR. JEFFRIES: Objected to as leading.

A. About the same.

5786 Q. How far is it from La Grange up the river to Copperas Creek dam?

A. About 83 miles.

Q. How far is the influence of La Grange dam felt up the river?

A. Well I don't know, but it is felt at Havana, about six inches there.

Q. Before the opening of the drainage canal what was the condition of the water between Copperas Creek and La Grange?

A. Well the water was low, you know, and there wasn't much current; it was stagnant the same as it was below.

Q. How was it for steaming purposes?

A. All right; that is, you couldn't tell any difference in it; as I said before we clean the boilers every so often anyhow.

Q. After the opening of the drainage canal what was the condition of the waters between La Grange and Copperas Creek?

A. Why it was improved, about the same as it was below.

Q. When you cleaned out the boilers, how did the mud compare with the time before the opening of the drainage canal?

A. Well, we had more real mud I think, before.

Q. How was it as to lime and scale?

A. Well as to lime and scale; I don't think it made any difference.

5787 Q. After the opening of the drainage canal, how was the water for steaming purposes, between Copperas Creek and La Grange?

A. It was all right.

Q. After the opening of the drainage canal how did the water between Copperas Creek and La Grange compare with the water between La Grange and Kampsville; was it better or worse?

A. Well the water up the river, the farther up you got, I think it is worse, until you get to Peoria.

Q. Before the opening of the drainage canal, what was the condition of the water from Pekin down to Copperas Creek dam?

A. Well it was pretty rank, pretty bad.

Q. What was the condition of the water from Pekin to Peoria?

A. Well it kept getting worse; that is in low water.

Q. In what respect was it bad from Pekin down and from Peoria to Pekin?

A. Well, there was more sediment in the water and it was more difficult to get an injector to work between Pekin and Peoria than it was below there.

Q. After the opening of the drainage canal, what was the condition of the water between Copperas Creek dam and Pekin?

A. Well, it was improved; there was more water.

Q. How was it for steaming purposes?

A. Well it was all right so far as steaming purposes were concerned; if you let the boilers get dirty or run them over, they would prime, it didn't make any difference where it was.

5788 Q. After the opening of the drainage canal what was the condition of the water between Peoria and Pekin?

A. Why, it was improved about the same as it was at the other places.

Q. Was it and is it still bad, between Pekin and Peoria?

A. Well, since then we haven't had any right dead low water.

Q. How does the water in the Illinois river since the opening of the drainage canal, below Pekin, and to Copperas Creek dam, compare with the water below Copperas Creek dam and to La Grange; is it better or worse?

A. It is better below.

Q. Prior to the opening of the drainage canal, what was the condition of the water in the Illinois river from Peoria to Chillicothe?

A. The water was all right, good.

Q. After the opening of the drainage canal what was the condition of the water from Peoria to Chillicothe?

A. Well it was still good.

Q. How did it compare with the water as to condition before the opening of the canal?

A. Well you couldn't tell very much difference in it here.

Q. Before the opening of the drainage canal, what was the condition of the water and the current between Chillicothe and Henry dam?

A. Well the water was all right, but there wasn't much
5789 current; it was kind of a stagnant place; the water wasn't
bad though; every now and then there would be a green
scum on it in low water or warm weather.

Q. Before the opening of the drainage canal, how did the water from Henry to Chillicothe compare with the water from Chillicothe to Peoria?

A. About the same.

Q. After the opening of the drainage canal, how did the water from Chillicothe to Henry compare with the water from Chillicothe to Peoria?

A. Well it was about the same.

Q. How was it for steaming purposes?

A. I couldn't notice any difference.

Q. How far is it from Peoria to Chillicothe?

A. Eighteen miles I believe.

Q. How far from Chillicothe to Henry?

A. Twenty-two miles.

Q. How far above Henry have you been upon the Illinois river on the State boats?

A. Thirty miles to La Salle.

Q. Were you on that stretch of river both before and after the opening of the drainage canal?

A. Yes sir.

5790 Q. What was the condition of the water from Henry to La Salle before the opening of the drainage canal?

A. Kind of stagnant, slow current, same as it was between here and Peoria.

Q. What has been the condition of the water between Henry and La Salle since the opening of the drainage canal?

A. Well there has been more water; it is improved.

Q. How does the water from Henry to La Salle, before the opening of the drainage canal compare with the water from Chillicothe to Peoria before the opening, better or worse?

A. About the same; I couldn't tell any difference.

Q. For steaming purposes?

A. Yes, we could go from Peoria to St. Louis and not notice any difference.

Q. Is that because you kept your boilers clean?

A. Well, we didn't never allow them to go overtime or get too much in them, because there is danger of dropping sheets and burning the boiler, you know. We always look out for that.

Q. Since the opening of the drainage canal, what has been the condition of the water between Henry and La Salle?

A. It has been just about the same as between here and Peoria.

Q. Well is it better or worse than before the drainage canal was opened?

A. Why it was better; it keeps the boat farther away 5791 from the bottom; it don't stir up as much mud all the way along here, and we don't pump it into the boilers. The more water you have for a boat, it don't stir up the sediment so they get it.

Q. Since the opening of the drainage canal below Peoria and down to Copperas Creek dam, have you cleaned your boilers at any time?

A. I have cleaned the boilers at Peoria several times, yes sir.

Q. After coming up the river?

A. Yes, we would go up the river and down the river; may be cover that part of the river two or three times, and on this part of the river too.

Q. Is there any smell in the water since the opening of the drainage canal below Peoria, down to Pekin as shown by the steam and the cleaning of the boilers?

A. Well, none to speak of.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Mr. McKinley, were you born and raised in Havana?

A. I was raised there pretty much; I wasn't born there.

Q. Describe as best you can the current of the river now as compared with what it was before the canal was opened, at ordinary stages of the water?

A. Well the current has increased.

5792 Q. Very much so?

A. Oh yes sir, you can notice that too; there is more water and it travels faster.

Q. At times before the canal was opened, there was no current, scarcely at all?

A. In places, not any; in wide water there was scarcely any.

Q. The channel is much better now than it was?

A. Yes sir, that is there is much more water and deeper water.

Q. The odor that you spoke of as coming from the water before the canal was opened, was from decayed vegetation, wasn't it?

A. Yes, mostly. In dead low water the boat would go along the river and I have just seen the boat clear up the mud for several miles, four or five miles, stir up the mud itself, and of course you have got to keep taking water all the time, and you take that in to a certain extent, you just get lots of mud.

Q. There isn't a great deal of navigation on the river is there?

A. Well there is more for the last two years or three years than there has been for five years before.

Q. You notice some since the canal was opened, don't you?

5793 A. A little bit; not very much. As far as the boilers are concerned, that is a poor thing to go by. Because sometimes we would clean our boilers, may be at Peoria; may be the next time at the mouth of the river; may be the next time at Peru or La Salle; you can't tell anything about the boiler; sometimes we clean out here and go to Quincy, and clean out there in the Mississippi river.

Q. There is more or less odor to all steam, isn't there?

A. Yes sir, after the boilers begin to get dirty.

Q. This green scum that you saw on the river before the canal was opened, and vegetation that grew out almost to the channel, grows now in places, doesn't it?

A. No, I haven't seen any since.

Q. Do you know whether it grows out in the shallows now, or haven't you been out there?

A. No, I haven't been out there in the bottoms; where it gets dry, the vegetation grows just the same as it does out in a field and in the fall it dies and decays.

Q. Does the water ever foam in your boilers?

A. If you run them too long it will; you can notice it when the whistle blows.

Q. And when the water foams in the boilers, it is because the boilers are dirty?

A. Yes sir, because they get very dirty and if we don't

5794 have a chance to clean out, we blow them out; blow the mud off of them and keep it down that way until we get a chance to clean them out.

Q. In that particular there has been very little difference between the water now and what it was before the canal was opened?

A. Not very much. As far as for boiler purposes are concerned, you can't notice very much difference.

Q. So far as your observation goes, it is only better for navigation purposes?

A. Well the water looks better and has a better appearance all the time, so far as that is concerned.

Q. You don't know what is in it?

A. No, sir; I don't know anything about that.

Q. You don't drink it?

A. No, sir.

Q. Why don't you drink it?

A. Because I can get better water for one thing, and another thing, I don't think anyone ought to drink it, because I don't think it is clean enough to drink; I don't think any of it is, especially when you can get other waters.

Q. Especially Illinois river water?

A. Yes, sir. I have drank the Illinois river water and do yet in the spring when I am out hunting and can't get any better. 5795

Q. You are working for the Illinois River Fish Commission?

A. Yes, sir.

Q. As engineer on their steamer "Illinois?"

A. Yes, sir.

WM. V. McKINLEY.

5796 Henry, Illinois, July 24, 1903.

A. G. HUMPHREY, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. A. G. Humphrey; Henry, Illinois; grain business.

Q. How long have you lived at Henry?

A. A little over twenty-one years.

Q. Have you fished and hunted upon the Illinois river in this vicinity during that time?

A. Every season, yes, sir; spring and fall.

Q. What was the condition of the Illinois river at this point before the opening of the drainage canal in January, 1900?

A. Why, the condition of the water was very bad, I considered it up to the time the drainage was turned in.

Q. In what respect?

A. It had a greasy scum on the surface of it and it smelled like coal tar, and in low water that was very bad.

Q. Did it have a vegetable growth in it before the opening of the drainage canal? 5797

A. Why, yes, sir; in low water in the summer time I have seen the water just covered with it.

Q. What was the condition of the water in the winter when the water was frozen over?

A. Why, after the river had been frozen over for a while we could notice a very strong odor of gas, or tarry; the wind would blow it towards town; you could smell it all the time in the winter.

Q. Since the opening of the drainage canal, what has been its condition?

A. I haven't noticed anything of the kind since; the water seems to be a good deal purer; and not that green stuff on the surface.

Q. How about the odor in the winter?

A. I haven't noticed any since.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Have you been out on the river a great deal?

A. Yes, I hunt and fish a great deal.

5798 Q. What is the difference between the current in the river now and what it was before the canal was opened?

A. I consider there is more current in low water now than there was before.

Q. Very much more, isn't there?

A. Yes, I think there is a great deal more in low water.

Q. This green scum that formed on the water was a vegetable formation, was it not?

A. There was two different kinds; there was a vegetable matter we called duck seed, but the other scum was a greasy substance that would be on the surface of the water when the water was calm; of course it would be there just the same I suppose, but we wouldn't notice it when the water was rough.

Q. There is some scum on the water now, isn't there?

A. I have never noticed any of that greasy substance on the water; I haven't noticed any.

Q. You don't drink the water from the Illinois river?

A. No, we have a well.

Q. You don't use it at your house?

A. No, never did.

Q. It is not considered good water?

A. No, it wouldn't be considered good water for domestic use.

Q. The people of this town have wells and use the water from the city supply?

5799 A. Yes, and they have cisterns mostly, too.

A. G. HUMPHREY.

5800 Henry, Illinois, July 24, 1903.

W. T. LAW, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. W. T. Law; Henry, Illinois; I am a banker in business here.

Q. How long have you resided in Henry?

A. Forty-four years.

Q. Is your bank a national or state bank?

A. National bank.

Q. What, in a general way, was the condition of the Illinois river here before the opening of the drainage canal in January, 1900?

A. Well, I don't consider it was in as good condition as it is today; the water wasn't very good; there was a smell about it in the summer time in the evening, and I don't notice that much now.

Q. Did you notice a smell about it in the winter when the river was frozen over?

A. No, I never noticed that; I never was on the river much in the winter.

Q. Was there a scum on the water here in the summer before the opening of the drainage canal?
5801

A. Usually a green scum.

Q. Did it have the appearance of being a greasy or oily scum?

MR. JEFFRIES: Objected to as leading.

A. Well, sir, I never noticed it particularly; only sometimes I would cross the river on the bridge and notice it; I never came down to the river except crossing or something of that kind the whole year round, unless to take a boat or something of that kind; I don't know very much about it from a close inspection of it at all. Just as to the general appearance of the river.

Q. And from that general appearance do you conclude that it is better or worse than before the opening of the drainage canal?

A. I judge it is better.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say you are not on the river much?

A. No.

Q. And were not before the opening of the canal?

A. No, sir.

5802 Q. The people here in Henry have a water system, have they not?

A. Just put in one this season.

Q. And prior to that water plant they used water from driven wells and open wells?

A. And cisterns.

Q. They don't use the water from the river?

A. Not to any extent.

Q. When you say the water is better now than it was before the opening of the canal, you have no means of ascertaining that except your casual observation of it?

A. Yes, sir; there is more current in the river and the water seems to be clearer.

Q. You have made no examination of it, nor had none made?

A. No, sir.

W. T. LAW.

5803 Henry, Illinois, July 24, 1903.

FRED. BAUTER, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. My name is Fred. Bauter; Henry, Ill.; fisherman.

Q. How long have you been a fisherman upon the Illinois river?

A. Between nine and ten years.

Q. Over how much of the river have you fished?

A. We fished from Copperas Creek dam to Marquette.

Q. When did you fish below Peoria?

A. Why, we fished below Peoria; we come up there four years ago; fished off and on nine or ten years ago down below Peoria.

Q. Do you run a steam tug or boat in your fishing on the river?

A. Yes, sir.

Q. What was the condition of the Illinois river before the opening of the drainage canal below Peoria to Copperas Creek?

A. Why, I don't understand what you mean.

Q. As to the condition of the substances in the water, the color of the water, the current?

5804 A. Why, before—you see I haven't been down there to amount to anything since the opening of the canal, but one fall;—before the opening of the canal the water down there, take it along in the winter time and when the water began to get cold, the water was so dirty and slimy that you couldn't set the nets. The slime stuck on the nets in big chunks, it was a white slimy stuff, sticky.

Q. Did you fish down there with a seine?

A. Yes, sir.

Q. What was your experience with reference to the fish living in the water after they had been caught in the seine?

A. Why, they woudln't live at all; I would catch them and would have to throw them out of the nets; and lots of times they would die right in the nets; I wouldn't have them out there fifteen minutes until they were dead.

Q. How did the water operate in the boilers of your steamboat?

A. In the summer time, in hot weather, it used to get so as you would have to clean out the boilers three or four times a week or put coal oil in it to keep the foam down; it foamed all the time.

Q. What was the condition of the water at Peoria?

A. Why, it was just the same at Peoria as down below. You mean above Peoria?

5805 Q. At Peoria?

A. It was not so bad; you didn't get no slime above Peoria.

Q. Above Peoria?

A. Yes, sir; you could fish most any time of the year up here and you never got no slime.

Q. How did the water act in the boilers above Peoria after the opening of the drainage canal?

A. We never had no trouble at all.

Q. What was the condition of the water in the Illinois river above Peoria and before the opening of the drainage canal?

A. Why, in the summer time it was awful green; especially along at Peoria, and a boat would stop along the bank; it would collect up and stink; you would have to get out and push it away or turn the boat around to let it pass; there was no current to let it pass.

Q. What was the condition at this point, Henry, before the opening of the drainage canal?

A. It was about the same as it was below; that is, down about Peoria.

Q. How was it in the winter when the river was frozen over, above Peoria and up to this point?

A. Why, the water in the winter time, when it used to freeze over, the water would get bad and kill the fish off, and the water and fish both would smell tarry, and taste tarry. 5806

Q. Since the opening of the drainage canal, what has been the condition of the water above Peoria and up to this point —Henry?

A. The water is more pure, I think, keeps cooler, and the fish keep a good deal better, and there is no time in the winter that you can't drink it.

Q. Is there a smell in the water since the opening of the drainage canal, in the winter?

MR. JEFFRIES: Objected to as leading.

A. Why, I never noticed any.

Q. Are you pretty well acquainted with the fishermen along the Illinois river where you fished?

A. Yes, sir.

Q. Since the opening of the drainage canal have you known of any typhoid fever among them?

A. I have not.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say you never fished up here before the canal was opened?

A. Yes I have, too; that was the summer we run up with the tug; we run to Marquette, and the water was so bad we
5807 had to come back, and the water would foam in the boilers terribly.

Q. The water before the opening of the canal was scarcely without a current?

A. There was no current to amount to anything, no.

Q. How has it been since the opening of the canal?

A. Well, I should judge it was about two miles and a half an hour.

Q. This scum that formed on the water before the opening of the canal was of a vegetable character, was it not?

A. No, I think it was not; I think it was filth; that is how it looked to me; there was a green scum that was from the duckseed, but this wasn't.

Q. Does that filth form on the water now?

A. I haven't noticed any; may be once in a while you will see a little piece.

Q. Where has it gone to?

A. I don't know.

Q. Up the river?

A. I think it is all stopped up.

Q. It is still in the water?

A. It must be.

FRED BAUTER.

5808 Henry, Illinois, July 24, 1903.

H. HALL, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. H. Hall; Henry, Illinois; iceman.

Q. How long have you been engaged in putting up ice at this point?

A. Well, this makes me nine seasons.

Q. What was the condition of the ice here before the opening of the drainage canal?

A. Why, it seemed—a good many sediments in it; and some of it would be clear in parts and some of it wouldn't; a good many sediments in it, and after we cut the ice out of the lake, why, there would be a scum over the water where we would take it out.

Q. Was there an odor to the water, smell?

A. Well, along there late in the winter after it was froze up a while there would be, yes; after the ice got about eignt or ten inches thick.

Q. How did the water affect the fish?

A. After it was froze up it killed them.

5809 Q. Did you find any fish in the ice that you cut?

A. Yes, sir; had quite a trouble with it; we would have to chop them out in the summer time.

Q. Now, after the drainage canal was opened, in January, 1900, did you make any examination of the ice to determine whether it was fit to put up?

A. Yes, sir.

Q. What kind of an examination did you make?

A. We took a chunk of ice out of the lake, and took a chunk that we took out a year before that, and boiled them and we found that the ice that we took out of the lake was better ice than the ice that we had in the house.

Q. How about the ice in the river?

A. Well, this was taken out of the river; you might say it was right there by the spiles, you might call it the river; in front of the ice house there.

Q. How about the sediment in the ice since the drainage canal was opened?

A. We haven't noticed much sediment in it.

Q. Has there been an odor in the water since the openi of the drainage canal in the winter?

A. Well, yes, there was last winter; but we didn't notice i where we took the ice out; it was over at the dam here.

5810 Q. How did that odor compare with the time before the drainage canal was opened?

A. Well, it wasn't quite as bad last year as it was before, not near.

Q. Have you found any dead fish in the ice since the opening of the drainage canal?

A. I have not.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. The curent in the river is much swifter now than it was before the canal was opened?

A. Yes, sir; quite a bit; you can't do any fishing here with a seine at all.

Q. The current is too swift?

A. Yes, sir.

Q. This ice that you have been cutting for the last nin years came from off the lake, did it not?

A. Part of it and part of it came from the river.

Q. Not from the channel of the river?

A. No.

Q. Now, you say there was a smell at the dam this last winter?

A. Yes, sir.

Q. Considerable smell?

5811 A. Considerable smell, but not as bad as it was before, not near.

Q. And a good stage of water?

A. And a pretty good stage of water.

Q. You say you found fish dead and frozen in the ice?

A. Yes, sir.

Q. Before the canal was opened?

A. Yes, sir.

Q. And that there was a smell came up from the ice—from where the ice was cut?

A. Yes, sir, and a scum.

Q. And notwithstanding all that, the scum, the smell and the dead fish, you packed the ice and sold it?

A. Yes, sir.

Q. The State Board of Health didn't condemn your ice, did it?

A. No.

Q. They didn't know anything about it?

A. No; it was supposed to purify when it froze.

Q. That is, you went on that theory?

A. It is everybody's theory, I guess.

Q. Does there any odor come from the ice now?

A. No, sir.

Q. Where it is cut?

A. Well, I don't think we are cutting any ice now at the present time out of the lake or river.

5812 **Q. Well, I mean since the opening of the canal?**

A. I haven't noticed any.

Q. What has become of the green scum or the sedimentation, as you call it, since the opening of the canal?

A. Well, I don't know what has become of it, unless the current caries it way.

H. HALL.

5813 MR. JEFFRIES: I move to strike out all the testimony of all the witnesses taken on the Illinois river, dating from Monday, July 13th to this day, Friday, July 24th, who have testified as to the character of the water before and since the opening of the Chicago Drainage Canal into the Illinois river, for the reason that said witnesses did not properly qualify themselves as being competent to express an opinion or give their judgment on the subject; and for the further reason that water may be apparently clear and at the same time be filled with germs of disease, and that testimony of the character in question is incompetent and immaterial and irrelevant.

I move to strike out all the testimony of witnesses and physicians as to the typhoid fever cases up the river for the reason that the evidence shows that the Illinois river water has not been used for drinking or domestic purposes to any extent and therefore could not be the source or cause of the increased typhoid death rate in St. Louis; and move to strike out all the evidence of witnesses testifying to the water foaming in the boilers for the reason that such fact does not prove or disprove that the water is in a better condition from a sanitary standpoint since the opening of the canal than it was prior thereto, and for the further reason that it is incompetent and irrelevant; and I move to strike out the testimony of all witnesses to the deposit of material in the Illinois river at Peoria and Pekin and other places for the reason that such 5814 fact is no justification for the right of the Sanitary District and the city of Chicago to discharge the sewage of Chicago into the drainage canal and thence into the Illinois river, and for the reason that all the testimony so taken between said dates and places is incompetent, irrelevant and immaterial.

5815 National Hotel, Peoria, Illinois. 2:00 P. M., Monday, August 10th, 1903. Parties met pursuant to agreement.

Present:—The Commissioner,
Judge Springer,
Mr. Todd,
Judge Johns,
Mr. Jeffries.

No witnesses being present, an adjournment was taken until 10:00 A. M., Tuesday, August 11th, 1903, at same place.

National Hotel, Peoria, Illinois.
5816 10:00 A. M., Tuesday, August 11th, 1903.
Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

H. E. BEASLEY,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. H. E. Beasley; Peoria, Illinois; City Engineer.

Q. How long have you been engineer for the city of Peoria?

A. Since the 15th day of October, 1900.

Q. As city engineer have you knowledge of and to some extent control of the construction of sewers in the town?

A. Yes sir.

Q. Has the city of Peoria a public water supply?

A. The water supply of the city of Peoria is owned by a private corporation, the Peoria Water Company.

Q. Was it at any time a public water supply?

5817 A. Until about 1888 the waterworks system was owned by the City of Peoria.

Q. And has been a private corporation since then?

A. Yes sir.

Q. From what source is the water obtained?

A. From a water bearing strata of gravel, located about three miles northeast of the Court House, or the central portion of the city.

Q. And how far from the Illinois river?

A. At ordinary stage of water I would judge it to be about 300 yards.

Q. What is the character of the means by which water is obtained, whether from wells or reservoirs?

A. From a well.

Q. How deep is this well?

A. I think about fifty feet.

Q. Do you know whether the water obtained in this well flows in from the direction of the Illinois river or from the opposite direction?

A. Well I cannot answer that positively, but in my opinion it comes in from the opposite direction.

Q. Does this single well afford enough water for the public water supply?

MR. JEFFRIES: Objected to as leading.

5818 A. There is an auxiliary well located some 330 feet east of the plant and connected with the main pumping plant by a vitrified pipe, some thirty inches in diameter, either 24 or 30 inches in diameter.

Q. How far from the Illinois river at ordinary stage is this auxiliary well?

A. Not more than 25 feet.

Q. With reference to the basin, bottom or uplands, where are these wells.

A. Located in what might be called the bottom lands.

Q. Are they subject to overflow and periods of high water in the Illinois river?

A. Not in the vicinity of the well, no sir.

Q. In your opinion do the bottoms of these wells extend below the ordinary level of the bottom of the Illinois river?

A. Yes sir.

Q. Are there in the city of Peoria or vicinity large establishments which have their own private water supply?

A. Yes sir.

Q. How many of these?

A. All the distilleries, the glucose works, in fact all large corporations located along the river bank.

5819 Q. If you know you may state from what source these corporations and manufactories obtain their water?

A. In all cases from wells sunk to this water-bearing gravel.

Q. In a general way, where are the wells located with reference to the Illinois river?

A. Located within from 100 yards to 300 yards of the water at ordinary stage.

Q. What amount of water is pumped into the public water supply here, stated in gallons, per day or month?

A. I am unable to state that positively, but I would judge it to be in the neighborhood of five or six million gallons every 24 hours. I might further add that the city of Peoria receives no information regarding the number of gallons of water pumped per diem, from the water company.

Q. What is the population of the city of Peoria?

A. The census of 1900 gives the population of Peoria as 58,600.

Q. Has there been any increase since?

A. Yes sir, a conservative estimate of the present population I would place it about 70,000 to 73,000.

Q. After being used for domestic and manufacturing purposes what becomes of the water from the public water supply?

A. In a large majority of cases it is turned into the 5820 public sewers of the city.

Q. If you are able you may state how many connections there are in the city of Peoria, with the public water supply?

A. I cannot state that.

Q. What person in the city of Peoria would be able to state that?

A. An official of the Peoria Water Company.

Q. If you are able you may state the number of connections from houses and business places, with the public sewer?

A. We have official records in the office of the connection of about 2500 connections with the public sewers. This record is not complete and I would judge that there would be in the neighborhood of 3,000.

Q. In what kinds and classes of places are these connections?

A. From all buildings, residences, hotels or any other public building.

Q. Are there hospitals in Peoria?

A. Yes sir.

Q. How many?

A. Three.

Q. Are they connected with the public water supply and do they discharge their sewage into the public sewers?

A. Yes sir.

5821 Q. How many public schools in the city of Peoria?

A. I would judge there were in the neighborhood of fifteen.

Q. From what source do they receive their water supply and where is their sewage disposed of?

A. In most cases from the public water supply and whereever they have sewers they discharge their sewage into the public sewers.

Q. In the instances which we have mentioned, where corporations and manufacturers have their private water supply into what is their sewage discharged?

A. Into their own private drains, leading into the Illinois river.

Q. Where is the city of Peoria situated with reference to the Illinois river?

A. On the west bank of the Illinois river.

Q. For what distance does it extend on the river?

A. It extends about five miles along the bank of the river.

Q. Is there a creek near Peoria known as Kickapoo Creek?

A. Yes sir.

Q. As to the current of the Illinois river, is that creek above or below Peoria?

A. Below.

Q. How far?

5822 A. It empties into the Illinois river very close to the south-western corporate limits of the city.

Q. If you know you may state the the length of Kickapoo Creek and its general size?

A. The creek is about eighteen miles in length and of an average width of about—in low water not more than ten or fifteen feet wide in places. In high water, it overflows and extends over the lowlands to a width of three hundred feet.

Q. Does this creek receive any of the sewage of Peoria through the public sewers?

A. No sir.

Q. Does it receive any from the private sewers?

A. There may be a few connections located in what was formerly North Peoria, now the city of Peoria, which we have no knowledge of as city officials.

Q. As an individual, if you have any knowledge as to the amount discharged through sewers or ditches into Kickapoo Creek, you may state the amount and from what sources?

A. The discharge of sewage into Kickapoo Creek, that is, eventually reaching the creek, is that from five or six house connections.

5823 Q. Does Kickapoo Creek become dry in its bed during any season of the year?

A. No sir, there is always an amount of water in the creek, at all times of the year.

Q. Is there a place near Peoria known as Averyville?

A. Yes sir, located north of the city and lying along the bank of the Illinois river, being about one mile in length and about three-quarters of a mile in breadth.

Q. Is it a village or a part of the city?

A. It is a distinct corporation, being a village.

Q. Describe the situation—the physical conformation of the city of Peoria with reference to the Illinois river?

A. The city of Peoria is located on the bank of the Illinois river, the ground rising from the river bed to the bluffs, and extending back from the brow of the bluff a distance of approximately a mile and a half.

Q. How high is this bluff?

A. About 200 feet above the river bed in some portions—from 150 to 200 feet above the river bed.

Q. How far in a general way, from the bank of the river to what might be termed the foot of the bluff?

A. From three-quarters of a mile to about a mile and a half.

5824 Q. Into what does the surface drainage of the streets, alleys and public areaways of Peoria flow?

A. Into the public sewers, wherever they are located.

Q. And in places where there are not sewers, where does it finally empty?

A. It empties into the Illinois river, through conduits or ditches.

Q. Are the streets of Peoria washed and kept clean by water?

A. No sir.

Q. How is that done?

A. The streets are kept clean by men with brooms or other tools, and the refuse is deposited in various places, including the dumping grounds, none of the material being thrown direct into the river.

Q. Where is the principal dumping ground for the street sweepings?

A. Along the river front in what is known as the levy, has been used as the principal dumping grounds, the larger portion however, being distributed on lots which are lying low, throughout the city.

Q. Where does the seepage from these dumping grounds in cases of storm finally discharge itself?

A. It distributes itself throughout the grounds.

Q. What is done in Peoria with the garbage, the refuse
5825 matter from households, and hotels, saloons and restaurants?

A. I could not state as to that.

Q. Over how much of the corporate limits of the city of Peoria is there a system of public sewers?

A. The corporate limits of the city are 8.40 square miles. Of this 3.41 are sewered, being about forty per cent of the total.

Q. In your judgment, what percent of population discharge their household and other sewage into the public sewers?

A. I would state in my opinion about one-quarter or one-third or about 33 per cent discharge their sewage into the city sewers.

Q. Into what is the household sewage of the other 66 per cent discharged?

A. Into vaults.

Q. Is there a system here to clean these vaults?

A. There are private parties who do that work yes sir; it is not connected with the city, though.

Q. I hand you now a paper on which is printed at the upper left hand corner "City of Peoria; Sewer Map, January, 1898." and ask you to state what the paper is as a matter of fact?

A. The paper represents the sewers of the city of Peoria; the entire sewer system of the city of Peoria at that date. I have further added in it lines which represent what is known as the Persimmon Street and Chestnut Street sewer sys-
5826 tems, which have been constructed within the past year.

Q. What portion of the city of Peoria is represented on that map? In other words, does it represent the entire city of Peoria or only such portion of the city as is sewered?

A. It represents the corporate limits of the city of Peoria before the annexation of what were formerly known as North Peoria and South Peoria. This map represents an area of approximately five square miles.

Q. If it is drawn to a scale, what is the scale?

A. The scale is marked on the map, this being a photograph reproduction, it is not drawn to any scale of inches,—and any measurements can be made by using the scale in the upper left hand corner.

Q. What are the different characters, of physical construction of the sewers in the city of Peoria?

A. All the sewers of Peoria are constructed on what is known as the combined system, taking in household and surface water, being constructed of vitrified tile—the larger sewers of brick.

Q. Are these sewers represented upon that map and if so how are they designated, and in answer you may explain the map fully.

5827 A. The map represents the entire sewerage system of the city of Peoria, the various systems being shown thereon; the sewers themselves are indicated by red lines; the size of the same being marked immediately above or below each red line.

Q. In inches or feet?

A. In inches. There is an omission of what—of a plat of ground known as the Uplands Addition located above Main Street between University Street and Cooper Street, produced. This is an area of about 85 acres, sewered and paved.

Q. How are the brick sewers designated on the map?

A. The brick sewers are designated by the fact that the lines are crossed; there is a note in the upper right hand corner, which is explanatory of the markings of the map.

Q. How are the tiled sewers designated?

A. By straight red lines.

Q. What is the entire length of the brick sewers of Peoria as they are now in existence?

A. The brick sewers of Peoria are about 21 miles in length; the pipe sewers about 58 miles in length.

JUDGE JOHNS: I now hand the Commissioner map described by the witness and ask him to mark it defendants Exhibit No. 1.

Received and so marked. Map not reproduced.

MR. JEFFRIES: I object to the introduction of the ex-
5828 hibit for the reason that it is incompetent and immaterial and does not prove or disprove any issue in the case, and

for the reason that any and all evidence with reference to the condition of the sewers of Peoria and the discharges of the sewage or other matter into the Illinois river does not justify Chicago in the discharge of its sewage into the river by means of the drainage canal.

I renew the objection heretofore made with reference to all testimony of witnesses at various towns and cities on the Illinois river with reference to the discharge of sewage and other matters into said river, for the reasons stated in said objection.

It is hereby agreed that every possible objection pertinent to any question to any witness may be considered as having been made by complainant to defendants testimony, with respect to the character of the deposits or discharges into the Illinois river from its mouth to Lockport dam, and this objection shall go either as to the form of the question or substance of the question.

F. S. B., COMMISSIONER.

Q. JUDGE JOHNS: Is this map Exhibit 1, a correct representation of the location of the sewers in the city of Peoria?

A. Correct as to the streets in which they are located?

Q. (Question read).

A. Yes sir.

5829 In so far as is stated in the former explanation of the map.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How long have you lived in Peoria?

A. Since 1872.

Q. And you have been city engineer of Peoria since 1900?

A. Yes sir.

Q. What month?

A. October 15th, 1900.

Q. How old are you?

A. I will be 31 my next birthday.

Q. You say all of the people living in Peoria do not obtain their water from the waterworks company?

A. No sir, for the reason that the mains of the Peoria Waterworks do not extend all over the city of Peoria.

Q. Will you state what portions of the city are without water mains?

A. What was formerly the village of North Peoria. Also a portion of what was formerly known as South Peoria.

Q. The people living in Peoria who don't obtain their water for domestic and drinking purposes from the water supply of the Peoria Water Company, have independent wells of their own have they not?

A. In some cases; other cases they have cisterns.

5830 Q. They have either wells or cisterns?

A. Yes sir.

Q. When the people of Peoria—Do any of the people of Peoria use the water of the Illinois river for domestic purposes?

A. Not unless it is those that live in shacks or house-boats on the banks of the river.

Q. And they are of a transient character, are they not?

A. Well, they are a class who do not amount to anything, being that of the rougher, lower element.

Q. The character of the earth in which these wells are dug, is gravel and sand, or what is the character?

A. The gravel from which they receive the water is gravel or sand, being below the clay and loam of the surface.

Q. Do you know how thick this strata of sand and gravel is?

A. Why it is varying depth; I could not say how thick it is.

Q. Do you know whether any of these wells are sunk to a sufficient depth to go through the entire strata of gravel?

A. No sir, they are not.

Q. I understood you to say that in your opinion this water coming in through this gravel into the wells, came from a direction opposite the river?

A. That was with direct reference to the water of the Peoria Water Company.

5831 Q. In other words it comes from the bluff?

A. It comes from the bluff.

Q. The river being on the south and the bluff on the north?

A. The river being on the south-easterly side.

Q. What in your opinion is the difference between the source of the supply in the well of the water company and that of the private wells?

A. The well of the water company—or the water from the well of the water company is taken from the lower side of an impervious strata of clay or shale; the private wells throughout the city are from above this point.

Q. What is the average depth of a private well?

A. That would be hard to state.

Q. Well, in your judgment?

A. From fifteen to thirty feet.

Q. Now they are sunk in gravel also, are they not?

A. The private wells?

Q. Yes?

A. They reach into the gravel, yes sir.

Q. You say none of the solid matter in the way of refuse is discharged or emptied into the sewers?

A. Not to my knowledge.

Q. It is carted away?

A. Yes sir.

5832 Q. But you don't know where it is dumped?

A. No sir.

Q. Haven't you in the course of your work observed the places where they have been dumping this refuse?

A. No sir.

Q. It is not dumped into the river, however?

A. Not to my knowledge.

Q. Describe the character of the surface of the river in and around Peoria, that is, the character and nature of the soil?

A. The soil—the top soil being loam; in some places fine sand, underneath that is gravel; beneath that comes the shale or clay; underneath that we find in most cases a gravel which bears considerable water.

Q. You don't know the amount or extent and character of the matter that is discharged from the distilleries, glucose and other factories of Peoria, do you?

A. No sir. I am not able to state that: that being discharged through their own private drains.

H. E. BEASLEY.

5833 Peoria, Illinois, August 11, 1903.

PETER CASEY,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Peter Casey.

Q. Where do you live?

A. Peoria, Illinois.

Q. What is your business?

A. I am manager of the Corning Distilling Company.

Q. How long have you been manager of the Corning Distilling Company?

A. Since June, 1901.

Q. What was your business before that?

A. From August 1895 until June, 1901, I was manager of the Whiskey Trust, known as the American Spirits Company, commonly called the Whiskey Trust.

Q. How many distilleries were included in the so-called whiskey trust in Peoria?

A. At the time I had the management, there were four active distilleries.

Q. Were these distilleries located in Peoria?

A. Yes sir.

5834 Q. Did you have the management of those four distilleries?

A. Yes sir.

Q. From 1895 up to 1900, about how many cattle were fed by the distilleries over which you exercised supervision?

A. Well, it ranged from 20,000 to 12,000; the most we ever fed was in 1896, I think; we fed 20,000 then.

Q. About how many were fed each year after that, from 1896?

A. Well I think in 1897, to the best of my recollection, somewhere in the neighborhood of 15,000; in 1898 I think it was probably 12,000 or 14,000; in 1899 I think probably we fed 12,000; in 1900 I think we probably fed 8,000—may be 10,000, I don't know just exactly; I haven't got the data; in 1901 it was about 10,000; in 1902 I think we fed at that time 8,000.

Q. What was the capacity for these years of the distilleries known as the trust distilleries, in bushels?

A. Well in 1896, we run a capacity of between 17,000 and 18,000 bushels a day.

Q. Will you describe in a general way how the corn was treated and how the cattle were fed in these distilleries, and what became of the excreta of the cattle?

A. Well the corn is first ground into meal; then it is put into large cookers and cooked up to about 65 or 70 pounds pressure, the cookers are closed; that is supposed to break up all the starch in that corn, and destroys all the bacteria 5835 in the grain that would contaminate fermentation. After this meal is thoroughly cooked up at that pressure, the heat is drawn out by a vacum and malt is added then to convert the starch into sugar. After the conversion is complete it is fermented, yeast is added to it and at the expiration of the fermenting period which is 72 hours, it is separated over what is known as a beer still; that separates the whiskey from the slop, and the slop is then pumped to the cattle and fed to them; sometimes we feed them three times a day and sometimes twice.

Q. What is this slop composed of?

A. Well it is principally composed of protein and fat; it has a certain amount of moisture and with other minerals in there such as ashes, etc.

Q. What percentage is protein and what percentage is fat as disclosed by analysis?

A. Well that varies some according to the quality of the corn we use; the minimum average, about the average protein is 33 per cent, and fat about 11 per cent.

Q. And the other 64 per cent are the other minerals that you speak of?

A. Yes sir.

5836 Q. Describe the cattle sheds in which the cattle are fed? And the manner of feeding them?

A. Well, the sheds are built where there are troughs, racks; the cattle stand with their tails together in the one section—they are built in sections. The slop is supplied to them—a large tub is pumped into from the distillery. The offals from the cattle are pushed out not less than twice a day into a sewer which is directly behind each steer, one headed this way and one headed this way, and they are behind each steer; that is pushed out into the main sewer that runs through the middle of the cattle barn, and water is used to flush that into the river.

Q. What else is fed to the cattle besides slop?

A. Hay and cotton-seed hulls and sometimes cotton-seed meal.

Q. What is the purpose of feeding hay, cotton-seed meal and cotton-seed hulls?

A. The object of feeding hay and cotton-seed hulls is to retain the slop; otherwise it would run through and they wouldn't get any benefit of it. Cottonseed meal is used to advance the cattle when they haven't sufficient slop to feed them with.

Q. How many cattle are fed from the slop of one bushel of corn?

A. The rule is to feed a bushel of slop to every steer, 5837 but lately that has been modified considerably; they don't feed them that now; about three-quarters of a bushel and finish up with cottonseed meal or something of that kind to tide them over.

Q. How many gallons in a bushel of slop?

A. There is about 31 gallons, that goes to the cattle; ordinarily there is forty, but about nine or ten gallons of that it taken back to mash back again several times which leaves net from 30 to 31 gallons.

Q. About how much hay is fed to a steer daily?

A. That varies considerably. I should judge somewhere in the neighborhood of seven to ten pounds; sometimes as high as fifteen.

Q. When hay is fed, are the cottonseed hulls fed also?

A. Yes sir.

Q. About how many pounds of hulls are fed on an average?

A. Well, from a pound and a half to two pounds.

Q. Are the cattle salted?

A. Yes sir, salted frequently.

Q. What is the manner of salting the cattle?

A. The salt is just thrown along on what is called the hay board there, for them.

5838 Q. Does any of the salt become wasted and go into the sewer before taken by the cattle?

A. Yes, I suppose some of it does go through, probably a little.

Q. Is there any way of measuring the amount of salt that is fed to 10,000 cattle?

A. Well I think there is, but I don't know what it is.

Q. How much salt is consumed a week in the feeding of these cattle?

A. Of 10,000 head?

Q. Yes.

A. Well I should judge about ten or fifteen barrels.

Q. About how much is given to each steer daily?

A. How much salt?

Q. Yes sir.

A. Why, really I don't know; I never gave that much attention.

Q. When the excreta of the cattle fed is scraped into the sewer running between the two rows of cattle in the pens as you have described, where does that urine and manure from the cattle go?

A. It goes into the river.

Q. How far are these cattle sheds at Peoria located from the banks of the river?

5839 A. Some of them are directly on the bank of the river and the furthest I think is about 700 feet.

Q. When this offal or excreta of the cattle is carried to the river, what becomes of it?

A. Well the current takes it down I suppose, and in running where you have quite a distance to run that out, there is a large trough that runs from the cattle barns to the river; sometimes the hay is thrown off on the ground on both sides, and it doesn't run through the trough into the river.

Q. Are there times when this manure accumulates on the banks of the river?

A. Yes sir.

Q. How extensive are these accumulations?

A. Well, they have been pretty extensive; this last high water took them all away again, about two years, most of them were removed.

Q. In the absence of high water how are they removed?

A. They just lay there and disintegrate; sometimes they are fired by spontaneous combustion in the summer, if it gets very dry.

Q. Have they at any time been dislodged by steamboats and floated down the river in large islands?

A. Oh yes.

5840 Q. When that condition obtained, what became of the islands?

A. Well, the islands several times lodged against Pekin bridge down there. I was notified by the Board of Health to come down there and take it away, and we did so; after that we never heard anything from it.

Q. Were these islands of manure so large that they couldn't pass between the piers of the Pekin bridge?

A. Yes sir.

Q. Have you observed the condition of the water of the Illinois river before the opening of the drainage canal, at Peoria and since the opening of the drainage canal?

A. Yes sir.

Q. Will you describe the condition of the river at Peoria before the opening of the drainage canal?

A. Well the condition of the river at Peoria before the opening of the drainage canal, below Peoria was very bad; it smelled so bad sometimes we could hardly stand it along there. The water seemed to be perfectly stagnant, and there was no life to it at all.

Q. Did you observe any gas bubbles in the water?

A. Well I have noticed a foam on it.

Q. What caused that condition of the river at Peoria?

A. I think it was the offal from the cattle barns in my opinion.

5841 Q. What was the condition of the water above where it received the offal of the cattle barns?

A. It was a great deal better, but nothing like it is now.

Q. Since the opening of the canal and the turning of lake Michigan water into the Illinois river, what has been its effect upon the condition at Peoria both where the water of the Illinois river receives the sewage discharged from the distilleries and cattle barns, as well as above the point where such sewage is received into the Illinois river?

A. Well I consider that it is very much improved in every way, especially for mechanical purposes.

Q. How about the stench in the river from the place of contact with the sewage of the distilleries, meaning by that the out-falls from the cattle-sheds for four or five miles down stream?

A. Well I think the river on an average is more polluted than it was before; a constant pollution, I will say.

Q. (Question read).

A. Oh since; I haven't noticed any stench since the opening of the canal, to amount to anything. I didn't exactly understand Mr. Todd's question previously.

Q. Have you noticed any improvements in the water ot the Illinois river from the railroad bridge down stream for a distance of three or four miles since the opening of the 5842 drainage canal, and the conditions previous to that time?

A. Oh yes, there is a great improvement in the river.

Q. What is the condition of the water today as compared with before the opening of the drainage canal as to purity?

MR. JEFFRIES: I object to the question for the reason that the witness has not properly qualified himself to express an opinion as to the purity of the water.

Q. (Question read). In your opinion?

A. In my opinion, it is purer than it was before.

Q. Please state what facts and reasons you have for entertaining that opinion?

MR. JEFFRIES: Objected to for the same reason.

A. Well, I only know those facts in a mechanical way; that is, the water in our boilers, we don't have that foaming now as we used to have; and we don't have that slimy formation on the coolers or condensors that we formerly had.

Q. Will you state at length how the water of the Illinois river before the opening of the drainage canal, acted in the generation of steam and other manufacturing purposes for which it was used, and what changes, if any have taken place since the opening of the drainage canal?

A. When I was with the American Spirits Manufacturing

Company we operated four distilleries at one time; the
5843 Great Western Distillery, the Manhattan Distillery, the
Grove Distillery and the Monarch Distillery. The Great Western Distillery was located above any of the cattle barns. We had less trouble there than most anywhere else, with slime both in the boilers and in the coolers. The Manhattan Distillery was located below the great Western Cattle barns on the river; we had considerable trouble there.

Q. In what way?

A. From water foaming in the boilers and the slime on the condensors and coolers. The Grove Distillery was located below the Manhattan Cattle barns and the Great Western cattle barns, and we had about the same amount of trouble there that we did at the Manhattan. The Monarch Distillery was located below all of the cattle barns except the Monarch cattle barns, and we had a great deal of trouble there. We had our river pipes out farther than any other pipes, and we were constantly pulling it up to get out the accumulation of slime and manure, and so forth. We have at times pumped nothing, but which looked like excrement from the cattle barns, up through that pipe.

Q. This trouble that you speak of, manifests itself in what way with the machinery?

A. Well, it causes the boilers to foam; an accumulation of
slime on the coolers and condensors, and gave us trouble
5844 in various ways.

Q. Did these four distilleries of which you speak, take their water from the Illinois river for steaming and condensation purposes?

A. Well, they did for steaming purposes; part of the water for condensation purposes was taken from wells.

Q. Take the distillery that took its water from the Illinois river before the Illinois river had received the discharge from the cattle-sheds, prior to the opening of the drainage canal—how did the water—how does the water used in that distillery before the opening of the canal, compare with the water that is used since the opening of the canal, for mechanical purposes?

A. Oh, the water is very much better now. In fact, I haven't heard of any trouble at all lately.

Q. You had trouble in all of the distilleries with the water before the opening of the drainage canal, did you?

A. At times we did, yes, sir; some more than others; those that were lower down.

Q. Since the opening of the drainage canal, how has the water from the Illinois river, which is used for mechanical purposes in these distilleries, compared with the water of the Illinois river used for mechanical purposes, in these distilleries?

A. Well, I have only had experience with one distillery
5845 recently; that is the Corning Distilling Company; that is
below all the houses that I have named.

Q. Further down the river?

A. Farther down, yes, sir; we haven't had any trouble at all.

Q. Did you have any trouble with the water of the Illinois river from 1900 to June, 1901, in the distilleries that you have mentioned, after the opening of the drainage canal?

A. In those years we only operated two of these distilleries, the Great Western and the Monarch, and they gave us very little if any trouble.

Q. Where do you get the water for steaming and mechanical purposes for the Corning Distillery, of which you are now manager?

A. Part of it from the river and part from driven wells.

Q. What are the uses to which the river water is put?

A. Well, it is used for mashing purposes and for feeding purposes, and cooling purposes, in the first stage of the cooling; they wind up the cooling with well water,—and for boiler purposes entirely—entirely for boiler purposes if possible.

Q. How does its usage today compare with its usage for the same purposes before the opening of the drainage canal?

MR. JEFFRIES: Objected to as a repetition.

5846 A. We consider it very much better.

Q. How is the water taken out of the river?

A. By pumps.

Q. Have you a supply pipe that runs out?

A. Yes, sir; we have got a twenty inch pipe running out.

Q. How far out in the river do you take the water?

A. Well, we are 250 feet out from the bank.

Q. How many pounds of excreta does a steer discharge in 24 hours?

A. Well, I really don't know, but considerable. I never tried to ascertain that; I couldn't positively say.

Q. How many pounds of salt in a barrel such as you speak of?

A. 280 pounds.

Q. And how many barrels of salt is fed to 10,000 cattle?

A. I should judge about ten to fifteen barrels a week.

Q. How long is a steer kept for fattening purposes before he is ready for market?

A. Well, that varies considerably, Mr. Todd; we formerly kept them nine months; now they endeavor to get them out in six or seven months.

Adjourned until 1:30 p. m., same day.

5847 Met pursuant to adjournment at one-thirty p. m.

Peoria, Ill., August 11, 1903.

LEWIS A. McFADDEN, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. Doctor, state your name, residence and occupation?

A. Lewis A. McFadden; residence, 305 North Madison avenue, Peoria, Illinois; occupation, physician and surgeon.

Q. How long have you lived in Peoria?

A. Since July, 1887. Fifth of July.

Q. Have you practiced your profession here during that time?

A. I have, continuously.

Q. Did you ever occupy any official position here?

A. I have.

Q. What was it?

A. I was county physician of Peoria county for five years. I was one of the United States pension examiners under President Cleveland's administration; was alderman from the First ward for four years, and also commissioner of health from October, 1901, until June, 1903.

5848 Q. During what period were you county physician?

A. I think it was from 1890 to about 1895 or 1896. That is my recollection of the years.

Q. As county physician, what were your duties?

A. To look after the poor of the city who were not able to employ a physician; to treat the prisoners in the jail and work-house who were sick, and also look after the inmates of the county almshouse.

Q. Did that position bring you in contact and acquaintance with a class of people who lived and existed upon the banks of the Illinois river at Peoria?

A. Yes, sir.

Q. In your judgment how many people in or near the city of Peoria live either immediately upon the banks of the river or upon the water of the Illinois river?

A. Well, I think when I was county physician, there must have been as many as 500 living in cabin boats on the river and along the river.

Q. How many in your judgment lived along the banks of the river in house-boats while you were the commissioner of public health?

A. Well, I should think about 400. I don't think there was quite so many as there were a few years ago.

Q. Do you know how many people, or have you an opinion as to how many people in the city of Peoria use the water
5849 of the Illinois river for domestic purposes?

A. You mean from the wells?

Q. No, directly from the river?

A. I couldn't say exactly as to the number. A great many of the people living on the cabin boats get their water from the springs along the river bank. Some of them from the dug wells on top of the bank, and others use the city water by carrying it from hydrants, I suppose.

Q. What was the condition of health of the people living along the banks of the Illinois river in this vicinity prior to the opening of the drainage canal in January, 1900?

A. I found a great deal of sickness among them, more than in any other part of the city.

Q. Of what character of diseases?

A. Malaria, malarial diseases, dysentery and typhoid fever.

Q. To what did you attribute those diseases at that time?

A. Principally to their mode of living and to the use of the river water.

Q. Since the opening of the drainage canal in 1900, what in a general way has been the health of that same class of people?

A. The health of those people is certainly as good now as it was before.

Q. Do you know of any typhoid fever among them since the opening of the canal?

5850 A. There may have been some cases; but none to my knowledge.

Q. Were you familiar with the condition of the water of the Illinois river above Peoria prior to the opening of the drainage canal, and if so, you may describe it?

A. I was only familiar in a general way, like any other citizen. The water has never been considered very good, there is so much stagnant water in the vicinity of Peoria, and in the summer time the waters have never been considered very good here; not fit for drinking purposes or domestic use. Across the river it was always covered with a green scum, and in many places there was quite a stench arising from decayed vegetation.

Q. Prior to the opening of the drainage canal, what was the condition of the Illinois river on the river front of Peoria and below, after having received the sewage of the city of Peoria?

A. The water never was so good, or so pure and wholesome in front or below, on account of the Peoria sewage that in various ways found its way into the river, and the slops from the distilleries that flowed into it.

Q. Since the opening of the drainage canal, as compared with the water before the drainage canal was opened, what has been the condition of the water above Peoria?

5851 A. So far as anyone could observe, the water is about the same, only there is more current; otherwise the water is about the same as it was before.

Q. Does this green scum form upon it now?

A. Yes, sir.

Q. Do you know whether that is the same as the fishermen and hunters call duck-weed?

A. Some of it is, yes, sir; some of it is kind of like a moss, such as you find in stagnant waters in some localities when the weather is warm.

Q. In the government of the city of Peoria, is there a department known as the health department?

A. There is.

Q. You may state whether the statistics of the causes of death in the city of Peoria are kept in that office, that record?

A. They are.

Q. Have you examined those records with reference to deaths from typhoid fever in Peoria for seven or eight years past?

A. I have since 1895.

Q. You may state the number of deaths from typhoid fever shown by these records in your examination, from 1895 up to the present time, giving it by years?

5852 A. Well, I haven't got the number of deaths for 1895. In August and September, in 1895, there were 45 cases of typhoid fever reported to the health department. This is a greater number than has ever been reported during the same time—same length of time since. But in 1897—1896 I haven't got—in 1897 there were fifteen deaths in the city of Peoria; in 1898 there were 18 deaths; 1899, ten deaths; 1900 there were 17; 1901 there were twelve; 1902 eighteen, and so far during the present year there have been three deaths.

Q. While you were Commissioner of Health and an officer of the city here, what was the practice in regard to the dejecta of typhoid patients?

A. The—in the families where typhoid fever existed, they were instructed by a sanitary officer to disinfect the stools and also to destroy them by boiling or burying.

MR. JEFFRIES: I move to strike out the answer as not responsive to the question.

Q. By the term "stools" do you include the discharges of urine as well as the fecal matter?

A. Yes, sir.

Q. While you were health officer, state whether or not these directions of the health department were observed?

A. To the best of my knowledge they were.

5853 Q. You have spoken here of wells from which people obtain water along the river, as a general rule, in this vicinity where are those wells and how deep are they?

A. We have some public wells in the city, perhaps a half a dozen; some of them close to the river and others further back, below the bluff. The depth of these wells is about 60 or 70 feet. Then there are about 60 private wells in the city; and also wells along the river bank that are used for—I don't know what they use them for, but the distilleries and factories, I suppose, use them for their engines and boilers; and some of the employes drink the water.

Q. Are these wells along the river supplied by water from the Illinois river or from an underlying strata of gravel in which the water flows?

A. A certain amount of this water must come from the river, as I understand the wells rise and fall with the height of the river.

Q. That is to say, the depth of the water in the wells corresponds to the height of the water in the river?

A. Yes, sir.

Q. Do you know whether there are cess-pools and privy vaults in the city of Peoria, and if so, how many?

A. Great many cess-pools in Peoria, but the number I
5854 am not able to state—cess-pools and privies. There is a
great portion of our city that is not sewered, and a great many persons living adjacent to sewers have not yet got connected with them.

Q. What per cent. of the population of the city of Peoria discharges its household sewage into the public sewer system?

A. I think it would approximate about one-third of the population.

Q. What is the practice of the department of public health in reference to the privy vaults and cess-pools?

A. The sanitary officers of the city during the spring and summer season, make a house to house canvass and when they find the privy vault filled within four feet of the top and the cess-pools nearly full, they give them notice—to the owner of the property, to have them cleaned out within a reasonable time, say about five days.

Q. By whom then are the vaults and cess-pools cleaned, public authority or private enterprise?

A. They are cleaned by sanitary engineers, who pay a license to the city for the privilege.

Q. Into what place are the contents of the privies dumped?

A. They get a permit from the city health department.

Q. After they are cleaned do the officers or persons having the permits report back to the department of public health as to the cleaning of vaults or cess-pools? 5855

A. No, sir; this is not usually done. After the permit is given to them, it is taken for granted that the work is done, and unless some complaint comes in or a report comes to the health department that the work is not done, they don't often go back and inspect. Sometimes we find people arbitrary; then those cases are looked after carefully.

Q. Into what place are the contents of the vaults and cess-pools deposited?

A. In the current of the Kickapoo Creek, near where it empties into the Illinois river.

Q. Do these materials then pass naturally into the Illinois river?

A. They do.

Q. You may state how many permits were issued during your administration of the health department, for the cleaning of such vaults and cess-pools?

A. About 750 a year.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Do you know, doctor, how often these cess-pools and privy vaults are cleaned?

A. No, sir; there is no stated time for cleaning them; 5856 some are much deeper than others, consequently do not need to be cleaned so often.

Q. None of them are cleaned as often as two or three times a year, are they?

A. Yes, sir; some of them are cleaned as often as five or six times a year, and some as often as twenty times a year.

Q. That's comparatively few of them, however?

A. Very few. I think the Home for the Friendless clean their every week or two weeks.

Q. There is no record of the amount of deposits taken from these cess-pools and privy vaults, is there?

A. No, sir; no record kept.

Q. And some of them are never cleaned, because of their depth and the small amount of matter that is deposited in them?

A. Possibly some of the old cess-pools that are scarcely used,—people connected with sewers—it may be for years and years they are not cleaned.

Q. Doctor, to what school of medicine do you belong?

A. The regular school.

Q. How long have you been practicing?

A. Since 1881.

Q. What school did you take your course of medicine in?

5857 A. Two years in the Miami Medical College at Cincinnati, Ohio, and graduated from the Kentucky School of Medicine at Louisville, Ky., in 1881.

Q. There were no records kept of the deaths from typhoid fever in Peoria prior to 1897, is that correct?

A. I can't answer that question. They were very careless about keeping the records, however, prior to that time.

Q. And they are not reliable, if they did keep them?

A. I don't think that prior to that time they would be very reliable for the simple reason it was not necessary to have a burial permit.

Q. Now, doctor, prior to the opening of the canal, from 1890 to 1895, I understood you to say that there were abot 500 people living along the river in cabin boats, at Peoria?

A. In cabin boats and shacks along the river banks; some of them lived right on top of the bank; but they were practically the same kind of people we found living in the cabin-boats.

Q. Their principal business was fishing, then, wasn't it, or did they have any business?

A. Some of them had no business; some of them worked in shops or factories; others fished; just drifted in and stayed a little while and went away to where they came, so the population along the river bank was constantly changing.

Q. A kind of floating population?

5858 A. Yes. I think about two-thirds of the people living there remained there permanently.

Q. Now from 1901 to May, 1903, or during the time that you occupied the position of health officer, there were about 400 of those people living along the river?

A. I would estimate the population at about 400, to the best of my knowledge.

Q. You stated, doctor, that prior to the opening of the drainage canal the character of the diseases which affected the people along the river, were malaria, malarial fever, dysentery and typhoid fever?

A. Yes, sir.

Q. How many cases of typhoid fever were there among that class of the people here at Peoria for three years prior to the opening of the canal?

A. I have no idea.

Q. They are subject to the same disease, to-wit, typhoid fever, now as during the period previously mentioned?

A. Yes, sir.

Q. How is that disease contracted by that class of people?

A. Typhoid fever?

Q. Yes. I understood you to say in regard to them, that it came from drinking the water of the river?

A. No, sir, I didn't say that.

Q. What did you say?

5859 A. Well I didn't say that. It might come from that. If there are typhoid germs in water and a person drinks that water, he is liable to contract typhoid fever. If those germs are in milk, in food that he drinks or eats, he is also liable to contract it. It is supposed that flies carry this disease, or the disease germs.

Q. The water in the Illinois river is not used by the people of Peoria to any great extent for domestic and drinking purposes, is it?

A. No sir.

Q. Do you know the extent to which it is used? By the people living along the river?

A. Well, a few of them use it; but as I said before most of the families get drinking water and water for domestic purposes from springs along the bank or from dug wells or from the hydrants or cisterns.

Q. The water that is used by the people here in Peoria for domestic and drinking purposes, comes from wells that are driven into the ground and is filtered through the sand, is it not?

A. Yes sir.

Q. So that it makes no difference whether it comes from the river—river water, or from some other source, it goes through a process of filtration?

A. Yes sir.

5860 Q. What do you say, doctor, of the process of filtration by which the water which is used by the people of Peoria is subjected so far as the sanitary condition of the water is concerned, and its effect upon the sanitary condition of the water?

A. Well, I think that the filtration helps to purify it.

Q. You don't recommend the water from the river as being suitable for domestic and drinking purposes since the opening of the canal?

A. I don't think it is any more suitable now than it ever was.

Q. Then you wouldn't recommend it?

A. No sir.

Q. I understood you to say, doctor, that since the canal was opened, a green scum forms on the river at times the same as it did prior to the opening of the canal?

A. Yes sir.

Q. Describe the character of this green scum?

A. There is a scum in the bogs in the low-lands where the water remains stagnant. In high water the water flows back on these low-lands and bogs and part of the water doesn't find its way back into the river, only by seepage I suppose; it gets out by evaporation.

5861 Q. That produced by decaying vegetation and the stagnant condition of the water?

A. Yes sir.

Q. That causes the stagnation of the water?

A. No, that don't cause the stagnation of the water. That causes this scum.

Q. The water in the river is not stagnant now because at all times of the year there is a good current, isn't that true?

A. It is not stagnant in the river proper.

Q. That's what I mean. In the channel?

A. No sir.

Q. This green scum and the stagnated condition is removed by reason of the current in the channel?

A. I think so to a greater extent than formerly.

Q. Then the fact, doctor, that the water in the river is not stagnated and that there is no green scum in the main channel of the river, because of the current and flow of the river, does not mean that the water contains nothing injurious, or that it contains less impurities than it did when there was practically no current before the opening of the canal?

A. I don't take the ground that there are more impurities or less impurities. I think a chemical analysis shows it always to be more or less impureness in the waters of the Illinois
5862 river, at least since the banks have been inhabited.

Q. What I mean doctor, is that the absence of the green scum and the stagnant condition does not necessarily imply that the water is good?

A. No, I understand you perfectly. I don't think that that cuts any figure. There is only one way of contaminating the water; it makes it impure and unfit for domestic use whilst these other things do the same thing.

Q. Then it may contain more impurities and yet be free from the stagnated condition and green scum?

A. Yes sir; the appearance of the water has nothing to do with the impurities that it contains.

RE-DIRECT-EXAMINATION.

By Judge Springer.

Q. I presume you have reference to those impurities that come from the presence of pathogenic germs?

A. Yes sir, I have.

Q. Is there any other explanation that you desire to make to the testimony you have given?

MR. JEFFRIES: Objected to as not being proper in redirect examination.

A. Well one thing I might explain, that our water is perhaps not as impure as we imagine.

MR. JEFFRIES: I object to the question and answer.

5863 MR. JEFFRIES: I move to strike out the answer for the reason that the witness has not qualified himself to testify in that respect having made no chemical or bacteriological examination of the water; and has not qualified as an epidemiologist, and for the reason that the question is improper on re-direct examination, and merely suggests to the witness that he is at liberty to inject by way of explanation what counsel for defendants might believe will be argumentative and not based upon material facts shown in evidence, or within the knowledge of the witness.

Q. Now you can go on and explain doctor, your reasons for that conclusion.

A. While we don't use the river water to any extent for drinking or domestic purposes, yet nearly all our ice is harvested from the Illinois river; that is used in and around the city. This ice is used by hundreds of families for drinking purposes, by putting the ice right into the water, and we don't find any bad results arising from that source.

MR. JEFFRIES: I move to strike out the last answer for the same reasons just above given.

RE-CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Doctor, don't you know that a great many physicians
5864 in the towns and cities on the Illinois river in passing
an opinion upon sanitary condition, of the ice cut from the river, have recommended that it should not be put in the water, but should be deposited around the receptacle containing the water?

MR. TODD: I object to the question on the ground that the statement made is not the fact.

A. I understand that there are a few physicians who do recommend that the ice should be packed around the receptacle in which the water is contained.

Q. Don't you know that the ice which is consumed in the towns and cities along the Illinois river, is as a general thing cut from the bays and back-water from the river and from lakes that are supplied by springs and small streams with outlets into the Illinois river, and from estuaries where the water goes through a process of sedimentation?

A. I will have to answer "Yes" to some parts of your question and "No" to some other parts. As to the first part of the question, I don't know about the ice being cut from the lakes and bayous and creeks; all I know is that they cut the ice here from the river; but what they do in other places—

Q. They cut it from what is known as Peoria Lake?

A. Yes sir, Peoria Lake, it is a widening of the Illinois river at this point.

5865 Q. You don't know about the other places?

A. No sir, but so far as sedimentation taking place, at the time the ice is taken, is true to some extent.

Q. The fact that the ice is consumed in that way does not necessarily mean that it contains no pathogenic germs?

A. Oh no, no sir. If there are germs in the water there are bound to be some in the ice.

Q. Do you know the extent of the ice consumption in Peoria?

A. The amount used?

Q. Yes.

A. Thousands and thousands of tons every year.

Q. There is less used in proportion to the population than in many other places by reason of the fact that the people obtain a cool supply of water from these driven wells?

A. I think not.

Q. That has nothing to with it?

A. No sir; I don't think so.

Q. Do you recommend the ice as being good ice?

A. Well I can't say that I have ever objected to the use of the ice on account of these impurities that it contains.

Q. And yet you don't recommend the water?

A. No, as I said a while ago; while we didn't use the water, we do use the ice.

5866 Q. Yes, but how do you reconcile the two recommendations; you recommend the ice and don't recommend the water?

A. Well, yo[illegible]now a good many of our apprehensions are groundless.

L. A. McFADDEN, M. D.

5867 Peoria, Illinois, August 11, 1903.

W. A. McMILLAN,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Springer and testified as follows:

Q. Will you state your name, residence and occupation?

A. F. A. McMillan, Peoria, Illinois, at present sanitary officer, health inspector.

Q. How long have you resided in the city of Peoria?

A. It will be twenty years the first day of January now coming.

Q. How long have you held the position which you now hold?

A. I served two years under a former administration. I was off two years and I have been at work about a month this last time.

Q. State the nature of your duties?

A. Well it is to inspect the premises where vaults are above the city ordinance limit;to condemn them and have them cleaned; have anything that is offensive in the way of garbage, have the premises cleaned up and put in a sanitary condition.

5868 Q. In what way is the sewage of the city of Peoria disposed of?

A. Well, through the sewers, where they are connected with the premises—do you mean the garbage?

Q. I mean the garbage and sewage of all kinds?

A. The water goes through the sewers where they are connected, and in some instances they are stored in the yard, and the garbage is hauled away. They generally have a box or can; they have a can that is about the size of a half barrel, and men that haul that stuff away, they come around once or twice or three times a week and haul it away.

Q. Where is this sewage from private vaults, and garbage deposited?

A. Well, it is on this Kickapoo Creek, the lower part of the city.

Q. What becomes of it finally?

A. It is dumped into the deep water of the creek there and finally reaches the river I suppose.

Q. By means of the sewers and the system which you have just described, state whether all the sewage of the inhabitants of Peoria is deposited into the Illinois river?

A. So far as they are on the line of sewers and they have a connection, it reaches the river; but where there is a wash woman, and she throws it on the ground, it simply sinks
5869 in the ground. Peoria being built on sandy ground, it
simply sinks away. Probably in an hour or two you wouldn't see any signs that the woman washed there.

Q. Do you know how many vaults of that kind were cleaned in the city of Peoria for the year 1899?

A. I don't know just the exact number, but I think it was above 600, possibly it would reach over 700.

Q. You may state from any information you have which is reliable, the number of vaults cleaned for the years 1899, 1900, 1901, 1902 and 1903?

A. You want the total amount?

Q. Yes.

A. Well I saw this paper copied from the register from the annual report.

Q. State what those figures are?

A. (referring to paper). They are privy vaults that have been cleaned. In 1899 there were 639;

1900,	725
1901,	700
1902,	735

and so far this year there have been 500 cleaned.

Q. Where were the contents of these vaults deposited, so far as you know?

MR. JEFFRIES: Objected to as a repetition.

5870 A. Part of them were dumped across the river and the
rest were dumped down here on the Dorse dump into the Kickapoo creek.

Q. They went finally into the Illinois river?

A. Yes sir.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. These vaults and cess-pools that were cleaned from 1899 to 1903 were private vaults, were they?

A. Yes sir.

Q. Do these figures represent the number of vaults cleaned or the number of cleanings, the times cleaned?

A. Those represent the number of vaults cleaned.

Q. For instance, in 1899, you said the number of privy vaults cleaned was 639; do you mean that there were 639 separate and distinct vaults or cess-pool in Peoria that were cleaned that year?

A. Yes sir.

Q. Where a vault was cleaned two or three times a year, was any record kept of the second cleaning?

A. I never knew of but one vault to be cleaned more than once, and it was on top of the bluff up here and it struck a vein
of water and filled up just like a well, and it was con-
5871 demned the second time about a week or ten days after-
wards, and didn't have nothing to haul away but the
water, and there was never any more condemned to my knowledge.

Q. Do you know how many privy vaults and cess-pools there are in Peoria?

A. No sir.

Q. Have you any way of obtaining that information?

A. I don't know unless I could make a distinct canvass for that purpose.

Q. Do you know whether that has been done?

A. I do not.

Q. How many ice plants are there in Peoria, where ice is manufactured?

A. I don't know as there is but one.

Q. Is that a small plant or a large plant?

A. It is the only one I ever saw in my life. I think it is a pretty good sized plant.

Q. Do you know its capacity?

A. No sir.

Q. Does it dispose of its ice here in Peoria?

A. Yes sir.

Q. To the people at their dwellings?

A. Yes sir.

5872 Q. The saloons, hotels, restaurants and other places of that character, obtain their ice from this plant do they?

A. I don't know who they sell it to. Our family took it from them one year, and the rest of the time we have been taking it from this other company.

Q. They sell their ice, do they?

A. Yes sir, they sell their ice.

RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. Do you know how often the vaults at the Home for the Friendless are cleaned?

A. I do not know.

W. A. McMILLAN.

5873 Peoria, Illinois, Aug. 11, 1903.

EDWARD N. WOODRUFF,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Edward N. Woodruff.

Q. What is your business?

A. I am mayor of the city of Peoria.

Q. How long have you been Mayor of Peoria?

A. Ever since the 5th of May.

Q. What other buisness are you engaged in except looking after the municipal business of Peoria?

A. I am a dealer in natural ice.

Q. By natural ice what do you mean?

A. Well ice that is cut from the river is natural ice.

Q. As distinct from artificial ice?

A. Yes.

Q. How many ice houses do you operate here?

A. Well, we have a capacity of 26,000 tons, divided into three locations along the river.

Q. Where are the three locations?

5874 A. Why above Spring Street, Peoria, here; they are within six blocks, that is from one to the other.

Q. Where do you get the ice which you put up in your ice-houses?

A. Peoria Lake, a widening of the Illinois river is all I suppose.

Q. Is Peoria Lake immediately above Peoria on the Illinois river?

A. Yes.

Q. Lake Peoria is but a widening of the Illinois river, is it not?

A. Yes sir.

Q. How long have you been gathering ice from Lake Peoria?

A. Well I have been in the ice business about 22 years myself; my father started in in 1865.

Q. Your business takes you upon the Illinois river a great deal, does it not?

A. Yes sir.

Q. Are you familiar with the condition of the water of the Illinois river before the opening of the canal and since?

A. Yes sir.

Q. Above and below Peoria?

A. Yes.

5875 Q. What was the condition of the Illinois river water and the Illinois river before the opening of the drainage canal in January, 1900?

A. Well, I—

Q. —as compared with the conditions that exist since the opening of the canal?

A. The water is better than it was. Particularly since the opening of the canal it is better than it was before.

Q. In what respect is it better?

A. Well the water is clearer—well that practically is all—clearer and better condition in every way. I can possibly answer that question better by saying that before the canal was turned in, we were simply figuring on hunting other locations for ice cutting purposes, and I made investigations all through this part of the country where railroad rate was within reason, and wasn't able to find such location and concluded that it would possibly be better to manufacture ice because we felt the time was coming when we would be shut out.

Q. What were the conditions of the water in the Illinois river at that time which led you to look for other places for collecting ice?

A. Well the natural prejudice of the people to begin with; the fact that the river at low water was more or less stagnated in a way; slow current. In winter when the river is 5876 covered with heavy ice there was always more or less odor to the water; particularly at the breaking up of the ice. And from analysis too.

Q. Prior to the opening of the drainage canal, when the ice covered the river and was cut through to the water did any odor emanate from beneath the ice?

A. No, I can't say that it did. It was after the river was covered a long while with ice that this was apparent, and we usually would be through ice cutting you know, in the course of a couple of weeks, so that I don't know as I ever noticed that.

Q. When the river was covered with ice for a considerable period, did you ever observe any effect it had upon the fish in the river, whether they lived or not?

A. No, I don't know; we have had times when there have been a lot of dead fish along the rivers. I have had that matter under discussion but I don't believe the quantity of dead fish that I have observed would warrant attributing it entirely to that.

Q. Since the opening of the drainage canal have you observed that odor under the ice of which you spoke in your previous answer?

A. No sir.

5877 Q. How does the quality of ice since the opening of the drainage canal compare with the quality before the opening of the drainage canal?

A. Well I won't be certain about that, having had an analysis made since the canal has been turned in.

MR. JEFFRIES: I move to strike out the statement of the witness as to the conditions of the water or the ice under an analysis for the reason that he has not testified that he is competent to make an analysis and if such was made, it is not the best of evidence; it is merely hearsay and secondary.

A. (Continuing). What I meant was this, that I meant I had no right to make a comparison by analysis for the reason that I can't recollect having had an analysis made since.

MR. JEFFRIES: I renew my motion to strike out.

Q. I am calling for your opinion as an ice man?

A. The ice is better beyond a question.

Q. Have you had any complaints from those who use the ice since the opening of the canal?

MR. JEFFRIES: Objected to as not competent evidence.

A. The only objection that we have had to the ice is from the soot that grows on the top and in soft weather gets into the ice and feezes there.

Q. How many tons of ice taken from the Illinois river is sold to the consumers in Peoria by you?

5878 A. Last year as near as I can recollect, 19,000 or 20,000 tons.

Q. What class of consumers use your ice?

A. Families and butchers, restaurants and in fact all the people who use ice.

Q. Do you know whether this ice is used for cooling water for drinking purposes?

A. Yes sir, it is. And beer too.

Q. Do you know whether the ice is put into the water that is used for drinking purposes, or kept separate from the water?

A. Well there is no general usage of the ice separate from the water that I know of.

Q. Before the opening of the canal how did the river below the Peoria bridge compare with the river above the Peoria bridge?

A. Well I don't know that I am competent. I have paid very little attention to it below the bridge except that I believe it is good; in fact I know it is good.

Q. Below the bridge the river receives the discharge from the distilleries and the glucose factory and the sewers of Peoria. does it not?

A. Yes sir.

Q. Did you gather ice above the sewers of Peoria?

5879 A. Yes sir.

Q. What in your opinion, is the condition of the river today as compared with the river before the opening of the drainage canal as to the purity of the water?

A. The water is very much better in my opinion.

CROSS-EXAMINATION,

By Mr. Jeffries.

MR. JEFFRIES: I move to strike out all the testimony of this witness for the reason that it is incompetent and immaterial. Incompetent because the witness has not shown proper qualications to render judgment upon the condition of the water from a sanitary standpoint which may be relied upon.

Q. MR. JEFFRIES: How many other ice plants are there that take ice from the Illinois river besides your own, not the artificial; I mean natural ice companies?

A. There are three dealers who sell ice in the city and two St. Louis parties who cut or harvest ice above us.

Q. What I mean is, how many dispose of ice here in Peoria, besides yourself?

A. Two others.

Q. Is there an artificial ice plant here?

A. One, yes.

5880 Q. Do you know the capacity of that plant?

A. No.

Q. Have you a general idea?

A. They claim seventy tons.

Q. Seventy tons a day?

A. Yes. From the information I have, fifty tons is the limit.

Q. Do they dispose of their ice here in Peoria?

A. Certainly.

Q. To the retail trade?

A. Yes.

Q. You are not a chemist nor a bacteriologist?

A. Thank God, no.

Q. And therefore never made an examination of the water?

A. I never did, no.

Q. And when you say the water is better now than it was before the drainage canal was opened, you judge from the appearance of the water?

A. Certainly; I thought that was understood, when I was asked to come here.

Q. Quite a number of people of Peoria don't put this ice that you cut, in the water, do they? They put it in the receptacle, or around the receptacle containing the water?

5881 A. I don't know of a single case where they do it.

Q. You don't deliver ice yourself?

A. No sir.

Q. You don't know then of your own knowledge whether they do or don't put the ice around the recptacle containing the water?

A. Well, I feel that I am in very close touch with the ice business, and I feel I know what is happening in the business, and I don't believe that anyone uses it, and there is no one using it that I know of.

Q. I understood you to say that the water was in very bad condition before the canal was opened?

A. Well it had a murky look, and in comparison with it after the canal was turned in, it was muddy; it was clearer after the canal was turned on.

Q. It made good ice though, before the canal was opened?

A. Oh, yes.

Q. You don't know whether the impurities that were in the water before the canal was opened, are in there now or not do you?

A. No, I couldn't tell by looking at the water, no.

Q. You can't tell whether or not the impurities contained in the water have been increased by the addition of Chicago sewage, can you, except by its appearance?

5882 A. The water is clearer, for the reason that tools dropped in the water at a depth of four and five feet can be discerned and picked up, which could not have been done before the drainage canal was turned in.

Q. That is the only reason that you say the water is better is because of its appearance?

A. Well, seeing is believing.

Q. For certain purposes?

A. Yes.

Q. Do you believe in the theory that disease germs frozen in the ice will die or that the freezing will kill them?

A. Yes sir.

Q. That is the theory upon which you work, and from which you testify in regard to the ice being better than it was before the canal was opened?

MR. TODD: I object to the question on the ground that it is not proper cross-examination, as this witness is not put on the stand as a bacteriologist, or a man learned in germs, and has not qualified as such, and I move to strike out the questions and answers in regard to the subject matter of germs for the reason above stated, unless the witness has qualified as a bacteriologist.

MR. JEFFRIES: In reply to the objection I beg to state that the question is competent of this witness for the 5883 reason that the witness stated in his direct-examination that the water is better since the opening of the drainage canal than it was prior; and this question is competent for the purpose of showing the extent of the information that the witness may have upon the subject, and the reason for stating his belief.

MR. TODD: I move to strike out the statement made by counsel as not proper.

Q. (Question read).

A. Well, vegetation is all dead in the winter, possibly from cold weather; it might seem a reasonable surmise to come at in believing that ice destroys germs.

Q. In other words the fact that the water is clearer than it was before the canal was opened, and the fact that you believe that freezing destroys germs, you pronounce it better ice than it was before the opening of the canal?

A. Yes.

RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. You have never made any experiments in bacteriology, have you?

A. No.

Q. Do you know as a matter of fact whether it has ever been demonstrated scientifically that germs live or do not
5884 in ice?

MR. JEFFRIES: I object to the question for the reason that the witness has disqualified himself from being able to testify on that proposition on behalf of defendants, who are responsible for his testimony.

A. No, I do not know that fact. In as much as I am able to learn, bacteriologists apparently differ on the question.

Q. JUDGE SPRINGER: Mr. Mayor, I believe you stated that three St. Louis firms have been engaged in taking ice from Peoria lake. Can you name those firms and when they were engaged in taking ice from the Peoria Lake?

A. I said two.

Q. Two then; can you name them?

A. The Muckerman Ice & Coal Company I think is the style of one firm and G. H. Donewald & Company I think are the others.

Q. When was that?

A. Last winter and I don't know how many winters before; a number of winters,—eight or ten or twelve.

Q. To what extent was their cutting and taking of ice from this place, if you know?

A. Combine, 12,000 to 14,000 tons.

Q. Each season—each winter?

A. Well probably every winter they didn't take the ice out; but they held it for reserve.

5885 Q. What would they do with this ice?

A. Ship it away.

Q. Do you know what points it was shipped?

A. I have no knowledge of their billing, except I presume it would all go to St. Louis.

MR. JEFFRIES: We move to strike out all the testimony of this witness on re-direct examination by Judge Springer for the reason that it is incompetent and immaterial, and no proof that the ice so cut by the two parties mentioned therein, having been used by the people of Missouri, St. Louis in particular, or anywhere else, for drinking purposes, or any means by which it could be taken into the human system, and we move to strike out what the witness supposes, assumes or presumes, for the reason that it is no testimony.

Q. JUDGE SPRINGER: Did you learn from either of these firms, or the members of the firms, what they were doing with the ice that they cut from this lake?

MR. JEFFRIES: We object to that question for the reason that the members of the firm are the best witnesses, and their testimony the best evidence, and whatever the members of the firm might have told the witness, would be purely hearsay and not proper.

A. I have had no conversation with either one of the concerns for possibly a year; but I have been told by both of
5886 them that they were making shipments into St. Louis.

E. N. WOODRUFF.

5887 PETER CASEY,

re-called for cross-examination by Mr. Jeffries, testified as follows:

Q. Mr. Casey, in your direct examination this morning you stated the number of cattle fed under your superivision, or that the company had supervision over?

A. Well the cattle were fed by Nelson, Morris & Company, and had no connection with the company; the company merely furnished the slop and the barns to them.

Q. How many cattle did you say were fed from 1895 to 1900?

A. In 1895, I don't know how many; in 1896, I think there was somewhere in the neighborhood of 20,000 head.

Q. That was by the four concerns of which you were manager?

A. Yes, the four distilleries, yes sir.

Q. Was the Corning Distilling Company in business at that time?

A. No sir; the Corning Distilling company commenced operations on the 28th of December, 1901. The Atlas Distillery was in operation at that time.

Q. Do you know how many cattle were fed by these four companies, after you had retired from their supervision?

A. Not exactly; I just know from hearsay, I don't know the exact number; only what they told me.

5888 Q. Then the number of cattle that you testified to as having been fed in 1901, were those that were fed by the Corning Company?

A. No sir, they were fed by the American Spirits Company.

Q. And also in 1902?

A. Yes sir; the Corning Company doesn't feed any cattle. With the exception of within the last month or two, we furnished a little slop to Dodd & Kiefer, just after the Atlas closed down, in order to feed the cattle out for them,—about 1300 or 1400 bushels a day.

Q. At the times that you were superintendent of these four companies—or of these four houses, what other companies were in existence here at Peoria?

A. The Atlas Distillery and Stark Brothers & Company.

Q. Do the Atlas people now, and have they for the last six or eight years, fed cattle?

A. Yes sir.

Q. All the time?

A. Ever since I remember, yes sir.

Q. Do you know how many they fed this year?

A. 2500 head; there may be a few more, but that was the amount of slop they furnished,—2500 bushels.

5889 Q. Do you know how many they fed last year and the year before?

A. I think they fed the same amount; I think they had a contract for five years.

Q. There were more cattle fed here in 1896, than are being fed here now?

A. Yes sir, there haven't been as many cattle fed since 1896 as there was in 1896.

Q. And there were more fed in 1897 than there has been since?

A. Yes, I think it has been decreased right along.

Q. A continual decrease right along every year?

A. Yes.

Q. Now what is the cause of the decrease in the number of cattle fed in the distilleries at Peoria?

A. Well the cause of the decrease in our company was this; when they took in cattle at that time, they had to feed those cattle clear through the season of nine months, whether they had a demand for their goods or not; they had to feed the cattle and store the goods, and for that reason they decreased the number of cattle to keep from storing the goods. They found it was a loss in storing high proof spirits in order to take care of the cattle.

5890 Q. How much corn and grain have been consumed by the distilleries here in Peoria in the last seven or eight years if you know?

A. Well, I haven't got that data; if I had known it would be necessary, I should have gotten it.

Q. Has it increased or decreased?

A. I think there is a slight decrease recently.

Q. In the last year?

A. In the last year or two, yes.

Q. That has been kept by the various companies I presume, the amount consumed?

A. Oh yes, that has been kept—the various companies have an account of each year's mashing. I haven't got it at hand, but the records all show that.

Q. You will get a statement of the amount of grain consumed by the distilling companies of Peoria during the last seven years, and hand it to us?

A. Yes sir.

It is agreed that after the statement is rendered that either side may offer it as evidence if they so desire.

Q. What bcomes of the slop which is not fed to the cattle?

A. It is dried.

5891 Q. Do you utilize it in any way?

A. Oh yes; it demands a very good price for export; it is being used a great deal now for domestic purposes.

Q. What is this slop composed of?

A. It is composed of corn, malt and a very little rye.

Q. When you are not feeding cattle, what is the nature of the material or substance that goes into the sewers and thence into the Illinois river?

A. When we are drying it up; the residue from the presses, when we dry?

Q. At all times from any source outside of the cattle?

A. Well, it is a water that it is hardly perceptible that there is anything in it at all; especially when such fine mash, all the solid is retained—is saved.

Q. What is the character of cattle that you feed and that is fed by the different companies?

A. They are a very good quality of cattle.

Q. You don't feed any diseased cattle?

A. No sir, not if we know it. The only cattle that we ever had here that were quarantined were cattle that came from the Texas district; we had to keep them separate until frost; we never lost a one of them.

Q. They were really not diseased?

A. No sir, they were not diseased at all; they had been
5892 down across that line.

Q. What are the cattle fed upon besides this slop?

A. Hay, cotton-seed hulls and some cotton-seed meal, and I believe lately, they have been feeding them some oil-cake.

Q. Now this offal that runs from the cattle to the river, through the trough, do you know what that is composed of?

A. I don't know exactly the chemical analysis of it; it is ammonia—

Q. In other words it is not treated in any way?

A. It is regular cow manure and urine.

Q. You spoke this morning of a condition of the water in the river being purer since the opening of the canal and in doing so you spoke from your observation of the river and not from any analysis—not from any examination that you made of the water, except from its effects mechanically?

A. From my observation and from its mechanical effects, that's all.

Q. The foaming of the water and the formation of the scale in the boilers was very bad you say at times?

A. The formation of scales?

Q. Yes?

A. No, that had a tendency to loosen up the scale, the deposit we had then.

Q. Before the canal was opened?

5893 A. Yes sir, the water would foam and come clear over the engine; couldn't hold it in the boilers; couldn't find the water line.

Q. You got the water direct from the river?

A. Yes sir, from the river all the time.

Q. It was not bad enough to use a drive well?

A. Well, we couldn't use this well water; there is too much alkali in it.

Q. Do you know whether or not the foaming of the water in the boilers before the canal was opened was caused by the decaying of vegetable matter or animal?

A. Well I think it was both; the water became very stagnant here in the summer—very.

Q. You don't know from any examination that you made that those same impurities are not in the water now, that were then?

A. No sir, we do not. The action is entirely different, is all we go by.

Q. Do you know whether the water in the river is as much polluted now as it was before the canal was opened?

A. I don't think it is; in fact I know it isn't.

Q. But you know only from an observation and for mechanical purposes?

A. That its all, yes sir; otherwise I never made any test.

5894 Q. The current now carries away these impurities that were in the stagnant places?

A. Yes sir, the rapidity of the current.

Q. And it didn't carry it way before?

A . No sir, not in low water.

PETER CASEY.

Whereupon at 5:45 P. M. an adjournment was taken until the following morning, Wednesday, August 12, 1903, at 9 A. M. National Hotel, Peoria, Illinois.

5895 9:00 A. M., Wednesday, August 12, 1903.

Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

ROBERT R. MARTIN,

called as a witness in behalf of the defendants being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Robert R. Martin.

Q. What is your business?

A. Chief Engineer, Peoria Waterworks Company.

Q. Mr. Martin, did you ever take samples of water for the Sanitary District?

A. I did; I had them taken along with myself.

Q. Who took the samples?

A. E. J. Cain and myself.

Q. And where was the water taken from?

A. From the Illinois river, in the channel.

Q. At what point?

A. At the Upper Free Bridge, close to the Upper Free
5896 Bridge.

Q. With reference to Peoria, where is that point that you took the water?

A. Well now, lets, see. It is sort of north—no its southeast of the pumping station of the Peoria Waterworks Company.

Q. Is that at Averyville?

A. Yes sir.

Q. Is Averyville an upper suburb of Peoria?

A. It is an independent corporation of its own.

Q. Above Peoria?

A. Yes sir.

Q. How far from Shady Beach?

A. Adjoining it.

Q. Above or below measuring by the river?

A. It is in Averyville. I can answer that a little better, adjoining the upper free bridge.

Q. Now at what point in the Illinois river at Averyville near the pumping works at the free bridge, was this water taken?

A. In the channel.

Q. How often was it taken?

A. Every day.

Q. In how many places was it taken every day?

A. One place.

Q. When did you first begin to take the water?

A. October 9th, 1901.

5897 At 8:00 a. m.

Q. And continued to take it daily up until when?

A. I think the 29th of December. I have a record of it in the book here; I think it is the 29th.

Q. Did you take any water in 1899?

A. We did.

Q. Will you look at your book and give the exact date that you began taking the water and when you ceased for the different periods that you took water for the Sanitary District?

A. I don't know whether I can refer back to 1899 in the book I have got, and my memory won't allow me to answer that question. I would have to look that up. (Witness refers to book.) I haven't got any record in this book in regard to 1899. I took a good many samples, and some of them I delivered to Mr. Maury.

Q. All the samples that you took, or that were taken under your supervision for the Sanitary District were treated the same way?

A. Yes sir.

Q. And the samples which you took in 1899 were handled by you in the same manner that the samples for 1900 and 1901 were handled?

A. Yes sir.

5898 Q. Will you describe briefly the method pursued by you in the collection of the samples out of the river; the kind of bottles used, where you got the bottles from and how you filled them?

A. When I received a letter from Mr. Maury, instructing me to do what I could if time would permit, for Mr. F. W. Schule. This is my instructions from Mr. Maury, superintendent of the Peoria Waterworks Company (handing counsel paper). The instructions were that the bottles, large one, and two small ones, were to be taken and rinsed out not less than twice with the water that we were to send away for a sample, then the bottles were to be submerged for the purpose of taking

samples. This was done and the samples were taken according to instructions at a certain hour each morning; then delivered, after packing the two small bottles in ice, they were delivered immediately by messenger to Mr. Schule in the Y. M. C. A. building, so that they could be shipped immediately. We had a certain time to get down there so as to make connection with the train. This was all lived up to and I have a record in a book here with all this matter written in. Mr. Cain at that time was working under me for the waterworks company in the capacity of oiler. Him and I have always worked together on these samples. He took most all these samples. Those that he didn't take, I took; but every now and then, very often
5899 I would go down with him to see that he was still living
up to the instructions. He done it; it was not necessary, but in order to see that Mr. Maury's request was lived up to, I done that.

Q. Where did you get the bottles from that you shipped the sample in?

A. From Mr. Schule; then taking the filled bottles down, I brought three back each day. Mr. Schule said they had to be thoroughly sterilized and that is the reason he wanted me to take them back each day.

Q. Where was Mr. Schule's office?

A. In the Y. M. C. A. building, Peoria, Illinois.

Q. You would get the bottles from Mr. Schule and after filling them with water from the Illinois river in the manner heretofore indicated by you, you delivered these bottles back to Mr. Schule and got other bottles to fill and that kept on daily until this work was completed?

A. Yes sir, omitting Sundays.

Q. You took no waters on Sunday?

A. No sir.

Q. After you had filled and packed the bottles in ice, what marks of identification did you place on the bottles?

A. Their size; the size of the bottles were marked.

5900 Q. Did you number the samples?

A. Mr. Schule tended to that.

Q. Did you give him the date and hour of taking?

A. I did, on a slip of paper.

Q. From where taken?

A. Yes sir.

Q. By whom collected?

A. Yes sir, and by whom delivered.

Q. And the height of the water?

A. Yes sir.

Q. Temperature of the water?

A. Yes sir.

Q. Direction of the wind?

A. No sir.

Q. Temperature of the air?

A. Yes sir, and conditions of weather, and the coloration of the water.

Q. This data was handed to him on a paper was it?

A. Yes sir.

Q. With each sample?

A. Yes sir; this coloration of water was taken by a turbidity gauge as he called it.

5901 Q. After this water was packed in ice, who delivered it to him?

A. Myself and Frank Heckenberger, but a day now and then I might have sent someone else along.

Q. But you saw that it was delivered to him in person?

A. I did.

Q. What was his full name?

A. F. W. Schule.

Q. By whom was he introduced to you?

A. By a letter from Mr. D. H. Maury, consulting engineer and superintendent of the Peoria Water Company.

Q. Do you know where he is?

A. I do not.

Q. He was acting for the Sanitary District was he not?

A. As much as I know.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. When did you say you commenced taking these samples?

A. October 9, 1901.

Q. Who was this man that assisted you?

A. E. J. Cain.

5902 Q. Who took the first sample?

A. I did, and showed him how to take them; I took the first three samples in his presence.

Q. This place where you took samples, is that above or below Peoria?

A. Above Peoria.

Q. Did you take any samples below Peoria?

A. I did not.

Q. What kind of an instrument did you use to gather these samples?

A. A regular device for that purpose; I don't know what they call it.

Q. It was a regular machine, was it?

A. Yes, it submerges and pulls the stopper out.

Q. How deep under the surface of the water did you go to get the samples?

A. Oh I should judge a foot and a half to two foot and a half, somewhere near. Sometimes we let her go down deeper.

Q. Did you do that purposely?

A. There was no specified depth given, so we had it well submerged.

Q. How many samples would you take at each place?

A. Took two small bottles and one gallon bottle.

5903 Q. How large was the small bottle?

A. Well, it must have been mighty nigh a quart, I should judge; I never measured them; between a pint and a quart I should judge.

Q. What was the size of the large bottle?

A. About a gallon.

Q. Did you rinse the bottles out before you collected the samples of water?

A. Yes sir, with the water that I took the sample of.

Q. You did that with both the large and the small bottles?

A. Yes sir.

Q. Do you know how long it was after the samples were gathered, before they were shipped?

A. I do not; we were instructed to be on time every morning; if we wasn't there was no use in bringing them down.

Q. Did you wrap the bottles with anything after you gathered the sample?

A. We wrapped a thick duck cloth around the bottle and put a string around it.

Q. Both the large and the small?

A. Yes sir.

Q. Did you pack any ice around them?

A. The small bottles were packed in considerable ice.

5904 Q. You don't know whether the bottles were sterilized or not?

A. No sir, only what I was informed.

Q. You don't know that of your own personal knowledge?

A. No sir, he cautioned me not to take the corks out until we drawed the samples, and he seemed to be very particular in giving me certain bottles back.

MR. TODD: Is this gentleman here (indicating) Mr. Cain?

A. Yes sir, E. J. Cain.

ROBERT R. MARTIN.

5905 E. J. CAIN,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. E. J. Cain.

Q. You are the Mr. Cain that it was testified about as assisting Mr. Martin in the collection of the water samples?

A. I am.

Q. You collected these samples of water under his supervision and direction did you not?

A. Yes sir, I did.

Q. You heard him testify here this morning?

A. Yes sir.

Q. Did you comply with the instructions such as he testified about, in the collection of these samples?

A. I did.

Q. And in the handling of these samples after collection?

A. Yes sir.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. What were his instructions to you?

A. To take these bottles to the river and rinse them out 5906 not less than twice and then submerge them and fill them and pack them in ice.

Q. Is that all you did?

A. I a few times delivered them to Mr. Schule at the Y. M. C. A.; that was a very few times though, when Mr. Martin couldn't go I would go. Before they were packed, the stopper was wrapped with a piece of cloth and tied.

Q. You stood on the bank of the river and got the samples?

A. No sir; we didn't stand on the bank; we took a boat and collected them when the weather would permit.

Q. How often did you gather samples?

A. Every day except Sundays.

Q. For how long?

A. From the 9th of October until about the 29th or 30th of December.

E. J. CAIN.

5907

ROBERT R. MARTIN,

re-called for further examination by Mr. Todd, testified as follows:

Q. Mr. Martin, were you acquainted with the Illinois river before and since the opening of the drainage canal?

A. I am for the last fifteen or sixteen years; I have worked along side of it.

Q. Were you acquainted with the water below and above Peoria before the opening of the drainage canal?

A. I am.

Q. What experience and opportunity did you have for observing the water of the Illinois river above Peoria and below Peoria?

A. By pumping it in the city mains.

Q. Were you out on the river a great deal of the time?

A. Well as a fisherman; I am quite a fisherman.

Q. Will you describe the condition of the Illinois river before the opening of the canal and the condition of the Illinois river since the opening of the canal?

A. As I said, I like to go out fishing and I like to eat fish. In the winter time when the river would be froze over here, these fish caught above Peoria, would have a tarrish, gassy taste; so much so that they weren't fit to eat in the 5908 winter after the ice was frozen over for a small time. We have had no time that I could mention this winter but what we have had fish once or twice a week at our house, and they haven't that taste now, where they used to have it before the canal came in; that is my judgment and opinion, we relish the fish as much in winter now as we do in the summer.

Q. What about the condition of the water now as compared with what it was before the opening of the canal?

A. It is clearer.

Q. Before the opening of the canal did the water have any odor in it?

A. It did.

Q. What is the condition now?

A. It is a great deal better.

Q. Do you observe any odor in the water now?

A. I have not.

Q. What in your opinion has been the effect of the drainage canal upon the water of the Illinois river?

A. I think it has given us a better river.

Q. In what way better?

A. Better water; I don't know whether it has any effect on the mosquitoes; in the last few years we have had less mosquitoes up here; I believe that is due to covering over the swamp land, with water; the mosquito part.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. When you say that the water is better now than it was before the canal was opened, do you mean to say that feces and urine and sewage from 1,700,000 people of Chicago, discharged into the Illinois river has improved its condition?

MR. TODD: I object to the question as assuming a fact not proven; there is not 1,700,000 people in Chicago today emptying their sewage into the Chicago river, and for the further reason that the question is misleading, and for another reason, that the question does not assume that there is 250,000 cubic feet of pure Lake Michigan water that dilutes the sewage that is discharged into the Illinois river.

A. I don't know anything about your figures.

Q. You don't know anything about the effect of the sewage discharged from Chicago into the Illinois river, do you, upon the sanitary condition of that water; not its appearance, but on its sanitary condition?

A. I will only say this, that if there is that much corruption coming down there they must give us good corruption for water and fish, for it has made it better. Fish are good to eat now winter and summer. We have fish at our house now positive once every week and almost always twice a week.
5910 We didn't before. We couldn't eat them. They were rotten with this tarrish and gassy taste. In going out fishing, I have taken a drink of this water now when real thirsty; of course I didn't do that because I love any river water, but thirst; but I wouldn't do it before because I knew what it was. I pumped it at the old pumping station and I saw enough. I only mean in winter time now when I am speaking about the condition of the fish, when the ice was froze over, before, I meant.

Q. The fish didn't taste bad in the summer time?

A. They were all right in the summer when they have plenty of air.

Q. When you say the water is better you judge simply from its appearance?

A. Well I drank it.

Q. Without any reference to the properties it might contain?

A. Only the properties and use of it, and sight.

Q. Are you engaged in the fish business?

A. No sir, I am not.

Q. Are you out on the river every day?

A. Well, I am around the river all the time. I have charge of about 450 feet altogether, river frontage; part of it is used for park purposes which is under my supervision. If I
5911 said 450 feet, I should have said 4,500 feet.

Q. You don't drink the water very often?

A. I drink it altogether—that is, what water do you mean now?

Q. I mean the water from the river?

A. Oh no. I didn't know what you did mean, but I drink water altogether.

Q. You are working at the water supply pump works of the city?

A. Chief engineer, yes sir; fifteen years' experience.

Q. How deep is the well from which they get their water?

A. One part is 51 feet from the surface, and the other—four caissons that goes beyond that; I think they run down about 26 feet further; to what is called hardpan.

Q. How far are those pumps or wells located from the river?

A. Well, that depends upon the elevation.

Q. I mean how far are they located from the river, on the bank?

A. You mean at high water mark or low water mark?

Q. At ordinary stage?

A. Without measuring it I should say anyway from an average of 350 feet to 450 feet.

Q. What is the character of the soil?

5912 A. It is what we call a loam and then a gumbo; water will not penetrate it. It is better than clay for a bank; I am talking from experience now.

Q. What is there below the gumbo?

A. Then comes the gravel and the clay.

Q. Do you know the direction from which the water comes that runs into those wells?

A. It seems to come from the north; I saw the stream; the effects of the stream comes from the north.

Q. Opposite from the river?

A. More east than north, yes sir.

Q. Then it seems to be running under the surface of the earth towards the river?

A. Yes sir.

Q. And not from the river?

A. No sir.

Q. To what extent is that water in those wells used by the people in Peoria?

A. For general use.

Q. What is your average daily pumping the year around?

A. I couldn't answer that without figuring it out. In real cold winter, when they let the faucets run, there is an increase, real wet time when there is no sprinkling, no freezing, the consumption decreases; in the middle of the summer 5913 when there is heavy sprinkling it increases; it varies; I will have to refer you to the books for that question.

Q. Well, can't you approximate it?

A. I don't want to answer that question without referring to the books. I make my daily reports to the office; you can get that from them.

Q. You make a report daily of the number of gallons pumped that day?

A. Everything; coal consumption; elevation of river, elevation of well, and all those you will find in the water company's office.

Q. How long have you been making that report?

A. All the time during my service.

Q. Now from those reports, what would you consider an average day's pumping?

A. Well, I wouldn't want to answer that.

Q. Well, I want your opinion?

A. Well, an average of from four to six million gallons a day for the last two years.

Q. You don't know how many private wells there are in Peoria do you?

A. No, I don't.

Q. I understood you to say that before the opening of the 5914 canal there was nothing wrong with the fish in the summer time. That was right, wasn't it?

A. Yes sir.

Q. And that the only time that they were in bad condition was when the river was frozen over?

A. Yes sir.

ROBERT R. MARTIN.

5915 CHARLES F. HIXSON,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. State your name, residence and occupation?

A. Charles F. Hixson; 605 Pennsylvania Avenue, Peoria, Illinois; my occupation is I run a summer resort and boat yard near the upper free bridge.

Q. Is that at or near a place called Shady Beach?

A. That's what we call it, Shady Beach.

Q. How long have you been engaged in that occupation at that place?

A. Eight years.

Q. Where is Shady Beach with reference to the city of Peoria, above or below?

A. It is about three miles and a half above Main Street.

Q. Do you know a place on the Illinois river called the Narrows?

A. Yes sir, we are right at the Narrows.

Q. Is there a part of the Illinois river above the Narrows called Peoria Lake?

5916 A. It is below the Narrows.

Q. What is the fact above the Narrows, is there an enlargement of the river there called a lake?

A. Yes sir, there is quite an enlargement above the Narrows.

Q. What is that enlargement called?

A. Well, it runs into Hooshaw's Slough. I never heard any particular name for the lake; simply the widening of the river where it goes into Hooshaw's Slough.

Q. What is the extent of that upper enlargement? How wide is it and how long?

A. Oh, it is probably three-quarters of a mile wide at an ordinary stage of the water and probably a mile and a half long; then we go into what we call Buffalo Bend, another widening place.

Q. How far above the place called Hooshaw's Slough, is Buffalo Bend?

A. About a mile and a half I should judge; possibly not more than a mile.

Q. What is the extent of that enlargement?

A. Well, it would probably be three-quarters of a mile each way.

Q. Are these two bodies sometimes designated as the Upper Lakes?

A. I presume so.

5917 Q. What was the condition of the Illinois river above the place called the Narrows prior to the opening of the drainage canal?

A. Well, before the opening of the canal in the summer time, when the water was very low, the water became very foul and had a very bad odor to it, and there would come a very heavy green scum through the months of July and August particularly; a man get up in the morning there at four o'clock or daylight, the odor that came from the river was something fearful.

Q. Do you know anything of its effect upon the fish?

A. Well, in the winter time, the fish when the river was froze over wasn't fit to eat; they had a peculiar tarrish, gassy taste; we couldn't eat them; lots of them would die. In the spring when the ice would break up you would see thousands and millions of dead fish floating in the river.

Q. Since the opening of the drainage canal, what has been the condition of the river above the Narrows?

A. It has been very much better; we have had a higher stage of water. The water has been purer to the naked eye, and clearer; and we haven't had that odor coming from the river that we had prior.

Q. And as to the fish?

A. We have had no trouble in regard to the fish since.

5918 Q. Were you engaged at any time in taking samples of water here at Peoria?

A. I was engaged in taking samples of water at my place, Shady Beach, along the Narrows.

Q. Who engaged you?

A. Mr. Jacob Harman.

Q. Under whose directions were you acting?

A. Under Mr. Long's, I don't know what capacity he has exactly; he is something under the state department.

Q. Were you acquainted with Prof. Long?

A. I don't remember that I ever met him.

Q. If you were instructed by any person as to the manner of taking these samples, you may state by whom?

A. By Mr. Long by letter, and Mr. Harman, I think; but I think I got my instructions direct from Mr. Long, printed instructions.

Q. Did you take the samples the same way each time?

A. Yes sir, as near as we could.

Q. Describe the manner of taking the samples and the preparation of them for shipping and the shipping?

A. Well, as near as I can remember now, they furnished us with a thermometer and we took the temperature of the air and of the water before we took the samples. Then we took a boat to the center of the river and there we sunk the bottles as 5919 far as we could underneath, and until they were full.

There was a large bottle which would hold a gallon or better, and a small bottle that probably wouldn't hold more than any place from a half a pint to a pint. The small bottle we packed in ice. We first put it into a small tin can and then packed ice around that. In the first place we sealed each one of those bottles, by tying a canvas cloth over them and tying a string over that, and then we sealed with a wax seal; sealed them and put our stamp on it which we were furnished by them, and my recollection is that we packed both—packed the ice in the big bottle; I ain't sure about that, but we packed I know, the small can in ice and put it in the big box, then we packed excelsior around the big bottle; but we didn't use any ice only around the tin can that contained the small bottle; it took quite a little of cracked ice to fill that can. We filled that can full of cracked ice after the bottle was put in, and the express left here in the afternoon some four or five o'clock, and we had arrangements made that the express company picked it up at a little confectionary opposite the Avery Planter Company. In case we missed that, we took it to the express office ourselves.

Q. How long a time would elapse from the time of the taking of the sample until it was delivered to the express company?

5920 A. Not to exceed an hour.

Q. What did you do with reference to putting a tag or label on these bottles?

A. We had printed labels that we put on; we put on the date and the temperature and the condition of the weather and the condition of the storms just prior to, and so forth. It was put in an envelope and tied onto the bottle.

Q. Was this card for which you made this memoranda signed by you?

A. Yes sir.

Q. And then put in an envelope?

A. And then put in an envelope.

Q. Tied to the bottle?

A. Tied to the bottle.

Q. During how many seasons or parts of seasons in different years, did you take these samples?

A. I ain't sure whether it was two or three.

Q. Did you take any before the opening of the drainage canal in January, 1900?

A. Well, in my mind I did, but I ain't positive about it.

Q. How frequently did you take samples?

A. Well there was a part of the time that we took twice and part of the time three times a week and part of the time only once a week.

5921 Q. Were the samples each season taken in the same way?

A. Just exactly, as near as I can remember.

Q. At what points were they taken, as nearly as you can tell?

A. Well, right opposite the beach, or probably we would go from the beach out to the center of the river and by the time we had taken the samples we would almost be under the bridge, or close to the bridge; the current would carry us down.

Q. Where is this bridge with reference to the sewers of Peoria, above or below?

A. Well, I don't think there is any sewers that empty into the river closer possibly than a mile or a mile and a half below the bridge, of the city sewers.

Q. With reference to that part of the river called the Narrows, where were these samples taken?

A. Right at the Narrows; the narrows formed in the Illinois river.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How long have you lived here in Peoria?

A. I have lived in Peoria most of the time for twenty-odd years.

Q. How long have you been engaged in your present business?

5922 A. About eight years.

Q. Before the canal was opened the water in the river at this point was stagnant at this time of the year, was it not?

A. Yes sir, very low.

Q. How is it now?

A. It is much better.

Q. There is a good current?

A. There is a good current and there isn't the odor that there was before.

Q. There is some odor?

A. Very little that you can detect.

Q. You never had any water analyzed?

A. That is, I suppose the water that I sent to Chicago was analyzed.

Q. But on your own account?

A. No sir.

Q. You don't know whether it contains injurious materials or not?

A. Not anything more than just as you see it going down.

Q. These samples that you took; did you take them yourself?

A. Not always; I had two men working for me, and sometimes they would go out in the river and get them and sometimes I would go out with them and get them. I was there when they were taken, I think, all of them, or possibly once may be or twice that I may have been absent when they were taken.

5923 Q. How many times did you personally take the samples?

A. Oh, I couldn't tell you. I generally went with them and either rowed the boat, but generally they rowed the boat and I took the water.

CHAS. F. HIXSON.

5924 **WILLIAM BAKER,**

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. William Baker; Peoria, Illinois, is my present residence. I am agent for the State Board Live Stock, or inspector, at the Union Stock Yards, Peoria, Illinois.

Q. How long have you occupied that position?

A. A year the first of September.

Q. What are your duties as inspector under the State Board of Health?

A. I have general supervision of the stock on foot that passes through the yards.

Q. Do you inspect some of the stock that is fed here by the distilleries?

A. Well, I can't say officially; that stock does not go through the stock yards as a rule.

Q. Where are the Peoria stock yards?

A. They are located at the foot of South Street, and the river.

5925 Q. How near the river?

A. Probably two or three blocks.

Q. What is the extent or area of the yards?

A. Well, they cover probably six blocks or thereabouts.

Q. Stated in acres how much?

A. I couldn't say as to the acreage.

Q. Can you state its approximate length and width, the dimensions in feet?

A. I would say that it would probably cover over an acre, the yards proper and their belongings, you know.

Q. That's what I mean.

A. Before I was speaking of the yards and pens.

Q. What is the length of the entire stock yards say east and west, in feet?

A. Probably—I would say they were two blocks wide and about four long; that is as near as I can get at it.

Q. We know nothing about the size of blocks here. Are they 1,000 feet wide and 3,000 feet long?

A. I would say they were, to the best of my ability.

Q. How are the yards proper constructed, with reference to pens, etc.?

A. Well, they have their divisions for cattle and others for hogs and sheep, laid out for convenience.

5926 Q. Are the pens floored, or right on the ground?

A. Well, the hog division is floored with wooden floors.

Q. What kind of animals are received in this yard?

A. Well, hogs, cattle and sheep.

Q. How many hogs are received there in the course of a year?

A. Well, that would be hard for me to state; not even close, I couldn't. I coudn't even give you anything that would be of benefit to you as a rough estimation.

Q. Well, that's what I want?

A. Hogs and cattle?

Q. Yes. A rough estimation.

A. I would say 6,000 hogs a week and from 300 to 600 cattle, and probably 100 sheep.

Q. What is done with the manure and urine from these animals while they are confined in the stock yards?

A. Well, each pen has a sewerage, or catch basin, and of course what is carried off in them and what is not is hauled out of the pens; the pens are cleaned of offals of different kinds.

Q. The materials which the catch basins receive, where does it go?

A. It passes into the sewers.

Q. Does it go from the sewers into the Illinois river?

A. Yes sir, to the best of my ability; they have a sewerage system in the yards that connects this with the city sewers. 5927

Q. Does this sewage eventually, through the sewers, get into the Illinois river?

A. Yes sir.

Q. What becomes of the material that is hauled away from these pens?

A. The greater part of it is hauled below, or near around the river bank.

Q. Is it washed off afterwards by high water, into the Illinois river?

A. To a certain extent, some of it.

Q. What becomes of the balance of it?

A. Well, it fills in a low portion of the ground that is located there.

Q. If rains or floods come into this low portion, does the water go from that into the Illinois river?

A. Well, part of it is dumped—on this side of the C. R. I. & P. Railroad track a part of it is dumped in the river and a part of it is dumped on the river bank.

Q. What becomes of the water flood that gets into this material which is dumped; does that finally go into the Illinois river?

A. I am not positive of there being any outlet to the embankment of the railroad, so that the seepage could get 5928 into the river; but the seepage of that would naturally have to pass into the Illinois river.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. What seepage do you have reference to?

A. Well the general dumping of the offals, which are hauled from the pens.

Q. How far did you say that is from the river?

A. The yards proper?

Q. No, the dumping ground?

A. Well, the C. R. I. & P. Railroad runs on the immediate bank of the river, and they dump some on the river side and some on the land side of the railroad embankment.

Q. Do you know the amount of offal that is carted away and dumped as you have stated?

A. Well, there is one team, I would say, hauling all the time.

Q. What is the character of the cattle, sheep and hogs that pass through the stock yards here?

A. You mean what quality?

Q. Yes.

A. Well, it is mostly cow-stuff and a great deal of through cattle that are unloaded here for resting and watering purposes.

5929 Q. What do you feed them?

A. Corn and hay. That is, speaking of the yards.

Q. Are the yards located above or below the city?

A. Below; that is in the 2100 block.

Q. And how far from the bank of the river?

A. Probably a thousand feet.

Q. About a quarter of a mile?

A. No.

Q. How many cattle did you say you run through the pens here a week?

A. From three to six hundred.

Q. And hogs?

A. About six thousand.

Q. And sheep?

A. About a hundred.

Q. They are not slaughtered here?

A. We have slaughtering houses here; they slaughter quite a good deal; principally cow-stuff, that are received. A great many cattle fed here at the distilleries.

Q. Is the number of cattle handled at the stock yards increasing or decreasing?

A. Well, I think it holds its average.

Q. How is it with reference to hogs and sheep?

A. About the same.

WM. BAKER.

930 PERCY M. SWAIN,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Percy M. Swain.

Q. What is your business?

A. Captain of the Steamer Fred Swain, plying between here and LaSalle.

Q. How long have been captain of the Fred Swain?

A. Since 1900.

Q. Prior to that time what was your business?

A. I was captain of the steamer Borealis West, on the same run.

Q. How long were you captain of that boat?

A. Since 1892.

Q. What business is the Fred Swain engaged in?

A. General freight and passenger business.

Q. It runs between Peoria and Peru?

A. Yes sir.

5931 Q. How often does it make the trip?

A. Why we make a trip every day to Hennepin now and every other day to Peru, but prior to this season we made the round trip from here to Peru every day, Sundays included.

Q. For how many years have you been a captain of a boat making the trip between here and Hennepin?

A. Since 1892.

Q. How far is it from here to LaSalle or Peru?

A. Why the Government survey gives LaSalle 72 miles and Peru 71.

Q. How far is it from Peru to Chillicothe?

A. About fifty miles.

Q. How far from Peru to Lacon? I mean from Peoria to Lacon?

A. Thirty-two and a fraction, I think.

Q. How far to Averyville from Peoria?

A. I should judge about two miles.

Q. How far from Peoria to Chillicothe?

A. 21 miles.

Q. How far from Peoria to Henry?

A. Between 40 and 41—forty and a fraction I think; I don't know just exactly; it is almost forty-one.

Q. Will you describe the condition of the river before the opening of the drainage canal in 1900?

5932 A. Well, prior to the turning in of the drainage there was very little current and there was a green scum formed on the river, and the water was not clear; the water had the appearance more of a kind of—in the lake here, a kind of a white appearance, more like sewage color you know; and in places, for instance the locks there, it had this greenness, it would also form on the gates and also formed on the boat and this kind of a white stuff, and a considerable odor came from the water. For instance Lacon, where there wasn't much of a current, there would be an odor there, and also at the locks.

Q. Did you observe how fish were affected?

A. Well, in the winter time when the river was frozen over there was more or less dead fish, and where they took up the nets in fishing, there was more or less odor, more than there is since the turning in of the drainage. The river is altogether different now than it was prior to the turning in of the drainage.

Q. In what way does it differ, Captain?

A. Well, it is clearer, and this green scum doesn't form any more, only in places like for instance, Lake Depew, or for instance the Illinois river where there is no current; that would be in eddies, you know.

Q. What is the condition of the water since the opening

5933 of the canal?

A. Why, heretofore it was necessary to clean the boilers once a week, every week, but of late once in two weeks is sufficient. We didn't have such accumulations in the boilers of—I don't know what substance you call it. One time we laid at Peru and started in the morning to clean out the boilers, and we had so much of that stuff accumulated in the pipes, we had to take it apart, and by the time we got the boilers cleaned out and washed up, it was so late we lost a trip.

Q. Before the opening of the canal did you fill any buckets on the boat with water from the river?

A. Yes sir, for fire purposes. We found a difference of late. Of course it evaporates as much at a time, but there isn't so much of this greasy appearance around the edge of the buckets as there was heretofore.

Q. How about the clearness of the water?

A. Oh, the water is clear; lots of time you can see right down to the bottom; prior to the drainage canal you couldn't see to the bottom of the river at any place at all. At times when there is no raise or extra current, you can see down three or four feet. At Peru the boys lost a wrench overboard and there must have been four feet of water or more—and got it
out, and heretofore it never was clear enough to see the
5934 bottom any place.

Q. What in your opinion has been the effect upon the condition of the water in the Illinois river by the opening of the drainage canal?

A. Well, the condition of the water is better. There is more or less current and this green slime doesn't form any more on the river; it is a good deal clearer and better in every way.

Q. Are you acquainted with the Illinois river immediately below the landing at Peoria?

A. Yes sir, about down to—well as far down as the stock yards. We don't go down below Pekin or Copperas Creek more than once or twice a season, but we go down to the stock yards every week and sometimes two or three times a week.

Q. Have you been down to the stock yards recently?

A. I was down yesterday.

Q. Do you observe any difference in the water above the Peoria Bridge from the condition below the Peoria bridge?

A. Why, above the bridge, the water is considerably different from the water below the bridge. Below the bridge where it gets the sewage from the stock yards and packing houses, it is a thick, heavy, mushy appearance. Two or three hundred feet from land you can see this stuff bubble up before
you are within two or three hundred feet of the shore.
5935 You see the bubbling up, this stuff raises up in the bot-
tom that way, a black appearance, an awful appearance; but we always stop the pumps before getting in there, to keep from pumping this stuff into the boiler and causing a stoppage

of the pipes, and it has a kind of a rotten smell coming off of it, or odor, a kind of a rotten smell like.

Q. What causes this, Captain?

A. Why, I suppose the turning in of those distilleries and cattle pens and packing houses; that stuff accumulates there, that thick refuse.

MR. JEFFRIES: We object to what the witness supposes is the cause and move to strike out that part of the answer.

Q. Can you see this sewage entering into the river as you pass up?

A. Why, you can at times, yes, coming out of those runs along there.

Q. Is this a matter of supposition with you or a matter of knowledge?

A. Why, it is a matter of knowledge, I have been there and seen it.

Q. How many distilleries along the river there?

A. Why I don't know as to that; I never counted and I don't know how many are in operation, I am sure. Some seem to be idle and others in operation. I couldn't say.

5936 Q. About how many have you observed along the river?

A. Well, there is a sugar refinery there. Only this one distillery that I am positive is in operation.

Q. Is there a glucose factory along the river there, or sugar refinery?

A. Well, I think—

MR. JEFFRIES: I object to what the witness thinks; unless he knows, I object to it.

A. I don't know whether there is or not.

Q. Are there any slaughter houses along the river?

A. There is two packing houses there.

Q. What are their names?

A. Peoria Packing and Provision Company and E. Goden & Sons.

Q. Do you carry freight from those places?

A. Why, yes; they bring it to us; we carry their produce up the river.

Q. How does the river above Peoria bridge compare with the river below, at this time?

A. Why, the river above the bridge is clearer. Below these stock yards and still houses, it is very sluggish and as I said before it has this odor coming from it; it is filled up.

5937 CROSS-EXAMINATION, by Mr. Jeffries.

Q. Are you an engineer, Captain?

A. Yes sir. I haven't done anything else except work around a machine shop and on a steamboat.

Q. The volume of water and the current of the Illinois river is much greater now than it was prior to the opening of the Chicago drainage canal is it not?

A. Yes sir.

Q. From Peoria to LaSalle there was very little current before the canal was opened?

A. Yes sir, very little current.

Q. How is it now?

A. Well, there is considerable more current. Of course we haven't been able just exactly to tell how much current, but we notice in the landing. Heretofore when the wind was blowing up stream we generally always had to take out a line to keep in the wind. Now we don't have to practice that as the current has an effect on the boat and has a tendency to hold her. At Peru, the current is stronger there than anywhere; we notice it more there than anywhere.

Q. Well, there is some green scum forms on the river yet, doesn't there?

A. Well, where the water is dead, where there is no cur-
5938 rent; and in the eddies and up in the sloughs. I notice
when the wind blows off from the direction of those sloughs, it comes out into the river.

Q. You don't know but what the same impurities or the same character of impurities which formed the green scum prior to the opening of the canal is yet in the water, do you?

A. Well, this scum, I suppose forms only where there was no current, or where there was very little current. We haven't seen any on the river only where it came out of these sloughs or bayous.

Q. So that since the opening of the canal it either doesn't form or else it is carried down the river by the current?

A. Well, I always believed that it formed when there wasn't any current, when it was stagnant. I know that before the turning in of this drainage, if we had a very hard wind blowing from the south up-stream, it would raise the water. For instance at Henry or Lacon, but it hasn't in the last few years since the drainage has been in. No wind blows hard enough up-stream to raise the water.

Q. You don't know anything about the sanitary condition of the water?

A. Well, the water is considerably clearer and that odor doesn't come from the water as it did before, and we don't get this slime.

5939 Q. You don't know anything about the particular elements or ingredients that are in the water, do you?

A. No sir.

Q. You don't know what effect the discharge of the Chicago sewage into the Illinois river through the canal, has had upon the sanitary condition of the water?

A. Well, only that the water has been more or less purer than it was heretofore.

Q. What do you mean by "more or less"?

A. Why, where there is a considerable current, the water will naturally purify itself in going a certain distance, would it not? Where there was no current heretofore, the water would be stagnant and it wouldn't purify itself so much.

Q. Well then at times since the opening of the canal there would be less impurities and at other times more impurities; do I understand you to mean that?

A. Well, there would be less impurities now than there was heretofore.

Q. And at times more?

A. No, I wouldn't think there would be any more. Well, there would be, yes, when the water was 21 feet on this Peoria gauge here, and there was a current of five or six miles an hour at Peru, the water would be more pure than it is now when there isn't so much current, and the water is down within
5940 the banks.

Q. The reason you say the water is better now than it was before the canal was opened, is based upon the fact that there is more current, a larger volume of water, and its appearance clearer, and more volume of water, than there was before the opening of the canal as I understand you?

A. Yes sir.

Q. And your idea of pure water is clear water?

A. Well, yes.

Q. That is clear to the eye?

A. Yes sir, I think this water when it is so clear you could see down through it would be purer than when it was so sluggish that you could just see that it was water.

Q. You have seen the water coming from the sewers, perfectly clear, have you not?

A. Well, I don't know as I have.

Q. Don't you know that you have?

A. I don't know that I have; the water that comes in from the sewers down there where we are is not clear; it has a whitish appearance. Of course there are sewers where waterworks —the water possibly, just where there is a closet or something like that, might be clear, but I never paid any attention; but the sewers that we come in contact with are city sewers
5941 here around the landing.

Q. Don't you know that water might be perfectly clear to the eye and yet contain disease germs and poison that would get into the human system?

A. Yes sir.

Q. Then not having made an examination of the water of the Illinois river, you don't know what effect the Chicago sewage has had upon that water from a sanitary standpoint?

A. No, I don't know what effect; only as I said before.

Q. Do you own any interest in that steamboat that you are captain of?

A. Yes sir.

Q. Boating is much better now than it was before the canal was opened?

A. Oh, you mean the stage of water?

Q. Stage of water?

A. Yes sir. PERCY M. SWAIN.

5942 Whereupon an adjournment was taken until 2:00 p. m. same day, Wednesday, August 12, 1903, at same place.

5943 National Hotel, Peoria, Illinois. 2:00 p. m., Wednesday, August 12, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

ALEXANDER RICHARDSON, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. Alexander Richardson; residence, Peoria, Illinois; house number 512 Fifth avenue.

Q. Are you now retired from business?

A. Well, no; I never expect to be retired; I shall always do something.

Q. What was your occupation?

A. I have been in the jewelry business for a number of years, and my trade was an engraver.

Q. How long have you lived in Peoria?

A. I have lived in Peoria for over thirty years.

5944 Q. If you have fished and hunted on the Illinois river you may state for what period of time and within what limits?

A. Well, I have fished for thirty years, annually, and hunted for fifteen to twenty.

Q. Have you fished with nets or hook and line?

A. Hook and line.

Q. How far from Peoria in each direction up and down the river, have you fished and hunted?

A. Oh, I have fished up and down the river for fifteen to eighteen miles.

Q. Do you own a launch or boat upon the river?

A. No, sir.

Q. How has your fishing and hunting been conducted, by boat?

A. By boat, skiff, small skiff, and then I have had them taken down on these steam tugs, or else tied on the tugs and taken down by the tugs or steam launch.

Q. What was the condition of the water in the Illinois river above Peoria before the opening of the drainage canal in January, 1900?

A. The condition of the water was very bad, extremely bad, in my opinion.

Q. In what respect?

A. Well, the water was very low at certain seasons of the
year,—summer, for instance, in the first place, and at
5945 some points it was covered with a green scum clear across,
and at some places near the city, up above the city, you
could smell it here, a very bad odor.

Q. Are you familiar with a plant that grows in the water here ordinarily termed duck-weed or water-clover?

A. Well, I have understood what it was; I have seen it and they called it duck-weed or water-clover.

Q. Was this scum upon the river which you noticed duck-weed or was it some other substance?

A. Well, at times I would notice it, apparently it would be a very small green seed floating on the water; at other times, most of the times, it was apparently a green scum on the water. I couldn't say positively what that was.

Q. Describe the odor as you noticed it?

A. Well, I don't presume I could describe it any better than to say it was very obnoxious, disagreeable, bad smell.

Q. Did you notice the quality of the fish at any time prior to the opening of the canal?

A. Yes, sir, I have.

Q. What was their condition?

A. Well, the fish that I caught and that others caught,
unless they were caught back in the sloughs where those numerous springs come down from the bluffs there; unless we caught
the fish around them springs, we couldn't eat them at all;
5946 they were very soft; but those that we caught near the
springs, were all right.

Q. What was the condition of the water of the Illinois river below Peoria, before the opening of the drainage canal?

A. Well, there is no doubt but that the water was always very bad below Peoria, that is below the stills at Peoria, for a number of miles.

Q. As compared with the water above Peoria, how was it below?

A. Well, it was bad above and a good deal worse below.

Q. Was there an odor to the water below the city?

A. Yes, sir.

Q. Did the scum form upon the river below the city?

A. Yes, sir.

Q. Since the opening of the drainage canal, in January, 1900, what has been the condition of the water in the Illinois river above Peoria?

A. Well, it is virtually a new stream you may say; it is so much improved. There has been so much larger volume of water and so much greater current, that we find that the water is purer, colder and better in every way.

Q. Has it now an odor above Peoria?

A. Not that I can detect, any more than the smell that any river has.

5947 Q. Does this green scum form on the river above Peoria now?

A. I haven't seen any as yet since the opening of the canal and the lake water coming down here.

Q. What is the condition of the water in the Illinois river below Peoria since the opening of the canal?

A. Well, it is like it was above; it is wonderfully improved. I might add that it is not what it ought to be, on account of the refuse from the distilleries.

Q. Is there still an odor in the water below Peoria?

A. Why, I think on real hot days I have noticed it, yes, sir. Oh, yes.

Q. How much have you hunted and fished on the river since the opening of the drainage canal?

A. Why, I have gone more or less every year during the hunting season and the fishing season; I go probably every two weeks, two or three days. Sometimes I go every week fishing, for one or two days.

BY JUDGE SPRINGER: Q. Have you noticed any difference in the quality of the fish since the opening of the canal as compared with those that you caught before that?

A. Yes, sir, I have.

5948 Q. What was that difference?

A. Well, the fish are harder and firmer and of a better flavor, and since the opening of the canal and the coming in of the water we catch larger fish, such as bass and pike, which we didn't catch before.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. What is the principal fish caught in the Illinois river by the fishermen?

A. Carp.

Q. Carp is the most abundant fish in the river?

A. It is just now.

Q. And has been?

A. Well, since the government planted them here three or four years ago; previous to that time carp was unknown.

Q. Carp is a scavenger fish, is it not?

A. Well, that is a matter that none of us fellows here know, whether they are or not. I find that they won't bite on any fresh bait, such as minnows and worms, or liver or meat.

Q. That they won't bite on worms?

A. Oh, occasionally, if one was real ravenous, we catch one occasionally.

5949 Q. You say there is a greater volume of water since the canal was opened?

A. Oh, yes, sir.

Q. And the channel or current of the river is very much faster since?

A. Oh, yes; yes, sir.

Q. You say you have examined the river here at this point in years past?

A. No, sir; I never examined it.

Q. You don't know anything about the sanitary condition of the river?

A. Not from analyzing it, I don't, but I know otherwise.

Q. Well, you know from its appearance?

A. Well, I know from its appearance and its smell, both.

Q. Well, the reason that there is no smell in there now is that there is a larger volume of water and more current?

A. That is right.

Q. Those same impurities are doubtless there?

A. Well, that may be.

Q. And carried away?

A. That may be.

Q. Or there may be more impurities there?

A. There may be.

5950 Q. The fishing industry is quite extensive here, is it not?

A. Yes, sir.

Q. And has been for a number of years past?

A. Yes, sir.

Q. Do you know whether the discharges from these distilleries here is decreasing or increasing?

A. I really don't know anything about that.

ALEXANDER RICHARDSON.

5951 MICHAEL D. HURLEY, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Michael D. Hurley.

Q. Where do you live?

A. Peoria, Illinois.

Q. What is your business?

A. Just now I am doing special work for the fish commission.

Q. How long have you been engaged by the fish commission?

A. About a month or two.

Q. What was your business before that?

A. Captain of police for two years.

Q. In Peoria?

A. Yes, Peoria.

Q. What was your business before becoming captain of police?

A. Wholesale fish dealer.

Q. How long were you in the fish business?

A. About seven years; close to that.

Q. Are you acquainted with the Illinois river?

A. I am.

5952 Q. What points on the Illinois river are you acquainted with?

A. Pretty generally the whole river, but particularly from Havana to Henry, during the time I was in the fish business.

Q. When you were in the fish business did you catch any fish yourself for sale?

A. I assisted on several occasions.

Q. Did you have men hired to do the fishing for you?

A. Yes, sir.

Q. How many men did you have?

A. On the fishing crew and market between fifteen and seventeen usually.

Q. How did they catch the fish?

A. With what is known as fyke nets and seines.

Q. How much time would you spend on the river?

A. All my time during the day. There was occasional off days, perhaps I wasn't off the river more than once or twice.

Q. Have you been up and down the river from Grafton to LaSalle?

A. I have, but not while I was in the fish business.

Q. What was the condition of the Illinois river prior to the opening of the drainage canal, from Peoria to Havana and from Peoria to Henry?

5953 A. Below Peoria, at a low stage of the water it was muddy, mixed with manure and what we used to call slop, when we were fishing in it, supposed to be from the sugar works, and the slop refuse from distilleries. It was generally pretty strong smelling when it was stirred up and even when it wasn't stirred up it would smell pretty strong; that is below Peoria; it would smell there some what different than it was above.

Q. What was its condition above Peoria before the opening of the drainage canal?

A. Well, in Peoria Lake and the lakes above here, it was covered with a green scum during the warm season. The water itself looked green. It smelled badly with a different smell than below, but I couldn't tell exactly what the difference was, except it was noticeable.

Q. What effect, if any, did the water have upon fish and the life of fish before the opening of the canal?

A. Well, there were times, both winter and summer, that the fish used to die in numbers; in the winter more particularly above Peoria; in the summer, just from the distilleries on down.

Q. Did you ever see any dead fish in the river at the Copperas Creek Locks?

A. I have seen them but not at the locks; above here,
5954 Peoria, and down about four or five miles below Peoria.

Q. Did you ever do any ice fishing, that is fish through the ice?

A. Not to any extent. In fact, we didn't do any ice fishing.

Q. What has been the condition of the river since the opening of the drainage canal?

A. From Peoria on up, there is an absence of that green slime—

(Question and answer withdrawn.)

Q. Before the opening of the canal, what was the extent of the scum on the water from Pekin to Peoria?

A. It was pretty general there all through, but not so much as at Peoria and above.

Q. What effect would passing boats have on this scum, before the opening of the canal?

A. Oh, they would leave a wake or trail like, behind, through the green scum, a very clear trail.

Q. How long would that trail be observed?

A. Well, about as far as the eye could reach generally, unless the river was choppy.

Q. What has been the condpition of the river above and below Peoria since the opening of the drainage canal?

A. There has been an absence of the scum, and the smell has disappeared, almost altogether, except a little below
5955 the city proper here. The water was clearer apparently, and better.

Q. How is the water immediately below the Peoria bridge?

A. Good at present.

Q. Below the Peoria bridge?

A. Well, there is two bridges; the first one it is quite good and a little below that it is bad.

Q. In what way bad?

A. Riley and muddy and discolored somewhat.

Q. How far does that condition obtain?

A. It is noticeable pretty well all the way down the river to the Havana territoy. Below that I can't say.

Q. Well, immediately at Peoria, opposite the distilleries, what is the condition of the river there?

A. Bad.

Q. Just describe it captain, how it looks?

A. Well, it just simply looks filthy; I can't describe that much clearer—in comparison to the rest of the river.

Q. Any oily scum on it?

A. Sort of a scum, or filthy appearance to the surface.

Q. Any bubbles on it?

A. Lots of bubbles; plenty of those little patches of bubbles floating down all over.

5956 Q. Now, how far down the river does the condition immediately opposite the distilleries continue?

A. It continues pretty well to Pekin; then it clears up somewhat, and then it begins again and extends below Pekin for six or seven miles.

Q. How does the condition of the water above Peoria compare with that at and below Peoria?

A. It seems clearer and better in every way; better looking river.

Q. Have you ever drank the water of the Illinois river?

A. Yes, sir; both before and after the drainage was turned in.

Q. How does the water compare now with what it was before the canal was opened, for drinking purposes?

A. I have never heard of much, if any, sickness caused since the drainage was turned in from drinking the water, while I know that it was making them sick before it was turned in; any way I judged it was making them sick after seeing them drink it.

Q. Knowing the river as you do, before the opening of the drainage canal and since the opening of the canal, what is your opinion as to the effect of the drainage canal upon the waters of the Illinois river?

A. I would say it purifies it.

5957 Q. Is that true below Peoria as well as above?

A. I think it is to a considerable extent.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Can you name anybody that was sick from drinking the water before the canal was opened?

A. I can name one that I accused of getting sick from drinking the water.

Q. It was simply your judgment based upon a coincidence of their drinking the water of the Illinois river?

A. Well, it was because they were drinking it generally and were getting sick day after day; one after another of the crew.

Q. You haven't fished much since the drainage canal was opened, have you?

A. Not with anything except hook and line.

Q. What did you use in fishing before the canal was opened?

A. We used nets and seines—fyke nets.

Q. And during that time you were on the river pretty generally all the time?

A. I want to qualify that question there. I fished for one year after the drainage canal was opened.

Q. What year was that?

A. 1901, I believe.

5958 Q. 1900 or 1901?

A. Both. It was 1901, May about the 20th, that I quit the fishing business.

Q. How does the volume of water in the river now compare since the opening of the canal to what it was prior to the opening of the Chicago drainage canal?

A. In the spring time, in flood tide about the same stage. At this season of the year, or low water season, it is somewhat higher now, since the opening of the canal.

Q. How does the current in the river since the opening of the canal compare to what it was prior to the opening?

A. More current, apparently; I think there is.

Q. Well, don't you know there is.

A. Well, I will say I know there is.

Q. Before the canal was opened, during the greater part of the year, the water was kind of stagnant or still, was it not?

A. Yes, it was, in the summer months, above Peoria; there was quite a current below the bridge at Peoria always.

Q. And wherever that current was prior to the opening of the canal, for instance, below the bridge at Peoria there was no green scum formed or found, except that which floated down from the river above?

5959 A. Not that I know of; I don't know exactly where it came from, but it was all over the river generally.

Q. What was the character of that green scum?

A. Well, I couldn't say anything more than it was green scum; not being capable or able to analyze it, I don't know what it did come from.

Q. When you say the water is better since the canal was opened you do so upon the hypothesis or fact that there is a larger volume of water and more rapid current and the absence of the green formation upon the surface, and without reference to any examination made as to the ingredients of that water, do you not?

A. Well, I don't know why the water is better, but it seems to be better. Possibly the greater volume might háve something to do with it. But I base my knowledge of its purity from the experience, as I stated. It made several sick and I have known it made them sick before and not any since.

Q. Will you testify positively that you know that that was the cause of the sickness?

A. I know that they were drinking it and I told them that they would get sick from it and they did get sick from it; that is as near as I can come to knowing it; apparently got sick from it. Of course I don't know what makes anybody sick.

5960 Q. You think then the fact that the water of the Illinois river prior to the opening of the canal was so polluted with germs of disease, as to cause persons drinking it to become affected with the disease; that the discharge of the Chicago sewage, from a million people more or less, into the river, purifies the water or renders it more wholesome than it was before the canal was opened?

MR. TODD: I object to the question on the ground that the witness has not testified to anything wherein the germs of disease were spoken of, or that any germ was the cause of the sickness of the people whom he stated were made sick by drinking the water, and for the additional fact that the sewage from Chicago and the number of people whose sewage empties into the canal is not correctly stated in the question, for it eliminates the question of dilution of 250,000 cubic feet per minute of pure Lake Michigan water, which is mixed with this sewage before it enters the Illinois river.

JUDGE JOHNS: I object for the further reason that the hypothetical question does not inform the witness that substantially the same amount of sewage is now discharged into the Illinois river as there was for sixteen years prior to the opening of the drainage canal, and that the amount of dilution with Lake Michigan water is now eight times greater than it was prior to the opening of the canal.

5961 MR. JEFFRIES: In reply to the objection, it is suggested by counsel for complainant that the question is proper in order to test the ability of the witness to testify in regard to the subject matter, and in order to ascertain the premises upon which his opinions as a layman are based, and in order to show prejudice, the question of dilution of an exact amount of sewage discharged into the Illinois river being unnecessary for the reason that the witness is not an expert on the subject of dilution from a sanitary standpoint.

Q. (Last question read.)

A. Well, I can't say anything except the facts were as I stated, from whatever cause, in my personal experience.

Q. The fact that the sewage is discharged into the Illinois river at Chicago has no effect upon your mind as to the sanitary condition of the water in the river below and at Peoria, and above Peoria?

A. It hasn't because I never had any ill effects come under my observation.

Q. The fact that Chicago has for years been discharging its sewage into Lake Michigan until the water in the lake at, around and for a considerable distance out into the lake has become polluted so as to be unfit for domestic and household
5962 use, and the fact that Chicago is now discharging its sewage, or a great part of it, into the Illinois river, and diluting it with the polluted lake water, has no bearing and no weight upon your mind in passing upon the condition of the water in the Illinois river at Peoria and the points above and below, while the water of the Illinois river prior to the opening of the canal was so badly polluted as in your judgment, as was testified to by you a few moments ago, that it could and did cause sickness from drinking it; is that true?

A. As I answered before, I only know of the ill-effects before and know of none since. That is the particular reason why I paid no attention to the Chicago so-called sewage.

Q. You say you know of no particular ill-effects before the canal was opened, from drinking the water?

A. Since the canal was opened.

Q. Well, didn't I understand you to say in that last answer that you knew of no ill-effects either before or since?

A. My answer was, the reason I paid no particular attention to what they were saying of the Chicago sewage, and its effect, was that I knew of ill-effects before the drainage was in and none since; hence I gave no weight or thought to anything in reference to the water being worse now. I think it is better.

MICHAEL D. HURLEY.

5963 CHARLES F. BARTSON,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. Charles F. Bartson; I live at 200 Green Street; I am in the saloon business.

Q. What was formerly your business?

A. Wholesale fish business.

Q. Where and for how long were you engaged in that business?

A. In 1892 I started and sold out in 1900.

Q. At what place were you in business?

A. Foot of Fulton Street, Peoria, Illinois.

Q. Were you engaged during that time in personally taking fish from the Illinois river with nets?

A. I was.

Q. Over what part of the river did your fishing operations extend?

A. Well, from I should judge about five miles below the Copperas Creek Lock, as far up as Chillicothe.

Q. Before the opening of the drainage canal, what was the condition of the Illinois river below Peoria, and down the river from Copperas Creek dam?

5964 A. Well, the water was a great deal lower then than it is now; the conditions that exist down there now are as they did then in regard to fishing.

Q. What are the conditions below here as to fishing, as to the matter upon the nets and the condition of the fish and the water?

A. The matter upon the nets is a sort of a slime; I can t say exactly what it is, but it accumulates on your nets so you have to wash the nets every day or two in order to fish successfully with nets.

Q. Was there any substance formed upon the surface of the water below Peoria before the opening of the drainage canal in 1900?

A. Well the water was green, a green scum formed upon it.

Q. Was there any odor to the water?

A. Yes there was some odor.

Q. What was the condition of the fish below Peoria before the opening of the canal?

A. Well, whenever we got a bad winter, it killed a great many of them. In summer I have seen fish come to the top by hundreds, the gas killed them.

Q. Did they have a taste?

A. Why at certain times of the year when there was ice on the river they got so bad we couldn't use them.

5965 Q. During what season of the year below Peoria was this scum upon the water ?

A. During the summer months.

Q. Was it a common thing below Peoria to have the fish die in summer?

A. Why yes, there was quite a few of them died.

Q. Above Peoria and before the opening of the drainage canal, what was the condition of the water?

A. The water was low and it had that green scum on top; it was virtually green.

Q. Did it have an odor?

A. No, not as bad as down below.

Q. Did it have any odor above Peoria prior to the opening of the drainage canal?

A. No, I don't think it did, none that I ever noticed.

Q. When fish were caught, how did they exist in live-boxes?

A. You couldn't keep them very long; they died very soon.

Q. Now since the opening of the drainage canal, what has been the condition of the Illinois river below Peoria?

A. Well the water is a great deal higher, and I have never seen any of the green scum on the river like it was heretofore.

Q. How about the slime upon the nets?

A. The slime is still there.

5966 Q. Above Peoria, what has been the condition of the Illinois river since the opening of the drainage canal?

A. Well there is more water and I have never seen it green or with a scum on it since the canal was opened.

Q. Have you fished any in the winter either above or below Peoria prior to the opening of the canal?

A. Yes sir.

Q. What was the condition of the water in the river below Peoria when it was frozen over?

A. The water was generally bad, especially so during a bad winter, a heavy winter.

Q. What effect did it have upon the fish in the winter under the ice?

A. It killed a great many.

Q. Was there an odor in the water under the ice in the river below Peoria?

A. There was.

Q. As to the strength of the odor was it a strong smell or was it scarcely perceptible?

A. Well at times it was stronger than others. Sometimes you could smell it real plain and others you wouldn't notice it so much.

5967 Q. Since the opening of the drainage canal, what has been the character of the water in the river above Peoria in the winter under the ice?

A. It has been good.

Q. Have the fish died under the ice since the opening of the canal?

A. Not that I know of.

Q. Prior to the opening of the canal above Peoria, what was the condition of the water in the winter?

A. Once in a while you could smell a slight odor above Peoria through the ice.

Q. Since the opening of the drainage canal, what has been the condition of the fish above Peoria as to their living in live-boxes?

A. It has been good.

Q. Do they now live longer than before the opening of the canal?

A. Yes, they live three or four times longer now than they did before.

Q. As to the condition, the strength and health of the fish, which time or period it seemed better, before or since the opening of the canal?

A. Since the opening of the canal.

5968 Q. Before the opening of the canal, were you personally engaged in fishing operations on the river?

A. Yes sir.

Q. Did you drink the river water sometimes?

A. Occasionally.

Q. What was its effect upon you?

A. Why, it caused me a spell of sickness.

Q. Since the opening of the drainage canal as compared with the time before the opening and above Peoria, how is the water for drinking purposes, better or worse?

A. Better.

Q. Are you acquainted with the fishermen along the Illinois river from Chillicothe to Copperas Creek?

A. Most of them.

Q. What has been the condition of the health of people living upon the river since the opening of the drainage canal as compared with their condition before the opening of the drainage canal?

A. It has been better.

Q. Since the opening of the drainage canal, have you known of any typhoid fever among the fishermen?

A. I have not.

Q. Prior to the opening of the drainage canal, did you know of typhoid fever among the fishermen?

5969 A. I knew of one case sure, and a few others that they said was typhoid. I couldn't swear as to that.

MR. JEFFRIES: I move to strike out what the witness was told by others, from the record, for the reason that it is hearsay.

Q. Take the fishermen as a class and compare them as a class with people engaged in other pursuits, in the same vicinity, how does the health of the fishermen compare with the health of the people engaged in other pursuits, is it better or worse?

A. It is better.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How long have you been fishing?

A. I started in 1892 and sold out in 1900, eight years.

Q. Have you ever fished any since 1900?

A. No sir; not since the spring of 1900.

Q. What month in 1900?

A. We sold out our business I think, in June; I am not positive about that.

Q. And you quit fishing immediately after you sold out?

A. Yes sir.

Q. And haven't fished any since?

A. Only with a hook and line.

Q. Then you have fished in the Illinois river as a fisherman only from January 17th, 1900 to June, 1900, since the canal has been opened?

5970 A. Yes sir.

Q. There has been a very large increase in the volume of water since the canal was opened?

A. Yes sir.

Q. And a very great increase in the flow of the current?

A. Yes sir.

Q. Prior to opening the canal, there was scarcely any current?

A. Very little current.

Q. How long before the canal was opened that these two cases of typhoid fever among the fishermen occurred?

A. Only one that I knew; that was my own; that was I think in 1896, when I got sick myself.

Q. 1896?

A. I think that was the year, yes sir.

Q. Did your physician tell you that you were immune from typhoid fever after that; that you wouldn't have it any more?

A. No sir, he did not.

Q. That's the only case that you know of?

A. I have heard of others, but that's only hearsay; I can't tell for certain that they had it.

Q. Well name some of them?

A. Some of the men that worked for me.

Q. Who were they?

A. A fellow by the name of Hughes.

5971 Q. You don't know that he had typhoid fever?

A. I don't know that I had it, only from what the doctor said.

Q. Not having been fishing since June, 1900, you of course haven't kept account of the sickness which occurred among the fishermen?

A. No, I never kept account of them; only those that I would meet.

Q. You are not on the river now and have not been since 1900, any considerably, only as you fished with a hook and line?

A. Oh I go out occasionally; I go out with the fishermen.

Q. Are you a retired fisherman?

A. I don't know what you mean by that.

Q. What business are you in now?

A. The saloon business.

Q. And have been ever since you sold out?

A. Yes sir.

CHAS. F. BARTSON.

5972 I. N. FEGER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. You may state your name, residence and occupation?

A. I. N. Feger; Peoria, Illinois; electric business.

Q. How long have you resided in Peoria?

A. Thirty years.

Q. Have you fished upon the Illniois river during your residence here and if so in what manner and during what time?

A. Well I have fished here all my life; just hook and line fisherman.

Q. Between what points on the Illinois river have you fished with a hook and line?

A. From Havana to Henry.

Q. Prior to the opening of the drainage canal in January, 1900, what was the condition of the water in the Illinois river above Peoria?

A. I considered it bad.

Q. In what respect?

A. Oh, it was scummy and green and sluggish.

Q. Did it have an odor?

A. Yes sir.

5973 Q. What was the condition of the fish above Peoria?

A. Well, very bad.

Q. In what respect?

A. Well they were soft, and I have known them to bury lots of them. I know down here at Pekin the city had to hire people to go and bury them; down at Pekin, Illinois.

Q. What was the condition of the water in the Illinois river below Peoria before the opening of the drainage canal?

A. Well I considered that bad too.

Q. Describe it as to its color, scum if any found upon it, and odor?

A. Well it was yellow scum; I can't tell what the odor was, but there was an odor, a bad odor.

Q. Since the opening of the drainage canal, what has been the condition of the river below Peoria?

A. It has been much better.

Q. What has been the condition of the fish?

A. They are better too.

Q. Since the opening of the drainage canal, what has been the condition of the water and the fish above Peoria?

A. Been good.

Q. Which is and has been the better water, that above

Peoria or that below Peoria, both before and since the opening of the canal?

5974 A. Above Peoria.

CROSS-EXAMINATION,
By Mr. Jeffries.

Q. When you say the water is better now than it was before the canal was opened, you are expressing your opinion from the fact that there is a better current, a larger volume of water and the water is clearer?

A. Yes sir.

Q. As to the chemical or bacteriological properties of the water, you know nothing?

A. No sir.

Q. You don't know whether the filth from Chicago has polluted the water with disease germs or not?

A. No sir. I. N. FEGER.

5975 R. R. BOURLAND,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Springer and testified as follows:

Q. Please state your name, residence and occupation?

A. R. R. Bourland, residence is Peoria, Illinois; my occupation is real estate and loan business.

Q. Have you held and do you now hold any position upon the Illinois River Valley Association?

A. Yes sir, I am the secretary of that association.

Q. Will you please state what the objects of that association are and how long it has been organized?

A. The object of the Association is to look after the interests of the residents in the Illinois Valley in relation to the use of the river itself.

Q. How long has that association been in existence?

A. About—the present association, since 1897, the present association being the successor of one or two like associations which came before it.

Q. How long have you been connected with the association?

A. Since 1897, since its organization.

Q. How long have you lived in Peoria?

5976 A. All my life.

Q. As a citizen of Peoria and as the secretary of this association, have you had occasion from time to time to observe the condition of the Illinois river?

A. Yes sir.

Q. You may state what the condition of that river was prior to the opening of the Chicago drainage canal in 1900?

A. It was an ordinary, sluggish stream that was disagreeable in low water.

Q. You may state if you can, the difference if any in the condition prior to the opening of the canal—above Peoria and below Peoria?

A. The river above Peoria was as I said an ordinary, prairie stream; below Peoria it was very much affected by the drainage of Peoria, and was a much more disagreeable stream below.

Q. Did you notice any odor coming from the water during this period, from above and below Peoria?

A. There was certainly an odor from below; I am not so positive as to the fact of the odor coming from above.

Q. Have you traversed the river above Peoria on steamboats and other crafts?

A. Frequently.

Q. Both before 1900 and after?

A. Yes sir.

5977 Q. You may state the condition of the water in the Illinois river since 1900 above Peoria first, and afterwards below Peoria.

A. Above Peoria, it is certainly a great deal better now than it was before 1900.

Q. In what respect?

A. The water is clearer in color and does not get so low at low water, and therefore does not have disagreeable features of the former low stage of water.

Q. Now state the conditions below Peoria, since 1900 so far as you have observed them?

A. Below Peoria, the waters still show the effect of the offal from the factories, but not to the same extent as before, because of the greater volume of water and I find the odor not nearly so apparent as it formerly was.

Q. State what is the difference between the conditions of the river and of the banks of the river next to the water since the opening of the canal with reference to its use for excursion parties, etc.?

A. Before 1900, the use of the river for pleasure craft was almost entirely given up during low stage of water. Since that time there is continual use of the river by a great many people for pleasure purposes. I don't think that there were any houseboats as they are called, on the river before 1900, and 5978 there are now quite a number which are used as summer residences by a number of people.

Q. For commercial purposes or mere pleasure?

A. Mere pleasure.

Q. Are there any pleasure boats used now as compared with what were used before the drainage canal was opened?

A. There are many more now.

Q. State whether there is any difference in the manner of rowing for pleasure on the river above Peoria compared to what it was before?

A. There is a difference in the amount; I don't know of any difference in the manner.

Q. A great many more row for pleasure?

A. For pleasure.

Q. A great many more?

A. A great many more.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. When did you say this society was organized?

A. My recollection is in 1897, or about that time.

Q. And is it a mutual association of individuals or is it a corporation?

A. It is a mutual association of individuals, yes.

5979 Q. What is the membership?

A. The membership is by appointment of the mayors of the cities and presidents of the villages and from the county officials sometimes, of the villages and cities situated along the river valley from Joliet to Alton. There were about forty members appointed in that way. I haven't the number exact in my mind. Our convention has been attended however, by from two to four hundred delegates.

Q. What did you say the object of the association was?

A. Simply to look after the interests of the residents of the Illinois river valley in relation to the use of the river itself.

Q. And no other object.

A. No other object.

Q. Do you mean the use of the river or the use of the land along the river?

A. The use of the river.

Q. You are not looking after the interests of the residents who have overflowed land caused by the increased flow of water in the Illinois river?

A. No sir.

Q. You are looking after deep water navigation?

A. I would like to amend that answer perhaps by saying that any question of that sort would be and has been sub-
5980 ject of discussion at the meetings.

Q. But no action has ever been taken on anything of that kind?

A. Yes sir, there was a committee appointed last fall which was authorized to take steps to secure the removal of the dams if possible; for that purpose. That however, was not one of the stated objects of the organization of the association.

Q. Now then, that other question that you didn't answer; to look after deep water navigation?

A. That is one of the objects, yes sir.

Q. That is the principal object?

A. At the present time it is the principal object.

Q. That has always been the principal object has it not?

A. Well, that has always been an object.

Q. Well, if that has not always been the principal object, what has been the principal object?

A. The general best use to be made of the river.

Q. Well, that is just a little bit too general; we want to get at the minutae upon which or for which this association was organized?

A. The organization originally grew out of the turning in or of the drainage law of 1889, which gave the prospect of an increased flow through the river, and the main object at 5981 the time of the first society of this kind which I refer to was to secure in the law of 1889, such provision as would protect the residents of the Illinois valley from any deleterious pollution of the river by Chicago drainage and at the same time to secure such advantages for navigation as might be secured by the increased flow through the canal if ever constructed.

Q. You knew at the time that there was no city or town on the Illinois river that obtained its water directly from the river, did you not?

A. The supply for Peoria was at that time drawn from the river. I know nothing about the supply for other cities.

Q. And since that time Peoria has abandoned the river?

A. Yes sir.

Q. You knew at the time that this canal was not being constructed for navigation purposes, did you not?

A. I certainly did not know that.

Q. You had read the drainage law had you not?

A. I certainly had.

Q. You knew that at the time that it was being constructed for the purpose of discharging the sewage from Chicago this way?

A. Yes sir, under the restrictions of the law of 1889.

Q. Now what has been, in your judgment, the extent of 5982 the increased volume of water in the Illinois river since the canal has been turned?

A. I think it has raised the water in the river about two and a half feet, in low water, and in high water it is absolutely impossible to estimate it.

Q. With reference to the current, what has been the effect?

A. That—from my observation I should say that the current in the narrow part of the river was materially increased.

Q. Now as a matter of fact before the canal was opened, during a great portion of the year, there was practically no current in the river?

A. There was no current at low water apparent between the dams.

Q. You have never examined the water chemically or scientifically?

A. Never.

Q. What is your business?

A. Real estate and loan business.

Q. As to whether or not it is better for domestic use, and as to whether it contains less or more deleterious substances, since the opening of the canal, you know nothing about it?

A. Nothing.

5983 Q. When you say it is better you simply judge from its appearance and also make that statement that it is better for the uses to which the river might be employed?

A. That is all to my knowledge.

RE-DIRECT EXAMINATION, By Judge Springer.

Q. When did Peoria abandon the Illinois river as a water supply?

A. I think that was about twelve years ago; but the best evidence would be the record.

Q. That is accurate enough. What was the cause, if you know, for abandoning the river at that time, as a water supply?

A. The river furnished water which was very offensive, especially during the time when it was covered with ice and also during the low water of the summer; two seasons of the year that the water was very bad.

R. R. BOURLAND.

5984 JOHN D. McCLURE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd, and testified as follows:

Q. What is your name?

A. John D. McClure.

Q. What is your business?

A. I am in the real estate and loan business.

Q. In Peoria?

A. Yes sir.

Q. How long have you lived in Peoria?

A. For fifty-three years.

Q. Have you been acquainted with the Illinois river before and since the opening of the drainage canal?

A. I have.

Q. During what years?

A. Well for fifty-three years I have been on the river every year a great many times; every summer fishing and hunting.

Q. Will you describe the condition of the Illinois river before and since the opening of the canal, and state what in your opinion has been the effect of the opening of the canal upon the waters of the Illinois river?

5985 A. Well, previous to the opening it was at times very offensive, a green scum would form on it and a sticky, gassy smell to it, especially in low water, and when the ice was on the river whenever we attempted to use the water, and my observation is that since the opening of the canal it has been very much improved; the water has been better; at least there is not so much of a smell and not so much scum forms as there did before.

Q. How about the purity of the water?

A. Why, the water apparently seems purer. I never have analyzed it or know what the action is on it, but it appears purer than it did before.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How long did you say you have lived in Peoria?

A. Fifty-three years last May.

Q. Are you out upon the river much now?

A. Fishing and so forth; I was out four or five times last spring.

Q. You don't know anything about the sanitary condition of the water other than what you observed?

A. No.

Q. You don't know what effect the sewage of Chicago has had upon the water as far as its sanitary condition is concerned?

5986 A. No, as to its sanitary condition I do not.

Q. You do know however, that there has been a better current and an increase in volume?

A. Yes sir.

Q. And a better current?

A. Better flow of water than there was before.

JOHN D. McCLURE.

5987 JUDGE JOHNS: I now hand the Commissioner an envelope containing twenty-six tickets, which it is admitted were made by the witness Charles F. Hixson, and which would have been identified by him in his testimony today if the tickets had been present.

I will ask the Commissioner to mark them State of Illinois Exhibit No. 11 for identification, to the testimony of the witness C. F. Hixson.

To all of which counsel for complainant assents.

Envelope marked as requested.

ADJOURNED until 9:00 a. m., following day, Thursday August 13, 1903.

5988 National Hotel, Peoria, Illinois. 9:00 a. m., Thursday, August 13, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

NAT H. COHEN,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. Nat H. Cohen, president Illinois Fish Commission, Urbana, Illinois.

Q. In what part of the state is Urbana?

A. Eastern part.

Q. How long have you been connected with the Illinois State Fish Commission?

A. Since 1897.

Q. Prior to that time were you at all familiar with the Illinois river?

A. I was.

Q. How did you become acquainted with it?

5989 A. By fishing in all the lakes from Havana to Meredosia.

Q. Prior to that time had you fished in the Illinois river any?

A. Not any.

Q. Is the Illinois State Fish Commission an organization authorized by the laws of the State of Illinois?

A. It is.

Q. What are its duties?

A. Enforcing of the law and to collect fish for distribution.

Q. That is the enforcement of the laws for the preservation of fish in the waters of Illinois?

A. For the preservation and protection of fish.

Q. Of how many persons is the Fish Commission composed?

A. Three members, the president, superintendent and treasurer; two of which are active, the superintendent and the president.

Q. For how long a time has such commission existed under authority of the laws of Illinois?

A. Organized in 1877.

Q. What is the principal stream in Illinois over which it exercises jurisdiction?

A. The Illinois river and its tributaries.

Q. In the exercise of this supervision has it men in its 5990 employ?

A. It has, wardens, and the crew of the steamer Illinois, consisting of seven or eight men.

Q. How many wardens under the employ of the Fish Commission are on the Illinois river as a usual thing?

A. The new law went into effect July 1st, which provides three wardens. Prior to that they were in every county along the river. There was a warden in almost every county along the river.

Q. To whom do these wardens make reports?

A. To me.

Q. What is the boat called the Illinois?

A. A steamboat employed by the Illinois Fish Commission to patrol the river for the enforcement of the law and to collect fish for distribution from the over-flows of the ponds and lakes adjacent.

Q. How are these fish collected?

A. With a crew, with a seine. They collect them in the seines in the bayous, bring them to the boat by a skiff. They are then put into receptacles on board of the steamer, ready for distribution.

Q. Are these fish afterwards distributed to the various waters of the State?

A. Yes.

5991 Q. How far up the river does the boat travel?

A. Our jurisdiction is from Grafton to LaSalle; that is as far as the Illinois boat can navigate.

Q. How much of a distance is that?

A. About 270 or 280 miles. I don't know exactly the distance, what it is.

Q. Now, in your business as president of the Fish Commission have you traveled the river considerably both since and before the opening of the drainage canal?

A. Yes sir.

Q. What was the condition of the Illinois river above Peoria before the opening of the drainage canal, as to the amount of water, the color, the growth in it, the odors, if any, and in your answer, give a full description—above Peoria?

A. That depends upon what time of year you refer to.

Q. Well you may tell at all times of the year.

A. In the spring during the freshet, I couldn't tell much difference in the water, but as the summer came on and the water receded from the banks, the water became stagnant, little or no current, covered with a green scum and with a bad odor. The lakes adjacent were low, in a very high temperature destroying fish from decayed aquatic matter; destroying what we term plantain. Plantain is the vegetable and animal life in the water that the fry, the small fish, live on. The temperature becomes so high that they are all destroyed. 5992

That I found in several lakes adjacent to the river; Stewart Lake, Spring Lake, Thompson Lake, where they were covered with thousands of dead fish from this cause. Since that time, the same lakes, the temperature is much lower; the water much clearer and we find an absence of dead fish.

Q. I was asking you more particularly in regard to the river above Peoria and confine your description to that, before the opening of the drainage canal?

A. Well I can't give you a great deal of information about above Peoria before the opening of the canal, except that the water is much clearer now than it was prior to that.

Q. Above Peoria and before the opening of the drainage canal did a scum form upon the water?

A. It did.

Q. Do you know an aquatic plant which is sometimes called duck weed?

A. Yes.

Q. And sometimes water-clover?

A. Yes.

Q. And sometimes shamrock?

A. Yes.

Q. Did that form upon the river prior to the opening of the drainage canal?

A. Yes.

5993 Q. If there was any scum upon the water in the river above Peoria prior to the opening of the drainage canal, different from this duck-weed, describe it?

A. Well, it was a scum that is usually on stagnant water; I can't exactly explain it any different; you find this scum all over the country on stagnant water.

Q. Did the water have an odor?

A. It had an odor.

Q. Can you tell the nature of that odor, or describe it?

A. No sir, I cannot, only it smelled very foul.

Q. What was the condition of the fish in the Illinois river above Peoria and before the opening of the drainage canal?

A. Well as a general thing the coloration was much lighter and they didn't have the tenacity of life that they have now.

Q. Do you know anything about the condition of the water of the Illinois river in the winter, above Peoria?

A. I do not.

Q. What has been the condition of the river above Peoria since the opening of the drainage canal?

A. The water seems to be clearer, the temperature lower, and a stronger current.

Q. What is the condition of the fish above Peoria since the opening of the drainage canal?

A. I think they are much better, those that I have seen.

5994 Q. Are they stronger and healthier now than before the opening of the drainage canal above Peoria?

A. Yes, because the temperature is lower.

Q. How is the temperature of the water in the sloughs and ponds which are filled up by the overflow?

A. Lower now at present, because all these sloughs and lakes have an inlet from the river.

Q. As to the quantity of the fish in the Illinois river above Peoria, which is it, greater, before or since the opening of the drainage canal?

A. As far as we are concerned, we have had no opportunity to find out as the water has been so high that we couldn't collect and we haven't taken as many fish since the drainage canal has emptied into the Illinois river than before; but in my opinion there are a great many more fish than before, but is has been impossible to take them with any other device than hook and line.

Q. When the fish spawn in the Illinois river where do they go?

A. To the shallow lakes and bayous, in from one to four feet of water, back in the woods; or shallow places of any description.

Q. Is the higher stage of the water more favorable to the production of fish?

5995 A. Yes, they have more territory to cover and a more favorable supply.

Q. And better protection?

A. Better protection, oh yes.

Q. Before the opening of the drainage canal, what was the condition of the Illinois river from Peoria to Pekin?

A. Very foul.

Q. In what way?

A. Bad odor, green scum and frequently we would find dead fish floating.

Q. What was the condition of the Illinois river during the same period, from Pekin to Copperas Creek dam?

A. It was bad down there too.

Q. Was it as bad seemingly, as from Peoria to Pekin, or did it seem to improve somewhat?

A. Well I never paid a great deal of attention to it, any farther than from Peoria to Pekin in regard to the pollution or bad odor, but we would frequently find these floating islands from the offals from the distillery as far down as Copperas Creek.

Q. What were the floating island composed of?

A. Refuse from the distilleries of Peoria.

Q. How did they get in the river?

A. That I don't know. But you wouldn't find them 5996 above.

Q. Prior to the opening of the drainage canal what was the condition of the Illinois river between Copperas Creek dam and La Grange dam

A. Well it was slow current, green scum as a general thing, at low water, and it had a bad odor certain months in the year.

Q. Take the stretch of river between Copperas Creek and La Grange before the opening of the drainage canal and the stretch of river from Copperas Creek to Pekin, which was the better water?

A. Below; from Copperas Creek to La Grange was better water than from Peoria to Pekin.

Q. Prior to the opening of the drainage canal, what was the condition of the Illinois river between La Grange dam and Kampsville dam?

A. Well I think it improved as it went down.

Q. Was there at that time some odor in the river and some scum upon it?

A. There was; almost as far down as Grafton.

Q. Take the stretch of river between LaGrange dam and Kampsville dam, prior to the opening of the drainage canal, how did it compare with the water between Peoria and Copperas Creek?

5997 A. I think the water was better as you went down further.

Q. How did the water between La Grange and Kampsville dam compare with the water in quality and appearance, between Copperas Creek and La Grange?

A. Well to tell the truth I couldn't tell much difference, only that I have the opinion that the farther you went down we found less green scum.

Q. What was the condition of the water before the opening of the drainage canal between Kampsville and Grafton?

A. I didn't find a great deal of difference between Kampsville and Grafton, than I did above, that is, Kampsville and La Grange, although we didn't go down there frequently; only occasionally.

Q. Was it a better water than the water between Copperas Creek and La Grange?

A. I think there was less green scum.

Q. And less evidence of impurities?

A. Yes, it looked as though there were.

Q. What was the condition of the fish between Peoria and Copperas Creek before the opening of the drainage canal?

A. Well the game fish were of a light color and they wasn't as healthful as they seem at present; they wouldn't live as long out of water. When the temperature gets up to
5998 90 to 100, it is hard for fish to exist, and the temperature was sometimes as high as 90 to 110 in some of those lakes adjacent to the river prior to the opening of the drainage canal.

Q. By 90 to 110, do you mean degrees of temperature Fahrenheit or Centigrade?

A. Fahrenheit.

Q. Since the opening of the drainage canal, what has been the condition of the water between Peoria and Copperas Creek?

A. Much better than it was prior to that.

Q. In what respect?

A. Clearer, less green scum, and a lower temperature.

Q. Is Pekin below Peoria and above Copperas Creek dam?

A. Yes.

Q. Is there a large amount of stuff cast into the river at Pekin?

A. There is.

Q. From what source?

A. From distilleries and city sewage.

Q. Do you know of a glucose factory at Pekin?

A. I have heard of one; I don't know of it.

Q. Since the opening of the drainage canal, what has been the condition of the water of the Illinois river between Copperas Creek and La Grange dam?

5999 A. Much better; the water looks better.

Q. How does it compare with the water above Copperas Creek?

A. It is better.

Q. What has been the condition of the fish between Copperas Creek and La Grange since the opening of the canal?

A. Much better, finer color, have more tenacity of life and I regard them healthier and better than ever before.

Q. Since the opening of the drainage canal, what has been the condition of the water between La Grange and Kampsville dam?

A. Much better than it was.

Q. How does it compare as to purity with the water between Peoria and Copperas Creek?

A. Well I can't say exactly as to that, only that it is much better than it was before the drainage canal entered the river. I couldn't tell exactly whether it is better than above because I have never tested it only by appearance, temperature and the quality of fish taken.

Q. Judged by its appearance and such superficial examination as you have made, which would you say was the better water now, that between Peoria and Copperas Creek or that between La Grange and Kampsville?

A. I think the water between La Grange and Kampsville is the best of the two.

Q. Since the opening of the drainage canal, what has been the condition of the water in the Illinois river between
6000 Kampsville and Grafton?

A. Well I can't say anything about that, any more than it improved as it went down.

Q. How does it compare now with the water in the same stretch of river before the opening of the drainage canal?

A. Oh, it is much better now.

Q. How does that stretch of water compare with the water between Peoria and Copperas Creek?

A. Well now, I have never tested that water down there; all I know about it is what the people and fishermen said at that part of the river. We have never fished down there so I can't say as to that; only what the fishermen say; but we found that the farther you go down the better the water is.

Q. Since the opening of the drainage canal have you traveled upon the river from Kampsville to Grafton several times?

A. Yes sir.

Q. And in traveling have you observed the water in a general way?

A. Yes sir.

Q. In your observation of the Illinois river, state whether or not, the waters as they travel from sources of impurity, tend to purify themselves? Seem to purify themselves?

A. Yes they do, in my observation.

6001 Q. Have the varieties of fish in the Illinois river increased or decreased since the opening of the drainage canal?

A. Well we occasionally find a herring from Lake Michigan but the conditions of the Illinois river are not suitable for the fish of Lake Michigan. The fish that inhabit Lake Michigan are mostly salmonidea and they require a very low temperature. Should they inhabit the Illinois river for any length of time they would deteriorate so that they would be worthless, as conditions are not right for that family of fish and they are only indigenous in a low temperature and in the Great Lake system. And the drainage canal has not added any new fish to the waters of the Illinois river.

Q. Was there a time in the Illinois river when pike and pickerel were very numerous here?

A. There was.

Q. Did they afterwards disappear?

A. Well now, they have disappeared for several years; they come one season and the next season they are not there. They are a migratory fish and they come and go. There was a time when they were plentiful in these waters, and they are becoming more plentiful now in the last two years, but I wouldn't like to state the cause why.

Q. What do you know of the fish ordinarily termed the spoon bill cat?

6002 A. Well we only know that as we see them. Scientists know very little of where they propogate and they are a migratory fish and come up the river and tributaries to spawn in high water. Regarding their other habits, there is very little known.

Q. Do they seem to be increasing in the Illinois river?

A. Well, we find them up above on account of the high water above the dams. They go up the river as high as they can go and that is the cause of their being more plentiful than they were before.

Q. Do you know of a fish termed by the fishermen "cushon" or Mississippi river catfish?

A. Yes.

Q. Do you know whether now they are found in the lower stretches of the Illinois river?

A. Yes, they are.

Q. Do they seem to be increasing since the opening of the drainage canal?

A. I can't tell you that.

Q. Along the entire stretch of the Illinois river from La Salle to Grafton, what is the condition as to lands overflowed during high water; is it much or little?

A. There is a great deal of land overflowed all along the river, from LaSalle to Grafton; thousands of acres of crops
6003 were destroyed last year; corn fields and wheat fields inundated and floated down the river.

Q. When the waters subside are there any ponds on these overflowed lands that lose their connection with the Illinois river?

A. Yes, a few. There is where the temperature becomes so high, in those places. It kills the fish.

Q. Is it such places that you seine?

A. Yes, those are the places where we get our fish for distribution. If there is an outlet we don't go in there to get our fish. It is only these sloughs and bayous that evaporate during the summer that we take these fish from. The larger and coarser fish we take from the river and only take such fish as bass, croppie and perch.

Q. In what condition when you seine now, do you find the fish in these ponds as compared with their condition in the same ponds prior to the opening of the canal?

A. They are darker; that is the sign that they are healthier. The water has hardly been low enough for the last three years for us to go into many of these sloughs, and those that we go into now are from two to three feet. Prior to that we used to get them in eighteen inches of water.

Q. Is there a large fishing industry on the Illinois river?

6004 A. Yes sir, from five to ten thousand people employed on on the river from LaSalle to Grafton, and bringing into the state probably $500,000 and shipping out from twelve to fifteen millions pounds of fish per annum.

Q. Where do these people who follow the business of fishing generally live?

A. Along the river, in boats, cabin-boats and in the villages, the larger part of them in cabin boats.

Q. So far as you have observed, what has been the condition of health of the people engaged in fishing, both before and since the opening of the drainage canal?

A. Well from all the information I get along the river, they say there is less malaria and scarcely any typhoid fever among the fishermen in the last three years. They tell me they drink the water now and they couldn't drink it before.

Q. As a general thing what is the condition of health of these people engaged in fishing as compared with a similar number of people engaged in some other occupation away from the river?

A. I can't tell you that.

6005 CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How long did you say you have lived on the Illinois river?

A. I don't live on the river; I have been connected with the river for five years; I have been connected with the fish Commission since 1897.

Q. You are connected with the State Fish Commsision?

A. Yes.

Q. How often were you on the river prior to 1897?

A. About five or six weeks every summer.

Q. What is the difference in the flow of the river now as compared to what it was before the drainage canal was opened?

A. Well, there is a much swifter current than there was before. It used to be about a half mile an hour; that's what they tell me, about a half an inch fall to the mile for two hundred miles and there wasn't over half to three-quarters of a mile current at certain seasons of the year. You could hardly tell which way the current went in the summer months.

Q. Can you tell which way the current runs now?

A. Yes.

Q. There has been a very great increase in the flow of the current?

A. Sometimes eight or ten feet or more. Yes. Whether 6006 that was due this year to the heavy floods or the drainage canal, I am not ready to say.

Q. But there has been a very great increase in the current since the drainage canal was opened, every year?

A. Yes sir.

Q. You spoke of a green scum being formed on the river before the canal was opened; now that forms along the water since the drainage canal was opened?

A. To some extent; there is a green seed that forms along the river and probably there is some green scum yet, but all I have found is that green seed.

Q. When you say the water in the river is better since the opening of the canal than it was before, you think that from the fact that the current is better, the temperature of the water is better, and from its appearance?

A. Yes, and the fish are better; the color of the fish is darker, and the temperature is lower;that is as far as I can judge myself.

Q. That is as far as your investigations have gone?

A. Yes sir.

Q. As to whether or not the sewage from Chicago contaminates the water, you don't know anything about?

A. No.

Q. The condition of the fish is improved because of the decrease in the temperature of the water?

6007 A. Yes.

Q. And the temperature of the water?

A. Yes.

Q. And not with reference to any particular purification or the absence of impurities in the water?

A. Well, you see, game fish will not live in anything but pure water, and they will not get the color they have got unless the water is pure, that is to say bass and light species.

Q. Do you mean chemically pure

A. Well, I won't say that exactly because I have never analyzed it or never had it analyzed, but from every observation that I have made, bass won't thrive only in pure water, and if the water should be foul and there is a spring close by yo will always find the bass in the pure water. Of course the fish, large mouthed bass can live in temperature from 35 to 95, but they deteriorate with a high temperature, and it isn't necessary that these large mouthed black bass will not live in waters that are somewhat foul.

Q. Water with a high temperature is not necessarily foul?

A. No I say that; not altogether; but the heat absorbs the oxygen and the fish cannot live; that is the cause. The heat and high temperature; that is in low water.

Q. The carp is the most prolific fish in the river isn't it?

A. Yes; they can live under any circumstances and under 6008 all conditions.

Q. And they feed on most anything?

A. They feed on most anything; but the quality depends upon the environments.

NAT. H. COHEN.

6009 DR. FRANK C. BOURSCHEIDT,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Springer and testified as follows:

Q. State your name, residence and occupation?

A. Frank C. Bourscheidt, Peoria, Illinois; I am a physician and surgeon.

Q. How long have you resided in Peoria?

A. Since 1874.

Q. What has been your connection with the city government if any?

A. I have been health commissioner.

Q. During what time?

A. That was in 1898 to 1901.

Q. Have you made any special study of chemistry and bacteriology?

A. I have.

Q. Have you observed during your residence in Peoria, the condition of the water in the Illinois river above Peoria and below Peoria?

A. I have at different times; different occasions.

Q. Will you please state the condition of the water above Peoria prior to the year 1900, the opening of the drainage canal?

(Question withdrawn).

6010 Q. As Health Commissioner of the City of Peoria, have you any knowledge as to the condition of the health of the city before and after the opening of the drainage canal?

A. Yes.

Q. Please state then, what you know in regard to this?

A. I don't think there is much difference, if any, in the death rate, before and after, from enteric diseases.

Q. You may explain what you mean by enteric?

A. Diseases like typhoid and intestinal disorders. Our death rate has always been normal.

Q. Does the period to which you refer relate to the time since the present waterworks system was established?

A. Yes.

Q. You may state what is the present water supply of the city of Peoria?

A. At the present time the supply of water is obtained from wells which intercept the spring water which comes from this high plateau north of the city.

Q. Are these wells supplied with water directly or indirectly from the Illinois river?

A. No sir.

6011 Q. Then your water supply has nothing to do with the conditions in the Illinois river?

A. Nothing at all.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You were not Health Commissioner twelve years ago?

A. No sir.

Q. You were not health commissioner, before or at the time the present system of water was established?

A. I wasn't health commissioner at the time.

Q. That's what I mean?

A. No.

RE-DIRECT-EXAMINATION,

By Judge Springer.

Q. Has there been any decrease or increase in the death rate from typhoid fever among those persons who reside on the immedate banks of the river or in house-boats on the river who use the water of the Illinois river?

MR. JEFFRIES: I object to that for the reason that it assumes that the persons referred to in the question use the Illinois river water for drinking and domestic purposes, without any proof of that fact.

6012 A. I don't know of any case of that kind during my incumbency in office, I haven't known of a case.

Q. State whether there has been any increase or decrease of malarial diseases among that class of people?

A. As to that I wouldn't be competent to answer, because I am not familiar with that; I haven't had any experience with those people.

Q. During the time you were health officer, state whether deaths from typhoid fever were reported officially to the Board of Health?

A. Every case. While I was in office there wasn't a body buried without a permit and the cause of death.

Q. Dou you know among what class of people, if there is any distinction, these cases of typhoid fever originated?

A. No I do not know of any distinction. The fact of the matter is gentlemen, I didn't know anything about this hearing.

RE-CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You say there has been no increase in typhoid fever since the opening of the drainage canal, while you were health officer?

A. There hasen't been.

Q. You stated you didn't know of a single case?

6013 A. I stated I didn't know of a single case on the river bank.

Q. Where they used the water?

A. Where they used the river water.

Q. Now does that answer apply both to the conditions that existed prior to the opening of the canal and since the opening of the drainage canal, the three years that you were health commissioner?

A. Yes sir.

FRANK C. BOURSCHEIDT, M. D.

6014 HENRY B. OCKER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. Henry B. Ocker; I live in Peoria, in the city, and I am a land agent by occupation.

Q. Were you ever engaged to take samples of water in the Illinois river?

A. Yes sir.

Q. By whom?

A. By Dr. Long of Chicago.

Q. When?

A. Well I can't say as to that; I think it was in 1900 though.

Q. At what point in the river were you engaged to take the samples?

A. Below the city, just opposite Wesley.

Q. Is Wesley above or below Kickapoo Creek on the river?

A. It is below Kickapoo creek.

6015 Q. How far below the city of Peoria is Wesley?

A. Well, I would say a mile and a half.

Q. Do any of the sewers of the city of Peoria enter the river below Wesley?

A. None that I know of.

Q. At what point in the river were you to take the samples?

A. Opposite Wesley.

Q. In the center of the current, or at the side?

A. In the center.

Q. Did you know of the fact of the opening of the drainage canal? Did you know that it was opened?

A. No, I don't think I did.

Q. Do you know whether the samples that you took were taken before or after the drainage canal was said to be opened?

A. I think I have taken some before and some after.

Q. How many different seasons did you take samples?

A. Well I can't state that even; it is so long ago and I didn't pay no attention since, and it has slipped my mind.

Q. Did you take them in two different years or one?

A. I kind of think it was in two different years.

Q. How often did you take samples?

A. I believe once a week.

6016 Q. What were your instructions as to the manner of taking samples?

A. Dr. Long showed me how to take them by taking me out in a boat and I should submerge the bottle at least a foot under the surface and let it fill and the smaller bottle should be submerged under the surface and filtered in. If I remember right, there was a cloth over the mouth of the bottle and we should let the water seep into the small bottle.

Q. At what depth below the surface did you take the sample?

A. About a foot; I reached down about that far (indicating) under the water.

Q. How many samples did you take each?

A. Well there was a double case and there was a large bottle and a small one, one in each case, and the large one and the small one were taken at the same time and shipped to Chicago at the same time.

Q. From whom did you obtain the bottles?

A. They were sent to me by Dr. Long by express from Chicago and I got them from the express office.

Q. When you took the samples, did you have a thermometer?

A. Yes sir.

Q. What did you do with the thermometer?

A. Took the temperature of the air and the temperature of the water.

6017 Q. At the same time you took the samples?

A. Yes sir.

Q. After you had filled the smaller bottle with water, what did you do with it?

A. I placed it in a can; I then sealed that can up and placed it in a larger can, and then packed ice and excelsior around it until the can was filled.

Q. After you had filled the larger bottle with water, what did you do with it?

A. Put it in the other side of the box and packed excelsior around it to keep it from breaking. That was all there was to that.

Q. How did you close the mouth of the bottle?

A. The large bottle?

Q. Both bottles?

A. Why there was a glass stopper if I remember right, and I think a cloth over it and a rubber around that to keep it tight.

Q. Did you cover the stopper after you had placed it in the bottle with a cloth, and fasten it there with a rubber?

A. Yes.

Q. When you took the samples did you make any ticket or do any writing?

A. Yes sir, sometimes.

6018 Q. What did you write upon the ticket?

A. I would put the temperature of the air and the temperature of the water, and I think I put the dates on and the name of the taker and the location where it was taken I believe, and I think who it was consigned to if I remember right. I don't remember about that.

Q. Is Wesley sometimes called Lower Peoria?

A. No sir.

Q. Where is the place called Lower Peoria?

A. In the south end of this city.

Q. On which bank of the river ,east, or west, is Wesley?

A. Well I don't know that it is either; I think it is on the south bank there, from the way the land lays—well it is I guess southeast probably.

Q. Is it on the same or the opposite side from Peoria?

A. It is on the opposite side.

Q. Is that part of the river opposite Wesley sometimes called Lower Peoria?

A. Well I don't know as the part of the river is. The city just above it there is what is called Lower Peoria.

Q. Do you know whether any samples of water were taken at a place called Lower Peoria, by any other person?

A. No, I do not; I was told though by the party that used
6019 to take me out in the boat to take the samples, that someone took them on the opposite side from where I did, but whether this was true or not I couldn't state.

Q. If anyone did take samples on the opposite side, do you know whether he was employed by Dr. Long or by some other person?

A. I do not know; I couldn't state.

Q. After you had placed the rubber over the mouth of the bottle, did you place any seal upon the bottle?

A. No, I think not, but I placed the seal on the can that the bottle was in.

Q. What kind of a seal was that?

A. We used sealing wax and I had a stamp; I think it was either 6 or number 9, that I stamped on the wax; I suppose that was my number as a water-taker.

Q. Have you now defective eye-sight?

A. Yes sir, very defective.

Q. Can you now see to read?

A. No sir.

Q. At the time you took these samples, what was the condition of your eye sight then, could you read and write then?

A. Yes, I could read and write, not like others but yet I could read and write for a certain length of time until my eyes would tire and give out.

6020 A. At the time you took these samples, did you do the writing upon the tickets yourself?

A. I did on some and others I didn't.

Q. Did you have some person assisting you in taking the samples?

A. Yes sir.

Q. Who was that person?

A. That was a young man by the name of Harry O'Reilly, my brother-in-law.

Q. When you did not write the tickets yourself, who wrote them?

A. Harry O'Rielly.

Q. After the writing was done upon the ticket, was it put in an envelope?

A. Yes sir and attached it to the box,—or I think it was attached to the neck of the larger bottle.

Q. In what way?

A. By a cord.

Q. What time in the day did you take the samples?

A. In the afternoon, probably in the neighborhood of three o'clock.

Q. After the samples were taken and packed in the box what did you do with the box?

A. Took it to the express office.

6021 Q. Where?

A. I think it was the American Express office here in this city, and sent it to Dr. Long.

Q. How long from the time the water was put in the bottle until you delivered the bottle at the express office?

A. It might have been an hour at the most.

Q. When you delivered the box at the express office did you take any receipt from the express company?

A. Yes sir.

Q. I have in my hand here forty-two tickets, on which your name appears—can you see to identify them?

A. No sir.

Q. When you delivered the boxes to the express company and took receipts, what did you do with the receipts?

A. I saved them in case any box got lost that I would have something to show that I sent the box, the sample.

Q. I have in my hand here fifteen receipts of the American Express Company which you handed to me this morning; are those the receipts which you received from the company?

A. Those are the ones; but I had more; I should have had more but I lost them or wore them out carrying them in my pockets.

Q. Do you remember whether the person to whom these boxes were shipped was named J. H. Long?

6022 A. The name was Long—Dr. Long.

Q. Do you know whether his name was John H. Long and whether you shipped them to a person of that name?

A. I don't recollect what his initials were, or his first name. I sent them to Dr. Long, and I think to his laboratory is where they were directed.

Q. Are these papers which I have in my hand and which you delivered to me this morning a part of the receipts which you received from the express company?

A. Yes sir.

JUDGE JOHNS: I now hand the Commissioner forty-two tickets bearing the name of the witness and ask that the Commissioner mark them State of Illinois Exhibit No. 12, for identification, to witness Henry Ocker's testimony.

Received and so marked by the Commissioner.

JUDGE JOHNS: I now hand the Commissioner an envelope containing fifteen receipts of the express company, and ask him to mark them State of Illinois, Exhibit No. 13, to the testimony of witness Henry Ocker, for further investigation.

Received and so marked by the Commissioner.

6023 CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Did you say you were assisted in this work by someone?

A. Yes sir.

Q. And that was your brother-in-law?

A. Yes sir.

Q. Where does he live?

A. He is residing on the corner of Webster and Smith Streets in this city.

Q. Who took the temperature of the water and of the air?

A. I did sometimes and he did sometimes.

Q. Was your sight sufficiently strong at that time for you to take the temperature?

A. Yes sir.

HENRY B. OCKER.

6024 S. P. BARTLETT,

caled as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. Captain, state your name, residence and occupation?

A. S. P. Bartlett; residence Quincy, Illinois, and my occupation is Field Superintendent United States Fish Commission.

Q. How long have you occupied that position?

A. About thirty-one years. I will state also that I am one of the Board of State Fish Commission, and have served consecutively for 24 years.

Q. When was the State Fish Commission organized?

A. 1877.

Q. Have you been almost continuously since then a member of that commission?

A. I have been almost continuously a member of that commission except during the Altgeld administration, when I was superintendent. I have been acting in that capacity during that time.

Q. What are your duties as an officer of the United States?

A. My duties as the Field Superintendent of the United States Fish Commission, are a Field Superintendent, that 6025 is to say, having oversight under the direction of the U. S. Fish Commissioner of their out-lying stations, but as a matter of fact they have turned my services over to the State of Illinois, the work being very similar so far as the distribution of fish is concerned.

Q. Have you under your charge an institution for the hatching and propogation of fish?

A. No sir, in the State of Illinois there are no artificial places for fish propogation, but we have retaining ponds under the supervision of the government and of the state, in which fish collected from the over-flows and left by the receding waters, are rescued, the gamier fish preserved for distribution, and the residue placed in the deeper waters.

Q. Where are these retaining ponds?

A. At Meredosia.

Q. What are your duties as a member of the State Fish Commission?

A. The collection and distribution of indigenous fishes; the management of their floating property; that is to say their boats.

Q. What have you to do if anything, in regard to the enforcement of the law?

A. Only in an advisory position in connection with my colleagues.

6026 Q. As a member of the State Fish Commission are you active or are you a passive member?

A. Active.

Q. The operation of the Fish Commission in the enforcement of the law is generally under your personal direction?

A. The active work of collecting and distributing the fish is directly under my superivision and the enforecement of the law directly under the superivision of my colleague, Mr. Cohen, but the work of the two are very closely intermingled.

Q. Prior to July, 1903, were there under the Fish Commission fish wardens along the Illinois river?

A. Yes sir.

Q. How many?

A. Prior to 1903, they would average one to each county, and perhaps two or three that had entire jurisdiction of the river. I should think in all perhaps, along the river, 25 or 30.

Q. How many men are in the employ of the Fish Commission of the State of Illinois?

A. In all work?

Q. Yes.

A. Well during the summer season, catching the fish, distributing them the operation of the boats and the wardens, prior to 1903, I should think perhaps 150 people.

6027 Q. How is the operation of catching fish conducted and at what places?

A. Well the whole length of the Illinois river. The smaller fish are taken from these low flat ponds by the use of small mesh seines; the seine is drawn to shore, the better qualities of the fish selected for distribution, that is to say to be carried to the retaining ponds, and the surplus, coarse fish and other fish put into the nearest deep water, be it lake or river.

Q. In the course of your business have you become familiar with the Illinois river from LaSalle to Grafton?

A. Yes sir, I have been intimately associated with it for over thirty years.

Q. Prior to the opening of the drainage canal, what was the character of the current of the Illinois river?

A. Well, that would depend upon the season of the year. In the early spring and after the snow and water had reached the river, the current at times would probably reach a mile or a mile and a half an hour; of course being swifter in places. Later in the season when the water was lower, it has been frequently impossible to tell which way the current was going, by an object on the surface; it was very sluggish, very slow.

Q. How many dams are there on the Illinois river between LaSalle and Grafton?

6028 A. Four.

Q. Commencing at the upper part of the river, name the dams in their order and give as nearly as you can the distance between the respective dams by river?

A. Well the first dam is at Henry; the next is the Copperas Creek; that would be close to seventy miles I should think—I am giving you this now in a general way. I don't know that that is correct. The next dam would be LaGrange Lock; that I should think would be close to 60 miles—fifty-five or sixty. The next will be Kampsville; I can't give you the exact distance but probably about the same, 55 or 60 miles.

Q. How many and which of these dams were erected by the government of the United States?

A. The first two in order that is to say Henry and Copperas Creek were built by the State of Illinois. Those at Kampsville and LaGrange were built by the United States.

Q. What was the effect of these dams upon the current of the Illinois river prior to the opening of the canal?

A. Well, that again would depend upon the stage of the water; in very low water it would have the effect of making the current of the river very slow. At very high water, there would be perceptibly no effect.

Q. During low water periods, have these dams the effect of backing up the water and creating pools above the dams?

6029 A. In very low water always; of course there is always a flow over the dam, but the effect would be to make slack water at a very low stage of water. That is the purpose of the dams.

Q. Prior to the opening of the drainage canal what was the condition of the waters of the Illinois river between LaSalle and Henry dam?

A. Well, the water was about on the average of river water. In high water reasonably clear; in low water there would be the incidental amount of vegetable growth and more or less impurities.

Q. Is LaSalle the head of navigation on the Illinois river?

A. Yes sir, practically the head.

Q. How far from LaSalle by river, to Henry dam?

A. Well it is about 45 miles.

Q. Do you know whether prior to the opening of the drainage canal there was an odor in summer in the water above the Henry dam?

A. Well there was an odor more or less as I remember it. It was given off as all low water does; it was from decayed vegetation and refuse matter dumped into it.

6030 Q. Do you know of the condition of the water above Henry in the winter when the river was frozen over and its effect upon the fish?

A. Well, that varies at different seasons. I have seen the stage of water so low in the Illinois river during the winter season, that the fish would perish under the ice during the winter.

Q. To what did you attribute that?

A. Well, the ice becomes very thick and covered with a heavy blanket of snow it stops the introduction or escape of any air, and the water I think becomes bad, it forms noxious gas under there which is very destructive to fish and other life. The water becomes impure.

Q. What was the condition of the fish between LaSalle and Henry before the opening of the drainage canal, as to their strength and quality.

A. Well that would vary with different seasons. I have seen seasons when they were very sluggish and very soft, and then again in the spring of the year when there was a heavy flow of water the fish would be nearly up to the average.

Q. You may state whether they died in the water; prior to the opening of the drainage canal, above Henry?

A. Oh yes, I have known fish to die there previous to the opening of the canal for many seasons.

6031 Q. Are fish very susceptible to the condition of the water in which they live, and easily and rapidly influenced by it?

A. Yes sir. It is nothing uncommon to find fish taking on a coloration from the character of the water that they are in.

Q. You may state if you know, whether or not fish will vary in their color that is, in their natural color, according to the condition of the water in which they are found?

A. Yes sir, the temperature and condition of the water have a very material effect on the coloration.

Q. Are their colors bright and quite distinct when the physical conditions of the fish are low and bad, or indistinct, or lighter?

A. Well, it is very distinct. There can be no mistake in it.

Q. As compared with fish in a strong, healthy condition, which have the brighter or more distinct color, the strong fish or the weak fish?

A. The strong fish always has a dark, bright color.

Q. Since the opening of the drainage canal, what has been the condition of the Illinois river above Henry dam?

A. Why judging from personal observation of it and going over it frequently, my judgment would be that the water shows a decided improvement in every way.

Q. Since the opening of the canal, have there been odors in the water above Henry?

6032 A. Well I can't state as to that. I can only judge of the water as I see it. I have no particular knowledge of it, as in some of the former seasons; that is to say the complaints of dead fish have not reached me, so I have had no occasion to investigate.

Q. Since the opening of the drainage canal, what has been the condition of the fish in the Illinois river between LaSalle and Henry?

A. Well, I know of no complaint; they are way up to the average.

Q. Before the opening of the drainage canal, what was the condition of the Illinois river between Henry dam and Peoria Narrows?

A. Why it depended entirely upon the season of the year. I have seen very good water in the spring and very bad water at low stages.

Q. Is the place called the Narrows on the Illinois river above Peoria?

A. Yes sir.

Q. So far as you know, is that place above the sewage discharge of Peoria?

A. Yes sir, I should think it was.

Q. In the stretch of river between Henry and Peoria, state what you know with reference to the vegetable growth

6033 before the opening of the drainage canal?

A. It would be probaly better to say that these vegetable growths are due as a rule to the outgrowth of low water and the high temperature, and I have almost every season, when we have had a low stage of water, found a large amount of vegetable growth on the surface, and moving backwards and forwards with the change of the wind.

Q. As the season advances to the winter what becomes of the vegetable growth in the Illinois river?

A. Well if there is in any way a large amount of it and the water is very low, decomposition takes up a great deal of it, and a great deal of it is consumed by vegetable consuming fishes and aquatic birds. In very low water a great deal of it is left upon the shore and decomposes which is frequently the cause of a great deal of bad odor.

Q. Does the vegetable growth in the Illinois river pursue the usual course of aquatic plants, come to fruition, form seeds, deposit them, and then die and decay?

A. Well I don't think I can answer that question scientifically.

Q. Does the vegetable growth in the river decay each year?

A. Yes sir.

Q. And is it renewed the next year?

A. Yes sir.

6034 Q. After the opening of the drainage canal, what was the condition of the Illinois river between Henry and Peoria Narrows?

A. My observation has been that the water was very much better, clearer.

Q. How about the vegetable growth in the river?

A. Well there has not been nearly as much of it, for one reason I think, on account of the greater volume of water.

Q. What about the temperature of the water?

A. The temperature has been lower.

Q. The water has been cooler?

A. The water has been cooler.

Q. What has been the condition of the fish between Henry and Peoria?

A. I have heard of no complaints; they seem to be in good merchantable condition.

Q. At Peoria, are there foreign substances deposited in the river and if so from what sources?

A. Yes, from all sources. The sewage is very large, and the refuse from the gas houses and distilleries and glucose factories, is immense.

Q. Is the amount of this deposit of foreign matter large or small at Peoria?

A. Very large.

6035 Q. Below Peoria have you noticed this foreign matter in the water?

A. Yes sir, in great quantities.

Q. In what form?

A. Well, in various forms. Principally the large deposit of offal from the distilleries and from the cattle pens breaking off and falling into the river in large masses; in the immense amount of sewage that collects at the river front during an east wind, driving it all onto the shore, or rather keeping it all on the shore, and particularly in the operation of the seine in collecting the fish. We find a very heavy, offensive deposit on all the shores along the river and the flat lakes adjoining.

Q. What was the character of that deposit?

A. Well, it looks like a greasy substance, a slime, I might call it, a very heavy slime; it is very offensive when brought to the surface. I am talking now about below Peoria.

Q. Yes and before the drainage canal was opened?

A. Yes.

Q. How far down the river below Peoria, did this condition of pollution exist?

A. Oh, I have met it frequently as far down as Havana, in limited quantities of course.

Q. How far is Havana from Peoria by river?

A. It is pretty close to seventy miles. I am talking
6036 of this floating substance on the water now, these islands.

Q. Did the water below Peoria, before the opening of the canal, have a scum upon it?

A. Yes, I have seen a very heavy scum on the water below Peoria and at Peoria.

Q. To what did you attribute that?

A. Well, I believed it to be the sewage and refuse from these places at Peoria.

Q. How far down the river did that extend?

A. Well, that didn't go down very far. I have met with that at Pekin, and below perhaps. It was a kind of a broth; it looks like grease on top of the water.

Q. Since the opening of the drainage canal, what has been the condition of the water below Peoria, and as far as Pekin?

A. Why I have seen some floating stuff in the river, but nothing like as bad as it was in previous years, previous to the opening of the canal. I probably, with your permission could give reasons for that, in my opinion.

Q. Yes?

A. This particular refuse from the gas works and distilleries and glucose works is run off in spouts at the edge of the water and it is allowed to accumulate there and when the very low water comes, it breaks off and floats off with the current. 6037 That would be an impossibility if the stage of the water was of sufficient height to keep the shores clean. Previous to the introduction of the canal, we had almost uniformly a much lower stage of water than after the introduction of the water from the canal, and I attribute the absence of it now some to the better condition of the water, and the swifter current, than in previous years where it was allowed to accumulate there during very low water and break off and float away.

Whereupon an adjournment was taken until 1:45 P. M., same day, Thursday, August 13th, 1903.

6038 National Hotel, Peoria, Illinois, August 13, 1:45 P. M., Thursday, August 13, 1903. Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

S. P. BARTLETT,

resumed the stand for further direct examination by Judge Johns and testified as follows:

Q. How far below Peoria prior to the opening of the drainage canal have you seen the substance cast into the river at Peoria, floating?

A. Well the best of my recollection is that I have met it coming up the river in a boat, just above Havana. If my recollection serves me right, it was just above Havana; but it was not in great quantities nor in large pieces.

Q. What was the condition of the fish in the Illinois river before the opening of the canal below Peoria as far as Copperas Creek dam?

A. Well, there were a good many seasons when the fish have been considered bad. When I say bad, I mean they would die in the water without apparent cause; you would see them floating.

6039 Q. Are there many lakes below Peoria and above Copperas Creek dam which have natural connection with the river?

A. Yes sir, there are a number of them. The lake containing the greatest area is Spring Lake, that has an opening into the river large enough to carry steamboats in and out. This is a canal cut from the river into the lake at the expense of the state to enable the farmers living along the bank of Spring Lake, that is the bluff side of the lake, to load their wheat and corn out into the river and bring it out into the river to Peoria or above or below as the case may be. This lake covers an area of, I should think, without computing it seven miles long to about three miles wide, and it is fed almost entirely by springs.

Q. In periods of low water, you may state whether the water from Spring Lake runs out through this canal into the river?

A. It has two ways of escaping from Spring Lake; when the river is rising, the water runs in; when the river is falling the water runs out ordinarily; but at its lower end the water has been raised a number of inches perhaps feet, by an abutment that has been thrown out from Copperas Creek dam to the bluffs and that is used as a road to and from the lock. The water flows over this road in places, varying in depth of course with the height of the river.

6040 Q. Prior to the opening of the drainage canal, how was it affected by this cast off matter from Peoria and Pekin?

A. Very materially. If the river was raising, and at such times this stuff woud break off from the shores very easily, it is taken in great quantities into this lake; in fact I have seen it in bulk sufficient in the canal to absolutely prohibit the going in with our boats, we had to break it up before we could get by. That floats off into the lake and that with other impurities makes the lake very foul at times.

Q. Since the opening of the drainage canal, what has been the condition of Spring Lake?

A. Well, I can only tell by comparison. I probably had best explain the conditions that existed and then the conditions as I understand them today. If it is permissible I will do that.

Q. Yes.

A. A number of years ago we had occasion to take some small fish out of the lake which lay immediately below this abutment, and going to and from the lake we used this road. The foreman of the fishing gang called my attention to the fact that there was a great many small bass on the upper side of this road, which would be in Spring Lake, and also to the fact that they seemed to be suffering; that is, the heads of the
6041 fish were out of the water trying to get oxygen. I ordered the men to go in and make a haul and see what they could find. In the meantime I went over to the steamboat to look after the collections already made, and on going back I found the men on the road, two of them absolutely sick. The accumulation next to this road which forms a kind of a dam was anywhere from 18 inches to two feet and a half deep, perfectly black and the stench so fearful and nauseating that the men couldn't stand it at all. From that I made a personal examination of a great deal of the lower end of Spring Lake, particularly the little pockets that had been filled up with water from the higher water, and cut off by the receding water. And I had them investigate the conditions in all of these pockets, or a great many of them; not all of them. I found the bottoms of those ponds frequently eight inches deep with this black slime, where there was only six or eight inches of water. This is at the lower end of that lake. I took occasion to go over the ground several times in later seasons and have always found a very bad state of affairs there.

Q. Where is the artificial canal leading into Spring Lake, with reference to Copperas Creek dam?

A. It is about four miles above on the east side of the river.
6042 It runs east about two miles through the—what we call the island itself, and then it takes a reflex across what is

known as Mud Lake which has been dredged to make a channel, and then out into the deep water of Spring Lake.

Q. Where in the state of nature was the natural outlet with reference to Copperas Creek dam, of Spring Lake?

A. The natural outlet would be some two miles below; the outlet is now cut off by this dam.

Q. If it were not for this abutment from Copperas Creek dam where would the natural outlet of Spring Lake be?

A. About a fraction over two miles on the east side of the river below Copperas Creek dam.

Q. This material which you found in Spring Lake above this abutment, how did it reach the lake and get into it?

A. Why it must have gone naturally through that canal or in seasons of higher water, through some of the sloughs which led into there.

Q. The material which you found below the abutment, could it have gone over the abutment, or gone through the woods to the channel of Spring Lake?

A. Why it must have gone over the revetment of course; but of course there was not so much found below as above.

Q. How long was this investigation before the opening
6043 of the canal?

A. Well, I think the last work of collection that we did from those lakes was in 1897 or 1898, I won't be positive of the year; the last year we ran the Lotus.

Q. Now since the opening of the drainage canal have you made inquiry into the condition of Spring Lake both above and below the revetment?

A. Yes sir, I have made a good many investigations of Spring Lake. We have made no collections there, but I have spent a good deal of time on the lake looking after the condition of the fish.

Q. Well, what has been the condition since the opening of the canal?

A. Well, again I will have to go back a little bit and make an explanation so you can understand the conditions. At that season of the year the weather was warm, and the boat lay at Copperas Creek dam, and I took occasion to make a critical examination of a number of the black bass brought in by those

who had been fishing on the lower end of Spring Lake, to satisfy myself as to the fish themselves. I found in a great many instances the fish very soft and I took occasion to open them up and found that the whole of the interior of the fish absolutely
dissolved—from what cause I am not prepared to state
6044 further than a few days later, a great quantity of black
bass were floating upon the water in the lower end of the lake and a postmortem disclosed the same state of facts, that all of the digestive organs of the fish had been absolutely dissolved; the fish died of course. I had no means of making an analytical examination of the liquid, but I was satisfied as far as I could be from observation that the cause of death was the very impure state of the water at that time.

Q. When was this, Captain?

A. That was about ten years ago; I can't remember dates; it was during one of the years that we collected there. It was previous to 1897, I think.

Q. On this occasion where you found the men sickened from making a haul of fish in 1897, above the revetment of Spring Lake, in what condition did you find the fish?

A. Well, my attention was called to it first by the very large quantity of fish evidently sick and suffering. The condition was bad right there.

Q. Since the opening of the drainage canal?

A. Since the opening of the drainage canal I do not believe that there has been a season when any dead fish have been found upon the lake. My own particular observation of that locality is that the water is very much clearer, and a personal examination of the bottom, while it shows quite a deposit, is
very slight as compared to the season of which I speak.

6045 Q. Before the opening of the drainage canal, what was
the condition of the water in the Illinois river between Copperas Creek and La Grange?

A. Well, it was just about as the river would naturally average at low water. At low water there would be a great deal of vegetable growth and in places a good many fish would die from the high temperature the water attained, and the decaying vegetable matter; this is along in Stewart Lake. I have noticed that where the plant life and vegetable life was thrown down the water became hot and it commenced to decay and a great many fish died in consequence. Stewart Lake is between those points named.

Q. Since the opening of the drainage canal?

A. Well, the condition has been that since the opening of the drainage canal of course there has been a very much greater volume of water; the water has been very much better; I have noticed a very great decrease in vegetation of various kinds. The best evidence that we have—if you will permit me to express it—of the increased betterment of the water at points below Copperas Creek, is the fact that there are more black bass in the river this year than I have ever known.

Q. Before the opening of the drainage canal, what was the condition of the water in the Illinois river between La Grange and Kampsville dam?

A. Well, I think the water as a rule, except in very low
6046 water classed as fairly good. In very low water of course
the same objections exist.

Q. Are there lakes and ponds in the bottoms of the Illinois river between La Grange and Kampsville?

A. Yes sir, a great many lakes and bayous and sloughs and bays. It is simply interwoven with water.

Q. Now have you dragged those lakes and bayous with seines for the purpose of getting fish before the opening of the canal?

A. Oh yes, the men have worked practically the whole length of the river.

Q. In what condition before the opening of the drainage canal were these lakes and bayous between La Grange and Kampsville, as to foreign substances, etc.?

A. Well, everything depended upon the season and conditions. Some seasons of course the water became very bad from decaying vegetation and very foul, and very destructive to fish life, and again in other seasons when the water would be high, it would be practically free from that down, that far down the river.

Q. Since the opening of the drainage canal, what has been the condition of the water between La Grange and Kampsville dam?

A. In my opinion, good.

6047 Q. What has been the condition of the fish between La Grange and Kampsville since the opening of the canal?

A. They have been good; in fine condition. As I stated a moment ago, there are more black bass—who are only habitats as a matter of choice, of clear water—in the Illinois river than there ever were before. I am speaking of the river proper now.

Q. What has been the condition of the ponds and bayous between these two dams since the opening of the canal?

A. Well, they have been higher and the water, and the fish propagate better.

Q. How far is it from Peoria by river to Kampsville dam?

A. About 125 miles, I think. Now in giving these distances, I am giving them to you off hand, without knowing exactly.

Q. From Kampsville dam to Grafton is how far by river?

A. Well it must be close to forty miles—forty-five miles.

Q. What is the condition of the river below Kampsville since the opening of the drainage canal?

A. It has been good.

Q. Between LaSalle and Peoria, you may state whether or not the character of the water improved, as it did on the river?

A. Yes sir, until we get to Peoria Lake, we get a practically good water.

6048 Q. Between Peoria and Copperas Creek, state whether or not the character of the water in your judgment improves as you get close to Copperas Creek?

A. Yes sir.

Q. Is the water in the Illinois river below Peoria, and down to Copperas Creek better or worse than in Peoria Lake?

A. Well, I think the water below Peoria, from Peoria to Copperas Creek dam is worse than Peoria Lake considerably; very considerably. Except under extraordinary conditions; there is very rarely a better body of water found anywhere than in Peoria Lake.

Q. How does the water below Copperas Creek and down to La Grange dam compare with the water above Copperas Creek?

A. I think it gets better all the time as you go further below, a great deal better. A man doesn't have to be an expert to notice that; you can see that all the time; the character of the water is better as you go down.

Q. From your experience on the Illinois river, what is your judgment as to its purifying itself as it flows from sources of impurity at Peoria and Lockport?

A. Well, in my judgment, where the water is sufficient to make the current carry the water along; but whenever it is held in suspension in the water long, there is no question but what it is a source of great purification.

6049 Q. How many dams were there in the Illinois river in 1877, when you commenced your duties as fish commissioner?

A. Two completed.

Q. What were they?

A. Henry and Copperas Creek. I think that one at La Grange was in course of construction.

Q. Describe the Illinois river in 1877 as to its size and depth and current?

A. Well, the river as I remember it in my first trip over it in 1877 on my own boat, doesn't differ very materially from its present outlook as to height. We found plenty of water. As I recollect it the water was very high all over the whole country. It was what steamboatmen would call a big river. Through the season, as I remember it, that fall we had very low water. The same condition of things existed then as have existed ever since. I remember very well seeing a calf wade the Illinois river at Meredosia that season. The river was filled with water plant and grass so that it would tangle up the oars, and the stench coming off of the river I have been told by those who lived at various points on the river, was of such a nature that when the wind blew from the river to their residences, it compelled them to change their quarters and go away from it. That was at a very low stage of water I am talking about now, and, as I recollect it, that was the year.

6050 Q. When were the other two dams put in by the United States Government?

A. I do not recollect the years which they were opened; I think that at La Grange was in course of construction at that time, and finished several years later, and this one at Kampsville has only been opened to the public five or six years. I don't think it was fully completed until five years ago.

Q. Prior to 1885, were you familiar with the Illinois and Michigan Canal?

A. Well, not intimately; I had been over it once or twice.

Q. Were you aware that in 1885, the city of Chicago commenced to pump water from the Chicago river into the Michigan Canal?

MR. JEFFRIES: Objected to as incompetent and immaterial, and as furnishing no excuse or justification for the turning of the sewage of Chicago into the river through the Chicago drainage canal.

A. Yes sir.

Q. Into what did the Illinois and Michigan Canal empty its waters?

A. Illinois river.

Q. What effect upon the Illinois river did the pumping of water into the Illinois and Michigan Canal and its subsequent emptying into the river have upon the character of the water in the Illinois river?

6051 MR. JEFFRIES: Objected to for the same reasons.

A. Well I am not prepared to state just what the effect was on the river itself.

Q. If it apparently enlarged the Illinois river and increased the current in it, you may state to what extent?

MR. JEFFRIES: We object to the question for the reasons stated in reference to a previous question and for the further reason that the counsel is undertaking to cross-examine his own witness after he has stated himself that he was not prepared to testify upon that subject.

A. Well I can't state intelligently as to that because I really don't know.

Q. What effect upon the Illinois river as to its size, current and general appearance, has the opening of the drainage canal and the consequent emptying of the waters of the drainage canal into the river had upon the river in a general way?

A. It has increased its volume very materially; it has accelerated the current.

Q. Have you an acquaintance with the fishermen upon the Illinois river?

A. Yes sir, a very large acquaintance.

Q. From La Salle to Grafton?

A. From Grafton to La Salle, yes sir.

Q. In your judgment how many people are engaged in 6052 the business of fishing for commercial purposes?

A. May I ask whether you mean directly or indirectly?

Q. Well directly, first, on the river?

A. My impression would be that there is anywhere from 2500 to 3500 people directly interested in fishing themselves; that doesn't include, however, the helpers. I am talking about the men who fish.

Q. How many people are engaged in the preparation of the fish for market and the shipping of them after they are caught?

A. Including the fishermen themselves?

Q. Yes.

A. Well I should think 5000 would be a fair estimate. Now I am talking about the men who make the boxes, ice them, and draying to the cars and all that.

Q. Does the business of this population bring these men upon and about the water during the fishing season?

A. Yes sir.

Q. What was the condition of health of this class of men prior to the opening of the drainage canal as to typhoid fever and malarial fever and malarial diseases?

A. Well I can only speak of that in a general way and as to my own men particularly. We had a great deal of 6053 sickness; not much typhoid, but a great deal of very low grade fever; that in my opinion—well I was going to say as a physician,—but from what knowledge I have of it,—owing to a very bad state of the water during low water.

Q. Were you educated for a physician and did you at one time practice medicine?

A. I never practiced medicine, I was educated and graduated as a physician—too poor.

Q. Since the opening of the drainage canal, what has been the condition of the health of the people engaged in business upon the Illinois river in the fishing industry?

A. My observation has been that there has been a very great decrease in typhoid and intestinal diseases.

Q. Do you know of typhoid fever among the people engaged in fishing in the Illinois river since the opening of the drainage canal?

A. Again only as applied to my own men. I know the condition of their health, after that and previous to the opening of the drainage canal. Of course I have heard a great deal from the different towns that I have come in contact with, but I do not know of it from my own knowledge,—of the difference in the prevalence of those diseases.

Q. From what you know and have heard, as a matter of general information along the Illinois river, what has
6054 been the condition of health of the people living along the river?

MR. JEFFRIES: I object to the question for the reason that it is incompetent, calls for hearsay evidence and evidence of the physicians of the community would be the best evidence, and any answer that might be given would be incompetent, immaterial and irrelevant, and for the further reason that the witness has not shown himself to be sufficiently acquainted personally acquainted with the general health of the respective communities to give an opinion on that subject, or to testify in respect thereto, so that whatever he might say will be based upon what other physicians have told him and therefore not competent.

A. My work as you know, carries me to almost every town along the Illinois river, and the natural tendency would be to drift in and talk over semi-professional matters with physicians. And I believe with one single exception—

MR. JEFFRIES: I object to what the witness believes.

A. (Continuing)—that every physician that I have talked to has commented on the decrease in typhoid and malarial fevers during the last two or three years.

Q. Taken as a class, what has been the condition of the health of the fishermen upon the Illinois river since the opening of the drainage canal?

MR. JEFFRIES: Object to the question because the
6055 witness has not qualified to testify on that subject.

A. I can only particularize as to my own men. I can't express an opinion as a whole.

Q. What has been their health?

A. Their health has been very vastly improved.

Q. From all your sources of information of whatever character, what has been the condition of the health of the fishermen on the Illinois river generally, since the opening of the drainage canal, in your opinion?

A. Well I should be inclined to say, from all sources of information, that it is a great deal better.

Q. How many people live upon the Illinois river in house-boats or upon the banks of the river immediately adjoining the water?

A. I don't believe such a thing as an exactly correct estimate could be made, for this reason: The Illinois river itself is only a small part of the water that is affected, or probably I might put in another way, is only a part of the whole river as a whole, taking in what we call the navigable portion.

Q. Including in the term "Illinois River" not only the body of water constantly flowing in its channel, but the waters of its bayous and lakes, how many people in your opinion, live upon the Illinois river?

6056 A. Well, my opinion is that there would be more than 5,000 people directly upon the river; that is to say in tents and flat-boats or in house-boats and on the sloughs and bayous and bays and lakes connected with the Illinois river.

Q. From all your sources of information and your personal knowledge, since the opening of the drainage canal, what has been the condition of the health of that kind of river population since the opening of the drainage canal?

A. Why, in my opinion, the health has improved. That from all sources of information that I have been able to discover.

Q. Is the Illinois river and its lakes and ponds much resorted to for pleasure fishing?

A. Yes sir.

Q. To what extent?

A. Well, to a very large extent. There is scarcely a town along the river that doesn't harbor during season an immense amount of strangers from other parts of the state who seek the Illinois river for sport annually; the citizens themselves take a good deal of pleasure out of it.

Q. What is the extent of the fishing industry— As to these people who use the Illinois river as a resort for pleasure and fishing, in what manner do they generally live, in camps or in hotels?

6057 A. Well the growth of interest in fishing and sport on the Illinois river, has been great, and almost every available lake on the river of any size has been taken up for a pleasure resort, and they build either club-houses on the bank or house-boats or as in the case at all of the locks, I believe I am safe in saying that a hundred can be found camping out there all season long for the purposes of fishing with a hook and line.

Q. Do the persons concerned in the fishing business and these pleasure fishermen use the water of the Illinois river for drinking and domestic purposes?

A. Well, I think they use it generally. Wherever they can they put down a drive well, but in a great many places that I know of they are now using the water for domestic and drinking purposes.

Q. Through what kinds of country does the Illinois river run?

A. The Illinois river is very peculiar in its formation, in that it has flat shores on both sides of the river. These bottoms extending from three to fifteen miles in width and filled almost in every case, with lakes and sloughs, aside from the river itself. As the fall is only a half inch to the mile, the overflows are very frequent and the lakes fill up and evaporate again several times during a season, during the dry seasons. The
6058 course of the river is inclined to be free from bars
and of a very even depth. The land on both sides of course on account of frequent overflows, is very much as nature left it.

Q. In times of extreme high water, what is the area covered by the Illinois river?

A. I can't answer that question specifically. The river in extreme high water will be of course from bluff to bluff, frequently twelve to fifteen miles wide.

Q. In times of extreme high water where is it narrowest, if you know?

A. Well, there are several real narrow places. One is right here at Peoria, and below Peoria a short distance is another one, and there are some down there after we get below Pearl, and then again after you get below Hardin. The character of the river changes there materially.

Q. In times of extreme high water, how wide is the Illinois river at the Narrows at Peoria?

A. Well in extremely high water there are practically no Narrows there, it is a regular lake; it extends from bluff to bluff.

Q. Does the Illinois river in extreme high water vary in its width and if so what are the extreme variations?

A. Well that of course will depend upon the height of the water.
6059 After the river has reached a certain height it couldn't vary.

Q. What I mean is, at times of high water, is it everywhere of equal width, or does it vary as the distances between the bluffs vary, and if so what is the variation in the distances between the bluffs?

A. Well, as I was saying a while ago, take it below Peoria here the bluffs are not very far apart.

Q. About what distance?

A. I should say in the neighborhood of three miles. As we go down further, down below Browning we have flat, low places on both sides of the river and I would say it would exceed twelve miles there. It does vary in width materially in very high water.

Q. Is the country immediately adjoining the Illinois river, in the arable lands, devoted to agriculture?

A. Yes sir.

Q. Do you know whether domestic animals adjoining the river are accustomed to drink of its waters?

A. Oh yes, all the time.

Q. Is the country adjoining the Illinois river abounding numerously with domestic animals which use the water?

A. Yes, the low-lands above Havana particularly, and a great many other places are used for pastures. Take Spring

Lake and a great many other places, are used for pas-
6060 tures during low water,—dry weather.

Q. You may state whether or not cattle are brought from distances in the seasons of low water for the purpose of being pastured on the low lands of the Illinois bottoms?

A. Yes sir. The land is rented for that purpose in a great many places.

Q. Are such animals watered from wells or do they use the waters of the Illinois river for drinking?

A. They use the water of the lake or the slough or whatever they happen to be located on, to drink, of course.

Q. Did you ever hear of a disease called anthrax, among the cattle of the Illinois river?

A. I have not amongst the cattle on the Illinois river, no. I have heard of the disease.

Q. Do you know or did you ever hear of any diseases among cattle drinking the water of the Illinois river which were attributed to the drinking of the water of the river?

A. No sir.

Q. Has it been before the opening of the drainage canal and is it since a good water for animal consumption and drinking?

A. I have never heard anything to the contrary; I believe it is.

Q. What in your opinion has been the effect as to the increase or decrease of fish in the Illinois river by reason
6061 of the opening of the drainage canal?

A. The increase in fish on the Illinois river has been very great in the last three years; but this is in part attributed to the fact that the stage of the water in the Illinois river has been at too great a height to permit the drawing of seines in the river itself. The character of the fish has been very much better.

Q. What is the extent of the fishing industry upon the Illinois river?

A. In 1901 the report of the Fishermen's Association which comprises an organization of about 1,000 men on the Illinois river, gives as a total of coarse fish caught, of nearly 18,000,000 pounds, with quite a per cent of fine fish added. The amount of money they report as having received for their output—I am giving you their figures now—a little over three quarters of a million of dollars. The bulk of this from coarse fish, a very large proportion of which were taken from the river proper, which would include Peoria Lake.

Q. Is there included in this estimate the fish caught by hook and line?

A. No sir, this is simply reports from the books of the Fishermen's Association and submitted to me under oath.

Q. From your knowledge and experience upon the river, and your connection with the fishermen do you believe 6062 these figures to be approximately correct?

A. Yes sir.

(Witness withdrawn for the present).

6063 WILLIAM H. BINNIAN, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. William H. Binnian.

Q. What is your business?

A. Manufacturing.

Q. Manufacturing what, Mr. Binnian?

A. Agricultural implements and straw-board; I am connected with two companies in the city of Peoria.

Q. What are the names of the companies?

A. Acme Harvesting Company and the Peoria Straw-board Company.

Q. Do you hold any position with the Acme Harvesting Company?

A. I am its president.

Q. How many men are employed by that concern?

A. An average of about seven hundred.

Q. Do you hold any position in the other company?

A. President of that company also.

Q. How long have you lived in Peoria?

A. Forty-six years.

Q. During the time that you have resided here are you acquainted with the Illinois river?

6064 A. Yes, sir; quite well.

Q. What was the condition of the Illinois river before the opening of the drainage canal?

A. Well, we considered it a pretty filthy stream and quite sluggish.

Q. How did the condition of the river immediately above Peoria compare with the condition immediately below Peoria prior to the opening of the drainage canal?

A. Well, the river was very much more filthy below the city than it was above, on account of the refuse matter thrown in by the manufacturing plants on the river bank.

Q. What has been the effect of the opening of the drainage canal upon the quality of the water in the Illinois river?

A. Well, to all appearances it has cleared it up very materially, and practically we have found that it has been of very great benefit; that is particularly through the straw-board mill.

Q. Prior to the opening of the canal was there any odor connected with the water or emanating from the water?

A. Yes, practically all the time.

Q. What is the condition since in regard to odor?

A. I don't notice any at all.

Q. What opportunities have you had for observing that fact?

6065 A. Well, I presume I have been on the river on an average of forty or fifty times a year for forty years.

Q. Before the opening of the canal did you take your family on the river?

A. Under protest from them, once in a while.

Q. Since the canal was opened have you taken them?

A. I don't hear any objections.

Q. In the manufacture of straw-board in the plant over which you preside as president, have you noticed any changes in the water of the river for mechanical and manufacturing purposes since the drainage canal was opened, over conditions that existed prior thereto?

A. Yes, there have been some very manifest differences apparent.

Q. Will you describe in detail these differences?

A. Well, the chief point that we have observed has been in the saving of felts. Prior to the opening of the drainage canal, it used to cost us from 50 to 60 cents per ton of board for felts, and our average cost now is 27 cents per ton of board for felts.

Q. How is that economy effected in the use of water of the Illinois river?

A. To answer that question I will have to explain somewhat in detail the office that is performed by these felts.

6066 These felts are from 64 to 94 inches in width and about 100 feet in length. The office that is performed by this felt is to take up the pulp as it is gathered on cylinders which are covered with brass wire screen. There are four of these cylinders in each stuff-chest, or vats which hold the pulp from which the straw-board is made. The felts pass over each of these rolls in succession taking up the pulp that has accumulated on them and then in returning to position they pass through a vat of water in which they are washed up, so that when they come back to the first roll and again take up the pulp they are washed up clean.

Q. What kind of water is used that they are washed in?

A. River water.

Q. How long do these felts live?

A. The life of a felt now is about five to six weeks, when formerly it was but three to four.

Q. How did the effect of the water prior to the opening of the drainage canal manifest itself upon these felts?

A. It rotted them more quickly than the water now does.

Q. Can you give any reason for it?

A. Simply on account of the impurities of the water; the process is identical now with the process of ten or fourteen years ago; there has been no change in the method of operation.

6067 Q. Have you observed any change in the economy of the water since the opening of the canal over that which existed prior to the opening, in regard to your machinery?

A. Yes, our bills for repairs are much lighter than they used to be. The present water doesn't have so evil an effect on the valves and pipes as the old water had; they don't rot out so quickly; don't wear out as quickly.

Q. Is the Acme Harvesting Company a corporation?

A. Yes, sir.

Q. Have you any objection to stating the capitalization of the company?

A. Capital and surplus about a million and a half.

Q. Where is the water used in the harvesting plant secured for condensation and steam making purposes?

A. From the Kickapoo creek.

Q. Where does the Kickapoo creek receive its supply of water?

A. Well, from two sources I should say; from the back water of the Illinois river and from surface drainage up in the country.

Q. About what portion of the time does it receive its water from the backwater of the Illinois river?

A. I think half of the time, or over.

6068 Q. Was that true before as well as since the opening of the canal?

A. No, it probably didn't get as much backwater prior to the opening of the canal as they have since, because the stage of the water was lower then than it has been since.

Q. How does the water secured from Kickapoo creek when it is Illinois river water,—back water from the Illinois river—compare in its steam-making qualities in the harvester factory with that which is gotten from the Kickapoo creek under other conditions?

A. I don't believe I could give you an intelligent answer to that question because we haven't kept close enough records on it.

Q. Has there been any perceptible change when the source of the water has been different in the manufacturing plant?

A. I hardly think there has.

Q. What is your opinion as a manufacturer, as to the quality of the water in the Illinois river at present, for manufacturing purposes and the uses to which water is put in manufacturing?

A. Why, I am firmly convinced that it is far superior today than what it was prior to the opening of the drainage canal, by practical experience and scientific tests that have been made at both plants at times.

6069 Q. Without instituting a comparison with conditions that obtained prior to the opening of the drainage canal, what is your opinion as to the water today for manufacturing purposes?

A. I don't think it can be excelled; it is a most excellent water for manufacturing purposes, for steaming purposes. We use about two million and a half gallons of water per day at the straw-board plant.

Q. What becomes of the refuse from the straw-board factory?

A. It is thrown back into the river.

Q. What is the character of that refuse?

A. It is impregnated with lime and the washings from the cooked straw which takes off the silica and other refuse matter of the straw.

Q. Are there any chemicals mixed in with that refuse?

A. No, there are not; there are none used in the manufacture of straw-board except certain acids used in washing up the brass screens so as to keep them clean.

Q. Will you locate the two factories, the Acme Harvesting Company and the straw-board factory?

A. The Acme Harvesting Company is about five miles from the courthouse or a mile and a half from the lower city limits. The straw-board factory is in Averyville, or a quarter of a mile above the upper city limits.

6070 CROSS-EXAMINATION, by Mr. Jeffries.

Q. The Acme Harvesting plant is located down the river?

A. Yes, sir, below the city.

Q. And the plant of the straw-board company is located above the city?

A. Yes, sir.

Q. How far from the river is the Acme Harvesting Company?

A. Fully a mile.

Q. And how far is the straw-board company from the river?

A. About 300 feet.

Q. Do you know whether or not the impurities that you speak of as being in the water before the Chicago drainage canal was opened, so that they would rot the pipes, was of vegetable or animal matter?

A. Well, I do not; I simply know the results.

Q. You don't know the character of the impurities?

A. No, I do not.

Q. You don't know but what there may be as much impurities so far as the sanitary condition of the water now is concerned, as there was before the canal was opened or even more?

A. No, sir; I can simply testify to the facts on the mechanical side of it.

6071 Q. The river at the point from which the water was drawn prior to the opening of the canal, was very sluggish, was it not?

A. Yes, sir.

Q. And at times practically quiet, with very little current?

A. There was very little current in the river at that time.

Q. How is the current now?

A. It is much swifter and there is a more equitable stage of water.

Q. This bad condition of the water, then, was caused largely because of a lack of a current?

A. No, I couldn't say that; there might be a swift current with bad water, or a sluggish current with clear water.

Q. It is not very apt to remain clear if it is sluggish very long?

A. No, possibly not.

Q. There is no substance contained in the refuse from the straw-board company discharged into the Illinois river that is deleterious to the human system, is there?

A. Not at all, sir; the entire substance that straw-board is made from is straw and water and steam and lime; none of them are very deleterious to the human family or animals.

6072 Q. Have you at any time used the water from wells in your straw-board factory?

A. Oh, yes, very frequently.

Q. For washing felts?

A. Yes, sir; it is used, however, for washing up the pulp after it is cooked principally.

Q. Do you use it now for that purpose?

A. Yes, sir.

Q. And for washing the felts?

A. No, I think the river water is used exclusively for that purpose now.

Q. There isn't a very large quantity of refuse that goes from the Acme Harvesting Company into the river, is there?

A. No, none whatever; we use water only for drinking purposes and for steam manufacture and for flushing the closets.

Q. Do you know the particular place in this Kickapoo river where the city authorities dump the contents of the private vaults in the city?

A. I don't think they dump any in Kickapoo creek; it is too far away from the city.

Q. You don't know whether it is above or below the point where you take your water?

A. No, I am very sure that the city don't dump into the Kickapoo creek at any point.

WM. H. BINNIAN.

6073 S. P. BARTLETT, resumed the stand for cross-examination by Mr. Jeffries, and testified as follows:

Q. Mr. Bartlett, how often do you visit the various towns and cities along the Illinois river?

A. This season very seldom. In former seasons very frequently.

Q. How often did you visit them last season?

A. Well, I was over the river a good many times; I can't tell you just how many times; some of the places several days at a time and other places just touch in and out again.

Q. Do you remember how many times you visited Chillicothe last season?

A. No, sir, I don't recollect the number of times. I was there, oh, five or six times during the season or oftener; I guess oftener last season.

Q. How often would you remain when you went there?

A. Well, my last visit to Chillicothe was nearly two days. It would vary from half an hour to a day owing to the business I was going through there on.

Q. As a general proposition when you would go to these small towns you went there for a particular purpose and as soon as you could get through with your work you left?

6074 A. Well, not always; sometimes it wouldn't take me over fifteen or twenty minutes to transact my business and it would be two or three hours between trains. I didn't always go by boat by any means. When the boat landed there I would transact my business and then go on.

Q. And it was during these times, or occasional visits that you obtained the condition of the health of the people in these towns?

A. Oh, in going to a town of that kind, after I would get through my work as a rule I would hunt up the people I was acquainted with and talk to them, and would naturally drift in with all kinds of people in a general way. I don't know as I ever made it a special business to investigate the health records, except just in a general way.

Q. Captain, the cattle and stock that are fed during the dry season, or grazed during the dry season upon the low lands of the Illinois river bottoms, are around and along these lakes and sloughs as I understood you to say, and is that where they would get their water from?

A. Well, I will particularize a case; at and about Clear Lake and Spring Lake, there are a great many acres of land which grows very luxuriantly in grasses around these lakes and back from the bottoms, and these places are as a rule turned over to people who herd and graze their cattle. I intimately
6075 know those two places that I call to mind right now.

Q. How large in area are those two places which you speak of?

A. Well, there must be several thousand acres of grass in each.

Q. Where are the lakes in reference to this land?

A. Well, at Spring Lake between the lake and the main shore, there is a very large body of land that they call the Meadows, in which the grass grows very luxuriantly and very tall; that is one of the grazing places, and then at the upper end there is a great deal of land that is subject to overflow, but is a good deal of the time out; that is used very extensively. At Clear Lake that is almost entirely surrounded by good grazing land.

Q. Do you know whether or not there are any small streams entering into Clear Lake?

A. No, I don't know that there are any small streams running into it. There are several inlets to the river in high water, and there may be for all I know, some creeks running in from the bluffs. I have no knowledge of them.

Q. Do you know how deep or what the average depth of the water is in these two lakes, Clear and Spring Lake?

A. The water is deep in Spring Lake, in the lake itself. In Clear Lake I should think the greatest depth is perhaps 12 to 14 feet and then slowing off on the edges.

6076 Q. Now, what other bodies of grazing land on the Illinois river are you acquainted with except those surrounding Spring Lake and Clear Lake?

A. Well, nearly all the bottoms of the Illinois river are used for pasturing cattle and hogs. I can't specify, because I should have to go almost the entire length of the river to do so.

Q. In nearly all places where there is a wide stretch of lowland you find these lakes and sloughs, do you not?

A. Oh, yes, almost the entire length of the river.

Q. I understood you to say in your direct examination, that the Illinois river had no tendency to bar?

A. Well, I perhaps ought to qualify that. What I meant to say there are no sand bars. Now and then there is what are known as mud bars or shell bars, but unlike the Mississippi river it doesn't make a sand-bar everywhere there is a stream going in, except right here at Peoria, Farm creek.

Q. The water in the Illinois river flows with a very good current since the canal was opened, does it not?

A. The current has increased; I notice this year a very rapid current at several points upon the river, more than usual.

Q. This pollution that you speak of, Captain, before the canal was opened, was of a vegetable character?

6077 A. Well, I can't tell you; when I speak of it I speak of such personal experience as I have had with it. A very large amount of the damage above Peoria is due to the decomposition of vegetable matter. Below Peoria, that is the worst, the greatest amount of damage is done in my opinion, from the offal and refuse and whatever escapes from the sewers from these manufacturing institutions.

Q. Do you know the exact character of the matter that is discharged from the stills, glucose factories and other industries?

A. Yes, sir, I say exact character. I know this; that all the manure and slop and general offal from the cattle pens is run down to the river through long chutes to the river edge, that is mixed up with a manure of some kind, what constitutes it I don't know, and that is deposited on the river bank, the fluid escaping, it dries out and that lays there until it hardens, and then with any rise in the river it is either broken off by the raise in the river or by some artificial means and turned in and it floats down the river. That is the perceptible cause of a good deal of pollution. My own personal opinion is, however, that some of the most destructive elements come directly from the sewers of Peoria and from the gas houses.

Q. The land along the river below Peoria is of the same character as that above, is it not?

6078 A. Along Peoria Lake on the left hand side of the river going up, you meet with a good deal of gravelly beach, more of a rough bank. The ground is higher and less subject to overflow. On the other side of the river the distance to the bluffs is shorter and the land practically worthless from being constantly submerged. That is true in the upper Peoria Lake. Chillicothe is on the edge of upper Peoria Lake. After you get below Peoria, after you get down, say to Copperas creek dam, the river commences to widen out on both sides and it changes again after you get below. You have high banks and bluffs again.

Q. Then the same cause or opportunity for pollution from decayed vegetation exists below Peoria as well as above, does it not?

A. In extremely low water, yes, sir.

Q. The fishing industry along the Illinois river was very great before the canal was opened, was it not?

A. Yes, sir.

Q. And has been for a number of years?

A. Well, the output of coarse fish from the Illinois river ran down in 1880, to about 1,000,000 pounds a year, and has been constantly increasing ever since. That has been due, however, not to the character of the water altogether, but to the protection of propagation.

6079 Q. And the protection that the state has given the industry through its State Fish Commission?

A. And in the introduction of the carp.

Q. What do the carp feed upon, Captain?

A. The carp are by construction, natural vegetable feeders; unlike the majority of fish, they have no teeth and cannot bite anything. Their food is taken in by a sucking motion and they are as liable to take a piece of meat as they are a grain of corn. They are a purely vegetable feeder.

Q. The carp multiply very rapidly in the Illinois river, do they not?

A. Yes, sir; the carp are especially adapted to the waters of the Illinois river and they multiply very fast.

Q. And they constitute the principal fish that is placed upon the market from the Illinois river?

A. Yes, sir; they are the principal industry today of the Illinois river.

Q. There is as much vegetable growth along the banks of the Illinois river today as there was before the canal was opened?

A. No, sir; for the reason that the water has been constantly higher than it was before the canal was opened and consequently there isn't the same chance to grow.

Q. You know nothing of the condition of the water from a sanitary standpoint other than what you have testified?

6080 A. Well, I heard you say a while ago that you didn't care to go into expert testimony in that case. My investigations are all along that line and I don't care to go into it unless you want me to.

Q. Have you been going up and down the river every year since you were a commissioner?

A. Yes, sir; more or less every year; some years more than others.

S. P. BARTLETT.

Adjourned until 9 a. m., Friday, August 14th, 1903, at the National Hotel, Peoria, Illinois.

6081 National Hotel, Peoria, Illinois, 9:00 a. m., Friday, August 14, 1903.

Parties met pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

W. F. YORK,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. W. F. York; Peoria, Illinois; I am a river man—captain.

Q. Are you a licensed captain and pilot on the Illinois river?

A. Yes sir.

Q. How long have you been engaged in steamboating upon the Illinois river?

A. Well, since 1850, I have been afloat on the river.

Q. Have you traveled the entire length of the river at various times?

A. Yes sir.

Q. Are you now engaged in running steamboats upon the Illinois river?

6082 A. Yes sir.

Q. What was the condition of the Illinois river before January, 1900, when the drainage canal was opened?

A. In what way, the stage of the water?

Q. Yes, and its condition and the growth in it?

A. Well, it was pretty sluggish and dirty; there was no current in it; and a green scum on it.

Q. Before the opening of the drainage canal what was its condition above Peoria?

A. Why there was no current to amount to anything before the drainage canal was put in; there was a low stage; it was covered with a green scum; dead, sluggish.

Q. Did it smell badly at times before the opening of the drainage canal and above Peoria?

A. Oh yes, bad condition, it didn't stir at all, it just lay around rotten, and full of all kinds of insects.

Q. Was there enough growth in it at that time above Peoria to hinder the traveling of the boat, would it clog up the wheels?

A. Oh no, nothing of that kind, no sir.

Q. How was the water above Peoria before the opening of the drainage canal for steaming purposes?

A. Well it was not as good as it is now.

6083 Q. What seemed to be the matter with it?

A. Well it was very dirty, we had to clean the boilers every week; we got a good deal of dirt out of the boilers.

Q. Since the opening of the drainage canal, and above Peoria, what has been the condition of the water?

A. Well, I think it has been better than it was before the drainage canal was put in; better for steaming purposes; we get lake water instead of river water and slough water; I think that is the cause of it; we get lake water, purer water.

Q. Below Peoria, what was the condition of the river down as far as Copperas Creek dam, before the opening of the drainage canal?

A. Well, it was just about a sewer; it was full of offal and manure and hay and everything that comes out of the cattle and hog pens; very dirty, and very bad smell, it would stink; there was islands of this stuff in the river.

Q. How was it for steaming purposes below Peoria before the opening of the canal?

A. Very bad; the boiler would foam; take it below the still houses the river just stood full of this stuff, all the time; and you would pump it up in your boilers and it would foam all over everything, and it would stop up your boat a few moments to check up your boilers to see where your water was; when the boiler would foam it would slobber up through your safety valve.

6084 Q. Now since the opening of the drainage canal and below Peoria down as far as Copperas Creek, what has been the condition of the water?

A. Why, it has been considerable better than it used to be; it has been purer and there hasn't been so much dirt in it; and we have never had any trouble since the drainage was put in; we have about three feet more water and about a mile more current. Before that we had about three-quarters of a mile an hour current and now we have got about a mile and three-quarters below Peoria.

Q. How is it for steaming purposes between here and Copperas Creek since the opening of the canal?

A. Oh, it is just as good as it was before any more than before we had to stop and now we don't have to stop, I don't know as it takes any more coal to make steam, and the water used to foam before and it don't foam now; it don't raise an eruption in the boilers.

Q. Before the opening of the drainage canal, what was the condition of the water between Copperas Creek and La Grange dam?

A. Why it was pretty dirty.

Q. Was it better or worse than above Copperas Creek?

A. It was better, for the simple reason that it went farther; it couldn't be any other way; the farther it goes the better it gets.

6085 Q. Since the opening of the drainage canal how has the water been between Copperas Creek and La Grange?

A. Well it has been better than it used to be.

Q. How is it for steaming purposes?

A. Why it is better for that; there isn't so much dirt in it.

Q. Before the opening of the drainage canal, what was the condition of the water between La Grange and Kampsville dam?

A. I think it is better today than it was. The farther down you go I think the better it is.

Q. Before the opening of the drainage canal was there any trouble with it for steaming purposes between La Grange and Kampsville?

A. Why, we never had to stop there; we got into the water where it settled and cleared. About the only place where we had to stop was between Pekin and Copperas Creek. After you passed over the dam there you know, that would purify it and shake it out and deposit it in spots, so that we didn't have to stop. We never foamed below Copperas Creek. You might a little after you left there, but after you blowed her off once or twice after you left Copperas Creek, she would be all right from there to St. Louis without you got a raise out of the Missouri, and got a chunk of mud out of there. And
6086 if you did, you would get some more trouble; that is always the case. If you get a seven or eight foot raise out of the Missouri, you would have some more foam after you went below Madison.

Q. When there is a raise in the Missouri or Mississippi river, the water from those rivers backs up the Illinois?

A. Yes it does, for a short distance, thirty or forty miles sometimes; owing to the condition of this river.

Q. And in that case the water in the Illinois would be of the character of the water of the river which is on the rise would it?

A. Why it would be similar to that, yes, where it was backed up, of course. Not so much so as the river itself, but it would be similar to it.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Are you an engineer?

A. No sir. Not a licensed engineer.

Q. You are a captain of a boat are you?

A. Yes sir, captain and pilot.

Q. What is the cause of foaming in your boiler?

A. Oh, it is dirt in the water, mud or grease, vegetation, rotten vegetation.

6087 Q. Did you ever steamboat any on the Missouri river?

A. Yes sir.

Q. Isn't it a fact that the foaming of the boilers is due to the unkept condition of the boilers?

A. Not necessarily; you can take a new boiler and put it into the Chicago river in the condition is was in before the drainage was put in—you can take a new one out of the shop and run it up through the packing houses and bring it back down and if you carry much water it will foam.

Q. Did that condition of the water with reference to the foaming in the boilers obtain throughout the entire year on the Illinois river?

A. Why not in the spring of the year when it was high, when there was a current.

Q. What is this green scum that you spoke of in your direct examination composed of?

A. Why I don't know exactly, it is stuff that floats out of the sloughs and along the shores, vegetation, that is my idea about it; I don't know that I am right or not.

Q. Well the sloughs are there yet are they not?

A. Why yes, I have noticed them always as I passed along, at the same place.

6088 Q. The same conditions obtain in the sloughs as formerly?

A. Well, I should think it would; I should think it would be the same as it always was; they have the appearance of being the same.

Q. Now as a matter of fact this green scum did not float upon the surface of the water except where it was stagnant, or where there was no current, or only at such times of the year when the water was low and there was no current?

A. Yes, that is about the time you would find it, when the water was low and there was no current to carry it off.

Q. When you say the water is better now than it was before the canal was opened, you have reference simply to observation from the condition of the water and the volume of water the very much stronger current, and the fact that the green scum that floats out of the sloughs into the current has disappeared down the river?

A. Well it passes off instead of staying there, and then there are other reasons. Before the drainage was put in, take it when the river was low and it would get covered with this scum and dirt on top it would get very thick and sluggish, you would find dead fish all along the shore; they would die from some cause or other; whether it was the water or not I don't know, but you would find them all along the shore at different places, and that isn't the case now. You hardly ever see a
6089 dead fish along the shore now. And the fish are in a livelier condition.

Q. It stands to reason then, doesn't it, that the conditions being similar, aside from the greater volume of water will send impurities from the sloughs and other places along the river—they are there yet as they were before, does it not?

A. Why I would think there would be about the same amount; there is about the same area of sloughs you know, and there is about as much vegetation. Under the same conditions it would be about the same I should think, any more than it passes off now and before it didn't; that is my idea about it.

Q. And that is your reason for saying that the water is better?

A. Why yes.

Q. How long have you been on the Illinois river?

A. I have been here since 1850, here and on the Chicago river, but mostly on this river.

WM. F. YORK.

6090 **ISAAC TAYLOR,**

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd, and testified as follows:

Q. State your name, residence and occupation?

A. Isaac Taylor; residence Peoria, Illinois; real estate and loan business.

Q. How long have you been in that business?

A. About 33 years.

Q. Have you held any position in the State government?

A. Canal Commissioner and also on the special commission to inspect the Chicago drainage channel.

Q. What is the position of Canal Commissioner?

A. The Board of Canal Commissioners have charge of the Illinois and Michigan Canal and also of the locks and dams at Henry and Copperas Creek.

Q. When were you canal commissioner?

A. From 1885 to 1889.

Q. In the performance of your duty as canal commissioner, were you on the Illinois river?

A. Frequently.

Q. Between what points?

A. Between La Salle and Copperas Creek.

6091 Q. Are you familiar with the Illinois river?

A. Yes sir, somewhat.

Q. Covering what period are you familiar with the river?

A. In a certain sense from 1850 until the present time.

Q. Have you ever had any connection with any association which had for its object the improvement of the Illinois river?

A. Yes sir, the Illinois Valley Association; I am chairman of that association and have been most of the time, since 1887.

Q. What is the object of the Illinois Valley Association?

A. It is to try to secure the improvement of the Illinois and DesPlaines rivers.

Q. For deep navigation?

A. Yes sir.

Q. During the last ten years have you been on the Illinois river?

A. Yes sir.

Q. How frequently?

A. Oh, half a dozen times probably or more; by boat I have inspected the river more than that, but by steamer about half a dozen times, may be a dozen.

Q. Were you one of the Committee appointed by Governor Tanner instructed to inspect the drainage canal and report to him as provided by the law under which the drainage 6092 canal was constructed?

MR. JEFFRIES: Objected to as leading.

A. Yes sir.

Q. When were you appointed and how long did you serve?

A. I was appointed I think in May, 1899, and held that position until June, 1900.

Q. What were the duties of that position?

A. They were to inspect the drainage channel for the employment of competent engineers and also of the Chicago river from the lake to—the connection of the canal with the river, and ascertain if the Sanitary District of Chicago had complied with the law in the construction of the canal.

Q. As such commissioner what did you do?

A. We employed an engineer in chief and made complete surveys of the entire channel and of the Chicago river and made a full investigation of all the requirements of the law.

Q. What did you find?

A. We found that the law had been complied with.

MR. JEFFRIES: We object to the question as incompetent, irrelevant and immaterial and leading, and it is not a proper examination of the witness to require him to pass judgment as to whether or not the law has been complied with. It is a question of fact for the Court to determine upon the testimony of the witness, after the witness has detailed what 6093 has been done. I move to strike the question and answer out for the reasons stated in the objection.

Q. As a member of the Valley Association have you made any inspection of the Illinois river?

A. Yes sir.

Q. When and for what purpose?

MR. JEFFRIES: We object to the witness testifying in regard to the inspection he made of the Illinois river as a member of the Illinois River Valley Association for the reason that the corporation as such has not been shown to have had authority to make such examination, and whatever the witness might say upon the subject must be limited to his own personal observation as a private citizen and without reference to any position which he might hold in this so-called association.

MR. TODD: In reply to the objection, counsel for defendant Sanitary District desires to state that the witness is only called to express his observations as a private citizen, but as a private citizen to give his knowledge of the Illinois river in the discharge of his duties both which he owed to the State, as well as the duty which he voluntarily assumed to perform in behalf of the Valley Association.

A. I made an inspection during the summer and fall of 1900, and the summer and fall of 1901, and more particularly—
and I have made frequent inspections of the river since
6094 that time, but not so frequently.

Q. For what purpose?

A. Well, for the purpose of ascertaining the character of the water as compared with the water before the Chicago drainage channel was opened and also to make some estimate of the amount of the flow. I will add to that, the effect of the flow upon the Illinois river.

Q. Before the opening of the drainage canal, what was the character and quality of the water in the Illinois river?

A. When the water was low, it was bad looking and bad smelling water, especially in the upper portion of the river.

Q. From what point to what point?

A. Well, from Lasalle—it was more noticeable from Lasalle to Henry and it was also noticeable from Henry to Peoria, but not so much so.

Q. How was it from Peoria down?

A. It was in bad condition.

Q. Can you describe it more fully?

A. When the water was low, from Peoria down to Copperas Creek, it was usually observed that the waters were of a dark character with considerable sediment in it.

Q. How far down did that condition obtain?

A. To a certain extent all the way down to Copperas Creek.

6095 Q. Since the opening of the drainage canal, what has been the effect of the turning of the waters of Lake Michigan, into the Illinois river, upon the Illinois river and the waters of the Illinois river?

A. It has made the water very much clearer and very much better.

Q. What is the condition of the water immediately above Peoria, in Lake Peoria?

A. At the present time?

Q. At the present time?

A. Very good condition.

Q. How about the odor of the water?

A. There is no odor discernible.

Q. How is the condition below Peoria?

A. I couldn't testify so definitely in regard to that, only that the water has a darker appearance below Peoria than it is above; it is not in as good condition below as it is above.

Q. As compared with the condition of the water before the opening of the canal, how does the condition below Peoria today compare with what it was then?

A. It is much better.

Q. How about the character of the river itself?

6096 A. The river has a larger flow of water; I estimate it is from two and a half to three feet deeper, the water is clearer and the water better in every way for navigation and sanitary purposes.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. What did you say was the condition of the water of the Illinois river below Peoria since the canal was opened?

A. I said that it was better than it was before, but not as good as it was above Peoria.

Q. Are you acquainted with the water in the canal as it runs over Bear Trap dam?

A. Not at the present time. I have seen it several times, but not within a couple of years.

Q. What was its condition as compared with the condition of the water of the Illinois river immediately below Peoria?

A. It was in a much worse condition.

Q. Do you know whether or not the water makes a continuous flow from Bear Trap dam to Peoria?

A. I couldn't say positively. I could only judge by the depth of the Illinois river at low water.

Q. What did you find in this respect in the examination and your study of the water in the river since and prior
6097 to the opening of the Chicago drainage canal?

A. I found that the river where I had made the inspection principally above Peoria, was clearer and better and more of it, a greater depth than before the opening of the canal.

Q. Then you did not examine the condition of the river from Peoria through its entire existence from Bear Trap dam to the city of Chicago?

A. Only by casual observation in traveling over the water, which was quite frequently, both before and after the opening of the channel.

Q. Are you an expert on the sanitary condition of water?

A. No sir.

Q. When you say that the water is better you mean from observation?

A. From observation; from looking at the water.

Q. You say one of the objects of this Valley Association was to see that the law with reference to the organization of the Sanitary District of Chicago, and the construction of the drainage canal by it was complied with? Or was it done by the special commission referred to by you in your direct examination?

A. It was done by the special commission appointed by the Governor.

Q. Did you make a report?

6098 A. Yes sir.

Q. In writing?

A. Yes sir, made a report in June, 1900.

Q. Where did you file that report?

A. Filed it with the Governor and Secretary of State. The Secretary of State's was the official copy; we filed one copy with the Governor and one with the Secretary of State.

MR. JEFFRIES: I move to strike out all that the witness has said with reference to the findings of his commission, for the reason that the original on file in the Secretary of State's office is the best evidence.

Q. Do you know the number of gallons per minute of water that has been coming over the Bear Trap dam since the opening of the canal?

A. They measure the water by cubic feet. I couldn't state positively only from reports and conversations with the Board of Trustees of the Sanitary District, excepting at the time that the water was turned in. I knew then what the flow was.

Q. What practical steps did this commission take to ascertain the volume of flow through the canal and the river over Bear Trap dam?

A. We employed a prominent engineer, Mr. Fitzgerald of Boston to make surveys and investigations of the channel with the view of ascertaining the velocity of the current in the 6099 channel after the water was turned in and the capacity that it would have for carrying water with a current not to exceed three miles an hour. That investigation was made thoroughly and in that investigation our commission depended largely upon our expert engineer in making the proper estimate to ascertain the facts.

Q. Do you know personally that he performed this work or that he obtained this data from the officials and employes of the Sanitary District?

A. We employed different engineers—sub-engineers to make actual surveys of the whole work, including the Chicago river, without any reference to the trustees of the Sanitary District.

Q. How long in period of time was it that he was performing this work?

A. About six months we had him in our employ I think.

Q. With reference to dates, what particular time was he thus employed?

A. He was employed from—I can't state definitely when he commenced, but I think in July, 1899—and closed his work I think sometime in December, the last of December or the first of January. I will not be definite about the exact time, but that was approximately the time.

Q. This work then was done before the canal was opened?

A. Yes sir.

6100 Q. And your principal object was to observe the construction and capacity of the canal?

A. Yes sir.

Q. But upon the question as to whether or not the drainage district has been turning the required amount of water through the canal and over the Bear Trap dam since the opening, you know nothing?

A. Practically nothing, excepting that I can ascertain from the river here.

Q. Don't you know that the War Department at Washington restricted them from passing the full amount of water required by the statute under which the district was organized, through the canal?

A. I was so informed.

Q. And that since that order was made, the Sanitary District of Chicago has not been complying with the statute authorizing its creation and the construction of the canal?

A. I can't state that, but then I don't know the exact flow that they are making.

Q. The water here in the river is not used by the people of Peoria for drinking and domestic purposes?

A. No sir, not as a rule.

6101 Q. Is it not a fact that the Board of Health or the Health Commissioner of Peoria is on constant watch to prevent the use of the Illinois river for domestic purposes?

MR. TODD: I object for the reason that the witness is not qualified to testify upon what the Health Commissioner is doing.

A. No sir, I couldn't state. Not to my knowledge.

Q. Is it not a matter of public concern by the officials of the city and in public documents to the people that the water of the Illinois river should not be used for drinking purposes?

A. Not to my knowledge. I have never heard anything of that kind.

Q. What is your opinion with reference to the extent of the pollution of the river at Bear Trap dam by the sewage from Chicago, as compared with the pollution of the river by the sewage of Peoria?

A. In my opinion it is greater.

Q. And it is greater in proportion to the population?

A. I couldn't state as to that.

Q. I don't know on what you base your opinion then?

A. Upon the character of the water, upon the looks of the water.

ISAAC TAYLOR.

6102 E. M. WYATT,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. E. M. Wyatt, 403 Wisconsin Avenue, Peoria. I am on the Health Department at present.

Q. Were you at any time an inspector at the Stock Yards in Peoria?

A. Yes sir.

Q. During what time?

A. From 1897 to 1901.

Q. Where are the stock yards at Peoria?

A. They are in the south part of town here on South Street, on the river.

Q. What is the area of the stock yards proper?

A. Well, I suppose—well, I couldn't say exactly.

Q. Your best judgment?

A. Well as to the number of cattle and hogs that they handle there—

Q. I am asking about the extent of them in acres?

A. I would judge they were about a block and a half each way, perhaps two acres and a half in the yard; not to exceed that I don't think. 6103

Q. Are there any slaughtering establishments near them?

A. A couple of packing houses, slaughter houses—well there are three, two packing houses and one slaughter house.

Q. What were your duties as inspector of stock?

A. To look after the diseased animals that were shipped in.

Q. When you found a diseased animal, what became of it?

A. We generally had it for a post-mortem examination; we took it down to this public slaughter house and had it slaugtered there; called their assistant state veterinary and he examined it to see whether it was fit for food or not.

Q. Do you know of a disease called anthrax among cattle?

A. I never knew any of it here; I have heard of it but I didn't know it.

Q. With what diseases were the cattle which were brought here affected?

A. Well there is what they called the lump-jaw; cancer eyes and lung trouble.

Q. How many cattle annually passed through the yards in Peoria during the four years that you were inspector?

A. Well, I couldn't tell you; I would judge it would average somewhere from five to seven hundred a month, that was brought in here for home consumption.

Q. Was this yard also used as a feeding point in transit?

6104 A. Well sometimes through cattle would come through here and be taken off to feed, very seldom though. Cattle shipped in from Missouri and sometimes Iowa, would stop off here and feed.

Q. How many hogs passed through these stockyards in these four years, each year?

A. Well I suppose there was anywhere from 15,000 to 25,000 a month.

Q. How many sheep?

A. Very few sheep,—very few.

Q. Was there any disease among the hogs that you inspected here, and if so, what was it?

A. Well I never inspected the hogs; I was just on cattle.

Q. Do you know in a general way, whether there was hog cholera among the hogs shipped in here?

A. Oh, there were some cases of hog cholera.

Q. What would become of the animals infected with that disease?

A. They generally killed them and sold them for people to eat; the scalpers would buy them you know. The packing houses never bought them and packed them.

Q. How were the animals fed here?

A. They were fed on corn, the hogs were in a pen, on board floors. The cattle was fed in mangers, hay-racks, hay mangers. 6105

Q. Was there any drainage in the pens in the stockyards?

A. Some, yes sir.

Q. What was it?

A. Why to drain the water off; there was catch basins to take the water out of the yard, out of the pens.

Q. Into what did the drainage flow finally?

A. I think it went into the river. The cobs and the dirt on the floors was hauled out and thrown on the river bank.

Q. Would it then be carried off by water in the river?

A. Well it would have to get pretty high to carry it off; they filled up holes with it on the river; I suppose some of it went down the river though.

Q. What kind of slaughtering is done here in these slaughter-houses adjoining the yards, hogs or cattle?

A. Hogs and cattle both.

Q. How many hogs were slaughtered here in your judgment?

A. Well, Goden and Sons I think, kill anywhere from three to five hundred a day sometimes; they would average anyway I guess 250 a day the year around.

Q. And the other firm?

A. Well, about the same. That public slaughter house down below there, the reason it is called the public slaughter house is because the farmers bring their stock in and have it killed there.

6106 Q. How many cattle are annually slaughtered here by the two slaughtering firms?

A. Well it is pretty hard to make an estimate of that because they don't kill very many cattle; perhaps they will kill 300 a week, the two firms.

Q. Is this institution you call the public slaughtering house owned by the city or is it a private enterprise?

A. Private.

Q. Where are these slaughtering houses and the public slaughter house situated with reference to the Illinois river?

A. The public slaughter house is situated I guess about a couple or three hundred feet west of the river; the two packing houses about a block and a half from the river.

Q. Into what place is the sewage from these three institutions emptied?

A. Into the river I think.

Q. Have you now some position with the city of Peoria as an officer?

A. I am on the Health Department.

Q. As a sanitary officer what are your duties?

A. To look after anything, to see there is no garbage, no nuisance laying around the street, to look after the vaults and
to see that the lots are cleaned up of weeds and rubbish
6107 and nothing strewn on the streets or alleys.

Q. What is done here with the contents of privy vaults?

A. Some of the vaults are connected with the sewerage system; some are hauled and dumped; I don't know where they do dump them—those that are not connected with the sewers. I think there is a place provided by the city though, where all this dumping is done; I think so.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How many stock yards companies are there in Peoria?

A. Only one.

Q. And that covers about two acres and a half?

A. I should judge about two acres and a half.

Q. How far is it situated from the river?

A. About a block and a half.

Q. What is the character of this public slaughter house that you spoke of?

A. Well, they kill stock there for anybody that brings it around; a great many of the farmers hogs that they kill for winter use, they bring them there and have them slaughtered,

and most of those scalpers in the yard there take theirs down there and kill them and some of the butchers that does their own butchering goes there and has them killed too; that is the
6108 reason it is called the public slaughter house.

Q. There are no diseased cattle killed there that you know of?

A. No, nothing only what are caught by the inspector and taken there to be killed; then they are post-mortemed by the assistant state veterinarian.

Q. There are no diseased cattle turned into the yards are there?

A. No, no fever or anything of that kind that I ever know of.

Q. And none goes out?

A. And none goes out; no if they would come here they would be quarantined and sent out; that would be the fever cattle; those with sore eyes, they would be condemned and killed if they weren't fit for food.

Q. Now what about these cattle that have sore eyes and lungs?

A. They are generally condemned; they are pressed and sold for fertilizers. They are steamed and then pressed.

Q. In other words cooked?

A. Oh yes sir, thoroughly cooked, dried and ground up and then go to the fertilizer.

Q. Could you approximate the number of cattle, hogs and sheep that go through the stock yards each year?

A. No, nothing more than I told there in answering that
6109 to the best of my ability.

Q. How much of your time is occupied in working as a health officer for the health department of the city?

A. Every day.

Q. Do you investigate and keep careful watch upon the manner and living and natural habits of the people living along the banks of the river?

A. That is not my territory at all.

Q. You have nothing to do with the territory along the river?

A. No sir.

Q. You do know though that every precaution is taken for the good of the health of the people living along the river?

A. It appears to be. I know there is up in my part of the town. There are eight wards here and there are eight sanitary inspectors, and my ward happens to be west. I have nothing to do with the river but I think that the people are doing everything they can for the benefit of the health of the people.

Q. They don't use the water from the river?

A. No sir, quite a good many have got wells and they all use city water.

6110 Q. How long have you been on the Board of Health?

A. Going on three months.

E. M. WYATT.

6111 R. D. CLARKE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. R. D. Clarke.

Q. What is your business?

A. In the distilling business.

Q. What distillery are you connected with?

A. Clarke Brothers & Company.

Q. What position do you hold in the distillery?

A. General Manager.

Q. Are you an officer of the Company?

A. Yes sir.

Q. What office do you hold?

A. General Manager of the concern and a director of the company.

Q. How long have you been in the distilling business?

A. Since 1892.

Q. Connected with the same distillery you are connected with now?

A. No sir.

6112 Q. What other distillery were you connected with prior to this one?

A. Clarke Brothers.

Q. What became of that distillery?

A. We organized under Clarke Brothers and Company and built a new distillery.

Q. Are you connected with any other institution except the distillery?

A. Yes sir.

Q. What other?

A. President of the Thomas & Clarke Cracker Manufactory.

Q. Any other institution in Peoria?

A. President of the Peoria Board of Trade.

Q. How long have you been president of the Peoria Board of Trade?

A. During this fiscal year.

Q. Are you acquainted with the practical operation of a distillery?

A. Yes sir.

Q. In your experience as a distiller, have you fed any cattle?

A. Yes sir.

Q. Will you describe the method of feeding cattle in the 6113 distilleries at Peoria?

A. Formerly all distillers attempted to feed one head of cattle for every bushel of grain mashed. At the present time there are feed houses taking the place of the cattle feeding industry, and there are not one-fifth the cattle fed here that there were formerly. The method used today is to give one steer about 275 gallons of slop and eight pounds of hay per day. This slop contains about twelve to thirteen pounds of solids, the rest of it is liquid, or gluten in solution.

Q. What is the purpose of giving the hay?

A. To hold the slop in them.

Q. Do you know the average number of cattle fed in Peoria during the last ten years?

A. For the last five years they would average about 10,000, perhaps a little more.

Q. Are these cattle salted?

A. Yes sir.

Q. In the fattening of 10,000 head of cattle, what is the amount of salt used?

A. About five carloads a year.

Q. How much salt is contained in a car load?

A. About 140 barrels.

6114 Q. How many pounds of salt in a barrel as used in this business?

A. Between two and three hundred.

Q. How is this salt fed to the cattle?

A. It is thrown along in front of the lead troughs, so they can lick it up if they want it.

Q. Do you know about how much excreta is discharged from a steer in 24 hours?

A. I don't believe I could answer that; it is a matter of record I think the Agricultural department in Washington know. I have seen it but I hate to say.

Q. What becomes of the excreta from the cattle?

A. Most of mine runs over the bottom-land back of the distillery.

Q. How long has that disposition been made of it?

A. Two years.

Q. How many cattle do you feed in your distillery?

A. 600 head of bulls at one time.

Q. Do you know of any other distillery which makes the same disposition of the offal of the cattle as you have of yours during the last two years?

A. No sir.

Q. Prior to that time what became of the offal?

A. We didn't feed at the new house at all.

6115 Q. In the old distillery what became of it?

MR. JEFFRIES: I object to the question for the reason that the old distillery was operated prior to the opening of the canal and was not in operation at the time the canal was opened in 1900, and it is therefore immaterial.

A. It run in the river.

Q. What becomes of the excreta of the cattle fed in other distilleries in Peoria?

A. It runs in the river.

Q. In the mashing of grain for distillation purposes, do you use the water of the Illinois river?

A. I have no connection with the river whatever.

Q. Do you know whether it is used in other distilleries?

A. Not positively at present.

Q. Since the opening of the canal do you know of any distilleries which use the water of the Illinois river for mechanical and condensation purposes?

A. They all use it for boilers except myself.

Q. Have you used it for boiler purposes since the opening of the drainage canal?

A. At one of my steam plants I have.

Q. Which plant is that?

A. The rectifying house.

6116 Q. What is a rectifying house?

A. Place where we rectify whiskey.

Q. How long have you used the Illinois river water in that business, for steam making purposes?

A. Four years.

Q. Are you acquainted with its operation in this institution?

A. Yes sir.

Q. How does the water of the Illinois river compare today with what it did before the opening of the drainage canal, in the manufacture of steam and for mechanical uses of the water?

A. It is better for boiler purposes.

Q. In what way?

A. The boilers don't seem to have the tendency to foam that they used to have when pushed pretty hard.

Q. Have you investigated the foaming in the boilers?

A. Yes sir.

Q. What is it that caused the boilers to foam before the opening of the drainage canal in using the waters of the Illinois river?

A. In my opinion, I think it must have been the organic matter.

Q. Will you explain that condition at length?

6117 A. On investigating this subject I find that there are three principal things that make boilers foam; one is sodium carbonate, one is organic matter and one is an alkali. I don't think we have enough sodium carbonates or alkalies in the water to make it foam, and therefore I judge it must be the organic matter. Our principal scale forming substances are carbonate of lime and magnesia, and sulphate of lime and magnesia.

Q. How did this foaming in the boiler affect the machinery?

A. Liable to knock a cylinder head out.

Q. Were any precautions taken prior to the opening of the canal to guard the safety of the boilers and the cylinder heads?

A. We took our chances on it, but at times we would put it through a heater and take out all we could in that way, the sediments. And we used different boiler compounds, but I don't think a boiler compound is good for foaming.

Q. What was the effect of this foaming upon the generation of steam?

A. I judge that the small particles would settle in a slush or mud in the bottom of the boiler and if your steam got at all low, they would prime and flow over into the engine, especially with a neglect of being blown off regularly.

6118 Q. Since the opening of the drainage canal, what changes, if any have you observed in the effect of the water of the Illinois river upon the boilers and machinery?

A. The scale appears to have a little different color to it.

Q. How about the foaming?

A. I don't hear of any complaint of it.

Q. Have you observed yourself, the operation of machinery using the water from the Illinois river?

A. Yes sir.

Q. Where and under what conditions?

A. In our old rye house; also at the rectifying house and at other distilleries.

Q. Have you formed a conclusion as to the condition of the water today for steam making purposes as compared with the water before the opening of the drainage canal—in the Illinoios river?

A. I have.

Q. What is that opinion?

A. It has very much improved.

Q. Are you acquainted with the Illinois river?

A. I am between the dams.

Q. What dams?

A. Copperas Creek and Henry.

6119 Q. How long have you been acquainted with that stretch of the river?

A. Fifteen or twenty years—fifteen years I guess.

Q. Do you own any land along the Illinois river?

A. Yes sir.

Q. How much?

A. Half owner of about 1000 acres.

Q. How did you become acquainted with tnat stretch of the Illinois river?

A. Hunting and fishing and on my yacht.

Q. How large is your yacht?

A. 52½ feet over all and ten foot beam.

Q. Operated by steam?

A. Gasoline.

Q. How often are you on the river?

A. Average once a week in the summer time and fall.

Q. Did that average prevail prior to the opening of the drainage canal?

A. Not so much, but I was on the river very frequently.

Q. What was the condition of the water in the Illinois river prior to the opening of the drainage canal from Peoria to Henry?

A. Summer or winter?

6120 Q. Both; all the seasons that you can speak of.

A. During high water it was good, but a trifle muddy; during the low water stage there appeared a sort of a green scum that would form and bubble after the boat, which I have not noticed of late.

Q. Was there any odor to the water?

A. Yes, considerable at times.

Q. What was the character of the odor from Peoria to Henry?

A. When the ice broke up, it was very foul.

Q. Did you observe any effects of the water under those conditions, upon fish in the river?

A. I have seen thousands of dead ones along the river, but do not remember seeing them above upper Peoria bridge.

Q. What was the condition of the water between Peoria Bridge and Pekin?

A. I don't think the current was as strong there as between Peoria and the Upper Bridge at Peoria.

Q. How did the stretch of river from Peoria bridge to a distance half-way between Peoria and Pekin compare with the same distance above Peoria prior to the opening of the drainage canal?

A. The river was considerably more dirty.

6121 Q. Any other differences?

A. It smelled a little different.

Q. What was the cause of that condition?

A. There could be several reasons for it.

Q. What are they?

A. Offal from the cattle and sewage from the city. Those are the principal ones I guess.

Q. As you left Peoria towards Pekin, how far down the river did the conditions at Peoria remain the same?

A. About to Kickapoo Creek.

Q. After leaving the creek, what changes, if any, did you notice in the Illinois river?

A. I noticed the color of the water; it seemed to be more of a muddy color caused by the washings from the hills, coming in from the creek.

Q. How did the condition at the Copperas Creek dam compare with the conditions at Peoria before the opening of the canal?

A. I always considered the river at Copperas Creek dam in the same condition that the river was above Peoria.

Q. Where was it that you observed these great quantities of dead fish?

A. I have seen them all the way along the river from a few miles above here, down. I never paid much attention to it
6122 above the upper bridge.

Q. Since the opening of the drainage canal, how does the water between here and Henry compare today with the water that was there prior to the opening of the drainage canal, at similar stages?

A. We have never seen the low stage of water since the canal was opened that we saw previously, therefore I cannot judge as to that.

Q. How does it compare in average condition today with what it was before the opening of the canal?

A. It seems to be very much improved.

Q. In what resepct do you note the improvement.

A. The color of the water and about an eight or nine foot stage.

Q. How about the odor?

A. That surely is better at that stage.

Q. Have you observed lately the condition of the Illinois river opposite the distilleries and glucose factory in front of Peoria?

A. Yes sir.

Q. What is the condition of the water along that two or three mile stretch of river?

A. It is much dirtier than it is above town.

Q. Does that condition immediately in front of Peoria 6123 obtain all the way down the river to Copperas Creek?

A. I am of the opinion that it disappears before it reaches Kickapoo Creek, less than two miles.

Q. And how does the water become as you go down the river towards Copperas Creek dam?

A. To Pekin it gets better; below Pekin for a mile or two it is bad again and by the time you reach Copperas Creek or even Spring Lake, the water is in good condition.

Q. How does the general condition of the water in the Illinois river from Copperas Creek to Henry, taking in the conditons that exist at Peoria and Pekin compare today with the conditions that existed prior to the opening of the drainage canal?

A. It appears to me it is very much better.

Q. Do you know of anyone who drinks the water of the Illinois river today?

A. I have drank it myself.

Q. How frequently?

A. Only when I couldn't get anything else to drink.

Q. Where did you drink the water; at what points on the rvier?

A. At Rome Flats.

Q. Did you ever experience any ill effects from the drinking of the water?

6124 A. None whatever.

Q. Have you known of others who have drunk the water?

A. I know a doctor that drank it; at Duck Island.

Q. Do you know of anyone who has gotten typhoid fever from drinking the water of the river since the opening of the canal?

A. No sir.

Q. What is your opinion as to the general sanitary condition of the waters of the Illinois river at present as compared with before the opening of the canal?

A. I took it for granted it is better than it used to be from the absence of smell and the color.

Q. Are there as many mosquitoes on the river now as there was before the opening of the canal?

A. There don't seem to be as many this year or last year as formerly, during a low stage of water.

Q. Do you notice any difference in the fish in the river today over the fish of before the opening of the canal?

A. I have eaten them both times; I don't know as I see much difference.

Q. Could the water today, of the Illinois river, be used for manufacturing purposes?

MR. JEFFRIES: Object to the question because the character or kind of manufacturing purposes is not stated in the question.

A. What kind of manufacturing purposes?

6125 Q. In the distilling business?

A. It could be used in the mashing process.

Q. Do you know of any distilleries that use it for that purpose?

A. Not positively, at present.

Q. You are a practical distiller, are you not?

A. Yes sir.

Q. Could the water be used to advantage in the mashing process at the distillery?

A. I would just as soon have it as any other.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. In what way is it used in the mashing process?

A. During that process it is boiled at 310 degrees.

Q. The corn with the water?

A. Yes sir.

Q. Now, how is the water afterwards separated from the corn or the product of the corn?

A. It is converted into sugar first; then to spirits—or then to alcohol, and a whiskey vapor is made at a much lower temperature than steam, hence the vapors are removed in that way and the water vapors are not saved at all to speak of. What water is in it is afterwards taken out.

6126 Q. So that the water in the condition in which it is drawn from the river does not and would not enter into any articles that you manufacture?

A. No sir.

Q. The whiskey is obtained by a process of evaporation?

A. Yes sir.

Q. And the water is poured into the vats, I suppose they are, containing corn?

A. Yes sir.

Q. And boiled to what temperature?

A. 310 degrees.

Q. Mr. Clarke, what did you say became of the offal from the cattle that you feed in your pens?

A. It is run onto the low-lands back of the distillery; we make ground in that way.

Q. Do you feed your cattle any substance that would be deleterious to health?

A. I will eat anything but the hay that my cattle get.

Q. I understood you to say that there was not now fed more than one-fifth of the cattle per annum that were fed at Peoria several years ago?

A. I judge not more than that.

Q. That is approximately correct?

A. Yes sir, it is so at my house.

6127 Q. Do you know how many bushels of corn you consume at your distillery during a year?

A. About a million bushels.

Q. Are there any chemicals used in your distillery that goes out in the offal out of the pens of the cattle, that finds its way into the Illinois river?

A. No chemicals used in distilling, whatever.

Q. Now in reference to the salt that is fed to the cattle, I suppose that has decreased in amount with the extent of the reduction in the number of cattle fed, has it not?

A. Not in the exact proportion; it takes more salt for cattle eating cotton-seed hulls in place of hay, than it does when they are fed hay.

Q. How much more does it take?

A. A quarter more.

Q. Then even assuming that it takes one-fourth more salt for the cattle under the present conditions than it formerly did, on account of the reduced number of cattle fed at the distillery, there is consequently still a very great reduction in the amount of salt consumed?

A. About two-thirds or three-fourths reduction.

Q. Mr. Clarke when you say that the water in the river is better now than it was before the canal was opened, you express that as your opinion depending upon the mechanical use
6128 of the water for the boilers and from your observation of the river?

A. That's the only way I have, yes sir.

Q. It is your opinion that the water in the river has become void of the impurities discharged into it at Peoria, by the time it reaches Copperas Creek dam?

A. It appears to me much before that.

Q. And that is simply your observation?

A. Yes sir.

Q. Was that also true prior to the opening of the canal?

A. Yes sir.

Q. Is there anything to your knowledge that is discharged from still houses in Peoria into the Illinois river that are injurious to health?

A. I don't think there is.

Q. As far as particular ingredients are concerned?

A. No sir.

Q. You are not an epidemiologist I suppose?

A. No.

RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. Mr. Jeffries asked you if the river water if used by you in the distillery would enter into the product, and you answered "No." Would any water whether received from the Illi-
6129 nois river or elsewhere enter into the product?

A. In some cheap whiskies, yes.

Q. But in the product that you manufacture?

A. Not at 100 proof,—not at absolute proof.

Q. And when water finds its way in whiskey, it is after the whiskey is made, is it not?

A. All except a very small percentage.

R. D. CLARKE.

Whereupon a recess was taken until 1:45 P. M., the same day at the same place, Friday, August 14, 1903.

6130 National Hotel, Peoria, Illinois.

1:45 P. M., Friday, August 14th, 1903.

Continuation after recess.

Present the Commissioner and the same counsel representing the respective parties.

LOUIS P. BAUER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. Louis P. Bauer; Superintendent of the Glucose sugar Refining Company, Peoria, Illinois. I reside at 224 Missouri Avenue.

Q. How long have you been superintendent of the guucose works here?

A. Since June, 1898.

Q. Where are the works situated with reference to the Illinois river?

A. They are situated within 500 feet of the shore of the Illinois river.

6131 Q. And in the city of Peoria?

A. And in the city of Peoria.

Q. What material is used in the manufacture of glucose?

A. Corn.

Q. How much corn do you use here each day?

A. On an average about 31,000 bushels.

Q. Have you been continuously in operation since January, 1900?

A. No sir.

Q. How much of the time have the works been idle?

A. About six weeks last year, I think it was about two months.

Q. What is the first process to which the corn is subjected?

A. It is steeped in a weak solution of sulphurous acid.

Q. Mixed of course with water?

A. Water.

Q. After the corn is steeped in the water, what becomes of this water?

A. It is concentrated in vacum apparatuses.

Q. What is taken out of the water by the concentration?

A. Well, there is pure water; pure water is taken out and the remainder in the concentrated state is mixed with feed.

6132 Q. When this water has gone through the concentration process what becomes of it?

A. Well the water becomes condensed and goes into the sewer.

Q. What color is it when it goes into the sewer?

A. Well there is no color to it. It is the same as going through a distilling process.

Q. After the corn is steeped, what do you do with it next?

A. Ground.

Q. In a wet state?

A. In a wet state.

Q. What is then done with it after it is ground?

A. First we separate the germ from the corn.

Q. What becomes of the germs?

A. From the germs we extract the oil.

Q. What becomes of the remainder of the germ?

A. The remainder of the germ is oil cake.

Q. After the germs are extracted what is done with the remainder of the ground product?

A. It is drawn through another grinding process; and is ground finer.

Q. Then what is done with this fine meal?

A. Then this mash passes over a silk bolting cloth. It passes through a stream of water which washes out the starch.

Q. After it comes into the form of starch do you use water
6133 upon it to wash it?

A. Yes.

Q. What becomes of the water which is used in washing the starch?

A. After the starch has been all settled off this water goes into the sewer.

Q. Has it a color and if so, what kind?

A. It is almost colorless, a little whitish, but almost colorless.

Q. What substance does it contain?

A. It contains a very small percentage of organic matters.

Q. Does it contain any percentage of acid?

A. Traces of acid.

Q. What kind of acid?

A. Sulphurous acid.

Q. Do you use water in this establishment for the purpose of washing out the rooms where the starch is dried?

A. We use water, not in the room where our starch is dried but in the room where the starch is separated from the water.

Q. For what purpose do you use it there?

A. For the purpose of washing the floors.

6134 Q. What becomes of the water used in washing the floors?

A. It goes into the sewer.

Q. Has it any color?

A. It has a whitish color.

Q. Is there any other refuse matter from your establishment than this water that runs into the sewer?

A. No sir.

Q. All the rest of the product you use in some form?

A. Yes sir.

Q. How many gallons of water a day do you use in the process of manufacturing glucose in your establishment?

A. We use altogether about six million gallons.

Q. From what source do you obtain the water?

A. About 1,000,000 from the river and the balance from wells.

Q. Where are these wells with reference to the Illinois river, how far away?

A. About one thousand feet; some are about 1000 feet and some about 800 feet.

Q. How deep are they?

A. About 32 feet.

Q. How many wells have you there?

A. Two, and then we have ponds besides, driven wells.

Q. How many driven wells have you?

6135 A. I think about ten.

Q. How deep are they?

A. I think they are forty feet, I don't know the exact depth of them they were there before my time.

Q. How far are the driven wells from the Illinois river?

A. About 800 feet.

Q. Are any part of your buildings subject to overflow in times of high water in the Illinois river?

A. No.

Q. Do you find any fluctuation or variation in the amount of water which you obtain from these various wells?

A. Well I find that the supply of these wells we are speaking of is bigger now than three years ago.

Q. Before the opening of the drainage canal, were you sometimes embarrassed by a short supply of water in these wells, an inadequate supply?

A. Yes sir, one summer we were.

Q. Since the opening of the drainage canal have you had any such trouble?

A. No sir.

Q. Does the amount of water in these wells vary with the height of the river?

A. I believe it does.

6136 Q. What kind of water did you use before the opening of the drainage canal for steaming purposes?

A. River water.

Q. What kind do you use since the opening of the canal?

A. Same thing.

Q. Do you filter the water before you use it for your boilers?

A. Yes sir.

Q. Before the opening of the drainage canal, did you sometimes use the river water direct for steaming purposes?

Objected to as leading.

A. Yes.

Q. Under what circumstances?

A. During times the filters were out of commission, when improvements were being made.

Q. What effect did the unfiltered water before the opening of the drainage canal have upon your boilers?

A. It caused them to foam.

Q. When they were cleaned out, after you were using the unfiltered water, what was found in the boilers?

A. A large amount of mud, soft mud.

Q. Since the opening of the drainage canal, do you some-
6137 times use the unfiltered water?

A. Yes sir.

Q. Under what circumstances?

A. Not long ago we had to renew the sand in those filters and a carload of sand was not shipped properly, and we had to wait for the sand about a week or two and during that time the filters were out of commission.

Q. Did you during that time use the unfiltered water?

A. Yes sir.

Q. How did that water act in your boilers?

A. There was nothing noticed; there was no foaming of the boilers.

Q. Do you use the river water for washing out the starch room, or the well water?

A. The well water.

Q. Which is the better water for manufacturing purposes in the Illinoios river, that before the opening of the drainage canal or that since?

A. After.

Q. Of the 6,000,000 gallons of water which you use each day how many gallons did you say are returned to the river through the sewers?

A. About the same amount.

6138 Q. How long has glucose been manufactured in Peoria?

A. I believe since 1878.

Q. Were the processes of manufacture formerly somewhat different than those now in use?

A. Yes sir.

Q. Was there formerly more solid matter discharged into the river through the sewers?

A. Yes sir, more or less.

Q. What kind of substance was that?

A. The gluten of the corn more or less starch and slop.

Q. Formerly were cattle fed at the glucose works?

A. Yes sir.

Q. About how many?

A. I do not know.

Q. When did they cease feeding cattle there to the best of your knowledge?

A. I do not know what year; I think about 1886.

Q. Are the glucose works at Pekin a branch of your works here or a separate institution?

A. Why, they belong to the Illinois Sugar Refining Company.

Q. Is that a separate institution from yours or are you all in the same institution?

A. Separate institutions.

Q. What is the substance which the glucose works at 6139 Pekin discharges into the river?

A. The Pekin factory does not concentrate its steep water; that is, they do now; they haven't done so until recently.

Q. And in that respect their manufacture is different from yours?

A. Yes sir.

Q. Before concentration, what is this steep water, what substances has it in it?

A. Well, it contains soluble part of the corn which consists of sugar, gluten and starch.

Q. Is that substance capable of dissolving in water or does it remain hard?

A. Yes, soluble in water. That is, there is only a certain amount of starch in the corn and a certain amount of gluten and the sugar that is soluble, and that is the stuff that undergoes the steeping process.

Q. What is the material deposited by the Pekin factory formerly, which creates a stench when exposed to the open air?

A. Well it is the substances contained in the steep-water that I mentioned before.

Q. How long since your factory here commenced the concentration of the steep-water?

A. About eight years ago.

Q. Prior to that time was the steep water discharged into the river?

6140 A. Yes sir.

Q. Do you know at that time what the capacity of the glucose works here was, as to the amount of corn used and their water consumption?

A. I think at that time it was about 12,000 to 15,000 bushels.

Q. Per day?

A. Per day.

Q. What is the capacity of the Pekin works now?

A. I don't know.

CROSS-EXAMINATION.

By Mr. Jeffries.

Q. Do you have anything to do with the Pekin works?

A. No sir.

Q. Now what is the correct name of the company that you are superintendent of here?

A. The Glucose Sugar Refining Company.

Q. When was the Glucose Sugar Refining Company organized?

A. I believe in 1896.

Q. Was it organized by the purchase of some other company or companies?

A. Yes sir.

6141 Q. What company was it the successor of?

A. The American Glucose Company.

Q. Any others?

A. Yes, the Rockford Sugar Refining Company.

Q. Is that all?

A. Well the Davenport Syrup Refining Company.

Q. Any other companies here in Peoria?

A. The Peoria Grape Sugar Company.

Q. Any others in Peoria?

A. No sir.

Q. Now the home office of your company is in New York is it not?

A. Chicago.

Q. The home office of the company down at Pekin is at New York?

A. Well I don't know as to that; they have got an office in the Rookery Building in Chicago.

Q. You say you have fed no cattle at the glucose works in Peoria since 1886?

A. Well I am not sure about that; possibly they have fed cattle here longer, but they didn't feed any after 1890.

Q. How long have you been connected with the company?

A. I made a mistake; they were organized in 1897. I have been connected with them since 1897.

6142 Q. There has been no cattle fed since you have been connected with it?

A. No sir.

Q. In your direct examination you say that there are traces of acid that go out into the water into the sewers?

A. Yes sir.

Q. What percentage of that material goes into the sewers—of that acid?

A. Of the total amount of water?

Q. Yes.

A. I should say about ten per cent. of the total amount of water.

Q. Yes, but the proportion of the acid to water then is ten per cent. is it?

A. No.

Q. That's what I am driving at?

A. No, about ten per cent. of the water that goes out of the factory contains traces of acid. I don't think it would be over about .001 part of a per cent.

Q. It is practically incapable of calculation is it not?

A. It can be calculated by chemical analysis.

6143 Q. Those traces are not sufficient to be observed with the eye are they?

A. You could only notice it by taste; you couldn't see it in the water.

Q. What did you say was the color of the water or matter that runs into the sewers?

A. Almost as clear as the river water.

Q. It is clearer than the river water, isn't it?

A. Not now.

Q. Of the six millions of gallons of water that you use in your factory per day, 1,000,000 of it is drawn from the river?

A. Yes sir.

Q. In what way do you use the water that comes from the river?

A. In a filtered way.

Q. Now that was both before and after the opening of the drainage canal?

A. Yes sir.

Q. Are there any solid matters passing out of the factory into the sewers in the water?

A. No sir.

Q. How is that avoided?

6144 A. Well by improved processes of operation.

Q. Processes of evaporation?

A. Yes sir, evaporation and separation.

Q. What do you do with the pulp or hull of the corn?

A. It is formed into feed.

Q. And all other materials that are not used in the preparation of the articles manufactured, go into the feed, do they not?

A. Yes sir. Well, the feed you know is a manufactured article too.

Q. Well, everything else, the refuse and everything of that kind goes into the feed?

A. Yes sir.

Q. Now you commenced to concentrate this water about eight years ago—the steep water?

A. Yes sir.

Q. That takes out all the solids, does it?

A. Yes sir.

Q. What article or product does the company of which you are superintendent, manufacture?

A. Well we manufacture glucose, starch, dextrine, oil and feed.

Q. Do you manufacture sugar?

A. Well yes, glucose and sugar are about the same. I may mention grape sugar.

6145 Q. Grape sugar is syrup, and sugar is solid glucose?

A. Yes sir.

Q. Now is there any other material deposited in the Illinois river by your company in the operation of its business, which you have not mentioned?

A. No sir.

Q. To what extent does the refuse and other material carried from your factory into the waters of the Illinois river, pollute that water?

A. I think to a very small extent.

Q. I will ask you if it isn't a fact within your knowledge in the last eight years, that there is less material, and being continually less material and offal deposited in the Illinois river at Peoria, than formerly?

A. Yes sir. It is less than eight years back.

Q. And has been gradually getting less all the time?

A. Yes sir. LOUIS P. BAUER.

6146 ADOLPH WOOLNER, JR.,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Adolph Woolner, Jr.

Q. What is your business?

A. I am manager of the Woolner Distilling Company.

Q. What is the capacity of the Woolner Distilling Company?

A. Well, the Woolner Distilling Company is just in process of construction, but I have been manager of the Atlas Distillery for the past nine years.

Q. What is the capacity of that distillery?

A. 7,500 bushels in 24 hours.

Q. How long have you been connected with the distilling interests in Peoria?

A. Since 1880.

Q. Are you familiar with the methods employed here by the distilleries in feeding cattle?

A. Yes sir.

Q. Have you fed cattle yourself in your distillery?

A. Yes sir.

6147 Q. What number of cattle has been fed here in Peoria by the different distilleries during the last seven or eight years, including the present year?

A. There have been as high as 40,000 head of cattle fed at one time, but I think that is more than seven years ago.

Q. Well, say ten years.

A. I should judge—

Q. When did they feed 40,000 head of cattle here?

A. In 1887 or 1888 I think they fed 40,000 head of cattle.

Q. What number of cattle are being fed now?

A. I should think in the neighborhood of 10,000 head now.

Q. How many head are fed in Pekin?

A. I am not positive, but I think between 5,000 and 8,000 head; I am not sure.

Q. What are the cattle fed on?

A. They are fed on the waste material from the distillery after the alcohol has been distilled.

Q. Has it a name?

A. Well, it is called slop—distillery slop.

Q. How much slop will a steer eat in 24 hours?

A. We generally aim to feed them about a bushel to the head, of distill; a distilled bushel.

Q. How many gallons?

A. That would be about 40 gallons.

6148 Q. How many pounds in a gallon of that slop?

A. I should judge it would weigh in the neighborhood of ten pounds to the gallon.

Q. That would be how many pounds of slop fed to a steer in 24 hours?

A. That would be 400 pounds.

Q. Do you feed them anything else?

A. Yes, they receive besides the slop, about ten or eleven pounds of hay and a small amount of salt.

Q. Do you know how many tons of urine and feces are discharged by a steer in one year?

A. I suppose I could tell if I had time to figure it out.

Q. I wish you would figure it out.

A. (Witness computes.) The only way I can get at it is this, a steer will gain in eight months feeding very close onto 400 pounds. That is 240 days that they are on feed. During that 240 days he will consume 98,400 pounds of liquid and solid food. As there is only 400 pounds gain on the steer the balance naturally must pass away from him.

Q. It leaves 98,000 pounds for eight months feed?

A. Yes.

Q. And for twelve months it would amount to what?

6149 A. About 120,000 pounds; about sixty-odd ton a year.

Q. And what would be the discharge from 40,000 head of cattle?

A. Well, it would be just 40,000 times that amount? It would be 2,400,000 tons.

Q. That would represent the amount of excreta from 40,000 head of cattle, would it not?

MR. JEFFRIES: I object to the question because it is leading and an attempt to put the answer in the witness' mouth, and for the further reason that it is argumentative.

A. About that.

Q. How many tons of excreta would come from 18,000 cattle?

A. 1,080,000 about.

Q. How many from 10,000 cattle?

A. 600,000, about.

Q. What becomes of the urine and faecal discharge from the cattle that are fed here in the distilleries?

A. It is run into the river.

Q. What river?

A. Illinois river.

Q. Has that always been the custom here?

A. Yes, sir.

Q. So that the amount of pollution from the cattle-sheds of
Peoria from 1887 to the present, has varied from 2,400,000
6150 tons when 40,000 head of cattle were fed and 600,000 tons
when 10,000 head of cattle were fed, is that correct?

MR. JEFFRIES: Objected to because the question is leading, argumentative, and counsel answers the question himself without respect to what the witness might say.

A. About that.

Q. Were you familiar with the Illinois river before and since the opening of the drainage canal?

A. Yes, sir.

Q. Did you use the water of the Illinois river for steam-making purposes before the canal was opened?

A. Yes, sir.

Q. And since?

A. Yes, sir.

Q. How does its use since compare with its use before the opening of the drainage canal?

A. I think the water is some better for steam-making purposes.

Q. Did it foam before the opening of the canal?

A. We had some trouble with foaming water before.

Q. Have you had any since?

A. Since the canal has been opened we have had very little trouble.

6151 Q. Have you been upon the Illinois river before and since
the opening of the drainage canal?

A. I have.

Q. What was the condition of the water in the Illinois river, prior to the opening of the drainage canal, from Peoria above and from Peoria bridge below?

A. I do not think that we had as much current in the river before the drainage canal was opened, and the water was sluggish and stagnant, and had a bad appearance and considerable odor.

Q. Was the water any different above Peoria than it was below the Peoria bridge?

A. Well, I think there was some difference owing to the less current, it naturally made the sloughs rather stagnant.

Q. How about that section of the river that received the discharge from the distilleries and cattle-sheds before the opening of the drainage canal?

A. Well, at low water, it was in pretty bad shape.

Q. Did it have any aroma to it?

A. Why, there was some smell.

Q. How much of a smell?

A. It is very hard to judge, but there was some.

Q. How does the condition of the river today compare with the river before the opening of the drainage canal?

A. I don't think it is any worse; if anything, some better.

6152 Q. How about the clearness of the water?

A. I think it is some little clearer than it was before.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How many cattle did you say were fed annually at Peoria for the last eight years?

A. Well, since 1887 I can't state the exact number, but we have had as high as 5,000 head of cattle in the cattle-sheds at a time; it varies; some years more and some years less, but that was about the average.

Q. When was that?

A. 1887 or 1888.

Q. The number has been decreasing of late, has it not?

A. Yes, sir; they are feeding less than they ever have fed.

Q. How many were fed last year?

A. I don't think there were over 10,000 head fed in Peoria last year.

Q. How many have you fed in your company, the Atlas?

A. That has fed 2500 head for the past nine years. That is, about that.

Q. This new company that you are organizing, how many do you intend to feed?

A. We do not intend to feed any.

6153 Q. What are your intentions as to the disposition of the pulp in the new factory?

A. Intend to dry the feed, to dry the slop.

Q. And export it?

A. Yes, sir; export it and for domestic purposes.

Q. Your idea of the condition of the water in the Illinois river being better since the opening of the canal than it was prior thereto, is based upon what?

A. It is based on two reasons; the first reason that the amount of water that is being sent down from the canal gives the river a stronger current, which naturally clears the river better than when the river is sluggish; secondly, that there is less cattle being fed and will be fed; there is less refuse going into the river.

Q. Less cattle being fed where?

A. Here in Peoria.

ADOLPH WOOLNER, JR.

6154 D. S. BROWN, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. State your name, residence and occupation?

A. D. S. Brown; 806 Glen Oak avenue, Peoria, Illinois; in the real estate and piano business.

Q. Have you formerly been a distiller in Peoria?

A. Yes, sir.

Q. When were you engaged in that business?

A. From 1876 to 1886.

Q. Where was your distillery?

A. About three miles from the courthouse down the river.

Q. From 1876 to 1886, how many distilleries were in operation in Peoria?

MR. JEFFRIES: I object to the question because it refers to the condition that existed long years before the opening of the Chicago drainage canal.

JUDGE JOHNS: In reply to which counsel for defendant State of Illinois, asks that in reference to the condition of the

Illinois river which was endured by the State of Missouri and the City of St. Louis for many years prior to the opening
6155 of the drainage canal.

MR. JEFFRIES: The statement of counsel is objected to for the reason that such endurance, if there be any, is not such as would justify the city of Chicago, or the Sanitary District thereof in the construction of the drainage canal and the discharge of the sewage from Chicago into the Illinois river?

(Question repeated.)

A. I couldn't remember to a certainty; I should think ten; possibly twelve, but I wouldn't be sure.

Q. What was the extent of the distillation of whiskey or spirits in that period as compared with the present time?

A. There is more distilled now; the larger revenue shows that.

Q. Were the distilleries then independent, each operating upon its own basis?

A. Yes, sir.

Q. What was the practice in regard to the slops mace in the process of distillation?

A. It was fed to the cattle.

Q. Much in the same manner as it is now?

A. I think many more cattle were fed then than now; some of the slop now is dried and sold as dry feed.

6156 Q. During that period what was done with the offal, fecal and urine, from the cattle?

A. It was run into the river.

Q. Were these distilleries at that time located near or on the river?

A. Yes, sir.

Q. How long have you been familiar with the condition of the Illinois river near Peoria?

A. Since 1876.

Q. Prior to the opening of the drainage canal, what was the condition of the water in the Illinois river above Peoria?

A. It was very bad, very offensive.

Q. Prior to the opening of the drainage canal, what was the condition of the river at Peoria and immediately below?

A. Bad and offensive.

Q. Describe in what way?

A. It showed the effects of stagnant water and emitted bad odors, and had a bad color.

Q. To what did you attribute the condition of the water at that time at and below Peoria?

A. To the Chicago sewage.

Q. To the Chicago sewage?

A. Yes, sir.

6157 Q. Now, below the sewage of Peoria, and after the sewage of Peoria was put in the river, and before the opening of the drainage canal, what was the condition of the Illinois river below Peoria?

A. It showed the effects of the distillery slop and the refuse from the cattle, in addition to the other.

Q. Was it offensive in its smell?

A. Yes, sir.

Q. How far below Peoria have you observed it before the opening of the drainage canal?

A. I went with my family to St. Louis on the boat, two trips; at different years.

Q. Do you own any property below Peoria?

A. Yes sir, just below Peoria, this side of Wesley City.

Q. Do you own property on both sides of the river?

A. Yes sir.

Q. Do you occasionally visit the property and did you notice the condition of the river at that point before the opening of the canal?

A. Yes sir.

Q. Describe its condition?

A. It showed the effects of sewage, had bad odor.

6158 Q. What was its color?

A. Well, an indescribable color, a dark, brown color.

Q. In the summer time was the odor offensive?

A. Yes sir.

Q. Since the opening of the drainage canal, what has been the condition of the water above Peoria?

A. Very good as compared with what it was before, and as I think with other rivers.

Q. In what respect is it better?

A. It is clearer, freer from the sewage and has a better color and no odor,—comparatively little odor.

Q. Since the opening of the drainage canal, what has been the condition of the Illinois river below Peoria?

A. I think it is far better than it was above Peoria before the opening of the canal.

Q. To what do you attribute this improvement in the condition of the water below Peoria?

A. The emptying in of the clear water from the lake.

Q. And the larger amount of water passing down the river?

A. Yes sir.

Q. What effect if any, in your judgment, has the opening of the drainage canal, had upon the value of lands, adjoining and in the vicinity of the Illinois river?

A. I think it has increased the value.

6159 Q. In what manner?

A. It is surer of a cleaner river, a steadier current, better transportation and a healthier river to live by.

Q. Did you consider the Illinois river immediately below Peoria and lands in the immediate vicinity of it, dangerous for habitation before the opening of the drainage canal?

A. I considered it unhealthy.

Q. Since the opening of the drainage canal, in the same vicinity below Peoria do you consider the situation and surroundings more healthy than before?

A. Yes sir.

Q. Is it on that account that you say the lands have become more valuable?

A. Yes sir. And on account of the statement I made to your previous question.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Mr. Brown, don't you know that since the opening of the canal transportation on the Illinois river has not increased to any considerable extent?

A. No sir, I don't know that.

Q. You are not acquainted then with that fact?

6160 A. I am not acquainted with that fact; I had supposed from all appearances that it had increased.

Q. You are not engaged in that business?

A. No sir; I live in sight of the river all the time and see what was going on and I supposed it had increased.

Q. Did I understand you to say that the bad condition of the water of the Illinois river at Peoria and above Peoria prior to the opening of the canal was caused by the sewage of Chicago?

A. I think so.

Q. Then if the sewage of Chicago came down the river before the canal was opened, why doesn't it come now?

A. I think that the motion of the water that has a greater current aerates it and clears it. There was a sluggish slow motion before that that was to our damage; while it was brought along in some flood tide and high water, this low water didn't give it motion enough to clear the water. Now we have a good current and the water seems to be clear and good.

A. A rapid current would bring it down quicker than a slow current, wouldn't it?

A. I think that a rapid current—

Q. Well, answer the question?

A. No sir, I don't think it would. That is, I don't believe
6161 it would bring it to here. A flood tide would bring it here; a rapid current would bring it here, but I don't believe it would clear the water like a steady, flowing current; I lived all my early life by a river in Massachusetts and I have seen the effects of the current, of the steady current and the low waters of summer and the high waters of winter seasons and I saw what effect it had upon the water, the waters that are used for drinking purposes, and I am satisfied that a good steady current will clear the water in a certain distance making it better than it woud be if it was a slow current, sluggish, lay along for months and then come a flood tide and carry it on down and then leave it again to spoil or decay, making the river bad. I am pretty sure that a steady, good current, will make clear water.

Q. If it would come down in flood time prior to the opening of the canal, would it come down yet?

A. They pump in Chicago the sewage into the canal, into the river, before the water brought it along regularly—

Q. Answer the question directly, Yes or No.

A. I will if I can.

Q. (Question repeated).

A. I think I explained that before—

Q. You say it would not; that question is capable of being
6162 answered yes or No.

A. No it wouldn't be there to be brought down; it would be there and be aerated by the motion of the water and wouldn't be brought here. In flood time that wouldn't be a steady current and it would come down during high water and be left.

Q. Don't you know Mr. Brown, that a very inconsiderable portion of the sewage discharged into the old Illinois and Michigan Canal and that a great proportion of it before the opening of the Chicago Drainage Canal was discharged into the Chicago River and thence into Lake Michigan, and that it was because of the pollution of the lake water, that the Chicago drainage canal was constructed in order to purify their own water and send that sewage down the Illinois river? Answer that Yes or No.

A. I will say No. I would like to explain my "No," if I can do it.

Q. You can explain on re-direct examination. Don't you know that that was the object of the construction of the drainage canal?

A. No sir.

Q. You don't know what the object was then?

A. Yes sir.

Q. How often were you down the river?

A. I made two family trips down the river.

6163 Q. When was that?

A. That was between 1876 and 1886 when I was in the distillery business.

Q. Have you made a trip down the Illinois river in the last eight years?

A. No sir; I am going down. If the water wasn't better I wouldn't go down though.

Q. Do you know whether disease germs will live in running water or not?

A. I think they will; I don't think they multiply as rapidly in running water as they do in sluggish water.

Q. Well, do you know anything about it?

A. My experience with them has been very limited. I belong to the Scientific Society and have seen them illustrated; the germs of the river water in the Illinois river at Peoria, under the magnifying glass, and know as much about them as a common business man would know I think, and no more.

Q. But you haven't a professional education on that line?

A. No, sir.

Q. Do you consider your judgment and opinion on that subject as good as any other ordinary business man?

A. I see no reason why it shouldn't be.

6164 RE-DIRECT EXAMINATION, by Judge Springer.

Q. Now, Mr. Brown, explain what you desired to explain in your answer.

MR. JEFFRIES: I object to any explanation being given by the witness with reference to the purpose and construction of the drainage canal and with reference to testimony from him on the transportation of the sewage from Chicago down the Illinois river for the reason that the witness has disqualified himself as being competent to testify on that subject for the reason that he stated in evidence that he has no scientific knowledge upon which his statements may be based, and whatever he might say on the subject would be the ideas of fancy without reference to the actual facts, conditions and circumstances, and without reference and without the aid of scientific knowledge on the subject.

JUDGE SPRINGER: In reply to this objection, counsel for defendants insist that the witness having been required to answer the question Yes or No, that he answered No and asks the privilege of explaining his answer, and by every rule of evidence he is entitled to make that explanation.

MR. JEFFRIES: I suggest that the question was asked for the sole and single purpose of ascertaining knowledge upon the part of the witness as to the purpose of the Sanitary 6165 District of Chicago in the construction of the canal, and that any other answer than that of Yes or No, would not and cannot now in explanation thereof, be responsive to the question.

Q. (Question read.)

A. I answered No, for I believe that it is—

MR. JEFFRIES: I object to what the witness believes; I object to the witness stating what he believes, he must confine himself to actual conditions.

Q. JUDGE SPRINGER: You may explain your answer now as you desire?

A. The City of Chicago was pumping its entire sewage into the Illinois river; that if it could have been pumped cheaper, the amount of water that is being turned into the canal could have been pumped cheaper than the canal cost, that it never would have been built. They built the canal because that was the cheapest way of getting the sewage into the canal with the proper quantity of water it should have with it. Previous to that they were not pumping the proper quantity of water; the sewage was lying by the sides of the river at the upper end and it was obnoxious and was brought down in flood tide in chunks. If they had pumped the proper amount of water that should have gone with that sewage, all the time, the river would 6166 then have been good and clean and more healthy, and my answer No, was that they built the canal because it was cheaper than they could pump the amount of water that would have been necessary to have carried down the sewage, and not allow it to run into the lake.

RE-CROSS-EXAMINATION, by Mr. Jeffries.

Q. Why didn't they want it to go into the lake?

A. It would damage their water supply; it had damaged their water supply for years and they had to make their current the other way, which they did.

Q. Then it is not true that the entire sewage from Chicago had been coming down the river before the opening of the canal?

A. Well, as much of it as comes down now, or very nearly as much. They are going to turn in more I think and turn in more water from the other canal, from the other sewers.

Q. Do you state to be a fact that they are turning no more sewage into the Illinois river now since the opening of the drainage canal than they did before the opening of the canal?

A. As far as the Chicago river is concerned, that sewage I don't know whether they have turned any other sewage into this. I understand that they are anticipating doing so.

6167 Q. I am talking about what you know; you are testifying on oath, and I want to know what you absolutely know and nothing else?

A. I don't know that. They may have opened a sewer yesterday. I understand that they are figuring on turning some additional sewage in, but I do understand they were pumping that from the Chicago river down into this canal before, and that is what is coming down now.

Q. All the Chicago river?

A. Yes, sir; all the sewage that went into the Chicago river. They had to do that or it would have gone out to the water supply. They had to keep the water away from the water supply.

Q. Then sewage going into the lake from Chicago prior to the opening of the canal would contaminate the lake water, but it won't contaminate the water when it comes down the Illinois river; is that your position?

A. If they would run it 150 miles out into the lake, I don't think that would hurt it. I think I would be perfectly satisfied to drink a little water 150 miles out in the lake; but four miles out in the crib, I would not and I would not want to drink water four miles below St. Louis.

6168 Q. How long prior to the opening of the canal did they pump all the sewage into the Chicago river and thence into the Illinois and Michigan canal?

A. I don't know exactly; I couldn't tell you. I think four or five or six years. I judge that from the time that it was first reported as shown at the crib.

Q. And they have had good water in Chicago ever since?

A. Since the canal was opened?

Q. No, since they ceased pumping their sewage into the Illinois and Michigan canal?

A. Oh, they haven't had good water. I don't think it was perfect as it is now, but I think now they have cleaned all the bad water that was in the Chicago river and it has had its effect even on the atmosphere.

Q. Can you describe the Chicago river?

A. Now?

Q. No, generally, the way it runs, the different forks; do you know anything about it?

A. I know how it shows on the map; I don't know the directions when I am on it; that is, I don't know all of the turns, but I know the river pretty well, because I am often along by it. I had a friend that was in business in the Northwestern there, right on the banks of it.

6169 Q. How many forks are there to the river?

A. Two main forks.

Q. Where are the pumps that are used to pump the water from the Chicago river into the Illinois and Michigan canal located?

A. I know the place, but I don't know what you call it.

Q. What fork is it on?

A. It is on the north fork of the Desplaines river, but I don't know whether you call it the north fork or not; I don't know which of the forks you call it.

Q. Don't you know that before the Chicago drainage canal was constructed and opened that the waters in the Chicago river ran into the lake and emptied and discharged into Lake Michigan?

A. If there was current enough in it to show it, I didn't see it.

Q. Then if it did not discharge into the lake, how could it pollute the water in the lake?

A. It had for years discharged into the lake; many times when they were not running the pumping works, it had to discharge into the lake. Many times the works were stopped, broken down and many times it was running before the pumping works were started, and when it got to the crib, if I understand they had to pump it out.

Q. Then if the pumps are broken down at times and it did
6170 run into the lake, they have been sending more sewage down the Illinois river since the opening of the drainage canal than they did before. One of the two propositions must be true, is it not?

A. I think they must have sent all they collected on the edge of the lake and in the river, down through that canal which had been collecting there for years, but now we have the regular sewage of Chicago and the water in good shape.

DELOSS S. BROWN.

6171 SOLOMON YORK, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. Solomon York; my occupation is steamboating; my residence is Peoria.

Q. Are you a licensed pilot and captain?

A. Yes, sir; have been for the last 34 years.

Q. How long have you been on the Illinois river in that time?

A. In 1852 I came on the Illinois river, when I was four years old.

Q. How long have you been a boatman upon the Illinois river?

A. Well, I boated, you might say ever since I was that old. My father was a boatman before me and I have never done anything else since but boat.

Q. Are you familiar with the Illinois river from La Salle to Grafton?

A. Yes, sir.

6172 Q. For ten years prior to the opening of the drainage canal in 1900, what was the condition of the Illinois river water above Peoria?

A. Well, it was bad.

Q. In what respect?

A. In regard to no current in the river and it was stagnant. Well, it was a scum on it good many times in dead, low water, and at times the growth in it would take the wheels of the boat that was turning over 25 or 30 revolutions a minute till a kind of whiskers would grow on it, we called it, a kind of a hair that long (indicating) would grow; I have seen it that long on the bucket, about four or five inches; that would grow on the bucket and the hull of the boat would have moss or hair up along on the side of the boat.

Q. How was it for steaming purposes above Peoria before the opening of the drainage canal?

A. It was no different from what it is now.

Q. Did it froth or foam in the boilers?

A. We never had it foam; the water never foamed.

Q. Before the opening of the drainage canal how was the water below Peoria?

A. Well, it was very bad below Peoria on account of the
sewage here; take it from here to Havana, down as far as
6173 Beardstown, you could see the offal from the distilleries
here; we worked for a boat down here in front of the distilleries three or four years down here digging that out and starting it on down the river; go into it with the wheel and dig it out; it would pile up there eight or ten feet deep.

Q. Below LaGrange dam before the opening of the drainage canal what was the condition of the water?

A. Very bad.

Q. Did it still have traces of the Peoria sewage in it below LaGrange?

A. Yes, sir.

Q. Since the opening of the drainage canal what has been the condition of the water above Peoria?

A. Well, it has been better, there is a great deal better current in the river and it makes it better.

Q. Is it cleaner, purer water?

A. Yes, sir, it is; I know it is.

Q. Since the opening of the drainage canal what has been the condition of the water below Peoria?

A. Well, it has been better; we have got more water; eighteen to twenty inches more water, which makes a current in the river.

Q. That scatters this sewage until it finally disappears, does it?

A. Yes, sir.

6174 Q. By the time you get down to LaGrange dam does it
disappear now?

A. Yes, sir; it gets purer, purified. You take the water that goes below Joliet, twelve or fifteen miles, it is clear.

Q. That is to say, the further you get away from the source of pollution the clearer the water gets and the purer?

A. Yes, sir.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You don't know anything about the sanitary condition of water, do you?

A. No, sir.

Q. And what you have said in reference to it is simply your observation of the river by being upon it?

A. Yes, sir, by being upon it.

SOLOMON YORK.

6175 National Hotel, Peoria, Illinois. 9:00 a. m., Saturday, August 15th, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

J. F. VINCENT, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. J. F. Vincent; I live at 415 Sixth street; my business is manager of the Peoria Union Stock Yards.

Q. What is the Peoria Union Stock Yards, a corporation, partnership or a private enterprise?

A. Well, they are owned by a company here, it is not a corporation—myself and my partner run them.

Q. How long have you been manager of the stock yards?

A. Well, I have been operating them under this lease, for I think about fourteen years.

6176 Q. What is the area of the stock yards?

A. Well, the stock yards company owns 22 acres altogether; part of that is taken up for packing houses and other purposes of that kind, and the part that I operate as stock yards is, I think, seven acres.

Q. Into what do the stock yards drain the sewers of the city?

A. We drain into the city sewers.

Q. And there are catch basins or inlets from the various pens of the stock yards to the sewers?

A. The pens, most of them, all of them, have an outlet from the watering trough, where we water the stock; when we empty those troughs there is an outlet to get into the sewers, from the waste water of the watering troughs, and there is a few of the pens that have inlets into the sewer to carry off the surface water, for instance, a rain like this, [a hard rain prevails as the witness is testifying], anything that comes like this it carries off. These pens that have these inlets to the sewer that carry the surface water are open pens and not floored; simply cinder foundations, and the pens that have the outlets simply from the water troughs are covered pens so that they don't catch any surface water.

6177 Q. How many cattle pass through these stock yards and have passed through them annually since 1897?

A. Well, I should judge probably an average of 50 a day. You see, we don't handle any cattle here except what our slaughterers handle; we don't handle cattle like these other places; just what the city handles; in fact, all of them don't come through the stock yards because they buy a good many cattle, you know, of what they call quarantined cattle, you know, and then they have chutes right at the packing houses to unload them and they don't come through the yards at all.

Q. Are these stock yards used also for the unloading and feeding of stock in transit?

A. Yes, sir, they are.

Q. How many cattle are passed through the stock yards which are simply fed here in transit, each year?

A. It probably wouldn't average more than two or three loads a week.

Q. Would that be 50 cattle a week?

A. Probably that, yes. We used to, a good many years ago, have a great many more than that when the western roads run this way in place of as they do now; for instance, the K. & W., we call it, running from Keokuk west, used to come to Keokuk and then run over the T., P. & W. to Peoria and then out to Chicago.

6178 Q. How many hogs are passed through these stock yards each year, since 1897?

A. Well, since then we run all the way from 300 hogs a day to probably 2,000 a day, an average of about 800 hogs a day would be about an average of what would run through.

Q. How many sheep?

A. Very few; probably wouldn't average over 150 a month.

Q. How many slaughtering houses are there in the vicinity of the stock yards?

A. There are two.

Q. What class of animals do they slaughter?

A. They slaughter cattle, hogs and a few sheep.

Q. Have they been running continuously since January, 1900?

A. One of the houses has run continuously for I should judge in the neighborhood of twelve years; the other has run for about eight years except two years it was standing idle; up to about two years ago. It was standing idle before that for two years.

Q. How many hogs do they kill each day?

A. The Goodel House will average about 500 a week and the other house I think may be might average 600.

Q. Into what does the sewage of these two slaughtering houses enter?

6179 A. One of them enters the city sewer; the city sewer runs right under the house and the other one has a private sewer from their place to the river.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How many cattle, hogs and sheep pass through the stock yards annually?

A. I think, as I stated here, the cattle run about 50 a day and about 50 a week of through cattle, just put off in transit to feed, and I think the average of hogs is about 800 a day through the year.

Q. Peoria is not situated on any trunk line, is it?

A. No, sir; there is no railroad that you can call a trunk line through here.

Q. And therefore there are very few through cattle passing through here?

A. That is one reason why there is very few through cattle, the reason of that mainly is, take the cattle going from the west, they don't pass through here at all, and the cattle that are in our territory here that are destined to Chicago don't have any occasion to stop after they load them; they go right through.

6180 Q. Now, that is also true with reference to the hogs and sheep?

A. All hogs that come here come here for sale; that is, we have more of a hog market than we have of a cattle market; that is, take the big head of cattle; we don't make any pretentions of having them at all; we simply have a market for butcher cattle, such as are slaughtered here in Peoria.

Q. How many hogs pass through the stock yards here in a day?

A. Well, about 800, I think, on the average take it the year through.

Q. And how many sheep?

A. Well, our sheep business is virtually so small that it is very hard to get at; our killers here handle very few of them; they might average, say 200 a month; I think that would cover it fully.

Q. Any horses handled at the stock yards?

A. Yes, sir, a few.

Q. How many will they average throughout a year?

A. Well, I judge may be a hundred a month.

Q. Now, are there any diseased animals of any kind taken into the stock yards?

A. No, sir, there is not anything; for instance, if we know there is any disease we don't take them into the yards. There is occasionally a lump-jaw steer, something of that kind, comes in, or a steer that will have a blemish on him or something 6181 like that. They are inspected after they come into the yards.

Q. After they are inspected and found to be diseased, what is done with them?

A. Well, if they are found to be diseased, beyond being fit for use they are slaughtered and tanked—rendered out for grease purposes.

Q. How far did you say these stock yards were located from the river?

A. The stock yards proper is in the neighborhood of 400 feet; but the stock yards property—that is, the company owns the property clear to the river. These packing houses are between the river and the stock yards.

Q. What do you feed at the stock yards?

A. Corn, oats and hay. All dry feed.

J. F. VINCENT.

6182 FREDERICK KINSINGER, called as a witness in behalf of the defendents, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Frederick Kinsinger.

Q. What is your business?

A. I am manager of the American Spirits Manufacturing Company.

Q. How many distilleries are there connected with that company in Peoria?

A. Directly in Peoria there are three houses.

Q. What are they?

A. The Monarch, The Great Western and The Atlas.

Q. What is the combined capacity of the three houses?

A. 25,500 bushels a day.

Q. How many cattle are fed in these three distilleries?

A. We don't feed in but one.

Q. How many are fed in that one?

A. Well, it varies; I would say it averages about 4,000.

Q. Are there any distilleries in Pekin operated under this same company?

A. Yes, sir, one.

6183 Q. How many cattle are fed there?

A. I think about 3,000 at present. I am not positive, but that is my judgment.

Q. These cattle are fed the slops from the distillery, are they not?

A. Yes, sir.

Q. What becomes of the excreta?

A. It runs into the river?

Q. Is there any sewage discharged into the river from other distilleries?

A. Yes, sir; there is the waste water sewers.

Q. What is this waste water sewage?

A. Well, it consists of the overflow from the condensers, principally.

Q. And is made up from what?

A. River water, that is portions of the river water. I will explain to you that the river water has less scale in it than well water and it is advisable when we can use it at the temperature we need, to use the river water.

Q. Does the sewage from the other distilleries contain any foreign substances in the water?

A. Nothing in the water that is objectionable; that is, there is nothing foreign in it except the water itself after it has been heated; it contains no refuse of any kind.

6184 Q. What becomes of the slop that is produced in the other distilleries?

A. We dry them by a drying process into feed and ship it, and the same is true where the cattle are fed, too. The slop there is not all fed, you know.

Q. Where do you get the water from that is used in the distilleries for condensation and steam purposes?

A. From the river.

Q. What is the quality of that water for that purpose?

A. It is first class for the boilers.

Q. Is it used for any other purpose than steam-making purposes?

A. For condensing; that is, certain condensers that you don't have to go below the temperature of these waters.

Q. How long have you been in Peoria?

A. Two years past.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How long did you say you have been here in Peoria?

A. Two years last June.

Q. What business did you say you were engaged in before you came here?

Q. Distilling business.

6185 At what point?

A. I was supervisor of the Sixth Kentucky district; also I had a house immediately under my charge which I am still running there; the Milldale of Kentucky.

Q. What position did you say you occupied with reference to the plants here?

A. General manager.

Q. What is the name of the plant that is controlled by this same company at Pekin?

A. The Globe.

Q. Your main office is in New York, is it?

A. Yes, sir.

Q. The company owns various other distilleries besides this one here and the one in Pekin?

A. About seventy—in Kentucky, at Omaha, Terre Haute, Chicago, Cincinnati.

Q. You say they have fed cattle in one of these stills that you are superintendent of since you have been here?

A. Yes, sir.

Q. And that is which one?

A. The Great Western.

Q. How many cattle have you fed since you have been here, per year?

6186 A. Well, it varies, you know; I suppose the average would be about 4,000 at a time.

Q. The cattle that are fed do not belong to the company?

A. No.

Q. You simply sell the slop?

A. Sell the slop.

Q. The contract that you have for the sale of the slop has not expired, has it, yet?

A. The new one, I think, has begun.

Q. Your new contract has not been closed?

A. I think it has; I am not positive; that is closed in New York, you know. They have a right under that contract to decrease or increase when ever they choose; the feeder has, and of course whenever he decreases, we dry that much more, and when he wants more, we dry that much less.

Q. Don't you know as a matter of fact, that no new contract is intended to be entered into by your company and that they intend to discontinue the feeding of cattle altogether in the still houses here at Peoria?

A. No, sir.

Q. That is, you don't know whether that is true or not?

A. No, sir.

Q. The water that runs from the stills to the river in the process of distillation and otherwise, is it contaminated 6187 in any way, chemically or otherwise?

A. Well not that is objectionable for the purposes that we use it for, for instance in cooking with it, it is subjected to such a high temperature that anything foreign in it would be precipitated.

Q. No chemicals used in distillation, are there?

A. No sir.

Q. No ingredients other than the grain that you use in the process?

A. And yeast and hops.

Q. Then hops and grain are all?

A. Yes sir.

Q. How far is this Great Western Company from the river?

A. It is right on the bank; there is just the railroad between them and the river.

Q. How many cattle have you there now?

A. I think there is less than 4,000.

F. KINSINGER.

6188 FRANK C. WHITE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testtified as follows:

Q. State your name, residence and occupation?

A. Frank C. White; residence, Peoria; occupation, dealer in live stock.

Q. Do you feed cattle at the distilleries in Peoria?

A. Yes sir.

Q. What is the style of your firm at present?

A. The cattle feeding firm, is Doud & Keefer, F. C. White & Company are partners in that firm; that is in feeding the cattle.

Q. At what distillery do you feed here?

A. We are feeding at the Atlas Distillery. At present we are getting the slops from the Corning Distillery, but our contract is with the Atlas; when they closed down the last two months we got slop from Cornings.

Q. How long have you been engaged in that business?

A. Twenty years; that is 20 years in the cattle feeding business; 30 years in the live stock business.

Q. Have you fed at other places than Peoria?

6189 A. For two years I had charge of Nelson Morris' Cattle all over the country, that is the cattle feeding in distilleries all over the country from Pittsburgh, on the east, Omaha on the west, St. Paul on the North, and Kentucky on the south, and one year I had charge of as high as 50,000 cattle.

Q. How many cattle have you been feeding for the last three years in Peoria?

A. Well you mean at one time?

Q. Yes?

A. From 2500 to 3,000 cattle.

Q. Have you continuously been feeding about that number during that time?

A. Well, in the winter season yes; in the summer season it runs down; we have about half the number of cattle we have in the winter season.

Q. Describe the process of feeding the cattle?

A. Well, they get their first feed of slop in the morning at six o'clock; after about eight o'clock they get their hay; then the barn is scraped down, the sewage all run out. At eleven o'clock they get their second feed of slop; after that they are hayed and the barn is scraped down again, and about five o'clock the last feed of slop.

Q. What do you mean by scraping down the barn?

6190 A. The men take a rubber scraper and scrape the urine and manure in the sewer; there is running water in the sewer all the time, while they are scraping and probably three parts of water to one part of sewage; I couldn't estimate exactly, but I should say at a rough guess that is it. Naturally the men will use as much water as they possibly can, so as to make the labor of scraping down easier.

Q. How much offal is there from a steer in a day in your judgment, urine and manure?

A. Well, the chances are that all the way from ten to fifteen gallons of urine and I don't see how it could be to exceed six or seven pounds of solids.

Q. Is this offal all washed away from the barns into the sewers?

A. Yes sir.

Q. What solid matter do you feed the cattle?

A. We feed cotton-seed hulls and hay; we estimate that we feed probably about eight pounds of hay or cotton-seed hulls per day; those are the only solids that we feed, so that in estimating the amount of manure I would safely say it couldn't exceed six or seven pounds for the reason the rest of it is absorbed.

Q. Where is the hay and cotton seed placed to be fed to the cattle?

6191 A. Placed on a platform right in front of the cattle; the cattle stand facing one another and the slop runs down right next to the cattle, and between the cattle and the platform, the hay put on that.

Q. What becomes of the refuse of the hay and cotton-seed hulls?

A. Whatever is left on the platform that the cattle don't eat is forked off and carted away.

Q. Is any solid matter washed into the sewers when you clean the sheds, except the manure?

A. No sir.

Q. Where is this other solid matter taken?

A. We put it out in the lot and the farmers come around during the year and haul it off.

Q. Where is the sewage from the cattle sheds deposited finally?

A. In the Illinois river.

Q. Prior to the opening of the drainage canal, did this distillery discharge accumulate and be washed off by the high waters, into the Illinois River?

A. Yes sir, it would accumulate and remain there for some time, even some springs it wouldn't have sufficient raise or sufficient water to wash it off and it would remain there during the whole season.

6192 There was times when it was a good deal of stagnant slop and manure that accumulated and remained there. We haven't been troubled that way for the last two or three years.

Q. Formerly, did this matter settle in the bottom of the Illinois river and was it dislodged by sending steam boats in to stir it up?

A. Yes sir; in fact, it is my impression now that they are forced to do that every year.

MR. JEFFRIES: I move to strike out what the witness says is his impression as not being based on absolute knowledge.

Q. Is any salt fed to the cattle in the distilleries?

A. Yes sir.

Q. In what quantities; what quantities of salt do you use per day?

A. Well I might say two table-spoons full; the men take it in the hand and give just a dash in front of each steer. Of course we watch the cattle very carefully and see how they are manuring, and if the manure is tight we salt a little more freely; when the manure is moving freely and not hard, why we know that they are receiving the proper amount of salt. New cattle off of the ranges require a little more salt to start with than cattle that are on feed two or three weeks.

6193 Q. Do you know of a disease among cattle called anthrax?

A. Yes sir, I have heard of it.

Q. Has there been any such disease among the cattle that you have handled here in Peoria?

A. Not in Peoria. I have had some experience with cattle in Omaha, that the veterinarians, claimed the sickness was anthrax.

MR. JEFFRIES: I move to strike out the testimony of the witness with reference to the cause of the sickness in the last answer as being merely hearsay testimony and the witness not being sufficiently informed on that subject to determine for himself whether or not that was the character and nature of the disease?

Q. When was that?

A. 1892.

Q. Now to what did you attribute that disease?

MR. JEFFRIES: I object to the question for the reason that the witness has not qualified himself as being proficient to express an opinion as to the cause of the disease and has already stated that he only knew what he had been told in reference to it.

A. I will say this much; that I didn't agree with the veterinarians at that time. I thought it was caused by sewer gas.

6194 Q. Were there any surroundings of the sheds at Omaha which led you to that belief?

A. There was a large smelter just above there, and in my opinion the poisonous gases got into sewers and up into the barn and cattle.

Q. Now if anything was done at that stage, to stop the escape of sewer gas into your cattle barns, state what was done and what the effect of it was?

A. When I got there they were losing from 25 to 35 cattle per day. I tried to doctor them with medicine, but came to the conclusion that the trouble was caused by poisonous gases, and I had the cattle removed. Part of them coming to the distilleries here in Peoria; part of them going to Mr. Morris' ranch in Nebraska, about 35 miles above Omaha. After the cattle were removed, we lost none. Later on they cemented the floor of the barn and they haven't had the same trouble with the barn since. That same season after the ground was froze up we put cattle in there without any cement, and took them out in the spring before the ground was thoroughly thawed up and we lost no cattle.

6195 MR. JEFFRIES: I move to strike out the question and answer for the reason that it is incompetent, irrelevant and immaterial and has no bearing on the issues involved in this case, and for the further reason that the witness is not qualified to give any opinion as to the disease.

Q. Upon what river is Omaha?

A. The Missouri river.

Q. Did the sewage from these barns in which these alleged diseased anthrax cattle were, enter into the Missouri river?

A. Yes sir.

MR. JEFFRIES: I move to strike out the question and answer because it is immaterial and incompetent. And because such facts will not in any manner justify such discharges into the Illinois river from the city of Chicago and for the further reason that such facts do not prove that the water in the Illinois river is wholesome and suitable for domestic and drinking purposes and do not prove or tend to prove any direct issue involved in this case.

CROSS-EXAMINATION,
By Mr. Jeffries.

Q. The number of cattle that are being fed at Peoria is growing less each year is it not?

6196 A. There was I think last year about 11,000 fed against 27,000 to 30,000 fed here ten years ago.

Q. The distilling business, however, is not decreasing, is it?

A. The capacity I think isn't nearly as great as it was. The number of houses isn't as great; the houses are bigger and larger.

Q. You are not a veterinary surgeon are you?

A. No sir.

Q. Your contract with the Distilling Company for the feeding of the stock is about expired, is it not?

A. Our contract has expired.

Q. And you are not feeding any more?

A. Well we still have cattle in the distillery; just a limited contract, you might say, running from day to day or month to month. We are allowed to give notice at any time.

FRANK C. WHITE.

Whereupon an adjournment was taken until Monday, August 17th, at 11 A. M., at La Salle, Illinois.

6197 La Salle, Illinois, Monday, August 17th, 1903. 11:00 a. m. Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

It is agreed by counsel representing the State of Missouri and the State of Illinois and the Sanitary District of Chicago, that the testimony of witnesses taken at La Salle, Ottawa, Marseilles and Morris, all in the state of Illinois, may be taken in shorthand by the stenographers, the signature of each witness to his testimony is hereby waived, and the Commissioner is to certify all testimony so taken and transcribed by the stenographers to the Supreme Court, without signatures of the witnesses, making such corrections as he deems fit and proper, and the testimony so taken and certified to by the Commissioner to have the same effect as if signed by the respective witnesses.

FRANK S. BRIGHT, Commissioner.

6198 ROMAN J. RIMMELE, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Roman J. Rimmele.

Q. Where do you live?

A. La Salle, Illinois.

Q. What is your business?

A. Tinner.

Q. Are you acquainted with the Illinois river at this point?

A. Yes, sir.

Q. How long have you been acquainted with the Illinois river?

A. Why, I have been on it for—off and on it, up and down it from a child; I was born and raised right in the town here, that is 46 or 47 years.

Q. How often are you on the river?

A. Well, some weeks two or three times; some weeks every evening; some times not once a week.

Q. What are you doing on the river?

A. Why, running a little launch, running parties up and down the river.

Q. Excursion parties?

6199 A. Little parties, yes, sir.

Q. How far up the river do you go?

A. Well, I don't go further than a mile above Starved Rock; we figure that about 11.8 miles up and around the river,—is what they figure it.

Q. Were you acquainted with the condition of the Illinois river before the opening of the drainage canal?

A. Yes, sir.

Q. In 1900?

A. Yes, sir.

Q. Will you describe the condition of the Illinois river prior to the opening of the drainage canal?

A. Well, the water used to be very low, and kind of—as near as I could call it, dirty looking color, and floating grass and weeds all the time; hardly any current at all except in high water.

Q. At any time did the water have any odor to it?

A. Why, at times it did a little, yes. I don't know what it was from.

Q. What has been the effect, in your judgment, of the opening of the drainage canal, on the Illinois river?

A. Why, in my judgment, I think it has improved the water; the water looks better; you have got a better channel, and you have got a better water in every way, clearer water.

6200 Q. Any odor in the water now?

A. Not as I notice; that is not on the river. That is, what you call the river?

Q. The river, yes?

A. Yes.

Q. How does the size and current of the river now compare with what it was before the opening of the canal?

A. About double the current, as near as I can say; there was hardly any current before; almost dead water.

Q. What is the rapidity of the current now?

A. Well, sir, it must travel up above the bridges, six miles an hour or seven, something like that, I think; I would not say positively. I can tell the difference in it; I used to take a heavily loaded boat 27 miles down the river and back six or seven hundred pounds in it. I wouldn't want to do it now. That is the difference in the current.

Q. Have you noticed any odor in the water since the opening of the canal?

A. No, sir, not to my knowledge.

Q. Do you use the water on your boat for steam-making prposes?

A. No, sir; mine is a gasoline launch.

6201 CROSS-EXAMINATION, by Mr. Jeffries.

Q. Have you lived here in La Salle all your life?

A. Yes, sir.

Q. Have you ever been engaged in any other business?

A. Why, my occupation is tinner; I follow up the tinner's trade and the boat business at the same time.

Q. You say you are on the river two or three times a week?

A. Yes, sir.

Q. You have been on the river two or three times a week for how many years?

A. Oh, I should say thirty years.

Q. Are you right certain that there is no odor now on the water since the opening of the canal?

A. I have never noticed any, no, sir.

Q. Now, then, when you say there is no odor coming from the water in the Illinois river at the present time, or since the opening of the canal, you mean by that, from that part of the river that has a current, or flows, do you not?

A. Yes, sir.

Q. Is there any odor at any other point in the river?

A. As far as I have gone in it, no.

Q. In the bays and sloughs?

6202 A. Why, there is, I think, take this side here, the basin, there is an odor there all the time, but that comes from the sewers here, from the town, in my opinion.

Q. You say before the canal was opened you nad no current?

A. Hardly any current at all.

Q. Except in very high water?

A. In high water.

Q. How does the current now compare with what it was before the canal was opened?

A. Why it is a little over double it, or so. That is as near as I could get at it. I couldn't just exactly say just what it is.

Q. How does the volume of water in the Illinois river compare now with what it was before the canal was opened?

A. Why, I think the water stands about on an average of two feet or more—between two and three feet, higher than it used to.

Q. That is what makes the increased current, is it?

A. Of course, I suppose, it is the water, I suppose, we are getting from above.

Q. The people here in La Salle don't use the water in the Illinois river, do they, for drinking purposes?

A. Well, not to my knowledge.

Q. Don't you know that they do not?

6203 A. The city don't, I know; but may be people on the river may be using it for all of that; I don't know about it.

Q. How does the city get its water supply?

A. From pumping stations,—different wells.

Q. Have you a public—have the public water supplied to them?

A. Yes, sir.

Q. How deep are those wells?

A. That is something I couldn't tell you; I don't know.

(F. S. B., Com'r.)

6204 WALTER A. PANNECK, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Walter A. Panneck.

Q. What is your business?

A. I am an attorney.

Q. Do you hold any official posiaion here in La Salle?

A. Yes, sir.

Q. What is it?

A. Mayor.

Q. How long have you been mayor of La Salle?

A. Since 1903, the first of last May.

Q. As mayor of La Salle, what kind of sewerage system has the city of La Salle?

A. The city has got a complete sewer system which empties into the Illinois and Michigan canal.

Q. Where does the Illinois and Michigan canal empty?

A. The Illinois and Michigan canal empties into the Illinois river about 2,000 feet west of the western limits of the city of La Salle.

What is the population of La Salle?

6205 A. About 14,000.

Q. What separates La Salle from Peru?

A. There is nothing but an imaginary line.

Q. What is the population of Peru?

A. About—between eight and nine thousand.

Q. Are you acquainted with the sewerage system of Peru?

A. Yes.

Q. What kind of a sewerage system have they at Peru?

A. They have about the same as we have, except that their system empties into the Illinois river below the bluffs.

Q. Are all the houses in La Salle connected with the sewerage system?

A. No, sir; but I would judge about two-thirds.

Q. What becomes of the excreta from the population that does not enter into the Illinois river through the sewers?

A. It is hauled by the employes of the city to what is known as the bottom lands lying about a quarter of a mile south of La Salle.

Q. Has that land any connection with the Illinois river?

A. No, sir.

Q. In flood times does that land become overflowed?

A. Yes, sir.

Q. Does the excreta so deposited there get into the Illinois river at flood times?

6206 A. It would if it was there.

Q. What becomes of the offal from outhouses in times of flood upon the Illinois river?

A. Well, as to that I don't know.

Q. What proportion of the population of Peru is connected with the sewerage system?

A. I should judge abot one-half in Peru, probably not one-half.

Q. Is there a board of health connected with the city of La Salle?

A. Yes, sir.

Q. Who is the president of the board of health?

A. Dr. Fullenwider.

Q. Is he in town?

A. No, sir.

Q. Are you acquainted with the operations of the board of health of the city?

A. Well, to a certain extent, yes, sir.

Q. Do you know what the condition of the public health in the city has been during the last three years?

A. Yes, sir.

Q. What has it been?

A. It has been very good.

6207 Q. Do you know whether there is any typhoid fever in the town?

A. No, sir, not at the present time, or has not been since I went into office; there were a few cases last winter, but not very many.

Q. What kind of water supply have you in La Salle?

A. We have not a very good water supply at present.

Q. Where is the source from whence water is taken?

A. It comes from what is known as Smith's Springs, and Spring Dell Springs, and water from the Illinois and Michigan canal that is driven through gravel and sand to what is known as the intake, three and a quarter miles east of La Salle and from there it comes by natural gravity into the pumping station and is from there sent out to the city.

Q. The water that is taken from the Illinois and Michigan canal, can you describe in detail the processes through which that water goes before it is taken into the water pipes of the city?

A. Yes, sir; the water goes through about three-quarters of a mile of gravel and sand before it strikes the intake. It goes from the Illinois and Michigan canal through gravel to a small lake, and from there it is let into the intake, traveling pretty near all the way on the surface of the ground, and over and through this gravel and sand.

Q. Does the water as it leaves the canal travel over the
6208 gravel and sand?

A. Yes.

Q. And how does it get to the intake?

A. It travels over the gravel and sand to this small lake, and from the small lake it is piped into the intake.

Q. Well, does high water that comes from the Illinois river pass through the sand?

A. We get no water from the Illinois river.

Q. I mean the Illinois and Michigan canal?

A. It passes over gravel and sand and the natural conditions as they exist there. There are trees there and weeds and everything.

Q. Well, is it an open drain?

A. Yes, sir.

Q. Is it a kind of a filter?

A. It was originally started upon the theory that the sand and gravel would filter the Illinois and Michigan canal water. To what extent it is filtered I am unable to state for the reason that the water that is taken at the intake also comes from Smith's Springs and Spring Dell water, and between the three waters we have pretty good water in La Salle.

Q. What I want to get at is to know whether the connection between this lake and the Illinois and Michigan canal, is a kind of a small canal with a sand and gravel bottom to it, and
6209 the water coming from the canal just simply flows over the sand and gravel into the lake?

A. Yes, sir, you have got it correctly.

Q. It doesn't flow through it?

A. No, sir, it travels over it.

Q. And when it gets into this lake, it is then pumped?

A. It goes by gravity; there is a valve in the bottom of this lake and the water comes by natural gravity into the intake from this lake.

Q. The Illinois and Michigan canal is above the city datum?

A. Yes, sir; it is above the intake.

Q. And into this lake do the other waters come at the same time, from the springs?

A. No, not into the lake; the water from the springs goes direct to the intake.

Q. The water that is used in the city is made up of a mixture, then, of the spring waters and the water of the Illinois and Michigan canal?

A. Yes, sir.

Q. Now, is this water used for domestic purposes?

A. Yes, sir.

Q. Do the people drink that water?

A. Yes, sir.

Q. Do you know where the Illinois and Michigan canal is fed from?

6210 A. Well, I don't know as I know that,—where it is fed from. I always supposed it was fed from Lake Michigan, but I am not certain about it; I don't know.

Q. Well, it is fed above La Salle?

A. Yes, sir.

Q. And empties into the Illinois river down here about one thousand feet, as you stated?

A. About two thousand feet; somewhere in that neighborhood, west of the limits of La Salle.

Q. And from drinking that water, do you know whether there has been any typhoid fever in the city, under your administration?

A. There has not been a case of it since I went into office.

Q. Are you acquainted with the Illinois river before and since the opening of the drainage canal?

A. Yes, I have known the Illinois river for years.

Q. What was the condition of the Illinois river at La Salle before the opening of the drainage canal?

A. I lived along the banks of the Illinois river in Peru for about twelve years, and frequently went to the Illinois river when I lived in La Salle; from about the middle of August until probably the middle of September, during the dry seasons, the water was very low and stagnant, there was generally a green scum extending pretty near three-quarter of the way across the
6211 river during that period of time and there was practically
no flow; that is, no current in the river during that time. That was prior to the time that the drainage people sent the waters of Lake Michigan into the Illinois river.

Q. Was there any odor connected with the water before the opening of the canal?

A. Yes, the odor was very strong.

Q. In what way?

A. Well, it was nauseous; I don't know as I could term it any way than that it smelled bad; that is about the way I would put it.

Q. What is the condition of the Illinois river at this point since the opening of the drainage canal?

A. It has improved considerably. There is no nauseous smell emanating from the river, and there is considerable current to it now. It doesn't get as low as it frequently did, and the water is clearer.

Q. What is the width of the Illinois river at this point?

A. The width of the Illinois river right south of La Salle is about 300 feet; somewhere in that neighborhood.

Q. Does the river widen out as it goes down towards Peru?

A. It does in some places, yes, sir; it is wider southeast of La Salle than it is right south of La Salle.

6212 Q. What stretch of the river have you been acquainted with?

A. I have been acquainted with the river from what is known as Little Rock, down to what is now known as Marquette, for years.

Q. What is the distance between those two points?

A. The distance between those two points is about six miles.

Q. Is there a river that enters the Illinois river at this point that you know of?

A. Yes sir, the little Vermillion river.

Q. Where does it come from?

A. Why it comes from the north and runs south. I couldn't tell where it starts from. It runs quite a distance north.

Q. About how large a river is that when it empties into the Illinois?

A. That is a small river, probably 40 feet in width when it is high; it is a small channel of water.

Q. Is that above or below Peru?

A. The Little Vermillion is east of La Salle.

Q. That is above, is it?

A. It is above the Illinois River; it comes down hill.

Q. Is it above La Salle on the Illinois River where it enters?

A. No, it is south of La Salle; it empties into the Illinois river south of La Salle, a distance of about 700 feet, south of the right of way of the Rock Island track; it empties into
6213 the Illinois River and there it is about 20 feet in width
where it empties, and it varies from that width to forty or fifty feet up farther north.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How long did you say you have lived in La Salle, Mr. Mayor?

A. I came to La Salle in 1873. In 1880 we moved to Peru, and I lived in Peru for ten years, and then since 1890 I have lived in La Salle.

Q. Describe again the three different sources from which La Salle gets its water supply?

A. It gets its water from the Spring Dell Springs, the Smith Springs and the water of the Illinois and Michigan canal.

Q. Now those Spring Dell Springs, what kind of a spring is that?

A. That is a surface spring, that comes down from between two hills about half a mile this side of the cement works.

Q. How far is Spring Dell spring from the Illinois River?

A. Spring Dell Springs are I should judge between one and two miles; probably a mile and a half north of the Illinois river, and about three and a quarter miles east of La Salle.

6214 Q. Do you know the volume of flow from that spring?

A. It is about 500,000 gallons per 24 hours.

Q. Do you know the character of the soil through which that water runs?

A. It is limestone gravel and a clay; I should call it clay; it is a sort of sub-soil of clayish—

Q. Do you know whether or not the water from this spring flows from towards the river before it comes out of the ground at the spring?

A. I don't know as I understand just what you mean. The water from the Spring Dell Springs flows south towards the river, from the north.

Q. That is what I want. Now Smiths' Springs, how far is that from the river?

A. The Smith springs are about half a mile from the river.

Q. With reference to the surface of the earth, how is it located?

A. Why there is a bed of gravel extending from about four miles east of La Salle to Peru, running to the surface at or about where the Smith Springs are located; it is about, between thirty and forty feet in width at La Salle and between 48 and 60 feet in Peru. The Smith Springs waters are almost upon the surface of the ground. The gravel bed from Smith
6215 Springs to Peru ranges from two feet to 35 feet in depth.

Q. Do you know the volume of water that comes from Smith's Springs?

A. That is probably in the neighborhood of three or four hundred thousand gallons of water per 24 hours.

Q. Does it flow from the river or towards the river?

A. As to that I am unable to state. We get the water right at the intake; we have a pipe from its source and I don't know which way it runs.

Q. Or where it comes from?

A. Or where it comes from.

Q. Except that it is your opinion that it comes from Lake Michigan, you say?

A. Oh, no; I didn't say that. I say—

Q. Didn't I understand you to say that in your direct examination?

A. No sir. I did say this; I understood that the supply of water for the Illinois and Michigan Canal came from Lake Michigan, as to that I was not certain.

Q. Now then how much water from the Illinois and Michigan Canal is being used?

A. At the present time we must be using, I would judge, about 500,000 gallons of water per 24 hours, out of the Illinois and Michigan canal. We are using considerable of that
6216 water at the present time.

Q. Now then, explain how that water is treated?

A. It comes out of the Illinois and Michigan Canal through a twelve-inch iron pipe, and it flows then upon the surface of the ground immediately south of the embankment, upon the south side of the canal. There it travels a distance of probably one-quarter of a mile through gravel, through weeds, shrubbery and such things until it comes to a small lake. The bed of the lake is sand, and below the level of the water is a valve, and a pipe connecting the lake with the intake, and whenever the valve is opened at the lake the water then is let in and comes down to the intake by gravity from this lake.

Q. Now how deep under the surface of the water is this valve that carries the water from the lake into the intake?

A. It must be about five or six feet.

Q. How deep is the water in the lake?

A. Probably must be in the same neighborhood. I never was in it, exactly, I couldn't tell you.

Q. What is the area of the lake?

A. Oh, it is not a large one, it is a smal lake.

Q. Well, about how many acres does it contain?

A. Oh, I don't know as it would cover a half an acre.

Q. About 1,400,000 gallons of water used per day from
6217 these three different sources?

A. Yes sir, we pump over that. That is approximately, I think we pump in the neighborhood of a million and a half gallons of water per 24 hours in this city.

Q. Are those water supplies and the water works owned by the city or by individuals?

A. They are owned by the city.

Q. Where does Peru get its water supply?

A. Peru gets its water supply from artesian wells.

Q. Exclusively?

A. Yes.

Q. The people living in La Salle and Peru, and what is this other little village above here?

A. Utica.

Q. No, Spring Valley—

A. Oh, that is west.

Q. Spring Valley and Utica—how do they get their water?

A. Spring Valley gets artesian water; so does Utica.

Q. From the intake where does the water go, direct into the mains?

A. Yes, it comes through 20 inch mains by natural gravity; it travels a distance of three and a quarter miles to the pumping station, there it empties into a large cistern and from that it is sent out throughout the city.

6218 Q. To the consumers?

A. Yes, direct pressure.

Q. How far is the valve which carries the water from the Illinois and Michigan canal into this bed of sand and gravel, from Chicago?

A. The valve that empties the water from the Illinois and Michigan Canal into our lake is a distance of probably about 97 miles from Chicago.

Q. From Lockport dam?

A. Why, if that is the channel; I am not familiar with the course of the canal beyond Lockport.

Q. Well, do you mean 94 miles to the corporate lmits or 94 miles from what particular point at Chicago?

A. We are one hundred miles from Chicago, and I would figure that about 97 miles. I couldn't tell you whether it is the limits or not; I don't know anything about that.

Q. The people at Peru, La Salle, Utica and Spring Valley do not use the water direct from the Illinois River, for domestic and drinking purposes?

A. No sir.

Q. What is the character of the sand and gravel through which this water runs or over which it runs from the valve which turns it out of the Illinois and Michigan Canal in its course toward the lake?

6219 A. The gravel is a coarse, clean gravel; the sand is a common sand that has been deposited there I guess for years.

Q. How deep is the gravel and sand, if you know?

A. The gravel or sand at that point runs probably from three to nine feet in depth.

Q. Now are there any means provided for spreading this water as it comes from the valve out over this sand and gravel?

A. No sir, we have never spent a dollar upon graveling or filtering that water.

Q. Does it naturally spread itself over the surface?

A. Yes sir, comes all over it, but it must travel a distance of three or four hundred feet around until it gets into this little lake. Some places it is two or three feet deep; I know I went into one of those holes and I have got it right.

Q. You say the current in the Illinois river at La Salle and Peru prior to the opening of the Chicago drainage canal was sluggish?

A. Yes sir, it was, from about the middle of July until the fall weather; until we received rains. Rains was the only method by which the current was increased in the river prior to the drainage.

Q. How is the current now at all seasons of the year?

A. The water is considerably deeper now. The river 6220 is deeper and there is considerable more current now than there was then; as to the exact difference, I couldn't tell you.

Q. I understood you to say that the water is clearer now than it was?

A. Yes sir.

Q. You have never chemically examined the water?

A. No sir, I am not a chemist. I know nothing about the—

Q. You know nothing about the deleterious substances that may be contained in the Illinois river water?

A. No sir, I do not; no sir.

Q. What is the condition of this water that comes into the lake through the valve, from the Illinois and Michigan Canal while it is in the canal at that point?

A. As to that I am unable to state.

Q. Did you ever notice it?

A. Yes sir.

Q. What are your observations of it?

A. It appeared muddy, dark.

Q. Well now, there has never been any criticism of the water that comes from these two springs, has there?

A. No sir, there has been no criticism. Well yes—strike that out. There has been criticism about the water generally, but not as to the water from these two springs. The water from the two springs is very good water.

6221 Q. How about the water from the Illinois and Michigan Canal?

A. Mixed with the three it is all right, but of itself, in my judgment it would not be the kind of water I would want to drink.

Q. Well, what is its reputation?

A. Well it is common ordinary canal water.

Q. What do the people in general say about it?

A. About the water?

Q. Yes, that particular water?

A. That it is unfit for domestic use, for domestic purposes.

Q. How far up and down the Illinois River are you acquainted?

A. From what is known as Little Rock to—well, I have been down that river a great many times; down to Marquette. I have been down that far.

Q. Are you on the river very much now?

A. No sir, I have not been for quite a while.

Q. Have you been on the river very much for the last four or five years?

A. No sir.

Q. So as to its exact condition at all times, you couldn't state positively?

A. No sir, not within the last four or five years. I have been on the river quite frequently and also noticed it and noticed it particularly after the waters of the Canal were emptied
6222 into the Illinois river.

Q. How large is this Little Vermillion?

A. You mean its width?

Q. Yes, what is the volume of water that is discharged into the Illinois river, if you know?

A. I don't know.

Q. It is a very small stream, is it not?

A. It is a small stream.

Q. At certain seasons of the year, it is large?

A. Yes.

Q. And at other seasons?

A. It is very small; it is just now small.

Q. But as a rule, taking it the year around, it is very small?

A. Yes, it is known as a small stream.

Q. Do you know and are you acquainted with the typhoid death statistics of La Salle and Peru and Utica?

A. No sir.

Q. For the last four years or five years?

A. No sir.

Q. There has been some typhoid fever, has there not?

A. Yes, there was in La Salle; I don't know anything about Peru, Utica or Spring Valley.

6223 Q. Do you know to what source it was attributed?

A. No sir.

Q. Never heard that discussed?

A. No sir, I never did. (F. S. B., Com'r.)

Whereupon an adjournment was taken until 1:00 P. M., same day at same place, La Salle, Illinois—Monday, August 17th, 1903.

6224 La Salle, Illinois, Harrison House. 1:00 P. M., Monday, August 17th, 1903. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

CHARLES H. NICOLET,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. Charles H. Nicolet; La Salle, civil engineer.

Q. How long have you lived in La Salle?

A. Since 1893.

Q. Have you had at any time any official position in the city of La Salle?

A. Yes sir.

Q. What was it?

A. City engineer.

Q. When was it and for how long a time?

A. Beginning with 1893, and for about four years.

Q. How far is La Salle from Joliet, by river?

6225 A. I don't know by river; sixty miles by rail.

Q. How far is it above Henry dam?

A. La Salle?

Q. Yes.

A. I couldn't say as to that.

Q. Well, about how far?

A. Well, I should think by river in the neighborhood of forty miles. That is a mere guess, however.

Q. What town immediately joins La Salle?

A. On the west, Peru.

Q. Now is there another town on the Illinois River named Spring Valley?

A. Yes sir.

Q. What is the population of Spring Valley in round numbers?

A. I should judge in the neighborhood of 4,000.

Q. And of Peru?

A. Probably 6,000.

Q. And of La Salle?

A. About 10,000.

Q. What is the source of the water supply in La Salle?

A. The water supply for La Salle is drawn from two different sources, three different sources I may say. In the first place, artesian wells; in the second place springs, and in the third place, seepage from the Illinois and Michigan canal.

6226 Q. Has La Salle a system of public waterworks?

A. Yes sir.

Q. Are these three sources of water received at the same intake?

A. Yes sir.

Q. How far is the water from the Illinois and Michigan Canal pumped until it reaches the intake?

A. In the neighborhood of 400 feet.

Q. Is it through an open ditch or is it through a natural layer of sand?

A. Through a gravel bed.

Q. Does it run on the surface a good deal of the way?

A. No sir, none of it.

Q. None of it?

A. No.

Q. You think it is seepage from the Illinois & Michigan Canal?

A. Yes, I think the so-called springs up there really have their source from the canal, and really they are seepage.

Q. Well but is there not a direct connection between the canal and a lake or pond into which these springs have their entrance?

A. About three or four years ago there was a connection
6227 with the lake, and these lakes had no connection with the
intake; whether they have been connected since I cannot
say; there is no connection I know of excepting the private—

Q. Now into what do the public sewers of La Salle empty?

A. Into the canal and the canal basin.

Q. And the canal basin into what?

A. Into the Illinois river.

Q. How far below La Salle?

A. About three-eights of a mile.

Q. What proportion of the population of La Salle has its domestic sewage emptied into the public sewers?

A. I should think about seventy per cent.

Q. What becomes of the household sewage of the remainder?

A. There is no scheme for disposing of the garbage, that is simply thrown on the surface as a rule.

Q. Is some of it hauled and deposited on some low land here near the Illinois river?

A. Oh, there is a little garbage thrown out there.

Q. Did you take samples of water for the State of Illinois in the years 1900 and 1901?

A. Yes sir. Well no, not in 1900 and 1901.

Q. In what years?

A. Well now, you will have to refer to the dates on those tickets (indicating).

6228 Q. Well, 1899 and 1900?

A. About that time. I don't remember as to dates; those are the correct dates, however (referring to tickets).

Q. Under whose employment or direction did you take the samples,—Professor Long's?

A. Yes, the chemist's.

Q. And to whom did you ship the samples?

A. To Prof. Long.

Q. How frequently did you take samples?

A. Once a week I believe, most of the time.

Q. Describe the method of taking them.

A. A bottle was sent to me—two bottles were sent to me in a case. One of them containing I should judge about two gallons, and the other one probably a pint. The bottles were always filled in the channel and were filled by removing the cap and the stopper under the water and they were replaced under the water.

Q. What kind of a cap was it, do you remember?

A. I have got that one bottle a little too large. I was thinking of the can. There wasn't over four ounces in that small bottle, I should say, and there was, as I recollect in the first place, a glass stopper; over the glass stopper was stretched a piece of rubber and that was bound on by a rubber band,

that is the small bottle. The large bottle I believe, had
6229 nothing but the—I don't remember whether there was
a cover over the glass stopper of the large bottle or not.

Q. When you had filled the smaller bottle, what did you do with it?

A. I replaced the stopper and put on the rubber arrangement, under the water, and removed it from the water and put it into a small can.

Q. With reference to packing it, did you use any ice?

A. Yes, it was then put in the wooden case that was provided for the two bottles, and packed in ice. Now I am not sure whether the large bottles were packed in ice, or just the small ones, I am not sure about that.

Q. The small ones.

A. I guess it was only the small ones.

Q. When the sample was taken, did you make out any ticket or card with reference to it?

A. There was a ticket.

Q. (Counsel hands paper to witness).

A. Well, you refer to this ticket?

Q. Yes?

A. Yes a ticket was made out, of which this is a copy, and that was put in an envelope and the bottles were tagged, stating the source—

6230 Q. Did you have a thermometer and take the temperature of the air and water?

A. Yes.

Q. Was that placed on the ticket each time?

A. Yes sir.

Q. I now hand you 36 tickets in an envelope and ask you to examine them and state whether or not they are tickets which were attached to bottles or samples of water which you took?

A. I suppose it is not necessary to identify each one o
them?

Q. Well, just look at each one of them.

(After examination by the witness).

A. Yes sir, these are the tickets that accompanied th
samples.

Q. Is the writing on those tickets in your hand?

A. In almost every instance they are. In two or three instances they are in my wife's hand.

Q. Were these tickets filled out by you or under your direction?

A. Yes sir.

Q. The tickets that were filled out by your wife were filled out at your request?

A. At my request, yes sir.

Q. How long from the time you took the samples until they were delivered to the express company?

6231 A. They were delivered to the express company the next morning in almost every instance. Once or twice they were delivered the same evening, if I recollect rightly now—let me see—yes, they were delivered the next morning, and went up, as I recollect it, on the ten o'clock morning train the next morning after the sample was taken.

Q. At what time of the day was the sample taken?

A. In the evening.

Q. In the samples taken in the Illinois river, where were they taken with reference to the sewage of the city of La Salle, above or below the city?

A. About some two or three miles above.

Q. Is there a stream comes into the Illinois river near there?

A. Yes sir.

Q. What is that?

A. There is two, the Little Vermillion and the big Vermillion, so-called.

Q. Now where is the Little Vermillion River?

A. The Little Vermillion lies to the east of La Salle.

Q. Is it above the city of La Salle, as the current of the Illinois River flows,—as to the current of the Illinois River?

A. Yes sir.

6232 Q. Where is the Big Vermillion?

A. It comes into the Illinois River about a mile above the mouth of the Little Vermillion.

Q. Did you take some samples of water in one of the Vermillion rivers?

A. Yes sir.

Q. In which one?

A. In the Big Vermillion.

JUDGE JOHNS: I now hand the Commissioner 36 tickets and ask to have them inclosed in an envelope and the envelope marked "State of Illinois Exhibit No. 13 for identification. Witness C. H. Nicolet."

Said tickets are so marked by the Commissioner.

Q. Examine the tickets I now hand you and state whether or not they are tickets representing the—or attached to samples of water taken in the Vermillion River?

A. They are.

Q. Is the writing upon those tickets in your hand?

A. Yes sir, I think in every instance—well, one or two are written in by my wife's hand.

Q. Such as are written by your wife's hand were under your direction?

A. Yes sir.

Q. Now are those the same tickets which, after being placed in an envelope, were attached to the bottles or samples of water taken in the Vermillion river? 6233

A. Yes sir.

Q. How far up the river from its mouth were these samples taken?

A. About one-quarter of a mile.

Q. Were these samples taken upon the dates and at the times stated in the tickets attached to them?

A. Yes sir.

MR. JOHNS: I now hand the Commissioner ten tickets, identified by the witness, and ask him to inclose them in an envelope and mark them "Exhibit 14 for the State of Illinois for identification. Witness C. H. Nicolet."

Q. Are you acquainted in any way here with the manufacture of zinc in La Salle?

A. Yes sir.

Q. How large a plant is there here, and how many plants for the manufacture of zinc?

A. Two plants.

Q. Well, what is in general numbers, their annual output?

A. I couldn't say as to their output as I am not familiar with that.

Q. What connection have you with the plant?

A. I am the engineer.

Q. The civil engineer?

6234 A. The civil engineer, yes sir.

Q. Do these zinc works use water of the Illinois River for any purpose?

A. No sir—well I can't speak for the Illinois Zinc Company. Our own company does not, the Matthiessen & Hegeler Zinc Company.

Q. From what source does the company which you represent obtain its water?

A. From the Little Vermillion.

Q. What is the name of the company for which you are the civil engineer?

A. Matthiessen & Hegeler Zinc Company.

Q. For what purpose does this company use the water of the Little Vermillion?

A. Well for a good many purposes; mainly for cooling bearings in journals.

Q. Do they use it for washing in any part of the ore or in any of the processes?

A. They use it incidentally for washing out tanks.

Q. Now is there some per cent of acid goes out of these tanks in the process of washing?

A. You can hardly say a per cent; there is a trace.

Q. Of what kind of acid?

A. Sulphuric acid.

Q. Into what is this washing, and the water used by the zinc works deposited finally, into the Vermillion river, or into the Illinois? 6235

A. Into the Vermillion river.

Q. And does it from thence pass into the Illinois?

A. Yes sir.

Q. Is that above or below La Salle?

A. Above La Salle.

Q. What amount of water do they use continuously from day to day?

A. Oh, I should judge perhaps a quarter of a million gallons a day.

Q. Pumped from the Little Vermillion River in, and then discharged again into the Little Vermillion?

A. Yes sir.

Q. What is the amount of water pumped here into the public water supply?

A. It varies from about 1,500,000 gallons to as much as 2,500,000 gallons per day,—24 hours.

Q. Daily—and after used that is discharged again into the Illinois River?

A. Most of it, presumably.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How long have you lived in La Salle?

6236 A. Since 1893.

Q. How long have you been city engineer?

A. I was City Engineer from 1893 to 1897,—1896 or 1897 —I don't remember just when I left—about four years.

Q. You are not city engineer now?

A. No sir.

Q. At the time you were City Engineer, was this valve connecting the Illinois and Michigan Canal open so as to run the water into this sand bed which furnished a part of the water supply of the city?

A. It was opened at times when the supply was short.

Q. But as to whether it is open now or not you cannot say?

A. I couldn't say, no sir.

Q. The people generally in the city get their water supply from this public source, do they not?

A. Yes sir.

Q. They do not use the water of the Illinois River for domestic and drinking purposes?

A. They do not use it for domestic purposes, but it gets into the system when the water is high.

JUDGE JOHNS: Into the public supply system?

A. Yes sir.

Q. MR. JEFFRIES: In what way?

A. Overflows. The bottoms of the pipes are unsound,
6237 and the pressure is reversed and the water from the river gets into the pipes and it is drawn into the pumps and circulated.

Q. That is the only way that it can get in?

A. Yes sir.

Q. Well, do you know whether that condition obtains now?

A. It does not.

Q. How long has it been since it obtained?

A. Oh, I should judge some two or three months, possibly; perhaps six weeks, since the river has been down to normal stage.

Q. It does not prevail to any great extent though, does it?

A. It has this year prevailed for about four or five months, the past year.

Q. What particular part of the city is supplied with that water.

A. The entire city.

Q. The entire city?

A. Yes sir.

Q. What proportionate part of that water is Illinois River water during those times, if you know?

A. I couldn't tell anything about that.

Q. Very small percentage, is it not?

A. Well, enough to make the water very riley, and probably a pretty good per cent.

6238 Q. You say you don't use the water from the Illinois river in your zinc factory?

A. No sir.

Q. But you do use the water from the Vermillion?

A. Yes.

Q. And you discharge the surplus water or refuse into the Vermillion?

A. Yes sir.

Q. Now I understood you to say that there was a trace of acid in this water that was discharged from the factory?

A. At times probably; I have never tasted it.

Q. How much acid do you use in the manufacture of zinc in the zinc process?

A. We don't use any in the manufacture of zinc. We manufacture acid. These tanks that I referred to are the commercial tanks that are mounted on cars and shipped,—large tank cars. They are the means of transporting the acid. When they are returned they are washed out. There is no acid that remains in them of course. The acid is too valuable a product to remain in them; we simply wash them out, and the product is very small that is left in the tank.

Q. Do you know what per cent of acid is left in the water?

A. We can't classify the per cent; it would be some small fraction of one per cent.

Q. It would be an infinitesmal amount?

6239 A. It would be a very infinitesmal amount, just a trace.

Q. Now is there any other substance that your factory discharges into the Illinois River?

A. Nothing of a contaminating nature. There is very little sewage, but there is nothing else to contaminate the water. The water is used almost exclusively for circulating purposes and it is almost pure as it comes out.

Q. In what way does this water from the Illinois River, get into the water system here during high water?

A. The springs and artesian wells are about two miles above the city in the Illinois river bottom, and are conducted by gravity to the supply well at the pumps, which are erected at the mouth of the Little Vermillion, within the city limits. This well is supplied at the pumping station by a 24-inch vitrified pipe which is placed underground through the Illinois river bottoms. At places this pipe has been broken so that in time of ordinary requirements, the water is coming out of the pipe through these leaks and holes in the pipe; it oozes out on top of the ground. When there is an inordinate supply in the city, that is all stopped and of course these holes are open for the entrance of water. Now when the Illinois overflows at times of course it finds its way into the cracks and crevices into the pipes.

6240 Q. And it depends largely on the number of the crevices and cracks there are in the pipes?

A. Yes, and the state of the Illinois water.

Q. Now what protection does the city use towards preventing any more of those holes and crevices in the pipes?

A. Occasionally when a leak becomes very bad, it is fixed up. The city has made several efforts—the water system has been bonded for the limit allowed by law; they have not been able to, so that the people simply have to suffer.

Q. The water then that comes from the river is not recognized by the people as good water during those high stages?

A. Not potable water.

Q. And all means within the city's power at the present time and heretofore have been used to avoid anything of that kind?

A. Practically, yes.

Q. Improvements are now going on to better the condition.

A. No sir.

Q. Are you interested in any other manufacturing interest?

A. No sir.

Q. Except that of zinc?

A. No sir.

Q. Do you know anything about the discharge of substances from the other zinc factories in town?

A. Well, the other zinc factory is in Peru. This is the only one in La Salle.

6241 Q. I suppose they have about the same facilities that your company has?

A. Well, I presume so, although I couldn't say as to that.

Q. They follow practically the same method of management and treatment?

A. So far as I know.

(F. S. B., Com'r).

6242 JOHN GRUBB,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. John Grubb.

Q. What is your business?

A. Fishermen.

Q. How long have you been in the fishing business?

A. Oh, I have been in the fishing business—I commenced—for about the last, oh, seven years.

Q. Are you acquainted with the Illinois River?

A. Yes sir.

Q. What stretch of the river are you familiar with?

A. Why, between Spring Valley bridge there and the shipping port bridge here in La Salle.

Q. How far are those two points apart from each other?

A. Well, they are about seven miles I guess.

Q. What was the condition of the Illinois River before the opening of the drainage canal?

A. Why it kind of stagnated along the shores there and slimy stuff would be running along the shores there for a while and it would stink. People couldn't live along there;
6243 they would get malaria ague, and one thing and another that way and the fishing wouldn't be no good along the shore.

Q. What has been the effect of opening the drainage canal on the waters of the Illinois river?

A. Why, the only effect I see is fishing has been a little bit better and the fish will live longer in the water, and furthermore when I go over there in the spring or in the fall I generally take a drink of it. It don't hinder me any or hinder any of the rest of them; they drink it right along now when they are out seining.

Q. Have you heard of any fishermen who drank the water being made sick from it?

A. No sir.

Q. Prior to the opening of the canal how did fish live in the water?

A. Why, they lived pretty good. Before that when I would put little sunfish or croppie in boxes they would die in there, or black bass or anything like that, they would die, and now the water is fresh, and they will stay alive in it—there is more fresh water.

Q. How long, before the canal was opened, would they live?

A. They wouldn't live until the next day hardly.

Q. How about now?

6244 A. Why, they live for a week.

Q. How was the condition in winter?

A. In winter they live all winter.

Q. Before the opening of the canal how was it under the ice?

A. Why, the fish that we used to catch under the ice would taste tarry, gassy, you couldn't eat them; you could catch lots of fish all right, but they were no good; they were froze in the ice and one thing and another.

Q. Since the opening of the canal what has been the effect?

A. Why, the fish has been tasting pretty good. There is no fishing like they used to be then; they would come to a hole then, you know, where they won't now; they have got plenty of fresh water, more air holes; there is a more strong current in the river, I guess, keeps the air-holes open.

Q. Have you drank the water of the Illinois river?

A. Yes, sir.

Q. Since the opening of the canal?

A. Yes, sir.

Q. How frequently?

A. Oh, eight or ten times a day in the spring and in the fall.

Q. What effect has it had on you, if any?

A. Not any effect at all.

Q. Has it made you sick?

6245 A. No, sir; it made me feel like drinking more.

Q. What, in your opinion, has been the effect of the opening of the drainage canal on the waters of the Illinois river as to the question of whether the river is better or worse than before the opening of the canal?

A. Why, I think the river is better for my part, and for the rest of their parts; they are all catching lots of good fish up there, which they never catched before, that is, until this drainage canal was turned in.

Q. What fish are they catching?

A. Catfish, these lake perch, a few white fish and all kinds of game fish; there was more pickerel and black bass around this spring than there has been for a good many years.

Q. Are lake perch and white fish natives of the Illinois river?

A. They are in the Illinois river here now, yes.

Q. But were not here before the opening of the canal?

A. No, I never caught any.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How long have you lived in La Salle?

A. I have lived in La Salle for about 22 years.

Q. And fished all the time?

A. Most all the time, yes, either net fishing or trot-line fishing.

6246 Q. Did you fish before the opening of the canal?

A. Yes, sir.

Q. And fished since the canal was opened?

A. Yes, sir.

Q. And are fishing now?

A. Yes, sir.

Q. There is a larger volume of water now, isn't there and a better current?

A. Oh, there is a swifter current, yes, sir.

Q. How much swifter is it?

A. Oh, it is just that swift that you can't run a seine hardly. Of course it is probably three or four feet higher than it was before.

Q. What is the difference in the water now as to what it was before the canal was opened?

A. Why, the difference in the water now is it is clearer.

Q. You don't know whether it contains Chicago sewage or not, though, do you?

A. I don't know nothing about that. I know when it rains it is muddy, and that is all, but when it is settled, why, it is as clear as a crystal, especially in the fall, last year and the year before, why, it was as clear as a crystal.

Q. You say you drink the water of the Illinois river?

6247 A. Yes, sir.

Q. And it always makes you feel like you want more of it?

A. Oh, it just makes me feel that way, that I think it is all right.

Q. Got a kind of a salty taste, has it?

A. No, no.

Q. Do you drink anything else besides water?

A. I do when I get it.

Q. What kind of fish are those you say you caught since the opening of the canal, that you didn't catch before?

A. Lake perch.

Q. Did you ever fish in the lake?

A. In Chicago lake?

Q. Lake Michigan?

A. No, sir, but I have had perch shipped in here from Lake Michigan.

Q. Well, do you know whether they come from Lake Michigan or not?

A. Why, that is what they claimed; they come through the drainage; they never catched them around here before that size; I have catched two or three white fish.

Q. Well, what are the most prolific fish in the Illinois river?

6248 A. Carp.

Q. And the most numerous?

A. Why, that is the most fish that there is in there, the biggest majority of the fish is carp.

Q. What do the carp feed on?

A. On mud, I guess, and dough, such as that, and little seeds.

Q. Anything else?

A. Well, they live on some of the other spawn, I guess.

Q. Well, don't they feed on most anything?

A. They feed on most anything except a fish like a minnow, they won't eat that, or a piece of meat. They will eat worms; we generally fish with what we call dough-balls, little corn meal and flour mixed; it makes little balls, and we catch carp, and this river is just full of them.

(F. S. B. Com'r.)

6249 CHARLES RIMMELE, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Charles Rimmele.

Q. What is your business?

A. Boat business.

Q. Where?

A. In the lower basin here.

Q. How long have you been in the boat business?

A. Between ten and twelve years.

Q. Do you run a boat on the river?

A. A small launch.

Q. A pleasure craft?

A. Yes.

Q. How long have you been running that?

A. About between four and five years.

Q. You and your father run it together?

A. Yes, sir.

Q. Were you acquainted with the river before the opening of the drainage canal?

6250 A. Yes, sir.

Q. What was the condition of the river before the water of Lake Michigan was turned into it?

A. Well, it was a strong smell to it, full of moss; the water was low; you might as well say pretty near dead water.

Q. Since the opening of the canal what effect has the water of Lake Michigan had on the waters of the Illinois river?

A. It has been a great deal clearer.

Q. Any other changes?

A. There has been no moss.

Q. Anything else absent?

A. Well, we have had better fishing.

Q. Any smell to the waters?

A. No, sir.

Q. Have you drank the water of the Illinois river since the opening of the canal?

A. Well, not to amount to anything.

Q. How are the fish—do you know anything about the fish?

A. Well, there is more fish than we have had.

Q. How about the size of the river, is there a better depth?

A. Yes, sir.

Q. In what way?

A. In the depth and the width.

6251 Q. How wide is the river at the upper basin, as you call it?

A. Well, a block and a half, I guess, or two blocks, such as that.

Q. How deep is the water there?

A. Well, in places it is ten or twelve feet.

Q. How does the current now compare with what it has been before the opening of the canal?

A. Well, we have got a better current there, a good deal better current.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say there is more fish than there were before the opening of the canal?

A. To my knowledge there is.

Q. Do you fish very much?

A. Yes, sir.

Q. The fish are no better than they were; there isn't any difference in that respect?

A. They are in the spring of the year.

Q. Do you fish for market?

A. No, sir.

Q. You don't drink the water when you can get anything else to drink, do you, out of the river?

6252 A. Very seldom, if I can get anything else to drink I don't touch it.

Q. Not even since the canal was opened?

A. Oh, I have drank it, but nothing to amount to anything.

Q. Well, you don't drink it unless—

A. Just in case of necessity, that's all.

Q. Now, did you drink it before the canal was opened?

A. Oh, I have drank it.

Q. Both before and since?

A. Yes, I have drank it.

Q. Why didn't you drink it all the time?

A. There was no use as long as I had good city water.

Q. So that you only drank it when it was absolutely necessary for you to drink it?

A. That's all.

(F. S. B., Com'r.)

6253 W. E. STAFFORD, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. W. E. Stafford.

Q. Where do you live, Mr. Stafford?

A. La Salle.

Q. What is your business?

A. I am manager of the Postal Telegraph.

Q. How long have you lived in La Salle?

A. Seven years.

Q. Were you acquainted with the Illinois river before the opening of the drainage canal?

A. Yes, sir.

Q. And since?

A. Yes, sir.

Q. What opportunities had you of knowing the river before the opening of the canal?

A. I have always made it a point to be around the river more or less all the time.

Q. On the river now?

A. Yes, running a boat with Mr. Masserman and myself.

6254 Q. What boat?

A. The steamer Creve Coeur.

Q. Where does it run to and from?

A. Runs from here to Starved Rock; any place between Starved Rock and Peru.

Q. What was the condition of the river before the opening of the drainage canal?

A. Well, it doesn't seem to have the clear appearance that it has since; then it had more grass, gas and stuff of that kind.

Q. Any odor on the river?

A. Sometimes there is.

Q. How since?

A. We don't discover it so much since; the water has more of a blue cast now; it looks clearer a great deal.

Q. What effect in a general way has the opening of the canal had upon the water of the Illinois river at this point?

A. It has raised the water some.

Q. How about the current?

A. The color is clearer than it used to be.

Q. How about the current?

A. Well, I think it has increased the current some; we never had a great deal of current here.

6255 Q. Do you know anybody that drinks of the water of the Illinois river since the opening of the canal?

A. No, I don't—well, we have drank it on the boat.

Q. Since the opening of the canal?

A. Yes, this summer.

Q. How many do you know that drank it?

A. Mr. Masserman and myself is all I know of.

Q. Did it ever make you sick?

A. No, sir.

Q. Have you had typhoid fever?

A. No, sir.

Q. Do you know of any typhoid fever in this town?

A. I don't think at present; they have had it.

Q. How long ago?

A. Last fall. At the same time, the city water is not supposed to come from the river.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say city water is not supposed to come from the river?

A. City water, no, sir.

Q. What does it come from?

A. It is supposed to come from springs.

Q. The water doesn't come from the Illinois and Michigan canal then?

6256 A. No, sir; it is not supposed to. I suppose it probably does when it overflows from there sometimes; it is supposed to come from Spring Dell.

Q. The people generally here don't use the water, do they, from the river?

A. No, sir.

Q. You don't know anything about the ingredients of the water, do you?

A. No, I don't; I never saw an analysis, although I understand it has been analyzed here.

Q. How often are you out on the river?

A. Well, we only generally run Sundays, once a week; sometimes we make one or two trips during the week.

Q. Has that continued during a series of years?

A. Yes, sir.

Q. Winter and summer?

A. Oh, no, in winter we don't, no.

RE-DIRECT EXAMINATION, by Mr. Todd.

Q. Do you know how much water comes from the Illinois and Michigan canal through that gravel channel, over to the lake?

MR. JEFFRIES: Objected to for the reason that the witness stated in his cross-examination that he didn't know 6257 where any other water came from, other than that which comes from the spring.

A. Which lake do you have reference to?

Q. What do you know I say, whether the water comes from the Illinois and Michigan canal to the waterworks—

A. Oh, to the waterworks?

Q. Yes?

A. Well, I suppose it does in high water, it overflows there.

Q. You have not investigated that?

A. I have been down there when the water was high, yes.

(F. S. B., Com'r.)

6258 F. L. MASTERMAN, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. F. L. Masterman.

Q. What is your business?

A. Agent for the Adams Express Company.

Q. How long have you lived in La Salle?

A. Well, I have lived in La Salle off and on for thirty years, I guess.

Q. Are you acquainted with the Illinois river at this point?

A. Pretty well acquainted with it, yes, sir.

Q. What opportunities have you had of knowing the river?

A. Well, since I was a boy I have hunted a great deal up and down the river from Ottawa to Peoria, and been on the river a great deal ever since, running steamboats.

Q. What boat do you run?

A. The steamer Creve Coeur.

Q. You and Mr. Stafford run that boat together?

A. Yes, sir.

Q. What is the condition of the Illinois river today as compared with the condition of the Illinois river before the
6259 opening of the canal?

A. Well, it is from eighteen inches to twenty-four inches higher.

Q. How is the quality of the water compared with what it was before?

A. The quality of the water in the upper river where we do the most of our boating, is a great deal better; nice clear running water, where it used to be stagnant, and there was pools covered with green scum, without any current at all in it. You could walk across the river in places.

Q. Any odor to the water under those conditions?

A. Oh, yes, there was a natural swampy odor to it.

Q. Since the opening of the canal have you noticed any odor of that kind on the water?

A. No, there is no chance for odor on the water; there is probably in the upper river, from four to five miles of a current.

Q. Have you drank the water of the Illinois river since the opening of the canal?

A. I have, yes, sir.

Q. How often?

A. Well, I couldn't say. I remember of times, very often when we were out on the river and ran out of water, that we would take with us, we would drink the river water.

6260 Q. Who would you take with you on those trips?

A. Well, it would be impossible to say; we had so many with us.

Q. I mean was it an excursion boat?

A. It is an excursion boat, but I don't know that they drank the water; generally nobody but ourselves. I have drank it; I don't know of anybody else drinking it.

Q. Did you ever experience any deleterious effects from the use of the water?

A. Not at all.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How often have you drank it?

A. Why, that is impossible to say. I have drank it a good many times.

Q. You never drank it when you could get anything else, did you?

A. Oh, no; I never drink it when we have ice water aboard. It is not my intention to drink it. We intend to have water on the boat, but when we have not—

Q. The people around here don't use the water, do they, for drinking purposes?

A. No, they don't. It is not used for drinking purposes generally.

6261 Q. Nor domestic purposes?

A. No, sir.

Q. How long have you been running this boat?

A. Why, I have been running the Creve Coeur—this is the second season. (F. S. B., Com'r.)

6262 C. L. DIESTERWEG, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns, and testified as follows:

Q. What is your name, residence and occupation?

A. C. L. Diesterweg.

Q. What is your occupation?

A. Shoe merchant.

Q. How long have you lived in La Salle?

A. About forty years.

Q. Are you acquainted with the waters of the Illinois river since you have lived here?

A. Why, I have as much acquaintance with it as any boy who was raised around here.

Q. Have you fished and hunted upon it?

A. Fished, hunted, swam in it, and so forth.

Q. Both before and since the opening of the drainage canal?

A. I have not swam in it since the opening of the canal.

Q. Have you fished some?

A. No, sir, not since.

Q. What was the condition of the Illinois river before the opening of the drainage canal, in 1900?

6263 A. Why, it was a very dirty, foul odored stream; the odor was very obnoxious during the low stage of water of course.

Q. How much, in your judgment, has the opening of the drainage canal increased the depth of the river here?

A. Why, about twelve to eighteen inches, I should judge.

Q. Now, since the opening of the drainage canal, what has been the condition of the water?

A. Why, I have never made an analysis of it, but from observation, it looks to be much purer and cleaner water; it is a good deal better colored.

Q. Is there a better current in the river?

A. A better current, yes, sir.

Q. How was the current before the opening of the canal?

A. At low stages it was very slow.

Q. Did a scum form on the water here before the opening of the canal?

A. Yes, very largely, a green scum.

Q. Was there plants in the water,—moss, something of that kind in the river?

Objected to as leading.

A. Yes, so much so, I have seen when riding in boats they would have to stop the propeller and take the grass off of it and moss.

6264 Q. Now, since the opening of the canal has there been any such thing?

A. I haven't noticed anything since.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How often have you been on the river since the opening of the canal?

A. Oh, that is pretty hard to tell; perhaps a dozen times, two dozen times, I couldn't tell you.

Q. In three years?

A. Yes, sir.

Q. How often were you on the river the three years prior to the opening of the canal?

A. About the same number of times.

Q. What you say with reference to the condition of the water is obtained altogether with reference to its appearance, is it not?

A. Yes, sir; altogether from its appearance.

Q. Do you know whether the water contains the sewage from Chicago or not at this time?

A. At this time?

Q. And since the opening of the canal?

A. Why, it is generally supposed that the drainage comes
6265 down here. I have stated that I did not make any chemical analysis.

Q. The people here don't use the water of the Illinois river for domestic and drinking purposes, do they.

A. No, they never have.

Q. That is, they don't use it if they know it?

A. Not if they know it. They never have used it. Some might seep into the wells during the extreme high water, but not very much.

RE-DIRECT EXAMINATION, by Mr. Todd.

Q. Is there anything in the appearance of the water that leads you to believe that Chicago sewage is in the water at this time?

A. No, sir. (F. S. B., Com'r.)

6266 DR. FLOYD CLENDENNEN, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Floyd Clendennen.

Q. What is your business?

A. Physician and surgeon.

Q. How long have you been practicing medicine in La Salle?

A. About thirty years.

Q. What is the condition of the public health in the city of La Salle since the opening of the drainage canal?

A. I think it has been improved.

Q. And is there any typhoid fever in the city?

A. Very little now; very little.

Q. What was the condition of the Illinois river before the opening of the drainage canal?

A. It was bad.

Q. How is the condition today as compared with what it was before?

A. Decidedly better, the water in the river is purer and decidedly better .

6267 Q. The drinking water that is used here in the waterworks is composed of what water?

A. It is composed of the water from the Illinois river, from the Illinois and Michigan canal and from some springs, and some artesian water. It is a mixture.

Q. And is that water drank by the people?

A. Largely.

Q. And is there any typhoid fever among the people who drink that water?

A. Very little; I am surprised at there not being more of it here, some of the water coming out of the canal, and swamps; I am surprised that there is not more than there is now.

Q. About how many cases of typhoid fever have there been in the town in the last year?

A. I can't say how many cases of typhoid fever in the last year; I had less typhoid to treat last year than I ever had before

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How many physicians are there in La Salle?

A. I think there is about twelve or fourteen.

Q. How many in Peru?

A. About five, I think; I am not positive.

6268 Q. Do you know how much water is consumed in La Salle in a day?

A. No, I do not.

Q. Do you know how much comes from the two springs?

A. Well, I cannot say; there is many getting drinking water from other places, and from wells; they don't like to use that water, they are afraid of it.

Q. A good many of them boil the water too, don't they?

A. A good many of them boil the water, yes.

Q. Do you know what per cent of the water comes from the Illinois and Michigan Canal?

A. No, I do not.

Q. Nor what comes from the Illinois River?

A. No, I do not.

Q. Now do you know of your own knowledge that any of it comes from the *Illinois* river?

A. Yes, I do, from the fact that the pipes have broken places and in an overflow from the river a good deal gets in and it runs through the pump really down as low—

Q. The town of late has been using every precaution to improve those conditions, has it not?

A. No sir.

Q. And do all they could in that direction?

A. No, they have simply done nothing, as I look at it.
6269 They are digging a hole up here on the bottoms now for a supply of water; they are spending money when it is useless.

Q. Are you a member of the Board of Health?

A. I used to be, but I am not now.

Q. When was that?

A. I was health officer here for two or three terms, but not in the last six years, not since it has been—but I observe the water pretty closely. I am interested in it.

Q. This water that comes from the Illinois and Michigan Canal, percolates through sand and gravel does it not, before it comes into the intake?

A. I cannot say—yes, it passes through more or less broken rock, sand loam, and so forth, more or less earth. Yes sir, it passes through more or less—some of it is in the St. Peter sand stone which is broken up there.

Q. The high water that comes through the river is what comes through these breaks in the pipes?

A. The high water comes through the breaks in the pipes along the bottom, low down on the river, where it has overflowed a good deal.

Q. You say you are surprised that there is not more typhoid fever than there is?

A. Yes, from the water we are using.

6270 Q. The people generally understand that the water is not good?

A. They understand that the water is not good; they do.

Q. For that reason they take every precaution?

A. They take every precaution. I don't know as they take every precaution; some of them drink it, you know.

Q. The local board of health advises against it, and recommends boiling the water?

A. I don't think the Board of Health does anything; I don't think they are doing anything.

Q. Well the physicians generally do?

A. The physicians generally do advise against it I think. As far as the local board of health having any influence on the health of the city, it does not in my opinion, for they don't do anything but draw their salary.

Q. What school of medicine do you belong to, doctor?

A. I have studied three schools; I first studied the old school, then homeopathy and then graduated from the eclectic college in Chicago.

Q. How long ago has that been?

A. I think when I graduated the last time it was in 1874.

Q. When did you graduate in the old school?

A. I didn't graduate at all. Before I went in the army; I was in the army as an army surgeon before I graduated, and I have taken out a certificate in Michigan.

6271 Q. When did you graduate?

A. I didn't graduate in homeopathy at all; I studied it, but didn't graduate.

Q. So then you are a graduate of the eclectic?

A. Yes, graduated from the eclectic college, but the others I have certificates from the others, not legal graduation, not legal diplomas. Only a legal diploma in the eclectic, that's all.

Q. How long have you been practicing in La Salle?

A. I think since 1876—I was here before though; but I have been here constantly since 1876.

(F. S. B., Com'r.)

Whereupon an adjournment was taken until 4:00 P. M., same day, Monday, August 17th, 1903, at Ottawa, Illinois, at the Clifton House.

Ottawa, Illinois, Monday, August 17th, 1903.

6272 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

W. A. PIKE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. W. A. Pike; Ottawa, Illinois; physician.

Q. How long have you been practicing medicine in Ottawa?

A. Seven years.

Q. Of what school of medicine are you?

A. Rush Medical College, Chicago.

Q. Did you take samples of water for the State of Illinois in the Illinois and Fox rivers here?

A. Yes sir.

Q. During what two years?

A. I think it was 1899 and 1900.

Q. Who engaged you to do that?

6273 A. I think it was Dr. Long of Chicago.

Q. Did he give you instructions as to how the samples should be taken, or the manner of taking them?

A. Yes sir.

Q. You may describe the manner of taking the samples, commencing with the receipt of the bottles, the taking of the samples and sealing the bottles and delivering them to the express company?

A. Well, I would get the bottles from the express office, and take them over to the Illinois river and there we have a boat house and I was a member of the club there, so I used to take the boat and go out into mid-stream and take the collection. The large bottle holds a gallon or so, I have forgotten what it was now. I would take that and also the small bottle, and they were both packed in a box, and all tagged. The small one was packed in ice, and they were sealed—both bottles sealed, and were delivered to the express company.

Q. At what point in the river with reference to the city of Ottawa did you take the samples?

A. Well, most of them were taken above the Illinois river bridge or just about at the Illinois river bridge.

Q. Where would that be with reference to the sewage of Ottawa?

6274 A. Above.

Q. Where were the samples taken in the Fox River?

A. The first sample I took in the Fox river was in the stream itself, but at that time the water was so low that there was practically no flow at all in the river, except a little under-current. All the flow of the Fox River came down the feeder, and I wrote Prof. Long in regard to that and said that if he wanted a test of the water in the Fox river that the proper place to get it would be from the feeder, so that he gave me the instructions after that to take the samples from the Fox, from the feeder which comes from Dayton, four miles above.

Q. What do you mean by the term "feeder"?

A. Well it is a race; there is a dam at Dayton in the Fox, and there is no water comes over the dam in the summer time; the water in the Fox river comes down this race to Ottawa, which is the feeder for the Illinois and Michigan Canal.

Q. In other words the Fox River furnishes water here in the Illinois and Michigan Canal?

A. Yes sir, this division is furnished by the Fox River.

Q. How frequently did you take these samples?

A. Every week in the Illinois river and every two weeks I think, in the Fox in the first year.

Q. And the second year?

6275 A. Why, the second year I didn't take but two or three samples in the Fox if I remember rightly. He told me to abandon them. It was every week in the Illinois during the months of June, July and August, and there was only three collections made out of the Fox or out of the feeder, in that year,

Q. What year was that?

A. The second year, 1900.

Q. How far below the surface of the stream did you immerse the bottles?

A. Well it was far enough so that whatever was floating on the surface would not enter the bottle. I would reach down from the boat about as far as I could conveniently and would get the bottle below the surface.

Q. The small bottle—was it uncorked before you put it into the water?

A. If I remember rightly the small bottle, the instructions were—I have forgotten what it was now; it was either to fill it under water, or else we kept the cork in the hand, I have forgotten which it was. I know there was something particular about the small bottle. Yes sir, I remember that now. That was without removing the stopper from the bottle; it was to place it down below. I used to reach that down as far as I could.

Q. And after it was filled, was the stopper inserted under the water?

6276 A. Yes sir.

Q. Now when the bottles were filled, what did you next do with them?

A. Why, I brought them over to my office and I had a contract with a man here for some ice. I used to pack the small bottle in a can. They came in a can, and I used to pack ice around the small bottle and then seal the can, you know, and the large bottle.

Q. Did you at the same time that you took the samples, take a thermometer and take temperature?

A. Yes sir.

Q. Of what did you take the temperature?

A. Of the water in the river,—the Illinois River, and also of the Fox River.

Q. Did you also take the temperature of the air?

A. Yes sir.

Q. Now did you have tickets or cards?

A. Yes sir.

Q. Upon which you recorded the facts?

A. Yes sir.

Q. Did you prepare those tickets yourself?

A. Yes sir.

Q. After the tickets were prepared with the data upon them, what was done with them?

6277 A. They were placed in an envelope, addressed to—I don't remember. They were placed in an envelope of some kind, I have forgotten whether they were addressed to Dr. Long or not; I don't remember.

Q. Were they attached to the bottle in any way?

A. I think they were in the form of a shipping tag, that is an envelope with a perforation and tied a string to it, and that was sealed in with the seal on the bottle.

Q. Do you remember your number,—the number of your seal?

A. No, I do not.

Q. Were the seals of wax?

A. Yes sir.

Q. How were the bottles covered at the top, over the stoppers?

A. Why, the large bottle had a large cork and I think my instructions were to place the string as I tied it around the neck of the bottle, and tied the shipping tag across the cork and the seal was placed on that so that the string was included in the seal.

Q. Do you know whether the small bottle had a rubber cover for the stopper, which was fastened to it by a rubber band?

A. Why, it had a rubber band of some kind, but I have forgotten now, just what it was, to hold the stopper in
6278 place.

Q. How long a time after the sample was taken and put into the box until it arrived at the express office?

A. Oh, not more than fifteen minutes.

Q. At what time in the day did you take the samples?

A. Usually in the morning.

Q. I now hand you 35 tickets and ask you to examine them and tell whether or not those are the cards upon which you recorded the various data and whether those tickets are in your handwriting?

A. Yes, they are all in my handwriting.

Q. I call your attention especially to the tickets numbered 166, 218, 235, 256, 283, 388, 402, 418, 439, 442, 457, 472, 484, 577 and 595, and ask you to state whether or not those tickets represent samples of water taken in the Illinois river as distinguished from the Fox River, and if necessary, you may refresh your recollection from any memorandum which you made at the time, and which you now have in your possession?

A. Yes sir, those were taken from the Illinois.

Q. Were the samples taken in the Fox River taken in the same way?

A. Yes sir.

Q. And also in the feeder from the Fox River feeder?

A. Yes sir.

6279 JUDGE JOHNS: I now hand the Commissioner 35 tickets, and ask him to inclose them in an envelope and mark it for the State of Illinois Exhibit No. 15, for identification; witness W. A. Pike.

Received and so marked by the Commissioner.

Q. I now hand you eight tickets and ask you to examine the same and state whether or not they are the tickets which were attached to the samples of water taken either from the Fox River or the Fox River feeder?

A. Yes sir.

Q. Were those samples taken in the same way as you were instructed to take them by Dr. Long?

A. This is the one taken in the feeder, so that they were not taken from a boat; they were taken along the shore, but out into the stream. The stream was very swift.

Q. The feeder stream is very swift?

A. Yes sir.

JUDGE JOHNS: I now hand the commissioner the eight tickets and ask him to inclose them in an envelope, marked State of Illinois' Exhibit No. 16 for identification; witness W. A. Pike.

Received and so marked by the Commissioner.

Q. What kind of a river is the Fox Rixer, that is, is it a large or a small stream?

A. Small, very.

6280 Q. Where does it enter the Illinois river?

A. At Ottawa.

Q. Above or below the sewage of Ottawa?

A. Above the main part of the sewage.

Q. Does any part of the sewage of Ottawa empty into the Fox River?

A. Yes sir.

Q. Where were the samples in the Fox river taken with reference to the sewage of Ottawa?

A. Above.

Q. So that neither the samples of the Illinois River water, nor of the Fox River water were affected by the sewage of the city of Ottawa?

A. No sir.

Q. Does the Fox River in seasons of drought become dry or cease to have a regular flowing current?

A. Well, it is very low in the summer. There is always a current, but it is low.

Q. And small?

A. Yes sir.

Q. How long have you been acquainted with the water of the Illinois River?

A. Fifteen years.

Q. In what way?

6281 A. Well, as having been boating, fishing, and passing over the stream every day.

Q. What was the condition of the Illinois River at this point before January, 1900 when the drainage canal waters were turned in?

A. At any particular season of the year?

Q. A general description?

A. Well, it was a good stream, except in the summer time; it got pretty low, and then there was a great deal of scum and weeds and such things as that floating down the stream, or stagnant in the stream. In the fall, winter and spring, of course the stream was much higher and swifter current.

Q. In season of low water did it have an odor?

A. It did at times, yes.

Q. Do you know whether it had an odor here in the winter, when the river was frozen over under the ice?

A. Well, I couldn't say as to that.

Q. Now since the opening of the drainage canal, what has been the condition of the Illinois River here?

A. Well, the current has been greater, and the average depth has been greater. There has been less scum on the surface a great deal less, and the general condition of the river in my opinion, has been very much improved.

6282 Q. Has the city of Ottawa a public water supply?

A. Yes sir.

Q. From what source?

A. Artesian wells.

Q. Where are they and how deep are they?

A. They are located to the north of the city within the limits, and perhaps a quarter of a mile from the Fox River; but as to their depth, I don't know, except that they are very deep, I know that they are very deep.

Q. Does that source of supply furnish a good water here?

A. Yes sir.

Q. What is the population of Ottawa?

A. Between 10,000 and 11,000, nearly 11,000.

Q. Into what is the sewage of Ottawa emptied?

A. Into both the Fox and the Illinois rivers.

Q. What proportion of the inhabitants of the city of Ottawa in your judgment empty their household sewage into the sewers?

A. Well, at the present time I should judge nearly two-thirds.

Q. Do you know what is done with the household sewage of the other one-third?

A. Well that is mostly deposited in vaults; that is, water-closets.

Q. Are they cleaned?

6283 A. They are at times, not as much as they should be, though.

Q. When cleaned, what becomes of the matter taken out?

A. As a rule that has been buried. I think at the present time it is being dumped into the river. I was health officer for four years, up until this spring, and during that four years it was all buried.

Q. Then you were health officer before January, 1900?

A. Yes, in 1899 I was.

Q. What do you know with reference to typhoid fever in Ottawa prior to January, 1900?

A. Well, I couldn't say now, to be positive.

Q. Has the city a Board of Health?

A. Well, they have, but practically the health officer is the entire board.

Q. Have they a system here of reporting the deaths and the causes of death?

A. Yes sir.

Q. To whom?

A. Until last July they were reported to the health officer. Now under the state law they are reported to the city clerk and he issues the burial permits.

Q. Prior to the reporting of the death statistics to the city clerk was a record kept here of the causes of death?

A. Yes sir.

6284 Q. Could you obtain from that the number of deaths from typhoid fever from 1899 to 1903 or 1902?

A. Yes sir.

Q. Since the opening of the drainage canal what has been the condition here as to typhoid fever?

A. There has been very little with the exception of one year, which I think was 1901.

Q. Was there much at that time?

A. Well, I think we had about 20 or 25 cases here.

Q. While you were the health officer of the city, in cases of typhoid fever, what was done with the dejecta of the patients?

A. Well the physicians had their instructions as to what to do, which was to use a disinfectant, either a bi-chloride or something of their own selection, and if practical to put it into the sewage.

Q. Bichloride of what?

A. Mercury.

MR. JEFFRIES: I move to strike out the answer for the reason that the instructions to the physicians constitute no evidence that the disposition of the dejecta was carried out in the manner provided for, and required in the instructions.

Q. JUDGE JOHNS: Do you know whether those instructions were observed here by the physicians?

6285 A. I do not; none of this was carried out under my supervision.

Q. Had you cases of your own, which you attended?

A. I had but one case that summer.

Q. Do you understand that the dejecta of the typhoid patients here, whether disinfected or not, were cast into the sewers and thence into the Illinois river?

A. I couldn't swear as to that, I don't know.

Q. Were the instructions here to either bury them or burn the dejecta?

Objected to as leading.

A. Well, that was the instruction to physicians; that they were to be disinfected and destroyed as well as they could under the existing circumstances. There was no positive orders given or no explicit directions given.

Q. Was there an ordinance of the city council in reference to it?

A. No sir.

Q. Or a rule of the Board of Health?

A. Not regarding typhoid fever. They were not even required to be reported to the health officer, so that a great many of the cases I never knew anything about until I would hear them reported in the papers.

Q. When cases of typhoid fever were known, were they
6286 quarantined or isolated?

A. No sir.

Q. Were any means taken to disinfect the rooms or homes where they occurred?

A. Not officially, excepting as they would do it themselves under the direction of their own physician.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Did you take any samples of water either from the Fox river or the Illinois river prior to the opening of the Chicago drainage canal?

A. Yes sir.

Q. Now what year was that?

A. In 1899 and 1900.

Q. What part of 1900 did you take samples before the canal was opened?

A. June, July and August.

Q. Well the canal was open at that time.

A. In 1900?

Q. Yes.

JUDGE JOHNS: It was opened in January, 1900.

A. Well it was in June, July and August, 1900 that I took the samples.

Q. MR. JEFFRIES: Then you took no samples in 1900
6287 before the opening of the drainage canal?

A. No sir.

Q. In other words you took no samples prior to January 17th, in 1900?

A. No, June, July and August the collections were made.

Q. In other words you took no samples from the first to the 17th day of January, 1900?

A. No sir.

Q. Now what month of the year did you take the samples of 1899?

A. July, August and September, October and November.

Q. And from what places?

A. From the Illinois and the Fox Rivers.

Q. With reference to the mouth of the Fox River, where were those samples taken?

A. They were all taken above the stream which comes from the Fox, although all of them were not taken geographically above the opening of the Fox.

Q. Now with reference to the Illinois and Michigan Canal, where were they taken in the Fox River?

A. They were taken above the opening of the feeder you mean into the—I only took one collection from the Fox River itself. The rest were all taken from the race or feeder which comes from Dayton; that was done before it emptied into the
6288 Illinois and Michigan Canal.

Q. That one sample?

A. No, those from the feeder were all taken before that.

Q. And there was one sample that was taken after it had passed through the Illinois and Michigan Canal?

A. No, the Fox river passes under the canal, and the canal is acqueducted over the river at this point. I took one from the Fox River itself. After that I was instructed to take them all from the feeder.

Q. And with reference to the Fox River, they were taken above the sewage discharges of this city, were they not?

A. Yes sir.

Q. Now did you take any samples from the Fox River in 1900?

A. Yes sir.

Q. During those months that you have just mentioned, June, July and August?

A. I took three in July and August,—one in July and two in August.

Q. Did you take any samples in 1901?

A. No sir.

Q. You took no samples at any time in 1901?

A. No sir.

Q. From either the Illinois or the Fox River?

A. No sir.

6289 Q. Now with reference to the mouth of the Fox River, where did you take the samples in the Illinois River, in 1899?

A. They were all taken above the stream of the Fox River.

Q. All of the samples that you took during the several periods were taken above the entrance of or the mouth of the Fox River?

A. Yes sir.

Q. And above the sewage discharges of the city of Ottawa?

A. Yes sir.

Q. Now did you have any instrument of any kind which you used to take these samples?

A. I had the bottles provided by the Commission.

Q. Aside from the receptacles, what instrument did you use?

A. Why the thermometers, when we would get the temperature of the air and the water.

Q. Well, did you have any machine of any kind that you put the bottle in and immersed the bottle under the surface of the water?

A. No sir.

Q. You used your hand?

A. Yes sir.

Q. And you went down under the surface about how deep?

A. Oh, three or four inches perhaps.

Q. Were you—or did you rinse the bottles out?

A. No sir.

6290 Q. What was the condition of these bottles at the time you received them?

A. They were cleaned and packed in a case.

Q. When did you remove the stopper or the cork—they were glass stoppers weren't they?

A. Yes. Of the large bottle I wasn't so very particular. I removed the stopper and put the bottle beneath the surface, and the small bottle, the stopper was removed under the surface of the water.

Q. Were your instructions upon that subject so that it required you not to be as careful with them as with the small ones?

A. Yes, as I understood it, the large one was simply for chemical analysis, and the small one was for bacteriological.

Q. And the small bottle, the corks were removed and replaced while the bottles were under the surface of the water?

A. Yes.

Q. Now that was not true always with reference to the large bottles?

A. No sir.

Q. Did you take all of these samples personally?

A. Yes sir.

Q. Every one?

A. Every one.

6291 Q. Did you use the thermometer that the parties had provided you with, or did you use your own?

A. Yes sir, I used one they furnished me with.

Q. Who furnished the thermometer?

A. Why I think Dr. Long sent it down.

Q. How far are the wells that are used to supply the inhabitants of Ottawa with water, from the Illinois River?

A. They must be three-quarters of a mile from the Illinois.

Q. How far from the Fox River?

A. And one-quarter of a mile from the Fox River.

Q. You say they were of some considerable depth?

A. Yes sir.

Q. Can you approximate it?

A. No, I can't.

Q. Do you know how many of them there are?

A. No, I don't know that; I know there are at least six.

Q. They are all stationed at one point, are they?

A. Yes sir.

Q. Do you know the character of the soil through which they are driven, whether it is clay, sand and gravel?

A. That is all gravel, I think, stratas of sand and gravel and a great deal of solid rock.

6292 Q. What percentage of the people of the city use the water from the public supply?

A. I should judge two-thirds, either all the time or part of the time.

Q. The city owns the water supply does it not, or the water plant?

A. Yes sir.

Q. Now in addition to these public wells, that are owned by the city, and the public waterworks, there are a large number of private wells, are there not?

A. Yes sir.

Q. Are they wells or cisterns, or both?

A. Artesian wells.

Q. Do the people living in this city and vicinity use the water of the Illinois River for drinking and domestic purposes?

A. No sir.

Q. It is one of the duties of the health officer is it not to keep close observation of the water supply?

A. Yes sir.

Q. To what extent is this town sewered?

A. Well, they have some sort of a sewerage sytem over about two-thirds of it.

Q. Where does that discharge?

A. In both the Illinois and Fox rivers.

6293 Q. Now you say the contents of the vaults are disposed of in what way?

A. They used to be buried; I don't know what disposition is made of them now.

Q. You have no personal information on that subject?

A. No.

Q. The comparison that you spoke of in your direct-examination since the opening of the canal and prior thereto, is based altogether upon your observation of the water, is it not?

A. Yes sir.

Q. You wouldn't recommend the water of the Illinois river for domestic and drinking purposes?

A. No sir.

Q. What school of medicine did you say you were of?

A. Rush Medical—regular.

Q. You have made no examination of the water or anything of that kind?

A. No sir.

Q. But your opinion as to it being suitable for drinking or domestic purposes is based upon your personal knowledge of the river and surroundings?

A. Yes sir.

(F. S. B., Com'r.)

6294 HENRY MAYO,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. Henry Mayo; I reside here in the city of Ottawa, County of La Salle and State of Illinois, and have lived here since 1854.

Q. And your occupation?

A. Why, my occupation has been an attorney at law, and still continues to be an attorney at law; although I am Postmaster here at the present time.

Q. Were you ever concerned with the improvement of the Illinois River as a member of any association, and if so, of what association?

A. Yes sir, in 1887, the first bill was prepared and presented to the legislature authorizing the formation of a drainage district in the city of Chicago. At that time the Illinois River Valley—

MR. JEFFRIES: I object to the question because it is incompetent, irrelevant and immaterial.

A. (Continuing)—Association, which was an organization of people looking into the question of turning the sewage
6295 from the city of Chicago into the valley of the Illinois; took the matter in hand and organized and—I was placed at the head of the executive and judiciary committee for the Illinois Valley Association which extended at that time from Joliet to the mouth of the Illinois river. I continued in that position until after all of the amendments that are now attached to the law, which was passed in 1889, were prepared and adopted by the legislature.

MR. JEFFRIES: I move to strike out the answer and the question for the reason that it is not responsive to the question, and for the further reason that the object and purpose of the legislation which was secured through the efforts of this witness and his associates in the Commission upon which he may have been engaged, speak for themselves with reference to any interpretation thereupon by the witness.

Q. JUDGE JOHNS: Were you afterwards in any way concerned in the Commission appointed by the Governor under the drainage law, for the examination of the canal at the time of its completion?

A. Yes sir, I was associate counsel for the special commission appointed by the Governor, until the water was turned into the channel of the Desplaines river.

Q. How long have you been acquainted with the condition of the Illinois and Michigan Canal prior to the opening of the drainage district canal?

6296 A. Ever since I came here in 1854, down to the time of the opening of the drainage channel, and since, also.

Q. Now do you know of the fact as to the City of Chicago pumping water from the Chicago River into the Illinois and Michigan Canal in 1885?

A. Yes sir, I know about it, and I have been there,—not at that period of time, but I have been at Bridgeport during the time they were pumping. My recollection is that that work commenced very much earlier, probably at Bridgeport, than 1885. My recollection is that that commenced along in either 1871 or 1872,—the construction of the pumping works.

Q. What was the condition of the Illinois and Michigan Canal for five years prior to the 17th of January, 1900, when the drainage canal was opened?

A. Prior to the time it was opened?

Q. Yes?

A. Why, the canal, the upper level of the Illinois and Michigan Canal itself supplied the water from the pumping works at Bridgeport, and the pumping works at Bridgeport, the water lifted by the pumping works into the canal was very largely sewage itself from the south branch of the Chicago river; it was almost thick. I won't say it was thick, but it was very dark colored, and very much contaminated with sewage.

Q. Now what became of the water of the Illinois and
6297 Michigan Canal when it arrived at or near Joliet, with reference to its discharge into the Desplaines river?

A. The average amount of water lifted by the pumps at Bridgeport, I think was about 45,000 cubic feet per minute; sometimes more and sometimes perhaps a little less, but the average amount would be about 45,000 cubic feet of water per minute, about 12,000 cubic feet of water per minute of that amount was required for the purposes of navigation in the Illinois and Michigan Canal. The balance, the excess drawn out by the pumping works at Bridgeport was spilled into the Desplaines river where the canal came to the river, and came down through the Desplaines river from the upper basin of the canal and thence into the Illinois River.

Q. Now what was the condition of the Desplaines River at Joliet and down to the Illinois River while this matter was discharged into it?

A. It was very offensive. There was a very strong odor over the water from the dams at Joliet, very dark colored, and very thoroughly impregnated with sewage.

Q. Where did the Desplaines River enter the Illinois with reference to Joliet?

A. Just above Wilmington, and forms the Illinois by its junction with the Kankakee River.

Q. How far is Wilmington from Ottawa?

6298 A. I couldn't tell you the exact distance. I think it is fourteen miles below Joliet, or sixteen—fourteen I believe it is. I couldn't give you the exact distance.

Q. What was the condition of the Illinois river where it was formed by the junction of these two prior to the opening of the drainage canal?

A. Very much impregnated with the sewage that was taken out of the south branch of the Chicago river by the pumping works at Bridgeport,—so much so that the water had a very strong smell,—very offensive and in a bad, unhealthy condition, as I considered it.

Q. In the vicinity of Ottawa were there scums formed upon it, and was there a vegetable growth in the river?

Objected to as leading.

A. There was a vegetable growth on the water in warm weather, in the summer, a scum formed upon it, but to a greater or less extent, it depended upon the stage of water largely, but in an extreme low water there was a good deal of vegetable growth.

Q. Had it an odor?

A. It had a very strong odor, not so much in the summer as in the winter when the river was frozen over. I live on the south side of the Illinois river and cross it two or three times a day
and for that reason know what I am talking about. I have
6299 seen times when it disturbed my meals very much to cross
the river, before the water was turned in, when the ice was breaking around the piers, and the odor from the water came up from around those piers.

Q. At which time was the odor the most offensive, in the summer, in low water or in the winter when the ice was formed on the river?

A. Generally most offensive in the winter. It became so bad that fish couldn't live in the water at that time long. I don't recall the year, but I guess in 1879, we built a dam across here for water power purposes, above Ottawa, and that spring, a great many, probably wagon loads of fish were made stiff and virtually destroyed by the bad condition of the water.

Q. Now, since the opening of the drainage canal what has been the condition of the Desplaines River at Joliet and down to Wilmington, and the Illinois River from Wilmington to Ottawa?

A. In my judgment very much improved. The condition of the water, both winter and summer has been very much better than it ever was before. Its condition has improved instead of deteriorating, very much.

Q. Has it now an odor in the winter?

A. Nothing that I have perceived; there may be a very 6300 slight odor, but nothing that I have noticed; nothing to call my attention to it.

Q. As to the quality of the water, its appearance, what do you say as compared with the time prior to the opening of the canal?

A. It has very much improved in appearance as well. In low stage of water according to the statement of our city engineer, Robert Wilson, who is now dead—

MR. JEFFRIES: We object to any statement of the city engineer.

A. (Continuing) According to the best information that I could obtain, in a low stage of water, below the mouth of the Fox River, and at the Illinois bridge, which is just below the mouth of the Fox River, there were 150,000 cubic feet of water per minute passed the Illinois River bridge, and the water in extreme low stage was very offensive because a large part of it—I say a large part of it because not the larger part, but perhaps one part in six was sewage that came through the pumping works at Bridgeport. That condition has improved vastly since the opening of the drainage channel.

6301 CROSS-EXAMINATION, by Mr. Jeffries.

Q. When were you last on the Desplaines river?

A. I think it is probably—let's see—about four months.

Q. How often have you been upon that river in the last twenty years?

A. I was on that river very often during the time that I was associated with the Illinois Valley Association, as chairman of its committee, and very often during the time that I was acting as attorney for the special commission appointed by Governor Tanner, to pass upon and accept the channel on the part of the state, after turning the water in—very often.

Q. That was prior to the opening of the canal, was it not?

A. Yes sir.

Q. Since the opening of the canal your visits upon that river have been—

A. Not so often. I occasionally go to Joliet and then I have been to Lockport since that time, where the controlling works are.

Q. When you say the river has improved in condition you simply give that as your opinion from observation?

A. I certainly do, because I am not an expert; I have no
analyses of the water; I only know from general appear-
6302 ances, and from comparing the present condition with the
very offensive condition that sometimes occurred prior
to that time.

Q. What means are employed by the city of Ottawa for its water supply?

A. Artesian wells.

Q. They do not use the water from the river?

A. No sir, we have the waterworks here, but the waterworks are supplied by artesian wells.

Q. How deep are these wells?

A. I think 350 and one or two of them are probably deeper.

Q. Do you know how many wells of this kind they have?

A. In the city?

Q. That belong to the city?

A. No, I don't myself, the mayor can probably tell you better about that. There are probably in the neighborhood of sixty or seventy of those artesian wells here in the city.

Q. Yes, but I am speaking now of the wells used in connection with the city water supply?

A. I couldn't tell you myself, though there is an abundance of water I know.

Q. Do you know the character of the soil through which these wells are driven?

A. I think I do; that is I know by representations by
6303 men who have bored the wells.

Q. It is through sand and gravel, is it not?

A. No sir, it is through sand, the first strata is sand rock for about 100 feet, then you have 100 feet about, or 160 feet of limestone. It is very hard—before you strike the water-bearing rock.

Q. Do you know the character of that water bearing rock?

A. No, I don't anything different from other water-bearing rocks of the same nature.

Q. How far are those wells located from the Illinois River?

A. Oh, they are located a considerable distance, probably three-quarters of a mile, I should think, nearly three-quarters of a mile from the Illinois River—the wells that are used by the city. Other wells are close to the river.

Q. How far from the Fox River?

A. They cannot be probably over thirty or forty rods from the Fox River.

Q. Now in addition to the wells that are owned by the city in connection with its waterworks, you say there are a large number of private wells of the same sort?

A. Yes sir, a great many.

Q. About sixty in all?

A. I think probably more.

Q. Now in addition to these sixty or more, how many
6304 private cisterns or living wells are there, or are there any?

A. I don't know of any myself at present; there may be for all I know.

Q. The people living in Ottawa do not use the water from the Illinois River for drinking and domestic purposes, do they?

A. Not that I am aware of. If there are such cases I don't know it.

Q. What, Colonel, is the difference in the flow of the current of the Illinois River now as compared with what it was prior to the opening of the Chicago Drainage Canal?

A. It is a very little greater—there is by the amount of water now put in, and I take it that the drainage trustees are not complying with the law fully, but the river is raised about two feet or nearly two feet at this place, and the current is a little more rapid than it was before.

Q. Now you stated a moment ago that the odor that came from the water in the river prior to the opening of the canal was principally in the winter time?

A. Well not principally, but it was great at the time when the river was entirely frozen over, the breaking of the ice first occurred, around the piers in the bridges—the Illinois River bridge, which I crossed every day.

6305 Q. Now there is some odor since the opening of the canal at times, is there not?

A. At times there has been perhaps some—none observable from the bridge. I have heard some men say, which of course, I don't know, but I have heard some men say who have been on the river that there was at times some odor on the river.

Q. Are you on the river very often here?

A. Not on it only to cross it. I cross it two or three times a day.

Q. On the bridge?

A. Yes, I live on the south side of the river, and have lived there ever since I arrived in the city, and cross it regularly from two to four or five times a day.

Q. What did you say was the purpose of the organization of the Illinois River Valley Association?

A. The first purpose was to oppose the turning of water in from Chicago, that contained the sewage of Chicago—into the Illinois River. A thorough investigation of that question, coupled with the condition of the ship canal in so far as the sanitary district completed it, induced the people to change their ideas and to protect themselves against any noxious odors or any injury to health in so far as they were able to do so by getting such amendments to the law as we felt would protect our people through the valley.

6306 Q. Then the turning of the sewage was not the prime question, it was more the deep water proposition?

A. No sir, not to consider that, the waterway was one of the things. We induced the Illinois Valley people to consent to the cutting of the drainage channel though.

Q. And that was upon a general belief that deep water would be obtained, that the tacit consent of the Valley Association was obtained and their co-operation was secured?

A. I think quite largely so; there was a difference of opinion, some of our medical men claimed that we were going to be injured rather than benefited. Some took the opposite position.

Q. It was not, however, for the purpose of obtaining a pure water supply for any of the towns and cities situated upon the banks of the Illinois River?

A. Oh no sir, we never thought of that so far as I am concerned, and I don't know that any of our people here thought of it.

Q. So that so far as the association was concerned, deep water was really the principal and prime object?

A. That was the primary object and purpose with our people through the valley.

Q. And that association has much to do yet before they get deep water?

6307 A. I think so. I have been connected with it now for about fifteen or sixteen years, I guess, and I haven't seen the end yet.

(F. S. B., Com'r.)

6308 CHARLES E. HOOK,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Charles E. Hook.

Q. What is your business?

A. Cashier of the First National Bank.

Q. Do you hold any official position in Ottawa?

A. Yes, I am mayor.

Q. How long have you been mayor?

A. About four months.

Q. Who was your predecessor?

A. Mr. Moloney.

Q. Are you acquainted with the Illinois River and if so, how long have you been?

A. Ever since I can remember.

Q. What opportunities have you had for becoming acquainted with the Illinois river?

A. Well, I have been on it more or less all my life, boating and swimming.

Q. What was the condition of the Illinois river prior to
6309 the opening of the drainage canal in January, 1900?

A. It was bad.

Q. By bad, what do you mean?

A. Well I mean it was in such condition that on evenings, you couldn't go out in a boat and stand it.

Q. Just describe all of its characteristics?

A. Well it was foul; it was a river with a scum or this green stuff that formed on the river—clover we used to call it.

Q. What is its condition now?

A. It is much cleaner.

Q. What effect, in your opinion, has the opening of the drainage canal had upon the Illinois River at this point?

A. It has produced more of a flow and the river appears to be much cleaner and freer from foul odors.

Q. What is the condition of the public health in Ottawa?

A. Good.

Q. Has Ottawa an open system of sewerage?

A. What do you mean by that?

Q. That is sewers connected with the houses?

A. It has not much of any system of sewerage.

Q. Where does the sewage of Ottawa find its outlet?

A. This portion of Ottawa here, empties into the Fox River; that south of the river empties into the Illinois.

6310 Q. What proportion of the population of Ottawa empties its sewage into the Fox River, and the Illinois River?

A. Well, I don't know; I should think that probably one-tenth of the territory emptied into the Fox River at present.

Q. What proportion into the Illinois?

A. I should say about one-fifth.

Q. What is the population of Ottawa?

A. About 11,000.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. The people living in Ottawa do not drink the water from the Illinois River, do they?

A. No sir.

Q. Do you know of any one using the water from the Illinois river for drinking or domestic purposes?

A. No, sir.

Q. Now when you speak of the condition of the water being better since the opening of the canal than it was prior thereto, you do so in a qualified way, do you not?

A. Yes sir, I am not an expert on the analysis of water.

Q. Governed altogether by your personal observation?

A. Yes sir.

6311 Q. What you saw?

A. Yes sir.

Q. The sewage from Chicago may be in the water now as well as the filth and other decayed matter, prior to the opening of the canal, may it not?

A. It may be.

Q. How far is it from here to Chicago?

A. 84 miles.

Q. By river?

A. I don't know. That is by the Rock Island road.

Q. You don't travel on the river?

A. No.

Q. Are you a member of this Valley Association they talk so much about?

A. No sir.

Q. How long have you lived in this town?

A. Forty-one years.

RE-DIRECT EXAMINATION, by Mr. Todd.

Q. From observation, can you detect the presence of any Chicago sewage in the waters of the Illinois river at this point?

A. I don't think you can.

(F. S. B., Com'r.)

6312 M. T. MOLONEY,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. M. T. Moloney.

Q. What is your business?

A. I have practiced law for a living most of my life.

Q. Are you connected with any of the industries of Ottawa?

A. Why yes, I control and own the gas plant in this city; I own a hotel and own an office building and considerable other property.

Q. Have you ever filled any public position?

A. Yes sir, I have been living in this county for a little over 32 years, and I have been city attorney for a number of years; I have been states attorney of the county, as we call it, four years, and have been attorney-general of the state for four years, and been mayor here of the city of Ottawa for the last four years, up until about two or three months ago.

Q. Are you acquainted with the Illinois River?

A. Yes, I am familiar all during, practically, I might say all my life, as man and boy.

6313 Q. How extensive has been your acquaintance with the Illinois River?

A. Well, I don't know that I could exactly describe it, but I have known of it practically from its source where the Desplaines and Kankakee, by their junction, form the Illinois River; from that down, I might say, to Hennepin, where I used to practice law, when I was more actively engaged in the practice of law than I am at present. I have known all along the river. I used to for about seventeen years, have a camp down here in the summer, about six miles west of Ottawa, right on the bank of the river. I might say that I have lived on the bank of the Fox River for about seven years, and for the last seventeen years, I have lived on the bank of the Illinois River, on what we call the west side of this city.

Q. What was the condition of the Illinois River prior to the opening of the drainage canal in January, 1900?

A. During the part of the year, say from about the middle of June after our freshets, until the end of September, the water was low; it was foul, and filthy, and the scum, that greenish plant, whatever you call it, that would be found on stagnant pools, permeated all of it right along from one end of it practically to the other. There was little or no current during

that portion of the year. Of course, during the winter season
practically the same condition of affairs existed, except
6314 of course it was frozen over. I mean so far now as the
foulness and the stench arising from it was concerned. It
would not be ordinarly proper to call it an odor, because that is a more refined word—a stench, a smell would be the proper designation for it—the exhalations that arose from it.

Q. What has been the condition of the river since the opening of the drainage canal, at this point?

A. So far as I have been able to detect, and living as I have been during all those years on the bank of the river, there is a very, very vast improvement upon it; that is the God's truth—a vast, vast improvement. I didn't belong to the Illinois Valley Association, and I may say frankly here to you that I never took any stock in the loose talk that took place along this valley here. They had some meetings at Ottawa, some at Peoria, some at Marseilles. There were two men that got up this association and that was Means, a most excellent man of Peru, who is now dead, and Sanford Morris, who is also dead. Both were perfectly honest and perfectly sincere, and they thought it would be a detriment if the Chicago water diluted as the law directed, were to come down here; it would be detrimental to the health of the people of the valley. The fact is, I never took any stock in it and never belonged to it. I believed it would be a good thing for the city of Ottawa and for the
valley if we could get that Chicago sewage diluted as
6315 it was coming down to us, through that canal. Anyhow,
that was awfully offensive, terribly so. I believed it
would be a great advantage to the entire valley if the water was let in as contemplated by law. The only trouble is that you people have not complied with the law of this state. There was to be 300,000 cubic feet of water at the population that the Chicago district then was, when that act was passed, and it was to be increased proportionately at every 100,000. Now you are about 2,000,000 of people and it was then about 1,500,000. You are simply not letting down enough of water in my judgment. Certainly you don't comply with the law, and that is apparently because navigation of the south branch of the Chicago river would be somewhat impeded, as I understand it.

Q. You understand why the law has not been lived up to, do you not, General, the Secretary of War—

A. Yes, I understand about the Secretary, Mr. Alger, while he was Secretary of War, having issued an order to that effect with regard to the possible impairment of the navigation of the south branch of the Chicago River. I understand that General Alger did that.

Q. Since the opening of the canal, what in your opinion has been the effect upon the water at Ottawa?

A. Of course, without any scientific knowledge, personally, I can only say that from observation and living upon the bank of the river, that it has been freed from all of those
6316 noxious odors, stenches, and the accumulations of that
stuff on the surface of the water, which of course, would indicate a breeding of malaria ordinarily, if continued to exist. I think we are very much benefited, I would say by reason of the accumulation of water that has been coming down here, I think that is the concensus of the opinion of all our people throughout this entire valley.

MR. JEFFRIES: I move to strike out the part of the witness' statement giving the concensus of opinion of the people living in the Illinois River valley, on the subject testified to.

THE WITNESS: That certainly is my own opinion, and my own observation.

Q. MR. TODD: What was the condition of the Illinois and Michigan Canal prior to the opening of the drainage canal?

A. Well, very offensive, even though the level between Marseilles and the lower level down here, is practically filled by the feeder from the Fox River, up at Dayton, still it was offensive. That is what we call the feeder, which is about four miles northeast of here, and the water is taken from the Fox River and put into the Illinois and Michigan Canal.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How does the flow of the current in the Illinois river
6317 compare now to what it was before the opening of the
canal?

A. Why, there is a marked difference, I notice that daily you know, because I live on the bank of the river.

Q. And the current carries this decayed matter away?

A. Yes, I think so; I think there is no doubt about it. It prevents, you see—

Q. That of course prevents the odor from arising?

A. Well, of course I don't know just exactly whether it does or not; it certainly prevents now that decayed material, that scum that used to form during the summer and practically during—possibly of course not in winter, but certainly during the summer; it has carried that off without any question. We have a steamboat on the Illinois River plying between Ottawa and what we call Starved Rock, and no such thing has been known for the thirty-two years that I have lived here prior to that time, though I have heard that about fifty years ago, boats did come up from this end to Ottawa and to the mouth of the Fox River here and land over here where there is an old landmark, or used to be, about two years ago, where Daniel Webster spoke at one time.

Q. You wouldn't undertake to say that while there is no odor in the winter time, that the same impurities are not in the water?

6318 A. I can only say in answer to that, this, that it is not detected, and it was formerly, and what could any reasonable man conclude from that?

Q. Yes, but I am speaking with reference to a comparison of the conditions existing between winter and summer?

A. I would say precisely the same thing. My answer would be the same, we formerly detected it, and we don't now; now what do you conclude?

Q. Pardon me, General, but I think you don't comprehend the question. What I want to know is the fact that prior to the opening of the canal there was no stench or odor that was discernible in winter time, while there was in the summer time, yet that did not necessarily imply that the impurities were not in the water in the winter time?

A. If you will just divide that question up and make two questions instead of one, I would say in the first part, you are mistaken.

Q. I understood from your testimony a moment ago that the odor was discernible in the summer time?

A. Certainly.

Q. But was not so discernible in the winter time?

A. I didn't say that. It was discernible in the winter time just as well. My attention, when I was talking, was directed to the summer and not to the winter.

6319 Q. So that it was discernible prior to the opening of the canal at all times?

A. I think so, it was just as offensive in the winter, so far as we were concerned down there. The boys would go skating across the river and most always used to come down there. I lived fifty feet from the river—

Q. Now what you have stated in reference to the condition of the water now and prior to the opening of the canal is simply from your observation and not on account of any personal or scientific investigation that you have made, or that has been made?

A. You would have to divide that question. Personal and scientific—I ain't a scientist, but personally, I can't help this nose of mine being used to smell.

Q. That comes within your observation?

A. It comes through ordinarily the nerves of my nose, anyhow.

Q. How long have you been living on the bank of the river now?

A. Why, I should think nearly eighteen years, a little over seventeen—between seventeen and eighteen years, I think probably it will be either eighteen years next September, or either seventeen, and I am inclined to the notion that it will be eighteen.

6320 Q. Now in speaking of the Illinois Valley Association, at the time of its organization and down even to the present time, and especially down to the time of the opening of the canal, the membership almost entirely were working for a deep water way as you understood it, were they not?

A. Why of course—why I guess that to a certain extent, and they thought that the sewage of Chicago would be offensive to them as I understood it, but I always told them if they wanted water to come down here that the law directed, that I thought it was to be a God's blessing to the whole valley.

Q. Now the object of the people, as you believe, on that subject, did not have in view the obtaining of a water supply for the various towns and cities in the valley, but the object was to free themselves from this offensive odor that might have come from this water in the past, is that not true?

A. Except by their talks, I couldn't tell what those people intended. I hadn't any possible way of devining what their notions were. My own opinion was this, that there never was any intention on the part of those people, to use the additional supply of water for domestic purposes, or for any purpose except to have an additional water-way, and to have the sewage so diluted with an accumulation of water, as that it would not be offensive to us. From a patriotic standpoint I was always in favor of a large, deep canal, because I believed and 6321 I still believe, that we ought to have an internal waterway for at least men of war or cruisers on the interior streams of the country, of small draught to be at comparatively a moment's notice, thrown right into our lakes to defend our large cities and come right up from the Gulf, because while we are apparently friendly with England now, nobody can tell how long that may be, and I believe that we ought to have cruisers on the lakes to defend our large cities.

Q. That, however, could be obtained without carrying the Chicago sewage down the Illinois river?

A. I know, but you have got to have always some little motive and some little incentive to our people. I found that out in the war of 1898 when we had to go down to Porto Rico and Cuba, we were not prepared; we always want to do things right off in a hurry, and then we got left and we got walloped like blazes for about five or six months before we were in condition to fight.

(F. S. B., Com'r.)

6322 J. O. LESLIE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. My name is J. O. Leslie; my residence is Ottawa; occupation, school teacher.

Q. What position do you occupy with reference to the public schools of Ottawa?

A. I am principal of the High School.

Q. How long have you lived in Ottawa?

A. Fifteen years.

Q. Do you live anywhere near either the river Fox or the Illinois River?

A. Well, when the Illinois overflows, it overflows my garden.

Q. How long have you lived there?

A. I have lived there ten years, that is to say I lived on one side of the street or the other, across the street—ten years at that place.

Q. Do you sometimes fish?

A. Yes, sometimes.

6323 Q. Were you acquainted with the condition of the waters of the Illinois river before January, 1900, when the drainage canal was opened?

A. I was.

Q. What was its condition?

A. Well, the water was pretty bad sir, and I noticed it especially in the summer time.

Q. In what respect?

A. When the water would be low, in the summer, you could notice an accumulation of slimy mud, and then the water would go off of the places where it wasn't very deep and leave mud on the banks, a dirty, stinking mud.

Q. You mean when the high water would recede?

A. Yes sir.

Q. Was that a regular condition here after a flood and when the waters retired?

A. Yes sir, so far as I know, it was from the time I came here.

Q. Take it in your lot, for instance, did it leave a deposit there?

A. Well, that particular lot I have only owned three years, but I have lived immediately across the road for seven years before that, so that that special lot I don't know about it.

Q. But other places in that vicinity?

A. Yes sir.

6324 Q. What was the character of that odor?

A. Well, it is hard to characterize an odor—offensive I should say. I didn't like the smell of it.

Q. Now as to the condition of the river in low water, before the opening of the drainage canal, what was it?

A. Well, the current was very sluggish for one thing; the water was dirty and full of floating—I don't know what you would call it, chunks of stuff; it never was free from them. All along the banks of the river the gravel line just along the banks was most always covered with a dirty slime; never clear sand or clean gravel.

Q. Was there an odor to the water?

A. Always, so far as I know. I didn't use to like to row on it because it did smell so.

Q. Do you know of the condition of the water in the winter?

A. I don't know so much about that. I have sometimes skated a little, but never noticed it particularly.

Q. Now since the opening of the drainage canal what has been the condition of the Illinois River at this point?

A. Well sir, it has been very much improved—very much, I should say; the water stands twenty inches higher than it did at any rate, and the old muddy banks we used to notice are not exposed any more, and the gravel and sand along the edge of the river is cleaned up. You see the white sand now and the
6325 clean gravel that you never used to see before the ditch was turned in.

Q. Since the opening of the drainage canal and after a period of high water, was there any deposits left upon the banks here in the gardens on the low-lands?

A. Oh yes sir, but it is silt that is washed in from the surrounding country; it is not what comes down the river proper. It is what is washed in; it is such silt as is washed in by any flood.

Q. It is not offensive now, as it was?

A. No sir.

Q. How long have you been connected with the schools here?

A. Fifteen years.

Q. What has been the health of the children in the schools since the opening of the drainage canal as compared with that before?

MR. JEFFRIES: Object to the question for the reason that the evidence shows that the people living in this city do not use the waters of the Illinois River for domestic or drinking purposes.

A. I can't see a very great deal of difference, that I know of. The water, as this gentleman says, is not used for drinking purposes or for domestic purposes at all. We use artesian water here and it does not come from the Illinois river.

6326 CROSS-EXAMINATION, by Mr. Jeffries.

Q. When you speak of the condition of the water in the river being improved, you do so simply from what you have observed?

A. Sure.

Q. Not with reference to any use of it or anything of that character?

A. What do you mean by having used it?

Q. Using it for drinking or domestic purposes?

A. Sure; never used it that I know of; never intended to.

Q. What is the flow of the current now as compared to what it was before the canal was opened?

A. Well, it is just a matter of observation and judgment—I should say it was at least twice as great.

Q. At times before the canal was opened, there was practically no current?

A. Oh, there never was a time when there was no current, but it was often sluggish.

Q. It has never been sluggish though since?

A. I never saw it sluggish, no sir.

(F. S. B., Com'r.)

6327 JAMES F. FARRELL,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. James F. Farrell; I reside at Ottawa, Illinois; I am a newspaper man and also city clerk.

Q. How long have you been city clerk?

A. I have been for the past four months, but I was city clerk on a former occasion; ten years ago, I was also city clerk.

Q. Is there in the office of the city clerk a record of the deaths from all causes?

A. Yes sir.

Q. For how long a time has that been kept?

A. For a period of thirty years, I think, about 35 years.

Q. Are you the custodian of that record?

A. Yes.

Q. Have you that record with you?

A. Yes sir.

Q. I wish you would open it and give from it the number of deaths from typhoid fever from 1897 until the present year?

6328 A. Fourteen deaths from typhoid fever.

Q. How many each year?

A. 1897, 5 deaths,
1898, None,
1899, 2 deaths,
1900, 2 deaths,
1901, 4 deaths,
1902, 1 death.

Q. And have you a record thus far in 1903?

A. Yes, there were none I believe in the last year, in 1903; nothing in 1903 at all.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Do you keep this book?

A. Yes sir.

Q. How long have you kept it?

A. Well this last time, I have kept it since the first of May.

Q. Have you kept it at any other time for the last six years?

A. No sir.

Q. Is there any distinction made between typhoid malaria, typhoid fever and malarial typhoid or typhoid malaria?

A. Well, I think not.

6329 Q. It all goes under the one head?

A. It all comes under the head of typhoid. Most doctors, in rendering their certificates, present them in that form.

Q. Just simply typhoid?

A. Typhoid, yes, and very frequently, if you will observe there you will find that in cases where deaths have been caused by pneumonia, it may have been typhoid pneumonia; I know nothing about that.

Q. And have you included those in your list?

A. I have not.

(F. S. B., Com'r.)

Whereupon an adjournment was taken to same place until 7:30 p. m., same day, Monday, August 17, 1903.

6330 Ottawa, Illinois, Monday, August 17, 1903.

Parties met pursuant to Adjournment. 7:30 p. m. Present, the Commissioner and same counsel representing the respective parties.

LESTER J. HORAN,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Lester J. Horan.

Q. Where do you live?

A. 311 East Superior Street, Ottawa, Illinois.

Q. Mr. Horan, did you take water for the Sanitary District of Chicago?

A. I did.

Q. When did you take it?

A. I kept no record of it; my cards are the only record.

Q. About what time was it?

A. Well, through the summer months up to along, October, I believe.

6331 Q. October of what year?

A. 1900.

Q. For whom did you take the water?

A. I understood it was for the Sanitary District of Chicago.

Q. At what places did you take the water?

A. From the Fox river north of Ottawa, and from the Illinois east of Ottawa.

Q. What did you take the water in?

A. Glass bottles, a gallon and a four ounce bottle, one of each of these from each river.

Q. Where did you get the bottles from?

A. They were shipped from the station to where the water was delivered.

Q. Where were they shipped from?

A. From the Department of Health and from the Illinois University at Champaign.

Q. When you got the bottles did they have a cork in them?

A. Yes sir.

Q. What kind of a cork?

A. Glass stopper.

Q. After you received the bottles, just relate the manner in which you filled them?

A. I placed the bottles elbow deep under the water, removed the stopper, let in a small quantity of water, placed the stopper in again; withdrew the bottles, rinsed them, emptied out the water and placed the stopper in again, placed the bottle again in the water and removed the stopper until they were filled within—well just left small air spaces in the top. 6332

Q. Now after you filled the bottle, what did you do with the bottle?

A. I sealed them.

Q. How did you seal them?

A. By placing a rubber cloth over it, and running a wire seal around it with the number, one was from one river and the other from the other.

Q. After you had sealed them what did you do with them?

A. I took them over to the house and packed them before shipping.

Q. How long after you took them out of the water before you packed them and prepared them for shipment?

A. Well, about twenty minutes I should judge.

Q. How did you pack them?

A. The large bottles were put in excelsior in the case; the small bottles placed in a small can and then in turn put in ice, in a larger can.

Q. After you had got them prepared in that manner, how did you identify them?

6333 A. There was an envelope containing a tag with the date of taking the water attached to the large bottle.

Q. Did that tag have the sample number on it?

A. Yes sir.

Q. The date?

A. Yes sir.

Q. Place taken?

A. Yes sir.

Q. Your name as collector?

A. Yes sir.

Q. Height of water?

A. Yes sir.

Q. Temperature of water?

A. Yes sir.

Q. Direction of wind?

A. Yes sir.

Q. And temperature of air?

A. Yes sir.

Q. With the directions on the back?

A. Yes sir, the directions for filling the bottle and filling out the card.

Q. I show you Sanitary District of Chicago Exhibit No. 11, for identification, Frank S. Bright, Commissioner, and ask 6334 you if the cards which you filled out were cards similar to the one that you have, as far as the printing matter was concerned?

A. Yes sir.

Q. With the directions on the back the same as that?

A. Yes sir.

Q. That card you attached to each sample that you sent?

A. That is the sample consisting of the large and the small bottle.

Q. The large and small bottle?

A. Yes sir.

Q. Now to whom did you send these samples?

A. To the University of Illinois.

Q. Anywhere else?

A. Well no, not in my name.

Q. Did you send any in any other name?

A. No sir.

Q. Do you know whether you sent any to Chicago or not?

A. I don't believe I did.

Q. How long after the samples were taken before they were put on the train?

A. Well, the samples—an hour and a half at the most.

Q. When you got bottles from Chicago, where did you send the bottles that you got from Chicago?

6335 A. The bottles were returned to Chicago.

Q. To whom did you send them?

A. To the Department of Health.

Q. You sent some to the Department of Health?

A. No, just returned bottles there.

Q. The bottles you sent were sent to Professor Palmer of the University of Illinois?

A. Yes sir.

Q. Didn't you send any to the Board of Health of Chicago and to Professor Jordan of the University of Chicago?

A. I don't remember. I had his tags but I don't remember of positively sending any.

Q. Well if you did send any to the University of Chicago, and the Board of Health of Chicago, they would have the tags, with your name?

A. Yes, have my name and the date on it.

Q. The same as these other samples?

A. Yes sir.

Q. And those tags would correctly state the facts as you wrote on the tags?

A. Yes sir.

6336

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You say this was in 1900 or 1901?

A. In 1900.

Q. What part of the year?

A. Along in the summer, up until October.

Q. How often did you take samples of water?

A. Once a week.

Q. From what particular place in the river?

A. North of Ottawa and East of Ottawa.

Q. How far north?

A. Above where any sewage emptied into the river and east of the same line.

Q. Well, about how many miles?

A. Well, half a mile I think, about.

Q. How far east?

A. East it was across from the Pioneer Works clay bed.

Q. Now did you take samples at both of these places each time?

A. Yes sir.

Q. When you took the sample above the town, did you pack that and ship it before you took the sample below?

A. No sir.

6337 Q. Then you collected the sample at both places, packed them, sealed them and tagged them and shipped them within an hour and a half from the time the first sample was taken?

A. That is about the time.

Q. Who assisted you in this work?

A. Nobody.

Q. Did you use an instrument or machine of any kind in which you placed the bottle before you submerged it into the water?

A. No sir.

Q. You used your hand for that purpose, did you?

A. Yes sir.

Q. Now when did you remove the stopper from the bottle?

A. After the bottle was of the length of my elbow under the water.

Q. Now that was with reference to both the small and the large bottle?

A. Yes sir.

Q. Did you rinse the bottles out?

A. Yes sir.

Q. After you had immersed the bottles in the water and drew them out and rinsed them, did you put the stopper in again before you immersed it in the water?

A. After I rinsed the bottle I put the stopper in and put
6338 the bottles down under the water, took the stopper out
and filled the bottle and then placed it in again before
I took it out of the water.

Q. Both the large and small bottle?

A. Yes sir.

Q. Now were the small bottles packed in ice upon every occasion?

A. Yes sir.

Q. Did you do that yourself?

A. Yes sir.

Q. No one did it for you at any time?

A. No sir.

Q. Now did you take samples at any other period than that which you have just mentioned?

A. No sir.

Q. You spoke of shipping bottles to Chicago that were empty bottles, how did that happen?

A. They sent an order and the order was countermanded.

Q. All of the orders then that came from Chicago were countermanded?

A. All of them?

Q. Yes?

A. I understood all of them came from Chicago.

6339 Q. Well all the orders that came to you from Chicago—

A. Well as far as I had to do with them, they were.

Q. And the only order that you shipped was from here to the University?

A. I had tags from the Chicago University and from the Department of Health, Chicago, but I don't remember positively of shipping them there.

Q. What express company did you send them by?

A. United States Express Company.

Q. How many times did you miss the train on the day that you took the samples?

A. I don't ever remember of missing it.

Q. You may have?

A. Not that I was aware of.

Q. How is that?

A. Not that I was aware of.

Q. After they sent the bottles down here to be filled and shipped to Chicago and countermanded the order, did they write you to that effect?

A. They wrote a letter saying, return the bottles and tags to the Department of Health of Chicago.

Q. And you did so?

A. Yes sir.

Q. There was no excuse given as to why they had countermanded the order?

6340 A. Not that I remember of.

MR. JEFFRIES: That's all.

MR. TODD: That's all.

(F. S. B., Com'r.)

6341 ALBERT HAHN,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows

Q. What is your name?

A. Albert Hahn.

Q. Where do you live?

A. 300 Jackson Street, Ottawa, Illinois.

Q. Did you ever take samples of water?

A. Yes.

Q. For the University of Illinois?

A. Yes sir.

Q. About what years did you take them?

A. 1898.

Q. Do you know whether you took any in 1899?

A. No sir.

Q. For whom did you take them?

A. Professor Palmer of the University of Illinois.

Q. Where did you take the water from?

A. Fox River.

Q. What point?

A. East of Ottawa.

6342 Q. How far above where the sewage of Ottawa enters the Fox River?

A. Well, it was between the Fox River Bridge here and the aqueduct.

Q. How often did you take the samples?

A. Once a week.

Q. Now just describe how you took the samples and what you did with them?

A. Well, the bottle was tied with a linen cloth or stopper, a linen cloth, when it came. You didn't open it until you got to the river and would go out about, well as far out as you could get into the river, where the current was, and put the bottle down at arm's length; remove the stopper and fill it about half full; place the stopper on again, and rinse the bottle; and then put the stopper in before you put it into the water, then withdrew it after you had it in there, filled the bottle, placed the stopper in while it was still in the water, then withdrew it, and tied that cloth around it.

Q. Then what did you do with it?

A. Packed it in excelsior and shipped it.

Q. Did you put any tag on it?

A. Yes sir.

Q. What kind of a tag did you put on it?

A. Well, I don't remember; it was a card of instructions 6343 that came in an envelope, a card of instructions with every bottle, and it was tied right onto the bottle.

Q. What did you put on the tag?

A. Date, the condition of the river, whether above or below normal, the weather, and signed my name.

Q. Did you see Professor Palmer at any time?

A. Yes sir.

Q. He gave you instructions?

A. Not at the time. I met the gentleman while I was taking water, but all I got was the written instructions from him.

Q. Now, after you got the sample packed, what did you do with it?

A. Took it to the express company's office.

Q. And whom did you express it to?

A. Professor Palmer, of the University of Illinois.

Q. You didn't pack any samples in ice?

A. No sir.

Q. How long after, from the time you took the samples out of the river was it before you put it in the express company's charge?

A. Not later than half an hour.

6344 CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How often did you take samples?

A. Once a week.

Q. For how many weeks?

A. I don't know.

Q. Have you any idea?

A. I began March, 1898, and the last I can remember is December the same year.

Q. Did you take any in 1899?

A. Not that I remember of.

Q. In 1900?

A. No sir, I know I didn't in 1900.

Q. Are you certain that you did not or that you did take them in 1899?

A. I am not certain that I did not take them.

Q. What is your impression or opinion?

A. Well, I have forgotten; it is so long ago.

Q. How can you remember that you did take them in 1898, and cannot remember as to whether you did in 1899?

A. Well I had a record of them when I took them.

Q. And you quit keeping the record?

A. Yes sir.

Q. Did you take any in the winter of 1898?

6345 A. Yes, began in March.

Q. Did you continue through the spring, summer, fall and winter?

A. Yes sir.

Q. And go into the following spring?

A. I don't remember.

Q. Were you out in a skiff to take these samples?

A. No sir.

Q. Get them on the edge of the water?

A. No sir, I waded out as far as I could. In cold weather when there was ice in the river I chopped a hole in the ice; went out as far as I could then into the river.

Q. You didn't get the sample from the channel of the river then?

A. Yes sir.

Q. All the time?

A. Yes sir.

Q. How deep was the water where you got the samples?

A. Oh, it varied from a foot in the summer time to probably four or five feet deep at the deepest.

Q. That was before the Chicago drainage canal was opened?

A. I don't remember when that was opened.

Q. Well, do you remember whether it was opened at that time or not?

6346 A. No sir, I didn't pay any attention.

Q. How long after you took these samples before you shipped them?

A. I took them to the express office, I don't know what became of them after that.

Q. Did you take a receipt for them?

A. No sir.

Q. Did you take samples at any other place than this one that you speak of?

A. No sir.

Q. And that was in the Fox River?

A. Yes sir.

(F. S. B., Com'r.)

6347 DANIEL C. WOODS, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Daniel C. Woods.

Q. What is your business?

A. My business at present is clerk in the Clifton Hotel, Ottawa, Illinois.

Q. Have you done any work for the government?

A. I have done a little lately in the way of reading the gauge of the river for the United States Geographical survey.

Q. How long have you been engaged in that?

A. Oh, a matter of—I should say a matter of a year or more.

Q. Prior to that time were you acquainted with the Illinois river?

A. I was.

Q. How long have you been acquainted with the Illinois river?

A. Well, a matter of—well, I will say forty years.

Q. What opportunities have you had of observing the Illinois river during that period?

A. Well, I have in past years hunted and fished 6348 and sailed on that river. I used to use, you might say, millions of gallons of water from that river in the line of business I was previously engaged in.

Q. What business were you previously engaged in?

A. Locomotive engineer on the C. R. I. & P. railroad.

Q. Were you acquainted with the Illinois river prior to the opening of the drainage canal?

A. Yes, sir.

Q. Describe its condition?

A. From what time?

Q. As much of the Illinois river as you have personal acquaintance with?

A. Well, I mean for what period of time; what year.

Q. Well, any period up to 1900?

A. Well, in the early days, way back, it was not so bad; they hadn't done so much in Chicago to make it bad. After and previous to 1900, after they went to pumping the drainage at Bridgeport, I suppose you gentlemen all know where that is,—that river became fouler and fouler and fouler until it was very foul. The Rock Island road abandoned their tanks in the stations in Joliet, and built a coal chute and tanks out about a mile and a half from the station. I suppose you have seen that. Now, that water was so foul that the Rock Island road was obliged to put in some filters, and they put in two very
6349 large filters that cost quite a sum of money, and while they were cleaning one filter they had to use the other filter; but even with using the filter the water was so foul that when it was running from the crane into the tank, if the wind happened to blow toward the engine, it was sickening on the engineer; it was a foul, stifling smell, and after taking the water on the engine any little steam escaping from the gauge cocks or from the boiler head would sicken you with the foul smell. Now these filters I spoke of, Mr. O'Brien, the man who had charge of all the water business—

Q. Never mind about going into that, just confine yourself to the river from Joliet down?

A. Yes, I was coming to that; I was going to say in regard to the water, if you will pardon me a minute, I just want to make that point,—that he had the utmost difficulty to hire men to clean those filters out; had to pay them extra pay; couldn't get men. That is how foul it was—to clean those filters. Well, now, at another place there, another point on that water in winter time when the river was froze up, then the water was foul, the gas and smell from that water was frightful at that time.

Q. At what point was this?

A. At Joliet station.

Q. Well, how about in the neighborhood of Ottawa?

6350 A. Well, you take it in the summer time when the river was not frozen, approaching Ottawa on a still night with the breeze blowing towards you, three miles before you reached Ottawa you would reach the smell, and the smell would continue until you was more than that beyond Ottawa, going west, and of course that was governed a good deal by the wind that was blowing, you know,—how you would get it.

Q. Were you on the river at any time prior to the opening of the canal in 1900?

A. Oh, yes, from time to time, yes.

Q. What was the condition of the water in the Illinois river?

A. Well, the condition of the water where I was on the river was of course much better than it was where we are speaking of, because it was many miles down the river.

Q. Where was it that you were on the river?

A. Well, from Bureau, and up around Bureau, hunting and fishing there. Of course it was very much better that distance from Joliet—the water improved as the water diffused itself in traveling.

Q. Now, in the neighborhood of Ottawa,—were you ever out on the river at this point?

A. What time are you speaking of?

Q. Prior to 1900?

6351 A. Well, I don't know as I was at Ottawa, out on the river, no.

Q. What has been the condition of the water since the opening of the drainage canal?

A. Oh, all the difference in the world. It is now what you would say a clear stream. In fact, if a man was not acquainted with the facts and knew that the drainage canal was coming into the river, he would never imagine for a moment but what it was the same as any other river that arose from a good course and continued on its way; he would never imagine but that it was the same as any other river of that kind.

Q. How often have you seen the river in the last year?

A. Oh, twice a day—I see it every day.

Q. At what point do you see it?

A. At the C., B. & Q. railroad bridge; I go to get my gauges.

Q. Do you notice any smell on the river now?

A. Not a particle, any more than any stream you would find in the country that was a clear, nice river.

Q. What is your opinion as to the effect of the opening of the drainage canal on the Illinois river?

A. The effect on the Illinois river?

Q. Yes, sir?

A. Why, it has changed it from a vile stream,—a stream that you would know at one glance was vile, that you
6352 wouldn't eat a fish out of the river, to a nice clear stream
that you would class with any other stream. The fish in the river—in fact, they are catching lake fish right here at Ottawa, lake fish from Lake Michigan, the same as you would catch in Chicago.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Did you ever fish in Lake Michigan?

A. Many a time.

Q. And they are the same fish?

A. Same fish; I have caught the same fish in Lake Michigan.

Q. What do you say to this proposition that the lake fish will not live in this water?

A. Well, I have seen them and had them in my hand. I don't ask any man. I have had them right in my hand, right down at the bridge, at this bridge where I go to get the gauge of the river every day. There is a great many men and boys fishing there, and it is a frequent thing for me to go down and see what they were doing and ask questions of course. They said they were catching perch and I would look and see what kind they was. They were the same lake perch I was catching in Chicago myself.

Q. Do you take the gauges of the river every day?

6353 A. Yes sir.

Q. What time of the day?

A. I get it in the morning; I time myself in the morning;—at 6:30 every morning, and 6:30 at night; that is the time I get it for the government. I get up at half-past five and go down the river.

Q. And you gauge it twice a day?

A. Yes sir.

Q. And do you keep a record of those?

A. Yes sir, the record is on my desk at the present time.

Q. How long does that record go back?

A. Well, I couldn't tell. I will go to the book and show you. A year I will say, perhaps more.

Q. Who kept it before you?

A. Nobody before I did here, that I know of. This is a new survey, the United States Geographical survey.

Q. Do you make a report?

A. Yes sir, every week.

Q. Who do you make the report to?

A. I make the report to—now to 263 Dearborn Street. Previous to that I made the report to Heilbron, 1010 Security Building.

Q. What is the name of the gentleman that you are making the reports to now?

6354 A. Well I have forgot; I could hunt it up on the register. He told me not to use his name, but just use the number, 263 Dearborn Street. Mr. Heilbron was afterwards promoted and then this man took his place.

Q. Do you know what he does with them?

A. Why yes, to denote the volume of water passing down the Illinois River valley.

Q. No, but what does he do with those reports?

A. Well, after I send them to him, I don't know anything more than what he told me.

Q. Do you know whether he keeps them there or not, at Chicago?

A. Yes, I dare say he keeps them, from all that I know and learned about it.

Q. Does he put them in a book and record them?

A. From what I know about it he does.

Q. Do you put them in a book and record them?

A. Yes, I copy each week's readings on a card that is furnished me,—I have a slip out there now, and make a report weekly on this card.

Q. Who furnished you this book?

A. The United States Geographical Survey force.

Q. Do you drink the water of the river?

A. Would I drink it?

6355 Q. Do you?

A. No sir, I don't drink the Illinois River water.

Q. The current in the river is much more now than it was before the canal was opened?

A. I think it is.

Q. Well, you know it is?

A. Yes, I know it is. I have been on that river for forty years. I know how it used to be and I think it is a little more rapid than it used to be; there is more water all the time too.

Q. How far is it from Chicago here?

A. 84 miles they will tear out of your mileage book on the Rock Island Railroad.

Q. How far is it by river?

A. To Chicago?

Q. Yes?

A. The river don't reach Chicago.

Q. Well up to the forks of the river Desplaines and the Kankakee and from there on in?

A. The river Desplaines reaches to Joliet. I always call that the Desplaines that we crossed there.

Q. How far is it by river to Joliet?

A. Well, the railroad is 45 1-2 miles, and I expect the river may be about the same distance, perhaps a little longer.
6356 I don't think it is much longer, though.

Q. Ninety-five or a hundred miles from here to Chicago, is it?

A. No, eighty-four.

Q. Well I am talking about the river?

A. Well the river don't reach Chicago; the Canal reaches Chicago.

Q. No, by water from here to Chicago, through the Illinois river, the Desplaines river and the Drainage Canal and the Chicago River, how far is it?

A. Well now, the distance from Chicago to Joliet by the canal or river, I wouldn't say the exact number of miles because I am not personally acquainted with that, but it is 41 miles by railroad from the Rock Island depot to Joliet and the river may be a little bit longer; I expect it is.

Q. How long have you lived here in Ottawa?

A. This will be my third year since I have been living here. I have been through this town before, all my life, backwards and forwards through this town, since I was thirteen years old, but I have only lived in this town three years.

(F. S. B., Com'r.)

6357 GUSTAVE KNEUSSL,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name?

A. Gustave Kneussl.

Q. What is your residence and occupation?

A. My residence is on 617 Illinois Avenue; my occupation is druggist.

Q. Where do you live with reference to the Illinois river; how close to it?

A. I live within ten yards of it.

Q. In time of high water are your premises overflowed in any part of them?

A. Yes sir.

Q. How much of it?

A. Why, what we term the pasture, that is a lot, oh, possibly 200 feet from the river bank.

Q. Were you residing there prior to the opening of th drainage canal in January, 1900?

A. Yes sir.

Q. Now what was the condition of the Illinois river
6358 prior to the opening of the drainage canal?

A. The condition of the Illinois river prior to the opening of the canal has always been, during the summer months, especially in the months of August and September, practically clogging up the channels between islands, and running from ten to 100 feet out into the stream on both sides of the Illinois River from the Illinois wagon bridge down to the rocks, that is the point of the first island, the mosses and high grass making it impossible for row boats to go through.

Q. As to its color and odor, what was it?

A. Well, of course that was always a stagnant water, you know, with an odor, an offensive odor, decaying vegetation and such as that.

Q. Do you know anything about this odor in the winter, under the ice?

A. Why a little, not very much, and what I do recall is that oftentimes there was a stagnant odor.

Q. Now in times of flood, and after the waters receded, what was the condition of the adjoining land, the land that had been flooded?

A. Why, there would be a deposit of mud, running from one-half an inch to three inches, and full of weeds and stuff of that kind,—debris.

Q. Did that mud have an odor?

6359 A. Why not that I can say.

Q. Now since the opening of the drainage canal, what has been the condition?

A. Why, there has been a clear channel in the last two years; I have not noticed any moss growing between the islands nor any moss, sea grass and weeds on the shores at all.

Q. Now as to the current, has it been greater or less than before?

A. Oh, it has been greater, much greater.

Q. Since the opening of the drainage canal, have there been the usual floods here?

A. Why yes.

Q. In what condition did it leave the banks of the river when the waters receded?

A. Why just as before, muddy deposits, that's all.

Q. Any different in character, that you noticed?

A. No, not that I noticed.

Q. As to the color and smell of the water, has there been any odor in it since the opening of the canal?

A. Why I didn't notice any odor; Monday or Tuesday I rowed down to Starved Rock in a row boat and back, and the odor of the river, why it didn't amount to anything.

Q. This is the season of the year when ordinarily before the opening of the drainage canal the river was very bad?

6360 Objected to as leading.

A. Yes sir.

Q. Is the water clearer now than before the opening of the drainage canal?

A. Why I really couldn't say; I really couldn't answer that.

Q. Is its general condition better or worse than since the opening of the drainage canal?

A. Why, much better.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. There is some odor since the canal was opened, is there not?

A. Why, not to my knowledge, no; I mean by that no more than any river would naturally give off an odor. Any water has an odor; but outside of that I would say there was not.

Q. What did you say your business was?

A. Druggist.

Q. How long have you been engaged in that business?

A. About 22 years.

Q. At this place?

A. Yes sir.

Q. How often were you upon the river?

A. Oh, I am on the river on an average about—well, previous to this year, on an average of twice a week in the summer time.

6361 Q. What are you doing? What were you doing?

A. Rowing, and previous to that I used to fish.

A. You say the water became stagnant prior to the opening of the canal?

A. Yes sir.

Q. That was only during the low stages?

A. Well, I should judge from the months of July until freeze-up time.

Q. What is freeze-up time with reference to this part of the country?

A. Why the last days of November to about the middle of December. The reason I say last days of November is because I distinctly remember one time on the last day of November I skated on the river.

Q. Now this statement that you have made about the river being in better condition than it was prior to the opening of the canal applies simply to the river, judging from its appearance, and you make it with some qualifications, do you not?

A. Why how do you mean that part—to its appearance?

Q. Yes?

A. Well, to its appearance certaintly, and also to your ability to get around in a row-boat.

Q. That is caused by a larger volume of water?

6362 A. Yes sir.

Q. And the current is much more rapid than it was?

A. Yes sir.

Q. In fact there is a good current now at all seasons of the year?

A. Well of course I don't know how it was in the winter, I should judge we have got more current in winter also.

Q. Well, so far as your knowledge goes?

A. Yes sir.

Q. Do you drink the water from the river?

A. No.

Q. Why not?

A. Why I have always had something better along. The fact is, it is too impure, I wouldn't think of drinking the water any more than you would think of drinking the Chicago River water. Then of course, you realize that I am a druggist and I certainly have some regards to the animal life that is in the river. I don't wish to drink one any more than any other.

Q. You are not a physician.

A. No, I am not a physician.

Q. The people here in Ottawa don't use the water of the river for domestic and drinking purposes at all?

6363 A. Not to my knowledge.

(F. S. B., Com'r.)

Whereupon an adjournment was taken to Marseilles, Illinois, at 9:00 A. M., Tuesday, August 18th, 1903.

Marseilles, Illinois, Tuesday, August 18, 1903.

6364 9:00 A. M.

Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

T. W. THIRY,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. T. W. Thiry.

Q. Where do you live?

A. Marseilles.

Q. What is your business?

A. Cigar manufacturer.

Q. How long have you been in that business?

A. Been in that business for about eight years.

Q. How long have you lived in Marseilles?

A. About eight years.

Q. Are you acquainted with the condition of the Illinois river at this point?

6365 A. Yes sir, considerable.

Q. What is the name of the river at this point?

A. Illinois.

Q. What opportunities have you had of observing the Illinois river during the last eight years?

A. Well, I have visited there on an average of twice or three times a week. I have fished in it and I have ate the fish.

Q. What was the condition of the Illinois river before the opening of the drainage canal in 1900?

A. In what respect; in regard to low water?

Q. In regard to the quality of the water, and the character of the water in the river?

A. Well it was not near as high at that time, and a sort of a greenish hue and during the summer months it would smell bad.

Q. How bad was the smell?

A. Well it was so that when you went down near the banks you could distinguish it very easily; it was not a very pleasant odor.

Q. What effect has the opening of the drainage canal had on the water at this point?

A. Well, it seems to have changed it to a sort of a blue, and it has taken the scum off the river, and a better flow; it seems to be better and larger.

6366 Q. How is it as to color?

A. Well before it was kind of a greenish hue and now it is a nice blue—not at all times of the year, but then, take it when we have no rains and let it drain out for three or four days and it turns to a nice blue color again.

Q. How do the fish compare today with what they were before the canal was opened?

A. Well, before this drainage came in, the fish seemed to have a kind of tarrish taste, gassy, and this year we have not been bothered with it at all. We don't taste it at all.

Q. Do you find the same kind of fish in the water now that you did before?

A. Yes, we have got several varieties that we didn't have before.

Q. What ones?

A. What we call the cisco, it is a kind of a herring, and we get these lake perch down here and there is another fish here—well, pickerel has been plentiful this year, at the right part of the year.

Q. Do you know whether there is as much malaria here now as there was before the opening of the canal, or was there any malaria here before the opening of the canal?

A. Well, with regards to that I don't know,—the people are generally pretty healthy here on account of the artesian water. We don't drink any surface water at all. 6367

Q. Have you any typhoid fever in this town that you know of?

A. Not that I know of.

Q. How large a town is Marseilles?

A. About 2500 I should judge.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Where do the people in Marseilles get their water supply?

A. At the present time?

Q. Yes?

A. Mostly from artesian wells. We have got a water system here but we don't rely much on that. In fact it is not in many of the houses.

Q. Where does this water system get its supply?

A. From an artesian well.

Q. Does anyone use the water from the Illinois river?

A. No, they wouldn't use it from the Illinois river.

Q. And they do not use it?

A. No.

Q. How deep are those wells?

A. Well this well—this artesian well down here is about 600 feet. Most of them run about 300 I guess.

Q. How large did you say this place was?

A. I should juge about 2500. Some claim more.

6368 Q. You don't know anything about the water in the river as far as its quality is concerned, for sanitary purposes, do you? Household and domestic uses?

A. They don't use it at all.

Q. So from what you said on that subject you judge only from the appearance of the water?

A. Well, not from the appearance. Of course a man can tell a good deal by going down there as much as I have been, probably the smell of it and the like. Even now you take it below the dam and before this flow came in and there was a nasty, yellow scum that run almost across the river, that gathered there, and you don't see it today.

Q. Do you know of anybody that does use the water for drinking purposes?

A. I don't think it is used for drinking purposes.

(F. S. B., Com'r.)

6369 **G. W. SMITH,**

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name?

A. G. W. Smith.

Q. What is your residence?

A. Marseilles.

Q. And your occupation?

A. Furniture business now; undertaker at the present time.

Q. Have you any official position in Marseilles?

A. Not at present, no sir.

Q. Have you ever had?

A. Yes sir.

Q. What?

A. I was Mayor six years ago, six to eight years ago, and I was in the Council as trustee and alderman for about ten years prior to that.

Q. How long have you lived in Marseilles?

A. Thirty years.

Q. Have you been engaged in any manufactory here?

A. I was working for the Marseilles Manufacturing Company for twenty years.

6370 Q. What is their business?

A. Corn shellers and agricultural implements.

Q. Have you been acquainted with the water of the Illinois river for some years prior to the opening of the drainage canal?

A. Yes, so far as the flumes was concerned, the water coming in through them.

Q. What were the flumes used for here?

A. Used for running the wheels, that is the race comes down through and the water comes through and the wheels furnish the mills and factories.

Q. Water power here?

A. Yes sir, water power.

Q. Now what was the condition?

A. The condition was very bad.

Q. In what respect?

A. Well, when the water was frozen over why it would pretty near make one sick to go into the mill. When you would go into the mill where the flume is, it would always be open there, that steam would come right out; the gas was so strong it was hard for men to work in there almost at times.

Q. What kind of an odor was it; how did it smell?

A. Why, it smelled like dead animals, fish, a stinking rotten smell,—decaying vegetables and everything else; very disagreeable.

6371 Q. Was it more disagreeable in the winter than in the summer?

A. Yes sir.

Q. Did you also notice that smell in the summer, in low water?

A. Yes sir, to a great extent, but not so much.

Q. Now from these flumes,—they are fed from the Illinois river?

A. Yes sir.

Q. And the water passing again into the Illinois river?

A. It passes back below the dam; they take it into the race above the dam and it goes out below.

Q. Now since the opening of the drainage canal, what do you say with reference to the water here?

A. I consider the water far better than it ever was before.

Q. Well, in what respect?

A. The water is clearer and when the water is clearer there is less color to it. Prior to that the water was so dark colored you could hardly see through it. Now it is very clear noticeably along the river.

Q. Is there an odor now upon it?

A. Not that is noticeable. There might be a trifle perhaps in the winter, but not that is noticeable; nothing to what it was.

6372 Q. None of that very offensive odor that it had before?

A. No sir.

Q. Now have you noticed the water in its steam making capacity?

A. I have not, not since the new water has been in.

Q. Had you noticed it before?

A. Yes sir.

Q. Its action in the boiler, what was it?

A. It had a tendency to foam where you used a great amount of it, unless the boiler was frequently cleaned.

Q. And when cleaned what kind of a sediment came out?

A. Well, it was a filthy, dirty sediment. Well,. the water will form a scale anyway; it would before, because the water is hard in the river. It would make a scale. When it burned down it was more like a muddy, yellowish color. You can tell good water from the color of the water you are using.

Q. The water supply of the inhabitants here is derived from what source?

A. For domestic purposes?

Q. Yes?

A. Artesian water.

Q. Now when you use the term artesian, do you mean water that flows up over the top—

6373 A. Well yes, we pump; we pump from the St. Peter's rock. These are dug wells here that they all use; they are all bored wells.

Q. How deep are they?

A. The first flow is evidenced about 100 feet. It will vary a little from that in different localities, but the average is about 100 feet. That is from the St. Peter's rock; it is known all over this country.

Q. Is there a sewerage system here?

A. No sir.

Q. Are there private sewers?

A. More or less, yes. That is, from house to road, to some ditch, open ditches, but no regular system.

Q. Well, take such sewage as is discharged here, where does it finally go?

A. It goes to the river.

Q. In times of flood, or hard rains do the surface waters run into the Illinois river?

A. Yes sir.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How far is the town located from the river bank?

6374 A. It goes right down to it. This part of the town, the center part of the town is probably very nearly a quarter of a mile to the river there.

Q. The residence part of the town is down on the river?

A. Yes, the residence part is down on the river, yes sir, and then it is back too, on the bluff.

Q. The people here in this place don't use the water do they, for domestic and drinking purposes?

A. No sir.

Q. Do you know whether or not the people in any of these other towns along the river here use the water for drinking purposes?

A. I don't think they do; I don't think Ottawa does; they may have used it in the past, but they don't now, I know.

Q. When did you quit working for this manuafcturing company?

A. Ten years ago; eleven years ago the first of June.

Q. You haven't worked there since the canal was opened?

A. No sir.

Q. Have you been running engines since that time?

A. No sir.

Q. Boilers, or anything of that kind?

6375 A. No sir.

Q. You don't know what the condition of the water is now?

A. Only from observation and smell, by passing over it.

(F. S. B., Com'r.)

6376 DONALD A. NICHOLSON,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. Donald A. Nicholson; I am a police magistrate here of the city of Marseilles.

Q. How long have you resided in the city?

A. Upwards of forty years.

Q. Is your residence near the Illinois river or removed from it?

A. I am about, well, probably a little over a quarter of a mile from the river. My residence is right under the bluffs here, and the river is a little over a quarter of a mile perhaps.

Q. Are any parts of the city of Marseilles overflowed at time of extreme high water in the Illinois river?

A. Yes sir.

Q. How much of it?

A. Well nothing north of the canal, the Illinois and Michigan Canal; it overflows some down there, and below town, down to what we call Matchtown; it got its name from formerly being a match factory there.

6377 Q. Were you acquainted with the condition of the Illinois river at this point before the opening of the drainage canal?

A. Yes, sir.

Q. Describe its condition?

A. The water was in a very bad condition. It had a kind of a soapy, greasy appearance on its surface, dark colored, and a green scum would form on top of the water. I at one time had charge of the water power company here and their works were up on the river above the head gates there, where the water was kind of still. I have seen the scum form there six or eight inches thick, a green scum, and after it would lay there a few days in the hot sun there would be a very bad stench coming from it.

Q. Now since the opening of the drainage canal what has been its condition?

A. The water is very much better, it is clearer, and that offensive odor is not there. Before the drainage water was turned in, especially in the evening, I could smell the water from the river up to my house where I lived there.

Q. Could you describe the odor?

A. Well it was—it had somewhat the smell of a privy, an outhouse and as though there might be dead fish or dead animals of some kind.

Q. Now since the opening of the drainage canal, have you
6378 any of that odor?

A. None of it at all; can't discover any.

Q. Is there a dam here in the Illinois river?

A. Yes sir.

Q. Is it known as the Marseilles dam?

A. Yes sir.

Q. What is the flow fall from the crest of the dam to the apron?

A. The dam when originally built was eight feet and a half I think.

Q. Fall?

A. Yes sir.

Q. Well is it higher or lower now?

A. It is perhaps a little bit higher; not very much; it has been repaired somewhat and the action of the water in going over the dam has naturally worn the rock away a little below, so as to make a little more of a fall than it was before, not very much.

Q. Did the power company put flash boards on the dam here?

A. Not since the drainage was turned in.

Q. Did they before?

A. Occasionally, yes; in low water they did.

Q. What was the height of the flash boards above the crest of the dam?

A. Generally about twelve inches.

6379 Q. How much manufacturing is done here by water power?

A. We have three paper mills, one agricultural works; we have a box factory, in fact two box factories now—Howe & Davidson have one. In fact all the manufacturing that is done here is done by water power. At the present time however, it is not, because the water is out of repair.

Q. What is the capacity of the paper mills here?

A. They run from six, I think to thirty tons.

Q. Per day?

A. Per day, yes sir.

Q. Do you mean the three together, or each one?

A. Each one.

Q. From six to thirty tons a day?

A. Yes sir.

Q. Now what is the waste matter from the paper mills here, what kind of looking stuff is it?

A. There is really no waste to speak of, excepting the liquid that the stock is cooked in which is composed almost exclusively of water and lime.

Q. What kind of looking liquid did that form when it ran off?

A. Well, it would be a dark colored liquid, especially where it cooked straw, it would be dark.

Q. And where did that go?

6380 A. That goes into the river.

Q. That is water mixed with lime and with some of the chemical substances that are used?

A. Yes sir, sometimes some chemical substance.

Q. Now is that a constant, regular thing here, or do they turn that in only at intervals?

A. Only at intervals.

Q. Have you any idea how much water is used here per day that is discharged into the river?

A. No, I couldn't tell; they use a large amount of water.

Q. Have they been running continuously since January, 1900, these paper mills?

A. Yes—well, the large one has not been in operation all that time, what is called the Howe & Davidson House.

Q. How much of the time has it been operated in the last three years?

A. In the last three years, it has been in operation perhaps about a year, may be a year and a half; it burned down at one time.

Q. And the other two?

A. One of the others has been in operation perhaps for—oh, it has been in operation for 25 years.

Q. And has it operated continuously since January, 1900?

6381 A. Yes sir, until recently.

Q. And the others?

A. The others the same.

Q. From what material do these institutions make paper?

A. Mostly of straw.

Q. You have no wood pulp manufacturing?

A. Yes we have wood pulp here too, but that has only been in operation I think, for the last—for about five years perhaps.

Q. How large an institution is that?

A. They will have, when they start up now, I think about eight stones for grinding the pulp; it is something like a mill stone, only they work the other way. The revolve and the wood works up against the stone.

Q. Is the wood ground in water here or ground dry?

A. They have water.

Q. Do they keep a continuous stream of water running over the stone as the grinding is done?

A. I think they do, yes.

Q. Now what kind of a liquid does that discharge into the Illinois river here?

A. That would be kind of a light substance, there would not be much to it.

Q. Was there any acid or chemicals mixed with it?

6382 A. No sir.

Q. Just the ordinary washings of wood pulp?

A. That is all, and the bark is taken all off the wood before it is ground, so that there would be no dark substances there.

Q. Is the bark used here then in some other—

A. No, the bark is ejected, I think it goes into the river perhaps.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Isn't the bark burned in some way after it is taken off?

A. I suppose it would be.

Q. Well I say, isn't it—don't they burn it?

A. I don't think so. I have been around the mills a good deal and I never saw any burn.

Q. You have seen the color of this water that comes out from this pulp into the river?

A. Yes sir.

Q. Well that is white, isn't it—water color?

A. Yes, it is about the color of water, if they had a wood that was dark colored it might make the water a little dark.

Q. There are no chemicals, you say?

A. No chemicals used.

6383 Q. Now how many such plants are there here?

A. Of wood pulp?

Q. Yes.

A. Only one.

Q. What was this other plant that you say was here

A. They manufacture principally straw-board.

Q. From this wood pulp?

A. No, there is very little wood pulp used in that kind of work.

Q. Well that is another company now that you have referred to?

A. The wood pulp is used principally in print paper.

Q. You say there is a straw-board company?

A. Yes, two of them.

Q. Do you know the character of the water from that that runs into the river—any chemicals used there?

A. Yes, there is some chemicals used there.

Q. But they don't escape into the water?

A. Yes sir.

Q. You know that do you?

A. Yes sir.

Q. Are you a chemist?

A. No sir.

Q. All you know is what you observed?

6384 A. Well, I had charge of these mills and know pretty near what the process is in the manufacture of paper.

Q. How much of the chemicals escape?

A. All of it that is used which is not retained by the pulp, it goes into the river.

Q. How much is there used?

A. Oh, it depends on the grade of paper that we are making. There is really no chemicals used in straw, but they have old papers, print papers, old newspapers that they use chemicals to take the ink out.

Q. You have not examined the water in the Illinois river, have you for the prpose of determining what solid matter it contains?

A. No sir.

Q. You don't know anything about its chemical ingredients or constituents?

A. No sir.

Q. You don't drink the water from the Illinois river?

A. No sir. F. S. B., Com'r.

6385 JAMES BRUCE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. James Bruce.

Q. Where do you live Mr. Bruce?

A. Marseilles.

Q. How long have you lived here?

A. Eight years.

Q. What is your business?

A. Grain merchant.

Q. Where you acquainted with the Illinois river prior to the opening of the drainage canal?

A. Yes sir.

Q. How long have you been acquainted with the Illinois river?

A. Well I have been on it practically all my life, since I was a boy.

Q. What part of the river are you acquainted with?

A. All the way from the head waters down to La Salle.

Q. What point on the head waters?

6386 A. Well I mean the junction of the two rivers, clear up to Romeo or Lemont on the Desplaines, or to Wilmington on the Kankakee.

Q. Prior to the opening of the canal what was the condition of the Illinois river?

A. Well, during the summer months, dry seasons, why the river was very low; showed the effect of the drainage of Chicago; and the gases from the river were very strong. There was places in the river where it showed stagnant water, covered with green slime. Today I think that is all disappeared with the extra head of water and very little gas is found.

Q. What improvement, if any, have you noticed in the waters of the Illinois River at this point,—Marseilles?

A. Well, there has been a general improvement. There is very little gas as I could detect now coming across the bridges, and when you would smell the gases take a still evening; there is practically no gas on the river; the river is fairly clean so far as I can see; no stagnant water; the water has a good flow.

Q. Prior to the opening of the canal you speak of gases—what opportunities have you had to observe the operation of the gas from the Illinois?

A. Well, at Joliet, my old home, especially between Lockport and Joliet, it showed the effect of the gases on the
6387 houses there. If you painted a house, inside of a year it
would turn black, like my father's place there, we didn't paint our house for two years, or until the drainage canal was completed, on that account.

Q. Since the canal was opened, what has been the effect?

A. Well, that trouble has disappeared entirely; we have no such trouble.

Q. How about the quality of the fish in the river, do you know anything about that?

A. Well the game fish is all returning up here where they disappeared before, and the cats coming up and there is fairly good fishing here now, where heretofore they had disappeared.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. What is the difference between the flow of the current now and what it was before the canal was opened?

A. You mean how much faster it is?

Q. Yes?

A. Well, you take from up the river above the dam here, there is a strong current up here now; in fact you can hardly go against it from here up to Seneca. Before there was very
little current there, and there is a good flow over the dam
6388 now.

Q. When there was no flow over it?

A. Practically none—no flow over it at all; you could trace the dam clear across. The races took it all here. Now there is I guess, six inches to a foot and a half at different stages, on account of the dam.

Q. You don't drink the water of the river?

A. No.

Q. And the people here do not?

A. No.

Q. You don't know whether it contains the same decayed matter that it did prior to the opening of the canal or not, then?

A. Well I know this, that before the bed of the river showed the effects of the sewage of Chicago, while that has practically disappeared today.

Q. It has washed away?

A. It has washed away, and the rocks all covered with black slime before. You could hardly step on it, while today you go into the bed of the river and it is practically clean.

Q. How often do you go on the river now?

A. Well, take during the summer months not very often; through the fall and the spring of the year I am on it a great deal; I fish some.

6389 Q. In the winter months?

A. No, take through the spring an along through May and June, why I hunt and fish a good deal.

Q. Now there is some odor arises from the river in the spring when the ice goes out?

A. Very little.

Q. There is some?

A. Yes, there is some. You can detect it if the air is just right,—a slight odor, but not very often.

Q. How wide is the river at this place?

A. Well, I couldn't tell you how many feet; there is five spans on the river bridge there.

Q. Well about how wide would that be in your judgment?

A. Oh, somewhere around eight or nine hundred feet.

Q. About three hundred yards?

A. Yes sir, at this point here. If there is any gas in the river it ought to show more than any other point, because the water is churned up thoroughly here on account of the dam and the rapids. Perhaps you wouldn't detect it above here, but you could here because it is stirred up.

Q. Where are those rapids?

A. Why, the dam is just above, about half a block up this Main street, while the rapids run down here very nearly a mile and a half.

6390 Q. Below the dam?

A. Below the dam.

Q. How deep is the water over those rapids?

A. Why, all the way, I guess from two to three feet deep now, while before the drainage water came down, it wasn't passable in a row-boat; you had to go out.

F. S. B., Com'r.

6391

W. H. SPENCER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. You may state your name, residence and occupation?

A. W. H. Spencer, my residence is Marseilles; my occupation is that of a grocer.

Q. How long have you lived in Marseilles?

A. I have always lived in Marseilles, except while I was in the country, until I was three years old—since I was three years old.

Q. Have you been acquainted with the condition of the Illinois river here before and since the opening of the drainage canal?

A. I have.

Q. What was its condition before the opening of the drainage canal in January, 1900?

A. Well its condition was then at various times during a rainy spell, it was just what you would call an ordinary river, but in the dry of the summer, when the water would get low, there would be a green scum form over it; it would smell very bad, and in the winter time when it froze over, the water 6392 would churn up in going over the dam and if there happened to be a south wind, the stench was almost unbearable at times, especially if it had been frozen over a long while, and turned warm.

Q. That is the south wind would bring the odors down?

A. The south wind would bring the odor down.

Q. But the stench would be there just the same?

A. The stench was there just the same, but it would go the other way when the wind was in the north it woudl bear it over the other way.

Q. Could you describe tht stench, what is seemed like?

A. Well, I don't know as I could. Smell is something hard to describe. It was like an outhouse that the city scavenger would condemn to be cleaned out. That is about as near as I can express it.

Q. Now after the opening of the drainage canal and up to this time, what has been the condition of the river?

A. Why I haven't noticed any of those conditions mentioned. I notice that the water is much clearer, and I have never noticed the smell since.

Q. Are you much upon the water yourself?

A. Why, I am not upon the water; I frequently go to the river—quite often go there of a pleasant Sunday; there is
6393 a nice walk along there, and my business takes me down there sometimes and I am this close to the river. My store is right just as close to the river as the hotel. My house is just as close as the hotel.

Q. How far are we now from the river?

A. Why, about a quarter of a mile, I think.

Q. Have you observed the odor of the water in the winter here in the flumes around the dam?

A. Do you mean recently?

Q. Yes?

A. No sir, I have not observed any odor since the drainage canal was turned in.

Q. Well, had you noticed it before?

A. I noticed it before, yes. I had noticed it almost,—well any time that I would go down to the river and any time as I speak of, when there was a south wind to blow it towards town.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Before the canal was opened, and the stench would get very bad, here, there was no current, was there, in the river?

A. Why at times there was a current, and at times there
6394 was not; I think it was worse when there was no current than it was before.

Q. It smelled at all times of the year?

A. Yes,—Well, I will take that back—after a hard rain, when there would be lots of fresh water all over the country, apparently it would dilute the water so that you would not notice the smell so much, but as quick as the abnormal rise in the river caused by the rains would go down, you would smell the smell; the lower the water got the worse the smell was.

Q. You don't know of anybody that uses the water in the river for domestic purposes?

A. No sir, I do not; we have good water laying 100 feet under us here, flowing artesian wells all through this valley.

Q. Well, you wouldn't consider it a good water anyway, would you?

A. Why I never lived any place where their custom was to use river water for domestic purposes. I have always been accustomed to either dug wells or flowing wells, artesian wells. I suppose if a man couldn't get anything else, it would be better than none.

Q. So you have noticed no odor whatever since the canal was opened?

A. Why I haven't noticed it, no sir.

6395 Q. How often are you on the river since the opening of the canal?

A. You mean across the river?

Q. On the river?

A. Why I never go on the river as far as that is concerned.

Q. You just go down to it and look at it?

A. I just go down to it and look at it and cross it on the bridge.

Q. Were you there last week?

A. Yes, I was along the river last week.

Q. How many times?

A. I think twice.

Q. How many times the week before?

A. Well I couldn't tell; I think probably about twice, I wouldn't swear to that exactly. My business takes me down there every week at least two or three times.

F. S. B., Com'r.

6396 A. S. GUM,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. A. S. Gum; Marseilles, eastern part of the city. I live a mile from here almost.

Q. What is your business?

A. Teaming.

Q. How long have you lived in Marseilles?

A. I have lived here over sixty years.

Q. Are you much upon the Illinois river in boats or otherwise?

A. Why, I often go fishing and have been any time when there is fishing, and like that.

Q. Do you fish with rod and line?

A. Yes sir.

Q. What was the condition of the Illinois river at this point before the opening of the drainage canal?

A. That is how long ago, did you say?

Q. It was opened in January, 1900, three years ago last January?

6397 A. Well, it is better; we don't get such a stench as we used to; the worst we used to get was in the winter when it was frozen over and then dropped over the dam; that was when we would notice it the most. Where I live, that is all of a mile from here when the wind was from the southwest.

Q. Did you notice the odor much in the summer?

A. Yes,—well I will say not as much as we did in the winter.

Q. What was the appearance of the river here above the dam in the summer?

A. Well it was kind of a dark water, like—of course it wasn't as dark as it has been often, but it is clearer than it was before the current went through.

Q. Before the opening of the dranage canal in January, 1900, did a scum form here upon the river?

A. Yes sir, it did; it did sir, for a fact.

Q. Could you describe this stench that you mentioned?

A. Well, it was like a kind of a rotten smell; I don't know how you would come at it. It was a very disagreeable smell; you would want to get out of it as soon as you could if you was any place where you could inhale it.

Q. Now since the opening of the drainage canal, have you had any of this odor?

6398 A. Not so much, no sir; I haven't noticed it. I don't notice it since, as I used to.

Q. Have you noticed here in the winter time, since the opening of the drainage canal, any of this odor?

A. Well, I don't hardly think I have; I don't remember of it.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You are not sure though, that there has been no odor since the opening of the canal?

A. Well, you see I live about a mile from here, and it would not be every day; it is when the wind is from the southwest that I get the most of it where I live. That is when I used to get it.

Q. There is an odor though, coming from it in the winter time, is there not?

A. Well, I haven't noticed it as I could say.

Q. The current is much more rapid now than it was before the canal was opened?

A. Yes sir, the water is purer and more clear than it was.

Q. When you say it is purer, you simply say so from observation?

6399 A. It is clearer, with a current in it.

Q. Well you say it is purer simply from observation, that is the only way you know of judging?

A. That would be it, yes sir.

Q. You don't drink the water from the Illinois river?

A. Oh no, we have good water here.

F. S. B., Com'r.

6400 **H. R. ADAMS,**

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. H. R. Adams.

Q. What is your business?

A. Manufacturing agricultural machinery.

Q. What concern are you connected with here, Mr. Adams?

A. The Marseilles Manufacturing Company.

Q. In what capacity are you engaged with that concern?

A. I am Vice President.

Q. How large a business is carried on by that concern?

A. Well, we employ from 150 to 250 men.

Q. How long have you lived in Marseilles?

A. I came here 36 years ago the 4th day of March.

Q. Are you acquainted with the Illinois river?

A. Yes sir.

Q. How long have you been acquainted with it?

A. A little over—well 36 years ago in January was the first that I came down on the river.

6401 Q. What was the condition of the Illinois river prior to the opening of the drainage canal?

A. The water was very impure; the water of the stream rising from swamps largely; the water was in a very impure condition.

Q. Were you acquainted with the river before the sewage of Chicago was turned into the Illinois and Michigan Canal?

A. Yes sir.

Q. Describe the conditions that existed at that time?

A. Before there was any sewage sent this way, the condition as I was saying, was very impure, so much so that we didn't dare to bathe in it for fear of getting mud itch, and it was quite a dark, dense color, and there was a good deal, at times of a kind of a formation, what we used to call frog spawn, at certain seasons of the year, would come down, and the water was not pure enough so you could see any depth in it.

Q. When the sewage of Chicago was turned into the Illinois and Michigan Canal, did it have any effect upon the Illinois river?

A. Yes sir, well, for some time we didn't notice the effect very much, but as it increased, there was a bad odor to it, and if the water was not high, so that there was a rapid current, you would see a kind of an oily substance on the surface, and this vegetable or spawn appearance increasing.

Q. Now just before the opening of the drainage canal, what was the condition of the Illinois river at this point?

6402 A. Well it was bad, as I have described.

Q. Was there any odor to the river?

A. No smell as of sewage; simply there was a swampy smell to it always.

Q. I mean immediately before the opening of the drainage canal in 1900?

A. Oh, the drainage canal—excuse me. Yes, there was quite a strong smell of this vegetation, to a very serious extent, so much so that this formation on top would come down and accumulate in our races here in such beds that it would sometimes obstruct our rights in our wheels, and where the water passes through our shop it was so intensely filthy there that the men's clothes would become saturated with it, and even their systems, so that when they would get away from the shop, sometimes for days, if you went near them, you would smell that shop, what we would call the shop smell of the water, it got very strong.

Q. What power did you use in your manufacturing industries here?

A. We used about 85 horse.

Q. Is that water power?

A. Water power, yes sir.

Q. Since the opening of the canal, what has been the condition of the river at this point?

6403 A. Well, since the opening of the drainage canal the water has improved very much. Well, when they first opened it, at times, there was a lot of that old smell left, but it has been gradually purifying, and during the past year, since they have let in some water, I don't know that there has hardly been a time that we have had any of that smell. Now in our head races, where it used to be so dense that you couldn't see any depth in it, there is a great deal of the time now when you can see two or three feet very clearly, and sometimes even deeper, when we have had no rains for sometime to disturb the soil, or no excavating in it, and the water has a chance to settle; it gets so clear that you can see it quite a depth. That we never could do before.

Q. What in your opinion has been the effect of the opening of the drainage canal upon the Illinois river?

A. It has been a very decided improvement in every way, in health and everything, I think.

Q. Prior to the opening of the canal, what was the condition of the health in Marceilles?

A. In some parts of the town we used to have quite a little malarial fevers, ague and such things as that. Of late I haven't heard anything of that at all. I don't think we have had it.

6404 CROSS-EXAMINATION, by Mr. Jeffries.

Q. How long has it been since they have had malarial fever?

A. Well, I can't say positively, for the reason that I have been away part of the time, but the knowledge that I have had of it is—the last that I knew of anything to amount to anything was four or five years ago, I think that last year, about a year ago now, I think there was a case of malarial fever reported here down here in this low ground district, but I doubt if it could be attributed to the river. I think that would be more local conditions from what I have heard of the case.

Q. You do not drink this water here, do you, that comes through the dam here?

A. No sir.

Q. The flow of the current is very much greater now isn't it, than it was before?

A. Yes, especially through the fall and winter. Last fall and winter we had quite a strong current. It is not very strong at the present time.

Q. You say you don't detect this odor at any time of the year now?

A. I have not noticed the odor—well, in nearly two years when I have gone out through the shop where the water wheels are.

6405 Q. Do you go out there very often now?

A. Yes, I am out there every little while.

Q. Every day?

A. Well, not every day, no sir, but out through there as I am apt to be through other parts of the shop.

(F. S. B., Com'r.)

6406 H. B. McKAHIN,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. My name is H. B. McKahin; I am Assistant Secretary of the Marseilles Manufacturing Company.

Q. How long have you resided here?

A. Why, my folks came here when I was about two years old; that would be about 1871.

Q. Have you been familiar with the condition of the Illinois river here before January, 1900, when the drainage canal waters were turned in?

A. Yes sir.

Q. Now were you much upon the river before that time?

A. Well, during the years 1883, 1884 and 1885 I used to boat a good deal up there for pleasure.

Q. In a row-boat or launch?

A. Row-boat at that time.

Q. Now prior to the opening of the drainage canal what was the condition of the water in the Illinois river?

A. Well, during the low stage of water in the summer time, it was very foul, so foul that I had to quit going on the 6407 river much after sun-down on account of the malaria.

Q. Was there an odor that came from the water?

A. A very perceptible odor after the sun left it.

Q. How was it in the winter?

A. Well, in the winter time we were not on the river, but we noticed the water coming through our water wheel at the plant, and the odor there was very foul, very similar to rotten cabbage out of an old cellar.

Q. Now, did it affect the men in the factory?

A. Why, I don't know how it affected their health, but the odor was so strong that you could smell it on their clothes when they came from the wood shop.

Q. After they came away from the place you could smell it?

A. Yes, sir.

Q. Now, since the opening of the drainage canal, how has it been?

A. I haven't noticed anything of the kind.

Q. Has there been any odor to the water here since the opening of the drainage canal?

A. I haven't noticed anything that was anywheres near as strong as it was before.

Q. In the winter how has it been?

A. We don't notice that odor in the winter time.

6408 Q. Nor in the race nor flume of the water power?

A. No, sir.

Q. Before the opening of the drainage canal did a scum form on the water here above the dam?

A. It did.

Q. Was that purely a vegetable, or did it seem to have some foreign substance in it?

A. Well, I would say it was both.

Q. What was its color and appearance?

A. Well, the perceptible part of it was this little plant that seems to grow on top of the water, of the foul water; it would accumulate down here against any obstruction and rot, the race would be full of it.

Q. Would it sometimes obstruct the wheels here in the race?

A. Well, that small plant would not obstruct them as much as the grass that used to come down in large quantities.

Q. Before the drainage canal was opened, was there considerable growth in the river of vegetable and animal life?

A. There was.

Q. What was its character, moss or grass?

A. Well, there was a long grass that would grow in the shallow places, and then this little three-leaf plant that grows on the surface of the water.

6409 Q. What do you call that plant here?

A. I don't know the name of it.

Q. You don't know whether it is called duck-weed, shamrock or water clover?

A. No, I don't. My impression is, though, that we used to call it a kind of a water clover.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Is your work there at the mill?

A. In the office, yes.

Q. How long have you been working in the office?

A. I have been in their employ since 1886.

Q. Were you out at the water—on the water every day?

A. Why, the head race runs right by the office. I have ten or fifteen feet of it in plain view all the time.

Q. There is a large volume of water now, is there?

A. Yes, sir.

Q. Swifter current?

A. Yes, sir.

Q. The current even runs over the dam?

A. Yes, sir.

Q. At all times of the year?

6410 A. So far as I have noticed. There is water going over the dam all the time now.

Q. There is some odor perceptible yet, isn't there from the water at times?

A. Yes, there is a slight odor there.

(F. S. B., Com'r.)

6411 U. T. SMITH, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. State your name, residence and occupation?

A. U. T. Smith; I live nearly opposite the depot on Rowe street.

Q. What is your business?

A. Well, it isn't anything in particular now. I run a livery stable here for about twenty years and I farmed.

Q. Have you retired from business now?

A. Yes, sir.

Q. Have you been acquainted with the waters of the Illinois river here prior to January, 1900, when the drainage canal was opened?

A. Yes, I have been here twenty-four years this fall. I have lived in the same place.

Q. What was the condition of the Illinois river at this point before January, 1900?

A. Well, the river was very offensive at that time, it smelled very bad, especially when it froze over a little; there was a terrible stench to it; you couldn't hardly endure it.
6412 In the morning it smelled very bad. In the summer time the water wouldn't run over the dam, it would be sometimes a foot or two below running over the dam and there would be a green scum form over the water, and it smelled very bad.

Q. Now, since the opening of the drainage canal what has been the condition of the water?

A. I have never smelled anything since the drainage water has been turned in; the water looks clear and very nice.

Q. Does this green scum form on the water since?

A. I haven't noticed any since; there is generally water running over the dam ever since the water has been turned in, I think. I have never seen that dam dry, and there is no scum forms on it.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How often are you on the river?

A. Oh, I don't know how often. I never was on it so very much, but in our livery business we were crossing it sometimes half a dozen times a day and perhaps sometimes not at all on some days.

Q. And the water flows much more rapidly than it did before, doesn't it?

A. Oh, yes; there is more current, sure; the water runs
6413 over the dam, I think, all the time now, some.

Q. You don't drink that water?

A. No, sir.

Q. When you say there has been an improvement in the water you mean an improvement for the purposes to which it is put at this point?

A. Well, it is an improvement as far as the smell is concerned and the water appears to be purer and cleaner and looks clearer.

Q. That is just from your observation?

A. Yes, certainly.

(F. S. B., Com'r.)

6414 G. H. SWADER, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. G. H. Swader.

Q. Where do you live?

A. Marseilles.

Q. What is your business?

A. Foreman of the Marseilles Manufacturing Company, wood department.

Q. Mr. Swader, were you acquainted with the Illinois river before the opening of the drainage canal?

A. Yes, sir.

Q. What was the condition of that river before the Sanitary District turned in the waters of Lake Michigan?

A. Well, it was pretty bad.

Q. In what way?

A. Well, there was a kind of a slaughterhouse smell to it, as near as I could tell you, in the summer time, this grass seed and stuff would run down the river here and stop us sometimes at the mill, we would have to—it would just almost
6415 hold you up to walk upon it.

Q. What was the color of the water?

A. Why, a kind of—like it went through a sewer like or a water-closet; dirty color to it.

Q. How did the odor of the water affect employes in the business?

A. Well, I don't know as it ever affected me any, but it made some of them sick.

Q. Well, how about the smell of it?

A. Well, it smelled just like—as Mr. Adams used to say, "George, I don't come over to see you very often, you smell like rotten cabbage." That is the way he used to put it, but it smelled like a slaughterhouse, in the winter time especially, more so than in the summer.

Q. What has been the effect upon the waters of the Illinois river of the opening of the drainage canal?

A. Why, we have got more water and it is purer and clearer and better.

Q. What is the color of the water at present?

A. Why, it is a kind of a greenish color, or blue or something like that.

Q. Well, is the water dark now?

A. No, sir; it is not; it is down there in the race where there is no water flows over the dam.

6416 Q. What is its color there?

A. Over there?

Q. Yes?

A. Why, it has more of a color.

Q. Do you observe that odor that you observed before the opening of the canal?

A. No, sir, there is no odor there.

Q. What is the general condition of the river?

A. Through here?

Q. Yes?

A. Why, it is better.

Q. How about the current?

A. Why, there is a lot more water running and of course the current is a lot swifter than it was.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Do you know whether the sewage from Chicago was turned into the Illinois river or not?

A. Do I know?

Q. Yes?

A. Why, it used to be years ago. They used to pump it up through the locks there at Lockport or Bridgeport.

Q. You don't know anything about it now?

6417 A. I don't know whether it is running down through the river now or not; it may be in the canal; I have never been up there.

Q. Do you drink the water from the river?

A. Why, no, sir, but I have.

Q. Since the canal was opened?

A. Why, not more than I have been placed where I had to. I am situated where if there is anything goes wrong with the wheel I have got to go down there and clean it out; go down into the water. I have drank it, more or less; I have had to.

Q. You don't know anything about what substances are contained in the water, do you?

A. No, sir, I don't.

Q. The people here in town do not use the water for drinking purposes?

A. No, sir, not that I know of. I don't know whether any of the water seeps down here in the reservoir, they have got down here or not.

Q. Is that the water supply?

A. Yes, it leaks, but I don't know whether any of the water goes through there or not.

(F. S. B., Com'r.)

6418 LEANDER G. DOUGLAS, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is you name?

A. Leander G. Douglass.

Q. Where do you live, Mr. Douglass?

A. At present I live in Marseilles.

Q. What is your business?

A. Well, I am kind of loafing now. I have always been a farmer up to within a few years.

Q. Do you own any land around Marseilles?

A. Yes, sir.

Q. How much?

A. Well, I can't tell you; I own what is on two sections on the north river front between the Illinois and Michigan canal and the river.

Q. About how many acres is included in that?

A. Well, I think the way I got it, there is about 330 or 340 acres. I really have never known its fractional inches and quarters, and so on. My deeds run from canal to river, so I couldn't make any more by measuring it, or any less.

Q. Were you acquainted with the Illinois river before the
6419 opening of the drainage canal?

A. Well, before the opening is a good ways back, but since I have been acquainted with it—

Q. I mean in 1900, the drainage canal?

A. Oh, what has been the condition?

Q. Yes?

A. Why, it has been, I suppose, not entirely free from filth; I don't think it has, but it has been decidedly better than it was before the opening of the drainage canal, the river has.

Q. What was the condition of the river before 1900, the date that the canal was opened?

A. It appeared clear and—well, before 1900?

Q. Before, yes?

A. Well, it had a stench in it; did always at times, except in an extreme flood.

Q. How was the color of the water?

A. Well, at times it was filthy like, and at times it wasn't.

Q. Did you have any cattle on your farm?

A. Yes, sir.

Q. How were they watered?

A. Well, up to 1880, they had to drink out of the river, or out of the canal, at dry times, in the wet times, why, we
6420 had what we call sloughs that we watered from.

Q. Up to 1890, would the cattle drink the water of the Illinois river?

A. Not after I got, in 1880—

Q. Up to 1900, I mean?

A. In 1880, I dug artesian wells and since I have had artesians on the farm, no live critter would touch the water. They would go to the artesian wells to drink ever since, whether the drainage run or not.

Q. Since the opening of the canal have they drank the water of the Illinois river during the last three years?

A. No, sir, not as a rule because I have two or three flowing wells, and they drink from the flowing wells.

Q. You keep them where they can get the well water?

A. Yes, they are kept in pastures so as they can get it.

Q. What has been the effect of the opening of the drainage canal on the Illinois river?

A. Why, the water is, in my judgment, decidedly better than it was before the opening of the drainage canal.

Q. In what way is it better?

A. It don't have the stench that it used to have. From 1866 or 1867 to 1880 I watered my cattle in dry times, and in the winter time, out of the river, and chopped holes in the ice, and don't recollect now of ever chopping holes in the ice—
6421 I have not smelled the water.

Q. Well, since the opening of the drainage canal have you noticed the smell?

A. Well, no, I have not chopped any holes in the ice much. As far as I know, the water is free of that stench.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Do you drink the water from the river?

A. No, sir.

Q. Do you use it for domestic purposes?

A. Never,—I don't know but that sometimes way back we might have been short of cistern water and drawed some river water to wash in, but I don't know as we did. I don't think we did more than one time anyway.

Q. How often are you on the river?

A. Well, that depends on how thick the ducks was; I was there pretty often or along the river.

Q. But here lately in the last two or three years?

A. Oh, my work was right along the river. I plowed down to the river here and kept a set line and catched fish when I would be plowing.

Q. How is it now?

A. Well, I don't know.

6422 Q. Are you on the river much now?

A. I have not been on the river very much for about seven years; not so much as I was when I lived on the farm, and my work and my business called me to the river.

(F. S. B., Com'r.)

6423 GILBERT HOWLAND, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name?

A. Gilbert Howland.

Q. Where do you reside?

A. Here in Marseilles.

Q. How long have you lived here?

A. I have lived here fifteen years or more.

Q. How long have you lived in the vicinity of the Illinois river?

A. Since a boy eight years old.

Q. And that would be about how many years?

A. Well, I am 67 years old.

Q. What was the condition of the Illinois river here before January, 1900, when the drainage canal was opened?

A. I considered it very bad, sir.

Q. Well, in what way?

A. Well, it smelled very bad. I fished a good deal; I didn't have any particular business and I fished a good deal. I have seen down there almost what you might call floating islands, I don't know what you call it, it is a plant or something
6424 that grows on the water; it used to come down and
lay—I have seen it eighteen inches to two feet thick kind of laying on the water there, and decaying there.

Q. Was there an odor from that in the summer?

A. Oh, terrible, sir, bad.

Q. Now, since the opening of the drainage canal what has been the condition of the water?

A. I haven't seen a thing of it since.

Q. You have seen nothing of this scum, of this plant?

A. No, sir, I haven't seen it at all.

Q. Has there been any odor on the water since the opening of the canal?

A. Not to amount to anything.

Q. Prior to the opening of the canal how was the water here in winter?

A. Oh, it was very bad; you could smell it about forty rods if the wind was right, either side of the bridge here, if the wind were blowing.

Q. Now, have you noticed in this river here any different varieties of fish since the opening of the drainage canal?

A. Yes, I have caught them. I have caught lake fish here.

Q. What ones?

6425 A. I think they call them ciscos; they average about a foot long, and I have caught perch,—lake perch, that I never saw in the river before. I caught any amount of them last season here.

Q. How long have you been noticing these lake fish in the river here?

A. Well, I have noticed them the next year after the water was let in.

Q. And they seem to be increasing?

A. I should judge so. There was more last year than there were the year before.

Q. Is it quite common here to catch lake perch and ciscos in the river?

MR. JEFFRIES: Objected to as leading.

A. Yes, I should think it was.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How often are you on the river now?

A. Oh, pretty much every day.

Q. Did you, or do you use the water from the river for drinking purposes?

A. No, sir.

Q. Do the people in this town use it for that purpose?

A. No, sir; not that I know of; I don't know of any.

6426 Q. You don't know whether the water contains deleterious substances or not, then?

A. No, sir, I don't know anything about that.

Q. You don't know whether the water contains Chicago sewage or not?

A. Well, all I know about it, is what I read, from what I have read, it does; I don't know personally.

Q. There is some odor now, is there not?

A. Very little, sir.

Q. A larger volume of water, though, and a stronger current?

A. Yes, sir.

Q. Very much stronger, isn't it?

A. Yes, the river used to be low, of course.

Q. Well, there is a current now all the time?

A. Yes, sir.

Q. When before the canal was opened, there was times in the year when there was no current ?

A. Oh, no, there wasn't times that there wasn't any current.

Q. Wasn't there times that you know, when the water wouldn't flow over the dam?

A. Well, very short; there might have been.

(F. S. B., Com'r.)

6427 H. W. COLLIER, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name?

A. H. W. Collier.

Q. How long have you resided in Marseilles?

A. Why, in Marseilles and vicinity, right around here within a mile and a half since the spring of 1870.

Q. What is your business here?

A. Why, I am running a pool room at present.

Q. Have you ever been engaged in the sprinkling of the streets?

A. Yes, sir, we are now and have been for the last nine years.

Q. Where do you obtain your water for the street sprinkling?

A. Why, with the exception of this year we have been getting it from the canal.

Q. Do you know whether the canal is fed from the Chicago river?

A. Well, they claim it is. I have not been right to the point of its feed; I couldn't say positively as to that, but that is the belief.

6428 Q. Now prior to the opening of the drainage canal, what was the condition of the Illinois river at this point?

A. It was very rotten, so to speak; you could smell it.

Q. In what way?

A. Why, seemingly from refuse; I don't know what else.

Q. In low water did the water run over the dam here?

A. Well there has been—yes, at all times I guess there is a little water run over the dam, if not run over it, run through a little, but nothing to speak of, so that but what you could go two-thirds of the way across the dam without wetting your feet at all, on the cone.

Q. Now did a scum form on the water here before the opening of the drainage canal?

A. Yes sir.

Q. What was the character of it?

A. Well, it was a floating weed; it seemed to be a kind of a slimy gathering; I really don't know what the composition of it was.

Q. Was there an odor in the water in the summer?

A. Yes sir.

Q. How in the winter?

A. Well it seemingly was even worse in the winter; that is when we noticed it more here, especially when it was froze up, on account of the opening, it not being opened all
6429 along, just open at the dam.

Q. It seemed to be worse in the winter?

A. Yes sir.

Q. Now for your sprinkling purposes here, was there an objection to the water before the opening of the drainage canal?

A. Yes sir.

Q. On what account?

A. Well, they claimed that it was so stinking that it wasn't fit to be thrown on the streets.

Q. Now since the opening of the drainage canal what has been the condition?

A. Well, I never have had any trouble; it has been much better. I never have had anyone refuse the water.

Q. Has it been clearer or purer here since the opening of the drainage canal?

A. Yes sir, it certainly has.

Q. Has there been any of this odor in it?

A. Well there has been some yes, but not one-hundredth part of what there was before, I would say.

Q. How has it been in the winter under the ice?

A. Well, it has not been near so bad; we have had some of course.

6430

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How long do you say you have lived here?

A. Since the spring of 1870.

Q. You don't drink the water from the river?

A. No sir.

Q. About the only purpose that they use it for is down here at the dam is it?

A. Yes sir.

Q. For water power?

A. Yes.

Q. Do you know whether it contains sewage from Chicago or not?

A. I don't—no sir; I have never examined anything of the kind to know anything about where is comes from.

Q. The people here in town don't use it at all?

A. No sir.

F. S. B., Com'r.

6431

J. W. VAN LOON,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name?

A. J. W. Van Loon.

Q. What is your occupation?

A. I am a painter.

Q. How long have you lived in Marseilles?

A. About eleven years.

Q. Have you been much upon the Illinois river here?

A. Yes.

Q. In what way?

A. In fishing.

Q. With a rod or nets?

A. With a rod.

Q. Are there net fishermen here?

A. No sir.

Q. Were there net fishermen here before the opening of the drainage canal?

A. Why, I don't know of any. Not to my knowledge.

6432 Q. Then the business of fishing here in the Illinois river was not an industry; it was not for commercial purposes?

A. No sir.

Q. What was the condition of the Illinois river before the opening of the drainage canal?

A. Oh, I don't know; it was a good deal worse then than it is now. I could say that.

Q. Well, in what respect?

A. Well in warm weather there was quite a stench to the water.

Q. What kind of substances were there in it?

A. Oh, it was just a mass of stuff floating in the water, it looked like a kind of a jelly that gathered along the shore.

Q. And did that stuff produce a stench?

A. Yes sir.

Q. What was the color of the water as compared with it now?

A. Well it was a very dark, oily, greasy color and muddy.

Q. Do you know of any odor in the river during the winter when it was frozen over?

A. Yes sir.

Q. What was it?

A. It was a very bad odor there at the dam, where it was open, where the water run over the dam; we could smell it bad around town here.

6433 Q. Now since the opening of the drainage canal what has been the condition of the water?

A. We don't see so much stink at all; the water seems to be purer.

Q. What is the color of it; has it a better color now?

A. Yes, days here it is just the same as lake water, blue.

Q. Is there any of this floating stuff on the water?

A. Don't see any, no.

Q. Any scum form on the surface?

A. No, don't see any at all.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You say you are a painter?

A. Yes.

Q. Spend a good deal of time on the river?

A. Yes, I fish a good deal of the time.

Q. You are not very busy at your business then?

A. Well I fish in the morning and the evening.

Q. Do you drink the water from the river?

A. No sir.

Q. Do you know of anybody that does?

A. No.

Q. You say the filth and slime used to stay along the banks of the river? 6434

A. Yes.

Q. On the rocks?

A. Yes, on the rocks.

Q. The rocks would be covered with it where it would settle on the little pebbles?

A. Yes sir.

Q. Does it do that now?

A. No, I have never seen it.

Q. Well, you would have seen it if it did, wouldn't you?

A. Certainly.

Q. What becomes of it?

A. I don't know—I couldn't tell you that.

Q. It is washed away, isn't it?

A. I couldn't tell you that.

Q. Well it isn't there?

A. It isn't there; it is not like it was.

Q. Well there is a larger volume of water and a stronger current now, isn't there?

A. Oh yes.

Q. When at times before the opening of the canal where this scum formed on the water, there was no current to amount to anything?

6435 A. Well there is always a current in the river.

Q. No current to amount to anything though—it was very sluggish, wasn't it?

A. Well it was a great deal more sluggish then than it is now. I noticed it this morning; it runs very slow.

Q. Do you mean to say that the current is not any faster now than it was before the canal was opened?

A. Well here above the dam, I am speaking. Below the dam it is always rapid along there.

Q. Well I am not speaking of above the dam; I mean any place.

A. Yes sir.

Q. A green scum formed before the canal was opened, but it don't form now?

A. No sir, and the water today is traveling much faster than it was then; when the mills was open, during the summer, low water, we had no water run over the dam; all the current it got in it was the water that passed through the mill.

Q. So you have got a better current now?

A. At certain times, yes, according to the stage of the water.

Q. What do you know about the water in the Illinois river for drinking purposes?

6436 A. I don't know anything about it.

Q. Do you know whether it contains as much filth as it did before the opening of the canal?

A. Well, I couldn't say that.

Q. Well, if the sewage from Chicago got down here from the old Illinois and Michigan Canal, why wouldn't it come from the other canal?

A. I couldn't say as to that.

Q. In other words, you don't know anything about it?

A. I know about the condition of the water, the smell of it and the slimy stuff, like that.

Q. And that is all you do know?

A. Yes.

F. S. B., Com'r.

Whereupon an adjournment was taken until 1:00 P. M., same day, Tuesday, August 18th, 1903, at Morris, Illinois.

6437 Morris, Illinois, Tuesday, August 18th, 1903. 1:00 P. M.

Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

HENRY COOPER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name?

A. Henry Cooper.

Q. What is your residence?

A. Morris, Illinois.

Q. What is your occupation?

A. Harness business.

Q. How long have you lived in Morris?

A. I came here in 1866,—a little more than 37 years.

Q. How far is Morris from Marseilles?

A. Why, I don't remember it exactly. If I should guess at it, something like 35 miles, I don't know.

Q. Do you know where the Desplaines and Kankakee Rivers join?

6438 A. Yes sir.

Q. How far is it from here?

A. That is about—well we call it nine or ten miles.

Q. By river?

A. Yes sir.

Q. After the junction of those two rivers is the river called the Illinois river?

A. That is what we call it.

Q. Have you been acquainted with the Illinois river between here and the junction of the two rivers forming it since you have lived in this community?

A. Yes sir.

Q. Through what means did you become acquainted with it?

A. Well, when we would go fishing, we always rowed a boat from here up the river all the way. We used to go up here in boats and stay all night, fishing.

Q. Now did you fish in this river prior to 1885, when the sewage from Chicago was pumped into the Illinois and Michigan canal?

A. Did I live here then?

Q. Yes.

A. Oh yes.

Q. Dd you fish in this river here at that time, and below?

6439 A. Yes, I didn't below; I did above.

Q. Now prior to that time what was the condition of the Illinois river before the sewage was pumped into the Illinois and Michigan Canal?

A. Why, I didn't see anything wrong with the river. We used to catch lots of fine fish there, but we found the river was getting polluted, and we understood, I think, that they was pumping this sewage in,—well then it stayed on the side of the Desplaines, on the north side of this river.

Q. Of the Illinois?

A. Yes, and from one-third to half way across the river would be what we called spotted, and we would go on the south side sometimes and catch fish, until it finally got so bad we could not catch them at all, for we couldn't stand it anyway, it smelled so bad, and they told me it was the sewage that was pumped into the Chicago river and of course from what I read and what I have heard, I supposed that it was.

MR. JEFFRIES: I move to strike out what the witness has been told on this subject; also what he has read.

Q. Now after this sewage was pumped in, you may state whether or not in this upper stretch of the river the fish disappeared?

A. Well they did after that, yes, after it became so bad
6440 here we couldn't catch any fish at all; couldn't get any,
and we saw lots of dead ones; they would be dead all along the shores of course, even catfish and bull-heads, and we knew when the water got so bad that catfish and bull-heads couldn't live in it, it was pretty bad.

Q. What was the matter with it?

A. Why the sewage, slime and stuff that came in.

Q. Did it create an odor in the water here?

A. Well, I should say so.

Q. In the summer?

A. Yes, sometimes when the wind was from the south, especially evenings,—I knew it was the river because I knew it was the same smell I got when I was up the river; it was the same smell exactly.

Q. What kind of a smell was that; can you describe it?

A. Well, it was a strong smell. I have often wished I could describe it; it is a smell that I can't describe, I don't believe.

Q. Now did that condition of affairs continue up to 1900, when the drainage canal was opened?

A. Yes sir, it did.

Q. How was the water in the winter here, under the ice?

A. Well, I don't know about that; I never was on the
6441 river here in the winter.

Q. You don't know whether if a break came, or there was a hole cut in the ice there was stench came up?

A. Not of my own knowledge; I have heard them say so, but I don't know that.

Q. Now after the drainage canal was opened, what was the condition of the river here?

A. Why, soon after it begun to get better, and we thought the water looked since that, as like as though it was about as clear and as good as it used to be before, but I have not tried to fish in it since that. Of course I know from what I hear they are catching fish in the river now, but I haven't tried to fish in the river because I got disgusted with it at that time and quit.

Q. What kind of a water system have you here,— a public water system?

A. Yes sir.

Q. From what source is the water obtained?

A. From wells,—artesian wells, I believe they call it.

Q. Have you a sewerage system?

A. Yes sir.

Q. How much sewer is in the town by miles?

A. Well, it ain't all sewered. That has only just
6442 recently been done; that is about a year. There is one
large sewer runs down the Main Street and some little branches from it, and that's all.

Q. But that is recent?

A. Yes, recent; just about a year.

Q. And such sewage as empties into that goes into the Illinois river?

A. Yes sir.

Q. Are there privy vaults in the town?

A. Oh yes.

Q. Is there a sytem here of cleaning them?

A. They have had scavenger work done of that kind I believe; I know they have.

Q. Do you know where the deposits from the privy vaults are made, when they are cleaned?

A. No sir, I do not.

Q. Is the water used here now from the Illinois river in manufacturing establishments?

A. I don't think it is.

Q. What manufacturing establishments have you in the town?

A. There is what you call the Coleman works and the tannery and the Nickel Works up here, similar to the Coleman works, and paper mill and so on.

6443 Q. How many paper mills in the town?

A. Only one.

Q. Is it straw-board or is it wood pulp?

A. Straw.

Q. Since the opening of the drainage canal you have seen the water in the Illinois river and seen the river?

A. Yes sir, I have been on it.

Q. Now how much better is it than before the opening of the drainage canal?

A. Oh, I think about five hundred or a thousand per cent, something along there. It looks good to me, and it wasn't fit to be seen before.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. They don't use it for domestic and drinking purposes here in town, do they?

A. No sir.

Q. Do you ever drink it?

A. No sir.

Q. When you say it is better than it was before the canal was opened, you get your information from simply observing the water?

6444 A. Yes, from looking at it, and I can see the fish in it, and before they couldn't live in it; it was so slimy then that you couldn't see in it hardly.

Q. Now then before there was no current to amount to anything?

A. Well I don't think there was as much as there is now.

Q. Well at times in the year there was practically no current?

A. Oh yes, there was always some current in the river in some places where it runs quite fast.

Q. Well it was very shallow there?

A. Yes, it was pretty shallow.

Q. It was so shallow and the current was so sluggish that it deposited this stuff along the banks, did it?

A. Yes sir, it deposited it along the banks and of course right in where the water ran you could see it on the water.

Q. None of that obtains now?

A. I have never seen anything of the kind now.

Q. How often do you visit the river?

A. Oh, once a week perhaps.

Q. You say you don't fish in the river?

A. I have not fished in it since that time.

Q. That was years ago?

A. Yes, that is a few years ago. I guess I will try it again; I see the rest of them are all catching fish now.

6445 Q. Are there any places in town along the river here in this locality that use the water of the river?

A. Well sir, I don't think there is; I don't think so; I don't know.

Q. How many people are there in this town?

A. I think they call it about 5,000.

Q. Now the sewers that are constructed in the town are in the business part of the town, aren't they?

A. Yes sir.

Q. What per cent of the town is sewered, according to the population, twenty-five or thirty per cent of it?

A. Well about, I should think 25 per cent, to guess at it. I haven't thought about it.

Q. Now how far is the town from the river?

A. Well from where we sit now, to the river, I don't think it is a quarter of a mile; something like that, may be.

Q. The Illinois and Michigan Canal is between the town and the river, is it not?

A. Yes sir.

Q. Now with reference to the construction of the sewer, does it pass under the canal?

A. Yes sir.

6446 Q. And the surface water that runs from the town, where does it go to?

A. Well, if it runs that way, I presume it runs into the canal.

Q. But not into the river?

A. Oh, no.

(F. S. B., Com'r).

6447 H. M. FERGUSON,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name, residence and occupation?

A. H. M. Ferguson, Morris, Illinois, physician.

Q. In what county in Illinois is Morris?

A. Grundy.

Q. Is it the county seat?

A. Yes sir.

Q. Is it an organized city under our general corporation act?

A. Yes sir.

Q. Has it a Board of Health or a health officer?

A. Yes sir.

Q. What is the name of the—or the official style of the health officer?

A. Executive officer.

Q. Have they a board of health here?

A. Yes sir.

Q. Now have you occupied any position in this board of health?

A. Yes sir.

Q. What was it?

6448 A. I was Executive Officer, health physician.

Q. When were you in this position?

A. Up until this last year, I served three, possibly four years.

Q. When did your term expire?

A. Last Spring.

Q. After the municipal elections?

A. Yes sir.

Q. You were then the health officer both before and after the opening of the drainage canal in 1900?

A. Yes sir, that would make it.

Q. Now what system of public water supply is there in this town, if any?

A. Artesian water.

Q. What is the depth of the wells?

A. The depth of the city supply?

Q. Yes.

A. I will say approximately about 900 feet; but that is only approximately, it has slipped my mind.

Q. How extensively in the town is the public water supply used?

A. Largely.

Q. What portion of the population take their water from the public water supply?

6449 A. The large bulk.

Q. Well, seventy or eighty per cent?

A. I would say fully that.

Q. From what source do the other people in the town obtain their water?

A. Well, the practice is almost universally taking city water. On the outskirts there is occasionally a well, and possibly one or two wells in the town that are being used.

Q. Are there any cisterns?

A. For drinking purposes?

Q. For drinking purposes?

A. I don't know of any families that drink cistern water.

Q. Is there a system here of reporting the statistics as to deaths from diseases, to any officer?

A. Yes sir.

Q. To whom?

A. It is reported to the City Clerk, but that is this last year only.

Q. Never before?

A. Not systematically.

Q. Do you mean by that that it has not been done regularly and carefully so that the statistics as to deaths would be reliable?

A. Yes sir, that would be what I would say. We tried
6450 to get the statistics before, to make report to the board.
Our mortality here is a little less than fourteen per thousand.

Q. Do you know with reference to the prevalence or existence here prior to January, 1900, of typhoid fever?

A. Formerly typhoid was very prevalent; now it is excellent, practically none except imported cases.

Q. You mean now there is scarcely any except imported cases?

A. Yes sir.

Q. Now since the opening of the drainage canal, what has been the condition of the people here as to typhoid fever?

A. We have had no typhoid fever practically except it is imported. I have noticed that and discussed it with other physicians only last night.

Q. Are you familiar with the manufacturing interests here, and their character?

A. Yes sir.

Q. What are they?

A. We have got a paper mill; we have got a foundry; we have a tannery; we have a large machine shop and we have an oat-meal mill and the usual small shops.

Q. What kind of a paper is made here, from straw or wood pulp?

A. Straw.

Q. Do you know into what it discharges its refuse water, into the canal or the river?

6451 A. I don't know positively, but I have understood it was into the river. This mill has been working very irregularly for it was idle for a long period, the paper mill.

Q. When was it in operation last?

A. It is in operation now. I can't give you accurate figures regarding that, but I think it has only been the last two or three years that it has been in operation.

Q. What is the extent of the tannery?

A. It is quite a tannery.

Q. The refuse from the tannery; do you know where it goes?

A. It empties below the bridge into the river.

Q. What amount of public sewers are there in the town?

A. Well, we have just inaugurated the sewerage system; the city has been surveyed of course, and we have two main outlets, one in the river and one in the Nettle Creek that empties below the river, or below the bridge.

Q. Does that mean below the city?

A. Yes sir.

Q. What is the extent of the Nettle Creek?

A. Well, there is always some water in it, but in midsummer it gets pretty low.

Q. Which direction from the city does it run?

A. It runs through the west side of the city, and parallel to the western boundary.

6452 Q. How long a creek is it?

A. Oh, I understand that its source is up in Wisconsin, from hearsay.

Q. So that it drains quite an extensive country?

A. Yes, during freshets, with a large amount of water.

Q. Now what was the condition of the Illinois river here before the opening of the drainage canal?

A. Bad.

Q. In what respect?

A. It was murky, ill-smelling, and dead, rotten.

Q. Was there an odor here to the water in the summer?

A. We could smell it here in town.

Q. How far is the business part of Morris from the river?

A. About a quarter of a mile away, and about an elevation of thirty or forty feet.

Q. Above the level of the river?

A. Yes sir. Those are approximate figures; I don't know for certain.

Q. Do you know whether there was a considerable growth of plant life in the river prior to the opening of the drainage canal?

A. Yes sir.

Q. Was there a scum upon the river?

A. Yes sir.

6453 Q. Of what character?

A. Why, I didn't examine it especially, a vegetable growth, a rank growth, I would describe it.

Q. Do you know the form of the plant life that appeared on the surface, whether it was a small plant, very small with three leaves and a very small root, three little sprangles of the root?

MR. JEFFRIES: Objected to as leading and suggestive.

A. I am familiar with one type only and that I could describe very accurately. It is probably a quarter of an inch across, shaped something like a clover leaf, and it had several little tendrils extending down into the water, and this would become matted and would grow in masses.

Q. Do you know by what name that plant was called here?

A. No sir.

Q. Duckweed, shamrock, or water clover?

A. Water clover seems familiar. I never had it—I don't know—but I picked it up out of the water and examined it.

Q. In addition to this plant life, was there a foreign substance appeared on the water here, grease or oil or something not connected with the plants?

A. Why I never noticed that specifically except that the whole body of water was bordering on putrid.

6454 Q. What was the character of plant that grew from the bottom of the river, moss or grass?

A. Well, I would hardly know how to differentiate those two. My recollection is that it would grow like seaweed, you would pull it up on an oar and it would mat down very heavy, and it would grow right close together, but the form of leaf I never noticed particularly. Sometimes they would have almost microscopic spikes running off from the side and that is as definite as I could give that.

Q. Did you notice the condition of the water here in the winter prior to the opening of the drainage canal?

A. Yes sir, by reputation and by casual observance.

Q. What was its condition then?

A. Bad.

Q. Was there a smell or an odor from it here in the winter?

A. I don't recollect that.

Q. Now since the opening of the drainage canal what has been the condition here?

A. Better.

Q. In what respect?

A. Well in all of the objectionable respects, the water is clearer, that is after the period of washing, after the water was first turned in, it was worse, but after that it cleared up; there was less odor apparently, less solids in suspension, 6455 and you could see the bottom more.

Q. Clearer you mean by that?

A. Yes sir.

Q. And better current?

A. Oh yes, the current is much better.

Q. What was the current here before the opening of the drainage canal?

A. Oh, it was sluggish.

Q. There was always some current?

A. Yes, there was some current but not very much.

Q. Now do you consider the water since the opening of the drainage canal better water than before?

MR. JEFFRIES: Objected to as leading.

A. Oh yes, decidedly so.

Q. Now did you take samples of water here for any person, either before or since the opening of the drainage canal?

A. Yes.

Q. For whom?

A. State Board of Health.

Q. In what years did you take the samples?

A. I think it was 1899 and 1900; I am not sure; I think that was the year; I have a memorandum at the office that I could refer to.

6456 Q. Were you instructed to take the samples?

A. Yes.

Q. By whom?

A. Dr. Long and Mr. Harman.

Q. They were together here?

A. Yes.

Q. Now at what point in the river did you take the samples?

A. About 50 or 100 feet above the railroad bridge.

Q. Is that above any of the sewage influences of the city of Morris?

A. Practically so; I went down to the bridge with them and viewed it, and it was agreed that it was a good place.

Q. At what point in the channel did you take it, middle or in the channel?

A. A little this side of the middle—middle of the center pier.

Q. In what way did you take it?

A. According to instructions.

Q. Well but at what depth?

A. Well the small bottle, or sample, for bacteriological examination—well both samples for that matter, I took as far down as my arms would reach, about here (indicating) oh twelve or fifteen inches.

Q. How frequently did you take the samples?

6457 A. My recollection is once a week.

Q. During what season of the year of each of the years, summer or winter?

A. Why, as I remember, I took them at all seasons. I remember cutting through the ice and I remember going in mid-summer.

Q. Now when you took the sample of water did you have a thermometer?

A. Yes sir.

Q. What did you observe upon the thermometer?

A. Observe in what way?

Q. What temperatures did you take with the thermometer?

A. I took the temperature of the water and of the atmosphere.

Q. Now did you record upon tags furnished to you the time and place of collection and the temperature of the air and the water?

A. Yes sir.

Q. And did you sometimes record other facts as to the condition of the river or showers, or anything of that sort, upon these tickets?

A. Yes I think I did. I replied in answer to Dr. Long, in reply to questions as I recollect it, commenting on the better condition of the water. I was interested in the work, 6458 being a physician and bacteriologist myself.

Q. From whom did you receive the bottles?

A. The express company.

Q. And to whom did you return them after they were filled?

A. The express company.

Q. Describe the bottles and their covering and the manner of taking the sample and preparing it?

A. The samples were taken in duplicate; there was a glass stoppered, clean bottle, sealed and steriled and an either four or six ounce—four, six or eight ounce, I don't recollect just the dimensions of it, a practically six or eight ounce glass stoppered and also sealed with a rubber cloth around it and tied.

Q. Now how did you take the sample in the smaller bottle, as to whether you opened the bottle before you put it into the water or after?

A. I took the water—that is, I took the seal off the bottle and closed the bottle under the surface twelve or fifteen inches, or as far down as it would get away from the surface drift.

Q. And then remove the stopper under the water?

A. Yes sir.

Q. And after the bottle was filled what did you do with the stopper?

6459 A. Well, I put the stopper into the bottle under the water.

Q. After it came up what did you do with this smaller bottle?

A. Why, I drove immediately to my office, sealed it and packed in ice and delivered it to the express company and sent it away that morning.

Q. Now with the larger bottle, what was the manner of treating it?

A. Well I sealed that and attached the envelope with the address on and the descriptive ticket under seal.

Q. How long from the time that you took the samples of water until they were delivered to the express company?

A. Well there was no delay from beginning to end. I went to the river, to my office and to the express company. I would say that I would start out at half-past eight and the express company would have them within an hour.

Q. Well, would it be thirty minutes from the time that you took the samples until you delivered them to the express company?

A. No, I couldn't possibly do it that quick, the work was completed while I was doing it—I took it to the office and sealed it and got it under the ice as quick as I could.

Q. The smaller bottle, was it enclosed in a larger case?

A. Yes sir.

6460 Q. And what was put in the larger case?

A. Ice.

Q. Do you remember whether in the box into which the two bottles were put you put ice outside of both bottles, both cases?

A. I don't recollect of icing the big bottle.

Q. I now hand you forty-two tickets and ask you to examine them and state whether or not the writing upon them is in your hand, or done under your direction?

A. Yes sir, those are mine.

Q. Now when these tickets were prepared as they appear, state what you did with them?

A. I enclosed them in a shipping envelope and sealed them.

Q. And what became of the envelope, was it attached to one of the bottles?

A. It was attached to the large bottles with sealing wax and string.

Q. Did you have a stamp which was placed on the wax?

A. Yes sir.

Q. Do you remember your number?

A. Three, I think it was.

JUDGE JOHNS: I now hand the Commissioner forty-two tickets, referred to by the witness and ask him to mark them Exhibit No. 16 for the State of Illinois for identification, to the testimony of H. M. Ferguson. 6461

Said tickets are so marked by the Commissioner.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. When did you say you took those samples, doctor?

A. In the morning.

Q. What year?

A. My recollection is in 1899 and 1900.

Q. What part of the year in 1899?

A. I can't say definitely.

Q. In the summer or winter?

A. Well that is four years ago; I don't care to state definitely without referring to my ledger.

Q. Did you take them in 1900 also?

A. I think I did.

Q. So you took samples during a part of two years?

A. Yes sir.

Q. But it was all one continuous duration of time, or was there a cessation?

A. No, I think it was irregular; that is when I was taking them I took them regularly, and then there would be an interval, or was an interval.

6462 Q. Did anybody assist you in this work?

A. No sir.

Q. How often did you take the samples?

A. My recollection is once a week.

Q. And who did you send them to?

A. To Dr. Long. The printed directions were on the ticket; I have forgotten whether it was sent to the University, but it was delivered to Long.

Q. How long have you been practicing medicine?

A. Thirteen years.

Q. What school of medicine do you belong to?

A. The regular.

Q. You stated, I believe that you were a bacteriologist yourself?

A. Oh yes, I have done quite a little of that work.

Q. Does your knowledge of bacteriology influence you in your opinion as to the condition of the water now and what it was prior to the opening of the canal?

A. I made no bacteriological examinations of it at all.

Q. You don't know what that shows?

A. No sir.

Q. Whether it is good or bad?

A. Why, I glanced over the report of the State Board and noticed.

Q. I am not talking about that; I am talking about 6463 from your own knowledge?

A. No, not from my own knowledge, I don't know.

Q. Did that have anything to do with you in expressing an opinion as to the condition of the water?

A. No sir.

Q. You just judged from its appearance?

A. Yes sir.

Q. Without having made any examinations whatever?

A. Yes sir.

Q. Either chemical or bacteriological?

A. Yes sir.

Q. And the fact that it has been examined, or your knowledge of the science of bacteriology and as a physician, had nothing to do with your forming an opinion on that subject?

A. My opinion is formed only on the microscopical condition that I found there, noticing it casually in collecting the samples.

Q. Did you take microscopical observations yourself?

A. No, I say the microscopical, that is the gross condition of it.

Q. Or from ocular observation?

A. Yes, sir.

Q. The river was very sluggish before the canal was opened, was it not, doctor?

6464 A. Yes, sir.

Q. And as a consequence it deposited this decayed vegetation and matter along the banks and held it in the body of the water, and permitted its going down the river?

A. I wasn't familiar with that condition, no; I never noticed it in fishing or anything of that kind.

Q. Was there any decayed vegetation along the river at that time?

A. At what time do you refer to?

Q. Prior to the opening of the canal, either winter or summer?

A. Well, I would say Yes and No to that question. There would be this shore wash, and this little clover leaf growth that I referred to.

Q. Is that shore wash there now?

A. No, sir.

Q. It has all gone?

A. So far as I know, yes.

Q. How often do you visit the river now?

A. Oh, I have been across the river on a boat twice, but I have been across on the bridge often, practicing and always noticed the water as I go by.

Q. What is the difference in the current now to what
6465 it was before the opening of the canal?

A. Well, the current is much stronger so that in boating you have to take it into consideration.

Q. The people in Morris and vicinity do not use the water of the Illinois river for drinking or domestic purposes, do they?

A. Oh, no, we have no system of getting it at all.

Q. Do they use the water from the Illinois and Michigan canal?

A. For commercial purposes?

Q. For drinking and domestic purposes?

A. No, just for mercantile work.

Q. Did they ever use the water from the Illinois and Michigan canal previous to this at any time for drinking and domestic purposes?

A. No, our well supply has always been pretty good.

Q. What was the cause of the typhoid fever several years ago, that you spoke of; you said there was more then than there is now.

A. Well, all through the country here there was shallow surface wells, and it got to be a fashion twelve or fifteen years ago to put down pipe wells, and then this strata of sand here down the river—the drainage gathered, and the cause of the typhoid fever was defective drainage on the prairie.

Q. Not due to anything connected with the Illinois river?

A. I don't know anything about that.

6466 Q. Well, what would be your judgment about it?

A. Whether the condition of the river produced typhoid or not?

Q. By reason of their drinking the water from the river?

A. I think it had an effect in view of the mosquitoes; we used to have an immense amount of them there, but the town and surrounding country is higher than the river, but the mosquitoes explained that.

Q. Well, then, it was not due to the inferior wells that they had?

A. Well, the well entered into the proposition, I know. Years ago we had an immense amount of typhoid fever.

Q. When did the condition commence to abate?

A. It commenced to abate—

Q. As soon as these wells were being sunk?

A. Typhoid fever, when I looked over the records—my recollection is that the typhoid fever wave dropped about the time that the city waterworks were instituted.

Q. When was that?

A. I couldn't say, it is five or six or seven years ago.

Q. About when, 1887, 1897 or 1895?

A. Well, let's see; call it eight years ago.

Q. Eight years ago?

A. Yes, sir.

6467 Q. How large a water system have they; what is the capacity of the water system here—sufficient to furnish water to all who want it?

A. Oh, yes, abundant.

Q. The source of the water is beneath the bed of the river is it not?

A. I think so.

Q. Does it come from the direction of the river, or from the opposite direction, if you know?

A. I only know by hearsay, as I understand, the strata drifts from the northeast.

Q. Towards the river?

A. Down through here (indicating).

(F. S. B., Com'r.)

6468 DEWITT C. HUSTON, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. What is your name?

A. DeWitt C. Huston.

Q. Where is your residence and what is your occupation?

A. Morris, Illinois; I am in the grocery business.

Q. Do you occupy any official position here?

A. I am just at present on the board of review.

Q. That is the board reviewing the system of taxes?

A. Yes.

Q. Are you appointed or were you a member of the board of supervisors?

A. No, sir, I was appointed.

Q. By the county judge?

A. Yes, sir.

Q. How long have you lived in Morris?

A. Well, continuous residence since 1874. I did live here awhile in 1855 and 1856.

Q. Have you been acquainted with the Illinois river for a considerable number of years prior to the opening of the drainage canal in January, 1900?

6469 A. Yes, sir.

Q. Through what means did you become acquainted with it?

A. Oh, passing over it.

Q. Did you fish or hunt much?

A. Well, not such a great deal; some.

Q. Prior to the opening of the drainage canal what was the condition of the Illinois river at this point?

A. Very bad, the water was.

Q. In what respect?

A. Well, it smelled bad and looked bad and dirty and nasty.

Q. What was its condition in the summer here as to its being covered over with any substance?

A. It used to be covered over with green scum along the edges, excepting in the middle; of course it was washed out. I have seen places where it was clear across the river.

Q. Was there an odor to the water in the summer?

A. Yes, sir.

Q. Can you describe that odor?

A. I know it was very disagreeable; I don't know as I could tell just exactly what it was.

Q. How about the water in the winter?

A. That I don't know anything about; I never was on the river in the winter to take any notice to that.

6470 Q. Do they take ice from the Illinois river here in the winter?

A. No, sir, not for use.

Q. Not for domestic purposes?

A. No, sir.

Q. Where is the ice supply obtained?

A. Well, they get it from the canal and they used to get it from the Mazon creek that comes into the river here opposite the city here.

Q. That is a different stream from Nettle creek?

A. Yes, Nettle creek is on this side of the river.

Q. And Mazon on the other?

A. Yes.

Q. How long a creek or river is the Mazon?

A. Oh, it is,—I should think it would be forty miles.

Q. Is it always full of water?

A. Yes, sir, most always; but towards the head of the creek it dries up.

Q. In dry weather is it a creek or a river of any considerable size?

A. Oh, it is pretty fair sized for a few miles along here.

Q. Now, since the opening of the drainage canal what has been the condition of the Illinois river?

A. It has been a great deal better.

6471 Q. Well, in what respects?

A. The water is clearer, and the water don't have that bad odor to it, it used to have; it don't scum over like it used to.

Q. Is there none of that green scum forming here now?

A. I never see any of it now, no, sir.

Q. Do you know anything about the condition as to the fish in the river here?

A. I know a few years ago we used to catch a good many fish, and late years there has been none at all; couldn't get any.

Q. What do you mean by a few years ago?

A. Well, I say twelve or fifteen years ago.

Q. Do you know of a time when the city of Chicago pumped this water from the Chicago river into the Illinois and Michigan canal?

A. Yes, sir.

Q. Now, with reference to that time when was the fishing good here—before or after?

A. Well, I don't know when that was, of course,—when that pumping started.

Q. It started in 1885.

A. Well, that is about the time the fishing quit.

MR. JEFFRIES: I object to the testimony of counsel here.

Q. Now, do you know anything of the fishing conditions here since the opening of the drainage canal?

6472 A. I understand—I have not fished any myself in the river, but I understand they are catching quite a few fish in the river here.

Q. Is fishing pursued here as a commercial enterprise, for profit?

A. No, sir, not to any extent.

Q. By nets or seines?

A. No, sir.

Q. You have no professional fishermen here?

A. No, sir.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. The water in the summer time prior to the opening of the Chicago drainage canal was very sluggish, was it not?

A. Oh, it would be in low water.

Q. Scarcely any current at all?

A. There wouldn't be very much, no.

Q. How is it since the opening of the canal?

A. Great deal stronger current.

Q. You don't drink the water from the Illinois river, do you?

A. Not when I can help it.

6473 Q. Do you know of anybody that uses it for domestic purposes?

A. No, sir.

Q. Its reputation is rather bad, isn't it?

A. Yes, sir; of course, a fellow could drink it now, if he was forced to, but, of course, as long as you can get better water, you wouldn't drink that.

Q. When you say the water is better than it was before the Chicago drainage canal was opened, you say so simply from your observation of it?

A. Yes, sir.

Q. Without any scientific knowledge as to whether it contains unwholesome ingredients or not?

A. No, sir, just from my own observation.

Q. That observation then is that it don't contain any contaminating matter at all?

A. Well, that,—I don't know about that. I know the water looks clearer a good deal.

Q. Is it your idea that all clear water is pure water?

A. Of course, it looks purer.

Q. Well, you don't want to be saying unqualifiedly that the water is purer now than it was before the canal was opened?

6474 A. Well, I think it is purer.

Q. Judging from its looks?

A. Yes, sir.

(F. S. B., Com'r.)

6475 L. B. RAY, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Johns and testified as follows:

Q. You may state your name, residence and occupation?

A. My name is L. B. Ray; my residence is Morris, Illinois, and my occupation—I am without any; I will say retired.

Q. Have you occupied any official position in the state or in Grundy county, if so, what?

A. Well, I have been a member of the Legislature, both houses, and have been lieutenant-governor of the state four years.

Q. How long have you lived in Morris?

A. Since 1855.

Q. Were you acquainted with the condition of the Illinois river at and above Morris prior to the opening of the drainage canal in January, 1900?

A. Well, only in a very general way. I have never boated on the river at all; I have never fished in the river and never made any examination. I have noticed it as I would go across the river, and know more about the condition from hearsay or talk with the people here, than from personal observation.

6476 Q. Where is the head and origin of the Illinois river?

A. It is about eight or ten miles east of here in this county, in the eastern edge of this county.

Q. What creates it there?

A. The Kankakee and Desplaines rivers come together there and make the Illinois river, the DuPage going into the Desplaines just above the junction of the Desplaines and the Kankakee.

Q. Now, do you know of a stream called the Mazon?

A. Oh, yes.

Q. On some of the maps it is put down as Mazon river, and others as Mazon creek—what is it designated here?

A. We have always called it Mazon creek.

Q. What country does that creek drain?

A. Well, it drains, I think, the northern part of Livingston and the south part of Grundy. I think it gets its head from near Dwight, I think it is; I may be mistaken as to that, and then it goes east and at Gardner the railroad crosses it. There is a place there just east of Gardner called Mazon, and it is quite a river there, quite a creek, and from there it comes in an indirect course down to the Illinois here, at the bridge.

Q. What is the length of this Mazon?

A. As it runs?

6477 Q. Yes?

A. Oh, I would hate to guess; it runs a good many miles going a little ways; some places it is a very crooked stream, particularly when it comes down to the bluff on the south side of the river.

Q. What is the extent of DuPage river?

A. That is quite an extensive river with its source up in Wisconsin, I don't know just where.

Q. Is the Desplaines river, before its junction with the Kankakee, ever called in this vicinity the Illinois?

A. No, sir.

Q. It is distinctly recognized as the Desplaines river?

A. Oh, yes, as the Desplaines river.

Q. And that comes down from Joliet?

A. It comes down through Joliet and Desplaines, and as I said, forms a junction with the Kankakee in the eastern edge of our county, perhaps eight miles east of here.

Q. Now, according to your observation, what was the condition of the Illinois river here before the opening of the drainage canal?

A. Well, in the dry season for the last several years the condition of the water has not been good; it has been bad.

Q. In what way?

6478 A. Oh, well, I don't know that I could give you a scientific answer to that.

Q. Well, have you noticed that there has been vegetation in it, and a scum upon the water in the summer?

MR. JEFFRIES: Objected to as leading.

A. Well, I never noticed that.

Q. Have you ever noticed here an odor coming from the river here in the summer?

A. Well, there has been times here that you could be in the town here and get an odor here, which I suppose was from the river.

Q. And in the winter, have you had any effects from that, or have you noticed it at all?

A. Well, I have noticed that the river has been frozen over, that is, years ago, driving on the river in the winter, when we came to an air-hole it would be vile,—the odor from the river would, in the winter particularly; I never paid any attention to it.

Q. Now, since the opening of the drainage canal what has been the condition of the river?

A. Well, I think the condition of the water has been improved.

Q. Is there a considerable greater volume of water?

6479 A. Or,—if they are not putting in what the law requires them to—they have got four or five feet more here in the bed of the river within a few rods from here—here at the bridge. Engineers tell me that if they are sending down what the law requires it will make a difference of four to five feet at this bridge; that in the dry season makes a great deal of difference; in the flood season like we had most of last year, why, it wouldn't count for so much.

Q. Now, in the flood season the Illinois river is a considerable body of water here, is it not?

A. Yes, sir.

Q. And is it subject here to sudden rises because of the confluence of these various creeks and rivers?

A. Oh, of course they all contribute. Its sudden raise is occasioned in the spring by the melting of the large body of snow; in the summer by heavy rains, the same as any other valley.

Q. Do you know this creek called Nettle creek?

A. Yes, sir.

Q. What is the extent of it?

A. Well, I don't know, it runs up through the northwest part of our county—how much further than that I don't know. In dry season at the present time there is very little water in
it, but in flood season here it may be very large, because
6480 the river takes it. It empties into the river just below
the town here, and that drains the western part of the town of course into the river.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. What has been your business before you were lieutenant-governor?

A. I was in the dry goods business here.

Q. The odor prior to the opening of the Chicago drainage canal was not so bad as to cause anybody to leave the town, was it?

A. No, I don't think so.

Q. What is the difference between the current in the river now and what it was prior to the opening of the canal?

A. Oh, I couldn't tell that.

Q. Could you approximate it?

A. *No, I never paid attention so as to say*; I was never on the river in a boat.

Q. How often do you visit the river?

A. Oh, very seldom.

Q. How far is the river from here?

A. Oh, it is forty rods, perhaps, it may be a little more 6481 or less, I very seldom go there.

Q. The people don't use the water?

A. Never have; we have got an excellent system of waterworks here and a partial system of sewerage.

Q. Then when you say the water has improved, you simply speak from your observation?

A. General observation.

(F. S. B., Com'r.)

6482 CHARLES D. FERGUSON, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Charles D. Ferguson.

Q. What is your business?

A. Blacksmith.

Q. How long have you lived in Morris, Illinois?

A. Nearly all the time since 1854.

Q. Were you acquainted with the Illinois river prior to the opening of the drainage canal in 1900?

A. I was.

Q. What opportunities have you had of becoming acquainted with the Illinois river?

A. Well, I used to fish a good deal for amusement, and our fishing club was about a mile up here; we used to row up the river and go up to the four-mile slough above Mazon.

Q. What was the condition of the Illinois river before the opening of the drainage canal in 1900?

A. Well, we called it bad. I did.

Q. What do you mean by bad?

6483 A. Why, it was very black and smelled very bad.

Q. You are pretty well acquainted with the county here, are you not?

A. Yes, sir.

Q. Have you ever held any official position in Grundy?

A. I was sheriff six years.

Q. What extent of the river were you acquainted with?

A. Well, I have been from the mouth of the river or from the Kankakee to Ottawa in a boat.

Q. What was the color of the water prior to the opening of the drainage canal?

A. Why, it was inky.

Q. Did it have any aroma to it?

A. Yes, it smelled like sewage.

Q. Did fish thrive in the Illinois river prior to the opening of the drainage canal?

A. Well, I never fished in the river from the time that the pumping works was started. I have never fished any since.

Q. What effect, if any, has the opening of the drainage canal and the turning of Lake Michigan water into the Illinois river had upon the Illnois river at this point?

A. Well, it is not so dark and it don't smell so strong.

Q. Is there any smell to the river at present?

A. Very little.

6484 Q. How perceptible is that odor?

A. Well, I was across the bridge Sunday night and you could smell a little, crossing the bridge last Sunday.

Q. How does the color of the water compare now with the color that existed prior to the opening of the drainage canal?

A. Why, it is a good deal lighter color, clearer.

Q. What is your opinion from what you know of the Illinois river as to whether the opening of the drainage canal has been a benefit or a detriment to the Illinois river at this point?

A. I should say it betters it.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Why do you say it has bettered it?

A. Why, it looks better, it is lighter colored, looks clearer and does not smell so strong.

Q. That is the only reason?

A. That is the reason; I judge from appearances.

Q. Nothing else?

A. No.

Q. What is the cause of this smell up here in the street now, today; I noticed it coming down here?

A. Why, I smelled the tannery along about eleven o'clock. You can smell the tannery when the wind is right.

6485 Q. Can you distinguish the difference between the smell from the tannery and that from the river ?

A. Yes, sir.

Q. You could before the canal was opened?

A. Yes, sir. The reason I say that, I am at the tannery quite often, and I know where the smells come from; a stranger might not be able to tell it.

Q. Well, you find that the current is much stronger in rowing up and down the river, since the canal was opened, don't you?

A. It is quite a good deal stronger.

(F. S. B., Com'r.)

6486 G. W. ELERDING, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. G. W. Elerding.

Q. What is your business?

A. I am photographer at present.

Q. How long have you lived in Morris?

A. About twenty-six years.

Q. Are you acquainted with the Illinois river?

A. Yes, sir.

Q. What opportunities have you had for becoming familiar with the Illinois river?

A. Well, I consider them the best. Hunted and fished on it all my life, pretty near.

Q. How often do you fish and hunt?

A. Well, when fishing was good in the river, I used to go out and fish two or three times a week, that is in the fishing season, spring and fall, and late years here every spring I go hunting.

Q. Prior to 1900, the opening of the drainage canal, what
6487 was the condition of the water in the Illinois river?

A. Well, that varied with the distance you went up.

Q. Well, just start here and differentiate between this point and as you went up?

A. Well, here at Morris the water was dark; it was pretty near black, and it had a kind of an oily appearance, just like grease, and it smelled very bad, and then the further you went up, why the better it got on the other side. On this side it got worse.

Q. What river enters the Ilinois river on the other side?

A. Well, there isn't any river enters it, the junction of the Desplaines and the Kankakee form the Illinois river.

Q. What side of the Illinois river does the Kankakee enter it?

A. On the south side.

Q. Now, as you went up, on which side would the water be better, and which side would it be worse, the side on which the Kankakee entered, or on the side the Desplaines came in?

A. It would be better on the Kankakee side.

Q. After you passed the Kankakee, what would be the condition of the water in the Desplaines river?

A. Very bad.

Q. To what did you attribute that variety of water on one side bad and on the other side good?

6488 A. Why, it was according to the volume of water coming down the Kankakee river.

Q. How was the water of the Kankakee as compared with the water of the Desplaines river?

A. Why, as much difference as there is between black and white.

Q. In favor of which river?

A. In favor of the Kankakee.

Q. Now, as you went down the stream how did the water become?

A. Well, it became somewhat better; that is what I call the sewage water was probably good water over on the other side.

Q. How far down did that condition obtain?

A. Well, there has been times here when this side of the river would be inky black and on the other side it would be comparatively clear.

Q. Are you acquainted with the river down below?

A. Yes, sir.

Q. How far down would you find that separation of the waters to extend?

A. Well, that depended on the time of the year. If there was a considerable amount of water coming from the Kankakee river, it would extend further and if it was in low water here, sometimes it would be clear across here; in fact further east than Morris.

6489 Q. Well, how far down the river would the Kankakee and the Desplaines river become mingled into a water of general appearance?

A. Well, now, that I wouldn't say.

Q. What was the condition of the water, the average condition of the water of the Illinois river at Morris?

A. At what time?

Q. At any time?

A. You mean since the—

Q. Before the opening of the canal?

A. Why, it was bad.

Q. What do you mean by bad?

A. Well, it had a bad odor, a very disagreeable odor, and there weren't any fish to speak of.

Q. Did you ever catch fish and put them in live-boxes?

A. Yes, sir.

Q. How did the fish live when so treated, before the opening of the canal?

A. Why, in the fall they would live quite awhile; in the summer time, the warmer months, they wouldn't live so long.

Q. Would the fish live in a live-box in the waters of the Illinois river at this point prior to the opening of the drainage canal?

6490 A. Well, I never kept any in live boxes in the Illinois;

those we kept in live-boxes was when we was camping up the river.

Q. What effect, if any, has the opening of the drainage canal had upon the water of the Illinois river at this point?

A. Why, it has improved the water.

Q. To what extent.

A. It is clearer; doesn't smell so bad, and there are more fish.

Q. What kind of fish do you catch here?

A. Rock bass, catfish, sturgeon. I heard of a few perch; I have not caught any myself, not of late years.

Q. Any odor to the water now?

A. At times, yes.

Q. How appreciable is the odor as compared with what existed here before the opening of the canal?

A. Well, before the opening of the canal you could smell the river most any place, that is, in the town here, if the wind was from the south. At the present time unless you are pretty close to the river you don't smell it.

Q. From appearances, can you detect the presence of sewage from Chicago in the water at this point?

A. At times you can.

Q. How does it manifest itself?

6491 A. There is a—it looks a little bit like a sediment of starch floating in the water; it is not on the surface; it is in the water.

Q. Kind of matters in suspension?

A. Yes.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. The current is much more rapid now, isn't it?

A. Yes, sir.

Q. Than it was before the opening of the canal?

A. Yes, sir.

Q. Where does the water from the Illinois and Michigan canal come as it passes up here, what is its source?

A. It comes from the Desplaines river.

Q. Above Joliet?

A. No, sir, it comes in at the junction of the Kankakee and the Desplaines.

Q. Then it empties first into the Desplaines and then it carries the water from the Desplaines as it comes on down?

A. I didn't understand you?

Q. It first empties into the Desplaines?

A. It comes down the canal.

Q. I know, but the canal empties into the Desplaines?

6492 A. Yes, sir.

Q. Then it leaves the Desplaines again further down?

A. The canal?

Q. Yes?

A. The canal and the Desplaines river cross each other at Shannaham.

Q. Have you seen the canal at that point?

A. Yes, sir.

Q. Does it empty into the Desplaines?

A. I think it does.

Q. And then gathers itself on the other side, or is it bridged over?

A. Here at Shanaham?

Q. Yes?

A. Well, it has been a number of years since I was up there, but if I recollect right, the canal—or the Dupage river rather—now just wait a minute, I am mixed up there. The Desplaines river crosses the Kankakee at Shannaham.

Q. How does it get across?

A. What, the canal?

Q. The canal?

A. There is a lock there; it is locked there.

Q. That is, it comes then through the lock?

A. No, sir; it comes from above the lock; the water 6493 mingles there.

Q. The water of the canal and the Desplaines?

A. Yes, I have not been up to Shannaham for a number of years now; that is my recollection. I didn't examine into the location exactly.

Q. Part of it comes down the Illinois and Michigan canal and part down the river?

A. Yes, sir.

Q. When you say the water is better now in the Illinois river than it was prior to the opening of the canal at this point, you are judging altogether from its appearance?

A. From its appearance, yes, and from its use.

Q. Do you use it for drinking and domestice purposes?

A. Why, two years ago we were camping, and we used it to cook with.

Q. You didn't drink it, though?

A. Well, we drank it in coffee; we didn't do that very long, though, it was a case of necessity.

Q. How far up or down the river was that?

A. It was up.

Q. How far?

A. About seven miles from here.

Q. How far down the river have you been?

6494 A. Well, I have been by boat as far as Marseilles, in fact, below Marseilles.

Q. Do you see the effects of the sewage that far down?

A. Well, I was down there before the sewage was turned in.

Q. You haven't been down there since?

A. No, sir.

(F. S. B., Com'r.)

6495 HENRY STOCKER, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Henry Stocker.

Q. Where do you live, Mr. Stocker?

A. Here at Marseilles.

Q. What is your business?

A. Oh, I have been in the boot, shoe and harness business, for the last thirty years or over.

Q. What opportunities have you had for observing the Illinois river in the last ten years?

A. Oh, I went up the river once, perhaps twice a week in a boat, that is in fishing and hunting season.

Q. What was the condition of the Ilinois river prior to 1900, the date of the opening of the drainage canal?

A. The water was pretty rotten and filthy.

Q. Just describe the water?

A. Well, it couldn't have been much worse.

Q. Did it have any odor to it?

A. Yes, sir.

6496 Q. What was the character of the odor?

A. It was a most disagreeable smell.

Q. What effect has the opening of the drainage canal had upon the waters of the Illinois river at this point?

A. Well, the water is much clearer and then it has lost that odor, and the only time that I have ever noticed the odor on it since, is some nights you get it on the boat, if it was a foggy night we would smell it. In the day time when the weather was clear there was very little odor to it.

Q. How does the water compare in color?

A. Well, the water is much brighter; it is not so dark and greasy looking.

Q. Has the opening of the drainage canal in your opinion been a benefit or a detriment to the Illinois river?

A. I think it has been a great benefit to it.

Q. In what way?

A. Well, it has done away with that odor and the water is much brighter and better. You can on the bank now, see an object laying in the water ten or twelve inches deep, you can see it. Before you couldn't.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You judge altogether from the appearance of the water, though, in passing upon the question as to whether it is better or worse than before the opening of the drainage canal? 6497

A. Yes, sir.

Q. You don't drink the water?

A. No, I am not much of a hand to drink water, but I have drank it, but not in the last few years.

Q. Not since the opening of the canal?

A. Well, yes, I have since the opening of the canal, I have drank it up on the other side, up above what we call the railroad bridge.

Q. And what you supposed then was the water from the Kankakee?

A. Well, I presume it was; it does not mix up there like it does after it gets further down.

Q. There is some odor on the water yet, is there not?

A. If I noticed it, it was especially, as I say, especially on a foggy night when the air would be heavy I would notice it. In the day time I wouldn't notice it.

Q. The water at times gets of a sort of a milky color, does it, showing the effects of the sewage?

A. Well, I don't know; I have not paid much attention as to that; I couldn't say as to that.

Q. There is a good current now, is there not?

A. Yes, sir.

Q. And prior to the opening of the canal there was not 6498 a good current?

A. No, this time of the year especially, there would be a very little current in the river.

RE-DIRECT EXAMINATION, by Mr. Todd.

Q. When you say that you judge by appearances, do you eliminate in that answer the observation and the knowledge you obtained through the sense of smell?

A. What do you mean?

Q. As to whether the river is in better condition now than it was before the opening of the canal?

A. That is sense of the smell and upon the appearance of the water, yes.

Q. You include that in appearances?

A. Why, yes, and then of course there is another thing. I don't suppose the fish after a while could have lived in that water here. I never heard of anybody catching any.

Q. Do they live now?

A. Now—indeed they do, I have seen them. Before it was opened up the fish would come floating down—they wouldn't be dead, but they would float on the surface. I have seen catfish, suckers and redhorse; but I don't see anything of that kind now, and have not.

(F. S. B., Com'r.)

6499 J. O. LERETTE, called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. J. O. Lerette.

Q. Where do you live?

A. In Morris.

Q. What is your business?

A. Saloon business.

Q. How long have you been in that business?

A. About 28 years,—27 years, I think.

Q. Are you acquainted with the Illinois river?

A. Yes, sir.

Q. What opportunities have you had of becoming acquainted with the Illinois river?

A. Well, I have boated here for years before that and was on it more or less.

Q. What was the condition of the water in the Illinois river prior to the opening of the drainage canal?

A. Well, a few years prior to that, it was very bad.

Q. By "very bad" what do you mean?

6500 A. Well, it was so bad that cattle and horses wouldn't hardly drink it, and it looked black and smelled a little loud.

Q. How loud was the smell?

A. Well, loud enough for most of the people here to kick in the evening. They complained of it.

Q. What effect has the opening of the drainage canal had upon the water of the Illinois river?

A. Well, it has made it a great deal better.

Q. In what respects is it better?

A. It looks better and well, I don't know as I have noticed any odor since that.

Q. Have you observed anything about the fish in connection with the Illinois river?

A. Well, since the canal has been opened, I have not had much to do with the river. I go down there occasionally and cross the river once in a while, but not so much as I have before that.

Q. You have seen it, though, frequently?

A. Yes, sir.

Q. What in your opinion has been the effect of the opening of the drainage canal and the turning of the water of Lake Michigan into the Illinois river?

A. Well, it has made it a great deal better.

6501 CROSS-EXAMINATION, by Mr. Jeffries.

Q. And when you say it is better, you say so simply from observation?

A. That's all.

Q. And from the fact that there is not as much odor as there was?

A. Well, I have not smelled any.

Q. You have noticed some odor since the opening, have you not?

A. No, sir, I have not. That is, if I have I have forgotten it; I don't recollect it.

Q. You don't use the water?

A. No, sir.

Q. Can you see the effects of the sewage on the water now at any time?

A. Well, I have not been down to the river but little lately, only from the bridge, it didn't seem as though there was any. Of course, I wouldn't want to say there was not.

Q. Your opinion is, though, that there is none?

A. I wouldn't want to say that, but from the general appearances there isn't any.

6502 Q. And the general belief is that there is not?

A. Well, I wouldn't say what I believe, of course that I don't know, but there must be some sewage in it, because there is in mostly all river water.

Q. And more particularly in this because of the immense amount of it discharged in the river and the small volume of water that passes down the river and the short distance from Chicago here?

A. There is a pretty good volume in it now, to what it used to be; there didn't use to be any current in it hardly.

Q. But since then there is?

A. Yes sir, there is.

(F. S. B., Com'r.)

6503 J. C. HORRIE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. J. C. Horrie.

Q. What is your business, Mr. Horrie?

A. Jewelry business.

Q. How long have you been in that business?

A. About twenty years.

Q. Do you live in Morris?

A. Yes sir.

Q. Are you acquainted with the Illinois river?

A. Yes sir.

Q. What opportunities have you had of becoming acquainted with the Illinois river?

A. Crossing it every day, living alongside of it for a life time.

Q. What was the condition of the Illinois river at this point before the opening of the drainage canal?

A. Why to all appearances it was bad, the smell—we smelled it up town easily, in the evening.

6504 Q. What effect has the opening of the drainage canal had upon the waters of the Illinois river at this point?

A. It has been good.

Q. Have you noticed any smell on the water since?

A. No sir, I have not.

Q. How does the water in clearness compare with the conditions that obtained before the opening of the drainage canal?

A. Why, it is a good deal clearer than it was before, more current.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You know nothing of the chemical ingredients of the water.

A. No sir.

Q. But you judge altogether from its appearance and the absence of the smell?

A. Yes sir.

Q. Do you see any evidences of Chicago sewage in the water now?

A. Why, I have noticed after a heavy rain there would be small pieces of sticks, something like that, that some have said was sewage, but I have noticed that there was pieces of sticks that would come from the bank or from the overflow.

6505 Q. Well, the current in the river is much more rapid now than it was before the Chicago drainage canal was opened?

A. Yes sir.

Q. And at times before the opening of the canal it was very sluggish?

A. Very sluggish.

Q. In fact the greater part of the year?

A. Yes sir.

Q. You don't use the water from the river?

A. No sir.

Q. And the people here don't use it?

A. No sir, to my knowledge; I don't know of anyone using it.

Q. It has a bad reputation among the people, here has it?

A. Yes sir.

Q. Do you notice that smell or odor that comes from the river now?

A. No sir, we don't smell it now.

Q. You notice it when you go down to the river, don't you?

A. No sir, I cross it quite often and wouldn't notice it at all.

Q. It is your opinion then that the sewage has dissappeared altogether from the water?

A. Compared with what it was before, it has, in my estimation.

6506 Q. You think that the Chicago sewage is having no effect on the water here at all?

A. Well, sure, it must have.

RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. Can you tell by appearances whether what you see in the water comes from Chicago or Joliet or Kankakee, up on the Kankakee river?

A. Well, what I would call it, it would be the overflow that would come from the banks, such as limbs and sticks and objects of that kind. I never noticed anything in the water outside of being ordinary river water.

Q. As far as appearances go there is nothing to indicate that there is any sewage in the water, is there?

A. Not to me.

RE-CROSS-EXAMINATION,

By Mr. Jeffries.

Q. What is your idea as to the appearance of sewage?

A. Well, my idea of the appearance of sewage would be a thick muddy water and smell bad,—the water.

Q. Do you know, or don't you know, that sewage when it comes from the pipes is a clear, bright color?

6507 MR. TODD: Objected to as it assumes that which does not exist.

A. I don't know.

Q. Did you ever see the water coming from a sewer pipe?

A. Well, I don't say that I have—yes, I have.

Q. You didn't see any mud coming from it, did you?

A. No, I did not.

Q. It was clear, wasn't it?

A. Clear water.

Q. Do you know whether it was pure water or not?

A. Well, I would hate to drink it.

(F. S. B., Com'r.)

6508 FRED SLACK,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Fred Slack.

Q. What is your business?

A. Deputy sheriff here in Grundy County.

Q. How long have you been connected with the sheriff's office?

A. Since last December.

Q. Are you acquainted with the Illinois river?

A. Yes sir.

Q. What opportunities have you had of becoming acquainted with the Illinois river?

A. I have fished and hunted on it a great deal.

Q. Do you know the condition of the Illinois river before the opening of the drainage canal?

A. Yes sir.

Q. What was its condition?

A. Why, it was sluggish; the water was stagnant and had a bad odor.

6509 Q. What was its color?

A. Black, so black at times I could hardly row a boat through it, it would get on the bottom of the boat like ink.

Q. What effect has the opening of the drainage canal had upon the waters of the Illinois river at this point?

A. Why, it has been a benefit to it.

Q. In what way?

A. Well, in one way there is much more water flowing through here and the water is clearer.

Q. Do you observe the odor?

A. No sir.

Q. Have you had any experience that would enable you to pass an opinion in regard to its effect upon fish?

MR. JEFFRIES: We object to the question because it is calling for an opinion from the witness without stating the reasons for his qualification, or the experience that he has.

Q. What experience have you had?

A. By rowing up and down the river.

Q. Have you fished in the river since the opening of the canal?

A. Yes sir, and before.

Q. Now what is its effect upon fish?

A. Since the opening?

6510 Q. Yes?

A. Why, there is fish in the river at the present time, they live in there.

Q. How do you know there is fish in the river at the present time?

A. I have caught them out of there.

Q. Before the opening of the canal did you catch any fish in the river?

A. Not for a long while.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Your opinion as to the condition of the water now as compared to what it was before the opening of the canal is based simply upon your observation as you have testified here, a moment ago in your direct-examination?

A. Yes sir.

Q. Nothing else?

A. No, I have never—

Q. Do you know whether there is any Chicago sewage in that water or not?

A. Well, they say there is, I have never seen it.

Q. Well, what is your opinion about it?

6511 A. Well I have an idea that there is, yes, but I have never been able to find it.

Q. Well, you know when sewage comes from these large cities, there being no solid matters of any kind in the water, or garbage thrown into the sewers, that it looks like pure water, don't it?

A. Yes sir.

Q. Then it would be a difficult matter to tell from the eye whether it contained sewage from Chicago or not, wouldn't it?

A. It would.

Q. That is so far as its appearance is concerned?

A. Just to look at it, you wouldn't think there was any in it.

Q. You don't drink the water, do you?

A. No.

Q. Nor use it for domestic purposes of any kind?

A. No sir.

RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. Do you know whether as a matter of fact there is any sewage in the water here?

A. I don't know.

6512 Q. Do you know whether as a matter of fact that all the sewage has completely disappeared by processes of oxidation before it reaches this point?

A. I couldn't tell that.

Q. You haven't gone into that?

A. No.

Q. All that you know about it is simply from its appearance?

A. That is all.

Q. And from its appearance can you detect the presence of any sewage in it?

A. No sir.

Q. Then as to whether there is any or not, it is purely conjectural with you?

A. Yes sir.

ADJOURNED.

STATE OF MISSOURI

6513 VS.

THE STATE OF ILLINOIS and the SANITARY DISTRICT OF CHICAGO.

Met pursuant to agreement of counsel representing the respective parties, at room 869 Rookery Building, Chicago, Illinois, 10 A. M., September 21, 1903.

Present: The Commissioner.
Messrs Jeffries and Woerner,
representing the complainant.
Messrs. Hamlin, Todd, Springer and
Drennan,
Representing the defendants.

6514 R. P. ELLIOTT,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. R. P. Elliott.

Q. What is your business?

A. I am express agent at Wilmington, Illinois.

Q. How long have you been engaged in that business?

A. I think since 1886 I have been the agent there.

Q. And on what river is Wilmington situated?

A. The Kankakee river.

Q. Mr. Elliott, did you ever take and collect any samples of water for the Sanitary District of Chicago?

A. I did.

Q. What year did you collect the water?

A. Commencing June 5th, 1899, and ending June 25th, 1900, is about the time I examined.

Q. Where did you collect the water from?

A. The Kankakee river just below Wilmington.

Q. For whom did you collect the water?

A. I collected it for the Health Department in Chicago and Prof. Jordan at Englewood, and what's-his-name at 6515 Urbana, Palmer,—W. A. Palmer, I think it was,—Urbana, Illinois.

Q. When you collected water for Prof. Jordan of Englewood, that is Prof. Jordan of the Chicago University, isn't it?

A. Yes.

Q. And the Health Department of the city of Chicago, and Prof. Palmer of the University of Illinois?

A. Yes sir.

Q. Where did you collect this water from?

A. The Kankakee river.

Q. At what point?

A. Just north of Wilmington— of the city of Wilmington.

Q. Does the sewage of Wilmington empty into the Kankakee river?

A. In fact we have no sewage there.

Q. There is no open system of sewerage used by the inhabitants of Wilmington?

A. No sir.

Q. Mostly privy vaults?

A. Yes sir, mostly privy vaults.

Q. In what did you collect this water?

A. In glass bottles.

Q. Where did you get the glass bottles from?

A. They were sent to me by the Health Department of Chicago, Mr. Reynolds I think.

6516 Q. Dr. Reynolds?

A. Yes sir.

Q. When you got these bottles, how did you get them, by freight or express?

A. They came by express.

Q. When you got them were they shipped in your name?

A. Yes sir.

Q. When you got them from the express office, in what condition were they?

A. They had a cloth tied around them with a string around it.

Q. And the stopper inserted?

A. A stopper inside with a cloth tied around it.

Q. Now after you got the bottles, for the collection of the water, will you describe the manner in which the water was collected?

A. Yes, I took these glass bottles with the glass stopper, and submerged them in the water of the river and let a little run in; then rinsed it out; then put it back and submerged it in the water and let it run full.

Q. How many bottles did you have?

A. Two bottles.

Q. What were the sizes of the different bottles?

A. I should judge about two gallons; I never measured them; the large bottles were that high (indicating).

6517 Q. Any small bottles?

A. Yes, there was a small bottle that I filled in the same way.

Q. Now describe the method you pursued in filling the bottles?

A. The small bottle?

Q. In filling it with water?

A. Well, I put the cork in and submerged it under water some eight or ten inches or more and let it run into the bottle.

Q. When you got the bottle, the cork was in the bottle, wasn't it?

A. Yes, sir.

Q. When did you take the cork out of the bottle?

A. After I got down to the river.

Q. Before or after the bottle was submerged in the water?

A. I took it out after I submerged the bottle in the water.

Q. You took the cork out after you put the bottle under the water?

A. Yes, sir.

Q. How much water did you put into the bottle the first time?

A. Probably a quart.

Q. Then what did you do with that water?

A. Rinsed it and threw it out.

6518 Q. Did you stop it up under the water? Stop the bottle under the water after rinsing it?

A. Yes sir.

Q. And after you had thrown the water out, then what did you do?

A. Then I put the stopper back, submerged it under and filled the bottle.

Q. After you had filled the bottle, did you stop it under the water?

A. Yes sir.

Q. Now after you had the bottles filled in the manner indicated, what did you do with the bottles of water so collected?

A. I took them out to the express office and put a cloth around them. It is a rubber cloth, and I put this wire seal that Prof. Reynolds sent me and wired it and pierced it through the cloth around this bottle and sealed it with these lead stamps that he sent me. He sent me a seal for the purpose.

Q. What else did you do?

A. Then I shipped them to these different parties by express. I made out that slip, of course, and put it in. I made out that slip, and I took the direction of the wind, I think and the water if it was raining I think. There were different 6519 directions. I forget just exactly now, what. I made out that slip; put it in an envelope, sealed the envelope and sent that to each one of the parties at the time I took the water, the hour and the date, etc., and put that in the envelope. That was in the tags they sent me with an envelope to put that in. And the slip was sent to each one of the parties I sent the water to.

Q. I show you a tag on the back of which is printed "Stream examination, Chicago Sanitary District; Sample of Water (In large type) Sample No. 4, and ask you if that card is in your handwriting?

A. Yes sir, that is in my handwriting.

Q. With instructions on the back of the card?

A. Yes sir.

Q. Did you place a card similar to that card upon the samples of water you sent out?

A. Yes sir.

Q. Filled out in the same manner that this card is filled out?

A. Yes sir.

Q. Did all the cards which you put on the water collected and sent to all the different parties indicated in your testimony, have a sample number, date, time from the place taken, collected by; height of water; temperature of water; direc- 6520 tion of wind; temperature of air, printed on it as indicated on this card I show you?

A. All filled out the same way.

Q. And the part of the card left to be filled out, you filled out in accordance with the facts as you observed them at that time, did you?

A. Yes sir.

Q. Now after you had collected the water and filled out the card as you have indicated, and sealed the packages, did you pack any of the samples in ice?

A. Yes, there was the little bottle I packed in ice. I don't know how long or how many times I did that. It was several times I did that. That came to Professor Jordan at the Chicago University.

Q. Just describe how you packed the sample that was to be packed in ice?

A. Now I chopped up the ice, and I think they sent me a little can or something. If I remember right, they sent me a can that I put that in, and the arrangement was sealed I think, the same as the large bottle. It was prepared the same way as the large bottle, only it was iced as near as I can remember.

Q. Now after you had prepared the sample in the manner you have indicated, both the large and small sample, 6521 what did you do with them?

A. Sent them to Prof. Jordan.

Q. And Professor Palmer?

A. Prof. Jordan is the one that I shipped the ice one to.

Q. I mean all the samples?

A. Prof. Palmer and the City Health Department of Chicago—that was the direction of the City Health Department of Chicago, and Professor Jordan at Englewood, and Professor Palmer at Urbana, Illinois.

Q. How did you ship them?

A. By express.

Q. How long after you collected the samples, was it, before you delivered the samples into the charge of the express company?

A. Well, ranging all the way from an hour to an hour and a half.

Q. By what express company did you ship the samples?

A. United States Express Company.

Q. Were you the agent of it?

A. Yes sir.

Q. You saw the samples went out on time.

A. Yes sir, over the next train, after I collected them.

MR. TODD: Mr. Commissioner, I offer this card as a sample of the cards which were placed upon all samples 6522 as testified by the witness as the Sanitary District of Chicago's Exhibit No. 12 for identification.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. When did you say you commenced taking these samples of water?

A. June 5th, 1899.

Q. How often did you take them?

A. Once a week.

Q. Now during all this time you took samples in two kinds of bottles, a large bottle and small bottle?

A. No, not all the time. I don't think I took it in the small bottle all the time; I don't remember that I did.

Q. June 5th, the first time you took the samples, did you take both the small and the large?

A. Now I am unable to tell that, whether I took the small bottle at that time, or just as to the times I took them.

Q. The small bottles, after being shipped to you you found them at the express office, did you?

A. I shipped them myself; I am the agent there.

Q. The question is, when you got them, where did you get them.

A. I got them from Professor Reynolds of Chicago; they were shipped to me from Chicago.

6523 Q. Where did you get them the first time?

A. At the express office.

Q. In Wilmington?

A. Yes sir.

Q. How did they come, shipped in boxes?

A. By express, two bottles in one crate.

Q. Were they wrapped in any way?

A. No they were packed; the top was wrapped, over the cork with a cloth; it was wrapped with a cloth.

Q. Now what did you do with them when you got them out of the express office?

A. I kept them there until the day I shipped them.

Q. Kept them right there at the express office?

A. Yes sir.

Q. You say you went from the express office how far to the place where the samples were taken, the place in the river?

A. A half a mile or three-quarters, I guess.

Q. How did you go—walk?

A. No sir, I took my express wagon.

Q. Did you unpack the bottles at the express office or wait until you got to the river?

A. At the river.

Q. You took the box and all, down to the river?

A. Yes sir.

6524 Q. How would you get out into the river to get the samples?

A. Drive my wagon out into the river.

Q. How deep was the water?

A. Probably a foot and a half or two feet deep, somewhere along there.

Q. How did you get down to the water from the wagon?

A. Got on the step of my express wagon and held the bottles down under the water.

Q. Now you took the cork out after you got the bottle under the water?

A. Yes sir.

Q. Now, how could you take the cork out of the bottle, hold one hand on the wagon and holding the bottle in the other hand?

A. I done that easy enough.

Q. How low was the step?

A. It was right down in the water.

Q. The step was right under the water?

A. Yes sir.

Q. You stooped down?

A. Yes sir.

Q. Took the cork out?

A. Yes sir.

Q. And put the bottle under water?

6525 A. Yes sir.

Q. Is that right?

A. Yes sir.

Q. This cork was taken out just when you submerged the bottle under water?

A. I always put it under water and then took the cork out.

Q. Well, the bottle was under water?

A. Yes sir.

Q. Then you let a little water in the bottle and rinsed it out?

A. Yes sir.

Q. Now while you had the bottle out of water shaking it, and before you poured the water out that you had just let in, where was the stopper?

A. Why I held that in my hand.

Q. Which hand did you use for holding it?

A. My left hand.

Q. How did you hold it?

A. In my hand.

Q. Just anyway?

A. Yes sir.

Q. Did you hold it tight in your hand this way (indicating)?

A. Yes sir.

Q. The whole stopper would be covered with your hand?

A. No sir, not all. I might have sometimes laid it on
6526 the seat of the wagon, I don't know.

Q. As a matter of fact you did, didn't you?

A. Sometimes I expect I did.

Q. Most all the time as a general proposition, that is the way you did it?

A. I expect so.

Q. Now were the roads muddy at that time?

A. Sometimes, and sometimes they were not.

Q. You would just drive the wagon right into the middle of the stream?

A. I wouldn't do it all the time.

Q. When you used the wagon?

A. Yes sir.

Q. You drove the wagon into the middle of the stream?

A. I didn't drive into the middle of the running water; just deep enough to take the water.

Q. How far?

A. 25 or 30 feet.

Q. You took the water from one side of the wagon and then from the other?

A. No; generally on the left side. I didn't get behind the wagon; I aimed to get good running water in the bottle.

Q. You don't know whether there was mud on the wagon wheels?

6527 A. No, nothing from the wagon wheels got into it at all.

Q. Wouldn't your feet sometimes be muddy?

A. No sir, I aimed to get good running water.

Q. That was your aim?

A. Yes sir, I did do it; I did get good running water out of the river; that was my object to get good running water. No I didn't try to get any mud on them or anything of that kind; I aimed to get a good running sample of water out of the river.

Q. Now after the bottle was cleaned you put the cork back in did you?

A. Yes sir.

Q. You poured the water out and then stuck the cork back in?

A. Yes sir.

Q. Then what did you do?

A. After I got the bottle filled, after I rinsed the bottle?

Q. Then what did you do?

A. I submerged the bottle and filled it.

Q. What did you do with the bottles?

A. Took them out and put them in the wagon, and put them in the box they gave me; took them to the express office and put these rubber cloths over them.

6528 Q. Now where did you put the rubber cloths over them?

A. At the express office.

Q. In other words you carried them from the river down to the express office just as they were when they came up out of the water?

A. Yes sir, that's right.

Q. You didn't wrap them?

A. No sir, not until I got to the office.

Q. Open to the light and everything?

A. The stopper was in.

Q. There was no rubber around to shut out the light or anything of that kind?

A. No sir.

Q. Now you took the correct temperature of the water did you at all times?

A. Why not always; sometimes I did. I couldn't always. One time I would and one time I wouldn't.

Q. You wouldn't always send the temperature?

A. Not always.

Q. When you did take the temperature you always got it correct?

A. Yes, they sent me an instrument for that purpose.

Q. Sent you a thermometer?

A. Yes sir.

6529 Q. Do you know what kind of a thermometer it was, whether it was Fahrenheit?

A. No sir, it wasn't Fahrenheit, I forget the name. It was the other instrument they sent, Centigrade.

Q. Did you use that instrument all the time?

A. All the time.

Q. Now after you got the bottles filled with water and back to the express office, how long was it before they were packed?

A. I wrapped them and packed them right away, as soon as I got to the office. I got them ready for shipment as soon as I got to the office.

Q. Now then, from the time you took the samples out of the river until you got to the express office, there was no iron around these sample bottles, was there?

A. No sir, I ironed them there; they were ironed right at the express office. There was no iron around them.

Q. You came along here and talked to people and stopped?

A. No sir, my time was pretty precious; I had to get back to the office.

Q. How long did it take you to go to the river?

A. It took me five or ten minutes.

Q. Sometimes longer?

6530 A. No sir, I shouldn't think over ten minutes.

Q. Now after you got back to the express office with the samples, there would be occasions, and in fact quite frequently some urgent business to be attended to and you simply set the samples of water aside and packed them at your leisure.

A. Very seldom.

Q. Occasionally?

A. I don't remember that I did. I made it a point. I wanted to get them out of the way as soon as I could get them.

Q. If there was some business to attend to?

A. If I had a customer there waiting, I had to set them aside until I waited on him.

Q. How long did they wait in the express office before being shipped?

A. Sometimes not over half an hour, sometimes an hour before they were shipped out.

Q. What express company did they go through?

A. United States Express Company.

Q. Now in the winter time how did you take the samples?

A. Sometimes I couldn't take them; I would have to violate the rules, I couldn't take them.

Q. How would you violate the rules, in what way?

6531 A. Took them under the ice. I couldn't follow the rules as I could in the summer time. Sometimes I would have to dip the water out and put it in.

Q. What did you dip it with?

A. A dipper that I had.

Q. You had a dipper that you carried from the express office down to the river?

A. Yes sir, I had. I couldn't comply with the rules in the winter time.

Q. Now how often did you use that dipper?

A. I guess there was several times I used it; I couldn't remember.

Q. In the winter time?

A. Yes.

Q. Did you rinse the bottles then?

A. Yes, I always rinsed the bottles out; I attended to that part of it.

Q. How much water was there in the river; what was the average volume of water in the river as to depth?

A. Well in some places pretty low.

Q. Where you took the samples, that place?

A. The average would be a foot, foot and a half or two feet. In the winter time it would be a little higher where 6532 I took it.

Q. Sometimes it would get lower than that, it would get lower than a foot?

A. Yes, but not much where I would generally get the samples. Some places it wasn't a foot.

Q. Some places no water at all?

A. Yes, there was a place where there was no water at all; that's right.

Q. Water there at all times of the year?

A. Yes, there is water that runs there all the time.

Q. Not very much in volume?

A. There is places where the river gets low.

Q. Now at some places the water in the river along there, doesn't cover over the place, twenty feet wide, does it?

A. There at Wilmington, yes it was wider than that.

Q. At all times of the year?

A. Well yes, pretty nearly all the times unless there was a very dry season.

Q. How is it a short distance above Wilmington?

A. There is a dam up there. It is wider up there.

Q. How is it below?

A. Well, it is the same way. The bridge there is 500 feet wide.

6533 Q. I am talking about the water.

A. The water spreads out all over the river. Of course you can go down there sometimes and wade out, but it spreads all over the river.

Q. How far from the edge of the water would you drive in to get these samples?

A. Drive in probably 25 or 30 feet.

Q. Now how wide is the water in the stream, the average width from one end to the other at Wilmington?

A. The wagon bridge there now is 500 feet wide, and the river covers that space between those piers.

Q. Do you mean to say that?

A. But there are some places that ain't that wide.

Q. At Wilmington?

A. Yes sir. Right there at the crossing of the wagon bridge I am speaking of.

Q. Is that above or below the dam?

A. Below.

Q. Now does the water run 500 feet wide during the entire year?

A. Yes, pretty near the entire year.

Q. What do you mean by pretty near?

A. Well, the entire year.

6534 Q. You say it is 500 feet wide there?

A. Well, I wouldn't confine myself to 500 feet. I am telling you that the average is 500 feet.

Q. The bridge might be 500 feet and yet the water not 500 feet?

A. The water is between those piers.

Q. Then the water must be 500 feet wide; do you say that?

A. Well, nearly that, I wouldn't want to be certain; I never measured it.

Q. How wide is it at the narrowest place?

A. At Wilmington?

Q. Yes, right along in there?

A. Well, the narrowest place occurs down below the island there. I should judge it was not less than 300 feet or 400, not much narrower than it is up above the bridge. That would be my opinion.

Q. About the same all along?

A. Yes, there are little islands growing out occasionally.

Q. What is the average depth?

A. I don't know. I don't think I know the average depth of the river.

Q. About a foot?

6535 A. I wouldn't swear what the average depth was.

(Sig. waived. F. S. B., Com'r.)

6536 JAMES MACK,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. James Mack.

Q. What is your business?

A. Moulder.

Q. Where do you live?

A. Morris, Illinois.

Q. Mr. Mack, did you collect any samples for the sanitary district of Chicago?

A. Yes, sir. I did.

Q. When did you collect them?

A. The latter part of May, 1899, to the last of November.

Q. For whom did you collect this water?

A. I made three collections; one went to the city laboratory of Chicago; one to the State University and one to the Chicago University.

Q. Where did you collect the water from?

A. Above the bridge at Morris, Illinois.

6537 Q. What river is Morris, Illinois, located on?

A. The Illinois.

Q. Well, where did you collect the samples of water?

A. Above the bridge at Morris, Illinois, in bottles.

Q. In what did you collect the samples of water?

A. In bottles.

Q. Where did you get the bottles from?

A. From the express office.

Q. By whom were the bottles sent to you?

A. Through Mr. Irons.

Q. Connected with the city laboratory of Chicago?

A. Of the Chicago University, I think.

Q. Ernest E. Irons, wasn't it?

A. Yes, sir.

Q. There were other bottles sent to you?

A. One was sent to Palmer.

Q. I mean, who sent the bottles to you?

A. He made arrangements to send them to me by express.

Q. And you got all the bottles that you collected the water with from the express office sent to you by Irons?

A. Yes, sir.

Q. Now, when you got the bottles, in what condition were they?

A. They were packed in a case.

6538 Q. Were the stoppers in them?

A. Yes, sir.

Q. What kind of stoppers?

A. Glass stoppers.

Q. Now, after you got the bottles, at what point in the Illinois river did you collect the samples from?

A. About 100 yards from the north side of the river in the middle of the channel, supposed to be in the middle of the channel.

Q. How did you get out in the middle of the channel?

A. In a boat.

Q. At what point in Morris, did you collect the samples?

A. Just a little above the river bridge.

Q. Has the city of Morris any open system of sewers?

A. No, sir.

Q. Now, when you went out in the river in a boat to collect the samples, just describe how you collected them?

A. Well, I rowed out into the river in a boat and when I got between 100 and 150 feet above the bridge, and got as near as I could to the center of the channel and stopped there and made the collection.

Q. Just tell how you collected the water, how you filled the bottles, and what you did?

A. Well, I took the bottles and took the stoppers out and 6539 rinsed the bottles out, put them under and filled them under.

Q. Where were the bottles when you took the stoppers out?

A. In the boat; I took them from the boat.

Q. Did you take the stoppers out under or above the water?

A. Above the water and kept the stopper in my hand.

Q. Did you rinse the bottles out first?

A. Yes, sir.

Q. After you had rinsed the bottles out, then what did you do?

A. I pushed them under the water and filled them.

Q. After you had filled them what did you do?

A. Put the stoppers in.

Q. Where were the stoppers?

A. The stoppers were right in my hand.

Q. Did you put the stoppers in above or under the water?

A. Above the water.

Q. After you had put the stopper in the bottle what did you do then with the sample you had collected?

A. Put them in the boat and rowed to shore, put them in my cellar where I live and packed them in the cases.

Q. After putting the stopper in the bottle, did you do anything then with the bottle?

6540 A. No, sir.

Q. Did you put any cloth over the stopper?

A. I took it to the house, put a cloth over it and sealed it; put a wire seal around it.

Q. Now, after you had done that what did you do with the bottle?

A. I took the small one and put it in a can and put it in ice. The large one I packed it in a case, and packed it with excelsior.

Q. How long after you collected the sample in the small bottle was it before you packed it in ice?

A. Ten or fifteen minutes.

Q. How far did you live from the river?

A. I live right on the river bank.

Q. After you had packed it in ice and packed the two samples in the large boxes, in excelsior, what did you do with the boxes containing the samples?

A. Sent them to the express office.

Q. What express office?

A. United States.

Q. Did you take them to the express office yourself?

A. No, sir, my boy did.

Q. Before you sent them to the express office, what did
6541 you do with the samples, did you put any card on them?

A. I put cards on them, yes, sir.

Q. What kind of a card did you put on the samples?

A. A card that was furnished or sent.

Q. I will show you a card which is marked Sample No. 2, June 5th, 1899, 6:00 a. m., at the top of which is written, Stream Examination, Chicago Sanitary District, Samples of water, with your name written on as collector, "by James Mack," and ask you if that card is in your handwriting?

A. No, sir. This is not; this is one my daughter filled out. I told her what to put on it.

Q. Did you see her doing it?

A. Yes, sir; I stood over her while she was putting it on.

Q. She did it under your instructions?

A. Yes, sir.

Q. All the data that is filled in in writing, you directed?

A. Yes, sir.

Q. And the data that you gave to be put into the cards, you collected this individually, did you?

A. Yes, sir.

Q. Now, was a card similar to this, printed as this one is
printed, containing the sample number, the date and the
6542 time, "collected by" the height of the water, tempera-
ture of the water, temperature of the air, remarks, etc.,
placed on each sample of water that you sent out?

A. Yes, sir.

Q. Were those placed on the card that you were left to be filled out, correctly filled by you and under your directions, for each sample that you collected and sent out?

A. They were.

Q. After you had attached the card to each sample of water, to whom did you send the water?

A. I sent the water to the express office, and I sent one to the city laboratory.

Q. The city laboratory where?

A.. Chicago, and one to the Chicago University to Mr. Jordan, and one to Mr. Palmer at the State University.

Q. What kind of a thermometer did you employ in taking the temperature?

A. A short thermometer the first two or three samples I took and then they sent me a centigrade.

Q. On the cards here where the temperature of the water and air is placed, it is according to a centigrade thermometer?

A. No, sir, that is not according to a centigrade in that one.

Q. I mean in the cards that you sent, with the exception
6543 that you stated?

A. No, the air temperature is Fahrenheit, and the water is centigrade.

Q. The water is centigrade?

A. Yes, I took the air temperature from the thermometer I had on the end of the bridge, and the water is centigrade.

Q. The kind of thermometer you used is indicated by "C" or "F" on the cards, is it?

A. Yes, sir.

Q. How long from the time of taking would it be before the samples were placed in the express office?

A. About a half an hour.

Q. How often did you take samples of water?

A. Once a week.

Q. During the whole time that you took them, from May to November I believe you stated?

A. No, there was some times I didn't take it on the same day. I didn't get the bottles back. I generally took it Mondays. Monday was the day set, sometimes it was Saturday and sometimes it was the middle of the week.

Q. You took them as the bottles came back to you?

A. Yes, sir.

6544 Q. And the date of taking you placed on the card, so that each card on the samples that contains your name indicates properly the time of taking?

A. Yes, sir.

Q. Did your daughter make out all the cards for you?

A. No, sir, some I made out myself.

Q. Anybody else make out any cards for you except your daughter?

A. No, sir, me and my daughter.

Q. When your daughter made them out, they were made out under your direction?

A. Yes, sir.

Q. And who attached the cards?

A. I did, I attached the cards.

Q. You attached all the cards after they were made out?

A. Yes, sir.

MR. TODD: I offer the card marked Sample No. 2, signed by James Mack, and ask to have the same marked Sanitary District's Exhibit No. 13 for identification.

So marked by the Commissioner.

6545 CROSS-EXAMINATION, by Mr. Woerner.

Q. Mr. Mack, what proportion of these cards did you fill out and how many were filled out by your daughter?

A. I couldn't tell. I could tell by seeing the writing there; that's the only way I could tell.

Q. Give us some idea?

A. Well, most of them were filled out by my daughter.

Q. Why, didn't you fill them out yourself?

A. I didn't have much time. I had to go to work about half-past six o'clock.

Q. Well, would it take you longer to fill them out yourself than it would to direct your daughter?

A. Yes, she could do it much quicker than I could.

Q. You would give the directions?

A. I told her what to put on the card. I told her the temperature of the air when I took it that morning, and the temperature of the water.

Q. And she put it on the card while you were not there?

A. She put it on the card while I was there.

Q. Did you see here write on the card?

A. Yes, sir, and I examined these cards before I put them in the envelopes.

Q. Where did you tell her these things?

A. In the house.

6546 Q. Whose house?

A. My own house where I live.

Q. Now, will you please explain how it is that your daughter could write these things faster when you gave her directions than you could do it yourself?

A. Simply because she could handle a pen quicker than I could; she had a better education than I had.

Q. You are not a good writer, then?

A. No, sir.

Q. Did you make any memorandum at all in respect to these cards that you told your daughter to make out?

A. Yes, sir; I have a memorandum of them all.

Q. Where did you make the memoranda?

A. I made them in the house myself.

Q. Where did you make the memorandum with regard to the height of the water?

A. I just kept that in my mind; I kept that in my memory from the time I took the samples. You see the water rose and fell in the Illinois river.

Q. You kept that in your memory?

A. Yes, sir.

Q. You didn't make any memorandum of that at the time you observed it first?

6547 A. No, sir, not at the time I observed it first.

Q. How did you take the temperature of the water?

A. I put a centigrade thermometer in the water and held it there for three or five minutes.

Q. Then you kept in your mind the number of degrees as shown by the thermometer until you got an opportunity to tell your daughter?

A. Until I got back.

Q. How long did it take you to get back?

A. About ten or fifteen minutes. I did the whole work in ten or fifteen minutes.

Q. You don't mean to say that as soon as you got back you always dictated this to your daughter?

A. Yes, sir.

Q. Was she waiting for you to come back?

A. Yes, sir.

Q. What else did you keep in your mind, the temperature of the air?

A. That I looked at as soon as I got back from the boat. I had a thermometer on the end of the bridge. I live in the river bridge house.

Q. And you kept the height of the water in your mind, too?

A. Yes, sir.

6548 Q. And all these other things to which you make a certificate here?

A. Yes, sir.

Q. Now, you say Monday was the day on which these were to be taken?

A. Yes, sir.

Q. What do you mean by that?

A. I shipped them every Monday.

Q. Who were the people you shipped them to?

A. Dr. Palmer of the State University and Jordan of the Chicago University.

Q. You say sometimes you took them Saturday, sometimes the middle of the week and sometimes Monday?

A. Yes, sir, just as the cases returned. If the cases didn't return in time I couldn't ship them Monday.

Q. Then practically you had to go out and make these tests whenever you got these bottles back?

A. Yes, sir.

Q. And didn't follow the rule about Monday?

A. I didn't follow the rule about Monday for the first four or five samples that were sent. They sent me extra cases so that I could take them every Monday after the first four or five times.

6549 Q. After that you got extra cases, extra bottles?

A. Extra bottles so that I could take them every Monday.

Q. What did you say your business was?

A. Moulder.

Q. Do you work all the time?

A. Yes, sir.

Q. Were you employed as such during this period when you made these tests?

A. I was employed as moulder, yes.

Q. Did you work during that time?

A. Yes, sir, I worked during that time.

Q. When did you begin work in the morning?

A. Seven o'clock.

Q. How long did you work?

A. I worked until half-past four in the afternoon, sometimes five o'clock, depending when I got through.

Q. When did you have your breakfast ?

A. About half-past five or six o'clock.

Q. Then you would go out and take these samples and then go to work?

A. Yes, sir.

6550 Q. You would just go out and take these samples and carry the things in your mind until you told your daughter?

A. No, a card was made out.

Q. You kept these things in your mind until you saw your daughter?

A. Yes, sir.

Q. How old is your daughter?

A. She is 20 years old now.

Q. Where is Morris, Illinois?

A. In Grundy county, 62 miles west of Chicago.

Q. How far is it from the mouth of the Illinois river?

A. About six miles.

Q. Above the mouth?

A. No, sir, west or below the mouth of the Illinois.

MR. TODD: You don't mean the mouth, you mean the source.

A. He calls it the mouth (referring to counsel).

MR. WOERNER: You don't mean it is above the source at all, do you?

A. No, I say it is six miles below the source.

Q. How long is the Illinois river?

A. I don't know, sir.

Q. What is the volume of water there?

MR. TODD: I object to the question as not proper cross-examination of anything brought out by this witness on direct and on the ground that he is not put on as a hydraulic engineer to state the volume of the Illinois river, but merely to show that he collected samples. 6551

Q. MR. WOERNER: How deep is the river there?

A. Where I took the samples about five feet.

Q. Five feet is the deepest?

A. No, there are deeper spots there.

Q. That is the bed of the river?

A. Yes, sir, that is in the channel.

Q. Any dams along there?

A. No, sir.

Q. How wide is the river?

A. A little over 600 feet, when it is full to the banks.

Q. Well, on the average how wide is it?

A. About 500 feet, about 550 feet.

Q. How far out in the river did you go to take these samples?

A. Oh, a hundred feet.

Q. Did you row out?

A. I rowed out, yes, sir.

Q. Did you take the bottles in the row-boat?

A. Yes, sir.

6552 Q. Did you take anybody else with you on the boat?

A. Sometimes I had my boy.

Q. Did you let the skiff float while putting the bottles in the water?

A. No, sir.

Q. What did you do?

A. I anchored it. I had an anchor. I had a float with an anchor attached to it and I attached my boat to that.

Q. You took the stoppers out before you put the bottles in?

A. Yes, sir.

Q. And then you just simply immersed the bottle while you held it in your hand?

A. Yes, sir.

Q. And when it was full you put the stoppers in?

A. Yes, sir.

Q. And then you went back home and had breakfast?

A. No, sir.

Q. You had breakfast first?

A. Yes, sir.

Q. Did you wash the bottles out before you allowed the water to run into them?

A. I filled them and rinsed them out and then filled them again.

6553 Q. How often did you do this?

A. How often did I do what?

Q. Take the samples?

A. I couldn't remember just how many samples I did take.

Q. Once a week?

A. Yes, sir.

Q. You aimed to do it once a week?

A. Yes, sir.

Q. How long did you keep them in the house before you shipped them?

A. I shipped them just as soon as I got back.

Q. How long would that be?

A. From the time I took them until they were on their way to the express office, would be probably half an hour.

RE-DIRECT EXAMINATION, by Mr. Todd.

Q. Right from the time that you took the temperature of the water, how long would it be before you would have it placed on the card by your daughter?

A. Not to exceed fifteen minutes.

Sig. waived. F. S. B.

6554 **JOSEPH WEIS,**

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Joseph Weis.

Q. What is your business?

A. That of milk inspector of the City of Chicago.

Q. How long have you been employed by the City of Chicago?

A. Six and a half years.

Q. Were you ever engaged to collect water for the Sanitary District?

A. Yes.

Q. When did you collect samples for the Sanitary District?

A. During the years 1898, 1899 and 1900.

Q. By whom were you directed to collect samples of water?

A. By Commissioner Reynolds.

Q. Of the Board of Health?

A. Yes, sir.

Q. At what points or places did you collect water, Mr. Weis?

A. At Bridgeport pumping station, at the Western Avenue bridge, at the Kedzie Avenue bridge and at the Lawndale Avenue bridge. 6555

Q. In what did you collect the samples?

A. In bottles.

Q. What kind of bottles?

A. Glass bottles.

Q. Where did you get the bottles from?

A. The city laboratory.

Q. Were those bottles prepared for you to collect the samples?

A. Yes, sir.

Q. How were they prepared, do you know?

A. Yes, sir.

Q. State how they were prepared?

A. There were two compartments in a wooden box, one compartment containing the big bottle holding about a gallon; the other compartment held a tin box that included a small four ounce bottle, and both packed in excelsior.

Q. Were those bottles sterilized before you took them?

A. Yes, sir.

Q. By whom were they sterilized, if you know?

A. They were sterilized in our bacteriological department.

Q. You work in that department, do you?

A. Yes, sir.

6556 Q. How many samples of water did you collect at the Bridgeport Pumping Works?

A. I don't remember that. When we started I took only two in 1898.

Q. I mean how often did you take samples on the various dates?

A. That was in 1898. In 1899 and 1900 I used to take three samples of water three times a week.

Q. In 1901?

A. I didn't take any in 1901.

Q. In 1899 how many did you take?

A. Well, that was subject to the order of Dr. Gehrmann.

Q. Now, when you would take this water at the Bridgeport Pumping Works, Kedzie Avenue, Western Avenue and Lawndale, how many samples did you take at a time?

A. Well, sometimes I took a big bottle, and I had a little bottle tied to my big bottle. We had a cylinder made with a lead bottom and that cylinder was fastened to a rope. I inserted the big bottle in that cylinder and tied my little bottle outside, so that I could submerge both bottles, the big and small bottle.

I couldn't get a fair sample any other way, because the borders of the canal were always covered with a fatty substance.

6557 Q. And you submerged this down under the water?

A. Yes, sir, I submerged it.

Q. How deep did you go down?

A. Just to have the big bottle submerged about a foot or a foot and a half.

Q. Then what did you do after you got the sample of water; how did you stop it up?

A. I got about a quart of water in the bottle first, took it out and emptied that bottle and let my bottles down again and filled them.

Q. Where did you cork them?

A. I corked them when I got them outside.

Q. Now, after you got the water—you did this at all the four places, did you, this same method that you pursued in collecting the water?

A. I took the samples at one place.

Q. You did the same thing, used the same methods?

A. Yes, when I went to Kedzie Avenue I did the same thing.

Q. And the same thing at Lawndale and Western Avenue?

A. Yes, sir.

Q. Now, after you got the samples of water collected and replaced the stoppers what did you do with the bottles?

A. I took the bottles and put them on top of my box, took 6558 my rubber, perforated rubber which was fastened with a wire, and sealed and tied my wire around the bottles, and with my pinchers I imprinted a seal on a little piece of lead.

Q. Did you pack any samples in ice?

A. Not the big sample bottle. I put that in one compartment and put excelsior around it, and the other, the four ounce bottle I placed in the tin box and the tin box I placed in a big tin box, and that I filled up with chopped ice.

Q. Where did you fill it with ice, right on the place?

A. I took these samples very early in the morning, at two o'clock in the morning sometimes, and I couldn't get any ice. I waited until I got to the West Side to get an ice man or a milkman that had ice in his wagon and I bought the ice of him and chopped it and filled the can.

Q. How often did that happen?

A. That I couldn't get any ice?

Q. Yes?

A. Very seldom.

Q. And after you got the samples packed in the boxes what did you do with them?

A. I drove down to the city hall and left one box in our laboratory, delivering that big bottle to the city chemist, and took the small sample out and placed it on ice in our
6559 ice box, the two other samples I delivered to the American Express Company, one directed to Professor Palmer in Champaign and one to Professor Jordan at the Chicago University. Sometimes, if I had any business down south, I took the box down there myself.

Q. How often did you deliver the box to Professor Jordan at the University of Chicago yourself?

A. In the morning, early in 1900, then, I had the express company deliver them or I delivered that box to another inspector who lives down there, all sealed.

Q. Did you put any card or memorandum on the sample of water that you took?

A. Yes, that wire with a seal on, went through an envelope in which was placed one of the cards.

Q. What kind of a card did you place on it?

A. A similar card to the one you have in your hand.

Q. I show you the card, on which is written Stream Examinations, Chicago Sanitary District, Samples of water, Sample No. 2943, October 8th, 1900, 2:00 a. m., from the Chicago Sanitary Collector, collected by Joseph Weis, and ask you if that is in your handwriting?

A. Now, here is the number, 2943. I forgot to state that we received a bunch of small tin tags which were num-
6560 bered in rotation. This sample was 2943, the next sample was 2944, and so on. We sealed that with a wire, and that wire onto an envelope and sealed the envelope after we placed these cards in. This is in my own handwriting.

Q. Is that the same kind of a card you used in these samples sent out by you to these different parties?

A. Yes, sir.

Q. And you filled in the blank spaces correctly with the data you collected?

A. Yes, sir.

Q. How did you collect the data?

A. In the first one I got there I had to go down to the canal with my thermometer to take the temperature of the water and I marked that on the card; then I took the temperature of the air and I filled out these cards, three of the cards, on the spot.

Q. What point was that taken at?

A. I couldn't tell; this isn't marked.

.Q In the sanitary canal?

A. It is taken in the Chicago Sanitary canal; it must be Western Avenue or Kedzie Avenue. That is one of the latest samples.

Q. Did you mark on the cards the point in the canal where it was taken?

6561 A. Yes. I cannot explain why it isn't marked on here.

Q. On the cards you took from Western Avenue, did you mark anything more on except Chicago Sanitary Canal?

A. Yes, I put in the number in those and point where it was taken.

Q. I notice in the cards where you took from the Kedzie Avenue, you put "Kedzie" in; but from the other points, I don't find that you indicated that.

A. Well, very likely I didn't indicate on the cards. I took samples at Western Avenue. It was self-understood. I didn't do that.

Q. Look at that card 2904, you have got from Chicago Sanitary Canal, Kedzie Avenue bridge, on the card, and preceding that is simply "Sanitary Canal."

A. Yes, this sample was taken in the morning from the middle of the Kedzie Avenue bridge.

Q. Now, what I asked you did you indicate for the Western Avenue bridge anything more than "Chicago Sanitary Canal?"

A. I do not remember. It seems to me during the year 1900, the instructions were to take the samples either at the Western Avenue or Kedzie Avenue bridge.

MR. WOERNER: I object to his testimony on the ground 6562 that it is having the witness describe what is on the cards and the cards are the best evidence.

Q. I will show you two bunches of cards and ask you to look through these cards and see whether those cards are all in your handwriting or not?

A. Yes, sir.

Q. And are those the cards that were taken and placed on the samples by you?

A. Yes, sir, written and marked by me.

Q. And are in your handwriting??

A. Yes, sir.

Q. The writing on the cards outside of the printed matter correctly states the truth, do they?

A. They contain correct statements, yes, sir.

Q. I mean of the temperature, etc.?

A. Yes, sir.

Q. I notice in this bunch of cards that I hand you three cards with T. J. Kelly's name on them; do you know him?

A. Yes.

Q. Who is he?

A. He is a fellow inspector. He is connected with the same office I am.

Q. Did he collect the samples for you?

6563 A. Well, I was sick one week and he took these samples in place of me.

Q. Outside of these three cards, all the rest of these cards were taken by you?

A. To the best of my recollection.

MR. TODD: Mr. Commissioner, I will ask to have this bunch of cards marked Sanitary District's Exhibit 14.

So marked by the Commissioner.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How long have you been in the employ of the milk inspection department?

A. Six and a half years.

Q. When did you first commence taking samples for the Sanitary District of Chicago?

A. Well, I can't say it was for the Sanitary District. Dr. Gehrmann ordered me in 1898 to take these samples at Bridgeport Pumping Station.

Q. Who is he?

A. He was the director of the city laboratory then.

Q. At what points did you take the samples in 1898?

A. Bridgeport Pumping Station; then we used to go out on the pier of the pumping station and take those samples at the end of the pier. 6564

Q. Do you know what the purpose was in taking those samples?

A. Yes, sir.

Q. In 1898?

A. Yes, sir.

Q. What was it?

A. For bacteriological examination and for chemical analyses in our own office, and for no other purpose.

Q. Now, how often did you take the samples in 1898?

A. Off and on may be three or four times a month.

Q. Now, did you take the small and large samples or just the small samples?

A. Large samples and small samples.

Q. Now, in 1899 where did you take the samples?

A. I took the samples then from the Bridgeport Pumping Works and from Western Avenue, if I remember right.

Q. How often did you take them in 1899?

A. The same way as in 1898.

Q. About how many samples did you take in the course of the year?

A. In 1898?

Q. Yes?

A. We commenced late in 1898; I wouldn't say.

6565 Q. You commenced late?

A. Yes, sir, it was in August, I should think, about the 15th.

Q. Three or four times a month?

A. Yes, I think fifteen or twenty samples all told in 1898.

Q. How many, all told, in 1899 did you take?

A. Well, I couldn't state that. That new system came in vogue then. We took three samples three times a week; I don't remember about that.

Q. Now, then, in 1900?

A. In 1900 up to about November 1st, we used to take samples regularly three times a week, I am sure, beginning with the spring anyhow.

Q. Now, where did you take the samples in 1900?

A. From the Western Avenue bridge, from the Kedzie Avenue bridge and from the Lawndale Avenue bridge.

Q. Now, in 1901 did you take samples?

A. I don't remember having taken any samples at the canal; we took the samples at the pumping station, and the city water pumping stations for our own analyses, the water reports you see in the newspapers.

Q. Now, in 1900 you took the samples you say, at the Western Avenue bridge?

6566 A. Yes, sir.

Q. As well as the other two points?

A. Yes, sir.

Q. Now, state how wide the river was at that point?

A. Well, I couldn't tell that exactly, I am a poor judge of distance.

Q. What river is it?

A. Well, it is the sanitary canal, the new canal.

Q. How far from the Desplaines river?

A. Well, I don't know how far. The Desplaines river is many miles away from the sanitary district.

Q. How far from the Chicago river?

A. From the Chicago river? I am twisted on that. Is that the Chicago river at the Bridgeport pumping works, one branch of it?

Q. I guess it is.

A. It must be a mile, because Ashland avenue is a mile from Western avenue.

Q. Now, you took the samples from the center of the canal?

A. The sanitary canal.

Q. How did you go at it to take them?

A. I have a rig, the inspectors employ a rig in my office.

6567 Q. Did you take them on the bridge?

A. Right on the center of the bridge.

Q. How did you get to the water?

A. We had a cylinder that I took my bottles in, tying the bottles on a rope. We had a device made with a cylinder, out of sheet iron, with a lead bottom.

Q. Now, how far under the surface would you sink that bottle?

A. I submerged the bottles about a foot I should say.

Q. Why did you put it down a foot?

A. I didn't want to get the surface water, I wanted some water below the surface.

Q. Well, what was the matter with the surface water?

A. Well, it was greasy.

Q. Now, you pulled the cork out of the bottle before you let it down?

A. Yes, sir, I couldn't do it any other way.

Q. What did you do with the cork while you were letting the bottle down?

A. I had it wrapped in my hand.

Q. How did you wrap it?

A. Just took the cork and put the rubber around it.

6568 Q. What kind of a rubber was it?

A. What kind of a rubber was it? It was sheet rubber.

Q. Where did you keep the rubber, in your pocket?

A. No I had a little box with a compartment where I kept my chipped ice. I had it in there with my wire and my pincers.

Q. It was loose?

A. No sir, in the little box.

Q. Did you clean the rubber in any way or wash it?

A. Well, the rubber was sterilized in our office and the box was sterilized.

Q. You put the bottle down and got some water in it and brought it up and emptied it out?

A. Yes sir, emptied the water out of the bottle.

Q. Then you would put it back again and fill it?

A. Then I would let it down again and fill it.

Q. Now that was true with reference to both the small and the large bottle?

A. Yes, the small bottle was tied outside of that cylinder.

Q. You submerged both at the same time?

A. Yes sir.

Q. Now after you brought the bottles out of the water, you immediately put the corks in?

A. I put the corks in right with the rubber on top of it,
6569 with the rubber on top of the cork.

Q. You would have to take the cork out of the rubber?

A. No sir, I kept the cork always covered with the rubber.

Q. Now where would the cork be at the time the bottles were being submerged?

A. Well, the cork was laying on the box. It was laying down flat sometimes.

Q. You took the cork out of the bottle and laid it down on this box:

A. Yes sir, wrapped in the rubber.

Q. Then you would sink the bottle in the water, bring it back up and put the cork back in again. You did it with your hands?

A. Yes sir, I couldn't do it any other way.

Q. Now after the samples were taken and corked, where would you take them to put the ice around them?

A. The big bottle I placed in one compartment.

Q. At once?

A. At once, and the small bottle I put the rubber on and tied my wire around it and sealed with the number and that envelope and then punched it so as to imprint that seal, placed it in the little tin box and placed that little tin box in the big tin box.

6570 Q. Now before you placed the small bottle in the little tin box, did you wrap the bottle with tin foil or anything of that kind?

A. No sir, it wasn't necessary.

Q. It don't make any difference what was necessary, I want to know what you did?

A. No I placed my small bottle in the small tin box and covered it up. The small box was very tight.

Q. What did you do after that?

A. Then I placed the little tin box into a big tin box and filled that tin box up with chipped ice.

Q. You always had your ice with you?

A. Yes sir, most of the time.

Q. And if you didn't you went out and hunted up the ice?

A. I drove from the bridge over to the West Side and the first milkman I struck that had any ice in his wagon.

Q. How far was it from where you were to the West Side?

A. About three-quarters of a mile.

Q. You would go directly would you?

A. Yes sir, I took the samples.

Q. What if you didn't happen to meet a milkman?

A. I didn't rely on the milkman at all; I was looking for an iceman.

6571 Q. And if you didn't happen to meet an ice man?

A. I went into a milk depot and got the ice there.

Q. Then you would take the small bottle out again and repack it?

A. Now in seventy-five per cent of the cases I did this way: I took these samples at Kedzie Avenue and drove over Kedzie Avenue to 31st Street. I drove to 26th and Kedzie Avenue and I stopped there. I had an arrangement with a milkman at 26th and Kedzie Avenue to have that ice for me, chipped. He had the ice already with me and I filled my big tin box.

Q. Now did you do the same way in 1898 and 1899?

A. I don't remember. Those samples were mostly taken in the afternoon.

Q. How deep under the surface did you go in 1898 and 1899 to get the samples?

A. I just went down below as far as my reach would carry the bottles, and drew the bottles out,

Q. And let them gather surface water and all the water?

A. That was all. I guess I couldn't do any different.

Q. Then you didn't use the same precautions in 1898 and 1899 to get the water from beneath the surface, that you did in 1900?

6572 A. No sir.

Q. You didn't pack them in ice either?

A. No sir.

Sig. waived. F. S. B., Com'r.

6573 HARRY HUDSON,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?
A. Harry Hudson.
Q. What is your business?
A. Switchman.
Q. Where do you live?
A. Joliet.
Q. Did you ever collect any samples of water for the sanitary district of Chicago?
A. I did.
Q. When did you collect them?
A. In 1899.
Q. From what time to what time?
A. I couldn't give you the exact dates, but from the early spring until along in June, if I remember correctly. It was along in March some time I started taking the samples.
Q. And when did you cease taking them?
A. I took them all that year and gave it up along in June of the next year.
Q. You took the samples in 1899, didn't you?
6574 A. Yes sir.
Q. And in 1900?
A. Yes, the first part.
Q. And where did you take the samples from?
A. From the east bank above Jackson Street, and from the east bank of the river below the Rock Island Bridge.
Q. What river?
A. The Desplaines river.
Q. At what point?
Q. What do you mean by at what point?
Q. Was it Joliet?
A. Yes, sir; at Joliet.
Q. These two points you have enumerated are within the corporate limits of the city of Joliet are they not?
A. Yes sir, they are.

Q. For whom did you take the water?

A. One for the Board of Health in Chicago and one for Professor Jordan of the University of Chicago and one for Professor Palmer at the State University.

Q. In what did you take the samples?

A. I took them in bottles that they shipped to us prepared for the taking of the samples.

Q. How were they shipped to you?

6575 A. They were shipped in a crate of two compartments. One was a large bottle that was packed with excelsior with a rubber covering over the top. This rubber cover was tied around so that the cork couldn't get loose; the other was a small bottle. It was sent in I should judge about a gallon tin pail with the small one inside of that.

Q. From whom did you get these receptacles to take the water?

A. I couldn't say. Mr. Irons made the arrangements to send the bottles to me direct.

Q. Where did you get them from?

A. They were gotten from the express office.

Q. Shipped in your name?

A. Yes sir.

Q. How often did you take the samples of water?

A. Once a week.

Q. Now just describe how you took the samples from the Desplaines river at these two points you have indicated.

A. We usually carried the crate as we received it from the express office to the bank at Jackson Street. There the bottle was taken out and submerged under for eight inches. There the cork was opened, the water was let in,—a little water let in and taken out and rinsed. The cork was put in and the
6576 large bottle put down underneath the water, the cork
taken out and the bottle was allowed to fill within four inches of the top and the cork was put in while the bottle was under water. The bottle was taken out then, this rubber covering was put over the top and the wires tied around under the bottom of it, and sealed with the regular seal, and there was cards with a description of where it was taken, what time and the temperature and the weather. These accompanied each sample. The small bottle was taken in the same way.

Q. You have described how you took the water, have you?

A. Yes sir.

Q. Go on and tell what you did with the small bottle?

A. The small bottle was taken in the same way, only when we took the small bottle up from the water we had to pack it in a compartment I should judge, about four inches high, and this small bottle had a rubber over the top in the same way. We put it inside of this smaller tin and put a top on that tin; then we iced it, filled the larger can up with ice, clear to the top, with chipped ice.

Q. Now after you had filled the bottles in the manner you have indicated and sealed them and packed them, what did you do with them?

A. Took them direct to the U. S. express office.

6577 Q. You took them yourself?

A. Yes sir.

Q. To whom did you send them?

A. Sent one to the Board here, the Board of Health in Chicago, one to Professor Jordan at the University of Chicago and one to Professor Palmer at the State University.

Q. How long from the time you took them out of the water until you got them into the hands of the express company?

A. Generally averaged three-quarters of an hour to an hour, long enough to drive from one place to another.

Q. I show you a tag that has printed on it, "Stream examination, Chicago Sanitary District, Sample of water, sample No. 183" and ask you if that is the kind of tag that you placed on each sample of water collected by you?

A. Yes sir.

Q. Is the sample I show you in your handwriting?

A. Yes sir.

Q. And each sample of water collected by you, did it have attached to it a card with the sample number on it, the date, the time, from where collected, and by whom, the height of the water, the temperature of the water, the direction of the wind, the temperature of the air and so forth?

A. Yes sir.

6578 Q. Were the instructions printed on the back as they are in the card which I show you marked Sample No. 183?

A. Yes sir.

Q. Did you fill out each card that you attached, correctly yourself?

A. Yes sir, I did.

Q. And a card similar to the card that you hold being card Sample No. 183, you attached to each sample of water which you shipped?

A. Yes sir.

MR. TODD: I ask to have card sample No. 183, marked Sanitary District of Chicago exhibit No. 15 for identification. So marked by the Commissioner.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Where did you say you took the samples of water in 1899?

A. From the east bank of the river above Jackson Street, about 150 feet above Jackson Street.

Q. That was here in Chicago?

A. No sir, in Joliet.

Q. What river was that from?

A. The Desplaines.

6579 Q. Did you take samples of water at other places than that one place during the year?

A. Yes, I took them from the east bank south of the Rock Island Bridge.

Q. How often did you take those samples?

A. Once a week.

Q. Did you always take them on the same day?

A. Yes sir, every Monday. I couldn't tell you or give you the exact time, I guess about a year I took them straight.

Q. A year in 1899?

A. No sir, not a year in 1899, but a year altogether from the time I started.

Q. You say the samples were sent you by express.—the bottles I mean?

A. The bottles were sent to me already for taking samples and were sent by express.

Q. What express office did you get them from?

A. The U. S.

Q. You went to the express office and got the bottles, did you?

A. Yes sir.

Q. How far is it from the express office to these two places where you took the samples?

6580 A. From the express office to Jackson Street is about 5 blocks from the express office to the Rock Island Bridge is about three blocks.

Q. And did you unpack the bottles at the express office?

A. No sir, the bottles were taken in the condition they were received to the place of collection.

Q. In what condition were they received?

A. Each case had two compartments in it. One side had a large bottle which was packed with excelsior around it, and a rubber covering over the stopper. The other side had a sort of a tin box to put a smaller bottle in, and inside of this tin was another small tin can. I call it a tin can; I don't know what else to call it, and inside of that was a bottle that was packed with cotton around it and a rubber covering over the top.

Q. Now you unpacked the bottles at the place where the samples were taken?

A. Yes sir.

Q. Now how did you get out that 150 feet out into the water?

A. I didn't take it 150 feet out. It was impossible to get it more than a foot out from the shore. The stream is too swift at Jackson Street. It is taken from the water just above the dam.

6581 Q. How deep under water?

A. Eight inches.

Q. Did you use an instrument or did you do that with your hand?

A. With my hand. I had my hand below the neck of the bottle with the stopper at the upper part of it. I held the stopper in that hand.

Q. You would hold the stopper in one hand and the bottle in the other?

A. No sir it was done in this way. I put the bottle down with the stopper in, I took out the stopper this way and let the water in.

Q. In other words, you uncorked the bottle then after it was under water?

A. Yes sir.

Q. Then you got a small amount in the bottle and you took it and rinsed it, poured that out and put it back?

A. Yes, first corked the bottle before putting it back.

Q. What did you do with the stopper while you rinsed the bottle?

A. Held the stopper in the same position.

Q. Then after you took the samples or the bottles out of the water, with the water in them, what did you do?

A. Wrote down the temperature of the water and the
6582 direction of the wind; also the temperature of the air
and the time that the sample was taken.

Q. You wrote that on the bottles?

A. No sir, I wrote that on the instruction card that goes with the samples.

Q. Then what did you do? Go to the other place?

A. These bottles were sealed there before I went to the other place.

Q. And packed in ice?

A. No sir. You couldn't carry ice to the point where the samples were taken. The rig was about 100 feet from where the samples were taken and they were packed there.

Q. After you took the first sample on each day, would you go then direct to the place of taking the other sample and take that sample?

A. Yes sir.

Q. Then from there you would take both samples to the express office?

A. Yes sir.

Q. And what did you do?

A. Stayed with the samples until I saw they were shipped on the 6:40 train.

6583 Q. Where did you put the ice around them?

A. The smaller can was put inside of the larger can and the ice packed around the small can.

Q. With reference to the time?

A. The ice was put in at Jackson Street before I left for the Rock Island Bridge.

Q. Then you would take the Rock Island Bridge sample, and when did you put the ice around that sample?

A. I always took the Jackson Street sample first, and put the ice around it before I left for the Rock Island Bridge.

Q. When did you put the ice around the Rock Island sample?

A. Right after taking the sample, put it around them.

Q. You packed them with ice?

A. Yes sir, took it all with me up from Jackson Street.

Q. Now what time of year was it you took the samples in 1899, spring or fall?

A. From the spring clear through.

Q. Now what part of 1900?

A. Up to about May.

Q. From January the first?

A. From January the first until May. I couldn't give you the exact date when I did quit taking the samples.

Q. Would you reach out from the bank and take these samples?

6584 A. They had to be taken that way.

Q. You took them all that way?

A. Yes sir.

Q. About a foot and a half from the shore?

A. About a foot and a half from the shore.

Sig. waived. F. S. B., Com'r.

ADJOURNED until 2:00 P. M. same day.

6585 2:00 P. M., Monday, September 21st, 1903. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

ARLIE TAYLOR,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Arlie Taylor.

Q. Where do you live Mr. Taylor?

A. Lockport.

Q. What is your business?

A. City Electrician.

Q. Did you ever take any water for the Sanitary District of Chicago?

A. I took for the University of Illinois,—I don't know whether—

Q. When did you take them?

A. I believe it was in 1899, I am not certain.

Q. Whom did you take them for, the University of Illinois?

6586 A. Palmer. I believe.

Q. Professor Palmer?

A. I believe.

Q. Where did you take them from?

A. I took one from the drainage at Lockport, above the dam, one from the old canal at Lockport; one from the east side of the drainage canal and a point there at Joliet above Jackson Street and one from the west side.

Q. That was after the drainage canal was opened, was it?

A. After the drainage canal was opened, yes.

Q. The drainage canal was opened in January, 1900.

A. Well the water was turned in, if that is what you mean by opened; that is it was running over the dam at that time.

Q. That is what I mean, it was open, water running over the dam?

A. Yes sir.

Q. And it was after that time that you collected the water?

A. It was after that time, yes sir.

Q. Now how did you collect the water there Mr. Taylor?

A. Well, the bottles used to come to Lockport. There was four of them, and they generally came ahead of time, so I could have them on hand. I used to make my collections on Sunday afternoon, right after dinner. The two bottles at Joliet I took first. I went down on the street car; I couldn't take

6587 the cases in my hands. I had strips around the necks of the bottles just as they came out of the express office, and I went over to Joliet and walked over to Jackson Street. Generally filled one on the east side first and then went to the west side and then back to Lockport and filled the one at the drainage there and then the one at the old canal, and packed them in their cases respectively, and sent them off by the United States Express.

Q. To whom did you send all those cases?

A. To the University of Illinois.

Q. To Professor Palmer?

A. There was no specific name, just University.

Q. Yes, but you were collecting for Professor Palmer?

A. Yes sir.

Q. Now after you had collected samples, how did you pack them?

A. Why, there was little envelopes that came on each bottle, that you filled out a slip which they sent,—you filled that out fully and put that in the box, and a tag on the bottle, in the envelope, and sealed the envelope.

Q. I show you a certificate and ask you if you used certificates of the same kind as the one that I show you?

A. Yes sir, one similar to them.

Q. Similar to that?

6588 A. Yes sir.

Q. And the filling in you did yourself, did you?

A. I did it myself, yes.

Q. And did you fill them all correctly?

A. Yes sir.

Q. And shipped them in the manner that you have stated?

A. Yes.

MR. TODD: I will ask to have certificate marked in pencil at the top 4706, marked Sanitary District of Chicago's Exhibit No. 16 for identification.

Same is so marked by the Commissioner.

Q. How often did you take this water Mr. Taylor?

A. Well, at first I took them every other week, and then finally it got to be every week,—every Sunday.

Q. Describe how you filled the bottles?

A. Well, in the summer time or in the fall when there wasn't ice on the water, I went—the one at Lockport and the drainage canal, I got down onto a scow that was there,—pretty well water-soaked, down rather close to the water. I took the rubber cover off and the string, and inserted the bottle below the water as far as I could reach, removed the stopper, allowed some water to enter, put the stopper back in and rinsed the bottle out; emptied the water out, put the cork back 6589 in, inserted the bottle into the water as far as I could reach, took out the stopper, filled the bottle, put the stopper back in and took it out of the water; put the rubber cloth over the stopper, tied the string around it, took it to the express office and shipped it off.

In the old canal the best I could do was to reach out from the bank as far as I could, from a projecting stone that was there.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. What time of the year did you commence taking samples in 1899?

A. I believe that I started about in the summer, and took up to about the next spring, though I am not certain.

Q. Are you right sure it was in 1899, or 1900?

A. Well, I say as to that I could not definitely state, because I don't remember; I kept no slips or anything. I was going to school at the time, and I did it then.

Q. It was one of those two years?

A. Yes sir.

Q. And you began when?

A. I think I began along the latter part of the summer.

6590 Q. And continued for how long?

A. Well, up to the next spring, or very nearly to the next spring and then they ceased to collect there.

Q. Now how often did you take the samples?

A. At first I believe that I took them every other week, or aimed to, and towards the latter part I took them every week,—every Sunday.

Q. Now when you would take one sample you would take a sample at the various places at the same time, on the same day?

A. On the same day, yes sir, after dinner, on Sundays.

Q. Now you say you took samples at Jackson Street?

A. Two there.

Q. Yes, one on the west side and the other on the east side?

A. Yes sir.

Q. Of the river or the canal?

A. Well there the old canal and the new canal and the river run together at Lockport, that is the Desplaines, so it is a combination of the three.

Q. It was below that then, was it?

A. It was below where the two flow together,—or the three rather.

Q. How far from the west side did you take the samples?

A. From the bank you mean?

Q. Yes?

6591 A. Well, there is a rock there and I used to get out on the point of the rock and—judging from the bank, it would be about twenty some feet.

Q. Now on the east side?

A. On the east side there was another scow there. It was just a scow or flat-boat that they had been using for telephone work and one thing and another. I used to go out on that. That would make it about ten or twelve feet from the bank, part of the time. Then that was removed, and I made a kind of steps down on the stones so at the latter part there, it wasn't quite as far out in the stream—out may be a foot and a half or two feet.

Q. Was there any ice there at any time?

A. Ice in winter time; there was considerable ice. I used to carry a hatchet and chop a hole through the ice and insert the bottle in the water.

Q. You say you went about eight inches under the surface of the water?

A. Yes sir, about that, as far as I could reach.

Q. Did you rinse the bottles out?

A. The bottles were rinsed.

Q. How did you do that?

A. How did I rinse them?

6592 Q. Yes?

A. Why, put the bottle down; took the rubber off and the string, and inserted the bottle down a ways and removed the cork and then I usually just took them up, put the cork in, shook them thoroughly; then inserted the cork, put the bottle down again, and filled it, and then inserted the cork underneath and then took them out of the water and tied it up—and took the temperature. I always took that, after I had filled the bottles and put that on a little slip of paper I used to carry with me—and the time of day. There was a town clock right there and I used to take it from that.

Q. Where did you hold that stopper while the bottle was under the water,—in your hand?

A. Why I removed the cork when the bottle was under water, and then I used to take the stopper out and hold it until the bottle was filled, and then put my other hand down under the water.

Q. You took that stopper clear up out of the water?

A. While the bottle was filling.

Q. And then put it back again?

A. Put it back again before I brought the bottle out of the water.

Q. Where did you put this stopper while the water was filling the bottle? In your hand?

6593 A. In my left hand, usually, yes sir.

Q. What was the shape and size of the stopper?

A. As near as I could state, I imagine it was just a glass stopper.

Q. Did it have a handle to it?

A. No, just a glass stopper about an inch and a half long about, across the top. I mean just the top of the cork.

Q. Did you ever lay the stopper down while the bottle was filling?

A. Why, I might have but not to my knowledge. If I did it was always laid on something.

Q. Laid on what?

A. Laid on the rubber cloth, but I usually held it in my hand all the time.

Q. Just held it in your hand?

A. Yes sir.

Q. Did you wash your hands?

A. Did I wash them? I suppose so.

Q. Did you wash them just before you took hold of the stopper?

A. Why, they were in the water before that. I suppose I had during the day before.

Q. Did you take the samples of water from the canal above or below where you stood?

A. At the side of me.

6594 Q. At the side, right opposite?

A. Yes.

Q. Never got above?

A. Not to my knowledge; I might have.

Q. Now, where did you go first and take the samples?

A. Down in Joliet the samples were taken first, generally on the east side first; then on the west.

Q. Now, then you would go first to the east side?

A. Generally.

Q. Then you took a sample there and then you went from there over to the west side?

A. Yes, sir.

Q. How did you get over there?

A. Went over Jackson street bridge.

Q. How far would you have to go?

A. Oh, two blocks or so.

Q. Now, then, after you took the sample on the east side, did you pack that in ice just there?

A. No, I had the large bottles. I didn't have any small ones. It wasn't necessary to pack them in ice.

Q. You didn't take any small samples at all?

A. No, sir, just the large, gallon bottles.

Q. Did you take any of the small samples at Lockport?

A. No, sir.

6595 Q. They were all large?

A. They were all large.

Q. Now you took those at Lockport the same way you did those at Jackson Street?

A. Practically, yes sir.

Q. What particular place in the canal did you take those at Lockport?

A. In the new or old?

Q. In the new?

A. Just above the dam.

Q. At the side of the canal or out in the center?

A. Well, about eight feet from the southern bank—eight or ten feet.

Q. How did you get out there?

A. On a scow.

Q. Now those that you took from the old canal, were they taken from the center of the canal?

A. No sir, they were taken from—well there was a rod projecting out and I used to go out on that. That would make it about two feet that I would be, from the bank.

Q. Now after you collected those samples, you then took them to the express office?

A. I did.

Q. What express office?

6596 A. The United States.

Q. And sent them to where?

A. Urbana.

Q. Urbana?

A. Yes sir.

Q. Do you know whether the stoppers in those bottles had been taken out or removed prior to your receiving them?

A. No sir, they had not.

Q. That is, they had not been taken out by you?

A. Well, by no one in the office there since they left whereever they came from.

Q. You unpacked them yourself, did you?

A. I unpacked them, yes sir.

Q. You put no ice around them or anything of that kind?

A. No sir.

(Signature waived, F. S. B., Com'r.)

6597 WILLIAM E. O'BRIEN,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:—

Q. What is your name?

A. William E. O'Brien.

Q. What is your business?

A. Drayman.

Q. Where do you live Mr. O'Brien?

A. Lockport.

Q. Did you ever take samples of water for the Sanitary District?

A. Yes sir.

Q. Where did you take them from?

A. They were taken from the Desplaines river at Lockport; from the drainage channel and from the old canal at Lockport.

Q. How often did you take samples of water?

A. Once a week.

Q. Who did you take them for?

A. I took them for Jordan, Palmer and Reynolds. I was to take some for Long, but I forget how often I did take those.

Q. When did you take those for Professor Long?

A. Same time I was taking them for the others.

6598 Q. How often did you take the samples for Professors Jordan, Palmer and the Board of Health of Chicago?

A. Once a week.

Q. When did you begin to take samples of water?

A. I think it was in the spring of 1900.

Q. Did you take any samples in 1899?

A. I don't believe I did; I couldn't say for certain.

Q. Will you look at a card of sample No. 1009, December 26, 1899, collected by P. W. O'Brien, and refresh your memory from that?

A. It is not mine.

Q. Isn't that yours?

A. No sir.

Q. When did you say you began to take the samples?

A. In the spring of 1900, some time.

Q. And how long did you take them?

A. I took them pretty near a year; took them until the fall or winter some place along in there, I couldn't say for certain what time it was.

Q. What did you take them in, Mr. O'Brien?

A. Used to take them in bottles.

Q. Where did you get the bottles from?

A. They were shipped to me from Jordan, Reynolds, Palmer— shipped to the express office. I used to get them from there.

6599 Q. Then just state how you took the water, will you please?

A. Why, took the bottles I got over there, dipped them under the water about a foot; took the cork out, rinsed the bottles out and then filled them up under the water again and packed them and shipped them off.

Q. You did this in all three places that you took the water from?

A. Yes sir.

Q. Did you uncork the bottles underneath the water or above it?

A. Underneath the water.

Q. And where did you put the stopper in?

A. I used to put it in underneath the water.

Q. What?

A. Put it in underneath the water.

Q. Did you rinse the bottles out before you filled them?

A. Yes sir.

Q. Then what did you do?

A. Put them in their cases, packed them up and shipped them off.

Q. Who did you ship them to?

A. To Reynolds, Palmer and the Board.

Q. Board of Health of the City of Chicago?

A. Board of Health—to Reynolds.

6600 Q. Now after you got through packing,—did you pack any of them in ice?

A. Yes sir, I used to pack those small bottles that came in cans; I used to pack those in ice.

Q. Did you take the temperature of the water?

A. Yes sir.

Q. Now after you got through packing them and before shipping them did you place any marks of identification on the bottle?

A. Why the cards that they sent us.

Q. What kind of a card did you put on?

A. Just a little white card. I used to place it in an envelope they sent us.

Q. I show you a card marked "Stream Examination, Chicago Sanitary District, Sample of water," Sample No. 2533, and ask you if that is the kind of a card that was placed on the sample?

A. Yes sir.

Q. And is that in your handwriting?

A. Yes sir.

Q. And did you place a card similar to that on all the samples of water that you collected?

A. Yes sir.

Q. And shipped to the different places?

A. Yes sir.

6601 Q. And on each card that you collected the water, did you fill out the place, sample number, with the number, the date, the time, the place from where the water was taken, with your name as collector, and the temperature of the water, the temperature of the air and the direction of the wind?

A. Yes sir.

Q. And did the cards that you placed on the bottle have the printed instruction on the back, similar to this one?

A. Yes sir.

Q. And each sample had a card of that character?

A. Yes sir.

Q. Now how long from the time that you collected the water, was it before you took it to the express office for shipment?

A. Why, just as soon as I got it packed, it would probably be twenty minutes or half an hour, I delivered it to the express office.

Q. You delivered it in person, yourself, did you?

A. Yes sir.

MR. TODD: I offer this card in evidence and ask to have it marked Sanitary District of Chicago's Exhibit No. 17 for identification.

Card so marked by the Commissioner.

6602 CROSS-EXAMINATION, by Mr. Jeffries.

Q. You say you took samples from the drainage canal at Lockport?

A. Yes sir.

Q. When did you commence?

A. Some time in the spring, in 1900.

Q. Now this same spring and at the same time, you commenced taking samples in the old canal?

A. Yes sir.

Q. Where did you take those?

A. At the bridge at Ninth Street.

Q. Ninth Street bridge?

A. Yes sir.

Q. How far is that from Lockport?

A. Just a block off the main street.

Q. How many samples did you take at those two places?

A. Why I used to take three.

Q. Three a week?

A. Yes sir, for different parties.

Q. You took three samples on one day each week?

A. Yes sir.

Q. For how many weeks about?

A. I couldn't say for certain, but I took it from some time I think it was along in March, I am not sure.

6603 Q. 1900?

A. 1900, along about October or November, some place in there.

Q. You never took samples at any other place or at any other time?

A. No sir.

Q. Where did you get the bottles you say that you put the water in?

A. At the expreses office.

Q. How far is that from Ninth Street Bridge in Lockport?

A. Why, at that time it was about two blocks. It is further now.

Q. And you went to the express office and got the bottles?

A. Yes sir.

Q. And carried them down to—

A. To the canal, yes sir.

Q. ——to the canal?

A. Yes sir.

Q. Did you take the large bottles or the small bottles?

A. I had large and small both.

Q. How did you carry them down—in the boxes in which they came?

A. Yes, sir, in the boxes that they came in. I used to take 6604 them down in a wagon.

Q. How far from the shore did you take those samples?

A. Well, probably a foot, just as far as I could lay on the bank and reach out.

Q. What kind of a bank was it, rock or soil?

A. Well it was partly rock and partly soil.

Q. What did you stand on when you took the samples?

A. Didn't stand on anything, I used to lay down and reach out.

Q. Did you take any samples in the winter time?

A. Yes sometimes it was cold; it was in the cold weather, along in March.

Q. You were on the bank then when you took the samples?

A. Yes sir.

Q. Now you say you took the stopper out of the bottles in the water?

A. Yes sir.

Q. And brought the stopper clear up out of the water did you?

A. Yes sir.

Q. What did you do with it while the bottle was being filled?

A. Held it in my hand.

Q. At all times?

A. Yes.

Q. How many times did you lay it down?

A. I couldn't say.

6605 Q. Several times though, didn't you?

A. I couldn't say that I laid it down at all.

Q. Don't you know that you did?

A. Not to my knowledge I don't.

Q. You know whether you did or not, do you not?

A. I don't recollect ever laying it down.

Q. How did you hold it in your hand?

A. Why; just immersed the bottle, took the stopper out and held it there until the bottle was filled and then put it in the bottle again under the water.

Q. You held the bottle with both hands in the water?

A. No with one hand.

Q. Always with one hand.

A. Always tried to hold it with one hand. I don't know whether I succeeded or not.

Q. Well if you didn't succeed you would know it would you not. Would you hold the bottle in both hands?

A. I might have.

Q. Where was the stopper when you were using both hands?

A. I couldn't say as to that.

Q. Well it might have been lying on the bank some place?

A. I think I held it in my hand all the time. That is all I know.

6606 Q. Now as a matter of fact, don't you know that you did hold the bottle with both hands on some occassions?

A. No sir.

Q. Did you bring the bottle out of the water before you put the stopper in?

A. To rinse it I did.

Q. Then you put it back in the water?

A. Put it back in the water.

Q. Was the stopper in it then?

A. No sir.

Q. You put the bottle down then into the water and took out the stopper while it was in the water?

A. Yes sir.

Q. And let some water run into the bottle?

A. Yes sir.

Q. Then you took the bottle from the water?

A. Yes sir.

Q. And rinsed it?

A. Yes sir.

Q. Put the bottle back?

A. Put the bottle back.

Q. Filled it with water?

A. Filled it with water.

6607 Q. Drew it out and then put the stopper in?

A. No, I used to put the stopper in under the water.

Q. All the time?

A. Yes sir, tried to do it all the time.

Q. Well, when you failed to do it, that way, what way did you do it?

A. Well, I don't know as I ever failed.

Q. What do you mean by saying that you tried to do it that way?

A. Because I don't remember any time that I didn't do it that way.

Q. Now that is true of both the large and small bottles?

A. Yes sir.

Q. Then after you got those samples, what did you do?

A. Why, used to pack them and do them up.

Q. Well, the first sample that you took that day, the first sample that you took each day, what did you do with it then —immediately? Carry it over to the other places where you were going to take samples?

A. Yes, I used to go to the river first and collect my samples there and then go over to the drainage canal, about two blocks from the river and collect them there and then go to the old canal and collect them at the old canal last and take them right up to the express office.

6608 Q. Now you collected them in the old river?

A. In the river.

Q. Just as soon as you had collected them there you went over to the canal?

A. Drainage canal.

Q. And took the samples there?

A. Yes.

Q. From there you went over to the Illinois and Michigan Canal?

A. Yes sir.

Q. Now how far is it from the Illinois and Michigan Canal to the drainage canal at the point where you took the samples?

A. Well, about three-quarters of a mile.

Q. Then after you had taken the samples of water from the old Illinois and Michigan canal, having previously taken the samples from the other two places, you then proceeded to pack all of the small bottles in ice?

A. Yes sir.

Q. You didn't pack them in ice at each place where the samples were taken?

A. At times I did, other times I didn't.

Q. Well, as a general proposition you packed them all in ice at the same time?

A. Yes sir.

6609 Q. Now then, how long was it from the time you took the first sample until the last sample was taken each day?

A. Well, I should judge about twenty minutes to half an hour, something like that.

Q. Then you would take the samples from the drainage canal at Lockport?

A. Yes.

Q. And from there you would go over to the—

A. To the old canal.

Q. —the old canal and from there where did you go?

A. To the express office.

Q. Now before that where did you take—you took samples only at two places?

A. At the river.

Q. You went to the river first?

A. I went to the river first.

Q. And took the sample at the river, then you went over to the drainage canal at Lockport, is that right?

A. Yes sir.

Q. Now then how far is it from the canal—from the river to the drainage canal?

A. About two blocks—two or three blocks.

Q. How long did it take you to go from there over to the drainage canal?

6610 A. Oh, about five minutes I guess.

Q. About five minutes?

A. Yes sir.

Q. How long did it take you to take the sample in the old river,—sometimes longer than others, didn't it?

A. Oh, about two or three miuntes is all, I guess,—probably five minutes.

Q. Well, it was longer than that, wasn't it?

A. I don't know.

Q. About five minutes, is that right?

A. About five minutes.

Q. Then you went direct, did you, to the drainage canal at Lockport?

A. Yes sir.

Q. Did you always hurry or take your time?

A. I used to always hurry because I had other work to do.

Q. Then after you took the sample in the drainage canal at Lockport you went to the old Illinois and Michigan Canal?

A. Yes sir.

Q. That is how far from the drainage canal?

A. About three-quarters of a mile.

Q. How long did it take you to go over that three-quarters of a mile?

6611 A. I ain't much of a race-horse; I guess ten or fifteen minutes.

Q. You drove over?

A. Yes sir.

Q. Now these bottles containing the water that you had taken at previous places were in the wagon, were they?

A. Yes sir.

Q. They had not at that time been packed in ice?

A. No sir.

Q. You took them with you then and after you took the samples out of the old Illinois and Michigan Canal, then you took them to the express office and packed them?

A. Yes sir.

Q. And put them in ice at the express office?

A. Yes.

Q. How far is it now from the old Illinois and Michigan canal to the express office?

A. About two blocks.

Q. About two blocks?

A. That is where it was at the time. It has moved since then.

Q. Now then, how long would it take you, commencing at the first place where samples were taken, out of the river,—to take the samples there, go over to the draingae canal at
6612 Lockport, take the sample there, and from thence to the old Illinois and Michigan Canal, take the sample there, and then on to the express office?

A. Half an hour as near as I could guess.

Q. About half an hour?

A. About half an hour.

Q. Sometimes longer than others wasn't it?

A. I don't see why it would take me any longer one time than it would another.

Q. Did you take the samples—put all of the bottles under the water about eight inches?

A. Yes sir.

Q. Both the large and small?

A. The large and small.

Q. Were those bottles under your care all the time?

A. From the time I received them from the express office, they was.

Q. You don't know whether anybody removed the stoppers from them or not?

A. They didn't I know, after I got them.

Q. You had them right with you all the time?

A. I had them right with me all the time. I used to follow them when they would come into the office.

Q. Well then you kept them right there with you?

A. Yes.

6613 Q. While you were following them?

A. While I was following them.

Q. Did you pack them immediately after you got back to the express office?

A. Yes.

Q. And labeled them?

A. And labeled them.

Q. And sent them out?

A. Yes sir.

Q. Were the packages containing the bottles sealed when you received them?

A. No sir, there was just a rubber cloth over them, tied tightly.

Q. You don't know whether they had ever been removed or not?

A. I couldn't swear to it.

(Signature waived, F. S. B. Com'r.)

ADJOURNED until 10:00 A. M., Tuesday, September 22nd, 1903.

6614 10:00 A. M., September 22nd, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

T. J. KELLY,

called as a witness in behalf of the defendants, being first duly sworn, was examined in chief by Mr. Todd and testified as follows:—

Q. What is your name?

A. T. J. Kelly.

Q. What is your business?

A. I am dairy inspector.

Q. Mr. Kelly, did you take any water for the sanitary district at any time when Mr. Joseph Weis was taken sick?

A. I took a few samples about two years ago I think it was.

Q. Now as to those samples that you took, where did you take them?

A. I took them from the Western Avenue viaduct in the drainage canal.

Q. How did you take the samples? Just describe what you took them in, how you took them and where you got the bottles?

6615 A. I got the bottles from the Health Department and I had a large bottle and a small bottle for each sample.

Q. Now how did you fill the bottles?

A. Well, we had a rope and I lowered it from the bridge into the water.

Q. Go on now and tell what you did?

A. After I had the bottles filled we packed them, the small bottle I put in a small can and put that into a larger can which was packed with ice. The large bottle, I put that in a case. There were two compartments in the case, and the large bottle I put in the other compartment and packed both of them with excelsior.

Q. Then what did you do after you packed them?

A. I took the three samples down to the Health Department and sent one to Champaign, one to the University of Chicago and one to Dr. Gehrmann, in the Health Department.

Q. Now the one that you sent to Champaign, was that sent to Professor Palmer?

A. Yes I think it was to him.

Q. And the one to the Chicago University was to Professor Jordan?

A. Yes sir.

Q. And the other one to the Health Department to Dr. Gehrmann?

A. Yes sir.

6616 Now did you place any cards on the samples of water?

A. Yes, there was a card with the address.

Q. I show you State of Illinois exhibit No. 11 for identification and ask you to look at the card and see whether that is the kind of a card that you used?

A. Yes sir, that's the card.

Q. Did it have instructions printed on the back for taking the water as this card has?

A. Yes sir.

Q. With the number of the sample and the date of collection?

A. Yes sir.

Q. And the place of collection?

A. Yes sir.

Q. Did you write your name as collector?

A. Yes sir.

Q. Giving the temperature of the water and the temperature of the air and the direction of the wind?

A. Well, I didn't give the temperature of the water; I didn't have any thermometer with me.

Q. You didn't give the temperature?

A. No sir.

Q. But the cards you had, had a place for the temperature?

A. Yes sir. I gave the temperature of the air.

6617 Q. And that card you attached to the samples which were collected by you?

A. Yes sir.

Q. And sent to the parties you have indicated?

A. Yes sir.

Q. How long did you collect the samples?

A. Just about a week; I think I took them three times.

Q. The three cards that have your name, in the package of Weis cards were signed by you and are your cards, are they not?

A. Yes sir.

Q. Those are the three samples that you collected?

A. Yes sir.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Where did you say you took the samples of water?

A. I took them all from the same place, the Western Avenue Bridge.

Q. And that was out of the drainage canal?

A. Out of the drainage canal.

Q. Now when was that?

A. It was about two years ago; I don't know exactly.

6618 In 1900 or 1901?

A. In 1901 I think; I am not positive agout that.

Q. You took two samples each time, a large one and a small one?

A. Three samples.

Q. Or did you take three of each?

A. Three of each, yes sir, three large ones and three small ones.

Q. Where did you get those bottles?

A. I got them from the Health Department of Chicago.

Q. Did you go to the Health Department and get them?

A. Yes sir.

Q. Then what did you do with them?

A. I drove out there and took the samples.

Q. Now how far out in the water did you get those samples?

A. Well, about the middle of the stream. Of course I was on top of the bridge, you understand.

Q. Now how would you get the bottles down in the water?

A. Why I had a long rope and I had a sinker attached to the neck of the bottle and I let it down.

Q. How deep under the surface did you sink the bottle?

A. Well it was about a foot, or two feet or three feet. You know——the bottle would sink.

6619 Q. You couldn't always tell exactly how deep you would put them?

A. No, so far (indicating) out of sight.

Q. Now, in gathering these samples you removed the cork or stopper of the bottle before you let it down into the water, didn't you?

A. Yes sir.

Q. The bottle had a tendency to fill on the surface of the water, didn't it?

A. No, the sinker would carry the bottle down. That is, it wouldn't carry it down at first, but just as soon afterwards—in a little while it would sink because some of the water would run in, but the neck of the bottle would be down in the water and it would sink.

Q. Some of the surface water would run in the bottle first and then it would go on down?

A. No, not the surface water. It might be six or eight inches below the surface, the neck of the bottle.

Q. Well you don't mean to say there was none of the surface water got into the bottle?

A. Just as it touched the water, there might have been.

Q. Necessarily some of the surface water must have got into the bottle, isn't that true?

6620 A. Well, this sinker naturally would pull the neck of the bottle down.

Q. That mouth of the bottle being opened, it couldn't very well get down without some of the surface water getting into it, could it?

A. Just when it struck the water.

Q. It didn't make any difference what position the bottle was in, some of the surface water would be bound to get into the bottle as it went down?

A. Well I wouldn't say there wasn't some; just a small amount, certainly.

Q. How large was the mouth of those bottles?

A. Well, as large as my finger.

Q. How large was the mouth of the small bottles?

A. Well a little larger than a lead-pencil.

Q. Did you rinse the bottles?

A. Yes sir.

Q. How would you do that?

A. Let them down as you know and pull them out and rinse them out and take the sample.

Q. Now then, when you first got on the bridge at the point where you intended to take the samples, you removed the stopper did you?

6621 A. I had everything prepared first.

Q. I know, but you removed the stopper before you let the bottle down?

A. Before I what?

Q. Before you let the bottle down in the water?

A. Just before I let it down.

Q. The stopper was not put back until after the bottle had been rinsed and the sample finally gathered and drawn up to the top of the bridge where you were, is that right?

A. Yes sir.

Q. Now then where was the stopper while you were gathering this sample while the bottle was submerged under the water and while you were rinsing it?

A. I usually left the stopper right off the sidewalk.

Q. Laid it down on the sidewalk?

A. No sir, it was up off the sidewalk on a piece of paper, something like that I had there (indicating).

Q. Just anything you could get to put it on you put it on?

A. Anything clean. I was always particular about that.

Q. You took it with your hands, picked it up with your hands and put it in?

A. I picked it up with my hand, picked up what you call the top of the stopper. I would not touch the round part of the stopper with my fingers.

6622 Q. Do you remember doing that?

A. Well, I never do that in taking any samples. I take samples every day of city water.

Q. You do now?

A. Yes sir.

Q. Now then after you took those samples what did you do with them?

A. I put the small bottle in the small can and sealed it up with that stopper. Not seal it, but put the stopper in it, and put that into a large tin can and packed it with ice; then I put that in one of the compartments of this box and packed the excelsior around that, and that large bottle, I put that into the other tin can, put that into the other compartment of this box and packed the excelsior around that and took it down.

Q. Where did you do it, immediately after taking it out of the water?

A. Yes sir.

Q. Right there on the bridge?

A. Yes sir, right there on the bridge.

Q. Then where did you take them?

A. I took them down to the Health Department.

6623 Q. How many samples did you say you took for Mr. Weis?

A. I took them three times.

Q. That's all the samples you did take for him?

A. Yes.

Q. Or for the Chicago Sanitary District?

A. Yes sir.

Q. Did you take any for the City Health Department?

A. No sir.

Q. Nor the Chicago Health Department?

A. No sir. These were for the Chicago Health Department.

Q. These were for the Chicago Health Department?

A. Yes. What I mean is, I was working under the direction of the Chicago Health Department.

Q. But you took these samples for Mr. Weis?

A. Yes sir.

Q. In his place?

A. Yes sir, in his place.

Q. Do you know anybody else that took any samples for Mr. Weis?

A. No, I do not.

Q. Did he tell you that anybody ever took any for him?

A. No sir, he was sick at that time.

Q. He was sick at that time?

6624 A. Yes sir.

It is agreed that the agreement made at La Salle in regard to the water takers not being required to sign their testimony shall apply to the water takers whose testimony has been taken in Chicago.

F. S. B., Com'r.

ADJOURNED until 2:00 P. M. same day.

6625 2:00 P. M., Tuesday, September 22nd, 1903. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

DR. WILLIAM H. FRASER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. William H. Fraser.

Q. What is your business?

A. I am a physician and surgeon.

Q. Where do you live, doctor?

A. I live in the city of La Salle, Illinois.

Q. How long have you lived there?

A. I have lived there over thirty years.

Q. Doctor, did you collect any samples of water for the Chicago Sanitary District from the Illinois river at La Salle?

A. I did.

6626 Q. What year did you collect the water?

A. In 1899 and 1900.

Q. How often did you collect samples of water?

A. About once a week, pretty regularly every week.

Q. Where did you collect the water from?

A. From the Illinois river immediately south of La Salle.

Q. For whom did you collect the water?

A. For Dr. Reynolds.

Q. Where did you send the water after collecting it?

A. I sent it to Chicago.

Q. Any other place?

A. I sent it also to the Illinois University at Champaign.

Q. Any other place?

A. To the Chicago University.

Q. Did you send any to Professor Palmer of the University of Illinois and Professor Jordan of the Chicago University?

A. Yes it was Palmer I sent it to, to the Illinois University and Jordan to the Chicago University.

Q. In what did you collect the water?

A. In large glass bottles.

Q. Where did you get the bottles from?

A. I think I got them originally from Reynolds. I had three sets of them and they were always shipped back
6627 to me empty, and I shipped them full or nearly full.

Q. How did you get the bottles from Reynolds; how did they come to you?

A. They came with glass stoppers in them and a rubber tied over the top and packed in a box. That is, each bottle was in a compartment in each box.

Q. Did they come by express?

A. Yes sir.

Q. And you received them by express directed to you?

A. Yes sir.

Q. After you received the bottles, just describe the method you pursued in filling them?

A. Well I had a box prepared to hold the number of bottles that I had, and the box fitted my buggy and I took them just as I received them to the river and filled them from the water of the river. Sometimes I took a boat and went out into the river; sometimes I went on the ice, cut a hole in the ice and

got the water from under the ice, or rather it came up of course to nearly the level, or top of the ice. I filled the bottles in that way, and then afterwards I collected a good many of the samples by getting it up from the bridge, the Illinois river bridge. I went to about the middle of the stream with a strap and a large pail, hauled up the water and poured it into the
6628 bottles.

Q. After you had collected the water in this way what did you do with it?

A. Put the stoppers in immediately and put the cover over; brought them home and sealed them with wire and a seal.

Q. And then what?

A. Shipped them by express to the three different places.

Q. Did you place any tag on the water?

A. Yes, there was a tag placed on each of the large bottles.

Q. What kind of a tag was it?

A. A card four or five by three inches.

Q. I show you a tag printed in large letters at the top: "Stream examination, Chicago Sanitary District; samples of water, sample No. 2316" and ask you if that tag is in your handwriting?

A. It is.

Q. And did you place a tag similar to that tag which I show you on each of the samples which you collected and shipped to the three different institutions?

A. Yes sir.

Q. On each tag did you put a sample number, the date of taking, the time of taking, from what river, collected by—(your name written in)—height of water, direction of
6629 wind, temperature of water and temperature of air?

A. I put in most of those things you mentioned, but I didn't put in the temperature of the water, because I had no thermometer. They sent a thermometer, or at least they claimed to have sent a thermometer, but I didn't get it. It must have been taken out of the box before it reached me. I sent them word that I had no thermometer; I got word that they had sent me another but I never got it.

Q. So your tags do not show the temperature of the water or the temperature of the air?

A. No sir.

Q. But with that exception you placed a tag similar to the one I hold in my hand, on each sample of water collected by you?

A. Yes, with the exception of the—I didn't always put on the height of the water, but I think practically they were the same. They were similar to that but perhaps some of the facts were not filled?

Q. On the back of each tag did they have instructions for collecting and sending samples of water as printed on the one indicated here?

A. Yes sir.

Q. How long from the time of taking the samples of water, would it be before the samples were placed in the express office for shipment? 6630

A. Well, inside of an hour or an hour and a half, I think at the outside two hours. It was about a mile from town and of course I had to go to town and seal them up, and it was always done immediately, and they were sent away generally on the morning train I think. They were collected the same morning they were sent.

Q. Did you pack any of the samples in ice?

A. I did.

Q. Just detail how you packed them in ice?

A. I had a small glass stoppered bottle that held perhaps I think about two ounces as near as I remember; perhaps they might have held a little more but not very much, and I had small tin cans with tin covers. I put the bottle into a tin can with some cotton around it; then I put the cover on the can and put that can into a larger can that would hold perhaps from two and a half to three quarts. It might perhaps hold a gallon, I am not sure. It was a good sized can and it had a tin cover as well. I packed the can full of excelsior and ice, put the cover on it and put that into the compartment of the box, it having a compartment around it so as to keep the bottle from breaking and also to prevent too rapid melting of the ice, and these boxes were kept in the same manner as the

6631 other, and shipped by express to the three different places.

MR. TODD: I ask to have the card marked Sample No. 2316 marked Sanitary District of Chicago's Exhibit No. 18 for identification. So marked by the Commissioner.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. When did you commence taking the samples doctor?

A. In the spring of 1899.

Q. How long did you continue?

A. I continued until the autumn of 1900.

Q. Almost two years?

A. Yes, two years with the exception of the winter.

Q You took right through one winter, didn't you?

A. Yes, I took right through one winter.

Q. How far did you say it was from the point where the samples were taken, to your office?

A. About a mile.

Q. Below the town?

A. No, directly opposite the town, directly south of the town. The river is about a mile south of La Salle, at the city of La Salle it takes a bend to the east of La Salle and then comes back again, west of La Salle.

6632 Q. How often did you take samples, once a week?

A. Once a week practically, yes. I think almost always on Tuesday morning of each and every week.

Q. Now how far out into the stream would you go to get the samples?

A. Most of the samples were obtained as near as possible to the middle of the stream.

Q. How would you get out there?

A. On the bridge.

Q. How high is the bridge above the surface of the water?

A. Probably fifteen, sixteen or seventeen feet.

Q. Now what means did you use to get the water up to the bridge from where you stood on the bridge?

A. I had a large tin can and a strap. I stood on the bridge and let the strap down to get the can perfectly full of water and then hoisted it onto the bridge.

Q. And filled the bottle on the bridge.

A. Filled the bottle on the bridge.

Q. Where did you keep the can?

A. I kept the can in the box at my own home.

Q. Now in getting those samples of water, did you get the surface water or the water underneath the surface of the stream?

A. Well, it was just as the can would fill.

6633 Q. With a mixture of both?

A. Yes I suppose so.

Q. How deep under the surface of the water would you let the can go?

A. It probably went down a couple of feet when it would get full. I would plump it or make it go down a full foot as near as possible, when it would come up.

Q. Now which side of the bridge did you take those samples from?

A. On the east side.

Q. On the east side?

A. On the upper side of the bridge. The bridge runs north and south crossing the Illinois river, which runs east and west, and I took it on the eastern side of the bridge.

Q. Was there a current there where you took the samples?

A. Yes, quite a good current.

Q. Did you have any mud on your feet or anything of that kind at any time?

A. The bridge was pretty clean and no mud would fall into the can or into it coming up. I was very careful. In fact it isn't a muddy bridge at all; it is swept pretty clean by the wind and it was taken right on the upper side.

6634 Q. The wind may have blown the dust and dirt from the bridge into the can as you let it down and pulled it up.

A. Oh, there was a possibility of course, of a particle or two of dust, but I was just as careful as I could be to get a proper sample.

Q. How many cans would you have to draw up before you could get both of your bottles filled?

A. One to rinse the can and the dipper, and then two to fill the bottles.

Q. Where did you keep the dipper?

A. With the can.

Q. Always with the can?

A. Yes sir, they were never used for any other purpose.

Q. Now you kept that at your home?

A. Yes sir.

Q. Did you use a spring wagon or a buggy or something of that kind to drive down to get the samples?

A. I used a buggy.

Q. Now where would you put the can and dipper in the buggy?

A. On the seat beside me.

Q. Now after you had drawn up one bottle of water, then you corked the bottle and put some water in them and rinsed them out?

6635 A. No, I didn't rinse the bottles out, no sir.

Q. What would you do with the stopper of the bottle while you were filling it?

A. Just generally put it on the railing of the bridge.

Q. What kind of a stopper was it?

A. A glass stopper.

Q. What was its shape?

A. It had a mushroom cover, that is, the top of it was mushroom shaped.

Q. Was the top of the mushroom cover flat?

A. No, not quite. It was somewhat rounded.

Q. You just laid that stopper up on the railing of the bridge?

A. Yes sir.

Q. How long would it lay there?

A. Just while I was hauling up the next bottle of water; I had to haul up two to get the bottles filled.

Q. Now how high is this railing on which the stopper was placed?

A. Probably three feet and a half.

Q. How close is it to the travel on the bridge?

A. The bridge is probably sixteen feet wide.

Q. How long had that railing been up there?

A. Not very long, it was a good fresh railing.

6636 Q. Was it a wood railing?

A. It was a good railing put on there.

Q. A wood railing?

A. A wood railing, yes sir.

Q. Was the railing planed or was it just in the rough?

A. It was a painted railing.

Q. Before it was painted though it was planed, wasn't it?

A. Yes, I expect so.

Q. You don't know though of your own knowledge?

A. I think it was.

Q. Now after you brought those bottles down from the bridge and filled them with water you didn't pack them in ice until you got them back up town?

A. No sir, the large bottles were not packed in ice; just the small bottles.

Q. The small bottles I have reference to.

A. Yes sir.

Q. You carried them from the bridge then about a mile up town?

A. Yes sir.

Q. And packed them at the express office?

A. No sir.

Q. Where did you pack them or take them?

A. Took them to my own house.

6637 Q. Did you always pack them immediately after you got home?

A. Right away the same morning that I got the water. They were packed and sent to the express office.

Q. How many times did you take those samples home, doctor, and find some business matter or professional call to make and be an hour or so before they would be packed.

A. No sir; I made it a point to do the work I had agreed to do and I charged them for it, and I did the work just as I would do professional work. That was my call in the morning and I attended to it just the same as I would a professional call and other things had to stop until that was attended to.

Q. Now did you take all these samples yourself, personally?

A. All except one.

Q. Who took that?

A. My son.

Q. Did you pack it and ship it?

A. He packed that and shipped it.

Q. How long would it take you to drive from the bridge up home?

A. Fifteen minutes, perhaps.

Q. Depending on the condition of the roads?

A. It is a good road.

Q. A gravel road?

6638

RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. Doctor have you investigated the water supply of the city of La Salle?

A. I have.

Q. How large a city is the city of La Salle?

A. It is a city of probably 12,000, from 10,000 to 12,000. It must be over 10,000 now. Somewhere in that neighborhood.

Q. From what source does the city of La Salle get its water supply?

A. Some of the people have private wells and most of the people get their water from a spring, or you might call it a series of springs about three miles to the eastward. The water comes those three miles in a vitrified pipe, and comes by gravity to the pumping station, and then is pumped of course through the city through mains.

Q. Where is the source of the water that goes into that reservoir, where the pumping works are located?

A. The source is about three miles east on the Illinois river bottoms, about perhaps 200 yards. Well perhaps 250 yards south of the Illinois and Michigan Canal.

Q. And where does that water come from?

A. There was a spring at that place that they called the 6639 Smith Spring, and it was first dug out and welled up and the pipe was brought into its bottom you might say; it was covered over the top with cement. It was in a bed of gravel, this spring, the water came up out of the ground and it was dug out and made larger, and then built up around and cemented over the top. It was found that the supply was not sufficient and two artesian wells were put down, and the supply from these artesian wells was run into this reservoir under this bottom into the spring, and there was a spring on the bluff about a quarter of a mile to the westward, that came down from the hill, that we call the dell. That spring was piped through below the canal and run into the same reservoir.

Q. Was there any other source?

A. Then, when we had dry weather—one year we had pretty dry weather; I think it was about three or four years ago that we had it very dry and our water supply was short, and it was late in the autumn, the water had been let out of the canal and this stream that runs into the canal about two or three hundred yards to the eastward of this spring, and a pipe was laid from that river called Crozier's Creek, and a pipe was laid from that creek through below the canal and it discharged this water into this bed of gravel and that made our supply sufficient for the time.

6640 Q. Where did this water come from?

MR. JEFFRIES: I object to the question and move to strike out all the testimony of this witness for the reason that it is incompetent, irrelevant and immaterial, and for the reason that it does not tend to prove or disprove any of the issues in this case.

A. This water of course came from the river, or Crozier's Creek, but the pipe got blocked up more or less from debris getting into it, the pipe leading from the river got blocked up so that it would not discharge the water sufficiently and some of the officials went up and punched holes in the bottom of the pipe as it crossed into the bottom of the canal and let canal water in, and so it discharged canal water instead of water from the river.

Q. What proportion of water from the Illinois and Michigan Canal entered the water supply of La Salle?

A. Well, there is a pool along the canal on the south side for quite a little distance, besides this pipe that runs out of the canal and the water collects in a large pond or pool, and from that pool there is a pipe laid to the water supply, and it is, I think, a six-inch pipe.

Q. Is there any water from the Illinois and Michigan canal
that enters into the water supply of La Salle?
6641 Objected to as leading.

A. Yes sir.

MR. TODD: Where is that?

A. That is at the place that I say—I will explain that if you wish. The Illinois and Michigan Canal stands probably ten feet higher than the ground immediately south of it, so that it has drainage through the bank, through the canal bank into this swampy place, and then that water is collected in the big pond, perhaps twice as big as this room, and there is a little bank of gravel and then there is a place walled off with brick, and the water running through that gravel into this place, in which there is a pipe leading directly from that to the water of Smith's Spring, or the water supply source.

Q. What proportion of the water of La Salle comes from this source?

A. I think there must be about one-quarter of it.

Q. Is there any artificial treatment of the water from the Illinois and Michigan canal that enters the water supply of La Salle before that water gets into the water mains of the city?

MR. JEFFRIES: I object to the question as leading.

A. There is no further treatment than just what I have
mentioned. It is seeping through the bank of the canal
6642 and coming through the pipe that I mentioned, and then
it runs into this swampy place and it runs into this pond, and then from the pond between the pond and the entrance to the pipe leading to the water supply there is a little bank of gravel which is very coarse and the water rushes right through in quite large streams. You can see it coming through quite distinctly.

Q. How thick is that gravel?

A. I think not more than three feet.

Q. Are you acquainted with the general conditions of the public health of La Salle?

A. Fairly well.

Q. Is there any typhoid fever in the city of La Salle?

A. I know of only four cases in the hospital and another on Canal Street and two others in the eastern part of the city.

Q. Have you investigated the source of those cases?

A. Two of them seem to have originated in the city of La Salle; the other two came from the outside.

Q. Those in La Salle, do you know what water they used?

A. Two of them were using city water as far as I could learn, that is two of those families. The others as I say came from the outside.

Q. Do you know what the mortality statistics of La Salle are for typhoid fever during the last two or three years?

6643 A. No, I couldn't tell you exactly; there were quite a number of cases that were brought into La Salle for treatment, from the south side, from Portland, Oglesby and Jones. They were brought into the hospital for treatment; then some of them were treated at home. Of course they belong to our La Salle district you might say, but they didn't use La Salle water.

Q. I mean the citizens of La Salle as a town?

A. We have been comparatively free from typhoid fever for a number of years.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How long has the water system of La Salle been in its present condition?

A. Well I will say in its present condition not more than about a year and a half I don't think; that is what you might call its present condition where the water is running directly out of the canal. Of course there was a certain amount of seepage before, but during this time I think, that it was broken, about a year and a half.

Q. Was that done by authority?

A. It was done by some of the authorities of the city I believe. I don't know just what authority they had.

6644 Q. Was it done by the authority of the Board of Health?

A. No, I don't think the Board of Health would give any authority of that kind.

Q. Would you recommend that water, doctor?

A. No sir, I would not.

Q. For domestic or household purposes?

A. No sir.

Q. Or for drinking purposes?

A. No sir.

Q. Now before this water gets into the supply of La Salle, it comes out of the canal into this swamp as I understand it?

A. Yes sir.

Q. Now this swamp is a kind of a bed of gravel, isn't it?

A. Yes, more or less, but there is a good deal of mud of course.

Q. And it spreads out all over that bed of gravel?

A. Yes sir.

Q. Now how large an area has that place where this water comes out and spreads out before it gets into the pond?

A. It must extend probably at least 100 feet. That is in the district that would affect Smith's Spring; it must be 100 feet.

Q. 100 feet wide?

A. About 100 feet.

6645 Q. How far does it have to travel over that swampy place?

A. This pond is not more than from 50 to 75 feet from the canal bank.

Q. Now then doctor, do you know the character of the soil to any considerable depth under the surface of the earth, where this water flows over?

A. It is gravel.

Q. And swampy?

A. Well, it is a part of the Illinois river bottom.

Q. Has it gravel and sand?

A. It has gravel and sand, yes. The bottom-land there is gravel, and mixes with the mud of course, and sand.

Q. Now does this pipe that runs the water from the canal into this stream, is it above or beneath the surface of the earth?

A. It comes out. You can see where it comes out on the surface.

Q. At the edge of the canal?

A. Yes, at the edge of the canal, down below.

Q. You can see it seeping out along there?

A. It runs out quite freely.

Q. Then it percolates on through that sand and gravel about 50 or 75 feet until it reaches the pond?

A. Well, it goes largely on the surface to the pond.

6646 Q. Now after it gets into the pond, there is a consideragle bed of water there, isn't there?

A. Yes, twice as big as this room.

Q. How deep?

A. I should judge not more than four or five feet deep.

Q. That was put there perhaps?

A. Yes, that was dug there perhaps. That was done more for the purpose of catching the spring water than anything else.

Q. Now what water was it put there originally to catch?

A. Well, to catch this water that came through.

Q. All the water that seeped through.

A. Well they had a pipe you know, leading from the river, and I could never understand why they couldn't run that pipe from the river directly into the water supply if they wanted that.

Q. This pipe originally ran from the river?

A. It came from the river.

Q. How far is the river from this point?

A. The river runs into the canal just a little above, a short distance.

Q. Then they run the water from this pipe into this sandy place—

A. And the intention was and they did for a long time, have no other way of getting into this Smith's spring, 6647 except through this bed of gravel that runs between that and Smith's spring, probably 250 or 200 yards away, but some foolish men, I might call them, thought they would have it a little more direct and they made this pond and run the water direct from that to Smith's spring.

Q. Now you say it is your judgment that about a quarter of the water at present comes into this supply through that source?

A. Yes, I think it must be about that.

Q. Are you connected with the water department in any way?

A. No sir.

Q. You just give what your judgment is?

A. Yes sir.

Q. With reference to it?

A. Yes sir.

Q. You haven't measured it or anything of that kind?

A. No sir.

Q. Then it is more of a guess than anything else?

A. Yes sir.

Q. Taking into consideration your knowledge of the situation there?

A. Yes sir.

Q. What other source of supply have they besides this one and the spring in there?

6648 A. Well, there is a spring below that first pipe leading from the spring on the bluff, through below the canal directly into Smith's spring.

Q. Now are there any driven wells there?

A. There are two, but not driven wells, they are artesian wells.

Q. Are they operated by the city?

A. They are flowing wells and they flow into Smith's spring.

Q. Do you know what volume of water they furnish daily?

A. No, I couldn't tell you the amount, but it is quite copious, a large supply. They do a great deal of pumping.

Q. Now what is the city doing to abate that difficulty in the water system?

A. They are digging wells on the bottoms to the south of the city.

Q. Is the city doing that?

A. The city is doing that, yes sir.

Q. With a view of getting rid of this other source?

A. Yes sir.

Q. That is the broken pipe?

A. Yes sir.

Q. The water has been condemned, has it not by your local authorities?

6649 A. The water we are using now?

Q. Yes.

A. Yes, it isn't counted good.

Q. Are you engaged in active practice there at La Salle, doctor?

A. Yes sir.

Q. How many physicians have you there?

A. Well we have generally over ten, ten or twelve I think.

Q. Now you say you have four cases of typhoid fever at La Salle?

A. Yes sir.

Q. Are they under your charge?

A. One of them is.

Q. Do you know of any others who have had typhoid fever there in the last three or four months?

A. Yes sir.

Q. More than now?

A. No I don't think so.

Q. There might be a great many other cases might there not that you haven't information on?

A. There is a possibility, but I made inquiry of the physicians yesterday and I spoke to quite a number of them, asking them if they had any cases of typhoid.

Q. How long have you been practicing medicine?

6650 A. Since 1867.

Q. What school do you belong to?

A. The regular school.

6651 J. W. MILLER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. J. W. Miller.

Q. What is your address Mr. Miller?

A. I live just now in Joliet.

Q. Where is your place of business in Joliet?

A. I am a guard in the State's Prison.

Q. Mr. Miller, did you ever collect samples of water for the Sanitary District of Chicago?

A. The Health Department of the City of Chicago; Dr. Reynolds I believe I got it from.

Q. Where did you collect the water for the sanitary district?

A. In the Illinois river at Morris, Illinois.

Q. When did you begin the collection of samples of water?

A. Well it was in the summer of 1900.

Q. Did you collect any water there in 1899?

A. Yes, it was in the summer of 1899 and on through 1900.

Q. At what point in Morris, did you collect samples of
6652 water?

A. Just south of the town, the Illinois river runs alongside of the city.

Q. How often did you collect samples of water?

A. Once each week.

Q. How many samples of water did you collect?

A. I collected and shipped three samples, two bottles in each sample.

Q. To whom did you ship the samples, Mr. Miller?

A. One to the University of Illinois.

Q. Professor Palmer?

A. Yes, sir, and one to the University of Chicago and I think one to the Health Department.

Q. Of the city of Chicago?

A. Yes sir.

Q. From whom did you get the bottles in which you took the samples?

A. They were shipped to me by those parties I shipped them to.

Q. How did they get to you at Morris?

A. Through the United States Express office.

Q. In what condition were they when they got to you?

6653 A. Well, the large bottle and the small one were in a wooden packing case divided into two compartments.

Q. When you received the bottles the stoppers were in them, were they not?

A. Yes sir.

Q. How did you proceed to fill those bottles?

A. I took them to the river as they were, in the case. I arrived there and sometimes took a boat and sometimes went out on the ice and a few times I went on the bridge, but nearly always in a boat or on the ice. I would remove the stopper from the bottle, put some water in it and rinse it out. Put in the stopper and put it in the water; take the stopper out and let it fill and put in the stopper again. That was when I was in the boat or on the ice. When I was on the bridge I would draw it up and fill it.

Q. After you got the bottles filled and the stoppers inserted what would you do then with the sample?

A. The large sample, I put it in its compartment and packed some excelsior about it; the small sample, I packed it in the small can with cotton around it; placed the tin cover on; put some ice in the larger can, put in the small can, and filled it up with ice. Put on the cover; put some excelsior around it, and they were sealed. This ice wasn't always packed
6654 out there.

Q. When was it packed?

A. Well, within a half an hour.

Q. Now after you had packed the samples, what else did you do, if anything?

A. There was an envelope and some printed slips that had blank spaces in them, the temperature, the height and distance, and there was an envelope with the address of the parties to whom I was to ship them, and some printed slips with blank spaces left for temperature, and the height of the water and some other things. I would put the slips inside the envelopes seal the envelope and attach it to the sample.

Q. I show you a slip printed at the top "Stream Examination, Chicago Sanitary District, Sample of Water, Sample No. 1356," and on the back of which are printed instructions for collecting and sending samples of water for analysis. I will ask you to look at that and state whether that is in your own handwriting or not?

A. Yes, sir.

Q. Is that a sample of the slips you used in sending the water to the different men to whom you sent the water which you collected?

A. Yes, sir, it is.

6655 Q. Did each slip which you attached to the samples contain the sample number, the date, the time, from whence the water was taken, collected by (with your name written in as collector) height of water; temperature of water, direction of wind, temperature of air, rain, similar to the tag that I show you, sample No. 1356?

A. Yes, sir.

Q. Did you attach a card similar to this to each one of the samples that you collected, and made by yourself, correctly stating the conditions?

A. I did.

Q. The same as in this card?

A. I did.

MR. TODD: I ask to have the tag, sample No. 1356, marked Sanitary District of Chicago's Exhibit 19 for identification.

So marked by the Commissioner.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Where was it you took these samples?

A. Illinois river at Morris, Illinois.

Q. How far above or below Morris?

A. Just opposite the town.

Q. Is there a bridge there?

A. Yes.

6656 Q. At what point in the river did you take them?

A. Near the center of the river.

Q. At the bridge?

A. Above the bridge, usually. Above the bridge always excepting a part of the time when I had to go upon the bridge to get the samples.

Q. How would you get out there to take them, in a skiff?

A. In a skiff when I could get out there, and other times on the ice.

Q. You would dip the bottles down under the water with your hands, would you?

A. Yes, sir.

Q. You took two kinds of samples, a large bottle and a small bottle?

A. Yes, sir.

Q. Where did you get the bottles?

A. At the express office.

Q. Now, how far did you carry them before you got down to the point where you took the water?

A. I should think about 60 rods.

Q. Did you open the box up, the packages that contained the bottles, at the express office?

A. No, sir.

6657 Q. You took them along with you?

A. Took the whole outfit.

Q. Did you take the ice with you?

A. Sometimes; not always; sometimes I had the ice there.

Q. Right there at the river?

A. Right there.

Q. But otherwise you didn't take it?

A. No, sir.

Q. Now, then, did you rinse the bottles?

A. Yes, sir.

Q. How would you do that?

A. Dip the bottles down under the water, filled them and turn the bottle up and shake it out and put in the cork or stopper, then go ahead and take the sample.

Q. Now, then, after you opened the packages containing the bottles, when did you remove the cork or stopper?

A. Why, at once.

Q. Before you put the bottle down under the water?

A. When I went to rinse it out, yes.

Q. You first took the stopper out and put the bottle down under water?

A. When I went to rinse it, yes.

6658 Q. Then you would take it out, rinse it, pour that out, and put it down and fill it?

A. Put the stopper in first.

Q. And shake it?

A. And sink it.

Q. Then you would do what?

A. Then sink it and pull the stopper out and let it fill.

Q. The first time when you went to get the water in the bottle to rinse it, you took the stopper out before you put it in the water?

A. I think so.

Q. Now, then in putting that bottle down under water, how far did you put it down?

A. Well, below the surface, six inches to a foot, I should think.

Q. Did you put the mouth of the bottle down or up?

A. Down.

Q. Then, some of the surface water would naturally run into the bottle, wouldn't it?

A. When I would rinse the bottle it would.

Q. But not when you filled the bottle for shipment?

A. No, the stopper would be in it at that time.

6659 Q. Was the stopper always in the bottle when you selected the sample that you took?

A. I think so.

Q. Do you know it to be so?

A. I calculated to follow the directions as near as possible, and that was the direction and I believe I did.

Q. Now, then, how many samples did you take at each particular place; how many bottles did you usually get at a time?

A. I would say three large and three small bottles.

Q. Now, after you got those bottles and put them in a box again you carried them up to the express office?

A. No, sir, I didn't take them to the express office; not always. If I had the ice there so as to finish shipping at the river, I would take them directly to the express office.

Q. That is in the winter time if you had the ice there?

A. Yes, sir; when I didn't have, I had a place where I took the bottles and had some ice delivered there and packed them in ice there.

Q. Now, where was that place?

A. About half way between the river and the express office.

Q. Now, how far was that?

A. About thirty rods.

6660 Q. You mean this place was about thirty rods from where you took the sample?

A. Yes, sir.

Q: And it was about sixty rods then from the express office to the river where the samples were taken?

A. Yes, sir, that's right.

Q. Now, when you removed the stopper from the bottle, preparatory to getting the water to rinse the bottle, where did you put the stopper, I mean the cork?

A. Yes, I know what you mean. I would just lay it down on the big end of it.

Q. Just any place?

A. If I had a boat I would lay it upon the boat seat. If I was on the ice I would lay it down on the ice.

Q. How long would it take you to get the samples, and before the ice was put around them, an hour?

A. I don't think as long as that. I don't think I was three-quarters of an hour at the outside.

Q. Did you take all those samples personally yourself?

A. Yes, sir.

Q. Every one of them?

A. All of them.

Q. Anyone assist you?

6661 A. No, I did the work myself; I had a man to haul the samples for me.

Q. I mean the physical act of getting the sample collected?

A. I did it myself.

Q. Did this fellow with you ever hold the stopper?

A. I couldn't say to that. He might possibly have had the stopper in his hand.

Q. Did you see him pick up the stopper and play with it in his hand?

A. I don't know whether he did or not; I wouldn't say that he did not; it would be an unusual thing if he did. He didn't bother with the business.

Q. You say it would be an unusual thing if he did?

A. Yes, I think so; he was there simply to haul the stuff.

Q. How often did you take these samples?

A. Once a week.

Q. Running through what period?

A. Oh, I don't know exactly, but along in the summer of 1899 and from that until the fall of next year.

Adjourned until 10:00 a. m., September 23, 1903.

6662 September 23rd, 1903. Parties met pursuant to adjournment, at 10:00 a. m.

Present, the Commissioner and same counsel representing the respective parties.

PROF. JOHN H. LONG,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. John H. Long.

Q. What is your business?

A. Teacher of chemistry, Northwestern University, Chicago.

Q. How long have you been connected with the Northwestern University?

A. Twenty-two years.

Q. What did you do prior to that?

A. For one year prior to that I taught;—the first year prior to that I taught in the Wesleyan University at Middletown, Connecticut, and for seven years prior to that I was
6663 engaged in the study of chemistry.

Q. At what institutions?

A. For four years, from 1873 to 1877, in the University of Kansas, and from 1877 to 1880 in the German Universities of Teubingen, Wuerzburg and Breslau.

Q. Where were you born, Professor?

A. Near Steubenville, Ohio.

Q. Have you held any positions in any scientific organizations or societies?

A. I am a member of a number of the American and foreign scientific societies and have been president of Section C of the American Association for the Advancement of Science; and at the present time I am president of the American Chemical Society.

Q. What is the American Chemical Society?

A. The American Chemical Society is an organization of American chemists, made up largely of professional men and teachers in the various institutions, and industrial chemists, with a membership of about 3,000.

Q. Are you the author of any books on the subject of chemistry?

A. I have written several books in general on analytical chemistry.

Q. Any other books?

A. These comprise all of the original publications that 6664 might be called books. I am translator of a large German work on optical chemistry.

Q. What branches of chemistry have you given special attention to in your studies?

A. My work has been mainly in the line of sanitary and medical or physiological chemistry.

Q. What do you mean when you employ the term "Sanitary chemistry?"

A. Well, I mean that kind of chemistry which has to do in a general way with the questions of public health. That is, examinations of water and air and milk and food supplies of all kinds.

Q. Have you had any connection with any of the boards of health in the state of Illinois or the cities of Illinois?

A. For a number of years I was chemist of the board of health of Chicago.

Q. When was that?

A. Between 1885 and 1890 or 1891, I have forgotten the last date. Since 1885 I have been chemist of the Illinois State Board of Health.

Q. What are the duties of the chemist of the State Board of Health?

A. The work which I have done for the Illinois State Board of Health, has been almost wholly in the line of water

6665 examinations. I have made in addition to these, some examinations of poisons for the board. The work has been very largely the examination of water.

Q. Have you made a special study of water analyses?

A. I have.

Q. When did you begin the study of water analysis?

A. Well, the subject of water analysis I took up while I was a student; but practically in an experimental way, after coming to Chicago, and in the summer of 1882 I made the first practical examinations.

Q. How long were you connected with the Board of Health of Chicago?

A. About five years.

Q. When did you begin work for the city?

A. My regular work for the City Board of Health began in the summer of 1885.

Q. What was the nature and character of the preliminary tests and investigations made by you of waters in Illinois?

A. The first examinations of water that I made in Illinois were in connection with the study of Lake Michigan beginning in 1882. I made numerous tests of the water from the various pumping stations, beginning with Evanston on the
6666 north, and Chicago avenue particularly, and later from the Hyde Park station. These first investigations were not official, but were taken up through my general interest in the question of the lake supply. I gave a portion of my time as instructor in the College of Liberal Arts of our institution at Evanston and there became acquainted with the varying conditions of Lake Michigan water, and was led to take up these investigations because of the very general complaints of the character of the water of that place, the supply being drawn from a point pretty near the shore. So, I began at that time rather an extended series of tests, carried on in the laboratory of my own motion. Later, some tests were made of the water taken at the city inlets I mention, particularly Chicago avenue and Hyde Park. This work was all preliminary to the work taken up by the City Board of Health in 1885. At that time the character of the water had become so altered here that an extended series of investigations was decided on and these were begun and continued for some years.

Q. You were acquainted with the condition of the Illinois and Michigan canal?

A. I was.

Q. When did your acquaintanceship with the Illinois and Michigan canal begin?

6667 A. As far back as 1883 or 1884,—I cannot give that date exactly, but a year or two before the beginning of these regular analyses. The difficulty with the lake water was recognized of course, as depending largely upon the water flowing out from the Chicago river, which in turn depended on the efficiency and flow in the canal; so I gave very early attention to the canal and to the sources of the water going into the canal.

Q. Are you acquainted with the history of the Illinois and Michigan canal?

A. Yes, in a general way.

Q. Do you know where the Illinois and Michigan canal begins and where it ends?

A. The Illinois and Michigan canal begins in a part of Chicago which is commonly described as Bridgeport. It begins at the pumping station which is very near the corner of Ashland avenue and 31st street, a little north of 31st street and a little east I believe, of Ashland avenue. It runs in a southwesterly direction connecting above Joliet with the Desplaines river; being led off again it follows down the north bank of the Illinois river to a point below LaSalle, where it connects with the river finally. This canal in a general way has been in operation since about 1850 or a little before, and was fed intermittently 6668 by pumps from the Chicago river, and to some extent by an old feeder known as the Sag feeder, the water being taken from the Calumet near Blue Island. This canal was so supplied for a good many years, until about 1866, the flow being small. Then it was decided to deepen it, enlarge it, and this was done about 1871, the work was completed about that time, the intention being to produce a gravity flow to carry over 30,000 cubic feet a minute,—30,000 to 35,000 cubic feet. This gravity flow began in 1871 and continued until after my examinations begun here, so I am familiar with those conditions, and continued until 1883 or 1884. By that time it became so filled with sediment that the flow was extremely uncertain. It very often did not exceed 10,000 cubic feet a minute, and with variations in the direction of the wind it was probably at times less than that, so that as a matter of fact the Chicago river was practically stagnant in those days. In 1884 as a consequence of the very general discussion and complaint of the people here, the present system of pumps was established at Bridgeport and these were intended to maintain a flow of fifty or sixty thousand cubic feet a minute. As a matter of fact the flow probably never reached 50,000 during the period in which they were operated. It is altogether likely that the flow did not average above 35,000 or 36,000. I speak of this because I several times went with committees of engineers and city officials to investigate the thing and we never could determine that the flow reached the volume which was claimed for it, so it is safe to say on the average it was much below 40,000 cubic feet all the time. 6669

MR. JEFFRIES: We move to strike out all the witness' answer to the last question and move to strike out the question as well with reference to the Illinois and Michigan canal for the reason that it is irrelevant, incompetent and immaterial and has no bearing upon any issue involved in this case and does not prove or tend to prove any issue involved.

MR. TODD: Where did the Bridgeport Pumping Works pump the water from that entered the Illinois and Michigan canal?

A. The Bridgeport Pumping Works pumped the water from the south fork of the Chicago river into the canal.

Q. When did the Bridgeport Pumping works begin operations?

MR. JEFFRIES: I object to the question for the same reasons stated in my motion to strike out the previous question and answer.

THE WITNESS: The present pumping system was begun in 1884.

6670 MR. TODD: What was the condition of the Chicago River at the time that the Bridgeport Pumping Works began operation in 1884?

A. The Chicago river at that time was extremely foul and practically stagnant for several reasons, which perhaps I ought to explain. In 1871 a systematic attempt was made to divert the sewage of the stock yards into the south fork. A large sewer which is known now as the Brennock sewer was constructed to drain from practically all of the packing houses and to divert and carry the water from those packing houses to the so-called stock yards slip. The amount of filth carried down in that sewer increased enormously for a number of years. Some years after 1871 a contract was given to Mr. John Brennock to take charge of that sewer and see that it was not allowed to clog up. The material was thrown out into the slip, and found its way, a good deal of it, into the river. Mr. Brennock carried that work on for some time as he was directed to do, but later put in a series of settling basins and wiers in the sewer unknown to the stock yards authorities. This is a matter of a great deal of importance as bearing on the amount of stuff which got into the river, so that I ought to explain the facts, as I am familiar with them personally. Mr. Brennock put in these series of settling basins and wiers, which he operated at night. He 6671 had a number of men who were employed by him privately, to take out an immense amount of grease and paunch waste, and practically everything which came out of the yards. To begin with, at the start nearly the whole of the stock yards sewage was discharged directly into the slip, but when his private system was brought into practical operation it took out the greater part of the solid waste. Later, when that fact was discovered, the packers themselves undertook to retain this stuff in or near their works by putting in similar systems. This of course would have a very considerable bearing on the amount of stuff that got away from the yards. In the early days very nearly the whole of that got into the slip and occasionally caused greater pollution than we have ever had since from the yards. From the days of Brennock to the present time there has been a gradual modification of the methods followed by the packers in discharging the filth into the river, so there has been a gradual decrease as shown by the various analyses which have been made at different times. By these wiers and settling basins it was possible, however, to retain only more or less insoluble and solid substances. Anything which passed into the sewers in a dissolved condition, extracted from the beef,—beef extract, escaped and finally got into the river. The amount of stuff

6672 which now escapes is largely of that character owing to the conditions improving from the days of Brennock to the present time. Practically the whole of the solid substances are removed, but when these pumping works were established that condition was not perfected and the river was foul very largely from the filth coming down in that way. Then another item of importance tending to foul the river and the lake is this: west of the city of Chicago is a small stream, small in dry weather, known as the Desplaines river. It drains a very large area and at times of wet season, at times of high water, the volume that comes down that river is very large. Ordinarily the stream flows southwest and enters finally the Illinois river, but in times of high water instead of taking that course a very large portion of it always overflows, or always did overflow, a low watershed west of the city and drained down into the Chicago river at a point near the Bridgeport Pumping Works. Within my own recollection I have seen hundreds of acres in the western part of the city flooded from that stream. Attempts were made on the part of the city to prevent that flow of water, and on the part of the land owners west, to increase the facilities in order to drain their land. As a matter of fact, on a great many occasions the dam at the head of the Ogden ditch, a name which is familiar to all of our old citizens of Chicago, was cut by the land owners permitting this flood of waters to
6673 go down and flow into the Chicago river and practically wash everything out into the lake. That was the case before 1884 and even after the establishment of the pumps it was frequently the case. When the Desplaines river overflowed its banks, or the dam was cut, there was a big flood of water coming down and entering there, sweeping everything into the lake. The pumps working at a maximum capacity in those days of 35,000 cubic feet per minute or 50,000 as was claimed, were quite inadequate to direct that flow of water, which, at times, flowed out into Lake Michigan unchecked, causing greater contamination. Those conditions were commonly known and recognized and discussed for several years.

MR. TODD: What other sewers emptied into the Chicago river except the ones you have described?

MR. JEFFRIES: At what time are you speaking of?

MR. TODD: From 1884?

A. The putting in of the pumping works and the stock yards sewer as far as the amount of filth discharged was of course most important. Further, two large sewers drained the same section of the city, the southern section. One is known as the Halsted Street sewer, which empties into the stock yards slip, which is north of the stock yards, approximately at the corner of 39th street and Halsted street, and another is
6674 known as the Western Avenue sewer, which in those days, however, drained a limited area, but which has since become a very important sewer. At that time another very important sewer was the 39th Street sewer which emptied also into the river. All of the west side was drained into the river in those days, and as at the present time, a large part of the south side and a large part of the north side also. Then, as now, in other sections of the north and south side most of the drainage was towards the lake. The sewer at 31st street and the big sewer at 22nd street discharged a very large volume of water into the lake.

Q. Are you acquainted with the gravity flow of the sewage system of Chicago?

A. In a general way, yes. Practically all of the sewers are gravity sewers. They were in the early days and are yet. Omitting a number of sewers which are pumped,—and they are few—practically the whole of the sewage is discharged by gravity and because of the general level condition of the city the flow is very slow and the sewage remains a long time in the sewers.

Q. Then what was the character of the water pumped by the Bridgeport Pumping Works into the Illinois and Michigan canal beginning in 1884 and down to 1900?

A. The water pumped into this canal was essentially the sewage of the city. The pumping works were practically
6675 adequate to counter-balance the tendency of the river to flow into the lake. In other words there was practically no current into the lake, so that the water pumped at Bridgeport corresponded to the sewage of the city.

Q. Are you acquainted with the history of the public agitation in regard to the contaminated water of Lake Michigan?

A. Yes, I have had some acquaintance with it from as far back as my residence in Chicago, since 1881.

Q. Are you acquainted with the work done by Dr. Rauch of the State Board of Health, and investigations made by him in regard to the studies of sanitary conditions existing?

A. I am.

Q. Who was Dr. Rauch?

A. Dr. Rauch was for many years, twelve to fifteen years at least, secretary of the State Board of Health, and a large part of his interest and activity was given to the subject of drainage of Chicago. He was one of the first of our Illinois men to take up the question of the disposal of the sewage in Chicago in some way, and suggestions which he made even before 1880, in the circulars and bulletins of the State Board of Health, were among the first and most important which led finally to a solution of the problem. His recommendations were practically followed in much of the subsequent engineering work.

6676 Q. Was the question involved in the sanitary condition of Chicago and its water supply, ever publicly discussed at any meetings?

A. Yes, it was the subject of very frequent discussion. Frequently in the meetings of the Chicago Academy of Science, for example, which I always attended, and took part in those discussions. They began even before 1885. This question was also discussed at the time of the first water-way convention, the large water-way convention, which was held in Peoria in 1887. While most of the formal addresses were given on the question of a deep water-way, the discussions in committees and the smaller bodies were very largely on the point of the disposal of the sewage of Chicago. I was a delegate to that convention and I was taken there at the instigation of Dr. Rauch, to be able to help to discuss that fact.

Q. Is Dr. Rauch living?

A. No sir, he is not. Dr. Rauch died seven or eight years ago. This general question of the disposal of the sewage of Chicago was discussed also at a very large meeting at Springfield in the following year,—1888. A meeting which was attended by health officers and sanitarians and public officials from all over the state. The meetings were held at the capitol building.

Q. Was there an organization known as the Citizens' Association?

A. At that time in Chicago, in those days, a voluntary organization known as the Citizens' Association, which
6677 was very active in stirring up discussion on these matters.

I was at one time, as early as 1884, employed by this association to make some examinations of the sewage coming from the stock yards and other points near the Bridgeport pumps. This association was perhaps a most important factor in crystalizing sentiment in favor of the Commission which was later established, known as the Hering Commission.

MR. JEFFRIES: I move to strike out all the evidence of this witness on the question of discussion of the pollution of the water in lake Michigan and the discharge of the sewage of Chicago for the reason that it is not competent evidence.

MR. TODD: In the meeting at Peoria, in 1887, what was the character of that meeting, and by whom was the meeting called?

A. That meeting was called by the people interested in the question of deep water-way from Chicago to the Mississippi River.

MR. JEFFRIES: I move to strike out the statement of the witness with reference to the meeting and also the questio because the answer shows upon its face that it has no beari upon the question involved in this controversy.

A. (Continuing) That convention was made up of delegates from all parts of the state of Illinois and adjacent states and cities.

Q. Were there any delegates at that convention from the state of Missouri or city of St. Louis?

6678 A. There were.

Q. Who were they?

A. Personally I remember the name of Mr. McMath.

MR. JEFFRIES: I object to that for the reason that it is not shown that the convention was held with legal authority.

We de not know whether it was held by some persons interested in the deep water-way, or whether it was held in the interests of some people financially, and for the further reason that it is not a subject which is involved in this controversy.

A. I met at that time delegates from a number of cities who were particularly interested in the question of sewage rather than the question of water-ways, as I said a little while ago, that question was, among many of these men, a prominent feature of the discussion. It was recognized that the construction of a water-way canal involved the disposition of the sewage of Chicago, so that that feature of the question received the greatest publicity in the discussion.

Q. Were there any other delegates to that convention except Mr. McMath of St. Louis, from the State of Missouri?

A. Yes, there were four or five other delegates from Missouri, and delegates from Iowa and delegates from several places farther down the river,—Tennessee.

6679 Q. Who was McMath?

A. Mr. McMath is an engineer of the city of St. Louis, who has had a great deal to do with water and sewerage systems of that place, and of considerable reputation, and his name has been known in connection, for years, with this work.

Q. After the Peoria convention, were the proceedings of the convention given publicity in the public press?

A. Yes sir, they were.

MR. JEFFRIES: I move to strike out the question and answer as incompetent and irrelevant.

MR. TODD: Do you know whether the public press of St. Louis gave any publicity to the convention at Peoria in 1887?

MR. JEFFRIES: I object to the question for the same reason.

A. I have not personally seen the St. Louis papers, but it is well known that the matter was discussed in them.

Q. When was the Hering Commission, so-called, appointed if you know?

MR. JEFFRIES: I object to the question unless it states the object and purpose of the Commission.

A. The Hering Commission was established as a result of this agitation for the improvement of the water supply of Chicago and the diversion of the sewage; agitation kept up for a number of years. It was established in 1886, or appointed at that time. It began work and continued through 1887 I believe. 6680

Q. Do you know what the condition of the lake and river was at this time which led to these investigations made by this commission?

MR. JEFFRIES: Objected to because the witness has already answered.

A. The lake water at that time, at periods of dry weather, was in general, fairly good. At the time of rain, however, when the discharge from the sewers into the lake was considerable and when the flow through the river was out instead of in, the water became, at the various pumping stations, more or less contaminated, noticeably contaminated. The river for that period was practically always bad and foul.

Q. Did you make any series of investigations of the water of the Illinois river, its tributaries, the Illinois and Michigan Canal, Lake Michigan, and the Chicago river, prior to the opening of the drainage canal in 1900?

A. Yes, I have made several series of those investigations. The first investigations were on the lake water to determine the fact of its increasing pollution, the water being taken from the Chicago Avenue tunnel and from the Evanston and Lakeview tunnels, and from the Hyde Park tunnel, the two longer tunnels not having been built at that time. The waters were
6681 taken from faucets connected with the city mains, and
were also taken by myself from the lake direct, at various times, to determine the general condition of the water at various distances from the shore, the object of all these investigations being to learn the facts of the condition of the lake with reference to increasing pollution. This work was done prior to any work which I took up on the Illinois river and canal.

Q. When did you make the first investigation? In what year?

A. You mean of the lake, in 1885 I began; the summer of 1885.

Q. What is the extent of the investigation?

A. That investigation included the examination of a great many samples of water from these stations that I have mentioned, weekly examinations carried on through a period of several months at each one of the stations.

Q. Have you those examinations?

A. I have not them with me, but they can be reached.

Q. When did you make the next examination?

A. The next examinations were concerned with the river and canal water, beginning at Bridgeport.

Q. When was that made?

A. That first series of investigations was started in 1886.

6682 Q. How extensive was that investigation?

A. That comprised a study of the water samples taken weekly at a number of points beginning at Bridgeport and continuing down the river to Peoria. It comprised examinations from Bridgeport, Lockport, Joliet, Ottawa and La Salle, to Peoria.

Q. How many samples of water did you analyze at each of those points?

A. The average number as I now recall it, was about twelve samples. They were not quite all the same number in 1886, between the beginning of the investigation and the early summer and fall. I have all the dates but I don't recall them. I didn't think they were essential.

Q. Have you the analytical data compiled from these analyses?

A. Yes I have in memoranda and reports, the results of those analyses.

Q. Have the results of those analyses in 1886, the summer of 1886 and the winter of 1886 and 1887 been published?

A. They have.

Q. Where have they been published, doctor?

A. They were published in the reports of the Illinois State Board of Health.

Q. Have you the reports of the Illinois State Board of Health?

A. I have parts of these reports.

6683 Q. Including these publications?

A. I have.

Q. When did you make your next investigation?

A. Following this first series in the summer and fall of 1886, I began a second series of experiments in the winter of 1886 and 1887, taking the colder months, beginning about the first of January, the end of December, 1886 to the first of January, 1887, and this series was continued through two or three months into March.

Q. At what points along the river?

A. These investigations were carried out at the same points between Bridgeport and Peoria.

Q. How many samples of water were analyzed at each point?

A. A smaller number than through the summer; as the period of investigation was shorter, the samples averaged six or seven I believe for each place. I can give the exact number by looking it up; I don't recall it now.

Q. Were the results of these examinations published and made a matter of record?

A. They were.

Q. Where?

A. In the same reports of the Illinois State Board of Health.

6684 Q. In the testimony of the different witnesses who testified for the State of Missouri in this case, reports from the Board of Health of the State of Illinois made by John H. Long were referred to ;are you the John H. Long who made those reports which were referred to by the witnesses?

A. I am.

Q. There is no other John H. Long in the Illinois State Board of health reports, is there?

A. No sir.

Q. When did you next make an investigation?

A. The next investigations were made two years later, beginning in 1888. I will give the exact dates on that. The summer of 1888.

Q. How extensive were the investigations in 1888?

A. In the summer of 1888 beginning with May 1st, and continuing into the fall and ending about the middle of November, I made along the river 650 chemical examinations, beginning with Bridgeport and including the same places included in the previous examination, but continuing below Peoria to the mouth of the river at Grafton.

Q. What points were included in the examinations of 1888. I would like to have you give all of the points?

A. I will have to refer for those to my data. I do not
6685 recall all of them. In 1888, during the period mentioned, May and the middle of November, samples were taken from Bridgeport, and Lockport, Joliet, Morris, Ottawa, La Salle, Henry, Peoria and Pekin, near the mouth of Copperas Creek in the Illinois river, Havana, Beardstown, near Pearl at the crossing of the Chicago & Alton railway, the Alton bridge as we call it, and Grafton. In that same investigation waters were taken from a number of the tributaries of the Illinois; from Dupage river which enters from the north from below Joliet; from the Kankakee river which enters from the south still farther down; from the Fox river which enters just above Ottawa; from the Big Vermillion river which enters from the south near La Salle, or a little above La Salle; from the Little Vermillion river which enters from the north near La Salle and from the Sangamon river which enters across from the town of Browning; enters from the opposite side of the river from Browning. Those were tributaries of the Illinois.

Q. Did you publish the results of your analyses in this investigation?

A. They were published.

Q. Where?

A. In the preliminary report of the State Board of Health, published and printed in 1889.

6686 Q. Did you make any subsequent investigations?

A. I did, but before going into that, I want to add a word of explanation about this preliminary report. This preliminary report was brought out by the Secretary of the State Board of Health for the use of some committee of the Springfield legislature in a very great hurry. The work of printing the report was begun but a few days after the completion of the last analyses, so that the work must be regarded only as of a preliminary character, and while the details were complete, the text and explanatory matter was comparatively meagre. The full report which was put in the hands of the secretary, in some way was lost and was never printed. The details are substantially completed here, but the report itself is not. That explanation is due the secretary of the State Board of Health, Dr. Rauch, and myself, to account for the peculiar character of this work. It was brought out in two or three days very hastily.

Q. The detailed analyses published in that report are correct are they not?

A. They are essentially correct as far as I could read the proof and correct the figures in the two or three days. The averages are practically all correct.

Q. When did you next make an investigation of the water in the Illinois river and its tributaries?

6687 A. The next investigation was of the sewer water in the neighborhood of Bridgeport. The intention of that investigation—

Q. Let me call your attention, Professor to this, did you not make an investigation in the winter?

A. Well, that should be mentioned as following this other. This investigation I have described was made in the late spring and summer and fall of 1888, and that was followed in the winter of 1888 and 1889, by another investigation, and the waters were collected at essentially the same points to determine the winter conditions of the river. I should have included them as one series.

Q. How many samples of water were analyzed in this investigation?

A. Ninety-six.

Q. Were the results of that series of analyses published?

A. They were.

Q. Where?

A. In the same report of the Illinois State Board of Health printed in 1889.

Q. Is that the so-called preliminary report to which you referred?

A. It is called a preliminary report.

6688 Q. Are the details and averages as published in that report correct?

A. They are essentially correct. The averages so far as I am able to determine by comparing with the originals are correct.

Q. When did you next make an investigation?

A. The next investigation was made in Chicago of the water in the neighborhood of Bridgeport pumps, in the winter of 1890 and 1891.

Q. At what points were the samples taken for this investigation?

A. The object of that investigation was to show the relative amounts of pollution coming from the stock yards and from the rest of the city. Therefore, samples were taken at points which would best show that. They were taken from the large sewers leading from the stock yards, and from the so-called Brennock sewer which I spoke of a little while ago, which enters the stock yards slip, very near Center Street, practically at Center Street; from the Ashland Avenue sewer which enters the south branch of this south fork some distance west of the stock yards slip, and from the Halsted Street sewer which enters the slip at Halsted Street just mentioned. Water was also taken from the 39th Street sewer, and from a point north of where the water is diverted from the main river, going
6689 to the Bridgeport pumps. Samples were marked "Main Street;" I cannot describe it more closely, but these samples included the bulk of the sewage, or represented the bulk of the sewage outside of the stock yards sewage.

Q. In the collection of the samples in the investigations heretofore made in 1886 to 1891, I wish you would take up each series of investigations and describe fully how the samples were collected and delivered and where analyses were made.

A. The samples through the series of 1886 were collected by Dr. Rauch of the State Board of Health,—secretary of the State Board of Health, through the health officers of various towns, which sent the samples. They were sent in jugs and and packed in boxes in sawdust or excelsior.

MR. JEFFRIES: I object to the witness testifying any further in reference to this question, for the reason that he doesn't know personally how the samples were taken, according to his own statement.

A. These samples were collected by Dr. Rauch as I explained, through his health officers, the directions for the collection being given by myself in a written or printed circular. Directions were given regarding the selection and cleansing of the jugs and the packing and corking of the jugs and the ship-

ping of them. In the first series of analyses in 1886,
6690 the water were sent to me at the laboratory of the old
Chicago Medical College, the institution now known as the Northwestern University Medical School, then located at the corner of 26th Street and Prairie Avenue in this city. The samples collected in the following fall investigation and winter investigation of 1886 and 1887 were collected by the same individuals mainly and collected in the same way, shipped in the same way and to the same place. The names of those collectors are given I think, in all cases in that report already referred to. In the series of analyses made in 1888, the same general method of collection, packing and shipping was followed, the samples being delivered however, to the laboratory of the Northwestern University School of Pharmacy, of which I had charge, the chemical laboratory, then located at 40 Dearborn Street in this city, being the southwest corner of Lake and Dearborn. The samples collected and analyzed through the winter of 1888 and 1889 were taken with the same authority, the Secretary of the State Board of Health and sent in the same way and analyzed at the same place, the College of Pharmacy, corner of Lake and Dearborn Streets. The collections through 1890 and 1891, of the sewer water, were made under my direction by methods suggested by myself, by employes of the Sanitary District
6691 of Chicago and were delivered to, and analyzed at the
laboratory last mentioned, being the laboratory of the College of Pharmacy, on the corner of Lake and Dearborn Streets.

6692 Q. In the analyses heretofore mentioned, from 1886 to
1890, what was the purpose of these investigations and analyses?

A. The purpose of these analyses was to show the effect of the discharge of the sewage from Chicago on the Illinois river.

Q. Will you describe in detail the method pursued by you in making these analyses and the significance of each chemical element which you discovered?

A. The analysis made of these waters was a so-called sanitary analysis, which embraced the determination of certain factors which are considered as important in showing the sanitary character of water.

The first of these is the determination of what is called the total solids of the water, that is the amount of solid substance left when a given volume of the water is evaporated to dryness in a platinum dish, and weighed. Generally for that determination 500 cubic centimeters or a liter was taken in this earlier work.

The determination of suspended matter was also made. That was made in two ways at different times. One method pursued was to evaporate some of the original water after thoroughly shaking it, and to evaporate also some of the same water after filtration through a very clean, pure Swedish filter paper, the suspended matter being left on the filter. The difference between the total solids obtained in the two determinations
6693 represents or shows the amount in suspension, or insoluble.

A number of determinations were also made by filtering some of the water through what is known as a Gooch crucible. The measured volume of the water was taken, allowed to settle somewhat, varying with the character of the water, and filtered through a Gooch crucible with light, porous asbestos bottom. When most of the water had passed through the sediment in the beaker in which the sample was allowed to settle to begin with, was poured on and washed through as a chemist washes a precipitate from a beaker in ordinary work of qualitative or quantitative analysis. This method was not always employed because while good, it was very much slower than the other, which was used finally, that is, filtering through the filter paper and making two determinations.

Third, a determination of nitrates or nitrogen in nitrates was made in these waters by a method then commonly followed by sanitarians. The evaporation of a measured volume of the water—a small volume of the water to a bulk of one or two cubic centimeters which was introduced into an instrument called a nitrometer, over mercury. The residue being brought into the instrument by the aid of some strong sulphuric

acid. In this instrument, because of a decomposition of the
nitrate, in the presence of the sulphuric acid and mercury
6694 oxide of nitrogen gas was liberated and measured. The
volume of that gas liberated being a measure of the
nitrate decomposed. That method was used before the introduction of the present simpler and more convenient methods.

The chlorine was determined in these samples by a standard method used commonly by chemists. In the more concentrated samples like the water from Bridgeport and Lockport, it was possible to make what we call a direct determination of the chlorine without previous concentration, there being enough chlorine present to be determined directly. In general I have always followed in these determinations what is known as the Volhard method in preference to a method very commonly used by sanitarians all over the country, an old method known as a chromate method.

Q. Describe the difference between those two methous, professor?

A. In the older chromate method the water, by sanitarians in general, is usually treated directly or titrated directly. A measured volume of the water is taken in a glass vessel, a flask or beaker; a few drops of potassium chromate which is called an indicator for this purpose, is added to the water and then from a measuring instrument called a burette, a standard solution of silver nitrate is run into the mixture until a certain color appears, which is due to the action of the nit-
6695 rate of silver with the chromate indicator just mentioned.
That indcates the end of the reaction or experiment, and the amount of silver nitrate used before this end comes is a measure of the chlorine in the water. Where this method is used directly on the waters low in chlorines the result, even with all of the refinements and modifications used, is too high, the ordinary eye not being sensitive enough to detect the point of the completion of the re-action, which often amounts to fifty per cent of the whole; in many cases it has amounted to over that. I therefore abandoned it as a method to be employed in water analysis for ordinary waters. I have used in preference to that the Volhard method, in which, if the water is strong in chlorine a direct titration can be made, adding first to the water

some nitric acid and then a ferric salt, preferably ferric sulphate, which is used here as the indicator. Then standard solution of silver nitrate, that is a solution of a definite strength containing a definite amount of silver nitrate which will therefore combine with a definite amount of chlorine, is added to this mixture,—that is to the water and the other things mentioned, —enough being added to more than combine with all of the chlorine present which point must be determined by some kind of a rough preliminary experiment. Then, after this
6696 excess of silver nitrate is added, the liquid is filtered from
the precipitate which forms—filtered into a clean vessel through good filter paper. The precipitate collected is washed with a little distilled water, and the excess of silver nitrate left in that liquid is measured by use of a second standard solution, —either a solution of ammonium thiocyanate or potassium thiocyanate. This solution measures the excess of silver used in the determination. The difference is the amount of silver which combines with the chlorine, and it is therefore a measure of the chlorine. That is the method which has been used in all of my late work, and as I recall, through most of the work here, —probably all.

Q. What other chemical elements did you make analyses of for the purpose of determination?

A. In these experiments I determined the so-called hardness of the water, that is the amount of certain salts of lime and magnesium in it, which decomposed soap solution, the hardness being determined by a well known simple method used by practically all analysts with the aid of a standard soap solution.

I determined further in all these waters, what is known as free ammonia, that is the ammonia which exists in the water either in the free, uncombined condition, or usually as a sort of ammonium or so-called saline ammonia. This am-
6697 monia can be liberated or driven off from water by
boiling under proper conditions a certain volume of it, with a solution of sodium carbonate; that is, with a weak alkali solution. For most of these tests a volume of 500 cubic centimeters was taken, except in the waters from the most highly contaminated points—Bridgeport, Lockport and Joliet, and perhaps a few others. Where the water is concentrated in

ammonia-furnishing material, it is necessary to start with a very much smaller volume, accurately measured, diluted with pure, distilled water, and carry on the distillation the same way. This ammonia is distilled free ammonia and is collected and measured by a method followed by chemists in general, which I do not believe needs any discussion, as there is practically the one method employed everywhere for that.

MR. JEFFRIES: We move to strike out all the evidence of this witness as to the means or manner used and employed in making the analyses of the water, for the reason that the witness has no personal knowledge or observation as to the correctness of the manner in which the samples were taken or as to whether they were taken according to instructions, and no other witness having testified, and no evidence having been offered showing that they were so taken in accordance with instructions, and therefore the testimony as to the results of such examination by the means described by the witness

6698 is valueless and does not constitute proper and competent evidence.

MR. TODD: In reply to the objection I will state that the experts at St. Louis in their testimony, adopted in part the conclusions of this witness, without giving the conclusions in their entirety, and for that reason as well as others, it makes this testimony competent.

MR. JEFFRIES: I move to strike out the objection or explanation of the counsel for the reason that it is argumentative and it should be more properly addressed to the court at the time of the hearing of the case.

Q. MR. TODD: Proceed, professor.

A. Following the determination of the so-called free ammonia, by a method used in general by chemists the next test was for what is known as albuminoid ammonia. Albuminoid ammonia is ammonia obtained by the distillation of a large number of nitrogenous organic bodies with a certain strong alkaline oxidizing solution known commonly as an alkaline permanganate solution. This solution is made up from a mixture of pure potassium permanganate and pure pottasium hydroxide in a manner which is in general followed by chemists with immaterial variations, and one suggested originally by an English chemist named Wanklyn. This ammonia is called albuminoid

ammonia because of the fact that the so-called protein or albuminous substances yield ammonia readily when dis-
6699 tilled in this way. Such bodies are types of those which yield ammonia by oxidation with alkaline permanganate solutions. The albuminoid ammonia determination as I make it, is made on the water after the distillation of the free ammonia, that is, on the water from which the free ammonia has been expelled.

Finally I made in these cases a determination of what is known as the oxygen consuming power or oxygen absorbing power of the water. The various organic substances commonly present in naturally pure or uncontaminated waters, undergo a destruction or alteration which may be called oxidation when they are boiled or treated in some way with certain standard oxidizing solutions, hence when a given volume of water is measured out and treated with an oxidizing reagent in certain amount,—a reagent of definite or known strength, and then after the boiling, the amount of this reagent left unchanged is determined, the difference, or the amount used up in the operation, is a measure of the oxygen given by the reagent to the substances in the water, which amount is commonly described by chemists as the oxygen consumption of the water.

The method which I have always followed in this determination is the so-called Kubel acid method. A measured volume of the water, usually 100 cubic centimeters is acidified with a small, definite volume of sulphuric acid—five
6700 cubic centimeters of about twenty per cent acid. The water is brought to the boiling point, being placed over a burner and heated to the boiling point and then a measured volume, known to be more than is required for the actual oxidation, of the standard solution I spoke of, which is a solution of potassium permanganate of known strength, is added to the hot water and the mixture is boiled a certain number of minutes. In all of my work the time is given in the reports as five minutes. At the end of this time the amount of this permanganate unacted on is measured by the aid of a second standard solution, that is a solution which combines with the permanganate solution and reduces it or uses up its oxygen very much as the organic matters in the waters do. By the aid of this solution we determine the residue of the permanganate and the dif-

ference shows that which the organic matter of the water used. This measures, in our usual terms, the oxygen consumption.

I want to add another word here. In all of my late analyses I have heated five minutes. I don't see here in the printed report at a glance whether it was five or a longer period. I want to be accurate about that. I will say that this is a method followed by a good many chemists and it is a standard recognized method.

All of these last measurements or tests are intended
6701 to measure what we call organic matter in the water, as
we are mainly concerned with these in arriving at the question of contamination or pollution of the water.

Q. Professor, did you make any determinations for the purposes of ascertaining the nitrites?

A. In these earlier tests no quantitative measurements were made and only occasionally qualitative measurements, for the reason that the accurate and delicate methods now used were scarcely known, or at any rate not commonly used at that time. The methods employed by water analysts were crude and not sufficiently delicate to be trustworthy. When I come to the later analyses I will tell about the nitrites.

Q. Will you state in detail how these results obtained by chemical analyses are interpreted by the chemists and what are their significance with reference to water?

A. From a sanitary standpoint the determination of total solids has ordinarily limited value, because in very good waters the total solids may be as low as, or less than 100 parts per million and may be as high as even a thousand parts per million, but if waters are known to furnish ordinarily, say 300 parts per million, and a new determination gives four or five hundred parts per million, it suggests an addition of some foreign or contaminating substance, so at times this test may
have importance, but ordinarily it does not have import-
6702 ance. The amount of suspended matter is a datum of im-
portance. Generally waters for household purposes should be practically free from suspended matters. Waters containing a large amount of suspended matter are unfit for household purposes, so we make this determination then to arrive at that condition. Nitrogen in its various forms is perhaps the most important element we have to deal with in water.

With few exceptions nitrogen is found in water as a result of the decay and decomposition and final oxidation of either animal or vegetable matter.

Nitrogen to begin with, comes mainly from the atmosphere and through the agency of plants it is taken up and fixed in plant tissue in more or less complex form. The plant dies and the substance decays. This nitrogen comes back into the soil or into the water and undergoes change there. The nitrogen compounds undergo decomposition, and the condition in which we find this nitrogen is in a way, an indication or measure of the stage of decomposition. Nitrogen of plants becomes, through the consumption of the plant by an animal nitrogen of the complex animal tissue, in time nearly the whole of it being built up in the animal body in the form of compounds known as the protein substances or albuminous 6703 substances or albuminoid—these various names are given.

Now in the metalbolism of the body, that is in the breaking down and elimination of the substances of the body, while most of the carbonaceous elements are given off from the lungs in the process of respiration, by far the larger part of the nitrogen is given off in an entirely different way, through the kidneys, with the urine in the form of two or three compounds, mainly, the most important of which are urea, and uric acid, creatine and creatinine, and this nitrogen so given off necessarily finds its way into the soil or into waters where it undergoes a series of changes, roughly described as oxidation. That is, these bodies that I have spoken of as coming from the breaking down of the animal tissue, when they reach the soil or water, undergo a further series of changes, and if these changes are not interrupted, the nitrogen is left finally in the form of free nitrogen gas, which goes back into the atmosphere or in the form of comparatively simple substances,—ammonia and oxidized bodies known as nitrites or nitrates, so it is important to determine then the condition in which this nitrogen is found, as measuring roughly the rate or stage of the destruction of the original matters from which it came. Now the nitrates represent as I say, one of the last stages in this decomposition 6704 of the nitrogenous bodies, and we therefore have the test for measuring the amounts of nitrate as a measure of the advance or the degree of the oxidation.

The chlorine is an extremely important element to be determined in most cases. Most natural waters contain very small amounts only of chlorine, this chlorine existing in the form of a chloride, usually sodium chloride, or common salt, and entering the water from the soil through which rain water percolates, to emerge finally as a spring or river or lake. Most soils do not contain much salt or chlorine, therefore the waters which percolate through these soils contain but small amounts, —usually but a few parts or even less than one part per million —from a fractional part up to perhaps eight or ten parts per million. Of course many soils may contain in certain regions near salt deposits, a much greater amount of that, but in speaking of ordinary soils it is safe to say that most of them furnish but a few parts per million of chlorine to water. In the disposition of the animal wastes of civilization, because civilized man everywhere uses comparatively large amounts of common salt, the excreted substances necessarily contain the salt, so that the determination of this element is roughly a measure of the salt excreta either by the urine or from the kitchen
6705 waste or from certain industries where salt is used, in the preparation of human food, for example. A very much smaller amount comes from the salt fed to cattle; so the determination of chlorine then in water, is always regarded by sanitarians as an important element, and also as a constant element. While nitrogen undergoes change, chlorine, being a mineral substance, is constant. It cannot be destroyed or lost. It is then an approximate measure of contamination of water by animal or household waste.

The hardness of water for sanitary purposes is important only within rather narrow limits; in my opinion, it is of very much greater importance in determining the technical value of the water, its use for making steam in boilers. In general we might say that very hard water is not very good for household use, but in the determinations made here, the question of hardness is not very important. There is no sufficient range here to have any importance.

The free ammonia determination is one of importance, because natural waters which have not come in contact with de-

composing nitrogenous matter anywhere, would not contain more than very minute traces of ammonia. Such traces perhaps might be taken up from the air, but in the breaking down of the body, protein or other substances or products eliminated from the body yield in one of the very first stages of their de-
6706 composition, ammonia, and in general in the decomposition of nitrogenous organic matters, whether they have come from the human body or from various industrial operations, free ammonia is one of the first products of decomposition to be recognized. It therefore becomes in a way a measure of the amount of this nitrogenous substance undergoing decompositon.

The ammonia which we recognize and describe as albuminoid ammonia is obtained from nitrogenous substances which have not been decomposed as far as to yield free ammonia. That is the albuminoid ammonia comes from bodies which are yet comparatively complex in their structure, and which have yet to undergo the main stages in decomposition and oxidation, so while the free ammonia is a measure of the comparatively advanced decomposition, the albuminoid ammonia is rather an indication of what is to be done yet with the nitrogenous substance which is to be broken down and oxidized.

The ogygen consumption is a rough measure of the amount of organic matter present. Nearly all the natural organic substances which can come from the breaking down of vegetable or animal tissues tend to take up oxygen, either directly or indirectly,—practically always directly. Many of them in water, through the aid of the minute plant organisms known as bacteria are gradually broken up and converted into products con-
6707 taining oxygen or in general what are called oxidized substances. Many of these bodies, if treated with an oxidizing agent,—something which will furnish oxygen, undergo a somewhat similar series of changes to that which would be brought about by the bacterial organisms if the organic matters were allowed to remain in the water; so that this oxygen consumption test then in a rough way, is a measure of the amount of substances to be still destroyed or oxidized, and it is considered as a test of some importance or value—considerable value.

Adjourned until 2:00 p. m., same day, Wednesday, September 23rd, 1903.

RECORD

The State of Missouri

vs.

The State of Illinois

and

Sanitary District of Chicago

VOL. 5

72

127
S.C

IN THE

Supreme Court of the United States

THE STATE OF MISSOURI
vs.
THE STATE OF ILLINOIS
and
THE SANITARY DISTRICT OF CHICAGO.

Original,
Docket No.

Before
FRANK S. BRIGHT,
Commissioner of the Supreme Court of the United States.

VOLUME 5.

VOLUME 5.

6708 2:00 p. m., Wednesday, September 23, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

JOHN E. THOME,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. John E. Thome.

Q. What is your business?

A. Mechanical engineer.

Q. Where are you employed?

A. At Washington Heights Pumping Station.

Q. Did you ever make any collections of water for the Sanitary District of Chicago?

A. I did.

Q. When did you make them?

A. About three years ago, I should judge; I have really forgotten the year—in 1889 I believe, somewhere around there.

Q. Did you make any in 1900?

A. Yes, there were some taken early in 1900.

6709 Q. At what point did you make the collections?

A. At the discharge of the Canal Pumping Station, about 300 feet west of the canal station probably.

Q. For whom did you make the collection?

A. For the Sanitary District. One sample to go to Chicago University, one to go to the laboratory at city hall and one to go, I believe, to Champaign.

Q. Where did you get the bottles that you collected the samples in?

A. They were delivered to me at the pumping station.

Q. By whom?

A. By a representative of Mr. Reynolds I believe.

Q. And you collected the water at that station?

A. Yes, sir.

Q. Where is that station located?

A. Ashland avenue and the old Illinois and Michigan canal.

Q. Is that what is known as the Bridgeport Pumping Station?

A. Yes, sir.

Q. How often did you take these samples?

A. Every Monday morning.

Q. Now, will you describe just exactly how you took these samples?

A. Why, I would take the bottle and submerge it with the cork in it; draw the cork, allow a little water to go in,
6710 then draw the bottle out and rinse it, replace the cork and submerge the bottle again, and draw the cork and let it fill.

Q. After you had filled the bottle, what did you do with them?

A. Sealed them.

Q. After you had sealed them what did you do?

A. Packed the small bottle in ice and the large one in excelsior.

Q. And then what did you do?

A. Tagged them for their destination, where they were assigned to.

Q. Where did you deliver them?

A. They were called for right from the station.

Q. By whom?

A. By one of Mr. Reynolds' employes, a milk inspector, I believe he was.

Q. What was his name, do you know?

A. No, I do not; he was a short, stout fellow; I could identify him, but I don't know his name.

Q. And you addressed the packages?

A. I addressed them, yes.

Q. And who were the packages addressed to?

A. One to go down to the city hall, one to the Chicago University, and the other one—I have forgotten the name
6711 now; I believe it was Champaign, Illinois.

Q. Prof. Palmer?

A. Yes, that's the name.

Q. I will show you a tag, sample number 1460, and ask you if that is in your handwriting?

A. Yes, sir.

Q. Did you place a tag similar to this tag, sample No. 1460, upon each of the samples you collected?

A. In every envelope.

Q. Did you make the proper memoranda upon the cards?

A. Yes, sir.

Q. The same as you did on this card?

A. Yes, sir.

Q. Did each card have written above in large type, "Streams Examination, Chicago Sanitary District, Sample No. ——, date, time, and where taken, collected by (with your name written in)?"

A. Yes, sir.

Q. Height of water, temperature of water, direction of wind, temperature of air, with instructions for taking the water printed on the back as in this case?

A. Yes, sir.

Q. This being sample No. 1460?

A. Yes, sir.

Q. And you attached a card similar to this to each one of 6712 the samples you collected and sent?

A. Yes, sir, it was enclosed in an envelope and sealed.

MR. TODD: I will ask to have the sample card, 1460, marked Sanitary District of Chicago's Exhibit 20 for identification.

Received and so marked by the Commissioner.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. When did you say you commenced taking samples?

A. I couldn't say positively. I kept no record of the actual date.

Q. About how long a time did you take samples?

A. I think it was close onto a year.

Q. Continuously?

A. Yes, every Monday morning.

Q. And you took three different sets of samples each day?

A. Yes, sir.

Q. And these were taken out of the Chicago river?

A. Taken out of the Illinois and Michigan canal.

Q. How far from the Bridgeport pumps?

A. About 300 feet west.

Q. Did you take them off the bridge?

A. Yes, sir.

6713 Q. What particular place in the canal did you get them?

A. Off the riprap there.

Q. The edge of the canal?

A. Yes, we had an old flat-boat up there; we turned that up and laid down and reached out.

Q. Now, you say you first submerged the bottle under the water?

A. Yes, sir.

Q. And after it was partially filled, withdrew it from the water and rinsed the bottle?

A. Emptied the bottle, yes, sir.

Q. Then what did you do?

A. Put the cork in again and submerged it, and drew the cork and let it fill submerged.

Q. Did you put the cork back in the bottle while it was under water?

A. Yes, sir.

Q. Now, did you take the cork out before you submerged it to rinse the bottle?

A. No, sir, that cork was in there all the time.

Q. Both times?

A. Yes, sir, those were the instructions and they were very explicit.

6714 Q. Now, then, after the bottle had been withdrawn from the water and while you were shaking it or rinsing it, where was the cork or stopper?

A. Put that in the boat alongside of me.

Q. On this flat-boat?

A. Yes, sir.

Q. Just laid it down on the boat?

A. Laid it on the boat, yes.

Q. How long would it remain there, two or three minutes?

A. Probably that, probably less.

Q. It varied?

A. Yes, it all depended on the time to take to shake it out and rinse it.

Q. Now, how deep under the surface of the water did you put the bottle before you drew the stopper?

A. About fifteen inches, up to the elbow generally, the depth.

Q. Where did you get those bottles that you used?

A. They were delivered there by the collector of the water; they were delivered at the station.

Q. Were they packed when they were delivered?

A. They were in cases.

Q. Now, where did you take them and put the ice in them?

6715 A. We had the ice brought there, and I broke up the ice right there and I then filled the little can full of ice, that's all.

Q. How did you take these samples in the winter time?

A. The same way.

Q. It would be frozen over sometimes?

A. No, sir; not there; not with that current.

Q. Too much current to freeze?

A. Sixty thousand cubic feet a minute; it could hardly freeze.

Q. Now, did you bring them down to the City Hall yourself?

A. No, sir, they were called for from the station.

Q. How long did they remain there before they were called for?

A. Probably two hours. Two hours at the longest.

Q. They were all called for?

A. Yes, sir.

Q. You didn't express any of them to Champaign?

A. No, sir, I had no facilities for doing it at all.

Q. How many bottles were broken before you received them, during the whole time?

A. I don't know of any having been broken, but there were quite a few broken in taking the samples and lost.

6716 Q. You broke them yourself?

A. Yes, sir, before I got used to taking out the cork properly, and lost them.

Q. What did you do when you lost the bottles?

A. We had extra ones.

Q. You had them there with you all the time?

A. Yes, sir.

Q. Where did you keep those extra bottles?

A. In a locker about eighteen inches deep and four feet wide; I kept my clothes in that while I was at work.

Q. You kept these bottles in amongst your clothes?

A. Yes, sir.

Q. Just threw the bottles in on the clothes?

A. No, sir, sat them down on the floor and hung my clothes up.

Q. Were the bottles exposed to the air?

A. No, sir, they were always corked and sealed the way I got them.

Q. But the naked bottles were not in a case or anything?

A. Yes, they were in a case, in a regular case.

Q. In the box?

A. In a regular case.

Q. Were those cases closed or open?

A. All open on top.

6717 Q. Now, did you have any of the small bottles?

A. Sir?

Q. Did you take any samples in small bottles?

A. Yes, three small and three large bottles.

Q. They were all taken the same way?

A. All the same way, yes, sir.

Q. When you took samples in the small bottles, you rinsed them out in the same way?

A. The same thing, yes, sir.

Q. And you laid the cork up on the boat in the same way?

A. Yes, sir.

Q. And you packed those in ice?

A. The small bottles were packed in ice after being sealed.

Signature waived, F. S. B., Com'r.

6718 **PATRICK O'BRIEN,**

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Patrick O'Brien.

Q. Have you a middle name?

A. Patrick William O'Brien.

Q. Where do you live, Mr. O'Brien?

A. Lockport, Illinois.

Q. Mr. O'Brien did you ever collect water for the Sanitary District of Chicago?

A. Yes, sir.

Q. And for the State of Illinois?

A. Yes, sir.

Q. When did you collect water?

A. In 1900 and 1901.

Q. Did you collect any in 1899?

A. I don't really think I did.

Q. Did you collect any water in 1899?

A. Yes, sir, I did.

Q. Where did you collect the water from?

6719 A. The Illinois and Michigan Canal and the Desplaines river.

Q. Any other place?

A. No, sir.

Q. At what point did you collect it in the Desplaines river?

A. At about 100 feet north of what is called the River Bridge.

Q. Where is that River Bridge relative to the Beartrap dam?

A. About 1600 feet on the south.

Q. And where did you collect from the Illinois and Michigan Canal?

A. On Ninth street—between 9th and 10th street in Lockport.

Q. Did you collect any water from the drainage canal at Lockport?

A. No, sir.

Q. For whom did you collect this water?

A. Mr. Reynolds, Mr. Palmer and Mr. Jordan.

Q. Palmer of the University of Illinois, Reynolds of the Board of Health and Jordan of the Chicago University?

A. Yes, sir.

Q. Where did you get the bottles from that you collected the water in?

A. They were shipped to me at the United States Express Company's office.

Q. When you got the bottles in what condition were they?

6720 A. Sealed.

Q. Now, will you just tell how you collected the water after you got the bottles?

A. Yes. I submerged the bottle in the water, took my cork out, filled it partially full and rinsed the bottle; put the cork back in, submerged it under water about six inches and let it fill; put my cork back in and raised it up and sealed it again.

Q. After you did that, after sealing it, what did you do with the sample?

A. The bottles I packed in excelsior, the large bottles, and the small bottles I packed in ice.

Q. How many samples did you take each day?

A. Six.

Q. Did you put any card on the samples?

A. Yes, sir.

Q. I will show you a card, sample number 1018, and ask you if that is in your handwriting?

A. Yes, sir.

Q. Did each sample card have written at the top in large type "Streams Examination, Chicago Sanitary District, sample of water?"

A. Yes, sir.

Q. "Sample No. ——. Date, time, from place taken, collected by (with your name, P. W. O'Brien inserted,) tem-
6721 perature of water; temperature of air; height of water,
direction of wind, rain, remarks," similar to the card that I show you of sample No. 1018?

A. Yes, sir.

Q. Did you attach a card similar to this to each sample which you collected and sent to the different parties?

A. Yes, sir.

Q. Did each card have instructions for taking written or printed on the back the same as this?

A. Yes, sir.

Q. Now, after you had taken them out and put this card, or a card similar to this one I have, just shown to you, marked sample No. 1018, what did you do with the samples?

A. I took them to the express office and billed them out and sent them by express.

Q. How long from the time they were taken before you delivered them to the express office?

A. Possibly an hour.

MR. TODD: I will ask to have the card, sample No. 1018, marked Sanitary District of Chicago's Exhibit No. 21 for identification.

Said card so marked by the Commissioner.

6722 CROSS-EXAMINATION, by Mr. Jeffries.

Q. What is your business, Mr. O'Brien?

A. Teamster.

Q. How long have you lived in Chicago?

A. I haven't lived in Chicago at all, sir.

Q. You don't live in Chicago?

A. No, sir.

Q. Where do you live?

A. Lockport.

Q. How long have you lived in Lockport?

A. I was born and raised there, 39 years.

Q. When was it you took these samples of water at Lockport?

A. 1899 and 1900.

Q. How long did you continue to take them after you commenced?

A. About six months or such a matter.

Q. Anybody else take samples in connection with you?

A. My nephew.

Q. At the same time?

A. After I did.

Q. Did he take any samples while you were taking samples?

A. No, sir.

Q. Did he take any for you?

A. No, sir.

6723 Q. Did you take any for him?

A. Yes, sir.

Q. In fact, all the samples you took were for him?

A. I started and he finished.

Q. You started and he finished?

A. Yes, sir.

Q. Then while he was taking the samples under contract with the Sanitary District, you helped him out?

A. When I could, yes.

Q. How often did you take samples for him?

A. I never took them; I helped him pack and finish them if I had time.

Q. If you had time you went with him?

A. No, sir; if I had time I helped him pack the samples and finish them.

Q. You just helped him to pack the samples?

A. Yes, sir.

Q. You never collected samples for him?

A. Not for him, no, sir.

Q. Did you collect all of your samples?

A. All my own samples.

Q. Nobody at all collected for you?

A. No, sir.

Q. Nobody with you?

6724 A. No, sir.

Q. At what particular place in the canal did you get these samples?

A. Between Ninth and Tenth streets, Lockport.

Q. Was it in the side or in the center?

A. It was in the side.

Q. What did you go out on when you took them, or did you just stoop on the edge of the water?

A. I could stoop on the edge and reach out.

Q. How far out would you reach?

A. About two feet.

Q. Is that above or below the pumps?

A. No pumps in Lockport.

Q. How wide is the canal at that place?

A. Ninety feet.

Q. Where did you say you got these bottles?

A. United States Express office.

Q. At Lockport?

A. Yes, sir.

Q. How far is that from the place where the samples were taken or collected?

A. From where I collected the samples to the express office?

Q. Yes?

A. It was at that time about a block and a half.

6725 Q. Would you go to the express office and get the bottles?

A. Yes, sir.

Q. And carry them from there over to the place where you took the samples?

A. Took them right on my wagon.

Q. Now, you would stoop down and put the bottles in the water, would you, or would you first take the cork out?

A. Put them in the water first.

Q. When you got the water to rinse the bottles out, you left the cork in?

A. Yes, sir.

Q. You stooped down and put the bottle in the water?

A. Yes, sir.

Q. You drew it out and then you took the cork out?

A. Yes, sir.

Q. And you shook the bottles?

A. Yes, sir.

Q. And you poured the water out?

A. Yes, sir.

Q. And you put the bottle back in the water?

A. Yes, sir.

Q. Now, while you were taking the bottles and rinsing them out, where was the stopper?

A. In my hand.

6726 Q. Always?

A. Always.

Q. With those large bottles you would have to use both hands, wouldn't you?

A. No, sir.

Q. How many times did you lay the cork down or the stopper down on the side?

A. I never laid it down; I had instructions not to.

Q. You never did lay it down?

A. No, sir.

Q. At no time?

A. No, sir.

Q. Did you ever let any of these bottles get away from you?

A. No, sir, I never lost a bottle.

Q. When you submerged these large bottles, didn't you have to hold them with both hands under the water?

A. Yes, sir, both hands were under the water.

Q. Where did you hold the cork if you held the bottle with both hands?

A. In one hand under the water.

Q. You say you held the big bottle in both hands, also the cork in your hand?

A. Yes, sir.

6727 Q. How would you hold the bottle and remove the cork under the water?

A. By the neck, with my fingers.

Q. How close up to the neck would you get your hand?

A. Just so (indicating). I could get my hand away from the top of the bottle.

Q. That would be right around the top?

A. I would get it.

Q. The water would rush into the bottle from over the top of your hand?

A. When I was rinsing it out.

Q. And also when you would be filling it, the water would have to run over your hand to get into the bottle?

A. Not when I filled it.

Q. When you first removed the cork, because you had to hold the bottle around the top or the neck?

A. Yes, sir.

Q. Now, that is the way you held both the large and small bottle?

A. The small bottle was an easier bottle to handle.

Q. You had to hold it in that way?

A. The small bottle you could hold by the bottom.

Q. You sometimes held it—it was far easier to hold it by the neck, wasn't it?

6728 A. No sir, not the small bottle it ain't.

Q. Now after you took those bottles out of the water and put the corks in, where did you take them?

A. To the express office.

Q. Did you pack them before you took them there?

A. No sir I packed them right on my wagon, right there.

Q. What did you do in the winter when there was ice in the canal?

A. I had an ax with me and chopped a hole in the ice.

Q. And put your hand right down in the cold water?

A. Yes sir.

Q. When you cut a hole in the ice, which side of the hole would you stand on when you took the sample?

A. Stand on the outside.

Q. On the lower side?

A. Yes sir.

Q. Not on the upper side?

A. On the lower side.

Q. Now then, when you took the samples out of the running stream in the summer time, where would you put your hands in the water with reference to where you stood?

A. On the south side of the running of the stream.

Q. Below?

A. Yes sir.

6729 Q. Your body then would be up-stream and your hand down-stream?

A. Yes sir.

Q. And about six or eight inches from the shore?

A. Yes, two feet from the shore.

Q. Could you reach out two feet?

A. Yes sir.

Q. And get your hand down six or eight or ten inches?

A. Yes sir.

Q. How long is your arm?

A. Not very long.

Q. How close to the edge of the water would you get?

A. Right down to the water's edge. There is a stone wall there, sir.

Q. And the water runs level with the stone wall?

A. No sir, the water don't. It is a foot from the top of the wall.

Q. Didn't you have to lay down on the wall to get those samples?

A. Yes sir.

Q. Is that right?

A. Yes sir.

6730 RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. Mr. O'Brien, did you take any samples of water for Prof. John H. Long of the Northwestern Laboratory?

A. Yes sir.

Q. When did you take them?

A. During the time that I was taking these others.

Q. What kind of samples did you take?

A. A small and a large bottle.

Q. Where did you get the bottles from?

A. From the United States Express Company.

Q. Were they sent to you?

A. They were sent to me.

Q. And how did you fill them, the same way you did the others?

A. The same way as I did others.

Q. Now in taking them, what kind of a tag did you use?

A. I had a slip like that with envelope (pointing).

Q. I will ask you to look at the envelope and slip that I show you and state whether or not that is the kind of a slip, or a slip similar to that and an envelope similar to that was employed by you?

A. Similar to that, but that isn't one of my slips.

Q. But similar to that?

6731 A. Yes sir.

Q. The card and slip that I show you is marked State of Illinois Exhibit No. 11 for identification, and the card is marked 462, accompanying that exhibit. Now did you fill out a card similar to the one I show you with your name, place of collection, date of collection, temperature of water and air, and enclose it in an envelope like this and attach it to the sample of water which you took for Professor Long?

A. Yes sir.

MR. TODD: Let the record show that the card and envelope shown this witness are marked State of Illinois Exhibit No. 11 for identification.

RE-CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Did you put the temperature of the water and the air on the cards?

A. Yes sir.

Q. Now when did you put that on the card with reference to the time you took the samples?

A. Right at the time I was taking it.

Q. You had the cards right there with you?

A. Yes sir.

Q. You put it on there then?

6732 A. Yes sir.

Q. You never carried it in your mind or put it on another piece of paper?

A. No sir.

Q. Did you ever forget your card?

A. No sir.

Q. You took these samples the same way you did these others that you spoke of, and at the same time?

A. Yes sir, at the same time.

Sig. waived. F. S. B., Com'r.

6733 PROF. JOHN H. LONG,

resumed the stand for further direct-examination by Mr. Todd, and testified as follows:

Q. Professor, what is the significance of chlorine in water?

A. Chlorine in water is found practically always in its commonest combination, sodium chloride or common salt. I think I explained this morning, that there is some amount, a small amount of this in all soils. Therefore rivers and lakes contain chlorine in that form, but it may be also a very important incidental constituent. The sewage contains the salt which is excreted in the urine, and the salt which comes from the ordinary kitchen waste, and the salt of various industries. I think I mentioned that. Now this salt is, inasmuch as it is an inorganic or mineral substance, in a very marked degree stable, and remains therefore, in the water. It does not undergo destruction or change. If it is found in the water in large amounts, above the amount found in waters of a region known to be uncontaminated, it is taken as an indication of a possible addition to the water of sewage in some form at some time. That is practically the significance of chlorine if found above a certain amount in mineral water or river water.

6734 Q. If chlorine is found in water and these other nitrogenous compounds of which you spoke are absent, what is the significance of its presence there?

A. It is simply a suggestion that possibly the water has received sewage of some kind.

Q. Necessarily sewage?

A. Not necessarily, because the water may have received drainage from a salt mine, or a salt well, so I say, it is a suggestion of the possible addition.

Q. Have you the table of analyses made by you in the summer of 1886?

A. Yes sir.

Q. I wish you would produce them, professor.

A. I have in this report of the proceedings of the Illinois State Board of health, the quarterly meeting at Chicago, October 28th and 29th, 1886, a table of results of examinations made at that time.

Q. Have you a table of averages drawn from those results?

A. I have. In this table of averages that I have here, there were but three determinations made in that year, 1886 -- free ammonia, albuminoid ammonia and the oxygen consumption. This table I have in two different forms. In the first re-

port the average of all the analyses was given. In the second, published along with the report, preliminary report as
6735 it is called, there is a table calculated from the individual experiments, leaving out certain ones, however, in order to include the sample taken in the same day; for instance, in the first table there are ten analyses at Bridgeport and only seven at Peoria. In calculating this table the averages are based on the same number of samples throughout. Therefore the fairer table to use would be this.

Q. The tables of analyses are found in these reports?

A. Yes sir.

Q. I wish you would read into the record the averages from the preliminary report, the one you say is a fair average.

MR. JEFFRIES: I object to the reading of the averages of such a table and such an examination, into the record, for the reason that there is no evidence to show that the samples of water of which the examination was made, were properly taken, and no evidence to show the manner in which they were taken, and therefore, such evidence would be incompetent, irrelevant and of no value.

MR. TODD: Just read that.

A. The results given are in parts per million.

Bridgeport.

Free ammonia,	26.563
Albuminoid ammonia,	1.633
Oxygen consumed,	26.20

6736 LOCKPORT, 29 miles below.

Free ammonia,	12.733
Albuminoid ammonia,	753
Oxygen consumed,	11.01

JOLIET, 33 miles below.

Free ammonia,	9.426
Albuminoid ammonia,	.432
Oxygen used,	9.34

OTTAWA, 81 miles below,

Free ammonia,	.413
Albuminoid ammonia,	.243
Oxygen consumed,	5.30

PEORIA, 159 miles below,

Free ammonia,	.027
Albuminoid ammonia,	.194
Oxygen used,	4.81

Q. Professor, will you give the page of the report of the Board of Health that table was taken from for identification?

A. That is taken from page XXVII of the preliminary report of the Illinois State Board of Health, published in 1889, by the authority of the State Board of Health.

Q. From those analyses professor, what conclusions do you draw?

A. These conclusions indicate beyond any question—

6737 MR. JEFFRIES: We object to any conclusions being drawn from these analyses for the reason, as heretofore stated, the results of the analyses are not shown to have been based upon samples of water properly taken or upon samples of water taken in any manner whatever.

A. These analyses show beyond any question a very marked destruction of organic matter in the flow between Bridgeport and Peoria, showing the effect of what is called bacterial oxidation in an extremely marked degree, the water at Peoria in that particular season being practically potable and actually used by a large number of the people. I was at Peoria during the season and observed that fact myself.

Q. That was in 1886?

A. That was in the summer of 1886. This effect is partly of course due to the oxidation and also to the dilution from tributaries, but the largest part of the effect is unquestionably due to actual destruction by bacterial oxidation.

Q. Have you the summaries for the winter of 1886 and 1887?

A. Yes sir, the summary for the winter of 1886 and 1887 is for four places, Bridgeport, Joliet, Ottawa and Peoria.

MR. JEFFRIES: Those summaries are objected to for the reasons heretofore stated. There is no evidence to show that the samples of water from which the examinations were made, were properly taken and no evidence of the particular 6738 place in the river or stream from which they were taken, and no evidence to show that the instructions given to the water-takers were carried out, and no evidence to show that any instructions were given in reference to the manner in which the samples were taken.

A. The analyses are expressed as before, in parts per million.

MR. TODD: Where are the tables you are reading from to be found?

A. This table is found in the same preliminary report on page XXIX, the figures being taken from a previous publication of the Board which I have not with me. These figures were published in a form similar to what I have here, but I have not a copy of that, but they are brought over into this report here.

Q. You made the summary yourself from your own analytical data?

A. Yes sir.

Q. Will you read the table into the record?

A. (Reading):

BRIDGEPORT,	
Free ammonia,	9.7
Albuminoid ammonia,	3.7
Oxygen consumed,	22.4
6739 JOLIET, 33 miles below.	
Free ammonia,	6.5
Albuminoid ammonia,	2.2
Oxygen consumed,	11.3
OTTAWA, 81 miles below.	
Free ammonia,	4.7
Albuminoid ammonia,	.75
Oxygen consumed,	9.0

PEORIA, 159 miles below.

Free ammonia,	1.7
Albuminoid ammonia	.43
Oxygen consumed,	6.45

Q. What conclusion do you draw from these averages for the winter of 1886 and 1887?

A. The conclusion that in the winter of 1886 and 1887, as in the summer of 1886, there is a very considerable destruction of organic matter in this stretch between Bridgeport and Peoria; but the destruction or oxidation is much less marked and characteristic than in the summer, as is always the case in these observations.

Q. Have you the summary for the summer of 1888?

A. I have.

Q. Where is the table of analyses to be found from which that summary is made, professor?

6740 A. The analyses from which this summary is taken are found in full in this book called "Preliminary report of the Illinois State Board of Health, published in 1889," and this summary is found on page 30 (Roman alphabet).

Q. Did you make that table of the analytical details, which you made at the time of the analyses?

A. I did.

Q. Will you read that?

MR. JEFFRIES: I object to that for the same reasons and I object to the introduction of the tables for the further reason that the tables themselves from which these samples were obtained, are the best evidence.

MR. TODD: Have you the tables there?

A. The tables are all in this book.

Q. Are those the tables from which this summary is made? And are they published in the report,—the preliminary report to the Illinois State Board of Health?

A. They are.

Q. Now will you indicate in the book which you hold and which has been denominated the Preliminary Report of the Water Supplies of Illinois and the pollution of its streams published in 1889 by authority of the Board of Health of the State

of Illinois, the pages where these tables appear, from
6741 which this summary that I ask you to read, and which
has not yet been read, appear?

A. The summary or mean of analysis given on page 30 (Roman notation) of this preliminary report, made up from results given in detail for Bridgeport, on page 10 of the report proper (Arabic notation). For Lockport on page 11; for Joliet on pages 12 and 13.

For Morris, on page 16,
For La Salle on pages 18 and 19,
For Henry, on page 21,
For Peoria on page 22,
For Pekin, page 24,
For Havana, page 25,
For Beardstown, on pages 26 and 27,
For Pearl, on page 27,
For Grafton, on page 28,
For Alton, on page 30.

MR. TODD: I offer the tables appearing on those pages as indicated in the preliminary report to the Illinois State Board of Health, as the State of Illinois Exhibit A for identification.

MR. JEFFRIES: That is, you offer the pages of the report?

MR. TODD: That includes these tables for identification.

MR. JEFFRIES: I object to the introduction and make
the same objection that I made to the summaries and
6742 tables heretofore read in evidence, and for the further
reason that the original tables are the best evidence.

A. This report is entitled "A Preliminary Report to the Illinois State Board of Health. Water Supplies of Illinois, and the Pollution of its Streams, by John H. Rauch, M. D., Secretary. With two appendices, first, Chemical Investigation of the Water Supplies of Illinois, by Prof. J. H. Long. Second, "The Illinois River Basin in its relations to Sanitary Engineering, by L. E. Cooley, C. E. Springfield, Illinois, H. W. Booker, Printer and Binder, 1889."

MR. TODD: Are the tables of analyses which you have just indicated in this preliminary report, true and correct tables of analyses made by you from the samples?

A. They are.

Q. Have you the summary made by yourself from those tables of analyses which are known as the State of Illinois Exhibit A for identification?

A. I have.

Q. Will you read that into the record, the table of averages?

A. The first table is entitled "Means of Analyses, May to October, inclusive, 1888." Results are expressed in parts per million, and are as follows: I also read table entitled "Means of Analyses During 1889." These tables follow each other.

6743

Table No. 1.

MEANS OF ANALYSES—MAY TO OCTOBER INCLUSIVE, 1888.

BRIDGEPORT.

Number of analyses,	29.	
Total solids,		471.2
Suspended matter,		129.20
Nitrogen in nitrates,		.000
Chlorine,		46.811
Hardness-$CaCO_3$,		201.3
Free ammonia,		12.253
Albuminoid ammonia,		2.558
Oxygen consumed,		23.113

LOCKPORT,

Number of analyses,	24.	
Total solids,		431.2
Suspended matter,		69.80
Nitrogen in nitrates,		.000
Chlorine,		46.120
Hardness-$CaCO_3$,		207.7
Free ammonia,		10.882
Albuminoid ammonia,		1.990
Oxygen consumed,		16.230

6744

JOLIET.

Number of analyses,	26.	
Total solids,		442.7
Suspended matter,		107.90
Nitrogen in nitrates,		.000
Chlorine,		43.658
Hardness-$CaCO_3$,		216.8
Free ammonia,		8.932
Albuminoid ammonia,		1.681
Oxygen consumed,		14.301

MORRIS.

Number of analyses,	24.	
Total solids,		355.9
Suspended matter,		30.85
Nitrogen in nitrates,		.380
Chlorine,		32.149
Hardness-$CaCO_3$,		214.8
Free ammonia,		4.107
Alb. Ammonia,		.707
Oxygen consumed,		10.920

6745

LA SALLE.

Number of analyses,	23.	
Total solids,		345.7
Suspended matter,		50.30
Nitrogen in nitrates,		1.037
Chlorine,		19.717
Hardness-$CaCO_3$,		211.7
Free ammonia,		.636
Alb. ammonia,		.526
Oxygen consumed,		8.558

HENRY.

Number of analyses,	19.	
Total solids,		306.0
Suspended matter,		27.50
Nitrogen in nitrates,		.683
Chlorine,		17.660

Hardness-$CaCO_3$,		202.4
Free ammonia,		.467
Alb. ammonia,		.481
Oxygen consumed,		8.657

6746 PEORIA.

Number of analyses,	19.	
Total solids,		329.75
Suspended matter,		54.27
Nitrogen in nitrates,		.8915
Chlorine,		12.358
Hardness-$CaCO_3$,		199.7
Free ammonia,		.210
Alb. ammonia,		.522
Oxygen consumed,		9.769

PEKIN.

Number of analyses,	16.	
Total solids,		353.0
Suspended matter,		84.30
Nitrogen in nitrates,		.795
Chlorine,		16.152
Hardness-$CaCO_3$,		204.6
Free ammonia,		.645
Alb. ammonia,		.650
Oxygen consumed,		9.410

6747 HAVANA.

Number of analyses,	25.	
Total solids,		301.78
Suspended matter,		45.4
Nitrogen in nitrates,		.731
Chlorine,		11.583
Hardness-$CaCO_3$,		204.2
Free ammonia,		.342
Alb. ammonia,		.430
Oxygen consumed,		8.142

BEARDSTOWN.

Number of analyses,	24.	
Total solids,		390.0
Suspended matter,		84.7
Nitrogen in nitrates,		.62
Chlorine,		7.524
Hardness-$CaCO_3$,		204.9
Free ammonia,		.202
Alb. ammonia,		.380
Oxygen consumed,		7.354

6748

GRAFTON.

Number of analyses,	12.	
Total solids,		301.6
Suspended matter,		50.3
Nitrogen in nitrates,		.582
Chlorine,		9.205
Hardness-$CaCO_3$,		242.4
Free ammonia,		.095
Alb. ammonia,		.483
Oxygen consumed,		7.300

ALTON.

Number of analyses,	15.	
Total solids,		278.6
Suspended matter,		75.2
Nitrogen in nitrates,		....
Chlorine,		4.083
Hardness-$CaCO_3$,		169.4
Free ammonia,		.166
Alb. ammonia,		.356
Oxygen consumed,		7.356

6749

TABLE NO. 2.

MEANS OF ANALYSES MADE DURING 1889.

BRIDGEPORT.

Number of analyses,	9.	
Total solids,		376.6

Suspended matter,	27.2
Nitrogen in nitrates,	0.00
Chlorines,	62.934
Hardness-$CaCO_3$,	....
Free ammonia,	8.925
Alb. ammonia,	2.806
Oxygen consumed,	26.502

LOCKPORT.

Number of analyses,	8.
Total solids,	408.6
Suspended matter,	24.6
Nitrogen in nitrates,	0.00
Chlorine,	56.083
Hardness-$CaCO_3$,	....
Free ammonia,	8.149
Alb. ammonia,	2.489
Oxygen consumed,	22.820

6750 JOLIET (Dam 2).

Number of analyses,	8.
Total solids,	432.8
Suspended matter,	55.5
Nitrogen in nitrates,	0.00
Chlorine,	57.17
Hardness, $CaCO_3$	....
Free ammonia,	8.488
Alb. ammonia,	2.666
Oxygen consumed,	21.717

MORRIS.

Number of analyses,	8.
Total solids,	325.2
Suspended matter,	29.1
Nitrogen in nitrates,	0.00
Chlorine,	28.748
Hardness, $CaCO_3$,	....
Free ammonia,	4.716
Alb. ammonia,	1.587
Oxygen consumed,	10.696

6751 LA SALLE.

Number of analyses,	9.
Total solids,	417.6
Suspended matter,	93.8
Nitrogen in nitrates,	.942
Chlorine,	13.105
Hardness-$CaCO_3$,	....
Free ammonia,	1.456
Alb. ammonia,	.637
Oxygen consumed,	8.582

HENRY.

Number of analyses,	5.
Total solids,	316.0
Suspended matter,	30.9
Nitrogen in nitrates,	.962
Chlorine,	11.691
Hardness-$CaCO_3$,	....
Free ammonia,	1.059
Alb. ammonia,	.404
Oxygen consumed,	8.626

6752 PEORIA (Upper bridge).

Number of analyses,	6.
Total solids,	331.0
Suspended matter,	26.9
Nitrogen in nitrates,	.510
Chlorine,	12.860
Hardness-$CaCO_3$,	....
Free ammonia,	1.637
Alb. ammonia,	.549
Oxygen consumed,	9.611

PEKIN.

Number of analyses,	6.
Total solids,	352.0
Suspended matter,	43.5
Nitrogen in nitrates,	1.259

Chlorine,	11.792
Hardness-$CaCO_3$,	....
Free ammonia,	1.591
Alb. ammonia,	1.015
Oxygen consumed,	13.358

6753

HAVANA.

Number of analyses,	9.
Total solids,	354.4
Suspended matter,	.8
Nitrogen in nitrates,	.414
Chlorine,	9.277
Hardness-$CaCO_3$,	....
Free ammonia,	1.078
Alb. ammonia.	.585
Oxygen consumed,	9.234

BEARDSTOWN.

Number of analyses,	6.
Total solids,	317.8
Suspended matter,	56.3
Nitrogen in nitrates,	.966
Chlorine,	6.933
Hardness-$CaCO_3$,	....
Free ammonia,	.762
Alb. ammonia,	.357
Oxygen consumed,	5.505

6754

GRAFTON.

Number of analyses,	9.
Total solids,	410.8
Suspended matter,	44.6
Nitrogen in nitrates,	.087
Chlorine,	7.523
Hardness-$CaCO_3$,	....
Free ammonia,	.875
Alb. ammonia,	.722
Oxygen consumed,	9.818

ALTON.

Number of analyses,	8.
Total solids,	309.9
Suspended matter,	61.3
Nitrogen in nitrates,	.317
Chlorine,	5.834
Hardness-$CaCO_3$	....
Free ammonia,	.422
Alb. ammonia,	.396
Oxygen consumed,	7.562

6755 Q. What conclusions do you draw from those two tables of summaries, professor?

MR. JEFFRIES: I object to any conclusion being drawn from the tables, for the reason that there is no evidence showing that the samples from which the examinations were made were properly taken, or that any instructions were given for their taking, and there is no evidence to show that the results as contained in these tables are the results of any actual examinations made with respect to the water at the particular places at which they purport to have been taken.

MR. TODD: Proceed, Professor?

A. These results show a purification of the river between the source of the water at Bridgeport and the outlet of the Illinois river at Grafton. The purification measured by the destruction of organic matter, showed a very great or a very marked diminution of the organic matter. This diminution of the organic matter is due to two principal factors, the dilution of the stream by the water from various tributaries, and to the destruction of the organic matters by the oxidation, using that term in a general sense, or broad sense. The disappearance of organic matter is very much more marked than is the dilution as indicated by the change in chlorines, the condition being finally reached in which the organic matters are not larger
6756 or greater in amount than in the tributary streams.

MR. JEFFRIES: I object to the statement of the witness to the effect that the chemical conditions of the water are not different from that contained in the tributaries of the Illinois river for the reason that, so far as this witness is concerned, or any testimony that he has given, or any testimony in behalf of the Sanitary District, there is no evidence to show the chemical or sanitary conditions of the tributaries of the Illinois river, and for the further reason that the statement of the witness does not relate to any particular river or rivers that are tributary to the Illinois river.

A. (Continued.) And are not larger in amount than in the streams commonly found in that part of the country.

MR. JEFFRIES: I object to the last statement of the witness for the reason that there is no evidence to show that any examination has been made of the waters of any river other than that of the Illinois.

MR. TODD: Did you make, in connection with this investigation, any analyses of the waters of the tributaries of the Illinois river?

A. I did.

Q. Will you state at what points, and the rivers and give the analytical results of each stream that you examined?

6757 MR. JEFFRIES: I object for the reason that the question does not embody the method of the examination, or the precautions used in obtaining correct analyses of them.

A. I made at the same time that these analyses referred to were made, examinations of the waters of the DuPage river, the Kankakee river, the Fox river, the Big Vermillion river, the Little Vermillion river, the Sangamon river. That is all bearing on that.

MR. TODD: At what points on these rivers were samples taken, for these analyses of these different rivers?

A. For the DuPage river the water was taken a short distance above its mouth. It was shipped to me from Channahan.

Q. Who collected this water and how was it collected?

A. These samples were collected by the representatives of the State Board of Health, engaged by the Secretary of the Board, Dr. Rauch, and collected under the same conditions as were those previously described.

Q. Will you indicate the points where the samples were collected from each of the tributaries of the Illinois river at this time, the number of samples taken and analyzed by you?

MR. JEFFRIES: On the tributaries?

MR. TODD: On the tributaries.

MR. JEFFRIES: I object to it for the reason that t
6758 question does not embody, but does assume that the sa
ples were properly taken, and there is no evidence th
they were so taken, and no evidence as to the particular place
the respective rivers where the samples were taken, either in t
center or at the side, whether surface water or water benea
the surface, or whether water from below or above the sewa
discharge of any particular city upon the tributaries of the Il
nois river.

A. The water from the DuPage river was taken near Cha
nahan, near the mouth of the river. 21 samples were taken b
tween May and the end of September in 1888. All these we
taken that year. From the Kankakee river they were taken
Wilmington and were 19 in number. From the Fox river th
were taken at Ottawa and were 18 in number. From the B
Vermillion river they were taken near La Salle and were sev
in number. In the Little Vermillion river they were taken ne
LaSalle and were seven in number. The Big Vermillion riv
enters the Illinois river from the south, the mouth of it bei
above La Salle between two and three miles. The Little V
million river enters from the north, practically at La Sal
That is, on the same side of the river on which La Salle is s
uated, hence both samples are marked "La Salle." The sampl
from the Sangamon river were eight in number and were tak
near the mouth of the river at the town of Chandlervil
6759 These samples were taken in all cases near the mouth
the river and were intended to represent a composition
the tributary streams just before they enter the Illinois. Th
streams contained the sewage of towns or cities in all cases.

Q. Have you the table of analyses made by you from th
samples for the DuPage river?

A. I have. That table is found on page 14 (Arabic no
tion) of this preliminary report of John H. Rauch.

Q. Will you read that table in evidence?

MR. JEFFRIES: I object to the reading of the table
evidence for the reason that it does not show that the samp
from which examinations were made were properly taken; d
not show the manner in which they were taken, and for the f

ther reason that the original tables themselves are the best evidence, and for the further reason that it does not appear that the tables from which the witness proposes to testify represent correctly the original.

MR. TODD: Is the table for the DuPage river which you have on page 14 of the printed report which you hold in your hand, a true and correct table made by you of the analyses of the water of the DuPage river?

A. It is to the best of my belief.

MR. JEFFRIES: I object to the statement of the witness for the reason that the evidence shows that the table which
6760 he holds in his hand was not written by himself.

A. The table is as follows:

6761 TABLE NO. 3.

CHANNAHAN, DUPAGE RIVER.

MAY 4.

Total solids,	347.5
Suspended matter,	26.0
Nitrogen in nitrates,	.156
Chlorine,	31.150
Hardness, $CaCO_3$,	252.0
Free ammonia,	4.700
Alb. ammonia,	.925
Oxygen consumed,	8.000

Physical conditions: Slightly colored; clear; odorless.

MAY 11.

Total solids,	353.0
Suspended matter,	24.0
Nitrogen in nitrates,	.882
Chlorines,	8.250
Hardness, $CaCO_3$,	249.0
Free ammonia,	.689
Alb. ammonia,	.395
Oxygen consumed,	7.440

Physical condition: Nearly colorless; odorless.

6762 MAY 18.

Total solids,	322.9
Suspended matter,	16.0
Nitrogen in nitrates,	.315
Chlorine,	11.920
Hardness $CaCO_3$,	250.2
Free ammonia,	1.271
Alb. ammonia,	.394
Oxygen consumption,	7.600

Physical conditions: Colorless, slight earthy odor.

MAY 25.

Total solids,	372.8
Suspended matter,	62.3
Nitrogen in nitrates,	.441
Chlorine,	8.500
Hardness, $CaCO_3$,	276.0
Free ammonia,	.306
Alb. ammonia,	.614
Oxygen consumed,	8.640

Physical condition: Yellowish, earthy odor.

6763 JUNE 1ST.

Total solids,	322.5
Suspended matter,	31.7
Nitrogen in nitrates,	1.764
Chlorine,	7.788
Hardness-$CaCO_3$,	240.0
Free ammonia,	.534
Alb. ammonia,	.426
Oxygen consumed,	9.680

Physical conditions: Nearly clear; bad odor.

JUNE 8TH.

Total solids,	321.2
Suspended matter,	18.5
Nitrogen in nitrates,	.867
Chlorine,	7.080
Hardness-$CaCO_3$,	230.0

Free ammonia,	.405
Alb. ammonia,	.459
Oxygen consumed,	6.560

Physical conditions: Slightly turbid; yellowish and earthy odor.

6764

JUNE 15TH.

Total solids,	345.8
Suspended matter,	13.7
Nitrogen in nitrates,	.252
Chlorine,	19.116
Hardness-$CaCO_3$,	206.0
Free ammonia,	1.596
Alb. ammonia,	.402
Oxygen consumed,	8.480

Physical conditions: Slightly turbid, yellowish, earthy odor.

JUNE 22ND.

Total solids,	318.8
Suspended matter,	18.6
Nitrogen as nitrates,	trace.
Chlorine,	34.196
Hardness-$CaCO_3$,	226.0
Free ammonia,	4.230
Albuminoid,	.600
Oxygen consumed,	6.080

Physical conditions: Nearly clear; yellowish, earthy odor.

6765

JUNE 29TH.

Total solids,	305.0
Suspended matter,	23.9
Nitrogen in nitrates,	.693
Chlorine,	37.520
Hardness-$CaCO_3$,	222.0
Free ammonia,	4.870
Albuminoid ammonia,	.600
Oxygen consumed,	6.080

Physical conditions: Nearly clear; yellowish and earthy odor.

JULY 6.

Total solids,	418.4
Suspended matter,	11.7
Nitrogen in nitrates,	.315
Chlorine,	56.640
Hardness-$CaCO_3$,	216.0
Free ammonia,	9.580
Alb. ammonia,	.605
Oxygen consumed,	5.160

Physical conditions: Nearly clear, yellowish, and earthy odor.

6766 JULY 13.

Total solids,	317.0
Suspended matter,	17.3
Nitrogen in nitrates,	1.260
Chlorine,	9.204
Hardness-$CaCO_3$,	236.0
Free ammonia,	.670
Alb. ammonia,	.360
Oxygen consumed,	5.200

Physical conditions: Slightly opalescent, earthy odor.

JULY 20.

Total solids,	354.9
Suspended matter,	11.0
Nitrogen in nitrates,	trace.
Chlorine,	45.782
Hardness-$CaCO_3$,	218.0
Free ammonia,	7.180
Alb. ammonia,	.0770
Oxygen consumed,	7.120

Physical conditions: Clear; yellow; odorless.

6767 JULY 27.

Total solids,	389.0
Suspended matter,	10.5
Nitrogen in nitrates,	.240
Chlorine,	46.720

Hardness-$CaCO_3$,	218.0
Free ammonia,	5.020
Alb. ammonia,	.465
Oxygen consumed,	7.360

Physical conditions: Nearly clear; earthy odor.

AUGUST 3rd.

Total solids,	304.9
Suspended matter,	7.2
Nitrogen in nitrates,	trace.
Chlorine,	45.428
Hardness-$CaCO_3$,	184.0
Free ammonia,	7.520
Alb. ammonia,	.540
Oxygen consumed,	4.900

Physical conditions: Opalescent; yellow; earthy odor.

6768 AUGUST 10.

Total solids,	306.5
Suspended matter,	13.5
Nitrogen in nitrates,	trace.
Chlorine,	8.142
Hardness-$CaCO_3$,	260.0
Free ammonia,	.920
Alb. ammonia,	.520
Oxygen consumed,	4.320

Physical conditions: Opalescent; colorless; earthy odor.

AUGUST 17.

Total solids,	281.2
Suspended matter,	17.8
Nitrogen in nitrates,	.756
Chlorine,	1.532
Hardness-$CaCO_3$,	220.0
Free ammonia,	.400
Alb. ammonia,	.360
Oxygen consumed,	5.360

Physical conditions: Opalescent; yellow; earthy odor.

6769 AUGUST 24.

Total solids,	250.1
Suspended matter,	14.1
Nitrogen in nitrates,	trace.
Chlorine,	5.664
Hardness-$CaCO_3$,	220.0
Free ammonia,	.370
Alb. ammonia,	.330
Oxygen consumed,	4.800

Physical conditions: Opalescent; yellow; earthy odor.

AUGUST 31st.

Total solids,	284.1
Suspended matter,	11.6
Nitrogen in nitrates,	.200
Chlorine,	6.726
Hardness-$CaCO_3$,	250.0
Free ammonia,	.780
Alb. ammonia,	.420
Oxygen consumed,	5.120

Physical conditions: Slight opalescence; colorless; earthy odor.

6770 SEPTEMBER 7.

Total solids,	308.0
Suspended matter,	12.2
Nitrogen in nitrates,	1.197
Chlorine,	5.426
Hardness-$CaCO_3$,	254.0
Free ammonia,	.142
Alb. ammonia,	.234
Oxygen consumed,	5.200

Physical conditions: Slight opalescence; colorless; earthy odor.

SEPTEMBER 14.

Total solids,	308.0
Suspended matter,	14.5
Nitrogen in nitrates,	trace.

Chlorine,	6.761
Hardness-$CaCO_3$,	240.0
Free ammonia,	.134
Alb. ammonia,	.290
Oxygen consumed,	4.400

Physical conditions: Slight opalescence; colorless; earthy odor.

6771 SEPTEMBER, 21st.

Total solids,	325.0
Suspended matter,	15.5
Nitrogen in nitrates,	.....
Chlorine,	6.250
Hardness-$CaCO_3$,	270.0
Free ammonia,	.176
Alb. ammonia,	.266
Oxygen consumed,	4.000

Physical conditions: Clear; odorless.

*MEAN.

Total solids,	294.7
Suspended matter,	14.1
Nitrogen in nitrates,	.307
Chlorine,	5.786
Hardness-$CaCO_3$,	244.8
Free ammonia,	.417
Alb. ammonia,	.346
Oxygen consumed,	4.743

*Mean for last seven.

6772 Q. Have you the table of analyses made of the Kankakee river?

A. I have.

Q. Is that printed table in that report a true and correct copy of the table of analyses made by yourself?

A. It is to the best of my belief. It is found on page 15 of this same report (Arabic notation).

MR. JEFFRIES: I object to it for the same reason that I objected to the previous one.

MR. TODD: Will you read that table into the record?

MR. JEFFRIES: I object to that for the reasons heretofore stated.

A. The table is as follows:

6773 TABLE No. 4.

WILMINGTON, (KANKAKEE RIVER).

MAY 4th.

Total solids,	230.3
Suspended matter,	11.0
Nitrogen in nitrates,	.060
Chlorine,	1.180
Hardness,-$CaCO_3$,	165.6
Free ammonia,	.125
Alb. ammonia,	.660
Oxygen consumed,	11.600

Physical conditions: greenish color; clear and odorless.

MAY 11,

Total solids,	244.5
Suspended matter,	15.0
Nitrogen in nitrates,	.151
Chlorine,	1.270
Hardness-$CaCO_3$,	172.2
Free ammonia,	.103
Alb. ammonia,	.620
Oxygen consumed,	14.400

Physical conditions: Yellowish; clear and odorless.

MAY 18,

Total solids,	269.0
Suspended matter,	16.0
Nitrogen in nitrates,	.060
Chlorine,	1.530
Hardness-$CaCO_3$,	213.6
Free ammonia,	.076

Alb. ammonia,	.590
Oxygen consumed,	14.880

Physical conditions: Yellowish; clear; odorless.

MAY 25.

Total solids,	246.6
Suspended matter,	12.2
Nitrogen in nitrates,	6.
Chlorine,	1.160
Hardness-CaCO$_3$,	196.8
Free ammonia,	.044
Alb. ammonia,	.460
Oxygen consumed,	13.049

Physical conditions: Slightly colored; earthy odor.

6775 JUNE 1st.

Total solids,	422.2
Suspended matter,	274.0
Nitrogen in nitrates,	1.323
Chlorine,	1.180
Hardness-CaCO$_3$,	141.6
Free ammonia,	.100
Alb. amonia,	.784
Oxygen consumed,	19.520

Physical conditions: Muddy; odorless and nearly clear.

JUNE 8.

Total solids,	251.4
Suspended matter,	20.7
Nitrogen in nitrates,	.....
Chlorine,	1.065
Hardness-CaCO$_3$,	140.0
Free ammonia,	.093
Alb. ammonia,	.580
Oxygen consumed,	15.200

Physical conditions: Yellowish; earthy odor and nearly clear.

6776 JUNE 15.

Total solids,	253.0
Suspended matter,	16.2
Nitrogen in nitrates,	Trace,
Chlorine,	.708
Hardness-$CaCo_3$,	......
Free ammonia,	.077
Alb. ammonia,	.710
Oxygen consumed,	12.320

Physical conditions: Yellowish; earthy; slightly turbid.

JUNE 22nd.

Total solids,	271.4
Suspended matter,	19.2
Nitrogen in nitrates,	.....
Chlorine,	1.770
Hardness, $CaCO_3$,	218.0
Free ammonia,	.088
Alb. ammonia,	.702
Oxygen consumed,	15.480

Physical conditions: Yellowish; odorless.

6777 JULY 6th.

Total solids,	211.7
Suspended matter,	29.5
Nitrogen in nitrates,	Trace
Chlorine,	1.062
Hardness-$CaCO_3$,	146.0
Free ammonia,	.090
Alb. ammonia,	.448
Oxygen consumed,	11.120

Physical conditions: Opalescent; yellowish; earthy odor.

JULY 13th.

Total solids,	223.2
Suspended matter,	42.3
Nitrogen in nitrates,	.189
Chlorine,	2.584

Hardness-CaCO$_3$,	138.0
Free ammonia,	.087
Alb. ammonia,	.480
Oxygen consumed,	14.329

Physical conditions: Yellowish; colorless; nearly clear.

6778 JULY 27th.

Total solids,	212.5
Suspended matter,	13.4
Nitrogen in nitrates,	trace,
Chlorine,	.354
Hardness-CaCO$_3$,	194.0
Free ammonia,	.104
Alb. ammonia,	.496
Oxygen consumed,	14.160

Physical conditions: Yellow; earthy odor.

AUGUST 3rd.

Total solids,	226.4
Suspended matter,	10.2
Nitrogen in nitrates,	.....
Chlorine,	.708
Hardness-CaCO$_3$,	174.0
Free ammonia,	.084
Alb. ammonia,	.586
Oxygen consumed,	13.200

Physical conditions: Clear; yellow, earthy odor.

6779 AUGUST 10.

Total solids,	205.0
Suspended matter,	22.0
Nitrogen in nitrates,	.....
Chlorine,	1.062
Hardness-CaCO$_3$,	160.0
Free ammonia,	.230
Alb. ammonia,	.584
Oxygen consumed,	8.480

Physical conditions: Slight cloudiness; yellowish; earthy odor.

AUGUST 17.

Total solids,	206.2
Suspended matter,	14.0
Nitrogen in nitrates,	.....
Chlorine,	.354
Hardness-$CaCO_3$,	144.0
Free ammonia,	.112
Alb. ammonia,	.630
Oxygen consumed,	13.020

Physical conditions: Opalescent; yellow, odorless.

6780 AUGUST 24th.

Total solids,	216.4
Suspended matter,	18.5
Nitrogen in nitrates,	.....
Chlorine,	.354
Hardness-$CaCO_3$,	148.0
Free ammonia,	.094
Alb. ammonia,	.582
Oxygen consumed,	9.280

Physical conditions: Opalescent; yellow, slight earthy odor.

AUGUST 31st.

Total solids,	241.3
Suspended matter,	27.8
Nitrogen in nitrates,	.....
Chlorine,	.354
Hardness-$CaCO_3$,	182.0
Free ammonia,	.098
Alb. ammonia,	.378
Oxygen consumed,	12.300

Physical conditions: Opalescent; yellow; slight earthy odor.

6781 SEPTEMBER 7th.

Total solids,	269.2
Suspended matter,	32.4
Nitrogen in nitrates,	.....
Chlorine,	.944
Hardness-$CaCO_3$,	188.0

Free ammonia,	.086
Alb. ammonia,	.730
Oxygen consumed,	10.120

Physical conditions: Opalescent; yellow; slight earthy odor.

SEPTEMBER 14th.

Total solids,	304.0
Suspended matter,	47.7
Nitrogen in nitrates,	.....
Chlorine,	.460
Hardness-$CaCO_3$,	190.0
Free ammonia,	.214
Alb. ammonia,	.600
Oxygen consumed,	10.400

Physical conditions; Opalescent; yellowish; odorless.

6782 SEPTEMBER 21st.

Total solids,	273.0
Suspended matter,	34.2
Nitrogen in nitrates,	.....
Chlorine,	1.175
Hardness-$CaCO_3$,	206.0
Free ammonia,	.272
Alb. ammonia,	.494
Oxygen consumed,	8.000

Physical conditions: Opalescent; yellowish; odorless.

MEAN.

Total solids,	251.4
Suspended matter,	35.6
Nitrogen in nitrates,	.094
Chlorine,	1.015
Hardness, $CaCO_3$,	164.1
Free ammonia,	.114
Alb. ammonia,	.585
Oxygen consumed,	12.661

6783 Have you the table of analyses of the Fox river, the Little Vermillion, the Big Vermillion and the Sangamon?

A. I have these tables. I have the table for the Fox rive found on page 17 of this preliminary report, and the table fo the Big Vermillion river found on page 18, and the table for th Little Vermillion river being found on page 18, and the tabl for the Sangamon river being found on page 26 of this repor

Q. Are those tables correct printed copies of the tables mad by you in the analyses of the waters from those four respecti rivers?

MR. JEFFRIES: I object to the question for the reaso that the tables themselves are the best evidence.

A. They are to the best of my knowledge and belief at th present time.

Q. Will you read the tables for the Fox River, the Bi Vermillion, the Little Vermillion and Sangamon Rivers as foun in the preliminary report of the Illinois State Board of Healt in 1889, in this table you say you made?

MR. JEFFRIES: I object to the reading of the tables fo the same reasons as stated in the previous objection to the rea ing of the tables into the record, and for the further reason tha there is no evidence to show the condition of the weather an no evidence to show the condition of the waters of thos 6784 rivers with reference to local showers and freshets, an no evidence to show that the samples of water were pro erly taken, or the particular places in the river where taken, an no evidence to show the manner in which the examinations wer made and no evidence to show that they were taken all at th same time, or approximately at the same time. No evidence t show who took the samples, and therefore the tables so offere are not competent and legal evidence, and any comparison tha may be drawn therefrom or any argument that may arise ther from would be misleading and improper.

A. The tables are as follows:

6785

TABLE NO. 5.

OTTAWA, FOX RIVER.

MAY 14, 1888.

Total solids,	281.0
Suspended matter,	5.0

Nitrogen in nitrates,	.....
Chlorine,	3.19
Hardness, $CaCO_3$,	244.2
Free ammonia,	.079
Alb. ammonia,	.365
Oxygen consumed,	9.76

Physical conditions: Nearly clear; slight earthy odor.

Mean temperature week ending:	50.51
Total rain fall, week ending:	.81

MAY 21.

Total solids,	281.8
Suspended matter,	13.6
Nitrogen in nitrates,	.126
Chlorine,	2.94
Hardness-$CaCO_3$,	220.8
Free ammonia,	9.116
Albuminoid ammonia,	.450
Oxygen consumed,	6.64

6786 Physical conditions: Nearly clear; slight earthy odor.

Mean temperature week ending:	50.47
Total rainfall, week ending:	.48

MAY 28.

Total solids,	280.9
Suspended matter,	28.3
Nitrogen in nitrates,	trace,
Chlorine,	1.77
Hardness-$CaCO_3$,	222.6
Free ammonia,	.084
Alb. ammonia,	.360
Oxygen consumed,	6.60

Physical conditions: Turbid from rain; earthy odor.

Mean temperature week ending:	64.20
Total rainfall week ending:	2.33

JUNE 5th.

Total solids,	322.5
Suspended matter,	50.6

Nitrogen in nitrates,	.....
Chlorine,	2.90
Hardness-$CaCO_3$,	248.4
Free ammonia,	.088
Alb. ammonia,	.394
Oxygen consumed,	8.60

Physical conditions: Clear; slight color, odorless,

Mean temperature week ending:	58.58
Total rainfall, week ending:	.38

6787 JUNE 11th.

Total solids,	312.5
Suspended matter,	18.6
Nitrogen in nitrates,	.....
Chlorine,	3.540
Hardness-$CaCO_3$,	250.0
Free ammonia,	.068
Alb. ammonia,	.344
Oxygen consumed,	5.28

Physical conditions: Slightly turbid; yellowish; odorless.

Mean temperature week ending:	64.02
Total rainfall week ending:	.00

JUNE 18th.

Total solids,	333.8
Suspended matter,	30.1
Nitrogen in nitrates,	.....
Chlorine,	4.650
Hardness-$CaCO_3$,	288.0
Free ammonia,	.128
Alb. ammonia,	.452
Oxygen consumed,	5.28

Physical conditions; Nearly clear; yellowish; odorless.

Mean temperature week ending:	75.61
Total rainfall week ending:	.47

6788 JUNE 25th.

Total solids,	368.0
Suspended matter,	51.0
Nitrogen in nitrates,	.060

Chlorine,	4.720
Hardness-$CaCO_3$,	280.0
Free ammonia,	.122
Alb. ammonia,	.490
Oxygen consumed,	7.60

Physical conditions: Nearly clear; yellowish; odorless.

Mean temperature week ending: 75.41

Total rainfall week ending: .25

JULY 2nd.

Total solids,	285.2
Suspended matter,	20.3
Nitrogen in nitrates,	.....
Chlorine,	2.94
Hardness-$CaCO_3$,	252.0
Free ammonia,	.086
Alb. ammonia,	.296
Oxygen consumed,	5.60

Physical conditions: Nearly clear; yellowish; odorless.

Mean temperature week ending: 66.91

Total rainfall, week ending: .36

6789 JULY 9th.

Total solids,	620.2
Suspended matter,	400.4
Nitrogen in nitrates,	.125
Chlorine,	7.496
Hardness-$CaCO_3$,	146.0
Free ammonia,	.272
Alb. ammonia,	1.140
Oxygen consumed,	9.28

Physical conditions: Muddy.

Mean temperature, week ending: 74.72

Total rainfall week ending: 1.54

JULY 16th.

Total solids,	320.5
Suspended matter,	43.1
Nitrogen in nitrates,	trace,

Chlorine,	5.897
Hardness-$CaCO_3$,	253.0
Free ammonia,	.100
Alb. ammonia,	.308
Oxygen consumed,	6.08
Physical conditions: Opalescent; odorless.	
Mean temperature, week ending:	69.36
Total rainfall week ending:	.00

6790 JULY 23rd.

Total solids,	413.0
Suspended matter,	30.3
Nitrogen in nitrates,	trace,
Chlorine,	7.434
Hardness-$CaCO_3$,	254.0
Free amonia,	.100
Alb. ammonia,	.358
Oxygen consumed,	4.72
Physical conditions: Opalescent; odorless.	
Mean temperature week ending:	71.45
Total rainfall week ending:	.20

*AUGUST 6.

Total solids,	463.2
Suspended matter,	41.8
Nitrogen in nitrates,	.180
Chlorine,	.....
Hardness-$CaCO_3$,	.....
Free ammonia,	3.118
Alb. ammonia,	.602
Oxygen consumed,	13.760
Physical conditions: Nearly clear; yellow earthy odor.	
Mean temperature week ending:	75.31
Total rainfall week ending:	1.11

6791 AUGUST 13th.

Total solids,	335.0
Suspended matter,	24.6
Nitrogen in nitrates,	.....

Chlorine,	8.021
Hardness-$CaCO_3$,	236.0
Free ammonia,	.084
Alb. ammonia,	.336
Oxygen consumed,	6.000

Physical conditions: Opalescent; yellowish; odorless.
Mean temperature, week ending: 61.24
Total rainafll week ending: .22

AUGUST 20th.

Total solids,	279.2
Suspended matter,	22.0
Nitrogen in nitrates,	trace,
Chlorine,	4.248
Hardness-$CaCO_3$,	244.0
Free ammonia,	.226
Alb. ammonia,	9.10
Oxygen consumed,	6.640

Physical conditions: Opalescent; yellowish; earthy odor.
Mean temperature week ending: 71.75
Total rainfall week ending: 1.72

6792 AUGUST 27th.

Total solids,	287.8
Suspended matter,	8.8
Nitrogen in nitrates,	.....
Chlorine,	4.176
Hardness-$CaCO_3$,	240.
Free ammonia,	.066
Alb. ammonia,	.278
Oxygen consumed,	5.120

Physical conditions: Nearly clear; slight earthy odor.
Mean temperature, week ending: 66.67
Total rainfall, week ending: .00

SEPTEMBER 3rd.

Total solids,	284.2
Suspended matter,	8.0
Nitrogen in nitrates,	.....

Chlorine,	7.667
Hardness-$CaCO_3$,	250.
Free ammonia,	.054
Alb. ammonia,	.420
Oxygen consumed,	7.520

Physical conditions: Nearly clear; slight earthy odor.

Mean temperature, week ending: 65.45

Total rainfall, week ending: .01

6793 SEPTEMBER 10th.

Total solids,	290.5
Suspended matter,	25.4
Nitrogen in nitrates,	.....
Chlorine,	5.189
Hardness-$CaCO_3$,	248.
Free ammonia,	.088
Alb. ammonia,	.440
Oxygen consumed,	6.400

Physical conditions: Floating matter; yellowish; earthy odor.

Mean temperature week ending: 62.69

Total rainfall, week ending, .29

SEPTEMBER 17th.

Total solids,	286.0
Suspended matter,	12.5
Nitrogen in nitrates,	.....
Chlorine,	7.788
Hardness-$CaCO_3$,	240.
Free ammonia,	.095
Alb. ammonia,	.400
Oxygen consumed,	4.880

Physical conditions: Clear; odorless.

Mean temperature, week ending: 57.37

Total rainfall week ending: 1.07

6794 MEAN.

Total solids,	330.3
Suspended matter,	46.3

Nitrogen in nitrates,	.027
Chlorine,	4.974
Hardness-$CaCO_3$,	242.1
Free ammonia,	.278
Alb. ammonia,	.463
Oxygen consumed,	7.066

*Not enough water sent.

These observations are the means of the records from Aurora and Oswego, the nearest available places. Dr. M. M. Robbins, observer, Aurora; John Seeley, observer, Oswego.—J. H. L.

TABLE NO. 7.

LA SALLE (Little Vermillion).

6795 MAY 7th. 1888.

Total solids,	446.0
Suspended matter,	37.5
Nitrogen in nitrates,	.207
Chlorine,	6.44
Hardness-$CaCO_3$,	112.8
Free ammonia,	.348
Alb. ammonia,	.358
Oxygen consumed,	5.44

Physical conditions: Light yellow; earthy color; floating organic matter.

MAY 14th.

Total solids,	346.0
Suspended matter,	10.0
Nitrogen in nitrates,	.252
Chlorine,	4.71
Hardness-$CaCO_3$,	177.0
Free ammonia,	.079
Alb. ammonia,	.250
Oxygen consumed,	5.08

Physical conditions: Odorless and colorless.

6796 MAY 21st.

Total solids,	420.3
Suspended matter,	48.4
Nitrogen in nitrates,	.125
Chlorine,	.425
Hardness-$CaCO_3$,	132.
Free ammonia,	.038
Alb. ammonia,	.436
Oxygen consumed,	4.96

Physical conditions: Light brown; earthy odor.

MAY 28th.

Total solids,	468.5
Suspended matter,	44.5
Nitrogen in nitrates,	1.700
Chlorine,	4.460
Hardness,-$CaCO_3$,	308.
Free ammonia,	.062
Alb. ammonia,	.278
Oxygen consumed,	10.40

Physical conditions: Nearly clear; colorless; odorless.

6797 JUNE 11th.

Total solids,	314.7
Suspended matter,	13.7
Nitrogen in nitrates,	.126
Chlorine,	6.478
Hardness-$CaCO_3$,	238.
Free ammonia,	.342
Alb. ammonia,	.434
Oxygen consumed,	7.60

Physical conditions: Colorless; floating organic matter.

JUNE 18th.

Total solids,	325.0
Suspended matter,	25.3
Nitrogen in nitrates,	.....
Chlorine,	5.876
Hardness, $CaCO_3$,	250.

Free ammonia,	.082
Alb. ammonia,	.674
Oxygen consumed,	7.76

Physical conditions: Nearly clear; yellowish; odorless.

6798 JULY 16th.

Total solids,	305.5
Suspended matter,	36.2
Nitrogen in nitrates,	.125
Chlorine,	7.434
Hardness-$CaCO_3$,	254.
Free ammonia,	.312
Alb. ammonia,	.450
Oxygen consumed,	8.80

Physical conditions: Slightly turbid; yellow; earthy odor.

MEAN.

Total solids,	375.1
Suspended matter,	30.8
Nitrogen in nitrates,	.362
Chlorine,	5.664
Hardness-$CaCO_3$,	210.2
Free ammonia,	.180
Alb. ammonia,	.411
Oxygen consumed,	7.15

TABLE NO 6.

6799 LA SALLE—Big Vermillion.

MAY 7th, 1888.

Total solids,	618.0
Suspended matter,	258.5
Nitrogen in nitrates,	1.323
Chlorine,	6.48
Hardness-$CaCO_3$,	242.4
Free ammonia,	.180

Alb. ammonia,	.693
Oxygen consumed,	9.04
Physical conditions: Turbid, no odor; yellowish.	
Mean temperature, week ending:	41.76
Total rainfall week ending:	1.46

MAY 14th.

Total solids,	457.5
Suspended matter,	101.0
Nitrogen in nitrates,	2.140
Chlorine,	2.58
Hardness-$CaCO_3$,	213.6
Free ammonia,	.142
Alb. ammonia,	.270
Oxygen consumed,	8.40
Physical conditions: Slight earthy odor; yellowish.	
Mean temperature, week ending:	39.11
Total rainfall, week ending:	.22

6800 MAY 21st.

Total solids	378.5
Suspended matter,	25.3
Nitrogen in nitrates,	4.347
Chlorine,	4.70
Hardness, $CaCO_3$,	244.8
Free ammonia,	.002
Alb. ammonia,	.194
Oxygen consumed,	3.36
Physical conditions: Slightly turbid; odorless.	
Mean temperature, week ending:	......
Total rainfall, week ending:	1.00

MAY 28th.

Total solids,	456.9
Suspended matter,	101.5
Nitrogen in nitrates,	4.914
Chlorine,	4.106
Hardness-$CaCO_3$,	260.
Free ammonia,	.073

Alb. ammonia,	**.340**
Oxygen consumed,	**6.64**

Physical conditions: Nearly clear; odorless.

Mean temperature, week ending: ......

Total rainfall, week ending: 3.02

6801 JUNE 11th.

Total solids,	429.5
Suspended matter,	22.3
Nitrogen in nitrates,	3.970
Chlorine,	6.440
Hardness, $CaCO_3$,	290.
Free ammonia,	.015
Alb. ammonia,	.182
Oxygen consumed,	7.20

Physical conditions: Colorless; odorless, with floating organic matter.

Mean temperature, week ending: 53.89

Total rainfall, week ending: .00

JUNE 18th.

Total solids,	436.2
Suspended matter,	60.0
Nitrogen in nitrates,	2.989
Chlorine,	9.204
Hardness-$CaCO_3$,	278.
Free ammonia,	.418
Alb. ammonia,	.440
Oxygen consumed,	5.60

Physical conditions: Nearly clear; yellowish; odorless.

Mean temperature, week ending: 63.40

Total rainfall, week ending: 1.58

6802 JULY 16th.

Total solids,	377.5
Suspended matter,	46.2
Nitrogen in nitrates,	3.843
Chlorine,	4.718
Hardness-$CaCO_3$,	262.

Free ammonia,	.077
Alb. ammonia,	.270
Oxygen consumed,	8.160
Physical conditions: Opalescent; earthy odor.	
Mean temperature, week ending,	61.14
Total rainfall, week ending,	.15

MEAN.

Total solids,	450.6
Suspended matter,	87.8
Nitrogen in nitrates,	3.348
Chlorine,	5.461
Hardness-$CaCO_3$,	255.8
Free ammonia,	.049
Alb. ammonia,	.341
Oxygen consumed,	6.914

6803 TABLE NO. 8.

CHANDLERVILLE (Sangamon River).

JULY 10th.

Total solids,	385.0
Suspended matter,	141.0
Nitrogen in nitrates,	.207
Chlorine,	1.876
Hardness-$CaCO_3$,	208.
Free ammonia,	.060
Alb. ammonia,	.322
Oxygen consumed,	5.800
Physical conditions: turbid; odorless.	
Mean temperature, week ending,	76.28
Total rainfall, week ending,	3.48

JULY 17th.

Total solids,	301.7
Suspended matter,	68.3
Nitrogen in nitrates,	.900
Chlorine,	9.583
Hardness,—$CaCO_3$,	186.

Free ammonia,	.049
Alb. ammonia,	.490
Oxygen consumed,	12.040

Physical conditions: turbid; earthy odor.

Mean temperature, week ending,	71.64
Total rainfall, week ending,	.77

6804 JULY 24th.

Total solids,	334.9
Suspended matter,	79.0
Nitrogen in nitrates,	1.134
Chlorine,	2.124
Hardness—$CaCO_3$,	226.
Free ammonia,	.010
Alb. ammonia,	.220
Oxygen consumed,	3.200

Physical conditions: cloudy; yellowish; odorless.

Mean temperature, week ending,	74.00
Total rainfall, week ending,	.00

AUGUST 1st.

Total solids,	330.8
Suspended matter,	134.5
Nitrogen in nitrates,	.630
Chlorine,	3.065
Hardness—$CaCO_3$,	142.
Free ammonia,	.031
Alb. ammonia,	.400
Oxygen consumed,	7.200

Physical conditions: turbid; odorless.

Mean temperature, week ending,	79.64
Total rainfall, week ending,	.34

6805 AUGUST 8th.

Total solids,	298.9
Suspended matter,	43.0
Nitrogen in nitrates,	.557
Chlorine,	2.832
Hardness—$CaCO_3$,	250.
Free ammonia,	.048

Nitrogen in nitrates,	2.016
Oxygen consumed,	3.760

Physical conditions: slight cloudiness; odorless.

Mean temperature, week ending,	74.28
Total rainfall, week ending,	.91

AUGUST 15th.

Total solids,	274.8
Suspended matter,	48.2
Nitrogen in nitrates,	.560
Chlorine,	2.357
Hardness—$CaCO_3$,	192.
Free ammonia,	.084
Alb. ammonia,	.222
Oxygen consumed,	4.960

Physical conditions: opalescent; earthy odor.

Mean temperature, week ending,	66.85
Total rainfall, week ending,	.09

6806 AUGUST 23rd.

Total solids,	307.4
Suspended matter,	28.7
Nitrogen in nitrates,	trace.
Chlorine,	3.540
Hardness—$CaCO_3$,	242.
Free ammonia,	.134
Alb. ammonia,	.172
Oxygen consumed,	3.680

Physical conditions: nearly clear; slight earthy odor.

Mean temperature, week ending,	67.71
Total rainfall, week ending,	.08

SEPTEMBER 3rd.

Total solids,	309.5
Suspended matter,	23.0
Nitrogen in nitrates,	.250
Chlorine,	3.500
Hardness—$CaCO_3$,	250.
Free ammonia,	.010

Alb. ammonia,	.240
Oxygen consumed,	3.200

Physical conditions: nearly clear; earthy odor.

Mean temperature week ending,	65.28
Total rainfall, week ending,	.12

6807 MEAN.

Total solids,	317.8
Suspended matter,	70.7
Nitrogen in nitrates,	.755
Chlorine,	3.609
Hardness—$CaCO_3$,	212.
Free ammonia,	.053
Alb. ammonia,	.285
Oxygen consumed,	5.480

6808 Q. MR. TODD: Professor, from the summary of the analyses of 1888 based upon the analytical tables contained in State of Illinois Exhibit A, and the table of analyses of the DuPage, Kankakee, Fox,, Big Vermillion, Little Vermillion and Sangamon rivers, that have been introduced in evidence, will you state what conclusions you draw from this table of analyses of the tributaries of the Illinois river, and the table of averages from the analyses made by you for the different points along the Illinois river?

MR. JEFFRIES: I object to the question for the reason that any conclusions or comparisons that may be drawn from the exhibits introduced and the analyses so made, are misleading, erroneous, and have no value, because there is no evidence to show that the samples upon which the analyses are based, were properly taken; no evidence to show the manner in which they were taken; no evidence to show the particular place in the various rivers where taken, whether with reference to the surface or from underneath the surface of the water; no evidence to show the local conditions with reference to rains and freshets; no evidence showing that the samples were taken at the same time or approximately at the same time, and no evidence showing that all samples were taken under like circumstances, like conditions and in the same manner, or in such a manner that the samples so taken from the various rivers are compar-

6809 able with each other, on the various points from which samples were taken from the Illinois river and no evidence to show that any samples whatever were taken from the places named in the exhibit.

A. The consideration of these tables which have been referred to and given by me, and the comparison of the results of the analyses of the Illinois river at its mouth, with the results of the analyses of the tributaries of the Illinois, indicate that a condition of organic purification of the Illinois at its mouth, has been reached, which is comparable with or similar to that found in the tributaries mentioned. As indicated by the various tests which have been described, the organic matters in the Illinois river have been reduced to a point where they are not larger in general than the organic matters found in the several tributaries. They have been reduced to a point beyond which the destruction of organic matter in the river by natural means can not practically be exceeded or surpassed. Apparently the limit of oxidation of the organic matters has been reached. The practical limit of oxidation has been reached in the Illinois river, judging from these comparisons. We have here a condition in which the organic matters have been broken down and destroyed largely, and the residues that are left, not destroyed, are of a stable type, very resistent to all oxidizing influences.
6810 A condition characteristic of organic matter of vegetable rather than of animal origin, from which I conclude that in general these organic matters must be attributed to the leechings of the soil, that is to products of vegetable origin rather than to the products of animal origin.

Q. In what rivers does that condition obtain?

A. This condition obtains in all rivers to some extent and in the Illinois river at its mouth and its tributaries.

Q. How does the presence of organic matter in the tributaries of the Illinois river compare with the Illinois river itself during this period?

MR. JEFFRIES: I object to that for the same reasons stated in the previous objection,—to the witness drawing any conclusions from the exhibits just introduced, and an objection is here made to any other or further conclusions being drawn from such exhibits by this or any other witness.

A. The organic matter in the Illinois river at points far above its mouth, is in general larger than the organic matter in most of its tributaries, but by the time the mouth of the river has been reached, the organic matter has become so far reduced that it compares in general very closely with that found in the tributaries, and does not exceed that in the tributaries in general.

6811 Q. How does the Illinois river at Peoria, before it takes on the pollution from the city of Peoria, compare with the tributaries of the Illinois river above Peoria?

MR. JEFFRIES: I object to that for the same reasons.

A. In most of the examinations the condition of the water at upper Peoria or Averyville, as it is sometimes called, is very analagous to that of the tributaries. There is a purification of the organic matter there so that the water corresponds closely to the water of the tributaries.

MR. TODD: My questions are all directed to the period of these examinations and analyses. You understand that Professor, do you?

A. Yes sir.

Q. How does the water at Grafton in the Illinois river, compare with the water in the DuPage, Kankakee, Fox, Big and Little Vermillion and Sangamon rivers, professor,—

MR. JEFFRIES: Objected to for the same reasons.

A. The water of the Illinois river at Grafton in this season, in the summer of 1888, has reached a degree of organic purity fully equal to the mean condition of the waters in the tributaries mentioned, the DuPage, the Kankakee, the Fox, the Big and Little Vermillion and the Sangamon.

Q. Will you point out from the analyses, those chemical elements which lead you to that conclusion, and explain so that an intelligent layman might understand it?

6812 MR. JEFFRIES: I object to the question for the same reason. Whatever the conclusions or conditions may have been with reference to the particular examinations or analyses of the water they cannot be relied upon, and I object to this character of testimony as being uncertain and not competent proof.

A. In drawing this conclusion I have taken into consideration essentially these three factors, the amount of free ammonia, the amount of albuminoid ammonia and the figure representing the oxygen consumption. I have also considered the condition of oxidation as shown by the amount of nitrates, nitrogen in nitrates. There are four elements in reality going to make up this conclusion and by comparison of these four elements, it has been shown that the Illinois river has reached a condition of organic purity comparable with the tributaries.

Q. Professor, will you give a comparison of these three chemical elements which you have employed in formulating your opinion from the details, their amounts as they appear from the details in the tributaries and at the mouth of the Illinois river?

MR. JEFFRIES: I object to the question for the reasons heretofore stated.

THE WITNESS: Expressed in parts per million as be-
6813 fore, the free ammonia, albuminoid ammonia and the oxy-
gen consumption figure as follows:

For Grafton at the mouth of the Illinois river:

Free ammonia,	.095
Albuminoid ammonia,	.483
Oxygen consumption,	7.3

For Channahan, DuPage river, I will give the figure and explain it later:

Free ammonia,	.417
Albuminoid ammonia,	.346
Oxygen consumed,	4.7

Kankakee River:

Free ammonia,	.114
Albuminoid ammonia,	.585
Oxygen consumed,	12.661

Fox River, Ottawa:

Free ammonia,	.278
Albuminoid ammonia,	.463
Oxygen consumed,	7.066

Big Vermillion River:

Free ammonia,	.129
Albuminoid ammonia,	.341
Oxygen consumed,	6.914

	Little Vermillion river:	
6814	Free ammonia,	.180
	Albuminoid ammonia,	.411
	Oxygen consumed,	7.15

Sangamon River,	
Free ammonia,	.053
Albuminoid ammonia,	.285
Oxygen consumed,	5.48

6815 In giving the result for the Dupage River, I have taken the figures from this report given in the average, which is made up from the last seven results, for the reason explained in the text, that there was some uncertainty about the point of collection of the first samples, and therefore in making up this average, they were omitted. The other average represent the whole collection.

Now a consideration of these results shows in general that the factors representing the nitrogenous elements in the water and the factor representing the amount of oxygen consumed, are no greater for the Illinois river at its mouth than for the tributaries considered in the mean. In the case of the Kankakee the condition at the mouth of the Illinois is evidently better than that of the Kankakee river. The same is essentially true of the Fox river and it is also true of the Little Vermillion river. The average of all of these results from all the rivers will show a condition of organic impurity as great as that of the Illinois at its mouth.

In the breaking down of the vegetable organic matters in water and in the leaching out of the organic matters from soils into water, products are present which are comparatively stable, which tend to persist and resist the destructive influences of bacterial action in general more markedly than do those of animal origin. The characteristic nitrogenous substances
6816 excreted by the animal—urea, uric acid, hipuric acid—
undergo oxidation very much more readily than do the corresponding substances of vegetable origin. The more complex products of animal origin break down finally into substances of comparatively stable type, which do not use up very

much oxygen in the oxidation process. On the contrary the substances of vegetable origin use up much more oxygen—Perhaps I should qualify that. The substances of vegetable origin use up more oxygen than do those of animal origin which have been subjected to bacterial influences. While fresh substances of animal origin consume large amounts of oxygen, —the bodies of animal origin which have been in water a long time have reached a condition of disintegration, forming products of comparatively stable type. Among the substances of animal origin the nitrogenous derivatives are the most characteristic. Among the substances of vegetable origin the carbohydrates on the other hand are the most characteristic and these bodies are pre-eminently those which are characterized by the oxygen-consuming power. Particularly we have in vegetable extracts substances belonging to the lower carbo-hydrates, more particularly pentoses and pentosans, which while showing nothing by the nitrogen tests, give extremely marked and characteristic results in the oxygen consumption tests, and these bodies at the same time are markedly stable and account
6817 for the large figure for oxygen consumption in the vegetable extractives.

I will say these bodies and similar bodies. I mentioned the pentoses and pentosans, as illustrations of vegetable extractive substances; we have also bodies of the acid type, of which oxalic acid or oxalates and similar substances would be representatives. These bodies show marked oxygen consuming power, so that these facts I have taken into consideration in the statement which I made a while back, that the oxygen consuming power in the lower Illinois river corresponds practically to what we can expect from a water fed from the tributaries of the Illinois river, and can be fully accounted for by considering the tributaries and not the nitrogenous waste coming from the original sewage starting at Chicago.

Q. Professor, are you acquainted with the Illinois river and its tributaries?

A. I am.

Q. To what extent have you personal knowledge of the Illinois river and its tributaries?

A. I have seen the whole of the Illinois river by daylight on several occasions. I have gone from Bridgeport to Grafton in a small boat, a gasoline launch, by daylight, observing the whole of the river. I have started at Grafton and come 6818 up the river by daylight, as far as LaSalle, and have continued the trip several times by rail along the bank of the river. I have gone down the river also again from Chicago to Lockport and along the banks of the river to La Salle and from LaSalle or a point immediately below, known as Peru, to the mouth of the river. In addition to that I have visited several points on the river at numerous times.

I have been on the Desplaines river a great many times hunting and fishing, near the mouth, and further up. I have been on the DuPage river and have been up and down the Kankakee river from its mouth, practically to its source, in Northern Indiana. I have been on the Sangamon river at several points and have paid attention to the appearance of the water.

I have been also on the Vermillion river up to Streator which is some distance from its mouth—the Big Vermillion river. I have acquaintance with the Spoon river and the Little Vermillion river only by observation of points where they have entered the Illinois,—but the rivers mentioned are the principal tributaries so far as the waters are concerned.

Q. Are you acquainted with the Sangamon river?

A. I mentioned the Sangamon, which I have visited at Chandlerville, at Springfield and at Decatur, and also at its mouth, across from the town of Browning.

6819 Q. Have you personal knowledge of the sources of sewage contamination entering the Illinois river and its tributaries?

A. Yes, I have knowledge of this from an examination of many points along the Illinois river and the tributaries.

ADJOURNED until ten o'clock A. M., Thursday, September 24, 1903.

Chicago, Illinois.
6820 10:00 A. M., Thursday, September 24, 1903.
Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. JOHN H. LONG,

resumed the stand for further direct-examination by Mr. Todd, and testified as follows:

Q. Professor, have you the table of analyses made by you in the winter of 1888 and 1889?

A. I have.

Q. You have already testified to where the analytical tables compiled by you for the summer of 1888 and 1889 appear in the preliminary report, have you Professor?

A. In the summer of 1888, yes.

Q. Professor, did you make examinations in the winter of 1888 and 1889?

A. I did.

Q. How many samples of water were taken?

A. Somewhat variable, but a mean eight or nine samples from each place.

Q. What places?

A. From Bridgeport, Lockport, Joliet, Morris, LaSalle,
6821 Henry, Peoria, Pekin, Havana, Beardstown, Grafton and Alton.

MR. JEFFRIES We object to the reading of these tables into the record or to this witness testifying to the result of the examination for the reason that there is no evidence showing the manner in which the samples of water were taken; no evidence showing the particulars of where taken; no evidence showing the condition of the water, with reference to local showers and freshets, or the stages of the water or the condition of the weather.

Q. MR. TODD: Where does the table of analyses appear?

A. In the State of Illinois Exhibit A for identification.

Q. Have you the summary made by you from these tables of analyses?

A. I have.

Q. Where is it?

A. It is in this preliminary report, page 30 with the Roman notation.

MR. JEFFRIES: We object to the summary being introduced for the reasons stated in the objections to similar testimony introduced yesterday, and for the reason that the original tables are the best evidence.

Q. MR. TODD: Is that the table that was read into the record yesterday by you, immediately following the table
6822 on the same page of the report from May to October, inclusive, 1888?

A. It is.

Q. From that table of analyses what conclusions, if any, do you draw?

MR. JEFFRIES: We object to the witness drawing any conclusions and we object to any conclusions being drawn from the tables for the reasons, first, that the original tables themselves are the best evidence; second, for the reason that there is no evidence showing what time or the manner in which the samples from which the examinations of water was made, and no evidence showing the condition of the river at the particular points where the samples were taken with reference to local showers and freshets, or the rise in the river, so that any conclusions that may be drawn would be misleading and unreliable, and therefore such testimony and such conclusions are of no value so far as the issues involved in this case are concerned.

A. This table giving the summary of the analyses made during the winter of 1888 and 1889, shows a considerable reduction of organic contamination of the water between Bridgeport and Grafton, but a very much less marked degree of reduction than was observed in the summer of 1888. This difference is particularly noticeable in the factor for the oxygen consumption, and for the albuminoid ammonia, and it is also shown by the factor expressing the amount of the free or saline
6823 ammonia present. One of the most important points in this table is found in the figures showing the amount of free ammonia, albuminoid ammonia, and the extent of oxygen consumption at Pekin during the winter. While in the summer work the amounts of organic matter in the river at Pekin as disclosed by the analyses does not appear to be excessive, at any rate no very great increase is detected there, during the winter of 1888-1889 these factors show, especially as regards the undecomposed nitrogenous substances indicated by the albuminoid ammonia, a very large residuant. The condition in-

dicated by the figures for oxygen consumption is also one of increased organic contamination. The explanation of this is not difficult and should be given here.

During the summer season in the stretch between Peoria and Pekin, which is a nearly level stretch of eight or ten miles in extent, an enormous decomposition of organic matter occurs, as is observable in passing through the stream. This decomposition is a bacterial or fermentive decomposition, as disclosed by the rapid evolution of gases in this part of the stream, so that roughly, this stretch may be compared to a great septic tank in which hundreds of tons of organic matter are undergoing decomposition all the time. The rate of decomposition of organic
matter varies as is well known, by temperature. In the
6824 winter season therefore, we have this rate very much
slower, so that at Pekin, below the distilleries and cattle sheds of Peoria, the enormous pollution as indicated by the residual albuminoid ammonia factor and the factor for oxygen consumption indicates fresh and recent additions.

MR. JEFFRIES: The statement made by the witness with reference to the discharge from the cattle sheds at Peoria is objected to for the reason that that condition relates to conditions existing in 1888 and 1889, while the evidence shows that there has been a great reduction in the number of cattle fed at that place since the opening of the Chicago Drainage Canal, as compared with the number fed prior thereto, and therefore any conclusions that may be drawn by this witness or any other witness, on that proposition is erroneous and misleading and absolutely irrelevant to the issues involved in this case.

A. (Continued) The consideration of these figures shows beyond any question whatever, that the addition of filth at Peoria is a very important factor in accounting for the organic matter in the river below.

Q. MR. TODD: You are confining your answer to the period of 1888 and 1889?

A. I am.

Q. And not to a date subsequent to that time, are you
6825 professor?

A. I am not.

MR. JEFFRIES: We move to strike out all that the witness said with reference to the filth deposits in the Illinois river at Peoria for the reason that the witness has not shown that he is acquainted with the conditions at Peoria, and the amount of deposits in the river at Peoria, and has not testified in reference thereto.

MR. TODD: Go ahead professor.

A. Another feature which must be referred to here is the high free and albuminoid ammonia as disclosed at Grafton, and the high oxygen consumption also. These figures,—this summary is made from the average of results given on page 28 Arabic notation, of the body of the report, and the individual examinations there show very great and considerable variations.

In the last of the examinations made in March of 1889, for some reason which I cannot explain now, the factors for free ammonia, for albuminoid ammonia and for oxygen consumption, were unusually high. The addition of these in making up the general average, as given on page 30, Roman notation—accounts for the relatively high figures given opposite Grafton,—figures higher than those given for the next town above,—Beardstown.

6826 It is evident from a consideration of the figures on page 28, Arabic notation, of the report, that at that time the river must have received at that point a very greatly increased contamination, possibly from the breaking up of ice and the washing down of accumulated filth. I have no data to show at the present moment how that could be accounted for. So, in resume, in consideration of this table while in general a reduction of organic matter appears during the colder season, it is markedly less than during the warmer summer weather before.

MR. JEFFRIES: Now in addition to what is contained in the objection to the conclusions of this witness, we move to strike out all of the answer for the reason that the conditions existing along the Illinois river in 1888 and 1889, were not the same a they have been since the opening of the Chicago Drainage Canal and we move to strike out all that was said with reference to the septic operation at and below Peoria, for the reason that the greater volume of water being discharged into the river by means of the drainage canal, has destroyed all septic operations at Peoria, or at any other place as shown by the evidence heretofore taken in this case,—if any such conditions existed in 1888 and 1889.

Q. MR. TODD: Professor, did you have any personal knowledge as to the condition of the sewage of Peoria during this period?

A. I had.

6827 Q. From what source did you get that knowledge?

A. From trips down the river at that time. I made several trips to Peoria during the period of these examinations, and between Peoria and Pekin.

Q. Have you read any of the testimony given by witnesses in this case at Peoria in regard to the sewage?

MR. JEFFRIES: We object to the question as incompetent, irrelevant and not a proper examination of the witness.

A. I have.

Q. MR. TODD: Whose testimony have you read?

MR. JEFFRIES: We object to the question for the further reason that whatever he might have read would be merely hearsay.

A. I have read the testimony given by Dr. Keiser, and Dr. Teichmann in their analyses.

Q. Of any other witnesses?

A. I do not recall any others.

Q. You heard the testimony of Dr. Keiser, did you not?

MR. JEFFRIES: Objected to as being incompetent and not the proper method of examination of this witness.

A. I did.

Q. Have you the table of analyses for the winter of 1890 and 1891?

6828 A. I have not, with me; those analyses were of the sewer waters discharged near Bridgeport, and were not published.

Q. Have you the summaries from those analyses?

A. I have a resume of these summaries in report form.

Q. Where is the resume to be found?

A. It is found in the report of the Illinois State Board of Health, published in 1901.

Q. By what authority?

A. By the authority of the State Board of Health of Illinois, published by the Secretary, page 67 of this report.

(Witness temporarily withdrawn).

6829 **JAMES M. QUINLAN,**

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. James M. Quinlan.

Q. What is your business?

A. Clerk in the Law Department of the Sanitary District.

Q. Of Chicago?

A. Chicago.

Q. Mr. Quinlan, did you take any samples of water from the Kaw and Missouri rivers?

A. Yes.

Q. When did you take those samples?

A. On the 22nd, 23rd—and let's see, I made a note of them. I could not be positive as to the dates. It was May this year (referring to notes). Took them from the Kaw River on the 26th, 27th and 28th days of May.

Q. At what point on the Kaw?

A. Took them from the Kaw river about a mile and a half from Kansas City, Kansas, above the sewers, on the 26th, 27th and 28th days of May.

6830 Q. How many samples of water did you take?

A. From the Kaw?

Q. From the Kaw?

A. Took three on each day, making nine for those days.

Q. At what points on the Kaw did you take the three samples?

A. About a mile and a half above the Kansas City sewers.

Q. Were these three samples a cross-section?

A. Yes, one was taken fifty feet from the right bank: one from the center, and one fifty feet from the left bank.

Q. Who was with you when these samples were taken?

A. Frank Burke and two boatmen.

Q. How did you get up the Kaw?

A. In a boat, rowed up.

Q. This is Mr. Burke who is in the room at present?

A. Yes, the gentleman sitting behind me to the right.

Q. Where, in the Missouri river did you take samples?

A. Above the mouth of the Kaw river on the 22nd, 23rd and 25th of May.

Q. How far above the mouth of the Kaw on the Missouri river did you take these samples?

A. About a mile.

Q. Were there any sewers from Kansas City, Kansas, or Kansas City, Missouri emptying into the Misouri river above the point where you took the water?

6831 A. No.

Q. How may samples of water did you take daily from the Missouri river?

A. I took the same number.

Q. How did you take them?

A. Why, we had a gallon water bottle—

Q. No, in cross sections?

A. Oh yes, we took them fifty feet from each bank and one from the center.

Q. And where else did you take samples of water on the Missouri?

A. We took them up at the other end, that is, above.

Q. Above what?

A. Above the sewers at the other end of the town.

Q. Were these last samples that you have testified to taken above or below the sewers?

A. The last that we took was above the mouth of the Kaw in the Missouri river. You see we took them at both ends of the city.

Q. Yes, what I want to get at—just describe the two places on the Missouri river that you took samples of water?

A. Well, we took some about a mile below where the Kaw flows into the Missouri, then we took them up above, the other end of Kansas City.

6832 Q. On the Missouri river?

A. On the Missouri river.

Q. The ones that you took above the mouth of the Kaw on the Missouri river, was that above the sewage discharge from Kansas City?

A. Yes sir.

Q. In the Missouri river?

A. Yes.

Q. Did you take a cross section there?

A. Yes, fifty feet from each bank and one in the center.

Q. Now the ones that were taken below the mouth of the Kaw river, how far below the sewage discharge of Kansas City were these samples taken?

A. Well—in the Missouri?

Q. Yes?

A. About a mile and a half from the last sewer.

Q. Down the river?

A. Yes.

Q. How did you take those samples, in a cross-section?

A. Same manner, cross-section.

Q. How many samples did you take?

A. Took nine in all.

Q. Above and below?

A. Nine in each place, on the three separate days, we took three each day.

6833 Q. Will you describe now the manner that you empl[illegible]d in the collection of these samples of water at the three different places?

A. Why, we had a half gallon or gallon,—I am not positive which—gallon glass jars, and we would take the glass jar in our hand and dip below the surface of the water about a foot, after cleansing the jars with the water of the river, and cleansing the stoppers in the same manner, and as soon as we filled the bottle for that place, we would lift it up, put the stopper in and seal it.

Q. Where did you get these jars from?

A. Why, they were sent to us by Professor Long, through the Express company. We got them in Kansas City.

Q. In what condition did these bottles come to you?

A. As to what?

Q. Open or closed?

A. Closed.

Q. What kind of a cork did they have in them?

A. They had a ground glass stopper.

Q. When did you remove the stopper from these bottles?

A. Just at the time that we dipped them in the river, just prior to the time,—immediately before.

Q. Now after you dipped the bottles in the water, rinsed them and filled them the second time and corked them,

6834 what did you do?

A. We sealed them.

Q. In what manner?

A. Why we had a linen piece of cloth with rubber, a sort of a rubber veneer on it. We placed that over the stopper and then we used an ordinary wire and lead seal.

Q. After sealing it what did you do?

A. Why, we attached thereto a card describing when we had taken the waters and where we had taken them.

Q. Then what did you do with them?

A. Then we took them to the express company and shipped them to Professor Long at the Northwestern University.

Q. This same method you pursued in each one of the three places where samples were taken?

A. Yes sir.

Q. On the cards which you placed on the bottles, did you sign your name to it?

A. Yes.

Q. I will ask you to look at the cards that I hand you, 36 in number, and state whether or not those are the cards which you attached to the bottles of water which you collected from the three different points and sent to Professor Long at the Northwestern University Laboratory?

A. Yes sir, they are.

6835 Q. Did each one of those cards accompany the bottle of water which you collected and sent to Professor Long?

A. They did.

Q. After you shipped the 36 bottles of water as you have stated, did you see those bottles again after that?

A. Yes.

Q. When?

A. The day after our arrival at Chicago, on the 31st day of May.

Q. Where did you see them?

A. At Professor Long's laboratory.

Q. Did you see the bottles there?

A. Yes.

Q. Were the bottles which you saw there the identical bottles of water which you collected from the Kaw river and the Missouri river?

A. Yes.

Q. When you were in Kansas City, did you investigate the sewage out-falls of the city of Kansas City, Missouri?

A. Yes.

Q. Will you describe where those sewers from the city of Kansas City, Missouri emptied?

A. Why, they all emptied into the Missouri river above the place where we took this water. That is, there are two or
6836 three—but we took the samples about a mile above where they entered and then below where they all entered.

Q. How many sewers emptied into the Missouri river from Kansas City?

A. Well there are four large sewers.

Q. Did you make special investigation of that fact?

A. Yes, I saw them.

Q. Are there any other sewers in Kansas City except the sewers that empty into the Missouri river directly?

A. Why no; there is one, but it was not completed at the time we were there,—one in course of construction.

Q. Where was the outlet of that sewer?

A. Well that was into the Missouri, but not within the limits of the place where we took the water. It was to empty into the Missouri about eight or nine miles above Kansas City, Missouri, proper. It was to empty into what they call the Blue, it is a creek.

Q. Is that below or above Kansas City?

A. Well, it is above Kansas City, but I mean below the place where we took the water.

Q. Have you correctly described the locaton of that sewer, relative to the Missouri river?

A. Well this sewer, I didn't examine at all, but I am just telling what the City Engineer there told us they were 6837 doing with the sewer.

MR. JEFFRIES: I move to strike out everything that the witness has said the City Engineer told him.

Q. MR. TODD: This sewer was not completed?

A. It was not completed at all.

MR. JEFFRIES: We object to the witness testifying further in regard to this sewer, because his own statement shows that he doesn't know anything about it.

Q. MR. TODD: The sewers that you investigated did empty into the Missouri river?

MR. JEFFRIES: Objected to as leading.

A. Every sewer that was in operation emptied into the Missouri river.

Q. MR. TODD: These cards that you have identified, which one of the Kansas Cities do you have reference to Mr. Quinlan?

A. Kansas City, Missouri.

MR. JEFFRIES: I move to strike out all this witness has said with reference to the sewers of Kansas City discharging the sewage of Kansas City into the Missouri river, because it is incompetent, irrelevant and immaterial and has no bearing upon the issues involved in this case.

Q. Did the cards which you have identified, were they enclosed in an envelope?

6838 A. Yes sir, an envelope similar to that (pointing).

CROSS-EXAMINTION,

By Mr. Jeffries.

Q. How long were you in Kansas City?

A. About two weeks.

Q. At this particular time?

A. Yes sir.

Q. Do you know then of your own personal knowledge that there were four sewers emptying into the Missouri river?

A. I know that there are four; there may be some smaller ones, but I know of my personal knowledge that there are four; there may be more.

Q. Do you know of any sewers emptying into the cess-pools to the south of the town?

A. No, I do not.

Q. You didn't investigate that?

A. No. I investigated those that emptied into the Missouri.

Q. You don't know then what proportion of the sewage of Kansas City empties into the Missouri?

A. Yes sir.

Q. And what proportion empties into the cess-pools?

A. Yes sir.

6839 Q. You investigated that personally, did you?

A. There is a very small proportion—

Q. Did you investigate that personally?

A. Yes.

Q. You got the figures yourself, did you?

A. Yes.

Q. As to the amount?

A. Yes.

Q. Do you know where these cess-pools are?

A. Well I couldn't state exactly where they are.

Q. Well name the locations, how far from the city and in what particular part of the city?

A. I couldn't say that, but I can say that five-sixths of the sewage empties into the Missouri, and that was what I paid the most particular attention to.

Q. Well, answer the questions. You needn't talk until I ask you a question, and then answer the question.

MR. JEFFRIES: I move to strike out what the witness said as not being responsive to any question put to him.

MR. TODD: I object to the motion on the ground that the answer is responsive, and was elicited by the cross-examination of counsel.

Q. MR. JEFFRIES: Where are these sewers that empty into the Missouri river, located?

6840 A. The largest sewer that empties into the Missouri river and the main sewer is at Ohio Street—

MR. TODD: You mean Kansas City?

A. Kansas City, Missouri. What they call the Ohio Street sewer empties into the Missouri river at Ohio Street, and that conveys most of the sewage from Kansas City, Missouri the largest portion of it.

Q. Now what time of the year was it that you were in Kansas City, and what year?

A. May 23rd, we got there, about the 21st day of May, this present year.

Q. 1903?

A. 1903.

Q. And you left there when?

A. We left there about the 30th.

Q. What was the stage of the Kaw river at that time?

A. We didn't take any stages of the Kaw.

Q. Was it before or after the flood?

A. It was before.

Q. How long before?

A. About ten days.

Q. The river was very high at that time though, was it not?

A. Not very high for that time of the year, about ordinary condition for that time of the year.

6841 Q. Oh, you were acquainted with the river prior to that time, were you?

A. Yes.

Q. What was the extent of your acquaintance with the river?

A. Well, I can't say that I was, but I made inquiries from the natives there—

Q. I am talking about your knowledge.

A. No, never was up and down the river and examined it before.

Q. Were you ever in Kansas City before?

A. Yes.

Q. Never was up and down the river before?

A. No. But you could see that the river was not extra high.

Q. Now you took two sizes of bottles, did you—samples in two sizes of bottles, a small and a large?

A. No, one size.

Q. Large bottle?

A. Large.

Q. You didn't pack them in ice or anything?

A. No sir.

Q. Did you hold the stopper under the water while the bottle was being filled?

6842 A. No sir.

Q. You held it in your hand?

A. Yes.

Q. Where was the stopper when the bottles were being rinsed, when you would rinse the bottles?

A. Held it in my hand.

Q. You held it in your hand all the time?

A. Yes.

Q. What express company did you take them to to ship them to Chicago?

A. United States.

RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. You say you knew the proportion of the sewage emptying into the Missouri river through these sewers. Will you state it?

A. Well, it was about five-sixths.

Sig. Waived.

F. S. B., Com'r.

6843 **FRANK C. BURKE,**

called as a witness in behalf of the defendants, being first duly sworn was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Frank C. Burke.

Q. What is your business Mr. Burke?

A. I am in the teaming business at the present time.

Q. Did you go to Kansas City with Mr. Quinlan?

A. Yes sir.

Q. Did you collect any samples of water from the Kaw River?

A. Yes sir.

Q. And Missouri river?

A. Yes sir.

Q. At what points did you collect samples from the Kaw and the Missouri?

A. From the Kaw river we collected samples about a mile and a half above Kansas City, Kansas, sewers, up above Argentine.

Q. On what river?

A. On the Kaw river. In the Missouri river we collected samples from about a mile or a mile and a half above the mouth of the Kaw, where the Kaw empties into the Missouri. We collected samples just below the mouth of the Kaw, between
6844 what they call the Ohio Avenue sewer, or the Ohio Street
sewer, and the mouth of the Kaw and the Missouri, and we collected samples below Kansas City, Missouri, city limits.

Q. Describe where you got the bottles from and how you collected the water?

A. We got the bottles from the United Express Company. They were sent to us. Some of them were sent to us, I believe it is, from the Northwestern University, where Professor Long is, and some of them were sent to us from the laboratory of the city Hall, we got them from the express office. We had them sent to the hotel. We went down and investigated the river and went along and located the sewers as near as possible and then we started in to collect water samples.

Q. Well, just describe how you collected them?

A. Well, we secured boatmen in the Missouri river and rowed up above the mouth of the Kaw, up between the mouth of the Kaw and the Quanderro, as near as I could judge, and we collected—first when we started to collect the water, we took and rinsed our bottles and washed our corks. Do you want the manner described, in which we took the water?

Q. Yes, state just how you did it.

A. We took our coats off. It was quite warm, and tucked up our sleeves and dipped the bottles down as deep as we possibly could, in the water.

6845 Q. How deep was that?

A. Well, I cannot estimate just how deep it would be. It was as far as we could reach out of the boat you know. I should judge possibly we would get a foot and a half under the water, something like that. Then afterwards we would take the bottle out and we immediately sealed it and placed our cards in the envelope. Then we took it in cross-sections. Went to the center of the river and then to the other side, fifty feet from the right bank, and we did that in every place that we took the water.

Q. How many places did you take the water?

A. In the Missouri river we took it at three different places.

Q. And one place on the Kaw river?

A. One place on the Kaw river, yes sir.

Q. After you took the water and sealed it, what did you do with it?

A. We took it back to the hotel and when we had collected all our water we expressed it to Professor Long at the Northwestern University.

Q. You expressed 36 bottles to Professor Long?

A. Yes sir.

Q. After you arrived in Chicago did you see those bottles?

A. Yes sir.

6846 Q. Where?

A. At Professor Long's Laboratory.

Q. Are those bottles that you saw in Professor Long's laboratory, were they the identical bottles you collected from those four different places?

A. Yes sir.

Q. I will show you 36 cards and ask you if those are the cards which you placed on each one of the bottles?

A. Yes sir.

Q. Did you investigate the sewage out-falls at Kansas City?

A. I don't quite understand that question.

Q. Did you investigate the sewage out-falls of Kansas City, the sewers?

MR. JEFFRIES: I object to the question for the reason that it is incompetent, irrelevant and immaterial and for the reason that the fact that the sewage is discharged into the Missouri river by Kansas City, has no bearing on the issues involved in this case and such fact does not justify the Sanitary District of Chicago in sending its sewage down the Illinois river.

Q. (Question repeated)?

A. Well, we investigated the different sewers that emptied into the Missouri river as far as we could do so.

6847 Q. How many sewers did you find emptying into the Missouri river?

A. We found four large sewers.

MR. TODD: I offer those 36 cards in evidence.

MR. JEFFRIES: To the introductin of this we object for the reason that such evidence is incompetet, irrelevant and immaterial.

THE COMMISSIONER: The cards are marked Defendant's Exhibit 2.

Not reproduced.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. What is your business?

A. I am in the teaming business.

Q. Do you know what Mr. Quinlan's business is,—the man who testified just before you did?

A. I understand he is connected with the Sanitary District.

Q. Mr. Todd's clerk, isn't he?

A. I don't know. I know he is connected with the Sanitary District and that's all; I don't know what their official positions are.

MR. TODD: He is a clerk in the law department of the Sanitary District of Chicago.

6848 MR. DRENNAN: He testified to that. He said he was a clerk in the law department of the Sanitary District.

Q. MR. JEFFRIES: Were you ever in Kansas City before this time?

A. No sir.

Q. You don't know anything about the stage of the water in the Kaw and Missouri rivers at that time, as compared with what it was at previous times?

A. With the exception of the report which we got from, I think, the Government office there; that is, on the Missouri river. They take the stagings of the Misouri river each day. I don't believe they take any stagings of the Kaw river.

Q. You say you think you got it from the government?

A. I am certain we got it.

Sig. waived.
F. S. B., Com'r.

6849 **PROF. JOHN H. LONG,**

resumed the stand for further direct-examination by Mr. Todd, and testified as follows:

Q. Have you made any examinations of the sewers of Chicago, and the discharges from those sewers, and if so when, and for what periods did the investigation relate to?

A. I made on several occasions, examinations of the sewers in the neighborhood of Bridgeport and south of Bridgeport. First in 1886 and later in 1890 and 1891. The winter of 1890—and 1891, I made more extended investigations to determine if possible, the proportions of organic matter discharged from the sewers of the city and from the stock yards, and the amount of this which passed the pumps at Bridgeport.

Q. When was this investigation made?

A. The first investigation in 1886 was made for the Citizen's Association; the time of year I cannot give you now, and it was concerned mainly with what I spoke of yesterday, as the large Brennock sewer, carrying the bulk of the stock yards sewage at that time. The amount determined then was equivalent to about 112 tons daily of dry, organic matter.

Q. Give the dates of the last examinations?

A. In the winter of 1890 and 1891. I made altogether 6850 about 130—I cannot give the number exactly, but about 130 examinations of water from the various sewers. This water was collected daily through a considerable period, at fifteen minute intervals. The collections were united in large hogsheads, thoroughly sampled and brought to me each day for analysis by employes of the engineering department of the Sanitary District of Chicago, the method of collection being suggested by myself. Analyses were made of these waters to determine the total organic matter as accurately as possible, and also the nitrogen from which a calculation was subsequently made. The results of these investigations were never published and at the preset time I am not able to find the averages which I made, but the figures from which I quote here were made when I had those averages in my possession some years ago. They have been mislaid since. These figures are important as showing as accurately as I could determine at that time the amounts of organic matter.

MR. JEFFRIES: I object to any statement by the witness of the amounts and the results of the examination, for the reason that the witness has no correct information with him with reference to the actual results of such examination that would make competent and legal proof or evidence, and for the reason that the original tables are the best evidence.

MR. TODD: Professor, the facts which you are about to
6851 detail you know of your own personal knowledge are correct?

A. I do.

MR. JEFFRIES: I object to the question and answer for the reason that the witness has not shown that he made any comparison between those before him and those contained in the original sheets; that the witness is now reading from a printed report of such examination, and also for the reason that the witness stated that the information he now has before him was furnished by assistants in his office.

MR. TODD: You state from what facts you are about to detail, are compiled from and by whom made?

A. These facts were obtained by myself in the analyses of the samples of sewer water collected in the year 1890-1891, the winter of 1890-1891. The original analyses I still have, but the memoranda which I have not, are memoranda of the flow in the sewers, which would be necessary to calculate the amount for 24 hours, but before those memoranda were mislaid the statement I have here was made and I vouch for the correctness of that statement.

Q. Made by whom?

A. By myself.

Q. Proceed?

A. I found at that time that the organic matter which was
discharged from the city and stock yards sewers in the
6852 neighborhood of the Bridgeport pumps amounted to ap-
proximately 240 tons daily, and I will have to explain or
should explain how that was reached.

Q. What date was that, professor?

A. That was through the winter of 1890-1891.

Q. Go ahead.

A. It is a very difficult matter to obtain an absolutely accurate determination of organic matter in mixtures as complex as this, using the term "accuracy" as understood by chemists. A great many of our analyses of organic matter are made with an accuracy of one-tenth or two-tenths of one per cent. Such a degree of accuracy is not possible in an examination of this kind. An accuracy of one or two per cent. or rather an error of one or two per cent. at the most, is as near as we could expect, so, probably the 240 tons daily which I have given, must not be assumed to be accurate within one per cent., perhaps, or two per cent of the whole. This determination was made in two ways mainly. The samples of water taken were mixed thoroughly, an average portion was subjected finally to analysis. Measured portions of the sample brought to me were evaporated to dryness in a platinum dish and the residue so obtained was incinerated, that is, burnt, not directly, but by the method known
as the Drown method, suggested and used first in the
6853 Massachusetts State Board of Health. A platinum dish
being placed inside of another much larger platinum dish,
supporting a platinum coil, a burner being placed below this dish and a radiating plate of metal, in my case, polished nickel, being placed some distance above the dish so that the organic matter under these conditions could be burned off at the lowest possible temperature without the destruction of any large amount of the inorganic substances. That test was made in all cases, using 500 cubic centimeters to a liter of the water in each test, 500 cubic centimeters with the stronger waters and more for those containing less sewage. In all these cases also, the determination of nitrogen was made by the methods employed by

chemists using the so-called Kjel Dahl process. A determination of this nitrogen served as a check in a measure, on the determination of the total solids, the nitrogen being essentially of a proteid character, it is possible by the calculation which I intend to explain here, and which is commonly known to chemists, to calculate the organic matter from the nitrogen. These two results agreed in giving the figures that I have stated here.

I also made similar determinations of the water by similar methods, as it passed the Bridgeport pumps, to determine what part of the organic matter was probably decomposed within the city. The figure that I have given here of 240 tons, is
6854 the amount discharged from the sewers. The next important question was what portion of this actually passed the pumps into the canal. These determinations were made a number of times and it was found that about five-sixths of the water in one series of investigations, the one which I have given, passed the pumps. The remainder being decomposed inside of the city, that is, the decomposition of the organic matter was in the city. In the warmer months a very much larger proportion of the organic matter is decomposed in the city than in the colder months. These determinations were made in the colder weather; the fall, winter and spring of 1890-1891.

Q. Were all these examinations that you have testified to made a matter of publicity?

A. The last ones I have testified to were not; the first ones made in 1886, were.

Q. And was the last one subsequently published?

A. The last ones were not published except in this book.

Q. What book is that; I want that in the record?

A. The details of this investigation were never published. The only publications made were in the resume which I have quoted from, given on pages 67 and 68 of the report of the Illinois State Board of Health, printed in 1901, by the authority of the State Board of Health of the State of Illinois.

6855 Q. Professor, from your examinations as you have testified, from 1886 down to the winter of 1888 and 1889 exclusive of the sewage examinations at Chicago made by you and testified to by you in the record, what did those examinations disclose as to the condition of the Illinois river for those separate periods?

MR. JEFFRIES: We object to the question for the simple reason that the examinations which the witness has just testified to referred to the sewage of Chicago and therefore had no connection with the Illinois river at that time.

(Question repeated.)

MR. JEFFRIES: I object to the question for the reason that the witness has already testified on that proposition and also for the reasons stated in our objections to the testimony given yesterday when similar questions were propounded, for the reason that there is no evidence to show the manner in which the samples of water were taken from the river, whether beneath or on the surface of the water; no evidence showing that any instructions were given as to the manner of taking the samples; no evidence showing that instructions if given, were carried out, in taking the samples, and no evidence showing the local condition of the weather and the water in the river, the stages of the river, and any comparison that may be 6856 drawn by this witness or any statement with reference to the condition of the river as drawn from these examinations would be misleading, and incorrect. Therefore it is incompetent and not legal proof.

A. The comparison of the results obtained in the Illinois river in 1886, with those obtained two years later, 1888, 1889, indicate increased pollution of the Illinois river at Peoria. From personal observation of the Illinois river at Peoria in 1886, I know that the water was potable, and formed a large part of the water supply of the city of Peoria. From personal observation I know that later this water supply was abandoned because of the increasing pollution of the river, which was shown also by the analyses.

Q. What was the condition of the river at Grafton during these periods based upon your analyses?

MR. JEFFRIES: We object to the question for the same reasons stated in the objection to the previous question.

A. I had no data for Grafton in 1886, so I cannot make a comparison. I am unable to make a comparison.

Q. What point farthest down the river have you data for?

A. Peoria for the year 1886.

Q. Were you acquainted or do you know when the so-called Hering Commission was appointed?

6857 A. I do.

Q. Are you acquainted with the facts that led to the appointment of this commission?

A. I am.

Q. Will you state them?

MR. JEFFRIES: Object to that as incompetent, irrelevant and immaterial and having no bearing on the issues involved in the case.

A. As the chemist to the Health Department of the city of Chicago and as the chemist of the State Board of Health, I was familiar with the discussion regarding the water supply of Chicago and the increasing pollution of the same. The necessity of doing something to prevent contamination of the drinking water by the discharge of sewage was recognized by everybody and many plans were suggested to correct this difficulty. Among the sanitarians within the city of Chicago several essentially different schemes of betterment were suggested, so that it was finally suggested to create a commission to decide on a scheme and bring in from outside of Chicago some expert of recognized ability who had not previously taken part in the local discussion.

Q. Were you present at all of these discussions?

A. I was not present at all of these discussions because 6858 they were general discussions. They took place in the engineer's office and in the Citizens' Association. I was frequently present there, being a member of the association. They were discussed by the daily press, and of course I couldn't be present at all of them. I was quite familiar with the general trend of the discussion. It was finally decided to appoint this commission and the appointment was made in 1886, with Mr. Rudolph Hering, an engineer, as the chairman of the commission, with Mr. Benezette Williams and the city engineer, Mr. Actingstall, as the other members of the commission. This commission after a year or more of work decided on a method by which the increasing sewage of the city of Chicago could be most effectually disposed of. This commission considered for a long time the question of the disposition of the sewage on land, in the vicinity of Chicago. I am somewhat familiar with the discussions, because I was asked several times to explain the character of the soil which would be necessary to receive and dispose of sewage continuously and in large amounts. The question of carrying the sewage through an immense tunnel a long distance into the lake and discharging it there, was also favored by some at the time and considered by this commission. After consideration of the various plans the commission decided on the construction of a so-called drainage canal, following essentially the recommendations which had been made by Dr. 6859 Rauch of the State Board of Health, and others years before.

Q. Are you acquainted with what the recommendations were as made by Dr. Rauch?

MR. JEFFRIES: We object to the witness testifying to any recommendations made by Dr. Rauch for the reason that it is merely hearsay evidence and is incompetent and immaterial.

A. The recommendation made by Dr. Rauch for years, and published in the reports and bulletins of the State Board of Health was that the drainage canal be constructed along the line, or near the old Illinois and Michigan Canal, to connect the water of Lake Michigan by gravity flow with the Desplaines, and subsequently the Illinois river, a sufficient volume of lake water being allowed to flow through this canal to so dilute the sewage taken up in the flow from the city of Chicago that the final result would be a product not objectionable to the senses of the people living along the canal and the valley towns. I should add in explanation of this that objections were expressed by people in the valley towns that the river so enlarged and carrying down perhaps more sewage, would emit a worse smell in the big canal than in the old. Their objections were based very largely on that supposition. The recommendation of Dr. Rauch was to dilute with sufficient pure water to overcome that objection. His recommendation provided for a maxi- 6860 mum flow of 600,000 cubic feet per minute, based on an estimated population of 2,000,000.

Q. Were Dr. Rauch's recommendations or views ever committed to any publication?

A. The recommendations of Dr. Rauch were frequently published in various bulletins from the State Board of Health and the proceedings of sanitary conventions and elsewhere.

Q. At what date were these recommendation made by Dr. Rauch, professor?

A. The recommendations of Dr. Rauch were made in 1879. That is one date I find here (referring to book).

Q. In what publication does that appear

A. Publications of the State Board of Health and referred to in the publication which I have here. The original I have not at hand now.

Q. Well, name it, so it will get into the record?

A. It is the preliminary report of the Illinois State Board of Health of the Water Supplies of Illinois and the pollution of its Streams, printed in 1889 by the Illinois State Board of Health by Dr. Rauch. It is a report published by Dr. Rauch, and reviews his previous recommendations regarding the disposition of the sewage, and gives the dates where some of these recommendations, or rather when some of these recommendations were made. I do not put my hand on them at this moment. 6861

Q. When was that preliminary report published, professor?

A. This preliminary report was published in Springfield, Illinois, in 1889.

Q. For what purpose, if you know?

A. For the purpose of giving the results of examinations of the water in the lake and Illinois river made by myself for the Illinois State Board of Health.

Q. At the time that report was published, was the legislature in session?

A. I am not positive except from hearsay. It was in session but I was not present, but I know it was in session.

Q. Do you know of your own knowledge whether the question of legislation involving the sanitary condition of Chicago was in the legislature for discussion at the time that report was published?

A. I do know that of my own knowledge. I have since found a reference to the recommendations of Dr. Rauch, in a note entitled "Explanatory and Supplemental," in this preliminary report of the Illinois State Board of Health referred to and printed in 1889, in which the explanation of the dilution of the sewage is given. That is, the explanation recommended by Dr. Rauch.

6862 Q. Do you know why this report was gotten out and entitled a preliminary report?

MR. JEFFRIES: I object to the question for the reason that such evidence is merely hearsay and based upon the opinion of the witness and is not competent proof and is immaterial.

A. This report was gotten out in answer to questions brought up in Springfield regarding the character of the water of the Illinois river and the changes in the water by flow from the sewage from Chicago through the canal, the Desplaines river and the Illinois to Peoria, and the towns below. It was called a preliminary report because in order to answer the questions then under discussion—

Q. Where did these questions emanate?

A. These questions emanated in the legislature at Springfield. This report is called a preliminary report, because in order to answer these questions it was necessary to bring it out in a very great hurry, the expectation being to issue the full report some time later. As an actual fact the full report was made by myself later, but it was not published.

MR. JEFFRIES: I object to the answer and move to strike out all the witness said with reference to the subject of discussion and where it emanated, for the reason that he states it emanated in the legislature and if so the records of the session of the legislature in which it was discussed and consid-
6863 ered are the best evidence and is the only evidence that can be considered.

Q. MR. TODD: Do you know whether the law creating the sanitary district was passed in the legislature in 1889?

MR. JEFFRIES: I object to the question for the reason that the law will show for itself when it was passed.

A. I cannot recall the date.

Q. MR. TODD: Professor, did you make any series of analyses in the year 1899?

A. I did.

Q. Will you state what you did preliminary to the arranging for collections of samples for that investigation.

A. In the summer of 1889 I was authorized by the State Board of Health to begin a chemical examination of the waters of the Illinois river and its tributaries and the canal leading from Chicago into the Illinois river. Before beginning those analyses, I made a trip of inspection from Bridgeport through the canal and down the Illinois river to the mouth of the river at Grafton. This trip was made in company with Mr. Jacob A. Harman, an engineer employed by the State Board of Health, and was for the purpose of familiarizing us with the locations and general conditions along the river and for the further purpose of selecting water takers to obtain samples of water
6864 for the various points and ship them to me at Chicago for examination.

MR. WOERNER: What date was that, Professor?

A. That was in 1889, in the early summer.

Q. MR. TODD: What points were selected for the collection of samples for this investigation?

A. The points selected were as follows: Bridgeport at the source of the Illinois and Michigan Canal within the city of Chicago, this point being located near the corner of Ashland Avenue and 31st Street. That was the first point. Samples were taken from under the bridge at the beginning of the canal just west from the pumping station and about 50 feet away from the station and were taken by an assistant sent from my laboratory.

Q. Do you know his name?

A. Yes, Mr. Frank Wright.

Q. Where was the second place?

A. The next collections were made in the Illinois and Michigan Canal at Lockport about 29 miles below Bridgeport. The samples were taken from a point in the canal 200 feet east of the main bridge, and above the entrance to a small stream. They were taken by Mr. P. O'Brien.

Q. Was that the gentleman who testified here yesterday?

6865 A. The man who testified yesterday, yes sir.

Q. And who identified the State's Exhibit 11 for identification, as a correct copy of the cards which he placed upon the samples sent to you?

A. It was the same man. Samples were also taken from the Desplaines river at Lockport, the location being above the stone bridge north of the town. These samples were taken by the same collector, Mr. P. O'Brien.

Q. Where was the next place?

A. The next collection of samples was made at Joliet 33 miles below Bridgeport, of the water of the canal and the Desplaines mixed, these two waters flowing together in the upper part of what is called the basin above Joliet. The collections were made by Mr. B. F. Long, at a point in this upper basin away from some construction work which was going on at the time, and far enough removed from this work to be unaffected by any sediment stirred up or brought into the water.

ADJOURNED until 2:00 p. m. same day, Thursday, September 24, 1903.

6866 2:00 p. m., Thursday, September 24, 1903.

Continuation pursuant to adjournment. Present the Commissioner, and same counsel representing the respective parties.

PROF. JOHN H. LONG

resumed the stand for further direct examination by Mr. Todd and testified as follows:

Q. Proceed, professor.

A. The next collections from the Illinois river were made at Morris, 58 miles below Bridgeport, from a point in the middle of the stream above what is known as the wagon bridge, south of the city. Those collections were made by Dr. H. M. Ferguson, of Morris.

The next collections in the Illinois river were made at the city of Ottawa, 81 miles below Bridgeport, by Dr. W. A. Pike, the water being taken from a point in the Illinois river above the entrance of the Fox, about 200 yards.

The next collections in the Illinois river below Ottawa were made at the city of LaSalle, 95 miles from Bridgeport, by Mr. C. H. Nicolet, at a point 600 feet above the mouth of the Big Vermillion river.

6867 The next Illinois river collections were made at Henry, by H. J. Gregory, 600 feet above the dam and above the town. Henry is about 123 miles below Bridgeport.

The next Illinois river collection was made immediately above the city of Peoria, at the part of the river described as the Narrows and sometimes described as Averyville, the water being taken from near the center of the river, a point near the Peoria waterworks, by Mr. C. F. Hixon. This station is about 157 miles from Bridgeport.

Another set of collections was made from Peoria, the point being described as Lower Peoria, or sometimes as Wesley, from the name of a small town on the opposite side of the river. The collection was made below the city of Peoria, and below the out-falls of the sewers of the city, and the drains leading from the distilleries and the cattle sheds at Peoria. This point is about 163 miles from Bridgeport. The collections were made there by Mr. Henry Ocker.

The next Illinois river collections were made in the town of Pekin, some nine miles below the point of the last collection and below the outlet from the cattle sheds of the distilleries at Pekin. The samples in this series of collections were taken by Mr. D. H. Jensen, then the surveyor of that place. These samples were taken about two miles below what is known as the Pekin bridge.

6868 The next Illinois river collections were made near the city of Havana, about 199 miles below Bridgeport, about 200 yards above what is known as the Wagon bridge at Havana, near the center of the stream. This was the first point of collection at which only two samples were taken. After that they were taken further up the river, above the mouth of the Spoon, the Spoon enters the Illinois from the west side, and but a short distance above the city of Havana. Mr. S. F. Kyle made the collections at this place.

The next Illinois river collections were made near the town of Pearl, at what is known as the Alton bridge—the point where the Alton railroad crosses the Illinois river. They were made close to the Alton bridge, about 200 feet below the Alton bridge, in the middle of the river. The name of the collector being E. H. Chandler.

The last Illinois river collections were made at Grafton, at the mouth of the river, where the river flows into the Mississippi, the point for the collections being taken about a mile and a half above the town, and above the point where the influence of the back water from the Mississippi river is felt. The name of the collector at this point was Mr. F. M. Calhoun.

In addition to these collections from the main river, a
6869 number of samples were taken from the tributaries of the
river.

The first of these tributaries considered, is the Kankakee river, which joins with the Desplaines below Joliet to form the Illinois. The samples were taken by Mr. C. D. Cassingham, near the middle of the river and below the town of Wilmington.

The next tributary samples were taken from the Fox river. The samples were taken at first from the river above the Rock Island bridge, about 100 yards, but later on account of the low water in the river proper, from what is known as the Fox river feeder. At this point water is drawn from the Fox river to feed the Illinois and Michigan Canal, and in dry weather a relatively large amount is diverted so that the fairest samples to represent the Fox river water were found in the feeder waters rather than in the bed of the river itself. The samples from the Fox river were taken by the same collector, Dr. W. A. Pike, who made the collections from the Illinois.

Samples were also taken from the Big Vermillion river, which flows into the Illinois from the south, at a point about two miles above LaSalle. The collections were made by Mr. Nicolet, the same who took the samples from the Illinois river
proper.
6870 The next tributary sample was taken from the Spoon
river by Mr. Kyle, who collected the Illinois river samples
at this point, and from a place in the river several hundred feet above its junction with the Illinois.

Samples of Sangamon river water were taken by Mr. G. P. Hollingsworth from near the mouth of the Sangamon river, from a point about 200 yards above the mouth of the river. These samples were marked as coming from Browning, because the collector lived at that place, and the point of collection was reached by him by rowing across from Browning and up into the Sangamon.

The last collections were made from the Mississippi river at Grafton, the samples being taken by Mr. Calhoun, the same man who collected the samples of the Illinois river at this point and from a point in the Mississippi river above the place where the Illinois enters, and far enough above to be beyond the effect of the mixing of the waters.

Q. Were those all the places and water-takers selected and appointed by you for the series of examinations in 1899?

A. These places given were the only ones from which collections were made along the Illinois river in that series of investigations, but samples of water were taken from the head waters of several of these tributaries some time later.

6871 Q. Were those samples that were taken some time later connected with this investigation?

A. They were.

Q. At what points was the water collected later?

A. In these examinations of the head-water samples, collections were made from the Kankakee river near South Bend, Indiana, the water being taken by Dr. George W. Van Benschotten; also from the water of the upper Desplaines, a sample being taken from a point near the town of Libertyville, by Mr. Clare Sherman; also from the upper DuPage, from a point near Wheaton, Illinois, by Dr. C. F. Blanchard; also from the upper Fox river, samples were taken by Dr. Charles H. Fegers, at McHenry, Illinois. Also from the upper waters of the Big Vermillion river; samples were taken by Dr. J. J. Stites, at Pontiac, Illinois. Also from the Mackinaw river, samples were taken by Dr. R. E. McKenzie at the town of Kappa, Illinois. Also from the upper Sangamon river; samples were taken by Dr. John H. Gardiner at Mahomet, Illinois. Also from the Upper Spoon river, samples were collected at Dahinda by Dr. J. B. Bedford.

Q. Are those all the places where samples of water were taken for this investigation in 1899, that you have detailed?

A. They are.

6872 Q. Did you make an investigation in 1900?

A. I did.

Q. At what points were samples taken and who were the water-takers that took them for you during the year 1900?

A. During the year 1900, samples were collected at the same points as during 1899, with two exceptions to be mentioned, the collections being made by the same collectors. The exceptions referred to are these: Samples were taken in 1900 from the now opened drainage canal at the Western Avenue bridge. These collections being made by an assistant from my laboratory, Mr. Wright. Collections were also made from the basin of the drainage canal at Lockport, by Mr. O'Brien.

Q. Did you make an investigation in 1901?

A. I did.

Q. At what points were samples collected in 1901?

A. In 1901 samples were collected at the mouth of the Illinois river at Grafton, the Mississippi river at Grafton—

Q. Give the names of the collectors?

A. The collector for both of those samples being Mr. F. M. Calhoun, the collector in the previous investigation.

Samples were also taken from the mouth of the Missouri river at a point about 200 yards above its junction with the Mississippi, the collector there being Mr. Gus. Bailey.

6873 Q. Were those the only places where samples were collected in 1901, those three places?

A. They are.

MR. JEFFRIES: I move to strike out the last statements of when and where examinations of water were made, for the reason that the witness did not testify from his own memory, but testified from a publication of some kind which is not produced before the Commissioner for examination by counsel.

MR. TODD: I want to concede the motion made by Mr. Jeffries to strike out the last answer made by the witness.

THE COMMISSIONER: That motion you assent to?

MR. TODD: I assent to that motion.

Q. Did you make an analysis or investigation of the waters of the Illinois, Mississippi and the Missouri river in 1901?

A. I did.

Q. At what points were samples taken for this investigation?

A. Samples were taken at a point above Grafton on the Illinois river, and on the Mississippi river, by Mr. F. M. Calhoun, who made the collections for the previous examination, the points in these two rivers being far enough above their junction to avoid any danger of a mixing of the waters.

Samples of Missouri river water were taken by Mr. Gus.
Bailey from a point in the Missouri river about 200 yards
6874 above the mouth of the river where it enters the Mississippi.

Q. Were those the only three places where water was collected from which you made your analyses for 1901?

A. They were.

MR. WOERNER: We now object to the witness reading from the printed documents which he has before him unless the counsel have an opportunity to know what document he is testifying from.

MR. TODD: I submit that the witness is not reading from any documents before him, but has a copy of the Illinois State Board of Health report for the year 1901, lying in front of him, and counsel on the other side have that document in their possession.

Q. Now, professor, have you given the stations along the rivers, the rivers and the other stations, together with the names of the collectors who collected the waters for the investigations made by you in 1899, 1900 and 1901?

A. I have.

Q. By whom were these collectors selected?

A. These collectors were selected by myself personally, at the time of a trip down the river. That is, the collectors along the Illinois river and the tributaries which I mentioned first.

Of the collectors of the head-water samples, two were
6875 selected by myself. The collectors of the upper Kankakee river water and of the upper Desplaines river water,
were selected by myself, while the collectors of the upper DuPage water, the upper Fox water, the upper Vermillion water, the upper Mackinaw water, the upper Sangamon water and the upper Spoon water, were selected by Dr. James A. Egan, the secretary of the State Board of Health of Illinois, the directions as to the method of collection being furnished by myself to Dr. Egan.

Q. Will you state what directions, if any, you gave to the collectors of this water to guide them in the collection of the water?

A. Before beginning the actual collection of these waters

I made a trip from Chicago to the mouth of the Illinois river, which I believe I referred to in the testimony of this morning. On that trip these collectors were selected by myself and instructed as to the method of collecting the samples, as to the place where the samples should be taken and as to the method of forwarding the sample to my address at Chicago. In order to make the method of collection plain to these men I had with me on that trip, bottles similar to those used in the actual collection, and in every instance I went with the collector to the stream in question and showed him by my own motions, how the sample of water was to be taken.

6876 Q. What was the size of the bottles employed by you in this work?

A. In this series of investigations, two samples of water were taken at each point, first a large sample of about a gallon was taken, in a so-called gallon bottle, this sample being used for the chemical analyses. A second, smaller sample of about six ounces was collected in a small bottle, this water to be used for the so-called bacterial examination.

Q. Have you a set of these bottles in your possession at present?

A. I have.

Q. Will you bring them to court when you come again?

A. I will.

Q. Will you state what your instructions were to the collectors of these samples of water, in full?

A. The instructions were these: It was first explained to the collectors that the bottles for the collections would be sent to them in perfectly clean condition, ready for the receipt of the water. Each bottle was closed by a ground-glass stopper, the stopper being tied down by means of a heavy piece of muslin and a strong cord, in the case of the larger sample for the chemical analyses, and by a small sheet of rubber cloth held in place by a rubber band in the case of the small bottle for
6877 the bacterial analyses The collector was instructed to take his two samples, the one for the chemical analysis and the one for the bacterial analysis, at the same time and place.

Directions were given to remove the cloth from the stopper of the large bottle and to remove the stopper, holding that in his left hand, or inverting it on the seat of the boat from which the collections were made, and by use of the right arm the bottle was to be immersed as far as possible below the surface of the water and filled nearly, but not quite full, the water to be filled within half an inch or an inch of the top so as to give sufficient space for expansion. This was to avoid the breaking of the bottles in case it should become warm after collection. It was explained also to the collector that the small bottle which received the sample of water for bacterial analysis, was thoroughly sterilized before being sent from my laboratory, and therefore must be handled with proper precautions. The collector was instructed as to how the sample was to be taken from the river in this case, in such a manner as to avoid as far as possible any contamination from his hands. The collector was instructed to loosen the rubber band which held the rubber cloth over the stopper and neck of the bottle and to remove the stopper from the bottle but not to remove the rubber cloth from the stopper; not to touch the stopper with his bare hands in
6878 any manner. This removal of the stopper of the bottle was to be made after the bottle was submerged beneath the surface of the water. Under those conditions it was possible to fill the bottle with water with little or no contamination from the outside. When the bottle was full, the stopper was to be re-inserted, the rubber band shoved down over the neck so as to hold the rubber cloth in place. This small bottle was then to be put inside of a small tin can which had a little cotton in it to prevent the bottle from shaking about and breaking. This small can in turn was to be placed inside of a large tin can, the small can I should state, was closed by a tin lid by insertion, a can such as commonly used for containing paints and varnishes and so on, of common type where the lid is inserted and remains in place because of its tight fit. This small can was to be placed as explained, inside of a large tin can similarly constructed, this large can holding about a gallon and a half. The collector was instructed to pack this large can as thoroughly as possible with broken ice and enough excelsior to hold the small can practically in a fixed position. He was in-

structed to have this ice with him on starting out onto the river to make the collection and to place the ice around the small can inside of the large one immediately after making the
6879 collection and not to bring it to the shore and then put in the ice. After so packing this large tin can it was to be placed in the proper compartment of the shipping box, packed and surrounded there by as much excelsior as could be crammed into the box around the can, this excelsior being used not only to hold the can in place, but to maintain the temperature and by its non-conducting power to prevent the action of the higher outside temperature as far as possible, the object of this being to prevent the water enclosed in the small bottle inside of the two cans, from reaching a high temperatcre.

The large bottle containing the sample for chemical analysis was placed in another compartment of the same shipping box, packed in with excelsior and the whole then was sent to me by express, one shipping envelope being attached usually to the neck of the large bottle by means of a stout cord. This shipping envelope contained also some memoranda which the collector was instructed to make in each case, regarding the time and place and conditions of collection. Such a memorandum I have here, as also a shipping envelope similar to those used throughout the collections.

MR. TODD: I offer the envelope and the blank slip in evidence as defendants' Exhibits Nos. 3 and 4.

Said documents received and so marked by the Commissioner.

Not reproduced.

6880 Q. What you have stated in regard to directions of packing and shipping of samples, applies to all the samples taken for the several investigations conducted by you, does it?

A. It does.

Q. How were those samples thus collected received at the laboratory?

A. Those samples were received by express at the laboratory, and I should state this point in addition. From places where two express services could reach Chicago, I picked out the express company which was able to deliver the sample most directly without transferring it. In some of these towns the United States, the Adams and the American express companies can reach Chicago, but usually only one of them directly. I picked out in every case that company which could bring the sample without re-shipping.

Q. After the samples were received or arrived in Chicago who received them at the laboratory?

A. These samples were delivered by the companies and received either by myself personally, or by one of two assistants, Mr. Frank Wright, or Mr. William Johnson, it being understood that some one of us was to be present all the time at the laboratory. The samples were received and taken care of without delay.

6881 Q. After they arrived at the laboratory what was done with them?

A. When these samples were brought to the laboratory, the analyses were undertaken at the earliest possible moment, and always the same day.

Q. How was each sample marked for identification?

A. Each sample reached the laboratory in a shipping box containing a large bottle and a small bottle. These boxes were opened and a label was pasted immediately on the bottle and on the can. The label indicated the place from which the sample was received and also the serial number of the sample. The number and name being carried out through the record.

Q. Did all the samples from each particular point have a serial number?

A. They did. As the samples came in, a number was given to each box. That number was marked to begin with, on the shipping envelope and the same number was put on a small label and pasted on the large bottle taken out from its compartment; also the same number was put on a small label and pasted on the tin can containing the small bottle for bacteriological analyses. These numbers were given, you might say, chronologically, according to the time and order in which they were received, and those numbers were followed throughout.

6882 Q. So that the serial numbers applied to the samples at the time that they were received in the laboratory and not at the time they were taken?

A. They applied at the time they were received at the laboratory and not at the time they were taken and only for our own identification.

Q. When the samples came to the laboratory, what was done with the cards accompanying the samples?

A. The cards were removed from the envelopes after these memoranda and labels were put on the bottle, as explained. The cards containing the name of the collector and the time of collection and place of collection, were received, and are now nearly all in existence. I will not guarantee that all are in existence, because no attempt was made to save all of them, although practically nearly all were saved.

Q. I show you the cards of H. M. Ferguson of Morris, marked "State of Illinois No. 17 for identification" and the cards of witness W. A. Pike, from the Fox river marked "State of Illinois Exhibit 16 for identification;" the cards of the witness W. A. Pike, of the Illinois river at Ottawa, marked "State of Illinois Exhibit No. 15 for identification;" the cards of Charles H. Nicolet, from the Vermillion river and the Illinois river at LaSalle, marked "State of Illinois Exhibits Nos. 13 and 14 for identification;" the cards of C. F. Hixon, 6883 Averyville or Peoria Narrows, marked "State of Illinois Exhibit No. 12 A, for identification;" the cards of witness Henry Ocker, at Wesley, marked the "State of Illinois Exhibit 12 for identification;" the cards of witness Will Sievers at Henry, Illinois, marked "State of Illinois Exhibit No. 10," the cards of witness D. H. Jensen of Pekin, marked "State of Illinois Exhibit No 9 for identification;" the cards of S. F. Kyle of Spoon river at Havana, marked "State of Illinois Exhibit No. 8 for identification;" the cards of witness S. F. Kyle, Illinois river samples at Havana, marked "State of Illinois Exhibit No. 7 for identification;" the cards of witness G. P. Hollingsworth, Browning, Illinois, marked "State of Illinois Exhibit No. 6 for identification;" the cards of witness J. Rader, of Pearl, Illinois, marked "State of Illinois Exhibit No. 6 for identification;" the cards of F. H. Chandler at Pearl Illinois, marked "State of Illinois Exhibit No. 5 for identification;" the cards of witness F. M. Calhoun at Grafton, in three separate exhibits for the Mississippi river and the Illinois river, and marked "State of Illinois

exhibits Nos. 1, 2 and 3 for identification;" the cards of witness G. Bailey, at the mouth of the Missouri river, and marked the "State of Illinois Exhibit No. 4 for identification;" and I will ask you to examine the cards and state whether all those cards with the sample attached were received in your
6884 laboratory in the city of Chicago from the different parties whose names I have mentioned?

A. Yes sir, these are the cards of the collectors which were received by me in the course of this examination.

MR. TODD: I offer in evidence defendants' Exhibit 3 and State of Illinois Exhibit No. 11, for identification as a sample of the envelope and cards contained in the State of Illinois Exhibits from 1 to 17 inclusive, for identification and submit said exhibits for identification to the inspection of the complainant in the case and will offer them in evidence if required, and I will withdraw defendants' Exhibit No. 14, and substitute for it Exhibit No. 11 for identification and ask to have that marked defendants' Exhibit No. 4.

So marked by the Commissioner.

Q. Have you the cards for the samples taken by Benjamin F. Long at Joliet?

A. I have.

Q. Are these cards which I hand you the cards attached to the samples of water received by you from Benjamin F. Long in Joliet?

A. They are.

MR. TODD: I offer these cards in evidence as the State of Illinois Exhibit 18 for identification.

Q. Have you the cards of P. W. O'Brien who testified yesterday that he sent the samples of water to you, upon cards which were similar to defendants' Exhibit 4, and which
6885 is now known as defendant's Exhibit 4?

A. I have those cards.

MR. TODD: I offer those cards in evidence for identification, to be treated in the same manner as the State of Illinois Exhibits already identified, from 1 to 17, to be governed by defendants' Exhibit 4.

Q. What is true of the Desplaines river and the cards directed by P. W. O'Brien, is true of the canal at Lockport, is it?

A. It is.

Q. Are those the cards of the samples collected and sent you by P. W..O'Brien as testified to by him yesterday, in your presence?

A. They are.

MR. TODD: I offer those cards as the State of Illinois Exhibit, to be placed with the State of Illinois Exhibits 1 to 17 inclusive, and as identified by defendants' Exhibit 4.

Q. Have you the cards collected by P. W. O'Brien at Lockport in the drainage canal?

A. I have.

Q. Are those the cards?

A. Those are the cards.

MR. TODD: I offer those cards to be treated and considered in the same manner as the State of Illinois Exhibits 6886 1 to 17, for identification, in connection with defendants' Exhibit 4.

Q. Have you the cards of the samples collected by Mr. C. B. Cassingham, from the Kankakee river, from the middle of the river just below the town of Wilmington?

A. I have.

Q. Are these the cards which I show you?

A. They are.

Q. Which were attached to the samples sent to you by C. D. Cassingham from the point indicated in the last question?

A. They are.

MR. TODD: I offer those cards as the State of Illinois Exhibit No. 19 for identification.

MR. JEFFRIES: To the introduction of which the complainant objects for the reason that there is no evidence to show that the samples were taken under instructions or that if instructions were given they were carried out, and there is no evidence as to the manner in which the samples from the Kankakee river were collected.

Q. MR. TODD: Have you the tags for the upper Kankakee water taken by Dr. George W. Van Benschotten, near South Bend, Indiana, the upper Desplaines water near Libertyville taken by Mr. Clare Sherman and the Upper DuPage samples taken near Wheaton by C. F. Blanchard; the upper Fox river samples taken

by Charles H. Fegers at McHenry; the upper Big Vermil-
6887 lion collected by J. J. Stites at Pontiac. The Mackinaw river water taken by R. E. McKenzie; the upper Sangamon collected by John H. Gardiner at Mahomet; the upper Spoon river collected at Dahinda by Dr. J. D. Bedford?

A. I have.

Q. Are these the cards?

A. Those are the cards.

MR. TODD: I offer these cards and ask to have them marked State of Illinois Exhibit No. 20 for identification.

MR. JEFFRIES: To which offer the same objection is made as to the previous offer with reference to the samples taken by Mr. Cassingham at Wilmington.

Q. MR. TODD: Professor, at what points did your assistants, Frank Wright and William Johnson, collect water for you?

A. From the city of Bridgeport in the drainage canal.

Q. And the samples collected by them, how were they conveyed to the laboratory?

A. They were conveyed to the laboratory in bottles similar to those used in the other collection.

Q. By express or in person?

A. In person.

Q. These two men are still living?

A. They are.

Q. And can be brought here to testify?

A. They can.

6888 Q. These cards that have been introduced here and testified to by you are all the cards received by you attached to samples of water for the three investigations which you made in 1899, 1900 and 1901?

A. They are all the cards which I have remaining. I stated a little while ago that some few of these cards are lost or mislaid, but all of them which I had at the conclusion of the investigation were included in these.

Q. And they apply to the three investigations?

A. They apply to the three investigations.

Q. In the first investigation of 1899, how often were the samples of water collected?

A. The samples of water were collected for most of these places weekly, the dates of collection being given in the report which I have referred to. The Illinois State Board of Health report of the investigation of the Illinois river and its tributaries, published in 1901 by the State Board of Health. The times and places of these analyses are all given in that report.

Q. You have already testified to the places?

A. Yes sir, and the times are given also along with the places and the tables, in this report.

Q. In the first investigation of 1899, how often were the samples of water collected?

6889 A. The samples were collected from points along the Illinois river and the tributaries weekly.

Q. That is, one sample a week?

A. That is one sample each week.

Q. How often were the samples collected in 1900?

A. The samples were collected in 1900 from the same place, also weekly.

Q. In 1901 how often?

A. In 1901 the samples were collected weekly or in some cases more frequently; I couldn't give those dates now, but at least weekly.

Q. In these samples which were received at your laboratory and collected in the manner that has been testified to here in the evidence, does each card represent one chemical and one bacteriological sample?

A. It does, the samples being collected at the same time and place by the same collector.

Q. And received at the same place?

A. And received at the same time and place.

Q. What was done with the bacteriological sample after it arrived at the laboratory?

A. After the arrival of the bacteriological sample at the
laboratory certain tests of a chemical nature, sometimes
6890 spoken of as bacteriological, were made by myself. The
portions of water from the small bottle being used for
this purpose, and being taken in such a manner as not to interfere with the use of the remainder for the bacteriological test

proper. The remainder of this sample was then turned over to Dr. Robert F. Zeit for examination.

Q. Did anyone in your laboratory except yourself handle the bacteriological sample first?

A. The bacteriological samples were all handled under my immediate direction and supervision, or by myself or Mr. Wright or Mr. Johnson, referred to. All experiments made with them were made under my supervision, handled simply for me and with me.

Q. And the remainder of the sample was turned over to Prof. Zeit as you stated?

A. Turned over to Professor Zeit by myself as I have stated. Prof. Zeit's laboratory being in the same building and on the same floor.

Q. How long after the chemical samples reached your laboratory before you proceeded with the analysis?

A. The analysis of these samples was taken up immediately as explained, the same day of their receipt, and completed as soon as possible afterwards. The determination of constituents liable to change being made first, for the element of quick rapid work was important in such cases.

6891 Q. Professor, you have stated in your testimony heretofore given, the method pursued by you in the analyses from 1886 down to 1890 and 1891 inclusive, and if in the analyses conducted by you during these last series you made any change in your method, I wish you would briefly state what that change was.

A. The variations in the methods employed in the later analyses from those employed in the earlier ones described in my previous testimony are these: The solids were determined essentially as described, the solids in solution and in suspension. The chlorine was determined as described by the Volhard process in the stronger waters; that is those containing the most chlorines by direct titration, but in most of them, after evaporating a measured portion of the water to a small volume. The titration was made in the usual way, as described, in this concentrated solution. The determination of the oxygen consumption was made by the method I described before. The free ammonia was determined as described before and also the albuminoid ammonia. In these later investigations a test was made for the substances known as nitrites,—combinations of nitrous acids with bases, the test usually being a modification of the so-called Gries method, employing the reaction which takes place when sulphanilic acid and naphthylamine are brought together in the presence of nitrous acid. In the presence of 6892 nitrous acid in the acid solution, these substances condense, to form a characteristic so-called, azo color. The formation of that color in the presence of these reagents mentioned is a proof of the presence of the nitrous acid. This is a standard method well known and commonly used by chemists and need not be more fully described. The nitrates are determined not as in the previous investigations, but in this case by the so-called phenol-sulphonic acid method. The test depending on the production of picric acid by the action of the nitrate in the water on the test reagent used. This picric acid when combined with ammonia in the last part of the test, strikes a characteristic color easily recognized and measured. The extent of this coloration is a measure of the amount of nitrate present. In some cases the total nitrogen in the water in the so-called organic or unoxidized condition, was determined by a method known as the Kjel-Dahl process. This comprises then, the variations from the method before detailed.

Q. In these analyses for the periods of 1899, 1900 and 1901 did you make examinations for the same determinations as were made in the previous analyses, from 1886 to 1890 as heretofore testified to by you?

A. Essentially the same with the addition of the test for 6893 nitrites which has just been described.

Q. In the series of 1899, will you give the number of samples analyzed by you at each place?

A. In that series of investigations I examined 21 samples of the canal water from Bridgeport.

Q. Read them off in order.

A. Bridgeport, canal water, 21 samples,
Lockport, canal water, 22 samples,
Lockport, Desplaines River water 27. samples,
Joliet, mixed canal and Desplaines water, 17 samples;
Wilmington, canal water, 9,

Morris, Illinois river water, 22,
Ottawa, Illinois river water, 22,
Ottawa, Fox river water, 6,
LaSalle, Illinois river water, 21,
LaSalle, Big Vermillion river water, 8,
Henry, Illinois river water, 19,
Peoria Narrows or Upper Peoria, Illinois river, 15,
Peoria, Wesley, or Lower Peoria, Illinois river, 21,
Pekin, Illinois River, 19,
Havana, Illinois River, 18,
Havana, Spoon river, 4,
Browning, Sangamon river, 7,
Pearl, Illinois, 18,
6894 Grafton, Illinois river, 21,
Grafton, Mississippi river, 13,
South Bend, Kankakee river, 3,
Libertyville, Desplaines river, 4,
Wheaton or Winfield, DuPage river, 3,
McHenry, Fox river, 3,
Pontiac, Big Vermillion, 3,
Dahinda, Spoon river, 3,
Kappa, Mackinaw river, 2,
Mahomet, Sangamon river, 3,

MR. JEFFRIES: Now we move to strike out all of the statement of the witness in reference to samples that were analyzed from water in all the rivers tributary to the Illinois river, for the reason that there is no evidence to show the manner in which the samples were taken and no evidence to show that samples were taken under instructions, and if the instructions were given, no evidence that such instructions were carried out, and for the reason that such examination of the waters of the said tributaries is incompetent, irrelevant and immaterial and we object to the witness stating or testifying to the examination or any other examination of such waters during any of the other periods or times when analyses or examinations were made of said water, for the same reasons.

ADJOURNED until 10:00 A. M. Friday, Sept. 25, 1903.

10:00 A. M., Friday, September 25, 1903.

6895 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. JOHN H. LONG,

resumed the stand for further direct-examination by Mr. Todd and testified as follows:

Q. Professor have you brought samples of the large and small bottles with which the collections were made under your directions, and from the contents of which bottles your analyses were based?

A. I have.

Q. Have you the large bottle present?

A. I have.

Q. And the small bottle?

A. I have.

Q. Which bottle was used for chemical analyses?

A. The large bottle.

Q. And which one for bacteriological analyses?

A. The small bottle.

6896 Q. Did you see the bottles that were used by the experts in St. Louis for the taking of water for chemical and bacteriological purposes?

A. I did.

Q. How do these bottles which you have presented here, compare with the bottles used by the St. Louis experts for the collection of water?

A. I believe they are essentially smiliar to those bottles. As a matter of fact the bottles were obtained from a dealer in St. Louis,—from Henry Hyle & Company.

MR. WOERNER: Both sized bottles I suppose?

A. Yes.

MR. TODD: I offer the two bottles presented here by the witness for the inspection of attorneys for complainant, and in view of the fact that the bottles here are substantially in all particulars the same as those offered by complainant, I will let complainant's Exhibit of bottles stand as exhibit for the defendants in the case, unless objected to.

Q. In the collection of all the samples made, was the same precaution observed in regard to each sample?

A. The same precaution was observed in all cases except that of the city collection from Bridgeport and the drainage canal, these points being close to the laboratory by street car, but one sample was taken in a large bottle and a portion of that sample was removed from the bottle when the laboratory was reached and used for the bacterial tests, after cooling. 6897

Q. When the samples arrived at your laboratory in the manner that you have indicated heretofore, in your testimony, who conducted the chemical analyses of the water?

A. The chemical analysis of these waters was conducted by myself or under my immediate direction, by two men, Mr. Frank Wright and Mr. William Johnson.

Q. You have already stated in your testimony the methods pursued by you in making these analyses, have you not, professor?

A. I have.

Q. Have you the results of your analyses with you?

A. I have.

Q. In what form have you those results?

A. I have these results in printed form as they appeared in my reports to the Illinois State Board of Health, published by the authority of the secretary of the State Board of Health.

MR. WOERNER: What period of time does this cover, Professor Long?

A. This covers 1899 and 1900.

Q. MR. TODD: In the report published by the Illinois State Board of Health, did you have anything to do with the printing of that report, the reading of the proof and the comparison of the tables there published, with your original memoranda?

6898 A. I had. The proofs were sent to me for comparison with the original manuscript, and notes. This comparison was made and to the best of my belief the figures given in this report are correct.

Q. Professor, in your examination yesterday, you made some reference to a bacterial examination in which you said that that examination was not strictly a bacterial examination according to modern methods. Will you explain that examination as made by you?

A. In addition to the ordinary generally recognized chemical tests which I have described, I made a certain number of tests which have been described as bacterial, but which are really of a nature of chemical tests or reactions intended to show the presence of organic matter in the living or organized forms. These tests included an estimation of the amount approximately of this organized organic matter described usually as a count of the colonies. That embraced also a test of the water with reference to the organic forms in it which are able to produce a certain kind of fermentation in the liberation of gases. It embraced also a determination of the behavior of water with reference to its power of liberating or forming acids from certain sugars, recognized by the coagulation of milk, and finally,
it embraced a test for those living forms in water which
6899 are able to decompose or break down protein matters
with the production of a substance known as indol. These tests being in a measure quantitative as well as qualitative, that is they give an indication of the kind of organized organic matter present and also to some extent of the amount of this organic matter present. These tests were made by the methods usually employed by bacteriologists or chemists in the examination of waters. The estimation of the approximate amount of this organized matter as disclosed by what is called a colony count was made in the usual way by inoculating a gelatin solution with a certain amount of the water in question. This gelatin solution being made from the usually mixture of gelatin, an extract of meat, but rendered neutral instead of acid as is most commonly recommended. In this combination of water containing organized forms with gelatin and the nutrient substances which were all protein, conditions are offered for the

multiplication of these organized forms in such a manner that the number, or roughly, the amount may be recognized and counted. The counts were made in the usual manner for several days, by methods well known to all bacteriologists.

The qualitative test for the organized forms in water which are able to liberate acid from carbo-hydrates was made by using a sterilized milk, from which the cream had
6900 separated. This sterilized milk being mixed with a small volume of the water in question, generally one cubic centimeter, or less in case of some of the most contaminated waters, and allowed to stand some time at the temperature of the human body, approximately 37 to 38 degrees centigrade. The extent of the contamination of water with organized forms which are able to decompose sugar with the liberation of acid, is indicated by the rapidity with which the milk coagulates, the coagulation of the milk depending on the liberation of the acid, and the subsequent precipitation of the casein of the milk.

Another test was made by the inoculation of water into a prepared mixture of bouillon broth and sugar containing about two per cent. of glucose. Various organized forms have the power of decomposing sugars and liberating certain gases. In this reaction where these organized forms are present the saccharine matter or sugar of the bouillon is decomposed and the gases, especially carbon dioxide and hydrogen gases, are liberated. An observation of the amount of this gas gives a rough measure, a clew to the kind and extent of the pollution. With these living organic forms, the test is at best but an approximation. A prepared peptone solution containing a small amount of some mineral salt, salts known as phosphates in partic-
6901 ular, is inoculated with water, usually one cubic centimeter, and kept warm or incubated through the period of several days. Certain living forms have the power of breaking down proteids or protein substances, producing a great many so-called aromatic compounds, and among these, one of the most characteristic and most easily recognizable, is a substance known as indol. Because of the facility with which this indol may be recognized, the detection of the substance is usually

taken as the best indication of the presence of certain kinds of living forms of bacteria which bring about putrefaction, the test depending finally on the combination of a certain test solution with the liquid left in the tube or flask in which the incubation has taken place. This liquid is a solution of a nitrite, usually sodium or potassium nitrite, to which strong sulphuric acid is added. The test may be made in various ways; the sulphuric acid may be added in different amounts and under different conditions, but with the final result of bringing about a combination of the nitrous acid with the indol, yielding a marked red or pink color, the detection of which is very easy. The measurement of the extent of the organic contamination with these forms of bacteria depends on the observation of the extent of this color or the amount of this color. This method is one commonly followed by bacteriologists, and
6902 I believe need not be described in any greater detail, with perhaps this further word of explanation. The nutrient solution used in these experiments was a peptone belonging to the class of albumose peptones as free as possible from sugar. The certainty of this test depends to a considerable extent on the character of the peptone used. The most highly converted peptones in the market not being as well adapted to bringing about this reaction as those which contain more of the albumose products, because in the highly converted peptones or highly digested peptones the bodies left are of a type which are not readily decomposed by the bacteria, and certainly not with the production of indol. As this is a matter of some little importance I paid attention to the quality of peptone used, and in preference to Witte's peptone which has been very frequently used for this purpose, I employed a kind which is made in Chicago at the stock yards or by some one working at the stock yards industries, the quality of which answered the purpose very well.

Q. Are the results of those tests incorporated in the tables of analyses made by you at your laboratory from the water taken from the points heretofore testified to?

A. They are.

Q. Have you the tables prepared by you for the 1899 series of investigations?

6903 A. I have.

Q. In what form have you those tables with you?

A. I have these tables in printed form as they appeared in the report of the Illinois State Board of Health, a report printed by the authority of the Secretary of the State Board of Health. These tables are cut out from two volumes of this report and pasted on sheets of paper.

Q. Did you compare the original tables with the proofs before it was printed in the reports?

A. I did.

Q. Are the tables as printed in the report true and correct copies of your original sheets?

A. They are.

Q. Will you read each of the tables prepared by you for the period of 1899?

A. I will.

Q. How are your tables numbered, professor?

A. They are numbered from table 2 up beginning at Bridgeport. The first one that I have here is numbered 2.

Q. In Roman?

A. Yes Roman.

Q. Were these tables prepared by you in your official capacity as a member of the State Board of Health of the State of Illinois? 6904

A. They were prepared by me as chemist to the State Board of Health of Illinois.

MR. JEFFRIES: Objected to for the reason that the witness is not a member of the State Board of Health and was not at this time.

Q. MR. TODD: Were you employed by the State Board of Health to make these investigations?

A. I was.

Q. Will you read table 2, Bridgeport pumping station, as it appears on pages 12 and 13 of the Illinois State Board of Health report published in 1901?

MR. JEFFRIES; To the reading of which complainant objects for the reason that the original sheets made out in the office of the witness are the best evidence.

A. I read now table No. 2 giving results of the analyses from Bridgeport, through the season of 1899:

6905 TABLE II.—*Bridgeport*—

Date.		Color.	Odor.	Sediment.	TEMPERATURE.		SOLIDS.			OXYGEN ABSORPTION.	
					Water......	Air.........	In solution	In suspension....	Total.......	Not filtered	Filtered ...
1899.											
July	1	....	Oily	Black..	....	....	....	....	578	30.2	.....
"	17	....	Bad...........	"	....	....	596	92	688	31.6	20.8
"	24	....	"	"	....	....	476	72	548	31.2	20.8
"	31	....	"	Some.......	....	....	476	64	540	25.2	10.4
Aug.	7	Dark, milky........	"	Little	....	....	404	56	460	22.7	16.3
"	14	Very turbid.........	"	Dark..... ..	....	....	504	64	568	25.6	13.2
"	21	Dark, milky	"	Black	....	....	500	56	556	19.2	10.7
"	28	"	"	"	....	....	484	48	532	20.1	20.2
Sept.	4	Dark.	"	"	....	....	460	68	528	24.0	17.6
"	11	"	"	"	....	....	558	104	662	34.2	20.2
"	18	Bluish black........	"	Little........	....	....	472	44	516	34.6	22.0
"	25	Dark, turbid.... ...	"	Black........	....	....	404	36	440	30.4	22.4
Oct.	2	Dark...	"	Dark.........	....	....	488	20	508	28.5	21.4
"	10	Dark, turbid	"	None.........	....	....	506	20	526	20.2	15.0
"	16	"	"	Little........	....	....	424	42	466	22.7	16.7
"	23	"	"	"	....	....	416	56	473	16.9	14.4
"	30	"	"	Black........	....	....	470	56	526	28.5	16.3
Nov.	6	"	"	Dark.........	....	....	446	54	500	21.1	13.1
"	13	Dark........	"	Black	....	....	492	80	572	26.6	16.3
"	20	"	"	Dark.........	....	....	468	172	640	28.8	17.0
"	27	Dark, turbid........	"	"	....	....	414	66	480	20.5	10.2
		Averages..........	....	....	....	....	473	63.5	536.5	26.65	15.95

Pumping Station.

Chlorine	AMMONIA.		NITROGEN.		Colonies—per cc.	FERMENTATION.			Coagulation of milk.	Indol produced?
	Free	Albuminoid	In nitrates.	In nitrites.		1-10 cc. (Per cent)	1 cc. (Per cent)	1 cc. (Per cent)		
105.3	18.0	3.4	None..	None..	*75,000	....	80	80	Rapid	Yes
81.7	11.5	4	"	0.04	*125,720	....	5	60	Very rapid	"
78.01	15.0	3.5	"	None..	1,015,000	....	10	10	"	No..
85.2	13.7	4.8	"	Trace..	940,000	....	45	30	Rapid	"
78.1	13.2	3.7	"	"	980,000	....	55	55	6 hours	"
117.1	20.0	2.1	"	None..	594,000	....	60	50	"	"
120.7	20.5	1.6	"	"	1,380,000	....	40	10	Rapid	"
113.6	21.0	2.1	"	"	2,125,000	10	70	....	Very rapid	"
124.3	22.5	2.9	"	Trace..	2,110,000	....	50	40	6 hours	Yes
142.0	27.1	2.2	"	"	63,000	30	30	....	18 hours	"
103.0	21.5	2.5	"	0.01	517,000	20	40	....	Rapid	"
60.4	17.5	1.4	"	None..	244,800	10	50	....	"	"
96.0	27.7	5.9	"	"	795,600	40	50	....	"	"
85.2	19.5	2.7	"	"	1,468,800	30	20	....	Very rapid	"
85.0	26.2	4.0	"	"	503,200	20	25	....	Rapid	"
81.7	19.7	2.2	"	"	161,200	40	50	....	Very rapid	"
81.7	18.3	2.6	"	Trace .	687,000	60	45	....	"	"
89.0	17.3	2.9	"	0.01	1,320,000	60	40	....	"	"
118.6	21.2	4.1	"	None..	2,082,000	20	30	....	Rapid	"
85.2	20.0	4.7	"	"	931,500	10	80	....	Very rapid	"
78.1	16.3	4.4	"	[illegible]	[illegible]	25	80	....	"	"
95.47	19.84	3.22		0.03						

*Acid medium.

6906 THE WITNESS: I read next, table marked Table 3, giving the results of the analyses of the canal water taken at Lockport in 1899, and table No. 4, giving the results of the

6907

TABLE III.—*Lockport*—

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Oxygen Absorption.	
					Water......	Air.........	In solution	In Suspension	Total	Not filtered	Filtered....
1899.											
July	3	Dark	Bad	Heavy					584	31.20	
"	10		"	Black					572	31.00	
"	17		"	"	71.0°	80°	560	52	612	15.20	8.80
"	24	Dark	"	"			528	128	656	25.92	14.56
"	31	"	"	"			476	80	556	27.52	14.24
*Aug.	7	"	"	"	60.8	80	512	56	568	29.12	22.40
"	14	Black	"	"	58.0	78	544	20	564	29.44	16.16
"	21	Very dark	"	"	72.5	84	472	52	524	26.56	17.60
"	28	"	"	"	75.2	85	512	68	580	30.08	21.76
Sept.	4	Dark	"	"	73.0	84	424	56	480	24.96	15.36
"	11	Very dark	"	"	61.0	78	498	78	576	32.00	22.72
"	18	Dark	"	"	68.0	70	448	56	504	29.44	19.20
† "	25	"	"	"	60.0	68	528	64	592	32.64	22.08
Oct.	2	"	"	"	52.0	75	480	56	536	21.76	12.16
"	9	Very dark	"	"	68.0	70	428	60	488	20.48	15.68
"	16	Dark	"	"	66.0	76	436	64	500	24.48	14.40
"	23	"	"	"	64.0	74	458	64	522	27.52	18.40
"	30	"	"	"	54.0	64	494	78	572	29.12	16.32
Nov.	6	"	"	"	55.0	65	518	64	582	30.22	19.20
"	13	"	"	"	50.0	60	476	64	540	25.60	17.92
"	20	Very dark	"	"	54.0	65	530	94	624	37.76	19.84
"	29	Dark			50.0	65	500	84	584	31.36	17.12
		Averages					491	67	558	27.90	17.31

*Bacterial sample warm.

†Bacterial sample taken from large bottle. Other broken.

TABLE IV.—*Lockport*—

1899.											
July	3		Good	Some					452	10.18	
"	17	Turbid	"	"	75°	80°	248	20	268	11.20	9.76
"	31	Light, turbid	"	Little			376	8	384	8.00	7.12
*Aug.	14	Light	Earthy	"			324	12	336	7.36	6.80
"	28	Light, clear	"	None	77	85	360	12	372	7.92	7.28
Nov.	6	"	Little.	Sandy	48	65	452	40	492	6.48	5.54
"	29	"	Good	None	52	65	480	4	484	5.36	5.36
		Averages					373	16	389	8.05	6.96

*Bacterial sample warm.

analyses of the Desplaines river water, taken in 1899 at Lockport.

MR. JEFFRIES: To the reading of which complainant makes the same objection as to the admission of table No. 2.

Canal.

Chlorine...........	AMMONIA.		NITROGEN.		Colonies—per cc....	FERMENTATION.			Coagulation of Milk.	Indol produced?....
	Free.......	Albuminoid	In nitrates.	In nitrites.		1-10 cc. (Per cent).....	1 cc. (Per cent).....	1 cc. (Per cent).....		
76.3	20.6	1.8	None..	None..	212,000	....	65	65	Rapid.............. ..	Yes....
95.85	21.0	6.0	"	"	64,320	10	10	None..	....	No.....
74.5	8.5	1.5	0.70	0.64	247,400	....	50	....	12 hours........	" ....
92.3	19.2	3.5	None..	None..	395,000	....	None..	None..	"	" ....
92.3	14.5	3.4	"	"	375,000	....	15	15	Rapid....	" ....
113.6	21.0	2.4	"	"	385,000	....	50	....	12 hours.......... ..	" ....
110.0	19.0	2.9	"	"	726,000	... .	60	90	Rapid................	" ....
92.3	10.10	4.9	"	"	560,000	....	60	60	"	" ....
113.6	16.8	3.4	"	"	1,750,000	5	40	....	"	" ....
81.7	19.7	1.9	"	"	147,500	30	50	... .	Very rapid............	Yes....
110.0	26.8	2.4	"	"	806,000	20	10	....	"	" ....
88.8	16.5	1.1	"	"	84,200	40	50	....	"	" ....
110.0	20.3	1.1	"	"	98,400	25	25	....	Rapid.......	" ....
103.0	22.5	5.7	"	0.02	315,000	20	20	....	"	" ....
71.0	16.5	3.0	"	Trace..	330,000	20	60	....	"	" ....
86.6	25.6	3.6	"	None..	334,800	35	40	....	"	" ....
96.0	23.0	2.6	"	0.02	285,000	20	50	....	Very rapid...........	" ....
103.0	25.0	4.1	"	0.01	161,200	40	40	....	"	" ....
103.0	20.0	5.0	"	None..	533,200	50	50	....	Rapid................	" ....
95.9	19.5	3.8	"	"	621,000	15	20	....	"	" ....
113.6	22.3	4.2	"	"	714,000	30	25	....	"	" ....
110.0	25.5	5.0	"	"	432,000	10	10	....	"	No.....
96.97	19.85	3.37	0.03	0.03						

The DesPlaines River.

4.26	0.70	0.90	None..	None..	108,900	....	None..	None..	Slow.................	No.....
3.55	0.35	0.68	0.32	0.05	....	....	"	"	24 hours..............	"
4.97	0.12	0.418	None..	None..	44,200	....	10	5	Slow.......	"
5.06	0.15	0.496	"	0.004	99,000	....	None..	None..	"	"
7.10	0.126	0.468	"	Trace..	59,400	....	"	"	"	"
2.84	0.114	0.55	"	0.01	29,200	None..	"	....	"	No....
13.50	0.042	0.40	"	Trace..	700	25	20	....	Very slow.......... ...	"
5.98	9.229	0.550	0.045	0.009						

6908 THE WITNESS: I read next table marked table 5, giving the results of the analyses of the canal water taken at Joliet in 1899, and the table marked table 6, giving the result

6909

TABLE V.—*Joliet*—

Date.		Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Oxygen Absorption. Not filtered	Oxygen Absorption. Filtered
1899.											
July	3	Dark	Bad	Yellow	....	....	....	....	530	20.00	..
"	17	"	"	Black	76°	90°	384	140	524	20.32	12.96
"	24	"	Bad, oily	"	78	85	496	48	544	17.76	10.56
Aug.	1	"	"	"	74	76	500	124	624	25.04	14.72
"	7	"	"	"	72	84	536	16	552	27.52	19.84
"	14	"	"	"	70	80	496	32	528	17.76	14.40
"	21	Dark, turbid	"	Some	82	88	476	40	516	16.00	11.52
"	28	Very dark	"	Heavy	78	86	528	332	860	40.32	18.24
Sept.	4	Dark	"	"	80	86	448	56	504	21.76	15.04
"	11	"	"	Heavy bl'k.	....	....	508	148	656	32.96	19.84
* "	18	"	"	Black	60	70	508	52	560	27.84	19.52
† "	27	"	"	"	62	54	496	160	656	35.84	19.20
Oct.	2	Very dark	"	"	61	58	520	144	664	31.68	15.36
"	9	Dark	"	"	60	68	474	136	610	27.85	15.68
‡ "	16	Dark, turbid	"	Heavy bl'k.	64	58	440	64	504	21.76	13.12
"	23	Very dark	"	Black	64	66	468	100	568	28.48	18.56
Nov.	6	Dark	"	"	52	46	512	74	586	25.92	18.24
		Averages					487	104	591	25.69	15.10

*Collected 12 hours after a rain.

†Collected 24 hours after a rain.

‡Rain at time of collection.

TABLE VI.—*Wilmington*—

1899.											
July	19				82°	86°	388	20	408	4.64	4.16
Aug.	2	Turbid	Good	Little	80	96	280	52	332	7.36	6.48
"	16	Light	"	"	78	84	276	52	328	7.04	5.52
"	30	Dark	"	Brown	82	90	260	78	338	5.92	5.84
Sept.	13	Light, turbid	"	Little	68	70	248	40	288	6.88	6.56
"	26	"	"	Sandy	58	68	258	22	280	5.28	4.96
Oct.	11	"	None	Very light	60	67	260	30	290	4.24	3.52
"	25	Light yellow	Good	Light	62	76	250	38	288	4.72	3.68
Nov.	15	"	None	None	52	47	348	......	348	5.36	5.12
		Averages					285	37	322	5.71	5.09

6910: THE WITNESS: I read next, table marked No. 7, giving the results of the analyses of the Illinois river water taken at Morris, in 1899, and next table 8, giving the results of the analyses of the Kankakee river water taken at Wilmington in 1899, these two tables being printed on one sheet.

MR. JEFFRIES: To the reading of which said table, the same objection is made by the complainant as to table No. 2.

Canal.

Chlorine.	Ammonia.		Nitrogen.		Colonies—per cc.	Fermentation.			Coagulation of milk.	Indol produced?
	Free	Albuminoid	In nitrates.	In nitrites.		1-10 cc. (Per cent)	1 cc. (Per cent)	1 cc. (Per cent)		
74.6	10.30	2.30	None..	None..	199,200	....	None..	80	Rapid	No.
54.00	4.15	1.01	0.25	0.20	....	....	" ..	40	"	Yes.
78.10	13.60	1.70	None..	None	74,000	....	" ..	None..	"	No.
78.10	10.45	2.34	" ..	" ..	262,500	....	5	10	"	"
103.00	14.00	2.48	" ..	" ..	480,000	....	50	40	"	"
81.70	15.38	1.84	" ..	Trace.	44,000	....	50	40	"	"
99.40	14.40	2.56	" ..	None..	410,000	....	35	65	"	"
103.00	18.80	3.16	" ..	" ..	Many millions	....	50	35	"	....
103.00	15.00	1.36	" ..	" ..	315,000	10	20	....	"	Yes.
99.40	13.60	2.04	" ..	" ..	29,000	10	15	....	"	"
88.75	19.40	3.32	" ..	" ..	26,000	None..	5	....	"	No.
95.85	17.80	1.10	" ..	" ..	96,600	10	10	....	"	Yes.
67.50	25.80	6.20	" ..	0.025	220,100	40	50	....	"	"
68.20	19.80	4.10	" ..	0.01	1,638,000	20	60	....	"	"
73.80	20.60	5.40	" ..	Trace..	1,060,800	40	70	....	Very rapid.	"
96.00	23.20	3.40	" ..	0.02	35,200	60	15	....	24 hours	"
89.00	16.70	4.80	" ..	None..	1,688,400	40	40	....	Rapid	"
85.49	16.05	2.88	0.014	0.015						

The Kankakee River.

1.4	0.08	0.32	5.00	0.06	285,120	....	None..	None..	12 hours	No.
3.53	0.078	0.458	None..	Trace..	5,300	....	5	10	24 hours	"
3.55	0.13	0.368	" ..	0.01	3,850	....	30	5	Slow	"
4.26	0.114	0.328	" ..	0.04	750	....	40	40	Rapid	Yes.
2.84	0.07	0.298	" ..	None..	5,095	10	10	....	Slow	No.
2.84	0.064	0.362	0.20	0.01	59,500	None..	None..	....	"	"
2.48	0.07	0.348	None..	None..	6,600	20	10	....	Rapid	"
1.40	0.084	0.258	" ..	" ..	7,900	None..	10	....	Very slow	"
2.85	0.046	0.30	3.20	0.01	4,750	25	None..	....	"	"
2.79	0.082	0.337	0.93	0.014						

of the analyses of the Illinois river water taken at Ottawa in 1899; tables 7 and 8 being printed on the same sheet.

MR. JEFFRIES: To the reading of which the same objection is made by the complainant.

6911

TABLE VII.—*Morris*—

Date.	Color.	Odor.	Sediment.	Temperature. Water....	Temperature. Air....	Solids. In solution	Solids. In suspension....	Solids. Total....	Oxygen Absorption. Not filtered	Oxygen Absorption. Filtered...
1899										
July 5	Light	Bad	Flocculent	....	....	....	....	390	8.22	....
" 11	....	....	....	....	....	....	....	462	11.84	10.08
* " 18	....	....	....	74°	74°	420	56	476	10.24	9.28
" 25	Nearly clear	Bad	Lumpy	79	83	440	12	452	9.12	8.90
†Aug. 1	Turbid	"	Light	79	74	436	16	452	9.44	6.96
" 8	Light	Faintly disagreeable.	Little	74	73	468	12	480	9.20	6.96
" 15	Dark	Faintly disagreeable	Flocculent	73	73	412	24	436	9.92	7.84
" 22	Light, clear	Bad	"	72	74	396	20	416	7.84	6.64
" 29	Dark, clear	Good	Light	78	76	420	20	440	8.00	6.80
Sept. 5	Light, clear	Faintly disagreeable.	Little	77	78	370	42	412	8.64	6.56
" 12	Dark	Bad	Black	69	68	448	16	464	14.56	10.88
" 19	Light	"	Little	65	62	424	16	440	8.72	7.76
" 26	" turbid	"	None	62	51	476	12	488	12.32	9.28
Oct. 3	Dark, turbid	"	"	55	61	450	20	470	28.80	20.16
" 10	Light, turbid	"	Little	58	66	480	32	512	9.92	7.92
" 17	"	"	None	58	55	368	16	384	7.28	6.96
" 24	"	"	Dark	....	....	316	88	404	7.92	7.52
" 31	"	"	Black, flocculent	50	48	414	20	434	11.36	7.84
Nov. 7	Light	"	Flocculent	44	38	422	18	440	11.20	7.84
" 14	"	"	Lumpy b'lk.	46	54	426	14	440	12.00	8.48
" 21	Slightly dark	"	Flocculent	52	58	404	24	428	8.56	6.32
" 28	Light, turbid	"	Little	42	42	402	12	414	8.40	7.92
	Averages					420	25	445	9.16	8.07

*Heavy rain for 4 days.

†Collected during a rain.

TABLE VIII.—*Ottawa*—

Date.	Color.	Odor.	Sediment.	Temperature. Water....	Temperature. Air....	Solids. In solution	Solids. In suspension....	Solids. Total....	Oxygen Absorption. Not filtered	Oxygen Absorption. Filtered...
1899										
July 8	Dark yellow	Fair	....	....	....	....	....	396	10.40	....
" 11	....	....	....	80.0°	....	....	....	466	9.44	9.44
* " 18	Yellow	Earthy	....	81.5	83°	344	28	372	8.48	7.04
" 25	Dark	"	Little	84.0	90	416	20	436	7.84	6.72
Aug. 1	"	Faintly disagreeable.	"	83.0	90	432	12	444	7.52	6.64
" 8	Light, clear	Earthy	"	80.0	81	452	16	468	6.80	6.64
" 15	"	None	"	76.0	78	384	12	396	6.08	5.08
" 22	"	Little	"	84.0	92	468	16	484	7.08	7.12
" 29	Fairly light	Not pleas'nt	"	85.0	90	444	4	448	7.28	6.48
Sept. 5	Dark yellow	Earthy	Dark	86.0	96	456	16	472	7.52	6.80
" 12	Light, clear	None	None	73.0	72	504	12	516	6.80	6.16
" 19	"	Little	"	75.0	78	464	....	464	7.04	6.80
" 26	"	Faint	"	64.0	65	440	4	444	7.12	6.64
Oct. 3	Clear, yellow	Bad	"	60.0	73	496	6	502	7.92	7.12
" 10	Light, clear	Faint	"	64.0	70	476	8	484	7.00	7.04
" 19	"	None	"	....	....	414	8	422	6.24	6.00
" 24	"	Faint	"	68.0	80	440	2	442	5.68	5.22
" 31	"	"	"	50.0	48	400	4	404	4.58	4.58
Nov. 7	"	None	"	46.0	59	400	20	420	4.56	4.56
" 15	"	Good	"	48.0	58	404	28	432	6.00	5.92
" 21	"	Little	"	52.0	60	432	8	440	7.76	7.76
" 27	"	None	"	42.0	50	420	4	424	6.40	....
	Averages					434	11	445	7.13	6.38

*Heavy rain; river high.

The Illinoi sRiver.

Chlorine........	AMMONIA.		NITROGEN.		Colonies—per cc....	FERMENTATION.			Coagulation of milk.	Indol produced?....
	Free........	Albuminoid	In nitrates	In nitrites.		1-10 cc. (Per cent)......	1 cc. (Per cent)......	1 cc. (Per cent)......		
58.5	5.90	1.10	None..	None..	55,800	....	None..	None..	Rapid..................	No.....
56.8	9.00	1.00	"	"	12,000	....	"	"	"	" ....
53.3	5.90	1.00	"	0.48	85,750	....	"	50	24 hours..........	" ....
49.7	9.50	1.36	"	0.12	115,000	....	"	None..	"	" ....
71.0	9.64	0.68	"	0.60	501,000	....	15	20	Rapid................	" ....
63.9	11.00	1.18	"	2.40	320,000	....	20	90	"	" ....
63.9	10.60	1.24	"	0.006	186,000	....	90	90	Slow..................	" ....
63.9	6.20	1.16	"	None..	52,800	....	100	30	24 hours..........	......
81.7	10.50	0.88	"	0.03	61,500	....	25	30	Slow..................	......
81.7	10.56	1.24	"	Trace.	3,514,500	....	45	45	Rapid................	......
74.6	10.50	1.28	"	None..	10,200	30	15	....	Very rapid	No.....
71.0	6.00	0.76	"	Trace.	31,500	50	40	....	24 hours..........	" ....
81.7	9.50	1.72	"	None..	43,200	10	10	....	Rapid................	" ....
43.9	12.00	1.28	"	0.015	489,600	10	60	....	"	Yes....
53.3	11.00	1.34	"	0.005	37,730	30	20	....	"	" ....
53.3	15.40	1.88	"	None..	56,700	5	80	....	"	" ....
67.5	8.60	0.72	"	Trace.	504,000	10	10	....	"	" ...
78.0	15.60	1.68	"	0.005	656,800	5	5	....	24 hours..........	No.....
53.2	9.10	1.36	"	0.01	1,366.200	70	30	....	Rapid................	Yes....
46.2	9.76	1.46	0.80	0.04	548,000	50	20	....	"	" ....
42.6	9.80	1.28	0.48	0.28	528,000	35	30	....	24 hours..........	" ....
49.7	12.50	1.20	0.32	Trace.	23,000	10	10	....	Slow..................	No.....
61.8	10.99	1.20	0.07	0.18						

The Illinois River.

49.7	8.10	0.80	None..	0.005	1,740	....	25	5	24 hours..........	No....
49.7	3.90	0.90	"	0.005	3,710	None..	None..	None..	"	" ....
28.4	2.00	0.75	0.64	1.60	990	"	"	"	"	" ....
35.5	4.80	0.76	Trace.	0.36	15,200	....	"	"	"	" ....
51.8	5.28	0.50	1.25	6.40	5,400	....	30	90	Rapid................	" ....
42.6	4.35	0.54	0.00	0.05	28,400	....	5	10	24 hours..........	" ....
50.4	3.93	0.46	0.48	0.50	7,600	....	50	90	19 hours..........	" ....
56.8	4.85	0.49	0.20	0.40	33,000	....	25	20	24 hours..........	" ....
78.1	3.75	0.52	1.00	0.20	270,000	....	5	10	Slow..................	......
85.2	5.55	0.69	0.40	0.05	871,000	....	40	30	Rapid................	Yes....
53.3	5.50	0.44	0.72	0.40	33,300	50	40	....	"	" ....
71.0	8.80	0.62	2.00	0.20	2,050	60	20	....	"	" ....
67.5	7.15	0.37	0.60	0.30	7,500	20	20	....	24 hours..........	" ....
76.7	10.63	0.59	0.72	0.20	28,000	5	5	....	"	No....
69.3	10.60	0.66	0.40	0.10	280,700	5	10	....	Rapid................	" ....
60.3	11.50	0.68	0.32	0.80	11,500	10	20	....	"	Yes....
71.0	5.20	0.64	0.60	0.28	35,200	60	15	....	24 hours..........	" ....
64.0	9.42	0.68	0.80	0.15	15,600	10	20	....	Rapid................	No.....
56.8	7.00	0.46	0.60	0.25	26,200	10	10	....	"	" ...
53.3	2.50	0.08	1.80	0.50	21,400	10	10	....	24 hours..........	" ....
42.6	4.16	0.60	2.00	0.70	6,600	5	10	....	48 hours..........	" ....
49.7	7.00	0.84	0.60	0.12	1,400	15	25	....	24 hours..........	" ....
57.4	6.23	0.62	0.74	0.61						

9612 THE WITNESS: I read next, table numbered 9, giving the results of the analyses of the Fox river water taken at Ottawa in 1899; and table No. 10, giving the results of the

6913 TABLE IX.—*Ottawa*—

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Oxygen Absorption.	
					Water	Air	In solution	In suspension	Total	Not filtered	Filtered
1899.											
July	5	Turbid	Good		73°	73°			306	8.46	
* "	16				81	83	304	92	396	12.64	8.32
Aug.	1	Turbid	Good	Light	80	90	320	24	344	6.48	5.04
"	15	Light, turbid	"	Little	75	78	296	36	332	5.84	5.60
"	29	Light	"	"	84	90	324	24	348	6.56	5.12
Nov.	27	Light, clear	"	None	42	50	324		324	3.84	3.84
		Averages					314	35	349	7.30	5.58

*Heavy rains; high water.

TABLE X.—*LaSalle*—

1899.											
July	13	Straw	Earthy		87°	85°	484	128	612	10.56	9.92
* "	20				84	82	444	44	488	8.48	6.88
"	27	Turbid	Good	Some	90	84	424	8	432	7.52	6.32
Aug.	2	Light	"	Granular	86	80	430	26	456	7.84	6.96
"	9	"	Earthy	Little	78	84	400	20	420	6.96	6.00
"	16	Greenish, clear	Slightly unpleasant	"	82	76	404	8	412	6.88	6.08
"	23	Yellow	Faint	"	82	98	484	16	500	7.44	6.24
"	30	Light yellow	Good		86	84	436	12	448	6.72	6.32
Sept.	6	Yellow	"	Little	86	86	436	28	464	7.60	7.36
"	12	Light	"	Yellow	70	68	444	32	476	6.56	6.08
"	20	"	"	None	66	70	426	10	436	5.92	5.44
"	28	Dark	Little	"	62	70	416	16	432	6.88	6.56
Oct.	4	Light	Bad	Little	62	80	436	4	440	7.68	7.44
"	11	"	Good	"	64	68	420	46	466	7.76	7.28
"	18	"	Faint	None			372	12	384	6.48	5.64
"	25	"	None	"	65	82	376	16	392	6.16	5.76
Nov.	1	"	Little	"	58	45	354	10	364	5.04	4.96
"	8	"	Faintly disagreeable	"	47	68	364	2	366	4.96	4.08
"	22	"	Bad	"	52	56	376		376	6.16	6.08
"	29	Light yellow	"	"	46	58	404		404	6.88	6.88
†Dec.	6	Yellow	Good	Fine	32	30	388	12	400	6.40	6.32
		Averages					415	21	436	6.99	6.44

*Heavy rain; river 2 feet above normal.

†Ice upon river.

analyses of the Illinois river water taken at LaSalle in 1899, tables 9 and 10 being printed on the same sheet.

MR. JEFFRIES: To the reading of which complainant makes the same objection.

The Fox River.

Chlorine......	AMMONIA.		NITROGEN,		Colonies—per cc....	FERMENTATION.			Coagulation of Milk.	Indol produced?....
	Free.......	Albuminoid	In nitrates	In nitrites.		1-10 cc. (Per cent).....	1 cc. (Per cent).....	1 cc. (Per cent).....		
3.55	0.20	0.50	None..	None..	3,200	5	....	None..	Slow.....	No.....
2.84	0.072	0.72	0.48	0.02	3,280	None..	....	" ..	Very slow............	" ....
4.26	0.06	08.38	0.003	None..	42,000	" ..	....	" ..	Slow...	" ...
3.55	0.12	0.398	0.01	" ..	8,800	" ..	....	5	24 hours...............	" ....
3.55	0.13	0.428	0.01	" ..	17,200	10	....	5	Slow........	....
4.97	0.29	0.84	Trace..	0.20	1,400	20	20	....	24 hours...............	No.....
3.78	0.145	0.454	0.11	0.007						

The Illinois River.

49.0	1.28	0.68	0.60	0.64	1,400	....	None..	None..	24 hours...............	No.....
30.5	1.75	0.71	2.00	0.32	3,500	... .	" ..	" ..	12 hours...............	" ....
32.7	0.65	0.75	1.00	0.006	136,500	....	" ..	" ..	14 hours...............	" ....
32.0	1.50	0.61	1.00	1.00	46,200	....	40	60	24 hours...............	" ....
42.6	1.00	0.47	1.40	0.01	26,200	....	90	50	Rapid..................	" ....
46.2	0.95	0.62	1.92	0.20	12,800	....	30	5	"	"
53.3	2.40	0.74	1.00	0.20	1,500	....	50	100	24 hours...............	"
56.8	1.95	0.55	1.60	0.40	....	....	35	20	Slow............... ..	"
46.2	4.05	0.56	4.00	Trace.	39,000	90	90	....	Very rapid	Yes....
60.4	4.35	0.42	0.60	0.32	1,525	60	5	....	Rapid	No.....
49.7	7.95	0.60	3.28	0.14	5,500	60	60	....	"	Yes....
42.6	9.50	0.28	1.00	0.15	6,400	80	80	....	"	" ....
42.6	5.00	0.38	1.00	0.02	14,220	10	50	....	"	No.....
39.8	9.80	0.06	1.00	1.00	6,400	None..	90	....	"	Yes....
37.0	10.10	0.58	0.68	1.50	16,250	60	40	....	"	" ....
46.1	4.80	0.88	2.40	0.20	5,700	30	20	....	24 hours...............	" ....
35.5	6.70	0.32	1.00	0.03	47,600	40	10	....	"	No.....
39.0	6.40	0.82	0.40	0.12	13,100	None..	10	....	"	"
25.0	4.60	0.44	1.40	0.16	1,800	10	40	....	"	Yes....
35.4	6.32	0.60	0.80	0.40	147,000	50	30	....	"	" . ..
25.0	6.30	0.68	0.60	0.60	1,200	50	40	....	Rapid..................	" ....
41.3	4.66	0.58	1.45	0.35						

6914 THE WITNESS: I read next table Number 11, which gives the results of the analyses of the Vermillion river water taken at LaSalle in 1899, and table No. 12, giving the re-

6915 TABLE XI.—*LaSalle*—

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Oxygen Absorption.	
					Water.	Air.	In solution	In suspension.	Total.	Not filtered	Filtered
1899.											
*July	13	Light yellow	None	Some	85°	85°	496	24	520	3.68	3.36
† "	29				86	82	476	44	520	3.28	3.04
"	27	Light	Earthy	Some	90	84	552	64	616	2.72	2.24
Aug.	2	Light, turbid	Good	"	88	80	752	32	784	3.28	2.80
"	16	Dark	None	"	80	76	652	44	696	4.08	2.48
"	29	Light	Good	Sandy	82	92	616	40	656	3.76	2.96
‡Nov.	16	None	None	None	50	62	1,776	54	1,830	6.16	4.00
§Dec.	6	Light	Good	"	33	40	1,672	20	1,692	1.84	1.54
		Averages					874	40	914	3.60	2.65

*Bacterial sample warm.
†Heavy rains; river two feet above normal.
‡Calcium, magnesium and SO_4 present in large amounts; CO_2 absent.
§As above. About one inch of ice.

TABLE XII.—*Henry*—

1899.											
July	10			Brown					426	9.60	
"	17	Turbid	None	Some	78°	72°	388	12	400	9.00	8.16
"	31	Very turbid	Good	Little			448	32	480	6.40	6.16
*Aug.	7	Light	"	Granular	74	66	476	52	528	7.44	6.80
"	14	Dark	"	Dark	70	68	432	44	476	6.24	5.36
"	21	Light, clear	Earthy	Little			440	24	464	6.64	6.32
"	28	"	Bad	Brown	92	78	520	20	540	6.96	6.64
Sept.	4	Dark	Faint	Dark	74	68	404	24	428	8.16	7.76
"	11	Light	Good	Sandy	74	68	406	50	456	6.80	5.92
"	18	Turbid	Earthy	None	70	66	416	32	448	8.16	7.36
"	25	Light, turbid	"	Little	66	60	404	36	440	8.64	8.08
Oct.	2	"	"	Scanty, yellow	56	52	420	20	440	6.80	6.08
"	9	"	None	Little	56	50	556	6	562	6.56	6.00
"	16	Dark, clear	Faint	"	66	70	436	24	460	6.72	5.68
"	23	Light	Good	"	60	66	420	18	438	5.68	5.44
"	30	Light, turbid	Little	Gray	56	40	370	28	398	5.52	4.64
Nov.	13	Light, clear	Faintly disagreeable.	None	48	40	380	28	408	5.04	5.04
"	27	"	Good	"	46	32	380		380	6.16	6.08
Dec.	4	Light	None	Little	36	32	374	10	384	5.92	5.60
		Averages					426	25	451	7.00	6.36

*Sample warm.

6916 THE WITNESS: I read next, table No. 13, giving the result of the analyses of the Illinois river water taken above Peoria at the point described as the Narrows, in 1899—

sults of the analyses of Illinois river water taken at Henry in 1899, these tables 11 and 12 being printed on the same sheet.

MR. JEFFRIES: To the reading of which the same objection is made.

The Vermillion River.

Chlorine....	Ammonia.		Nitrogen.		Colonies—per cc....	Fermentation.			Coagulation of milk.	Indol produced?...
	Free....	Albuminoid	In nitrates.	In nitrites.		1-10 cc. (Per cent)......	1 cc. (Per cent)......	1 cc. (Per cent).....		
7.81	0.02	0.23	1.40	0.03	....	....	None..	None..	24 hours	No.
7.80	0.06	0.110	2.04	0.04	2,700	....	"	"	Slow	"
20.60	0.116	0.276	0.53	0.045	77,000	....	"	"	"	"
34.06	0.10	0.208	None..	0.01	72,600	....	50	35	Rapid	"
28.40	0.084	0.214	0.40	0.06	700	....	70	None..	Slow	"
34.10	0.16	0.318	None..	0.01	600	....	20	100	24 hours	"
95.90	0.814	0.105	0.34	0.02	1,200	5	50	....	Slow	"
78.10	0.96	0.136	0.24	0.00	13,400	None..	None..	....	"	"
38.35	0.286	0.199	0.61	0.102						

The Illinois River.

42.6	1.61	0.68	0.50	0.0025	2,120	....	None..	None..	24 hours	No.
37.6	2.60	0.600	0.75	0.24	....	....	"	"	"	"
31.2	0.12	0.478	0.40	0.12	3,600	....	50	60	Rapid	"
37.0	1.10	0.438	1.10	0.14	1,750	....	None..	90	16 hours	"
32.0	1.54	0.59	0.25	0.24	13,300	....	10	10	Slow	"
32.5	1.09	0.538	0.90	0.24	792,000	....	100	90	Very rapid	"
49.7	1.32	0.495	1.20	0.16	3,591,000	....	5	5	Rapid	....
51.5	1.45	0.445	1.08	0.32	7,400	....	10	5	"	....
32.0	1.16	0.37	1.00	0.06	630	90	20	....	12 hours	No.
60.4	2.04	0.535	3.00	0.32	19,250	50	60	....	Very rapid	Yes.
56.8	1.08	0.61	2.00	2.00	750	20	30	....	Rapid	"
49.7	5.05	0.85	1.00	3.00	1,450	60	50	....	24 hours	"
42.6	8.74	0.55	3.00	0.20	1,700	40	60	....	Rapid	"
54.0	7.93	0.74	2.80	0.10	8,900	None..	50	....	"	"
46.2	6.50	0.50	2.00	2.00	12,600	95	80	....	24 hours	"
42.6	4.31	0.49	1.00	0.20	1,200	None..	45	....	Rapid	No.
30.0	6.48	0.48	None..	0.06	48,000	"	80	....	24 hours	"
35.4	3.98	0.47	0.60	0.06	4,500	"	None..	....	Very slow	"
28.4	4.08	0.65	1.20	0.36	13,200	"	55	....	24 hours	Yes.
43.2	3.28	0.566	1.30	0.517						

this point also being known as Averyville. I read next table No. 14, giving the results of the analyses of the Illinois river water taken below Peoria, opposite a point known as Wesley, sometimes described as Lower Peoria, in my reports. These analyses being made in 1899, the tables 13 and 14 are printed on the same sheet.

6917 TABLE XIII.—*Peoria Narrows—*

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Oxygen Absorption.	
					Water.....	Air..	In solution	In suspension......	Total.	Not filtered	Filtered ...
1899											
July	5	....	....	Yellow........	....	......	....	....	428	8.64	......
"	13	....	Earthy........	"	....	......	432	52	484	10.56	10.24
* "	19	....	....	....	....	......	464	8	472	5.76	4.64
"	26	Turbid........................	Good........	Yellow........	....	......	336	46	382	6.56	5.44
Aug.	2	"	"	Little........	....	......	404	8	412	6.72	5.68
"	9	Light, turbid........	"	Fine........	....	......	432	24	456	6.32	6.08
"	16	"	"	Clay........	....	......	420	36	456	6.08	5.60
"	23	"	Little........	Some........	....	......	372	20	392	6.32	5.36
"	30	Light	Good	Little........	....	......	364	16	380	7.52	6.08
Sept.	6	Clear, yellow	"	Brown........	....	......	372	32	404	6.80	5.52
"	20	Light, turbid........	"	Little........	....	......	408	32	440	6.86	5.92
Oct.	4	"	"	Sandy.	....	......	420	8	428	5.36	5.20
"	18	"	"	Little........	....	......	412	20	432	7.44	6.08
Nov.	8	Yellow........................	Earthy........	None........	....	......	372	14	386	4.72	4.24
"	22	Light	Faint.....	Sandy........	....	......	360	24	384	7.20	5.60
		Averages........	....	....	....	......	398	24	422	6.66	5.46

*Rain, with river rising.

TABLE XIV.—*Lower Peoria—Wesley—*

1899											
July	5	....	....	Yellow........	....	......	....	....	428	10.40	......
"	13	Turbid	Sour........	....	....	......	480	24	504	16.64	12.80
"	19	....	....	....	84°	92°	416	140	556	14.40	9.28
"	26	Turbid	Sour........	Yellow	84	96	360	32	392	8.80	8.00
Aug.	2	Dark........................	Bad........	"	82	92	380	32	412	13.04	10.64
"	9	"	" sour...	Brown........	74	84	388	44	432	9.28	7.28
"	16	Dark, turbid........	"	Dark........	74	84	452	36	488	20.48	11.92
"	23	Light, clear........	"	Gray	80	84	428	28	456	10.88	8.00
"	30	Dark.	"	Little	83	88	460	20	480	11.52	10.88
Sept.	6	"	"	Brown	82	96	396	20	416	7.12	6.00
"	13	Light, turbid	"	Lumpy, bl'k	70	70	400	36	436	18.56	13.12
"	20	Dark....	"	Brown	68	72	408	76	484	17.12	10.72
"	27	Yellow........................	"	"	62	70	404	28	432	10.40	7.36
Oct.	4	Dark, turbid........	"	Dark........	60	70	522	56	578	27.84	16.24
"	11	Dark, yellow........	"	Flocculent, brown.....	64	64	420	122	542	5.60	4.64
"	18	Dark........................	"	Dark	70	90	492	88	580	28.00	18.24
Nov.	1	Yellow........................	"	Yellow........	50	48	540	132	672	41.12	30.08
"	8	Light, turbid........	"	Flocculent..	48	66	452	42	494	19.80	14.72
"	15	"	"	Dark	52	56	478	14	492	24.48	21.44
"	22	Yellow........................	"	"	54	58	462	70	532	29.12	19.84
"	29	Yellow, turbid........	"	"	44	92	432	52	484	21.76	13.76
		Averages........	....	....	....	......	428	55	483	17.44	12.64

*Rains and river rising.

†Heavy rain day before collection.

‡Steamboat passing.

§River rising.

MR. JEFFRIES: To the reading of which complainant makes the same objection as previously given.

The Illinois River.

Chlorine	Ammonia.		Nitrogen.		Colonies—per cc.	Fermentation.			Coagulation of milk.	Indol produced?
	Free	Albuminoid	In nitrates	In nitrites.		1.10 cc. (Per cent)	1 cc. (Per cent)	1 cc. (Per cent.)		
33.4	0.40	0.50	0.60	0.0025	3,000		20	10	24 hours	No
32.0	0.50	1.20	None	None	460		None	None	"	"
39.0	0.50	0.43	2.00	0.04	34,200		"	"	Slow	"
26.3	0.40	0.525	0.70	0.44	4,300		"	"	"	"
30.5	0.15	0.32	1.25	0.06	2,800		10	5	24 hours	"
24.9	0.30	0.37	1.00	0.01	4,200		85	90	Slow	"
28.4	0.36	0.545	1.12	0.30	6,000		None	15	"	"
28.4	0.25	0.46	0.80	0.12	2,800		100	100	"	"
35.5	0.385	0.67	0.44	0.06	31,900		5	20	24 hours	"
24.9	0.725	0.735	0.40	0.12	40,600	None	70		12 hours	"
42.6	0.15	0.705	1.20	0.11	3,850	20	20		Slow	Yes
31.2	0.365	0.57	1.00	0.70	200	None	60		24 hours	No
30.8	0.30	0.645	3.20	0.07	864,350	70	80		Slow	"
46.2	3.815	0.425	1.30	0.03	93,800	None	10		24 hours	"
42.6	4.55	0.49	0.80	0.03	5,400	20	20		slow	"
33.04	0.896	0.572	1.10	0.141						

The Illinois River.

Chlorine	Free	Albuminoid	In nitrates	In nitrites	Colonies—per cc.	1.10 cc. (Per cent)	1 cc. (Per cent)	1 cc. (Per cent.)	Coagulation of milk.	Indol produced?
17.8	0.60	0.85	None	0.003	43,200		None	None	Rapid	No
17.8	0.75	2.80	"	None	691,200		10	40	12 hours	"
35.5	3.00	1.38	"	0.08	231,000		50	50	12 "	"
24.9	1.00	1.00	0.70	0.20	1,023,000		30	25	14 "	"
28.4	2.15	1.24	None	None	3,255,000		40	75	12 "	"
25.6	0.32	1.04	0.45	0.06	36,300		20	25	Rapid	"
32.0	3.45	2.74	None	0.004	3,780,000		10	10	"	"
32.0	1.26	1.04	"	None	3,528,000		20	25	"	"
35.5	0.64	1.32	"	"	7,268,000		20	50	"	"
42.6	0.87	0.56	0.28	0.10	280,000	5	50		"	Yes
35.5	0.02	2.10	None	None	63,000	5	5		Very rapid	"
21.3	2.80	3.08	Trace	0.008	1,015,000	30	60		Rapid	No
49.7	1.00	1.60	0.80	0.10	903,000	5	5		"	Yes
30.0	6.86	4.28	None	None	1,106,000	None	None		"	No
45.3	3.90	7.08	"	"	23,668,000	"	10		24 hours	"
30.0	10.20	7.76	"	"	347,000	90	20		Rapid	Yes
42.6	13.92	7.04	"	"	1,138,500	5	10		"	"
46.2	7.60	4.86	"	"	648,000	None	10		"	"
39.0	7.88	4.20	"	"	923,000	"	5		"	"
49.7	13.60	7.00	"	"	876,000	10	10		"	"
82.0	10.20	4.20	"	"	1,173,000	20	20		"	"
34.97	4.36	3.20	0.106	0.026						

6918 THE WITNESS: I give next table 15, which contains the results of analyses of Illinois river water collected at Pekin in 1899. I read next table No. 16, which gives the re-

6919 TABLE XV.—*Pekin*—

Date.	Color.	Odor.	Sediment.	Temperature.		Solids.			Oxygen Absorption.	
				Water	Air	In solution	In suspension	Total	Not filtered	Filtered
1899.										
July 16				79°	90°	440	20	460	8.16	7.68
*Aug. 1	Turbid	Earthy	Some	82	94	396	12	408	7.76	6.88
" 8	Light, clear	Slight	Clay	70	74	424	20	444	6.96	6.48
" 15	"	Good	Little	77	92	396	28	424	6.48	6.24
" 22	Dark	None	Brown	79	91	396	8	404	6.88	6.08
† " 30	Green	Bad	Green	86	100	440	56	496	20.96	10.72
Sept. 5	Light	None	Sandy	82	100	360	32	392	8.48	6.64
" 12	"	Bad	Fine	68	80	388	36	424	7.36	6.72
" 19	Light yellow	Earthy	Clay	68	70	356	40	396	7.12	5.84
" 26	Dark	"	Brown	59	65	384	32	416	8.48	6.88
Oct. 3	Clear, yellow	Good	Yellow	54	75	394	20	414	6.00	5.68
" 10	Light	"	"	54	71	368	16	384	6.16	6.16
" 18	Light, turbid	Faintly disagreeable.	Little	59	70	394	22	416	7.88	6.96
" 25	Yellow, turbid	Disagr'able.	Sandy	61	58	414	38	452	8.40	5.76
" 31	Yellow, clear	Peculiar	Little	50	58	416	24	440	7.84	6.40
Nov. 7	Yellow	Bad.	"	43	50	394	28	422	6.56	5.84
‡ " 15	Light	Good	Sandy	50	68	384	36	420	6.16	4.88
" 22	"	Little.	Brown	50	42	380	4	384	5.44	5.12
" 30	Light, not clear	Bad	Flocculent		48	352	16	368	5.36	4.88
	Averages					393	26	419	7.81	6.41

*Collected during a shower.
†Bottle containing bacterial sample broken.
‡Light showers.

TABLE XVI.—*Havana*—

1899.										
July 6			Clay					734	9.44	
* " 13	Slightly dark	None	Feathery	80°	96°	396	116	512	9.44	9.28
" 20				80	85	448	36	484	9.60	8.96
" 27	Light, turbid	Good	Little	85	90	308	44	352	7.52	7.04
Aug. 3	Turbid	"	Fine	80	84	348	60	408	6.56	5.28
† " 10	"	Little	"	74	78	416	24	440	6.72	6.08
" 17	Cloudy, dark	Good	Dark	78	84	392	76	468	6.64	6.24
" 24	Light, turbid	Earthy	Light brown	76	78	388	72	460	6.96	5.76
" 31	"	Good	Little	74	78	388	52	440	6.40	6.16
Oct. 5	"	Earthy.	Sandy	50	50	340	20	360	5.44	4.32
" 12	Yellow	"	Yellow	62	70	408	68	476	6.96	6.40
" 18	"	Little	Dark	48	52	376	56	432	8.08	6.96
‡ " 26	Dark yellow	"	Sandy	58	64	400	68	468	6.48	5.52
Nov. 2	Yellow, unclear	Faint	Light	44	34	402	90	492	7.12	5.76
" 16	Dark yellow	Earthy	Dark yellow	50	56	398	22	420	7.52	6.64
" 30	Light yellow	Slightly disagreeable.	Sandy	46	50	344	28	372	5.84	5.12
Dec. 7	Dark	Little	"	36	44	364	12	376	5.92	5.60
§ " 14	Yellow	None	"	32	30	356	20	376	6.64	6.24
	Averages					381	51	432	7.18	5.96

*Bacterial sample warm.
†Storms.
‡Rain at time of collection.
§Snow.

sults of analyses of Illinois river water collected at Havana in 1899, tables 15 and 16 being printed on the same sheet.

MR. JEFFRIES: Complainant makes the same objection as previously given.

The Illinois River.

Chlorine....	Ammonia.		Nitrogen.		Colonies—per cc....	Fermentation.			Coagulation of milk.	Indol produced?....
	Free....	Albuminoid	In nitrates	In nitrites.		1-10 cc. (Per cent).....	1 cc. (Per cent).....	1 cc. (Per cent).....		
28.4	0.85	0.45	None..	0.280	52,500	....	10	10	24 hours..............	No.....
24.9	0.87	0.67	" ..	0.320	665,000	....	10	15	"	" ....
24.9	0.82	0.59	0.50	0.015	778,000	....	10	20	Rapid.	" ....
17.8	0.85	0.49	0.48	0.080	289,000	....	20	40	"	" ....
35.5	0.70	0.97	0.88	0.160	7,200	....	10	15	"	" ....
39.0	0.37	2.74	None..	None..	....	....	....	....	....	....
42.6	0.83	0.87	" ..	0.080	291,000	....	50	40	Rapid..............	Yes ...
24.9	1.32	0.64	" ..	None..	36,000	20	20	....	"	" ....
39.0	0.75	0.62	0.48	0.080	325,000	25	15	....	"	" ....
23.0	0.63	0.54	0.48	0.100	224,000	15	20	....	"	" ....
37.0	0.60	0.54	1.00	0.120	148,000	40	50	....	"	" ....
31.2	1.05	0.82	1.00	0.300	250,700	50	50	....	24 hours..............	" ....
31.2	1.33	0.94	1.40	0.400	300,000	5	10	....	"	No.....
30.0	1.80	0.93	1.40	0.400	257,400	10	20	....	"	Yes....
46.0	0.73	0.81	2.50	1.200	72,600	None..	50	....	"	No.....
49.7	2.50	0.56	0.80	1.200	63,900	15	35	....	"	Yes....
42.6	3.31	0.60	1.00	0.050	8,200	None..	10	....	"	No.....
30.0	4.50	1.45	1.00	0.200	14,000	" ..	30	....	Rapid..............	" ....
24.9	2.75	0.50	0.60	0.200	2,378,500	10	10	....	48 hours..............	" ....
34.70	1.30	0.828	0.71	0.273						

The Illinois River.

15.6	1.76	0.82	None..	Trace.	1,800	....	None..	None..	24 hours..............	No.....
22.7	1.50	1.05	1.20	0.06	....	....	" ..	" ..	16 "	" ....
32.7	1.15	0.35	1.20	0.28	39,600	....	" ..	" ..	12 "	" ....
23.4	0.82	0.57	0.67	0.24	79,200	....	" ..	" ..	24 "	" ....
21.3	1.05	0.44	1.00	0.12	56,000	....	50	50	Rapid..............	" ....
21.3	1.00	0.46	0.80	0.02	81,600	....	50	60	24 hours..............	" ....
24.9	1.30	0.41	0.40	0.08	26,400	....	60	50	14 "	" ....
24.9	0.90	0.69	0.28	0.12	59,400	....	90	90	Rapid..............	" ....
28.4	0.70	0.52	0.48	Trace.	....	....	40	20	"	Yes....
25.0	0.45	0.54	0.52	0.02	59,500	40	50	....	"	" ....
38.3	0.47	0.67	1.00	0.60	42,000	25	60	....	24 hours..............	" ....
30.0	1.08	0.99	2.00	0.01	9,750	90	60	....	Rapid..............	" ....
46.2	1.72	0.86	1.60	0.03	35,300	90	90	....	"	" ....
44.4	2.18	0.83	1.60	0.25	323,400	5	10	....	"	" ....
35.4	4.08	0.95	2.00	1.00	42,200	20	30	....	24 hours..............	No.....
35.4	3.75	0.95	0.48	0.20	363,000	20	20	....	"	" ....
21.3	2.65	0.62	1.00	0.70	301,000	10	10	....	"	" ....
24.9	3.95	0.80	1.60	0.12	....	....	....	....	....	....
29.17	1.69	0.695	1.02	0.21						

6920 THE WITNESS: I read next table No. 17, which gives the results of analyses of Spoon River water collected near Havana in 1899. I read next the table numbered 18, which gives the results of the analyses of Sangamon River water collected near Browning in 1899.

I read next table No. 19, which gives the results of the analyses of Illinois river water collected at Pearl, in 1899, tables 17, 18 and 19 being printed on the same sheet.

MR. JEFFRIES: The same objection is made, with the

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TABLE XVII.—*Havana*—

Date.	Color.	Odor.	Sediment.	Temperature.		Solids.			Oxygen Absorption.	
				Water	Air	In solution	In suspension	Total	Not filtered	Filtered
1899.										
Sept. 7	Light	Good	Dark	84°	88°	280	76	356	5.44	4.48
" 14	"	Earthy	Sandy	52	68	260	122	382	6.48	4.72
" 21	Clay	Good	Clay	58	52	164	564	728	12.96	6.
" 28	Light	"	Yellow	54	52	228	66	294	6.48	4.56
Averages						233	207	440	7.84	4.94

TABLE XVIII.—*Browning*—

1899.										
July 6			Yellow					428	5.28	....
" 20				81°	82°	332	44	376	3.52	2.56
Aug. 3	Light, turbid	Good	Fine granular	89	91	302	30	332	3.44	3.12
" 17	Turbid	"	Dark	83	87	292	48	340	4.16	3.60
Sept. 1	Dark	"	Little	86	87	376	8	384	5.12	4.88
*Nov. 9	Light	None	None	51	65	310	18	328	3.76	3.44
† " 23	"	Good	Sandy	52	48	292	28	320	3.36	2.96
Averages						317	29	346	4.09	3.42

*River had risen some.

†Rain; river high.

additional objection to the table referring to the Sangamon river taken at Browning, for the reason that there is no evidence showing that the samples were taken under instructions, and no evidence showing the manner of taking, so that the tables so submitted and the results of such analyses are misleading and unreliable and not competent evidence, and for the further reason that any analyses of water taken upon the tributaries of the Illinois river is immaterial, incompetent and not legal proof, having no bearing upon the issues involved in this controversy.

The Spoon River.

Chlorine	AMMONIA.		NITROGEN.		Colonies—per cc.	FERMENTATION.			Coagulation of milk.	Indol produced?
	Free	Albuminoid	In nitrates.	In nitrites.		1-10 cc. (Per cent)	1 cc. (Per cent)	1 cc. (Per cent)		
1.06	0.31	0.184	0.38	None..	4,100	50	100	....	Rapid	No.....
5.68	0.43	0.308	None..	0.05	1,100	60	60	....	24 hours	'' ....
7.8	0.392	0.944	0.40	0.09	5,150	None..	5	....	Slow	'' ....
2.13	0.078	0.548	0.32	0.02	6,200	'' ..	None..	....	''	'' ....
4.17	0.302	0.496	0.27	0.04						

The Sangamon River.

4.97	0.10	0.50	None..	None..	1,040	....	20	10	Slow	No.....
4.26	0.12	0.192	0.50	0.01	1,640	....	None..	None..	24 hours	'' ....
4.26	0.05	0.258	None..	0.02	650	....	10	25	''	'' ....
3.55	0.08	0.264	'' ..	0.06	6,600	....	50	70	Slow	'' ....
27.00	0.35	0.388	0.48	0.10	....	....	5	10	''	'' ....
4.25	0.09	0.314	0.28	Trace..	2,200	None..	10	....	''	'' ....
5.08	0.232	0.324	0.32	None..	800	80	10	....	''	'' ....
*7.71	0.146	0.320	0.22	0.03						

*4.49 average—exclusive of Sept. 1.

TABLE XIX.—*Pearl—*

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Oxygen Absorption.	
					Water......	Air........	In solution	In suspension......	Total......	Not filtered	Filtered...
1899.											
July	7	....	Fair....	Clay..........	......	......	......	......	382	6.40	......
* "	14	Turbid................	Earthy......	....	86°	86°	312	64	376	6.40	5.76
"	21	"	Good........	Clay.........	84	90	340	88	428	6.00	5.84
† "	28	Light.......	"	Little........	87	91	428	16	444	5.76	4.64
Aug.	3	" very turbid....	"	Heavy	88	96	284	72	356	5.12	4.48
‡ "	10	Yellow...............	Earthy	Heavy clay.	78	82	196	396	592	8.48	5.92
"	18	Light, turbid... ...	Bad	Some.........	86	92	324	48	372	4.64	4.00
§ "	24	Very turbid.........	Good.	Clay..........	86	90	324	72	396	5.28	4.16
"	31	Light, turbid........	"	Sandy.........	......	......	284	32	316	4.48	4.24
**Sept.	7	Light.................	None.........	"	92	100	312	40	352	5.12	4.96
"	14	Light, turbid........	Good	"	76	74	340	40	380	5.76	5.28
"	21	"	"	Yellow.......	70	74	292	76	368	4.88	4.56
Oct.	5	"	Earthy	Yes....	64	74	310	32	342	4.32	4.08
†† "	12	Light, not clear.....	Good...... .	Sandy........	67	80	328	26	354	5.08	4.96
‡‡ "	19	"	"	Light	67	77	272	16	288	4.32	4.00
"	26	Yellow................	None........	Sandy... ...	67	68	324	66	390	5.20	4.96
§§Nov.	2	"	Good........	Yellow	52	32	356	48	404	4.88	4.32
"	16	Light, turbid........	"	Clay..........	54	72	368	64	432	6.56	4.72
		Averages	....	....	......	......	317	71	388	5.51	4.73

*Sample warm, light rain.

†Shower night before.

‡Violent storms, floods.

§River low.

**Sample arrived two days late and warm.

††Bacillus coli communis separated and identified.

‡‡Water collected during a rain.

§§Blizzard and snow storm.

The Illinois River.

Chlorine..........	AMMONIA.		NITROGEN.		Colonies—per cc....	FERMENTATION.			Coagulation of milk.	Indol produced?....
	Free.......	Albuminoid	In nitrates.	In nitrites.		1-10 cc. (Per cent).....	1 cc. (Per cent).....	1 cc. (Per cent).....		
9.38	0.11	0.46	0.77	None..	294,400	....	10	5	Rapid......	No.....
10.70	0.12	0.52	0.80	" ..	....	....	5	None..	24 hours...............	" ....
18.50	0.062	0.30	1.20	0.04	31,500	....	None..	" ..	"	" ....
27.70	0.014	0.128	1.00	Trace..	15,700	....	" ..	" ..	Rapid	" ....
14.90	0.11	0.318	0.75	0.14	2,700	....	20	25	Slow..................	" ....
8.52	0.64	1.02	0.56	None..	140,000	....	20	40	24 hours...............	" ....
15.60	0.28	1.09	0.80	0.10	55,600	....	None..	5	Slow........	" ....
17.00	0.076	0.348	0.48	0.08	....	....	" ..	70	Rapid...	" ....
14.20	0.13	0.308	0.52	Trace..	....	....	5	40	"	Yes...
17.80	0.19	0.254	0.32	None..	585,000	50	50	....	"	" ....
17.60	0.076	0.578	0.44	0.005	100	None..	90	....	"	No ....
7.10	0.55	0.308	0.52	0.07	3,850	" ..	10	....	24 hours...............	" ....
11.40	0.136	0.374	0.60	0.01	400	" ..	None..	....	Slow...................	" ....
31.20	0.43	0.584	0.28	0.01	1,330	" ..	50	....	"	Yes...
18.00	0.154	0.458	0.80	0.04	49,000	25	30	....	"	No.....
30.00	0.70	0.404	1.20	0.04	11,200	None..	15	....	Very slow........	" ....
28.40	0.65	0.53	1.80	0.00	2,700	" ..	None..	....	....	" ....
39.00	1.25	3.95	1.40	0.01	2,930	50	90	....	48 hours...............	" ....
18.73	0.315	0.672	0.79	0.06						

6922 THE WITNESS: I read next table No. 20, which gives the results of the analyses of the Illinois river water collected at Grafton in 1899.

I read next table No. 21, which gives the results of the

6923

TABLE XX.—*Grafton—*

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Oxygen Absorption.	
					Water	Air	In solution	In suspension.	Total.....	Not filtered	Filtered ...
1899.											
July	10	Turbid..............	....	Yellow.......	80°	84°	....	....	296	5.92	.....
"	17	"	Good.........	Some...	87	92	288	36	324	5.76	5.12
"	24	Straw.......	"	"	85	82	296	24	320	4.64	4.16
* "	31	Light.....	"	Yellow......	84	71	400	28	428	5.20	4.88
Aug.	7	"	"	"	83	77	320	40	360	5.44	4.80
"	14	Yellow............	"	Heavy clay.	79	80	140	236	376	7.20	5.92
"	21	Light, turbid.........	"	Yellow	87	87	304	36	340	4.80	3.76
"	28	"	"	Little........	67	92	348	28	376	6.08	4.64
Sept.	4	"	None........	Yellow.......	80	92	304	52	356	6.32	5.76
"	11	"	"	Little.........	78	82	310	20	330	5.44	4.96
"	18	"	Good........	"	72	66	348	8	356	5.08	4.72
"	25	"	None	"	66	62	272	68	340	5.60	4.56
Oct.	3	"	Good........	Yellow......	56	72	272	36	308	4.80	4.64
"	9	"	"	Light.........	60	74	384	28	412	4.80	4.72
"	16	"	"	Brown	72	80	324	36	360	4.16	3.96
† "	23	"	"	Little.........	....	....	320	30	350	4.16	3.16
‡ "	30	Light yellow.........	"	Heavy	....	....	220	204	424	6.88	5.28
Nov.	6	Yellow..............	"	Light........	48	56	332	28	360	5.04	4.40
"	13	Light yellow.........	"	Yellow.......	50	54	308	80	388	6.96	4.96
§ "	20	Yellow..............	"	Sandy.......	54	68	336	50	386	7.12	4.32
¶ "	28	Very turbid..........	None........	Light........	48	60	292	60	352	5.92	5.32
		Averages..........	....	....	....	....	306	53	362	5.61	4.65

*Rain.

†Rain during 38 hours before collection.

‡River rising.

§Rain.

¶No ice used in packing.

TABLE XXI.—*Grafton—*

1899.											
July	10	Yellow.	Good.........	Clay..........	79°	84°	....	....	288	15.52	....
"	17	"	"	"	80	92	164	156	320	11.20	9.44
"	24	"	"	"	85	82	180	164	344	6.88	6.40
* "	31	"	"	"	80	71	176	172	348	7.04	6.32
Aug.	7	Light	"	Yellow......	81	77	200	68	268	7.20	6.32
"	14	"	"	Clay..........	78	80	148	232	380	7.60	6.08
"	21	"	"	Yellow......	83	87	176	76	252	6.64	5.44
"	28	Light, turbid........	"	Slight........	83	92	164	64	228	6.32	5.12
Sept.	11	"	"	Sandy........	75	88	168	104	272	7.12	5.36
"	25	"	None.........	Little........	65	62	168	84	252	8.16	7.04
Oct	9	Light	Good.........	Clay..........	59	74	172	64	236	7.80	7.00
Nov.	6	Yellow..............	"	"	46	56	164	76	240	7.06	6.80
"	20	Light yellow.........	"	Sandy........	52	58	144	52	196	11.08	10.08
		Averages.	....	....	......	......	169	109	278	8.52	6.82

*Rain.

analyses of Mississippi river water collected above Grafton in 1899. Tables 20 and 21 being printed on the same sheet.

MR. JEFFRIES: That is objected to for the same reasons heretofore stated.

The Illinois River.

Chlorine	Ammonia.		Nitrogen.		Colonies—per cc.	Fermentation.			Coagulation of milk.	Indol produced?
	Free	Albuminoid	In nitrates.	In nitrites.		1-10 cc. (Per cent)	1 cc. (Per cent)	1 cc. (Per cent)		
9.2	0.11	0.32	0.70	None	6,500		None	None	Very slow	No
9.2	0.042	0.35	None	0.04			"	"	Slow	"
14.9	0.098	0.56	0.58	None	4,850		"	"	"	"
20.5	0.11	0.358	1.20	0.06	5,600		"	"	"	"
16.3	0.08	0.336	0.75	0.07	10,800		10	20	16 hours	"
4.3	0.154	0.514	0.40	0.04	3,250		20	10	Very slow	"
12.8	0.106	0.478	0.40	0.05	16,500		20	10	12 hours	"
14.9	0.102	0.418	0.24	0.04	2,700,000		5	10	Rapid	"
12.4	0.30	0.478	0.46	0.10	900		None	None	Slow	"
17.0	0.19	0.316	Trace.	0.05	211,400	70	90		24 hours.	"
19.9	0.24	0.328	0.60	0.05	625	10	15		Slow	"
19.2	0.38	0.314	0.60	0.03	3,400	None	None		Very slow	"
10.7	0.206	0.418	0.48	0.15	350	"	90		24 hours	"
17.0	0.164	0.328	0.80	0.03	17,200	"	10		Slow	"
17.0	0.188	0.388	0.60	0.015	3,200	10	10		"	"
18.0	0.174	0.414	0.52	0.01	3,100	100	25		24 hours	Yes
12.5	0.386	0.584	1.30	0.10	18,300	10	10		Slow	No
25.0	0.628	0.372	0.48	0.04	4,200	5	60		"	Yes
33.7	0.244	0.352	1.20	0.02	810	50	10		24 hours	No
22.0	0.284	1.00	0.80	0.03	2,500	None	10		Slow	"
21.3	1.02	0.44	0.40	Trace.	48,000	80	35		Rapid	"
17.50	0.247	0.455	0.50	0.044						

The Mississippi River.

Chlorine	Ammonia.		Nitrogen.		Colonies—per cc.	Fermentation.			Coagulation of milk.	Indol produced?
	Free	Albuminoid	In nitrates.	In nitrites.		1-10 cc. (Per cent)	1 cc. (Per cent)	1 cc. (Per cent)		
2.13	0.11	0.46	None	None	10,450		None	None	24 hours	No
2.13	0.068	0.43	"	"			"	"	Slow	"
1.42	0.076	0.56	"	"	13,600		"	"	Very slow,	"
1.42	0.07	0.388	"	"	550		"	"	"	"
1.78	0.076	0.418	"	"	17,500		"	"	12 hours	"
2.13	0.13	0.558	0.15	Trace.	1,100		25	30	Slow	"
2.13	0.10	0.356	None	None	1,700		10	None	"	"
1.78	0.08	0.348	"	"	5,850,600		50	45	Rapid	
1.42	0.082	0.328	"	"	1,050	90	90		24 hours	No
1.42	0.036	0.512	0.20	0.003	1,180	5	5		Very slow	"
2.13	0.036	0.458	Trace.	None	9,210	None	10		"	"
1.06	0.09	0.476	None	0.01	6,600	"	50		24 hours	"
2.15	0.076	0.466	"	Trace.	1,200	"	90		Very slow	"
1.77	0.08	0.443	0.03	0.001						

6924 THE WITNESS: I read next table No. 22, which gives the result of analyses of water from the Kankakee river, collected at South Bend in 1899.

I read next table No. 23, which gives the results of analyses of the Fox river water collected at McHenry, in 1899.

I read next table No. 24, which gives the results of the analyses of the Desplaines River water collected at Libertyville in 1899, and in January, 1900.

I read next table No. 25, which gives the results of analyses of Sangamon river water collected at Mahomet in 1899;

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6925 TABLE XXII.—*South Bend, Indiana*—

Date.	Color.	Odor.	Sediment.	Temperature.		Solids.			Oxygen Absorption.	
				Water......	Air.........	In solution	In suspension......	Total......	Not filtered	Filtered...
1899										
*Nov. 9	Light, clear	None.........	None.........	....	... ..	472	14	486	5.44	5.44
" 19	"	Good.........	Flocculent .	......	... ..	398	6	404	4.64	3.84
†Dec 17	Yellow........... ...	"	Lumpy......	....	......	400	8	408	6.88	6.88
	Averages........	... .	....	. ...	...	423	9	432	5.65	5.38

*Bacterial sample warm.

†Much snow and rain.

TABLE XXIII.—*McHenry*—

1899										
Nov. 10	Light.	Good	Sandy.......	50°	50°	284	40	324	6.32	5.92
" 24	Light yellow crystal clear..........	"	None........	40	40	280	12	292	4.48	4.48
Dec. 7	Light, clear.........	"	"	40	42	344	......	344	4.40	4.40
	Averages.......	....	....	......	.....	303	17	320	5.06	4.98

TABLE XXIV.—*Libertyville*—

1899										
Nov. 24	Light	Good	None.........	... .		368	8	376	6.56	6.48
Dec. 19	Light, clear.........	"	"	....		448	8	456	4.96	4.86
" 28	"	"	"	....		564	26	590	5.84	5.44
1900										
Jan. 4	Light	"	Little........	... .		668	20	688	3.30	2.80
	Averages	....	....	....		512	15	527	5.18	4.88

tables 22, 23, 24 and 25 giving the analyses of waters from the sources of these rivers and being printed on the same sheet.

MR. JEFFRIES: To which complainant makes the same objection, with the additional objection that there is no evidence showing the manner of taking the samples of water from which the analyses were made, and for the further reason that all of said examinations and analyses were made of waters from the tributaries of the Illinois river, and are therefore incompetent, irrelevant and immaterial, having no bearing on the issues involved in this case.

SOURCES.

The Kankakee River.

Chlorine........	AMMONIA.		NITROGEN.		Colonies—per cc....	FERMENTATION.			Coagulation of milk.	Indol produced.....
	Free... ...	Albuminoid	In nitrates.	In nitrites.		1-10 cc.(Per cent).....	1 cc. (Per cent).....	1 cc. (Per cent).....		
1.40	0.060	0.25	1.8	Trace..	46,200	40	50	....	24 hours..........	Yes....
1.07	0.054	0.22	None..	None..	1,600	40	40	....	Rapid.....	No.....
1.06	.076	0.32	7.2	Trace..	30,400	40	50	....	Slow	Yes....
1.17	0.063	0.29	3.0	....						

The Fox River.

4.25	0.096	0.51	None..	None..	20,100	60	40	....	20 hours................	No.....
3.54	0.094	0.37	"	"	2,600	None..	None..	....	Slow..	" ....
2.80	0.25	0.384	"	"	32,000	Little.	"	....	"	" ....
3.53	0.147	0.421								

The DesPlaines River.

4.30	0.104	0.41	Trace.	None..	1,400	100	10	....	Rapid.......	No.....
1.10	0.086	0.34	0.16	0.02	9.000	15	10	....	24 hours................	" ....
1.40	0.058	0.51	Trace,	0.03	6,200	5	5	....	Slow....................	" ....
6.40	0.076	0.57	None..	0.04	3.700	None..	None..	10	24 hours...............	"
3.30	0.061	0.46	Trace.	0.02						

STREAMS

TABLE XXV.—*Mahomet*—

Date.	Color.	Odor.	Sediment.	Temperature.		Solids.			Oxygen Absorption.	
				Water......	Air.........	In solution	In suspension......	Total......	Not filtered	Filtered ...
1899										
*Nov. 1	Light	Earthy	Sandy	65°	40°	272	36	308	6.56	5.12
† " 15	"	Good	"	50	56	318	32	350	2.96	2.48
" 22	Light and slightly turbid	"	Light	62	58	308	64	372	5.12	3.28
	Averages...	....	....	......	....	299	44	343	4.88	3.62

*Bacterial sample warm.

†½ inch rain fall day before collection.

6926 THE WITNESS: I read next, table No. 26, giving the results of the analyses of the Mackinaw river water collected at Kappa in 1899.

I read next table No. 27, which gives the results of analyses of Spoon river water collected at Dahinda in 1899.

I read next table No. 28, which gives the results of analyses of the Big Vermillion river water collected at Pontiac, in 1899.

I read next table No. 29, which gives the results of the

6927

TABLE XXVI.—*Kappa*—

1899.										
*Nov. 2	Light, unclear	Good.........	Sandy..... ..	40°	44°	290	42	332	5.52	4.48
Dec. 14	Dark.	"	Brown......	34	45	332	48	380	6.56	5.44
	Averages........	....	....	......	....	311	45	356	6.04	4.96

*Sample warm.

TABLE XXVII.—*Dahinda*—

1899.										
*Nov. 9	Light	Earthy	Sandy	50°	53°	352	44	396	4.88	4.40
* " 24	Little	Good.........	Light........	......	......	372	32	404	4.24	3.92
†Dec. 9	Light, nearly clear.	"	Little.... ..	33	44	336	18	354	3.60	2.96
	Averages........	....	....	.....	......	353	31	384	4.24	3.76

*Bacterial sample warm. Not iced.

†Bacterial sample warm. Not iced. Rain beginning to fall.

SOURCES.

The Sangamon River.

Chlorine......	Ammonia.		Nitrogen.		Colonies—per cc....	Fermentation.			Coagulation of milk.	Indol produced? ....
	Free........	Albuminoid	In nitrates.	In nitrites.		1-10 cc. (Per cent)......	1 cc. (Per cent)......	1 cc. (Per cent)......		
0.90	0.22	0.47	None..	0.005	27,700	80	50	....	Slow	Yes....
2.50	0.05	0.28	"	None..	14,900	20	10	. ...	24 hours.....	No....
2.15	0.13	0.34	Trace.	. "	4,500	None..	None..	....	Slow..	" ....
1.85	0.13	0.36	....	0.002						

analyses of the West DuPage river water collected at Winfield, sometimes described as Wheaton, in 1899. Tables 26, 27, 28 and 29, giving the results of analyses of water from the stream sources; these tables 26, 27, 28 and 29 are printed on the same sheet.

MR. JEFFRIES: To the reading of which said tables the same objection is made as that in the last preceding objection.

The Mackinaw River.

1.42	0.154	0.446	None..	Trace.	14,000	60	50	....	24 hours................	Yes....
4.24	0.176	0.540	1.40	0.03	30,300	5	None..	....	Slow........	No.....
2.83	0.165	0.493	0.70	0.015						

The Spoon River.

9.58	0.130	0.29	0.56	None..	40,100	90	30	....	24 hours................	Yes....
12.80	0.090	0.35	None..	" ..	69,000	15	50	....	Rapid............	No.....
7.16	0.076	0.206	0.48	" ..	208,400	40	30	....	"	Yes....
9.82	0.098	0.282	0.52							

STREAMS

Table XXVIII.—*Pontiac*—

Date.	Color.	Odor.	Sediment.	Temperature.		Solids.			Oxygen Absorption.	
				Water.....	Air........	In solution	In suspension	Total	Not filtered	Filtered ...
1899.										
*Nov. 9	Light......	Good.........	None.........	49°	73°	318	6	324	3.52	2.88
† " 24	Dark.............	"	Sandy.	48	46	328	24	352	4.40	2.96
‡Dec. 8	Light..................	"	Little.......	40	59	388	10	398	3.68	3.12
	Averages.........	....	....	....	.. ...	345	13	358	3.86	2.98

*From river above dam and above where sewage enters stream at Pontiac.

†From intake in river for pumping station of city water works. Bacterial sample warm. Hard rain one week before collection.

‡Thin ice upon river.

Table XXIX.—*Winfield*—

1899.										
Nov. 9	Light.	Good.........	Brown.......	52°	50°	444	64	508	6.40	3.28
" 23	Light, turbid.........	"	Little........	46	40	458	20	478	3.04	2.56
Dec. 7	Light..................	"	"	40	34	550	10	560	1.68	1.44
	Averages........	... .	....	......	....	484	31	515	3.70	2.42

SOURCES.

The Big Vermillion River.

Chlorine	Ammonia.		Nitrogen.		Colonies—per cc.	Fermentation.			Coagulation of milk.	Indol produced ?
	Free	Albuminoid	In nitrates	In nitrites.		1-10 cc. (Per cent)	1 cc. (Per cent)	1 cc. (Per cent)		
2.84	0.160	0.24	None	Trace	4,900	None	25	....	Slow	No
3.54	0.102	0.22	"	None	36,000	50	10	....	Rapid	Yes
2.80	0.090	0.28	2.8	"	13,240	10	10	....	"	No
3.06	0.117	0.24	0.9	Trace						

*West DuPage River.**

2.80	0.14	0.35	None	None	28,800	None	5	....	Slow	No
1.42	0.024	0.24	"	"	2,200	"	10	....	Rapid	"
7.10	0.246	0.10	"	0.03	17,000	15	None	....	Slow	"
3.77	0.136	0.23	....	0.01						

*Stream twenty (20) feet wide; ten inches of water

6928 Q. Have you a table of averages prepared from the preceding tables of analyses which you have read into evidence?

A. I have.

Q. By whom was this table prepared?

A. This table was prepared by myself.

Q. Is that table that you have a true and correct table of averages?

A. It is.

Q. Based upon the preceding tables of analyses?

A. It is.

Q. Prepared in the same manner as the other tables that have already been read?

A. It was.

Q. Will you read the table of averages for 1899?

MR. JEFFRIES: To the reading of which complainant objects for the same reason stated in the previous objections to the reading of tables, and for the further reason that the evidence shows a variable number of samples taken at the respective places and therefore the results obtained from such samples are not comparable with the average results obtained and for the reason that said table includes analyses of water taken from the the tributaries of the Illinois river, which is immaterial, incompetent and not legal proof.

THE WITNESS: I now read table 30, which gives the 6929 averages of the results of the analyses made in 1899 of the waters of the Illinois and Michigan canal at Bridgeport, and Lockport and the Desplaines river at Lockport, of the canal at Joliet; of the Kankakee river at Wilmington; of the Illinois river at Morris; of the Illinois river at Ottawa; of the Fox river at Ottawa; of the Illinois river at LaSalle; of the Big Vermillion river at LaSalle; of the Illinois river at Henry; of the Illinois river at Peoria at the points known as the Narrows or Averyville; of the Illinois river at Peoria at the point known as Wesley, or lower Peoria; of the Illinois river at Pekin; of the Illinois river at Havana, of the Spoon river at Havana; of the Sangamon river across from Browning; of the Illinois river at Pearl; of the Illinois river at Grafton; and of the Mississippi river at Grafton.

6930 TABLE XXX.—AVERAGES, 1899.

	Total solids...	OXYGEN ABSORPTION.		Chlorine.......	Free ammonia...	Alb. ammonia.	Nitrogen in nitrates......	Nitrogen in nitrites......
		Not filtered...	Filtered					
Bridgeport, canal......	596.5	28.65	15.95	95.47	19.04	3.22	... .	0.03
Lockport, canal................	558.0	27.90	17,31	96.97	19.85	3.37	0.03	0.03
Lockport, DesPlaines......	380.0	8.05	6.96	5.98	0.229	0.159	0.045	0.009
Joliet................................	501.0	25.00	15.10	85.49	16.05	2.86	0.014	0.015
Wilmington	322.0	5.71	5.00	2.79	0.082	0.337	0.93	0.014
Morris	445.0	9.16	8.07	61.80	10.09	1.20	0.07	0.16
Ottawa, Illinois................... .	445.0	7.18	6.52	57.4	6.23	0.92	0.74	0.61
Ottawa, Fox....	349.0	7.30	5.58	3.78	0.145	0.454	0.11	0.007
LaSalle, Illinois	436.0	6.90	6.44	41.30	4.06	0.86	1.45	0.35
LaSalle, Big Vermillion............	914.0	3.00	2.95	38.35	0.296	0.199	0.61	0.102
Henry.................	451.0	7.00	6.28	43.20	3.28	0.553	1.30	0.517
Peoria, Narrows.....................	422.0	6.86	5.48	33.04	0.805	0.572	1.10	0.141
Peoria, Wesley..........	493.0	17.44	12.84	34.97	4.36	3.20	0.106	0.026
Pekin	419.0	7.81	6.41	34.76	1.30	0.828	0.71	0.273
Havana, Illinois..........	433.0	7.18	5.96	29.17	1.60	0.605	1.02	0.21
Havana, Spoon.................... .	440.0	7.84	4.94	4.17	0.302	0.496	0.27	0.04
Browning......	346.0	4.00	3.42	4.49	0.146	0.320	0.22	0.03
Pearl...................................	388.0	5.51	4.73	18.73	0.315	0.672	0.79	0.06
Grafton, Illinois.	362.0	5.61	4.65	17.50	0.247	0.455	0.50	0.044
Grafton, Mississippi..	278.0	8.52	6.82	1.77	0.080	0.443	0.03	0.001

6931 MR. TODD: From a consideration of these tables of analyses as introduced by you, and the table of averages drawn from these tables of analyses, what conclusions do you draw as to the waters of the Illinois river?

MR. JEFFRIES: Complainant objects to the question for the reason that the tables containing the analyses of water taken from the tributaries of the Illinois river are incompetent, irrelevant and immaterial and do not tend to prove any issue involved in this case. The complainant objects for the further reason that the tables show samples of water as taken at variable times, and in a variable number, so as not to be comparable with each other and any conclusions or opinions that may be drawn therefrom would be misleading and erroneous, and for the further reason that there is no evidence showing that the tables of analyses of water from the tributaries of the Illinois river were properly taken. No evidence showing the manner in which they were taken; no evidence showing that instructions were given, or if given, were carried out, in taking the same, and for the reason that the question does not call for conclusions upon propositions involved in this controversy, and doesn't state upon what the conclusions are to be drawn or based, and is therefore indefinite and misleading.

A. From a consideration of the tables presented and from
the tables of averages drawn from these individual tables,
6932 these general conclusions may be reached:

First: That the first and most general examination of this table shows a very great diminution in the organic pollution of the Illinois river and its tributaries, and the source between Bridgeport and Upper Peoria or Averyville, a diminution of the organic matter which cannot be accounted for by the dilution from the tributary waters as shown approximately by the decrease in the chlorine contents. This discrease in organic matter is explained by a consideration of several factors. We find in considering the data given for oxygen absorption or oxygen consumption in the filtered water as well as in the unfiltered water, that between Bridgeport and Peoria there is a very marked decrease, a point being reached finally where the organic matter as disclosed by the oxygen consumption test does not appreciably differ from that found in the tributaries of the Illinois as shown by the same test. I find also a very marked decrease in the amount of the product indicated by the albuminoid ammonia, a decrease from over 3 parts per million to .57 parts per million. This last amount being not a great deal different from that found in several of the tributaries of the Illinois. I find also in considering this table a very marked change in the decrease in the amount of the so-called free ammonia, the decrease here being very nearly from 20 parts per million to less
than one part per million, this decrease being in a meas-
6933 ure, an index of the extent of bacterial oxidation or puri-
fication which has taken place in this part of the stream.
We observe also in the figures showing the amount of nitrogen

present in the form of nitrates, that a very great oxidation has taken place in the Illinois river, the nitrates resulting from the bacterial oxidation of the nitrogen which has previously existed in some other form and which has gone through the stage of free ammonia. We observe also the appearance of nitrites in considerable amounts in the lower stretch of this part of the river. The nitrites indicating also the advance of oxidation. A very noticeable feature of these tables is that after upper Peoria or Averyville, or the Peoria Narrows is passed, the condition of the river as disclosed by the analyses shows a very marked organic pollution again. We find that below Peoria the amount of organic pollution as measured by the albuminoid ammonia is very nearly as great s that observer in the canal at Bridgeport. We find also in passing Peoria that the free ammonia has increased from less than one part per million to over four parts per million. We find also that the figures measuring the oxygen consumption in passing Peoria have increased in the case of the unfiltered water from over six parts per million to over
17 parts per million, and the figure indicating the oxygen
6934 consumption in the filtered water has increased approximately
from 5 and one-half parts per million to nearly 13 parts per million. This remarkable increase in the numbers given shows that at this point a very great amount of organic matter has been added to the Illinois river. From the investigations which I have myself made at different times, an explanation of this increase is given. It is a matter of personal investigation and also of common knowledge that in the city of Peoria there are great industries which discharge waste of a highly organic nature into the Illinois river and the samples of water collected at Wesley were taken from a point below the discharge of these industries These industrial wastes are mainly from distilleries and from cattle sheds in which cattle feeding on the slops of these distilleries are kept, and from glucose factories. Coming down the river from Peoria we observe again as we did in coming down from Bridgeport to Peoria, a very marked gradual decrease in organic contamination. This decrease is observed in a gradual fall in the figures indicating the oxygen consumption in the filtered and unfiltered

water and in the free ammonia and in the albuminoid ammonia, so that a change takes place in the Illiniois river below Peoria, and is due to the same general causes, as indicated by the
amount and character of the products given here, as takes
6935 place in the river above Peoria, so that finally, at the
mouth of the river at Grafton, we have reached a condition in which the factors for organic pollution are not greatly different, or essentially different from those observed in the tributaries of the Illinois river. Taken as a whole, then, these tables disclose two main sources of contamination of the Illinois river, first, the sewage from the city of Chicago which decreases very greatly before Peoria is reached, and secondly the industrial wastes from the city of Peoria which decrease greatly before the mouth of the river at Grafton is reached. A consideration of these figures shows beyond any question whatever that the main factor in the contamination of the Illinois river at its mouth is not the waste or sewage contributed from Chicago, but the industrial waste contributed from the various industries of the city of Peoria.

MR. JEFFRIES: Now we move to strike out the answer to the question for the reason that the conclusions reached by the witness and contained in his answer are misleading, incorrect and not applicable to the conditions that exist in the Illinois river and that have existed since the opening of the Chicago drainage canal. We move to strike out the answer for the further reason that on account of the discharge of the Chicago
sewage into the drainage canal, mixed with the polluted
6936 water from Lake Michigan, making an increased flow of
approximately 250,000 cubic feet of water a minute in the Illinois river; that the conditions of the river from source to mouth have been so changed as to make the chemical analyses from which the witness has drawn his conclusions absolutely unreliable, misleading and of no value so far as the questions involved in this case are concerned. Removing the various means and processes of chemical changes in the river from the mouth to the source, is to make the testimony unreliable, and for the further reason that the statement and opinion of the witness with reference to the deposit of products in the Illinois river at Peoria by the various industries is shown by the evi-

dence to have decreased materially since the taking of the samples from which the testimony was given and that such deposits are continually decreasing at that point, therefore rendering such opinion worthless as testimony upon the issues involved in this case, and for the reason that the witness stated that certain deposits were made from glucose factories, when the evidence shows that the only discharge from the glucose factories of Peoria and Pekin is pure distilled water, mixed perhaps with a certain slight amount of sulphuric acid shown by the evidence of the witnesses at these points, the superintenents of the factories, that it was an infinitesmal part of one-one-hundredth per cent, and for the further reason that
6937 the witness has not stated that he was acquainted with the sources of pollution or with the precise amount and character of the pollution of the waters of the Illinois river, and for the further reason that the witness stated in his answer to the question that his deductions were drawn in part from information and belief and not based upon the tables to which the question referred.

MR. TODD: I move to strike out so much of the objection as is argumentative and is based upon a misstatement of the evidence already heard in this case, as not proper in the presentation of a legal objection.

Q. From the table of analyses made by you, how does the condition of the water in the Desplaines river at Joliet compare with the condition of the water at Wesley, below Peoria, for 1899, the time that you made this investigation?

MR. JEFFRIES: I object to the question for the same reasons stated in the motion to strike out the answer of the witness to the preceding question.

A. In comparing the results of the analyses made for the canal and the Desplaines river at Joliet, and the obtained analyses of the Illinois river water at Wesley, we see that the number for the albuminoid ammonia is greater at Wesley than it is at Joliet, indicating a larger amount of protein
6938 products, decomposable in the albuminod ammonia distillations at Wesley, than is found in the Desplaines river and canal at Joliet. We have also the albuminoid ammonia at Joliet, being measured by 2.88 per million, while that at Wesley

is measured by 3.2 per million. This average being drawn from individual experiments which are comparable in time and number. It is seen from comparing Joliet with Wesley, that we have at Wesley, as indicated by the oxygen consumption number, an amount of organic matter almost as great as at Joliet, in the filtered water. In the filtered water of Joliet, the oxygen consumption being 15.1 parts per million, while at Wesley it is 12.84 parts per million. In the water not filtered the oxygen consumption number is 25.9 parts per million at Joliet, and 17.44 parts per million at Peoria. As the waste of Peoria is known to be largely of a nitrogenous character, this difference in the numbers is simply and easily accounted for, the oxygen consumption number being relatively greater at Joliet, and the albuminoid ammonia numbers being relatively greater at Peoria; the albuminoid ammonia numbers measure most fairly the protein condition of contamination.

MR. JEFFRIES: I move to strike out the answer of the witness for the reason that there is no evidence to show what portion of the alleged reduction in organic matter is due
6939 to errors in sampling and the analyses.

A. (Continuing) The comparison of the water at Joliet with that at the Peoria Narrows is very instructive, the condition of the water at Joliet in every way being much worse than that at the Narrows.

MR. JEFFRIES: I move to strike out the answer for the same reasons and for the reasons stated in the objection to the next preceding question.

Q. MR. TODD: How do those two conditions manifest themselves in your analyses?

MR. JEFFRIES: The question is objected to for the same reason stated in the previous objection to the witness testifying from the tables introduced.

A. In my analyses the numbers given for oxygen consumption and for free ammonia and albuminoid ammonia, indicate at Joliet a very highly polluted condition, such as we find in the waters of marked sewage contamination, while at the Peoria Narrows the numbers given for oxygen consumption and free ammonia and albuminoid ammonia are not greatly different or essentially different from those which are found in the waters of the ordinary streams of the state of Illinois, not unreason-

ably contaminated, or not contaminated with anything more than is taken up by the passage of these waters through the soil
6940 rich in ordinary organic matters.

Q. How does the water at Peoria Narrows compare with the waters of the Fox river at Ottawa?

MR. JEFFRIES: I object to the question for the same reasons heretofore stated in objections to previous questions on this line, and for the further reason that a comparison of the waters of the Illinois river with those of its tributaries is immaterial so far as the issues in this case are concerned.

A. The water of the Fox river at Ottawa contains as indicated by the oxygen consumption test, practically as much organic matter as that contained in the Illinois river water at the Narrows, the average result showing a greater oxygen consumption for the filtered water of the Fox at Ottawa than for the filtered water of the Illinois at the Narrows. While the oxygen consumption results for the unfiltered water at Ottawa are slightly greater than for the unfiltered water at the Narrows, the free ammonia figure of the Fox river water at Ottawa is very much less than the free ammonia figure for the Illinois river water at Peoria, the free ammonia at this place, the Narrows, not yet having undergone complete oxidation. In the case of the albuminoid ammonia figures, the amount in the Fox river at Ottawa is almost as great as that of the Illinois river or canal, both figures being in the proportion that
6941 we find in the ordinary streams of the State of Illinois, flowing through soil containing a large amount of organic matter.

Q. How does the condition of the water at La Salle, Illinois, compare with the condition of the water at Pekin, Illinois?

MR. JEFFRIES: To which question the same objection is made as was made to the questions heretofore put, of the same nature.

A. By a consideration of the figures given for the analyses of the Illinois at La Salle and at Pekin, these relations are observed: The organic matter as indicated by the albuminoid ammonia at Pekin is very much greater than the organic matter indicated by the albuminoid ammonia at La Salle; the amount of free ammonia at La Salle on the contrary is greater than the free ammonia found at Pekin.

Q. What does that indicate?

A. That indicates that the oxidation of the free ammonia at La Salle has not gone as far as the oxidation of the ammonia at Pekin. In the case of the contamination as measured by the oxygen absorption, the condition at Pekin is very similar to that at La Salle, the numbers being very nearly the same.

6942 Q. How does the condition of the water at Peoria Narrows compare with the waters of the Illinois river at Grafton?

MR. JEFFRIES: The question is objected to for the same reasons heretofore stated.

A. In comparing the waters of the Illinois river at Peoria and the Peoria Narrows, and Grafton, we find as measured by the oxygen consumption figures and by the free and albuminoid ammonia figures somewhat more organic matter indicated at Peoria than at Grafton, but not a great deal more.

Q. How does the water at the Narrows compare with the water of the Mississippi river at Grafton for this period?

MR. JEFFRIES: I object to the question for the same reasons.

A. As indicated by the oxygen consumption test, the Mississippi river water at Grafton contains more organic matter than the Illinois river water at Peoria Narrows. As indicated by the figures for free ammonia, oxidation has gone very much further in the Mississippi river at Grafton than at the Narrows at Peoria. As indicated by the albuminoid ammonia test, the organic matter in the Mississippi river at Grafton is about eighty per cent of that in the Illinois river at the Peoria Narrows.

Q. How does the water of the Illinois river at Grafton compare with the Mississippi river at Grafton?

6943 MR. JEFFRIES: I desire to make the same objection.

A. As measured by the oxygen consumption test, the Mississippi river water at Grafton contains more organic matter than the Illinois river water at Grafton. As measured by the albuminoid ammonia, the Illinois river at Grafton resembles very closely the Mississippi river water at Grafton.

Q. How about the other determinations?

MR. JEFFRIES: I object to the question for the reasons heretofore stated.

A. The other determinations show that in the Illinois river water at Grafton we have evidence of a large amount of nitrogenous matter which has undergone oxidation. Nitrites for example at Grafton, or the Illinois river at Grafton, being nearly twenty times as great as the nitrites in the Mississippi river water at Grafton. We have also in comparing the Mississippi with the Illinois river at Grafton this fact, that of the unoxidized ammonia we have in the Illinois river about three times as much as in the Mississippi river water.

Q. From your analyses and tables, what do they indicate as to the oxidation of the sewage discharged through the Illinois and Michigan canal into the Desplaines river from the Bridgeport pumping works for that period?

6944 MR. JEFFRIES: To which question the same objection is made and for the further reason that the conditions have been so changed since these samples of water were taken in the Illinois river as to render this testimony unreliable, incompetent, immaterial and of no value.

A. From a consideration of all these tables and averages, the conclusion is a necessary one, that the organic matter discharged at Bridgeport into the canal and subsequently into the Illinois river, has undergone practically complete oxidation before the mouth of the Illinois river is reached at Grafton because at this last point we find no more organic matter than can be accounted for readily by that discharged from the tributaries and from the contamination at Peoria.

Q. Professor, have you made analyses of the Desplaines river water above Lockport?

A. I have.

Q. Are you acquainted with the Desplaines river above that point?

A. I am.

Q. Will you give the extent of your personal acquaintanceship with the river?

A. I am familiar with the Desplaines river from the point where it joins with the canal near Joliet, above Joliet, 6945 to a point many miles north of Chicago, where the river flows out from a certain swampy region. I am familiar with the towns on the river and the character of the drainage entering the river.

Q. Well, just describe the character of the drainage area, the names of the towns and whether those towns empty their sewage into the Desplaines river above Lockport.

MR. JEFFRIES: We object to the question for the same reason, that it is immaterial.

A. The Desplaines river is a sluggish stream which drains a number of suburban towns around Chicago. One of these is the town of Riverside, which is not far above the controlling works at Summit, north of Summit. The town of La Grange is also in part drained into the Desplaines, the sewage of La Grange flowing into a small stream, a small creek which in turn enters the Desplaines near Riverside. Above Riverside there are several towns located on the Desplaines, the drainage of which is taken up by that stream. Maywood is one and Norwood Park is another. The Desplaines furnishes the only outlet for drainage for these various towns, and when it becomes mixed with the canal water, it is not a potable stream and has not been in a great many years, not in twenty years.

Q. MR. TODD: At the point near where the Bear Trap Dam is located, which is at Lockport, have you made any
6946 analyses of the water there?

A. Yes, I have some figures here in this table for the Desplaines river at Lockport.

Q. Do your analyses show that that river would be a safe and potable river, or that the water of that river would be safe and potable for drinking purposes at that point?

MR. JEFFRIES: I object to the question as leading and immaterial.

A. I should not consider from these analyses that the water is a safe and potable water.

Q. MR. TODD: From your analyses and from your present knowledge of the Desplaines river above Lockport and of the towns that empty their sewage into the river, would you consider that a safe and potable river?

A. I would not.

MR. JEFFRIES: I object to the question and answer for the same reasons.

Q. MR. TODD: How large is the Desplaines river above that point?

A. The Desplaines river is extremely variable. At times of high water it carries a flood, but in dry seasons it is almost dry. It contains little more than the sewage from the towns draining into it.

ADJOURNED until 2:00 P. M. same day, Sept. 25, 1903.

6947 2:00 P. M., Friday, September 25th, 1903. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. JOHN H. LONG,

resumed the stand for further direct-examination by Mr. Todd, and testified as follows:

Q. Professor, you have testified as to the chemical results of the 1899 investigation. What does the bacterial result, such as you explained that you made this morning, disclose as to the quality and conditions of the waters of the Illinois river and its tributaries?

MR. JEFFRIES: That question is objected to for the same reason given in the objection to the conclusions of the witness in the previous questions of the same character in reference to the same tables concerning the chemical results.

A. These bacterio-chemical results agree in a general way with the chemical results, in showing the condition of extreme organic contamination at Bridgeport, Lockport and Joliet, which show gradual improvement as we go down the river un-
6948 til Peoria is reached,—upper Peoria or the Narrows, or Averyville, as it is called, where the individual results obtained by the various methods which I referred to this morning do not differ essentially from similar results obtained from the tributaries of the Illinois. But leaving Peoria Narrows and going down to Wesley, we find as indicated by these bacterio-chemical results, great and marked increases of contamination again. The number of forms of organic matter in the organized condition, or living condition at lower Peoria or Wesley as

disclosed by what is called the colony count, is certainly as great as that found at Bridgeport, while the factors indicating the fermentation of carbo-hydrates by the bacteria present, and indicating the presence of those bacteria which convert carbohydrates into acids and coagulate milk are likewise as great at Wesley as at Bridgeport, so these bacterial results then in general, agree with the chemical results in showing an enormous increase of pollution, as Peoria is past, and these chemical bacterial results show as we leave Peoria and go down the river, a gradual diminution in the organized forms until the mouth of the river is reached at Grafton, where the number of bacteria present and the behavior of the bacteria with the reagents mentioned, show a condition similar to that found in many of the tributaries of the Illinois.

6949 Q. Have you the tables of analyses compiled by you from the chemical analyses of samples of water taken from the points heretofore testified to by you in the year 1900?

A. I have.

Q. Were these tables made in the same manner as the tables for 1899?

A. They were.

Q. Do these tables appear in the official record of the State Board of Health of Illinois, published in the report of the Illinois State Board of Health in 1901?

A. They do.

Q. Were these tables prepared by you and corrected in the same manner as the tables for 1899, as heretofore testified to by you?

A. They were.

Q. Do these tables correctly state the result of your analyses as made in the manner heretofore stated in your testimony?

A. They do.

Q. Will you read all the tables which you have prepared from the analyses of 1900, stating before each table the place where the samples of water were taken to make the analyses?

MR. JEFFRIES: To the reading of which said tables
6950 complainant objects for the reason that the original tables are the best evidence.

A. I have, in 1900, two sets of tables, one embracing examinations made shortly after the drainage canal was opened in the spring of 1900, and the other taking up a later period in the same year. I read first table 32, which gives the result of one examination of water from the Bridgeport Pumping station and Illinois and Michigan Canal made March 6, 1900.

I read next, table 33, which gives the results of the analyses of water from the large or main drainage canal, the water being taken at the Western Avenue bridge, between March 13th, and April 24, 1900. The results of these two sets of analyses are printed on the same sheet, which tables are as follows:

6951 TABLE XXXII.—

Date.	Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on ignition.		Oxygen absorption.	
				Water....	Air......	In solution	In suspension	Total......	Not filtered	Filtered ...	Not filtered	Filtered ...
1900 Mar. 6	Dark.....	Bad.	Dark...	...	....	440	224	694	140	72	24.96	11.68

TABLE XXXIII.—*The Drainage Canal*—

1900 Mar. 13	Light	Unpleasant.	Little....	....	....	238	22	260	58	50	9.92	6.24
" 20	Light, clear...........	Bad..........	None..........	....	....	194	10	204	32	30	9.41	4.64
" 27	Light, turbid	"	Little	....	....	204	30	234	68	66	8.96	6.72
April 3	"	"	None...........	....	....	200	12	212	54	52	7.36	3.44
" 10	"	Not good....	Little	....	....	182	42	224	40	34	6.88	4.32
" 17	Light.	Bad.	"	....	....	194	20	214	52	46	5.92	4.64
" 24	Light, nearly clear..	"	None...........	....	....	176	28	204	28	28	6.24	3.36
	Averages	... .	....	....	....	198	23	221	47	43	7.82	4.77

6952 THE WITNESS: I read the next table, No. 34, which gives the results of the analyses of the Illinois river water taken at Morris, in the spring of 1900.

I read the next table No. 35, which gives the results of analyses of the Illinois river water taken below Peoria at Wes-

Bridgeport Pumping Station.

Chlorine	Ammonia.		Nitrogen.		Nitrogen by Kjeldahl Process	Colonies—per cc	Fermentation.		Coagulation of milk.	Indol produced?
	Free	Albuminoid	In nitrates	In nitrites			1-10 cc	1 cc		
93.9	6.00	2.50	None..	0.03	9.10	540,000	20	30	Rapid.......	Yes...

Western Avenue Bridge.

17.8	3.46	1.46	None..	None..	5.18	490,000	20	50	Rapid..................	Yes....
10.7	3.00	0.64	0.16	0.04	3.53	483,000	15	20	"	" ....
14.2	1.00	1.70	None..	0.03	3.62	26,500	10	10	"	" ....
14.2	1.74	0.92	0.20	0.05	2.39	340,000	10	10	Very rapid............	" ....
7.1	0.96	1.16	0.20	0.16	2.07	810,000	15	80	"	" ....
8.5	0.79	0.69	0.24	0.07	1.31	609,000	10	50	"	" ....
9.2	0.88	0.80	None..	0.02	1.33	203,000	40	10	"	" . ..
11.7	1.78	1.04	0.11	0.05	2.78	....	... .	....	....	....

ley, or opposite Wesley from the river in March and April, 1900.

I read next, the table numbered 36, which gives the results of the analyses of Illinois river water collected at Havana, in March and April, 1900.

These three tables Nos. 34, 35 and 36, are printed on the same sheet and are as follows:

6953

Table XXXIV.—*Morris*—

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on ignition.		Oxygen absorption.	
					Water.....	Air.......	In solution	In suspension......	Total......	Not filtered	Filtered ...	Not filtered	Filtered ...
1900.													
Mar.	7	Light, turbid........	Sour!.........	Little.......	32°	37°	302	8	310	58	42	5.76	3.52
* "	14	Clay	Little........	Heavy clay.	34	36	128	354	482	54	32	14.40	6.40
† "	21	Light	Bad	Light	32	36	208	64	272	40	26	9.60	6.16
‡ "	28	Dark..................	Little........	Fine black..	32	34	194	36	230	48	42	9.76	7.76
Apr.	4	Light	Bad	Sandy.......	42	58	220	48	268	58	48	9.44	6.88
"	11	Dark...	Little........	Dark fine...	40	35	242	22	264	54	52	9.28	6.56
"	18	Light	Faint.........	Granular ...	51	54	304	36	340	82	76	9.44	6.24
"	25	"	Bad	Little	52	64	252	24	276	36	36	6.40	5.04
		Averages	....	....	....	....	231	74	305	54	45	9.26	6.07

*Snow melting and river very high.

†River high.

‡River high.

Table XXXV.—*Peoria*—

Date.		Color.	Odor.	Sediment.	Water	Air	In solution	In suspension	Total	Not filtered	Filtered	Not filtered	Filtered
1900.													
Mar.	7	Light	Bad	None........	32°	42°	252	28	280	60	40	8.16	4.96
§ "	14	Clay	Not good....	Heavy clay.	35	39	190	304	494	70	48	12.32	5.44
‖ "	21	"	Bad	"	34	44	152	144	296	62	46	15.04	8.32
"	28	Dark........... . ..	"	Flocculent..	33	35	230	98	328	62	60	20.80	14.72
Apr.	5	"	"	Sandy.......	36	60	240	78	318	79	68	12.80	7.68
"	11	Light	Little.......	"	38	36	218	54	272	52	50	9.92	6.40
"	18	Dark..................	Very bad...	Flocculent..	44	64	282	26	308	86	62	19.52	15.04
¶ "	25	"	" ...	He'vy green	58	64	392	50	442	162	114	34.88	29.28
		Averages	....	....	....	....	244	98	342	82	61	16.93	11.48

§River very high.

‖Water muddy from creek emptying above.

¶Kjeldahl determination gave 18.1 Mgm. of organic nitrogen per liter.

Table XXXVI.—*Havana*—

Date.		Color.	Odor.	Sediment.	Water	Air	In solution	In suspension	Total	Not filtered	Filtered	Not filtered	Filtered
1900.													
Mar.	5	Dark............	Bad	Dark........	34°	26°	242	42	284	64	64	9.44	7.60
* "	12	Clay.	Good........	Clay.........	34	38	222	138	360	54	50	8.96	5.52
† "	19	"	"	"	34	48	244	90	334	38	28	10.88	7.68
"	26	"	Little........	"	36	38	164	68	232	46	28	8.00	5.20
April	2	Light	Good........	"	40	46	182	14	196	30	28	7.68	5.92
"	9	Sandy	Little........	Sandy.......	42	45	206	26	232	44	36	7.68	6.24
"	16	Yellow	"	"	46	60	214	26	240	52	36	7.84	6.88
"	23	Light	Good........	Little	56	65	238	26	264	32	30	6.24	6.08
"	30	....	....	....	60	70	248	24	272	64	60	....	......
		Averages........	....	....	....	....	218	50	268	47	40	8.31	6.39

*Heavy snow melting river high.

†River very high.

The Illinois River.

Chloride..........	AMMONIA.		NITROGEN.		Colonies—per cc....	FERMENTATION.		Coagulation of milk.	Indol produced?....
	Free........	Albuminoid	In nitrates	In nitrites		1-10cc. (Per cent).....	1 cc. (Per cent)		
21.3	3.30	0.70	0.16	0.02	288,000	15	35	Very rapid.........	Yes....
3.6	1.20	0.96	0.44	Trace..	244,900	50	30	"	" ....
9.2	3.50	6.80	1.00	0.03	3,820,000	10	100	"	" ....
6.4	1.54	0.70	0.72	0.04	147,000	15	35	"	" ....
9.2	1.44	0.65	0.16	0.34	204,000	30	50	"	" ....
10.0	1.35	0.55	[illegible]	0.02	124,000	45	100	"	" ....
23.4	2.85	0.55	0.72	0.02	76,000	15	50	"	" ....
15.6	1.85	0.65	0.40	0.03	54,000	60	60	"	" ....
12.3	2.13	0.69	0.57	0.06					

The Illinois River. (below Wesley.)

12.1	1.80	1.20	[illegible]	0.02	360,000	25	20	Very rapid......	No.....
6.4	[illegible]	0.80	[illegible]	Trace .	162,000	15	25	"	Yes....
5.7	4.24	[illegible]	None..	0.40	312,000	40	15	"	" ....
9.2	2.06	5.40	" ..	[illegible]	42,000	10	25	"	" ....
8.5	3.54	1.66	" ..	Trace .	2,752,000	40	45	"	" ....
5.7	[illegible]	[illegible]	2.0	[illegible]	9,600	35	60	"	" ....
11.4	3.82	3.00	None..	None..	141,500	10	20	"	" ....
14.2	7.30	4.10	" ..	" ..	589,000	20	50	"	" ....
9.1	3.06	2.21	0.37	[illegible]					

The Illinois River.

7.8	1.18	0.55	0.60	0.04	1,300,000	15	15	24 hours........	Yes....
4.3	1.00	0.43	0.88	None..	673,000	20	20	"	No.....
3.2	1.75	0.53	1.00	0.02	321,600	40	30	"	Yes....
2.8	0.75	0.48	0.72	Trace..	147,600	None..	20	"	No.....
4.3	0.88	0.41	0.08	0.25	16,200	" ..	5	Very rapid....	" ....
5.0	0.74	0.43	1.20	0.02	44,400	" ..	10	24 hours......	Yes....
5.0	0.66	0.43	2.24	0.04	870,000	" ..	None..	18 "	No.....
7.8	0.45	0.49	1.60	0.06	198,000	30	5	Rapid......	Yes....
7.1	0.28	0.63	1.68	0.02	4,300	20	25	24 hours.	No.....
5.2	0.86	0.55	1.11	0.05					

6954 THE WITNESS: I read next table 37, which gives the results of analyses of the Spoon river water, taken near Havana, in March and April of 1900.

I read next, table 38, which gives the results of analyses of the Illinois river water taken at Pearl, in March and April, 1900.

6955 TABLE XXXVII.—*Havana*—

Date.	Color.	Odor.	Sediment.	TEMPERATURE.		SOLIDS.			LOSS ON IGNITION.		OXYGEN ABSORPTION.	
				Water....	Air........	In solution	In suspension	Total......	Not filtered	Filtered...	Not filtered	Filtered ...
1900 Mar. 5	Yellow...............	Peculiar	Sandy.......	34°	26°	248	36	284	50	46	7.36	6.96
* " 12	Dark..................	Earthy......	Very heavy clay.......	34	38	102	1338	1440	112	20	30.08	4.80
" 19	Yellow..................	Good........	Sandy.......	34	48	214	54	268	40	30	7.36	4.56
" 26	Clay.	Little.......	Dark.........	36	38	208	30	238	45	32	9.12	5.52
April 2	Dark...........	Earthy.....	Very heavy	40	46	176	1898	2074	178	28	50.88	5.28
" 9	"	"	Sandy.......	42	45	222	40	262	48	38	7.04	4.48
" 23	Light..................	Little......	Little.	56	65	296	30	326	26	26	4.80	4.32
	Averages.........	....	....	.....	.....	210	489	699	71	31	16.66	5.13

*Heavy snow melting; river high.

I read next table 39, which gives the results of analyses of the Illinois river water taken at Grafton in February, March and April, 1900.

The three tables, 37, 38 and 39 are printed on one sheet and are as follows:

The Spoon River.

Chlorine	AMMONIA.		NITROGEN.		Colonies—per cc.	FERMENTATION.		Coagulation of milk.	Indol produced?
	Free	Albuminoid	In nitrates	In nitrites		1-10 cc. (Per cent)	1 cc. (Per cent)		
4.3	0.75	0.43	0.80	0.08	386,400	10	5	24 hours	No
2.1	0.60	1.60	None	0.05	264,000	10	10	"	"
2.8	2.23	0.48	0.80	0.02	198,000	10	65	"	"
2.8	0.60	0.45	0.80	0.05	118,800	None	None	"	"
6.4	0.78	2.45	0.16	0.30	180,000	10	10	Very rapid	Yes
8.5	0.25	0.39	1.52	0.04	31,000	None	30	"	"
4.3	0.14	0.26	1.76	0.03	6,200	50	60	Slow	No
4.5	0.76	0.87	0.83	0.07					

TABLE XXXVIII.—*Pearl*—

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on Ignition.		Oxygen Absorption.	
					Water.....	Air........	In solution	In suspension....	Total	Not filtered	Filtered...	Not filtered	Filtered...
1900													
*Mar.	7	Clay..................	Good.... ...	Clay.........	58°	34°	200	568	768	58	44	11.84	5.12
† "	13	"	"	Very heavy	44	54	176	876	1052	66	40	15.36	4.56
"	20	Light	"	Sandy	36	32	194	254	448	48	36	11.36	5.12
"	27	Yellow	"	"	46	56	190	86	276	48	44	8.80	4.32
Apr.	3	Light..	Earthy......	Little........	45	65	184	66	250	58	32	7.84	4.96
"	10	"	Good.........	Sandy	32	44	190	110	300	52	30	6.08	5.60
"	17	"	None.........	"	53	62	212	60	272	44	39	7.84	5.76
"	24	"	Good.........	"	60	72	224	74	298	48	44	5.12	4.96
		Averages.........	....	....	....	....	190	262	456	53	39	9.28	5.05

*River high; heavy snow melting.

†River very high.

TABLE XXXIX.—*Grafton*—

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on Ignition.		Oxygen Absorption.	
					Water.....	Air........	In solution	In suspension....	Total	Not filtered	Filtered...	Not filtered	Filtered...
1900													
Feb.	15	Yellow	Good........	Clay.........	32°	36°	204	824	1028	....	....	10.24	4.88
"	19	"	"	Heavy	34	40	268	236	504	92	92	11.84	5.44
"	28	Dark......	"	Clay.........	30	20	220	410	630	82	64	16.00	8.32
*Mar.	7	Clay......	"	Heavy clay.	32	38	200	842	1042	74	28	13.12	5.04
"	14	"	Little	"	39	42	178	436	614	68	36	11.36	5.36
"	21	Light	Good........	Very heavy	35	40	140	704	844	76	36	13.44	4.56
"	28	Clay.................	"	Clay.........	42	56	140	338	478	46	30	9.92	5.76
Apr.	4	Dark.................	Little	Sandy	45	56	150	202	352	34	28	8.80	5.28
"	11	Light	None........	"	50	36	192	276	468	56	40	6.88	4.48
"	18	"	Good........	"	54	58	204	142	346	38	30	7.20	4.96
"	27	"	None........	"	60	76	228	66	294	46	38	6.40	5.36
		Averages	....	....	....	....	193	407	600	61	42	10.47	5.40

*River high.

The Illinois River.

Chlorine........	AMMONIA.		NITROGEN.		Nitrogen by Kjeldahl Process......	Colonies—per cc....	FERMENTATION.		Coagulation of milk.	Indol produced ?....
	Free........	Albuminoid	In nitrates	In nitrites.			1-10 cc (Per cent).....	1 cc. (Per cent).....		
4.6	0.67	0.51	1.20	0.10	....	21,000	50	30	Rapid....	Yes.,..
3.6	0.39	0.72	0.92	0.01	....	158,400	20	40	Very rapid............	No.....
2.8	0.80	0.52	1.00	0.02	....	32,450	None..	5	"	" ....
3.6	0.53	0.40	1.36	Trace .	....	8,200	15	40	24 hours..........	" ....
3.5	0.42	0.32	0.08	0.32	....	5,400	None..	50	"	" ....
6.4	0.40	0.35	1.36	0.02	....	4,600	"	15	"	" ....
5.0	0.23	0.28	1.76	0.03	....	5,800	"	25	"	" ....
5.0	0.21	0.48	1.80	0.05	....	30,000	40	50	Very rapid............	Yes..
4.3	0.46	0.45	1.18	0.07						

The Illinois River.

6.4	0.98	1.20	1.20	0.02	2.42	....	....	....	....	....
5.7	0.86	0.82	0.80	0.03	1.71	....	....	....	....	....
3.9	0.72	0.70	0.60	0.03	1.72	21,000	None..	None..	24 hours................	No.....
5.0	0.48	0.94	1.12	Trace .	1.72	22,200	25	10	Rapid.....	Yes....
4.3	0.44	0.67	1.04	"	1.35	62,000	15	25	24 hours.	No.....
3.6	0.50	0.73	1.28	0.02	2.06	106,800	10	30	Rapid..................	" ....
4.3	0.48	0.53	0.80	0.03	1.50	5,400	40	60	24 hours................	Yes....
3.5	0.49	0.40	0.04	0.20	1.06	4,700	None..	None..	Very slow.............	No.....
4.3	0.23	0.37	1.60	0.03	1.91	6,200	"	80	24 hours...............	" ....
5.0	0.18	0.40	1.36	0.03	0.80	10,400	"	30	"	" ....
6.4	0.18	0.50	1.40	0.04	1.07	18,000	40	70	"	" ....
4.8	0.50	0.66	1.02	0.04	1.58					

6956 Q. Have you the table of averages for the period covered by the tables which you have just read for work done by you in 1900, in the spring?

A. I have.

Q. Will you read the table?

MR. JEFFRIES: To the reading of which said table complainant makes the same objection as to the preceding questions.

A. I now read table 40, which gives the averages of the results of analyses made in the spring of 1900, of samples of water taken from the Illinois and Michigan canal at Bridgeport, the drainage canal at Western Avenue, and the Illinois River at Morris; from the Illinois river at Wesley; from the Illinois river at Havana; from the Spoon river at Havana; from the Illinois river at Pearl; from the Illinois river at Grafton, as follows:

6957 TABLE XL.—*Averages for Spring work*, 1900.

	Total solids...... ..	LOSS ON IGNITION.		OXYGEN ABSORPTION.		Chlorine............	Free ammonia	Alb. ammonia......	Nitrogen in nitrates	Nitrogen in nitrites	Total nitrogen Kjeldahl.........
		Not filtered	Filtered....	Not filtered	Filtered..						
Bridgeport, I. & M canal.......	664	140	72	24.96	11.68	95.9	6.00	2.50	0.0	0.03	9.10
Western av., drain. canal......	221	47	43	7.82	4.77	11.7	1.78	1.04	0.11	0.05	2.78
Morris, Illinois river............	305	54	45	9.26	6.07	12.3	2.13	0.69	0.57	0.06	......
Peoria, Wesley, Ill. river.......	342	82	61	16.93	11.48	9.1	3.06	2.21	0.37	0.06	......
Havana, Illinois river....... ..	268	47	40	8.34	6.38	5.2	0.86	0.55	1.11	0.05	......
Havana, Spoon river.............	699	71	31	16.66	5.13	4.5	0.76	0.87	0.83	0.07	......
Pearl, Illinois river.............	458	53	39	9.28	5.05	4.3	0.46	0.45	1.18	0.07	......
Grafton, Illinois river..........	600	61	42	10.47	5.40	4.8	0.50	0.66	1.02	0.04	1.58

6958 MR. TODD: From this table of averages which you have just read, and the analytical tables which have been read by you, what conclusions are you able to draw from the tables thus presented, as to the condition of the water in the Illinois river during this period, at these various points?

MR. JEFFRIES: We object to the witness giving any conclusions or drawing any conclusions from the tables so read in evidence by him for the reason that the tables are not the best evidence, and therefore any conclusions drawn therefrom would be improper and of no value, and for the further reason that there is no evidence showing what portion of the alleged reduction in organic matter is due to errors in sampling, and in analyzing and there is no evidence showing what portion of the alleged reduction is due to actual reduction, and for the further reason that the tables show that the samples were collected at variable times and places and are therefore not comparable with each other.

Q. (Question repeated).

A. From these various tables I note that the amount of organic matter at Bridgeport in the old canal and the drainage canal at Western Avenue is less than disclosed by the previous analyses given in 1899. An exact comparison is however, difficult because of the fact that in this period, in the spring of
1900, the water flowed through both canals, through the
6959 Illinois and Michigan Canal and through the drainage
canal, but not at a constant rate, so that an exact comparison of these figures is difficult. However, as we proceed down the river to Morris, where there is a complete mixing of the waters, we find for the numbers representing the free and albuminoid ammonia a lower amount than disclosed in the analyses made in 1899. When Lower Peoria or Wesley is reached, there is here a very great increase in the figures for all constituents. In the factor representing the oxygen absorption, the free ammonia and the albuminoid ammonia the increase is very marked. Following below Peoria, we observe a decrease in these factors, representing or pointing to the amount of organic matter present. We find at Pearl that the factors for oxygen consumption and for albuminoid ammonia are as low as in the 1899 examinations in general, and as low as disclosed in the waters of many of the tributaries of the Illinois. We find at Grafton, however, below Pearl, for some reason which cannot be given, a slightly larger amount of organic matter in the mean, than at Pearl, but the point of greatest importance in this table is the very marked increase of the organic matter at Peoria and at Wesley, the point below Peoria, as compared with the amount found at points above during this same examination.

Q. How does the pollution in the Illinois river at Morris
6960 compare with the pollution in the Illinois river at Wesley, immediately below Peoria?

MR. JEFFRIES: That question is objected to for the same reasons stated in the objection to the previous question, and for the further reason that the chemical analyses of the two waters cannot be correctly used showing the amount of pollution without knowing the volume of the stream at the respective points of collection.

A. A comparison between the waters at these points is a fair one because they were collected through the same months, and shows this; that at Wesley, below Peoria, the organic matter as measured by the oxygen absorption and by the albuminoid ammonia and as indicated also by the results of the bacterio-chemical examinations, is greater than that found at Morris through the same period. Any increased dilution below Morris would tend to decrease rather than increase the contamination at Peoria, making it appear even more strongly. The organic matter is larger than at Morris.

Q. How does the condition of the water at Morris compare with the condition of the water at Grafton?

A. At Grafton, the various factors given in the table show a lower condition of contamination than at Morris, in practically all cases.

6961 Q. How did the condition of the water at Morris in 1899 compare with the condition at Morris in 1900?

MR. JEFFRIES: Objected to for the same reasons stated in the last previous objection.

A. At Morris in 1900, after the opening of the drainage canal the amount of albuminoid ammonia is very much less than the amount found in 1899, before the opening of the drainage canal. The factor for oxygen consumption in 1899, is, in the filtered water somewhat greater than for the filtered water in 1900, but for the unfiltered water slightly less.

Q. What would you say as to the general condition of the water at Morris for those two periods, 1899 and 1900, based upon your analyses?

MR. JEFFRIES: To which question the same objection is interposed as to the last two preceding questions.

A. I will say that the amount of organic matter present in 1900 is less than that present in the same volume in 1899.

Q. MR. TODD: And what does that indicate?

A. That indicates simply as stated, that the amount of organic matter is less one year than the other, to make that direct comparison.

Q. What was the condition at Wesley in 1900 as compared with 1899?

6962 A. At Wesley, in 1899, in the mean, as indicated by the albuminoid ammonia there was more organic matter present than in 1900, as indicated by the oxygen consumption; also somewhat more in 1899 than in 1900. The free ammonia at Wesley in 1899 is greater than that at Wesley in 1900.

MR. JEFFRIES: I move to strike out the answer for the reasons contained in the objection to the last preceding questions.

Q. MR. TODD: Does it show more or less pollution in 1900 than in 1899?

MR. JEFFRIES: That is objected to for the same reasons.

A. It contains less pollution in 1900 than it showed in 1899.

Q. MR. TODD: What was the condition at Havana during those two periods?

MR. JEFFRIES: Objected to for the same reasons.

A. At Havana, in 1899 the amount of organic matter as measured in parts per million by the free and albuminoid ammonia, was greater than in 1900, and the oxygen consumed shows a somewhat similar condition. The oxygen consumed is a little greater in the spring of 1900 than in 1899.

Q. MR. TODD: What does that show as to the amount of pollution for those two periods?

6963 MR. JEFFRIES: Objected to for the same reasons and for the further reason that the witness does not take into consideration the increased volume of water going down the river since the canal was opened.

A. As measured by the albuminoid ammonia, in a given volume of the water, the analyses showed that there is a greater pollution in 1899 than in 1900. While, as measured by the oxygen consumption the result for 1900 appears to be slightly greater than the result for 1899.

Q. MR. TODD: What was the condition at Pearl during those two periods?

MR. JEFFRIES: Objected to for the same reasons heretofore stated, and for the further reason that the witness does not take into consideration the increased volume of water that comes down the Illinois river since the opening of the drainage canal.

A. As measured by the oxygen consumption, the organic matter in parts per million is greater in 1900 than it is in 1899, but as measured by the albuminoid ammonia present, the contamination in 1899 is greater than that in 1900.

Q. MR. TODD: How does the river at Grafton compare in 1900 with the river at Grafton in 1899?

MR. JEFFRIES: Objected to for the same reasons as heretofore stated.

6964 A. Comparing the river through the summer of 1899 at Grafton, with that at Grafton through the Spring of 1900, we find that the condition at Grafton shows more organic matter from a given volume in 1900 than it does in 1899. This comparison, however, is made between the river at the time of high floods in the second year and through the summer conditions in the first year.

Q. From the analyses in 1900, made by you of the Illinois river, and the analyses of the river made in 1899, what in your opinion as a chemist, was the difference between the river in 1900 and 1899?

MR. JEFFRIES: That is objected to for the reason that the tables giving the result of the examinations purported to have been made, and as exhibited in evidence, are not the best evidence, and therefore any conclusions or reasoning that may be drawn therefrom would be unreliable, uncertain and not trustworthy, and for the further reason that in such analyses of the water the witness has not taken into consideration the volume of the water coming down the Illinois river during the various periods of examinations and has not taken into consideration the changes that have come in the Illinois river by reason of the opening of the Chicago drainage canal, which have changed materially the chemical operations of the water in the river and the chemical processes in the water.

6965 (Question repeated).

A. From the fact that these analyses which I last gave, made in 1900, were carried out in the spring of that year, when the waters in general were high, any comparison between the river at this time,—the lower stretches of the river at this time, with the lower stretches of the river in 1899, is impossible,—any fair comparison is impossible. The Illinois river in the spring of 1900 in its lower stretches shows the condition of the ordinary western rivers at the same time, irrespective of the source of their contamination. We have here the large amounts of free and albuminoid ammonia, and high figures for oxygen consumption which are found in the ordinary tributaries of the river. A comparison in this table is important mainly as it shows the increased contamination at Peoria, or Wesley.

MR. JEFFRIES: I move to strike out that part of the answer in which the witness undertakes to compare the water of the Illinois river with that of its tributaries, and with other rivers, for the reason that he has not shown in evidence sufficient data as to the chemical character of the waters of the tributaries of the Illinois river to give an opinion thereupon or to make a comparison of the waters of the Illinois river with those of its tributaries.

6966 Q. MR. TODD: Professor, will you please state the number of samples taken at the different places mentioned in the tables for the period during the spring of 1900,—February, March and April?

A. The number of samples collected from those points were as follows:

Illinois and Michigan Canal at Bridgeport,	1,
From the main drainage canal at Western Avenue bridge,	7,
From the Illinois river at Morris,	8,
From the Illinois river at Lower Peoria, or Wesley,	8,
From the Illinois river at Havana,	9,
From the Spoon river at Havana,	7,
From the Illinois river at Pearl,	8,
From the Illinois river at Grafton,	11,

Q. Have you the tables of analyses made by you from the various places testified to by you from which water was taken in the summer of 1900?

A. I have.

Q. The analyses were made in the same way that you have testified they were made in the previous examinations of 1899 and 1900?

A. They were.

6967 Q. Were the tables prepared in the same way that you have heretofore testified?

A. They were.

Q. And published in the report of the State Board of Health of Illinois for the year 1901?

A. They were.

Q. Are these tables true and correct tables of the analytical results obtained by you from the analyses of the samples

6968 TABLE XLII.—*Bridgeport*—

Date.		Color.	Odor.	Sediment.	TEMPERATURE.		SOLIDS.			LOSS ON IGNITION.		Chlorine
					Water	Air	In solution	In suspension	Total	Not filtered	Filtered.	
1900. July	29	Light, turbid	Bad	Little			494	42	536	72	72	127.8
"	31	Dark	"	Black			440	24	464	82	72	113.6
Aug.	2	"	"	"			244	54	298	48	40	39.0
"	7	Light	"	"			336	40	376	72	52	78.1
"	10	Dark	"	"			290	22	312	64	42	49.7
"	14	"	"	"			520	72	592	90	46	177.5
*"	17	"	"	Blk, floc'l'nt			474	112	586	92	42	127.8
"	21	"	"	Brown			276	42	318	62	36	39.0
"	24	"	"	Black			544	140	684	136	74	191.7
"	29	"	Very bad	"			534	48	582	86	70	14.9
"	31	"	Bad	"			526	38	564	60	56	134.9
Sept.	4	"	Little	"			164	16	180	38	36	10.7
"	11	"	Bad	Little			234	22	256	56	44	28.4
"	18	Light, turbid	"	"			426	150	576	100	60	166.8
"	25	Dark	"	Black			244	144	388	86	68	46.1
		Averages					383	64	447	76	54	89.7

*Aug. 17. Tug passed before collection was made.

received at your laboratory in the manner as you have heretofore testified they were?

A. They are.

Q. Will you please read the tables?

MR. JEFFRIES: To the reading of which the complainant objects for the reason that the original sheets or tables upon which is recorded the result of the examinations, are the best evidence.

A. I now read table No. 42, which gives the results of examinations of the water of the Illinois and Michigan Canal at Bridgeport, collected in July, August and September, 1900, which table is as follows:

Illinois and Michigan Canal.

OXYGEN ABSORBED.		AMMONIA.		NITROGEN.		Nitrogen by Kjeldahl process......	Colonies—per cc....	FERMENTATION.		Coagulation of Milk.	Indol produced?....
Not filtered	Filtered ...	Free........	Albuminoid	In nitrates.	In nitrites.			1-10 cc. (Per cent).....	1 cc. (Per cent)......		
15.36	7.54	13.30	1.30	None..	None..	13.58	......	......	......	......	......
12.96	5.92	13.00	2.80	"	0.03	13.00	720,000	15	15	......	No...
12.78	9.60	5.50	2.20	0.00	2.00	6.83	872,000	25	20	Very rapid....	" ..
15.36	5.76	10.50	4.50	None..	0.08	10.90	438,000	15	15	"	" ..
13.12	12.48	10.00	2.20	"	0.03	10.50	310,000	·20	25	12 hours.....	" ..
20.80	8.80	21.00	3.50	"	0.10	19.90	2,460,000	20	25	Very rapid....	" ..
25.28	11.20	17.20	3.00	"	0.01	18.76	1,838,000	20	10	15 hours.......	" ..
15.68	9.76	7.50	2.00	"	None..	8.47	306,000	20	20	Very rapid....	" ..
26.88	21.12	23.50	2.00	"	"	23.29	864,000	20	25	"	" ..
19.20	8.96	22.80	2.50	"	0.20	20.80	1,518,000	15	25	" ...	Yes ..
15.04	10.24	25.50	3.80	"	None..	23.90	632,000	15	None..	" ...	" ..
4.64	4.00	2.50	1.30	1.00	0.08	3.37	330,000	30	40	Rapid..........	No...
7.52	4.00	5.80	1.60	0.36	0.16	6.75	1,344,000	20	30	"	" ..
17.60	8.00	35.50	3.00	None..	Trace..	....	780,000	10	5	"	" ..
22.40	9.28	......	.....	"	None..	....	Liquifi'd	15	10	"	" ..
16.31	9.11	15.26	2.55	0.13	0.17	13.85					

6969 THE WITNESS: I read next, table 43, which gives the results of the analyses of water from the main drainage canal collected at the Western Avenue bridge in June, July, August and September, 1900.

6970

TABLE XLIII.—

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on Ignition.		Chlorine
					Water	Air	In solution	In suspension	Total	Not filtered	Filtered	
1900.												
June	5	Light	Bad	Little	....	....	168	46	214	30	26	7.1
"	12	Dark	"	"	....	....	194	26	220	34	26	16.3
"	19	Light	"	"	....	....	162	18	180	42	42	7.1
"	26	Light, turbid	"	"	....	....	160	30	190	48	38	7.8
July	3	Light, nearly clear	"	None	....	....	212	10	222	68	68	13.5
"	10	Light	"	Little	....	....	186	28	214	38	36	9.2
"	17	Light, turbid	"	"	....	....	168	14	182	36	36	8.5
* "	24	"	"	"	....	....	200	18	218	34	32	9.2
"	31	"	"	"	....	....	164	28	192	58	48	9.9
Aug.	7	Light	"	"	....	....	168	28	196	52	34	8.5
"	14	Dark	"	Black	....	....	186	34	220	40	40	6.4
"	21	"	"	"	....	....	194	22	216	48	32	11.4
"	29	Dark turbid	"	"	....	....	180	36	216	52	38	8.5
Sept.	4	Dark	Little	Dark	....	....	150	10	160	38	34	5.7
		Averages			....	....	178	25	203	44	38	9.2

*July 24. Rain at time of collection.

TABLE XLIV.—*Lockport*—

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on Ignition.		Chlorine
					Water	Air	In solution	In suspension	Total	Not filtered	Filtered	
1900.												
June	4	Light, slightly turbid	Bad	None	62°	78°	186	12	198	28	26	11.4
"	11	Light, clear	"	Little	50	71	212	12	224	38	36	13.5
July	2	Light, nearly clear	"	None	69	90	200	40	240	64	36	10.6
"	9	Light	"	Granular	....	....	246	26	272	56	46	22.7
"	23	Light, nearly clear	"	None	....	86	164	8	172	28	22	8.5
"	30	Light	"	"	....	84	182	16	198	52	46	10.6
Aug.	6	"	"	Very fine	....	90	182	14	196	38	34	11.4
* "	13	"	"	None.	....	92	166	18	184	28	22	11.4
"	20	Dark	"	Granular	72	90	192	58	250	52	30	16.3
"	27	Light	"	Flocculent	76	90	218	12	230	46	40	17.0
Sept.	4	Light, turbid	Little	None	74	90	170	....	170	36	36	5.7
		Averages			....	....	193	19	212	42	34	12.6

*Aug. 13. Arrived late and was not iced.

I read next the result of analyses of water collected from the drainage canal at Lockport, in June, July, August and September, 1900; tables 43 and 44 being printed on the same sheet and which are as follows:

Western Avenue Bridge—Drainage Canal.

OXYGEN ABSORBED.		AMMONIA.		NITROGEN.		Nitrogen by Kjeldahl process......	Colonies—per cc....	FERMENTATION.		Coagulation of Milk.	Indol produced?....
Not filtered	Filtered...	Free.......	Albuminoid	In nitrates.	In nitrites.			1-10 cc. (Per cent......	1 cc. (Per cent)....		
5.60	4.88	1.38	0.70	None..	0.03	2.45	162,000	....	50	....	Yes...
9.92	5.44	1.50	1.50	None..	0.01	2.55	310,000	20	30	Very rapid....	" ..
4.96	4.08	1.15	0.68	0.12	0.01	2.27	1,656,000	None..	None..	" ...	No.....
5.60	4.72	0.96	0.70	None..	0.02	2.43	Liqu'fied	10	25	Rapid...	" ..
6.48	5.60	1.00	0.90	0.40	0.20	2.80	890,000	15	15	20 hours.......	" ..
8.00	4.00	1.57	0.69	None..	0.32	2.61	170,000	10	10	12 hours.......	" ..
7.20	4.32	1.04	0.90	None..	0.04	2.66	300,000	5	40	Very rapid....	Yes....
5.68	5.20	3.10	1.42	None..	0.02	4.19	326,000	10	10	"	" ..
5.76	3.92	1.00	0.82	None..	0.08	1.72	Liqu'fied	15	15	"	No.....
5.12	4.32	1.00	1.02	0.00	0.03	2.14	"	40	5	"	" ..
6.08	3.20	1.40	1.10	None..	0.04	2.47	960,000	20	20	Rapid..........	" ..
7.52	4.88	1.82	0.94	None..	0.64	3.14	462,000	10	10	Very rapid....	" ..
5.52	4.16	1.00	1.20	0.12	0.04	2.80	1,140,000	10	10	15 hours.......	" ..
4.48	3.20	0.80	0.80	0.52	0.04	1.81	480,000	30	30	24 hours.......	Yes....
6.28	4.42	1.31	0.95	0.12	0.11	2.58					

Drainage Canal.

OXYGEN ABSORBED.		AMMONIA.		NITROGEN.		Colonies—per cc...	FERMENTATION.		Coagulation of Milk.	Indol produced?....
Not filtered	Filtered...	Free.......	Albuminoid	In nitrates.	In nitrites.		1-10 cc. (Per cent)	1 cc. (Per cent)		
4.96	4.08	1.65	0.57	None..	Trace..	165,000	None..	50	12 hours..............	Yes....
4.88	4.32	2.40	0.74	" ..	0.01	653,000	30	50	Very rapid	" ....
4.56	4.48	1.56	0.55	0.02	0.02	502,500	40	40	"	No.....
7.20	5.04	2.90	0.64	None..	Trace..	104,000	55	35	"	" ....
4.80	3.12	1.50	0.64	" ..	"	82,000	10	80	"	" ....
4.00	3.76	1.90	0.94	" ..	"	840,000	35	40	Rapid..............	Yes....
4.56	3.92	2.20	1.30	" ..	0.04	1,880,000	25	45	Very rapid	" ....
4.24	3.36	2.24	0.34	" ..	None..	... .	....	....	....	....
8.00	5.00	2.16	1.10	" ..	0.40	660,000	30	50	Rapid.....	No.....
6.08	5.44	3.56	0.90	" ..	0.20	720,000	20	20	"	" ....
4.96	4.56	1.70	0.36	" ..	Trace..	288,000	50	40	"	" ....
5.20	4.34	2.16	0.76	....	0.06					

6971 THE WITNESS: I read next, table 45, which gives the results of analyses of waters collected at Joliet, these waters being a mixture of the canal and Desplaines river waters—

MR. JEFFRIES: Which canal?

A. Both canals.

6972

TABLE XLV.—

Date.	Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on ignition.		Chlorine........
				Water......	Air........	In solution	In suspension.......	Total.	Not filtered	Filtered ...	
1900.											
June 4	Yellow	Bad..........	Light........	60°	72°	224	16	240	52	52	24.8
" 11	"	"	Little	70	70	276	32	308	60	56	32.7
" 18	"	Faintly disagreeable.	Flocculent..	72	76	264	40	304	80	68	36.3
" 25	Dark yellow..........	Not good....	Rusty.......	72	80	264	58	322	74	48	35.5
July 2	Light............	Bad..........	Yellow	74	86	208	18	226	58	52	17.0
" 9	"	Not good....	Granular ...	74	80	282	38	320	58	40	43.3
" 16	"	"	" ...	76	84	232	24	256	52	44	29.8
" 23	"	Bad	Yellow	78	86	232	58	290	50	38	31.2
" 30	Yellow	"	Granular ...	76	84	262	30	292	52	46	35.[illegible]
Aug. 6	Light.................	"	Flocculent..	78	90	244	42	286	38	20	29.[illegible]
" 13	"	"	" ..	72	86	236	48	284	48	34	30.5
" 20	Yellow	"	Granular ...	78	90	256	34	290	46	40	39.0
" 27	Dark	"	Flocculent..	76	80	258	54	312	64	38	34.0
Sept. 3	Yellow	Little	Yellow......	76	80	232	14	246	42	40	27.0
Oct. 1	Dark	Bad	Dark	64	68	208	20	228	40	40	24.1
	Averages..........	....	....			245	35	280	54	44	31.4

TABLE XLVI.—*Morris*—

1900.											
June 4	Light..................	Bad	Dark, flocculent........	60°	70°	220	44	264	40	38	14.9
" 11	"	"	Dark, flocculent........	65	86	292	10	302	68	64	24.1
" 18	"	"	Flocculent..	55	70	224	32	256	34	24	17.0
" 25	"	Not good....	Little........	71	80	208	14	222	40	36	16.3
July 2	"	Bad	"	64	84	226	12	238	44	42	22.7
" 9	"	"	Flocculent..	65	78	220	24	244	64	60	22.7
" 16	Light, turbid.........	Faintly disagreeable.	Very little..	70	85	210	14	224	48	46	20.6
" 23	Light...........	Bad	Very fine....	72	90	218	18	236	36	36	17.8
" 30	"	Not good....	Flocculent..	70	90	216	42	258	56	40	17.7
Aug. 6	"	"	Sandy	80	92	198	30	228	20	18	15.6
*" 13	Yellow	Bad	Dark, sandy	72	75	[illegible]	14	224	36	34	21.3
" 20	Light..................	Earthy	Fine.........	80	85	238	[illegible]	258	46	34	10.7
" 27	Dark	Bad	Gray	78	98	242	28	270	54	46	17.0
Sept. 4	Light....	"	Little..	76	74	208	52	260	40	38	14 2
Oct. 3	Dark	"	Yellow......	60	65	192	84	276	34	28	14.9
	Averages..........	....	....	....	....	222	29	251	44	39	17.8

*Heavy winds.

The samples were collected in June, July, August, September and October, 1900.

I read now, table 46, which gives the results of analyses of water of the Illinois river collected at Morris in June, July, August, September and October, 1900; tables 45 and 46 being printed on one sheet, and are as follows:

Joliet.

OXYGEN ABSORBED.		AMMONIA,		NITROGEN.		Colonies—per cc....	FERMENTATION.		Coagulation of milk.	Indol produced?....
Not filtered	Filtered ...	Free	Albuminoid	In nitrates.	In nitrites.		1-10 cc......	1 cc.		
6.24	5.20	4.47	0.71	None..	0.01	264,000	50	50	....	Yes....
6.72	4.64	5.46	0.94	" ..	0.03	248,000	80	30	Very rapid............	" ....
5.52	3.52	6.40	0.80	" ..	0.03	35,000	None..	30	Rapid...........	" ....
8.96	3.36	7.10	0.92	" ..	0.04	Liquifi'd	" ..	None..	Very rapid..	No.....
6.64	3.84	3.06	1.18	0.28	0.08	650,000	25	30	Rapid.................	" ....
6.64	4.88	5.20	0.94	None..	0.04	173,000	10	10	Very rapid............	" ....
7.84	3.92	3.80	0.56	" ..	0.04	37,000	80	50	Rapid.................	Yes....
8.00	4.00	4.20	1.16	" ..	0.03	4,500	15	25	"	No.....
7.20	5.92	5.30	0.44	" ..	0.04	125,000	10	20	Very rapid............	" ....
5.84	4.80	4.20	1.00	" ..	0.40	845,000	20	10	"	" ....
6.80	4.08	3.98	0.90	" ..	0.06	616,000	25	50	12 hours..............	Yes....
6.40	4.80	4.60	0.41	" ..	0.32	152,000	60	40	Very rapid.	" ....
7.36	5.44	4.80	1.40	Trace.	0.04	488,000	10	25	15 hours......	No.....
5.92	4.96	3.40	0.70	None..	0.08	896,000	20	10	24 hours..............	" ....
8.48	4.40	4.00	0.66	" ..	0.08	Liquifi'd	30	30	16 hours..............	" ....
6.97	4.62	4.66	0.85	0.02	0.09					

The Illinois River.

8.80	5.76	1.70	0.49	0.40	0.50	18,000	10	25	24 hours..............	No.....
7.36	5.12	3.25	0.65	0,28	0.20	217,600	50	60	14 "	Yes....
5.44	3.92	2.93	0.50	0.16	0.16	45,200	None..	None..	Very rapid............	No.....
5.60	3.60	4.20	0.86	None..	0.20	Liquef'd	" ..	" ..	24 hours..............	" ....
6.72	4.32	2.25	0.45	0.32	0.32	19,400	20	20	Slow...........	" ....
4.64	3.60	3.45	0.37	None..	0.24	41,000	50	25	Very rapid........ ...	Yes....
4.80	4.48	2.76	0.70	" ..	0.20	2,000	30	90	"	No.....
6.00	4.56	1.70	1.10	0.20	0.14	2,000	50	35	24 hours..............	Yes....
6.48	4.24	3.10	0.70	0.20	0.16	17,500	35	40	Rapid	No.....
5.76	4.40	2.80	0.80	0.12	0.80	11,000	15	25	24 hours..............	" ....
6.64	4.48	2.40	0.46	None..	0.32	27,000	50	40	15 "	Yes....
6.00	5.52	1.50	0.60	" ..	0.48	18,500	None..	30	Slow..................	No.....
7.20	4.40	4.40	0.60	Trace.	0.20	19,500	60	90	Rapid.................	" ....
7.76	5.92	2.70	0.70	0.80	0.16	550,000	10	40	24 hours..............	" ....
6.80	5.60	3.40	0.50	None..	Trace.	Liquef'd	10	None..	"	" ....
6.40	4.06	2.84	0.63	0.17	0.27					

6973 THE WITNESS: I read next, table 47, which gives the results of the analyses of waters of the Illinois river collected at Ottawa in June, July, August, September and October, 1900.

I read next table 48, which gives the results of analyses of

6974 TABLE XLVII.—*Ottawa*—

Date*	Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on Ignition.		Chlorine..........
				Water.....	Air........	In solution	In suspension......	Total.	Not filtered	Filtered...	
1900											
June 4	Dark....................	Bad..........	Dark	72°	84°	236	86	322	48	48	11.4
" 11	Yellow..................	Earthy......	Little........	76	82	332	16	348	102	96	17.8
" 18	Light....	"	"	72	77	264	40	304	42	32	17.7
" 26	"	Good........	"	78	90	274	42	316	96	74	22.0
July 2	"	Earthy......	"	78	92	236	8	244	52	44	16.3
" 9	"	Good........	Fine..........	75	80	226	14	240	54	50	19.2
" 17	"	Earthy......	None.........	76	75	208	6	214	28	26	15.6
" 23	"	"	Little........	78	90	218	4	222	36	34	17.8
" 30	Dark, turbid.........	Little........	Fine, dark..	76	84	240	80	320	54	52	15.6
Aug. 6	Slightly yellow.......	Faintly disagreeable.	Sandy	96	80	222	10	232	32	32	14.9
* " 13	Light..................	Faintly disagreeable.	Fine	78	90	218	22	240	42	32	18.5
" 20	Yellow............... ..	Good.........	Sandy.	80	94	222	30	252	40	24	17.0
† " 27	Dark	Not good....	Fine	78	85	246	42	288	48	48	23.4
Sept. 4	Light..................	Faint	Little........	76	85	224	24	248	52	48	14.2
Oct. 16	"	Good	Very little..	62	56	206	2	208	28	26	16.3
	Averages..........	....	....	....	....	238	28	266	50	44	17.2

*Aug. 13, heavy rains.

†Aug. 27, river high and muddy.

TABLE XLVIII.—Ottawa –

1900											
July 30	Light..................	Good	Little..	76°	84°	288	12	300	78	78	6.4
Aug. 6	Very light...........	None........	Very fine...	96	80	298	22	320	62	62	3.5
‡ " 13	Light yellow.........	Earthy......	Fine, sandy	78	90	290	26	316	88	78	5.0
	Averages..........	....	....	....	....	292	20	312	79	72	4.9

‡Aug. 13, heavy rains.

waters of the Fox River collected in June, July, and August, 1900.

I read next, table 49, which gives the results of analyses of waters of the Illinois river collected at La Salle, in June, July, August, September and October, 1900; tables 47, 48 and 49, being printed on one sheet and which are as follows:

The Illinois River.

OXYGEN ABSORBED.		AMMONIA.		NITROGEN.		Nitrogen by Kjeldahl process......	Colonies—per cc....	FERMENTATION.		Coagulation of milk.	Indol produced ?....
Not filtered	Filtered...	Free......	Albuminoid	In nitrates	In nitrites.			1-10 cc.....	1 cc.........		
11.04	5.36	1.63	0.65	1.60	0.25	....	6,500	20	None..	20 hours........	Yes....
6.64	6.00	0.60	0.58	1.60	0.28	....	18,800	15	90	14 hours.......	No....
5.28	4.40	1.58	0.42	0.48	0.20	....	127,200	None..	None..	24 hours........	" ....
5.60	5.44	1.30	0.41	1.20	0.44	....	28,000	10	40	Rapid...........	" ....
4.88	4.56	0.40	0.34	1.40	0.32	....	33,500	None..	50	Very slow....	" ....
5.04	4.16	1.02	0.27	0.88	0.80	....	3,000	70	20	12 hours........	" ....
5.04	4.16	0.30	0.28	0.40	0.32	....	5,500	10	10	24 hours.. ...	" ....
5.36	4.56	0.35	0.34	0.88	0.20	....	2,500	30	25	Slow............	" ....
7.20	6.08	0.90	0.65	1.20	0.40	....	25,000	26	60	24 hours........	" ....
6.48	4.88	0.78	0.38	1.20	0.80	....	14,000	15	30	Very rapid....	....
4.88	4.08	1.05	0.33	Trace .	0.32	....	64,000	50	50	Rapid.....	Yes....
5.20	4.96	0.85	0.42	None..	0.64	....	19,500	....	70	24 hours........	No....
5.76	5.36	0.79	0.25	0.80	0.32	....	25,500	10	30	24 hours........	" ....
6.64	6.40	0.56	0.20	1.12	0.20	....	3,500	35	30	24 hours........	" ....
5.12	5.04	0.72	0.30	1.08	0.12	....	....	....	....	....	....
5.94	5.03	0.81	0.39	0.92	0.37						

The Fox River.

6.96	6.24	0.09	0.52	None..	None..	....	2,232,000	None..	60	Slow...........	No.....
6.32	5.84	0.15	0.52	"	0.02	1.27	36,000	5	10	Very Slow	" ....
7.04	6.88	0.10	0.47	"	0.04	1.23	6,500	70	10	24 hours	" ....
6.77	6.32	0.11	0.50	.. .. ..	0.02	1.25					

TABLE XLIX.—*LaSalle*—

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on Ignition.		Chloride............
					Water	Air........	In solution	In suspension......	Total.	Not filtered.	Filtered ...	
1900												
June	4	Light........	Little..	Sandy	76°	86°	232	54	286	40	32	10.6
* "	11	"	"	Little........	76	86	284	30	314	40	40	19.2
"	18	"	Faint	"	75	74	260	24	284	72	68	17.8
"	25	"	"	Fine	78	90	236	14	250	42	40	18.5
July	2	"	Little........	Little.........	80	80	244	16	260	36	28	17.0
"	9	"	"	Fine	80	82	232	22	254	42	36	19.9
"	17	"	Good...	Sandy.........	78	72	228	22	250	32	28	18.5
"	23	"	Little........	Little.........	79	82	218	22	240	34	34	18.5
"	30	Light, turbid.........	"	Sandy..	80	80	252	82	334	80	72	14.2
Aug.	6	Light...................	"	Granular ...	84	80	282	38	320	52	52	14.9
"	13	Light, turbid.........	Faintly disagreeable.	Fine..........	82	82	224	16	240	52	52	17.7
"	20	Yellow	Good	Little.........	82	83	236	20	256	42	40	16.3
"	27	"	"	Sandy.........	80	80	246	16	262	38	32	12.8
Sept.	3	Light..................	"	Fine..........	82	84	370	6	376	70	74	8.5
Oct.	8	"	"	Little.........	70	80	230	12	242	40	38	13.5
		Averages.........	....	....	....	....	252	26	278	48	44	15.8

*June 11 sample delayed.

6975 THE WITNESS: I read next table 50, which gives the results of analyses of waters of the Vermillion river collected at LaSalle in August and September, 1900.

6976

TABLE L.—*LaSalle*—

Aug.	20	Clay.	Earthy	Clay	84°	82°	270	82	352	76	48	5.0
"	27	Light, turbid.	Little.......	Sandy..... .	82	80	218	36	254	58	40	7.8
Sept.	3	Yellow.......	Good...... ..	Fine..........	84	84	226	18	244	56	56	15.6
		Averages.	....	....	....	....	238	45	283	63	48	9.5

The Illinois River.

OXYGEN ABSORBED.		AMMONIA.		NITROGEN.		Nitrogen by Kjeldahl process	Colonies—per cc....	FERMENTATION.		Coagulation of Milk.	Indol produced?....
Not filtered.	Filtered ...	Free..... ..	Albuminoid	In nitrates.	In nitrites.			1-10 cc.....	1 cc.........		
6.32	5.68	0.63	0.33	0.60	0.25	....	16,000	50	50	20 hours.......	Yes....
6.56	6.48	0.80	0.50	1.20	0.50	....	41,600	30	50	Rapid	" ....
5.28	4.08	1.50	0.45	0.80	0.20	....	72,900	60	None .	24 hours	No.....
5.44	4.31	1.06	0.41	0.92	0.12	....	150,000	None..	"	"	" ....
5.04	4.00	0.60	0.27	1.60	0.32	....	105,000	"	15	"	" ....
5.04	4.10	0.89	0.25	0.56	0.40	... .	3,500	30	60	12 hours.......	" ....
4.72	4.32	0.25	0.40	0.56	0.28	....	4,000	25	40	Rapid	" ....
4.96	4.08	0.14	0.48	1.00	0.20	....	2,000	70	40	"	" ....
7.44	5.20	0.78	0.45	0.80	0.24	....	2,000	35	50	"	Yes....
5.68	4.80	0.19	0.35	1.00	0.28	....	1,800	40	40	"	" ...
4.56	4.24	0.18	0.33	Trace.	0.24	.. ....	8,000	70	50	"	No.....
5.60	4.96	0.10	0.35	0.40	0.14	... .	13,200	50	30	20 hours.......	" ....
5.68	5.52	0.43	0.38	0.80	0.32	....	72,000	25	35	Rapid	" ....
4.96	4.72	0.10	0.20	0.52	0.12	....	5,500	50	40	20 hours.......	Yes....
6.72	5.84	0.64	0.32	0.56	0.12	....	... .	....	....	....	....
5.60	4.83	0.55	0.36	0.77	0.25						

I read next table 51, which gives the results of analyses of water of the Illinois river collected at Henry in June, July, August, September and October, 1900—tables 50 and 51 being printed on the same sheet, and are as follows:

The Vermillion River.

6.16	4.64	0.06	0.38	0.16	0.12	1.12	22,000	25	50	Very slow.....	No ....
5.12	4.64	0.07	0.27	0.32	0.04	1.13	25,500	25	40	20 hours.......	Yes ...
6.40	6.40	0.22	0.31	0.80	0.16	1.06	4,500	20	10	Slow	No.....
5.89	5.23	0.12	0.32	0.43	0.10	1.30					

TABLE LI.—*Henry*—

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on Ignition.		Chlorine
					Water	Air	In solution	In suspension	Total	Not filtered	Filtered	
1900.												
June	7	Light	Earthy	Little	74°	84°	[illegible]	[illegible]	[illegible]	30	30	12.8
"	14	"	Good	"	74	72	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17.0
"	19	Yellow	None	Dark	73	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14.2
"	26	Light	Little	Little	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16.3
July	3	Dark	Not good	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14.9
"	10	Light	Little	Fine	[illegible]	74	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	22.7
"	17	"	None	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	19.2
*"	24	"	Little	Little	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16.3
"	31	Yellow	Good	None	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15.6
Aug.	7	"	Little	Dark	[illegible]	[illegible]	244	16	[illegible]	[illegible]	44	14.9
† "	14	Light, turbid	Fair	Little	[illegible]	[illegible]	[illegible]	46	[illegible]	[illegible]	[illegible]	17.0
‡ "	21	Light	Good	"	[illegible]	[illegible]	[illegible]	34	[illegible]	[illegible]	50	18.5
"	28	"	"	Sandy	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	40	38	16.3
Sept.	4	Dark, turbid	"	"	[illegible]	[illegible]	[illegible]	42	[illegible]	64	30	13.5
Oct.	1	Light yellow		"	[illegible]	[illegible]	198	42	[illegible]	44	40	14.2
		Averages					248	35	283	51	44	16.9

*July 24, rain.
†August 14, rain.
‡August 21, rain.

6977 THE WITNESS: I read next table 52 which gives the results of the analyses of waters of the Illinois river collected at Peoria at the Point known as Upper Peoria, or the Narrows, or Averyville, collected in June, July, August and October, 1900—

JUDGE SPRINGER: Were none collected in September?

The Illinois River.

OXYGEN ABSORBED.		AMMONIA.		NITROGEN.		Colonies—per cc....	FERMENTATION.		Coagulation of Milk.	Indol produced?....
Not filtered	Filtered.	Free	Albuminoid	In nitrates.	In nitrites.		1-10 cc......	1 cc.........		
5.76	4.72	0.55	0.40	1.28	0.20	5,400	None..	100	Very slow....	No.....
6.56	5.28	0.22	0.43	1.60	0.24	6,000	20	40	24 hours	" ....
9.28	5.20	0.28	1.05	0.92	0.14	*73,000	None..	None..	"	" ....
5.28	4.72	0.84	0.36	1.40	0.20	13,200	" ..	10	Slow..........	" ....
5.12	4.56	0.20	0.33	1.44	0.20	7,230	60	40	Rapid	" ....
6.00	4.80	0.94	0.46	0.72	0.22	202,500	10	5	12 hours.....	" ....
5.92	4.40	0.28	0.39	0.40	0.20	500	None..	30	Slow..........	" ....
4.96	4.80	0.38	0.40	1.00	0.24	2,000	" ..	10	24 hours	" ....
6.56	5.68	0.35	0.38	0.88	0.28	Liq'f'd	70	90	"	" ....
5.52	5.36	0.13	0.43	0.88	0.20	"	30	25	15 hours......	" ....
5.92	4.08	0.30	0.20	0.60	0.24	1,000	60	50	24 hours......	Yes....
5.12	4.80	0.71	0.30	2.00	0.04	*22,000	25	50	Very slow....	No.....
5.02	5.28	0.25	0.25	0.88	0.24	6,500	40	50	24 hours	Yes....
5.76	5.12	0.15	0.30	1.12	0.22	5,000	5	15	20 hours .. .	No.....
4.56	4.08	0.56	0.27	0.80	0.20	Liq'f'd	15	20	Slow..........	" ....
5.80	4.80	0.41	0.40	1.00	0.22					

*No ice used.

A. No, none were collected in September.

I read next table 53, which gives the results of analyses of waters of the Illinois river collected at Wesley, or Lower Peoria, as it is sometimes called, in May, June, July, August, September and October, 1900,—tables 52, and 53 being printed on one sheet and being as follows:

6978 TABLE LII.—*Peoria, Narrows*—

Date.		Color.	Odor.	Sediment.	Temperature. Water.	Temperature. Air.	Solids. In solution.	Solids. In suspension.	Solids. Total.	Loss on Ignition. Not filtered	Loss on Ignition. Filtered	Chlorine
1900.												
June	7	Clear, yellow	None	Flocculent	....	....	296	46	342	36	34	9.2
"	14	Light	Faint	Fine	....	....	238	34	272	62	46	8.5
"	21	"	Good	Little.	72°	72°	306	2	308	84	82	15.6
"	28	"	"	Fine	80	88	256	22	278	56	56	15.6
July	10	"	Little.	"	78	76	232	32	264	62	22	15.6
"	17	Light, turbid	"	None	79	78	256	28	284	72	68	22.7
"	24	Light	Good	Very little.	80	78	230	20	250	30	30	17.8
"	31	"	"	None	81	96	234	8	242	24	16	18.5
Aug.	7	"	None	"	84	94	232	....	232	48	48	12.0
"	14	"	Good	Fine	81	85	238	24	262	62	50	17.0
"	21	"	"	None	84	98	216	20	236	36	36	18.5
"	28	Light, clear	"	Little	82	86	232	12	244	52	40	14.9
Oct.	9	Light	"	Sandy	66	68	212	20	232	28	18	16.3
		Averages			....	....	244	21	265	49	43	15.5

TABLE LIII.—*Peoria, Wesley*—

1900.												
May	30	Very dark	Faint	Much	70°	80°	280	490	770	94	60	8.5
June	7	Light, clear	"	Very little.	74	80	266	28	294	60	60	14.9
"	14	Dark	Bad	Little	70	84	298	56	354	96	42	17.0
"	19	Light	Good	Sandy	70	86	316	24	340	92	76	17.0
"	26	"	Faint	Little	73	84	254	50	304	66	64	14.9
July	3	Dark	Little	"	75	89	242	30	272	58	40	13.5
"	10	Light	"	Fine	80	80	250	52	302	48	44	15.6
"	17	Dark	Bad	Black	77	70	328	64	392	84	84	24.8
"	24	Yellow	Good	Fine	78	78	244	124	368	368	40	18.5
"	31	Light	Little	Granular	80	88	240	18	258	38	38	15.6
Aug.	7	Yellow	Not good	Flocculent	82	90	208	20	228	48	48	17.8
"	14	Dark	Earthy	Clay	80	78	224	384	608	48	26	15.6
"	21	"	Very bad	Fine, black.	84	90	254	50	304	78	58	9.9
"	28	Light	Not good	Fine	81	84	238	32	270	38	36	16.3
Sept.	4	Dark	"	Dark	80	74	252	102	354	74	48	15.6
Oct.	10	Dark and turbid	Bad	Flocculent	65	80	318	26	344	88	74	23.7
		*Averages			....	....	262	71	333	65	52	16.6

*Excluding May 30.

6979 THE WITNESS: I now read table 54, which gives the results of the analyses of the waters of the Illinois river collected at Pekin in May, June, July, August and September, 1900.

I read next table 55, which gives the results of the analyses

The Illinois River.

OXYGEN ABSORBED.		AMMONIA.		NITROGEN.		Colonies—per cc....	FERMENTATION.		Coagulation of milk.	Indol produced?....
Not filtered	Filtered....	Free........	Albuminoid	In nitrates.	In nitrites.		1 cc. (Per cent)......	1-10cc. (Per cent)......		
5.44	5.44	0.35	0.48	1.40	-0.10	20,000	None..	None..	Slow	No.....
5.52	4.04	0.22	0.28	1.40	0.06	72,000	" ..	90	24 hours.............. ..	" ....
5.28	4.80	0.08	0.36	1.80	0.10	....	....	....	....	....
5.52	4.48	0.56	0.38	1.00	0.16	35,000	None..	None..	Very rapid.	No.....
4.80	4.56	0.15	0.31	0.68	0 10	2,000	35	" ..	12 hours..................	" ....
4.88	4.48	0.24	0.37	0.56	0.24	90,000	10	40	Rapid..................	" ....
4.96	4.24	0.24	0.34	0.80	0.08	51,500	85	50	24 hours..................	" ....
4.24	4.24	0.14	0.28	0.96	0.08	180,000	20	10	Very slow..	" ....
4.88	4.32	0.20	0.28	0.72	0.16	7,000	None..	70	24 hours..................	" ....
4.32	3.92	0.16	0.28	0.40	0.20	2,500	5	10	Rapid..................	" ....
4.72	4.32	0.27	0.42	0.20	0.12	7,500	50	50	Very slow..............	Yes....
4.64	4.48	0.12	0.42	0.72	0.12	472,500	None..	15	24 hours................	No.....
6.56	4.96	0.08	0.30	1.08	0.10	....	....	....	....	....
5.06	4.53	0.21	0.34	0.96	0.12					

The Illinois River.

16.00	6.08	0.75	0.96	0.56	0.06	51,100	10	10	24 hours..................	Yes....
7.04	5.12	1.22	0.80	1.00	0.12	23,500	50	40	Rapid.....	" ....
16.64	9.92	3.00	3.00	None..	None..	3,180,000	None..	None..	Very rapid..............	No.....
6.64	4.88	1.00	0.54	1.08	0.12	238,000	" ..	" ..	"	" ....
5.36	4.64	1.14	0.80	1.08	0.16	230,000	25	10	"	" ....
5.20	4.56	0.38	0.76	2.00	0.20	215,000	10	10	Rapid..................	" ....
6.08	3.52	0.40	0.76	0.48	0.12	126,000	5	40	12 hours................	" ....
18.56	6.72	1.88	2.30	None..	None..	150,000	5	5	Rapid..............	" ....
6.24	4.48	0.00	0.50	0.80	0.08	32,000	None..	None..	"	" ....
6.16	4.48	0.70	0.50	0.92	0.12	420,000	20	10	Very rapid.	" ....
7.12	6.80	0.86	0.92	0.72	0.20	2,720,000	5	20	Rapid.	" ....
10.24	4.16	0.46	0.60	0.36	0.12	218,000	5	10	Very rapid..............	" ....
15.20	7.36	4.50	2.64	None..	0.02	About 24,000,000	10	13	15 hours................	" ....
5.44	5.04	0.56	0.52	1.00	0.12	236,000	15	10	Very rapid..............	" ....
10.32	8.16	2.10	1.36	1.30	0.24	8,352,000	40	10	"	" ....
22.40	19.04	5.50	4.10	None..	None..					
9.91	6.59	1.62	1.34	0.72	0.11					

of waters of the Illinois river collected at Havana in June, July, August, September and October, 1900.

I next read table 56, which gives the results of analyses of waters of the Spoon river collected at Havana in July and August, 1900. Tables 54, 55 and 56 are printed on one sheet and are as follows:

TABLE LIV.—*Pekin*—

Date.	Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on Ignition.		Chlorine....
				Water....	Air....	In solution	In suspension....	Total....	Not filtered	Filtered...	
1900											
May 30	Dark, very turbid....	Little	Light col'r'd	70°	80°	276	480	756	88	56	9.2
June 6	Light....	Earthy	Sandy	76	96	260	80	340	54	58	14.9
* " 13	"	"	Fine...	73	78	260	60	320	38	36	11.4
" 20	"	" . ..	Sandy	75	72	304	28	332	80	60	15.6
" 27	"	Good	"	76	86	284	52	336	100	88	16.3
July 5	Dark.	Little.......	Little........	81	90	252	20	272	50	48	16.3
" 9	Light, turbid.........	None.........	Fine	77	88	260	30	290	62	54	15.6
† " 18	"	Little..	"	76	75	260	40	300	40	40	22.0
‡ " 24	Light..................	Good........	"	77	78	246	26	272	22	22	15.6
Aug. 1	Yellow...............	"	"	80	95	234	22	256	40	34	17.8
" 9	"	Little........	Little.......	82	88	244	4	248	40	38	14.2
§ " 17	Dark, turbid..........	Good	Granular....	78	88	222	108	330	44	38	15.6
" 29	Yellow	"	Sandy........	82	92	170	118	288	42	20	13.5
Sept. 5	Yellow, turbid.........	"	"	78	88	258	26	284	56	48	12.1
‖ " 12	Light, yellow turbid.	"	"	75	86	224	48	272	48	48	14.9
	Averages..........	....	....	....	....	250	76	326	53	46	15.0

*June 13. Rain night before collection. Sample delayed.

†July 18. Rain during two days preceding collection.

‡July 24. Heavy rain day previous to collection.

§Aug. 17. Heavy rains during four days previous to collection.

‖Sept. 12. Delayed.

TABLE LV.—*Havana*—

1900.											
June 7	Light, turbid	Earthy	Dark, sandy	68°	78°	272	106	378	42	40	12.8
" 14	Light	Good	Little	68	66	256	96	352	52	52	12.8
" 19	"	Little........	Sandy	68	65	270	88	358	72	70	11.4
" 26	"	Earthy	"	70	88	248	76	324	72	64	12.1
July 2	Light, turbid	"	"	78	90	288	42	330	76	76	11.4
" 10	Light....................	Little	Fine, dark..	78	82	268	84	352	64	60	14.2
* " 17	Light, turbid	"	Very fine...	76	78	252	86	338	72	56	14.9
" 24	Light yellow...........	None.........	Fine..........	76	80	264	46	310	54	40	22.1
" 31	Dark.	Little.........	"	70	64	248	38	286	42	36	14.2
Aug. 7	Yellow	"	Dark	78	80	226	18	244	40	40	18.5
" 14	Yellow, very turbid..	Not good....	Clay..........	76	74	274	134	408	64	48	14.9
" 21	Light, turbid	Little........	Fine	80	84	204	46	250	42	36	12.1
" 28	Yellow	Good........	Sandy.	78	80	228	48	276	48	34	16.3
†Sept. 4	Dark, turbid...........	Little..	Fine..........	74	76	148	214	362	52	36	16.3
Oct. 10	Sandy	"	Sandy.	60	52	240	20	260	36	32	21.3
	Averages...........	....	....	..	....	245	77	322	55	48	15.0

*July 17, rain at time of collection.

†September 4, heavy rain second day before collection.

TABLE LVI.—*Havana*—

1900.											
July 31	Yellow	Good.........	Sandy	70°	64°	270	14	284	50	48	4.3
Aug. 7	"	"	Fine.........	78	60	254	6	260	40	40	5.7
" 14	Yellow, turbid........	"	Sandy	76	74	240	90	330	56	46	4.3
" 21	Yellow	None	Heavy clay.	....	....	134	306	440	64	28	3.5
	Averages.....	....	....	....	....	224	104	328	53	40	4.4

The Illinois River.

OXYGEN ABSORBED.		AMMONIA.		NITROGEN.		Nitrogen by Kjeldahl process......	Colonies—per cc...	FERMENTATION.		Coagulation of milk.	Indol produced?....
Not filtered	Filtered ...	Free	Albuminoid	In nitrates	In nitrites.			1-10 cc. (Per cent).....	1 cc. (Per cent)......		
17.44	6.56	0.50	0.98	0.88	0.05	....	43,600	25	5	24 hours......	Yes....
6.72	6.32	0.77	0.49	0.56	0.12	....	6,500	20	15	15 hours........	No.....
5.68	5.20	0.40	0.45	1.20	0.14	....	105,000	20	70	24 hours........	Yes....
6.48	5.04	0.45	0.54	0.68	0.14	....	88,800	30	None..	"	" ....
5.00	4.72	0.12	0.44	1.00	0.44	....	16,000	50	20	Rapid	No.....
5.28	4.88	0.49	0.39	1.04	0.44	....	52,500	30	30	24 hours........	" ....
5.44	4.96	0.40	0.36	0.40	0.24	1.32	12,000	10	20	20 hours........	" ....
6.16	4.96	0.50	0.36	0.60	0.20	1.56	24,000	40	10	Rapid..........	Yes....
5.00	4.08	0.34	0.48	0.60	0.08	0.94	450,000	20	10	"	No.....
5.60	4.80	0.41	0.36	0.80	0.04	....	136,000	20	30	"	" ....
7.60	6.00	0.32	0.38	0.40	0.12	1.33	240,000	50	55	"	Yes....
8.48	4.96	0.39	0.40	0.32	0.74	1.47	72,000	None..	25	"	No.....
4.96	4.56	0.18	0.40	0.40	0.12	1.30	70,400	5	10	Very rapid	" ....
8.00	6.72	0.38	0.40	0.80	0.12	1.40	440,000	10	20	Rapid..........	" ....
6.08	5.76	0.28	0.38	1.72	0.08	....	....	....	....	....	....
7.01	5.31	0.39	0.46	0.74	0.17	1.34					

The Illinois River.

8.16	5.60	0.38	0.37	1.00	0.10	....	16,600	60	80	15 hours.......	Yes....
6.96	5.04	0.44	0.39	1.20	0.14	....	345,600	50	10	24 hours.......	" ....
6.32	5.68	0.65	0.52	0.92	0.18	....	108,000	None..	40	"	No.....
6.72	5.20	0.52	0.48	1.40	0.12	....	Plates liquified	10	15	"	" ....
5.52	4.56	0.33	0.40	1.00	0.24	....	82,000	20	20	Rapid........	" ....
5.92	4.48	0.12	0.40	0.48	0.40	....	2,500	50	50	"	" ....
6.72	5.04	0.44	0.38	0.12	0.14	....	8,500	20	60	24 hours.......	" ....
6.32	5.20	0.49	0.45	0.72	0.12	....	25,000	30	80	"	" ....
5.76	4.56	0.40	0.25	0.72	0.16	....	83,500	50	50	20 hours.......	" ....
6.72	6.24	0.23	0.54	0.80	0.24	....	292,500	25	25	Slow	" ....
8.56	5.92	0.60	0.59	None..	0.01	....	161,000	15	20	24 hours.......	" ....
5.84	4.88	0.15	0.26	0.48	0.24	....	55,500	40	40	"	" ....
5.60	4.72	0.13	0.48	0.60	0.24	....	32,000	50	20	20 hours.......	" ....
6.80	6.00	0.14	0.33	1.16	0.16	....	93,000	10	45	Rapid..........	" ....
5.04	8.92	1.18	0.31	0.92	0.12	....	... .	....	....	....	....
6.46	5.14	0.41	0.41	0.77	0.18	....					

The Spoon River.

5.00	4.80	0.20	0.48	Trace .	0.04	1.15	14,800	30	30	Slow...........	No.....
6.96	6.16	0.33	0.41	" ..	0.08	1.27	Liquifi'd	15	40	"	"
5.68	5.44	0.42	0.42	None..	0.12	1.66	193,000	50	30	24 hours	"
13.60	5.84	0.12	0.56	0.32	0.08	1.58	122,500	50	40	20 hours	Yes...
7.96	5.56	0.27	0.47	0.08	0.08	1.41					

6981 THE WITNESS: I read next, table 57, which gives the results of analyses of the waters of the Illinois river collected at Pearl in June, July, August and October, 1900.

6982 TABLE LVII—*Pearl*—

Date.	Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on Ignition.		Chlorine.
				Water.	Air.	In solution.	In suspension.	Total.	Not filtered.	Filtered.	
1900											
June 7	Light, turbid	None	Clay	80°	85°	288	194	482	44	40	8.5
" 14	Light	Earthy	Sandy	73	84	268	222	490	74	48	9.2
" 19	"	Good	"	77	84	264	52	316	52	52	9.2
" 26	"	Earthy	"	79	87	306	138	444	90	72	12.8
July 3	Light, turbid	Good	"	82	95	260	122	382	42	36	11.4
" 10	" "	None	Fine	82	75	242	72	314	54	44	9.2
* " 17	" "	Not good	"	80	76	236	82	318	38	26	10.6
" 24	" "	Good	None	83	80	254	52	306	50	34	16.3
Aug. 2	" "	Earthy	Flocculent.	82	98	230	42	272	30	26	13.5
" 9	Light	Good	Sandy	88	102	260	44	304	48	28	14.2
† " 16	Yellow	Earthy	Yellow	88	98	240	1236	1476	88	40	13.5
‡ " 23	Dark yellow	Good	Sandy	88	96	180	280	460	64	30	8.5
" 31	Yellow	Earthy	"	90	102	230	150	380	48	40	13.5
§Oct. 2	"	Good	"	76	94	266	94	360	52	40	12.8
	Averages					252	198	450	55	39	11.6

*July 17. Rain night before collection.
†Aug. 16. Heavy rains, river muddy.
‡Aug. 23. Heavy rains, river muddy, bacterial sample warm.
§Oct. 2. River high.

TABLE LVIII.—*Grafton*—

Date.	Color.	Odor.	Sediment.	Temperature.		Solids.			Oxygen Absorption.		Chlorine.
				Water.	Air.	In solution.	In suspension.	Total.	Not filtered.	Filtered.	
1900											
*June 7	Light, turbid	Good	Sandy	76°	74°	280	102	382	86	62	7.1
" 14	Yellow	None	Clay	78	89	280	254	534	40	44	9.2
" 19	Light	Good	Little.	77	86	260	92	352	74	60	9.2
" 28	Light, turbid	"	Sandy	80	90	204	184	388	44	38	9.2
July 3	"	"	"	82	88	272	114	386	94	76	11.4
" 10	Yellow	None	Fine	87	78	222	74	296	52	56	9.2
" 17	Light, turbid	Good	Very fine	81	75	260	42	302	68	64	11.4
" 24	Yellow, turbid	None	Fine	83	90	208	72	280	46	44	9.9
† " 31	Very light	Good	None	83	96	244	20	264	40	36	14.9
Aug. 7	Light	None	Very little	88	96	294	6	300	52	46	12.0
" 14	"	Good	Little	87	90	272	36	308	48	42	14.9
" 21	Yellow	"	Sandy	86	94	200	136	336	64	60	9.9
" 28	Light, turbid	"	"	84	92	206	94	300	54	32	11.4
Sept. 4	Dark, turbid	"	"	82	86	214	70	284	54	42	10.6
" 10	Yellow, turbid	"	"	83	88	226	86	312	48	32	9.2
" 17	Light, yellow	"	"	73	70	264	68	332	72	48	11.4
" 24	Yellow	"	"	68	82	234	42	276	40	36	10.6
	Averages					243	88	331	57	47	10.6

*Sample delayed.
†River rising and muddy.

I read next table 58 which gives the results of the analyses of waters of the Illinois river, collected at Grafton in June, July, August and September, 1900—tables 57 and 58 being printed on one page, and being as follows:

The Illinois River.

Oxygen Absorbed.		Ammonia.		Nitrogen.		Colonies—per cc....	Fermentation.		Coagulation of Milk.	Indol produced?....
Not filtered.	Filtered ...	Free........	Albuminoid	In nitrates.	In nitrites.		1-10cc. (Per cent).	1 cc. (Per cent).....		
7.92	6.24	0.17	0.45	0.80	0.01	12,800	50	None..	24 hours.	No.....
7.20	4.80	0.14	0.46	1.28	0.06	Liquefi'd	None..	" ..	Slow	"
6.24	4.56	0.10	0.43	1.00	0.08	1,100	" ..	" ..	"	"
7.20	4.96	0.08	0.56	1.40	0.32	3,200	" ..	10	Rapid	"
6.16	5.68	0.11	0.31	1.60	0.01	1,900	45	20	24 hours	"
5.44	4.56	0.08	0.33	0.40	0.16	500	None..	None..	Rapid	"
7.84	6.08	0.07	0.32	0.60	0.08	5,500	10	10	24 hours.	"
4.64	4.24	0.08	0.41	0.88	0.06	21,500	10	None..	12 "	"
5.20	4.32	0.08	0.20	0.88	0.04	31,000	30	40	24 "	"
5.68	4.88	0.14	0.46	None..	0.01	142,000	90	15	20 "	"
13.44	4.80	0.30	0.98	0.40	0.01	330,000	10	15	24 "	"
6.16	4.56	0.12	0.48	0.32	Trace.	52,000	25	80	15 "	"
6.08	5.28	0.10	0.38	0.16	0.12	‡				
6.96	5.92	0.18	0.33	0.80	0.08	Liquefi'd	20	25	15 "	"
6.87	5.06	0.12	0.43	0.75	0.07					

‡ Delayed, bacterial sample warm

The Illinois River.

Oxygen Absorbed.		Ammonia.		Nitrogen.		Nitrogen by Kjeldahl process......	Colonies—per cc....	Fermentation.		Coagulation of Milk.	Indol produced?....
Not filtered.	Filtered ...	Free.......	Albuminoid	In nitrates.	In nitrites.			1-10 cc. (Per cent).....	1 cc. (Per cent).....		
8.00	5.52	0.09	0.42	1.12	Trace.	1.14	148,800	80	80	Slow	No.....
7.36	5.20	0.12	0.46	1.36	None..	1.18	2,100	None..	None..	"	"
5.28	4.16	0.10	0.34	1.40	0.02	1.23	4,600	50	50	24 hours	"
7.28	5.44	0.18	0.56	1.08	0.10	1.30	6,000	10	10	Rapid	"
6.96	4.80	0.11	0.31	1 44	0.01	1.16	5,500	50	10	Slow	"
5.20	4.72	0.07	0.35	0.60	0.08	0.88	5,000	None..	50	"	"
5.04	4.80	0.04	0.27	0.32	0.04	0.94	4,500	20	10	"	"
5.36	5.12	0.05	0.28	1.00	0.04	0.94	1,400	60	10	"	"
4.88	4.08	0.02	0.24	0.72	Trace.	0.84	1,200	None..	30	36 hours	"
5.44	4.88	0.06	0.39	0.80	0.02	1.28	Pl's liq'd	10	10	18 "	"
5.52	4.96	0.09	0.44	0.28	0.02	1.14	4,500	35	60	20 "	"
6.56	5.36	0.05	0.36	0.28	0.02	1.19	18,000	15	10	Very rapid	"
6.96	5.20	0.10	0.34	0.80	0.04	1.23	4,500	35	35	24 hours	"
5.60	4.80	0.03	0.28	1.00	0.08	1.17	95,000	25	50	Rapid	"
5.36	4.64	0.02	0.35	1.04	0.04	1.33	161,000	25	20	24 hours	"
5.52	4.64	0.03	0.34	1.20	0.02	....	1,400	10	20	20 "	"
4.16	3.68	......	......	0.40	0.02	....	Liquef'd	15	20	24 "	"
5.85	4.82	0.07	0.36	0.87	0.03	1.13					

6983 THE WITNESS: I read next, table 59, which gives the results of analyses of the Mississippi river water collected at Grafton in July, August and September, 1900, at a point above the mouth of the Illinois, as I explained, for all these collections.

I read next, table No. 60, which gives the results of analyses of the waters of the Sangamon river collected near the mouth

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TABLE LIX.—*Grafton*—

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on Ignition.		Chlorine.... ....
					Water.....	Air.........	In solution.	In suspension....	Total.....	Not filtered	Filtered....	
1900.												
July	31	Very dark.............	Little	Heavy clay.	82°	96°	144	474	618	66	32	2.8
Aug.	7	Yellow, turbid........	None........	Yellow.......	83	96	184	122	306	44	44	2.5
"	14	Yellow	Earthy.......	Dark..........	84	90	160	92	252	46	42	2.1
Sept.	10	Yellow, turbid........	Good.	Sandy	82	88	150	108	258	50	48	1.4
"	17	Dark yellow...........	"	Clay..........	71	70	142	138	280	56	44	2.1
"	24	Yellow	"	Sandy	70	82	130	236	366	54	32	1.4
		Averages..........	.. ..	....	.....	.....	152	195	347	53	40	2.0

TABLE LX.—*Browning*—

1900.												
*Aug.	27	Light, turbid.........	Good.........	Sandy........	83°	80°	424	42	466	86	72	5.0
"	30	Yellow	Earthy......	"	82	83	180	140	320	44	32	2.8
Sept.	5	Yellow turbid...	Good.........	"	81	85	226	90	316	52	44	13.5
		Averages..........	....	....	.....	.....	277	90	367	61	49	7.1

*Aug. 27, river very high.

TABLE LXI.—*Wilmington*—

1900.												
‡Aug.	22	Dark	Good.........	Brown	78°	82°	180	76	256	42	42	2.1
Sept.	6	Yellow, turbid.......	"	Sandy.	78	88	250	58	308	56	46	2.1
"	11	Yellow	"	"	80	92	304	30	334	74	72	1.4
		Averages..........	....	....	.....	.....	244	55	299	57	53	1.8

‡Aug. 22, river very muddy.

of the river at a point opposite Browning, in August and September, 1900.

I read next table 61, which gives the results of analyses of waters of the Kankakee river collected in August and September, 1900, near Wilmington. Tables 59, 60 and 61 are printed on one page and are as follows:

The Mississippi River.

OXYGEN ABSORBED.		AMMONIA.		NITROGEN.		Nitrogen by Kjeldahl process.	Colonies—per cc....	FERMENTATION.		Coagulation of milk.	Indol produced?....
Not filtered	Filtered....	Free...	Albuminoid	In nitrates.	In nitrites.			1-10 cc......	1 cc.........		
16.64	6.96	0.06	0.63	None..	Trace..	1.53	1,400	30	25	16 hours.......	No.....
15.84	10.08	0.14	0.53	" ..	None..	1.48	Liquef'd	5	25	Very slow.....	" ....
6.00	5.92	0.06	0.39	" ..	Trace..	1.30	2,500	50	60	24 hours......	" ....
11.44	8.16	0.04	0.62	0.20	0.06	1.66	62,000	10	10	"	" ....
12.00	5.44	0.03	0.63	Trace..	Trace..	....	2,000	10	20	20 hours.......	" ....
8.48	5.92	.....	......	None..	0.01	... .	Liquef'd	15	15	24 hours.. .. .	" ....
11.73	7.08	0.07	0.54	0.03	0.02	1.49					

The Sangamon River.

OXYGEN ABSORBED.		AMMONIA.		NITROGEN.		Nitrogen by Kjeldahl process.	Colonies—per cc....	FERMENTATION.		Coagulation of milk.	Indol produced?....
Not filtered	Filtered....	Free...	Albuminoid	In nitrates.	In nitrites.			1-10 cc......	1 cc.........		
6.16	5.44	0.09	0.28	0.24	0.08	1.31	13,000	30	30	24 hours.......	No.....
7.04	6.40	0.06	0.32	None..	0.04	1.28	5,500	50	15	24 hours..	" ....
5.76	4.88	0.04	0.44	0.80	0.48	1.10	2,500	50	25	24 hours.......	" ....
6.32	5.57	0.06	0.35	0.35	0.20	1.23					

The Kankakee River.

OXYGEN ABSORBED.		AMMONIA.		NITROGEN.		Nitrogen by Kjeldahl process.	Colonies—per cc....	FERMENTATION.		Coagulation of milk.	Indol produced?....
Not filtered	Filtered....	Free...	Albuminoid	In nitrates.	In nitrites.			1-10 cc......	1 cc.........		
7.44	6.88	0.13	0.30	0.60	0.06	1.26	45,500	20	40	15 hours.......	No.....
10.08	7.68	0.10	0.50	0.80	0.08	1.40	3,300	70	20	20 hours.	Yes....
10.08	8.48	0.08	0.48	0.92	0.04	1.55	1,200	20	40	Slow......	No.....
9.20	7.68	0.10	0.46	0.77	0.06	1.40					

6985 MR. JEFFRIES: We move to strike out the tables referring to examination of samples of water, the samples of which were taken at Kankakee, at Wilmington, from the Sangamon at Browning, from the Spoon river at Havana, and the Fox river at Ottawa, and the Vermillion river at La Salle, for the reason that said rivers are tributaries only of the Illinois river and an analysis of such water has no bearing upon the issues involved in this case, and for the further reason that there is no evidence showing the manner in which the samples were collected, and that instructions for the collection of the samples were carried out, if such instructions were given.

Q. MR. TODD: Professor, have you prepared and have you with you, a table of averages compiled from the analytical tables which you have just read in evidence, for the summer of 1900?

A. I have.

Q. Was that table prepared by you?

A. It was.

Q. Is it a true and correct table of averages based upon the analytical tables which have been read into evidence by yourself?

A. It is.

Q. Will you read that table?

MR. JEFFRIES: That is objected to for the same reasons as heretofore stated, that the table consists of a page from
6986 the report of the Illinois State Board of Health, and therefore it is not the original.

A. I now read table 62, which gives the averages from the results of the analyses made through the summer of 1900, of waters collected from the Illinois and Michigan canal at Bridgeport; from the main drainage canal at the Western Avenue bridge; from the main drainage canal or basin as it is called, at Lockport; from the mixed Desplaines and canal water at Joliet; from the Kankakee river water at Wilmington; from the Illinois river at Morris; from the Illinois river at Ottawa; from the Fox river at Ottawa; from the Illinois river at La Salle; from the Vermillion river at La Salle; from the Illinois river at Henry; from the Illinois river at the Narrows or the point known as Averyville or upper Peoria; from the Illinois river at the point known as Wesley, or lower Peoria; from the Illinois river at

Pekin; from the Illinois river at Havana; from the Spoon river at Havana; from the Sangamon river at a point near its mouth, opposite the town of Browning; from the Illinois river at Pearl; from the Illinois river above Grafton, and from the Mississippi river above Grafton, which table is as follows:

6987 TABLE LXII.—*Averages for Summer* 1900.

	Total solids	Loss on Ignition.		Oxygen Absorption.		Chlorine	Free Ammonia	Alb. Ammonia	Nitrogen in nitrates	Nitrogen in nitrites	Total nitrogen (Kjeldahl)
		Not filtered	Filtered	Not filtered	Filtered						
Bridgeport, I. & M. canal	447	76	54	16.31	9.11	89.7	15.26	2.55	0.13	0.17	13.85
Western Av. drainage canal	303	44	38	6.28	4.42	9.2	1.34	0.95	0.12	0.11	2.58
Lockport, basin	212	42	34	5.29	4.34	12.6	2.16	0.76	.00	0.06	.....
Joliet, Desplaines river and canal	280	54	44	6.97	4.52	31.4	4.66	0.85	0.02	0.09	......
Wilmington, Kankakee river	290	57	53	9.20	7.68	1.8	0.10	0.46	0.77	0.06	1.40
Morris, Illinois river	251	44	30	6.40	4.66	17.8	2.84	0.63	0.17	0.27	......
Ottawa, Illinois river	266	50	44	5.94	5.03	17.2	0.81	0.30	0.92	0.37	......
Ottawa, Fox river	312	70	72	6.77	6.32	4.9	0.11	0.50	.00	0.02	1.25
LaSalle, Illinois river	278	48	44	5.60	4.83	15.8	0.55	0.36	0.77	0.35	......
LaSalle, Vermillion river	283	63	48	5.89	5.23	9.5	0.12	0.32	0.43	0.10	1.30
Henry, Illinois river	283	51	44	5.86	4.86	16.9	0.41	0.40	1.06	0.22	.....
Peoria (narrows) Illinois	265	49	43	5.05	4.53	15.5	0.21	0.34	0.95	0.12	......
Peoria (Wesley) Illinois	333	65	52	9.91	6.59	16.6	1.62	1.34	0.72	0.11	.....
Pekin, Illinois river	326	53	46	7.01	5.31	15.0	0.39	0.46	0.74	0.17	1.34
Havana, Illinois river	322	56	48	6.46	5.14	15.0	0.41	0.41	0.77	0.18	......
Havana, Spoon river	328	53	40	7.96	5.56	4.4	0.27	0.47	0.06	0.08	1.41
Browning, Sangamon	367	61	49	6.32	5.57	2.1	0.06	0.35	0.35	0.20	1.23
Pearl, Illinois	450	66	39	6.87	5.06	14.6	0.12	0.43	0.75	0.07	.....
Grafton, Illinois	331	57	47	5·85	4.82	10.6	0.07	0.36	0.87	0.03	1.13
Grafton, Mississippi	347	53	40	11.73	7.08	2.0	0.07	0.54	0.03	0.02	1.49

6988 Q. MR. TODD: Will you state the number of samples and the places where the same were taken, for the series of analyses which you made in the summer and autumn of 1900?

A. During the summer of 1900, analyses were made of the waters collected at these points:

From the Illinois and Michigan Canal at Bridgeport,	15,
From the main drainage canal at Western Avenue,	14,
From the basin of the main drainage canal at Lockport,	11,
From the mixed canal and Desplaines river water at Joliet,	15,
From the Illinois river water at Morris,	15,
From the Illinois river water at Ottawa,	15,
From the Fox river water at Ottawa,	3,

From the Illinois river at La Salle,	15,
From the Big Vermillion river water at La Salle,	3,
From the Illinois river water at Henry,	15,
From the Illinois river water at Peoria Narrows,	13,
From the Illinois river water at Peoria at the point called Wesley,	16,
From the Illinois river water at Pekin,	15,
From the Illinois river water at Havana,	15,
From the Spoon river water at Havana,	4,
6989 From the Illinois river water at Pearl,	14,
From the Illinois river water at Grafton,	17,
From the Mississippi river water at Grafton,	6,
From the Sangamon river water at Browning,	3,
From the Kankakee river water at Wilmington,	3.

Q. From the analyses made by you in 1900, and the table of averages read by you for that period, what do your analyses show the condition of the Illinois river and its tributaries to be as to pollution from Bridgeport to Grafton?

MR. JEFFRIES: We object to the question for the reason that the condition of the water in the tributaries of the Illinois river has nothing to do with the issues involved in this case, and for the further reason that there is no evidence showing that proper precautions were taken in collecting the samples of water from the tributaries, and there is no evidence showing the manner in which the samples were taken, and for the further reason that the statements were based on the tables introduced as secondary evidence, and are therefore unreliable, and for the further reason that the samples were never so collected as to obtain comparable results at the different points on the river where collected, and this witness has given no evidence which shows that he knows the volume of the stream flow at the
6990 time the samples were taken or collected, or at any rate, there is no evidence showing the weather conditions under which the samples were collected, with reference to local freshets, showers and the stages of the rivers, and no evidence showing that this witness has any information with reference to the extent of the sources of pollution.

A. These tables considered in comparison with each other, and a consideration of the averages of the tables for the work of the summer of 1900, show in general, to begin with, a lower initial contamination of the water at Bridgeport than was the case in the examinations of the waters made in the previous year, 1899. The tables show further, as we proceed down the river and canal from Bridgeport to Lockport and Joliet, and down the Illinois river proper a gradual and continuous diminution in the factors indicating the organic contamination, and to an extent which is very much greater than can be accounted for in any way by the amount of dilution coming in from the tributaries.

An examination of these tables shows first, in general, a marked reduction of organic matter as compared with the amounts present at the source of contamination,—Bridgeport, in the main drainage canal. At the Narrows above Peoria, the factors indicating the extent of organic pollution as drawn from the results of the oxygen consumption test, and the free 6991 and albuminoid ammonia tests are not greater than those found from an examination of the ordinary tributaries—from the ordinary tributary waters of the Illinois in this state.

We find also on further consideration of the table that after Peoria Narrows is passed and the next point is reached, a remarkable increase in the organic pollution again, as measured by the important factors already referred to, the oxygen consumption and free and albuminoid ammonia, this increase being in the free and albuminoid ammonia several hundred per cent. The figures for oxygen consumption increase are likewise very large. The increase, from the known nature of the contaminating material entering the river at Wesley, is largely nitrogenous, and hence the much greater increase apparent in the figures for free and albuminoid ammonia than that apparent in the figures for oxygen consumption. Below Peoria as we proceed down the river we observe a decrease again in these figures,—a decrease in the oxygen consumption by the water, a decrease or disappearance of the free ammonia, and a very marked decrease in the albuminoid ammonia at Pekin. At the points below Pekin there is but little further decrease in the albuminoid ammonia for the reason that we have reached here a condition in the amount of albuminoid ammonia which is comparable with that found in the ordinary rivers of the state, beyond which the reduction

6992 does not commonly proceed to a great degree, for the reason, that we have reached here the comparatively stable types of organic substances which are not much subject to reduction by the bacterial oxidizing agents. In the case of the free ammonia, however, as this substance does undergo change, we find a progressive improvement or disappearance by oxidation to the mouth of the river, the figure for free ammonia at Grafton being .07 parts per million.

In considering the indications given by the figures for the oxygen consumption we have a similar condition. Below Pekin there is a general, gradual decrease until Grafton is reached, where the figures for the oxygen consumption again have sunk to a point corresponding to those given by the waters of the tributaries entering the Illinois, and by waters of this type in general, which flow through soil containing a large amount of organic matter. These figures for oxygen consumption have reached a point which is not passed in the waters of this region when exposed to the contamination of ordinary organic substances of vegetable origin.

In drawing full comparisons in this table, it is necessary to make, to begin with, a calculation of the combined flow through the main drainage canal and the Illinois and Michigan canal.

6993 Inasmuch as the water reaches the Desplaines river at Joliet through two canals, carrying unequal portions, and drawing different kinds of water, it is necessary to make a calculation of this kind in order to have a starting point for the comparison. The calculation which I refer to is to determine what the constituents present would amount to on the supposition that all the water was carried through one channel instead of two, because in considering the points further down the stream, we are dealing with only one channel. In order to make a computation of this kind, I have taken from the published tables of the Chief Engineer of the Sanitary District the flows through the two canals at the periods in question, and have combined them in such a way as to obtain the total flow. Knowing the total flow in each canal and the chemical composition of the water in each canal it is a matter of arithmetical calculation to find what the content would be on the supposition that all of the water passed through one channel.

During the period in question, as deduced from the tables of the Chief Engineer of the Sanitary District, about sixteen per cent. of the flow was through the old, or Illinois and Michigan canal, and about eighty-four per cent. of the flow through the main drainage canal, and these figures were used in a calculation which I will next present, which, however, has not been carried out for all constituents but only for the most important ones.

6994 Assuming that all of the water passed through one channel the volume being equivalent to the volume flowing through the two channels, the constituents in that one channel would be this: Chlorine 23.5 parts per million. Free ammonia—

JUDGE SPRINGER: At what place is this?

A. This is the assumed entrance of the one channel at Bridgeport, supposing the water all went through one instead of through two.

Chlorine,	23.5	parts per million,
Free ammonia,	3.9	do.
Albuminoid ammonia,	1.13	do.
Oxygen consumption in unfiltered water,	7.46	do.

These numbers may be taken as representing then the composition of the total flow through the combined channels. It will be seen by comparing these numbers which I have just given, with those given for the water at Joliet, that there is a discrepancy in some of the figures. That discrepancy depends on this fact, that at Joliet in the basin there is not, or was not at all times, a perfect mixture of the Desplaines and main drainage canal water, and the old canal water, so that the results are somewhat dependent on the point there at which the samples
were taken, and at the times there at which the samples
6995 were taken. Because of that discrepancy the Joliet collection is not considered in the comparison that I wish to make. With this calculated composition of the canal on the assumption that the water all flows through the one channel, I have made some graphic charts which illustrate the variations in the amount of substances present, expressed in parts per million in the whole flow between Bridgeport and Grafton at the mouth of the river, these charts illustrating somewhat more

clearly and plainly the variation than do the figures as read from the tables. The first chart shows a decrease in the chlorine, which is a measure approximately, of dilution by tributary waters.

MR. JEFFRIES: I move to strike out the comparisons of the analytical results of the last named period with those previous periods for the reason that it is not responsive to the question and for the further reason that in such comparison the witness has not testified or shown himself possessed of sufficient data regarding the sources and extent of pollution of the Illinois river at the various points where samples were taken, and for the further reason that the tables from which the conclusions were drawn do not contain a sufficient number of examinations of water from the various places to enable a creditable conclusion or determination to be made, as to the chemical condition of the water, and for the further reason that the witness 6996 has not taken into consideration the change in the condition of the water since the opening of the Chicago drainage canal in January, 1900, as compared to its condition prior to the opening of the canal and has not taken into consideration the chemical changes in the water during those respective periods, and for the further reason that the samples from which the analyses were made were not taken at places and times so as to be comparable with each other, and we move to strike out all that the witness has said with reference to the volume of water flowing through the drainage canal proper and the old Illinois and Michigan canal for the reason that his information was obtained from sources other than such as is now in evidence, and that his testimony in respect to the source of his information cannot be considered as evidence. The publications from which he read and obtained his information are not competent evidence and no testimony on that subject has been introduced by defendants or called to the attention of the witness.

MR. TODD: In reply to part of the objections counsel for defendants desire to state that the facts assumed by the witness as given by the Chief Engineer of the Sanitary District will be verified by the Chief Engineer when opportunity is given to place him on the stand, and we would thereby establish the assumption made by the witness as to the flow from the drainage canal and the Illinois and Michigan canal.

MR. JEFFRIES: I suggest in response to counsel's suggestion that the information which the witness obtained 6997 from the Chief Engineer of the Sanitary District of Chicago, is not in evidence and so long as it is not disclosed, that the information which the witness has possession of, is the same as that which actually exists and which will be shown by said Chief Engineer when he comes upon the stand, and testifies, is not competent and is therefore unreliable and is an assumption which is erroneous and cannot be of any force.

Q. MR. TODD: Professor, I show you a chart and ask you if the chart was constructed by you from the tables?

A. It was.

Q. What does this chart indicate?

A. This chart represents the decrease in the chlorine present, expressed in parts per million, between Bridgeport and Grafton.

Q. What year?

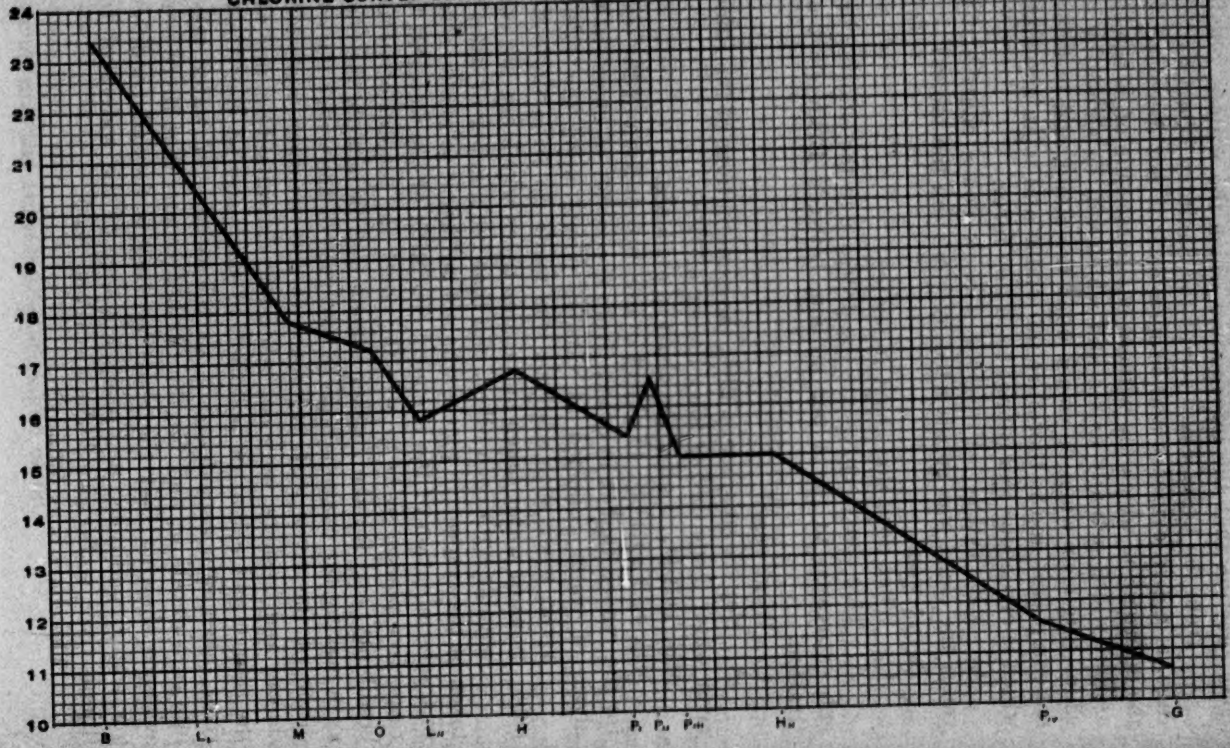
A. For the summer of 1900, the examinations of the Illinois river water made during the summer of 1900.

MR. TODD: I offer the chart in evidence.

MR. JEFFRIES: I object to the introduction of the chart for the reason that it is drawn from the result of chemical analysis of water collected at various points upon the Illinois river, when such analysis was made up from the collections of water taken at various times which are not com- 6998 parable with each other, and that the number of samples taken at the respective places was not sufficient to enable a correct determination of the chemical condition of the water at the respective places, so as to give the chart the respect of proper credibliity, and for the further reason that in making the chart as in making the examinations of analyses of the water the condition of the river with reference to the weather and local shower and freshets, were not taken into consideration, nor was the source and extent of pollution of the water of the Illinois river taken into consideration, or the volume of water taken into consideration; and for the further reason that there is no evidence showing that the chart represents flooded condition, low water conditions, or ordinary stages of the waters of the Illinois river, so far as chlorines are concerned.

The chart is as follows:

CHLORINE CURVE. ORDINATES=PARTS PER MILLION ABSCISSAS=DISTANCES



7000 Q. MR. TODD: Will you explain in detail all the figures and letters upon the chart which is introduced, and what their significance is?

A. This chart represents the change in the amount of chlorine present in the water of the canal and the Illinois river from Bridgeport to the mouth of the Illinois river at Grafton, assuming for the Bridgeport flow, the combined flow calculated as explained some distance back. The curve represents the amount of chlorine present in parts per million. The ordinates in this curve are vertical lines on the curves with the figures at the ends of these lines, which represent whole units of parts per million, starting from the base line of ten parts per million and ending at a line equivalent to 24 parts per million. The large abscissa space corresponds to a distance of fifteen miles, the equivalent to three miles for one of the small spaces. The letters at the bottom of the chart are initial letters of the points at which waters were collected for the examination. These letters being placed under marks proportionate to the distances of these points from Bridgeport.

B stands for Bridgeport. L_{1} representing Lockport; M. representing Morris; O. representing Ottawa; L_{11} representing La Salle; H. representing Henry; P_{1} representing Upper
7001 Peoria, or Averyville or the Narrows.

P_{11} representing Lower Peoria or Wesley.

P_{111} representing Pekin.

H_{11} representing Havana.

P_{1111} representing Pearl.

G. representing Grafton.

In this chart we have a decrease of the chlorine from Bridgeport to La Salle; an increase at Henry corresponding to the chlorine coming into the river at or below LaSalle from the industries there present, largely. A further decrease to Upper Peoria; a slight increase at Wesley, a decrease at Pekin; about the same amount at Havana, and a gradual decrease to the mouth of the river.

Q. What do the figures on the left hand side of the chart from 10 to 24 indicate

A. These indicate, or express the amount of chlorine present in parts per million, a long space representing one part per million and one of the short spaces one-fifth of one part per million.

Q. The chart which I hold in my hand represents what?

A. That chart represents the change in the amount of free ammonia present in the water between Bridgeport and
7002 Grafton, for the period of the summer of 1900, that chart being drawn from the average of the results of chemical analyses made through that period.

Q. Do the notations on the chart at the bottom indicate the same points as were described in the last chart?

A. They do.

MR. TODD: I ask to have this chart made a part of the evidence.

MR. JEFFRIES: The same objection is made to the introduction of this chart as was made with reference to the previous chart, with the statement that this chart applies to free ammonia found, while the previous chart applies to chlorine found.

Q. MR. TODD: Professor, will you explain the significance of that chart and what it indicates?

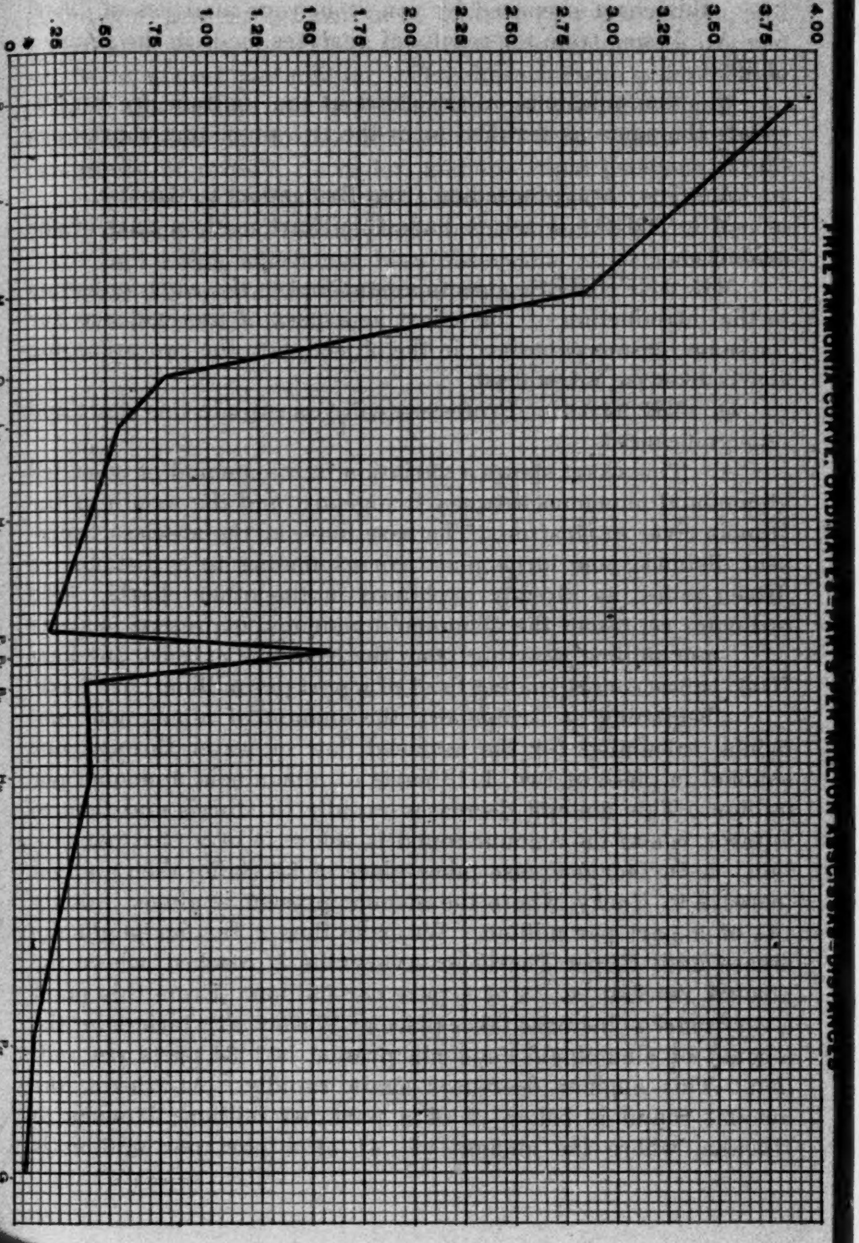
A. The base line or abscissas in this chart have the same significance as in the chart for chlorines, just explained. The ordinates represent the amount of free ammonia present at the different points, expressed in parts per million starting from the base line at zero, this chart shows that at Bridgeport we have nearly four parts per million of free ammonia, which decreases to about 2.8 parts at Morris, and still further decreases to Ottawa, and La Salle, and Henry, until Upper Peoria or
7003 Averyville is reached, where the amount present is less than .25 of one part per million. We have then an increase in the free ammonia at Wesley, to about 1.6 parts per million, and the decrease again to Pekin; about the same condition at Havana, and a gradual decrease until the mouth of the river at Grafton is reached, where the amount of free ammonia is less than .1 part—about .07 of a part per million.

Q. What does the chart indicate as to the ammonia above, at and below Peoria?

A. The chart indicates a very great decrease in ammonia from the starting point, until Upper Peoria is reached, and then a remarkable increase,—followed by a decrease to Pekin.

The chart is as follows:

7004


0
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
3.75
4.00
B
L.
M
O
G
FREE AMMONIA CURVE. ORDINATES=PARTS PER MILLION ABSCISSAS=DISTANCES

7005 Q. I show you a chart for albuminoid ammonia. Was this chart prepared by you from your analyses of 1900?

A. It was from the results of analyses made in the summer of 1900.

Q. The notations on the chart at the bottom are for the points the same as testified to in the two preceding charts, are they?

A. They are, proceeding from Bridgeport to Grafton.

MR. TODD: I ask to have this chart made a part of the evidence.

MR. JEFFRIES: Complainant makes the same objection to the introduction of this chart as a part of the evidence, for the same reasons contained in the objection to the two preceding charts likewise introduced.

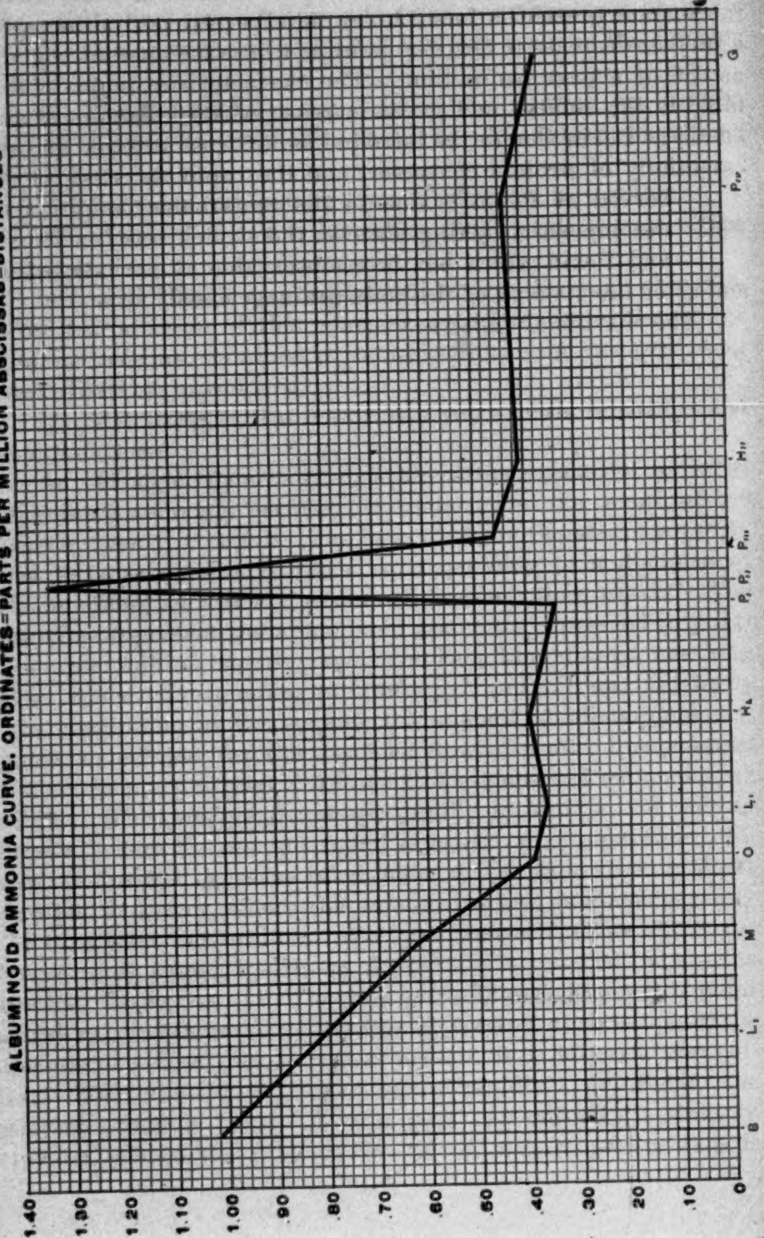
Q. MR. TODD: Professor, will you explain this chart and its significance?

A. This chart shows a variation in the amount of so-called albuminoid ammonia between Bridgeport and the mouth of the Illinois river at Grafton. The base lines, or the abscissa represent distance, one large place corresponding to a distance of fifteen miles, as already explained in the other charts. The ordinates represent the albuminoid ammonia expressed in parts per million, starting from the base line at zero, one long
7006 space corresponding to .1 of a part per million. We have, beginning at Bridgeport, the amount of albuminoid ammonia, calculated for the assumed flow of water through one channel in place of two, 1.13 parts of albuminoid ammonia per million. This amount decreases rapidly to Morris and then to Ottawa, where the amount found is below .4 of a part per million. A further decrease takes place at La Salle; then a slight increase to Henry, where the amount present is almost exactly .41 of a part per million. We have then a further slight decrease until Upper Peoria or Averyville is reached, where the amount reached is .34 of a part per million. From this point a very marked increase takes place at Wesley, at which point the amount of albuminoid ammonia present is 1.34 parts per million. This amount decreases again rapidly. At Pekin the amount found is below .5 of a part per million; it sinks to Havana, where the amount of .41 of a part per million is

reached. A slight increase is observed from here to Pearl where the amount present is found to be .43 of a part per million, and a further decrease to Grafton follows, where the amount is given as .36 of a part per million. The characteristic point in this table is the sudden and great increase of the albuminoid ammonia at Pekin, due to the introduction of fresh organic matter, essentially of protein character, and the rapid decrease as observed at Pekin is due to the remarkable condition of
7007 decomposition taking place in the stretch between Peoria
and Pekin which has been observable at periods before and after the opening of the main drainage canal.

The chart is as follows:

7008


ALBUMINOID AMMONIA CURVE. ORDINATES=PARTS PER MILLION ABSCISSAS=DISTANCES
1.40
1.30
1.20
1.10
1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
0
B
L_1
M
O
L_{11}
H_4
P_1 P_{11}
P_{111}
H_{11}
P_{11}
G

7009 Q. MR. TODD: I show you a chart entitled Oxygen Consumption curve, and ask you if you made this chart from your chemical analyses of 1900, the same as the three preceding charts were made?

A. This chart was so made, from the analyses of the summer of 1900.

Q. The notations at the bottom on the abscissas line represent the same locations where water was taken, as before testified to in the first chart offered?

A. They do.

MR. TODD: I ask to have this chart made a part of the evidence.

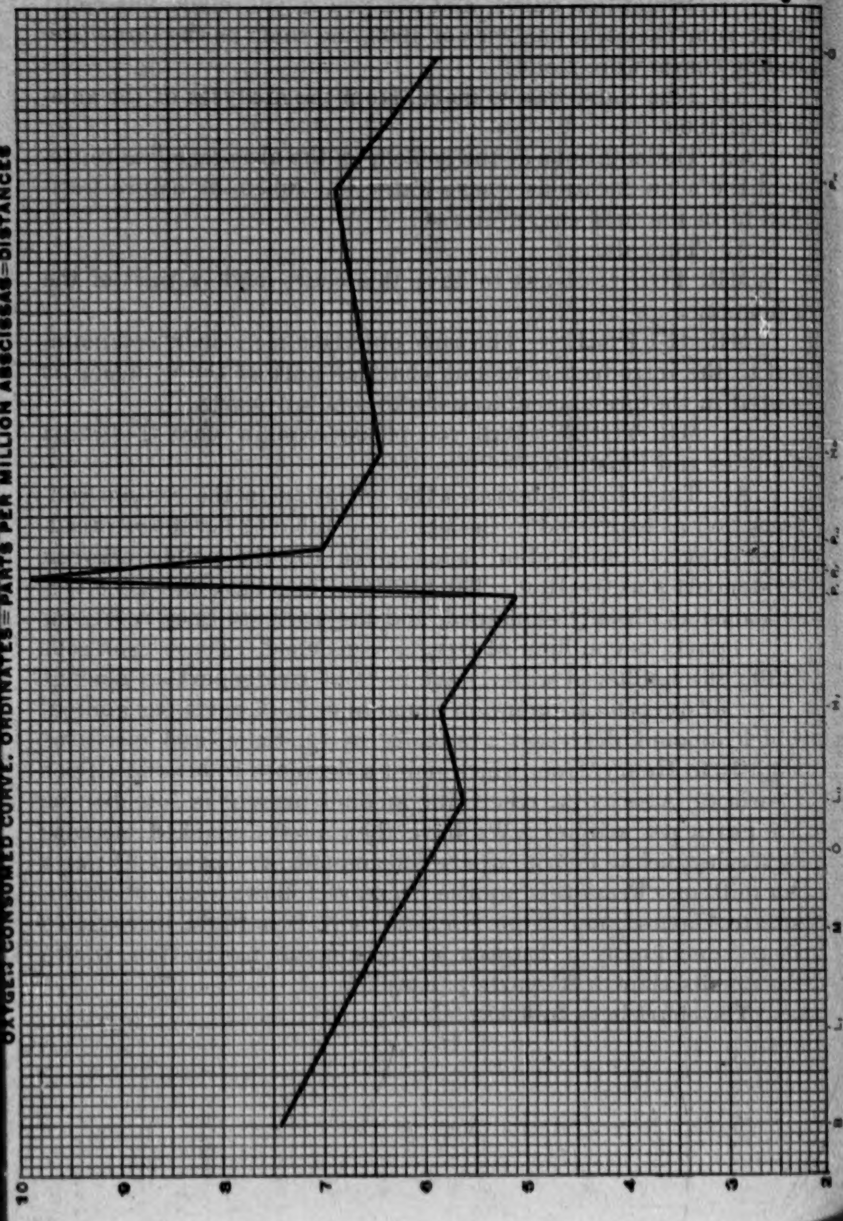
MR. JEFFRIES: The same objection is made by complainant to the introduction of this chart as part of the evidence as stated in the previous objections to similar charts.

Q. MR. TODD: Will you please explain what this chart signifies and illustrates?

A. This chart illustrates the variation in the oxygen consumption as expressed in the figures of table 62 heretofore read. This oxygen consumption being given for the points between Bridgeport and Grafton. The abscissa lines have the same significance as already explained, and the ordinate lines represent parts per million of oxygen consumed. These represent
7010 the unfiltered water. We have at Bridgeport an amount of oxygen consumption found to be 7.46 parts per million, which amount decreases gradually to La Salle, and increases slightly to Henry, from which point a decrease follows to Upper Peoria or Averyville, where the amount present is found to be 5.5 parts per million. We have then a very marked increase to Wesley, below Peoria, where the amount present is 9.91 parts per million. From this point a decrease follows again to Pekin, and to Havana, and from Havana there is a slight increase to Pearl, and finally a decrease in the amount to Grafton, where the results show 5.85 parts per million.

The chart is as follows:

7011



OXYGEN CONSUMED CURVE. ORDINATES=PARTS PER MILLION ABSCISSAS=DISTANCES

7012 MR. JEFFRIES: Now, we move to strike out all of the charts just offered as a part of the evidnece for the reason that there is no evidence showing what part of the alleged reduction in organic matter in each of the charts introduced, is due to errors in sampling and in analyzing, and what portion is due to actual reduction, on the ground that the evidence shows specifically the errors and irregularities in collecting samples at Joliet and La Salle during the period in which samples were collected for the analyses from which these charts are made.

Adjourned until 10:00 a. m., Saturday, September 26, 1903.

Met pursuant to adjournment, Saturday, September 26, 1903; whereupon a further adjournment was taken until 10 a. m., September 28, 1903.

7013 10:00 A. M., Monday, September 28th, 1903. Parties met pursuant to adjournment.

Upon telegraphic notice from Attorneys for complainant—the State of Missouri, of their detention by railroad wreck, the case was adjourned until 2:00 P. M., same day.

7014 2:00 P. M., Monday, September 28th, 1903. Parties met pursuant to adjournment.

Attorneys for complainant not being present, on account of the railroad wreck, an adjournment was taken until 10:00 A. M., Tuesday, September 29th, 1903.

7015 10:00 A. M., Tuesday, September 29th, 1903. Parties met purusant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

JOSEPH WEIS,

recalled for further direct-examination by Mr. Todd, testified as follows:

Q. What is your name?

A. Joseph Weis.

Q. You have testified heretofore in this case have you not Mr. Weis?

A. Yes sir.

Q. Mr. Weis, do you know Mr. John E. Thome of the Bridgeport pumping works?

A. Yes sir.

Q. During the time that samples were collected by him who was it that went to the Bridgeport pumping works and got the samples which he collected and took them to the city hall, and took them to the University of Illinois, to Professor Palmer, and to the University of Chicago to Professor Jordan, and left the samples at the City Laboratory?

A. I did.

7016 Q. You handled all the samples collected by him?

A. Yes sir, I did.

Q. Now when you got the samples from him, what did you do with them?

A. Well, I left—as I did afterwards, I left the sample in our laboratory, and delivered one sample to the American Express Company for shipment to Champaign, Illinois, and delivered one sample to Professor Jordan of the Chicago University.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Did you assist Mr. Thome in taking any of these samples?

A. No sir, never.

Q. How many did you carry from this place where they were taken, down to the laboratory?

A. On Saturday I delivered my boxes there and on Monday I went for the samples, and he usually took the samples in my presence, and sealed them in my presence.

Q. Did you assist him?

A. No, not at all.

Q. Well, how many times—how many trips did you make?

A. Well, I don't remember distinctly. It was once or twice a week.

7017 Q. For how many weeks?

A. Well, I don't remember. That must have been for three or four months, if my recollection don't fail me.

Q. You don't know how the samples were taken or anything about that?

A. Well, most of the time I was present. He took his bottles and dumped them right as the water comes out of the Bridgeport pumping station. It was mighty filthy.

Q. How long would it take you to get down to the city laboratory with them?

A. Oh, I should judge about twenty or twenty-five minutes.

Q. Do you know who received them there; who did you turn them over to?

A. I turned one sample over to the city chemist, and one sample to Dr. Gammon. There was a small bottle and a big bottle.

Q. Well, they were not always there to take them, were they?

A. No, they were not, but the bottles were sealed.

Q. I know, but who did you give them to there in the office?

A. I put the big bottle on the desk of the City Chemist, and the small bottle I put in the ice-box on ice.

7018 PROF. JOHN H. LONG,

resumed the stand for further direct-examination by Mr. Todd, and testified as follows:

Q. Professor, state your general conclusions from the work of the summer of 1900, as shown by the tables and charts offered in evidence, as to the character of the waters of the Illinois river and its tributaries?

MR. JEFFRIES: We object to the question for the reason that the witness has already answered, and for the further reason that the tables are not the best evidence, as stated in

previous objections, and for the further reason that the tables showed that the samples of water were taken at such times as not to be comparable with each other; also that a sufficient number of samples were not taken upon which to base a conclusion which would be reliable, and for the further reason that in the analyses, the witness did not take into consideration the volume or flow in the Illinois river, the source and extent of pollution in that river, and for the further reason that the conditions in the river have so changed since the opening of the drainage canal as to render any comparisons or general conclusions on examinations made prior to and subsequent thereto,
7019 unreliable and not trustworthy, and I also object to the
question because it includes the character of the water of the tributaries of the Illinois river, as incompetent, irrelevant and immaterial and has no bearing upon the issues involved in this case.

A. A consideration of all the tables presented, and of the charts drawn from them leads to this important and necessary conclusion: That in the flow of the sewage water from the pumps at Bridgeport through the drainage canal and subsequently into and through the river there is a very remarkable reduction or destruction of organic matter to Peoria; a great increase again between Peoria and Pekin, beyond which the reduction follows which continues to the mouth of the river, and at the mouth of the Illinois river as far as the organic content is concerned, the Illinois river is not more contaminated than are the ordinary tributaries, and rivers of this region flowing through a soil which contains large organic matter, and finally, and the most important conclusion to be drawn from these tables and charts, is that the main factor in contamination of the Illinois river is the addition of sewage, stock yards and distillery waste, of the city of Peoria.

MR. JEFFRIES: Now we move to strike out all the witness said with reference to the stock yards and distillery waste of Peoria for the reason that such statements are irrele-
7020 vant and incompetent, and for the further reason that the
number of samples of water examined by this witness, together with the continually decreasing amount of the de-

posits in the river at Peoria, do not justify conclusions of this character.

THE WITNESS: I wish to add that by stock yards of Peoria I mean the cattle sheds.

Q. MR. TODD: Professor, did you make any chemical surveys in 1901?

A. I did.

Q. And in the spring of 1902?

A. I did.

Q. At what points?

A. In the Illinois river above Grafton; in the Mississippi river above Grafton, and in the Missouri river above the mouth of that river, or the point where it flows into the Mississippi.

Q. Those were the points selected in 1901?

A. They were.

Q. At what time was this investigation made in 1901?

A. This investigation was made in 1901 between September—the last part of September and the middle of December.

Q. And when did you make the next investigation?

A. The next investigation was made in the spring of
7021 1902, through the month of February—part of February and March.

Q. At what points, professor?

A. At the same points. In the Illinois river above Grafton; in the Mississippi river above Grafton; in the Missouri river above the mouth of that river.

Q. Samples for these tests were taken in the manner that you have heretofore testified, and the tables have been introduced in evidence, have they not?

A. The samples were so taken and the cards or tickets describing the location and so on, have already been introduced.

Q. Were these analyses made different from the analyses made in 1900?

A. They were not.

Q. You have already described in your testimony the manner in which you made the chemical analyses?

A. I have.

Q. Have you the tables of the analyses made by you from the samples of water collected during this period at these different points?

A. I have.

Q. In what form have you the tables, professor?

A. I have these tables in the form in which they were printed by the authority of the Illinois State Board of 7022 Health, in one of the bulletins or reports of the Board of Health printed in 1902, under the direction of the secretary of the State Board of Health.

Q. By whom were these tables prepared?

A. These tables were prepared by myself.

Q. By whom was the proof for these tables corrected?

A. By myself.

Q. Are these tables which are printed in the advance sheets of the report of the Sanitary investigations of the Illinois, Mississippi and Missouri Rivers for 1902, by the Illinois State Board of Health true and correct tables of the analyses made by you?

A. They are.

Q. The printing was done under your direction and supervision?

A. The printing was done under the direction of the Secretary of the Illinois State Board of Health. The report was sent to the Secretary by myself and the proof was read by myself.

Q. And the tables as prepared are correct tables of your analyses based upon the samples which you analyzed in your laboratory?

A. They are.

Q. Will you read the tables of analyses made by you for this period?

7023 A. I now read table No. 1, which gives the results of the analyses of the water of the Illinois river taken above Grafton, between September 23rd, 1901 and December 12th, 1901, this table being printed on one sheet.

MR. JEFFRIES: We object to the reading of these tables for the reason that the original tables prepared by the witness are the best evidence. There is no evidence to show that the tables now being read are exact copies of the original tables, and no evidence showing that the corrections were made on the proof after reading by the Professor, as stated by him in his testimony about them being printed.

Q. MR. TODD: Are these tables exact copies of the original tables made by you?

A. They are.

Q. Proceed:

TABLE I.—*Mouth of*

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on Ignition.	
					Water	Air	In solution	In suspension	Total	Not filtered	Filtered
1901											
Sept.	23	Light turbid	None	Sandy	64°	76°	280	18	298	42	38
"	24	"	"	"	68	82	224	50	274	38	32
"	26	Light	"	"	71	84	212	62	274	40	32
"	30	Yellow	"	"	69	80	232	60	292	34	30
Oct.	1	"	Good	"	70	80	220	52	272	40	28
"	3	"	"	"	66	60	232	60	292	48	42
"	7	"	None	"	60	71	256	52	308	40	38
"	8	"	"	"	63	66	254	50	304	40	38
"	10	"	"	"	64	72	248	60	308	30	28
"	14	"	"	"	58	80	244	49	293	61	68
"	15	"	"	"	58	62	232	40	272	38	38
"	17	"	"	"	57	55	228	42	270	32	30
"	21	"	"	"	58	64	226	62	288	36	36
"	22	"	"	"	56	63	240	38	278	34	32
"	25	"	"	"	60	64	212	58	270	36	22
"	29	"	"	"	61	72	232	36	268	24	16
"	31	"	"	"	62	63	200	46	246	20	16
Nov.	4	"	"	"	54	44	268	12	280	46	36
"	5	"	"	"	52	43	216	40	256	36	36
"	7	"	"	"	49	48	242	10	252	28	38
"	11	"	"	"	49	61	224	38	262	34	28
"	12	"	"	"	49	45	230	42	272	28	24
"	14	"	"	"	47	55	236	16	252	44	32
"	18	"	"	"	42	42	226	22	248	42	30
"	19	"	"	"	39	43	226	16	242	44	42
"	21	"	"	"	40	50	222	24	246	34	26
"	25	"	"	None	41	45	238	4	242	30	30
"	26	"	"	Little	40	46	214	14	228	38	36
"	28	"	"	"	41	44	228	20	248	50	46
"	29	"	"	None	40	50	232	4	236	48	36
Dec.	2	"	"	"	43	40	222	10	232	54	50
"	3	"	"	"	42	38	228	2	230	50	48
"	5	"	"	Little	38	32	230	18	248	54	54
"	6	"	"	None	38	35	220	2	222	32	32
"	9	"	"	"	37	34	216	12	228	42	42
"	10	"	"	"	36	36	226	2	228	64	62
"	11	"	"	Sandy	37	34	150	70	220	36	34
"	12	"	"	"	37	40	217	0.3	220	44	44
		Means			53°	55°	229	32	261	40	36

Illinois River—Grafton.

Chlorine..	Oxygen Absorbed		Ammonia.		Nitrogen.		Organic ammonia by Kjeldahl process..........	Colonies per cc......	Fermentation.		Coagulation of milk 38°.	Indol produced ?.....
	Not filtered	Filtered ...	Free.......	Albuminoid	In nitrates	In nitrites.			$\frac{1}{10}$ cc.........	1 cc.........		
16.0	4.80	4.32	0.19	0.29	1.20	0.040	0.43	2,800	No gas	No gas	24 hours	....
16.7	4.64	4.00	0.14	0.24	1.40	0.040	0.63	700	"	35%	Very slow....	....
17.0	4.00	3.52	0.16	0.21	0.40	0.040	0.63	250	80%	No gas	24 hours.......	....
16.7	2.88	2.56	0.15	0.32	0.08	0.035	0.63	1,050	No gas	"	"	....
17.7	3.04	2.72	0.12	0.28	1.00	0.040	0.43	Liquefied.	"	"	"	No.....
17.7	4.48	3.64	0.16	0.27	1.00	0.035	0.63	400	20%	5%	....	" ....
19.1	4.80	4.16	0.15	0.28	0.96	0.080	0.82	400	No gas	No gas	Slow....	" ....
19.5	4.32	4.00	0.12	0.27	1.20	0.080	0.72	250	....	....	....	" ....
22.3	3.84	2.88	0.09	0.27	0.64	0.050	0.72	....	No gas	No gas	....	" ....
17.4	3.36	2.56	0.11	0.40	0.96	0.030	0.82	1,250	"	"	Slow.....	" ....
17.8	3.04	2.88	0.12	0.25	1.44	0.030	0.82	850	80%	10%	24 hours	" ....
18.1	4.16	3.04	0.11	0.25	1.40	0.030	0.62	20,200	10%	10%	"	" ....
18.1	4.48	3.28	0.10	0.45	1.52	0.080	0.72	13,100	60%	20%	"	" ....
18.0	4.32	2.72	0.17	0.38	0.96	0.050	0.72	400	No gas	60%	20 hours	" ....
18.1	4.32	2.88	0.10	0.33	1.60	0.250	0.62	Liquefied.	"	No gas	Slow..........	" ....
19.2	4.48	3.20	0.08	0.40	1.00	0.015	....	2,050	50%	80%	Very slow ...	" ....
17.0	4.32	2.32	0.05	0.40	1.20	0.015	1.28	450	No gas	No gas	Slow.	" ....
17.0	2.40	2.08	0.13	0.39	1.20	0.020	0.62	4,100	"	"	Rapid.........	" ....
16.7	3.08	1.92	0.10	0.44	1.40	0.030	0.62	1,150	"	5%	"	" ....
17.0	6.08	5.60	0.08	0.38	1.00	0.020	0.92	100	10%	No gas	24 hours	" ....
17.0	8.00	2.72	0.10	0.48	1.00	0.025	0.70	400	No gas	"	Very slow....	" ....
16.0	4.00	3.04	0.11	0.44	0.60	0.025	0.60	150	"	80%	Slow......	" ....
16.7	3.36	2.72	0.06	0.54	1.12	None	1.40	450	20%	No gas	24 hours.....	" ....
17.7	5.12	3.08	0.09	0.71	0.80	0.020	1.40	150	No gas	"	Slow.....	" ....
16.0	5.12	3.36	0.14	0.70	1.12	0.025	1.40	1,150	"	10%	12 hours..	" ....
14.9	4.04	3.36	0.13	0.69	0.56	None	0.70	Liquefied.	"	No gas	None..........	" ....
13.5	4.80	3.68	0.22	0.78	0.64	0.020	1.00	1,050	"	85%	Very slow....	" ....
13.5	4.96	3.36	0.19	0.53	0.48	0.020	1.10	25,800	"	....	None..........	" ...
16.3	4.96	3.52	0.19	0.51	1.12	C.030	1.10	Liquefied.	"	....	12 hours.	" ....
12.8	4.32	4.00	0.30	0.38	1.12	0.030	1.10	"	"	No gas	Very slow....	" ...
16.0	3.84	2.40	0.31	0.46	0.88	0.080	1.10	....	....		None........ ..	" ....
16.4	3.68	3.20	0.28	0.40	1.20	0.020	1.10	....	....	"	Slow..... ..	" ....
15.3	4.64	3.36	0.66	0.42	1.12	0.020	1.12	Liquefied.	No gas	25%	Rapid	" ...
17.0	4.16	3.86	0.74	0.41	1.44	0.030	0.72	"	"	25%	"	" ....
15.6	4.04	2.56	0.71	0.44	1.12	0.015	0.92	"	"	60%	"	" ....
14.2	3.84	3.68	0.79	0.46	0.80	0.015	0.84	....	30%	25%	20 hours.......	" ....
11.7	4.96	3.04	0.81	0.32	1.12	0.020	0.52	....	20%	40%	"	" ....
13.5	3.36	2.32	0.76	0.41	1.20	0.025	0.92	... .	15%	50%	"	Yes....
16.4	4.31	3.21	0.238	0.413	1.042	0.034	0.81					

7025 THE WITNESS: I now read table No. 2, which gives the results of the analyses of the Mississippi river water taken above Grafton, above the mouth of the Illinois, between September 23rd, 1901 and December 12th, 1901, these figures all being printed on one sheet.

7026 TABLE II.—*Mississippi River*—

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on Ignition.	
					Water	Air	In solution.	In suspension	Total	Not filtered	Filtered
1901.											
Sept.	23	Yellow	None	Sandy	61°	76°	160	40	200	38	36
"	24	Light, turbid	"	"	64	82	156	44	200	40	40
"	28	Yellow.	"	"	66	84	150	32	182	34	31
"	30	"	"	"	67	86	150	52	202	34	32
Oct.	1	"	"	"	66	80	140	56	196	38	30
"	3	"	"	"	65	80	150	72	222	36	32
"	7	"	"	"	58	71	136	78	214	34	22
"	8	"	"	"	61	86	144	74	218	40	24
"	10	"	"	"	62	73	152	96	248	32	28
"	14	"	"	"	56	50	152	58	210	34	30
"	15	"	"	"	56	52	148	44	192	40	40
"	17	"	"	"	55	55	158	50	208	38	26
"	21	"	"	"	56	64	140	52	192	38	32
"	22	"	"	"	57	66	132	66	198	40	36
"	28	"	"	"	58	64	144	68	212	46	38
"	29										
"	31	"	"	"	60	62	136	58	194	30	26
Nov.	4	"	"	"	52	44	144	52	196	44	36
"	5	"	"	"	50	43	140	48	188	40	40
"	7	"	"	"	47	48	132	50	182	30	30
"	11	"	"	"	47	64	142	30	172	34	34
"	12	"	"	"	47	45	140	36	176	30	28
"	14	"	"	"	45	45	156	18	174	36	26
"	18	"	"	"	38	42	148	18	166	34	22
"	19	"	"	Little	37	43	148	20	168	30	22
"	21	"	"	"	38	50	154	26	180	24	22
"	25	"	"	None	39	45	152	2	154	32	32
"	26	"	"	"	38	48	136	2	138	22	30
"	28	"	"	"	40	44	136	10	146	44	34
"	29	"	"	Little	39	50	140	26	166	38	36
Dec.	2	"	"	"	41	40	142	16	158	40	36
"	5	"	"	None	36	32	150	2	152	46	44
"	6	"	"	"	36	35	148	6	154	48	48
"	9	"	"	"	35	34	144	8	152	46	38
"	10	"	"	Little	35	38	148	20	168	48	44
"	11	"	"	"	36	34	140	22	162	52	32
"	12	"	"	"	36	40	136	16	152	40	28
		Means			50°	54°	145	38	183	36	33

MR. JEFFRIES: Let it be understood that my objection goes to the reading of all these tables during the period of 1901 and 1902.

MR. TODD: That is understood.

Grafton—Above Mouth of Illinois.

Chlorine	Oxygen Absorbed		Ammonia.		Nitrogen.		Organic ammonia by Kjeldahl process	Colonies—per cc.	Fermentation.		Coagulation of milk	Indol produced?
	Not filtered	Filtered	Free	Albuminoid	In nitrates	In nitrites			1-10 cc.	1 cc.		
1.80	7.68	6.88	0.06	0.42	0.16	None	0.68	Plate Liquefied.	No gas	No gas	18 hours	......
2.13	9.12	8.32	0.04	0.41	0.12	"	0.98	1,700	"	90%	24 hours	......
2.50	8.00	7.36	0.09	0.35	0.12	"	0.65	450	50%	No gas	"	......
2 13	7.68	5.60	0.06	0.44	1.20	"	0.53	1,750	No gas	"	"	......
2.13	7.04	6.40	0.00	0.42	0.14	Tr'ce	0.63	......	"	"	......	No.
2.50	8.16	6.56	0.08	0.45	0.12	None	0.98	Liquefied.	"	10%	......	"
2.13	8.32	6.56	0.07	0.46	0.06	"	0.72	250	"	No gas	......	"
1.90	6.56	6.56	0.07	0.40	0.06	"	0.92	360	......	......	......	......
1.80	8.00	4.96	0.07	0.41	0.08	Tr'ce	0.72	......	10%	10%	Slow	No.
1.60	7.20	5.92	0.06	0.37	None	"	0.52	700	10%	No gas	"	"
1.90	6.56	6.24	0.06	0.34	0.08	"	0.72	450	No gas	60%	24 hours	"
2.13	7.36	3.20	0.09	0.37	0.06	None	0.72	5,200	"	No gas	Slow	"
1.42	11.08	9.28	0.11	0.46	0.08	"	0.92	2,100	30%	5%	24 hours	"
1.42	7.68	7.04	0.06	0.44	Tr'ce	"	0.92	550	No gas	60%	20 hours	"
1.78	9.76	8.48	0.09	0.43	None	0.100	1.02	400	"	60%	"	"
......	......	......	......	......	......	......	......	Liquefied.	5%	50%	"	"
1.78	9.00	8.10	0.10	0.48	0.10	None	0.62	750	No gas	No gas	24 hours	"
2.13	10.40	5.12	0.10	0.42	0.10	"	0.62	700	"	50%	Rapid	"
2.18	9.92	9.60	0.11	0.45	None	"	0.82	300	10%	50%	Very slow	"
2.84	9.44	8.16	0.09	0.36	"	"	0.62	3,550	No gas	No gas	48 hours	"
2.13	7.04	5.92	0.09	0.35	"	"	0.80	600	15%	40%	Slow	"
2 13	8.64	5.92	0.10	0.36	"	"	0.80	450	5%	50%	"	"
2.84	6.40	5.92	0.06	0.43	0.08	"	0.80	350	60%	90%	"	"
2.48	6.40	5.60	0.09	0.35	None	"	1.30	350	No gas	No gas	Very slow	"
2.13	5.76	5.28	0.09	0.42	"	"	0.80	450	"	40%	14 hours	Yes.
1.06	......	......	0.06	0.31	"	0.025	1.50	100	40%	......	Slow	No.
2 48	7.68	6.08	0.06	0.36	"	None	0.70	450	No gas	100%	Very slow	"
Tr'ce	7.20	5.92	0.06	0.39	0.16	"	0.60	250	6%	... .	48 hours	"
0.71	6.56	6.56	0.05	0.36	0.12	"	0.70	2,200	No gas	5%	12 hours	"
1.06	7.20	6.56	0.06	0.36	None	"	0.70	1,960	"	No gas	24 hours	"
2.48	7.36	7.20	0.05	0.36	"	"	0.70	150	"	"	No coag.	"
1.78	7.20	6.72	0.07	0.36	"	"	0.72	Liquefied.	5%	"	12 hours	"
2.13	7.84	5.92	0.06	0.34	"	"	0.72	"	No gas	20%	Rapid	"
2.84	7.68	6.40	0.05	0.34	"	"	0.72	"	"	No gas	24 hours	"
1.42	7.36	5.76	0.05	0.31	0.04	"	0.52	"	"	"	Rapid	"
2.13	7.52	6.72	0.04	0.34	None	"	0.50	......	"	"	28 hours	"
Tr'ce	6.64	5.52	0.07	0.38	"	"	0.62	......	40%	20%	Rapid	"
1.88	7.84	6.53	0.07	0.39	0.06	0.004	0.74					

7027 THE WITNESS: I now read table No. 3, which gives the results of the analyses of the water of the Missouri river taken above the mouth of the Missouri river some 600 feet,

7028 TABLE III.—*Mouth of*

Date.	Color.	Odor.	Sediment.	TEMPERATURE.		SOLIDS.			LOSS ON IGNITION.	
				Water....	Air....	In solution	In suspension....	Total....	Not filtered.	Filtered....
1901 Sept. 17	Dark yellow......	None........	Clay.........			354	652	1006	82	36
" 24	"	Earthy	"	65°	63°	304	2506	2810	144	46
Oct. 10	"	None........	"	62	64	296	1690	1986	116	22
" 14	"	"	"	60	58	296	934	1230	78	28
" 15	"	"	"	60	70	280	870	1150	68	28
" 16	"	"	"	61	62	296	792	1088	88	24
" 17	"	"	"	60	59	306	746	1052	82	12
" 21	"	"	"	62	76	360	1062	1422	86	24
" 22	"	"	"	64	78	384	1316	1700	92	32
" 23	"	"	"	64	80	330	1508	1838	170	42
" 24	"	"	"	64	72	334	1462	1796	152	32
" 28	"	"	"	62	76	320	948	1268	80	16
" 29	"	"	"	64	76	362	872	1234	86	26
" 30	"	"	"	64	72	346	916	1262	72	14
" 31	"	"	"	64	64	354	1070	1424	56	22
Nov. 4	"	"	"	54	48	340	1038	1378	66	24
" 5	"	"	"	50	46	352	1088	1440	102	28
" 6	"	"	"	52	68	332	968	1300	78	30
" 7	"	"	"	52	50	336	932	1268	72	16
" 8	"	"	"	50	60	350	878	1228	56	24
" 11	"	"	"	54	74	356	1784	2140	58	22
" 12	"	"	"	52	50	396	1800	2196	114	10
" 13	"	"	"	52	60	369	1617	1986	20	12
" 14	"	"	"	50	50	411	1611	2022	104	12
" 15	"	"	"	46	40	344	1352	1696	54	26
" 18	"	"	"	44	67	328	1060	1388	84	16
" 19	"	"	"	44	46	322	914	1236	72	20
" 20	"	"	"	42	48	328	786	1114	90	40
" 21	"	"	"	42	50	350	740	1090	62	24
" 22	"	"	"	44	48	326	684	1010	60	22
" 25	"	"	"	44	48	338	638	976	60	18
" 26	"	"	"	44	48	388	584	972	102	72
" 27	"	"	"	44	44	340	608	948	46	28
" 28	"	"	"	42	42	362	600	962	84	36
" 29	"	"	"	44	58	362	532	894	74	30
Dec. 2	"	"	"	44	40	382	506	888	108	26
" 3	"	"	"	44	38	350	498	848	76	34
" 5	"	"	"	40	32	372	434	806	88	46
" 6	"	"	"	40	38	362	448	810	52	38
" 9	"	"	"	40	33	368	398	766	82	40
" 10	"	"	"	38	45	362	356	718	76	42
" 11	"	"	"	40	42	374	356	730	72	46
" 12	"	"	"	42	54	356	356	712	72	56
	Means.........	....	....	51°	56°	346	948	1294	82	29

7029 THE WITNESS: I now read table No. 4, which gives the results of the analyses of the water of the Illinois river taken above Grafton between February 24th, 1902 and March 18th, 1902.

I next read table No. 5, which gives the results of the analyses of the water of the Mississippi river taken above Grafton, between September 17th, 1901 and December 12th, 1901. This table is printed on one sheet.

The Missouri River.

Chlorine	Oxygen Absorbed.		Ammonia.		Nitrogen.		Organic ammonia by Kjeldahl process	Colonies—per cc.	Fermentation.		Coagulation of Milk.	Indol produced?
	Not filtered.	Filtered	Free	Albuminoid	In nitrate.	In nitrite.			1-10 cc.	1 cc.		
9.2	7.36	2.72	0.18	0.33	0.48	Tr'ce	0.73	Plate Liquefied.	20%	20%	Rapid	No
25.2	26.24	3.04	0.12	1.02	0.16	None	3.83	1,470	No gas	10%	"	"
10.3	12.00	3.68	0.04	0.92	0.14	"	2.32	....	20%	No gas	Slow	"
12.0	8.96	1.92	0.06	0.55	0.22	"	1.32	....	10%	10%	24 hours	"
10.6	9.76	4.32	0.08	0.61	0.36	"	1.52	1,100	90%	90%	24 "	"
12.8	8.48	2.56	0.03	0.50	0.14	Tr'ce	1.22	4,700	90%	50%	24 "	"
11.4	8.16	3.84	0.15	0.61	0.14	"	1.32	16,200	No gas	No gas	Slow	"
20.6	30.08	15.04	0.14	0.72	0.16	"	1.32	18,600	5%	30%	Rapid	Yes
9.9	11.52	4.48	0.14	0.76	0.24	None	2.72	6,800	5%	50%	12 hours	"
12.1	15.04	3.20	0.10	0.92	0.24	"	2.72	6,100	No gas	15%	Rapid	No
11.4	21.44	2.88	0.11	0.87	0.16	"	2.22	6,200	5%	10%	20 hours	"
13.5	13.12	2.24	0.12	0.61	0.10	"	2.02	1,400	40%	50%	Slow	Yes
14.9	10.40	4.00	0.16	0.58	0.08	"	1.28	5,300	20%	No gas	"	No
17.8	9.92	2.64	0.04	0.65	0.20	"	1.52	11,800	10%	5%	"	"
14.2	12.48	3.04	0.07	0.68	0.16	"	1.26	4,250	No gas	No gas	24 hours	"
12.8	11.68	3.36	0.08	0.55	0.20	Tr'ce	1.66	7,350	50%	20%	Rapid	Yes
14.9	8.64	2.88	0.13	0.56	0.28	"	1.82	....	20%	50%	24 hours	"
12.8	9.44	2.56	0.08	0.46	Tr'ce	"	1.42	18,100	10%	50%	Rapid	No
16.3	12.80	3.84	0.08	9.52	0.14	"	1.42	5,650	50%	10%	Slow	Yes
17.0	12.00	5.60	0.07	0.68	0.18	0.005	1.40	800	60%	40%	"	No
16.3	10.08	1.92	0.09	0.73	0.80	Tr'ce	1.40	14,200	5%	5%	24 hour	"
26.1	11.36	2.08	0.12	0.72	0.10	"	2.20	9,950	No gas	10%	Rapid	Yes
24.8	10.56	2.08	0.07	0.74	0.10	None	2.10	10,600	"	No gas	16 hours	"
17.0	13.44	2.88	0.11	0.95	0.08	"	3.0	4,700	80%	80%	18 hours	"
22.7	12.64	2.72	0.12	0.97	0.28	Tr'ce	2.20	2,400	60%	50%	Rapid.	"
14.2	10.88	2.72	0.14	0.81	0.12	0.005	2.20	2,850	No gas	No gas	16 hours	No
12.8	9.92	2.24	0.13	0.71	0.14	0.005	2.04	10,700	50%	20%	12 hours	Yes
12.8	8.00	3.20	0.10	0.64	None	Tr'ce	1.90	5,850	50%	40%	Rapid	"
7.1	8.80	2.72	0.10	0.61	"	"	1.50	Liquefied.	30%	50%	"	"
12.1	5.44	1.92	0.21	0.71	"	"	1.50	9,000	80%	40%	14 hours	"
16.3	7.52	3.04	0.10	0.51	0.32	"	1.50	15,800	10%	50%	12 "	"
9.2	6.72	4.32	0.10	0.58	None	None	1.10	9,400	5%	10%	Rapid	"
14.2	7.36	2.40	0.10	0.46	0.12	0.010	1.50	21,200	50%	40%	"	"
17.0	8.32	3.04	0.08	0.43	None	Tr'ce	1.34	18,050	20%	60%	"	"
14.2	6.56	3.04	0.09	0.35	"	"	1.10	4,750	....	40%	"	"
14.2	6.24	2.08	0.09	0.40	"	"	.90	1,350	....	10%	Slow	No
6.4	6.08	2.08	0.11	0.39	"	None	1.10	Liquefied.	....	30%	18 hours	Yes
16.3	5.28	2.72	0.10	0.35	0.10	"	1.12	"	20%	40%	Rapid	"
14.2	6.56	2.56	0.09	0.28	0.14	"	1.12	....	10%	10%	"	No
19.9	5.28	1.60	0.13	0.37	0.08	"	.72	....	40%	50%	"	Yes
17.8	4.96	2.24	0.13	0.86	0.12	"	.72	....	10%	10%	12 hours	No
11.4	6.24	3.52	0.11	0.30	None	"	.64	....	20%	40%	14 hours	Yes
12.8	4.32	1.44	0.11	0.31	"	Tr'ce	1.12	....	10%	50%	Rapid	"
14.9	10.28	3.17	0.10	0.60	0.13	0.0006	1.61					

above the mouth of the Illinois, between February 24th, 1902, and March 17th, 1902.

I now read table No. 6, which gives the results of the analyses of the waters of the Missouri river taken about 600 feet above the mouth of the Missouri in March, 1902,—these three tables being printed on one sheet:

TABLE IV.—*Mouth of the*

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on Ignition.	
					Water......	Air........	In solution.	In suspension.......	Total......	Not filtered	Filtered...
1902.											
Feb.	24	None		Little	34°	50°	253.2	6.4	259.6	30.0	31.2
"	25	"		None	34	55	252.8	0.4	253.2	45.6	46.8
"	26	Yellowish		Little	34	45	252.0	30.0	282.0	62.4	56.0
"	27	"		"	34	44	239.2	16.4	255.6	42.0	46.4
*Mar.	3	Dark		Muddy	35	40	208.8	504.8	713.6	72.0	42.8
* "	4	"		"	34	30	224.0	429.6	653.6	90.0	62.0
"	5	"		"	34	40	264.0	206.0	470.0	70.4	47.6
"	6	"		"	34	45	224.0	335.6	559.6	68.0	42.0
"	10	"		"	39	60	228.0	161.6	389.6	90.0	28.0
"	11	"		"	42	55	198.8	180.8	379.6	90.0	42.4
"	13	"		"	42	50	199.2	180.8	380.0	85.2	58.4
"	17	"		"	44	22	214.0	503.6	717.6	84.0	38.8
"	18	"		"	41	22	228.0	252.8	480.8	59.2	40.8
		Means			37°	43°	229.7	216.0	445.7	68.4	45.0

TABLE V.—*The Mississippi River—*

Date.		Color.	Odor.	Sediment.	Water	Air	In solution	In suspension	Total	Not filtered	Filtered
1902.											
Feb.	24	None		Nearly clear.	34°	50°	202.0	10.8	212.8	49.6	52.0
"	25	"		"	34	55	205.2	8.4	213.6	54.8	47.2
"	26	"		Clear	34	45	196.0	1.6	197.6	44.0	47.2
"	27	"		"	34	44	195.2	5.6	200.8	53.2	57.2
Mar.	3	Little		Turbid	34	40	196.0	43.6	239.6	30.0	48.0
"	4	"		"	33	30	194.8	35.6	230.4	45.6	60.8
"	5	"		"	34	40	198.4	22.6	221.0	34.0	50.4
"	6	"		"	34	45	190.0	23.0	213.0	42.0	56.0
"	10	Dark		Muddy	36	60	178.0	173.6	351.6	64.0	30.0
"	11	"		"	38	55	158.0	247.6	405.6	46.0	24.0
"	12	"		"	40	50	165.6	342.4	508.0	64.0	78.6
"	17	"		"	42	22	174.0	200.0	374.0	60.0	13.0
		Means			35°	45°	187.8	93.0	280.8	48.9	49.3

TABLE VI.—*Mouth of*

Date.		Color.	Odor.	Sediment.	Water	Air	In solution	In suspension	Total	Not filtered	Filtered
1902.											
Mar.	10	Yellow		Muddy	44°	64°	338.0	1184.0	1522.0	134.0	54.0
"	11	"		"	46	60	320.4	1211.6	1532.0	148.4	16.8
* "	12	"		"	48	48	301.6	1384.8	1686.4	164.8	43.6
"	13	"		"	50	60	384.0	1217.6	1601.6	158.0	122.0
"	18	"		"	48	42	346.0	1600.0	1946.0	505.2	63.6
"	19	"		"	46	50	306.0	1303.6	1609.6	150.0	56.0
"	20	"		"	48	64	228.0	1182.0	1410.0	116.4	45.6
"	21	"		"	48	62	210.4	1238.4	1448.8	111.2	26.4
		Means			47.2°	55.2°	304.3	1290.2	1594.5	186.0	54.0

Illinois River—Grafton.

Chlorine.......	Oxygen Absorbed.		Ammonia.		Nitrogen.		Organic ammonia by Kjeldahl process..	Colonies—per cc.....	Fermentation.		Coagulation of milk	Indol produced?....
	Not filtered	Filtered....	Free......	Albuminoid	In nitrates.	In nitrites.			1-10 cc.....	1 cc.......		
13.49	2.80	2.64	1.340	0.182	0.250	0.0	1.00	270	No gas	No gas	None....	No..
14.91	2.88	2.80	0.674	0.194	0.240	0.0	1.00	40	"	"	"	"
15.62	3.84	3.20	1.512	0.216	0.320	0.0	0.80	180	10%	....	24 hours.	"
13.49	3.04	2.96	1.500	0.168	0.200	Minute trace	1.00	....	20%	20%	28 hours.	"
12.78	12.80	6.00	1.592	0.744	0.200	0.0	2.40	1,040	No gas	No gas	20 hours.	"
11.20	10.00	4.64	1.624	0.704	0.200	0.0	2.40	500	5%	"	36 hours.	"
12.07	10.00	5.20	1.064	0.484	0.200	0.0	1.60	Plate Liqu'fi'd	80%	....	Rapid...	Yes..
11.36	10.40	5.00	1.612	0.564	0.220	0.0	2.00	280	No gas	No gas	24 hours.	No..
14.20	10.72	5.44	1.520	0.564	0.400	0.0	1.40	14,880	"	"	20 hours.	"
13.49	10.80	6.08	1.440	0.544	0.300	0.0	1.20	4,410	20%	20%	"	"
9.23	13.60	6.96	1.180	0.464	0.700	Trace........	1.40	4,200	50%	50%	16 hours.	"
8.52	14.80	4.72	0.740	0.544	0.800	Minute trace	1.00	550	20%	....	24 hours.	"
12.07	10.60	7.20	0.760	0.504	1.120	0.04	1.20	820	100%	100%	18 hours.	Yes..
12.49	8.96	4.88	1.344	0.452	0.398	0.008	1.40					

Grafton—above mouth of Illinois.

2.13	4.64	4.48	0.140	0.106	0.100	0.0	1.20	60	No gas	No gas	None....	No..
2.84	5.60	4.32	0.090	0.122	0.120	0.0	1.00	520	"	"	"	"
2.13	4.16	4.08	0.072	0.072	0.280	0·0	1.00	420	"	"	"	"
2.84	4.56	4.00	0.084	0.112	None	Minute trace	....	800	"	"	"	"
2.84	5.04	4.40	0.154	0.112	0.240	0.0	1.40	450	"	"	"	"
2.84	4.88	4.80	0.124	0.162	0.100	0.0	1.20	60	"	"	"	"
2.13	4.48	3.84	0.102	0.162	0.100	0.0	0.80	3,600	10%	....	Rapid...	Yes..
2.48	6.24	4.40	0.106	0.162	0.100	0 0	0.80	120	No gas	....	24 hours.	No..
2.13	8.30	7.12	0.370	0.472	1.700	0.0	1.60	12,400	"	No gas	24 hours.	"
2.24	6.88	4.80	0.540	0.702	1.000	0.0	1.60	4,350	"	"	14 hours.	"
2.84	16.00	7.00	0.600	0.064	0.640	Trace.......	2.00	7,040	30%	30%	24 hours.	Yes..
1.42	13.76	4.24	0.544	0.544	0.640	0.08	1.40	420	50%	....	24 hours.	"
2.45	7.00	4.84	0.244	0.293	0.479	0.008	1.24					

the Missouri River.

18.46	11.60	3.20	0.360	0.644	0.300	0.0	2.40	Plate Liquefied.	10%	....	18 hours.	Yes..
17.75	13.20	6.24	0.240	0.524	0.240	0.0	2.40	1,440	35%	....	16 hours.	No ..
19.88	15.60	4.88	0.232	0.664	0.300	Trace........	2.80	680	No gas	....	14 hours.	Yes..
17.75	17.20	5.20	0.344	0.684	0.400	"	3.60	42,160	60%	....	12 hours.	No ..
14.20	20.60	5.20	0.272	1.224	0.900	0.04	4.00	9,200	40%	....	20 hours.	Yes..
11.36	22.40	4.96	0.332	1.084	1.200	0.008	....	280	15%	....	16 hours.	"
7.81	18.40	4.40	0.312	1.084	1.200	0.020	3.00	500	30%	20%	20 hours.	"
8.52	18.00	5.60	0.268	0.884	0.800	0.020	3.00	160	30%	20%	18 hours.	"
14.46	17.15	4.96	0.295	0.849	0.675	0.011	3.27					

7031 Q. MR. TODD: Have you prepared from these tables of analytical data a table of averages?

A. I have.

Q. Was this table of averages prepared by yourself?

A. It was.

Q. Is it true and correct?

A. It is.

Q. Will you read the table of averages so prepared by you?

MR. JEFFRIES: We object to the reading of the tables of averages for the reason that the samples of water from which the analyses were made were not sufficient in number to enable any legal or competent conclusions to be drawn therefrom and for the further reason that in the analyses made by the witness, the question of volume of water, extent and source of pollution, of the various rivers, was not taken into consideration, and for the further reason that the samples from which the examinations were made were so taken as not to be comparable with each other.

MR. TODD: I suggest that the witness will not be called on for legal, but for chemical conclusions.

Q. MR. TODD: Does this table which you have prepared, show the averages for the spring and fall as based upon the tables which you have read?

A. It does; it is merely a compilation of the averages 7032 from the other tables.

Q. Will you read the table?

A. I now read this table of averages, from results of analyses of the waters of the Illinois, Mississippi and Missouri rivers, made in the fall of 1901, and the spring of 1902, showing solids in solution, solids in suspension; the loss on ignition in the filtered water, and the loss on ignition in the unfiltered water; the chlorine, oxygen absorption in unfiltered water, and oxygen absorption in filtered water; the free ammonia, and albuminoid ammonia; nitrogen in nitrates and nitrogen in nitrites, and the albuminoid ammonia shown by the Kjeldahl process; this all being printed on one sheet.

7033

	Illinois Fall	Mississippi Fall	Missouri Fall	Illinois Spring	Mississippi Spring	Missouri Spring
Solids in solution	229	145	346	220	186	304
Solids in suspension	52	39	948	216	93	1290
Loss on ignition, filtered	35	33	29	46	49	54
Loss on ignition, unfiltered	40	36	82	66	49	186
Chlorine	16.4	1.88	14.9	12.5	2.45	14.46
Oxygen absorbed, filtered	3.21	6.53	3.17	4.08	4.84	4.96
Oxygen absorbed, unfiltered	4.31	7.64	10.28	8.96	7.09	17.15
Free ammonia	0.236	0.07	0.10	1.344	0.244	0.295
Albuminoid ammonia	0.413	0.39	0.60	0.452	0.283	0.840
Nitrogen in nitrates	1.042	0.08	0.13	0.396	0.473	0.675
Nitrogen in nitrites	0.054	0.004	0.0006	0.002	0.003	0.011
Organic ammonia, Kjeldahl	0.81	0.74	1.61	1.46	1.24	3.27

7034 Q. MR. TODD: Professor, from this table of averages, what conclusions do you draw as to the relative pollutions of the Illinois river above Grafton, the Mississippi river above Gratfon, and the Missouri river, 600 feet above its mouth?

A. From a consideration of these several tables, I draw the following general conclusions:

That the organic condition of the Illinois river above Grafton, is very much better than the organic condition of the Missouri river above its mouth. This is shown by several factors. By the factor measuring the oxygen absorption, which for the Illinois river are for the unfiltered water, 4.31 parts per million, and for the filtered water, 3.21 parts per million. For the Missouri river, for the unfiltered water, 10.28 parts per million, and for the filtered 3.17 parts per million.

By the factor for the albuminoid ammonia, as measuring the substances of comparatively complex composition to be yet decomposed, 0.413 parts per million in the Illinois, as against .6 parts per million in the Missouri.

By the factor measuring the organic ammonia, as determined by the Kjeldahl process, which is .81 parts per million for the Illinois, as compared with 1.61 parts per million for the Missouri.

7035 As measured by the oxygen absorption, the Illinois river contains less organic matter above its mouth than does the Mississippi river.

As measured by the albuminoid ammonia, the Illinois river contains very nearly the amount of organic matter that is contained in the Mississippi river.

As measured by the organic ammonia determined by the Kjeldahl process, the amount in the Illinois river is not greatly different from that in the Mississippi river.

Considering the chemical reactions due to the living organic matter in the Illinois and the Missouri rivers, it is evident that the condition of the Illinois is very greatly superior to that of the Missouri, throughout the whole period. This is especially shown by the chemical determinations made to indicate the presence of those living organisms which decompose protein matters, with the production of indol. The reaction for indol is found at the mouth of the Illinois river above Grafton very rarely, while in the Missouri river 600 feet above its mouth, this reaction is extremely common, showing a very much greater number of the living organisms capable of bringing about this peculiar chemical decomposition in the Missouri river than are found in the Illinois river.

From the information obtained from the tests for the presence of those organisms, which have the power of breaking down carbo-hydrates, with the liberation of acid, 7036 which subsequently coagulates milk, it is likewise evident that the contamination in the Missouri river is very much greater than the contamination in the Illinois river through the same period. The number of acid forming organisms as disclosed by the results of the tests being greater in the Missouri than in the Illinois.

It also appears by a comparison of the tables in which a determination of the number of living organisms was made by the so-called colony count process, that the Missouri river shows a greater contamination than does the Illinois, through this same period. In its organic condition as indicated by these chemical tests which I have described as sometimes called bacterial, although they involve true chemical reactions, the Illinois river is as pure as the Mississippi at the point of junction of the Illinois with the Mississippi, and the Illinois river is very much purer than the Missouri at the point where the Missouri flows into the Mississippi.

When we turn to these results just given as applied to a comparison of the results for the fall of 1901, and when we turn to the results obtained in the spring of 1902, the same general conclusions follow. The indol reaction is more common in the Missouri river than it is in the Illinois.

7037 The purely chemical tests indicate the presence of a larger amount of organic matter in the Missouri river than is indicated in the Illinois.

Q. From your chemical analyses, is the Illinois river, during the period that this investigation was made, a more or less polluted stream than the Missouri for the same period?

MR. JEFFRIES: We object to the question because it is leading, and we object to the question further for the reason that any such comparison to be drawn by the witness with reference to the Missouri river, is incompetent, irrelevant and immaterial, and has no bearing on the issues in this case.

A. It is, beyond question, true, that at the period of this investigation the Illinois river at its mouth, was a much less contaminated stream than the Missouri river at its mouth.

Q. How did the Missouri river compare with the Mississippi river at the points where this investigation was made?

MR. JEFFRIES: Objected to for the same reasons.

A. As disclosed by the experiments described, the Missouri river is far more contaminated organically than the Mississippi at the points at which the samples analyzed were taken.

Q. Did you make any other analyses of waters aside from those you have already testified about, Professor?

A. I have.

7038 Q. What other waters have you analyzed in connection with this investigation?

A. I have examined the waters of the Kaw, and the Missouri rivers.

Q. Professor, are you acquainted with the Kaw river?

A. I am.

Q. To what extent are you acquainted with the river Kaw?

MR. JEFFRIES: I object to the question as immaterial.

A. I am familiar with the Kaw from its mouth for a distance of 100 miles or more west. I lived for a number of years on the Kaw, and have been on it at numerous points.

Q. At what points in the Kaw and the Missouri did you make this last investigation you are about to testify to?

MR. JEFFRIES: Objected to as immaterial.

A. This investigation was made in the Kaw at a point above its entrance into the Missouri; in the Missouri above Kansas City, and above also the confluence of the Kaw; in the Missouri below the entrance of the Kaw and finally in the Missouri below Kansas City.

Q. Who directed the location for the taking of samples?

A. I suggested and directed the locations.

Q. To whom?

A. To employes of the Sanitary District of Chicago,—Mr. Quinlan and Mr. Burke.

7039 Q. What instructions did you give to them?

A. I instructed those men to go to Kansas City with apparatus for collecting water, and collect a certain number of samples at these points which I have mentioned, in May, 1903.

Q. At each point how many samples were collected under your direction?

A. At each point I directed that nine samples be taken.

Q. In what manner?

A. That they be taken on three days, three samples on each day, a sample from the middle of each stream and from near the right and left banks, making a cross-section of three points

Q. Did you ever receive any samples from them?

A. I did.

Q. How were those samples marked, Professor?

A. Those samples were marked with cards placed in shipping envelopes similar to those which have been shown here already,—a shipping envelope containing the card being tied around the neck of the bottle in which the water was collected.

Q. How large were the bottles?

A. The bottles were gallon bottles.

Q. I show you 36 cards which have been offered as de-
7040 fendants' Exhibit 2, and ask you if these cards were the cards that accompanied the bottles of water which you analyzed?

A. These are the cards which accompanied the bottles.

Q. How did the bottles reach you?

A. The bottles were packed in shipping cases such as have been used in all previous examinations, and were sent by United States Express, to my laboratory at 2421 Dearborn street, Chicago.

Q. After the bottles arrived there, did you see Mr. Quinlan and Mr. Burke in your laboratory at any time inspecting the bottles?

A. I did.

Q. The bottles that you had there were the bottles that were collected by them?

A. They were the bottles which I shipped to them for the collection, which I prepared myself and shipped.

Q. And they were the bottles that had these cards on them?

A. They were.

MR. TODD: I will ask now to withdraw 35 of the 36 cards which are made defendants' Exhibit No. 2, and leave one card as a sample of the 36 cards, known as defendants' Exhibit No. 2, and ask that the one card be substituted for defendants' Exhibit No. 2, and offer the 35 cards remaining, for the inspection of counsel and if required, will offer them in evidence. 7041

MR. JEFFRIES: All of which is assented to, and I move to strike out the remaining card as an exhibit for the sole reason that it is incompetent, irrelevant and immaterial and has no bearing upon the issues involved in the case.

MR. TODD: I want to state that one of the purposes of introducing this evidence is to rebut the testimony given by Dr. Teichmann, as to the chlorine in the Kaw river, and upon that theory as well as others I claim the evidence is competent.

Q. After you received these samples of water, Professor, what analyses did you make—for the ascertainment of what organic constituents?

A. I used these waters for the determination of the amount of chlorine present.

Q. Did you make any other analyses of the water except that for chlorine?

A. No other special determinations.

Q. That was the purpose you had in view in selecting these samples, was it?

A. It was.

Q. Have you the volumes of the Kaw and the Missouri for this period?

7042 A. I have.

MR. JEFFRIES: Do you intend to ask him to give the volumes?

MR. TODD: Yes.

MR. JEFFRIES: I object to the witness answering the question unless he discloses the source of his information as to the volume of water in the respective rivers at this time.

Q. MR. TODD: Where did you get the volumes of the Kaw and the Missouri rivers for this period?

A. From the engineer of the United States Geographical Survey at Washington, by whom the gaugings are kept and reported.

MR. JEFFRIES:. I move to strike out the answer of the witness for the reason that he does not state that the information covers the volume of the water in the Kaw and the Missouri rivers at Kansas City, or at the places where the samples of water were taken.

Q. MR. TODD: At what point do these volumes apply, that you have?

A. For the Kaw, at the town of Lecompton, Kansas, and for the Missouri at a point a short distance above the city, where the gauge is read.

Q. Where is the town of Lecompton located?

A. Lecompton is a small town in Kansas on the Kaw,
7043 about forty miles above its mouth, no tributaries of any importance entering the Kaw below Lecompton; nothing but small creeks.

Q. To what periods do these volumes apply, Professor?

A. They apply to the period of examinations between May 20, and May 30th, 1903.

Q. Will you give the volumes of these rivers?

A. The volumes here are given in cubic feet per second.

For the Kaw,

May 24th,	51,000
May 25th,	49,600
May 26th,	39,100
May 27th,	63,500
May 28th,	72,200

The examinations do not proceed beyond those dates, so I will not read the other figures.

For the Missouri,

May, 22,	125,000
May 23rd,	145,000
May 24th,	184,000
May 25th,	198,000
May 26th,	226,000
May 27th,	242,000
May 28th,	310,000

Q. Cubic feet per second?

A. Cubic feet per second.

Q. Have you prepared a table of analyses for chlorine?

7044 A. I have.

Q. Made from these samples?

A. I have.

Q. Were these tables made by you?

A. They were.

Q. You have explained the method by which the chlorine test employed by you is made, have you not?

A. I have.

Q. Will you read the tables?

MR. JEFFRIES: Complainant objects to the reading of the results of such examinations into the record for the reason that it is incompetent, irrelevant and immaterial, and has no bearing upon the issues involved in this case.

7045

	1903. Date.	Right.	Middle.	Left.
Kaw, one and one-half miles above Kansas City, Kas.:				
	May 26,	9.94	10.65	10.29
	May 27,	10.15	9.58	9.94
	May 28,	8.52	9.22	9.10
Averages,		9.53	9.82	9.78

General average, 9.71.

	1903. Date.	Right.	Middle.	Left.
Missouri above Kansas City:				
	May 22,	9.94	12.75	8.97
	May 23,	10.65	14.20	10.08
	May 25,	10.28	9.95	9.20
Averages,		10.29	12.31	9.42
General average 10.67.				
Mo. River below mouth of the Kaw:				
	May 22,	11.72	11.52	9.60
	May 23,	11.40	12.80	10.66
	May 25,	9.58	12.07	9.37
Averages,		10.90	12.31	9.88
General average, 10.97.				

7046

	1903. Date.	Right.	Middle.	Left.
Missouri below Kansas City:				
	May 22,	12.78	16.33	10.65
	May 23,	10.66	12.80	11.71
	May 25,	12.42	12.07	11.40
Averages,		11.95	13.73	11.25
General average, 12.31.				

MR. JEFFRIES: Inasmuch as counsel for defendants admitted that this testimony was offered in rebuttal to the testimony of Dr. Teichmann, we move to strike out the table just read in evidence for the reason that it is not shown that the conditions of the Kaw river at the time of the taking of the samples for the discovery of chlorine, were the same as the conditions at the time the samples that Dr. Teichmann examined were taken, as to volume, local showers, freshets and weather conditions, and I move to strike out the tables just read for the further reason that they are incompetent, irrelevant and immaterial, and have no bearing upon the issues involved in this case, and that proof of pollution of the Missouri river at Kansas City and other points does not justify the turning of the sewage of

Chicago through the natural divide between the water-sheds
of Lake Michigan and the Mississippi river, into the Illi-
7047 nois river and thence into the Mississippi.

MR. TODD: I desire to suggest in reply to the objection, that counsel does not offer this evidence solely to rebut the testimony of Dr. Teichmann, in view of the fact that Dr. Teichmann made no chemical analyses of the Kaw, but drew conclusions in regard to the condition of the Kaw from official reports, and this evidence is offered for other purposes aside from that one purpose, but for that purpose alone the evidence woud be competent, if for no other.

MR. JEFFRIES: I move to strike out the suggestion of counsel for the reason that he does not disclose the purpose for which the testimony is offered, and inasmuch as he states it is offered for a particular purpose we move to strike it out because that purpose is not disclosed to the court.

Q. MR. TODD: Professor, have you a table of averages drawn from these analyses?

A. I have.

Q. Has that table been read into evidence?

A. It has.

Q. How does the chlorine in the Missouri river above Kansas City and the chlorine in the Kaw and the chlorine below Kansas City, and at Kansas City, compare from these tables?

MR. JEFFRIES: This question is objected to for the same
reason stated in the objection to the question referring to
7048 the introduction of the tables just read in evidence, and
for the reasons mentioned in the motion to strike the
tables from the record.

A. The averages drawn from these tables show a considerably larger figure for chlorine below Kansas City, than in the Kaw or in the Missouri above Kansas City. The excess of chlorine below Kansas City being more than can be accounted for by any addition from the Kaw, and showing the fact that a certain proportion must come from the stock yards industries, and the sewers of Kansas City.

Q. How does the volume of the Kaw, that is the amount of chlorine in the Kaw, compare with the volume of chlorine in the Missouri river before it empties into the Kaw, and what effect, if any, does the increased volume of water in the Missouri river have upon the waters of the Kaw river after the two waters are intermingled?

A. The volume of the Missouri river is very considerably greater than the volume of the Kaw throughout this period, and the amount of chlorine in the Kaw, taking its volume into consideration cannot act to increase the amount of chlorine in the Missouri above the figure given for the Missouri above Kansas City.

MR. JEFFRIES: I move to strike out the answer for 7049 the same reasons mentioned in the objection to the preceding question.

Q. MR. TODD: In your analyses of the waters of the Missouri river in 1902, did those analyses disclose high chlorines in the Missouri river?

A. Relatively high, yes.

Q. How did the chlorines in the Missouri river compare with the chlorines in the Mississippi river?

A. The chlorine in the Missouri river is always much higher than the chlorine in the Mississippi river.

Q. Can the chlorines in the Missouri river be accounted for as being attributed to the Kaw river at the mouth of the Missouri river?

MR. JEFFRIES: We object to the question for the reason that it is incompetent, irrelevant and immaterial, and for the further reason that the witness is not possessed of sufficient data upon which to base or express an opinion, and has not given such data in evidence.

A. The chlorine at the mouth of the Missouri river can be attributed only in part to the chlorine of the Kaw river, the tables showing that the additions from Kansas City is an important factor.

Q. How did the chlorines in the Missouri river above Kansas City compare with the chlorines in the Missouri river below Kansas City at the point where samples were taken?

A. The analyses show considerably less chlorine above 7050 Kansas City than below Kansas City, at the time the examinations were made.

MR. JEFFRIES: We move to strike out the answer and question for the reasons stated in the previous objection.

Q. MR. TODD: How did the chlorine below Kansas City compare with the chlorines in the Kaw?

A. The chlorine below Kansas City is greater, considerably greater than the chlorine in the Kaw.

MR. JEFFRIES: I move to strike out the question and answer for the reason that the witness has not shown himself possessed of sufficient data to base a proper chemical opinion upon that subject, and for the further reason that the witness himself did not make the proper number of analyses in order to determine with any degree of accuracy, the chemical chlorine constituents of the water so as to be able to make any reliable comparison between the waters of the Kaw and the Missouri river, below Kansas City.

Q. MR. TODD: From your analyses of the samples taken, what is your opinion as a chemist as to whether you had sufficient data to draw these conclusions?

A. It is my opinion that I have sufficient data to draw a fair conclusion in this case.

Q. Was that your opinion before you ordered the samples taken?

A. It was.

7051 Q. How did the chlorine below Kansas City compare with the chlorine in the Missouri river at its mouth, in the examinations as made by you in 1902?

MR. JEFFRIES: We object to the quesiton for the reason that the conditions under which the samples were taken are not shown to have been the same or shown to have been taken under conditions which would be comparable with each other, and we object to the question for the further reason that the evidence showing pollution of the Missouri river is not justification for the Sanitary District of Chicago polluting the waters of the Illinois river by the discharge of the sewage from Chicago into it.

A. It is not possible or profitable to make comparison here because the samples were not collected at the same time or under identical conditions.

Q. MR. TODD: Professor, as a chemist, and from your chemical knowledge as well as your chemical examinations made of the Illinois, Mississippi and Missouri rivers, what is your opinion as to whether any portion of the original organic matter of the sewage from Chicago finds its way into the intake tower of the water works of St. Louis?

A. From all the examinations I made of the Illinois river and its tributaries, it is my opinion that no part of the original organic matter leaving Chicago through the Sanitary 7052 canal, and finding its way into the Illinois river, can reach the mouth of the Illinois river, and much less the intake tower of the St. Louis Waterworks.

Q. Will you state whether or not in your opinion as a chemist and from your analyses of these waters, the Illinois and Mississippi and Missouri rivers, the water supply of St. Louis is contaminated, polluted or injured from a sanitary standpoint, by the Chicago drainage canal and the sewage emptied into it from the City of Chicago?

A. It is my belief that the sanitary condition of the water supply of St. Louis is not and cannot be injured by any pollution passing through the drainage canal from Chicago to the Illinois river and down.

Q. Is the volume of water going down the Illinois river greater or less than it was before the opening of the drainage canal?

A. The volume is now greater than it was before the opening of the drainage canal.

Q. What has been the effect of this greater volume of water in disposing of the sewage of Chicago?

A. As the sewage is disposed of in two general ways, practically, by dilution and by oxidation, or chemical destruc- 7053 tion through bacterial means—inasmuch as the volume of water is greatly increased, the diminution of the sewage for a given volume, per cubic centimeter, for example, or per liter, is necessarily less, and inasmuch as at the same time with this new dilution there is no decrease enforced in the bacterial activity throughout the channel, so there can be no decrease in the purification from those causes. We have remaining, the diminution of organic matter by dilution, making the final effect better rather than a worse condition of the river.

Q. Are you acquainted with the Illinois river in flood time?

A. I have seen the Illinois river several times in high water, in flood periods.

Q. What effect do the flood periods in the Illinois river have upon the river?

A. Well, the effect of very high water in the Illinois river is a complicated one. The floods carry into the river an immense amount of organic matter from all the tributaries and numerous living organisms or bacteria which are practically always associated with this organic matter. The floods in general, from the gathering up of this large amount of organic matter, have the effect of increasing the organic contamination, irrespective of any original contamination which may
7054 have been present. A further effect of these floods, inasmuch as the banks of the Illinois river are very low, is to spread an enormous volume of water over an area of many hundreds of thousands of acres, providing for the sedimentation and oxidation to a marked degree, of the matters carried by the waters at these periods. The conditions in the Illinois river because of the peculiar character of the banks, are unique in this respect. The overflow disposes in this manner of a vast amount of organic matter, which in a stream with high banks would have to be carried forward. The great overflow area provides numerous settling and purification basins in the Illinois river.

Q. If the increased waters at flood time, from the tributaries of the Illinois, and the Illinois itself, cause a large area of land to overflow along the Illinois river valley, what effect does this overflow have upon sedimentation and sewage from Chicago entering the Illinois river by way of the drainage canal?

A. Inasmuch as by far the largest volume of the water at flood time, leaves the natural channel of the Illinois river, and is distributed through a vast area of land, as a matter of necessity, any original sewage or remnants of sewage carried by this water must be in a like manner, so distributed and delivered into
7055 a condition for purification by sedimentation or oxidation.

Q. Are you acquainted with the physical character of the Illinois river as it exists today, and as it has existed for the last five or six years?

A. I am.

Q. Are you acquainted with the lakes between Chicago and Grafton on the Illinois river?

A. In a general way I am acquainted with those lakes, without being able to give their names. I know the locations where many of them are found.

Q. Are you acquainted with Lake Joliet?

A. I am.

Q. What effect has Lake Joliet upon the waters of the Desplaines river, after it receives the sewage discharged through the drainage canal?

A. Lake Joliet has the general effect of offering a large basin for oxidation, and has the effect of holding up the water to some extent, for that purpose.

Q. Is that true of all the lakes upon the Illinois river?

A. It is true for most of the lakes in a far greater degree than Lake Joliet, which is in a measure hemmed in and limited in extent. These lakes, extensions and widenings of the Illinois river below Henry and particularly below Peoria and
7056 the region around Havana, north and south of Havana,
and in fact for the whole region practically between Havana and Beardstown, these widenings or lakes in the river provide very important agencies in the disposition of organic matter at flood time, and also to some extent at the time of low water, because some of them communicate with the river at all periods.

Q. Do you know how many dams are on the Illinois river, along the Illinois and the Desplaines river, from Lockport to Grafton?

A. Yes, I think I can give the number there. To begin with the dam at the end of the main drainage channel, now known as the Beartrap Dam. We have also at the present time, I believe, two dams in Joliet, and a dam is also located at Henry, and another at a point below Pekin some distance, called Copperas Creek. Further down the river at La Grange is one at Kampsville, I believe. That's all.

Q. Are you acquainted with the dam at Marseilles?

A. I am not well acquainted with that. I recall having been once there. I left that out.

Q. What effect have these dams on the Illinois river in the way of acting as purification agencies?

A. These dams in the Illinois river are extremely important factors in holding up the water, retarding its rate of
7057 flow; distributing it over a wider area, and therefore of
importance in hastening general purification.

Q. In what way, Professor?

A. They are important because of the effect which I have mentioned, that they serve to distribute the water over a greater superficial area and retard its rate of flow.

Q. Now can you state whether or not from your chemical examination of the Mississippi river throughout the time of these examinations as testified to by you, that the Mississippi river at the chain of rocks,—at the Illinois shore opposite the chain of rocks, was a potable river and fitted for use for drinking and domestic purposes?

A. It is my belief that the Mississippi river is not at that point a potable stream, and fit for drinking purposes, household use.

Q. Was it a river furnishing a suitable supply of drinking water for domestic and drinking purposes prior to the opening of the drainage canal?

MR. JEFFRIES: I object to the question for the reason that the witness has not testified to any chemical analyses of the water of the Mississippi river made by him prior to the opening of the drainage canal.

A. The Mississippi river was not at any near period a suitable river for household use.

7058 Q. Have you analyzed the waters of the Mississippi prior to the opening of the drainage canal?

A. Yes, on several occasions, I made numerous analyses of the Mississippi in years back.

MR. JEFFRIES: I move to strike out the last question and answer for the reason that there was but one analysis of the Mississippi river made prior to the opening of the drainage canal, by this witness, and the witness has not yet disclosed any other analysis so made by him, the manner of the analysis or the manner of taking, or the number of analyses, or that he has possessed any sufficient data that is necessary in order to form a competent opinion on the subject, and for the further reason, I move to strike out the last question and answer,—that since the testimony is not competent or relevant to the issues involved in this case, and the condition of the water of the Mississippi river, whether potable or non-potable, does not offer or extend to Chicago the privilege or permission of discharging its sewage, by means of the Sanitary District of Chicago, into the Illinois river and thence into the Mississippi.

MR. TODD: Since the opening of the drainage canal, what has been the effect of the turning of the waters of Lake Michigan through the drainage canal into the Illinois river, upon the sanitary quality of the water in the Illinois river?

7059 A. Because of the addition of a large volume of Lake Michigan water to the canal water flowing down the Illinois, and because further, the increase in the amount of pure water, is very much in excess of the increase in the amount of sewage carried at the same time, the resultant effect is produced that the mouth of the Illinois river today, is in a far better sanitary condition than obtained before the drainage canal opened.

MR. JEFFRIES: I object to the answer and move to strike it out, on the ground that it is based upon analytical data prepared by the witness from samples of water taken from the Illinois river and that such samples were taken at various times without reference to local conditions, the volume of water, and taken in such a manner as not to be competent, and that in the analyses made by this witness, the volume of water was not considered a source of pollution and the extent of pollution was not considered as an element of the analyses.

MR. TODD: Taking into consideration all the knowledge that you have upon the question of the quality of the water of the Illinois river, has the sanitary condition of the water of the Illinois river been improved or damaged by the opening of the drainage canal?

MR. JEFFRIES: I object to the question for the reason that it does not include therein the element of the increased volume of pollution, and therefore the increased volume of 7060 pollution being discharged from the Illinois river at its mouth at Grafton into the Mississippi river.

Q. (Question repeated).

MR. JEFFRIES: And I object to it for the further reason that the answer to the question would be misleading and erroneous, and not applicable to the issues involved in the case.

MR. TODD: I would suggest that counsel cannot determine the sex of the child before it is born, and the answer itself will disclose whether it is misleading or not.

MR. JEFFRIES: In answer to the counsel for the defendants, I will submit that the witness has already produced the child.

A. Taking into consideration all the conditions which have been supposed, and especially the condition of the increased pollution I am still of the opinion that the sanitary condition of the water of the Illinois river at its mouth has been improved instead of injured by the increased flow through the drainage canal.

MR. TODD: Since the opening of the drainage canal, what is your opinion as to whether the waters of the Illinois river are more or less sanitary than the waters of the Missouri or the Mississippi rivers?

MR. JEFFRIES: I object to the question for the reason
7061 that the sanitary condition of the water in the Missouri river, or the Mississippi river above Grafton, has no bearing upon the vital issues in this case.

A. Beyond all possible question the sanitary condition of the Illinois river at its mouth is far superior to the Missouri river at its mouth, and not greatly different from the condition of the Mississippi river at a point where the Illinois and Mississippi rivers unite.

MR. JEFFRIES: I move to strike out the answer for the reason that the witness states that the condition of the water in the Mississippi river above Grafton is better than that of the Illinois river since the opening of the canal at Grafton, for the reason that the witness in his answer has not taken into consideration the increased volume of polluted water entering the Mississippi river at Grafton, from the Illinois river, therefore increasing the amount of pollution entering the intake at St. Louis.

Q. MR. TODD: What effect does the sewage discharged through the drainage canal have upon the waters of the Mississippi river and Missouri river at the chain of rocks?

A. As I have not made any analyses at the chain of rocks, the question ought to apply to some other point.

Q. Changing from the chain of rocks to the point where the Missouri and Mississippi rivers mingle, at the mouth
7062 of the Missouri?

MR. JEFFRIES: I object to the question for the reason that the evidence shows that samples from which examinations were made by this witness and upon which this opinion was based, were not so made as to be competent, and in the examination of samples of water taken from the various rivers, the extent and source of pollution of the various water, and the volume of water, were not considered by the witness.

A. As I have stated in my previous testimony, I believe the effect of the Chicago sewage is completely lost before the mouth of the Illinois river is reached, and therefore cannot be a factor in determining any pollution in the Mississippi or Missouri rivers.

Q. MR. TODD: Assume that the waters of the Illinois river in 1902 were emptied directly into the Missouri river at its mouth, before the Missouri river enters the Mississippi, or before the Illinois empties into the Mississippi, would the waters of the Illinois river pollute the waters of the Missouri river?

MR. JEFFRIES: I object to the question for the reason that it eliminates entirely the mixing and dilution of the waters of the Upper Mississippi.

A. No; on the contrary the water of the Missouri will
7063 contaminate the water of the Illinois, the water of the
Illinois being in a purer and better sanitary condition at
that time, than the water of the Missouri.

MR. TODD: Q. Professor, assume that 107 barrels of 40 gallons each of culture of bacillus prodigiosus, consisting of one thousand million bacilli per cubic centimeter as contained in said barrel, were deposited into the Chicago drainage canal at the town of Lemont on the afternoon and evening of the 6th day of November, 1901, during a period of from four to eight hours; assume further, that immediately after said barrels were emptied into the drainage canal at the point aforesaid, the laboratories established at Lockport, Joliet, Peoria and Grafton on the Illinois river; at the intake tower of the St. Louis waterworks at the chain of rocks, were notified, and that samples were collected at each of these places every hour of the day and night, for the purpose of bacteriological analyses for the ascertainment of these bacillus prodigiosus, and assume that at Lockport these hourly samples taken day and night, were taken from November 7th to November 25th, a period of eighteen days; the total number of samples taken being 432 or thereabouts. Assume that at Joliet these hourly samples taken day and night,

were taken from November the 7th to November the 25th, a period of eighteen days, the total number of samples being 432,
and assume that at Peoria these hourly samples taken
7064 day and night from November 8th to November 30th, a
period of 22 days, amounting to a total of 528, and assume that at Grafton these hourly samples were taken day and night from November 12th to December 15th, a period of 33 days, the total number amounting to 732, of which 384 were analyzed by Dr. Ravold, and assume that the total number of samples taken hourly day and night was 720, and assume that at the laboratory tap these hourly samples taken day and night from November 20th until March 1st, 1902, a period of 100 days, amounting to a total of 2400, and assume that the total number of samples analyzed at the different points for the period above mentioned was 5,304; and assume further that on December 4th, at 8:45 A. M., one bacterium-bacillus prodigiosus was found at the intake tower at the chain of rocks; assume that on December the 5th, at 9:00 A. M. one bacterium bacillus prodigiosus was found at the intake tower at the chain of rocks; assume that on December the 8th at midnight, one bacterium bacillus prodigiosus was found at the intake tower at the chain of rocks; assume that on December 6th, at 8:00 A. M., at Grafton one bacillus prodigiosus was found; assume that on December 7th at midnight at Grafton one bacillus prodigiosus was found; and assume further that these five organisms were all of the organisms of prodigiosus that were found in the examinations made
from Lockport to the intake tower at the chain of rocks,
7065 and the laboratory tap in the city of St. Louis, which
were made during the progress of this investigation as hereinbefore set forth; that at no time was there more than one bacterium found in each of these places. Assuming all of the facts as hereinbefore stated to be true, what is your opinion as to the value of this experiment as indicating the probable longevity of the typhoid bacillus as measured by the longevity of the bacillus prodigiosus, and the probability that a typhoid bacillus entering the drainage canal from the sewers of Chicago would ultimately find its way through the Desplaines and Illinois rivers to the town of Grafton?

MR. JEFFRIES: I object to the question for the reason that the witness is not a bacteriologist, or at least has not qualified as such, and for the further reason that the question assumes a fact not in evidence, or rather fails to assume all the facts of the investigation upon which the hypothesis is stated; particularly in this: that it assumes that every particle of each respective sample of water so examined was examined with a view of determining the presence of prodigiosus, when as a matter of fact, only one cubic centimeter of said water was so examined, and I object to the question further because the witness has not shown any knowledge or acquaintance with the bacilli prodigiosus, or the typhoid fever bacillus, and if he is possessed of such information, he has not stated it in evidence as a part of his professional experience.

7066 A. Considering the longevity of the typhoid bacillus as measured by the longevity of the bacillus prodigiosus, which consideration in no way involves a knowledge of bacteriology, but simply a knowledge of arithmetic as set forth in this question, I would say that the suppositions advanced in this question indicate that the longevity of the bacillus prodigiosus, and of the typhoid bacillus as compared with it, is so extremely slight as to make the probability of a germ of this character being able to survive a passage from the drainage canal to Grafton, so remote as to be entirely unworthy of consideration. This conclusion depends on certain calculations which I have made and which I will present. As the various data are given in terms of the metric system, it is necessary to make certain reductions, in order to be able to reach a proper comparison. First, it is necessary to determine the concentration of the germs in the canal water at the time when they were dumped from the barrels as supposed in the question. At this period the flow in the canal was almost exactly 235,000 cubic feet per minute, which I have reduced to liters by use of the factor 28.3 liters per cubic foot, which is almost the exact factor, giving 6,650,000 liters, very nearly, per minute. Reducing this number of minutes to hours I find that for four hours or 240 minutes assumed to be consumed in this addition of the bacteria to the water, a

7067 volume of water flowed equivalent to 1,596,000,000 liters or approximately 1,600,000,000 liters. As the calculations are finally based on the cubic centimeter rather than the liter, I have reduced this volume to cubic centimeters by multiplying

by 1,000, giving as the volume of this water in cubic centimeters, into which the substance from the barrels was dumped, 1,600,000,000,000, or expressed most accurately in the method now common among mathematicians, 1.6×10^{12}. This is the flow of the canal in cubic centimeters in four hours. I will say for the purposes of comparison it makes no difference whether we assume four hours or eight hours, as the same factor enters later into the calculation at the mouth of the river. We have next to consider from the assumptions of the question the number of bacteria mixed with this volume. 107 barrels, of forty gallons each, gives the amount of 4,280 gallons, which, when reduced to liters give us something over 16,000 liters, 16,017 and more liters, but in round numbers I will use 16,000 liters, or 16,000,000 cubic centimeters. The number of bacteria per cubic centimeter, according to the assumption of the question, was 1,000,000,000. The total number of bacteria then discharged would be the product of 1,000,000,000 per cubic centimeter, by the number of cubic centimeters, or 16,000,000 multiplied by 1,000,000,000, which multiplied out, gives us the number 16,000,000,000,000,000, or more accurately or definitely
7068 expressed, 1.6^{16}. We have therefore, as the number of bacteria
following the assumption of the question, which must have been thrown into the canal, 1.6^{16}, as given. As the number of cubic centimeters into which this number was thrown was given as 1.6^{12}, the quotient of one of these by the other, gives the concentration of ten at the fourth power, or ten thousand bacteria to the cubic centimeter, on the assumption that the mixing or dumping took place through a period of four hours. We have therefore as concentration, 10,000 to the cubic centimeter. Now supposing this wedge of water to pass down the river absolutely unchanged, and supposing further that no increase or decrease in this number of bacteria should follow by death or by any other means, it is simply a statement of fact to say that we should find 10,000 per cubic centimeter at some corresponding time, in some part of the river below, but admitting the fact that a change by dilution follows by taking up the water of the tributaries, and through the uneven flow of the water, the particles moving more rapidly in the center than along the sides of the stream, a certain dilution must be calculated, must be admitted as taking place in this

volume. From the fact that these samples were all found within a 4-day period, or rather these bacteria were all found in samples collected in a period of four days, as presented in the question, I have calculated this original volume of water as
7069 diluted with the volume of water which flows at the mouth of the river in a period of four days. On that assumption, a number of at least 200 should be found per cubic centimeter, for each cubic centimeter examined, on the assumption that no death or loss of these bacteria takes place anywhere in the course. As a matter of fact not 200 were found in one cubic centimeter, but a very large number of examinations had to be made to find a cubic centimeter in which there was one contained. It is evident that an enormous destruction of these organisms must take place between the point at which the bacteria were thrown in, and the mouth of the river where the examinations were made. The actual finding is not over one ten-thousandth of what should be expected from 107 barrels on the assumption that these organisms did not die out; that is, we find less than one ten-thousandth of the expected amount. If we consider a number less than 107 barrels as added, one barrel for example, the probability of any organism of this character reaching the mouth of the Illinois river is less than one chance in 1,000,000. If we consider one barrel, or one one-hundredth of a barrel as added, the chance of one of these organisms reaching the mouth of the river and being found in a cubic centimeter becomes correspondingly reduced. Therefore, without involving any question of bacteriology, but simply a question of calculation, it is evident that the probabilities of any number of bacteria
7070 in a given small volume, reaching the mouth of the Illinois river, is extremely remote and not one which can be practically or seriously considered.

MR. JEFFRIES: I move to strike out the answer of the witness because the witness says that it is altogether a mathematical calculation and if so, it is incompetent, and for the further reason that the witness says that there is a continual change in the volume of the water and in the water with which the prodigiosus would be mixed on its journey from the canal to Grafton, and that such changes are brought about by the rapidity of the current, the general conditions of the river with reference to low and high water and ordinary stages, without the witness having qualified as a hydraulic engineer, or without having sufficient information upon that subject to give the correct amount of dilution that will be thus brought about during the journey of the prodigiosus from the canal to Grafton, and that the volume indicating the dilution is not contained in the hypothetical question upon which the answer is based.

ADJOURNED until 2:30 P. M. same day.

7071 2:00 P. M., Tuesday, September 29, 1903. Parties met pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. JOHN H. LONG,

resumed the stand for further direct-examination by Mr. Todd, and testified as follows:

Q. Professor, assuming all the facts to be true in the foregoing hypothetical question which was first presented to you and assume that the longevity of a typhoid bacillus is measured by the longevity of a bacillus prodigiosus, what is your opinion as to the probability of a typhoid bacillus entering the drainage canal at Chicago, from the sewers of Chicago, surviving the journey down the Illinois river and Mississippi river to the intake tower at the chain of rocks at St. Louis, based upon all the facts contained in the foregoing hypothetical question?

A. Measuring the longevity of the typhoid bacillus by that of the bacillus prodigiosus, from the fact as stated in the question that in the large number of examinations made at Lockport and Joliet and Peoria, no prodigiosus bacteria were found at all, and from the further fact that at the mouth of the river and at the intake tower at the chain of rocks, and in the water 7072 supply of St. Louis, the small number mentioned were obtained, and none at all in a period before the fourth of December, and none after the 8th of December, the possibility is extremely remote, and it is practically improbable, that a typhoid bacillus with longevity and virility as measured by that of the bacillus prodigiosus, could ever survive the passage down the drainage canal and the Illinois river and enter the water supply of St. Louis.

MR. JEFFRIES: Now we move to strike out the answer for the reason that the witness is not a bacteriologist, or at least has not so qualified, and that without such knowledge or information on the part of the witness governing the bacterial changes and conditions which govern bacteria in water, controlled largely by changes in volume, in temperature and local conditions and local disturbances of the water, the witness cannot testify with any degree of accuracy, and whatever opinion he may have on the subject is ill-founded and can not be considered as legal or competent proof or evidence upon the issues in the case, and for the further reason that the essential facts covering the life history of typhoid fever bacilli and prodigiosus in running water and in stream, is not sufficiently set out and embodied in the hypothetical question propounded to the witness, and upon which the opinion of the witness is based.

7073

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Professor, you are a chemist by profession, are you?

A. That is my profession, yes.

Q. You have made a specialty, among other things, of sanitary chemistry, in the last twenty years, or more?

A. I have.

Q. You were connected, were you not, with investigations made of the character of the different waters, by the National Board of Health, in the early eighties?

A. I was not.

Q. Were you a member of the National Board of Health?

A. I was not, although I made some investigations which were contributed to their publication.

Q. What was the object of those investigations if you know?

A. The investigations which I made were on the question of impurities in the atmosphere; the measurement of organic matter in the air.

Q. Those were the investigations that you made?

A. Yes sir.

Q. Was your investigation confined solely to that character of investigation?

A. For the National Board of Health, or for their publication, yes.

7074 Q. Now so far as sanitary chemistry is concerned, what experience have you had outside of your connection with the State Board of Health of Illinois?

A. The greater part of the work I have done in the way of sanitary chemistry has been done in connection with the State Board of Health of Illinois, and with the department of health of the city of Chicago.

Q. Confined practically to those two propositions?

A. Yes?

Q. Have you given attention to physiological chemistry?

A. I have.

Q. To what extent?

A. Part of my duty is the teaching of physiological chemistry to the classes of the medical school of Northwestern University. I have given such instructions over twenty years, and during that time have carried out various investigations in the field of physiological chemistry.

Q. That is in connection with your school work?

A. In connection with my school work.

Q. You stated in your direct-examination professor, that you had made certain bacterial tests in connection with your study of the Illinois river?

A. Yes.

Q. That you have taken pains to distinguish from the bacterial tests proper?

7075 A. Yes.

Q. Now will you explain just how it was you make use of these bacterial tests in your regular practice in the sanitary analysis of water?

A. In my examination of water I have made no attempt whatever to go into the question of the identification of bacteria. That is a field calling for the work of a specialist in bacteriology, but inasmuch as certain changes or reactions of a purely chemical nature are brought about by bacteria, I have given some attention to the conditions of such reactions. Those are properly of a chemical rather than of a bacterial nature. Certain bacteria have the power of producing certain decompositions, which can also be produced by chemical means. For example, the decomposition of protein matters by bacteria are analagous in many cases to those by chemical reagents, and in such examinations as I have made I have confined my attention to these reactions in using what are sometimes called bacterial methods in water analysis.

Q. You say sometimes that you use it. Why is it, professor, that you don't always use it?

A. Well that is a question I couldn't answer off-hand. To begin with, I might answer this; that years ago I did not realize the importance of making such tests. These tests in general have been made only within comparatively recent years, 7076 and in the first examinations I made the advisability of including these bacterio-chemical reactions did not occur to me, but in all recent examinations I include these bacterio-chemical tests with the others.

Q. Is there any well defined and regular line of distinguishment between the chemical-bacterial tests and those that are purely bacterial?

A. No, it is fair to say that there is not any sharply marked line. Chemists make both tests. Make the tests called bacterio-chemical and the bacteriological. The border line is not very sharp between them.

Q. Then, practically speaking, you have made bacterial experiments or examinations?

A. I have made experiments in which the action of bacteria are concerned, but I consider them as chemical experiments; not bacterial.

Q. Which do you consider the more important, the chemical or the bacterial tests?

A. That I cannot say. I consider both tests of importance in such work, but it would be impossible to state which has the greater value. In some cases one might have, in other cases the other. In the present consideration it would be impossible to say to which line of investigation the greater weight should always be attached.

7077 Q. Then both should always be considered?

A. I think both lines of investigation should be considered, yes.

Q. Now your interpretation of these results to which you have testified, and the tables which you introduced and read into the record were altogether chemical, were they not?

A. No, I have in some cases—I cannot exactly specify which ones now,—in some cases I have drawn from the bacterial examinations also.

Q. You made no mention of that fact in the testimony at the time?

A. Yes, I have mentioned that fact several times, but I cannot turn back now,—or I cannot recall now just which instances.

Q. Were the bacterio-chemical tests that you made sufficient to draw conclusions based upon a bacterial knowledge of water?

A. That question is not put exactly in a clear way, so I can not answer it.

Q. Well, without reference to the chemical analyses?

A. In some cases that I now recall, the evidence of the bacterial examinations is sufficiently definite to lead to a definite conclusion without appeal to the results of the chemical analyses.

7078 Q. Now you say you recall certain instances?

A. Yes sir.

Q. Now will you state some of those instances?

A. For example, in comparison of the Missouri with the Illinois river in 1901, where the bacterial evidence is very strong that the Missouri river is a more contaminated stream than the Illinois.

Q. What do you mean by the bacterial evidence?

A. I mean the bacterio-chemical evidence as it appears from the purely chemical reactions, brought about by the microorganisms, the production of indol and the liberation of acid and the coagulation of milk.

Q. Now, can you determine from a chemical bacterial examination which you have just referred to, whether or not the pollution spoken of is sewage pollution or from other sources?

A. I cannot.

Q. Chemical bacterial tests then do not show the character of the pollution?

A. The chemical bacterial tests,—no, in a majority of cases not.

Q. Well, now, can you tell from your examination whether or not the bacteria which you discovered are harmless or not?

A. I cannot.

7079 Q. Now, is there a difference between the bacteria that are harmless, and that that are not?

A. I could answer that question only in general terms. That involves a consideration of the bacterial phenomena outside of my province, which I cannot go into.

Q. Then you are not a bacteriologist at all?

A. I am not a bacteriologist at all, and I can answer no questions involving expert bacteriological knowledge.

Q. Then from your chemical-bacterial analyses of the waters, how can you tell that the pollution is of such character as to make the water unhealthy or not potable?

A. That I have not stated,—that it is unhealthful at all, at any place.

Q. Well, how can you judge as to the character of the water from a sanitary standpoint, not being able to tell from the chemical-bacterial tests,—the character of the pollution?

A. The character of the pollution—that can be answered in a very simple manner. I do not consider any river water receiving organic matter or drainage of farms or towns, as at all suitable for drinking purposes directly. That is a general answer to that.

Q. So your testimony in chief upon the sanitary condition of the water was not altogether based upon the chemical and chemical-bacterial tests that you made of that water, but also in connection with your general opinion upon the sanitary condition of river water? 7080

A. In general, yes.

Q. What is the source, Professor, of the most objectionable contamination of river water?

A. Well, that is a complex question very difficult to answer in brief terms. The answer to that question would involve a theory as to the origin of diseases. I am not attempting to testify at all as to the origin of infectious diseases, and therefore cannot attempt to tell what is the most objectionable contamination in water. It calls for a kind of knowledge outside of my special province.

Q. Are you familiar with what is regarded generally by sanitarians as the most objectionable?

A. I am familiar with what is generally stated by sanitarians as the most objectionable addition to be made to river water.

Q. Now, do you concur in their opinion?

A. Yes, in a general way.

Q. Now, what is it?

A. That certain products of human excretion are the most objectionable substances in water for consumption, or certain products of animal excreta.

Q. What particular products of animal excreta are the most objectionable?

A. Well, that is not the question, I believe,—what par-
7081 ticular products are considered by sanitarians. I am tes-
tifying to what I know of the belief of others.

Q. You stated that you concurred in their opinion in a general way?

A. I did, in a general way, but I wish to state here, explicitly, that I am not giving an opinion as an etiologist or bacteriologist. I could say this, that from my education as a scientific man I may concur in general with their opinions without passing an opinion of my own on that subject.

Q. You consider the opinion of scientists upon this subject to comprise the field of both chemistry and bacteriology and epidemiology as being worthy of confidence and respect, do you not?

A. Yes, I think some scientists agree on the origin of diseases, and on such points in which they agree I should concur naturally with the belief held in general.

Q. Then the extent and scope of your scientific work has not been sufficient to enable you to state upon your own information and experience exactly what product of excreta is the most damaging?

A. No, sir, I would not pretend to state that from my own experience.

7082 Q. Then, not being able to state what product of excreta
is the most harmful, you are not able to—from your
training and knowledge as a scientist, to determine what source of pollution is the most harmful?

A. Yes, in general I am able to make such determination.

Q. Then how is that determination made and what is the most harmful source of pollution in water?

A. To answer the first part of the question, the determination is made by the general methods already outlined. The methods of chemical and bacterio-chemical analyses. The most harmful source of pollution is that coming from animal excreta.

Q. How do you measure that?

A. That is measured by the character of the refuse or matter thrown off in this excretion. It is measured by the large number of micro-organisms which may be detected by the chemical-bacterial tests, which I have described, and by the relatively large amounts of certain nitrogenous constituents recognized in the chemical tests.

Q. Now, from these chemical-bacterial tests how can you determine the origin of the bacteria?

A. There is no way of always determining sharply the origin of all the bacteria but where enormously great numbers are found in sewage products, from the known facts re-
7083 garding the production of these substances, the conclusion
is in general warranted as to where they come from.

Q. Then your opinion as to the origin is based practically upon your fore-knowledge of the source of the pollution rather than upon the chemical bacterial tests themselves?

A. That fore-knowledge or general fore-knowledge has to be taken into consideration in reaching a conclusion.

Q. Now, in making bacterio-chemical tests of water composed partly from that flowing from a swamp and partly from the sewage of some city, how would you determine the origin?

A. In most cases it would not be possible to determine the origin. After water flowing from a city or from the sewage of a city, has become considerably diluted, it would be practically impossible to sharply deterimne the exact origin.

Q. Are there any cases in which it can be determined?

A. Only sharply in the case of very strong, fresh solutions of either the sewage or the vegetable products, found from the decayed or vegetable matter.

Q. Is that usually by the bacterial tests or the chemical tests?

A. It is shown by both tests to some extent.

Q. Now, can you determine from the chemical-bacterial tests which is which?

A. Yes. The chemical-bacterial test would show in the
7084 gas or fermentation test a very large amount of carbohydrate decomposition, and would indicate a larger amount of the production of indol for the sewage, than for the extracts of purely vegetable origin.

Q. Now, that shows a general polluted condition, but does not show the specific character of pollution?

A. No, it does not disclose the exact specific character of the pollution.

Q. How, then, do you get the specific character of the pollution?

A. In the case of the vegetable extracts, from the known fact regarding the substances produced in the decay of vegetation, and from the reactions for oxygen consumption, and free and albuminoid ammonia, we can pretty safely infer the origin of such fresh extracts—vegetable extracts containing pre-eminently more bodies of the carbo-hydrate groups and the derivatives of carbo-hydrates in comparison with the extracts of animal origin. These extracts give rather marked re-actions with the permanganate solution and at the same time not very marked re-actions with the re-agents measuring the nitrogenous matters. So there is that peculiarity in the examination of the fresh substances which is of value in distinguishing between them, which does not appear to the same extent in the examination of the older substances.

7085 Q. Now, that is derived from the chemical test, and not from the chemical bacterial test?

A. Yes, that is concluded from chemical tests.

Q. Confining the answers to the chemical-bacterial tests?

A. In the chemical-bacterial tests, the extractive substances from vegetation being of this peculiar nature in the main, there is practically little for the bacteria of putrefaction to feed on and therefore these factors measured by putrefactive changes are less marked in the case of the vegetable extract than in the case of the animal extract.

Q. Now, assuming, Professor, that the water in the stream comes from a sewage polluted district, and also from a district not a swamp, but of a swampy character, how would you detect the source of pollution and differentiate the pollution so far as the source of pollution is concerned?

A. Well, it is not always possible to differentiate sharply in a case of that kind unless considerable is known of the character of the soil through which the swamp or swamp-like water flows. In general waters of that character show very much less chlorine than do waters affected or contaminated by sewage, and we are very often able, although not always sharply, to draw from a determination of the chlorine a conclusion as to
7086 the possible source of the water. In general, in these swamp waters or waters which have taken up the extracts of decaying vegetation, as I said a little while ago, there are products characteristic of carbo-hydrate rather than protein decomposition and the detection of these, or the measurement of these gives frequently a clew to the origin of the water. The carbo-hydrates themselves, the pentose bodies particularly, which make up a considerable part of the vegetable extracts of swamps and various acid substances which are also extracted, yield no nitrogen at all, therefore, in responding to the nitrogen tests, but they at the same time, absorb a very large amount of oxygen from permanganate or similar solutions; we have therefore that clew to the origin of the water which sometimes would lead to a correct conclusion, but I cannot say that it always does. It is not always possible to differentiate between two waters.

Q. Now, what other information do you use in chemical-bacterial tests to assist you in determining the source of pollution?

A. Well, the amount of nitrogen in different forms is usually, or should be determined. The nitrogen in nitrites, for example, seems to be more characteristic, and to be formed in larger amounts from the breaking down of the products of the animal rather than of a vegetable origin, for the simple reason as I have said, that the products of vegetable origin con-
7087 tain more characteristically carbo-hydrates and the acid products derived from carbo-hydrates, rather than proteins, and therefore in general there is less of the oxidation products of the proteins, finally formed in the vegetable extract.

Q. Is there any other element?

A. Well, these are the most important elements,—the ones usually considered.

Q. Well, now, what other information is necessary or desirable besides the chemical or bacterial elements,—the two combined, or together?

A. It is always desirable of course in drawing a conclusion from such examinations, chemically and bacteriologically, to have as much knowledge as possible of all the conditions that obtain in any stream in question,—all possible factors should be taken into consideration in reaching a conclusion.

Q. Now, what are the most important conditions of that stream?

A. Well, the character of the watershed—what is called the watershed, the tributaries in the watershed, the character of the water in these tributries, the abundance of salt deposits for example, as contributing to the main stream or the tributaries, and many factors of this kind which it is always desirable to have in reaching a final and fair conclusion.

7088 Q. Now, can a fair conclusion be reached without that information?

A. I think it would be unsafe in most cases to draw very sharp conclusions without more or less of this information.

Q. Specify, Professor, in detail the desired information for instance, that which is upon the watershed in question. Now, what do you mean by that? Specify in detail what is meant?

A. I mean the towns on the watershed, and the contribution of sewers in general from those towns; whether there are great industries and of what kinds, on the watershed, and the rate or character of the flow from the watershed. These I think, as it appears to me, are the most important points that should be known.

Q. Are they essential points to be considered?

A. I think these are all important in a way, yes, essential before drawing a full conclusion.

Q. What particular importance do you attribute to the number of people or the population living upon the watershed of the stream of water that is being examined or under consideration?

A. Well, on the assumption that this population drains into the stream we have a means of accounting for and estimating perhaps roughly, any large amount of organic matter which may be observed in the stream.

7089 Q. What do you mean by organic matter?

A. Well, I mean substances characterized by chemists as organic compounds, or compounds of carbon with oxygen and hydrogen and nitrogen in certain complex composition.

Q. Whether it be excreta or what not?

A. Whether it be excreta or products of industrial waste.

Q. What consideration would be given in these determinations, the fact that a large portion of the people upon the watershed reside in a city sewered into the stream and those living upon the watershed on farms and in towns having no sewers. In other words, distinguish the difference in the consideration that would be given those respective classes of people?

A. Well, that is a simple proposition. The population residing away from the stream or not sewering into the stream would have of course, comparatively little effect in contributing anything to that stream, while those sewered directly into the stream would have naturally very much more effect.

Q. Now, do you give consideration to those facts in expressing your opinion upon the pollution of streams

A. In any opinion that I have expressed here today, I have given attention of course, to that fact.

Q. Professor, state in as simple a way as possible so that 7090 an intelligent layman can understand just what you mean by organic pollution?

A. In broad terms, we can consider two kinds of pollution,—organic and inorganic contamination. The inorganic contamination or pollution, if it may be called such, being made up of what chemists call the inorganic or mineral salts which are the combination of the so-called metallic elements, sodium, potassium, calcium and magnesium mainly, and ammonium also, with the inorganic groups and elements described as chlorine and sulphuric acid, nitric acid, phosphoric acid, and carbonic acid in general, while the substances spoken of as organic or described by chemists as organic are combinations, usually complex, of carbon and hydrogen and oxygen or carbon, hydrogen oxygen and nitrogen, and occasionally carbon, hydrogen oxygen and nitrogen, with small amounts of sulphur or phosphorus,

these latter substances, these so called organic substances, being distinguished from the so-called inorganic substances, in general, by this fact, that they undergo generally decomposition relatively easier, and that by high heat, they all suffer destruction, while in general, the so-called mineral or inorganic substances are practically fixed, or unchanged, so far as any alteration in water takes place, and are not fundamentally altered by
7091 ordinary heat, the inorganic substances being distinguished from the organic substances by a very much greater degree of stability.

Q. State the source of nitrates, oxygen and nitrites in polluted waters?

A. Well, nitrates in polluted waters or in natural waters, come from the breaking down of more complex substances, containing nitrogen. All organic substances which contain nitrogen suffer very peculiar changes in soils and waters, whether they be natural substance or products of excretion. In some of the simpler cases these substances break down, yielding comparatively simpler organic bodies containing nitrogen. These in turn go further, yielding ammonia, for example, and also other substances, and by further stages of change which take place in waters with substances of either vegetable or animal origin, this ammonia undergoes oxidation through the agency of plant forms, bacteria in general, taking up oxygen, forming the inorganic substance known as nitrous acid, which, however, cannot exist in waters as a rule as such, but combined with mineral bodies, forming calcium nitrites, sodium nitrites, potassium nitrites. The nitrites in turn undergo oxidaton by takng up oxygen and form nitrates. The course of oxidation, however, does not always proceed in this way. There are times when the breaking up
7092 of the nitrogen compounds, goes so far as to leave free nitrogen, which goes back into the atmosphere instead of producing nitrites or nitrates, which remain in the water. This re-action seemingly depends on an excess of organic matter present when the substance yielding the nitrite or nitrate, which substance is generally ammonia, comes in contact with the organisms which bring about oxidation. This fact is of the very highest importance in determining the amount of nitrate which remains in the soil. For example, when a soil is treated with certain kinds of fertilizers which are highly ammoniacal, and

the fertilizers are added in the presence of a very great excess of organic matter, particularly carbo-hydrate, then the expected result does not follow in general, but the substance is decomposed and the nitrogen is lost in the air. That point is well established by agricultural investigations, and unquestionably this same thing takes place in streams, although it would be very difficult to show it other than by showing it in solutions. Nitrates and nitrites then are products of oxidation.

Q. Professor, have you been familiar with the sewerage system of Chicago since 1886?

A. Yes. I have been reasonably familiar with that system.

Q. Now, will you state the leading features of that system during the period since 1886? 7093

A. The leading features of the sewerage system of Chicago are these: Chicago is, roughly divided, or for all practical purposes, divided into three sections known as the North, West and South sides. Practically the whole of the west side, certainly everything which was regarded as the west side as far back as 1886, was sewered, where sewered at all—and most of it was—into the Chicago river, and that is the condition which remained and remains down to the present time so far as the West Side is concerned.

In the North side, many of the sewers then were led into the river, and a certain number also into the lake, which number, however, has been gradually decreased up to the present time, so that only a portion north of Fullerton avenue is led into the lake, and the others into the river.

On the south side, while to begin with, most of the sewers were led into the river, a certain number flowing from State street to the east, were led into the lake, but these down to 31st street and south, have been gradually retired. At the present time and for a couple of years, most of the South Side sewers have been led directly or indirectly into the river. South of 31st street, however, there is still the area bounded practically by State street, and further south by Wentworth avenue, where the sewers are led directly or indirectly into the lake. All west of that still into the river directly or indirectly. By indirectly I mean this: In most of the cases the sewers are all low level sewers, passing directly into the river, but some of the larger ones are pumped. For instance, the large 7094 sewer which is known as the Halsted Street sewer, which drains a considerable territory, is pumped in one part of its course, and it reaches the river indirectly.

Q. It is pumped into the river?

A. It is pumped into another sewer which flows into the river.

Q. Now, that is on the south side of the city?

A. Yes. On the west side, it goes into the river,—a large part of the North side and a good part of the south side. I have had, from my study of this question, the exact figures on that, but I think I have given the case near enough for practical purposes.

Q. Professor, explain the difference in the sewerage system of the Sanitary District of Chicago and that of the city of Chicago?

A. There is practically no difference, because practically the whole of Chicago is in the Sanitary District, the part outside having a very small population,—an extremely small population.

7095 Q. What population and what part?

A. Well, south of 73rd street, near the lake, there is a part of the city not included in the sanitary district, but the population is very small and farther south of this, I think it is to 88th street, there is a district, the population of which is in the city, and that is likewise very small. On the west side I believe practically everything is included in the sanitary district. So as far as any practical consideration is concerned, the sanitary district includes the sewerage of Chicago

Q. What is the population of the sanitary district as compared with the population of the city of Chicago?

A. That I cannot give you exactly, but there is not a very great amount.

Q. Several hundred thousand?

A. No, it could not be as much as that.

Q. As much as 100,000?

A. No, I would say not.

Q. Do you know anything about the Calumet District, Professor?

A. Yes, I am quite familiar with the Calumet District.

Q. How large is that and what is the population?

A. Well, the boundaries of the Calumet District are very
poorly defined; the Calumet District, however, in general, is a
territory south of Chicago proper, and drained by what is
7096 known as the Calumet river, a small and rather sluggish
stream which flows into Lake Michigan near South Chicago. That river drains in addition to a portion of Chicago a very considerable area in northern Indiana and Illinois, a farm area, swampy in character.

Q. The Calumet river empties into the lake?

A. Finally into the lake. Yes, there are several branches included in the Calumet.

Q. Is the Calumet district included in the Sanitary District?

A. At the present time it is not. That is, what is commonly recognized as the Sanitary District, but it is expetced that it will be included through recent action of the Legislature.

Q. It had been authorized by the Legislature?

A. I understand so, yes.

Q. Now, what additional population will that bring into the district?

A. Well, the additional population that this would bring into the district, including the whole region south of 31st street, I cannot give you distinctive figures, but if the whole territory, including this Calumet region were brought into the district it would add about 250,000 to the present population draining into the canal.

7097 Q. Is that district growing rapidly?

A. It is growing rapidly in a manufacturing way, but not as regards increase of population.

Q. Where do the people live now that work in the factories there?

A. The people live—many of them in parts of Chicago,—go down there by street cars. Some live in towns in that region, in Pullman, for example, in Kensington, West Pullman, South Chicago, and some across the line in Indiana, in Hammond.

Q. Now, are there any other contemplated annexations to the district?

A. Well, this of course I can testify to only from general information. It is expected to include sooner or later the district north of Chicago, so-called Evanston, or the North Shore district.

Q. Now, what is the population of that district?

A. Oh, I cannot give you that; I haven't that.

Q. That is outside of the limits of the city of Chicago?

A. That is outside the Chicago limits at the present time.

Q. State if you know, Professor, what portion of the population of the Chicago Sanitary District now drains into the lake and what portion into the Chicago river?

7098 A. Well, at the present time about one-fourth or perhaps
a little less than one-fourth of the population drains into the lake, and the rest into the river—three-fourths or a little above three-fourths, into the river.

Q. What is the population of the district now?

A. That I am unable to say exactly. The population is not far from 2,000,000,—somewhere in the neighborhood of 1,600,000 people drain into the river.

Q. Do you know how much of the sewered population drains into the branches of the river, and what portion into the river proper?

A. It is not possible to answer that question exactly. I have stated that about 1,600,000 of the population drain into the river. When I use the term river, I include the so-called north and south branches of the river,—the larger part of this draining into the several branches of the south fork of the river.

Q. Professor, how long a time is ordinarily taken by the sewage of Chicago to flow through the pipes from its source to the point of discharge into the Chicago river?

A. I have no data at hand from which I could answer that question. In general this statement can be made as a fair one, that because of the flat character of the city of Chicago, the time consumed in the flow of sewage through the sewers is
7099 comparatively large, as compared with the time in most
of our American cities; the sewage remains a comparatively long time in these sewers.

Q. Now, Professor, you stated in your testimony in chief that you had made frequent examinations and inspections of the Chicago river in 1886 to 1891?

A. Yes.

Q. Please state what the general conditions have been at the times of your examination, and especially with reference to the changes which have occurred in the river during that time?

A. In general the condition of the Chicago river in this period from 1886 to 1891, has been bad. It has been foul, and there have been perhaps two general kinds of changes taking place here. There has been an increasing amount in general, of sewage going into the river, and an increasing amount from the population, and an increasing amount probably from the stock yards. In my testimony I explained that while there has been an increase in general in the number of cattle slaughtered at the stock yards, and consequently in the amount of filth produced, there has been at the same time an increasing effort made to retain this filth in the stock yards because of its commercial value, so that it is impossible to say whether much more 7100 or much less has found its way into the river. But this in general may be stated as now true, that whereas in the former conditions, rather large amounts of insoluble substances, or floating substances found their way into the river, at the present time practically only that escapes which cannot be precipitated or separated by pressure, or by retarding the flow by means of weirs or dams in the sewers. In general, those extractive matters only which are not easily retained are now allowed to escape from the stock yards. Practically all of the fats and insoluble proteids are retained because of their commercial value for fertilizers or other purposes. It would be difficult to say at the present time whether there is more or less actual matter coming from the stock yards than was the case some years ago.

Q. What, Professor, was the condition of the current or flow of the river during that period—the Chicago river I have reference to.

A. The flow of the Chicago river was somewhat uncertain. Still, in general, it was to the west and south. That is this was maintained by means of the pumps at Bridgeport. In flood time, at the time of heavy rains, the flow was very often reversed, and went toward the lake. Sometimes the condition appeared practically stationary, no current could be observed. At other times it was perceptibly more to the south; and at still other times, to the lake.

7101 Q. That reversal in the current occurred at intervals, did it not?

A. That occurred at intervals of heavy rains. Of course in the main the flow was through the canal. It was south and west. At times of heavy storm for a day or so perhaps, 24 to 48 hours at a time, the current might be in the opposite direction.

Q. That has not occurred since 1900?

A. No. Subsequent to 1900, the flow has been to the west and south, and not out into the lake.

Q. Now, how was it from 1891 up to 1900?

A. At several periods of short duration each, the flow was out toward the lake. In the rainy season of 1892, for example, there were a number of days where the flow was toward the lake.

Q. How far did the water from the river extend into the lake during these periods of reversal?

A. That I cannot say. It is impossible to estimate for this reason: those periods were periods of storm, and while the river carried dirty water into the lake, and while it might be supposed that from the extent of this dark colored water, the distance to which the river extended could be determined, that is not the case. The storms which produced the high water in general had the effect of stirring up the sediments in the bottom
7102 of the lake, producing a degree of turbidity which masked the effects of the river, so the limits could not be determined with any accuracy.

Q. Did you ever make any analyses of the water at the mouth of the river and in the lake, after these reversals?

A. At the mouth of the river?

Q. At the mouth of the river?

A. No, not directly at the mouth of the river.

Q. Or elsewhere?

A. I have made some analyses in the lake, that is, of water taken from the lake, and from some of the hydrants, at this time.

Q. How near the mouth of the river were those samples taken from the lake?

A. I cannot state that fact, of the distance exactly now, but to the best of my recollection, about a mile from the mouth of the river, and up and down the shore.

Q. Now, Professor, during this period from 1886 down to

January, 1900, you would call the Chicago river a very foul and contaminated water, would you not?

A. Yes, sir, Chicago river would be considered a very foul water.

Q. Now, that is true of the south branch of the river yet, is it not?

7103 A. Not exactly, it depends upon what you understand by the south branch. Will you explain to me what you mean by the South Branch?

Q. Well, south of Bridgeport?

A. You mean, probably, what we speak of there as the south fork of the south branch.

Q. Yes, the south fork?

A. Yes, at the present time the south fork of the south branch is rather foul.

Q. Very foul?

A. It is a pretty foul stream, yes.

Q. Now, how about the north fork?

A. The north fork is in general in very much better condition than the south fork of the south branch.

Q. Professor, do you know the population from which the sewage drained into the lake in 1886?

A. No, I cannot give you that.

Q. Can you give the population that drained into the river during that period?

A. I can only say in general that the larger part by far, of the population drained into the river, but I have no data from which I can give you the proportion of those draining into the lake and into the river at that period.

Q. How often did you conduct a series of examinations 7104 of the water of Lake Michigan, from 1886, down through the next succeeding seventeen years, or sixteen years?

A. From 1886 down my examinations were not as numerous as they were before 1886. The longest series of examinations I made was beginning with 1885, but I made occasional examinations down to about 1900, and since then I have made, during the progress of this investigation, some more.

Q. Are those results published anywhere?

A. Those results were all published, that is, by far the greater number of the recent ones in the reports of the Illinois State Board of Health already considered here.

Q. From your chemical analyses of the water of Lake Michigan during this period, what was the nature and character and source of the pollution of the water of the lake that you examined?

A. Well, from my various examinations I should conclude that the substances going into the lake came from the Chicago river, or the sewers leading directly into the lake.

Q. Did you conclude that any of it came from the Chicago river itself?

A. Yes, at the time of flood water which I have spoken of.

Q. How was that proportion shown in the analyses?

A. It was shown more especially by the increase of the
7105 amount of chlorine, and also by free ammonia and by
albuminoid ammonia, but not to any very marked degree by the oxygen consumption test. The chlorine is perhaps the best indication of additional substances from the sewers.

Q. What increase in those constituents did you find over and above those that are naturally present in lake water?

A. The chlorine has been slightly increased to the extent of about one-half a part per million, since the beginning of my investigations, one-half a part per million. The free ammonia is occasionally increased. At times, free ammonia has not been measurable by our ordinary tests, as we make them; expressed in the usual way, as .00; that is, using two places of decimals. At times when there is low recordable free ammonia, and it has been found since those earlier years, up to .05 and even more, but it has not always been certain that this increase has come from the lake proper. The evidence was that it very frequently came from nearer shore, or from the city itself.

Q. At what points or places in the lake did these evidences of pollution exist?

A. The waters taken at the Lake View tunnel, Chicago Avenue tunnel, the Four Mile tunnel and from the Hyde Park
tunnel, that is, from the four main supplies of the city
7106 have shown a slight increase in these factors. At times
there has been apparently a very considerable increase in these factors, and false conclusions have been drawn from obser-

vations made at those times. It is now well known that there have been several periods when the water was assumed to come through the tunnels when it was pumped from very near the shore. For example, in 1892, when very erroneous and widespread conclusions were published regarding the source of typhoid fever in Chicago, when it was assumed that the waters were all drawn from the long tunnels, it is now well known that a large part of the water used on the North side was pumped from a so-called emergency tunnel, extending out four or five hundred feet in the lake and ending within the break-water. The engineers, anxious to make a record of economy in use of coal, drew from the short tunnel, delivering a very contaminated supply, and the epidemiologists, seeing the results of this contamination, concluded that the supply from several miles out was badly polluted.

At a much later period, which has likewise been very generally discussed, it is known that water has been drawn from sewers in Chicago at frequent intervals. In the matter of discussion, why, the mortality for certain diseases should be apparently greater in a part of the city which is furnished with the best water supply, this increased mortality having
7107 been apparent through a great many years, certain pronounced conclusions were drawn from observations to the detriment of the reputation of the water supplied from the long tunnels. It has since been discovered that owing to very faulty construction in the pumping station drawing water for one of our supplies, that at frequent intervals in the last thirteen or fourteen years water has been drawn not from the tunnel as supposed, but from the overflow of a sewer into a well in the waterworks, the sewer discharging as much as a volume of ten inches or twice ten inches into the pumping well for hours at a time.

I mention this fact because it is to illustrate that it is not always best to draw a definite conclusion from the result of analyses of the Chicago water which came through the taps. The location of the pumping station which I refer to was on the west side, drawing water from the so-called Four Mile tunnel—the Harrison Street station.

Q. How do you associate typhoid fever with polluted water?

A. I do not associate it. I am simply speaking of the association which others have made.

Q. So in your last answer you said simply what others say rather than what you say yourself?

7108 A. I state the conclusion which others have drawn from the apparent conditions.

Q. How far out into the lake do these different tunnels extend?

A. The most northerly one of these tunnels, the so-called Lake View tunnel, extends out about a mile, practically a mile. The so-called Carter Harrison crib supplies water through a tunnel about four miles in length. The oldest of the tunnels is the so-called Chicago Avenue tunnel, which is about two miles out. Opposite about Twelfth or Fourteenth street on the South Side another tunnel extends into the lake about four miles, and that crib is usually spoken of as the Four Mile Crib, while in the southern part of the city another tunnel commonly spoken of as the Hyde Park tunnel also extends out about two miles. I think I have stated for the Lake View tunnel a mile. It is over that. It is two miles. We have two tunnels extending out approximately four miles and two tunnels extending out practically two miles.

Q. What, from your analyses, is the chemical condition or the constituents of the water at the mouth of these tunnels?

A. You mean in the lake where they take the water?

Q. In the lake?

A. I have no large number of analyses made there. Some years ago, since 1890, I made some collections in the lake,
7109 two and four miles out, at about the location of some of these tunnels. At that time the water was very good at the tunnels themselves, that is, no pollution measured in the ordinary terms, could be recorded; no appreciable difference between the water there and the water taken six or eight miles out. I made certain determinations of that water, but since then I have made no collections out in the lake, so I have no data to answer your question further.

Q. The water at these points remained generally the same, or was there a change in the chemical constituents of the water?

A. The water at these points is subject to some changes on account of high winds, particularly. At the time of high wind the lake becomes extremely rough, and there is always more or less sediment washed into the water, stirred up in the water, even as far out as the intake of the two four mile tunnels. The water shows then some change in certain of the determinations.

Q. What effect does the stirring up of the sediments by the wind have upon the chemical analyses?

A. It has the effect of increasing the organic matter as measured by the oxygen consumption and the albuminoid ammonia, not very greatly, but there is an appreciable increase.

Q. How great?

7110 A. The albuminoid ammonia as measured quite far out in the lake is ordinarily about this: .07. It may increase at time of high wind to .09 or even .1. I am referring to the conditions through the long tunnels. The oxygen consumption as measured by the Kubel acid test is usually about one or below one part per million. It may increase to one and one-half parts per million in time of high wind.

Q. How about the nitrites in the river?

A. The nitrites and nitrates are practically always absent in Lake Michigan. Occasionally we find traces of each, but the traces are so extremely minute as to be beyond any accurate estimation.

Q. Now as to the character of the water?

A. As to its appearance, you mean?

Q. Its general appearance and its general character?

A. At time of high wind the water appears somewhat turbid, a very large amount of this turbidity, however, being certainly mineral origin, which I should explain. Owing to the building of parks east of the city in the last eight or ten years perhaps, I am not very sure of that time, but for a number of years back,—a very large amount of substance has been dumped there,—a very large amount of clay from the construction of a tunnel under the city has been dumped into
7111 the lake. At one time, and perhaps at the present time, in building one of the parks a large amount of street sweepings have been dumped into the lake, into the lake at a point largely enclosed by a breakwater, but not completely enclosed. A considerable part of this matter has gradually washed out along the bed of the lake. The tests which I mentioned

indicate the presence of this clay substance which I think is mainly responsible for the opalescent condition which is very frequently observed now.

Q. Was it formerly observed?

A. In former years not. In my earlier examinations of the water of Lake Michigan, the water was very clear most of the time.

Q. Not always, however?

A. No, not always. Occasionally it was somewhat turbid, but through the greater part of the time it was practically clear.

Q. Now how far are these tunnels from the mouth of the Chicago river with reference to the end of the tunnel located out in the lake?

A. The intake of the Chicago Avenue tunnel is the nearest to the mouth of the Chicago river, and is approximately, I
should say, two and a half miles from the mouth of the
7112 river. The entrance to the intake of the Four Mile tun-
nel is probably four and a half miles from the mouth of the river. The entrance of the Hyde Park intake is seven or eight miles from the mouth of the river, and the entrance of the Lake View tunnel intake is probably five miles from the mouth of the river. These are only estimates.

Q. What do you say as to the water at these four respective tunnels or intakes being potable water?

A. The water at the intakes at the entrance of these tunnels I consider in the main, generally potable.

Q. Do you consider it absolutely safe for drinking purposes at all times?

A. Well, it would be hardly fair to say that it should be so considered at all times.

Q. Now in making the statement as to the potability of the water, do you take into consideration only the results of your chemical analyses or do you combine these results with the experience of the people living in Chicago and using the water?

A. In reaching this conclusion I consider my own analyses. I depend to some extent also on the opinions of those who are making investigations in other lines, bacterial tests proper. They have some weight in influencing me.

Q. Now what is that opinion and results of scientists
7113 making examinations along other lines. State plainly
what that is that you take into consideration?

A. Well, as I said in my answer, I considered my own results there, but have been influenced to some extent by the opinions advanced by others, who are making what are called bacterial tests proper. I will say here that there is considerable disagreement among scientists as to the conclusions which should be drawn from those tests. I am not a bacteriologist and perhaps should not pass on the merits of their conclusions.

Q. Here is what I want to get into the record, is what are those conclusions of other scientists upon which you in part base your opinion, that is it?

A. Some of the scientific men who have made examinations in Chicago of the lake water, have considered from the results of their examinations, that the water is frequently bacterially contaminated, and therefore they object to its use.

Q. Now, do you take into consideration in passing judgment upon that water, its effect upon the people who use it?

MR. TODD: I want to interpose an objection to this line of cross-examination as it is not proper cross-examination of anything brought out in chief.

MR. JEFFRIES: I suggest that the quality of the water
of Lake Michigan was brought out on direct-examination
7114 and, if not, it is competent at any time for the purpose
of showing that the water discharged by the Sanitary District into the Desplaines river at Bear Trap Dam, is polluted water and not free of contamination.

Q. (Last question read).

A. I will have to answer that question this way. Inasmuch as it is practically impossible to determine the effect of the real lake Michigan water on the people who are using it, or supposed to be using it, I am inclined to depend very little on the stated effect. So little dependence do I place on the statements of the epidemiologists and etiologists that I use and have
used, without boiling, Lake Michigan water for twenty
7115 years.

Q. Did you ever have typhoid fever?

A. Never, sir, and don't expect to.

Q. Have any steps been taken by the Health Department of the city of Chicago or by the State Board of Health of the State of Illinois, to determine the effect of the water of Lake Michigan upon the people using it for domestic and drinking purposes, and have you ever been associated with any such steps or endeavors?

A. I cannot testify directly as to that. I am not connected with any such examination for the city or for the state.

Q. Well, have you ever been?

A. I have not.

Q. Well do you know of any such steps being taken?

A. I know that attempts have been made to connect the character of the water, with the appearance—

Q. Then you discredit the reliability of the effect of the water upon people who use it as being any indication whatever of the sanitary condition of the water?

A. No, that is not what I said. I discredit the assumed effect of the Michigan Lake water on the people of Chicago, since it has been determined that many of the conclusions have been drawn from, not lake water, but from the sewer water, water pumped almost directly from a sewer. The most weighty and unsound conclusions ever drawn were drawn from water collected in that way. 7116

ADJOURNED until 10:00 A. M., Wednesday, September 30th, 1903.

7117 10:00 A. M., Wednesday, September 30th, 1903. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. JOHN H. LONG,

resumed the stand for further cross-examination by Mr. Jeffries and testified as follows:

Q. Professor, do you recognize the difference between a polluted water and an infected water?

A. Such a difference is made.

Q. Is it chemically made?

A. No.

Q. Well, in what way is it made?

A. The distinction usually made at the present time is that polluted water is one which may contain foreign substances,—substances foreign to the water, while infected water is one which contains or is assumed to contain the elements of disease, or the elements which produce infection or disease.

Q. Now then, state briefly, professor, the sources of pollution in water and the sources of infection in water?

7118 A. I have already stated the general sources of pollution in water. The addition to the water of trade wastes, household wastes, sewage, and practically everything which does not belong in a normal water. The sources of infection I can speak of only in a general way, as I am not an etiologist, a bacteriologist nor an epidemiologist. Infections are supposed by those who claim to have knowledge on that subject, to come from so-called pathogenic bacteria, about which I am not testifying.

Q. And that, as solely to the infection of the water?

A. Yes.

Q. Then what does infected water mean to you as a chemist?

A. As a chemist really, in the limited sense, infected water has no meaning to me.

Q. Now as a sanitarian, what effect has it?

A. As a sanitarian of course I should object to the use of the infected water.

Q. Now then, how do you differentiate the infection from a sanitary standpoint from that of the chemist,—how do you differentiate between the two?

A. Well, as a chemist I would not speak at all of infection.

Q. And you haven't considered that anywhere in your analyses?

A. I have been very careful not to go into a province which is outside of my line of inquiry.

7119 Q. So then, from your chemical analyses you have been unable to determine the presence of infected matter in the water?

A. That is true. I have not attempted to.

Q. That does not necessarily mean that the infection is not there?

A. Just make that a little bit plainer.

Q. Well, the fact that your chemical analyses did not disclose infected matter in tthe water, does not necessarily mean that no such infection is contained in the water that you have analyzed?

A. Certainly not.

Q. Professor, are all pollutions equally dangerous?

A. No, in general it would be safe to say not.

Q. Of what benefit then is the chemical analysis of the water which you have examined, and which is represented by the tables which you have introduced in evidence here, in deriving knowledge as to the sanitary condition—or information as to the sanitary condition of the water?

A. Well, this chemical knowledge, combined with the knowledge of the origin and sources of the waters, in question, permits a comparison to be made between the different waters as to the amount of their pollution. The work is of comparative value.

Q. And not infection?

7120 A. I have not gone into the question of infection at all, at any time.

Q. Then from the analyses that you have made, you cannot, as I understand you to say,—you cannot determine whether infection is in the water or not?

A. I cannot; I never attempted to.

Q. Then as a chemist any conclusions as to the sanitary condition of the water from the chemical analyses that were introduced by the tables here, would be unreliable, would it not, so far as infection is concerned?

A. That does not follow, because we must call upon our practical knowledge and practical experience regarding the sources of water, as we know that infection in the general sense of the term cannot and does not take place in water except by the addition of something else, which the chemist can recognize and does recognize. These tables then have some value in measuring the relative danger or the relative safety of water.

Q. Can the chemist tell whether or not the organic matter that is contained in the water is in part infected matter or not?

A. Not from his chemical analyses alone, no sir.

Q. Can he tell whether there is any infection?

7121 A. The chemist, from the chemical investigations alone, can not.

Q. Then the chemical analysis is beneficial to the sanitarian only to the extent of showing the amount of organic pollution, regardless of the character of that pollution, is it not?

A. Well yes, that is a practical statement of the question, although the chemical analyses as I explained yesterday, under certain conditions, certain circumstances, do give a clew to the kind of the pollution.

Q. What is there, professor, in albuminoid ammonia that has any specific injury or harm in it?

A. In albuminoid ammonia itself, of course, there is nothing which is injurious. What the chemist terms albuminoid ammonia is a product or is ammonia separated by decomposition in the laboratory process, of certain relatively complex substances, of which albumen is a type. That albumen is of course not the only substance which in the laboratory process yields this albuminoid ammonia, inasmuch as I explained fully yesterday, the substances which yield albuminoid ammonia are more largely animal than vegetable because in the animal products the protein or albumen substances predominate over the other. Then it follows from that, that the measurement of large amounts of albuminoid ammonia on the one hand and 7122 large oxygen consumption on the other, give in many cases a clew to the source of, or origin of this albuminoid ammonia. The substance itself is suggestive and in a small amount found of course it is harmless.

Q. Then albuminoid ammonia in water is not specifically injurious?

A. Albuminoid ammonia in water itself is not injurious.

Q. And how is it as to free ammonia?

A. Free ammonia in water is itself, not injurious, and the conclusion which one must draw from the presence of free ammonia, is to be made only after the analyst is in possession of knowledge, and often considerable knowledge, of the source of the water. I have found in artesian well waters, an amount of free ammonia,—about two or three parts per million, which would certainly condemn any lake or river or ordinary well water. This free ammonia is merely a step in the gradual breaking down of the original complex nitrogenous substances which enter the water from animal or vegetable source, and the measurement of the amount gives in many cases, an idea of the extent of this breaking down, or the amount of the substance which undergoes decomposition or breaking down.

Q. Professor, how much free ammonia is necessary to condemn water for domestic purposes?

A. An answer to that is practically contained in what I 7123 have just said that free ammonia in enormously large amounts will not condemn an artesian well water, but in very much smaller amounts it is suggestive of contamination. in shallow well waters. You can't give any hard and fast rule in conclusion of contamination of water from free ammonia.

Q. Then it is not a correct index under all conditions?

A. No one element taken alone should be considered as a correct index under all conditions.

Q. Now, professor, is the health of the community drinking a certain water an index to its potability?

A. Not absolutely. If we could assume that that was the case, we should also have to assume that the water consumption is the prime or only factor entering into the health of the community, leaving out of consideration the air and the soil and the temperature, and the winds, and so on, so the conclusion that can be drawn from the water is necessarily limited.

Q. Now there are certain diseases known as water-borne diseases, are there not?

A. I have heard of those.

Q. Do you recognize that to be the fact?

A. I am not discussing etiology.

Q. Well, as a sanitarian do you recognize that fact?

A. As a sanitarian I recognize that certain diseases are spoken of as water-borne diseases, yes.

7124 Q. Well, what do you say on the subject?

A. Well I say as I said yesterday, that many of the conclusions of sanitarians on this point have been based on such faulty observations that this is quite unsafe,—to draw any general or radical conclusions from them.

Q. Then I understand you to say that you do not agree to the proposition that there are certain diseases which are water-borne diseases, and known as such and recognized as such?

MR. TODD: I object to the question on the ground that the witness is not called upon to testify to what counsel understands him to say.

A. I would like to have the stenographer read over what I have said here lately. I think the counsel misunderstands my answer.

(Last questions and answers read.)

A. Now, while not saying or intending to testify at all as an etiologist, or as an epidemiologist, as a further illustration merely of what I have said, take the case of yellow fever, which all sanitarians for many years, have assumed to be a water-borne disease, but which is now by sanitarians traced to other causes. So I say that because of lack of more specific knowledge on these things, I would not like to be forced into the position of drawing a very sharp conclusion, and do not intend to.

7125 Q. Then in order to understand you correctly, do you put much stress and lay much importance to the proposition of sanitarians that certain diseases are transmitted by water, known as water-borne diseases?

A. I would answer again, that while a discussion of that subject is outside of my province and I must be distinctly understood as not wishing to pass an original opinion on that, I will admit this: that sanitarians do regard certain diseases as water-borne, and in some cases, where the weight of evidence seems to be very great, I am inclined to accept the opinion of sanitarians, without advancing an original opinion of my own on the subject.

Q. Then, professor, not being an epidemiologist or an etiologist, to what extent have you considered the information and opinions of others in connection with your own, in determining the sanitary condition of water in the Illinois river?

A. In determining the condition of the water in the Illinois river I depended almost solely on the information afforded by my own experience—my own examinations of a chemical nature, and what I spoke of as bacterial chemical experiments.

Q. Then you did not take into consideration infection?

A. I did not, as I have said repeatedly this morning.

Q. Did you take into consideration the infection in the
7126 Mississippi river when you gave an opinion upon that
water from your analyses?

A. I did not.

Q. In the Missouri?

A. I did not.

Q. Then, professor, in making the analyses and in expressing or drawing your conclusions therefrom, you have left out of consideration the question of infection, which is the most important, in fact, the only thing to be considered of importance in the analysis of water, for sanitary purposes, and for drinking purposes, have you not?

MR. TODD: I object to the question on the ground that counsel assumes infection as testified to by the witness, is the most important matter for consideration.

(Question read).

MR. TODD: I would like to ask counsel what meaning he attaches to the word "infection," for my own information.

MR. JEFFRIES: In answer to the suggestion of counsel or the request of counsel I refer him to Professor Long's definition of infection,—who is the witness now on the stand.

MR. TODD: I merely wanted to understand in what sense counsel used the term, and understanding that he uses
7127 the term according to the definition given by Professor Long, his explanation is entirely satisfactory.

Q. (Last question read).

A. In answer to the question I will say that in forming my conclusions, I have left out of consideration the question of infection, because it does not come within my province of discussion, but I cannot agree with the assumption of counsel in the question that that is the only point of importance to be considered here. I differ from that very decidedly and strongly.

Q. Is it not the most important?

A. For the purpose of the examination that I have made, it is not the most important at all.

Q. Is it not more important for the purpose of ascertaining whether or not the water is suitable and safe for drinking and domestic purposes?

A. The object of all of my investigations has been to determine the extent and rate of destruction of organic pollution in the waters in question and to compare these several waters with each other.

Q. Then it has not been with a view of determining whether or not the water is safe to drink?

A. In that sense—in that narrow sense, it has not been.
7128 I have declared that in my opinion that none of these
waters under consideration are safe to drink.

Q. Why not?

A. Because they receive a large amount of filth of all kinds from innumerable places, and whether there is any infection there or not, I object to the drinking of such waters.

Q. Does that include Lake Michigan?

A. It would include Lake Michigan in case it received an amount of filth at all comparable with the waters in question, which it does not.

Q. Well, how does the water of the Illinois river since the opening of the drainage canal, compare with the water of Lake Michigan, so far as the sewage discharges are concerned, speaking with reference to their being comparable?

A. Well, I still prefer Lake Michigan to the Illinois river as drinking water.

Q. Well is there any comparison whatever to be drawn between the lake and the river?

A. Not as a drinking water I think.

Q. On what do you base that opinion?

A. On the statement which I made a short time ago, that because of the very large amount of substances of all kinds entering the Illinois river, and because of the known fact that
a very much smaller amount of substances enters Lake
7129 Michigan, I prefer lake Michigan water to Illinois river
water.

Q. What amount of polluting substances would be necessary to make the water of Lake Michigan unfit for drinking purposes?

A. I am not doing any guessing on the witness stand. I don't know.

MR. TODD: You are not an epidemiologist?

A. I am not an epidemiologist, no.

Q. MR. JEFFRIES: Do you know what amount of polluting substances in any water would be necessary to make it un-drinkable?

A. It is not possible to assign a hard and fast rule in any such case, and I should not be drawn into any such discussion as that.

Q. Well, what amount in any particular water that you are acquainted with, would be necessary?

A. Well, if I should find five parts of albuminoid ammonia per million, in Lake Michigan, I should certainly be afraid to drink it.

Q. Have you found one part in Lake Michigan—one part per million?

A. No, I have never found one part per million of albuminoid ammonia in Lake Michigan.

Q. Did you ever find .1 of a part?

A. I am not going to follow in tenths, from one tenth
7130 up to ten-tenths, to tell or attempt to tell where the line
of demarkation would be between a bad water and a good
water in Lake Michigan.

Q. Why do you decline to tell, Professor?

A. Becaue it has no bearing on my testimony in any way. It is simply a question which if followed out consecutively would lead to an impossible answer. I have been there before on such questions.

Q. That is one reason, is it?

A. That is a good and sufficient reason for me at the present time. There may be others.

Q. Professor, if all organic pollution consisted of dead and not living matter, would the water containing any of it be specifically injurious?

A. Not at all times, but under many circumstances it would be.

Q. Why?

A. Well, that question requires an answer perhaps at some little length. A great many kinds of so-called dead organic matter are of such a nature that when taken into the human stomach they interfere with the natural and necessary and normal processes which go on. There are some of them acting as toxins or poisons, and thereby interfering with normal pro-
cesses; others because of a sense of disgust which they
7131 may arouse, so influencing the normal functions that they
will not take place in their usual manner. Dead organic

matters of these kinds, and products from dead organic matter may be in themselves then harmful and injurious from the reasons which I have just given.

Q. Would they kill people?

A. Yes, in sufficient amount they would undoubtedly kill people.

Q. Now, do your chemical methods enable you to differentiate between dead and living materials or dead or living organic matter in the water?

A. No, the chemical analyses certainly not, but the bacterial chemical tests which I have made, indicate the presence of the living organic matter as I have explained, on several occasions.

Q. Then it may contain both vegetable and animal?

A. It may.

Q. What is your opinion on the subject?

A. It does; most waters do.

Q. But you cannot detect it from the chemical analysis?

A. Chemical analysis would not; that is chemical analysis as ordinarily made would not. I would not like to give a perfectly sharp answer to that, because off-hand I do not want to attempt to limit the power of organic chemistry in detecting certain things. 7132

Q. You are speaking then of its possible future results?

A. No, I am speaking of possible present conditions, but I say I would not like to state sharply what chemistry could detect by the use of more refined processes than we have already applied in the sanitary examination of waters.

Q. Now, you are speaking of conditions that you have applied in this investigation?

A. Yes, of course. In what we call sanitary water analysis, no attempt is made by chemical means to differentiate between the living and the dead organic matters.

Q. And is there any chemical means by which they can be differentiated?

A. That is the point which I have just explained, when I said that I am not able to state definitely what the limits should be to the work of a skillful chemist in this field, using methods more refined than those which we ordinarily require in sanitary water analyses.

Q. Professor, why do people boil their water which they think is unsafe for drinking puposes?

A. Well, I can answer that from the general standpoint, they have been told that there are germs in it and they boil it.

7133 Q. And boil it?

A. Well, some of them do, and some of them do not; I do not.

Q. What is the object of scientists in recommending the boiling of water?

A. Well, scientists in recommending that think that by boiling it, they will destroy this assumed infection.

Q. Now, you say "assumed infection" do you mean that it is an infection assumed upon your part or assumed upon their part?

A. Assumed on the part of the so-called epidemiologists and others.

Q. As a chemist you know nothing about it?

A. As a chemist I know nothing about infection.

Q. Or the causation of diseases relating to drinking water?

A. Absolutely nothing as a chemist. I don't bother about that at all.

Q. So that when you testify or express an opinion upon the sanitary condition of water, aside from what your chemistry tells you, it is nothing more than the opinion of an ordinary citizen or layman?

A. Well, I think that is going a little too far . I believe the chemist by his chemical methods is still able to tell a
7134 great deal about water. I am very careful not to express an opinion, however, which is unwarranted by the extent of my investigations.

Q. Aside from your chemical tests, what aid as a scientist, do you get from the opinions and experience of epidemiologists and to what extent do you use it in expressing your opinion, if any?

A. In expressing my opinion I make practically no use of the assumed experience of epidemiologists.

Q. Professor, as a chemist, are you able to differentiate between organic matter that comes from human excreta, and that which comes from street washings, barnyards, cattle pens, and other places of like character?

A. No, as a chemist I should not attempt to make any such differentiation in the course of water analysis.

Q. And you have not so attempted in any of these investigations?

A. I have not, no.

Q. Now, Professor, I understood you to say that you, in making your chemical analyses and giving your opinion upon the sanitary condition of the water of the Illinois river, you disregarded the opinion of epidemiologists and those sanitary experts who recognize an association between the pollution
7135 in water and disease germs and diseases which are brought upon people who are in the habit of drinking the water?

A. In forming my conclusion, or in stating my conclusions, I will say that I have not attached much importance to the opinions of epidemiologists, but I have in the reports which have been published referred to the work of others who have made parallel investigations and who will testify when the time comes, whose investigations were made parallel with my own, and on the same waters in most instances.

Q. You have never investigated the relations of health and water here at Chicago or anywhere else, have you, Professor?

A. Not in a very extended way, but far enough to show that the assumptions made by certain epidemiologists who claim that they have made studies of the water supply of Chicago at several periods in the history of Chicago, but not founded on sufficient knowledge of the facts to merit the attention which the publications really attracted.

Q. Now, Professor, will you state the reason why you have thus concluded?

A. I stated yesterday in some detail, one of the main reasons for my lack of faith in the opinions advanced by these infant industry scientists called epidemiologists. It is well known that in drawing their conclusions these people have been
7136 so often ignorant of the most important facts in the case, that the conclusions are finally of no value. From my own studies, and investigations, and from my knowledge of things as a citizen of Chicago,—things which I have paid close

attention to for over twenty years, I am able to state positively that in several of the most noted of these cases where epidemiologists from abroad have passed on the condition of affairs in Chicago, they were certainly mistaken in their conclusions.

Q. Now, Professor, I would like you to state some of the *conclusions that were reached* by epidemiologists with reference to the water supply of Chicago, and the reason which you give,—a substantial reason,—a substantial fact which makes you disbelieve the correctness of their position?

MR. TODD: I want to interpose an objection to this line of cross-examination on the ground that it is not cross-examination of anything that is brought out in the examination in chief, and therefore it is not proper cross-examination of the witness.

MR. JEFFRIES: I suggest that the question of the quality of the water of Lake Michigan was brought out in direct examination and I suggest further that this witness has given an opinion as to the sanitary condition of the water of the Illinois river, and we have a right to ask him any question on cross-examination that would tend to disclose the source of his information or the extent of his knowledge upon the subject. 7137

MR. TODD: As a further objection, I wish to urge that counsel for defendants have no objection to the conduct of the examination upon the lines indicated in the last question, but we do object to interrogating the witness upon epidemiologists and their views and their conclusions, as being no part of the direct examination in this case, and brought out by the cross-examiner himself and was not gone into on direct testimony, and it is to that phase of the cross-examination that I interpose my objection.

Q. (Last question repeated)?

A. In answer to that question I am willing to repeat in substance the statement which I made yesterday, which I thought was sufficiently definite.

In two periods of the recent history of Chicago it has been assumed by epidemiologists that infection comes from certain of the tunnel waters brought into the city. It has been shown by investigation, which will be detailed here later, at the proper time, that before the World's Fair, at a time when a great deal was said about the infection of Lake Michigan water, a good

part of the supply in one section of the city was drawn,—not as was supposed,—from the Chicago Avenue tunnel, extending out about two miles, but from a short, or emergency
7138 inlet,—a short tunnel extending out to a distance of about
500 feet, to be used in case of emergencies,—in case of a large fire, for example. At that time the pumps which were at work in the pumping station at Chicago avenue, were generally in pretty poor condition. There was frequent complaint of the amount of water which they could pump. There was very frequent complaint of lack of sufficient head to carry the water above the first or second stories of the buildings. At that time, in order to lessen these complaints, it has been established by investigations as will be explained, that water was drawn by the engineer in a large quantity and through a very considerable period from the short inlet. This water was very dirty. It was drawn from a point where there was considerable contamination from dumpings, and washings, and sewers and so on. Therefore I say that the conclusion that the water from the two mile tunnel was the source of the disease which the epidemiologists described at that time, is not a fair conclusion.

At a later period, last year, through the spring and summer of last year, there was a remarkable epidemic of typhoid fever in Chicago. It was a very singular fact—a puzzling fact, that the greatest prevalence of this appeared to be in a part of the city which received what was supposedly the purest
7139 water drawn from the longer tunnel, and a great deal
was written and expressed in public addresses, in regard to the infection of the water at that great distance, shown from the appearance of the fever in this part of the city. It was later discovered, some time in June, I believe, that through some accident or oversight which occurred many years ago,—how many we cannot say definitely,—perhaps over ten or fourteen years—certainly at a period beyond the recollection of the men employed in the pumping station, a connection was left between a well in the pumping station and a sewer, so that at the time of high water, at the time of heavy rains, it was possible for one of the large sewers in that part of the city to flush over and throw a great volume of foul water through a ten inch pipe into this well, so that it could be drawn into the supply. That fact

is known to many people in the city and in the engineer's office. I state that here then as a further explanation of why I am not willing to accept the determinations of the etiologists and epidemiologists. I am referring principally to people in Chicago who made these complaints of last year, that the source of the infecion must be referred to Lake Michigan. It is evident that that was not the source of the pollution in the mains in that part of the city. Those are two, and I think, sufficient illustrations for all practical purposes.

7140 Q. The increase of typhoid fever following the use of the water from the sewer at the particular place mentioned, and of the water of the lake near the shore, a distance of 500 feet I believe, out, associates the typhoid fever rate with the water that was used by Chicago at the time, doesn't it?

A. It is so assumed by epidemiologists.

Q. What do you say on the subject? You made that statement a minute ago?

A. I made the statement a moment ago only from facts that were brought forward to suggest an explanation of this typhoid fever. I was disposed to doubt the accuracy of the conclsions in the first statements. I have made no original statements on the matter at all.

Q. Then the epidemiologists who passed judgment on the water were correct in that the typhoid came from the drinking water, still, it matters not where it may be taken from?

A. From the standpoint of modern etiology I believe that is true. As a chemist I wouldn't like to pass on the question.

Q. Have you any reason to doubt that was caused by the water?

A. No, I will not say that. I do not doubt it, although I do not care to pass, as I say, an opinion as a chemist on that.

7141 Q. Do you regard it as a proper subject of study, that is the relation between the water and the water-borne diseases?

A. Most certainly.

Q. And you recognize that it has been made quite an extensive study?

A. I recognize that certain people are engaged in this very legitimate study.

Q. And have been for the last twenty years?

A. For some years back, I think. I cannot place the beginning of the study.

Q. But from a chemical standpoint you have not been able to make it a study?

A. I have not tried from a chemical standpoint.

Q. Being acquainted with the sanitary conditions, and being connected with the State Board of Health and the Chicago Board of Health as an official chemist and in connection with your work for the Sanitary District of Chicago what is the reason you have not given it consideration and study?

A. Because in the employ of the State Board of Health there is a competent bacteriologist and etiologist to whom these questions are always referred. I have not been the official chemist of the city of Chicago for a good many years, since about 1890, and have not therefore, given any opinions.

7142 Q. Professor, at the time of your investigation, what was the amount and character of pollution in the Chicago river from the stock yards of Chicago?

A. I stated in a general way several times,—I think twice, something about the character of this pollution. In the earliest period of these investigations that pollution consisted of a large amount of water which was used in washing carcasses of meat or shreds of organic matter separated in the process of cutting up the meat, in residues from evaporation coming from these various industries, such as slaughtering and canning industries for example, of the contents of stomachs and intestines of the cattle slaughtered, the cattle and hogs slaughtered and of the manure from the cattle from the pens in which the cattle are kept for slaughtering. I explained that in the early history of the stockyards the amount of this matter which was allowed to go into the river was very large but that it decreased greatly when the commercial value of the substances was recognized, so that finally practically everything separable by sedimentation or separable by screens or weirs was taken out, and at the present time the filth which leaves the stock yards is largely of a soluble nature, that is materials which cannot be readily separated by mechanical means. The separation takes place
7143 usually in the packing houses themselves, and also to some extent in a big sewer outside, which is the one main,

principal sewer which drains most of the packing houses, but the packers themselves try to save and do save as much as possible and make use of it largely as a fertilizer, and in making soaps and so on, while what escapes into the large sewer is, or was for a very considerable period, and is yet, if there is sufficient of it to pay, separated in the Brennock sewer. Now, the amount of this that passes into the river at the present time I cannot give exactly. I think I stated some time ago that at the period when my investigations were made it was about ninety tons a day of organic matter escaping in this way.

Q. That was in 1899?

A. Yes, sir. Through the period.

Q. Now in 1886, you said there was about 112 tons daily?

A. In 1886, from experiments I made, I concluded there was that much more escaping in the intervening period. The method of saving and separating this stuff has been improved to some extent.

Q. Now, then, what changes, if any, have occurred since 1899 in the amount of dry organic matter entering the Chicago river from the stock yards sewage, and if so, what amount?

A. I cannot state that very definitely beyond this ex-
7144 planation, that since that period of 1891, these people
saw the importance of retaining within their own establishment matter which formerly was allowed to escape because of the commercial value of the substance.

Q. What was the amount of nitrogen that you estimated was contained in this refuse matter from the stock yards?

A. Well, the amount of nitrogen was approximately somewhere between thirty and forty tons—no, not from the stock yards, excuse me. That includes the determinations made of the total flow. The amount of nitrogen corresponded very closely to the amount of organic matter, being in the neighborhood of one-sixth or one-seventh of the dry organic matter.

Q. Now, what factor do you use in extracting the nitrogen into the equivalent weight of the total organic matter coming from those sources?

A. I have used the usual factor for products of the complex nature of those known to be in existence there,—six and one-fourth.

Q. What do you find the ratio to be of free ammonia to albuminoid ammonia?

A. I don't recall now; I believe I made no statement in regard to that.

7145 Q. You don't remember what the ratio was?

A. No, sir.

Q. Now, Professor, if the refuse matter coming from the stock yards sewers were diluted in Lake Michigan water in a volume equivalent to 250,000 cubic feet a minute, for 24 hours, what amounts would that give you of the various constituents that you recorded in your chemical analyses if expressed in parts per million?

A. Your question is not definite enough to permit an answer to be given. You have not included the number of minutes,—250,000 cubic feet a minute for how long?

Q. Well, we will say for 24 hours?

A. Well, let me see, I will have to figure a little on that. That calls for a calculation which I have not made, and prefer not to make off-hand. It is a matter of arithmetical calculation.

Q. Will you make that?

A. Yes, sir.

Q. You needn't make it right now.

A. I will make that calculation and give it some time.

Q. (Question repeated)?

A. What am I to calculate now?

Q. You have stated that the total solids were so much per 24 hours, per day, from the stock yards.

7146 A. Yes, sir.

Q. Is that calculated, then, on the basis of 250,000 cubic feet of water per minute, for the 24 hours?

A. And you want to know, expressed in parts per million, what these 90 tons would make; is that the proposition?

Q. That's it.

A. Well, that readily appears to be about 90 parts per million of organic matter.

Q. Now, that would be the amount for the various constituents which you reported?

A. Yes, sir.

Q. How much would that be for nitrogen?

A. That would be, if I have made my calculation there correctly, about fourteen, but I wouldn't want to put this in as an absolute calculation until I look it over.

Q. Professor, I believe you stated that in 1899, you estimated that from a population of 1,500,000 people connected with sewers emptying into the Chicago river, that they contributed more than 150 tons per day of dry organic matter and this amount was equivalent to more than 30 tons daily of nitrogen?

A. Yes, I think I have made a statement of that kind.

Q. What is the ratio of the amount of this nitrogen in the form of free ammonia, as compared with the form of al-
7147 buminoid ammonia as compared with that in the form of albuminoid ammonia?

A. The ratio of nitrogen where?

Q. In the 50 tons per day of the dry organic matter?

A. Well, that dry organic matter is not ammonia at all; that is not ammonia.

Q. Is any part of it?

A. There might be, yes, probably a small amount of complex ammonical salts that could be included there, not at all ammonia.

Q Is any of the nitrogen in the form of free ammonia?

A. Not any of this organic matter, no.

Q. What is its nature?

A. This organic matter?

Q. Yes?

A. I have made no very specific investigation to find what it is. I simply judge from the source from which it came, as to about what it was to be.

Q. Now, how did you determine that?

A. Oh, from my knowledge of the stock yards industries, which I have visited hundreds of times in twenty years.

Q. You determined it then from observation?

A. Observation of what goes in there permits me to tell.

7148 Q. Not by chemical analyses?

A. Not by chemical analyses, no. I haven't attempted to differentiate it in that way.

Q. Now, Professor, is it fair to assume that one ton of dry organic matter per day, is generally correct for each 10,000 population in the Chicago Sanitary District, contributing house drainage and industrial waste to the city sewage?

A. That question I cannot answer without some little calculation. By the statement which I have made in the Board of Health report, and the figures which I gave are based on experiments. I would have to reduce those. I think that I made a fair estimate of what was going on at that time.

Q. Now, in what way did you make that estimate?

A. The estimate of the dry organic matter from the stock yards was made—

Q. We are speaking now, Professor, of the house drainage.

A. I made no estimate of the house drainage directly; I made certain examinations of the water at several points.

Q. And that of course, included the drainage from the stock yards, the house drainage and factories of all kinds?

A. Some of it, yes, but most of the stock yards drainage goes through one large sewer. I was aiming to get a pretty fair estimate of that because of the fact that it goes through
7149 the Brennock sewer.

Q. Then you made no examination, did you, with the view of examining that particular factor, what the house drainage is?

A. I couldn't make it in the same way, no, sir.

Q. Did you ever figure out the amount in grams, per capita daily, of the quantity of household drainage and industrial waste, corresponding to and expressed in these constituents which you employed in reporting the results of your chemical analyses?

A. Yes, in this report which I have I think I have such a calculation, but I wouldn't like to make a positive statement about that now.

Q. You don't know what amount in grams it would be?

A. No, sir, I do not.

Q. You never published any such statement, did you?

A. Well, if there is no statement in that report, I haven't published it anywhere else.

Q. Professor, you stated, did you not that in 1890 and 1891 you estimated that five-sixths of the sewage in the stock yards refuse entered the Chicago river and passed into the Illinois and Michigan canal?

A. Yes, I have some such proportion among my statements.

Q. Now, you made that statement in your direct testimony?

A. I believe I did.

7150 Q. Now, upon what basis did you make that estimate?

A. That estimate was made by comparing as well as possible the amount of matter contained in the water west of Bridgeport, that is, the pumping station, with the amount discharged as near as I could estimate it, from the stock yards and other sewers.

Q. In other words, you made a comparison of the two waters?

A. I attempted to make a comparison of the two waters.

Q. How often in the year was that comparison made?

A. These investigations were made largely as I now recall them, in the fall and winter of 1890 and 1891. In that investigation something over 130 examinations were made, but I am not now able to state how they were divided. I think the larger part were concerned with the stock yards sewage itself.

Q. How was that examination made?

A. That examination was made of the sewers in this way: weirs were built in these sewers over which the water was allowed to flow, and the object of that was to get the volume of the water flowing, by methods known to engineers—these measurements I didn't make,—at points in the sewers above the weirs,—the contents were thoroughly stirred up and samples were taken every 15 minutes through 24 hours, and mixed. Employes of the sanitary district made those collections that often. These samples were thrown into large barrels and thoroughly mixed 7151 and brought to me subsequently on the same day, or at the end of 24 hours, for examination, the stock yards sewage coming, therefore, in a very fresh condition for examination. The examinations made then were by the usual methods known to chemists which I have described heretofore. Total solid matter by evaporation was determined, and by careful incineration, by the Drown or perhaps the Drown-Hazen method in a platinum dish under a radiator the organic matters were then burned off at as low a temperature as possible, leaving the inorganic residue. In that way, I say, an average estimate of the organic matter was so obtained, but, as I explained in my direct testimony, this method is not absolutely accurate as chemists understand that term, as in making, for example, a complete organic ultimate analysis, but it is accurate enough for purposes of comparison. The nitrogen was also determined in all these samples by means of the ammonia found by the Kjeldahl process. The incineration and determination of fixed residue was made in every case.

Q. Now, did these estimates take into consideration the times when the current of the Chicago river was reversed?

A. At that time the current in the Chicago river was all towards Bridgeport. The pumps were in operation and drawing the water in that direction.

Q. At the particular time these examinations were made?

7152 A. Yes, sir.

Q. But in these estimates have you included the nitrogen in the form of free ammonia and the chlorine, and the oxygen consumption?

A. Yes, I think those were all included; they were never published.

Q. Do you consider them of any importance?

A. The determination of the free ammonia was important as showing a relatively small amount of decomposition which had already taken place in the stock yards sewer. The chlorine is of no very great importance there, because of the enormous amount of salt used in the packing industries. As a matter of course there is a great volume of salt thrown out there, and therefore I attached no especial importance to its determination.

Q. Do I understand you to say that during this period when these estimates were made as to the amount of sewage in the stock yards refuse entering the Chicago river, and passing into the Illinois and Michigan canal, that the Chicago river did not reverse?

A. Yes, I made that statement from recollection; I would not like to say absolutely that it was not reversed for a short period, but in general I remember that the river was flowing past the pumps.

Q. Did it flow for several years without any reversals whatever?

7153 A. No. There were periods when there were reverses in nearly all years. In wet years there were frequently reverses, as I explained in my direct testimony. I explained that at times of high water, because of the peculiar relation of the Desplaines water-shed and the Chicago river, frequently a very large body of water would come down from the Desplaines in this direction instead of going west or southwest to Riverside. It would break over the low water-shed there and come this way and enter the Chicago river somewhere in the vicinity of these pumps and on these occasions the river very often was carried out to the lake.

Q. Now, when these freshets happened, it flushed out the sewage that had been deposited into these rivers, did it not?

A. In the Chicago river you mean?

Q. Yes?

A. No, not all of it. This freshet from the Desplaines would carry out practically only that part of the sewage which was in the south branch, between the main river and the pumping station. It would not affect, this Desplaines freshet could not affect the north branch or the part of the south branch south of Bridgeport.

Q. How far is the Desplaines from the north branch?

A. The Desplaines from the north branch, north of the city, is not far removed. The north branch and the Des-
7154 plaines river follow in approximately a parallel direction, from somewhere near the Wisconsin line, they come down, one on one side of the water-shed and one on the other.

Q. Now as a matter of fact a freshet in one generally meant a freshet in another, didn't it?

A. No, not at all, the water-shed of the North branch is very much less than the water-shed of the Desplaines, and freshets have very little effect on the North branch.

Q. You know the size and capacity of the pumps at Bridgeport?

A. I have seen those pumps many times through a period of ten years. There was no subject in Chicago more frequently discussed and on which more varied opinions were given, than the capacity of the Bridgeport pumps and it would be foolish for me to attempt to give any accurate definition of what they did.

Q. Professor, what became of the one-sixth of the polluted matter that entered the Chicago river in 1890 and 1891, but which you said, did not enter the Illinois and Michigan canal?

A. Well, an answer can be given to that question only in

a general way. In the river itself and in all streams, there is always some decomposition going on. In the Chicago river this decomposition has often been active enough to be easily visible to the eye. Part of the organic matter disappears
7155 by actual destruction and the products formed pass in the shape of nitrogen and carbonaceous gases into the air. The loss of organic matter can be explained only by this actual destruction mainly through bacterial agency.

Q. Some of the sediment went into the lake, didn't it?

A. At times a portion of the sediment must have found its way into the lake.

Q. What was the condition of the Chicago river from 1886 to 1900 regarding sediment accumulations at the bottom of the stream?

A. I am not able to make any very definite statement as to the condition throughout all of the river, but in the extreme south part of the river, however, there was always a very considerable collection of sediment, and in certain parts of the North branch.

Q. Now, at that time the Chicago river was constantly undergoing purification?

A. There were changes going on all the time in the river, as in all streams with large amounts of organic matter in them.

Q. There was constantly arising foul and putrid gases from it during that time, wasn't there?

A. Yes, the odors in the neighborhood of the river were very unpleasant.

Q. What produced that odor of gas?

A. That is impossible to state, just what were the particu-
7156 lar products of organic decomposition which occasioned the most disagreeable odor. You cannot say. I think that part of this odor is always due to discharge of gas-house waste. These products in the neighborhood of the river have a peculiar so-called aromatic odor—not using that term to describe a pleasant odor, but using it in the sense employed by chemists—a certain aromatic odor, and from the prevalance of that odor I have always believed that gas-house refuse had something to do with it.

Q. As a chemist, what would you say was the cause of it?

A. Well, I don't know. I can ascribe it in part to the products of putrefaction or organic matter and in part to the gas-house refuse which has a very strong and very disagreeable odor, an odor very similar to that which you notice in these rivers.

Q. What produces the decomposition about which you speak?

A. Decomposition in general, in waters containing much organic matter, is a bacterial process.

Q. And you are not familiar with that?

A. I am familiar with it in a general way.

Q. Now, Professor, how does the water in the Chicago river and branches since the opening of the main drainage canal, compare with that existing prior to 1900, as regards the
7157 degree of decomposition which it is undergoing, or has undergone?

A. I have not made any examinations of the Chicago river since the opening of the drainage canal and am therefore unable to make a statement in answer to that question.

Q. Professor, as a chemist, the conditions for decomposition were better in the Chicago river prior to the opening of the drainage canal than since, were they not?

A. Prior to the opening of the drainage canal, some of the conditions for decomposition in a part of the Chicago river, were doubtless somewhat better than after the opening of the canal.

Q. In what way were they better?

A. In this particular, that since the opening of the canal in a certain stretch of the river less time is given for the oxidation or for the completion of these changes, than before.

Q. Is that the only way in which they are better, and the only reason that may be assigned for the conditions being better for decomposition prior than since the opening of the canal?

A. That is the principal reason.

Q. Can you name any other?

A. Nothing that occurs to me now.

7158 Q. You don't know the extent of the advanced degree of decomposition in the river prior to the opening of the canal as compared with what it has been since?

A. No, I do not. I have not made any examination since with which I could compare.

Q. Professor, have you ever investigated the relative change in the amount of free ammonia and albuminoid ammonia, as the sewage undergoes decomposition?

A. Yes, I have made some such investigations.

Q. Now, what is the explanation of this change?

A. By following out the changes through a period of time, we observe a marked increase of free ammonia for a time, and a gradual decrease of albuminoid ammonia. I made once some experiments in which these changes were followed through a period of a number of months.

Q. What caused the changes?

A. In which the free ammonia increased from almost zero to a large figure which I do not now recall, and the albuminoid ammonia decreased correspondingly from a maximum to a very minute figure. These changes were brought about undoubtedly by the usual agency affecting such changes,—bacteria.

Q. Now, that also brought about decomposition in the Chicago river, didn't it?

A. Yes, I believe that bacteria are the main agencies that
7159 work in such decomposition, as I stated a little while ago.

Q. Then the result of these limitations in the method of analyses are due to the change in the two forms of ammonia?

A. Yes, the change in the two forms of ammonia of course is to be considered in our analysis.

Q. Now, then, the results frequently indicate a change which is apparent and not real so far as the total organic matter is concerned?

A. Under artificial conditions that might be true, but the changes as observed in rivers or streams, do have a fairly definite meaning.

Q. Then the analytical results even show putrefactions, which in reality have not taken place?

A. Well, I cannot now recall a case where that is true.

Q. As a chemist what is your opinion on the subject?

A. I would like to consider that some time before I pass an opinion, because the question is not exactly plain to me.

Q. Professor, do you consider that the organic nitrogen as determined by the Kjeldahl method is a more accurate measure of the amount of organic matter in water than albuminoid ammonia?

A. Well, by the Kjeldahl method we obtain the total amount of nitrogen in the organic condition in the water,
7160 while under the most favorable conditions by the albuminoid ammonia process we obtain less.

Q. What percentage?

A. That is quite variable with the character of the substance decomposed. In the decomposition of fresh albumen I have on many occasions found that we obtained practically one-half of the nitrogen as albuminoid ammonia, and practically the whole of it could be obtained by the Kjeldahl process, but there are various decomposition products of albumen, complex products of the decomposition of albumen, products which are formed in the breaking down of the albuminoid molecule, which will give up practically the whole of the nitrogen as albuminoid ammonia, as well as by the Kjeldahl process.

Q. What percentage of organic nitrogen do you get compared with the albuminoid ammonia in your analyses of the waters of the Chicago river and the Illinois and Michigan canal?

A. That I could not answer now directly. It is variable in different places; I do not recall the proportions.

Q. Not variable, are they?

A. Well, the ratio has not been a constant one—I am not able now to give very definite figures from memory.

Q. Professor, do you know what is the population since 1900, that has been contributing house drainage and industrial waste into the main drainage canal by means of the Chicago river?

7161 A. I think I stated that yesterday, about 1,600,000.

Q. Professor, what is the source of the pollution entering the Illinois and Michigan canal since July, 1900, the principal source?

A. The source of the pollution since, is as before, the combined house and general industrial and stock yards sewages.

Q. Are the pumps operated regularly?

A. What pumps?

Q. The pumps at Bridgeport?

A. That is a difficult question to answer; it depends on the stage of politics in Illinois. I don't know.

Q. What do you now consider to have been the normal flow in the old Illinois and Michigan canal in 1900, and what has been the so-called flow since 1900 in the main canal, and when I say the main canal I mean the canal of the Sanitary District of Chicago?

A. As I have explained several times, it is difficult to give a very sharp and close answer as to the flow in the old Illinois and Michigan canal. The flow at that time was assumed to be about 50,000 cubic feet per minute. It is generally believed and I have used this acceptation in my experiments, that the flow was nearly 35,000 cubic feet per minute. In 7162 the main drainage canal, the flow is approximately 250,000 cubic feet per minute.

Q. Are you able to state, Professor, what the lineal velocity of the flow is in the two canals under the conditions of the flow last stated?

A. I am not.

Q. What have your investigations of the old Illinois and Michigan canal indicated as to changes in the polluting matters entering that canal by the time it reaches Lockport?

A. These investigations have disclosed different conditions there. In one series of these experiments the results indicated a very great diminution of the factors measuring the organic pollution. At a later period, when many of the conditions, as far as we could determine were the same, we found only a very slight diminution of these factors in the same flow.

Q. Now, what canal have you reference to?

A. I am speaking of the old Illinois and Michigan canal.

Q. State what the conditions were as to the purification of the water in the Illinois and Michigan canal in 1886?

A. That has been stated in my direct-examination, whether I can find the figures at once, now, I cannot say. My recollection is that the experiments showed a nearly complete destruc- 7163 tion of the organic matter or the breaking down of the nitrogenous products. The loss of organic matter was very marked between Bridgeport and Lockport. This reduction being shown particularly in the change in the free ammonia to the albuminoid ammonia and also in the oxygen consumption, the amount being reduced, the amount as indicated by these determinations being reduced to one-half of what we had at Bridgeport.

Q. Now, will you please state what the corresponding conditions were in 1899?

A. In 1899 at the same place, and for some reason which I am not able to assign in detail, practically no change in the free ammonia, the albuminoid ammonia or the oxygen consumption was observed between these same points,—Bridgeport and Lockport.

Q. Now, you say you are unable to explain the reasons for the difference in the two periods?

A. I am not able to assign any perfectly specific reason for the fact that in one season in this stretch there is an enormous destruction of this nitrogenous matter, while in the other season there is a very much less destruction of the organic matter,—practically no destruction at all.

Q. Is there anything in the realm of the science of chemistry that might explain it?

7164 A. Perhaps not in the field of pure chemistry.

Q. From the standpoint of a scientific sanitary chemist, is there any way in which the same conditions might appertain to any other stream of water?

A. Yes, I believe that might happen elsewhere under certain conditions.

Q. Is there anything in the realm of chemistry by which you can forecast that the same results may obtain at any other time with reference to the Illinois and Michigan canal as shown by the 1886 analyses?

A. That is a pretty broad question to answer definitely. I would not like to say definitely that with our present chemical knowledge and our present power of analyzing water that we would be able to forecast exactly what would take place in a given stream in a certain time. On the other hand I would not like to say that we would be unable to forecast what in general might take place there. Inasmuch as this kind of a change must depend on the activity of bacterial organisms, any chemical factor which would lessen the activity or power of doing chemical work, of these organisms would necessarily interfere with the destruction of the organic matter. Now I am not prepared to state whether with our present knowledge, a chemist could detect that addition of some chemical element which would interfere with or impede the bacterial activity.

Q. With your present chemical knowledge, and the pres-
7165 ent state of the science of chemistry, can it be stated?

A. I shouldn't like to state it; I don't know whether anyone else could or not.

Q. Then the question as to the cause of the change in the purification, the reasons for the change, the facilities for the change as observed from the analyses, cannot be ascertained so far as a comparison or examination of the waters for the two periods, to-wit, 1886 and 1889?

A. I am not able to assign any specific explanation.

ADJOURNED until 2:00 P. M., same day.

7166 2:00 P. M., Wednesday, September 30th, 1903. Continuation pursuant to adjournment. Present, the Commissioner, and same counsel representing the respective parties.

PROF. JOHN H. LONG,

resumed the stand for further cross-examination by Mr. Jeffries and testified as follows:

Q. Professor, we were speaking of the comparative difference in the purification observed in the Illinois and Michigan Canal from the analyses of 1886, and that taken in 1899.

A. Yes.

Q. Do you know of any conditions as to flow or as to the amount or kind of impurity or any other matter which would account for this difference?

A. Not positively.

Q. You have no knowledge upon that subject?

A. Nothing definite. Nothing to state, no.

Q. That you account as definite or reliable?

A. No.

Q. You regard the sewage matter from Chicago in its
7167 original condition as detrimental to the quality of any water supply with which it is mixed, do you not?

A. I should consider such mixtures, producing a product unfit to use in general.

Q. Now when you state that in your judgment the sewage matter from Chicago was not injurious to the water supply of St. Louis, you were relying, were you not, upon the purification which takes place *en route*; or assuming that that purification is of the kind and extent such as has been shown by your analyses?

A. That was the basis of my answer.

Q. Do you know with certainty that your analyses covered all the conditions that there are?

A. They covered all of the conditions which I considered necessary to reach the conclusion expressed; the conditions are all explained by my report as far as I know them, and I think they have been explained here.

Q. State briefly the principal conditions that were covered by those analyses and which you consider as necessary?

A. Well, I determined in those analyses the factors measuring organic matter, as judged from the oxygen consumption, the albuminoid ammonia, free ammonia,—the presence of nitrites and nitrates; that is, I observed the usual chemical
7168 conditions, and in addition to these the results of so-called bacterial chemical tests or investigations.

Q. Now do these analyses that you have introduced in evidence fully cover flood periods in the Illinois river?

A. They cover some periods of high water, probably not the maximum or excessive floods.

Q. Do they cover cold weather periods?

A. Yes, to some extent they cover cold weather periods too.

Q. Do they cover periods particularly when the river was frozen over with ice?

A. In the recent analyses I don't recall that the river was frozen over when the samples were collected.

Q. Since the canal was opened?

A. Since the canal was opened.

Q. It freezes over, does it not?

A. That I will not say from my own observation; I don't know.

Q. Have you been on the river in the winter time when the water was frozen over with ice?

A. I have not.

Q. Then you would not undertake to express an opinion as to the sanitary condition of that water in the winter time, when the water was frozen over with ice?

A. I have only expressed an opinion as to the condition 7169 at the periods covered by my investigations.

Q. How many days do those respective periods cover?

A. That I cannot tell, except by reference to the dates and the tables. Through some months of the summer and spring or fall of this two years—four or five months I think in the two cases.

Q. No one of the periods of investigation made by you cover the entire year?

A. No, by myself personally, no investigations were conducted through the whole year.

Q. Professor, if a very marked purification was obtained in the Illinois and Michigan canal in 1886, and practically no purification in 1899, the conditions remaining the same, is it not possible that the conditions of purification as you have observed them since the opening of the drainage canal—since the drainage canal has been in operation, have been at times changed in some way, unknown to you, so that the water has passed down the Illinois river with a lack of purification corresponding to that which you observed in the Illinois and Michigan canal in 1899?

A. No, I would not be willing to admit that in general, because in leaving the Illinois and Michigan canal, the disturbing factors which interfered with the oxidation in 1899, have evidently largely disappeared, because of the observed 7170 fact that the oxidation has gone on further down. The pouring in of this canal water, in which the oxidation in that later or second period, was very much retarded, into the river below apparently restored the conditions of oxidation, so we find a better effect below than would be pre-supposed from what we observed from the canal itself. Hence I would not like to conclude, or would not conclude that there might possibly be conditions interfering with the oxidation in the whole river below.

Q. Do you know that the change of the character just mentioned, has not taken place in the Illinois river since the drainage canal has been opened?

A. I don't know that because I have not recognized by investigations, such condition.

Q. Then you don't know that the matter so discharged into the drainage canal and into the Illinois river from the Sanitary District has always been such as not to be innocuous?

A. *I make positive statements only about the periods* which I have covered in my investigation. I think that is what I have done in my previous statements.

Q. You know nothing then about what the conditions were, or what changes took place during other times?

A. I would not say from any direct personal experience, what the changes have been in other times.

7171 Q. And you speak of the condition at other times simply from analogy with those that were in existence at the time you made the examination?

A. I do, yes, where I speak of other times at all.

Q. Do you know the actual dates or time in the winter season that these examinations were made, and that the winter conditions were observed by you?

A. The dates are given in my report. I cannot recall them off-hand.

Q. Now, professor, assume that the Illinois river was frozen over with ice the entire distance from the entrance of the canal into the Desplaines, to Grafton, would the sewage of Chicago during that time have any effect upon the condition of the water at Grafton?

A. An exact and definite reply cannot be given to such a question from any personal experience I have had, extending through an investigation as long as that.

Q. Have you ever made an examination as a sanitary chemist, of the condition of the water in any river when it was completely frozen over with ice?

A. I have not.

Q. Do you consider that fact as material in determining the sanitary condition of the water, following down the river from one end of the year to the other?

7172 A. Yes, in general I would consider the question of temperature and all questions of the exclusion of the air by ice, as having some bearing on this question.

Q. Isn't it a fact that the means of purification are more adequate in the summer season than in the winter season?

A. Yes, it is in general true, that the changes which we describe in broad terms as oxidation, are more characteristic in the summer season than in the winter season.

Q. Then in making an examination of the water of the Illinois river with the view of determining its sanitary conditions, have you not omitted a period of time which is material to enable a correct determination of that question?

A. One of the factors necessary to reach a conclusion for the whole year has not been considered in this investigation. My conclusions extend to the period through which my investigations were carried.

Q. Do you consider flood periods as important in determining the sanitary condition of water in the running stream?

A. Yes, as was explained at some length yesterday, the condition of floods in the Illinois river has a bearing on this question.

Q. And I understand you to say that you have omitted from your analyses and examinations, flood periods in the
7173 Illinois river since the opening of the drainage canal?

A. I think I said I omitted any very large flood periods. I do not recall that any very extended flood period was embraced in these examinations.

Q. Can you recall any period of flood or floods which is included in this examination for the determination of the sanitary condition of the water, and state whether or not the water was examined at the flood periods for the purpose of determining the chemical conditions and sanitary condition of that water during flood times alone?

A. The investigations made in the earlier part of 1900, I think, came the nearest to the observation in flood period. In the investigations of 1899, as I recall, the water was in general, not high, and in the investigations of the later part of 1900, the water was I believe, in general, not very high, but in the earlier investigations that year there was some high water.

Q. Did the high water continue throughout the entire series of examinations that you made at any one particular period?

A. It did not.

Q. In making these examinations in high water time, which you speak of, were the samples so taken as to follow the volume of water from the source of the flood to the mouth of
7174 the Illinois river with a view of determining the chemical changes that took place in that water during the flood time?

A. In this period of 1900, in the early part of 1900, to which I refer, I believe the samples were taken in the upper part of the river and that they also extended to Grafton.

Q. Were the samples during any period of your examination taken in the manner indicated in my next previous question?

A. Yes, they were taken through 1899 and 1900 from the source to the mouth of the river. Your last question evidently does not refer to flood periods.

Q. Now then, were they so taken during any of those periods for the purpose of determining the conditions that existed all along the river during that flood period, following the flood from the source of the flood to the mouth of the river?

A. They were not.

Q. Professor, have you made any examination of the water of the Illinois river so as to enable you to determine its sanitary condition at its mouth, or at Grafton in January and February, 1902?

A. I believe that is the period of the last examinations made—1902. Let me see now what the dates were (Witness refers to book). In 1902 the period covered was the latter part of February and March.

Q. Now how do those examinations that were made in
7175 February and March, 1902, compare with those that were made the preceding summer?

A. Well, in general, without hunting up the figures exactly, I can say that during the later period, during the early spring period of 1902, we have a greater amount of the unoxidized free ammonia than in the last examination made, and before this period—that was in the fall of 1901. As compared with those examinations, we have as would naturally be expected, a greater amount of albuminoid ammonia, and especially a greater amount of the free ammonia, which represents a much later stage always, in oxidation,—and larger amounts also of the substances which are measured by the oxygen consumption,—a condition which would naturally be expected at different seasons.

Q. Now, I will ask you if from your analyses made in February and March, 1902, the water in the Illinois river at Grafton, is not shown to be in a more polluted condition, and in worse condition for domestic purposes, than the examinations made by you in the summer of 1901?

A. I said in general that I do not consider this water or any of the waters in comparison and under discussion, suitable waters for domestic consumption. That I wish to be understood
on distinctly. I do not and have not said at any time, that
7176 the water of the Illinois river at its mouth, at Grafton,
could be considered as good suitable water.

As to the second part of your question, whether this water is less pure in the colder season than in the warmer season, as measured by these several factors, I would say yes. They indicate a much less degree of oxidation in the colder weather than in the warmer times, but at no time would I consider them good, wholesome, safe, waters.

Q. Now the degree of purification is very much less, is it not?

A. The degree of purification as measured by the oxidation of ammonia is decidedly less, but free ammonia, when it appears, is one of the last stages in the oxidation of organic matter. The main stages have been long past. When we reach ammonia we are in a comparatively very advanced condition of oxidation, when we consider the breaking down of protein molecules, whose molecular weights are 15,000 or 16,000, and reach bodies like ammonia, or even the more complex substances,—urea, or uric acid, the molecular weights of which are very small as compared with the molecular weights for the proteins,—we have reached a condition in which the substances remaining can scarcely be compared with the original substances.

Q. I will ask you, professor, if that condition is not usually

reached in sewers before it reaches the outlet of those
7177 sewers?

A. It is reached largely by one portion of the substance in sewers. One of the common products in sewers is urea, which represents a very large fraction of the excretion of human urine. Urea is a body which undergoes hydrolysis very rapidly, and it breaks down, yielding ammonia, and therefore ammonia does appear early in the sewers.

Q. Now professor, the conditions shown by the analyses in February and March, 1902, would be very much worse if the samples had been taken in the latter part of December and January preceding, would they not?

A. Why, there is nothing whatever to indicate that they would be worse.

Q. Is there anything to indicate the reverse?

A. I have nothing to indicate either one way or the other.

Q. Do you know anything on the subject that would give light?

A. At the present moment I cannot recall from my own experience anything which would throw light on this particular question, but the temperature in February in this latitude is usually as low as at any time in the year, and we can scarcely expect any worse condition in December than in Feb-
7178 ruary?

Q. How is it in March?

A. In March in this latitude we generally have just about as bad and ugly cold weather, as we have in January.

Q. Do you know the character of the weather they have in the lower Illinois river towns?

A. The lower Illinois river was bad at those times; that is, the weather was cold.

Q. Do you know when the ice forms on the lower Illinois river; what part of the year?

A. Not absolutely, and the amount of ice in the lower Illinois river as I recall, is at no time of the year very great.

Q. Do you know what time the ice breaks up upon the lower Illinois river?

A. Not absolutely, no.

Q. Now professor, were not all these samples of water you used for the purpose of determining the character of the water in the Illinois river taken during extreme low water time or periods?

A. As to whether they were taken during extreme low water periods I am not able to state very definitely. From my recollection of 1899 and the summer of 1900, the seasons were pretty dry and the water relatively low, I believe, but as 7179 to whether they were extreme low water or not, I cannot now say.

Q. But like those that were taken during high water, none of the samples were selected during the respective periods for the purpose of determining the condition of the water in extreme low water time—

A. For that purpose, no, not as I recall now. At least it was not the intention. They were to take them as long in the season as they could. How low the water was in either one of those years, I cannot now say.

Q. Professor, you stated, I believe, that albuminoid ammonia and oxygen absorption are more characteristic of vegetable organic matter than of sewage?

A. No; you have not stated my testimony quite correctly there.

Q. Well, what did you state?

A. Well I have stated quite a number of things, and I do not know now what you refer to.

Q. Well, what are the characteristics of vegetable origin as distinguished from sewage origin?

A. I was pretty careful not to go into any sharp characterization of those things. I stated this much, as I recall, that under certain circumstances we are able to know cer- 7180 tain distinctions between vegetable matter and animal matter, and I think I explained here why it was a chemical impossibility—

Q. Then you didn't go into that discussion of those perhaps, for the reason that you were not able to do so from the standpoint of a chemist?

A. I explained that in a great majority of cases, such a sharp distinction is not possible.

Q. And that statement is made in view of the fact that it cannot be determined from a chemical analysis as stated yesterday, the source of the pollution, whether it is sewage, swamp, or from what source?

A. It is not always possible to draw a conclusion from such examinations. This, however, is true, as I explained, that in the vegetable extracts in general, because of the character of the matter going into water from vegetation, the ratio or relation of the oxygen consumption figure to the albuminoid figure, is comparatively high, these vegetable substances containing comparatively more of the carbo-hydrates or carbo-hydrate derivatives, bodies, than protein or protein derivates bodies, so as the vegetable substances break down, we have a much more rapid diminution of protein factors than we have of the carbohydrate factors, so that in waters of vegetable origin there is usually remaining, a pretty high factor for oxygen consumption. 7181

Q. Is there any way to determine from the standpoint of a chemist whether the pollution in the Illinois river at its mouth is sewage pollution or pollution of some other character?

A. I should not attempt to make any such characterizations there.

Q. Then why is it that you say the water of the Illinois river at its mouth is not fit for drinking purposes?

A. I explained this morning that I consider any water unfit for household purposes or drinking purposes, which receives a large amount of organic matter from any source. I make a general conclusion there,—the Illinois river, the Mississippi river and the Missouri river.

Q. Now is that without reference to the character of the organic matter that is deposited in the river?

A. In general I object to any large amount of organic matter of any kind in a river.

Q. Now then, which to you as a sanitary chemist, would be more objectionable, deposits from sewers and from a country thickly inhabited, and the water from a river flowing through a country sparsely inhabited?

A. In general I should object more to the water from the sewered region than to the water from the uninhabited region.

7182 Q. Do you know the difference in the impurities and the extent of the impurities that are deposited in the Illinois river than those in the Missouri river?

A. Not absolutely, but I have some ideas on the subject.

Q. Do you know the comparative volume of water flowing out at the mouth of both streams?

A. No, but the Missouri is usually a very much greater volume than the Illinois, both receiving enormous amounts of organic filth.

Q. Do you know whether or not the organic matter contained in the Missouri river or any part of it, is harmful or harmless?

A. Well, I should consider from general knowledge of the situation, a part of the organic matter discharged at Omaha and Council Bluffs, and Kansas City and other points, as very objectionable, and as—

Q. Then I will ask you if that is not an exceedingly small portion of pollution, considering the volume of water flowing down the Missouri river as compared to the pollution of the water in the Illinois river by the city of Chicago?

A. As compared with the pollution of the Illinois river by Chicago, and most especially by Peoria, I consider the pollution from the household waste and stock yards industries 7183 of Omaha and Kansas City, as small, comparatively—or relatively smaller than the amount of pollution from these places, but it is still large.

Q. But it is very much smaller than that of Chicago is it not?

A. From these sources it is smaller—considerably smaller than the original discharge at Chicago.

Q. Do you know the time distance of the water from Omaha and Council Bluffs to St. Louis?

A. No, not of my own knowledge, nor the distance from Kansas City to St. Louis, except as it was brought out in the testimony as given in St. Louis. The time distance from Kansas City to St. Louis being so much less than the time distance from Chicago to St. Louis as to very materially counteract the effect of the greater amount of organic matter from Chicago.

Q. What do you mean by "very materially"?

A. Well in a very large proportion, the time distance from St. Louis to Kansas City, as I recall from the testimony given in St. Louis, is probably not one-fifth of the time distance from Chicago to St. Louis.

Q. Do you know the number of days required for water to flow from Omaha and Council Bluffs to St. Louis?

7184 A. Not exactly. From Kansas City a period of three or four days was given. I do not recall the statement of any period for Omaha or Council Bluffs.

Q. At what stage of the water?

A. That I do not now recall.

Q. Then you consider that the sewage from Omaha would pollute the water in the Mississippi river at St. Louis, do you?

A. I did not make that statement at all. I simply spoke of the large amount of organic matter discharged, at those places.

Q. I will ask you as a sanitary chemist, if the discharge of the sewage of Omaha into the Missouri river affects the sanitary condition of the water of the Mississippi river at St. Louis?

A. As a sanitary chemist I should feel that this discharge of organic matter coming down very rapidly, in a swiftly flowing stream would be a factor to be considered.

Q. Now I will ask you if in your opinion as a sanitary chemist, the discharge of the sewage of Chicago,—into the Illinois river, would affect the sanitary condition of the water at Grafton?

A. In reply to that question I will state, as I just stated for the Missouri river, that this discharge would be an extremely important factor to be considered in forming any opinion regarding the purity of the water at the mouth of the Illinois river. 7185

Q. And for the same reason it would be an important factor for St. Louis?

A. It would be a factor to be considered in any case.

Q. Now what is your opinion as to the strength of that as a factor?

A. From the tables which I have presented, and from the curves which I drew, illustrating some of these tables, I made the statement that I believed the pollution from Chicago is the least important, and a comparatively unimportant factor in any residual pollution left at the mouth of the Illinois river.

Q. Well, it is a factor?

A. All these things are factors to be considered of course, but I stated further that the determinations made through these investigations, show a larger amount of organic matter as measured in the usual way at the mouth of the Illinois river, than can be well accounted for by the contribution of the tributaries and the contribution of Peoria, so that the Chicago contribution is completely covered up and lost sight of and minimized as compared with the other.

Q. Now you talked of the organic matter?

A. Yes.

7186 Q. Do you know the different characteristics of the Missouri river with reference to sand-beds, and the turbidity of the water as compared with that of the Illinois river proper, and its tributaries, aside from the sewage of Chicago?

A. Yes, I am pretty familiar with the appearance of the Missouri river, its turbidity and the various conditions along the river.

Q. I will ask you if there is not more known harmless organic matter in the Missouri river than there is in the Illinois river?

A. No, I would say decidedly not. We have no proof that the products of organic decomposition left in the Missouri river are any less harmful than the decomposition left in the Illinois river.

Q. Now then, professor, in considering that proposition and in making the statement that you have just made, have you taken into consideration the character of the soil through which the rivers run and the population residing on those rivers and their tributaries?

A. I have most decidedly.

Q. And have you taken into consideration the volume of the stream flow?

A. Certainly; certainly.

7187 Q. Then one batch of the organic matter is just as bad as another, isn't it?

A. That doesn't follow from anything I have said at all.

I should say "No." Some organic matter is very much worse than others.

Q. Take the nitrites as a measure of organic matter; what does it show?

A. The showing from nitrites is an extremely uncertain thing, because nitrites are products of partial oxidation, and also in certain conditions of reduction, and of all the factors which have been discussed by sanitarians, the nitrite factor is one of the least certain.

Q. What do accumulations of these show?

A. It shows that there is a certain amount of substance of original complex nitrogenous origin which has not yet been completely oxidized, but it doesn't show what it comes from or what it is.

Q. Now we are comparing the water of the two rivers at the mouth. What river shows the more of nitrites?

A. I haven't made any examinations there; that is, I don't recall. I can look that up presently.

Q. (Question repeated).

A. Well, there is a great deal of nitrite in the Illinois river, —more than in the Missouri river, which simply indicates
7188 this, that there is a larger amount of nitrites in that form
which has yet to be oxidized, whether that nitrogen came originally in ammonical form, or from the nitrate form, we are absolutely unable to determine.

Q. But it is there nevertheless?

A. It is there, and as such, it hasn't any importance one way or the other.

Q. Professor, do you consider a comparison of the gross organic matter contained in the waters of the two rivers a fair comparison without knowing more about them, than the gross organic matter contained in the water?

A. In drawing a conclusion from the observation of organic matter I should want to know, as I explained yesterday, that a chemist should know, in all cases, something about the original conditions along the river giving rise to this organic matter.

Q. You know about the source of the organic matter in the two rivers. Now I will ask you if it is a fair comparison.

A. Yes, I should consider the comparison a perfectly fair one. The organic matter left in the river is in itself harmless.—That must be admitted. The organic matter as such is harmless.—in its advanced stage of decomposition. The comparison therefore is a fair one.

7189 Q. That is, it is harmless so far as the chemical tests show?

A. Yes, and undoubtedly as far as any test can show, that this residual organic matter must be harmless in either river; that it as far as its capability of producing disease is concerned

Q. Then why is it condemned for drinking purposes?

A. I have stated in general that I should condemn water containing any large amount of substance other than water, for the reason that along with this organic matter other things may enter which are not harmless.

Q. What are they?

A. This organic matter of course, supports a certain amount of organic life which we object to.

Q. Now why do we object to it?

A. I object to that from the opinions of the class of sanitarians referred to who have worked on the modern theory of diseases, (I cannot give an original opinion) that some of these living forms of organic matter are the important agencies in the production of disease; that is, I borrow from the knowledge of others in coming to a conclusion regarding the harmfulness of the living organic matter.

Q. Now do you take that into account as a factor in
7190 comparing the waters of the Illinois river at its mouth with those of the Missouri river at its mouth?

A. I did in my statement yesterday refer distinctly to the fact that the determinations measuring what is called the bacterial contamination in the mouth of the Missouri are more pronounced than those in the mouth of the Illinois.

Q. What do you mean by bacterial contamination?

A. I mean the presence of those organisms which are able to decompose complex nitrogenous matter, break down complex nitrogenous matters, and yield the aromatic compound or substance known as indol, that very long experience has shown to be a reaction produced in waters by certain kinds of bacteria, a

reaction which, however, can be brought about in laboratories by other agencies. In addition to this we include in this pollution all those substances or bodies, which are able to decompose carbo-hydrates, with the liberation of acid, which is recognized in turn by its power of coagulating milk. If therefore, we expose milk to the action of water under proper conditions, the speedy coagulation of that milk points to the presence of a relatively large number of these micro-organisms which decompose the sugar in the milk and liberate the acid, which precipitates the casein of the milk, and further, in addition to that, we detect the presence of these micro-organisms by the activity of
the liberation of certain gases, when the water is mixed
7191 with a solution containing a constituent which the bac-
teria will decompose with the liberation of gases. Certain carbo-hydrate substances are decomposed by the bacteria yielding several gases, particularly carbonaceous gases, carbon-dioxide gas, some of them cause even the liberation of methane. These factors are pronounced in the Missouri river, more pronounced there than in the Illinois river.

Q. How do all these things indicate the quality of the water?

A. Well, these things simply point to the presence of a certain kind of pollution, the presence of certain micro-organisms which may or may not be pathogenic. I pronounce no opinion on that.

Q. Now then, what particular character of pollution is indicated by any particular chemical constituent in the water?

A. Ammonia and albuminoid ammonia indicate an original pollution with, at some time, nitrogenous matter of some kind. What, I will not attempt to say. The oxygen consumption reaction indicates also the presence of organic matter in the water, because we know from long experience that the mineral substances in the water are not able to bring about the production of permanganate in this way.

Q. Are you able to determine, Professor, from any of
7192 these above kinds of constituents that you have in the
water, the character of the pollution contained in that water?

A. I will say in general that I cannot draw any very sharp conclusions from that, from those determinations.

Q. Then, how can you tell about the absence of any sewage matter at Chicago at the mouth of the Illinois river?

A. In regard to the question of the presence or absence of sewage matter at the mouth of the Illinois river I have reached my conclusions by observing the very rapid rate of change of organic matter as we go down the river, reaching finally a condition where the organic matter as measured by the tests is not at all larger than would be properly accounted for by what is going in from the tributaries and from the great contamination at Peoria.

Q. Now, then, do you know whether or not these certain smaller micro-organisms coming from Chicago that feed upon this decomposed matter, that continually feed upon the decomposition in the water, are absent at Grafton or not?

MR. TODD: I object to the question on the ground that the witness has not testified that any micro-organisms come from Chicago, and for the additional reason that the witness has disclaimed any desire or knowledge to testify as to bacteriology or epidemiology, but merely as a chemist.

7193 MR. JEFFRIES: And I submit in response to the objection that the witness has stated in evidence, that he presents the ability and presence of these certain micro-organisms as one of the material reasons upon which and by which he pronounces the water unsafe for drinking purposes, that receives the sewage discharge of the city and for the further reason that the result of certain micro-organism tests are recorded in the tables of analyses made by this witness.

MR. TODD: I still suggest that the evidence doesn't show that the witness has testified that any micro-organisms came from Chicago and got to Grafton.

Q. (Question repeated.)

A. I don't know whether any of these micro-organisms started at Chicago or somewhere else.

MR. JEFFRIES: You have answered the objection and not the question.

Q. (Question repeated.)

JUDGE SPRINGER: Do you mean by that to ask this witness whether the micro-organisms that start at Chicago, have disappeared at Grafton; is that what you mean?

MR. JEFFRIES: No, sir; I want him to tell—

THE WITNESS: I don't know that any micro-organisms ever get to Grafton from Chicago. Therefore I cannot answer.

Q. In other words, you do not know whether they are there or not?

7194 A. I don't know that any Chicago micro-organisms are there or not.

Q. There are micro-organisms there, are there not?

A. I should judge so from these reactions, but whether they are Chicago micro-organisms or not I don't know.

Q. Are they the same kind of micro-organisms that go over the Bear Trap Dam?

A. I wouldn't attempt to say that; I am not a bacteriologist; that is a question for another kind of an expert.

Q. In other words, Professor, so far as the science of chemistry and bacteriological chemistry go, you are unable to determine the presence or absence of micro-organisms that are discharged from Chicago into the Illinois river at Grafton. In other words, you are unable to determine at Gratfon?

A. I am unable to make such a determination at Grafton.

Q. In other words, from the standpoint of the science of chemistry and of bacteriological chemistry, there is no way of making such determination?

A. There is not.

Q. Now, Professor, I will ask you if from your experience as a sanitary chemist, and your experience in the science of bacteriological chemistry, if there isn't more of the polluted

7195 matter and micro-organisms in the water during the cold seasons of the year at Grafton, than there is in the summer time, comparatively speaking. In other words, doesn't this scientific investigation show a greater degree of reduction in the summer time than in the cool seasons of the year?

A. In general that is true, but the bacterial chemical tests at the mouth of the Illinois river at Grafton in the cool or colder seasons, February and March, 1902, do not show a markedly greater or appreciably greater contamination than during the warmer seasons.

Q. Professor, what significance do you attribute to this certain kind of bacteria that you find in the water from your analyses, as to the sanitary condition of the water for drinking purposes?

A. The presence of some of these bacteria is suggestive of the presence of substances which are widely decomposed, or greatly decomposed. We have nothing present which can yield indol, and the bacteria which thrive on these matters so decomposed, therefore, tend to disappear. Now, the fact of the absence in general of these bacteria at the mouth of the Illinois river, is a very strong suggestion of the breaking down of the original protein matters beyond that stage where such bacteria thrive, certain bacteria thriving, as we know from chemical experience, on original protein matter, or protein-
7196 like matter not far removed from the original protein
matter, either on original protein molecule or the albuminoid molecule or the peptone molecule derived from it, but as we continue disintegration or breaking down of these molecules, we reach gradually bodies which will not support certain kinds of bacterial life, that is, where the original proteins can support certain kinds of bacteria the more advanced products of the decomposition of this protein cannot. The absence of these bacteria then, through the investigation made at the mouth of the Illinois river, is a very strong suggestion of the practical absence of that kind of matter.

Q. In other words, it suggests the absence of that kind of bacteria?

A. It shows the absence of that kind of bacteria.

Q. Now, then, showing the absence of bacteria, do you know whether the bacteria that is absent, is harmful bacteria or not?

A. I do not know, as far as producing disease is concerned.

Q. Do you know whether it shows the absence of bacteria that are harmful?

A. No, I do not. There is no close relation between those
that I am familiar with, as far as each bacterial chemical
7197 reaction is concerned.

Q. Do you know whether or not these indol-producing bacteria have any relation to the bacteria producing diseases?

A. No, not in a general way. This fact, however, can be drawn from a general knowledge of physiological chemistry, that indol producing bacteria are practically always present in the human system whether diseased or not. They do not produce disease there.

Q. In other words, then, they are supposed to be a harmless bacteria?

A. I couldn't say it, because they are plural. I wouldn't pretend to testify to that anyhow. There is more than one kind of bacterium of that nature, but in so far as I know, they are not what bacteriologists call pathogenic or disease producing.

Q. Then, practically speaking, they are harmless?

A. I think most of these particular things are in themselves harmless.

Q. And so far as you know, all the bacteria that you have studied are harmless?

A. I have made no experiments to determine their disease-producing character.

7198 Q. How do you know, and upon what premises do you base your conclusion, then, when you say that the water at Grafton has lost all of its pollution from Chicago?

A. Well, that is the factor which I have just spoken of as a very important one in reaching that conclusion. If there was original complex organic matter left there, we should unquestionably find the class of bacteria which prey on that matter, but those bacteria not being there, we have the strongest kind of a suggestion that the organic matter has been so decomposed it will not support them.

Q. But reasoning of that character, or an analogy of that kind, is not a reliable analysis. You cannot associate in the same way the bacteria that are harmless with those that are harmful?

A. No, that doesn't follow at all. There is no necessary relation there. I am speaking of the disappearance of protein matter as dependent on, or as in a measure indicated by the disappearance of the bacteria, which are usually associated with decomposing matter.

Q. Professor, I wish you would turn to table No. 4, read in evidence in your direct examination, and giving the result of your analyses of the water at Grafton at the mouth of the Illinois river in February and March, 1902?

A. Yes, sir.

7199 Q. Now, I will ask you to note the rapidity of the coagulation of milk, in those samples taken February 24, 25, 26 and 27th? What do you find there?

A. I find that the rapidity there as given is comparatively slow. Two cases no coagulation; in other cases through 24 hours.

Q. And one case at 20 hours?

A. You gave me four numbers, did you not?

Q. That's right. Now, pass through the month of March, the 3rd, 4th, 5th, 6th, 10th, 11th, 17th and 18th?

A. Yes, we find a period of 20 hours in March, one of 36 hours in one case. The period was rapid inside of ten or twelve hours undoubtedly, and the next is 24, 30, 16, 24 and 18 hours.

Q. Now, how was it as to indol?

A. Indol out of thirteen tests I believe, was recognized twice. In regard to the coagulation of milk, of course it was well known that the bacteria producing this coagulation could come from many sources, derived from cow pastures as well as any other source.

Q. Will you state specifically that it doesn't come from Chicago?

A. I do not pretend to state that it doesn't come from Chicago.

7200 Q. But you do state that you do not know from what source it comes?

A. I will state that I do not know from what source these bacteria which coagulate milk, come; but since the matter has been referred to, I will state that the Illinois as compared with the Missouri river shows a very much less marked indol reaction in the Illinois than in the Missouri. We have production of indol twice in thirteen cases in the Illinois, while we had six times out of eight for the Missouri.

Q. Do you consider the information as to indol invaluable in forming an opinion as to the sanitary condition of the water?

A. No, I consider it one of the valuable points, not one of the absolutely essential points, but one of the valuable points to be considered, along with a great many others.

Q. Why do you say "considered?"

A. From the statements I have already made regarding the general character of the substances known to physiologists which support organisms which produce this indol reaction.

Q. You cannot determine, then, from the chemical analyses, and from the different constituents contained in the water the exact significance of any one constituent?

7201 A. The absolutely exact significance of any one constituent would be extremely hard to give; practically impossible.

Q. Now, then, can you give the significance of any two constituents?

A. Significance in what way?

Q. From their presence in determining the particular character of the pollution, or the wholesomeness of the water?

A. Not in a great number of cases. Perhaps in a great majority of the cases the determination of two constituents alone would not afford such information.

Q. Now, then, is there any particular case or instance, throughout your whole examination of the water in the Illinois river where any two of these properties enables you to determine the character of the pollution, so far as the wholesomeness of the water was concerned?

A. Yes, that is fairly easily answered. I find a certain large amount of albuminoid ammonia, for example, at Peoria,—a very large amount. I can say that the pollution occasioning that is highly nitrogenous. I can say that without hesitation, it is more than comes from any ordinary source and I should condemn the water immediately on that determination alone.

Q. Now, then, is there any graduated scale by which ammonia in the water may be reduced until it becomes permissible?

7202 A. There is no gradual scale which will obtain for all waters. As I explained this morning, we have to judge the waters very largely by what we know of their sources. I explained that an amount of free ammonia, for example which would be extremely suspicious in Lake Michigan would be regarded as perfectly normal and natural in an artesian well, so there isn't any graduated scale. I know that at one time sanitarians attempted to prescribe limits of that kind, but they are not now regarded as of much value.

Q. That was before the science of bacteriology came into existence, wasn't it?

A. Yes, sir.

Q. And for some time afterwards?

A. Yes, sir, and also before the method of chemical water analysis had been fully developed, and before data from various sources had been compared, so as to see the meaning of these data, their general bearing.

Q. Now, are there any two constituents in the water or in the samples of water taken at the mouth of the Illinois river at Grafton, which will enable you or do enable you to determine the character of the pollution in that water?

A. I will say as I have said before, I cannot attempt to state exactly the character of the residual pollution, whether from two or from all of the chemical determinations I have made.

7203 Q. Are the nitrites in water characteristic of organic matter—animal organic matter?

A. Not necessarily, no. The fact that nitrites may come from the oxidation of ammonia, or from the reduction of nitrates, shows that they cannot be taken as characteristic.

Q. Are they more characteristic of sewage pollution than of pollution of some other character?

A. Not necessarily. It would depend very largely upon the drainage area in which the water is found, for example, agricultural lands, which have been manured with certain kinds of salts, particularly, show a reduction of those salts to the nitrite condition, and even to the condition of free ammonia, with the loss of nitrogen. Now, if such soil drained into a water, we can have and do have, as investigations have shown, nitrites present, which cannot be considered as derived from animal origin.

Q. Has that been proven?

A. That has been proven from the examination of waters draining from such places. In general I have said that because sewage contains more nitrogen than the vegetable products do, we should naturally expect more of these products of oxidation there than we do from other places. It would naturally and necessarily follow.

7204 Q. Now, Professor, take the two rivers with cities situated upon their respective water-sheds, which discharge their sewage into those rivers, and the samples of but one water, show an average of .034 parts of nitrogen as nitrites, and the other showing .0006 nitrogen as nitrites, what significance would you give to those two constituents and their relative importance?

A. Well, it would not be possible—as I practically answered the same question some time ago, it would not be possible to draw any very sharp conclusions from such a consideration. The large amount of nitrites in one place you have mentioned, may come from imperfect oxidation of ammonia, but it may come from a reduction of the nitrate already formed, if this nitrate happens to be present with a considerable amount of fresh organic matter, for instance, such as would be left in the stream by the death and decomposition of water plants. We have there a condition similar to that which has been observed frequently by agricultural chemists; there the reduction of nitrates may follow. So from that fact it is very difficult and practically an impossible matter to draw any conclusions from the case you state.

Q. Now, then, eliminate everything from those rivers, all deposits of every character, from the water of those rivers, save the sewage discharges of the cities upon the rivers, 7205 what would you say as to those results?

A. I would say exactly the same thing as I have said, there is nothing more could be said. My answer covered just such a case.

Q. Even if you eliminate everything except the sewage from the water?

A. Yes, sir.

Q. The result would be the same?

A. Yes, you might have just such a condition, because the products of decomposition of sewage in some stage, may bring about a large growth of water plants which dying off in the presence of nitrates,—products of oxidation, would lead to a reduction of these nitrates and a reduction of nitrites. That is the case any way you look at it.

Q. Now, then, you have stated what might be the result. State, Professor, what would be the most likely result?

A. What I have stated is as likely as any. As we know, it has been shown frequently that nitrates are so reduced that the result I have given is as likely as any other result.

Q. You cannot tell whether the sewage discharge, irrespective of the cities upon the two rivers, would have any effect upon those, or not?

7206 A. No, we have two different conditions of oxidation. We do not know whether the condition is one of advanced oxidation, or a retrograde change of reduction.

Q. Suppose, Professor, the nitrites were accompanying very high free ammonia, what would you say as to the character of the pollution?

A. Well, when the nitrites were accompanied by free ammonia, it might still just as well follow, too, that we have a reduction of nitrates to nitrites in the presence of organic matter. The presence of free ammonia wouldn't interfere with that fact at all.

Q. Then if I understand you correctly, it is as liable to come from one source as another?

A. Yes, as far as we know, it is.

Q. And the fact that the river contains, situated upon its banks, a large and populous city of 1,500,000 people would have some effect naturally on those results?

A. Certainly, in the way of discharging sewage from such a large population. In general, that large amount of nitrogen would bring about the conditions which would give rise to those products of nitrogenous decomposition. The larger the amount of nitrogen present, the larger the amount of various decomposition products we would naturally expect.

7207 Q. Isn't it reasonable to expect from a scientific standpoint that as the population increases, as the sewage discharge from the city increases, that these particular properties will increase and be shown in the chemical analyses?

A. It would necessarily follow that there must be an increase in the preducts of carbon dioxide in the various amido and aromatic compounds, in the ammonia produced and in the nitrates produced, but of the subsequent reactions between these things themselves, it would be very difficult to say very much from the present state of our knowledge of just how those changes were all brought about.

Q. Isn't it natural for scientists to expect large results in these different properties and forms of nitrites or nitrogen coming from the sewage of a large and populous city?

A. Yes, a very large protein discharge from any source; from such a discharge we would naturally expect correspondingly large amounts of nitrates, whether it be from a city or from a distillery or a cattle shed. Such as, for example, are in the city of Peoria in the state of Illinois.

Q. Professor, do not nitrites and free ammonia as a rule run higher in the Illinois river at its mouth than they do in the Missouri river and the Mississippi river?

A. I believe they do.

7208 Q. Now, if this be true, doesn't it show that the Illinois river is more polluted than the other streams?

A. Not necessarily, because the pollution is measured by many factors in addition to those. If it was measured by those alone I would say "Yes," but inasmuch as pollution is measured by a great many factors, I could not so conclude from your question.

Q. Are they not the best measures of recent sewage pollution in water?

A. Well, free ammonia is considered as a measure of sewage pollution, but nitrites absolutely not. As it has been shown so conclusively by the investigations of agriculturalists that nitrites can come just as well from the reduction of nitrates, as from any other source.

Q. Now, Professor, speaking of free ammonia and assuming that it is indicative of organic matter of animal origin, give me the average amount of free ammonia disclosed by your analyses at Grafton of the Illinois river for the year 1900?

A. For the summer of 1900 we have left at Grafton in the Illinois river an amount of free ammonia measured by .07.

Q. Now, then, I will ask you to read the average for free ammonia at that place in 1901?

7209 A. In 1901, through the late season, the summer, fall and early winter season, we have .238.

Q. Now, how as to 1902?

A. During the spring of 1902, we have left free ammonia at Grafton, an amount measured by 1.344.

Q. Now, Professor, assuming that free ammonia is indicative of organic matter of animal origin, that is sewage, I will ask you to state if those figures that you have just read do not show that the Illinois river contained less contamination and sewage pollution in 1900 than in 1902

A. If, as assumed by the question, the only indication of organic pollution is that of free ammonia, then I should answer affirmatively, that the Illinois river in 1902 in the winter, appears to be more contaminated than in the summer of 1900, but as we have other measures of organic polution besides free ammonia, it would be necessary to consider them before drawing a final conclusion for the whole case.

Q. I will ask you, Professor, if your nitrites do not increase for the year 1901 over those of 1900?

A. Well, if the table says so, they did.

Q. Well, it don't say so.

(Question repeated.)

A. Well, there isn't much difference anyway.

Q. There is a little increase, isn't there?

7210 A. There is a trifle.

Q. Professor, what is the significance in free ammonia during these respective periods at Grafton?

A. That I am not fully able to explain just what condition obtained in the Illinois river in the summer of 1901 and the summer and fall as compared with the season of 1900, to give rise to this increase of free ammonia in the second year. I could not tell. Whether it is an increased flow of pollution with nitrogenous wastes from the distilleries of Peoria and the cattle sheds of Peoria, or from some other cause, I could not state. The large amount of free ammonia in the spring of 1902 indicates a lower degree, of course, of oxidation; that we would naturally expect from the colder season. Whether this is due to the great increase of material at Peoria I have no means of knowing, as I made no determination of Peoria at a corresponding time.

Q. Assume, Professor, that the deposits from the cattle sheds and distilleries of Peoria actually decreased during the years 1900, 1901 and 1902, what would you say?

A. I would say then in general, and that is as much as can be said, that the oxidation of this factor is not as far advanced as in the other seasons. That the breaking down of the proteid from the more complex stage, or the breaking down of the 7211 nitrogenous matter from the complex proteid stage, has apparently gone practically as far, but the oxidation of the ammonia as one of the products of this decomposition has for some reason been delayed, why, I don't know.

Q. Then, Professor, from your last answer I take it that no correct analyses could be made upon which a credible opinion could be based unless the analyses be taken from one end of the year to the other?

A. No, that doesn't follow. A credible opinion is an opinion which can be believed, and I insist that the opinion I have given can be believed as much for these analyses as for any other.

Q. So that the opinion that you have given from the analyses that you have made, represents correctly the conditions of the river at Grafton at all times of the year?

A. I believe the analyses which I have presented do represent those conditions.

Q. Now, Professor, assume that for the next ten years there shall be the same ratio of increase in free ammonia at Grafton, as there is disclosed from the samples analyzed by you from that point for the years 1900, 1901 and 1902, what would you say as to the character of that water?

7212 A. If for some reason not suggested by the question there should be a corresponding increase of free ammonia, I should think something had struck the mouth of the river.

Q. The mouth, or the source?

A. The mouth.

7213 Q. Well, with the water flowing down the river, would you say that the mouth of the river was struck from the direction of its source, or from the direction opposite its mouth?

A. Well, with the water flowing down the river I should say simply that someone must have dumped some dead hogs into the river to produce such results.

Q. Assuming that no such temporary and continuous actions of that character were brought about?

A. Then it would be impossible to answer the question as such an increase as was assumed has never been observed through a period of ten years and could not take place.

Q. Assuming that the city of Chicago would grow of sufficient size and proportion from the standpoint of population, that its sewage discharged into the canal and thence into the Illinois river, so as to produce this same ratio of increase in free ammonia in Grafton, what would you say as to the result?

A. I would say it was a very bad water to show such an increase in the amount of ammonia.

Q. Is it a fact with the rapidity of oxidation, the impurities in the water decrease rapidly as the proportion of impurity is smaller?

A. That rate would be measured in various ways. In a highly contaminated water, the initial rate of change is greater than in the less contaminated water.

7214 Q. Now, then, if that be true, doesn't this show, or doesn't that show that it takes longer to oxidize the sewage of Chicago since the drainage canal was opened, than it did before?

A. No, it wouldn't follow from that at all.

Q. Why not?

A. Well, the statement I have just made refers to the initial rate of change in sewage of a very concentrated and highly contaminated condition, and the rapid beginning rate of change which is followed up more slowly later. Now, there is nothing to show that the rate doesn't continue afterwards as rapidly in one case as in another.

Q. I will ask you, Professor, if the opening of the canal and the discharge of the water into the lake from the Illinois river has not carried the sewage of the Illinois river including the sewage from Chicago, farther down the river before it becomes oxidized than it was prior to the opening of that canal, or than it did prior to the opening of the canal?

A. Yes, I believe that in a general way this period of beginning oxidation has been somewhat retarded, how much I don't know.

Adjourned until 10:00 a. m., October 1st, 1903.

10:00 A. M., Thursday, October 1st, 1903.

7215 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. JOHN H. LONG,

resumed the stand for further cross-examination by Mr. Jeffries and testified as follows:

Q. Professor, did you make an extended analysis of the Mississippi river water near the city of St. Louis?

A. I made at one time an examination of the Mississippi river water above Grafton, and that is the only examination of the Mississippi river water I made.

Q. To what extent was that examination made?

A. The results of the analyses have been given in evidence.

Q. Yes, but I mean with reference to the duration of the examination and the number of samples examined?

A. That examination was made in the fall—late fall and early winter of 1901, and spring of 1902. The examinations were in the fall, probably 25 to 30, and in the spring about ten—ten or twelve.

7216 Q. Now, professor, suppose that you had made a series of analyses of water on both sides of the Mississippi river at St. Louis, for a long period of time, and that you had found that organic nitrogen in its different forms invariably ran so much higher on the Illinois shore than on the Missouri shore, and suppose further that you had also made analyses of the water of the Mississippi at a point above Alton, and of the water of the Missouri river above its mouth, for a long period of time, and had found that organic nitrogen always ran higher in the Mississippi than in the Missouri, and suppose that you had also made analyses of the Illinois at Grafton, and of the Mississippi above Grafton, and had found that as a rule organic nitrogen in its various forms was higher in the Illinois than in the Mississippi, what would you say as to the effect of the Illinois river upon the water of the Mississippi at St. Louis?

MR. TODD: I object to the question on the ground that the facts predicated in the hypothetical question are not based upon the evidence offered by this witness on direct.

A. If I had ever made such analyses and had obtained such results, I should of course be obliged to attribute the high nitrogen in the Mississippi to the Illinois, but I do not believe that such results are found or ever have been found in any such examination in any given period of time.

Q. Professor, would it not follow from these conditions that the Illinois river was the source of very much higher
7217 organic nitrogen which found its way into the Mississippi, and down the river to St. Louis?

A. If, as I said, before, I should observe such conditions, I should then be obliged to admit or to consider that the Illinois river was the source of high organic nitrogen, but I have never observed any such condition.

Q. Professor, eliminating all other sources of pollution of the Illinois river save that caused by the sewage of Chicago flowing through the canal and down that river, what would you say of the sanitary condition of the water at the mouth of the river, if you found that it disclosed large quantities of organic nitrogen at that point?

A. If I found that it disclosed large quantities of organic nitrogen, in excess of that found in the tributaries of the Illinois, flowing through farm lands, tributaries not contaminated to any large extent by household drainage or sewage; then I should say that the organic nitrogen starting from Chicago had not been completely decomposed, but as a matter of fact at the mouth of the Illinois we do not find any such condition, even with everything which is added. At the mouth of the Illinois the condition reached, considering all circumstances, is so close to that found in the tributaries, that the supposition made is impossible.

7218 Q. Now do you mean by that answer all constituents of the water as found at the mouth of the river during the flood times, freshets, and winter season and during the conditions of the weather throughout the entire year?

A. I mean to say that at the mouth of the Illinois river during flood times; times of high water, because of the spread of this water over enormously great area, the fraction of contamination starting from Chicago has been so far reduced by this dilution that any effect which it might have in retarding oxidation is fully counterbalanced by the enormously greater dilution; and that condition of the Illinois river so far as the original sewage is concerned, I believe, is no worse then than at any other time.

Q. Now, professor, assuming that the low lands along the

Illinois river which you speak of as being flooded in high water times, was levied so that there would be no overflow of any considerable moment, what effect would that have?

A. Well, if we can assume that the land is so much levied that there is no overflow, then conditions would be changed, and we would find a different result; but as a matter of fact the levees are practically always overflowed in floods and high waters, and have been for years.

Q. Now professor, during these flood times, wouldn't
7219 there be a very rapid channel and wouldn't this organic matter be carried from the source of pollution to the mouth of the river much more rapidly than during the low stages, or ordinary stages of the water?

A. An answer to that is included in my former answer, that while because of the greater rapidity of flow, there may be some—there is naturally a more rapid carrying of the substances, because of the very great dilution that takes place—at the same time the distribution of this substance over an enormously great area, more than counterbalances that effect.

Q. Have you made any determinations on that proposition?

A. No sir, but I am basing my opinion there on the numerous examinations of the Illinois river, and consultations with the engineers regarding the extent of the overflow and the volume of water scattered over the land, as compared with that left in the channel, and which opinions of competent engineers place the fraction of drainage canal water in these overflows as but a minute portion of the whole volume of water flowing. This matter will be testified to by those who have made the calculations and the exact observations. Not being a hydraulic engineer I do not care to go into details, but the facts are known.

MR. TODD: All those facts will be brought out by men competent to testify on them.

7220 Q. MR. JEFFRIES: Then so far as you are concerned, you are basing your opinion upon speculation and upon the opinions of others?

A. I should not be willing to admit that that opinion is based on speculation, but upon the very careful measurements made by men who are quite competent to make such measurements.

Q. It is not based upon any experiment or examination that you have made yourself?

A. That particular part of it is not.

Q. Now then, have you made any examination with reference to the winter conditions in the ice?

A. I have made only the one set of examinations in the cold weather, and it has been put in evidence in this case already.

Q. Professor, suppose that the Illinois river should be frozen over in the winter time near its source, and that in the spring time when the ice broke up that this ice was carried down for ten or fifteen days, I will ask you to state what chemical changes would take place in the chemical constituents of the water so frozen during its journey?

MR. TODD: I would like to ask if the question refers to the water or the ice?

(Question read)

MR. JEFFRIES: It speaks for itself.

7221 A. Well, I am not able to answer that question in all minute details because I have never observed, and do not know of such a condition obtaining in the Illinois river throughout; but as far as I am able to judge from the analyses made, which were certainly made at a time when the conditions were very unfavorable to what we call oxidation, it is evident that the organic condition of the river at its mouth is not essentially a bad condition, as measured by the albuminoid ammonia left, and especially as measured by those chemical bacterial elements which I have explained already, that are important in giving a clew to what is left and what is going on in a river of this kind; and furthermore, the river at this time does not differ greatly, if at all, from the ordinary tributaries carrying water of purely vegetable origin.

Q. Now, professor, in determining the aggregate amount of pollution flowing into the Mississippi river from the Illinois at Grafton, would you not consider the quantity?

A. What do you mean by the quantity?

Q. The quantity of pollution.

A. The total pollution?

Q. The total pollution?

A. Total weight in the whole river?

Q. Yes?

7222 A. No sir, the total weight of the pollution in any large volume of water is the least important factor to be considered. If we consider the whole weight of common salt for example, in Lake Michigan, you would have enough there to poison an army; but in drinking Lake Michigan water we are not concerned with the total amount of salt present, but only the small amount of it which is contained in the water we work with. So in the Illinois river we do not care, nor should anybody care what the total amount of pollution is. We are practically concerned there, and in every other case only with that part which is contained in a given volume.

Q. Would you take into consideration the increased volume of flow in the river?

A. The increased volume of flow in the river is a very important element,—any dilution of the total contamination. The increased flow in the Illinois river will put a volume of water down there ten times,—yes,—near twenty times the volume of water which was discharged through the original Illinois and Michigan canal. With a dilution of twenty times, and no possible increase of contamination beyond perhaps fifty per cent., it is prefectly preposterous to think that there should be a larger amount of organic matter from Chicago in a given volume 7223 reaching the mouth of the Illinois river under such conditions.

Q. Now then in that answer have you taken into consideration the condition of the Illinois river as it existed prior to the opening of the canal and the condition of that river as it has existed since the opening of the canal?

A. Most certainly. I have been familiar with the Illinois river for eighteen years.

Q. That is not the question. Have you taken into consideration this fact?

A. I have, certainly.

Q. In what way have you?

A. I have compared the volume of flow in the Illinois river before the canal was opened, with the volume after the canal was opened, the amount of sewage going into the canal, in the old Illinois and Michigan canal, with the maximum amount which can go into the canal when the proper sewage connections are made in Chicago.

Q. Now I will ask you if it is not a fact during a great part of the year, the Illinois river prior to the opening of the canal from source to mouth, was a sluggish river, with very little current, and at times practically no current, and I will ask you to state what effect that slack in the current had upon the water in that river so far as its chemical constituents
7224 are concerned?

A. Frequently in the Illinois river, before the opening of the canal it is a fact that the water was low. At times it was very low; but in those times, however, the Illinois river water received from a source outside of Chicago a very much greater portion of—or a somewhat greater portion of contamination than it does at the present time. The increase of water in the Illinois river has not carried any corresponding increase of contamination from Chicago at all. This increase of water has not been sufficient to impede in any material way, the rate of destruction of organic matter. As a matter of fact we find today at the mouth of the Illinois river in general a better organic condition than was found before the opening of the canal.

Q. I want to know professor, what effect did that slack water and the condition of the river with practically no current during the greater part of the year, have upon the sanitary condition of that water with reference to the action of the chemical constituents in the water?

MR. TODD: At what period?

MR. JEFFRIES: Prior to the opening of the canal.

A. For that I will simply refer to the record which I have already presented. I will say briefly, that the results—
7225 the condition of the Illinois river after the opening of the canal, is also given. I will state again, that the condition in general, after the opening of the canal, is better than it was before the opening of the canal.

Q. Now professor, as a chemical sanitarian, I want you to state what effect the condition of that water prior to the opening of the canal, had upon the chemical action in the water?

A. Well, I would like to have that question read to see what it means. I am not quite clear on it.

(Question read)

A. That does not mean anything. I cannot answer it.

Q. I will ask you professor, if the water of the Illinois river prior to the opening of the Chicago drainage canal was in any better condition for the purposes of sedimentation, aeration, oxidation and the breaking up of the solid matters, than the Illinois river is during flood time, since the opening of the canal?

A. In answer to that question I will say, as determined by my investigations, that the condition of the Illinois river at its mouth after the opening of the canal is very much better than it was before the opening of the canal. It is evident from this fact that the conditions for the destruction, elimination, and reduction of organic matters must therefore be better now than they were in 1899.

7226 Q. Now professor, with a slow current, with practically no current at times, with the life period of all bacteria limited, with the period of the breaking up of the solid parts in water limited, I will ask you if it is not more reasonable to believe and if it is not according to the experience of scientists, upon the subject, that the solid matters and the decomposing matter that came from the source of the river prior to the opening of the canal, was more readily removed before it reached Grafton than it has been since?

MR. TODD: I want to object to that question on the ground that it assumes that the conditions in the Illinois river prior to the opening of the canal and that the life period of all bacteria was limited, and that fact has not been established by any evidence in this case on either side, as to the limitations of the life of bacteria.

A. In answer to that question I will say that I base my conclusions simply on the record. I cannot go behind that, the record shows the reverse of what you assume in your question.

Q. Why is it, profesor, that when the last question was put to you that you confined yourself to the chemical analyses that you made, when you testified as to the condition of the water at Grafton—you say that you took into consideration the volume of flow, winter conditions, summer conditions, 7227 flood times, and the character of the soil, the flow of the water, the volume of the water and population and other conditions?

A. Well that can be very easily answered in the same way. I base my conclusions on various things, and very largely on this record which has been presented. The record shows the fact, I have given the fact, and that is as far as I can go. I cannot enter into any explanation of why this and that thing is not otherwise.

Q. Assuming, professor, that it required twenty days for the water in the Illinois river to run from its source to its mouth, prior to the opening of the canal, and that it requires ten days since the opening of the canal, I would like to ask you what effect this time limit has upon the determination of whether or not decomposition has more rapidly taken place during the previous period than the subsequent period?

MR TODD: I object to that question on the ground that in assuming the time limit the volume of water is not included; whether this time limit is at high flood times, or at low water stages, and for that reason I consider the question improper, and I object in addition on the ground that there is no evidence upon which to base the hypothesis that it took 20 days prior to the opening of the drainage canal.

7228 A. Now before I try to answer that, I would like to have it talked over to me a little slow again. It is not quite clear to me.

Q. (Question repeated.)

A. This time limit can have no possible bearing on the question of the determination of the fact whether the decomposition has taken place more rapidly or not.

Q. Why not?

A. The chemical analysis is made irrespective of the rapidity with which the water comes down there.

Q. I will ask you, professor, as a sanitary chemist, if sewage thrown into water discharged into running water is not more dangerous for domestic purposes when the water into which it is thrown gets to a given point in ten days than it is when it gets to that same point in twenty days?

A. With all the conditions I stated, it would be very difficult to answer that question; but supposing this more rapid flow is due to enormously greater dilution, instead of being more dangerous for household consumption, inasmuch as we are concerned only with a small volume—with the small volume of water which we use for practical purposes, and not with the gross condition, the final condition, instead of being worse may be better, as far as household use is concerned.

7229 Q. Yes, but professor, do you say that by the dilution whatever bacteria or germs that may have been contained in that sewage and follow the river from the place of discharge to the given point mentioned in the previous question, are not present?

MR. TODD: I object to the question on the ground that the witness has repeatedly claimed that he was not a bacteriologist, but was testifying as a chemist.

Q. I will change the question so that the word "harmful ingredients" may take the place of the word "bacteria."

(Question read as corrected.)

A. No, I will not say that they are not present. I simply stated that the effect of any harmful ingredient is proportional to the amount of that ingredient.

Q. Then dilution does not destroy?

A. Dilution does not necessarily destroy, but it renders less probable an effect in proportion to the extent of the dilution. The effect diminishes as the dilution increases.

Q. The probability of effect diminishes, you mean?

A. Well, based on all my experience, that is a fact.

Q. Now then, professor, what effect have you given dilution in your opinion expressed upon the condition of the water of the Mississippi and the Missouri river?

7230 A. I have considered these waters in comparison with each other, based on the composition in the same number of parts in comparable parts, in parts per million, and the question of dilution in making that comparison, does not come in at all.

Q. So that you have not considered the question of dilution in expressing your opinion?

A. I have not compared the gross pollution of the Missouri with the Mississippi, or the gross pollution of the Illinois with the Mississippi. I say that for all practical purposes, for the purposes of household use, such a comparison is absolutely valueless and absurd.

Q. But in expressing your opinion upon the sanitary condition of the water of the Missouri river alone, regardless of the condition of the Mississippi or the Illinois, have you given the question of dilution any consideration whatever?

A. I have recognized the fact that the Missouri river carries a large volume of water. I have not been called upon to in any way consider what that volume of water is.

Q. But, professor, you gave an opinion as to the sanitary condition of the water of the Missouri river. Now I want to know whether or not you considered the question of dilution in passing upon the condition of that water. Yes or no?

7231 MR. TODD: I submit that he can answer the question any way he wants to.

A. In the very narrow and utterly unfair sense in which this question is put, I will say I did not consider that dilution.

Q. Now professor, I would like to ask you to state in this record wherein the question is unfair.

A. As I have stated myself several times, the only practical problem we are concerned with in considering waters, is not the gross pollution in any large amount, as a lake, sea or the ocean, but the pollution appearing in a given volume. It makes no difference what the volume of the Mississippi river is, or the volume of the Missouri, or the volume of the Illinois, or the volume of Lake Michigan. The chemist is concerned therefore only with that amount which one is liable to come practically in contact with in his daily usage as drinking water or for household purposes, and parts per million or grains per gallon or any other unit per given volume is the only thing which a practical man has to take into consideration at all.

Q. Now professor, if you did not take into consideration the question of dilution, and if, as you have previously stated, the chemical analysis can be relied upon with any degree 7232 of certainty in determining the sanitary condition of water, I would like for you to state if it would not be necessary for you to take into consideration the question of dilution?

A. Inasmuch as the question assumes something which I never stated, I would have to have it put in different form before I could answer it.

Q. Then I will ask you if it is not a fact that you can or you cannot determine strictly from your chemical analyses of the water the sanitary condition of that water?

A. I have not attempted to determine in all cases from chemical analyses alone—the sanitary condition. I believe no chemist would make as broad a claim as that.

Q. Then professor, in determining the sanitary condition of any given quantity of water, which you have just explained, regardless of the volume of the water, regardless of the dilution, how do you arrive at a correct conclusion as to the sanitary condition of that water?

A. In expressing results in parts per million, dilution is a factor that goes in; volume as compared with the amount of stuff present. The dilution factor enters right into that opinion every time it is given.

7233 Q. Now then, professor, I will ask you if in addition to the dilution and in order to determine the per cent or the amount of dilution, it is not necessary to take into consideration the amount of harmful matter or objectionable matter that is deposited into that water?

A. That is a very important fact always, in reaching any conclusion, and that appears of course, in the examination of water, in some course of the examination.

Q. Now professor, in determining the sanitary condition of the water of the Missouri river, have you taken into consideration the sewage discharges into that river, and if you have what effect has dilution had upon the sanitary condition of that water in connection with the population the sewage from which is drained into the river?

A. I have not made any examination of the sewage discharges of Kansas City, or Lawrence, or Topeka, or Manhattan or Junction City, or Council Bluffs, or Omaha, or Sioux City—in fact the whole drainage of the great Missouri valley with its tributaries entering into the river. I do not know what it amounts to, but it is unquestionably large. As I made no such examinations, in giving my opinion as to the pollution of the Missouri river in parts per million, of course I have never considered the amount of sewage flowing in. It would not be necessary to consider. I know it is there; I have no means of knowing how much it is.

7234 Q. Now professor, coming back to the Illinois river, are your calculations of dilution based upon the information that you obtained from the sample of water that you have analyzed alone, or is that information obtained from your knowledge of the actual amount of water that passes into the river?

A. My opinion regarding the Illinois river is based on my experience as an analyst. It is based further on my experience as a pretty close observer, extending back through a period of eighteen or twenty years.

Q. I insist on your answering the question.

A. I will answer it as near as I can.

Q. (Question repeated.)

A. I submit I have given a very good answer to that question.

JUDGE SPRINGER: I think the record shows that.

Q. Do those observations go to the volume of water that is discharged into the river, and do you consider that as a factor in determining the dilution of that water?

A. Why that of course is a necessary factor. The dilution depends on the volume of the water. I have kept tab on that for a long time, as close as any man in Chicago.

Q. But when you come to analyze the water of the Missouri river, you are in total daarkness as to the volume of water?

7235 A. As far as making an analysis is concerned, the question of volume does not enter at all. The analyst does not consider that in making an analysis.

Q. Well, how as to determining the dilution?

A. I have not attempted to determine the dilution in the Missouri river. I must repeat, as I have said probably twenty times in this record, that in expressing any opinion on the Missouri river, or on the Mississippi, or on the Illinois river, my reports here are based solely on parts per million of the contamination in a given volume and nothing else, and that is the only way in which a sanitarian can express his result. It is the only practical consideration with which the consumer of the water is concerned. He does not care how many tons of organic nitrogen, whether there are hundreds of tons or whether there are thousands of tons there, either in Lake Michigan or any other stream. He is concerned practically only with a small amount—the organic nitrogen which he comes in contact with when he drinks a cup of water or a cup of coffee, or when he comes in contact with this water through the way in which it has been used in washing dishes, or in preparing food. It is not the gross amount of stuff in the lake or the river, but it is only the practical small volume which he actually deals with which concerns him in any way, practically.

7236 Q. Now then, professor, if that was true, why is it that you state that no sanitarian can give a correct opinion or pass competent judgment upon the sanitary condition of water from the chemical analyses alone?

A. I think if I put the statement in that way, that I must have been dreaming. I don't believe I made any such a broad statement to cover all possible cases, because there are a great many cases in which the chemist, from his chemical examination alone can say that a water is absolutely unfit for use. He doesn't care where it has been or where it comes from, but in other cases, where the evidence is not so pronounced, or tangible, before coming to a conclusion it is a very good thing to know all the circumstances surrounding the history of the water, and that is the careful analyst who, before venturing on an opinion in a case which on its face is not very plain, who looks into these matters.

Q. Then it is or is not absolutely essential that he shall have additional information other than that which he derives directly from the sample of the water that he analyzes?

A. No, I have just explained—not always absolutely essential. I say it is a good thing when he knows it. Sometimes with more information he gets on better. I always want all the information I can get before giving an opinion.

7237 Q. Then your opinion is that the sanitary condition of water can be determined by chemical analyses of that water, regardless of source of pollution or drainage territory of that river?

A. In numerous cases, decidedly, decidedly.

Q. Give some example of cases where that can be done?

A. Well, if I should be sent a jug of water taken up from the river at Joliet, and analyzed it, I could determine in one-twenty-fifth of a second that that was pretty poor stuff to use. I would not recommend it for household use.

Q. Now suppose you would have been sent a sample of the Mississippi river water at St. Louis, without knowing where it came from?

A. If I were to be sent a sample of water from the Mississippi or the Missouri, without knowing anything further, I should not be inclined to give a very definite opinion on the results of one examination, and should not.

Q. Do you make any distinction in your testimony, professor, with reference to the particular sample of water that you examine being in a sanitary condition, and the water of the river from which that sample was taken, and what relationship do they bear to each other in passing judgment upon the water?

7238 A. Well, I assume in such a case that the sample of water which is sent to me is a representative of the water as it exists in the river.

Q. Then if that be true, why can't you determine from the chemical analyses the condition of the water without any further information on the subject?

A. Because there are a great many intermediate cases, as I said, where the evidence in any kind of an examination is doubtful—somewhere between the upper limits and lower limits, and it is very hard to say where we step from one territory over into the other. If in addition to my chemical analyses I find in that Mississippi river water, that there are no fermentation elements there; nothing which would bring about putrefaction or fermentation, I have the further suggested evidence that the water probably contains no harmful substances, and if I find many of those elements there, I should be inclined to be suspicious about that water, thinking that along with these peculiar living forms, there may be others, or that others may have come in at the same time, of more harmful character.

Q. Supposing a sample of water should be sent to you for analysis, with the statement that it came from water which flowed through no natural salt beds, the soil of which 7239 was not of a saline character, and that the sample so analyzed would disclose from 12 to 15 parts per million of chlorine, what would you say as to the condition of that water?

A. Well, I would say it contained so much salt.

Q. And that is all there would be to it?

A. There would be no question. That is all I could say.

Q. Would you be able to express any opinio as to the source of that salt?

A. Not an absolutely definite opinion, but I should be inclined to think that it had been exposed to some organic contamination somewhere, if all of the assumptions in the question were correct—that the water has not been able to take up salt from any other source.

Q. However, the presence of the chlorine does not imply the absence of deleterious matter, does it?

A. No, not necessarily. Of course it could not have any such bearing.

Q. Professor, I suppose you will admit that the water that passes through the canal and enters the Illinois river at its source, reaches the Mississippi river at the chain of rocks?

A. Yes I suppose most of it does.

Q. Subject of course to evaporation and absorption?

A. Yes.

7240 Q. And when that water reaches there it is necessarily diluted?

A. Yes.

Q. From your chemical analyses are you able to determine the substance with which it is diluted and the source of that substance?

A. Not absolutely.

Q. I will ask you professor, what particular constituents of the sewage of Chicago would remain with that water in its journey down the Illinois river to the chain of rocks?

A. There are in general, the constituents which we term the mineral or inorganic; they are the only ones of which we can say with certainty, that they must remain largely, or in the main. Of these it is perhaps safe to say that some changes would also take place by what we call double decomposition in the river. To illustrate: while the sodium chloride may pass down practically unchanged, in the processes of oxidation going on in the river, in which acids are liberated, it is altogether likely that carbonates originally present are more or less modified, and changed into other salts, so we cannot say with absolute definiteness that even these mineral substances pass from the source to any given point. They doubtless undergo some changes on the way. Now as regards the
7241 organic substances, these are the bodies in which the
most pronounced changes take place, while the mineral substances suffer little or no alteration or decomposition. The organic bodies are those on which the bacterial destructive processes are carried out. These are the substances which are changed and altered and in many cases absolutely destroyed—worked into bodies bearing little or no relation to the original substances.

Q. Now the processes which you have spoken of simply change the form of the organic matter, but it is still there?

A. No, they change the form and they change profoundly the character of the organic matter. Organic matter is a term including a great variety of substances. The original organic substances entering waters as sewage or other drainage are comparatively complex and these break down into substances gradually which are comparatively simple in their composition.

Q. There would still be a residue, wouldn't there, from the sewage of Chicago remaining in the water?

A. I think beyond question there must be some organic substances of stable type which remain for long periods unchanged in natural waters. What these are it would be very difficult to say.

Q. Your chemical analyses do not show?

A. No attempt is made in our general chemical analysis to determine the exact nature of these residual products of organic destruction.

7242 Q. Can you determine whether they are living or dead organic matter?

A. From the chemical analysis alone, as I think I explained a few days ago, we cannot determine that. But the so-called bacterial chemical test would give us an indication of the presence of living substances.

Q. Then there is certain stability of organic impurity in the water at Grafton?

A. In general, organic substances undergoing decomposition, are not completely reduced to the elements of carbon, hydrogen and oxygen. It is undoubtedly true that types of extremely stable bodies are finally reached in the decomposition of protein matters. It is well known that the bodies of the so-called aromatic group, ring structure compounds as we call them, are remarkably stable. Now as these bodies are found in the water, we are practically unable to determine their ultimate fate. I think these substances are concerned in forming organic sludges which accumulate in rivers and on the bed of the ocean and in time they serve, or have aided in the formation of coal and oil deposits.

Q. Now these statements you have made are purely speculative and do not rest on any actual results from your analyses of the water?

7243 A. Not from my own analyses, no indeed. Those statements depend on the investigations of men that have been carried out through many years. The residues or sludges from beds of rivers have shown these aromatic compounds from which peculiar hydrocarbons may be distilled. I have not made them.

Q. Now the organic matter and the residue may be a part of the sewage pollution of Chicago and it may not. In other words that question is inderterminable by you?

A. As a matter of fact I suppose in the breaking down of protein molecules, for example, discharged into a river, there are residues left, possibly, even probably at the mouth of the Mississippi river, residues of stable character which at one time were component parts of these very complex molecules. These original substances have, as compared with the final products a complexity, which may be roughly expressed by the ratio of fifteen or sixteen thousand to a hundred or less; that is the decomposition of the protein substances leaves finally these aromatic residues which I spoke of, going so far as to break down the enormously great groups of which we know that protein molecules consist, to residues of that relative minuteness.

Q. Then if I understand you correctly it is possible that
7244 some of the residue and bacteria from Chicago deposited
in the Illinois river, remain with that water until it reaches the chain of rocks?

A. You have involved two assumptions in your question which do not at all go together. While it is possible that the ring structure residues may remain, which bodies are of a remarkable stable character, it would not follow that bacteria leaving Chicago would exist one-one-hundredth of the time or distance.

Q. Now then, how do you know that they would not, and will you please separate them?

A. These organic substances are different in general from the bacteria which we class as organized substance. These true organic substances which are products of protein decomposition are universally recognized by chemists as bodies of immensely great stability. On the other hand, the living organisms or organized structures as distinguished from the organic structures, are universally recognized as bodies of very slight stability, subject to change by the action of all kinds of agencies. I think while it may be true that one of these stable products might survive the journey from Chicago to St. Louis, or to New Orleans even, it would not even remotely follow that there would be any reason at all for supposing that a highly unstable,
organized bacterium would survive the same journey;
7245 the bodies are so unlike that it would be unsafe to draw
a conclusion from the life of one as to the existence of the other.

Q. Has your chamical knowledge led you to any substantial reasons why they would not follow each other?

A. Not any chemical experiments I have made, no sir.

Q. Has the stability of all characters of disease germs been determined?

MR. TODD: I object to the question as this witness has not qualified as an expert bacteriologist.

MR. JEFFRIES: I suggest that the witness has testified upon the proposition that the passage of the residue from Chicago to St. Louis does not necessarily mean that the bacteria in pollution would pass from Chicago to St. Louis.

MR. TODD: I submit that the witness has refused to testify upon that proposition, and I renew my objection that the question is not proper as the witness has not qualified as an expert in bacteriology.

MR. JEFFRIES: I suggest that the witness has qualified as a scientific chemist and as a bacteriological chemist, and that the witness has stated that there is no correct line of demarkation between bacteriological chemistry and bacteriology proper and I think I have the right to ask the question in order to determine the extent of the witness' information
7246 and learning and knowledge upon the subject.

MR. TODD: I submit that the record discloses what the witness has said.

Q. (Question repeated).

A. Not that I know of.

MR. JEFFRIES: Then why do you say that it doesn't necessarily follow that because the residue of the organic matter from Chicago reaches St. Louis, that the disease producing bacteria will not reach there also and follow this residue?

A. It would be perfectly absurd to assume that because various stable bodies can pass down the river, that the very unstable substances should likewise be able to pass down the river.

Q. Wouldn't it be as reasonable to belive that the presence of this residue and the fact that the residue has passed from Chicago to St. Louis, that in their journey they are accompanied with the dangerous living elements specific in character and which have a deleterious effect on the health of the people using the water. I suggest to the witness he may call those living elements, chemical elements or living elements

A. Well a chemist cannot call them chemical elements, because they are not. In answer to that question, it could not be said without positive knowledge of the field of pure 7247 bacteriology, which the witness declines under any circumstances to enter. That there isn't the slightest likelihood that because of the passage of these various stable residues through a long stretch of the river and that the bodies which were at one time concerned in the breaking down of the protein molecules, should follow the same course. The one set of bodies are very stable, existing under extradordinary conditions of temperature, pressure and chemical action, while the other substances are well known to succumb most readily to the slightest variations in temperature, acidity, alkalinity and alteration in the surrounding mediums.

Q. I want you to state, professor, whether or not, if you know, that such living germs or living substances, disease producing, do pass from Chicago to the intake at St. Louis. Yes or no?

A. In as much as in spite of all the investigations which have been made, no one has yet found a disease germ passing from Chicago to St. Louis, I am inclined to say that I do not believe it could pass. No I do not believe that a disease germ would pass.

Q. Do you know that they would or would not?

A. As a chemist I do not know that. I depend for this opinion upon the well known results of experiments of others.

7248 Q. Professor, why is it, in answer to these questions you rely upon your chemical analyses and chemical information, yet at the same time you believe that on account of the bacterial changes in the water that these disease producing elements or material, do not come from Chicago to St. Louis?

A. That question is not put in quite a clear form to answer, it is contradictory in itself.

Q. When you testify as a chemist and not as a bacteriologist, and profess no knowledge from the standpoint of a bacteriologist?

A. I am certainly not attempting to give testimony from the standpoint of a bacteriologist and I have been careful to state where I have ventured an opinion on that line, that I am using the information and experience of others.

Q. Then, professor, you do not know that these disease producing materials or substances of a living character do not pass from Chicago to the intake of St. Louis?

A. As a chemist pure and simple, I don't know.

Q. And further than that you decline to state?

A. Well no, that is not a correct proposition.

Q. Well, do you state as a bacteriologist?

A. I do not speak as a bacteriologist, but I am very far from declining to speak on anything I know about.

7249 Q. Do you know about this, about their passing from Chicago to St. Louis?

A. I don't know. I am not aware that anyone has ever discovered their passage.

Q. And simply because they have not been discovered, you take the position they are not there?

A. In as much as through these investigations they have not been discovered, I am justified in taking the position they are not there.

Q. Professor, I will ask you this proposition: if you do not believe that in the taking of the number of samples to which you have referred, there have been as many as one typhoid bacillus discovered, if it would not have produced death and destruction to the people using that water for drinking and domestic purposes; if that proportion being maintained in the water supply of the cities usually, in the event that one typhoid fever bacillus should have been discovered during that series of investigations.

A. Not being an etiologist or a bacteriologist, I cannot answer that proposition from that professional standpoint. But from the standpoint of an educated layman, I should think the possibility or probability of death and destruction following in St. Louis, the detection of one typhoid fever bacillus
7250 is so absurd as not to be worthy of consideration.

Q. I will ask you to state the quantity of water that would be absolutely examined with a view of determining the bacteria contained in it, using one cubic centimeter of water for each test, how much or how great would the volume of water be in ten thousand tests or ten thousand cubic centimeters of water, and how does that water so examined, in volume, compare with the total volume of water flowing down the Illinois river?

A. The result is the examination for typhoid bacteria referred to here. That is the question, is it?

Q. No, I am trying to get into the absolute volume of water in pints, quarts or gallons, that would be actually examined in 10,000 examinations, using one cubic centimeter of water for each test or examination, and after that is obtained, how does that water compare with the volume of water flowing down the Illinois river?

A. Well, in answering that question, I will say that the volume of water examined to determine the number of bacteria present varies with the different observations and different locations of the water, but in the mean the number would be estimated in such places as the mouth of the Illinois river, in probably one cubic centimeter. In 10,000 such tests, then 10,000 cubic centimeters would be brought under observation.
7251 How these 10,000 cubic centimeters compare with the whole volume of the river at that point, I am not able to state now, and furthermore this is not the most important point in the question. The important point is the relation of the 10,000 cubic centimeters to the volume of water which any one person would consume; not to the volume in the rivers. As I have said, it is not the total quantity we are concerned with, but the quantity an individual uses. 10,000 cubic centimeters is a very large quantity for a consumer, and that is the point which I think we are practically concerned with, not the total volume.

Q. I want the latter part of my question answered. Assume further that these 10,000 samples were examined in the course of two years, how would the volume of water in the Illinois river compare with the quantity analyzed by these 10,000 samples of water, using one cubic centimeter for each examination?

MR. TODD: I object to the question for the reason that it is purely mathematical and not chemical and it would require the services of a hydraulic engineer rather than those of a chemist, as this witness has not testified that the has made estimates of the volume of water in the Illinois, Mississippi and

Missouri rivers for the periods covered by this question, when the 10,000 cubic centimeters of water were taken.

MR. JEFFRIES: I suggest that the witness has pre-
7252 viously stated time and again, that he is acquainted with the stream flow of the Illinois river.

A. Now in answer to the last part of the question I will say that I am unable to state exactly the relation of the 10,000 cubic centimeters to the total flow in the three rivers in question, but this much can be safely said, that the 10,000 cubic centimeters would be relatively a very minute part of the whole flow.

Q. It would be an infinitesimal part?

A. It would be an infinitesimal part of the whole flow.

Q. How many gallons would 10,000 cubic centimeters of water be?

A. Ten thousand cubic centimèters, is ten liters, and to reduce this to gallons we must divide by 3.78, I believe is the factor. It would be something like two and a half or two and three-quarter gallons.

Q. Then because a typhoid bacillus was not discovered in two and a half or two and three-quarter gallons of water taken from the river at various times and during various parts of the year you reach the conclusion that the water contains no typhoid bacilli?

MR. TODD: I object to the question, as the witness has disclaimed that he is an etiologist, bacteriologist or epi-
7253 demiologist, and has not asserted that he has arrived at any conclusion based upon any analyses made by himself, but has expressed his belief based upon the investigation of others, and not upon his own original investigation of these subjects.

MR. JEFFRIES: Counsel for complainant states that for the reasons stated in the objection of counsel for defendants, the opinion as to the water of the Illinois and Mississippi rivers, and especially the water at the intake in the Mississippi containing no disease producing elements, the opinion so expressed by the witness is ill-founded and of no value, because as stated by counsel for defendants, the witness is not possessed of sufficient scientific learning to be able to express an opinion thereon.

MR. TODD: In reply to the statement I desire to state that the statement is not based upon any statement made by counsel for complainant, and if counsel wants to have that statement stated in the record he may do so. My objection is as to the proper cross-examination of the witness upon matters which were brought out in chief and not as to the weight to be given to this witness for any opinion that he may express when requested by counsel for complainant.

MR. JEFFRIES: I again suggest that the witness qualified
as a sanitary chemist and qualified as a bacteriological
7254 chemist, and stated in his examination in chief that there
was no direct line of demarkation between bacteriological
chemistry and bacteriology proper, and therefore this testimony in addition to the reasons heretofore stated is competent to obtain the source of the witness' information, and the strength and importance that should be attached to it.

Q. (Question repeated.)

A. In answer to that question I will say that inasmuch as I have disclaimed any intention of testifying as an expert bacteriologist, and inasmuch further, as I am not perfectly familiar with the methods which bacteriologists employ in the identification of the typhoid bacterium, I am unable to give an answer to that question.

Q. Then professor, why do you state that because in your opinion no typhoid germs have been discovered in the great number of samples that have been taken, that no such germs existed in the water of the river, you not being an epidemiologist, etiologist or bacteriologist?

A. My statement of opinion was based on the experiments of others, and again from the standpoint of an intelligent layman and not a bacteriologist. That was merely a question of probability. After these thousands of examinations have been
made and none found, there was no evidence apparently,
7255 that they were there.

Q. Then your statement in that respect is not made as a scientific sanitary expert?

A. My statement in that respect is not made as a bacteriologist.

Q. Well is it made as an sanitary expert?

A. Well, that depends on who defines sanitary expert.

Q. In other words, is it not your individual opinion as a layman, as you express it?

A. Yes, I am very glad to put it that way. It is my individual opinion as a layman, that because out of these thousands of investigations, no disease germs have been found, it strikes me as highly improbable that there is any reason for assuming that they are there.

Q. Now then, as a layman, the failure to find does not necessarily mean that disease producing material was not there?

MR. TODD: I want to interpose an objection to this line of cross-examination as being improper and if counsel desires to get an opinion of the witness on any other subjects aside from that which he qualified on, he may do so.

MR. JEFFRIES: I suggest that the witness belongs to the defendants, and he voluntarily expressed his opinion in his 7256 direct examination, and expressed opinions bearing upon the matter now under discussion and we have a right to cross-examine the witness in this respect so as to determine the source of his information and the strength and importance that should be attached to it.

Q. (Question repeated) Yes or No.

A. No. As a layman it would not necessarily follow. From the standpoint of a layman it would not necessarily or absolutely follow but the layman would naturally desire some stronger proof than has yet been presented, proof that a layman can appreciate and understand if he is a man of fair intelligence.

Q. Professor ,assuming that there are billions of bacteria discharged from the sewage of Chicago into the Illinois river by means of the drainage canal, you do not take the position that it is impossible for some of them at least to reach the Mississippi river at the chain of rocks

MR. TODD: I object to the question on the ground that this witness has not qualified as a bacteriologist and has repeatedly disclaimed that he was a bacteriologist.

Q. (Continued)—limited to the bacteria that you have studied and reported upon in this testimony, and basing your judgment and knowledge upon the information which

7257 you have obtained in your scientific researches in that respect alone?

A. From my knowledge as a chemist, I would not be able to state that it is impossible.

Q. From your knowledge as a bacteriological chemist, what would you say?

A. From my knowledge as a bacteriological chemist, I would not be able to make any answer on that proposition at all. That is a question which calls for the knowledge of the expert bacteriologist.

Q. Now professor, going back to these live organic substances, following the various specific organic matter found in the waters of the Illinois river and the residue of the organic matter, I will ask you to state if it is not a fact that these small particles of injurious substances that may follow, will not more readily reach the Mississippi river at the chain of rocks from the Chicago drainage canal during high stages of the river than during low stages?

A. No, I would say, in general it does not follow for the reason already explained, that because of the character of the pollution in spreading out in the waters over land, the probability of any single thing reaching the mouth of the Illinois river from the drainage canal is correspondingly diminished.

Q. Doesn't the great dilution increase the stream flow?

7258 A. While great dilution increases the stream flow, it at the same time increases the stream expanse, covering an enormous area for sedimentation and settling and loss of organic matter.

Q. Then you take the position that all the discharge from the large canal into the Illinois river during flood times is practically separated out over a broad area of land upon the river, and that none of it follows the main channel of the river from Joliet to St. Louis?

A. I haven't taken that position. I have said that a part of it is spread out and ordinarily a very large part of it is so spread out.

Q. Now what part if it is not spread out?

A. That part of it is not spread out which remains in the channel of the river, but at the time of flood this part is but a fraction and even a very small fraction of the whole.

Q. The dilution does not mean the absence of the germ, does it, of the polluted matter?

A. No, not necessarily. The absence or the distribution of whatever matter is there through a larger volume.

Q. Now professor, wouldn't this polluting organic matter
from Chicago reach the Mississippi river at the chain of
7259 rocks more readily in the winter time than in the summer time, and in larger quantities, and have you not so stated?

A. Inasmuch as bacterial activity is less in winter than in summer time, it is altogether probable that the amount of material passing down the river in the colder season is greater than the amount passing down the river in the warmer season, how much greater I don't know.

Q. Is not oxidation retarded in the winter time as compared with the summer time?

A. Yes, the explanation of the former question depends on what is called chemical oxidation.

Q. Professor, will you please describe a septic tank and septic operation?

A. I can describe septic tank operation only in a general way. I have not testified as a sanitary engineer and do not care to go into any description.

Q. Well aside from the engineering feature altogether, as a chemist from a chemical standpoint?

A. Well that I will attempt only very briefly. In what are called septic tanks organic matters are brought or left in connection with the destructive germ agents in such a way as to bring about the breaking down or decomposition of these organic matters.

7260 Q. What are the characteristics of a septic tank exclusive of air?

A. Exclusive of air, the presence of certain bacteria.

Q. Then the exclusion of air is a vital part in connection with a septic tank?

A. In certain kinds of septic tanks I believe, yes. It depends on what the desired action is, whether it is the breaking down, destruction without air or destruction by oxidation processes from the start. As I am not practically familiar with the methods of construction and workings of all kinds of septic tanks I would not care to go further into that discussion as to how far practically the action of air is important and necessary or not important or necessary.

Q. What is the difference between septic operation and oxidation?

A. In what is generally called septic operation the process is one of disintegration or breaking down. It is very largely what chemists would describe as a process of hydrolysis. The substances undergo a change in many cases, breaking up by the combination with the elements of water, large groups breaking up in this way to form smaller groups, and by many sanitarians, or some sanitarians at any rate, I believe this breaking down operation is considered as preliminary to the oxidation
7261 processes which follow the product of the first reaction.

Q. Then septic operaton is never oxidation, or is not oxidation?

A. That I am not prepared to say absolutely, because, as I said a little while ago, I am not familiar with the methods of operation here, but I believe this is true, that certain tanks called septic tanks, or certain processes of purification which are considered in connection with septic tank processes are carried out in the presence of oxygen, or with oxygen. As I have stated, however, at the outset, this field itself is one somewhat outside of my own line of investigation. There has been enormous literature on it, and I do not pretend to be acquainted with all of the facts, as much new matter is being added all the time, to the discussion.

Q. What effect has dissolved oxygen upon septic operation?

A. I believe that point is still in dispute. I cannot state from my own experience, because I have no experience in the operation of septic tanks, but from the discussions which I have paid attention to, I believe the question of oxygen from the start, and the effect of oxygen from the start is in dispute, as regards the final work of these tanks in some cases.

Q. State, Professor, whether you know anything about septic operation of the water in sewage in the Chicago
7262 river prior to the opening of the main drainage canal?

A. Yes, I have some little knowledge perhaps, on that point. For the purpose of the comparison I have described the conditions in the Illinois river, as comparable with those conditions which obtain perhaps more or less perfectly in the operations of a septic tank; I have observed the conditions in the old canal and in the river before the canal was built, and also in Peoria above Pekin, at Wesley, and these conditions seemed to me analagous to those which would obtain in a septic tank.

Q. Now state, Professor, the particular characteristics of septic operaton that were visible at these places?

A. The operations which I have noted at those places are largely the disturbances due to the liberation of gases and in some cases I have observed also a coating or scum over the water which is described by the people who were in charge of the operation of these septic tanks as a peculiar thing very frequently noticed in them.

Q. Did you notice any bubbles in the canal?

A. I have answered that question.

Q. Was there any dissolved oxygen flowing into the Illinois and Michigan canal from the river prior to the opening of the main drainage canal?

A. I have never made any experiments to determine the dissolved oxygen. I am unable to answer that question,
7263 but they have been made by others.

Q. Did you ever notice any characteristics of septic operation in the main drainage canal?

A. No, I do not recall of ever noticing anything in the main canal of that character, before Joliet was reached, but I have observed after the opening of the canal, the same thing above Pekin.

Q. Was it due to the new or old deposits?

A. As I did not stir up the deposit, I cannot state with absolute certainty there. But from the fact that at the opening of the canal there was a very general stirring up of the old deposits, it so happened that the opening of the canal came at a time of rather high water, I believe the septic action I observed there would be compared to septic action following I think new, rather than from the old deposits.

Q. Could you have told whether the deposits were old or new, if you had dug that out and studied it?

A. It is difficult to answer that question except in a general way. There is a difference in the character of the deposits there, between the old and the new. The character of the Peoria discharge is peculiar, and it is in general not a very difficult matter to determine whether it is old or new. There is so much
7264 visible matter discharged with it, one can generally recognize what he is dealing with.

Q. Do you know, Professor, whether or not there is dissolved oxygen in the Illinois river from mouth to source and through the canal in the Desplaines river, since the opening of the canal?

A. I will not pretend to answer that from my own experience, but I will state as I have already said, that such determinations I believe, have been made and can be testified to by others.

Q. Now, I will ask you if the presence of dissolved oxygen is not necessary in the determination of, or rather the determination of the presence of dissolved oxygen is not necessary in ascertaining the sanitary condition of the water?

A. I have not considered that necessary in looking at the condition of this water in the important parts of the river above Peoria and at Peoria, Wesley, and the mouth of the Illinois river, whether there is dissolved oxygen there or not does not concern me and I have not considered it important.

Q. Therefore, you have eliminated the question of dissolved oxygen from your determination?

A. The question of dissolved oxygen is left out from my determination. I observed the important fact of a large
7265 amount of filth added at Peoria, half way down the Illinois river and it does not concern me at all, and does not enter into the problem as important, whether there is dissolved oxygen there or not.

Q. Professor, is there any element of more vital importance in determining the changes, and changing characteristics of the water in a river, in determining its sanitary condition?

A. I would not be prepared to admit that in an investigation of any kind the presence or absence of dissolved oxygen at Peoria, Wesley and the mouth of the river, cuts any figure at all.

Q. In other words, you are not prepared to speak on that subject?

A. I am not prepared to state the amount of dissolved oxygen, because as I said several times, I did not determine it, but I am glad it has been determined. In the lower part of the river I have no doubt that the testimony will show it was abundantly present.

Adjourned until 2:00 p. m., same day, Thursday, October 1st, 1903.

7266 2:00 p. m., Thursday, October 1st, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. JOHN H. LONG,

resumed the stand for further cross-examination, by Mr. Jeffries, and testified as follows:

Q. Professor, in your analyses of water in the Illinois river at Peoria, or at Wesley, did you take cross-sections of samples?

A. I did not; but in my examination of the water at Wesley, below Peoria, these precautions were taken to secure fair samples for the purpose of this investigation:

I had been pretty familiar with the situation at Peoria for some time, some years, so in 1899, when the first long series of tests was made, in company with the engineer of the State Board of Health, Mr. Jacob A. Harman of Peoria, I spent considerable time in looking at the river and determining the point at which the mixture of the cattle shed and distillery waste or discharge, with the river water, was practically complete and uniform. The point at which the samples were taken there 7267 was selected only after a very thorough examination, made from a boat. We took first a gasoline launch, with a small boat attached, and when we reached a part of the river where we wished to make the examination, I got off into that small boat and we went backwards and forwards and studied the situation, so that we decided finally on a place far enough out to secure what I considered a very fair representative sample, neither exaggerating nor diminishing the average condition of purity there.

Q. Now, is that the only manner in which you undertook to obtain a fair mixture?

A. That is the manner in which I undertook to obtain it.

Q. Now, how could you tell that you had so obtained a fair mixture in this manner?

A. At that time it was possible to observe by the general appearance of the river, how far around the bend, below and opposite Wesley, the main current extended without mixing thoroughly with the pollution; there was sufficient difference in the appearance of the water so that one could recognize by proper and sufficiently long inspection, where this mixture was practically complete.

Q. Now, during this period of 1899, when these samples were taken, state whether or not there was septic operation going on in the river there below Peoria?

7268 A. At that time there appeared to be considerable of this operation which I have described as septic. That is the liberation of more or less gases in places, from the river. There is always at Peoria, the deposition of large accumulations or large masses of stuff containing a good deal of the stable shed or barn-yard waste, of hay, as well as the slop, and this material going far enough below the bend across, from and below Wesley, becomes pretty uniformly distributed over the whole river and it was as near as possible in the center of that, between the east and the west banks, far enough down below Wesley, that the samples were taken.

Q. Did this apparent septic operation appear to be taking place near the sides of the river on the shores of the river or in the center, or was it distributed all over the surface of the river?

A. As I recall now, this action was pretty general at the point below Wesley.

Q. Was there not more septic operation visible on the Peoria shore than on the opposite shore?

A. By noting a point sufficiently up stream, that is true; that is, the septic operation began further up on the Peoria shore than on the Wesley shore, but these samples were taken a considerable distance below that point.

7269 Q. When you state that you had a fair sample of the water in the river at that point, you say so from your observation of the water at the time?

A. Yes.

Q. And not with reference to the chemical analyses which were made of the water at various places in cross-sections, across the river?

A. No, I made no cross-section there. I determined what I considered the fairest point of that inspection, and instructions were given to the collector to obtain the sample at that place.

Q. Now, how far below Peoria proper were these samples taken. In other words, I understand that they were taken at Wesley. Now, how far is Wesley from Peoria?

A. These samples were not taken really at what should be called Wesley, although that location is so described in my report. Wesley is really a point on the opposite side of the river. The collections for me were made by a collector who went from the Peoria side of the river and some considerable distance below Wesley, it would really amount to. Opposite Wesley itself, or directly out from Wesley, the mixing has not taken place at all.

Q. Now, how far below did you go?

7270 A. Below Wesley it would be probably a quarter of a mile, possibly further. I cannot really describe the exact location now.

Q. Now, Professor, if the water in the river was in such condition as to be undergoing the process of septic operation, there would be very little current in the river, would there not?

A. The current would be relatively smaller than it has been at other times, but the current is still quite perceptible, and the movement of these great masses of filth is perceptible. The masses which are locally described as floating islands there. It is quite marked.

Q. Now, this was prior to the opening of the canal, as I understand it?

A. This observation I am speaking of was in 1899, before the opening of the canal.

Q. Now, you speak of floating islands, Professor. Those formed in the river at Peoria prior to the opening of the drainage canal, did they not?

A. Yes.

Q. And it was during a time that some of these islands were being washed out or pushed out into the river that these examinations were made?

7271 A. Oh, these islands have been formed and broken up and formed and broken up through years; it was a regular phenomenon there and they have been seen since the canal was opened also, and also collected.

Q. Now, Professor, assuming that disease germs of these living organisms of the objectionable character contained in the water and this pollution that may come from Peoria or from Chicago or from any other place, has a certain life time limit, I will ask you if it is not your opinion that a great many more of those living organisms would perish in those islands lying there upon the shore of the river at Peoria prior to the opening of the canal, when since the opening of the canal, by the increased volume of water they are carried on down the river, and that those organisms would perish there at Peoria, while since the opening of the canal, if they perish, it is further on down the Illinois river?

MR. TODD: I object to the question for the reasons heretofore stated in other objections, that this witness is not an expert on bacteriology.

A. An answer to that question would involve a much greater knowledge of the fate of so-called pathogenic bacteria, and the conditions under which pathogenic bacteria are destroyed, than I,—not being a bacteriologist,—am able to furnish, but
7272 it is fair to state this, that by those who are engaged in this work the effect of a septic tank and similar operations on the pathogenic bacteria passing through them, is still in dispute. I would not therefore attempt to answer that question positively.

Q. Professor, assuming in connection with the question that has just been propounded to you, that prior to the opening of the canal this offal from the stock yards, and distilleries and cattle sheds at Peoria, formed in islands upon the banks of the river, which would remain there for a conisderable time, and afterwards were pushed out into the river either by steam-boats or by floods and freshets, in the Illinois river, if during the time that those deposits containing objectionable pollution and matter, did not gradually increase while resting there upon the shore of the river, so that after the drainage canal was open and the similar discharges cast into the Illinois river was carried at once down that river, that those germs would find their way further down the river before they perished, as a practical chemical proposition, is that not true?

MR. TODD: I object to the question for the reason that the question is not a practical chemical proposition, but taken in
connection with the previous question, is a bacteriologi-
7273 cal proposition involving questions of disease germs of
which this witness has disclaimed to be an expert in and
for that reason it is not proper cross-examination.

Q. MR. JEFFRIES: Limit it, professor, to your investigation in a bacterialogical chemical examination and experience, with the assumption that the objectionable pollution is in the shape of disease producing living organisms; what do you say upon that subject?

A. If we are limited to that assumption I will say that as a chemist and not as a bacteriologist dealing with questions of pathogenic germs, I cannot answer it. The limit goes quite beyond my powers of answering.

Q. Do you not maintain professor, that while that objectionable substance was lying upon the shore of the Illinois river at Peoria, fresh sewage being continually added to it so as to keep it in a moist condition, in a condition suitable for decomposition, that the objectionable features of that material would not disappear in part while it remained there upon the banks of the river, and that the same sewage if carried down at once—that the same deposits, if carried at once into the river and passing down the river, would carry more objectionable qualities with it, than it would if it remained on the banks of the river for
a certain length of time?

7274 A. If all the assumptions made in the question were true,
it would necessarily follow as a matter of course, that
this objectionable matter would be further carried down the river, but the assumption does not correspond to the practical case. Going back to my record, on which I must depend, my record of analyses, I find that the reverse of what has been assumed in the question is the actual situation.

Q. Professor, those samples that you have reference to were taken at one point. Now I would like to ask you what proof you have that they are representative and characteristic of the water in connection with these times that we speak of?

A. I have stated as explicitly as possible what were the directions that I gave—I first showed the collector where the samples should be taken and in addition to this, cautioned the men to collect those samples in the fairest possible manner. He was warned distinctly and implicitly against the collection of samples from near these floating islands; that they were to represent a fair average condition of that part of the river below Peoria.

Q. Professor, did you ever examine any of these islands, prior to the opening of the canal with a view of determining their chemical constituents and the chemical changes that they underwent from the time that the deposit was placed upon
7275 the banks of the river at Peoria, until they were started
floating down the Illinois river?

A. No, I have never examined the chemical composition of one of these floating islands.

Q. You know it to be a fact, do you not, professor, that since the opening of the drainage canal there has been no such islands form in the Illinois river?

A. On the contrary I have seen since the opening of the canal just such deposits.

Q. Not so many as there were prior to the opening of the canal?

A. Well I cannot say that I counted them in either case.

Q. Then professor, I will ask you this question, that if these islands have formed since the opening of the Chicago drainage canal, if the effect of the opening of the canal has not been to hasten those islands in their passage down the Illinois river to its mouth?

A. Well that is possibly true. I have no data to show anything about the rapidity with which these islands break up. I must add this, that the islands do not flow as such any very great distance down the river. The formation and breaking up of these so-called floating islands is rather a curious phenomenon, as I have seen the operation several times. They appear to break to pieces and sink and come up again and eddy

7276 about. I do not recall that I ever saw them any very considerable distance below that particular location in the river.

Q. Now I will ask you, professor, if you do not know it to be a fact that prior to the opening of the canal, upon a number of occasions, these large islands were formed upon the banks of the Illinois river, and the authorities, or the persons who were responsible for those islands employed steam-boats to pull them from the shore and start them down the Illinois river, and if since the opening of the canal no such conditions have existed?

A. Personally I am not familiar with any such condition and have no knowledge—

Q. Now then, I will ask you professor, if the cutting loose of these Peoria islands, so-called, into the Illinois river prior to the opening of the drainage canal, that river being in a septic condition as stated by you a few moments ago, if the septic operation of the water upon those islands would not have a tendency to break the islands up and break the polluted matter and the solids more rapidly than it would in a running stream?

A. The question does not distinguish between mechanical breaking up and subsequent chemical disintegration. It is probably true that a mechanical disintegration or breaking up of these islands into smaller masses, would take place more 7277 rapidly and more efficiently perhaps under the influence of the stronger current. It does not however, follow that the chemical disintegration or breaking up should be modified in the same way. There is a very important distinction between mechanical destruction of the large mass and its subsequent chemical decomposition.

Q. Professor, if it should be shown to you that a chemical analysis of the water at the points where the samples were taken by you were of different chemical constituents and in a different condition chemically in various parts of the river in cross-sections, at the time these samples were taken by you, what effect would the result of those samples have upon the conclusions drawn by you from the samples that you have taken?

A. Although that question is considerably mixed, and if I didn't know what is wanted, I would not be able to answer it, I think I can make this statement very fairly: That if I should

find, as the question assumes, that a fair cross-section set of samples was taken and showed results at the same points different from that of my sample, I should be in duty bound to think that perhaps there was some mistake made in the collection of my sample, assuming all the conditions. But if I have no such evidence that a cross-section was made at the proper
7278 point, then I would have no reason to modify in any respect the opinion which I give, based on the evidence of the analysis of the sample at the point where my directions were given to collect the sample.

Q. Professor, are you acquainted with the number of cattle that have been fed at Peoria in the last few years?

A. I have heard various statements about the number.

Q. I don't want what you have heard, I want to know if you know?

A. I have not been in the cattle sheds and have not attempted to count the cattle present. I don't know.

Q. Have you made any examination of the character of the discharges from those cattle sheds?

A. Yes, I have seen the discharges.

Q. Have you ever analyzed them?

A. I have not.

Q. Do you know the population of the city of Peoria?

A. Not exactly, no.

Q. Do you know the amount of the sewage discharged from the city of Peoria?

A. I do not.

Q. Is it 50,000?

A. 50,000 what?

Q. Population?

7279 A. I don't know. I believe it is considerably above 50,000,—nearer 100,000 than 50,000.

Q. Well, will you say it is 100,000?

A. I will not say anything about it; I don't know.

Q. In your chemical analyses then you have not taken into consideration the population of Peoria, or the extent of the cattle industry at that place?

A. In my analyses I am not concerned with that.

Q. Well, in your opinion upon the sanitary condition of the water below Peoria have you?

A. In forming my opinion I have taken in consideration the fact that there is a large amount,—or there are a large number of cattle fed there, and that there is a very large amount of grain mashed at Peoria, mashed before fermentation, and that this offal or slop from this in various years has been sufficient to amount to a contamination equal or in excess of that proceeding from Chicago.

Q. Professor, which is the more objectionable as a polluting substance in water used for domestic purposes,—the swill discharges from the distilleries or the sewage discharges from the human excreta of the city of Peoria?

A. Inasmuch as the swill discharges from the city of Peoria are mixed discharges, that is the distillery discharges
7280 are mixed discharges containing in many cases the excreta of animals as well as the residues left in the mashing and fermentation of grain, and inasmuch, further as these residues left in the mashing and fermentation of grain are comparatively large and almost wholly nitrogenous in character, and because of the further fact that this nitrogenous substance has not yet begun to undergo chemical or bacterial disintegration, and that such disintegration is a factor which consumes considerable time, and as the first products of this disintegration require a relatively large time for the final disposition, it is my opinion that the discharges from Peoria are as important,—probably more important in the contamination of the lower Illinois river, than the discharges from Chicago. The discharges from Chicago when they reach—

Q. Professor, I don't believe you understand my question. Pardon me for interrupting you. I don't have Chicago in the case.

A. Well I am putting it in comparison here.

The discharges from Peoria consisting as they do, largely of material in which the progress of oxidation is very slightly advanced, require a longer time for their final decomposition than would the discharges which have gone through the human organism, and in which the decomposition has been practically
7181 completed. That while from an esthetic standpoint the excreta discharged may appear very much worse, yet from a chemical standpoint, when we consider the nature of the substances, it is a very strong and reasonable prop-

osition that the highly nitrogenous and proteid discharge of a distillery must be considered as a more objectionable substance than the organic matter of fecal discharge.

Q. Objectionable in what way?

A. Objectionable because of the fact that a longer time,— a much longer time is required for its final disposition; because of the fact that it will afford for a much longer time a medium for the growth and development of these organisms which the bacteriologists tell us are really objectionable.

Q. Now you wish to draw that distinction between the chemical constituents of fecal matter that comes from the human being, and that which comes from the animal?

Q. No, that is not a distinction that I have attempted to make. I am speaking of the residues from distillery discharges, in which we have for every bushel of grain mashed, seven or eight pounds of waste, largely nitrogenous.

Q. Now professor, I will ask you if there is anything harmful to your knowledge in the mash that is not used by the distillery, after the spirits are taken from it?

7282 A. In the fresh mash there is certainly nothing harmful, but I know of no fouler contamination or worse smelling, or worse acting putrefying substance than this slop material when it begins to undergo bacterial decomposition.

Q. How does that mash that is so deposited into the Illinois river, compare with the ordinary farm and barnyard washings of the country?

A. That substance when deposited into the Illinois river, consists pre-eminently and characteristically of undecomposed protein substances, and must be considered as far more objectionable than the ordinary agricultural farm washings.

Q. Professor, are you using the word "objectionable" in this connection with reference to the health of those people who drink the water?

A. I am using that word "objectionable in the sense of applying to the character of the products, as produced from this material in its early stages of putrefaction.

Q. But do you use it in connection with the effect that it produces upon the health of the people who drink it?

A. The effect of that material on the health of the people I think would be markedly bad. To tell what that effect

would be is a proposition which I would not care to discuss, but
I have made and have seen made, experiments on the put-
7283 refaction or bacterial decomposition of this material and
I consider that the effect of such a production if consumed,
on the health of the people would be from the most superficial examination, bad.

Q. Then professor, if the effect of the decomposition and putrefaction of that material in a running stream produces ill effects upon the people who drink it, what effect would the sewage from the entire city of Chicago have upon the people who drink it, in comparison with that which comes from Peoria?

A. It is not possible to make a comparison between the sewage of Chicago and that material, because of the vastly different character of the two substances. I have been at some pains to explain that the sewage of a large city consisting in the main of the products of animal disintegration, contains substances which have been largely broken down, and in which the complex molecules have to the extent of 95 to 99 per cent at least been broken down, or in the proportion, as I think I explained this morning, of 16,000 to below 100, while in the sewage of such a region as Peoria these complex organic substances have still to undergo decomposition, and the effect of this will therefore be observed for a very much longer time. Now to make my meaning a little clearer, perhaps, I will say this; that in
the disintegration or breaking down of the protein sub-
7284 stances from foods, the products of excreta, the nitrogen-
ous products of excreta are in the main these: urea, uric
acid and creatine, with smaller amounts of other substances in nature similar to uric acid. The extent of decomposition here is measured as I have said, by the relative size of the molecules in question. The original substances to be decomposed,—or which have undergone decomposition, are of infinite complexity. The protein bodies have a complexity measured by the molecular weight itself, in some cases 15,000 or 16,000,—so great that we cannot determine it with the highest accuracy. The products formed from this are smaller. In the case of urea, we have a molecular weight of 60, and urea represents a very large portion,—perhaps 85 to 90 per cent of the total destruc-

tion of the proteid of our food. Uric acid, of which a very much smaller amount is excreted, has I believe a molecular weight of 168. It is not very important. The creatine, I think is 131. But the point is that we have the destruction of the original substances in that proportion. These are all far advanced on their way to final disposition when they leave the body and enter the sewers, and furthermore, from the fact of their being broken down into these substances, they are in a condition to speedily undergo further decomposition. As everyone knows, the final decomposition of urea is a process which takes place very rapidly,—extremely rapidly in sewers, and the
7285 decomposition of uric acid and creatine as I have observed in experiments, is also comparatively rapid, so in the household sewage or ordinary city sewage, the products have been already largely decomposed and are more readily finally decomposed. In the distillery refuse, because we have the very large complex substance there not yet broken down, and because they must undergo the first as well as the final stages of decomposition a very much longer time is required for that decomposition.

Q. Then professor, based upon your last answer, why is it that you refuse to recommend for domestic and drinking purposes, the water of any river into which the sewage from any human being is discharged?

A. In answer to that question I will state that which I have already stated, that while these organic matters are in a way objectionable, where we find them there is always the possibility that something else may be present of much worse character. The presence of organic matter may suggest the presence of organized matter, and that the bacteriologists and etiologists tell us is something to look out for.

Q. Professor, do you know how much residual matter remains in the analyses of the water of the Illinois river above Peoria, coming from Chicago?

7286 A. I know only what I have already stated in my reports, and which have been put in evidence. I know it is reduced to a rather small amount. I cannot tell you without going back over the reports again, how much.

Q. Professor, assuming that during the entire year of 1900, there were frequent heavy rainfalls on the water-shed of the Illinois river so as to cause more than an ordinary large volume of water to flow continuously throughout that year down the Illinois river, from natural sources, and assuming that in addition to this flow during that year there was added the water and sewage coming from Lake Michigan and the city of Chicago through the canal; and assuming further that at some succeeding year, since the opening of the canal there was comparatively small rainfall throughout the Illinois river valley and its tributaries, and that the volume of water coming down the river from natural sources was materially less than that coming down in 1900, and that during that period, water from Lake Michigan, and the sewage from Chicago came through the drainage canal and into the Illinois river, what effect would the increased flow in 1900 have upon the pollution of the water of the Illinois river with the sewage of Chicago, as compared with the suceeding year mentioned?

MR. TODD: I object to the question being predicated 7287 upon succeeding years, because it does not assume any increased flow of water in the drainage canal in succeeding years, over that which existed in 1900, and in order to make the conditions obtaining, such as will obtain in any succeeding year that increased volume of flow from Lake Michigan into the drainage canal over the Beartrap dam, is a matter that should be taken into consideration.

A. Well, before I attempt to answer that question I would like to have it read again slowly.

(Question read).

A. If as assumed in this question, in 1900 there was a large amount of water from tributaries and from rainfalls, in addition to the large amount of water from the drainage canal, and then assume that that in some subsequent year we have a very much smaller amount of water from the tributaries of the Illinois, and the same amount of water flowing through the drainage canal, or no increase of water from Lake Michigan through the canal, with the same amount of sewage discharged, it would follow as a matter of course, that in the succeeding years the dilution at the mouth of the Illinois river, as compared with the 1900 period, would be less, making all those assumptions.

7288 Q. Now then, professor, as to the increased and decreased volume of water passing down the Illinois river from these natural sources, such as were referred to in the preceding question, would that not create a variation in the extent of the pollution, and therefore a variation in the sanitary condition of the water as it enters the Mississippi river, from the standpoint of dilution alone?

A. If the dilution at the mouth of the Illinois river were allowed to depend mainly on the water of the tributaries, then there would be of necessity a variation in pollution there, and possibly some variation in the sanitary condition, but if the water from the tributaries becomes gradually a small factor, compared with the great and to be, greater flow in the drainage canal, then these variations become of less and less moment in the succeeding years.

Q. Now professor, assuming that in the future there is an increased volume of water flowing through the Chicago drainage canal and an increased amount of polluted matter from the city of Chicago caused by an increase in its population, I will ask you if this additional body of water flowing into the Illinois river would not hasten the water from Chicago to the mouth of the Illinois river, and to the extent of time limit, retard oxidation of such polluted matter as it might contain—Yes or No?

7289 A. It is possible that an increase of water might, by hastening the flow, push farther down the point at which oxidation is completed.

Q. Now that would be particularly true during low water periods wouldn't it, Yes or No?

A. That cannot be answered by Yes or No, because it gives no relation to the flow of the river in the low water period.

Q. Well as compared to the high water period?

A. Well perhaps in the low water period it would. That would be very hard to answer directly or positively, Yes or No.

Q. Professor, assuming that the amount of organic matter in the Illinois river at Grafton is the same as it was prior to 1900, is it not true that due to the increased volume of stream flow, the aggregate amount of objectionable organic matter in the Mississippi river is greater now than it was prior to 1900?

By that I mean the organic matter as shown in the samples from which analyses were made and shown by your tables introduced in evidence.

A. If we grant that assumption that the amount of organic matter in the Illinois river is greater now than it was before 1900, then it would necessarily follow, taking in the stream
flow also, that the aggregate amount of matter in the
7290 Mississippi river must be increased, but not necessarily
the important factor, which is parts per given volume.

Q. Professor, assuming that the Illinois river exists in its primal condition, with no pollution there either as to human beings or as to domestic animals, and that the Illinois river itself exists as at the present time and that the Chicago sewage enters as it now does, into the Desplaines river and thence into the Illinois river, are you able to state that all objectionable and injurious qualities of the Chicago sewage would be eliminated by the time it reaches Grafton?

A. In answer to that question I will say, as I have said before from the study of all the results of the chemical analyses which I have made of the water from Chicago to Peoria, and through Peoria and to the mouth of the river, I see nothing in the condition at the mouth of the river which suggests at all that the condition today organically is any worse than that in the ordinary streams of the state, and any worse than that which might have existed in the upper Illinois river. In comparing the Illinois river at its mouth, with the waters of the various tributaries through the season of 1899 and 1900, when such comparisons were made, I notice, and have noticed and have referred to the fact that the peculiar relation of the factors of albuminoid ammonia, to oxygen consumption,—in other words the ratio
which the factors expressing the albuminoid ammonia,
7291 bear to the factors expressing the oxygen consumption,
are very similar, practically, identical at the mouth of the Illinois river with what we observe in the examination of the tributaries. It is a peculiar and very interesting fact that for the tributaries the relation of the oxygen consumption, or the ratio of the albuminoid ammonia to the oxygen consumption is nearly a constant value which would be expressed, taking the average of all streams, by .07 about; we find by observing the same relation as I have before mentioned, several times, prac-

tically the same figure at the mouth of the Illinois river, while the characteristic figures of waters with known animal pollution or containing essentially animal pollution, show a factor in the mean, about double this; so from these observations I am inclined to say that as far as the organic pollution is concerned, the Illinois river today, as disclosed by the analyses I have made, and these are the only things on which I am at the present basing an opinion—is very similar, practically identical with the waters flowing through our state, and taking up a large amount of organic matter from the soil and decaying vegetation.

Q. Now professor, assuming the conditions mentioned in the last preceding question, will you state that no part of the objectionable pollution from the city of Chicago under
7292 those conditions, or under the conditions mentioned in the question, reach the intake tower at St. Louis?

A. I do not undertake to make any positive assertion of that kind, but from all of the evidence with which I am acquainted I see no reason to believe that any of the original elements of the Chicago sewage have reached the intake of the St. Louis waterworks.

Q. Now professor, you understand that in these last two questions I have eliminated every source of sewage pollution and domestic animal pollution and industrial waste, and I have placed the Illinois river valley, which includes its tributaries, in their primal condition.

A. That condition is fully understood and the answer is based upon that understanding of the question.

Q. Professor, under the assumptions just made in the last preceding questions, with the discharge of the sewage from the people of Chicago, containing 1,600,000 people, into the Illinois river, would you recommend under those assumptions, the use of the Illinois river at Grafton for domestic purposes in its raw condition?

A. As I have several times stated I would not under any circumstances recommend any river water in its raw condition for consumption, and in that general statement I will
7293 include the Illinois river and the Mississippi river and the Missouri river, or any river.

Q. And would you include the Illinois river under the conditions mentioned in the assumptions of the questions previously read?

A. I will include all large natural streams in that.

Q. Would you include the waters of the Illinois river at Grafton under those assumptions?

A. I will say that under all the assumptions, I will object to the waters of natural large streams. That is, I wouldn't recommend them for household consumption in general.

Q. Now professor, supposing we eliminate from the river the sewage of Chicago and also make some limitation as to the deposits into the rivers and its tributaries, as contained in the assumptions in the previous question, what would you say as to the condition of the water?

A. If I knew that all possible sources of contamination were eliminated from the Illinois river I shouldn't object to its use for household purposes.

Q. Professor, assuming that all possible sources of pollution are removed from the entire drainage area of the Mississippi river above the chain of rocks, and that the said watershed and drainage area was in its primal condition, what would you say as to the condition of the water at the chain of
7294 rocks in the Mississippi river, as suitable for domestic purposes from a hygienic standpoint?

A. Necessarily under those conditions, with all possible sources of contamination removed, the water would have to be considered suitable for household use.

Q. Now assuming professor that the entire watershed of the Mississippi river above the chain of rocks at St. Louis, to be in the same condition as expressed in the former question; in other words in its primal condition, and assuming that the sewage discharges from 1,600,000 people residing in the city of Chicago being discharged into the Illinois river by means of the canal as it now exists and the waters of the Illinois river entering into the Mississippi above the chain of rocks as they now enter, what would you say as to the sanitary condition of the water of the Mississippi at the chain of rocks for domestic use from a hygienic standpoint?

JUDGE SPRINGER: I object to this question on the ground that the assumption is not based on any facts that are in this case or that can possibly be brought into the case; it is wholly an abstraction and not pertaining in any way to this case, being a condition that never has existed and never can exist.

7295 A. With such an assumption, and the evidence that I have of the rate and conditions of purification in the Illinois river, and with no other discharges into the Illinois river in its course of 300 miles and over, I see no reason to condemn the Mississippi river at the chain of rocks, because of the entrance of the sewage of Chicago plus no other contamination, over 300 miles above.

Q. Can you state, professor, whether or not under those conditions the contaminating qualities or properties from Chicago would not reach the Mississippi river at the chain of rocks at St. Louis?

A. From all the evidence in my possession, I believe that none of the contaminating properties of Chicago would reach that far. I have nothing to show that they do.

Q. Professor, how far is it from the chain of rocks to the mouth of the Illinois river?

A. Thirty or forty miles.

Q. Now then, I want to ask you, that inasmuch as you have under the first assumption which referred to the primal condition of the Illinois river valley except as regards the sewage of Chicago coming through the canal, stated that you would not recommend the water at the mouth of said river as suitable for domestic purposes in its raw condition, will you state 7296 whether or not under such an assumption which takes in the entire Mississippi river watershed above the chain of rocks, that no part of the pollution from the city of Chicago reaching there and being objectionable to you under the first assumption, does not reach the chain of rocks under the second assumption, the increased distance caused by the stretch of river from the mouth of the Illinois river at Grafton to the chain of rocks being about 34 miles?

A. That question is still pretty complicated and seems to hinge on what is understood by raw water. In making these comparisons of raw water I have in mind the natural water such as existed in our streams, but from the various examinations which I have made, I cannot consider a water as raw which has undergone purification through a distance of 300 miles, and therefore I would not be inclined to condemn the Illinois river on that basis and for that reason.

Q. The question is not, do you condemn the water of the Illinois river, professor, but whether or not any of this pollution,—polluted matter which was objectionable to you under the assumption with reference to the primal condition of the Illinois river valley, except as to the sewage discharges of the city of Chicago through the canal which existed at Grafton, whether it would reach the St. Louis waterworks intake
7297 at the chain of rocks, a distance of nearly 34 miles.

A. I have nowhere stated that. There was no evidence to show that any of this original pollution ever reached Grafton, and there would be still less evidence to show that it reached the chain of rocks. If I have conveyed that impression in any answer, and I don't see how I have, it is a mistake. I insist emphatically that there is nothing to show that original contamination from the city of Chicago does reach the mouth of the Illinois river or the chain of rocks.

Q. I will ask you if there is anything to show that it doesn't reach there?

A. I have answered in substance that question several times.

Q. Well, answer it Yes or No, as to whether or not there is anything to show accurately and exactly whether it does?

A. It is not possible to answer a question of that kind accurately by Yes or No.

Q. And the most of it is derived largely because of the varying temperatures of the water, for instance, the temperature of the water in the summer time as compared with what it is in the winter time, thereby retarding oxidation. Among other things, isn't that true?

A. There is also the temperature to some extent. It does interfere with the rapidity of oxidation, I suppose.

7298 Q. Then taking all these things into consideration, wouldn't you say that the objectionable matter that might exist in the river at Grafton, under the circumstances mentioned in this assumption would not reach the St. Louis waterworks intake at the chain of rocks?

A. If it has been anywhere assumed that this objectionable matter reaches Grafton, that assumption was not made by myself.

Q. But we are speaking now, of that objectionable matter exists and the objectionable matter coming from Chicago, if it exists at Grafton, at the mouth of the Illinois river, does it or does it not reach the chain of rocks, a distance of 34 miles?

MR. TODD: I object to the question on the ground that the assumption is not based on the assumption of this witness, and for the additional reason that taking the assumption purely hypothetically it does not state the original amount of objectionable matter that is at Grafton which came from Chicago.

Q. (Question repeated)—under the assumptions made in the last preceding question?

A. If the assumption be granted, which it is not, that original organic contamination reaches Grafton from Chicago, then I would not be prepared to state that it might not reach the chain of rocks.

7299 Q. Then assuming that it reaches Grafton, you would not state that it would not reach the chain of rocks?

A. Assuming that this contamination reaches Grafton, I would not like to state that it might not reach the chain of rocks, but I have not made any such assumption myself.

Q. And the quantities that reach the chain of rocks would depend upon the quantity relatively speaking, that reached Grafton?

A. As we say in mathematics it would be a function of it.

RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. Professor, upon the assumption that the Illinois river was a virgin stream, receiving no pollution or contamination from Lockport to Grafton except that which enters through the drainage canal, you want to be understood as saying that at Grafton then can not be found the original organic matter which empties into the Illinois river from the Bear Trap Dam and the drainage canal of Chicago? Under that assumption of pristine purity of the Illinois river?

A. Under that assumption, I do not wish to be understood as saying that any of the original pollution could pass that far in the channel.

7300 Q. Will you locate definitely, or as definitely as possible, the points where the samples of water were taken below Peoria, at the location which you have denominated Wesley?

A. Well, I have described that as accurately as possible, in answer to a question of Mr. Jeffries, that the point is on the opposite side of the river from Wesley, Wesley being opposite Peoria and farther down.

Q. How far from the opposite shore of Wesley was it?

A. It is, as near as I can now recollect, about a half mile below Wesley. It was around a considerable bend in the Illinois river at that point, which bend is also below Wesley. There is rather a marked bend there and this bend is a considerable distance below that.

Q. And how far from the Peoria shore?

A. Oh, from the Peoria shore, it was half way across as near as I could estimate, between the Peoria shore and the opposite shore.

Q. Did you say a half a mile below Wesley?

A. Yes, sir.

Q. A half a mile below Wesley in the center of the river?

A. As near as could be determined, in the center of the river.

RE-CROSS-EXAMINATION, by Mr. Jeffries.

Q. Now, Professor, were those samples taken below Peoria, always taken at the same place each day?

A. I gave my instructions to the collector to take them at
7301 the same place, but of course I wasn't present when he
took them.

Q. I will ask you if the increased volume of water from day to day, and the variations in the decrease of the water from day to day would not have some effect on changing the places in the river where you would get a general mixing of the water from Chicago and the deposits from the cattle pens in the Illinois river?

A. It is possible.

Q. So that unless the river remained in the same condition from day to day during the time these samples were taken and that point of mixing did not change, you could not absolutely rely upon all these samples as properly representing a fair mixing of the water at that point?

A. I think they would be as fair as samples can be taken. Of course I am willing to grant that all water-takers are more or less uncertain, but it was my aim to have those samples collected, representing the volume of water at that point as fairly as possible.

Q. Now, Professor, in the first question asked you by Mr. Todd in his re-direct examination, you meant, as I understood it, that it was your opinion that no part of the original organic matter representing the sewage of Chicago, could be found
7302 at Grafton under the virgin condition of the Illinois river?

A. That was as I understood his question.

Q. You didn't mean by that that the residual organic matter could not be found there?

A. No, as I have explained, that residual organic matter was so comparatively stable that it may pass very long distances in a stream.

Q. And you did not mean by that that these certain specific living organisms that follow the result of these properties in the analyses of the water, would not be absent at that place?

A. I have not wished to make any statement about the length of time that those organisms would live. That I have frequently stated, is outside of my province.

Q. Then as I understand it, you would not say that they would not be present there?

A. I would not say from my own knowledge, whether they would or would not be present. On that proposition I do not care to give any opinion.

JOHN H. LONG.

7303 F. ROBERT ZEIT,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Springer, and testified as follows:

Q. What is your name?

A. F. Robert Zeit.

Q. Where do you live?

A. At 4016 Vincennes avenue, city.

Q. What is your occupation?

A. Teacher at Northwestern University Medical School and Post Graduate Medical School of Pathology and Bacteriology.

Q. How long have you occupied that position in the Northwestern University?

A. This is the fifth year.

Q. State what courses of study you pursued before your acceptance of this position, your early education?

A. My early education was received in Switzerland and Germany and my medical degree is from the Western Reserve University at Cleveland, Ohio. I was afterwards three years with Prof. Klebs, and when he opened his laboratory here in the city, I was his instructor for three years.

Q. Who is Professor Klebs?

7304 A. He is one of the noted bacteriologists. For twenty-five years he was a teacher of pathology and bacteriology, at German, Swiss and Austrian universities, and was induced to come to this country, and was here five years in all. He was called to Rush Medical College as professor of pathology.

Q. How long were you in that position at Rush Medical College?

A. He was professor of pathology of Rush Medical College, and besides had a private laboratory where I was instructor and collaborator with him for three years. From there I was called to the Northwestern University as a teacher in bacteriology. After one year I was made professor of bacteriology at Northwestern University Medical School and one year or more ago I was given the whole department of pathology and bacteriology. So really my function at the school was originally bacteriologist purely. I was that when this report was made.

Q. You stated that you took a degree at the Western Reserve Medical College at Cleveland, state what the nature of your duties there, was?

A. The regular medical course. I obtained my M. D. degree at Cleveland, Ohio, in 1887.

Q. How long did you remain in that school?

A. From 1884 to 1887.

7305 Q. Have you attended any other medical school?

A. I have not.

Q. Or any other institution?

A. No, no other except those named.

Q. Have you practiced your medical profession at any time?

A. I have practiced medicine and surgery.

Q. How long?

A. About ten years.

Q. Where?

A. Partly in Wisconsin and partly in Chicago.

Q. Have you made any special studies as to the causes of disease of human beings?

A. Yes, at repeated times.

Q. How is that?

A. Of course constantly during my occupation as a teacher, I have in the last seven years been purely employed in the teaching of bacteriology and pathology. I have not practiced medicine or surgery for the past seven years.

Adjourned until 10:00 a. m., following day, Friday, October 2nd, 1903.

10:00 A. M., Friday, October 2nd, 1903.

7306 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. F. ROBERT ZEIT,

resumed the stand for further direct-examination by Judge Springer and testified as follows:

Q. Professor, did you make any bacteriological examinations of the waters of the Chicago drainage canal and the Illinois river in the year 1900?

A. I did, between February 6th and October 1st, 1900.

Q. From whom did you get the samples of water examined by you?

A. From Professor Long.

MR. JEFFRIES: We object to the answer for the reason that there is no evidence showing that the samples obtained by this witness or any of the samples that were taken out of the Illinois river or the drainage canal, and no evidence showing that the samples were taken under his direction, or the manner in which the samples were taken.

7307 JUDGE SPRINGER: In reply to that objection, I call the attention of counsel to the evidence of Dr. Long, and to the evidence of the various persons who testified in regard to taking the samples of this water, and their examination in the investigation, so far.

MR. JEFFRIES: *I suggest that there is no water taker* who testified that he took samples for this witness.

JUDGE SPRINGER: No, this witness states that he got the samples from Professor Long.

Q. Did you personally know anything about the taking of samples of the water from the canal or river?

A. I do. I have seen many of those samples arrive by express, and I received from Professor Long the original four ounce bottles, ice packed, covered with rubber cloths, which were used in my experiments.

MR. JEFFRIES: Now I move to strike out all that the witness has said with reference to the bottles received from Professor Long, for the reason that bottles so received by this witness, as shown by the testimony in evidence, was a limited number and not such a number as would justify any conclusions as to the sanitary condition of the water in the Illinois river, and for the further reason that sanitarians are unable to derive any value from the results of a limited number of 7308 analyses of any water, and especially water flowing in a running stream, and for the further reason that the evidence shows that the samples so collected were not so taken as to cover storm periods, cold weather periods and all the variations of the river, and the water therein, and for the further reason that the evidence does not show that the samwere so taken as to obtain a correct bacteriological examination of the water in the Illinois river at flood times, commencing at the source of the flood, or the entrance of the flood into the Illinois river and following it to its mouth, so that any analyses made by this witness of the water of the Illinois river would be incompetent, irrelevant and immaterial and of no probative force.

JUDGE SPRINGER: In reply to this objection I will state that it is principally argumentative and would be better addressed to the court, rather than put into the evidence. We will proceed to show how far the testimony will disclose the value of these examinations.

MR. JEFFRIES: I object to the statement of counsel for the reason that he is not on the witness stand.

JUDGE SPRINGER: I say, we will proceed to prove that.

MR. JEFFRIES: I object to the statement going into the record.

Q. JUDGE SPRINGER: I call attention to the book 7309 entitled: Illinois State Board of Health, Sanitary Investigations of the Illinois River and Tributaries, 1901—

MR. JEFFRIES: I object to the witness' attention being called to the report of the Illinois State Board of Health for the reason that the report is no evidence.

Q. (Continuing) I also call your attention to page 46 of that report—

MR. JEFFRIES: Objected to for the same reason.

JUDGE SPRINGER: You will save trouble if you will wait until I finish my question.

Q. (Continued) I call your attention to page 46 and the succeeding pages down to page 62, and the tables that are printed therein. Please state whether the tables which you find printed on those pages of that report contain the chemical analyses of similar samples examined by you bacteriologically during that period?

MR. JEFFRIES: Do I understand this witness to be a chemist?

JUDGE SPRINGER: No. These were Dr. Long's chemical analyses and he used the same water for samples taken at the same time for bacteriological examinations.

MR. JEFFRIES: I object to the question for the same reason stated in the objection to these tables when called 7310 to the attention of Professor Long. I object to them for the reason that the original tables upon which the results of the analyses were recorded, is the best evidence, and that these tables constitute no evidence whatever; that there is no evidence showing that the result of the bacteriological examinations are properly recorded, and any statement that this witness might make in reference thereto, is not competent, because the original table is not present so that the witness may be cross-examined thereupon, and that unless the said tables upon which the original results are recorded are produced in order to enable counsel to cross-examine him thereon, any statements that he may make in reference thereto are incompetent, irrelevant and immaterial, and I object to the question for the further reason that the tables themselves do not show that a sufficient number of examinations were made at the various places to enable any scientist, etiologist or epidemiologist, to determine the character and condition of the water of the river at the points where taken, or at any other place, so that such testimony and such evidence would not be trustworthy, of no moment and of no consequence, and therefore not competent proof, nor legal evidence.

JUDGE SPRINGER: I would suggest that in reference to this objection, that it would be better addressed to the court, as it goes to the weight of the evidence and not to the materiality. 7311

MR. JEFFRIES: I suggest that the objection as to the right to be shown the tables from which analyses were made, in order to cross-examine the witness on the point, is proper at any time, and I state here to the Court that no opportunity is given to me to cross-examine the witness upon the original tables made at the time the examinations were made, and upon which the results of the examination were recorded.

JUDGE SPRINGER: You have reference to Dr. Long?

MR. JEFFRIES: I have reference to this witness.

JUDGE SPRINGER: We have not got to the cross-examination of this witness yet.

Q. Now professor, you may answer the question that I put before.

(Last question read)

A. They do.

JUDGE SPRINGER: I will state here for the purpose of explanation, that these tables were put in evidence by Dr. Long in his testimony, and that I simply refer to the tables as already in evidence, and not to put these in evidence at this time, but referring to them as already in evidence.

MR. JEFFRIES: If it be true that the bacteriological tables of this witness were introduced in evidence by Professor Long and so sworn to by him, I move to strike them out for 7312 the reasons stated in our previous objection, that we have not been given an oportunity, on account of the failure to produce the original tables, to cross-examine this witness as to the correctness of the entries made thereon.

Q. JUDGE SPRINGER: I call your attention in these tables, professor, to the column headed "Colonies per C. C." Will you please state whether those ascertainments were made by you?

A. They were not.

Q. They were not?

A. No.

MR. JEFFRIES: We move to strike them out for the reason that the witness says that they were not made by him.

Q. JUDGE SPRINGER: Now state what you did in reference to making examinations of the samples of water that came to you at the times and from the places stated in these tables?

MR. JEFFRIES: I object to the question for the reason that the witness has not stated that a sufficient number of examinations were made to enable anyone to determine the quality of the water at that place, or the particular bacteriological properties of that water with reference to the sanitary condition or unsanitary condition of that water.

A. The specimens of water which I received from Professor Long were plated out on gelatin and agar, from three to 7313 sixteen dilutions were made in Petri dishes. We also made glucose agar plates for growth of an-aerobes. The object of our examination was principally to determine the presence of pathogenic bacteria, or the absence of pathogenic bacteria in the specimens of water submitted. That was our function in the investigation. No other. We did not make any counts of colonies nor tests for fermentation or indol production, or any of the usual tests. All the gelatin plates were kept at a temperature from 20 to 22 degrees centigrade; the agar plates in the incubator at 37 degrees.

Q. Centigrade?

A. Centigrade. The plates were examined daily and pure cultures obtained on agar from the various colonies, between the second and eleventh day. The pure cultures were then subjected to such further study as seemed necessary for their identification, such as growth on the different cultures media.

We further made a number of animal experiments, with all the samples obtained, or which were given to us by Professor Long. The experiments included intraperitoneal injections of guinea pigs with four cubic centimeters of the water of every station. Another set of experiments with the same waters included the inoculation, also intrapitoneally, with cultures made by adding one cubic centimeter of the suspected water
to five cubic centimeters of nutrient bouillon and keeping
7314 the mixture in the incubator at a temperature of 37 de-
grees centigrade for 24 hours. Of these cultures, one
cubic centimeter was injected intraperitoneally into guinea pigs. The object of the latter experiment was to favor the growth of pathogenic bacteria and keep back the growth of non-pathogenic saprophites and water bacteria. In other words, to enrich the water in disease producing bacteria by adding a favorable culture medium and exposing them to a favorable temperature. Disease producing bacteria are favored and multiply rapidly at 37 degrees centigrade, whereas water bacteria would be somewhat held back by such a temperature. The culture thus enriched in pathogenic bacteria was injected intraperitoneally and when the animal died, cultures were taken from the blood, the heart blood, the spleen and lymph glands. Also smears were made at that time, and a diagnosis as to the disease and the organism causing the death was attempted and made in most of the cases.

Q. Please state, professor, in detail now, the results obtained by the various bacterial examinations which you made, the number of examinations made of the waters of each place, indicating the number of bacteria, pathogenic and non-pathogenic, found, and what tests were made, if any, to determine the number of pathogenic bacteria that may have been in the samples?

7315 MR. JEFFRIES: The question is objected to for the same reasons stated in previous objections,—that the witness has not produced the original table from which these results were recorded, and by reason of failure to so produce and so testify, counsel for complainant have been denied the privilege of cross-examining the witness upon the correctness of said tables. We object to the question for the further reason that the witness is reading from the report of the Board of Health of the State of Illinois; that that part of the report which he is reading from, which he is testifying about, shows that no sufficient number of samples was analyzed by him and his assistants to determine the correct character and state of the water in the Illinois river at the various places that the samples were taken; nor do these samples display the correct bacteriological character of the water of the Illinois river, at flood times, at winter times, at low stages, at high stages; nor are any floods followed from source to mouth, so as to correctly determine the bacteriological condition and changes that the water undergoes from the source of the flood to the mouth of the Illinois river, and for the further reasons that the samples were so sparsely taken, and that there were so few examinations made, that no epidemiologist or etiologist, and no sanitary engineer or 7316 sanitarian of any character would consider them of any importance whatever in passing upon the sanitary condition of the water flowing down the Illinois river, and the bacteriological changes resulting therein.

JUDGE SPRINGER: I object to the argument of counsel in which he states that these findings are of no value. That is a question for the court to determine, and not one as to the admissibility of the evidence; it goes to the weight only.

MR. JEFFRIES: It goes exactly to the admissibility of the evidence, Judge Springer, for the purposes for which it is introduced.

Q. (Question repeated).

A. We examined from Lake Michigan tap water seven specimens. In the determination of pathogenic bacteria we found the colon bacillus three times;

the bacillus lactis aerogenes, once;
the micro rhizopodiformis, once.

The guinea pigs infected with four cubic centimeters of the different specimens of water injected intraperitoneally, all recovered. Three of the specimens containing pathogenic bacteria were placed in the incubator at 37 degrees centigrade for 24 hours with nutrient bouillon, one part of the water to five

parts of bouillon. Three guinea pigs received an in-
7317 trapitoneal injection of one cubic centimeter of this 24 hour bouillon culture. Only one died of sepsis. The blood of the animal contained bacilli coli communis. Subcutaneous injections caused only a local abscess, the animal recovering. Some of these specimens of water contained a moderate variety of bacteria commonly found in sewage, but only one of the samples contained virulent coli bacilli.

Q. Will you please state the non-pathogenic bacteria or micro-organisms you found in these waters, and the number of times each genus or specimen was found?

MR. JEFFRIES: Does that mean with reference to all of the examinations?

JUDGE SPRINGER: Yes. Please read my question.

(Question read).

A.	Micrococcus aquatilis,	2 times
	Micrococcus flavus liquefaciens,	1
	Bacillus subtilis,	4
	Bacillus mycoides,	1
	Bacillus mesentericus,	3
	Bacillus reticularis,	1
	Bacillus liquidus,	2
	Bacillus aquatilis,	2
	Bacillus flourescens liquefaciens,	1
7318	Bacillus flavescens, Pohl,	1
	Vibrio aquatilis, Gunther,	2
	Vibro aureus,	1
	Sarcina rosea,	1

Q. Did you make any examinations of the samples of water coming from Western Avenue in the new drainage canal, if so how many such specimens were examined and what bacteria were identified?

A. We examined thirteen specimens and the following bacteria were identified, of the pathogenic bacteria:

Bacillus coli communis,	9 times
Bacillus lactis aerogenes,	4
Bacillus enteritidis,	3
Proteus vulgaris,	6

Of the non-pathogenic bacteria the following were identified:

	Micrococcus candicans,	3
	Micrococus agilis,	1
	Sarcina lutea,	2
	Bacillus subtilis,	3
	Bacillus mycoides,	2
	Bac. mesentericus,	2
	Bac. aquatilis sulcatus I,	3
	Bac. aquatilis,	3
7319	Bac. acidi lactici,	2
	Yellow water bacillus,	1
	Bac. cloacae-Jordan,	3
	Bac. reticularis-Jordan,	1
	Bac. delicatulus-Jordan,	1
	Bac. ubiquitus-Jordan,	1
	Bac. albus putidus,	1
	Vibrio aquatilis-Gunther,	1

Intraperitoneal injection of guinea pigs with four cubic centimeters of the sample of water did not prove fatal. Twenty-four hour mixtures grown at 37 degrees centigrade with one part of water and five parts of nutrient bouillon caused a fatal septicemia by intraperitoneal injection of one cubic centimeter.

Several of the pure cultures of the bacillus coli communis obtained from these samples were non-virulent, whereas the above mixture invariably proved fatal.

Q. Did you make any examinations of samples of water which came from Bridgeport, and if so, state the organisms identified.

A. I received seven samples of water from Bridgeport. The organisms identified are as follows:

Pathogenic.

	Bac. coli communis,	6
	Bac. lactis aerogenes,	4
7320	Bac. enteritidis,	2 times
	Proteus vulgaris,	6
	Bac. pyocaneus,	2

Non-pathogenic.

Micro. candicans,	2 times
Micro. flavus desidens,	2
Bac. subtilis,	2
Bac. mycoides,	1
Bac. mesentericus,	1
Bac. superficialias,	2
Bac. aquatilis sulcatus I,	1
Bac. aquatilis,	1
Bac. liquidus,	1
Bac. florescens liquefaciens,	2
Bac. acidi lactici,	2
Bac. rubidus,	1
Bac. aerogenes,	1
Bac, plicatus,	1
Bac. cyanogenus,	1

MR. JEFFRIES: I object to the witness reading the table for the reason that he has stated that he only received seven samples at this place, while he received a larger number at other places, and that by reason thereof, no comparison can be
7321 drawn from the bacteriological condition of the water
in the respective places. In other words the results so obtained from the samples are not competent.

JUDGE SPRINGER: I submit the question of competency is not involved. It is a question as to the weight of the evidence.

Q. Proceed, professor, to state what examinations you made for the purpose of determining the character of these organisms.

A. The intraperitoneal injection of four cubic centimeters of several samples of water into a guinea pig did not produce death, whereas, one cubic centimeter of a mixture of one part of water to five parts of bouillon, kept in the incubator over night at 37 degrees centigrade, proved invariably fatal to guinea pigs in a short time. Even subcutaneous injections of one guinea pig produced a fatal septicemia.

Q. Did you make any examination of samples of water received by you from Professor Long, taken from Lockport?

A. I received seven samples from Lockport, in which we found the following organisms:

Pathogenic.	
Bac. coli communis,	4 times
Bac. lactis aerogenes,	2
Bac. enteritidis,	1
7322 Proteus vulgaris,	2 times
Proteus mirabilis,	1
Non-pathogenic.	
M. candicans,	2 times
M. flavus liquefaciens,	1
M. luteus,	1
Sarc. lutea,	2
Sarc. aurantiaca,	1
Bac. subtilis,	1
Bac. mycoides,	1
Bac. aquatilis, sulcatus,	1
Bac. aquatilis,	1
Bac. acidi lactici,	2
Orange red water bac.,	1
Bac. cloacae,	1
Bac. ubiquitus,	2
Bac. rubidus,	1
Bac. plicatus,	1
Oidium lactis,	1
Mucor mucedo,	1

Q. State what examinations you made for the purpose of determining the character of these bacteria?

7323 A. Intraperitoneal injection of 4 cubic centimeters into guinea pigs produced no effect.

24 hours mixture grown at 37 degrees centigrade of one part of water and five parts of bouillon was uncertain in its effect. Some animals recovering after two cubic centimeters by intraperitoneal injection. One promptly died of sepsis. All those recovering had an elevated temperature and lost rapidly in weight for several days. One died two weeks later after having apparently recovered. No cause for death could be made out post mortem and no bacteria were found in the blood or organs nor in the abdominal cavity. In the animal which died promptly, the proteus forms were most prominent.

Q. State whether you received any samples of water during the period mentioned from Joliet, and what examinations were made, if any, to determine the character of the bacteria found therein?

A. We examined six samples of this water and found the following pathogenic and non-pathogenic bacteria:

Pathogenic.

Bac. coli communis,	3 times
Bac. entertidis,	2
Proteus vulgaris,	3

7324 Non-pathogenic.

Micro. aquatilis,	2 times
Micro. aerogenes,	2
Micro. luteus,	1
Sarcia lutea,	3
Bac. subtilis,	1
Bac. mycoides,	3
Bac. mesentericus,	1
Bac. aquatilis, sulcatus—I,	1
Bac. fluorescens liquefaciens,	1
Bac. cloacae,	2
Bac. superficilis,	2
Bac. fulvus,	1
Bac. plicatus,	2
Bac. rubidus,	1
Bac. mucormucedo,	1
Saccharomyces cerevisiae,	1
Bac. cyanogenus,	1

Intraperitoneal injection of four cubic centimeters into guinea pigs produced no effect. Of four guinea pigs inoculated with one cubic centimeter of the 24 hour culture at 37 degrees centigrade of one part of the different waters and five parts of the bouillon by intraperitoneal injection, one died of sepsis, the others recovered. 7325

Q. State whether any samples of water were received by you from Wilmington on the Kankakee river, during that period and if so, what examinations you made of such waters for the purpose of determining the character of the bacteria found?

MR. JEFFRIES: The specific objection is made to any testimony showing examinations of water made by this witness from samples taken in the Kankakee river at Wilmington, or at any other point, for the reason that it is incompetent, irrelevant and immaterial and has no bearing upon the issues involved in this case, and for the further reason that there is no evidence showing that any such samples were ever taken; that they were properly taken, or by whom taken, or in what quantities, at what places, or in what manner.

Q. JUDGE SPRINGER: Proceed.

A. We examined two specimens from this place and found no pathogenic bacteria, and the following non-pathogenic bacteria:

Bac. subtilis,
Bac. mycoides,
Bac. mesentericus,
Bac. aquatilis,
Bac. plicatus.

7326 Intraperitoneal injection of guinea pigs of four cubic centimeters of the water, as well as both the bouillon cultures proved non-pahtogenic.

Q. Did you receive any specimens of water during that period from Morris on the Illinois river, and if so, what examinations did you make of these samples of water for the purpose of determining the character of the bacteria found therein?

A. We examined ten specimens of water from this locality, and the following bacteria were found:

Pathogenic:

Bac. coli communis,	6 times
Proteus vulgaris,	4
Proteus mirabilis,	1
Bac. tetani,	1

Non-pathogenic.

Micro, candicans,	2 times
Sarcina lutea,	1
Sarcina rosea,	1
Bac. subtilis,	3
Bac. mycoides,	4
Bac. aquatilis,	3
Bac. cloacae,	1
Bac. megaterium,	2

7327 Bac, plicatus, 2 times

Direct intraperitoneal injection of one specimen of this water caused the death of a guinea pig in 11 days.

No post mortem findings or bacteria were found in the blood or organs of this animal. Other samples of water from the same place did not cause death by direct injection. Experiments with mixed cultures gave uncertain results, the animals sometimes dying and sometimes not.

Q. State whether you received any samples of water during that period from Ottawa or the Illinios river, and if so what examinations were made by you for the purpose of determining the character of the bacteria found therein?

A. We received five specimens of water from Ottawa. The pathogenic bacteria found were two:

Bacillus coli communis	2 times
Proteus vulgaris	1

Non pathogenic.

	Microc. aerogenes,	1
	Microc. candicans,	1
	Diploc. roseus,	1
	Bac. subtilis,	1
	Bac. mesentericus,	1
	Bac. clocae,	1
	Bac. liquiefaciens,	1
	Bac. fulvus,	1
7328	Vibrio flavus,	1
	Pink yeast,	1

Both the water and the mixed cultures proved non-virulent after intraperitoneal injections into guinea pigs in the same manner.

Q. Did you receive any samples of water from the Fox river at Ottawa during this period and if so, what examinations were made to determine the character of the bacteria found in such waters?

MR. JEFFRIES: The question is objected to for the same reason contained in the objection to the analyses of the water assumed to have been taken at Wilmington from the Kankakee.

A. We received four samples of water from Ottawa, Fox river, and found the coli communis, and the following non-pathogenic bacteria, which were identified:

Non-pathogenic.

	Diploc. citreus,	1 time
	Diploc. roseus,	1
	Sarcina lutea,	1
	Bac. mycoides,	1
	Bac. aquatilis sulcatus I,	1
	Bac. liquidus,	3
	Bac. aquatilis,	3
	Bac. flavocoriaceus,	1
7329	Bac. plicatus,	1
	Orange red water bac.,	1

Neither the water nor mixed cultures proved pathogenic to animals.

Q. Did you receive any samples of water from the Illinois river at LaSalle, and if so, what examinations were made to determine the character of the bacteria found in these waters?

A. Of the six samples we received, the organisms found were the following:

Pathogenic.

	Bac. coli communis,	2 times
	Bac. enteriditis,	2
	Proteus vulgaris,	3

Non-pathogenic.

	Microc. albicans,	1 time
	Sarcina lutea,	2
	Bac. mycoides,	3
	Bac. aquatilis sulcatus I,	3
	Bac. aquatilis,	2
	Bac. megaterium,	2
	Bac. fulvus,	1
	Bac. ochraceus,	1
	Bac. plicatus,	4
	Bac. subflavus,	1
7330	Bac. rubidus,	1
	Bac. cloacae,	1
	Oidium lactis,	1

Pink yeast,	1
Vibrio. aquatilis,	1

One guinea pig which received an intraperitoneal injection of four cubic centimeters of this water, died of sepsis, the others recovered, but the one to five bouillon mixture grown in the incubator for 24 hours, proved very virulent to guinea pigs.

Q. Did you receive any samples of water from the Illinois river at Henry, during this period, and if so, what examinations were made in reference to those waters?

A. We received and examined five samples from Henry, and found the following pathogenic and non-pathogenic bacteria:

Pathogenic.

Bacillus coli communis,	2 times
Proteus vulgaris,	1
Bac. tetani,	1
Staphylococcus pyogenes aureus,	1

Non-pathogenic.

Sarc. rosea,	1
Bac. subtilis,	1
Bac. mesentericus,	4
7331 Bac. cloacae,	1
Bac. megaterium,	1
Bac. aquatilis sulcatus I,	1
Bac. aquatilis,	2
Bac. subflavus,	2
Bac. rubefaciens,	1
Bac. striatus flavus,	1

Besides the above an organism like oospora farcinica was obtained again, but not positively identified.

Direct injection of the water did not cause death. Mixed bouillon cultures of 24 hours growth at 37 degrees centigrade were virulent.

Q. Did you receive any samples of water during that period from upper Peoria or a place sometimes called Averyville, and if so, what examinations were made of those waters?

A. We received five samples from this place. The pathogenic and non-pathogenic germs are as follows:

Pathogenic.

Bac. coli communis,

Non-pathogenic.

Microc. citreus,
Sarcina aurantiaca,
Sarcina rosea,
Saccharomyces cerevisiae,
7332 Pink yeast,
Bac. mesentericus,
Yellow water bacillus (Lustig),
Bac. liquidus.

Direct intraperitoneal injection of water as well as mixed 24 hours bouillon cultures proved entirely non-virulent. Even large doses of a 24 hour culture at 37 degrees centigrade of one part of water and five parts bouillon could be given to guinea pigs by intraperitoneal injection without causing death.

Q. State what evidences of bacterial self-purification are indicated by these examinations at this place, and the preceding examinations about which you have testified?

MR. JEFFRIES: We object to the question for the reason that the tables shown in evidence are incompetent as heretofore stated, and for the further reason that there were not a sufficient number of samples examined; the character and changes of the water with reference to flood times and winter season were not so followed as to enable any scientist to express any opinion as to the bacterial changes taking place in the water of the Illinois river at the point where these samples were taken, or at any other point. I object to the question for the further reason that the witness has not testified 7333 that he is acquainted with the bacterial organisms and the bacterial changes of river water and has not stated in evidence the extent of his experience upon that subject, if he has any.

JUDGE SPRINGER: I will ask the witness to state briefly what experience he has had in making such examinations before he answers the other question?

A. In examining water?

Q. Yes, generally speaking, now not with reference to these examinations.

A. I have taught classes in bacteriology for years how to find pathogenic bacteria in various mixtures and waters. My problem in this investigation was to determine the presence or the absence of pathogenic, that is disease producing bacteria, in the specimens of water presented to me.

As to experience, I have that of a teacher in bacteriology. I have taught bacteriology for 5 years, and while I have not an extended experience in sanitary investigations, I certainly have done enough work in the separation and identification of pathogenic bacteria, I think, to feel that I am entitled to an opinion as to whether they are present or not, and as to whether they disappear or not, and that is what I have done in this case.

7334 Q. (Question repeated):

MR. JEFFRIES: Now then, after the statement of the witness, I renew my objection, that he has not had sufficient experience with reference to the bacterial examination of running streams, knowing the bacterial changes of the water therein at all seasons of the year, at the various times in the year, particularly the relative conditions between winter and summer, flood times and low water stages, and the experience of the witness having been confined to the school room and the laboratory as stated by him, any opinion as to evidences of disappearance of bacteria from the water, is incompetent, ill-founded, of no probative force and of no value in the consideration and determination of the sanitary condition of the water in the Illinois river.

JUDGE SPRINGER: I submit that this objection goes to the weight of the evidence and not as to its competency.

MR. JEFFRIES: It goes to the whole weight of the evidence, and I suggest that from the witness' statement he has absolutely disqualified himself as being a competent witness upon the question propounded to him.

JUDGE SPRINGER: That of course is a question as to the weight of the evidence and not as to its competency.

Q. Proceed to answer the question, professor.

7335 A. I think I have distinctly stated in the beginning, that my part of this investigation was the finding and identification of pathogenic organisms, and such other sewage and water bacteria as could be identified, and I have, I think, qualified sufficiently in that direction.

MR. JEFFRIES: Now I object to the question for the further reason that the answer is not limited to the particular character of bacteria upon which the witness was making the examinations and which he was trying to ascertain.

Q. (Question repeated). Now proceed.

A. I found that there was a gradual decrease in the number as well as in the kind of pathogenic or disease producing bacteria in the water specimens submitted as we got further away from Chicago. Further, I found that bacteria that are generally known as sewage bacteria or saprophytic organisms gradually decrease as we approach Upper Peoria. The number as well as the kind of disease-producing bacteria, as well as the sewage bacteria, is continually decreasing to this point, and the absence of pathogenic effect in animals, I think is also a sufficient proof that the zone of bacterial self-purification, which every river has which has become polluted, must be located somewhere above or near Upper Peoria.

Q. State whether you received any samples of water from the Illinois river at a place called Lower Peoria—

7336 MR. JEFFRIES: I move to strike out the last answer for the reason that the witness's opinion is based solely upon samples analyzed by him without reference to knowing the particular place in the river from which they came, whether from the center, the side, or by cross-sections or otherwise; without reference to knowing the local conditions of the river and the water and the weather at the time the samples were taken, and further that his opinion thus formed is based only upon five samples taken in certain places, seven samples at other places, and eight samples at another place, and a few more samples at other places, so that the samples so examined by the witness are absolutely insufficient to enable any bacteriologist to determine the place in the river where self-purification from a bacterial standpoint, has taken place.

JUDGE SPRINGER: I would refer counsel to the testimony of Professor Long on this point, and other witnesses heretofore examined. The witness is called upon to state his conclusions in reference to the specimens examined by him during this period and the objection goes to the weight of his evidence and not as to its competency.

MR. JEFFRIES: I suggest that Professor Long absolutely refused to qualify as a bacteriologist, or to express any opinion in reference thereto.

7337 JUDGE SPRINGER: I know, but he stated the points from which these samples came at the time, the manner in which they were received, and in addition, that they were transmitted—that he transmitted those samples to Professor Zeit, and Professor Zeit states that he got these samples from him.

MR. JEFFRIES: Well, such facts have not been substantially proven in evidence, and the witness has stated that he only examined five samples at Henry, I believe, and probably six or seven at Upper Peoria—in fact less at Upper Peoria than at other places, and that based solely upon this proposition, upon this fact, this limited number of examinations, no bacteriologist can safely express an opinion as to the exact point in the river where bacterial purification has taken place.

JUDGE SPRINGER: That objection goes also to the weight of the evidence and not as to its competency.

7338 MR. JEFFRIES: I move to strike out the opinion of the witness and the statement of the witness that self-purification of bacteria had taken place at the point above Peoria, for the reason that he did not properly qualify as a sanitarian, as a bacteriological sanitarian, to make any such conclusions or determinations.

Q. JUDGE SPRINGER: State whether or not you received any samples of water from the Illinois river at a point near Peoria, and if so what examinations of these samples were made by you?

A. We received 11 samples of water from Lower Peoria, and found the following pathogenic organisms:

Bacilli coli communis,	8 times
Bac. lactis aerogenes,	2
Proteus vulgaris,	5

And the following non-pathogenic organisms:

Microc. aquatilis,	4 times
Microc. luteus,	1

A. We received ten samples from Pearl, finding the following pathogenic germs:

Bac. coli communis,	1
Proteus vulgaris,	1

And the following non-pathogenic germs:

Microc. candicans,	1
Microc. aquitilis,	1
Sarc. rosea,	1
Sarc. lutea,	1
Bac. subtilis,	3
Bac. mycoides,	5
Bac. mesentericus,	1
Bac. megaterium,	2
Bac. aquatilis sulcatus,	2
Bac. aquatilis,	4
Bac. aurantiacus,	1
Bac. rubidus,	1
Bac. acidi lactici,	1
Bac. flovocoriacens,	1

7343 Neither water nor culture, one to five, was pathogenic by intraperitoneal injection.

Q. State whether any samples of water were received from the Illinois river at Grafton, and if so how many and what examinations were made of these waters?

A. We examined ten specimens of water from Grafton, finding the following pathogenic germs:

Bac. coli communis,	2
Proteus vulgaris,	2
Staphylococcus pyogenes aureus,	1

And the following non-pathogenic:

Microc. luteus,	1
Microc. aquatilis,	1
Sarc. lutea,	2
Diploc. roseus,	1
Bac. subtilis,	5
Bac. mycoides,	2
Bac. megaterium,	3
Bac. aquatilis,	2
Bac. liquidus,	3

Bac. acidi lactici,	2
Bac. aurantiacus,	1
Bac. fluorescens liquefaciens,	2
Bac. subflavus,	1

Intraperitoneal injection of four cubic centimeters into guinea pigs did not prove fatal. Mixed cultures, one to five, were non-virulent.

7344 Q. Do the ordinary water bacteria multiply in river water?

A. They do.

Q. Do the pathogenic bacteria multiply in river water?

A. They do not.

Q. When the pathogenic bacteria and the ordinary water bacteria, and saprophytes all are present in river or lake water, what is their relative longevity?

MR. JEFFRIES: I object to the question for the reason that it confines the witness to the lake or the river and not to the samples of water taken from the lake and the river.

JUDGE SPRINGER: This question is general, but you may confine it to the Illinois river and drainage canal?

A. The conditions of the water bacteria are the same everywhere, that is, they will be able to grow and multiply even when there is very little organic matter present and even at a low temperature. The condition of growth of the saprophytic bacteria depends more or less on the presence or absence of dead organic material; the more organic material, the greater the number of saprophytic bacteria, and they usually require a somewhat higher temperature for rapid multiplication than do the water bacteria. In other words, the greatest multiplication of saprophytes will take place in the presence of the greatest quantity of organic material, and a tempera-
7345 ture slightly above that of the lake or river water. The existence or disappearance of disease producing bacteria, typhoid bacilli, the cholera vibrio, and various pus micro-organisms depends upon dilution, light, the temperature and the presence or absence of large numbers of saprophytes. Conditions exactly, as shown by experiments, are these: In the presence of many saprophytic bacteria, that is at a temperature at which saprophytes grow best, at room temperature, typhoid

bacilli, staphylococci, anthrax bacilli, and similar pathogenic bacteria are rapidly overgrown by the saprophytes and disappear from the mixture. Even in the absence of organic material where there are only water bacteria present, the water bacteria multiply also at a tremendous rate, and we find that the typhoid bacilli disappear in eight or ten days. In the first case, where many saprophytes are present, there is great multiplication of saprophytes at room temperature, and the typhoid bacilli are overgrown and disappear very much sooner, in five or six days. When there are only water bacteria and no colon bacilli, no sewage contamination, but simply the common water bacteria, as found at times in pure Lake Michigan, or non-
7346 polluted river water, the typhoid bacillus lives somewhat longer. If typhoid bacilli are put into a sterile water they can live still longer than in either one of the other cases. The typhoid bacillus in sterile water can live for weeks, even in the absence of food. These statements are all based on personal experiments, and I have repeatedly observed that in the presence of much organic material the greater the number of saprophytic bacteria, the sooner the cholera vibrio, staphylococci, anthrax and streptococci and typhoid bacilli will disappear. Another point which I ought to add here is, the higher the temperature, of course, the more favorable it is for the growth of the disease producing bacteria, and that in the low temperature of a river or lake water the typhoid bacillus can not multiply. These lower temperatures are favorable to the growth and multiplication of water bacteria and many saprophytic bacteria. The typhoid bacillus in the absence of many water bacteria and saprophytes might live for some time. The smaller the number of saprophytic bacteria which are present, the longer, of course, the typhoid bacilli may exist, and the less they will be overgrown by the rapidly multiplying saprophytes or sewage bacteria or water bacteria.

Q. You have spoken of three kinds of bacteria, ordinary water bacteria, saprophytes and pathogenic bacteria. Will you please state what meaning you attach to each of these genera?

A. Every lake and every river has a normal bacterio-
7347 logic flora. By water bacteria, I mean bacteria which do not cause putrefaction, which do not produce gas,

which do not produce indol, which can live even when there is little or no organic material present. They are organisms that are found in every water. By saprophytic bacteria or sewage bacteria I mean those which produce gas, cause putrefaction, coagulate milk, produce acids and so on, and require for their rapid multiplication organic material in a larger quantity, and a higher temperature than water bacteria. The water bacteria grow and multiply best at the temperature of the water; the sewage bacteria or saprophytic bacteria grow best at room temperature. The pathogenic bacteria are disease-producing bacteria and grow best at blood temperature, so that when the three are mixed, it is mainly a question of temperature as to which kind will multiply most. If you mix pathogenic germs and saprophytic bacteria and keep the mixture at blood temperature, the pathogenic germs will multiply more rapidly than the saprophytes; but if you keep them at the temperature of air, the saprophytic bacteria, in the presence of much organic material, will increase at a tremendous rate, whereas the disease producing organisms cannot multiply because the temperature will not allow them, and they are overgrown by the saprophytes. For instance, the typhoid bacillus doesn't multiply at all at the temperature of water.

7348 Q. Under what conditions will the typhoid bacillus multiply?

A. The typhoid bacillus will multiply only by being in a favorable temperature. It grows best at blood temperature, 37 degrees, but can grow at as low a temperature as 24 degrees.

Q. Is that centigrade?

A. 24 degrees centigrade. And secondly, there must be organic material for food. For a mixture with other rapidly growing bacteria at this temperature, the typhoid bacillus will be annihilated, it will be overgrown and it will disappear, even when the temperature is in the neighborhood of 24 to 30 degrees. The typhoid bacillus will disappear, due to the rapid growth of the other bacteria present.

Q. Professor, state whether at any time heretofore you made any experiments of tap water in Chicago, taken from the waters coming from Lake Michigan, for the purpose of ascertaining the longevity of the bacillus typhosus or other pathogenic germs?

A. I did.

Q. Please state the times if you can, and the circumstances of this examination, and what results you obtained?

A. Some five years ago, Professor Klebs suggested that I
test this question, and we at that time made a number of ex-
periments with common tap water. We took liter flasks, and
inoculated the liter flasks of hydrant water, of Lake Mich-
7349 igan water, with known quantities of a fresh 24 hour
bouillon culture of typhoid bacilli, the first flask receiving
one platinum loop full of the culture, the second five loops, the third ten, and so on, up to the last flask to which a whole tube full of bouillon culture, that is five cubic centimeters, of the typhoid bacillus was added. These experiments we ran in four series, so that there were ten of the one liter flasks in each series. One series was kept in the light at room temperature, the other set in the dark, room temperature; the third set in the dark at 37 degrees centigrade and the fourth set in the light at 37 degrees centigrade.

Q. Please state the temperatures Fahrenheit of those temperatures?

A. 37 degrees is about 98 and a half Fahrenheit.

Q. That is, 37 is 98½?

A. Yes, and 20 degrees centigrade is 68 Fahrenheit. We plated out daily and when we could no longer find typhoid bacilli we plated out as many as twenty plates from many of the flasks where we were unable to find them, and we found that the typhoid bacilli in all flasks, in all temperatures, disappeared, that is, in different times. If the temperature was most favorable to the growth of water bacteria, and in this par-
ticular instance I remember the most prominent in our speci-
mens were cocci, large water cocci. These increased at a
7350 tremendous rate. This was supposed to be as pure water
of Lake Michigan as we had at that time, and it did not
contain more than about 80 to 300 colonies to the cubic centimeter at that time. If we kept it at room temperature we found that the cocci increased at a tremendous rate even in a few days, and that the typhoid bacilli we had inoculated it with,

in all cases and in all flasks had died after three weeks. Now as to the time of disappearance of typhoid bacilli under different conditions, I have here a few of the data as to the time of disappearance. Those which we kept at blood temperature—

MR. JEFFRIES: What are you reading from?

A. I put some of the results of that experiment into the report made to the Illinois State Board of Health.

JUDGE SPRINGER: He is stating from memory now.

THE WITNESS: It is mostly from memory. I think I can give it entirely from memory, if you will give me a little time.

MR. JEFFRIES: Go ahead and read it, I don't care.

A. At blood temperature in diffuse day light and another set in the dark-room, we obtained colonies for probably two weeks, a little over two weeks—at room temperature in the dark we obtained colonies for ten days, but at room temperature in the light we obtained colonies for about eight days. We further added sewage, and later on made additional experiments under the same conditions just given, but the difficulty in distinguishing between the colon types and the typhoid bacilli was immense, and therefore these latter experiments were not as complete as those sets of four that I have
7351 mentioned with plain Lake Michigan water. We found that the typhoid bacilli disappeared very soon when sewage was added. In fact, much sooner. After five or six days we were unable to find typhoid bacilli in any water to which we had been adding sewage. I have before mentioned the difficulty met here, of not being as positive about the result as in the other case with lake water alone. We found mainly a rapid overgrowth of water cocci, whereas here we had the colon types in large numbers, and the great difficulty of separation and differentiation between these and typhoid types. We became thoroughly convinced from our work at the time, that typhoid bacilli, in the presence of much organic material and the overgrowth of saprophytic bacteria, disappeared entirely from the water inside of a week, that if only water bacteria were present and no sewage contamination, typhoid bacilli could live a somewhat longer time, but that no multiplication took place at the temperature of lake and river water and they

finally were annihilated. Whenever saprophytes were numerous the typhoid bacillus disappeared rapidly, that is in five or six days. Briefly stated, in the presence of water bacteria only, the typhoid bacillus can live a longer time than in the presence of much organic material and saprophytes, but in all cases it rapidly disappears from any water to which sewage is added.

7352 Q. Professor, which is the more important factor to be considered in determining the purity or impurity of a stream or body of water, the number of bacteria found in the water, or their character?

MR. JEFFRIES: Now I suggest to the Court, and object to the question for the reason that the witness has not qualified as a sanitarian and for the reason in his qualifications he did not state that he had any experience as to the sanitary condition of water, or with the condition of water in running streams from a hygienic standpoint.

A. The number of bacteria has not as much importance as the kind of bacteria. The number of water bacteria may be very great and have not much significance, whereas, if they are sewage bacteria and pathogenic or disease producing bacteria, the number may be very small, and the water might be called perfect, chemically, and yet it might not be called perfect bacteriologically. If we judge only according to the numbers of bacteria present, and the water contained less than 50 germs per cubic centimeter, it would of course have to be called a good water, and yet, if these fifty germs happened to be disease producing germs, that water should be condemned. The number has only significance in so far as after the normal number of bacteria in a stream or lake or river has been 7353 once determined in the summer and winter and at all times and under all conditions, a sudden great increase in the number found above that which is normally found under like conditions, would mean pollution. That would be the only value a numerical determination would have in my opinion. A judgment as to whether a water is good or bad, based upon the number of bacteria found in it, of course, is wrong. The quality of the germs, whether they are pathogenic or non-pathogenic, disease producing organisms is the essential point.

Also the question, if we are able to say so, whether the germs present are sewage or water bacteria.

Q. In the numerous bacterial examinations which you have made of the water of the drainage canal and the Illinois river as stated in your testimony in this case, have you ever found the bacillus typhosis?

MR. JEFFRIES: I object to the question as leading and incompetent for the reason that the witness has not made any extensive examinations of the water.

JUDGE SPRINGER: The question is confined to the examinations as made, extensive or otherwise.

Q. (Question repeated.)

A. I have not. Nor is that strange. We cannot find the
7354 typhoid bacillus usually because even if sewage contaminated with typhoid bacilli should get into the lake for instance, the dilution would be so tremendous, that it would be very difficult to find them again. The typhoid bacillus does not multiply at the low temperature of such water, and in case of sewage contamination of lake and river water the sewage and water bacteria overgrow it and other elements such as tremendous dilution and the effect of light, cause its disappearance. Even where we know that pollution of a water supply with sewage containing typhoid bacilli has taken place, bacteriologists cannot find typhoid bacilli. First the unfavorable temperature of water prevents multiplication of pathogenic germs. Secondly, sewage bacteria or saprophytes undergo rapid multiplication and overgrow the parasitic bacteria. Third, extensive dilution takes place and separates the bacilli so far that the bacteriologist is unable to find them any more. Another factor to be considered is that in most of the epidemics where bacteriologists have searched for typhoid bacilli and were unable to find them, the time of infection or of contamination has no doubt been passed by several weeks, and typhoid bacilli,
7355 which might have been found earlier, have been entirely annihilated during the period.

Q. If the typhoid bacillus was present in the water, would you in the examination of a cubic centimeter, determine that fact if it was in that cubic centimeter?

A. If one typhoid bacillus was present in one cubic centimeter?

Q. Yes?

A. I think with our present means of differentiating the typhoid bacillus, we would.

Q. What advantage or what assistance do you have in ascertaining the presence of these bacilli by the bouillon cultures to which you have referred?

A. I do not quite get your question.

Q. Would you recognize it directly or more readily by a bouillon culture?

A. The recognition of the typhoid bacillus from bouillon cultures taken from a specimen of water is impossible.

Q. You have stated that a 24 hour culture, at a certain temperature of one part of the water to five parts of the bouillon would produce a certain result?

A. Yes sir.

Q. What assistance does that afford you?

7356 A. The object of making, and enriching the culture in pathogenic bacteria or rather the object of infecting the bouillon with the suspected water, and exposing it to blood temperature is this: I want to favor the growth of disease producing bacteria, and with it of course also, the typhoid bacilli if they are present. They should multiply more rapidly than the saprophytic or water bacteria, and by having this culture in the incubator for 24 hours we keep back the sewage and water bacteria which do not grow so well at blood temperature as the disease producing bacteria. In this way we allow the disease producing bacteria or parasites to multiply more rapidly so that for 24 hours we are very liable to have favored and multiplied the disease producing bacteria, and to have kept back the others. In the water the conditions are just the opposite, due to its lower temperature, which keeps back the disease producing bacteria and favors the growth of the water bacteria and saprophytes or sewage bacteria. The injection of a 24 hour culture at blood temperature is liable to prove a great deal more pathogenic if disease producing bacteria were present in the water than if water itself had been injected. The injection of the water itself is very, very unsatisfactory, because if disease producing bacteria are present in the water itself, they are not in sufficient number to produce death or disease.

7357 Q. If there were then only one bacterium in the water as taken from the river or lake, this culture might produce a greater number?

A. If there was only one germ, we will say, of any pathogenic kind in four cubic centimeters of the water that I injected into the animal, that of course would have no effect on the animal at all, but after 24 hours in the incubator with bouillon, the one germ would have produced billions, and would certainly now prove virulent and produce disease or death.

Q. The presence then of one bacterium in four cubic centimeters of water, when it is intraperitoneally injected, would not produce any effect?

A. Even much greater quantities than that might not produce any virulent effect. It is but very rarely that a river or lake water that is injected intraperitoneally will cause death in a guinea pig. A few germs do not produce an infection even if they are virulent or pathogenic germs.

Q. Is that true of human beings as well as of the lower animals?

A. That is true in all cases, the number is just as essential as the presence of the germ itself, and as essential as the decreased resistant forces of the organisms, and as essential as the virulence of the germ. Those are really the four con-
7358 ditions of infection.

MR. JEFFRIES: I move to strike out the answer so far as the experiments made, for the reason that I take it this witness has not made any such experiments upon human beings, and I move to strike out the answer because the question assumes a fact not proven in the evidence, that is, that the question and answer assume a fact not proven in the evidence, and which cannot be proven except by actual experiments upon the two subject matters supporting the assumption, to-wit, animal life and the life of a human being.

JUDGE SPRINGER: Professor, you qualified as a pathologist?

A. Yes, sir.

Q. What is the accepted opinion of pathologists as to the probable effect of taking into the human system one bacterium of typhoid, or a single organism of any pathogenic kind?

A. It is true that in all diseases,—all infectious diseases, the number of the germs is very, very essential in producing an infection. We may have a germ and it may be virulent, and even the resistant forces of the organism may be decreased, and yet we have no effect, no infection, even in cases where there is a certain known source of infection, to which many people have been exposed. The same holds true not only of the typhoid bacillus, but of all other germs. We find that of the persons
7359 who die of other diseases, that ninety per cent. have evidences of an infection by tubercle bacilli somewhere in their bodies; I mean healed tubercular foci. Of those, then, infected by tubercle bacilli at some time during their life, 90 per cent. die from other causes, and show at the post mortem old foci, due to infection, which have healed. The numbers in all these cases have evidently been too small to cause death by tuberculosis, and the same also holds true with typhoid. The number of typhöid bacilli essential to produce infection, are not found in the amount of water usually used by an individual for drinking purposes, be it lake or river water. I do not believe personally that a direct infection can take place in such a manner. I think that if all the sewage of Chicago containing the typhoid bacilli from every case of typhoid fever in the city should get into Lake Michigan, that no one could be infected by the water of Lake Michigan *directly*, because the dilution of the bacilli and of such sewage, would be so great that one would have to swallow thousands of quarts of water to supply the necessary numbers of typhoid bacilli to produce typhoid fever, and that typhoid infections, in view of the fact that typhoid bacilli do not multiply at the low temperature of water, must take place in an *indirect* manner. To illustrate the infected water containing, we will say, one typhoid bacillus to so many thousands of gallons, would reach some favorable culture medium, like various food products, and in a favorable temperature, like that of a hot summer day, or in the house, in milk, or in oysters or on vegetables, or in various other foods, the few typhoid
7360 bacilli present begin to multiply and produce a pure culture in or upon these foods. A person partaking of such food, will swallow the necessary number of typhoid bacilli, to

bring about an infection and have typhoid fever, because he has swallowed a culture of many millions of typhoid bacilli, whereas, the other idea of the direct infection by drinking the water is illogical, when we consider the biology of the typhoid bacillus, and the tremendous dilution that takes place when turning sewage or other pollution into a large body of water, and the fact that the typhoid bacillus does not multiply at the low temperatures of lake or river waters.

Q. Assuming, Professor, that sewage and pathogenic bacteria gradually disappear in running water, what significance would you attach to this fact?

A. If the sewage gradually disappeared and with it the sewage bacteria, I would judge that by the overgrowth of saprophytes in the presence of organic material and a temperature favorable to rapid multiplication of saprophytes, pathogenic bacteria that might have been present in this mixture have been wiped out entirely. In other words, by the rapid multiplication of sewage bacteria, the disease producing bacteria which grow best at the temperature of the body, will be overgrown and 7361 perish, so that by the time the sewage bacteria and organic material has disappeared, the purification of the river or lake, of pathogenic bacteria, must be most complete.

Q. As a bacteriologist, what is your opinion as to the kinds of bacteria that have short vitality or longevity?

A. Pathogenic or non-pathogenic?

Q. Pathogenic.

A. That depends altogether upon the conditions and circumstances. The average germ can live under favorable conditions for weeks, but under unfavorable conditions it may die in a few days. That depends entirely upon the surrounding conditions and competition by other bacteria present.

Q. Assuming the conditions that ordinarily prevail in the Chicago drainage canal and the Illinois river, what would you say as to the relative longevity of the bacteria found therein?

MR. JEFFRIES: I object to the question for the reason that the witness has not made a sufficient number of examinations of the water of the Illinois river and the canal to testify on the subject and for the further reasons that his examinations have been made in water where pathogenic and non-pathogenic germs were prisoners, and not in their natural condition, and the

witness has not stated that the same operations bacteri-
7362 ologically take place in the river or streams in which these
examinations were made, as takes place in the bottles or receptacles, and therefore, any statement made by the witness on this proposition is incompetent, irrelevant and immaterial and has no bearing on this case, his experience going solely to the examination of the water for bacteria in the laboratory and not with reference to any observations of any stream, nor sanitary conditions of any streams.

Q. JUDGE SPRINGER: I desire to suggest in reference to this objection, that all of the examinations, with few exceptions, that have been introduced in evidence by the complainant and defendants were laboratory analyses or examinations.

MR. TODD: With the exception of the prodigiosus.

Q. (Question repeated.)

MR. JEFFRIES: I object to the question for the further reason that the witness has not stated or has not shown that he is acquainted with the conditions that existed in the Illinois river or canal; that he is not acquainted with the volume of water discharged into the Illinois river by means of the canal or into the Chicago river, and that he is not acquainted with the extent or amount of the pollution of the water that flows through the
Chicago river and canal, the Desplaines, and into the
7363 Illinois river, and therefore is incompetent to testify upon
that subject.

Q. JUDGE SPRINGER: Have you ever made any personal examinations or observations of the waters in the Chicago drainage canal and the Illinois river?

A. I have.

Q. State what they were?

A. I have been all over the territory from here to St. Louis.

Q. On the water?

A. And have seen the water and formed some opinions on this subject.

Q. How recently have you traveled over this region?

A. I have recently, about two weeks ago, something like that, gone over this whole region.

Q. Did you have occasion to observe the conditions that prevailed in these streams?

A. I did.

MR. JEFFRIES: I renew my objection to the question after the last statement of the witness, for the reason that he has stated that the question about which he is asked, depends upon the state of dilution, and that the witness has not obtained sufficient information as to the exact amount of water flowing through the drainage canal, the Desplaines river and down the Illinois river, nor has he been directed to con-
7364 sider the figures as to the amount of sewage pollution and other polluting matter entering the Chicago river, drainage canal and the Desplaines river, and that unless the witness has obtained these facts and was acquainted with them at the time of his ocular observation, any statement that he may make upon the subject is incompetent, irrelevant and of no probative force, and therefore illegal.

Q. Assuming the conditions that ordinarily prevail in the Chicago drainage canal, in the Illinois river, what would you say as to the relative longevity of the bacteria found therein?

A. I would like to separate those two a little, that is the drainage canal proper and the Illinois river. I think that in the drainage canal the growth and multiplication of immense numbers of saprophytes, due to the presence of a large quantity of organic material, is unfavorable to the life, the multiplication, or even the existence of disease producing bacteria. I believe that in the drainage canal the conditions must be such that they are gradually wiped out, whereas, in the Illinois river, the saprophytes are less numerous, and any disease producing bacteria that would enter the Illinois river, would be tremendously diluted, but they could probably exist longer in the Illinois river than they could in the drainage canal. Any disease producing bacteria that would get into the Illinois river could, on ac-
7365 count of the absence or the decrease in the number of saprophytic bacteria, live longer. The question could be answered by saying that in the drainage canal the existence or multiplication of pathogenic, disease-producing bacteria would be made impossible, and that they would disappear in such a sewage tank during the overgrowth of saprophytes.

Q. In how long a time?

A. The time, of course, would depend also upon the resistence of the organism, but under the conditions of my laboratory experiments, I would judge that a week ought to be sufficient to wipe out all the cholera vibrio, staphylococci and typhoid bacillus.

Adjourned until 2:00 p. m., the same day, Friday, October 2nd, 1903.

7366 2:00 p. m., Friday, October 2, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. F. ROBERT ZEIT,

resumed the stand for further direct-examination, by Judge Springer, and testified as follows:

Q. Professor, I call your attention to a pamphlet entitled "Illinois State Board of Health, Advance Sheets of Report of Sanitary Investigations of the Illinois, Mississippi and Missouri Rivers, 1902." Professor Long, in the testimony which he submitted in this case, stated that you had made some bacteriological examinations of the waters at the mouth of the Illinois river at Grafton, and at the mouth of the Mississippi river above the mouth of the Illinois river, and of the waters of the Missouri river above its confluence with the Mississippi. Please state whether the tables found in that pamphlet beginning on page 21 and ending on page 23, were prepared by you from samples of water furnished to you by Professor Long at the times stated in those tables?

MR. JEFFRIES: Now, we object to that part of the question which calls the witness' attention to the fact that 7367 Professor Long had testified to certain things. We object to the witness testifying from the pamphlet which he now has before him, and to which his attention has been called, by counsel, as being a certain pamphlet containing a preliminary report or advance sheet report of the Board of Health of the State of Illinois, for the reason that the original tables upon which the analyses of the water made by this witness were recorded, are the best evidence, and for the reason that such original tables are not before the Commissioner, and this witness, so as to give counsel an opportunity to cross-examine the witness as to the correctness of said tables, and that the table to which the witness has been referred is not the best evidence, and for the further reason that the samples so examined by this witness at the places mentioned here are so few in number that no opinion or conclusion as to the bacterial condition of the water in the rivers examined can be made, and no conditions obtained that would be reliable or trustworthy.

Q. (Question repeated).

A. They were.

Q. Please state when these investigations were made?

A. They were made between October 3rd, 1901, and March 11th, 1902.

7368 Q. Where were they made?

A. At my laboratory, Northwestern University Medical School.

Q. In what condition did you receive the waters in those samples at your laboratory?

A. Four ounce glass stoppered bottles, covered with rubber sheeting and tied with rubber strings.

Q. How were they sent to you?

A. They were sent to me in that form, immediately after they had been removed from the ice packed cases or boxes.

Q. How did they come to this city?

A. They came here ice-packed, as much as I know from those samples which I saw arrive at the college, some of them. I have not seen all of them arrive.

Q. They came by express, I presume?

A. By express, yes.

Q. They delivered them to your laboratory?

A. Delivered them at Professor Long's laboratory, and we got them from there.

Q. Are those laboratories near each other?

A. Yes, sir, they are. He is on the floor above me.

Q. Yes, the same building?

A. Yes.

7369 Q. So that when these samples came to Professor Long, the smaller bottles were delivered to you?

A. Were delivered to me.

Q. State how long after delivery to you was it, that you made your bacteriological examinations of the waters contained in them?

A. We plated out these waters always immediately upon receipt from Professor Long, and also after plating them out on gelatin and agar, we took the whole bottle—our technique differed somewhat here from that employed in the older examination. We took the whole bottle of water that was left and added to it nutritive bouillon and placed the whole bottle of water into the incubator, and then, 24 hours afterwards injected guinea pigs with one cubic centimeter of this water that had been kept in the incubator, intraperitoneally. The object was to remove the possible doubt of using too small a quantity of water in the growing of pathogenic bacteria, by using the whole bottle, adding nutritive bouillon to it, and then putting the whole bottle into the incubator. That favored the growth and multiplication of the pathogenic bacteria, and would thus enrich the water in any pathogenic bacteria that were present in the bottle
instead of only using one cubic centimeter from this bottle
7370 and cultivating that as we had done before.

Q. In other words, you favored the best opportunity for obtaining the greatest number?

A. We used all the water and made cultures from it, and the high incubator temperature was supposed to favor the growth and multiplication of disease producing bacteria and hold back the water bacteria.

Q. How many examinations of these waters were made by you and from what points?

A. We examined thirty-eight specimens of water from the Illinois river.

Q. At Grafton?

A. At Grafton. We examined 37 samples or specimens of water from the Mississippi river,—the mouth of the Mississippi river—

Q. You don't mean the mouth of the Mississippi river?

A. I do not know the exact place of collection of these waters.

Q. I mean you don't mean the mouth of the Mississippi river. That is at New Orleans, or below New Orleans.

A. No.

Q. You mean at the confluence of the Illinois with the Mississippi?

A. Yes. I am thinking so much now of the Illinois river, I make the usual mistake.

Q. Locate that place, the last place on the Mississippi 7371 river.

A. I don't know the place of collection on the Mississippi river.

Q. Where did the sample purport to come from?

A. The sample purported to be from some distance up the Mississippi river, before the Illinois river joined it.

MR. JEFFRIES: We move to strike out what the witness says with reference to what the sample purports to be, or from what point it purported to have been taken, and we object to the witness testifying further upon this proposition for the reason that he does not know the particular place in the river these samples came from and for the further reason that there is no evidence showing that these particular samples which he examined, were the identical samples that were collected from the various rivers, and at the various places, and sent to Professor Long, and there is no evidence showing that these samples were not collected at some other times and by other collectors than those who made the collections for Professor Long as shown in the evidence, and we object, therefore, to the witness further testifying upon this proposition, for the reason that the samples that he examined have not been properly indentified in evidence by this witness.

JUDGE SPRINGER: I submit that this witness is not 7372 called to identify them so far as the taking of the samples from the rivers is concerned. That Professor Long has stated in his testimony heretofore submitted in this case,—where these samples were obtained and the conditions under which they were obtained, and that is the evidence upon which we predicate the statements that are now going into the record.

MR. JEFFRIES: I submit that the witness has stated that he did not know from what particular points they came, and that in view of that fact, and not having followed the samples coming into Professor Long's hands, and from him to this witness, the testimony of this witness based upon those facts is incompetent.

Q. JUDGE SPRINGER: What means do you have of knowing the places from which these samples came?

A. The number of the specimen,—the fact that these specimens arrived by express in Professor Long's office; that he examined them chemically—the larger bottles, and that I received the smaller bottles which came in the same package, as his specimens did, convinced me that we evidently received the water from the same source.

MR. JEFFRIES: I still object to the testimony for the reason that the witness has not properly identified these samples, he being in this business, examining samples of water 7373 from day to day and from various sources; that there is no evidence showing that the samples concerning which he is now testifying were those that were collected in the manner testified to by Professor Long, and by the water carriers down the river, and at the places testified, and that the evidence taken heretofore shows that this witness has no information as to the exact place in the river where the samples were taken.

Q. JUDGE SPRINGER: State what information you obtained at the time you got these bottles, and as to the place from which they came, and from whom you obtained them?

A. In the first place I was not in charge of this water examination. Professor Long was in charge of the water examination and he asked me to do the bacteriological work for him, so, if there is to be any identification of specimens he ought to be the one to identify them. He is the one responsible for this water examination, and I simply did this bacteriological work for him.

Q. What numbers, if any, were upon the labels accompanying each bottle, and what did you do in regard to those numbers?

A. I took down the numbers which I found on those bottles, and which you will find in this report as to the bacteriological findings, and also the dates,—the dates and the numbers both were always given to me by Professor Long with the bottle.

7374 Q. Now, how many of these samples did you receive from the Missouri river, and from what point in the river?

A. I received thirty-six water specimens from the Missouri river, which were marked with the date and the number given in this report.

Q. Was there anything else on the bottle that indicated the place from which it came?

A. It did not always say from what river,—whether it came from the Mississippi or the Missouri or the Illinois, so very frequently we had nothing but the date and the number. We didn't even know whether it was the Missouri river or the Mississippi river, but after the completion of our work I obtained a list of the places by the number and date of the specimens examined and received from Professor Long. All of the specimens were numbered so we could easily refer to his record as to where they came from.

Q. Then at the time you made the bacterial examinations, you did not know whether it was Illinois river or Mississippi river or Missouri river water?

A. That was very frequently the case; we didn't know.

Q. State whether you tabulated the results of your examination in regard to each of these specimens?

A. I did, and when we were through with our investigation I had to assort all of these numbers according to Professor
7375 Long's record, to tabulate them under these headings: Illinois river, Mississippi river, Missouri river, because I had only findings of numbers, and only here and there as to what river it was.

MR. JEFFRIES: I move to strike out all that the witness has said with reference to the findings by the numbers, for the reason that he has not shown himself familiar with the manner in which the samples were collected; and the numbers, and with reference to whether it was serial numbers commencing with "1," covering all the rivers, or whether each river was numbered separately, by itself.

Q. JUDGE SPRINGER: State whether the tables found on pages 21, 22 and 23 of the pamphlet called "Advance Sheets," are those prepared by you at that time?

A. Yes.

MR. JEFFRIES: We object to the witness answering the question for the reasons that the original tables are the best evidence.

A. They are, I have them here.

Q. Bring them in.

A. I find I am mistaken, but I can have them here tomorrow. I still have them. Also in regard to the other water examinations if it is desired to have them. I have the original tables.

7376 Q. Did you prepare these tables from the originals in your office that you made yourself?

A. I did.

Q. Do the tables printed on pages 21, 22 and 23 of the "Advance Sheets," to which your attention has been called, contain a correct statement and a true statement of the results of your examinations of the waters indicated?

MR. JEFFRIES: Now, I object to the question for the reason that the witness says he has the original tables, and certainly under all rules of evidence, original tables are the best evidence, and that the witness should not be permitted to testify except from those original tables so long as they are in his possession.

JUDGE SPRINGER: I will get them here.

A. They do.

Q. Have you the original tables from which these were printed in your possession?

A. I have.

MR. TODD: I submit that original tables made by the witness are not original evidence in themselves, but a true and correct copy which correctly states the results of his analyses and sworn to by him, becomes original evidence, and competent in the case, even in the absence of any original memoranda 7377 which he may have made, so long as the tables which he swears to are true and correct tables of the results of his analyses.

MR. JEFFRIES: In response to counsel's statement, that the copy is evidence, I suggest that when the witness says he has the original tables in his possession, and without some showing being made as to inability to produce them, that counsel for complainant have the right to their production, in order that cross-examination may be based thereon, and I suggest also as this witness has stated that he did not know that the pamphlet which he now holds before him had been published, and not having seen the pamphlet until now, he cannot state that it is an exact copy of the original.

MR. TODD: In reply I will state that the original copies will be furnished to counsel before he begins his cross-examination of the witness, if he so elects, and will be offered in evidence if he requires it or requests it.

JUDGE SPRINGER: I was just about to state that we would put the originals in evidence, but if the counsel prefers the manuscript copy he can have it.

MR. JEFFRIES: I want to see the original when I can. I don't know whether I want to use them or not, but I would like to look at them.

JUDGE SPRINGER: I will furnish counsel for complainant tomorrow morning, with the original papers made by
7378 this witness, and he can have the benefit of those in the
cross-examination of this witness, and that in so far as there is any variation between the printed copy, if any should appear,—and the original, that the original copy be the evidence of the fact, and the table corrected accordingly.

MR. JEFFRIES: That is satisfactory so far as the tables themselves are concerned, but as to the competency of this witness and the conclusions he might make from these tables, I make no such arrangement.

MR. TODD: I would like to state right at this point, Mr. Jeffries, I am going to use printed copies of all my tables that have been compared by the witnesses who made the original tables. Now, if you want the original tables, why, I will get them here, and all other witnesses.

MR. JEFFRIES: I don't care about introducing the original tables.

MR. TODD: I will get copies of the printed tables, and they will be sworn to as being correct tables, and if you want the originals I will have them brought in. I don't mean this witness alone, but the others.

MR. JEFFRIES: I would like to have them brought in subject to our investigation, to look at them, just the same as
we did for you. Introduce them as exhibits for identifi-
7379 cation and you can withdraw them afterwards.

MR. TODD: These printed copies to be offered in evidence, and the originals will be submitted to counsel for his inspection, and if the objection is made that the original should be introduced in lieu of the printed ones, we will then introduce the originals in evidence.

JUDGE SPRINGER: Then under that statement we offer these now, and they can be printed afterwards. Let the first table be numbered Table No. 1, 1901-1902.

Q. Now, I will ask the witness to read Table No. 1 of the investigation of 1901-1902.

A. The table is as follows:

7380 No. 1.

38 Water Specimens from Illinois River.

Date of Collection	Number	Bac. Coli Communis	Proteus Vulgaris	Bac. Mycoides	Bac. Mesentericus	Bac. Megatorium	Bac. Subtilis	Bac. Liquidus	Bac. Enteritidis	Mic. Candicans	Other Micro-Organisms
1901 Oct. 3	639			+						+	
" 8	643			+	+		+				Bac. striatus flavus
" 10	646			+	+		+				
" 14	649				+			+			
" 15	653	+				+	+				Mic. luteus
" 17	656										Bac. aurantiacus
" 21	659	+									Bac. aurantiacus
" 22	662	+	+			+	+	+	+		
" 28	667	+	+								Bac. acidi lactici
" 29	670	+	+			+	+	+			
" 31	674	+					+				
Nov. 4	677	+		+	+						
" 5	680						+				
" 11	688		Sterile								
" 12	691		Sterile								
" 14	695			+							Streptothrix
" 18	699	+		+							
" 21	706		Sterile								
" 25	710					+	+				
" 26	713		Sterile								
" 30	716		Sterile								
Dec. 1	720				+		+				
" 2	723					+					
" 3	725	+		+							
" 5	728				+		+				
" 6	731		Sterile								
" 9	733		Sterile								
" 10	734	+		+			+				
" 11	740			+							
" 12	743				+						Mic. luteus
1902 Feb. 24	744	+					+				
" 25	746						+				
" 27	750						+				
Mar. 4	752		+		+		+	+			
" 5	754			+	+						
" 6	756		+		+		+				
" 7	758		+		+	+	+				Aspergillus and Mucor
" 11	760	+									Bac. acidi lactici

7381 MR. JEFFRIES: We object to the reading of the table for the reason that the witness has not properly shown the particular place in the Illinois river where these samples were taken, whether from the mouth of the river, Peoria, La Salle or any other point. The witness from his statement does not know the particular place in the Illinois river where the samples were taken, and inasmuch as the witness has testified in his qualification that he has on various occasions examined the waters of rivers and performed bacteriological experiments in his laboratory, strict proof has not been given by this witness as to the correctness of the samples so set out in these tables, as being those received from Professor Long, and coming from any one particular place in the Illinois river.

JUDGE SPRINGER: I submit that Professor Long has stated with sufficient definiteness the facts concerning the taking of these samples and their delivery to Professor Zeit.

MR. JEFFRIES; I suggest here that there is no evidence showing that all of the 38 specimens of water that are contained in the table offered—this witness has shown no facts which authorize a conclusion or a belief that they came from any one particular place in the Illinois river, or from more than
7382 one place, or that these are the particular samples testified
to by Professor Long as coming from the Illinois river at its mouth at Grafton or at any other point.

Q. JUDGE SPRINGER: Professor, you may state now for the information of counsel again, all the facts which came to your knowledge in regard to the places from which the samples were taken, the examinations of which are set forth in this table?

A. Professor Long asked me if I would do for him the bacteriological work in the way of identification of pathogenic bacteria, and such other non-pathogenic bacteria as could easily be identified, such as water and sewage bacteria, from the water specimens which he would receive regularly from the Illinois river, the Missouri river and the Mississippi river.

Q. At what points?

A. The Illinois river at Grafton, the Missouri above its mouth, and the Mississippi some distance above the mouth of the Illinois. So when the examination was begun, the specimens were received by him. They were properly labeled with the date and with the number, and he turned them over with this date and number, to me. I knew that they were water specimens from one of those three places, and I simply identified them by the number that he gave them afterwards. These 7383 numbers that are in this report from 639 are *his* numbers, in his record book. He enters them and he receives them by the express company immediately upon its receipt, and with this number they are turned over to me, and when I report to him I report to him by the same number.

Q. Then the numbers in the first column after the dates?

A. Are Professor Long's numbers.

Q. And they were on each of those bottles?

A. They were on each of those bottles.

Q. And from those numbers?

A. The examination was always made and the report made upon that number of the specimen, and only at the end of our investigation when it was necessary to tabulate our findings did we have to go over these numbers and put all those together which came from the same place, and in that way these tables have resulted.

Q. Then from what you learned at the time, will you state whether the table which has just been put in evidence, the 38 water specimens from the Illinois river, was made from specimens of water taken from the Illinois river at its mouth, or at Grafton, above its mouth?

A. They were.

7384 Q. About how long after the dates here given of collection was it until you received the specimen and made your bacteriological examination thereof?

A. When the specimens were received, I don't know how long they had been on the way when they were received by Professor Long, but he immediately turned them over, when they arrived, to me.

Q. How long after that was it until you made your determinations?

A. Immediately. We plated out the water immediately and then added bouillon, and placing it in the incubator until the next day and then inoculated guinea pigs the next day.

Q. Professor, I see in this table, over the head line, "Bacillus coli communis," a certain mark,—a cross. Please explain what that cross means at the point indicated here where it occurs?

A. The cross means that that particular organism was found in the specimen of water whose number appears in the second column.

Q. And at what time was the collection taken?

A. The date given here represents the date that we received the specimen.

Q. October 15th?

A. Yes, sir.

7385 Q. State whether that is true in regard to the other crosses which appear in that table?

A. It is.

Q. Do those crosses indicate all the times at which the bacteria mentioned in the head lines were found in that specimen at that time?

A. No. The cross indicates not the time, but the fact that that particular organism was found in that specimen of water,—not the times it was found in that number, but that the germ was present in that particular specimen of water.

Q. And where there is no cross indicated, what are we to understand from the fact that there is a blank?

A. When there is a blank, the organism was not found in that specimen of water.

Q. Now, when do the times of collection on that column begin and end in this table?

A. It begins October 5th, 1901, and ends March 11th, 1902.

Q. State what is the significance of the wide column in the table, under the head of "Other Micro-organisms?"

A. Those were organisms which were but rarely found, and which received no special column therefor.

Q. Now, I call your attention to the table printed on page 22, which will be numbered Table No. 2, 1901-1902, of 37 7386 water specimens from the Mississippi river, and I will ask you to read that table?

A. Thirty-seven specimens from the Mississippi river, the examinations were begun October 8th, 1901, up to March 11th, 1902, and the table is as follows:

7387 No. 2.

37. *Water Specimens from Mississippi River.*

Date of Collection	Number	Bac. Coli Communis	Proteus Vulgaris	Bac. Mycoides	Bac. Mesentericus	Bac. Mergaterium	Bac. Subtilis	Bac. Liquidis	Bac. Enteritidis	Mic. Candicans	Other Micro-Organisms
1901											
Oct. 8	642		+		+		+				Steptothrix
" 10	645				+		+				Sarc. aurantiaca
" 13	638			+							
" 14	648					+	+				
" 15	651	+		+		+					
" 17	655	+			+			+	+		
" 21	658				+						
" 22	661			+							
" 28	666	+		+			+				
" 29	669			+		+					
" 31	673	+	×	+						+	
Nov. 4	676				+						
" 5	679	+				+	+				
" 11	687			+		+	+				
" 12	690			+			+				
" 14	694			+	+		+				Bac. aurantiacus
" 18	698				+						
" 21	705			+							
" 25	709					+	+				
" 26	712			+	+						
" 28	716			+	+						
" 29	719	+	+		+		+			+	
Dec. 2	722		+		+						
" 5	727	+		+	+		+		+		
" 6	730	+		+		+		+			
" 9	732	+			+	+					
" 10	736	+			+						
" 12	742				+						
1902											
Feb. 24	745	+			+	+		+	+		
" 25	747	+			+						
" 26	749	+		+			+				
" 27	751	+			+			+			
Mar. 3	753	+			+		+				Sarc. lutea
" 5	755	+	+				+			+	
" 6	757	+	+			+	+	+			
" 7	759	+	+			+				+	
" 11	761	+						+			Aspergillus and oidium.

7388 Q. Now then, please state what is to be understood by the crosses that appear in this table at many places?

A. The crosses indicate that the organism indicated at the top of the column, was found in that particular specimen of water. The absence of the crosses means that that particular germ was not found in that specimen of water.

Q. State whether the numbers in the second column after the dates there, represent the numbers upon the bottles which you examined?

A. Yes sir, they are Professor Long's numbers of identification.

Q. State whether these marks or crosses and their absence, indicate the results of all the examinations made of those waters?

A. From the Mississippi river?

Q. Yes, from the Mississippi river?

A. Yes sir.

Q. Above the mouth of the Illinois river?

A. Yes sir.

Q. I call your attention to page 23, which will be called table No. 3, 1901-1902, of 36 water specimens from the Missouri river. Will you read that table?

A. Thirty-six water specimens from the Missouri river which were examined between Oct. 10, 1901 and March 11, 1902, and the table is as follows:

7389

No. 3.

36 *Water Specimens from Missouri River.*

Date of Collection...	Number	Bac. Coli Communis	Proteus Vulgaris...	Bac. Mycoides......	Bac. Mesentericus..	Bac. Megaterium...	Bac. Subtilis...	Bac. Liquidus......	Bac. Enteritidis....	Mic. Candicans.....	Other Micro-organisms.
1901. Oct. 10	644	......	..	......	......	+	+	......	......	+	Bac. albus putidus; streptothrix...
" 14	647	+	..	......	+	+	+	......	......	....	Bac. albus putidus; sarc. aurantiaca
" 15	650	......	..	......	+	......	+	......	......	......	....
" 16	653	+	+	+	+	......	......	......	+	+	M. flavus liquefaciens..............
" 21	657	+	+	+	+	......	......	......	......	+	Bac. acidi lactici.................
" 23	663	+	..	+	......	......	+	......	......	......	Mucor..........................
" 24	664	+	..	......	......	......	+	......	......	......	Micr. luteus.....................
" 28	665	+	+	+	+	......	......	+	......	+	B. acidi lactici;..................
" 29	668	+	..	......	+	+	......	......	......	....	Sarc. aurantiaca..................
" 30	671	+	+	......	......	......	......	......	......	......	....
" 31	672	+	..	+	......	+	......	......	......	......	....
Nov. 4	675	+	+	....	+	......	+	......	+	+	....
" 5	678	......	..	......	+	......	......	......	......	......	....
" 6	681	+	+	+	......	+	......	......	......	+	....
" 7	682	......	..	......	......	......	......	......	......	......	Mucor..........................
" 8	685	+	+	......	....	......	......	......	......	....	....
" 11	686	......	..	+	......	......	+	......	......	......	....
" 12	689	......	..	......	+	+	......	......	......	......	....
" 13	692	+	..	......	......	......	+	......	......	......	Bac. albus putidus................
" 14	693	+	+	......	......	......	......	......	......	......	Aspergillus......................
" 15	696	......	..	+	......	+	+	......	......	......	....
" 18	697	+	..	......	+	......	......	......	......	......	....
" 21	704	+	+	+	......	+	......	......	+	+	Bac. acidi lactici; oidium..........
" 22	707	......	+	......	+	......	......	......	......	......	....
" 25	708	+	..	......	......	......	......	......	......	......	Bac. striatus flavus...............
" 26	711	+	+	......	......	......	......	......	......	......	....
" 28	715	+	+	......	......	......	......	......	......	......	....
" 29	718	+	+	......	+	......	......	......	......	......	....
Dec. 2	721	......	+	......	......	......	......	......	......	......	....
" 3	724	......	+	......	......	......	......	......	......	......	....
" 5	726	+	+	+	......	+	......	......	......	......	....
" 6	729	+	+	+	+	......	+	......	+	+	B. acidi lactici..................
" 9	734	+	+	......	+	......	+	......	......	+	....
" 11	738	+	+	......	......	......	+	......	......	+	....
" 12	741	+	+	......	......	......	......	......	......	......	....
1902. Mar. 11	762	+	+	+	......	......	+	......	......	+	Aspergillus, mucor, oidium.......

7390 Q. State whether the crosses which are seen here in this table have the same significance that the crosses do in the other tables to which you have referred?

A. They do.

Q. And their absence also?

A. And their absence also.

Q. State whether the numbers in the second column after the dates there, represent the numbers on the bottles containing the samples of water which you examined?

A. They do. They are Professor Long's numbers for identification.

MR. JEFFRIES: I move to strike out all the tables just introduced in evidence for the reasons stated in the objection to the introduction of the first table.

MR. TODD: Let me understand your objection, Mr. Jeffries. Is this objection to the tables offered, because they are not the originals?

MR. JEFFRIES: No.

MR. TODD: This objection does not go to the tables because they are not the original tables?

MR. JEFFRIES: No, it is understood that this objection does not go to these tables so far as their not being the original tables, provided the original tables be produced tomorrow for the inspection of counsel, and for cross-examination.

7391 Q. JUDGE SPRINGER: In your testimony today in reference to your examinations of waters of the Illinois river, you stated that the bacterial self-purification of the Illinois river began at Morris, and was practically completed between Henry and Upper Peoria?

A. Yes sir.

Q. Now state whether the results of the examinations to which you have just testified, strengthen or weaken those conclusions in regard to the water at Grafton?

MR. JEFFRIES: Now the first question and answer which is asked, I move to strike out, because the question is leading, and because it is a repetition and not proper direct-examination. The last question I object to for the reason that it is leading and argumentative, and for the further reason that the witness has already given testimony upon that proposition, and that whatever further conclusions may be drawn from these facts are argumentative upon the part of the witness, as well as upon the part of counsel in propounding the question. I object to the question as decidedly leading and suggestive and argumentative.

(Question and answer read).

MR. JEFFRIES: I suggest that it is not a proper question to ask the witness on direct-examination based upon 7392 the analyses he has given, and I object for the further reason that counsel has no right to assume that it would have any effect either one way or the other, or has no right to assume that any conclusions are to be drawn from the analyses of the water made by him of the Illinois river above Grafton.

JUDGE SPRINGER: I desire to assure counsel of my earnest desire to comply with his wishes, but I do not see how I can do it and get anything into this record.

Q. Now you may answer the question,—the latter question.

(Last question read).

MR. JEFFRIES: I object to the question for the reasons stated and I object to this witness giving any conclusions upon the bacteriological condition of the water in the Illinois river.

A. Bacteriologically I do not see any reason for changing the opinion expressed, that bacterial purification has taken place in the Illinois river long before the water reaches Grafton.

Q. What efforts did you make in these examinations for the purposes of the identification of pathogenic bacteria and for the purposes of determining the virulence of such bacteria?

MR. JEFFRIES: I object to the question for the reason that the witness has already stated in all of these exam- 7393 inations that he made no effort to discover the typhoid bacillus, which is one of the most important of the pathogenic germs found in running water and existing in running water. I submit that he has stated several times that he has made no efforts to find the bacillus typhosus.

MR. JEFFRIES: Repeat that question.

Q. (Question repeated).

MR. JEFFRIES: I object to the question for the further reason that the witness testified this forenoon that on account of the extreme pollution or diluting effect of river water in which pathogenic germs are discharged, and on account of the very small quantity of water examined in comparison with the entire volume of stream flow, that any observations that he may have made in this direction constitute no evidence and no reliance could be placed upon any conclusions that may be arrived at by him from the analyses made.

JUDGE SPRINGER: Answer the question.

A. I have plated out the suspected water and obtained pure colonies of the various organisms found, passed them through the usual cultures in order to identify them, and immediately after plating out, I have added to the suspected water enough bouillon, nutritive bouillon, to the four ounce bottle of the specimen of water to favor the growth of the bacteria therein, and incubated the whole bottle for 24 hours at 37 de-
7394 grees centigrade. After this time I injected one cubic
centimeter of this water, enriched in pathogenic or disease-producing bacteria, intraperitoneally, into Guinea pigs. When the animal died a complete bacteriological examination was held and the cause of death determined. Cultures were made from all the organs of the animal, particularly the blood, the spleen and the lymph glands and the contents of the abdominal cavity.

Q. How much water or how many cubic centimeters of water were actually charged with the bouillon for the purpose of obtaining these results?

A. 120 cubic centimeters usually.

Q. Of each sample?

A. Of each sample, that is four ounces.

Q. At each of the three places?

A. Of every water specimen, consisting of four ounces in a bottle, that is 120 cubic centimeters, and it was this that I incubated.

Q. You incubated the whole bottle?

A. Yes, I incubated the whole bottle. We also, in a number of instances, plated out afterwards this water, after it had been in the incubator for 24 hours. In fact we made a number of side experiments in order to arrive at a more cer-
7395 tain diagnosis of the pathogenic bacteria found there. We
also tried more modern means of precipitating typhoid

bacilli by agglutination, if there should be any and then enriching the water, using the serum of an immunized rabbit to agglutinate the typhoid bacilli, but these efforts to detect typhoid bacilli proved entirely unsuccessful and we dropped that again. In fact we never produced any precipitation, so we gave it up.

Q. Professor, if there had been one typhoid bacillus in one of these bottles, what would have been the effect of the cultures, the bouillon culture which you placed in the bottle in reproducing that bacillus into sufficient quantities to indicate the greater number per cubic centimeter?

A. There would have been millions of typhoid bacilli in 24 hours in this water in the incubator. In fact we have done that. We have taken some water specimens, other water specimens, not from these sources, and we have added minute quantities of typhoid bacilli to the water in the regular laboratory courses, and after incubating them for 24 hours, had them plated out and the colonies and cultures that looked like typhoid colonies were run through and tested as to whether they were typhoid bacilli. So, according to this method it seemed to me we were able yet to find typhoid bacilli even if there was one C. C. of bouillon culture to a million liters of water.

7396 Q. Please make that explanation a little clearer if you can professor, for the benefit of counsel?

A. If you take two milligrams of a suspension of a typhoid culture in sterile water and add it to a liter of common drinking water and keep the latter in an incubator for 24 hours, at a temperature of 37° C. you would enrich the typhoid bacilli and keep back the multiplication of the common water bacteria to such an extent that afterwards when you plated it out, after 24 hours, you find numerous colonies of typhoid bacilli, whereas at a low temperature that wouldn't take place because the water bacteria would overgrow the typhoid bacilli.

Q. What temperature did you use?

A. 37° C. blood temperature.

Q. That would be 98 Fahrenheit?

A. Yes sir. They would, even at this temperature of 37 C. after a while become less and less, but the first few days there would be a rapid multiplication at 37 centigrade, when some bouillon has been added to the suspected water.

Q. Now I understand you to say that if there had been one bacillus of typhoid fever in any one of these bottles, that in the whole contents of the bottle, you would have ascertained its presence by this method?

A. I would have thereby increased the number of typhoid bacilli to such an extent that they could easily be found.

7397 Q. So that the quantity you actually examined, the quantity of water you actually examined was enriched by culture of what might have been in the original if it had been there?

A. I inoculated the water with a known quantity, a very small quantity, and yet was able to find them afterwards by this enriching process. I want to add here that if such water was badly polluted with colon bacilli, the difficulty of finding them would be very great, and we would sometimes find it impossible to separate them because the colon bacilli would grow so much more rapidly than the typhoid bacilli, but in the average water specimen, such as we tried, we had no difficulty in finding colonies of typhoid bacilli in the regular laboratory experiments done by the students in their regular course of instruction.

Q. Then I understand you to say that if there had been in all the specimens examined by you, one bacillus typhosus that your experiments were sufficient to have demonstrated this fact?

A. I am of the opinion, that by this enriching process I should have succeeded in finding colonies of typhoid bacilli if one bacillus had been present in the water, although I, of course, repeat again that difficulties may arise in some specimens containing great numbers of colon bacilli.

7398 Q. Now you may state whether you in any of these investigations found the presence of the bacillus typhosus?

A. I did not. I found a number of other pathogenic bacteria.

Q. What were they?

A. The colon bacilli in the Illinois 13 times; in the Mississippi 19 times; in the Missouri 26 times.

Proteus Vulgaris,	
Illinois river,	6
Mississippi river,	7
Missouri river,	21

Bac. mycoides.	
Illinois river,	11
Mississippi river,	15
Missouri river,	12
Bac. Mesentericus,	
Illinois river,	11
Mississippi river,	19
Missouri river,	14
Bac. Megeterium,	
Illinois river,	6
Mississippi river,	11
Missouri river,	9
7399 Bac. subtilis,	
Illinois river,	17
Mississippi river,	15
Missouri river.	13
Bac. liquidus,	
Illinois river,	4
Mississippi river,	6
Missouri river,	2
Bac. enteritidis,	
Illinois river,	1
Mississippi river,	3
Missouri river,	4
Bac. acid lactici,	
Illinois river,	2
Mississippi river,	0
Missouri river,	4
Mic. candicans,	
Illinois river,	1
Mississippi river,	4
Missouri river,	11

MR. JEFFRIES: The same objection is made to the introduction of this table and to these statements, as was made to the
introduction of the tables of analyses offered by this wit-
7400 ness of the water taken from the Illinois river, the Mis-
sissippi river and the Missouri river.

Q. You may state whether during the spring of 1902 any other specimens were found?

A. During the spring we found great numbers of moulds, numerous spores of moulds, such as mucor, aspergillus, and oidium types in great numbers.

Q. Do the presence of these species of bacteria have any special signification, and if so, what?

A. I think they were mainly found in such great numbers on account of the entrance of surface waters into the river during the early spring.

Q. Do they bring to you any suggestion of sewage pollution?

A. I didn't think so much of sewage pollution then because it was spring and there was heavy precipitation all along the river during the spring and I think it is the common experience in all rivers during some parts of the year, particularly the early spring.—I looked this up at the time and found that it is common to find such an unusual increase of hyhpomycetes, or moulds during the spring in all rivers, also those which are not badly polluted with sewage or anything of that sort.

MR. JEFFRIES: I move to strike out the answer for the reason that the witness has limited his opinion to the spring time, that is, to the conditions existing in the spring time and not to the conditions existing from one end of the year to the 7401 other, witness has eliminated from his opinion and analyses the temperature of the water at the time the samples were taken and at the time the examinations were made, and for the further reason that those examinations do not show that they were made in the same temperature as that contained in the water at the time the samples were taken, so as to correctly describe and exhibit the true bacterial character of the water at that time.

JUDGE SPRINGER: I submit that the tags which were put in evidence in this case for identification contain the data as to the temperature of the air and water at the time each specimen was taken.

MR. JEFFRIES: I suggest that the analyses are not made in the same temperature.

JUDGE SPRINGER: Would the fact that the analyses for the purposes which you have indicated were made at a different temperature of the water affect the result materially of pathogenic bacteria?

A. The specimens we received were ice-packed. There could have been no multiplication of the pathogenic bacteria present. There might have been some growth of the water bacteria there, but there couldn't have been much growth of the sewage bacteria or saprophytic bacteria under those
7402 conditions, so I do not believe there could have been so very much difference.

MR. JEFFRIES: Then from the statement of the witness that there could have been no growth of any importance in the pathogenic bacteria or saprophitic bacteria, the samples being packed in ice, that the analyses of the witness from those samples testified to in this case, do not disclose nor display a correct bacteriological condition of the water in the Illinois river at all periods of the year. And for the further reason that the fact that the low temperature of the water during the time the samples were taken, or the high temperature of the water during the time the samples were taken necessarily mean an increased number or decreased number of pathogenic bacteria, if such bacteria existed in the samples when taken, and therefore a correct display and precipitation of the bacteriological condition of the Illinois river at all times of the year was not disclosed by the samples the witness examined.

JUDGE SPRINGER: Professor, will you state whether there would be any increase of the pathogenic bacteria known as typhoid bacillus, without the increase of temperature to 98 degrees Fahrenheit, and with the presence of bouillon culture?

7403 A. The typhoid bacillus can grow above 24 centigrade.

Q. What is that Fahrenheit?

A. Seventy-five. It grows best at 37 centigrade, that is 98 2-5 Fahrenheit. It multiplies best at blood temperature. It will not multiply below 20 centigrade or 68 Fahrenheit. It will not multiply in the absence of organic material. It will not die by freezing, and it will die at a temperature of 60 in ten minutes, 60 centigrade being equal to 140 Fahrenheit, which is in brief the maximum temperature. It can grow up to 42° C. which is 107 1-2 Fahrenheit, and will grow as low as 20° C. which is 68° Fahrenheit, at times. The optimum or most favorable temperature is 37° C., blood temperature. A typhoid bacillus dies at 140° Fahrenheit in ten minutes. Its most favorable temperature is 98 1-2° Fahrenheit. Its minimum temperature is 22° Centigrade or 71° Fahrenheit, and 107 1-2 Fahrenheit is the maximum.

Q. Will a typhoid bacillus multiply in river water with the aid of bouillon cultures?

A. It will not multiply at all in river water because the temperature is unfavorable.

Q. Then state whether under the conditions in which you received these samples of water, it were possible for there to have been any increase of the typhoid bacillus if there had
7404 been any present in the water, between the time of the packing of the sample and the making of the examination?

A. There would not have been any increase of typhoid bacilli.

Q. Assuming that the dejecta of typhoid fever patients in Chicago were deposited into the sewers of the city and were thence carried into the Chicago drainage canal and that the waters in that canal contained immense numbers of saprophytes and ordinary water bacteria, to the number of 70,000 of them and frequently as many as four million per cubic centimeter and assuming that it required at least 24 hours and as much as 48 hours for the water to pass from the Chicago sewers into the Chicago river and Drainage canal and Beartrap Dam, and assuming that the flow in the Desplaines and Illinois rivers is equal to forty miles in 24 hours. Under the conditions stated and from your own examinations of these waters and from your own experience as a bacteriologist, pathologist and bioligist, would in your opinion, such typhoid bacilli survive as far as Peoria?

MR. JEFFRIES: We object to the question for the reason that the witness has not made a sufficient number of bacteriological examinations of the water in the Chicago drainage canal or the Chicago river or the Desplaines river, and
7405 the Illinois river, to enable him to determine from such examinations, taking into consideration all seasons of the year, flood seasons, hot weather seasons and cold seasons, taking into consideration the time when the river is frozen over with ice and other local conditions, to enable him to express an opinion or form any conclusion as to the disappearance of

pathogenic germs or typhoid germs discharged from the sewers of Chicago into the Chicago river and the drainage canal, and for the further reason that the witness has not been able to determine the exact duration of the life of typhoid germs in a running stream, and for the further reason that the samples of the water taken from the canal are insufficient in number to determine whether or not the dilution is the same at all times, so as to enable him from the absence of all such substances as the witness says may destroy the typhoid germs, to prevent the passage of such germs from Chicago to the point mentioned in the question and for the reason that the witness is not acquainted or has not testified or given any opinion from the amount of sewage pollution entering the drainage canal and mixed with the water from Lake Michigan, and has not testified as to the amount and volume of such water so flowing through the canal at all times of the year, and for the further reason
that the witness has given no evidence and has testified
7406 to no evidence as to velocity of the river from the entrance
of the sewage into the Chicago river and the canal to the point mentioned in the question. That there is nothing in the question assumed, stating the time required for the water to flow from Chicago or the point of the sewage entrance into the canal, to the point designated in this case or designated in the question.

Q. (Question repeated).

MR. JEFFRIES: A further objection is made, that this witness has not qualified as a scientific bacteriological sanitarian and has not qualified as having thoroughly acquainted himself in any scientific way with the effect of sewage discharges in a running stream from a hygienic standpoint, and for these reasons, whatever conclusions the witness may draw will be speculative and imaginary.

MR. TODD: May I ask counsel to define what he means by a scientific, bacteriological sanitarian, as no witness of that character has yet testified in this case to my knowledge, so that it would be possible for defendants to remove the objection if the same is possible.

MR. JEFFRIES: I mean by that that the witness has not qualified as a sanitarian, and not having qualified as a

7407 sanitarian his bacteriological knowledge does not justify the assumption upon the part of counsel for respondents, or upon the part of the witness that he is a sanitarian.

A. In my opinion they would not for the reason that the saprophytic bacteria increase at such a tremendous rate in the drainage canal as to actually overgrow and annihilate any pathogenic or disease producing bacteria.

Q. JUDGE SPRINGER: Professor, knowing as you do the conditions that exist in the waters of the Chicago river, the drainage canal and the Illinois river and the Mississippi and Missouri rivers at their confluence, and taking into consideration the enormous dilution which the sewage passing through the drainage canal receives from Lake Michigan and from other sources on its way to the chain of rocks in the Mississippi river, is it possible in your opinion for typhoid bacilli deposited into a sewer in Chicago which empties into the Chicago river to survive the passage and enter the intake of the St. Louis Waterworks?

A. In my opinion it is not possible that they can reach there. I have stated before that my opinion is based upon the fact that whenever conditions are made favorable for the rapid multiplication of saprophytic bacteria, pathogenic bacteria disappear, and it is my opinion further that the reason why 7408 reputable bacteriologists have been unable to find the typhoid bacillus in the polluted supply of streams or localities where a typhoid epidemic existed, was due to the same cause.

MR. JEFFRIES: I move to strike out the question for the reason stated in my objection to the previous question and I move to strike out the answer because the witness has overlooked the fact that epidemiologists have attributed and it has become a scientific established fact that typhoid germs do pass from the sewers a long distance down the waters of running streams.

MR. TODD: I move to strike out that part of counsel's objection wherein he testified that it was a scientific, established fact that typhoid fever germs passed down stream, and also that part of his statement as to what epidemiologists hold as the defense in this case is not bound by the testimony of any so-called epidemiologist and not bound by any conclusions testified to by any expert calling himself by that title.

JUDGE SPRINGER: Professor, the table which you have read into evidence in this case already, which is found at the top of page 20 of the "Advance Sheets," state what conclusions you draw as a bacteriologist, pathologist and biologist as to the relative bacterial purity of the waters of the respective
7409 streams, at the points indicated in these examinations to which you have testified during the latter part of the year 1901 and the first part of the year 1902?

MR. JEFFRIES: I object to the question for the reason that the qualifications of the witness do not show that he is a competent witness to pass judgment or to form conclusions which would have probative force or be considered as competent testimony and for the reasons mentioned in the objection to the introduction of the table from which the witness is now called upon to base his conclusion, and for the reason that the witness is not a sanitarian.

Q. (Question repeated).

A. In regard to the bacteriologic flora of the three rivers at that time, from the investigations made as a bacteriologist, I would judge that the Missouri was more polluted than either the Mississippi or the Illinois during the periods of these examinations, and that the Mississippi was more polluted than the Illinois at the same time.

MR. JEFFRIES: Now we move to strike out the answer for the reason that the question does not call upon the witness to consider and the witness did not consider the amount of the sewage discharged into the various rivers mentioned or
7410 the population residing upon the water-shed of said rivers.

Q. JUDGE SPRINGER: Would your conclusion which you have just stated which was based on certain bacterial examinations made by you and to which you have testified be changed in any way by a consideration of the question of the amount of sewage that may have been deposited in any of these streams at any points above the places at which you made your investigation?

A. This investigation is entirely independent of any other

data. It is simply to determine, if the water of these three rivers, specimens of which were examined is to be condemned bacteriologically and which of the three is more dangerous than the other two, and I think bacteriologically and qualitatively that can be determined a great deal better in this way than by a great many of the methods that are employed sometimes as the more dependable methods by sanitarians. A physically pure water that contains a great number of pathogenic bacteria is certainly to be condemned. A water may be physically bad and contain a thousand times the number of bacteria that the other water contained and yet it may not contain any pathogenic bacteria. In spite of its apparent bad character physically it need not be condemned. I would be perfectly willing to swallow water, in which I was capable of producing a culture, like I have done here and keep it 24 hours in the incubator and inject it intraperitoneally into the abdominal cavity of a guinea pig, with-
7411 out any effect. After all, the question of determining the safety of drinking water from a river or a lake does not depend upon its physical character and the number of bacteria that may be present, but depends upon the number and kind of pathogenic bacteria present in the water. I testified as a medical bacteriologist, and I believe my opinion in this matter has some cause and some justice.

ADJOURNED until 10:00 A. M., following day, October 3, 1903.

10.00 A. M., Saturday, October 3rd, 1903.
7412 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. F. ROBERT ZEIT,

resumed the stand for further direct examination by Judge Springer and testified as follows:

Q. Professor, in your examination yesterday, you gave the bacterial results of certain examinations of lake water taken from the tap at your laboratory, for the purpose of ascertaining if possible the longevity of the typhoid bacillus. Four examinations were stated by you under different conditions. Will you please state in which of these experiments the conditions in your laboratory conformed most nearly, if at all, with the condition of the waters of the Chicago drainage canal?

MR. JEFFRIES: We object to the question for the reason that the examinations made by this witness of the tap water in the city of Chicago is not such as to make the temperature and condition of lake Michigan water, and the water in the canal comparable.

A. If there is to be any comparison, the only comparison
7413 that could be made, would be to say that the one nearest
conforming to conditions in the canal is of course the one with the lowest temperature. As to a comparison, we could say that the conditions for the disappearance of typhoid bacilli from the waters here were, if anything, more unfavorable than they would be in a water like the drainage canal, which is teeming with saprophytic bacteria. The Lake Michigan water was comparatively pure and therefore the typhoid bacillus had, if anything a better chance to exist there for a longer time than it would have in the drainage canal.

Q. If then in your opinion you had used the water from the drainage canal instead of from Lake Michigan, what would have been the probable longevity of the cultures of typhoid bacillus?

A. I made no experiments as to that, but I should judge that they would disappear sooner yet. The more saprophytic bacteria are present and the more favorable the temperature for these the sooner the disappearance of pathogenic bacteria in general.

Q. You stated, I believe yesterday, that those experiments disclosed a longevity of not exceeding five days, of that class?

A. No, in Lake Michigan water the shortest time was six days.

Q. Six days, yes. Then if the drainage canal water had
7414 been used in your opinion, the time would have been
shorter than this?

A. At least as short.

Q. Please state what relation there is, if any, between bacteriology and sanitation?

A. Well, I believe modern sanitation owes its advances mainly to the advances of bacteriology. Modern epidemiology and sanitary science has been entirely changed, as we have learned to know the etiology of infectious diseases, and their spread, so the modern sanitarian makes a specialty of applying that which we have learned from chemistry and bacteriology, and associated branches in the study of infectious diseases, as well as their prevention.

Q. What advantage if any, have the modern investigations by bacteriologists afforded to sanitation?

MR. JEFFRIES: I object to the question unless the witness qualifies as a sanitarian.

JUDGE SPRINGER: In answer to this objection I will say that the witness has stated that the sanitation receives its principal advantages or instruction from the knowledge of bacteriology.

MR. JEFFRIES: If it is to be so understood, that the witness has so stated, that the principal information of the
7415 sanitarian is derived from bacteriology, I move to strike
out the answer, for the reason that the witness has not qualified as a sanitarian.

JUDGE SPRINGER: Please read his answer.

(Answer read).

MR. JEFFRIES: I stand on my original motion to strike out the answer.

Q. (Last question read).

A. They have studied morphology and biology of bacteria, the etiology of disease, and determined in a great many of the infectious diseases the actual cause of the disease as well as the means of destroying that cause, and the modern bacteriologist bears about the same relation to the sanitarian, as the anatomist and physiologist or the chemist or the pathologist or the bacteriologist bears to the physician. The physician bases his knowledge upon the accumulated achievements of these other branches, and for the physician to deny the achievements of pathology or bacteriology or anatomy or chemistry would have about the same signficance as for the sanitarian to deny the achievements of the science of bacteriology in modern sanitary science. The whole knowledge of disease and the treatment of disease, has been entirely changed since the days of bacteriology,

and we may well say that modern medicine owes its greatest triumphs and advancement to bacteriology. When we know the cause of the disease, we can usually also destroy it or
7416 avoid it, or prevent it, and I think the bacteriologist has the right to claim, that this science has given to the medical man as well as to the sanitarian, the proofs of the factors which cause most of the infectious diseases. That is true in most of the infectious diseases. Not all of them have been determined yet. And I think just as soon as they are discovered by the bacteriologist, that the sanitarian will make use of it, just as he does now of other facts which have been brought out by the bacteriologist, and which he simply applies on a large scale in the prevention of epidemics and the spread of infectious diseases.

Q. You stated yesterday that you had graduated at a medical college?

A. Yes sir.

Q. What year was that?

A. 1887.

Q. About sixteen years ago?

A. Seventeen years ago, yes.

Q. Since that time what effect has the increased knowledge of bacteriology had upon the science of medicine?

A. We have learned to know the causes of many infectious diseases; we have learned to prevent and to cure infectious diseases by the employment of substances which either
7417 destroy the germ itself, or will destroy its poisonous products, as for instance in the case of diphtheria anti-toxin and in the use of tetanus anti-toxins. We have learned that some of the diseases that were supposed to be due to the effluvia of swamps like malaria and so on, are really infections caused by micro-organisms which are carried from man to man by intermediate hosts, such as mosquitoes and the like.

Q. What is the relative longevity, if you know, of the typhoid bacillus as compared with the bacillus prodigiosus?

A. I think the longevity of the two is quite similar.

Q. Which would have the greater longevity in your opinion, under the same conditions?

A. It depends entirely upon the conditions as to the longevity of the micro-organisms, whether it be a typhoid or prodigiosus bacillus.

Q. Assuming that they were in the waters of the Illinois river and the Illinois and Michigan canal?

MR. JEFFRIES: We object to the question unless the witness shows that he has examined and experimented upon the longevity of both germs in the waters of the Illinois river and the canal.

Q. (Question read).

7418 A. The longevity of the prodigiosus should be longer under those conditions than that of the typhoid bacillus, for this reason: The optimum temperature or the most favorable temperature for the bacillus prodigiosus is 25 degrees centigrade—

Q. What is that Fahrenheit?

A. 77 Fahrenheit. The optimum temperature of a typhoid bacillus is blood temperature,—98 Fahrenheit. Therefore the conditions for existence amongst other saprophytes are not more favorable to the prodigiosus than to the typhoid bacillus.

Q. How do you ascertain the presence of the prodigiosus in water?

A. We plate out the suspected water on agar or gelatin. The colonies are red when grown in the temperature of the air, which colonies liquefy gelatin, produce an odor of trimethylamin on potatoes and by microscopic examinations show a small organism about 1 to ½ microns long, and not quite one-half micron thick, which is slightly motile, which is non-pathogenic to animals, which has no spores, which produces no gas and which grows very poorly or not at all on bananas, although it grows very well on all other common culture media. It does not develop its red color when grown at blood temperature, and is then white instead of red. In air it produces a deep, bluish red, rich and glistening colony with sharp borders on 7419 potatoes, where it also produces this odor of trimethylamin most distinctly.

Q. What do you say as to the significance of the red color to which you have referred?

A. The significance of the red color is not so great that by it alone we could distinguish a prodigiosus colony.

Q. If while you are making an examination for the presence of the prodigiosus you should reach that point in your investigations where the red color appeared, and were to stop there, what value would that examination have for determining whether it was prodigiosus or some other bacteria?

A. We could not be certain by the color alone, whether we had a pridigiosus or some other red organism.

Q. Have you ever in any of your bacteriological examinations of the waters of Lake Michigan or the Chicago river or the Illinois river or the drainage canal, discovered the presence of the bacillus prodigiosus?

A. I have not.

Q. Have you discovered the presence of any bacillus which disclosed the red color to which you have referred? 7420

A. I did, in Lake Michigan.

Q. Please state the facts?

A. In Lake Michigan, in the early part of our work in 1900, we ocasionally obtained a few red colonies which appeared to have all the characteristics of a prodigiosus. This organism was different, however, from a prodigiosus, in the fact that it grew very well on sterilized banana slices, and the organism itself was larger than a prodigiosus commonly is, and it occasionally produced some gas. I was unable to find any germ like it described in the literature and I was very much inclined to call it a bacillus prodigiosus. We found this probably four or five times in the waters of Lake Michigan, and we did call it, for lack of a better name, the sealing wax organism because on agar it had the appearance of red sealing wax, whereas on other culture media it looked almost identical with the prodigiosus, also microscopically and morphologicaly it was similar, although larger.

Q. If you had rested your experiments on discovering the red appearance to which you refer, what would have been your conclusions as to whether it was a prodigiosus or not? 7421

A. Oh, I would have called it a prodigiosus. In fact I did at first.

Q. Professor, you stated on yesterday, that the zone of bacterial purification of the waters of the Illinois river had been reached as disclosed in your examinations of that river, at Averyville, just above Peoria. Will you please state what is considered by you and by bacteriologists generally, as the zone of bacterial purification of a river?

A. The zone of bacterial purification is that part of a sewage polluted river, where saprophytic organisms and pathogenic bacteria have disappeared and where the normal bacteriologic flora of the river, before it received such pollution, is again established. In other words, where practically the same bacteria are found or exist that are found in the same river before it receives such pollution. The zone of bacterial purification varies in the different localities and in the different cities that empty their sewage into rivers, in its distance between very short distances, as short as nine miles, and longer distances, to the extent usually of forty miles.

Q. Can you give any examples of other rivers where the zone of purification has been ascertained by bacteriologists?

A. Yes, I can. The river Seine in Paris has 70 kilometers below the city of Paris, after receiving all of the sewage
7422 of Paris, the same bacterial flora practically, having the same number of micro-organisms, that the river Seine had before it entered the city of Paris. This is a distance of 43 miles.

The river Oder at Breslau receives the sewage of the city of Breslau 32 kilometers below the city it has the same number of bacteria again that it had before it entered the city of Breslau.

In the city of Zurich, Switzerland, we have the lake sending out a river, the Limmat. The lake water contains only few bacteria to the cubic centimeter and is considered very pure—200 about, 100 to 200. The river receives all the sewage and the effluent of Zurich, and has again, 33 kilometers below the city, practically the same bacteriological flora as it had before receiving the sewage.

Q. How many miles would that be?

A. I see I made a mistake with regard to the distance. The Limmat had its zone of purification nine miles, or 14 kilometers from the source of pollution. If you care to hear the number of bacteria found at the different places, I have them here.

Q. 33 kilometers is how much?

A. 33 kilometers is the purification zone of the Isar, in Munich. 33 kilometers is about 20 miles.

7423 MR. JEFFRIES: Is that a historical fact that he is stating or is it an actual measurement made by the witness himself?

THE WITNESS: If you wish, I will give you the original communication, the data, so you can look them up yourself.

MR. JEFFRIES: If it is a historical fact I object to its going into the record.

MR. TODD: I submit that it is a scientifically established fact, acknowledged and received by the scientists of Europe as being established, as well as in this country.

MR. JEFFRIES: I suggest that this question of distances is not a scientific proposition.

JUDGE SPRINGER: He is translating kilometers into miles, which is a proper thing to do. It is a mere mathematical calculation.

Q. How many feet are in a kilometer?

A. 100 kilometers is about 62 miles, and it is on that scale that I am figuring out these distances.

Q. Now proceed, professor, if you have any other instances?

A. The Isar at Munich, in a distance of 20 miles, after receiving the sewage of the city of Munich, again—

MR. JEFFRIES: Before the witness reads any further,
7424 I want to know whether these measurements and distances were obtained by the witness himself, or whether they were obtained from some other source, I want to know the source of his information so I will have some grounds for objection if I see proper to object.

A. The Limmat in Zurich, the investigation was made by Schlatter—Zeitschrift fur Hygiene, page 56, volume 190, which is a journal on hygiene. The first I gave you, the River Seine. You will find in Rubner—Hygiene, Berlin.

The Oder you will find—I have not the data of that here, but you will find them also given in Frankland.

The Isar at Munich shows a zone bacterial purification which is complete 33 kilometers below the city of Munich, or twenty miles. This is given in Prausnitz,—Hygiene.

MR. JEFFRIES: When were these data compiled?

A. The Rubner in 1901; the Prausnitz is I think 1900 or 1901. I will bring them here so you can have them.

Q. JUDGE SPRINGER: They are in German, in the German language?

A. Yes sir. The Spree, in Berlin, also receives sewage which then allows the bacteria to raise up to 1,000,000 per cubic
millimeter. Then it goes into the small lake of Havel
7425 and at the exit of that lake, or Sacrow the bacteriological
flora is again the same as it was in the river Spree before it entered the city of Berlin. This is given also in the Zeitschrift fur Hygiene, page 355, volume 3.

Q. Do you know the width of that lake and its length?

A. I do not. It is a small lake, but I do not know its length nor its exact diameter.

Q. In Frankland's Micro-organisms, it is given as seven miles long. This lake is?

A. I should judge that the whole distance traveled was about nine miles, but I am not positive about this distance. I think nine miles would be a fair allowance.

Q. State whether the authors you have mentioned and to which you have referred are recognized authorities upon such subjects?

MR. JEFFRIES: We object to the question as immaterial.

A Rubner is Professor of Hygiene in Berlin. His textbook on hygiene is considered the standard book, and Prausnitz also is one of the standard text books; and the others quoted in the various journals also are considered good men. These determinations have been mainly made under the supervision of the government laboratory. The first work for instance, in Berlin was done by Koch the discoverer of the tubercle bacillus.
Some of these facts were already determined by Koch, be-
7426 fore these later publications which went into the question
much more thoroughly than had ever been done before.

MR. JEFFRIES: Now we move to strike out what the witness says with reference to the books from which he has read, being from standard authors on the subject, for the reason that the authors are not witnesses on the stand and we have no opportunity to cross-examine them.

Q. JUDGE SPRINGER: State whether the instances which you have cited are recognized by bacteriologists as a part of the accepted literature upon this subject.

A. I think this is mainly a question for sanitarians to consider and is not so much a question of pure bacteriology. This is a question of the application of bacteriology to hygiene, and these autherities I have mentioned, would no doubt be recognized by any sanitarian as well as bacteriologists, as competent and reliable.

Q. Returning then to your conclusions in reference to the zone of bacterial purification having been reached at Peoria, state whether the conditions which you took into consideration, and upon which you reach this conclusion are materially different from those existing elsewhere, where a similar conclusion has been reached as to other rivers?

7427 MR. JEFFRIES: We object to the question for the reason that it is ambiguous and misleading, and for the reason that the witness is not confined in his conclusions to personal observations taken by him, and without reference to the observations of others, and if it is intended to cover the observations of others, then we object to it for the reason that such other persons are not before the Commissioner for the purpose of testifying and therefore counsel have no opportunity to cross-examine them, and for the farther reason that any conclusions that the witness might make in this respect would be merely hearsay and of no probative force.

Q. (Last question read).

A. I think the zone of purification here ought to be even nearer to the city of Chicago, than what I have allowed. In fact, I think that the zone of purification is above Upper Peoria. I spoke of it simply there as being bacteriologically complete. I believe that the real zone of bacterial purification, is complete very soon after leaving the drainage canal.

7428 DIRECT-EXAMINATION,

By Mr. Todd.

Q. Professor, the samples of water which you examined or analyzed in both of these investigations you received directly from Professor Long, did you?

A. I did.

Q. Were those samples numbered when you got them from Professor Long?

A. They were numbered.

Q. And your analyses were based on these samples and your tables correctly indicate what the numbers signify and the places from which they were taken?

A. Yes sir. They did not always state as to the places from whence they were taken.

Q. I believe you stated that when the place was not on the sample you went to Professor Long, and with the number secured from him, the location?

A. Yes sir.

MR. JEFFRIES: I object to the question as leading.

Q. MR. TODD: What position does the science of bacteriology occupy in regard to the ascertainments of the purity of water?

7429 A. The bacteriologist can determine whether there are pathogenic bacteria present, whether the normal number of bacteria of a river has increased suddenly, and in that way might indicate a possible danger. He certainly is able to tell in a fair manner, whether a water is safe to drink.

Q. Is there any substantial difference between the demarkation of bacteriology and pathology and that which is denominated sanitary science?

A. Bacteriology has given rise to very great changes in both, in pathology as well as in sanitary science. Modern bacteriology has changed the views held in regard to the causative factors in infectious diseases, and also has given rise for proper preventative measures.

Q. Now in some of those examples which you have related in your last answer to the question put by Judge Springer as to the zone of purification in running streams, are those ex-samples recognized by the scientists of Europe as established scientific facts?

MR. JEFFRIES: Before the witness answers the question I want to know whether he is speaking as a bacteriologist, epidemiologist, etiologist or as a sanitarian and I object to the question for the reason that the witness has qualified for nothing save that of bacteriologist.

7430 MR. TODD: In reply I will state that in view of the diversified definitions that have been given by all the different witnesses who have testified in this case as to what epidemiology, sanitary engineering or any of the scientific terms which the witnesses in this case have applied to themselves, I leave that matter for counsel to draw his own conclusions from the testimony that has already been introduced.

MR. JEFFRIES: I suggest for the benefit of counsel that if he does not correctly understand the qualifications of this witness in reference to the extent and scope of his investigations and his experience. and with reference to his ability to pass judgment and give conclusions upon all these questions, that he re-open the examination and proceed now to qualify him the second time.

MR. TODD: Counsel in reply will state that he is amply able to take care of what he understands to be the qualifications of this witness.

Q. (Question repeated).

A. In my opinion they are.

Q. Professor, as an expert bacteriologist and pathologist, what is your opinion as to whether typhoid bacilli lying in the bed of streams for a period in excess of 60 days would be able to cause typhoid fever if taken into the human system, after it had remained in such sediment for that length of time? 7431

A. My opinion would be that it is dead by that time under those conditions.

Q. What is your opinion as an expert bacteriologist and pathologist as to whether or not a substance deposited on the bottom of the Illinois river between Chicago and Peoria coming from the sewage of Chicago through the drainage canal can remain there for a considerable length of time, and yet retain its dangerous qualities, as well as a pathogenic bacterium?

MR. JEFFRIES: I object to the question for the reason that the witness has shown no qualifications in that he has had no experience in investigating any such conditions.

MR. TODD: In reply will state that this witness has shown as much qualification as the epidemiologists on the side of the complainant who have testified to this state of facts without having made any examinations, chemically, bacteriologically or otherwise, but have expressed an opinion merely as the conclusions of the witness making them.

A. My opinion would be that the pathogenic bacteria would have died in the drainage canal, due to the great increase of saprophytic bacteria and the overgrowing of the pathogenic germs both in the sewers and the drainage canal. 7432

Q. MR. TODD: From your knowledge of the Illinois river and your experience as a bacteriologist and a pathologist, what is your opinion as to whether sewage deposited by the drainage canal from the city of Chicago into the Illinois river at different seasons of the year and at different stages of water in the Illinois river could possibly be an injury and menace to the citizens of the State of Missouri and the citzens of the city of St. Louis using the water of the Mississipi river at the intake tower at the chain of rocks?

MR. JEFFRIES: I object to the question for the same reason stated in the previous objection, that the witness has not qualified himself as a sanitary engineer.

A. As to the pathogenic bacteria it is my opinion there will be no source of danger to St. Louis or to the inhabitants of Missouri.

JUDGE SPRINGER: Using this water for drinking purposes?

A. Yes sir.

MR. TODD: From your bacteriological examinations of the water of the Illinois, Mississippi and Missouri rivers as represented by the tables you have submitted which one of these three rivers from your examinations discloses the least amount of impurities as manifested and evidenced by your bacteriological tests?

7433 MR. JEFFRIES: I object to the question for the reason that the samples of water so examined by this witness from the various rivers mentioned are not so taken as to be comparable and only a limited number were taken and not a sufficient number were taken to enable any bacteriologist or sanitarian to express an opinion ,as to the comparative conditions and relative conditions of the waters of the three rivers, and for the further reason that the examinations do not include flood times, low water seasons, nor do they include cold weather seasons and summer seasons.

MR. TODD: In reply I will state that the complainant's witness, Dr. George Whipple, drew conclusions from two samples taken in the Missouri river and three samples taken from the Mississippi river and that the objection of counsel goes to the weight of the evidence and not to its competency or its admissibility.

MR. JEFFRIES: In reply to counsel's suggestion, I submit that the statement made by complainant's witness Whipple was not based alone upon examinations made by him, but from his experience as a sanitarian, and not from purely laboratory tests as have been shown by the testimony of this witness.

(Question repeated).

A. From 38 specimens of the Illinois river, and 37 from the Mississippi river and 36 from the Missouri river made dur-
7434 ing the months of October, November and December, 1901 and February and March, 1902, I concluded that bacteriologically the Illinois river was less polluted than either the Mississippi or Missouri.

Q. If the Illinois river discloses the least amount of impurities, what would be the effect of the Illinois river emptying into the Mississippi river at Grafton and subsequently uniting with the Missouri river at its mouth, upon the combined waters of the Mississippi and Missouri rivers at the intake tower at the chain of rocks, and does the mixing of the Illinois river with the Mississippi and the Missouri rivers as indicated, add any danger to the already polluted waters of the Missouri and Mississippi rivers.

MR. JEFFRIES: I object to the question for the same reasons mentioned in the previous questions with reference to the qualifications of this witness and with reference to the irregularity in the number of samples taken and the irregularity in the time and season and weather conditions at which the samples were taken or during which the samples were taken.

Q. (Question repeated.)

A. I can only judge from the results of these tables, and if such a condition would exist and would have existed during this time it would have only tended to make the Missouri
7435 less infectious to add the water of the Illinois to it, because
the Illinois river was less infected than either the Mississippi or the Missouri. So during those times I would say that there would have been no source of danger to add the Illinois to the already severely polluted Mississippi or Missouri.

Q. MR. TODD: As an expert bacteriologist and pathologist, do you consider the sewage of Chicago entering the drainage canal and the Illinois river, which in turn empties into the Mississippi river, a menace and a danger to the inhabitants of the State of Missouri and to the citizens of the city of St. Louis taking their water supply from the intake tower at the chain of rocks in the Mississippi river?

MR. JEFFRIES: I object to the question as leading and for the same reasons heretofore mentioned that this witness is testifying from his analyses alone, and that a sufficient number of analyses were not made to make any determination whatever or to draw any conclusions whatever as to the sanitary condition of the water in the Illinois river and for the reason that this witness is not testifying as a sanitarian and for the further reason that the samples examined by him were not taken during all conditions of the water and the weather.

MR. TODD: In reply will state that this question is ad-
7436 dressed to him as an expert bacteriologist and pathologist.

JUDGE SPRINGER: I desire to submit further that his opinion based upon these examinations, the analysis to which he has referred is much more valuable than an opinion as based upon no examinations whatever of the same water.

A. I do not believe that the drainage canal or the sewage entering the drainage canal can be of any danger due to pathogenic bacteria remaining in it, to St. Louis or Missouri, for the

reasons already stated. My opinion being based mainly on the behavior of pathogenic bacteria in the presence of saprophytes and my opinion also being based on the general knowledge the world over of the existence of a bacterial zone of purification in any river, and a continuous and permanent purification as the river flows along. As it flows along new pollution occurs and new bacterial purification zones formed which is my reason for feeling certain that no pathogenic bacteria entering the sewers of Chicago or the drainage canal, will pass beyond Averyville, where bacterial purification was complete. This distance is much greater than that which is generally found the world over, in every river. I would have liked of course very much to have more material, make more examinations and to determine more positively the exact place of the bacterial purification,
7437 which I am quite certain is far above upper Peoria. I wanted to feel safe in saying that the absolute disposal of all pathogenic bacteria had been completed for the reason that even the saprophytic bacteria and the sewage bacteria have disappeared, and for the reason that, here, practically no bacterial pollution whatever of the river existed.

Q. Assume that an epidemic of Asiatic cholera should break out in the city of Chicago and the sewage of Chicago should enter the drainage canal and the Illinois river, what is your opinion as to whether or not the germs of Asiatic cholera would survive the journey from Chicago to the intake tower at chain of rocks, a distance of 357 miles, and be a menace and danger to the inhabitants of the city of St. Louis and the inhabitants of the State of Missouri?

MR. JEFFRIES: I object to the question for the same reasons stated in the previous objections and for the reason that the witness has not qualified as to his knowledge and information as to the life and characteristics and life history of the chlorea germs. I submit his answer will disclose that fact.

MR. TODD: That is a matter of cross-examination. If counsel has any doubt as to his knowledge of Asiatic
7438 cholera he may bring that out on cross-examination.
(Question repeated).

A. Practically the same conditions apply here that applied in the case of typhoid bacillus. They would be exposed to the same conditions and they would die due to the same causes, the overgrowth of saprophytic bacteria in the sewers and in the drainage canal and the zone of bacterial purification would exist just the same. The great pollution of the drainage canal by sewage bacteria and by saprophytic bacteria will be unfavorable to the existence of the cholera vibrio. The cholera vibrio cannot exist in a bed of saprophytes.

Q. Professor, from your knowledge as a bacteriologist, what is your opinion as to whether or not the germ of typhoid fever could lie in the sediment of the drainage canal or the Illinois river or the Mississippi river for a period of one to five years and still retain its virulence?

MR. JEFFRIES: I object to the question on the ground that the question assumes that sedimentation has taken place in the drainage canal and there is no evidence to show that sedimentation takes place in the main drainage canal and for the reason stated in previous objections to testimony of this 7439 character by this witness.

A. Of course I am thoroughly convinced that typhoid bacilli even under the most favorable conditions, would not live one year, much less five years.

Q. Do you know of any instance on record or in the literature on the subject of bacteria where typhoid bacilli have lived for a period of one to five years in the sediment of rivers?

A. I do not.

Q. Do you believe it possible for typhoid bacilli to be deposited on the bottom of the Illinois river and remain there for a period of one to five years and then be stirred up by the action of the waves, or by the wind or steamboats and by any other means, and continue its way down the river to St. Louis and be a cause of danger to the inhabitants of the State of Missouri and to the citizens of the city of St. Louis?

MR. JEFFRIES: I object to the question for the same reasons mentioned in the objection to the question previously put to the witness of this respect and of this character.

A. I don't think that is possible for the same reason, that I feel certain that typhoid bacilli would not live one year.

Q. MR. TODD: Professor, assume that 107 barrels of 40 gallons each of the culture of bacillus prodigiosus, consisting of one thousand million bacillus prodigosus per centi- 7440 meter is contained in said barrel, were deposited in the Chicago drainage canal at the town of Lemont on the afternoon and evening of the 6th day of November, 1901, during a period of from four to eight hours. Assume further that immediately after said barrels were emptied into the drainage canal at the point aforesaid, the laboratories established at Lockport, Joliet, Peoria and Grafton on the Illinois river and at the intake tower of the St. Louis waterworks at chain of rocks, were notified and that samples were collected at each of these places every hour day and night for the purpose of bacteriological analysis for the ascertainment of these bacilli prodigiosus, and assume that at Lockport these hourly samples taken day and night were taken from November 7th to 25th, during a period of eighteen days the total number of samples taken being 432 or thereabouts. Assume that at Joliet these hourly samples taken day and night were taken from November 7th to November 25th, a period of eighteen days, the total number of samples being 432. Assume that at Peoria these hourly samples were taken day and night from November 8th to November 30th, a period of 22 days, amounted to a total of 528. Assume that at Grafton these hourly samples were taken day and night from November 12th to December 15th, a period of 33 days, the total number amounting to 732, of which 384 were analyzed by Dr. Ravold; assume that the total number of samples taken hourly 7441 day and night at the chain of rocks was 720; assume that at the laboratory tap these hourly samples taken day and night were taken from November 20th to March 1st, 1902, a period of 100 days, amounting to the total of 2400; assume that the total number of samples analyzed at the different points for the period above mentioned were 5304; assume further that in the bacteriological test for the ascertainment of the prodigiosus, the red reaction on the medium used was the only test made for the ascertainment of the bacillus prodigiosus, and that the test was carried no further than that initial color of red, and assume further that on December the 4th at 8:45 A. M. o'clock one bacterium bacillus prodigiosus was found at the intake tower at the chain of rocks, based upon the red results as before indicated; assume on December 5th at 9:00 A. M. one

bacterium bacillus prodigiosus was found at the intake tower at the chain of rocks in the same manner; assume that on December 8th at midnight one bacterium bacillus prodigiosus was found at the intake tower at the chain of rocks in the same manner; assume that on December 6th at 8:00 A. M., at Grafton, one bacillus prodigiosus was found in the same manner; assume that on December 7th at midnight at Grafton one bacillus prodigiosus was found in the same manner, based upon the
7442 red coloring as above indicated, and assume further that these five organisms separated in the manner heretofore stated, were all the organisms of prodigiosus that were found in the examinations made from Lockport to the intake tower of the chain of rocks and the laboratory tap in the city of St. Louis which were made during the progress of this investigation as hereinbefore set forth, and at no time was there more than one single bacterium found at each of these places, assuming all the facts as hereinbefore stated to be true, what is your opinion as to the value of these experiments as indicating the probable longevity of the typhoid bacillus as measured by the longevity of the bacillus prodigiosus and the probability that the typhoid bacillus entering the drainage canal from the sewage of Chicago would survive the journey down the Illinois and the Mississippi river to the intake tower at the chain of rocks at St. Louis, based upon all the facts contained in the foregoing hypothetical question?

A. In the first place there would be some remarkable doubt whether the red colonies were really prodigiosus colonies. In the second place the great numbers that were poured into the canal and the practical absence of them afterwards would only illustrate what the self-purification of rivers means, because this germ grows best at room temperature. It would perhaps not die as easily in water as a typhoid bacillus, because it
7443 could probably exist better than a typhoid bacillus under those conditions, and I think it would prove that if it is true that the prodigiosus disappears under such conditions, that it would be much more true of the typhoid bacillus.

Q. Professor, in order to establish to an absolute certainty that the germs denominated as bacillus prodigiosus were found at the places indicated in the last hypothetical question, would it be necessary on the part of a bacteriologist to establish their identity beyond all question?

A. It would be necessary to pass the germs through different culture media and it would be necessary that this germ conform to the description as given in the literature in order to name it a bacillus prodigiosus.

Q. Would the examination as far as its assumption in the hypothetical question, is concerned, enable the bacteriologist to establish to a certainity that the germ that gave red coloring matter as idicated, was a prodigiosus bacillus?

A. No. It cannot be distinguished by the color alone.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Professor, do you know how long a time elapsed between the collection of these samples that you examined and the actual examination which you made, took place?

7444 A. I do not.

Q. You do not know whether it was one day or two days or ten days?

A. I know that the specimens were shipped by express to Professor Long and that they were sent to me at my laboratory on the day that they arrived. In fact some of them I saw arrive and I received them at once, but as to how long before they reached the college, they were under way, I have no knowledge.

Q. Did any of them remain in Professor Long's laboratory over night before you received them?

A. No.

Q. Do you know of your own knowledge that they did not?

A. I answered the former question by my own knowledge. If this happened it happened without my own knowledge.

Q. You do not know of your own knowledge that none of them did not remain over night?

A. No sir.

Q. In making these anlayses did you make any allowance for the time that it required the samples to get from the place of taking to your laboratory?

A. I did not.

Q. Can you state whether or not this time allowed changes
7445 to take place which would vitiate the result?

A. There must be changes if a considerable time elapsed between the collection of the specimens of water and the time it is plated out.

Q. Was the ice packed around these samples in the winter time as well as in the summer time?

A. The ice packing was used in winter also, as much as I remember; the specimens arrived by express and went to Professor Long. I only saw some of them arrive. I received them in four ounce bottles when they were not any more ice packed.

Q. They were not packed in ice when you received them?

A. They were not packed in ice when I received them from Prof. Long, no sir. Those I did see, I just saw accidentally in his laboratory after they arrived.

Q. Now then, how far is your laboratory from his?

A. My laboratory is on the floor below. At that time it was on the same floor. In 1900 it was on the same floor.

Q. How many feet apart?

A. Oh, about fifteen feet.

Q. Did you go into his laboratory and get the samples or would he bring them in to you?

7446 A. He would send them in.

Q. Now you do not know how long they had been removed from the ice when they were sent in?

A. No, except some that, as I have said, I saw arrive and saw packed in ice afterwards, coming to my laboratory.

Q. Now that would have some effect upon the results, wouldn't it and upon the bacterial changes in the water?

A. What's that?

Q. From the time they were taken out of the ice until you received them and they underwent the bacterial examination?

A. I think the time was too brief there for much change to take place.

Q. That is in relation to the samples that you took yourself, that you went to Professor Long's laboratory and got yourself, but now in the event some of these samples were taken from the ice and laid aside for a while, that would invariably according to the extent of time have some effect upon the bacterial change in the water wouldn't it?

A. If they were unpacked from the ice and allowed to stand in the room there would be changes.

Q. And those changes would vary with the temperature of the room?

A. They would vary according to the temperature of the
7447 room and according to the organisms that happened to
be in the water?

JUDGE SPRINGER: Do you refer in your question to the pathogenic or the non-pathogenic?

MR. JEFFRIES: I refer to both.

JUDGE SPRINGER: Answer as to both.

THE WITNESS: I did; I said it would depend upon the bacteria, the temperature and the kind of bacteria present.

MR. JEFFRIES: There is no distinction made there in that connection between the pathogenic and non-pathogenic?

A. Yes, the temperature would have influence in varying the result. If a specimen of water was ice packed and was sent to some distance there would already be some changes; then if it was unpacked and allowed to stand for some time, then the changes would depend first upon the temperature existing there, secondly upon the kind of organisms present and thirdly upon the number of the indivdual organisms present.

Q. I understand that but that applies both to the various kinds, pathogenic and non-pathogenic, doesn't it?

A. That refers to both.

Q. That is the way I understood it.

A. Yes, but we take it that they would be present, and it
would depend upon the temperature and the numbers of each
kind in the mixture as to what changes really could take
7448 place.

Q. Why did you use ice in sending your samples from the place of taking to the laboratory?

A. To preserve the conditions as nearly like those in the river as it could be done.

Q. That is, the ice tends to prevent the multiplication of the bacteria?

A. Yes sir.

Q. Does it tend to prevent their death?

A. Ice usually, does not kill bacteria, although the ice packing is not the best way of doing nor sending bacteria from long distances. I try to get them as nearly like their normal condition. The temperature should be as nearly like the temperature of the water as possible.

Q. Do you know, professor, what the effect of the sealing of the bottle would have upon the life and death of the bacteria in the bottle as compared with the life and death of the bacteria in the canal water?

A. The sealing could, for the short time that they were sealed, not have so much effect, whereas, if that existed for a long time it would have some effect. The aerobes which require oxygen would find enough there for some time so that the effect of sealing couldn't be very marked.

Q. The effect of ice then was to hold the water in such a condition as to prevent the growth and prevent the death
7449 of the bacteria?

A. Yes, it was to prevent the growth of one kind at the expense of another kind.

Q. Professor, what experiments have you made with reference to the life of the typhoid germ?

A. I have inoculated liter flasks with known quantities of the typhoid bacillus in lake water, into the Missouri river water, into the Mississippi water and into the Illinois river water.

Q. Now all these experiments were made at a temperature ranging from 20 to 37 degrees centigrade?

A. No; some were made at twelve degrees. Those of the river water at Grafton, the Illinois river water, and the Mississippi and Missouri were made at a temperature varying between ten and twelve degrees centigrade in the refrigerator.

Q. Those are the experiments on the life of typhoid germs, are they?

A. Yes sir.

Q. Did you describe those yesterday?

A. I did not; I was not asked it.

Q. How long did they live professor?

A. At that temperature I was not able to find a typhoid
7450 in five days and in six days.

Q. At what temperature?

A. Ten to twelve centigrade.

Q. How were they made?

A. The river water was inoculated with different quantities of 24 hour bouillon culture of typhoid bacilli, and placed into the refrigerator. The water was then daily plated out on agar, in a number of dilutions. As many as fifteen to twenty plates were made; then we would take the plate which had the most distinct colonies, and mark all the suspicious colonies that looked like typhoid. Then we would examine these colonies, whether it was a bacillus and if so, whether the bacillus was motile. If it was a motile bacillus then we would use the serum of an immunized rabbit, or we would use the blood of a typhoid fever patient to obtain a Widal reaction; then we would make a potato culture; we would grow it in glucosebouillon too for absence of gas production and we would make a test for indol, but we were usually satisfied in our work when we found a positive serum reaction that we had found the typhoid bacillus. In all cases when we were not able to get such a reaction, we made the usual cultures of the supicious motile bacilli. The first point was always 7451 to look for suspicious colonies; the next point, whether it was a bacillus; otherwise that colony was thrown out. If it was a bacillus, it would have to be motile; otherwise that was thrown out, and in that way with the help of pure cultures we were able to tell that the typhoid bacilli disappeared in 5 to 6 days. There was an increase sometimes, in the numbers of typhoid bacilli during the first days. I thought, when the temperature of the laboratory had varied a little bit, but under all conditions we were unable to find colonies of typhoid bacilli in this river water after six days, even in those experiments where we had inoculated large quantities of bouillon culture into it.

Q. Now in what particular water was that done?

A. It was done with all three and it was done during the time of these investigations. The water was in four ounce specimens.

Q. And it came from where?

A. With specimens from the Illinois river at Grafton, the

Missouri above its mouth and the Mississippi before the Illinois enters it.

Q. You didn't take a sample of the Mississippi after it received both the Illinois and the Missouri?

A. No sir, I did not.

Q. Did you have two samples from each source?

A. No, we had many samples; we examined 38 about from each river.

Q. I am talking about one particular day did you have more than one sample for any one particular day?

A. No sir.

7452 Q. Did you use these samples for these tests?

A. Partly.

Q. Now in your testimony yesterday I believe you stated that you examined these samples for typhoid by another process?

A. Yes, we made other experiments from each river. There were 36, 37 or 38 speimens from each river and we did not use all the water in a bottle or specimen when we made a test as to how long the typhoid bacillus would remain alive in it.

Q. You did not use all the water that came in one of those bottles to determine whether or not it contained pathogenic bacteria or not?

A. No sir.

Q. I understood you to say yesterday that you did?

A. No, that was only for animal experiments and only in some the cases where we did not inoculate typhoid bacilli into the water specimen.

Q. So that in these examinations of the water that you have made in the Illinois river the canal and the other places, you did not use all of the water in the four ounce bottles that you received to determine whether or not any pathogenic germs were contained in that water, in the whole volume of water sent you?

A. We did that in no cases, in none of the examinations.

The only times when I used all of the water was when 7453 we made animal experiments. After we had plated out the water which was received in the laboratory, and for which plating we used only a small quantity, we would add nutritive bouillon to the water and place the whole bottle in the incubator for 24 hours and then inject guinea pigs.

Q. I understand that.

A. And then if the plates which were grown from these small quantities, showed large numbers of pathogenic bacteria and the number of colonies was very great, we would inoculate one cubic centimeter of this water, which had been in the incubator with bouillon, intraperitoneally into a guinea pig.

Q. How many samples of Illinois river water did you test that way?

A. Thirty-eight.

Q. Now did you test all these 38 on animals?

A. We did not.

Q. I want to know how many you tested on animals?

A. Six.

Q. With what results?

A. The results were that the animals usually died of proteus infection, but not always.

7454 Q. Now going back professor to these typhoid experiments, what did you say was the temperature of the water?

A. Between ten and twelve degrees centigrade in the refrigerator.

JUDGE SPRINGER: What is that Fahrenheit?

A. 50 to 53. This was in the refrigerator; the temperature may have varied a little sometimes.

Q. MR. JEFFRIES: Now then professor, as the temperature decreases the life of the typhoid increases, doesn't it? In other words do you know whether the typhoid will live longer at a low temperature than it will at a high temperature?

A. The cause of the earlier death here is the overgrowth of saprophytic bacteria that grow best at a low temperature. That is the cause of their disappearance.

Q. Have you made any examination of this water with reference to the various changes of the life of typhoid germs in the water?

A. No.

Q. At various temperatures?

A. I have only experimented with this water in the refrigerator, inoculating known quantities of typhoid bacillus.

Q. At this one time?

A. At several times during this investigation.

Q. But at no place more than one time?

A. No one day more than one time.

7455 Q. And the whole investigation was how many times at any one place?

A. At any one place for the life of the typhoid bacillus in river water?

Q. In that water, yes.

A. I should think that we did not more than ten tests, that would be about three for each water.

Q. At what temperature?

A. All these experiments were done in a refrigerator.

Q. How long did they live?

A. They lived no longer than six days. Sometimes after four days we were unable to find any colonies of typhoid baccilli.

Q. Can you produce a table, produce examinations showing the number of typhoid bacteria in each bottle each day?

A. No.

Q. And the total number of bacteria?

A. No, I have never attempted either to count the total number of bacteria nor have I attempted to make a count of the typhoid colonies that appeared.

Q. If the samples can be prevented from changing by ice, is it not a mathematical conclusion that when a river water is at the temperature of ice as it is in the coldest part of the year that it would be correspondingly protected from changes in composition?

7456 A. Yes, I think that is true.

Q. Your experiments made at a temperature of 12 and 20 centigrade, would throw no light upon the life of the germ with temperatures at the freezing point, would they?

A. No, they would not. If it was at the freezing point, there would be no increase of saprophytes, so in the frozen specimens, both the saprophytes as well as the typhoid bacilli would probably remain as they are in the ice.

Q. Increase of the saprophytes would be measured as you approach the freezing point; that is, the decreasing number would be measured as you approach the freezing point, isn't that true?

A. As the temperature becomes lower than that of air and water the saprophytes would increase less and less.

7457 Q. State how much organic matter was contained in the water in which your experiments on the life of typhoid germs was made, first now, in the aggregate. In other words, the amount of aggregate organic matter?

A. I can not state the amount of organic matter that was present. We used Lake Michigan water in the first experiments and we used river water in the other experiments, and the question was simply in regard to the life of the typhoid bacillus in the presence of saprophytes as they were found under usual conditions at the time, and I have never made any determinations as to how much organic matter was present in either the Lake Michigan or the river water.

Q. Now professor, state the amount of organic matter coming from the bouillon containing the culture of bacteria?

A. That was very little. Besides 3-10 per cent of meat extract, my bouillon contained one per cent of peptone and one-half a per cent. of salt.

ADJOURNED until 2:00 p. m. same day.

7458 2:00 p. m., Saturday, October 3, 1903.

Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. F. ROBERT ZEIT,

resumed the stand for further cross-examination by Mr. Jeffries, and testified as follows:

Q. Professor, were analyses made to determine the amount of organic matter contained in the water in which your experiments on the life of typhoid germs was made, and the aggregate amount of organic matter coming from the bouillon contained in the culture of the bacteria?

A. No.

Q. Professor, I will ask you if it is not a fact that the smallest amount of bouillon adds a large percentage to the organic matter of the water?

A. A large percentage? I don't think it would add such a large percentage, except where I add five cubic centimeters of bouillon to 100 cc. of water.

Q. Can you make a computation of the additional amount?

A. The bouillon contains about one per cent; less than 7459 one-twentieth gramme I should judge in the case mentioned.

Q. Now how many parts per million would that be?

A. Per million of water, is that the question?

Q. Yes, parts per million?

A. Well, it would be about one-half to the thousand.

Q. And to a million how much?

A. Five hundred.

Q. Then the water would contain how much?

A. Five hundred.

Q. The natural water though, before the bouillon was added—how much would the natural water contain before the bouillon was added?

A. That would depend upon circumstances. I think a great deal less than that.

Q. A great deal less than 500?

A. Oh yes.

Q. So then you would have to increase it many times, would you not?

A. Yes.

Q. Now professor, wouldn't this greatly increased percentage of organic matter materially influence the life of the germ?

A. That would depend upon the other bacteria present and the temperature.

Q. It would, or it might?

7460 A. No, it would.

Q. What kind of other bacteria?

A. Saprophytes, sewage bacteria would multiply more rapidly when there was much organic material, than if there was little organic material.

Q. Then if the saprophytes would multiply more rapidly, wouldn't that also influence materially the life of the typhoid germ which you state is destroyed by the saprophytes?

A. It would, but these conditions do not exist in my experiments. In my experiments I added merely small quantities, inappreciable quantities of typhoid bacilli to the water. For instance one or more loopfuls of typhoid bouillon were added to the water so that the amount of organic matter added to the water in this way was not appreciable in amount.

Q. Now then in what way did you determine the amount of organic matter that you had?

A. I didn't determine the amount of organic matter.

Q. Well then, how do you know that it was inappreciable?

A. I know by the original bouillon culture, only containing about one per cent of organic matter,—about that, and if I use of this original culture only one loopful and add that to water, that would be an inappreciable amount of organic matter that I have added to the water.

7461 Q. Well now, that was the way that you determined the life of the typhoid germ in the Illinois river water, is it?

A. Yes, and in lake water.

Q. Now then, in those determinations, what quantity of Illinois water did you use in making the determination of the life of the typhoid bacilli in that water?

A. We took usually about five cubic centimeters of the water into a sterilized test tube, and added,—for the first experiment, one platinum loopful of a 24 hour bouillon culture of typhoid bacilli that had been grown at 37 degrees centigrade, and this was then plated out.

Q. Then the increased organic matter in the bouillon must necessarily have had a great effect upon the multiplication of these saprophytic germs?

A. No, there was no chance for that. To explain: I first make a bouillon culture of typhoid bacilli. I grow that for 24 hours in the incubator, and of this bouillon culture of typhoid bacilli I take one loopful and add it to five cubic centimeters of river water. After that has been added this is immediately plated out on agar. These bacilli do not grow or multiply to

any extent in the water because I immediately plate out the mixture and the bacteria cannot multiply before being
7462 plated out.

Q. Now then, professor, does that determine the life of the typhoid bacillus in that water?

A. Well, that is done as a control experiment and is the way we start. In the following experiments we do not plate out until the typhoid bacilli have been in the water for one day, for two days, for three days, for four days and so on, until we do not find any more typhoid bacilli in the plates.

Q. Now what is plated out one, two, three, four and five days?

Q. The river water, to which has been added a loopful of the bouillon culture of the typhoid bacillus.

Q. Which contains an increased amount of organic matter and which produces this saprophytic growth?

A. Yes, an inappreciable amount of organic matter.

Q. But isn't that true?

A. Yes.

Q. And the saprophytic growth under your testimony in chief, brings about the death and destruction of the typhoid bacilli?

A. Yes, but the organic material which I have added by one platinum loopful of bouillon culture is inappreciable compared to the amount of organic material which must already be present in that water.

7463 Q. Now you stated a moment ago that that was about how much?

A. In the bouillon I stated it was one per cent.

Q. But you have not computed and have not measured it?

A. I have not in the water.

Q. And therefore do not know?

A. In the water, I don't know.

Q. And to that extent the experiments that you made are not representative of the true characteristics of the Illinois river water which you examined, with reference to the longevity of the typhoid germ in that water?

A. In that respect I will answer that the addition—

Q. Yes or no, professor?

MR. TODD: I object.

MR. JEFFRIES: He can explain afterwards. That question is capable of an answer "yes" or "no," and he may make any such explanation as he may desire afterwards.

MR. TODD: I submit that he can answer it any way he wants to.

MR. JEFFRIES: I submit that under all rules of evidence, that we have a right to demand an answer of the witness, Yes or No.

MR. TODD: I submit that you have not. The witness can answer it in any way that he thinks proper.

MR. JEFFRIES: Mr. Commissioner, I insist on his answering Yes or No.

7464 MR. TODD: The Commissioner has no power to enforce any such demand.

(Question read.)

MR. TODD: I submit that the question is not a question that ought to be answered Yes or No, or that you have any right to demand an answer "Yes" or "No," because the witness says he cannot.

MR. JEFFRIES: I submit, in view of what the witness has testified to, and the statements that he has made with reference to the character of his examinations, that this question is answerable "Yes" or "No," and I give to the witness the privilege of making any such explanation afterwards as he may desire, if he thinks an explanation is necessary.

JUDGE SPRINGER: After this statement of counsel, let the witness make any answer now that he sees fit. The objection is in.

THE COMMISSIONER: Go ahead, Professor?

A. I do not see what difference there exists whether I add typhoid bouillon to the river water or whether the typhoid bacillus enters that water in the form of fresh sewage containing typhoid bacilli. I believe in fact that in my case I am introducing less organic material with the typhoid bacillus than 7465 under natural conditions where sewage containing typhoid bacilli enters the water.

Q. Now, Professor, I will ask you if it is not a fact that your analyses did not determine accurately ,the longeviety of the typhoid bacillus in the Illinois river water, according to the analyses that you made, Yes or No?

MR. TODD: I submit that the witness does not have to answer the question Yes or No.

Q. I ask you if it is not a fact that your analysis does not show the exact life of the typhoid bacillus in that water?

A. My experiments only show the life of the typhoid bacillus in that water under conditions as they exist in the laboratory.

Q. And those conditions are different from what they are in the river?

A. Yes, although I have made them as closely similar to those of the river as I could.

Q. That may be all true, but yet the conditions in the river are different than they were in the laboratory, isn't that true?

A. Yes, the conditions would be somewhat different in the test tube than they would be in the flowing water.

Q. Now professor, I will ask you if it is not necessarily true in all cases of a bacteriological examination, that the conditions are very materially different in the running stream to what they are in the laboratory? 7466

A. There are slight differences, but the principal question as to the life and possibility of existence of a pathogenic organism in the presence of conditions favorable to rapid multiplication of saprophytes would be very much alike.

Q. So when you add conditions which bring about saprophytic growth, the conditions for the destruction of the typhoid bacilli are greater in that examination than they would be in the water, aren't they, and to the extent of the additional organic matter which produce an additional saprophytic growth, the death of the typhoid bacillus in the experiment is hastened —or is hastened in the experiment?

A. I believe that the conditions in a seriously sewage polluted water, are more unfavorable for the life of the typhoid bacillus than they would be in the laboratory experiments, on account of the greater amount of organic material that would be present there. My experiments were all done with water that was not seriously polluted. I mean that the water specimens I experimented with did not contain abnormal

7467 amounts of saprophytes, like, for instance, the water in the drainage canal.

Q. Then you did not examine the life or longevity of the typhoid germ in the canal or in the water of the canal?

A. I did not.

Q. But, professor, going back now to my previous question. I don't believe you quite understood me. Confining yourself to the experiment and the bacteriological examination of the water which you made, or which you may make, or which any other bacteriologist may make, using the same system, and carrying out the same line of procedure, if it is not a fact that when you add additional organic matter in the bouillon, which produces the saprophytic organisms, if it is not a fact that this additional increased production of saprophytic organisms does not have a tendency to hasten the death of the typhoid germ and reduce the longevity of that germ in the expereiments which you make, confining this proposition now solely to the experiment?

A. To the test tube?

Q. To the test?

A. Yes, I think that is true. The real cause of any difference between laboratory experiments and natural conditions exists, however, in the fact that the excretions of saprophytes, as they multiply in the test tube, are not carried away as rapidly as they would be in the running water, or in the river
7468 water, but remain in the test tube. That is really the only point where the two could be called not identical.

Q. Except as to temperature?

A. Well, I have tried to produce the temperature of river water as nearly as I could.

Q. At the time the samples were taken?

A. Yes. It is mainly this accumulation of excretion products due to the life of the saprophytes upon organic material, which is retained in the test tube, which constitutes different conditions from those which exist in the flowing river water.

Q. Now professor, you spoke in your direct examination of the purification of the sewage from a number of European cities in the streams upon which those cities were situated.

A. Yes.

Q. You mentioned, I believe, Munich?

A. Yes.

Q. And Zurich?

A. Yes.

Q. Paris?

A. Paris.

Q. Berlin?

A. Yes.

7469 Q. And Breslau?

A. Breslau.

Q. Do you understand that the sewage from these cities is discharged into the respective rivers upon which they are located?

A. The effluent of the sewage passes into those rivers.

Q. And do you understand that this sewage is absorbed by the waters of these rivers?

A. The effluents are absorbed by the waters of these rivers.

Q. And reduced to harmless substances within the distances which you have mentioned?

A. Yes.

Q. And without injury to those residing on the rivers below the point of discharge?

A. Below the points of the purification zones which I mentioned.

Q. Now professor, if you should learn that out of the five cities mentioned, three of them have constructed intercepting sewers, pumping stations and conduits, and a complete system of sewage purification, so that no sewage from them is discharged into the rivers, but on the contrary, that all injurious and polluting matters are removed from the sewage before it is so discharged, and if you should learn that these improvements have been carried out at an expense of many 7470 millions of dollars, and were maintained at heavy annual expenditures, would this modify your views of the adequacy of dilution, to dissipate and destroy in a harmless manner the sewage of those cities and would this affect materially the value of the precedent so far as it gives a precedent, for the disposal of the Chicago sewage in the manner now practiced?

A. I have only spoken of the experiments shown at that time in regard to the zone of bacterial purification at those places, the increase of the bacteria in the waters after receiving the effluent and the gradual purification in a certain zone of the river after its exit from the city. As to these amounts which have been paid in perfecting the sewage systems, I am perfectly aware that immense sums have been spent to produce a pure water—to supply a pure water, but that does not alter the results of the bacteriological tests; that there exists a zone of bacterial purification in even the most polluted river.

Q. What effect would the information that these cities are withholding from deposit in those rivers, all of the objectionable polluting matter have upon your statements and conclusions and opinions made this morning, with reference to those cities?

A. In a general way it is attempted everywhere to avoid
7471 pollution as much as is possible, and that particularly
must be true where river water is used for drinking purposes, which under such conditions should be always filtrated.

Q. You say wherever river water is used it should always be filtrated?

A. I speak of the general proposition that any river ought to be polluted as little as possible where it is necessary that towns near by use that water for drinking purposes. As a general proposition in such cases it is not desirable to turn anything into a river.

Q. And that is from a bacteriological standpoint?

A. That is not from a bacteriological standpoint, but from a general hygienic standpoint.

Q. Supported by the science of bacteriology?

A. And by the science of hygiene.

Q. Well, has bacteriology got anything to do with the science of hygiene?

A. Yes, in so far as hygiene has originally taught us that there was no river long enough that it could purify itself of any pollution it received, and as bacteriology has proven that that dogma is not correct and that there is in every river a purification zone.

Q. I want to ask you the proposition, professor, if the
doctrine has not grown into existence, right the reverse
7472 from what you have stated; that the original belief was

among scientists, that a river running a long distance would purify itself, and that modern science has turned back on the original proposition?

A. English authorities on hygiene have taught twenty years ago that no river was long enough that it could purify itself of any pollution it received.

JUDGE SPRINGER: No river in Great Britain.

A. (Continued) And as soon as bacteriology was employed in the examination of river waters, as to the possibility of determining the quality and effects of pollutions an entirely different condition was found than that which was generally accepted by the specialist on hygiene. It was found that there is a zone of bacterial purification in every river and that sewage bacteria turned into it really disappeared within a certain distance. I, as a bacteriologist, have of course accepted that view, and, based upon my own findings in the matter, have expressed it also as my opinion that there is a bacterial purification zone in every river.

Q. Then professor, if it be true in these European rivers, that you have mentioned, and with respect to the cities 7473 that you mentioned, that when the sewage in its polluted condition was turned into those rivers that there was a zone of purification easily and readily determined, as stated by you, that these cities would spend millions of dollars for preventing that sewage from going into the river?

A. They spent millions of dollars already before this was determined.

Q. How about Paris?

A. The attempt of course in all places is to do away with as much of the pollution as possible, in only turning the effluent into the river instead of the sewage itself, but that does not prevent the great multiplication of sewage bacteria in those rivers and the figures that I have given are based upon the bacteriological examinations of those figures.

Q. And not with reference to the pathogenic bacteria that may be contained in that water?

A. No, not with reference to the pathogenic bacteria in that particular instance, only with reference to the number of bacteria—their increase in the city and their rapid decrease within a certain distance below the city—to a number of bacteria similar to that before it entered the city.

Q. So that in your testimony with reference to those rivers, you did not refer to anything of a pathogenic order?

7474 A. I did not.

Q. Then you reason, professor, that because the nonpathogenic bacteria had disappeared in those rivers, that the pathogenic bacteria had disappeared also?

A. Yes sir. For the reason which I stated several times, that saprophytic bacteria decrease much more rapidly—or as they increase more rapidly, pathogenic bacteria disappear, and that if saprophytic bacteria have decreased in number, the pathogenic bacteria must have been disappearing long before the saprophytes did.

Q. Now then, professor, I will ask you if you are acquainted with the conditions as they exist at Paris, and have for the last two years?

A. In regard to the bacteriological investigations?

Q. In regard to the manner in which the sewage is taken care of in that city and their precautions with reference to their water supply?

A. I am not familiar with the sewage disposal of Paris today, or as it exists in any of the other cities. I have only referred to these bacteriological tests with regard to the disappearance of bacteria which did occur below those cities, in the polluted river water.

Q. I will ask you, professor, if at the time that those 7475 experiments were made, that these large and enormous sums of money had been expended prior to the making of the experiments towards extracting the objectionable polluting matter from the sewage of those cities?

A. Munich was filtering its water at the time when Schlatter—when that report was made in regard to the Isar.

Q. I am not talking about the water now; we are talking about the sewage.

A. How is that question again?

(Question repeated.)

A. The investigation that was made in the Isar, as well as that of the Spree was purely made from the standpoint of determining whether any purification of the river took place or not, of the increased amount of bacteria that had been found in the river in the city, and whether that disappeared as the river flowed on.

Q. And that was made without reference to the objectionable bacteria and polluting bacteria and disease bacteria that might have been in the water in the event the sewage had been turned in?

A. It was made without any reference to pathogenic bacteria as much as I understand.

Q. Now I will ask you, professor, when those improve-
7476 ments were made if you know?

A. I don't know the various improvements that have been made in any of those places. I only know of the tests made to determine the question of the disappearance of bacteria in the polluted river water.

Q. I will ask you, professor, when it was known that there was a zone of purification in the river from a bacteriological standpoint in any river?

A. I have stated the dates of the experiments at the different cities and it is known today as it was then.

Q. And it has been known ever since the science of bacteriology has been born, has it not?

A. No, it has been known particularly since these questions were investigated in Zurich, Berlin and Munich and Breslau.

Q. And that was prior to the construction of these sewage purification plants?

A. That I am not able to state.

Q. Well, you don't know then whether it was or not?

A. No, I am not able to state that.

Q. I will ask you, professor, if you know that they are still building such plants in Europe and in this country?

A. I understand they are everywhere trying to filter the water.

7477 Q. We are talking about sewers now, and sewage.

A. The disposal of sewers into rivers has, to my knowledge, been somewhat improved by turning only the effluent into rivers, of such sewage, instead of the sewage itself.

Q. I will ask you again professor, if you are not aware that since these sewage purification plants were established in Europe which we have referred to, with reference to the particular cities about which you testified in chief, and if since it has been determined, as you say, that there is a zone of purification in every river, that various cities throughout Europe and the United States, are today expending large sums of money to purify their sewage and remove from it the objectionable material before it goes into the river. Now isn't that a fact?

A. To destroy the organic material by saprophytic overgrowth and allow the parasites or pathogenic bacteria to die before the material is poured into the river.

Q. Professor, I will have to insist on your answering my question. I don't see that that answer applies at all.

A. I will have to have that question again please.

Q. (Question read.)

A. I do not know.

Q. Professor, under those conditions and under the statements which you gave in evidence and your conclusions 7478 and opinions, would it be necessary to construct those plants?

A. I think those plants are constructed for other reasons than those of direct danger, by pathogenic bacteria entering the sewage. There is no doubt at all that the people living along the infected district, the district in which the sewage is turned into the river, are exposed to some disagreeable conditions.

Q. Don't you know as a matter of fact, as a bacteriologist, a pathologist, as a biologist, and as a scientific man, that the sole object that those cities have in purifying their sewage before they discharge it into the river, is to remove from it the objectionable and deleterious material in the construction of those sewage purification plants, so that the water would not be rendered objectionable to their neighbors.

JUDGE SPRINGER: I object to this question upon the ground that it assumes that the cities referred to which may have established these sewage purification plants, have not done so with a view to purifying their own water supply, but merely their drainage system, that they still get their water supply from above the place where their own sewage empties into the river.

Q. (Question read.)

JUDGE SPRINGER: Below them on the stream, you mean?

7479 MR. JEFFRIES: Yes.

A. The filtration even under those most favorable circumstances, will allow some bacteria to pass through, and some of them might be pathogenic.

Q. Professor, answer my question.

A. They would still get into the river.

Q. That doesen't make any difference, I want my question answered.

(Question repeated.)

A. There are many features that may make a water objectionable and I don't see that I can answer that question any more thoroughly than I have because I am not an epidemiologist.

Q. Do you consider it a question of epidemiology or something with which you are not acquainted?

A. I consider that a question which is simply a matter of prejudice in a good many respects. It is objectionable to use a water which smells because sewage has been turned into it, and there are a great many reasons why people living near the source of such pollution should go to great expense to avoid such nuisance.

7480 Q. Now do you consider in that answer, the effect of pathogenic germs upon the health of the people who use that water, as one of the reasons for the constructions of those plants?

A. You ask me about imaginary plants.

Q. I ask you about real plants?

A. That I have testified I don't know anything about.

Q. I ask you about real plants which you admitted were in existence.

A. Now give me that last question.

(Previous questions and answers read).

Q. MR JEFFRIES: I will state this, professor, that in your statement as to the reason for the construction of these plants, you mentioned many things, but for some reason you eliminated the question of pathogenic germs and water borne diseases, and the effect that they would have upon the people using that water. Now I want to know whether you include that as one of the reasons for the construction of these plants or whether it is material or not?

A. I can only say that I have only testified to things that I know, and you now ask me to testify on things that I don't know. That is with regard to sewage disposal plants, and their efficiency in preventing contamination of rivers by pathogenic germs. If you will kindly ask me questions as to things that I have testified to I will try and answer them.

7481 Q. Then professor, you say that you don't know anything about the rivers in Europe about which you testified this morning, or the cities that are situated upon their banks?

JUDGE SPRINGER: I object to that question because it assumes a condition that the witness does not mean.

A. I have not testified as to the plants, as to the sewage systems or as to anything of that order. I simply testified as to some experiments made in those cities with regard to the disappearance of bacteria in the polluted rivers after they have received the sewage of those cities.

Q. Now do you know that they receive the sewage of the cities?

A. They receive the effluent as well as a great deal of sewage, from those cities.

Q. Do you know that?

A. I know that from the literature, yes.

Q. Would you be surprised, professor, to learn that the opposite was the case?

A. I understand what you mean. You mean where they receive the effluent. I spoke of that also, in my testimony this morning, when they received only the effluent. I admit that.

JUDGE SPRINGER: I submit that at the time this Paris experiment was made, that the sewage of the entire city of Paris, of 2,500,000 people, was discharged into the river Seine, and that the literature will show that fact,—or four-fifths of 7482 the sewage of 2,500,000 people, which would be 2,000,000 people anyway.

Q. MR. JEFFRIES: Professor, according then to the literature from which you obtained your information, this zone of purification was known in the river into which the sewage from Paris was deposited, at the time the experiment was made; isn't that true?

A. Yes.

JUDGE SPRINGER: I further desire to submit here that this examination is not fair to the witness for the reason that the zone of purification of Paris was fixed at 40 miles below the city. It is well known by everybody that below Paris is a very populous country, and that the people living below the city have some rights and that the city was trying to protect those people as well as their own inhabitants, in Paris.

MR. JEFFRIES: I suggest in response to the counsel's suggestion, that the city of St. Louis in the State of Missouri belongs to the United States. I suggest also that if the present rate of increase in population continues, it will not be many years until the territory between the city of Chicago and the city of St. Louis, and the territory in the Illinois river valley and the Mississippi valley will be as populous as that at Paris
or at any other place in the civilized world; that that is
7483 a matter of future prospects and future conditions, and
we are willing to submit to counsel's statement and take that in view in our consideration of this case.

Q. Professor, I will ask you if you don't know that in this country and in Europe there have been various plants of the character about which we have been speaking, plants for the purpose of removing the objectionable substances, the disease producing substances from the sewage of cities, in order to protect the public health of the people who are exposed to the use of the waters of the rivers into which the sewage formerly was discharged?

A. Yes, I know that in a general way.

Q. I want to ask you this question. If the purification, or rather the removal of the objectionable material from sewage of a large and populous city would not make the sanitary condition of the water into which those sewage discharges formerly entered a better sanitary condition than the water was in while the sewage in its raw condition was being discharged into the river?

JUDGE SPRINGER: I object to the question on the ground that it does not fix a point down the river at which the objectionable features might be eliminated by the means indicated in this examination heretofore, in regard to the Illinois river

7484 between here and Peoria for instance.

Q. (Question read).

MR. TODD: At the places of discharge?

MR. JEFFRIES: The water of that river.

Q. (Question read).

A. I think as a general proposition that sewage filtered of course would be more favorable than sewage not filtered when it went into the river.

Q. But with the raw sewage being deposited into the river, is it not a fact that it renders the water in the river much more objectionable than it is without the sewage?

A. Raw sewage? I do not quite understand what you mean by raw sewage. Now is that sewage that has remained, stood in the sewers for some time or is that sewage as found in the drainage canal?

Q. I mean professor, isn't it a fact that the discharge of the sewage such as ordinarily is discharged from the sewers of the large and populous cities of this country or any other country, without treatment of some kind, into a river, renders the water in that river in a less sanitary condition than without the sewage?

A. There is no question about that in a general way.

7485 Q. Well, that is just it exactly.

A. The river is better without sewage than with it.

Q. Professor, do you know whether or not the city of Peoria abandoned the Illinois river as its water supply some years ago?

A. I do not.

Q. Do you know the condition of the Illinois river prior to the opening of the Chicago drainage canal as far as Peoria?

A. I do not.

Q. You have been at Peoria?

A. I have lately been down the river—down the canal and the Illinois river to St. Louis. That is the first time I have seen it.

Q. From your analyses would you think it necessary for them to abandon the Illinois river as a water supply?

JUDGE SPRINGER: Who abandons it?

MR. JEFFRIES: The city of Peoria.

A. Bacteriologically considered, not.

Q. As a sanitarian would you—oh, you don't speak as a sanitarian.

A. No. In other words, the question—may I say why?

Q. Yes.

7486 A. A water may be chemically and it may be physically pure, and yet it may contain pathogenic bacteria. Now then the bacteriologist would condemn that, whereas the chemist and the sanitarian does not make those examinations and would consider that a pretty fair supply. Bacteriologically I might call a water bad that contains only two pathogenic germs per cubic centimeter, whereas that would not be considered bad under normal conditions and vice versa where only a quantitative test is made a water containing we will say 10,000, or 50,000 germs might be called generally bad, when in fact those are nothing but water bacteria.

Q. Now professor, when you condemn water from a bacteriological standpoint that contains two germs or two bacteria per cubic centimeter, you would do that because of the condition of the test itself, or would you take into consideration your knowledge of the stream and the stream flow?

A. If I found pathogenic bacteria anywhere I would consider that substance, whether it be food or water, as dangerous, and to be prohibited from drinking it.

Q. Then if I understand you professor correctly, it is not a question of the number of the bacteria of all kinds and classes that are found in the water that condemns it?

A. No sir.

Q. But it is the presence of pathogenic bacteria?

7487 A. The pathogenic bacteria, or the presence of bacteria commonly found in sewage.

Q. Now then, professor, in passing upon that proposition as a practical question, aside from the laboratory, I will ask you if you do not think it is essential to take into consideration the opportunity for those pathogenic germs to be found in the water as well as the fact that they are not really found there, in passing upon the sanitary condition of the water?

A. Pathogenic germs may be found in the water.

Q. Then you must take into consideration the opportunity of their getting there if they are being found there?

A. Certainly.

7488 Q. Then professor, taking those things into consideration, must you not in addition take into consideration the temperature of the water at all times of the year, the stream flow of the water at all times of the year, and the condition of the river with reference to low stages of the water and high stages, freshets and floods?

A. In passing a general opinion as to the potability and safety of water for drinking purposes that should all be included, as well as the chemical examination, as well as the physical, to arrive at the potability of water.

Q. Now I will ask you this question: if you found a pathogenic germ in one water, at the mouth of one stream, for instance, we will designate that as stream A, and you find pathogenic germs in stream B, and the pathogenic germ in the sample of water taken from stream C; now in order to pass upon the relative amount of pollution that may be found in those rivers, the relative character and the comparative character of the water, or the sanitary condition of the water in those rivers, wouldn't you consider the source and the extent of known polluted matters of a deleterious character, entering those streams?

A. Yes, I would consider that also.

Q. And that too, without reference to the number of bacteria or characters that you may find in any of the waters? 7489

A. Yes sir.

Q. Now professor, in passing your judgment and opinion upon the sanitary condition of the water in the Illinois river at Peoria or above Peoria, I will ask you if you took into consideration those facts or the facts contained in that preceding question?

A. I only expressed an opinion in regard to the bacteriological purification at that place and the absence of pathogenic bacteria.

Q. Then your opinion is based solely and alone upon your bacteriological tests, the results of the analyses of the water made by you in your laboratory here in Chicago?

A. With regard to the bacteriological flora at that place.

Q. And from that bacteriological flora you express that judgment and drew certain conclusions, did you not?

A. Only in regard to the bacterial purification, but not with regard to any other purification.

Q. So then you do not know whether the water at that point, above Peoria or the water at Grafton, or the water at St. Louis is pure or not, or free from pathogenic germs?

A. A water may be objectionable besides that of the
7490 bacterial contents for physical reasons purely, and it may
be objectionable for chemical reasons. My examination
refers purely to the bacteriological side.

Q. Now professor, I want to ask you if from a bacteriological standpoint, bacteriologists do not determine the physical stability of a water from its bacterial content, and if they do not, of what benefit is bacteriology in determining the sanitary condition of any water?

A. You do not determine the sanitary condition of any water purely by bacteriology. You only determine the bacterial pollution of a river or lake water by bacteriology and not any other element. Bacteriology has nothing to do with the final judgment. We leave that to the sanitarian to decide upon all the factors which he has collected from all different sciences. A water may be bacteriologically pure and may be chemically impure and vice versa.

Q. Then professor, you want to be understood as saying or speaking as a bacteriologist purely and simply, is that true, and not one step farther?

A. The opinions I have expressed all the time are purely on bacteriological grounds, and every judgment that I may have expressed in this matter is purely based on my experience as a bacteriologist and also my experience with the water of this
river and only refers to the contents of the bacteria in the
7491 river and not to the chemical or physical aspects of the
question, whether the water is potable or not.

Q. Now then, professor, confining yourself to bacteriology and confining your opinion and judgment and your conclusions as to the sanitary condition of the water in the Illinois river at Peoria and at other points, I want to ask you if it would not be necessary before you could express a reliable and adequate conclusion as to the condition of that water, for you to first have a bacteriological analysis of that water from one end of the year to the other, taking into consideration the various changes in temperature, cold weather, hot weather, warm weather, flood times, low water seasons and local conditions from one end of the river to the other, and if it is not necessary to have all this information. What is there in the analysis which you have made, which leads you to believe and which furnishes you sufficient information to pass judgment upon that water?

A. I did not pass judgment on that water. I examined a number of specimens between February and October from each place and mainly for the presence of pathogenic bacteria. I was not to pass judgment on the potability of the water, but I was to determine during this period what pathogenic or disease producing bacteria could be found in the specimens submitted to me for examination. 7492 As to the rest of the question, I am willing to say that the more numerous the examinations, the better the final conclusions are. There is no doubt that 10,000 examinations are better than ten.

Q. How about the necessity of having the water examined bacteriologically and bacterially at all seasons of the year?

A. That is another point that is desirable.

Q. Now professor, do I understand you to say that you have not stated in evidence that the sewage of Chicago has any influence whatever upon the sanitary condition of the water in the Mississippi river at the chain of rocks in St. Louis?

A. Yes, and I have given my reasons for that opinion.

Q. And that as I understood you a moment ago, was a conclusion based solely upon your bacterial analyses and what they showed?

A. Of the water, no. That was based purely and solely upon the experiments in the laboratory as to the behavior of pathogenic bacteria in water generally, and my findings about the gradual disappearance of pathogenic bacteria in the presence of large numbers of saprophytic bacteria.

Q. But the conclusion which you came to, as you stated, was based upon your analysis, bacteriologically speaking, 7493 of that water and I want to ask you if you did not state a few moments ago that that opinion was based solely upon that examination?

MR. TODD: I object to the question as it is double-barreled. The first question is an assertion of what counsel understands. The second question is a straight question and I submit that the two questions ought to be separated.

MR. JEFFRIES: The witness can separate them if he wants to. He is an intelligent witness.

JUDGE SPRINGER: Read the first part of it and answer that first.

(First part of question read to witness)

A. My opinion as to the bacteriological purification of the river was based upon the findings in this report, to the State Board of Health.

(Last part of question repeated to witness)

A. I do not remember that I said I was basing my opinion solely on that.

7494 Q. I will ask you this question, professor, if you did not state a few moments ago that in determining the sanitary condition of the water from a bacteriological standpoint that it was necessary for you to take into consideration the temperature of the water at all seasons of the year, the stage of the water the flood seasons, winter season, summer season, the extent of the polluting material entering that river, and that you stated you had not taken such facts into consideration in forming these conclusions?

A. Yes. I have not. I did not determine the sanitary condition of the water. I determined the bacterial purification.

Q. Now professor, I believe you stated that the pathogenic germs live longer as the amount of organic matter is less. In other words a decreasing amount of organic matter meant longer life and greater longevity to pathogenic germs?

A. I made the statement that when organic matters increase, that the saprophytic bacteria multiply more rapidly and overgrow the pathogenic bacteria, and that they therefore die sooner in the presence of large quantities of organic matter than the saprophytes; than they would if there were no saprophytes and large quantities of organic material present.

Q. Now professor, this being so, how would the life of the pathogenic germs compare in the water of the Chicago drainage canal and the Illinois river as they now are, that is
7495 as the rivers now are, as compared with the life of germs
in the water of the Illinois and Michigan canal, and in the Chicago river prior to the opening of the drainage canal?

JUDGE SPRINGER: I object to the question on the ground that the witness has stated that he was not familiar with the waters of the drainage canal or the Illinois river prior to the opening of the canal.

A. Nor with the Illinois and Michigan canal and the conditions of the Chicago river.

MR. JEFFRIES: Now professor, assuming that the sewage of Chicago prior to the opening of the canal flowed into the Chicago river, its various forks and branches, that a certain portion of it was pumped into a canal several miles in length which flowed a distance of twenty or more miles without dilution and at a much less rate than is now maintained in the main drainage canal; that there was pumped on the average about 35,000 cubic feet per minute of this sewage polluted water which has been characterized at times as an open sewer, and that this volume of water was pumped, and that the current at times in the Chicago river reversed its natural flow from the west to Lake Michigan, so that the river flowed in an opposite direction; that this volume of 35,000 cubic feet of water and sewage per minute, represented about three-fourths of the sew-
4796 age of Chicago containing the same amount of sewage as
now flows down the main drainage canal diluted with 250,000 cubic feet of water per minute, how would the life of a pathogenic germ compare, in the water of the Chicago drainage canal and the Chicago river and the Illinois and Michigan canal under the assumption I have just stated, prior to the opening of the main drainage canal?

A. Well, I will simply say that in a long canal, 30 miles long, sewage entering and remaining more or less stagnant, will allow the same multiplication of saprophytes that we find here in the drainage canal and the same destruction of pathogenic bacteria.

Q. Considering, professor, the greater concentration of the polluted matter,—sewage for instance—in the Chicago river prior to the opening of the canal than there is now in the main drainage canal, would not the conditions be less favorable in the Chicago river prior to the opening of the canal for the life and vitality of pathogenic germs than now?

A. I can answer that in a general way. The slower the flow and the less dilution and the more organic matter, the more saprophytes, the sooner the death of the pathogenic bacteria. 7497

Q. So that, professor, if you take a gallon of water and dilute it with a pint of sewage the conditions for the disappearance of pathogenic germs would be more favorable in that composition than it would to take a barrel of water and dilute it with a pint of sewage?

A. Yes, I think that would be the case.

Q. So that whatever pathogenic germs that a pint may have contained, the pint that was poured into the gallon of water, they would disappear much more rapidly than the same pathogenic germs would were they deposited in a barrel of water?

A. If the same amount of sewage had been deposited in a barrel of water. The more sewage, the more organic material, the better opportunities for saprophytic life. I take it now you are speaking of conditions at the usual low temperature of water.

Q. Then, professor, assuming that the same amount of sewage is discharged into the two streams, the one with the flow of 35,000 cubic feet per minute, the other with the flow of 250,000 cubic feet per minute; the facilities for the disappearance of pathogenic germs are better and more favorable in the smaller stream than it would be for the larger stream, isn't that true?

A. In the larger stream the dilution would be so much greater.

7498 Q. Aside from the dilution?

A. Yes, but that is an important factor.

Q. We are talking now, aside from dilution.

JUDGE SPRINGER: You cannot eliminate that.

Q. MR. JEFFRIES: We are talking about the life of the germ, which eliminates the dilution entirely.

JUDGE SPRINGER: I submit that the question which has just been put speaks of a dilution of 250,000 cubic feet of water per minute in the drainage canal and that therefore it is not eliminated.

MR. JEFFRIES: I suggest that this question is put for the purpose of showing the opportunity for the pathogenic germs to live in running streams?

A. I will say that the greater the dilution, the further separated of course will be the pathogenic germs, and the less will be the bad effect upon them of the rapidly multiplying saphrophytes and their products, and therefore as a general proposition a pathogenic germ ought to live longer, the purer the water.

Q. And from your scientific information there is no reason why it would not live longer, is there? And you are ready to believe it will live longer?

7499 A. My opinion is that a pathogenic germ will live longer in water that doesn't contain any other bacteria at all, than in water which contains organic material and saprophytic bacteria. The greater the dilution, the further apart will be the individual bacteria and the less effect the growth of the saprophytic bacteria exert upon pathogenic germs.

ADJOURNED until 10:00 A. M., Monday, October 5th, 1903.

7500 10:00 A. M., Monday, October 5, 1903. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

By agreement of counsel, witness, Professor F. Robert Zeit, was temporarily withdrawn, in order to take the testimony of witness W. E. Lautz.

W. E. LAUTZ,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Springer and testified as follows:

Q. What is your name, residence and occupation?

A. W. E. Lautz, Pekin, Illinois.

Q. How long have you resided in Pekin?

A. All my life.

Q. State whether during the year 1901 you received any instructions from any person in regard to taking samples of water from the Illinois river?

A. Yes sir, I did.

7501 Q. From whom did you receive those instructions?

A. Mr. Irons and Mr. Schule.

Q. For whom were they working, do you know?

A. As far as I know for the drainage canal commission.

Q. Were you employed by these two gentlemen to take samples from the Illinois river?

A. Yes.

Q. Will you please state then what instructions you received from them and the place at which you took the samples and what you did with them?

A. The point at which I took the samples was about a mile and a half down the river from Pekin.

Q. Below Pekin?

A. Yes sir, and I would get so many bottles to be filled each day, with a mechanical contrivance to fill that bottle, and recork it while it was held three or four feet below the surface of the water.

Q. What was the capacity of it, of each of these bottles?

A. The chemical sample was a large bottle, I think about a gallon.

Q. And the others?

A. The others were smaller bottles, I should judge they held about eight or ten ounces. I could not say as to that however.

7502 Q. State what you did with the samples when you took them from the water?

A. I packed them in ice and shipped them by express, part of them to Professor Palmer at Champaign, and some of them I took in person to Mr. Schule, at his office in Peoria.

Q. How did you ship them, in what manner?

A. They were packed in excelsior and ice, and securely sealed and shipped by express.

Q. From what point?

A. Pekin.

Q. State now distinctly, how you took the samples of water, what precautions you took if any, in regard to getting the sample out of the river?

A. I first fastened the bottle in the contrivance for the removal of the stopper, and the lowering of the bottle below the surface. My instructions were to be very careful that my hands did not come in contact with the mouth of the bottle or the stopper. I was always very careful to see that that bottle was opened and closed while it was below the surface.

Q. And they were filled below the surface?

A. Yes.

Q. And stoppered before you raised them out of the water?

7503 A. Yes sir.

Q. What kind of a stopper was it?

A. Glass stopper.

Q. Which size of the bottles did you ship to Professor Palmer?

A. Both sizes.

Q. Both sizes?

A. Yes sir.

Q. What kind did you give then to Mr. Schule?

A. Both sizes.

Q. Well, how did you give those to Schule, did you state?

A. I took them up in person.

Q. Took them up to Peoria in person ?

A. Yes sir.

Q. Did you put any tag upon the bottle for the purpose of identifying?

A. I did, sir.

Q. What was the nature of it?

A. It was a tin tag with numerals stamped in the tin, these were pierced by a hole and I stuck a wire through the hole and around the neck of the bottle. The neck of the bottle was covered by a cloth, a sort of a canvass, and that wire was drawn up very securely and run through the lead similar to a 7504 freight car seal. That is as near as I can describe it, and the lead was smashed so that it was held securely.

Q. Did you receive any blank cards for the purpose of making your notations upon?

A. Yes sir, I did.

Q. In reference to each bottle of water taken?

A. I did.

Q. Look at that card and see if it is one of them?

A. Yes sir, it is.

Q. Look at that package and see if they are those that you made out?

A. I think they are all just as I made them out, in my handwriting.

Q. Now state when the first sample was taken, according to the dates there entered?

A. These are mixed up. I don't know that I can find the first card. My first sample was taken I think on the 16th day of September, 1901.

Q. When was the last taken?

A. On the 31st day of December, 1901.

Q. From your examination of those cards, state whether they are the cards that you made at the time,—the blanks of which you filled out?

7505 A. They were the cards I made at the time, the cards were filled out at the point where I took the sample each day.

Q. Do those cards then as filled out present a true statement of the conditions which you noted at the time, upon them?

A. They do, sir, yes sir.

Q. And the true date?

A. Yes sir, the true date.

Q. State what was included in the card that you took, what facts?

A. The temperature of the air, I took each day, and the temperature of the water, and the directions of the current if I could detect them, and the appearance as to rain, and also the turbidity of the water.

Q. State how far from the shore or either shore was it in the stream that you took the sample?

A. Why the current at that point was quite close to the western shore of the river, that is, the Peoria county side. I should judge that it was 100 feet from the Peoria county shore at that point.

Q. Was it intended to be in the mid-stream?

A. No sir, it was intended to be in the current.

Q. I mean in the mid-current?

A. In the mid-current.

7506 Q. How deep below the surface of the water did you take your samples, as you state?

A. About the full depth of the contrivance, I think that was three and a half to four feet.

Q. Was the sewage of Pekin entering the river at the place where you took these samples,—above the point?

A. Yes sir.

Q. You took them below the Pekin sewage?

A. Yes sir.

Q. State whether there had been at the place where you took these samples, a complete mixing of the water in the river—of the Peoria and Pekin sewage, with the water in the river?

A. As to the Peoria mixture, I think likely that was quite thoroughly mixed, but the Pekin sewage—

MR. JEFFRIES: I object to the question for the reason that the witness has not properly qualified himself to be able to give any testimony that would be reliable upon the question at hand.

Q. JUDGE SPRINGER: You can state from your personal observation of the water so far as it appeared to you?

A. I know that the Pekin sewage was not mixed with the water.

Q. The Pekin sewage was not mixed?

A. No sir.

7507 Q. How could you tell that?

A. It was in the fall of the year that I took these samples, and the sewage was of a higher temperature than the temperature of the river water. You could see the steam arising from the sewage in the water along the Tazewell county shore of the river, and hugging that shore all the way down. It didn't come out into the current.

MR. JEFFRIES: I move to strike out the question and answer for the reason stated in my previous objection.

Q. Which side of the river is Tazewell on?

A. The east side.

Q. The side opposite from that where you took the samples?

A. Yes, sir, and that is where the current was.

JUDGE SPRINGER: We present this package of tickets, consisting of 48, numbered consecutively as appears thereon, and ask that they be marked Defendant Sanitary District of Chicago's Exhibit No. 22 for identification.

Received and so marked by the Commissioner.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Did you take any other samples than those to which you have testified?

A. No, sir.

7508 Q. Did you take samples of water from any other points than that to which you have testified?

A. No, sir.

Q. And you always took them from the same place in the river?

A. From the same points.

Q. What was the character of this piece of machinery that you used to take these samples with?

A. It was a rod or hollow tubing that branched out in the form of a loop, large enough to take the bottle at the bottom. It sat upon a sort of a plate at the end of that fork. Then it had a clamp right at the top of the fork to engage the cork with a wire coming through the hollow handle or cross-piece on the top which, when the cork was attached to the clamp and the bottle immersed all you had to do to take out the cork was to pull on the wire coming up through the hollow handle.

Q. Now, state whether or not you rinsed the bottles?

A. No, sir. Why, I rinsed them at the time—no doubt at the same time there, with the river water, before doing anything, I think.

Q. Before what?

A. Just as soon as I got down there I immersed the bottle full.

Q. With your hand?

A. No, sir, with the machine.

7509 Q. Then what did you do?

A. Put on the cork below the surface of the water and pulled it up and put that canvas covering on top and tied that down and put it in the compartment.

Q. Yes, but that was after you rinsed the bottle?

A. No, sir.

Q. State how you rinsed the bottle?

A. I didn't rinse the bottle.

Q. I will ask you if instructions were not given you to rinse them, and if the instructions upon the card which you used, which you said were your instructions, did not state that the bottles must be rinsed?

A. I fail to recall definitely whether I did or not.

Q. Then if the card does state that the bottles should be rinsed before they are filled, to be shipped, you did not carry out the instructions on the back of the card, did you?

A. I carried out the instructions on the backs of the cards to the letter.

Q. But you didn't rinse the bottles?

A. As I recall it I did not.

Q. I will ask you to examine the card and see whether or not it does not require that the bottles should be rinsed before they are filled for shipment.

7510 JUDGE SPRINGER: On the back of the card.

(Witness examined card.)

A. I notice sir, that the instructions are that the bottles should be rinsed.

Q. Well, now, did you do that?

A. Yes, sir.

Q. Are you sure you did?

A. Yes, sir, if these were the instructions, I followed them.

Q. Still, don't you know aside from the card itself whether you followed them or not?

A. As I remember, I think I did.

Q. Do you remember whether you rinsed the bottles or not?

A. Yes.

Q. Now state just how you did that?

A. It was rinsed with river water.

Q. Well, how did you do it?

A. That is to put the bottle below the surface and take a little water in and pour it out, and immerse it again.

Q. What did you do with the stopper while you were rinsign the bottles?

A. It was held some way in my hand.

Q. Or you would lay it down?

7511 A. No, sir. I was very careful of that stopper, that it did not come in contact with anything else under my instructions.

Q. Except your hands?

A. Well, I had to take hold of the top of the stopper to remove it of course.

Q. You remember very distinctly now of having rinsed the bottles,—all those bottles, every one of them?

A. Yes, sir.

Q. As a matter of fact, don't you know that you did not rinse the bottles?

A. No, sir, I do not. I rinsed them.

Q. So then you wish to be corrected in your statement that you did not rinse them?

A. Why, there is no statement to correct. I said I rinsed them.

Q. Didn't you state a few minutes ago that you did not rinse them?

A. I don't think I did, sir.

JUDGE SPRINGER: Just read that.

(Previous questions and answers read.)

JUDGE SPRINGER: Now, since refreshing your memory, can you state whether you did or not?

7512 A. I can say that I did if those were the instructions on the backs of those cards. Those were my instructions and I followed the instructions absolutely.

Q. MR. JEFFRIES: All that you know now is that you did just what those cards say on the back and nothing more. You don't remember anything else that you did do, is that true?

A. Those were my instructions on the back. I know I followed those.

Q. How deep under the surface of the water did you go to get the water in the bottles that you rinsed them with?

A. About the depth of the mechanical contrivance.

Q. The same depth that you got the samples?

A. Yes, sir.

Q. Where did you get these bottles that you used

A. They were shipped to me by Mr. Schule. Mr. Schule or Professor Palmer, before I went up there.

Q. Went up where?

A. When I took the sample to Mr. Schule, at his office in Peoria, he had a bottle ready for me to return with empty.

Q. You carried them from Pekin up to Peoria?

A. Yes, sir.

Q. You first went to Peoria and got the bottles and then
took them down to Pekin and filled them and then carried
7513 them back to Peoria.

A. No, when I took the full sample up I carried the empty cases back the following morning and took these down and filled them, and repeated the performance each day.

Q. What condition were they in when you got them?

A. They were all packed in excelsior in cases. The tops were securely tied on with rubber cloth.

Q. Did you open them before you left Peoria?

A. No, sir, I never touched them at all until I got down to the places where I was to take the samples.

Q. When did you pack ice around the samples?

A. At the boat landing in Pekin.

Q. You went out into the river and got the sample, brought it to shore and then packed ice around it?

A. I took the cases and packed them with ice at the boat landing in Pekin when I went down with it.

Q. Before you put the water in?

A. Before I put the water in, yes. The case that I packed the sample in was in two compartments, one compartment for ice and one for the bottle.

Q. Did you pack all the samples at the same time before you put any of them in ice—how many samples did you take each time?

7514 A. Three days a week I would ship to Professor Palmer at Champaign. On those days my samples were doubled; on the other days I only took Mr. Schule's samples.

Q. Now, then, when you took more than one set of samples, you took them all at the same time?

A. Yes, sir.

Q. And carried them from the point in the river where the samples were taken, to the shore, and packed them?

A. No, sir, all the packing was done right in the boat there on the river.

Q. Then as you collected the samples you packed them, is that it?

A. Yes, sir. All I had to do when I had a bottle full was to shove it down in the compartment and close the lid.

Q. Well, you always did that, did you?

A. Yes, sir.

Q. Did you have any trouble getting out to where you took the samples?

A. No, sir.

Q. How did you get out?

A. In a row boat.

Q. Always in a row boat?

A. Always in a row boat.

7515 Q. There was no ice on the river when you took the samples?

A. No, sir.

(Signature waived.)

7516 PROF. F. ROBERT ZEIT,

resumed the stand for further cross-examination, by Mr. Jeffries, and testified as follows:

Q. Professor, what is pathology?

A. Pathology is the study of disease, of the diseased organs, briefly.

Q. Is that all there is to it?

A. Well, if I shall be more explicit, pathology includes all the causes and manifestations of disease, as well as their results, a study of tissue changes and disturbances of functions of various organs.

Q. I will ask you now if in this connection you have studied the causation of diseases?

A. I have not in that connection studied the causation of diseases as much as I have in connection with bacteriology —infectious diseases you refer to?

Q. Well, I have reference to all kinds of diseases?

A. Then I can answer your question with yes. As far as infectious diseases are concerned, I have studied those more from the standpoint of a bacteriologist.

Q. So, then, so far as the causation of infectious disease is
concerned, as applied to and as connected with pathology,
7517 you have given it no other study than that which you have
made from a bacteriological standpoint, is that true?

A. I have studied infectious diseases with regard to their cause, with regard to the manner in which these causes infect the human organisms; with regards to the ways in which these cause, mostly micro-organisms, are spread and find entrance into the human body, and through what avenues they enter the human body and what changes they produce in the organs or tissues of the human body and animal body.

Q. Now, Professor, I want you to state the extent of your studies with reference to the causation of infectious diseases and more particularly diseases known as water-borne diseases?

A. The principal study of such diseases consisted in studying the disease itself and the biology of the germ—which caused it. Just repeat that question, please. I don't know if I have answered it fully.

Q. (Question repeated.)

A. With regard to the causation of those diseases, the cause is the infecting organism, and I have studied the infecting organisms,—the biology of the infecting organism as well, as I stated before, how it enters the human body, and the changes
that it produces there.

7518 Q. Now I will ask you, Professor, if you have studied
the biology of the infecting germ as obtained from the
water in which it may be found, or have you studied the biology of that germ as you found it in the laboratory, and as it came from the excreta of a patient suffering with that particular disease?

A. I have studied the biology of the organism as it came from the human body.

Q. And have you studied the biology of the organism as it is contained in the water infected with the germ of disease?

A. Yes, I have also studied the behavior of pahtogenic bacteria or disease producing micro-organisms in water.

Q. Now, then, I want you to state, Professor, clearly the full history of your investigations and your experiments on that subject and along that line?

A. With regard to the behavior of pathogenic bacteria in water, I found that when pathogenic bacteria are put into water containing much organic material, and polluted with sewage bacteria or containing many water bacteria, and the mixture is kept at a low temperature, as low as ten to twelve degrees centigrade, the water bacteria multiply rapidly and the other saprophytic bacteria multiply and overgrow the pathogenic bacteria which then die out quickly. If the temperature is somewhat
higher, say the temperature of the room, the other condi-
7519 tions being the same, the saprophytes grow—multiply
most and overgrow the pathogenic bacteria to such an extent that they disappear also within several days. When the pathogenic bacteria are put into pure water,—I mean sterilized water, containing no bacteria of any kind, they will live for weeks.

Q. Four weeks, you say, or for weeks?

A. For weeks—three or four weeks even, even if there is no organic material present. If there is a slight amount of organic material present, and the temperature is favorable, they will even increase and they will live in there for weeks. If we take pathogenic bacteria and put them into a so-called pure and potable water, a water containing no saprophytic bacteria, but only water bacteria, such as are commonly found in water, innocent water bacteria, and keep the temperature at that of the water or even at that of the room, there is a great multiplication of water bacteria only. I am speaking now of a water which is almost free of organic material. Water bacteria seem to be able to grow more rapidly, even in the absence of any organic material, whereas, saprophytes will grow better and increase more
when organic material is present, so that even in a pure
7520 water where there are no saprophytic bacteria present, a
rapid multiplication of the common water bacteria takes place and the pathogenic bacteria are overgrown and disappear. The experiments that I have made were mostly with Lake Michigan water, and also with sterilized water, and finally they were

made with the waters of the Illinois river above Grafton, with the Mississippi river just before the Illinois enters it, and of the Missouri above the mouth of the Missouri. Those three waters contained great numbers of saprophytic bacteria and the pathogenic bacteria died out quicker than they did in Lake Michigan water.

JUDGE SPRINGER: Can you state within how much time?

A. In five to six days. I might add here, that I also know this to be a common experience. For instance, in the water of the river Ganges, and the river Yumma, which is very rich in organic material, the vibrio of Asiatic cholera will die in two to four hours, according to the experiments of Hankin. I have in none of my experiments found any such conditions. The shortest periods of life I have observed were five days in the waters that I have examined.

Q. Have you made any experiments with the germ of cholera?

A. I have. In these experiments I have always used the typhoid bacillus, the vibrio of Asiatic cholera, the staphylococcus aureaus and the anthrax bacillus.

7521 Q. Now, Professor, state where you got your cultures of typhoid bacilli?

A. The cultures that I have used were anywhere from the fifteenth to the thirtieth generation from a case of typhoid fever, whnere I obtained them in the following manner: At a post-mortem, the spleen was seared with a red-hot spatula and a sterile knife was inserted into this area. A platinum loop was then inserted into the spleen and inoculations made upon agar slants. These agar slants were grown in the incubator 24 hours and then showed a pure culture of the typhoid bacillus. By "generations" I mean that I inoculated another tube of agar from the first. This was then the second generation. If from that tube a third one was made, that was called the third, and so on. The typhoid bacilli I used in the experiments were the fifteenth to the thirtieth generation, possibly more, in some instances.

Q. Now, Professor, I will ask you if you know whether or not it is not a fact that these low generations of typhoid bacilli were less hardy, less vigorous and shorter lived than those which came from the patient sick of that disease?

A. They, no doubt, in passing so many generations lose some of their virulence, but they were still alive. They might grow even better in the later generations, although they 7522 lost their virulence entirely. They may be alive and show all the characteristic biological factors by which we recognize the typhoid bacillus even if their virulence was lost.

Q. Then you could not say that the later experiments which you made were virulent or not.

A. I am unable to state with regard to these experiments whether in all cases the typhoid bacillus I used was a virulent bacillus or not, because I have not in all cases tested its virulence upon guinea pigs. The problem was simply to find the typhoid bacillus in water which I had inoculated with it to see whether it would remain alive in water. The problem was not as to whether it would lose or increase its virulence in that water.

Q. Professor, how do you keep the typhoid bacilli alive in the laboratory for a number of years?

A. We cannot do it.

Q. How do you keep them alive for any length of time?

A. We keep them alive in this way: We inoculate agar slants by means of a platinum wire. This is grown in the incubator over night, at the most 24 hours. After 24 hours we have along the streak of inoculation a colony which looks somewhat elevated, glistening and is probably not wider than one-sixteenth of an inch, to about one-eighth of an inch along the whole streak of inoculation, and now we place this culture 7523 in the ice box to prevent it from dying. If we would allow the culture to stand in the room or allow it to remain in the incubator, there would be an overgrowth of bacteria and they would die in their own poisons. Cultures that are allowed to remain in the temperature of the room will generally die very soon, so we do not allow them to grow longer than one night in the incubator, and then in this condition in the ice chest or in the cellar, they will keep alive from between three to six weeks. Sometimes, when the temperature is a little bit high, they multiply rapidly, and when we inoculate other tubes they don't grow any more because they are dead. That is the common laboratory experience with the typhoid bacillus which we constantly cultivate, because it is used daily in the diagnosis of suspected cases of typhoid fever.

Q. Then, Professor, as your experiments are removed from the person or the patient, and as the typhoid fever bacilli is removed from the patient, to that extent those germs become less and less hardy and strong, do they not?

A. A typhoid bacillus is a parasitic organism which will live best upon living beings, living organic material, and it will not live as well on dead organic material as it does in
7524 the living.

Q. And therefore will not live as well on the broth that you use as it will in the human being?

A. It lives only too well. It will multiply at such a tremendous rate, if the temperature is that of human blood, that it will kill itself by producing substances, which are poisonous to itself. If you let a culture grow, the bacilli will die in their own poisons on account of the tremendous increase of them under favorable temperature conditions.

Q. Then, that is a saprophyte, is it not?

A. Well, it has the faculty of growing as a saprophyte, and if you wish to have it described so, we will call it a facultative saprophyte, and not a pure or obligate saprophyte.

Q. Isn't it a fact, Professor, that it is always a saprophyte when taken in connection with laboratory experiments?

A. No, we obtain it from the human being in the laboratory.

Q. But as grown in the laboratory?

A. As grown, yes.

Q. Now, then isn't it a fact that it is only a parasite as applied to the system of man?

A. Yes.

7525 Q. That is the only time in which a typhoid bacillus is a parasite, is when it is getting its work in on the human system?

A. It is a parasite at that time.

Q. And at no other time?

A. At no other time. It is only a parasite at that time, because it never occurs free in nature except when it has come from the intestinal canal of a case of typhoid fever, or from the urine.

Q. Now, Professor, the different cultures of typhoid fever bacilli that are made from the typhoid bacilli coming from various and different human patients have various degrees of hardiness and vitality, have they not?

A. There isn't very much difference in regard to their hardiness. They all grow fairly well on culture media.

Q. But as to the length of life, the longevity as applied to the tests?

A. I think very little is known in regard to that, but I would say that my experience is that there is not so much difference with regard to their longevity. I think that any differences that do occur are mostly due to different compositions of the media upon which they are grown, or are due to
7526 variations of temperature in which they are grown,—surrounding conditions. I don't believe that it occurs from—

Q. Well, I will ask you then if typhoid bacilli coming from the patient, are not more hardy than those that are cultivated in the laboratory?

A. Oh, no, we very frequently find that a parasitic germ will grow much better after it is grown a few times as a facultative saprophyte. It may be more virulent when coming from the patient than it would be in our cultures, but it might grow better and be more hardy perhaps.

Q. But do you not also sometimes find the reverse? In other words, that from your cultures, you don't get as hardy a form as from new cultures?

A. Now, what do you mean by hardy?

Q. I mean longevity and the toughness,—their ability to maintain themselves?

A. Let me have the other question now.

(Question read.)

A. That is right, we find that also.

Q. Professor, you stated that in your experiments the pathogenic bacteria died in five to six days. Under slightly different conditions, might they not live somewhat longer?

A. Under different conditions of temperature and other factors, yes.

7527 Q. You stated that in your experiments the pathogenic bacteria died in five to six days. Under slightly different conditions, might they not live longer?

A. Well, they died in five to six days in the presence of large numbers of saprophytes, at a temperature between ten and twelve degrees centigrade, and if these conditions are changed, if the saprophytes are absent, or the temperature is changed, they will live longer.

Q. So, then, even in the laboratory experiments, the life of the typhoid germ depends largely upon the presence of what you denominate the saprophytic bacteria?

A. Which are in the water.

Q. The presence in the water used on the experiments?

A. It depends upon their presence, yes.

Q. And as you increase or decrease the organic matter which produce these saprophytes, these saprophytic bacteria, you increase and decrease the life of the typhoid bacilli in that experiment, do you not?

A. Yes, sir. Increase of organic material and saprophytes decrease the life of the typhoid bacilli.

Q. So that no laboratory experience can accurately portray the life of the typhoid bacillus under all conditions?

A. Under all conditions?

Q. Yes?

7528 A. I stated last Saturday already that I made the conditions identical, except in one point, that in the laboratory experiments the products of the saprophytes have remained in the culture, or in the water with the typhoid bacilli, whereas in river water they would be diffused; otherwise the experiments that have been made have been made as nearly identical to the conditions existing in the river, as was possible.

Q. How do you know whether or not the oxygen conditions were the same in the samples that you experimented upon as in the river?

A. The typhoid bacillus can grow in the presence or absence of oxygen. It can grow without any oxygen. It is not an obligate aerobe.

Q. But, Professor, would not the absence of oxygen in the sample have a tendency to produce large numbers of your saprophytic bacteria?

A. The oxygen was never absent in my samples; they were cotton stoppered.

Q. Unless you had the same amount at all times, of oxygen in your samples as contained in the river water, would not that condition have a tendency to create a larger number of saprophytic bacteria in your samples than would be created in the water, because of the absence of oxygen in the samples?

7529 A. Why, there was no absence of oxygen in the samples. When I put a cotton stopper into a bottle, the oxygen of the air is present upon that water.

Q. I will ask you, Professor, if you consider the conditions similar with a bottle corked?

A. It is not corked; there is cotton in it, and cotton allows the air to pass in and out, but it does not allow the bacteria to pass in and out. It is a germ filter, but it does not prevent free access of air.

Q. Will you state, Professor, that the same amount of oxygen is always present, passing through the cotton into your sample, that is always present on the surface of the water in the running stream?

A. The amount of oxygen—

Q. And that the water in the sample is continually taking on the same amount of oxygen measured by the quantity of water the same amount of oxygen that is taken on in a running stream,—if you know?

A. The amount of oxygen on the surface of my bottle of water is the same as the amount of oxygen that exists in the air and ought to be the same as that at the surface of the river water.

Q. But is it, and are you sure that it is, and are you sure that the air reaches through the cotton as it does in the water?

7530 A. As it does in the river water. I have no doubt. No means were used to stir up the sample of water which might might occur under certain conditions in the river, mixing more air with the water, and yet we move these bottles about a good deal. I don't know if there is not enough oxygen there under all conditions; certainly, I cannot state any definite figures as to the amount of oxygen in the one and the other case.

Q. In other words you could not tell?

A. The difference, no.

Q. There may be some difference and there may not?

A. Yes.

Q. What is the object of putting the cotton in the bottles?

A. The object is principally to prevent other bacteria from the air to get into the water, and at the same time also to let those which are in the water, not get out. The only object of the cotton is to act as a germ filter; it has no other object.

Q. The object then is to keep the bacteria from the air, from getting in?

A. Yes sir.

Q. But you cannot say that that cotton would not keep the oxygen out to any extent?

7531 A. I am quite certain that that cotton allows the oxygen to pass through, just as well as it allows the gases which may form in the bottle to pass out. That happens also.

Q. You have no way of determining the exact amount of oxygen that goes in that—the comparative amount that goes in with reference to that that is taken up by the water in the river?

A. No.

Q. And just to the extent that the presence of oxygen in the samples of water is limited, a condition is brought about whereby the saprophytic bacteria increase more rapidly than they do in the running stream and therefore the destruction of the typhoid germ is hastened to that extent in the sample?

A. No that is not quite correct because some of these saprophytes can grow very well with little or no oxygen. They are not all strict aerobic bacteria. The strictly aerobic bacteria must have oxygen or they will not multiply. Some bacteria grow best in the presence of oxygen, but can grow also in the absence of oxygen.

Q. Now professor, increased oxygen in the water has a tendency to kill off your saprophytic bacteria, does it not?

A. No, that is not certain. The bacteria which are called obligate aerobic require oxygen for their existence. If you take the oxygen away they will not grow. Oxygen does not act as a germicide at all.

7532 Q. But there is another bacterium present, isn't there that—a bacterial operation in that water that takes place before the aerobe comes in, is there not?

A. Yes.

Q. Now what is that?

A. If there are an-aerobes in that water.

Q. Is the an-aerobic bacteria a saprophyte?

A. An an-aerobe may be a saprophyte or it may be a parasite. An an-aerobe grows only in the absence of oxygen.

Q. Then as you decrease the amount of oxygen you increase the amount of an-aerobic bacteria?

A. That is it.

Q. That is it, isn't it?

A. Yes.

Q. So that the absence of oxygen from a polluted water or water containing organic matter, increases the bacterial content of that water does it?

A. It decreases the growth of the an-aerobes that may be present.

Q. Now then, professor, the life of the typhoid bacilli depends, as I understood you to say, upon the presence of organic matter in the water?

A. Yes, there ought to be some organic matter and a favorable temperature, else it will not multiply.

Q. I will ask you professor, in the analyses which you 7533 have made of the water of the Illinois river, if you know that the same amount of organic matter, or that the organic matter in the samples which you had, remained the same during the whole period of your investigations with reference to determining the life history of—or the longevity of the typhoid germ as it did in the running stream?

A. The lake Michigan water contained not much organic material.

Q. We are talking about the Illinois river water now.

A. The Illinois river water contained more organic material.

Q. But professor, did the samples in which you made the test contain the same amount of organic matter at all times during that test as was contained in the original sample as it came from the water?

A. Of course not, that must have changed.

Q. In other words, the same amount of organic matter and the same kind of organic matter?

A. No, that certainly must have decreased as the saprophytic bacteria multiply. They live upon the organic material and as they multiply they overgrow the typhoid bacillus, and the typhoid bacillus then disappears.

Q. Then the conditions in the laboratory were not the same as those existing in the river at the point where the samples of water were taken?

7534 A. In the river the same condition—

Q. Yes or No, professor?

A. Well, the same condition must exist where there is much organic material in the river, it will be used up by the saprophytic bacteria and if they increase very rapidly the typhoid bacillus will disappear just the same as in the laboratory.

Q. But you stated a moment ago, professor, that the same amount of organic material and the same character of organic matter was not present at all times during the experiment, as was found in the sample at the time it was taken from the river?

A. I stated that the organic material decreased, due to the growth of saprophytic bacteria in the laboratory experiment. I did not state that I had determined at any time the amount of organic matter either before or after the experiment.

Q. That is true. You didn't state that you had determined the amount, but you did say that there was a different amount of organic matter present at all times in the sample, from what was present in the original sample when it came from the water in the river?

A. But I am now only judging from general knowledge, 7535 that if saprophytes grow in a solution of organic material, that they live upon that organic material and if we see an increasing number of saprophytes, we know that they must have multiplied because they have been living upon and using up as food the organic material that is there, so that is a matter of experience and physical laws.

Q. We are speaking now professor, with reference to samples which you examined, and your manner of conducting the experiments with reference to a determination of the longevity of the typhoid germ in that water?

A. Yes.

Q. Now then, you stated the other day I believe, that there was a certain amount of organic matter added in the experiments?

A. Yes, I added some.

Q. And you also stated that that had the effect of producing an additional amount of saprophytic bacteria?

A. No, that I didn't do. I said it was an inappreciable amount that I added, because the amount I added was a platin loopful of a 24 hour bouillon culture, added to four ounces of river water, so in the four ounces of river water a loopful—that is a loop made by turning a small wire around the point
of a pencil, and dropping that into a bouillon culture,
7536 so that the organic matter is what there is in the film of
fluid of this loop, and that is waived through 4 ounces
of the water, so it is only an inappreciable amount of organic matter that I have added to the water. The organic matter I spoke of is that which is already in the water. This decreased in amount when favorable temperatures cause multiplication of saprophytes. I judge that this organic matter decreases because of the great increase in the number of saprophytic bacteria at certain temperatures.

Q. But to the same extent of that organic matter, it has the same effect does it not, upon the experiment?

A. That I have added by a loopful of typhoid bouillon to the 4 ounces of water.

Q. Yes.

A. No, I don't think so; that is imaginary; that is a mere trace.

Q. Well, how about the change that comes over the growth of the saprophytic bacteria? Now that destroys organic matter does it not?

A. Yes, that is the cause, no doubt, of the decrease of organic material in sewage anywhere, and in rivers, as the river flows on.

Q. Now then have you any knowledge, professor, that that decrease was going on in your bottles and in the river in a parallel condition?

A. No, I have already said before that I made no de-
7537 termination of the organic matter there, in the experi-
ments or in the river. Professor Long has determined
the organic matter in the river.

Q. Now professor, are not bacteria extremely sensitive to all changes in foods or to small changes in their foods?

A. Yes, they are.

Q. Now professor, I wish you would explain fully what you mean by the term pathogenic bacteria?

A. Disease producing bacteria.

Q. Is that all there is to it?

A. That is all; disease producing in the animal or in the human being.

Q. I will ask you professor, if you call the colon bacillus pathogenic?

A. That is sometimes virulent and sometimes it is not. That depends upon its virulence. A pathogenic germ may be virulent and may be non-virulent. For instance, the diphtheria bacillus may be virulent, producing diphtheria, and other diphtheria bacilli may not produce diphtheria.

Q. In what way would a colon bacillus produce disease?

A. Colon bacillus would probably not produce disease if it was swallowed, but would do so if it entered the tissues in large numbers from the intestine. It is normally found
7538 in about thirty varieties, in the normal intestine of animals and human beings, and it is perfectly innocent there, but if it should by accident gain access to any of the other tissues of the body it may prove pathogenic. Under such conditions it may or may not prove pathogenic. As to the swallowing of colon bacilli, this is, in my opinion not pathogenic. In fact it has been advocated recently for the treatment of chronic constipation, to drink pure cultures of colon bacilli, so those who believe in that sort of treatment might go to the drainage canal.

Q. Would you recommend that sort of treatment, as a physician?

A. No, I would not.

Q. Professor, can you draw a line of demarkation representing the point when the color bacillus becomes pathogenic?

A. Becomes virulent, you mean?

Q. Yes,—well it is not pathogenic unless it is virulent.

A. It is always considered more or less pathogenic when found anywhere in the body except in the intestine.

Q. You would not under any circumstances then, class it as a saprophyte?

A. It is a facultative saprophyte. It can exist as a saprophyte.

7539 Q. How is that?

A. It is a parasite but has the faculty of existing as a saprophyte so I call it a facultative saprophyte.

Q. Now professor, is there any sharp line between parasites and saprophytes?

A. We find that some organisms appear to be purely parasitic organisms and do not grow at all on dead organic material, so that is an obligate parasite, whereas, we find that a number of the disease producing bacteria can be made to grow on dead organic material, so those can be accustomed to live as saprophytes, that is, on dead organic material.

Q. So, you draw the line of demarkation between the two?

A. Yes, I think we ought to draw the line and we ought to say that there are some bacteria that grow only on living organic material (obligate parasites) and then there are some that live only on dead organic material and are destroyed immediately they are injected into the tissue of man or animal (obligate Saprophytes) and then there are some that stand between those extremes, favoring the living organic material but capable of existing on dead organic material. (Facultative Saprophytes).

Q. Now how is it about the typhoid and the cholera germs with reference to this proposition?

A. The typhoid bacillus is a facultative Saprophyte and 7540 has the faculty of growing on dead organic material. The cholera vibrio the same. Neither one of them, however, occurs in nature and whenever found, it must have come from the intestinal canal of a case which had the disease.

Q. Then each of the two germs is favored in its longevity by the presence of organic material?

A. Both of these germs require for their multiplication organic material. They may live in the absence of all organic material for a short time.

Q. Then professor, if it is true they require organic matter for their multiplication, is it not also true that the proper kind of organic matter as nourishment would have a tendency to increase their longevity?

A. The proper kind of organic materials will produce a better growth.

Q. Then professor, as I understand, you have studied bacterially those bacteria which produce disease?

A. Yes sir.

Q. Have you studied any other waters bacterially for the presence of pathogenic germs than those that you have testified to?

A. I did.

7541 Q. What other waters?

A. Well water of a great many different places.

Q. Any other river water?

A. Yes, I have examined some river waters for Professor Long but I cannot think what they were.

Q. Those were laboratory experiments altogether?

A. Yes all of them. In fact all of my work in this direction has been laboratory work.

Q. Have you studied bacterially any water which has been known to produce disease?

A. Yes sir.

Q. Now will you state what water that is?

A. A number of water specimens received from Professor Long.

Q. Well, what water was that?

A. Well ask him; he can tell you. I am not certain about the places.

Q. You do not know then?

A. I do not know. The question was a question of typhoid infection.

Q. You do not know whether the water came from the Atlantic ocean or the Pacific ocean?

A. I think it came from Rock Island.

Q. But you do not know?

A. I do not know; I have also examined numerous well waters from different parts of the state.

Q. Water that was known to produce disease?

7542 A. Suspected of producing disease.

Q. Did you apply to those waters the same test or a similar test to those which you have testified to?

A. In most of the cases we made plates, growing them in the incubator, and made animal experiments. Water, to which had been added bouillon, was incubated from 24 to 36 hours, and then injected into a Guinea pig, intraperitoneally, usually one cubic centimeter. If these injections proved non-pathogenic to animals, such water was usually considered harmless, but if it proved pathogenic, then other factors had to be considered to determine its dangerous or nondangerous character.

Q. What were the disease germs which you were looking for in those waters?

A. We looked for all pathogenic bacteria.

JUDGE SPRINGER: Are you speaking of this Rock Island experiment?

MR. JEFFRIES: I am speaking of the various examinations he made.

THE WITNESS: We looked for all pathogenic bacteria; that is what we made the plates for.

Q. Professor, suppose that the samples of water that you tested upon the Guinea pigs, with a view of obtaining the effect of that water when injected into Guinea pigs, proved fatal, 7543 would that necessarily mean that the water would be bad as a water supply for the human family?

A. If it proved fatal our test was not considered of much value. The test was only considered of value if the animal did not die inside of several days. When a large quantity of water is supplied with some organic material put into the incubator, the multiplication of pathogenic bacteria is favored, whereas the water bacteria are held back by their growth by the incubator temperature. If injected, the water would have to be very free of disease producing bacteria or the Guinea pig would die. This test is of value only when the animal recovers. It is a very severe test, I realize that.

Q. Professor, I want to ask you if you know whether or not the injection of typhoid bacilli into a Guinea pig will produce death?

A. Yes sir.

Q. Will it under all conditions?

A. If you use enough of it, under all conditions, providing the germ is alive of course, and virulent.

Q. Now is the same true of a colon bacillus if you use enough of it?

A. There is a difference. I don't think the two can be compared.

7544 Q. Well, state it?

A. If you inject bouillon culture of typhoid bacilli you produce no infection of the animal. The animal dies of the poisons of the typhoid bacilli, so it is a toxic effect. The animals cannot get typhoid fever. All animals are immune to typhoid fever, but when you inject the germ of typhoid into an animal, the animal dies of the poisons of the virulent germ. Now, in the colon bacillus, that is quite different. If you inject colon bacilli intraperitoneally, in bouillon culture, in large quantities, you can also kill the animal by the poisons of the colon bacillus, but usually a virulent colon bacillus will cause an infection, and the animal then lives for about five or ten days, then dies with septic peritonitis, that is purulent inflammation of the peritoneum.

Q. Then professor, a water might be perfectly harmless for drinking purposes and yet contain properties that would kill a Guinea pig if injected into it?

A. Yes, that is possible. That is the reason why you attach so little importance to the cases where the animal dies promptly. A water may contain no pathogenic, no disease producing bacteria at all, and yet kill a Guinea pig by the poisonous products of saprophytes produced by some of these germs. These germs themselves do not produce an infection but their products may be poisonous.

7545 Q. What then, professor is the value of that test for ascertaining the condition of the water for drinking purposes?

A. The value of that test is mainly this, that if an animal can live after such a test that it is pretty certain that that water will not be injurious to the person who drinks it. If such a severe test does not have any effect on a Guinea pig, then I think it would be perfectly safe to drink such water from a bacteriological standpoint.

Q. But does that signify that there is or is not pathogenic bacteria present in that water?

A. Pathogenic bacteria in the sense of the colon bacillus might be present in any water.

Q. Well, might not some other pathogenic germs be present?

A. Of course, but it is not virulent then according to the animal experiment. We also plated out this water and looked for pathogenic bacteria. We have always plated out and incubated and examined growing colonies for pathogenic bacteria and perhaps condemned at times a water on the ground of finding pathogenic bacteria there even when the animal did not die.

7546 Q. (Question repeated).

A. I said Yes.

Q. And at the same time there might be no pathogenic germs of any kind of water and yet produce death in the pig, when injected into the pig. That is, I mean pathogenic when taken into the mouth. That is true, isn't it? In other words, as I understood you, you differentiated between pathogenic germs. One might be pathogenic if injected under the skin or into the blood?

A. Pathogenic germs may be virulent and non-virulent I say.

Q. But I understood you to say professor, there might be certain saprophytic production in the water, which when injected under the skin might produce death, but which in fact is not pathogenic, is that right?

A. Yes, that is correct.

Q. Then there can be absolutely no reliance placed upon tests of this character and they mean nothing, do they?

A. Oh yes. I mentioned before that we also made plates and determined pathogenic bacteria from the plates, and secondly, if there are no pathogenic bacteria present, an animal might die anyway of the poisons produced by saprophytes.

7547 Q. Why is it condemned if there are no pathogenic germs in it?

A. Waters which are teeming with saprophytes, usually are found by the chemical test to be very bad. That is the reason.

Q. And that is the only reason?

A. That is the reason, yes. We must judge the potability of a water by three tests, first the physical characteristics of the water may be bad. Now if they are not bad, then the chemical characteristics of the water may be bad, and if both of these are good, then there still may be the third point, the bacteriological character of the water may be such as to condemn it, but the bacteriological character may be good and the others bad. Why, then of course I would condemn it on other grounds than purely bacteriological grounds.

Q. Then it is necessary to have both the chemical side as well as the bacteriological side in this present judgment of the water?

A. All three. I have always insisted on the importance of the bacteriological examination, in cases where neither a physical examination of the water nor a chemical examination reveals any danger. To illustrate: If the water contains only very
7548 few colon bacilli, a test for indol would probably be negative because there were so few colon bacilli there, but in my plates and cultures, I find colon bacilli, so really the bacteriological test is much more sensitive than the chemical test for certain impurities. On the other hand there may not be any pathogenic present although chemical tests reveal other impurities.

Q. Now then professor, going back to these injections into a Guinea pig, I will ask you if you cannot take and in any of these experiments you did not take the bacteria of all kinds, whether pathogenic or non-pathogenic and cultivate them until you had large quantities of that bacteria before the injection was made?

A. No. When you grow that water in the incubator containing the organic material and saprophytes and pathogenic bacteria,—we multiply mostly the pathogenic bacteria.

Q. We are going to eliminate the pathogenic bacteria.

A. If you grow such waters at a low temperature saprophytes will grow better than at a high temperature. At the temperature of the blood the parasitic bacteria grow best; at the temperature of the room the saprophytes grow best. At the temperature of the water, the water bacteria grow best; so it depends upon the temperature as to which one of these classes you will favor in its multiplication. Now, if you
7549 are going to favor the saprophytes, by a low temperature they overgrow the parasites.

Q. You don't understand me, professor. We take a known quantity of water coming from a certain stream. For instance we will take a quantity of water coming from one of those wells that you examined. Now the experiment is being made in your laboratory for the purpose of determining the effect of that water upon a Guinea pig. I mean by that, that you produce a multiplication of the germs contained in that water of all kinds at a temperature of the water in the wells as near as you can.

A. No, we don't do that. Only water bacteria would be favored.

Q. Well then, of what value is the test?

A. The value of the test is in favoring the multiplication of disease producing bacteria. We leave the saprophytes to the chemist. We want to determine simply, are there disease producing organisms present in that water; therefore we favor the growth of the pathogenic bacteria and retard the growth of the saprophytes by growing the water at blood or incubator temperature.

Q. Do you know whether or not all pathogenic germs increase at the same temperature, or require the same temperature?

A. As a rule, all disease producing bacteria have for their optimum temperature, the temperature of the human blood.

7550 Q. Then you use that temperature?

A. Yes sir.

Q. In determining the bacterial contents of the water?

A. We enrich the water in pathogenic bacteria and retard the others by the incubator temperature.

Q. Now, professor, a moment ago we eliminated all pathogenic bacteria from that water. Then you take the water and you must multiply in your experiment the bacteria that is in the water, at what temperature?

A. At 37 degrees which would be the same as blood temperature.

Q. Now you increase the bacteria until you have more in a certain given quantity than really exists in the water?

A. Yes, saprophytes increase some also. There is no question about that. Although the temperature of 37 is unfavorable to the saprophytes. That is the point. It is unfavorable, so they wouldn't multiply very much. Now if the animal dies and we find no bacteria at all in the peritoneal cavity, and it has died very rapidly, we know of course that it has been killed by toxins or poisons that were in that water and yet we may not find in our plates any disease producing bacteria. If there were disease producing bacteria present and they were virulent,

they would multiply more rapidly at 37° C. and overgrow the saprophytes and we could find them in the test. If the animal is infected, we find the germs in the blood of the animal
7551 and in the spleen or in the purulent exudate of the peritoneum in great quantities. In fact that is a common finding in infected animals always, if they do not die right away. If they do die right away we know nothing.

Q. Do you know professor, what the infection was in the water that you examined from these wells, any particular one?

A. Yes, they were mostly proteus and colon. They were mostly saprophytes and colon bacillus.

Q. I mean what was it that caused the water to become suspicious, in other words was it typhoid fever?

A. I don't know.

Q. Have you ever examined the water in any well that has been charged with being infected with typhoid bacillus?

A. Yes sir.

Q. In your examinations of that water did you discover any typhoid bacilli?

A. Never.

Q. Have you in your investigations of any typhoid infected water ever been able to discover in your investigations the typhoid bacillus?

A. I have not except in laboratory experiments when I infected a water with typhoid bacilli.

Q. Professor, is your Guinea pig method one that is actually used by sanitarians in determining the value of water
7552 for domestic purposes?

A. Will you let me add something to my answer to the former question?

Q. Yes.

A. In regard to the finding of typhoid bacilli in supposedly infected wells, I want to add here that I had excellent opportunities at one time. It was in Wisconsin where about sixty cases of typhoid fever occurred in a small hamlet which all seemed to be traced to drinking the water of a certain well, after the arrival in this little hamlet of one person who had been infected with typhoid fever several hundred miles away. In that particular instance it was almost certain that a certain well had been polluted with discharges of this case and was a source of infection in all the cases but at no time was I able to find any typhoid bacilius in this well water.

Q. But from your inability to find them you do not say that they were not in the water?

A. No, I couldn't do that.

Q. You are reasonably certain that the water in that well was typhoid infected?

A. I think we were reasonably certain because people who drank from other wells in the neighborhood were not infected. In one family alone there were six cases of typhoid, two of which died. I reasoned the time of incubation had been sufficient to allow the typhoid bacilli to disappear from the
7553 well water. What became of the typhoid bacilli in this well
water? Why weren't they there any more? If we figure that it takes two weeks to infect, it almost seems as if those weeks had been enough to wipe out the typhoid bacteria that must have been in there, to judge from the whole history of this epidemic. I believe the cause why we did not find the typhoid bacillus is, aside from the difficulty of finding it in small quantities of water, that we never examined that water until the epidemic had already existed for several weeks, and after that time the typhoid bacilli seem to have disappeared. Most of the investigators who examined water in districts where the typhoid infection seems to have been positively traced to the water supply were unable to find them any more.

Q. Now professor, did you examine that water at the time those persons were sick with the fever?

A. Yes, I treated them for six or eight weeks.

Q. Did they cease the use of the water?

A. Yes sir.

Q. Then you cannot measure the appearance or disappearance of typhoid fever germs in that water?

A. When I examined that water, it was several weeks after the epidemic had broken out, probably two or three weeks.

Q. After you had examined it, did you then pronounce to the users of that water that it was good water and that they might then resume the use of it?

7554 A. We condemned the water on suspicion at that time, already before I examined it.

Q. But after you had examined it and failed to find typhoid germs in that water, did you tell those people that they might commence the use of it again?

A. I did not.

Q. Did you not tell them to remove the water from the well?

A. I told them not to use the water.

Q. And they did not.

A. Yes, they did. That is a fact; they did, and it was finally proven that our warnings were not heeded. This epidemic ceased just as quickly as it had come after sixty or eighty cases, I think, had all run their course. It was clearly brought there by one case that came home ill, and everything started from that well. It was such an ideal case for tracing the infection to the drinking water that I was very diligent at that time to find typhoid bacilli in the water.

Q. Now how many tests did you make for the purpose of observing the typhoid bacilli in that water?

A. I plated out probably 250 times.

Q. And found no typhoid bacillus?

A. No, but in some of my cases of typhoid fever, I could
7555 not find them in the excrements either, frequently.

Q. But you do not doubt that they were there?

A. Well, they are at some times but not at all times.

Q. It depends on the stage of the case?

A. It depends on the stage of the case and the number of bacteria in the stools.

Q. And the stage of the disease?

A. There are certain times in the infection when you do find them and at other times you do not.

Q. Did you make Guinea pig tests in those cases?

A. I did not in any of those. They were simply plated out in agar plates; that is all I used at that time, and afterwards I took the suspicious colonies and ran them through to see if I would be able to identify them as typhoid bacilli.

JUDGE SPRINGER: Will you give the name of this place?

A. Little Black, Wisconsin.

Q. What year?

A. Ten or twelve years ago—ten years ago, about.

Q. MR. JEFFRIES: I will ask you professor, which 7556 then is the better test to determine whether or not water is typhoid infected or whether it is infected with disease germs, the bacteriological examination of that water, or the effect of the water upon the persons who use it for drinking and domestic purposes?

A. I think that it is pretty hopeless to examine water for typhoid bacilli.

Q. Then the effect of the water upon the human system is the better test, and in fact is the only test?

A. Upon the human system in regard to typhoid you mean?

Q. Yes, and water-borne diseases?

A. I couldn't make such tests.

Q. Well the experience of the people who use the water for domestic purposes is a better test for the determination of whether or not it contains infected material, disease germs, than any bacterial analyses of the water, is it not?

A. No, the bacteriological examination for disease producing bacteria is the better test.

Q. Then professor, even though you should know that a certain well had had poured into it a certain amount of typhoid infected matter and you had made various bacterial analyses of that water and had been unable to find the presence of typhoid germs in your examination, would you pronounce that water perfectly safe, and would you consider that a far better test 7557 with reference to the sanitary condition of that water, than the effect that that water had upon the people who drank it?

A. I didn't make any such statement anywhere. Now in answer to your last question I will have to say again that the bacteriological test is only one of the tests employed in judging a water; and I do not want to be understood as urging a bacteriological test alone as to the potability of water. I want to be understood as saying that it is a most valuable test to determine the disease producing bacteria present in water. I have stated also the difficulty of finding typhoid bacilli at times of epidemics in suspected water supplies.

Q. Professor, we have a certain well. You are called upon to determine the sanitary condition of the water in that well.

A. I wouldn't determine it by a bacteriological examination alone.

Q. With reference to whether or not it contains disease germs of any character. You are told that bacterial investigations have been accurately made, or as accurately as the science of bacteriology can make them, limited in number of course. You are also told that from the use of the water by the people, it has produced certain effects. In other words the effect of the water upon the human system when taken into it and the result of the
bacterial analyses are not disclosed to you at all, and you
7558 are asked the question, Which do you prefer in order to
pass judgment upon that water. We do not propose to give you the opportunity to use both, but which of the two means is the better and which of the two would you call for, the effect of the water upon the human system of those who drink it, or the result of the bacterial analysis standing alone, the two standing alone?

A. I wouldn't pass my opinion on one point alone. I would want in a case like that, where I was to decide as to the sanitary question of water being used, not to pass any opinion as to the potability of the water unless I had all the data, physical, chemical and bacteriological, and if those were lacking why I might prohibit the use of the water on general suspicion.

Q. Then professor, you do not consider the fact that a certain water producing the typhoid disease when used for domestic purposes and that fact alone as being sufficient to condemn a water that is used in that way?

JUDGE SPRINGER: I object to the question because he has stated specifically that he would condemn it on suspicion.

A. Yes sir, I did that.

Q. MR. JEFFRIES: Now then, which of the two tests, the bacterial test or the actual results, or the actual experience
of the people who drink the water, is the better?
7559 A. If I knew that a certain water was exposed to all
sorts of pollutions, even if a complete purification of those pollutions took place again, conditions as they exist in rivers generally, with continuous and repeated pollutions by all sources, and in such river water, I didn't find bacteriologically, chemically or physically, evidences of disease, I would still prohibit

that water, but I think I would prohibit that water on general suspicion, as not fit to be used as drinking water because every river is exposed to continual pollutions, even if no sewage at all enters it. River water used for domestic purposes should always be filtered.

Q. Professor, let us eliminate all physical conditions. Let us eliminate everything except the water itself contained in a well for instance and you are told that the water is typhoid infected because the people who drink it were made sick of typhoid fever, would you consider it necessary to call upon a bacteriological analysis of the water before you condemned it?

A. No sir, that is just the point and the reason for my former statement. I would condemn the water on the experience you mention, just the same as I would condemn any river water that was not filtered, for the use of any city, even
7560 if it had not received sewage.

Q. We are talking about water in a well now.

A. The conditions are the same with regard to condemnation of a water on suspicion.

Q. Suppose you are called upon to pass an opinion upon the sanitary condition of a water in a well, what is the first question or the first condition that you inquire into?

A. I think I have stated before that I would not undertake to decide the sanitary condition and potability of the water on bacteriological examination alone.

Q. I am not talking about the potability of the water, but as to the quality of the water?

A. I would have nothing to do with such an investigation except the bacteriological side of it.

Q. I want to see how far you rely and how much confidence you have in the bacterial analysis of water?

A. I think I can easily answer that.

Q. I want to know whether or not you would put more reliance upon your bacterial analysis of the water than you would upon the effect of the wa[illegible] upon the people who drank it, if its effects were known?

A. I think that if I was able to make such a test, an animal test, as I have described, with that water, without producing any effects upon the animal, whatever, I think that I would be willing to drink that water.

7561 Q. You have not answered that question, professor?

A. That is not excluding even the presence of small numbers of typhoid bacilli in that water.

Q. Now professor, I am confining you to two tests, one the experience of the people who use the water and the other your bacteriological examination of that water, which of the two would you place the more reliance on, the bacteriological analysis of the water or the experience of the people who drank it?

A. What do you mean by the experience of the people who drank it?

Q. Well the experience with reference to the condition of disease.

A. That may be all imagination on the part of the people who drink it. That may be pure imagination. People frequently attribute various affections to water, and it is usually something entirely different which has made them sick. They always imagine when they go from one place to another and eat and drink all sorts of things that it is the change of water that has made them sick. You hear that constantly.

Q. Supposing, though, professor, it should be determined by persons capable of making an examination that the water from the well was the cause of typhoid fever and that the typhoid fever was the experience of the people in drinking
7562 the water, which of the two tests would you consider the most reliable?

JUDGE SPRINGER: I object to the question.

A. If it had been the supposed experience, even the suspicion that the water was the cause of an epidemic I would prohibit the use of that water on suspicion.

Q. Then that would be the better test, the experience.

A. That is no test. It is only a safeguard against suspected danger.

Q. Now you stated a moment ago that if you had examined the water of the well about which we spoke and had tried the guinea pig test and found that it produced no bad results,in other words did not produce the death of the pig, that you would have pronounced the water good?

A. No symptoms of any infection, no elevated temperature, no decrease of weight in the animal, yes.

Q. Now might not those experiments have been made and the water contain typhoid germs, and yet no serious results have been produced upon the pig?

A. Yes but then they would be present in very small number. You refer now to the fact that I use only comparatively little water, and, therefore, would inject but few typhoid bacilli whigh might not produce the death of the guinea pig, and yet there would have been typhoid bacilli in the water. Now if they are so much diluted and in such small numbers 7563 as that, I have some serious doubt whether they could in fact produce a direct infection by drinking such water. It is my opinion that they would not produce infection. I have stated in this testimony that I did not believe in the direct infection by water as much as in the indirect infection by polluted water containing very few typhoid bacilli, reaching and multiplying upon favorable culture media, and this culture media, vegetables, milk, etc., being swallowed by the patient who then becomes infected.

Q. Professor, take this well in Wisconsin which you examined?

A. If I had examined the milk in that case I might have found something, but I didn't.

Q. I understood you to say that you felt reasonably certain that the typhoid fever came from the well?

A. At that time, yes.

Q. Now assuming that it did come from the well, cutting out all possibility. making the assumption that it did come from the well, are you reasonably certain if you had applied your tests of that water upon Guinea pigs, that it would have produced death?

A. I am certain it would not have produced death by typhoid toxin.

Q. Because you did not find typhoid in it?

A. Yes.

ADJOURNED until 2.00 P. M., same day, Oct. 5, 1903.

2:00 P. M., Monday, October 5th, 1903.

7564 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. F. ROBERT ZEIT,

resumed the stand for further cross-examination by Mr. Jeffries and testified as follows:

Q. Professor, do you know whether or not it is a fact that cities using water containing small amounts of sewage have higher death rates from certain causes than cities using water containing no sewage?

A. I think that is true. Intestinal diseases particularly. That is when unfiltered water is used.

Q. Now then, do you know whether or not it is a fact that cities using water of much sewage have higher death rates from certain diseases than other cities using water containing smaller amounts of sewage?

A. I should judge that that is the case. Intestinal diseases particularly, where unfiltered river water is used will be more numerous when there is much fresh sewage entering it at a place shortly above the intake.

7565 Q. Professor, what do you say as to the hygienic effect of the organic matter contained in the Chicago sewage?

A. The hygienic effect?

Q. Yes?

A. It is no doubt there, and the Chicago sewage should not be drank. I don't know if I understood your question, Mr. Jeffries?

Q. I think you do. In other words, what do you say as to the hygienic effect of the organic matter contained in the Chicago sewage?

A. What do you mean by hygienic effect?

Q. Well, supposing it is to be used for drinking purposes?

JUDGE SPRINGER: Have on the health of the people drinking it you mean?

Q. MR. JEFFDIES: Hygienic effect?

A. I should judge that if there was so much organic matter in the water, there also would be large quantities of saprophytic organisms, which could produce substances that bring about intestinal diseases ,aside from any pathogenic bacteria.

Q. Aside from the presence of pathogenic germs?

A. Yes.

Q. Yes. Now then, professor, does this organic matter
7566 in distinction from the organisms which accompany it, have any qualities which make it injurious to health?

A. I would leave that to the sanitarian and to the chemist to decide.

Q. Suppose, professor, that the chemist should say that there were certain living organisms accompanying the organic matter, certain living organisms the nature of which he could not tell, accompanying these organic matters down the waters of the river, is there anything in bacteriology that would determine the character of those organisms as to whether they were pathogenic or non-pathogenic?

A. Yes. I could determine whether they were pathogenic or non-pathogenic.

Q. That is on condition that you could make an analysis that would directly portray the condition of those organisms throughout the whole year?

A. Yes, although also my individual sample might prove to contain such pathogenic bacteria.

Q. And it might contain pathogenic germs, and yet they not be detected, might it not?

A. If the pathogenic germs would be greatly diluted, they could escape detection.

7567 Q. And there might be a great many pathogenic germs contained in those living organisms following the organic matter which even could not be detected from a bacteriological examination of the water?

A. No, if there is much organic matter there would be much saprophytic life there. The saprophytic bacteria would increase at such a tremendous rate that the other bacteria which produce disease, the pathogenic bacteria, would be overgrown,—not that there is a lack of food supply for them, but they are simply overgrown, annihilated by the great increase of other bacteria which are found to multiply in that organic matter.

Q. Now what do mean, professor, by the term "overgrowth of the saprophytic bacteria?"

A. They would increase at the temperature of water much more rapidly than the pathogenic bacteria, which would not multiply at all at the temperature of the water, while pathogenic germs need not be directly killed, they would certainly not multiply at the temperature of water, whereas, the other saprophytic and water bacteria would multiply and they would increase in the presence of organic matter at such a tremendous rate that they would overgrow the pathogenic bacteria. To illustrate: If we take grass seeds and we take the seed of one tropical and
delicate plant, which can only grow in a different climate
7568 under a different temperature, and you sow them all out
together, the conditions of temperature will be favorable to the grass seeds, and they will be growing up rapidly and exterminate by their overgrowth the more delicate plant or flower. So it is with disease producing bacteria, when they are mixed with saprophytes or when they are mixed with water bacteria and exposed to a temperature unfavorable to the growth of disease producing germs, but very favorable for the rapid multiplication of saprophytes whose dense growth make life and existence impossible for the disease producing germ. In my opinion that is the most important cause of the disappearance of pathogenic bacteria, even in laboratory experiments. We see the same competition of micro-organisms in the laboratory daily, when we sow out a mixture of three or four germs and the conditions of temperature for one are more favorable than for the other. Some will be wiped out by others for which the temperature is more favorable. The same occurs in water into which equal quantities of germs have been inoculated. When this water is plated out, some of them will grow so thickly as not to allow the others to appear at all, yet we know they have been alive and know they were there, and yet they cannot grow. They disappear.

Q. Now eliminating the large quantities of organic matter
from the water and assuming that there is only a small
7569 quantity of organic matter in the water, that does not
necessarily imply that there are no living pathogenic bacteria in that water, does it?

A. No, in fact that would rather favor their persistence there. The less organic material, the less saprophytic life, the longer the pathogenic germs are capable of existing there, even if they can not multiply on account of the low temperature of water. If there are but few other bacteria present, pathogenic germs will live longer and it will take a longer time before they are destroyed than if there were billions and billions of the saprophytes, making it impossible for pathogenic germs to exist.

Q. What then, professor, in your opinion is the active principal of water that is not wholesome?

A. Bacteriologically speaking, it is the presence of disease producing micro-organisms, or even the presence of saprophytic bacteria in great number.

Q. Now then, state plainly again how the presence of both characters of bacteria which you have just mentioned, produce disease. In other words, the pathogenic bacteria and the saprophytic bacteria?

A. If pathogenic bacteria are in the water and have not died there yet, they will be distributed and separated more
7570 or less by dilution, according to the different conditions
existing for dilution and then require mostly, for their pathogenic effect, of first meeting with a favorable temperature, and favorable culture media, before they produce an infection. If a very pure water and a very potable water is infected with pathogenic bacteria, a water tolerably free from organic material they would live longer than in a badly polluted water with much organic material. Now, even under the latter conditions there would be a large separation by dilution, which is probably the reason why we do not find them, so they would be separated so far apart from each other that in order to produce an infection it would be necessary that they should first meet conditions favorable for multiplication. Take the case of the typhoid bacillus, one germ might be in a barrel of water and if that one germ happened to get into a milk can, during a hot summer day, for 24 hours perhaps, this bacillus would find in the milk a favorable culture medium, and the persons drinking that milk would drink a culture of typhoid bacilli; whereas, one would have to drink all that water to get one baccillus, and further one germ alone would not produce an infection. Numbers are

very essential to produce an infection. In order to produce typhoid fever the germ must be swallowed, it must be virulent; it must be swallowed in great enough numbers, and even 7571 then the resistent forces of the organism must be decreased. We see occasionally, where the infection has been traced to milk, that some people partaking of it develop typhoid fever and others do not.

Q. Now professor, in view of what you have just stated, I will ask you what effect, aside from dilution, that the discharge of 250,000 cubic feet of water per minute through the main drainage canal, has had upon the sewage of Chicago, assuming that prior to the opening of the canal the diluted substances containing the sewage of Chicago passed through the canal at the rate of 35,000 cubic feet per minute, and that the discharge in both instances passes down the Illinos river. Do you understand the question?

A. Yes. I think so. That is very hard to answer. I should judge that the less the dilution the more rapid will be the multiplication of saprophytes, and the destruction of the organic material but the greater the dilution the slower will be the destruction of organic material by saprophytes. In other words, if you have much organic material, you favor the growth 7572 of great quantities of saprophytes, and they dispose of the organic material more rapidly than if you spread them over large areas and allow the saprophytes to attack it there.

Q. State professor, what difference there would be in the longevity of pathogenic germs, or disease producing germs in those two streams of water which I have just mentioned?

A. I have no data as to that and this would be merely speculative, if I wanted to compare that. I will however, in a general way try to answer you.

Q. That is what I want

A. I will say what I have said several times, that the more organic material there is, the more rapid the destruction of the pathogenic bacteria, so the dilution of the organic material does not increase the rapidity of destruction of pathogenic bacteria. In fact it would rather tend to decrease it. If we place pathogenic bacteria in sterilized water, where no other bacteria are present, they live longer than if we put them into the worst sewage contaminated water. The purer the water the longer the life of the pathogenic germ. By purer I mean less organic matter, therefore less saprophytes.

Q. So that with two streams flowing side by side, carrying the sewage from the city of Chicago, or three-fourths of the sewage from the city of Chicago, with a population of 1,600,000 people, the one existing in a diluted condition with the
7573 flow limited to 250,000 cubic feet of water per minute; the
other stream limited to a flow of 35,000 cubic feet per minute, if I understand you, you say that the disease producing germs will disappear much more rapidly in the smaller stream than in the larger?

A. Yes sir.

By agreement of counsel witness Professor F. Robert Zeit is temporarily withdrawn from the stand, and witness Wm. S. Sayer is permitted to testify at this time in view of the fact that he is about to leave the city and will be absent for three months.

7574

WILLIAM S. SAYER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Springer and testified as follows:

Q. State your name, residence and occupation?

A. My name is William S. Sayer.

Q. Your residence?

A. My present residence is 619 West 66th Street.

Q. Chicago?

A. Chicago.

Q. What is your occupation?

A. I am employed by the Kennicott Water Softener Company.

Q. Where were you educated?

A. I took my college course at Beloit College.

Q. How long were you there?

A. Four years.

Q. After your college course did you attend any other university?

A. I attended the University of Chicago.

Q. How long?

A. I begun the first of January, 1900, and was there until the beginning of this work.

7575 Q. Beginning of this work here; what was that date?

A. October 1st, 1901.

Q. Nearly two years?

A. Yes.

Q. What was the nature of your studies at the University of Chicago?

A. My work was chemistry and bacteriology.

Q. State what amount of bacteriological work you performed, if any, during that period?

A. Well, my work covered all of the courses given in the non-pathogenic and pathogenic bacteriology, under Dr. Jordan and Dr. Davis and others connected with that department.

Q. Did that include the asecrtainment of the number of bacteria in given quantities of water?

A. It did.

Q. Were you able to by that instruction, to make such ascertainments?

A. I was.

Q. State whether you received any instructions from anyone in the latter part of 1901, to make certain bacteriological examinations of water, and if so, where?

A. I was instructed by Dr. Jordan under the direction of Mr. Irons, to go to Grafton, and proceed with this work.

Q. Well, what did you do at Grafton?

7576 A. We established a laboratory at Grafton, and during the period from October 1st until about the 25th of December, we made daily analyses of the water, bacteriological analyses of the water of the Mississippi river, of the Illinois river—

Q. From what points were those samples taken that you analyzed or examined?

A. The sample from the Illinois river was taken about three miles, I think, from the mouth of the Illinois river.

Q. Was it above any possible mixing of the waters of the Mississippi river water?

A. It was.

Q. And where were the others taken?

A. The Mississippi samples were for the most part taken near the government dyke, near the mouth of the Illinois river.

Q. How far above the mouth of the Illinois river was that?

A. It was very near the government dyke, but the Mississippi river is some eight or ten inches higher than the Illinois river, so that there was no possible means of contamination or mixing.

Q. Who took the samples from the water?

A. Mr. B. F. Robinson, took most of these samples.

Q. Were you with him at the time?

A. I was with him most of the time during the first two
7577 months and once or twice a week during the last month.

Q. And what did you see so far as what was being done by Mr. Robinson, and yourself, in regard to the taking of the samples, what method did you pursue?

A. We took all samples in bottles which had been previously sterilized by subjecting to a temperature of 170 degrees, dry temperature—

Q. Fahrenheit?

A. Centigrade. And these bottles, after sterilization, were used for the taking of the samples.

Q. How many samples did you take each day?

A. One sample from each of the two rivers.

Q. Each day during this period?

A. Yes, Sundays excepted.

Q. From what part of the stream did you take them?

A. We took the Illinois from mid-stream, and the Mississippi perhaps a little bit to one side, but it was near the center of the current.

Q. How far down below the surface did you get the water?

A. About six or eight inches.

Q. What kind of an instrument did you use for that purpose?

A. These samples were taken by hand.

7578 Q. What did you do when you took the samples out of the water, what did you do with them?

A. They were taken to the laboratory as soon as possible, in order to make the detrmination within the hour. These determinations were all made with very few exceptions, within an hour of the time of taking.

Q. Now what was the nature of the determinations that you made of those samples?

A. The principal determination was a count, an enumeration of the bacteria developed on gelatin plates.

Q. Had you had sufficient experience in developing numerical bacteria upon gelatin plates to ascertain accurately the presence of bacteria in the samples that you examined?

MR. JEFFRIES: That is objected to. Let him state his qualifications.

A. I think Dr. Jordan perhaps will answer for that.

Q. Well you did make them in that way?

A. Yes sir.

Q. During nearly two years time that you were with Professor Jordan, did any of your work cover this kind of ascertainment?

A. It did.

Q. How much of it?

7579 A. Why simply in the course, we make the routine examination of waters and then take a period of some months, I was working in Dr. Jordan's laboratory under Mr. Irons; before this period I worked in Dr. Jordan's laboratory as an assistant.

Q. MR. JEFFRIES: With whom?

A. Mr. Irons.

MR. DRENNAN: How long as an assistant?

A. I think it was two months, I am not certain.

Q. JUDGE SPRINGER: Well, how did you record, if at all, the results of your examinations?

A. We were furnished blanks which have been submitted, and all of the results were submitted on these blanks, printed blanks.

Q. I will hand you this paper, and you may state whether that is ones of the blanks and whether the others were of the same character, which were furnished you?

A. This is one of my blanks, with my signature.

Q. Just explain now, generally, what this blank provided for, and what you did in order to fill it up?

A. The blank provides for the date, the number of the sample, source of water, hour of collection, hour of examination, temperature of the water; temperature of the air; the amount of dilution, the number of bacteria per cubic centimeter, and other remarks. Some of these I believe contain additional information. 7580

MR. JEFFRIES: Let me look at that sheet.

THE WITNESS: Some of the later sheets contain more information I believe, than that. That was the first week's work.

JUDGE SPRINGER: I hand you also several other blanks of the same kind, numbering in all I believe, 18. State whether those are the blanks that you received, and whether the writing on these blanks was entered upon them by you?

A. These were the blanks furnished to me and this is my work.

Q. You did that writing yourself?

A. I did.

Q. State whether the tables which I have shown you contain a correct statement of the facts purporting to be recorded in them?

A. This work is correct so far as we were able to determine.

Q. And these tables are correct ascertainments of the results which you obtained in the examinations which you made during that period?

A. Yes, as near as could be made. You will find duplicate sheets for part of them.

Q. Professor Jordan has them?

A. The first sheet here for Mississippi and Illinois river, I believe, and the later sheets give the Illinois on one sheet and the Mississippi on another.

7581 Q. Those are the originals?

A. These I believe to be the originals.

MR. JEFFRIES: I want to know which refer to the Illinois river, which refer to the Missouri river and which refer to both.

JUDGE SPRINGER: They are right here on the face of it, Illinois river at Grafton, and the Mississippi river at Grafton.

Q. State whether each sheet contains the result of your examinations of the water of the Illinois at Grafton, at the points you have indicated before, and the Mississippi river at Grafton, on the dates stated therein?

A. I don't want to put this down for evidence. I think you mean—

Q. I want to know whether this sheet has on it both the Mississippi and the Illinois rivers at Grafton?

A. Some of the sheets have both; some of the sheets are made out for the Illinois exclusively and some for the Mississippi exclusively.

Q. Is that fact stated on the sheets themselves?

A. It is.

MR. JEFFRIES: If one set of sheets contain the whole information what is the use of putting all in?

MR. DRENNAN: They do not.

7582 THE WITNESS: There is no duplication here, I believe.

JUDGE SPRINGER: It requires all of these sheets to correctly set forth all the bacteriological examinations that you made?

A. I believe it does.

Q. And they do contain all, do they that you made during that period?

A. So far as regards enumeration, they do.

Q. Was there any determination made under what is known as the fermentation test?

A. There was.

Q. What did you do with those sheets?

A. I turned all of those sheets into Dr. Jordan.

Q. And when those sheets shall be presented by him with your signature, as it is here they would contain the fermentation tests that you made at that time?

A. They would.

MR. JEFFRIES: I object to the question for the reason that the witness cannot tell now what they contain, since they passed out of his hands.

Q. JUDGE SPRINGER: Have you indicated upon these plates the facts which are called for in the blank at the head of each of these columns, as for instance, source of the water

and the date of collection and so on, temperature and
7583 so on?

A. The blanks have been to a certain extent modified to suit the work as it was carried out.

Q. To correspond with the facts?

A. Well, to correspond with the method of work. These blanks were not exactly suited to our work.

Q. The blank was not exactly suitable, but you have corrected it so it does correspond?

A. Yes sir.

Q. So that these sheets then do show all of the facts as stated on them, according to the manner of our ascertaining them?

A. I believe they do.

JUDGE SPRINGER: I want it understood that he may read them in evidence, each one of them, or it may be considered as having been read in evidence. I want to put these in evidence. I don't want them offered for identification, because they are evidence; they are the original plates; they prove what they are on the back of them, and I want the record to show that they are read in evidence.

MR. JEFFRIES: I object to the reading of the tables into the record or to their being introduced as exhibits for the reason that the proper foundation has not been laid so as to constitute evidence upon any of the issues involved in this
7584 case.

JUDGE SPRINGER: The record will show that the witness read these sheets, beginning with 1 to the end, and they are as follows:

(It is this 3rd day of December, 1903, agreed by counsel that these sheets shall be marked by the Commissioner Defendants' Exhibit F, for identification sheets 1 to 18, and that witnesses may hereafter draw conclusions from these records as if they were here set out in extenso, but that said exhibits need not be printed.

JAMES TODD,
Counsel Sanitary District.
H. CREA,
Representing State of Illinois.
SAM. B. JEFFRIES,
Ass't Att'y-Gen., State of Mo.)

7585 MR. JEFFRIES: I object for the reasons before stated, to their being read in evidence.

CROSS-EXAMINATION.

By Mr. Jeffries.

Q. What is your name?

A. William S. Sayer.

Q. Are you connected with Professor Jordan now in any way?

A. I am not.

Q. How long has it been since you have been working for him?

A. I have not worked for him since the close of this work, in January, 1902, although I worked under him for six months after that, that is doing the bacteriological work.

Q. What was your relation to Mr. Irons?

A. Mr. Irons visited the laboratory at Grafton periodically, while I was there. I had charge of the laboratory and he inspected the laboratory about once a week.

Q. You did not collect all the samples of water yourself?

A. I did not.

Q. What was your relation to Professor Jordan at that time?

A. All of my work was done under Professor Jordan's direction.

7586 Q. How many assistants did you have?

A. One.

Q. Did he assist you all the time; was he there with you all the time?

A. After the first month he was with me all the time.

Q. Now how long was he with you?

A. About two months · approximately. I don't know whether I quite understood your last question. He helped me all the time, but he gave his entire time for the first part of the period.

Q. Who was that?

A. Mr. B. F. Robinson.

Q. Did you ever go off and leave Mr. Robinson in charge?

A. No sir.

Q. You were there with him all the time?

A. I was there whenever there was any work done, all of the time.

Q. State again the time of the year that these samples were taken?

A. These samples were taken beginning with October 1st, and continuing then for nearly three months.

Q. Do you know the exact date that the last sample was taken?

A. I am not positive; I believe it to have been December 24th.

Q. December 24th?

7587 A. December 24th.

Q. Was it not December 20th?

A. As I have said, I am not positive, but I believe it to have been the day before Christmas.

Q. Well, you were ordered to stop at that time, were you not, by Professor Jordan?

A. We were ordered to stop at about that time.

Q. What was the stage apparently of the water in the Illinois river during that time; it ran practically the same did it not during the whole time?

A. You mean the water level?

Q. Yes.

A. The river was rather low as will be shown by my reports.

Q. During the whole time?

A. During nearly all of the time, excepting the first part of the period. I cannot state how long.

RE-DIRECT-EXAMINATION,

By Judge Springer.

Q. I believe you stated that you were personally cognizant of the fact that these samples came from the places indicated on this blank?

A. I saw most of the samples taken and this would itself
7588 show whether the others were taken similarly.

Q. And those that you didn't take personally were handed to you by the person that did take them?

A. They were.

Q. Mr. Robinson?

A. Mr. Robinson.

Q. I believe you stated that within an hour after you had taken them you had plated them on this—

MR. JEFFRIES: Objected to as leading.

I move to strike out the tables so read in evidence for the reason that the proper foundation has not been laid for their introduction as would make any evidence in this case.

MR. DRENNAN: We think the foundation sufficient, so we will stand by them.

It is hereby stipulated and agreed between counsel for both parties, that the witness Mr. William S. Sayer shall not be required to sign his testimony, but that the same shall be examined by the Commissioner, and the Commissioner shall be permitted to make any corrections that may be necessary to correspond with the testimony as given by the witness, such as typographical errors, and the evidence when so corrected and certified by the Commissioner shall be read and considered in evidence the same as though signed by the witness.

7589 Professor Zeit resumed the stand for further cross-examination by Mr. Jeffries.

Q. Assuming professor, that all the sewage of the city of Chicago was discharged into the Illinois river in a diluted condition, or in a diluted state of sewage and water amounting to a flow of 35,00 cubic feet per minute, what effect would the addition of 250,000 cubic feet of water per minute have upon the life and longevity of disease producing bacteria contained in the sewage of Chicago?

JUDGE SPRINGER: I object to this question upon the ground that it doesn't state the point in the Illinois river at which this assumed sewage of Chicago is emptied into the Illinois river, and further that it does not state the place at which the dilution was added to the sewage content.

A. I think I have answered that in a general way before.

Q. No, not in the way the question is put.

A. The greater the dilution the longer the life of pathogenic bacteria, but as to the possibility of infections, the greater the dilution the less the possibility for direct infection, on account of the greater dilution. If you turn a thousand typhoid

bacilli from a case of typhoid fever into a badly polluted stream with very much sewage, then they will die sooner, than if you pour a thousand bacilli into a stream that does not have sewage otherwise, except from the discharge of the typhoid fever
patient. The more water, the greater the dilution; the
7590 further will be separated the individual bacilli and, there-
fore, also the less the danger of direct infection by the typhoid bacilli, on account of the smaller number.

Q. But what effect has that upon the life of the typhoid germ, the disease producing germ; that is the question?

A. I gave that. It will live longer when there is no sewage than where there is sewage.

Q. Then professor, with the additional flow of water, the disease producing germs will flow much longer in the water than they will in a lesser volume of water?

MR. DRENNAN: I object to the question because it does not specify the character of the water.

MR. JEFFRIES: Under the hypotheses first stated, assuming that the sewage of Chicago went through two streams, one with a capacity of 35,000 cubic feet per minute; the other stream at the capacity of, and at the rate of 250,000 cubic feet per minute—

MR. DRENNAN: I object to the question unless it is specified that it is the quality of water that flows in the streams, the drainage canal and the Illinois river.

MR. JEFFRIES: What do you mean by quality?

MR. DRENNAN: The same water.

MR. JEFFRIES: I don't care whether it is the same kind
of water or not. I presume counsel for defendants do not
7591 take the position that Chicago emits 35,000 cubic feet
per minute of pure sewage?

MR. DRENNAN: No, we don't admit that.

Q. (Question repeated).

A. A typhoid bacillus will live longer in a water not seriously polluted by sewage, than in another water that is seriously polluted by sewage.

Q. Then in this particular instance that I have mentioned, the typhoid germs and the disease producing germs will live much longer in the one containing the larger flow, will they not?

A. The one having the greatest dilution; it will.

Q. Well, which one would have the greatest dilution?

A. The one that receives the most water.

Q. The one that had a flow of 250,000, or the one that had the 35,000 flow?

A. Well, the one with the 250,000.

Q. Now professor, would not the addition then of 215,000 cubic feet per minute, have some effect upon the zone of purification in the river?

A. You are asking me again questions on sanitation,
7592 not purely bacteriological questions. A river water of
sufficient quantity to dilute the sewage water fifteen times with a flow of at least six-tenths meter per second permits sedimentation banks of sewage to be formed. No putrefaction or stench forms, which, however, is the case in the drainage canal, no algae or fishes are destroyed, which is the case in the drainage canal. The chemical impurities becomes insignificant as the dilution becomes greater than the ratio given and the bacterial impurities, of course, remain longer, but also disappear in what I have been terming here, the purification zone.

Q. In other words, they disappear in the quantity of bacteria contained in the known volume of that water?

A. We cannot find them any more.

Q. Now do I understand you to take this position, professor, that the sanitary condition of a water does not necessarily mean that water is free from disease-producing germs, but that they have been so distributed by dilution, as to disenable the bacteriologists to discover them in his analyses of that water?

A. Yes, that is true.

Q. That is your position, is it?

7593 A. For a certain length of time, as I have mentioned be-
fore, and as seen in my experiments. I believe that typhoid bacilli can exist in a slightly polluted water for some time.

Q. And just as the other bacteria decreases the ability of the typhoid germ to live, increases?

A. No, that would not be quite correct. If in a water which has been badly polluted by sewage and pathogenic germs, the saprophytic bacteria decreases again, the typhoid bacilli, must have already disappeared before. The pathogenic bacteria disappear sooner than the saprophytes.

Q. That, professor, is taking the sewage in its original state and without adding to it at any time any other substance, diluting substance, is it not?

A. That is taking the river water, contaminated with various organic material.

Q. And as the saprophytic bacteria disappear by dilution or what not, it renders the water more favorable to the life of the typhoid germ?

A. Mr. Jeffries, you mean that after the sewage had been deposited in the river, or do you now speak of a primarily pure water which is infected with typhoid bacilli only.

Q. I am speaking now professor, not of the sewage in its original condition, but I am speaking of the sewage being
7594 discharged into a volume of water which prior or formerly
was less than now. If the conditions conducive and favorable to the life of the typhoid germ, are not greater under the added volume of water than formerly?

A. Yes, because the dilution of the organic material is greater.

Q. Then professor, as you add the volume of water you increase the rapidity of the flow, you increase the abilities of life of the typhoid and other pathogenic germs. Now as you increase the ability of life, and as you increase the ability to flow, do you not at the same time change this zone of purification that you spoke about a few days ago?

A. Yes sir, you change the zone of purification if you do that.

Q. Push the zone on farther down to the mouth of the river, do you not?

A. Yes sir.

Q. Now professor, taking the conditions as they exist with an added flow of 250,000 cubic feet of lake water per minute, from Lake Michigan, which is disease-laden, pure lake water or what-not, this additional flow added to the Illinois river when the combined discharge of the sewage and diluting

7595 substance, prior to the opening of the canal was only 35,000 cubic feet per minute, as testified to by Professor Long—assuming those conditions I will ask you if it is not a fact that the disease producing germs would live longer and swim farther or flow farther down the river since the opening of the canal than they would prior to the opening of the canal?

A. From my own investigation of the matter, I look upon the drainage canal as one big sewage tank, even as it is now, with an increased amount of water, and I hardly believe that very much will get out of the drainage canal in the way of pathogenic bacteria, alive, because the conditions are certainly such as to show no lack there of organic material and no lack of saprophytic life.

Q. Do you know that they will not get out?

A. No, I do not know. I only argue now from the results of my experiments in the laboratory.

Q. If it be a fact professor, that they would not get out in the short length of the drainage canal, why is it that all these improvements have been going on in the last few years in this country, to correct the sanitary conditions of the water supply?

A. Oh there is no question that there are many causes for objection to turning sewage into a river. At the place where sewage enters it, there must be, no doubt, many physical
7596 characters about this water to make it objectiona[illegible], to
make it a nuisance. Alone for the nuisance, it would be essential not to turn sewage into river waters, and if most of the cities now turn only the effluent of sewage into a river water, it is simply to remove the nuisance, but also the effluent of sewage has been known to contain micro-organisms which were injurious, but that was not as objectionable to the senses as when sewage itself is turned into the water.

Q. Do you know how they treat this sewage?

A. Yes, in a general way.

Q. Isn't the ability and the facilities for removing the objectionable matter from the sewage in these plants far more favorable than the water now contained in the drainage canal?

A. To prevent the pollution of the river?

Q. Yes.

A. There is no question about that.

Q. Then, professor, if it is possible for some disease germs to escape these plants, and get into the water, why can you make the assertion that no objectionable material will pass out of the canal, that is no objectionable disease producing substances will pass out of the canal.

A. I did not say pathogenic bacteria in the effluent; I
7597 said objectionable substances. Such objectionable substances may be for instance, the products of saprophytic bacteria; they pollute the river just the same.

Q. Now I will ask you professor, if they are less or more objectionable than the substances that pass out of the drainage canal?

A. I think they are less objectionable because they are less in amount.

Q. Now how about the quality as well as the quantity? We have been speaking now of the quantity. How about the quality of the matter that escapes through these works and also the drainage canal?

A. As to quality, the effluent is not as objectionable as sewage when thrown into the river.

Q. I wil ask you professor, if it is not a known fact that the output from the sewage purification plants about which we have been speaking, is far superior to the water flowing out of the Chicago drainage canal?

A. I should judge that was so. You are asking me now again sanitary questions.

Q. Now professor, I understood you to say that you con-
7598 sidered the drainage canal as it is at present, an open sewer?

A. Yes sir.

Q. Now I will ask you if you have made any guinea pig experiments with that water?

A. Yes sir.

Q. Where were those samples of water taken with which the Guinea pig experiments were made?

A. They were taken at Lockport and I have here also samples from Bridgeport. Those from Bridgeport proved invariably fatal—those from Lockport proved sometimes fatal but not always.

Q. That was the Illinois and Michigan canal, wasn't it?

A. No, this is from Lockport, the drainage canal. The animals that died, died mainly of proteus infections.

Q. Now then professor, state what light those experiments poured upon the condition of the water in the drainage canal, or threw upon the condition of the water in the drainage canal, if any?

A. The specimen from the upper part of the drainage canal produced a condition of sepsis, and the animals promptly died from saprophytic poisons. Inoculations of specimens of
7599 the drainage canal at Lockport, did not always cause
death. The animals which died had proteus vulgaris infections.

JUDGE SPRINGER: Explain what that is.

A. The proteus injected into the peritoneum of the animal set up a peritonitis usually of a purulent type. The animal had an enlarged spleen, and bacilli in the heart blood. One animal died of sepsis, the same as at Bridgeport. There were evidently bacteria present pathogenic to animals in Lockport, not only toxic substances produced by saprophytes.

Q. Then they are not killed out by the water flowing through the canal?

A. No, not according to that.

Q. And they do enter the Desplaines river?

A. Yes sir.

Q. Then that is not altogether in line with what you previously stated, that they did die out in the canal?

A. My report showed the presence of this germ, but the proteus usually is not considered as a pathogenic organism to men under common conditions, when swallowed.

Q. Now what other explanation can you give for the typhoid dying out?

A. Only my experiments as to their behavior in sewage
7600 contaminated water.

Q. Your experiments were not parallel with the drainage canal were they?

A. I made no typhoid bacillus experiments on drainage canal water. Only on Lake Michigan water, and the others that I mentioned, the Illinois, Mississippi and Missouri.

Q. So then when you say that the typhoid germ has disappeared from the sewage of Chicago before it gets out of the drainage canal, you did not say so upon any experiments which you made with the life of the typhoid germ in the water of the canal?

A. No, that is only by analogy of the laboratory experiment, and the conditions existing in the drainage canal.

Q. Now professor, you stated Saturday that your examinations of the samples from the Illinois river, were made with such thoroughness, that if a single germ of typhoid had existed in any one of the samples examined, that you would have detected it, did you not?

A. No, I did not. If there had been a single typhoid germ in the water I would have detected it?

Q. Yes.

A. No sir.

Q. Well you mean by that you didn't make any such 7601 statement?

A. I did not make the statement that if there had been one typhoid bacillus in all the water received from there that I would have found it. I simply made the statement that I didn't find typhoid bacilli in that water.

Q. Now the typhoid bacilli might have been in the water that you examined, in the samples that you examined, and yet you not find them?

A. The possibility of finding the typhoid bacillus in water, when the water contains, we will say, one typhoid bacillus to a billion gallons of water ,is of course very remote.

Q. Well, professor, in these typhoid infected wells, there is more than one typhoid fever germ to every billion gallons of water isn't there?

A. Yes, at times perhaps, for short periods.

Q. And yet no bacteria of that character have ever been found. Might not professor, the typhoid bacillus be contained in the samples of water that you collected for your analyses and yet you not find it? That's what I want to know?

A. The possibility of a typhoid bacillus being in the river at Grafton, coming from Chicago is, in my view, of the matter, improbable.

Q. I am assuming now, professor, that in the sample of 7602 water that you examined, typhoid germs existed. Was your examination so accurate as to enable you to have detected it if it was there?

A. No bacteriologist is able to do that.

Q. That is just exactly what I want to know. You may find it and you may not.

A. Where it is very much diluted, it is possible that the typhoid bacillus may be in the water and the bacteriologist is unable to find it, if the dilution is very great. That is just the reason why I believe in indirect infection by typhoid bacilli, where polluting material enters the water.

Q. Now did you examine all the water contained in those little sample bottles sent you?

A. No sir.

Q. Which part did you examine?

A. I plated it out in the usual way, that is one cubic centimeter of the water being plated out of every specimen, and looked for all disease producing bacteria. When we did plate that out we would make no great or special attempt to discover the typhoid bacilli. With the past experience of polluted rivers, or even of polluted wells, where we know that near-by cess pools contain a large amount of sewage and typhoid discharges, we are unable to find them there.

7603 We do, in a general way, look for all typhoid-like organisms, in fact we have in our list a number of organisms that look similar, but when we come to run them through various culture media, we always found that they are not typhoid bacilli.

Q. So that you use only one cubic centimeter of water from each sample?

A. That is the amount that was used for plating most of the plates.

Q. Now how many samples of water did you examine with a view of detecting the typhoid fever germ if any existed.

A. We made about sixteen plates from most of the samples. Of some we made only ten plates.

Q. How many samples of water taken at the various times did you examine, with the view of detecting the presence of typhoid germs, of the Illinois river at Grafton?

A. Thirty-eight.

Q. Now then I understand you to say that in all you examined, 38 centimeters of water to detect the presence of typhoid germs?

A. No, we made about ten plates, ten to sixteen plates from each sample.

Q. And how much water did you use in each plate?

A. That varied. We used one-half cubic centimeter in some one cubic centimeter mostly, five cubic centimeters, sometimes in less polluted waters. We varied the quantity a little so as to obtain discreet colonies, separate colonies.

7604 Q. Now professor, I will get you to state, in the 38 samples of water that were examined by you for the purpose of detecting typhoid fever germs, how much would be the entire volume of water examined in round numbers?

A. Only a few cubic centimeters of each specimen.

Q. Now how much in the whole thing, according to your best judgment?

A. In all the 38 specimens?

Q. Yes, how much was examined for the purpose of detecting the typhoid fever germs? In other words, professor, a glass of water holding 200 cubic centimeters?

A. We have used of the Illinois river water about 120 to 130 cubic centimeters in all, about four ounces.

Q. Now that would be a very small glass of beer, wouldn't it?

A. Yes, rather small.

Q. Now assuming professor, that you used one small glass of water or in other words, about 130 cubic centimeters, how does that quantity of water compare with the volume of water flowing down the Illinois river?

A. I realize perfectly the difficulty of finding typhoid bacilli in infected waters, and I think I mentioned before, that for the reason of this great dilution it is difficult to find the typhoid bacilli in polluted waters, where we know the discharges of typhoid fever cases have entered. 7605

Q. Now professor, I will ask you if it would need great dilution in order to miss it in making only a few examinations like you did, whether it required great dilution to miss them?

A. No, not by this method. But we also used the enriching method.

Q. Considering that the amount examined by you is nothing more than a trifling infinitesmal part of the whole volume of water flowing through the river?

A. It is possible to miss the typhoid bacilli on account of dilution.

Q. Supposing that you had found the presence of one typhoid fever bacillus in each cubic centimeter of water that you had examined, what would you say as to the condition of the Illinois river with reference to typhoid fever germs.

A. If that were possible, people should be prohibited from using that water either with or without filtering.

Q. Professor, if you had found one typhoid fever germ in each cubic centimeter you had examined, wouldn't it be a fact that it disclosed a greater polluted stream than you have ever come in contact with in your bacteriological examinations?

A. Yes

7606 Q. Is it not a fact that if you had found one bacterium in each cubic centimeter you examined at the mouth of the Illinois river, that the condition of that water there would have been, from a bacteriological examination, far more impure and far less wholesome than the water in the Illinois river at Henry or at other places examined?

A. Yes, if I found typhoid bacilli in the water I would consider that very serious.

Q. Then professor, this inability or failure to find them, does it throw much light or any light upon an investigation of this character or upon their presence or absence?

A. Of the typhoid bacilli alone?

Q. Yes.

A. As to a general pollution, no; the absence of the typhoid bacilli would not say that a certain water is free from them.

Q. Free from them or not?

A. That can never be said when the findings are negative. It is possible, even if not probable. The things we find in bacteriologic examinations have more diagnostic importance than the things that we do not find.

Q. Now professor, you have made no examinations for typhoid germs in the Illinois river in mid-winter have you, especially from December 12th to February 24th?

7607 A. My examinations were made from February to October, 1900, and from October 3rd, to March 11th, 1901 and 1902.

Q. What were the results in winter time as compared with the summer time?

A. Well, I would have to have the tables to tell that. I cannot compare the results for the reason that the investigations in 1901 and 1902 were made at different places than those in 1900. I can however, compare Grafton. As to the findings summed up at Grafton, I find the colon bacillus and the proteus types, and there is no appreciable difference in the kind of pathogenic bacteria found during the two periods.

Q. ·Professor, in these examinations you did not take the quantity of any particular bacteria did you?

A. No, I never made any counts.

Q. And therefore no comparison can be drawn from these tables that can be relied upon?

A. Not as to numbers, only as to kinds, and the kinds were the same, there is no difference.

Q. But all things being equal, the science of bacteriology leads you to believe that there cannot be more of each kind in the winter time than in the summer time?

7608 A. There will be more of these kinds in spring and summer, when more pollution results, due to rains and other pollution. When the precipitation is less, there will of course be less pollution, and therefore in winter there is no doubt less general pollution than in summer or spring.

Q. In other words there was less saprophytic life in the winter time than in the summer?

A. Yes, that is not only due to the temperature, but also due to the fact that there is less pollution.

Q. As a matter of fact the same quantity of organic matter in the same volume of water, with that there is less saprophytic life is there not, in the winter time than in the summer time, is there not?

A. They multiply less in the winter time than in the summer.

Q. And because they multiply less, there is less saprophytic life in the winter time than in the summer time?

A. There is less saprophytic life. The other cause is the greater pollution that occurs during rainfalls that occur during the summer and spring.

Q. And when you say less saprophytic life, you mean less saprophytic activity?

A. Yes.

7609 Q. Professor, I will ask you if it is not a fact that the term "purification zone," or the zone of bacterial purification, is not a term that is used peculiarly by yourself?

A. It is not used peculiarly by myself, no sir.

Q. Used by all bacteriologists is it?

A. It is used by bacteriologists and it is used in hygiene. The zone of bacterial purification is a term which you find in every modern text book on hygiene.

Q. Can you cite a few cases in which it is referred to, in rivers for instance, where the bacterial purification is cited as such?

A. Yes sir. The Seine in Paris had, during the time of the experiments 70 kilometers below Paris, the same bacteriological flora that it had before it enters the city of Paris. The river Isar in Munich at 32 kilometers below the city of Munich has the same bacteriological flora that it had before arriving in the city of Munich. The purification zone of the river Oder, in Breslau, is 33 miles below the city. The purification zone of the Spree in Berlin—here conditions varied a little bit, because it flows into the Havel lake, a small lake, and as the river again leaves this lake, the purification is complete, a distance of nine miles from the city of Berlin. At Zurich, Switzerland, the Limmatt receives a very pure water from the lake, containing
7610 about 100 to 200 germs per cubic centimeter. This river purifies itself and is of the same bacteriologic flora as when it leaves the lake fourteen kilometers below the city of Zurich, which would be about nine miles.

Q. Professor, do you know whether or not the sewage of Berlin enters the river Spree?

A. Now it does not.

Q. Did it at the time those experiments were made?

A. It did at the time these experiments were made as much as I know.

Q. When were these experiments made?

A. These experiments were made in 1889 and 1890.

Q. Was bacteriology, the science of bacteriology at that time capable of determining that question?

A. I think the tables speak for themselves in that respect. I will just illustrate that by one example. Switzerland. After the river Limmatt containing 100 to 200 germs per cubic centimeter, passes through the city of Zurich, at Stadtmuehle it contains 160 to 6,000 germs; at the bridge of the Witkinger it contains 788,700 germs per cubic centimeter; at the Hoengger, three kilometers down, it only contains 150 to 16,000 per cubic centimeter. Eight kilometers down at the Kloster Fahli, it contains 900 to 17,000 and fourteen kilometers down, at
7611 Dietikon, it contains 250 germs again per cubic millimeter.

Therefore this distance of 14 kilometers has been called the zone of bacterial purification.

Q. Do you know when that was?

A. That was in 1890. Schlatter was the investigator.

Q. Do you know the conditions of the river at the time with reference to whether it was winter time or summer time or flood water?

A. The river comes out of the lake, Lake Zurich and simply flows through the city and receives there different sewage.

Q. Was it in winter time or summer time these experiments were made?

A. These experiments were made over long periods and more thoroughly than any others, except those in Munich. I have some figures here from Munich. These examinations were made all the year around.

Q. And it was fixed at one definite place?

A. And the place was practically always the same. These places I have mentioned in regard to the numbers of bacteria only, not as to the kind of bacteria.

Q. Now then in fixing the zone of bacterial purification, you as a bacteriologist, and whoever made the experiments along that line, have simply made them for the purpose of de-
7612 termining the presence of bacteria, without reference to the character and kind of the bacteria that exist?

A. They have been determined mainly to find out what effect sewage had upon the water, and whether it was possible for a river to free itself again of any bacterial pollution which it received.

Q. But professor, these determinations do not entirely enable one to determine that the river has been freed from sewage pollution, do they?

A. That the river has been freed of bacterial pollution only; not of chemical or other conditions.

Q. Does the science of bacteriology enable you to determine the place in a running stream where it has been freed from disease producing bacteria caused by the discharge of sewage into that stream?

A. Under the conditions which I have stated here, yes.

Q. Then professor, if it is possible, bacteriologically to obtain reliable information as to the disappearance of disease producing germs deposited into a river, with the sewage from the city, why are you not able, and why is not any other bacteriologist able to state as a bacteriologist without the aid of chemistry, without the aid of the extent of the pollution, the source of the pollution, without the aid of the volume or stream flow, the
rate of stream flow, the exact place where purification is
7613 taking place from the pathogenic germs, purification from
pollution from pathogenic germs?

A. We do. The bacteriologist claims that with the disappearance of the saprophytes the pathogenic bacteria have disappeared. Why? Because the pathogenic bacteria will disappear very much sooner in water than saprophytes.

Q. Then professor, you take the position that as a bacteriologist pure and simple you can determine the sanitary condition of the water in a running stream?

A. Only in regard to that particular question stated,—the question of what becomes of the pathogenic germs in the sewage and in the river, when the sewage gets into the river. According to the experiments made on the subject, I see no other way out of it excepting to conclude with these data that bacterial purification takes place. Our laboratory experiment tells us that pathogenic bacteria die long before non-pathogenic do, and that the more the saprophytes multiply the sooner the path-

ogenic bacteria are destroyed, and therefore, if I see the numbers of bacteria in a river rise to millions after sewage enters it, and then after a certain distance of flow decrease to the normal number of a non-polluted stream, I must conclude that the saprophytes have died and disappeared, and the parisites too, and long before, because the conditions for them are more
7614 unfavorable than for the saprophytes, that is the reason.

Q. Professor, assuming that in Lake Michigan bacterial analyses should show no pollution of any considerable consequence, in other words show less pollution than the Illinois river does at Grafton and it should be proven to you that the water in Lake Michigan as drawn through the water mains into the water supply of the city of Chicago had produced typhoid fever, what would you say then were your conclusions as to the absence of pathogenic and disease producing germs at the intake cribs, was it a conclusion or opinion that could be relied upon?

MR. DRENNAN: I object to the question for the reason that the witness is not called upon as an expert to give an opinion as to the value of his own testimony?

A. Not as to its sanitary condition, but as to the disappearance of parasites before saprophytes.

Q. Professor, you conclude simply that because the saprophytes have disappeared, that all parasites are gone?

A. If you conclude—

Q. Answer the question?

A. I will.

Q. Do you, from these analyses conclude that inasmuch as the saprophytes have disappeared, that all parasites have
7615 gone before?

A. Long before.

Q. Then professor, the absence of saprophytes in the water of Lake Michigan necessarily means that the parasites have gone before, although that water when taken into the human system by the people of Chicago produces typhoid fever?

MR. DRENNAN: I object to that assumption on the ground that there is no evidence that the water of Lake Michigan has ever caused a person drinking it to become infected with typhoid fever, or is free from saprophytes.

A. If Lake Michigan water had been badly polluted with much sewage and the bacteria had increased up to millions, and the tap water should contain millions of bacteria, we may take it for granted now that some of the water containing typhoid bacilli had also been taken in at the same time. If the saprophytic bacteria in that water disappeared, it is quite certain that before they disappeared, that the pathogenic bacteria must have disappeared, but if we put the typhoid bacilli into pure lake Michigan water, where there is little or no organic material and where there are no other saprophytic bacteria, then the typhoid bacillus may live in that water for some time, but it will be tremendously diluted of course, under those conditions.

7616 Q. But it is there nevertheless?

A. It is there nevertheless, therefore I have always tried to make that clear. I draw these conclusions only by the great increase of saprophytes, showing that there really is something there which is destroying pathogenic bacteria and that if pure water is inoculated with typhoid bacilli, there is nothing to destroy them. They simply have to die out from starvation, lack of organic material, etc. It is quite a different thing if you have sewage pollution and pathogenic bacteria with it than when you have pure water and pathogenic bacteria. In the first case pathogenic bacteria die sooner than if you put pathogenic bacteria into pure water free of organic material and saprophytes. If at a previous examination we found millions of saprophytic organisms, as we have them here in the drainage canal and then saw the saprophytes disappear, it is quite certain that the parasites must have died long before the number of the saprophytes decreases markedly.

ADJOURNED until 10:00 A. M., Tuesday, October 6, 1903.

10:00 A. M., Tuesday, October 6, 1903.

7617 Continuation pursuant to adjournment

Present, the Commissioner and same counsel representing the respective parties.

PROF. F. ROBERT ZEIT,

resumed the stand for further cross-examination by Mr. Jeffries and testified as follows:

Q. Professor, is this bacterial purification zone to which you have referred in your direct and also in your cross-examination sharply defined?

A. Yes sir, that is very sharply defined.

Q. Can that point always be determined?

A. Bacterial purification is usually determined by the number of bacteria rather than by the quality of the bacteria. In all the experiments which I have made, or in these cases which I have mentioned.

Q. You define the zone of purification simply by the great reduction of bacteria of all characters?

A. The bacteria of all characters, yes sir.

Q. Without reference to whether those bacteria be pathogenic or non-pathogenic?

A. Yes, in all instances which I have given, that was so.

7618 Q. I will ask you professor, if that zone is not continually changing from day to day?

A. Yes sir, that zone is continually changing. I would like to give here an illustration of continously increased pollution and continuous purification. You spoke of the river Dee. This river Dee above Braemar shows 84 colonies per cubic centimeter, below the old Mar Castle; after receiving the sewage of Braemar, 2,829 colonies per cubic centimeter were found. Below at the bridge of Ballater, 1139 colonies were found. Below Ballater, after the sewage effluent of Ballater has entered the river, 3780 colonies per cubic centimeter were found, whereas the effluent of Ballater contained from 235,000 to 26,000,000 per cubic centimeter. At Kincardine, O'Neil, 938 colonies only were found in one cubic centimeter. After the junction of the river, Neil-burne, again 860 colonies were found in one cubic centimeter. The Neil-burne, 12 yards before the sewage outfall of the river contained 1,200,000 colonies per cubic centimeter. In Invercarnine, only 950 colonies per cubic centimeter were found, so we have here a reduction in the total of 40,000,000 a rapid pollution and a rapid bacterial purification, and in spite of all these pollutions of sewage containing 26,000,000 germs per cubic centimeter and in the other case 1,200,000 per cubic centimeter, you have finally again only 950, per cubic centimeter.

7619 Q. Where do the bacteria disappear in these instances?

A. At Invercarnine.

Q. What became of it?

A. The organic material which entered the river, with rapid multiplication of the saprophytes, accounts for the increase of bacteria, and as the organic material became less, was consumed, was eaten up by the bacteria. The conditions for life and multiplication of saprophytic bacteria became unfavorable and they died out.

Q. Do you know this for a fact or is this your theory?

A. This is a fact which holds true in all cases, of rivers, that the rapid multiplication of saprophytes corresponds to the great quantity of organic matter present, and that if these great numbers of saprophytes disappear, the organic matter has been consumed.

Q. That is your theory of the matter?

A. That is not a theory. That is something which we can see in the laboratory right along. When the organic material in a water has been consumed by the immense multiplication of the bacteria, the number of bacteria decreases from day to day.

Q. Professor, I will ask you if anyone ever examined the mud in the river Dee, or do you know?

A. Not that I know of.

7620 Q. Then you do not know but what large quantities of the bacteria do disappear in the mud and sediment?

A. The sedimentation—

Q. I want to know if you know now?

A. I don't know.

Q. With reference to this particular stream.

A. I don't know.

Q. Now I will ask you professor, whether or not it was determined from the analyses of the water in the river Dee, that the bacteria remaining were pathogenic or non-pathogenic, disease producing or non-disease producing?

A. In that particular instance, that was not the question to be determined. The question to be determined in this instance was simply how does the sewage entering the river, increase the total number of bacteria and do they disappear again.

Q. And no distinction was made between the sewage proper and the effluent of the sewage?

A. No, no distinction was made.

Q. Then your position is that because of the rapid disappearance of the bacteria in the effluent, the same condition would be true with reference to the sewage proper and that the water in the river after it reached that particular point 7621 was freed from the disease producing germs, whether it be the reduction of the effluent from the bacteria, or the reduction of the sewage proper from the bacteria?

A. I do not know with regard to that in that particular case.

Q. And what is true with reference to that particular case will apply to any river with reference to the zone of purification will it not, from your own standpoint?

A. That the more organic material there is present in the river, the more the water bacteria and saprophytes will increase.

Q. With reference to the nature and character of the remaining bacteria in the water, whether it comes from the untreated sewage of the city, or whether it comes from the effluent of the sewage of the city?

A. I am speaking now only of numbers of bacteria in this case, and I say the greater the number of saprophytes, the greater must be the quantity of the organic material that has been poured into that river, else those saprophytes would not be there, and the disappearance of the saprophytes in the purification zone means also the decrease of the organic material.

Q. But professor, does the disappearance of the organic material necessarily mean the death of the pathogenic germs or disease producing germs?

A. Yes, because the saprophytic bacteria die later than the pathogenic bacteria—

7622 Q. That depends, doesn't it upon the temperature of the water?

A. That depends not only on the temperature, but it depends mostly on the overgrowth of the saprophytic bacteria which destroy the pathogenic bacteria. The pathogenic bacteria cannot exist when they are in small numbers present in millions and millions of saprophytes.

Q. Professor, do you know of any cases in Great Britain or in the United States ,in which the instance of the bacterial zone of purification has been so well established, that the water below it is considered by competent authorities, safe for drinking purposes?

A. The epidemiologist who neglects entirely the bacterial questions and their significance, of course condemns all waters which are polluted, but the bacteriologist speaks of a zone of bacterial purification due to those conditions which I have mentioned many times.

7623 Q. Professor, assuming that the sewage of the city of Cumberland is discharged into the Potomac river, and that the city of Washington is situated on that river 160 miles below Cumberland, and assuming that from a bacteriological standpoint the zone of purification had taken place in that river ordinarily 40 miles below Cumberland, and assuming further that there was a typhoid fever epidemic in the city of Washington, and assuming that that typhoid epidemic was the result of a previous typhoid epidemic at the city of Cumberland which discharged its sewage into the Potomac river—

A. That is a theory.

Q. Just wait. This is an assumption. There is no theory about it.

I would like to ask you what effect and what bearing the ascertainment of the zone of bacterial purification at a point ordinarily forty miles below the city of Cumberland would have upon establishing the sanitary condition of the water of that river, after it had received the sewage of Cumberland and passed down as far as the city of Washington?

A. If it was proven bacteriologically that at forty miles the bacterial purification and the disappearance of saprophytes, and the consequent decrease of the organic mattter which it must have contained, according to your assumption, had taken
7624 place, then I would judge that with the disappearance of the saprophytes at forty miles in the zone of bacterial purification, not only the saprophytes would have died by that time, but that all the other pathogenic bacteria would have died before that time, and that therefore an epidemic of typhoid fever 160 miles away from the source of such pollution, according to bacteriologic judgment, would have been due to other causes. and that the water, if condemned, was condemned on suspicion

only, because there has been a typhoid epidemic higher up on the river.

Q. Now professor, on the basis of the previous question, we will assume that it is an established fact that a typhoid epidemic at the city of Washington, was caused by a preceding typhoid epidemic in the city of Cumberland, on the Potomac river 160 miles above Washington. Now with the assumption that the typhoid epidemic at Washington was caused from the people of that city drinking the water which had been infected with the typhoid germs of the disease at Cumberland, of what value then, is the ascertainment of the zone of purification when that, according to the bacteriologist, would be ordinarily about 40 miles below the city of Cumberland?

A. Yes, but such an assumption is impossible, according to my view.

7625 Q. Well, we are assuming that to be a fact, now, aside from your views?

A. Yes, but the assumption is an impossibility. I think that in a case like that it is much more probable that the typhoid bacilli have been brought by a patient, directly and not by way of the water, to the city of Washington, 160 miles below.

Q. But assuming, professor, aside from your theory, or from the investigations that you have made, that the typhoid epidemic occurred in Washington and that it was the direct result of people drinking the water from the Potomac river, which had been polluted with this typhoid infected sewage at Cumberland, 160 miles from Washington. Of what value would the ascertainment of the bacterial zone of purification, which is ordinarily 40 miles below Cumberland, be in determining the sanitary condition of the water at Washington?

JUDGE SPRINGER: I object to this question for the reason that there is no evidence in this record that the zone of bacterial purification in the Potomac river is fixed at 40 miles below Cumberland, and further I object to this question for the reason that it ignores entirely the most important factor in reference to the Potomac river, namely it is a rapid flowing stream, it being a mountain stream, from its source to

7626 the city of Washington.

Q. (Question repeated).

A. If we were able to find at Washington, in the river, typhoid bacilli, and you were unable to find them forty miles below Cumberland, in the zone of bacterial purification of saprophytes, then of course you would have to conclude that the infection must have been nearer Washington rather than from Cumberland. It would have to be proven that typhoid bacilli must be found not only at Washington, but also higher up on the river. I consider that the only proof.

Q. Professor, I have cut out all of those conditions in the question, which of course cannot be of any harm to you.

A. Yes, but it is an impossible assumption according to my theory.

Q. Here is the proposition now. We are assuming that there is an epidemic at Washington—

A. Yes.

Q. We are assuming that prior thereto there was an epidemic at Cumberland?

A. Yes.

Q. We are assuming that the typhoid dejecta of the patient at Cumberland passed into the Potomac river through the sewers of that city. We are assuming further that the typhoid infected
water flowed from Cumberland down to Washington and
7627 produced the typhoid epidemic at that place. We are as-
suming further that the zone of bacterial purification has ordinarily been found at a point about forty miles below Cumberland. Now then I want to know what effect those assumptions being true, the ascertainment and the determination of the bacterial zone of purification being ordinarily 40 miles below Cumberland, would have upon the sanitary condition of the water at Washington?

JUDGE SPRINGER: I object to this question for the rea- that these assumptions are impossible, and purely theoretical; that any answer the witness can give to this question will be irrelevant to the issues in this case, for no such assumptions can exist, and that therefore any answer or testimony in reference to such assumptions will be of no value in the case and it will not tend to establish any of the issues involved.

MR. JEFFRIES: I suggest that the question is not so much a theory as a direct and correct ascertainment of the zone of purification.

JUDGE SPRINGER: My objection is that none of these things has been ascertained as to this river; no bacterial examinations have ever been brought to the attention of the Commissioner, or brought into this record, and that according to the knowledge of the witness, and according to my understanding, most of these assumptions are utterly impossible and
7628 irrelevant therefore to the issues involved in this case.

A. Well, it is a pure hypothesis, and I can only answer it as such, that in that case, if that all was proven, we would prohibit the use of the water.

Q. And the ascertainment of the zone of bacterial purification would be valuless?

A. Would be valuless.

Q. Now professor, I will ask you if it is not a fact that this zone of bacterial purification moves up and down the river according to the amount of pollution, the amount of dilution, the temperature of the water, the volume of flow, the rate of flow, and with reference to flood seasons, and dry weather seasons?

A. Yes sir.

Q. Then it cannot be fixed at any one particular time so as to be found at that particular point at all seasons and at all times of the year?

A. The particular point is only established on an average of many examinations.

Q. Now then professor, going back to the hypothesis which we gave you in reference to the typhoid epidemic at the city of Washington, I will ask you if it is not entirely possible and reasonable from your standpoint alone, to believe that
7629 if the typhoid fever at Washington is assumed to have
been caused by the infected water or the infected sewage of Cumberland, 160 miles away, and that the typhoid epidemic at Washington was the direct result of the deposit of the infected sewage at Cumberland into the Potomac river, that the zone of purification had not established itself until after the water had passed Washington, while at other times it might have

established itself further up the river, between Washington and Cumberland.

A. I do not believe that the zone of bacterial purification will vary within such large distances as 40 and 160 miles, because the disappearance of saprophytes takes place with the disappearance of organic material, and taking the average for the exminations of a whole year, the variations will not be 120 miles.

Q. Is it a question of distance or a question of time?

A. It is a question of sewage being present in greater or smaller quantities, and the question of temperature and the question of dilution.

Q. It is not then a question of distance?

A. It is a question of distance in one respect also, with regard to the rapidity of flow of the river, this bacterial zone of purification may be moving up and down somewhat
7630 with the variations of those conditions, but the variation would not be within such wide limits as 120 miles.

Q. Isn't time required to effect the saprophytic elimination?

A. Yes but the time depends entirely again on temperature; that is, at a favorable temperature the time will be very much shorter than at an unfavorable temperature.

Q. And if the time and the temperature were unfavorable, the time would be very much longer, and of course the distance traveled would be very much further would it not, the flow being the same at all times?

A. There are so many factors—

Q. If the temperature is unfavorable, for the saprophytic bacteria, it is unfavorable for the pathogenic bacteria is it not?

A. No, that is not the conclusion. The favorable temperature for pathogenic bacteria is the temperature of human blood, so if the temperature is lower than room temperature, at which saprophytic bacteria grow less rapidly, then the saprophytes will grow slower, so there would be a question of lower temperature. If the temperature is lower the saprophytes do not increase—

Q. Do you mean, professor, that the pathogenic germs 7631 will live longer in warm water than in cold water?

A. Not necessarily. It will multiply in higher temperature, and will not multiply at a low temperature.

Q. We are cutting out now the proposition of the pathogenic germs multiplying, and we are leaving them in the condition that they came from the human system, from the excreta. I will ask you if it is not a fact that the lower the temperature of the water the more unfavorable for saprophytic elimination, and the more suitable for the life of the pathogenic germ, is that not true?

A. That also will vary considerably. We have no exact data. They are only observations.

Q. Then professor, if those things are variable according to the temperature of the water, according to the amount of organic matter deposited, according to the saprophytic growth, or saprophytic elimination, I will ask you why it is that there is not a great variation in the place where the bacterial zone of purification is established in any river?

A. Well, I think I can explain my position easily. A disease producing germ when kept at a high temperature will multiply and when it multiplies rapidly it will produce toxins and poisons which are poisonous to itself, and therefore will die sooner, which would not be the case if that same room be kept at 7632 a low temperature.

Q. Now professor, you are speaking altogether of the laboratory experiment, are you not?

A. Well, that is a biological factor—

Q. I want to know then if that be true, if you have ever known of the pathogenic germ multiplying in a running stream?

A. No.

Q. Have you ever known of its multiplying in an open sewer?

A. No.

Q. Do you have any reason to believe that they will multiply?

A. In an open sewer?

Q. Yes?

A. No.

Q. Then, professor, we must eliminate the question of multiplication in the determination of the presence of pathogenic germs in running streams and in sewage, must we not?

A. Yes.

Q. Then I want to ask you if it is not a fact, taking the water in the stream or the sewage in the Chicago drainage canal that the lower the temperature of water the less probability there is of the disease infecting germs dying out?

A. They will die out more rapidly in cold water than they will in warm water.

7633 A. They will die more rapidly in cold water, than in warm water when saprophytes are present with them and organic material.

Q. The disease producing germs?

A. The disease producing germs.

Q. Well, now, what is it in cold water that brings about their death?

A. The unfavorable temperature first, prevents of course, multiplication, and at low temperatures, while they may exist for a long time, they are certainly influenced unfavorably.

Q. Professor, you say it prevents their multiplication. Now that you have eliminated the question of multiplication, because you said you had never known any of them to multiply in the river or in the sewage—we are dealing now with the question of longevity, of vitality, of ruggedness and the ability to live. We put pathogenic germs into cold water; we put pathogenic germs of the same character in hot water, which will live the longer?

A. Well, that will vary as a general proposition. It is generally said that they will live longer in cold water than in warm water, but that depends upon other bacteria present in the water. I can say nothing definite with regard to that question. In cold water it would depend on other bacteria present how long they would live. In warm water they might
7634 even multiply. Many of them will live longer in cold water than in warm water if the water is sterile.

Q. Then professor, it is absolutely impossible from your laboratory experiments, to determine anything with reference to the life and character of disease bearing germs in a running, stream is it not?

A. That depends also upon the presence of other bacteria.

Q. I will ask you professor, if it is not a fact that what you learn of the life characteristics of disease producing germs, in the laboratory, is very unreliable, and very limited, so far as the life in the running water is concerned?

A. The laboratory conditions are certainly somewhat different for the pathogenic germ in the test tube, than they would be in the open river, or in the open sewer, but if these conditions are made as similar as possible, then there is only one feature remaining, and that is the products or excretions of other bacteria in the mixture with the typhoid bacillus, that constitute a difference. The other conditions can be made, practically made alike to those in the river.

Q. Now professor, coming back to this zone of purification. Do I understand you to say that it may always be found within certain limits, or do I understand you to say that it may be very remote from the point of pollution, and that it
7635 may be removed long distances upon certain physical
conditions which manifest themselves in the water of the river?

A. The zone of purification in a river may move up and down, according to the elements of rapidity of flow, the temperature and the amount of water.

Q. Hasn't the amount of sewage got anything to do with it?

A. Well, it is that which gives rise to the increase of bacteria. With regard to the zone of purification I am speaking of bacteria, that is the zone of bacterial purification.

Q. How remote is this zone of purification from the source of pollution?

A. That will vary according to those conditions mentioned.

Q. May they be as remote as 100 miles?

A. Usually not as much as that.

Q. May it not be much more than 100 miles?

A. No, it should be much less than 100 miles.

Q. Are you not aware, professor, that competent bacteriologists have placed it as far off as at least 160 miles?

A. I am not.

Q. May it not be even more remote than 160 miles?

A. Not in my opinion.

7636 Q. Professor, you stated, I believe that the conclusion of the British River Pollution Commission was that there is no river in Great Britain long enough to purify itself from sewage introduced into it even at its source?

A. I did.

Q. And that that conclulsion is no longer necessarily accepted?

A. That that conclusion is not accepted by bacteriologists.

Q. Now then, have English authorities on sanitation ever withdrawn or corrected that statement?

A. According to the experiments I mentioned today, of the bacteriologist Frankland, with regard to the river Dee, in July, 1892, that ought to be withdrawn.

Q. But you don't say that it has been withdrawn?

A. It has been denied absolutely in Germany.

Q. Have the English authorities denied it and withdrawn it?

A. Some English authorities still continue that prejudice, in spite of the work of the bacteriologists.

Q. Professor, I will ask you if there is any other people on the face of the earth that have made more thorough investigations of this subject than the English people?

A. Yes sir.

Q. Who are they?

A. The Germans.

7637 Q. Are there any better authorities upon the pollution and purification of rivers in general than the English?

A. They must have had very, very bad conditions there, and it was not until bacteriologic research thoroughly investigated those conditions, that this statement with regard to "no river being long enough to purify itself of any pollultion it receives in its course" was disproven--bacteriologically disproven. That statement dates back to the time when such subjects were treated without much bacteriological research or without much chemical research even, and that statement was given up by a good many as soon as bacteriological research proved its incorrectness.

Q. But professor, with all the bacteriological examinations of water, and with all the conclusions that they have drawn with reference to the bacterial zone of purification and the self-purification of streams, I want to ask you if it is not a fact that human experience with reference to the rivers investigated and considered, has not always been the same?

A. In spite of all the investigations by the bacteriologists into the subjects, people have retained their objections to turning sewage into rivers as a general proposition; if for no other purpose than that of preventing a nuisance in the river at the time and place where the sewage enters the river.

7638 Q. Isn't it a fact, professor, that in the face of all that bacteriology has determined with reference to the self-purification of a stream, the bacterial operation of the organic substance that is deposited into the river, that the experience of the human family with reference to those rivers, has always been the same, has remained the same since those discoveries were made by bacteriology, as it was prior thereto, and that the people now living upon those streams, polluted with the sewage of large cities, are using a more determined effort, and stronger effort, and greater effort, and more accurate means of freeing those rivers from pollution than it did prior to these bacteriological discoveries?

A. That was the very result of the bacteriologic investigation. No city should use water from a river, unless that river water be filtered, even if it did not receive the sewage of a city, it would be polluted by all sorts of material entering it, after rains and from various industrial establishments, so river water has always been by the public looked upon as dangerous to use, even if it did not receive any sewage. Industrial products from factories, and so on, may be much more harmful than the decomposed sewage of human beings.

Q. Professor, assume that a city has grown up on the 7639 banks of a stream and has used the water of that stream from the time of its foundation, during the entire history of the city, and that suddenly upon the banks of that stream above, a large and populous city of more than three times the population of the former city, should suddenly begin to discharge its sewage into that stream upon which the former city was located, what attitude would the former city occupy in the minds of the civilized world with reference to this water supply, speaking from a scientific standpoint?

A. Have you mentioned any distances in your question?

Q. I mentioned no distances of any kind.

A. What is the question?

Q. (Question repeated.)

JUDGE SPRINGER: I object to that question for the reason that it is based upon assumptions which do not exist, have not existed and cannot be proven to exist in this case, and that any answer predicated upon such assumptions would be irrelevant, incompetent and immaterial, for the purpose of establishing any of the issues involved in this suit.

A. I would say that it would have been wrong of the first city under all conditions, to use the water of that river, even if no city had grown up upon the banks of this river above.

7640 Q. What would you say as to the second city discharging its sewage into the river, and what effect would that have upon the intelligence of the civilized world?

A. That would be a question for the sanitarian, and the chemist and the bacteriologist to decide, as to what effect it would have upon the health of the people of the second city. The other is purely a matter of sentiment, and we all have objections to the turning in of sewage into a river, if we are located below on the river a short distance, and the shorter the distance below, of course the more serious would be such objection.

Q. Professor, if you were employed to remove the sources of pollution from a running stream all things being equal, would you commence at the mouth of the stream or would you first commence at its source and pass down the river, clearing the sources of pollution away?

A. It is impossible to remove all the sources of pollution of a river which receives the sewage or receives the products of various industries. Even the most modern filtration plants will not prevent all organic substances from passing through those filters, and if they are located a short distance above the city that is using that water, it is all a question of dif-

ference in dilution, with regard to inorganic substances, and
with regard to organic substances it is a question of thor-
7641 ough destruction of the organic material, a distance long
enough above the city using such water, that it can be
called safe in that respect, but even then filtration must be used, because continuous new pollutions will take place all along the river by all other sources. Even if all the cities along the Illinois river would stop turning their sewage and other products into the river, there would still be pollution of that river by rains, by ships, and other unavoidable pollutions by industrial agricultural products. Rains would wash all kinds of impurities of the surrounding country into the river. It cannot be avoided, and is, therefore, a constant source of pollution. If it wasn't for continual bacterial purification, you would not have as little disease in St. Louis as you have now. It is due to repeated and continual bacterial purification which takes place all along the river, after repeated and continuous pollution of the river. That is the best evidence of the great value of bacterial purification and the destruction of pathogenic bacteria.

Q. In other words, professor, a half a loaf is better than no bread at all, is that true?

A. Yes, certainly, that is true.

Q. Professor, I am going to ask you again as a biologist,
pathologist and a bacteriologist, that if authority was given
you to remove all the sewage source of pollution in a given
7642 stream, if it is not a fact that you would commence first
to remove the sources of pollution at the source of the
river rather than at its mouth?

JUDGE SPRINGER: I object to this question for the reason that there is no power on earth that can give such authority to a human being. It is an utter impossibility to keep sewage out of the river, as much as it is impossible to keep rain out, and that any answer that this witness should give to that question would be immaterial, irrelevant and of no value in establishing any issue in this case.

MR. JEFFRIES: I suggest to the counsel that the Thames Conservancy looks after the condition of the Thames river, and keeps the sewage discharges of the cities from entering that river.

JUDGE SPRINGER: I would suggest that they approximately do, but to say that they actually do, is contrary to the condition that exists there, and that are known to all those having charge of the London waterworks. They endeavor to protect the sources of the river above the water intake, and accomplish it in a great many respects, but not all respects, it is utterly impossible.

MR. JEFFRIES: They certainly improve the condition of the River Thames, or the Conservancy would not be maintained.

Q. (Last question repeated.)

7643 A. I would not take such a responsibility, because I know that that would be impossible, to remove the pollution from the river.

Q. We are speaking now of the sewage pollution and all possible sewage pollution that might be under modern contrivances, eliminated from the river?

A. It cannot. For instance, every heavy rain will sweep all the material from all the farms along the river, into that river.

Q. Then, professor, as a bacteriologist, as a biologist, and as a pathologist, should not every endeavor be made to permit as little sewage from towns and cities entering the river, as is possible and pratical under modern conditions?

A. Modern cities have to get rid of their sewage or effluents and they will have to dispose of it in some way, and what shall they do with it if not turning it into the river and depending upon the natural purification, bacteriological as well as chemical? That is the way to dispose of it.

Q. Are you familiar with Berlin?

A. Yes, I am.

Q. Do you know the system of sewage disposal there?

A. Now, only the effluent is turned into the river Spree. Formerly the sewage entered the Spree itself.

7644 Q. In other words, then, there is a great populous city that has, to a large extent, eliminated the sewage from the pollution of the stream?

A. Because much of the water was used a short distance below the city of Berlin and it was obnoxious to the senses, it was physically as bad as that of the river Seine in Paris. Black thick scum, even dead animals were floating around on the river, and big gas bubbles would come up. The people below Berlin had to use the water, and they had to be protected. It would be just the same here, as though you had people living along the drainage canal and they would have to use the canal water for drinking purposes. They would object to the odors of the big sewage tank in the upper part, particularly they would object to the odor. They would object to the use of that water, and some provision would have to be made for them. If we had to provide for those people, it would be the same condition as it existed below Berlin.

Q. But they have made those improvements?

A. For the reasons stated.

Q. I am not talking about the reasons now. I want to know whether they did or not?

A. Yes, they did; they made those improvements for 7645 the people living shortly below Berlin, but those living further down were not the ones affected or complaining.

Q. Now professor, this bacterial zone of purification depends largely upon the amount of sewage in the stream, does it not?

A. Yes sir, the more sewage the more rapid the disposal of the disease producing bacteria on account of the overgrowth of saprophytes.

Q. Then the more sewage means a change in the position of the zone of purification?

A. That alone, no. The more sewage and the more favorable the temperature for the growth of saprophytic bacteria in that sewage tank, the sooner the disposal of the organic material and the earlier will be the purification zone.

Q. The more sewage with an additional increased flow, means a change in the position of the bacterial zone of purification, does it not?

A. Yes sir.

Q. Now then, assuming that Chicago has a population of 4,000,000 of people rather than a population of 1,600,000, as now discharging the sewage into the drainage canal, the additional discharge produced by the increased number of popu-

lation with an additional flow would necessarily move the
7646 zone of bacterial purification down the Illinois river,
would it not?

A. That condition could be made so that there would not be much difference, so that there would not be much shifting of the zone of bacterial disappearance.

Q. Well, why?

A. Well, the more organic material with a certain head of water—

Q. No, but we are basing the assumption upon the idea that the water will be increased as the pollution is increased.

A. Yes.

Q. So that the stream will be very much quicker in flow?

A. This is mainly a question of dilution. The greater the dilution the farther down will be the zone of purification.

Q. Professor, if there is deposited into the drainage canal, the sewage from 1,600,000 people, when that drainage canal is taking from the waters of Lake Michigan 250,000 cubic feet of water per minute, would there be any change in the dilution if the sewage of 3,200,000 people should be discharged into that canal when the canal draws from the Lake 500,000 cubic feet of water per minute—what would be the difference in dilution?

A. It would be the same.

7647 Q. It would be the same, that is it exactly. Now then
if the dilution under those circumstances would be the same, would not the increased volume of water from the lake and the increased sewage polluted water coming through the canal, create a more rapid current, and therefore remove the zone of bacterial purification farther down the river?

A. Yes sir.

Q. Now professor, I will ask you if it is an easy matter to detect typhoid bacilli in sewage?

A. No sir.

Q. Isn't it a difficult matter, professor, to distinguish between typhoid bacilli and coli in sewage?

A. Yes sir.

Q. May not the disappearance of typhoid germs in your experiments be due largely to an overgrowth of coli, rather than the actual death of the typhoid?

A. You mean in the waters of the Illinois river?

Q. Experiments that you made?

A. Well, do you mean laboratory experiments or do you mean river water examinations?

Q. I am talking about the experiments now that you made.

(Previous question read.)

A. In the water experiments made with Lake Michigan water there were no colon bacilli; they were mainly cocci or large water bacilli.

7648 Q. Well, there is no coli bacilli in the waters of Lake Michigan?

A. Sometimes; not always.

Q. Then you made no experiments under that condition?

A. With Lake Michigan water—it contained no coli bacilli.

Q. With the river and the—

A. With the river water—our specimens of water were free from the colon types of bacteria in the Lake Michigan water. With regard to the rivers, we did have colon bacilli in our specimens.

Q. May not the disappearance of the germs—

A. I found them for days, and then I could not find them any more.

Q. Then the colon bacillus had so grown that you could not find them?

A. In all bacteriological tests the finding of the germ is evidence. If we do not find the germ it is not as good negative evidence as the other is positive.

Q. In other words, not having found them did not mean that they were not there?

A. Because we have usually a large quantity of water and we have not examined all of it.

Q. And you have a large production of the colon?

A. We have a large production of the coli types if present; they grow rapidly.

7649 Q. And which you cannot easily distinguish from the typhoid?

A. Oh yes, you can distinguish them, but there are some difficulties, considerable difficulties in distinguishing a typhoid bacillus from a coli bacillus.

Q. Then in your examination of the life of the typhoid germ in the Illinois river water, the disappearance of the typhoid germs from that water that you examined may be due largely to an overgrowth of the coli rather than the actual death of the typhoid, may it not—or may have been due?

A. I think I have been very careful in those experiments, and I have been able to find them for days, even in such very small quantities as I have inoculated into those waters. The difficulties were great on account of the colon types being very numerous. I judge from the results of these experiments, that if I am able to find them at all for five or six days, and thereafter am unable to isolate them, that they must have disappeared or died.

Q. But still, on account of the great numbers of colon bacilli which have been produced, they may be there and you not find them?

A. The great numbers of colon bacilli that have been produced may have been the cause of the death of the typhoid bacillus. 7650

Q. And still they may be there and you not find them?

A. I would rather say they must have died, due to the overgrowth of colon bacilli, but not that they are there.

Q. Do you know that they died, and do you know that they were not there simply because you didn't find them?

A. Yes, it is my opinion that they must have died because I found them before when the difficulties were just as great. We can have opinions in such things, and we may be mistaken.

Q. Well, it is merely an opinion then?

A. Well, my opinion is that they have died, due to the great increase of other bacteria in that water, colon bacilli types among the others.

Q. Now then, professor, the condition of that water—what was the temperature of that water at the time those examinations were made?

A. Ten to twelve, centigrade.

Q. And that would be how much Fahrenheit?

A. 50 to 53 Fahrenheit.

Q. Now then that is supposed to have represented the temperature of the water in the river?

A. That is supposed to have been as near the temperature of the water as it was then.

7651 Q. Now then, if those experiments had been made with the water at 32 Fahrenheit, there would not have been such a growth of the colon bacilli, would there.

A. All the bacteria—you speak now of Fahrenheit?

Q. Yes.

A. —At 32 Fahrenheit, would have frozen.

Q. There would have been no increase then, would there?

A. There would not have been any increase, no.

Q. At 33 Fahrenheit, there would not have been as much increase as there was at 53?

A. No.

Q. Then if there would not have been as much increase at 33 and the examinations had been made at 33, the typhoid bacilli would have better opportunities and a better chance to live, would they not?

A. I don't think there would have been any difference between 32 and 50 with regard to the growth of typhoid bacilli.

Q. Do you think temperature has nothing to do with it at all?

A. Oh so little, no; such a few degrees that is.

Q. Then why didn't you make all the experiments at one certain point and make no variations whatever?

A. I simply wanted to produce a low temperature, that was all—conforming somewhat to the temperature of the river water, that was the only object.

7652 Q. Don't you know that the temperature gets much lower than that at times, and much higher than that at times?

A. I don't know the temperature of the Illinois river, but I took it that the temperature of river water in general is 10 to 12 and so I took those temperatures, and it varied between those degrees in the refrigerator.

Q. You think then the change in the temperature of the water has very little to do with the life of pathogenic germs?

A. Slight variations, like that; but greater variations if you take blood temperature, now, 98 that increases the growth of the typhoid bacilli.

Q. And as you recede from 98?

A. As you make it less—

Q. You say blood temperature in the running stream has what effect on the typhoid?

A. The typhoid bacilli increase rapidly at that temperature.

Q. In the running stream?

A. Yes.

Q. Do you mean to say that in the running stream—

A. In the river water, in my laboratory experiments, if you keep that at 37 degrees C.

Q. We are talking now about the water in the stream.

A. The water in the stream is never blood temperature.

7653 Q. Are you right certain of that?

A. I think so—98 1-2.

Q. As you recede from 98 1-2, you increase the opportunity of the typhoid germ to live, don't you?

A. Yes, it lives longer as a general proposition in colder temperature when no other bacteria are present.

Q. Then as you go towards the freezing point he lives longer?

A. Typhoid bacilli can live a long time in ice.

Q. Well then as you approach the freezing point, the typhoid bacillus lives longer?

A. Than at a higher temperature?

Q. Yes?

A. Well, I must modify that. The typhoid bacillus lives best in a high temperature, but it multiples rapidly then and when it multiples, produces poisons to itself.

Q. You are talking about the typhoid in the laboratory?

A. Yes.

Q. We are talking about it in the running stream now. If you can draw any conclusions whatever from your laboratory experiments as to the conditions and changes that take place in the running stream, that is what I am after right now. Now I understood you to say a while ago that the typhoid fever

bacillus did not multiply in a running stream, or in sew-
7654 age, and that the only place that he did multiply so far as you know was either in the human system or in some preparation or medium that had been prepared for it?

A. No, but in pure water—it can multiply in pure water in a favorable temperature. If the temperature is blood temperature and the water is pure, and there are no saprophytic bacteria present to overgrow it, then it can even multiply in water.

Q. Now do your experiments show that?

A. Yes, sir.

Q. Professor, you stated in your direct examination that at the Western Avenue bridge, out of 13 specimens you found colon bacillus present only nine times. Bearing in mind the fact that the liquid at this point is very rich in sewage, and that sewage is extremely rich in colon bacilli how do you account for your failure to detect this germ oftener?

A. The explanation of that would be there were innumerable other saprophytic bacteria multiplying at this place, for which the temperature and the conditions were more favorable than they were for the colon bacillus.

Q. What has become of the colon?

A. In those particular specimens they had evidently either died out or been overgrown by the saprophytic bacteria.

7655 Q. What do you mean by overgrown?

A. Multiply more rapidly — the saprophytic bacteria multiply more rapidly at that temperature than the colon bacillus.

Q. Then you could not detect the colon bacilli in those samples?

A. No.

Q. Might not the same conditions be true as to the typhoid germ?

A. That is what I always maintained, that the rapid overgrowth of saprophytic bacteria kills out or destroys the pathogenic bacteria, so the same holds true for the typhoid bacillus. The colon bacillus is capable of existing longer with the saprophytic bacteria than the typhoid bacillus.

Q. Now then, in your direct examination—

A. I want to add something yet. And in regard to the colon-like bacteria, there were bacilli enteritidis, which belong also to the colon type. It was also found several times there.

Q. It is not what you designate as a colon, or it would be put in that column.

A. It is one of the colon group.

Q. In your direct examination you stated that in city water drawn from the tap, out of seven specimens you were 7656 able to detect the colon bacillus three times. How did it happen that all these revealed no more colon bacilli in the drainage canal than in Lake Michigan, bearing in mind the fact that the former is practically sewage?

A. The cause of that was, that in the Western Avenue sample that we examined here, we had great numbers of saprophytic bacteria present, which had overgrown the colon types, in the sewage already, whereas in the lake water there was no such overgrowth by the saprophytic bacteria, because the water was very much purer and the colon bacillus therefore had a better chance to grow. In other words the competition between the sewage bacteria and the colon bacillus was not as great as it was in the Western Avenue bridge specimen, otherwise, we should have found the colon bacillus every time.

Q. Then, professor, there were better facilities for self-purification in the sewage than there would be in Lake Michigan, is that correct?

A. That is right for the pathogenic bacteria. The sewage is much more favorable for overgrowth of saprophytes than pure water.

Q. Now then, if you start the sewage out on its journey without giving the saprophytes an opportunity to appear, and as dilution takes place you remove the chances for the death of the pathogenic germs, do you not, yes or no?

7657 A. I couldn't answer it that way for the reason that the sewage itself furnishes the organic material for the growth of the saprophytes. It is the sewage that causes the multiplication of saprophytes, whenever there is much organic material.

Q. Under all conditions?

A. All conditions particularly temperature being right.

Q. Then, as you increase the dilution, you increase the ability for the saprophytes to get in their work?

A. No sir, it is the opposite. As you increase the dilution, you spread the organic material over a larger area, and therefore the saprophytes will not be able to multiply as rapidly and overgrow the pathogenic bacteria which are mixed with them.

Q. Well, that is it exactly; that is just exactly the question that I asked you, or aimed to ask you. As you increase the dilution in the running stream and remove the whole material farther down, you increase the ability of the pathogenic germ to live, do you not?

A. Yes sir.

Q. And if the pathogenic germ should get out into the stream and get free from any saprophytes, or saprophytic influence or effect, they would live much longer than they would if they run their chances in a septic tank? 7658

A. Yes sir.

Q. Professor, is it or is it not a fact so far as you know, that the water of Lake Michigan, or rather to the water of Lake Michigan, has been attributed repeatedly, the typhoid fever from which Chicago has long suffered?

A. Yes sir.

Q. Professor, if it is your opinion that the water is not the direct cause of the typhoid fever in Chicago, is it the general opinion of the physicians in the city, if you know?

A. I do not know what their opinion is, but I wish to say that I do not wish to deny the presence of the typhoid bacillus in Lake Michigan, when there are many cases of typhoid fever in the city of Chicago and when the sewage of such patients is emptied into the lake, but the tremendous dilution taking place in the lake with billions and billions of gallons of water before such sewage can enter the inlets will produce such a tremendous dilution and spread of typhoid bacilli that the one who drinks this polluted water is not liable to be infected directly because only very few typhoid bacilli could be swallowed in this way.

Q. The dilution in the lake would be much greater than in the canal, isn't that true? 7659

A. Yes sir.

Q. And much greater than in the Illinois river?

A. Yes and much greater than in the Illinois river.

Q. Now then professor, what I want to know, you stated that it was your opinion that water was not the direct cause of typhoid fever.

A. The indirect cause.

Q. That it is the indirect cause, is that your position?

A. Yes sir.

Q. I want to know if you know whether or not your opinion is the same as that of the physicians generally throughout the city?

A. The majority of physicians treat the subject in a somewhat like manner. They think when the germ is present, that that is all that is necessary.

Q. In other words they believe in the direct cause?

A. Many physicians are under the impression that one germ is all that is necessary to produce typhoid fever, but bacteriologists are trying to instruct their students as well as physicians in general, that it is not true, and that a large number of virulent germs must be swallowed for infection results.
7660 And further, that not only a great number of virulent germs is necessary to produce an infection, but that the resisting forces of the organism must be reduced.

Q. Now, Professor, if you know, state whether or not it is a fact that the drainage canal was built largely in order to secure greater purity of the water supply of the city of Chicago?

A. Yes sir.

Q. Professor, if I understood you correctly, disease producing germs would disappear more rapidly in a warm mixture than in a colder mixture?

A. In a blood temperature they would not.

Q. That would be a warm mixture?

A. But if you will say in room temperature, yes.

Q. Now if this be true, professor, what effect practically speaking, does the addition of 250,000 cubic feet per minute, of lake water have upon the temperature of the water in the drainage canal? In other words doesn't it have the effect of lowering the temperature, a cooling effect?

A. I think the temperature of the water in the drainage canal is very similar to that in the lake.

Q. And the temperature of the water in the lake is lower than it is in the Illinois river without the lake water?

A. I should judge that the temperature is lower.

7661 Q. The temperature of lake water generally is lower than that of river, isn't it?

A. I should judge it was lower.

Q. Then the addition of 250,000 cubic feet per minute from the lake would have a tendency to lower the temperature of the water in the drainage canal, which you have termed an open sewer, wouldn't it?

A. Yes, sir.

Q. Now that professor, would have a tendency to prolong the life of disease producing germs?

A. The temperature in the drainage canal is such as to allow the rapid multiplication of saprophytes as indicated by the gas production which can be seen in the drainage canal, the large bubbles of gas that arise, and as seen also by the great increase of saprophytic life.

Q. Do those gas bubbles arise since the canal has been opened?

A. Yes sir.

Q. Even though there is 250,000 cubic feet per minute: do they still arise?

A. Yes sir.

7662 Q. But if that deposit or composition of water and sewage has increased to the temperature of the Chicago river, prior to the opening of the canal the reduction of the pathogenic germs and disease producing germs would be very much greater than now wouldn't it?

A. If the temperature was higher there would still be more growth of saprophytes.

Q. Correspondingly a more rapid reduction of the pathogenic germs?

A. Of the organic material and the pathogenic germs.

Q. Professor, may disease producing germs live in ice?

A. Yes sir.

Q. Then might not the germs of typhoid fever be carried from the Illinois river and on into the Mississippi, on floating ice formed in the river?

A. I have no experiments of my own of how long they live in ice but some experiments have been conducted lately that prove that typhoid bacilli die in ice within a certain period.

Q. That is about how many days? Thirty days?

A. Yes less than thirty days.

Q. Do they all die in thirty days?

A. From my experience I would judge that typhoid bacilli could live in ice for thirty days.

7663 Q. Then if the ice made the journey down the river to the intake tower at the chain of rocks in the Mississippi river in thirty days, they would carry the typhoid germs with them, wouldn't they. It would carry the typhoid germs with it?

A. If the germs were still alive it could, and if the ice could travel down in that time. If it could go in thirty days and the germs lived that long. they could be carried there, and be alive under those conditions.

Q. Now professor, assume that during a cold snap, late in the winter, some of the water of the drainage canal containing typhoid germs, is frozen into a block of ice, and that soon thereafter owing to a thaw and a freshet this block of ice or a large part of it is swept as ice over the Bear trap dam and down the Illinois river to Grafton. Assuming further that as it enters the Mississippi river and passes on in it, and after reaching the Mississippi river it gradually melts and mingles with the water of the river, arriving by the time it is completely melted, on the Missouri shore, and the intake tower at the chain of rocks, of the St. Louis waterworks, is it not a fact that typhoid fever germs alive and virulent, derived from this source might as readily enter the intake at the chain of rocks as any other microbe in the Misissippi water?

7664 JUDGE SPRINGER: I object to this question on the ground that it assumes that blocks of ice may be formed and have been formed in the Chicago drainage canal, which is contrary to the facts, for it is known here that the drainage canal does not freeze up.

MR. JEFFRIES: I submit that on account of the additional 250,000 cubic feet per minute, and on account of the fact that it has not been determined what additional flow will hereafter be made, that the experience of the Chicago river which contained only a small amount of water, in comparison with the conditions that will exist in the future, and there is no reason why ice may not be formed in the Chicago drainage canal, and for the further reason that the period or number of years that the canal has been opened is too short to form a conclusion that the water will never freeze in the canal or in the future, and for the further reason that as stated by counsel for defendant the organic and oxygen consuming powers are not now what they were in the Chicago river at the time mentioned by counsel.

JUDGE SPRINGER: I object to this further for the reason that the assumption is based upon the conditions in the drainage canal and not in the Chicago river, and also to the assumption that the water freezes below the drainage canal before it enters the Illinois river, because it is well known
7665 here that the water in the Des Plaines river before it
enters the Illinois river, after receiving the sewage outfall of the drainage canal does not freeze during the winter months, so that there is an absence of ice in the drainage canal and the Desplaines river, as far down as the confluence of the Desplaines and the Illinois rivers.

MR. JEFFRIES: I suggest further that because no ice has been formed during the three years that the drainage canal has been opened is no reason why it will not form in that river in the future.

JUDGE SPRINGER: I object further for the reason that this assumption assumes diminution in the oxidizing power which is contrary to the evidence in this case, therefore I object to the assumption contained in your question.

Q. (Question repeated).

A. In the first place the typhoid bacillus arriving in the drainage canal would have had to pass through the sewers of Chicago and in the temperature of those sewers there would have been such rapid multiplication of the saprophytic bacteria due to the great quantities of the organic material, that in my opinion the typhoid bacillus never reaches the drainage

canal; at least the lower part of the drainage canal and probably not even the upper part of the drainage canal. In my
7666 opinion they are dead when they arrive in the canal, because the sewage in our sewer system is in a much more favorable condition for the growth of saprophytes than the drainage canal. This depends, of course, upon the length of time, the sewage remains in the sewers.

Q. Now professor, assuming that in this ice so frozen, as contained in the last preceding question, there was contained typhoid bacilli?

A. You put them in you mean?

Q. We are assuming that they are in the water before the ice is frozen; that the typhoid germs are frozen in the ice, what would you say then?

JUDGE SPRINGER: At what place?

MR. JEFFRIES: At the place of freezing.

JUDGE SPRINGER: They would freeze in a great many places.

MR. JEFFRIES: Now professor, assume that during the cold snap late in the winter, some of the water of the drainage canal containing typhoid germs is frozen into a block of ice, and that soon thereafter owing to a thaw and freshet this block of ice or a part of it, is swept as ice over the Bear trap dam, and on down the Illinois river to Grafton. Assume further that as it enters the Mississippi and passes on in it, it gradually melts and mingles with the waters of that river, arriving by the time it is completely melted, on the Missouri shore, and at the in-
7667 take tower of the St. Louis waterworks at the chain of rocks, is it not a fact that the typhoid fever germ arriving, frozen in said ice, alive and virulent derived from this source, might not as rapidly enter the intake at the chain of rocks, as any other microbe in the Mississippi river water?

JUDGE SPRINGER: I object to the question for the reason stated in my former objection.

A. There would be a possibility of the typhoid bacillus which has not died in this ice, to enter, of course, the intake.

Q. And be distributed into the water supply?

A. With great dilution of course.

Q. That is true, isn't it?

A. The proposition that a typhoid bacillus could live in ice is true, whether in a river or otherwise.

Q. Assuming professor that the assumptions contained in this question are true?

A. Yes.

7668 Q. We are talking now about the assumptions. Admitting those assumptions are true?

A. Yes sir.

Q. It would find its way to the chain of rocks in St. Louis, and be just as liable to enter into the intake in the water supply of St. Louis as any other microbe in the water.

A. Yes, or it might go any other way.

Q. I believe you stated professor, that you made no examination as to the life of the typhoid germ in the polluted waters of the present drainage canal?

A. No sir.

Q. Professor, not having made any examination as to the life of typhoid germs in canal water, you of course cannot say how long they would live in that water?

A. I have stated my opinion, that when the saprophytes increase in great numbers, the pathogenic bacteria disappear before the saprophytes.

Q. That is an opinion?

A. Based upon experiments.

Q. Laboratory experiments?

A. Yes sir.

Q. Professor, assuming that an examination of the water in
the canal was made for the purpose of determining the
7669 life of the typhoid bacilli, and assuming that they were
found present in the tests at the end of six, seven, eight or
ten days, might it not be possible and is it not altogether probable that they do exist in the flask and have not all perished at that time, and that one may be unable to determine their presence because of the overgrowth of the colon bacilli?

A. Just as soon as colon bacilli overgrow them they disappear. Competition between different bacteria is of such a nature that the overgrowth of one is the cause of the destruction of the other, so I am reasonably certain that when one kind has disappeared and another kind has increased at a tremendous rate, that the cause of the disappearance or the destruction of the one, was due to the overgrowth of the other.

Q. Now then assuming that they would live in experiments in the flask, for five, six or seven days in the laboratory, is it not natural to conclude that they would live much longer in the canal with the water flowing through it at the rate of 250,000 cubic feet a minute?

A. No, the very opposite would be true, because in the laboratory experiments I made, I was not using the seriously polluted drainage canal water, but only river water which has not so much organic material or saprophytic bacteria as
7670 are found in the drainage canal. Even in this much less
polluted Illinois river water they disappear in five or six days, and therefore I judge that the more organic material the more saprophytic life there is, as it would be in the drainage canal, the sooner they ought to disappear. Such experiments have been made with regard to other bacteria, such as the cholera vibrio. Rivers containing great quantities of organic material, cause death of cholera germs in from two to four hours, whereas, the less organic material the longer the cholera vibrio would exist.

Q. Professor, assuming that they do live five, six and seven days in the laboratory experiments in water from the canal, upon that assumption is it not natural and reasonable to believe as a bacteriologist that they would live much longer in the canal itself?

A. I have already admitted that several times, that the difference here between the laboratory experiments and the river or canal, would be this, that in the laboratory experiment the products of the other rapidly increasing saprophytic bacteria would remain in the mixture, while in the river it is diffused.

Q. In the canal proper they are able to take care of themselves?

A. Yes sir. Now whatever influence that these saprophytic excretion products may have upon the growth of the
7671 typhoid bacilli, of course, is not present in the river water
or the canal where these products would be diffused.

Q. Then professor, assume that they would live five or six or seven days in the laboratory tests, how much longer would you say they would live in the canal itself?

A. I couldn't tell because I haven't made that experiment, and I do not know what influence these saprophytic bacterial products have upon the typhoid bacillus in the laboratory experiment. It might hinder or favor their disappearance from the mixture.

Q. And that cannot be ascertained?

A. Unless you had experiments in the drainage canal or in the Illinois river for comparison.

Q. Is it not natural to assume, professor, or to suppose, speaking now from the standpoint of analogy, as applied to the science of bacteriology, that if they live five, six and seven days, in the laboratory samples of the water taken from the canal that they would live ten or twelve days in the canal proper?

A. That may be true, but the very opposite may be true. It might be similar to conditions existing in the river Ganges. Cholera vibrio live longer in the laboratory experiments than they do in this river; so the very opposite may be true also. I have not admitted that this production of the saprophytes, necessarily is harmful to the typhoid bacilli and there-
7672 fore destroy them sooner. It may be that the diffusion of these saprophytic products under normal conditions in the drainage canal, causes a still earlier disappearance of typhoid bacilli.

Q. So then it is only a matter of determination one way or the other?

A. Unless the experiments is made in the canal itself.

Q. In other words, if I understand you right, the increased growth of the saprophytic bacteria in the samples, may destroy the typhoid germ because of the products that they throw off?

A. That's it.

Q. While on the other hand the growth of the saprophytic bacteria in the canal proper, with the addition of the water from Lake Michigan may have a tendency to furnish food for the bacteria, for the typhoid?

A. No, it may have a tendency to carry these saprophytic products off by diffusion.

Q. It may have a tendency to carry these products that the saprophytic bacteria throw off, away from the typhoid?

A. Yes sir, by diffusion in the water.

Q. And it is perfectly natural to believe that, is it not?

A. Yes sir.

Q. Upon the theory that all live organisms have the faculty of making an effort to preserve their own life?

A. Yes sir. This diffusion in water is not dependent upon any faculty possessed by the germ.

7673 Q. It is also true, is it not, that while the various organisms of a pathogenic character that do not grow well in the samples and in the tests, that do not multiply in the natural stream, that if they are confined as prisoners, that the condition of imprisonment will in all probability, have a tendency to destroy the life much more readily than it would if you put them out in a running stream, where they could in that way take care of themselves. Is not that natural and true from the standpoint of analogy as applied to bacteriology?

A. Well, the pathogenic bacteria are unfavorably influenced in the stream by the low temperature of the water.

Q. That is unfavorably influenced by the low temperature as far as multiplication is concerned?

A. Yes sir.

Q. But they are favorably influenced so far as life preservation is concerned, by the low temperature, are they not?

A. Yes, but after all, if they cannot multiply, they cannot produce products.

Q. That is exactly true, but at the same time if the temperature is favorable to the life, conditions will necessarily be favorable for their ability to preserve themselves; isn't that true?

A. Yes sir.

7674 Q. Now professor, assuming that the discharge of the typhoid fever patients in Chicago were deposited into the sewers of the city and assuming that they were thence carried into the Chicago river and thence into the Chicago drainage canal and into the canal mixed with the water of Lake Michigan, and that the water in the canal contained numerous numbers of saprophytes and ordinary water bacteria, to the number of 70,-

000 and frequently as many as 4,000,000 per cubic centimeter, and assuming that it required at least 24 hours for the water to pass from Chicago sewers into the Chicago river and the drainage canal and over the Bear trap dam, and assuming that the flow in the Desplaines river and the Illinois river is actually about 40 miles in 24 hours; how far might a typhoid bacillus travel in the water of the Illinois river, assuming that it did not perish while contained therein, earlier than ten days from the place of deposit. How far would it travel, professor?

A. I don't believe they would travel at all; I think they would be destroyed by the time they reach the Bear trap dam.

Q. Professor, we are assuming now everything in this question, based on an assumption.

MR. DRENNAN: I object to the question upon the ground
that there is no evidence in this case upon which the as-
7675 sumption can be predicated that they will live ten or
twelve days in the waters of the drainage canal.

MR. JEFFRIES: I would like to have counsel for defendant prove that they do not live that long. The respondents admit that they put the germs into the river, the burden is on them to get them out.

JUDGE SPRINGER: We have not admitted that we put them into the Illinois river or the Desplaines river.

MR. JEFFRIES: I submit this hypothetical question is based upon the evidence introduced and is therefore a competent question to ask this witness. It is not a scientific question, but is purely based on scientific investigations. It only calls for a mathematical calculation to answer.

A. According to the rate of the flow which you have given me, this could get down to St. Louis in ten days, at the rate of flow of 40 miles in 24 hours.

Q. And would get as far as the chain of rocks and the intake tower?

A. Forty miles a day for ten days would be four hundred miles and that would be beyond St. Louis.

Q. And if typhoid germs were there and were alive, they would be just as likely to get into the water of the St. Louis supply, as any other bacteria that might be found at the chain
7676 of rocks?

A. If any typhoid germs were in the water after ten days, getting in by any manner or any source, and were alive, they of course could get into the intake.

By agreement of counsel, witness Prof. F. Robert Ziet is temporarily withdrawn.

7677 FRANK WRIGHT,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Springer and testified as follows:

Q. What is your name, residence and occupation?

A. Frank Wright, 2500 Michigan Avenue; Medical student.

Q. Have you at any time taken in any of these lakes or rivers samples of water for analysis?

A. I have.

Q. Please state what you did and when you did it?

A. I took samples from the Illinois and Michigan Canal at Bridgeport, and from the drainage canal at Western Avenue, and from the Illinois and Michigan Canal at Western Avenue.

Q. When?

A. During the period of analyses in 1899 and 1900.

Q. Can you give the dates?

A. The exact dates are given opposite the numbers I think, on the records.

Q. Well, will you please state from whom you received instructions as to the manner of taking these samples?

A. From Dr. John H. Long.

7678 Q. What were those instructinos?

A. A perfectly clean and steriled bottle was taken and this was immersed in the canal, filled, stoppered immediately, the bottle placed in a container and taken to the laboratory immediately.

Q. Did you take them yourself to the laboratory?

A. I did.

Q. Did you follow the instructions that Prof. Long gave you in regard to taking these samples of water?

A. I did.

Q. How long was it, after you took the samples from the water was it until you delivered them to Prof. Long's laboratory?

A. Depending upon the car connection it was anywhere from fifteen to twenty minutes; in a few cases it might have been a half an hour.

Q. You took a street car?

A. A street car in each case.

Q. I will call your attention to the tables introduced in evidence by Prof. Long, beginning with table No. 2, Bridgeport Pumping station and ask you to state whether the samples which you furnished Professor Long were those referred to in that table?

A. They were.

7679 MR. JEFFRIES: I object to the question and I move to strike out the answer because it is incompetent, irrelevant and immaterial, and there is no proof that the witness ever saw this book, and never made the compilations therein contained, and therefore is not able to state that the samples are the same samples that are examined and mentioned in that book. And I move to strike out the testimony of this witness with reference to these samples for the reason that no proper foundation has been laid, and I move to strike out the statement of the witness in which he testified from the publication of the Illinois State Board of Health.

Q. JUDGE SPRINGER: State whether you placed any numbers on the samples that you took from the water, that is, placed any numbers on the bottles?

A. Yes sir, the bottles were delivered to Dr. Long and the numbers were placed on the bottles.

Q. Were the dates placed on the bottles?

A. The numbers and dates.

Q. What else was placed on this label that you furnished to Dr. Long?

A. The place of collection and time.

Q. You may state whether the dates on which you took the samples and the places in the table to which your attention has been called the Bridgeport pumping station, are the same 7680 in the table as those were which you took from that place to Professor Long?

A. Well, these bottles were delivered to Professor Long, and the dates and the numbers and place of collection were placed upon them.

Q. Is that the correct date they were delivered that you see upon them?

A. I have no reason to believe otherwise.

MR. JEFFRIES: I object to the question and answer as not being competent evidence.

Q. What do you know about that?

A. These samples were collected and brought to the laboratory and the dates placed upon them and I believe these dates were the dates on which they were brought.

Q. Please look at the tables following this one in that book which were put in evidence by Professor Long.

MR. JEFFRIES: The book was not put in evidence.

JUDGE SPRINGER: The tables were put in evidence by Professor Long beginning with table No. 2 and continuing with table No. 3.

A. I collected from Bridgeport, Western Avenue, over a period of time between July and December, the 1st of July and the 1st of December, 1899, and during the year 1900 from Bridgeport, and a few samples from the drainage canal, and

7681 from the Illinois and Michigan canal at Western Avenue. And in 1899, over a period from along the first of March until the first of September from the Illinois and Michigan canal at Bridgeport, and at Western Avenue and from the drainage canal at Western Avenue.

Q. I call your attention to the tables put in evidence in this case by Professor Long of samples taken at those places during that time. State whether the dates in the tables to which your attention has been called, and the samples of water referred to there, are the same as those which you furnished Professor Long?

MR. JEFFRIES: I object to the question, as it does not establish the fact that the samples of water taken by this witness, if taken at all, are the samples contained and mentioned in this table.

A. I collected the water. I couldn't tell each and every date, but I collected the water during this period of time that

I have said and this water was delivered to Dr. Long at his laboratory and there the samples passed out of my hands.

Q. And after that——They were delivered between the periods mentioned in these tables?

A. Yes sir, they were.

Q. And after you delivered them, you took no further account of them and know nothing about what became of
7682 them?

A. They were then delivered to Dr. Long, and after that I couldn't say.

MR. JEFFRIES: I move to strike out the testimony of this witness and also the tables as introduced by Dr. Long upon which these samples so taken, or alleged to have been taken by this witness, upon which they are predicated, for the reason that no proper foundation has been laid for their introduction and for the further reason that there is no evidence showing the manner in which this witness took the samples, and therefore the examinations of Professor Long and the results as shown on these tables are incompetent, irrelevant and immaterial.

JUDGE SPRINGER: I understand the witness to have testified since he had been upon the stand, as to the manner in which he took the samples.

Q. What was the manner of taking the samples; what method did you pursue in taking them?

A. I left the laboratory with a bottle that was cleaned and steriled, getting to the place mentioned, this bottle was immersed in the canal, filled, stoppered and brought back to the laboratory in the shortest possible time.

Q. How far did you immerse the bottle in the water?

A. Depending upon the rapidity of the current any where from six inches to two feet.

7683 Q. Did you have any instrument for the purpose of enabling you to immerse it further, or did you use your hands?

A. I used a rope and the length of this rope, which was wet would be the means of telling how far the bottle was immersed.

Q. Did you pursue the same course in each case when you took the samples?

A. Yes sir in each and every case.

Q. In the period of time you have mentioned?

A. Yes sir.

Q. How far from the shore were those samples taken?

A. They were taken as near as possible to mid-stream.

Q. Did you note the temperature of the water or air at that time?

A. The temperature of the water. The air was not taken by me.

Q. How long after you took the water from the canal was it until you reached the laboratory of Dr. Long?

A. On an average fifteen or twenty minutes.

Q. During this time I presume there was no packing of it in ice?

A. No sir, there was not.

7684 CROSS-EXAMINATION, by Mr. Jeffries.

Q. Where do you live?

A. In Chicago, 2500 Michigan Avenue.

Q. How long have you lived here?

A. Eight years.

Q. What is your business?

A. I am a student of medicine.

Q. Were you a student of medicine at the time these samples were taken?

A. I was doing preparatory work at that time.

Q. Did you rinse these bottles?

A. These bottles were cleaned and steriled before giving them to me.

Q. Who cleaned them and steriled them?

A. I couldn't say.

Q. How do you know they were steriled then?

A. They were delivered to me as such.

Q. All you have got is the word of the man who delivered them to you?

A. Yes sir.

Q. Was Professor Long there all the time, every time you got the bottles?

A. Not each and every time.

7685 Q. You had a certain place where they were put and you would go there and get them?

A. I would.

Q. You do not know who had been there before you got there?

A. They were kept under a key and I have reason to believe that no one outside of the laboratory had access to them.

Q. You do not know who steriled them?

A. I do not.

Q. You do not know whether they were sterilized under directions or not?

A. I couldn't say.

Q. How long was it from the time you took the samples until you delivered it to Professor Long?

A. On an average of fifteen or twenty minutes.

Q. Were they put on ice or ice put around them or anything of that kind?

A. No sir.

Q. Do you know whether he commenced his examination of the water immediately after receiving it or not?

A. I couldn't say.

Q. You delivered it to his office sometimes when he wasn't there?

A. If he wasn't there, his laboratory assistants were, the

7686 men who received them.

Q. What did they do?

A. They received this water, the number of it, the date and the place of collection was placed upon it.

Q. But you don't know what they did with it?

A. No sir, I do not.

Let the records show that the same stipulation as to the waiver of signature of this witness be made as that with reference to the signature of the witness W. S. Sayer.

Adjourned until 2:30 P. M. same day, October 6th, 1903.

7687 2:30 p. m., Tuesday, October 6, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. F. ROBERT ZEIT,

resumed the stand for further cross-examination by Mr. Jeffries and testified as follows:

Q. Professor, does the typhoid fever bacillus form spores?

A. No.

Q. If it did, would its longevity in water be greater?

A. Yes sir.

Q. Are there any pathogenic bacteria found in water of streams which do form spores?

A. The spores of anthrax may get into a river.

Q. And the anthrax does form spores?

A. An anthrax bacillus forms spores; whenever it is placed in unfavorable conditions of growth, it takes on the resistant type of the organism which is a spore.

Q. How about lockjaw or tetanus?

A. The tetanus bacillus also produces spores.

Q. How about the staphylococcus?

A. It produces no spores.

7688 Q. And the bacillus enteritidis?

A. It produces no spores.

Q. Now you testified, I believe, that you found anthrax germs and tetanus germs as well as one of the pus formers, in the Illinois river water?

A. Yes sir.

Q. And also the an-aerobic bacillus enteritidis?

A. The bacillus enteritidis, yes.

Q. And of those the anthrax and tetanus form spores?

A. Yes.

Q. Professor, will you state whether or not the spores of anthrax, lockjaw and other highly dangerous pathogenic germs would have a greater resistance and greater longevity in a running stream than the ordinary germs themselves?

A. The spores of all bacteria are highly resistant, and can in the absence of food, exist for a long time without being destroyed.

Q. Now isn't it a fact that the spores of these diseases might readily survive in the Illinois river for many days, weeks, and even months?

A. The spores of anthrax, or of tetanus bacillus might be washed into the river and exist for many months.

Q. Then, professor, if these germs were detected by a 7689 bacteriologist below Peoria, would there be any difficulty whatever in their having had their origin in the Chicago stock yards or hospitals?

A. Tetanus spores are found in nearly all garden earth, and street dirt, and could therefore be washed into a river during any heavy precipitation. Anthrax spores are not commonly found free in nature. They must come from an infected animal or an infected person.

Q. Then the tetanus spores, commonly known as lockjaw —lockjaw may be found and is ordinarily found in street washings and earth?

A. Yes.

Q. Around the gardens?

A. Garden earths, and street dirt.

Q. Then do you know, professor, the ordinary longevity of the tetanus germ, or the tetanus spore, or is there any way by which it may be measured?

A. The spore can live a great deal longer than the bacillus.

Q. How long might the spores of tetanus live?

A. The spore of tetanus can live for months.

Q. For months?

A. Yes.

7690 Q. And then might not the spore of tetanus from the street washings of the city of Chicago be deposited into the drainage canal and from thence into the Illinois river and thence into the Mississippi and reach the chain of rocks at the city of St. Louis, provided it traveled that distance within thirty or more days and be alive?

A. Yes sir, and tetanus spores are found usually in all rivers, so it would not be surprising to find tetanus spores in rivers.

Q. Would there not be very likely to be more tetanus spores deposited into the Chicago river and the drainage canal, coming from the street washings of a city of 1,600,000 people than a city containing 70,000 people?

A. That would not depend upon the amount of people at all; it would depend upon the amount of earth that enters the river, because the spores are found in earth and not in sewage.

Q. What earth is more likely to contain those spores?

A. Garden earth, and street dirt.

Q. Then there would necessarily be more street washings in a larger city than a small one would there not?

A. Yes.

7691 Q. And more waste that partakes of the nature of earth in the larger city than in the smaller, would there not?

A. Well, that would be insignificant. The amount of earth that could be washed from the street washings into a river would be insignificant, as compared with the amount of earth that enters that river by heavy precipitations all along the river.

Q. But professor, the addition of the street washings of the city containing 2,000,000 of people to a stream such as the Illinois river, would be considerable, would it not?

A. No, I said it would be insignificant compared with the large area that a river traverses, and with the large amount of washings that that river would receive from heavy precipitations all along the river. It does not depend upon the number of people in a city as to how many tetanus bacilli are in that city, because the people do not contribute to the increase of tetanus bacilli.

Q. Now then, professor, the addition however, of the street washings of the city containing the 1,600,000 people might be the source of the tetanus germ or spore which may be found, or which might exist in that water of the stream at any given point below the city?

A. It might be the source.

7692 Q. But one could not determine from the presence of the spore itself whether it came from the street washings of the city in question or from some other source?

A. No.

Q. So that if a tetanus germ be detected in the water supply of the city of St. Louis, it could not be determined by the examination of the sample of water from which the germ was extracted, that its original source was the city of Chicago or some other point along the Illinois river, could it?

A. No, that could not be determined.

Q. Professor, I will ask you if you are aware that the intestines of herbiverous animals are known today to be a common source of tetanus, or tetanus germs?

A. They may contain tetanus germs.

Q. Has it not been recently discovered that the intestines are a fertile source of tetanus germs, the intestines of herbivorous animals, and has it not been ascertained to such an extent that it is a serious question for scientists today in determining whether or not they thrive better in the earth or whether or not they thrive better in the intestines of the herbivorous animals, such as cattle, and whether or not the intestines of these animals are not better conducive to their vitality, their production and their strength than the soil of the earth?

7693 A. The contents of the intestines of animals as to tetanus bacilli must be mainly due to the foods that have been eaten and that were soiled with earth, or dirt containing those spores, and in that way the tetanus bacilli may be found in the intestines of those animals.

Q. Then, professor, do you mean to say that there is found in the intestines of the animal the spore that was picked up by the animal and taken into its intestines, or has there been an accumulation of spores of tetanus in the intestine of the animal after the germs have been taken into the animal at its mouth?

A. My opinion is that it is simply the germ in the soiled food that has entered the intestine in that manner, foods soiled by street dirt or garden earth.

Q. Is it your opinion that it remains there?

A. If there was a great increase or multiplication in the intestinal canal of the animal, the animal would die of the toxins produced by the bacillus.

Q. That is your opinion?

A. The toxin would be absorbed and the animal would die.

Q. Might that toxin be drawn off in some other way, or

7694 in someway?

A. It takes such a minute quantity of this toxin to destroy animals that they would need but very few tetanus bacilli to produce a deadly dose.

Q. Might not the animal be immune to the disease?

A. The animal might be immune to the disease also, in that case the bacilli could grow without killing the animal.

Q. Now assume, professor, that the tetanus germ can live and does live in the intestines of the animal and that it multiples in the intestines of the animal?

A. The immune animal?

Q. The immune animal; and assume that the excreta of the animal, the offal of the animal containing these germs, is deposited into the drainage canal, at Chicago, state whether or not, in your judgment, it would be reasonable to expect those germs to pass down the river a great distance before they perish?

A. Tetanus spores can exist for a long time without being destroyed, under all forms of unfavorable conditions.

Q. And under all forms of unfavorable conditions?

A. Yes.

Q. Now have you any approximate idea as to their length of life?

7695 A. No, I have no definite ideas, although I would judge that the longevity of the tetanus spore may amount to months.

Q. To months?

A. Yes.

Q. Professor, what is the size of a tetanus spore?

A. A tetanus spore is about one-fifth to one-sixth the size of the bacillus.

Q. And how do they compare in size with the ordinary water bacteria?

A. It is about—water bacteria? Well now, which one? Water bacteria vary a great deal.

Q. Is it as large as the largest of water bacteria?

A. No, it is much smaller.

Q. Is it as small as the smallest water bacteria?

A. It is slightly larger than the smallest water bacterium. The usual water bacteria are larger than tetanus spores.

Q. Can you observe them with the naked eye?

A. No; you cannot see any bacteria or their spores with the naked eye.

Q. Assuming, professor, that the cattle industry of the city of Chicago averages a daily slaughter of from 15,000 to 20,000, from one end of the year to the other, and assuming that in the intestines of those cattle there is a large number of tetanus germs, active and alive, and assume that a considerable 7696 portion of those germs after being removed from the intestines find their way by the washings of the slaughter houses, into the Chicago drainage canal and that within thirty days, or from thirty to sixty days they find their way into the waters of the Mississippi river at the chain of rocks, is it not possible and is it not probable that those germs will find their way into the water supply of the city of St. Louis, and is it not as reasonable to believe that they will so find their way into the water supply of the city of St. Louis, as it is to believe that any other water bacteria will find its way into the water supply of the city of St. Louis, after it has reached the Mississippi river at the chain of rocks?

A. Yes, that is true, but tetanus is not produced by swallowing the germ; tetanus is produced by inoculation subcutaneously, in the form of a wound, not by swallowing.

Q. Professor, assuming that the tetanus germ is there and in the tap, being supplied in that water from the Mississippi river, and that one of the tetanus germs coming from the slaughter pens referred to in the preceding question—a citizen of St. Louis who cut his finger, and placed it under the tap might not that tetanus germ inoculate the finger?

A. No. In order to inoculate, tetanus bacilli must enter the deeper parts of the skin, where there is no air, other- 7697 wise this germ cannot multiply. Tetanus spores or bacilli are strict an-aerobic bacteria, they will only grow in the absence of oxygen, and therefore it is necessary that the germ enter the deeper portions of the tissues in order that it produce a growth and an infection with resulting tetanic convulsions.

Q. Might not a boy shoot his wet finger with the wad of a toy pistol and produce tetanus?

A. If the skin has been simply moistened with the water containing the tetanus spores, and the wad enters the finger—it is possible for the one or two tetanus germs in the water to enter the deeper parts of that finger, but it is still questionable whether one or two germs would be sufficient to produce an infection, because here again numbers are as essential as they are in all other infections.

Q. Assume, professor, that a citizen of St. Louis should step on a tack or a nail with his bare foot, turn the water from the tap into a receptacle of some kind containing the tetanus germs, and that germ should enter the point where the nail caused the wound on the foot, state whether or not it might not produce tetanus?

A. No. The reason is this, it is a well known fact that the rusty nail is more dangerous in producing tetanus than the clean nail, because in the crevices of the rust, as the nail is entering the skin, is found dirt and tetanus spores.

7698 Q. There was no rust or anything assumed in this question?

A. But it explains the condition here. In withdrawing the nail you leave some of the rust, and with it the dirt and the tetanus spores, in the depth of the wound, where the conditions for growth and multiplication of an-aerobic bacteria are favorable. Now, in the clean nail the spores and the dirt is wiped off as it enters the wound and therefore bacteria remain near the surface and cannot grow. Therefore in a puncture wound, such as you mention it, in the nail wound, the characteristic nail infection by tetanus would not occur if the nail had been free of tetanus spores, by simply washing the external wound with water containing tetanus spores because the parts have already closed when the instrument has been withdrawn.

Q. Then assume, professor, that the nail is rusty and moistened by the water from a sprinkling cart, drawn from the city supply, that has just passed by?

A. Then if that water contains tetanus spores, then they may be alive to be wiped off in the depth of the wound.

Q. And carried into the foot?

A. And left in there as the nail is withdrawn.

Q. Professor, anthrax, I believe you said was a spore producing germ?

A. Anthrax can either be found as a bacillus or as a spore.

7699 Q. What is the size of the spore of anthrax?

A. The spore of anthrax is about one-third to one-fourth the size of the bacillus.

Q. How does it compare with the tetanus spore?

A. It is usually larger, but it varies a little in its size.

Q. What, generally speaking, is the source of the anthrax germ and spores?

A. The source of anthrax is always an infected animal that has had the disease, the bacilli are found in great numbers in the blood of the animal that dies of anthrax, also on the hair of the infected animal and in the discharges.

Q. May it not be on the hair of those animals that have not had anthrax, by their coming in contact with those that had?

A. Yes.

Q. Suppose, professor, that an animal that has been in contact with another animal infected and sick of the disease of anthrax, and assume that that animal coming in contact with the animal affected with the disease or sick of the disease, would obtain the germs of anthrax in its hair, and assuming that that animal obtaining the germs of anthrax by getting in contact with one sick of the disease should be shipped to the city 7700 of Chicago, and slaughtered in one of the slaughter houses of that city, and with the washings of the hair and of the animal passing from the slaughter house into the sewer, and from the sewers into the canal and from the canal into the Illinois river and from the Illinois river into the Mississippi in from thirty to ninety days, state whether or not when those anthrax spores or bacilli reach the city of St. Louis, within from thirty to ninety days, they would be alive.

A. Such a condition is excluded by government inspection here in the city, where all anthrax infected animals as well as other infected animals are destroyed.

Q. Do you know professor, whether the government inspectors examine the hair of each animal that is brought into the slaughter houses or stock yards?

A. If the animal had the spores or the bacilli of anthrax, on its hair, it would be also very liable to be ill of the disease of anthrax. Therefore, if it should reach the slaughter house, it would soon be known.

Q. That is if it had the disease?

A. The disease is rapidly fatal in animals; it is a very pathogenic germ to animals and produces death very rapidly.

Q. Professor, aside from any government inspection, taking the assumptions which I have laid down in the question, to be true, what would you say as to whether or not those germs of anthrax would be alive and vigorous when they reached the city of St. Louis on the Missouri shore? 7701

A. Such a condition would produce immediately a general epidemic of anthrax, amongst all the cattle.

Q. Amongst all the cattle where on the Missouri shore?

A. Wherever the infected animal reaches.

Q. You mean where the animal reaches, or where the infected material reaches?

A. You spoke of an infected animal reaching the stock yards.

Q. Now I am assuming that that animal was slaughtered, and that the washings of the hair and of the animal got from the pens, and the slaughter house into the sewers, carrying with it the germs of anthrax, and that those germs within thirty days reached the Missouri shore in the Mississippi river, state whether or not those germs would be alive and active?

A. They would, if they were spores.

Q. State what effect, professor, they would have upon stock drinking the water and at the same time taking into their system with the water, the germs of anthrax?

7702 A. They would if numerous enough and virulent, produce anthrax in susceptible animals, the fact, however, remains that such animals could not pass inspection here.

Q. Now professor, you say that you found anthrax in the Illinois river. Do you know whether that germ of anthrax or spore of anthrax, whatever it was, that you found came from Chicago or from some other source?

A. No, I do not.

Q. It may have come from Chicago, may it not?

A. There must have been spores, else I probably would not have found them virulent any more, or not found them at all.

Q. But it may have come from Chicago, may it not?

MR. DRENNAN: Objected to as to what may have happened.

A. It may have come from anywhere above the place where I found it.

Q. In other words, if it came from a diseased animal, anywhere upon the watershed above where the sample was taken from the river, it may have come from that source, it may have found its way there, I mean?

A. It may have come from anywhere above the place where it was found. And it is quite probable that anthrax spores come from either tanneries or cattle sheds. I think the danger of anthrax in our state is not so great from slaughtering establishments as it is from tanneries using imported hides
7703 from China and Brazil which have been known to cause
anthrax. In fact I know of one instance in Wisconsin where hides imported from China and Brazil had infected a river with anthrax spores.

Q. But still it was the hide of a herbivorous animal?

A. Yes sir.

Q. Have you any knowledge of the endurance or longevity of these germs in mud, sewage deposits or river swill?

A. An anthrax spore can live anywhere without any food under adverse conditions.

Q. At what temperature will they die?

A. They die at the temperature of boiling water, and will resist even higher temperatures if the heat is dry heat. Moist heat destroy them quicker.

Q. So then they are not liable to perish by any natural causes?

A. No sir.

Q. Will freezing temperature hurt them?

A. Freezing will not affect them.

Q. Professor, are you aware that the germs of anthrax have in fact been found in mud?

7704 A. Whenever they have been found they must have come from infected cattle. They could be found in mud or sewage, may enter the water.

Q. Then you are aware from what you previously said, are you, that this disease of anthrax has been transmitted and that it has been so transmitted in river water from tanneries or the hides of animals?

A. Yes sir.

Q. Professor, do you know whether or not the second outbreak of anthrax in Germany was traced to water?

A. Anthrax bacilli have been found in water occasionally, anthrax spores I mean, and have been supposed to be the cause of infections among cattle.

Q. Through water?

A. That was the supposition because it was known in these cases that infected material had been poured a short distance above, into the river.

Q. Then professor, knowing these facts that you have just stated, what would you say as to the danger from the transmission of anthrax from the stock yards at Chicago to the Missouri shore, in the event that the germs of anthrax found their way to the stock yards of Chicago by the cattle that were put in there?

7705 A. If the anthrax spores get into the river as well as the tetanus spores, they may remain alive. They form resistant spores, which resist all unfavorable influences, such as unfavorable temperature and lack of food, and therefore can remain alive for longer times. Both of them, in order to produce infections, are usually inoculated subcutaneously in man and do not produce infection by swallowing.

Q. That is the tetanus?

A. That as a rule also holds true with anthrax, although cases of intestinal anthrax have occurred.

Q. Now professor, assuming that to be true, the question and the answer just stated, what effect would those anthrax germs have upon herds of cattle that drink water containing anthrax germs on the shore of the Mississippi river below the entrance of the Illinois river into the Mississippi?

A. In that case if they drink large enough quantities of virulent anthrax spores, it would be possible that the animals would develop intestinal anthrax.

Q. Professor, in view of your last answer, what examinations have been made with reference to the determination of how many spores of anthrax are necessary to infect an animal with that disease?

A. I think very little is known with regard to that, very little definitely. The infections where they have occurred 7706 have been of such a violent character, and the infectious material has been in such a large quantity that it was not surprising that large herds of cattle were infected.

Q. But professor, this source of that great infection which you spoke of, must have originated with one spore in one centimeter of water that the first animal infected drank, and that animal in turn infected the whole entire herd?

A. One spore per cubic centimeter is quite a good many bacteria in a liter of water.

Q. Assuming that there was but one spore passing into the intestines of the animal first made ill with the disease, is it not likely that the infection of the entire herd came from the one animal first infected, and might not that have happened?

A. Here the same general rules hold true, with regard to the number of bacteria necessary to produce an infection. From my laboratory experiments with anthrax, in which I regularly use that germ for class experiments, I must say that I have frequently infected guinea pigs, small animals, which are very susceptible to anthrax, and they usually died promptly in 24 to 48 hours with a general infection, but I have also frequently infected guinea pigs with small quantities of living anthrax 7707 spores and they did not die.

Q. Have you any idea as to the virulence of these anthrax germs?

A. Evidently the virulence here must have been decreased, but sometimes I found that the germs were virulent, and that certain animals would recover and others would die, so that the virulence alone also does not explain it.

Q. Then you assume the same position in reference to anthrax and the direct infection as you do to the typhoid bacilli?

A. The indirect infection must be a more frequent source of infection on account of the large numbers of germs that may be formed in favorable culture media, whereas the few individual germs diluted and distributed over large areas of water drank by cattle might not produce the infection.

Q. No, but here is the proposition, professor, do you maintain that anthrax—that there is no direct infection, the same as you maintain that the typhoid germ when applied to the human system, that there is no direct infection?

A. Yes, with regard to rivers and lakes, I think that is the proper position to take.

Q. In other words, your position is; that one anthrax germ will not produce the disease if taken into the intestines of an animal?

7708 A. That's it.

Q. Now then, professor, have you any conclusive evidence that it will not?

A. I have those mentioned in the laboratory, on guinea pigs.

Q. I will ask you, professor, if it might not be true that there are certain conditions pertaining to the intestines of the animal that when a spore is introduced into it, it operates as a media and produces a culture and one culture after another until the animal becomes sick of the disease?

A. Yes, if it becomes infected, but that is the very problem, that infection doesn't always take place, due to the resistant forces of the organism which destroy these germs, even large numbers of them.

Q. If the system of an animal be in a certain condition, is it not likely that the germ of anthrax, the spore of anthrax entering into the intestinal cavity of the animal, that the conditions may be favorable for its multiplication untii the animal becomes sick of the disease?

A. The conditions may be favorable, or may be unfavorable to the infection.

Q. In other words, that is the proposition which the science of bacteriology has as yet been unable to investigate or explore, is it not? 7709

A. What problem?

Q. The conditions that take place inside of the intestinal cavity of the animal after the disease spore or germ has been introduced into it?

A. We know in a general way—

Q. Has it been investigated?

A. Yes, in certain ways.

Q. Now in what way?

A. We have determined that if we reduce the resistant forces of the animal, for instance by destroying the red blood corpuscles, that germs will prove much more infectious, even if the germs were attenuated, and we have found that large numbers of highly virulent germs, introduced into an animal which was resistant, did not produce infection.

Q. Then if the animal be run down, not properly fed, or be ill with some other disease, might not its system be in the condition to produce anthrax if the germ of anthrax is introduced into the system?

A. With a decreased resistant force even smaller numbers of pathogenic bacteria would probably produce an infection, which in the healthy animal would produce no infection.

7710 Q. And aside from all of our opinions and our beliefs on the subject, professor, it may be may it not, that there is a certain condition in the animal itself, that if the germ of anthrax is taken into its system, that it will produce the disease of anthrax in the animal?

A. That condition would be the reduced resistant force.

Q. That it may exist?

A. That may exist with the reduced resistant force of the animal.

Q. Professor, what can you say with regard to the life of pathogenic germs in the soil of the earth—pathogenic microbes in the soil or the earth?

A. The life of pathogenic bacteria in the soil will be somewhat similar to that in water. It would depend entirely upon the number and kind of other bacteria that might be present there and their rapid multiplication. Probably they would exist a little bit longer in soil or earth than they would in water that was rich in organic material.

Q. Then such microbes live longer in the soil and earth, do they not?

A. They could live upon the surface of the earth, dependent on competition and overgrowth of other bacteria for which the conditions for growth are more favorable. They could live

for some time in the dried state, because there would be
7711 nothing to overgrow them.

Q. Would they live longer in lumps of earth or mud or masses of fecal matter than when suspended in water or sewage?

A. When they are in masses of fecal matter you will have again the great number of saprophytes and intestinal bacteria present which grow much more rapidly at the temperature of the air, and would overgrow pathogenic organisms which are of a slower growth and cannot multiply at that temperature to any extent, at least not as rapidly as the colon types and saprophytes.

Q. Professor, are there any intestinal diseases, the germs of which are liable to grow in sewage or polluted rivers, whose spores are more resistant than those of typhoid fever?

A. I have mentioned those which are highly resistant by means of forming spores, that is the anthrax spore and the tetanus spore, but as to non-spore bearing bacteria or non-spore bearing pathogenic bacteria their resistance in water is subject to the overgrowth by saprophytic bacteria, and water bacteria.

Q. Is it not a fact that the germs of diarrhoea live longer than typhoid germs in water?

A. If you will tell me what kind of germs you mean by the germs of diarrhoea—

7712 Q. Well are there any forms of germs of diarrhoea that live longer than the typhoid germ?

A. It has lately been shown that dysentery and some of the summer complaints of children are due to Shiga bacilli, and I have it from the investigator of this subject that this bacillus dies in sewage in a few hours, so that seems to be much less resistant than the typhoid bacillus. This germ is supposed to produce the summer diarrhoea of children.

Q. That is the Shiga germ?

A. Yes sir.

Q. Does that come from the human intestines?

A. That is found in the intestines in dysentery and in children having summer complaint.

Q. Do you know, professor, of any epidemics of diarrhoea in which the germs of diarrhoea have appeared to live longer than the typhoid germs?

A. The bacteria that are normally [illegible] intestinal tract are all more resistant than the typhoid bacillus and grow much more rapidly and much more easily.

Q. And live much longer?

A. And live longer than the typhoid bacillus.

Q. Now professor, is it possible that other diseases than
typhoid fever or Asiatic cholera can be carried by water
7713 and that the vitality of the germs will be greater in water
than that of the germs of typhoid fever?

A. I answered that before. You spoke of the germs of diarrhoea, but you did not mention cholera. Just as soon as you include cholera then of course I shall have to modify that statement because the cholera vibrio dies as easy as the typhoid bacillus in sewage. I have been speaking of the colon type of bacteria entirely in my former answer.

Q. What I mean, professor, is this: Is there any other disease germ, any disease germ other than cholera or typhoid fever that can be carried by water, with a vitality greater than that of either the cholera or the typhoid fever germ?

A. Yes, the colon group of bacteria, they are more resistant than the typhoid bacillus or the cholera vibrio.

Q. What character of disease do they produce?

A. None, when in the intestine, as far as known.

Q. You cannot tell whether it is diarrhoea or something else?

A. In diarrhoeal diseases we occasionally find that these bacteria are present in abnormally great numbers and in various types.

Q. What bacillus is present?

A. The colon types, and there are a great number of
7714 different bacteria of this colon group, which are all more
or less similar in some respects and dissimilar in other
respects. They have not been sufficiently studied, as to their role in the household of the intestine, or as to their role in the causation of diarrhoeal diseases. In fact the etiology of diarrhoeal diseases, outside of the well known infectious diseases Asiatic cholera and typhoid fever, is still very doubtful, for instance, just to illustrate; the disease known as tropical or Amoebic dysentery is supposed to be due entirely to protozoa, small

animal organisms, and not vegetable organisms, whereas, other men who have studied it just as thoroughly believe that these are only accidental invaders of the intestines, and that the causative factor is a streptococcus, which is also occasionally found in intestinal diseases as well as in health, so we know very little in regard to the true etiological factors of diarrhoeal diseases, very little which has been proven.

Q. And both the protozoa and the staphylococcus may come from sewage?

A. The staphylococcus and the streptococcus may come from the sewage, whereas the protozoa that are found in
7715 cases of so-called Amoebic dysentery die quicker in sewage than bacteria would.

Q. But it may come from sewage?

A. It may come from sewage also. Protozoa or Amoebic dysentery are found in the stagnant waters of the tropics and those who drink of that water simply develop a violent diarrhoea. These organisms are found in the discharges and may even produce abscesses in the liver, the pus containing similar organisms and yet other men under the same conditions have found a similar picture of disease and have found a streptococcus, so that the disease, tropical dysentery, is something whose etiology has not yet been definitely settled.

Q. Now, how about dysentery in this part of the country?

A. Dysentery in this part of the country, is most of it due to the streptococcus and to staphylococcus infections, aside from the great number of bacteria of the colon group, such as the Shiga bacillus, the pathogenesis of which must be still definitely determined.

Q. Professor, how about the hardness and durability of the dysentery germs in water?

A. The streptococcus is a germ that dies very easily; it is one of the most sensitive germs kept in the laboratory
7716 and usually dies under the most favorable conditions in a very short time, in spite of all favorable media that we may provide, in spite of all our efforts, they constantly die. The protozoa of tropical dysentery might live, if they are the causative factors of the disease, they might live in stagnant water at higher temperature, for some time, but they do not

exist in sewage. The Shiga bacillus is rapidly overgrown by other bacteria like a typhoid bacillus.

Q. I will ask you, professor, if it is not a fact that the streptococci germs are not very commonly found in sewage?

A. My experience says No, although I know that other men have found them very frequently. My experience is different from that.

Q. Have they been found professor, by competent observers?

A. Yes, some of the men who have found the streptocci are absolutely competent. And I have also found streptococci in serious cases of diarrhoea occasionally.

Q. Now do you know anything about their life in streams, the streptococci?

A. A streptococcus that is found in the intestine—a streptococcus that is capable of producing a spreading infection, such as it does in septicemia and erysipelas, or as is found in rapidly spreading lymphangitis or lymphadentis, die very easily and very readily under favorable conditions and 7717 much more so in the presence of any other bacteria or unfavorable temperature conditions.

Q. That is with reference to the condition in the laboratory and not in the river?

A. And also with reference to the condition in lake water and river water.

Q. Now how about the staphylococcus that produces intestinal diseases?

A. The staphylococci are frequently found in the intestines, where there is a disease, and where there is no disease at all.

Q. What do you know professor, about their life and endurance in water?

A. The same holds true in regard to their endurance in Lake Michigan water and the river water. The staphylococcus, is capable of growing a longer time on culture media and is more resistant than the streptococcus.

Q. How does it compare, professor, with the typhoid germ in this respect?

A. The staphylococcus is capable of defending itself better against overgrowth by other bacteria than either the typhoid or the streptococcus germs, even against the overgrowth of the colon bacilli, so that in cultures from the intestines even from the excrement of a healthy person, we may find easily colonies of the staphylococcus aureaus, and the albus sometimes if they were present in the faeces.

7718 Q. Now I will ask you professor, if it is not a fact that all these bacteria of the various diseases that we have just mentioned, including the typhoid germs, which have been cultivated in flasks or tubes, and especially upon solid media in laboratory experiments, are much less vigorous, becoming weakened and die more rapidly in water than typhoid germs, and the germs of the various other diseases mentioned, coming directly, fresh from the human body?

A. The germs that come directly from the diseased tissue of the human body are always more virulent than those that we have cultivated for many generations in the laboratory. Otherwise their persistence of life and competition with other bacteria in the mixture do not seem to suffer much. They suffer mainly in the virulence, which is decreased or lost.

Q. Is it not a fact, professor, that they often tend to die out under this cultivation in the laboratory?

A. In cultures in the laboratory the streptococci die out very readily; the staphylococci do not; the colon bacilli do not, and the typhoid bacilli die in three to six weeks, but generally the streptococcus is the one that dies out the quickest on artificial culture media.

7719 Q. So that, professor, some of these products have become invisible by multiplication in the tests and by being removed from generation to generation from the original parent. Would they be in such a condition after a series of tests to be comparable with those that come directly from the human system in respect to endurance?

A. In respect to endurance they would grow just as well in a mixture, whether they were the twentieth generation or the first generation.

Q. But in reference to their longevity?

A. In reference to their virulence after the twentieth generation, if it was injected into an animal, it might not prove virulent, whereas the first generation might prove virulent and kill the animal, but as to the manner of growth and the quality of growth, and their ability to grow, and their ability to defend themselves against other bacteria, there wouldn't be much difference, as long as they are alive.

Q. They are weakened however, in some respects?

A. They are weakened in their virulence in many cases.

Q. And being weakened in their virulence, they would be weakened if put back into a running stream?

A. If they would not produce the death of the animal of course they could also be put into the stream and be
7720 found there without producing any pathogenic effect.

Q. Professor, take the typhoid bacilli of the thirtieth generation as produced in the laboratory; take an equal quantity of typhoid bacilli, coming from a patient sick of the disease, and deposit those two quantities of typhoid bacilli into a running stream, which in point of vitality would live the longest?

A. I think the one that had accommodated itself to grow in artificial culture media for thirty generations, would be the one that would be capable of existing longer than the other, which is still used to its parasitic existence. To illustrate, a tubercle bacillus, as it comes from the body, will not grow at all, or it will grow very sickly even on favorable culture media, and it will do so for five or six or eight or ten generations, and suddenly it begins to grow on all common culture media in such a profuse manner, that a rich heavy growth is seen after 24 hours cultivation instead of a thin barely perceptible scale after 2 weeks of growth, as it originally took. It finally begins to grow like a saprophyte, like a common water germ or like a common saprophyte, showing that it has accommodated itself to the new conditions. Now that germ when placed with saprophytes will have a better ability to grow like they do, and to resist their overgrowth, than the parasitic tubercle bacillus, which will be overgrown by the saprophytic bacteria.

7721 Q. Supposing the temperature of the water into which they are deposited, is as much different, for a saprophytic growth, as it is for those that are taken directly from the patient sick of the disease?

A. The colony of the typhoid bacillus, the thirtieth generation, is no doubt more capable for competition with common saprophytic bacteria than the parasitic typhoid bacillus coming from the human body but when you speak of virulence, then the conditions are reversed. The one from the body may produce disease and the one from the culture may not.

Q. None of which is based on experience?

A. Yes sir.

Q. On experiments I mean.

A. Yes sir, on experiments.

Q. In the laboratory?

A. Yes, in the laboratory.

Q. Professor, you have stated in your direct examination that you have frequently observed various so-called pathogenic organisms in the waters which you have examined. Now have you any reason to suppose that these pathogenic organisms when swallowed by a man in drinking water, would have any effect on the health of that man?

7722 A. They might and they might not. That would depend on number, virulence and resistant forces of the man.

Q. It would depend altogether on the character of the germ, would it?

A. No, it would also depend upon the question: Is that germ still virulent or not?

Q. And would it depend in anywise upon the condition of the man with reference to his health?

A. I will repeat again, first the germ must be present to produce infection. Second, the germ must be in sufficient quantities to produce infection, and third, the germ must be virulent. Fourth, the resistant forces of the organism must be decreased. Those are the four conditions in which infection takes place, so that the simple finding of the germ alone would not mean that infection would take place.

Q. Then professor, it is possible, is it, that any of these germs, if given the proper conditions in the human system, would produce disease?

A. If they were in sufficient quantities and virulent, yes.

Q. Isn't it possible that any one of the germs if given—

if any one single germ, given sufficient conditions in
7723 the human system would produce disease?

A. According to my opinion, not.

Q. Not even if the person is out of order? In other words not well; his physique is run down; his health is run down?

A. Not even then, for the reason that over ninety per cent of the persons dying have healed tuberculous foci somewhere in their body, so that ninety out of every hundred of us are infected with tubercle bacilli and yet we do not die of the disease.

Q. But have the disease though?

A. There are some that have the disease, due to the great number of tubercle bacilli with which they were infected, and due to the reduced resistant forces.

Q. How do you measure the quantity of bacilli that is necessary to produce disease when taken into the human system.

A. That is an unknown factor. That we cannot measure.

Q. Then, if it is an unknown factor, you cannot say whether it would take more than 100,000, 10,000, 5,000, 1,000, 100, 5, 2 or 1 can you?

A. No, I cannot. Those four factors must all be present. The germ must be in sufficient numbers. It is unknown, what is a sufficient number. It must be a large number.

7724 Q. If it is an unknown factor, it may be 1 and it may be 10?

A. No. My opinion is that larger numbers than 1 or 10 or 100 are required even if all the other three factors are favorable for an infection.

Q. Might it not be this way, professor, that the one, if the conditions in the human system are sufficient, if surrounded by proper conditions, would finally produce disease, sickly, though its preliminary course might be run for a considerable time while upon the other hand, if there are a great number of the same character of bacilli that are introduced into the system, that they would more readily and more rapidly produce sickness, and also that the infection of the one bacteria is more liable to be overcome by some organisms contained in the human system, than the great number of them are, and that while one may be overcome, yet there is a possibility always of that one producing more bacilli, and those others, until the patient finally becomes sick of the disease?

A. If that was true, then the human race would have had to die out long ago, because we are continually surrounded by disease producing germs and exposed to infections by food and water with small numbers of pathogenic bacteria.

Q. Now I will ask you if you can state postively that one germ of disease, if given the right conditions in the human system, will not produce disease? 7725

A. I could not state that because that has never been tried by anyone, nor myself either.

Q. And has never been determined?

A. We cannot determine that, because we cannot count the germs; they are too small to be handled.

Q. So that what you say upon the subject is more reasoning by analogy than anything else in the science of bacteriology?

A. Yes, and also upon what you see at post-mortems of persons who have died of the disease and also what you see in infections generally.

Q. Professor, do you recognize any difference in the practical importance of these germs, and anthrax, typhoid fever germs, or Asiatic cholera germs, as disease producers?

A. Yes sir.

Q. Now in what way?

A. They must be present to produce the infection. The germ must be present, first, or the infection will not take place, but the germ alone is not the only condition to produce infection. The other three factors I mentioned before must be present, the number, the reduced resistant force and the virulence.

Q. What I have reference to professor, are colon germs and simple water bacteria, which you have called—

7726 Repeat the question.

(Question repeated).

A. I did not hear the word "difference" before.

Q. What is that difference, professor?

A. The organisms that you mentioned, are the typhoid bacillus, the cholera vibrio, anthrax bacillus and tetanus bacillus.

Q. As to their pathogenic character.

A. Anthrax and tetanus are more resistant by reason of their spore formation and if they enter the water they will exist for a long time without being destroyed, whereas the other two will be rapidly destroyed, so that would be the essential difference.

Q. Now as to their pathogenic character, and not as to their endurance, profesor?

A. They are all pathogenic, if entering the body in sufficiently large quantities.

Q. How about the colon bacillus that is found in the body at all times?

A. The colon bacillus may, if it is swallowed in large enough quantities produce diarrhoea. If it enters the tissues, it may produce a slow infection, a purulent, inflammatory process, in different parts of the body. It is the normal inhabitant of the intestines and contributes to intestinal digestion or metabolism.

7727 Q. Now, professor, I will ask you whether or not you consider the germs of anthrax or typhoid fever or tetanus, Asiatic cholera or dysentery—

A. You mean the streptococcus now?

Q. The germs of dysentery, as comparing in any respect with reference to the severity of the disease which they produce with those of the colon bacilli, and others of a similar character which you have mentioned?

A. Well, if you speak of the dysentery organism, you do not mention whether you mean the streptococcus, whether you mean the Amoebic or tropical dysentery organism or the Shiga bacillus.

Q. I am eliminating tropical dysentery.

A. Well, do you mean the streptococcus or the Shiga bacillus.

Q. I want the streptococcus if that applies to the dysentery that usually occurs in this country and climate.

(Question repeated).

A. The colon bacilli I look upon as the least important in regard to their disease producing qualities.

Q. Then professor, are the bacilli coli communis, the bacilli megaterium, or any other that you have found in the

Illinois river or lake Michigan, to be compared for a moment, practically as dangerous germs, menacing the public health, with the germs of typhoid fever and Asiatic cholera and dysentery?

7728 A. With the exclusion of those you mean?

Q. In other words, are the germs of bacilli coli communis, bacillus megaterium or any other that you have found in the waters of lake Michigan or the Illinois river and described as pathogenic, to be compared practically as dangerous germs, menacing the public health, with those of typhoid fever, Asiatic cholera and dysentery?

A. I have not described the bacillus megaterium under pathogenic germs.

Q. Well, eliminating that bacillus, are any of the bacilli which you denominated pathogenic, and which you found in the waters of Lake Michigan and of the Illinois river, to be compared as dangerous germs with the germs of typhoid fever, Asiatic cholera and dysentery, and in that we might include anthrax and tetanus?

A. Yes. I have described the dangerous and disease producing germs which I found as pathogenic germs.

Q. In point of danger, professor, to the public health, in point of the severity of an epidemic that may be produced by them; in point of their ability to destroy the life and health of people, is there any comparison between the germs which you denominate as pathogenic and found in the waters of lake Michigan and the Illinois river with those of typhoid, Asiatic
7729 cholera, tetanus, anthrax and dysentery?

A. I found tetanus and anthrax, and gave them.

Q. Eliminating those two, tetanus and anthrax?

A. I will say that the colon bacillus when entering the tissues in a large quantity, may produce inflammatory processes, but as to its importance in comparing with cholera and typhoid, I will say that all of those found are less important.

Q. They are practically of no importance as compared with typhoid are they?

A. Oh yes, they are of considerable importance; for instance, they may produce, even some of them which I denominated as non-pathogenic poisons, which swallowed in sufficiently large quantities, may cause intestinal diseases, diarrhoea.

Q. You say a large number of those which you classified?

A. Even of the saprophytes. If you should drink for instance, the products of a number of those non-pathogenic saprophytes, it might produce intestinal disease or ptomaine poisoning, a condition more severe in its effects than that produced by the staphyloccoccus, or the streptococcus.

Q. Then, professor, practically speaking, without reference to cultivating large quantities of them and injecting them under the skin in a chemical way that ordinarly, in every 7730 day life as people move about over the surface of the earth? You have referred to the colon bacillus as a pathogenic germ. Now then, taking all these things into consideration, how is it that you can do this, knowing that it is constantly present, a normal inhabitant of the intestines of healthy persons?

A. Whenever it gets out of the intestines into the tissue, it is pathogenic.

Q. The typhoid germ doesn't ever get out of the intestines into the tissues?

A. It also gets out of the intestines, into the blood, the spleen and into the liver.

Q. It goes all through the system?

A. Yes sir.

Q. You recognize a practical difference between the typhoid bacilli and the colon bacilli?

A. Yes sir.

Q. As disease producing?

A. Yes sir. Colon bacilli in large number in the intestine are normal. Typhoid bacilli in large numbers in the intestine cause typhoid fever.

Adjourned until 10:00 A. M., Wednesday, October 7, 1903.

7731 10:00 A. M., Wednesday, October 7th, 1903. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. F. ROBERT ZEIT,

resumed the stand for further cross-examination by Mr. Jeffries, and testified as follows:

Q. Professor did I understand you to state in your direct-examination that you had discovered the bacillus enteritidis in the Illinois river?

A. Yes.

Q. Now state whether or not this was a bacillus enteritidis sporogenes?

A. No.

Q. In other words, it was not in the shape, in the form of a spore?

A. This bacillus produces no spores. It is not the bacillus enteritidis sporogenes of Klein; it is the bacillus enteretidis of Gaertner.

Q. Then it is not true that a spore bearing an-aerobic bacillus named the bacillus enteretidis sporogenes is very common in sewage of all great cities?

7732 A. Klein has described that in England as very common in sewage.

Q. And that character of bacillus is spore forming?

A. That is a spore forming bacillus.

Q. Has it not been found by others in the sewage of large cities?

A. It has been denied by others, amongst which I will mention that some men,—I cannot think of the names of them, some men thought the description identical with Welch's Bacillus Aerogenes capsulatus, and denied that the organism as described by Klein was anything else but Welch's bacillus aerogenes capsulatus.

Q. And that was not spore forming?

A. That was not spore forming.

Q. Are you sure of that professor?

A. Welch's is not according to his first descriptions of the organism.

Q. Now isn't it true that others have found this particular an-aerobic bacillus named the bacillus enteritidis sporogenes?

A. In sewage?

Q. In sewage?

A. Yes, and have described it as Klein's.

Q. And have found them in great abundance?

A. In great numbers, they claimed.

Q. With spores?

A. Spores.

7733 Q. Now professor, is it not also true that its spores are very abundant and very resistant?

A. The spores of that organism, as all spores of bacilli, are all very resistant.

Q. That is a pathogenic bacterium, is it not?

A. That may produce disease.

Q. Is it not pathogenic professor in the same sense that other bacilli that you have found in the waters of Lake Michigan and the Illinois river are considered by you as pathogenic?

A. I know by Klein's description that when injected into the peritoneum of the Guinea pig, that it may produce here a septic peritonitis. I have no personal experience as to its pathogenic character in animal or man.

Q. Is it not commonly described by bacteriologists as a pathogenic germ?

A. I think not. You mean its pathogenic effect to man?

Q. No, we are speaking of it now as a pathogenic germ, in other words, we are classifying bacteria found in water. Now we want to know whether or not bacteriologists would class this bacillus enteritidis sporogenes as pathogenic, along with the colon bacilli and others of like character?

7734 A. That is where I would class it, in its pathogenic effect,—with the class of the colon group.

Q. Then you would class it with the others that you discovered in Lake Michigan water and those that you discovered in the Illinois river, except the anthrax and tetanus. In other words, you would put it in the same class, except that before you made the classification you would withdraw anthrax and tetanus?

A. Yes. I would want to modify that a little. As to its pathogenic effect, I would put it with the class of the colon group of bacteria.

Q. Now professor, do the colon bacteria form spores?

A. They do not.

Q. Do they produce spores?

A. They do not.

Q. State professor, if you know the longevity of this particular bacillus, enteritidis sporogenes?

A. It will, like all spore bearing bacteria, be capable of existing in the spore form for a long time, in water, earth and air.

Q. Would it live in the spore form for months?

A. Yes sir.

Q. Then it is very resistant, is it?

A. It is.

7735 Q. Could it travel from the sewers of Chicago, through the drainage canal, the Illinois river and the Mississippi river to the intake at the chain of rocks at St. Louis, under any conditions—likely to travel between these cities under existing conditions?

A. Spores can exist for months.

Q. Therefore they can find their way to the chain of rocks?

A. Therefore, if in months they should get down there, they would still be spores and alive.

Q. Do you know anything as to the size of these spores of this particular organism?

A. They are oval, and about one-fourth the size of the micro-organism. They vary in diameter; some are larger, some are smaller, slightly.

Q. How do they compare in size, professor, to the spores of anthrax and tetanus?

A. Oh, there is not much difference.

Q. Similar in size?

A. Yes.

Q. You can't observe them with the naked eye?

A. No; you cannot see even the bacteria with the naked eye. This is much smaller.

Q. They are much smaller that what?

A. Than the bacteria.

Q. That is the ordinary water bacteria?

A. Yes.

7736 Q. These spores are much smaller than the ordinary water bacteria found in the water?

A. Well, to give you an idea; they are about one-fifth the size of an averaged sized bacillus.

Q. Water bacillus.

A. Yes. In a tetanus bacillus, the spore is about one-fifth the size of the whole bacillus.

Q. Of its own bacillus?

A. Yes.

Q. And that is also true with reference to this particular germ?

A. With reference to the spores of all bacilli.

Q. Of all bacilli?

A. Yes sir.

Q. So then it is a more difficult matter to detect the spore than it is the germ?

A. No, the spore is detected easy enough; it is a glistening, white body, so that if there are many spores in a culture they are easily found, very easily, in fact just as easy as the bacteria.

Q. Professor, if you should find this particular spore or organism in the water that you were examining, along
7737 with the colon bacilli, and those of like character, it would
have some effect would it not, upon your conclusions as to the condition of the water examined?

A. If I found large numbers of colon bacteria it would.

Q. And the more of this particular organism known as enteritidis sporogenes, you found, the more unfavorable an opinion you would have of the water?

A. No, that wouldn't make it any more unfavorable. If there were large numbers of different bacteria belonging to the colon class, I would consider that as sewage polluted water.

Q. Then you would consider this bacillus about which we have been speaking, and which produces abundantly, highly resistant spores, pathogenic or a disease producing organism, along with the class of colon bacilli?

A. I would.

Q. Then professor, is it not true that using the term pathogenic in the sense in which you as a pathologist employ it, pathogenic being disease producing germs, they may be and actually are frequently passing from the sewers of Chicago, into the drainage canal and down the Illinois river into the Mississippi river to the Missouri shore, to the intake of the St. Louis waterworks at the chain of rocks?

7738 JUDGE SPRINGER: I think there is a great deal of difference between the movement of the spore bearing and those that are not spore bearing. I think the question should distinguish between the two and therefore I object to the question for the reason that it does not.

MR. JEFFRIES: We have reference to the spore forming germs.

JUDGE SPRINGER: Spore forming germs only?

MR. JEFFRIES: Spore forming germs only.

MR. DRENNAN: Then it is objected to because there is no evidence to support the hypothesis as to the facts.

A. Pathogenic bacteria even if present, may be virulent, and they may be non-virulent. Even spores—

Q. MR. JEFFRIES: Professor, we are not talking as to the virulence; we are talking now of the existence in the water?

A. Of pathogenic bacteria?

Q. Of pathogenic bacteria,—of the spore forming character, about which we have been speaking?

A. It is true that pathogenic bacteria in the form of spores, can exist in the water for a long time, and may be either virulent or non-virulent.

Q. And therefore may pass down the Illinois river to the Mississippi on to the Missouri shore, and the intake of the St. Louis Waterworks at the chain of rocks?

7739 A. Spores may do that.

Q. Professor, state whether or not bacteriologists are in close agreement concerning the longevity of the typhoid bacillus under various conditions?

A. It seems not.

Q. That is, it seems that they have agreed on the—

A. No, it seems not; it seems they are not in close agreement.

Q. Is it not a fact that they differ widely as to the number of days during which typhoid germs may live in water and in sewage?

A. I think that the majority of bacteriologists are pretty well agreed that typhoid bacteria can live but a short time in water, as well as in sewage, and shorter in sewage of course than in water, and that they live the longer in water, the purer the water and the more free the water is from saprophytic bacteria and water bacteria, the longer they live.

Q. But professor, don't they differ widely as to the number of days they may live under such conditions?

A. By widely? I would like to know what you mean by widely?

Q. Well, materially then, considerably. Some experiments showing that they live longer than they do in others?

7740 A. Some men have found that with water bacteria only, they live for twenty days; or that typhoid bacilli live in water twenty days, thirty days, providing the water is not badly polluted by saprophtes. Others have found them to die very much earlier.

Q. We are speaking now of what you would term competent bacteriologists?

A. I believe that all competent bacteriologists are agreed that typhoid bacilli in the presence of large numbers of water bacteria and saprophytes at low temperatures, have no opportunity of existing there more than for a number of days.

Q. Now then you regard those men I understood you to say, as competent bacteriologists?

A. Yes, I regard these men as competent bacteriologists.

Q. And of course all of those experiments were made in the laboratory?

JUDGE SPRINGER: They couldn't be made any place else.

A. That is true, all those men have made their experiments in the laboratory.

Q. And I believe you stated a few days ago that they might live longer in the running stream, and they might not live so long as in the laboratory, in other words, that that point had never been determined?

7741 A. That point has never been determined as to what role the products of saprophytic bacteria play in the rapid annihilation of typhoid bacilli in the laboratory experiments, in the bottle.

Q. Then I understood you to say, professor, that it had not been determined and could not be determined from a bacterial standpoint just what effect the changes taking place in the water by the removal of old and the addition of new, would have upon the bacterial conduct of the water or operation of the water, and the life of the typhoid germ in that water?

A. That is correct. I will admit that it world probably live longer if those saprophytic products were not present, but were capable of being removed. As to the time, I think it has never been determined by anyone what the difference would be between the laboratory experiment and the actual experiment in the river water.

Q. That is under the actual condition of the water?

A. Under the exact conditions of the water. That has not been determined.

Q. You did not undertake to give the number of days that they would live or that anyone found that they would live. I understood you to say that they would live for days?

7742 A. For days, not weeks.

Q. Not one, two, three, four days?

A. I said that reputable bacteriologists had found in the laboratory experiments conditions like those I found in my experiments, and to which I have testified before.

Q. That they would live how long?

A. That they would live for days. I did not say "four,"—I said "for a number of days," because bacteriologists differ somewhat as to the number of days a typhoid bacillus can live in water.

MR. DRENNAN: What was the number you gave, professor?

A. In my experiments?

Q. Yes?

A. In my experiments with river water, the shortest time was five days, when I was unable to find them. In Lake Michigan water the shortest time was in one case where there were many colon bacteria—six days, and in the others where there were many water bacteria, ten days, and the longest that I found them in very pure Lake Michigan water at room temperature, eighteen days.

Q. MR. JEFFRIES: Others have found them longer than that, but whether or not it was under the same conditions, you don't know?

A. The experimenters that I am referring to varied in 7743 their statements from five to thirty days, but it is of course all a matter of conditions,—temperature, etc.

Q. They may have used different methods,—different temperatures?

A. Well, as a general rule with all of them, death was earlier at low temperatures. At higher temperatures the typhoid bacilli even seem to increase a little for some days, and then disappear. In that case it took longer, because they really first increase. In the cold temperature, they never increase. At very low temperature, 10 degrees C., therefore, they were very much sooner overgrown by water bacteria. The majority of experimenters agree that the typhoid bacillus lives longest in sterilized water where there are no other bacteria at all present, anywhere from three weeks to nearly two months and six weeks at least in cultures.

Q. Then professor, state whether or not you know that it has been found alive in the river Thames or in the water from the river Thames for five weeks or even longer?

A. The typhoid bacillus?

Q. The typhoid bacillus?

7744 A. I know in a general way, of some instances where the typhoid bacillus has been found in river water, but those instances are very rare and I cannot recollect the names of those men who have found them, but I will admit in a general way that there are some experimenters who claim that they have been able to separate the typhoid bacillus from river waters, in polluted rivers.

Q. I will ask you professor, if they have not been found to live as long as seventy-five days in river water in laboratory experiments?

A. At what temperature?

Q. I don't know the temperature.

A. It all depends on that. I stated that it depends upon the temperature and other bacteria present, as to how long they can live. The purer the water the longer they may live, and that they may live six weeks in a perfectly sterile water, where they are not destroyed by the overgrowth of water bacteria or saprophytes, so that is a question of competition of bacteria. If the temperature conditions are favorable for one kind they will multiply and wipe out the others, which do not multiply at that temperature.

Q. Or if the conditions are so that the sapropytic bacteria will not multiply, they will live longer?

7745 A. That would be a higher temperature. If river water was placed at a temperature of 37 degrees centigrade then the typhoid bacilli would increase, in fact that is one of the methods now, of finding them in river water. One of the latest and most modern methods is to first enrich the water in disease producing bacteria and hold back the growth of water bacteria and saprophytes by the higher temperature. Typhoid bacilli would multiply at the higher temperature, whereas water bacteria and saprophytes, for which the temperature would be unfavorable, would be held back in their multiplication. So here you have enriched the water in typhoid bacilli and held back the others by temperature conditions favorable to typhoid bacilli and unfavorable to water bacteria and saprophytes.

Q. And vice versa?

A. Yes, the same holds true of course. That only illustrates that it is all a question of temperature with regard to the time that the typhoid bacillus can exist in water, and that it is a question of other bacteria present, and their manner of life at different temperatures.

Q. So that with it all, there is no practical way of telling just how long they will live outside of the laboratory?

A. I think there is a way of telling it outside of the laboratory, how long they will live in the river, but I don't know that that has ever been tried.

7746 Q. There is nothing on the record to that effect?

A. No.

Q. Now professor, I will ask you if it is not a fact that the results of different experimenters differ greatly as to the longevity of the cholera microbe, in natural waters?

A. This is due to the same conditions just mentioned.

Q. And the cholera microbe is subject then to the same conditions as the typhoid?

A. Cholera vibrio have been known to die and disappear from waters after hours. It depended entirely upon the organic material, and the other bacteria present, and then it depended again on the water, the purer the water, the longer they live.

Q. I will ask you if it is not a fact that competent observers have found the cholera germs alive for a period of seven to fifteen and twenty days, and even for three months?

A. In steriled water, yes.

Q. Is it not also true that one observer found it alive after 392 days?

A. Oh, we have in medical literature all sorts of statements. You must not forget that bacteriology is a young science, only 25 to 30 years, and over-enthusiasm has done more harm to it—I for instance, remember with regard to the typhoid bacil-
7747 lus that one man found typhoid bacilli in the gall bladder fourteen years and a half after the patient had had typhoid fever, and they were alive. Well, that is quoted also in the literature and might be quoted by you.

Q. And it might be correct?

A. Well, not according to what I know of the biology of the typhoid bacillus.

Q. There might be something, however, that you do not know about it, isn't that true?

A. I admit it.

Q. I will ask you professor, if you would consider the observer who found the germ of cholera alive in water after 392 days, to be a competent observer?

A. I don't like to discredit any one else's opinion in a science that is just developing, although with our present knowledge of the subject I would not accept that statement any more.

Q. But it is a fact, professor, that competent observers have found the cholera germ able to live in sewage as long as seven to thirteen days?

A. I think that also is a statement that could not be proven to be true by the laboratory experiment, that the cholera vibrio could live in sewage for that length of time.

7748 Q. But there are such cases on record, are there not?

A. Such cases may have been reported.

Q. Have any observers found that the cholera germs live longer in sewage than in pure water?

A. No.

Q. That has never been found?

A. Not to my knowledge.

Q. I will ask you professor, if a competent observer has not stated editorially that the cholera germs live longer in sewage than in pure water?

A. That may all be true, but I think that the laboratory experiments discredit that. For instance, Hankin in the reports in the Annals of the Institute Pasteur, says that cholera vibrio have lived only two to four hours in the presence of great numbers of saprophytic organisms and much organic material, so here we have the condition for death even in a few hours. In sterilized water they can live for a long time and they may even multiply in sterilized water.

7749 Q. Professor, assuming as has been stated by competent observers, that the germs of cholera live in sewage and river water as long as thirteen days; assuming that Asiatic cholera should appear in Chicago, and assuming that the germs of this disease discharged into the Chicago drainage canal through the sewage system of Chicago, state whether or not the germs of this disease would not find their way to the St. Louis water supply entering the intake at the chain of rocks, provided the water from the canal covered the distance to St. Louis within thirteen days?

JUDGE SPRINGER: I object to the question that the first assumption is accompanied by the statement that it is based upon the opinion of competent observers, which statement is in the nature of testimony and necessarily a part of the assumption, and I object to it further upon the ground that it is argumentative in character, and does not present all the conditions which exist in the waters of the drainage canal, the Desplaines and the Illinois rivers, which are necessary to pass a judgment upon a question of this kind.

Q. MR. JEFFRIES: Now professor, I want an answer upon the assumptions contained in this question.

(Question repeated).

A. Taking it for granted that they would live thirteen days?

7750 Q. That's it.

A. If they were not killed before, they would of course arrive there. I wish to add that even if they did arrive there; even if they should enter the chain of rocks intake, we would again have to consider the same conditions which I have mentioned so many times: That is the germs would have to be swallowed in sufficient number, they must not have lost their virulence, and the resistant forces of the body must be reduced because Professor Pottenkofer swallowed fresh bouillon cultures of the cholera vibrio, the Asiatic cholera vibrio, repeatedly, to bring the experimental proof that if the resistant forces were normal, you could not produce Asiatic cholera.

Q. I will ask you professor, if he did not, when he made this experiment have a severe diarrhoea?

A. He did have the diarrohea, but he did not get cholera.

Q. Your last statement professor, is based upon your opposition and your judgment against the theory of direct infection is it not?

A. Not only on that. First with regard to that opinion, that it is an indirect infection, that the germ first gets upon some favorable culture media, and secondly upon the basis of the absolute destruction of cholera vibrio in the sewage-polluted water before it even leaves Lockport.

7751 Q. Now professor, state whether or not in your opinion the condition of the system of the person taking the cholera germ into his intestines, that there can or cannot be certain conditions existing with the human system that would produce the culture and produce a growth of cholera germs and that growth continue until the patient finally becomes sick of the disease?

A. From one germ?

Q. From one germ?

A. In my opinion, no.

Q. Now then professor, might not such conditions exist in the human system, that in some systems the vitality and strength of the organisms of the human being would be sufficient to destroy and throw off these germs, while in other systems, run down and in bad health, in bad condition, that those conditions would be favorable to the increase of cholera germs inside of the human system, and the multiplication of them would occur to such an extent that finally the system of the person would be overcome with the disease?

A. Well, in my opinion it is necessary to decrease the resistant force of the human organism. It is also necessary that the germs be virulent and that a sufficient number of them be introduced to produce the disease. If one or more of these factors is absent the disease is not produced.

Q. Might not the resistant force of the organism of the
7752 patient be sufficient at the time one typhoid germ is taken
into the system, to be unable to overcome the effect of that germ, and such a run down and insufficient condition in the organism would bring about a production of cholera germs, until the patient would be finally overcome by the disease? I want your opinion on that subject?

A. I have given it. Even if the resistant forces of the body were reduced or absent, it is very necessary that a sufficiently large number of virulent bacteria be introduced to cause an infection. It is true that the germ multiplies in the human body, and that this multiplication takes place much better when the resistant forces are reduced but it is also true that this factor of reduced resistant force alone is not sufficient to cause an infection. There must be great numbers of virulent bacteria besides the reduction of the resistant force.

Q. I will ask you this question. I want to get right on this proposition. I want to get your idea. Is it not reasonable to believe that if a large quantity of the germs of cholera when introduced into the system of a well patient, a reasonably well and strong patient, that they would overcome the organisms of that patient, that person, until he became sick of the disease. Why will not one bacilli, or one germ of cholera produce a disease in the run down and worn out system of a man,
7753 when it is injected into the system in that condition, and
does not the scale of infection increase and decrease proportionately as the number of germs are introduced into the system and as the system is built up or reduced?

A. Reduced resistant force is only one factor.

Q. Is that a fact?

A. Besides the germ, there are three other factors, number of bacteria, virulence and resistant force. Pettenkofer has drunk virulent cholera vibrio in great numbers in the bouillon culture. So the factor of resistant force must have prevented the disease.

Q. At the same time he had a severe case of diarrhoe?

A. But he didn't develop Asiatic cholera.

Q. But he had diarrhoea?

A. He had vibrios in the stools, but it is shown thereby that even a great number of the virulent germs is not sufficient to produce the disease when the factor of reduced resistant force is absent. All the factors have to be present to produce infection.

Q. Was it clear that Pettenkofer was run down?

A. No, he was in very good health.

Q. Wasn't he in excellent health?

A. Yes sir.

Q. And because of that excellent health he made the experiment upon himself?

A. He overcame the infection of virulent cholera vibrio
7754 in great quantities.

Q. I will ask you if before he made that experiment on himself he did not diet himself and prepare himself for the test?

A. Not at all, he even took the same food that he took all the time. The only proof at that time that the germ alone was not everything, that the other factors which are recognized today in bacteriology, all played an important part, first the germ, second the number must be great; third, the resistant force of the organism must be reduced, and fourth, the germ must be virulent, and only when all factors are right an infection takes place.

Q. I believe you have stated repeatedly, that typhoid with other pathogenic germs, survive longer in purer water than in the more polluted water?

A. Yes sir.

Q. Now, assuming the dilution of the Chicago sewage should at any time become greater, more water of Lake Michigan being mingled in any way with it, is it not also true that the pathogenic bacteria will tend to survive longer?

7755 A. Yes.

Q. And that owing to the quicker flow, caused by a greater volume of water, the bacteria will be more alive and virulent farther down the stream.

A. It is true that the greater the dilution the longer will be the life of the typhoid bacillus, but at the same time also the greater will be the dilution or separation of typhoid bacilli which entered that water, so that a given quantity of water will also contain a smaller number of typhoid bacilli.

Q. But professor, assuming that they live thirteen days and assuming that it requires 11 days for the water to pass from the sewers at Chicago to the intake tower at the chain of rocks in the city of St. Louis, and assuming further that there is a large volume of water added to the flow through the canal with the same amount of sewage going through as now, I will ask you whether or not there will not be a greater number of typhoid bacteria reach the chain of rocks at St. Louis and be deposited into the Mississippi river than with the less flow?

A. Most of them will be destroyed.

Q. And more of them will live with the increased flow?

A. More of them are capable of living with the increased flow under the assumption stated.

7756 Q. Professor, have you any information as to the number of typhoid germs that are discharged from patients sick of that disease?

A. I have never counted them.

Q. I will ask you whether or not they are measured by millions per day?

A. Some days you cannot find any at all.

Q. And other days?

A. And other days there might be millions, and we do find them.

Q. You can find them almost a million per cubic centimeter some days, can't you?

A. Yes in the urine sometimes we find great numbers of them.

Q. You see millions in the urine at times?

A. Yes, there will be millions found in the urine in 24 hours during certain days. I have never counted them.

Q. That would be a difficult test wouldn't it?

A. Well one could determine the number of typhoid bacilli in a quantity of urine, but I have never done so.

Q. You would have to determine it by an examination of each cubic centimeter of urine, unless they were at the same rate and the same amount all the time?

A. No, we would take it for granted that they are 7757 evenly distributed through the urine, because they are motile and are supposed to move at the same rate all through the urine, so the number in one cubic centimeter is determined and the total number figured out for the entire amount of urine voided.

Q. Not during the entire sickness of the patient?

A. Sometimes they are not found at all in the urine.

Q. Do they not clump together sometimes?

A. They clump together in the tissues of the spleen. In the urine they also clump when a patient becomes more or less immunized.

Q. That is generally at the last part of the sickness?

A. Oh no, that is sometimes as early as the fourth day.

Q. On account of that clumping then, the counts might be too low, might they not?

A. If the patient's serum showed the presence of this immunizing substance, we wouldn't be able to determine by the count how many would be in the quantity of urine.

Q. Professor, does the typhoid bacillus multiply rapidly upon food or vegetables at the ordinary temperature of a room?

A. They can grow, but they do not multiply as rapidly 7758 as they do at blood temperature.

Q. At what—it would multiply comparatively slowly wouldn't it?

A. The multiplication is quite slow in room temperature.

Q. Does it multiply rapidly or readily upon vegetables?

A. On a hot summer day, yes.

Q. How would it be in the cold winter or spring?

A. They wouldn't multiply in the winter.

Q. Nor the autumn?

A. What I mean by the room temperature is the average temperature of a room, 70. At that temperature the typhoid bacilli are capable of growing fairly well on culture media. They do not grow rapidly, but they grow. They do not grow as well as they do at the body temperature, but they are capable of growing at that temperature. Now just as soon as the temperature falls more and more, they grow less, until you reach 18 or 20 degrees centigrade, where they would not grow at all any more.

Q. So that in a refrigerator they wouldn't grow?

A. In a refrigerator at a temperature near the freezing point, they would not multiply at all.

Q. Then professor, on your theory of no direct infec-
7759 tion from drinking water, at what season of the year
should typhoid fever be the most abundant when derived from drinking water?

A. The season has nothing to do with it. If water that contains very few typhoid bacilli should get into the milk and the milk into the household, and the common temperature of a room in the household, even in winter for that matter, should be favorable, the typhoid bacilli can multiply. There will be a culture of typhoid bacilli in that milk, and persons drinking that milk will drink a culture of typhoid bacilli. I realize that the seasons for typhoid fever are the spring and fall and not very much in the summer.

Q. But professor, broadly speaking, the temperature of the weather has something to do with it, has it not?

A. Yes sir.

Q. Then the seasons of the year would have something to do with it?

A. The seasons of the year in which typhoid is most common are the spring and fall.

Q. And not in the summer as you would expect, in the
7760 hottest weather?

A. I have seen typhoid fever all through the summer.

Q. But on your theory, professor, assuming that typhoid fever is always present in the same quantity in the water that is being used, wouldn't it be natural to believe that there would be more typhoid fever in the summer than at any other time of the year?

A. I have also an explanation for that. The reason why there are less cases of typhoid fever in the summer than in the spring and fall is because in the summer the temperature of the water is more favorable to the life and growth of saprophytes, and if any typhoid bacilli do get into the water, they are rapidly overgrown by saprophytes, more rapidly than in the fall and winter when the temperature is low. I realize that my theory is perhaps not quite accepted by some epidemiologists, but I have reasons for it, which are entirely based upon the biology

of the germ, and its behavior when it gets into competition with other bacteria, such as water bacteria and saprophytes, as observed in the laboratory experiments stated. There can be no such great and essential differences between laboratory
7761 experience and the behavior of typhoid bacilli in nature.

Q. Then professor, according to your theory it is not surprising that some of the worst outbreaks of the typhoid fever in Chicago have been attributed to the drinking water, and have come in the spring?

A. No.

Q. And also it is not surprising to you that the great epidemic of typhoid fever at Plymouth, Pennsylvania, which has been universally attributed to polluted drinking water, occurred in March, April and May?

A. No, I think that could be explained on the same ground, that the saprophytes cannot multiply as rapidly when the temperature is low. In the warm summer temperature, the conditions are more favorable for the rapid multiplication of saprophytes, and they will then overgrow the typhoid bacillus, whereas, in the spring and fall there may be much organic material, but the saprophytes cannot multiply rapidly, so the typhoid bacillus has a chance to exist longer. It is not overgrown so soon by saprophytes and may thus reach the milk or food supply and then multiply there.

Q. Then professor, I believe you stated that you realized that your opinions as to the direct infection from drinking water, that in that opinion you are diametrically opposed by many of the pathologists, epidemiologists, bacteriologists and san-
7762 itarians of the world?

A. I don't think I am opposed. I believe that most of the leading epidemiologists agree with me in saying that they condemn a polluted water by inspection, although they have not seen the typhoid bacillus in it but they condemn it on simple inspection when it is found that some contamination has taken place or that the discharges of a typhoid patient may have reached it.

Q. But professor, upon your theory of no direct infection of drinking water, are you not diametrically opposed by many of the leading pathologists, epidemiologists, bacteriologists and sanitarians?

A. I think I am not. I believe that most epidemiologists admit the great role and importance that this indirect infection plays in the epidemics of typhoid fever.

Q. Professor, I understood you to say that you did not believe there was such a thing as direct infection from drinking water?

A. That is perhaps the one point where we differ.

Q. And in that you do differ?

A. I think that I differ there from many epidemiologists.

Q. Now professor, I will ask you if it is not reasonable to believe that the infection of typhoid fever by drinking water, may take place either by direct infection, or by the means and in the manner stated, and believed by you, that is, by in-
7763 direct infection, and that the infection depends largely upon the condition of the system, into which either indirectly or directly the infection is introduced?

A. In answer to that I will state that in view of what I know of the biology of the typhoid bacillus I cannot see that a direct infection can occur, except perhaps under the following conditions: If the excrements of typhoid fever patients containing millions of typhoid bacilli, should get into a well, where there is little water, and other persons drinking that water should develop typhoid fever, then it would seem evident that in that case, due to the great number of bacteria swallowed in that way, there was a direct infection from water. I certainly admit that, but I am speaking here in regard to conditions that exist in Chicago, where a large body of water, Lake Michigan, receives sewage polluted material containing typhoid bacilli, or in the Illinois river water, after the sewage of Chicago enters the drainage canal. Even if no saprophytic life whatever should occur and typhoid bacilli should be able to exist until they reached St. Louis, there would be such a tremendous dilution with billions and billions of barrels of water, and the distribution of the individual bacilli to such extent, that they could not, if they did arrive there, produce a direct infection because their number would be too small and only by finding in milk or food supply and favorable temperature conditions a possibility for multiplication sufficient to produce infection.

7764 Q. But they may under that condition at St. Louis and upon your theory, produce an indirect infection?

A. If they are in absolutely pure water and are not exposed to saprophytic over-growth of any kind as they would be in sewage, the conditions would be like those in a laboratory in sterilized water.

Q. Assuming now as stated by you that they reach St. Louis and get into the water supply, and assuming further that they get into a room at room temperature,and find their way onto some vegetable, or in some media on which they would grow, according to your theory, might not the citizens of St. Louis be indirectly infected?

A. Certainly, that would be an indirect infection.

Q. That is your position?

A. Yes sir.

Q. Assuming now, in the case of Chicago, which you mentioned, that the typhoid fever germs came from Lake Michigan, is it not reasonable to believe that the typhoid fever cases so brought about in the city of Chicago were produced in two ways, first in the manner stated by you, that is, indirect infection; secondly, that by reason of the run down condition of the 7765 system of the patients, after affected by the disease, that it obtained conditions in the system, that the one germ or bacteria grew and multiplied until the patient was finally overcome with the diseases. In other words, might not the typhoid fever cases in Chicago, coming from the water supply of Lake Michigan, or coming from Lake Michigan as a water supply, be brought about in both ways, either by direct or indirect infection?

A. The history of the last Chicago epidemic illustrates better than anything else I know, that my opinion is the correct one, because the district that had the greatest number of typhoid fever cases was the district receiving the purest water from Lake Michigan; in other words was the district that received the water from the Four Mile crib, whereas the district receiving the water from the Two Mile crib, much nearer to the shore, had no typhoid fever at all. The district which had most of the cases of typhoid fever here in the city evidently may have used the water which contained typhoid bacilli in a greatly diluted condition. Now if the dilution of typhoid bacilli had been equal all over the lake, why is it that the people that were drinking the water from the Two Mile crib should not have had typhoid

fever, if it was direct infection, why should they not have had more typhoid bacilli and more cases than the district re-
7766 ceiving the water from the Four Mile crib? The fact was that Hyde Park had very few or no cases of typhoid and the poorer district, supplied with the purest water of Lake Michigan, had all the cases of typhoid fever. In that poorer district the water reached decomposing vegetables, and did get into the milk supply of that locality—these people were too poor to buy ice and keep their various food products in the best condition—

Q. And too poor to boil the water also?

A. And too poor to boil the water also, and the result was that if there was one typhoid bacillus in one barrel of water one could have drank the whole barrel without becoming infected but if that one bacillius happened to reach the milk supply or food materials, and was exposed to a favorable temperature it multiplied and these people then simply swallowed cultures containing millions of typhoid bacilli. Now if it were direct infection by drinking water, why did not the people who used water from much nearer the shore, where there was supposedly much more sewage; why did they not have typhoid fever? Because they were people living under the best of sanitary conditions, using only the best of foods, preventing any multiplication or growth of typhoid bacilli reaching their milk supply or food material by way of lake water, which may have contained them in small numbers, by refrigerators and so on.

Q. Now professor, take this barrel of water containing
7767 one typhoid bacillus which you referred to. Supposing that typhoid bacillus should be found going from Chicago within the life of the germ, should find itself in a barrel of water in St. Louis, in a house with a family, and it should, and in your own way of indirect infection, find itself on some vegetable at room temperature or in some media at room temperature, might not it grow until the whole family would become infected with the disease?

A. It would multiply in any favorable culture medium and favorable temperature; it certainly would multiply and if virulent it would infect those with decreased resistant force.

Q. When it multiplies, it becomes a source of danger to the family?

A. Provided it would be capable of passing through the drainage canal without being destroyed, which in my opinion is impossible.

Q. Now then, professor, you stated that this Four Mile crib supplied the water to the poorer section in Chicago?

A. Yes sir.

Q. Do you know whether or not they were the particular class of people who are run down physically and whose systems are susceptible to infection?

7768 A. Admitting all that, that the poorer districts have people whose resistant forces are greatly decreased, that wouldn't settle the question, because we have in the better district—in Hyde Park, also many people who are run down in general health. If typhoid bacilli were in the water and would have been evenly distributed all over the city, they would have had typhoid fever there also, if direct infections took place by drinking lake water.

Q. Now assuming professor, that the water from the Four Mile crib in Lake Michigan, with all of its immense dilution would produce a typhoid epidemic among people who used that water in the city of Chicago, and assuming that typhoid fever germs lived 13 days in the drainage canal and the Illinois river, and passed from the Chicago river to the St. Louis water supply, would not the dilution in Lake Michigan be far greater than that contained in the St. Louis water supply?

A. I have no means of judging here of the conditions. What I have seen of the immense bodies of water of the Mississippi and Missouri as they mingle, with the Illinois river, it seemed to me so immense that it would compare favorably with the distance from our shore to the Four Mile intake.

Q. Professor, I will ask you this question, if the facilities in Lake Michigan at the Four Mile water crib, are not far 7769 better for the life preservation of the typhoid germ where there is an ability to swim away from all objectionable substances, than in the Illinois, Missouri and Mississippi rivers?

A. Yes sir.

Q. Now professor, taking your theory that there is no direct infection of typhoid fever from drinking water, as granted, and assuming that it is correct, how do you explain the fact that in many epidemics the time which has elapsed between the arrival of the infected water within the city or town has been no more than sufficient for the incubation of the disease, and totally insufficient for any intermediary infection of vegetables, or oysters, or other uncooked foods, followed by the multiplication of the microbes upon these substances, and afterwards by an infection of human beings through the consumption of such foods, vegetables and oysters?

A. In the first place my theory as you mention it, does not deny the possibility of a well water containing a sufficient quantity of typhoid bacilli, if it has a short time before, been receiving a large amount of bacilli and causing direct infection.

Q. How about tap water?

A. Tap water usually comes from a large body, like a
7770 large lake, so that this theory refers to great dilutions as
they would exist in rivers and lakes, and not with regard to wells that have recently or a short time before been polluted with large quantities of typhoid discharges. Secondly, as to the time being insufficient for the infection of food. That is not insufficient at all. It only takes twelve to twenty-four hours for a culture of typhoid bacilli to grow. One or two or three typhoid bacilli will produce millions upon a culture medium in a favorable temperature in 24 hours.

Q. Even under unfavorable conditions?

A. The conditions of temperature must be right. The blood temperature is most favorable. In room temperature the growth would be much slower but even at room temperature, 70 Fahrenheit, it would be possible for great numbers of typhoid bacilli to form, even in six hours. So the time is not insufficient for the production of pure cultures on food.

Q. Professor, wouldn't it be a remarkable fact if they grew in such large quantities on vegetables of every town and city, within twenty-four hours?

A. That would depend on the temperature, how fast it would grow and upon the competitive growth of saprophytic bacteria present upon such vegetables.

Q. Now professor, how do you explain the fact that children appear to have taken the disease at school, workmen
7771 in factories, and many people in places where there is
no food?

A. They take their lunch, and they may take their milk along and the milk-can may have been washed out with polluted water, containing one typhoid bacillus. Again, the same proposition, they take it into a warm school room or a factory room and by the time it has stood there four or six hours, they are drinking a culture of typhoid bacilli.

Q. Then, according to your theory, there would be no necessity for the boiling of the water as used by the school children at school houses, for drinking purposes?

A. Now that is a question of conscience. I will answer it as good as I can. I think under these conditions of extreme dilution that it is tolerably safe, according to my knowledge of the biology of the typhoid bacillus to drink lake water, except perhaps during a bad storm where the sewage itself may be carried out rapidly to the intake channels and is gathered in in large quantities.

Q. Suppose that a storm should take place, and turn the sewage from Chicago as rapidly down the Illinois river as it does out into the lake, what effect would that have, wouldn't it push them farther down?

A. Conditions in lake and river are not the same. If Chicago sewage could reach St. Louis as quickly as the Chicago intake channels, typhoid bacilli together with other bacteria would still be alive, although also extreme dilution would have taken place.

Adjourned until 2 P. M., same day, Wednesday, October 7, 1903.

7772 2:00 P. M., Wednesday, October 7th, 1903. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. F. ROBERT ZEIT,

resumed the stand for further cross-examination by Mr. Jeffries and testified as follows:

Q. Professor, you stated in your direct-examination that in all cases the typhoid fever bacillus rapidly disappears from any water to which sewage is added. Now you stand on that statement, do you?

A. Yes, if the temperature is favorable to the growth of saprophytes or water bacteria.

Q. Professor, if a thimble full of sewage is added to a barrel of water containing some typhoid fever germs, do you mean to say that the germs would for that reason rapidly disappear?

JUDGE SPRINGER: I object to this question upon the ground that it does not state whether the water in the barrel was sterilized or unsterilized and for the further reason that it does not state whether there are other bacteria such 7773 as saprophytes and ordinary water bacteria in the water of the barrel before the thimble full of sewage was put in.

A. If in the barrel there is organic material present, or if the organic material that is added with the sewage, is sufficient to favor the growth of the saprophytes, which are in the sewage, then the typhoid bacilli will be again overgrown. If however, the organic matter is very little,—inappreciable; if it is a very potable, pure water comparatively, then the water will contain mostly water bacteria which can multiply even in the absence of organic material and will multiply and also will overgrow at the temperature of the river or the temperature of the lake, which is favorable to the rapid multiplication of water bacteria. These will also overgrow the typhoid bacilli which will disappear. They will, of course, disappear slower where only water bacteria multiply, than they would if there was organic matter present, and saprophytes.

Q. Now professor, if a thimble full of sewage is added to a barrel of water containing some typhoid fever germs, this barrel of water taken from Lake Michigan at the mouth of the Four Mile crib, do you mean to say that the germs of typhoid fever would, on account of the discharge of the thimble- 7774 full of sewage into the barrel of water cause the typhoid germs to more rapidly disappear?

JUDGE SPRINGER: I object to this question upon the ground that the assumptions stated are not such as pertain to the waters of the Chicago drainage canal, or the Desplaines river, or the Illinois river, and that any answer that the witness might give to this question would be immaterial and not tend to establish any of the issues in this case.

MR. JEFFRIES: I suggest that the question goes to the strength of the witness' qualifications, and the statements that he has made concerning the condition of the Illinois river at Grafton, and in reference to the degree of reliance that is to be placed upon bacteriological experiments, as applied to the bacterial contents of running streams.

JUDGE SPRINGER: In reply to that statement I desire to state that the condition which is assumed, of a thimble full of sewage being added to a barrel of Lake Michigan water is an assumption that is not applicable to any of the conditions with which we are now dealing and cannot be applicable to any of the issues in this case, and for the further reasons stated heretofore, I object to the question and to the answer that may be given.

MR. JEFFRIES: In reply to counsel's objection I will state that if it be true that the mixture of the water from Lake Michigan, with the Chicago sewage is equal to a barrel
7775 of water to a thimbleful of sewage, or in any way approaches a greater pollution, as suggested by counsel, that the question is certainly competent as proof on the main issue involved in the case, aside from the question as to the strength and character and extent of credit that is to be given to this witness as a bacteriologist.

Q. (Question repeated).

A. If the Lake Michigan water in this case did not contain larger quantities of organic material it would not do so.

Q. You are acquainted with the water of Lake Michigan at that point, are you not?

A. Yes, but that varies according to precipitation and winds.

Q. And as that varies, the water in the Illinois river of course would vary likewise?

A. It would vary likewise.

Q. Suppose, professor, that a large volume of comparatively pure water containing typhoid fever germs, such as the water in Lake Michigan, receives a relative small volume of sewage, itself containing typhoid, do you mean to say that this small volume of sewage would cause the typhoid fever germs to disappear rapidly and if so, what do you mean by the term "rapidly?"

A. By the term "rapidly" I mean that typhoid bacilli
7776 can disappear in the presence of large numbers of saprophytes, and much organic material, in five or six days, and as to the proposition, I would say that the drainage canal is nothing but a large septic tank now.

Q. What is a septic tank?

A. A tank containing sewage in all conditions of rapid multiplication of saprophytes, due to the presence of large quantities of organic material; water containing sewage in which sewage bacteria are disposing of the organic material by rapid multiplication, as long as the food lasts.

Q. Has the presence or absence of dissolved oxygen anything to do with the septic operations in sewage?

A. Yes.

Q. Are all sewers septic tanks?

A. Yes, sewers are septic tanks in a measure.

Q. If they are septic tanks, and if a stream such as the Chicago drainage canal is a septic tank, why professor, has it been necessary for people to make large—for large cities to make these vast and extensive improvements towards purifying the water into which the sewage is discharged?

A. Because the people living just below a large city which disposes of its sewage by turning it into the river, had to use such water for various purposes, and the water as thus
7777 polluted with large quantities of sewage, produced a nuisance to those living near to the city which disposes of its sewage in that way.

Q. A nuisance in what way?

A. A nuisance mainly by the stench produced, and by the other objectionable features of living on a river which is receiving sewage.

Q. If it was objectionable on account of the stench, would it not also be objectionable for drinking purposes?

A. Certainly.

Q. And would not those objections for drinking purposes continue long after the stench had left it?

A. It would continue for some distance.

Q. And for some time?

A. Until purification had again taken place.

Q. And that would depend on various and an innumerable number of conditions?

A. All conditions, yes sir.

Q. Are all septic tanks and septic conditions equally favorable for the destruction of pathogenic germs?

A. Pathogenic germs disappear and cannot live whenever there is a rapid multiplication of saprophytic bacteria, at a
temperature which is favorable to the bacteria of sewage,
7778 and of water, and is unfavorable to the rapid multiplica-
tion of pathogenic bacteria.

Q. Professor, if the Chicago drainage canal today is a septic tank, as you term it, what effect has the discharge of 250,000 cubic feet of water per minute from Lake Michigan through that canal had upon its septic operation and septic effect and conditions?

A. As much as I can see, only that of diluttion, and removing some of the objectionable features with regard to stench.

Q. Has it not, on account of the increased flow in the canal over and above what the conditions were in the Illinois and Michigan Canal and the Chicago river, removed or reduced the septic operations?

A. Yes, but the septic operations and the disposal of pathogenic bacteria by rapid multiplication of saprophytes, need not be carried to such an extent as to produce a nuisance, by producing stench. There is no doubt a point between extreme dilution and stench where the same process will go on, the destruction of organic material, by saprophytes, and with it also the disposal of disease producing bacteria, and where at the same time, by dilution by lake water, the other objectionable features,
such as stench, can be removed. The septic operation
7779 might remain complete in the drainage canal even with-
out destruction of the fauna and flora of the Illinois river,
and the animal life, I will say, of the river.

Q. Do you put yourself on record as saying that the addition of 250,000 cubic feet of water from Lake Michigan, passing through the canal every minute, has favored the septic operation of the water in the canal, and the sewage in the canal?

A. No. It has simply done this—

Q. As a matter of fact, professor, has not the addition of the 250,000 cubic feet of water per minute reduced the septic operation?

A. It has by dilution reduced the septic operation, but not stopped it.

Q. Don't you know as a matter of fact, professor, that the addition of 250,000 cubic feet of water per minute into the canal from Lake Michigan, has cooled the temperature, and has injected dissolved oxygen and has in a large sense and to a large degree, practically destroyed septic operation in that canal?

A. All that granted, but the fact remains that the dilution of sewage can be carried to such an extent that no stench is present and that even no algae and no fishes are destroyed, and yet the bacterial impurities are disposed of—

7780 Q. When those conditions exist, it is simply the result of the bacterial operation of the water?

A. Yes.

Q. Without reference to the septic operation, is that true?

A. Yes, sir, the bacterial operation.

Q. Then do you mean to say, professor, that the addition of 250,000 cubic feet of water per minute, passing through the canal, does not reduce the multiplication of your saprophytes, does not in turn reduce the time limit for ultimate destruction of all organic matter that is contained in the sewage of Chicago, and that is discharged into the canal?

A. That is true, but at the same time, it is not of such an effect as to allow pathogenic bacteria to remain, because there are no fish and no algae capable of living in the drainage canal. Therefore the action of saprophytic bacteria upon sewage and organic material in the drainage canal in spite of the great dilution that you speak of, has not been affected, so that I would say that the operation in the drainage canal, even with this large body of water that is turned in, is perfect as far as the multiplication of the saprophytes is concerned and its septic tank action.

Q. Do you take the position that because no fish live
7781 in the drainage canal, that there are no pathogenic germs there?

A. No, I take the position that the dilution is not sufficient in the drainage canal for fish and algae to live, and that therefore as far as the disposal of the sewage is concerned, the addition of the water has not had the effect of allowing the pathogenic bacteria to pass, because the saprophytes are in such immense numbers in this sewage tank as to overgrow them.

Q. Professor, would not the pathogenic germs be destroyed very much more rapidly in the old Chicago river before the canal was opened, than they will in the canal since the water from Lake Michigan has been running through it?

A. The more sewage, the more organic material, and the more rapid the pathogenic bacteria—

Q. Answer my question professor.

(Question repeated.)

JUDGE SPRINGER: You are speaking of the Chicago river or the Illinois and Michigan canal?

MR. JEFFRIES: I am talking of the Chicago river now.

A. The Chicago river was as bad physically as the upper part of the drainage canal is now.

Q. Wasn't it worse?

A. I don't think it can be very well—be worse than the upper part of the drainage canal is now.

7782 Q. But you didn't see it though at the time?

A. Yes, I think I have smelled it.

Q. Before the canal was opened did you see it?

A. Yes, and smelled it.

Q. And even with the addition of 250,000 cubic feet of water per minute, it still smells?

A. It still smells.

Q. I will ask you professor, if it is not a fact that conditions existing prior to the opening of the Chicago drainage canal, when the Chicago river was flushed out into the lake, that there was less liability for pathogenic germs or typhoid fever germs passing with those floods into Lake Michigan, than there is now in those germs passing down the drainage canal into the Illinois river?

A. I think the opposite is true. I think the 30 miles of drainage, canal with all its saprophytic life, is more destructive to the pathogenic bacteria than the short distance of the lake.

Q. Then professor, the sewage of Chicago remaining in the Chicago river for a number of days prior to the opening of the canal, the deleterious matter was removed was it, and if that be true, how is it that that sewage when passing out into Lake Michigan, by means of the flood when the channel of the river was reversed, has produced typhoid fever in Chicago?

7783 JUDGE SPRINGER: I object to the question on the ground of assuming a fact not contained in the evidence given in the case, and that the answer will not tend to establish any issues in this case.

MR. JEFFRIES: I submit that that fact has been shown by the evidence of this witness.

MR. DRENNAN: Well, we disagree with you.

Q. (Question repeated.)

A. I don't know that that was the cause of typhoid fever in Chicago.

Q. Assuming, professor, that that was the cause, and assuming that the flushing out of the Chicago river prior to the opening of the present drainage canal was the cause of the typhoid fever in the city of Chicago. I want to ask you now if the facilities for those typhoid fever germs being discharged into the Illinois river are not far better today than the facilities for their discharge into Lake Michigan were prior to the opening of the canal?

A. No, I think not, for the reason that these typhoid bacilli now would have to travel in the drainage canal thirty miles. The distance from the Chicago river to the lake is not as great, therefore they would not remain as long there.

7784 Q. Assuming professor, that the typhoid germs coming from the sewers of Chicago, remain in the Chicago river for days and weeks prior to the opening of the present canal?

A. They then would be destroyed.

Q. Then assuming that although they remain in the Chicago river for days and weeks, and were afterwards flushed out into Lake Michigan and produced typhoid fever in Chicago, I want to know if, assuming those premises to be true, if the conditions and the facilities for the germs of typhoid fever today, passing through the canal into the Illinois river, are not far better than the facilities were for their living in the Chicago river and passing from that river into Lake Michigan prior to the opening of the canal?

MR. DRENNAN: That is objected to as assuming a condition of facts foreign to the testimony.

A. That condition has not been proven.

MR. JEFFRIES: I suggest to the witness that he answer the question, and I suggest to the counsel that Professor Long did testify that the sewage remained in the Chicago river for weeks and days, and that at storm times, flood times, it flushed out into Lake Michigan.

MR. DRENNAN: I submit that he did not testify that typhoid germs remain in there for days and weeks and then were washed out.

7785 MR. JEFFRIES: I submit that the results on the people drinking the water, is the best evidence on that proposition.

JUDGE SPRINGER: That may be true, but that was not the testimony of Professor Long. He was testifying in regard to the sewage solely.

MR. DRENNAN: They have a right to base a question upon their recollection of the testimony of course.

MR. JEFFRIES: I am willing to stand on my question, and the assumptions made, as having been proven in evidence.

Q. (Question repeated)

A. In the first place the assumption, according to my view is impossible, that the typhoid bacilli can remain for weeks in the sewage polluted Chicago river——

Q. But professor, we are assuming that it does.

MR. DRENNAN: Let him get through with his answer.

MR. JEFFRIES: Yes, that's right.

A. But granted, that they were still alive, they would have even then a shorter way to travel into Lake Michigan, than they would have through the drainage canal and therefore there would be more certainty that they had been alive and remained alive after they once entered Lake Michigan, than they would when they entered the Chicago river, or entered the Illinois river. 7786

Q. But professor, were not the facilities for destruction of the pathogenic germs remaining in the Chicago river, with scarcely no current, for days and weeks, more readily produced than in the drainage canal today?

A. Yes, I think that is true.

Q. That is exactly what I want to get at.

A. In other words the sewage was present for a longer time without any current whatever, and therefore had a longer time to destroy other pathogenic bacteria.

Q. Then to that extent their ability to get into Lake Michigan would not be so great as their ability to get into the Illinois river, by means of the canal, because of having remained in the stagnant sewage of Chicago in the Chicago river, for days and weeks?

A. They would have disappeared in both cases, according to my view.

Q. But assuming, professor, that they got to Lake Michigan in the one case, and assuming that they got into the Illinois river in the other case, now which condition is the most favorable for their reaching the points of destination about which we have been speaking, to-wit, the Illinois river in one case, and the Lake Michigan in the other?

7787 A. Under that assumption, to the Illinois river.

Q. It would be more unfavorable?

A. It would be more favorable.

Q. In what way would it be more favorable?

A. Because the saprophytic bacteria would not be as numerous.

Q. Where?

A. In the drainage canal.

Q. Would not be as numerous in the drainage canal when?

A. You are still questioning on your assumption now?

Q. Yes. In other words, there would be more reason to believe that they would get to the Illinois river than there would to believe that they would get to Lake Michigan?

A. Yes sir, under the assumption made first.

Q. Now professor, assuming that the sewage of Chicago would remain in the Chicago river for days and weeks before it was discharged into the lake or discharged into any other stream, assuming also that the sewage of Chicago is discharged into the drainage canal, with the present flow of water from

Lake Michigan, and that it requires only 24 hours for the water to run from the mouth of the Chicago river at Lake Michigan, to Bear Trap Dam, which condition is the most favor-
7788 able for the destruction and death of pathogenic germs?

A. The one in which the pathogenic bacteria are the longest present, with the saprophytic bacteria—

Q. In other words the best place for their disappearance and destruction would be in the Chicago river then prior to the opening of the drainage canal, would it not?

A. For that distance and that time of flow, yes sir.

Q. Don't you know as a matter of fact, professor,—you stated I believe that you were acquainted with the Chicago river prior to the opening of the canal. Don't you know as a matter of fact that the sewage of Chicago leaves the city much more rapidly now than it did prior to the opening of the drainage Canal?

A. Yes, I think that is the case.

Q. In other words, the sewage of Chicago now does not remain in the river, but by reason of the addition of water from Lake Michigan, it is swept on through into the canal and from there into the river Desplaines, isn't that true?

A. As much as I know, yes.

7789 Q. Professor, a great deal has been said by you about the diffusion of typhoid germs in water by dilution. Have you any evidence where such germs are mixed with sewage, the dilution or distribution of the germ is strictly uniform, or do they not go in eddies, groups, masses or otherwise, and thus become concentrated in some portion of the water, rather than uniformly distributed, or is there anything to be known on that subject?

A. I think very little is known with regard to that, as to their behavior in water, because they apparently by the tremendous dilution, become entirely lost, so that bacteriologists, even with the most modern means, have difficulty in finding them in large bodies of water into which they have been turned.

Q. They may go in eddies and in groups and masses or otherwise, according to floods and freshets?

A. And according to surrounding conditions.

Q. Are they diffused, professor, only in water?

A. No, the typhoid bacillus is a motile bacillus, it has motility of its own and is capable in that way of moving from place to place.

Q. And he will find conditions that will best suit his own purpose?

A. If it is not killed before.

7790 Q. Are not bacteria, suspended bodies in water?

A. Yes.

Q. And are they not subject to all laws which govern the destruction of suspended matter in water?

A. Except when they have motility of their own.

Q. With the addition of the motility of their own, they are subject to the same laws?

A. Otherwise they are subject to the same laws.

Q. Have you made any personal investigation of the behavior of bacteria in a septic tank process?

A. I have not.

Q. Therefore you have no precise knowledge on that subject?

A. No.

Q. Professor, have you made any experiments upon the behavior of bacteria in sedimentation?

A. I have not.

Q. Have you made any personal investigation of bacteria in sediments of river muds?

A. I have not.

Q. Have you made any experiments upon the actual behavior of bacteria in streams or rivers, when exposed to dilution with a view of determining whether or not they move in masses, groups and the like, or are uniformly distributed? 7791

A. I have not.

Q. Then is it not a fact that bacteria are such small forms of suspended matter in water as cannot be possibly diffused uniformly through the water, under dilution, as dissolved material itself or dissolved substances are diffused? That I believe you answered?

A. Yes, with the exception of the motility of some of the organisms.

Q. When you say Yes, you mean you have previously answered it?

A. Yes sir.

Q. Is it not a fact, professor, that the whole matter of diffusion and transmission of the germs and sewage in water is very different under different conditions?

A. Yes, there will be very little sedimentation if the flow is sufficient.

Q. And dilution?

A. There will be very little sedimentation if the flow is sufficient. If the flow is not sufficient, there will be more sedimentation.

Q. Is it not a fact that if the sewage of Chicago or any part of it passes into Lake Michigan, that there is good reason to suppose that owing to the conditions existing in Lake Michigan, its disappearance, if it did disappear is largely due 7792 to sedimentation, and that the facilities for sedimentation in Lake Michigan are far greater than those in the drainage canal and the Illinois river, and that the facilities for sedimentation in the Illinois river and the drainage canal do not in any conditions resemble or compare with the conditions and facilities for sedimentation in Lake Michigan?

A. That is more a question for the sanitary expert. As a general proposition I believe, that it is true, the greater the flow of the river the less opportunities for sedimentation.

Q. As a bacteriologist, professor?

A. That is no doubt true.

Q. As a bacteriologist?

A. That there is more sedimentation in the lake than in the river, with a rapid flow.

Q. And as the current of the Illinois river is increased by an added volume of water, the conditions for sedimentation are changed, and there is less ability and less facilities for sedimentation, added increased current, added volume and increased current than there was prior to the increased current?

A. Yes, the more the flow the less sedimentation; the more rapid the flow the less sedimentation.

7793 Q. You mean of bacteria?

A. Of all suspended substances.

Q. Which includes bacteria?

A. Yes sir.

Q. Can a sewer containing a fluid, suddenly change in composition from hour to hour, even from moment to moment, fairly be regarded as in any degree comparing with the vessel that rests in the laboratory experiment?

JUDGE SPRINGER: For what purpose?

MR. JEFFRIES: For the purpose of detecting its bacterial changes?

A. It can be made as nearly right as possible, except the feature of disposal of products of sewage bacteria, which in the vessel cannot be disposed of by dilution and carried off, but which in the sewage or in the river, would be capable of being disposed of. The other conditions can be made as similar as possible.

Q. Professor, does the sewage ever remain in the sewers of a city, a modern city for any such length of time, or for any great length of time?

JUDGE SPRINGER: I object to the question unless it locates Chicago or St. Louis.

A. It probably does not remain very long there, although
7794 I have no idea at all of how long it does remain in the sewers of Chicago.

Q. Does it remain from five to ten days?

A. It might; I don't know.

Q. Yet you have drawn comparisons without knowing the length of time sewage remains in the sewers?

JUDGE SPRINGER: I object to the question.

Q. MR. JEFFIRES: In other words, comparisons between your experiments and the conditions existing in the sewers of large cities?

A. I have not. I have made comparison experiments in the laboratory, as to how long typhoid bacilli live in Lake Michigan water and how long it lives in the Illinois river water, but not how long it lives in the sewer.

Q. Professor, if sewage can be held in sewers for a sufficient length of time to remove all deleterious and disease producing germs, why is it that large and populous cities have constructed plants at enormous expenditures to purify their sewage?

A. For the reason to reduce the pollution of their water supply by sewage, I take it, and for the reason that it is a nuisance for those who live near by and are obliged to use this water.

Q. Professor, do you believe that all disease producing 7795 germs have been destroyed before the sewage leaves the sewers in the city of Chicago?

A. No sir, I never stated that.

Q. Now professor, if they are not destroyed in the sewers, assuming that it takes a certain number of days to destroy them —or is it possible that they are all destroyed in passing from the mouths of the sewers of Chicago to the canal through the Bear Trap dam?

A. It is possible.

Q. Assuming also that they are discharged into a diluting substance of 250,000 cubic feet of water a minute, after they leave the sewers into the canal and Chicago river?

A. It is possible, except spores.

Q. Well, now I don't understand the answer.

A. You spoke of pathogenic bacteria and I said it might be possible that they would all be destroyed in the drainage canal except perhaps the spores.

Q. Now upon the other hand, unless they would all be destroyed within two days in the sewers, and they only remained in the sewers one day, state whether or not they would be destroyed after being discharged into the canal at the end of the first day, passing down the canal at the end of the second day, this immense dilution considered?

7796 A. If it takes 24 hours to go down there, they might not be destroyed at the Bear Trap dam.

Q. And if they would live three days in the sewer and only remain there one day, then the chances are that a great many more of them would get to the Bear Trap dam and be discharged into the Illinois river at the end of the third day than they would at the end of the second day, isn't that true?

A. Yes sir.

Q. And so on, the ratio increases, if they will live ten days in the sewer, then there are greater possibilities and probabilities of their passing further down the drainage canal and on still farther down the Illinois river, isn't that true?

A. Yes sir.

Q. Assume, professor, that it has been demonstrated by bacteriologists that typhoid germs will live in sewage five days, and assuming further that these bacteria of typhoid remain in the sewers one day, that is in the sewage of Chicago one day, that at the end of the first day they are discharged into the drainage canal where they meet 250,000 cubic feet of water per minute; state whether or not that increased dilution would have any effect upon the longevity of the typhoid bacillus?

7797 A. I have already said that the more water, the more pure water the longer they would live.

Q. Then if they lived five days in sewage, after being deposited into this mixture of lake water, they might live ten days, or they might live twelve days. In fact the number of days that they might live has not and cannot be accurately determined?

A. According to experiments, the typhoid bacilli disappear in lake water in six to eighteen days, according to the temperature.

Q. Now then, taking into consideration the fact that you testified to a few days ago, that reasoning by bacteriological analyses, the germs of typhoid would live longer in the running water than they will in the laboratory experiments, taking those things into consideration, might not those germs live not only five days, but ten, twelve, fifteen or twenty days additional in the Illinois river water, mixing with the water from Lake Michigan?

A. They might live somewhat longer.

Q. In other words, there is nothing in the science of bacteriology that can be made perfectly applicable so as to be reasonably safe at all times, and to express an opinion that would carry with it a degree of certainty and a degree of accuracy, is there, as to the exact longevity of the typhoid

7798 germ in a running stream?

A. Yes, I think a bacteriological examination allows of some opinions in that matter to be expressed.

Q. And under the conditions that have been assumed, the typhoid bacillus might live five, it might live ten, it might live fifteen, it might live twenty or even thirty days more, by the analyses that have been made by various bacteriologists in this country and Europe, isn't that true?

A. That would depend entirely upon how pure the water is and what the temperature of the water is.

Q. Isn't it true that it might do that, taking all these assumptions as true, and these experiments that have been obtained by bacteriologists in this country and in Europe?

A. A typhoid bacillus can live, as stated before, eighteen days in Lake Michigan water, according to the greater or lesser presence of organic life and saprophytes.

Q. But professor, going back now to all the assumptions with reference to the typhoid germ being deposited in the sewers of Chicago and remaining there one day; going back to the assumption that it has been known to live five days in sewage, and going back to the assumptions contained in the preceding question with reference to the longevity of the germ in running water as compared to the longevity of the germ in the laboratory 7799 experiment, are not the conditions so uncertain, and is not the field in such an unexplorable condition, taking into consideration the fact that the bacteriologists have found that they live in samples of water taken from running streams, from five to thirty days, that they may pass from the sewers of Chicago into the canal, into the Illinois river, into the Mississippi river and pass to the chain of rocks in less than thirteen or fourteen days, isn't that a fact?

A. No sir, that is not a fact in my opinion.

Q. But taking these assumptions that I have stated as true, isn't that a fact?

A. Yes, but they cannot be accepted, for this reason: We have a continual pollution of the river from Chicago to St. Louis, a river which receives pollution at all times of all forms of material, of organic material and saprophytes, therefore even if living typhoid bacilli should pass the Bear Trap dam, and even if they should get much farther down, they will be constantly exposed again to overgrowth by the saprophytic bacteria and will be constantly exposed to the destructive effects of such overgrowth. Further, the temperature of the water is too low to allow multiplication.

Q. Then professor, if that be true, what effect would the additional discharge of 250,000 cubic feet per minute of water into the Illinois river by means of the drainage canal, 7800 have upon carrying the germs farther down and into the Mississippi river?

A. It would affect and increase the dilution.

Q. Wouldn't it have the effect of hastening their journey on into the Mississippi river before that?

A. Yes, but it would also have the effect of greater dilution and greater separation of the individual germs.

Q. We are not talking about the dilution now; we are talking about the ability of the typhoid germ to live in the canal water and be carried in that water. Now then I want to go back to the original assumption and I want that read, and I want the witness to answer, confining himself to the assumption and taking it for granted that the assumption stated in the question is true.

(Question repeated).

JUDGE SPRINGER: I object to it because the assumption does not state all the conditions which exist in the waters of the drainage canal, the Desplaines or the Illinois rivers, which would materially affect the longevity of the typhoid germs in such water.

A. You pre-suppose a number of conditions which I have convinced myself are impossible, so what is the value of an opinion on such a hypothesis?

7801 Q. It may be of great value to me, and I admit that you do not accede to all those assumptions, but assuming or taking it for granted that all those assumptions are true, what would you say?

A. The most serious one of the assumptions in your question is that bacteriologists have found in river waters typhoid bacilli for thirty days. Now that is not so.

Q. Well I have raised it from five to thirty days.

A. But they have not found it in river water.

Q. They have been found in the laboratory, from the river water?

A. For thirty days?

Q. Yes.

(No answer).

Q. (Question repeated).

A. If all those assumptions were true, of course.

Q. It would?

A. Yes sir.

Q. Now then professor, under the same assumption, with the addition, that all sorts of pollution are removed from the Illinois river and the Illinois river valley, so that the Illinois river valley would be in its primal condition, state whether or not these germs would not reach the Mississippi river and the chain of rocks, if discharged into the Illinois river
7802 through the drainage canal?

JUDGE SPRINGER: I object to this question; that these assumptions are utterly impossible and that any answer based upon such assumptions would be immaterial, irrelevant and would not tend to prove any of the issues involved in this case.

A. That is practically what I would have said, that there is no such thing as a river like the Illinois river which can possibly be pure; that even if no sewage, from adjoining cities along its course would be turned into it, it would still be polluted with various micro-organisms, and more so after heavy rains and floods.

Q. Professor, assuming that all sorts of pollution from the sewage of cities situated upon the Illinois river water-shed, and pollution from domestic animals were eliminated, so that the Illinois river and the watershed of that river would be in its primal condition; state whether or not, in your opinion, the germs of typhoid fever and other pathogenic germs would not pass from the sewers of Chicago into the drainage canal, the Desplaines river, down the Illinois to the Mississippi; assuming that they would not perish in the sewers or in the drainage canal within two days, within the two days that they are confined therein, if so confined, and assuming further that it requires less than fifteen days for the water to flow from Lake Michigan to St. Louis by means of the drainage canal, the
7803 Desplaines and the Illinois rivers?

A. If all those impossible assumptions were true, the typhoid bacillus would no doubt arrive there.

Q. And be virulent?

A. That is another question, whether it would not have lost its virulence; it might and it might not.

Q. What is your judgment about it if it had lived fifteen days, would you consider it virulent, as a bacteriologist?

A. With nothing else to affect it, except the low temperature, during the fifteen days, if it had been virulent before, it probably would preserve its virulence.

Q. Professor, assume that the number of typhoid germs discharged by a sewer is millions and millions per day; that the time of flow from Chicago to St. Louis is ten days; that 99 per cent of the original number of bacteria die in ten days, then it would be a fact wouldn't it, that the number of typhoid germs coming from Chicago, passing the chain of rocks at St. Louis would average ten thousands of millions daily, isn't that true?

JUDGE SPRINGER: I object to the question upon the ground that the assumptions have not been established and cannot be proven in this case.

A. These are again purely assumptions and entirely opposed to the true conditions existing, both in the sewers
7804 or in the drainage canal, but if these assumptions were true of course those calculations would no doubt be correct.

Q. Now then, professor, under these assumptions or conditions, if ten thousand millions of typhoid germs pass the chain of rocks daily, coming from Chicago, is it not reasonable to expect that a large quantity of them should enter the St. Louis intake and a great many of them be swallowed by the people of St. Louis find their way into the milk, bread, vegetables, and at room temperature produce a media causing the multiplication of the typhoid bacilli, that would infect the families, and would affect the health and endanger the lives of families in St. Louis?

JUDGE SPRINGER: I object to this question because it assumes a statement of facts which have not been proven in this case, for the reason that those samples of water taken in St. Louis at the chain of rocks, in the Missouri river at its mouth, in the Illinois river at Grafton and the Illinois river at various places between Chicago and Grafton, and also in the Illinois and Michigan canal and in the drainage canal and in Lake Michigan, there has never been a typhoid bacillus found come from Chicago and passed to the St. Louis intake is without any foundation in fact and cannot be assumed as a 7805 fact that is based upon anything in this case.

MR. JEFFRIES: In answer to the objection of counsel for defendant, I suggest that the witness has stated that on the examination of water known to be infected with typhoid germs, bacteriologists have been unable to obtain a germ in that water. I will also suggest to counsel, that in the event of one typhoid germ being discovered in the samples of water that were taken by both parties in this controversy from the Illinois river or the Mississippi river below Grafton, taking into consideration the very small amount of water examined, and that had the river been infected with typhoid germs, proportionately throughout the entire volume that it would have meant death and destruction to all the people using that water for drinking and domestic purposes?

A. Even if all those assumptions were true, the possibility of millions of typhoid bacilli coming from Chicago to the chain of rocks would be absolutely impossible, even if all the typhoid bacilli of all the typhoid cases in Chicago would reach without destruction the chain of rocks, the dilution would be such a tremendous one that but very few of them could enter the inlet.

Q. Professor, if that be true, why is it, that occasional 7806 discharges, and carrying out of the sewage from the Chicago river into Lake Michigan at the mouth of the Four Mile crib produce typhoid fever in Chicago?

A. Because the one bacillus that might have been in a million barrels of water happened to get into the milk supply of a number of families and produce by multiplication in a favorable temperature millions of bacilli and these people were drinking cultures of them. Such a multiplication does not take place in water.

Q. And might not that condition also exist at the other end, to-wit the chain of rocks?

A. Yes, but you referred to the direct infection by water, and the numbers of typhoid bacilli which would arrive in that way from Chicago.

Q. Professor, do you mean to say that, assuming that there are ten thousands of millions of typhoid bacteria daily passing down the Mississippi river at the chain of rocks, that necessarily a large quantity of them will not be taken into the water system of St. Louis at the chain of rocks?

A. Owing to the tremendous dilution.

Q. In other words, that if all of the typhoid bacteria that are discharged by the people of Chicago, were deposited into the Mississippi river one mile above the chain of rocks, that the dilution would be so great that it would not affect
7807 the health of the people of St. Louis, do you mean that? Then if you do, professor why is it that the people are called upon to build filtration plants, and why is it they are called upon to expend large sums of money to purify the sewage of the larger cities of this country and of Europe?

A. Because a polluted river constitutes a nuisance, and because in such infectious material, if deposited right at the intake in immense quantities, the conditions are entirely different than they are in this case where 300 miles away a septic tank receives all the sewage of a city and destroys it.

Q. I understood,—I insist professor, that you did not answer my question. You stated in answer to a question a few moments ago that you believed that if all the typhoid fever germs discharged by the people of Chicago or by the typhoid patients of Chicago should pass down the Illinois river and arrive at the chain of rocks alive and virulent, that with the dilution there, they would have no effect upon the life and health of the people of St. Louis?

JUDGE SPRINGER: I object to the question and submit that he didn't say that.

MR. JEFFRIES: I submit that he said those very words.

A. All the typhoid bacilli that are produced by all the
7808 typhoid cases in Chicago, if they were all turned into the river and if they were not exposed to any conditions whatever of destruction and if they all arrived in the Mississippi at that locality, they would be so far distributed and so diluted through the immense amount of water, that the number of them would be inappreciable, and that it would be a great question whether any of them, even one, would enter the inlet at the chain of rocks.

Q. Professor, do you know or have you any information upon the volume of water that flows past the chain of rocks in the Mississippi?

A. I have only my own inspection which was made recently of the drainage canal, the Desplaines, the Illinois river, and the Mississippi and the Missouri.

Q. Do you know whether or not professor, that for months the volume of flow past the chain of rocks in the Mississippi is less than 600,000 cubic feet per minute?

A. No, I don't know that.

Q. Don't you know professor, that the volume of flow down the Mississippi river past the chain of rocks during the greater part of the summer season and the early fall season is less than 400,000 cubic feet per minute; in other words is not double the amount of water that passes through the drainage canal at Chicago. Not knowing this, I will ask you professor, if it
7809 would not be important and necessary for you to know
the exact volume of water which would flow down the Mississippi river past the chain of rocks, in order to determine whether or not there would be a sufficient dilution to protect and be a constant barrier against any deleterious effect upon the health of the people of St. Louis, on account of taking in the typhoid germs that might pass there?

A. I will repeat here in answer to that; if there is sufficient river water to be fifteen times that of the sewage, and the flow per second is one and a half meters, that no sedimentation banks of sewage form in the river, that no putrefaction or stench forms, that no algae or fishes are destroyed, that the chemical impurities are insufficient and that the bacterial impurities disappear in the purification zone. This I have stated before, and it really represents the opinion which I have formed, with regard to the sanitary side, although I have not attached much importance to this statement before, but you seem to insist on having me answer such questions, and therefore I have simply stated here the opinion of authorities on sanitation.

Q. I would not have insisted upon such answers professor, unless you had qualified and so testified in your direct-examination.

7810 A. Not in the direct; that was in the cross-examination.

Q. I want to know professor, if upon your proposition and your statement that you do not believe that if all the typhoid fever germs coming from the typhoid patients of the city of Chicago were passed down the Illinois river, were to pass down the Illinois river into the Mississippi river and on past the chain of rocks and be alive and virulent, it would not depend largely upon the volume of water passing down the Mississippi past the chain of rocks in order to determine what effect, what material effect that would have upon the life of the people of St. Louis?

JUDGE SPRINGER: I wish to enter an objection to this question and to all questions of similar character for the reason that the assumptions are utterly impossible and that any answer based upon such assumptions would be immaterial, irrelevant and would not tend to establish any of the issues involved in this suit.

MR. JEFFRIES: I suggest there is not a single assumption in the question that was not injected into the controversy by the witness himself.

JUDGE SPRINGER: The witness has never suggested that thousands of millions of bacteria could come from 7811 Chicago and get to St. Louis.

MR. JEFFRIES: The witness has suggested that if he believed that all the typhoid bacteria from the typhoid infected persons of Chicago were discharged into the canal and passed down the Illinois river to the chain of rocks and arrived there active, virulent and alive, it would have no effect upon the health or life of the people of St. Louis.

JUDGE SPRINGER: Even if he did state that, it would be utterly immaterial, because it is based upon an assumption of facts that do not exist and cannot exist, and therefore any answer upon this subject is utterly immaterial and proves no issue in this case, nor tends to prove any.

MR. JEFFRIES: Then I take it for granted that counsel admits the position that inasmuch as it is not material how much bacteria reach the intake tower at St. Louis, that the proof of their deposition in Chicago and presence, and ability to be present in the lower stretches of the Illinois river is all that is in controversy in this case.

JUDGE SPRINGER: No, the assumption is whether those typhoid germs will come from Chicago to St. Louis and is an assumption that is utterly impossible under any statement of the case. Nobody would ever assume that all those germs could possibly get to St. Louis.

7812 MR. JEFFRIES: But the witness has relied upon dilution, and this question is based upon the statement that he makes himself, and for that reason we have a right to propound the question.

THE WITNESS: I do not like to answer questions which are put on such purely theoretical assumptions and then afterwards be accused of having expressed opinions that are not in harmony with Mr. Jeffries' conviction. I do not wish to go on record as saying that if all the germs or bacteria of all the typhoid fever patients entering the river, if there was absolutely no destruction whatever by any saprophytic bacteria or products, could reach the chain of rocks, that none of those that should get there, got into the intake. I stated and want to be understood that the dilution would be such a tremendous one, that there would be very few only, and that those few would not produce infections by drinking that water containing them. This was the idea which I have expressed right along, of not believing in direct infections with water that contained greatly diluted typhoid discharges, so if you say that I have denied the possibility of any typhoid bacilli entering the inlet under the assumptions stated, I have either expressed myself wrongly, or you have misunderstood me.

Q. Well, the record will show what you said professor. Is it not necessary to know in this connection and in the con- 7813 nection about which we have just been speaking, the volume of water that passes down the chain of rocks at all times, in order to determine whether or not the sewage and typhoid germs from Chicago would have any deleterious effect and would sufficiently dilute the water as to render its sanitary condition safe, in the event that it can be rendered safe if typhoid germs had been deposited into it.

JUDGE SPRINGER: I object to the question upon the ground that one of the assumptions is that the typhoid fever germs from Chicago reach the St. Louis intake, an assumption which has not been established in this case; but on the contrary it has been proven that they cannot.

A. My former answer was based on the fact that I have inspected the waters of those rivers.

Q. MR. JEFFRIES: At all times of the year?

A. No sir.

Q. The question is professor, is it not necessary to take into consideration the volume of water passing a given point?

A. Certainly, but what will become of billions of minute organisms like these in a body of water like that of these three great rivers. It would be a similar dilution to that of gallons
and gallons of arsenic solution being poured into the
7814 Illinois river, and then employing the finest chemical
tests for arsenic on the St. Louis water supply. Not the minutest trace of arsenic could be found anywhere.

Q. If that is true, why is it, that typhoid fever has been traced by scientists and by competent men to Lake Michigan, or rather to the city of Chicago from Lake Michigan, to the city of Cleveland, Ohio, from Lake Erie, and would not the dilution in the lakes be far greater than the dilution in the Mississippi river or in any river where it is confined by narrow banks?

A. The conditions were, no doubt, due to sudden flooding of sewage into the lake and intakes by winds and storms.

Q. And the sudden floodings which you speak of, into the lake in part resemble the current of the river as it flows down the stream, and in addition to that the conditions in the river are not such as to allow sedimentation to take place to the same extent it does in the lakes, isn't that true?

A. During a storm, if sudden pollution of the lake takes place by sewage material containing typhoid bacilli, there would not be any chance for sedimentation either.

Q. And there never would be any chance for sedimentation in a river as long as the stream was flowing?

7815 A. Not in the river.

ADJOURNED until 10:00 A. M. following morning, Thursday, October 8th, 1903.

7816 10:00 A. M., Thursday, October 8th, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. F. ROBERT ZEIT,

resumed the stand for further cross-examination by Mr. Jeffries, and testified as follows:

Q. Professor, we were speaking at the close yesterday, about dilution. I want to ask you that if you should deposit three or four virulent typhoid germs into a cubic foot of water, knowing that those germs were in that water, would you recommend that water for domestic use in the household?

A. I would not.

Q. If any city obtains a water supply that is infected with typhoid germs to any such extent, you would not consider that water good and safe for domestic purposes, would you?

A. That has not been claimed in my testimony.

Q. But professor, assuming now that they are there in those quantities, three or four to the cubic foot of water?

MR. DRENNAN: That is objected to as being so foreign to any of the facts in this case as to become purely imaginary.

7817 MR. JEFFRIES: I suggest that it bears upon the credibility to be placed upon this witness' testimony yesterday afternoon on the question of dilution.

A. It should not be recommended on the ground that even if it did not produce any direct infections by the drinking of the water itself, it might pollute articles of food and then allow rapid multiplication of typhoid bacilli at room temperature, leading to indirect infections.

Q. It might get in the other cultures?

A. Other media such as food, milk, etc., and multiply there under favorable temperature conditions and in that way produce indirect infections if the water itself had not been exposed to those conditions of saprophytic overgrowth, which lead to the destruction of pathogenic germs.

Q. But professor, wouldn't there be great danger of producing this growth upon vegetables and various media in the house or in the room where the family live, if the water was taken into that room containing these germs?

A. If the water contained living typhoid bacilli, yes.

Q. Now, that I understand is your theory of the matter. In other words, that the infection comes on account of the growth of the germ upon some media in the room rather than upon taking the typhoid directly into the human system by drinking the water?

A. Now Mr. Jeffries, you have continually called that a
theory of mine. It is not. This is the accepted opinion
7818 of the majority of sanitarians the world over.

Q. Well, whether it be your theory or not, professor, that is your opinion as drawn from your experience as a bacteriologist?

A. And from reading of the experiences of the sanitarians the world over, and my opinion is based upon the same argument they base theirs. The biology of the typhoid bacillus is such that direct water infections can almost be excluded. In fact some say, can entirely be excluded because the organism does not multiply in water at the usual temperature of drinking water, bacteria and saprophytic bacteria which multiply well at these low temperatures. Under those conditions a typhoid bacillus cannot multiply even if it remains alive. It cannot multiply unless temperature and culture media are favorable. This is not my individual and personal theory, but is the opinion of sanitarians in general,—with some exceptions.

Q. Then professor, there would be as much liability of contracting typhoid fever if the water containing those germs were used in the household at room temperature, and used to
wash vegetables at the proper temperature, and in various
7819 ways at proper temperature, as there would be if they
should drink the water,—conceding that they could contract it by drinking?

A. They, in my opinion, could not contract it by drinking the water because the number of the typhoid bacilli would be too small, due to dilution.

Q. Now this is the question professor: Assuming now that there are two ways, one by drinking the water direct, and the other by indirect infection, which you say is the accepted way. Now then, assuming that it may be contracted in both ways, we will take it for granted that science is divided on that proposition; take it for granted that it can be contracted in both ways, are they not as liable to contract it by reason of its being brought into the household and used in cleaning vegetables at the proper temperature, and in various media at the proper temperature in the household, as they would be in drinking it direct?

A. There are some exceptional conditions in which a direct infection could, no doubt, take place. If the sewage or the excrements of a typhoid, fever patient, containing innumerable numbers of typhoid bacilli should enter a well in 7820 large quantities, and such highly and recently polluted water be consumed, it might be possible that the necessary numbers to infect would be present. Such conditions would not exist in rivers where great dilution takes place, or in lakes where dilution reaches a tremendous figure. The infections by lake and river waters must always be indirect and not direct.

Q. Then professor, your position is that infection can be more readily brought about by smaller quantities of bacteria in the water when used in the household for domestic purposes than in the case of larger quantities taken into the human system directly by way of drinking the water?

A. Yes, because small numbers of typhoid bacilli contained in the river or lake water could, on favorable culture media, when kept at favorable temperatures, multiply rapidly and produce millions of bacilli. Such infected food would contain millions more of bacilli to the cubic centimeter than well water which had received the discharges of a typhoid patient.

Q. Now then professor, assuming that typhoid fever germs live from ten to twenty days in the sewage of Chicago, the Chicago river, the drainage canal, the Illinois and the Mississippi rivers, as they flow from the sewers from Chicago to and down the Mississippi river; assume that they are dis- 7821 charged into the Illinois river from the Desplaines river, and assume that the Illinois river is frozen over with ice from mouth to source, that the Mississippi river in turn is frozen over from Grafton to the point below the chain of rocks. Assume that the water coming from Lake Michigan and the drainage canal passes the chain of rocks within from ten to thirteen days, would not disease producing germs in larger quantities find their way to the Mississippi river at the chain of rocks, than they would in the summer time when the river is open?

A. The lower the temperature the longer the life of pathogenic bacteria, because the saprophytes do not overgrow them. That is true as a general proposition. Even pathogenic bacteria will eventually decrease in number by very low temperatures to which they have been exposed for a long time. The low temperature not only prevents the growth of parasites but also of saprophytes, and therefore they will multiply less and the typhoid bacillus—

Q. But parasites never grow in a running stream do they?

A. If the temperature of water should rise to that of blood, or even less, and there would be no increase of water bacteria or saprophytic bacteria, there might be even a little multiplication, but as a—

Q. But as a general proposition?

A. But as a general proposition they do not, because 7822 water bacteria and saprophytes are more favored by the usual temperature of water and thus overgrow disease producing germs. This overgrowth is the important element in the destruction of pathogenic germs.

Q. But under the conditions assumed in the question, what would be the effect at St. Louis as compared to the conditions which would naturally exist in the summer time?

A. The destruction of organic material by multiplication of saprophytes would be slower and the typhoid bacilli, or some other pathogenic bacteria might live longer. Some disease germs would be destroyed by low temperature; for instance the cholera vibrio dies in ice in a few days.

Q. How about the typhoid germ?

A. The typhoid germ would live longer. Some disease producing bacteria are more susceptible to low temperatures than others. The typhoid bacillus lives much longer at low temperatures than the cholera vibrio.

Q. Now professor, assuming that typhoid fever germs pass from the canal into the Illinois river, and that as they reach the Illinois river they meet a flood, what effect would that flood have,—a flood in the Illinois river, have upon carrying them down stream?

A. The flood would mean greater dilution; it would sep-
7823 arate them further apart. It would mean more water;
it would mean more rapid flow, so they would pass a further distance down the river than if the flow was slower as in low water. The saprophytic life and destructive effect of organic matter would be less.

Q. In other words there would be greater quantities of typhoid fever carried down the river by the flood alive?

A. Greater numbers of typhoid bacilli could pass further down the river before they were destroyed, yes sir.

Q. And if they live from ten to thirteen days, and the water of that flood reached St. Louis within the thirteen days, they might flow on right through, might they not?

A. If they could live thirteen days, which is improbable, because floods carry immense quantities of organic material into the river and immense numbers of other bacteria, which would again take up this competitive struggle. The more the flood the more impurities would reach the river and the more saprophytic bacteria would be present, and therefore the struggle would be the same. The only difference that I can see is the greater dilution of pathogenic germs and the more rapid flow, so that less time is given for these competitive struggles to take place.

Q. And therefore larger quantities would reach the river at St. Louis?

A. If that was possible.

7824 Q. If they got into the flood?

A. If they were not destroyed by all these elements mentioned, in thirteen days, of course they would still be there.

Q. Professor, what is it that destroys the typhoid germs? In other words, is it an absolute warfare between the saprophytes and the parasites or is it simply because of the overgrowth of the one that the other disappears?

A. The factors are the following:

First, the overgrowth of saprophytes.

Second, the excreted material present in the water of these saprophytes. The more organic material present, the more rapidly do these saprophytes multiply and the more of these excretion products.

Third, the temperature. The more favorable the temperature for the growth of saprophytic life, the more rapid the destruction of the typhoid bacilli. I might now add another factor which I have never mentioned, and that is the factor of sunlight, or light—

JUDGE SPRINGER: What effect would that have?

A. The destructive effect of sun light upon all disease producing bacteria in rivers and in lakes. Aside from the competition between saprophytic and pathogenic bacteria, there are some other factors.

7825 Q. But the fact is that these germs have been found to live in the sunlight for days and weeks?

A. No sir, pathogenic bacteria die in sunlight in a few hours.

Q. No, but I mean in the samples of water in which you undertook to imitate the conditions in the river as far as possible?

A. In my experiments I excluded the effects of sunlight entirely. I think my experiments were rather more favorable to the life of the typhoid bacillus, than natural conditions in the river.

Q. Well don't you know that experiments have been made by competent bacteriologists in undertaking to imitate as far as possible the conditions with reference to light in the river?

A. Experiments upon the longevity of the typhoid bacillus with regard to diffuse light?

Q. Yes?

A. Why I have done that too. In my series of experiments I exposed some of the flasks and tubes in the dark room to different temperatures, and another series in diffuse daylight. In diffuse daylight typhoid bacilli disappeared quicker than they did in the dark.

Q. Now then, professor, in time of flood the water is very turbid, is it not?

7826 A. Yes.

Q. And that has a tendency to prolong the life of the germ?

A. By decreasing the effect of light.

Q. Professor, you have spoken of the zone of bacterial purification in streams below cities,—have not bacteriologists described a zone of pollution of streams above cities?

A. Above cities—

Q. Some bacteriologists, I don't mean all.

A. I think sanitarians have had most to do with that, and it wasn't so much an examination of the bacteria in the streams above the city which led them to speak of such pollution as it was the general knowledge that the discharges of diseased persons and sewage had been known to have been poured into the river, above cities.

Q. Assuming that typhoid fever germs will live in the Chicago sewers, the drainage canal and the Illinois river for thirteen days or longer, and assuming that the germs from the sewers of Chicago when discharged into Lake Michigan sometimes find their way to the Four Mile crib, and after reaching the crib cause typhoid fever in Chicago among the users of the water from that crib; assuming further that the typhoid germs discharged into the drainage canal entered the water suply of St. Louis within thirteen days; assuming further that the dilution of said germs in the water of the Mississippi river
7827 at the chain of rocks is not greater than that of the
typhoid germs in the water of Lake Michigan at the mouth of the Four Mile crib, would not the using of the water from the Mississippi river at the chain of rocks by the people of St. Louis produce as much typhoid fever as would be produced among the people of Chicago using the water of Lake Michigan drawn from the Four Mile crib?

A. The two conditions in my opinion, cannot be compared because even if it could be proven that direct infections by swallowing the water did occur or that indirect infection occurred in the manner indicated, by typhoid bacilli multiplying in milk and other food at favorable temperatures, from water supplied by the Four Mile crib, a severe storm on Lake Michigan might rapidly carry out large masses of pollution to an intake, located only four miles from shore, whereas the distance from here to St. Louis is over 300 miles by way of the river, and there would be a great deal more time for destruction of pathogenic bacteria that had entered it, than if fresh sewage containing typhoid bacilli, just received by the lake, were suddenly washed out by storms and flooded into the intake.

Q. Professor, answer the question.

A. Well, there are those differences between the two conditions.

7828 MR. JEFFRIES: Read the question.

(Question read.)

JUDGE SPRINGER: I suggest that the witness has already answered this question.

MR. JEFFRIES: I suggest that the witness has not answered a single word of this question.

JUDGE SPRINGER: For the reason that the conditions are not comparable in this, that the assumption is that the typhoid germs from the sewers of Chicago reach the intake within thirteen days. They may have reached it within one day, but in the other case they must have a much longer time to reach their destination, and the conditions would all be changed.

MR. JEFFRIES: Now answer the question professor.

A. I think I have answered it before.

JUDGE SPRINGER: I insist that the assumption which states that the germs that enter the St. Louis intake had been deposited in the Chicago sewers for more than thirteen days before they reached the intake, in order to make the comparison whole in the one case they may have reached the intake in one day and in the other case it is impossible to reach it until after ten or twelve or fifteen days, or thirteen days, whatever you fixed it.

Q. MR. JEFFRIES: What do you say as to the question professor?

7829 A. How does the question stand now?

Q. The question stands just as it did before.

A. If typhoid bacilli from whatever source they come, entered the intake of St. Louis, they are capable to produce the same conditions in St. Louis that they would if typhoid bacilli reached the city of Chicago from the four mile crib. I mean by this that typhoid bacilli, from any source, entering the intake at the chain of rocks at St. Louis, will not produce a direct infection by the drinking of the water, because too small in by any person, and that assumption that millions of them have number—but they are capable of getting upon favorable culture media, such as milk and foods, multiply at room temperature and produce infections.

Q. So that it would be as liable to produce as much fever in one case as in the other?

A. Every one swallowing such cultures of typhoid bacilli on food stuffs, which result when a few germs in the water multiply under favorable temperatures, could be infected and develop typhoid fever.

Q. Now then professor, I will state the question in another way. Assuming that typhoid fever germs will live in the Chicago sewers, the drainage canal and the Illinois river for thirteen days or longer, and assuming that prior to the opening of the Chicago drainage canal typhoid germs lived in 7830 the Chicago river and Lake Michigan for thirteen days or longer, and that they sometimes found their way to the Four Mile crib and after reaching the crib caused typhoid fever in Chicago among the users of the water from that crib; assuming further that the typhoid germs discharged into the drainage canal since the opening of the canal, enter the water supply of St. Louis within thirteen days; assuming further that the dilution of said germs in the water of the Mississippi at the chain of rocks is not greater than that of the typhoid germs in the water of Lake Michigan at the mouth of the Four Mile crib, prior to the opening of the drainage canal, would not the use of water from the Mississippi river at the chain of rocks by the people of St. Louis produce as much typhoid fever as would be produced among the people of Chicago using the water of Lake Michigan drawn from the Four Mile crib?

A. That is true, but the whole proposition has been proven to be impossible.

Q. Professor, this is an assumption which I am responsible for. I am responsible for the question; you are responsible for the answer, and I want you to answer the question?

A. I do.

Q. Well, now let us hear your answer.

7831 A. I said, "Yes." But the proposition itself is excluded by my testimony which states that they do not live thirteen days under the conditions stated, in the drainage canal and in the Illinois river.

Q. But assuming these conditions to be true, as contained in this question, you will have to admit that they would produce as much typhoid fever in the one place as in the other, would you not?

A. I answered that with "Yes," before.

ADJOURNED until 1:30 p. m., same day, October 8, 1903.

7832 1:30 p. m., Thursday, October 8, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

By agreement between counsel, witness Prof. F. Robert Zeit was temporarily withdrawn from the stand.

FRANCES C. BLANCHARD,

called as a witness in behalf of the defendants, being first duly sworn, was examined in chief by Judge Springer, and testified as follows:

Q. State your name, residence and occupation, madam?

A. Frances C. Blanchard; Wheaton, Illinois; physician.

Q. State whether at any time you were employed by Professor Long, for the purpose of taking samples of water from the head waters of the DuPage river?

A. Yes sir, I was asked by Professor Long to send him samples in the fall of 1899.

MR. JEFFRIES: I object to any evidence as to samples of water being taken from the head waters of the DuPage or
any of the tributaries of the Illinois river for the reason
7833 that any analyses that may have been made of such wat-
ers, as applicable to the condition of the water in the Illinois river, is incompetent, irrelevant and immaterial, and for the reason that such evidence will throw no light upon the question as to whether or not the disease producing germs that flow from the sewage of Chicago by means of the drainage canal reach the waters of the Mississippi along the shore of the state of Missouri.

JUDGE SPRINGER: For the purpose of facilitating this examination, counsel for respondents agrees that this objection may be considered as having been made to all of the questions put to this witness, as they relate to one of the tributaries.

MR. JEFFRIES: And such further objections as I may see fit to make from time to time.

JUDGE SPRINGER: At what time did you begin to take the samples and when did you quit?

A. I began I think about the first of November or the last of October, I do not remember the dates.

Q. What instructions did you receive from Professor Long, if any, in regard to taking these samples?

A. There were printed instructions on the backs of the cards that were sent me and I referred to the cards.

Q. Did you follow those instructions?

7834 A. I did sir, most implicitly.

Q. What kind of bottles or receptacles did you receive for the purpose of containing this water?

A. If I remember correctly they were gallon bottles in cases.

Q. How were they prepared, if you know?

A. There was one small vial also. They were prepared, stoppered and covered by some rubber, I think.

Q. What did you do in reference to taking the samples; how did you proceed to get the water from the stream?

A. The directions on the back of the card gave the method of the procedure. I remember one thing was that the bottle was to be opened after it entered the water before the water was allowed to enter the bottle.

Q. Did you follow that instruction?

A. I did.

Q. And closed it after you had it below the surface?

A. Yes sir.

Q. What did you do with the bottle when you filled it?

A. It was immediately stoppered and recovered and taken at once to the express office.

Q. Was it packed in anything?

A. It was packed in a box.

7835 Q. Was it packed with ice?

A. No sir, it was so late in the year that ice was not necessary. The latest collection was December 7th.

Q. How many samples in all did you take?

A. I collected three.

Q. Please look at the papers that I hand you and state whether those were the papers containing the instructions and the blank for making out the returns in reference to the water taken?

A. That is my handwriting and my signature, all of them.

Q. Did you fill those blanks?

A. I filled them myself.

Q. Did you, or do you recognize the instructions on the back?

A. I do.

Q. And those are the instructions that you followed?

A. I did.

Q. Are the statements made upon each of these cards in your handwriting, correct statements of the facts stated upon these cards?

A. They are so far as I was able to make them. They are correct.

7836 Q. These that are here are correct?

A. Yes, I did everything as I was ordered to.

Q. On these cards I observe the following date, the date of collection on one is November 9, 1899; on the other is November 23, 1899; on the other December 1, 1899. Are those the dates upon which these collections were made?

A. I think they are.

Q. Is this your signature upon each of them?

A. Yes sir, that is my signature.

Q. Have you correctly noted the temperature of the air and water, in the samples?

A. Yes sir.

Q. And forwarded them by express as you have stated?

A. Yes sir.

JUDGE SPRINGER: We will put these in as part of defendants' Exhibit 1 to 17 for identification.

MR. JEFFRIES: It is agreed by counsel for complainant that the cards so shown this witness are the same as defendants' Exhibit No. 3.

7837 CROSS-EXAMINATION, by Mr. Jeffries.

Q. Did you collect the samples in one bottle each day or two bottles?

A. Only one bottle was sent me at a time.

Q. And that was a large bottle?

A. Yes sir.

Q. You made no collection of the small bottles?

A. There was a small bottle, I think, in the same package.

Q. A four ounce bottle?

A. I don't remember the size of it. Two bottles in one express package, and they were collected at the same time.

Q. They all went to Professor Long?

A. Yes sir.

Q. You only made three collections?

A. I only made three collections, yes sir.

MR. JEFFRIES: Now I move to strike out all the evidence of this witness, and also the testimony of Professor Long with reference to the chemical analyses of the DuPage river water at this point, for the reason that this evidence is incompetent, irrelevant and imaterial. Incompetent because it does not tend to prove any issue in this case, and has no bearing
upon the issues in this case, and for the reason that even
7838 though the condition of the water in the DuPage river or
any other tributary of the Illinois river, was in any way essential in the determination of any question in this case, that a sufficient number of samples was not taken to be comparable with the conditions applicable to the Illinois river and for the reason that flood times are not considered, and low water stages are not considered, and that even the samples that were taken, were not taken with reference to the condition of the tributaries in low water stages of the river, and have not been considered.

RE-DIRECT EXAMINATION, by Judge Springer.

Q. Will you state what was the stage of the river so far as you could observe at the time you took these samples?

MR. JEFFRIES: I object to the question as not proper re-direct.

JUDGE SPRINGER: It is competent on the ground of your objection.

THE WITNESS: The water was low.

Q. Was it lower than ordinary?

A. It was not as low as I have seen it, but it is what you call low water.

Q. How large is that stream?

7839 A. It is not a very large stream, perhaps at Warrenville, where I took the samples, from eighteen to fourteen feet, it widens and narrows.

Q. In width?

A. Yes sir.

Q. How deep?

A. Perhaps a foot and a half or two feet.

MR. JEFFRIES: Now I renew my motion to strike out this testimony for the reasons stated in the motion just made.

(Signature waived.)

7840 PROF. F. ROBERT ZEIT,

resumed the stand for re-direct examination by Judge Springer and testified as follows:

Q. Professor, in one of the questions submitted to you on cross-examination by Mr. Jeffries, it was assumed that English authors or bacteriologists were more thoroughly informed on questions of sanitation and hygiene and bacteriology than the scientists of other countries. To this intimation you suggested your non-concurrence on the ground that you thought the German writers were better informed upon this subject. Now will you state what position the Franklands, the authors of a book called Micro-organisms in water, a work which Dr. Ravold in his testimony stated was of the highest authority, have taken with reference to the zone of bacterial purification in rivers?

MR. JEFFRIES: I object to the question for the reason that no such assumption was contained in any question that I propounded to the witness; that I did not refer to hygiene, but I referred to river pollution, and river pollution alone, and that the question so propounded to this witness in redirect examination does not contain the assumptions contained in the question which was propounded by me in cross-examination.

7841 JUDGE SPRINGER: I will modify my question by quoting the words exactly used by Mr. Jeffries whether "there is any people on the face of the earth that have made more thorough investigations of this subject than the English people." That is the phrase to which I referred in my previous question, and to which I have confined my assumption as stated therein.

Now what position was taken by them in reference to the self-purification of the River Dee, to which you referred?

A. Frankland states in his text-book that the River Dee affords a most perfect example of the repeated pollution and the repeated restoration of a stream to a state of comparative purity—

MR. JEFFRIES: I object to the witness reading from Frankland's as he is now doing.

Q. JUDGE SPRINGER: Does that book state the position of leading German bacteriologists on this subject, if so, please state the facts.

MR. JEFFRIES: I object to the question for the reason that the book is no evidence. The question is the opinion of this witness, and not as to what any other person will say, and for the reason that we have not Mr. Frankland or any other person from whom the witness might quote, here personally, in order to cross-examine him on the subjects about which this witness is testifying.

7842 JUDGE SPRINGER: This testimony in my opinion is competent for the reason that counsel for complainant has intimated that this witness was not supported by the English authors and writers on this subject and that he has a right therefore to show that he is supported by their writings.

MR. JEFFRIES: I object to the question for the reason that if, as assumed by Judge Springer, that any such position should be taken by the complainant, that the witness has no right to read from a book in support of his proposition, but that he may from his own memory and own information derived from reading publications upon the subject, or from his experience as a scientist, state relatively his position with reference to the positions of other men engaged in the same scientific investigation.

JUDGE SPRINGER: I submit that the highest evidence is the exact text of the writer.

Q. Now will you state as to the other question?

MR. JEFFRIES: I submit that there has been no evidence that the text-book which he is reading from was written by any person or persons testifying in this case, and there is no evidence that that position has always been maintained or was not subsequently shifted and changed by the writer of the book and that proof of these facts can only be obtained in a 7843 competent way by the judgment and opinion of the person speaking from the witness stand, and the witness stand alone and not through the medium of books.

Q. JUDGE SPRINGER: You may answer the question.

A. The Franklands state in their book, "It will be seen from a careful study of the numerous investigations which have been made on the behavior of pathogenic organisms in water, what enormous differences exist in their capacity for living in this medium, that whereas, some varieties are destroyed in a few hours, some will live and flourish for many months. Moreover, it is obvious how greatly in some cases, the character of the water influences the vitality of the micro-organisms, a point which is especially brought out in Trenkmann's experiments with cholera bacillus, and it is of particular interest to note how in the case of unsterilized waters, the ordinary water bacteria are able to overwhelm and suppress those foreign pathogenic forms which have been introduced. Krause's experiments are particularly instructive in this respect, for they exhibit the multiplication which takes place in the ordinary water bacteria, and the simultaneous disappearance which ensues of the pathogenic organisms introduced."

Q. State whether Trenkmann and Krause, referred to 7844 there, are recognized authorities upon the subject of bacteriology and hygiene in Germany?

MR. JEFFRIES: I move to strike out the answer of the witness, and all that he has read into the record for the reasons stated in my objection to the question, and my objection to his reading what he did into the record, for the reason first that it is not shown what it was that he read and for the second reason that it is not responsive to the question.

Q. JUDGE SPRINGER: Will you please state the page and title of that book?

A. The title of the book is "Micro-organisms in water," by Percy Frankland and Mrs. Percy Frankland, page 94, page 101, and page 331.

Q. What position have German scientists and bacteriologists taken on this subject so far as you know?

A. They have taken the same position that I have stated in my testimony.

Q. Are there any other German authors whose works you are familiar with, that you could cite upon that subject?

A. Yes sir, I could cite Rubner, Prausnitz, Flugge.

Q. Who is Mr. Rubner to whom you have referred?

A. Rubner is professor of hygiene at the University of Berlin.

7845 MR. JEFFRIES: I move to strike out the answer because Professor Rubner is not on the stand and we have no opportunity of cross-examining him.

Q. In what estimation is he held by scientists of the world?

A. He is considered as one of the foremost sanitarians of Europe.

Q. Can you cite any statements in his works upon this subject which show that you are not standing alone in reference to the longevity of pathogenic germs in river water?

A. Yes sir.

Q. Will you please do so and state what volume you are consulting?

MR. JEFFRIES: I object to the witness testifying as to whether or not he stands with others or alone on the question of longevity of disease producing germs, for the reason we have not the opportunity to cross-examine the persons who are the authors of the books that he now proposes to read from, and for the further reason it has been disclosed by this witness who is a witness for the defendants, that it is absolutely beyond the science of bacteriology to determine the exact duration of the time that they will live under all circumstances, and under such changing circumstances and conditions of water and flood and temperature, so that no laboratory test that may be made 7846 by any scientist upon the subject, could be compared, and could be taken as the true test to be applied to any running stream, when the lives of millions of people are at stake.

JUDGE SPRINGER: I will state in reference to this objection that these matters were not referred to in the examination in chief and are only called out at this time by reason of the course pursued in the cross-examination, in assuming that this witness was propounding a doctrine which was contrary to the accepted opinions of others on this subject, and that he has a right therefore to show that he is not standing alone.

MR. JEFFRIES: Standing alone on what proposition?

JUDGE SPRINGER: In reference to the questions to which he has been testifying.

MR. JEFFRIES: I said that it has never been questioned upon the part of the complainant that this witness stands alone as to the longevity of the typhoid or any other disease producing bacillus in running water. In other words that it has never been determined by this witness and has never been determined by any other scientist, and that it is so uncertain that scientists have been unable to agree as to the exact length of time that disease producing germs will live in running streams, taking into consideration the various changes which take place from source to mouth—temperature, flood seasons, freezing 7847 seasons, ice seasons, dry weather seasons and all other conditions that pertain to the various rivers throughout the world, so that it is a matter that is absolutely out of the reach of any bacteriologist to determine from a laboratory examintaion, the character of the water, and the disappearance of all pathogenic germs in any running stream, and that when such conditions are true as have been shown by this witness, who is a witness for the State of Illinois and the Sanitary District of Chicago, that any effort to limit the life and fix the life of a typhoid or other disease producing germ in a running stream to a certain definite number of days, is inadmissible, irrelevant and incompetent, when the life and health of the people of an entire state are involved.

Q. JUDGE SPRINGER: Now proceed, professor. I will ask you what language that book is printed in?

A. This is printed in German, and is a text-book on hygiene by Rubner, published in the year 1900. In the first place, as to my standing alone with regard to the question that direct infections by water did not occur—

MR. JEFFRIES: I object to the answer so far, because it is not responsive to the question. The question went as to the longevity of the germ.

7848 THE WITNESS: Well that comes too.

JUDGE SPRINGER: And on this subject I stated, spoken of in his testimony.

A. First with regard to my position that the indirect infection is the common way of infection of typhoid, and not the direct infection by drinking of the water itself. There are many other ways of carrying the infection from the diseased person to the well, than that by direct drinking of polluted water. Rubner states: "It is peculiar that even now days, after we know the biology of the typhoid bacillus so well, people cannot separate themselves from the theory that direct infections take place by drinking of polluted water, although it is well known that the typhoid bacillus can be carried and is carried in so many other ways, which would explain the epidemics that arise."

In the same connection he states that "in water, particularly in cold water, the longevity of the typhoid bacillus is longer than that of the cholera vibrio—that is the vibrio of Asiatic cholera—but the typhoid bacillus cannot multiply and dies in about six days.

MR. JEFFRIES: Now Professor, I want to get the page and the section of the book from which you read.

7849 A. This is page 931 and page 930 of the edition of the year 1900—the sixth edition of the book. 1900.

JUDGE SPRINGER: Read the title of the book?

A. The title of the book is "Text-Book of Hygiene, by Max Rubner, Professor of Hygiene at the University of Berlin, and director of the Hygienic Institute of Berlin."

On page 325 he states, that at the present state of our knowledge it has a certain value to determine, in an experimental way, the relations which pathogenic bacteria have to water. Experiments in which the artificial inoculation of cholera, typhoid, anthrax and pus germs into water was practiced, show that not one of these organisms persists; all of them die in a shorter or longer time. The rapidity of their destruction depends upon (a) the richness or the poverty in organic material

In slightly polluted waters, the quantity of organic material is too small to cause the growth of pathogenic germs.

(b) Upon the temperature. In ice, cholera vibrio died in a few days. The other bacteria named are more resistant. Anthrax spores live a long time.

(c) The third condition—the competition with other water bacteria. In sterilized water, which of course never occurs in nature, all pathogenic bacteria live better. Anthrax spores, cholera vibrio and typhoid bacilli die in non-steriled tap-
7850 water in a few days, at the temperature of 10.5 centigrade.

(d) The fourth condition. The influence of light destroys bacteria.

Furthermore, according to the practical conditions, or stimulating practical conditions, Kalinski infected wells with anthrax spores and typhoid bacilli, as well as with the excrements of typhoid fever patients, and could not find these germs after one week. According to these results, it is certain that the bacteria mentioned have no ability of multiplying in drinking water, but may remain alive a few days. The germs have lost a great deal of their danger because they cannot multiply."

Q. Professor, if there were not zones of purification in rivers, and if pathogenic germs were not short-lived, as you have testified, what would be the condition of the rivers in the world in inhabited regions?

A. I think I stated once before, that if there was no such purification of rivers, such natural purification of rivers of the polluted material that constantly enters these, the human race would long ago have died out by the overgrowth of pathogenic bacteria.

Q. Is the tetanus bacillus a water bacterium?

7851 A. No, it is a bacillus found in earth. It is most commonly found in nearly all earth, practically everywhere, where there is garden earth.

Q. May not tetanus spores reach St. Louis from Kansas City and other points along the Missouri river in the State of Missouri?

MR. JEFFRIES: I object to the question because it is irrelevant, immaterial and incompetent, and for the reason that the condition of the Missouri river is not in question, and for the further reason that proof of such condition of the Missouri river is no justification for the discharge of such germs into the Illinois river by the city of Chicago or by the drainage district thereof, and for the further reason, if it is a fact that the Missouri river is polluted at points above by the sewage discharges therein, they being situated upon the natural watershed of said river, that said statements and such position assumed by counsel for defendants should be concluded as an admission that said disease producing germs are deposited into the canal by the city of Chicago and pass from there down the Illinois river and the Mississippi to the State of Missouri, and that upon such confession, judgment should go for the complainant.

(Last question read.)

7852 A. Yes sir, they may. In fact tetanus spores will get into rivers in large numbers, after every rainfall that washes dirt into a river.

Q. What, professor, takes place in the human system when typhoid bacilli are taken into the system in drinking water?

A. If the number of typhoid bacilli is small, in my opinion, as I have already stated, no infection takes place. If the number of bacilli is large, and they are virulent, and the resistant forces of the organisms are reduced, then infection takes place. If any of the factors are lacking, no infection takes place. Even when large numbers of virulent bacilli are swallowed the resistant forces might be so great as to overcome the infection. In fact, if any of those factors would be lacking, no infection would take place.

Q. What are the resistant forces in the human system that prevent the fatal effects of drinking water containing typhoid or other pathogenic bacilli? 7853

A. We cannot definitely state what those influences are, although in a general way we may say the resistant forces of the organism may be reduced by exposure, starvation, destruction of red blood corpuscles, loss of blood, destruction of hemoglobin, lesions, where tissues have been more or less destroyed, and many other factors. The term resistant force does not allow of an exact determination although we mean by it the ability of the healthy body fluids and cells to resist destructive agents.

Q. Which are impossible of correct determination.

A. Yes.

Q. Professor, have you ever made any bacterial examinations of ice for the purpose of ascertaining the longevity of pathogenic bacilli which have been frozen in such ice?

MR. JEFFRIES: Objected to as not proper re-direct examination.

JUDGE SPRINGER: It is proper for the reason that ice was not referred to at all in the direct examination.

A. I have not.

Q. Have any such examinations, so far as you know, been made in this country or in Europe, if so, with what result?

7854 MR. JEFFRIES: I object to the question for the reason that the witness is undertaking to give the experiments of others, without having any personal knowledge on the subject and without ever having made any examinations of his own, and therefore he is incompetent to testify upon that subject, not knowing the manner in which the examinations are made, and more particularly not knowing the manner in which the particular examination upon which the witness is called to testify, were made, and for the further reason that the persons who made the examinations are not upon the witness stand and we have no opportunity to cross-examine them and whatever the witness might say on the subject would be merely hearsay and therefore not competent.

Q. (Question repeated.)

A. According to what I know of the literature on the subject of the experiments of others, the cholera vibrio died in a few days, and according to experimental work done by Winslow, under Professor Sedgwick's direction, typhoid bacilli also are destroyed within three weeks in ice. Although not entirely destroyed numerically, a great destruction of them takes place, and only very few remain after 3 weeks. The experiments of Hill of the Boston City Board of Health established the fact that typhoid bacilli died very rapidly in ice.

7855 Q. Assuming that ice should form in the Chicago drainage canal and the Desplaines and the Illinois rivers, should be frozen over as far down the streams as Peoria, and should continue frozen from six to eight weeks, and that the ice should then be broken up and float down the rivers, being obstructed as is usually the case, in its flow, by ice gorges and the dams in the river, and assuming that typhoid bacilli should have been frozen in the ice formed in the drainage canal and that they should be carried in that ice as far as the mouth of the Missouri river, and that the ice should melt before reaching the St. Louis intake at the chain of rocks; what is your opinion, based upon the experiments made by you to which you have testified in this case, and upon your general knowledge as a bacteriologist, would any of the typhoid bacilli thus borne from the drainage canal, reach the St. Louis intake alive, and would such bacilli be a menace or danger to the persons who might use the waters at that place for drinking or domestic purposes?

MR. JEFFRIES: I object to the question first, because the witness has not testified as to any actual experiments made by him with reference to the duration of the life of the typhoid bacillus in frozen ice. I object to the question for the further reason that it is unfair to the witness and to the complainant because it does not assume that the time consumed in carrying the ice from the Desplaines river and the Chicago drainage canal, to St. Louis, and I object to the question for the further reason that it assumes that the ice is frozen on the river, and remains so frozen for six to eigth weeks, for the reason that that ice is continually freezing from day to day, especially in cold weather time, and that as it freezes, bacteria being present they will be frozen in the ice, and for the further reason that there is no evidence that the ice would be retarded in its progress down the Illinois river after being broken up in the spring time, but on account of the floods and high water, it rushes directly from the place of breaking up to the Mississippi river. 7856

A. I will say in answer to that that there are two factors which would allow me to express the opinion that no living typhoid bacilli would enter the chain of rocks. The first one, the experiments stated with regard to the destruction of the typhoid bacillus at freezing temperatures, if the typhoid

bacillus should really be in the ice. The second one, the fact that if typhoid bacilli should really get into the drainage canal by way of the sewage from typhoid fever cases, that they might, by reason of their own motility seek the warmer strata of
7857 the water and not rise to the surface where the colder strata of water could be frozen.

Q. Then it is your opinion that they would not reach there alive under those conditions?

A. They would not reach there alive in either case. In the warmer strata saprophytic products would destroy them.

Q. Assuming the same facts to exist as those stated in the previous question, except that the bacteria contained in the ice were cholera, streptococcus and staphylococcus, would in your opinion such bacilli survive and be alive or a menace or danger to the people who might use the water at the St. Louis intake, for drinking or domestic purposes?

MR. JEFFRIES: I object to the question for the same reasons stated in the previous objection and for the further reason that the witness has not qualified as a sanitarian and has had no experience and no observations upon that subject and as to whether there would be a sufficient number as to what is a sufficient number of disease producing germs in water to constitute a menace to people using it and drinking it, this witness has not qualified himself as being able to give or express an opinion in reference thereto, having had no experience either in the science of epidemiology or in investigating the sanitary condition of water as applicable to the various large cities throughout the United States.

(Question repeated.)

7858 A. Cholera vibrio would die in a few days in ice. The others would probably disappear, if we can reason by analogy at least as rapidly as the typhoid bacillus, although I do not recollect from the literature, any experiments with ice as to the streptococcus, and staphylococcus. I can only reason by analogy here, but as regards a cholera vibrio, that is different; that has been determined. Cholera vibrio die in ice in a few days.

Q. Assuming the same facts to exist as these stated in the previous questions, except that the ice contained anthrax spores, in your opinion would such spores be dangerous to cattle that might drink the waters from the Mississippi river from the mouth of the Illinois river to the southern border of the State of Missouri?

A. Is this in reference to ice, or with reference to anthrax spores in general?

Q. With reference to the anthrax spores being in ice—the same conditions, except that the ice contained anthrax spores—would such spores be dangerous to the cattle that might drink the waters in the Mississippi river from the mouth of the Illinois river to the southern border?

MR. JEFFRIES: In other words, do I understand you to ask the witness whether or not the anthrax spores will
7859 live in ice, on their journey from Chicago to the Missouri shore of the Mississippi river.

JUDGE SPRINGER: No, I didn't ask him that. I asked him whether the anthrax spores thus borne would be a menace to cattle that might drink that water.

A. Borne by the ice, or borne without the ice, simply passing down?

Q. This would include of course the melting of the ice before they get there.

A. Well I can answer that in a general way. Anthrax spores remain alive under the most unfavorable conditions, therefore with anthrax spores we would simply have the question of dilution and separation in the water, and there would still be spores present. Now as to the infectious nature of anthrax spores we can only again take the actual experience of anthrax infections in general, and the fact that whenever an epidemic of anthrax amongst cattle or sheep has broken out, that it was confined to the immediate neighborhood of such source of infection, and that even where we know that the infectious material containing anthrax spores did get into the river, the cattle and sheep some distance down the river did not develop the disease, only those in the immediate vicinity of the original source of pollution being infected. Anthrax spores can
7860 live a long time in water, and we must, therefore, conclude that either the factor of great numbers of infecting bacteria is absent further down the river, due to great dilution, or

to the factor of lost virulence of the germ. Where intestinal anthrax amongst animals could be traced to direct pollution of rivers, the disease was only prevalent near the original source of pollution, and not further down the river. Man is not very susceptible to anthrax. We have had infections, but they have been very rare and could not be traced to the drinking of infected water.

Q. Has there been any case of anthrax infection to your knowledge recently?

A. I know of one river which was polluted with the discharges of a tannery where sole leather was produced, the hides having come from Brazil and China. In that particular
7861 instance the cattle which were grazing on the meadows
just below the tannery died of intestinal anthrax or anthrax bacteraemia, having great numbers of anthrax bacilli in the blood. They had swallowed food or water of the polluted river containing anthrax spores. Further down on this river, however, no death of cattle took place. It was all within the immediate vicinity of this tannery, through an area of probably at the most one mile. The river overflowed both banks in the spring and overflowed the banks further down the river just as much as in the immediate vicinity of the tannery, and yet the cattle further down the river appeared to be perfectly safe from infection. Now, we cannot for a moment think that there should not have been anthrax spores for long distances along this river. I refer to the Black river in Wisconsin—and yet no cases arose. I take it from this that the factor of sufficient number of germs was lacking, further down the river due to dilution and probably the factor of loss of virulence by the spores being in that water also might be considered although I know that the loss of virulence cannot be a factor in this case because I know the bacteriologist, who still has water of that river which still proves infectious today when injected into animals, therefore I think I am safe in my first proposition that the principal factor
was probably that of lack of numbers. In other words,
7862 here the same as everywhere, it seems that the polluted
river spreading the water over both banks, only produced infections in the immediate neighborhood of the tannery where the number of disease germs must have been exceptionally great.

Q. How long ago was it that that epidemic broke out among the cattle in Wisconsin?

A. That is probably seven years ago.

Q. Assuming then that anthrax spores might pass through the Chicago drainage canal and reach the Mississippi river, what in your opinion would be the probability or possibility of the infection of cattle with Texas fever if they should drink the waters of that river below the mouth of the Illinois river?

A. Well, according to what I know of the literature of anthrax infections and the case I have just mentioned, I would say that there would be no danger of a direct anthrax infection by the drinking of that water at St. Louis.

Q. In view of the rigid inspection and strict regulations established and carried into effect by the government of the United States to prevent the spread of Texas fever, what in your opinion is the probability of anthrax spores ever getting into the Chicago drainage canal?

A. That is quite improbable with the thorough system of inspection—

7863 MR. JEFFRIES: I object to the question on the ground that it is immaterial, incompetent and irrelevant, and for the further reason that it assumes that originally inspection was made, when as a matter of fact common experience has shown that practically no inspection is made in various instance, and for the further reason that it has not been shown in evidence that any inspection whatever is made, and for the further reason that there is no evidence that the inspection if one is made, will be continued or effected, and for the further reason that there is no evidence showing the character of the inspection and no evidence showing that the inspection is sufficient to absolutely prevent the entrance or the carrying of anthrax or any other disease producing germ into the stock pens and slaughter houses, and for the further reason that this witness has not shown sufficient knowledge of the manner of inspection, if one is made, to be able to express an opinion in that respect.

Q. JUDGE SPRINGER: Answer the question.

A. From what I know with regard to this question, I think the inspection is a very thorough one by the government meat inspectors in the stook yards.

MR. JEFFRIES: I object to what the witness thinks.

THE WITNESS: Well, it is my opinion that it is a very—

7864 MR. JEFFRIES: I object to his expressing an opinion on that subject when it can be made a matter of proof.

Q. JUDGE SPRINGER: Have you had any opportnuities of examining personally the inspections that are made, there, or knowing personally what kind of inspections were made?

A. I know personally and in a general way the methods employed by the government meat inspectors at the stock yards in Chicago. I have learned those during a course which I have given some of those men in histopathology and bacteriology, and in that way I have learned the ways and means of preventing diseased meat getting into the market, or even diseased cattle getting into the slaughter houses, also the manner of disposal—

MR. JEFFRIES: I move to strike the answer out because it has no relevancy and carries no weight; it is incompetent and irrelevant, and all that the witness has said upon the subject has been gathered from hearsay and is hearsay testimony; that he knows nothing of his own knowledge and his own experience, and I move to strike out the answer and the question for the reason that he has eliminated the greatest source of anthrax infection, to-wit, the importation of hides and wool into the city of Chicago.

7865 Q. JUDGE SPRINGER: Assuming, professor, that tetanus spores should be deposited or get into the drainage canal, and should be carried by ice or otherwise, down the canal and into the Desplaines and Illinois rivers, and down to the Mississippi, river, would, in your opinion such spores be a menace or danger to the people who might use the water coming into the St. Louis intake at the chain of rocks, for drinking or domestic purposes?

MR. JEFFRIES: I object to the question for the reason that the witness is not a sanitarian and has had no experience upon the quantity of disease producing germs necessarily present in order to render themselves a menace and a detriment and a harm to the people drinking and using the water of a river for domestic purposes, and while the witness might from his bacteriological experience, be able to say whether or not a certain germ produces disease, and as to how long from his experience, certain disease germs might live under the laboratory experiments, the witness is not sufficiently experienced in sanitary matters to be able to judge from the experience of the civilized world and of the large cities, the amount of infected germs necessary to be present to render conditions harmful and deleterious and injurious to the health and life and property and business interests of a city and state.

7866 A. In answer to that question I will say that tetanus spores may remain alive in the sewers and drainage canal and river, but that the amount of tetanus spores entering the drainage canal and arriving at the intake channel at the chain of rocks in St. Louis, would be insignificant as compared with the amount of tetanus spores that would enter the river from all other sources along the river, the Illinois as well as the Mississippi and Missouri; further that the number of tetanus spores from Chicago sewage that would really be capable of entering the inlet at St. Louis, and would be absolutely insignificant as compared with the number already present in the streets of the City of St. Louis, as well as in any other city, or as well as in any other town all along the river.

7867 Q. What disease does the tetanus bacillus produce and how is that disease communicated?

A. Lockjaw and tetanus. The disease is communicated by the germs entering the tissues.

MR. JEFFRIES: I object to the question for the reason that it is not proper re-direct examination, the witness having testified that he discovered a tetanus germ or a spore in the waters of the Ilinois river in his direct-examination and all questions in reference thereto should have been asked of this witness at the time of his direct-examination.

JUDGE SPRINGER: This question is proper in my judgment for the reason that a great many questions were asked this witness on cross-examination, whereas, it is only incidentally referred to in the examination in chief.

A. With regard to the manner of the infection, briefly stated, it is necessary that the germ enter the tissues subcutaneously and at some depth, and that the wound be closed hermetically. Otherwise the germs cannot grow. The germ only

grows in the absence of oxygen. Therefore the germ must enter the tissues, usually by way of a deep wound, and that wound must close before the germ can grow. As soon as the germs grow they produce a toxin which when absorbed into the body, produces first conclusive movements of the muscles of the lower jaw, then of the upper extremities, then of the lower ex-
7868 tremities and finally death.

Q. Have you ever heard of a case of lockjaw being communicated by drinking water that contained tetanus germs?

A. I have never heard of any case of lockjaw being communicated by drinking any water.

Q. What in your opinion is the relative longevity of the typhoid bacillus, the cholera vibrio, the staphylococcus and the streptococcus in river water under similar conditions, and of the anthrax and tetanus bacilli not in spore form?

MR. JEFFRIES: I object to the question for the reason that the witness has stated that the science of bacteriology has been unable to prove the exact length of time that any of these disease producing organisms will live in a running stream, and I object to the question further for the reason that if it has not been determined by any science, that it is not aplicable to the Illinois river, the Desplaines river, the Mississippi river and the Chicago drainage canal, because inasmuch as experiments have been with reference to the water of that river. I object to the question for the further reason that the longevity of the disease producing organisms depends upon different conditions in various streams, and that it depends upon the different conditions throughout the year of the water in any particular stream. It depends upon the conditions of the water at flood times,
7869 the conditions of the water at low stages; it depends upon the temperature of the water with reference to the winter seasons and summer seasons; it depends upon the water that is discharged into the stream, whether discharged from the natural tributaries, or whether discharged by some artificial means, so that there is no known source of experiments, and there is nothing within the science of bacteriology that will enable any bacteriologist to state with any degree of accuracy, the length of time that the disease producing organisms referred to in the

question will live in the waters of the Drainage Canal, the Desplaines river, the Illinois river and the Mississippi river.

(Question repeated).

MR. JEFFRIES: I object to the question for the further reason that the water throughout all the stretches of the river from the very nature of things and from nature itself cannot at all times be similar and therefore it cannot be determined exactly how long the disease producing germs of the character mentioned in the question will not live, and how long they may not live and be alive, active and virulent.

A. Judge Springer, you simply want me to state how do the tetanus bacillus and the anthrax bacillus in the non-
7870 spore bearing form, compare in their longevity with the other bacteria, is that your question?

Q. Yes, under similar conditions in water?

A. If those bacteria are present in their non-spore bearing form, all I have stated with regard to the behavior of pathogenic bacteria in water, applies here, that is all I have stated with regard to pathogenic bacteria in general, leaving out the spores. As soon as those organisms form spores, then of course the spores are not subject to that general rule to which I have testified in the earlier examination.

Q. The question refers to what is the relative longevity of these respective organisms as compared to the typhoid bacillus?

MR. JEFFRIES: I make the same objection to this question that is made to the preceding question. I object to it for the reason that no examination has been made and no bacteriologist has as yet furnished any means of examining and ascertaining the behavior of pathogenic germs in a running stream, but that all of such examinations have been with reference to their behavior in the laboratory experiments.

Q. I find my question is incomplete, I will repeat it.
Would the typhoid bacillus live longer or die sooner than
7871 the other organisms mentioned in this question, if they
were placed in the waters of the drainage canal or the
Illinois river under similar conditions?

MR. JEFFRIES: I still object to the question for the same reasons stated above.

A. Tetanus bacilli as well as anthrax bacilli will die at least as soon if not sooner than the typhoid bacilli, in their non-spore bearing form under similar conditions.

Q. What as to the cholera vibrio?

A. The cholera vibrio dies sooner the lower the temperature.

Q. What as to the staphylococcus and streptococcus?

A. They die sooner than typhoid bacilli.

Q. State what organisms are spore bearing or spore producing?

A. Of the pathogenic germs?

Q. Yes?

A. The anthrax bacillus, the tetanus bacillus, malignant oedema, the bacillus aerogenes capsulatus. Of the important disease producing bacteria, these are the ones.

Q. Now, professor, assuming there is a remote possibility that a tetanus spore might be carried from Chicago through the drainage canal and down the Desplaines, and Illinois rivers and
a possibility that such a spore might enter the St. Louis
7872 intake and the hydrants of the St. Louis waterworks, and
the possibility that a St. Louis urchin might moisten his finger with water and then shoot a wad into his finger, thus moistened as aforesaid, as stated by Mr. Jeffries in one of his hypothetical questions, and that such moisture may contain a Chicago tetanus spore, as assumed in one of the other questions by Mr. Jeffries, and that such tetanus spore thus sub-cutaneously injected into the finger of said urchin may have entered the anatomy of said urchin at a time when his system was susceptible to tetanus infection, and the possibility that said St. Louis urchin might then and there contract the disease of lock jaw;—are such remote possibilities as I have mentioned, in your opinion as a bacteriologist, of such a grave and serious character as to constitute a menace or danger to the inhabitants of St. Louis or of the State of Missouri?

MR. JEFFRIES: I object to the question for the reason, first that the opportunities and abilities for the infection are not remote, are not impossible and are not improbable under the assumptions contained in the question, and that the question as to the remoteness, improbability or impossibility, is one for

the Court to consider, and not for this witness. I also object to the question for the reason that it is not for the witness to say that the infection of tetanus caused by the one germ
7873 being injected into the foot of the street urchin, in St. Louis, is not a menace to that city. Upon the other hand I insist that under the assumptions contained in the question, that if such occurred it would be a menace and would be liable to lead to other cases of tetanus, and that if such be true, and that if such conditions should exist under the assumptions of the question, judgment for complainant should go. I object to the question for the further reason that the witness is not a sanitarian and it is not for him to say, not having qualified upon that subject, whether one tetanus germ, two tetanus germs, a hundred or a thousand are necessary to be found in the water supply of the city of St. Louis in order to render it in such a condition that it would be a menace to the people of that city.

JUDGE SPRINGER: I desire to suggest to counsel that the question is not put to him to be answered, and suggest that that part of his objection which answers the question is not proper. The witness is asked to state whether it would be a menace and not the counsel on the other side.

MR. JEFFRIES: I am addressing myself to the Court and not to the witness.

JUDGE SPRINGER: You are answering as a witness that it would not be a menace, which question is not put to you.

7874 MR. JEFFRIES: I insist, Judge Springer, that my objection is addressed to the Court; not to counsel and not to the witness.

THE WITNESS: I will have to answer that question with No. Tetanus infection takes place when street dirt or garden earth, containing numerous virulent germs, enters the deeper tissues and not by water as stated.

RE-CROSS-EXAMINATION by Mr. Jeffries.

Q. Professor, speaking now of the frozen condition of the water in the Illinois river, under the assumptions contained in the questions propounded to you by judge Springer in the re-direct examination, you made a statement, I believe that bacteria would not freeze in the ice as long as they possibly could avoid it themselves, in other words that they would swim away from the place where the ice was forming, into the warmer water. Now then I want to know, having the ability to swim away from the ice or the point where the ice is being formed, is it not reasonable to believe also that they will swim away from the light as far as they can, that they will swim away from the saprophytic bacteria and from all other material and from all other conditions that will not be conducive to their welfare and their longevity; isn't that true? Just answer that question. 7875

A. That is no doubt true.

Q. Then, professor, will they not also when swimming away from the formation of the ice, swim into the water and be carried down underneath the ice with the rapidly flowing current under the ice, isn't that true?

A. They will not move large distances, their motility is not as great as that.

Q. As they swim away from the point where the water is frozen they are carried by the current itself without any action on their part, down the river, aren't they?

A. According to the current that happens to exist.

Q. Then professor, if that ice is formed over the whole bed of the river and remains there from six to eight weeks, and if the conditions of the water are such as will permit the typhoid bacilli to live from ten to twenty days or thirty days in that cold water underneath the ice and it only requires either ten or twelve days for the water to go from Chicago to St. Louis, is it not altogether reasonable to believe that these germs will find their way during their life time down the entire course of the Illinois river?

7876 JUDGE SPRINGER: I object to this question for the reason that it assumes that typhoid germs will live in that water, in the Illinois river and drainage canal for ten or twelve days.

A. If the bacilli would live at these lower temperatures without dying, and would be alive in St. Louis, of course.

Q. That is, if they would live that long?

A. That is your assumption.

Q. And whether they would travel that distance in that time, they would pass down.

A. That is your assumption, although the conditions are not such.

Q. Conceding that the assumptions are true; in other words that they will live that long and in other words assuming that the water would pass down in that period, they would arrive there?

A. If the lower temperature and saprophytic products had not entirely exterminated them they would arrive there.

Q. In answer to a question propounded to you by Judge Springer, in which it was assumed that ice was formed in the drainage canal, the Desplaines and the Illinois river, and that it remained frozen from six to eight weeks, and that in the spring of the year, when the ice broke up it was carried out, whether or not they would arrive in the Mississippi river
7877 and the chain of rocks alive, and in your answer you stated
that you did not believe they would be alive on their arrival in the Mississippi river, and I want to ask you if it is not a fact that experiments on typhoid fever in ice, have shown that some typhoid germs may live for three months in ice?

A. It is my opinion, and, in fact, some of my testimony has been to the effect, that typhoid bacilli could live in the absence of other bacteria in water and also in ice for a long time, but I see that some experimenters have come to different conclusions with regard to that. Some have come to the conclusion that a very low temperature, such as the temperature of ice, destroys the typhoid bacilli very quickly, so I have answered Judge Springer's question with that in view, that they can live six to eight weeks, knowing that some experimenters have found it so. The cholera vibrio died in two days in ice.

Q. We are speaking of typhoid?

A. Yes, but I am now taking everything into consideration by analogy. The resistance of the one germ is not so much greater than that of the other, but everything considered, it is not unlikely that some of the germs would not live longer than thirty days or six or eight weeks, in the ice.

Q. Would you consider it unlikely that they would live that long, that some of them would?

7878 A. According to some experimenters they have lived longer in ice.

Q. Then professor, is it not a question which cannot be determined, as to the exact length of time which they will live and as to the exact time in which they are all eliminated from life in the ice?

A. It has not been definitely determined, if we take all the evidence from all sides. Some find they die in a short time, others say they only die in great numbers, but some of them remain alive for a longer time. It has not been definitely determined.

Q. So that yet it has not been determined?

A. No sir. That is, there is a difference of opinion.

Q. Then taking those conditions to be true, that they do live in ice and that the time in which they live in ice has not as yet been determined, may not large quantities of them remain longer than thirty days, while it is true that large quantities may also die in that time?

A. No, that is not true. Large quantities will not remain. The majority of them will die, even according to the experimenters that say that some remain alive.

Q. But the percentage that will remain alive, cannot be determined?

7879 A. It is an insignificant one.

Q. In your judgment?

A. According to their findings.

Q. Professor, in reference to this epidemic of anthrax, or infection by anthrax, in Wisconsin I believe it was?

A. Yes sir.

Q. Do you know whether or not there were any precautions taken by the people living below the place of infection to avoid that disease or to keep that disease out of the cattle?

A. There were no precautions taken of any kind.

Q. That you know of?

A. I know that there were none taken; I know all the details of that.

Q. Professor, you know, do you not, that competent observers have found the spore of anthrax live in water for seven years?

A. For years. The spore of anthrax can no doubt live for years.

Q. Profesor, you testified I believe that unless the germs or spores of anthrax were very numerous, there could, as in the case of typhoid be no direct infection from water?

JUDGE SPRINGER: You mean by drinking spores?

MR. JEFFRIES: Yes.

7880 A. Well, in that respect I will say that I realize fully that it takes a very minute quantity of anthrax material to produce an infection, but I have taken into consideration the history of epidemics where we know there must have been large quantities of the infectious material polluting a river and where we know that the material was spread over meadows and eaten by cattle and sheep which promptly died. In such cases we hear of no anthrax infections a few miles down the river. Knowing that the spores can live for years and also knowing that such spores certainly must be in the water and upon the overflowed shores of this river for longer distances, although only the animals near the original source of pollution die of anthrax infection, I conclude that the factor here, that was lacking, was the necessary number to infect.

Q. May it not professor, depend upon the fact that no animal whose system was in a proper condition, swallowed one of those spores?

A. Then they shouldn't have all died nearer the source of infection there, whereas no deaths occurred further down the river.

Q. May it not have been professor, that the source of infection, that one animal, the system of which was in a proper condition to produce a colony or large quantities of the germs, until the disease overtook the system and the animal finally died, and that animal in turn infected the whole herd, and the whole neighborhood?

7881 A. Well that is another way of infection.

Q. May not that also be done?

A. That may also be done.

Q. Now then, professor, may not the absence of the infection farther down have been brought about by reason of the fact that no animal, either a sheep or a cow, drank or carried into its system, an anthrax spore, with the system of the animal in proper condition to produce and develop the disease?

A. That is possible, but the history of the case that was stated here, is that all animals eating of the same food, from the same overflowed meadow, died of anthrax. It was not one animal that died, but all the animals on pastures bordering the river at its source of pollution died. It was evident that an infection had taken place by a sufficient number of virulent bacteria.

Q. Granting that to be true, professor, and that it may happen in certain cases, may it not also be true that the one animal in the first instance may have carried into its system one spore from the meadow, or from its food, and that its system was in such a condition as to grow anthrax and produce large quantities of it, and that the discharges from that animal went over the field and meadow and place where the other cattle
7882 were feeding, so that the whole herd became infected,
and from that herd other herds and so on?

A. That is another manner of infection and a very common one, and finally the animal is transferred to some other locality and an epidemic of anthrax starts there.

Q. Now I would like to have you describe professor, as accurately as you can, this epidemic of anthrax that took place up in Wisconsin that you referred to in your re-direct examination?

A. This epidemic originated near a tannery in Medford, Wisconsin. Some of the hides used came from Brazil and from China, by the experiments, I believe of Professor Russel, these hides were found to contain anthrax spores. A number of animals just below the tannery had suddenly died and practically all at the same time on the meadows immediately below this tannery. The Black River received the sewage of the tannery and had shortly before overflowed the meadows on both shores of this river. In fact the whole epidemic came suddenly amongst the cattle on the banks of the river, and there was much apprehension among the farmers farther down the river because it had also flooded its banks there. I have a farm a few miles below this tannery on this river and my neighbors were of course also very much alarmed. Their cattle were usually on

my land, which is simply wild woods, the river crossing it,
7883 on both banks of the river there are openings, where
the cattle of the whole neighborhood is grazing, because this wooded land is not fenced in, consisting of virgin forests, whereas all the surrounding land is cleared up. All the herds of the neighbors around there have been grazing on the banks of the river on my lands which are frequently overflood. This is only a few miles below the tannery but none of these animals died whereas horses, cattle and sheep died just below that tannery. Horses of farmers living within a distance of half a mile or a mile died. Lawsuits followed by many of the people living below the tannery. This matter was investigated by Professor Russell of Madison, Wisconsin, as the State Bacteriologist. He found anthrax spores in the water of this Black river below the tannery and he has yet water specimens in his laboratory which when injected into animals produce anthrax showing that there are still virulent spores present. This is now a number of years ago. During all these years there has been no death of any animal, I think I may safely say, one mile below this tannery or farther down the river. This is such a striking case
7884 where water can be shown to contain virulent spores and
retain them for many years, and yet farther down the river not an animal dies, in spite of the fact that there must have ben a tremendous pollution with anthrax material, of that river.

JUDGE SPRINGER: How far is Medford from the mouth of the Black river?

A. Why this tannery is in Medford just south of the city, and the City of Medford is on the banks of Black river. The tannery is located directly on the banks of the river and emptied its refuse into the Black River at the time of this epidemic.

Q. How far is it from the town of Medford to the mouth of the river where it empties into the Mississippi?

A. I don't know.

Q. It empties into the Mississippi, doesn't it?

A. It empties into the Mississippi at La Crosse, I believe. The name of the stream is Black river. It passes through Medford. My land is about five miles from the city.

Q. MR. JEFFRIES. Professor, even though it did not continue to spread, may it not have been the peculair character of the spore which was weakened on account of its long travel or journey, or its surrounding conditions, or its origin, so as not to be as effective, and strong and healthy and virulent, as other spores in other epidemics, or as it might be at another time? 7885

A. Yes, that would be another factor. Aside from the factor of the number, we have the factor of virulence to consider.

Q. And on the journey from China?

A. And on the journey, but this loss of virulence doesn't seem to have taken place in Professor Russell's samples of water which are still virulent today.

Q. But that water was taken at the time the epidemic was going on?

A. Yes, that was taken at a time when a number of the cattle died.

Q. And in testing the virulence of the spores in samples of water today they probably used more susceptibile animals?

A. Yes they used guinea pigs which are very susceptible. I don't know whether Professor Russell has tried this on any sheep or cattle, but when we speak of virulence, we usually mean virulent to laboratory animals, guinea pig, rabbit, and mouse.

Q. So then it may have been of such a character as to have lost its virulence as applied to sheep and cattle?

A. It may.

7886 Q. Professor, do you know whether or not the spore of anthrax will multiply under favorable conditions in the food?

A. Yes sir.

Q. And in the fodder and corn and grain and shipping stuff or whatever may be used?

A. The anthrax spore will under favorable conditions of temperature, and of food multiply.

Q. At what temperature?

A. The most favorable temperature is that of the human body, at which it grows best.

Q. Will the typhoid germ multiply at a lesser temperature?

A. They can multiply at a lower temperature.

Q. Then professor, may not these spores find their way from the fields into the hay-mow, or the corn-bin or the oat bin, and in the preparation of the food, in the mixture of the food find their way into the food and in the summer time in the pasture and in the field, and in the feed troughs, conditions be brought about like this in reference to the increase in the typhoid germs, isn't that true?

A. Yes, I think anthrax spores may find conditions favorable for again multiplying.

7887 Q So that under favorable conditions professor, an infection will take place in an indirect manner?

A. Although we know of no such infection.

Q. May not, professor, the first animal at Medford, have been infected in that very way? In other words, isn't it altogether a question that has not as yet been fully determined?

A. Yes. I should perhaps in this case state the fact that the first case of anthrax that died in Medford was a human being; it was one of the scrapers in the tannery. The scraper is a person who scrapes the hair from the hide after it has gone through a process of fermentation in the sweat house, where a strong odor of ammonia is produced, and the hairs become loosened. The hides then go upon a wood block and the scraper allows a stream of water to run over this hide, while he scrapes off the hairs. If he has wounds, or if he wipes his fingers over his lips he becomes infected or developes intestinal anthrax. I know of at least one case, although there have been a number of mysterious deaths, but in one case that I have examined, I feel certain that it was the cause of the death although doubted at the time because no autopsy was held. The patient had 7888 gone to his work in the morning as usual, came home at two o'clock and died without other symptoms except some fever, slight headache and general malaise. It was the first case of anthrax in Medford. The deaths of the cattle followed later, investigated and diagnosed by the State authorities as anthrax.

JUDGE SPRINGER: How long after this man was supposed to have been infected, was it that he died?

A. The man was not sick long because he went to his work in the morning and went home at two o'clock and died. It is one of those mysterious deaths that happen so frequently in tanneries in the United States, which no doubt are cases of anthrax Bacteremia. In this case there is no doubt at all that the primary infection was simply carried by the hides from the sweat house, where they multiplied to the river. The river was polluted with anthrax spores and overflowed the banks, causing infections of cattle near the tannery but none further down the river.

Q. And that cannot be accounted for, first because of no direct infection, and second, because of the loss of 7889 strength and virulence?

A. Well, as to the loss of virulence, they are still virulent today, those spores in the water.

Q. But as to the loss of virulence in the germs, after it had been deposited in the soil and on the earth, and also those that are preserved today, they may have a loss of virulence because while they may be able to produce infection in guinea pigs, yet they might not in animals such as a cow or a sheep or a horse?

A. That might be, although when we see a guinea pig die in 24 hours after inoculation of a minute quantity of material, we take it for granted that it is virulent, and will be virulent to man, or virulent to animals, the other factors being right.

Q. There is none of your land under cultivation?

A. No sir, it is just wild woods.

Q. I want to ask you this question. In the case of anthrax it matters not where it may be, if the water infected with the spores should find its way upon the meadows, corn fields, wheat fields and cultivated land and be deposited there upon the receding of the water, that they might not in turn find their way into the haymow, into the corn bin, oat bin, feed bin, and be mingled with the food preparation, and that in the summer time, with that preparation, get into such a condition, either on 7890 account of the water from the horses, mouths, or the water that is poured into the feed of this preparation, that it would produce conditions that would be conducive to the growth and multiplication of the anthrax and that in turn might not produce the disease of anthrax in the animal eating it or swallowing it any time within the life of the germ, from one to seven years or whatever time they may live?

A. As to anthrax spores I can say that it is probable that they die under the usual conditions of exposure in water as well as on the ground, after being exposed to the sun and the air for a long time, but the possibility exists of them living for a long time and when they find a favorable culture medium and temperature they can, of course, increase, and they may then, or may not be virulent after they have increased.

Q. Assuming there was annually a daily receipt of 30,000 head of sheep in the stock yards and slaughtering houses of the city of Chicago and assuming that there is an annual daily receipt of 20,000 head of cattle and that these cattle and sheep are slaughtered and prepared for consumption, in the slaughtering houses of the city of Chicago and assuming that said cattle and sheep are shipped to Chicago from various surrounding towns, do you not consider it probable and possible that
7891 the germs of anthrax may be carried into the stock yards and slaughtering houses in the hair and wool of the cattle and sheep and discharged into the drainage canal and thence into the Illinois river?

A. Such a condition is possible, but it exists all along the Illinois river.

Q. Now professor, assuming that there are a large number of tanneries and brush factories in the city of Chicago, state whether or not those establishments may not be a source of pollution by anthrax?

A. If the brushes that are made come from infected animals, the bristles are liable to contain the spores of anthrax.

Q. How about the tanneries?

A. In the tanneries, the hides of infected animals that have been killed and have escaped detection in government inspection, I think the government has recently taken steps to prevent the entrance of suspected hides—

Q. That is in reference to the imported hides?

A. Yes sir.

Q. But that doesn't apply to the domestic hides?

A. No, the domestic hides are not supposed to have anthrax.

Q. But they may have?

A. Yes, they may have.

7892 Q. And often times do?

A. And often times do. I believe there is a little town here in the state of Illinois that has had an anthrax epidemic and may be sending their water into the Mississippi. It is Palatine, Illinois. There is government inspection at the various slaughtering establishments in the city.

Q. Anthrax may be carried in the wool of sheep might it not?

A. Yes sir.

Q. Professor, is Professor Rubner, to whom you have referred in your re-direct examination and in your testimony in this case a bacteriologist?

A. Every institute of hygiene in Germany has as its most important branch a bacteriological laboratory and a chemical laboratory.

Q. But do you know that he is a practical actual bacteriologist, or in other words, isn't he just simply a professor of hygiene?

A. The modern sanitarian assumes to be a perfect bacteriologist and I think he ought to be and he certainly is entitled to be considered so, and, therefore, I think Rubner is entitled to the same credit.

Q. But you cannot say that you know that he is an actual practicing bacteriologist?

7893 A. I think it is safe to say that the opinion of Rubner on bacteriological questions, is as valuable as those of any bacteriologist, in matters of sanitary importance.

Q. Do you know whether or not he is a bacteriologist?

A. He must be or he could not be professor of hygiene and director of the hygienic institute in Berlin.

Q. But professor, aside from what in your judgment is required of a man to occupy that position, and without knowing, do you know whether or not he is an actual practicing experimental bacteriologist?

A. He, no doubt, does not do much of the bacteriological work himself any more.

Q. Do you know of your knowledge that he ever did any of it?

A. I think I am safe in saying that he could not occupy the position he does, if he was not thoroughly proficient in bacteriology.

Q. Now is it not a fact, professor, that you do not know whether he is or ever has been an actual practicing, experimental bacteriologist?

A. No, the opposite even is true. I know that the Hygiene Institute in Berlin has a bacteriological as well as a chemical laboratory, in which most thorough work has been done 7894 and is being done.

Q. I am not talking about what is being done there, but about what Professor Rubner has been doing. Now then, isn't it a fact that he is not an actual, experienced bacteriologist, and if he is not a bacteriologist, isn't an authority on the longevity of bacteria.

A. I think by his studies in the bacteriological laboratory he would be entitled to be considered an authority with regard to the life of those bacteria, on which he has expressed an opinion.

Q. Now professor, is not tetanus the disease to which both man and animals are subject?

A. Yes sir.

Q. Now assuming that the germs of anthrax are deposited into the Illinois river by means of the Chicago drainage canal and that they flow down the Illinois river into the Mississippi and that being discharged into the Mississippi river in high flood times, they are carried by the waters of that river into the low-lands along said river, into the various river counties of the State of Missouri below the mouth of the Illinois river, and are deposited there upon the earth, weeds, grass and growing substances, and assume that after the water has receded, leaving the anthrax germs on the soil and vegetation, that 7895 by some means these anthrax spores are carried into the food preparation, which is brought to a temperature favorable for the multiplication of the anthrax spore, and the cattle and horses and sheep of said counties should feed upon such food when reduced to such a temperature as would produce a multiplication of the spores, there being present, would they not and might they not be infected with the disease of anthrax.

Assuming those conditions to be true, I want you to answer the question.

A. The remote possibility exists, although all the history with regard to epidemics of anthrax, and their spread, would be opposed to the spread of anthrax in that way.

Q. Professor, assuming that you visited the stock yards of Chicago or the slaughtering pens of Chicago or the tanneries or the brush factories of Chicago and collected a quantity of anthrax spores. In the course of a month, two months, three months, four months or a year, you scattered those spores on the surface of the soil in one of the counties of Missouri, in the southeastern part of the State that overflows from the water of the Mississippi river. Those spores are gathered on the grass and carried into the barns and enter into the preparation of the food that is fed to the cattle, the sheep and horses, upon the farms of southeast Missouri, and in the preparation 7896 of the food a temperature is produced that will favor the multiplication of the germs of anthrax from that spore. State whether or not under those assumptions, the disease of anthrax might not be produced in those animals so eating the food prepared in that way, and under the conditions assumed in the question, even though there should be but one spore of a number of spores so carried by you, that would find its way into the food preparation at a favorable temperature?

A. I think I have already stated before that it is my opinion that we would never hear of those spores again.

Q. Professor, we are talking about the spores that you collected at Chicago and took down there and distributed on the grass and meadows, and that one of them finds its way into the food under the conditions assumed in the question, whether under the assumptions that would produce anthrax?

A. That is what I mean. We would never hear of those spores again; they would never produce anything, even if they had been spread in large numbers. I reason again by analogy, according to the history of epidemics of anthrax where we know that large quantities have been spread over large districts, and you never hear of them again.

Q. That it has lost its virulence because of that?

A. It must have lost its virulence, or the number of

7897 spores is not sufficient. The individual germ will not produce infection.

Q. Now if that be true, why is it that those hides could be shipped from Japan to the little city of Medford and still produce disease?

A. Because they were there in immense numbers and multiplied in the sweat houses. An animal that has died of anthrax, has every blood vessel of the body filled with anthrax bacilli, as we have in no other bacterial infection.

Q. Do you mean to say then that you could not in your laboratory or under the proper conditions in the food of the animal take a spore of anthrax and cultivate a sufficient quantity to infect a whole herd of animals, do you assume that position?

JUDGE SPRINGER: I object to that; he hasn't assumed that.

MR. JEFFRIES: There is one thing true, and that is that anthrax is either contracted directly or it is contracted by indirect infection and unless it can be contracted in one of the two ways, then there is absolutely nothing to the proposition that anthrax is a disease producing germ.

A. There is a great difference between numbers of bac-
7898 teria in a hide which comes from an animal infected with anthrax, teeming with millions and millions of spores, and the distributed product in nature, on earth and in water, where great dilution and competition with other bacteria occurs.

Q. Professor, may not the epidemic of anthrax at Medford, to which you have testified, been caused by one spore falling from the hide, or one hide that was shipped from Brazil or Valparaiso, or elsewhere to Medford, by it having been injected into the proper media?

A. The possibility exists, but it is not probable.

Q. With the proper culture media?

A. I say the possibility exists, but it is not probable.

Q. Then professor, what is there in the theory of indirect infection?

A. I say the possibility exists but it is not as probable as is the case with the typhoid bacillus.

Q. Professor, if the theory of bacteriologists and sanitarians is true, that the disease is produced in an indirect manner

and the infection brought about in an indirect manner, is it not intirely probable and reasonable to believe that one of the spores that is carried from the tanneries of Chicago to the proper food media in one of the southeastern counties of Missouri might not produce a culture of anthrax germ and
7899 produce disease?

A. I say it is possible.

Q. Is it not reasonable to believe that if it was transplanted, assuming that it is, assuming that you have transplanted it yourself to the food and that the food will be a proper media, and at a proper temperature to bring about a multiplication of the germs, that it will produce disease, isn't that true?

A. It is possible.

Q. Isn't it probable and isn't it reasonable to believe it?

A. No.

Q. Now professor, we are taking an experiment of your own, a laboratory experiment for instance. You go to the tanneries of Chicago. You find a hide that you know is infected with anthrax. You get a spore that is alive and virulent; you carry that to Southeast Missouri to a food preparation, and you reduce that food preparation to the proper temperature that would bring about a multiplication of the germs. Now if that spore was alive and active and it produced a large number of spores upon that media, wouldn't that produce an infection of the disease?

JUDGE SPRINGER: I object to this question and to the preceding one of a similar nature, because it assumes a fact that can never take place, namely; that this witness would deliberately carry an anthrax spore from Chicago to Southeast
7900 Missouri and plant it there, where it would become a matter of infection to cattle and horses, or that any such condition is likely to arise on account of the well known good character of this witness.

MR. JEFFRIES: Well, that may be true, as far as the physical conduct of the witness himself is concerned, yet we ask the question in the form presented, because it is as near a practical, actual laboratory experiment, and is as close to nature and so closely associated and related to nature, that it is competent as such, and for the further reason that the question as stated comes nearer to what takes place in nature than to what takes place in the laboratory.

A. It is possible under the usual conditions of infection, but not as probable as in the case of the typhoid bacillus.

Q. You say it is possible. I want to know if as a bacteriologist, you do not consider it reasonable on the theory of indirect infection?

A. It is even reasonable under the conditions which usually govern direct infection, that is, first, that the germ is present; second, that it be virulent; third, it is necessary that it finds the proper temperature for its rapid multiplication, and fourth, that the animal infected shall have the necessary reduced resistant forces, and fifth, it is necessary that the animal receive a sufficient number of these germs to produce infection.

7901 F. ROBERT ZEIT.

ADJOURNED until 10:00 A. M. Friday, October 9, 1903.

7902 10:00 A. M., Friday, October 9th, 1903. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

ADOLPH GEHRMANN,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Springer, and testified as follows:

Q. Will you please state your name, residence and occupation?

A. My name is Adolph Gehrmann, residence Chicago, occupation physician.

Q. You might give your address.

A. 3816 Ellis Avenue is my residence address.

Q. And occupation physician?

A. Physician and bacteriologist.

Q. State what positions you have occupied in reference to scientific matters?

A. Do I understand, public positions now?

Q. Yes sir.

A. From the year 1893 I was connected with the Chicago

7903 Department of Health in the capacity of bacteriologist and microscopist for the milk department, during 1893, and from January, 1894 until June, 1902, as the director of the laboratory and bacteriologist of the department.

Q. From what time?

A. From January, 1894 until June, 1902.

Q. Where were you educated, doctor?

A. I received the ordinary high school education in Chicago and entered the Chicago Medical College, the Medical Department of the Northwestern University and was graduated with the degree of doctor of medicine in 1890. Since then I have studied in this country and to some extent abroad.

Q. Have you ever taught chemistry or bacteriology in any of the institutions of this country,—or hygiene?

A. I have taught bacteriology and hygiene in the College of Physicians and Surgeons.

Q. Where is that?

A. The medical department of the University of Illinois, in Chicago. My connection there began in the spring of 1892, and continues up to the present time.

Q. What was the nature of the text books that you taught at that time, what kind of text books were you using and teaching from at that time?

A. Text books used in our work?

7904 Q. Yes.

A. We were using the most recent editions of the text books on bacteriology and hygiene, at different times,—changing from time to time.

Q. Have you taught in any other institution or institutions?

A. I am now connected as professor of hygiene in the Dearborn Medical college.

Q. In this city?

A. At Chicago; and as professor of Bacteriology in the Harvey Medical College in Chicago.

Q. How long have you been connected with those two institutions?

A. Well, in Harvey Medical College, about a year and a half; the other school is a new school, that is just started, so it is only a few months.

Q. Are you still engaged with any institutions as a teacher upon any of these subjects?

A. I have all of these connections now.

Q. Then you have been engaged in teaching what branches and for what length of time?

A. I have been teaching bacteriology for eleven years, and hygiene for about eight years.

7905 Q. As a teacher of hygiene and bacteriology, and as a graduate of a medical college, and as a professor of medicine, have you given any special attention to the causes of diseases of the human race?

A. Yes, that has been a part of my daily work.

Q. What was the nature of your employment and what were your duties when you were connected with the health department of the city of Chicago?

A. It was the conduct of the laboratory for chemical and bacterial examinations and the making of bacteriologic examinations,—particularly as a bacteriologist. Those were my duties.

Q. Of what waters?

A. Well, there was no question as to waters—

Q. Well I now put the question. I say, what were the waters that you were examining chemically and bacteriologically in the health department of the city of Chicago?

MR. JEFFRIES: I understood the witness to say that he examined no waters.

A. No, I did not. The question was asked what were my general duties. I anwsered that they were general supervision of the laboratory, and the conduct of the bacteriologic work in particular. Now if there is another question I will answer that.

7906 Q. JUDGE SPRINGER: Where were the samples of water obtained,of which you made bacterial examinations?

A. The laboratory received samples from a number of different places, that is—we were continuously making examinations of water samples from the city water supply, were a large part of the number of samples of water. The samples of water were from places where ice was obtained, connected with farms from which milk was supplied from time to time, and for a period, samples of water from the Illinois and Michigan

Canal, the Illinois and Desplaines rivers and tributaries and the Mississippi and Missouri rivers.

Q. State how frequently samples of water were taken from Lake Michigan, if any?

A. During the year 1893, a weekly examination of the water was made from Lake Michigan, from the four tunnels, in use, and the water supply as delivered in the laboratory, making five samples per week, in 1893.

Q. From what places?

A. Do you want the name of the tunnels?

Q. Yes?

A. Well there was the Lake View tunnel, the Chicago Avenue tunnel, the Fourteenth Street tunnel and the Sixty-eighth Street tunnel.

7907 Q. Where did you obtain the samples at the point of intake of the tunnel or at the shore end of the tunnel?

A. These samples were taken at the shore end of these tunnels, except the one which was taken in the laboratory, which was takn from the tap in the laboratory.

Q. Yes, from the laboratory tap?

A. Yés. From the beginning of 1894 on, to as long as I was connected with the work, these samples were taken daily for every working day. The laboratory tap sample was discontinued some time during 1897, and later there were some additional samples added,—added territory, such as Rogers Park was added. There were occasional samples from the added territory west of the city, Austin, and a sample from the new tunnel that was constructed from Oak Street, known as the Carter H. Harrison Tunnel or Crib. These later ones were not daily samples; they were taken bi-weekly or every other day.

Q. Who made the chemical analyses of those samples taken during the period when you were director of the Chicago laboratory?

A. During 1893, 1894, 1895 and part of 1896, Mr. Cass L. Kennicott was the city chemist and made the chemical examinations. From that time on until January, 1900, Mr. D. B. Bisbee was the city chemist and made the examinations.

7908 During 1900, Mr. W. L. Maharg—I think his name is, was the city chemist, and made the examinations, and from

1901 again, Mr. Bisbee was the city chemist and made the examinations.

Q. There were two persons by the name of Bisbee?

A. No, D. B. Bisbee was his name.

Q. I thought you mentioned Bisbee a little while ago, the first man after Kennicott?

A. Well that was Bisbee.

Q. . The same person?

A. Yes, that is the same man.

Q. He dropped off for a time then according to your statement?

A. Yes, during 1900, he was away, at least part of the year, I don't remember the exact date.

Q. State in what manner the results of these chemical and bacterial examinations were entered of record, and whether they were published as a part of the health reports of the city of Chicago?

A. The examinations daily were recorded in series and arranged by months. The work of each month was tabulated together, averages were drawn, and with the reports that were published from the department a large number of the records for the months were published in detail. They were not all published up to date.

7909 MR. JEFFRIES: For the months?

A. Yes, these monthly records were published in a number of the reports but they have not all been published up to date, there are one or two years left out.

Q. JUDGE SPRINGER: Those that were published are they contained in the printed reports issued by the Board of Health of the City of Chicago?

A. Yes, those which were published are in the reports published by the department.

Q. What was the object of taking the samples, making these analyses and publishing them in said reports?

A. The object of such work was to learn as to the conditions that could be ascertained from bacterial and chemical examinations of the water, as to its quality.

Q. And bacterial also?

A. Yes, I said, chemical and bacterial also.

Q. How long since you ceased to be connected with the health department?

A. I left the service of the health department in June, 1902.

Q. Do you hold any official position at this time in the city government?

A. No.

7910 Q. 1902 is when you ceased?

A. Yes.

Q. Or in the government of the state?

A. No, not in the state.

Q. Or in the general government, the national government?

A. No.

Q. Were you at any time called upon to make bacterial examination of waters from the Illinois and Michigan canal, the drainage canal the Illinois and other rivers in this state?

A. Yes sir.

Q. When was that?

A. In the early months of 1899, I was instructed by the Commissioner of Health of the city of Chicago to arrange for the examination of samples from the Illinois and Michigan canal, the Desplaines river, the Illinois river and its tributaries, and the Mississippi and Missouri rivers, and attended a number of conferences with Professors Palmer and Burrill of the University of Illinois and Professor Jordan of the University of Chicago.

Q. What was the object of those conferences, and what work if any, did they bring about?

A. The object of these conferences was for the purpose of laying out a plan for the collection of samples and the 7911 chemical and bacterial examination of the same at points as before stated, and to arrange for the details of such an investigation.

Q. What particular points were established in reference to the investigation which was to be made? I do not have reference to the places, but I mean the subject matter, or detail of your investigation, what was the scope of it?

A. These conferences were to settle first, the localities in which the samples would be collected; second, all matters relating to the exact points in the rivers from which samples would be taken, and the selection of the collectors to be left to the mutual agreement of Professors Jordan and Palmer. The arrangements for the transportation of the samples and the equipment of the collectors with outfits to be conducted by the Health Deparment laboratory. It was decided as to the outfits to be used by the collectors,—

Q. What did that embrace?

A. That embraced the cases in which the bottles would be shipped, the bottles themselves, the necessary labels, tags and matters of that kind.

MR. JEFFRIES: I object to the witness stating what was decided to be done. Let him state what was done.

7912 Q. JUDGE SPRINGER: Well, what was done?

A. I am stating now what was done. These are the things that were done.

Q. You not only decided to do these things, but you did them I understand?

A. Yes. One more. It was agreed to, a summary of procedures as to the methods to be used in making the examinations.

Q. How many places were agreed upon for the purpose of making the chemical and bacterial examinations,—chemical analyses and bacterial examinations?

A. At this time, forty—

Q. No, I mean the laboratories?

A. Three laboratories were engaged in the investigation.

Q. What were they?

A. The laboratory of the University of Illinois, the laboratory of the University of Chicago, and the Health Department of the city of Chicago.

Q. What was the character of the work done at the Chicago laboratory under your charge, generally speaking, in regard to these samples?

A. Oh, a chemical and bacteriologic examination was made of the samples.

Q. The samples that came to you under this arrangement?

7913 A. Yes sir.

Q. Who conducted those examinations?

A. The chemical examination was conducted by Mr. D. B. Bisbee, and the bacteriological examinations were conducted by myself.

Q. Was it understood at that time that similar analyses and examinations were to be made at the other two places that you mentioned?

A. Yes sir.

MR. JEFFRIES: I object to the question and object to the witness stating what he understood was to be done. He should state what was done.

JUDGE SPRINGER: This witness has stated that he met these three gentlemen and they agreed on a program of operations.

MR. JEFFRIES: I don't see what effect their understanding would have upon the work done in this case. This man cannot testify as to what the others did.

JUDGE SPRINGER: He can testify that they were to make those examinations at their places, and he was to make it here. Now then I will let him tell what he did, and let them tell what they did when they come on the stand. It is simply a matter of detail.

7914 MR. JEFFRIES: All right.

Q. JUDGE SPRINGER: Now then, professor, you may state what arrangements you made and carried out as chief of the health department laboratory, after the taking of these samples, their transportation to the places indicated and their analyses and examinations thereafter?

MR. JEFFRIES: Now do I understand that question to relate back to 1894, and down to the present time?

JUDGE SPRINGER: It relates to the times when it was done. He has given the time before.

MR. JEFFRIES: Yes, but he has testified that he made examinations of the Illinois river, Lake Michigan as far back as 1894. Now this arrangement about which he has been speaking, made with these other gentlemen of these other institutions, was made prior to 1898 or 1899.

JUDGE SPRINGER: What we are speaking about now is exclusively with reference to the examinations made by him and the other professors.

MR. JEFFRIES: When was that?

JUDGE SPRINGER: This was in 1899.

Q. (Last question repeated).

A. During April and the early part of May, 1899, I purchased the required number of outfits, and prepared them
7915 for the collectors to use in making their collections and arranged with the express companies for transportation of the samples from the various points that had been agreed upon, and reported to me by Professor Palmer and Professor Jordan, where the samples were to be taken. On the 19th of May, I sent a letter under the direction of Dr. Arthur R. Reynolds, the Director of Streams Examinations, to each of the collectors, in which the following was stated:

"According to arrangements that have been made by Professor Jordan and Palmer, you are to make collections of samples of water for the Chicago Sanitary District. These samples are to be collected at the particular places from where you have been instructed, on a certain day of each week. From each spot from which water is obtained three separate samples must be collected. As each sample is representd by a large bottle and a small one, six bottles must be filled with water. The shipping cases and outfits have been sent to you. The tags, seals and numbers you will find in one of three cans belonging to each sample. There is one press for the seals. This bears a number. This is your number as collector. The three samples are to be packed in the shipping case and sent to the three addresses indicated upon the shipping envelopes. The ship-
7916 ping envelope is to be fastened to neck of the large bottle, by the wire seal. The small bottles do not require shipping envelopes. The samples are to be numbered with the tin tags bearing numbers. Use the numbers in regular order. As there are six bottles from each locality there are six tags numbered alike and one of these is to be fastened by the seal to each bottle. In putting on the seals, pass the wire in and out through the holes in the cloth cover of the bottle. Read carefully the instructions on the cards that go in the shipping envelopes.

Q. You need not state how the bills were rendered for payment. That is immaterial as far as we are concerned. Was there any other circular sent after that to these collectors, if so, state when?

A. On the 31st of May, 1899, I sent the following letter to each of the collectors:

It is desired that you proceed in the following manner regarding the packing of the small sample bottles in the cans. When the bottle is placed in the sample can, the lid must be pressed firmly in place, so as to present water getting into it. The smaller can is then to be packed in ice in the large can. This can must be completely filled with ice. In the shipping case the packing paper goes around the can; the excelsior is to be stuffed into the 7917 corners and packed over the top of the can, filling up the top of the shipping case. The ice must be kept from melting as well as possible. We are about to send you one complete outfit for sample to use in case of accident to any of the regular bottles or cans that are in use. We are also sending you the thermometers for taking temperatures."

Q. Were any verbal instructions to be given to the takers of samples, and if so, by whom?

MR. JEFFRIES: I object to this witness stating about any verbal instructions being given to any sample takers unless such instructions were given by this witness.

JUDGE SPRINGER: I don't propose to put this in at this time; simply to lay the foundation.

MR. JEFFRIES: I don't suppose he would know whether there were or not.

(Question repeated).

MR. JEFFRIES: I object to the witness stating by whom they were given because that is no more competent than what the verbal instructions were themselves.

JUDGE SPRINGER: Well I withdraw the question then and will put another.

Q. Who selected the exact points in these various waters, at which samples were to be taken and employed the 7918 persons who were to take the samples?

A. Professor Palmer and Professor Jordan did that.

Q. Then personally you did not see any of these water takers or employ any of them?

A. I did see some of them at one time or another, but I didn't see them at the beginning of the investigation.

MR. JEFFRIES: The question was as to whether or not the witness saw any of them employed.

JUDGE SPRINGER: Yes.

A. Engaged?

Q. Yes?

A. No, I didn't see any of them engaged.

Q. That is what I mean, did you see any of them engaged in their work at any time?

A. Yes, I saw them several times engaged in their work along the river.

Q. What points did you yourself visit where water was being taken?

A. Well, I was at Bridgeport a number of times. I was at Lockport and Joliet.

Q. Did you yourself give any verbal instructions or other instructions than those you have mentioned, to the water takers at those places?

7919 A. I had a number of times, occasion to write to them, and wrote to them rather personal letters about their work, as special directions or instructions, to explain points more fully.

Q. Who selected them?

A. Professors Palmer and Jordan.

Q. Do you know the points in these various waters at which collections of samples were taken?

A. I know in a general way as to the points.

Q. Can you name them?

A. Illinois and Michigan canal—well, we had better put a heading to this. The samples were collected from the following points:

Illinois and Michigan canal at Bridgeport, 500 feet west of the pumping station.

Illinois and Michigan canal at Lockport.

Desplaines river at Lockport.

Illinois and Michigan canal north of Joliet, east bank, north of Jackson Street.

Illinois and Michigan canal south of Joliet, east bank of the railroad bridge.

Kankakee river at Wilmington.

Illinois river at Morris, at the bridge.

Fox river at Ottawa above the canal viaduct.

7920 Illinois river at Ottawa,

Illinois and Michigan canal at Ottawa,

Big Vermillion river at LaSalle at the bridge,

Little Vermillion river, once in four weeks,

Illinois river, LaSalle, at the wagon bridge,

Illinois river, Henry, at the dam.

Illinois river, Peoria, at Averyville bridge, at the Narrows,

Illinois river at Wesley City,

Illinois river at Pekin,

Illinois river at Havana, above the mouth of the Spoon river, in Quiver Lake.

Sangamon river at Chandlersville,

Illinois river at Beardstown,

Illinois river at Kampsville, above the dam,

Illinois river, Grafton, two miles above the mouth of the Illinois river,

Mississippi river, Grafton, above the mouth of the Illinois,

Mississippi river, Alton, Illinois, 100 feet from the east bank,

Mississippi river, Alton, east of the middle of the river.

7921 Mississippi river, Alton, Illinois, mid-stream,

Mississippi river, Alton, Illinois, west of the middle of the stream,

Mississippi river, Alton, Illinois, 100 feet from the west bank.

These five samples were taken opposite the new pumping station of the city waterworks at Alton.

Mississippi river, Mitchell, 400 yards from the Illinois shore.

Mississippi river at Mitchell, in the main channel.

Mississippi river, Mitchell, at the in-let tower,

Mississippi river, Mitchell, 400 feet from the Missouri shore.

These samples were taken opposite the St. Louis city pumping station.

Missouri river at West Alton, at the C. B. & Q. railway bridge.

Mississippi river at Jefferson Barracks, east bank, Mississippi river, Jefferson Barracks, east of the middle of the stream,

Mssissippi river, Jefferson Barracks, mid-stream,

Mississippi river, Jefferson Barracks, west of the middle of the stream,

7922 Mississippi river, Jefferson Barracks, west bank,

St. Louis city tap water, at St. Louis.

Q. Were the collectors of samples established at each of these places to which you have referred?

A. Yes.

Q. Did you know the names of those persons who were appointed by Professors Palmer and Jordan to take the samples of water at the various places here?

A. Yes sir, I had the names of the following individuals as collectors at the beginning of the investigation. There were a few changes afterwards that I cannot state just now.

Q. Well, you may state those names that were furnished you?

A. At Bridgeport J. E. Thomas. Do you want his title? The Assistant engineer at the pumping station.

Q. Yes, always give that. I want to ask you, was this in the Illinois and Michigan canal or in the drainage canal. There are the two at Bridgeport.

A. I know. This is the Illinois and Michigan canal.

Q. Well, just state that then.

A. Illinois and Michigan canal at Bridgeport, J. E. Thomas, Assistant engineer at the Bridgeport pumping station.

At Lockport from the canal and Desplaines river, P. W. O'Brien, the lock-keeper at Lockport.

Q. In the Illinois and Michigan canal? You must distinguish between those two canals. 7923

A. Yes.

Q. Well, proceed then.

A. At Joliet, in the canal, R. P. Eliott, Agent United States Express Company.

Ottawa from the Fox river and the canal, Dennis Foley.

Morris, Illinois river, J. W. Miller, and Miller had a man helping him named James Mack.

LaSalle, Big Vermillion river, Little Vermillion river and Illinois river, collector William Frazer.

Henry, Illinois river, James McCune.

Peoria, Averyville, sample, Illinois river, D. J. Forbes, Peoria Water works. He was connected with the Peoria water works.

Wesley city, Illinois river, D. H. Jansen, county surveyor.

Pekin, Illinois, Illinois river, collector D. H. Jansen.

Havana, Illinois river, H. J. Heberling,

Chandlerville, Sangamon river, E. O. Spink.

Beardstown, Illinois river, J. A. Carney.

Kampsville, Illinosi river, C. V. Brainard, Assistant United States Engineer.

7924 Grafton, Illinois river, Mississippi river above the mouth of the Illinois, and the Missouri river, B. F. Robinson, Grafton.

Alton, Illnois, five samples from the Mississippi river, George Brooks of Alton.

Mitchell, four samples, Henry Atkins of Mitchell.

West Alton, Missouri, James Matthews.

St. Louis, August Johnson.

Q. State doctor, whether any blanks were furnished these collectors upon which the results of their operations were to be entered?

A. Yes, the outfits were accompanied by a slip on which was recorded the number of the sample, the date and the time of collection, place of collection, by whom collected, the height of the water and the temperature of the water; direction of the wind, and the temperature of the air, and the rainfall to be noted at the time, for the time since the last samples were taken, and a place for remarks as to passing vessels or any other special circumstances.

Q. Was there anything printed on the back of this certificate?

A. On the back of this slip were printed the specific instructions for the collection of samples.

7925 Q. Will you state what the printed instructions on the back of these certificates were?

A. The instructions were as follows:

The outfit for obtaining water samples consists of two parts, the large gallon-bottle is for the chemical sample, and the

small four ounce bottle is for the bacterial sample. The large and the small bottle together constitute one sample or set. The two bottles must be filled at the same time and at the same place, and in the same general manner. They must then be placed in their respective compartments of the shipping cases, for transportation. In filling the bottles the stoppers must be taken out only when the spot from which water is to be taken is reached. The bottle is immersed with the stopper in place, about one foot below the surface and is filled, leaving about two or three inches air space. The large and the small bottles are then immediately sealed by placing the rubber cloth over the stopper and drawing the wire seal with the number of the sample, tight about the neck. The small bottle is to be placed in the smaller can, and the lid pressed down, it is then to be packed with ice within the large can. The card and the shipping envelope is then to be filled out and attached to the neck of the larger bottle. The bottles must not be filled until just
7926 before the time for delivery at the express office. As series of samples are to be sent to the different laboratories, all of the bottles should be filled at the same time at the same place, and the different sets placed together as described. The certificate of collection on the reverse side is to be filled out completely in every case.

Q. State in what condition were the samples received at your office in the city laboratory of Chicago, during this period?

A. The samples were received in very good condition as to their appearance, and the presence of the ice and the evidence that the instructions had been followed.

Q. Were these blank certificates filled up in the manner pointed out by you?

A. Yes, they were filled out. One or two of the collectors had some difficulty in getting temperatures, and they did not always fill in the temperature; that is the only point in which they failed.

Q. Who received the boxes containing the samples from the express office in your office?

A. Mr. Bisbee received all of the samples.

Q. What was done with the certificates or tags which accompanied these bottles?

A. The certificates were all saved and put up in serial
7927 order.

Q. By him?

A. Yes sir.

Q. After these samples were received in the Chicago laboratory, what was done with them?

A. Mr. Bisbee took his large bottles for the chemical analyses and delivered the small bottles for the bacteriological examinations to me, and I proceeded with my examination of the samples.

Q. Did he or you note on the certificate the time of the collection as it appeared upon the certificate and the time of making the examinations to which you have referred?

A. Mr. Bisbee filled out that part of the sheet.

Q. What method of physical or chemical examination was pursued in your office so far as these samples were concerned?

A. Well I left that to Mr. Bisbee and he made his chemical analyses.

Q. What method was pursued by you in making the bacterial examinations of those samples?

A. I made an examination for the numbers of bacteria of all kinds present in the samples by making Petre plate cultures on agar culture medium, and counting the number of colonies
developed, estimating then the number of bacteria present
7928 per cubic centimeter of water. Beyond this, an examination for bacteria of the colon-typhoid group was made. Preliminary cultivation of the water sample in glucose broth and separation of the bacteria therein present, with isolation of the colonies, and studied the specific characteristics presented by the cultures obtained from these colonies.

Q. What record, if any, did you make of those examinations?

A. I recorded the results of the examination on a record sheet.

Q. Did you record the height of the water or the temperature of the air from the cards which accompanied each sample, if those entries were upon such cards?

A. No, I didn't do that. Mr. Bisbee made those entries upon those cards.

Q. As to the bacterial examinations?

A. What?

Q. He made them as to all the samples?

A. As to all the samples?

Q. Did you make an entry upon any tables prepared by you of the presence or absence of the bacillus coli communis?

A. Yes.

Q. And did you make any entry of the number of bacteria per cubic centimeter?

A. Yes.

7929 Q. State how you designated on the tables prepared by you, the presence of the bacilli coli communis?

A. I designated it by a plus sign.

Q. A cross?

A. Yes.

Q. And where there is no designation, what does that mean?

A. Where there is no designation at all?

Q. Yes.

A. That for some reason or other the examination was not completed or fully carried out.

Q. And perhaps there was no ascertainment at all. You did not reach a conclusion I mean, as to whether they were present or not?

A. No, the fact that there was no examination upon which to draw a conclusion in that particular case.

Q. Did it mean that you looked for them and did not find them or that your examination was insufficient to find them?

A. In that case the examination was insufficient or lost or destroyed in some way. Where they were not found the record was made by indicating a minus sign, a straight dash.

Q. Professor, I hand you certain tables numbered from 159 to 196 inclusive, entitled "Streams Examinations, Sanitary District of Chicago, Sanitary Water Analyses, Parts Per
7930 Million; Source of water" indicating at each place in that table where the source was, and designated as a report of Adolph Gehrmann, and D. B. Bisbee, Municipal Laboratory, Chicago, Illinois. Will you please examine these tables and state whether or not these are the tables that were prepared by

you and Mr. Bisbee, as chemist in the city laboratory of Chicago, at the times indicated on each of these tables, as the results of chemical analyses and bacteriological examinations of the samples of water taken at various places during the time indicated, in the waters indicated by you in your examination up to this time?

A. These tables that I present are the tables that are prepared in connection with Mr. Bisbee,—the record of work on the samples that we received from the collectors at the points as stated before.

Q. Were these tables made as to both analyses, and examinations under your direction and supervision?

A. Yes; that is, we worked together on them.

Q. And you were in charge of the work?

A. Yes, in a general way.

Q. State whether these tables then so far as the column indicating presence or absence of the coli and that indicating the number of bacteria per cubic centimeter were made by you, entered by you and whether they are the correct ascertainments of the examinations you made of said waters at the times indicated and the places indicated? 7931

A. The column here designated presence of bacilli coli communis, contains the record of the results of the determinations that I made on various samples received from the localities, as stated at the head of the table.

Q. We will take as a sample of all of them, table No. 159. It is stated upon that table that the sample was taken July 3rd and examined July 3rd of the year 1899, and that the presence or absence of the bacilli coli communis is indicated by a cross. Explain what that means.

A. This means that on the 3rd of July we examined a sample collected on the 3rd of July from the Illinois and Michigan Canal at Bridgeport, and found the bacillus coli present.

Q. In the sample collected on the 14th of August and examined on that day, what is indicated on that table?

A. The indicaion as regards the sample of water examined August 14th, collected August 14th from the Illinois and Michigan Canal was that the examination was not completed and no definite record was made.

Q. As to the colon?

7932 A. Yes.

MR. JEFFRIES: In other words, there may have been colon and there may not have been, and that determination was not made because the sample was either lost or destroyed, or something of that kind?

A. It was mainly because I was doing other work and did not finish it, or could not finish it.

Q. In other words, no determination of that particular organism was made?

A. Yes.

Q. JUDGE SPRINGER: Now doctor, you may state whether similar entries were made on those tables with regard to the presence or absence of coli communis in all of the tables that you have in your hand?

A. Yes sir.

Q. And that where they appear there to be understood as indicating the results which you have explained as to this table, the same sign for the same meaning, in other words?

A. There is in one or two places you will find, as for instance on the Lockport table No. 160 on October 11, a question mark,—an interrogation point.

Q. What does that mean?

7933 A. That means that there was doubt as to the result of the examination one way or the other, as to the presence of the colon bacillus. I believe there are only one or two such points, or only one I believe.

Q. Well, in other words, with that explanation then, the same method was pursued in making up each of the tables to which I have called your attention?

A. Yes sir.

Q. Now I call your attention to the last column on the right hand side of that table, which is headed "Number of bacteria per cubic centimeter." State what that column is intended to convey?

A. This column which is marked "Number of bacteria per cubic centimeter" records the number of bacteria found by an average of the portions of the sample examined, as estimated present per cubic centimeter.

Q. Did you make all those bacterial examinations and ascertainments of results by the usual methods employed by bacteriologists for making such counts?

A. I made them by the agreed methods, as I have already partially stated.

Q. What were those?

A. Agar plates of aliquot portions of the samples, counting the number of colonies, estimating the number of bacteria present. 7934

Q. State whether that system has been used by bacteriologists generally for the purpose of making such ascertainments?

A. Yes, it is the standard method.

Q. State whether or not then in the tables to which I have called your attention the column on the right hand side of the page, the last column, contains a true statement of the result of such counts of the samples taken and examined, and the dates indicated, and the places indicated on that table?

A. That is a true record of the results of the examinations made by me.

Q. And those entries were made by you as the results of your examinations?

A. Yes sir.

Q. State whether or not the subsequent tables to the end of the number I have given you contain similar results of your bacterial examinations?

A. You mean beyond 159?

Q. Yes?

A. The tables 159 to 196 inclusive contain the record of my examinations as to the numbers of bacteria present in these samples of water.

7935 Q. Then these tables, the numbers of which you have given, so far as the two columns about which we have been speaking are concerned, were made by you, and are the results of examinations made by you?

A. Yes sir.

Q. And are known to you to be correct examinations?

A. Yes sir.

Q. Doctor, you will now please read each of the tables to which your attention has been called, beginning with tables 159 and ending with table 196.

MR. JEFFRIES: To the reading of which said tables, complainant objects for the reason that an adequate number of samples was not examined to enable a sanitarian to express an opinion or draw any conclusions thereform as to the sanitary condition of the water in the river at the points where the samples were taken, and for the further reason that examinations were made and samples collected without reference to flood seasons or low water seasons, without reference to low temperature or high temperature and without reference to the changing conditions of the water, and the variations of the water and
7936 the weather. I object to the reading of the tables into the record for the further reason that certain analyses bacteriological and chemical have been made or purport to have been made by said tables, of the waters of the tributaries of the Illinois river, such examinations being immaterial and having no bearing upon the issues involved in this case, and for the further reason that even if they should under any circumstances be considered evidence of the remotest character or of any character whatever, a sufficient number was not taken from these tributaries to determine the sanitary condition of the water in the tributaries. I object for the further reason that the samples so taken from the tributaries were not taken with reference to the sources of pollution from the water-shed of the tributaries, and were not taken with reference to the changing conditions of the tributaries, with reference to flood season, low water season, winter season and summer season. I object to the reading of the tables into the record for the further reason that they do not furnish proof of any character as to the disappearance of pathogenic organisms passing from the city of Chicago down the Illinois river.

I object to the introduction of the tables for the further reason that the life and conduct of disease producing germs in running streams has never been determined, and that
7937 all bacteriologists practically agree that such a determination has never been made and cannot be made. That they will live in the laboratory under various conditions from five to 90 days and possibly longer, and that from bacteriological

analogy, they will live much longer in a running stream, where they are able to leave, swim or move from the sources of danger, and where all sources of danger and destruction to them is continually being swept away by the water; that they may live much longer in the running stream than in the laboratory experiment. And I object therefore to the reading of the tables into the record for the reason that the only question so far as the defense is concerned in this case is that as to whether or not the life time limit of the disease producing germs has expired before the water from the Chicago river passing through the drainage canal, has reached the State of Missouri. I also object for the further reason that the defense has proven the presence of pathogenic germs of spore forming character, which lived for months, and not in a running stream, and that as to those the chemical analyses are of no importance as to showing the disappearance of such germs from the Illinois river.

I object to the reading of the tables into the record for the further reason that the proper foundation has not been
7938 laid for their introduction, no evidence as to the proper
precautions having been 'given with reference to the increase and growth of the bacteria in the samples of water after they were taken, prior to the experiment, or the analysis and for the further reason that the witness has not stated the character and amount of solid organic matter added to the samples by way of his experiment, which would produce an added and increased number of bacteria in the samples, and therefore change the bacteria conduct in the operation of the water so analyzed.

I object to the reading of the tables into the record for the reason that they are not the tables made by the witness when the experiments were made, and could not have been the original tables for the reason that the tables now being read into evidence are printed, while the originals must necessarily have been made with a pencil or pen and ink.

JUDGE SPRINGER: Counsel for defendants states that this objection ought not to be entered of record in this case for the reason that it is in most respects merely a comment upon the weight of the evidence and not a proper objection as to its admissibility, and for the further reason that counsel has recited in his objection a number of alleged facts which ought not to go into this record except as the testimony of a witness 7939 and are merely his conclusions as to the weight of the testimony that has heretofore been introduced in evidence, and further that the part of the objection which states that there is no evidence as to the height of the water in the channel is incorrect for the reason that there is a column in these tables showing the height of the water, the temperature of the water and the temperature of the air at each of the places where the respective samples were taken; also a table showing the residue on evaporation or the total solids, and that these matters will be referred to by subsequent witnesses who made up that part of the table, this witness merely being confined to the two columns in this table which he prepared himself, and further that the statement that these tables are not the highest evidence is merely an opinion of counsel and therefore improper as an objection. That the witness has stated in his examination that this table was made up by him, of the results of examinations of the water made by him and that it is a correct statement of the result of those examinations. Now he can make that statement as the person who made the examination, without reference to a book of any kind. He can make it from his memory, or he can refresh his memory from any table that he has got before him.

MR. TODD: For the information of myself, one of the counsel in this case, I would like to request counsel for 7940 complainant to state if possible, the number of samples that it would be necessary to take in order to render this objection made by him void if the same be good, and also whether there has been established in this case or out of it, any established rules requiring any certain number of samples to be taken in order to make the testimony admissible. The reason for this request is based on the fact that witnesses on complainant's side of the case drew conclusions from as many as one sample taken, and in some cases from as many as two, and as many as three in number, and others drew conclusions from a greater number of samples, so that if counsel knows of any established rule that would apply against the defense in this case, to show that his objection as stated is a good legal objection, and for the information of counsel and for the illumination of the record upon that point, I would like to ask counsel to state what that number is, and this request is made with the greatest deference and respect to counsel's knowledge on the subject.

MR. JEFFRIES: I suggest to the Court that I don't object to counsel as contained in Judge Springer's dictation, commenting upon the evidence and what it shows, but I do suggest to the Court that the defendants' own witnesses have shown that no determination of the longevity of disease-producing germs and spores in running water can be determined
7941 from a laboratory experiment or from laboratory experiments, although a large number of the examinations may be made. For the information of Mr. Todd I will say that upon the admission of the deposit of disease producing germs into the sewage of Chicago river and the canal, and upon the evidence of the bacteriologists introduced on the part of the defendants, and taking into consideration the evidence thus far introduced by the defendants, that the typhoid bacilli and various other forms of disease producing germs, anthrax and tetanus spores, which have been found in the waters of the Illinois river since the opening of the canal live for a period limited only by years, and that the typhoid and other disease producing bacilli lived from five to ninety days under various conditions in water taken from running streams, and that the bacteriological analogy applied thereto, and as testified to by witnesses for the defense, that they would live much longer in running streams it remains for the defense to purge the river of disease producing germs, deposited into it by the city of Chicago.

MR. TODD: In view of the fact that this objection is made to the very first tables introduced in evidence by the defendants, on the ground that the number of samples were not sufficient to predicate a judgment on, and to other subsequent tables, counsel's explanation may be sufficiently understood by the
7942 superior wisdom of the Court, but he failed entirely to give me the number of samples necessary, for an expert to predicate a judgment on as modestly requested by myself.

MR. JEFFRIES: I suggest to counsel that if the samples of water were examined at given points as shown by the testimony of defendant's witnesses during the entire year, that that would not be evidence, and the result of these experiments would not be evidence of the absence, or would not show the absence and be proof of the absence of pathogenic germs. Now I object further to the reading of the tables into the record for the reason that on their face they show nothing that would prove or tend to prove that the typhoid bacilli, anthrax, tetanus, cholera vibrio and various other disease producing germs will disappear or have disappeared from the Illinois river after being deposited into the sewers of Chicago and thence into the Chicago river and the drainage canal by the time the water from the Illinois river reaches the shores of the State of Missouri on the river.

MR. TODD: I still insist that counsel has given his opinion as a standard to govern a scientific investigation such as this and that was not what I called for, because his opinion 7943 is rated by the evidence that was put in by the side of the case that he represents, but I ask for any accepted standard of numbers of analyses and not for an opinion.

MR. JEFFRIES: I take it for granted that a reference upon this proposition will satisfy counsel and in this connection I refer him to the testimony of Professor Zeit, who is a witness of the Sanitary District of Chicago and the State of Illinois in this case, and who has furnished me my information and reason stated in the objection.

MR. TODD: In reply will state that this objection was made heretofore and this request made before Professor Zeit went on the stand.

JUDGE SPRINGER: If the Court please, I move to eliminate all of these objections that have been made since these tables were offered in evidence for the reason that they are principally arguments addressed to the court in reference to the weight of testimony and conclusions of counsel as to what testimony has established in this case proves, and that all such matters must be addressed to the Court either in oral arguments, or in briefs, which they will submit to the Court when the case is called for hearing.

MR. JEFFRIES: I will suggest to counsel that I have never yet known of a case where the Court has sustained 7944 a motion to strike out objections to evidence.

MR. TODD: I would in reply to counsel state that that counsel has set the precedent in this hearing of moving to strike out objections to testimony.

JUDGE SPRINGER: The witness will now please read the tables to which I have referred, into the record.

MR. JEFFRIES: To the reading of which said tables into the record, I renew my objection.

THE WITNESS: The tables are as follows:

ABLE 159.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS AND MICHIGAN CANAL, BRIDGEPORT.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

Date of: 1899 Collection.	Date of: 1899 Examination.	Appearance: Turb'y.	Appearance: Sediment.	Appearance: Color.	Odor	Residue on Evaporation: Total.	Residue on Evaporation: Dissolved.	Residue on Evaporation: Suspended	Chlorine.	Oxygen Consumed: Total.	Oxygen Consumed: By Dissolved	Oxygen Consumed: By Suspd Matter	Nitrogen as Ammonia: Free Ammonia.	Nitrogen as Ammonia: Albuminoid Am. Tot'l	Nitrogen as Ammonia: Albuminoid Am. Dissolv'd	Nitrogen as Ammonia: Albuminoid Am. Suspnd'd	Organic Nitrogen: Total.	Organic Nitrogen: Dissolved.	Organic Nitrogen: Suspended	Nitrogen as Nitrites	Nitrogen as Nitrates	Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
July 3	July 3	VVH.	H.	Muddy	Gassy	482.	416.	66.	80.	40.	23.	18.	12.60	2.40	.94	1.46	2.98	1.72	1.26	.0	.0	......	......	......	+	105,000
" 17	" 17	VVH.	M	.4	SlGas'y	601.	534.	70.	77.	31.6	17.	14.6	6.40	1.52	.70	.82	3.48	2.08	1.40	.64	.76	7.	6.	21.	+	81,850
" 24	" 24	VVH.	H.	Muddy	St'gGas	591.	522.	69.	101.	41.2	18.4	22.8	16.40	1.88	1.20	.68	3.08	1.35	1.73	......	.20	5.4	25.5	27.	+	302,250
" 31	" 31	VVH.	H.	"	Gassy	426.	385.	41.	75.	39.2	19.2	20.	9.00	1.30	.70	.60	3.08	1.38	1.70	.0	.0	4.7	10.	24.	+	200,000
Aug. 6	Aug. 7	VVH.	M.	"	"	490.	414.	76.	103.	36.	16.	20.	13.00	1.80	.80	1.00	3.45	1.38	2.07	.11	.09	5.5	19.	24.	+	515,000
" 14	" 14	VVH.	H.	"	"	540.	489.	51.	130.	34.2	15.7	18.5	19.00	2.05	1.16	.89	4.08	1.88	2.20	.003	.41	......	19.	21.	......	642,000
Sept. 11	Sept. 11	VVH.	S.	......	"	533.	468.	65.	125.5	38.	20.	18.	18.00	1.84	1.04	.80	3.96	......	......	.0	.10	5.	12.	19.	+	2,650,000
" 18	" 18	VVH.	VS.	......	St'gGas	524.	483.	42.	125.	40.8	23.6	17.2	19.40	2.24	1.23	1.01	3.80	1.60	2.20	......	......	5.	9.	15.	+	486,000
" 25	" 25	VVH.	VS.	......	"	635.	572.	63.	162.	48.4	23.2	25.2	23.40	2.25	1.39	.86	4.98	2.50	2.48	.005	......	5.2	13.	19.	+	460,000
Oct. 2	Oct. 3	VVH.	VS.	......	"	499.	441.	58.	108.	37.6	18.	19.6	14.60	2.52	1.26	1.26	4.30	1.84	2.46	.0	......	4.7	13.	10.	+	302,000
" 16	" 16	VVH.	VS.	......	Gassy	532.	459.	73.	137.	37.2	16.4	20.8	20.60	2.12	1.20	.92	4.14	2.30	1.84	.0	......	5.6	7.	10.	+	845,000
" 23	" 23	VVH.	VS.	......	St'gGas	458.	390.	68.	103.5	34.4	16.4	18.	13.00	1.98	1.13	.80	3.84	1.78	2.06	......	......	5.	10.	20.	+	......
" 30	" 30	VVH.	S.	......	Gassy	524.	456.	68.	103.5	44.4	22.8	21.6	14.60	2.68	1.46	1.22	4.36	2.42	1.94	......	......	5.5	0.	10.	+	622,500
Nov 6	Nov. 6	VVH.	S.	......	"	427.	373.	54.	77.	32.	17.6	14 4	10.00	2.00	1.26	.74	3.90	2.02	1.88	.0	.0	5.6	8.	11.	+	2,160,000
" 13	" 13	VVH.	VVS.	......	"	567.	498.	69.	138.5	38.8	20.4	18.4	17.40	2.79	1.64	1.15	4.10	1.70	2.40	.003	.0	5.	6.5	4.	+	725,000
" 20	" 20	VVH.	VH.	......	"	707.	556.	151.	149.	30.4	20.4	30.	22.00	3.32	1.50	1.82	5.74	2.30	3.44	......	.0	5.	5.5	10.	+	1,825,000
" 27	" 27	VVH.	H.	......	"	505.	43[illegible]	157.	103.	48.0	17.6	30.4	16.60	3.20	1.30	1.90	4.70	2.00	2.70	......	.20	5.	9.	0.	+	8,425,000
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 160.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS AND MICHIGAN CANAL, LOCKPORT, ILL.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

	Date of		Appearance.				Residue on Evaporation.				Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as						
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.	Odor	Total.	Dissolved.	Suspended	Chlorine.	Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Dissolv'd	Susp'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates	Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
0	July 3	July 5	VVH.	H.	Muddy	Gassy	570.	441.	129.	107.	41.2	16.2	25.	13.00	2.60	.92	1.68	4.84	2.36	2.48	.0	.0	......	25.	29.4	+	102,250
12	" 10	" 10	VVH.	H.	"	"	560.	491.	69.	104.	34.8	16.6	18.2	13.20	2.72	1.66	1.06	4.88	3.08	1.80	.0	.0	......	21.	27.	+	630,000
14	" 17	" 17	M.	M.	SS.	SlGas'y	591.	522.	69.	123.	24.4	17.2	7.2	7.30	1.00	.65	.35	1.88	1.28	.60	.40	.30	......	22.	29.	+	2,280,000
16	" 24	" 24	VVH.	H.	Muddy	Gassy	582.	527.	55.	100.	40.4	21.0	19.4	14.00	2.70	1.60	1.10	3.48	2.68	.80	.0	.20	......	24.	29.	+	180,000
18	" 31	" 31	VVH.	H.	"	"	517.	445.	72.	99.	37.2	21.8	15.4	11.40	1.74	1.00	.74	4.72	2.58	2.14	......	.30	......	22.	29.	+	212,500
0	Aug. 7	Aug. 7	VVH.	M.	"	"	556.	497.	59.	132.	42.4	27.8	14.6	16.60	2.60	1.60	1.00	4.48	2.50	1.98	.0	.0	......	21.	27.	+	479,000
2	" 14	" 15	VVH.	H.	"	"	532.	477.	55.	124.	37.6	17.7	19.9	17.40	2.76	1.50	1.26	4.68	2.16	2.52	.0	.40	......	......	......	......	42,750
4	" 21	" 22	VVH.	H.	....	"	517.	449.	68.	108.	37.6	17.4	20.2	15.36	1.85	1.10	.75	3.66	1.94	1.72	.005	.40	......	22.5	31.	+	302,500
6	" 28	" 28	VH.	M.	....	"	552.	484.	68.	124.	39.6	21.4	18.2	16.60	3.00	1.94	1.06	4.72	1.98	2.74	.0	.0	......	24.	29.	+	490,000
7	Sept. 4	Sept. 5	VVH.	S.	....	"	489.	437.	52.	106.	29.6	14.	15.6	13.70	2.28	1.06	1.22	4.20	1.68	2.52	.007	......	......	23.	29.	+	1,200,000
9	" 11	" 12	VVH.	S.	....	"	533.	466.	65.	134.	41.6	24.	17.6	20.00	2.55	1.33	1.22	3.56	2.28	1.28	.0	.0	......	18.	26.	+	2,350,000
1	" 18	" 18	VVH.	VS.	....	St'gGas	524.	482.	42.	116.	37.6	24.	13.6	16.00	2.12	1.44	.68	3.80	2.10	1.70	.006	.10	......	20.	21.	+	167,500
3	" 25	" 26	VVH.	M.	....	"	650.	514.	136.	139.	45.2	24.4	20.8	16.60	2.52	1.30	1.22	3.84	2.30	1.54	.07	.8	......	15.5	20.	+	370,000
5	Oct. 2	Oct. 3	VVH.	VS.	....	"	529.	455.	74.	113.5	39.2	21.2	17.	10.40	2.87	1.26	1.61	4.60	2.26	2.34	.03	......	......	11.	25.	+	110,000
7	" 9	" 11	VVH.	S.	....	Gassy	432.	395.	37.	91.	34.4	19.2	15.2	13.00	2.00	1.30	.80	......	......	......	......	......	......	20.	21.	+	....
9	" 16	" 17	VVH.	VS.	....	"	462.	411.	51.	108.5	37.2	18.3	18.4	14.00	2.20	1.40	.80	3.06	2.30	1.36	.04	.0	......	10.	21.	......	....
1	" 23	" 24	VVH.	M.	....	"	531.	443.	88.	114.5	37.6	17.6	20.	14.70	2.80	1.54	1.26	4.54	2.36	2.18	......	......	......	19.	23.	+	1,070,000
3	" 30	Nov. 1	VVH.	M.	....	"	559.	485.	64.	116.5	47.6	26.8	20.8	14.00	3.20	2.15	1.05	5.50	3.62	1.88	.30	......	......	12.	18.	+	1,072,500
5	Nov. 6	" 8	VVH.	S.	....	"	575.	498.	77.	119.	42.8	20.	22.8	14.60	3.75	2.00	1.75	5.22	2.50	2.72	.06	.0	......	12.	18.	+	830,000
7	" 13	" 14	VVH.	H.	....	"	520.	458.	62.	122.5	42.8	21.2	21.6	14.70	2.60	1.30	1.30	4.34	2.10	2.24	.03	.10	......	10.	......	—	573,500
9	" 20	" 21	VVH.	VH.	....	"	620.	522.	98.	125.	54.	23.6	30.4	16.00	4.40	1.60	2.80	5.50	3.24	2.26	.0	.0	......	12.	18.	......	....
2	" 27	" 28	VVH.	VS.	....	"	547.	487.	60.	120.5	43.2	19.2	24.0	17.00	2.80	1.30	1.50	4.82	2.56	2.32	.0	.10	......	9.	18.	+	177,500

APPEARANCE—H., Heavy. VH., Very Heavy VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 161.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—DESPLAINES RIVER, LOCKPORT.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of: 1899 Collection.	Date of: 1899 Examination.	Appearance: Turb'y.	Appearance: Sediment.	Appearance: Color.	Odor	Residue on Evaporation: Total.	Residue on Evaporation: Dissolved.	Residue on Evaporation: Suspended	Chlorine.	Oxygen Consumed: Total.	Oxygen Consumed: By Dissolved	Oxygen Consumed: By Susp'd Matter.	Nitrogen as Ammonia: Free Ammonia.	Albuminoid Am.: Tot'l	Albuminoid Am.: Dissolv'd	Albuminoid Am.: Susp'd	Organic Nitrogen: Total.	Organic Nitrogen: Dissolved.	Organic Nitrogen: Suspended	Nitrogen as: Nitrites	Nitrogen as: Nitrates	Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
9	July 3	July 5	VVS.	VS.	.3	None	396.	383.	13.	6.2	13.8	13.6	.2	.08	.56	.52	.04	.96	.92	.08	.013	.45	......	25.	29.	—	100,000
11	" 10	" 10	VVS.	VVS.	.2	"	410.	376.	34.	6.2	12.4	11.8	.6	.08	.53	.50	.03	.96	.84	.12	.018	.56	1.	24.	27.	......	500,000
13	" 17	" 17	M.	M.	.5	"	268.	190.	78.	3.1	15.	11.2	3.8	.10	.44	.36	.08	1.08	.80	.28	.038	.86	2.4	24.	29.	+	150,000
15	" 24	" 24	VS.	S.	.3	"	323.	309.	14.	4.3	13.8	12.8	1.	.08	.56	.48	.08	1.00	.80	.20	.01	.69	1.	26.	29.	+	280,000
17	" 31	" 31	VVS.	VVS.	.4	"	345.	337.	8.	5.1	12.2	12.	.2	.08	.56	.48	.08	.46	.46	....	.007	.0	1.	23.	27.	+	260,000
19	Aug. 7	Aug. 7	VS.	VVS.	.5	"	339.	335.	4.	7.	12.3	11.0	1.3	.08	.56	.52	.06	.88	.76	.12	......	.20	1.	23.	27.	+	520,000
21	" 14	" 14	VVS.	VVS.	.5	"	308.	308.	......	6.2	11.9	11.7	.2	.08	.616	.456	.16	.88	.88	....	.014	.0	......	......	......	+	287,500
23	" 21	" 22	VVS.	VVS.	....	"	366.	354.	12.	11.1	12.	12.	....	.04	.50	.47	.03	.74	.68	.06	.003	.40	1.2	24.	29.	—	62,000
25	" 28	" 28	VVS.	VVS.	....	"	332.	322.	10.	9.6	12.8	11.	1.8	.08	.50	.50	......	.82	.72	.10	.0	.10	1.	25.	29.	+	780,000
476	Sept. 4	Sept. 5	VVS.	VVS.	....	Gassy	321.	333.	......	9.6	13.4	13.2	.2	.08	.50	.48	.02	.86	.70	.16	.004	......	1.	21.	29.	+	....
478	" 11	" 12	VVS.	VVS.	....	None	308.	300.	......	8.2	12.4	12.	.4	.04	.55	.53	.02	1.14	1.00	.14	.008	.20	......	20.	26.	+	....
480	" 18	" 19	VVS.	VVS.	....	"	294.	287.	7.	9.	12.4	11.6	.8	.048	.50	.43	.07	.94	.74	.20	.006	.40	......	18.	21.	+	72,500
482	" 25	" 26	VVS.	VVS.	....	"	327.	317.	10.	7.	9.6	9.4	.2	......	.416	.40	.016	.72	.66	.06	.004	.20	......	15.5	20.	+	45,500
484	Oct. 2	Oct. 3	VVS.	VVS.	....	"	338.	343.	......	7.3	9.6	8.8	.8	.08	.44	.42	.02	.86	.70	.16	......	......	......	14.	24.	—	19,750
486	" 9	" 11	VVS.	VVS.	....	"	377.	372.	5.	8.6	9.6	9.4	.2	.04	.46	.44	.02	....	....	....	......	......	......	......	......	......	....
488	" 16	" 17	VVS.	VVS.	....	"	358.	351.	7.	9.1	9.6	9.	.6	.034	.48	.44	.04	.74	.58	.16	.002	.0	1.	20.	24.	+	35,000
490	" 23	" 24	VVS.	VVS.	....	"	373.	365.	8.	7.9	8.6	8.6	....	......	.41	.34	.07	.72	.64	.08	......	.0	1.	20.	23.	+	14,625
492	" 30	Nov. 1	VVS.	VVS.	....	"	434.	415.	19.	7.7	8.8	8.3	.5	.08	.36	.36	......	.58	.56	.02	.0	.0	1.4	14.	18.	+	32,250
494	Nov. 6	" 8	VVS.	VVS.	....	"	302.	298.	4.	12.2	9.5	8.1	1.4	.12	.56	......	......	1.00	.62	.38	.01	.0	1.	9.	20.	+	28,650
496	" 13	" 14	VVS.	VVS.	....	"	469.	465.	4.	14.8	8.	7.4	.6	......	.44	.36	.08	.74	.56	.18	.012	.30	1.	8.	......	+	24,250
498	" 20	" 21	VVS.	VVS.	....	"	459.	449.	10.	16.3	7.4	7.	.4	.04	.30	.28	.02	.62	.58	.04	......	.0	......	11.	18.	......	24,750
1001	" 27	" 28	VVS.	VVS.	....	"	461.	447.	14.	17.2	6.8	6.2	.6	.07	.32	.28	.04	.64	.62	.02	.005	.55	......	8.	18.	+	17,000
....	....	....	....	....	....	....	......	......	......	......	....	....	....	......	......	......	......	....	....	....	......	......	......	......	......	......	....

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 162.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—DESPLAINES RIVER, NORTH OF JACKSON ST., JOLIET.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am.												
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Suspd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Susp'nd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
62	July 3	July 5	VVH.	H.	Muddy	Gassy	530.	472.	58.	116.	29.2	14.2	15.	14.4	2.00	1.20	.80	3.88	2.28	1.60	......	.0	......	22.	24.	+	55,000
64	" 10	" 10	VH.	M.	"	"	585.	553.	32.	109.	27.6	16.0	11.6	13.00	2.00	1.36	.64	4.28	2.26	2.02	.003	1.00	......	21.5	19.	+	365,000
66	" 17	" 17	VH.	M.	.5	SlGas'y	508.	425.	83.	83.	26.	17.	9.	7.00	1.46	.85	.61	2.68	1.48	1.20	.028	.07	......	21.	19.	+	800,000
68	" 24	" 24	VH.	M.	.3	"	570.	538.	32.	93.	26.	19.6	6.4	12.00	1.60	1.30	.30	3.48	1.78	1.70	.003	.0	......	25.	23.	+	380,000
70	" 31	" 31	H.	VS.	Muddy	Gassy	540.	492.	48.	108.	26.0	16.4	9.6	11.40	1.60	.96	.64	3.08	2.02	1.06	.007	.10	......	22.	15.	+	280,000
72	Aug. 7	Aug. 8	VVH.	M.	.3	"	657.	487.	170.	109.	36.	15.2	20.8	20.00	2.00	1.30	.70	3.88	.....	.....	.21	.0	......	21.	10.5	+	4,202,000
74	" 14	" 14	VVH.	M.	.2	"	562.	447.	115.	107.	26.6	12.5	14.1	29.00	2.42	1.06	1.36	3.64	1.48	2.16	.002	.40	......	22.	15.	+	197,500
176	" 21	" 21	VVH.	M.	....	"	520.	466.	54.	106.	27.2	13.6	13.6	16.60	1.80	1.20	.60	3.00	1.60	1.40	.008	.40	......	24.	16.	—	355,000
178	" 28	" 28	VH.	VS.	....	"	534.	476.	58.	115.	32.4	17.4	15.	18.40	2.20	1.20	1.00	3.68	1.82	1.86	.008	.0	......	22.	18.	+	342,500
180	Sept. 4	Sept. 5	VH.	S.	....	"	535.	477.	58.	117.	25.2	13.8	11.4	19.40	1.97	.86	1.11	.....	1.32	.....	.18	.....	......	20.	15.	+	612,500
182	" 11	" 11	VH.	S.	....	"	506.	454.	52.	116.	25.2	13.2	12.	17.60	1.72	.94	.78	4.54	2.30	2.24	.0	.20	......	11.	17.	+	1,765,000
184	" 18	" 18	VVH.	VVS.	....	"	478.	416.	62.	111.	28.4	14.1	14.4	18.45	1.92	1.26	.66	3.64	1.80	1.84	.004	.20	......	18.	12.	+	385,000
187	" 25	" 25	VVH.	VS.	....	"	568.	491.	77.	123.	29.6	15.6	14.	18.60	2.00	1.06	.94	3.90	2.38	1.52	.006	.....	......	15.	9.	+	230,000
186	Oct. 2	....	....	....	....	....	......	......	......	......	.....	.....	.....	......	......	......	......	....	....	....	.....	.....	......	14.	9.	......	....
190	" 9	Oct. 11	VH.	S.	....	Gassy	522.	447.	75.	10.4	32.4	15.4	17.	14.00	2.52	1.30	1.22	....	....	....	.....	.....	......	22.	.....	......	....
191	" 16	" 17	VVH.	M.	....	"	467.	410.	57.	94.	27.2	17.	10.2	13.65	2.17	1.14	1.03	3.90	1.90	2.00	.17	.0	......	20.	16.	+	222,500
192	" 23	" 24	VVH.	S.	....	"	512.	449.	63.	110.5	31.2	15.4	15.8	16.00	2.68	1.58	1.10	4.14	2.22	1.92	.03	.....	......	13.	17.	+	205,500
193	" 30	" 31	VVH.	M.	....	"	554.	470.	84.	126.	32.8	19.4	13.4	14.40	2.68	1.74	.94	4.62	2.76	1.86	.01	.....	......	0.	2.	+	232,500
1330	Nov. 6	Nov. 7	VVH.	VS.	....	"	595.	547.	48.	139.	40.8	24.8	16.	16.00	2.92	1.90	1.02	4.70	2.42	2.28	.025	.0	......	—1.	—6.	+	255,000
1331	" 13	" 14	VVH.	S.	....	"	532.	479.	53.	118.	36.	20.4	15.6	13.02	2.80	1.36	1.44	4.70	2.70	2.00	.035	.0	......	3.	6.	......	....
1332	" 20	" 21	VVH.	VH.	....	"	830.	582.	248.	141.	53.6	19.6	34.	18.00	3.40	.94	2.46	6.06	2.30	3.76	.0	.0	......	8.	0.	+	1,300,000
1333	" 27	" 28	VVH.	H.	....	"	655.	482.	173.	112.	43.6	15.2	28.4	14.60	3.08	1.06	2.02	6.06	1.10	4.96	.005	.10	......	0.	—8.	+	900,000

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 163.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—DESPLAINES RIVER, SOUTH OF TOWN, JOLIET.

Report of ADOLPH GEHRMANN.
D. B. BISBEE.
Municipal Laboratory, Chicago, Ill.

Serial No.	DATE OF		APPEARANCE.			Odor	RESIDUE ON EVAPORATION.			Chlorine.	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am. Tot'l.	Albuminoid Am. Dissolv'd.	Albuminoid Am. Suspnd'd.	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
63	July 3	July 3	VVH.	H.	Muddy	SlGas'y	561.	483.	78.	117.5	28.	12.2	15.8	14.4	2.12	1.20	.92	3.56	2.16	1.42	......	.0	......	22.5	21.	+	52,250
65	" 10	" 10	VH.	M.	"	"	600.	551.	49.	105.	27.2	15.4	11.8	12.80	2.20	1.40	.80	4.28	2.16	2.12	.066	.80	......	21.	19.	+	365,000
67	" 17	" 17	VH.	H.	.45	"	582.	441.	141.	85.	29.2	16.2	13.	7.00	1.50	.63	.87	3.00	1.28	1.72	.04	.26	......	22.	19.	+	960,000
69	" 24	" 24	VVH.	H.	.2	Gassy	656.	536.	120.	94.	30.	16.8	13.2	12.00	2.00	1.00	1.00	3.68	1.48	2.20	......	.05	......	25.	23.	+	326,500
71	" 31	" 31	VH.	H.	.15	"	689.	493.	196.	108.	39.2	13.2	26.	11.40	2.24	.80	1.44	4.88	1.48	3.40	.0	.40	......	22.	18.	+	390,000
73	Aug. 7	Aug. 7	VVH.	H.	.3	"	731.	557.	174.	138.	40.4	14.4	26.	18.00	2.60	1.00	1.60	5.48	1.48	4.00	.018	.28	......	26.	18.	—	360,000
75	" 14	" 14	VH.	M.	.35	"	601.	513.	88.	114.	26.8	11.4	15.4	16.40	2.60	1.06	1.54	4.68	1.60	3.08	007	.40	......	22.	17.	......	55,000
177	" 21	" 21	VH.	H.	....	"	700	483.	217.	117.	27.2	20.2	7.	12.60	2.40	1.14	1.26	3.88	1.48	2.40	.023	.78	......	23.	18.	—	325,000
179	" 28	" 28	VH.	VH.	....	"	679.	514.	165.	119.	40.4	13.2	27.2	14.60	2.70	1.00	1.70	4.48	.88	3.60	.065	.04	......	23.	18.	+	483,500
181	Sept. 4	Sept. 5	S.	VH.	....	"	601.	507.	94.	131.	24.4	9.4	15.	14.00	2.00	.60	1.40	3.80	.56	3.24	.035	......	......	22.	17.	+	425,000
183	" 11	" 11	VH.	S.	....	"	503.	457.	46.	115.	27.6	12.2	15.4	17.40	2.12	1.06	1.06	4.46	1.52	2.94	.0	......	......	17.	12.	+	1,445,000
185	" 18	" 18	VVH.	VVS.	....	"	481.	427.	54.	111.	28.	15.2	12.8	17.60	1.72	1.16	.56	3.40	1.80	1.60	.08	.16	......	18.	11.5	+	435,000

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 164.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—KANKAKEE RIVER, WILMINGTON, ILL.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am.												
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved	By Suspd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Suspnd'd	Total.	Dissolved.	Suspended.	Nitrites	Nitrates					
80	July 3	July 3	VS.	VS.	.3	None	296.	280.	16.	2.6	11.6	11.2	.4	.08	.40	.37	.03	.65	.53	.12	.018	.63	.833	25.	22.	—	9,350
81	" 10	" 10	S.	M.	.1	"	316.	272.	44.	2.8	11.	8.8	2.2	.08	.40	.36	.04	.88	.76	.12	.014	.80	1.	23.	18.	......	....
82	" 17	" 17	VS.	M.	.1	"	363.	333.	30.	2.7	10.4	8.6	1.8	.07	.40	.33	.07	.88	.64	.24	.065	.43	1.6	23.	18.	+	21,065
83	" 24	" 24	VVS.	S.	.05	"	346.	293.	53.	3.	10.7	10.5	.2	.08	.48	.34	.14	.74	.44	.30	.008	.40	1.3	27.	26.	+	1,500
84	" 31	" 31	VH.	VVS.	.15	"	324.	265.	59.	3.1	11.4	8.2	3.2	.08	.52	.24	.28	.96	.36	.60	.01	.10	1.3	24.	16.	—	23,000
85	Aug. 7	Aug. 7	VH.	VS.	.3	"	340.	273.	67.	3.4	12.6	8.8	3.8	.04	.56	.36	.20	1.06	.56	.50	......	.20	1.	22.	18.	......	....
86	" 14	" 14	VH.	VS.	.15	"	319.	249.	70.	3.6	11.6	7.8	3.8	.65	.48	.32	.16	.88	.40	.48	.02	.40	1.	22.	17.	......	....
87	" 21	" 21	H.	VVS.	....	"	324.	253.	71.	3.7	10.9	7.8	3.1	.04	.45	.34	.11	.78	.42	.36	......	.60	1.	22.	22.	—	24,750
88	" 28	" 28	VH.	VS.	....	"	319.	252.	67.	4.4	13.4	8.7	4.7	.03	.50	.35	.15	.78	.48	.30	......	.20	1.	25.	20.	+	7,800
89	Sept. 4	Sept. 5	H.	M.	....	"	325.	254.	71.	4.8	10.6	7.4	3.2	.08	.43	.34	.09	.66	.34	.32	.009	......	1.	23.	17.	......	....
90	" 11	" 11	H.	VS.	....	"	297.	242.	55.	4.8	9.6	7.4	2.2	.08	.40	.32	.08	.80	.60	.20	.004	.40	1.	19.	16.	—	32,000
91	" 18	" 18	H.	VS	....	"	290.	230.	60.	4.4	10.	6.9	3.1	.04	.36	.29	.07	.80	.60	.20	.007	.20	1.	20.	16.	+	45,000
92	" 25	" 25	H.	VVS.	....	"	285.	249.	36.	5.1	8.8	6.8	2.	....	.206	.202	.004	1.46	1.42	.04	......	......	1.	11.	16.	+	44,000
93	Oct. 2	Oct. 2	VS.	VVS.	....	"	263.	245.	18.	4.6	6.9	6.	.9	....	.25	.25	......	.50	.42	.08	.0	......	.8	8.	10.	—	14,350
94	" 9	" 11	M.	VS.	....	"	290.	258.	32.	4.6	6.7	5.6	1.1	.02	.29	.22	.07	....	....	....	......	.. ..	1.	13.	7.	......	....
95	" 16	" 16	M.	VS.	....	"	300.	257.	43.	4.4	6.4	4.6	1.8	....	.25	.20	.05	.58	.36	.22	......	.10	1.	19.	19.	+	37,500
96	" 23	" 23	M.	VS.	....	"	293.	257.	36.	4.6	5.8	4.6	1.2	.06	.25	.22	.03	.46	.30	.16	.0	.0	1.	14.	18.	+	19,500
97	" 30	" 30	M.	VVS.	....	"	254.	242.	12.	4.3	5.1	4.5	.6	....	.18	.15	.03	.38	.24	.14	.005	......	1.	10.	17.	+	35,000
98	Nov. 6	Nov. 6	VS	VVS.	....	"	279.	275.	4.	4.3	5.6	4.	1.6	.016	.23	.21	.02	.48	.40	.08	.0	.0	1.2	5.	1.	......	....
99	" 13	" 13	VVS.	VVS.	....	"	333.	324.	......	3.8	7.6	7.2	.4	.033	.28	.23	.05	.76	.82	....	.003	2.00	1.5	5.	7.	+	19,000
100	" 20	" 21	VVS.	VVS.	....	"	334.	313.	21.	3.3	8.8	8.3	.5	.08	.31	.25	.06	.78	.72	.06	.027	2.80	1.8	8.	5.	+	30,000
1878	" 27	" 27	VS.	VS.	....	"	322.	307.	15.	3.0	10.0	9.3	.7	.02	.30	.28	.02	.74	.74	....	.015	2.38	1.6	5.	0.	+	5,250

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium,

TABLE 165.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, MORRIS, ILL.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Il

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended	Nitrites	Nitrates					
															Tot'l	Dissolv'd	Suspend'd										
106	July 3	July 3	VS.	VS.	.25	None	389.	380.	9.	57.	15.	14.2	.8	7.00	.68	.52	.16	1.48	1.16	.32	.02	.60	5.2	26.	21.	—	19,65
107	" 11	" 12	VVS.	S.	.4	"	464.	450.	14.	72.	16.4	14.	2.4	8.71	.88	.76	.12	1.56	1.08	.48	.13	.67	5.3	24.	19.	—	75,60
108	" 17	" 17	VS.	M.	.1	"	380.	327.	53.	39.	13.4	10.8	2.6	4.60	.56	.40	.16	1.16	.88	.28	.11	.....	7.5	24.	18.	+	100,00
109	" 25	" 25	VS.	VS.	.25	"	448.	439.	9.	57.5	13.8	11.8	2.	7.75	.68	.60	.08	1.08	.76	.32	.08	.67	6.3	27.	22.	+	716,00
110	" 31	" 31	M.	VVS.	.25	"	428.	417.	11.	64.	14.4	12.	2.4	10.00	.90	.70	.20	1.62	1.08	.54	.01	.29	6.	24.	13.	+	772,50
111	Aug. 7	Aug. 8	M.	VVS.	.3	"	423.	428.	......	72.	14.2	11.8	2.4	11.00	1.03	.67	.36	1.68	1.20	.48	.01	.20	6.3	23.	14.	+	700,00
112	" 14	" 15	VS.	VVS.	.3	"	401.	395.	6.	79.	14.4	10.7	3.7	12.00	1.35	.70	.65	1.68	.98	.70	.004	.20	5.8	21.	14.	—	26,50
113	" 21	....	....	....	....	....	413.	400.	13.	71.	14.2	11.2	3.	9.70	.90	.60	.30	1.68	1.12	.56	.017	.40	5.1	25.	19.	+	632,75
114	" 29	" 30	S.	VS.	....	None	463.	452.	11.	96.5	15.8	13.2	2.6	15.00	1.10	.87	.23	1.74	1.34	.40	1.08	.12	4.1	26.	17.	+	900,00
115	Sept. 4	Sept. 5	VVS.	M.	....	"	451.	437.	14.	96.	14.2	12.4	1.8	13.50	.82	.67	.15	1.74	1.08	.66	.075	.....	4.1	25.	14.	+	500,00
116	" 12	" 13	M.	VVS.	....	"	445.	429.	16.	100.	16.6	12.8	3.8	14.50	1.40	.77	.63	2.60	2.10	.50	.16	.04	5.3	29.	16.	+	997,00
117	" 19	" 20	VS.	VS.	....	"	417.	408.	9.	94.	15.	12.2	2.8	13.60	.92	.65	.27	1.80	1.24	.56	.37	.0	5.2	13.	11.	+	600,00
118	" 25	" 27	VS.	S.	....	"	455.	446.	9.	97.5	16.8	12.2	4.6	13.60	.99	.69	.30	1.62	1.02	.60	.14	.26	5.6	17.	10.	+	161,50
119	Oct. 2	Oct. 3	M.	S.	....	"	459.	436.	23.	97.	16.2	11.6	4.6	12.60	1.00	.60	.40	1.76	1.02	.74	.18	.08	5.4	10.	12.	+	39,25
120	" 16	" 17	VS.	S.	....	"	343.	331.	12.	63.	11.	9.2	1.8	8.00	.66	.56	.10	1.02	.80	.22	.052	.15	5.6	20.	19.	+	56,25
121	" 23	" 24	M.	VS.	....	"	403.	390.	13.	74.5	15.	11.6	3.4	10.60	1.44	.70	.74	2.08	1.22	.86	.012	.0	5.6	15.	16.	+	255,00
122	" 30	" 31	M.	M.	....	"	397.	386.	11.	78.	17.4	11.6	5.8	10.00	1.50	.88	.62	2.58	1.50	1.08	.008	.0	5.1	10.	—2.	+	647,750
123	Nov. 6	Nov. 7	M.	VS.	....	"	402.	378.	24.	65.5	15.	10.6	4.4	7.60	1.10	.66	.44	2.24	1.16	1.08	.08	.17	5.6	16.	—4.	+	627,000
124	" 14	" 15	M.	M.	....	Slight	401.	380.	21.	55.5	16.	11.	5.	6.40	1.06	.66	.40	2.04	1.38	.66	.065	1.64	6.3	8.	7.	—	282,250
125	" 20	" 22	M.	M.	....	"	409.	382.	27.	47.5	14.8	11.2	3.6	7.00	.88	.58	.30	1.54	1.18	.36	.09	1.61	6.3	9.	1.	+	246,000
1353	" 27	" 28	MH.	M.	....	"	410.	417.	......	55.5	19.2	12.8	6.4	8.00	1.26	.76	.50	2.30	1.54	.76	.09	1.11	6.3	6.	—4.	+	73,500

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 166.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—FOX RIVER, OTTAWA, ILL.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspend'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
134	July 3	July 3	VVS.	VS.	.1	None	306.	300.	6.	4.8	7.3	7.2	.1	.12	.32	.31	.01	.52	.44	.08	.025	.28	3.	28.	35.	−	12,350
136	" 10	" 11	VS.	VVS.	.05	"	308.	288.	20.	5.0	7.	7.2	....	.06	.32	.30	.02	.68	.52	.16	.0	.80	9.	28.	33.	+	13,500
138	" 17	" 18	S.	H.	.1	"	417.	283.	134.	3.9	15.6	9.2	6.4	.06	.84	.40	.44	1.56	.64	.92	.025	1.07	5.	26.	32.	......	....
140	" 24	" 25	VS.	S.	.15	"	248.	215.	33.	4.	10.8	8.	2.8	.07	.40	.40	......	1.00	.60	.40	......	.20	3.	28.	35.	+	11,250
142	" 31	Aug. 1	VS.	VVS.	.2	"	289.	276.	13.	4.7	8.2	8.1	.1	.08	.42	.40	.02	.68	.58	.10	.01	.19	3.	25.	32.	−	29,500
144	Aug. 7	" 9	VVS.	VVS.	.15	"	303.	289.	14.	4.9	8.4	7.9	.5	.05	.44	.37	.07	.82	.62	.20	......	.20	4.	27.	33.	......	13,000
146	" 14	" 15	VS.	VVS.	.15	"	305.	301.	4.	6.4	7.8	7.8	.0	.06	.46	.36	.10	.66	.56	.10	.0	.40	3.6	26.	29.	......	13,000
148	" 21	" 22	None	VVS.	....	"	303.	281.	22.	5.6	8.2	8.1	.1	.04	.41	.40	.01	.76	.70	.06	......	.30	4.	28.	33.	......	4,900
150	" 28	" 29	VVS.	VVS.	....	"	299.	281.	18.	6.3	9.	7.7	1.3	.04	.46	.41	.05	.68	.56	.12	.0	.20	3.	31.	37.	......	....
824	Sept. 4	Sept. 5	VS.	S.	....	"	323.	318.	5.	7.5	9.	8.6	.4	.10	.42	.45	......	.72	.60	.12	.0	.20	3.6	26.	31.	......	....
802	" 11	" 12	VVS.	VS.	....	"	285.	271.	14.	5.6	8.3	7.9	.4	.012	.38	.38	......	.66	.62	.04	.0	.20	4.	25.	26.	......	....
804	" 18	" 19	VS.	S.	....	"	290.	280.	10.	6.1	7.6	7.4	.2	.02	.36	.34	.02	.66	.60	.06	......	.0	4.	21.	24.	......	....
806	" 25	" 26	VVS.	VVS.	....	"	311.	298.	13.	6.8	7.1	6.8	.3	......	.36	.30	.06	.58	.54	.04	.006	.10	4.	18.5	22.	+	7,750
808	Oct. 2	Oct. 3	VVS.	VVS.	....	"	313.	322.	......	6.8	6.5	6.4	.1	......	.31	.30	.01	.60	.54	.06	.0	......	4.	16.	24.	−	12,250
810	" 9	" ..	VS.	VS.	....	....	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	....
812	" 16	" 17	VVS.	VVS.	....	None	326.	319.	7.	6.7	6.6	6.3	.3	......	.32	.32	......	.54	.54	......	.008	......	4.	17.	30.	+	30,650
814	" 23	" 24	VVS.	VVS.	....	"	322.	337.	......	7.4	6.4	6.4	....	......	.31	.33	......	.62	.58	.04	.005	.0	4.5	17.5	31.	+	10,000
816	" 30	" 31	VVS.	VVS.	....	"	291.	291.	......	7.	6.2	6.3	....	.028	......	.31	......	.64	.54	.10	.012	.10	4.	13.	23.	+	21,500
818	Nov. 6	Nov. 7	VVS.	VVS.	....	"	302.	298.	4.	7.	5.9	5.9	....	......	.29	.25	.04	.54	.48	.06	.004	.0	4.	9.	21.	+	11,500
820	" 13	" 14	VVS.	VVS.	....	"	306.	306.	......	6.5	6.2	6.	.2	......	.28	.28	......	.42	.42	....	.008	.80	3.6	9.5	10.	−	10,500
1304	" 27	" 28	VVS.	VVS.	....	"	308.	302.	6.	6.8	6.1	5.7	.4	.05	.28	.28	......	.50	.50	....	.03	.73	3.6	7.	8.	−	18,500

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 167.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, OTTAWA, ILL.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of: 1899 Collection.	Date of: 1899 Examination.	Appearance: Turb'y.	Appearance: Sediment.	Appearance: Color.	Odor	Residue on Evaporation: Total.	Residue on Evaporation: Dissolved.	Residue on Evaporation: Suspended	Chlorine.	Oxygen Consumed: Total.	Oxygen Consumed: By Dissolved.	Oxygen Consumed: By Susp'd Matter.	Nitrogen as Ammonia: Free Ammonia.	Nitrogen as Ammonia: Albuminoid Am.: Tot'l	Nitrogen as Ammonia: Albuminoid Am.: Dissolv'd	Nitrogen as Ammonia: Albuminoid Am.: Suspend'd	Organic Nitrogen: Total.	Organic Nitrogen: Dissolved.	Organic Nitrogen: Suspended	Nitrogen as: Nitrites	Nitrogen as: Nitrates	Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
133	July 3	July 3	VVS.	VS.	.25	None	373.	371.	2.	42.	13.6	12.6	1.	3.82	.50	.46	.04	1.08	1.08	.0	.75	1.40	3.5	27.	35.	......	85,000
135	" 10	" 11	VVS.	VVS.	.1	"	408.	394.	14.	65.	12.2	12.2	....	2.70	.51	.48	.03	1.32	1.00	.32	.75	3.00	4.	27.	33.	—	138,500
137	" 17	" 18	S.	None	.05	"	403.	344.	50.	44.5	12.2	9.6	2.6	4.80	.52	.40	.12	1.00	.76	.24	.44	1.06	6.	25.	32.	......	....
139	" 24	" 25	VS.	S.	.2	"	407.	388.	19.	37.	11.8	10.	1.8	1.60	.56	.40	.16	.96	.76	.20	.60	1.60	4.	29.	35.	+	25,650
141	" 31	Aug. 1	VS.	VS.	.1	"	427.	413.	14.	56.	11.4	10.	1.4	4.47	.75	.54	.21	1.28	.94	.34	.68	.92	4.	26.	32.	+	50,000
143	Aug. 7	" 9	VVS.	VVS.	.3	"	386.	378.	8.	54.	10.8	10.4	.4	3.60	.43	.41	.02	1.08	.98	.10	.54	1.71	3.	28.	33.	+	16,750
145	" 14	" 15	VVS.	VVS.	.3	"	377.	383.	......	60.	10.3	9.3	1.	4.96	.48	.48	.0	.88	.88	.0	.56	1.90	3.	24.	29.	+	13,000
147	" 21	" 22	None	VVS.	....	"	412.	398.	14.	68.	11.2	10.4	.8	3.30	.45	.42	.03	.96	.96	....	.90	2.80	3.	27.	33.	+	35,750
149	" 28	" 29	VVS.	VVS.	....	"	440.	410.	30.	80.	12.6	11.4	1.2	4.87	.70	.55	.15	1.18	1.00	.18	1.20	2.10	4.	30.	37.	+	30,750
855	Sept. 4	Sept. 5	VVS.	VVS.	....	"	442.	......	......	90.	11.	10.4	.6	5.20	.55	.51	.04	1.00	.86	.14	.80	....	3.	25.	30.	—	100,000
801	" 11	" 12	VVS.	S.	....	"	444.	423.	21.	96.	11.6	10.4	1.2	6.87	.63	.50	.13	1.40	1.00	.40	1.30	1.40	3.6	24.	27.	+	....
803	" 18	" 19	VVS.	S.	....	"	416.	398.	18.	96.	11.6	10.4	1.2	10.00	.63	.50	.13	1.06	1.00	.06	.40	1.90	3.6	20.5	24.	+	46,000
805	" 25	" 26	VVS.	S.	....	"	415.	407.	8.	85.	10.	9.8	.2	7.00	.51	.50	.01	....	.88	....	.40	2.28	3.	18.	23.	+	60,000
807	Oct. 3	Oct. 3	VVS.	VVS.	....	"	451.	451.	......	98.5	10.2	10.2	....	8.20	.52	.52	......	.96	.90	.06	.30	2.50	3.	15.	24.	+	25,000
809	" 9	" ..	VVS.	VVS.	....	....	......	......	......	......	....	....	....	......	......	......	......	....	....	....	....	....	3.	16.	25.	......	....
811	" 16	" 17	VVS.	VVS.	....	None	374.	375.	......	72.	10.8	9.4	1.4	10.50	.66	.52	.14	.96	.90	.06	.15	.06	3.	18.	26.	+	41,500
813	" 23	" 24	VVS.	VVS.	....	"	366.	363.	3.	69.	8.8	8.	.8	6.30	.44	.42	.02	.78	.74	.04	.60	1.30	3.	18.	26.	+	29,350
815	" 30	" 31	VVS.	VVS.	....	"	338.	338.	......	64.5	7.8	7.4	.4	8.20	.44	.42	.02	.68	.66	.02	.28	.22	3.6	13.5	23.	+	19,750
817	Nov. 6	Nov. 7	VVS.	VVS.	....	"	375.	377.	......	65.	10.	9.2	.8	7.30	.50	.44	.06	1.12	.76	.36	.14	.51	3.	8.	21.	+	37,500
820	" 13	" 14	....	VVS.	....	"	344.	342.	2.	41.	8.8	8.2	.6	4.70	.42	.36	.06	.74	.70	.04	.22	1.28	3.	9.	10.	+	10,750
1303	" 27	" 27	VS.	VVS.	....	"	393.	386.	7.	46.	10.4	10.2	.2	5.53	.48	.48	......	.94	.90	.04	.36	1.84	3.	7.	8.	+	19,000

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 168.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—BIG VERMILLION RIVER, LA SALLE, ILL.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am.												
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Susp'd Matter	Free Ammonia.	Tot'l	Dissolv'd	Suspnd'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
169	July 4	July 5	VS.	S.	.0	None	706.	684.	22.	42.	4.2	3.2	1.	.11	.24	.16	.08	.38	.32	.06	.03	1.17	9.1	......	......	—	11,250
172	" 11	" 12	VVS.	VS.	.05	"	352.	314.	38.	10.	5.1	4.7	0.4	.08	.28	.22	.06	.68	.56	.12	.045	4.66	9.11	......	......	—	15,250
378	" 18	" 19	S.	M.	.05	"	424.	385.	39.	18.5	9.2	7.8	1.4	.52	.44	.34	.10	1.00	.84	.16	.15	2.00	11.6	......	......	......	......
379	" 25	" 26	VS.	M.	.05	"	532.	513.	19.	24.5	4.6	4.1	.5	.10	.24	.14	.10	.40	.36	.04	.03	1.67	9.11	......	......	—	26,250
382	Aug. 1	Aug. 2	S.	S.	.0	"	748.	708.	40.	40.	4.	3.8	.2	.12	.22	.18	.04	.52	.52	....	.008	1.35	9.5	......	......	—	22,650
385	" 8	" 9	M.	VVS.	.05	"	982.	917.	65.	54.	5.4	4.1	1.3	.15	.32	.21	.11	.68	.40	.28	.012	.69	9.3	......	......	......	......
388	" 15	" 16	M.	M.	.05	"	638.	598.	40.	33.5	6.	4.	2.	.148	.302	.198	.104	.60	.28	.32	.007	.65	9.1	......	......	+	20,000
391	" 22	" 23	M.	M.	......	"	638.	564.	74.	38.	7.8	4.5	3.3	.20	.52	.30	.22	.76	.36	.40	.01	.09	9.3	......	......	+	4,600
394	" 29	" 30	M.	M.	......	"	805.	735.	70.	54.	8.	4.7	3.3	.72	.41	.24	.17	.74	.28	.46	.015	.09	......	......	......	+	28,833
397	Sept. 5	Sept. 6	M.	H.	......	"	1049.	973.	76.	68.5	8.1	5.	3.1	.36	.40	.25	.15	.70	.20	.50	.013	.0	9.2	......	......	+	34,000
400	" 12	" 13	M.	M.	......	"	1134.	1101.	33.	83.5	7.	4.7	2.3	.19	.37	.22	.15	.82	.68	.14	.005	.20	......	......	......	......	......
403	" 19	" 20	S.	M.	......	"	1230.	1191.	39.	7.	6.4	4.5	1.9	.14	.23	.10	.13	.80	.44	.36	.008	.26	......	......	......	+	30,750
406	" 26	" 27	M.	M.	......	"	1782.	1743.	39.	137.	5.5	4.	1.5	.19	.30	.16	.14	.48	....	....	.02	.18	......	......	......	+	39,000
409	Oct. 3	Oct. 4	M.	S.	......	"	1659.	1619.	40.	13.0	5.4	3.2	2.2	.13	.24	.18	.06	.52	.38	.14	.02	.28	9.5	......	......	+	22,750
412	" 10	" 11	M.	VS.	......	"	1831.	1792.	39.	122.5	4.7	3.3	1.4	.15	.20	.16	.04	.54	.48	.06	.....	.20	......	......	......	......	23,000
415	" 17	" 18	M.	M.	......	"	1634.	1591.	43.	128.	5.	3.	2.	.12	.19	.13	.06	.44	.22	.22	.018	.18	9.7	......	......	+	20,000
418	" 24	" 25	M.	S.	......	"	1618.	1567.	51.	110.5	4.6	2.9	1.7	.08	.20	.14	.06	.48	.26	.22	.01	.0	......	......	......	+	24,000
421	" 31	Nov. 1	VVS.	VVS.	......	"	1675.	1644.	31.	117.5	4.1	....	....	.04	.21	.17	.04	.56	.38	.18	.007	.10	......	......	......	+	21,500
1378	Nov. 7	" 8	VVS.	VVS.	......	"	1661.	1645.	16.	121.	2.9	2.5	.4	.48	.16	.13	.03	.36	.24	.12	.014	.64	......	......	......	+	29,750
1381	" 14	" 15	VVS.	VVS.	......	"	1788.	1754.	34.	131.5	2.8	2.4	.4	.76	.12	.11	.01	.80	.30	.50	.012	1.90	......	......	......	—	33,350
1384	" 21	" 22	VS.	VVS.	......	"	1327.	1336.	......	84.	3.1	2.5	.6	.48	.16	.12	.04	.32	.32	....	.032	.97	......	......	......	......	......
1387	" 28	" 29	VVS.	VVS.	......	"	1591.	1581.	10.	105.	2.3	....	....	.60	.12	.08	.04	.30	.28	.02	.035	.84	......	......	......	+	10,650
....	......	......	......	......	......	......	......	......	......	......	....	....	....	......	......	......	......	....	....	....	.....	.....	......	......	......	......	......

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

Table 169.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

Source of Water—Illinois and Michigan Canal, La Salle, Ill.

Report of Adolph Gehrmann,
D. B. Bisbee,
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am.												
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Tot'l.	Dissolv'd.	Susp'd.	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
171	July 4	July 5	VS.	S.	.15	None	346.	301.	45.	12.5	10.8	8.8	2.	.72	.58	.40	.18	1.04	.88	.16	.043	.56	9.1	......	......	+	22,650
174	" 11	" 12	VVS.	S.	.1	"	375.	326.	49.	13.0	12.2	8.6	3.6	.32	.80	.42	.38	1.24	.92	.32	.07	.53	9.1	......	......	—	60,000
377	" 18	" 19	VS.	M.	.06	"	383.	332.	51.	10.	7.	5.6	1.4	.06	.26	.18	.08	.56	.40	.16	.055	4.04	11.6	......	......	+	43,000
381	" 25	" 26	VS.	S.	.1	"	348.	323.	25.	15.	8.	7.	1.	.54	.36	.28	.08	.76	.60	.16	.075	.43	9.11	......	......	+	77,000
384	Aug. 1	Aug. 2	S.	M.	.25	"	313.	276.	37.	13.5	9.	7.6	1.4	.70	.58	.36	.22	.76	.38	.38	.06	.39	9.5	......	......	+	99,250
387	" 8	" 9	M.	VVS.	.25	"	308.	279.	29.	13.	8.7	7.8	.9	.78	.48	.40	.08	1.08	.96	.12	.045	.16	9.3	......	......	+	81,000
390	" 15	" 16	VVS.	S.	.1	"	331.	307.	24.	12.5	9.3	7.2	2.1	.68	.48	.34	.14	1.04	.84	.20	.033	.37	9.1	......	......	—	29,750
393	" 22	" 23	VS.	M.	......	"	346.	298.	48.	13.	10.8	7.8	3.	.77	.58	.45	.13	.90	.84	.06	.06	.....	9.3	......	......	—	199,000
396	" 29	" 30	M.	VS.	......	"	337.	313.	24.	14.5	9.5	8.3	1.2	.68	.52	.40	.12	.94	.78	.16	.122	.28	9.3	......	......	+	433,333
399	Sept. 5	Sept. 6	M.	H.	......	"	362.	325.	37.	16.5	10.2	8.5	1.7	.55	.51	.41	.10	.90	.70	.20	.027	.22	9.2	......	......	+	45,000
402	" 12	" 13	M.	H.	......	"	382.	325.	57.	18.0	12.2	8.2	4.	.67	.55	.37	.18	1.26	1.14	.12	.043	.06	9.3	......	......	—	103,500
405	" 19	" 20	S.	M.	......	"	413.	346.	67.	21.5	11.8	8.3	3.5	.75	.54	.37	.17	1.12	1.06	.06	.08	.59	9.5	......	......	+	98,000
408	" 26	" 27	M.	M.	......	"	384.	311.	73.	21.5	11.6	7.7	3.9	.62	.59	.36	.23	1.14	.71	.43	.02	.18	9.4	......	......	+	88,665
411	Oct 3	Oct. 4	M.	S.	......	"	362.	334.	28.	18.	9.6	6.9	2.7	.50	.56	.40	.16	.74	.70	.04	.12	.18	9.4	......	......	+	108,500
414	" 10	" 11	M.	M.	......	"	383.	336.	47	15.	10.2	6.7	3.5	.48	.45	.31	.14	1.02	.98	.04	.....	.....	9.5	......	......	+	85,000
417	" 17	" 18	M.	M.	......	"	368.	319.	49.	17.	10.	7.2	2.8	.56	.48	.34	.14	1.02	.66	.36	.11	.....	9.7	......	......	+	71,500
420	" 24	" 25	M.	M.	......	"	388.	340.	48.	15.5	9.6	6.2	3.4	.456	.44	.30	.14	.86	.62	.24	.07	.0	9.7	......	......	+	104,000
423	" 31	Nov. 1	M.	S.	......	"	392.	346.	46.	17.	11.	6.2	4.8	.46	.51	.40	.11	.94	.60	.34	.043	.06	9.9	......	......	+	194,350
1380	Nov. 7	" 8	VS.	S.	......	"	370.	350.	20.	16.	7.6	6.2	1.4	.40	.42	.34	.08	.94	.60	.34	.035	.0	9.9	......	......	+	91,500
1383	" 14	" 15	M.	S.	......	"	340.	309.	31.	14.	10.2	6.5	3.7	.12	.58	.32	.26	1.18	.60	.58	.006	.30	10.3	......	......	—	66,750
1386	" 21	" 22	M.	S.	......	"	348.	324.	24.	15.	9.4	6.3	3.1	.22	.55	.29	.26	1.10	.78	.32	.03	.37	10.	......	......	+	167,500
1389	" 28	" 29	M.	VS.	......	"	351.	330.	21.	13.5	7.6	5.8	1.8	.32	.44	.24	.20	1.02	.80	.22	.025	.08	10.2	......	......	+	150,000
....	....	....	....	....	....	....	......	......	......	......	....	....	....	......	......	......	......	....	....	....	.....	.....	......	......	......	......	....

Appearance—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium,

TABLE 170.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, LA SALLE, ILL.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended	Nitrites	Nitrates					
															Tot'l	Dissolv'd	Suspnd'd										
170	July 4	July 5	VS.	S.	.25	None	427.	389.	38.	41.	14.	11.4	2.6	1.10	.60	.40	.20	1.24	1.08	.16	.05	2.05	9.1	......	......	+	4,000
173	" 11	" 12	VVS.	VS.	.30	"	433.	410.	23.	63.5	12.8	10.8	2.	2.80	.62	.48	.14	1.16	.95	.21	.55	2.96	9.9	......	......	−	40,000
376	" 18	" 19	VS.	M.	.1	"	371.	313.	58.	30.	13.6	9.8	3.8	2.00	.64	.38	.26	1.20	.96	.24	.44	2.08	11.6	......	......	+	43,650
380	" 25	" 26	VS.	M.	.15	"	453.	356.	97.	32.	14.	9.4	4.6	.08	.56	.34	.22	1.64	.68	.96	.40	1.70	9.11	......	......	+	44,000
383	Aug. 1	Aug. 2	S.	H.	.35	"	470.	402.	68.	45.	13.	9.4	3.6	1.25	.70	.40	.30	2.08	1.38	.70	.80	2.60	9.5	......	......	+	48,650
386	" 8	" 9	M.	M.	.35	"	430.	381.	49.	47.5	11.4	8.6	2.8	.84	.48	.41	.07	1.16	.84	.32	.70	2.00	9.3	......	......	−	68,000
389	" 15	" 16	VS.	S.	.3	"	412.	385.	27.	57.5	10.8	9.	1.8	1.60	.536	.40	.136	1.20	1.00	.20	.70	2.25	9.1	......	......	+	11,250
392	" 22	" 23	VS.	S.	....	"	422.	395.	27.	65.	11.	9.8	1.2	1.50	.73	.47	.26	1.18	.92	.26	.85	2.10	9.3	......	......	+	21,500
395	" 29	" 30	M.	S.	....	"	429.	402.	27.	70.	12.4	10.8	1.6	1.70	.60	.44	.16	1.18	.92	.26	.70	2.50	9.4	......	......	+	40,000
398	Sept. 5	Sept. 6	M.	H.	....	"	501.	445.	56.	79.	12.4	10.	2.4	2.97	.63	.43	.20	1.06	.80	.26	1.10	1.96	9.2	......	......	−	21,000
401	" 12	" 13	S.	M.	....	"	443.	425.	18.	72.5	10.8	9.4	1.4	4.40	.50	.40	.10	1.00	.94	.06	.65	1.05	9.4	......	......	+	77,500
404	" 19	" 20	S.	M.	....	"	433.	393.	40.	75.5	11.	9.	2.	4.68	.48	.44	.04	1.04	.90	.14	.33	1.37	9.4	......	......	+	86,000
407	" 26	" 27	S.	S.	....	"	418.	389.	29.	73.5	9.8	9.2	.6	6.33	.456	.44	.016	.86	.78	.08	.28	2.12	9.5	......	......	+	41,750
410	Oct. 3	Oct. 4	S.	VS.	....	"	464.	446.	18.	83.	10.	9.4	.6	6.87	.56	.50	.06	1.02	.98	.04	.80	1.80	9.5	......	......	+	....
413	" 10	" 11	S.	S.	....	"	450.	438.	12.	76.5	11.	9.8	1.2	6.63	.50	.48	.02	1.26	1.04	.22	.....	.....	9.	......	......	+	66,000
416	" 17	" 18	M.	S.	....	"	414.	386.	28.	68.	10.8	8.6	2.2	5.67	.52	.42	.10	1.02	.82	.20	.36	1.44	9.8	......	......	+	34,750
419	" 24	" 25	S.	S.	....	"	381.	369.	12.	50.	9.2	7.6	1.6	4.66	.42	.40	.02	.78	.72	.06	.36	1.54	9.8	......	......	+	38,500
422	" 31	Nov. 1	S.	S.	....	"	364.	350.	14.	53.	7.8	7.4	.4	5.33	.48	.40	.08	.72	.70	.02	.36	1.24	9.11	......	......	+	35,750
1379	Nov. 7	" 8	VVS.	VVS.	....	"	382.	372.	10.	55.	8.4	8.	.4	5.33	.40	.40	......	.96	.66	.30	.14	.76	9.11	......	......	+	24,500
1382	" 14	" 15	VVS.	VVS.	....	"	340.	326.	14.	31.	8.4	7.6	.8	3.00	.36	.34	.02	.74	.74	.....	.16	1.34	10.3	......	......	−	22,250
1385	" 21	" 22	VVS.	VVS.	....	"	354.	354.	......	35.5	8.6	8.	.6	3.13	.40	.32	.08	1.02	.78	.24	.36	2.04	10.4	......	......	+	83,750
1388	" 28	" 29	VVS.	VS.	....	"	381.	373.	8.	30.	10.	8.8	1.2	3.60	.40	.38	.02	.72	.....	.....	.36	1.94	10.2	......	......	+	59,250
....	....	....	....	....	....	....	......	......	......	......	....	....	....	......	......	......	......	....	....	....	.....	.....	......	......	......	......	....

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 171.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, HENRY, ILL.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of 1899 Collection.	Date of 1899 Examination.	Appearance. Turb'y.	Appearance. Sediment.	Appearance. Color.	Odor	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Susp'd Matter.	Free Ammonia.	Nitrogen as Ammonia. Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspend'd	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended	Nitrogen as Nitrites	Nitrogen as Nitrates	Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
206	July 5	July 6	S.	M.	.25	None	392.	367.	25.	36.5	16.6	12.2	4.4	.67	.96	.52	.44	1.96	1.05	.91	.....	.....	7.5	29.	29.	+	36,750
208	" 18	" 19	VS.	M.	.2	"	346.	272.	74.	24.	12.6	9.6	3.0	1.45	.60	.34	.26	1.24	.80	.44	.28	1.97	.....	.....	.....	+	19,000
209	" 26	" 27	VS.	M.	.3	"	376.	357.	19.	29.5	10.6	9.	1.6	.28	.52	.42	.10	1.00	.84	.16	.28	1.82	8.	31.	31.	−	12,500
210	Aug. 2	Aug. 3	M.	M.	.3	"	429.	376.	53.	38.	12.2	10.6	1.6	1.11	.70	.50	.20	1.38	1.02	.36	.32	1.88	8.	29.	29.	+	12,000
211	" 8	" 9	M.	M.	.35	"	441.	412.	29.	46.5	10.2	8.2	2.	1.34	.46	.38	.08	1.14	.76	.38	.35	1.35	7.	26.	23.	+	253,750
212	" 15	" 16	S.	M.	.3	"	419.	388.	31.	47.5	9.6	7.8	1.8	1.00	.50	.344	.156	1.13	.71	.42	.30	2.00	8.	25.	22.	+	11,000
213	" 22	" 23	VS.	S.	....	"	424.	392.	32.	57.5	20.4	12.4	8.	1.26	2.10	.90	1.20	3.78	1.56	2.22	.45	1.35	6.8	28.	29.	+	34,750
214	" 29	" 30	S.	M.	....	"	436.	390.	46.	63.	11.	10.	1.	.96	.80	.50	.30	1.74	.98	.76	.40	1.55	6.8	28.	27.	+	290,000
215	Sept. 6	Sept. 7	S.	M.	....	"	420.	386.	34.	64.5	13.0	10.8	2.2	.92	.75	.43	.32	1.46	.90	.56	.80	1.06	6.8	29.	30.	+	50,000
216	" 12	" 13	S.	M.	....	"	439.	399.	40.	63.	12.4	9.	3.4	1.25	.68	.40	.28	1.70	1.06	.64	.38	.97	6.8	20.	21.	−	52,000
217	" 19	" 20	S.	M.	....	"	430.	398.	32.	71.5	13.	9.8	3.2	2.90	.82	.41	.41	1.80	1.00	.80	.90	.96	7.1	21.	21.	+	49,000
218	" 26	" 27	M.	S.	....	"	428.	388.	40.	70.	13.4	9.6	3.8	1.33	.80	.40	.40	1.54	.78	.76	1.95	1.75	7.	18.	20.	+	31,333
219	Oct. 3	Oct. 4	M.	S.	....	"	440.	401.	39.	68.	14.	9.2	4.8	3.60	.95	.38	.57	.88	.....	.....	.70	2.10	7.	15.	14.	+	28,750
220	" 10	" 11	S.	S.	....	"	477.	444.	33.	76.5	12.2	8.2	4.	4.52	.74	.44	.30	1.50	.84	.66	.....	2.40	7.1	13.	16.	+	48,500
221	" 17	" 18	M.	S.	....	"	436.	407.	29.	60.	10.4	8.	2.4	4.00	.54	.38	.16	1.18	.78	.40	.22	1.78	7.2	13.	17.	−	19,500
222	" 25	" 26	S.	S.	....	"	420.	405.	15.	63.	10.	7.6	2.4	5.60	.56	.34	.22	1.06	.68	.38	.22	1.16	7.2	14.	16.	−	13,250
224	Nov. 7	Nov. 8	S.	S.	....	"	381.	367.	14.	55.	7.4	6.8	.6	.52	.38	.34	.04	.90	.82	.08	.16	1.24	7.3	9.	7.	+	11,500
225	" 14	" 16	M.	M.	....	"	389.	370.	19.	50.	8.4	7.6	.8	4.52	.40	.36	.04	.90	.70	.20	.10	1.56	7.5	9.	7.	.....	.....
1403	" 22	" 23	S.	S.	....	"	388.	366.	22.	40.	8.6	7.4	1.2	2.60	.38	.29	.09	.74	.70	.04	.18	1.82	7.6	8.	7.	+	23,000
1404	" 28	" 29	VS.	VVS.	....	"	366.	360.	6.	35.5	8.2	8.	.2	3.30	.37	.34	.03	.74	.70	.04	.17	1.63	7.6	8.	6.	+	14,250

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 172.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, AVERYVILLE, ILL.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am.												
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Suspd Matter.	Free Ammonia	Tot'l	Dissolv'd	Suspnd'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
431	July 3	July 5	VS.	M.	.3	None	403.	360.	43.	24.5	12.6	10.8	1.8	.12	.52	.44	.08	1.08	.92	.16	.20	2.30	27.1	26.	25.	+	27,000
432	" 10	" 12	S.	S.	.35	"	405.	384.	21.	37.5	12.8	11.	1.8	.40	.60	.40	.20	1.68	1.24	.44	.25	2.25	27.7	26.	28.	—	16,950
433	" 18	" 19	VVS.	S.	.1	"	396.	370.	26.	45.5	10.4	8.6	1.8	1.36	.60	.40	.20	1.04	.88	.16	.48	2.02	29.1	26.	26.5	+	22,650
434	" 24	" 26	VS.	M.	.1	"	337.	313.	24.	30.	8.6	7.8	.8	.78	.34	.26	.08	.84	.70	.14	.34	2.36	28.8	28.	30.	+	28,000
435	Aug. 1	Aug. 2	H.	M.	.35	"	292.	239.	53.	35.5	9.5	8.4	1.1	.43	.63	.36	.27	.88	2.08	....	.24	1.96	27.6	25.	24.	+	12,750
436	" 8	" 9	M.	M.	.35	"	423.	367.	56.	30.5	9.4	7.6	1.8	.26	.40	.36	.04	.92	.64	.28	.12	1.23	27.6	24.	20.	—	41,000
437	" 15	" 16	M.	M.	.3	"	433.	387.	46.	38.5	10.	7.9	2.1	.38	.44	.36	.08	1.11	.44	.67	.20	1.60	27.	23.	28.	+	30,250
438	" 22	" 23	S.	M.	....	"	393.	349.	44.	43.	13.	8.6	4.4	.26	.68	.41	.27	1.12	.72	.40	.14	1.21	26.7	26.	23.	—	34,750
439	" 29	" 30	M.	M.	....	"	398.	347.	51.	47.	11.8	7.8	4.	.38	.65	.38	.27	1.58	.88	.70	.12	.93	26.7	28.	25.	+	41,250
440	Sept. 5	Sept. 6	M.	H.	....	"	409.	362.	47.	52.	10.6	8.6	2.	.35	.48	.42	.06	.86	.66	.20	.67	.63	27.	27.	26.	+	27,500
441	" 12	" 13	M.	M.	....	"	408.	364.	44.	54.5	10.8	8.6	2.2	.26	.70	.41	.29	1.50	.94	.56	.11	.60	27.3	21.	26.	+	29,000
442	" 19	" 20	S.	M.	....	"	402.	374.	28.	56.5	10.4	8.	2.4	.16	.63	.36	.27	1.30	.84	.46	.05	.80	27.6	20.	17.	....	....
443	" 26	" 27	M.	M.	....	"	398.	373.	25.	57.5	9.4	7.4	2.	.14	.54	.40	.14	1.02	.78	.24	.24	.70	27.4	13.	11.	+	13,250
444	Oct. 3	Oct. 4	S.	VVS.	....	"	423.	404.	19.	67.	11.	8.2	2.8	.12	.68	.37	.31	1.18	.70	.48	.80	2.40	27.3	12.	15.	+	60,000
445	" 10	" 11	M.	S.	....	"	434.	401.	33.	68.5	12.2	8.4	3.8	.17	.80	.34	.46	1.46	.72	.74	.....	2.90	27.3	15.	17.	+	12,650
446	" 17	" 18	M.	VS.	....	"	416.	389.	27.	66.5	11.4	8.6	2.8	.18	.58	.31	.27	1.30	.78	.52	.96	3.04	27.6	18.	13.	+	24,500
447	" 24	" 25	M.	S.	....	"	455.	421.	34.	72.	12.	8.4	3.6	1.40	.72	.38	.34	1.32	.70	.62	1.48	3.62	27.6	15.	18.	+	22,000
448	" 31	Nov. 1	S.	S.	....	"	418.	410.	8.	64.	9.8	8.	1.8	1.40	.50	.32	.18	.88	.52	.36	1.04	1.66	27.8	12.	8.	+	7,350
449	Nov. 7	" 8	S.	S.	....	"	373.	363.	10.	55.	7.4	6.6	.8	.38	.42	.30	.12	.82	.68	.14	.32	1.63	27.8	7.	8.	+	14,750
450	" 14	" 15	VS.	VS.	....	"	361.	353.	8.	53.	8.4	6.6	1.8	2.09	.48	.32	.16	.86	.62	.24	.30	1.70	28.2	9.	9.	....	....
1428	" 21	" 22	M.	VS.	....	"	365.	360.	5.	50.	8.2	6.8	1.4	4.40	.42	.29	.13	.86	.78	.08	.08	1.20	28.3	10.	12.	+	25,500
1429	" 28	" 29	VS.	VVS.	....	"	356.	343.	13.	34.	7.4	6.6	.8	2.00	.36	.30	.06	.70	.46	.24	.07	1.61	28.10	6.	4.	+	7,500
....	....	....	....	....	....	....	.....	.....	.....	.....	....	....	....	.....	.....	.....	.....	....	....	....	.....	.....	.....	.....	.....	.....	....

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 173.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, WESLEY CITY, ILL.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspnd'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
350	July 3	July 5	VS.	M.	.25	None	400.	356.	44.	24.	13.2	11.4	1.8	.09	.49	.41	.08	1.24	1.08	.16	.18	1.92	6.	......	24.	+	1,916,000
330	" 10	" 12	S.	S.	.35	"	418.	381.	37.	35.	13.2	11.6	1.6	.21	.64	.44	.20	1.30	1.24	.12	.22	2.88	6.	25.	30.	—	670,000
*	" 16	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
344	" 24	July 26	VS.	S.	.1	None	327.	305.	22.	31.5	8.4	8.	.4	.42	.34	.26	.08	.84	.76	.08	.28	1.82	6.	......	33.	+	5,510,000
*	Aug. 1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
*	" 8	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
363	" 16	Aug. 17	M.	M.	......	None	424.	347.	77.	31.5	10.5	7.9	2.6	1.10	.48	.36	.12	1.00	.68	.32	.12	.98	......	25.	21.	......	......
329	" 21	" 23	VVS.	M.	......	"	420.	377.	43.	44.	12.6	10.	2.6	.60	.98	.53	.45	1.58	.90	.68	.25	1.30	6.	......	......	+	500,000
331	" 28	" 30	M.	M.	......	"	381.	346.	35.	46.	13.	9.4	3.6	.42	.60	.44	.16	1.32	.88	.44	.085	.62	7.	......	......	+	212,500
241	Sept. 5	Sept. 6	S.	H.	......	"	439.	352.	87.	49.	17.	10.2	6.8	.35	.95	.43	.52	1.52	.74	.78	.07	.88	......	28.	38.	......	......
242	" 12	" 13	M.	M.	......	"	399.	366.	33.	53.5	11.6	9.4	2.2	.30	.63	.46	.17	1.40	1.04	.36	.11	.60	1.	20.	27.	+	1,030,000
245	" 26	" 27	M.	VS.	......	"	390.	359.	31.	56.5	10.8	8.8	2.	.32	.74	.44	.30	1.42	.90	.52	.10	.90	1.	15.	18.	......	......
247	Oct. 3	Oct. 4	S.	M.	......	"	418.	391.	27.	63.	11.4	7.6	3.8	.16	.72	.36	.36	1.30	.78	.52	.20	1.40	1.	12.	24.	+	940,000
249	" 10	" 12	S.	VS.	......	"	410.	375.	35.	69.5	15.2	10.8	4.4	1.12	.83	.50	.33	1.74	1.08	.66	.84	......	1.	12.	22.	+	1,550,000
1030	" 18	" 20	M.	S.	......	"	416.	396.	20.	69.5	17.6	12.6	5.	.84	1.81	1.00	.81	2.40	1.48	.92	1.68	......	1.	15.	21.	+	6,765,000
1032	" 26	" 27	M.	M.	......	"	429.	404.	25.	67.	13.4	9.6	3.8	1.24	.88	.48	.40	1.84	1.06	.78	.96	2.14	1.	16.	15.	......	......
1036	" 31	Nov. 2	S.	M.	......	"	472.	426.	46.	67.	26.0	13.6	12.4	1.20	1.86	.84	1.02	3.30	1.42	1.88	1.44	3.56	1.5	10.	15.	+	5,000,000
1035	Nov. 7	" 9	S.	S.	......	"	413.	395.	18.	61.	12.2	9.4	2.8	2.80	.86	.52	.34	1.54	.98	.56	.60	2.20	1.	6.	16.	+	77,500
1041	" 15	" 16	M.	M.	......	"	401.	390.	11.	55.	15.8	10.6	5.2	3.00	1.44	.78	.66	2.30	1.50	.80	.24	2.28	3.	10.	16.	......	......
1038	" 22	" 24	M.	VS.	......	"	386.	357.	29.	51.5	8.6	6.8	1.8	3.74	.44	.27	.17	.94	.66	.28	.09	1.50	1.5	0.	5.	......	......

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

*No Sample.

TABLE 174.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, PEKIN, ILL.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of .		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am.												
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Susp'd Matter	Free Ammonia.	Tot'l	Dissolv'd	Susp'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
232	July 6	July 8	VS.	S.	.15	None	383.	365.	18.	25.	13.4	11.8	1.6	.70	.60	.52	.08	1.38	.96	.42	......	......	1.	24.	30.	......	....
233	" 12	" 13	VVS.	S.	.2	"	416.	391.	25.	36.5	14.8	12.	2.8	.75	.70	.44	.26	1.72	1.12	.60	.36	1.74	1.	28.	33.	+	686,500
234	" 19	" 19	VVS.	S.	.1	"	399.	353.	46.	40.5	12.4	10.2	2.2	.83	.64	.48	.16	1.48	.84	.53	.28	1.97	2.	26.	32.	+	370,000
235	" 25	" 26	VS.	M.	.1	"	333.	299.	34.	31.	9.4	8.	1.4	.83	.40	.30	.10	1.08	.84	.24	.24	1.66	1.5	30.	34.	+	1,653,500
236	Aug. 1	Aug. 2	M.	S.	.4	"	346.	319.	27.	34.	12.9	9.8	3.1	1.00	1.00	.70	.30	1.48	.88	.60	.68	1.02	1.	25.	34.	+	2,880,000
237	" 8	" 9	VS.	M.	.35	"	368.	345.	23.	29.5	10.2	8.4	1.8	.68	.56	.40	.16	1.12	.84	.28	.21	.74	1.	21.	23.	+	1,157,000
238	" 15	" 16	VS.	M.	.3	"	399.	370.	29.	35.5	10.4	8.5	1.9	.744	.48	.40	.08	1.11	.71	.40	.30	1.50	.5	25.	33.	+	16,000
338	" 22	" 23	VVS.	VS.	....	"	384.	372.	12.	43.5	12.4	10.4	2.	.50	.70	.44	.26	1.56	.98	.58	.33	1.32	.5	26.	40.	+	42,000
240	" 29	" 30	S.	S.	....	"	384.	366.	18.	54.	12.	10.2	1.8	.49	.90	.42	.48	1.64	.88	.76	.11	.49	1.	29.	40.	+	45,000
241	Sept. 5	Sept. 7	S.	M.	....	"	426.	360.	66.	50.	15.6	9.4	6.2	.35	.83	.38	.45	1.12	.70	.42	.16	.54	1.	28.	41.	+	187,500
242	" 12	" 13	S.	M.	....	"	396.	365.	31.	53.	11.6	9.6	2.	.30	.56	.40	.16	1.42	1.00	.42	.07	.79	1.	20.	27.	+	1,020,000
243	" 18	" 21	S.	M.	....	"	427.	355.	72.	52.	12.8	8.6	4.2	.17	.90	.42	.48	1.40	.76	.64	.065	.52	1.6	20.	21.	+	462,000
245	" 26	" 27	M.	VS.	....	"	373.	356.	17.	54.5	10.6	8.6	2.	.04	.63	.41	.22	1.50	.90	.60	.06	1.24	1.	15.	18.	......	....
247	Oct. 3	Oct. 4	S.	M.	....	"	391.	372.	19.	55.	10.6	8.6	2.	.36	.60	.38	.22	1.20	.96	.24	.28	1.22	1.	12.	24.	+	580,000
249	" 10	" 12	S.	S.	....	"	358.	337.	21.	56.5	10.6	8.6	2.	.68	.70	.39	.31	1.38	.86	.52	.64	.86	1.	12.	23.	+	3,490,000
1027	" 18	" 19	S.	S.	....	"	401.	390.	11.	68.	12.6	9.	3.6	.82	.80	.48	.32	1.66	.94	.72	.64	2.36	1.	15.	21.	+	617,500
1031	" 26	" 27	M.	M.	....	"	437.	410.	27.	67.	13.4	8.6	4.8	1.28	1.04	.54	.50	1.82	1.10	.72	1.12	1.70	1.	16.	15.	+	2,225,000
1036	" 31	Nov. 2	S.	S.	....	"	427.	405.	22.	66.	12.2	9.4	2.8	.20	.84	.40	.44	1.34	.70	.64	.36	3.74	1.5	10.	14.	+	305,000
1037	Nov. 7	" 9	S.	S.	....	"	415.	395.	20.	60.	9.2	7.6	1.6	2.00	.56	.36	.20	1.46	.84	.62	.80	1.90	1.	6.	15.	+	60,000
1042	" 15	" 16	M.	S.	....	"	390.	370.	20.	52.5	9.	6.8	2.2	2.80	.48	.32	.16	1.18	.86	.32	.12	2.58	2.	10.	16.	......	....
1034	" 22	" 24	M.	S.	....	"	394.	370.	24.	50.5	10.	8.	2.	4.00	.70	.52	.18	1.38	.90	.48	.13	1.27	1.5	0.	5.	......	....

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium,

TABLE 175.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

Report of ADOLPH GEHRMANN,
D. H. BISBEE,
Municipal Laboratory, Chicago, Ill.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, HAVANA, ILL.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coll.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved	Suspended		Total.	By Dissolved	By Susp'd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Susp'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
256	July 5	July 6	M.	M.	.2	None	401.	387.	14.	20.	13.2	11.2	2.0	1.00	.56	.52	.04	.76	.28	.48	.....	.....	4.7	26.	24.	+	11,500
257	" 12	" 13	VVS.	M.	.1	"	407.	374.	33.	28.	12.2	10.6	1.6	1.10	.52	.42	.10	1.36	.84	.52	.25	1.45	4.1	26.	29.	+	19,065
259	" 19	" 20	VVS.	VVS.	.1	"	384.	379.	5.	37.5	10.6	9.8	0.8	.84	.40	.37	.03	1.00	.82	.18	.26	1.74	4.9	27.	30.	+	74,500
260	" 26	" 27	VS.	S.	.25	"	348.	317.	31.	31.5	8.4	7.8	.6	.84	.54	.36	.18	.92	.76	.16	.28	1.12	4.8	30.	35.	+	23,650
261	Aug. 2	Aug. 3	M.	M.	.3	"	364.	322.	42.	30.5	9.8	8.7	1.1	.87	.62	.55	.07	1.28	1.08	.20	.21	.60	......	......	......	−	7,000
262	" 9	" 10	M.	M.	.2	"	384.	330.	54.	30.	9.4	7.4	2.	1.00	.50	.30	.20	1.02	.76	.26	.165	1.04	4.1	26.	30.	+	21,250
263	" 16	" 17	M.	M.	....	"	424.	347.	77.	31.5	10.5	7.9	2.6	1.10	.48	.36	.12	1.00	.68	.32	.32	.98	3.2	25.	27.5	+	9,250
264	" 23	" 24	M.	M.	....	"	419.	349.	70.	35.	10.4	8.5	1.9	.87	.59	.35	.16	.94	.58	.36	.26	.20	3.	26.	31.	+	34,500
265	" 30	" 31	M.	S.	....	"	423.	384.	39.	42.	11.	9.6	1.4	.50	.60	.45	.15	1.28	.98	.30	.24	.16	2.2	29.	26.	+	30,333
266	Sept. 6	Sept. 7	M.	M.	....	"	398.	345.	53.	41.5	12.8	10.6	2.2	.75	.75	.48	.27	1.56	.62	.94	.036	.17	2.4	29.	33.	+	67,000
267	" 13	" 14	M.	M.	....	"	435.	343.	92.	46.	13.2	9.4	3.8	.95	.70	.50	.20	1.54	.94	.00	......	.34	......	......	......	+	250,000
268	" 20	" 21	H.	M.	....	"	410.	303.	107.	39.5	12.4	8.4	4.	.70	.68	.40	.28	1.04	.76	.28	.15	.25	3.6	14.	12.	......	....
269	" 27	" 28	H.	S.	....	"	429.	350.	79.	50.	11.2	8.	3.2	.84	.68	.44	.24	1.26	.78	.48	.11	.29	3.	16.	17.	+	22,500
270	Oct. 4	Oct. 5	M.	M.	....	"	425.	359.	66.	53.	12.6	7.9	4.7	.40	.76	.45	.31	1.82	1.02	.80	.27	.83	3.	14.5	13.	+	145,000
271	" 11	" 12	M.	S.	....	"	460.	397.	63.	62.0	11.6	8.2	3.4	.80	.72	.44	.28	1.20	.98	.22	......	.60	2.6	15.	21.	+	21,250
272	" 18	" 19	S.	M.	....	"	423.	348.	75.	60.	13.4	9.	4.4	1.44	.80	.44	.36	1.66	.86	.80	.60	.60	3.2	17.	9.	+	17,000
273	" 25	" 26	M.	M.	....	"	446.	391.	55.	60.	11.8	8.6	3.2	1.00	.68	.44	.24	1.38	.88	.50	.78	.60	3.	12.	19.	+	32,750
274	Nov. 1	Nov. 2	S.	S.	....	"	435.	393.	42.	64.5	12.	9.	3.	1.40	.74	.41	.33	1.38	.....	.....	1.04	2.16	3.5	9.	8.	+	41,000
275	" 8	" 9	S.	S.	....	"	404.	395.	9.	56.5	11.	8.2	2.8	2.40	.69	.50	.19	1.90	.96	.94	1.20	1.60	4.6	7.	15.	+	845,000
1101	" 15	" 16	S.	S.	....	"	385.	369.	16.	52.	10.2	7.2	3.	3.00	.73	.40	.32	1.88	.94	.94	.22	1.98	3.7	10.	11.	......	....
....	" 22	" 23	S.	S.	....	"	332.	308.	24.	33.	9.6	5.6	4.	2.40	.35	.36	.00	.94	.....	.....	.12	1.28	4.4	11.	12.	+	106,000

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 176.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—SANGAMON RIVER, CHANDLERVILLE, ILL.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago.

Serial No.	Date of 1899 Collection.		Date of 1899 Examination.		Appearance. Turb'y.	Appearance. Sediment.	Appearance. Color.	Odor	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved	Oxygen Consumed. By Susp'd Matter.	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Am. Tot'l	Nitrogen as Ammonia. Albuminoid Am. Dissolv'd	Nitrogen as Ammonia. Albuminoid Am. Suspnd'd	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended	Nitrogen as Nitrites	Nitrogen as Nitrates	Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
279	July	5	July	6	H.	H.	....	None	447.	290.	157.	5.1	8.4	3.5	4.9	.02	.32	.14	.18	.00	.80	.....	.....	.....	....	27.	28.	+	16,500
280	"	12	"	13	VVS.	H.	....	"	402.	266.	136.	4.6	7.9	4.	3.9	.08	.36	.17	.19	.72	.48	.24	.036	2.06	4.	27.	33.	−	94,000
281	Aug.	3	Aug.	3	M.	M.	....	"	372.	308.	64.	5.6	4.5	3.5	1.	.08	.30	.17	.13	.62	.44	.18	.022	.38	3.	26.	33.	+	10,500
282	"	9	"	10	M.	H.	....	"	421.	255.	166.	4.5	7.8	3.8	4.	.14	.37	.17	.20	.76	.50	.26	.06	.91	3.6	25.	29.	+	44,350
283	"	16	"	17	M.	H.	....	"	388.	295.	93.	5.8	6.6	3.6	3.	.04	.33	.16	.17	.52	.20	.32	.025	.98	.5	26.	29.	−	34,750
284	"	31	Sept.	1	M.	M.	....	"	651.	319.	332.	6.4	9.8	3.8	6.	....	.60	.50	.10	.....	.....	.....	.006	.20	....	27.	27.	−	11,750
285	Sept.	13	"	14	M.	M.	....	"	378.	285.	93.	4.5	6.2	3.3	2.9	.02	.32	.16	.16	.66	.30	.36	.....	.20	Low	22.	21.	−	5,465
286	"	20	"	21	H.	M.	....	"	372.	277.	95.	......	6.1	3.2	2.9	.016	.32	.16	.16	.64	.28	.36	.008	.30	"	19.	21.	+	68,000
287	"	28	"	28	H.	S.	....	"	429.	350.	79.	5.0	11.2	8.	3.2	.84	.68	.44	.24	1.26	.78	.48	.11	.20	"	7.	16.	+	28,250
288	Oct.	4	Oct.	5	H.	S.	....	"	320.	290.	30.	4.9	3.9	2.1	1.8	.02	.28	.20	.08	.78	.34	.44	.004	.....	"	6.	23.	+	7,750
289	"	18	"	19	S.	S.	....	"	354.	294.	60.	5.3	4.8	2.4	2.4	....	.23	.11	.12	.52	.24	.28	.005	.....	"	12.	22.	+	44,250
290	"	25	"	26	M.	S.	....	"	353.	308.	45.	5.6	4.8	2.7	2.1	.010	.26	.14	.12	.56	.26	.30	.....	.....	"	18.5	27.	+	13,250
291	Nov.	1	Nov.	2	S.	S.	....	"	333.	294.	39.	6.7	4.6	2.8	1.8	....	.20	.11	.09	.74	.18	.56	.008	.....	"	10.	8.	+	18,350
292	"	8	"	9	VS.	S.	....	"	317.	291.	26.	6.8	3.9	3.2	.7	.048	.18	.17	.01	.58	.22	.36	.....	.....	1.	10.	14.	+	14,750
293	"	15	"	16	S.	S.	....	"	310.	288.	22.	7.0	3.8	2.8	1.	.04	.36	.30	.06	.66	.38	.28	.015	.00	1.	12.	16.	....	....
294	"	22	"	23	M.	M.	....	"	330.	279.	51.	6.6	5.3	3.8	1.5	.12	.22	.15	.07	.54	.40	.14	.04	.....	2.	13.	14.	+	13,750

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 177.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, BEARDSTOWN, ILL.

Report of ADOLPH GEHRMANN,
D. B. BISBEE.
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am.												
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Suspnd'd	Total.	Dissolved.	Suspended.	Nitrites	Nitrates					
304	July 6	July 8	VH.	S.	.1	None	438.	319.	119.	15.	11.6	8.6	3.	.36	.50	.40	.10	1.08	.88	.20	.....	.....	7.1	25.	26.5	+	30,250
305	" 13	" 14	M.	M.	.1	"	376.	301.	75.	18.5	10.8	8.4	2.4	.45	.42	.30	.12	1.04	.88	.16	.135	2.77	6.8	29.	34.	−	3,000
306	" 20	" 21	VH.	M.	.1	"	452.	358.	94.	28.0	10.8	9.5	1.3	.56	.50	.37	.13	1.04	.84	.20	.20	1.00	6.9	28.	31.	+	5,500
307	" 27	" 28	VS.	M.	.3	"	406.	342.	64.	33.5	7.8	6.8	1.0	.62	.42	.36	.06	.88	.64	.24	.23	2.07	6.8	21.	27.	+	2,400
308	Aug. 3	Aug. 4	M.	M.	.1	"	364.	309.	55.	26.5	7.6	6.5	1.1	.55	.40	.32	.08	.92	.60	.32	.12	1.88	6.4	25.5	31.	−	10,750
309	" 10	" 11	H.	M.	.3	"	337.	283.	54.	25.5	7.8	6.7	1.1	.50	.44	.32	.12	.82	.68	.14	.140	.85	7.9	21.	27.	+	16,750
310	" 17	" 18	M.	M.	....	"	380.	324.	56.	24.	8.	6.9	1.1	.48	.40	.32	.08	.76	.58	.18	.20	.90	6.3	23.	27.	−	15,000
311	" 24	" 25	M.	M.	....	"	334.	291.	43.	23.	8.2	6.8	1.4	.45	.36	.29	.07	.84	.68	.16	.12	.78	6.2	21.	27.	+	49,999
312	" 31	Sept. 1	M.	S.	....	"	374.	372.	2.	28.	7.4	6.9	.5	.80	.40	.40	.....	.....	.....	.....	.14	.86	6.	20.	27.	−	9,000
313	Sept. 7	" 8	M.	S.	....	"	364.	350.	14.	30.5	7.3	6.8	.5	.41	.36	.35	.01	.74	.64	.10	.....	.....	6.2	25.5	32.	+	28,000
314	" 14	" 15	S.	S.	....	"	354.	315.	39.	27.	8.	7.3	.7	.88	.41	.34	.07	.84	.76	.08	.....	.....	6.2	15.5	13.	+	45,000
315	" 21	" 22	VH.	H.	....	"	346.	243.	103.	22.	9.2	6.7	2.5	.46	.42	.27	.15	.80	.60	.20	.072	.73	7.	21.	16.	−	38,750
316	" 28	" 29	VH.	H.	....	"	355.	312.	43.	35.5	7.6	6.6	1.	.72	.37	.31	.06	.86	.....	.....	.06	.54	6.4	15.5	13.	+	17,750
317	Oct. 5	Oct. 6	H.	S.	....	"	370	334.	36.	41.	8.	6.7	1.3	.42	.53	.36	.17	1.02	.62	.40	.....	1.00	6.2	13.	16.	+	9,250
318	" 12	" 13	M.	S.	....	"	391.	350.	41.	44.5	8.2	7.5	.7	.20	.54	.43	.11	.96	.54	.44	.....	.....	6.3	16.	20.	+	26,500
319	" 19	" 20	M.	S.	....	"	370.	319.	51.	41.5	8.6	7.	1.6	.86	.40	.36	.04	1.04	.68	.36	.10	.....	6.6	18.	14.	+	20,500
320	" 26	" 27	M.	S.	....	"	395.	355.	40.	51.	8.6	6.8	1.8	1.04	.46	.36	.10	1.06	.86	.20	.22	1.00	6.5	19.	18.	+	16,500
321	Nov. 2	Nov. 3	M.	S.	....	"	411.	378.	33.	50.5	8.9	6.5	2.4	1.08	.49	.32	.17	.96	.60	.36	.43	1.42	6.7	2.	0.	+	17,000
322	" 9	" 10	S.	S.	....	"	386.	362.	24.	54.	10.9	7.4	3.5	.46	.82	.36	.46	1.58	.76	.82	.43	2.88	6.6	8.	6.	+	27,500
323	" 16	" 17	S.	M.	....	"	383.	365.	18.	46.	9.4	7.2	2.2	2.20	.64	.34	.30	1.28	.70	.58	.24	1.76	6.8	12.	12.	.....	.....
324	" 23	" 24	S.	M.	....	"	377.	341.	36.	40.	8 6	6.6	2.	2.40	.49	.33	.16	.86	.....	.....	.10	1.30	7.2	10.	12.	+	24,500
325	" 30	Dec. 1	S.	S.	....	"	376.	350.	26.	39.5	8.	6.4	1.6	2.80	.48	.33	.15	.90	.58	.32	.07	1.33	6.6	6.5	6.	+	13,500

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 178.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, KAMPSVILLE, ILL.

Report of ADOLPH GEHRMANN,
D. H. BISBEE,
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspend'd	Total.	Dissolved.	Suspended.	Nitrites	Nitrates					
357	July 12	July 13	VVS.	M.	.05	None	304.	254.	50.	10.5	8.	7.4	.6	.04	.34	.25	.09	.80	.64	.16	.11	1.29	13.9	27.	29.	—	2,400
358	" 19	" 20	M.	VVS.	.1	"	342.	317.	25.	17.5	7.6	7.4	0.2	.08	.38	.30	.08	.78	.70	.08	.13	1.07	16.	29.	33.	—	6,150
360	Aug. 2	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	—	14,500
361	" 11	Aug. 14	......	......	.15	None	412.	173.	239.	10.	6.9	5.4	1.5	.16	.39	.22	.10	.76	.36	.40	.115	.80	16.5	27.	31.	+	25,500
363	" 16	" 24	M.	M.	......	"	329.	296.	33.	19.	7.6	7.3	.3	.04	.40	.29	.11	.80	.48	.32	.076	.52	15.5	28.	32.	+	2,325
364	" 30	" 31	M.	M.	......	"	343.	298.	44.	20.	8.4	6.9	1.5	.05	.44	.28	.16	.96	.82	.16	.112	.30	15.2	29.	32.	+	49,500
365	Sept. 6	Sept. 7	S.	S.	......	"	320.	301.	19.	20.	7.5	6.9	.6	.19	.35	.29	.06	.60	.40	.20	......	......	15.1	29.	32.	—	40,500
366	" 13	" 14	S.	S.	......	"	359.	322.	37.	25.	7.5	6.7	.8	.21	.36	.29	.07	1.04	.80	.24	......	.46	15.3	22.	20.	+	34,000
367	" 20	" 21	H.	M.	......	"	319.	230.	89.	19.3	8.4	6.6	1.8	.36	.40	.29	.11	.70	......	......	.057	.65	15.6	19.	18.	+	54,000
....	" 27	" 28	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	15.3	17.	18.	+	28,000
370	Oct. 11	Oct. 12	M.	VS.	......	None	345.	330.	15.	33.	7.2	6.4	.8	.20	.34	.27	.07	.76	.68	.08	.04	.56	15.2	17.	22.	+	34,000
371	" 18	" 19	M.	M.	......	"	362.	322.	40.	38.	7.6	6.1	1.5	.15	.41	.33	.08	.98	.64	.34	.012	.24	15.5	17.	14.	......	......
372	" 25	" 26	M.	S.	......	"	366.	329.	37.	38.	7.3	6.2	1.1	.31	.33	.29	.04	.84	.70	.14	.06	.90	15.4	17.5	23.	+	12,750
373	Nov. 1	Nov. 3	M.	S.	......	"	375.	336.	39.	40.5	7.3	6.	1.3	.56	.37	.34	.03	.86	.60	.26	.04	.80	15.6	12	9.	......	......
374	" 8	" 10	M.	S.	......	"	361.	335.	26.	41.5	6.6	5.7	.9	.07	.43	.36	.07	1.42	.66	.76	.005	2.50	15.6	10.	12.	+	9,000
375	" 15	" 16	S.	S.	......	"	350.	326.	23.	44.	13.4	6.8	6.6	.12	1.06	.31	.75	......	.78	......	.20	1.20	15.7	12.	15.	......	......
1227	" 22	" 23	M.	S.	......	"	370.	327.	49.	33.	10.	5.6	4.4	.64	.68	.27	.41	1.46	.60	.86	.075	2.80	16.	12.	13.	+	34,000

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 179.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

Source of Water—Illinois River, Grafton, Ill.

Report of Adolph Gehrmann,
D. B. Bisbee,
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am.												
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Tot'l.	Dissolv'd.	Suspend'd.	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
514	July 5	July 7	VS.	VVS.	.05	None	313.	306.	7.	10.5	8.4	7.8	.6	.03	.42	.32	.10	.76	.60	.16	.....	.....	14.6	29.	28.	—	11,350
516	" 12	" 13	VVS.	VVS.	.05	"	307.	300.	7.	10.4	7.5	7.1	.4	.15	.38	.32	.06	.76	.58	.18	.12	1.18	13.2	29.	32.	+	13,700
518	" 19	" 20	M.	VVS.	.05	"	329.	313.	16.	14.0	7.5	7.4	0.1	.12	.44	.30	.14	.92	.76	.16	.08	.12	9.7	33.	36.	—	20,500
521	" 26	" 27	VVS.	VS.	.25	"	317.	299.	18.	24.5	7.6	7.5	.1	.12	.35	.33	.02	.....	.....	.....	.12	1.68	7.6	31.	37.	—	15,350
522	Aug. 2	Aug. 3	M.	VS.	.3	"	367.	345.	22.	32.5	7.	7.	.....	.02	.38	.22	.16	.92	.68	.24	.12	2.08	6.1	33.	37.	—	32,750
524	" 9	" 10	VH.	M.	.25	"	381.	203.	178.	15.5	8.2	5.2	3.	.12	.35	.21	.14	.84	.54	.30	.105	2.90	7.6	25.	25.	+	63,500
551	" 16	" 17	VH.	M.	....	"	300.	183.	117.	8.5	9.6	7.2	2.4	.08	.37	.23	.14	.58	.50	.08	.08	.84	6.	26.	29.	+	25,000
553	" 21	" 24	M.	M.	....	"	311.	276.	35.	17.5	8.4	7.6	.8	.02	.275	.27	.005	.72	.36	.36	.05	.49	4.2	31.	31.	+	11,750
555	" 30	" 31	H.	VS.	....	"	310.	275.	35.	15.	8.	6.8	1.2	.05	.31	.28	.03	.76	.36	.40	.05	.25	3.3	30.	31.	+	19,250
557	Sept. 6	Sept. 7	H.	VS.	....	"	336.	318.	18.	21.	7.9	6.7	1.2	.18	.41	.28	.13	.50	.40	.10	.....	.....	3.4	35.	34.	—	44,000
559	" 13	" 14	M.	VS.	....	"	336.	309.	27.	21.	7.5	6.4	1.1	.24	.33	.31	.02	.86	.66	.20	.....	.....	4.4	21.	22.	+	23,000
561	" 20	" 21	H.	S.	....	"	356.	291.	65.	24.5	7.5	6.3	1.2	.25	.37	.29	.08	.76	.72	.04	.057	.75	4.8	20.	19.	+	46,650
563	" 27	" 29	H.	VVS.	....	"	305.	256.	49.	23.5	7.2	6.2	1.	.40	.32	.31	.01	.64	.56	.08	.....	.....	4.1	19.	20.	+	17,250
565	Oct. 4	Oct. 5	VH.	VS.	....	"	280.	234.	46.	20.	6.7	5.7	1.	......	.29	.28	.01	.62	.42	.20	.018	.90	......	16.	20.	+	29,000
567	" 11	" 12	M.	VVS.	....	"	346.	316.	30.	31.	6.3	6.	.3	.22	.34	.32	.02	.80	.66	.14	.030	.56	3.2	17.	21.	—	17,750
569	" 25	" 26	M.	VS.	....	"	341.	296.	45.	29.	7.6	6.	1.6	.16	.33	.31	.02	.82	.64	.18	.026	.57	2.7	19.	24.	+	47,500
571	Nov. 1	Nov. 3	H.	S.	....	"	352.	258.	94.	27.	8.6	6.7	1.9	.30	.36	.28	.08	.36	.02	.34	.06	.72	3.4	18.	10.	+	28,000
573	" 8	" 10	M.	VS.	....	"	342.	315.	27.	30.	6.6	5.9	.7	.56	.38	.33	.05	.76	.66	.10	.05	1.45	5.4	9.	17.	+	5,000
576	" 15	" 16	VH.	VS.	....	"	350.	302.	48.	43.	12.8	6.4	6.4	.15	.88	.31	.57	2.06	.74	1.32	.13	.....	6.2	10.	14.	......	....
578	" 22	" 23	H.	VS.	....	"	386.	301.	85.	31.5	11.	5.7	5.3	.08	.72	.28	.44	1.42	.48	.94	.06	2.42	6.	13.	17.	+	40,250
580	" 29	Dec. 1	MH.	S.	....	"	344.	301.	43.	27.5	8.	6.3	1.7	.96	.72	.52	.20	.72	.56	.16	.....	.....	5.9	8.	12.	+	17,500

Appearance—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 180.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, GRAFTON, ILL.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of: 1899 Collection.	Date of: 1899 Examination.	Appearance: Turb'y.	Appearance: Sediment.	Appearance: Color.	Odor	Residue on Evaporation: Total.	Residue on Evaporation: Dissolved.	Residue on Evaporation: Suspended	Chlorine.	Oxygen Consumed: Total.	Oxygen Consumed: By Dissolved	Oxygen Consumed: By Susp'd Matter	Nitrogen as Ammonia: Free Ammonia	Nitrogen as Ammonia: Albuminoid Am.: Tot'l	Nitrogen as Ammonia: Albuminoid Am.: Dissolv'd	Nitrogen as Ammonia: Albuminoid Am.: Suspend'd	Organic Nitrogen: Total.	Organic Nitrogen: Dissolved.	Organic Nitrogen: Suspended	Nitrogen as: Nitrites	Nitrogen as: Nitrates	Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
515	July 5	July 7	VH.	H.	.7	None	319.	146.	173.	1.2	20.	13.8	6.2	.02	.56	.36	.20	1.16	.84	.32	.....	.....	14.6	26.	28.	+	9,500
517	" 12	" 13	VH.	H.	.25	"	543.	154.	389.	.8	22.8	11.4	11.4	.04	.72	.30	.42	1.36	.48	.88	.....	1.00	13.2	27.	32.	+	28,700
519	" 19	" 20	H.	M.	.3	"	307.	194.	113.	1.3	14.8	11.4	3.4	.04	.42	.28	.14	.88	.64	.24	.....	.20	9.7	28.	36.	+	42,000
521	" 26	" 27	H.	M.	.3	"	586.	175.	411.	2.2	13.	10.1	2.9	.12	.40	.30	.10	.80	.72	.08	.0	.80	7.6	30.	37.	−	11,500
523	Aug. 2	Aug. 3	M.	M.	.3	"	248.	173.	75.	2.3	11.6	9.5	2.1	.01	.....	.....	.....	.92	.....	.....	.....	.40	6.1	28.	37.	−	25,750
525	" 9	" 10	VH.	H.	.3	"	437.	173.	264.	2.5	12.6	7.3	5.3	.04	.50	.24	.26	1.04	.38	.66	.002	.30	7.6	26.	29.	−	50,000
552	" 16	" 17	VH.	S.	....	"	319.	180.	139.	2.5	12.	6.5	5.5	.04	.46	.20	.26	.70	.36	.34	.....	.70	6.	27.	29.	+	20,000
554	" 21	" 24	M.	M.	....	"	237.	165.	72.	2.8	9.9	7.4	2.5	.03	.34	.21	.13	.64	.32	.32	.....	.0	4.2	26.	31.	+	19,425
556	" 30	" 31	M.	M.	....	"	237.	185.	52.	3.0	.....	7.	.....	.....	.36	.24	.12	.68	.36	.32	.0	.30	3.3	28.	31.	+	43,500
558	Sept. 6	Sept. 7	M.	M.	....	"	259.	196.	63.	4.8	8.9	6.6	2.3	.05	.35	.19	.16	.50	.36	.14	.....	.....	3.4	30.	36.	−	23,000
560	" 13	" 14	M.	M.	....	"	283.	168.	115.	2.9	11.2	6.5	4.7	.....	.46	.21	.25	.80	.40	.40	.....	.20	4.4	23.	22.	+	32,000
562	" 20	" 21	M.	M.	....	"	275.	161.	114.	2.8	12.	8.2	3.8	.....	.44	.23	.21	.84	.52	.32	.017	.19	4.8	20.	19.	+	31,350
564	" 27	" 28	M.	M.	....	"	242.	144.	98.	2.5	12.8	8.7	4.1	.016	.50	.25	.25	.88	.40	.48	.....	.....	4.1	18.	20.	+	20,250
566	Oct. 4	Oct. 5	M.	S.	....	"	229.	148.	81.	2.4	13.6	9.2	4.4	.....	.44	.25	.19	.76	.38	.38	.....	.....	.....	18.	20.	+	17,250
568	" 11	" 12	M.	S.	....	"	243.	171.	72.	3.1	12.6	9.6	3.	.....	.40	.30	.10	.82	.42	.40	.....	.08	3.2	16.	21.	+	23,350
570	" 25	" 26	M.	S.	....	"	247.	166.	81.	3.	11.4	8.2	3.2	.....	.36	.21	.15	.66	.38	.28	.004	.....	2.7	18.	24.	+	13,050
572	Nov. 1	Nov. 3	M.	M.	....	"	241.	162.	79.	3.4	10.8	7.8	3.	.04	.36	.19	.17	.66	.34	.32	.007	.0	3.4	16.5	10.	+	18,500
574	" 8	" 10	M.	M.	....	"	229.	149.	80.	2.8	12.	9.4	2.6	.04	.47	.29	.18	.74	.40	.34	.....	.0	5.4	9.	17.	+	14,350
577	" 15	" 16	M.	S.	....	"	219.	137.	82.	2.8	17.4	15.	2.4	.032	.42	.30	.12	.88	.70	.18	.0	.0	6.2	10.	14.	.....	....
579	" 22	" 23	M.	S.	....	"	241.	138.	103.	3.0	17.2	15.4	1.8	.04	.40	.29	.11	.76	.42	.34	.0	.0	6.	12.	17.	+	29,000
581	" 29	Dec. 1	MS.	VS.	....	"	184.	142.	42.	3.6	15.8	14.4	1.4	.03	.36	.28	.08	.58	.40	.18	.....	.....	5.9	7.	12.	+	8,350

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 181.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 100 FEET FROM ILLINOIS SHORE, ALTON, ILL.

Report of ADOLPH GEHRMANN,
D. H. BISBEE,
Municipal Laboratory, Chicago, I

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
															Tot'l.	Dissolv'd.	Suspend'd.										
704	July 5	July 7	VH.	H.	.7	None	285.	171.	114.	3.3	15.6	13.	2.6	.03	.44	.30	.14	.80	.56	.24	......	......	15.3	26.	27.	+	30,00
709	" 12	" 13	VH.	H.	.25	"	334.	200.	134.	3.4	16.8	12.2	4.6	.08	.50	.30	.20	.92	.56	.36	.028	.67	15.8	29.	28.	+	37,35
714	" 19	" 20	H.	H.	.15	"	291.	224.	67.	4.7	12.4	10.2	2.2	.02	.40	.28	.12	.84	.54	.30	.015	.38	13.2	28.	31.	+	92,00
719	" 26	" 27	H.	H.	.25	"	321.	239.	82.	10.7	10.2	7.8	2.2	.04	.36	.28	.08	.72	.40	.32	.035	1.07	9.	30.	34.	+	17,65
724	Aug. 2	Aug. 3	M.	M.	.3	"	295.	242.	53.	16.3	9.4	7.8	1.6	.04	.80	.32	.48	.88	.60	.28	.044	1.38	7.2	29.	32.	—	6,50
729	" 9	" 10	M.	VH.	.15	"	622.	219.	403.	13.1	14.8	6.2	8.6	.06	.50	.28	.22	1.28	.42	.86	.07	1.03	7.	26.	28.	—	38,00
739	" 23	" 24	M.	M.	....	"	284.	196.	68.	6.4	10.2	7.3	2.9	......	.37	.28	.09	.68	.30	.38	.014	.0	4.3	28.	32.	+	24,75
744	" 30	" 31	S.	M.	....	"	269.	209.	60.	8.6	10.	7.1	2.9	.03	.38	.25	.13	.76	.40	.36	.015	.19	3.1	28.	28.	+	88,00
753	Sept. 6	Sept. 7	M.	M.	....	"	......	......	......	5.7	9.	6.8	2.2	......	.34	.23	.11	.48	.30	.18	.013	.20	2.9	30.	29.	—	30,00
754	" 13	" 14	M.	M.	....	"	270.	190.	80.	6.	9.6	6.8	2.8	......	.44	.24	.20	.88	.34	.54	.....	.36	3.6	24.	22.	+	34,75
759	" 20	" 21	M.	M.	....	"	309.	214.	95.	10.2	10.4	6.5	3.9	.08	.44	.28	.16	.84	.56	.28	.016	.19	4.	20.	20.	+	52,00
764	" 27	" 29	M.	M.	....	"	245.	167.	78.	7.3	11.6	8.2	3.4	.06	.46	.24	.22	.80	.58	.22	.013	.19	3.8	18.	19.	+	30,35
769	Oct. 4	Oct. 5	M.	M.	....	"	234.	173.	61.	6.	11.8	8.6	3.2	......	.44	.24	.20	1.02	.48	.54	.008	......	2.8	15.	16.	+	7,00
774	" 11	" 12	M.	M.	....	"	255.	194.	61.	7.	11.4	8.8	2.6	.04	.36	.25	.11	1.26	.42	.84	.012	.19	2.2	16.	17.	+	18,75
779	" 18	" 20	M.	M.	....	"	257.	206.	61.	11.4	10.4	8.5	1.9	.02	.44	......	......	.82	.38	.44	.008	......	2.1	18.	20.	+	14,00
784	" 25	" 27	M.	M.	....	"	257.	190.	67.	9.5	10.8	8.	2.8	.06	.40	.25	15	.76	.50	.26	.0	.10	1.9	18.	19.	+	7,25
789	Nov. 1	Nov. 2	M.	M.	....	"	279.	185.	94.	11.3	10.4	7.8	2.6	.08	.32	.21	.11	.64	.32	.32	.03	.10	2.3	12.	10.	+	17,25
794	" 8	" 9	M.	M.	....	"	274.	208.	66.	11.8	10.2	8.	2.2	.13	.38	.25	.13	.96	.44	.52	.018	.20	3.9	9.	12.	+	10,25
1051	" 15	" 16	M.	S.	....	"	254.	185.	69.	12.1	15.2	11.6	3.6	.06	.66	.28	.38	1.18	.62	.56	.038	.52	5.4	10.	13.	......	....
1056	" 22	" 23	M.	S.	....	"	280.	208.	72.	15.2	15.4	15.2	.2	.08	.74	.31	.43	1.16	.70	.46	.04	.56	4.7	13.	14.	+	26,00
....	....	....	....	....	....	......	......	......	......	......	....	....	....	......	......	......	......	....	....	....	.....	.....	......	......	......	......	....

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 182.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, ONE-FOURTH DISTANCE FROM ILLINOIS SHORE, ALTON, ILL.

Serial No	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Susp'd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Susp'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
705	July 5	July 7	VH.	H.	.8	None	258.	160.	98.	1.9	17.6	14.6	3.	.04	.40	.33	.07	.80	.56	.24	......	......	15.3	26.	27.	+	36,350
710	" ..	" ..	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	15.8	29.	28.	+	28,500
715	" 19	" 20	H.	H.	.15	None	268.	190.	78.	2.4	15.2	10.8	4.4	.03	.40	.30	.10	.76	.54	.22	.003	.30	12.3	28.	31.	+	85,000
720	" 26	" 27	H.	H.	.3	"	303.	190.	113.	5.8	12.	8.8	3.2	.03	.40	.28	.12	.68	.44	.24	.013	.94	9.	30.	34.	+	15,250
725	Aug. 2	Aug. 3	M.	M.	.3	"	238.	194.	44.	6.4	10.6	8.6	2.0	.02	.57	.34	.23	.72	.48	.24	.022	.68	7.2	29.	32.	−	7,750
730	" 9	" 10	M.	H.	.15	"	433.	204.	229.	8.2	12.8	6.6	6.2	.06	.43	.28	.15	.96	.40	.56	.055	.85	7.	26.	28.	−	24,635
735	" 16	" 17	VH.	H.	......	"	310.	152.	158.	2.9	11.8	7.2	4.6	.04	.40	.23	.17	.73	.28	.45	.015	.49	7.2	26.	30.	−	14,000
740	" 23	" 24	M.	M.	......	"	257.	184.	73.	5.6	10.4	6.9	3.5	......	.35	.24	.11	.68	.28	.40	.012	.0	4.3	28.	32.	+	12,666
745	" 30	" 31	S.	M.	......	"	266.	213.	53.	5.8	10.4	7.1	3.3	.03	.35	.23	.13	.72	.36	.36	.012	.09	3.1	28.	28.	+	56,650
752	Sept. 6	Sept. 7	M.	M.	......	"	262.	197.	65.	5.1	9.2	6.8	2.4	......	.39	.24	.15	.44	.34	.10	.01	.10	2.9	30.	29.	−	44,000
755	" 13	" 14	M.	M.	......	"	278.	193.	85.	5.5	10.2	6.8	3.4	......	.44	.23	.21	.90	.44	.46	......	.20	3.6	24.	22.	+	36,000
760	" 20	" 21	M.	M.	......	"	290.	203.	87.	5.9	10.8	7.2	3.6	......	.44	.27	.17	.90	.36	.54	.012	.39	4.	20.	20.	+	29,500
765	" 27	" 28	M.	M.	......	"	241.	159.	82.	5.7	11.8	8.9	2.9	.016	.46	.23	.23	.88	.44	.44	.01	.15	3.8	18.	19.	+	26,750
770	Oct. 4	Oct. 5	M.	M.	......	"	238.	170.	68.	5.	13.	8.8	3.2	.06	.44	.28	.16	1.04	.38	.66	.01	......	2.8	15.	16.	−	15,000
775	" 11	" 12	M.	M.	......	"	256.	186.	70.	6.5	11.6	8.9	2.7	.02	.39	.24	.15	.94	.48	.46	.016	.09	2.2	16.	17.	+	23,000
780	" 18	" 20	M.	M.	......	"	273.	197.	76.	9.8	11.2	8.4	2.8	.01	.48	.27	.21	.94	.40	.54	.008	......	2.1	18.	19.	+	17,350
785	" 25	" 27	M.	M.	......	"	257.	180.	77.	8.3	11.4	8.	3.4	.028	.38	.24	.14	.78	.48	.30	......	.10	1.9	18.	19.	+	11,000
790	Nov. 1	Nov. 2	M.	M.	......	"	269.	177.	92.	9.	10.8	7.6	3.2	.04	.32	.33	......	.66	.32	.34	.015	.10	2.3	12.	10.	+	17,000
795	" 8	" 9	M.	M.	......	"	258.	190.	68.	8.3	10.8	8.2	2.6	.06	.39	.28	.11	.88	.44	.44	.007	.0	3.9	9.	12.	+	6,750
1052	" 15	" 16	M.	S.	......	"	234.	163.	71.	7.6	15.8	12.8	3.	.048	.54	.28	.26	.94	.54	.40	.02	......	5.4	10.	13.	......	......
1059	" 22	" 23	M.	S.	......	"	242.	176.	66.	10.	16.	12.6	3.4	.02	.54	.29	.25	.96	.68	.28	.03	.38	4.7	13.	14.	+	21,000

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 183.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, MIDSTREAM, ALTON, ILL.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Il

Serial No.	Date of 1899 Collection.		Date of 1899 Examination.		Appearance. Turb'y.	Appearance. Sediment.	Appearance. Color.	Odor	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved	Oxygen Consumed. By Suspd Matter.	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Am. Tot'l	Nitrogen as Ammonia. Albuminoid Am. Dissolv'd	Nitrogen as Ammonia. Albuminoid Am. Suspnd'd	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended	Nitrogen as Nitrites	Nitrogen as Nitrates	Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
706	July	5	July	7	VH.	H.	.8	None	318.	161.	157.	1.3	18.8	14.4	4.4	.04	.48	.33	.15	.88	.58	.30	......	......	15.3	26.	27.	—	34,750
711	"	12	"	13	VH.	VH.	.25	"	595.	172.	423.	1.4	24.8	11.8	13.	.06	.76	.28	.48	1.32	.54	.78	.006	.90	15.8	29.	28.	—	19,000
716	"	19	"	20	VH.	H.	.2	"	290.	183.	107.	1.7	16.	10.8	5.2	.08	.42	.28	.14	.76	.52	.24	.003	.30	12.2	28.	31.	—	66,500
721	"	26	"	27	H.	H.	.3	"	304.	188.	116.	2.4	13.4	9.2	4.2	.03	.42	.28	.14	.66	.36	.30	.006	.65	9.	30.	34.	+	23,000
726	Aug.	2	Aug.	3	M.	M.	.3	"	231.	170.	61.	2.3	11.	8.2	2.8	.01	.53	.34	.19	.78	.40	.38	.004	.40	7.2	29.	32.	—	6,250
731	"	9	"	10	M.	M.	.15	"	305.	182.	123.	3.6	11.2	7.7	3.5	.06	.40	.26	.14	.70	.38	.32	.01	.33	7.	26.	28.	—	33,000
741	"	23	"	24	M.	M.	....	"	244.	162.	82.	3.7	10.4	7.3	3.1	......	.41	.26	.15	.68	.28	.40	.005	.0	4.3	28.	32.	+	19,666
746	"	30	"	31	S.	M.	....	"	260.	189.	71.	4.4	10.	7.3	2.7	.016	.37	.25	.12	.68	.38	.30	.006	.04	3.1	28.	28.	+	84,650
751	Sept.	6	Sept.	7	M.	M.	....	"	256.	193.	63.	3.9	9.6	6.8	2.8	......	.39	.23	.16	.48	.30	.18	.006	.10	2.9	30.	29.	—	12,000
756	"	13	"	14	M.	M.	....	"	276.	169.	107.	4.	10.2	7.	3.2	......	.48	.23	.25	.86	.42	.44	......	.20	3.6	24.	22.	+	54,000
761	"	20	"	21	M.	M.	....	"	288.	183.	105.	5.7	10.8	7.7	3.1	......	.46	.27	.19	.84	.50	.34	.007	.10	4.	20.	20.	+	56,000
766	"	27	"	29	M.	M.	....	"	248.	148.	100.	3.7	12.4	8.9	3.5	.016	.46	.25	.21	.88	.46	.42	.008	.0	3.8	18.	19.	+	12,650
771	Oct.	4	Oct.	5	M.	M.	....	"	233.	158.	75.	3.8	12.6	8.9	3.7	......	.46	.26	.20	.86	.34	.52	.005	......	2.8	15.	16.	+	7,350
776	"	11	"	12	M.	M.	....	"	250.	173.	77.	4.6	12.4	9.2	3.2	......	.39	.26	.13	1.14	.40	.74	.012	.07	2.2	16.	17.	+	9,000
781	"	18	"	20	M.	M.	....	"	273.	195.	78.	9.	11.2	8.6	2.6	......	.46	.28	.18	.78	.52	.26	.007	......	2.1	18.	20.	+	11,750
786	"	25	"	27	M.	M.	....	"	257.	176.	81.	6.6	11.4	8.	3.4	.012	.40	.24	.16	.68	.42	.26	......	.0	1.9	18.	19.	+	9,000
791	Nov.	1	Nov.	2	M.	M.	....	"	254.	173.	81.	7.8	11.	7.8	3.2	.02	.33	.32	......	.72	.32	.40	.013	.06	2.3	12.	10.	+	21,250
796	"	8	"	9	M.	M.	....	"	244.	164.	80.	3.6	11.4	9.2	2.2	.024	.37	.25	.12	.73	.38	.34	......	.0	3.9	9.	12.	+	9,500
1053	"	15	"	16	M.	S.	....	"	223.	142.	81.	3.3	16.	14.2	1.8	.04	.44	.32	.12	.98	.54	.44	.004	.74	5.4	10.	13.	......	....
1058	"	22	"	23	M.	S.	....	"	206.	147.	58.	4.8	16.2	14.8	1.4	.08	.44	.28	.16	.84	.66	.18	.0	.34	4.7	13.	14.	+	14,750

APPEARANCE—H., Heavy VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 184.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, ONE-FOURTH DISTANCE FROM MISSOURI SHORE, ALTON, ILL.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am.												
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Susp'd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Suspend'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
707	July 5	July 7	VH.	H.	.75	None	361.	151.	210.	1.3	20.	13.8	6.2	.04	.52	.28	.24	.96	.60	.36	......	......	15.3	26.	27.	+	19,000
712	" 12	" 13	VH.	VH.	.2	"	626.	164.	462.	1.6	25.6	10.8	14.8	.06	.88	.28	.60	1.40	.56	.84	.006	1.00	15.8	29.	28.	−	25,500
717	" 19	" 20	VH.	H.	.1	"	339.	180.	159.	1.9	16.8	10.	6.8	.03	.50	.26	.24	.94	.60	.34	.008	.30	12.2	28.	31.	−	23,500
722	" 26	" 27	H.	H.	.3	"	330.	170.	160.	2.4	....	8.8	....	.04	.41	.26	.15	.68	.36	.32	.005	.80	9.	30.	34.	+	24,000
727	Aug. 2	Aug. 3	M.	M.	.3	"	225.	180.	45.	2.7	11.2	8.8	2.4	.01	.40	.26	.14	.72	.36	.36	......	.40	7.2	29.	32.	−	3,250
732	" 9	" 10	M.	M.	.15	"	290.	178.	108.	2.7	11.	7.7	3.3	.06	.35	.24	.11	.70	.40	.30	.003	.30	7.	26.	28.	−	28,350
737	" 16	" 17	VH.	H.	....	"	301.	137.	164.	3.3	11.6	7.3	4.3	.04	.384	.23	.154	.68	.30	.38	.015	.50	7.3	26.	30.	−	15,333
742	" 23	" 24	M.	M.	....	"	239.	160.	79.	3.1	11.8	7.6	4.2	......	.40	.24	.16	.73	.24	.49	......	.0	4.3	28.	32.	−	14,000
747	" 30	" 31	S.	M.	....	"	245.	186.	59.	3.8	9.4	7.1	2.3	......	.37	.25	.12	.76	.44	.32	......	.0	3.1	28.	28.	+	35,500
752	Sept. 6	Sept. 7	M.	M.	....	"	244.	185.	50.	3.5	9.2	6.8	2.4	......	.35	.24	.11	.44	.30	.14	......	.20	2.9	30.	29.	−	20,000
757	" 13	" 14	M.	M.	....	"	263.	162.	101.	3.5	10.6	6.8	3.8	......	.42	.20	.22	.86	.36	.50	......	.20	3.6	29.	22.	+	40,500
762	" 20	" 21	M.	M.	....	"	274.	163.	112.	3.1	11.6	7.8	3.8	......	.46	.24	.22	.88	.44	.44	.005	.20	4.	20.	20.	+	48,500
767	" 27	" 28	M.	M.	....	"	237.	145.	92.	2.6	12.6	9.	3.6	......	.48	.24	.24	.80	.42	.38	.006	.0	3.8	18.	19.	+	10,000
772	Oct. 4	Oct. 5	M.	M.	....	"	232.	156.	76.	2.4	13.	9.3	3.7	......	.44	.25	.19	.86	.32	.54	......	......	2.8	15.	16.	+	14,500
777	" 11	" 12	M.	M.	....	"	238.	162.	76.	3.4	12.4	9.3	3.1	......	.37	.26	.11	.90	.44	.46	.008	.0	2.2	16.	17.	−	12,500
782	" 18	" 20	M.	M.	....	"	269.	177.	92.	4.5	11.4	8.9	2.5	......	.45	.24	.21	.86	.48	.38	.007	......	2.1	19.	20.	+	17,500
787	" 25	" 27	M.	M.	....	"	249.	168.	81.	4.3	11.2	8.4	2.8	......	.38	.25	.13	.66	.46	.20	......	.0	1.9	18.	19.	+	8,000
792	Nov. 1	Nov. 2	M.	M.	....	"	242.	163.	80.	4.5	10.8	8.	2.8	.02	.36	.24	.12	.66	.42	.24	.01	.0	2.3	13.	10.	+	22,750
797	" 8	" 9	M.	M.	....	"	237.	162.	75.	3.0	11.2	9.	2.2	......	.40	.25	.15	.72	.38	.34	......	.0	3.9	9.	10.	+	10,500
1054	" 15	" 16	M.	S.	....	"	239.	135.	104.	2.6	16.4	14.2	2.2	.04	.40	.32	.08	.74	.58	.16	......	.20	5.4	10.	13.	......	....
1057	" 22	" 23	M.	S.	....	"	203.	129.	73.	2.9	16.6	14.8	1.8	.02	.41	.28	.13	.68	.58	.10	.0	.26	4.7	13.	14.	+	19,500

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 185.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 100 FEET FROM MISSOURI SHORE, ALTON, ILL.

Report of ADOLPH GEHRMANN,
D. H. BISBEE,
Municipal Laboratory, Chicago, Ill

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am.												
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Tot'l.	Dissolved.	Susp'd.	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
708	July 5	July 7	VH.	H.	.75	None	407.	141.	266.	1.8	21.6	13.2	8.4	.04	.52	.21	.31	.92	.52	.40	......	......	15.3	26.	27.	+	20,500
713	" 12	" 13	VH.	VH.	.2	"	568.	161.	407.	2.0	24.	11.	13.	.08	.76	.28	.48	1.36	.54	.82	.000	.90	15.8	29.	28.	−	18,000
718	" 19	" 20	VH.	H.	.1	"	301.	180.	121.	1.9	16.	10.	6.	.02	.42	.28	.14	.90	.64	.26	.002	1.60	12.2	28.	31.	+	62,000
723	" 26	" 27	H.	H.	.3	"	290.	169.	121.	2.6	12.6	8.6	4.	.12	.44	.32	.12	.78	.48	.30	......	.70	9.	30.	34.	−	22,000
728	Aug. 2	Aug. 3	MH.	M.	.3	"	227.	167.	60.	2.6	10.6	9.	1.6	.01	.55	.24	.31	.78	.38	.40	......	.40	7.2	29.	33.	−	19,000
733	" 9	" 10	M.	M.	.15	"	312.	163.	149.	2.9	11.6	7.9	3.7	.04	.40	.24	.16	.84	.44	.40	.003	.30	7.	26.	28.	+	13,000
743	" 23	" 24	M.	M.	....	"	228.	166.	62.	3.1	11.0	7.7	3.3	......	.40	.24	.16	.68	.26	.42	......	.0	4.8	28.	33.	+	16,000
748	" 30	" 31	S.	M.	....	"	249.	189.	60.	4.0	9.	7.	2.	......	.35	.24	.11	.68	.38	.30	......	.0	3.1	28.	28.	+	16,000
749	Sept. 6	Sept. 7	M.	M.	....	"	235.	187.	48.	3.7	9.2	6.9	2.3	......	.34	.22	.12	.50	.34	.16	.005	.16	2.9	30.	30.	−	22,600
758	" 13	" 14	M.	M.	....	"	240.	157.	83.	3.2	9.8	6.8	3.	......	.36	.20	.16	.78	.30	.48	......	.20	3.6	24.	23.	+	23,500
763	" 20	" 21	M.	M.	....	"	247.	167.	80.	2.9	11.	7.8	3.2	......	.41	.25	.16	.84	.48	.36	.007	.10	4.	20.	20.	+	50,250
768	" 27	" 29	M.	M.	....	"	219.	155.	64.	2.8	12.2	8.7	3.5	......	.44	.24	.20	.72	.48	.24	.005	.0	3.8	18.	19.	+	12,350
773	Oct. 4	Oct. 5	M.	M.	....	"	213.	157.	56.	2.6	12.6	9.5	3.1	......	.42	.26	.16	.80	.32	.48	......	......	2.8	15.	16.	+	13,350
778	" 11	" 12	M.	M.	....	"	239.	162.	77.	3.3	12.4	9.2	3.2	......	.37	.25	.12	.82	.38	.44	.008	.0	2.2	16.	17.	−	11,000
783	" 18	" *20	M.	M.	....	"	233.	167.	66.	3.9	11.0	8.9	2.1	......	.47	.25	.22	.74	.48	.26	.006	......	2.1	18.	20.	+	16,000
788	" 25	" 27	M.	M.	....	"	239.	157.	82.	3.7	11.4	8.8	2.6	......	.40	.24	.16	.74	.44	.30	......	.0	1.9	18.	19.	+	8,350
793	Nov. 1	Nov. 2	M.	M.	....	"	237.	157.	80.	4.2	10.8	7.8	3.	......	.36	.26	.10	.68	.30	.38	.01	.0	2.3	12.	10.	+	19,500
798	" 8	" 9	M.	M.	....	"	183.	144.	39.	3.4	10.8	8.4	2.4	.04	.38	.25	.13	.68	.50	.18	......	.0	2.9	9.	10.	+	9,000
1055	" 15	" 16	M.	S.	....	"	219.	143.	76.	2.3	16.2	14.2	2.	.04	.40	.32	.08	.66	.54	.12	......	.10	5.4	10.	13.	......	....
1056	" 22	" 23	M.	S.	....	"	202.	129.	73.	2.9	16.6	14.8	1.8	.02	.41	.28	.13	.68	.58	.10	.0	.26	4.7	13.	14.	+	23,000
....	....	....	....	....	....	....	......	......	......	......	....	....	....	......	......	......	......	....	....	....	......	......	......	......	......	......	....

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 186.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

SOURCE OF WATER—MISSISSIPPI RIVER, 400 YARDS FROM ILLINOIS SHORE, AT CHAIN OF ROCKS, PUMPING STATION ST. LOUIS WATER WORKS.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1890 Collection.	1890 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dis-solv'd	Albuminoid Am. Sus-pend'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
657	July 6	July 7	VVH.	VVH.	.2	None	1822.	195.	1627.	4.0	31.6	9.8	21.8	.04	.94	.32	.62	1.88	.52	1.36	......	......	......	......	......	+	21,350
658	" 13	" 14	VVH.	VVH.	.05	"	2184.	166.	2018.	3.6	47.6	8.8	38.8	.07	1.70	.20	1.50	2.88	.54	2.34	.006	1.50	23.9	27.	35.	+	40,500
659	" 20	" 21	VVH.	VVH.	.05	"	2083.	187.	1896.	4.	22.4	6.9	25.5	.10	1.06	.17	.88	2.20	.32	1.88	......	.30	20.6	26.	37.	+	19,000
660	" 27	" 28	VVH.	VVH.	.05	"	1540.	194.	1346.	4.9	23.6	6.4	17.2	.02	.77	.19	.58	1.68	.26	1.42	.004	.60	16.6	29.	38.	+	9,350
661	Aug. 3	Aug. 4	VVH.	VVH.	.1	"	2066.	212.	1854.	5.2	26.	5.5	20.5	.02	.90	.20	.70	2.08	.20	1.88	.0	.40	14.3	29.	37.	+	7,750
662	" 10	" 11	VVH.	VVH.	.05	"	2656.	194.	2462.	5.8	15.	6.2	8.8	.04	.30	.21	.09	1.40	.52	.88	.028	.58	12.9	30.	29.	+	29,250
663	" 17	" 18	VVH.	VH.	......	"	1333.	174.	1159.	5.3	22.	5.3	16.7	.04	.70	.17	.53	1.56	.22	1.36	.004	.75	13.9	27.	32.	......	......
664	" 24	" 25	VVH.	VVH.	......	"	844.	179.	665.	5.8	18.4	6.	12.4	.03	.61	.31	.30	1.28	.40	.88	.009	.39	9.7	27.	33.	+	17,700
665	" 31	Sept. 1	VVH.	VH.	......	"	831.	214.	617.	6.3	14.	4.8	9.2	......	.43	.18	.25	......	.40	......	.004	.60	7.5	27.	32.	−	17,000
666	Sept. 7	" 8	VVH.	VH.	......	"	581.	214.	367.	......	12.4	6.1	6.3	.02	.42	.17	.25	.94	.24	.70	......	......	6.6	29.	38.	......	......
667	" 14	" 15	VVH.	VH.	......	"	328.	183.	145.	4.8	10.8	7.	3.8	......	.45	.21	.24	1.12	.60	.52	......	......	6.6	22.	24.	+	47,350
668	" 21	" 22	VVH.	M.	......	"	327.	197.	130.	7.1	11.8	7.2	4.6	.02	.48	.27	.21	1.00	.48	.52	.004	.60	6.6	19.	20.	−	25,750
669	" 28	" 29	VVH.	M.	......	"	300.	164.	145.	5.4	11.8	7.8	4.	......	.46	.24	.22	.86	.42	.44	.026	......	5.3	16.	18.	+	16,000
670	Oct. 5	Oct. 6	VVH.	M.	......	"	264.	164.	100.	4.4	12.4	6.6	5.8	......	.49	.30	.19	.78	.40	.38	......	......	4.5	15.	21.	+	6,250
671	" 12	" 13	VVH.	M.	......	"	309.	182.	127.	6.	12.4	7.9	4.5	......	.47	.25	.22	.86	.30	.56	......	.40	3.5	17.	......	+	60,000
672	" 20	" 23	VVH.	H.	......	"	312.	201.	111.	8.6	11.0	8.3	2.8	......	.42	.27	.15	.78	.74	.04	......	......	3.3	17.	18.	......	......
673	" 26	" 28	VVH.	M.	......	"	300.	183.	126.	7.6	10.4	6.	4.4	.016	.22	.14	.18	.80	.32	.48	......	......	3.	17.	19.	+	13,650
674	Nov. 2	Nov. 3	VVH.	M.	......	"	322.	186.	136.	8.6	10.4	7.	3.4	.04	.34	.20	.14	.86	......	......	.013	.0	3.9	9.	3.	+	8,500
675	" 13	" 14	VVH.	M.	......	"	......	......	......	6.4	......	......	......	.032	.46	.30	.18	......	......	......	.01	......	6.2	9.	14.	−	12,000
1120	" 23	" 24	VVH.	VH.	......	"	349.	192.	157.	10.5	16.2	12.2	4.	.03	.50	.25	.25	1.16	.38	.78	.01	.40	6.2	11.	......	+	60,750
1133	" 30	Dec. 1	MH.	MS.	......	"	226.	173.	54.	8.1	14.0	12.2	1.8	.22	.36	.28	.08	......	.86	......	.012	.59	5.5	8.	17.	−	14,250

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 187.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, MIDSTREAM, AT CHAIN OF ROCKS, PUMPING STATION ST. LOUIS WATER WORKS.

Report of ADOLPH GEHRMANN,
D. H. BISBEE,
Municipal Laboratory, Chicago, Ill.

Serial No.	DATE OF		APPEARANCE.			Odor	RESIDUE ON EVAPORATION.			Chlorine.	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of [illegible] Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Susp'd Matter	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspend'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
632	July 6	July 7	VVH.	VVH.	.2	None	2456.	196.	2260.	4.1	35.6	8.	27.6	.04	1.20	.30	.90	2.48	.48	2.00	......	......	22.6	26.	27.	+	45,000
633	" 13	" 14	VVH.	VVH.	.05	"	2574.	172.	2402.	4.	50.8	8.	42.8	.08	1.70	.20	1.50	3.28	.48	2.80	.003	1.90	23.9	27.	35.	−	53,650
634	" 20	" 21	VVH.	VVH.	.05	"	2562.	188.	2374.	4.6	35.6	6.3	29.3	.10	.97	.16	.81	2.28	.30	1.98	......	.30	20.6	30.	27.	+	25,000
635	" 27	" 28	VVH.	VVH.	.05	"	2163.	189.	1974.	5.	29.2	5.4	23.8	.16	.85	.16	.69	1.88	.22	1.66	.011	.35	16.6	29.	33.	+	9,350
636	Aug. 3	Aug. 4	VVH.	VVH.	.1	"	2462.	210.	2252.	5.4	25.9	4.9	21.0	.02	1.00	.20	.80	2.16	.20	1.96	......	.40	14.3	29.	27.	−	2,309,500
637	" 10	" 11	VVH.	VVH.	.05	"	1945.	182.	1763.	4.4	24.	5.2	18.8	.04	.80	.16	.64	1.88	.42	1.46	.000	.40	12.9	28.	29.	+	28,000
638	" 17	" 18	VVH.	VVH.	....	"	1869.	155.	1714.	5.5	26.4	4.9	21.5	.04	.80	.16	.64	1.60	.18	1.42	.002	.60	13.9	27.	32.	+	....
639	" 24	" 25	VVH.	VVH.	....	"	1315.	182.	1133.	5.9	26.	4.7	21.3	.02	.93	.164	.766	1.74	.32	1.42	.010	.40	9.7	27.	32.	−	26,666
640	" 31	Sept. 1	VVH.	VVH.	....	"	1028.	219.	809.	6.6	15.6	5.5	10.1	......	.58	.16	.42	1.08	.44	.64	.001	.40	7.5	27.	32.	+	8,000
641	Sept. 7	" 8	VVH.	VVH.	....	"	831.	258.	573.	7.	14.8	5.7	9.1	.02	.48	.14	.34	1.10	.22	.88	......	......	6.6	29.	38.	+	40,650
642	" 14	" 15	VVH.	VH.	....	"	851.	224.	627.	7.9	13.4	5.	8.4	......	.48	.15	.33	1.34	.50	.84	......	......	6.6	23.	24.	+	24,000
643	" 21	" 22	VVH.	VH.	....	"	747.	234.	513.	8.8	11.8	5.	6.8	.02	.42	.16	.26	.96	.28	.68	.0	.40	6.6	19.	20.	+	33,500
644	" 28	" 29	VVH.	VH.	....	"	378.	230.	148.	9.7	11.2	5.	6.2	......	.45	.15	.30	.82	.30	.52	.017	......	5.3	16.	18.	−	19,500
645	Oct. 5	Oct. 6	VVH.	VH.	....	"	702.	256.	446.	12.4	11.	4.9	6.1	......	.40	.14	.26	.86	.24	.62	......	......	4.5	15.	21.	+	14,500
646	" 12	" 13	VVH.	H.	....	"	661.	276.	385.	12.4	10.	4.1	5.9	......	.37	.15	.22	.86	.22	.64	......	.50	3.5	17.	22.	+	25,000
647	" 20	" 23	VVH.	VH.	....	"	595.	274.	321.	14.3	9.2	4.6	4.6	......	.41	.16	.25	.78	.44	.34	......	......	3.3	17.	18.	......	....
648	" 26	" 28	VVH.	VH.	....	"	613.	274.	339.	14.2	8.4	4.3	4.1	......	.28	.14	.14	.74	.20	.54	......	......	3.	17.	19.	+	30,250
649	Nov. 2	Nov. 3	VVH.	VH.	....	"	649.	265.	384.	13.8	9.	3.6	5.4	......	.30	.10	.20	.78	.24	.54	.006	.0	3.9	9.	2.	+	34,750
650	" 13	" 14	VVH.	M.	....	"	......	......	......	13.2	.....	.....	.....	.02	.33	.19	.14	.....	.....	.....	.003	......	6.2	9.	14.	+	18,750
1128	" 23	" 24	VVH.	VH.	....	"	623.	249.	374.	10.6	13.4	7.3	6.1	.02	.36	.13	.23	.88	.26	.62	......	.26	6.2	11.	10.	+	35,000
1132	" 30	Dec. 1	VVH.	H.	....	"	566.	256.	310.	13.	10.8	6.	4.8	.03	.32	.13	.19	.76	.32	.44	.004	.30	5.5	8.	17.	+	68,250

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 188.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, AT CHAIN OF ROCKS, INLET TOWER, ST. LOUIS WATER WORKS.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved	By Susp'd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Dis-solv'd	Sus-pnd'd	Total.	Dis-solved.	Sus-pended.	Nitrites	Nitrates					
607	July 6	July 7	VVH.	VVH.	.1	None	2687.	210.	2477.	4.4	37.6	8.2	29.4	.04	1.30	.22	1.08	2.88	.48	2.40	.....	.....	22.6	26.	27.	+	25,000
608	" 13	" 14	VVH.	VVH.	.05	"	3115.	185.	2930.	4.1	54.4	7.4	47.	.08	1.95	.18	1.77	3.68	.46	3.22	.003	1.90	23.9	27.	25.	+	46,000
609	" 20	" 21	VVH.	VVH.	.05	"	2651.	195.	2456.	4.9	37.2	6.	31.2	.10	1.17	.16	1.01	3.08	.30	2.78	.....	.30	20.6	26.	27.	+	22,350
610	" 27	" 28	VVH.	VVH.	.05	"	2502.	214.	2288.	4.7	32.	5.2	26.8	.16	1.00	.16	.84	2.16	.20	1.96	.008	.50	16.6	29.	26.	+	11,650
611	Aug. 3	Aug. 4	VVH.	VVH.	.1	"	2616.	211.	2405.	5.4	30.	4.5	25.5	.02	1.10	.19	.91	2.28	.20	2.08	.003	.40	14.3	29.	37.	−	13,750
612	" 10	" 11	VVH.	VVH.	.05	"	2378.	189.	2189.	4.9	26.4	4.4	22.	.04	.90	.12	.78	2.08	.34	1.74	.003	.40	13.9	26.	29.	+	27,000
613	" 17	" 18	VVH.	VVH.	....	"	2107.	187.	1920.	6.8	29.5	4.5	25.	.04	1.00	.14	.86	2.08	.13	1.95	.004	.70	13.9	27.	32.	....	....
614	" 24	" 25	VVH.	VVH.	....	"	1558.	188.	1370.	6.6	30.	4.2	25.8	.02	1.10	.14	.96	2.04	.36	1.68	.006	.50	9.7	27.	32.	+	27,323
615	" 31	Sept. 1	VVH.	VVH.	....	"	1173.	212.	961.	7.4	17.6	4.1	13.5	......	.63	.12	.51	1.08	.30	.78	.004	.50	7.5	27.	32.	+	19,000
616	Sept. 7	" 8	VVH.	VVH.	....	"	1072.	232.	840.	8.	16.4	4.4	12.	.02	.48	.13	.35	1.06	.24	....	.....	.....	6.6	29.	28.	+	50,500
617	" 14	" 15	VVH.	VVH.	....	"	1019.	239.	780.	9.6	13.8	4.5	9.3	......	.48	.13	.35	1.18	.44	.74	.....	.....	6.6	23.	24.	+	47,500
618	" 21	" 22	VVH.	VVH.	....	"	896.	249.	647.	10.6	12.	3.9	8.1	.02	.42	.12	.30	1.00	.24	.76	.0	.40	6.6	19.	20.	+	34,250
619	" 28	" 29	VVH.	VVH.	....	"	787.	247.	540.	11.3	11.	4.2	6.8	......	.40	.13	.27	.94	.32	.62	.017	.....	5.3	16.	18.	−	21,750
620	Oct. 5	Oct. 6	VVH.	VH.	....	"	757.	269.	488.	13.2	11.	3.8	7.2	......	.39	.13	.26	.90	.20	.70	.....	.....	4.5	15.	21.	+	11,000
621	" 12	" 13	VVH.	VH.	....	"	691.	285.	406.	13.8	9.8	3.5	6.3	......	.36	.12	.24	.88	.30	.58	.....	.....	3.5	17.	22.	+	24,000
622	" 20	" 23	VVH.	VH.	....	"	661.	295.	366.	15.8	8.6	3.4	5.2	......	.35	.18	.17	.68	.38	.30	.....	.....	3.3	17.	18.	....	....
623	" 26	" 28	VVH.	VH.	....	"	581.	291.	290.	10.	8.8	3.3	5.5	......	.28	.09	.19	.70	.20	.50	.....	.....	3.	17.	19.	+	20,750
624	Nov. 2	Nov. 3	VVH.	VH.	....	"	654.	266.	388.	14.2	9.4	3.5	5.9	.02	.30	.10	.20	.78	.22	.56	.006	.....	3.9	9.	2.	+	22,500
625	" 13	" 14	VVH.	M.	....	"	......	......	......	16.1	....	....	....	......	.25	.16	.09	....	....	....	.007	.....	6.2	9.	14.	+	10,350
1127	" 23	" 24	VVH.	VH.	....	"	688.	236.	452.	12.	13.2	6.3	5.9	.02	.37	.12	.25	.90	.36	.54	.003	.20	6.3	11.	10.	+	50,000
1131	" 30	Dec. 1	VVH.	H.	....	"	632.	282.	350.	14.4	9.4	4.7	4.7	.024	.32	.13	.19	.72	.30	.42	.004	.40	5.5	8.	17.	+	....

APPEARANCE—H , Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 189.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 400 FEET FROM MISSOURI SHORE, AT CHAIN OF ROCKS.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Il

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspend'd	Total.	Dissolved.	Suspended.	Nitrites	Nitrates					
532	July 6	July 7	VVH.	VVH.	.1	None	3024.	214.	2810.	4.8	38.4	7.4	31.	.04	1.20	.20	1.00	2.88	.66	2.22	......	......	22.6	26.	......	—	43,650
533	" 13	" 14	VVH.	VVH.	.06	"	3303.	184.	3119.	4.4	58.	6.6	51.4	.09	2.10	.18	1.92	3.78	.44	3.34	.008	1.90	23.9	27.	35.	+	48,650
534	" 20	" 21	VVH.	VVH.	.05	"	2942.	199.	2743.	5.1	38.4	5.1	33.3	.10	1.20	.14	1.06	2.68	.24	2.44	......	.40	20.6	26.	37.	+	23,000
535	" 27	" 28	VVH.	VVH.	.05	"	2576.	200.	2376.	5.2	36.4	4.6	31.8	.12	1.00	.16	.84	2.28	.20	2.08	.008	.35	16.6	29.	36.	+	14,350
536	Aug. 3	Aug. 4	VVH.	VVH.	.1	"	2902.	310.	2592.	5.4	30.5	3.8	26.7	.02	1.05	.20	.85	2.36	.20	2.16	.0	.80	14.3	29.	37.	+	17,750
537	" 10	" 11	VVH.	VVH.	.05	"	2656.	194.	2462.	5.2	28.4	3.5	24.9	.04	.90	.12	.78	2.40	.26	2.14	.003	.50	12.9	26.	29.	+	21,500
538	" 17	" 18	VVH.	VVH.	....	"	2388.	187.	2201.	7.2	33.2	4.	29.2	.04	1.05	.15	.90	2.20	.10	2.10	.004	.90	13.9	27.	22.	......	....
539	" 24	" 25	VVH.	VVH.	....	"	1662.	194.	1468.	6.9	30.8	4.1	26.7	.02	1.10	.13	.97	2.28	.30	1.98	.006	.60	9.7	27.	22.	—	50,000
540	" 31	Sept. 1	VVH.	VVH.	....	"	1241.	209.	1032.	7.4	18.2	3.9	14.3	......	.63	.09	.54	1.28	.28	1.00	.004	.70	7.5	27.	22.	—	15,000
541	Sept. 7	" 8	VVH.	VVH.	....	"	1064.	236.	828.	8.	16.8	4.6	12.2	.02	.48	.13	.35	.96	.26	.70	......	......	6.6	20.	28.	—	30,000
542	" 14	" 15	VVH.	VVH.	....	"	1107.	258.	849.	10.8	15.2	4.3	10.9	......	.50	.16	.34	1.30	.50	.80	......	......	6.6	22.	24.	+	82,350
543	" 21	" 22	VVH.	VVH.	....	"	1009.	268.	741.	12.1	12.8	3.8	9.0	.02	.42	.11	.31	.80	.24	.56	.0	.60	6.6	19.	20.	+	33,000
544	" 28	" 29	VVH.	VH.	....	"	831.	262.	569.	11.6	11.	4.1	6.9	......	.45	.12	.33	.94	.26	.68	......	......	5.3	16.	18.	—	24,000
545	Oct. 5	Oct. 6	VVH.	VH.	....	"	794.	275.	519.	13.9	11.6	3.8	7.8	......	.39	.13	.26	.82	.30	.52	......	......	4.5	15.	21.	+	11,750
546	" 12	" 13	VVH.	VH.	....	"	727.	304.	423.	14.7	9.6	2.9	6.7	.04	.36	.12	.24	.82	.28	.54	......	.40	3.5	17.	22.	+	21,500
547	" 20	" 21	VVH.	VH.	....	"	696.	313.	383.	17.2	8.6	3.1	5.5	......	.37	.16	.21	.70	.54	.16	......	......	3.3	17.	18.	......	....
548	" 26	" 28	VVH.	VH.	....	"	602.	291.	311.	15.7	8.6	3.	5.6	.016	.30	.09	.21	.70	.20	.50	......	......	3.	17.	19.	+	22,350
549	Nov. 2	Nov. 3	VVH.	VH.	....	"	692.	274.	418.	14.9	9.	3.3	5.7	.03	.32	.10	.22	.72	.16	.56	.01	......	3.9	9.	2.	+	30,000
550	" 13	" 14	VVH.	M.	....	"	......	......	......	23.2	.....	.....	.....	.008	.24	.14	.10	.....	.....	.....	.005	.....	6.2	9.	14.	+	20,250
1128	" 23	" 24	VVH.	VH.	....	"	846.	290.	556.	14.7	12.	3.7	8.3	.02	.36	.06	.30	.86	.16	.70	.002	.20	6.3	11.	10.	+	47,000
1130	" 30	Dec. 1	VVH.	VH.	....	"	718.	293.	425.	17.0	9.	3.1	5.9	.03	.32	.08	.24	.74	.26	.48	.004	.30	5.5	8.	17.	+	53,500

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 190.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSOURI RIVER, FORT BELLEFONTAINE, WEST ALTON, MO.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Il

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Susp'd Matter	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspnd'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
451	July 27	July 29	VVH.	VVH.	.05	None	3097.	224.	2873.	5.2	33.2	3.3	29.9	.01	1.20	.08	1.12	1.28	.20	1.08	......	.60	13.3	29.	......	+	34,65
452	Aug. 2	Aug. 4	VVH.	VVH.	.05	“	3430.	......	......	5.3	36.5	3.3	33.2	.03	1.10	.12	.98	2.88	.12	2.76	......	.70	12.4	29.	34.	+	771,75
453	“ 10	“ 12	VVH.	VVH.	.05	“	3243.	202.	3041.	5.7	30.6	1.	29.6	.08	.93	.08	.85	2.72	.52	2.20	.0	.40	11.6	27.	30.	+	38,25
454	“ 17	“ 18	VVH.	VVH.	......	“	2743.	199.	2544.	8.8	35.	3.4	31.6	.06	1.10	.12	.98	2.48	.14	2.34	.008	1.00	11.2	28.	25.	+	30,75
455	“ 24	“ 25	VVH.	VVH.	......	“	1898.	198.	1700.	10.6	34.8	3.2	31.6	.03	1.02	.15	.87	2.68	.25	2.43	.005	.70	9.2	28.	25.	+	36,25
456	“ 31	Sept. 1	VVH.	VVH.	......	“	1468.	217.	1251.	8.1	19.6	......	......	......	.60	.10	.50	1.36	.14	1.22	......	.80	8.3	28.	29.	+	17,00
457	Sept. 7	“ 8	VVH.	VVH.	......	“	1153.	244.	909.	9.	14.8	2.7	12.1	......	.45	.13	.32	1.00	.30	.70	......	......	7.3	29.	34.	+	52,00
458	“ 14	“ 15	VVH.	VVH.	......	“	1243.	268.	975.	11.2	16.	3.1	12.9	......	.45	.09	.36	1.12	.26	.86	......	......	6.7	22.	27.	+	56,77
459	“ 21	“ 22	VVH.	VVH.	......	“	1114.	276.	838.	12.3	13.2	2.6	10.6	......	.46	.16	.30	.98	.32	.66	......	.20	6.1	20.	23.	+	61,75
460	“ 28	“ 29	VVH.	VVH.	......	“	950.	292.	658.	14.1	10.6	2.4	8.2	.016	.41	.15	.26	1.02	.20	.82	......	......	5.5	18.	17.	+	60,75
461	Oct. 5	Oct. 6	VVH.	VVH.	......	“	......	......	......	15.3	10.6	2.2	8.4	......	.34	.08	.26	.68	.28	.40	......	......	5.	17.	21.	+	18,50
462	“ 12	“ 13	VVH.	VH.	......	“	819.	316.	503.	16.	8.6	1.7	6.9	......	.33	.11	.22	.98	.26	.72	......	.60	4.8	22.	25.	+	31,50
463	“ 19	“ 20	VVH.	VH.	......	“	771.	324.	447.	17.6	8.8	2.1	6.7	......	.31	.11	.20	.70	.24	.46	.0	......	4.6	18.	19.	+	18,50
464	“ 26	“ 27	VVH.	VH.	......	“	774.	314.	460.	17.6	7.6	2.	5.6	......	.24	.08	.16	.74	.24	.50	......	......	4.5	19.	23.	+	38,50
465	Nov. 2	Nov. 3	VVH.	VH.	......	“	807.	303.	504.	17.	8.	2.3	5.7	......	......	.08	......	.80	.18	.62	......	.0	4.7	11.	0.	+	37,25
466	“ 9	“ 10	VVH.	VH.	......	“	699.	328.	[illegible]	24.0	7.4	2.3	5.1	.016	.32	.11	.21	.72	.18	.54	......	.40	4.5	12.	23.	+	35,00
467	“ 16	“ 17	VVH.	VH.	......	“	676.	339.	337.	20.6	5.8	2.3	3.5	......	.23	.10	.13	.64	.14	.50	......	.40	4.4	12.	19.	......	......
468	“ 23	“ 24	VVH.	VH.	......	“	952.	313.	639.	16.2	8.5	2.5	6.	.02	.37	.08	.29	.86	.20	.66	......	......	4.9	11.	10.	+	47,75
469	“ 30	Dec. 1	VVH.	VH.	......	“	793.	330.	463.	17.7	8.2	2.	6.2	.04	.30	.08	.22	.82	.22	.60	.006	.30	5.	10.	17.	+	47,50

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 191.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 100 YARDS FROM ILLINOIS SHORE,
JEFFERSON BARRACKS, MO.

Report of ADOLPH GEHRMANN,
D. B. BISBEE.
Municipal Laboratory, Chicago, Ill

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am.												
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Tot'l.	Dissolv'd.	Suspend'd.	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
850	July 14	July 17	VVH.	VVH.	.05	None	2556.	188.	2368.	3.7	48.4	9.3	39.1	.08	1.56	.18	1.38	3.68	.48	3.20	......	......	23.6	28.	......	+	49,000
886	" 21	" 24	VVH.	VVH.	.05	"	2017.	191.	1826.	4.9	34.4	7.4	27.	.08	1.18	.19	.99	2.00	.28	1.72	.006	.60	19.8	28.	......	−	10,250
853	" 27	" 28	VVH.	VVH.	.05	"	1690.	197.	1493.	5.6	28.	6.1	21.9	.02	.72	.16	.56	1.68	.24	1.44	.008	.50	16.3	30.	......	+	35,250
917	Aug. 3	Aug. 4	VVH.	VVH.	.06	"	1984.	211.	1773.	5.5	26.	5.1	20.9	.03	.80	.16	.64	2.00	.20	1.80	......	.40	......	......	......	+	20,250
923	" 11	" 14	VVH.	VVH.	.05	"	2645.	199.	2446.	5.5	25.	2.6	22.4	.08	.95	.13	.82	2.36	.20	2.16	......	.60	14.4	30.	......	−	27,750
919	" 17	" 18	VVH.	VVH.	......	"	1393.	178.	1215.	5.5	24.	5.5	18.5	.04	.70	.16	.54	1.48	.22	1.26	.007	.70	13.9	29.	......	−	......
912	" 25	" 25	VVH.	VH.	......	"	860.	186.	674.	6.1	18.4	5.1	13.3	.02	.60	.18	.42	1.58	.40	1.18	.008	.50	8.4	30.	......	−	25,250
906	" 31	Sept. 1	VVH.	H.	......	"	894.	215.	679.	6.4	16.4	4.8	11.6	......	.47	.14	.33	.88	......	......	.006	.40	7.5	30.	......	+	28,000
911	Sept. 8	" 9	VVH.	VH.	......	"	541.	196.	345.	6.4	10.	6.1	3.9	.024	.43	.22	.21	.80	.40	.40	......	.36	6.3	30.	......	+	100,000
917	" 14	" 15	VVH.	VH.	......	"	410.	208.	202.	5.6	10.8	6.5	4.3	......	.40	.23	.17	.84	.40	.44	......	......	6.8	22.	......	+	63,000
923	" 22	" 23	VVH.	M.	......	"	349.	198.	151.	6.5	11.8	7.	4.8	......	.58	.24	.34	.88	.52	.36	......	.0	6.7	19.	......	......	......
924	" 28	" 29	VVH.	M.	......	"	303.	182.	121.	6.1	11.2	7.2	4.	......	.49	.29	.20	.94	.30	.64	......	......	5.3	17.	......	+	25,750
930	Oct. 6	Oct. 7	VVH.	M.	......	"	......	......	......	5.8	12.6	8.7	3.9	......	.48	.26	.22	.86	.44	.42	......	......	4.1	16.	......	+	43,750
936	" 12	" 13	VVH.	M.	......	"	......	211.	......	6.8	11.6	7.3	4.3	......	.48	.33	.15	.78	.42	.36	......	......	3.5	20.	......	+	35,250
943	" 19	" 20	VVH.	M.	......	"	317.	204.	113.	9.2	11.	7.3	3.7	......	.46	.25	.21	1.10	.40	.70	.008	......	3.2	19.	......	+	29,000
948	" 26	" 27	VVH.	H.	......	"	330.	202.	128.	8.6	10.2	6.9	3.3	......	.44	.23	.21	.86	.32	.54	.006	.0	2.8	19.	......	+	38,000
941	Nov. 3	Nov. 4	VVH.	H.	......	"	323.	211.	112.	8.7	10.	6.3	3.7	.03	.44	.24	.20	.84	.30	.54	......	......	4.	9.	......	+	27,250
955	" 11	" 13	VVH.	M.	......	"	293.	179.	114.	6.4	12.	9.1	2.9	.04	.42	.26	.16	......	......	......	.08	.40	5.4	9.	......	+	15,750
1481	" 16	" 17	VVH.	S.	......	"	213.	153.	60.	7.8	15.2	12.6	2.6	......	.52	.35	.27	.98	.52	.46	.014	.50	6.5	10.	......	+	25,500
1482	" 23	" 24	VVH.	M.	......	"	265.	168.	97.	8.6	16.4	12.6	3.8	.06	.53	.29	.24	1.00	.50	.50	.008	.36	6.6	12.	......	+	34,000
1483	" 30	Dec. 2	VH.	MH.	......	"	233.	172.	61.	8.1	14.2	11.6	2.6	.13	.38	.21	.17	.90	.64	.26	......	......	5.6	9.	......	+	15,750

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 192.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, EAST OF MIDSTREAM, JEFFERSON BARRACKS, MO.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspnd'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
916	Aug. 3	Aug. 4	VVH.	VVH.	.05	None	2463.	229.	2234.	5.3	26.	5.	21.	.02	.90	.16	.74	2.08	.28	1.80	......	.50	14.3	33.	......	+	33,500
922	" 11	" 14	VVH.	VVH.	.05	"	2289.	196.	2093.	4.7	23.8	4.5	19.3	.04	.90	.13	.77	1.88	.20	1.68	......	.50	14.4	29.	......	+	46,000
918	" 17	" 18	VVH.	VVH.	....	"	1367.	166.	1201.	5.4	24.4	5.3	19.1	.04	......	......	......	1.42	.20	1.22	.006	.55	13.0	29.	......	......	......
911	" 25	" 25	VVH.	VVH.	....	"	1077.	182.	895.	6.1	25.2	5.7	19.5	.02	.74	.20	.54	1.08	.34	1.34	.008	.60	8.4	30.	......	+	32,000
904	" 31	Sept. 1	VVH.	VH.	....	"	973.	221.	752.	6.8	15.6	4.6	11.0	......	.50	.16	.34	1.08	.24	.84	.006	.40	7.5	30.	......	−	29,000
910	Sept. 8	" 9	VVH.	VH.	....	"	657.	207.	450.	6.6	11.6	5.9	5.7	.024	.43	.21	.22	1.06	.36	.70	......	.40	6.3	30.	......	+	112,000
916	" 14	" 15	VVH.	VH.	....	"	494.	197.	297.	5.7	11.6	6.2	5.4	......	.50	.20	.30	1.30	.44	.76	......	......	6.8	23.	......	+	45,500
922	" 22	" 22	VVH.	M.	....	"	483.	206.	277.	6.9	12.	6.6	5.4	......	.54	.21	.33	......	.48	......	......	.10	6.7	19.	......	+	......
923	" 28	" 29	VVH.	H.	....	"	366.	179.	187.	6.2	13.	7.	5.	......	.50	.22	.28	.96	.42	.54	.025	......	5.3	17.	......	+	30,000
929	Oct. 6	Oct. 7	VVH.	H.	....	"	......	......	......	5.8	13.	8.5	4.5		.50	.30	.20	.86	.38	.48	......	......	4.1	16.	......	+	19,500
935	" 12	" 13	VVH.	H.	....	"	360.	204.	156.	7.2	11.2	7.3	3.9	......	.46	.23	.23	.86	.40	.46	......	......	3.5	20.	......	+	31,750
941	" 19	" 20	VVH.	H.	....	"	382.	204.	178.	9.4	11.4	6.8	4.6	......	.47	.24	.23	1.06	.38	.68	.006	......	3.3	19.	......	+	23,500
947	" 26	" 27	VVH.	H.	....	"	362.	208.	154.	9.1	10.2	6.5	3.7	......	.41	.22	.19	.86	.32	.54	.004	.0	2.8	19.	......	+	26,250
940	Nov. 3	Nov. 4	VVH.	H.	....	"	359.	205.	154.	8.4	9.8	6.5	3.3	.03	.46	.25	.21	.82	.46	.36	......	......	4.	9.	......	+	12,000
954	" 11	" 13	VVH.	H.	....	"	331.	185.	146.	6.3	12.2	9.	3.2	.04	.42	.27	.15	......	......	......	.01	.25	5.4	9.	......	+	10,250
1480	" 13	" 17	VVH.	M.	....	"	227.	157.	70.	8.	15.4	12.8	2.6	.016	.52	.26	.26	.94	.54	.40	.014	......	6.5	10.	......	+	27,500
1481	" 23	" 24	VVH.	H.	....	"	284.	164.	120.	8.	16.6	13.	3.6	.03	.50	.28	.22	1.20	.48	.72	.006	.20	6.6	12.	......	+	22,750
1487	" 30	Dec. 2	VH.	H.	....	"	268.	182.	86.	8.2	14.	10.9	3.1	.12	.38	.20	.18	.86	.56	.30	......	......	5.6	9.	......	+	22,000

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

Table 193.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

Source of Water—Mississippi River, Midstream, Jefferson Barracks, Mo.

Report of Adolph Gehrmann,
D. H. Bisbee,
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of 1899 Collection.		Date of 1899 Examination.		Appearance. Turb'y.	Appearance. Sediment.	Appearance. Color.	Odor	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved	Oxygen Consumed. By Susp'd Matter	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Am. Tot'l	Nitrogen as Ammonia. Albuminoid Am. Dissolv'd	Nitrogen as Ammonia. Albuminoid Am. Suspend'd	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended	Nitrogen as Nitrites	Nitrogen as Nitrates	Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
844	July	14	July	17	VVH.	VVH.	.06	None	2871.	199.	2672.	3.8	50.8	8.7	42.1	.06	1.76	.17	1.50	3.88	.36	3.52	......	......	23.6	28.	......	+	52,650
833	"	21	"	24	VVH.	VVH.	.06	"	2452.	......	......	5.0	36.	6.9	29.1	.06	1.25	.24	1.01	3.32	.28	2.04	.006	.60	19.8	28.	......	+	30,650
859	"	27	"	28	VVH.	VVH.	.06	"	1927.	222.	1705.	5.6	27.6	5.6	22.	.02	.76	.13	.63	1.76	.20	1.56	.006	.30	16.2	30.	......	+	14,250
915	Aug.	3	Aug.	4	VVH.	VVH.	.06	"	2489.	224.	2265.	5.5	28.	4.9	23.1	.02	.87	.16	.71	2.48	.20	2.28	.002	.50	14.3	32.	......	—	20,500
921	"	11	"	14	VVH.	VVH.	.06	"	1551.	177.	1374.	4.	21.	5.5	15.5	.08	.80	.22	.58	1.40	.26	1.14	......	.50	14.4	29.	......	+	48,750
917	"	17	"	18	VVH.	VVH.	....	"	1679.	186.	1493.	5.9	26.8	5.	21.8	.04	......	......	......	1.88	.20	1.68	.005	.80	13.9	29.	......	......	....
911	"	25	"	25	VVH.	VVH.	....	"	1077.	182.	895.	6.1	25.2	5.7	19.5	.02	.74	.20	.54	1.68	.34	1.34	.008	.60	8.4	30.	......	+	29,750
903	"	31	Sept.	1	VVH.	VVH.	....	"	1065.	224.	841.	6.8	16.8	4.4	12.4	......	.50	.18	.32	1.28	......	......	.005	.50	7.5	30.	......	—	10,000
909	Sept.	8	"	9	VVH.	VH.	....	"	818.	218.	600.	6.9	16.	5.4	10.6	.024	.47	.20	.27	.80	.36	.44	......	.40	6.3	30.	......	+	76,000
915	"	14	"	15	VVH.	VVH.	....	"	780.	220.	560.	7.8	13.6	5.	8.6	......	.48	.16	.32	1.30	.44	.86	......	......	6.8	22.	......	+	54,250
921	"	22	"	23	VVH.	VH.	....	"	681.	233.	448.	7.9	13.	5.8	7.2	......	.48	.20	.28	.88	.50	.38	......	.60	6.7	19.	......	+	....
922	"	28	"	29	VVH.	VH.	....	"	505.	195.	310.	7.4	11.8	6.3	5.5	......	.46	.20	.26	.98	.40	.58	.020	......	5.3	17.	......	—	16,350
928	Oct.	6	Oct.	7	VVH.	VH.	....	"	......	......	......	10.	12.	6.1	5.9	......	.46	.22	.24	.86	.34	.52	......	......	4.1	16.	......	+	23,750
934	"	12	"	13	VVH.	VH.	....	"	489.	227.	262.	8.6	11.2	6.	5.2	......	.45	.21	.24	.74	.36	.38	......	......	3.5	20.	......	+	12,350
940	"	19	"	20	VVH.	VH.	....	"	490.	222.	268.	10.6	11.	5.8	5.2	......	.44	.21	.23	1.14	.32	.82	.008	......	3.2	19.	......	+	20,250
946	"	26	"	27	VVH.	VH.	....	"	525.	250.	275.	10.7	9.8	5.2	4.6	......	.39	.16	.23	.74	.28	.46	.008	.0	2.8	19.	......	+	22,000
939	Nov.	3	Nov.	4	VVH.	VH.	....	"	470.	228.	242.	9.8	9.6	5.4	4.2	.03	.41	.20	.21	.86	.28	.58	......	......	4.	9.	......	+	26,000
953	"	11	"	13	VVH.	VH.	....	"	367.	206.	161.	6.8	12.2	8.5	3.7	.048	.38	.24	.14	....	...	....	.007	.85	5.4	9.	......	+	14,250
1479	"	16	"	17	VVH.	M.	....	"	262.	159.	103.	7.8	15.4	13.2	2.2	.016	.52	.26	.26	.98	.56	.42	.014	.10	6.5	10.	......	+	35,000
1480	"	23	"	24	VVH.	H.	....	"	352.	177.	175.	7.1	15.6	....	....	.02	.36	.21	.15	.76	.42	.34	.008	.20	6.6	12.	......	+	28,000
1486	"	30	Dec.	2	VVH.	VH.	....	"	429.	239.	190.	10.5	12.4	8.6	3.8	.07	.33	.16	.17	.82	.46	.36	......	......	5.6	9.	......	+	18,750

Appearance—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 194.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, WEST OF MIDSTREAM, JEFFERSON BARRACKS, MO.

Report of ADOLPH GEHRMANN,
D. B. BISBEE,
Municipal Laboratory, Chicago, Ill.

Serial No.	DATE OF		APPEARANCE.			Odor	RESIDUE ON EVAPORATION.			Chlorine.	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
														Free Ammonia	Albuminoid Am												
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Suspd Matter		Tot'l	Dissolv'd	Suspnd'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
914	Aug. 3	Aug. 4	VVH.	VVH.	.05	None	2762.	225.	2537.	5.3	29.5	4.1	25.4	.02	.90	.16	.74	2.48	.20	2.28	......	.60	14.3	32.	......	−	63,000
920	" 11	" 14	"	"	.06	"	2480.	204.	2276.	5.2	25.0	3.8	21.2	.04	.93	.13	.80	2.28	.20	2.08	.015	.49	14.4	29.	......	−	53,250
913	" 17	" 18	"	"	......	"	2112.	188.	1924.	7.4	31.2	4.2	27.	.04	1.05	.18	.87	2.48	.16	2.32	.005	1.00	13.9	29.	......	+	......
909	" 25	" 25	"	"	......	"	1487.	196.	1291.	6.1	29.6	4.5	25.1	.02	1.00	.16	.84	2.08	.32	1.76	.008	.60	8.4	30.	......	+	41,750
902	" 31	Sept. 1	"	"	......	"	1124.	208.	916.	7.3	17.2	4.	13.2	......	.55	.18	.37	1.24	.28	.96	.005	.80	7.5	30.	......	+	22,500
906	Sept. 8	" 9	"	"	......	"	890.	232.	658.	7.7	13.2	6.3	6.9	.024	.45	.14	.31	1.10	.28	.82	......	.36	6.3	30.	......	+	121,350
914	" 14	" 15	"	"	......	"	956.	237.	719.	9.4	14.	4.5	9.5	......	.50	.14	.36	1.50	.44	1.06	......	......	6.8	22.	......	−	34,000
920	" 22	" 23	"	"	......	"	808.	245.	563.	9.6	13.	4.8	8.2	......	.50	.16	.34	.92	.36	.56	......	.20	6.7	19.	......	−	......
921	" 28	" 29	"	"	......	"	633.	339.	294.	9.7	11.	5.	6.	......	.44	.16	.28	.92	.32	.60	.022	......	5.3	17.	......	+	31,650
937	Oct. 6	Oct. 7	"	"	......	"	......	......	......	12.4	11.6	4.8	6.8	......	.45	.21	.24	.86	.40	.46	......	......	4.1	16.	......	+	19,250
933	" 12	" 13	"	VH.	......	"	681.	270.	411.	12.3	10.4	4.3	6.1	......	.41	.20	.21	.86	.38	.48	......	......	3.5	20.	......	+	28,000
939	" 19	" 20	"	"	......	"	630.	249.	381.	13.4	10.4	4.7	5.7	......	.45	.16	.29	1.14	.28	.86	.005	......	3.2	10.	......	+	76,650
944	" 26	" 27	"	"	......	"	594.	262.	332.	12.7	8.8	4.4	4.4	......	.38	.16	.22	.74	.28	.46	.012	.0	2.8	19.	......	+	33,250
968	Nov. 3	Nov. 4	"	"	......	"	631.	250.	382.	12.4	9.2	4.6	4.6	.02	.36	.19	.17	.78	.30	.48	......	......	4.	9.	......	+	48,250
952	" 11	" 13	"	"	......	"	509.	254.	255.	13.9	9.4	5.3	4.1	.048	.34	.16	.18	......	......	......	.007	.30	5.4	9.	......	+	19,500
1478	" 16	" 17	"	M.	......	"	274.	152.	122.	7.6	15.6	12.8	2.8	.016	.52	.26	.26	.92	.54	.38	.012	.05	6.5	10.	......	+	22,750
1479	" 23	" 24	"	VH.	......	"	575.	243.	332.	11.4	12.	7.4	4.6	.03	.35	.13	.22	.90	.36	.54	......	.20	6.6	12.	......	+	40,750
1485	" 30	Dec. 2	"	"	......	"	537.	264.	273.	13.4	11.	6.6	4.4	.04	.33	.12	.21	.90	.38	.52	......	......	5.6	9.	......	+	26,000
....	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 195.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 100 YARDS FROM MISSOURI SHORE, JEFFERSON BARRACKS, MO.

Report of ADOLPH GEHRMANN,
D. H. BIBBS,
Municipal Laboratory, Chicago, Ill.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am												
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Suspend'd	Total.	Dissolved.	Suspended.	Nitrites	Nitrates					
840	July 14	July 17	VVH.	VVH.	.05	None	3090.	198.	2892.	4.2	52.4	8.7	43.7	.08	1.80	.17	1.63	3.68	.28	3.40	......	......	23.6	28	......	+	53,000
828	" 21	" 24	"	"	.05	"	3001.	208.	2453.	5.8	38.	6.	32.	.06	1.20	.19	1.01	2.40	.28	2.12	.006	.60	19.8	28	......	......	......
865	" 27	" 28	"	"	.05	"	2444.	202.	2242.	5.9	29.6	4.7	24.9	.02	.86	.12	.74	1.68	.20	1.48	......	.70	16.2	30	......	+	10,500
913	Aug. 3	Aug. 4	"	"	.05	"	2760.	242.	2518.	5.4	32.	3.8	28.2	.03	1.15	.18	.97	2.80	.20	2.60	.0	.60	14.8	32	......	−	67,000
919	" 11	" 14	"	"	.05	"	1255.	156.	1099.	4.6	19.4	6.1	13.3	.08	.93	.23	.70	1.40	.36	1.04	.08	.47	14.4	30	......	+	45,750
912	" 17	" 18	"	"	......	"	2178.	181.	1997.	7.9	33.5	4.1	29.4	.04	1.10	.15	.95	2.68	.12	2.56	.004	.85	13.9	29	......	......	......
908	" 25	" 25	"	"	......	"	1555.	196.	1359.	7.1	28.4	4.2	24.2	.02	1.05	.15	.90	2.08	.38	1.70	.009	.50	8.4	30	......	−	59,000
901	" 31	Sept. 1	"	"	......	"	1177.	227.	950.	7.5	17.6	4.	13.6	......	.45	.18	.27	1.24	.32	.92	.004	.60	7.5	30	......	+	30,000
907	Sept. 8	" 9	"	"	......	"	906.	224.	682.	8.4	13.2	5.9	7.3	.034	.42	.15	.27	.96	.28	.68	......	.40	6.3	30	......	−	134,500
913	" 14	" 15	"	"	......	"	953.	238.	715.	9.5	13.6	4.4	9.2	......	.50	.13	.37	1.40	.50	.90	......	......	6.8	22	......	+	51,200
919	" 22	" 23	"	"	......	"	818.	247.	571.	10.	12.6	4.4	8.2	......	.42	.16	.26	1.02	.34	.68	......	.90	6.7	19	......	+	......
920	" 28	" 29	"	VH.	......	"	708.	239.	469.	10.4	11.8	4.9	6.9	......	.44	.15	.29	.94	.28	.66	.052	......	5.3	17	......	−	30,650
926	Oct. 6	Oct. 7	"	"	......	"	......	......	......	11.1	11.8	5.1	6.7	......	.44	.21	.23	.86	.30	.56	......	......	4.1	16	......	−	28,250
932	" 12	" 13	"	"	......	"	663.	274.	389.	11.7	10.6	4.4	6.2	......	.43	.19	.24	.86	.38	.48	......	......	3.5	20	......	+	24,750
938	" 19	" 20	"	"	......	"	627.	260.	367.	13.6	10.2	4.5	5.7	......	.43	.16	.27	1.02	.26	.76	.008	......	3.3	19	......	+	39,500
464	" 26	" 27	"	"	......	"	774.	314.	460.	17.6	7.6	2.	5.6	......	.24	.08	.16	.74	.24	.50	......	......	2.8	19	......	+	40,666
937	Nov. 3	Nov. 4	"	"	......	"	646.	263.	383.	13.	9.2	4.	5.2	.02	.43	.18	.25	.86	.32	.54	......	......	4.	9	......	+	42,000
951	" 11	" 13	"	"	......	"	529.	293.	236.	15.3	9.4	5.	4.4	.056	.33	.16	.17	......	......	......	.007	.60	5.4	9	......	+	25,750
1477	" 16	" 17	"	M.	......	"	489.	267.	222.	20.6	10.8	6.5	4.3	.052	.32	.13	.19	.56	.30	.26	.005	.20	6.5	10	......	+	30,000
1478	" 23	" 24	"	VH.	......	"	627.	262.	365.	13.4	11.2	6.4	4.8	.06	.34	.12	.22	.78	.30	.48	.006	.20	6.6	12	......	+	48,500
1484	" 30	Dec. 1	"	"	......	"	565.	277.	288.	13.6	10.4	5.7	4.7	.05	.33	.11	.22	.98	.38	.60	......	......	5.6	9	......	+	10,000

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

TABLE 196.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

Report of ADOLPH GEHRMANN,
D. H. BISBEE,
Municipal Laboratory, Chicago, Ill.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ST. LOUIS, MO., TAP WATER.

Serial No.	Date of 1899 Collection.	Date of 1899 Examination.	Appearance. Turb'y.	Appearance. Sediment.	Appearance. Color.	Odor	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved	Oxygen Consumed. By Susp'd Matter.	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Am. Tot'l	Nitrogen as Ammonia. Albuminoid Am. Dissolv'd	Nitrogen as Ammonia. Albuminoid Am. Suspend'd	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended	Nitrogen as Nitrites	Nitrogen as Nitrates	Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
918	Aug. 3	Aug. 4	VVH.	M.	.05	None	350.	213.	137.	4.8	5.4	4.5	.9	.02	.20	.16	.04	.36	.18	.18	....	.70	....	....	....	−	9,500
924	" 11	" 14	....	....	....	....	295.	215.	80.	5.6	5.	4.8	.2	.04	.16	.12	.04	.28	.22	.06	....	.50	....	....	....	−	19,750
930	" 17	" 18	VVH.	VS.	....	None	408.	195.	213.	5.6	6.1	4.	2.1	.0	.20	.12	.08	.44	.16	.28	.007	.80	....	....	....	−	....
913	" 25	" 25	"	S.	....	"	345.	191.	154.	6.	7.2	4.6	2.6	.08	.18	.143	.037	.48	.45	.03	.004	.60	....	....	....	−	35,000
906	" 31	Sept. 1	"	S	....	"	289.	217.	73.	6.7	6.8	3.8	3.0	....	.18	.15	.03	.66	....	....	.005	.70	....	....	....	+	10,000
912	Sept. 8	" 9	"	VS.	....	"	309.	211.	98.	7.2	4.8	4.3	.5	.024	.17	.18	....	.38	.30	.08	....	.50	....	....	....	−	40,000
918	" 14	" 15	"	"	....	"	290.	244.	45.	8.	3.8	3.5	.3	....	.20	.14	.06	.40	.36	.04	....	....	....	....	....	+	39,000
924	" 22	" 23	"	"	....	"	312.	251.	61.	9.2	4.	4.	....	....	.17	.14	.03	.36	....	....	....	.40	....	....	....	−	....
925	" 28	" 29	"	"	....	"	182.	131.	51.	9.6	4.	3.8	.2	....	.17	.17	....	.42	.22	.20	.007	....	....	....	....	+	35,250
931	Oct. 6	Oct. 7	"	"	....	"	....	....	....	11.4	4.3	3.7	.6	....	.19	.16	.03	.34	.30	.04	....	....	....	....	....	....	....
937	" 12	" 13	"	"	....	"	....	263.	....	12.6	....	3.3	....	....	.14	.14	....	.30	.26	.06	....	....	....	....	....	−	17,500
943	" 19	" 20	"	"	....	"	316.	278.	38.	13.8	4.	3.5	.5	....	.16	.15	.01	.32	.24	....	.005	....	....	....	....	−	27,250
949	" 26	" 27	"	"	....	"	340.	284.	56.	14.4	3.7	3.3	.4	....	.14	.14	....	.30	.20	.10	.000	.0	....	....	....	+	7,250
942	Nov. 3	Nov. 4	"	"	....	"	323.	292.	31.	14.5	3.3	3.2	.1	....	.14	.13	.02	.30	.20	.10	....	....	....	....	....	+	17,750
956	" 11	" 13	"	"	....	"	334.	263.	72.	14.0	4.2	3.4	.8	....	.16	.14	.02	....	....	....	....	.25	....	....	....	+	14,000
1482	" 16	" 17	"	"	....	"	314.	260.	54.	17.	4.5	4.1	.4	....	.15	.11	.04	.32	.32	....	....	.40	....	....	....	+	22,750
1483	" 23	" 24	"	"	....	"	300.	257.	43.	15.6	5.8	5.1	.7	....	.14	.13	.01	.26	.20	.06	.0	.14	....	....	....	+	30,500
1489	" 30	Dec. 2	"	"	....	"	305.	262.	43.	14.4	6.	5.6	.4	.0	.13	.11	.02	.40	.32	.08	....	....	....	....	....	+	179,250
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

APPEARANCE—H., Heavy. VH., Very Heavy. VVH., Very, Very Heavy. S., Slight. VS., Very Slight. VVS., Very, Very Slight. M., Medium.

7982 Adjourned until 2:00 P. M., same day, Friday, October 9, 1903.

2:00 P. M., October 9th, 1903.

Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ADOLPH GEHRMANN,

resumed the stand for further direct-examination by Judge Springer, and testified as follows:

Q. At the time of the noon adjournment, you had read in evidence the tables about which you had testified, beginning with No. 159 and concluding with No. 196. Please state whether or not these tables so read in evidence by you contain a correct statement of the results which you obtained by the bacteriological examinations which you made of the waters referred to in those tables, and also in your ascertainment of the presence or absence of the bacilli coli communis?

A. They contain a correct statement of the results of the findings.

Q. I call your attention to the first table. Please state from what point table No. 159 purports to have received the samples of water?

A. This table of analysis shows the results of the examination of samples from the Illinois and Michigan canal at Bridgeport. 7983

Q. And the next table, No. 160, where were the waters taken from upon which that table is based?

A. This table, table 160, is a record of the results of examinations of the waters of the Illinois and Michigan Canal at Lockport, Illinois.

Q. I desire to call your attention to table 165, and ask you at what point the samples of water were taken upon which that table is based?

MR. JEFFRIES: Now I object to the witness testifying from the tables or to anything in connection with the tables for the reason mentioned in my objection to the reading of the tables into the record.

A. This table, table No. 165, is a record of the examinations made of the waters of the Illinois river at Morris, Illinois.

Q. Now I will ask you to turn to table No. 171 and state at what point in the Illinois river were the samples taken, the results of which are stated in that table?

A. This table, table 171, contains results of the examinations of the water of the Illinois river at Henry, Illinois.

7984 Q. Now I call your attention to the table numbered 172, from what point was the water taken upon which that table is based?

A. This table, table 172 contains the results of the examination of the waters of the Illinois river at Averyville.

Q. Well, state if all the examinations which you have referred to in all these questions, mean bacterial examinations?

A. Yes.

Q. Please cast your eyes over the last column at the right hand,—the right hand column of table No. 159, which shows the results obtained from examinations of waters, taken from the Illinois and Michigan Canal at Bridgeport. Did you make any averages of the total findings for the various dates mentioned during that period?

A. No, I have no averages for these figures.

Q. What dates do those samples cover,—the examinations?

A. The samples in table 159 are for a period from July 3rd to November 27th, 1899, and the samples in table 172 are for a period from July 3rd to November 28th, 1899.

Q. Substantially the same period?

A. The same period practically.

Q. Now what do you find upon the column which is headed "Number of bacteria per cubic centimeter" on table 159, Bridgeport, as to the numbers?

7985 MR. JEFFRIES: I object to the question for the reason that the witness is called upon to give comparative statements as to conditions existing prior to the opening of the canal and those conditions representing merely the conditions that existed in the Chicago river prior to the opening of the canal, and therefore are not comparable with conditions existing since the opening of the drainage canal.

JUDGE SPRINGER: They are comparable in the opinion of counsel for defendants for the purpose of establishing the conditions previously existing, and those which existed subsequently to the turning in of the waters coming from the drainage canal.

MR. JEFFRIES: I submit that it is not a question as to whether the conditions are the same or different now from what they were prior to the opening of the canal, but the question involved in this case is the disease producing germs discharged into the canal by the city of Chicago by means of the drainage canal constructed on the part of the sanitary district, being removed before the waters reach the Missouri shore.

(Question repeated).

Q. JUDGE SPRINGER: What is the least number stated there in that column?

A. Is this another question?

7986 Q. This is the same question. I asked you to look at it. What is the lowest number stated?

MR. JEFFRIES: At which point, Judge?

JUDGE SPRINGER: At Bridgeport,—table 159.

A. The lowest figure as to the bacteria per cubic centimeter in the analyses made of the waters of the Illinois and Michigan canal at Bridgeport was 81,350 bacteria per cubic centimeter.

Q. On what date is that?

A. That was on July 17th, 1899.

Q. What was the largest number found?

A. The largest count was made from the sample collected November 27th, 1899.

Q. What was that?

A. 8,425,000.

Q. State whether the other ascertainments given in that column are within the limits to which you have referred?

A. Yes, they are within the limits.

Q. You stated that you have made no averages. What is your opinion as to what the average would be from this column?

A. Well the average number of bacteria would be—

Q. For the period?

A. For the period would be somewhere in the hundred thousands column.

7987 Q. Now take the corresponding column for Averyville in table 172, what is the lowest ascertainment there?

A. The least number of bacteria found in any of the examinations of the Illinois river water at Averyville, is 7,350 bacteria per cubic centimeter.

Q. What is the largest you found?

A. The largest number of bacteria found in any of these samples was 50,000 bacteria per cubic centimeter.

Q. From an examination of these two tables, and the results stated therein as to the bacterial count at Bridgeport, and the bacterial count at Averyville, what conclusions do you draw, as a bacteriologist?

MR. JEFFRIES: I object for the reason that the witness is called upon to draw conclusions upon conditions that existed prior to the opening of the canal and which do not exist now, so that any conclusions that may be drawn by this witness or any other witness upon such prior existing conditions, is not relative, material or competent in this case, because the conditions by reason of the added volume of water and by reason of the construction of the canal and by reason of the hastening of the disease producing germs away from Chicago have materially changed.

Q. (Question repeated).

7988 A. From an examination of these two tables, and the figures contained therein, I should conclude that in the first place there was a difference of from ten to twenty per cent. in the number of the bacteria present, it being less for the samples at Averyville than for those at Bridgeport, and in some instances a difference of 100 per cent., in favor of the samples at Averyville. I should further conclude that the samples collected at Averyville showed a much greater bacterial purity than those collected at Bridgeport.

Q. Please make a similar comparison with the waters mentioned in table 160, of samples collected from the Illinois and Michigan Canal at Lockport, and those that were mentioned on page 172 at Averyville. Now state your conclusions as a bacteriologist?

A. From an examination of the samples collected from the Illinois and Michigan canal at Lockport and those collected from the Illinois river at Averyville, I should conclude in the first place that there were from ten to twenty per cent. less numbers of bacteria in the Illinois river waters at Averyville and in some

instances a difference of 100 per cent., in favor of the samples from the Illinois river at Averyville, and should conclude that the water in the Illinois river at Averyville shows a much greater bacterial purity than the waters of the Illinois
7989 and Michigan Canal at Lockport.

Q. I call your attention to table No. 165, showing results of examinations made of waters taken from the Illinois river at Morris, Illinois. Please state what in your opinion is disclosed by bacterial count of the samples of water indicated, at Morris, Illinois, as compared with those at Bridgeport in the Illinois and Michigan canal and also as compared with those at Averyville, contained in table 172?

A. Comparing the results of my examinations of the waters of the Illinois and Michigan Canal at Bridgeport, the waters of the Illinois river at Morris, the waters of the Illinois river at Averyville, I should conclude in the first place that the numbers of bacteria present are not materially different in the waters of the Illinois and Michigan canal at Bridgeport, and the Illinois river at Morris, and that the waters of the Illinois river at Averyville contain from ten to twenty per cent. of the number found at the other two points, and in some instances one per cent. of the numbers found at the other two points, more particularly at Bridgeport, and that the bacterial condition of the water represented by these tables, shows that the water of the Illinois river at Averyville is of greater bacterial purity than the water of the Illinois river at Morris or the waters of
7990 the Illinois and Michigan Canal at Bridgeport.

Q. I call your attention to table 171, which states the results of bacterial examinations of water taken from the Illinois river at Henry. Please state what is indicated by the differences here disclosed as to the number of bacteria found at this place and at Morris and at Averyville?

A. A comparison of the results of the examination of the samples of the water in the Illinois river at Morris, Illinois, the Illinois river at Henry, Illinois, and the Illinois river at Averyville, show from the numbers of bacteria present, that there is not a material difference between samples collected at Henry, Illinois and Averyville, except in two instances,—August 8th and September 30th, when they were much higher in the Illinois river at Henry. The bacterial counts at these two points are ten to twenty per cent of those as found at Morris, and show that the water at Henry and at Averyville is of greater bacterial purity than the water of the Illinois river at Morris.'

Q. Please examine table No. 164, which shows the results of your examinations of the water taken from the Kankakee river at Wilmington and also state what relation they bear numerically to those found in the Illinois river at Averyville?

A. The bacterial counts of the waters of the Kankakee
7991 river at Wilmington, Illinois and of the Illinois river at
Averyville, show only slight differences. In some instances they are in favor of the Illinois river and other instances they are in favor of the Kankakee river. The samples are taken about the same time, or near the same time.

Q. From an examination of these two tables, what do you conclude as to their relative significance from a bacterial standpoint?

A. From a bacterial examination or standpoint I should conclude that there was no material difference in these two waters as to their bacterial purity.

MR. JEFFRIES: I move to strike out the conclusions of the witness drawn in reference to the bacterial condition of the water in the tributaries of the Illinois river, and object to the witness testifying in reference thereto, for the reason that it is incompetent, immaterial and irrelevant.

Q. JUDGE SPRINGER: Assuming, professor, that the Kankakee river above the mouth of the Desplaines river is merely an upper portion of the Illinois river, differing only in name, from the lower reaches, and assuming that the condition of the water contained in the Kankakee river before its confluence with the Desplaines river to be as stated in your testimony heretofore, what is your opinion as a bacteriologist,
from an examination of the two tables to which your at-
7992 tention has been called, as to whether or not the Illinois
river at Averyville has reached a condition bacterially substantially the same as that which it had before the waters of the Desplaines river and the Chicago drainage canal and the Illinois and Michigan canal were emptied into it?

MR. JEFFRIES: I object to the question first because the condition of the Kankakee river is not in controversy in this suit.

I object to the question for the further reason that it is not assumed in the question that the same amount of sewage material is deposited in the Kankakee, as is deposited in the Desplaines, the canal and the Illinois river.

I object to the question for the further reason that the assumptions are based upon the bacterial changes in the waters of the Illinois river without reference to the reduction of pathogenic germs.

I object to the question for the further reason that when a river has been subjected to sewage pollution, it is not a question as to the number of bacteria alone that may be found in that river, but the character of the bacteria, with reference to whether they be pathogenic or non-pathogenic, and I object to the question therefore for the further reason that there is nothing within the science of bacteriology, outside of the lab-
7993 oratory or in the laboratory that will enable a bacteriolo-
gist from his examinations alone, to determine from mere counts of bacteria the presence or non-presence of disease producing germs in the water of the river.

A. From an examination of the bacterial counts as made of the samples of water from the Kankakee river at Wilmington, and from the Illinois river at Averyville, I should conclude that the examination showed very much the same conditions as regards bacterial purity, the numbers in the majority of instances being not very different.

Q. Then if we assume that there is such a thing in the Illinois river as a zone of bacterial purification where in your opinion as a bacteriologist, is this zone to be found in the Illinois river?

MR. JEFFRIES: I object to the question for the reason that it is impossible to determine the zone of bacterial purification in any stream after it has been once polluted by sewage.

JUDGE SPRINGER: By bacterial zone I mean a place in the river where it resumes bacterially the conditions which were observed in the water before any alleged pollution was received in the river.

MR. JEFFRIES: Modify my objection so that it may
7994 read as follows:

I object to the question for the reason that there is nothing in the science of bacteriology that will enable one to determine the exact zone of purification of a running stream for sanitary and hygienic purposes, after it has been polluted by the sewage of a city, unless the time of life or longevity of disease producing germs is taken into consideration in connection with the flow of the stream.

Q. (Question repeated).

A. In reply to this question I can say that from the examination of the samples and the number of bacteria found, that there is a point at about Averyville where the condition as to the number of bacteria exists about equal to that of the tributaries of the river, and that the waters here show the least numbers of bacteria in the course of the river to the point at which they increase next below. I should therefore say that a degree of purification had taken place at about the location of Averyville in the river.

Q. So far professor, as the number of bacteria found in a given quantity of water indicates bacterial purity or impurity, what is your opinion as to whether a comparison of the counts in the Kankakee river to which your attention has been
7995 called, and those at Averyville, indicate any effect upon
those numbers which may have been created by the incoming at the mouth of the Desplaines river of any sewage from the city of Chicago.

MR. JEFFRIES: I object to that question for the same reasons contained in the previous objection.

A. My opinion would be from the bacterial count, that there was no particular difference in the bacterial purity of the waters at these two points, and nothing that would indicate to us to what amount pollution had been applied between these points or near these points.

Q. I call your attention now to the table numbered 173, which shows the result of your bacterial examinations of waters taken from a place below Peoria called Wesley City, and also table 174 which shows the results of your bacterial examinations of waters taken from a place below Pekin, Illinois. State what those two tables disclose to you as to bacterial counts, compared with the table in reference to Averyville about which you have already testified?

A. The results of the examinations of Illinois river water at Wesley City, and at Pekin showed very much the same condition. There is a wide variation between the counts made at different times, some being as high as two or three million.

Q. Six million at Wesley City?

7996 A. Well, several million, and again others as low as 10,-
000. In comparison, the examination of the waters of the Illinois river at Averyville shows in general a much smaller number of bacteria present, not in any instance having been over tens of thousands, and would indicate to me that the water of the Illinois river at Averyville is of greater bacterial purity than the water of the Illinois river at Wesley City, or at Pekin.

Q. From the difference in these results which is apparent, to what do you attribute the increased bacterial count at Wesley City and Pekin as compared with that at Averyville, if you know?

A. I attribute that to increased pollution of the river.

Q. Do you know from your knowledge, where that increased pollution comes from?

A. I have seen it coming from the city of Peoria and in that neighborhood.

Q. If you should compare, professor, the tables in reference to Wesley City and Pekin with those in reference to Bridgeport and Lockport, state whether there is any similarity or not as apparent from these counts as to the bacterial condition of the waters at the respective places?

A. A comparison of the bacterial counts of the Illinois and
Michigan canal at Lockport and the Illinois river at
7997 Wesley City and at Pekin show approximately the same
amount of bacterial impurity as to numbers, except that at Wesley City and at Pekin the individual figures are subject to slightly more variation.

Q. I now call your attention to table 179, which shows the result of the bacterial examination of the waters taken from the Illinois river at Grafton, Illinois, if you compare that table with the tables in reference to Wesley City and Pekin, what is indicated as to the bacterial changes if any, which have taken place?

A. The results of the examination of the Illinois river water at Wesley City and Pekin as compared with those at Grafton, in the Illinois river, show that at Grafton there are from ten to twenty per cent of the bacteria present as shown in the samples from Wesley City, and Pekin, and in some instances, one per cent of the bacteria that are present at Pekin and Wesley City.

Q. What conclusion do you draw from this as a bacteriologist?

A. I should conclude from this that the waters of the Illinois river at Grafton show a much greater bacterial purity than those at Wesley City and at Pekin.

Q. If you compared the waters of the Illinois river as disclosed by table 179 at Grafton, with the waters of the
7998 Illinois river at Averyville, as disclosed in table 172, what conclusion do you draw so far as these counts are concerned, as to the relative bacterial purity or impurity of the water?

A. I should conclude that the bacterial purity of the water or its condition, was about the same.

Q. What inference do you draw then as a bacteriologist, and considered from a bacterial standpoint, as to whether the pollution which entered the Illinois river at Peoria has or has not disappeared at Grafton?

A. I should conclude from the bacterial count made on samples of the water of the Illinois river at Wesley City, and Pekin, and at Grafton, that as far as the bacterial purity is concerned, the river had changed to the condition that we find it in from examination of the samples taken at Averyville, above the city of Peoria.

Q. I call your attention professor to table No. 180, which purports to contain the results of examinations of water made of the Mississippi at Grafton, and I call your attention to the bacterial counts found upon that table and ask you to compare those counts with those of the waters of the Illinois river at Grafton found in table 179, and state what those tables disclose as far as those two places are concerned?

7999 MR. JEFFRIES: I object to the question for the reason that the condition of the Mississippi river above Grafton is not at issue in this case and for the same reasons stated in the previous objections with reference to not being a question of the number of bacterial counts contained in the river, but a question as to whether or not disease producing germs from Chicago are not of such a character as to produce fatal effects upon the citizens of the State of Missouri.

Q. (Question repeated). In reference to the bacterial purity or impurity of the two streams?

A. The results of bacterial count of waters—of samples taken from the waters—of the Illinois river at Grafton and those taken from the Mississippi river at Grafton show no material difference and I should conclude from this that the bacterial condition of the two rivers is approximately the same, from the numbers of bacteria present.

Q. I call your attention professor, to table No. 190, which contains the results of your examination of the waters of the Missouri river at Fort Bellefontaine, or West Alton, Missouri, and ask you to state whether or not that point is above the mouth of the Missouri river and where that river has received no waters from the Mississippi river as far as you know?

8000 A. As far as I know it is above that point.

Q. Please examine the bacterial count on that table and compare it with the bacterial count of table 171, which contains the results of your examinations of the Illinois river water at Grafton and state what is disclosed by these respective tables as to the relative bacterial purity or impurity of the waters of the two streams at the respective points indicated?

MR. JEFFRIES: I object to any testimony with reference to the bacterial purity or impurity of the Missouri river, because that question is not in controversy in this case, and for the same reasons stated in the previous objections upon this subject and in reference to conclusions drawn from these tables.

A. The results of the bacterial counts made on the Illinois river at Grafton, and the Missouri river water from Fort Bellefontaine, show that there is no great difference as to the numbers of bacteria from these two points. I should therefore conclude that the bacterial purity or impurity of the two streams is about the same.

Q. I call your attention professor, to tables Nos. 186, 187, 188 and 189, which show bacterial counts of water taken from the Mississippi river at the chain of rocks above the city of St. Louis, where the city of St. Louis takes its water supply?

8001

A. Bacterial counts made of the samples of water taken from the Mississippi above the station at the chain of rocks, the pumping station of the St. Louis waterworks, all show practically the same bacterial counts, and I should conclude that the bacterial purity or impurity of the water at this point is about the same.

Q. I call your attention to the fact that table 186 shows the examination of samples taken from the Mississippi river 400 yards from the Illinois shore at the chain of rocks, and that table 189, contains the results of your examination of samples taken at the same place, 400 feet from the Missouri shore; what difference do you discover if any, in these bacterial counts at these two places?

A. There is no material difference. The bacterial counts from samples 400 yards from the Illinois shore, compare with those 400 feet from the Missouri shore, at the chain of rocks.

Q. I desire you to look at table 195, which shows the results of examinations of water taken from the Mississippi river 100 yards from the Missouri shore, and Jefferson Barracks, Missouri, which is a point on the Mississippi river about eight miles below the Eads Bridge of St. Louis, and about eighteen
miles below the St. Louis intake. That above Jefferson
8002 Barracks, the greater portion of the sewage of St. Louis
is discharged into the Mississippi river. Please state what the bacterial count for these places indicates as compared with the count in table No. 188, which is the result of your examinations of the waters taken from the chain of rocks inlet tower of the St. Louis waterworks?

MR. JEFFRIES: I object to the question because it is incompetent, irrelevant and immaterial.

A. Examination of the result of samples of Mississippi river water taken at the chain of rocks, as shown in table 188, compared with the examination of samples of the Mississippi river water taken at Jefferson Barracks, 100 yards from the Missouri shore, shown in table 195, show no material differences as to the number of bacteria present, and I should conclude that the waters at these particular points show approximately the same bacterial purity or impurity.

Q. State professor, in the examinations which you made of the waters of the Illinois and Michigan canal and of the Illinois river whether you made any effort to ascertain the presence of pathogenic germs?

A. I made an examination for the colon bacillus and the typhoid bacillus.

Q. Did you make any examinations to determine the
8003 presence of any other pathogenic germs?

A. No sir.

Q. State whether the results of your examinations for the presence of the bacillus coli communis are correctly stated in the tables which you have read in evidence?

A. They are.

Q. As heretofore explained by you?

A. Yes sir.

Q. State whether you discovered in any of these examinations, the presence of the typhoid bacillus?

A. No, I did not.

Q. State whether you discovered in any of these waters, or in any of the waters you examined during the time you were director of this laboratory, the presence of the bacillus prodigiosus?

A. You mean in waters?

Q. Yes, in any of the waters you examined coming from Lake Michigan, the Illinois and Michigan Canal or the drainage canal?

A. I cannot say that I found it in waters. I can say however, that I have found it during the examination of waters.

Q. That is what I mean, your examination of waters.
8004 Where did it come from in your opinion?

A. My opinion is that it was an accidental entrance upon the culture plate.

Q. What in your opinion caused that entrance?

A. In some way through the making of the plates, the preparation of the plates, that it arrived on the plates as a contamination approximately.

Q. Did such ascertainment or discovery indicate there were in any of these waters in the vicinity of Chicago the bacillus prodigiosus?

A. I cannot say positively that it indicated that.

MR. JEFFRIES: I object to the question as leading.

Q. JUDGE SPRINGER: What did your tests indicate?

A. They indicated to me that the bacillus prodigiosus is occasionally present in this vicinity, and can be found by exposing material suitable for it to grow, in various places.

Q. I believe you stated, professor, that you made no tests in reference to determining the presence of any other pathogenic germ than the bacillus coli communis and the typhoid bacillus, is that correct?

A. That is correct, yes sir.

Q. If there had been any other germs which are denominated pathogenic, you wouldn't have discovered them as you made no effort to do so? 8005

A. In regard to that point of course, if there had been large numbers of any particular kind, I would have found them. They were evidently not numerous enough to show in the procedures that we used for the isolation of the colon and typhoid and intermediate organisms.

Q. Are the bacterial examinations which you made of waters for the purpose of ascertaining the presence of bacteria generally of such a nature as to disclose the presence of any kind of bacteria which could be in the particular sample of water which you are examining if the particular bacillus is of sufficient size to be discovered by a microscope?

A. Yes, examinations for bacterial counts will give organisms that will grow under the conditions in which the colonies are made, and some bacteria of course will not be developed. We will have to admit that they are lost in the examination. If certain other varieties are present in large enough numbers, they will appear in the examination as a definite part of the examination, so that in reply to this question I cannot say that we would have positively isolated the other bacteria present.

Q. What did you state was the method employed by you 8006 for the purpose of ascertaining, the presence of bacteria in the waters which you examined?

A. Do I understand now the count of bacteria?

Q. Yes.

A. It is what is known as the Petri plate culture method.

Q. What kind of culture or material do you use for the purpose of developing bacteria?

A. In this case we used the agar culture media.

Q. What is agar?

A. Agar is a vegetable substance in the nature of starch found in some plants, and extracted by boiling, seaweed plants, extracted by boiling and purified.

Q. It is a substance then which bacteriologists have found suitable for the purposes of making these tests?

A. Yes sir, it is suitable for the solidifying of culture media, so prepared or containing such material, suitable for the growth of bacteria.

Q. Please state professor, what your duties were at the time you were connected with the Health Department of this city?

A. My general duties were as superintendent of the laboratory to arrange the work and see that it was carried on properly, in the examination of samples of the city water and milk and food products brought in, material from cases of suspected sickness, and especially and individually to conduct the bacteriological examinations of water, milk, meat, foods and specimens of suspected cases of sickness. 8007

Q. Did you have anything to do with the Health Department in other respects?

A. We were in close touch with the work of the Health Department and received many specimens through the direct work of the Health Department, and assisted them in much of the work by making analyses and examinations of various materials that they used and that they had to do with.

Q. Did your duties require your presence in the various hospitals of the city at any time?

A. Well, as bacteriologist of the department, I did not have to go to any of the hospitals officially, for official duty. The isolation hospital occasionally called upon my laboratory and myself for examination, the men employed there, but I have had other hospital connections.

Q. In the city?

A. Yes sir.

Q. Do you know what the regulations are in the hospitals of Chicago in regard to the treatment of typhoid patients and efforts to isolate them, etc., to prevent the spread of the disease?

8008 A. Yes, I know in a general way. I know specifically about some and I do not know specifically about others.

Q. You mean about some hospitals?

A. Yes sir, some hospitals.

Q. What efforts are made in the hospitals to prevent the spread of infectious diseases and especially the typhoid disease?

A. I think it would be just as well to make this answer somewhat specific because it would be impossible for me to describe all of the methods used for infectious diseases.

Q. Confine it then to the hospitals where you are personally cognizant of the course that was pursued?

A. In regard to some cases, special rules and special rooms are set apart. In regard to other cases the discharges are disinfected.

Q. What diseases are these?

A. Especially the typhoid cases, the intestinal discharges and urine are disinfected.

Q. State the manner of disposing of that kind of material and the disinfecting?

A. The specific way in which it is done?

Q. Yes.

A. Well I can only state positively now for the County
8009 Hospital where I had something to do with it. Something over two years ago, with the recommendation that was made to be carried out at that time and which was instituted. It was to place a quantity of one to one thousand of bichloride solution in the vessels in which the discharges were passed, and they were allowed to stand several hours before they were emptied.

Q. Emptied into the sewers?

A. Yes, before they were emptied into the drains.

Q. And were carried into the sewers?

A. Yes sir.

Q. What effect did that have upon any pathogenic germs that might have been discharged from the patients?

A. That would kill them.

Q. Do you know whether similar efforts were made and similar work carried out in all the hospitals or places where such diseases are treated in this city?

A. Well I cannot state positively from my own personal knowledge of the conduct of these institutions, but in a general way of course, physicians disinfect the stools and urine.

Q. Are there any general regulations upon this subject issued from the head of the health department, or by the Health Department? 8010

A. The Health Department issued a circular regarding the care and disinfection of typhoid.

Q. Do you know the nature and the substance of the instructions given by the Health Department in reference to the disposition of dejecta of persons who may have typhoid fever in this city?

A. Yes, I have seen those regulations and know their contents.

Q. I will ask you to look at this paper and refresh your memory and state what those instructions were as far as you know?

A. In regard to the destruction of the discharges the following recommendation was made:

"If you are so unfortunate as to have a case of typhoid in your family disinfect every discharge as a duty to your neighbors as well as to prevent others of the family from getting poisoned.

Sulphate of copper (blue vitriol) is the best typhoid disinfectant,—one pound (costing ten cents) dissolved in 2 1-2 gallons of water. Keep a pint of this in the vessel for discharges from both the bowels and the bladder. Stir thoroughly for a few minutes; let stand for 15 minutes and the poison will be destroyed. Don't allow any discharges either from the bowels or the bladder to be received or disposed of except in this manner." 8011

Q. In the hospitals where you visited and in your own practice as a physician and from what you know of the practice of other physicians, state if you know, whether these rules were enforced, so far as you know?

A. Well, as far as I know, although I don't believe that this particular disinfectant was used in all cases; its equivalent or something else was used.

Q. Something was used that was equally efficacious?

A. Yes sir.

ADJOURNED until 10:00 A. M., Saturday, October 10, 1903. .

8012 10:00 A. M. Saturday, October 10th, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

R. J. BEDFORD,

called as a witness in behalf of the defendants, being first duly sworn by the Comissioner, was examined in chief by Mr. Todd and testified as follows:—

Q. What is your name?

A. R. J. Bedford.

Q. Where do you live?

A. Dahinda, Illinois, Knox county.

Q. Mr. Bedford, did you ever collect any water from the upper Spoon river for Professor J. H. Long, of the Northwestern University?

A. Yes sir.

Q. When did you collect this water?

A. I took one sample November 9th, and the second sample November 24th, and the third sample December 9th, in 1899.

Q. Any samples subsequent to that?

8013 A. Not to my knowledge.

Q. You collected in all, three samples?

A. Yes sir.

Q. At what point in the upper Spoon river did you collect these samples?

A. Let me understand that question.

Q. At what point in the Upper Spoon river, did you collect these samples?

A. At Dahinda, in Knox County.

Q. In what manner did you collect these samples?

A. I collected a gallon sample bottle and a small bottle for microscopic purposes in each case.

Q. How did you get the water into the bottles?

A. I was the possessor of a row-boat and I went out into the river in the boat and took the gallon bottle and immersed it at arm's length under the water and alowed it to fill, and the small bottle was used in the same manner, excepting the cork was not removed until the bottle was under the water and then it was removed, and then tightly corked before taking it out and packing it in the container that they sent out for taking, and according to the directions on the card packed with the main container.

8014 Q. Did you pack the smaller bottle any differently from what you did the larger bottle?

A. Yes sir.

Q. Describe the difference?

A. The small bottle was packed in a tin can with ice, and that can was packed in another larger tin can, and that can was packed in the original container.

Q. Now after you had packed the samples that you collected in that manner, that you have indicated, what did you do with them?

A. I took them to the express office and expressed them to J. H. Long.

Q. How long from the time of taking the samples before they reached the express office?

A. Probably not over twenty minutes.

Q. From whom did you get the bottles in which you collected the samples?

A. I think they were sent from Dr. Long.

Q. Now the card that was placed upon these three samples. will you describe it?

MR. JEFFRIES: It is admitted by counsel for complainant that the card placed by this witness upon the samples of water and attached to the samples, was the same as that exhibited in evidence and known as defendants' Exhibit 4.

8015 MR. JEFFRIES: I move to strike out all the evidence of this witness, because it is incompetent, irrelevant and immeterial, for the reason that the proper number of samples were not taken or analyzed to be of service in determining the sanitary condition of the water, in this river, and for the further reason that the sanitary condition of the water in the Spoon river is not an issue, and for the reasons heretofore stated in objections to testimony in reference to the analyses of water from the various tributaries of the Illinois river.

No Cross-examination. (Signature waived.)

8016 JUDGE SPRINGER: Mr. Comte Max le Couppey de la Forest, who is visiting this country at the instance of the French Government for the purpose of making a report upon the sanitary conditions in the great cities in the United States, is present, and in an interview with him I suggested that we would like to have his views in regard to the conditions existing in the city of Paris, in its water supply, its drainage system, and the manner of disposition of its sewage, or the irrigation of that city, and that we would confine the investigation solely to this point, for the reason that it would be indelicate for him to make any statement in regard to the conditions here in this country, for the reason that he is here to report to his government on that subject.

MR. JEFFRIES: Do you mean to make a witness of him?

MR. DRENNAN: Yes, as to the conditions in Paris alone.

JUDGE SPRINGER: He can be sworn, or he can give his views without being sworn.

MR. JEFFRIES: I object to the statement that was made by Judge Springer going into the record, and if this man is put on the stand he shall go on the stand the same as any other witness in the case, and I make no distinction between this witness and any other witness, in his testimony.

MR. DRENNAN. We explain that we want the record to 8017 show why we don't ask him anything about this country, and why he would decline to answer if asked in regard to his views.

MR. JEFFRIES: He can state why he declines. It is not necessary for counsel to state why he declines.

Witness Prof. Adolph Gehrmann is temporarily withdrawn from the stand.

8018 COMTE MAX LE COUPPEY DE LA FOREST,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Springer and testified as follows:—

Q. Mr. de la Forest, will you please state, so as to get it upon record, your name, official title and residence?

A. My name in Comte Max Le Couppey de la Forest. My official residence Paris, France, my title, Secretary of the Commission d'Etudes des Eaux, Paris, France.

Q. The meaning of that in English is?

A. The Secretary of the Commission of studies of water,—that is the study of the sewer waters and water supply for the city of Paris, and the metropolitan district of Paris, what we call the Department of the Seine, in France. I am also Secretary of the Society of Hygiene of France, but that is private business. It is not official business.

Q. State whether you held any official position in the Congress of Sanitarians which assembled in Paris during the late Universal exposition in that city?

A. Yes, during the great exposition, in 1900, it was an international congress of hygiene, in Paris, and I was one of the secretaries of this congress.

8019 Q. State what is the nature of your duties in regard to the water and hygiene systems of the city of Paris?

A. For the water and sewage system, I am the secretary of the Commission. We have many meetings every month and I must keep the record of the meetings, and also I must make experiments for this commission, chemical experiments, and also bacteriological, but especially chemical. I am a sanitary engineer also.

Q. How long have you been connected with the government of the city of Paris?

A. Four years and two months.

Q. Will you please state when the city of Paris began the construction of what is known as the irrigation system?

A. The construction was made at many times. We begun this construction in 1868. Experiments were made before,—from 1866 to 1868, in Clichy, near Paris, for the purification of sewers, and irrigation, and after these experiments it showed that the sewage could readily be purified with irrigation, so the city of Paris began, after these experiments were closed, in 1868, to irrigate the fields. In the begining it was a very small area, it was only fifteen acres that was in operation in 1869, in the

place known as Gennevillier, but the areas were not increased immediately because we had a great war between Germany and France, and it was not possible at this time to work,
8020 but in 1872 we began to increase this area and every year
it would be increased, and now,—in 1889 the area of Gennevillier was 1900 acres instead of fifteen acres as in the beginning. The system is very good. The rent of the land before the irrigation was about 45 fracs, or $9.00 an acre, and after the irrigation the land,—the same land would rent for 200 francs instead of 45, or $40.00 instead of $9.00 in the beginning. Soon there was no more room in Gennevillier for further irrigation, so we had to go farther away to a place where the soil was good for irrigation. We went afterwards to Acheres. In the field of Acheres in 1879 we put in operation a superficial area of 2600 acres. The population of Paris increased, and before that we had very many private cess-pools and we built great sewers and obliged all the houses to be connected with the sewers, and so we must always increase the area of the irrigation field.

After Acheres, we built an irrigation field at Mery, of 3,000 acres. This was put in operation in 1898; and after that we built the field at Triel, of 1800 acres, so the amount now of our irrigation fields is 9,300 acres.

Q. At this time?

A. Yes sir, now. Our houses are connected with the
8021 sewer system in Paris. There are in Paris 80,000 houses,
or there were on the 1st of April, 1903. 35,000 of these houses were connected directly with the sewer system. About 25,000 houses have filter cess-pools. The urine and liquids of these filter cesspools go directly into the sewers, and the solids are afterwards emptied into the Seine, in many places near Paris. So we have in Paris perhaps 60,000 houses which were connected directly or indirectly with the sewer system. The population of Paris is now 2,750,000 inhabitants. Of this the residences of six-eighths were connected with the sewer system, so it is about 2,100,000 of the inhabitants that are directly or indirectly connected with the sewer system.

The method of irrigation is not everywhere the same. In Gennevillier, there are little garden farmers who have only a little garden in which to grow vegetables or fruit, and these people can take as much sewage water as they will and when they will. A comparison since twenty years has shown that these people take always an average of the same amount of water every year.

Q. Sewage water?

A. Yes, sewage water; always the same average every year. They average over 40,000 cubic meters every year, per hectare. I will reduce that to gallons. That is 6,500,000
8022 gallons per acre per year; but for the other fields, for
Acheres, Mery and Triel all the land, all the country is the property of the city of Paris, and this land is rented to the great farmers, who give some money to the city of Paris for it, and the people are obliged to take every year the same amount of sewage as before. It is a law, which allowed the building of this irrigation field near Paris; the farmers are obliged to take this amount of sewage and to be sure that the people do that we have many employes of the city of Paris who every day open the gate of the sewer to give the required amount of sewage to the farmers, and we have foremen and engineers to oversee the employes.

I think upon the irrigation question that is all that I can say now.

Q. How is the water that was brought onto the land through the irrigation pipes taken away from the land again and returned to the river?

A. It is not the same everywhere. The field of Gennevillier, the field of Acheres and of Triel are near the Seine river, and the field of Mery is near one affluent of the Seine river, near the river Oise, which empties afterwards into the Seine river. We have drained a great portion of the irrigation field with tile drain and this tile drain empties into little creeks that
8023 afterwards empty into the river Seine or the river Oise.
All the effluent of the sewage will be discharged into the river Siene after purification through the soil, and this purification is good.

In Acheres, Mery and Triel, where the land is the property of the city, the city of Paris has built little gardens, because cities desire always that her works are pretty for the visitors and in these gardens are lakes. These lakes are supplied only with the effluent water from the irrigation field, and in these lakes live many fish, and at the point where the main drain comes into, or empties into the lakes there are springs, but the springs are all of the effluent water. And all of the workmen who live on these different farms,—there are perhaps two hundred or four hundred of these workmen living in this country, they drink only the water of the effluents, and we have a medical survey of these men. All the physicians of the country are connected with the City of Paris and must give weekly reports upon the sanitary conditions of all these men, of all these workmen, and since these different irrigation fields are in operation we have had no typhoid fever or cholera or dysentery, or the diseases which come from water.

Q. Among those who use the water from the irrigation
8024 fields or the effluents, have they not had any of these diseases?

A. No sir.

Q. Have you ever drank any of this water yourself?

A. I have drank it very often, and many times people, foreign people who come to see our irrigation field, whom I, as engineer of the city of Paris would take to the irrigation field, and I drank always the water, and many times the foreign people would drink also.

In 1900, during the International Hygiene Congress in Paris, we made an excursion with this congress to the irrigation field and I and the other engineers drank this water, and many of the foreign people also drank this water.

Q. Will you please state what it was, what reason existed which caused the government of the city of Paris to adopt this irrigation system?

A. There are three reasons. The first reason you might say is only a pleasure reason; the other was a sanitary reason, the third an industrial. Above Paris are little cities and residence towns, to which came in the summer time many people of Paris. There are perhaps three or four hundred thousand people who come from Paris during the summer to live, near Paris, twenty or thirty miles below, from Paris.

Q. Below the city?

8025 A. Below the city, and all these residences are built on the banks of the river, and the banks of the river Seine are very pretty, many trees and little hills; it is very pretty, and very agreeable, but when the city of Paris began to discharge its sewage into the Seine, there was a great smell, the water was very dirty; it was no more possible to bathe in the water and every year the condition got worse and worse, and that began in 1860 and from 1860 to 1870, that was always worse and worse. That is the pleasure reason, if I can say so.

And the second reason is the sanitary reason, and that is that in summer when the river Seine is low the people who lived near the Seine had in time a little fever not typhoid but malaria or something like that. Not quite malaria, but a little fever,—intermittent fever, at the point where the river Seine was low and where the river had many branches.

And the third reason is an industrial reason if you can say so. There are a great deal of people who live below Paris, between Paris and perhaps sixty miles below, engaged in the fishing industry, and all of the fish died, because there was too much sewage in the water, and every year the condition of the fish became worse and worse, because the amount of the sewage that was discharged into the river was in summer diluted in a very small amount of water. 8026 The dilution of the sewage in the Seine was only at this time one fifteenth or one-eighteenth. That means one part of sewage was diluted in fifteen times that many parts of Seine water, or eighteen parts of Seine water.

Q. How far down the river did this pollution extend at that time, during that period?

A. Perhaps 35 miles, about 35 miles below Paris, in the summer time. I have here the different chemical analyses of the river Seine, above Paris, in Paris, below Paris, and at many points below Paris, from five miles to 100 mies below Paris.

Q. Miles or kilometers?

A. Miles. That was before the irrigation was begun. One of the analyses is for 1847 and the other 1869, when we were ready to begin the irrigation in the field of Gennevillier and I also have here the organic matter and the total nitrogen in the water. You can see that where the main sewer emptied at this time into the river Seine, it was 25 parts of total nitrogen in the water per 100,000 parts of the river Seine, and 42 miles below, near the city of Maneese, it was only 1.4 instead of 25 parts.

8027 I have also the figure for the organic nitrogen at the same point where the main sewer emptied into the river Seine. It was 7.2 parts of organic nitrogen per 100,000 parts of the river Seine, and near the city of Meulan 40 miles below Paris, it was only .4 of a part of organic nitrogen per 100,000 parts of water of the river Seine. So we can see that at this time the river Seine had a self-purification after 45 miles, at this time in 1869.

Q. How many people, inhabitants of the city, were draining or depositing their sewage into the river at that time, directly or indirectly?

A. At that time it was perhaps only 800,000.

Q. Now how many inhabitants in the vicinity of Paris, residing below the city on the banks of the Seine, are there who deposit their sewage into that river?

A. Now?

Q. Yes now, at this time?

A. At this time I have said that the city of Paris has 2,750,000 inhabitants. The people of the city of Paris do not discharge the sewage into the sewers and into the river Seine, they discharge it into the irrigation field,—six-eighths of the inhabitants discharge sewage into the irrigation field, and the other two-eights sell their sewage to a company who make fertilizer of it.

8028 Q. They sell it to persons who use it for a fertilizer?

A. Yes. But the suburbs of Paris discharge all their sewage directly into the Seine. . The suburbs below Paris and above Paris also discharge their sewage directly into the Seine, and that was a population of about 1,100,000 inhabitants in 1899, and that is the latest figure which I can find; but you can say perhaps now since four years it has increased and it is now perhaps 1,300,000.

Q. That number whose water-closets in the houses and the wastes from the houses go into the river Seine at this time?

A. Into the river Seine at this time.

Q. What do you say Mr. de la Forest, was done with the sewage of the two-eighths of the city of Paris whose sewage was not carried off into the irrigation fields; what became of that?

A. They have fixed cess-pools in their houses and a company will empty these cess-pools one or two times per year and will make fertilizer with all the matter that was in the cess-pool.

Q. Do they pay for that or are they paid for getting it?

A. They must pay something to the company, and the company makes money.

Q. Do you know how much is paid per family to the company?

A. No, they pay per cubic meter, which is emptied, and it is not everywhere the same price. In one ward of
8029 Paris it will be so much, but I do not know how much.
I think in some parts of Paris it is two francs per cubic meter, but it is not the general price. I do not know the general price. I know that for some wards in Paris it is two francs per cubic meter.

Q. Do you know how much the irrigation plant has cost the city of Paris up to this time?

A. Gennevillier cost	5,200,000	francs,
Acheres,	10,500,000	francs,
Mery,	10,800,000	francs,
Treil,	15,000,000	francs.

Buildings for housing of machinery and general expenses 5,000,000 francs.

Q. What does it cost per year to maintain the service, and keep this plant in operation?

A. I am sorry, but I have not here the cost of maintainance. I have only the cost of the elevation of the sewage, to put the sewage into the irrigation field, and this cost is something high, because we must elevate the sewage very much. The pumping of the sewage comes very high. This cost in 1901, was 2,967,500 francs, or $593,000.

MR. JEFFRIES: That is the cost of operation?

A Only for the pumping. I have not the other figures
8030 here, and the other cost is very high, because I have said
to you that in Acheres, Mery, and Triel we have a great many employes who must open every day the gates of the sewers, and we have perhaps 200 of these men, and I do not know how much these people cost.

Q. What class of employes must you obtain for this purpose?

A. They are what we call municipal employes.

Q. Yes, but as to their qualifications?

A. The name in French is what we call skilled workmen.

Q. Well informed people?

A. Yes, well informed, and they do not work alone. There are all the time foremen and superintendents,—many superintendents who keep an eye over the work and then three engineers above the superintendents,—sanitary engineers.

Q. State, if you please, what measures are taken by the city authorities of Paris for the purpose of ascertaining the character and condition of the water in the Seine above and below the city at this time?

A. We made also experiments upon the water,—chemical analyses and bacteriological experiments.

Q. They are making continually these experiments?

A. Yes, continually we make analyses and examinations of the drainage of the different irrigation fields, and also the same analysis is made of the water of the river Seine at
8031 Paris, above Paris and below Paris. Below Paris we take
two samples every week, five miles below Paris, ten miles and fifteen miles below Paris, two times every week, and the effluents of the different drains in the different irrigation fields are also examined for bacteria and for chemical compositions, every week, one or two times or three times; not always the same.

Q. What is the condition of the water in the river Seine at various seasons of the year at this time?

A. The high water in the river Seine, you mean?

Q. Yes. What is the condition of it as to purity at this time?

A. Oh, the river Seine at all times is polluted by many cities which are above Paris, so when the river Seine flows through Paris the river Seine is too bad; it is not possible to drink the water of the river Seine in Paris, but below Paris the river Seine—I said in Paris the water of the river Seine is too bad to be drunk, but fish can live in the river Seine, but below Paris, after it has emptied into the river Seine the sewage perhaps of 1,000,000 or 1,200,000 inhabitants, the condition of the river Seine is very much worse below Paris than above Paris,

and in summer, immediately above Paris especially, fish
8032 can no more live in the water of the river Seine. We
have spent in the city of Paris a great deal of money to build the irrigation fields of Acheres, Gennevillier, Mery and Triel, but that is not sufficient, because the cities above, discharge sewage directly into the river Seine, and we have now a metropolitan commission to purify the sewage of the suburbs of Paris, because the conditions of the cities that are above Paris and near Paris, are in very bad condition in summer, and in summer also the fish cannot live immediately below Paris.

Q. What is the volume of the water in the Seine below Paris in the lowest stages of the river, in the summer time?

A. In the summer time the lowest stage is 60 cubic meters per second, that is 126,000 cubic feet per minute.

Q. In the low stages?

A. In the lowest stages, in summer.

Q. How much higher than that does it get in the winter months?

A. In the ordinary months it is 190,000 cubic feet per minute.

Q. Can you state from your knowledge, obtained officially in Paris, how far down the river at this time the effects of the sewage from the suburbs of Paris disappear?

A. I have said that in 1869 when 800,000 people discharged their sewage in the river Seine, the purification of the Seine
was perhaps—the zone of purification was perhaps 45
8033 miles below Paris, but now we have perhaps 1,200,000
people who discharge their sewage into the river Seine, and the zone of purification is something more far below Paris. The zone is, I think,—I am not quite sure,—it is perhaps 55 miles below Paris. I have no figures here, but I think that it is so, 55 miles. I have the figures in Paris, but I have not them here. I am almost sure that it is 55 miles from Paris, and I must say that the sewage is diluted now in the proportion 1 to 20. One part of sewage to 20 parts of the river Seine.

Q. Will you please explain the manner in which the city of Paris now obtains its water supply?

A. We have in Paris a double water supply. We have two kinds of water in Paris, and in each street and in each house we have two kinds of pipes. We have drinking water and clean-

ing water. The drinking water is for drinking purposes and to cook with and bake bread with, and for all the preparations of food. The people are obliged in Paris, when they make food, to use the drinking water to make food in the restaurants and everywhere. The cleaning water is used for cleaning the streets, for running elevators or to clean the house, to clean the courts of the houses, to clean the carriages and also for industrial use and
industrial purposes.

8034 Q. And for flushing the water-closets of the private
houses?

A. Yes, also the water-closets. But not always for water-closets, because this water has not always pressure enough, but in two or three years we will have more pressure to this water and in two or three years all our water-closets will be supplied with river water.

Q. You use this river Seine water for everything except drinking purposes and cooking purposes?

A. Yes, but for industries, for the great industries in Paris the people have built private artesian wells, which are 2,000 feet deep and the great industries of Paris do not buy water from the city, but have their own artesian wells. The cleaning water comes from the river Seine, Marne, Ource and also in a very little amount from artesian wells, which belong to the city; but these artesian wells are only one-fortieth part of the total amount of the water that is used. Also we use in Paris drinking water that comes from springs. The springs are far away from Paris, the water comes to Paris over aqueducts. The shortest aqueduct is 60 miles long, and the greatest in length is 110 miles long, and now we are bringing into Paris new springs, and the aqueduct
will be 200 miles long. And this water comes to Paris
8035 with gravity and comes to the tops of the buildings also
by gravity. We furnish each day 24 gallons of drinking
water and 45 gallons of cleaning water per capita.

Q. How much of this water is furnished by the river Vanne?

A. The river Vanne furnishes one-third of the amount of the drinking water. Vanne is not a river; there are springs which are in the valley of the river. We say sometimes in common language, river, but it is not a river, it is a spring. In the valley of the river Vanne there are springs, and they get the water from the springs. The different springs of Vanne which supply Paris are the springs of the valley Vanne, the valley Avre, the valley Loing et Lunain, and the valley Dhuys.

8036 CROSS-EXAMINATION, by Mr. Jeffries.

Q. Is it the intention of the city of Paris to further extend its sewer fields?

A. It is not quite sure whether it will be a sewage field or septic tanks or the aerobic system, because these septic tanks, or the aerobic system do not cost us so much as the irrigation field. Two years ago the chief engineer of the sewers of Paris was sent to England to study the septic tanks, Mr. Launay, and this year I was sent to America to see what the American people are doing for sewage disposal, because we must increase our system of purification of sewage in Paris. I have said to you that now it is only 60,000 houses that are connected directly or indirectly with the sewerage system, and 20,000 houses are not directly connected with the system and we must build a purification plant for those 20,000 other houses and this purification plant can be a field irrigation or a septic tank or something else. I don't know now what it will be in some years.

Q. Will you please state what the object of the authorities of Paris is in treating this sewage?

A. Its object is to purify the Seine river between Paris and 55 miles below Paris, where the self-purification of the
8037 river is not great enough.

Q. How far is it from Paris to the sea, by the river Seine?

A. 250 miles, perhaps.

Q. Is there any income from the sewage fields?

A. The city of Paris has two sources of revenue for the sewage. First, each house that connects with the sewage system must pay a tax, and second the irrigation fields are rented to farmers who give a great sum of money, but I think that in all it costs something to the city of Paris, because we must elevate the sewage very much and so we must increase often the tax for the connection from the houses to the sewer to do that. It costs nothing to the city.

Q. Then each of the citizens makes his own connection?

A. Not in all. A part of the connection is built by the city.

Q. And is charged up to the individual?

A. Yes, sir.

Q. Now, the city of Paris keeps a separate account, doesn't it, of its sewage plant and all the expenditures and all the sources of revenue?

A. Yes, sir.

Q. Now, do you know about how the expenditures compare with the receipts?

8038 A. No, because that is not my part. I am sanitary engineer, and I know nothing of that. I am very sorry to say that.

Q. As a citizen of Paris. The question is discussed among the people there, isn't it?

A. I have heard only by the papers and the papers do not always say the truth.

Q. I understood you to say that the farmers paid a handsome price, a very large price for this sewage from the field?

A. Yes, because they produce very good crops.

Q. They produce splendid crops?

A. Yes, sir.

Q. And therefore there is a good market for them?

A. Yes, a good market. I must say something. Now, it is no more possible for the farmer to produce all kinds of crops. They won't allow them to grow the crops which people eat raw without cooking, such as raw fruit and salad, and it is no more allowed to make the crops of wheat that will grow very near from the soil, because we have seen that people who will eat the crops that grow very near to the soil, which is covered with the sewage, and which has in it the bad bacteria, and the people who eat that, afterwards can be sick. The board of health of Paris first, and afterwards several boards of health of France, prohibited the use of the soil for fruits and crops 8039 which grow very near to the soil, that can be eaten without cooking, and since the board of health, two or three years ago, made this prohibition, or regulation, the condition for the farmer is not so good as before, because before that they had very good strawberries and slaw and salad, which they cannot any more have now. I must say that I and my family before the board of health said that, for the last fifteen years, we have never eaten any Paris raw salad because the greatest quantity of salad in Paris came from the irrigation fields, and I say it is very dangerous to eat the salad.—Not so now, because now the salad comes no more from the irrigation field, but comes from other gardens or fields and does not come any more from the irrigation fields, but before that it was very dangerous to eat the salad from Paris.

Q. Now, they can grow potatoes, you say, from these fields?

A. Yes, because you eat always cooked potatoes and you will not eat the shell of a potato, but it will be dangerous to eat the raw shell of a potato but nobody ever does that.

Q. Now, you say this order was made by the board of health fifteen years ago?

A. Three years ago.

Q. Three years ago the sewage fields were a source of considerable revenue?

8040 A. Yes, sir, a good revenue. Considerable is putting it a little strong, but a good revenue. And I can say something upon this, that it is not in Paris, but it is something which we have studied as a board of health. In the center of France some time ago there was a lady who was sick, three years ago, and Metchnikoff, a great physician of Paris, came to see what was the matter with this lady and he gave a laxative to this lady and found in the excrement, eggs of a little animal, of an intestinal worm that lives only in Switzerland, and so he said to this lady: "You were in Switzerland this summer." She answered: "No, I have not been in Switzerland for twenty years; I have not left my house here," and the doctor made an investigation and he saw that in the house of this lady there was a gardener, and he had come from Switzerland in the last two or three months, and this gardener made his excrement upon the salad bed, and used it as a water-closet and he had in his intestines this worm and this lady had eaten the whole salad and had the worm afterwards.

Q. Do you know how much revenue per acre they derive from these sewage fields?

A. No, I can say only for the field at Gennevillier. That doesn't belong to the city. That belongs to private people, and there they have crops like strawberries and salad and
8041 asparagus. This kind of crops will give very much more money than the other crops, perhaps ten times more, and I know that for Gennevillier, the rent of the soil is 300 francs per

acre, and that is six times as much as they get for good soil in France.

Q. I understood you to say that the effort was now being made to purify in some way the sewage from the suburban towns around Paris?

A. It will be the sewage of 1,200,000 people, which is directly emptied into the river Seine and the sewage of perhaps 500,000 people who live near Paris.

Q. So then they intend to utilize the sewage of those two suburban places?

A. Yes, sir.

Q. Comprising 1,600,000?

A. Yes, sir.

Q. And to provide companies and they will treat the sewage in that way?

A. No, the sewage will be purified in an irrigation field, a septic tank or with other scientific methods.

Q. Now, they are going to do away with the sale of it to the private companies?

A. Yes, sir.

8042 Q. And they are going to treat it in some way that has not yet been determined upon?

A. Yes, sir.

Q. After that has been treated, it will comprise practically all the population of Paris?

A. And the suburbs of Paris, yes, sir.

Q. The idea of Paris now is, in making this investigation, to obtain the most approved and scientific method of treatment?

A. Yes, sir.

Q. With a view of removing all of the harmful substances from the sewage?

A. Yes sir.

Q. How long is the sewage permitted to remain on these fields before it is taken in charge by the farmers?

A. It is immediately taken in charge by the farmers night and day. An employe of the city of Paris will open the gates of the sewers, just as the man will say to this man, one day in one part of the field and the other day in the other part, and none of the sewers will remain without being used. They are used immediately. It goes through the sewer and is immediately discharged upon the field.

Q. In other words, every farmer takes his part each day?

A. Yes, sir.

8043 Q. Or every other day or every third or fourth day?

A. Every day each farmer has a certain amount of sewage. Every day every farmer must choose so much sewage, so much as is said by the engineer, and that is the amount of sewage as set by the law of Paris. It is 40,000 cubic meters per hectare. I have given it to you before in acres.

Q. Now, every farmer must take this rain or shine?

A. Yes, sir.

Q. Whether it rains or not?

A. And it is sure that he takes that. It isn't the farmer that opens the gate; it is the employe of the city of Paris, so we are sure that each farmer will take what he is obliged to take.

M. le Couppey de la Forest.

Adjourned until 2:00 p. m., same day, Oct. 10.

8044 2:00 p. m., Saturday, October 10th, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

J. J. STITES,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Springer, and testified as follows:

Q. Please state your name, residence and occupation?

A. J. J. Stites.

Q. Where do you reside?

A. Pontiac, Illinois, on the Big Vermillion river.

Q. What is your occupation?

A. Well, I am a physician.

Q. State whether you ever took any samples of water from that river, and if so, at whose instance they were taken?

MR. JEFFRIES: We object to the testimony of this witness as to the taking of samples from the Big Vermillion river, for the same reasons stated in our objection to the testimony of other witnesses about the taking of samples of water for analyses from other tributaries of the Illinois river.

8045 Q. Now, proceed to answer.

A. I did, sir.

Q. At whose instance?

A. At the instance of J. H. Long, of the Northwestern University.

Q. When was that?

A. It was in November and December, 1899.

Q. State what instructions, if any, you received from Dr. Long in regard to the taking of those samples?

A. Well, I received printed instructions on a card which I followed implicitly. The instructions, with the exception of the sample for the bacteriologist, did not differ from any other samples that I collected for the University of Illinois.

Q. Please look at that paper and state whether that contains the instructions, and the blank that you were requested to fill up in making the return of the samples taken?

A. That is a report of the first water taken on November 9th, 1899, in which I found the temperature of the water 49 degrees Fahrenheit, and the temperature of the air 50 degrees. It was taken above the mill-dam in the Vermillion river and about a mile perhaps above where the sewage enters the same river.

8046 Q. State whether that is the form of blank that was furnished you for filling up with the data and whether on the back of it is printed the instructions which you received?

A. The same, sir.

Q. State whether you followed the instructions upon that card?

A. I did, sir, implicitly, with a great deal of care.

Q. State whether you filled this blank yourself?

A. I did, sir.

Q. And whether the statements contained in this card as filled up by you contain a true statement of the condtions which are reported?

A. They do, sir.

Q. Did you follow the same course in regard to each of the three samples you took?

A. Yes, sir, precisely the same.

Q. What kind of bottles did you receive from Professor Long, and what did you do with them after they were filled?

A. I received a case containing two bottles. One I would suppose would hold a gallon,—a ground glass stoppered bottle, and then that was, I should think about six ounces, a bottle with a ground glass stopper, covered with a rubber wrapper, that was enclosed in tin, and that was enveloped after the 8047 water was in it, in cotton and placed in this little tin and closed and then pounded ice, or crushed ice was put around it, and it was sealed up hermetically.

Q. Then what did you do with it?

A. Put it in the case and shipped it to Dr. Long.

Q. By express?

A. Yes, sir.

Q. State how you took the sample from the water; what did you do?

A. Well, I immersed the bottle about,—well up to my elbows, below the surface of the water before I removed the stopper and allowed it to fill, and I don't know whether he said to empty it three times or not, but I did empty it three times to be sure that it was thoroughly rinsed with the river water. Then after filling it the fourth time I emptied out enough just to leave a narrow space, about an inch, below the stopper, and put the stopper in it without touching my fingers to anything only the crown of it and tied the cloth over it, and when I took it to the express office, after tying the tag on, I had a knot tied right on top of the cloth and sealed, and the seal of the express company put upon that knot so that it could not be disturbed without breaking the seal, and if so, I suppose the doctor would not examine it.

8048 Q. Did you put upon the card that you returned, the date at which you took the sample?

A. I did, upon the card that accompanied the sample.

Q. Was that the correct date at which the sample was taken?

A. Yes, sir.

Q. How many samples did you say you took from the Vermillion river?

A. Three.

Q. Now, will you please state where that river has its origin, and whether it passes through Pontiac, and where it empties into the Illinois river?

A. Well, I don't know that I can tell you just exactly where it has its origin.

Q. Well, generally?

A. I think one branch of it is over in Ford county, I am not certain about that, but the most of it is from springs and creeks in Livingston county.

Q. How large a stream is it at Pontiac?

A. Oh, perhaps 150 or 200 feet wide.

Q. Does it receive the sewage of Pontiac below the place where you took these samples?

A. Below the place, yes, sir.

8049 Q. And what important towns does it pass through before it goes to the Illinois river?

A. It passes through Streator and I suppose La Salle.

Q. No, La Salle is on the opposite side of the river, isn't it?

A. Yes.

Q. It goes through Streator and empties into the Illinois river, and enters the Illinois river opposite La Salle?

A. Yes, sir.

JUDGE SPRINGER: These cards have already been offered as defendants' Exhibit No. 17.

MR. JEFFRIES: And it is admitted that they are of the same character as defendants' Exhibit No. 4.

8050 CROSS-EXAMINATION, by Mr. Jeffries.

Q. How many samples did you collect at this point?

A. Three of each kind, three of the water for chemical analysis, and three for bacteriological examination.

Q. How near together were they taken?

A. Right from the same spot.

Q. I mean with reference to the time of taking the three samples?

A. Well, I always took them in the large bottle first.

Q. No, with reference to the date, the time?

A. All the same date, same hour.

Q. Yes, but you took two samples each day?

A. Yes.

Q. Now, how far apart were the days on which those samples were taken?

A. Well, now, I think the first one was taken on the 9th of November, and the second one on the 24th of November and I ought to remember the date of the third in December, but I don't because I fell in the river that day and got wet and like to froze to death before I got home, but I can't tell you the date.

JUDGE SPRINGER: Is it on the card?

8051 A. I think it is. I think it is December 8th.

MR. JEFFRIES: They were all taken about two weeks apart?

A. Yes, two weeks apart.

Q. Did you take any samples in the spring time?

A. No, sir, that is the only time I took them.

Q. Did you take any samples in flood time?

A. The second one was taken in a few days after a very hard rain, but the river was not raised any perceptibly,—not more than an inch or two, but it was quite muddy.

Q. Was there ice on the water at any time?

A. There was the last time, thin ice, about a quarter of an inch in thickness.

Q. How long had it been frozen?

A. I think a day or two.

Q. And you only took three samples during the whole time?

A. That is all.

MR. JEFFRIES: I move to strike out the evidence of this witness for the reasons stated in my objections to his testimony.

(Signature waived.)

8052 B. F. LONG,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Springer, and testified as follows:

Q. What is your name?

A. B. F. Long.

Q. Where do you reside?

A. Joliet.

Q. What is your occupation?

A. Engineer.

Q. What kind of an engineer?

A. Stationary engineer. I worked at the steel works.

Q. Did you at any time take any samples of water from the river at Joliet?

MR. JEFFRIES: What river?

JUDGE SPRINGER: From the Desplaines river at Joliet, at the instance of Dr. Long?

A. Yes, sir.

Q. When was that?

A. Well, it was the summer of 1899 and the summer of 1900.

8053 Q. What instructions, if any, did you receive from Dr. Long?

A. Well, he came down there and I seen him personally. He told me how to take them,—to dip the large bottle down about ten or twelve inches under the surface of the water and leave it fill up to about an inch of the top and then cork it up; and the small bottle the same way, and pack it in ice—tied a little rubber over the top after being corked, and packed in ice and sealed and then I shipped them by express. The bottles I generally rinsed out about once, or dipped them down and put water in them and rinsed them out, and then filled them up.

Q. Would you recognize the cards that you filled up if you would see them?

A. Yes, sir.

Q. Look at these and state whether those are the blanks that you received from Dr. Long, and whether the handwriting in there is yours?

A. They are the same, and my handwriting.

Q. What is the first date then?

A. That I cannot tell.

Q. It is on the card there, isn't it?

A. Yes, sir, September 3rd.

Q. That was the beginning of it, then?

8054 A. I lost the cards or burned them up,—or the express receipts. I had them and I either burned them up or lost them.

MR. JEFFRIES: It is admitted by complainant that the cards now produced to this witness are the same cards produced to Professor Long while he was upon the stand, and testified to by him as having been received with the samples of water from this witness.

Q. JUDGE SPRINGER: Now state whether you followed the instructions on the back of that card in taking these samples?

A. Yes sir, I did, as near as I possibly could.

Q. State whether the entries made by you in your handwriting upon those cards state truly the conditions which you reported or intended to report of the acts which you performed in taking these samples at that time?

A. Well the interest—I took full interest in it.

Q. Please state whether these state the truth, whether these are the true conditions that you found there?

A. This is true. I put down the truth, nothing but the truth. I had no object in doing anything dishonest.

Q. You have stated I believe how you collected this water. What did you do with the samples after you took them away from the river?

8055 A. I took them straight to the express office.

Q. How did you pack them?

A. I packed the little one in ice. The large one was just in a box, packed with excelsior around it.

Q. What did you do then with it?

A. I took them to the express office and then shipped them.

Q. Shipped them addressed to whom?

A. To Dr. Long, 2421 Dearborn Street.

Q. You have not stated exactly the times when these specimens were taken.

A. Oh, they were all taken in the evening between five and half-past six o'clock. I would have to get them to the express office by seven.

Q. And the dates upon which these were taken are all noted upon these cards?

A. Yes sir, the dates. The dates were put on every collection I made.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. At what point in the Desplaines river did you take these samples?

A. The first samples, that was in 1899, I took them above the basin in the neighborhood of Ruby Street bridge, that 8056 is the upper bridge. Sometimes it was north of the bridge and sometimes south of it. I managed to take the samples always north of the bridge. The dredge worked here in that vicinity all summer, and my instructions was from Dr. Long to manage to take the sample above the bridge.

Q. Now with reference to the mouth of the drainage canal, and its entrance into the river Desplaines, where did you take the samples?

A. Well at that time it was emptying below there. It emptied down right opposite the blast furnace, if you know where that is.

Q. And you took the samples above?

A. Above that.

JUDGE SPRINGER: That is the Illinois and Michigan casal, you mean, the first one?

MR. JEFFRIES: No, we are talking about the drainage canal.

A. Well, it wasn't out of the canal I took it. I didn't take the sample out of the canal. That water laid dead. I had no instructions to take it out of the canal.

JUDGE SPRINGER: Out of the Desplaines river?

A. I took it out of the Desplaines river, and of course the canal run in there, but was above the locks, the river and the canal was partly together. Then there was a part of the 8057 river that ran down at one side a little west of that and emptied down further. Since then it has been better.

Q. If the canal was opened, where did you take the samples with reference to the mouth of the canal?

A. At Jefferson Street bridge, above the sewers.

Q. Where is Jefferson Street bridge, with reference to the mouth of the canal. Is it above or below?

A. The canal is away up above Jackson Street.

Q. Then you took the samples after the canal was opened, out of the water that had been mixed with the water coming from the drainage canal?

A. Well, I took them below where the mouth was. The water ran into the canal and down the river both.

Q. The water ran from the drainage canal?

A. Yes, exactly.

Q. Into the river above the point where you took the samples?

A. Yes, above, exactly.

Q. In other words you took samples below the place of discharge of the water from the canal into the Desplaines river.

A. Well the discharge of the canal in the Desplaines river is away below that—south of that.

Q. South of what?

8058 A. Now here, the mouth of the canal is up north of Jackson Street, and it empties out into the river again away below Jefferson Street, and the river and the canal runs together.

Q. The drainage canal

A. Well yes,—well the drainage canal or whatever you call it, the old river bed—there is only one stream along there, whatever you might call it, the drainage, the river, the canal the whole three runs together.

Q. Well, I understand that. Did you take samples out of the mixed water of the Desplaines river and the drainage canal?

A. Yes sir, the mixed water.

Q. Did you take any samples out of the Desplaines river before it had been mixed with the water of the drainage canal?

A. Well I can't answer that, to answer it truthfully. The canal water was mixed with the other water of course, when I took the samples.

Q. But you never went far enough above the Desplaines river to get beyond the influence of the water from the canal?

A. Well, I think not.

Q. Now how did you take these samples?

A. I always took the large bottle first.

Q. Took the cork out?

A. Took the cork out and filled it full of water within about an inch of the top.

Q. You would take this big bottle and take the cork out
8059 and put it under the water?

A. I always put it under the water before I took the cork out, in order that it wouldn't get any of the surface water.

Q. How far under did you put it?

A. Ten or twelve inches.

Q. Then you would bring it out, put the cork in and rinse it, would you?

A. Yes.

Q. Put the cork in after you brought it out of the water?

A. After I brought it out. It was plumb full to the top when I brought it out. Then I would pour some more out of it. I kept it under the water until it was perfectly full, running over, and pulled it up and threw some of the water out.

Q. Pulled it right up with the mouth to the surface of the water?

A. Yes, I had my hand—

Q. Did you have your hand around the neck of the bottle?

A. Yes, sir.

Q. Both the small and the large bottle?

A. Yes.

Q. Just jerked them right up out of the water?

A. Pulled them up out of the water. I managed to take it where it was clear.

Q. Did the surface water get in as you pulled them up?

8060 A. How would it get in when it was full?

Q. Well, it was exposed to the surface water, was it not?

A. Well, the bottle was exposed to it, certainly.

Q. And the mouth of the bottle?

A. The mouth of the bottle was full just the same as if you had a cork in it. You can't get no more in them after they are full enough to run over.

Q. Are you right certain that the surface water didn't crowd some of the water out?

A. I am satisfied of that. I would bet my life on that part of it.

Q. Now, where would you hold the stopper when you was rinsing it, what would you do with it?

A. I generally laid it down at first, rinsed it out, and then I would hold it in my hand, after I had dipped the bottle down and took the stopper out. My instructions was not to touch the bottom of the cork.

Q. When you laid it down where did you lay it?

A. Set it up on end, right on a stone or on a rock.

Q. Dry stone, was it, or rock?

A. Dry.

Q. Wind blowing and dust flying?

A. No, I don't know as there was any wind. Of course
8061 there was air.

Q. Do you know there was no wind; do you know there was no dust?

A. Well, there is always dust blowing, too.

Q. Would you stake your life on that?

A. No, I wouldn't stake my life on that because there is always dust blowing.

(Signature waived.)

8062 PROF. ADOLPH GEHRMANN,

resumed the stand for cross-examination by Mr. Jeffries, and testified as follows:

Q. Doctor, how much does the determination of the numbers of bacteria show in regard to the purity of the sample of water?

A. The determination of the number of bacteria present in water is a small part of the examination of water for purity. It indicates a degree rather than an absolute fact.

Q. Depending considerably upon the examiners, and the source of the bacterial ingredients, does it not?

A. Yes, the kinds are more important than numbers.

Q. And the kinds, so far as pathogenic bacteria are concerned, depend largely upon the source of the pollution. Isn't that true?

A. Upon the source of the pollution?

Q. Yes?

A. Well, they can to a degree depend upon the source of pollution.

Q. How large a quantity is one cubic centimeter—put it in cubic inches, or teaspoonfulls?

A. About four cubic centimeters make a drachm. It is about a quarter of a drachm.

8063 Q. How would it compare with an ordinary thimble?

A. Well, I don't know as to thimbles. I have no experience as to thimbles.

Q. Now, how many cubic centimeters from each sample bottle sent you did you ordinarily examine?

A. We very rarely for the colony count examined a cubic centimeter. These examinations were made in water known as dilutions. That is, it became necessary, owing to the large number of bacteria, present, to dilute the water one hundred times or a thousand times, and then take a portion of this dilution for the plate cultivation, so that in none of the instances was a cubic centimeter taken.

Q. And you diluted the water according to the impurities that it contained, or according to the number of bacteria that it contained?

A. Yes, we diluted it according to our previous preliminary examinations that had given us an idea of how many we might expect.

Q. So that in waters that contained more bacteria than others according to your previous examinations, you made greater dilutions?

A. Yes, those where we expected to find more we diluted more than the others.

8064 Q. What was the average amount of dilution that you used in the samples taken from the Illinois river?

A. Well, the Illinois river, of course, at the different points, it was different. I could not give you anything that would indicate an average amount of dilution. One hundred and one thousand were the usual dilutions for points around Henry, Averyville and Chandlersville, Beardstown and Grafton, and one thousand and ten thousand for points like Wesley City, Pekin and Morris—points as high up as Morris.

Q. So that where you used the thousand parts in dilution, you simply analyzed the quantity of bacteria in 1-1000 part of a cubic centimeter of the water that was actually taken fom the river?

A. That would be the procedure, yes.

Q. And if you diluted it 100 parts, you would examine 1-100 part of a cubic centimeter of water, taken at the various places for the purpose of determining the number of bacteria per cubic centimeter?

A. Well, that is not altogether true. We might take two or three hundredths. The multiplication would not necessarily always be by 100. It might be 50. In some cases we might have taken more water than one one-hundredth.

8065 Q. But any of the instances in which you took 50 or 100 or 1,000, you would examine 1-50, 1-100 or 1-1000 of the water taken—per cubic centimeter of the water taken from the river?

A. Yes, the calculation would indicate that. It might not be absolutely that. It might be a little more or a little less.

Q. But that is the way the calculation was made?

A. Yes.

Q. Now, Doctor, was this small quantity of water examined sufficient to determine with accuracy the bacterial condition of the whole canal or river from which it came?

A. I might confess that an examination of this kind shows a degree of accuracy that gives results that can be comparable with other results made about the same time or in the same line of work.

Q. But it is not such a determination as might be considered the result of an exact mathematical calculation or science, is it?

A. It is scientific, but it is not like mathematics.

Q. It is not an exact science?

A. I shouldn't say that it was as exact as mathematics.

Q. Professor, state whether or not each particular sample

8066 would be necessarily a representative of all the water in the river at that point, or at the point where taken?

A. I believe it would be representative for that time and moment that it was collected.

Q. You don't mean by that, do you, Professor, that if there should have been certain kinds of pathogenic germs at that point that they would have been disclosed by that sample?

A. No, not at all, the count is simply for numbers, without any reference to the kinds.

Q. And you confine yourself to the count with reference to the character?

A. Yes.

Q. Now, might another sample taken from nearer the shore or nearer the bottom of the river, or a few hours later, have given different results?

A. They could give different results to a degree.

Q. Now, Doctor, does bacterial count alone afford sufficient information upon which to base an opinion of the sanitary condition of a body of water?

A. No, I don't think that the count in itself will decide as to the sanitary condition.

Q. Assuming, Doctor, that the same number of bacteria are detected in two samples of water, sent you for examination,
would you as a bacteriologist be able to say that any two
8067 bodies of water from which they may have been derived,
are of the same sanitary quality?

A. No, I could not from a bacterial count alone, make such a statement.

Q. Is it true—or is it not true that one might have come from a typhoid infected lake or river and the other from one free from such infection?

A. The two samples having the same amount may have come from many different localities. The number indicates nothing with regard to the locality from which it comes, in itself, except as far as the numbers indicate bacterial activity in that sample.

Q. Then it would indicate nothing as to the presence of pathogenic germs?

A. No, it would not show pathogenic germs.

Q. Would it indicate anything as to the absence of pathogenic germs—the presence or absence of pathogenic germs?

A. The bacterial count is not a statement of quality—it is distinctly a statement of quantity. It has nothing to do with the kinds.

Q. In your examination yesterday, Doctor, you testified that the bacterial purity of water examined by you from the Illinois river at Grafton, and from the Mississippi river at the
same place, was about the same. Just what do you mean
8068 by that?

A. I was speaking at the time about the numbers of bacteria present, and the results indicate that as far as the numbers of bacteria and the activity of bacteria present in the water in these two localities, is approximately the same.

Q. Then bacterial purity as you have stated does not necessarily mean sanitary purity?

A. No, bacterial purity is not recognized as its sanitary condition, except as far as the general activity of decomposition that is taking place is concerned, which has a slight bearing on the question as to purity or impurity.

Q. You have stated that the bacterial purity of the water of the Mississippi at Jefferson Barracks and at the chain of rocks was of about the same bacterial purity. Doesn't this show as heretofore stated by you that the term "bacterial purity" used in this sense has little or no significance—sanitary significance?

A. It has only the significance of the numbers of bacteria present, and the activities of the bacteria present and the extent of the decomposition that has taken place in given samples of water at these two points.

Q. Doctor, do you recognize any general relations between numbers and purity in water?

8069 A. Yes.

Q. Hundreds, bacterially speaking, indicate more purity than thousands?

A. Yes, that is true.

Q. The counts?

A. Yes, sir.

Q. That is, basing it on bacterial counts, and yet those hundreds may contain more pathogenic bacteria than the thousands, may they not?

A. That is true. The numbers in themselves are simply estimations of quantity and not quality.

Q. Now, are you acquainted with, and you are, I suppose, with the number of bacteria in Chicago tap water?

A. Yes, sir.

Q. Are those not hundreds rather than thousands?

A. We have made a great many examinations and found that the averages for some years were thousands and the averages for other years hundreds.

Q. Aside from averages, what would you say as to single examinations, as applied to the tap water of Chicago?

A. Single examinations have been as low as tens, and single examinations have been as high as 10,000.

Q. Have single examinations been as low as ten and as 8070 high as thousands practically at the same time, at the same tap?

A. No.

Q. But for considerable periods they might run hundreds, might they not?

A. Oh, yes.

Q. You have examined bacterially the water from Lake Michigan, have you not?

A. Yes.

Q. Have you examined the water taken from the mouth of the Four Mile crib?

A. Yes.

Q. And from the other cribs?

A. Yes, sir.

Q. State whether or not, Doctor, you examined the water from the mouths of these cribs during, prior to or subsequent to any increase in the number of typhoid fever cases in the city of Chicago?

A. I had occasion during the past year to examine the tap water from the various taps including the Four Mile crib at the time when there was an increase of typhoid fever in the city of Chicago, during June and July and extending into August.

Q. JUDGE SPRINGER: What year?

A. Last year. My examination of the water did not con- 8071 tinue after the last of June or the first of July, but I examined the water up to that time myself. There was an increase in typhoid during the months of June and July in the city of Chicago.

Q. Was this a general increase all over the city?

A. No, it was not a general increase.

Q. To what part of the city was it confined?

A. 19th ward.

Q. And what crib do they get their water supply from?

A. They get it from the Harrison Street Pumping Station which is a mixed water,—Four Mile water and old Chicago Avenue water.

Q. And the Chicago Avenue water comes from how far out in the lake?

A. That is a two mile tunnel.

Q. So it was a mixture between the two mile tunnel water and the four mile tunnel water?

A. Yes, it is more four mile water than two mile water; it is some Chicago Avenue water.

Q. Now, did you examine the water from the mouths of those two tunnels during that time?

A. Yes, sir.

Q. Had you examined it prior thereto?

A. Yes.

8072 Q. State whether or not you discovered any typhoid bacilli in those examinations?

A. No, I did not.

Q. Did you think it strange that you did not?

A. No, I did not.

Q. You didn't expect to find them, did you, Doctor?

A. I didn't have any reason to suspect that there would be typhoid bacilli in the water at that particular time. There was nothing that would indicate any special reason for the presence of typhoid bacilli.

Q. And yet it was there?

A. I don't believe it was.

Q. Then you think that epidemic did not come from the water?

A. I am quite certain that it did not.

JUDGE SPRINGER: From what water?

A. Lake water.

Q. MR. JEFFRIES: Did you ever examine the water of Lake Michigan when typhoid was common all over the city?

A. No, sir. That is an epidemic,—what I would consider an epidemic. No, I never had occasion to examine it during an actual epidemic.

8073 Q. Did you ever examine it when it was commonly supposed by physicians and others to be coming from the water?

A. Such cases as occurred in the city from time to time and could be looked upon as coming from the water, I examined the water because I had been examining it continuously for a number of years.

Q. Doctor, is it your opinion that the typhoid fever cases and epidemics of Chicago have been caused by the using of the water from Lake Michigan or not?

A. The epidemics that I have any definite knowledge of outside of the one of the past year, were due to the water.

Q. Were due to the water?

A. Yes.

Q. Did you not examine the water during any of those epidemics?

A. No, not what I would call an epidemic.

Q. Do you know whether or not there was any great change in the bacterial contents of the water during those epidemics from that which it had been prior thereto, so far as shown by laboratory experiments?

A. There were no laboratory experiments made that I know of.

Q. Do you attribute any part of the typhoid fever in Chicago since 1894, to the water supply of the city?

8074 A. Yes, I would say that about one-half of the cases under all circumstances came from the water supply, and they come from the water supply owing to two or three causes. There has been continuously a certain amount of flow of sewage into the lake, especially along the south side, from 35th street, south, so that infectious matter could be carried out to the cribs, and there has been dumping of dredges along shore almost continuously during these years.

Q. And that is going on now, is it not?

A. That is going on at the present time, yes.

Q. Now, during all this time from 1894 down have there been any bacterial changes in the bacterial condition of the water from Lake Michigan as taken from these various cribs?

A. There have been a few times when the figures would vary with a degree, that is, different years would be different. I don't consider that there is any great variation at any time.

Q. But in those variations and as the bacterial contents would vary, so far as the numbers of bacteria are concerned, would you notice a corresponding variation either prior to or subsequent to the variations, in the number of typhoid cases in Chicago?

A. I have noted some slight differences. In one small increase in typhoid that occurred in 1897 where the bac-
8075 teria were more numerous and the water was worse at that time, and there was an increase in typhoid two or three weeks later. That is the only one that I can recall that is very definite.

Q. How does the water in Lake Michigan during all of these years that analyses have been made by you and in your laboratory taken from the various cribs, compare in respect to bacterial count, and bacterial purity with the averages which you have obtained from Grafton?

A. They are better.

Q. Doctor, have you any means of telling the source of the bacteria in the counts which you found in the water of Lake Michigan while you were making these various examinations?

A. I am very certain upon many occasions that they came from the dredgings that were deposited in the lake, because I had occasion to follow the dredge, or follow the water for as much as an entire afternoon, as to its movement in the lake.

Q. What connection, doctor, do you place upon the stirring up of the lake by these dredges, and this dredging, with the typhoid fever cases in Chicago and what significance do you attach to it?

A. In the first place the dredging referred to is not one of stirring up, but it is the emptying of dredgings from the scows into the water, and my view is that a proportion of the
8076 typhoid comes from these dredgings, but not any material proportion of the typhoid.

Q. Where does it come from?

A. The typhoid that we have, that is, that portion of it that we can attribute to the water, comes from the direct transfer of infectious matter from the sewers to the cribs.

Q. But you take into consideration both as a means of producing the typhoid cases, both the dredging and the direct passage?

A. I think the dredging is a party to it, but to a less extent.

Q. When you said the counts were better in your previous answer, in comparing the bacterial counts of the water in Lake Michigan, than that of the Illinois river at Grafton did you mean that they were lower in the waters of Lake Michigan?

A. Yes, lower.

Q. Doctor, you testified I believe that your bacterial counts were made upon agar plates?

A. Yes sir.

Q. At what temperature were they incubated?

A. We kept them at 18 to 20 occasionally,—about that temperature.

8077 Q. That is 18 to 20 centigrade?

A. Centigrade. It was the intention to maintain it exact, but it ranged from 18 to a little over 20.

Q. They were not at the blood heat were they?

A. No, it would be known as moderate room temperature.

JUDGE SPRINGER: 37 is blood heat?

A. Yes sir.

MR. JEFFRIES: You stated doctor, that the bacillus prodigiosus that you found in your laboratory might have come from a contamination of some kind, did you not?

A. I didn't say, as I remember it, that I found it in my laboratory.

Q. Well, that is true. Where did you find it? I have forgotten.

A. As I remember it I said that I found it in examinations of different kinds and so on.

Q. Did you have any reason to believe or to know where it came from?

A. No, except that when I really tried to get a culture of bacillus prodigiosus, I took plates where there was decomposed vegetable matter in considerable quantity found, for instance, a garden, cabbage field, or something of that sort.

Q. Did you find it there?

8078 A. I found it there, yes.

Q. You believe then that it lives wild in the United States, do you?

A. I believe so, yes.

Q. It is very rare in nature is it not?

A. It is not common. Sometimes it appears in considerable numbers at a given point, as a general thing it does not; it is not prevalent as many other organisms.

Q. Is that the case in this country?

A. Yes, in this country that is the case.

Q. Doctor, in view of the fact that the sewers of Chicago into Lake Michigan have produced typhoid fever in Chicago, what significance do you place upon the rules of the Board of Health in regard to the different disinfections of typhoid excreta always proving effective?

A. My view in regard to these particular points, the disinfection of stools is that we have now in the educated physicians, that I believe we have in this country, the trained nurses, and others, an almost universal disinfection of the stools during cases of typhoid fever. In the majority of cases the spread of typhoid fever comes after the patient is convalescent, and the urine which often contains large numbers of typhoid bacilli, that
the patient or the person can deposit and spread about
8079 for several weeks or months after he is actually out of
bed, when he is out of the control of any regulations or management.

Q. And may that not also be true before the doctor and nurses have been called in?

A. Less true than afterwards.

Q. But it may be true to some extent?

A. It may be true, yes.

Q. Are there not many so-called walking or un-recognized cases of typhoid fever in which the disinfectant is never applied?

A. Not as many as formerly, because with blood examinations we could single out those cases much better than previously, and anyone who has a continuous fever for a time is pretty apt to find out what it is in the course of a few days, or a week.

Q. May they not be of such a character as not to come under the observation of the doctor at all?

A. There are cases of that kind, yes.

Q. Isn't it a fact doctor, that even when it is applied in private families, it is often done in an unskillful and inefficient way?

A. You mean the disinfection of the stools?

Q. Yes, disinfection of the stools and urine.

8080 A. Well, there is always a possibility of not having a person who appreciates entirely the value of disinfection, and so it is not carried out to its full extent. That is always a risk, a possibility that might exist.

Q. How far out in Lake Michigan from the Lake Front at Chicago does bacterial contamination sometimes extend, according to the examinations which you have made?

A. The examinations that I have made as to the extent of the contamination, had been at various points along shore, different distances out, and especially out in a direct line east from the mouth of the Chicago river. The degree to which the sewage and shore contamination would extend into the lake varies a great deal and varies rapidly at times, depending upon wind movement and the amount of rainfall, as to the flushing of the sewers. I have some recorded examinations that I could present as to the results. Some of these show that there is no evidence of any pollution any further out than two miles, and again we have evidence of pollution by the presence of excessive numbers of the bacteria and colon bacillus, ten miles out.

Q. Isn't the sewage entering Lake Michigan highly diluted before it enters the intakes of the city waterworks?

A. Yes, it is highly diluted.

Q. An extreme dilution, is there not?

8081 A. Undoubtedly an extreme dilution of sewage matter.

Q. Doctor, have you ever used in water examinations the so-called Guinea pig test?

A. Yes sir.

Q. For the purpose of determining the presence of pathogenic germs?

A. Yes.

Q. Is this test capable of revealing the presence of or the absence of the typhoid fever germs?

A. No, it will not necessarily show the presence of typhoid bacilli. It might under some circumstances, but not as a routine method.

Q. Do they show the absence of it?

A. I don't believe it would positively in all cases show the absence.

Q. Do you regard that as an important test?

A. Yes, I consider that an important test in water examinations.

Q. Why was it not used in your examinations of the water of the Illinois river?

A. The examinations that were made were made in the way they were made on account of a mutual agreement between a
number of parties to which I was a part, and the con-
8082 census of opinion was to conduct them in that way. That
is all I know about it. The difficulties of animal experiments may have a possible bearing on a question of that kind.

Q. Now doctor, state in the language of Mr. Todd, so that an intelligent layman can understand, just what is implied or meant by the term pathogenic germs?

A. I don't like to term them germs. I never use that unless I have to.

Q. Organisms then?

A. Micro-organisms.

Q. Pathogenic micro-organisms?

A. Bacteria. A pathogenic micro-organism is one that under conditions is able to alter physiological conditions.

JUDGE SPRINGER: Is what?

A. Able to alter or change physiological conditions.

Q. MR. JEFFRIES: It is not necessarily a disease germ?

A. Alteration of any physiological function has in it at the bottom the disease or pathological condition.

Q. But it may not be an infectious disease germ?

A. Infections? No, it might be a toxic disease.

Q. What do you understand is meant in hygiene by the term saprophytic bacteria?

A. The saprophytic bacterium is one that is capable of living upon dead organic matter.

8083 Q. Are not pathogenic germs capable of living on dead material in laboratories?

A. And hence also, saprophytic. Yes, they can be what we call facultative, that is, they can live either upon dead material or as parasites upon living material.

Q. Is there then doctor, any sharp line between saprophytic and pathogenic germs, or bacteria?

A. The sharp line comes when you arrive at the question of the alteration of the physiological conditions. The minute that you come to that line of changing a physiological condition or altering it in any way, you reach the point of pathogenicity. It may be in an extremely light degree, or a very marked degree, leading to the death of the individual, but as soon as you get any alteration due to these things you have what can be considered, and is considered, a pathogenic property.

Q. Can it always be accurately ascertained or determined, as applied to the human system, when a germ ceases to be a saprophyte and becomes pathogenic, or vice versa?

A. It is limited by the ability of our instruments, and the precision in our chemical methods, or biologic methods. There is the possibility of the presence of changes that our present methods cannot give us an accurate idea of at this time, at least the beginning of them. After they have advanced to a
8084 certain point they become obvious, but the beginnings are often very difficult to trace, and our methods give us no exact knowledge of it.

Q. In your analyses of the water down the Illinois river, doctor, in 1899, and to which you have testified in chief, did you record the number of colon bacilli that you found or merely the presence of the colon?

A. I recorded simply the presence of the colon bacillus and not the numbers, for the reason that in order to get at the numbers one has to make quite a large series of dilutions, and separate tests, and I found that the amount of work I had that I couldn't follow this out accurately enough to decide upon it, and I made those tests for qualitative determination.

ADJOURNED until Monday morning, October 12, 1903, at 10 o'clock.

10:00 A. M., Monday, October 12, 1903.

8085 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ADOLPH GEHRMANN,

resumed the stand for further cross-examination by Mr. Jeffries and testified as follows:

Q. Professor, how long were you connected with the city health department after these examinations about which you have testified, were made?

A. One year and seven months.

Q. Were these analyses all made by yourself?

A. They were made under my immediate supervision, with the assistance of two or three assistants who worked with me. I made a great many of the counts, and the direct examinations personally. I supervised the work personally throughout.

Q. Now who were those assistants?

A. I had an assistant of the department, Kierueff, working with me, and Dr. Kilburn, who was assigned especially for assistance in this work. They made the culture media and 8086 cleaned the apparatus and kept the work going, as an assistant would.

Q. Now those are the only examinations of the water from the Illinois river that you made?

A. I made some analyses or some examinations once before

Q. Did you make any since that I mean?

A. No, not since then.

Q. Have you been down the Illinois river recently?

A. I was down the Illinois river from Chicago, through the length of the river to St. Louis in September.

Q. You are not connected with the Health Department now then are you?

A. No, not at the present time.

Q. I understood you to say you were professor of hygiene in some college or institution here in Chicago?

A. Yes, I am professor of hygeine and bacteriology in the College of Physicians and Surgeons, the medical department of the University of Illinois.

RE-DIRECT-EXAMINATION,

By Judge Springer.

Q. Professor, what was the effect of taking the 12th and 22nd Street sewers from the lake and turning them into the Chi-

cago river, and what effect did this have on the typhoid
8087 death rate in Chicago, if you know?

MR. JEFFRIES: Turning them into what river?

JUDGE SPRINGER: The sewers were emptying formerly into the lake and they were turned from the lake and turned into the Chicago river, and then out the other way, and I ask him the effect of this upon the typhoid fever rate of the city.

MR. JEFFRIES: We object to the question as not proper re-direct examination, not having been brought out by the witness on direct examination.

A. These two sewers were relaid in 1898 and 1899, the work was completed in the fall and winter of 1899, and the drainage of all of the district as far south as 31st Street in this city was changed from discharge into the lake to discharge into the river, that is westward. And the records of the following year show that 1900 is the best year that the city has had as regards typhoid fever. It is due in part to the removal of this amount of drainage from the lake, because these sewers were in such a position that their discharge would pass more nearly opposite the important intakes.

Q. What effect has the removal of the intakes further out into the lake had?

A. The removal of the intakes further into the lake has reduced the amount of typhoid fever in Chicago because of
8088 the greater dilution, and greater time required for the sewage matter to reach the intakes.

Q. Will you state what was the cause of the typhoid increase last year, of which you spoke in your testimony on cross-examination. By last year I mean the year 1902.

A. The increase in typhoid last year was mainly a local epidemic in the Nineteenth Ward, and was due to the overflow of the portion of the basement and a pump well of the Harrison Street pumping station during the early summer and also to the presence of open vaults in this ward, as shown by the investigations of the members of Hull House and published in the report of the City Homes Association. In the overflow of this pump well as stated, it was found that a sewer connection had over flowed and was the direct cause of the flooding by sewage from the street sewers.

Q. Do you know what proportion of the deaths in the city during that year were in the immediate vicinity of this break in the sewer, or overflowing of the water pipe?

A. Out of 402 deaths recorded, 180 were in this immediate neighborhood. That is something over 35 per cent., practically I don't know the exact figures.

Q. How great an area do you include in this estimate as being in the immediate vicinity?

8089 A. The 19th ward—the area of which I don't exactly know.

Q. That is what you refer to when you say in the immediate vicinity, you mean in the 19th ward?

A. Yes sir, the 19th ward.

Q. Are the wards in this city constructed mainly in reference to the population or the area in territory?

A. They are entirely arbitrary. I don't know how they reach their ideas about the wards. They are arbitrary.

Q. You don't know what proportion of the poulation of the city was in that ward?

MR. JEFFRIES: I suggest that that is a matter of record.

A. Yes. Off-hand I could not state. Probably 30,000 or 40,000 people.

Q. JUDGE SPRINGER: If sewage should pass into the lake at this time or if sewage is now passing into the lake why is there not more typhoid fever in Chicago?

A. The intakes are at such a distance from the shore that the dilution of the sewage is so great and the time for the passage to the intakes and back to the poulation is sufficient to give opportunity for destruction in a considerable portion of the infectious matter.

Q. From your studies of the water supply of Chicago and from your knowledge of what has been done in reference 8090 to this supply, will you state what improvements, if any, have been made in the system from time to time?

MR. JEFFRIES: Now we suggest that that question is not permissible under any of the rules of evidence, as far as re-direct-examination is concerned. It is not brought out in chief by counsel for defendants and therefore he has no right to bring it out in re-direct.

JUDGE SPRINGER: The reason for submitting this question is that it relates to the question of typhoid which was brought out on the cross-examination.

A. Up to the years 1890 and 1891, the intakes for the obtaining of water were not over two miles from shore, the furthest being two miles. Other intakes were less than a mile from shore, and up to that time there had been a continuous excess of typhoid fever in the city. In the epidemic of 1890 and 1891, and a portion of 1892, which was due to the special taking of water from the shore intake, the extension of the intakes was completed, and from that time a marked decrease in typhoid was noticeable. In 1899 the work of re-laying the sewers at 12th and 22nd Streets, was completed and a further decrease in typhoid resulted.

Q. In your cross-examination you used the term "infectious matters" in water. Will you please give your definition of that term as you understand it?

8091 A. By infectious matter I mean portions of the structures or tissues or excretions of the individual containing the micro-organisms that will lead to infection.

Q. In one of your answers on cross-examination you stated that you objected to the use of the term "germ," the word "germ," will you state what your objection to the use of that word is?

A. The term "germ" is a very indefinite term. Germs mean simply the origin of anything, in a very general way, as for instance, the germs of freedom, or any obscure, indefinite thing that gives rise to anything in speaking of disease conditions, we should confine ourselves to the definite objects or causes that have to do with the origin of such diseases.

Q. Your objection then is that it is too general when applied to micro-organisms?

A. Yes.

RE-CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Doctor, if all the sewage of Chicago was turned into Lake Michigan today, would it not in your opinion increase the number of typhoid cases in the city of Chicago?

A. Undoubtedly the turning of all of the sewage would
8092 increase typhoid in the city.

Q. I will ask you doctor, if the typhoid micro-organisms have not a better chance for sedimentation in passing out into the lake and the Four Mile Crib, than they do in a stream that has a continuous current?

A. I doubt whether I could reach any definite information on that point, from my knowledge of Lake Michigan, I know that it is not a quiet body of water by any means, and as far as streams are concerned, it would depend entirely upon the rapidity of the stream and the conditions involved in the stream, a comparison would be extremely difficult for me to draw; therefore I would be almost without any data upon which to draw a definite conclusion as to a question of that kind.

Q. When is sedimentation most rapid?

A. When the water is quiet.

Q. That is shown in the laboratory, is it not?

A. It is a principal of physics.

Q. Do you have any idea of the extent of the dilution of typhoid bacteria or micro-organisms in the water of Lake Michigan when the average typhoid conditions at Chicago existed?

A. Yes, I have an idea. It must be extremely great, because I cannot find the typhoid bacillus in the water.

8093 Q. And you have made numbers and numbers of examinations of the water of Lake Michigan for that purpose?

A. Yes sir, I have.

Q. A great many more examinations of that water—of the water of Lake Michigan than you made of the Illinois river?

A. Yes, more examinations.

Q. Was there anything in the water of Lake Michigan in your examination that indicated to you that it was not potable?

A. During the long series of examinations that we have made, and a comparative study of the returns of deaths from typhoid fever in the city, we have reached a certain degree of recognition, of the finding from bacteriologic and chemical examinations, which indicate to us that the water at one time is more infectious than it is at other times.

Q. But, doctor, taking into consideration the bacterial analyses alone, without reference to your knowledge of the effect that the use of the water has had upon the people of Chicago, confining yourself now strictly to the bacterial examinations, did you find anything that would lead you to believe that it was not a potable water?

A. The findings of the colon bacillus has given us an idea as to the potability at different times,—variations in potability. 8094

Q. And that without respect to the number of the colon per cubic centimeter?

A. In my work it has been in reference to the continuance—

Q. The continual presence?

A. The continuance of finding it; the greater frequency of finding it.

Q. And you reason by bacterial analogy that if you find the colon present, that other pathogenic germs are present?

A. The presence of the colon bacillus is recognized as indicating sewage matter,—

Q. Yes, but of what importance—

JUDGE SPRINGER: Let him finish the answer.

MR. JEFFRIES: I beg your pardon, doctor?

A. Indicating sewage matter and its more continual presence increases the possibility of other pathogenic organisms possibly being present.

Q. In other words, the presence of the colon leads a bacteriologist to believe that there are other pathogenic micro-organisms present while they may not be found in the sample examined, yet on account of the immense dilution, pathogenic germs or micro-organisms of more serious moment are present though in a more diluted state than the colon, is that not true? 8095

A. The presence of the colon bacillus gives bacteriologists the idea of suspicion in regard to a particular sample of water. It is suspicious.

Q. But professor, when you find the colon bacilli present in that water, that you are examining, and which water you know has produced typhoid fever among the people using it, do you not then conclude that the presence of the colon is in part significant of the presence of the typhoid?

A. It is in part significant of the presence of other organisms.

Q. But the best test, professor, of the sanitary condition of water is the effect that it has upon the people using it, is it not?

A. Yes, that is a better index than the simple finding of the colon bacillus.

Q. Doctor this dilution—does dilution remove pathogenic micro-organisms from a lake or running stream?

A. Dilution?

Q. Yes?

A. Pure and simple?

Q. Pure and simple dilution?

A. I don't think that dilution would remove them; it would aid in their destruction.

8096 Q. In what way?

A. It would bring about a more rapid dissemination and breaking up of the particles derived from indivduals that are sick with the various diseases, and in that way would liberate the micro-organisms from the protection of particles, so the destructive effects might be more easily operative in bringing about their ultimate death.

Q. Then you are of the opinion that the typhoid micro-organisms or the disease producing micro-organisms will live longer in highly contaminated water than water that is free from contamination; is that the way I understand you?

A. No, I don't say anything of that kind at all.

MR. JEFFRIES: Read the previous answer.

(Answer read).

Q. And that liberation of the solids from the protective effect would be caused or produced by the friction in the running stream; do I understand it in that light?

A. No, we are speaking now about dilution itself.

Q. Dilution itself, yes?

A. Now leaving aside other reasons, for it is the same thing that might occur under other conditions, in dilution itself, infectious matter would be disintegrated more quickly than if it remained as a little mass of dried or semi-dried ma-

8097 terial in some particular spot, for instance on clothing, or in a small drop of water.

Q. Are you of opinion that disease producing micro-organisms will live longer in highly contaminated water than in water that is less contaminated?

A. No, I believe that in highly contaminated water, where decomposition and the action of saprophytes is very active, the pathogenic organisms, or disease producing organisms are more quickly destroyed.

Q. Now doctor, does not dilution merely separate the disease producing micro-organisms rather than cause their disappearance in the water. When we speak of dilution pure and simple, is not that what it means?

A. Yes, dilution is the separation of the individuals, and of course with dilution we have agencies operative which lead to the death of certain numbers of them.

Q. Doctor, assuming that a typhoid bacillus was deposited in an ordinary well, would you recommend the use of that water knowing that the bacillus had been deposited there?

A. No, I should not.

Q. If a typhoid bacillus had been deposited in a hogshead of water containing 65 or 70 gallons,—one typhoid bacillus,—you knowing that that bacillus was there alive and virulent, would you recommend the use of that water for domestic purposes? 8098

A. In reply to this question, I have some views of the typhoid organisms, and typhoid infection that I believe would be necessary to explain before arriving at any positive answer. I do not believe that there is very much danger from even a few single free typhoid bacilli. I must draw a distinction between infectious matter and free, single typhoid bacilli, and in a case where I knew positively that one typhoid bacillus had been placed in a certain quantity of water, without knowing anything of the conditions under which that water were to be placed, the amount of organic matter in it, the possibility of the rejuvenation and growth of them---of this single typhoid bacillus, of course I should say that the water was not potable. But under conditions where I knew that there would probably be no multiplication of that typhoid bacillus in the water,---no, as it were, incarnation of the amount of infection present, I should not myself have any hesitation in drinking the water.

Q. Because you believe that even though you would swallow that one germ, it would not affect you?

A. I do not believe it would.

Q. Might not that germ be placed in some other condition which would produce—after it had been drawn into the household, that would produce typhoid?

8099 A. Oh, it is possible that we might have incidental circumstances accompanying the condition, which would lead to a condition in the bacillus, and the condition under which they were placed, after a time that it might make it possible to infect individuals again.

Q. Isn't it possible that there might be certain conditions in the human system, a broken down system, run down system, or weak system that would be conductive to the multiplication of those typhoid bacilli when the one germ has been swallowed by the person, or in other words, isn't it as likely for that germ to have got in contact with the proper medium in the system of the person swallowing it, as it would if it had been taken into a laboratory and grown upon a media, or taken into a household and accidently placed upon the proper media at the proper temperature and multiply?

A. This question involves so many possibilities that a direct answer without qualification to my mind is a matter that is not entirely possible. It is without doubt true that a single bacillus can be taken and through the proper circumstances either without the body first, or within the body afterwards, can be brought to such a condition that it will bring about infection, but still we must recognize that the closer the micro-organism comes from infected individuals, to the time they 8100 get into the second individual, the more certain will be the infection, and that the conditions within the individual must be exceptional from a chemical, from a mechanical and from a biologic standpoint, in order that a single, or even a few free separate micro-organisms shall find conditions which will be suitable under those circumstances for the bringing about of the infection of the second party,—the second individual.

ADOLPH GEHRMANN, M. D.

THE COMMISSIONER: It being now 11:00 A. M., Chicago time, which is noon, Washington time, and the limit set by the Supreme Court for the taking of testimony in this case, but a motion for the extension of that time being now pending before the Court, it is understood and agreed by counsel that if the Court grants said motion the testimony hereafter taken until the Court acts on said motion, shall be and become a part of the record, with the same probative force as other parts, but if the Court deny the motion, the testimony hereafter taken shall be, with the consent of the Court, considered as a part of the testimony taken in this case.

(Motion granted by the Court Oct. 13, 1903.

F. S. BRIGHT,
Commissioner.)

8101 D. B. BISBEE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Springer and testified as follows:

Q. You may state your name, residence and occupation?

A. D. B. Bisbee, LaGrange, Illinois. I am a chemist.

Q. Where were you educated, at what college or institution?

A. The college is the agricultural college of Iowa.

Q. How long did you attend that college?

A. I took the full course, four years and then took a post-graduate course afterwards.

Q. How long was that?

A. Altogether it was six years and a half, I was at the school.

Q. Were any of your studies especially directed to the subject of chemistry?

A. Yes; I made that my special branch right straight through.

Q. What studies have you pursued since that post-graduate course in reference to chemistry?

A. Why, no systematic course of study. It has been simply

what I read in periodicals and books, and what I take up
8102 from meetings and conventions and things of that kind. No regular course of study was laid out.

Q Have you performed any chemical work since you left the college, in the way of making analyses of water?

A. Yes.

Q. Please state what?

A. For four years, beginning in February, 1896, I was the assistant city chemist of Chicago and was engaged all that time in water analysis. I made some water analyses before I became city chemist. I don't know how many now. I haven't any idea, but I made some examinations before. I was familiar with the subject, and since 1900, since the fall of 1900, I have been chief chemist of the city and the water examination has been under my direction. I made part of the examinations, but they have all been under my direction up to the present time.

Q. How many chemical analyses of water were made each day, by you during that period?

A. Well the water—of the water there were never less than four and they were from that number up to 12 made each day. I should say about an average of seven samples a day, that is six days in a week.

Q. How long a period did that cover?

8103 A. Four years.

Q. Did you make chemical analyses of other liquids than water?

A. Yes, a large number of ices, and then various other liquids?

Q. Milk?

A. Yes, sir, a large number of milks, a great many more milks than water, of course.

Q. That is part of your general work?

A. Part of my general duties.

Q. How were the samples brought to your laboratory, or where did you get them, of water that you analyzed during this period?

A. They were brought to the laboratory by various people who collected them and they were brought in five-pint glass stoppered bottles. That is the waters for the examinations. These samples I mean were all samples of city water, taken from the various pumping stations throughout the city.

Q. Yes, that is what I am speaking of now. Are you still connected with the chemical department of the Board of Health of Chicago?

A. Yes sir.

Q. Are you acquainted with Dr. Adolph Gehrmann?

A. Yes.

8104 Q. Did you hear any part of his testimony in this case?

A. I heard parts of it, yes.

Q. Dr. Gehrmann stated that certain tables which he read in evidence, numbered, beginning with No. 159 and including consecutive numbers down to and in cluding 196, were made jointly by him and yourself. Would you recognize those tables now if you should see them?

A. I think so.

Q. Please look at the tables to which I call your attention, beginning with No. 159 and ending with 196, being the tables to which Dr. Gehrmann referred, are they those which you participated in making?

A. Those are the tables that were drawn up from my notes, that of Streams Examination work wihch I did jointly with Dr. Gehrmann.

Q. What part of those tables was it that you made yourself?

MR. JEFFRIES: We object to the witness stating in the record his having made any part of the tables which were read in evidence by Dr. Gehrmann, for the reasons stated in our objection to their being read into the evidence at the time, and for the further reason that there is nothing within the science of chemistry that can determine the sanitary condition of water for drinking and domestic purposes, and for the further 8105 reason that a sufficient number of samples were not taken and examined with a view of making any determinations whatever that would be reliable or carry with them any degree of credibility or probative force, and for the reason that the samples of water were not taken with reference to flood stages and low water stages, winter seasons and summer seasons and the various changing conditions of the Illinois river or the Desplaines river, and the Chicago drainage canal, and for the further reason that the defense has proven by Professor Long that certain living micro-organisms existed in the water analyses made by him chemically, though he could not determine their character, whether they were pathogenic or non-pathogenic, and for that reason the science of chemistry throws no sufficient light upon the sanitary condition of the water for drinking and domestic purposes, that could be relied upon by a tribunal passing upon the condition of the water in question and such testimony, the evidence of such tables and such analyses would have no probative force whatever.

JUDGE SPRINGER: I desire to suggest that this objection goes to the weight of the evidence and not to its competency, and it would be more properly addressed to the Court than to the Commissioner.

8106 Q. (Question repeated).

A. All of the tables with the exception of the notes under headings "Height of water", "Temperature of water", "Temperature of air", "Presence or absence of coli, and the number of bacteria per cubic centimeter."

Q. Wherever in these tables then the height of the water, temperature of the water, temperature of the air, are noted, state where those figures were obtained by you?

A. They were obtained from the paper or the tag which came with each sample of water. This paper tag was filled out; it was a blank form which was filled out by the water takers.

Q. Now please state in what condition the water samples were received by you, the analyses of which are recorded in these tables?

A. The sample was received by me from the various express companies in wooden boxes, these boxes had two, four or six compartments, according to the number of samples that were sent in them, taking the two compartment box as a sample, one of the compartments held a gallon bottle of water for my examination, and the other compartment held the bacteriological sample. The chemical sample, the gallon bottle, was sealed by means of a rubber cloth, which was fastened over the stopper and had a wire running through the various holes in the
8107 cloth around under the stopper of the bottle, and sealed

with a lead seal. This was simply to prevent the stopper being removed after being sealed, without either the seal or the rubber cloth being destroyed, so as to show that it had been unopened. Then this bottle was packed by means of excelsior or other packing in the compartment of the box. Do you care about the description of the way the bacteriological sample came?

Q. Yes?

A. The bacteriological sample came in a four ounce, I think, bottle, which as far as the stopper was concerned, was sealed in the same way, as I remember, that is, with a rubber cloth over it, and sealed by means of the lead seal, and a wire. Then this bottle was put inside of a tin can which was just large enough to hold it, and packed in there with cotton. Then this tin can, after being fastened up, that is the top put on, was packed in a large tin pail with about one gallon capacity, and this pail was then filled with ice. It came to me with part ice and part water. Then this gallon tin pail was packed in excelsior in the second compartment of the box.

Q. Were all the packages you received during the periods mentioned in these tables packed in that way?

A. Yes.

8108 Q. I see on table No. 159, for instance, that you put on the left hand column, serial numbers, what do those indicate, 33 and so forth?

A. That was the number on the small tin tag which was sealed on each large bottle, that is, one tag was stuck on the wire before it was sealed, and that was the number stamped in the tin tag. Now that number corresponded to a number written on the paper tag, which also accompanied the sample. It served simply as a means of identification of the sample.

Q. Did you put those numbers on yourself, or did you take them from the cards that came from the water takers?

A. They were taken from the card that came from the water taker.

Q. I notice in the next column there, 1899 collections, are certain dates, showing I presume, the dates of collection. Where did you get those data?

A. Those were also taken from the card filled out by the water taker.

Q. Did you correctly enter the dates according to the dates found on the cards furnished by the water takers?

A. Yes sir.

Q. Now I call your attention to the second column—"examination", who entered those dates?

A. I did.

8109 Q. What do you mean to convey by the dates mentioned in that column?

A. Well, that was the date upon which each sample,—that is the date for instance, July 3rd, is the date upon which sample No. 31 was started in the laboratory, the analysis was started, or the date upon which the examination commenced.

Q. In the next column I see the word "Turb'y". That refers to turbidity?

A. Turbidity.

Q. Who made the entries in that column and in the next column from that, "color" and "odor," the next four columns. Who made those entries?

A. I made all four of them.

Q. Now are the explanations at the bottom of the column correctly stated, "H" standing for heavy?

A. Yes, they are all correctly stated.

Q. "V. H." very heavy and so on?

A. Yes sir.

Q. How did you determine these qualities, turbidity, sediment, color and odor?

A. The turbidity I simply gave a relative description of—well, I can hardly call it the opacity of the liquid, but it was the solid matter, or the suspended matter rather, which would 8110 not settle. It was either there as silt or very fine clay, or something like that, but it would not settle, at least for several days.

The sediment refers to the amount, (and under the sediments I gave the relative amount of matter) solid matter which would settle to the bottom of the water, and which was on the bottom of the bottle at the time I received it. All of those four entries were made on my notes immediately on the receipt of the sample. Two of them before the bottle had been opened, then the odor immediately on opening the bottle and the color, wherever there was any which was determined, was determined immediately.

Q. Those three ascertainments then were not made from any chemical analyses but from merely the physical appearance?

A. Those are all physical appearance. Yes, they are all physical appearance.

Q. What are we to understand by these various designations which you have entered in this table with regard to the character of the water?

8111 MR. JEFFRIES: That is objected to for the same reasons stated in our objection to the witness being examined with reference to the tables that have previously been read into the record by Dr. Gehrmann.

A. I hardly know what you mean.

Q. Read the question again.

(Question read).

A. You mean those four designations?

Q. Yes, these four designations?

A. Why, they don't mean anything particularly, except the first two columns, the relative amount of the undissolved matter and the odor might give a person an indication as to some of the impurities in the water. That is as to the source of some of the impurities. The color does not indicate anything in regard to a water, except possibly certain kinds of contamination, from vegetable matter.

Q. Muddy, for instance?

A. Well, mud, yes. You couldn't see any color to it, but there was a kind—there was a color to it, but at the same time it wasn't a yellow, it wasn't anything. The word "Muddy" expressed the appearance of the water, even after it was filtered, better than anything else.

Q. These various entries then are not accurate ascertain-
8112 ments of physical conditions, even, but merely the opinion that you entertained as to the appearance of the water when you looked at it?

A. With the exception of certain figures under the column in the first table, for instance there is one marked .4. That means then it is a slightly yellow color, and it corresponds to .4. The color is as intense as it would be in a similar column of water containing .4 of a cubic centimeter with a certain solution.

Q. What was that solution?

A. It was a solution which we used for determining the ammonia. It is a mixture of ammonia and double iodide of mercury and potash. Nessler's solution, as made with the Nessler—

Q. And whenever those numbers occur in the other tables, under the head of color the meaning is as you have indicated?

A. It is the determination of the amount of color which was compared with—that is it is a comparative statement of the amount of color, but it was an actual determination.

Q. Did that color have any particular significance in regard to this water?

A. I should say that it had. The color usually shows organic matter, of vegetable origin in the water, but I would not think that the color of the water had any material 8113 significance as to the classification of it from a sanitary standpoint.

Q. In the three columns following under the head of "residue on evaporation" will you please state how those results were obtained?

A. Each sample of water which I received was filtered in part, that is, part of the water was filtered so as to obtain this same sample of water freed from the undissolved matter. Now the residue on evaporation was determined in the unfiltered water and in the filtered water. I obtained this residue by evaporating in each case 100 cubic centimeters of the water to dryness, in a platinum evaporating dish, on a steam bath. After the water had been completely evaporated, the dish was taken from the steam bath and wiped,—that is the bottom of it was wiped to get rid of the water on the outside, and it was then heated for about half an hour at a temperature of about 160 to 170 degrees centigrade; then placed in a dessicator, and cooled and weighed. The increase in weight was the amount of solid matter or residue deposited by 170 cubic centimeters of the water, and from that amount the figure was calculated,—simply a matter of multiplication. The residue dissolved was determined in the same manner, only using the clear filtrate.

That is, it was the water which had had the solids not dis-
8114 solved removed, by simple substraction of the dissolved
residue from the total residue. We obtained in the third column the suspended residue, which gives exactly the amount of solid matter present in the water but not dissolved. That is like clay or sand, little pieces of grass, and one thing and another.

Q. State whether the figures entered in those respective columns correctly indicate the results of your analyses upon each branch of the subject?

A. Yes.

Q. In the next column I see the word "chlorine" heading. State how you ascertained the presence of chlorine in the samples that you examined?

A. In that particular sample, that is the sample from the Illinois and Michigan canal, at Bridgeport, 50 cubic centimeters of the water, or even less, were titrated in a small flask with a solution of silver nitrate, of a certain strength. There had been previously added to this water in the flask one cubic centimeter of a five per cent. solution of potassium chromate. This was added merely as an indicator, to show when the reaction between the chlorine and the silver nitrate was complete. Then this titration was made, as usually made in all cases in that test and this figure is the calculated result of that test.

8115 Q. Do the figures in that column indicate the results of
your analyses for the ascertainment of the presence of chlorine?

A. Yes.

Q. You stated that this water was taken from the Illinois and Michigan canal. Was a different method used in regard to waters taken elsewhere?

A. Where the amount of chlorine was known to be small, or was supposed to be small, a larger amount,—250 cubic centimeters of the water were evaported or concentrated to a bulk of 50 centimeters and then titrated, the idea being that whatever error there might be in this method, is an error which is greater where the amount of chlorine is small, so by concentrating the water and of course the amount of chlorine,—we reduce the amount of the proportion of error.

Q. State whether there are other approved methods of ascertaining chlorine than the one which you used?

A. Yes.

Q. Do you know which of these methods the one you used or other recognized methods, would produce a greater or less degree of chlorine?

A. Personally I think this method will yield a slightly higher amount of chlorine than the gravo-metric method or possibly the Volhard method.

8116 Q. In the next three columns under the head of "Oxygen Consumption" please state what method you adopted in making your analyses of the waters indicated for the purpose of obtaining these results?

A. According to the amount of organic matter in the water, varying amounts of the water under examination were taken, and in each case, the amount was diluted to 100 cubic centimeters. Now for instance, water very rich in organic matter, I might take as low as ten cubic centimeters of the well mixed water and dilute with distilled water to 100, if I didn't think it was heavy enough with organic matter to require that dilution I might take 25, 50 or 100, but if I took less than 100 cubic centimeters I diluted with distilled water, to a volume of 100 cubic centimeters. This definite volume of water was placed in a flat bottomed glass flask and to it we added five cubic centimeters of concentrated pure sulphuric acid, and 10 cubic centimeters of a standard permanganate of potash solution. Then this flask was placed in boiling water so that the level of the water outside of the flask was slightly higher than the level of the water inside the flask. This water on the outside was kept boiling for a period of 30 minutes exactly, if the permanganate of potash should happen to be completely reduced
8117 or nearly reduced in this flask, I would add more so as to keep an excess of permanganate of potash all the time in the glass. When the thirty minutes had expired, the flask was taken from the water and as soon as possible, as soon as I could handle it, the amount of undecomposed permanganate of potash in the flask was determined. From this we could calculate the amount of oxygen which had been consumed by this water in the thirty minutes cooking,—by the water and its contents. The

determinations were made in the unfiltered water, and in the filtered water, then by simple subtraction you found the amount of oxygen consumed by the suspended matter or the undissolved matter in the sample under consideration.

Q. Do the figures stated in those columns indicate correctly the result of your ascertainment?

A. Yes.

Q. Under those heads, first, total dissolved and suspended matter?

A. Yes.

Q. The four columns following, or under the heading, nitrogen as ammonia, please state what methods you pursued in order to ascertain these rules of free ammonia and albuminoid ammonia in the various conditions?

A. The method is the standard method,—in fact
8118 I think now it is the only standard method used for those
various determinations. It was Wanklyn's method, I think,—500 cubic centimeters of the water under examination were placed in an eight or nine hundred cubic centimeter glass flask and five cubic centimeters of the 20 per cent solution of carbonate of soda was added, which simply meant that there was one gramme of carbonate of soda added to the water in the flask. This flask was then connected by means of a glass trap—I don't know the name of it now,—it was simply a trap put in to prevent any of the liquid spattering over into the distilling tube, but it was connected through this glass trap with a block tin condenser. Then it was heated by a gas lamp and boiled at such a rate that 200 cubic centimeters of distillate were collected in one hour. Then this 200 cubic centimeters were mixed thoroughly and an aliquot part was taken for the determination of the free ammonia. The free ammonia was determined only on the original water, the unfiltered water. The albuminoid ammonia was determined in all these samples, after the free ammonia had been distilled. Immediately on completion of the free ammonia distillation the flask was disconnected and 50 cubic centimeters of alkaline permanganate solution were added, to the contents in
the flask and the flask was connected again and again
8119 boiled; boiled at such a rate that 200 cubic centi-
meters of distillate were collected in one hour. Then this

200 cubic centimeters of distillate was mixed and an aliquot part taken for the determination of ammonia. This ammonia, distilled after the addition of the permanganate solution, is known as albuminoid ammonia, and its determination was made on the unfiltered water and on the filtered water both. Then by subtracting the amount in the filtered water, or the amount under the column dissolved, from the amount in the unfiltered water, or the amount in the column "Total," we get the amount of albuminoid ammonia which came from the suspended matter, or the undissolved matter in that water.

Q. How did you ascertain the free ammonia?

A. The free ammonia was ascertained by distilling 200 cubic centimeters of water from 500, after the addition of one gramme of carbonate of soda, and then mixing the distillate and determining the ammonia in an aliquot part of this distillate.

Q. What does sub-column headed "Total nitrogen as albuminoid ammonia" refer to?

A. That is the amount of albuminoid ammonia which was yielded by unfiltered water. The water as it was received by me.

Q. Do the respective figures in those four columns indicate the correct results ascertained by your chemical analyses of the waters indicated?

8120 A. Yes, sir.

Q. The next three columns under the heading "Organic nitrogen" please state how you ascertained those results?

A. A certain amount of the water, 250 cubic centimeters was boiled in, I think, a 500 cubic centimeter Kjeldahl flask,—I am not sure as to the size. It is what we call a Kjeldahl flask, and it was boiled after the addition of one gram of carbonate of soda. This boiling was simply for the purpose of removing all free ammonia and after this had been removed, a certain amount, 25 or 20, I think 25 cubic centimeters of strictly pure sulphuric acid was added to the contents of the flask and then the boiling was continued until all the water had been driven off and until the contents of the flask had become either a very light straw color or clear white. Then after cooling, the flask was rinsed out with water; that is distilled water of course, ammonia free, and an excess of caustic soda added, so that the liquid was alkaline. Then from this alkaline liquid the ammonia was distilled

in the same manner as it was distilled for the water for the determination of free ammonia and albumnioid ammonia. That is, distilled from a glass flask, through one of these glass tubes I spoke of before, and through a block tin condensor, and
8121 from the mixed distillate the amount of ammonia was
determined. This ammonia came from the decomposition of the organic matter in the water under examination and therefore it is called organic nitrogen. It was determined on the unfiltered water and on the filtered water, and from the difference between these two, the figure under the column "suspended" was obtained.

Q. State whether the figures under the column of "total" represent the aggregate of the other two ascertained amounts?

A. Yes, sir, they do.

Q. In the two columns following, under the head of nitrogen as nitrites and nitrates, please state how you ascertained that results?

A. Nitrogen as nitrites was determined by what is known as the Griess method. In this method the clear water is treated with naphthalamine chlorides and sulphanilic acid, and I used hydro-chloric acid. This napthalamine and sulphanilic acid are in an acid solution. Some people use acetic acid and some use hydro-chloric, but I use the hydro-chloric acid. In the presence of nitrites, this re-agent produces gradually a pink color, and the intensity of this pink color is proportional to the amount of nitrogen as nitrites in the water, and the amount of it was determined by comparing the depth of this pink color, or the intensity, with the intensity of the pink color produced un-
8122 der similar conditions, that is, the temperature and time,
when a certain amount of a standard solution of nitrite was tested with this same re-agent. The nitrates were determined by boiling a certain volume of water—200 cubic centimeters I took, and I am not sure as to the amount, I think it was one gram of caustic potash. This boiling was for the purpose of removing all of the ammonia which existed as free ammonia in the water, and which also existed in the rather easily decomposable nitrogenous compounds. Now, after all this ammonia had been boiled off, I usually boiled it down to about one-fifth of the original volume and then I diluted that with cold distilled

water to the original bulk, 200 cubic centimeters, and placed in this water a piece of aluminum wire, pure aluminum wire. The action between the aluminum and the caustic potash which was in the solution still, produced hydrogen, which reduced the nitrites and nitrates to ammonia, and the amount of ammonia after standing until the next day was determined by the same method which I used for determining the ammonia as free ammonia; that is the Nessler determination. Now, from this amount of ammonia which I obtained from the reduction by aluminum, I had to subtract the amount of ammonia which would be produced by the reduction of the amount of nitrites present, then this remainder was the ammonia which was due to the reduction of the nitrate, and that was calculated back to nitrogen and reported as nitrogen.

8123 Q. Having examined the tables to which your attention is called, and which were read in evidence by Dr. Gehrmann, beginning with table 159 and ending with table 196, please state whether the serial numbers placed on each of these tables and the time of collection are correctly entered there from the cards found upon the samples that you received?

A. Yes, sir.

Q. Please state whether under the head of "Examination" the dates there entered correctly state the dates upon which the chemical analyses were begun, to which you referred?

A. Yes, sir.

Q. Now, you will please state whether all the tables to which your attention has been called, contain the correct results of the chemical analyses made by you on the dates indicated in these tables?

A. Yes, sir, they do.

Q. And state also whether the appearance of the water is correctly indicated in all the tables to which your attention has been called?

A. Yes, sir. Of course you understand under the head of "turbidity" and "sediment" that those are just simply comparative. It is no determination. It is just my judgment
8124 at that time, but the sediment as made there is the way I put them down at the time.

MR. JEFFRIES: I move to strike out all the testimony of this witness for the reason that it has no bearing upon the issues involved in this case, and the testimony that has reference to the taking of samples and the analyses of samples of water taken, prior to the chemical analyses of the water made prior to the opening of the drainage canal and that he has not testified to any analyses having been made by him of that water, subsequent to the opening of the drainage canal.

I move to strike out his testimony for the further reason that the defendants have shown that it is impossible to determine from chemical analyses the sanitary condition of the water for domestic and drinking purposes, and for the further reason that the defendants have shown that certain living organisms exist in the water so analyzed, the character and nature of which organisms they are unable to determine, and that from a chemical standpoint they are unable to determine whether they be disease producing organisms or non-disease producing organisms,
so that all of such testimony has no probative force in the
8125 determination of the issues involved in this case.

JUDGE SPRINGER: I move to strike out all of this objection as stated with reference to what the defendants have proven in this case, as merely a comment upon the evidence.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. You testified as to table 159?

A. Yes, sir.

Q. Your analyses contained on table 179 were made in the same manner as that of 159?

A. Yes, sir.

Q. And along at the same time?

A. Yes, sir, a few days difference, during different parts of the week, but that is all.

Q. How did you make the test for the sediment?

A. Why, it was no test, it was just simply the relative amounts that I judged present. That notation was always made before the sample was stirred up and I judged the relative amount, whether there was a very small amount or a medium amount or a very large amount, whatever it might be, of matter which had already settled to the bottom.

Q. Does it appear on the bottom of the table?

A. Yes.

8126 Q. By ocular observation?

A. That was all.

Q. Now, if that sediment had been of the same color of the water, would you have been able to detect it?

A. Yes, you could see whether there was any sediment on the bottom of the bottle or not.

Q. If the sediment had been as transparent as the water would you have been able to detect it?

A. No, I would not.

Q. If there had been living organisms existing in the water, swimming around in the water, capable of motility, were motile, would you have been able to detect them with the naked eye?

A. No, sir.

Q. Now, to determine the turbidity of the water you disturbed the sand at the bottom, didn't you?

A. No, I judged the turbidity. I would rather use the word "judged" than determined, because it was simply an estimation; that was all; it was my judgment.

Q. And that estimation might be of a different result as made and determined by different persons?

A. Oh, yes, but as I was going to say, this judging of the turbidity was done before the sample had been stirred up. It was the relative amount of suspended matter, undissolved
8127 matter which had not settled to the bottom during the shipment.

Q. Now, if there had been deposited in one of these bottles a number of disease producing organisms or germs, and in another bottle of the same character of water, no germs had been deposited, would those germs have any effect on the turbidity of the water?

A. I don't think they would.

Q. In other words, it might have been a living mass of germs?

A. Yes, sir.

Q. And yet have no effect so far as the turbidity is concerned?

A. I don't think it would have made any perceptible difference.

Q. So that the question of turbidity does not determine the presence or absence of living organisms that produce or do not produce disease?

A. Not in itself, no, sir.

Q. Does it in any way add to the determination of whether or not there are such germs or organisms present?

A. No, it has nothing to do with the question of presence or absence of micro-organisms.

Q. Couldn't the water be very turbid indeed and yet not 8128 contain a single germ that would produce disease of any character?

A. It might be produced that way, yes, sir.

Q. And upon the other hand, as you stated before, it might contain many such germs, and yet not have any effect upon the turbidity of the water?

A. Yes, it might.

Q. So then the turbidity of the water would not be considered of any value, would it, in the determination alone; that is the turbidity alone would be of no value in determining the presence or absence of organisms?

A. Not the turbidity alone.

Q. Now, then, of what value would it be in determining the condition of the water in connection with any other chemical constituent, or analysis or operations through which a water is put to determine its sanitary condition?

A. Well, it will have an effect when you consider the entire result; that is the result of all the tests which are made.

Q. I will ask you if it is not a fact that samples of water may contain large quantities of the various chemical substances that we find in it, which would be considered by chemists as rendering water unpotable or unfit for sanitary use, objectionable to the chemist in the laboratory, and at the same time, 8129 that the sample of water would not contain a single disease producing organisms?

A. Yes, we might find that kind of water.

Q. And at the same time you might find a very small quantity of each and all of the various constituents, chemical elements in the water, and yet it would be a living mass of disease producing organisms?

A. I don't know that I would want to state that.

Q. If it was a living mass of disease producing organisms, could you detect it in your chemical analyses?

A. It would not be a living mass of organisms of any kind unless there was at least a certain amount of organic matter for them to live upon and you could detect that.

Q. But the organic matter may be present with the disease producing germs absent, may it not?

A. Yes, sir.

Q. Do you reason that the disease producing germs could not be present unless the organic matter was there?

A. Unless the organic matter was there. They could be present but would not live.

Q. So, then, the idea is, the more organic matter, of whatsoever character contained in any water, the more dangerous it is for domestic purposes, is that it?

8130 A. The more apt we are to mark it suspicious, or call it unpotable water.

JUDGE SPRINGER: I move to strike out of the record all questions put to this witness and all answers made by him in reference to the presence or absence of bacteria or pathogenic germs in water, this witness not having qualified as a bacteriologist. I haven't asked the witness a question in bacteriology.

MR. JEFFRIES: I have referred in my examination thus far, of the witness, to living organisms contained in the water, whether they be bacterial germs or organisms of some other character.

JUDGE SPRINGER: Chemistry has nothing to do with living organisms.

MR. JEFFRIES: I accept the admission of counsel that chemistry has nothing to do with living organisms and knows nothing about it.

Q. Now, then, going back to this living mass of organisms, or mass of living organisms, let us dilute those organisms and say it contains a large number of living organisms of disease-producing character, would it necessarily show in the turbidity of the water?

A. No, not necessarily.

8131 Q. Now, would they be shown by any other portion of your chemical analysis of that water?

A. No, there is nothing in the chemical analysis that would show that.

Q. Now, under the head of Residue on Evaporation in table 171 I find you have a column of totals, what does that mean?

A. Those figures give the number of parts of solid matter contained in 1,000,000 parts of the water under examination in each case.

Q. Then there is dissolved parts, what does that mean?

A. That is the number of parts of solid matter, of dry matter contained in one million parts of filtered water, so that, take for instance, the first one, 306, and 313, comparing the two, the water as it was received by me contained 313 parts per million of dry matter, or solid residue, but the clear water contained only 306. That is of the 313 parts, 306 were dissolved in the water, while seven were not dissolved.

Q. Now, was it dissolved in water as the water then existed, or did you dissolve it?

A. I simply took the water as it came; I didn't do anything with it, except to filter it.

Q. The seven parts were suspended matter?

A. Yes, sir.

8132 Q. What was the character of that suspended matter and what may the character of suspended matter in water be?

A. As a matter of fact I made no examination of that suspended matter to tell what it was.

Q. It might be germs of anthrax spores?

A. Well, I am inclined to think that anything as small as that would go through the filter paper, possibly it would not, but part of it would.

Q. Then you do not know whether you took all the solids in suspension out or not, do you?

A. Well, I do not think I did take all bacteria out.

Q. Where did it go to if you did not take all of it out in suspension?

A. It went through the filter paper.

Q. The solids in suspension, so-called?

A. Yes, the solids in suspension.

Q. But if they were living organisms of sufficient minuteness to pass through the filter paper, then you did not get it in the suspended matter, did you?

A. No, sir.

Q. And if they were of sufficient size to be kept in the filter, you did get them in the solids in suspension?

A. In the suspended solids, yes.

8133 Q. Now, then, what treatment did you put that total suspended matter through after that?

A. I didn't do anything with it.

Q. You don't know what its character was?

A. No.

Q. It might have been spores of disease producing character, and it might not?

A. Yes, sir.

Q. Is it not a fact that you find that the total solids in suspension of the water examined at Grafton in 1899, was from five to six times as much during December to what it was during the month of July that year, November and December?

A. In November the amount was very much higher than it was in July, five or six times.

Q. I will ask you if the sample examined on the 7th day of July and the 13th day of July was not seven parts per million of suspended matter?

A. Yes, sir.

Q. And that the sample examined on the 20th of July was 16 parts per million?

A. Yes, sir.

8134 Q. And the sample examined on the 27th of July was 18 parts per million?

A. Yes, sir.

Q. Now, I will ask you if the sample examined on the 3rd day of November was not 94 parts per million?

A. Yes, sir.

Q. And the sample examined on the 10th day of November, 27 parts per million?

A. Yes, sir.

Q. And the sample on the 16th of November, 48 parts per million?

A. Yes, sir.

Q. And the sample on the 23rd of November, 85 parts per million?

A. Yes, sir.

Q. So that there was a greater amount of suspended matter during the month of November than there was during the month of July?

A. Yes, sir.

Adjourned until 2:00 p. m., same day.

8135 2:00 p. m., Monday, October 12th, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

D. B. BISBEE,

resumed the stand for further cross-examination by Mr. Jeffries, and testified as follows:

Q. What did you say you meant by the residue on evaporation?

A. The amount of dried matter left by the evaporation of the water under consideration, expressed in parts per million.

Q. Both as to the dissolved matter and the suspended matter?

A. Yes, as to the dissolved solids and the suspended solids.

Q. Now, how did you obtain those determinations?

A. A definite volume of the water was evaporated to dryness in a weighed platinum dish, placed on a steam bath so that the heating agent was live steam, and after the water had been entirely evaporated from the contents of the dish, apparently so, at least, the dish was placed in an air bath and heated for about half an hour at a temperature from 160 to 170 centi-
8136 grade. Then the dish was cooled in a dessicator and weighed and the increase in weight is the amount of residue referred to.

Q. Now, that is the way you have changed it,—the dissolved?

A. Well, the dissolved, yes, and the total increase. You understand the figure for total is the figure.

Q. Well, the total is the dissolved and suspended added?

A. Yes, but I obtained the suspended by subtracting the dissolved from the total. The suspended is not a direct determination.

Q. Well, now, is that an accurate determination?

A. Yes, sir. Just as accurate as any work that I can do.

Q. If the water should be permitted to stand in the sun until evaporation had taken place, would you have the same results?

A. Yes, if the sample, if the dish after having been dried in the sun was exposed to that heat of 160 or 170 degrees. I would not want to say that I would have the same results without that. Of course it is pre-supposed that dirt or stuff from the air will not flow in in either case.

Q. Now, did you ever examine the contents of these samples by a microscope ?

A. No, sir, I made no such examination.

Q. Never discovered any living organisms in them?

8137 A. Not at all.

Q. You know they were there, though, don't you?

A. From what I was told. I didn't know it from any personal knowledge.

Q. What system did you say you used in obtaining the chlorine test?

A. I don't remember the name of it. I titrated a certain volume of the water with silver nitrate, using chromate of potash as the indicator, to show that the re-action was complete.

Q. Now, you spoke of one plan being more accurate than another. You mean by that that a certain part of the chlorine would escape from the tests?

A. No.

Q. In other words, you said that one system would produce a larger quantity of chlorine than another?

A. Slightly higher, I said.

Q. One method, then, will produce a slightly higher amount than another?

A. Yes, I think so.

Q. Now, will any system exactly obtain and accurately obtain the exact amount of chlorine in any sample of water?

A. Yes, sir, I think so. I think the Gravo-metric method

8138 will give the closest results, and give results which are within the limits of errors, as we say.

Q. You have got to figure on some errors, have you not?

A. There is a certain amount of error that is alowed in all technical work.

Q. Where did you say you got these samples of water that you used?

A. They were delivered to me by the various express companies.

Q. Were they shipped to you?

A. Shipped to the city laboratory. That was the way they were addressed.

Q. The health department?

A. Yes, sir.

Q. How soon after you received them before the examinations were made?

A. Well, the examination for nitrites was started at once, just as soon as I could get at it, and the notations as to turbidity, sediment, color and odor were made on the spot at once. The other tests were usually started within a few hours—the free ammonia was started within a few hours of the time they were received.

Q. Would the exposure to the light and the hot, warm temperature of the room for any length of time have any 8139 effect upon the results so far as the dissolved and suspended solids were concerned?

A. I don't think they would. That is of course, you understand if exposed a day or two. I would not want to make that statement with regard to any indefinite time.

Q. You don't know whether some chemical changes would be going on in that bottle, that would be in the river?

A. No, I would not want to say that it would be the same.

Q. Your idea is, however, that there would not be much change in a day or two?

A. Very little in the amount of the solids.

Q. Then there would be very little change in the water of the river from day to day, would there not?

A. The change in that particular,—the change would be very slight in water,—the exact duplicate of that; that is the water flowing down would not change very much.

Q. The chemical constituents of the water then would remain practically the same from day to day?

A. Aside from sedimentation, and with slow processes of oxidation.

Q. You are of opinion that a day or so in the samples exposed to the various temperatures,—changing temperatures, would have but slight effect upon the water?

8140 A. On the solids. Are you referring to the solids now?

Q. The solids.

A. Referring to the solids, the difference of a day or two in the time of determining them would make very little difference.

Q. Well, now, what effect would it have on any of the chemical constituents? Is there any chemical constituent that you have obtained from these analyses that would be affected?

A. Why, yes.

Q. By the sample remaining in the bottle for a day or so, exposed to a warmer temperature or a colder temperature, as the case may be?

A. The ammonias and the nitrates and nitrites in a natural water are generally in a state of change all the time, so that even a day's difference in time of analysis of two exactly similar samples might show a decided difference in those elements.

Q. In other words, there might be more nitrites by reason of the water standing?

A. There might be more and might be less. I don't know just which.

Q. Then if these nitrites are to be considered in any way as affecting the sanitary condition of the water, you must consider the time that it has stood in the bottle before it has been analyzed, must you not, or do you know?

8141 A. I would rather answer that in a different way. I would rather say this, that if I was going to use the determination of nitrites as any basis at all for the determination of the sanitary condition of the water, I would want to make the nitrites immediately on the samples being taken.

Q. Then it would not be a safe proposition to use the nitrites as any element of the sanitary condition of the water in the river when they had been obtained from the examination after it had remained in the bottle for a day or so?

A. Well, I would consider them—

Q. Well, now, isn't it a fact?

A. Oh, I could not place as much credence in my opinion as if I had made that test right on the spot, at the time the sample was taken.

Q. Isn't it a fact that the chemical analyses, where samples are taken and shipped with a varying temperature, do not disclose the actual chemical conditions of the water in the river at the place the samples were taken and at the time the samples were taken?

A. I don't think there would be very much difference in anything except the nitrites and nitrates and the free ammonia.

Q. Then we come down to the proposition that the water is
practically in the same condition from day to day, if we
8142 don't consider the nitrites or nitrates to any great extent,
upon the sanitary condition of the water, and they are the
only things that do change, then the water is naturally about
in the same condition from day to day, is it not?

JUDGE SPRINGER: He didn't state that. He stated a day or two,—not continuously.

Q. MR. JEFFRIES: Well, for a day or two, then there was practically no change in the water?

A. Well, I said a very slight change, except from sedimentation and from a very slow oxidation.

Q. Did you take any of these samples yourself?

A. No, sir.

Q. You don't know how long they had been on the road?

A. Only from the marks made on the collectors' tag. That is the only means I have of knowing anything about that.

JUDGE SPRINGER: What time of the day would they be received?

A. At all times. I have had them come in after five o'clock at night.

MR. JEFFRIES: Were there any times when there was some delay in the shipment of the sample or in the analysis, after it had been received in the laboratory of the city health department?

A. Yes, there was an occasional time when they were,—
when the analysis was started, say the second day after
8143 they were taken. Sometimes it would result from their
not being delivered promptly; sometimes the train late,
something like that.

Q. And examined as much as the third day after they were delivered?

A. I don't remember that.

Q. Take sample 553, on table 179—sample collected August 21, and analysis was made August 24th?

A. Yes, there was a big delay.

Q. Would you think that there was any considerable change in the condition of the water while it remained in the bottle those three days?

A. Yes, I should think that the nitrites might be materially different from what they were when taken, and that the free ammonia might be a little bit different, but not as much. Of course you will understand there will be a great deal slower changes in the bottle than there would be in the open air, because there would be no gases escaping or nothing of that kind in the bottle. Whatever was in the bottle would stay there.

Q. The septic operation would be better then wouldn't it?

A. Well, I don't know as I would want to say that. The
bottles were never completely full. There was always a
8144 little bit of air in the top of the bottle.

Q. Wouldn't the temperature have a great deal to do with it?

A. With the rapidity of bacterial action, yes, the formation of the nitrites.

Q. Doesn't that condition cause chemically change?

A. In the formation of nitrites, yes—the conversion of nitrogen compound into nitrites and nitrates.

Q. Then to that extent these samples did not correctly portray the actual chemical condition of the water at the time these were taken?

A. At the time the samples were taken, yes—these as I said would be true to whatever extent there might have been a change in the amount of nitrates or nitrites, or free ammonia. Otherwise I think the analysis would show their condition, or should show their condition.

Q. Where did the free ammonia come from if not from the albuminoid ammonia?

A. Well it would possibly come from the destruction of albuminoid ammonia.

Q. Well then, it would affect the free ammonia to some extent wouldn't it, or the albuminoid ammonia, I mean?

A. Well, I don't think the albuminoid ammonia would be affected very much by a day or two.

8145 Q. Well, would the free ammonia be affected?

A. It might be affected to a slight extent.

Q. Well, then, free ammonia is affected and albuminoid ammonia is not affected, and free ammonia comes from albuminoid ammonia. How do you reconcile those statements?

A. The free ammonia would be the one that would change. That is, for instance, if the ammonias are oxidized.

Q. They would change into albuminoid ammonia?

A. Into nitrites.

Q. Go into nitrates and nitrites?

A. No, because they would result in increased nitrates for instance, and decreased free ammonia.

Q. Are those nitrates included in the free ammonia?

A. No.

Q. In the albuminoid ammonia?

A. No, in neither one.

Q. They form no part of it?

A. They are not included at all in that.

Q. How did you obtain the exact amount of free ammonia and albuminoid ammonia in the sample of water and at the same time obtain nitrites and the nitrates in that sample of water?

A. The nitrates and nitrites were done by an entirely different method on a different specimen of water. That is,
8146 a different part of that same sample.

Q. And that might cause a variation, might it not, by not being able to obtain the exact nitrates that are in the particular sample of water that you examined for the purpose of ascertaining the amount of ammonia?

A. There would be no difference there because the samples were all mixed every time before any determination was made, so that they would be parallel.

Q. Then they run parallel, do they?

A. That is you have the same samples right straight through from the time they started.

Q. Well, unless the total solids were properly diffused in the water they would not run parallel, would they?

A. Oh no, certainly not. Not necessarily.

RE-DIRECT-EXAMINATION, by Mr. Springer.

Q. If the time of the delay between the taking of the sample and the analysis affected the results, that effect would be shown would it not by comparing the ascertainments of the sample of that day with the previous or succeeding day, when the delay was less?

MR. JEFFRIES: I suggest now, under the testimony of
8147 this witness himself there could be no comparison drawn
between the samples of the various days, or the analyses that were made on the various days, because they were taken at least a week apart and although they may have been taken at the same exact spot in the river, the conditions in that river were changed so that the same chemical constituents were not found in one sample that were found in all the other samples, so that not any two samples are comparable.

Q. (Question repeated).

A. No, I would not want to say that at all, because I understood you to mean comparing the results obtained, for instance today with the results of the sample taken yesterday or the sample taken tomorrow.

Q. Yes.

A. Well, unless we could know that these two or three different samples taken on different days would have the identical composition,—we could not make any comparison between them.

Q. You could not compare them?

A. No. What I meant to say was, you would have to have the assurance that these samples taken the different days or at different times, were exactly the same.

MR. JEFFRIES: Chemical constituents?

A. Chemical constituents present in them. If they had
8148 exactly the same, why then you could compare the figures,
but unless you know them you cannot compare them.

JUDGE SPRINGER: You could only make comparison then by holding the same sample over?

A. Yes, holding it over another day and then make a comparison.

Q. Those samples show some difference I suppose?

A. Yes, they will show some difference in the water.

D. B. BISBEE.

8149 **ARTHUR W. PALMER,**

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Springer and testified as follows:—

Q. You may state your name, residence and occupation?

A. Arthur W. Palmer, Champaign, Illinois; Professor of chemistry in the University of Illinois.

Q. How long have you held that position?

A. Fourteen years.

Q. Where were you educated?

A. In the public schools of Illinois; at the University of Illinois, at Harvard; at Berlin and Goettingen in Germany.

Q. What course did you take in the University of Illinois?

A. I took the course in chemistry.

Q. How long?

A. Four years. From 1879 to 1883.

Q. What at Harvard?

A. Two years in chemistry, from 1884 to 1886.

Q. And what courses in Germany at the colleges?

A. Chemistry still, at Berlin and Goettingen, in 1888 and 1889.

8150 Q. Have you made any further study at schools with reference to chemistry?

A. Well, I have been instructor in chemistry for—

Q. I had reference to being as a student only?

A. No, not as a student, except that we are always students.

Q. Now state what experience you have had as an instructor in chemistry?

A. As an assistant for a year in 1883 and 1884, as an instructor in the years 1886, 1887 and 1888, that is two years and during the last fourteen years as Professor of chemistry in the State University.

Q. What are your duties in the University as Professor of chemistry?

A. To teach chemistry.

Q. Do you teach practical analyses of water?

A. I do.

Q. You haven't made a specialty of bacteriology I believe?

A. I have not.

Q. Has the subject of chemical analysis and analyses of water been considered practically and to any considerable extent in your course of instructions?

A. It has.

Q. Have you personally engaged in making chemical analyses.

8151 A. I have.

Q. During how many years?

A. About 22 years as a student and as investigator.

Q. What degrees have you taken if any, in colleges?

A. I took the degree of Batchelor of Science in Chemistry at the University of Illinois in 1883; the degree of Doctor of Science in Chemistry at Harvard in 1886.

Q. Any other?

A. That is all.

Q. State whether you had any conferences with Professor Jordan of the University of Chicago at any time in reference to making certain examinations and analyses of the waters of the Illinois and Michigan canal, and the Sanitary canal, the Desplaines and Illinois and other rivers?

A. I did.

Q. When were those conferences held?

A. At various times beginning in March, 1899, if I remember the month right (after referring to book). Yes, in March.

Q. State what agreement you and Professor Jordan reached in regard to making chemical analyses and bacteriological examinations of the waters to which I have referred?

8152 A. Well, the conference in March, 1899, included a number of other individuals besides Professor Jordan and myself and at that conference it was decided that samples of water should be taken at various points along the Illinois river, the Mississippi river, the Missouri river at one point, and from the Illinois and Michigan canal. Also from some of the tributary streams of the Illinois; and that samples should be taken from each point selected, once a week, and that the number of samples taken at each point simultaneously should be sufficient to send one set of said samples to Professor Jordan at the University of Chicago; one set to Dr. Gehrmann, at the municipal laboratory, Chicago, and one sent to me at the University of Illinois.

MR. JEFFRIES: I object to the witness stating anything about conferences being held and I object to any questions upon that proposition as incompetent, irrelevant and immaterial. The witness should be confined to what was done and not with reference to what was agreed upon.

JUDGE SPRINGER: The things that were done will be shown hereafter. The conferences to which reference has been made have been referred to for the purpose of showing that a concerted effort was made to make on three parallel lines certain investigations, and that this is one of the lines which
8153 was pursued?

Q. State who selected the persons who were to take the samples of water and the places at which they were to be taken?

A. Professor Jordan and I jointly selected the points and selected the persons who were to make the collections of the samples.

Q. State how you made these selections of persons and places.

A. We went to different points along the different streams mentioned just before—visited them, noted local conditions, pointed out the spot where a sample which should be most representative of the conditions in the river in that vicinity could be obtained. We selected men to make the collections by reason of their availability and their apparent fitness for doing the work.

Q. What instructions orally, if any, did you give to them and directions as to taking samples?

A. We showed them the spot at which the sample was to be taken and tried to impress upon them the fact of the importance of always getting the sample at that same spot. We showed them how to collect the sample by demonstrating, by collecting samples ourselves in their presence, showing them how to do the work.

8154 Q. Did you cause any blanks or certificates to be furnished to these collectors?

A. We did.

Q. What were those certificates to contain?

A. They were to contain the dates, name of the place where the collection was made, and such matters as temperature of the water, temperature of the air, height of water in the river, the direction of the prevailing winds, the rainfall and so on, passage of vessels, and other things. They are given here; I am not sure that I remember all these points, but they are stated here in the copy that is printed in our report.

Q. Was there anything printed on the back of these certificates?

A. There was.

Q. What was it?

A. Directions as to the collecting, the packing and the shipping of the samples.

One of the certificates known as defendants' Exhibit No. 11 for identification, used for this purpose having been shown to the witness, he identified it as being the blank furnished.

8155 THE WITNESS: I identify that as one of the certificates so prepared and used.

Q. And the instructions on the back?

A. I do. These are instructions that we prepared and placed upon the certificates for the guidance of the collector.

Q. I wish you would state please the points at which these samples were to be taken and your reasons for selecting those points?

A. The first point was at Bridgeport, a short distance below the pumping station, which conveys water or sewage from the south fork of the south branch of the Chicago river into the old or Illinois and Michigan canal. The reason for taking the sample at this point was to show the condition of the discharges which at that time and for many years before, had been pumped into the old canal and sent thence into the Desplaines river at Lockport and Joliet and so on down into the Illinois river.

Q. And after the drainage canal was opened, what other points in this vicinity were selected?

A. After the opening of the drainage canal samples of water were taken every week at Bridgeport, the Kedzie Avenue crossing, for the purpose of showing the condition of the more dilute discharges which from that time on were sent down
8156 into the Desplaines and thence into the Illinois through this new channel.

Q. State who was selected at that point to take the samples?

A. Mr. Joseph Weis took samples at this point.

Q. What was the next place selected?

A. The next point was Lockport. Here a sample was taken from the Illinois and Michigan canal for the purpose of showing what if any changes had taken place during the flow from Bridgeport, about 29 miles away, and particularly for the purpose of showing the character of the sewage and water discharged from this channel into the Desplaines river, this being the point of discharge into the natural valley of the Desplaines.

Q. Now in the next period, in 1900, did you take any other samples at Lockport from the drainage canal?

A. Well we did throughout, both in 1899 and 1900, take samples at Lockport and also from the Desplaines river. At first the samples taken in the Desplaines river showed the natural, or unnatural as it may be,—condition of that stream just above—just above the point at which the Chicago sewage was discharged. After the opening of the sanitary canal, the conditions were greatly changed just at the point where the collections in the Desplaines river had been made, and after that
8157 time inasmuch as the natural discharge of the Desplaines river above this point was small, as compared with the combined discharges of the Illinois and Michigan canal, and the new Sanitary canal, the collection of samples from this somewhat comparatively insignificant tributary, was discontinued.

Q. Who was your collector at these three places?

A. The collector at these three places was Mr. O'Brien.

Q. An expressman?

A. Yes, he has been a stationary engineer I believe there, but was an express agent at the time he was doing most of this work.

Q. Now what other place in the Desplaines river did you select and for what reason?

A. The point at Joliet just above the town, a point in the basin, where the Illinois and Michigan canal crosses the Desplaines river, as it from that point on passes down along the west bank or just at this point, what is the north bank of the Desplaines river. The reason for making the collection at this point was to determine the condition of the combined mixture of Chicago sewage discharged at first through the Illinois and Michigan canal, and subsequently through it and the new drainage canal. The mixture of the liquids from these two
8158 sources with the water from the upper Desplaines.

Q. Before the opening of the canal where was this old canal water received at this point?

A. The old canal discharged in part at Lockport, and in part where the canal joins and crosses the river at Joliet, four miles below, but the entire discharge of Chicago sewage is effected by the time we reach this point. A large part of it takes place at Lockport nearly four miles above, but the final emptying of the canal occurs at this point, Joliet, so that this is the first point where we get the complete effect of the discharge of Chicago sewage into the Desplaines valley.

Q. That is, by the Illinois and Michigan canal, you mean?

A. By the Illinois and Michigan canal, yes and since the opening of the drainage channel the entire effect of its discharge also.

Q. What was the average flow of the Illinois and Michigan canal at this place?

A. The average flow for many years preceding 1900 was from 35,000 to 36,000 cubic feet per minute. This being the amount pumped into the canal at Bridgeport. The flow at times at Lockport would exceed this amount because of the discharge of various ditches along the line of the canal and the surface wash, and sometimes too, from the overflow of the Desplaines river into the canal, but the quantity pumped from the

8159 Chicago River into the canal is indicated by the figure I have given, 35,000 to 36,000 cubic feet per minute. Since the opening of the sanitary canal, the pumping into the old canal has been greatly reduced in volume and in time. In 1900 the pumping was continuous throughout the year, but the quantity pumped was much less, averaging 26,700 cubic feet per minute during the year. In 1901 pumping occurred only during the navigation season, which lasted practically from the beginning of May to the end of November, or until well in November. It continued seven months only. During this time an average of 23,000 cubic feet per minute was raised by the pumps at Bridgeport. The average, if calculated for the entire year being about 13,800 cubic feet per minute, but it is to be noted that the pumping continued only seven months, and that at the rate given above, namely 23,000 cubic feet—

Q. Was the rate during the time that the pumps were actually in operation?

A. That the pumps were actually in operation.

Q. Did you select any other place on the Desplaines river for taking samples, and if so, for what reason?

A. Samples were also taken at a point just below Joliet. The purpose was to note what effect was caused by the discharge of the sewage of Joliet into the Desplaines river,
8160 but as it proved that in the dry summer season there was no flow in the Desplaines river below Joliet, the entire flow at that time being carried by the canal and distributed along into the river at various points along the 66 miles of its course between Joliet and its terminus at LaSalle or Peru, the collection of samples in the stream, or bed, rather, in the bed of the Desplaines below Joliet was discontinued and for a time the collections were made in the canal just below Joliet.

Q. Who made these collections at Joliet?

A. At Joliet the collections were made by Mr. Raymond Hurd.

Q. What place did you select in the Kankakee river, if any, and for what reason?

A. The point upon the Kankakee river that was selected for collection of samples was Wilmington, a point near to the mouth of the river and where it was believed the samples would show the general character of the water of the Kankakee river, as it was about to be discharged into the upper end of the Illinois,—that is, to mix with the discharge of the Desplaines river and by confluence with the latter, to form the Illinois river.

Q. The confluence of the Kankakee and the Desplaines rivers forms what is known as the Illinois river?

A. Yes sir.

8161 Q. Which is the larger stream of the two forming the Illinois?

A. Ordinarily the Kankakee river is the larger. It is much more uniform in flow, though at times the upper Desplaines may discharge as much water for short periods as the Kankakee does. Take it the year through, the discharge of the latter far exceeds the discharge of the Desplaines.

Q. How far did you say above the mouth of the Kankakee was it that you had the samples taken?

A. Why, it is about fifteen miles. I cannot say exactly, the twists and turns of the river.

Q. Was it below or above Wilmington?

A. The sample?

Q. Yes?

A. Right at Wilmington.

Q. Above the town or below the town?

A. Why the samples were taken near the dam there, which I believe is right in the town. I cannot state positively. This place Wilmington is the one point that I did not personally visit. Professor Jordan visited Wilmington and selected the spot there, and he can give you more specific information as to the precise point, but by correspondence I understood that the sample was taken right close to the dam.

Q. Has that town a sewerage system if you know?

8162 A. I think not.

Q. Who made the collections there?

A. The express agent made the collections at Wilmington, Mr. R. P. Elliott.

Q. What was the next point which you established for the taking of samples?

MR. JEFFRIES: We move to strike out all the testimony of this witness with reference to the analyses of samples of water taken from the tributaries of the Illinois river, and object to the witness testifying further in reference to samples taken and examined from the tributaries of that river for the reasons heretofore stated at the time previous witnesses were examined in reference thereto.

Q. JUDGE SPRINGER: Proceed now with regard to Morris.

A. The next point was upon the Illinois river, the town of Morris, situated between nine and ten miles below the junction of the Kankakee and the Desplaines, a point at which the dilution of the Chicago sewage and the Desplaines river water with the Kankakee river water may to some extent be determined. At this point in the very dry season the flow before the opening of the drainage channel, might at times consist mainly of the sewage discharged from Chicago, but there was always 8163 slight dilution at this point, because the Kankãkee river never went entirely dry, as do some of the other streams of the state. In fact the Kankakee might be regarded as really the upper section of the Illinois, because it is the only feeder with the exception of Chicago, that never goes entirely dry.

Q. Who made the collections at this place?

A. Mr. J. W. Miller collected at this point.

Q. Where was the next point selected and for what reason?

A. The next point was the Fox river at Ottawa. The Fox river next to the Kankakee ordinarily serves as the chief supply of the waters of the upper Illinois. The sample was taken at a short distance above the aqueduct which carries the Illinois and Michigan canal across the Fox river, and the purpose was to note the character of the water of this tributary with a view to studying its effect upon the waters flowing in the Illinois river channel.

Q. Did you ascertain the area drained by the Fox river?

A. Yes, it is stated here, 2,697 square miles.

Q. How does that compare with the area drained by the Kankakee river?

A. It is about half of it. The latter is something over 5,000 square miles.

8164 Q. What sewage, if any, is received by the Fox river?

A. It receives the sewage of a number of manufacturing towns all along its course, among which, Elgin and Aurora are the largest. It included also the discharge of a large amount of nitrogenous organic matters at Geneva, where there is a large glucose works.

Q. How far is Geneva above the mouth of the Fox river?

A. If I remember rightly, it is about 45 miles above the mouth of the Fox river. I cannot be positive, but we can look it up and easily correct it. Somewhere in the neighborhood of 45 miles, possibly a little more.

Q. What was the next place selected, and what was the reason for making the selection there?

A. The next point?

Q. Yes?

A. The Illinois river at Ottawa. The purpose was to determine the condition of the water at this point just before the Fox river water enters, and to note what change if any, took place during the flow of the mixture of the Illinois river from Morris to Ottawa.

Q. How far was that?

8165 A. This is 33 miles below the junction of the two streams, and about 23 miles below Morris, the town at which the last sample from the Illinois river was taken. That is, the one last mentioned.

Q. Whom did you select to make these collections?

A. Mr. Lester Horan made the collections at Ottawa, both from the Fox river and from the Illinois river.

Q. What was the next place selected?

A. The next place was LaSalle, and at LaSalle, several samples were taken, one from the Big Vermillion river, which is a somewhat considerable tributary entering from the left bank as you go towards the mouth.

Q. How large an area does that drain?

A. About 1400 square miles. But it is extremely variable in the volumes of water discharged, like nearly all other Illinois rivers in that respect. In the freshet season it carries a comparatively great volume of water. In the dry season it may go almost entirely dry.

Q. What important towns in Illinois are situated on the banks of this river above its mouth?

A. The towns of Streator, and Pontiac, are the most important on this stream. Their sewage is emptied into the river;
they get their water supply from the river and in dry
8166 weather they pump all the water out of the river and
after passing it through themselves and their households,
they send it back into the river.

Q. Where was the other point that you selected?

A. Then the Illinois river at LaSalle. Sample taken at the wagon bridge, which is about three miles below the mouth of the Big Vermillion river. I should have stated that the sample collected from the Big Vermillion river was taken at a point about half a mile within its mouth. The sample from the Illinois river at LaSalle taken beside the wagon bridge, three miles below the mouth of the Big Vermillion. The purpose was to determine the condition of the water in the Illinois river at this point, and to note particularly too, what changes, if any, took place during the flow from Ottawa to LaSalle.

Q. How far was that—what was that distance between those two towns?

A. Well, that is about 25 miles. I have got it here in the table somewhere. I cannot always keep these in my mind. Fifteen miles from Ottawa to LaSalle. I came near giving that wrong. Then another sample was taken from the Illinois and Michigan canal at LaSalle. The water in the Illinois and Michigan canal is diluted at various points between Joliet and La-
Salle, by the introduction of water from various sources.
8167 On the other hand, at different points along this stretch
it discharges into the Illinois, and then, too, it is itself
polluted by discharges of sewage from various towns, into the canal. The analysis made at LaSalle was for the purpose of showing the condition of the water in the old canal just as it was about to discharge finally at the lower end of the canal into the Illinois river.

Q. Do you know the length of that canal from Bridgeport to this point?

A. The canal is about 100 miles long,—99 and some large fraction.

Q. And this is practically the mouth of the canal is it, this place?

A. Yes, at LaSalle or rather Peru,—the two towns are contigous,—the canal just passes LaSalle. They always speak of it as ending at LaSalle, but the real end where the canal rejoins the river, or first joins the Illinois river is at Peru, about three miles below LaSalle. The last locks are at LaSalle, but there is a continuation down the river to Peru.

Q. Who was selected for the purpose of making these collections?

A. Dr. William Frazer of the town of LaSalle.

8168 Q. Where was the next point selected?

A. The next point was upon the Illinois river at Henry, where there is a dam across the stream.

Q. Did you visit that dam?

A. Yes sir.

Q. State what kind of a dam it is?

A. So far as I can tell, it is an excellent dam, a large one for the purpose of aiding navigation in the Illinois river, provided with locks to facilitate such use, and furnshed, if I may use the term, with a lock-keeper who is on duty to look after the dam and lock. The purpose of making the collection at Henry was to note again the changes which took place between the next preceding point of collection and this,—changes occurring in the waters of the Illinois river, and due to natural processes, and a contribution of LaSalle's and Peru's sewage to the Illinois river, which contribution takes place just below the point at which the LaSalle samples were collected.

Q. State the nature of that sewage from Peru and LaSalle?

A. Well, it includes house sewage, manufacturing wastes from zinc works,—the largest in the world are there at Peru—I should say first, the largest in the world are at LaSalle and the next largest in the world are at Peru, and discharges from both of them go into the river. Then there are fertilizer works
8169 there, cement works, and coal mines and others, and wastes of all sorts from these various industries, as well as the house sewage from these towns is discharged into the river just below LaSalle and Peru.

Q. Do you know the distance between Peru and Henry?

A. It is about thirty miles,—the distance from LaSalle to Henry,—33 miles.

Q. Who made these collections for you at Henry?

A. It was the lock-keeper, Mr. McCune, and the samples were taken just above the dam.

Q. Where was the next place selected?

A. The next place was at the Narrows, about three miles above the Court House at Peoria. The name of the immediate locality being called Averyville. It might be called a suburb of Peoria. The sample was taken at the bridge across the Narrows at this point.

Q. How far is it from Henry to this point, if you know?

A. It is about thirty miles again--yes, it is just 30 miles from Henry.

Q. And how far from Lockport, the mouth of the drainage canal?

A. About 130 miles.

Q. Who collected these samples for you at Averyville?

8170 A. They were collected by employes of the Peoria waterworks, under the general direction of the superintendent of the Peoria waterworks, Mr. Dabney H. Maury. They were collected by Mr. Robert Martin, and by others who had been designated by Mr. Maury, and who have testified here.

Q. Where was the next point selected?

A. The next point at which collections were taken was Wesley City, three miles below the Court House at Peoria, about six miles below the point at Averyville. The reason for making the collections at this point was to determine the influence of Peoria sewage upon the waters of the Illinois river, for the reason that enormous discharges in the aggregate, of household sewage and wastes from various manufacturing industries take place just above Wesley City.

Q. Is there a creek near there?

A. Just below the town of Peoria, Kickapoo Creek discharges into the Illinois river, and it also conveys some industrial wastes into the stream of the Illinois.

Q. State in what part of the river the samples at this place were to be taken?

A. The instructions to our collectors were that the samples at Wesley City should be taken at mid-stream, at a point almost opposite the railway station at Wesley City.

Q. Did you select the exact point in the river?

8171 A. Yes.

Q. And point this out to the water taker?

A. I did.

Q. Where was the next place that you selected?

A. The next point was the Illinois river at Pekin. The reason for taking the sample at Pekin was that at Pekin again there are enormous discharges of refuse matters from distilleries and other industries, as well as a portion of the house sewage of the town. The sample was collected at the point in the river a short distance below the point at which the final discharge of refuse matters at Pekin occurs.

Q. How far is Pekin from Peoria?

A. It is about fifteen miles,—twelve to fifteen. The river men always give various different figures.

MR. JEFFRIES: It is three miles further by water than it is by land?

A. Always, yes. From Peoria—well, it is about twelve miles, from twelve to fifteen. People give it variously. I have been along both ways several times, but I never carried a pedometer.

Q. Was this point at Pekin selected as the place below the sewers of that city?

A. It was.

8172 Q. And below the wastes of the distilleries, etc?

A. It was.

Q. Who made these collections at Pekin and Wesley City?

A. Mr. D. H. Jansen, county surveyor, and an engineer.

Q. Where was the next point which you selected?

A. The next point was just above the town of Havana, on the Illinois river. The collection was made a short distance above the mouth of the Spoon river, which is a considerable tributary entering on the right bank of the Illinois. The purpose in making the collection at this point being to determine the effect of the flow for a distance of about thirty miles, 33 miles from Pekin to Havana, to see what effect occurred upon the refuse matters introduced into the stream at Peoria and Pekin, 33 and 45 miles respectively, above this point.

Q. Who took these samples at this place?

A. The samples at Havana were taken by Mr. H. G. Heberling.

Q. Were any samples taken from the Sangamon river?

A. Samples were taken from the Sangamon river at Chandlerville.

Q. What is the drainage area of the Sangamon river?

A. About 5,600 square miles.

8173 Q. Any towns upon that stream?

A. The towns of Decatur and Springfield discharge their sewage into the Sangamon river, or into small tributaries of the Sangamon, which in the case of Springfield, soon finds its way into the Sangamon river.

MR. JEFFRIES: I move to strike out the answer of the witness and all testimony with reference to the drainage area of the tributaries of the Illinois river unless it be supplemented with the entire drainage area of the Illinois river valley.

JUDGE SPRINGER: We will put that all in.

Q. Did you make a collection at this point opposite Chandlerville?

A. I did.

Q. Who made this collection there?

A. Mr. E. O. Spink made the collections at Chandlerville.

Q. What other points on the Illinois river?

A. The town of Beardstown, 31 miles below Havana was the next point. The collection was taken near the C., B. & Q. bridge.

Q. Was this above or below the mouth of the Sangamon?

A. Below the mouth of the Sangamon, the purpose being to discover what changes took place in the waters of the Illinois while flowing from Havana to Beardstown and the effect of the introduction of the Sangamon river water, which occurs between these two points. 8174

Q. Who made these collections?

A. The collections were made by Mr. G. W. Barneycastle, under the supervision of Mr. J. A. Carney, engineer of the C., B. & Q. railway.

Q. What other place was selected on the Illinois river?

A. The point at Kampsville, just above the dam, 30 or 31 miles above the mouth of the river and about 57 miles below

Beardstown. The point was to note the changes which took place in the Illinois river water in its flow from Beardstown, 57 miles above, down to this point, which is near the mouth of the stream.

Q. What is there at Kampsville that is notable, in the stream?

A. There is the United States Government dam there which is under the charge of a United States engineer, who is permanently in residence there and who has charge of the improvements along the lower Illinois river. The water at this point in the Illinois river is ordinarily unaffected by changes in the height of the water in the Mississippi river, but at times when the water is high in the Mississippi the flow at this point is retarded and at times even the water may back up as far as this in the Illinois river. The collection at 8175 this point was made by Mr. C. V. Brainard, the assistant United States engineer in charge of the dam.

Q. Were any samples taken at Grafton at the mouth of the river and if so state what was done there?

A. At the mouth of the river at Grafton samples were taken at a point about two miles within the mouth of the Illinois river, a point at which ordinarily none of the water of the Mississippi river affects the Illinois, or rather at which Mississippi river water does not ordinarily mix with the Illinois river water. Samples at this point were collected by Mr. B. F. Robinson.

Q. Did you take any samples from the Mississippi river at this point or above the mouth of the Illinois?

A. We did. Mr. B. F. Robinson again collected the samples from the Mississippi river at a point in mid-channel about two miles above the town of Grafton, and where the water of the Illinois river does not mix with the Mississippi river water.

Q. Do you know what the relative volume of flow of the two rivers is at this point?

A. Well, it varies greatly at different seasons. Sometimes the Mississippi is high and the Illinois is low; sometimes the Illinois is high and the Mississippi is low. Sometimes they are both low together and at other times they are both high 8176 together, but taking the mean for the year through, and the flow in the Mississippi river in the year 1899, was about five times or a little more than five times the flow in the Illinois river.

MR. JEFFRIES: I object to the witness testifying as to the relative stream flow of the Illinois and Mississippi rivers, for the reason that he has not disclosed the source and means of his information.

MR. TODD: In reply to the objection will state that if counsel wants to know the source and means of his information, that will be afforded him on cross-examination.

A. The measurements were made by United States engineers about the year 1882, at the mouth of the Illinois river and at Hannibal in the Mississippi river. The results of their measurements are stated in various reports, including that by Mr. Leverette upon the Water Resources of Illinois. Measurements of the flow in the Illinois river have been made at Kampsville, where the flow, as measured, constitutes ordinarily practically all of the flow of the Illinois river at Grafton, and so indicates the volume of water discharged into the Mississippi at the mouth at Grafton.

MR. JEFFRIES: Now I move to strike out the answer of
the witness for the reason that it does not state the rep-
8177 resentative conditions that have existed since the open-
ing of the Chicago drainage canal and the answer of the
witness discloses the fact that it is based on conditions that existed long years before the opening of the canal.

JUDGE SPRINGER: I will ask you now if you have made any estimate of the comparative flow of these two streams for the year 1900, after the drainage canal was opened?

A. I have.

Q. What was it?

A. For 1900 the flow of the Illinois amounted to about 22.6 parts as compared with 77.4 for the upper Mississippi. These determinations being made from the determinations of the proportions of chlorine contained in the Illinois river water, and a comparison with the proportions of chlorine contained in the upper Mississippi river water and in the water of the Mississippi river below the mouth of the Illinois, where partial mixing of the two streams had occurred.

Q. Were any points selected below this where samples were taken, if so, state what?

A. At Alton about 17 miles below Grafton, samples of water were taken from the Mississippi river at five points across the stream, opposite the new pumping station of the Alton city waterworks. The five different points across the stream
8178 being selected as the points of collection, for the purpose of determining, if possible, what degree, or in what degree, the mixing of the Illinois river water with the upper Mississippi river water had taken place at the time the two streams had joined at Grafton, and progressed in their course, to this point, 16 miles below. The samples at Alton were taken by Mr. George Brooks.

Q. Were any samples taken at the mouth of the Missouri river at the place called West Alton?

A. Samples were taken from the Missouri river at a point a short distance within its mouth at the crossing of the C., B. & Q. bridge, known as Fort Bellefontaine, but near to the hamlet of West Alton.

Q. West Alton being on the north bank?

A. And Fort Bellefontaine I suppose on the south bank, though I could not find the fort.

Q. Who took these samples?

A. The samples at this point were taken by Mr. James Matthews.

Q. And do these samples represent the Missouri river water before the mixing takes place with the Mississippi?

A. They do.

Q. What was the next point on the Mississippi river?

8179 A. It was the chain of rocks, which we called Mitchell, since I couldn't find anyone to collect the samples for us there, except a prominent farmer named Henry Atkins, who who lived on the Illinois side, and whose post office is at Mitchell, several miles away from his house.

Q. Just explain, will you, what was done at this place, as it is an important point?

A. At this point four samples of water were collected.

Q. You mean each time?

A. Yes sir. Each day a collection was made, four sets of samples were taken at four different points across the stream, one being towards the Missouri shore about 400 yards, sometimes they say 400 feet—but supposed to be in the middle of the stream as it flows down to the intake tower of the Missouri shore. The next sample was taken immediately beside the intake tower of the St. Louis waterworks. The third sample at this point, or the third set of samples at this point were collected at mid-channel, which is possibly midway between the inlet tower and the Illinois shore, and the next sample, the fourth at this point, was collected toward the Illinois shore, about 400 yards from the land.

Q. Yards or feet?

A. Well, it varied somewhat; at certain times in the year the water spread farther across, and if you got the point
8180 as located in the bed of the river, it was farther away from the shore when the water was away up.

Q. What was the object of taking the samples at the various points in the stream at this place?

A. The object of taking the samples at these four different points was to note the character of the water at the different points across the stream. To note and determine if possible what amount of mixing of the three streams, the Illinois the Mississippi and the Missouri had taken place by the time this body of waters reached the intake or the point opposite the intake tower of the St. Louis waterworks.

Q. Where was the next point selected for taking samples?

A. The next point selected was a tap in St. Louis, the sample was taken by Mr. Emil A. Lapelle, but when he left the country, the samples were taken by Mr. August Johnson, the latter doing most of the work.

Q. Were there any other points on the Mississippi river selected?

A. Samples were taken at cross-section points in the Mississippi river at Jefferson Barracks, about nine miles below the center of the town, the purpose being to note what amount of mixing of these various waters had occurred by the time they reached this point, and in a secondary manner to see what effect the St. Louis sewage had upon the lower Missis-
8181 sippi, although the latter was perhaps a sentimental part

and no such continuous or thorough study of the conditions below the chain of rocks was made, as was made at and above the chain of rocks, along the streams that we have been considering.

Q. Now I believe you stated that you saw these collectors in person?

A. Yes sir.

Q. What instructions or directions did you give them in regard to the manner of immersing the bottles into the river and of taking the samples of water, and at what part of the stream they were to take their samples?

A. With the exception of the various cross-section points to which I have referred the collectors were directed to make the collections at the middle of the channel and they were told to immerse the bottle with the stopper in place, to a depth of a foot below the surface, then to remove the stopper allowing the water to enter until the bottle was nearly full, then to replace the stopper, withdraw the bottle and immediately tie it up and tag, pack and ship by the earliest and most direct route.

Q. And to rinse the bottle?

A. In some of the collections they were directed to rinse the bottle first with some of the water of the river, yes sir.

Q. Who prepared the bottles and how were they prepared?

8182 A. In the various laboratories they of course were prepared by the different people looking after the work. In my own laboratory we all looked after it. I looked after part of it and some of my assistants were helping. The bottles were cleaned out by means of a mixture of dilute sulphuric acid and bichromate of potash, then rinsed thoroughly with distilled ammonia free water, and drained and tied up securely with a piece of sheet rubber over the stopper and so prepared for the chemical samples.

Q. Were they sterilized?

A. Not for the chemical samples, no sir, except as the treatment with these agents might effect that perhaps.

Q. How about the smaller bottles?

A. The smaller bottles were sterilized.

Q. What were they used for?

A. They were for the bacterial samples.

Q. Were they prepared in your laboratory?

A. No, not in general. Professor Burrill, who made the bacteriological examinations at our place, looked after the shipping and preparation of the bottles for the bacterial samples, but they were sent over to us and packed with our chemical bottle.

8183 Q. How were they to be shipped, in what manner?

A. Shipped in wooden cases and packed in excelsior. The bacterial samples were packed in ice, the chemical samples were not.

Q. Who received these samples at your laboratroy?

A. I received them myself, with my assistants.

Q. When a sample was received, what did you do?

A. The first thing was to place a number upon the tag which was upon the bottle, a serial number, and to enter that number in our record. Then the tag number was placed also upon the certificate which was inside of it. A number placed upon the bottle itself, upon the outside tag, and upon the certificate which accompanied the sample.

Q. What else as to the analyses?

A. Then the analysis was begun immediately, particularly the determination of such constituents as are susceptible readily to change?

Q. What were those?

A. The nitrites, the nitrates in particular, and steps were taken to get the free ammonia determinations under way at once. The other determinations, particularly the total solids and chlorine, were ordinarily not started until after these
8184 determinations I have mentioned were under way, for
the reason that the substances mentioned are not so liable to change as are the nitrites, nitrates and free ammonia. Of course the determination of albuminoid ammonia, which accompanies that, or rather immediately follows the determination of free ammonia was started when the free ammonia determination was started.

Q. Was the turbidity of the water entered of record?

A. After numbering the bottles and tags and certificates of course a note was taken of the physical appearance of the

water, the turbidity, the amount of sediment there might be in the bottom of the bottle and in a general way the odor. The sample, before any of it was poured out for analysis, was thoroughly shaken, in order that such matters as had deposited upon the bottom of the bottle during transit, could be shaken up and intimately mixed with the sample of water. Then the samples were poured out for the various determinations, care being exercised to keep such matters as were shaken up, in the water, in suspension during the time that the various portions of the given sample were being measured out for the different determinations. At the same time too, notice was taken of the odor, if any, by bringing the mouth of the bottle containing the water, into near proximity with the nostrils and sometimes a sample of water was heated in order to note
8185 whether any odor was developed or made more pronounced by warming the water.

Q. How did you note the odor?

A. We simply made a record of the report brought by one's nostrils as to the possession by the sample of a fishy, gassy, or any other odor that we could recognize and distinguish by any of the ordinary terms, musty, as sewage, gassy, as when the discharges of gas works, liquor, gas into the water; fishy perhaps in some cases, or odorless, in case we failed to detect any particular odor.

Q. Did you note the color of the water?

A. Yes sir.

Q. For what purpose and in what way?

A. The determination of color was made by comparison with the color developed by the Nessler solution, such as is customary in the determination of free ammonia. This seemed the most feasible means of noting and recording the color, in the case of these waters, since the natural color of the water was more nearly comparable to that produced by the Nessler reagent than to any other substance we were familiar with. And in the determination of color usually it was necessary to filter the water because the waters of most of these streams at nearly all times, is too turbid to admit of even an approximate determination of the color, unless the floating matters
8186 be removed.

Q. What kind of tubes were used for this purpose?

A. The Nessler tube, made especially of a colorless glass, rather thin, about ten inches in length, about eight inches high to the mark which indicates the measured volume of 50 cubic centimeters.

Q. Did you make any analyses for the purpose of determining total solids and if so how did you reach that determination?

A. We did. Total solids were determined by evaporating 250 cubic centimeters of the water, after adding two hundredths of one gram of sodium carbonate, the addition of the sodium carbonate being made by measuring in five cubic centimeters of a four-tenths per cent. solution into a sample of 250 cubic centimeters of the water. The dish with the contents being placed upon a water bath until the water was substantially all evaporated and then being transferred to an air bath where it was heated at 180 degrees centigrade until practically all of the water was removed from the residue. It ordinarly taking an hour for this purpose.

Q. Did you determine the loss on ignition?

A. We determined the loss on ignition by treating the residue of evaporation, after it had been heated in the oven as above indicated, by heating the dish and its contents to a dull redness over a Bunsen lamp. The dish and residue being suspended within a larger platinum dish, the latter being kept at redness by the direct application of the flame of the Bunsen lamp mentioned above. 8187

Q. What method did you employ for the purpose of determining the presence of chlorine?

A. The method for the determination of chlorine was the ordinary standard method by titration with silver nitrite solution, using, potassium chromate as indicated. The quantity of chromate used was in all cases one cubic centimeter of a five per cent solution. The end point of a reaction was in all cases determined by comparison with the color of a blank. The quantity employed for the purpose was in many cases fifty cubic centimeters of the original sample, but in cases where it was known or suspected that the contents of contained chlorine, that is the chlorine was small, a larger quantity was employed for the purpose, 250 to 500 centimeters of the original sample accurately measured, was treated with sodium carbonate, five cubic centimeters of the solution of four tenths per cent strength being employed, and the mixture was evaporated so far that a sample of fifty cubic centimeters should be obtained for the tiration with silver nitrate as indicated above.

Q. Did you make any analyses for the purpose of determining the amount of oxygen consumed?

8188 A. I did.

Q. Please state what it was?

A. The determination of oxygen consumed was made by a slight modification of the standard method, that is digestion with potassium per manganate in acidified condition; a hundred cubic centimeters of the water were used for the purpose. To this quantity of sample 2 cubic centimeters of pure concentrated sulphuric acid were added. Then ten cubic centimeters of the standard permanganate solution were run in and the mixture heated within a flask which was immersed in the boiling water of a bath and kept so immersed, and the water kept boiling for thirty minutes. At the end of this time, if the color of permanganate was apparent the samples were removed from the bath and a measured quantity of oxalic solution was added. The excess of oxalic acid titrated with the same permanganate solution, and the difference between the quantity of oxalic acid solution and the permanganate solution employed in these several portions, indicated the quantity of oxygen taken by the organic matters from the permanganate, and hence indicated as oxygen consumed. In a good many cases the organic matters in the waters consumed more oxygen than could be furnished by the ten cubic centimeters of potassium permanganate employed. In such cases another sample of the water was taken, 8189 heated as indicated above, with the exception that twenty, that is double the quantity of permanganate was directly added to the water, the rest of the process following substantially as indicated above.

Q. Did you determine the presence of nitrogen as free or saline ammonia?

A. I did, for this purpose 250 cubic centimeters of the water sample were diluted to 500 cubic centimeters with the nitrogen free distilled water. Five cubic centimeters of a twenty per cent sodium carbonate solution were added, and the liquid distilled in a round bottomed 900 cubic centimeter Jena glass flask over a naked Bunsen flame. The flasks supported upon asbestos rings, were conneeted with the condensor by means of a modified form of Reitmair and Stutzen distillation bulbs. That is the modification made by Hopkins. The condensor is used where half inch or three-quarter inch block tin tubes, which pass through a tank of cold water. The length of the tube exposed to the cooling influence of the water being about 20 to 22 inches. During the latter part of the investigation, tubes of somewhat thinner aluminum were employed for the purpose. As nearly all of the waters which we had to examine in the course of these investigations, were high in free ammonia, comparatively. We made the collection by distillation into two hundred cubic centimeter flasks, instead of collecting in separate lots of 50 C. C. in Nessler tubes, and subsequently the determination of the quantity of free ammonia was made by thoroughly mixing the contents of the flask and taking out an aliquot portion for the Nesslerization. The samples being allowed to stand at the temperature of the room, until the temperature should adjust itself to that of the room, so that the standards used in the Nesslerization should be of the same temperature as the distillates from the water samples which were being investigated. 8190

Q. What determination did you make for the purpose of determining the presence of the albuminiod ammonia?

A. The albuminoid ammonia was determined by the ordinary standard method by use of the residue remaining from the distillation of the free ammonia. After this determination the distillation was stopped, the flask disconnected from the condensor, 50 cubic centimeters of alkaline permanganate solution—the ordinary standard solution employed for the purpose was introduced. The flask immediately connected again with the still and the distillation proceeded with at the same rate as for the distillation of the free ammonia, that is at about the rate of 200 cubic centimeters per hour until 200 cubic centimeters of distillate was obtained, which then was used for the determination of the nitrogen as albuminoid ammonia 8191 in ways similar to that indicated above, for the determination of the nitrogen as free ammonia, namely by Nesslerization.

MR. JEFFRIES: I move to strike out all the testimony of this witness with reference to the manner in which the various chemical constituents of the water were obtained, for the reason that no connection is shown between these chemical constituents so ascertained from the samples, and the sanitary condition of the water at the places the samples were taken.

ADJOURNED until 10:00 A. M. Tuesday, October 13, 1903.

8192 10:00 A. M., Tuesday, October 13th, 1903.

Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further direct-examination by Judge Springer and testified as follows:

Q. Professor, you have used the term "Nesslerization" in defining the methods you employed in obtaining certain results. Will you please state what you mean to convey by that term,—what Nesslerization is?

A. Nesslerization is the determination of free ammonia in solution by means of the so-called Nessler reagent, a solution of iodide of mercury in iodide of potassium with caustic potash present. When free ammonia in solution is brought into contact with this reagent a color develops, varying from the faintest yellow to a dark reddish yellow, according to the quantity of ammonia in the liquid. The process goes by the name of Nesslerization, and is a standard method in chemistry, especially for water analyses. In our work care was taken that the distillates in which the free ammonia from the samples 8193 of river water obtained as indicated above, was to be determined, were of the same temperature as the standards which were mixed up with known quantities of ammonia for the purpose of making comparison, and thereby determining the quantity of ammonia in the distillate, and so in the original water sample. Ammonium chloride solution used for making up these comparison standards was of such strength that one cubic centimeter contained ammonium chloride corresponding to .01 of a milligram of nitrogen. The eighteen standard mixtures made for the purpose of comparison, contained quantities of the standard ammonium chloride solution, as follows:

.05 of a cubic centimeter; .01, .2, .4, .6, .8, 1., 1.2, 1.4, 1.6, 1.8, 2., 2.5, 3., 3.5, 4., 4.5, and 5. cubic centimeters.

In Nesslerizing, one cubic centimeter of the Nessler solution was added to the contents of each Nessler tube, and the mixture allowed to stand twenty minutes for the development of the full color, because the full color does not develop instantaneously upon making the mixture, nor within fifteen to twenty minutes or more of the time of mixing. The reagent was always added to the samples, that is, the distillate from these samples, and the standard mixtures simultaneously, for the purpose of giving the same time for the development
8194 of the tint in the sample and in the standard with which
it was to be compared, and the readings were all taken within one hour of the time that the mixing occurred. That is within one hour of the time that the Nessler solution was added to the various samples and standards. For facilitating an accurate comparison of the tints a special camera which cuts out all side lights was employed, the camera being arranged with mirrors for the purpose of sending northern sky light up throughout the length of the tube, and reflecting to the eye an image of the cross section of the tube. The light having been passed through an eight inch column of the liquid before being so reflected to the eye. The same method of Nesslerization applied to the determination of the nitrogen as free ammonia, and to the determination of the nitrogen as albuminoid ammonia.

Q What method did you employ for the purpose of determining the total organic nitrogen?

A. The total organic nitrogen was determined by the method of Kjel Dahl. For this purpose 250 cubic centimeters of the water were diluted with 250 cubic centimeters of nitrogen free distilled water. Then five cubic centimeters of a twenty per cent sodium carbonate solution which would contain one gram of potassium carbonate, was added to the mixture,
8195 and this final mixture subjected to distillation for the re-

moval of all free ammonia, the distillation being conducted in the same manner and pushed to precisely the same point as that reached in the distilling over of free ammonia, in the determination of the free or saline ammonia. After the removal of the free ammonia as indicated, ten or twenty cubic centimeters of pure nitrogen free sulphuric acid were added and the solutions heated under the proper precautions, until the water was all expelled, and the organic matters completely destroyed. After cooling the resulting liquid, 250 cubic centimeters of ammonia free, distilled water were added, and then an excess, usually about 50 cubic centimeters, of strong nitrogen free sodium hydroxide solution was added. The flask was immediately connected with the condenser. The contents of the flask mixed by thorough shaking, and the distillation which was conducted at first very slowly was continued until 200 cubic centimeters were distilled over into the 200 cubic centimeter flask. The contents of this flask were then mixed thoroughly and an aliquot portion of the distillate so obtained and mixed was employed for Nesslerization in the ordinary manner. And from the result of the Nesslerization comparison, the quantities of nitrogen existing in the water in organic combination were determined.

8196 Q. What method was employed by you for the purpose of determining the presence of nitrogen as nitrites?

A. Nitrogen as nitrites were determined by the ordinary standard method, as follows:

50 cubic centimeters of the water were placed in the Nessler tube, one cubic centimeter of an acid solution of napthalamine hydro chloride, the solution being of strength as follows: Eight grams of the napthalamine, eight cubic centimeters of strong hydro-chloric acid, with sufficient water to make up one liter of solution. The other solution employed was the hydro-chloric acid solution, containing five per cent of strong hydrochloric acid, and as much sulphanilic acid as the mixture of hydrochloric acid and water, which was added to make up a liter, would hold in solution.

The test with the sample was made by adding one cubic centimeter of each of the above solutions, to the 50 cubic centimeters which had been placed in the Nessler tube, and the mixture so made was allowed to stand for an hour in order that the development of the full tint might have time to take place. Sim-

ultaneously with the addition of the reagents to the water sample which was being examined, the same quantities of the reagents were added to a series of solutions which contained accurately known quantities of pure sodium nitrite. If a color ap-
8197 peared in the water sample in the course of twenty min-
utes to one hour after the addition of the reagents, it was matched with some one of the tints developed in the series of standards, and the quantity of nitrite contained in the original water was recorded, as being the same as that contained in the standard mixture which produced the same tint. If no color developed in the course of an hour, the water was regarded free of nitrites.

Many of the river waters examined contained so much nitrite that the color developed in the undiluted sample was too deep for accurate comparison. In such cases quantities of from 1 to 10 cubic centimeters of the sample were diluted to 50 cubic centimeters with nitrogen free distilled water, before adding the reagents. Waters which were turbid, or deeply colored, were clarified and decolorized by treatment with aluminum hydroxide and filtration, before making the test for nitrites. The comparison of tints was made in the camera, and in the tubes which were used for Nesslerizing. The standard solution of sodium nitrite employed was prepared from pure silver nitrite by reaction with sodium chloride, and for convenience in making up the standards, was made in two strengths, one solution containing in each cubic centimeter the equivalent of .005 of a milligram of nitrogen; the other contained .0005 of a milligram of nitrogen.

8198 Q. What method did you employ for the purpose of determining the presence of nitrogen as nitrates?

A. I determined nitrogen as nitrates by the usual aluminum reduction method. For the purpose, 100 cubic centimeters of the water were treated with two cubic centimeters of nitrogen free sodium hydroxide solution of 33 per cent strength. The solution was then boiled down rapidly to about one-third its volume in order to remove the free ammonia. The liquid was then diluted to 100 cubic centimeters with nitrogen free distilled water. It was cooled and put into a large test tube. Then one gram of aluminium in the form of a strip of comparatively thin foil was introduced and the tube with its contents was placed in a water bath, the temperature of which was kept at about

25 degrees centigrade (78.2 Fahrenheit) where it was allowed to remain over night. The reductions to ammonia were ordinarily complete when the examinations were continued next morning. The contents of the reduction tube, including such portion of aluminum foil as remained intact were transferred to a distillation flask, 250 cubic centimeters of nitrogen free distilled water being used to wash out the tube and dilute the liquid. The distillation of the free ammonia thus produced by the reduction of the nitrates was conducted precisely as for the determination of free or saline ammonia. In all the various samples of river water which were examined, determinations
8199
were made of the total solids and loss on ignition of free ammonia and albuminoid ammonia, the total organic nitrogen and of oxygen consumed, and the other determinations as hereinbefore set forth,—to use a legal term,—but a number of these determinations were made not only upon the original sample, but upon a filtered portion of the original sample, for the purpose of distinguishing between matters in suspension and those in solution,—these total solids were determined not merely in the original water, which contained much matter in suspension, but also in a filtered sample of the same, and the suspended solids were thus indirectly determined, as the difference between the total solids in the original sample and the total solids obtained by the method given above, in the filtered sample. Filtered portions were used also for the determination of albuminoid ammonia in solution. The total organic nitrogen in solution, and for the oxygen consumed by the matters in solution. The differences between the results thus obtained in the filtered samples and the figures obtained upon the original whole or unfiltered samples being due to matters in suspension.

Q. What method did you employ for the purpose of determining dissolved oxygen in the samples of water analyzed by you? 8200

A. Dissolved oxygen we determined chiefly by the method of Albert Levy—if that is the way the Frenchmen pronounce his name—though some determinations were made by the Winkler method, mainly for purposes of comparison with the Levy method. The Levy method was used for the reason that we found it more convenient. It is as follows:

A special pipette with a glass cock at each end, attached to the cock at one end being a funnel tube, the capacity of the apparatus between the two stop-cocks being 107 cubic centimeters, was filled with the water sample to be examined, by immersion in the river, when the determination was made on the spot; by drawing the water up into the pipette when the determination was made at the laboratory. The pipette was filled with water between the two cocks; then two cubic centimeters of the caustic alkali solution which is described below, were introduced by placing it in the funnel at the top and by so manipulating the two stop cocks that the caustic alkali solution was allowed to run down and mix with the water sample without introducing any air. The funnel was then rinsed out and five cubic centimeters of the ammonia ferrous sulphate, the solution described below, were introduced first into the funnel and then into the pipette, by the same manip-
8201 ulation as indicated above. The water which ran out of the pipette at the bottom as the reagents were admitted at the top was caught in a beaker in which the subsequent titration with potassium permanganate was to be effected, and which already contained two cubic centimeters of a fifty per cent solution of sulphuric acid. It is assumed that the alkali and the iron solution in entering the pipette displace their own volume of water, and with careful manipulation this is undoubtedly essentially effected, so that we may assume that within the pipette there remains 100 cubic centimeters of the original water sample, together with the seven cubic centimeters of the reagents. The mixing of the liquids within the pipette was effected by shaking the pipette with an eccentric rotary motion. In the course of a few minutes the action is completed, and from the color of the precipitate one may gather an idea as to the relative amount of oxygen contained in solution in the water. That is, if the water is about saturated the precipitate is apt to show a somewhat brownish color, due to the formation of ferric hydroxide, while if the quantity of oxygen is very small the precipitate is likely to be black, owing to the preponderance of ferrous hydroxide in the precipitate. After a few minutes, when

the action appears to be complete—five cubic centimeters 8202 of sulphuric acid are introduced into the funnel, the cock between the funnel and the pipette being open, the cock at the bottom of the apparatus remaining closed; the sulphuric acid by reason of its greater gravity passes down from the funnel through the orifice in the stop-cock, into the interior of the vessel and mixing with the liquid, dissolves the hydroxides of iron, rendering the entire liquid acid, and yielding a clear solution. When this action is complete as shown by the perfect clearing up of the solution, the contents of the pipette are run into the beaker and the excess of ferrous salt remaining unaffected by the dissolved oxygen in the original sample, is determined by titration with the standard potassium permanganate solution. A blank test is run upon 107 cubic centimeters of the original water for every determination that is made, this being easily accomplished while the reactions within the pipette are taking place. In running the blank, 107 cubic centimeters of the original water sample are measured into a beaker. Then seven cubic centimeters of the sulphuric acid are added and the liquid mixed. After this the caustic potash, two cubic centimeters in quantity is added, and finally, precisely five cubic centimeters of the ammonio-ferrous sulphate solution is added.

After mixing, titration of this solution by means of the 8203 potassium permanganate solution is effected, precisely as in the actual determination as indicated above. The difference between the two sets of readings, that is the figures obtained for the blank test and those obtained from the direct determination, represents the quantity of dissolved oxygen in 100 cubic centimeters of the water.

Q. State whether the Albert Levy method is more convenient than that used by Winkler?

A. In our practice we found it more convenient to use the Levy method rather than the Winkler method, because of the necessity of running a blank on every sample of water examined. Because of the organic matters and other matters in these river waters, which were the subject of the present examination, it was essential that a blank for correction be run upon every sample. That blank can be much more easily and quickly made for the Levy method than for the Winkler method.

Q. Please state whether you made the oxygen determinations on the spot or otherwise?

A. A considerable number of the determinations were made on the spot, but it was not practicable to make all of them so, and consequently a large number were made upon samples which were especially collected for the purpose and were shipped to the laboratory.

8204 Q. How long after the taking of the sample was it until you made your determinations in the laboratory?

A. Ordinarily they were made at the laboratory within 24 hours. In some cases, a few cases, comparatively, the samples were longer in transit, and the determinations were not made for 48 hours after the time of collection of the sample.

Q. Do the waters of the Illinois and Mississippi rivers contain great amounts of organic matter?

A. They do. We found it possible to prevent the consumption of the dissolved oxygen during the time that the samples were in transit between the points of collection and the laboratory by adding mercuric chloride to the original sample, but the determinations were rendered somewhat more difficult in consequence of this addition, although it was found possible to make the determinations so, and the comparison of determinations made on the spot with samples shipped to the laboratory after treatment with mercuic chloride, showed that under these conditions there was practically no loss of the dissolved oxygen during the time required for transportation.

Q. Did you make any comparisons with the Winkler method of making these determinations?

A. Yes, and we found that ordinarily the differences between the results given by the two methods were not
8205 great. They are indicated in the tables which will be considered later. I referred to the solutions used in the method. The reagents employed consist of a solution of 150 grams of caustic potash in a liter of water, a solution of 22 grams of ammonio-ferrous sulphate in a liter of water. A solution of sulphuric acid containing fifty per cent of sulphuric acid by volume, and a standard solution of potassium permanganate of such strength that one cubic centimeter, is exactly equivalent to .1 of a milligram of oxygen.

Q. State how many different determinations you made from these various analyses to which you have referred?

A. What various analyses?

Q. The ones that you have just described?

A. Oh yes. In the sanitary chemical analyses, there have been fourteen quantitative determinations made upon each sample of water.

Q. That is, parts per million you mean by that, do you?

A. Well, determination of quantities yes, and the results of these appear in tables No. 1 to 80, and in tables, A. B. C, D, respectively, and in tables 95a, 95b, 95c, 95d, 95e, 95f and 95g, respectively.

Q. You have stated that the results of these analyses about which you have been testifying were set forth in 8206 certain tables which were numbered from 1 to 80. I hand you certain tables, and ask you to look at these and state whether the results of the chemical analyses made by you during the time indicated, and of the samples of water indicated, taken at the different points about which you have testified here are set forth in the tables which I have just placed in your hands, numbered from 1 to 80 inclusive?

A. I identify the tables which you have just placed in my hands, as the ones to which I but a moment ago referred as incorporating the results of the various analyses of the samples of river waters which are the subject of the present investigation.

Q. Were these results entered by you in your office and under your supervision?

A. They were.

Q. And do they contain a correct statement of the determinations which are indicated in the tables, respectively?

A. They do.

Q. Were these various results reached in the manner that you have indicated in your testimony heretofore?

A. They were.

Q. You may now, professor, read the tables indicated, in evidence in this case?

8207 MR. JEFFRIES: To the reading of which said tables into the record complainant objects because no proper foundation has been laid for their introduction or their reading.

Complainant further objects for the reason that according to the explanation given by this witness and all other witnesses who have been produced by defendants, they are unable to give any connection between the analyses of the samples of water taken from the Illinois river, the drainage canal, and the Chicago river, and the sanitary condition of the water in the river.

Complainant objects for the further reason that this witness has not qualified as a sanitarian or a pathologist, and for the further reason that there is nothing in the tables which shows the presence or absence of disease producing organisms, and for the further reason that defendants have proved that that is beyond the power of the science of chemistry to determine, the sanitary condition of water for domestic and drinking purposes.

Complainant objects for the further reason that the samples of water were not taken with reference to all conditions of the river so far as temperature and the seasons of the year are concerned, and the manner of taking was not such that the results of the analyses based thereon are comparable with 8208 each other, or that the results are in any way comparable with the conditions actually existing in the river at any time, and at all times.

JUDGE SPRINGER: I move to strike out this objection for the following reasons: First, the question as to whether a proper foundation has been laid for the introduction of this evidence, is one for the Court to determine—

MR. JEFFRIES: I addressed my objection to the Court.

JUDGE SPRINGER: And it is therefore referred to the court for that purpose, and it is not a part of the testimony in this case. Secondly, I desire to move to strike it out for the reason that counsel has assumed to summarize the testimony which has been put in this record by the defendants in this case. Third, he has stated that the tables do not contain any reference to the stage of the river, or the temperature of the air or water. These determinations do appear upon the table. And for the further reason that it does not state whether there was present in this water pathogenic or other micro-organisms, which facts do appear in the tables, and to which reference will hereafter be made. And for the further reason that the final question as to whether these tables prove certain facts or not, goes to the weight of the evidence and not as to its competency.

THE WITNESS: The tables referred to are as follows:

TABLE 1.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS AND MICHIGAN CANAL, BRIDGEPORT.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dis-solv'd	Sus-pnd'd							Tot'l	Dis-solv'd	Sus-pnd'd										
4974	April 27	April 28	*	Cons'd	M. F.5	Gas'y	562.8	504.	58.8	84.	61.6	22.4	B.	102.	39.	21.	18.	13.6	2.4	1.44	.96	5.2	2.57	2.63	.005	.15	....	....	....	....	....
5030	May 11	May 15	*	Much	M. F.15	"	774.4	615.6	158.8	118.4	58.4	60.	B.	137.5	45.6	24.2	21.4	16.92	2.4	1.28	1.12	5.21	2.73	2.48	....	.17	....	....	....	....	....
5111	" 29	" 31	*	Cons'd	M. F.5	"	1201.6	1000.	201.6	113.6	63.2	50.4	B.	308.	57.7	25.	32.7	40.	4.96	1.76	3.2	10.73	1.69	9.04	.004	.4	4.5	5.5	12.7	....	....
5238	June 19	June 20	*	"	M. F.5	"	640.8	540.	100.8	45.2	34.4	10.8	B.	130.	47.5	26.	21.5	18.4	2.96	1.164	1.796	5.88	2.6	3.28	.002	.24	4.8	10.5	26.	+	1,035,500
5329	July 3	July 4	*	"	M. F.15	"	475.2	405.6	69.6	64.	54.	10.	B.	86.	36.	4.8	31.2	12.8	2.24	.64	1.6	4.92	2.28	2.64	....	.12	5.3	14.	21.	....	2,355,000
5429	" 17	" 18	*	"	M. F.15	"	685.2	574.	111.2	90.	48.8	41.2	B.	96.5	27.7	17.6	10.1	10.	1.44	.48	.96	3.32	1.272	2.048	.45	1.2	7.	6.	21.	....	4,500,000
5475	" 24	" 25	*	"	M. F.6	"	610.4	544.	66.4	84.8	72.	12.8	Gh.	129.	43.2	24.4	18.8	19.8	1.92	1.056	.864	3.96	2.2	1.76	.008	.24	5.4	25.5	27.	....	4,831,666
5833	Sept. 11	Sept. 12	*	"	M. F.3	"	520.	450.	70.	43.6	41.6	2.	B.	120.	35.8	17.5	18.3	17.6	2.16	1.04	1.12	3.8	1.88	1.92	.002	.2	5.	12.	19.	+	1,070,000
5878	" 18	" 19	*	Much	M. F.5	"	534.4	485.6	48.8	70.	47.6	22.4	B.	120.	40.9	22.5	18.4	20.8	2.64	1.088	1.552	4.44	2.76	1.68	.004	.2	5.	9.	15.	−	4,770,000
5931	" 25	" 26	*	"	M. F.6	"	564.4	....	....	59.6	....	....	B.	130.	33.	21.1	11.9	18.8	2.16	1.28	.88	4.74	2.58	2.16	.004	.24	5.2	13.	19.	+	1,610,000
5980	Oct. 2	Oct. 3	*	"	M. F.5	"	491.2	438.	53.2	74.4	26.4	48.	R	107.	38.1	17.3	20.8	14.	2.16	1.04	1.12	4.42	1.7	2.72	.006	.16	4.7	13.	10.	+	2,515,000
6054	" 9	" 12	*	"	M. F.8	"	375.2	334.4	40.8	24.	22.4	1.6	B.	73.5	23.3	18.5	4.8	10.8	1.6	.544	1.056	2.9	1.224	1.676	.007	.2	5.6	10.5	18.	+	3,240,000
6075	" 16	" 17	*	"	M. F.5	"	580.8	485.2	95.6	64.	22.4	41.6	B.	156.	34.7	18.8	15.9	18.4	2.24	1.088	1.152	3.24	1.88	1.36	.008	.28	5.6	7.	10.	+	1,425,000
6140	" 23	" 24	*	"	M. F.4	"	444.	392.4	51.6	24.8	23.2	1.6	B.	99.	22.9	10.8	12.1	14.	1.6	1.2	.4	2.76	1.8	.96	.002	.28	5.	10.	20.	+	1,420,000
6187	" 30	" 31	*	"	M. F.3	"	483.6	403.6	80.	38.	10.4	27.6	G.	94.5	35.7	15.4	20.3	12.	2.72	.608	2.112	5.16	1.16	4.	.005	.16	5.5	0.	10.	....	1,500,000
6234	Nov. 6	Nov. 7	*	Cons'd	M. F.3	"	426.4	390.8	35.6	22.	20.8	1.2	G.	79.	24.3	13.2	11.1	10.	2.16	1.04	1.12	3.24	2.28	.96	.008	.36	5.6	8.	11.	+	4,790,000
6270	" 13	" 14	*	"	M. F.4	"	....	....	....	....	....	....	....	138.	29.9	15.9	14.	18.	2.56	.8	1.76	5.16	2.36	2.8	.006	.24	5.	6.5	4.	+	1,960,000
6333	" 20	" 21	§	V.M'ch	VM.F.5	"	714.4	563.6	150.8	66.	27.2	38.8	B.	150.5	37.	14.	23.	24.	3.2	1.44	1.76	5.32	2.6	2.72	.002	.12	5.	5.5	10.	+	3,920,000
6398	" 27	" 28	*	Much	M. F.3	"	552.8	432.4	120.4	52.	26.8	25.2	B.	102.5	25.1	13.	12.1	14.8	2.64	.8	1.84	6.44	2.36	4.08	.004	.08	5.	9.	33.	+	315,000
6141	Dec. 4	Dec. 5	*	"	M. F.6	"	461.6	404.	57.6	54.8	26.8	28.	G.	101.	23.7	12.4	11.3	16.	2.32	1.28	1.04	4.52	2.28	2.24	.004	.24	5.	5.	4.	+	4,520,000
6540	" 18	" 19	*	Cons'd	M. F.30	"	544.4	489.6	54.8	71.6	56.	15.6	G.	122.	32.4	17.6	14.8	16.8	3.2	1.84	1.36	6.6	3.08	3.52	.011	.4	5.	8.	3.	+	845,000
6578	" 25	" 27	*	Much	M. F.4	"	624.	541.6	82.4	101.6	45.2	56.4	....	160.	38.8	24.	14.8	20.	3.6	2.56	1.04	7.72	4.92	2.8	.007	.8	4.	6.5	−8.	?	1,990,000
....	....	....	..	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

TURBIDITY—*Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 2.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS AND MICHIGAN CANAL, LOCKPORT.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of 1899 Collection.	Date of 1899 Examination.	Appearance. Turb'y.	Appearance. Sediment.	Appearance. Color.	Odor.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Loss on Ig'n. Tot'l.	Loss on Ig'n. Dissolv'd.	Loss on Ig'n. Suspnd'd.	Color on Ignition.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspd Matter.	Nitrogen as Ammonia. Free Ammonia.	Albuminoid Am. Tot'l.	Albuminoid Am. Dissolv'd.	Albuminoid Am. Suspnd'd.	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
5072	May 22	May 23	*	Much	M. F.3	None	633.2	558.	75.2	73.6	56.	17.6	B.	107.	48.	27.2	20.8	16.2	3.68	1.04	2.64	5.85	1.85	4.	......	.25	....	....	......	....	....
5118	" 29	" 31	*	Cons'd	M. F.2	"	826.	688.	138.	74.8	60.	14.8	B.	187.5	38.5	18.6	19.9	27.2	3.84	1.056	2.784	6.33	2.09	4.24	.002	.28	18.3	....	24.4	....	....
5158	June 5	June 6	*	"	M. F.7	"	749.2	660.	89.2	69.2	48.8	20.4	B.	133.	43.3	20.	23.3	9.2	2.96	1.248	1.712	4.57	2.89	1.68	.002	.2	17.8	....	32.2	+	528,00
5204	" 12	" 14	*	"	M. F.5	"	633.2	508.4	124.8	82.8	48.4	34.4	B.	109.5	59.5	27.1	32.4	16.	2.96	1.184	1.776	5.96	2.2	3.76	.001	.32	....	....	27.7	+	5,540,00
5248	" 19	" 21	§	V.M'ch	VM. F.6	"	675.6	574.8	100.8	84.8	74.	10.8	B.	125.	58.	23.5	34.5	20.8	2.88	1.36	1.52	5.08	2.52	2.56	......	.32	....	24.	29.4	+	6,175,00
5291	" 26	" 27	*	Much	M. F.25	"	590.8	484.	106.8	55.2	30.4	24.8	B.	108.	47.	20.5	26.5	15.2	2.64	1.184	1.456	5.08	2.44	2.64	......	.12	....	21.	26.5	+	3,300,00
5331	July 3	July 4	*	"	M. F.5	"	562.4	447.2	115.2	71.2	50.	21.2	B.	109.	41.4	21.7	19.7	14.6	2.8	.8	2.	5.56	2.68	2.88	......	.2	....	25.	29.4	....	10,250,00
5387	" 10	" 11	*	Cons'd	M. F.6	"	534.	480.4	53.6	63.2	48.	15.2	B.	104.	34.5	15.9	18.6	12.8	2.24	.736	1.504	4.76	1.496	3.264	.001	.24	....	21.	27.	....	4,115,000
5434	" 17	" 18	*	"	M. F.9	"	582.8	511.2	71.6	55.2	44.8	10.4	B.	123.	22.6	16.4	6.2	6.72	1.024	.576	.448	2.04	1.272	.768	.45	.24	....	22.	29.	....	3,680,000
5483	" 24	" 25	*	Much	M. F.7	"	592.4	510.4	82.	101.6	70.	31.6	B.	102.	40.3	21.7	18.6	13.6	2.4	1.04	1.36	4.36	3.	1.36	......	.8	....	24.	29.	....	3,250,000
5532	" 31	Aug. 1	§	Cons'd	M. F.5	"	525.2	451.6	73.6	96.4	78.8	17.6	B.	98.	41.	17.	24.	11.6	2.24	1.04	1.2	4.76	1.8	2.96	.006	.2	....	22.	29.	....	6,080,000
5577	Aug. 7	" 8	§	V.M'ch	M. F.5	"	548.8	482.4	66.4	79.2	49.6	29.6	Gh.	130.5	43.2	22.8	20.4	20.	2.16	.96	1.2	4.44	2.04	2.4	......	.2	....	21.	27.	+	2,800,000
5628	" 14	" 15	§	Much	M. F.5	"	532.8	468.4	64.4	92.	72.4	19.6	Gh.	118.	43.3	23.5	19.8	16.	2.16	.736	1.424	5.76	1.48	4.28	......	.16	....	....	......	....	....
5676	" 21	" 22	*	"	M. F.6	"	504.	439.6	64.4	74.8	51.2	23.6	Gh.	106.	36.3	24.3	12.	15.2	2.56	1.472	1.088	5.24	3.32	1.92	.001	.28	....	22.5	31.	+	2,360,000
5731	" 28	" 29	*	Cons'd	M. F.5	"	553.6	484.	69.6	71.6	40.	31.6	Gh.	118.	35.4	25.2	10.2	18.	2.4	1.44	.96	4.12	3.	1.12	......	.28	....	24.	29.	....	1,620,000
5790	Sept. 4	Sept. 5	*	Much	M. F.8	"	488.	423.6	64.4	52.8	30.4	22.4	Gh.	103.	32.2	17.8	14.4	15.	2.24	.608	1.632	4.76	1.944	2.816	.004	.16	....	23.	29.	+	1,010,000
5837	" 11	" 12	*	"	M. F.6	"	558.	490.4	67.6	81.6	63.6	18.	Gh.	129.5	36.9	18.8	18.1	17.6	2.32	.704	1.616	4.44	1.24	3.2	......	.16	....	18.	26.	....	....
5882	" 18	" 19	*	"	M. F.5	"	501.6	441.2	60.4	70.4	44.4	26.	B.	110.	33.2	17.4	15.8	15.4	2.24	.72	1.52	4.28	2.44	1.84	.002	.2	....	20.	21.	....	660,000
5936	" 25	" 26	*	"	M. F.7	"	582.	506.4	75.6	63.2	40.	23.2	B.	139.	45.6	23.6	22.	18.	2.24	1.44	.8	4.26	2.5	1.76	......	.24	....	15.5	20.	+	420,000
5984	Oct. 2	Oct. 3	*	"	M. F.5	"	526.	451.6	74.4	61.6	36.4	25.2	B.	114.	41.1	21.4	19.7	14.	2.4	1.44	.96	4.74	2.66	2.08	......	.16	....	11.	25.	+	1,237,500
6079	" 16	" 17	*	"	M. F.2	"	480.4	415.2	65.2	52.8	20.4	32.4	B.	116.	23.5	11.8	11.7	14.8	2.16	.96	1.2	4.68	2.04	2.64	......	.2	....	19.	21.	+	1,410,000
6146	" 23	" 24	*	"	M. F.7	"	489.2	431.2	58.	36.8	15.6	21.2	G.	118.	31.3	16.3	15.	14.8	2.8	.672	2.128	4.68	1.864	2.816	......	.28	....	19.	23.	+	1,410,000
6193	" 30	" 31	*	"	M. F.7	"	532.8	468.	64.8	56.4	30.8	25.6	G.	116.5	26.3	12.3	14.	14.8	2.96	.8	2.16	5.48	1.4	4.08	.003	.4	....	12.	18.	+	1,110,000
6243	Nov. 6	Nov. 7	*	"	M. F.5	"	546.	498.4	47.6	45.6	23.2	22.4	B.	121.	34.7	14.8	19.9	14.8	2.8	1.28	1.52	5.48	2.12	3.36	......	.28	....	12.	18.	+	320,00
6279	" 13	" 14	*	Cons'd	M. F.4	"	534.	476.4	57.6	59.2	28.4	30.8	B.	.....	28.9	8.9	20.	13.6	2.16	.512	1.648	4.56	1.32	3.24	......	.08	....	10.	......	+	180,00
6338	" 20	" 21	*	Much	M. F.6	"	613.6	498.8	114.8	67.2	24.8	42.4	B.	125.	35.	12.	23.	16.	3.36	1.92	1.44	6.92	3.4	3.52	......	.2	....	12.	18.	+	775,00
6400	" 27	" 28	*	"	M. F.3	"	529.6	460.8	68.8	55.2	22.	33.2	B.	123.	35.5	....	....	17.6	2.56	1.28	1.28	4.52	2.6	1.92	.001	.08	....	9.	18.	+	525,00
6446	Dec. 4	Dec. 6	*	"	M. F.4	"	531.2	451.2	80.	64.4	37.6	26.8	G.	111.	27.3	18.7	8.6	15.2	2.4	1.44	.96	5.	2.344	2.656	.001	.16	....	9.	......	+	695,00
6543	" 18	" 20	*	Cons'd	M. F.04	"	553.2	483.6	69.6	81.2	40.8	40.4	G.	111.5	27.3	14.6	12.7	14.4	4.32	2.08	2.24	6.76	3.16	3.6	.002	.16	....	9.	4.	?	490,00
6583	" 26	" 27	*	Much	M. F.6	"	633.6	562.4	71.6	69.2	44.	25.2	G.	167.5	36.6	23.	13.6	20.	4.	2.24	1.76	7.72	5.48	2.24	.005	.2	....	7.	7.	....	875,00

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 3.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—DESPLAINES RIVER, LOCKPORT.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illino

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Suspnd'd							Tot'l	Dissolv'd	Suspnd'd										
5071	May 22	May 23	†	Little	F.03	None	369.6	350.8	18.8	27.6	13.6	14.	B.	3.95	15.2	15.	.2	.016	.512	.448	.064	1.21	1.05	.16	.026	.24	....	....	......	....	......
5119	" 29	" 31	*	"	M. F.3	"	375.6	353.6	22.	38.	36.	2.	B.	1.5	17.	14.	3.	.132	.72	.416	.304	1.21	.97	.24	.027	.4	18.4	....	24.4	....	......
5157	June 5	June 6	†	Cons'd	M. F.6	"	300.	264.4	35.6	36.	26.	10.	B.	2.5	16.7	14.5	2.2	.1	.48	.416	.064	1.29	.89	.4	.07	.48	17.9	....	32.2	—	7,50
5203	" 12	" 14	†	"	M. F.5	"	439.2	358.	81.2	67.2	36.8	30.4	B.	3.4	18.3	15.4	2.9	.144	.768	.704	.064	1.16	1.016	.144	.02	.44	18.7	....	27.7	—	15,30
5247	" 19	" 21	*	"	M. F.2	"	418.4	405.2	13.2	56.	52.8	3.2	B.	2.5	16.2	13.4	2.8	.144	.544	.448	.096	1.24	1.016	.224	.002	.36	1.	20.	28.3	—	3,70
5290	" 26	" 27	†	Little	F.2	"	319.6	280.	39.6	35.6	34.	1.6	B.	5.5	15.8	14.3	1.5	.06	.544	.48	.064	1.16	.952	.208	.001	.12	1.	24.	27.	—	33,15
5330	July 3	July 4	†	"	F.2	"	383.6	369.2	14.4	39.6	38.8	.8	B.	7.3	15.2	15.	.2	.08	.544	.496	.048	1.176	1.112	.064	.001	.16	....	25.	29.	....	6,10
5388	" 10	" 11	†	"	M. F.4	"	349.6	342.8	6.8	38.8	36.	2.8	B.	6.45	13.7	12.6	1.1	.04	.448	.4	.048	1.08	.76	.32	.008	.4	1.	24.	27.	....	1,35
5435	" 17	" 18	*	Cons'd	M. F.5	"	271.6	194.8	76.8	45.2	40.	5.2	B.	3.2	15.3	11.6	3.7	.128	.544	.32	.224	1.24	.824	.416	.03	.52	2.4	24.	29.	....	8,75
5482	" 24	" 25	†	"	M. F.4	"	309.6	284.4	25.2	49.2	48.4	.8	B.	4.1	15.	13.4	1.6	.088	.544	.416	.128	1.24	.92	.32	.012	.36	1.	26.	29.	....	28,45
5531	" 31	Aug. 1	†	Little	M. F.2	"	331.2	325.6	5.6	61.2	59.2	2.	Gh.	5.7	15.5	14.5	1.	.028	.512	.448	.064	.888	.782	.106	.011	.2	1.	23.	27.	....	10,20
5578	Aug. 7	" 8	†	"	M. F.4	"	338.	324.8	13.2	72.8	70.4	2.4	Gh.	6.8	14.3	13.4	.9	.02	.48	.416	.064	1.16	.856	.304	.002	.2	1.	23.	27.	+	9,80
5627	" 14	" 15	†	"	F.15	"	302.	297.2	4.8	78.4	73.2	5.2	Gh.	7.25	12.8	12.7	.1	.044	.48	.368	.112	1.16	.856	.304	.....	.2	....	....	......	....	......
5675	" 21	" 22	‖	"	F.15	"	346.8	343.6	3.2	68.4	....	....	Gh.:	10.4	13.7	13.1	.6	.032	.448	.416	.032	1.16	1.08	.08	.002	.16	1.2	24.	29.	+	15,400
5732	" 28	" 29	†	"	M. F.25	"	316.8	313.6	3.2	46.4	46.	.4	Gh.	9.2	13.7	13.1	.6	.04	.512	.464	.048	.92	.84	.08	.003	.08	1.	25.	29.	....	120,000
5789	Sept. 4	Sept. 5	†	"	M. F.15	"	310.4	302.4	8.	50.	49.2	.8	B.	8.6	13.1	13.	.1	.092	.576	.416	.16	1.112	.824	.288	.005	.16	1.	21.	29.	+	15,800
5836	" 11	" 12	‖	"	F.08	"	300.8	298.8	2.	67.6	66.	1.6	G.	8.55	12.6	12.6	0.0	.06	.512	.432	.08	1.16	.888	.272	.001	.12	....	20.	28.	+	21,000
5883	" 18	" 19	†	"	F.05	"	289.2	288.8	.4	46.	45.6	.4	B.	8.85	8.9	....	....	.062	.512	.432	.08	1.24	.924	.316	.003	.32	....	18.	21.	....	44,000
5937	" 25	" 26	†	"	M. F.04	"	304.	304.	0.0	27.2	26.8	.4	GB.	7.4	9.6	8.8	.8	.024	.404	.34	.064	.868	.74	.128	.001	.16	....	15.5	20.	?	12,200
5985	Oct. 2	Oct. 3	†	"	F.07	"	315.2	312.8	2.4	54.4	52.8	1.6	B.	7.7	10.	....	....	.054	.448	.416	.032	.82	.612	.208	.002	.12	....	14.	24.	....	......
6036	" 9	" 11	†	"	F.1	"	352.8	343.6	9.2	43.2	41.6	1.6	B.	7.9	9.3	9.1	.2	.032	.392	.332	.06	.772	.664	.108	.001	.2	1.	20.	21.	....	......
6078	" 16	" 17	†	"	M. F.10	"	360.4	351.6	8.8	35.6	34.8	.8	B.	9.6	13.1	12.5	.6	.232	.32	.288	.032	.904	.808	.096	.....	.16	1.	20.	24.	+	37,200
6145	" 23	" 24	‖	"	M. F.15	"	355.2	351.2	4.	26.	18.	8.	G.	8.4	7.9	7.7	.2	.028	.352	.32	.032	.76	.52	.24	.....	.12	1.	20.	23.	+	30,500
6194	" 30	" 31	‖	"	M. F.25	"	406.	397.2	8.8	24.8	22.	2.8	B.	8.5	8.1	7.7	.4	.024	.368	.32	.048	.648	.424	.224	.002	.08	1.4	14.	18.	+	19,700
6242	Nov. 6	Nov. 7	†	"	F.08	"	438.8	433.	5.8	36.	23.5	12.5	B.	12.3	8.1	7.2	.9	.104	.48	.256	.224	.904	.632	.272	.001	.24	1.	9.	20.	—	4,800
6280	" 13	" 14	‖	"	F.03	"	475.6	469.2	6.4	47.6	45.2	2.4	B.	15.1	7.1	7.1	0.0	.06	.512	.288	.224	1.	.584	.416	.006	.4	1.	8.	......	—	4,500
6337	" 20	" 21	‖	"	F.03	"	438.4	428.4	10.	19.6	19.2	.4	G.	18.	6.7	6.6	.1	.032	.432	.32	.112	.744	.584	.16	.001	.28	....	11.	18.	+	9,300
6399	" 27	" 28	‖	"	F.02	"	450.4	446.8	3.6	32.8	31.6	1.2	B.	18.5	6.3	....	....	.028	.224	.192	.032	.616	.488	.128	.006	.48	....	8.	18.	+	9,900
6447	Dec. 4	Dec. 6	‖	"	F.02	"	444.	440.	4.	50.	48.4	1.6	G.	15.	5.3	5.2	0.0	.044	.208	.192	.016	.68	.552	.128	.001	.32	....	0.	......	—	4,960
6495	" 11	" 13	†	"	F.10	"	377.2	344.8	32.4	36.4	30.4	6.	G.	11.	7.8	4.9	2.9	.048	.32	.16	.16	.68	.424	.256	.003	.32	1.	9.	18.	+	......
6544	" 18	" 20	†	"	M. F.03	"	431.6	421.6	10.	40.	38.	2.	B.	13.75	8.2	8.2	0.0	.34	.368	.352	.016	.776	.68	.096	.003	1.04	....	8.	4.	+	20,950
6582	" 26	" 27	†	"	F.04	"	538.	514.	24.	65.2	56.4	8.8	B.	12.75	8.9	8.9	0.0	.152	.272	.256	.016	.776	.584	.192	.003	.72	1.	6.	0.	....	......

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 4.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—DESPLAINES RIVER, NORTH OF JACKSON ST., JOLIET.

Report of **ARTHUR W. PALMER,**
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dis-solv'd	Loss on Ig'n. Sus-pnd'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dis-solv'd	Albuminoid Am. Sus-pnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
5077	May 23	May 24	*	Cons'd	M. F.5	None	544.	500.4	43.6	55.6	34.8	20.8	B.	69.7	33.3	23.	10.3	8.8	2.4	.768	1.632	5.13	2.65	2.48	.012	.35	....	....	......	....	....
5109	" 29	" 30	§	"	M. F.3	"	500.4	460.8	99.6	52.8	25.6	27.2	B.	76.	30.5	18.6	11.9	10.8	2.56	.864	1.696	5.05	1.85	3.2	.001	.4	....	....	......	....	....
5153	June 5	June 6	†	"	M. F.5	"	464.8	399.2	65.6	44.4	38.	6.4	B.	50.	27.2	17.1	10.1	7.4	1.152	.608	.544	2.33	1.274	1.056	.09	.36	....	....	......	+	1,072,500
5202	" 12	" 13	*	"	M. F.6	Gas'y	640.	559.6	80.4	97.6	49.6	48.	B.	97.5	37.1	19.8	17.3	12.8	2.64	1.28	1.36	5.08	1.48	3.6	.003	.2	....	....	......	+	2,465,000
5239	" 19	" 20	*	"	M. F.4	"	646.	587.6	58.4	57.2	49.2	8.	B.	120.	40.5	25.4	15.1	16.	2.72	.96	1.76	4.92	1.88	3.04	.004	.2	....	21.	24.	+	672,500
5284	" 26	" 27	*	"	M. F.5	"	552.8	467.6	85.2	52.8	34.4	18.4	B.	91.7	36.8	22.2	14.6	12.8	2.24	1.024	1.216	4.28	2.2	2.08	.001	.16	....	21.	24.	+	1,576,000
5327	July 3	July 4	*	"	M. F.2	"	546.4	483.2	63.2	76.	52.	24.	B.	111.5	33.9	4.2	29.7	16.4	1.92	1.12	.8	4.92	2.76	2.16	.....	.12	....	22.	24.	....	1,320,000
5380	" 10	" 11	.	....	M. F.5	"	587.2	537.6	49.6	80.	63.2	16.8	B.	110.5	24.7	15.	9.7	12.8	1.52	.88	.64	4.28	1.88	2.4	.005	.24	....	21.5	19.	....	....
5431	" 17	" 18	*	Cons'd	M. F.15	"	505.2	400.	105.2	60.	50.	10.	B.	81.	23.1	15.7	7.4	6.4	1.12	.496	.624	2.52	1.016	1.504	.021	.44	....	21.	19.	....	1,700,000
5477	" 24	" 25	*	"	M. F.8	"	560.	521.6	38.4	87.6	78.8	8.8	B.	95.	25.1	17.2	7.9	11.4	1.44	.864	.576	3.64	1.56	2.08	.004	.2	...	25.	23.	....	5,525,000
5544	" 31	Aug. 3	*	"	M. F.25	"	508.	439.6	68.4	85.6	54.8	30.8	B.	86.	26.2	13.4	12.8	10.8	1.44	.4	1.04	3.72	1.4	2.32	.015	.24	....	22.	15.	....	5,300,000
5572	Aug. 7	" 8	*	"	M. F.05	"	625.6	468.	157.6	91.2	66.8	24.4	B.	106.	33.8	20.2	13.6	20.	1.84	.56	1.28	4.12	.984	3.136	.003	.24	....	21.	10.5	+	4,300,000
5629	" 14	" 15	*	Much	M. F.5	"	549.2	435.2	114.	91.6	54.	37.6	Gh.	105.	29.	15.7	13.3	26.4	1.6	.544	1.056	3.4	1.432	1.968	.005	.2	....	22.	15.	....	....
5669	" 21	" 22	*	Cons'd	M. F.3	"	502.4	450.	52.4	54.8	48.	6.8	Gh.	104.	26.6	18.2	8.4	16.8	1.6	.64	.96	3.16	1.72	1.44	.002	.2	....	24.	16.	+	2,550,000
5727	" 28	" 29	§	V.M'ch	VM.F.25	"	527.2	468.	59.2	30.	23.6	6.4	B.	109.	29.5	16.8	12.7	19.2	1.92	.704	1.216	4.28	1.4	2.88	.022	.12	....	22.	18.	....	7,300,000
5787	Sept. 4	Sept. 5	*	Much	M. F.25	"	517.6	475.2	42.4	47.6	30.	17.6	B.	111.2	28.1	20.7	7.4	19.6	1.04	.864	.176	3.72	1.88	1.84	.005	.16	....	20.	15.	....	350,000
5829	" 11	" 12	*	"	M. F.4	"	492.8	450.4	42.4	37.2	35.6	1.6	B.	110.5	24.6	15.1	9.5	17.6	1.84	.448	1.392	3.16	1.08	2.08	.002	.24	....	11.	17.	+	216,000
5933	" 25	" 26	*	Cons'd	M. F.06	"	542.8	448.5	94.3	42.8	9.6	33.2	B.	121.	26.8	16.5	10.3	18.4	2.	.608	1.392	3.7	1.54	2.16	.002	.2	....	15.	9.	+	85,000
6024	Oct. 2	Oct. 7	*	Much	M. F.25	"	583.6	532.	51.6	34.8	18.4	16.4	B.	129.	31.8	16.9	14.9	18.	2.24	.64	1.6	3.7	1.06	2.64	.003	.08	....	14.	9.	....	....
6076	" 16	" 17	*	"	M. F.4	"	444.8	400.4	44.4	39.6	26.8	12.8	B.	92.5	23.4	14.6	8.8	12.8	2.	.928	1.072	3.56	2.04	1.52	.015	.2	....	20.	16.	+	710,000
6139	" 23	" 24	*	"	M. F.5	"	505.2	463.2	43.	28.	22.8	5.2	B.	111.5	17.9	11.2	6.7	14.8	2.24	1.2	1.04	4.68	1.64	3.04	.006	.2	....	13.	17.	+	1,550,000
6180	" 30	" 31	*	Cons'd	M. F.3	"	524.	470.4	53.6	44.	24.8	19.2	G.	123.5	24.1	13.9	10.2	15.2	2.4	.64	1.76	4.52	1.32	3.2	.005	.16	....	0.	2.	....	680,000
[illegible]	Nov. 6	Nov. 7	*	"	M. F.6	"	606.	558.4	47.6	53.6	37.6	16.	G.	138.5	27.6	17.9	9.7	17.6	3.2	1.04	2.16	4.68	2.04	2.64	.01	.32	....	-1.	—6.	+	830,000
6271	" 13	" 14	*	"	M. F.5	"	......	496.8	......	.....	24.4	....	......	116.	27.8	18.6	9.2	14.8	2.24	.704	1.536	5.	2.28	2.72	.008	.12	....	6.	3.	+	1,280,000
[illegible]	[illegible] 20	" 21	§	V.M'ch	M. F.1	"	828.4	582.	246.4	84.4	28.	56.4	B.	144.	35.	12.1	22.9	18.	3.2	.832	2.368	6.44	1.72	4.72	.004	.2	....	8.	0.	+	1,980,000
[illegible]	[illegible]	[illegible] 28	*	Much	M. F.25	"	611.6	498.4	143.2	65.6	32.8	32.8	B.	111.	25	11.4	13.6	14.	2.8	.704	2.096	6.12	1.16	4.96	.004	.08	....	0.	—8.	+	345,00
[illegible]	[illegible]	[illegible] 5	[illegible]	"	M. F.25	"	622.4	492.	130.4	64.	48.	16.	G.	106.	23.5	10.6	12.9	15.2	2.24	.704	1.536	4.36	1.16	3.2	.004	.32	...	2.	10.	+	1,185,00
[illegible]	[illegible]	[illegible]	[illegible]	"	M. F.50	"	587.2	430.	157.2	58.	32.4	25.6	G.	98.5	15.6	11.1	4.5	12.	2.96	.96	2.	5.32	1.88	3.44	.001	.12	...	4.5	11.	+	2,210,00
[illegible]	[illegible]	[illegible]	[illegible]	Cons'd	M. F.25	"	647.6	540.4	107.2	78.8	54.8	24.	B.	123.5	28.5	14.9	13.6	16.8	4.32	1.2	3.12	8.52	1.96	6.56	.01	.2	....	9.	10.	+	340,00
6575	" [illegible]	[illegible] 27	*	Much	M. F.2	"	632.	515.2	116.8	69.6	24.8	44.8	B.	121.	39.7	19.4	20.3	14.	3.04	1.76	1.28	6.76	3.72	3.04	.027	.28	....	10.	15.	+	370,00

TURBIDITY—*Decided. §Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.
COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red.
Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 5.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—DESPLAINES RIVER, SOUTH OF TOWN, JOLIET.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	DATE OF		APPEARANCE.			Odor.	RESIDUE ON EVAPORATION.						Color on Ignition.	Chlorine.	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on ig'n.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dis-solv'd	Sus-pnd'd							Tot'l	Dis-solv'd	Sus-pnd'd										
5076	May 23	May 24	*	Cons'd	M. F.4	None	648.	509.2	138.8	59.2	31.6	27.6	B.	71.	37.	17.8	19.2	8.	2.64	.72	1.92	5.53	2.49	3.04	.006	.3	....	....	......	....	....
5108	" 29	" 30	§	"	M. F.2	"	596.	373.2	222.8	51.6	30.	21.6	B.	76.	32.9	16.6	16.3	10.8	2.56	.832	1.728	5.69	1.61	4.08	.009	.36	....	....	......	....	....
5152	June 5	June 6	†	"	M. F.5	"	454.4	388.8	65.6	41.2	32.8	8.4	B.	50.2	23.2	17.5	5.7	7.2	1.12	.56	.56	2.09	1.4	.69	.07	.2	....	....	......	+	1,137,500
5201	" 12	" 13	*	"	M. F.5	Gas'y	657.6	546.4	111.2	96.8	38.6	58.2	B.	98.	35.	19.	16.	13.6	2.08	.96	1.12	3.96	1.88	2.08	.004	.2	....	....	......	+	1,715,000
5240	" 19	" 20	*	"	M. F.4	"	678.8	582.	96.8	57.6	34.	23.6	B.	120.	40.	23.	17.	17.6	2.64	.72	1.92	5.72	1.368	4.352	.002	.45	....	22.	......	+	1,330,000
5285	" 26	" 27	*	"	M. F.4	"	554.	464.8	89.2	58.8	40.8	18.	B.	89.	35.1	19.3	15.8	12.	2.32	.704	1.616	4.44	1.4	3.04	.001	.24	....	21.	25.	+	1,295,000
5228	July 3	July 4	*	"	M. F.2	"	549.2	487.2	62.	72.4	50.4	22.	B.	107.5	30.7	5.1	25.6	14.8	2.	.72	1.28	4.6	1.8	2.8	.001	.24	....	22.5	24.	....	1,955,000
5379	" 10	" 11	*	"	M. F.5	"	577.6	130.5	447.1	78.4	67.6	10.8	B.	104.	25.3	15.4	9.9	13.2	1.68	.672	1.008	4.28	1.336	2.944	.004	.24	....	21.	19.	....	....
5430	" 17	" 18	*	"	M. F.2	"	579.2	412.	167.2	52.8	44.8	8.	B.	84.	25.9	15.7	10.2	7.4	1.28	.512	.768	2.76	1.048	1.712	.03	.48	....	22.	19.	....	1,560,000
5478	" 24	" 25	*	"	M. F.5	"	615.6	503.6	112.	79.6	54.	25.6	B.	93.	28.1	16.4	11.7	12.	1.84	.736	1.104	4.28	1.16	3.12	.004	.24	....	25.	23.	....	6,090,000
5545	" 31	Aug. 3	*	"	M. F.3	"	631.2	442.8	188.4	109.2	62.8	46.4	B.	85.5	35.5	14.4	21.1	11.2	2.08	.48	1.6	4.6	1.24	3.36	.006	.28	....	22.	18.	....	6,800,000
5573	Aug. 7	" 8	*	Much	M. F.06	"	719.6	505.6	214.	28.8	24.4	4.4	Gh.	134.7	39.	17.	22.	16.	2.56	.64	1.92	5.56	1.144	4.416	.002	.32	....	20.	18.	?	6,300,000
5630	" 14	" 15	*	"	M. F.25	"	550.8	512.4	38.4	82.8	60.8	22.	Gh.	113.	27.9	17.5	10.4	14.	1.36	.48	.88	3.	1.176	1.824	.004	.2	....	22.	17.	....	....
5670	" 21	" 22	§	V.M'ch	M. F.15	"	686.8	497.6	189.2	73.6	43.2	30.4	Gh.	114.	35.	18.2	16.8	13.8	2.24	.512	1.728	5.08	1.08	4.	.002	.2	....	23.	18.	+	3,266,660
5728	" 28	" 29	§	"	VM. F.06	"	647.6	512.8	134.8	83.6	39.6	44.	B.	116.	32.7	14.4	18.3	16.	2.16	.512	1.648	4.76	.84	3.92	.002	.08	....	23.	18.	....	2,090,000
5786	Sept. 4	Sept. 6	*	Much	M. F.08	"	590.8	510.8	80.	42.4	25.6	16.8	B.	130.	26.7	14.7	12.	11.9	1.12	.352	.768	4.28	.92	3.36	.01	.2	....	22.	17.	....	1,750,000
5830	" 11	" 12	*	"	M. F.35	"	490.8	442.4	48.4	52.	42.8	9.2	B.	110.5	24.2	14.	10.2	18.	1.68	.448	1.232	3.32	1.08	2.24	.002	.2	....	17.	12.	+	220,000

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 6.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—KANKAKEE RIVER, WILMINGTON.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dissolv'd	Loss on Ig'n. Suspnd'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
5156	June 5	June 6	†	Cons'd	M. F.5	None	326.8	264.4	62.4	30.4	29.6	.8	B.	3.7	17.1	13.	4.1	.072	.56	.364	.196	1.29	.92	.37	.026	1.32	3.	....	......	—	46,900
5200	" 12	" 13	†	"	M. F.5	"	346.4	289.6	56.8	46.8	42.8	4.	B.	2.	19.5	17.5	2.	.128	.684	.608	.076	1.48	1.176	.304	.009	.76	2.3	....	21.	—	23,700
5255	" 19	" 21	†	"	M. F.4	"	317.2	299.6	17.6	24.8	22.8	2.	B.	2.	19.5	16.6	2.9	.06	.544	.448	.096	1.32	1.024	.296	.005	.48	1.5	20.	8.	....	4,000
5292	" 26	" 27	†	"	M. F.3	"	350.8	298.4	52.4	24.8	12.8	12.	B.	2.	18.9	16.3	2.6	.042	.48	.368	.112	1.24	.952	.288	.001	.12	1.	24.	21.	—	17,700
5382	July 10	July 11	*	"	M. F.15	"	292.4	260.4	32.	42.4	32.4	10.	B.	3.9	10.2	7.5	2.7	.044	.384	.24	.144	.92	.6	.32	.01	.52	1.	23.	18.	....	810
5424	" 17	" 18	†	"	M. F.05	"	364.4	332.8	31.6	67.2	60.	7.2	Gh.	3.2	11.8	10.2	1.6	.076	.352	.256	.096	1.016	.824	.192	.06	3.6	1.6	22.	18.	....	12,400
5479	" 24	" 25	†	Little	M. F.15	"	298.8	263.2	35.6	39.6	35.2	4.4	Gh.	3.65	11.4	9.2	2.2	.016	.48	.256	.224	.84	.....	.....	.008	.32	1.3	27.	26.	....	950
5530	" 31	Aug. 1	*	Cons'd	M. F.05	"	316.4	250.	66.4	51.6	50.8	.8	Gh.	3.4	14.2	11.	3.2	.068	.448	.228	.22	.84	.6	.24	.012	.24	1.3	24.	16.	....	2,550
5571	Aug. 7	" 8	*	"	M. F.03	"	372.4	245.6	126.8	100.4	54.	46.4	Gh.	3.2	15.	10.5	4.5	.048	.48	.24	.24	1.16	.504	.656	.004	.24	1.	22.	18.	+	2,100
5626	" 14	" 15	†	"	M. F.1	"	303.6	230.8	72.8	52.	46.4	5.6	Gh.	4.1	14.	9.4	4.6	.052	.448	.208	.24	.984	.536	.448	.006	.16	1.	22.	17.	....	....
5673	" 21	" 22	†	"	M. F.15	"	297.6	237.2	60.4	30.8	....	....	Gh.	3.9	11.8	9.	2.8	.044	.352	.272	.08	.984	.552	.432	.002	.08	1.	22.	22.	....	4,550
5729	" 28	" 29	*	"	M. F.06	"	312.8	239.2	73.6	23.6	17.2	6.4	Gh.	3.9	11.5	9.2	2.3	.06	.48	.256	.224	1.	.536	.464	.007	.2	.1	25.	20.	....	6,800
5788	Sept. 4	Sept. 5	*	"	M. F.04	"	303.6	241.2	62.4	28.	22.8	5.2	B.	4.55	11.1	9.1	2.	.092	.448	.256	.192	.888	.6	.288	.008	.2	.1	23.	17.	+	6,050
5832	" 11	" 12	*	"	M. F.15	"	278.	238.4	39.6	36.8	24.8	12.	B.	5.3	11.3	7.8	3.5	.08	.32	.224	.096	.92	.796	.124	.013	.2	.1	19.	16.	+	2,850
5879	" 18	" 19	*	"	M. F.08	"	286.4	226.4	60.	43.2	32.4	10.8	B.	4.75	9.8	6.2	3.6	.044	.416	.272	.144	.84	.648	.192	.007	.2	.1	20.	16.	—	9,300
5932	" 25	" 26	†	"	M. F.04	"	263.2	234.	29.2	22.4	21.6	.8	B.	5.4	8.9	7.	1.9	.036	.272	.24	.032	.804	.548	.256	.004	.16	.1	11.	16.	?	2,750
5981	Oct. 2	Oct. 3	†	Little	M. F.07	"	240.8	232.8	8.	28.4	26.8	1.6	B.	4.8	8.3	6.9	1.4	.012	.256	.208	.048	.58	.404	.176	.004	.16	.8	8.	10.	+	5,750
6029	" 9	" 10	†	"	M. F.03	"	265.6	253.6	12.	22.	....	....	B.	4.9	7.	6.7	.3	.012	.256	.24	.016	.532	.392	.14	.005	.12	.1	13.	7.	+	2,200
6077	" 16	" 17	†	"	M. F.03	"	288.4	249.2	39.2	26.	23.2	2.8	B.	4.9	7.3	6.8	.5	.028	.176	.096	.08	.68	.36	.32	.005	.24	0.1	19.	19.	+	3,850
6142	" 23	" 24	†	Cons'd	M. F.04	"	......	241.2	......	.....	14.4	....	G.	4.7	5.8	4.9	.9	.016	.24	.16	.08	.456	.36	.096	.004	.08	0.1	14.	18.	+	32,500
6188	" 30	" 31	†	Little	M. F.04	"	255.2	229.2	26.	31.2	30.	1.2	G.	4.7	5.3	4.7	.6	.02	.176	.128	.048	.312	.2	.112	.005	.16	0.1	10.	17.	+	4,450
6237	Nov. 6	Nov. 7	†	"	F.04	"	276.	273.6	2.4	16.	15.8	.2	G.	4.8	6.5	5.6	.9	.02	.24	.208	.032	.552	.424	.128	.002	.32	1.2	5.	1.	+	4,100
6269	" 13	" 14	†	"	F.04	"	......	.....	......	.....	.....	....	......	4.	7.7	7.7	0.0	.012	.288	.256	.032	.76	.712	.048	.03	2.4	1.6	5.	7.	+	4,100
6332	" 20	" 21	†	Cons'd	M. F.1	"	317.6	300.8	16.8	36.	33.6	2.4	B.	3.55	8.4	8.	.4	.036	.288	.256	.032	.808	.616	.192	.02	3.6	1.8	8.	5.	+	3,800
6396	" 27	" 29	†	"	M. F.2	"	310.4	297.6	12.8	25.2	21.2	4.	G.	3.6	9.5	9.2	.3	.054	.32	.288	.032	1.	.84	.16	.024	2.4	1.6	5.	0.	+	41,800
6443	Dec. 4	Dec. 5	†	Little	F.15	"	296.4	289.2	7.2	39.2	38.4	.8	G.	3.6	8.8	8.8	.0	.036	.336	.304	.032	.776	.68	.096	.007	1.68	1.8	4.	4.	+	33,800
6493	" 11	" 12	‖	"	F.07	"	280.8	279.2	1.6	41.2	41.2	.0	B.	3.7	9.3	9.1	.2	.028	.432	.364	.068	.776	.68	.096	.005	1.48	1.8	6.	6.	+	7,80
6541	" 18	" 19	*	Cons'd	M. F.20	"	313.2	280.	33.2	50.	15.2	4.8	G.	3.1	11.6	9.7	1.9	.06	.352	.224	.128	1.	.84	.16	.018	6.	0.	2.	0.	+	39,00
6580	" 26	" 27	†	"	M. F.15	"	297.2	272.	25.2	41.6	36.8	4.8	B.	3.5	10.7	9.7	1.	.068	.288	.24	.018	.936	.68	.256	.013	4.	1.8	5.	5.	+	20,60

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 7.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, MORRIS, ILL.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n. Tot'l	Dissolv'd	Suspnd'd			Total.	By Dissolved	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Dissolv'd	Suspnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
5112	May 29	May 30	†	Cons'd	M. F.4	None	445.2	419.2	26.	63.2	54.	9.2	B.	44.2	19.2	15.	4.2	8.8	.88	.544	.336	1.93	1.18	.75	.035	.44	7.3	21.	17.	....	....
5164	June 6	June 7	*	"	M. F.25	"	402.8	324.8	78.	55.2	52.	3.2	B.	32.	15.4	11.4	4.	3.6	.8	.544	.256	2.17	1.23	.94	.06	.64	8.9	25.	25.	?	455,000
5209	" 13	" 14	*	"	M. F.5	"	427.2	420.4	6.8	39.6	34.4	5.2	B.	43.5	19.1	15.2	3.9	5.6	.736	.624	.112	1.72	1.24	.48	.06	.44	6.	26.	22.	+	1,397,000
5245	" 19	" 20	..	....	....	"	......	......	......	......	......	....	......	......	....	....	....	......	......	......	......	......	......	....	....	....	5.3	24.	......	?	717,500
5299	" 27	" 28	†	Cons'd	M. F.25	"	372.4	355.6	16.8	27.2	24.4	2.8	B.	48.	17.6	15.2	2.4	6.8	.672	.512	.16	1.4	.92	.48	.028	.24	5.2	24.	20.	+	1,430,000
5332	July 3	July 4	†	"	F.2	"	403.2	395.6	7.6	33.6	22.8	10.8	B.	57.5	15.3	13.5	1.8	7.52	.672	.448	.224	1.72	1.144	.576	.011	.2	5.2	26.	21.	....	2,070,000
5393	" 11	" 12	†	"	M.	"	451.6	445.2	6.4	47.6	40.4	7.2	B.	71.	15.8	14.1	1.7	8.8	.768	.528	.24	1.88	1.08	.8	.03	.2	5.3	24.	19.	....	441,000
5428	" 17	" 18	*	"	M. F.06	Gas'y	373.2	312.8	60.4	49.6	46.	3.6	B.	37.	15.5	11.6	3.9	5.6	.8	.336	.464	1.8	.824	.976	.08	1.08	7.5	24.	18.	....	112,000
5484	" 25	" 26	†	Little	M. F.25	None	432.	422.4	9.6	55.6	52.8	2.8	Gh.	58.	14.	12.3	1.7	7.04	.768	.48	.288	2.68	1.48	1.2	.035	.24	6.3	27.	22.	....	1,000,000
5529	" 31	Aug. 1	*	Cons'd	M. F.04	"	421.2	401.2	20.	64.4	54.	10.4	W.	63.	17.3	14.2	3.1	7.68	.736	.448	.288	1.64	1.16	.48	.018	.2	6.	24.	13.	....	1,239,500
5570	Aug. 7	" 8	†	Little	M. F.04	"	425.2	420.4	4.8	46.8	43.2	3.6	Gh.	70.2	16.3	11.9	4.4	12.	.72	.48	.24	1.96	.996	.964	.002	.24	6.3	23.	14.	+	5,850,000
5624	" 14	" 15	†	"	M. F.07	"	394.	......	......	54.	....	....	Gh.	79.	16.3	13.3	3.	11.	.864	.448	.416	1.752	1.048	.704	.005	.28	5.8	21.	14.	....	....
5672	" 21	" 22	†	"	M. F.15	"	398.4	395.6	2.8	39.6	38.	1.6	Gh.	75.	15.5	13.	2.5	12.	.832	.48	.352	1.56	1.08	.48	.005	.12	5.1	25.	19.	....	5,800,000
5738	" 29	" 30	*	Cons'd	M. F.08	"	446.4	440.4	6.	96.8	69.2	27.6	Gh.	92.	14.7	12.7	2.	14.	.88	.464	.416	2.12	1.144	.976	.017	.16	4.1	26.	17.	....	6,550,000
5785	Sept. 4	Sept. 5	*	"	M. F.1	"	434.4	433.2	1.2	44.4	42.	2.4	B.	93.	14.8	13.9	.9	10.4	.64	.448	.192	2.04	1.144	.896	.005	.08	4.1	25.	14.	....	4,890,000
5842	" 12	" 13	†	"	M. F.1	"	444.	361.2	82.8	40.	39.2	.8	G.	98.	17.5	14.3	3.2	12.8	1.344	.528	.816	2.64	1.144	1.496	.004	.08	5.3	20.	16.	+	1,285,000
5930	" 25	" 26	†	"	M. F.05	"	453.6	444.4	9.2	35.2	17.6	17.6	B.	97.5	18.8	11.8	7.	13.2	1.28	.576	.704	2.18	1.06	1.12	.008	.08	5.6	17.	10.	+	383,300
5982	Oct. 2	Oct. 3	*	"	M. F.2	"	448.4	444.4	4.	36.	31.2	4.8	GB.	100.	17.2	11.1	6.1	13.6	.96	.608	.352	1.94	1.06	.88	.015	.24	5.4	10.	12.	+	380,000
6074	" 16	" 17	*	"	M. F.03	"	334.8	328.8	6.	20.8	18.	2.8	B.	62.5	10.7	9.1	1.6	8.	.512	.384	.128	1.124	.836	.288	.012	.4	5.6	20.	19.	+	115,000
6143	" 23	" 24	†	"	M. F.2	"	390.4	372.	18.4	21.2	18.	3.2	G.	75.	11.7	8.6	3.1	10.8	1.184	.608	.576	1.8	.776	1.024	.002	.28	5.6	15.	16.	+	1,020,000
6190	" 30	" 31	†	Little	M. F.15	"	383.6	370.	13.6	24.4	16.	8.4	G.	73.4	11.9	10.9	1.	10.	1.152	.416	.736	1.96	.648	1.312	.001	.08	5.1	10.	—2.	+	2,080,000
6235	Nov. 6	Nov. 7	†	Cons'd	M. F.2	"	389.2	382.	7.2	22.8	22.	.8	G.	65.	12.3	10.5	1.8	8.	1.184	.544	.64	2.04	1.064	.976	.014	.32	6.	16.	—4.	+	910,000
6294	" 14	" 15	†	"	M. F.06	"	401.8	398.4	6.4	43.2	40.	3.2	B.	51.	11.5	8.6	2.9	6.4	1.04	.832	.208	1.96	1.56	.4	.044	1.84	6.3	8.	7.	+	385,000
6329	" 20	" 21	†	"	M. F.13	"	384.4	372.4	12.	35.6	30.	5.6	G.	50.5	11.3	9.7	1.6	6.8	.864	.544	.32	1.64	1.	.64	.08	1.72	6.3	9.	1.	+	245,000
6395	" 27	" 28	†	"	M. F.3	M'sty	401.6	397.6	4.	33.6	28.4	5.2	G.	56.5	12.3	11.8	.5	6.4	1.184	.704	.48	1.96	1.44	.52	.05	1.04	6.3	6.	—4.	+	115,000
6590	Dec. 26	Dec. 27	*	"	M. F.3	None	401.6	389.2	12.4	48.	46.	2.	G.	49.5	12.3	11.9	.4	5.6	1.312	.96	3.52	2.28	1.64	.64	.035	2.8	....	14.	—8.	+	170,000

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 8.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—FOX RIVER, OTTAWA, ILL.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dis-solv'd	Sus-pnd'd							Tot'l	Dis-solv'd	Sus-pnd'd										
5113	May 29	May 30	§	V.M'ch	M. F.06	None	1060.4	244.	816.4	65.6	30.4	35.2	B.	.3	35.5	9.8	25.7	.12	1.92	.32	1.6	5.53	.73	4.8	.05	1.68	6.	....	24.	....	....
5163	June 5	June 7	*	Cons'd	M. F.2	"	459.6	306.4	153.2	44.4	40.8	3.6	B.	1.	15.	9.5	5.5	.128	.64	.304	.336	1.61	.826	.784	.08	.92	4.	29.	21.	—	28,500
5207	" 12	" 14	†	Little	M. F.1	"	335.2	306.	29.2	24.	24.	0.0	B.	2.	10.5	9.3	1.2	.048	.448	.32	.128	1.16	.952	.208	.015	.72	3.	26.	29.	—	1,450
5241	" 19	" 20	†	"	F.1	"	321.6	306.	15.6	36.	35.2	.8	B.	2.5	9.5	9.3	.2	.048	.352	.272	.08	.68	.536	.144	.001	.2	4.	28.	33.	—	12,700
5294	" 26	" 27	†	"	M. F.05	"	320.4	311.6	8.8	39.2	30.8	8.4	B.	4.	9.4	9.3	.1	.04	.256	.24	.016	.84	.536	.304	.....	.08	3.	27.	32.	—	1,460
5335	July 3	July 4	†	"	F.05	"	309.2	305.2	4.	37.6	32.4	5.2	B.	5.	7.7	7.4	.3	.04	.312	.212	.1	1.	.652	.348	.002	.16	3.	28.	35.	....	900
5385	" 10	" 11	†	"	F.1	"	297.2	184.8	112.4	54.8	54.4	.4	B.	6.2	9.	8.6	.4	.048	.32	.24	.08	.84	.504	.336	.....	.24	3.	28.	33.	....	8,750
5433	" 17	" 18	*	Cons'd	M. F.3	"	420.	282.4	137.6	62.	39.2	22.8	B.	4.5	16.8	10.2	6.6	.092	.896	.368	.528	1.8	.792	1.008	.045	1.28	5.	26.	32.	....	4,355
5480	" 24	" 25	‖	Little	M. F.25	"	238.4	220.	18.4	56.4	49.6	6.8	Gh.	4.1	11.4	10.3	1.1	.016	.512	.288	.224	1.16	.632	.528	.005	.2	3.	28.	35.	....	675
5535	" 31	Aug. 2	‖	"	F.15	"	282.4	278.8	3.6	130.8	64.8	66.	Gh.	5.2	10.3	10.3	0.0	.044	.352	.32	.032	.76	.664	.096	.001	.2	3.	25.	32.	....	990
5580	Aug. 7	" 8	†	"	M. F.05	"	296.4	272.4	24.	64.8	61.6	3.2	Gh.	5.3	11.5	10.2	1.3	.012	.448	.288	.16	.92	.536	.384	.....	.16	4.	27.	33.	—	1,010
5632	" 14	" 15	‖	Cons'd	F.05	"	293.6	282.8	10.8	76.	66.	10.	Gh.	4.8	9.5	8.8	.7	.08	.352	.288	.064	.76	.6	.16	.....	.2	3.6	26.	29.	—	2,700
5678	" 21	" 22	‖	Little	F.1	"	285.2	280.8	4.4	58.	58.	0.0	Gh.	5.8	10.4	9.8	.6	.036	.448	.416	.032	.76	.68	.08	.....	.16	4.	28.	33.	?	1,240
5733	" 28	" 29	†	"	M. F.04	"	304.	290.4	13.6	55.2	54.8	.4	Gh.	6.	19.9	19.4	.5	.036	.384	.272	.112	.76	.6	.16	.....	.04	3.	31.	37.	+	15,000
5797	Sept 4	Sept. 6	*	"	M. F.03	"	311.2	306.8	4.4	50.8	49.2	1.6	B.	6.7	8.9	7.1	1.8	.04	.336	.288	.048	.824	.376	.448	.001	.2	3.6	26.	31.	—	10,400
5838	" 11	" 12	‖	"	F.08	"	279.2	270.	9.2	45.6	38.8	6.8	G.	6.1	8.8	8.8	0.0	.02	.32	.288	.032	.728	.536	.192	.....	.12	4.	25.	26.	—	3,430
5880	" 18	" 19	‖	"	F.02	"	291.6	277.6	14.	62.	60.8	1.2	B.	6.15	7.9	6.1	1.8	.024	.352	.256	.096	.76	.6	.16	.....	.08	4.	21.	24.	+	4,000
5939	" 25	" 26	†	"	M. F.04	"	298.8	297.2	1.6	46.	44.	2.	B.	7.2	8.2	7.	1.2	.02	.368	.276	.092	.704	.532	.172	.....	.16	4.	18.5	22.	—	1,460
5996	Oct. 2	Oct. 4	†	"	M. F.05	"	308.8	296.8	12.	68.8	57.2	11.6	G.	7.7	8.9	7.6	1.3	.016	.304	.192	.112	.548	.42	.128	.....	.28	4.	16.	24.	+	2,500
6033	" 9	" 10	†	"	F.04	"	309.2	308.	1.2	38.	38.	....	B.	7.4	7.1	7.	.1	.02	.264	.256	.008	.644	.596	.048	.001	.12	4.	17.5	25.	+	8,000
6083	" 16	" 18	†	"	F.02	"	326.	318.8	7.2	52.4	51.2	1.2	B.	8.	7.	6.9	.1	.128	.416	.336	.08	.648	.488	.16	.001	.24	4.	17.	26.	+	7,000
6152	" 23	" 25	‖	"	F.05	"	318.	308.8	9.2	37.6	33.2	4.4	G.	7.7	6.6	6.6	0.0	.032	.288	.256	.032	.44	.36	.08	.....	.44	4.6	17.5	31.	—	4,400
6199	" 30	Nov. 1	‖	"	F.04	"	320.	299.6	20.4	14.	....	....	G.	7.6	6.2	6.2	0.0	.024	.288	.256	.032	.456	.408	.048	.008	.28	4.	13.	23.	—	6,550
6240	Nov. 6	" 7	†	"	F.03	"	315.2	300.8	14.4	46.	41.6	4.4	B.	7.2	5.9	5.8	.1	.032	.304	.272	.032	.584	.52	.064	.002	.24	4.	9.	21.	—	3,25
6378	" 13	" 14	‖	"	F.03	"	337.6	328.8	8.8	38.8	32.4	6.4	B.	7.	4.6	4.5	.1	.012	.352	.208	.144	.488	.296	.192	.....	.08	3.6	9.5	10.	+	2,30
6336	" 20	" 21	‖	"	F.02	"	315.6	312.	3.6	36.	34.8	1.2	G.	7.7	5.5	5.3	.2	.024	.304	.256	.048	.616	.552	.064	.003	.24	3.6	13.	11.	—	4,35
6402	" 27	" 28	‖	"	F.02	"	312.4	309.6	2.8	57.2	56.4	.8	B.	8.	5.	....	....	.02	.224	.16	.064	.456	.36	.096	.012	.4	3.6	7.	8.	—	13,00
6505	Dec. 11	Dec. 14	‖	"	M. F.02	"	330.4	326.4	4.	60.4	58.4	2.	B.	7.6	6.2	6.2	.0	.16	.272	.256	.016	.616	.488	.128	.01	.56	4.	11.	11.	—	8,70
6574	" 21	" 23	†	"	F.02	"	328.4	324.8	3.6	40.4	40.	.4	......	7.6	6.9	6.8	.1	.168	.224	.224	.0	.6	.48	.12	.01	.72	4.	2.	3.	—	10,80
6594	" 28	" 29	†	"	F.02	"	420.8	418.	2.8	88.	86.8	1.2	G.	9.	7.1	6.7	.4	.12	.224	.176	.048	.52	.424	.096	.004	.8	3.6	0.	0.	+	1,50

TURBIDITY—*Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.
COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bb., Brownish. R., Red.
Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 9.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, OTTAWA, ILL.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Susp'd							Tot'l	Dissolv'd	Susp'd										
5242	June 19	June 20	†	Little	F.3	None	392.8	383.2	9.6	61.6	53.4	8.2	B.	30.	15.9	15.8	.1	1.36	.544	.512	.032	1.24	.984	.256	.5	1.28	4.6	26.	33.	—	12,800
5295	" 26	" 27	†	"	M. F.3	"	402.8	400.4	2.4	24.	23.6	.4	B.	47.	15.5	14.9	.6	3.28	.512	.496	.016	1.24	1.176	.064	.6	.6	4.	26.	32.	—	28,300
5334	July 3	July 4	†	"	F.15	"	392.	374.4	17.6	43.6	26.8	16.8	B.	45.	14.5	13.	1.5	3.28	.516	.432	.084	1.16	1.016	.144	.575	1.4	3.5	27.	35.	....	12,045
5386	" 10	" 11	†	"	F.2	"	406.	394.4	11.6	46.8	46.8	0.	B.	65.25	14.2	12.9	1.3	5.12	.48	.4	.08	1.24	.98	.26	.75	1.84	4.	27.	33.	....	12,300
5432	" 17	" 18	*	Cons'd	M. F.06	Gas'y	394.4	340.4	54.	39.6	39.2	.4	G.	47.	12.6	9.9	2.7	3.76	.384	.304	.08	1.24	.792	.448	.5	.44	6.	25.	32.	....	....
5481	" 24	" 25	†	"	M. F.2	None	408.	374.8	33.2	59.2	54.	5.2	G.	36.25	13.4	12.	1.4	.96	.48	.364	.116	1.21	.952	.288	.55	1.72	4.	29.	35.	....	3,550
5534	" 31	Aug. 2	*	"	M. F.2	"	419.2	396.4	22.8	64.4	64.4	0.0	G.	45.	14.3	12.7	1.6	4.48	.592	.432	.16	1.4	.824	.576	.7	2.6	4.	26.	32.	....	4,800
5579	Aug. 7	" 8	†	Little	M. F.05	"	376.8	369.6	7.2	72.8	55.6	17.2	G.	54.	12.5	11.5	1.	4.	.512	.304	.208	1.16	.856	.304	.875	2.6	3.	28.	33.	....	9,850
5631	" 14	" 15	‖	Cons'd	F.1	"	380.4	374.	6.4	60.	.....	.....	G.	60.5	11.7	10.8	.9	4.24	.416	.32	.096	.856	.696	.16	.55	1.32	3.	24.	29.	....	....
5677	" 21	" 22	‡	Little	F.08	"	393.2	392.8	.4	51.2	49.2	2.	G.	69.	11.9	11.7	.2	3.08	.448	.416	.032	.76	.68	.08	.95	2.6	3.	27.	33.	....	11,600
5734	" 28	" 29	*	Cons'd	M. F.15	"	432.8	411.2	21.6	47.6	42.8	4.8	G.	75.5	14.3	12.3	2.	3.04	.688	.416	.272	1.56	.744	.816	1.25	2.8	4.	30.	37.	....	3,800
5798	Sept. 4	Sept. 6	‖	Little	F.06	"	438.	436.	2.	51.2	49.6	1.6	B.	88.	11.2	10.9	.3	4.8	.364	.352	.012	.856	.824	.032	1.125	3.	3.	25.	30.	—	37,400
5839	" 11	" 12	‖	"	F.07	"	436.4	426.	10.4	36.4	29.6	6.8	G.	93.	11.8	11.5	.3	6.08	.48	.368	.112	1.112	.696	.416	.9	2.24	3.6	24.	27.	+	60,000
5881	" 18	" 19	‖	"	F.04	"	428.4	414.	14.4	33.6	30.	3.6	B.	90.75	11.4	8.4	3.	7.68	.496	.288	.208	1.16	.824	.336	.375	1.48	3.6	20.5	24.	—	21,000
5938	" 25	" 26	†	"	M. F.06	"	402.4	389.2	13.2	30.4	24.4	6.	GB.	82.5	10.2	8.4	1.8	6.4	.512	.448	.064	1.06	.836	.224	.375	2.4	3.	18.	22.	+	42,000
5995	Oct. 3	Oct. 4	†	Cons'd	M. F.3	"	444.	440.	4.	43.6	40.4	3.2	G.	97.	11.9	11.7	.2	7.54	.464	.432	.032	.9	.836	.064	.4	3.	3.	15.	24.	+	56,000
6032	" 9	" 10	†	Little	F.15	"	438.8	429.2	9.6	37.6	29.2	8.4	B.	85.	9.5	9.5	0.0	8.8	.544	.512	.032	1.06	.964	.096	.4	1.48	3.	16.	25.	—	4,200
6084	" 16	" 18	†	"	F.04	"	366.8	319.6	47.2	57.6	44.8	6.8	B.	70.	9.4	9.3	.1	8.8	.4	.368	.032	1.	.52	.48	.175	.68	3.	18.	26.	+	48,000
6153	" 23	" 25	‡	"	F.1	"	372.	356.4	15.6	20.	19.6	.4	G.	69.5	8.4	8.1	.3	6.08	.384	.352	.032	.92	.68	.24	.625	2.2	3.	18.	26.	+	24,000
6198	" 30	Nov. 1	‖	"	F.1	"	370.8	349.2	21.6	19.6	.....	.....	G.	61.5	7.	7.	0.0	8.	.384	.32	.064	.744	.648	.096	.225	.88	3.6	13.5	23.	—	26,600
6241	Nov. 6	" 7	†	"	F.05	"	390.	369.6	20.4	36.	18.	18.	B.	65.	7.7	7.1	.6	7.52	.512	.432	.08	1.064	.712	.352	.15	.64	3.	8.	21.	+	28,000
6277	" 13	" 14	‖	"	F.06	"	364.4	358.	6.4	34.8	28.	6.8	B.	30.	6.9	6.8	.1	4.8	.448	.352	.096	.68	.488	.192	.225	.56	3.	9.	10.	—	3,000
6335	" 20	" 21	‡	"	F.04	"	368.4	360.	8.4	31.6	18.	13.6	G.	45.5	7.8	7.5	.3	4.8	.528	.4	.128	1.196	.936	.26	.25	2.2	3.	13.	11.	+	8,000
6401	" 27	" 28	‖	"	F.03	"	381.6	373.6	8.	27.6	23.2	4.4	B.	47.	3.3	.....	.....	5.28	.432	.416	.016	.936	.84	.096	.27	2.	3.	7.	8.	+	24,750
6504	Dec. 11	Dec. 14	†	"	M. F.03	"	371.2	365.6	5.6	35.6	34.4	1.2	B.	44.5	11.2	10.9	.3	5.6	.608	.512	.096	1.48	.968	.512	.013	1.2	3.	11.	11.	+	356,000
6575	" 21	" 23	†	Cons'd	M. F.05	"	361.	332.4	28.6	27.2	23.6	3.6	G.	36.	15.5	9.9	5.6	3.68	.8	.528	.272	1.48	.84	.64	.055	3.	3.6	2.	8.	+	217,300
6595	" 28	" 29	*	"	M. F.04	"	339.6	327.2	12.4	24.8	23.2	1.6	G.	24.5	11.9	10.7	1.2	2.4	.528	.304	.224	1.256	.936	.32	.05	4.	3.	0.	0.	?	212,000

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 10.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—BIG VERMILLION RIVER, LA SALLE, ILL.

Report of **ARTHUR W. PALMER,**
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dis-solv'd	Loss on Ig'n. Sus-pnd'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dis-solv'd	Albuminoid Am. Sus-pnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
5079	May 24	May 25	†	Little	M. F.02	None	494.8	468.	26.8	67.2	56.4	10.8	B.	11.	5.9	5.1	.8	.096	.144	.112	.032	.65	.41	.24	.003	2:2	....	....	......	....	....
5115	" 30	" 31	†	Cons'd	M. F.02	"	525.6	457.2	68.4	69.2	53.2	16.	B.	15.3	5.2	3.7	1.5	.104	.224	.16	.064	.49	.374	.116	.017	1.48	....	....	......	....	....
5159	June 6	June 7	*	"	M. F.1	"	398.	316.8	81.2	18.	16.	2.	B.	7.5	10.2	7.1	3.1	.096	.32	.176	.144	.73	.57	.16	.046	.8	....	....	......	—	7,650
5218	" 15	" 16	*	"	M. F.1	"	521.6	475.6	46.	39.2	33.6	5.6	B.	38.	7.	4.8	2.2	.052	.224	.16	.064	.92	.568	.352	.01	1.76	....	....	......	—	3,100
5249	" 20	" 21	*	"	M. F.05	"	404.4	356.8	47.6	84.4	64.	20.4	B.	12.	6.2	4.6	1.6	.08	.32	.176	.144	.68	.248	.432	.022	2.28	....	....	......	+	2,600
5296	" 27	" 28	†	Little	M. F.02	"	561.6	540.8	20.8	62.8	54.4	8.4	B.	26.	4.5	3.9	.6	.168	.144	.112	.032	.76	.312	.448	.014	1.28	....	....	......	—	14,900
5340	July 4	July 5	†	"	F.02	"	701.6	673.6	28.	57.2	43.2	14.	B.	37.2	7.8	5.1	2.7	.064	.248	.144	.104	.68	.376	.304	.015	.88	9.1	....	......	....	1,450
5391	" 11	" 11	†	"	F.15	"	318.	294.8	23.2	51.2	48.8	2.4	B.	8.9	7.4	6.2	1.2	.04	.208	.176	.032	.72	.664	.056	.035	.64	9.11	....	......	....	730
5440	" 18	" 19	*	Cons'd	M. F.06	"	422.8	409.2	13.6	64.4	64.4	0.0	B.	18.	11.3	9.9	1.4	.512	.416	.288	.128	1.08	.696	.384	.175	.8	11.6	....	......	....	11,350
5489	" 25	" 26	‖	Little	M. F.08	"	494.8	470.	24.8	48.8	40.8	8.	B.	21.8	4.8	4.2	.6	.12	.256	.192	.064	.6	.44	.16	.045	1.32	9.11	....	......	....	....
5537	Aug. 1	Aug. 2	‡	Cons'd	M. F.04	"	724.8	707.6	17.2	112.8	112.	.8	B.	40.	6.9	6.5	.4	.088	.256	.176	.08	.68	.408	.272	.007	.32	9.5	....	......	+	560
5586	" 8	" 9	†	"	M. F.03	"	919.6	913.2	6.4	89.2	44.4	44.8	Gh.	53.	6.7	6.1	.6	.112	.272	.16	.112	.52	.408	.112	.014	.4	9.3	....	......	?	1,805
5638	" 15	" 16	†	"	M. F.04	"	612.4	562.	50.4	92.	80.4	11.6	Gh.	31.	8.1	6.2	1.9	.124	.224	.192	.032	.844	.44	.404	.012	.36	9.1	....	......	....	....
5687	" 22	" 23	*	Much	M. F.07	"	634.4	554.4	80.	69.6	45.2	24.4	Blk.	39.	9.8	6.2	3.6	.144	.504	.176	.328	.76	.408	.352	.03	.2	9.3	....	......	—	1,055
5735	" 29	" 30	*	Cons'd	M. F.02	"	789.6	736.	53.6	78.4	78.	.4	Gh.	53.5	9.	5.1	3.9	.256	.288	.176	.112	.92	.504	.416	.017	.08	....	....	......	....	2,500
5793	Sept. 5	Sept. 6	*	"	M. F.03	"	1054.	1000.8	53.2	107.6	106.8	.8	B.	66.7	8.7	4.	4.7	.352	.32	.192	.128	.824	.6	.224	.03	.24	9.2	....	......	....	3,210
5846	" 12	" 13	†	"	M. F.03	"	1132.4	1084.	48.4	91.6	88.8	2.8	B.	80.9	9.	3.6	5.4	.12	.416	.176	.24	.664	.392	.272	.003	.16	....	....	......	....	1,890
5891	" 19	" 20	†	Little	M. F.02	"	1215.6	1182.	33.6	85.6	82.8	2.8	B.	84.5	7.6	4.4	3.2	.064	.32	.148	.172	.84	.44	.4	.008	.16	....	....	......	+	4,950
5940	" 26	" 27	*	Cons'd	M. F.01	"	1774.	1750.	24.	133.6	118.4	15.2	B.	136.2	8.	4.5	3.5	.128	.24	.12	.12	.516	.388	.128	.01	.4	....	....	......	+	2,360
5999	Oct. 3	Oct. 4	†	"	M. F.03	"	1638.8	1602.8	36.	150.8	130.8	20.	GB.	132.5	6.6	5.9	.7	.128	.24	.144	.096	.74	.34	.4	.008	.28	9.5	....	......	—	3,000
6040	" 10	" 11	*	"	M. F.03	"	1826.8	1806.8	20.	119.2	116.	3.2	G.	122.5	5.4	4.8	.6	.112	.24	.16	.08	.42	.276	.144	.008	.2	....	....	......	—	3,000
6082	" 17	" 18	†	Little	M. F.01	"	1621.6	1575.6	46.	77.2	72.4	4.8	B.	128.5	6.8	6.7	.1	.192	.272	.208	.064	.632	.36	.272	.012	.56	9.7	....	......	—	6,350
6148	" 24	" 25	†	Cons'd	M. F.04	"	1596.	1575.2	20.8	78.4	76.8	1.6	G.	112.5	6.9	4.5	2.4	.128	.224	.156	.068	.52	.168	.352	.008	.36	....	....	......	+	3,600
6200	" 31	Nov. 1	†	"	M. F.03	"	1696.	1682.8	13.2	132.	124.4	7.6	G.	116.	4.3	3.6	.7	.16	.256	.208	.048	.392	.248	.144	.008	.4	....	....	......	+	15,700
6246	Nov. 7	" 8	†	Little	F.03	"	1704.8	1702.8	2.	128.	119.2	8.8	B.	123.	3.4	3.	.4	.48	.144	.12	.024	.36	.328	.032	.008	.6	....	....	......	—	6,900
6297	" 14	" 15	†	"	M. F.02	"	1858.8	1850.	8.8	154.	150.4	3.6	B.	134.	3.	2.8	.2	.8	.112	.096	.016	.328	.....	.....	.008	.28	....	....	......	—	5,850
6342	" 21	" 22	‖	"	F.03	"	1348.4	1329.2	19.2	112.4	104.	8.4	B.	86.	3.8	3.7	.1	.56	.208	.16	.048	.552	.488	.064	.021	1.	....	....	......	—	24,200
6406	" 28	" 29	†	"	M. F.03	"	1615.6	1601.2	14.4	165.6	164.	1.6	B.	105.5	2.	2.	0.0	.528	.096	.08	.016	.424	.36	.064	.028	.84	....	....	......	—	17,600
6464	Dec. 5	Dec. 7	†	"	M. F.01	"	1639.2	1616.4	22.8	143.2	143.2	0.0	B.	110.	2.4	2.4	.0	.72	.112	.096	.016	.392	.296	.096	.02	.88	....	....	......	+	11,200
6509	" 12	" 14	†	"	M. F.06	"	1449.2	1446.8	2.4	174.8	172.8	2.	G.	84.5	4.9	4.9	0.0	.96	.128	.112	.016	.584	.424	.16	.01	.68	....	....	......	....	18,000
6546	" 19	" 20	†	"	F.02	"	611.6	608.4	3.2	39.6	39.6	0.0	G.	30.	5.6	5.	.6	.48	.272	.224	.048	.552	.328	.224	.008	.4	....	....	......	+	4,600
6589	" 26	" 28	†	"	M. F.02	"	433.2	419.6	13.6	30.	24.4	5.6	G.	13.5	5.6	5.6	0.0	.16	.176	.12	.056	.68	.328	.352	.036	4.8	....	....	......	+	17,350

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.
COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red.
Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GR., Gray-Brown.

TABLE 11.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS AND MICHIGAN CANAL, LA SALLE, ILL.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of: 1899 Collection.		Date of: 1899 Examination.		Appearance: Turb'y.	Appearance: Sediment.	Appearance: Color.	Odor.	Residue on Evaporation: Total.	Residue on Evaporation: Dissolved.	Residue on Evaporation: Suspended.	Loss on Ig'n: Tot'l.	Loss on Ig'n: Dissolv'd	Loss on Ig'n: Suspnd'd	Color on Ignition.	Chlorine.	Oxygen Consumed: Total.	Oxygen Consumed: By Dissolved.	Oxygen Consumed: By Suspd Matter.	Nitrogen as Ammonia: Free Ammonia.	Albuminoid Am.: Tot'l	Albuminoid Am.: Dissolv'd	Albuminoid Am.: Suspnd'd	Organic Nitrogen: Total.	Organic Nitrogen: Dissolved.	Organic Nitrogen: Suspended.	Nitrogen as: Nitrites.	Nitrogen as: Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
5081	May	24	May	25	*	Cons'd	M. F.03	None	468.	402.	66.	51.6	32.4	19.2	B.	13.25	12.	9.1	2.9	2.	.48	.32	.16	1.29	1.122	.168	.035	1.2	....	....	....	....	....
5117	"	30	"	31	*	"	M. F.05	"	432.	396.8	35.2	55.2	52.	3.2	B.	14.	12.	10.	2.	.72	.32	.224	.096	1.29	1.05	.24	.064	.72	....	....	....	....	....
5161	June	6	June	7	†	"	M. F.2	"	419.2	362.4	56.8	38.8	32.8	6.	B.	13.4	14.3	9.4	4.9	.088	.8	.384	.416	1.53	1.02	.51	.06	.6	....	....	....	?	4,200
5220	"	15	"	16	*	Much	M. F.15	"	364.4	322.	42.4	41.2	31.2	10.	B.	22.	12.7	9.3	3.4	.64	.576	.288	.288	1.48	.984	.496	.04	.48	....	....	....	+	3,500
5251	"	20	"	21	*	Cons'd	M. F.15	"	384.	333.6	50.4	45.2	45.2	0.0	B.	11.5	14.	9.	5.	.8	.608	.368	.24	1.4	.824	.576	.03	.36	....	....	....	+	152,500
5298	"	27	"	28	†	Little	M. F.4	"	337.2	308.8	28.4	26.	24.8	1.2	B.	13.	11.9	11.7	.2	.88	.48	.4	.08	1.24	.984	.256	.027	.24	....	....	....	+	520,000
5338	July	4	July	5	*	Cons'd	M. F.1	"	267.2	207.2	60.	41.6	10.	31.6	B.	15.	14.4	11.2	3.2	.72	.72	.448	.272	1.4	1.048	.352	.027	.12	9.1	....	....	....	374,000
5389	"	11	"	11	†	"	M. F.15	"	358.4	321.2	37.2	59.2	54.4	4.8	B.	13.	13.4	10.4	3.	.32	.608	.336	.272	1.4	.76	.64	.02	.36	9.1	....	....	....	79,000
5441	"	18	"	19	*	"	M. F.04	"	384.8	331.2	53.6	56.	50.	6.	Gh.	11.	7.5	6.1	1.4	.096	.224	.144	.08	.68	.504	.176	.05	3.	11.6	....	....	....	20,300
5488	"	25	"	26	‖	Little	M. F.1	"	320.	313.6	6.4	54.4	47.6	6.8	Gh.	16.	8.8	7.5	1.3	.56	.368	.304	.064	.92	.792	.128	.05	.28	9.11	...	....	....	....
5539	Aug.	1	Aug.	2	*	Cons'd	M. F.15	"	306.8	280.	26.8	66.4	61.2	5.2	Gh.	14.5	12.1	9.8	2.3	.736	.448	.304	144	1.16	.728	.432	.055	.32	9.5	....	....	+	170,000
5584	"	8	"	9	†	"	M. F.04	"	286.8	248.4	38.4	45.6	26.	19.6	Gh.	13.	11.2	10.4	.8	.592	.448	.272	.176	1.08	.824	.256	.15	.36	9.3	....	....	+	497,000
5636	"	15	"	16	†	"	M. F.15	"	320.	286.	34	66.8	64.	2.8	Gh.	13.	11.6	9.7	1.9	.88	.432	.352	.08	1.112	.952	.16	.026	.28	9.1	....	....	....	....
5685	"	22	"	23	*	"	M. F.1	"	335.6	291.6	44.	56.8	54.8	2.	Gh.	13.5	12.1	9.9	2.2	.544	.496	.368	.128	1.08	.888	.192	.024	.12	9.3	....	....	+	77,000
5737	"	29	"	30	*	"	M. F.03	"	318.4	310.8	7.6	39.2	39.2	0.0	Gh.	13.5	9.5	7.9	1.6	.64	.432	.304	.128	1.16	.984	.176	.013	.2	9.3	....	....	....	220,000
5791	Sept.	5	Sept.	6	*	"	M. F.03	"	338.4	303.2	35.2	42.4	41.2	1.2	Gh.	14.5	11.5	7.3	4.2	.72	.352	.32	.032	1.24	.888	.352	.035	.24	9.2	....	....	+	95,500
5844	"	12	"	13	†	"	M. F.05	"	357.6	318.8	38.8	55.2	54.4	.8	B.	17.	12.2	10.6	1.6	.512	.48	.288	.192	1.336	.856	.48	.03	.28	9.3	...	....	+	172,500
5892	"	19	"	20	†	"	M. F.03	"	390.	349.2	40.8	59.6	58.4	1.2	B.	19.	12.1	8.9	3.2	.64	.448	.368	.08	1.24	.856	.384	.075	1.08	9.5	....	....	....	354,000
5942	"	26	"	27	*	"	M. F.04	"	364.	308.4	55.6	64.	57.6	6.4	GB.	22.	12.5	7.7	4.8	.56	.544	.32	.224	1.348	.752	.596	.05	.36	9.4	....	....	+	43,500
5998	Oct.	3	Oct.	4	†	"	M. F.05	"	333.2	301.6	31.6	73.6	58.	15.6	GB.	20.	12.9	9.6	3.3	.416	.512	.384	.128	1.3	.836	.464	.035	.36	9.4	....	....	+	188,000
6038	"	10	"	11	*	"	M. F.04	"	363.2	319.4	43.8	37.2	36.6	.6	B.	15.	9.5	9.4	.1	.4	.496	.384	.112	1.22	.74	.48	.012	.08	9.5	....	....	+	80,000
6081	"	17	"	18	†	Little	M. F.2	"	360.4	323.2	37.2	58.	48.8	9.2	B.	17.	8.9	7.2	1.7	.592	.432	.32	.112	1.192	.504	.688	.02	.24	9.7	....	....	+	143,000
6150	"	24	"	25	†	Cons'd	M. F.04	"	386.	328.8	57.2	30.8	18.8	12.	G.	18.	8.2	7.2	1.	.464	.448	.352	.096	.84	.584	.256	.022	.44	9.7	....	....	+	114,000
6202	"	31	Nov.	1	†	"	M. F.04	"	389.2	363.6	25.6	44.	42.4	1.6	G.	17.5	8.7	7.	1.7	.496	.496	.256	.24	.968	.68	.288	.035	.44	9.9	....	....	+	376,000
6245	Nov.	7	"	8	†	Little	F.04	"	374.4	339.6	34.8	38.	34.4	3.6	B.	15.	7.1	6.1	1.	.432	.432	.272	.16	1.096	.76	.336	.032	.36	9.9	....	....	+	80,000
6298	"	14	"	15	†	"	M. F.03	"	352.4	341.2	11.2	37.2	34.	3.2	B.	14.	7.8	6.2	1.6	.144	.72	.288	.432	1.48	.744	.736	.004	.2	10.3	....	....	?	77,000
6341	"	21	"	22	†	Cons'd	M. F.03	"	350.4	329.2	21.2	52.4	46.	6.4	B.	14.	8.	6.6	1.4	.192	.544	.32	.224	1.48	.744	.736	.016	.28	10.4	....	....	+	65,000
6404	"	28	"	29	†	Little	M. F.03	"	351.6	338.	13.6	73.2	71.2	2.	B.	14.	7.1	6.5	.6	.336	.416	.256	.16	1.16	.744	.416	.025	.24	10.2	....	....	+	224,000
6466	Dec.	5	Dec.	7	†	"	M. F.02	"	357.6	356.8	.8	61.6	58.4	3.2	B.	13.	7.7	5.6	2.1	.224	.512	.24	.272	1.096	.744	.352	.012	.36	10.2	....	....	+	168,000
6507	"	12	"	14	*	Cons'd	M. F.03	"	540.8	440.8	100.	71.6	56.	15.6	B.	23.5	15.5	8.1	7.4	.96	.64	.288	.352	1.88	.64	1.24	.05	1.4	10.9	....	....	+	462,000
6547	"	19	"	20	†	"	M. F.20	"	377.2	369.2	8.	33.6	31.2	2.4	G.	32.25	10.	9.2	.8	3.52	.576	.512	.064	1.448	.808	.64	.08	1.68	11.2	....	....	+	138,500
6587	"	26	"	28	‖	Little	M. F.03	"	474.8	470.8	4.	62.8	62.4	.4	G.	41.25	13.4	9.9	3.5	3.2	.496	.352	.144	1.288	1.128	.16	.175	3.12	11.1	....	....	+	123,500

TURBIDITY—*Decided. §Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 12.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, LA SALLE, ILL.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dis-solv'd	Sus-pnd'd							Tot'l	Dis-solv'd	Sus-pnd'd										
5006	May 5	May 6	†	Cons'd	M. F.06	None	414.4	358.4	56.	45.2	44.	1.2	B.	22.	14.2	13.9	.3	1.76	.56	.512	.048	1.29	1.17	.12	.25	1.28	....	....	......	....	....
5080	" 24	" 25	†	Little	M. F.04	"	389.2	364.	25.2	29.6	24.8	4.8	B.	16.	14.5	12.8	1.7	.8	.48	.352	.128	1.21	.945	.265	.06	1.6	....	....	......	....	....
5116	" 30	" 31	§	Much	M. F.2	"	507.6	292.8	214.8	83.2	59.2	24.	B.	11.5	22.1	12.1	10.	.8	.656	.32	.336	1.85	.826	1.024	.2	1.24	....	....	......	....	....
5160	June 6	June 7	†	Cons'd	M. F.3	"	354.	308.8	45.2	36.	35.2	.8	B.	9.	15.9	12.6	3.3	.36	.48	.384	.096	1.29	.826	.464	.32	1.32	....	....	......	—	45,500
5219	" 15	" 16	*	Much	M. F.3	"	420.4	350.4	70.	40.8	37.6	3.2	B.	47.5	19.2	14.9	4.3	1.28	.608	.352	.256	1.56	1.144	.416	.4	1.22	....	....	......	—	4,900
5250	" 20	" 21	*	Cons'd	M. F.3	"	462.	374.4	87.6	72.	52.	20.	B.	27.	14.8	12.9	1.9	.88	.704	.384	.32	1.32	.856	.464	.35	1.84	....	....	......	—	8,400
5297	" 27	" 28	†	Little	M. F.4	"	451.2	402.	49.2	34.8	27.6	7.2	B.	43.5	16.3	14.1	2.2	1.92	.576	.422	.154	1.64	1.16	.48	.56	1.76	....	....	......	—	12,400
5339	July 4	July 5	*	Cons'd	M. F.15	"	412.8	376 4	36.4	52.	49.2	2.8	B.	42.	17.	12.9	4.1	1.04	.544	.432	.112	1.56	.92	.64	.55	2.4	9.1	....	......	....	7,150
5390	" 11	" 12	†	Little	M. F.25	"	412.4	374.	38.4	53.6	46.8	6.8	B.	66.	14.	12.3	1.7	2.8	.512	.368	.144	1.16	.984	.176	1.1	2.8	9.1	....	......	....	1,530
5442	" 18	" 19	*	Cons'd	M. F.15	"	350.	292.4	57.6	49.6	43.2	6.4	G.	30.	13.6	10.5	3.4	2.48	.608	.272	.336	1.4	.728	.672	.38	1.8	11.6	....	......	....	12,100
5487	" 25	" 26	†	"	M. F.15	"	411.6	344.	67.6	60.8	57.6	3.2	G.	31.5	13.1	9.8	3.3	.24	.576	.32	.256	1.32	.792	.528	.28	1.76	9.1	....	......	....	4,700
5538	Aug. 1	Aug. 2	*	"	M. F.25	"	432.4	377.6	54.8	85.2	78.	7.2	G.	47.	16.	12.	4.	1.28	.544	.352	.192	1.32	.888	.432	.7	2.4	9.5	....	......	+	17,300
5585	" 8	" 9	†	"	M. F.07	"	407.6	374.4	33.2	60.4	53.2	7.2	G.	47.5	13.7	11.5	2.2	.896	.528	.304	.224	1.32	.76	.56	.7	2.8	9.2	....	......	—	9,900
5637	" 15	" 16	†	"	M. F.15	"	406.4	385.6	20.8	64.	61.2	2.8	G.	57.5	13.3	11.4	1.9	1.6	.496	.352	.144	1.208	.664	.544	.6	2.8	9.1	....	....	....	....
5686	" 22	" 23	*	"	M. F.15	"	420.4	381.6	38.8	51.2	43.6	7.6	G.	64.	13.7	10.8	2.9	1.2	.576	.384	.192	1.24	.888	.352	.34	3.2	9.3	....	......	+	11,600
5736	" 29	" 30	*	"	M. F.08	"	418.4	397.2	21.2	57.6	43.6	14.	G.	66.	12.3	9.	3.3	.288	.528	.32	.208	1.32	.92	.4	.75	2.6	9.3	....	......	....	4,800
5792	Sept. 5	Sept. 6	*	"	M. F.06	"	492.	426.	66.	32.8	28.	4.8	B.	75.5	13.3	7.9	5.4	2.8	.544	.48	.064	1.464	.856	.608	1.	3.5	9.2	....	......	....	5,000
5845	" 12	" 13	†	"	M. F.06	"	426.4	393.2	33.2	40.	36.	4.	B.	69.25	12.2	11.1	1.1	4.	.416	.32	.096	1.08	.312	.768	.5	2.4	9.3	....	......	—	7,050
5893	" 19	" 20	‡	Little	M. F.03	"	424.4	392.	32.4	33.2	33.2	....	G.	73.	11.	7.9	3.1	4.4	.448	.368	.08	1.16	.392	.768	.325	2.4	....	....	......	+	14,350
5941	" 26	" 27	*	Cons'd	M. F.04	"	402.	388.8	13.2	28.	24.8	3.2	GB.	73.	10.1	8.	2.1	.576	.448	.336	.112	.868	.74	.128	.3	1.88	9.4	....	......	+	12,400
5997	Oct. 3	Oct. 4	†	"	M. F.15	"	437.2	421.6	15.6	86.4	49.2	37.2	GB.	84.5	12.	10.8	1.2	5.92	.448	.416	.032	1.14	.804	.336	.175	1.72	9.4	....	......	+	37,00
6039	" 10	" 11	*	"	M. F.08	"	432.	424.8	7.2	26.4	25.2	1.2	B.	76.	9.7	9.4	.3	6.08	.464	.416	.048	1.06	.9	.16	.225	1.44	9.5	....	......	—	28,00
6080	" 17	" 18	†	Little	M. F.03	"	400.4	378.4	22.	33.2	29.2	4.	B.	68.	11.6	9.3	2.3	5.92	.416	.384	.032	1.032	.704	.328	.375	1.88	9.7	....	......	—	14,05
6149	" 24	" 25	†	Cons'd	M. F.1	"	395.6	353.6	42.	33.2	22.4	10.8	G.	60.	10.4	7.8	2.6	4.64	.464	.368	.096	.92	.584	.336	.3	2.	9.7	....	......	—	29,40
6201	" 31	Nov. 1	†	"	M. F.12	"	387.6	367.2	20.4	38.4	30.4	8.	G.	53.5	7.7	7.7	0.0	4.32	.4	.288	.112	.84	.612	.228	.275	1.44	9.9	....	......	—	10,90
6214	Nov. 7	" 8	†	Little	F.04	"	403.6	399.2	4.4	32.8	19.6	13.2	B.	54.	7.4	7.1	.3	5.12	.512	.272	.24	1.032	.68	.352	.15	1.16	9.9	....	......	—	8,95
6296	" 14	" 15	†	"	M. F.03	"	351.2	341.6	9.6	24.	24.	0.0	B.	33.	7.2	7.	.2	3.04	.32	.288	.032	.76	.584	.176	1.5	1.12	10.3	....	......	+	15,10
6340	" 21	" 22	†	Cons'd	M. F.04	"	348.4	345.2	3.2	36.	34.	2.	B.	36.5	7.5	7.2	.3	2.72	.32	.288	.032	1.196	.68	.516	.325	3.	10.	....	......	+	10,40
6405	" 28	" 29	†	Little	M. F.04	"	402.8	389.2	13.6	50.8	49.2	1.6	B.	38.	7.9	7.6	.3	3.84	.368	.32	.048	.936	.744	.192	.24	.51	10.2	....	......	+	14,20
6465	Dec. 5	Dec. 6	†	Cons'd	M. F.1	"	380.	362.8	17.2	48.4	36.8	11.6	B.	42.5	9.4	....	....	4.32	.416	.32	.096	1.065	.776	.289	.14	2.08	10.2	....	......	+	55,00
6508	" 12	" 14	†	"	M. F.06	"	403.6	373.6	30.	45.6	43.2	2.4	G.	42.5	10.	9.5	.5	4.32	.56	.448	.112	1.128	.904	.224	.15	1.4	10.9	....	......	....	76,60
6545	" 19	" 20	†	"	M. F.30	"	368.	353.2	14.8	37.2	29.2	8.	B.	31.5	12.3	10.7	1.6	3.84	.648	.528	.12	1.48	1.064	.416	.065	2.8	11.2	....	......	+	84,00
6588	" 26	" 28	*	"	M. F.06	"	358.	326.	32.	48.4	48.4	0.0	G.	21.	13.9	9.8	4.1	1.92	.432	.32	.112	1.	.872	.128	.065	4.	11.1	....	......	+	190.0

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 13.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, HENRY, ILL.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Suspnd'd							Tot'l	Dissolv'd	Suspnd'd										
5121	May 30	May 31	*	Little	M. F.05	None	465.2	378.	87.2	87.2	84.	3.2	B.	17.	16.	12.	4.	.896	.576	.352	.224	1.53	.97	.56	.14	1.08	8.7	....	24.	....	....
5165	June 6	June 7	*	Cons'd	M. F.15	"	390.2	315.6	83.6	56.	34.4	21.6	B.	12.5	16.1	12.7	3.4	.576	.512	.4	.112	1.53	.986	.544	.32	1.28	8.4	29.	28.	?	8,850
5205	" 12	" 14	*	"	M. F.3	"	376.	316.	60.	39.2	29.6	9.6	B.	17.5	14.4	10.6	3.8	.64	.608	.384	.224	1.72	1.24	.48	.4	1.52	8.2	29.	29.	....	159,000
5256	" 20	" 21	*	Much	M. F.1	"	468.	294.4	173.6	23.6	20.	3.6	B.	18.	24.1	12.6	11.5	.32	1.344	.448	.896	3.16	1.048	2.112	.08	.32	9.7	30.	30.	....	48,750
5300	" 27	" 28	†	Cons'd	M. F.15	"	436.	404.4	31.6	32.8	31.2	1.6	B.	41.5	16.8	13.9	2.9	1.2	.672	.48	.192	1.56	1.08	.48	.62	2.2	6.3	28.	31.	....	40,800
5348	July 5	July 6	*	"	M. F.03	"	386.8	342.	44.8	44.4	....	...	B.	35.5	16.6	13.2	3.4	.64	.864	.48	.384	1.96	1.176	.784	.34	1.28	7.5	29.	29.	—	45,500
5404	" 12	" 13	*	"	M. F.08	"	429.6	402.8	26.8	48.8	47.2	1.6	B.	51.5	13.4	11.8	4.6	1.390	.416	.368	.048	1.304	1.16	.144	.400	1.28	7.5	30.	32.	—	34,000
5443	" 18	" 19	*	"	M. F.3	"	343.2	255.2	88.	45.2	43.6	1.6	Gh.	25.	13.6	10.2	3.4	1.024	.48	.24	.24	1.08	.696	.384	.25	1.44	9.	28.	27.	+	7,550
5496	" 26	" 27	*	"	M. F.15	"	347.2	326.	21.2	51.6	44.4	7.2	Gh.	28.5	12.6	12.	.6	.384	.448	.304	.144	1.16	.568	.592	.22	1.52	8.2	31.	31.	—	2,400
5551	Aug. 2	Aug. 3	*	"	M. F.2	"	405.6	364.8	40.8	39.2	50.	9.2	B.	38.25	14.8	12.5	2.3	.64	.496	.352	.144	1.48	.792	.688	.32	1.48	8.	29.	29.	—	77,000
5590	" 8	" 9	†	"	M. F.04	"	429.2	374.	55.2	54.8	43.2	11.6	Gh.	46.	12.5	11.5	1.	1.184	.544	.384	.16	1.16	.44	.72	.35	1.88	7.	26.	23.	?	2,450
5639	" 15	" 16	†	"	M. F.03	"	416.4	374.	42.4	74.8	65.6	9.2	Gh.	48.	12.1	11.6	.5	1.024	.448	.32	.128	1.32	.76	.56	.36	1.96	8.	26.	22.	....	....
5688	" 22	" 23	†	"	M. F.2	"	396.	394.4	1.6	44.8	44.4	.4	Gh.	57.	14.5	12.1	2.4	1.664	.848	.704	.144	1.8	1.16	.64	.44	1.52	6.8	28.	29.	—	4,150
5744	" 29	" 30	†	"	M. F.03	"	412.	388.8	23.2	48.4	39.2	9.2	Gh.	60.	13.8	12.5	1.3	.96	.56	.32	.24	1.4	.92	.48	.4	1.88	6.8	28.	27.	....	21,800
5811	Sept. 6	Sept. 7	†	"	M. F.03	"	423.2	386.8	36.4	35.2	34.4	.8	B.	60.75	11.9	7.5	4.4	1.12	.544	.352	.192	1.32	1.08	.24	.4	1.76	6.8	29.	30.	....	32,600
5849	" 12	" 13	*	"	M. F.05	"	428.4	385.2	43.2	58.8	52.	6.8	B.	63.	12.3	6.8	5.5	1.28	.544	.368	.176	1.4	.84	.56	.35	2.	6.8	20.	21.	+	4,550
5895	" 18	" 19	†	"	M. F.02	"	422.8	394.4	28.4	36.8	32.8	4.	G.	68.	14.	8.5	5.5	2.24	.656	.32	.336	1.72	.856	.864	.6	2.28	7.1	21.	21.	+	6,300
5945	" 26	" 27	*	"	M. F.04	"	407.2	385.2	22.	36.	33.6	2.4	G.	71.	13.	9.2	3.8	1.12	.8	.304	.496	1.46	.74	.72	1.75	4.	7.	18.	20.	—	950
5994	Oct. 3	Oct. 4	*	"	M. F.2	"	404.	375.2	28.8	51.6	43.2	8.4	G.	68.5	14.5	12.6	1.9	3.36	.864	.368	.496	2.1	.868	1.232	.6	2.4	7.	15.	14.	?	4,450
6042	" 10	" 11	†	"	M. F.15	"	441.2	435.6	5.6	28.4	27.2	1.2	G.	76.	12.3	9.4	2.9	5.6	.64	.4	.24	1.464	.472	.992	.17	2.8	7.1	16.	16.	—	15,500
6088	" 17	" 18	†	"	M. F.05	"	439.2	422.4	16.8	29.6	28.	1.6	G.	68.	9.1	8.1	1.	4.	.608	.432	.176	1.24	.84	.4	.25	1.84	7.2	13.	17.	—	8,350
6169	" 25	" 26	*	"	M. F.02	"	408.	389.6	18.4	28.8	25.6	3.2	G.	60.4	8.8	8.1	.7	5.2	.56	.4	.16	1.08	.776	.304	.15	1.68	7.2	14.	16.	—	6,000
6212	Nov. 1	Nov. 2	*	"	M. F.04	"	407.6	375.6	32.	41.2	19.2	22.	G.	57.	8.1	7.2	.9	3.52	.56	.336	.224	.968	.648	.32	.14	1.88	7.3	10.	13.	—	12,500
6260	" 7	" 8	†	"	M. F.04	"	396.8	379.2	17.6	29.6	28.	1.6	G.	54.5	6.8	6.7	.1	4.8	.432	.256	.176	.92	.488	.432	.11	1.48	7.3	9.	7.	—	3,100
6315	" 14	" 15	*	"	M. F.04	"	388.4	368.4	20.	41.6	32.4	9.2	B.	50.	7.	6.2	.8	3.52	.448	.304	.144	.808	.552	.256	.09	1.12	7.5	9.	7.	—	1,000
6344	" 22	" 23	†	Little	M. F.03	"	381.6	372.	9.6	32.	28.	4.	G.	39.5	7.2	6.8	.4	2.56	.432	.24	.192	.744	.552	.192	.15	2.2	7.6	8.	7.	+	2,000
6407	" 28	" 29	†	"	M. F.03	"	357.2	356.8	.4	48.8	48.8	0.0	B.	37.	7.6	7.6	0.0	3.2	.432	.32	.112	.936	.744	.192	.21	1.92	7.6	8.	6.	—	10,800
6449	Dec. 5	Dec. 6	†	"	M. F.03	"	384.4	376.4	8.	36.4	32.	4.4	G.	41.	8.	8.	0.0	3.68	.4	.336	.064	.904	.584	.32	.013	1.68	7.3	3.	—9.	+	15,900
6506	" 12	" 14	†	"	M. F.05	"	377.2	360.	17.2	[illegible]	44.8	4.4	B.	44.	9.6	9.5	.1	4.	.576	.48	.096	1.192	.936	.256	.085	1.36	7.6	2.	6.	+	51,000
6548	" 19	" 20	†	Cons'd	M. F.15	"	[illegible]	348.4	2.8	[illegible]	[illegible]	2.	G.	35.	10.	9.1	.9	4.32	.672	.48	.192	1.512	.84	.672	.08	1.2	8.	0.	—11.	+	113,000

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 14.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, AVERYVILLE, ILL.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
										Loss on Ig'n.									Albuminoid Am.												
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Tot'l	Dissolv'd	Suspnd'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Suspnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
4982	May 1	May 2	*	Cons'd	M. F.04	None	318.	302.8	15.2	50.	49.2	.8	B.	13.	12.5	9.3	3.2	.208	.48	.224	.256	1.05	.53	.52	.064	.95	32.	....	......	....	....
5039	" 15	" 16	*	"	M. F.2	"	430.4	374.8	55.6	63.6	60.	3.6	B.	19.2	14.	9.4	4.6	.864	.512	.416	.096	1.29	.89	.4	.085	.96	29.9	....	......	....	....
5073	" 22	" 23	*	"	M. F.04	"	391.2	354.	37.2	31.2	21.2	10.	B.	10.5	14.6	10.	4.6	.96	.416	.352	.064	1.29	.97	.32	.045	.52	31.3	....	......	....	....
5132	" 30	June 1	†	"	M. F.1	"	394.4	341.2	53.2	58.8	39.2	19.6	B.	16.	11.3	10.7	.6	.352	.48	.32	.16	1.05	.89	.16	.08	1.48	30.4	....	......	....	....
5192	June 8	" 9	†	"	M. F.15	"	415.6	290.	125.6	34.4	32.	2.4	B.	17.5	13.1	11.4	1.7	.288	.524	.416	.108	1.24	.986	.254	.25	1.8	31.8	25.	26.	....	4,65
5253	" 20	" 21	*	"	M. F.1	"	365.2	333.2	32.	35.2	32.8	2.4	B.	17.5	13.3	11.1	2.2	.088	.448	.384	.064	1.32	.952	.368	.13	1.2	29.4	26.	27.	....	9,10
5302	" 27	" 28	†	"	M. F.1	"	407.6	362.4	45.2	29.6	28.8	.8	B.	25.	14.	12.7	1.3	.256	.512	.432	.08	1.24	1.048	.192	.185	1.68	28.	28.	28.	—	12,35
5333	July 3	July 4	*	"	M. F.2	"	400.4	356.4	44.	69.6	62.4	7.2	B.	26.	14.3	12.3	2.	.144	.528	.368	.16	1.32	.92	.4	.13	1.76	27.1	26.	25.	+	13,50
5394	" 10	" 12	†	"	M.	"	396.8	374.	22.8	26.	24.	2.	B.	37.25	13.5	13.2	.3	.352	.544	.336	.208	1.24	.728	.512	.26	1.8	27.7	26.	28.	?	8,65
5439	" 18	" 19	*	"	M. F.15	"	423.2	378.4	44.8	50.8	48.4	2.4	Gh.	46.	12.9	11.3	1.6	1.6	.512	.352	.16	1.32	.824	.496	.46	2.	29.1	26.	26.5	....	....
5486	" 24	" 25	†	"	M. F.1	"	315.2	294.4	20.8	50.4	48.8	1.6	Gh.	31.	9.1	8.3	.8	.704	.512	.304	.208	1.16	.856	.304	.29	1.76	28.8	28.	30.	—	5,92
5536	Aug. 1	Aug. 2	*	"	M. F.2	"	386.4	323.6	62.8	61.2	59.2	2.	Gh.	34.	12.7	10.5	2.2	.384	.448	.288	.13	1.16	.728	.432	.25	1.52	27.6	25.	24.	—	7,10
5587	" 8	" 9	†	"	M. F.06	"	392.4	338.8	53.6	49.6	48.	1.6	Gh.	30.	12.2	10.8	1.4	.16	.352	.272	.08	1.08	.856	.224	.15	1.4	27.6	24.	20.	—	2,80
5634	" 15	" 16	†	"	M. F.15	"	400.	352.4	47.6	85.2	76.	9.2	Gh.	38.25	11.9	10.6	1.3	.416	.416	.24	.176	1.016	.728	.288	.22	1.8	27.	23.	26.	+	24,00
5684	" 22	" 23	*	"	M. F.2	"	387.6	337.2	50.4	58.	34.8	25.2	Gh.	43.	12.5	10.5	2.	.24	.544	.272	.272	1.24	.824	.416	.12	1.4	26.7	26.	26.	+	1,95
5741	" 29	" 30	*	"	M. F.15	"	375.2	345.2	30.	36.8	36.8	0.0	Gh.	44.	13.	9.1	3.9	.272	.576	.288	.288	1.48	.712	.768	.08	1.	26.7	28.	25.	—	4,15
5794	Sept. 5	Sept. 6	*	"	M. F.04	"	392.4	367.6	24.8	36.4	36.4	0.0	B.	50.25	10.8	7.2	3.6	.368	.416	.304	.112	1.08	.856	.224	.12	1.08	27.	27.	26.	—	5,90
5840	" 12	" 13	†	"	M. F.1	"	393.2	360.4	32.8	37.2	34.4	2.8	G.	54.5	11.6	10.8	.8	.24	.512	.384	.128	1.4	.76	.64	.09	1.16	27.3	21.	26.	—	2,20
5890	" 19	" 20	†	Little	M. F.03	"	390.8	368.4	22.4	58.	54.4	3.6	B.	54.75	11.7	7.5	4.2	.168	.64	.336	.304	1.32	.824	.496	.12	1.08	27.6	20.	17.	—	3,25
5944	" 26	" 27	*	"	M. F.04	"	383.6	368.	15.6	45.6	36.	9.6	GB.	58.	10.1	8.3	1.8	.128	.512	.416	.096	1.028	.804	.224	.17	1.16	27.4	12.	11.	—	1,05
5992	Oct. 3	Oct. 4	†	"	M. F.2	"	392.8	384.8	8.	37.2	36.8	.4	G.	69.	11.	9.3	1.7	.128	.592	.336	.256	1.46	.708	.752	.85	3.2	27.3	12.	15.	+	2,00
6037	" 10	" 11	*	"	M. F.1	"	408.	391.6	16.4	34.	34.	0.0	G.	66.5	11.4	9.6	1.8	.192	.688	.336	.352	1.464	.708	.756	.75	1.4	27.3	15.	17.	—	1,97
6087	" 17	" 18	†	"	M. F.03	"	410.	392.4	17.6	39.6	12.8	26.8	G.	67.	9.8	8.8	1.	.256	.464	.4	.064	1.32	.808	.512	1.	3.68	27.6	18.	13.	—	5,50
6151	" 24	" 25	†	Cons'd	M. F.08	"	444.8	414.8	30.	27.6	14.8	12.8	G.	72.5	10.5	8.8	1.7	1.12	.64	.24	.4	1.32	.584	.736	1.5	4.	27.6	15.	18.	+	5,60
6197	" 31	Nov. 1	†	"	M. F.03	"	421.2	407.6	13.6	29.2	36.8	....	G.	62.	8.7	8.2	.5	1.44	.48	.304	.176	.968	.52	.448	1.35	3.6	27.8	12.	8.	—	2,55
6247	Nov. 7	" 8	†	"	F.04	"	404.8	389.2	15.6	23.6	22.8	.8	B.	55.	6.5	6.1	.4	3.2	.384	.304	.08	.52	.424	.096	.35	2.6	27.8	7.	8.	—	55
6296	" 14	" 15	†	"	M. F.03	"	398.8	380.8	18.	45.2	44.8	.4	B.	54.	7.1	6.6	.5	3.2	.416	.288	.128	.872	.552	.32	.1	1.	28.2	9.	9.	—	1,10
6339	" 21	" 22	†	"	M. F.03	"	372.4	354.4	18.	31.2	22.	9.2	B.	50.5	7.1	6.4	.7	3.52	.48	.288	.192	.92	.68	.24	.07	1.6	28.3	10.	12.	—	1,20
6408	" 28	" 29	†	Little	M. F.03	"	350.4	348.	2.4	45.6	44.8	.8	B.	34.	7.2	7.2	0.0	1.92	.32	.176	.144	.776	.552	.224	.06	1.84	28.1	6.	4.	+	2,80
6448	Dec. 5	Dec. 6	†	"	M. F.02	"	385.6	364.4	21.2	48.4	40.8	7.6	G.	36.	7.7	6.7	1.	1.6	.432	.256	.176	.936	.52	.416	.08	2.8	27.9	3.	—3.	....	....
6502	" 12	" 13	†	"	M. F.04	"	390.	376.4	3.6	44.4	40.8	3.6	G.	39.5	9.1	8.3	.8	1.4	.48	.4	.08	1.	.68	.32	.08	2.32	28.2	5.	3.	—	3,90
6551	" 19	" 20	‡	Cons'd	M. F.05	"	374.4	358.4	16.	41.6	41.6	0.0	G.	41.	9.6	8.9	.7	4.	.48	.432	.048	1.	.808	.192	.08	1.4	28.9	1.	—2.	+	13,6
6577	" 26	" 27	†	"	M. F.04	"	376.4	372.	4.4	31.2	28.4	2.8	G.	33.75	9.9	9.4	.5	3.36	.432	.336	.096	.84	.68	.16	.07	2.2	29.8	0.	—2.	—	10,4

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 15.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, WESLEY CITY, ILL.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
										Loss on Ig'n.									Albuminoid Am.												
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Tot'l	Dissolv'd	Susp'd			Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Susp'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
5122	May 29	May 31	*	Little	M. F.1	None	399.2	366.	33.2	79.2	74.4	4.8	B.	16.55	12.6	9.3	3.3	.752	.64	.288	.352	2.01	.89	1.12	.08	1.52	3.	....	......	....	....
5191	June 7	June 9	†	Cons'd	M. F.1	"	402.4	356.4	46.	55.6	54.8	.8	B.	20.	14.5	10.8	3.7	.48	.56	.432	.128	1.56	1.082	.478	.22	1.6	4.	....	21.	....	1,787,500
5208	" 12	" 14	*	"	M. F.2	"	372.4	302.	70.4	41.6	28.8	12.8	B.	16.5	14.3	11.1	3.2	.4	.608	.496	.112	1.64	.792	.848	.11	1.4	6.	....	27.	....	1,865,000
5254	" 19	" 21	*	"	M. F.05	"	389.2	316.4	72.8	46.	42.4	3.6	B.	15.5	13.5	11.3	2.2	.48	.448	.352	.096	1.32	1.048	.272	.08	1.28	8.	....	30.	....	1,408,340
5301	" 26	" 28	†	"	M. F.1	"	399.2	350.	49.2	27.6	12.4	15.2	B.	24.	12.9	12.4	.5	.16	.448	.4	.048	1.24	1.048	.192	.185	1.6	8.	....	30.	....	845,000
5337	July 3	July 5	*	"	M. F.15	"	327.2	280.4	46.8	58.8	50.8	8.	B.	25.	14.2	12.5	1.7	.144	.48	.352	.128	1.4	.952	.448	.13	1.6	6.	....	24.	+	300,000
5384	" 10	" 11	†	"	M. F.2	"	417.6	379.2	38.4	67.6	67.6	0.0	B.	38.	15.3	14.2	1.1	.224	.864	.528	.336	2.12	1.304	.816	.2	1.76	2.6	25.	30.	+	120,000
5485	" 24	" 26	†	"	M. F.1	"	322.	286.8	35.2	46.8	43.2	3.6	B.	31.	11.4	8.7	2.7	.432	.384	.304	.08	1.08	.856	.224	.27	1.64	6.	....	33.	+	3,750,000
5683	Aug. 21	Aug. 22	*	"	M. F.1	"	409.6	371.2	38.4	66.	49.2	16.8	Gh.	43.	14.3	11.1	3.2	.512	.88	.368	.512	1.72	.856	.864	.22	1.48	6.	....	......	+	3,900,000
5739	" 28	" 30	*	"	M. F.2	"	388.8	350.	38.8	51.6	50.4	1.2	Gh.	43.	11.3	8.7	2.6	.24	.544	.304	.24	1.24	.84	.4	.07	.8	7.	....	......	+	813,000
5796	Sept. 5	Sept. 6	*	"	M. F.08	"	365.6	353.2	12.4	52.8	49.2	3.6	B.	48.	14.9	8.3	6.6	.224	.928	.384	.544	2.12	1.048	1.072	.09	.36	....	28.	38.	....	590,000
5843	" 12	" 13	†	"	M. F.08	"	380.4	357.6	22.8	33.2	32.8	.4	B.	49.75	13.	11.8	1.2	.96	.512	.4	.112	1.976	1.24	.736	.18	.4	1.	20.	27.	+	560,000
5913	" 26	" 27	*	"	M. F.04	"	362.8	358.8	4.	40.8	40.	.8	GB.	56.	10.6	7.9	2.7	.096	.608	.368	.24	1.36	.74	.64	.08	.88	1.	19.	18.	+	43,300
5991	Oct. 3	Oct. 4	†	"	M. F.06	"	430.8	385.2	45.6	62.	53.2	8.8	G.	63.	13.3	11.2	2.1	.08	.704	.352	.352	1.78	.708	1.072	.2	1.72	1.	12.	24.	+	55,000
6052	" 10	" 12	*	"	M. F.2	"	474.4	354.8	119.6	49.2	46.	3.2	B.	68.	17.1	11.7	5.4	1.36	.88	.512	.368	1.86	1.	.86	.575	1.6	1.	12.	22.	....	1,270,000
6096	" 18	" 19	*	"	M. F.2	"	396.4	392.	4.4	30.8	30.	.8	G.	67.5	13.4	11.6	1.8	.88	1.12	.416	.704	2.84	1.	1.84	1.	1.48	1.	15.	21.	+	4,400,000
6181	" 26	" 27	*	"	M. F.04	"	462.	422.8	39.2	34.4	21.2	13.2	B.	68.3	12.2	9.6	2.6	1.76	1.36	.432	.928	2.44	1.	1.44	1.3	2.8	1.	16.	15.	+	3,770,000
6195	" 31	Nov. 1	†	"	M. F.08	"	434.8	430.	4.8	52.8	51.2	1.6	G.	65.	9.3	9.2	.1	.288	.64	.336	.304	1.32	.68	.64	1.	1.88	1.5	10.	15.	....	200,000
6254	Nov. 7	" 9	†	"	M. F.05	"	421.6	402.8	18.8	46.4	40.	6.4	B.	57.5	9.4	8.2	1.2	2.32	.768	.32	.448	1.416	.904	.512	.55	2.6	1.	6.	16.	+	40,000
6312	" 15	" 16	*	"	M. F.03	"	399.2	384.	15.2	34.8	30.8	4.	B.	54.5	10.8	7.1	3.7	3.2	1.28	.576	.704	2.44	1.	1.44	.375	2.	2.	....	16.	+	660,000
6361	" 22	" 24	†	"	M. F.03	"	399.6	367.2	32.4	43.6	40.	3.6	G.	51.	7.1	6.8	.3	3.2	.48	.336	.144	.808	.52	.288	.075	1.6	1.5	0.	5.	+	1,920,000
6472	Dec. 5	Dec. 8	†	"	M. F.04	"	377.2	356.4	20.8	42.	32.	10.	B.	35.	10.	6.9	3.1	1.6	.56	.332	.208	1.32	.808	.512	.007	2.8	.5	....	3.	....	....
6523	" 13	" 15	†	"	M. F.03	"	400.4	323.6	76.8	48.4	45.2	3.2	G.	38.5	10.5	7.4	3.1	2.72	.592	.32	.272	1.12	.744	.376	.07	2.8	2.	....	−1.	+	20,000
6549	" 20	" 20	†	"	M. F.04	"	378.8	358.	20.8	36.	34.8	1.2	G.	38.	9.9	8.9	1.	3.2	.512	.4	.112	1.	.68	.32	.08	1.88	2.	....	0.	+	7,000
6592	" 28	" 29	†	Little	M. F.03	"	395.2	380.4	14.8	48.8	37.2	11.6	G.	33.	11.3	9.7	1.6	3.2	.48	.384	.096	.932	.776	.156	.045	2.4	2.6	....	−12.	....	35,000

TURBIDITY—*Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 16.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, PEKIN, ILL.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois

Serial No.	Date of 1899 Collection.	Date of 1899 Examination.	Appearance. Turb'y.	Appearance. Sediment.	Appearance. Color.	Odor.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dissolv'd	Loss on Ig'n. Suspnd'd	Color on Ignition.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspd Matter.	Nitrogen as Ammonia. Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspnd'd	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
5087	May 24	May 27	*	Cons'd	M. F.03	None	395.2	374.	21.2	41.2	38.	3.2	B.	15.8	13.3	11.3	2.	.96	.56	.48	.08	1.13	.89	.24	.044	1.6	3.6	18.	19.	....	....
5120	" 30	" 31	*	Little	M. F.1	"	419.2	376.8	42.4	73.6	70.	3.6	B.	15.	14.8	11.2	3.6	.96	.64	.352	.288	1.45	.762	.688	.08	1.52	3.6	25.	28.	....	....
5162	June 6	June 7	*	Cons'd	M. F.15	"	436.	328.	108.	44.8	42.8	2.	B.	15.	14.3	10.6	3.7	.544	.608	.416	.192	1.37	.86	.51	.2	1.52	4.7	26.	33.	....	307,00
5210	" 13	" 14	*	"	M. F.2	"	374.8	328.	46.8	38.8	38.8	0.0	B.	14.5	14.	11.2	2.8	.72	.576	.336	.24	1.64	1.048	.592	.25	.8	3.6	25.	28.	....	1,097,50
5258	" 21	" 22	*	"	M. F.2	"	448.4	341.6	106.8	81.6	18.4	63.2	B.	16.	15.1	12.3	2.8	.576	.544	.384	.16	1.56	.92	.64	.17	1.36	2.	26.	34.	....	585,00
5310	" 27	" 29	†	"	F.15	Sli'ht	390.	358.4	31.6	34.4	32.8	1.6	B.	23.	15.6	13.4	2.2	.96	.704	.448	.256	1.4	.856	.544	.34	1.12	1.	27.	28.	....	4,010,50
5355	July 6	July 7	*	"	M. F.05	None	375.6	346.8	28.8	57.6	51.2	6.4	B.	26.	14.3	13.3	1.	1.2	.576	.416	.16	1.4	.984	.416	.24	1.2	1.	24.	30.	+	300,00
5403	" 12	" 13	†	"	M. F.15	"	409.6	381.6	28.	62.8	47.6	15.2	B.	36.	15.	13.6	1.4	.72	.672	.432	.24	1.368	1.08	.288	.34	1.22	1.	28.	33.	+	1,190,00
5446	" 19	" 20	*	"	M. F.1	"	379.6	335.2	44.4	42.8	38.8	4.	Gh.	42.	13.5	11.9	1.6	.836	.448	.288	.16	1.08	.724	.356	.32	1.4	2.	26.	32.	+	640,50
5492	" 25	" 26	†	"	M. F.05	"	316.8	285.2	31.6	42.8	42.	.8	Gh.	31.	11.3	9.8	1.5	.96	.352	.304	.048	1.	.824	.176	.27	1.28	1.5	30.	34.	+	820,00
5533	Aug. 1	Aug. 2	*	"	M. F.2	"	345.6	320.	25.6	67.2	63.6	3.6	Gh.	34.	15.1	13.	2.1	.864	.736	.48	.256	1.88	1.048	.832	.4	1.04	1.	25.	34.	?	3,635,00
5583	" 8	" 9	†	"	M. F.06	"	342.4	322.4	20.	47.2	38.4	8.8	Gh.	29.	13.3	12.	1.3	.672	.496	.368	.128	1.32	.952	.368	.25	.72	1.	21.	23.	+	3,073,33
5635	" 15	" 16	†	"	M. F.15	"	378.8	350.4	28.4	77.2	65.6	11.6	Gh.	35.5	12.2	11.	1.2	.608	.432	.352	.08	1.496	.792	.704	.36	1.44	.5	25.	33.	....	....
5682	" 22	" 23	†	"	M. F.15	"	376.	364.8	11.2	55.6	52.	3.6	Gh.	93.	13.1	11.5	1.6	.48	.672	.4	.272	1.56	.92	.64	.24	1.48	.5	26.	40.	+	950.00
5740	" 29	" 30	*	"	M. F.1	"	374.8	352.	22.8	38.	37.2	.8	Gh.	43.	14.3	9.7	4.6	.432	.752	.352	.4	1.88	1.	.88	.12	.76	1.0	29.	40.	....	55,00
5790	Sept. 5	Sept. 6	*	"	M.	"	378.4	370.	8.4	60.4	54.8	5.6	Gh.	46.5	14.1	9.9	4.2	.24	.896	.48	.416	1.72	1.08	.64	.09	.44	1.	28.	41.	+	40,00
5841	" 12	" 13	†	"	M. F.8	"	375.6	363.2	12.4	28.	28.	0.0	Gh.	50.	13.4	7.8	5.6	1.024	.576	.416	.16	1.72	.984	.736	.2	.24	1.	20.	27.	+	445,00
5898	" 18	" 21	*	"	M. F.04	"	375.6	323.2	52.4	39.2	38.8	.4	Gh.	44.	13.2	8.3	4.9	.512	.672	.336	.336	1.8	.856	.944	.012	.68	1.6	20.	21.	+	570,00
5946	" 26	" 27	*	"	M. F.06	"	440.	364.	76.	36.	33.6	2.4	GB.	56.	14.8	9.	5.8	.496	1.12	.416	.704	2.1	.964	1.136	.1	1.24	1.	15.	18.	+	510,00
5990	Oct. 3	Oct. 4	†	"	M. F.07	"	382.4	368.8	13.6	46.8	44.4	2.4	GB.	55.	11.8	8.	3.8	.336	.752	.368	.384	1.62	.804	.816	.14	1.4	1.	12.	24.	+	920,00
6053	" 10	" 12	*	"	M. F.1	"	435.2	334.4	100.8	29.6	25.6	4.	B.	58.5	11.4	....	....	.672	.88	.4	.48	1.38	.744	.636	.475	1.88	1.	12.	22.	....	520,00
6097	" 18	" 19	*	"	M. F.08	"	398.4	386.	12.4	27.2	25.6	1.6	G.	66.5	11.8	11.5	.3	.8	.72	.416	.304	1.64	.936	.704	.85	2.4	1.	15.	21.	?	650,00
6182	" 26	" 27	*	"	M. F.04	"	424.	410.	14.	33.2	30.8	2.4	B.	64.7	10.6	9.	1.6	1.088	1.04	.336	.704	1.72	.552	1.168	1.	3.2	1.	16.	15.	+	2,100,00
6196	" 31	Nov. 1	†	"	M. F.3	"	460.8	426.4	34.4	47.2	38.8	8.4	G.	65.	18.	12.	6.	.96	1.64	.544	1.096	3.64	1.16	2.48	1.5	1.88	1.5	10.	14.	+	2,780,00
6253	Nov. 7	" 9	†	"	M. F.04	"	418.8	410.	8.8	37.2	24.8	12.4	B.	60.2	8.	7.2	.8	1.76	.528	.32	.208	.968	.712	.256	1.	2.8	1.	6.	15.	....	170,00
6313	" 15	" 16	*	"	M. F.04	"	398.8	377.6	21.2	19.6	16.8	2.8	B.	52.5	7.5	5.7	1.8	2.56	.48	.336	.144	1.256	.584	.672	.1	.24	2.	10.	16.	+	145,00
6360	" 22	" 24	†	"	M. F.03	"	389.6	372.	17.6	39.6	34.4	5.2	G.	50.	10.5	7.5	3.	4.8	1.04	.48	.56	1.8	.904	.896	.08	1.45	1.5	0.	5.	+	95,00
6434	" 30	Dec. 2	†	"	M. F.03	"	362.8	348.4	14.4	54.	51.6	2.4	B.	35.	7.2	6.	1.2	1.92	.384	.32	.064	1.064	.808	.256	.05	1.52	1.5	0.	9.	?	870,00
6171	Dec. 5	" 8	†	"	M. F.01	"	376.8	363.2	14.6	48.	46.4	1.6	B.	36.5	10.3	6.5	3.8	1.6	.608	.32	.288	1.384	.808	.576	.008	3.2	.5	....	......	....	....
6524	" 13	" 15	†	"	M. F.01	"	395.2	367.6	27.6	40.	37.6	2.4	G.	38.5	9.6	8.2	1.4	2.56	.736	.384	.352	1.64	.84	.8	.07	2.8	2.	....	—1.	+	45,00
6550	" 19	" 20	†	"	M. F.04	"	376.4	363.2	13.2	44.	41.2	2.8	G.	39.	9.7	8.9	.8	3.68	.512	.4	.112	1.	.648	.352	.08	2.	2.	....	0.	+	7,00
6593	" 28	" 29	†	Little	M. F.03	"	383.2	380.4	2.8	39.6	38.	1.6	G.	34.	9.9	9.7	.2	3.04	.448	.352	.096	1.064	.808	.256	.055	2.32	2.5	....	—12.	....	155,00

TURBIDITY—*Decided. §Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gb., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 17.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, HAVANA.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coll.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dis-solv'd	Loss on Ig'n. Sus-pnd'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dis-solv'd	Albuminoid Am. Sus-pnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
1990	May 2	May 3	*	Cons'd	M.	None	324.4	293.2	31.2	50.8	50.	.8	B.	11.	13.	9.	4.	1.44	.48	.248	.232	1.29	.85	.44	.065	.5	....	....	......	....	....
5011	" 9	" 10	†	"	M. F.04	"	341.2	305.6	35.6	33.6	32.	1.6	B.	13.	11.2	10.1	1.1	.56	.44	.384	.056	1.21	.97	.24	.1	1.6	....	....	......	....	....
5048	" 16	" 17	†	Little	F.04	"	359.	316.6	42.4	23.6	4.	19.6	B.	18.	12.8	12.2	.6	1.024	.48	.352	.128	1.13	.89	.24	.12	1.12	....	....	......	....	....
5078	" 23	" 24	*	Cons'd	M. F.04	"	426.	344.4	81.6	47.2	43.2	4.	B.	18.25	15.4	12.8	2.6	.96	.56	.384	.176	1.45	1.114	.336	.075	1.08	....	...	......	....	....
5114	" 30	" 31	†	"	M. F.1	"	347.6	328.	19.6	28.	26.4	1.6	B.	13.15	11.7	10.3	1.4	.72	.448	.384	.064	1.05	.86	.19	.12	1.56	8.7	21.	26.	....	....
5123	" 30	June 1	*	Little	M. F.15	"	366.	319.2	46.8	52.	32.2	19.8	B.	11.	10.4	9.	1.4	.64	.416	.288	.128	1.21	.506	.704	.115	.92	9.3	....	......	....	....
5206	June 13	" 14	*	Cons'd	M. F.10	"	361.6	317.6	44.	37.6	36.8	.8	B.	15.	12.3	10.5	1.8	.72	.416	.352	.064	1.4	.824	.576	.24	1.2	8.8	25.	27.	....	10,600
5246	" 20	" 21	*	"	M. F.15	"	356.8	343.6	13.2	50.	48.8	1.2	B.	14.5	14.3	11.	3.3	.396	.512	.32	.192	1.16	.856	.304	.16	1.12	7.5	26.	36.	....	6,400
5303	" 28	" 29	*	"	M. F.1	"	371.2	324.4	46.8	29.2	26.4	2.8	B.	19.	13.1	12.	1.1	.688	.512	.464	.048	1.32	1.016	.304	.14	.76	5.2	25.	27.	....	3,450
5352	July 5	July 6	*	"	M. F.03	"	391.2	318.8	72.4	44.	39.2	4.8	B.	21.5	14.1	6.5	7.6	.8	.48	.332	.128	1.48	1.112	.368	.18	.4	4.7	26.	24.	+	13,300
5401	" 12	" 13	*	"	M. F.1	"	389.6	356.8	32.8	72.	68.8	3.2	Gh.	28.	14.5	11.8	2.7	.88	.416	.352	.064	1.16	.888	.272	.23	1.12	4.1	26.	29.	+	1,420
5447	" 19	" 20	*	"	M. F.08	"	358.	340.4	17.6	44.4	40.	4.4	Gh.	36.	12.6	11.7	.9	.784	.48	.288	.192	1.	.724	.276	.3	1.28	4.9	27.	30.	+	5,880
5494	" 26	" 27	†	"	M. F.07	"	306.	292.8	13.2	47.6	47.2	.4	Gh.	30.	11.	10.2	.8	.96	.416	.272	.144	1.08	.76	.32	.24	.84	4.8	30.	35.	+	3,200
5540	Aug. 2	Aug. 3	*	"	M. F.2	"	345.2	314.	31.2	74.	51.6	22.4	Gh.	30.	12.7	11.7	1.	.64	.448	.384	.064	1.24	.792	.448	.18	.76	4.	27.	33.	?	3,650
5601	" 9	" 10	*	"	M. F.04	"	370.	320.8	49.2	49.6	42.4	7.2	Gh.	31.	11.7	10.	1.7	.96	.384	.224	.16	.92	.728	.192	.17	.4	4.1	26.	30.	—	9,450
5640	" 16	" 17	*	"	M. F.07	"	410.	341.2	68.8	80.	68.4	11.6	Gh.	30.5	13.4	11.5	1.9	.972	.432	.304	.128	1.32	.728	.592	.23	.6	3.2	25.	27.5	....	....
5695	" 23	" 24	†	"	M. F.05	"	408.	347.2	60.8	46.4	45.2	1.2	Gh.	35.	13.3	9.8	3.5	.59	.592	.32	.272	1.4	.728	.672	.23	.64	3.	26.	31.	—	3,550
5749	" 30	" 31	†	"	M. F.04	"	397.2	334.4	62.8	44.8	24.	20.8	Gh.	40.	12.	10.8	1.2	.544	.64	.32	.32	1.4	.84	.56	.11	.36	2.2	29.	26.	—	6,250
5803	Sept. 6	Sept. 7	†	"	M. F.06	"	395.6	340.	55.6	29.6	29.2	.4	Gh.	41.	13.1	8.6	4.5	.768	.64	.4	.24	1.72	.92	.8	.002	.6	2.4	29.	33.	—	3,400
5859	" 13	" 14	*	"	M. F.1	"	423.2	352.8	70.4	49.2	46.4	2.8	Gh.	44.25	12.9	7.5	5.4	.928	.64	.4	24	1.56	1.	.56	.05	.32	2.6	22.	22.	+	3,500
5897	" 20	" 21	†	"	M. F.04	"	387.6	294.8	92.8	44.4	44.	.4	Gh.	35.5	12.9	8.2	4.7	.608	.48	.272	.208	1.4	.824	.576	.08	.6	3.6	14.	12.	+	12,900
5962	" 27	" 28	*	Much	M. F.06	"	416.4	352.8	63.6	46.4	40.	6.4	GB.	50.	12.2	9.3	2.9	.752	.592	.368	.221	1.54	1.06	.48	.09	.64	3.	16.	17.	—	4,750
6008	Oct. 4	Oct. 5	*	Cons'd	M. F.08	"	406.8	351.6	55.2	45.2	21.2	24.	B.	54.	15.	10.3	4.7	.432	.768	.4	.368	1.86	.772	1.088	.24	1.16	3.	14.5	13.	—	9,400
6055	" 11	" 12	*	"	M. F.15	"	443.6	389.6	54.	32.8	26.4	6.4	B.	61.5	13.4	11.2	2.2	.64	.56	.4	.16	1.32	.6	.72	.45	1.32	2.6	15.	21.	+	6,000
6104	" 18	" 19	†	"	M. F.25	"	402.4	352.	50.4	21.6	19.2	2.4	B.	60.5	14.3	7.1	7.2	1.6	.704	.432	.272	1.96	1.096	.864	.7	.56	3.2	17.	9.	+	21,900
6170	" 25	" 26	*	"	M. F.05	"	417.6	375.6	42.	18.4	17.6	.8	G.	58.2	9.2	7.8	1.4	1.6	.672	.48	.192	1.224	1.	.224	.625	1.76	3.	12.	19.	....	....
6211	Nov. 1	Nov. 2	*	"	M. F.04	"	436.8	415.2	21.6	42.8	24.8	18.	G.	63.5	10.5	9.	1.5	1.472	.624	.368	.236	1.384	.584	.8	.9	2.6	3.5	9.	8.	+	12,200
6258	" 8	" 9	†	"	M. F.04	"	414.4	404.	10.4	49.6	46.4	3.2	B.	57.	9.3	8.1	1.2	2.56	.704	.416	.288	1.4	.808	.592	.875	2.8	4.6	7.	15.	?	231,000
6317	" 15	" 16	*	"	M. F.04	"	397.6	374.	23.6	35.6	32.4	3.2	B.	53.	8.2	7.9	.3	2.7	.736	.4	.336	1.16	.68	.48	.25	2.	3.7	10.	11.	+	138,000
6357	" 22	" 23	†	"	M. F.04	"	383.2	363.6	19.6	27.6	22.	5.6	G.	48.	8.2	7.	1.2	3.36	.48	.288	.192	1.48	.52	.96	.07	1.48	4.4	11.	12.	+	150,000
6421	" 29	" 30	†	"	M. F.03	"	365.6	356.	9.6	41.2	39.6	1.6	G.	43.	8.5	7.4	1.1	3.28	.56	.336	.224	1.224	.872	.352	.06	1.28	4.	6.	5.	+	164,000
6469	Dec. 6	Dec. 8	†	"	M. F.03	"	366.	358.4	7.6	38.4	35.2	3.2	B.	34.	9.6	8.4	1.2	1.76	.672	.352	.32	1.88	.808	1.072	.08	1.52	3.8	2.	4.	+	275,000
6522	" 13	" 15	†	"	M. F.12	"	362.8	357.2	5.6	41.6	39.2	2.4	G.	35.5	10.8	9.4	1.4	2.56	.96	.432	.528	1.64	.904	.736	.08	2.4	4.3	2.	−2.	+	574,000
6558	" 20	" 21	†	"	M. .03	"	373.2	371.2	2.	31.2	30.8	.4	G.	36.	13.4	9.8	3.6	2.24	.512	.432	.08	1.16	.84	.32	.08	1.76	4.1	1.	2.	+	55,000

TURBIDITY—*Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 18.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—SANGAMON RIVER, CHANDLERVILLE, ILL.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	DATE OF		APPEARANCE.			Odor.	RESIDUE ON EVAPORATION.						Color on Ignition.	Chlorine.	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dissolv'd	Loss on Ig'n. Suspnd'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
5131	May 31	June 1	*	Much	M. F.3	None	398.	180.8	217.2	47.2	39.6	7.6	B.	1.	10.6	10.	6.6	.04	.512	.192	.32	1.37	.474	.896	.04	1.28	8.	33.	24.	....	....
5176	June 7	" 8	†	Cons'd	M. F.1	"	274.	227.2	46.8	31.6	31.6	0.0	B.	2.	8.5	7.1	1.4	.064	.304	.208	.096	1.05	.762	.288	.085	2.	8.	26.5	27.	....	3,700
5259	" 21	" 22	*	"	M. F.3	"	518.8	314.4	204.4	80.8	39.6	41.2	B.	4.5	12.7	4.4	8.3	.048	.352	.16	.192	1.	.376	.624	.048	2.	6.	27.	32.	—	10,550
5349	July 5	July 6	*	"	M. F.01	"	440.	289.6	150.4	55.6	46.8	8.8	B.	5.7	9.6	4.5	5.1	.032	.192	.08	.112	.84	.248	.592	.022	1.2	....	27.	28.	—	9,900
5405	" 12	" 13	*	"	M. F.8	"	399.6	256.4	143.2	56.8	48.	8.8	B.	5.6	9.6	5.4	4.2	.02	.256	.208	.048	.856	.344	.512	.024	1.4	4.	27.	32.	....	....
5552	Aug. 3	Aug. 4	*	"	M. F.03	"	332.	292.4	39.6	48.4	39.2	9.2	B.	5.75	7.1	6.	1.1	.052	.288	.192	.096	.408	.28	.128	.012	.16	3.	26.	33.	+	19,700
5600	" 9	" 10	*	"	M. F.3	"	412.	248.4	163.6	62.	33.2	28.8	B.	5.2	10.2	5.9	4.3	.044	.32	.096	.224	.76	.392	.368	.036	.48	3.6	25.	29.	—	37,250
5649	" 16	" 17	*	"	M. F.04	"	387.2	279.2	108.	60.	49.2	10.8	Gh.	5.8	7.9	6.	1.9	.032	.256	.16	.096	.856	.408	.448	.03	.28	.5	26.	29.	....	....
5770	" 31	Sept. 1	*	"	M. F.04	"	386.4	285.6	100.8	58.8	37.2	21.6	B.	6.	8.5	4.1	4.4	.02	.256	.1	.156	1.	.296	.704	.002	1.	....	27.	27.	—	2,400
5858	Sept. 13	" 14	*	"	M. F.03	"	334.	289.2	44.8	28.	21.2	6.8	B.	5.15	5.8	3.	2.8	.016	.32	.12	.2	.76	.28	.48	.013	.28	Low	22.	21.	—	10,500
5911	" 20	" 21	*	"	M. F.03	"	366.8	262.	104.8	34.4	17.6	16.8	B.	5.3	7.3	3.3	4.	.012	.256	.092	.164	.696	.376	.32	.001	.24	"	19.	21.	+	45,500
5973	" 28	" 29	*	Much	M. F.02	"	266.4	266.4	0.0	33.2	28.8	4.4	G.	5.8	6.	4.7	1.3	.016	.256	.116	.14	.9	.228	.672	.002	.16	"	7.	16.	—	4,900
6009	Oct. 4	Oct. 5	*	Cons'd	M. F.03	"	334.4	262.4	72.	38.	22.4	15.6	B.	6.	5.7	3.7	2.	.024	.208	.112	.096	.484	.228	.256	.005	.16	"	6.	23.	—	1,950
6105	" 18	" 19	*	Little	M. F.03	"	296.	245.6	50.4	22.4	17.2	5.2	B.	5.3	4.8	3.5	1.3	.024	.208	.124	.084	.68	.328	.352	.001	.12	"	12.	22.	+	4,900
6168	" 25	" 26	*	Cons'd	M. F.02	"	322.4	260.8	61.6	13.2	12.	1.2	B.	6.	5.1	3.6	1.5	.012	.24	.084	.156	.584	.152	.432	.004	.16	"	18.5	27.	—	4,200
6213	Nov. 1	Nov. 2	*	Little	M. F.03	"	330.	303.6	26.4	22.8	14.	8.8	G.	6.8	4.5	4.2	.3	.028	.208	.172	.036	.392	.328	.064	.012	.4	"	10.	8.	—	12,300
6259	" 8	" 9	†	"	M. F.03	"	323.6	302.8	20.8	48.8	22.4	26.4	B.	7.3	4.5	4.4	.1	.06	.256	.224	.032	.488	.392	.096	.009	.28	1.	10.	14.	—	2,400
6316	" 15	" 16	†	"	M. F.03	"	323.2	298.	25.2	30.8	28.	2.8	B.	6.5	4.	3.9	.1	.036	.128	.12	.008	.52	.36	.16	.005	.36	1.	12.	16.	....	4,300
6358	" 22	" 23	†	Cons'd	M. F.02	"	333.6	290.	43.6	19.6	16.4	3.2	G.	7.	5.9	4.2	1.7	.108	.208	.164	.044	.488	.36	.128	.022	.72	2.	13.	14.	+	11,200
6420	" 29	" 30	†	"	M. F.03	"	324.4	307.6	16.8	43.2	35.6	7.6	G.	6.5	3.8	3.5	.3	.048	.16	.148	.012	.328	.296	.052	.01	.6	1.	8.	14.	+	5,300
6470	Dec. 6	Dec. 8	‡	Little	F.03	"	300.4	289.6	10.8	31.2	24.8	6.4	B.	5.95	2.9	2.9	0.0	.14	.128	.12	.008	.38	.296	.084	.207	.4	4.	3.	5.	—	2,300
6521	" 13	" 15	‡	"	M. F.02	"	288	286.8	1.2	26.8	26.	.8	G.	6.6	4.2	4.2	0.0	.08	.208	.144	.064	.52	.296	.224	.01	.68	1.6	4.	1.	+	16,100
6561	" 20	" 22	†	"	M. F.03	"	355.2	276.4	78.8	46.	41.6	4.4	G.	7.1	9.7	6.5	3.2	.32	.352	.256	.096	.76	.424	.336	.015	.92	2.6	2.	4.	—	12,400

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. | Slight.

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 19.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, BEARDSTOWN, ILL.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	DATE OF		APPEARANCE.			Odor.	RESIDUE ON EVAPORATION.						Color on Ignition.	Chlorine.	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dis-solv'd	Sus-pnd'd							Tot'l	Dis-solv'd	Sus-pnd'd										
5098	May 24	May 26	*	Cons'd	M. F.05	None	462.8	275.2	187.6	42.	22.4	19.6	B.	11.	12.2	10.3	1.9	.448	.384	.288	.096	1.29	.86	.43	.065	.2	10.9	....	27.	....	....
5143	June 1	June 2	*	Much	M. F.1	"	450.2	258.8	200.4	39.6	38.4	1.2	B.	7.5	13.6	10.2	3.4	.32	.48	.224	.256	1.21	.442	.768	.09	1.2	11.8	....	31.	....	....
5244	" 19	" 20	*	"	M. F.15	"	572.8	304.4	268.4	53.6	52.4	1.2	B.	11.	18.7	10.7	8.	.192	.768	.304	.464	1.16	.432	.728	.085	1.12	9.4	26.	27.	....	4,400
5354	July 6	July 7	*	Cons'd	M. F.06	"	421.2	309.2	112.	50.	44.8	5.2	B.	16.	12.2	8.2	4.	.32	.416	.256	.16	1.08	.712	.368	.15	.88	7.1	25.	26.5	—	2,570
5412	" 13	" 14	*	"	M. F.15	"	388.4	322.	66.4	32.8	32.	.8	B.	16.	11.	8.9	2.1	.704	.352	.272	.08	1.	.664	.336	.175	1.12	6.8	29.	34.	—	1,040
5460	" 20	" 21	*	"	M. F.06	"	429.2	340.8	88.4	50.	44.8	5.2	B.	28 25	12.5	10.8	1.7	.32	.448	.32	.128	1.32	.76	.56	.2	1.12	6.9	28.	31.	—	750
5516	" 27	" 28	*	"	M. F.06	"	373.2	315.2	58.	32.4	....	....	Gh.	34.	16.	11.7	4.3	.352	.32	.288	.032	1.24	.792	.448	.325	1.08	6.8	21.	27.	—	1,050
5566	Aug. 3	Aug. 4	*	Much	M. F.04	"	369.2	302.4	66.8	49.2	41.2	8.	B.	26.	11.2	9.8	1.4	.32	.352	.264	.088	1.08	.6	.48	.2	.92	6.4	25.5	31.	....	850
5613	" 10	" 11	*	Cons'd	M. F.04	"	345.2	266.8	78.4	44.8	16.	28.8	B.	26.	10.2	9.	1.2	.16	.32	.24	.08	.92	.632	.288	.18	.62	7.9	21.	27.	—	5,700
5666	" 17	" 18	†	"	M. F.15	"	309.2	186.8	122.4	41.6	38.8	2.8	B.	22.	10.	8.8	1.2	.448	.384	.32	.064	1.08	.648	.432	.1	.52	6.3	23.	27.	....	....
5716	" 24	" 26	*	Much	M. F.06	"	337.2	276.	61.2	49.6	23.6	26.	Gh.	21.	9.5	7.1	2.4	.416	.416	.204	.212	.92	.664	.256	.17	.6	6.2	21.	27.	+	25,000
5769	" 31	Sept. 1	*	Cons'd	M. F.08	"	346.	334.8	11.2	52.8	45.2	7.6	B.	28.	8.2	7.3	.9	.48	.32	.256	.064	.92	.648	.272	.12	.56	6.	20.	27.	+	9,600
5820	Sept. 7	" 8	†	"	M. F.01	"	349.6	320.	29.6	28.4	28.	.4	B.	29.	5.9	5.7	.2	.448	.516	.192	.324	1.16	712	.448	.05	.2	6.2	25.5	32.	+	3,960
5873	" 14	" 15	*	"	M. F.06	"	332.4	302.4	30.	36.	32.	4.	B.	25.4	8.8	6.2	2.6	.8	.384	.268	.116	1.	.808	.192	.05	.44	6.2	15.5	13.	—	965
5917	" 21	" 22	*	Much	M. F.15	"	338.	224.	114.	20.	17.2	2.8	B.	22.	9.6	6.6	3.	.528	.32	.272	.048	1.	.44	.56	.036	.44	7.	21.	16.	+	2,820
5975	" 28	" 29	*	Cons'd	M. F.03	"	335.6	304.8	30.8	39.2	36.8	2.4	B.	34.5	8.9	8.7	.2	.672	.384	.24	.144	.9	.596	.304	.06	.6	6.4	15.5	13.	+	4,410
6015	Oct. 5	Oct. 6	*	"	M. F.03	"	362.8	336.8	26.	34.	32.	2.	B.	40.	17.	9.2	7.8	.432	.448	.272	.176	.964	.676	.288	.05	.88	6.2	13.	16.	—	2,950
6066	" 12	" 13	*	"	M. F.03	"	374.8	342.4	32.4	18.8	17.2	1.6	B.	45.	9.5	7.3	2.2	.176	.432	.32	.112	.968	.484	.484	.05	.96	6.3	16.	20.	+	3,300
6121	" 19	" 20	†	"	M. F.1	"	364.4	313.2	51.2	18.8	15.6	3.2	GB.	42.	8.2	7.4	.8	.8	.4	.288	.112	1.	.52	.48	.08	.96	6.6	18.	14.	+	9,750
6184	" 26	" 27	*	"	M. F.04	"	384.8	351.6	33.2	19.6	6.	13.6	B.	48.8	8.	7.	1.	1.088	.416	.304	.112	.904	.616	.288	.17	1.4	6.5	19.	18.	+	4,000
6221	Nov. 2	Nov. 3	†	"	M. F.02	"	453.2	394.	59.2	14.4	....	....	B.	50.	8.7	8.1	.6	1.13	.432	.336	.096	1.032	.76	.272	.6	1.92	6.7	2.	0.	+	6,500
6261	" 9	" 10	†	"	M. F.04	"	420.	397.2	22.8	50.4	47.2	3.2	B.	50.5	9.3	7.8	1.5	.48	.656	.352	.304	1.32	.584	.736	.7	2.8	6.6	8.	6.	+	21,500
6325	" 16	" 17	*	"	M. F.04	"	393.2	361.2	32.	30.8	28.	2.8	B.	46.	8.5	7.2	1.3	1.92	.56	.304	.256	1.256	.616	.64	.2	2.2	6.8	12.	12.	+	7,150
6373	" 23	" 24	*	"	M. F.03	"	373.2	342.8	30.4	24.4	21.6	2.8	B.	40.5	8.2	7.4	.8	2.64	.432	.32	.112	.904	.68	.224	.07	1.6	7.2	10.	12.	....	35,200
6432	" 30	Dec. 1	†	"	M. F.02	"	380.	361.6	18.4	49.6	46.8	2.8	G.	40.5	7.4	6.7	.7	3.04	.432	.32	.112	.936	.616	.32	.05	1.12	6.6	6.5	6.	+	60,000
6488	Dec. 7	" 9	†	"	M. F.04	"	351.6	348.8	2.8	44.	42.4	1.6	B.	30.	19.	7.	12.	1.44	.528	.288	.24	1.48	.744	.736	.045	1.2	6.4	4.5	8.	+	29,000
6531	" 14	" 16	*	"	M. F.03	"	357.6	320.	37.6	40.	36.4	3.6	G.	27.	9.9	7.3	2.6	1.44	.608	.272	.336	1.24	.584	.656	.05	1.8	6.8	0.	—6.	+	194,500
6573	" 21	" 23	†	"	M. F.04	"	370.	347.2	22.8	28.	27.6	.4	G.	32.	12.2	9.3	2.9	1.68	.544	.368	.176	1.24	.776	.464	.06	1.48	7.1	0.	—3.	+	184,500
6597	" 28	" 29	†	"	M. F.04	"	364.4	362.4	2.	45.2	44.8	.4	G.	33.	11.3	9.8	1.5	2.64	.416	.304	.112	1.196	.936	.26	.07	1.48	7.	0.	—11.	....	48,400

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red.
Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

Table 20.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

Source of Water—Illinois River, Kampsville, Ill.

Report of Arthur W. Palmer,
T. J. Burrill,
University of Illinois.

Serial No.	Date of 1899 Collection.	Date of 1899 Examination.	Appearance. Turb'y.	Appearance. Sediment.	Appearance. Color.	Odor.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dissolv'd	Loss on Ig'n. Suspnd'd	Color on Ignition.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspd Matter.	Nitrogen as Ammonia. Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspnd'd	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
4986	May 2	May 3	*	Much	M. F.4	None	458.	272.8	185.2	57.2	30.8	26.4	B.	7.9	13.7	8.3	5.4	.08	.48	.248	.232	1.21	.63	.58	.075	.45	....	....	......	....	....
5010	" 9	" 10	*	Cons'd	M. F.05	"	496.8	280.8	216.	34.8	33.6	1.2	B.	8.3	13.1	8.3	4.8	.01	.48	.272	.208	1.21	.81	.4	.075	.84	....	....	......	....	....
5042	" 16	" 17	*	"	M. F.08	"	492.4	286.4	206.	23.6	18.8	6.8	B.	8.85	13.9	8.3	5.6	.224	.512	.32	.192	1.37	.666	.704	.1	1.	....	....	......	....	....
5075	" 23	" 24	*	"	M. F.03	"	490.	236.4	253.6	26.4	18.8	7.6	B.	6.5	14.	10.1	3.9	.288	.448	.192	.256	1.37	.666	.704	.038	.68	....	....	......	....	....
5125	" 31	June 1	*	V.M'ch	M. F.1	"	636.4	176.4	460.	48.4	24.8	23.6	B.	4.	20.5	7.5	13.	.128	.672	.224	.448	1.61	.81	.8	.045	.88	....	22.	18.	....	....
5177	June 7	" 8	*	Much	M. F.15	"	536.8	214.8	322.	32.8	25.2	7.6	B.	4.	15.4	8.8	6.6	.032	.48	.176	.304	1.53	.858	.672	.065	1.4	20.1	27.	27.	....	4,950
5212	" 14	" 15	*	"	M. F.15	"	548.	305.6	242.4	36.8	35.6	1.2	B.	9.	13.5	7.8	5.7	.112	.512	.288	.224	1.24	.664	.576	.032	1.6	18.5	25.	29.	....	6,200
5260	" 21	" 22	*	Cons'd	M. F.25	"	601.6	272.8	328.8	48.8	26.	22.8	B.	8.5	13.9	9.2	4.7	.048	.416	.304	.112	1.24	.76	.48	.034	1.2	17.1	26.	33.	....	96,500
5309	" 28	" 29	*	Little	M. F.06	"	369.6	285.6	84.	35.2	....	....	B.	10.	11.7	9.6	2.1	.024	.352	.288	.064	1.	.76	.24	.085	1.2	16.4	24.	28.	....	5,100
5347	July 5	July 6	*	Cons'd	M. F.02	"	361.2	294.4	66.8	48.4	43.2	5.2	B.	13.	11.1	9.4	1.7	.032	.192	.16	.032	1.	.792	.208	.11	1.36	16.9	27.	29.	+	11,350
5402	" 12	" 13	*	"	M. F.2	"	304.8	257.2	47.6	53.2	33.2	20.	B.	10.	9.7	8.9	.8	.064	.384	.224	.16	.84	.536	.304	.1	.92	13.9	29.	35.	—	480
5445	" 19	" 20	†	Little	M. F.1	"	310.4	285.2	25.2	47.2	42.	5.2	Gh.	16.3	11.6	10.6	1.	.04	.32	.224	.096	.92	.724	.196	.056	1.2	16.	29.	33.	—	460
5493	" 26	" 27	†	Cons'd	M. F.07	"	344.4	324.4	20.	33.6	32.	1.6	Gh.	30.	9.6	9.5	.1	.064	.32	.256	.064	.92	.728	.192	.19	.4	15.9	28.	33.	+	355
5541	Aug. 2	Aug. 3	†	Little	M. F.25	"	316.	278.4	37.6	46.8	46.	.8	Gh.	22.	10.5	10.3	.2	.024	.24	.192	.048	.696	.6	.096	.1	1.12	15.9	28.	37.	—	3,300
5611	" 11	" 12	*	Much	M. F.05	"	372.8	147.2	225.6	44.	22.8	21.2	B.	7.9	11.	7.6	3.4	.16	.288	.132	.156	.84	.488	.352	.065	.48	16.5	27.	31.	+	17,400
5643	" 16	" 17	†	Little	M. F.2	"	263.6	244.	19.6	62.8	56.	6.8	G.	16.5	9.3	8.5	.8	.08	.304	.176	.128	1.	.456	.544	.1	.8	15.7	28.	28.	....	....
5703	" 23	" 24	†	Cons'd	M.	"	328.8	270.8	58.	40.	39.2	.8	G.	18.	8.5	8.	.5	.056	.352	.212	.14	.88	.632	.248	.07	.72	15.5	29.	32.	+	2,650
5746	" 30	" 31	†	"	M. F.03	"	341.2	272.8	68.4	64.	37.6	26.4	G.	18.	11.5	9.1	2.4	.04	.4	.192	.208	1.24	.552	.688	.1	.68	15.2	29.	32.	—	1,550
5802	Sept. 6	Sept. 7	†	"	M. F.05	"	309.6	283.6	26.	41.2	40.4	.8	B.	20.	8.4	5.8	2.6	.144	.336	.256	.08	1.	.792	.208	.04	.32	15.1	29.	32.	....	345
5850	" 13	" 14	*	"	M. F.04	"	346.4	312.	34.4	34.	25.2	8.8	B.	22.3	8.5	6.	2.5	.24	.352	.304	.048	.84	.6	.24	.06	.48	15.3	22.	20.	+	1,550
5900	" 20	" 21	*	"	M. F.04	"	311.6	222.	89.6	21.2	21.2	0.0	B.	16.5	8.7	6.9	1.8	.36	.352	.224	.128	1.	.472	.528	.04	.68	15.6	19.	18.	+	11,025
5961	" 27	" 28	†	Little	M. F.06	"	305.2	270.4	34.8	20.4	20.4	0.0	B.	26.4	8.2	7.5	.7	.3	.336	.272	.064	.82	.58	.24	.03	.6	15.3	17.	18.	....	1,000
6000	Oct. 4	Oct. 5	†	"	M. F.03	"	286.	264.	22.	36.	36.	0.0	GB.	25.7	9.5	8.7	.8	.324	.32	.288	.032	.676	.628	.048	.03	.48	15.3	16.	19.	—	825
6051	" 11	" 12	†	"	M. F.04	"	327.2	308.8	18.4	27.2	26.4	.8	B.	32.	8.9	7.1	1.8	.164	.288	.272	.016	.804	.392	.412	.024	.64	15.2	17.	22.	+	3,800
6098	" 18	" 19	†	"	M. F.07	"	330.4	321.6	8.8	27.2	25.2	2.	G.	37.5	8.2	8.	.2	.16	.368	.272	.096	1.08	.776	.304	.02	.56	15.5	17.	14.	+	1,145
6167	" 25	" 26	*	Cons'd	M. F.04	"	344.	309.2	34.8	19.6	17.2	2.4	G.	37.1	7.	6.9	.1	.296	.352	.24	.112	.872	.584	.288	.035	1.08	15.4	17.5	23.	+	1,100
6214	Nov. 1	Nov. 3	*	"	M. F.04	"	370.4	336.	34.4	21.6	....	...	G.	38.6	7.3	7.1	.2	.552	.4	.208	.132	.744	.52	.224	.045	1.	15.6	12.	9.	?	4,800
6255	" 8	" 9	†	"	M. F.05	"	365.6	362.8	2.8	30.	28.8	1.2	B.	41.	7.1	6.6	.5	.512	.336	.24	.096	.744	.616	.128	.12	1.68	15.6	10.	12.	—	1,025
6314	" 15	" ..	..	....	....	......	......	......	......	......	......	......	......	......	....	....	....	......	......	.....	.....	.....	......	......	......	....	15.7	12.	15.	—	1,450
6345	" 22	" 23	†	Cons'd	M. F.03	None	373.6	325.2	48.4	28.8	24.4	4.4	G.	34.5	8.	6.4	1.6	.688	.752	.288	.464	1.64	.704	.936	.05	.16	16.	12.	13.	+	11,200
6411	" 29	" 30	†	"	M. F.02	"	343.4	316.8	25.6	34.4	31.6	2.8	B.	32.	6.9	6.8	.1	1.44	.368	.272	.096	.936	.584	.352	.046	1.32	15.7	11.	12.	—	6,850
6453	Dec. 6	Dec. 7	†	"	M. F.03	"	344.8	342.4	2.4	37.6	37.2	.4	B.	34.	8.6	5.7	2.9	1.184	.56	.24	.32	1.284	.776	.608	.04	1.76	15.6	5.5	9.	+	5,900
6516	" 13	" 14	*	"	M. F.06	"	341.6	321.6	20.	37.6	35.6	2.	G.	26.	9.9	7.2	2.7	.368	.752	.208	.544	1.48	.584	.896	.035	1.8	15.8	4.	—1.	+	30,650
6572	" 20	" 22	*	"	M. F.04	"	324.8	292.	32.8	34.	32.	2.	G.	19.8	10.5	7.4	3.1	.672	.48	.256	.224	1.	.552	.448	.04	1.08	16.	2.	3.	+	70,000

Turbidity—*Decided. §Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

Color—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

Color on Ignition—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gb., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 21.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, GRAFTON, ILL.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Chicago

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Igni-tion.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centi-meter.
	1899 Collec-tion.	1899 Exami-nation.	Turb'y.	Sedi-ment.	Color.		Total.	Dis-solved.	Sus-pended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dis-solv'd	Loss on Ig'n. Sus-pnd'd			Total.	By Dis-solved.	By Suspd Matter.	Free Am-monia.	Albuminoid Am. Tot'l	Albuminoid Am. Dis-solv'd	Albuminoid Am. Sus-pnd'd	Total.	Dis-solved.	Sus-pended.	Nitrites.	Nitrates.					
5005	May 3	May 5	†	Cons'd	M. F.03	None	329.3	266.4	62.9	42.	39.2	2.8	B.	7.8	10.2	7.2	3.	.096	.44	.272	.168	1.21	.53	.68	.052	1.05	....	....	....	....	....
5024	" 10	" 12	†	"	M. F.04	"	323.2	258.	65.2	25.6	20.8	4.8	B.	7.1	9.9	9.14	.76	.128	.352	.288	.064	.89	.7	.19	.08	.72	....	....	....	....	....
5059	" 17	" 19	*	"	M. F.04	"	350.4	300.4	50.	42.8	38.2	4.6	B.	9.	10.	8.8	1.2	.06	.32	.288	.032	.89	.73	.16	.02	1.08	....	....	....	....	....
5090	" 24	" 26	*	"	M. F.04	"	369.6	245.2	124.4	38.	33.6	4.4	B.	7.	12.1	11.	1.1	.352	.48	.384	.096	.97	.7	.27	.07	1.72	17.5	....	....	....	....
5092	" 24	" 26	*	"	M. F.4	"	332.	231.6	100.4	28.8	25.6	3.2	B.	7.15	7.	6.6	.4	.384	.416	.288	.128	.89	.76	.13	.06	1.56	17.5	....	....	....	....
5135	" 31	June 1	*	Much	M. F.1	"	674.8	174.	500.8	51.2	21.4	29.8	B.	3.59	16.8	7.9	8.9	.08	.576	.288	.288	1.53	.57	.96	.042	.52	16.1	21.	26.	....	....
5185	June 7	" 9	*	"	M. F.7	"	442.4	263.2	179.2	45.2	42.4	2.8	B.	4.5	9.4	8.6	.8	.008	.4	.224	.176	1.37	.666	.704	.011	.96	16.7	22.	30.	....	2,600
5222	" 14	" 16	*	"	M. F.2	"	368.	254.4	113.6	25.2	24.	1.2	B.	8.	12.7	9.	3.7	.128	.512	.288	.224	1.	.856	.144	.007	1.4	14.1	26.	29.	....	4,000
5262	" 21	" 23	*	Cons'd	M. F.3	"	343.6	276.4	67.2	24.	23.2	.8	B.	7.	11.2	8.9	2.3	.096	.352	.176	.176	.92	.6	.32	.019	1.24	....	26.	31.	....	9,100
5323	" 28	" 30	*	"	M. F.05	"	300.8	300.	.8	19.6	....	....	B.	9.4	9.5	9.2	.3	.04	.224	.192	.032	.68	.6	.08	.033	.96	....	28.	31.	....	920
5351	July 5	July 6	†	Little	M. F.02	"	284.	318.	66.	44.	....	....	B.	10.7	10.8	9.3	1.5	.06	.32	.256	.064	.92	.64	.28	.054	1.2	14.6	29.	28.	—	560
5411	" 12	" 14	†	"	F.1	"	316.8	274.4	42.4	34.4	27.2	7.2	B.	10.4	8.9	7.8	1.1	.176	.352	.256	.096	.76	.568	.192	.165	.96	13.2	29.	32.	—	9,750
5453	" 19	" 20	†	"	M. F.04	"	503.6	286.4	217.2	86.8	48.	38.8	B.	12.9	10.4	9.4	1.	.04	.32	.304	.016	.92	.696	.224	.08	1.04	9.7	33.	36.	—	7
5498	" 26	" 27	†	"	M. F.1	"	343.2	314.8	28.4	50.8	46.	4.8	B.	22.2	12.	9.9	2.1	.052	.384	.256	.128	1.	.728	.272	.1	.84	7.6	34.	37.	—	135
5543	Aug. 2	Aug. 3	†	"	M. F.25	"	348.4	314.4	34.	59.2	52.4	6.8	Gh.	32.	10.2	9.7	.5	.024	.272	.224	.048	.792	.68	.112	.096	1.2	6.1	33.	37.	—	760
5598	" 9	" 10	†	"	M. F.04	"	374.	187.2	186.8	54.	34.4	19.6	B.	15.	11.3	8.1	3.2	.01	.256	.112	.144	1.08	.36	.72	.07	.72	7.6	25.	28.	+	4,550
5642	" 16	" 17	*	"	M. F.15	"	282.8	178.8	104.	75.6	47.6	28.	B.	6.9	11.9	9.3	2.6	.04	.368	.24	.128	1.08	.504	.576	.07	.64	6.	26.	29.	....	....
5696	" 21	" 24	†	"	M. F.05	"	308.8	273.2	35.6	44.	43.2	.8	Gh.	16.75	9.1	7.1	2.	.024	.384	.224	.16	.92	.544	.376	.05	.6	4.2	31.	31.	—	1,215
5747	" 30	" 31	†	"	M. F.03	"	297.2	256.	41.2	28.	27.6	.4	Gh.	14.	10.	9.	1.	.044	.288	.176	.112	.92	.488	.432	.05	.52	3.3	30.	31.	—	70
5805	Sept. 6	Sept. 7	†	"	M. F.04	"	324.4	294.	30.4	36.	33.2	2.8	B.	19.75	9.1	5.9	3.2	.084	.4	.272	.128	1.08	.76	.32	.05	.4	3.4	35.	34.	—	410
5852	" 13	" 14	*	"	M. F.04	"	320.	296.4	23.6	37.6	34.	3.6	B.	19.2	7.9	6.	1.9	.24	.352	.24	.112	.84	.552	.288	.05	.52	4.4	24.	22.	—	620
5902	" 20	" 21	*	"	M. F.03	"	344.8	287.2	57.6	24.4	24.	.4	B.	22.35	8.4	6.8	1.6	.18	.288	.224	.064	.84	.536	.304	.045	.6	4.8	20.	19.	+	1,720
5959	" 27	" 28	†	"	M. F.06	"	290.	256.	34.	23.6	17.6	6.	GB.	22.45	8.6	7.3	1.3	.396	.272	.256	.016	.82	.58	.24	.04	1.	4.1	19.	20.	—	425
6001	Oct. 4	Oct. 5	†	"	M. F.05	"	266.8	226.6	40.2	36.8	30.8	6.	GB.	19.3	9.1	8.3	.8	.192	.336	.272	.064	.708	.612	.096	.018	.48	....	18.	20.	—	750
6045	" 11	" 12	†	"	M. F.4	"	331.6	300.4	31.2	33.2	13.6	19.6	B.	28.9	8.3	8.	.3	.172	.32	.24	.08	.98	.628	.352	.023	.72	3.2	17.	21.	—	520
6166	" 25	" 26	*	Cons'd	M. F.03	"	320.8	282.	38.8	32.8	29.6	3.2	B.	28.	7.4	6.9	.5	.084	.368	.224	.144	.84	.472	.368	.022	.8	2.7	19.	24.	+	960
6205	Nov. 1	Nov. 2	*	"	M. F.15	"	340.	257.6	82.4	22.8	17.6	5.2	B.	26.3	8.2	7.4	.8	.404	.368	.256	.112	.648	.52	.128	.03	1.12	3.4	18.	10.	—	20,000
6257	" 8	" 9	†	Little	M. F.06	"	362.	334.4	27.6	40.4	32.	8.4	B.	36.6	7.8	6.5	1.3	.48	.32	.272	.048	.84	.44	.4	.06	1.48	5.4	9.	17.	+	1,210
6347	" 22	" 23	*	Cons'd	M. F.02	"	385.2	329.2	56.	29.6	27.2	2.4	B.	32.5	9.	7.2	1.8	.16	.752	.224	.528	1.8	.68	1.12	.05	1.6	6.	13.	17.	?	8,300
6412	" 29	" 30	†	"	M. F.02	"	339.2	306.	33.2	33.6	30.4	3.2	B.	27.	8.	6.6	1.4	.88	.352	.304	.048	1.064	.68	.384	.045	1.68	5.9	8.	12.	+	5,640
6462	Dec. 6	Dec. 7	†	"	M. F.03	"	342.	328.	14.	25.6	25.2	.4	B.	31.5	9.4	4.7	4.7	1.12	.512	.224	.288	1.256	.744	.512	.036	1.68	4.3	3.	6.	+	1,125
6519	" 13	" 14	*	"	M. F.07	"	346.4	315.6	30.8	45.2	36.4	8.8	G.	24.	10.6	6.4	4.2	.176	.704	.24	.464	1.64	.456	1.184	.025	1.68	4.3	3.	0.	+	3,250
6559	" 20	" 22	†	"	M. F.02	"	364.8	299.2	65.6	33.6	31.6	2.	G.	22.25	11.7	7.7	4.	.432	.672	.24	.432	1.16	.648	.512	.03	1.68	4.4	2.	6.	+	28,000
6585	" 27	" 28	*	"	M. F.03	"	329.2	282.	47.2	27.2	18.	9.2	G.	20.2	12.7	8.8	3.9	.88	.512	.224	.288	1.08	.616	.464	.026	1.68	2.1	0.	—1.	....	122,000

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ǁ Slight.   COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 22.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, GRAFTON, ILL.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Igni-tion.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centi-meter.
	1899 Collec-tion.	1899 Exami-nation.	Turb'y.	Sedi-ment.	Color.		Total.	Dis-solved.	Sus-pended.	Loss on Ig'n.					Total.	By Dis-solved.	By Suspd Matter.	Free Am-monia.	Albuminoid Am.			Total.	Dis-solved.	Sus-pended.	Nitrites.	Nitrates.					
										Tot'l	Dis-solv'd	Sus-pnd'd							Tot'l	Dis-solv'd	Sus-pnd'd										
5004	May 3	May 6	*	Much	M. F.30	None	891.2	130.4	760.8	17.1	6.7	10.4	B.	2.	26.9	8.4	18.5	.01	.96	.208	.752	1.85	.49	1.36	.02	.65	14.8	....	......	....	....
5025	" 10	" 13	*	"	M. F.15	"	348.	127.6	220.4	28.	22.	6.	B.	.69	14.6	10.6	4.0	.036	.416	.256	.16	1.13	.474	.656	.035	.4	....	....	......	....	....
5060	" 17	" 18	*	"	M. F.05	"	287.6	133.6	154.	27.2	16.4	10.8	B.	2.4	18.4	13.8	4.6	.06	.448	.256	.192	1.13	.794	.336	.006	.28	....	....	......	....	....
5091	" 24	" 26	§	V.M'ch	VM. F.3	"	1097.6	138.8	958.8	50.8	24.4	26.4	B.	2.	26.5	13.4	13.1	.184	1.12	.288	.832	2.65	.7	1.95	.05	.16	17.5	....	......	....	....
5136	" 31	June 1	§	"	M. F.3	"	844.	147.6	696.4	61.6	26.	35.6	B.	2.	24.8	10.9	13.9	.052	.832	.192	.64	2.01	.762	1.248	.016	.52	16.1	23.	26.	....	....
5186	June 7	" 9	§	"	M. F.6	"	705.2	155.6	519.6	68.4	34.	34.4	B.	1.5	25.5	12.1	13.4	.012	.88	.24	.64	2.65	.57	2.08	.007	.6	16.7	23.	30.	....	5,500
5221	" 14	" 16	§	"	M. F.6	"	521.6	181.2	340.4	29.2	21.6	7.6	B.	1.5	23.4	13.5	9.9	.044	.672	.256	.416	1.64	.856	.784	.002	.56	14.1	24.	29.	....	6,000
5261	" 21	" 23	§	Cons'd	M. F.5	"	403.6	113.2	290.4	32.	19.6	12.4	B.	1.5	20.4	13.1	7.3	.028	.512	.256	.256	1.4	.6	.8	.004	.52	....	27.	31.	....	6,900
5322	" 28	" 30	§	"	M. F.5	"	395.6	140.4	255.2	24.8	22.	2.8	B.	1.	19.3	14.6	4.7	.024	.48	.192	.288	1.08	.52	.56	.002	.48	....	26.5	31.	....	1,670
5350	July 5	July 6	†	Little	M. F.15	"	286.	122.8	163.2	21.2	20.4	.8	B.	1.15	17.7	14.6	3.1	.036	.4	.224	.176	1.	.728	.272	.004	.36	14.6	26.	28.	—	1,030
5410	" 12	" 14	*	Cons'd	M. F.5	"	172.4	159.6	12.8	45.6	45.2	.4	B.	1.3	24.6	12.5	12.1	.024	.576	.256	.32	1.4	.664	.736	.002	.6	13.2	27.	32.	+	1,000
5454	" 19	" 20	*	"	M. F.3	"	282.8	161.2	121.6	52.4	42.4	10.	B.	2.2	16.3	13.3	3.	.04	.416	.24	.176	1.	.568	.432	.02	.32	9.7	28.	36.	+	1,165
5497	" 26	" 27	*	"	M. F.08	"	267.6	165.2	102.4	55.2	45.6	9.6	Gb.	2.2	15.2	13.2	2.	.048	.416	.224	.192	.92	.376	.544	.01	.4	7.6	30.	37.	+	465
5542	Aug. 2	Aug. 3	†	Little	M. F.25	"	224.	158.	66.	46.	36.	10.	Gb.	2.4	14.9	12.3	2.6	.024	.32	.176	.144	.76	.536	.224	.001	.2	6.1	28.	37.	—	1,450
5597	" 9	" 10	†	Cons'd	M. F.04	"	438.	163.6	274.4	55.6	41.2	14.4	B.	2.6	15.2	11.1	4.1	.036	.416	.16	.256	1.32	.328	.992	.005	.12	7.6	26.	28.	+	2,823
5641	" 16	" 17	*	"	M. F.15	"	305.2	152.8	152.4	66.4	48.	18.4	B.	2.7	13.9	10.4	3.5	.036	.432	.176	.256	1.32	.....	.....	.011	.28	6.	27.	29.	....	....
5697	" 23	" 24	†	"	M. F.05	"	265.2	178.	87.2	41.2	34.	7.2	B.	3.1	11.2	7.8	3.4	.012	.336	.192	.144	1.	.44	.56	.004	.16	4.2	26.	31.	—	910
5748	" 30	" 31	†	Little	M. F.02	"	244.4	182.8	61.6	38.8	36.4	2.4	B.	3.5	10.9	9.9	1.	.032	.272	.176	.096	.92	.424	.496	.002	.12	3.3	28.	31.	—	1,200
5804	Sept. 6	Sept. 7	†	Cons'd	M. F.03	"	246.4	170.8	75.6	31.6	28.8	2.8	B.	3.5	10.6	6.	4.6	.036	.32	.16	.16	1.	.44	.56	.05	.2	3.4	30.	36.	—	530
5851	" 13	" 14	*	"	M. F.04	"	270.4	156.	114.4	29.2	14.4	14.8	B.	2.45	11.8	6.8	5.	.04	.384	.208	.176	.92	.552	.388	.007	.2	4.4	23.	22.	—	2,835
5901	" 20	" 21	*	"	M. F.04	"	265.6	162.8	102.8	35.2	33.6	1.6	B.	2.3	13.	8.6	4.4	.016	.432	.144	.288	1.08	.328	.752	.01	.32	4.8	20.	19.	—	4,500
5960	" 27	" 28	*	"	M. F.15	"	234.8	141.6	93.2	32.4	21.6	10.8	B.	2.8	13.5	11.9	1.6	.014	.416	.244	.172	.98	.484	.496	.005	.16	4.1	18.	20.	—	1,560
6002	Oct. 4	Oct. 5	*	"	M. F.07	"	206.8	148.8	58.	32.	25.2	6.8	B.	6.8	16.6	15.3	1.3	.032	.4	.224	.176	.868	.372	.496	.005	.2	....	16.	20.	—	2,170
6044	" 11	" 12	†	"	M. F.15	"	228.	163.6	64.4	27.6	24.8	2.8	B.	2.8	13.7	13.6	.1	.016	.416	.208	.208	.74	.404	.336	.003	.2	3.2	16.	21.	—	2,550
6165	" 25	" 26	*	"	M. F.05	"	230.8	154.4	76.4	25.6	15.6	10.	B.	3.6	9.8	8.7	1.1	.02	.416	.18	.236	.76	.296	.464	.005	.12	2.7	18.	24.	+	2,500
6204	Nov. 1	Nov. 2	*	"	M. F.04	"	232.4	162.	70.4	14.8	12.	2.8	B.	3.7	8.9	8.6	.3	.028	.384	.16	.224	.68	.36	.32	.006	.16	3.4	16.5	10.	+	8,700
6256	" 8	" 9	†	"	M. F.08	"	244.4	173.6	70.8	30.	22.	8.	B.	2.8	10.2	9.2	1.	.028	.32	.24	.08	.84	.44	.4	.005	.24	5.4	9.	17.	+	4,550
6305	" 15	" 16	*	"	M. F.03	"	303.2	169.2	134.	20.8	17.2	3.6	B.	2.5	12.5	12.5	0.0	.088	.368	.32	.048	.68	.424	.256	.006	.2	6.2	10.	14.	+	3,600
[illegible]346	" 22	" 23	*	"	M. F.3	"	241.2	150.8	90.4	38.8	33.2	5.6	B.	3.2	12.7	12.3	.4	.064	.4	.224	.176	.84	.52	.32	.006	.16	6.	13.	17.	+	18,000
[illegible]413	" 29	....	..	....	....	......	178.8	156.8	22.	37.6	27.2	10.4	B.	3.1	12.	11.6	.4	.096	.336	.272	.064	.936	.52	.416	.006	.16	5.9	3.	12.	+	7,050
[illegible]461	Dec. 6	Dec. 7	†	Cons'd	M. F.15	None	170.8	146.	24.8	28.8	20.8	8.	B.	3.	14.4	13.5	.9	.048	.32	.208	.112	.84	.68	.16	.006	.32	4.3	3.	6.	+	1,250
[illegible]620	" 13	" 14	*	"	M. F.13	"	157.2	134.8	22.4	23.6	22.	1.6	B.	3.7	12.5	11.8	.7	.001	.352	.224	.128	.744	.52	.224	.005	.12	4.3	3.	0.	+	2,500
[illegible]60	" 20	" 22	†	"	M. F.10	"	169.6	147.2	22.4	23.2	19.6	3.6	B.	3.6	12.1	11.9	.2	.032	.32	.208	.112	.6	.296	.304	.006	.16	4.4	1.	6.	+	7,300

TURBIDITY—*Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.
COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red.
Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 23.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER — MISSISSIPPI RIVER. 100 FEET FROM ILLINOIS SHORE, ALTON, ILL.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of: 1899 Collection.	Date of: 1899 Examination.	Appearance: Turb'y.	Appearance: Sediment.	Appearance: Color.	Odor.	Residue on Evaporation: Total.	Residue on Evaporation: Dissolved.	Residue on Evaporation: Suspended.	Loss on Ig'n: Tot'l	Loss on Ig'n: Dis-solv'd	Loss on Ig'n: Sus-pnd'd	Color on Ignition.	Chlorine.	Oxygen Consumed: Total.	Oxygen Consumed: By Dissolved.	Oxygen Consumed: By Suspd Matter.	Nitrogen as Ammonia: Free Ammonia.	Albuminoid Am.: Tot'l	Albuminoid Am.: Dis-solv'd	Albuminoid Am.: Sus-pnd'd	Organic Nitrogen: Total.	Organic Nitrogen: Dissolved.	Organic Nitrogen: Suspended.	Nitrogen as: Nitrites.	Nitrogen as: Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
5000	May 3	May 4	*	Much	M. F.1	None	590.8	191.2	399.6	46.	33.2	12.8	B.	4.5	17.2	9.1	8.1	.022	.76	.288	.472	1.61	.49	1.12	.042	.6	....	....	......	....	....
5018	" 10	" 11	*	Cons'd	M. F.25	"	483.6	205.6	278.	44.6	18.4	26.2	B.	4.87	15.	8.4	6.6	.06	.512	.256	.256	1.21	.742	.468	.04	.6	....	....	......	....	....
5057	" 18	" 19	*	Much	M. F.2	"	509.6	229.2	280.4	34.8	26.4	8.4	B.	5.4	19.5	12.1	7.4	.068	.512	.288	.224	1.53	.794	.736	.015	.56	....	....	......	....	....
5086	" 24	" 25	*	"	M. F.08	"	720.	182.8	537.2	38.8	32.8	6.	B.	3.7	24.	12.7	11.3	.12	.88	.24	.64	1.85	.57	1.28	.006	.84	17.5	18.	16.	....	....
5126	" 31	June 1	*	"	M. F.50	"	884.8	170.4	714.4	45.6	26.8	18.8	B.	3.6	20.	8.9	11.1	.044	.8	.224	.576	2.09	.506	1.584	.033	.72	16.5	21.	20.	....	....
5180	June 8	" 9	*	"	M. F.30	"	680.8	193.6	487.2	42.	28.8	13.2	B.	3.8	19.8	10.3	9.5	.008	.48	.24	.24	1.85	.73	1.12	.006	1.2	16.1	18.	16.	....	3,400
5217	" 15	" 16	*	"	M. F.25	"	475.2	238.8	236.4	30.4	26.8	3.6	B.	6.9	15.5	8.6	6.9	.036	.544	.208	.336	1.24	.696	.544	.005	1.36	17.	19.	20.	....	1,350
5263	" 22	" 23	*	"	M. F.30	"	373.6	216.8	156.8	28.	22.4	5.6	B.	5.1	14.9	10.3	4.6	.016	.512	.192	.32	1.08	.664	.416	.008	.84	14.4	19.	21.	....	4,000
5304	" 28	" 29	*	Cons'd	M. F.5	"	349.6	180.4	169.2	23.2	22.8	.4	B.	3.4	15.7	11.7	4.	.02	.448	.224	.224	1.32	.44	.88	.006	.52	13.5	27.	22.	....	1,080
5341	July 5	July 6	*	"	M. F.5	"	282.8	165.6	117.2	48.8	36.4	12.4	B.	3.9	16.8	13.8	3.	.02	.384	.24	.144	1.06	.564	.516	.017	.56	15.3	26.	27.	....	1,895
5396	" 12	" 13	*	"	M. F.4	"	331.6	188.8	142.8	56.8	48.8	8.	B.	4.3	15.4	12.4	3.	.05	.448	.256	.192	1.24	.504	.736	.02	.48	15.8	20.	28.	....	2,300
5448	" 19	" 20	*	"	M. F.1	"	269.6	189.6	80.	25.6	20.	5.6	B.	5.6	13.6	11.6	2.	.032	.448	.288	.16	.92	.536	.384	.025	.44	12.2	28.	31.	....	415
5499	" 26	" 27	*	"	M. F.15	"	309.2	226.4	82.8	57.6	42.4	15.2	B.	10.8	12.6	11.3	1.3	.04	.352	.272	.08	.92	.568	.352	.022	.72	9.	30.	34.	....	360
5550	Aug. 2	Aug. 3	*	"	M. F.3	"	300.8	238.4	62.4	40.	39.6	.4	B.	17.4	12.4	11.9	.5	.028	.304	.208	.096	.824	.664	.16	.04	.72	7.2	20.	32.	+	2,050
5592	" 9	" 10	†	"	M. F.03	"	614.	224.8	389.2	60.8	39.6	21.2	B.	13.	16.	9.7	6.3	.036	.48	.208	.272	1.32	.488	.832	.065	.88	7.	26.	28.	+	5,407
5648	" 16	" 17	*	"	M. F.3	"	302.8	158.8	144.	64.8	38.	26.8	B.	5.75	12.2	9.	3.2	.028	.32	.192	.128	1.16	.408	.752	.06	.6	7.2	26.	30.	....	....
5698	" 23	" 24	†	"	M. F.05	"	251.2	192.4	58.8	40.4	36.8	3.6	B.	6.5	10.2	7.2	3.	.016	.32	.192	.128	.84	.632	.208	.013	.32	4.3	28.	32.	—	2,500
5750	" 30	" 31	†	"	M. F.04	"	256.8	211.2	45.6	39.2	24.	15.2	B.	6.3	10.	8.9	1.1	.052	.32	.192	.128	.84	.424	.416	.013	.32	3.1	28.	28.	....	....
5806	Sept. 6	Sept. 7	†	"	M. F.04	"	242.4	189.2	53.2	24.8	17.6	7.2	B.	6.	9.6	6.	3.6	.056	.304	.208	.096	.92	.536	.384	.008	.2	2.9	30.	29.	—	1,700
5857	" 13	" 14	*	"	M. F.06	"	260.8	184.8	76.	36.4	32.4	4.	B.	5.8	10.9	6.3	4.6	.024	.384	.232	.152	.84	.408	.432	.008	.36	3.6	24.	22.	+	3,050
5907	" 20	" 21	*	"	M. F.04	"	294.4	206.8	87.6	36.8	30.	6.8	B.	9.9	11.	7.	4.	.032	.384	.176	.208	.84	.376	.464	.014	.36	4.	20.	20.	+	7,200
5958	" 27	" 28	*	"	M. F.06	"	227.2	173.6	53.6	34.	2.8	31.2	B.	7.3	11.4	10.2	1.2	.04	.352	.256	.096	.9	.532	.368	.01	.28	3.8	18.	19.	—	2,500
6003	Oct. 4	Oct. 5	*	"	M. F.07	"	221.2	158.8	62.4	36.	22.8	13.2	B.	6.6	13.3	12.3	1.	.032	.384	.24	.144	.804	.472	.332	.008	.2	2.8	15.	16.	—	1,900
6050	" 11	" 12	*	"	M. F.15	"	231.2	170.8	60.4	12.	9.2	2.8	B.	7.	11.6	11.3	.3	.016	.4	.24	.16	.664	.472	.192	.008	.2	2.2	16.	17.	+	2,450
6095	" 18	" 19	*	"	M. F.08	"	230.	207.2	22.8	12.8	12.	.8	B.	11.4	9.7	9.6	.1	.028	.352	.24	.112	.92	.424	.496	.005	.28	2.1	18.	20.	+	4,700
6160	" 25	" 26	*	"	M. F.04	"	234.	179.6	54.4	24.	18.	6.	B.	9.2	9.5	8.1	1.4	.044	.432	.352	.08	.92	.536	.384	.009	.2	1.9	18.	19.	+	2,050
6210	Nov. 1	Nov. 2	*	"	M. F.08	"	276.4	194.4	82.	20.4	10.8	9.6	B.	11.2	8.9	8.	.9	.084	.368	.256	.112	.712	.564	.148	.016	.52	2.3	12.	10.	?	21,200
6248	" 8	" 9	†	"	M. F.06	"	279.2	214.8	64.4	24.	17.6	6.4	B.	15.3	10.	9.4	.6	.096	.336	.24	.096	.904	.552	.352	.016	.48	3.9	9.	12.	+	2,000
6311	" 15	" 16	*	"	M. F.15	"	244.	184.4	59.6	26.8	25.6	1.2	B.	11.7	11.3	9.5	1.8	.064	.56	.288	.272	1.032	.584	.448	.03	.36	5.4	10.	13.	—	4,200
6348	" 22	" 23	*	"	M. F.25	"	272.8	217.2	55.6	23.6	14.8	8.8	B.	15.8	11.9	10.8	1.1	.06	.64	.24	.4	1.384	.68	.704	.025	.8	4.7	13.	14.	—	10,000
6414	" 29	" 30	†	"	M. F.3	"	233.6	202.	31.6	19.2	16.4	2.8	B.	12.1	10.6	10.2	.4	.398	.352	.208	.144	.968	.584	.384	.02	.72	3.8	8.	12.	+	10,600
6451	Dec. 6	Dec. 7	†	"	M. F.04	"	224.4	207.6	16.8	14.	12.8	1.2	B.	11.2	11.8	11.1	.7	.224	.448	.32	.128	.872	.552	.32	.015	.8	3.1	8.	8.	—	2,250
6510	" 13	" 14	*	"	M. F.10	"	224.	206.8	17.2	22.	20.8	1.2	B.	11.3	12.	9.9	2.1	.084	.448	.272	.176	1.064	.552	.512	.013	.6	3.	4.	1.	+	4,200
6553	" 20	" 21	†	"	M. F.03	"	253.6	216.	37.6	32.	24.8	7.2	......	11.7	11.2	9.9	1.3	.1	.48	.224	.256	1.32	.52	.8	.018	.8	3.	0.	0.	+	64,800

TURBIDITY—*Decided. §Very Decided. † Distinct. ‡ Very Slight. ∥ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 24.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

SOURCE OF WATER—MISSISSIPPI RIVER, ONE-FOURTH DISTANCE FROM ILLINOIS SHORE, ALTON, ILL.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dissolv'd	Loss on Ig'n. Suspnd'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
4999	May 3	May 4	*	Much	M. F.04	None	638.8	154.	484.8	48.	26.8	21.2	B.	3.4	18.2	8.5	9.7	.008	.76	.208	.552	1.53	.49	1.04	.032	.5	....	....	......	....	....
5017	" 10	" 11	§	Cons'd	M. F.1	"	404.4	134.4	270.	40.4	20.	20.4	B.	1.43	18.3	10.4	7.9	.008	.544	.256	.288	1.29	.54	.75	.02	.36	....	....	......	....	....
5056	" 18	" 19	§	Much	M. F.3	"	569.6	243.6	326.	36.8	27.6	9.2	B.	4.	21.9	13.	8.9	.076	.608	.224	.384	1.69	.646	1.044	.023	.6	....	....	......	....	....
5085	" 24	" 25	§	"	M. F.04	"	847.6	164.	683.6	52.	33.2	18.8	B.	2.51	25.9	13.2	12.7	.002	.96	.24	.72	2.17	.6	1.57	.017	.84	17.5	16.	16.	....	....
5129	" 31	June 1	*	"	M. F.30	"	948.	224.8	723.2	70.8	62.	8.8	B.	3.05	21.7	11.5	10.2	.032	.832	.32	.512	2.25	.826	1.424	.032	.72	16.5	21.	20.	....	....
5181	June 8	" 9	*	"	M. F.60	"	624.	181.6	442.4	45.6	35.6	10.	B.	1.8	24.5	11.6	12.9	.016	.727	.208	.519	2.01	.57	1.44	.007	.72	16.1	18.	16.	....	1,950
5216	" 15	" 16	§	"	M. F.50	"	470.	196.8	273.2	32.	19.6	12.4	B.	3.4	19.2	7.7	11.5	.032	.576	.208	.368	1.72	.728	.992	.002	1.	17.	19.	20.	....	3,200
5264	" 22	" 23	§	Cons'd	M. F.50	"	348.8	168.	180.8	24.	11.2	12.8	B.	2.	19.2	13.4	5.8	.02	.524	.24	.284	1.24	.504	.736	.004	.48	14.4	19.	21.	....	10,550
5305	" 28	" 29	§	"	M. F.7	"	339.	154.4	183.6	12.8	12.	.8	B.	1.64	17.4	12.5	4.9	.012	.448	.256	.192	1.16	.472	.688	.003	.44	13.5	27.	33.	....	8,650
5342	July 5	July 6	§	"	M. F.60	"	202.8	144.8	118.	46.4	38.4	8.	B.	1.8	18.2	16.5	1.7	.016	.352	.272	.08	1.08	.664	.416	.005	.4	15.3	26.	27.	....	1,270
5397	" 12	" 13	§	"	M. F.4	"	443.6	158.	285.6	75.2	50.	25.2	B.	2.	21.1	14.6	6.5	.02	.512	.272	.24	1.32	.44	.88	.002	.44	15.8	29.	28.	....	1,120
5449	" 19	" 20	*	"	M. F.2	"	236.8	159.6	77.2	28.	24.	4.	B.	2.6	15.	12.4	2.6	.06	.416	.256	.16	.84	.472	.368	.015	.28	12.2	28.	31.	....	419
5500	" 26	" 27	*	"	M. F.15	"	278.8	192.4	86.4	48.4	43.2	5.2	B.	5.5	13.9	11.5	2.4	.036	.384	.192	.192	.84	.6	.24	.01	.48	9.	30.	34.	....	430
5549	Aug. 2	Aug. 3	*	"	M. F.3	"	232.	183.6	48.4	30.	29.6	.4	B.	6.6	13.	12.2	.8	.036	.272	.192	.08	.76	.472	.288	.028	.2	7.2	29.	32.	+	1,750
5593	" 9	" 10	†	"	M. F.04	"	422.4	196.8	225.6	56.8	44.4	12.4	B.	8.4	14.	10.2	3.8	.052	.352	.208	.144	1.16	.488	.672	.044	.44	7.	26.	28.	+	2,920
5647	" 16	" 17	§	"	M. F.25	"	297.6	146.4	151.2	53.2	38.8	14.4	B.	3.4	13.1	10.8	2.3	.036	.384	.224	.16	1.24	.456	.784	.023	.62	7.2	26.	30.	....	....
5699	" 23	" 24	†	"	M. F.03	"	252.	197.2	54.8	38.8	37.6	1.2	B.	5.7	10.3	7.5	2.8	.016	.368	.176	.192	1.	.472	.528	.01	.2	4.3	28.	32.	—	2,250
5751	" 30	" 31	†	"	M. F.06	"	250.	190.4	59.6	31.2	30.8	.4	B.	5.7	10.6	9.3	1.3	.04	.32	.16	.16	.92	.456	.464	.011	.28	3.1	28.	28.	+	2,500
5807	Sept. 6	Sept. 7	†	"	M. F.02	"	240.8	184.4	56.4	20.4	15.2	5.2	B.	5.55	9.9	6.2	3.7	.048	.288	.224	.064	1.08	.552	.528	.005	.4	2.9	30.	29.	—	1,750
5856	" 13	" 14	*	"	M. F.05	"	260.	172.4	87.6	26.	15.2	10.8	B.	5.5	11.	6.7	4.3	.028	.352	.216	.136	.84	.392	.448	.008	.2	3.6	24.	22.	+	3,200
5906	" 20	" 21	*	"	M. F.04	"	283.2	189.2	94.	29.2	20.	9.2	B.	7.75	11.7	7.	4.7	.036	.432	.16	.272	1.13	.504	.656	.012	.28	4.	20.	20.	—	5,250
5957	" 27	" 28	*	"	M. F.07	"	233.	160.4	72.6	27.6	27.2	.4	B.	5.6	12.3	11.2	1.1	.016	.4	.292	.108	.82	.5	.32	.007	.2	3.8	18.	19.	—	1,800
6004	Oct. 4	Oct. 5	*	"	M. F.06	"	212.4	158.	54.4	26.	25.6	.4	B.	5.2	13.5	12.3	1.2	.04	.448	.24	.208	.964	.472	.492	.008	.16	2.8	15.	16.	—	2,300
6049	" 11	" 12	*	"	M. F.10	"	229.2	174.4	54.8	16.8	12.4	4.4	B.	6.8	13.1	11.5	1.6	.02	.4	.224	.176	.74	.472	.268	.007	.36	2.2	16.	17.	+	1,600
6094	" 18	" 19	*	"	M. F.08	"	250.8	185.2	65.6	15.6	12.4	3.2	B.	10.	9.7	8.9	.8	.024	.384	.24	.144	1.	.424	.576	.005	.2	2.1	18.	20.	—	2,400
6161	" 25	" 26	*	"	M. F.04	"	243.6	174.	69.6	25.2	20.	5.2	B.	8.2	9.7	8.	1.7	.044	.416	.24	.176	.744	.312	.432	.008	.2	1.9	18.	19.	+	2,150
6209	Nov. 1	Nov. 2	*	"	M. F.08	"	268.8	187.6	81.2	34.	9.6	24.4	B.	9.5	9.	7.7	1.3	.068	.368	.24	.128	.616	.44	.176	.013	.48	2.3	12.	10.	+	16,000
6249	" 8	" 9	†	"	M. F.05	"	254.	197.6	56.4	31.2	24.	7.2	B.	8.3	9.6	3.8	.8	.076	.352	.288	.064	.936	.456	.48	.013	.36	3.9	9.	12.	—	3,800
6310	" 15	" 16	*	"	M. F.4	"	230.	164.8	65.2	26.	25.4	.6	B.	7.8	12.1	10.3	1.8	.104	.48	.272	.208	.84	.584	.256	.022	.36	5.4	10.	13.	+	1,95
6349	" 22	" 23	*	"	M. F.3	"	234.4	178.4	56.	18.8	14.8	4.	B.	10.6	12.1	11.5	.6	.048	.544	.208	.336	.968	.616	.352	.02	.52	4.7	13.	14.	+	7,00
6415	" 29	" 30	†	"	M. F.3	"	223.2	189.6	33.6	27.2	16.8	10.4	B.	10.6	10.1	10.	.1	.28	.352	.208	.144	.904	.584	.32	.022	.48	3.8	8.	12.	+	9,40
6450	Dec. 6	Dec. 7	†	"	M. F.03	"	215.6	192.4	23.2	28.	26.	2.	B.	8.7	11.8	11.4	.4	.18	.432	.272	.16	1.064	.616	.448	.014	.44	3.1	8.	8.	—	1,70
6512	" 13	" 14	*	"	M. F.15	"	220.4	172.4	48.	21.6	19.2	2.4	B.	9.8	12.9	11.6	1.3	.072	.48	.192	.288	1.032	552	.48	.008	.56	3.	4.	1.	+	3,50
6554	" 20	" 21	†	"	M. F.03	"	224.8	190.4	34.4	25.2	20.4	4.8	B.	11.3	11.7	10.7	1.	.052	.48	.208	.272	1.08	.488	.592	.015	.16	3.	0.	0.	+	62,40

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 25.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION

SOURCE OF WATER—MISSISSIPPI RIVER, MIDSTREAM, ALTON, ILL.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois

Serial No.	Date of 1899 Collection.	Date of 1899 Examination.	Appearance. Turb'y.	Appearance. Sediment.	Appearance. Color.	Odor.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dis-solv'd	Loss on Ig'n. Sus-pnd'd	Color on Ignition.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspd Matter.	Nitrogen as Ammonia. Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dis-solv'd	Albuminoid Am. Sus-pnd'd	Organic Nitrogen. Total.	Organic Nitrogen. Dis-solved.	Organic Nitrogen. Sus-pended.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
4998	May 3	May 4	*	Much	M. F.3	None	769.2	136.4	632.8	66.	22.4	43.6	B.	1.4	18.4	8.7	9.7	.008	.92	.224	.696	1.85	.45	1.4	.034	.45	....	....	....	....	....
5016	" 10	" 11	*	Cons'd	M. F.3	"	474.	157.2	316.8	46.	38.1	7.9	B.	.95	16.8	8.8	8.	.04	.64	.256	.384	1.45	.54	.91	.016	.52	....	....	....	....	....
5055	" 18	" 19	*	Much	M. F.4	"	737.2	153.2	584.	46.4	20.8	25.6	B.	2.3	24.8	14.4	10.4	.06	.96	.32	.64	1.85	.6	1.25	.023	.48	....	....	....	....	....
5084	" 24	" 25	*	"	M. F.06	"	1172.4	146.8	1025.6	72.8	30.	42.8	B.	.74	26.2	12.5	13.7	.068	1.04	.256	.784	2.65	.54	2.11	.017	.92	17.5	18.	16.	....	....
5128	" 31	June 1	*	"	M.	"	1247.6	165.2	1082.4	78.8	26.	52.8	B.	.4	26.	12.6	13.4	.044	1.072	.256	.816	2.41	.474	1.936	.019	.56	16.5	21.	20.	....	....
5182	June 8	" 9	*	"	M. F.60	"	769.6	167.2	602.4	54.8	34.1	20.7	B.	.3	24.2	12.8	11.4	.016	.8	.208	.592	2.65	.57	2.08	.007	.72	16.1	18.	16.	....	6,200
5215	" 15	" 16	*	"	M. F.25	"	481.6	162.4	319.2	33.2	27.2	6.	B.	1.2	19.7	10.7	9.	.022	.64	.224	.416	1.88	.536	1.344	.002	.52	17.	19.	20.	....	1,500
5265	" 22	" 23	*	Cons'd	M. F.40	"	470.8	158.8	312.	21.6	20.	1.6	B.	1.5	21.8	13.6	8.2	.032	.576	.192	.384	1.48	.632	.848	.005	.48	14.4	19.	21.	....	8,700
5306	" 28	" 29	*	"	M. F.7	"	415.2	149.2	266.	18.4	12.8	5.6	B.	.9	19.6	12.6	7.	.032	.48	.208	.272	1.24	.16	1.08	.004	.4	13.5	27.	32.	....	6,700
5343	July 5	July 6	*	"	M. F.7	"	302.8	140.	162.8	52.8	33.2	19.6	B.	1.3	17.	10.8	6.2	.028	.416	.224	.192	1.08	.568	.512	.006	.36	15.3	26.	27.	....	1,150
5398	" .12	" 13	*	"	M. F.7	"	554.4	164.8	389.6	74.	48.8	25.2	B.	2.1	22.8	14.2	8.6	.072	.576	.224	.352	1.64	.568	1.072	.005	.56	15.8	29.	28.	....	6,050
5450	" 19	" 20	*	"	M. F.2	"	295.6	161.2	134.4	44.8	39.6	5.2	B.	2.6	16.	12.4	3.6	.034	.448	.224	.224	.92	.408	.512	.007	.32	12.3	28.	31.	....	615
5501	" 26	" 27	*	"	M. F.2	"	298.4	167.2	131.2	53.2	44.8	8.4	B.	2.4	15.1	12.2	2.9	.028	.416	.256	.16	1.08	.488	.592	.004	.4	9.	30.	34.	....	270
5548	Aug. 2	Aug. 3	*	"	M. F.3	"	228.	176.2	51.8	54.8	50.4	4.4	B.	1.2	13.6	12.	1.6	.024	.288	.176	.112	.728	.568	.16	.008	.12	7.2	29.	32.	—	3,300
5594	" 9	" 10	*	"	M. F.03	"	288.4	167.6	120.8	46.	36.8	9.2	B.	3.6	13.1	10.9	2.2	.044	.352	.176	.176	1.08	.408	.672	.01	.44	7.	26.	28.	+	1,363
5646	" 16	" 17	*	"	M. F.3	"	309.6	140.8	168.8	46.4	40.4	6.	B.	2.8	13.3	10.6	2.7	.024	.384	.176	.208	1.16	.456	.704	.017	.28	7.2	26.	30.	....	....
5700	" 23	" 24	†	"	M.	"	241.6	130.4	81.2	28.4	24.8	3.6	B.	3.7	10.7	8.	2.7	.012	.352	.172	.18	1.	.44	.56	.005	.16	4.3	28.	32.	—	3,200
5752	" 30	" 31	†	"	M. F.02	"	256.4	183.6	72.8	35.6	33.2	2.4	B.	4.45	10.8	9.3	1.5	.056	.288	.16	.128	.92	.44	.48	.008	.2	3.1	28.	28.	—	2,000
5808	Sept. 6	Sept. 7	†	"	M. F.02	"	211.2	175.2	66.	20.8	20.4	.4	B.	4.3	9.9	6.	3.9	.04	.288	.144	.144	.76	.392	.368	.003	.2	2.9	30.	29.	—	1,650
5855	" 13	" 14	*	"	M. F.04	"	262.	161.2	100.8	36.8	21.2	15.6	B.	3.6	11.3	6.3	5.	.018	.416	.184	.232	.92	.376	.544	.006	.2	3.6	24.	22.	+	4,900
5905	" 20	" 21	*	"	M. F.04	"	272.4	174.8	97.6	28.4	20.	8.4	B.	5.75	12.	7.	5.	.016	.32	.144	.176	.92	.472	.448	.009	.28	4.	20.	20.	—	5,950
5956	" 27	" 28	*	"	M. F.08	"	233.2	149.2	84.	27.2	26.	1.2	B.	3.8	13.	11.5	1.5	.034	.432	.244	.188	.9	.532	.368	.004	.16	3.8	18.	19.	....	2,400
6005	Oct. 4	Oct. 5	*	"	M. F.06	"	212.	151.6	60.4	36.4	15.2	21.2	B.	4.4	13.7	12.7	1.	.048	.384	.224	.16	1.06	.42	.64	.007	.12	2.8	15.	16.	—	2,350
6048	" 11	" 12	*	"	M. F.15	"	220.8	174.6	46.2	22.8	22.	.8	B.	5.1	12.4	12.1	.3	.02	.432	.176	.256	.74	.404	.336	.007	.16	2.2	16.	17.	—	2,700
6093	" 18	" 19	*	"	M. F.1	"	240.8	174.	66.8	19.2	12.	7.2	B.	8.8	11.1	9.2	1.9	.04	.352	.208	.144	.84	.448	.392	.007	.2	2.1	18.	20.	—	2,350
6162	" 25	" 26	*	"	M. F.05	"	228.	166.4	61.6	25.6	13.6	12.	B.	6.3	9.5	8.2	1.3	.024	.4	.224	.176	.84	.36	.48	.008	.2	1.9	18.	19.	+	2,300
6208	Nov. 1	Nov. 2	*	"	M. F.1	"	225.6	184.	41.6	26.	7.2	18.8	B.	7.7	9.1	7.3	1.8	.06	.384	.144	.24	.872	.408	.464	.01	.44	2.3	12.	10.	+	10,050
6250	" 8	" 9	*	"	M. F.1	"	256.8	201.6	55.2	29.2	26.8	2.4	B.	4.2	12.5	9.9	2.6	.028	.384	.304	.08	.84	.424	.416	.008	.2	3.9	9.	12.	—	3,500
6309	" 15	" 16	*	"	M. F.4	"	222.	147.6	74.4	30.4	26.4	4.	B.	3.2	12.2	11.	1.2	.092	.416	.32	.096	.808	.584	.224	.007	.28	5.4	10.	13.	+	3,450
6350	" 22	" 23	*	"	M. F.3	"	204.8	150.4	54.4	32.4	24.4	8.	B.	5.3	11.8	11.	.8	.044	.448	.224	.224	.808	.488	.32	.007	.28	4.7	13.	14.	+	9,600
6416	" 29	" 30	†	"	M. F.25	"	195.2	176.	19.2	33.6	26.8	6.8	B.	7.3	10.5	10.4	.1	.116	.32	.24	.08	.808	.552	.256	.012	.28	3.8	8.	12.	+	9,200
6452	Dec. 6	Dec. 7	†	"	M. F.03	"	205.6	176.	29.6	18.8	18.	.8	B.	6.8	12.5	11.6	.9	.08	.432	.32	.112	.968	.68	.288	.012	.52	3.1	8.	8.	+	2,200
6513	" 13	" 14	*	"	M. F.15	"	193.6	190.	3.6	38.8	37.2	1.6	B.	6.6	11.8	9.8	2.	.04	.464	.208	.256	.904	.584	.32	.008	.24	3.	4.	1.	—	2,500
6555	" 20	" 21	†	"	M. F.04	"	228.8	181.6	47.2	37.2	35.6	1.6	B.	7.7	14.6	11.4	3.2	.052	.416	.172	.244	1.	.488	.512	.009	.44	3.	0.	0.	+	50,200

TURBIDITY—*Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 26.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, ONE-FOURTH DISTANCE FROM MISSOURI SHORE, ALTON, ILL.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of 1899 Collection.		Date of 1899 Examination.		Appearance. Turb'y.	Appearance. Sediment.	Appearance. Color.	Odor.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dis-solv'd	Loss on Ig'n. Sus-pnd'd	Color on Ignition.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspd Matter.	Nitrogen as Ammonia. Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dis-solv'd	Albuminoid Am. Sus-pnd'd	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
4997	May	3	May	4	*	Much	M. F.3	None	879.2	133.6	745.6	43.6	26.4	17.2	B.	1.4	17.3	8.3	9.	.006	.96	.208	.752	2.09	.49	1.6	.034	.5	....	....	....	....	....
5015	"	10	"	11	*	Cons'd	M. F.15	"	614.	162.8	451.2	44.	38.4	5.6	B.	.95	19.2	9.8	9.4	.056	.64	.224	.416	1.85	.634	1.216	.012	.44	....	....	....	....	....
5054	"	18	"	19	*	Much	M. F.4	"	958.	146.	812.	50.4	13.2	37.2	B.	1.8	26.	14.	12.	.044	1.184	.288	.896	2.17	.6	1.57	.016	.56	....	....	....	....	....
5083	"	24	"	25	*	"	M. F.6	"	1285.6	150.	1135.6	84.8	30.8	54.	B.	.54	27.7	13.8	13.9	.064	1.12	.304	.816	2.73	.666	2.064	.01	.96	17.5	18.	16.	....	....
5127	"	31	June	1	*	"	M. F.50	"	1262.4	139.2	1123.2	84.4	27.6	56.8	B.	.4	18.6	11.4	7.2	.068	1.152	.16	.992	2.73	.442	2.288	.02	.56	16.5	21.	20.	....	....
5183	June	8	"	9	*	"	M. F.60	"	947.2	151.6	795.6	64.8	22.4	42.4	B.	1.2	22.	11.2	10.8	.008	1.12	.24	.88	2.81	.826	1.984	.006	.72	16.1	18.	16.	....	5,000
5214	"	15	"	16	*	"	M. F.40	"	473.6	141.6	332.	29.6	24.	5.6	B.	1.3	19.1	10.8	8.3	.04	.672	.24	.432	1.56	.792	.768	.002	.8	17.	19.	20.	....	2,250
5266	"	22	"	23	*	Cons'd	M. F.60	"	578.4	160.4	418.	36.4	25.6	10.8	B.	1.4	23.2	12.8	10.4	.036	.576	.288	.288	1.56	.6	.96	.007	.44	14.4	19.	21.	....	9,000
5307	"	28	"	29	*	"	M. F.8	"	449.2	164.	285.2	18.4	8.8	9.6	B.	1.3	18.7	12.7	6.	.024	.512	.208	.304	1.4	.504	.896	.003	.44	13.5	27.	32.	....	6,650
5344	July	5	July	6	*	"	M. F.8	"	356.8	142.8	214.	52.4	36.8	15.6	B.	1.9	18.8	14.8	4.	.016	.416	.256	.16	2.12	.728	1.392	.004	.52	15.3	26.	27.	....	2,090
5399	"	12	"	13	*	"	M. F.3	"	560.4	154.4	406.	83.2	47.2	36.	B.	2.2	23.8	13.2	10.6	.032	.64	.24	.4	1.656	.44	1.216	.004	.6	15.8	29.	28.	....	3,325
5451	"	19	"	20	*	"	M. F.3	"	324.8	166.8	158.	51.6	41.6	10.	B.	2.2	16.1	12.4	3.7	.036	.48	.256	.224	1.16	.504	.656	.006	.36	12.2	28.	31.	....	340
5502	"	26	"	27	*	"	M. F.2	"	303.2	192.8	110.4	60.8	30.	30.8	B.	2.2	14.9	12.1	2.8	.024	.384	.176	.208	1.	.504	.496	.004	.4	9.	30.	34.	....	1,260
5547	Aug.	2	Aug.	3	*	"	M. F.3	"	228.4	168.4	60.	55.2	52.4	2.8	B.	1.2	13.2	12.	1.2	.02	.256	.192	.064	.76	.504	.256	.002	.12	7.2	29.	33.	−	3,950
5595	"	9	"	10	*	"	M. F.04	"	266.8	163.6	103.2	41.	35.6	8.4	B.	3.	13.	11.3	1.7	.036	.288	.176	.112	.84	.376	.464	.003	.4	7.	26.	28.	+	1,340
5645	"	16	"	17	*	"	M. F.25	"	301.2	134.	167.2	46.	36.8	9.2	B.	2.5	13.6	10.2	3.4	.036	.4	.144	.256	1.24	.408	.832	.02	.44	7.2	26.	30.	+	6,900
5701	"	23	"	24	†	"	M.	"	233.6	163.2	70.4	38.8	32.4	6.4	Gb.	3.2	11.	8.2	2.8	.016	.368	.204	.164	1.	.344	.656	.003	.2	4.3	28.	32.	−	4,200
5753	"	30	"	31	†	"	M. F.03	"	235.2	179.2	56.	32.4	30.4	2.	Gb.	3.6	10.5	9.3	1.2	.048	.24	.176	.064	.84	.424	.416	.001	.24	3.1	28.	28.	−	1,100
5809	Sept.	6	Sept.	7	†	"	M. F.04	"	230.	165.6	64.4	33.6	21.2	12.4	B.	3.6	9.9	6.2	3.7	.032	.288	.176	.112	.76	.28	.48	.001	.16	2.9	30.	29.	−	1,000
5854	"	13	"	14	*	"	M. F.04	"	252.4	164.8	87.6	36.4	27.6	8.8	B.	2.5	11.	6.6	4.4	.028	.384	.172	.212	.96	.456	.464	.005	.2	3.6	24.	27.	....	1,460
5904	"	20	"	21	*	"	M. F.03	"	264.8	161.2	103.6	32.	28.	4.	B.	3.1	12.4	8.3	4.1	.012	.352	.16	.192	1.08	.248	.832	.01	.2	4.	20.	20.	+	5,100
5955	"	27	"	28	*	"	M. F.07	"	220.	145.2	74.8	28.4	28.	.4	B.	2.8	13.1	12.3	.8	.044	.4	.304	.096	.82	.516	.304	.006	.2	3.8	18.	19.	−	2,560
6006	Oct.	4	Oct.	5	*	"	M. F.07	"	213.6	147.6	66.	26.8	24.4	2.4	B.	3.2	13.2	11.2	2.	.048	.416	.272	.144	.836	.472	.364	.005	.08	2.8	15.	16.	+	2,300
6047	"	11	"	12	*	"	M. F.15	"	210.8	163.6	47.2	22.4	21.2	1.2	B.	3.7	14.3	11.	3.3	.02	.448	.192	.256	1.06	.324	.736	.005	.2	2.2	16.	17.	+	3,600
6092	"	18	"	19	*	"	M. F.06	"	228.8	156.4	72.4	21.2	16.8	4.4	B.	4.9	11.6	9.7	1.9	.052	.384	.176	.208	1.	.36	.64	.005	.2	2.1	18.	20.	−	1,450
6163	"	25	"	26	*	"	M. F.06	"	205.6	160.	45.6	24.	16.	8.	B.	4.3	9.6	8.6	1.	.016	.384	.208	.176	.584	.36	.224	.006	.12	1.9	18.	19.	−	2,150
6207	Nov.	1	Nov.	2	*	"	M. F.08	"	244.4	174.4	70.	21.2	7.2	14.	B.	4.5	9.2	8.4	.8	.028	.4	.144	.256	.68	.392	.288	.007	.28	2.3	12.	10.	−	8,300
6251	"	8	"	9	†	"	M. F.06	"	233.2	173.6	59.6	31.6	31.2	.4	B.	3.4	12.9	9.3	3.6	.028	.352	.24	.112	.936	.36	.576	.006	.2	3.9	9.	10.	+	3,600
6308	"	15	"	16	*	"	M. F.3	"	225.2	143.2	82.	34.	23.2	10.8	B.	2.5	12.5	11.2	1.3	.004	.368	.272	.096	.744	.552	.192	.005	.2	5.4	10.	13.	−	4,650
6351	"	22	"	23	*	"	M. F.3	"	191.6	143.2	48.4	25.2	17.6	7.6	B.	3.3	12.8	12.1	.7	.036	.432	.24	.192	.808	.52	.288	.006	.12	4.7	13.	14.	+	6,400
6417	"	29	"	30	†	"	M. F.3	"	182.8	157.	25.8	32.	24.4	7.6	B.	3.8	11.4	11.	.4	.02	.32	.182	.138	.68	.424	.256	.008	.12	3.8	8.	12.	−	9,000
6453	Dec.	6	Dec.	7	†	"	M. F.03	"	176.4	161.6	14.8	36.	23.6	12.4	B.	4.7	12.3	11.9	.4	.016	.4	.32	.08	.968	.616	.352	.011	.44	3.1	8.	8.	+	1,05
6514	"	13	"	14	*	"	M. F.15	"	172.	155.6	16.4	32.	24.	8.	B.	4.	12.6	11.5	1.1	.028	.336	.24	.096	.84	.456	.384	.006	.12	3.	4.	1.	+	2,20
6556	"	20	"	21	†	"	M. F.04	"	191.2	162.	29.2	30.	28.4	1.6	B.	5.4	11.9	11.4	.5	.032	.336	.176	.16	.92	.456	.464	.007	.16	3.	0.	0.	+	23,00

TURBIDITY—*Decided. §Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 27.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 100 FEET FROM MISSOURI SHORE, ALTON, ILL.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dissolv'd	Loss on Ig'n. Suspnd'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
4996	May 3	May 4	*	Much	M. F.3	None	801.2	136.4	664.8	50.8	20.2	21.6	B.	1.6	18.5	8.4	10.1	.01	.92	.304	.616	2.03	.41	1.62	.088	.5	....	....	....	....	....
5014	" 10	" 11	*	Cons'd	M. F.06	"	697.6	150.	547.6	26.4	24.4	2.	B.	.8	21.3	10.1	11.2	.056	.796	.256	.48	1.85	.666	1.184	.04	.48	....	....	....	....	....
5053	" 18	" 19	*	Much	M. F.4	"	862.4	146.8	715.6	38.8	26.8	12.	B.	1.4	26.	13.5	12.5	.096	1.024	.256	.768	2.11	.474	1.636	.014	.52	....	....	....	....	....
5082	" 24	" 25	§	V.M'ch	M. F.5	"	1061.4	147.6	916.8	72.	29.2	42.8	B.	.8	27.1	14.1	13.	.1	1.04	.256	.784	2.41	.7	1.71	.021	1.08	17.5	18.	16.	....	....
5130	" 31	June 1	*	"	M. F.30	"	1412.8	153.2	1259.6	93.2	49.6	43.6	B.	.36	24.7	11.9	12.8	.032	1.312	.224	1.088	2.73	.73	2.	.021	.56	16.5	21.	20.	....	....
5184	June 8	" 9	*	Much	M. F.70	"	1006.	170.4	835.6	78.4	35.2	43.2	B.	.5	26.1	13.4	12.7	.024	.96	.288	.672	2.65	.826	1.824	.007	.48	16.1	18.	16.	....	2,850
5213	" 15	" 16	*	"	M. F.40	"	462.8	169.2	293.6	24.	20.	4.	B.	1.6	18.4	10.8	7.6	.036	.608	.224	.384	1.8	.76	1.04	.008	.72	17.	19.	20.	....	3,300
5267	" 22	" 23	*	Cons'd	M. F.50	"	500.	168.8	331.2	35.6	32.	3.6	B.	1.6	21.4	12.7	8.7	.04	.64	.248	.392	1.64	.632	1.008	.007	.36	14.4	19.	21.	....	13,600
5308	" 28	" 29	*	"	M. F.60	"	433.2	150.4	282.8	37.2	26.4	10.8	B.	1.6	19.8	12.	7.8	.02	.552	.208	.344	1.32	.472	.848	.005	.4	13.5	27.	32.	....	9,250
5345	July 5	July 6	*	"	M. F.8	"	412.8	142.8	270.	62.8	34.8	28.	B.	2.	19.	14.6	4.4	.02	.48	.24	.24	2.04	.536	1.504	.004	.36	15.3	26.	27.	....	2,700
5400	" 12	" 13	*	"	M. F.6	"	618.8	161.6	437.2	88.4	46.4	42.	B.	2.15	22.8	13.2	9.6	.032	.544	.24	.304	1.464	.472	.992	.002	.6	15.8	29.	28.	....	6,000
5459	" 19	" 20	*	"	M. F.6	"	289.2	179.2	110.	53.2	44.4	8.8	B.	2.6	15.4	11.6	3.8	.032	.32	.208	.112	.84	.472	.368	.006	.36	12.2	28.	31.	....	510
5503	" 26	" 27	*	"	M. F.2	"	287.2	158.8	128.4	51.2	39.6	11.6	B.	3.2	14.4	11.5	2.9	.02	.384	.224	.16	.92	.408	.512	.005	.4	9.	30.	34.	...	2,500
5546	Aug. 2	Aug. 3	*	"	M. F.3	"	229.6	164.8	64.8	54.	45.2	8.8	B.	2.6	13.2	11.2	2.	.016	.272	.224	.048	.64	.536	.104	.004	.2	7.2	29.	33.	—	3,400
5596	" 9	" 10	†	"	M. F.04	"	293.6	165.6	128.	64.	38.	26.	B.	3.1	13.4	11.5	1.9	.024	.288	.192	.096	.84	.44	.4	.008	.2	7.	26.	28.	+	1,400
5644	" 16	" 17	*	"	M. F.3	"	326.	138.8	187.2	63.2	40.8	22.4	Gh.	2.8	13.7	10.5	3.2	.02	.384	.192	.192	1.16	.492	.668	.023	.4	7.2	26.	30.	....	....
5702	" 23	" 24	†	"	M.	"	217.2	183.2	34.	74.	55.6	18.4	Gh.	3.45	11.	8.2	2.8	.016	.4	.24	.16	1.08	.312	.768	.004	.16	4.3	28.	32.	—	2,350
5754	" 30	" 31	†	"	M. F.03	"	230.8	176.8	54.	40.	38.4	1.6	Gh.	3.4	10.5	9.6	.9	.036	.272	.18	.092	.92	.328	.592	.001	.28	3.1	28.	28.	—	1,800
5810	Sept. 6	Sept. 7	†	"	M. F.03	"	228.8	171.6	57.2	26.4	24.4	2.	B.	3.8	9.5	6.1	3.4	.032	.288	.128	.16	.76	.392	.368	.001	.12	2.9	30.	29.	—	1,400
5853	" 13	" 14	*	"	M. F.06	"	222.4	165.2	57.2	28.4	17.2	11.2	B.	2.6	9.6	6.3	3.3	.028	.352	.176	.176	.84	.408	.432	.007	.24	3.6	24.	22.	—	2,300
5903	" 20	" 21	..	....	....	....	.....	.....	.....	.....	.....	.....	....	....	....	....	....	.....	.....	.....	.....	.....	.....	.....	.....	....	4.	20.	20.	+	9,500
5954	" 27	" 28	*	Cons'd	M. F.06	None	216.4	141.6	74.8	37.2	32.	5.2	B.	3.1	12.5	11.8	.7	.012	.4	.264	.136	.82	.5	.32	.008	.12	3.8	18.	19.	?	1,050
6007	Oct. 4	Oct. 5	*	"	M. F.07	"	204.	146.8	57.2	31.2	23.6	7.6	B.	3.5	12.4	11.8	.6	.032	.368	.272	.096	.74	.372	.368	.004	.08	2.8	15.	16.	—	2,050
6046	" 11	" 12	*	"	M. F.15	"	214.8	162.8	52.	12.	11.6	.4	B.	3.3	12.9	12.8	.1	.02	.432	.24	.192	.772	.404	.368	.006	.08	2.2	16.	17.	—	2,300
6091	" 18	" 19	*	"	M. F.06	"	213.6	161.2	52.4	19.6	12.4	7.2	B.	4.2	11.5	9.7	1.8	.044	.352	.192	.16	.92	.36	.56	.007	.16	2.1	18.	20.	—	2,600
6164	" 25	" 26	*	"	M. F.06	"	209.2	153.6	55.6	19.6	14.8	4.8	B.	4.	9.9	8.6	1.3	.02	.4	.208	.192	.76	.376	.384	.006	.16	1.9	18.	19.	—	1,850
6206	Nov. 1	Nov. 2	*	"	M. F.07	"	228.8	179.2	49.6	17.2	12.	5.2	B.	4.4	9.	8.2	.8	.088	.352	.192	.16	.648	.392	.256	.007	.2	2.3	12.	10.	—	8,100
6252	" 8	" 9	†	"	M. F.06	"	205.2	162.	43.2	16.	14.4	1.6	B.	3.2	12.	9.5	2.5	.04	.432	.192	.24	.904	.424	.48	.007	.2	3.9	9.	12.	+	3,100
6307	" 15	" 16	*	"	M. F.5	"	212.4	145.2	67.2	26.	17.2	8.8	B.	2.6	12.2	10.9	1.3	.04	.384	.304	.08	.68	.52	.16	.007	.28	5.4	10.	13.	—	4,500
6359	" 22	" 23	*	"	M.	"	186.	144.4	41.6	14.4	11.2	3.2	B.	3.4	12.8	12.1	.7	.032	.368	.32	.048	.68	.552	.128	.007	.16	4.7	13.	14.	—	6,000
6418	" 29	" 30	†	"	M. F.25	"	168.8	162.4	6.4	25.6	22.8	2.8	B.	3.5	10.8	10.8	....	.016	.304	.192	.112	.68	.456	.224	.008	.12	3.8	8.	12.	—	6,950
6454	Dec. 6	Dec. 7	†	"	M. F.04	"	189.6	168.4	21.2	38.4	38.	.4	B.	3.6	12.9	11.9	1.	.02	.384	.32	.064	.808	.712	.096	.006	.48	3.1	8.	8.	+	1,400
6515	" 13	" 14	*	"	M. F.20	"	181.6	150.4	31.2	18.8	16.8	2.	B.	3.4	11.8	10.8	1.	.036	.352	.192	.16	.904	.488	.416	.007	.24	3.	4.	1.	+	1,550
6557	" 20	" 21	†	"	M. F.05	"	168.	153.2	14.8	21.6	30.4	1.2	B.	4.6	14.4	11.5	2.9	.036	.368	.176	.192	1.	.424	.576	.008	.16	3.	0.	0.	+	9,600

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ǀ Slight.

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red.
Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 28.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 400 FEET FROM ILLINOIS SHORE, AT CHAIN OF ROCKS, PUMPING STATION, ST. LOUIS WATER WORKS.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Suspnd'd							Tot'l	Dissolv'd	Suspnd'd										
4077	April 28	April 29	§	V.M'ch	VM.F.03	None	2656.4	208.8	2447.6	84.	21.2	62.8	B.	4.	30.5	8.1	22.4	.044	1.04	.16	.88	2.49	.314	2.176	.029	.55	....	....	....	....	....
5029	May 12	May 13	§	"	VM.F.06	"	1455.6	203.6	1252.	44.4	31.6	12.8	B.	4.2	22.7	9.	13.7	.044	.88	.192	.688	1.93	.314	1.616	.022	.4	....	....	....	....	....
5101	" 25	" 26	§	"	VM.F.3	"	886.4	122.8	763.6	37.2	2.	35.2	B.	2.4	23.8	11.9	11.9	.06	.88	.224	.656	2.33	.666	1.664	.035	.81	25.	....	....	....	....
5142	June 1	June 2	§	"	VM.F.1	"	801.2	182.6	618.6	61.6	28.8	32.8	B.	3.2	21.9	10.9	11.	.028	.8	.192	.608	2.17	.474	1.696	.03	.72	22.7	22.5	27.	....	....
5190	" 8	" 9	§	"	VM.F.15	"	2861.6	277.5	2584.1	100.4	14.4	86.	B.	4.5	26.6	7.5	19.1	.016	1.28	.22	1.06	3.53	.474	3.056	.005	.72	23.7	24.	30.	....	29,500
5223	" 15	" 16	§	"	VM.F.1	"	3572.8	241.6	3331.2	96.8	14.	82.8	B.	5.1	34.2	7.7	26.5	.056	1.68	.224	1.456	5.24	.44	4.8	.002	1.04	24.8	24.5	28.	....	15,500
5272	" 22	" 23	§	"	VM.F.1	"	3114.4	252.	2862.4	77.6	22.4	55.2	B.	4.8	31.3	8.1	23.2	.02	1.36	.176	1.184	4.12	.44	3.68	.003	.6	20.8	26.	32.	....	25,800
5312	" 29	" 30	§	"	VM.F.04	"	1734.	199.6	1534.4	49.2	15.6	33.6	B.	3.5	26.6	9.8	16.8	.016	.768	.176	.592	2.04	.472	1.568	.002	.44	20.4	24.	20.	....	8,025
5356	July 6	July 7	§	"	VM.F.05	"	1666.8	106.8	1560.	77.2	22.4	54.8	Blk.	4.3	24.6	9.6	15.	.02	.832	.16	.672	2.2	.472	1.728	.005	.52	22.6	23.	27.	....	6,100
5400	" 13	" 14	§	"	VM.F.15	"	2242.	206.8	2035.2	82.4	33.6	48.8	B.	3.9	27.1	8.4	18.7	.02	1.368	.16	1.208	3.48	.408	3.072	.002	.6	23.9	27.	35.	....	....
5459	" 20	" 21	§	"	VM.F.06	"	2069.6	195.6	1874.	72.	36.4	35.6	B.	4.15	27.2	10.8	16.4	.04	.88	.224	.656	2.2	.504	1.696	.003	.44	20.6	26.	27.	....	4,500
5515	" 27	" 28	§	"	VM.F.08	"	1523.6	214.	1309.6	42.8	26.	16.8	B.	4.6	24.	10.9	13.1	.016	.576	.24	.336	2.08	.344	1.736	.01	.4	16.6	29.	36.	....	8,100
5553	Aug. 3	Aug. 4	§	"	VM.F.04	"	2012.	200.8	1811.2	68.8	35.2	33.6	B.	5.3	27.	8.6	18.4	.012	.8	.16	.64	2.12	.408	1.712	.01	.36	14.3	20.	37.	+	9,650
5605	" 10	" 11	§	"	VM.F.04	"	828.8	154.	674.8	63.2	31.2	32.	B.	6.	17.6	9.5	8.1	.044	.544	.112	.432	1.56	.36	1.2	.042	.36	12.9	26.	20.	+	8,350
5653	" 17	" 18	§	"	VM.F.1	"	1205.6	167.2	1038.4	102.	44.4	57.6	B.	5.6	21.8	7.3	14.5	.036	.672	.144	.528	1.8	.424	1.376	.01	.48	13.9	27.	32.	....	....
5712	" 24	" 25	§	"	VM.F.06	"	663.6	180.	483.6	51.2	28.8	22.4	B.	5.8	16.7	7.	9.7	.024	.512	.16	.352	1.4	.36	1.04	.005	.43	9.7	27.	32.	+	2,300
5757	" 31	Sept. 1	§	"	VM.F.06	"	853.6	215.2	638.4	55.2	22.8	32.4	B.	7.3	13.2	8.5	4.7	.06	.384	.144	.24	1.24	.416	.824	.007	.32	7.5	27.	32.	+	5,800
5815	Sept. 7	" 8	*	Much	M. F.03	"	559.6	193.2	366.4	28.	17.2	10.8	B.	6.	11.5	5.8	5.7	.024	.384	.224	.16	1.08	.376	.704	.004	.24	6.6	29.	38.	+	2,500
5866	" 14	" 15	*	"	M. F.03	"	310.4	253.2	57.2	29.6	18.	11.6	B.	4.6	11.6	5.8	5.8	.024	.384	.252	.132	1.16	.488	.672	.006	.16	6.6	22.	21.	−	2,750
5913	" 21	" 22	*	"	M. F.04	"	300.	175.6	124.4	37.2	29.6	7.6	B.	7.1	11.5	6.9	4.6	.02	.448	.188	.26	1.16	.456	.704	.01	.4	6.6	19.	20.	+	6,950
5971	" 28	" 29	*	"	M. F.06	"	215.6	165.2	50.4	23.6	18.	5.6	GB.	5.6	12.9	9.9	3.	.012	.448	.196	.252	1.06	.5	.56	.007	.2	5.3	16.	18.	−	4,100
6013	Oct. 5	Oct. 6	*	"	M. F.1	"	641.2	154.4	486.8	32.	17.6	14.4	B.	5.5	15.3	12.7	2.6	.012	.432	.24	.192	.98	.468	.512	.005	.12	4.5	15.	21.	+	1,850
6063	" 12	" 13	*	Cons'd	M. F.04	"	275.6	170.	105.6	9.6	7.2	2.4	B.	6.7	11.6	10.6	1.	.02	.336	.192	.144	.76	.212	.548	.005	.2	3.5	17.	22.	−	4,100
6127	" 20	" 21	*	"	M. F.08	"	286.4	180.	106.4	14.	13.2	.8	B.	9.4	9.3	6.5	2.8	.02	.432	.184	.248	.92	.408	.512	.005	.12	3.3	17.	18.	−	2,700
6179	" 26	" 27	*	"	M. F.04	"	397.2	182.8	214.4	18.8	12.	6.8	B.	7.9	9.6	8.1	1.5	.02	.416	.176	.24	.936	.264	.672	.007	.32	3.	17.	19.	+	3,650
6215	Nov. 2	Nov. 3	*	Much	M. F.05	"	309.6	204.4	105.2	21.2	....	....	B.	8.6	9.3	9.1	.2	.064	.384	.22	.164	.776	.488	.288	.015	.32	3.9	9.	2.	+	8,200
6276	" 13	" 14	*	Cons'd	M. F.2	"	276.	188.	88.	26.4	21.6	4.8	B.	7.9	11.4	9.5	1.9	.016	.432	.304	.128	.92	.488	.432	.014	.48	6.2	9.	14.	−	1,850
6362	" 23	" 24	*	Much	M. F.25	"	338.4	192.8	145.6	36.	32.4	3.6	B.	10.5	15.6	10.8	4.8	.032	.56	.28	.28	1.	.68	.32	.015	.56	6.2	11.	10.	+	4,850
6423	" 30	Dec. 1	*	Cons'd	M. F.2	"	219.2	179.6	39.6	20.	17.6	2.4	B.	9.	10.7	5.4	5.3	.184	.352	.228	.124	.904	.616	.288	.015	.36	5.5	8.	17.	+	5,250
6489	Dec. 7	" 9	†	"	M. F.03	"	210.	168.8	41.2	18.4	16.	2.4	B.	8.2	12.	10.6	1.4	.108	.512	.24	.272	.968	.648	.32	.008	.28	4.9	3.	8.	+	3,400
6534	" 15	" 16	†	"	M. F.25	"	215.6	179.2	36.4	25.6	19.6	6.	B.	8.1	11.5	6.2	5.3	.032	.48	.248	.232	1.	.488	.512	.008	.52	4.6	0.	5.	+	10,05
6568	" 21	" 22	†	"	M. F.04	"	244.4	190.4	54.	36.4	29.2	7.2	B.	8.4	14.2	10.	4.2	.002	.432	.208	.224	.92	.552	.368	.015	.64	4.7	0.	5.	+	16,00

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 29.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

SOURCE OF WATER—MISSISSIPPI RIVER, MIDSTREAM, AT CHAIN OF ROCKS, PUMPING STATION ST. LOUIS WATER WORKS.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coll.	No. of Bac. per Cubic Centimeter.
	1890 Collection.	1890 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Suspend'd							Tot'l	Dissolv'd	Suspend'd										
4975	April 28	April 29	§	V. M'ch	VM. F.02	None	2404.	198.8	2205.2	64.	20.8	43.2	B.	3.7	29.7	6.1	23.6	.008	.8	.144	.656	2.33	.314	2.016	.027	.5	....	....	......	....	....
5028	May 12	May 13	§	"	VM. F.15	"	1794.4	230.8	1563.6	67.2	26.8	40.4	B.	4.2	22.2	8.2	14.	.028	.96	.224	.736	2.41	.442	1.968	.017	.28	....	....	......	....	....
5100	" 25	" 26	§	"	VM. F.04	"	2027.6	190.	1837.6	77.2	29.6	47.6	B.	2.28	27.5	10.3	17.2	.072	1.44	.176	1.264	4.00	.576	3.424	.016	.72	25.	....	......	....	....
5139	June 1	June 2	§	"	VM. F.3	"	1554.8	226.8	1328.	88.	27.2	60.8	B.	2.9	25.4	12.1	13.3	.032	1.12	.224	.896	2.65	.57	2.08	.02	.64	22.7	22.	27.	....	....
5189	" 8	" 9	§	"	VM. F.1	"	3104.4	253.6	2850.8	103.2	16.8	86.4	B.	4.2	27.8	8.1	19.7	.024	1.28	.22	1.06	4.57	.506	4.064	.006	.6	23.7	24.	29.	....	....
5226	" 15	" 16	§	"	VM. F.2	"	3802.	249.6	3552.4	65.2	13.2	52.	B.	4.7	35.	8.	27.	.064	1.6	.208	1.392	5.4	.472	4.928	.003	1.	24.8	24.5	28.	...	10,500
5271	" 22	" 23	§	"	VM. F.15	"	3309.6	280.4	3029.2	83.6	32.4	51.2	B.	4.8	29.6	9.8	19.8	.032	1.2	.16	1.04	3.16	.504	2.656	.004	.6	20.8	26.	32.	...	12,350
5313	" 29	" 30	§	"	VM. F.04	"	2420.8	217.2	2203.6	48.4	9.2	39.2	G.	3.6	27.5	8.9	18.6	.02	.992	.128	.864	2.68	.472	2.208	.001	.44	20.4	24.	30.	....	15,800
5359	July 6	July 7	§	"	VM. F.05	"	2512.	205.2	2306.8	104.	32.4	71.6	B.	4.4	30.1	10.7	19.4	.036	.96	.16	.8	3.	.44	2.56	.004	.52	22.6	26.	27.	....	11,500
5408	" 13	" 14	§	"	VM. F.2	"	2665.6	208.8	2456.8	126.8	46.8	80.	B.	4.2	28.2	7.8	20.4	.032	1.6	.192	1.408	3.56	.408	3.152	.002	.8	23.9	27.	35.	....	6,100
5456	" 20	" 21	§	"	VM. F.05	"	2323.2	200.	2123.2	106.	39.2	66.8	B.	4.35	32.1	11.5	20.6	.032	.8	.176	.624	2.36	.472	1.888	.006	.52	20.6	26.	27.	....	7,500
5514	" 27	" 28	§	"	VM. F.04	"	2141.6	188.8	1952.8	92.4	21.2	71.2	B.	4.9	23.8	9.3	14.5	.012	.576	.192	.384	2.2	.376	1.824	.008	.36	16.6	29.	36.	....	2,220
5556	Aug. 3	Aug. 4	§	"	VM. F.01	"	2390.8	197.6	2193.2	73.6	28.4	45.2	B.	5.4	27.5	8.5	19.	.008	.768	.128	.64	2.12	.36	1.76	.011	.36	14.3	29.	37.	+	10,050
5604	" 10	" 11	§	"	VM. F.04	"	1646.4	161.6	1484.8	72.	28.4	43.6	B.	4.6	23.1	8.2	14.9	.016	.736	.112	.624	1.88	.28	1.6	.007	.32	12.9	26.	29.	+	7,450
5652	" 17	" 18	§	"	VM. F.15	"	1580.8	177.6	1403.2	126.8	44.	82.8	B.	6.	23.9	6.8	17.1	.036	.704	.164	.54	2.04	.36	1.68	.007	.48	13.9	27.	32.	....	....
5714	" 24	" 25	§	"	VM. F 04	"	1283.2	186.8	1096.4	76.8	28.8	48.	B.	5.95	21.	6.9	14.1	.02	.736	.14	.596	1.8	.408	1.392	.004	.4	9.7	27.	32.	+	34,000
5760	" 31	Sept. 1	§	"	VM. F.05	"	1008.4	195.2	813.2	30.4	17.6	12.8	B.	6.4	15.	7.8	7.2	.024	.384	.192	.192	1.32	.296	1.024	.017	.28	7.5	27.	32.	+	11,900
5817	Sept. 7	" 8	*	Much	M. F.03	"	829.2	202.8	626.4	36.4	13.2	23.2	B.	6.8	11.9	4.2	7.7	.012	.416	.144	.272	1.32	.296	1.024	.004	.28	6.6	29.	38.	+	9,600
5869	" 14	" 15	*	"	M. F.03	"	752.4	215.2	537.2	43.6	24.4	19.2	B.	7.3	12.4	4.5	7.9	.024	.64	.132	.508	1.48	.328	1.152	.004	.24	6.6	23.	24.	+	7,900
5916	" 21	" 22	*	"	M. F.03	"	1407.2	299.2	1108.	.....	.....	.....	B.	8.35	13.3	5.1	8.2	.012	.384	.104	.28	1.	.36	.64	.008	.3	6.6	19.	20.	+	5,500
5970	" 28	" 29	*	"	M. F.04	"	671.6	231.6	440.	47.6	26.	21.6	B.	9.9	11.9	5.9	6.	.016	.448	.124	.324	1.06	.308	.752	.012	.16	5.3	16.	18.	?	17,500
6012	Oct. 5	Oct. 6	*	"	M. F.06	"	662.8	232.4	430.4	29.2	17.2	12.	B.	11.3	14.1	7.9	6.2	.008	.416	.128	.288	.98	.356	.624	.005	.12	4.5	15.	21.	+	11,150
6062	" 12	" 13	*	Cons'd	M. F.03	"	630.	259.6	370.4	16.4	9.2	7.2	B.	13.3	11.7	8.	3.7	.036	.336	.116	.22	.84	.18	.66	.005	.2	3.5	17.	22.	+	15,700
6126	" 20	" 21	*	"	M. F.04	"	552.8	253.6	299.2	5.6	5.2	.4	B.	14.6	8.7	4.6	4.1	.022	.32	.092	.228	1.08	.344	.736	.008	.16	3.3	17.	18.	+	10,950
6178	" 26	" 27	*	"	M. F.02	"	600.4	266.4	334.	13.6	7.6	6.	B.	14.4	8.1	5.2	2.9	.016	.336	.14	.196	.744	.152	.592	.006	.24	3.	17.	19.	+	9,300
6216	Nov. 2	Nov. 3	*	Much	M. F.04	"	597.2	271.2	326.	32.	29.6	2.4	B.	14.8	8.9	5.8	3.1	.032	.336	.124	.212	.648	.28	.368	.012	.32	3.9	9.	2.	—	11,700
6275	" 13	" 14	*	Cons'd	M. F.06	"	375.2	236.4	138.8	20.	18.4	1.6	B.	11.7	9.1	7.7	1.4	.012	.352	.208	.144	.84	.36	.48	.005	.28	6.2	9.	14.	—	6,600
6364	" 23	" 24	*	Much	M. F.04	"	573.2	224.	349.2	38.4	20.8	17.6	B.	9.9	12.5	7.4	5.1	.032	.352	.216	.136	.808	.488	.32	.008	.28	6.2	11.	10.	+	36,200
6424	" 30	Dec. 1	*	Cons'd	M. F.03	"	574.8	257.6	317.2	18.	11.6	6.4	G.	13.1	10.	6.1	3.9	.048	.4	.152	.248	.936	.328	.608	.01	.16	5.5	8.	17.	+	45,800
6485	Dec. 7	" 9	*	Much	M. F.03	"	668.4	274.	394.4	16.8	9.2	7.6	B.	15.9	9.4	6.	3.4	.056	.368	.16	.208	.904	.36	.544	.007	.28	4.9	3.	8.	+	22,800
6535	" 15	" 16	*	"	M. F.04	"	588.8	254.8	334.	33.2	18.	15.2	B.	14.3	11.8	6.8	5.	.024	.352	.256	.096	.92	.424	.496	.008	.24	4.6	0.	5.	+	7,000
6571	" 21	" 22	*	Cons'd	M. F.02	"	556.4	256.8	299.6	19.6	15.6	4.	B.	14.9	12.3	6.3	6.	.05	.288	.144	.144	.84	.36	.48	.006	.32	4.7	0.	5.	+	15,750

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 30.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, AT CHAIN OF ROCKS, INLET TOWER, ST. LOUIS WATER WORKS.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1890 Collection.	1890 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig n. Tot'l	Loss on Ig n. Dis-solv'd	Loss on Ig n. Sus-pnd'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dis-solv'd	Albuminoid Am. Sus-pnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
6027	May 12	May 13	§	V.M'cb	VM.F.04	None	2400.	226.4	2173.6	65.6	27.6	38.	B.	4.2	24.7	6.8	17.9	.044	1.12	.192	.928	3.05	.314	2.736	.019	.36	....	....	......	....	....
5099	" 25	" 26	§	"	VM.F.03	"	3052.4	186.8	2865.6	106.4	21.2	85.2	B.	3.41	29.3	9.1	20.2	.06	1.92	.224	1.696	4.73	.506	4.224	.011	.6	25.	....	......	....	....
5140	June 1	June 2	§	"	VM.F.08	"	2448.4	186.8	2261.6	105.6	21.6	84.	B.	3.8	28.9	10.7	18.2	.044	1.44	.16	1.28	3.45	.442	3.008	.011	.64	22.7	23.	27.	....	....
5188	" 8	" 9	§	"	VM.F.06	"	3139.2	240.	2899.2	75.2	42.4	32.8	B.	3.6	28.1	8.	20.1	.032	1.12	.24	.88	4.41	.54	3.87	.008	.36	23.7	24.	29.	....	26,000
5225	" 15	" 16	§	"	VM.F.1	"	4032.8	236.8	3796	52.8	12.	40.8	B.	4.5	31.7	8.6	23.1	.02	1.6	.192	1.408	5.72	.472	5.248	.002	1.12	24.8	24.5	28.	....	17,500
5270	" 22	" 23	§	"	VM.F.1	"	3509.6	266.8	3242.8	81.4	20.4	61.	B.	4.8	31.3	8.	23.3	.02	1.28	.16	1.12	3.64	.504	3.136	.003	.6	20.8	26.	32.	....	21,250
5314	" 29	" 30	§	"	VM.F.04	"	2511.6	219.2	2292.4	65.2	13.2	52.	B.	3.5	29.2	8.9	20.3	.018	1.024	.128	.896	2.84	.504	2.336	.001	.6	20.4	24.	29.	....	7,650
5358	July 6	July 7	§	"	VM.F.05	"	2916.	209.6	2706.4	113.6	26.8	86.8	B.	4.5	31.8	8.4	23.4	.04	1.184	.128	1.056	3.48	.344	3.136	.002	.48	22.6	26.	27.	....	7,000
5407	" 13	" 14	§	"	VM.F.15	"	2974.4	191.6	2782.8	119.2	30.8	88.4	B.	4.3	29.4	7.2	22.2	.04	1.664	.176	1.488	3.8	.6	3.2	.002	.68	23.9	27.	35.	....	6,750
5457	" 20	" 21	§	"	VM.F.05	"	2560.	188.8	2371.2	84.4	32.4	52.	B.	4.55	30.7	9.2	21.5	.024	.96	.192	.768	2.84	.408	2.432	.006	.44	20.6	26.	27.	....	23,000
5513	" 27	" 28	§	"	VM.F.08	"	2422.4	192.	2230.4	74.4	26.4	48.	B.	4.85	24.2	7.8	16.4	.008	.8	.16	.64	2.48	.232	2.248	.008	.4	16.6	29.	36.	....	9,050
5565	Aug. 3	Aug 4	§	"	VM.F.04	"	2646.	212.8	2433.2	82.8	36.	46.8	B.	5.4	28.7	8.1	20.6	.006	.8	.132	.668	2.68	.328	2.352	.013	.44	14.3	29.	37.	+	20,600
5603	" 10	" 11	§	"	VM.F.04	"	2129.6	176.	1953.6	100.4	23.6	76.8	B.	4.9	23.7	7.8	15.9	.02	.96	.076	.884	2.68	.392	2.288	.004	.28	12.9	26.	29.	+	11,050
5654	" 17	" 18	§	"	VM.F.1	"	1918.	174.8	1743.2	134.4	48.	86.4	B.	6.8	24.3	6.1	18.2	.04	.704	.124	.58	2.36	.344	2.016	.008	.52	13.9	27.	32.	....	....
5713	" 24	" 25	§	"	VM.F.05	"	1421.6	185.2	1236.4	83.2	16.4	66.8	B.	9.	22.5	5.7	16.8	.016	.896	.122	.774	2.2	.248	1.952	.008	.4	9.7	27.	32.	+	38,000
5750	" 31	Sept. 1	§	"	VM.F.05	"	1227.6	200.	1027.6	39.2	18.	21.2	B.	7.	14.7	7.5	7.2	.028	.416	.128	.288	1.48	.28	1.2	.002	.32	7.5	27.	32.	....	12,100
5818	Sept. 7	" 8	*	Much	M. F.03	"	1088.	216.	872.	50.8	18.4	32.4	B.	7.7	12.9	3.6	9.3	.018	.384	.08	.304	1.32	.28	1.04	.002	.24	6.6	29.	38.	+	16,900
5868	" 14	" 15	*	"	M. F.04	"	1010.	246.	764.	32.4	14.8	17.6	B.	8.9	12.9	5.6	7.3	.024	.384	.12	.264	1.32	.28	1.04	.004	.24	6.6	22.	24.	+	12,800
5914	" 21	" 22	*	"	M. F.04	"	840.8	239.2	601.6	26.8	16.	10.8	B.	10.35	12.4	4.1	8.3	.008	.384	.128	.256	1.	.312	.688	.005	.45	6.6	19.	20.	+	11,050
5969	" 28	" 29	*	"	M. F.03	"	775.6	248.	527.6	42.	12.8	29.2	B.	11.35	11.8	5.2	6.6	.012	.48	.108	.372	1.14	.308	.832	.01	.28	5.8	16.	18.	+	18,200
6010	Oct. 5	Oct. 6	*	"	M. F.07	"	717.6	256.4	461.2	30.8	16.4	14.4	B.	14.1	13.	6.2	6.8	.012	.352	.112	.24	.98	.352	.628	.007	.2	4.5	15.	21.	+	14,500
6065	" 12	" 13	*	Cons'd	M. F.03	"	658.8	276.	382.8	27.6	12.4	15.2	B.	14.3	11.8	7.6	4.2	.04	.368	.08	.288	1.	.148	.852	.006	.24	3.5	17.	22.	+	34,200
6125	" 20	" 21	*	"	M. F.03	"	622.4	278.	344.4	10.	6.	4.	B.	16.1	7.9	3.9	4.	.02	.272	.144	.128	1.	.36	.64	.007	.16	3.3	17.	18.	—	11,050
6177	" 26	" 27	*	"	M. F.02	"	632.8	281.6	351.2	16.8	11.6	5.2	B.	15.4	7.6	4.9	2.7	.02	.32	.14	.18	.84	.264	.576	.006	.28	3.	17.	19.	+	8,100
6217	Nov. 2	Nov. 3	*	Much	M. F.04	"	625.6	269.6	356.	15.6	10.	5.6	B.	14.3	8.5	6.6	1.9	.032	.352	.1	.252	.744	.248	.496	.01	.36	3.9	9.	2.	+	12,000
6274	" 13	" 14	*	Cons'd	M. F.03	"	422.8	281.6	141.2	22.8	16.4	6.4	B.	16.4	7.6	6.2	1.4	.016	.256	.16	.096	.84	.392	.448	.007	.16	6.2	9.	14.	—	7,700
6363	" 23	" 24	*	Much	M. F.05	"	676.	256.	420.	32.	21.2	10.8	B.	11.85	11.9	6.4	5.5	.028	.368	.148	.22	1.16	.36	.8	.008	.24	6.2	11.	10.	+	16,750
6425	" 30	Dec. 1	*	Cons'd	M. F.03	"	625.6	278.8	346.8	32.4	17.6	14.8	B.	14.4	9.8	5.4	4.4	.04	.288	.156	.132	.84	.36	.48	.008	.28	5.5	3.	17.	+	70,000
6486	Dec. 7	" 9	*	Much	M. F.03	"	689.2	290.	399.2	34.4	16.4	18.	B.	16.3	9.2	5.	4.2	.064	.368	.144	.224	1.128	.36	.768	.006	.32	4.9	3.	8.	+	35,500
6532	" 15	" 16	*	"	M. F.03	"	702.8	288.4	414.4	28.4	17.6	10.8	B.	16.2	11.6	5.4	6.2	.032	.352	.112	.24	.92	.232	.688	.004	.24	4.6	0.	5.	+	54,000
6570	" 21	" 22	*	"	M. F.02	"	654.8	284.	370.8	27.2	18.8	8.4	B.	16.8	11.2	6.7	4.5	.052	.352	.112	.24	.68	.424	.256	.008	.24	4.7	0.	5.	+	5,450

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 31.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION

SOURCE OF WATER—MISSISSIPPI RIVER, 400 FEET FROM MISSOURI SHORE, AT CHAIN OF ROCKS, PUMPING STATION ST. LOUIS WATER WORKS.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
										Loss on Ig'n.									Albuminoid Am.												
	1890 Collection.	1890 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Tot'l	Dissolv'd	Suspend'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Suspend'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
5026	May 12	May 13	§	V.M'ch	V.M F.03	None	3256.4	248.	3008.4	63.8	15.2	47.6	B.	5.22	26.6	6.3	20.3	.04	1.2	.16	1.04	3.53	.282	3.248	.012	.24	....	....	....	....	....
5102	" 25	" 26	§	"	V.M F.3	"	3759.2	216.8	3542.4	61.6	13.2	48.4	B.	3.81	29.9	7.8	22.1	.088	2.4	.16	2.24	6.33	.41	5.92	.016	.6	25.	....	....	....	....
5141	June 1	June 2	§	"	V.M F.1	"	2922.8	206.8	2716.	108.4	22.8	85.6	B.	3.6	28.4	10.2	18.2	.036	1.6	.16	1.44	4.25	.474	3.776	.007	.6	22.7	23.	27.	....	....
5187	" 8	" 9	§	"	V.M F.05	"	3565.2	262.8	3302.4	130.8	44.4	86.4	B.	3.8	27.9	7.1	20.8	.036	1.36	.24	1.12	5.37	.57	4.8	.006	.6	23.7	24.	29.	....	27,500
5224	" 15	" 16	§	"	V.M F.1	"	4139.2	231.6	3907.6	80.4	14.4	66.	B.	4.6	35.6	7.6	28.	.032	2.24	.192	2.048	6.04	.6	5.44	.001	.96	24.8	24.5	28.	....	17,000
5269	" 22	" 23	§	"	V.M F.1	"	3813.6	281.6	3532.	88.4	21.2	67.2	B.	4.8	33.	6.8	26.2	.024	1.2	.16	1.04	4.6	.472	4.128	.004	.76	20.8	26.	32.	....	25,800
5315	" 29	" 30	§	"	V.M F.05	"	2603.6	222.8	2380.8	52.8	10.4	42.4	B.	3.6	29.2	9.6	19.6	.09	1.088	.112	.976	2.68	.344	2.336	.001	.6	20.4	24.	30.	....	4,700
5357	July 6	July 7	§	"	V.M F.05	"	2896.8	224.8	2672.	75.2	25.2	50.	B.	5.	29.8	7.8	22.	.04	1.216	.144	1.072	3.48	.312	3.168	.002	.6	22.6	26.	27.	....	8,350
5406	" 13	" 14	§	"	V.M F 15	"	3253.2	196.8	3056.4	132.4	38.	94.4	B.	4.6	30.1	6.6	23.5	.048	1.856	.144	1.712	4.76	.472	4.288	.002	.8	23.9	27.	35.	....	4,160
5456	" 20	" 21	§	"	V.M F.05	"	2866.8	194.8	2672.	112.8	36.	76.8	B.	4.6	32.3	9.2	23.1	.032	.88	.16	.72	2.36	.536	1.824	.005	.48	20.6	26.	27.	....	2,100
5512	" 27	" 28	§	"	V.M F.05	"	2622.8	188.4	2434.4	61.6	27.2	34.4	B.	4.6	25.5	7.4	18.1	.012	.864	.16	.704	2.68	.232	2.448	.005	.44	16.6	29.	36.	+	9,000
5554	Aug. 3	Aug. 4	§	"	V.M F.03	"	2719.6	216.4	2503.2	97.6	34.	63.6	B.	5.55	28.8	7.	21.8	.012	.8	.16	.64	2.68	.376	2.304	.016	.56	14.3	29.	37.	+	29,800
5602	" 10	" 11	§	"	V.M F.02	"	2518.8	182.4	2336.4	74.4	21.6	52.8	B.	5.1	34.	6.8	27.2	.008	.96	.072	.888	2.68	.248	2.432	.005	.36	12.9	26.	29.	+	24,700
5655	" 17	" 18	§	"	V.M F.1	"	2187.2	168.4	2018.8	119.6	28.	91.6	B.	7.3	24.5	5.5	19.	.028	.804	.096	.708	2.6	.328	2.272	.006	.48	13.9	27.	32.	....	....
5711	" 24	" 25	§	"	V.M F.06	"	1605.6	204.4	1401.2	78.8	24.8	54.	B.	6.8	22.6	6.6	16.	.016	.96	.18	.78	2.6	.296	2.304	.007	.52	9.7	27.	32.	+	53,000
5758	" 31	Sept. 1	§	"	V.M F.06	"	1239.2	204.4	1034.8	62.4	17.2	45.2	B.	7.2	15.	8.	7.	.032	.448	.096	.352	1.48	.264	1.216	.005	.36	7.5	27.	32.	+	21,600
5816	Sept. 7	" 8	§	"	V.M F.03	"	1060.4	219.6	840.8	41.2	22.	19.2	B.	8.	13.	4.2	8.8	.012	.416	.12	.296	1.24	.302	.938	.005	.24	6.6	29.	38.	+	10,560
5867	" 14	" 15	*	Much	M. F.04	"	1081.2	247.6	833.6	32.	20.4	11.6	B.	10.35	12.9	3.5	9.4	.016	.416	.088	.328	1.32	.232	1.088	.007	.4	6.6	22.	24.	+	7,650
5915	" 21	" 22	*	"	M. F.02	"	964.4	258.4	706.	67.2	22.8	44.4	B.	12.25	12.3	3.3	9.	.008	.416	.056	.36	1.16	.28	.88	.006	.45	6.6	10.	20.	+	12.550
5972	" 28	" 29	*	"	M. F.03	"	825.6	256.8	568.8	32.4	23.2	9.2	B.	12.3	11.3	10.2	1.1	.012	.352	.1	.252	.9	.148	.752	.008	.16	5.3	16.	18.	+	6,250
6011	Oct. 5	Oct. 6	*	"	M. F.03	"	772.4	271.2	501.2	34.8	12.4	22.4	B.	14.8	12.9	5.5	7.4	.008	.352	.144	.208	.98	.244	.736	.008	.24	4.5	15.	21.	+	10,450
6064	" 12	" 13	*	Cons'd	M. F.02	"	701.2	280.8	420.4	18.	8.	10.	B.	14.9	10.5	7.5	3.	.02	.272	.08	.192	.92	.148	.772	.005	.28	3.5	17.	22.	+	13,200
6124	" 20	" 21	*	"	M. F.03	"	643.2	291.2	352.	12.	4.8	7.2	B.	17.1	7.7	4.5	3.2	.02	.272	.108	.164	.92	.296	.624	.01	.2	3.3	17.	18.	—	7,800
6180	" 26	" 27	*	"	M. F.02	"	663.6	294.4	369.2	16.8	14.4	2.4	B.	15.7	7.8	3.7	4.1	.03	.336	.072	.264	.744	.232	.512	.006	.36	3.	17.	19.	+	9,300
6218	Nov. 2	Nov. 3	*	Much	M. F.05	"	654.4	287.2	367.2	31.2	10.	21.2	B.	14.8	8.6	6.7	1.9	.024	.352	.084	.268	.712	.2	.512	.008	.32	3.9	9.	2.	+	12,000
6273	" 13	" 14	*	Cons'd	M. F.02	"	484.4	315.2	169.2	16.4	9.6	6.8	B.	22.1	6.	4.3	1.7	.012	.208	.16	.048	.68	.328	.352	.007	.32	6.2	9.	14.	+	8,400
6366	" 23	" 24	*	Much	M. F.02	"	798.8	289.6	509.2	32.	16.	16.	B.	14.9	10.	4.5	5.5	.028	.352	.132	.22	1.	.264	.736	.008	.24	6.2	11.	10.	+	36,000
6422	" 30	Dec. 1	*	Cons'd	M. F.02	"	710.	301.6	408.4	28.	16.	12.	B.	16.8	9.5	4.9	4.6	.04	.288	.12	.168	.872	.296	.576	.007	.28	5.5	8.	17.	+	64,100
6487	Dec. 7	" 9	*	Much	M. F.02	"	768.4	316.4	452.	30.8	14.8	16.	B.	18.4	8.3	3.8	4.5	.06	.384	.24	.144	1.16	.36	.8	.008	.2	4.9	3.	8.	+	25,000
6533	" 15	" 16	*	"	M. F.02	"	764.8	299.2	465.6	24.4	11.6	12.8	B.	18.7	11.4	4.	7.4	.04	.336	.076	.26	.84	.296	.544	.004	.24	4.6	0.	5.	+	40,000
6569	" 21	" 22	*	"	M. F.02	"	705.2	304.	401.2	23.2	20.4	2.8	BG.	18.7	11.	4.7	6.3	.008	.256	.112	.144	.76	.296	.464	.009	.32	4.7	0.	5.	+	10,700

TURBIDITY—*Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B. Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 32.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSOURI RIVER, FORT BELLEFONTAINE, WEST ALTON, MO.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of: 1899 Collection.	Date of: 1899 Examination.	Appearance: Turb'y.	Appearance: Sediment.	Appearance: Color.	Odor.	Residue on Evaporation: Total.	Residue on Evaporation: Dissolved.	Residue on Evaporation: Suspended.	Loss on Ig'n: Tot'l	Loss on Ig'n: Dissolv'd	Loss on Ig'n: Suspend'd	Color on Ignition.	Chlorine.	Oxygen Consumed: Total.	Oxygen Consumed: By Dissolved.	Oxygen Consumed: By Suspd Matter.	Nitrogen as Ammonia: Free Ammonia.	Albuminoid Am.: Tot'l	Albuminoid Am.: Dissolv'd	Albuminoid Am.: Suspend'd	Organic Nitrogen: Total.	Organic Nitrogen: Dissolved.	Organic Nitrogen: Suspended.	Nitrogen as: Nitrites.	Nitrogen as: Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
5369	July 10	July 10	*	Cons'd	M.	None	......	......	......	......	......	......	......	7.5	......	......	......	......	......	......	......	......	......	......	......	.12	11.	27.	......	?	48,500
5505	" 27	" 28	§	V. M'ch	M. F.08	"	3246.	201.2	3044.8	133.6	14.8	118.8	B.	5.1	27.4	7.4	20.	.02	.864	.128	.736	2.68	.328	2.352	.01	.36	13.3	29.	......	+	20,000
5565	Aug. 2	Aug. 4	§	"	VM.F.03	"	3514.	214.4	3299.6	193.6	17.6	176.	B.	5.6	31.9	6.5	25.4	.012	.8	.16	.64	3.16	.312	2.848	.004	.4	12.4	29.	34.	....	8,450
5614	" 10	" 12	§	"	VM.F.02	"	2989.2	198.4	2790.8	96.8	20.8	76.	B.	6.35	28.3	7.4	20.9	.018	1.024	.064	.96	2.84	.184	2.656	.006	.32	11.6	27.	30.	+	36,000
5662	" 17	" 19	§	"	VM.F.1	"	2478.8	345.6	2123.2	100.	64.4	95.6	B.	5.8	25.5	5.8	19.7	.016	1.052	.144	.908	2.84	.382	2.456	.01	.68	11.2	28.	35.	....	....
5715	" 24	" 25	§	"	VM.F.05	"	1926.4	196.4	1730.	82.8	25.6	57.2	B.	6.3	16.	5.2	10.8	.02	1.024	.1	.924	2.36	.232	2.128	.004	.56	9.2	28.	35.	+	70,333
5768	" 31	Sept. 1	§	"	VM.F.04	"	1500.8	221.6	1279.2	43.2	22.4	20.8	G.	8.1	15.1	4.	11.1	.028	.48	.1	.38	1.88	.248	1.632	.002	.44	8.3	28.	29.	+	16,000
5821	Sept. 7	" 8	*	Much	M. F.02	"	1152.4	248.8	903.6	40.	16.	24.	B.	9.2	12.6	3.4	9.2	.02	.544	.064	.48	1.32	.28	1.04	.003	.36	7.3	29.	34.	....	....
5872	" 14	" 15	§	"	M. F.03	"	1192.	260.4	931.6	48.4	24.	24.4	B.	10.9	12.9	3.	9.9	.012	.416	.116	.3	1.4	.28	1.12	.006	.28	6.7	22.	27.	+	14,400
5918	" 21	" 22	*	"	M. F.03	"	1034.	200.8	833.2	32.4	14.8	17.6	B.	12.4	12.7	3.5	9.2	.06	.352	.08	.272	1.08	.28	.8	.007	.4	6.1	20.	22.	+	15,850
5976	" 28	" 29	*	"	M. F.02	"	921.6	277.2	644.4	23.2	14.	9.2	B.	14.8	11.5	5.4	6.1	.006	.48	.104	.376	1.14	.276	.864	.008	.28	5.5	18.	17.	+	40,000
6014	Oct. 5	Oct. 6	*	"	M. F.02	"	860.8	372.4	488.4	22.4	9.6	12.8	B.	16.3	10.9	4.2	6.7	.024	.416	.06	.356	1.092	.228	.864	.007	.2	5.	17.	21.	—	21,500
6067	" 12	" 13	*	"	M. F.03	"	810.	307.2	502.8	33.6	11.6	22.	B.	17.	9.	3.7	5.3	.012	.288	.092	.196	.744	.18	.564	.007	.28	4.8	22.	25.	—	16,000
6122	" 19	" 20	*	"	M. F.03	"	706.4	301.2	405.2	16.4	9.6	6.8	B.	18.1	10.1	3.9	6.2	.024	.288	.092	.196	1.	.184	.816	.005	.36	4.6	18.	19.	+	18,000
6183	" 26	" 27	*	"	M. F.03	"	831.2	309.6	521.6	13.6	10.8	2.8	B.	18.	7.7	3.6	4.1	.024	.288	.08	.208	.744	.232	.512	.007	.36	4.5	19.	23.	—	9,800
6220	Nov. 2	Nov. 3	*	"	M. F.02	"	694.	308.	386.	61.6	14.4	47.2	B.	16.9	8.6	3.8	4.8	.032	.32	.072	.248	.68	.168	.512	.015	.28	4.7	11.	0.	+	12,500
6262	" 9	" 10	*	"	M. F.02	"	672.4	336.	336.4	18.8	8.8	10.	B.	23.9	7.8	4.	3.8	.028	.32	.112	.208	.68	.216	.464	.009	.24	4.5	12.	23.	+	25,400
6326	" 16	" 18	*	"	M. F.02	"	687.2	340.8	346.4	18.8	13.6	5.2	B.	29.9	6.7	3.7	3.	.032	.208	.144	.064	.68	.36	.32	.008	.24	4.4	12.	19.	—	6,650
6372	" 23	" 24	*	"	M. F.03	"	882.8	314.	568.8	22.8	16.8	6.	B.	16.15	10.9	4.8	6.1	.04	.352	.124	.228	.904	.36	.544	.005	.24	4.9	11.	10.	+	60,000
6435	" 30	Dec. 1	*	"	M. F.01	"	736.	318.8	417.2	16.8	15.2	1.6	B.	17.9	6.6	2.5	4.1	.032	.24	.12	.12	.808	.296	.512	.008	.36	5.	10.	17.	+	38,000
6490	Dec. 7	" 9	*	Cons'd	M. F.02	"	832.	317.2	514.8	16.4	14.8	1.6	B.	18.8	7.9	3.	4.9	.05	.32	.112	.208	1.224	.424	.8	.008	.32	5.5	5.	12.	+	12,000
6536	" 14	" 16	*	Much	M. F.03	"	845.2	310.	535.2	32.4	18.	14.4	B.	19.5	11.3	3.9	7.4	.04	.416	.112	.304	1.08	.232	.848	.005	.28	4.7	2.	—5.	....	17,400
6576	" 21	" 23	*	"	M. F.03	"	517.2	336.8	180.4	15.2	13.6	1.6	BG.	22.	11.	4.7	6.3	.06	.272	.096	.176	.92	.328	.592	.005	.16	4.9	2.	9.	+	4,500
6596	" 28	" 29	*	"	M. F.02	"	517.2	336.8	180.4	15.2	13.6	1.6	G.	22.	8.5	4.4	4.1	.08	.176	.08	.096	.456	.232	.224	.005	.36	3.2	1.	—3.	....	8,000

TURBIDITY—*Decided. §Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 33.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 100 YARDS FROM ILLINOIS SHORE, JEFFERSON BARRACKS MO.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Suspnd'd							Tot'l	Dissolv'd	Suspnd'd										
4985	May 1	May 2	§	V.M'ch	M. F.06	None	2220.4	196.	2024.4	96.	19.6	76.4	B.	2.8	27.	7.3	19.7	.022	1.04	.192	.848	1.85	.45	1.4	.035	.6	....	...	....	....	....
5016	" 16	" 17	§	"	M. F.04	"	1519.6	187.6	1332.	47.6	13.6	34.	B.	3.4	16.8	7.7	9.1	.08	1.024	.224	.8	2.89	.49	2.4	.009	.6	....	....	....	....	....
5170	June 6	June 7	§	"	M. F.15	"	2717.2	214.	2503.2	75.2	16.4	58.8	B.	4.3	38.	9.	29.	.02	1.52	.224	1.296	4.25	.506	3.744	.004	.8	....	....	....	....	90,500
5237	" 16	" 17	§	"	M. F.1	"	3007.2	274.4	2732.8	74.4	21.2	53.2	B.	5.2	34.	7.5	26.5	.032	1.36	.192	1.168	4.44	.504	3.936	.011	.64	22.8	26.	....	....	66,000
5281	" 23	" 24	§	"	M. F.15	"	2994.8	258.	2736.8	36.	13.2	22.8	B.	4.6	30.4	7.2	23.2	.024	.88	.192	.688	3.8	.44	3.36	.003	.52	22.	28.	....	....	63,000
5320	" 29	" 30	§	"	VM.F.04	"	2107.6	216.4	1891.2	46.	28.	18.	B.	3.4	27.1	9.7	17.4	.02	1.024	.112	.912	2.44	.344	2.096	.002	.64	20.5	26.	20.	....	45,500
5365	July 6	July 7	§	"	VM.F.1	"	1930.8	214.	1716.8	76.8	30.4	46.4	B.	4.6	29.1	12.6	16.5	.028	.96	.192	.768	2.76	.472	2.288	.004	.6	22.9	26.	....	....	10,050
5415	" 14	" 15	§	"	VM.F.5	"	2403.6	178.4	2225.2	124.8	33.6	91.2	B.	3.8	43.8	8.2	35.6	.098	1.376	.16	1.216	3.32	.552	2.768	.006	.64	23.6	28.	....	....	4,050
5462	" 21	" 22	§	"	VM.F.07	"	2016.	186.8	1829.2	81.6	32.8	48.8	B.	4.9	29.6	7.7	21.9	.028	.832	.192	.64	2.68	.36	2.32	.011	.48	19.8	28.	....	....	11,850
5508	" 27	" 28	§	"	VM.F.2	"	2665.6	208.8	2456.8	126.8	46.8	80.	B.	4.2	28.2	7.8	20.4	.032	1.6	.192	1.408	3.56	.408	3.152	.002	.8	16.2	30.	....	....	14,250
5558	Aug. 3	Aug. 4	§	"	VM.F.04	"	1988.8	207.6	1781.2	76.	34.	42.	B.	5.4	24.3	8.3	16.	.012	.672	.116	.556	1.8	.376	1.424	.007	.36	14.3	32.	....	+	18,700
5616	" 11	" 12	§	"	VM.F.04	"	1145.6	156.4	989.2	71.2	30.8	40.4	B.	5.	23.	11.2	11.8	.032	.576	.132	.444	1.56	.504	1.056	.033	.32	14.4	29.	....	+	25,000
5660	" 17	" 18	§	"	VM.F.2	"	1184.8	164.4	1020.4	98.8	39.2	59.6	B.	5.5	19.7	7.8	11.9	.036	.608	.14	.468	1.44	.376	1.064	.008	.48	13.9	29.	....	....	....
5720	" 25	" 26	§	"	VM.F.07	"	752.	184.4	567.6	56.	21.6	34.4	B.	6.4	17.5	6.	11.5	.06	.48	.144	.336	1.4	.392	1.008	.007	.28	8.4	30.	....	—	41,000
5764	" 31	Sept. 1	§	"	VM.F.03	"	844.4	216.	628.4	34.4	27.6	6.8	B.	6.4	13.9	6.	7.9	.04	.416	.128	.288	1.16	.376	.784	.007	.4	7.5	30.	....	+	266,000
5826	Sept. 8	" 9	*	Much	M. F.03	"	529.6	198.	331.6	43.6	22.4	21.2	B.	6.05	10.9	5.8	5.1	.012	.384	.128	.256	1.16	.44	.72	.004	.24	6.3	30.	....	+	124,500
5860	" 14	" 15	*	"	M. F.08	"	367.2	192.8	174.4	24.	22.8	1.2	B.	5.3	11.2	6.6	4.6	.024	.416	.18	.236	1.16	.376	.784	.01	.16	6.8	22.	....	+	19,500
5919	" 22	" 23	*	"	M. F.03	"	326.	195.2	130.8	31.2	21.2	10.	B.	6.75	12.8	7.5	5.3	.094	.352	.168	.184	1.	.28	.72	.007	.12	6.7	19.	....	+	100,000
5967	" 28	" 29	*	"	M. F.07	"	300.	173.6	126.4	25.2	....	....	B.	6.4	12.4	10.5	1.9	.012	.448	.2	.248	1.22	.58	.64	.009	.16	5.3	17.	....	+	33,000
6018	Oct. 6	Oct. 7	*	Cons'd	M. F.05	"	255.6	172.	83.6	17.2	11.2	6.	B.	6.1	14.2	11.3	2.9	.068	.432	.212	.22	1.124	.356	.768	.005	.12	4.1	16.	....	+	71,000
6058	" 12	" 13	*	"	M. F.06	"	280.	192.	88.	18.8	10.4	8.4	B.	7.3	11.9	9.7	2.2	.032	.332	.216	.116	.92	.276	.644	.006	.16	3.5	20.	....	—	60,000
6116	" 19	" 20	*	"	M. F.04	"	301.2	198.	103.2	24.8	18.	6.8	B.	9.4	11.	7.8	3.2	.032	.352	.196	.156	.84	.424	.416	.006	.2	3.2	19.	....	....	....
6171	" 26	" 27	*	"	M. F.03	"	327.6	194.	133.6	26.4	22.8	3.6	B.	8.9	9.	7.3	1.7	.032	.432	.172	.26	.872	.36	.512	.004	.28	2.8	19.	....	?	47,500
6223	Nov. 3	Nov. 4	*	"	M. F.05	"	316.4	210.	106.4	26.4	21.6	4.8	B.	8.9	9.3	8.2	1.1	.04	.384	.172	.212	.968	.264	.704	.012	.36	4.	9.	....	+	4,500
6264	" 11	" 13	*	Much	M. F.06	"	310.4	197.6	112.8	36.	30.8	5.2	B.	6.6	12.4	9.3	3.1	.052	.448	.284	.164	1.064	.616	.448	.013	.36	5.4	9.	....	+	4,500
6319	" 16	" 17	*	Cons'd	M. F.15	"	194.8	165.6	29.2	19.2	16.	3.2	B.	7.45	12.	10.4	1.6	.068	.544	.316	.228	1.064	.584	.48	.014	.28	6.5	10.	....	+	2,000
6367	" 23	" 24	*	Much	M. F.3	"	267.6	189.2	78.4	30.8	28.	2.8	B.	8.4	12.7	6.2	6.5	.028	.48	.3	.18	1.	.68	.32	.015	.32	6.6	12.	....	?	12,750
6430	" 30	Dec. 1	*	Cons'd	M. F.2	"	242.	180.8	61.2	30.8	30.4	.4	B.	8.6	11.	10.2	.8	.108	.384	.204	.18	.904	.552	.352	.013	.36	5.6	9.	....	+	5,000
6473	Dec. 7	" 8	*	Much	M. F.15	"	217.2	176.	41.2	22.8	20.	2.8	B.	7.8	14.1	11.7	2.4	.144	.512	.288	.224	1.08	.648	.432	.007	.28	4.8	3.	....	?	3,500
6528	" 14	" 15	*	Cons'd	M. F.06	"	260.4	190.8	69.6	30.	30.	0.0	B.	7.9	13.8	10.	3.8	.016	.448	.268	.18	.92	.488	.432	.014	.36	4.6	2.	....	+	1,500
6563	" 21	" 22	*	"	M. F.03	"	257.2	194.8	62.4	15.2	14.	1.2	B.	9.1	12.	11.2	.8	.02	.432	.224	.208	.84	.488	.352	.016	.64	5.3	0.	....	+	13,400

TURBIDITY—*Decided. §Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 34.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, EAST OF MIDSTREAM, JEFFERSON BARRACKS, MO.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on ig'n.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Susp'd							Tot'l	Dissolv'd	Susp'd										
5160	June 6	June 7	§	Much	M. F.25	None	2755.2	218.8	2536.4	82.	15.2	66.8	B.	4.3	44.2	9.	35.2	.044	1.6	.176	1.424	4.73	.54	4.19	.002	.52	....	....	....	....	74,000
5236	" 16	" 17	§	V. M'ch	VM. F.3	"	3736.4	288.	3448.4	136.8	26.	110.8	B.	4.8	35.2	6.5	28.7	.076	1.84	.192	1.648	5.08	.44	4.64	.007	.64	22.8	26.	....	....	46,000
5282	" 23	" 24	§	"	VM. F.15	"	3448.4	264.8	3183.6	110.	19.2	90.8	B.	4.6	30.1	7.5	22.6	.022	1.36	.192	1.168	4.28	.504	3.776	.008	.56	22.	28.	....	....	19,550
5318	" 29	" 30	§	"	VM. F.08	"	2054.4	219.6	1834.8	66.	31.6	34.4	B.	4.3	28.5	9.1	19.4	.09	.928	.112	.816	2.6	.344	2.256	.001	.56	20.5	26.	20.	....	10,350
5363	July 6	July 7	§	"	VM. F.07	"	2284.8	201.2	2083.6	59.6	24.	35.6	B.	4.8	30.6	12.5	18.1	.032	1.024	.176	.848	2.92	.536	2.384	.002	.48	22.9	26.	....	....	22,450
5414	" 14	" 15	§	"	VM. F.1	"	2422.8	195.6	2227.2	99.6	36.8	62.8	B.	3.8	44.7	9.6	35.1	.052	1.312	.192	1.12	3.4	.456	2.944	.01	.6	23.6	28.	....	....	7,850
5463	" 21	" 22	§	"	VM. F.07	"	2262.	170.8	2091.2	108.4	24.4	84.	B.	4.8	30.1	7.5	22.6	.028	.768	.208	.56	2.53	.296	2.224	.007	.44	19.8	28.	....	....	12,700
5506	" 27	" 28	§	"	VM. F.04	"	1822.8	196.8	1626.	71.2	25.2	46.	B.	5.	24.6	9.5	15.1	.09	.544	.16	.384	2.36	.408	1.952	.008	.36	16.2	30.	....	....	10,600
5557	Aug. 3	Aug. 4	§	"	VM. F.04	"	2207.6	196.	2011.6	86.	28.8	57.2	B.	5.4	25.7	9.4	16.3	.016	.672	.124	.548	2.2	.392	1.808	.008	.24	14.3	32.	....	+	16,550
5617	" 11	" 12	§	"	VM. F.03	"	1306.	146.	1160.	71.2	25.6	45.6	B.	4.5	22.8	10.7	12.1	.02	.704	.128	.576	1.72	.472	1.248	.02	.44	14.4	29.	....	+	30,800
5639	" 17	" 18	§	"	VM. F.05	"	1309.8	158.8	1151.0	116.	35.2	80.8	B.	5.8	19.5	7.	12.5	.028	.64	.096	.544	1.88	.36	1.52	.000	.4	13.9	29.	....	....	....
5721	" 25	" 26	§	"	VM. F.1	"	1063.2	182.4	880.8	50.8	22.8	28.	B.	6.2	19.3	6.	13.3	.02	.704	.14	.564	1.56	.344	1.216	.004	.4	8.4	30.	....	—	89,500
5765	" 31	Sept. 1	§	"	VM. F.03	"	924.8	213.6	711.2	36.2	23.2	12.	B.	6.2	14.	5.4	8.6	.036	.384	.124	.26	1.24	.392	.848	.004	.4	7.5	30.	....	....	46,000
5825	Sept. 8	" 9	§	Much	M. F.03	"	610.	197.6	412.4	34.8	15.6	19.2	B.	6.35	11.4	6.2	5.2	.02	.352	.128	.224	1.06	.344	.736	.004	.12	6.3	30.	....	+	126,500
5864	" 14	" 15	*	"	M. F.04	"	484.8	188.	296.8	25.2	24.	1.2	B.	5.7	12.7	5.4	7.3	.024	.384	.168	.216	1.32	.384	.936	.008	.2	6.8	22.	....	+	17,500
5921	" 22	" 23	*	"	M. F.03	"	451.6	204.8	246.8	37.2	19.2	18.	B.	7.9	12.3	7.3	5.	.006	.516	.156	.36	1.16	.44	.72	.005	.12	6.7	19.	....	+	16,000
5965	" 28	" 29	*	"	M. F.05	"	346.	176.8	169.2	24.4	15.6	8.8	B.	6.4	13.2	9.2	4.	.016	.448	.188	.26	1.22	.532	.688	.011	.16	5.3	17.	....	+	15,000
6017	Oct. 6	Oct. 7	*	Cons'd	M. F.04	"	312.8	174.8	138.	22.8	16.8	6.	B.	6.6	13.6	12.2	1.4	.032	.464	.132	.332	.9	.372	.528	.008	.2	4.1	16.	....	+	38,000
6057	" 12	" 13	*	"	M. F.1	"	333.6	187.2	146.4	21.2	14.4	6.8	B.	7.4	13.9	9.8	4.1	.032	.384	.216	.168	.92	.244	.676	.004	.2	3.5	20.	....	—	66,000
6114	" 19	" 20	*	"	M. F.04	"	368.	205.2	162.8	19.2	15.2	4.	B.	8.9	12.	7.7	4.3	.04	.448	.176	.272	.92	.228	.692	.008	.2	3.2	19.	....	+	23,500
6173	" 26	" 27	*	"	M. F.04	"	360.6	200.4	160.2	20.2	16.8	12.4	B.	9.	8.9	7.7	1.2	.024	.416	.176	.24	.936	.28	.656	.005	.28	2.8	19.	....	+	18,000
6229	Nov. 3	Nov. 4	*	"	M. F.04	"	340.	208.	132.	26.	14.	12.	B.	8.9	9.6	8.5	1.1	.04	.384	.232	.152	.904	.28	.624	.012	.2	4.	9.	....	+	4,000
6263	" 11	" 13	*	Much	M. F.06	"	339.6	206.4	133.2	36.	28.8	7.2	B.	6.6	16.	8.9	7.1	.032	.432	.268	.164	1.	.68	.32	.013	.36	5.4	9.	....	+	8,000
6320	" 16	" 17	*	Cons'd	M. F.15	"	240.4	161.2	79.2	20.	16.8	3.2	B.	7.7	12.1	5.5	6.6	.028	.512	.228	.284	1.064	.488	.576	.012	.28	6.5	10.	....	+	6,250
6371	" 23	" 24	.	....	....	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	6.6	12.	....	+	15,000
6431	" 30	Dec. 1	*	Cons'd	M. F.2	None	271.6	182.8	88.8	34.4	24.	10.4	B.	8.	10.6	9.4	1.2	.1	.32	.272	.048	.904	.616	.288	.014	.32	5.6	9.	....	?	11,750
6474	Dec. 7	" 8	*	Much	M. F.15	"	239.6	184.8	54.8	23.6	18.8	4.8	B.	7.6	14.	11.8	2.2	.14	.528	.256	.272	1.128	.584	.544	.008	.56	4.8	3.	....	+	2,000
6529	" 14	" 15	*	Cons'd	M. F.04	"	261.6	199.6	62.	48.4	41.2	7.2	B.	8.4	13.8	10.9	2.9	.016	.432	.228	.204	.92	.584	.336	.012	.36	4.6	2.	....	+	1,125
6562	" 21	" 22	*	"	M. F.03	"	322.4	190.4	132.	13.6	11.6	2.	B.	9.8	13.1	10.6	2.5	.044	.48	.192	.288	1.	.456	.544	.012	.44	5.3	0.	....	+	24,600

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 35.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, MIDSTREAM, JEFFERSON BARRACKS, MO.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	DATE OF 1899 Collection.	DATE OF 1899 Examination.	APPEARANCE. Turb'y.	APPEARANCE. Sediment.	APPEARANCE. Color.	Odor.	RESIDUE ON EVAPORATION. Total.	RESIDUE ON EVAPORATION. Dissolved.	RESIDUE ON EVAPORATION. Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dissolv'd	Loss on Ig'n. Suspnd'd	Color on Ignition.	Chlorine.	OXYGEN CONSUMED. Total.	OXYGEN CONSUMED. By Dissolved.	OXYGEN CONSUMED. By Suspd Matter.	NITROGEN AS AMMONIA. Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspnd'd	ORGANIC NITROGEN. Total.	ORGANIC NITROGEN. Dissolved.	ORGANIC NITROGEN. Suspended.	NITROGEN AS Nitrites.	NITROGEN AS Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
4964	May 1	May 2	§	V.M'ch	VM.F.05	None	2489.6	222.	2267.6	114.	26.	88.	B.	3.2	27.7	6.8	20.9	.022	1.12	.176	.944	2.33	.37	1.96	.025	.65	.....	.....	....	.....	....
5044	" 15	" 17	§	"	VM.F.03	"	2112.	170.8	1941.2	60.	20.	40.	B.	3.8	23.2	6.7	16.5	.052	1.152	.192	.96	3.13	.40	2.64	.012	.64	.....	.....	....	.....	....
5045	" 16	" 17	§	"	VM.F.03	"	2134.8	196.4	1938.4	62.8	14.	48.8	B.	3.6	18.3	5.9	12.4	.056	1.152	.192	.96	3.13	.40	2.64	.012	.64	.....	.....	....	.....	....
5168	June 6	June 7	§	"	VM.F.1	"	3134.4	237.6	2896.8	76.4	20.	56.4	B.	4.4	45.3	10.	35.3	.036	2.	.24	1.76	4.73	.666	4.064	.001	.68	.....	.....	....	.....	58,500
5235	" 16	" 17	§	"	VM.F.15	"	3551.2	266.4	3284.8	112.4	38.8	73.6	B.	4.6	39.1	7.6	31.5	.028	1.68	.176	1.504	4.76	.472	4.288	.004	.64	22.8	35.	....	.....	12,000
5277	" 23	" 24	§	"	VM.F.15	"	3643.2	246.8	3396.4	96.	16.	80.	B.	4.6	28.3	6.8	21.5	.052	1.408	.208	1.2	4.6	.44	4.16	.006	.48	22.	28.	....	.....	67,750
5317	" 29	" 30	§	"	VM.F.05	"	2583.2	222.4	2360.8	43.6	12.	31.6	B.	3.9	30.1	8.9	21.2	.028	1.088	.112	.976	3.08	.344	2.736	.001	.52	20.5	26.	30.	.....	6,150
5360	July 6	July 7	§	"	VM.F.06	"	2446.4	212.8	2233.6	73.2	35.2	38.	B.	4.45	30.2	10.6	19.6	.064	1.12	.16	.96	2.92	.376	2.544	.002	.52	22.9	26.	....	.....	2,000
5413	" 14	" 15	§	"	VM.F.1	"	2824.	199.6	2624.4	80.8	32.8	48.	B.	4.3	45.2	8.2	37.	.048	1.44	.176	1.264	3.64	.408	3.232	.01	.52	23.6	28.	....	.....	12,000
5461	" 21	" 22	§	"	VM.F.06	"	2491.2	183.6	2307.6	111.2	38.	73.2	B.	5.6	33.	7.2	25.8	.032	.864	.176	.688	2.76	.328	2.432	.007	.44	19.8	28.	....	.....	2,100
5507	" 27	" 28	§	"	VM.F.05	"	2078.8	185.2	1893.6	78.8	26.8	52.	B.	5.05	24.2	8.5	15.7	.02	.544	.16	.384	2.2	.382	1.818	.006	.44	16.2	30.	....	.....	11,750
5561	Aug. 3	Aug. 4	§	"	VM.F.02	"	2480.	208.	2272.	86.	18.8	67.2	B.	5.5	24.5	8.3	16.2	.016	.768	.156	.612	2.44	.44	2.	.005	.16	14.3	32.	....	+	15,850
5620	" 11	" 12	§	"	VM.F.02	"	2100.8	166.	1934.8	102.4	24.8	77.6	B.	5.25	23.7	8.	15.7	.024	.768	.076	.692	2.2	.392	1.808	.009	.28	14.4	29.	....	+	30,000
5658	" 17	" 18	§	"	VM.F.04	"	1650.8	182.4	1468.4	119.6	30.4	89.2	B.	6.2	22.9	6.8	16.1	.032	.736	.116	.62	2.04	.36	1.68	.007	.16	13.9	29.	....	.....	....
5719	" 25	" 26	§	"	VM.F.06	"	1256.4	182.4	1074.	35.6	21.2	14.4	B.	8.	20.5	5.5	15.	.016	.8	.1	.7	1.88	.36	1.52	.004	.4	8.4	30.	....	+	29,000
5761	" 31	Sept. 1	§	"	VM.F.07	"	1049.6	195.6	854.	56.8	18.4	38.4	B.	6.8	14.5	7.6	6.9	.028	.384	.116	.268	1.32	.264	1.056	.004	.28	7.5	30.	....	+	44,900
5827	Sept. 8	" 9	§	Much	M. F.03	"	881.2	216.	665.2	39.2	14.8	24.4	B.	8.	12.3	5.6	6.7	.016	.4	.1	.3	1.16	.36	.8	.004	.32	6.3	30.	....	+	28,500
5861	" 14	" 15	*	"	M. F.04	"	758.8	220.4	538.4	30.4	30.	.4	B.	7.65	13.5	5.1	8.4	.016	.416	.144	.272	1.24	.312	.928	.005	.28	6.8	22.	....	+	10,000
5924	" 22	" 23	*	"	M. F.04	"	573.2	......	....	34.8	......	.....	B.	8.15	12.6	5.7	6.9	.006	.448	.144	.304	1.08	.36	.72	.004	.36	6.7	19.	....	+	37,500
5966	" 28	" 29	*	"	M. F.05	"	503.6	213.2	290.4	24.4	17.6	6.8	B.	7.6	12.5	8.7	3.8	.02	.416	.108	.308	1.14	.468	.672	.009	.12	5.8	17.	....	+	9,150
6022	Oct. 6	Oct. 7	*	"	M. F.04	"	516.8	225.6	291.2	22.8	16.8	6.	B.	9.8	13.8	9.3	4.5	.024	.432	.152	.28	1.028	.292	.736	.005	.12	4.1	16.	....	.....	11,000
6061	" 12	" 13	*	Cons'd	M. F.04	"	448.8	212.4	236.4	30.4	28.	2.4	B.	8.6	12.5	9.	3.5	.024	.352	.156	.196	.92	.196	.724	.005	.28	3.5	20.	....	+	7,500
6115	" 19	" 20	*	"	M. F.03	"	513.6	238.	275.6	14.4	10.	4.4	B.	11.6	9.2	7.7	1.5	.024	.384	.156	.228	.84	.228	.612	.006	.2	3.2	19.	....	.....	....
6175	" 26	" 27	*	"	M. F.03	"	515.2	234.4	280.8	24.8	15.2	9.6	B.	11.3	8.5	6.3	2.2	.028	.368	.208	.16	.872	.376	.496	.007	.24	2.8	19.	....	?	17,000
6225	Nov. 3	Nov. 4	*	"	M. F.05	"	457.2	245.2	212.	16.	13.2	2.8	B.	10.3	9.	7.4	1.6	.032	.352	.112	.24	.936	.264	.672	.011	.2	4.	9.	....	+	6,500
6265	" 11	" 13	*	Much	M. F.06	"	352.8	198.8	154.	33.6	28.	5.6	B.	7.25	12.1	9.2	2.9	.032	.48	.236	.244	1.096	.488	.608	.009	.36	5.4	9.	....	+	2,000
6322	" 16	" 17	*	Cons'd	M. F.2	"	257.6	154.4	103.2	24.	11.6	12.4	B.	7.35	11.9	10.8	1.1	.024	.528	.32	.208	.776	.52	.256	.015	.28	6.5	10.	....	+	4,000
6369	" 23	" 24	*	Much	M. F.25	"	329.6	182.4	147.2	35.2	31.6	3.6	B.	7.55	14.8	11.6	3.2	.052	.4	.216	.184	1.16	.552	.608	.008	.36	6.6	12.	....	+	20,500
6427	" 30	Dec. 1	*	Cons'd	M. F.04	"	420.8	224.4	196.4	28.	16.4	11.6	B.	10.5	10.2	8.2	2.	.06	.336	.2	.136	.936	.36	.576	.009	.24	5.6	9.	....	+	25,000
6477	Dec. 7	" 8	*	Much	M. F.15	"	261.6	192.4	69.2	21.6	18.	3.6	B.	7.8	14.	12.9	1.1	.02	.48	.352	.128	1.16	.616	.544	.007	.28	4.8	3.	....	+	3,250
6525	" 14	" 15	*	Cons'd	M. F.04	"	393.2	213.6	179.6	25.6	20.8	4.8	B.	10.1	12.9	8.9	4.	.02	.448	.216	.232	1.	.328	.672	.01	.32	4.6	2.	....	+	5,375
6564	" 21	" 22	*	"	M. F.03	"	473.2	225.2	248.	28.8	16.	12.8	B.	12.3	12.9	8.2	4.7	.032	.368	.208	.16	.76	.36	.4	.011	.32	5.8	0.	....	+	11,400

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 36.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION

SOURCE OF WATER—MISSISSIPPI RIVER, WEST OF MIDSTREAM, JEFFERSON BARRACKS, MO.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Susp'nd'd							Tot'l	Dissolv'd	Susp'd										
5167	June 6	June 7	§	V.M'ch	M.F.1	None	3453.2	242.4	3210.8	106.	17.2	88.8	B.	4.35	46.2	8.7	37.5	.02	2.08	.176	1.904	5.85	.44	5.41	.004	.68	23.5	26.	......	....	39,000
5234	" 16	" 17	§	"	VM.F.1	"	3555.6	255.2	3300.4	98.8	27.2	71.6	B.	4.9	39.6	8.4	31.2	.028	1.76	.192	1.568	4.76	.472	4.288	.004	.6	22.8	26.	......	....	36,000
5278	" 23	" 24	§	"	VM.F.1	"	2504.4	260.4	3244.	107.2	16.8	90.4	B.	4.6	29.2	7.4	21.8	.036	1.472	.192	1.28	4.12	.408	3.712	.01	.48	22.	28.	......	....	18,950
5316	" 29	" 30	§	"	VM.F.04	"	2346.	219.6	2126.4	60.4	8.4	52.	B.	3.8	28.4	8.9	19.5	.02	.992	.124	.868	2.76	.376	2.384	.001	.6	20.5	26.	20.	....	127,450
5361	July 6	July 7	§	"	VM.F.05	"	2832.8	219.6	2613.2	85.2	26.8	58.4	B.	4.8	31.3	9.2	22.1	.032	1.28	.192	1.088	3.08	.408	2.672	.002	.6	22.9	26.	......	....	1,900
5417	" 14	" 15	§	"	VM.F.1	"	2778.	186.	2592.	122.4	38.	84.4	B.	3.9	43.7	8.	35.7	.04	1.44	.176	1.264	3.72	.52	3.2	.004	.56	23.6	28.	......	....	6,350
5464	" 21	" 22	§	"	VM.F.5	"	2483.6	200.4	2283.2	83.6	30.	53.6	B.	5.3	30.1	7.4	22.7	.044	1.056	.192	.864	3.	.382	2.618	.004	.52	19.8	28.	......	....	3,500
5509	" 27	" 28	§	"	VM.F.05	"	2354.	180.8	2173.2	89.2	22.4	66.8	B.	5.4	23.4	7.7	15.7	.016	.736	.128	.608	2.52	.232	2.288	.007	.4	16.2	30.	30.	....	11,200
5560	Aug. 3	Aug. 4	§	"	VM.F.03	"	2800.4	224.8	2575.6	70.4	24.8	45.6	B.	5.5	24.9	8.3	16.6	.012	.704	.14	.564	2.68	.312	2.368	.008	.44	14.3	32.	......	....	28,500
5618	" 11	" 12	§	"	VM.F.03	"	2409.2	178.4	2230.8	91.6	26.	65.6	B.	5.75	25.5	8.5	17.	.02	.8	.072	.728	2.76	.264	2.496	.006	.36	14.4	29.	......	+	34,600
5657	" 17	" 18	§	"	VM.F.15	"	2061.6	178.8	1882.8	137.2	31.2	106.	B.	6.1	23.1	5.5	17.6	.04	.896	.14	.756	2.6	.328	2.272	.012	.24	13.9	29.	......	....	....
5717	" 25	" 26	§	"	VM.F.05	"	1421.6	185.2	1236.4	83.2	16.4	66.8	B.	9.	22.5	5.7	16.8	.016	.896	.122	.774	2.2	.248	1.952	.008	.4	8.4	30.	......	+	118,000
5762	" 31	Sept. 1	§	"	VM.F.03	"	1111.2	198.	913.2	62.4	18.4	44.	B.	6.8	14.2	6.	8.2	.024	.416	.104	.312	1.4	.216	1.184	.008	.4	7.5	30.	......	+	37,000
5823	Sept. 8	" 9	*	Much	M. F.03	"	895.6	215.6	680.	40.4	14.	26.4	B.	8.	12.7	5.9	6.8	.012	.384	.132	.252	1.24	.296	.944	.005	.24	6.3	30.	......	+	87,000
5863	" 14	" 15	*	"	M. F.03	"	906.8	230.	676.8	33.2	20.4	12.8	B.	9.2	12.9	4.1	8.8	.024	.384	.132	.252	1.44	.248	1.192	.008	.24	6.8	22.	......	+	22,500
5923	" 22	" 23	*	"	M. F.03	"	789.2	167.6	621.6	25.2	14.	11.2	B.	9.95	12.8	4.3	8.5	.008	.384	.124	.26	1.16	.28	.88	.007	.2	6.7	19.	......	+	46,000
5964	" 28	" 29	*	"	M. F 04	"	702.	247.2	454.8	28.8	11.6	17.2	B.	10.3	12.1	7.1	5.	.012	.544	.14	.404	1.3	.34	.96	.012	.24	5.3	17.	......	+	13,000
6021	Oct. 6	Oct. 7	*	"	M. F.03	"	299.2	239.6	59.6	26.4	10.8	15.6	B.	13.1	13.	8.4	4.6	.028	.432	.108	.324	1.156	.276	.88	.007	.24	4.1	16.	......	+	27,000
6059	" 12	" 13	*	Cons'd	M. F.03	"	648.	257.6	390.4	21.6	8.4	13.2	B.	13.1	11.5	8.7	2.8	.032	.32	.108	.212	.84	.164	.676	.009	.24	3.5	20.	......	?	42,000
6112	" 19	" 20	*	"	M. F.03	"	597.6	261.2	336.4	12.4	6.4	6.	B.	14.6	11.6	8.	3.6	.036	.336	.092	.244	1.	.312	.688	.005	.36	3.2	19.	......	....	93,800
6176	" 26	" 27	*	"	M. F.03	"	566.4	252.4	314.	26.8	14.4	12.4	B.	13.1	8.4	5.3	3.1	.024	.352	.152	.2	.872	.232	.64	.007	.24	2.8	19.	......	?	20,500
6226	Nov. 3	Nov. 4	*	"	M. F.04	"	630.4	268.8	351.6	21.2	13.6	7.6	B.	12.	9.4	6.7	2.7	.044	.272	.1	.172	.904	.184	.72	.01	.2	4.	9.	......	+	11,500
6267	" 11	" 13	*	Much	M. F.07	"	490.	259.2	230.8	30.8	26.8	4.	B.	14.	8.	6.2	1.2	.04	.368	.212	.156	.904	.488	.416	.011	.36	5.4	9.	......	+	28,000
6321	" 16	" 17	*	Cons'd	M. F.02	"	281.6	167.2	114.4	20.	20.	....	B.	7.55	12.3	10.4	1.9	.024	.512	.284	.228	.84	.52	.32	.01	.32	6.5	10.	......	+	3,750
6368	" 23	" 24	*	Much	M. F.03	"	580.4	244.8	335.6	39.2	24.8	14.4	B.	11.5	12.2	6.9	5.3	.036	.384	.144	.24	1.144	.264	.88	.012	.28	6.6	12.	......	+	47,500
6428	" 30	Dec. 1	*	"	M. F.03	"	526.4	249.2	277.2	20.8	14.4	6.4	B.	13.	8.8	6.1	2.7	.048	.32	.14	.18	.936	.328	.608	.008	.24	5.6	9.	......	+	38,750
6476	Dec. 7	" 8	*	"	M. F.04	"	576.	260.	316.	32.	20.8	11.2	B.	13.	11.2	5.7	5.5	.128	.4	.16	.24	.872	.424	.448	.005	.28	4.8	3.	......	....	....
6526	" 14	" 15	*	Cons'd	M. F.02	"	531.6	248.8	282.8	22.	14.4	7.6	B.	13.2	12.4	....	....	.016	.4	.16	.24	.84	.456	.384	.008	.4	4.6	2.	......	?	7,875
6565	" 21	" 22	*	"	M. F.02	"	585.6	253.6	332.	19.6	17.6	2.	B.	14.6	12.9	7.8	5.1	.044	.32	.24	.08	.76	.392	.368	.009	.28	5.3	0.	......	+	30,300

TURBIDITY—*Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 37.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION

SOURCE OF WATER—MISSISSIPPI RIVER, 100 YARDS FROM MISSOURI SHORE, JEFFERSON BARRACKS, MO.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1890 Collection.	1890 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Suspnd'd							Tot'l	Dissolv'd	Suspnd'd										
4983	May 1	May 2	§	V.M'ch	V.MF.03	None	2680.	253.2	2426.8	90.4	20.	70.4	B.	4.8	29.5	6.2	23.3	.03	.92	.176	.744	2.17	.33	1.84	.04	.6	....	....	......	....	....
5166	June 6	June 7	§	Much	M. F.1	"	3593.6	258.8	3334.8	30.	14.	16.	B.	4.4	47.7	8.8	38.9	.076	2.08	.176	1.904	5.53	.57	4.96	.008	.4	....	....	......	....	72,500
5233	" 16	" 17	§	V.M'ch	V.MF.1	"	3605.2	277.2	3328.	62.	30.8	31.2	B.	4.6	40.	7.6	32.4	.084	1.92	.224	1.696	2.6	.472	2.128	.01	.08	22.8	26.	......	....	5,500
5279	" 23	" 24	§	"	V.MF.1	"	3445.6	262.8	3182.8	80.8	15.2	65.6	B.	4.6	29.5	7.5	22.	.036	1.36	.192	1.168	4.44	.472	3.968	.007	.48	22.	28.	......	....	19,700
5319	" 29	" 30	§	"	V.MF.04	"	2775.2	234.	2541.2	53.6	28.8	24.8	B.	4.8	29.5	8.3	21.2	.02	1.096	.096	1.	3.08	.36	2.72	.002	.56	20.5	26.	20.	....	36,850
5362	July 6	July 7	§	"	V.MF.05	"	2967.2	222.	2745.2	101.2	40.8	60.4	B.	4.8	32.2	8.8	23.4	.048	1.12	.176	.944	3.16	.92	2.24	.004	.52	22.9	26.	......	....	9,800
5416	" 14	" 15	§	"	V.MF.1	"	3001.2	193.2	2808.	136.8	35.2	101.6	B.	4.8	45.9	7.4	38.5	.036	1.632	.16	1.472	4.76	.392	4.368	.004	.6	23.6	28.	......	....	10,050
5465	" 21	" 22	§	"	V.MF.08	"	2827.6	189.6	2638.	111.2	26.	85.2	B.	5.8	31.9	6.6	25.3	.028	1.12	.192	.928	3.32	.344	2.976	.005	.48	19.8	28.	......	....	9,750
5510	" 27	" 28	§	"	V.MF.05	"	2312.8	201.6	2111.2	91.6	23.2	68.4	B.	5.45	24.3	7.3	17.	.012	.736	.192	.544	2.2	.248	1.952	.006	.44	16.2	30.	......	....	18,600
5559	Aug. 3	Aug. 4	§	"	V.MF.02	"	2849.6	216.4	2633.2	100.8	29.6	71.2	B.	5.8	25.7	6.9	18.8	.008	.768	.12	.648	2.76	.264	2.496	.008	.4	14.3	32.	......	+	11,600
5619	" 11	" 12	§	"	V.MF.03	"	2570.8	186.8	2384.	115.6	26.4	89.2	B.	5.8	26.9	8.2	18.7	.028	.768	.06	.708	2.36	.248	2.112	.005	.28	14.4	29.	......	+	36,400
5656	" 17	" 18	§	"	V.MF.2	"	2050.	172.8	1877.2	120.4	30.8	89.6	B.	7.1	23.4	5.3	18.1	.036	.864	.12	.744	2.6	.312	2.288	.013	.12	13.9	29.	......	....	....
5718	" 25	" 26	§	"	V.MF.04	"	1462.4	186.4	1276.	40.	16.	24.	B.	9.3	22.8	5.3	17.5	.02	.844	.1	.744	2.2	.312	1.888	.009	.4	8.4	30.	......	+	149,000
5763	" 31	Sept. 1	§	"	V.MF.02	"	1152.	200.4	951.6	46.4	16.	30.4	B.	7.	14.	5.7	8.3	.036	.416	.104	.312	1.4	.184	1.216	.007	.28	7.5	30.	......	....	55,500
5822	Sept. 8	" 9	*	Much	M. F.02	"	827.6	212.8	614.8	60.8	22.4	38.4	B.	7.2	12.3	5.9	6.4	.008	.352	.108	.244	1.16	.472	.688	.003	.2	6.3	30.	......	+	104,000
5862	" 14	" 15	*	"	M. F.02	"	941.2	235.6	705.6	26.	18.4	7.6	B.	9.55	12.8	3.6	9.2	.02	.384	.136	.248	1.44	.28	1.16	.008	.28	6.8	22.	......	+	49,500
5922	" 22	" 23	*	"	M. F.04	"	793.2	251.6	541.6	22.4	13.2	9.2	B.	10.4	12.5	4.1	8.4	.008	.352	.1	.252	1.08	.28	.8	.008	.28	6.7	19.	......	+	71,000
5963	" 28	" 29	*	"	M. F.04	"	696.8	238.8	458.	36.8	18.8	18.	B.	10.8	12.3	6.9	5.4	.016	.352	.12	.232	1.06	.324	.736	.01	.2	5.3	17.	......	+	16,000
6020	Oct. 6	Oct. 7	*	"	M. F.03	"	266.	258.8	7.2	18.8	10.8	8.	B.	12.8	12.1	7.7	4.4	.032	.448	.156	.292	1.028	.26	.768	.008	.04	4.1	16.	......	+	24,000
6060	" 12	" 13	*	Cons'd	M. F.03	"	649.2	260.4	388.8	24.	18.4	5.6	B.	12.2	12.3	9.3	3.	.028	.336	.108	.228	.84	.18	.66	.009	.2	3.5	20.	......	+	59,500
6113	" 19	" 20	*	"	M. F.02	"	611.2	252.	359.2	19.2	10.4	8.8	B.	13.2	11.7	7.9	3.8	.044	.352	.092	.26	.92	.312	.608	.006	.24	3.2	19.	......	+	82,000
6174	" 26	" 27	*	"	M. F.03	"	596.	261.6	334.4	28.8	16.4	12.4	B.	13.5	8.1	5.1	3.	.016	.368	.184	.184	.936	.28	.656	.006	.28	2.8	19.	......	+	46,000
6224	Nov. 3	Nov. 4	*	"	M. F.03	"	616.8	278.8	338.	29.2	28.8	.4	B.	13.6	8.5	6.1	2.4	.048	.352	.112	.24	.936	.328	.608	.012	.32	4.	9.	......	+	10,000
6266	" 11	" 13	*	Much	M. F.05	"	509.2	280.8	228.4	40.	33.2	6.8	B.	15.4	7.9	7.7	.2	.036	.352	.196	.156	.904	.36	.544	.008	.24	5.4	9.	......	+	27,000
6323	" 16	" 17	*	Cons'd	M. F.06	"	490.8	263.6	227.2	13.2	12.4	.8	B.	20.2	8.8	7.1	1.7	.018	.32	.188	.132	.68	.36	.32	.005	.36	6.5	10.	......	+	2,750
6370	" 23	" 24	*	Much	M. F.03	"	618.	260.4	357.6	22.4	15.2	7.2	B.	12.9	11.8	7.6	4.2	.036	.304	.12	.184	.872	.36	.512	.01	.32	6.6	12.	......	+	50,500
6426	" 30	Dec. 1	*	Cons'd	M. F.03	"	558.8	259.2	299.6	28.	11.2	16.8	G.	13.8	10.3	6.1	4.2	.044	.304	.144	.16	.904	.36	.544	.008	.24	5.6	9.	......	....	....
6475	Dec. 7	" 8	*	Much	M. F.15	"	622.4	271.6	350.8	37.6	20.8	16.8	B.	14.15	10.1	5.6	4.5	.148	.4	.208	.192	1.	.424	.576	.004	.44	4.8	3.	......	?	13,750
6527	" 14	" 15	*	Cons'd	M. F.02	"	604.4	261.2	343.2	24.4	18.	6.4	G.	14.6	6.1	6.1	....	.048	.352	.12	.232	.84	.392	.448	.014	.28	4.6	2.	......	+	12,500
6586	" 21	" 22	*	"	M. F.03	"	646.4	273.2	373.2	25.6	23.6	2.	BG.	6.35	12.3	6.2	6.1	.068	.384	.096	.288	1.	.296	.704	.008	.36	5.3	0.	......	+	22,800

TURBIDITY—*Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White. Gh., Grayish. Blk., Black. GB., Gray-Brown.

TABLE 38.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ST. LOUIS, MO., TAP WATER.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1899 Collection.	1899 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Suspend'd							Tot'l	Dissolv'd	Suspend'd										
5171	June 6	June 7	*	Cons'd	M. F.7	None	406.4	204.8	201.6	18.8	16.4	2.4	B.	4.5	11.3	7.5	3.8	.016	.384	.176	.208	.922	.474	.448	.001	.04	31.8	25.	26.	....	58,500
5232	" 16	" 17	§	V.M'ch	M. F.5	"	382.	243.2	138.8	39.2	36.8	2.4	B.	5.3	11.1	7.5	3.6	.016	.32	.192	.128	.92	.44	.48	.007	.48	....	26.	......	....	2,000
5280	" 23	" 24	*	Cons'd	M. F.3	"	403.6	247.6	156.	22.8	22.	.8	B.	4.1	8.6	5.8	2.8	.02	.48	.16	.32	.824	.376	.448	.003	.48	22.	24.	......	....	2,160
5321	" 29	" 30	§	"	M. F.15	"	512.4	236.	276.4	26.4	24.4	2.	Blk.	4.	13.	8.1	4.9	.024	.32	.112	.208	.92	.392	.528	.001	.48	....	26.	20.	....	910
5364	July 6	July 7	§	Much	M. F.1	"	447.2	229.2	218.	39.6	30.8	8.8	B.	4.7	16.8	10.4	6.4	.02	.272	.192	.08	.92	.312	.608	.002	.56	22.9	26.	......	....	1,065
5418	" 14	" 15	*	Cons'd	M. F.15	"	483.2	208.8	274.4	59.6	46.4	13.2	B.	4.8	11.	7.8	3.2	.012	.224	.176	.048	.84	.392	.448	.003	.52	23.6	28.	......	....	1,180
5466	" 21	" 22	*	....	....	"	......	.....	......	.....	....	....	......	.....	....	....	....	.....	.....	.....	.....	....	.....	.....	.....	....	19.8	28.	......	....	....
5511	" 27	" 28	*	Cons'd	F.4	"	338.8	208.4	130.4	42.	29.4	12.6	B.	4.75	8.8	7.6	1.2	.012	.192	.144	.048	.792	.392	.4	.006	.48	16.2	....	......	....	770
5562	Aug. 3	Aug 4	*	"	M. F.06	"	326.8	208.4	118.4	29.6	26.8	2.8	B.	5.4	9.6	8.	1.6	.02	.144	.112	.032	.76	.408	.352	.005	.32	....	....	......	+	910
5621	" 11	" 12	*	Little	M. F.03	"	253.2	199.6	53.6	46.4	30.4	16.	B.	6.3	5.5	....	....	.02	.096	.096	.000	.44	.344	.096	.004	.24	....	....	......	—	710
5661	" 17	" 18	§	V.M'ch	M. F.25	"	313.6	169.2	144.4	52.4	36.8	15.6	B.	5.6	6.5	....	....	.02	.16	.096	.064	.52	.392	.128	.000	.44	....	....	......	....	....
5722	" 25	" 26	*	Cons'd	M. F.13	"	303.2	176.8	126.4	26.	23.2	2.8	B.	6.2	6.7	5.	1.7	.012	.176	.108	.068	.76	.312	.448	.004	.4	....	....	......	—	10,000
5766	" 31	Sept. 1	*	"	M. F.15	"	260.	199.6	60.4	25.2	24.	1.2	B.	7.2	6.5	4.7	1.8	.032	.144	.088	.056	.472	.312	.16	.002	.44	....	....	......	....	....
5824	Sept. 8	" 9	*	Much	M. F.06	"	287.2	202.8	84.4	28.8	15.6	13.2	B.	7.	5.8	5.2	.6	.012	.128	.104	.024	.408	.264	.144	.003	.24	....	....	......	—	840
5865	" 14	" 15	*	"	M. F.04	"	254.4	226.	28.4	15.2	13.2	2.	B.	8.	4.7	4.3	.4	.016	.16	.12	.04	.52	.232	.288	.006	.3	....	....	......	—	2,380
5920	" 22	" 23	*	"	M. F.05	"	296.	247.2	48.8	16.2	11.6	4.6	B.	9.45	5.2	3.9	1.3	.004	.128	.076	.052	.344	.28	.064	.004	.2	....	....	......	....	....
5968	" 28	" 29	*	Cons'd	M. F.06	"	314.	248.	66.	30.	15.6	14.4	GB.	9.8	4.9	4.2	.7	.012	.144	.1	.044	.548	.356	.2	.005	.32	....	....	......	+	2,750
6019	Oct. 6	Oct. 7	*	Much	M. F.03	"	282.4	252.4	30.	8.8	6.	2.8	B.	11.3	6.4	5.9	.5	.016	.144	.116	.028	.472	.308	.4	.007	.08	....	....	......	—	1,320
6056	" 12	" 13	*	Little	M. F.5	"	294.8	273.2	21.6	16.	15.6	.4	B.	13.2	5.4	5.2	.2	.016	.176	.1	.076	.338	.13	.208	.004	.24	....	....	......	—	2,500
6117	" 19	" 20	†	"	M. F.03	"	319.6	270.4	49.2	10.	8.8	1.2	B.	14.1	4.8	4.5	.3	.032	.128	.08	.048	.392	.2	.192	.007	.28	....	....	......	....	....
6172	" 26	" 27	*	Cons'd	M. F.03	"	333.6	276.4	57.2	14.	11.6	2.4	B.	14.9	4.8	4.5	.3	.016	.208	.132	.076	.392	.28	.112	.008	.32	....	....	......	—	1,310
6237	Nov. 3	Nov. 4	†	Little	M. F.02	"	325.6	297.6	28.	12.4	10.4	2.	G.	14.5	4.2	4.1	.1	.02	.128	.072	.056	.248	.152	.096	.008	.32	....	....	......	+	1,560
6268	" 11	" 13	†	"	M. F.04	"	284.	......	......	.....	....	....	......	14.7	4.9	4.5	.4	.024	.176	.148	.028	.552	.328	.224	.007	.24	....	....	......	—	4,000
6324	" 16	" 17	†	"	M. F.03	"	314.8	268.8	46.	11.2	8.8	2.4	B.	16.1	5.7	5.1	.6	.012	.128	.12	.008	.424	.328	.096	.008	.28	....	....	......	+	1,950
6366	" 23	" 24	†	"	M. F.05	"	466.8	291.2	175.6	28.4	19.6	8.8	B.	15.8	6.1	6.	.1	.028	.144	.136	.008	.36	.296	.064	.008	.2	....	....	......	+	2,750
6429	" 30	Dec. 1	†	"	M. F.04	"	290.4	258.4	32.	13.6	12.4	1.2	B.	13.9	5.7	5.2	.5	.028	.176	.16	.016	.552	.328	.224	.004	.2	....	....	......	+	34,500
6478	Dec. 7	" 8	*	Much	M. F.20	"	295.2	270.	25.2	14.	11.6	2.4	B.	15.9	5.2	5.1	.1	.108	.192	.176	.016	.52	.488	.032	.001	.28	....	....	......	+	1,800
6530	" 14	" 15	†	Little	M. F.03	"	300.8	271.2	29.6	15.6	14.	1.6	B.	14.4	6.	5.9	.1	.012	.12	.108	.012	.392	.264	.128	.007	.28	....	....	......	+	4,05
6567	" 21	" 22	*	Cons'd	M. F.02	"	318.8	280.	38.8	18.	17.6	.4	G.	15.75	6.7	6.4	.3	.028	.128	.096	.032	.44	.296	.144	.006	.32	....	....	......	—	1,45

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

TURBIDITY—*Decided. §Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. Blk., Black. GB., Gray-Brown.
Rh., Reddish. W., White. Gh., Grayish,

TABLE 30.

STREAMS EXAMINATION — CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS — PARTS PER MILLION.

SOURCE OF WATER — SANITARY CANAL, KEDZIE AVENUE.

Report of ARTHUR W. PALMER.
T. J. BURRILL,
University of Illin

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. o Bac. per Cubic Centimeter.
										Loss on Ig'n.									Albuminoid Am.												
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Tot'l	Dissolv'd	Suspnd'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Suspnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
6666	Jan. 11	Jan. 12	*	Much	M. F.3	Gas'y	466.	226.8	239.2	41.2	26.	15.2	B.	24.	21.3	10.6	10.7	3.2	1.44	.384	1.056	2.88	.768	2.112	....	.16	....	.....	......	....	....
7431	Apl. 30	May 1	†	Cons'd	M. F.03	"	244.	235.2	8.8	13.2	12.8	.4	B.	22.	13.2	7.4	5.8	2.72	1.12	.288	.832	2.16	.68	1.48	.038	.28	....	3.	8.	+	2,025,00
7477	May 8	" 9	*	Much	M. F.30	"	403.2	244.4	158.8	31.2	30.4	.8	B.	23.	22.1	9.	13.1	1.92	1.12	.384	.736	3.14	.84	2.3	.15	1.4	....	8.	15.	+	3,150,00
7523	" 14	" 15	†	Little	M. F.01	M'sty	199.6	161.6	38.	19.6	17.6	2.	G.	11.	7.8	5.	2.8	.8	.352	.192	.16	2.5	.452	2.048	.015	.16	....	13.	20.	+	200,00
7577	" 21	" 22	†	"	M. F.01	Oily	217.2	182.4	34.8	27.2	22.4	4.8	B.	16.5	11.5	7.	4.5	1.6	.8	.448	.352	.996	.516	.48	.023	.32	....	3.	9.5	+	825,00
7615	" 28	" 29	†	Cons'd	M. F.06	Gas'y	213.2	150.8	62.4	33.2	24.	9.2	B.	11.	13.1	6.1	7.	.688	.512	.224	.288	1.16	.452	.708	.016	.24	....	8.	13.	....	1,170,00
7648	June 4	June 5	†	"	M. F.04	"	205.2	169.6	35.6	36.4	22.8	13.6	B.	12.	9.9	4.6	5.3	.88	.432	.24	.192	.84	.42	.42	.01	.2	....	9.	14.5	+	280,000
7706	" 11	" 12	†	Little	M. F.02	....	198.4	191.6	6.8	30.	29.6	.4	B.	14.	7.	5.3	1.7	1.52	.288	.24	.048	.8	.42	.38	.01	.4	....	15.5	19.	....	135,000
7733	" 18	" 19	*	"	M. F.05	M'sty	198.	171.6	26.4	19.2	15.6	3.6	B.	10.	6.6	5.8	.8	1.04	.416	.128	.288	.58	.34	.24	.005	.24	....	12.	18.	+	750,000
7774	" 25	" 26	‡	"	T. F.03	"	212.8	170.4	42.4	26.8	20.4	6.4	B.	10.	7.3	4.3	8.	.56	.288	.096	.192	1.54	.308	1.232	.011	.16	....	21.	25.	?	845,000
7851	July 6	July 7	‖	Slight	F.02	"	223.2	202.8	20.4	22.8	20.8	2.	B.	14.5	8.8	4.	4.8	1 04	.448	.176	.272	1.156	.228	.928	.012	.12	....	17.	......	?	70,000
7884	" 9	" 10	*	Little	T. F.03	....	211.6	184.4	27.2	19.2	15.2	4.	B.	13.	8.	5.3	2.7	.92	.352	.208	.144	.548	.276	.272	.019	.12	...	..	......	....	....
7908	" 11	" 12	*	"	T. F.02	Gas'y	197.6	157.6	40.	24.4	14.	10.4	B.	12.	10.9	5.6	5.3	.23	.272	.176	.096	.776	.222	.484	.012	.12	....	....	......	....	....
7924	" 13	" 14	†	"	F.01	"	188.4	162.4	26.	26.	8.4	17.6	B.	11.	6.7	4.8	1.9	1.04	.272	.16	.112	.84	.66	.18	.008	.12	....	....	......	....	....
7932	" 16	" 17	‡	"	T. F.02	"	183.2	163.6	19.6	12.	11.6	.4	B.	10.5	5.7	3.9	1.8	2.32	.272	.112	.16	.9	.372	.528	.009	.24	....	15.	......	....	550,000
7960	" 18	" 19	*	Much	M. F.02	"	194.8	161.2	33.6	18.	6.4	11.6	B.	12.	7.3	4.5	2.8	1.	.24	.144	.096	.68	.42	.26	.011	.04	....	13.	......	....	3,600,000
7992	" 20	" 21	*	Little	T. F.02	"	190.	156.	34.	37.6	9.6	28.	B.	11.	6.5	4.3	2.2	.88	.304	.128	.176	.76	.5	.26	.012	.12	....	14.	......	....	1,165,000
8002	" 23	" 24	†	"	T. F.01	"	176.8	161.2	15.6	19.2	9.6	9.6	G.	10.	6.2	3.8	2.4	.88	.24	.112	.128	.76	.456	.304	.009	.36	....	16.	......	....	970,000
8024	" 25	" 26	†	"	T. F.02	"	252.	......	......	38.4	.....	....	......	23.	11.5	5.8	5.7	1.88	.688	.176	.512	.156	.92	.64	.038	.4	....	....	......	....	....
8037	" 27	" 28	*	"	T. F.01	"	226.	172.	54.	34.4	24.	10.4	B.	13.	11.8	5.4	6.4	1.68	.512	.128	.384	.124	.44	.8	.014	.2	....	13.	......	....	530,000
8055	" 30	" 31	*	"	T. F.01	"	174.8	158.4	16.4	20.4	19.6	.8	B.	10.5	6.3	5.2	1.1	1.04	.352	.176	.176	.68	.48	.2	.013	.2	....	11.	......	....	195,000
8070	Aug. 1	Aug. 2	*	"	T. F.01	"	192.4	158.8	33.6	23.2	20.8	2.4	G.	13.	6.9	4.2	2.7	1.48	.416	.104	.312	1.08	.52	.56	.017	.24	....	15.	......	....	2,110,000
8093	" 3	" 4	*	"	T. F.01	"	197.6	172.8	24.8	24.	24.	....	B.	11.	7.1	4.	3.1	1.04	.304	.16	.144	1.	.44	.56	.006	.12	....	14.	......	....	1,760,000
8098	" 6	" 7	†	V Little	T. F.01	"	173.2	145.6	27.6	30.	8.	22.	B.	12.	6.4	3.7	2.7	1.16	.342	.176	.166	.92	.328	.592	.005	.16	....	19.	......	....	965,000
8115	" 8	" 9	*	Little	T. F.01	"	183.6	166.4	17.2	29.6	28.4	1.2	G.	12.	7.4	4.	3.4	1.04	.336	.16	.176	1.064	.354	.710	.007	.28	....	16 5	......	....	1,615,000
8152	" 10	" 11	*	"	T. F.01	"	140.	115.2	24.8	40.4	39.2	1.2	B.	13.	11.6	4.3	7.3	1.36	.352	.176	.176	1.08	.316	.764	.009	.16	....	17.	......	....	810,000
8167	" 13	" 14	*	"	T. F.01	"	171.6	148.4	22.2	26.	22.8	3.2	G.	11.	6.1	3.6	2.5	.8	.304	.16	.144	.68	.28	.40	.007	.28	....	18.	......	....	4,200,000
8172	" 15	" 16	*	"	T. F.01	"	214.8	161.2	53.6	32.8	31.2	1.6	G.	16.5	13.1	4.7	8.4	1.76	.512	.176	.336	1.224	.28	.944	.028	.44	....	15.5	......	....	530,000
8200	" 17	" 18	*	"	T. F.01	"	203.6	158.	45.6	25.2	18.4	6.8	G.	12.	8.2	4.1	4.1	.56	.368	.24	.128	.776	.28	.496	.011	.56	....	15.	......	....	150,000
8229	" 20	" 21	*	"	T. F.01	"	237.6	194.	43.6	35.2	15.2	20.	G.	20.	17.1	6.	11.1	1.76	.512	.176	.336	1.2	.316	.984	.028	.36	....	16.5	......	....	380,000
8257	" 22	" 23	*	"	T. F.02	"	208.4	169.6	38.8	22.8	9.6	13.2	G.	18.	8.6	4.	4.6	1.32	.432	.16	.272	.888	.172	.716	.013	.4	....	15.5	......	....	1,010,000
8280	" 24	" 25	*	"	T. F.02	"	227.2	189.2	38.	16.8	14.	2.8	G.	16.	9.	3.8	5.2	1.2	.368	.096	.272	.68	.188	.492	.04	.2	....	16.	......	....	1,820,000
8305	" 27	" 28	*	"	T. F.01	"	197.2	187.2	10.	18.4	17.6	.8	G.	13.	7.7	4.	3.4	.896	.352	.064	.288	.6	.228	.372	.014	.36	....	16.5	......	....	505,000
8318	" 29	" 30	*	"	T. F.	"	215.2	175.2	40.	23.6	12.8	10.8	B.	11.	8.2	4.1	4.1	.4	.208	.112	.096	.6	.3	.3	.009	.2	....	16.	......	....	220,000
8343	" 31	Sept. 1	†	"	M. F.02	"	190.4	165.6	24.8	22.4	21.6	.8	B.	11.	7.9	3.6	4.3	.608	.32	.208	.112	.636	.316	.32	.006	.24	....	15.	......	....	1,480,000
8356	Sept. 3	" 4	*	Cons'd	M. F.02	"	212.	170.8	41.2	16.	14.	2.	B.	11.	10.5	3.3	7.2	.88	.448	.096	.352	1.24	.364	.876	.01	.24	....	16.	......	....	160,000
8375	" 5	" 6	†	Cons'd	.03	"	180.4	154.	26.4	17.2	15.2	2.	DB.	13.	9.2	3.4	5.8	1.12	.352	.144	.208	.924	.204	.72	.017	.24	....	15.5	......	....	2,280,000
8414	" 7	" 8	‖	Little	F.02	"	220.8	206.4	14.4	20.8	13.2	7.6	B.	21.	11.5	3.7	7.8	2.16	.56	.096	.464	1.16	.496	.664	.001	.16	....	15.	......	....	1,970,000
8428	" 10	" 11	‖	"	F.1	"	196.8	179.6	17.2	19.6	17.6	2.	G.	13.	7.7	3.8	3.9	.128	.352	.112	.24	.86	.512	.348	.008	.36	....	14.	......	....	1,010,000
8452	" 12	" 13	†	"	F.02	M'sty	218.4	195.2	23.2	21.6	19.2	2.4	G.	19.	10.2	4.	6.2	1.76	.688	.272	.416	1.5	.416	1.084	.003	.12	....	15.	......	....	1,180,000
8473	" 14	" 17	†	"	M. F.01	Gas'y	262.8	219.6	43.2	32.4	13.2	19.2	B.	27.	14.4	5.8	8.6	3.44	1.12	.16	.96	2.22	.288	1.932	.004	.24	....	14.	......	....	1,175,000
8476	" 17	" 18	†	"	F.01	"	170.8	152.	18.8	20.8	14.8	6.	G.	9.	6.1	3.2	2.9	.544	.272	.112	.16	.588	.176	.412	.01	.32	....	15.5	......	....	260,000
8495	" 19	" 20	†	"	F.03	"	201.6	189.2	12.4	24.4	19.6	4.8	G.	17.	12.4	5.	7.4	.464	.768	.16	.608	1.8	.304	1.496	.007	.24	....	15	......	....	70,000
8520	" 21	" 22	†	"	M. F.2	"	307.6	268.4	39.2	38.4	28.	10.4	B.	34.	24.6	14.1	10.5	3.84	1.6	.256	1.344	3.24	.704	2.536	.002	.2	....	14.5	......	....	1,760,000
8528	" 24	" 25	†	"	M. F.02	"	216.8	188.4	28.4	34.8	29.6	5.2	B.	16.	9.8	3.6	6.2	1.241	.928	....	.....	1.42	.....	.....	.02	.16	....	14.5	......	....	410,000
8549	" 26	" 27	†	"	M. F.03	M'sty	206.8	171.2	35.6	31.2	16.8	14.4	G.	13.	8.4	4.2	4.2	.72	.752	...	.....	1.276	.352	.924	.014	.32	....	....	......	....	1,550,000
8567	" 28	" 29	†	"	M.	"	195.6	168.	27.6	24.	12.	12.	Bh.	12.	8.1	3.9	4.2	.656	.608	.176	.432	1.404	.416	.988	.009	.4	....	14.5	......	....	340,000
8587	Oct. 1	Oct. 2	†	"	M. F.04	Gas'y	202.	157.2	44.8	23.2	21.6	1.6	Bh.	9.	10.5	5.3	5.2	.752	.48	.192	.288	.832	.416	.416	.01	.32	....	15.	......	....	210,000
8607	" 3	" 4	†	"	C. F.03	M'sty	183.6	162.4	21.2	17.2	14.	3.2	B.	10.	11.4	5.7	3.7	1.216	.432	.256	.176	.864	.336	.528	.013	2.4	....	....	......	....	285,000
8623	" 5	" 6	‖	"	F.03	"	188.	154.8	23.2	24.4	22.	2.4	Bh.	10.	6.2	4.2	2.	.768	.384	.....	......	.704	.16	.544	.007	.273	....	....	......	....	765,000
8642	" 8	" 9	‖	"	F.02	......	169.2	147.2	22.	18.	16.4	1.6	G.	8.	6.5	4.	2.5	.528	.352	.256	.096	.864	.236	.028	.009	.151	....	....	......	....	240,000

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.
COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White

TABLE 40.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS AND MICHIGAN CANAL, BRIDGEPORT.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of: 1900 Collection.	Date of: 1900 Examination.	Appearance: Turb'y.	Appearance: Sediment.	Appearance: Color.	Odor.	Residue on Evaporation: Total.	Residue on Evaporation: Dissolved.	Residue on Evaporation: Suspended.	Loss on Ig'n: Tot'l	Loss on Ig'n: Dissolv'd	Loss on Ig'n: Suspend'd	Color on Ignition.	Chlorine.	Oxygen Consumed: Total.	Oxygen Consumed: By Dissolved.	Oxygen Consumed: By Susp'd Matter.	Nitrogen as Ammonia: Free Ammonia.	Albuminoid Am.: Tot'l	Albuminoid Am.: Dissolv'd	Albuminoid Am.: Suspend'd	Organic Nitrogen: Total.	Organic Nitrogen: Dissolved.	Organic Nitrogen: Suspended.	Nitrogen as: Nitrites.	Nitrogen as: Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
6600	Jan. 2	Jan. 3	*	Cons'd	M. F.30	Gas'y	458.	428.	30.	54.4	35.6	18.8	B.	92.2	34.8	19.8	15.	15.2	2.88	1.76	1.12	5.8	3.08	2.72	.004	.24	4.8	0.	.2	?	1,980,000
6642	" 7	" 9	*	"	M. F.3	"	444.8	412.	32.8	42.	34.4	7.6	G.	113.5	8.5	8.	.5	11.2	2.16	1.44	.72	4.52	1.88	2.64	.035	.28	5.	5.	4.4	+	860,000
6685	" 15	" 16	*	"	M. F.5	"	347.2	319.2	28.	42.4	28.8	3.6	G.	65.5	19.3	11.2	8.1	7.2	1.92	1.28	.64	3.36	2.08	1.28	.028	.28	4.	4.5	8.3	+	5,100,000
6732	" 22	" 23	*	"	M. F.3	"	520.4	472.4	48.	39.2	24.4	14.8	B.	136.	22.6	12.	10.6	13.2	2.16	1.52	.64	4.32	2.32	2.	.036	.32	4.6	0.	4.5	+	11,080,000
6779	" 29	" 30	*	Much	M. F.4	"	669.2	605.2	64.	52.	42.	10.	B.	202.	23.9	21.	2.9	18.	3.6	2.8	8.8	7.04	4.88	2.16	.012	.2	2.5	0.	......	+	310,000
6831	Feb. 5	Feb. 7	*	Cons'd	M. F.37	"	406.	390.4	15.6	39.2	24.4	14.8	B.	102.	23.9	12.5	11.4	10.8	2.	.528	1.472	4.	1.184	2.816	.028	.2	4.5	....	2.	....	....
6891	" 11	" 14	*	"	M. F.	"	410.4	360.4	50.	36.8	20.8	16.	B.	88.5	18.2	8.	10.2	7.2	1.6	.592	1.008	4.08	1.088	2.992	.012	.08	4.8	0.	6.5	+	10,350,000
6929	" 19	" 20	*	Much	M. F.06	"	389.2	354.	35.2	48.4	28.	20.4	B.	90.	18.1	7.9	10.2	7.36	1.92	.752	1.168	4.48	1.92	2.56	.027	.2	4.2	6.5	0.	+	5,660,000
6981	" 26	" 27	†	Cons'd	M. F.20	"	382.4	365.6	16.8	47.6	35.2	12.4	G.	94.	18.5	12.5	6.	6.4	2.16	1.408	.752	4.16	2.56	1.6	.032	.44	3.6	1.5	2.	....	2,180,000
7016	Mar. 5	Mar. 6	†	"	M. F.20	"	302.	283.2	18.8	27.2	14.8	12.4	B.	56.5	14.	8.9	5.1	4.16	1.088	.688	.4	2.24	1.056	1.184	.03	.2	4.	0.	6.5	....	1,880,000
7065	" 12	" 13	*	Much	M. F.04	"	326.4	262.	64.4	26.	16.	10.	B.	39.	17.2	7.4	9.8	3.52	1.376	.288	1.088	2.8	.544	2.256	.065	.8	5.	0.	4.	....	3,550,000
7109	" 19	" 20	†	Cons'd	M. F.50	"	393.2	368.8	24.4	28.4	22.	6.4	B.	86.	18.6	10.9	7.7	7.2	2.16	1.184	.976	4.76	2.36	2.4	.175	.52	4.	8.	3.	....	3,550,000
7163	" 26	" 27	†	"	M. F.50	"	430.4	360.8	69.6	44.	26.	18.	B.	88.	21.5	13.7	7.8	8.8	2.24	.8	1.44	4.28	2.52	1.76	.22	.4	4.	11.	12.	....	8,000,000
7209	April 2	April 3	†	"	M. F.40	"	477.2	450.4	26.8	35.6	15.6	20.	B.	94.5	.....	.....	.....	8.	1.76	.88	.88	4.28	2.36	1.92	.18	.36	4.	8.	11.	+	5,300,000
7254	" 9	" 10	†	"	M. F.30	"	576.4	547.6	28.8	43.2	20.8	22.4	B.	147.	24.2	12.2	12.	14.	1.6	.736	.864	3.48	2.12	1.36	.16	.36	3.	9.	14.	+	3,725,000
7318	" 16	" 17	†	"	M. F.25	"	390.4	284.4	106.	32.	27.2	4.8	B.	.....	18.3	10.7	7.6	8.8	1.6	.96	.64	3.16	1.4	1.76	.08	.36	4.5	12.	16.	+	11,200,000
7391	" 23	" 24	†	"	M. F.08	"	336.8	289.6	47.2	12.	10.8	1.2	B.	.....	12.7	6.7	6.	6.8	1.28	.432	.848	2.36	.984	1.376	.035	.32	4.	11.	13.	+	3,925,000
8109	Aug. 7	Aug. 8	*	Little	T.	"	500.4	469.6	30.8	45.	38.8	6.2	B.	148.5	17.1	7.4	9.7	17.6	1.168	.384	.784	2.6	.872	1.728	.002	.36	....	20.	......	....	690,000
8120	" 8	" 9	*	"	T.	"	441.2	380.	61.2	42.	27.6	14.4	B.	117.5	15.8	9.	6.8	12.	1.152	.288	.864	2.36	.636	1.644	....	.28	....	17.	......	....	3,140,000
8151	" 10	" 11	*	"	T.	"	494.2	400.4	93.8	47.2	36.4	10.8	B.	161.	20.4	7.8	12.6	17.6	1.184	.384	.8	2.52	.78	1.74	....	.2	....	....	......	....	....
8165	" 13	" 14	*	"	T.	"	296.	256.4	39.6	36.	33.2	2.8	B.	62.	14.3	5.4	8.9	8.4	.864	.176	.688	1.72	.316	1.404	.018	.4	....	1.8	......	+	3,900,000
8227	" 20	" 21	*	"	T. F.01	"	498.	472.4	25.6	41.6	23.2	18.4	B.	156.	18.4	7.9	10.5	15.6	1.504	.416	1.088	3.	.508	2.492	....	.2	....	17.	......	+	210,000
8298	" 27	" 28	*	"	M. F.02	"	462.	435.2	26.8	28.	26.8	1.2	B.	127.	14.8	8.1	6.7	6.4	.896	.314	.582	2.52	.572	1.948	.013	.24	....	17.	......	?	90,000
8355	Sept. 3	Sept. 4	*	Cons'd	M. F.15	"	673.6	602.	71.6	46.4	29.6	16.8	DB.	233.	21.7	11.5	10.2	25.6	1.36	.352	1.008	3.16	.604	2.556	.001	.16	....	16.5	......	+	126,000
8429	" 10	" 11	†	"	F.04	M'sty	435.6	432.	3.6	26.8	16.	10.8	B.	122.	14.	6.1	7.9	1.48	.896	.304	.592	1.74	.528	1.212	.001	.24	....	14.	......	—	680,000
8477	" 17	" 18	†	Little	F.01	Gas'y	206.	169.2	36.8	24.8	15.6	9.2	G.	14.	9.1	3.5	5.6	1.28	.496	.08	.416	.956	.384	.572	.014	.24	....	15.5	......	—	140,000
8529	" 24	" 25	*	Cons'd	M. F.4	"	845.2	768.4	76.8	77.6	42.	35.6	DB.	283.	29.	17.4	11.6	30.4	2.64	.464	2.176	4.92	.....	.....	.001	.24	....	13.	......	+	1,610,000
8586	Oct. 1	Oct. 2	†	Little	M. F.15	"	447.6	406.8	40.8	32.	23.8	9.2	Bh.	135.	16.6	8.8	7.8	12.8	1.216	.496	.72	2.864	1.184	1.68	.002	.24	....	13.	......	+	2,515,000

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., Whit

TABLE 41.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS AND MICHIGAN CANAL, LOCKPORT.

Report of ARTHUR W. PALMER.
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dis-solv'd	Sus-pnd'd							Tot'l	Dis-solv'd	Sus-pnd'd										
6602	Jan. 2	Jan. 3	*	Cons'd	M. F.5	Gas'y	513.6	444.4	69.2	59.6	39.2	20.4	B.	107.	34.3	22.8	11.5	10.4	3.36	2.08	1.28	8.52	4.84	3.68	.002	.64	....	0.	......	+	1,100,000
6643	" 8	" 9	*	"	M. F.4	"	440.4	376.4	64.	43.6	28.8	14.8	G.	90.	21.1	14.8	6.3	10.4	2.48	1.04	1.44	4.84	2.44	2.4	.001	.24	....	0.	......	+	3,980,000
6688	" 15	" 16	*	"	M. F.5	"	535.6	468.	67.6	60.4	21.6	38.8	B.	134.	24.6	17.2	7.4	12.8	3.36	2.16	1.2	6.4	3.36	3.04	.001	.2	....	4.5	......	+	510,000
6738	" 22	" 24	*	"	M. F.5	"	458.	439.	19.	42.8	31.6	11.2	B.	106.	20.6	11.6	9.	9.6	2.24	1.04	1.2	5.28	1.68	3.6	.015	.2	....	4.5	......	+	5,400,000
6780	" 29	" 30	*	"	M. F.25	"	545.2	230.	315.2	55.6	25.6	30.	G.	151.	16.3	13.1	3.2	13.2	2.56	1.76	.8	4.8	2.24	2.56	.002	.2	....	0.	......	—	290,000
6831	Feb. 5	Feb. 6	*	"	M. F.6	"	372.	342.4	29.6	41.2	24.	17.2	B.	83.	18.9	10.6	8.3	6.4	1.92	.464	1.456	4.16	.992	3.168	.017	.16	....	....	—9.5	....	....
7022	Mar. 5	Mar. 6	*	"	M. F.4	"	499.2	431.6	67.6	44.4	28.	16.4	B.	118.	21.7	11.9	9.8	10.4	3.36	1.76	1.6	7.04	4.	3.04	.014	.36	....	0.	—12.	....	1,870,000
7069	" 12	" 13	*	"	M. F.3	"	369.2	255.6	113.6	42.8	38.	4.8	B.	58.8	22.	9.4	12.6	15.76	1.84	.64	1.2	4.64	1.184	3.456	.075	.84	....	0.	3.5	....	9,450,000
7117	" 19	" 20	*	"	M. F.4	"	434.	384.4	49.6	33.2	32.8	.4	B.	78.4	21.9	11.8	10.1	6.4	2.4	1.216	1.184	4.76	2.52	2.24	.15	.72	....	?	......	+	2,000,000
7165	" 26	" 27	*	"	M. F.3	"	399.6	372.	27.6	39.2	32.4	6.8	B.	73.2	18.8	11.1	7.7	7.2	1.92	1.024	.896	4.44	2.6	1.84	.17	.4	....	0.	......	....	3,700,000
7217	Apr. 2	Apr. 3	*	"	M. F.50	"	526.	497.2	28.8	35.2	24.	11.2	B.	130.5	22.5	11.3	11.2	11.2	2.88	1.28	1.6	5.24	2.52	2.72	.002	.2	....	0.	3.5	....	8,000,000
7272	" 9	" 10	†	Little	M. F.50	....	643.6	632.8	10.8	50.	45.2	4.8	B.	175.	22.4	14.9	7.5	13.6	2.64	1.68	.96	5.24	3.32	1.92	.008	.12	....	9.5	1.5	+	1,490,000
7328	" 16	" 17	*	Cons'd	M. F.40	....	509.6	482.	27.6	24.8	18.4	6.4	B.	117.	18.	11.2	6.8	10.8	1.6	.704	.896	3.48	1.368	2.112	.004	.24	....	8.	22.	+	2,925,000
7398	" 23	" 24	*	Much	M. F.04	Gas'y	571.6	522.8	48.8	38.	32.8	5.2	B.	119.8	21.4	10.7	10.7	14.4	2.16	.688	1.472	3.48	1.72	1.76	.004	.2	....	12.	21.	+	3,150,000
7438	May 1	May 1	*	Cons'd	M. F.16	"	360.4	271.2	89.2	32.	19.2	12.8	B	53.	18.7	7.9	10.8	5.92	1.36	.432	.928	3.14	1.14	2.	.008	.2	....	15.5	25.	+	2,050,000
7480	" 8	" 9	*	"	M. F.30	....	457.2	372.	85.2	28.4	28.	.4	B.	101.	18.8	9.3	9.5	11.2	1.36	.704	.656	2.98	1.14	1.84	.008	.24	....	14.5	23.5	+	915,000
7533	" 15	" 16	..	....	....	M'sty	425.2	397.6	27.6	36.4	21.2	15.2	B.	88.	16.6	9.1	7.5	7.2	2.24	.64	1.6	3.14	.74	2.4	.004	.12	....	20.	27.5	....	2050,000
7587	" 22	" 23	*	Cons'd	M. F.1	Gas'y	462.4	448.	14.4	29.6	26.4	3.2	B.	130.	16.5	11.2	5.3	15.2	1.472	.528	.944	2.18	.8	1.38	.006	.08	....	15.5	26.5	+	1,465,000
7623	....	" 30	*	"	M. F.20	"	505.2	496.8	8.4	37.2	35.6	1.6	B.	152.5	20.6	11.4	9.2	21.48	1.28	.736	.544	2.18	1.22	.96	.02	.4	....	19.	20.5	+	1,765,000
7654	....	June 5	*	"	M. F.50	"	579.2	539.6	39.6	52.	39.6	12.4	G.	165.5	17.4	10.8	6.6	19.2	1.44	.448	.992	2.9	1.86	1.04	....	.24	....	18.	25.5	+	280,000
7703	....	" 13	*	"	M. F.30	"	467.2	440.8	26.4	44.4	29.2	15.2	B.	107.	17.2	8.2	9.	12.4	1.36	.448	.912	2.74	1.6	1.14	.011	.2	....	18.	22.	+	2,315,000
7739	....	" 19	*	"	M. F.2	"	666.8	640.4	26.4	45.2	39.6	5.6	B.	217.	23.1	15.7	7.4	21.6	1.52	1.056	.464	2.74	2.1	.64	....	.12	....	21.	28.	+	365,000
7781	June 26	" 27	*	Much	T. F.3	"	722.8	659.2	63.6	56.4	37.6	18.8	B.	227.	26.9	12.7	14.2	23.4	1.408	1.152	.256	3.88	1.54	2.34	.002	.2	....	22.	31.	—	750,000
7832	July 3	July 4	*	Little	T. F.01	"	363.6	319.2	44.4	29.6	17.6	12.	B.	75.	13.2	7.8	5.4	6.4	.88	.24	.64	1.46	.74	.72	.002	.12	....	19.	......	—	1,195,000
7893	" 9	" 11	*	"	T. F.20	M'sty	500.	442.8	57.2	36.	20.	16.	B.	120.5	16.8	8.3	8.5	8.8	.576	.496	.08	.97	.644	.336	.004	.04	....	—	......	+	160,000
7938	" 16	" 17	†	"	T. F.03	Gas'y	437.6	406.4	31.2	37.6	28.4	9.2	B.	117.	16.2	7.2	9.	8.8	.88	.352	.528	1.28	.612	.668	....	.12	....	....	......	?	780,000
8008	" 23	" 24	†	"	T. F.02	"	418.8	392.	26.8	24.4	24.	.4	B.	117.5	10.7	7.8	2.9	12.	.96	.288	.672	1.8	.616	1.184	.001	.2	....	....	......	+	780,000
8057	" 30	" 31	*	"	T. F.03	"	582.4	570.4	12.	46.	46.	0.0	B.	182.	16.7	14.8	1.9	13.6	1.248	.448	.8	2.52	1.08	1.44	....	.24	....	....	......	+	420,000
8113	Aug. 6	Aug. 8	*	"	T. F.02	"	609.2	572.8	36.4	45.6	45.2	.4	B.	193.	21.	8.4	12.6	19.2	1.36	.48	.88	3.32	1.112	2.208	.001	.12	....	....	......	?	430,000
8173	" 13	" 15	*	"	T. F.02	"	408.	383.6	24.4	44.4	30.4	14.	B.	116.	17.1	6.5	10.6	12.	1.184	.208	.976	1.88	.44	1.44	....	.4	....	....	......	+	190,000
8233	" 20	" 21	*	"	T. F.02	"	595.2	523.6	71.6	45.2	23.6	21.6	DB	188.	27.1	10.6	16.5	19.2	1.68	.336	1.344	3.32	.572	2.748	....	.2	....	24.	......	+	370,000
8307	" 27	" 28	*	"	T. F.02	"	551.2	529.6	21.6	35.6	20.	15.6	B.	166.5	18.7	6.8	11.9	9.2	1.088	.368	.72	2.04	.54	1.5	....	.08	....	25.5	......	?	930,000
8368	Sept. 4	Sept. 5	*	"	M. F.02	"	595.6	558.4	37.2	38.8	22.8	16.	B.	184.	16.7	7.	9.7	21.6	1.28	.436	.844	2.46	.412	2.048	....	.28	....	24.	......	—	610,000
8436	....	" 11	*	Cons'd	M. F.1	"	565.6	516.8	48.8	58.	31.6	26.4	B.	170.	25.3	7.4	17.9	19.2	1.44	.432	1.008	2.86	.72	2.14	.001	.16	....	23.	......	—	5,780,000
8491	Sept. 17	" 19	*	"	M. F.2	"	724.8	281.6	443.2	49.2	45.6	3.6	B.	256.5	23.8	11.7	12.1	24.8	1.6	.496	1.104	2.14	.56	1.58	.001	.2	....	19.	......	—	170,000
8546	" 24	" 27	§	Much	Black	"	833.6	605.6	228.	76.	27.2	48.8	B.	212.5	41.2	18.1	23.1	20.	2.96	.352	2.608	6.04	.928	5.112	....	.28	....	19.	......	?	6,600,000
8594	Oct. 1	Oct. 2	†	Little	M. F.4	M'sty	613.2	525.2	88.	47.2	18.4	28.8	B.	189.	28.3	13.5	14.8	.372	1.76	.72	1.04	2.704	1.104	1.6	....	.08	....	—	......	—	1,240,000

TURBIDITY—*Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.
COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. BB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 42.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—DES PLAINES RIVER, LOCKPORT.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinoi

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Suspnd'd							Tot'l	Dissolv'd	Suspnd'd										
6607	Jan. 2	Jan. 3	†	Little	F.1	......	735.6	696.8	38.8	62.8	40.8	22.	B.	15.5	13.5	12.3	1.2	.06	.512	.4	.112	1.48	.872	.608	.007	1.52	1.	0.	......	....	1,500
6644	" 8	" 9	‖	"	F.03	......	359.2	348.	11.2	54.4	54.4	....	G.	7.7	5.4	5.	.4	.048	.24	.224	.016	.68	.488	.192	.003	.84	....	....	......	—	30,000
6689	" 15	" 16	‖	"	F.04	......	444.8	442.	2.8	48.8	46.4	2.4	B.	10.	7.2	7.2	....	.024	.256	.24	.016	.64	.544	.096	.004	1.04	1.	0.	......	—	6,150
6737	" 23	" 24	†	"	M. F.05	......	402.	379.2	22.8	26.4	23.6	2.8	B.	8.4	8.	7.9	.1	.728	.352	.288	.064	.8	.64	.16	.015	.8	....	3.3	......	+	156,000
6781	" 29	" 30	*	Cons'd.	M. F.5	......	257.2	242.	15.2	41.2	36.8	4.4	B.	4.3	12.9	12.2	.7	.24	.416	.384	.032	.96	.864	.096	.007	1.6	....	0.	— 8.	+	18,200
6840	Feb. 5	Feb. 6	†	Little	M. F.5	......	291.2	285.6	5.6	36.8	35.2	1.6	B.	5.5	4.8	4.7	.1	.14	.32	.304	.016	.864	.8	.064	.01	1.12	....	0.	— 9.5	+	3,000
7021	Mar. 5	Mar. 6	†	"	M. F.3	......	376.8	366.4	10.4	14.4	13.6	.8	B.	7.	8.6	8.6	....	.456	.352	.256	.096	.864	.64	.224	.013	1.32	....	0.	—12.	—	5,000
7068	" 11	" 13	*	Cons'd	M. F.4	......	168.	124.8	43.2	23.6	18.8	4.8	B.	3.4	12.2	7.6	4.6	.256	.352	.288	.064	.992	.64	.352	.012	.56	....	0.	— 3.5	+	460,000
7118	" 19	" 20	*	"	M. F.6	......	170.4	142.4	28.	17.2	13.2	4.	B.	1.2	13.8	10.2	3.6	.26	.448	.272	.176	1.	.6	.4	.014	.72	....	10.	......	+	120,000
7164	" 26	" 27	*	"	M. F.5	......	228.8	138.4	90.4	23.6	17.2	6.4	B.	2.8	13.4	9.4	4.	.18	.416	.304	.112	1.176	.888	.288	.011	.48	....	0.	......	+	96,000
7216	April 2	April 3	*	"	M. F.2	......	197.6	172.	25.6	20.4	14.4	6.	B.	3.5	12.4	9.2	3.2	.148	.336	.304	.032	.728	.696	.032	.022	.68	....	0.	3.5	+	68,000
7271	" 9	" 10	*	"	M. F.30	......	277.2	238.4	38.8	34.4	22.8	11.6	B.	4.4	13.4	9.4	4.	.08	.368	.32	.048	.856	.696	.16	.016	.64	....	10.	1.5	+	15,000
7329	" 16	" 17	*	"	M. F.15	......	333.6	296.4	37.2	32.4	26.	6.4	B.	7.	9.5	9.5	0.0	.048	.4	.32	.08	.984	.568	.416	.015	.48	....	8.8	22.	+	6,000
7397	" 23	" 24	†	Little	M. F.04	.....	368.4	354.4	14.	23.6	19.2	4.4	B.	.....	11.3	10.1	1.2	.48	.512	.32	.192	.984	.76	.224	.014	.56	....	8.8	21.	+	2,500
7437	" 30	May 1	†	Cons'd	M. F.30	......	411.6	396.4	15.2	37.6	31.2	6.4	B.	5.9	13.8	6.5	7.3	.012	.512	.444	.068	.92	.772	.148	.008	.16	....	14.4	25.	+	4,000
7479	May 8	" 9	*	"	M. F.10	......	459.6	387.2	72.4	43.6	34.8	8.8	B.	6.2	11.9	9.2	2.7	.068	.576	.432	.144	1.06	.8	.26	.008	.32	....	....	......	....	....
7534	" 15	" 16	‖	Little	M. F.30	......	380.8	349.6	31.2	30.	28.4	1.6	B.	7.	13.5	10.4	3.1	.082	.48	.32	.16	1.16	.548	.612	.04	.8	....	15.5	28.	+	10,600
7586	" 22	" 23	*	Cons'd	M. F.1	......	391.2	244.	147.2	43.2	43.2	0.0	B.	9.2	11.5	9.4	2.1	.114	.512	.448	.064	.74	.676	.064	.004	.16	....	23.2	26.5	—	4,550
7632	" 29	" 30	*	"	M. F.10	......	413.2	387.2	26.	48.4	45.6	2.8	B.	9.4	12.4	9.4	3.	.08	.416	.32	.096	.8	.68	.12	.01	.48	....	16.6	20.5	+	3,400
7665	June 4	June 5	†	"	M. F.10	......	374.	344.4	29.6	43.2	36.	7.2	B.	9.9	9.8	8.8	1.	.306	.432	.4	.032	.964	.708	.256	.008	.2	20.5	....	25.5	+	136,700
7704	" 12	" 13	†	Little	M. F.03	......	357.6	340.4	17.2	32.8	27.6	5.2	B.	9.5	9.5	8.4	1.1	.048	.432	.288	.144	.8	.52	.28	.008	.44	24.	....	22.	—	17,550
7740	" 18	" 19	†	"	M. F.2	......	367.6	356.4	11.2	50.	42.4	7.6	B.	10.2	11.6	9.2	2.4	.06	.736	.32	.416	.692	.42	.272	.003	.16	20.5	....	25.5	—	1,500
7780	" 26	" 27	‡	"	M. F.15	M'sty	304.8	298.	6.8	44.4	17.6	26.8	B.	9.	9.7	9.4	.3	.062	.368	.304	.064	.644	.516	.128	.004	.08	20.5	....	31.	—	3,90
7821	July 3	July 4	*	"	T. F.10	......	388.8	379.6	9.2	62.4	60.8	1.6	B.	9.7	11.2	11.	.2	.13	.48	.368	.112	.996	.644	.352	.005	.08	17.3	....	......	....	5,10
7864	" 9	" 11	*	"	T. F.30	......	361.6	351.6	10.	58.4	56.	2.4	B.	9.	9.8	9.3	.5	.06	.368	.304	.064	.804	.74	.064	....	.16	....	....	......	....	3,10

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White

TABLE 43.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—DRAINAGE CHANNEL, BEAR TRAP DAM, LOCKPORT.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Turb'y.	Appearance.		Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.		Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on ig'n. Tot'l	Loss on ig'n. Dis-solv'd	Loss on ig'n. Sus-pnd'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dis-solv'd	Albuminoid Am. Sus-pnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
7895	July 9	July 10	*	Little	T. F.20	Gas'y	272.4	255.2	17.2	44.4	32.8	11.6	B.	24.	9.5	7.5	2.	2.08	.68	.176	.504	1.092	.42	.672	.004	.04	....	....	......	....	....
7923	" 11	" 14	‡	V. "	C. F.01	"	192.8	178.	14.8	15.6	14.4	1.2	B.	12.	5.	4.3	.7	1.36	.256	.176	.08	.76	.42	.34	.004	.12	....	....	......	....	....
7939	" 16	" 17	†	"	T. F.02	"	210.4	190.	20.4	22.4	11.6	10.8	B.	16.	7.4	4.3	3.1	1.52	.368	.272	.096	.6	.452	.148	.001	.2	....	....	......	....	....
7961	" 18	" 19	‖	V. "	F.02	"	176.8	162.	14.8	17.2	14.	3.2	B.	12.	5.2	4.2	1.	1.00	.324	.16	.164	.....	.....	.....	.005	.16	....	....	......	....	335,000
7990	" 20	" 21	*	"	T. F.02	"	176.8	160.4	16.4	17.6	11.6	6.	B.	14.	5.4	4.	1.4	1.04	.208	.176	.032	.68	.54	.14	....	.04	....	....	......	....	680,000
8007	" 23	" 24	†	"	T. F.01	"	190.	164.4	25.6	26.8	18.8	8.	G.	12.	5.7	5.3	.4	1.32	.272	.144	.128	.68	.42	.26	.001	.12	....	....	......	....	695,000
8023	" 25	" 26	†	"	T. F.04	"	164.4	156.	8.4	19.6	19.6	0.	B.	10.	5.5	4.8	.7	1.36	.272	.112	.16	.68	.392	.288	.007	.2	....	....	......	....	....
8045	" 27	" 28	*	Much	T. F.01	"	257.2	208.	49.2	40.4	30.4	10.	B.	19.	7.5	6.1	1.4	2.44	.368	.208	.16	.8	.6	.2	.001	.16	....	....	......	....	....
8058	" 30	" 31	*	Little	T. F.01	"	197.2	176.8	20.4	19.6	18.8	.8	B.	15.	5.6	5.4	.2	1.2	.48	.176	.304	1.16	.52	.64	....	.08	....	....	......	....	520,000
8082	Aug. 1	Aug. 2	*	"	T. F.01	"	197.2	157.6	39.6	35.2	19.2	16.	G.	13.	5.8	5.5	.3	1.6	.288	.192	.096	.76	.44	.32	....	.28	....	....	......	....	1,890,000
8114	" 6	" 8	*	"	T. F.01	"	198.	180.8	17.2	36.8	30.	6.8	W.	16.	7.5	4.9	2.6	1.88	.352	.256	.096	.84	.712	.128	.001	.52	....	....	......	....	550,000
8130	" 8	" 9	*	"	T. F.01	"	192.8	174.	18.8	37.6	28.4	9.2	B.	14.	6.1	5.3	.8	1.44	.448	.192	.256	1.12	.68	.44	.001	.16	....	....	......	....	2,030,000
8155		" 13	*	"	T. F.01	"	171.2	166.8	4.4	32.4	29.2	3.2	G.	16.	6.	4.2	1.8	1.92	.304	.176	.128	.76	.284	.476	....	.2	....	....	......	....	210,000
8174	" 13	" 15	*	"	T. F.01	"	154.4	154.	.4	29.2	22.4	6.8	G.	14.	4.6	3.8	.8	1.36	.272	.176	.096	1.	.504	.496	.001	.28	....	....	......	....	80,000
8192	" 15	" 16	*	"	T. F.01	Foul	178.4	165.2	13.2	30.8	26.4	4.4	B.	13.	11.	4.4	6.6	2.88	.992	.144	.848	2.52	.36	2.16	....	.2	....	....	......	....	340,000
8216	" 17	" 18	*	"	T. F.01	Gas'y	218.	188.8	29.2	41.2	31.6	9.6	B.	20.	8.	5.	3.	2.16	.368	.16	.208	.76	.348	.412	.001	.36	....	....	......	....	....
8232	" 20	" 21	*	"	T. F.02	"	218.8	209.2	9.6	32.8	22.	10.8	B.	25.	14.9	5.1	9.8	2.	.688	.176	.512	1.4	.284	1.116	....	.2	....	22.	......	....	250,000
8264	" 22	" 23	*	"	T. F.02	"	200.8	174.8	26.	12.8	10.4	2.4	G.	16.	7.1	3.4	3.7	1.84	.384	.112	.272	.94	.22	.72	....	.16	....	23.	......	....	415,000
8281	" 24	" 25	*	"	T. F.02	"	230.	205.2	24.8	30.8	17.6	13.2	G.	22.	7.7	4.	3.7	2.4	.368	.112	.256	1.	.3	.7	.004	.16	....	23.	......	....	985,000
8308	" 27	" 28	*	"	M. F.02	"	221.6	217.6	4.	20.4	18.8	1.6	B.	23.	11.2	4.5	6.7	2.08	.432	.08	.352	1.16	.268	.892	.001	.16	....	24.	......	....	4,900,000
8335	" 30	" 31	*	"	T. F.02	"	202.4	180.4	22.	19.2	16.4	2.8	G.	15.	5.7	4.	1.7	2.08	.32	.16	.16	.76	.3	.46	.002	.24	....	22.	......	....	70,000
8349	" 31	Sept. 3	‖	"	M. F.02	"	212.4	159.2	53.2	14.8	12.	2.8	B.	15.	7.	3.9	3.1	1.336	.4	.208	.192	.6	.38	.22	.01	.16	....	23.	......	....	200,000
8367	Sept. 4	" 5	‖	"	F.4	"	173.2	166.8	6.4	12.	10.4	1.6	G.	12.	6.	3.	3.	.112	.208	.128	.08	.62	.22	.4	.007	.16	....	23.	......	....	545,000
8388	" 5	" 6	‖	"	F.01	"	179.2	173.6	5.6	17.6	13.2	4.4	B.	14.	6.9	3.	3.9	1.28	.384	.16	.224	.62	.328	.292	.002	.24	....	24.	......	....	120,000
8416	" 7	" 8	†	Cons'd	F.1	M'sty	206.4	192.8	13.6	38.4	13.2	25.2	B.	17.	17.4	5.6	11.8	1.2	.64	.208	.432	1.4	......	......	.004	.2	....	....	......	....	....
8435		" 11	†	Little	F.04	"	198.	180.4	17.6	19.2	17.2	2.	DG.	19.	9.5	4.1	5.4	2.08	.544	.176	.368	1.212	.384	.828	.003	.16	....	20.5	......	....	3,545,000
8455	" 12	" 13	†	Cons'd	.1	"	200.	197.2	2.8	18.	16.8	1.2	B.	19.	10.2	4.6	5.6	2.52	.652	.124	.528	3.1	......	......	.001	.16	....	24.	......	....	400,000
8472	" 14	" 15	†	Little	.2	"	216.4	215.2	1.2	22.4	22.	.4	B.	24.	10.6	8.4	2.2	2.8	.688	.208	.48	.62	.336	.284	....	.28	....	25.	......	....	395,000
8490	" 17	" 19	†	"	.02	"	176.8	146.	30.8	14.8	13.2	1.6	G.	13.	6.1	4.4	1.7	1.36	.32	.096	.224	.652	.32	.332	.012	.4	....	10.	......	....	355,000
8508		" 20	..	....	....	......	......	......	......	....	......	......	......	.....	....	....	....	.....	.....	.....	......	.....	.....	.....	.....	....	....	....	......	....	....
8522	" 21	" 22	‖	VLittle	F.02	M'sty	199.2	194.4	4.8	19.6	18.4	1.2	DB.	17.	7.6	5.9	1.7	.192	.352	.124	.228	.6	.4	.2	.001	.8	....	15.	......	....	130,000
8547	" 24	" 27	‖	"	.02	"	168.4	166.8	1.6	24.	18.	6.	G.	10.	3.2	3.	.2	1.52	.144	.096	.048	.636	.384	.252	.007	.24	....	17.	......	....	70,000
8565	" 26	" 28	†	"	F.03	"	200.8	177.2	23.6	24.8	20.	4.8	B.	15.	6.3	3.9	2.4	1.76	.224	.096	.128	.572	.336	.236	.001	.28	....	22.	......	....	3,480,000
8574	" 28	Oct. 1	†	"	.05	"	184.8	170.	14.8	16.4	13.6	2.8	Bh.	12.	6.	3.8	2.2	.02	.48	.128	.352	.54	.352	.188	.002	.28	....	16.	......	....	380,000
8593		" 2	‖	"	F.05	....	186.8	173.6	13.2	16.4	15.2	1.2	B.	14.	6.5	5.6	.9	1.12	.544	.224	.32	.928	.496	.432	.001	.04	....	....	......	....	2,070,000
8615	Oct. 3	" 4	‖	"	F.03	M'sty	168.8	164.8	4.	31.2	26.	5.2	G.	11.	5.3	4.5	.8	1.12	.304	.272	.032	.592	.496	.096	.001	.16	....	....	......	....	680,000
8627	" 5	" 6	‖	"	F.01	......	178.8	163.6	15.2	22.4	18.4	4.	Bh.	11.	5.5	4.	1.5	1.31	.24	.....	.....	.592	.272	.32	.001	.24	....	....	......	....	120,000

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 44.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—DESPLAINES RIVER, NORTH OF JACKSON ST., JOLIET.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of 1900 Collection.	Date of 1900 Examination.	Turb'y.	Appearance. Sediment.	Appearance. Color.	Odor.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Loss on Ig'n. Tot'l.	Loss on Ig'n. Diss'd.	Loss on Ig'n. Susp'd.	Color on Ignition.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Susp'd Matter.	Nitrogen as Ammonia. Free Ammonia.	Albuminoid Am. Tot'l.	Albuminoid Am. Diss'd.	Albuminoid Am. Susp'd.	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
6603	Jan. 2	Jan. 3	*	Cons'd	M. F.4	Gas'y	530.4	488.	42.4	81.6	58.4	23.2	B.	112.	34.6	21.9	12.7	15.2	3.84	2.88	.96	7.4	3.92	3.48	.005	.2	....	?	9.5	+	1,680,000
6639	" 8	" 9	*	"	M. F.5	"	476.8	453.2	23.6	44.4	36.	8.4	B.	113.5	27.8	20.8	7.	10.8	2.48	2.	.48	6.12	4.52	1.6	.002	.2	....	10.	12.	+	970,000
6690	" 15	" 16	*	"	M. F.5	"	478.	430.8	47.2	48.	47.6	.4	B.	93.	18.1	15.6	2.5	10.8	2.32	1.68	.64	5.12	3.36	1.76	.02	.08	....	0.	0.	+	1,245,000
6731	" 22	" 23	*	"	M. F.4	"	378.4	308.	70.4	50.4	31.2	19.2	B.	35.	21.6	11.5	10.1	4.4	1.28	.64	.64	3.2	1.024	2.176	.013	.16	....	4.5	6.	+	805,000
6777	" 29	" 30	*	Much	M. F.04	"	297.6	194.4	103.2	23.2	14.8	8.4	B.	14.	11.8	5.6	6.2	.96	.8	.256	.544	2.08	.56	1.52	.002	.28	....	0.	—16.5	+	165,000
6833	Feb. 5	Feb. 6	†	Little	M. F.03	"	220.4	208.8	11.6	20.4	17.2	3.2	B.	22.	17.3	6.3	11.4	1.76	.48	.204	.276	.96	.64	.32	.01	.32	....	....	—11.	....	....
6886	" 12	" 13	*	Much	M. F.15	"	336.	206.	130.	33.6	18.	15.6	B.	21.	17.4	8.3	9.1	2.08	1.04	.352	.688	2.4	.864	1.536	.06	.56	....	10.	3.5	+	1,580,000
6932	" 19	" 20	*	Cons'd	M. F.04	"	232.4	184.4	48.	22.4	21.6	.8	B.	15.	9.	6.8	2.2	.96	.704	.352	.352	1.52	.64	.88	.025	.48	....	13.	13.5	....	1,550,000
6984	" 26	" 27	*	"	M. F.06	"	223.6	196.8	26.8	37.6	17.6	20.	G.	17.	7.2	4.9	2.3	1.28	.672	.384	.288	1.68	1.216	.464	.018	.56	....	8.	—14.5	....	1,275,000
7015	Mar. 5	Mar. 6	†	"	M. F.3	"	270.	248.4	21.6	19.2	13.2	6.0	B.	23.	12.4	8.6	3.8	2.4	1.12	.608	.512	2.24	.96	1.28	.07	.36	....	18.	— 2.	+	1,720,000
7062	" 12	" 13	*	"	M. F.04	"	249.2	202.8	46.4	22.8	15.2	7.6	B.	23.	11.6	7.4	4.2	1.92	.832	.272	.56	1.92	.864	1.056	.055	.56	....	13.	— 4.	+	825,000
7111	" 19	" 20	*	"	M. F.5	......	259.6	239.2	20.4	29.2	15.2	14.	G.	24.	16.6	10.8	5.8	2 16	1.184	.48	.704	2.92	.92	2.	.02	.48	....	3.5	4.5	....	4,535,000
7161	" 26	" 27	*	"	M. F.50	Gas'y	262.	152.8	109.2	31.4	16.8	14.6	B.	11.5	14.9	11.6	3.3	1.04	.608	.288	.32	1.56	.984	.576	.027	.48	....	4.	— 3.5	....	980,000
7215	Apr. 2	Apr. 3	†	Little	M. F.03	......	210.	174.8	35.2	17.6	16.	1.6	B.	12.	12.8	7.2	5.6	1.12	.56	.272	.288	1.368	.76	.608	.018	.6	....	2.	2.	+	1,340,000
7267	" 9	" 10	*	Cons'd	M. F.03	......	235.6	197.2	38.4	19.2	16.	3.2	B.	12.	8.3	6.8	1.5	.96	.48	.24	.24	1.016	.536	.48	.03	.52	....	6.	4.5	+	3,060,000
7330	" 16	" 17	*	"	M. F.06	......	271.2	245.2	26.	14.8	13.2	1.6	B.	34.3	9.3	7.1	2.2	2.96	.736	.304	.432	1.8	.984	.816	.038	.36	....	—	11.	+	3,150,000
7390	" 23	" 24	†	"	M. F.03	......	302.4	276.	26.4	27.6	26.4	1.2	B.	34.7	9.	6.3	2.7	3.36	.506	.26	.246	1.	.728	.272	.018	.36	....	1.1	11.	+	470,000
7434	" 30	May 1	†	Little	M. F.02	......	230.8	218.8	12.	30.2	18.4	20.8	G.	30.	6.7	5.	1.7	2.96	.336	.216	.12	.74	.52	.22	.013	.2	....	8.	12.	+	80,000
7474	May 7	" 8	*	Cons'd	M. F.02	Foul	250.8	238.8	12.	28.	25.6	2.4	G.	40.	12.2	7.9	4.3	4.16	.608	.288	.32	1.444	.532	.912	.006	.16	....	14.	16.	+	2,125,000
7524	" 14	" 15	†	Little	.01	......	266.4	258.	8.4	29.6	26.8	2.8	G.	30.	9.3	6.5	2.8	3.	.352	.224	.128	.74	.388	.352	.03	.36	....	18.	20.	+	90,000
7570	" 21	" 22	†	"	M. F.01	......	243.6	220.4	23.2	30.4	23.6	6.8	B.	30.	8.	6.8	1.2	3.84	.416	.384	.032	.644	.452	.192	.023	.32	....	22.	21.	+	70,000
7612	" 28	" 29	†	Cons'd	M. F.03	Gas'y	287.6	260.	27.6	22.4	21.6	.8	G.	47.5	9.8	8.	1.8	5.6	.608	.432	.176	1.94	1.22	.72	.035	.36	....	20.	21.	+	60,000
7652	June 4	June 5	†	"	M. F.04	M'sty	276.8	250.	26.8	40.	36.	4.	B.	39.	8.5	6.6	1.9	4.32	.48	.256	.224	.9	.612	.288	.035	.24	....	22.	20.	+	60,000
7696	" 11	" 12	†	Little	M. F.02	......	224.	210.	14.	32.4	29.2	3.2	B.	19.5	7.4	7.1	.3	2.24	.368	.224	.144	.706	.452	.256	.035	.28	....	22.	16.	+	400,000
7734	" 18	" 19	†	"	M. F.2	M'sty	214.	201.2	12.8	22.	20.	2.	B.	16.	8.6	8.6	0.0	1.52	.384	.256	.128	.98	.5	.48	.03	.08	....	20.	21.	+	175,000
7772	" 25	" 26	†	Slight	T. F.02	"	214.	195.2	18.8	25.2	24.8	.4	B.	17.	5.7	4.6	1.1	1.52	.256	.128	.128	.324	.132	.192	.023	.12	....	24.	22.	?	85,000
7816	July 2	July 3	*	Little	T. F.03	"	217.6	204.	13.6	32.	24.4	7.6	B.	23.	7.1	5.8	1.3	1.92	.324	.208	.116	.812	.308	.504	.018	.12	....	30.	......	....	150,000
7925	" 14	" 16	†	"	T. F.01	"	236.4	208.	28.4	24.	10.4	13.6	B.	24.	7.	5.4	1.6	2.32	.288	.128	.16	.76	.58	.18	.15	.28	....	....	......	....	....
7940	" 16	" 17	†	"	T. F.02	......	239.2	200.	39.2	25.2	24.8	.4	B.	19.7	8.	5.5	2.5	2.08	.368	.096	.272	.76	.430	.324	.036	.16	....	—	......	?	240,000
8006	" 23	" 24	†	"	T. F.01	Gas'y	189.2	177.6	11.6	29.2	12.	17.2	G.	52.5	5.9	5.5	.4	2.	.24	.208	.032	.64	.48	.16	.026	.2	....	?	......	+	120,000
8060	" 30	" 31	†	"	T. F.01	"	214.8	179.6	35.2	36.4	27.6	8.8	G.	15.	5.1	4.5	.6	1.12	.192	.144	.048	.52	.44	.08	.03	.2	....	....	......	+	145,000
8105	Aug. 6	Aug. 7	†	"	T. F.01	"	219.2	197.6	21.6	34.8	34.8	0.0	G.	16.	6.8	6.1	.7	1.52	.24	.144	.096	.76	.296	.464	.026	.44	....	15.5	......	?	25,000
8164	" 13	" 14	*	"	T. F.01	"	200.4	173.6	26.8	28.	24.8	3.2	G.	19.	7.9	3.4	4.5	1.92	.272	.176	.096	.68	.268	.412	.032	.36	....	15.5	......	?	330,000
8219	" 20	" 21	*	"	T. F.01	"	249.6	204.8	44.8	40.4	26.	14.4	B.	25.	11.1	5.7	5.4	2.64	.512	.192	.32	.92	.092	.828	.048	.36	....	....	......	....	....
8306	" 27	" 28	*	"	T. F.	"	262.4	245.2	17.2	25.2	13.6	11.6	B.	29.	8.8	4.	4.8	3.28	.416	.144	.272	.84	.444	.396	.008	.08	....	10.	......	?	49,000
357	Sept. 3	Sept. 4	*	"	M. F.03	M'sty	215.2	208.8	6.4	17.2	14.8	2.4	B.	13.	8.6	4.4	4.2	1.344	.352	.192	.16	.54	.268	.272	.04	.2	....	15.5	......	....	8,000
426	" 10	" 11	‖	"	F.02	Gas'y	240.	230.8	9.2	25.2	16.	9.2	B.	26.	9.4	4.6	4.8	2.8	.48	.192	.288	.86	.512	.348	.046	.44	....	....	......	....	....
79	" 17	" 18	*	Cons'd	M. 1.01	"	261.6	252.4	9.2	32.8	18.8	14.	B.	37.	8.9	4.4	4.5	2.	.464	.096	.368	.856	.4	.456	.02	.32	....	1.0	......	?	182,00
31	" 24	" 25	†	Little	M. F.03	M'sty	266.	218.	48.	22.8	20.8	2.	B.	25.	7.6	4.1	3.5	1.64	.448	.16	.288	.802	.464	.438	.040	.4	....	30.	......	....	490,00
0	Oct. 1	Oct. 2	..	"	F.04	......	220.8	186.4	34.4	20.	16.	4.	B.	15.	8.9	5.2	3.7	2.	.496	.272	.224	1.168	.416	.752	.03	.24	....	30.	......	....	610,00

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

on IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., Wh

ABLE 45.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—KANKAKEE RIVER, WILMINGTON.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Susp'd							Tot'l	Dissolv'd	Susp'd										
6601	Jan. 1	Jan. 2	†	Little	F.08	......	371.6	361.6	10.	39.6	36.4	3.2	B.	4.	14.5	14.5	0.0	.08	.384	.368	.016	1.164	.936	.228	.015	4.8	2.6	0.	8.	+	5,500
6640	" 8	" 9	†	"	F.1	......	370.4	364.8	5.6	51.6	46.8	4.8	B.	4.7	11.6	11.	.6	.018	.432	.4	.032	1.16	.936	.224	.017	4.4	2.	0.	0.	+	3,900
6686	" 15	" 16	‡	"	F.02	......	314.	313.2	.8	40.4	40.	.4	B.	3.9	8.1	7.9	.2	.04	.224	.208	.016	.704	.64	.064	.013	3.	1.8	0.	5.	+	7,000
6723	" 22	" 23	†	"	F.15	......	302.4	302.4	0.0	19.6	19.6	0.0	B.	3.	7.6	7.6	0.0	.048	.24	.224	.016	.608	.544	.064	.01	3.4	1.8	1.	3.	+	10,000
6782	" 29	" 30	†	"	F.06	......	288.	282.4	5.6	39.6	37.2	2.4	G.	3.2	8.4	8.4	0.0	.096	.352	.256	.096	.64	.48	.16	.005	2.6	1.3	0.	—8.	—	3,900
6852	Feb. 5	Feb. 6	†	"	F.10	......	327.6	327.2	.4	40.8	20.4	20.4	B.	3.7	12.3	10.8	1.5	.024	.32	.288	.032	.804	.708	.096	.005	2.3	......	......	0.	......	......
6887	" 12	" 13	*	Much	M. F.15	......	877.6	173.2	704.4	64.8	22.4	42.4	B.	2.6	23.9	8.3	15.6	.16	1.184	.352	.832	2.56	.8	1.76	.02	4.	1.8	—0.	9.	—	108,000
6926	" 19	" 20	†	Little	M. F.15	......	306.	290.	16.	40.	40.	0.0	B.	3.6	9.	8.5	.5	.10	.416	.336	.08	.768	.608	.16	.017	4.2	1.	1.	3.	—	9,500
7053	Mar. 9	Mar. 10	*	Cons'd	M. F.04	......	246.4	167.2	79.2	22.8	22.	.8	B.	2.6	13.2	6.4	6.8	.16	.32	.192	.128	1.04	.544	.496	.017	1.70	.1	0.	6.	......	68,000
7092	" 15	" 16	*	"	M. F.40	......	612.4	112.	500.4	30.4	16.	14.4	B.	1.25	21.2	8.3	12.9	.112	.96	.256	.704	.24	.48	1.92	.01	1.08	.1	0.	—6.	+	188,000
7119	" 19	" 20	*	"	M. F.30	......	243.2	161.2	82.	26.	13.6	12.4	B.	2.8	12.3	8.6	3.7	.112	.384	.24	.144	.92	.568	.352	.009	1.8	1.8	3.	3.	+	38,000
7166	" 26	" 27	*	"	M. F.25	......	199.6	166.8	32.8	22.8	16.	6.8	B.	2.4	11.	8.8	2.2	.08	.64	.256	.384	1.08	.824	.256	.007	1.70	1.8	3.	3.	+	32,000
7210	Apl. 2	Apl. 3	*	"	M. F.20	......	369.6	150.4	219.2	31.6	16.	15.6	B.	2.7	17.3	9.6	7.7	.072	.512	.24	.272	1.24	.632	.608	.011	2.88	1.8	5.	6.	+	147,000
7265	" 9	" 10	*	Little	M. F.03	......	348.8	301.2	47.6	28.8	28.8	0.0	B.	1.1	6.1	5.1	1.	.02	.224	.144	.08	.536	.408	.128	.014	5.6	1.8	9.	4.	+	42,000
7322	" 16	" 17	†	"	M. F.04	......	318.	304.8	13.2	42.8	40.4	2.4	B.	3.9	4.3	4.3	0.0	.008	.176	.128	.048	.408	.344	.064	.014	3.2	2.	......	......	+	13,000
7382	" 23	" 24	†	"	M. F.03	......	307.6	298.4	9.2	47.2	38.	9.2	B.	4.2	7.4	4.4	3.	.006	.112	.104	.008	.6	.472	.128	.016	4.6	1.8	......	......	+	6,000
7435	" 30	May 1	†	"	F.02	......	336.4	327.6	8.8	67.6	64.4	3.2	G.	4.3	4.3	4.3	0.0	.016	.16	.128	.032	.548	.48	.068	.08	2.96	1.8	12.	10.	+	2,300
7472	May 7	" 8	†	Cons'd	M. F.30	......	318.8	296.4	22.4	28.	26.	2.	G.	3.7	18.2	13.5	4.7	.044	.512	.464	.048	1.06	.9	.16	.01	1.12	2.	15.5	15.	+	3,550
7532	" 14	" 15	*	"	M. F.3	......	312.	280.4	31.6	42.8	35.2	7.6	G.	4.	15.3	10.9	4.4	.064	.544	.32	.224	1.06	1.028	.032	.015	1.24	1.8	20.5	23.	+	2,050
7570	" 21	" 22	*	Little	M. F.3	......	330.4	292.4	38.	48.8	44.8	4.	B.	3.4	17.1	12.7	4.4	.050	.512	.432	.08	.944	.56	.384	.013	1.32	1.6	15.	11.5	—	2,800
7613	" 28	" 29	†	"	M. F.20	......	320.	276.4	43.6	40.4	40.4	0.0	B.	3.5	13.8	9.6	4.2	.044	.368	.256	.112	.96	.8	.16	.08	3.	1.8	21.	18.	+	6,300
7650	June 4	June 5	†	Cons'd	M. F.03	......	360.4	324.8	35.6	58.	51.6	6.4	B.	4.5	7.5	5.5	2.	.024	.24	.208	.032	.52	.452	.068	.035	2.6	1.8	17.	15.5	+	4,300
7696	" 11	" 12	*	"	M. F.08	......	363.6	302.	61.6	45.6	44.8	.8	B.	3.5	9.5	6.9	2.6	.072	.272	.144	.128	.612	.452	.16	.08	4.6	1.8	19.	18.	?	7,000
7735	" 18	" 19	*	Little	M. F.05	......	316.	194.8	121.2	32.4	14.8	17.6	B.	3.5	9.4	6.1	3.3	.048	.304	.192	.112	.74	.356	.384	.008	1.	1.6	19.	14.5	+	1,850
7773	" 25	" 26	‡	"	M. F.03	......	329.6	294.8	34.8	34.4	30.4	4.	B.	3.4	8.7	7.5	1.2	.042	.24	.224	.016	1.06	.612	.448	.008	.92	1.8	23.	20.	+	1,550
7815	July 2	July 3	*	Much	T. F.20	M'sty	261.6	235.6	26.	41.6	38.4	3.2	B.	3.	9.	8.7	.3	.074	.24	.176	.064	.676	.58	.096	.013	.96	......	......	......	......	......
8108	Aug. 6	Aug. 7	*	Little	T. F.01	......	274.4	225.6	48.8	54.4	36.8	17.6	B.	2.2	10.8	8.5	2.3	.144	.304	.256	.048	.644	.324	.32	.008	.76	1.8	......	......	—	1,850
8102	" 13	" 14	*	"	T. F.01	......	271.2	231.2	40.	38.	38.8	0.0	B.	3.4	10.7	7.7	3.	.12	.336	.304	.032	.644	.412	.232	.013	.6	1.3	......	......	?	2,050
8220	" 20	" 21	*	"	T. F.02	......	296.8	229.2	67.6	30.	28.4	1.6	B.	4.5	9.	5.7	3.3	.16	.288	.208	.08	.632	.38	.252	.022	.96	2.	......	......	+	1,100
8290	" 30	" 31	*	"	M. F.15	......	288.	194.	94.	34.	32.	2.	B.	2.6	10.3	5.4	4.9	.124	.272	.256	.016	.568	.452	.116	.013	1.04	2.	21.	......	—	2,300
8391	Sept. 6	Sept. 7	*	Cons'd	M. F.2	......	313.6	266.	47.6	30.8	21.6	9.2	DB.	2.2	10.3	8.	2.3	.110	.208	.192	.016	.536	.496	.04	.01	.72	1.3	21.	......	+	4,500
8461	" 13	" 14	*	"	M. F.3	......	329.2	295.2	34.	32.8	31.6	1.2	DB.	3.	12.7	9.9	2.8	.084	.32	.288	.032	.556	......	......	.006	.56	1.6	......	......	—	1,700
8514	" 21	" 22	*	Little	M. F.35	......	295.6	259.2	36.4	25.6	22.8	2.8	DB.	3.2	11.8	9.9	1.9	.108	.32	.272	.048	1.304	......	......	.002	.16	1.3	......	......	+	5,700
8561	" 27	" 28	*	Cons'd	M. F.3	......	289.6	264.6	25.	31.2	24.4	6.8	DB.	3.8	8.4	7.9	.5	.004	.304	.24	.064	.524	.416	.108	.004	.32	1.3	......	......	+	7,900

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. | Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B. Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 46.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, MORRIS.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l.	Dissolv'd	Suspnd'd							Tot'l.	Dissolv'd	Suspnd'd										
6637	Jan. 5	Jan. 8	*	Cons'd	M. F.5	......	432.	424.	8.	38.	29.6	8.4	B.	63.	22.2	17.6	4.6	7.2	1.6	.896	.704	2.76	1.88	.88	.5	.68	5.	0.	.4	?	296,000
6665	" 10	" 12	*	"	M. F.5	......	432.	418.	14.	44.4	40.	4.4	B.	85.	18.5	12.3	6.2	8.	2.	.8	1.2	3.36	1.84	1.52	.035	.44	5.	0.	5.	+	4,200,000
6703	" 16	" 18	†	"	M. F.06	......	364.	355.2	8.8	52.	48.4	3.6	B.	50.	11.	9.7	1.3	5.36	.496	.448	.048	1.76	1.04	.72	.015	1.	5.	2.	2.	+	1,850,000
6773	" 26	" 29	*	"	M. F.04	Gas'y	408.	221.6	186.4	40.4	24.8	15.6	B.	23.5	22.9	7.8	15.1	2.4	1.44	.288	1.152	3.04	.672	2.368	.03	.44	-4.9	0.	— 6.	....	2,040,000
6786	" 29	" 29	*	"	M. F.03	......	306.	254.	52.	31.6	22.	9.6	G.	18.	12.1	7.4	4.7	1.76	.528	.256	.272	1.04	.48	.56	.025	.72	.....	...	— 6.	....	....
6846	Feb. 6	Feb. 7	†	Little	M. F.04	......	246.	220.	26.	16.8	16.4	.4	G.	26.5	7.7	6.2	1.5	2.24	.528	.304	.224	1.04	.64	.4	.02	.32	-3.1	0.	0.	....	130,000
6893	" 12	" 14	§	V.M'ch	M. F.5	......	598.	206.	392.	48.	22.8	25.2	B.	12.7	21.1	9.4	11.7	1.2	1.088	.304	.784	2.08	.576	1.504	.06	2.6	9.2	5.	4.	?	1,530,000
6943	" 19	" 21	*	Cons'd	M. F.04	......	277.2	239.6	37.6	54.	40.4	13.6	G.	24.	8.4	5.9	2.5	1.76	.768	.288	.48	1.68	.8	.88	.04	.92	7.9	0.	— 3.	—	2,905,000
6986	" 26	" 28	*	"	M. F.04	......	265.2	214.	51.2	22.	20.4	1.6	B.	21.	9.2	6.8	2.4	1.68	.88	.352	.528	1.84	1.12	.72	.03	1.08	9.	0.	......	+	2,280,000
7037	Mar. 7	Mar. 9	†	"	M. F.03	......	301.2	268.4	32.8	23.6	17.6	6.	G.	20.5	13.7	7.3	6.4	2.8	.8	.288	.512	1.84	.608	1.232	.045	.56	6.4	1.	5.	+	1,115,000
7094	" 14	" 16	..	....	....	......	.....	.....	.....	.....	.....	.....	......	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16.6	0.	— 3.	+	1,490,000
7123	" 19	" 21	*	Much	M. F.30	......	289.6	188.8	100.8	25.2	20.4	4.8	B.	13.2	16.1	9.3	6.8	1.28	.96	.336	.624	1.64	.824	.816	.05	1.2	.....	.....	0.	+	3,050,000
7187	" 28	" 30	*	Cons'd	M. F.30	......	221.6	192.4	29.2	16.8	14.8	2.	B.	12.	15.4	8.8	6.6	1.12	.448	.304	.144	1.144	.824	.32	.04	.88	12.5	1.	— 1.	+	790,000
7230	Apr. 3	Apr. 4	*	"	M. F.15	......	372.8	190.4	182.4	32.4	20.4	12.	B.	10.1	15.8	8.3	7.5	.72	.656	.352	.304	1.432	.728	.704	.031	2.2	11.6	6.	9.	+	660,000
7273	" 9	" 11	*	"	M. F.05	......	279.2	236.4	42.8	16.	15.2	.8	B.	19.8	13.5	7.4	6.1	1.76	.48	.32	.16	1.4	.856	.544	.06	.88	7.5	8.	5.	+	280,000
7335	" 16	" 18	*	"	M. F.04	......	333.6	252.	81.6	30.4	14.	16.4	B.	26.1	11.	7.1	3.9	2.16	.48	.24	.24	1.304	.664	.64	.03	.68	5.8	9.	15.	+	475,000
7393	" 23	" 24	†	Little	M. F.03	......	270.	234.	36.	28.	19.6	8.4	B.	16.7	8.7	7.	1.7	2.4	.496	.272	.224	1.048	.696	.352	.05	.8	6.	10.	15.	+	115,000
7441	" 30	May. 2	†	Cons'd	M. F.07	......	334.4	304.	30.4	38.	32.8	5.2	B.	18.2	9.3	7.7	1.6	4.32	.48	.32	.16	1.12	.84	.28	.04	.44	4.4	15.	21.	+	40,000
7476	May 8	" 9	†	"	M. F.04	......	215.6	200.4	15.2	20.4	20.	4.	B.	18.	7.7	7.2	.5	2.24	.384	.272	.112	.84	.52	.32	.04	.36	4.4	14.	23.	+	75,000
7559	" 15	" 17	†	"	M. F.03	......	245.2	229.2	16.	29.6	28.	1.6	B.	20.1	7.3	6.2	1.1	2.8	.32	.176	.144	.836	.516	.32	.125	.4	4.5	18.	28.	+	48,000
7588	" 21	" 23	‖	Little	M. F.1	......	272.	249.6	22.4	43.6	32.4	11.2	B.	25.	7.8	7.5	.3	2.	.448	.32	.128	.644	.48	.164	.125	.6	3.6	16.	17.	+	41,000
7620	" 28	" 29	‖	"	M. F.04	......	206.8	191.6	15.2	18.8	18.4	.4	B.	21.	6.2	6.	.2	1.92	.288	.224	.064	.68	.612	.068	.065	.72	4.3	16.	23.	+	27,000
7657	June 4	June 6	†	Cons'd	M. F.03	......	257.2	205.6	51.6	34.4	27.6	6.8	G.	17.	9.1	6.8	2.3	1.44	.4	.304	.096	.964	.68	.284	.125	1.4	5.3	17.	23.	?	241,000
7705	" 11	" 12	†	Little	M. F.03	......	264.	254.	10.	20.8	20.4	.4	B.	25.	7.2	6.4	.8	2.16	.32	.272	.048	.8	.48	.32	.2	.96	4.	19.	30.	—	294,000
7743	" 18	" 20	*	Cons'd	M. F.04	M'sty	229.6	227.6	2.	23.6	22.	1.6	B.	21.	6.8	5.8	1.	2.08	.272	.128	.144	.58	.388	.192	.08	.32	3.9	18.	25.	+	98,000
7790	" 26	" 28	‡	Little	T. F.01	"	258.	235.6	22.4	21.6	20.8	.8	B.	22.	6.9	6.2	.7	2.04	.24	.224	.016	.484	.42	.064	.16	.6	4.3	21.	30.	?	357,500
7850	July 5	July 7	‖	V.Sl'ht	T. F.02	"	248.4	226.8	21.6	38.	30.4	7.6	B.	19.5	8.1	4.6	3.5	1.2	.192	.176	.016	.612	.404	.208	.4	.68	3.6	26.	......	?	13,500
7887	" 9	" 11	*	Little	T. F.03	"	343.2	321.2	22.	28.4	28.	.4	B.	64.5	12.	6.7	5.3	3.68	.288	.208	.08	.516	.42	.096	.23	.52	3.6	19.	......	?	27,000
7944	" 17	" 18	†	"	T. F.	"	240.4	221.6	18.8	27.2	26.	1.2	B.	25.	6.8	6.7	.1	1.64	.288	.144	.144	.74	.484	.256	.275	.72	3.5	21.	......	?	40,000
8012	" 23	" 24	†	"	T. F.	"	244.4	216.8	27.6	24.4	23.6	.8	G.	25.	7.7	5.4	2.3	2.04	.272	.096	.176	.76	.42	.34	.18	.52	3.9	21.	......	?	89,000
8062	" 31	Aug. 1	*	Much	T. F.02	......	337.2	191.6	145.6	44.8	28.	16.8	B.	17.	12.5	5.2	7.3	1.216	.432	.192	.24	1.14	.58	.56	.18	.76	4.9	18.	......	?	56,000
8128	Aug. 7	" 9	*	Little	T. F.01	......	254.8	233.6	21.2	43.2	38.8	4.4	G.	26.	6.6	4.	2.6	2.56	.288	.192	.096	.648	.488	.16	.13	.44	3.9	20.	......	+	89,000
8191	" 14	" 16	*	"	T. F.01	.....	240.8	196.	44.8	20.4	19.6	.8	B.	23.5	7.4	3.6	3.8	1.84	.448	.128	.32	.932	.3	.632	.15	.56	4.	.....	......	+	75,000
8247	" 20	" 22	*	"	M. F.02	SlGas	260.8	226.	34.8	22.8	22.	.8	B.	18.	5.8	5.1	.7	1.12	.368	.24	.128	.796	.252	.544	.23	1.64	5.5	7.	......	—	20,000
8338	" 30	" 31	*	"	M. F.04	"	309.6	230.8	78.8	35.2	26.	9.2	B.	19.	12.5	4.4	8.1	1.536	.576	.224	.352	1.052	.332	.72	.08	.68	5.5	0.	......	?	143,00
8382	Sept 5	Sept. 6	†	Cons'd	M. F.02	M'sty	269.6	227.2	42.4	25.6	14.4	11.2	DB.	22.	8.4	4.	4.4	1.536	.432	.224	.208	.924	.4	.524	.225	.68	.....	.....	......	+	2,400,00
8434	" 10	" 11	†	Little	F.04	"	250.4	246.4	4.	22.	19.6	2.4	DB.	29.	7.6	4.8	2.8	2.4	.256	.24	.016	.588	.544	.044	.15	.46	3.3	0.	......	+	80,00
8505	" 19	" 20	..	....	F.15	......	266.	263.2	2.8	22.	21.6	.4	DB.	26.	8.9	6.7	2.2	2.72	.336	.272	.064	.54	.....	.....	.006	.48	1.1	8.	......	+	9,50
8541	" 25	" 26	*	Little	M. F.05	Gas'y	269.2	238.	31.2	27.6	26.	1.6	B.	29.	8.	4.	4.	1.48	.544	.112	.432	.924	.4	.524	.08	.36	3.8	2.	......	?	9,50
8626	Oct. 4	Oct. 6	*	Cons'd	M. F.09	......	272.4	194.8	77.6	26.	18.4	7.6	B.	23.	9.5	4.6	4.9	1.6	.4	.176	.224	.928	.464	.464	.12	.28	.....	0.	......	+	3,4

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

LOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., Wh

BLE 47.

Report of Arthur W. Palmer,
T. J. Burrill,
University of Illinoi

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

Source of Water—Fox River, Ottawa.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
										Loss on Ig'n.									Albuminoid Am.												
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Tot'l	Dissolv'd	Suspnd'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Suspnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
6629	Jan. 4	Jan. 5	†	Little	M. F.03	......	460.	450.	10.	81.2	76.4	4.8	B.	9.9	6.8	6.4	.4	.072	.224	.208	.016	.68	.52	.16	.006	.56	3.	2.	2.	+	3,350
6678	" 11	" 12	|	"	F.02	......	318.8	307.2	11.6	49.2	42.4	6.8	B.	6.5	4.5	4.3	.2	.064	.176	.16	.016	.56	.352	.208	.009	.32	3.6	2.	2.	+	8,750
6725	" 18	" 20	†	"	F.02	......	311.6	310.4	1.2	60.4	60.	.4	B.	7.3	4.5	4.5	0.0	.092	.176	.128	.048	.48	.32	.16	.013	.56	3.	3.	3.	+	14,800
6772	" 25	" 27	|	Cons'd	M. F.15	......	292.4	258.8	33.6	44.4	36.4	8.	B.	4.5	8.3	7.6	.7	.32	.352	.32	.032	.88	.672	.208	.022	1.52	4.	4.	4.	+	22,300
7076	Mar. 12	Mar. 14	*	Much	M. F.50	......	202.8	160.4	42.4	29.6	23.2	6.4	B.	3.8	11.6	8.2	3.4	.324	.352	.288	.064	1.04	.608	.432	.012	.72	4.	5.	4.	+	150,000
7128	" 20	" 22	*	Cons'd	M. F.30	....	218.	178.4	39.6	19.2	16.4	2.8	B.	3.6	9.4	8.7	.7	.332	.352	.256	.096	.84	.728	.112	.014	.84	4.	3.	2.	—	56,000
7175	" 27	" 29	*	Much	M. F.30	......	281.6	173.6	108.	30.8	26.	4.8	B.	3.1	15.1	9.4	5.7	.38	.576	.256	.32	1.24	.632	.608	.015	.68	4.	3.	7.	+	46,500
7232	Apr. 3	Apr. 5	*	"	M. F.30	......	626.8	131.2	495.6	34.	17.2	16.8	B.	2.8	23.5	9.4	14.1	.26	1.024	.288	.736	2.2	.792	1.408	.022	1.6	4.	3.	16.	—	245,000
7288	" 10	" 12	*	Cons'd	M. F.15	......	286.4	199.2	87.2	31.2	22.	9.2	B.	2.2	11.	9.	2.	.144	.512	.24	.272	1.08	.664	.416	.02	1.16	4.	3.	11.	—	12,500
7340	" 17	" 19	*	"	M. F.03	......	297.2	226.8	70.4	35.6	33.2	2.4	B.	3.8	9.6	9.	.6	.064	.432	.208	.224	1.08	.6	.48	.018	.76	5.	4.	4.	—	20,500
7408	" 24	" 26	†	Much	M. F.	......	302.8	256.8	46.	28.8	28.	.8	B.	4.	11.2	8.8	2.4	.072	.64	.288	.352	1.368	.792	.576	.011	.32	4.6	.....	27.	—	4,000
7449	May 1	May 3	*	Cons'd	M. F.06	......	302.8	250.	52.8	36.4	30.	6.4	B.	4.8	15.8	9.8	6.	.024	.64	.368	.272	1.188	.708	.48	.001	.2	4.	27.	27.	—	2,500
7489	" 8	" 10	*	"	M. F.04	......	402.8	251.2	151.6	32.	30.	2.	B.	4.6	15.5	10.3	5.2	.052	.592	.288	.304	1.16	.612	.548	.015	.36	3.6	19.	19.	+	18,300
7547	" 15	" 17		....	M. F.1	......	300.8	285.2	15.6	52.8	51.2	1.6	B.	6.6	8.9	8.5	.4	.088	.544	.288	.156	.9	.568	.332	.002	.04	3.6	22.	22.	+	1,450
7599	" 22	" 24	†	Cons'd	M. F.06	......	294.	266.	28.	53.2	52.	1.2	B.	5.3	9.4	8.4	1.	.134	.368	.224	.144	.804	.42	.384	.....	.12	3.6	19.	19.	—	800
7670	June 5	June 6	†	Little	M. F.03	......	299.2	292.8	6.4	47.6	46.8	.8	B.	5.4	7.9	7.7	.2	.088	.256	.224	.032	.68	.468	.212	.011	.32	3.	23.	24.	—	1,100
7702	" 11	" 13	†	"	M. F.03	......	326.8	312.	14.8	50.4	41.6	8.8	B.	5.3	9.3	8.3	1.	.04	.336	.288	.048	.708	.52	.188	.001	.24	3.	25.	26.	+	2,950
7745	" 18	" 20	†	"	M. F.02	......	322.4	312.8	9.6	47.6	47.2	.4	B.	6.5	6.8	6.8	0.0	.052	.224	.192	.032	.452	.....	.....	.008	.24	3.	24.	21.	+	1,650
7786	" 25	" 27	*	Much	T. F.01	......	301.2	293.2	8.	36.8	30.4	6.4	B.	5.0	6.5	6.5	0.0	.072	.368	.304	.064	.42	.296	.124	.001	.36	3.6	29.	32.	+	3,950
7820	July 2	July 4	*	Little	T. F.25	......	321.2	318.4	2.8	42.4	40.	2.4	B.	5.4	7.1	7.	.1	.04	.272	.24	.032	.452	.308	.144	.013	.16	.....	26.	......	....	7,900
7892	" 9	" 11	*	"	T. F.20	......	304.	300.	4.	52.4	48.8	3.6	B.	5.2	7.	6.8	.2	.096	.192	.16	.032	.516	.42	.096	.005	.16	3.6	30.5	......	—	2,400
7937	" 16	" 17	†	"	T. F.02	......	313.6	288.4	25.2	37.6	25.6	12.	B.	7.6	7.	6.3	.7	.073	.272	.208	.064	.564	.452	.112	.005	.12	.....	.....	......	....	......
7996	" 23	" 24	*	"	T. F.02	......	316.	282.4	33.6	54.4	42.	12.4	G.	6.4	7.9	6.5	1.4	.12	.304	.144	.16	.548	.....	.....	.002	.2	3.6	28.	......	+	2,500
8047	" 30	" 31	*	Much	M. F.02	......	302.	263.	39.	45.2	30.	15.2	B.	6.6	9.2	8.1	1.1	.072	.352	.24	.112	.564	.388	.176	.005	.08	3.	23.	......	—	2,300
8137	Aug. 6	Aug. 9	*	Little	T. F.02	......	358.	285.	73.	64.8	.....	.....	B.	6.2	12.1	7.6	4.5	.172	.512	.32	.192	.836	.564	.272	.005	.16	3.	23.	......	?	4,000
8171	" 13	" 15	*	"	T. F.02	......	294.8	255.6	39.2	60.4	53.2	7.2	B.	5.5	7.9	7.5	.4	.132	.368	.304	.064	.548	.46	.088	.002	.28	3.6	26.	......	—	2,700
8243	" 20	" 22	*	"	T. F.02	Sl.Gs.	301.2	232.4	68.8	43.6	34.4	9.2	B.	5.	8.9	6.1	2.8	.168	.352	.224	.128	.796	.212	.584	.030	.68	.....	.....	......	....	......
8296	" 27	" 28	*	"	M. F.02	......	440.4	266.8	173.6	41.6	24.8	16.8	G.	6.2	13.2	6.7	6.5	.136	.384	.144	.24	1.116	.38	.736	.001	.24	4.6	25.5	......	?	2,850
8366	Sept. 4	Sept. 5	†	Cons'd	M. F.05	......	297.6	270.	27.6	30.4	22.	8.4	B.	4.4	8.9	5.8	3.1	.110	.324	.272	.052	.488	.38	.108	.006	.28	4.	25.5	......	—	21,900
8433	" 10	" 11	†	Little	.2	......	304.4	281.2	23.2	46.	34.8	11.2	B.	4.8	8.8	7.2	1.6	.132	.432	.33	.102	.604	.576	.028	.003	.28	3.6	29.	......	—	4,250
8485	" 17	" 18	|	"	F.01	......	271.2	267.6	3.6	47.6	34.8	12.8	G.	5.	9.8	7.9	1.9	.064	.4	.224	.176	1.34	.672	.668	.002	.16	4.	20.5	......	—	2,450
8537	" 24	" 25	†	"	F.05	......	296.	280.4	15.6	46.8	41.6	5.2	B.	5.4	8.3	7.8	.5	.162	.352	.224	.128	.498	.....	.....	.008	.24	3.	22.	......	—	8,900
8596	Oct. 1	Oct. 2	|	"	F.2	......	304.	288.8	15.2	55.6	40.	15.6	B.	5.8	8.	7.6	.4	.084	.48	.288	.192	.48	.....	.....	.....	.16	3.6	21.	......	—	3,050
8635	" 6	" 8	‡	"	F.01	......	299.6	291.6	8.	46.	35.6	10.4	Bh.	5.6	8.8	7.7	1.1	.142	.432	.416	.016	.64	.512	.128	.002	.038	.....	.....	......	—	4,700

Turbidity—* Decided. § Very Decided. † Distinct. ‡ Very Slight. | Slight. Color—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

Color on Ignition—G., Gray. B., Brown. DB., Dark Brown LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 48.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, OTTAWA.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinoi

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coll.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Suspnd'd							Tot'l	Dissolv'd	Suspnd'd										
6628	Jan. 4	Jan. 5	†	Cons'd	M. F.07	......	414.4	410.	4.4	39.6	38.	1.6	B.	39.	14.8	13.6	1.2	4.8	.656	.464	.192	1.56	.936	.624	.2	2.2	3.6	2.	2.	+	10,000
6677	" 11	" 12	†	"	M. F.07	......	364.4	352.8	11.6	37.2	33.6	3.6	B.	40.	11.2	9.4	1.8	4.4	.736	.512	.224	1.44	.56	.88	.13	1.28	3.	2.	2.	+	300,000
6724	" 18	" 20	†	"	M. F.04	......	351.2	334.	17.2	24.6	24.	.6	B.	31.	9.3	8.5	.8	3.2	.512	.368	.144	.96	.8	.16	.035	1.48	3.6	3.	3.	+	93,000
6771	" 25	" 27	*	"	M. F.06	......	330.4	278.4	52.	38.4	37.6	.8	B.	25.	11.5	6.6	4.9	2.56	1.056	.32	.736	1.92	.672	1.248	.035	1.08	5.6	4.	4.	?	632,000
6844	Feb. 5	Feb. 7	†	Little	M. F.03	......	236.	235.2	.8	20.4	19.2	1.2	B.	21.	7.4	5.9	1.5	1.76	.416	.256	.16	.88	.544	.336	.02	.72	5.6	0.	3.	....	101,000
6949	" 20	" 23	*	Cons'd	M. F.20	......	312.	290.4	21.6	46.4	28.8	17.6	G.	17.	9.1	7.9	1.2	1.76	.496	.304	.192	.8	.576	.224	.06	2.6	5.6	3.	16.	—	355,000
7024	Mar. 5	Mar. 7	†	Little	M. F.30	......	336.4	334.	2.4	28.4	26.	2.4	B.	19.	11.5	10.6	.9	1.76	.384	.32	.064	.896	.704	.192	.014	2.	5.	3.	3.	—	160,500
7077	" 12	" 14	*	Much	M. F.04	......	262.4	166.	96.4	24.	16.8	7.2	B.	8.5	12.6	6.3	6.3	.864	.512	.256	.256	1.28	.48	.8	.022	1.48	5.	5.	4.	+	230,500
7127	" 20	" 26	†	Cons'd	M. F.03	......	194.8	184.	10.8	7.2	6.8	.4	B.	3.2	4.1	3.6	.5	.576	.176	.144	.032	.392	.344	.048	.032	1.04	3.	3.	—2.	—	6,000
7174	" 27	" 29	†	Little	F.04	......	315.6	309.2	6.4	34.8	30.8	4.	G.	8.	15.1	9.4	5.7	1.2	.352	.224	.128	.76	.6	.16	.07	3.2	5.	2.	7.	—	80,000
7231	Apr. 3	Apr. 5	†	"	M. F.03	......	380.4	368.	12.4	15.6	12.	3.6	B.	7.2	8.1	7.9	.2	1.12	.336	.256	.08	.728	.6	.128	.06	1.76	5.	3.	16.	—	245,000
7289	" 10	" 12	*	Cons'd	M. F.15	......	391.6	382.8	8.8	16.8	14.4	2.4	B.	8.9	10.3	9.3	1.	1.2	.512	.32	.192	1.112	.792	.32	.09	2.8	5.	3.	11.	—	7,000
7339	" 17	" 19	*	"	M. F.04	......	422.8	418.8	4.	36.8	33.2	3.6	B.	8.3	12.6	11.3	1.3	.608	.768	.44	.328	1.72	1.08	.64	.08	2.4	4.	4.	4.	—	5,000
7407	" 24	" 26	†	"	M. F.	......	379.2	366.8	12.4	29.2	29.2	0.0	B.	7.1	12.2	11.2	1.	.24	.96	.528	.432	1.88	1.016	.864	.07	1.04	3.6	....	27.	—	17,000
7448	May 1	May 3	*	"	M. F.10	......	336.4	251.2	85.2	26.8	16.4	10.4	B.	11.4	14.2	9.1	5.1	.56	.48	.288	.192	1.12	.8	.32	.14	1.48	3.6	27.	27.	—	12,000
7488	" 8	" 10	†	"	M. F.03	......	269.2	228.	41.2	33.6	25.2	8.4	B.	16.2	9.1	8.1	1.	1.12	.416	.288	.128	.96	.68	.28	.3	.92	3.	19.	19.	+	38,000
7546	" 15	" 17		....	M. F.05	......	302.	278.	24.	44.4	42.	2.4	B.	18.4	9.3	8.	1.3	.576	.416	.224	.192	1.06	.484	.576	.35	1.68	3.	22.	22.	+	6,500
7598	" 22	" 24	†	Cons'd	M. F.05	......	280.	258.8	21.2	42.	35.2	6.8	B.	14.2	8.5	7.3	1.2	.48	.24	.128	.112	.804	.612	.192	.02	1.4	3.	19.	19.	+	4,000
7671	June 5	June 6	*	"	M. F.03	......	259.6	217.2	42.4	42.	36.	6.	B.	18.	8.6	6.	2.6	.704	.288	.128	.16	.74	.468	.272	.55	1.76	3.	22.	24.	+	8,000
7701	" 11	" 13	†	Little	M. F.03	......	308.4	288.8	19.6	42.8	27.2	15.6	B.	27.	8.7	7.7	1.	1.04	.288	.16	.128	.74	.48	.26	.5	2.8	3.	25.	26.	+	31,900
7744	" 18	" 20	†	"	M. F.01	M'sty	257.2	240.	17.2	26.	26.	0.0	B.	23.	6.6	6.2	.4	1.36	.224	.192	.032	.532	.372	.16	.18	1.2	3.	25.	25.	—	8,800
7785	" 25	" 27	‡	Much	T. F.01	"	235.2	230.8	4.4	34.	31.6	2.4	G.	23.	5.7	5.4	.3	.656	.256	.192	.064	.528	.484	.044	.45	1.2	3.6	20.	22.	—	8,250
7819	July 2	July 4	*	Little	T. F.03	"	249.2	243.2	6.	27.6	22.8	4.8	B.	22.5	7.2	5.8	1.4	.210	.208	.16	.048	.456	.28	.176	.8	2.16	3.6	25.5	......	....	1,150
7891	" 9	" 11	*	"	T. F.10	......	256.8	243.2	13.6	35.2	25.6	9.6	B.	25.	5.7	4.7	1.	.496	.176	.144	.032	.484	.292	.192	.425	1.86	3.6	23.	......	—	2,800
7936	" 16	" 17	†	"	T. F.02	......	417.6	261.2	156.4	40.4	31.6	8.8	B.	27.	5.4	4.8	.6	.376	.176	.112	.064	.484	.244	.24	.4	1.64	....	....	......	....	......
7997	" 23	" 24	*	"	T. F.02	......	238.4	217.2	21.2	19.2	17.6	1.6	G.	23.	6.9	5.1	1.8	.336	.176	.096	.08	.596	.452	.144	.325	1.48	3.6	25.	......	?	4,900
8046	" 30	" 31	*	"	T. F.02	......	261.6	238.4	23.2	28.	28.	0.0	B.	20.	7.6	6.9	.7	.704	.272	.192	.08	.632	.42	.212	.4	1.68	4.	24.	......	—	7,450
8138	Aug. 6	Aug. 9	*	"	T. F.02	......	236.4	217.2	19.2	35.2	......	......	G.	22.	6.3	5.	1.3	.144	.288	.272	.016	.516	.468	.048	.6	1.73	3.6	30.	......	—	32,000
8170	" 13	" 15	*	"	T. F.01	......	218.4	192.4	16.	36.	19.2	16.8	G.	24.	4.8	3.9	.9	.704	.272	.176	.096	.52	.284	.236	.325	1.44	4.6	25.5	......	+	48,000
8242	" 20	" 21	*	"	T. F.02	Sl.Gs.	226.4	224.	2.4	34.8	14.8	20.	G.	22.	6.1	4.3	1.8	.576	.24	.144	.096	.54	.332	.208	.45	1.52	4.6	38.	......	—	1,900
8297	" 27	" 28	*	"	T. F.01	......	280.8	250.4	30.4	31.6	30.8	.8	B.	32.	6.9	4.7	2.2	1.80	.192	.192	.000	.732	.62	.112	.475	1.12	5.	24.	......	?	4,80
8366	Sept. 4	Sept. 5	†	Cons'd	M. F.03	M'sty	234.8	220.	14.8	20.	17.2	2.8	G.	20.	6.1	4.5	1.6	.288	.27	.208	.062	.344	.28	.064	.3	1.68	4.6	25.	......	—	6,30
8433	" 10	" 11	†	Little	F.1	......	300.	282.8	17.2	31.6	27.2	4.4	B.	28.	8.7	6.	2.7	.576	.32	.304	.016	.764	.496	.268	.5	1.8	4.	27.	......	—	6,6
484	" 17	" 18	‖	"	F.08	Gas'y	248.4	231.2	17.2	28.	19.2	8.8	G.	29.	7.7	4.1	3.6	2.24	.4	.192	.208	.764	.32	.444	.017	1.04	4.3	19.	......	—	117,0
[illegible]	" 24	" 25	†	"	F.08	......	231.	230.8	.2	38.8	26.	12.8	G.	54.	8.1	6.7	1.4	4.8	.48	.224	.256	.7	.64	.06	.3	1.28	3.6	21.	......	?	9,
[illegible]	Oct. 1	Oct. 2	‖	"	F.04	......	223.6	217.2	6.4	20.8	19.6	1.2	G.	27.	5.2	4.3	.9	1.52	.288	.128	.16	.528	.368	.16	.375	1.28	4.3	16.	......	?	9,
[illegible]	" 8	" 9	‖	"	F.08	......	211.6	198.	13.6	29.4	19.2	3.2	Bh.	29.	5.6	4.6	1.	1.216	.192	......	......	.512	.304	.208	.25	.37	....	....	......	+	2,

TURBIDITY—*Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.
ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., Wh

BLE 49.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—BIG VERMILLION RIVER, LA SALLE.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illino

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Igni-tion.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centi-meter.
	1900 Collec-tion.	1900 Exami-nation.	Turb'y.	Sedi-ment.	Color.		Total.	Dis-solved.	Sus-pended.	Loss on Ig'n.					Total.	By Dis-solved.	By Suspd Matter.	Free Am-monia.	Albuminoid Am.			Total.	Dis-solved.	Sus-pended.	Nitrites.	Nitrates.					
										Tot'l	Dis-solv'd	Sus-pnd'd							Tot'l	Dis-solv'd	Sus-pnd'd										
6604	Jan. 2	Jan. 3	†	Little	F.02	......	584.8	584.	.8	36.8	33.6	3.2	B.	24.	5.8	4.7	1.1	.176	.128	.12	.008	.472	.152	.32	.048	8.	....	....	......	—	20,800
6651	" 9	" 10	†	"	M. F.03	......	738.8	728.4	10.4	91.6	90.	1.6	G.	37.	3.	3.	0.0	.468	.144	.112	.032	.32	.256	.064	.036	5.2	...	....	......	—	27,400
6693	" 16	" 17	‖	"	F.02	......	576.	541.6	34.4	62.	37.2	24.8	B.	23.	9.6	9.4	.2	.24	.104	.096	.008	.352	.192	.16	.032	3.8	....	....	......	+	2,150
6743	" 23	" 24	*	Cons'd	M. F.03	......	407.6	333.6	74.	47.6	4.6	1.6	B.	10.	9.2	3.9	5.3	.096	.192	.128	.064	.448	.32	.128	.018	4.8	....	....	......	+	10,400
6790	" 30	" 31	†	Little	M. F.01	......	469.2	454.4	14.8	37.2	36.8	.4	G.	12.5	3.7	3.6	.1	.144	.128	.112	.016	.32	.256	.064	.035	6.	....	....	......	—	8,000
6850	Feb. 6	Feb. 7	†	"	M. F.01	......	601.6	596.8	4.8	70.	66.4	3.6	G.	22.2	3.	2.9	.1	.192	.128	.12	.008	.32	.288	.032	.03	5.6	....	....	......	.....	3,550
6895	" 13	" 14	*	Much	VM. F.06	......	631.6	245.6	386.	96.8	39.6	57.2	B.	5.	18.2	5.9	12.3	.128	.704	.256	.448	1.6	.544	1.056	.024	6.	....	....	......	—	48,900
6940	" 20	" 21	†	Little	M. F.03	......	373.6	366.	7.6	45.6	39.6	6.	G.	7.8	8.9	8.8	.1	.08	.144	.128	.016	.....	.....	.....	.017	7.6	....	....	......	+	25,300
6988	" 27	" 28	*	Cons'd	M. F.50	......	287.6	224.	63.6	72.	35.2	36.8	B.	5.3	7.9	7.3	.6	.112	.24	.208	.032	.8	.544	.256	.016	4.8	....	....	......	+	106,000
7029	Mar. 6	Mar. 7	†	Little	M. F.05	......	361.2	354.8	6.4	28.	24.4	3.6	G.	10.2	5.3	5.2	.1	.176	.144	.112	.032	.352	.256	.096	.017	5.4	....	....	......	+	19,000
7073	" 13	" 14	§	V.M'ch	VM.F.60	......	580.8	87.2	493.6	54.8	14.8	40.	B.	1.	27.7	11.8	15.9	.32	.96	.432	.528	2.32	.832	1.488	.011	.4	....	....	......	—	312,500
7121	" 20	" 21	*	Cons'd	M. F.03	......	391.2	205.2	186.	38.	20.	18.	B.	4.6	12.9	5.8	7.1	.08	.448	.24	.208	.856	.376	.48	.014	3.6	....	....	......	—	68,000
7168	" 27	" 28	*	"	M. F 03	......	307.6	288.	19.6	32.8	29.6	3.2	G.	5.7	4.8	4.1	.7	.08	.16	.128	.032	.504	.408	.096	.015	5.6	....	....	......	+	18,000
7223	Apr. 3	Apr. 4	*	"	M. F.50	......	605.2	234.8	370.4	37.2	26.8	10.4	G.	3.7	12.8	6.2	6.6	.048	.608	.16	.448	1.336	.568	.768	.017	5.4	....	....	......	—	101,000
7275	" 10	" 11	†	Little	M. F.01	......	350.8	326.8	24.	38.8	38.	.8	B.	5.7	5.5	3.9	1.6	.08	.128	.096	.032	.376	.12	.256	.02	6.	....	17.6	......	+	11,500
7332	" 17	" 18	†	Cons'd	M. F.01	......	349.2	332.8	16.4	39.2	26.8	12.4	B.	6.3	3.7	3.4	.3	.048	.096	.088	.008	.312	.28	.032	.018	5.6	....	....	......	+	12,000
7400	" 24	" 25	*	"	M. F.02	......	336.8	299.6	37.2	43.2	41.6	1.6	B.	6.	5.2	4.	1.2	.04	.144	.096	.048	.408	.216	.192	.018	6.6	....	....	......	+	7,800
7445	May 1	May 2	‖	Little	F.02	......	381.2	374.8	6.4	34.	22.4	5.6	B	9.	3.2	3.1	.1	.012	.096	.096	0.0	.....	.....	.....	.025	5.2	....	14.8	......	—	1,350
7481	" 8	" 9	*	Much	M. F.15	......	512.4	297.6	214.8	45.2	43.2	2.	B.	8.6	17.1	6.6	10.5	.08	.496	.192	.304	1.092	.484	.608	.03	4.	....	....	......	+	100,500
7527	" 15	" 16		....	....	......	390.8	364.8	26.	44.8	44.4	.4	G.	12.	4.4	3.6	.8	.052	.128	.048	.08	.356	.26	.096	.03	4.	..	14.	......	+	2,100
7582	" 22	" 23	‖	Little	M. F.01	......	425.6	395.6	30.	59.6	42.	17.6	B.	12.4	4.	3.4	.6	.034	.192	.128	.064	.356	.26	.096	.016	2.8	....	11.4	......	—	4,300
7618	" 29	" 30	†	"	M. F.03	......	435.2	400.	35.2	78.	77.6	.4	B.	16.	5.6	4.2	1.4	.064	.224	.112	.112	.48	.36	.12	.025	3.36	....	....	......	+	3,100
7660	June 5	June 6	†	"	M. F.02	......	349.2	336.4	12.8	61.2	60.	1.2	G.	7.5	4.5	4.1	.4	.032	.208	.144	.064	.388	.28	.108	.03	5.2	....	....	......	+	3,500
7700	" 12	" 13	†	"	M. F.02	......	369.2	358.	11.2	65.6	59.6	6.	B.	7.8	5.	4.8	.2	.04	.208	.16	.048	.52	.324	.196	.015	5.6	....	11.6	......	+	3,600
7748	" 19	" 20	†	"	M. F.03	......	463.6	427.2	36.4	66.	54.	12.	B.	17.	3.9	3.6	.3	.044	.112	.096	.016	.292	.176	.116	.016	3.4	....	....	......	+	4,400
7778	" 26	" 27	*	Much	M. F.30	......	485.6	194.4	291.2	41.6	25.2	16.4	B.	2.7	19.2	9.1	10.1	.047	.608	.176	.432	1.384	.468	.916	.014	1.32	....	....	......	...	23,700
7826	July 3	July 4	*	Little	T. F.01	......	408.	325.6	82.4	44.8	44.4	.4	B.	8.2	7.1	5.	2.1	.094	.192	.16	.032	.716	.336	.38	.017	3.28	....	....	......	....	17,800
7888	" 10	" 11	*	"	T. F.03	......	382.8	378.	4.8	42.	37.6	4.4	B.	11.7	5.2	3.8	1.4	.044	.144	.128	.016	.548	.292	.256	.014	2.6	....	10.4	......	—	1,000
7941	" 17	" 18	†	"	T. F.	......	471.2	464.	7.2	69.6	62.4	7.2	G.	21.2	4.4	4.2	.2	.057	.176	.08	.096	.708	.328	.38	.013	2.6	....	10.	......	?	1,700
8009	" 24	" 25	†	"	T. F.01	......	570.	535.6	34.4	78.8	58.4	20.4	G.	27.2	4.8	3.3	1.5	.096	.176	.064	.112	.34	.212	.128	.014	1.44	....	10.6	......	?	1,900
8061	" 31	Aug. 1	*	"	T. F.01	......	549.2	548.	1.2	56.	52.8	3.2	B.	32.5	3.6	3.3	.3	.104	.224	.208	.016	.42	.356	.064	.006	.76	....	12.2	......	+	1,100
8110	Aug. 7	" 8	*	"	T. F.01	......	635.2	620.8	14.4	62.	67.2	....	B.	42.	4.3	4.	.3	.162	.272	.176	.096	.74	.356	.384	.005	.36	....	10.9	......	—	650
8176	" 14	" 15	*	"	T. F.01	......	652.4	604.4	48.	73.6	62.8	10.8	G.	38.	6.9	4.2	2.7	.162	.32	.192	.128	.74	.268	.472	.007	.28	....	11.1	......	+	24,000
8246	" 21	" 22	*	"	M. F.02	......	313.6	240.8	72.8	21.6	18.	3.6	B.	6.6	7.8	4.7	3.1	.148	.352	.16	.192	.924	.332	.592	.028	.88	....	11.	......	?	3,400
8312	" 28	" 29	*	"	M. F.02	......	478.	389.6	88.4	30.	23.2	6.8	DB.	14.6	7.1	3.7	3.4	.144	.272	.128	.144	.412	.252	.16	.016	.92	....	11.1	......	—	5,850
8360	Sept. 4	Sept. 5	†	Cons'd	M. F.04	......	391.2	360.	31.2	28.8	25.6	3.2	DB.	14.	5.6	3.5	2.1	.096	.208	.192	.016	.392	.272	.12	.012	.72	....	11.6	......	+	2,300
8439	" 11	" 12	†	"	F 03	......	430.8	417.6	13.2	30.8	17.2	3.6	DB.	20.7	4.7	4.	.7	.05	.368	.224	.144	.476	.384	.092	.001	.64	....	10.5	......	—	950
8488	" 18	" 19	*	"	M. F.01	......	523.4	521.4	4.	29.6	21.6	8.	DB.	32.2	5.1	5.	.1	.154	.272	.16	.112	.392	.304	.088	.001	.4	....	10.5	......	—	3,100
8540	" 25	" 26	†	"	M. F.1	......	713.6	735.2	8.4	77.2	70.	7.2	G.	51.	4.8	3.4	1.4	.170	.272	.064	.208	.52	.304	.216	.004	.49	....	10.	......	—	2,450
8600	Oct. 2	Oct. 3	†	Little	M. F.02	......	907.2	896.4	10.8	89.6	72.	17.6	G.	57.	4.	3.4	.6	.184	.272	.144	.128	.496	.368	.128	.008	-.232	....	....	......	+	2,550

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White

TABLE 54.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, LA SALLE.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Suspnd'd							Tot'l	Dissolv'd	Suspnd'd										
6605	Jan. 2	Jan. 3	†	Cons'd	M. F.04	......	418.8	418.	.8	53.2	52.4	.8	B.	40.2	11.6	11.	.6	3.84	.64	.512	.128	1.32	1.064	.256	.065	3.52	....	....	......	+	324,000
6652	" 9	" 10	†	"	M. F.05	......	392.8	389.2	3.6	49.6	46.	3.6	B.	39.	11.	9.6	1.4	4.16	.672	.448	.224	1.56	.984	.576	.1	.2	....	....	......	+	162,000
6692	" 16	" 17	†	"	M. F.06	......	359.2	332.4	26.8	34.8	24.4	10.4	B.	24.	9.4	8.5	.9	3.2	.528	.416	.112	1.28	1.024	.256	.03	1.72	....	....	......	+	111,000
6741	" 23	" 24	*	"	M. F.15	......	327.6	270.8	56.8	32.4	32.	.4	B.	21.7	14.2	9.1	5.1	2.24	.704	.384	.32	1.76	.864	.896	.035	1.6	....	12.4	......	+	254,000
6792	" 30	" 31	*	"	M. F.05	......	254.8	239.6	15.2	18.4	14.8	3.6	G.	14.	9.4	6.9	2.5	1.36	.32	.24	.08	.8	.544	.256	.04	1.24	....	....	......	+	111,000
6852	Feb. 6	Feb. 7	†	Little	M. F.08	......	276.4	270.	6.4	30.8	29.6	1.2	G.	17.	6.7	6.7	0.0	1.28	.288	.256	.032	.606	.544	.064	.05	.76	....	....	......	....	14,000
6897	" 13	" 14	*	Much	VM. F.30	......	454.8	198.8	256.	44.8	24.	20.8	B.	11.	18.5	8.6	9.9	.896	.8	.336	.464	1.84	.736	1.104	.07	3.	....	18.3	......	....	208,000
6939	" 20	" 21	*	Cons'd	M. F.30	......	285.6	259.2	26.4	52.8	39.6	13.2	B.	14.2	8.9	8.8	.1	1.152	.448	.304	.144	1.12	.736	.384	.035	2.6	....	14.9	......	+	582,000
6987	" 27	" 28	*	"	M. F.40	......	276.	222.8	53.2	56.8	30.8	26.	B.	14.7	8.8	7.8	1.	1.04	.448	.32	.128	1.04	.768	.272	.032	2.4	....	....	......	−	311,000
7028	Mar. 6	Mar. 7	†	"	M. F.10	......	260.	253.6	6.4	20.	16.8	3.2	B.	14.	10.6	7.9	2.7	1.088	.352	.288	.064	.896	.8	.096	.023	1.6	....	....	......	....	....
7074	" 13	" 14	§	V. M'ch	VM. F.40	......	436.8	82.	354.8	38.	14.8	23.2	B.	4.0	26.6	8.3	18.3	.368	.864	.368	.496	2.08	.64	1.44	.011	.48	....	25.3	......	+	265,000
7122	" 20	" 21	*	Cons'd	M. F.30	......	242.4	174.8	67.6	20.	20.	0.0	B.	3.5	12.6	8.9	3.7	.592	.48	.272	.208	1.16	.632	.528	.03	1.72	....	23.	......	+	695,000
7167	" 27	" 28	*	"	M. F.30	......	237.6	174.4	63.2	23.6	15.6	8.	B.	5.7	13.	9.5	3.5	.384	.432	.32	.112	1.24	.76	.48	.014	1.8	....	19.6	......	+	143,000
7221	Apr. 3	Apr. 4	*	"	M. F.40	......	412.4	180.4	232.	33.6	21.2	12.4	B.	5.6	16.7	8.5	8.2	.288	.592	.256	.336	1.304	.632	.672	.018	2.4	....	21.	......	+	225,000
7276	" 10	" 11	*	"	M. F.15	......	269.2	217.6	51.6	27.6	26.8	.8	B.	9.1	12.2	8.5	3.7	.576	.384	.256	.128	1.048	.632	.416	.035	1.76	....	17.6	......	+	56,500
7331	" 17	" 18	†	"	M. F.10	......	274.8	236.8	38.	32.	29.2	2.8	B.	11.	9.	8.8	.2	.56	.32	.256	.064	.824	.6	.224	.038	1.32	....	15.6	......	−	81,000
7399	" 24	" 25	*	"	M. F.04	......	290.	260.8	29.2	29.6	27.2	2.4	G.	10.9	9.5	8.4	1.1	.72	.384	.272	.112	1.08	.76	.32	.065	1.6	....	16.	......	−	22,000
7443	May 1	May 2	†	"	M. F.20	......	299.6	262.	37.6	37.6	24.	13.6	B.	8.5	14.5	9.6	4.9	.176	.448	.288	.16	1.16	.8	.36	.08	1.52	....	14.8	......	−	4,000
7482	" 8	" 9	†	"	M. F.25	......	284.	254.4	29.6	32.4	25.6	6.8	B.	16.	13.7	8.7	5.	1.12	.48	.4	.08	1.092	.644	.448	.25	1.08	....	15.3	......	+	52,500
7528	" 15	" 16	..	....	....	......	276.	268.4	7.6	28.8	26.4	2.4	B.	14.2	8.4	8.1	.3	.256	.372	.256	.116	.9	.836	.064	.15	1.6	....	14.	......	+	3,450
7581	" 22	" 23	*	Little	M. F.03	M'sty	277.2	272.4	4.8	36.	35.6	.4	G.	13.9	9.5	8.6	.9	.32	.256	.224	.032	.74	.644	.096	.075	1.12	....	11.4	......	+	2,500
7617	" 29	" 30	†	"	M. F.04	......	247.6	226.4	21.2	28.	27.6	.4	B.	18.	8.3	7.2	1.1	.48	.32	.208	.112	.74	.58	.16	.175	1.68	....	11.6	......	?	3,600
7659	June 5	June 6	†	Cons'd	M. F.04	......	283.2	206.8	76.4	38.4	29.6	8.8	G.	16.	9.2	6.5	2.7	.448	.352	.208	.144	.9	.52	.38	.3	2.4	....	12.8	......	−	9,100
7699	" 12	" 13	†	Little	M. F.03	......	302.8	281.6	21.2	20.8	16.	4.8	B.	23.	7.6	6.9	.7	.456	.272	.224	.048	.64	.52	.12	.35	2.6	....	11.8	......	−	16,500
7747	" 19	" 20	†	"	M. F.15	......	272.8	252.4	20.4	32.	24.	8.	B.	21.	17.6	6.3	11.3	.832	.32	.224	.096	.484	.452	.032	.021	1.	....	11.6	....	−	20,000
7777	" 26	" 27	‖	"	T. F.05	M'sty	262.	236.	26.	22.	21.2	.8	B.	19.5	7.7	6.4	1.3	.616	.24	.112	.128	.692	.516	.176	.22	1.28	....	12.4	......	+	3,500
7825	July 3	July 4	*	"	T. F.01	"	262.8	240.4	22.4	38.8	28.4	10.4	G.	20.	6.5	6.3	.2	.176	.192	.16	.032	.548	.484	.064	.25	1.84	....	10.6	......	....	5,750
7889	" 10	" 11	*	"	T. F.03	......	279.6	244.	35.6	26.4	22.4	4.	B.	27.	8.5	5.8	2.7	.112	.272	.176	.096	.548	.452	.096	.375	1.84	....	10.4	......	?	1,050
7942	" 17	" 18	†	"	T. F.	......	268.	238.	30.	28.	22.4	5.6	B.	25.	6.2	5.2	1.	.224	.192	.08	.112	.58	.436	.144	.3	2.	....	10.	......	?	2,800
8010	" 24	" 25	†	"	T. F.01	......	301.2	232.	69.2	22.	22.	0.0	G.	21.	7.2	4.9	2.3	.144	.288	.112	.176	.612	.42	.192	.17	1.28	....	10.6	......	+	4,400
8060	" 31	Aug. 1	*	"	T. F.02	......	258.8	216.4	42.4	42.	40.4	1.6	G.	19.5	7.7	5.	2.7	.272	.272	.176	.096	.996	.356	.64	.18	1.32	....	12.2	......	?	3,850
8111	Aug. 7	" 8	*	"	T. F.01	M'sty	229.2	227.6	1.6	32.	34.8	....	G.	23.	7.	4.9	2.1	.272	.24	.192	.048	.52	.408	.112	.425	1.72	....	10.9	......	?	1,800
8177	" 14	" 15	*	"	T. F.01	......	220.4	204.4	16.	23.6	16.	7.6	G.	22.5	6.5	4.2	2.3	.256	.272	.192	.08	.644	.348	.296	.35	1.72	....	11.1	......	−	36,00
8245	" 21	" 22	*	"	T. F.01	......	248.4	226.	22.4	31.6	18.4	13.2	G.	20.	6.9	4.6	2.3	.144	.272	.224	.048	.572	.124	.448	.2	1.44	....	11.	......	−	5,60
8311	" 28	" 29	*	"	M. F.02	Gas'y	278.4	240.	38.4	22.8	20.	2.8	G.	20.	8.1	4.6	3.5	.352	.304	.096	.208	.7	.38	.32	.475	1.64	....	11.1	......	?	17,75
8350	Sept. 4	Sept. 5	†	Cons'd	M. F.03	......	258.8	238.8	20.	21.2	18.4	2.8	B.	19.	8.1	4.7	3.4	3.08	.256	.192	.064	.392	.232	.16	.3	1.72	....	11.6	......	−	22,50
440	" 11	" 12	†	Little	F.05	M'sty	278.	266.8	11.2	26.4	24.8	1.6	B.	26.	7.8	6.2	1.6	.4	.32	.16	.16	1.24	.592	.648	.325	1.72	....	10.5	......	−	4,40
37	" 18	" 19	*	Cons'd	F.01	......	252.8	244.	8.8	27.2	17.6	9.6	B.	27.	8.	5.9	2.1	2.08	.272	.176	.096	.92	.608	.312	.018	1.08	....	10.5	......	−	36,0
[illegible]	" 25	" 26	†	Little	F.02	......	335.2	319.2	16.	36.4	26.4	2.	G.	47.	8.2	6.6	1.6	3.28	.48	.208	.272	.824	.672	.152	.22	1.96	....	10.	......	−	4,7
[illegible]	Oct. 2	Oct. 3	†	"	F.01	......	250.8	238.	12.8	27.6	22.	5.6	G.	24.	6.	5.2	.8	.272	.32	.256	.064	.524	.416	.108	.28	1.12	....	....	......	?	2,

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.
COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bb., Brownish. R., Red. Rb., Reddish. W., Wh

urbidity—*Decided. § Very Decided. † Distinct. ‡ Very Slight. | Slight. Color—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.
on Ignition—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., Wh

LE 51.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS AND MICHIGAN CANAL, LA SALLE.

Report of Arthur W. Palmer,
T. J. Burrill,
University of Illin

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coll.	No. o Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Suspad'd							Tot'l	Dissolv'd	Suspad'd										
6606	Jan. 2	Jan. 3	†	Cons'd	M. F.04	....	560.4	554.4	6.	40.8	39.6	1.2	B.	52.	13.7	11.6	2.1	3.52	.624	.464	.16	1.48	1.16	.32	.25	3.2	....	9.6	......	+	198,00
6653	" 9	" 10	†	"	M. F.05	....	428.	423.2	4.8	37.2	33.2	4.	B.	43.	9.	8.8	.2	4.	.672	.576	.096	1.24	1.	.24	.18	1.8	....	9.9	......	+	554,00
6691	" 16	" 17	†	"	M. F.06	....	525.2	495.2	30.	54.4	38.4	16.	B.	54.	13.2	11.1	2.1	3.68	.672	.64	.032	3.2	1.76	1.44	.15	1.32	....	10.	......	+	4,000
6742	" 23	" 24	*	"	M. F.2	....	405.2	386.	19.2	30.8	28.4	2.4	B.	33.	11.8	9.3	2.5	3.2	.672	.448	.224	1.68	.896	.784	.08	1.52	....	12.4	......	+	83,500
6791	" 30	" 31	†	Little	M. F.03	....	333.6	325.2	8.4	35.2	32.4	2.8	G.	23.5	8.3	7.5	.8	1.84	.384	.32	.064	.96	.768	.192	.06	1.48	....	12.6	......	?	127,000
6851	Feb. 6	Feb. 7	†	"	M. F.	....	289.6	280.8	8.8	18.4	16.	2.4	G.	21.	6.7	....	....	1.36	.304	.224	.08	.704	.576	.128	.035	.8	....	11.4	......	....	28,000
6896	" 13	" 14	*	Much	VM. F.50	....	325.6	210.8	114.8	32.8	31.2	1.6	B.	13.	16.4	10.4	6.	1.056	.704	.384	.32	1.44	.8	.64	.035	1.33	....	18.3	......	—	44,000
6938	" 20	" 21	*	Cons'd	M. F.30	....	328.	239.2	88.8	36.	34.4	1.6	B.	12.5	13.1	10.3	2.8	1.024	.528	.432	.096	1.36	.832	.528	.035	2.2	....	14.9	......	+	438,000
6989	" 27	" 28	*	"	M. F.50	....	265.6	241.2	24.4	45.6	29.6	16.	B.	13.7	9.4	7.	2.4	1.12	.512	.448	.064	1.12	.96	.16	.035	2.4	....	15.6	......	+	168,500
7027	Mar. 6	Mar. 7	†	"	M. F.30	....	236.8	222.	14.8	25.2	16.4	8.8	B.	12.	9.8	8.6	1.2	1.024	.352	.288	.064	1.024	.736	.288	.03	1.76	....	14.6	......	—	164,500
7075	" 13	" 14	*	Much	M. F.50	....	236.4	160.4	76.	25.6	19.2	6.4	B.	6.4	15.2	10.5	4.7	.8	.544	.416	.128	1.52	.704	.816	.02	.96	....	25.3	......	+	347,500
7120	" 20	" 21	*	Cons'd	M. F.60	....	231.6	168.	63.6	30.	13.6	16.4	B.	6.8	13.8	10.6	3.2	1.184	.544	.432	.112	1.32	.952	.368	.04	1.28	....	....	......	—	272,000
7169	" 27	" 28	*	"	M. F.50	....	223.6	193.2	30.4	23.6	21.2	2.4	B.	8.4	10.8	8.7	2.1	.688	.32	.288	.032	1.08	.792	.288	.03	1.12	....	19.6	......	+	64,000
7222	Apr. 3	Apr. 4	*	"	M. F.25	....	284.8	241.6	43.2	19.6	19.6	....	B.	14.	10.8	8.1	2.7	.8	.32	.224	.096	.792	.664	.128	.04	1.4	....	21.	......	+	220,000
7277	" 10	" 11	*	"	M. F.15	....	375.2	333.6	41.6	21.6	18.8	2.8	B.	19.	10.8	7.5	3.3	.56	.288	.256	.032	.824	.664	.16	.075	2.6	....	17.6	......	+	112,500
7330	" 17	" 18	†	"	M. F.04	....	344.4	340.8	3.6	38.4	16.4	22.	B.	18.	8.1	8.1	0.0	.56	.288	.24	.048	.92	.664	.256	.065	2.28	....	....	......	+	257,500
7401	" 24	" 25	*	"	M. F.04	....	380.8	356.	24.8	32.	31.6	.4	G.	18.	8.6	6.5	2.1	.48	.4	.24	.16	1.144	.76	.384	.065	1.36	....	....	......	+	41,000
7444	May 1	May 2	†	Little	M. F.05	....	356.8	328.4	28.4	23.6	20.8	2.8	B.	17.	7.9	7.8	.1	.502	.4	.256	.144	.9	.644	.256	.08	1.52	....	14.8	......	+	48,000
7483	" 8	" 9	†	Cons'd	M. F.15	....	404.4	365.2	39.2	38.8	36.	2.8	B.	19.5	11.5	6.7	4.8	.72	.496	.416	.08	1.092	.772	.32	.076	1.08	....	....	......	+	53,500
7520	" 15	" 16		....	....	....	354.8	338.	16.8	38.8	34.8	4.	B.	16.5	11.1	8.	3.1	.653	.48	.288	.192	1.316	.9	.416	.05	.72	....	14.	......	+	6,000
7583	" 22	" 23	*	Little	M. F.04	Mst'y	398.4	361.6	36.8	90.	54.8	35.2	B.	17.	11.	8.4	2.6	.8	.48	.288	.192	.9	.72	.18	.06	.68	....	11.4	......	+	8,500
7619	" 29	" 30	†	Cons'd	M. F.15	....	370.	343.2	26.8	59.2	47.6	11.6	B.	16.	12.7	8.9	3.8	.502	.56	.448	.112	1.33	.74	.58	.045	.8	....	11.6	......	+	10,500
7656	June 5	June 6	†	"	M. F.15	.....	352.4	316.	36.4	60.4	55.6	4.8	B.	16.	8.2	8.	.2	.736	.4	.352	.048	.964	.772	.192	.065	.56	.. .	12.8	......	?	11,700
7698	" 12	" 13	†	Little	M. F.03	....	363.2	342.4	20.8	39.6	38.8	.8	B.	15.	9.3	8.8	.5	.768	.352	.272	.08	.9	.74	.16	.06	.44	....	11.8	......	+	62,000
7746	" 19	" 20	*	Cons'd	M. F.05	....	371.6	341.6	30.	50.	46.8	3.2	B.	15.	9.3	8.5	.8	1.04	.8	.32	.48	.9	.708	.192	.023	.24	....	11.6	......	+	31,050
7776	" 26	" 27	‡	Slight	T. F.07	Mst'y	339.6	334.	5.6	49.2	44.4	4.8	B.	14.	9.	7.8	1.2	.288	.448	.304	.144	1.412	.9	.512	.028	.2	....	....	......	—	19,500
7824	July 3	July 4	*	Little	T. F.05	....	345.6	329.6	16.	61.2	52.	9.2	B.	13.	9.6	8.8	.8	.232	.48	.352	.128	.932	.516	.416	.028	.24	..	10.6	......	....	100,500
7890	" 10	" 11	*	"	T. F.05	....	362.4	330.8	31.6	34.	29.2	4.8	B.	15.	12.5	8.	4.5	.416	.512	.368	.144	.836	.516	.32	.017	.16	....	10.4	......	+	13,000
7943	" 17	" 18	†	"	T. F.	....	346.	325.2	20.8	41.2	37.6	3.6	B.	14.	11.1	7.9	3.2	.456	.368	.272	.096	.76	.612	.148	.014	.44	....	10.	......	....	21,000
8011	" 24	" 25	†	"	T. F.01	Gas'y	295.2	276.4	18.8	42.4	40.4	2.	G.	15.	8.9	7.	1.9	.224	.448	.24	.208	1.08	.484	.596	.008	.36	....	10.6	......	?	19,000
8059	" 31	Aug. 1	*	"	T. F.01	Sl.	327.6	305.6	22.	56.4	54.4	2.	B.	16.	8.	5.8	2.2	.408	.464	.288	.176	1.028	.548	.48	.021	.28	....	12.2	......	?	9,500
8112	Aug. 7	" 8	*	"	T. F.01	....	313.6	295.6	18.	58.	62.8	....	B.	17.	10.7	6.6	4.1	.288	.368	.304	.064	.968	.....	.....	.002	.12	....	10.9	......	?	4,000
8178	" 14	" 15	*	"	T. F.01	....	338.8	368.	170.8	57.6	54.	3.6	B.	14.5	11.7	6.5	5.2	.24	.448	.272	.176	1.028	.456	.672	.008	.36	....	11.1	......	—	40,000
8244	" 21	" 22	*	"	T. F.01	Sl.Gs.	269.2	262.4	6.8	30.	25.6	4.4	B.	17.	7.9	5.6	2.3	.56	.336	.16	.176	.732	.156	.576	.04	.76	..	11.	......	+	25,000
8310	" 28	" 29	*	"	M. F.02	"	327.2	291.6	35.6	35.2	28.	7.2	B.	15.	9.2	5.7	3.5	.368	.368	.144	.224	.892	.604	.288	.038	1.24	....	11.1	......	+	7,500
8361	Sept. 4	Sept. 5	*	Cons'd	M. F.04	....	370.4	296.	74.4	24.8	21.6	3.2	B.	13.	13.1	5.8	7.3	.32	.512	.288	.224	1.112	.604	.508	.012	.2	....	11.6	......	+	7,000
8441	" 11	" 12	*	"	M. F.04	Mst'y	332.	281.2	50.8	29.6	24.4	5.2	B.	11.	9.	6.1	2.9	.352	.432	.224	.208	.68	.336	.344	.007	.2	....	10.5	......	+	45,000
8489	" 18	" 19	*	"	M. F.01	"	335.2	284.	51.2	31.2	28.8	2.4	B.	11.	12.5	7.6	4.9	.288	.56	.288	.272	1.02	.4	.62	.007	.24	....	10.5	......	—	36,100
8539	" 25	" 26	†	Little	F.15	....	325.2	300.	25.2	51.2	48.8	2.4	B.	11.	8.8	6.8	2.	.272	.608	.224	.384	.84	.432	.408	.008	.24	....	10.	......	?	205,000
8598	Oct. 2	Oct. 3	†	"	M. F.05	....	338.4	306.8	31.6	33.2	28.8	4.4	B.	12.	8.8	7.7	1.1	.273	.576	.416	.16	.96	.736	.224	.008	.232	....	....	......	+	32,000

Turbidity—*Decided. § Very Decided. † Distinct. ‡ Very Slight. | Slight. Color—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

Color on Ignition—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 52.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, HENRY.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of 1900 Collection.	Date of 1900 Examination.	Appearance. Turb'y.	Appearance. Sediment.	Appearance. Color.	Odor.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dissolv'd	Loss on Ig'n. Suspend'd	Color on Ignition.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Susp'd Matter.	Nitrogen as Ammonia. Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspend'd	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
6649	Jan. 9	Jan. 10	†	Little	M. F.07	......	350.0	344.4	6.	52.8	50.	2.8	G.	30.7	8.6	8.5	.1	2.88	.48	.4	.08	.92	.664	.256	.048	3.2	7.3	0.	2.	−	6,400
6694	" 16	" 17	†	Cons'd	M. F.15	......	328.8	322.4	6.4	42.8	36.	6.8	B.	25.	9.6	9.4	.2	2.56	.528	.496	.032	1.184	.704	.48	.055	1.84	6.5	0.	1.	−	5,050
6730	" 23	" 24	*	"	M. F.15	......	316.4	272.8	43.6	32.4	30.4	2.	B.	19.	12.2	8.5	3.7	2.24	.496	.32	.176	1.2	.704	.496	.025	1.44	8.2	2.	3.	+	108,000
6776	" 29	" 30	*	"	M. F.15	......	295.2	290.	5.2	22.4	21.6	.8	G.	19.	7.9	7.7	.2	1.76	.56	.352	.208	.88	.576	.304	.025	1.6	7.6	0.	0.	−	46,400
6829	Feb. 5	Feb. 6	†	Little	F.07	......	264.8	258.8	6.	28.	25.2	2.8	B.	15.	8.2	6.9	1.3	1.2	.432	.224	.208	.88	.544	.336	.025	.92	....	....	12.	....	....
6888	" 12	" 13	*	Much	M. F.50	......	448.	197.6	250.4	38.8	20.8	18.	B.	9.	17.7	9.4	8.3	.8	.736	.352	.384	1.84	.896	.944	.018	1.52	11.3	0.	4.	+	187,000
6930	" 19	" 20	*	Cons'd	M. F.50	......	325.6	218.4	107.2	32.4	32.	.4	B.	12.	13.2	9.5	3.7	.8	.512	.352	.16	1.28	.64	.64	.030	1.08	10.7	0.	−12.	+	108,000
6968	" 26	" 27	*	"	M. F.50	......	253.6	220.	33.6	54.	29.2	24.8	B.	12.	11.4	9.5	1.9	.896	.512	.416	.096	1.12	.896	.224	.023	1.76	12.6	0.	−13.	?	191,500
7020	Mar. 5	Mar. 6	†	"	M. F.40	......	262.8	250.4	12.4	13.6	12.8	.8	B	12.2	11.5	9.8	1.7	.96	.368	.32	.048	1.04	.8	.24	.025	1.84	11.	0.	−11.	−	16,500
7064	" 12	" 13	*	"	M. F.15	......	258.4	220.8	37.6	22.4	16.4	6.	B.	10.8	10.6	7.7	2.9	1.04	.416	.272	.144	.88	.544	.336	.019	.96	15.9	0.	− 1.	+	75,500
7112	" 19	" 20	*	"	M. F.30	......	313.6	112.	201.6	24.8	10.	14.8	B.	3.7	14.2	8.9	5.3	.32	.512	.224	.288	1.170	.44	.736	.012	.96	19.9	0.	4.	−	505,000
7160	" 26	" 27	*	"	M. F.50	......	189.2	181.6	7.6	22.8	17.6	5.2	B.	5.9	8.7	8.1	.6	.496	.352	.24	.112	.92	.696	.224	.017	1.76	16.9	0.	3.	+	137,500
7218	Apr. 2	Apr. 3	*	"	M. F.40	......	274.8	183.6	91.2	20.4	17.2	3.2	B.	5.9	12.7	8.5	4.2	.512	.416	.272	.144	.860	.664	.196	.016	1.52	17.5	4.	3.	+	90,500
7266	" 9	" 10	*	"	M. F.60	......	267.6	176.4	91.2	26.8	18.	8.8	B.	5.7	13.6	9.7	3.9	.336	.416	.288	.128	.728	.6	.128	.03	1.8	14.	4.	1.	+	42,000
7321	" 16	" 17	*	"	M. F.30	......	263.2	209.2	54.	24.4	12.8	11.6	B.	9.	11.4	8.7	2.7	.48	.32	.24	.08	1.	.76	.24	.035	1.64	13.9	4.	2.	−	22,000
7369	" 23	" 24	†	"	M. F.08	......	263.4	244.8	23.6	24.4	23.2	1.2	B.	9.	9.4	7.7	1.7	.384	.384	.24	.144	1.304	.696	.608	.045	2.2	13.	10.	10.	−	5,000
7432	" 30	May 1	†	"	M. F.04	......	284.	248.	36.	36.8	23.6	13.2	B.	10.5	9.1	8.8	.3	.288	.432	.288	.144	.86	.6	.26	.075	1.44	11.6	12.	11.	+	7,000
7471	May 7	" 8	†	"	M. F.05	......	325.2	268.	57.2	44.	26.8	17.2	B.	13.7	13.9	10.4	3.5	.502	.48	.32	.16	1.22	.84	.38	.15	1.2	10.	11.	17.	+	52,500
7532	" 15	" 16	..	....	....	......	301.2	282.4	18.8	36.	34.4	1.6	B.	17.	11.6	8.7	2.9	.448	.288	.192	.096	1.188	.836	.352	.15	1.4	9.8	22.	28.	−	1,100
7576	" 21	" 22	*	Little	M. F.01	M'sty	320.8	262.	58.8	35.2	30.4	4.8	B.	13.4	12.1	8.	4.1	.416	.416	.384	.032	.964	.452	.512	.11	1.2	9.	16.	10.	+	7,000
7614	" 28	" 29	†	Cons'd	M. F.15	......	287.2	252.4	34.8	39.2	33.6	5.6	B.	18.	9.6	7.6	2.	.512	.4	.24	.16	.8	.452	.348	.14	1.52	9.	20.	17.	−	3,700
7649	June 4	June 5	†	"	M. F.03	......	320.4	288.8	31.6	40.8	40.4	.4	B.	17.	9.6	6.5	3.1	.512	.32	.192	.128	.8	.644	.156	.3	2.04	9.5	20.	17.	−	2,300
7694	" 11	" 12	*	"	M. F.03	......	322.	255.6	66.4	26.	22.	4.	B.	16.	12.	7.8	4.2	.368	.496	.256	.24	.96	.52	.44	.37	1.68	9.1	22.	24.	+	3,600
7736	" 18	" 19	*	"	M. F.05	......	347.2	273.6	73.6	25.2	23.6	1.6	B.	23.	11.6	6.5	5.1	.256	.4	.176	.224	1.06	.452	.608	.2	2.	7.4	20.	23.	−	3,150
7776	" 25	" 26	*	Little	M. F.04	Sl. M.	320.	237.2	82.8	34.	20.4	13.6	B.	18.	8.	4.9	3.1	.272	.304	.112	.192	.670	.308	.366	.18	1.08	7.5	22.	22.	−	4,900
7826	July 2	July 4	*	"	T. F.03	......	313.6	264.	49.6	33.6	30.	3.6	B.	18.	8.7	6.5	2.2	.216	.4	.324	.076	.964	.5	.464	.17	1.04	7.	24.	....	....	98,000
7882	" 9	" 10	*	"	T. F.02	......	274.8	229.2	45.6	27.6	17.6	10.	B.	19.	7.9	5.	2.9	.16	.32	.16	.16	.612	.452	.16	.18	1.68	8.	23.	....	+	23,000
7935	" 16	" 17	†	"	T. F.03	......	286.	274.	12.	40.8	36.	4.8	B.	20.	7.	5.1	1.9	.304	.272	.112	.16	.612	.42	.192	.22	1.32	....	....	....	....	....
8000	" 23	" 24	*	"	T. F.02	......	279.6	216.	63.6	32.8	15.2	17.6	B.	21.	6.4	4.1	2.3	1.04	.24	.112	.128	.7	.372	.328	.2	1.52	7.3	24.	....	?	2,300
8103	Aug. 6	Aug. 7	*	"	T. F.02	......	254.4	231.6	22.8	34.8	34.8	0.0	B.	20.	7.	5.8	1.2	.112	.304	.208	.096	.836	.436	.4	.2	1.68	7.2	28.	....	−	2,800
8166	" 13	" 14	*	"	T. F.02	......	245.2	214.	31.2	36.	34.4	1.6	G.	23.	7.5	4.1	3.4	.144	.288	.176	.112	.776	.3	.476	.225	1.08	7.3	20.	....	−	2,200
8228	" 20	" 21	*	"	T. F.01	......	278.	230.	48.	30.4	20.8	9.6	G.	24.	6.5	4.1	2.4	1.66	.304	.192	.112	.632	.428	.204	.175	1.08	8.7	28.	....	+	1,500
8304	" 27	" 28	*	Cons'd	M. F.02	Sl.Gs	268.4	254.	14.4	24.	14.8	9.2	B.	23.	7.4	4.8	2.6	.304	.272	.096	.176	.888	.356	.532	.425	1.56	8.5	27.	....	−	800
8364	Sept. 4	Sept. 5	†	"	M. F.04	......	279.6	247.2	32.4	24.4	19.6	4.8	B.	16.	7.8	4.4	3.4	.16	.32	.192	.128	.6	.396	.204	.008	1.36	8.	28.	....	−	3,100
8442	" 10	" 12	*	"	M. F.02	......	282.	252.8	29.2	23.2	19.2	4.	B.	24.	8.1	5.3	2.8	.256	.32	.192	.128	.824	.4	.424	.25	1.04	7.	28.	....	+	294,000
8530	" 24	" 25	*	Little	M. F.01	......	302.	273.6	28.4	31.6	29.2	2.4	Bh.	24.	8.9	5.5	3.4	.72	.464	.176	.288	1.34	.688	.652	.15	1.28	7.6	21.	....	−	24,000
[illegible]	Oct. 1	Oct. 2	*	"	T. F.05	M'sty	281.2	264.4	16.8	22.	20.8	1.2	Bh.	22.	6.9	5.8	1.1	1.536	.336	.208	.128	.976	.512	.464	.15	1.28	7.6	20.	....	+	11,500

TURBIDITY—*Decided. §Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.
on IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. RD., Reddish. W., Whit

53.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, AVERYVILLE.

Report of ARTHUR W. PALMER.
T. J. BURRILL.
University of Illino

Serial No.	Date of: 1900 Collection.	Date of: 1900 Examination.	Appearance: Turb'y.	Appearance: Sediment.	Appearance: Color.	Odor.	Residue on Evaporation: Total.	Residue on Evaporation: Dissolved.	Residue on Evaporation: Suspended.	Loss on Ig'n: Tot'l	Loss on Ig'n: Dissolv'd	Loss on Ig'n: Suspnd'd	Color on Ignition.	Chlorine.	Oxygen Consumed: Total.	Oxygen Consumed: By Dissolved.	Oxygen Consumed: By Suspd Matter.	Nitrogen as Ammonia: Free Ammonia.	Albuminoid Am.: Tot'l	Albuminoid Am.: Dissolv'd	Albuminoid Am.: Suspnd'd	Organic Nitrogen: Total.	Organic Nitrogen: Dissolved.	Organic Nitrogen: Suspended.	Nitrogen as: Nitrites.	Nitrogen as: Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
6603	Jan. 2	Jan. 3	†	Little	F.03	......	375.6	370.8	4.8	46.8	40.8	6.	B.	22.5	9.6	8.6	1.	1.98	.352	.272	.08	.904	.584	.32	.04	3.44	28.1	.1	2.	—	16,000
6650	" 9	" 10	†	"	M. F.03	......	369.6	364.4	5.2	60.8	60.4	.4	G.	26.	8.3	7.8	.5	2.	.384	.32	.064	.76	.6	.16	.04	3.4	28.3	2.	3.	—	28,000
6695	" 16	" 17	†	Cons'd	M. F.06	......	384.	382.4	1.6	41.2	39.6	1.6	B.	23.	9.	8.5	.5	2.96	.432	.368	.064	1.056	.8	.256	.065	2.8	28.4	2.	3.	+	3,800
6740	" 23	" 24	*	"	M. F.2	......	351.2	302.	49.2	41.6	34.4	7.2	B.	23.	12.3	8.9	3.4	2.	.4	.32	.08	1.024	.544	.48	.08	1.52	31.	3.	4.	+	24,250
6847	Feb. 6	Feb. 7	†	Little	M. F.04	......	267.2	265.6	1.6	28.8	28.	.8	G.	18.	6.5	6.3	.2	1.44	.272	.192	.08	.56	.448	.112	.035	1.4	......	......	—1.	....	....
6898	" 13	" 14	§	V. M'ch	VM. F.3	......	476.4	178.8	297.6	48.	24.8	23.2	B.	9.	19.4	8.3	11.1	.736	.704	.288	.416	1.76	.416	1.344	.025	2.	34.6	0.	—2.	+	129,000
6941	" 20	" 21	*	Cons'd	M. F.2	......	328.4	223.6	104.8	75.2	29.6	45.6	B.	10.	12.	9.9	2.1	1.04	.448	.384	.064	1.12	.608	.512	.03	2.2	34.6	1.	0.	+	122,000
6995	" 27	Mar. 3	*	"	M. F.08	......	343.2	281.2	62.	20.8	20.4	.4	B.	12.	12.8	9.4	3.4	1.024	.416	.208	.208	.8	.576	.224	.027	1.6	35.6	0.	—3.	+	137,000
7023	Mar. 6	" 7	†	Little	M. F.4	......	255.6	242.8	12.8	14.4	10.8	3.6	B.	11.7	11.	8.8	2.2	.864	.32	.288	.032	.88	.64	.24	.03	2.2	34.7	0.	3.	—	84,000
7078	" 13	" 14	*	Much	M. F.4	......	327.6	189.6	138.	27.2	17.6	9.6	B.	8.4	12.6	7.1	5.5	.96	.384	.288	.096	1.12	.544	.576	.016	1.44	36.9	1.	5.	—	74,000
7124	" 20	" 21	*	"	M. F.5	......	292.	115.6	176.4	30.4	16.4	14.	B.	3.5	14.3	11.9	2.4	.384	.48	.272	.208	1.24	.6	.64	.015	1.	42.	1.	—3.	+	154,000
7170	" 27	" 28	*	Cons'd	M. F.6	......	200.4	158.4	42.	27.6	14.4	13.2	B.	5.2	10.5	8.1	2.4	.48	.288	.256	.032	1.	.632	.368	.014	1.6	29.7	3.	3.	+	61,500
7219	Apr. 3	Apr. 4	*	"	M. F.40	......	234.8	176.4	58.4	23.2	14.4	8.8	B.	6.2	10.8	8.2	2.6	.432	.352	.288	.064	.824	.664	.16	.016	1.52	40.1	6.	9.	+	28,000
7274	" 10	" 11	*	"	M. F.30	......	263.4	180.4	83.	22.4	19.2	3.2	B.	5.6	13.7	7.7	6.	.352	.336	.24	.096	.824	.632	.192	.03	2.6	39.2	9.	3.	—	17,000
7336	" 17	" 18	*	"	M. F.20	......	230.4	214.	16.4	19.2	17.6	1.6	B.	8.1	8.7	8.5	.2	.432	.256	.208	.048	.76	.568	.192	.038	2.	36.9	10.	14.	—	5,500
7402	" 24	" 25	*	"	M. F.	......	261.8	246.8	15.	30.8	20.8	10.	B.	9.	9.	8.	1.	.32	.448	.256	.192	1.016	.632	.384	.045	2.12	36.1	14.	18.	—	1,850
7442	May 1	May 2	*	"	M. F.07	......	285.2	266.4	18.8	43.2	24.8	18.4	B.	11.	9.	8.	1.	.112	.432	.24	.192	.932	.644	.288	.06	1.76	34.8	18.	23.	—	3,500
7478	" 8	" 9	†	Little	M. F.20	......	270.	258.8	11.2	25.6	23.6	2.	B.	11.6	12.9	8.	4.9	.16	.512	.352	.16	1.092	.644	.448	.07	1.08	33.3	19.	23.	—	13,850
7549	" 16	" 17	..	....	M. F.1	......	294.8	267.6	27.2	49.2	38.8	10.4	B.	14.7	9.3	9.	.3	.384	.64	.288	.352	1.252	.676	.576	.125	1.08	32.8	22.	23.	+	22,250
7589	" 22	" 23	‖	Little	M. F.1	......	296.8	268.4	28.4	40.4	28.4	12.	B.	16.	10.8	7.2	3.6	.304	.32	.24	.08	.676	.484	.192	.1	1.28	33.1	19.	23.	—	31,000
7621	" 29	" 30	*	Cons'd	M. F.15	......	322.	255.6	66.4	26.	26.	0.0	B.	16.	8.6	8.	.6	.24	.416	.24	.176	.84	.64	.2	.07	1.2	31.9	21.	21.	+	8,900
7656	June 5	June 6	†	"	M. F.04	......	256.4	242.8	13.6	42.4	41.6	.8	G.	19.	7.	6.7	.3	.224	.304	.272	.032	.64	.452	.188	.16	1.4	32.1	23.	21.	—	3,200
7707	" 12	" 13	†	Little	M. F.04	......	262.8	242.	20.8	19.6	19.6	0.0	B.	16.	6.6	6.5	.1	.224	.24	.208	.032	.56	.50	.06	.2	2.08	31.8	23.	22.	—	2,000
7749	" 19	" 20	*	Cons'd	M. F.01	......	322.	288.4	33.6	37.6	34.4	3.2	B.	20.	9.3	6.5	2.8	.256	.272	.192	.08	.66	.58	.08	.14	1.48	30.6	22.	19.	—	550
7779	" 26	" 27	‖	Little	T. F.07	......	281.6	260.	21.6	25.2	21.2	4.	B.	20.	7.	6.8	.2	.56	.256	.16	.096	.74	.052	.688	.11	1.16	30.4	25.	24.	—	8,000
7818	July 3	July 4	*	"	T. F.03	......	282.	253.6	28.4	26.	25.2	.8	B.	20.5	7.9	7.	.9	.352	.324	.208	.116	.612	.34	.272	.19	1.48	30.5	26.	......	....	3,400
7896	" 10	" 11	*	"	T. F.10	......	302.4	260.8	41.6	42.	25.2	16.8	B.	20.	6.	5.8	.2	.128	.208	.16	.048	.564	.388	.176	.125	1.44	30.	25.	......	—	7,200
7945	" 17	" 18	‡	"	.02	Mst'y	283.2	256.	27.2	25.2	24.4	.8	B.	27.	6.2	5.8	.4	.288	.176	.08	.096	1.64	.468	1.172	.23	3.	....	....	......	....	....
8013	" 24	" 25	†	"	T. F.01	......	248.8	231.2	17.6	30.4	30.4	0.0	G.	23.	6.3	4.5	1.8	.144	.224	.112	.112	.596	.42	.176	.13	1.32	29.9	26.	......	?	2,100
8063	" 31	Aug. 1	*	"	T. F.01	......	258.8	234.8	24.	41.2	34.8	6.4	G.	22.	5.5	4.4	1.1	.07	.208	.176	.032	.708	.548	.16	.22	.92	30.4	26.	......	—	3,500
8107	Aug. 7	" 7	*	"	T. F.01	......	219.2	215.6	63.6	40.	40.	0.0	G.	19.	6.	6.4	....	.176	.272	.176	.096	.708	.468	.24	.12	1.12	30.3	28.	......	—	6,500
8175	" 14	" 15	*	"	T. F.01	......	144.	135.6	8.4	46.8	36.4	10.4	G.	21.	5.3	4.6	.7	.08	.272	.176	.096	.453	.348	.104	.125	1.12	....	....	......	....	....
8234	" 21	" 21	*	"	T. F.01	......	222.6	197.2	25.4	38.	20.4	17.6	G.	25.	5.7	4.4	1.3	.32	.272	.192	.08	.54	.284	.256	.13	1.12	31.2	28.	......	+	2,000
8309	" 27	" 28	*	"	M. F.02	......	250.	220.4	29.6	19.2	18.4	.8	G	20.	6.7	4.6	2.1	.176	.24	.144	.096	.636	.38	.256	.1	1.12	31.	27.	......	—	4,300
8358	Sept. 4	Sept. 5	*	Cons'd	M. F.02	......	264.8	260.8	4.	18.	16.8	1.2	G.	22.	6.4	4.6	1.8	.176	.272	.192	.08	.456	.....	.....	.23	1.52	....	....	......	....	....
8437	" 11	" 11	*	Little	M. F.02	......	264.	229.6	34.4	16.4	15.2	1.2	G.	18.	7.4	4.5	2.9	.128	.256	.128	.128	.536	.384	.152	.075	1.04	30.	26.	......	—	4,900
8486	" 18	" 18	*	Cons'd	M. F.01	......	272.8	253.2	19.6	36.8	15.6	21.2	G.	20.	7.5	6.1	1.4	.144	.32	.224	.096	.....	.....	.....	.01	1.2	29.5	19.	......	—	5,100
8535	" 25	" 25	†	Little	M. F.05	......	318.	286.8	31.2	39.2	38.4	.8	Bh.	30.	8.5	6.4	2.1	.864	.352	.16	.192	.636	....	.....	.13	1.44	28.5	21.	......	—	3,400
8597	Oct. 2	Oct. 2	†	"	M. F.02	......	317.6	294.4	23.2	25.6	23.2	2.4	B.	37.	6.7	5.8	.9	1.28	.416	.224	.192	.656	.48	.176	.15	1.28	29.7	20.	......	+	1,050

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight ‖ Slight. COLOR—M., Muddy VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 54.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, WESLEY CITY.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dis-solv'd	Loss on Ig'n. Sus-pend'd			Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dis-solv'd	Albuminoid Am. Sus-pend'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
6632	Jan. 5	Jan. 6	†	Little	M. F.04	......	377.2	370.8	6.4	50.	48.8	1.2	B.	24.	8.2	7.6	.6	1.92	.352	.272	.08	1.	.68	.32	.04	2.96	2.	....	......	+	96,000
6664	" 11	" 12	*	Cons'd	M. F.04	......	367.2	325.2	42.	40.	15.2	24.8	B.	25.	9.	8.6	.4	1.6	.528	.352	.176	.96	.72	.24	.005	3.4	1.	....	......	+	32,000
6721	" 18	" 19	*	Much	M. F.4	......	619.6	288.8	330.8	40.4	23.6	16.8	B.	20.	17.7	9.8	7.9	1.92	.912	.32	.592	1.76	.768	.992	.045	.32	2.	....	2.6	+	168,000
6756	" 25	" 26	*	Cons'd	M. F.08	......	356.8	337.2	19.6	36.	25.6	10.4	B.	18.	12.9	8.8	4.1	2.4	.592	.368	.224	1.44	.96	.48	.022	1.32	4.	....	......	+	60,000
6788	" 30	" 31	*	"	M. F.04	......	321.2	306.	15.2	37.6	35.6	2.	G.	23.7	11.1	9.1	2.	2.4	.432	.368	.064	.96	.672	.288	.025	1.52	4.	....	......	+	119,000
6849	Feb. 6	Feb. 7	†	Little	M. F.03	......	294.8	271.2	23.6	33.6	32.4	1.2	G.	16.	7.6	6.1	1.5	1.12	.4	.224	.176	.8	.576	.224	.025	1.	4.	....	4.	....	49,000
6894	" 13	" 14	§	VMuch	VM. F.	......	470.8	214.8	256.	28.4	25.2	3.2	B.	13.	15.5	7.6	7.9	1.056	.576	.272	.304	1.6	.64	.96	.027	1.28	7.	....	—7.	+	99,000
6947	" 21	" 22	*	Cons'd	M. F.50	......	330.4	214.	116.4	75.2	23.6	51.6	B.	10.	14.2	8.3	5.9	.864	.576	.32	.256	1.04	.64	.4	.04	1.88	7.8	....	—0.	?	130,000
7031	Mar. 6	Mar. 7	†	"	M. F.50	......	264.	246.	18.	33.6	31.2	2.4	B.	10.4	12.1	9.2	2.9	.8	.352	.304	.048	.96	.8	.16	.006	1.76	7.	....	—4.	+	128,000
7090	" 14	" 15	*	"	M. F.20	......	392.8	231.6	161.2	24.8	19.2	5.6	B.	30.2	13.2	7.1	6.1	.736	.416	.256	.16	1.12	.416	.704	.015	1.2	12.	....	—1.	+	90,000
7128	" 20	" 22	*	Much	M. F.40	......	266.8	134.8	132.	28.4	14.4	14.	B.	3.9	13.9	6.5	7.4	.448	.48	.208	.272	1.24	.6	.64	.013	1.08	13.6	....	—6.	?	260,000
7201	" 29	" 30	*	Cons'd	M. F.10	......	209.2	151.2	58.	21.2	10.	11.2	B.	7.	11.	7.	4.	.4	.288	.224	.064	.664	.536	.128	.013	1.4	11.	....	4.	+	206,000
7241	Apr. 4	Apr. 5	*	"	M. F.40	......	215.2	169.6	45.6	26.	22.4	3.6	B.	6.1	11.3	8.	3.3	.4	.272	.256	.016	.632	.568	.064	.015	1.48	12.	7.	4.5	+	24,000
7284	" 10	" 11	*	"	M. F.70	......	229.6	176.8	52.8	26.8	13.6	13.2	B.	5.2	11.8	7.7	4.1	.32	.288	.208	.08	.696	.536	.16	.027	2.2	....	5.5	3.	+	36,500
7338	" 17	" 18	*	"	M. F.20	......	235.2	200.	35.2	26.	25.6	.4	B.	6.5	9.	7.7	1.3	.384	.272	.208	.064	.76	.536	.224	.01	2.1	9.	10.	18.	+	13,000
7405	" 24	" 26	†	"	M. F.	......	258.8	234.8	24.	32.	28.4	3.6	B.	9.4	8.2	7.9	.3	.176	.272	.208	.064	.824	.632	.192	.006	1.8	8.4	13.	22.	—	17,500
7464	May 3	May 4	†	"	M. F.06	......	286.	252.4	33.6	28.8	27.6	1.2	B.	10.5	14.1	8.5	5.6	.16	.528	.24	.288	1.28	.64	.64	.056	1.64	7.	15.5	21.	+	114,500
7486	" 8	" 9	†	"	M. F.10	......	437.6	262.	175.6	23.8	23.	.8	B.	10.9	13.6	7.8	5.8	.24	.592	.272	.32	1.44	.48	.96	.075	1.2	6.	17.	23.	+	48,500
7531	" 15	" 16	†	"	......	......	324.4	267.2	57.2	31.2	24.	7.2	B.	14.3	12.4	8.8	3.6	.128	.592	.256	.336	1.28	.896	.384	.075	.76	5.2	20.	29.	....	35,000
7566	" 22	" 23	*	Cons'd	M. F.06	......	325.2	286.	39.2	65.6	47.6	18.	B.	13.6	10.8	8.3	2.5	.448	.256	.224	.032	.836	.516	.32	.09	1.	4.1	16.5	24.	+	62,000
7604	" 29	" 31	*	Much	M. F.25	......	638.8	241.2	397.6	50.4	36.8	13.6	B.	14.	17.1	8.1	9.	.32	.688	.288	.4	1.92	.612	1.308	.065	.8	5.	21.	28.	—	92,000
7662	June 6	June 7	*	"	M. F.02	......	346.4	238.8	107.6	26.8	14.	12.8	B.	19.	11.	7.2	3.8	.256	.368	.176	.192	.96	.644	.316	.15	1.08	4.6	24.	30.	+	283,000
7712	" 13	" 14	†	Little	M. F.08	......	312.8	250.4	62.4	33.6	28.	5.6	B.	16.	6.9	6.2	.7	.192	.256	.192	.064	1.12	.52	.6	.15	1.88	4.	22.	26.	+	4,500
7757	" 20	" 21	*	Cons'd	M. F.05	......	287.2	248.8	38.4	32.	31.6	.4	B.	20.	7.5	7.5	0.0	.080	.256	.192	.064	.676	.452	.224	.12	1.44	3.	24.	29.	+	2,500
7791	" 27	" 28	‡	Little	T. F.01	M'sty	290.4	258.4	32.	26.	26.	0.0	B.	20.	6.5	6.2	.3	.4	.208	.192	.016	.996	.548	.448	.14	1.4	3.1	24.5	30.	+	4,000
7839	July 5	July 6	*	VLittle	T. F.10	......	275.2	253.2	22.	34.4	31.2	3.2	G.	10.5	6.5	6.5	....	.208	.208	.176	.032	.548	.516	.032	.13	1.44	2.9	27.	......	+	4,000
7897	" 10	" 12	*	"	M. F.20	......	306.2	272.8	33.4	55.2	30.	25.2	B.	20.	6.3	5.5	.8	.176	.208	.144	.064	.532	.44	.092	.13	1.56	2.6	25.	......	+	130,000
7959	" 18	" 19	*	Little	T. F.01	......	296.4	254.	42.4	37.2	32.8	4.4	B.	26.	5.9	5.7	.2	.304	.224	.16	.064	.510	.42	.096	.12	1.44	2.	24.	......	+	80,000
8019	" 24	" 26	*	"	T. F.01	......	373.2	243.2	130.	42.	14.8	27.2	B.	23.	16.6	4.3	12.3	.208	.272	.112	.16	.564	.324	.24	.07	1.36	2.5	25.	......	?	180,000
8069	Aug. 1	Aug. 2	*	"	T. F.01	......	244.8	232.	12.8	27.6	25.2	2.4	G.	22.	4.1	4.3	....	.112	.208	.176	.032	.484	.436	.048	.08	1.12	2.9	24.	......	+	170,000
8139	" 9	" 10	*	"	T. F.01	......	236.8	231.2	5.6	38.4	43.2	....	G.	20.	5.7	5.	.7	.208	.288	.224	.064	.548	.436	.112	.08	.98	2.7	28.	......	+	180,000
8202	" 16	" 18	*	"	T. F.02	......	316.	209.2	106.8	35.6	32.4	3.2	G.	23.	6.3	4.1	2.2	.224	.288	.208	.08	.58	.268	.312	.13	1.12	4.	25.5	......	+	29,000
8314	" 29	" 30	*	"	T. F.01	......	285.2	235.2	50.	25.2	14.8	10.4	G.	20.	7.	4.9	2.1	.16	.304	.176	.128	.54	.332	.208	.08	1.28	3.6	28.	......	+	8,000
8373	Sept. 5	Sept. 6	†	Cons'd	M.	......	306.8	252.	54.8	20.	17.2	2.8	B.	21.	7.1	4.6	2.5	.112	.24	.224	.016	.492	.268	.224	.15	1.32	3.7	25.5	......	+	10,500
8456	" 12	" 14	*	"	M. F.01	......	280.8	234.4	46.4	28.8	21.6	7.2	B.	19.	7.6	5.7	1.9	.16	.304	.192	.112	.7	......	......	.07	1.4	3.	24.	......	+	28,500
8498	" 19	" 20	*	"	M. F.01	......	282.4	240.4	42.	35.6	24.8	10.8	LB.	20.	7.7	6.7	1.	.176	.288	.192	.224	.7	.496	.204	.004	1.4	3.5	18.	......	+	24,500
8554	" 26	" 27	†	Little	M. F.15	......	230.4	202.	28.4	24.8	22.8	12.	LB.	29.	11.6	6.2	5.4	.8	.768	.304	.464	1.56	.800	.760	.1	1.08	1.6	22.	......	?	1,000,00
[illegible]	Oct. 3	Oct. 4	†	"	C. F.05	......	326.4	296.8	29.6	35.2	31.2	4.	......	25.	6.6	6.2	.4	1.12	.288	.24	.048	.64	.592	.048	.17	1.96	....	....	......	?	10,00

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. | Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

on IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bb., Brownish. R., Red. Rb., Reddish. W., Whi

ABLE 55.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, PEKIN.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illino

Serial No.	Date of: 1900 Collection.	Date of: 1900 Examination.	Appearance: Turb'y.	Appearance: Sediment.	Appearance: Color.	Odor.	Residue on Evaporation: Total.	Residue on Evaporation: Dissolved.	Residue on Evaporation: Suspended.	Loss on Ig'n: Tot'l	Loss on Ig'n: Dissolv'd	Loss on Ig'n: Susp'd	Color on Ignition.	Chlorine.	Oxygen Consumed: Total.	Oxygen Consumed: By Dissolved.	Oxygen Consumed: By Susp'd Matter.	Nitrogen as Ammonia: Free Ammonia.	Albuminoid Am.: Tot'l	Albuminoid Am.: Dissolv'd	Albuminoid Am.: Susp'd	Organic Nitrogen: Total.	Organic Nitrogen: Dissolved.	Organic Nitrogen: Suspended.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
6631	Jan. 5	Jan. 6	†	Little	M. F.04	......	389.2	379.2	10.	44.	35.2	8.8	B.	24.5	9.5	8.6	.9	1.92	.64	.352	.288	1.32	.616	.704	.04	2.88	3.	10.	......	?	900,00
6663	" 11	" 12	•	Cons'd	M. F.05	......	394.4	352.4	42.	48.	46.	2.	B.	25.5	9.8	9.4	.4	1.76	.56	.384	.176	1.12	.768	.352	.04	3.2	1.	0.	......	+	96,00
6723	" 18	" 19	•	Much	M. F.03	......	645.6	276.4	369.2	68.8	38.	30.8	B.	20.	17.9	9.1	8.8	2.	.912	.32	.592	1.76	1.024	.736	.045	1.5	2.	....	— 1.	?	150,00
6755	" 25	" 26	•	Cons'd	M. F.04	......	364.8	334.	30.8	45.6	30.4	15.2	B.	17.	12.	8.9	3.1	2.32	.608	.352	.256	1.36	.896	.464	.087	1.36	4.	....	—12.	+	47,500
6787	" 30	" 31	•	"	M. F.08	......	329.6	302.	27.6	44.	38.4	5.6	G.	23.5	10.4	8.3	2.1	2.56	.432	.288	.144	.96	.672	.288	.025	1.05	4.	....	—17.	+	128,000
6848	Feb. 6	Feb. 7	†	Little	M. F.03	......	287.6	275.6	12.	33.6	30.	3.6	G.	16.5	7.4	6.2	1.2	1.04	.416	.208	.208	.88	.544	.336	.025	1.06	4.	....	4.	....	36,000
6898	" 13	" 14	§	VMuch	VM. F.20	......	416.	206.8	209.2	38.	27.2	10.8	B.	13.	16.	7.4	8.6	.88	.608	.272	.336	1.44	.416	1.024	.08	1.32	7.	....	— 7.	+	77,500
6948	" 21	" 22	•	Cons'd	M. F.40	......	324.	217.6	106.4	87.6	21.6	66.	B.	10.	14.7	8.3	6.4	.864	.56	.32	.24	1.2	.48	.72	.084	2.8	7.8	....	0.	+	138,500
7022	Mar. 6	Mar. 8	†	"	M. F.40	......	277.6	237.2	40.4	22.4	22.	.4	B.	10.8	12.1	9.1	3.	.96	.368	.288	.08	1.04	.832	.208	.027	1.84	7.	....	......	+	45,500
7091	" 14	" 15	•	"	M. F.40	......	331.2	206.4	124.8	22.4	19.6	2.8	B.	9.4	12.5	9.4	3.1	.752	.416	.24	.176	.96	.544	.416	.014	1.4	12.	....	— 1.	....	70,000
7137	" 20	" 22	•	Much	M. F.50	......	275.6	148.8	126.8	20.	16.4	3.6	B.	5.4	12.7	7.2	5.5	.448	.408	.192	.216	1.08	.6	.48	.012	1.2	13.6	....	— 0.	+	250,000
7203	" 29	" 30	•	Cons'd	M. F.05	......	206.	144.8	61.2	16.	15.6	.4	B.	5.3	11.4	7.4	4.	.432	.304	.192	.112	.696	.504	.192	.012	1.58	11.	....	4.	?	128,000
7240	April 4	April 5	•	Much	M. F.25	......	212.4	171.6	40.8	15.6	15.6	0.0	B.	6.	11.2	8.2	3.	.448	.272	.224	.048	.632	.532	.1	.015	1.6	12.	7.	4.	+	55,500
7283	" 10	" 11	•	Cons'd	M. F.60	......	254.8	176.	78.8	30.	15.2	14.8	B.	5.3	13.1	8.5	4.6	.368	.288	.256	.032	.728	.6	.128	.064	2.	....	5.5	3.	—	34,500
7337	" 17	" 18	•	"	M. F.30	......	230.	209.6	20.4	31.6	28.8	2.8	B.	7.	10.8	8.3	2.5	.4	.32	.208	.112	.68	.536	.144	.04	2.	9.	10.	18.	+	10,500
7404	" 24	" 26	†	"	M. F.	......	277.2	254.4	22.8	29.2	27.6	1.6	B.	8.8	8.4	7.5	.9	.176	.288	.192	.096	.824	.632	.192	.04	1.76	8.4	13.	22.	+	28,500
7465	May 2	May 4	†	"	M. F.06	......	307.6	263.6	44.	26.	26.	0.0	B.	11.1	12.	8.8	3.2	.16	.608	.256	.352	1.3	.644	.656	.07	1.68	7.	15.5	21.	?	372,500
7486	" 8	" 9	†	"	M. F.10	......	442.	262.	180.	28.4	27.2	1.2	B.	11.	13.4	7.8	5.6	.24	.592	.272	.32	1.08	.54	.54	.075	1.08	6.	17.	23.	+	37,500
7530	" 15	" 16	...	......	......	......	330.	264.8	65.2	35.6	34.8	.8	B.	14.6	12.4	8.6	3.8	.128	.48	.288	.192	1.252	.832	.42	.096	.76	5.2	20.	20.	+	26,000
7584	" 22	" 23	•	Cons'd	M. F.05	......	326.	270.	56.	43.6	30.	13.6	B.	13.2	11.3	8.8	2.5	.32	.48	.288	.192	.836	.676	.16	.1	.96	4.1	17.	24.	+	12,500
7625	" 29	" 31	•	Much	M. F.10	......	668.	241.6	426.4	47.2	37.2	10.	B.	14.	21.6	8.	13.6	.272	.72	.288	.432	2.18	.612	1.568	.07	.84	5.	21.	28.	+	85,000
7661	June 6	June 7	†	Cons'd	M. F.02	......	294.8	242.	52.8	33.2	29.6	3.6	G.	18.7	8.4	6.9	1.5	.288	.24	.192	.048	.58	.52	.06	.014	1.44	4.6	24.	25.5	+	8,000
7713	" 13	" 14	...	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	4.	23.	25.5	......	......
7756	" 20	" 21	•	Cons'd.	M. F.05	......	341.2	285.2	56.	38.8	28.4	10.4	B.	20.	9.	8.	1.	.448	.352	.224	.128	.706	.57	.136	.15	1.36	3.	24.	20.	+	390,000
7792	" 27	" 28	‡	Little	T. F.01	......	298.4	261.6	36.8	36.	33.6	2.4	B.	21.	7.1	5.9	1.2	.544	.24	.224	.016	.82	.612	.208	.15	1.2	3.1	24.5	30.	......	164,000
7826	July 5	July 6	•	VLittle	T. F.06	......	276.8	241.6	35.2	32.	30.4	1.6	G.	20.5	7.	6.3	.7	.312	.24	.176	.064	.516	.452	.064	.14	1.44	2.9	27.	......	?	38,500
7865	" 10	" 12	•	"	T. F.20	......	285.2	273.6	11.6	46.4	39.2	7.2	B.	19.	8.3	6.5	1.8	.368	.324	.176	.148	.628	.356	.272	.13	1.36	2.6	25.	......	+	555,000
7900	" 18	" 19	•	"	T. F.02	......	285.6	256.	29.6	36.8	36.	.8	B.	26.5	6.9	4.8	2.1	.416	.272	.176	.096	.548	.432	.116	.17	1.44	2.	25.5	......	+	370,000
8030	" 24	" 26	•	"	T. F.01	......	275.6	237.2	38.4	26.	22.4	3.6	B.	24.	6.1	5.1	1.	.272	.24	.192	.048	.628	.356	.272	.09	1.32	2.5	25.	......	+	220,000
8062	Aug. 1	Aug. 2	•	Little	T. F.01	......	266.8	222.4	43.4	32.	24.8	7.2	B.	23.	5.2	4.6	.6	.272	.272	.176	.096	.676	.436	.24	.08	1.08	2.9	27.	......	+	400,000
8140	" 9	" 10	•	"	T. F.01	......	250.8	230.4	20.4	48.8	40.	8.8	G.	20.	6.	5.3	.7	.272	.288	.272	.016	.516	.468	.048	.08	.88	2.7	28.	......	+	215,000
8201	" 16	" 18	•	"	T. F.02	Gas'y	325.2	212.8	112.4	22.	20.	2.	B.	23.	7.	4.2	2.8	.288	.288	.176	.112	.772	.38	.392	.11	.84	4.	25.5	......	+	141,000
8315	" 29	" 30	•	"	M. F.01	......	282.8	229.6	53.2	14.8	13.6	1.2	B.	19.	8.5	4.6	3.9	.256	.288	.112	.176	.796	.54	.256	.09	1.08	3.8	28.	......	+	380,000
8374	Sept. 5	Sept. 6	•	Cons'd	M.	......	300.	259.6	40.4	20.4	18.	2.4	B.	21.	7.9	4.5	3.4	.288	.272	.24	.032	.7	.492	.208	.225	1.28	2.7	25.5	......	+	1,280,000
8459	" 12	" 14	•	"	M. F.03	......	277.2	236.	41.2	27.6	19.2	8.4	G.	18.	7.9	5.7	2.2	.256	.288	.144	.144	.568	.448	.12	.1	1.08	3.	24.	......	+	600,000
8493	" 19	" 20	•	"	M. F.01	......	280.4	253.6	26.8	26.	14.4	11.6	B.	21.	8.2	6.6	1.6	.208	.384	.224	.16	.62	.608	.012	.004	1.64	2.6	18.	......	+	47,500
8542	" 26	" 27	•	"	M. F.18	......	305.2	281.2	24.	29.2	28.4	.8	B.	28.	7.8	5.7	2.1	.672	.432	.208	.224	1.08	.492	.588	.375	1.04	1.6	22.	......	+	3,280,000
8606	Oct. 3	Oct. 4	...	....	M. F.08	......	343.6	313.6	30.	41.2	31.6	9.6	Bh.	26.	7.9	7.1	.8	1.184	.432	.256	.176	.8	.704	.096	.225	1.48	....	....	......	?	740,000

TURBIDITY—• Decided. § Very Decided. † Distinct. ‡ Very Slight. | Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 56.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, HAVANA.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
										Loss on Ig'n.									Albuminoid Am.												
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Tot'l.	Dissolv'd.	Suspnd'd.			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Tot'l.	Dissolv'd.	Suspnd'd.	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
6679	Jan. 11	Jan. 12	†	Cons'd	M. F.04	......	361.2	352.8	8.4	51.2	45.2	6.	B.	21.5	8.8	8.3	.3	1.6	.48	.304	.176	1.04	.736	.304	.04	2.4	4.6	—0.	1.	+	300,000
6752	“ 24	“ 25	*	“	M. F.04	......	368.	338.4	29.6	26.8	24.8	2.	B.	26.7	11.2	9.	2.2	2.56	.448	.352	.096	.88	.64	.24	.05	2.	6.7	4.	......	+	25,000
6795	“ 31	Feb. 1	*	“	M. F.15	......	311.2	295.6	15.6	15.2	15.2	....	B.	23.	9.1	8.8	.3	2.4	.512	.32	.192	1.04	.64	.4	.03	2.4	7.1	0.	—15.	+	46,500
6861	Feb. 7	“ 8	*	“	M. F.06	......	312.8	266.8	46.	18.	17.2	.8	B.	18.	9.3	7.	2.3	1.76	.464	.24	.224	.96	.64	.32	.027	1.36	7.4	1.	9.	+	66,800
6907	“ 14	“ 15	*	“	M. F.06	......	302.8	232.4	70.4	36.8	25.6	11.2	B.	15.7	9.7	7.	2.7	1.216	.416	.304	.112	.96	.576	.384	.031	1.4	10.	0.	......	—	54,500
6946	“ 21	“ 22	*	“	M. F.15	......	262.8	224.4	38.4	55.6	20.	35.6	B.	12.2	10.8	7.6	3.2	.896	.544	.32	.224	.88	.64	.24	.03	1.28	10.1	2.	......	?	67,000
6996	Mar. 1	Mar. 2	*	“	M. F.06	......	290.8	230.	60.8	20.8	20.4	.4	B.	11.	13.	10.9	2.1	.864	.448	.304	.144	.88	.64	.24	.04	1.48	11.8	1.	......	—	130,000
7042	“ 7	“ 8	*	“	M. F.5	......	266.4	234.4	32.	32.2	28.4	8.8	B.	11.	11.7	10.9	.8	.88	.416	.288	.128	.96	.64	.32	.035	1.8	11.1	1.	......	+	70,500
7081	“ 14	“ 15	*	Much	M. F.2	......	1067.6	85.6	982.	44.4	11.6	32.8	B.	.8	28.2	13.1	15.1	.4	1.44	.24	1.2	3.04	.576	2.464	.01	.4	14.5	0.	......	+	365,000
7149	“ 22	“ 23	*	“	M. F.4	......	255.2	138.8	116.4	19.2	10.8	8.4	B.	6.5	12.1	6.9	5.2	.528	.416	.224	.192	1.24	.6	.64	.008	1.08	17.	3.	9.	?	262,500
7200	“ 29	“ 30	*	Cons'd	M. F.2	......	201.2	147.6	53.6	16.4	14.4	2.	B.	4.	8.6	6.1	2.5	.32	.224	.176	.048	.632	.472	.16	.017	1.38	15.2	4.	......	?	20,500
7239	Apr. 4	Apr. 5	*	“	M. F.20	......	193.6	166.4	27.2	19.6	17.6	2.	B.	5.6	11.2	7.7	3.5	.448	.272	.208	.064	.536	.456	.08	.018	1.68	14.9	6.	7.	?	75,500
7292	“ 11	“ 12	*	“	M. F.20	......	227.	202.	25.	22.	22.	0.0	G.	5.	9.1	7.3	1.8	.256	.224	.192	.032	.6	.536	.064	.03	2.2	14.3	9.	3.	—	20,000
7346	“ 18	“ 19	*	“	M. F.15	. . .	220.2	189.6	30.6	34.	32.8	1.2	G.	5.3	8.1	6.9	1.2	.24	.224	.176	.048	.504	.44	.064	.035	2.2	12.9	11.	11.	?	7,000
7406	“ 25	“ 26	†	“	M. F.	......	220.4	202.8	17.6	30.	24.	6.	B.	6.9	9.8	8.1	1.7	.048	.4	.256	.144	1.24	.664	.576	.036	1.68	12.	11.5	18.	—	3,500
7446	May 2	May 3	†	“	M. F.10	......	234.4	216.4	18.	35.6	33.6	2.	B.	9.	10.3	8.4	1.9	.08	.56	.272	.288	1.16	.74	.42	.052	.88	11.2	20.	23.	+	3,000
7490	“ 9	“ 10	*	“	M. F.03	......	302.8	250.8	52.	22.8	20.	2.8	B.	9.8	10.8	8.2	2.6	.16	.448	.288	.16	.9	.612	.288	.08	.8	10.3	17.	17.	+	57,500
7548	“ 16	“ 17		....	M. F.1	......	327.2	264.	63.2	36.	34.8	1.2	B.	13.2	12.4	8.5	3.9	.384	.416	.32	.096	1.284	.132	1.152	.075	.76	9.1	24.	26.	+	8,000
7591	“ 23	“ 24	*	Little	M. F.05	......	382.8	294.	88.8	57.6	35.6	22.	B.	13.5	12.2	7.7	4.5	.448	.352	.24	.112	.9	.74	.16	.115	.12	9.	24.	27.	+	40,500
7696	“ 30	“ 31	*	Cons'd	M. F.10	......	328.4	267.6	60.8	24.8	19.6	5.2	B.	16.	11.1	8.5	2.6	.432	.368	.272	.096	1.16	.644	.516	.075	1.2	8.4	27.	32.	+	43,900
7711	June ..	June 14	*	“	M. F.03	......	342.	265.2	76.8	66.8	36.8	30.	B.	14.	9.7	6.4	3.3	.272	.32	.272	.048	1.22	.772	.448	.210	1.84	8.1	25.	33.	+	15,000
7847	July 5	July 6	*	Much	T. F.	Cla'y	285.6	262.4	23.2	29.2	24.4	4.8	B.	18.	7.	6.8	.2	.408	.224	.208	.016	.612	.388	.224	.16	1.59	7.	30.	......	—	60,000
7900	“ 11	“ 12	*	Little	T. F.02	......	276.4	248.	28.4	32.	30.8	1.2	B.	12.	6.5	6.2	.3	.288	.176	.16	.016	.516	.324	.192	.096	1.12	6.3	28.	......	?	2,000
7958	“ 18	“ 19	*	“	T. F.02	......	301.6	244.4	57.2	31.6	27.6	4.	B.	22.	7.5	5.9	1.6	.448	.24	.144	.096	.804	.58	.224	.12	1.24	6.3	26.	......	?	10,000
8021	“ 25	“ 26	*	“	T. F.01	......	310.	233.2	76.8	27.6	27.6	0.0	B.	25.	6.5	6.2	.3	.33	.272	.24	.032	.836	.356	.48	.08	1.4	5.6	27.	......	?	24,500
8081	Aug. 1	Aug. 2	*	“	T. F.01	......	273.2	232.	41.2	25.6	23.6	2.	G.	24.	6.5	5.1	1.4	.24	.248	.204	.044	.546	.356	.19	.13	1.28	6.4	29.	......	+	47,000
8142	“ 9	“ 10	*	“	T. F.01	......	269.2	219.2	50.	43.2	42.8	.4	G.	17.	7.2	4.3	2.9	.144	.304	.224	.08	.836	.456	.38	.08	.68	....	....	......	....	....
8203	“ 16	“ 18	*	“	T. F.02	Gas'y	316.2	200.4	115.8	24.8	22.	2.8	B.	18.	7.8	4.4	3.4	.416	.304	.192	.212	.836	.38	.456	.1	.76	7.	30.	......	+	27,500
8256	“ 22	“ 23	*	“	M. F.02	......	221.2	203.6	17.6	15.2	13.2	2.	G.	20.	6.6	4.7	1.9	.352	.288	.16	.128	.508	.316	.192	.15	1.04	7.7	29.	......	?	5,500
8313	“ 29	“ 30	*	“	M. F.01	......	273.6	228.	45.6	30.	19.2	10.8	B.	21.	6.5	4.4	2.1	.448	.368	.176	.192	.668	.3	.368	.16	1.08	7.3	28.	......	?	5,400
8392	Sept. 6	Sept. 7	†	“	M. F.01	......	290.4	249.6	40.8	21.2	19.2	2.	B.	20.	6.6	4.4	2.2	.176	.32	.192	.128	.536	.384	.152	.13	1.08	6.9	27.	......	+	35,500
8451	“ 12	“ 13	†	“	M. F.03	......	252.	234.4	17.6	26.8	24.	2.8	B.	16.	6.6	4.5	2.1	.512	.4	.16	.24	.76	.4	.36	.11	1.	6.6	25.	......	?	4,150
8510	“ 20	“ 21	*	Consid	M. F.1	......	294.4	253.2	41.2	29.6	25.6	4.	B.	21.	8.1	5.6	2.5	.391	.4	.192	.208	.76	.384	.376	.19	1.	5.2	20.	......	+	144,000
8543	“ 26	“ 27	*	“	M. F.2	......	322.	266.8	55.2	31.2	24.	7.2	B.	23.	7.6	5.8	1.8	.584	.352	.176	.176	1.084	......	......	.12	1.08	4.8	23.	......	+	19,000
8613	Oct. 4	Oct. 4	*	“	M. F.03	......	308.4	254.4	54.	30.	27.6	2.4	Bh.	18.	6.2	4.9	1.3	.896	.304	.272	.032	.98	.888	.086	.13	1.2	....	....	......	?	15,300

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. | Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

olor on Ignition—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., Whit

BLE 57.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—SANGAMON RIVER, CHANDLERVILLE.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illino

Serial No.	Date of: 1900 Collection.	Date of: 1900 Examination.	Appearance: Turb'y.	Appearance: Sediment.	Appearance: Color.	Odor.	Residue on Evaporation: Total.	Residue on Evaporation: Dissolved.	Residue on Evaporation: Suspended.	Loss on Ig'n: Tot'l	Loss on Ig'n: Dissolv'd	Loss on Ig'n: Suspnd'd	Color on Ignition.	Chlorine.	Oxygen Consumed: Total.	Oxygen Consumed: By Dissolved.	Oxygen Consumed: By Suspd Matter.	Nitrogen as Ammonia: Free Ammonia.	Albuminoid Am.: Tot'l	Albuminoid Am.: Dissolv'd	Albuminoid Am.: Suspend'd	Organic Nitrogen: Total.	Organic Nitrogen: Dissolved.	Organic Nitrogen: Suspended.	Nitrogen as: Nitrites.	Nitrogen as: Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
6612	Jan. 3	Jan. 4	†	Little	M. F.05	....	344.4	334.8	9.6	31.2	30.8	.4	G.	6.4	6.4	5.8	.6	.14	.128	.12	.008	.488	.424	.064	.016	2.6	3.	0.	3.5	—	9,400
6662	“ 10	“ 11	†	“	F.02	....	324.4	308.	16.4	40.4	38.8	1.6	B.	8.	3.3	3.3	0.0	.212	.112	.096	.016	.32	.288	.032	.012	1.86	3.6	1.	2.	—	11,100
6707	“ 17	“ 18	†	Cons'd	M. F.03	....	307.6	282.8	24.8	43.2	42.	1.2	B.	5.6	5.6	4.	1.6	.2	.208	.112	.096	.64	.224	.416	.013	1.3	3.6	4.	7.	—	11,950
6754	“ 24	“ 25	*	“	M. F.03	....	352.4	290.8	61.6	35.6	33.6	2.	B.	5.8	6.6	3.4	3.2	.24	.208	.144	.064	.64	.256	.384	.018	2.2	4.	5.	15.5	+	18,800
6800	“ 31	Feb. 1	†	Little	F.01	....	320.	313.2	6.8	34.8	33.2	1.6	G.	5.8	3.6	3.5	.1	.128	.128	.12	.008	.48	.32	.16	.018	1.4	4.	0.	15.	—	1,850
6863	Feb. 7	“ 8	*	Cons'd	M. F.03	....	348.	272.	76.	19.2	19.2	0.0	B.	6.4	7.6	4.8	2.8	.148	.224	.112	.112	.64	.32	.32	.015	1.36	5.	2.	13.	—	50,800
6914	“ 14	“ 15	*	Much	M. F.30	....	807.2	164.8	642.4	72.	11.2	60.8	B.	3.	29.8	6.3	23.5	.18	1.36	.176	1.184	2.64	.48	2.16	.015	1.52	7.	0.	— 4.	—	128,000
6997	Mar. 1	Mar. 3	*	Cons'd	M. F.03	....	384.8	229.6	155.2	45.2	39.2	6.	B.	4.5	13.1	8.1	5.	.224	.432	.16	.272	.88	.544	.336	.016	2.92	6.	0.	1.	+	125,500
7033	“ 7	“ 8	*	Much	M. F.02	....	408.8	207.6	201.2	29.6	24.4	5.2	B.	4.4	11.8	4.7	7.1	.108	.448	.144	.304	.88	.48	.4	.016	2.6	7.	1.	8.	+	123,000
7084	“ 14	“ 15	*	“	M. F.50	....	298.8	123.6	175.2	32.	12.	20.	B.	2.4	15.9	6.6	9.3	.14	.512	.208	.304	1.28	.416	.864	.012	1.48	10.	5.	4.	+	135,000
7136	“ 21	“ 22	*	“	M. F.20	....	490.8	179.6	311.2	35.2	8.	27.2	B.	3.2	17.7	5.6	12.1	.124	.608	.208	.4	1.68	.536	1.144	.02	2.72	12.	5.	4.	+	136,500
7184	“ 28	“ 29	*	Cons'd	M. F.03	....	324.	244.8	79.2	19.2	18.4	.8	B.	4.4	7.6	3.6	4.	.08	.24	.112	.128	.456	.28	.176	.014	3.4	8.	5.	6.	+	29,000
7242	April 4	April 5	*	“	M. F.03	....	346.4	272.8	73.6	29.2	26.8	2.4	B.	5.	6.2	3.9	2.3	.08	.192	.096	.096	.376	.248	.128	.02	3.4	8.	9.	11.	—	26,000
7300	“ 11	“ 12	*	“	M. F.01	....	323.6	271.2	52.4	20.	20.	0.0	G.	5.3	14.8	3.2	11.6	.016	.256	.128	.128	.472	.312	.16	.022	3.2	6.	9.	3.5	+	14,000
7348	“ 18	“ 19	*	“	M. F.03	....	311.6	276.	35.6	37.2	34.8	2.4	B.	5.4	5.	3.2	1.8	.048	.144	.112	.032	.408	.376	.032	.016	2.28	4.	16.	19.	?	7,500
7404	“ 25	“ 26	*	“	M. F.02	....	357.2	277.6	79.6	34.8	28.4	6.4	B.	5.8	6.6	3.8	2.8	.064	.224	.08	.144	.536	.28	.256	.018	1.52	4.	15.	25.	+	7,000
7456	May 2	May 3	*	“	M. F.03	....	372.4	300.	72.4	36.	26.	10.	B.	6.1	5.8	4.2	1.6	.024	.224	.128	.096	.484	.292	.192	.02	1.72	3.	18.	22.	+	4,300
7501	“ 10	“ 10	*	“	M. F.01	....	426.	259.	167.	34.8	33.6	1.2	B.	6.1	11.	4.2	6.8	.052	.416	.144	.272	1.3	.26	1.04	.015	1.64	3.	19.	22.	+	26,750
7562	“ 16	“ 17	*	“	M. F.04	....	370.4	295.6	74.8	39.6	38.	1.6	G.	5.9	7.9	4.8	3.1	.08	.32	.128	.192	.804	.356	.448	.025	1.	2.	25.5	31.	....	3,850
7602	“ 23	“ 24	§	V.M'ch	M. F.04	....	449.6	252.	197.6	46.4	28.8	17.6	B.	5.4	12.5	7.3	5.2	.076	.32	.16	.16	.836	.36	.476	.04	2.	3.	19.	22.	—	12,600
7637	“ 30	“ 31	*	Cons'd	M. F.03	....	522.	285.6	236.4	68.	38.4	29.6	B.	5.	13.2	4.4	8.8	.04	.32	.128	.192	.9	.308	.592	.032	2.2	3.	25.5	27.	+	11,700
7675	June 6	June 7	*	Much	M. F.03	....	445.2	248.4	196.8	42.	35.6	6.4	B.	5.4	13.3	4.6	8.7	.02	.336	.096	.24	.868	.34	.528	.04	2.06	4.	25.5	30.	+	13,000
7730	“ 13	“ 14	*	Cons'd	M. F.04	....	420.4	236.	184.4	41.6	26.4	15.2	B.	3.8	11.4	5.1	6.3	.032	.4	.176	.224	1.	.452	.548	.033	3.2	5.	25.5	30.	+	7,050
7760	“ 20	“ 21	§	V.M'ch	M. F.03	....	416.	312.4	103.6	84.	52.8	31.2	B.	4.9	9.	4.8	4.2	.024	.256	.16	.096	.52	.308	.212	.025	2.	3.	27.	24.	....	5,200
7800	“ 27	“ 28	*	Cons'd	M. F.05	M'sty	480.4	278.8	201.6	71.2	39.6	31.6	B.	5.8	11.7	5.4	6.3	.054	.304	.176	.128	1.032	.368	.664	.03	1.92	3.	28.	30.	+	98,000
7834	July 4	July 5	*	Much	T. F.08	“	391.2	191.2	200.	37.2	31.2	6.	B.	3.	13.6	6.6	7.	.080	.324	.176	.148	1.156	.532	.624	.07	1.2	5.	28.	....	....	3,500
7882	“ 18	“ 19	†	Cons'd	M. F.02	....	446.8	254.8	192.	35.2	21.6	13.6	B.	6.	10.5	5.5	5.	.076	.272	.176	.096	.708	.324	.384	.032	1.08	4.	25.5	....	?	5,500
8135	Aug. 8	Aug. 9	*	VLittle	T. F.01	....	382.	277.6	104.4	49.2	40.8	8.4	B.	5.	6.3	4.7	1.6	.068	.208	.144	.064	.516	.308	.208	.008	1.04	2.	30.	....	+	3,000
8295	“ 22	“ 23	*	Little	M. F.04	SLGs.	383.2	194.8	188.4	34.8	22.	12.8	B.	4.5	10.6	4.4	6.2	.120	.416	.224	.192	.796	.54	.256	.018	.92	4.	30.	....	—	1,650
8340	“ 30	Sept. 1	*	Much	M. F.04	....	414.4	214.8	199.6	37.6	30.4	7.2	B.	5.	10.3	5.1	5.2	.116	.352	.224	.128	.824	.316	.508	.035	.88	3.	21.	....	—	8,700
8389	Sept. 5	“ 6	*	Cons'd	M. F.03	....	399.2	230.	169.2	36.4	12.8	23.6	B.	3.6	9.6	3.8	5.8	.152	.32	.16	.16	.504	.32	.184	.015	.92	3.	27.	....	—	4,000
8506	“ 19	“ 20	*	Little	M. F.01	....	329.2	280.	49.2	21.6	16.	5.6	B.	5.4	5.1	3.3	1.8	.128	.208	.192	.016	....	.304	....	.005	.68	2.	18.	....	—	3,300
8561	“ 26	“ 27	†	“	M.	....	342.	291.8	50.2	28.	21.2	6.8	B.	6.	4.8	3.6	1.2	.172	.272	.112	.16	.492	.4	.092	.001	.56	3.	24.	....	—	5,050
8612	Oct. 3	Oct. 4	*	Cons'd	M. F.05	....	374.8	274.8	100.	28.4	21.6	6.8	B.	5.4	13.1	6.1	7.	.106	.384	.24	.144	1.208	.48	.728	.002	.88	..	....	....	?	5,100

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ∥ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White

TABLE 58.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, BEARDSTOWN.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l.	Dissolv'd.	Susp'nd.							Tot'l.	Dissolv'd.	Susp'nd.										
6627	Jan. 4	Jan. 5	†	Cons'd	M. F.04	......	386.	375.2	10.8	44.	35.6	8.4	B.	29.	11.	8.2	2.8	2.56	.48	.304	.176	1.	.808	.192	.04	2.6	7.	0.	−2.	−	21,500
6680	" 11	" 12	†	"	M. F.03	......	343.6	338.8	4.8	39.2	34.4	4.8	B.	20.	8.2	7.3	.9	1.25	.368	.288	.08	.96	.64	.32	.035	1.28	7.1	0.	−1.	+	690,000
6722	" 18	" 19	*	Much	M. F.03	......	558.	279.6	278.4	52.	42.	10.	B.	16.	13.6	7.3	6.3	1.12	.528	.208	.32	1.28	.576	.704	.030	2.6	8.	0.	1.	+	238,000
6764	" 25	" 26	*	"	M. F.03	......	498.	320.4	177.6	53.2	34.4	18.8	B.	25.	14.6	8.1	6.5	2.03	.608	.352	.176	1.28	.64	.04	.04	1.84	......	......	−9.	......	......
6804	Feb. 1	Feb. 2	*	Cons'd	M. F.04	......	329.6	308.4	21.2	34.8	28.	6.8	G.	23.	10.4	8.	2.4	2.16	.368	.256	.112	.864	.512	.352	.027	1.84	7.8	0.	−15.5	+	15,500
6871	" 8	" 9	*	Much	M. F.04	......	1250.8	216.8	1034.	49.2	17.6	31.6	B.	......	17.9	6.8	11.1	1.2	.864	.272	.592	1.92	.512	1.408	.017	1.4	9.2	0.	−1.	......	256,000
6930	" 15	" 16	§	V. "	M. F.03	......	733.6	211.2	522.4	47.6	18.8	28.8	B.	12.	18.4	4.9	13.5	.8	.64	.32	.32	2.08	.64	1.44	.019	1.34	10.4	0.	−15.5	+	760,000
6967	" 22	" 23	§	V. "	M. F.10	......	603.2	201.2	402.	31.2	23.6	7.6	B.	6.4	17.3	7.5	9.8	.704	.576	.304	.272	1.08	.04	1.04	.035	2.34	10.9	0.	0.	+	260,000
6994	Mar. 1	Mar. 3	§	Cons'd	M. F.05	......	339.6	237.6	102.	43.6	29.6	14.	B.	11.	13.3	9.8	3.5	.864	.432	.336	.096	.8	.64	.16	.035	1.44	9.8	0.	−1.	+	316,000
7051	" 8	" 9	*	"	M. F.30	......	352.	229.2	122.8	31.6	16.4	15.2	B.	9.2	13.6	10.6	3.	.752	.448	.32	.128	1.12	.576	.544	.035	1.72	11.3	0.	−3.	+	61,500
7095	" 15	" 16	*	Much	M. F.60	......	410.4	160.8	249.6	43.6	21.6	22.	B.	4.3	15.5	7.5	8.	.32	.512	.256	.256	1.76	.576	1.184	.013	.64	16.8	0.	−2.	+	250,000
7151	" 22	" 23	*	"	M. F.15	......	305.2	144.	161.2	22.4	14.	8.4	B.	5.7	14.	5.7	8.3	.48	.416	.208	.208	1.24	.536	.704	.013	1.16	17.4	0.	7.	+	113,000
7204	" 29	" 30	*	Cons'd	M. F.15	......	239.2	119.2	120.	26.4	18.	8.4	B.	4.3	11.2	6.8	4.4	.384	.256	.192	.064	.728	.408	.32	.012	.76	15.9	1.	1.	−	158,500
7253	Apr. 5	Apr. 6	*	Much	M. F.06	......	358.	148.	210.	26.8	14.4	12.4	B.	4.9	15.8	7.9	7.9	.4	.448	.176	.272	1.112	.472	.64	.013	1.64	14.7	1.	7.	+	46,500
7318	" 12	" 13	*	Cons'd	M. F.06	......	284.8	174.8	110.	30.8	29.2	1.6	B.	5.8	19.1	7.5	11.6	.4	.32	.24	.08	.92	.568	.352	.017	1.72	14.1	1.	0.	−	20,000
7373	" 19	" 20	*	"	M. F.15	......	290.8	199.6	91.2	36.	24.8	11.2	B.	6.	11.3	9.1	2.2	.32	.208	.096	.112	.856	.664	.192	.032	1.12	13.	8.	13.	+	19,000
7429	" 26	" 27	*	"	M. F.02	......	310.	229.6	80.4	24.	24.	0.0	B.	7.2	12.3	6.6	5.7	.128	.432	.208	.224	1.048	.536	.512	.045	1.88	12.1	10.	17.	?	17,000
7467	May 3	May 4	*	"	M. F.07	......	302.	204.8	97.2	25.6	24.	1.6	B.	9.1	12.6	8.2	4.4	.176	.48	.24	.24	1.16	.48	.68	.06	1.4	11.1	11.	8.	+	9,500
7518	" 10	" 11	*	"	M. F.07	......	387.2	249.2	138.	34.4	32.8	1.6	B.	9.5	27.	8.	19.	.24	.48	.24	.24	1.08	.512	.568	.04	1.08	10.3	18.	8.	?	30,000
7563	" 16	" 17	*	"	M. F.06	......	375.6	274.	101.6	49.6	46.8	2.8	B.	12.	12.6	8.1	4.5	.192	.4	.208	.192	.996	.74	.256	.03	.72	9.6	25.5	20.	+	6,300
7601	" 23	" 24	§	V.M'ch	VM. F.1	......	440.4	274.	166.4	48.8	44.	4.8	B.	12.2	12.2	8.8	3.4	.256	.368	.224	.144	.9	.48	.42	.075	.9	9.5	25.5	20.	−	2,600
7636	" 30	" 31	*	Cons'd	M. F.04	......	400.	287.2	112.8	56.8	52.	4.8	B.	13.	11.3	7.5	3.8	.272	.384	.288	.096	1.092	.68	.412	.07	.92	9.1	27.	21.	+	7,000
7684	June 7	June 8	*	"	M. F.03	......	400.	241.2	158.8	45.2	26.8	18.4	B.	14.5	9.5	7.5	2.	.224	.352	.224	.128	.708	.548	.16	.144	1.28	9.	27.	22.	+	15,500
7729	" 14	" 15	*	"	M. F.04	......	380.	240.8	139.2	24.4	22.4	2.	B.	14.	11.5	6.8	4.7	.16	.32	.288	.032	.802	.56	.242	.14	1.76	8.8	24.	18.	+	6,950
7765	" 21	" 22	*	Much	M. F.07	......	384.	286.8	97.2	40.4	36.4	4.	B.	15.	10.8	6.8	4.	.16	.32	.208	.112	.708	.5	.208	.115	1.12	8.3	24.	20.	......	4,500
7806	" 28	" 29	*	Cons'd	M. F.15	......	358.8	272.8	86.	65.6	50.4	15.2	B.	16.	10.8	6.7	4.1	.112	.336	.24	.096	.648	.58	.068	.01	1.64	7.9	24.5	27.	+	4,900
7846	July 5	July 6	*	Slight	T. F.	Sl. M.	326.	240.	86.	25.2	20.8	4.4	B.	14.	7.9	7.7	.2	.112	.272	.208	.064	.688	.432	.256	.13	1.64	8.1	21.	......	......	3,5
7916	" 12	" 13	*	Little	T. F.03	......	338.8	249.2	89.6	37.6	29.6	8.	B.	16.	7.2	6.5	.7	.096	.272	.24	.032	.616	.56	.056	.13	1.28	7.7	25.5	......	−	4,00
7965	" 19	" 20	*	"	T. F.02	......	306.	233.2	72.8	32.	24.	8.	B.	16.	7.8	6.	1.8	.112	.24	.192	.048	.42	.308	.112	.13	1.32	7.4	27.	......	−	3,00
8034	" 26	" 27	*	"	T. F.01	......	347.6	250.8	96.8	55.2	36.	19.2	B.	22.	7.	5.5	1.5	.056	.272	.144	.128	.676	.42	.256	.1	1.32	7.5	27.	......	−	6,60
8066	Aug. 2	Aug. 3	*	"	T. F.01	......	319.6	238.	81.6	50.	43.2	6.8	G.	23.	6.5	4.7	1.8	.08	.24	.192	.048	.708	.56	.148	.09	1.32	7.4	28.	......	−	4,05
8143	" 9	" 10	*	"	T. F.01	......	287.6	247.2	40.4	37.2	32.8	4.4	G.	22.	7.6	4.4	3.2	.08	.304	.176	.128	.516	.264	.252	.09	1.08	7.4	28.	......	+	32,40
8195	" 16	" 17	*	"	T. F.01	......	336.	195.2	140.8	52.	20.	32.	B.	18.5	7.5	4.7	2.8	.176	.368	.192	.176	.968	.332	.636	.09	1.24	7.3	24.	......	−	14,45
8273	" 23	" 24	*	"	M. F.04	M'sty	278.	208.	70.	27.2	20.	7.2	B.	18.	7.5	4.1	3.4	.112	.304	.112	.192	.626	.3	.326	.13	.96	8.4	28.	......	−	16,0
8339	" 30	" 31	*	"	M. F.04	Gas'y	308.4	230.8	77.6	30.	29.2	.8	B.	19.	7.7	4.7	.3	.128	.32	.288	.032	.636	.3	.336	.15	1.08	8.1	28.	......	−	[illegible]
8406	Sept. 6	Sept. 7	*	V.M'ch	M. F.03	......	433.2	226.8	206.4	31.6	20.4	11.2	B.	19.	9.1	4.3	4.8	.056	.32	.256	.064	.508	.384	.124	.1	1.2	8.2	27.	......	?	[illegible]
8462	" 13	" 14	*	Cons'd	M. F.04	......	315.2	235.2	80.	20.8	18.4	2.4	B.	18.	9.3	5.6	3.7	.224	.704	.144	.56	1.02	.392	.628	.13	1.04	7.7	22.	......	+	[illegible]
8509	" 20	" 21	*	"	M. F.1	......	402.8	247.6	155.2	28.4	20.	8.4	B.	18.	10.5	5.8	4.7	.280	.512	.208	.304	.984	.32	.664	.075	.8	7.2	20.	......	+	[illegible]
8566	" 27	" 28	*	"	M.	......	344.8	250.	94.8	35.2	28.8	6.4	......	19.	7.8	6.2	1.6	.32	.368	.224	.144	.632	.608	.024	.1	1	6.8	14.5	......	+	[illegible]
[illegible]	Oct. 4	Oct. 5	*	"	M. F.04	......	337.4	251.8	85.6	33.2	26.8	6.4	B.	28.	6.9	4.7	2.2	.064	.288	.256	.08	.688	.608	.08	.13	1.47	......	......	......	+	[illegible]

TURBIDITY—*Decided. §Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

or on IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., W

T. J. BURRILL,
University of Illino

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, KAMPSVILLE.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dis-solv'd	Sus-pnd'd							Tot'l	Dis-solv'd	Sus-pnd'd										
6660	Jan. 3	Jan. 4	†	Little	F.08	......	389.6	379.6	10.	45.6	42.	3.6	B.	31.7	8.1	8.	.1	2.24	.432	.304	.128	.84	.616	.224	.06	1.68	15.7	2.	—2.	—	1,700
6704	" 17	" 18	†	Cons'd	M. F.03	......	343.2	338.4	4.8	50.8	47.6	3.2	B.	17.	7.2	6.6	.6	1.28	.384	.272	.112	.8	.64	.16	.036	2.60	15.9	3.	6.	—	72,000
6757	" 25	" 26	•	"	M. F.2	......	382.4	218.	164.4	32.8	21.6	11.2	B.	10.	13.7	6.8	6.9	1.04	.448	.224	.224	1.12	.32	.8	.03	3.	16.6	4.	16.5	+	53,500
6794	" 31	Feb. 1	•	"	M. F.05	......	330.8	305.2	25.6	16.	13.2	13.2	B.	19.	8.6	8.3	.3	1.6	.368	.24	.128	.88	.576	.304	.027	1.8	16.2	0.	—13.	—	19,700
6862	Feb. 7	" 8	•	"	M. F.03	......	426.8	270.	156.8	28.8	28.8	....	B.	16.	12.2	7.3	4.9	1.6	.512	.272	.24	1.04	.544	.496	.018	1.84	16.4	....	......	+	300,000
6906	" 14	" 15	§	V.M'ch	VM. F.06	......	1240.8	193.6	1047.2	71.2	26.	45.2	B.	9.	17.8	7.0	10.8	.736	1.376	.208	1.168	3.2	.416	2.784	.023	1.72	17.5	1.	—4.	+	150,000
6964	" 21	" 22	•	Much	VM. F.	......	768.8	180.4	588.4	90.8	20.8	70.	R.	7.6	16.9	7.1	9.8	.672	.736	.336	.4	2.32	.608	1.712	.022	2.	18.5	1.	4.	+	108,000
7050	Mar. 7	Mar. 9	•	Cons'd	M. F.04	......	917.2	178.8	738.4	43.6	14.8	28.8	B.	6.4	17.3	6.4	10.9	.656	.608	.208	.4	1.84	.544	1.296	.015	1.64	18.6	1.	......	+	122,000
7093	" 14	" 16	§	V.M'ch	M. F.3	......	905.2	136.4	768.8	30.	13.6	13.4	B.	4.1	17.2	5.8	11.4	.32	.672	.192	.48	1.92	.32	1.6	.013	1.04	21.9	3.	2.	+	31,800
7126	" 21	" 22	§	Much	M. F.1	......	534.8	165.2	369.6	34.8	20.	14.8	B.	4.6	16.	8.	8.	.352	.496	.208	.288	1.24	.6	.64	.013	1.20	24.4	1.5	—2.	+	9,300
7181	" 28	" 29	•	Cons'd	M. F.4	......	311.2	147.6	163.6	26.	15.6	10.4	B.	4.8	11.5	8.5	3.	.432	.304	.192	.112	.984	.504	.48	.012	1.4	23.9	6.	12.	—	90,500
7230	Apr. 4	Apr. 5	•	"	M. F.30	......	292.	144.4	147.6	24.	8.4	15.6	B.	4.2	11.	6.9	4.1	.336	.288	.176	.112	.664	.44	.224	.015	1.32	23.2	8.	6.	+	31,000
7291	" 11	" 12	•	"	M. F.30	......	331.2	166.8	164.4	20.	18.8	1.2	B.	5.3	11.6	7.7	3.9	.272	.32	.192	.128	.696	.568	.128	.035	1.64	21.8	9.	8.	+	11,800
7347	" 18	" 19	•	"	M. F.30	......	325.6	190.8	134.8	26.4	26.4	0.0	B.	5.5	11.8	6.8	5.	.208	.352	.256	.096	.92	.824	.096	.03	2.08	23.	11.	22.	+	15,800
7414	" 25	" 26	•	"	M. F.21	......	353.2	224.	129.2	39.2	20.4	18.8	B.	6.8	11.3	7.1	4.2	.144	.336	.208	.128	.824	.568	.256	.026	1.12	19.5	15.	19.	—	5,300
7458	May 2	May 3	•	"	M. F.03	......	402.8	251.6	151.2	35.6	26.4	9.2	B.	8.6	12.5	7.4	5.1	.096	.512	.224	.288	.136	.464	.896	.03	1.6	18.1	20.	......	+	4,100
7492	" 9	" 10	•	"	M. F.08	......	457.6	233.6	224.	26.	24.8	1.2	B.	9.	13.	7.7	5.3	.192	.48	.224	.256	.1	.484	.516	.025	1.	17.8	15.	......	+	6,000
7575	" 16	" 18	..	......	......	......	...	......	......	....	....	....	......	.....	....	....	....	......	......	......	......	......	......	......	....	......	....	....	......	....	......
7600	" 23	" 24	§	V.M'ch	M. F.05	......	515.6	268.8	246.8	48.4	44.8	3.6	B.	10.2	13.8	8.4	5.4	.256	.416	.224	.192	.904	.52	.384	.04	.8	17.2	19.5	30.	—	5,450
7634	" 30	" 31	§	"	M. F.05	......	444.	262.	182.	42.	36.8	5.2	B.	14.	12.5	6.8	5.7	.136	.368	.256	.112	1.092	.548	.544	.06	1.36	17.	27.	25.	+	6,000
7698	June 6	June 7	§	Cons'd	M. F.03	......	399.2	248.	151.2	49.6	47.6	2.	B.	14.	11.3	8.2	3.1	.096	.336	.208	.128	.772	.52	.252	.09	1.48	16.8	27.	......	+	1,150
7721	" 13	" 14	§	"	M. F.03	......	430.8	270.4	160.4	47.6	27.6	20.	B.	15.	9.4	6.4	3.	.048	.32	.224	.096	1.	.5	.5	.05	1.76	16.7	26.	......	+	4,050
7759	" 20	" 21	§	Much	M. F.05	......	377.6	262.8	114.8	44.	23.2	20.8	B.	13.	8.7	6.	2.7	.032	.256	.192	.064	.516	.402	.114	.06	1.48	16.6	25.	......	....	1,800
7799	" 27	" 28	§	V. Sl'ht	T. F.1	......	392.4	295.6	96.8	82.4	56.	26.4	B.	15.	8.7	6.3	2.4	.032	.304	.24	.064	.744	.564	.18	.06	1.24	16.4	29.	......	+	2,300
7862	July 4	July 5	§	Little	T. F.05	......	335.2	248.4	86.8	28.	27.2	.8	B.	16.5	8.9	6.3	2.6	.048	.208	.192	.016	.452	.368	.084	.035	1.36	16.5	29.	......	....	1,950
7910	" 11	" 12	§	"	T. F.03	......	266.	222.	44.	22.4	17.2	5.2	B.	15.	6.	6.	0.0	.096	.176	.16	.016	.452	.372	.08	.06	1.52	....	....	......	....	......
7961	" 18	" 19	§	"	T. F.01	... .	281.2	233.2	48.	35.2	18.	17.2	B.	15.	7.1	4.6	2.5	.048	.192	.176	.016	.5	.308	.192	.04	1.08	16.2	27.	......	+	2,300
8025	" 25	" 26	§	Cons'd	T. F.01	......	280.8	240.4	40.4	41.2	27.2	14.	B.	20.	6.3	5.2	1.1	.152	.272	.176	.096	.616	.244	.372	.07	1.52	16.1	27.	......	—	1,500
8084	Aug. 1	Aug. 3	§	Little	T. F.02	......	253.6	240.	13.6	28.	24.	4.	G.	20.	5.1	4.6	.5	.112	.224	.208	.016	.74	.58	.16	.04	1.28	16.1	29.	......	+	1,700
8141	" 7	" 10	§	"	T. F.01	......	282.8	238.	44.8	40.8	25.6	15.2	G.	20.	5.1	5.	.1	.144	.24	.224	.016	.728	.36	.368	.045	.92	16.1	30.	......	—	16,050
8190	" 15	" 17	§	"	T. F.01	......	276.	231.2	44.8	35.2	36.4	....	B.	19.	6.9	4.9	2.	.112	.32	.176	.144	.676	.316	.36	.04	.96	15.9	29.	......	•	680,000
8272	" 22	" 24	§	"	M. F.3	......	348.	61.2	286.8	30.4	16.4	14.	B.	15.	8.8	4.7	4.1	.144	.288	.16	.128	.972	.268	.704	.01	.92	16.6	29.	......	—	24,150
8333	" 29	" 30	§	"	T. F.02	......	312.8	210.8	102.	29.6	24.	5.6	B.	17.	7.8	5.	2.8	.112	.32	.128	.192	.72	.38	.34	.04	1.08	16.4	27.	......	—	1,300
8387	Sept. 5	Sept. 6	..	......	F.02	......	326.8	221.2	105.6	22.	12.8	9.2	B.	15.	7.4	4.4	3.	.112	.288	.112	.176	.472	.4	.072	.05	1.04	16.6	28.	......	+	4,100
8456	" 12	" 13	§	Cons'd	M. F.08	......	297.2	248.4	48.8	23.6	16.8	6.8	B.	18.	7.7	5.8	1.9	.112	.288	.24	.048	.7	.4	.3	.035	1.	16.3	22.	......	+	1,050
8507	" 19	" 20	§	"	M. F.1	......	294.4	232.4	62.	24.8	22.	2.8	B.	16.	7.7	5.4	2.3	.128	.32	.128	.192	.536	.416	.12	.04	1.	16.	17.	......	+	15,350
8560	" 26	" 27	§	"	M.	......	302.	248.8	53.2	32.4	24.	8.4	B.	18.	6.3	5.9	.4	.16	.272	.256	.016	.6	......	......	.075	.88	15.8	25.	......	+	2,000
8614	Oct. 3	Oct. 4	§	"	M. F.04	......	314.8	250.8	64.	37.2	35.6	1.6	Bh.	18.	7.5	5.9	.6	.128	.304	.256	.048	.8	.544	.256	.06	1.28	....	....	......	—	2,100

TURBIDITY—• Decided. § Very Decided. † Distinct. ‡ Very Slight. ǀ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 60.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, GRAFTON. (Regulars and Extras.)

Serial No.	Date of 1900 Collection.		Date of 1900 Examination.		Turb'y.	Appearance. Sediment.	Appearance. Color.	Odor.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Loss on Ig'n. Tot'l.	Loss on Ig'n. Dissolv'd.	Loss on Ig'n. Suspend'd.	Color on Ignition.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspd Matter.	Nitrogen as Ammonia. Free Ammonia.	Albuminoid Am. Tot'l.	Albuminoid Am. Dissolv'd.	Albuminoid Am. Suspend'd.	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
6626	Jan.	4	Jan.	5	*	Cons'd	M. F.04	......	395.2	382.	13.2	40.4	38.8	1.6	B.	30.	11.8	8.3	3.5	2.34	.416	.288	.128	.92	.552	.368	.07	1.76	2.9	0.	......	—	57,300
6666	"	10	"	11	†	Little	M. F.03	......	308.	305.2	2.8	28.4	28.	.4	G.	27.	7.5	7.4	.1	2.16	.432	.304	.128	.792	.6	.192	.03	2.28	4.2	0.	......	—	30,600
6706	"	17	"	18	†	Cons'd	M. F.03	......	338.4	329.6	8.8	47.6	44.4	3.2	B.	16.	7.2	6.5	.7	.704	.32	.208	.112	.72	.544	.176	.03	2.4	3.5	3.	......	—	41,300
6751	"	24	"	25	*	Much	M. F.02	......	502.4	216.	286.4	40.	22.4	17.6	B.	10.	16.	8.1	7.9	.8	.512	.208	.304	1.12	.704	.416	.03	2.	5.1	4.	......	+	60,000
6783	"	28	"	31	*	Cons'd	M. F.03	......	438.8	304.4	134.4	34.	29.2	4.8	B.	19.	11.5	8.5	3.	1.6	.416	.256	.16	.96	.64	.32	.04	2.2	4.9	0.	......	+	28,500
6785	"	29	"	31	*	"	M. F.03	......	435.6	315.6	120.	33.3	32.5	.8	G.	20.	11.1	8.1	3.	1.6	.368	.24	.128	.88	.576	.304	.035	2.4	4.5	0.	......	+	14,800
6793	"	30	Feb.	1	*	"	M. F.03	......	388.8	312.8	76.	30.4	28.4	2.	B.	19.5	9.3	8.7	.6	1.6	.352	.256	.096	.88	.544	.336	.028	2.4	3.7	0.	......	—	17,300
6802	"	31	"	2	*	"	M. F.02	......	439.2	311.2	128.	38.	29.2	8.8	G.	21.	10.	8.1	1.9	1.6	.352	.208	.144	.88	.576	.304	.032	2.2	2.8	0.	......	—	24,900
6808	Feb.	1	"	2	*	"	M. F.03	......	412.	314.8	97.2	30.4	26.	4.4	G.	19.	11.2	7.6	3.6	1.44	.384	.208	.176	.864	.448	.416	.025	2.4	2.	0.	......	—	5,200
6819	"	2	"	3	*	"	M. F.03	......	430.4	314.4	116.	40.	38.	2.	B.	19.	10.5	7.5	3.	1.44	.4	.288	.112	.768	.576	.192	.024	1.8	....	0.	......	+	72,000
6820	"	3	"	5	*	"	M. F.03	......	455.2	314.	141.2	34.	25.6	8.4	B.	19.5	12.3	7.7	4.6	1.36	.4	.24	.16	.8	.48	.32	.026	1.52	1.2	0.	......	.....	113,400
6834	"	4	"	6	*	"	M. F.04	......	391.2	303.2	88.	30.	30.	0.0	G.	19.	8.6	7.2	1.4	1.44	.416	.256	.16	.88	.576	.304	.015	1.6	1.5	0.	......	.....	189,000
6839	"	5	"	6	*	"	M. F.03	......	382.8	304.4	78.4	24.8	23.6	1.2	B.	19.	7.8	5.9	1.9	1.504	.384	.24	.144	.72	.544	.176	.02	1.48	....	....	......	....	....
6856	"	6	"	7	*	"	M. F.04	......	466.8	388.8	78.	46.4	38.4	8.	G.	18.5	9.6	6.6	3.	1.52	.416	.208	.208	.88	.512	.368	.021	1.12	2.8	0.	......	—	100,800
6864	"	7	"	8	*	"	M. F.03	......	326.8	271.2	55.6	18.4	12.4	6.	B.	17.	10.9	7.7	3.2	1.36	.384	.176	.208	.8	.576	.224	.018	1.6	2.8	0.	......	+	258,000
6873	"	8	"	9	*	Much	M. F.03	......	832.8	284.8	548.	43.6	35.2	8.4	B.	15.	17.1	6.4	10.7	1.28	.752	.24	.512	1.84	.416	1.424	.015	1.88	5.4	0.	......	+	206,000
6880	"	9	"	10	§	"	M. F.03	......	595.6	221.6	374.0	31.6	18.0	13.6	B.	13.	13.9	6.3	7.6	.96	.592	.208	.384	1.28	.448	.832	.015	1.32	7.8	0.	......	+	212,000
6882	"	10	"	11	*	V.M'ch	VM.F.15	......	908	202.4	705.6	64.	27.6	36.4	B.	9.	17.5	6.6	10.9	.72	.768	.256	.512	1.84	.512	1.328	.017	1.48	7.1	0.	......	+	69,000
6886	"	11	"	13	§	Much	VM.F.15	......	1364.	244.	1120.	65.2	18.	47.2	B.	9.	24.	7.9	16.1	.576	1.216	.24	.976	2.88	.768	2.112	.028	1.48	6.7	0.	......	+	131,250
6890	"	12	"	13	§	V.M'ch	VM.F.3	......	1175.6	180.4	995.2	69.2	21.6	47.6	B.	8.5	21.7	8.7	13.	.608	1.152	.384	.768	2.56	.832	1.728	.019	1.52	6.7	0.	......	+	180,000
6900	"	13	"	14	§	"	VM.F.4	......	1671.6	167.2	1504.4	56.8	23.2	33.6	B.	5.1	24.9	6.9	18.	.512	1.6	.288	1.312	3.84	.544	3.296	.018	1.48	....	0.	......	+	160,000
6913	"	14	"	15	§	"	VM.F.6	......	1481.6	170.4	1311.2	72.4	45.6	26.8	B.	5.1	24.7	7.9	16.8	.544	1.376	.288	1.088	3.52	.544	2.976	.013	1.44	6.6	0.	......	—	240,000
6921	"	15	"	16	§	Much	M. F.03	......	1022.8	192.	830.8	54.4	17.2	37.2	B.	9.	21.8	5.5	16.3	.8	.96	.256	.704	2.4	.544	1.856	.013	1.76	6.8	0.	......	—	143,000
6925	"	16	"	18	§	V.M'ch	VM.F.03	....	1400.	212.8	1187.2	66.8	11.2	55.6	B.	11.	31.8	4.	27.8	.8	1.12	.224	.896	2.48	.704	1.776	.025	1.76	6.9	0.	......	+	308,000
6926	"	17	"	18	§	"	VM.F.04	......	912.	247.2	664.8	54.	50.8	3.2	B.	12.	18.8	4.6	14.2	.896	.864	.224	.64	1.76	.576	1.184	.021	1.8	6.5	0.	......	—	202,000
6927	"	18	"	20	*	Cons'd	M. F.04	......	566.	217.2	348.8	44.4	36.8	7.6	B.	10.	15.1	7.1	8.	.768	.64	.352	.288	1.28	.672	.608	.018	1.8	6.6	0.	......	+	280,000
6938	"	19	"	20	*	"	M. F.05	......	512.	204.8	307.2	42.	26.	16.	B.	9.5	14.1	6.7	7.4	.8	.64	.352	.288	1.44	.576	.864	.017	2.	6.8	0.	......	+	287,000
6943	"	20	"	21	*	"	M. F.05	......	454.4	144.4	310.	77.2	30.	47.2	RB.	10.	15.5	6.7	8.8	.8	.64	.224	.416	1.12	.544	.576	.015	2.	6.9	0.	......	+	416,000
6956	"	21	"	23	*	Much	M. F.2	......	732.8	202.	530.8	83.6	29.2	54.4	B.	8.	16.9	8.3	8.6	.704	.864	.272	.592	1.28	.64	.64	.021	2.	8.3	0.	......	+	172,000
6965	"	22	"	23	*	"	VM.F.2	......	1466.4	196.8	1269.6	101.6	24.8	76.8	B.	7.4	19.6	7.1	12.5	.688	1.12	.24	.88	1.92	.544	1.376	.027	2.	8.3	0.	......	+	108,000
6978	"	24	"	26	§	V.M'ch	VM.F.06	......	1862.	172.	1690.	98.	36.	62.	G.	6.6	24.8	9.2	15.6	.544	1.408	.288	1.12	3.36	.672	2.688	.027	1.88	8.3	0.	......	+	280,000
6982	"	25	"	27	*	Much	M. F.03	......	1264.4	168.	1096.4	107.6	24.8	82.8	B.	6.4	23.	11.7	11.3	.544	1.12	.352	.768	2.64	.448	2.192	.018	1.8	7.9	0.	......	+	196,000
6985	"	26	"	28	*	"	M. F.3	......	1047.2	252.	795.2	94.8	38.8	56.	B.	6.2	19.9	8.4	11.5	.512	.96	.256	.704	3.28	.64	2.64	.03	2.2	7.2	0.	......	+	270,000
6991	"	27	Mar.	1	*	"	M. F.4	......	758.8	193.2	565.6	45.6	16.	29.6	B.	6.4	19.3	10.6	8.7	.544	.768	.32	.448	1.92	.852	1.068	.018	1.96	6.6	0.	......	+	265,000
6998	"	28	"	2	*	"	M. F.3	......	729.2	218.8	510.4	100.	32.4	67.6	B.	7.	16.1	6.2	9.9	.528	.64	.272	.368	1.68	.64	1.04	.018	2.	6.4	0.	......	+	116,500
[illegible]	Mar.	1	"	3	*	Cons'd	M. F.03	......	574.8	218.	356.8	42.8	25.2	17.6	B.	7.4	16.3	9.8	6.5	.576	.56	.176	.384	1.12	.544	.576	.017	1.88	6.	0.	......	+	288,000

TURBIDITY—*Decided. § Very Decided. † Distinct. ‡ Very Slight. | Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

on IGNITION—G., Grey. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., Whi

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, GRAFTON. (Regulars and Extras.)

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinoi

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Igni-tion.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centi-meter.
	1900 Collec-tion.	1900 Exami-nation.	Turb'y.	Sedi-ment.	Color.		Total.	Dis-solved.	Sus-pended.	Loss on Ig'n.					Total.	By Dis-solved.	By Susp'd Matter.	Free Am-monia.	Albuminoid Am.			Total.	Dis-solved.	Sus-pended.	Nitrites.	Nitrates.					
										Tot'l	Dis-solv'd	Sus-pnd'd							Tot'l	Dis-solv'd	Sus-pnd'd										
7005	Mar. 2	Mar. 3	*	Cons'd	M. F.03	......	654.8	335.6	319.2	66.4	24.4	42.	B.	8.4	14.9	8.4	6.5	.56	.48	.272	.208	1.12	.704	.416	.010	1.76	5.6	0.	......	+	100,000
7013	" 3	" 5	*	"	M. F.07	......	524.8	226.8	298.	26.4	24.	2.4	B.	8.2	13.7	7.1	6.6	.528	.48	.304	.176	1.12	.576	.544	.08	2.12	4.9	0.	......	+	228,000
7017	" 4	" 6	*	Much	M. F.08	......	500.	223.6	276.4	34.	24.8	9.2	B.	8.4	13.3	8.3	5.	.56	.448	.224	.224	1.04	.64	.4	.021	2.4	4.5	0.	......	+	173,000
7019	" 5	" 6	*	"	M. F.04	......	714.	220.4	493.6	25.6	17.6	8.	B.	7.8	15.6	8.9	6.7	.56	.592	.304	.288	1.2	.672	.528	.022	2.08	5.3	0.	......	−	177,000
7030	" 6	" 7	*	V. M'ch	VM. F.1	......	2241.2	165.2	2076.	47.6	20.4	27.2	B.	6.2	25.4	6.6	18.8	.592	1.184	.208	.976	3.36	.416	2.944	.014	1.48	7.2	0.	......	......	237,000
7035	" 7	" 8	*	Much	M. F.05	......	973.2	178.	795.2	56.8	18.8	38.	B.	6.6	17.6	6.4	11.2	.528	.736	.264	.472	1.92	.544	1.376	.012	1.44	9.3	0.	......	+	233,000
7036	" 8	" 9	*	"	M. F.3	......	1131.2	150.4	980.8	39.6	17.2	22.4	B.	4.2	23.4	7.6	15.8	.416	.96	.16	.8	2.4	.416	1.984	.017	1.04	10.4	0.	......	+	150,000
7059	" 9	" 10	§	V. M'ch	VM. F.15	......	1316.	128.	1188.	57.6	11.2	46.4	B.	3.8	22.5	5.4	17.1	.32	.896	.128	.768	2.56	.352	2.208	.007	1.08	10.6	0.	......	+	231,000
7060	" 10	" 12	§	"	VM. F.15	......	1139.6	120.4	1019.2	41.6	11.6	30.	B.	3.8	23.4	6.	17.4	.304	.832	.176	.656	2.4	.48	1.92	.011	1.2	11.6	0.	......	+	244,000
7062	" 12	" 13	§	"	M. F.1	......	1088.	138.8	949.2	32.4	15.6	16.8	B.	4.4	20.6	6.5	14.1	.384	.8	.224	.576	1.84	.512	1.328	.014	1.28	12.5	2.	......	+	225,000
7070	" 12	" 13	*	Much	M. F.4	......	1175.6	137.2	1038.4	55.2	4.4	50.8	B.	4.	22.7	6.3	16.4	.33	.896	.272	.624	1.84	.512	1.328	.011	1.2	13.2	2.	......	+	260,000
7079	" 13	" 14	*	"	M. F.4	......	1292.	157.6	1134.4	47.6	30.	17.6	B.	4.4	23.	7.6	15.4	.368	.96	.224	.736	2.4	.544	1.856	.009	1.4	15.	3.	......	+	260,000
7082	" 14	" 15	*	"	M. F.2	......	799.2	153.2	646.	45.2	21.6	23.6	B.	4.2	16.2	6.2	10.	.32	.608	.208	.4	1.6	.384	1.216	.011	1.4	16.3	4.	......	+	237,500
7096	" 15	" 17	*	"	M. F.03	......	816.8	148.4	668.4	33.2	10.8	22.4	B.	4.	18.7	5.3	12.4	.304	.64	.192	.448	1.92	.448	1.472	.012	1.32	16.9	3.	......	+	206,000
7103	" 16	" 17	*	"	M. F.2	......	776.	132.	644.	44.	20.	24.	B.	4.4	17.2	5.1	12.1	.272	.736	.192	.544	2.	.448	1.552	.008	1.12	17.1	2.	......	+	176,000
7105	" 17	" 19	*	"	M. F.05	......	737.6	116.8	620.8	25.6	14.8	10.8	B.	4.2	18.9	5.1	13.8	.288	.736	144	.592	1.92	.504	1.416	.008	1.28	17.1	0.	......	−	87,500
7108	" 18	" 20	*	"	M. F.3	......	677.6	120.4	557.2	34.8	12.8	22.	Rh.	3.8	16.3	6.8	9.5	.256	.672	.224	.448	1.56	.472	1.088	.013	1.48	16.5	0.	......	+	185,000
7116	" 19	" 20	*	"	M. F.6	......	844.4	131.2	713.2	33.2	15.6	17.6	B.	4.	17.6	7.	10.6	.24	.704	.208	.496	1.56	.472	1.088	.008	1.12	15.6	0.	......	+	90,000
7125	" 20	" 21	*	"	M. F.06	......	1060.	125.6	934.4	34.	19.2	14.8	B.	4.2	21.6	6.3	15.3	.32	.768	.208	.56	2.12	.536	1.584	.009	1.32	15.2	0.	......	+	107,000
7130	" 21	" 22	*	"	M. F.15	......	807.6	133.6	674.0	40.8	18.4	22.4	B.	4.8	17.9	6.	11.9	.288	.864	.176	.688	1.88	.6	1.28	.011	1.32	14.8	3.	......	+	119,000
7150	" 22	" 23	*	"	M. F.04	......	674.	132.	542.	28.8	14.	14.8	B.	4.	16.1	5.6	10.5	.224	.512	.192	.32	1.88	.472	1.408	.013	1.4	14.8	3.	......	−	148,000
7153	" 23	" 24	*	"	M. F.3	......	654.4	148.	506.4	34.8	12.8	22.	B.	4.8	16.6	6.	10.6	.288	.528	.208	.32	1.56	.536	1.024	.012	1.44	14.6	2.	......	−	175,500
7155	" 24	" 26	*	"	M. F.6	......	668.4	166.8	501.6	38.8	14.	24.8	B.	4.2	15.1	7.8	7.3	.288	.512	.208	.304	1.56	.6	.96	.012	1.6	14.2	4.	......	+	107,000
7162	" 25	" 27	*	"	M. F.3	......	715.2	155.6	559.6	45.6	17.6	28.	B.	4.6	15.9	7.5	8.4	.304	.512	.192	.32	1.172	.536	.636	.011	1.6	13.2	4.	......	+	76,000
7171	" 26	" 28	*	"	M. F.4	......	555.2	152.8	402.4	28.8	14.8	14.	B.	4.4	15.	8.	7.	.32	.448	.192	.256	1.32	.44	.88	.012	1.56	......	......	......	......	......
7173	" 27	" 28	*	"	M. F.03	......	560.8	143.2	417.6	32.8	16.4	16.4	B.	4.4	13.3	6.1	7.2	.288	.448	.24	.208	1.08	.472	.608	.009	1.52	13.	4.	......	−	78,000
7185	" 28	" 29	*	Cons'd	M. F.04	......	544.4	149.2	395.2	34.	13.2	20.8	B.	4.4	14.	6.	8.	.256	.416	.176	.24	1.112	.408	.704	.01	1.52	12.7	3.	......	†	48,500
7203	" 29	" 30	*	"	M. F.04	......	504.	144.	360.	22.4	12.	10.4	B.	4.2	13.7	6.7	7.	.24	.384	.192	.192	.92	.504	.416	.011	1.08	12.4	3.	......	+	47,500
7206	" 30	April 2	*	"	M. F.05	......	463.6	141.2	322.4	36.4	16.	20.4	B.	4.2	14.1	6.9	7.2	.288	.352	.176	.176	.952	.44	.512	.015	1.56	12.1	2.	......	−	94,000
7208	" 31	" 2	*	"	M. F.05	......	466.8	142.4	324.4	29.6	12.4	17.2	B.	4.2	13.7	5.7	8.	.272	.352	.224	.128	1.08	.472	.608	.013	1.52	11.7	3.	......	−	61,500
7211	April 1	" 3	*	"	M. F.06	......	426.	144.	282.	23.2	10.4	12.8	B.	4.4	13.8	7.1	6.7	.272	.336	.208	.128	.856	.44	.416	.013	1.48	11.3	4.	......	−	74,000
7213	" 2	" 3	*	"	M. F.04	......	388.8	141.2	247.6	22.8	12.4	10.4	B.	4.6	13.1	6.	7.1	.224	.336	.192	.144	.792	.44	.352	.015	1.6	11.2	4.	......	−	22,000
7226	" 3	" 4	*	"	M. F.06	......	399.2	151.2	248.0	13.6	13.2	.4	B.	4.9	12.6	6.1	6.5	.224	.352	.144	.208	.760	.44	.320	.013	1.6	11.3	4.	......	+	30,000
7238	" 4	" 5	*	"	M. F.15	......	375.6	147.6	228.0	31.2	18.8	12.4	B.	4.1	13.3	6.0	7.3	.256	.320	.176	.144	.696	.472	.224	.017	1.6	11.8	4.	......	−	33,500
7254	" 5	" 6	*	"	M. F.04	......	369.2	153.2	216.0	26.4	16.0	10.4	B.	4.5	12.4	6.3	6.1	.224	.304	.160	.144	.856	.440	.416	.015	1.60	12.3	5.	......	+	12,000
7259	" 6	" 7	*	"	M. F.03	......	371.2	158.0	213.2	42.4	17.6	24.8	B.	4.7	11.8	6.2	5.6	.304	.304	.208	.096	.696	.456	.240	.017	1.48	13.	5.	......	......	23,500

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 60—Continued.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, GRAFTON. (Regulars and Extras.)

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of 1900 Collection.	Date of 1900 Examination.	Turb'y.	Appearance: Sediment.	Appearance: Color.	Odor.	Residue on Evaporation: Total.	Dissolved.	Suspended.	Loss on Ig'n: Tot'l	Loss on Ig'n: Dissolv'd	Loss on Ig'n: Suspnd'd	Color on Ignition.	Chlorine.	Oxygen Consumed: Total.	By Dissolved.	By Susp'd Matter.	Nitrogen as Ammonia: Free Ammonia.	Albuminoid Am.: Tot'l	Albuminoid Am.: Dissolv'd	Albuminoid Am.: Susp'd	Organic Nitrogen: Total.	Dissolved.	Suspended.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
7261	Apr. 7	Apr. 9	•	Cons'd	M. F.07	......	361.6	159.6	202.0	32.8	26.0	6.8	B.	4.3	12.0	6.4	5.6	.272	.320	.176	.144	.76	.504	.256	.027	1.60	13.4	8.	......	+	11,000
7263	" 8	" 10	•	"	M. F.05	......	375.2	171.2	204.0	26.8	16.0	10.8	B.	5.1	12.3	8.0	4.3	.256	.288	.224	.064	.76	.44	.32	.030	1.44	13.6	9.	......	−	28,000
7270	" 9	" 10	•	"	M. F.15	......	356.8	168.0	188.8	21.6	18.4	3.2	B.	4.7	11.6	7.4	4.2	.24	.256	.192	.064	.664	.472	.192	.029	1.32	13.7	10.	......	−	9,000
7282	" 10	" 11	•	"	M. F.30	......	364.0	171.2	192.8	12.0	10.0	2.0	B.	4.7	12.0	6.9	5.1	.224	.304	.208	.096	.824	.568	.256	.025	1.32	13.4	10.	......	−	16,500
7296	" 11	" 12	•	"	M. F.04	......	386.4	170.8	215.6	19.2	11.2	8.0	B.	5.0	11.8	6.2	5.6	.208	.384	.208	.176	.920	.504	.416	.030	1.68	13.1	9.	......	+	21,000
7311	" 12	" 13	•	"	M. F.07	......	353.6	173.2	180.4	19.6	14.8	4.8	B.	5.6	10.8	5.9	4.9	.192	.320	.192	.128	.84	.472	.368	.034	1.52	12.8	9.	......	−	13,500
7315	" 13	" 14	•	"	M. F.06	......	327.6	182.4	145.2	26.0	22.0	4.0	B.	5.5	10.9	6.4	4.5	.224	.352	.208	.144	.856	.536	.320	.027	1.60	12.5	9.	......	....	20,500
7316	" 14	" 16	•	"	M. F.10	......	331.6	184.0	147.6	38.0	37.2	.8	B.	5.4	8.7	6.5	2.2	.224	.352	.224	.128	.856	.536	.320	.030	1.64	12.1	9.	......	....	16,000
7323	" 15	" 17	•	"	M. F.20	......	328.8	200.0	128.8	29.6	27.6	2.0	B.	5.5	10.8	6.9	3.9	.207	.272	.176	.096	.632	.504	.128	.027	1.60	11.9	9.	......	−	16,500
7327	" 16	" 18	•	"	M. F.40	......	309.2	182.0	127.2	11.2	9.6	1.6	B.	7.	11.2	7.0	4.2	.176	.288	.224	.064	.856	.568	.288	.027	1.52	11.5	10.	......	−	16,000
7334	" 17	" 18	•	"	M. F.04	......	354.8	193.2	161.6	34.4	30.	4.4	B.	5.4	10.9	6.7	4.2	.144	.304	.176	.128	1.016	.440	.576	.035	1.72	11.2	10.	......	−	7,500
7349	" 18	" 20	•	"	M. F.25	......	338.0	182.0	156.0	26.8	23.	3.8	B.	5.6	11.9	6.6	5.3	.176	.288	.224	.064	.840	.568	.272	.027	1.80	10.9	11.	......	−	7,000
7380	" 19	" 21	•	"	M. F.05	......	344.8	182.0	162.8	24.4	21.2	3.2	B.	5.0	11.5	6.5	5.0	.128	.288	.160	.128	.856	.536	.320	.060	1.72	11.	11.	......	−	3,300
7381	" 20	" 21	•	"	M. F.03	......	311.6	181.2	130.4	24.0	19.2	4.8	B.	5.2	11.2	6.0	4.6	.192	.304	.176	.128	.920	.472	.448	.065	1.76	....	11.	......	+	9,750
7382	" 20	" 21	•	"	M. F.15	......	321.6	133.2	188.4	21.2	21.2	....	B.	3.2	12.7	7.5	5.2	.080	.416	.192	.224	.824	.472	.352	.030	.56	....	....	......	....	....
7386	" 22	" 24	•	"	M. F.04	......	314.4	201.6	112.8	21.6	21.2	.4	B.	5.7	8.8	7.1	1.7	.176	.320	.192	.128	.984	.504	.480	.030	2.0	12.4	12.	......	....	8,300
7387	" 21	" 24	•	"	M. F.06	......	322.4	186.0	136.4	19.2	17.6	1.6	B.	5.6	11.5	6.3	5.2	.176	.352	.192	.160	.984	.600	.384	.034	2.08	12.3	11.	......	....	28,300
7396	" 23	" 25	•	"	M. F.08	......	318.8	200.0	118.8	20.8	17.6	3.2	B.	6.0	9.1	8.1	1.0	.96	.320	.176	.144	.76	.504	.256	.035	1.98	12.5	14.	......	−	7,000
7423	" 25	" 27	•	"	M. F.20	......	316.8	216.0	100.8	36.0	27.2	8.8	B.	6.2	10.5	6.7	3.8	.128	.272	.208	.064	.952	.504	.448	.036	1.12	12.7	15.	......	+	6,700
7450	May 2	May 3	•	"	M. F.03	......	313.2	156.4	156.8	34.0	22.0	12.0	B.	7.5	11.1	7.0	4.1	.096	.416	.24	.176	1.12	.484	.636	.035	1.28	10.7	20.	......	−	2,400
7500	" 9	" 11	•	"	M. F.03	......	368.0	229.6	138.4	24.8	22.4	2.4	B.	8.4	12.0	7.6	4.4	.144	.384	.256	.128	1.38	.548	.832	.030	.96	12.2	19.	......	+	17,600
7561	" 16	" 17	•	"	M. F.02	......	329.2	253.6	75.6	36.0	34.8	1.2	B.	[illegible]	10.9	7.5	3.4	.072	.32	.208	.112	.804	.452	.352	.04	.76	8.5	25.	......	'	4,050
7603	" 23	" 25	§	V.M'ch	VM. F.05	......	374.8	265.2	109.6	46.8	37.2	9.6	B.	10.5	11.4	9.4	2.0	.064	.32	.192	.128	.74	.360	.380	.038	.9	8.4	20.	......	−	4,100
7627	" 30	" 31	•	Cons'd	M. F.07	......	364.0	265.6	98.4	40.8	26.8	14.0	B.	14.	10.8	7.6	3.2	.032	.320	.208	.112	.84	.52	.32	.034	1.48	6.5	25.	......	+	6,100
7674	June 6	June 8	•	"	M. F.08	......	352.0	243.6	108.4	36.	35.6	.4	B.	12.	9.5	6.6	2.9	.032	.288	.160	.128	.80	.468	.332	.008	1.40	6.	25.	......	+	19,550
7722	" 13	" 15	•	"	M. F.04	......	360.8	258.8	102.0	37.6	37.2	.4	B.	14.	7.6	5.8	1.8	.048	.272	.176	.096	.90	.58	.32	.008	1.76	5.2	27.	......	+	4,400
7750	" 20	" 21	•	Little	M. F.05	......	308.8	270.8	38.0	35.6	35.2	.4	B.	13.	8.0	6.5	1.5	.032	.256	.192	.064	.42	.356	.064	.013	1.48	5.2	27.	......	−	1,050
7769	" 25	" 26	•	Much	M. F.03	......	360.8	267.6	93.2	31.2	28.4	2.8	B.	13.	8.1	6.7	1.4	.048	.272	.24	.032	.596	.580	.016	.007	1.04	....	....	......	....	....
7789	" 27	" 28	¦	VLit'le	T.	M'sty	371.6	236.4	135.2	39.2	34.4	4.8	B.	12.	11.3	6.2	5.1	.100	.272	.160	.112	.968	.516	.452	.070	1.28	5.7	27.	......	+	2,500
7808	" 29	" 30	•	Cons'd	T. F.15	......	341.6	317.2	24.4	44.8	38.0	6.8	G.	12.8	7.6	7.5	.1	.048	.304	.192	.112	.644	.516	.128	.044	.80	....	....	......	....	....
7813	July 2	July 3	•	Much	T. F.05	......	384.8	255.2	129.6	42.8	29.2	13.6	B.	14.	8.2	6.4	1.8	.040	.240	.176	.064	.564	.436	.128	.019	1.00	....	....	......	....	....
7835	" 4	" 5	•	"	T. F.03	M'sty	364.4	256.4	108.0	33.6	21.6	12.0	B.	15.	7.2	5.6	1.6	.070	.240	.144	.096	.548	.292	.256	.020	1.40	....	....	......	....	....
7848	" 6	" 7	•	"	T. F.02	......	343.2	253.2	90.0	35.6	31.2	4.4	B.	15.	7.7	6.9	.8	.070	.208	.176	.032	.612	.372	.240	.013	1.28	14.0	29.	......	−	560
7886	" 9	" 10	•	Little	T. F.03	......	314.4	246.4	68.	36.	25.6	10.4	B.	13.	7.8	5.9	1.9	.160	.272	.160	.112	.516	.292	.224	.018	1.72	4.1	30.	......	−	5,300
7899	" 11	" 12	•	"	T. F.30	......	289.2	241.2	48.0	58.0	26.8	31.2	B.	13.	7.6	6.2	1.4	.090	.320	.176	.144	.548	.356	.192	.026	1.36	4.	30.	......	'	1,600
7917	" 13	" 14	•	"	T. F.08	......	306.8	243.6	63.2	26.4	25.6	.8	B.	13.	6.7	6.6	.1	.096	.240	.160	.080	.568	.350	.218	.015	1.32	3.9	31.	......	+	3,300

TURBIDITY—• Decided. § Very Decided. † Distinct. ‡ Very Slight. ¦ Slight.
COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.
lor on Ignition—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bb., Brownish. R., Red. Rb., Reddish. W., Whit

BLE 60—Concluded.

Report of Arthur W. Palmer,
T. J. Burrill,
University of Illinois.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, GRAFTON. (Regulars and Extras.)

Serial No.	Date of		Turb'y.	Appearance.		Odor.	Residue on Evaporation.			Loss on Ign.			Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.	Albuminoid Am.			Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.		Sediment.	Color.		Total.	Dissolved.	Suspended.	Tot'l.	Dissolv'd.	Susp'd.			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Tot'l.	Dissolv'd.	Susp'd.	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
7926	July 16	July 17	*	Little	T. F.02	......	289.6	233.2	56.4	47.2	19.2	28.	B.	13.	6.3	6.1	.2	.032	.176	.144	.032	.50	.272	.228	.014	1.00	3.9	31.	......	—	1,700
7960	" 18	" 19	*	"	T. F.02	......	288.4	218.0	70.4	26.4	19.2	7.2	B.	14.	6.9	5.1	1.8	.080	.208	.176	.032	.548	.324	.224	.024	1.28	4.3	27.	......	?	4,900
7965	" 20	" 21	*	"	T. F.02	......	347.6	210.4	137.2	31.2	29.2	2.0	B.	13.	8.9	6.5	2.4	.048	.272	.176	.096	.452	.276	.176	.035	.88	5.	27.	......	+	8,350
7985	" 23	" 24	*	"	T. F.02	......	264.4	199.6	64.8	24.0	21.2	2.8	B.	11.	7.0	4.8	2.2	.056	.224	.112	.112	.292	.116	.176	.014	1.04	6.3	28.	......	......	3,000
8031	" 25	" 26	*	"	T. F.02	......	298.8	210.8	88.	56.	44.8	11.2	B.	11.	8.6	7.0	1.6	.160	.272	.176	.096	.70	.484	.216	.086	1.08	6.3	28.	......	+	5,250
8035	" 27	" 28	*	"	T. F.02	......	342.4	228.8	113.6	56.	56.	.....	B.	13.	11.9	7.7	4.2	.048	.352	.176	.176	.644	.372	.272	.018	.88	7.	29.	......	—	1,800
8049	" 30	......	*	Much	M.	......	347.6	195.2	152.4	52.	40.4	11.6	B.	14.	10.	7.	3.	.032	.320	.176	.144	.596	.420	.176	.030	1.12	7.3	29.	......	—	6,500
8067	Aug. 1	Aug. 2	*	Little	T. F.01	......	290.6	215.6	75.	30.8	26.	4.8	B.	17.	7.3	5.3	2.	.08	.224	.176	.048	.50	.292	.208	.014	1.16	7.	29.	......	—	1,300
8088	" 3	" 4	*	"	T. F.01	......	259.2	223.6	35.6	28.8	28.4	.4	B.	19.5	5.1	5.6	.....	.080	.224	.176	.048	.484	.340	.144	.094	1.16	6.8	29.	......	+	1,850
8096	" 6	" 7	*	"	T. F.01	......	272.0	243.8	28.2	44.4	38.	6.4	G.	18.	6.7	5.1	1.6	.112	.256	.160	.096	.644	.452	.192	.014	.92	6.1	30.	......	—	500
8126	" 8	" 9	*	"	T. F.01	......	283.2	239.6	43.6	46.0	30.4	15.6	G.	20.	6.1	4.3	1.8	.144	.256	.224	.032	.616	.452	.164	.028	1.12	5.5	30.	......	—	4,000
8146	" 10	" 11	*	"	T. F.01	......	274.4	216.8	57.6	26.8	25.6	1.2	B.	20.	5.8	4.1	1.7	.016	.272	.224	.048	.516	.38	.136	.021	.92	5.	31.	......	—	1,850
8157	" 13	" 14	*	"	T. F.01	......	284.8	232.8	52.	40.8	34.8	6.	B.	22.	6.6	4.7	1.9	.080	.304	.176	.128	.740	.428	.312	.016	1.08	4.4	30.	......	+	5,275
8180	" 15	" 16	*	"	T. F.01	......	305.2	236.4	68.8	28.	19.6	8.4	B.	21.	6.7	4.8	1.9	.112	.320	.192	.128	.676	.332	.344	.023	.92	4.2	30.	......	+	2,700
8214	" 17	" 18	*	"	T. F.05	......	283.2	141.6	141.6	26.8	20.8	6.	B.	3.6	11.3	8.3	3.	.176	.352	.04	.....	.568	.332	.236	.009	.36	4.2	31.	......	+	2,750
8221	" 20	" 21	*	"	T. F.01	......	328.	198.8	129.2	28.4	18.4	10.	B.	17.	7.3	4.7	2.6	.08	.304	.224	.08	.6	.316	.284	.019	1.12	6.8	30.	......	+	2,700
8256	" 22	" 23	*	Much	T. F.	......	327.2	170.8	156.4	42.8	16.	26.8	B.	14.	8.2	5.	3.2	.112	.352	.16	.192	.798	.3	.498	.013	1.04	7.8	30.	......	—	800
8275	" 24	" 25	*	Little	T. F.2	......	370.	197.6	172.4	35.2	16.8	18.4	B.	15.	9.	4.4	4.6	.112	.336	.112	.224	.796	.204	.592	.006	1.04	7.5	29.	......	—	2,900
8296	" 27	" 28	*	"	T. F.03	......	302.8	175.2	127.6	31.6	15.6	16.	B.	15.	6.7	4.9	1.8	.096	.352	.128	.224	.668	.188	.48	.013	.96	6.8	29.	......	—	1,300
8316	" 29	" 30	*	"	M. F.03	......	297.6	212.4	85.2	21.6	20.	1.6	B.	16.	8.1	4.4	3.7	.104	.384	.256	.128	.508	.332	.176	.016	1.08	6.4	29.	......	......	2,300
8342	" 31	Sept. 1	*	Much	M. F.03	......	338.8	193.2	145.6	32.4	24.	8.4	B.	15.	8.8	5.1	3.7	.064	.288	.192	.096	.568	.348	.22	.006	.92	6.5	29.	......	......	3,100
8363	Sept. 3	" 5	*	Cons'd	M. F.04	......	317.6	234.	83.6	35.2	12.	23.2	B.	17.	7.3	4.5	2.8	.064	.192	.176	.016	.472	.444	.028	.013	1.12	6.9	28.	......	......	1,700
8372	" 5	" 6	*	Much	M.	......	366.	219.6	146.4	23.2	14.	9.2	B.	14.	10.6	4.6	6.	.112	.4	.224	.176	.698	.39	.308	.009	1.3	6.7	27.	......	—	30,000
8407	" 7	" 8	*	"	M. F.03	......	326.4	293.6	33.8	25.6	21.2	4.4	DB.	16.	8.2	4.2	4.	.112	.304	.128	.176	.696	.416	.28	.011	1.12	6.4	28.	......	—	1,400
8431	" 10	" 11	*	"	M. F.03	......	329.6	225.2	104.4	23.2	14.	9.2	B.	18.	7.6	4.6	3.	.064	.256	.24	.016	.504	.384	.12	.012	1.48	6.2	29.	......	—	5,700
8454	" 12	" 13	*	Cons'd	M. F.03	......	300.4	242.4	58.	26.	20.8	5.2	B.	18.	7.1	5.	2.1	.064	.224	.192	.032	.508	.416	.092	.013	.12	6.1	28.	......	—	1,650
8470	" 14	" 15	*	"	M. F.01	......	281.8	236.4	48.4	29.6	16.	13.6	B.	18.	6.9	5.4	1.5	.048	.144	.104	.08	.476	.336	.14	.08	.12	5.8	26.	......	—	1,050
8475	" 17	" 18	*	"	M. F.01	......	296.	230.4	65.6	24.	17.6	6.4	B.	16.	6.7	5.7	1.	.096	.24	.16	.08	.64	.372	.268	.035	1.16	5.7	26.	......	+	1,300
8500	" 19	" 20	*	"	M. F.01	......	305.8	225.2	77.6	23.6	20.4	3.2	B.	15.	7.4	5.4	2.	.112	.320	.192	.224	.6	.448	.152	.025	1.08	5.6	20.	......	—	3,150
8512	" 21	" 22	*	Little	M. F.04	......	303.2	235.2	68.	22.	20.4	1.6	B.	16.	7.7	6.	1.7	.104	.256	......	......	.504	.352	.152	.028	.56	5.7	20.	......	+	900
8532	" 24	" 25	*	Cons'd	M. F.15	......	304.4	234.8	69.6	42.4	23.2	19.2	B.	16.	6.2	5.9	.3	.064	.324	.128	.196	.636	.432	.204	.044	.92	6.1	23.	......	?	2,100
8545	" 26	" 27	*	"	M. F.15	......	288.8	218.	70.8	37.2	22.	15.2	B.	14.	8.	6.8	1.2	.16	.352	.208	.144	.530	......	......	.004	.76	6.6	21.	......	+	5,500
8575	" 28	Oct. 1	*	"	M.	......	283.8	244.4	39.4	18.8	16.4	2.4	......	27.	5.9	5.3	.6	.056	.272	.144	.128	.470	......	......	.08	1.28	......	......	......	......	......
8584	Oct. 1	" 2	*	"	M. F.4	......	278.4	234.4	44.	25.2	21.6	3.6	......	14.	7.4	6.5	.9	.112	.32	.24	.08	.608	.592	.016	.08	1.	8.5	22.	......	—	1,300
8603	" 3	" 4	†	Little	C. F.05	......	271.6	246.4	25.2	27.6	25.2	2.4	......	16.	6.	5.9	.1	.16	.24	.224	.016	.544	.464	.08	.015	.96	......	......	......	+	4,900
8623	" 5	" 8	†	"	M. F.03	......	273.6	248.4	25.2	30.	27.6	2.4	Bh.	17.	6.	5.6	.4	1.12	.256	.192	.064	.528	......	......	.002	1.16	......	......	......	?	900

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 61.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, GRAFTON. (Regulars and Extras.)

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of 1900 Collection.	Date of 1900 Examination.	Appearance Turb'y.	Appearance Sediment.	Appearance Color.	Odor.	Residue on Evaporation Total.	Residue on Evaporation Dissolved.	Residue on Evaporation Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dissolv'd	Loss on Ig'n. Suspend'd	Color on Ignition.	Chlorine.	Oxygen Consumed Total.	Oxygen Consumed By Dissolved.	Oxygen Consumed By Suspd Matter.	Nitrogen as Ammonia Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspend'd	Organic Nitrogen Total.	Organic Nitrogen Dissolved.	Organic Nitrogen Suspended.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
6625	Jan. 4	Jan. 5	*	Cons'd	M. F.05	......	232.4	210.8	21.6	23.2	21.2	2.	B.	9.5	18.	9.3	8.7	.08	.352	.208	.144	.76	.328	.432	.007	.16	3.9	0.	......	–	9,600
6656	" 10	" 11	*	"	M. F.1	......	206.4	192.4	14.	20.	16.8	3.2	B.	4.8	11.6	9.3	2.3	.012	.48	.176	.304	.792	.344	.448	.003	.08	4.2	0.	......	+	6,000
6706	" 17	" 18	†	"	M. F.06	......	204.8	178.8	26.	39.2	26.4	12.8	B.	4.4	10.7	8.8	1.9	.024	.352	.176	.176	.88	.384	.496	.001	.08	3.5	3.	......	+	6,300
6750	" 24	" 25	*	Much	M. F.06	......	374.4	180.4	94.	30.4	20.	10.4	B.	3.8	11.2	5.2	6.	.028	.352	.176	.176	.8	.512	.288	.008	.48	5.1	4.	......	+	34,750
6784	" 28	" 31	*	Cons'd	M. F.1	......	234.4	168.8	65.6	30.8	18.4	12.4	B.	3.4	14.	10.6	3.4	.104	.384	.176	.208	.88	.448	.432	.007	.44	4.9	0.	......	+	23,200
6801	" 31	Feb. 2	*	"	M. F.25	......	213.6	172.8	40.8	34.8	22.8	12.	B.	4.	13.3	11.2	2.1	.12	.32	.24	.08	.8	.416	.384	.006	.48	2.8	0.	......	+	12,200
6839	Feb. 5	" 6	*	"	M. F.03	......	202.8	174.	28.8	24.8	14.	10.8	B.	7.1	9.3	8.5	.8	.14	.288	.192	.096	.672	.544	.128	.006	.36	1.5	0.	......	+	44,400
6854	" 6	" 7	*	"	M. F.15	......	226.4	193.6	32.8	32.	26.4	5.6	B.	7.2	10.9	9.4	1.5	.12	.352	.16	.192	.72	.48	.24	.006	.4	2.8	0.	......	+	31,000
6865	" 7	" 8	*	"	M. F.03	......	248.4	181.2	67.2	24.4	13.6	10.8	B.	5.8	13.2	9.2	4.	.090	.368	.24	.128	.96	.32	.64	.006	.4	3.8	0.	......	–	51,000
6879	" 9	" 10	§	V.M'ch	M. F.05	......	2134.4	145.2	1989.2	67.6	15.6	52.	B.	3.3	27.	6.8	20.2	.188	1.44	.176	1.264	3.52	.544	2.976	.007	.72	7.8	0.	......	+	107,000
6881	" 10	" 12	§	"	M. F.4	......	779.6	156.8	622.8	55.2	20.8	34.4	B.	4.4	19.4	7.5	11.9	.092	.864	.192	.672	2.08	.416	1.664	.005	.68	7.1	0.	......	+	59,000
6884	" 11	" 13	§	Much	VM. F.05	......	676.	241.6	434.4	....	22.8	....	B.	4.	12.9	7.5	5.4	.08	.701	.208	.496	2.08	.512	1.568	.012	.68	6.7	0.	......	+	31,800
6889	" 12	" 13	§	V.M'ch	VM. F.30	......	747.2	161.6	585.6	57.6	18.8	38.8	B.	3.9	18.	8.3	9.7	.10	.736	.256	.48	1.84	.64	1.2	.006	.72	6.7	0.	......	+	69,000
6912	" 14	" 15	*	Much	VM. F.40	......	531.6	148.8	382.8	38.8	26.	12.8	B.	3.7	17.	8.6	8.4	.112	.672	.224	.448	1.52	.416	1.104	.006	.72	6.6	0.	......	+	80,000
6924	" 17	" 18	*	Cons'd	M. F.50	......	292.8	166.	126.8	37.2	22.	15.2	B.	3.8	16.8	8.1	8.7	.172	.512	.24	.272	.88	.608	.272	.012	.64	6.5	0.	......	+	182,500
6935	" 19	" 20	*	"	M. F.30	......	309.2	166.4	142.8	39.2	26.8	12.4	B.	3.4	12.4	10.6	1.8	.2	.528	.32	.208	1.28	.64	.64	.008	.8	6.8	0.	......	+	119,000
6957	" 21	" 23	*	Much	VM. F.50	......	318.	137.2	180.8	64.	30.4	33.6	B.	3.3	13.5	11.3	2.2	.304	.688	.352	.336	1.36	.864	.496	.012	.72	....	0.	......	+	116,000
6979	" 22	" 26	*	"	M. F.50	......	428.4	172.	256.4	68.	29.2	38.8	B.	3.4	16.9	11.6	5.3	.316	.688	.352	.336	1.52	.896	.624	.012	.96	8.3	0.	......	+	145,000
6999	Mar. 1	Mar. 3	*	Cons'd	M. F.08	......	210.	152.4	57.6	37.2	17.6	19.6	B.	3.8	13.7	11.2	2.5	.228	.4	.176	.224	.72	.48	.24	.008	.68	6.	0.	......	+	35,500
7006	" 2	" 3	*	"	M. F.5	......	212.4	171.6	40.8	38.4	34.8	3.6	B.	3.9	13.4	11.	2.4	.208	.32	.288	.032	.96	.672	.288	.000	.32	5.6	0.	......	+	31,500
7018	" 5	" 6	*	"	M. F.4	......	218.4	157.6	60.8	16.4	15.2	1.2	B.	4.7	12.9	9.9	3.	.224	.352	.256	.096	.88	.64	.24	.008	.56	5.2	0.	......	–	50,000
7034	" 7	" 8	*	Much	M. F.06	......	777.2	103.2	674.	32.	12.8	19.2	B.	3.4	18.2	7.7	10.5	.208	.8	.208	.592	2.08	.512	1.568	.006	.88	9.3	0.	......	+	73,000
7058	" 9	" 10	*	"	M. F.40	......	499.6	142.8	356.8	25.6	14.4	11.2	B.	3.4	14.8	7.4	7.4	.152	.48	.208	.272	1.44	.512	.928	.007	.64	10.6	0.	......	+	65,500
7071	" 12	" 13	*	"	M. F.50	......	877.2	122.	755.2	52.8	15.2	37.6	B.	2.8	21.1	7.6	13.5	.24	.672	.208	.464	1.92	.48	1.44	.005	.68	13.2	2.	......	+	170,000
7083	" 14	" 15	*	"	M. F.30	......	1583.6	96.	1487.6	68.	14.8	53.2	B.	.9	19.3	8.4	10.9	.3	1.6	.24	1.36	3.52	.512	3.008	.007	.52	16.3	4.	......	+	555,000
7115	" 19	" 20	*	"	M. F.50	......	533.6	125.6	408.	34.8	16.4	18.4	B.	2.0	22.4	8.8	13.6	.352	.736	.256	.48	1.64	.536	1.104	.008	.52	15.6	0.	......	•	247,500
7129	" 21	" 22	*	"	M. F.50	......	516.	105.2	410.8	31.2	16.4	14.8	B.	1.	19.6	8.6	11.	.384	.864	.24	.624	1.72	.792	.928	.008	.52	14.8	3.	......	–	198,000
7154	" 23	" 24	*	"	M. F.60	......	479.2	199.6	279.6	37.6	24.8	12.8	B.	1.3	24.	9.5	14.5	.44	.72	.32	.4	2.36	.92	1.44	.008	.64	14.6	3.	......	+	99,500
7172	" 26	" 28	*	"	M. F.30	......	367.2	108.8	258.4	32.	13.6	18.4	B.	2.8	17.1	9.5	7.6	.42	.56	.304	.256	1.48	.696	.784	.01	.48	13.	4.	......	–	88,000
7186	" 28	" 29	*	"	M. F.20	......	320.	114.4	205.6	22.4	17.2	5.2	B.	3.2	15.	8.2	6.8	.384	.512	.256	.256	1.272	.6	.672	.007	.48	12.7	4.	......	–	85,000
7207	" 30	Apr. 2	*	"	M. F.20	......	344.	107.6	236.4	28.4	16.8	11.6	B.	3.1	16.2	8.8	7.4	.348	.48	.224	.256	1.144	.44	.704	.012	.6	12.1	4.	......	–	71,000
7214	Apr. 2	" 3	*	Cons'd	M. F.06	......	259.6	125.2	134.4	22.4	13.6	8.8	B.	3.4	14.	7.3	6.7	.332	.448	.272	.176	.952	.612	.34	.008	.6	11.2	5.	......	–	81,000

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 61—Continued.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, GRAFTON. (Regulars and Extras.)

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Suspnd'd							Tot'l	Dissolv'd	Suspnd'd										
7239	Apr. 4	Apr. 5	*	Cons'd	M. F.15	......	306.8	141.2	165.6	24.	16.8	7.2	B.	3.2	14.3	7.8	6.5	.34	.4	.176	.224	.984	.472	.512	.01	.48	11.8	5.	......	+	66,000
7260	" 6	" 7	§	V.M'ch	VM.F.40	......	1206.	170.8	1035.2	50.8	29.6	21.2	B.	2.4	31.5	9.3	22.2	.244	1.312	.24	1.072	3.	.536	2.464	.018	1.08	13.	4.	......	—	300,000
7269	" 9	" 10	§	"	VM.F.30	......	1024.	116.8	907.2	46.8	22.8	24.	B.	1.5	27.6	9.3	18.3	.272	1.088	.304	.784	2.52	.76	1.76	.017	1.04	13.7	9.	......	—	210,000
7294	" 11	" 12	*	Cons'd	M. F.60	......	684.	116.4	567.6	59.2	14.4	44.8	B.	2.4	21.9	8.6	13.3	.28	1.024	.256	.768	2.36	.632	1.728	.022	1.08	13.1	8.	......	+	111,000
7314	" 13	" 14	*	"	M. F.06	......	440.4	122.4	318.	47.2	29.2	18.	B.	3.	18.3	7.9	10.4	.188	.64	.288	.352	2.04	.664	1.376	.022	.8	12.5	8	......	....	36,000
7336	" 16	" 17	*	"	M. F.30	......	302.4	141.2	161.2	22.	21.2	.8	B.	3.5	14.4	8.2	6.2	.14	.432	.272	.16	1.08	.664	.416	.022	.68	11.5	11.	......	+	59,000
7350	" 18	" 19	*	"	M. F.30	......	246.	127.6	118.4	24.4	18.8	5.6	B.	3.3	12.8	7.5	5.3	.096	.32	.208	.112	.92	.6	.32	.017	.64	10.9	11.	......	+	22,000
7395	" 23	" 24	§	V.M'ch	VM.F.40	......	1171.6	118.4	1053.2	64.	16.8	47.2	B.	2.	21.7	6.6	15.1	.044	1.28	.176	1.104	2.92	.44	2.48	.026	.8	12.5	14.	......	+	74,000
7422	" 25	" 26	§	"	M. F.40	......	775.2	128.	647.2	36.8	31.2	5.6	B.	3.	19.9	8.3	11.6	.08	1.184	.208	.976	2.2	.504	1.696	.08	.72	12.7	15.	......	+	66,000
7451	May 2	May 3	*	Cons'd	M. F.05	......	311.6	137.2	174.4	32.8	20.8	12.	B.	3.4	14.9	8.2	6.7	.016	.416	.24	.176	1.14	.484	.656	.011	.6	10.7	19.	......	+	15,000
7499	" 9	" 10	*	"	M. F.3	......	264.8	102.	162.8	30.4	21.2	9.2	B.	3.	17.6	11.9	5.7	.04	.4	.272	.128	1.06	.84	.22	.000	.12	12.2	18.	......	+	17,000
7560	" 16	" 17		....	M. F.2	......	326.4	123.6	202.8	41.2	23.2	18.	B.	3.	18.5	9.7	8.8	.056	.448	.176	.272	1.06	.356	.704	.02	.2	8.5	23.	......	....	2,500
7604	" 23	" 24	§	V.M'ch	VM.F.2	......	494.8	147.2	347.6	54.4	24.4	30.	B.	3.	17.1	10.9	6.2	.040	.48	.24	.24	.904	.42	.544	.013	1.	8.4	19.	......	—	4,300
7628	" 30	" 31	*	Cons'd	M. F.10	......	270.4	136.4	134.	39.2	24.8	14.4	B.	3.4	12.	8.5	3.5	.012	.352	.192	.16	.96	.452	.508	.008	.48	6.5	24.	......	+	4,100
7673	June 6	June 8	*	"	M. F.05	......	277.6	136.	141.6	36.	30.8	5.2	B.	3.9	12.6	8.2	4.4	.024	.352	.128	.224	.9	.324	.576	.006	.2	6.	25.	......	—	6,000
7723	" 13	" 15	*	"	M. F.15	......	239.2	165.2	74.	35.6	28.	7.6	B.	4.	9.4	8.1	1.3	.028	.32	.16	.16	.708	.28	.428	.001	.16	5.2	26.	......	+	1,000
7749	" 20	" 21	*	Little	M. F.05	......	257.2	181.6	75.6	38.8	22.8	16.	B.	3.7	11.8	7.5	4.3	.040	.288	.128	.16	.66	.292	.368	.004	.12	5.2	26.	......	—	2,600
7770	" 25	" 26	*	Much	M. F.03	......	562.8	164.	398.8	40.4	22.8	17.6	B.	3.4	16.	6.9	9.1	.042	.48	.112	.368	1.156	.452	.704	.013	.28	.....	..	......	....	....
7788	" 27	" 28	†	Little	M. F.01	M'sty	526.4	152.	374.4	43.2	20.8	22.4	B.	3.7	16.2	6.1	10.1	.042	.512	.16	.352	1.416	.356	1.06	.005	.6	5.4	27.	......	—	5,000
7809	" 29	" 30	*	Cons'd	T. F.20	"	427.6	171.6	256.	41.6	31.2	10.4	B.	3.5	15.7	9.8	5.9	.062	.48	.112	.368	.836	.292	.544	.004	.52	.....	.....	......	....	....
7812	July 2	July 3	*	Much	T. F.05	......	318.	220.	98.	36.8	34.8	2.	B.	4.	9.9	6.8	3.1	.078	.32	.16	.16	.868	.324	.544	.000	.36	4.5	-27.	......	—	1,200
7836	" 4	" 5	*	Little	T. F.03	......	312.8	178.4	134.4	34.8	18.8	16.	B.	7.7	12.	6.8	5.2	.058	.324	.176	.148	.772	.34	.432	.005	.24	.....	.....	......	....	....
7849	" 6	" 7	*	Much	T. F.02	......	438.4	178.8	259.6	40.8	19.6	21.2	B.	4.4	15.5	8.	7.5	.068	.416	.176	.24	.836	.196	.64	.005	.36	.....	.....	......	....	....
7885	" 9	" 10	*	Little	T. F.05	......	348.4	189.2	159.2	22.	7.2	4.8	B.	4.8	12.2	6.9	5.3	.06	.32	.176	.144	1.092	.18	.912	.005	.4	4.1	-20.	......	+	4,700
7900	" 11	" 12	*	"	T. F.05	......	361.2	178.	183.2	38.4	22.8	15.6	B.	5.3	12.	7.9	4.1	.038	.416	.176	.24	.772	.356	.416	.007	.2	4.	20.	......	—	2,250
7918	" 13	" 14	*	"	T. F.02	......	297.2	192.4	104.8	43.2	38.8	4.4	B.	4.1	11.	8.2	2.8	.072	.272	.112	.16	.584	.272	.312	.002	.44	3.9	30.	......	—	2,300
7927	" 16	" 17	*	"	M. F.02	......	280.8	181.2	99.6	20.	17.2	2.8	B.	4.2	11.3	6.5	4.8	.08	.336	.176	.16	.9	.308	.592	.008	.36	6.9	30.	......	—	4,700
7957	" 18	" 19	*	"	T. F.02	......	278.	160.4	117.6	24.8	21.6	3.2	B.	4.6	11.2	6.4	4.8	.102	.304	.144	.16	.6	.308	.292	.008	.24	4.3	26.	......	—	3,800
7987	" 20	" 21	*	Much	T. F.02	......	342.8	162.8	180.	28.8	25.2	3.6	B.	4.	12.2	6.8	5.4	.078	.416	.176	.24	.6	.292	.308	.005	.32	5.	27.	......	—	5,100
799.	" 23	" 24	*	"	M. F.02	......	354.8	138.4	216.4	34.8	20.8	14.	B.	3.3	12.9	6.7	6.2	.074	.336	.192	.144	.68	.212	.468	.001	.36	6.3	28.	......	?	3,300
8032	" 25	" 26	*	Cons'd	M. F.02	......	407.2	129.2	278.	62.	43.2	18.8	B.	2.6	15.1	7.7	7.4	.006	.48	.144	.336	1.4	.292	1.108	.005	.6	6.2	27.	......	+	3,500

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. | Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, GRAFTON. (Regulars and Extras.)

Serial No.	DATE OF		APPEARANCE.			Odor.	RESIDUE ON EVAPORATION.						Color on Ignition.	Chlorine.	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dis-solv'd	Sus-pnd'd							Tot'l	Dis-solv'd	Sus-pnd'd										
8036	July 27	July 28	*	Cons'd	M. F.02	......	541.6	116.8	424.8	77.2	38.	39.2	B.	2.9	17.4	11.6	5.8	.050	.672	.208	.464	1.384	.516	.868	.002	.68	7.	28.	......	—	3,100
8048	" 30	" 31	*	Much	M. F.02	......	564.	123.2	440.8	69.2	26.4	42.8	B.	2.6	19.	8.	11.	.004	.544	.16	.384	1.224	.388	.836	.004	.68	7.3	30.	......	—	2,100
8066	Aug. 1	Aug. 2	*	Cons'd	M. F.02	......	582.4	117.2	465.2	62.	26.8	35.2	B.	2.9	21.3	7.4	13.9	.12	.624	.272	.352	1.24	.34	.9	.003	.68	7.	28.	......	—	4,650
8087	" 3	" 4	*	"	M. F.02	......	423.2	138.	285.2	58.	27.2	30.8	B.	2.8	16.9	8.4	8.5	.072	.448	.208	.24	1.	.404	.596	.003	.6	6.8	28.	......	—	2,000
8097	" 6	" 7	*	"	T. F.01	......	285.2	142.	143.2	58.4	47.2	11.2	B.	2.7	14.7	12.8	1.9	.082	.384	.342	.042	.76	.548	.212	.003	.44	6.1	30.	......	+	1,450
8127	" 8	" 9	*	"	M. F.02	......	255.6	149.2	106.4	52.4	48.8	3.6	B.	5.8	15.6	10.8	4.8	.066	.352	.304	.048	.92	.452	.468	.004	.36	5.5	30.	......	—	7,400
8145	" 10	" 11	*	"	M. F.05	......	226.8	132.4	94.4	44.4	35.2	9.2	B.	3.2	13.9	10.9	3.	.08	.448	.272	.176	.84	.38	.46	.005	.36	5.	30.	......	?	3,350
8156	" 13	" 14	*	Little	T. F.02	......	235.2	155.6	79.6	39.6	37.6	2.	B.	3.	15.4	10.	5.4	.08	.32	.24	.08	1.	.43	.57	.001	.28	4.4	29.	......	—	4,150
8181	" 15	" 16	*	"	T. F.09	......	216.	141.6	74.4	37.2	32.	5.2	B.	3.2	11.8	8.4	3.4	.088	.416	.192	.224	.84	.316	.524	.002	.2	4.3	29.	......	—	4,600
8215	" 17	" 18	*	"	T. F.01	......	286.8	214.	72.8	20.4	18.8	1.6	B.	4.	6.7	4.6	2.1	.178	.304	.224	.08	.6	.576	.024	.023	.88	4.2	29.	......	+	5,900
8220	" 20	" 21	*	"	T. F.01	......	383.6	148.8	234.8	42.	22.4	19.6	B.	3.6	12.7	7.2	5.5	.130	.512	.208	.304	1.	.252	.748	.007	.44	6.8	29.	......	+	3,250
8256	" 22	" 23	*	Cons'd	M. F.2	......	1066.8	125.6	941.2	63.8	23.	40.8	DB.	4.2	23.1	6.5	16.6	.184	1.04	.176	.864	1.88	.264	1.616	.008	.8	7.8	28.	......	+	1,200
8274	" 24	" 25	*	"	M. F.2	......	691.6	120.4	571.2	37.6	20.4	17.2	DB.	3.	19.7	6.4	13.3	.150	.576	.192	.384	1.48	.332	1.148	.002	.52	7.5	29.	......	—	3,100
8294	" 27	" 28	*	"	M. F.2	......	423.2	132.	291.2	38.	20.	18.	DB.	3.	16.	7.	9.	.128	.384	.192	.192	1.16	.252	.908	.005	.64	6.8	29.	......	—	1,700
8317	" 29	" 30	*	"	M. F.02	......	369.6	147.6	222.	33.2	14.8	18.4	DB.	3.6	14.8	7.2	7.6	.114	.384	.24	.144	.664	.188	.476	.001	.44	6.4	27.	......	—	2,250
8341	" 31	Sept. 1	*	Much	M. F.15	......	314.8	138.8	176.	34.	29.6	4.4	DB.	3.2	14.4	8.	6.4	.120	.416	.256	.16	.568	.332	.236	.003	.32	....	....	......	—	2,300
8362	Sept. 3	" 5	*	Cons'd	M. F.25	......	325.2	167.6	157.6	32.8	23.2	9.6	DB.	3.	16.1	9.2	6.9	.122	.368	.192	.176	.696	.572	.124	.003	.32	6.9	27.	......	—	1,500
8371	" 5	" 6	*	Much	M.	......	309.6	154.8	154.8	24.4	20.4	4.	DB.	2.6	19.3	8.8	10.5	.068	.4	.24	.16	.664	.412	.252	.005	.32	6.7	28.	......	+	2,750
8408	" 7	" 8	*	"	M. F.3	......	297.2	148.4	148.8	31.6	21.6	10.	DB.	2.8	15.2	8.6	6.6	.088	.48	.208	.272	.664	.432	.232	.004	.28	6.4	28.	......	—	2,750
8420	" 10	" 11	*	"	M. F.1	......	248.	149.6	98.4	35.6	18.4	17.2	DB.	2.6	15.4	9.2	6.2	.144	.512	.256	.256	.6	.544	.056	.004	.28	6.2	28.	......	—	2,450
8453	" 12	" 13	*	Cons'd	M. F.2	......	216.2	149.6	66.6	34.	24.8	9.2	DB.	3.	17.5	11.2	6.3	.090	.464	.192	.272	.616	.464	.152	.002	.24	6.1	29.	......	+	2,800
8469	" 14	" 15	*	Much	M.	......	270.8	145.2	125.6	33.2	21.6	11.6	DB.	2.6	17.2	15.3	1.9	.122	.448	.288	.16	.696	.624	.072	.002	.48	5.8	26.	......	+	4,350
8474	" 17	" 18	*	"	M. F.08	......	274.	148.	126.	38.	13.6	24.4	DB.	2.8	16.2	11.6	4.6	.096	.432	.208	.224	.632	.384	.248	.006	.36	5.7	25.	......	—	2,000
8501	" 19	" 20	*	"	M. F.04	......	260.8	148.	112.8	40.	27.6	12.4	DB.	2.8	15.4	11.8	3.6	.098	.4	.288	.112	.888	.592	.296	.004	.32	5.6	19.	......	—	2,300
8513	" 21	" 22	*	Little	M. F.4	......	262.4	160.8	101.6	28.	24.	4.	B.	2.8	16.2	13.6	2.6	.104	.384	.304	.08	.792	.....	.....	.001	.24	5.7	19.	......	—	2,300
8533	" 24	" 25	*	Cons'd	M. F.6	......	370.8	150.8	220.	64.	34.8	29.2	DB.	2.4	16.7	14.6	2.1	.144	.48	.256	.224	1.08	.624	.456	.006	.48	6.4	21.	......	—	3,500
8544	" 26	" 27	*	"	M. F.8	......	306.	144.4	161.6	51.6	31.6	20.	B.	2.2	17.6	11.7	5.9	.162	.432	.24	.192	.792	.656	.136	.002	.36	6.6	20.	......	+	11,100
8576	" 28	Oct. 1	*	"	M.	......	354.8	144.	210.8	51.2	26.	25.2	DB.	2.2	17.9	14.8	3.1	.118	.528	.288	.24	1.052	.592	.46	.005	.28	7.6	21.	......	+	10,400
8585	Oct. 1	" 2	*	"	F.1.2	......	282.4	132.4	150.	47.2	36.	11.2	DB.	1.4	22.7	19.3	3.4	.156	.48	.352	.128	1.048	.656	.392	.004	.36	8.5	21.	......	—	1,750
8604	" 3	" 4	*	"	M. F.1.2	......	372.	153.6	218.4	104.	44.8	59.2	......	1.3	27.6	18.3	9.3	.164	.528	.224	.304	1.28	.624	.656	.002	.44	....	....	......	+	2,900
8629	" 5	" 8	*	"	M.	......	333.6	132.8	200.8	48.	32.8	15.2	DB.	1.4	22.3	18.	4.3	1.12	.56	.256	.304	.944	.64	.304	.003	.237	....	....	......	—	7,050

TURBIDITY—*Decided. § Very Decided. † Distinct. ‡ Very Slight. ǁ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.
COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 62.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, GRAFTON. (Regulars.)

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dis-solv'd	Sus-pnd'd							Tot'l	Dis-solv'd	Sus-pnd'd										
6696	Jan. 4	Jan. 5	*	Con'sd	M. F.04	....	395.2	382.	13.2	40.4	38.8	1.6	B.	30.	11.8	8.3	3.5	2.24	.416	.288	.128	.92	.552	.368	.07	1.76	2.9	0.	6.	—	87,200
6655	" 10	" 11	†	Little	M. F.03	....	368.	365.2	2.8	28.4	28.	.4	G.	27.	7.5	7.4	.1	2.16	.432	.304	.128	.792	.6	.192	.03	2.28	4.2	0.	3.	—	20,000
6705	" 17	" 18	†	Con'sd	M. F.03	....	338.4	329.6	8.8	47.6	44.4	3.2	B.	16.	7.2	6.5	.7	.704	.32	.208	.112	.72	.544	.176	.03	2.4	3.5	3.	18.	—	41,300
6751	" 24	" 25	*	Much	M. F.2	....	502.4	216.	286.4	40.	22.4	17.6	B.	10.	16.	8.1	7.9	.8	.512	.208	.304	1.12	.704	.416	.08	2.	5.1	4.	......	+	59,000
6802	" 31	Feb. 2	*	Cons'd	M. F.03	....	439.2	311.2	128.	38.	29.2	8.8	G.	21.	10.	8.1	1.9	1.6	.352	.208	.144	.88	.576	.304	.032	2.3	2.8	0.	—0.	—	24,900
6864	Feb. 7	" 8	*	"	M. F.03	....	326.8	271.2	55.6	18.4	12.4	6.	B.	17.	10.9	7.7	3.2	1.36	.384	.176	.208	.8	.576	.224	.018	1.6	3.8	0.	13.	+	256,000
6913	" 14	" 15	§	V.M'ch	V.M. F.6	....	1481.6	170.4	1311.2	72.4	45.6	26.8	B.	5.1	24.7	7.9	16.8	.544	1.376	.288	1.088	3.52	.544	2.976	.013	1.44	6.6	0.	2.	—	240,000
6956	" 21	" 23	*	Much	M. F.2	....	732.8	202.	530.8	83.6	29.2	54.4	B.	8.	16.9	8.3	8.6	.704	.864	.272	.592	1.28	.64	.64	.023	2.	8.3	0.	5.5	+	172,000
6998	Mar. 1	Mar. 3	*	Cons'd	M. F.03	....	574.8	218.	356.8	42.8	25.2	17.6	B.	7.4	16.3	9.8	6.5	.576	.56	.176	.384	1.12	.544	.576	.017	1.88	6.	0.	......	+	302,000
7035	" 7	" 8	*	Much	M. F.05	....	973.2	178.	795.2	56.8	18.8	38.	B.	6.6	17.6	6.4	11.2	.528	.736	.264	.472	1.92	.544	1.376	.012	1.44	9.3	0.	2.	+	222,000
7082	" 14	" 15	*	"	M. F.2	....	799.2	153.2	646.	45.2	21.6	23.6	B.	4.2	16.2	6.2	10.	.32	.608	.208	.4	1.6	.384	1.216	.011	1.4	16.3	4.	4.	+	237,500
7130	" 21	" 22	*	"	M. F.15	....	807.6	133.6	670.	40.8	18.4	22.4	B.	4.8	17.9	6.	11.9	.288	.864	.176	.688	1.88	.6	1.28	.011	1.32	14.8	3.	4.	+	119,000
7185	" 28	" 29	*	Cons'd	M. F.04	....	544.4	149.2	395.2	34.	13.2	20.8	B.	4.4	14.	6.	8.	.256	.416	.176	.24	1.112	.408	.704	.01	1.52	12.7	3.	17.	?	48,500
7228	Apr. 4	Apr. 5	*	"	M. F.15	....	375.6	147.6	228.	31.2	18.8	12.4	B.	4.1	13.3	6.	7.3	.256	.32	.176	.144	.696	.472	.224	.017	1.6	11.8	4.	14.5	—	23,500
7296	" 11	" 12	*	"	M. F.04	....	386.4	170.8	215.6	19.2	11.2	8.	B.	5.	11.8	6.2	5.6	.208	.384	.208	.176	.92	.504	.416	.03	1.68	9.	....	3.	+	21,000
7349	" 18	" 19	*	"	M. F.25	....	338.	182.	156.	26.8	23.2	3.6	B.	5.6	11.9	6.6	5.3	.176	.288	.224	.064	.84	.568	.272	.027	1.8	10.9	11.	13.	—	7,000
7423	" 25	" 26	*	"	M. F.20	....	316.8	216.	100.8	36.	27.2	8.8	B.	6.2	10.5	6.7	3.8	.128	.272	.208	.064	.952	.504	.448	.036	1.12	12.7	15.	21.	+	6,700
7450	May 2	May 3	*	Much	M. F.38	....	246.	127.6	118.4	24.4	18.4	5.6	B.	9.3	12.8	7.5	5.3	.096	.32	.208	.112	.92	.6	.32	.017	.64	10.7	20.	24.	—	2,400
7500	" 9	" 10	*	"	M. F.03	....	368.	229.6	138.4	24.8	22.4	2.4	B.	8.4	12.	7.6	4.4	.144	.384	.256	.128	1.38	.548	.832	.08	.90	13.2	19.	21.	+	17,000
7561	" 16	" 17	*	"	M. F.02	....	329.2	253.6	75.6	36.	34.8	1.2	B.	10.	10.9	7.5	3.4	.072	.32	.208	.112	.804	.452	.352	.04	.76	8.5	25.	30.	?	4,050
7603	" 23	" 24	§	V.M'ch	M. F.05	....	374.8	265.2	109.6	46.8	37.2	9.6	B.	10.5	11.4	9.4	2.	.064	.32	.192	.128	.74	.36	.38	.038	.9	8.4	20.	27.	—	4,100
7627	" 30	" 31	‡	Cons'd	M. F.07	....	364.	265.6	98.4	40.8	26.8	14.	B.	14.	10.8	7.6	3.2	.032	.32	.208	.112	.84	.52	.32	.024	1.48	6.5	25.	27.	—	6,100
7674	June 6	June 7	*	"	M. F.03	....	352.	243.6	108.4	36.	35.6	.4	B.	12.	9.5	6.6	2.9	.032	.288	.16	.128	.8	.468	.332	.008	1.4	6.	25.	32.	+	19,550
7722	" 13	" 14	*	"	M. F.04	....	360.8	258.8	102.	37.6	37.2	.4	B.	14.	7.6	5.8	1.8	.048	.272	.176	.096	.9	.56	.34	.008	1.76	5.2	27.	31.	+	4,400
7750	" 20	" 21	*	Little	M. F.05	....	306.8	270.8	36.	35.6	35.2	.4	B.	13.	8.	6.5	1.5	.032	.256	.192	.064	.42	.356	.064	.013	1.48	5.2	27.	28.	—	1,050
7769	" 25	" 26	*	Much	M. F.03	....	360.8	267.6	93.2	31.2	28.4	2.8	B.	13.	8.1	6.7	1.4	.048	.272	.24	.032	.596	.58	.016	.007	1.04	.....	.....	29.	.....	....
7813	July 2	July 3	*	"	T. F.03	....	384.8	255.2	129.6	42.8	29.2	13.6	B.	14.	8.2	6.4	1.8	.040	.24	.176	.064	.564	.436	.128	.019	1.	.....	.....	....	.....	....
7848	" 6	" 7	*	"	T. F.02	....	343.2	253.2	90.	35.6	31.2	4.4	B.	15.	7.7	6.9	.8	.072	.208	.176	.032	.612	.372	.24	.13	1.28	14.6	29.	....	—	590
7917	" 13	" 14	*	"	T. F.03	....	306.8	243.6	63.2	26.4	25.6	.8	B.	13.	6.7	6.6	.1	.096	.24	.16	.08	.568	.35	.218	.015	1.32	3.9	31.	....	+	3,300
7986	" 20	" 21	*	Little	T. F.02	....	347.6	210.4	137.2	31.2	29.2	2.	B.	13.	8.9	6.5	2.4	.048	.272	.176	.096	.456	.276	.176	.035	.88	5.	27.	....	+	8,350
8035	" 27	" 28	*	"	T. F.02	....	342.4	228.8	113.6	56.	56.	0.0	B.	13.	11.9	7.7	4.2	.048	.352	.176	.176	.644	.372	.272	.018	.88	7.	29.	....	—	1,800
8096	Aug. 6	Aug. 7	*	"	T. F.01	....	272.	243.8	28.2	44.4	38.	6.4	G.	18.	6.7	5.1	1.6	.112	.256	.16	.096	.644	.452	.192	.014	.92	6.1	30.	....	—	500
8157	" 13	" 14	*	"	T. F.01	....	284.8	232.8	52.	40.8	34.8	6.	B.	22.	6.6	4.7	1.9	.08	.304	.176	.128	.74	.428	.312	.016	1.08	4.4	30.	....	+	5,275
8221	" 20	" 21	*	"	T. F.01	....	328.	198.8	129.2	28.4	18.4	10.	B.	17.	7.3	4.7	2.6	.08	.304	.224	.08	.6	.316	.284	.019	1.12	6.8	30.	....	+	2,700
8296	" 27	" 28	*	"	T. F.03	....	302.8	175.2	127.6	31.6	15.6	16.	B.	15.	6.7	4.9	1.8	.096	.352	.128	.224	.608	.128	.48	.013	.96	6.8	29.	....	+	1,200
8372	Sept. 5	Sept. 6	*	Much	M.	....	366.	219.6	146.4	23.2	14.	9.2	B.	14.	10.6	4.6	6.	.112	.4	.224	.176	.688	.38	.308	.008	1.2	6.7	27.	....	—	30,000
8454	" 12	" 13	*	Cons'd	M. F.03	....	300.4	242.4	58.	28.	20.8	5.2	B.	18.	7.1	5.	2.1	.064	.224	.192	.032	.508	.416	.092	.013	.12	6.1	28.	....	—	1,650
8500	" 19	" 20	*	"	M. F.01	....	302.8	225.2	77.6	23.6	20.4	3.2	B.	15.	7.4	5.4	2.	.112	.336	.192	.224	.6	.448	.152	.025	1.08	5.6	20.	....	—	3,150
8545	" 26	" 27	*	"	M. F.15	....	288.8	218.	70.8	37.2	22.	15.2	B.	14.	8.	6.8	1.2	.16	.352	.208	.144	.536	......	......	.034	.76	6.6	21.	....	+	8,500
8606	Oct. 3	Oct. 4	†	Little	C. F.05	....	271.6	246.4	25.2	27.6	25.2	2.4	B.	16.	6.	5.9	.1	.16	.24	.224	.016	.544	.504	.02	.015	.96	.....	.....	....	+	4,900

TURBIDITY—*Decided. §Very Decided. † Distinct. ‡ Very Slight. ǂ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

SOURCE OF WATER—MISSISSIPPI RIVER, GRAFTON. (Regulars.) University of Illinois.

Serial No.	Date of 1900 Collection.	Date of 1900 Examination.	Appearance. Turb'y.	Appearance. Sediment.	Appearance. Color.	Odor.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dissolv'd	Loss on Ig'n. Suspend'd	Color on Ignition.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspd Matter.	Nitrogen as Ammonia. Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspend'd	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
6625	Jan. 4	Jan. 5	*	Cons'd	M. F.05	......	232.4	210.8	21.6	23.2	21.2	2.	B.	9.45	13.	9.3	3.7	.08	.352	.208	.144	.76	.328	.432	.007	.16	2.9	0.	6.	—	9,600
6656	" 10	" 11	*	"	M. F.1	......	206.4	192.4	14.	20.	16.8	3.2	B.	4.8	11.6	9.3	2.3	.012	.48	.176	.304	.792	.344	.448	.008	.08	4.2	0.	3.	+	6,000
6706	" 17	" 18	†	"	M. F.06	......	204.8	178.8	26.	39.2	26.4	12.8	B.	4.4	10.7	8.8	1.9	.034	.352	.176	.176	.88	.384	.496	.001	.08	3.5	3.	13.	+	6,300
6750	" 24	" 25	*	Much	M. F.06	......	274.4	180.4	94.	30.4	20.	10.4	B.	3.8	11.2	5.2	6.	.028	.352	.176	.176	.8	.512	.288	.008	.48	5.1	4.	17.	+	34,700
6801	" 31	Feb. 2	*	Cons'd	M. F.25	......	213.6	172.8	40.8	34.8	22.8	12.	B.	4.	13.3	11.2	2.1	.12	.32	.24	.08	.8	.416	.384	.008	.48	2.8	0.	— 9.	+	12,200
6865	Feb. 7	" 8	*	"	M. F.03	......	248.4	181.2	67.2	24.4	13.6	10.8	B.	5.8	13.2	9.2	4.	.00	.368	.24	.128	.96	.32	.64	.006	.4	3.8	0.	13.	—	51,000
6912	" 14	" 15	*	Much	M. F.4	......	531.6	148.8	382.8	38.8	26.	12.8	B.	3.65	17.	8.6	8.4	.112	.672	.224	.448	1.52	.416	1 104	.006	.72	6.6	0.	2.	+	80,000
6957	" 21	" 23	*	"	M. F.5	......	318.	137.2	180.8	64.	30.4	33.6	B.	3.3	13.5	11.3	2.2	.304	.688	.352	.336	1.36	.864	.496	.012	.72	....	0.	5 5	+	116,000
6999	Mar. 1	Mar. 3	*	"	VM.F.08	......	210.	152.4	57.6	37.2	17.6	19.6	B.	3.8	13.7	11.2	2.5	.228	.4	.176	.224	.72	.48	.24	.006	.68	6.	0.	......	+	35,500
7058	" 9	" 12	*	"	M. F.4	......	499.6	142.8	356.8	25.6	14.4	11.2	B.	3.4	14.8	7.4	7.4	.152	.48	.208	.272	1.44	.512	.928	.007	.64	10.6	0.	2.	+	65,500
7115	" 19	" 20	*	"	M. F.5	......	533.6	125.6	408.	34.8	16.4	18.4	B.	2.	22.4	8.8	13.6	.352	.736	.256	.48	1.64	.536	1.104	.008	.52	15.6	0.	4.	?	247,500
7172	" 26	" 28	*	"	M. F.30	......	367.2	108.8	258.4	32.	13.6	18.4	B.	2.8	17.1	9.5	7.6	.42	.56	.304	.256	1.48	.696	.784	.01	.48	13.	4.	17.	—	88,000
7214	April 2	April 3	*	"	M. F.06	......	259.6	125.2	134.4	22.4	13.6	8.8	B.	3.4	14.	7.3	6.7	.332	.448	.272	.176	.952	.612	.34	.008	.6	11.2	5.	14.5	—	81,000
7269	" 9	" 10	§	V.M'ch	VM.F.30	......	1024.	116.8	907.2	46.8	22.8	24.	B.	1.5	27.6	9.3	18.3	.272	1.088	.304	.784	.252	.76	1.76	.017	1.04	13.7	9.	2.	—	210,000
7326	" 16	" 17	*	Much	M. F.30	.. ...	302.4	141.2	161.2	22.	21.2	.8	B.	3.5	14.4	8.2	6.2	.14	.432	.272	.16	1.08	.664	.416	.022	.08	11.5	11.	13.	+	50,000
7395	" 23	" 24	§	V.M'ch	VM.F.40	......	1171.6	118.4	1053.2	64.	16.8	47.2	B.	2.	21.7	6.6	15.1	.044	1.28	.176	1.104	2.92	.44	2.48	.026	.8	13.5	14.	21.	+	74,000
7451	May 2	May 3	*	Much	M. F.05	......	311.6	137.2	174.4	32.8	20.8	12.	B.	3.4	14.9	8.2	6.7	.016	.416	.24	.176	1.14	.484	.656	.011	.6	10.7	19.	24.	+	15,000
7499	" 9	" 10	*	Cons'd	M. F.30	......	264.8	102.	162.8	30.4	21.2	9.2	B.	3.	17.6	11.9	5.7	.04	.4	.272	.128	1.06	.84	.22	.006	.12	12.2	18.	21.	+	17,000
7560	" 16	" 17	..	....	M. F.2	......	326.4	123.6	202.8	41.2	23.2	18.	B.	3.	18.5	9.7	8.8	.056	.448	.176	.272	1.06	.356	.704	.002	.3	8.5	23.	30.	....	12,500
7604	" 23	" 24	§	V.M'ch	VM.F.2	......	494.8	147.2	347.6	54.4	24.4	30.	B.	3.	17.1	10.9	6.2	.04	.48	.24	.24	.964	.42	.544	.013	1.	8.4	19.	27.	—	4,300
7628	" 30	" 31	*	Cons'd	M. F.10	......	270.4	136.4	134.	39.2	24.8	14.4	B.	3.4	12.	8.5	3.5	.012	.352	.192	.16	.96	.452	.508	.008	.48	6.5	24.	27.	+	4,100
7673	June 6	June 7	*	"	M. F.05	......	270.6	136.	141.6	36.	30.8	5.2	B.	3.9	13.6	8.2	5.4	.024	.352	.128	.224	.9	.324	.576	.006	.3	6.	25.	32.	—	6,000
7723	" 13	" 14	*	"	M. F.15	......	239.2	165.2	74.	35.6	28.	7.6	B.	4.	9.4	8.1	1.3	.028	.32	.16	.16	.708	.28	.428	.001	.16	5.2	26.	31.	+	1,000
7749	" 20	" 21	*	Little	M. F.05	......	257.2	181.6	75.6	38.8	22.8	16.	B.	3.7	11.8	7.5	4.3	.04	.288	.128	.16	.66	.292	.368	.004	.12	5.2	26.	28.	—	2,600
7770	" 25	" 26	*	Much	M. F.03	......	562.8	164.	398.8	40.4	22.8	17.6	B.	3.4	16.	6.9	9.1	.042	.48	.112	.368	1.156	.452	.704	.013	.28	....	....	......	....	....
7812	July 2	July 3	*	"	T. F.02	......	318.	220.	98.	36.8	34.8	2.	B.	4.	9.9	6.8	3.1	.078	.32	.16	.16	.868	.324	.544	.000	.36	4.5	27.	......	—	1,200
7885	" 9	" 10	*	Little	M. F.03	......	348.4	189.2	159.2	22.	17.2	4.8	B.	4.8	12.2	6.9	5.3	.06	.32	.176	.144	1.092	.18	.912	.005	.4	4.1	29.	......	+	4,700
7927	" 16	" 17	*	"	M. F.02	......	280.8	181.2	99.6	20.	17.2	2.8	B.	4.2	11.3	6.5	4.8	.08	.336	.176	.16	.9	.308	.592	.006	.36	6.9	30.	......	—	4,700
7994	" 23	" 24	*	Much	M. F 02	......	354.8	138.4	216.4	34.8	20.8	14.	B.	3.3	12.9	6.7	6.2	.074	.336	.192	.144	.68	.212	.468	.001	.36	6.3	28.	......	?	3,300
8048	" 30	" 31	*	"	M. F.02	......	564.	123.2	440.8	69.2	26.4	42.8	B.	2.6	19.	8.	11.	.064	.544	.16	.384	1.224	.388	.836	.004	.68	7.3	29.	......	-	2,100
8097	Aug. 6	Aug. 7	*	Cons'd	T. F.01	......	285.2	142.	143.2	58.4	47.2	11.2	B.	2.7	14.7	12.8	1.9	.082	.384	.342	.042	.76	.548	.212	.002	.44	6.1	30.	......	+	1,450
8156	" 13	" 14	*	Little	T. F.02	......	235.2	156.6	79.6	39.6	37.6	2.	B.	3.	15.4	10.	5.4	.08	.32	.24	.08	1.	.43	.57	.004	.28	4.4	29.	......	—	4,150
8220	" 20	" 21	*	"	T. F.01	......	383.6	148.8	234.8	42.	22.4	19.6	B.	5.6	12.7	7.2	5.5	.13	.512	.208	.304	1.	.252	.748	.007	.44	6.8	29.	......	+	3,250
8294	" 27	" 28	*	Cons'd	M. F.	......	423.2	132.	291.2	38.	20.	18.	DB.	3.	16.	7.	9.	.128	.384	.192	.192	1.16	.252	.908	.005	.64	6.8	29.	......	—	1,700
8371	Sept. 5	Sept. 6	*	Much	M.	......	309.6	154.8	154.8	24.4	20.4	4.	DB.	2.6	19.3	8.8	10.5	.088	.4	.24	.16	.664	.412	.252	.005	.32	6.7	28.	......	+	2,750
8453	" 12	" 13	*	Cons'd	M. F.2	.... .	216.2	149.6	66.6	34	24.8	9.2	DB.	3.	17.5	11.2	6.3	.09	.464	.192	.272	.616	.464	.152	.002	.24	6.1	29.	......	+	2,800
8501	" 19	" 20	*	"	M. F.04	......	260.8	148.	112.8	40.	27.6	12.4	DB.	2.8	15.4	11.8	3.6	.008	.4	.288	.112	.828	.532	.296	.004	.32	5.6	19.	......	—	2,300
8544	" 26	" 27	*	"	M. F.8	......	306.	144.4	161.6	51.6	31.6	20.	B.	2.2	17.6	11.7	5.9	.162	.432	.24	.192	.792	.656	.136	.002	.36	6.6	20.	......	+	11,100
8604	Oct. 3	Oct. 4	*	"	M. F.2	......	372.	153.6	218.4	104.	44.8	59.2	B.	1.3	27.6	18.3	9.3	.164	.528	.324	.204	1.28	.624	.656	.002	.44	....	....	......	+	2,900

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 64.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 100 FEET FROM ILLINOIS SHORE, ALTON.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dissolv'd	Loss on Ig'n. Suspnd'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
6620	Jan. 4	Jan. 5	*	Cons'd	M. F.04	......	311.6	202.4	19.2	41.2	40.	1.2	G.	19.2	11.8	9.6	2.2	1.16	.448	.24	.208	1.02	.616	.404	.035	.92	.....	0.	4.	—	16,400
6657	" 10	" 11	*	"	M. F.06	......	283.2	261.2	22.	31.6	27.6	4.	G.	11.8	9.5	8.4	1.1	.844	.48	.176	.304	1.08	.472	.608	.014	.92	2.4	0.	0.	—	3,150
6698	" 17	" 18	†	"	M. F.04	......	258.4	252.8	5.6	41.2	40.4	.8	G.	9.4	9.2	8.2	1.	.344	.464	.192	.272	.88	.544	.336	.014	.92	1.4	0.	......	—	16,800
6745	" 24	" 25	*	Much	M. F.03	......	435.6	201.2	234.4	39.6	27.6	12.	B.	7.	15.1	10.5	4.6	.028	.464	.224	.24	1.2	.544	.656	.036	1.32	3.9	0.	......	+	50,800
6811	Feb. 2	Feb. 3	*	Cons'd	M. F.04	......	316.	258.4	57.6	35.6	34.	1.6	B.	12.4	10.4	8.9	1.5	1.228	.368	.208	.16	.8	.544	.256	.019	1.28	.0	0.	......	—	15,200
6856	" 7	" 8	*	"	M. F.04	......	308.	239.6	68.4	37.6	35.2	2.4	B.	12.4	11.8	7.5	4.3	.962	.368	.176	.192	.8	.48	.32	.015	1.28	2.6	11.	......	.....	54,000
6906	" 14	" 15	§	VMuch	VM.F.2	......	1483.2	146.	1337.2	60.	20.	40.	B.	4.4	29.7	7.5	22.2	.368	1.44	.288	1.152	3.	.544	2.456	.014	1.13	5.	0.	......	+	96,000
6960	" 21	" 22	*	Much	M. F.2	......	1552.4	175.6	1376.8	123.6	6.4	117.2	B.	6.2	23.3	7.9	15.4	.608	1.184	.272	.912	2.4	.576	1.824	.018	1.32	5.	0.	......	—	131,000
7000	Mar. 2	Mar. 3	*	Cons'd	M. F.04	......	392.	198.	194.	38.	24.4	13.6	B.	6.5	14.1	9.6	4.5	.448	.432	.224	.208	.88	.64	.24	.018	1.36	3.4	0.	......	—	65,000
7053	" 9	" 10	§	Much	VM.F.3	......	1438.8	139.6	1299.2	35.2	14.	21.2	B.	3.8	24.9	5.7	19.2	.384	.896	.208	.688	2.72	.512	2.208	.015	.92	11.6	0.	9.	+	119,000
7085	" 14	" 15	§	VMuch	VM.F.04	......	1204.4	142.4	1062.	42.	12.8	29.2	B.	3.8	23.1	5.8	17.3	.368	.96	.16	.8	2.4	.384	2.016	.009	1.4	17.	4.	6.	+	215,000
7131	" 21	" 22	*	Much	M. F.06	......	878.	135.2	742.8	42.8	15.2	27.6	B.	3.6	18.4	6.	12.4	.272	.672	.16	.512	1.88	.536	1.344	.009	1.2	19.1	0.	......	+	82,000
7180	" 28	" 29	*	"	M. F.06	......	616.	140.8	475.2	37.2	12.8	24.4	B.	4.6	14.6	6.8	7.8	.288	.448	.176	.272	1.08	.472	.608	.013	1.48	11.5	0.	......	+	62,000
7233	April 4	April 5	*	Cons'd	M. F.15	......	417.2	146.	271.2	25.2	17.2	8.	B.	4.2	12.	6.3	5.7	.24	.384	.176	.208	.76	.376	.384	.015	1.68	10.1	9.	......	—	34,000
7296	" 12	" 13	*	Much	M. F.40	......	534.	109.6	424.4	26.	21.2	4.8	B.	3.3	11.8	7.	4.8	.224	.576	.256	.32	1.06	.388	.672	.031	1.58	11.4	8.	5.	+	15,000
7341	" 18	" 19	*	Cons'd	M. F.04	.....	374.	185.6	188.4	32.4	24.4	8.	B.	5.3	12.2	6.2	6.	.16	.352	.192	.16	1.08	.536	.544	.03	2.2	10.5	10.	10.	—	11,500
7409	" 25	" 26	*	Much	M. F.04	......	340.4	196.4	144.	35.6	28.	7.6	B.	5.7	13.6	7.6	6.	.096	.4	.208	.192	1.24	.44	.8	.004	1.72	11.9	15.	25.	—	12,000
7453	May 2	May 3	*	Cons'd	M. F.03	......	494.4	224.	270.4	33.2	25.2	8.	B.	7.3	13.7	7.4	6.3	.048	.544	.288	.256	1.348	.484	.864	.02	1.44	10.1	20.	23.	—	13,500
7493	" 9	" 10	*	Much	M. F.04	......	606.	205.6	400.4	36.8	20.8	16.	B.	7.7	15.1	7.7	7.4	.088	.528	.256	.272	1.	.58	.42	.025	.8	11.4	19.	16.	+	44,500
7542	" 16	" 17	*	Cons'd	M. F.06	......	452.	247.6	204.4	42.8	22.4	20.4	B.	8.9	13.9	7.8	6.1	.124	.512	.24	.272	1.316	.292	1.024	.03	.76	8.8	24.	20.	+	14,000
7595	" 23	" 24	*	"	M. F.03	......	516.4	259.6	256.8	52.8	42.4	10.4	B.	9.4	14.1	7.8	6.3	.064	.4	.112	.288	.74	.388	.352	.025	.92	8.4	19.	21.	+	14,000
7632	" 30	" 31	*	Much	M. F.20	......	284.8	148.	136.8	29.2	24.4	4.8	B.	7.5	11.9	7.7	4.2	.024	.384	.192	.192	.8	.388	.412	.013	.53	7.2	24.	25.	—	2,100
7684	June 6	June 7	*	Cons'd	M. F.03	......	388.8	216.4	172.4	34.	32.4	1.6	B.	7.6	12.7	8.1	4.6	.012	.352	.192	.16	.84	.58	.26	.01	.92	6.1	24.	26.	+	9,000
7714	" 13	" 14	*	"	M. F.03	......	728.8	222.4	506.4	46.4	38.8	7.6	B.	8.5	15.4	7.8	8.3	.024	.48	.24	.24	1.7	.52	1.18	.013	1.08	5.2	24.	26.	+	30,000
7751	" 20	" 21	*	"	M. F.04	......	339.6	239.6	100.	36.8	35.6	1.2	B.	8.	9.8	6.4	3.4	.046	.272	.144	.128	.692	.356	.336	.01	.92	5.3	23.	25.	.....	4,000
7793	" 27	" 28	*	Distl'ct	M. F.01	......	480.4	201.6	278.8	56.	33.2	22.8	B.	7.4	13.6	5.4	8.2	.042	.368	.16	.208	1.	.356	.644	.048	.88	7.2	26.	29.	+	9,500
7827	July 4	July 5	*	Little	T. F.03	......	357.2	230.	127.2	45.6	33.6	12.	B.	10.	9.	7.	2.	.110	.24	.176	.064	.552	.484	.068	.012	1.04	5.3	30.	......	.....	3,300
7906	" 11	" 12	*	"	T. F.02	......	318.	214.8	103.2	39.2	30.	9.2	B.	9.4	8.3	6.7	1.6	.084	.272	.16	.112	.52	.276	.244	.013	1.08	4.7	28.	......	+	2,000
7976	" 18	" 19	*	"	T. F.02	......	301.6	198.8	102.8	26.4	16.	10.4	B.	9.4	8.5	6.8	1.7	.052	.224	.208	.016	.6	.42	.18	.011	.76	4.5	26.	......	?	4,500
8072	Aug. 1	Aug. 2	*	Cons'd	M. F.02	......	508.4	180.8	327.6	39.2	38.4	.8	B.	8.4	13.8	6.6	7.2	.056	.208	.176	.032	1.	.436	.564	.008	1.08	6.5	29.	......	—	8,000
8130	" 7	" 8	*	"	M. F.02	......	272.8	189.2	83.6	45.3	40.	5.6	B.	10.	11.	7.8	3.2	.110	.448	.208	.24	.92	.436	.484	.01	.59	4.6	31.	......	+	1,100
8190	" 15	" 16	*	Little	T. F.02	......	276.	190.8	85.2	36.	32.	4.	B.	10.6	9.5	6.4	3.1	.006	.32	.288	.032	.76	.54	.22	.008	.52	3.	29.	......	—	1,950
8256	" 22	" 24	*	Cons'd	M. F.05	......	645.6	155.6	490.	52.	18.8	33.2	DB.	8.	14.	5.3	8.7	.112	.72	.24	.48	1.08	.588	.492	.008	.96	5.2	29.	......	—	1,100
8323	" 29	" 30	*	"	M. F.02	......	373.6	178.	195.6	36.	12.4	23.6	B.	9.6	11.2	5.5	5.7	.084	.352	.112	.24	.52	.252	.268	.008	.88	5.2	28.	......	—	2,750
8390	Sept. 5	Sept. 6	§	VMuch	M. F.04	......	376.	208.4	167.6	38.	18.	20.	DB.	10.2	10.4	5.8	4.6	.078	.304	.24	.064	.6	.432	.168	.008	.92	6.	29.	......	—	3,300
8450	" 12	" 13	*	Much	M. F.25	......	323.6	193.2	130.4	39.6	22.8	16.8	B.	9.4	13.5	8.3	5.2	.070	.272	.192	.08	.728	.512	.216	.011	.72	4.7	27.	......	—	5,050
8504	" 19	" 20	*	Cons'd	M. F.15	......	304.8	188.4	116.4	36.4	27.6	8.8	B.	8.	12.7	8.2	4.5	.164	.368	.272	.096	1.3	.576	.724	.015	.56	4.	19.	......	—	6,750
8557	" 26	" 27	*	"	M. F.4	......	320.	176.8	143.2	43.2	28.4	14.8	B.	6.	16.5	11.7	4.8	.136	.48	.32	.16	.92	.64	.28	.015	.56	4.9	24.	......	+	11,750
8611	Oct. 3	Oct. 4	*	"	M. F.01	......	405.2	160.8	244.4	39.2	28.8	10.4	DB.	5.4	25.3	16.5	8.8	.196	.448	......	......	1.216	......	......	.008	.6	.....	.....	......	.....	....

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. | Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 65.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, ONE-FOURTH DISTANCE FROM ILLINOIS SHORE, ALTON.

Serial No.	Date of 1900 Collection.	Date of 1900 Examination.	Appearance. Turb'y.	Appearance. Sediment.	Appearance. Color.	Odor.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dissolv'd	Loss on Ig'n. Suspnd'd	Color on Ignition.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspd Matter.	Nitrogen as Ammonia. Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspnd'd	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
6621	Jan. 4	Jan. 5	*	Cons'd	M. F.04	......	293.6	285.	8.6	35.6	35.2	.4	B.	18.	11.7	9.9	1.8	1.04	.4	.24	.16	.84	.488	.352	.08	.72	0.	0.	4.	—	11,000
6658	" 10	" 11	*	"	M. F.06	......	274.4	254.8	19.6	28.4	26.4	2.	B.	10.9	12.4	8.8	3.6	.712	.48	.224	.256	1.08	.472	.608	.014	.72	2.4	0.	0.	—	5,900
6699	" 17	" 18	†	"	M. F.03	......	240.	226.8	13.2	39.6	36.4	3.2	B.	8.2	9.5	8.3	1.2	.24	.48	.208	.272	.92	.512	.408	.012	.70	1.4	0.	......	—	7,000
6746	" 24	" 25	*	Much	M. F.03	......	426.4	186.8	239.6	47.2	25.2	22.	B.	6.	14.8	8.8	6.	.36	.448	.16	.288	1.04	.352	.688	.018	1.24	3.9	0.	......	+	57,000
6812	Feb. 2	Feb. 3	*	Cons'd	M. F.1	......	316.	244.	72.	46.4	38.4	8.	G.	11.2	12.5	8.8	3.7	1.09	.416	.224	.192	.96	.48	.48	.018	1.24	.0	0.	......	—	12,000
6857	" 7	" 8	*	"	M. F.06	......	314.8	244.4	70.4	28.	24.	4.	B.	12.2	11.5	7.9	3.6	.88	.416	.16	.256	.88	.576	.304	.014	1.2	2.6	11.	......	....	76,000
6905	" 14	" 15	§	V.M'ch	VM. F.07	......	1252.	151.6	1100.4	77.2	22.	55.2	B.	4.6	24.3	7.7	16.6	.304	1.44	.272	1.168	2.88	.48	2.4	.015	1.08	5.	0.	......	+	98,000
6951	" 21	" 22	*	Much	M. F.15	......	1223.2	164.	1059.2	117.6	14.8	102.8	B.	5.8	21.7	8.4	13.3	.56	1.056	.272	.784	2.32	.544	1.776	.018	1.22	5.	0.	......	+	171,000
7001	Mar. 2	Mar. 3	*	Cons'd	M. F.06	......	364.8	191.2	173.6	38.4	20.	18.4	B.	6.4	14.1	9.2	4.9	.432	.48	.256	.224	.88	.448	.432	.013	1.28	3.4	0.	......	+	53,500
7054	" 9	" 10	§	Much	VM. F.04	......	1157.2	133.2	1024.	39.2	21.6	17.6	B.	4.4	18.8	6.	12.8	.352	.832	.176	.656	2.56	.352	2.208	.012	.88	11.6	0.	9.	+	101,000
7086	" 14	" 15	§	V.M'ch	VM. F.04	......	1324.	118.8	1205.2	53.6	8.	45.6	B.	3.2	25.8	6.8	19.	.288	.768	.224	.544	2.56	.448	2.112	.006	.68	17.	4.	6.	+	200,000
7132	" 21	" 22	*	Much	M. F.2	......	744.4	119.6	624.8	36.4	16.	20.4	B.	3.6	18.3	7.2	11.1	.432	.896	.192	.704	2.04	.664	1.376	.008	1.	19.1	0.	......	—	256,000
7179	" 28	" 29	*	"	M. F.1	......	470.8	138.	332.8	26.8	18.8	8.	B.	4.	14.3	7.	7.3	.384	.544	.176	.368	1.112	.472	.64	.011	1.12	11.5	0.	......	—	54,000
7236	Apr. 4	Apr. 5	*	Cons'd	M. F.20	......	380.4	142.4	238.	24.8	19.6	5.2	B.	3.8	12.8	6.8	6.	.296	.336	.192	.144	.664	.504	.16	.015	1.36	10.1	9.	......	—	44,000
7297	" 12	" 13	*	"	M. F.10	......	442.8	142.	300.8	32.8	10.	22.8	B.	3.8	16.7	7.8	8.9	.224	.576	.224	.352	1.32	.504	.816	.026	1.16	11.4	8.	5.	+	15,000
7342	" 18	" 19	*	"	M. F.04	......	301.6	164.8	136.8	26.	19.6	6.4	B	4.4	12.3	6.5	5.8	.176	.32	.176	.144	1.016	.504	.512	.025	1.66	10.5	10.	10.	—	11,000
7410	" 25	" 26	§	V.M'ch	VM. F.30	......	656.	135.6	520.4	52.8	20.4	32.4	B.	......	12.9	8.6	4.3	.048	.768	.16	.608	1.8	.44	1.36	.03	.84	11.9	15.	25.	+	80,000
7454	May 2	May 3	‡	Cons'd	M. F.04	......	284.	153.6	130.4	25.2	22.4	2.8	B.	3.1	14.8	7.9	6.9	.02	.48	.192	.288	.984	.38	.604	.01	.94	10.1	20.	22.	+	30,000
7494	" 9	" 10	*	Much	M. F.3	......	441.6	156.4	285.2	35.6	20.4	15.2	B.	5.4	16.4	10.7	5.7	.08	.528	.272	.256	1.092	.388	.704	.02	.44	11.4	19.	16.	+	22,000
7543	" 16	" 17	*	Cons'd	M. F.1	......	379.2	186.	193.2	34.	21.6	12.4	B.	6.5	15.9	8.6	7.3	.08	.416	.224	.192	1.06	.548	.512	.025	.4	8.8	24.	29.	+	7,000
7594	" 23	" 24	*	"	M. F.05	......	506.4	192.	314.4	46.	30.4	15.6	B.	5.8	18.4	8.1	10.3	.064	.48	.112	.368	1.06	.56	.5	.02	.52	8.4	19.	21.	+	38,000
7633	" 30	" 31	*	Much	M. F.05	......	363.2	201.2	162.	39.2	32.8	6.4	B.	6.3	13.	6.8	6.2	.016	.352	.192	.16	1.028	.452	.576	.015	1.32	7.2	24.	25.	+	6,900
7668	June 6	June 7	*	Cons'd	M. F.03	......	378.	185.2	192.8	34.8	33.6	1.2	B.	6.2	13.1	8.1	5.	.024	.368	.16	.208	.8	.52	.28	.000	.72	6.1	24.	26.	+	9,500
7715	" 13	" 14	*	"	M. F.02	......	589.2	218.8	370.4	52.	40.	12.	B.	7.8	13.3	7.4	5.9	.02	.432	.224	.208	1.94	.484	1.456	.01	1.	5.2	24.	26.	+	10,000
7752	" 20	" 21	*	"	M. F.04	......	329.2	232.4	96.8	38.4	34.8	3.6	B.	6.8	10.6	6.4	4.2	.04	.272	.192	.08	.628	.244	.384	.007	.8	5.3	23.	25.	....	4,000
7794	" 27	" 28	*	"	M. F.01	......	514.	210.4	303.6	69.6	42.	27.6	B.	6.8	14.2	5.6	8.6	.044	.368	.192	.176	1.32	.372	.948	.025	.72	7.2	26.	29.	+	8,000
7828	July 4	July 5	*	Little	T. F.01	......	344.8	219.6	125.2	37.6	26.	11.6	B.	8.5	10.6	7.7	2.9	.092	.304	.16	.144	.552	.42	.132	.012	1.	5.3	30.	......	....	2,100
7905	" 11	" 12	*	"	T. F.02	......	310.4	213.6	96.8	29.2	16.4	12.8	B	8.3	8.7	7.7	1.	.106	.272	.176	.096	.712	.356	.356	.013	.88	4.7	28.	......	?	5,500
7979	" 18	" 19	*	"	T. F.02	......	301.2	195.2	106.	26.8	20.	6.8	B.	8.6	8.6	7.2	1.4	.082	.272	.192	.08	.84	.308	.532	.012	.68	4.5	28.	......	+	10,300
8071	Aug. 1	Aug. 2	*	Cons'd	M. F.03	......	474.4	152.4	322.	51.2	24.8	26.4	B	6.5	15.8	6.3	9.5	.072	.448	.176	.272	1.08	.356	.724	.004	.68	6.5	29.	......	—	2,200
8121	" 8	" 9	*	"	M. F.02	......	280.8	188.8	92.	63.2	52.	11.2	B.	8.2	12.3	8.4	3.9	.118	.352	.192	.16	.84	.42	.42	.009	.48	4.6	31.	......	+	3,000
8180	" 15	" 16	*	Little	T. F.02	......	276.8	186.8	90.	37.2	35.6	1.6	B.	10.1	9.5	6.6	2.9	.108	.416	.176	.24	.68	.348	.332	.009	.48	3.	29.	......	+	2,800
8267	" 22	" 24	*	Cons'd	M. F.1	......	701.6	138.4	563.2	63.6	20.8	42.8	B.	5.4	18.4	5.7	12.7	.096	.72	.16	.56	1.336	.22	1.116	.003	.96	5.2	30.	......	?	2,050
8324	" 29	" 30	*	"	M. F.03	......	350.4	152.8	197.6	35.6	16.8	18.8	DB.	6.4	12.8	6.2	6.6	.112	.352	.16	.192	.52	......	......	.001	.68	5.2	28.	......	—	1,050
8379	Sept. 5	Sept. 6	§	Much	M. F.05	......	333.6	182.8	150.8	34.	12.8	21.2	DB.	7.8	13.8	6.7	7.1	.084	.304	.192	.112	.6	.448	.152	.006	.76	6.	29.	......	—	5,500

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 66.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, MIDSTREAM, ALTON.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinoi

Serial No.	Date of: 1900 Collection.	Date of: 1900 Examination.	Appearance: Turb'y.	Appearance: Sediment.	Appearance: Color.	Odor.	Residue on Evaporation: Total.	Residue on Evaporation: Dissolved.	Residue on Evaporation: Suspended.	Loss on Ig'n: Tot'l	Loss on Ig'n: Dis-solv'd	Loss on Ig'n: Sus-pnd'd	Color on Ignition.	Chlorine.	Oxygen Consumed: Total.	Oxygen Consumed: By Dissolved.	Oxygen Consumed: By Suspd Matter.	Nitrogen as Ammonia: Free Ammonia.	Albuminoid Am.: Tot'l	Albuminoid Am.: Dis-solv'd	Albuminoid Am.: Sus-pnd'd	Organic Nitrogen: Total.	Organic Nitrogen: Dissolved.	Organic Nitrogen: Suspended.	Nitrogen as: Nitrites.	Nitrogen as: Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
6622	Jan. 4	Jan. 5	*	Cons'd	M. F.04	......	282.8	272.8	10.	35.2	33.2	2.	B.	15.6	11.2	9.1	2.1	.72	.352	.272	.08	.76	.616	.144	.08	.6	.0	0.	4.	—	3,900
6659	" 10	" 11	*	"	M. F.06	......	265.6	235.6	30.	24.8	23.2	1.6	B.	8.8	10.5	8.8	1.7	.52	.464	.208	.256	1.016	.28	.736	.012	.52	2.4	0.	6.	—	14,200
6700	" 17	" 18	†	"	M. F.05	......	229.6	206.8	22.8	32.4	22.	10.4	B	7.	10.2	8.9	1.3	.12	.4	.24	.16	.88	.64	.24	.006	.56	1.4	0.	......	—	18,200
6747	" 24	" 25	*	Much	M. F.2	......	344.	187.6	156.4	45.2	28.	17.2	B.	5.4	14.6	9.	5.6	.24	.448	.24	.208	1.04	.64	.4	.013	.8	3.9	0.	......	—	51,000
6813	Feb. 2	Feb. 3	*	Cons'd	M. F.1	......	305.2	230.	75.2	47.6	40.	7.6	G.	10.6	12.6	9.4	3.2	.384	.368	.224	.144	.768	.576	.192	.014	.96	.0	0.	......	—	29,600
6858	" 7	" 8	*	"	M. F.04	......	290.8	232.4	58.4	26.4	25.6	8.	B.	11.	9.2	8.	1.2	.72	.384	.24	.144	.8	.576	.224	.012	.76	2.6	11.	......	......	50,000
6904	" 14	" 15	§	V.M'ch	M. F.15	......	1315.2	152.	1163.2	43.6	20.8	22.8	B.	4.2	23.7	19.5	4.2	.376	1.344	.24	1.104	3.04	.448	2.592	.012	1.08	5.	0.	......	+	140,000
6952	" 21	" 22	.	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	5.	0.	......	+	172,000
7002	Mar. 2	Mar. 3	*	Cons'd	M. F.05	......	371.6	172.	199.6	29.2	21.2	8.	B.	5.4	14.1	9.4	4.7	.384	.432	.208	.224	.72	.48	.24	.011	.4	3.4	0.	......	+	58,500
7055	" 9	" 10	§	Much	VM.F.1	......	892.	133.6	758.4	36.8	11.2	25.6	B.	3.6	17.4	6.6	10.8	.288	.672	.208	.464	2.24	.48	1.76	.011	.8	10.	0.	9.	+	88,000
7067	" 14	" 15	§	V.M'ch	VM.F.2	......	1537.6	96.8	1440.8	35.6	12.4	23.2	B.	1.	26.8	9.1	17.7	.368	1.216	.208	1.008	3.04	.544	2.496	.007	.6	17.	4.	6.	+	200,000
7133	" 21	" 22	*	Much	M. F.3	......	490.8	105.2	385.6	45.6	13.6	32.	B.	2.4	21.5	8.8	12.7	.416	.96	.288	.672	2.2	.92	1.28	.008	.56	19.1	0.	......	+	280,000
7178	" 28	" 29	*	"	M. F.3	......	364.4	110.4	254.	27.2	21.2	6.	B.	3.	16.3	8.5	7.8	.4	.576	.192	.384	1.4	.568	.832	.01	.56	11.5	0.	......	—	60,000
7235	Apr. 4	Apr. 5	*	Cons'd	M. F.25	......	314.4	134.4	180.	28.8	12.	16.8	B.	3.	14.6	7.8	6.8	.256	.384	.224	.16	.856	.536	.32	.012	.68	10.1	9.	......	—	95,500
7298	" 12	" 13	*	Much	M. F.25	......	571.2	167.2	404.	39.2	24.	15.2	B.	1.	19.6	9	10.6	.224	.864	.304	.56	2.12	.728	1.392	.08	1.	11.4	8.	5.	+	82,500
7343	" 18	" 19	*	Cons'd	M. F.06	......	251.2	118.	133.2	25.6	13.6	12.	B·	3.	12.5	7.1	5.4	.136	.368	.144	.224	.84	.504	.336	.02	.72	10.5	10.	10.	—	13,000
7411	" 25	" 26	*	"	M. F.20	......	829.6	104.8	724.8	63.2	9.6	53.6	B.	1.	24.	8.9	15.1	.096	.768	.176	.592	1.96	.408	1.552	.024	.8	11.9	15.	25.	+	72,000
7456	May 2	May 3	*	"	M. F.04	......	301.6	125.6	176.	26.8	22.8	4.	B.	3.4	14.6	7.8	6.8	.024	.48	.224	.256	.932	.42	.512	.007	.56	10.1	20.	23.	—	28,000
7495	" 9	" 10	*	Much	M. F.40	......	326.8	100.4	226.4	38.4	10.8	27.6	B.	2.8	17.1	11.8	5.3	.08	.48	.224	.256	.84	.48	.36	.008	.32	11.4	19	16.	+	46,000
7541	" 16	" 17	*	Cons'd	M. F.4	......	365.2	121.2	244.	38.4	20.8	17.6	B.	5.2	17.8	9.7	8.1	.008	.48	.144	.336	.642	.292	.35	.01	.24	8.8	24.	20.	+	13,500
7596	" 23	" 24	§	V.M'ch	M. F.05	......	570.	141.6	428.4	58.	40.4	17.6	B.	3.6	16.6	8.1	8.5	.044	.48	.112	.368	1.156	.196	.96	.015	.32	8.4	19.	21.	+	38,000
7631	" 30	" 31	*	"	M. F.20	......	306.	164.	142.	42.4	36.	6.4	B.	4.4	12.2	7.4	4.8	.02	.32	.176	.144	.866	.308	.56	.01	.8	7.2	24.	25.	+	6,500
7665	June 6	June 7	*	Cons'd	M. F.02	......	327.2	156.8	170.4	31.2	28.8	2.4	B.	4.6	14.3	7.9	6.4	.02	.352	.192	.16	.8	.388	.412	.008	.36	6.1	24.	26.	—	4,000
7716	" 13	" 14	*	"	M. F.04	......	338.	188.4	149.6	48.8	29.2	19.6	B.	6.3	12.4	7.8	4.6	.032	.352	.176	.176	.98	.52	.46	.008	.48	5.2	24.	28.	—	1,000
7753	" 20	" 21	*	"	M. F.04	......	296.4	210.4	86.	48.4	46.4	2.	B.	4.8	9.1	7.9	1.2	.044	.288	.192	.096	.612	.244	.368	.004	.32	5.3	23.	25.	......	1,500
7795	" 27	" 28	*	......	M. F.01	......	546.	181.2	364.8	60.8	24.4	36.4	B.	5.	15.1	5.6	9.5	.064	.496	.144	.352	1.32	.244	1.076	.013	.72	7.2	25.	28.	+	11,000
7829	July 4	July 5	*	Little	T. F.02	......	320.	184.8	135.2	40.	21.6	18.4	B.	5.4	11.8	6.4	5.4	.078	.32	.128	.192	.68	.356	.324	.007	.24	5.3	30.	......	......	3,450
7904	" 11	" 12	*	"	T. F.02	......	317.2	212.4	104.8	40.4	36.4	4.	B.	6.5	9.3	6.8	2.5	.070	.272	.16	.112	.692	.26	.432	.012	.6	4.7	28.	......	?	5,200
7977	" 18	" 19	*	"	T. F.02	......	300.	172.	128.	26.	20.	6.	L.	5.8	8.7	7.4	1.3	.062	.272	.176	.096	.56	.292	.268	.008	.36	4.5	26.	......	?	12,250
8073	Aug. 1	Aug. 2	*	Cons'd	M. F.02	......	554.4	135.2	419.2	48.	24.	24.	B.	4.2	16.7	8.4	8.3	.08	.528	.192	.336	1.16	.372	.788	.006	.72	6.5	29.	......	—	13,500
8122	" 8	" 9	*	"	M. F.02	......	272.4	170.8	101.6	82.8	61.2	21.6	B.	4.8	14.	10.7	3.3	.104	.416	.208	.208	.92	.516	.404	.004	.36	4.6	31.	......	+	4,800
8188	" 15	" 16	*	Little	T. F.02	......	230.4	159.2	71.2	39.2	33.6	5.6	B.	6.6	10.8	7.3	3.5	.106	.416	.208	.208	.76	.316	.444	.005	.24	3.	29.	......	+	8,700
8268	" 22	" 24	*	Cons'd	M. F.2	......	884.8	138.	746.8	59.6	22.	37.6	DB.	3.6	21.2	6.1	15.1	.152	.73	.192	.538	1.74	.316	1.424	.002	.76	5.2	29.	......	—	3,900
8325	" 29	" 30	*	"	M. F.	......	375.2	139.6	235.6	42.	20.8	21.2	DB.	4.	15.2	6.8	8.4	.102	.48	.192	.288	.92	.284	.636	.003	.44	5.2	28.	......	?	3,250
8378	Sept. 5	Sept. 6	§	Much	M.	......	321.6	160.4	161.2	34.	27.2	6.8	DB.	3.4	20.7	8.7	12.	.104	.352	.272	.08	.664	.268	.396	.003	.4	6.	29.	......	?	4,000
8449	" 12	" 13	*	"	M. F.25	......	284.	140.	144.	34.4	20.4	14.	DB.	3.8	17.2	11.6	5.6	.118	.48	.24	.24	.92	.448	.472	.005	.32	4.7	27.	......	+	2,450
8503	" 19	" 20	*	Cons'd	M. F.4	......	270.4	153.6	116.8	37.6	26.	11.6	DB.	3.4	15.1	12.7	2.4	.180	.48	.224	.256	.728	......	......	.007	.48	4.	19.	......	+	7,850
8556	" 26	" 27	*	Much	M. F.7	......	314.8	147.2	167.6	48.8	23.6	25.2	DB.	2.8	18.	13.9	4.1	.136	.56	.192	.368	.984	.608	.376	.005	.28	4.9	24.	......	+	18,500
8610	Oct. 3	Oct. 4	*	"	M. F.9	......	504.	135.6	368.4	50.4	29.2	21.2	......	1.6	27.6	17.7	9.9	.170	.592	.288	.304	1.424	.624	.8	.002	.4	......	......	......	......	......

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. | Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 67.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

SOURCE OF WATER—MISSISSIPPI RIVER, ONE-FOURTH DISTANCE FROM MISSOURI SHORE, ALTON.

Serial No.	Date of 1900 Collection.	Date of 1900 Examination.	Appearance. Turb'y.	Appearance. Sediment.	Appearance. Color.	Odor.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dis-solv'd	Loss on Ig'n. Sus-pnd'd	Color on Ignition.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dis-solved.	Oxygen Consumed. By Suspd Matter.	Nitrogen as Ammonia. Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dis-solv'd	Albuminoid Am. Sus-pnd'd	Organic Nitrogen. Total.	Organic Nitrogen. Dis-solved.	Organic Nitrogen. Sus-pended.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
6623	Jan. 4	Jan. 5	*	Cons'd	M. F.04	....	255.2	241.6	13.6	26.8	24.8	2.	B.	12.	10.7	9.2	1.5	.42	.384	.24	.144	.76	.448	.312	.012	.44	....	0.	4.	−	4,400
6660	" 10	" 11	*	"	M. F.07	....	244.4	212.4	32.	25.2	18.8	6.4	B.	6.4	10.9	9.	1.9	.2	.48	.176	.304	1.12	.448	.672	.006	.2	2.4	0.	0.	−	10,000
6701	" 17	" 18	†	"	M. F.05	....	209.2	189.2	20.	34.2	34.2	....	B.	5.2	10.9	9.	1.9	.036	.368	.16	.208	.8	.352	.448	.008	.08	1.4	0.	0.	+	16,800
6748	" 24	" 25	*	Much	M. F.06	....	322.4	164.8	157.6	31.6	20.	11.6	B.	4.	14.1	9.2	4.9	.08	.416	.16	.256	.96	.576	.384	.008	.76	3.9	0.	10.	+	43,400
6814	Feb. 2	Feb. 3	*	Cons'd	M. F.1	....	288.8	227.6	61.2	29.6	26.	3.6	G.	9.6	12.8	....	....	.74	.368	.24	.128	.8	.512	.288	.013	1.08	....	0.	0.	−	20,000
6859	" 7	" 8	*	"	M. F.4	....	244.	201.2	42.8	20.	20.	....	B.	8.4	9.3	7.6	1.7	.352	.384	.144	.24	.72	.32	.4	.009	.68	2.6	11.	10.	−	36,000
6903	" 14	" 15	§	V. M'ch	VM. F.3	....	796.8	146.	650.8	42.8	14.	28.8	B.	3.8	18.8	8.3	10.5	.16	1.04	.208	.832	1.84	.512	1.328	.013	1.	5.	0.	0.	+	136,000
6953	" 22	" 22	*	Much	M. F.4	....	558.	156.8	401.2	84.	30.4	53.6	RB.	4.6	18.8	9.5	9.3	.416	.88	.304	.576	1.84	.672	1.168	.014	1.08	5.5	0.	0.	+	148,000
7003	Mar. 2	Mar. 3	*	Cons'd	M. F.4	....	222.4	161.6	60.8	21.6	20.8	.8	B.	4.2	13.5	9.8	3.7	.352	.448	.288	.16	.88	.64	.24	.008	.64	3.4	0.	0.	−	34,000
7056	" 9	" 10	§	Much	VM. F.15	....	670.	112.	558.	40.	16.8	23.2	B.	3.2	17.1	6.8	10.3	.208	.512	.208	.304	1.76	.512	1.248	.009	.84	10.	0.	9.	+	81,000
7088	" 14	" 15	§	V. M'ch	VM. F.4	....	1584.	100.4	1483.6	45.2	10.	35.2	B.	.6	25.7	8.5	17.2	.24	1.312	.272	1.04	3.2	.544	2.656	.006	.64	17.	4.	6.	+	200,000
7134	" 21	" 22	*	Much	M. F.5	....	577.2	116.4	460.8	38.	15.6	22.4	B.	1.4	19.5	9.3	10.2	.464	.928	.288	.64	2.2	.864	1.336	.01	.68	14.1	0.	....	−	102,500
7177	" 28	" 29	*	"	M. F.5	....	359.2	125.6	233.6	27.6	20.8	6.8	B.	3.	16.3	8.6	7.7	.432	.576	.224	.352	1.304	.6	.704	.012	.4	11.5	6.	....	+	66,000
7234	Apr. 4	Apr. 5	*	Cons'd	M. F.06	....	344.	138.	206.	16.4	14.	2.4	B.	3.5	14.2	7.5	6.7	.32	.4	.192	.208	.856	.504	.352	.012	.4	10.1	9.	10.	....	....
7290	" 12	" 13	*	Much	M. F.40	....	613.2	116.	497.2	37.6	18.	19.6	B.	1.4	25.6	8.8	16.8	.224	.8	.256	.544	2.04	.6	1.44	.032	1.08	11.4	8.	5.	+	72,500
7344	" 18	" 19	*	Cons'd	M. F.05	....	260.4	132.	128.4	20.8	17.2	3.6	B.	3.6	13.	7.2	5.8	.112	.368	.208	.16	.84	.44	.4	.02	.72	10.5	10.	10.	−	20,500
7412	" 25	" 26	§	V. M'ch	VM. F.30	....	913.6	110.4	803.2	46.4	16.8	29.6	B.	1.1	25.7	7.3	18.4	.08	1.088	.176	.912	2.2	.44	1.76	.035	.72	11.9	15.	25.	+	76,000
7456	May 2	May 3	*	Cons'd	M. F.05	....	328.4	168.8	159.6	22.8	22.	.8	B.	5.3	13.9	8.4	5.5	.04	.528	.176	.352	1.028	.42	.608	.014	.88	10.1	20.	23.	−	12,000
7496	" 9	" 10	*	Much	M. F.40	....	534.	109.6	424.4	26.	21.2	4.8	B.	3.3	17.9	11.8	6.1	.084	.576	.256	.32	1.06	.388	.672	.01	.28	11.4	19.	16.	+	16,000
7544	" 16	" 17	*	Cons'd	M. F.3	....	452.8	124.4	328.4	31.2	21.6	9.6	B.	3.8	20.8	9.1	11.7	.074	.576	.144	.432	.74	.452	.288	.015	.1	8.8	24.	29.	+	20,000
7596	" 23	" 24	§	V. M'ch	M. F.1	....	619.2	146.4	502.8	56.8	36.4	20.4	B.	3.1	21.1	8.1	13.	.116	.512	.128	.384	1.94	.308	1.632	.022	.4	8.4	19.	21.	+	29,500
7630	" 30	" 31	*	Much	M. F.30	....	293.2	150.4	142.8	41.6	34.8	6.8	B.	3.7	11.7	8.	3.7	.022	.288	.224	.064	.74	.5	.24	.013	.48	7.2	24.	25.	+	2,700
7667	June 6	June 7	*	Cons'd	M. F.07	....	324.4	141.6	182.8	44.4	21.2	23.2	B.	3.9	13.3	8.5	4.8	.032	.384	.112	.272	.8	.154	.646	.01	.4	6.1	24.	26.	+	11,000
7717	" 13	" 14	*	"	M. F.04	....	263.6	180.8	82.8	42.4	27.2	15.2	B.	4.4	12.5	8.3	4.2	.02	.32	.192	.128	.9	.452	.448	.007	.08	5.2	24.	26.	+	1,000
7754	" 20	" 21	*	"	M. F.05	....	275.6	192.	83.6	40.4	38.	2.4	B.	3.6	11.	9.5	1.5	.036	.288	.16	.128	.58	.244	.336	.004	.08	5.3	23.	25.	....	3,500
7796	" 27	" 28	*	"	M. F.01	....	560.4	164.4	396.	56.8	28.	28.8	B.	3.7	15.1	5.7	9.4	.074	.528	.304	.224	1.288	.296	.992	.013	.56	7.2	26.	28.	+	11,500
7830	July 4	July 5	*	Little	T. F.02	....	311.2	181.2	130.	27.2	24.8	2.4	B.	3.8	11.7	7.	4.7	.072	.304	.112	.192	.68	.228	.452	.004	.28	5.3	30.	28.	....	1,750
7903	" 11	" 12	*	"	T. F.05	....	319.6	195.6	124.	46.8	38.4	8.4	B.	4.8	10.7	7.1	3.6	.082	.32	.176	.144	.724	.212	.512	.005	.36	4.7	28.	29.	?	3,600
7960	" 18	" 19	*	"	T. F.02	....	279.6	168.	111.6	24.	16.4	7.6	B.	4.3	11.3	7.7	3.6	.048	.272	.24	.032	.76	.292	.468	.005	.16	4.5	26.	26.	?	2,300
8075	Aug. 1	Aug. 2	*	Cons'd	M. F.03	....	574.4	127.6	446.8	56.	32.	24.	B.	3.3	18.2	8.7	9.5	.092	.528	.208	.32	1.4	.404	.996	.003	.68	6.5	29.	32.	+	8,000
8123	" 8	" 9	*	"	M. F.02	....	270.	145.6	124.4	58.	42.4	15.6	B.	3.8	16.2	11.1	5.1	.102	.416	.288	.128	.92	.436	.484	.003	.4	4.6	31.	29.	+	6,000
8187	" 15	" 16	*	Little	T. F.02	....	227.6	149.6	78.	46.4	36.	10.4	B.	4.6	11.2	8.3	2.9	.096	.416	.208	.208	.76	.412	.348	.002	.24	....	....	29.	....	....
8269	" 22	" 24	*	Cons'd	M. F.1	....	896.8	126.	770.8	57.2	18.	39.2	B.	3.4	21.4	6.	15.4	.134	.8	.192	.608	1.326	.316	1.01	.002	.76	5.2	29.	30.	−	4,400
8326	" 29	" 30	*	"	M. F.2	....	382.	141.6	240.4	39.2	22.	17.2	B.	3.	15.7	7.4	8.3	.106	.48	.192	.288	.92	.236	.684	.002	.44	5.2	28.	30.	−	2,900
8377	Sept. 5	Sept. 6	§	Much	M.	....	336.8	160.4	176.4	31.6	21.2	10.4	DB.	3.	16.5	8.9	7.6	.078	.432	.304	.128	.76	.428	.332	.004	.36	6.	29.	30.	?	6,400

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White

TABLE 68.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 100 FEET FROM MISSOURI SHORE, ALTON.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ign.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Suspnd'd							Tot'l	Dissolv'd	Suspnd'd										
6624	Jan. 4	Jan. 5	*	Cons'd	M. F.03	......	262.8	244.4	18.4	27.2	16.	11.2	B.	13.	10.5	8.9	1.6	.42	.416	.224	.192	1.	.456	.544	.01	.28	....	0.	4.	−	7,500
6661	" 10	" 11	*	"	M. F.08	......	222.	200.4	21.6	26.4	19.6	6.8	B.	5.2	12.9	10.8	2.1	.028	.464	.208	.256	.92	.448	.472	.003	.12	3.4	0.	0.	−	18,400
6702	" 17	" 18	†	"	M. F.05	......	197.2	190.8	6.4	28.	27.6	.4	B.	4.8	10.8	9.1	1.7	.036	.384	.176	.208	.8	.544	.256	.001	.16	1.4	0.	0.	−	16,000
6749	" 24	" 25	*	Much	M. F.2	......	327.6	174.4	153.2	44.	30.	14.0	B.	3.6	14.4	9.6	4.8	.048	.432	.192	.24	1.04	.512	.528	.008	.72	3.9	0.	10.	+	41,600
6815	Feb. 2	Feb. 3	*	Cons'd	M. F.1	......	276.4	234.	42.4	31.6	23.2	8.4	B.	9.2	12.	9.1	2.9	.74	.384	.256	.128	.768	.544	.224	.014	.88	....	0.	0.	−	9,600
6860	" 7	" 8	*	"	M. F.3	......	229.2	199.2	30.	38.4	12.8	25.6	B.	8.4	9.4	8.5	.9	.352	.336	.224	.112	.72	.544	.176	.008	.68	2.6	11.	10.	−	22,400
6902	" 14	" 17	§	V.M'ch	VM.F.06	......	617.6	146.4	471.2	32.4	22.8	9.6	B.	3.4	17.9	8.	9.9	.192	.96	.256	.704	1.92	.544	1.376	.011	.88	5.	0.	0.	+	168,000
6954	" 21	" 22	*	Much	M. F.3	......	496.	150.	346.	86.	21.2	64.8	B.	3.8	16.2	10.5	5.7	.352	.768	.256	.512	1.6	.768	.832	.015	.8	5.5	0.	0.	−	186,000
7004	Mar. 2	Mar. 3	*	Cons'd	M. F.4	......	213.2	174.	39.2	24.8	24.8	....	B.	4.4	13.7	11.5	2.2	.208	.336	.288	.048	.72	.64	.08	.01	1.08	3.4	0.	0.	−	40,000
7057	" 9	" 10	*	Much	M. F.5	......	814.	82.4	731.6	41.6	9.2	32.4	B.	1.	17.9	6.4	11.5	.176	.64	.192	.448	2.08	.32	1.76	.011	.8	10.	0.	9.	+	128,000
7089	" 14	" 15	§	V.M'ch	VM.F.6	......	1460.	83.2	1376.8	32.8	12.8	20.	B.	.8	23.	7.5	15.5	.224	1.184	.176	1.008	2.72	.384	2.336	.007	.8	17.	4.	6.	+	200,000
7136	" 21	" 22	*	Much	M. F.6	......	590.	130.4	459.6	30.4	14.8	15.6	B.	2.6	19.2	13.6	5.6	.416	.896	.32	.576	2.04	.952	1.088	.009	.68	14.1	0.	......	−	182,500
7176	" 28	" 29	*	"	M. F.5	......	500.	133.2	366.8	34.	14.8	19.2	B.	2.4	17.	9.6	7.4	.416	.608	.24	.368	1.368	.664	.704	.012	.56	11.5	6.	......	−	72,000
7237	April 4	April 5	*	"	M. F.20	......	359.2	139.2	220.	22.8	12.4	10.4	B.	3.4	14.1	7.4	6.7	.336	.416	.192	.224	.856	.568	.288	.011	.72	10.1	9.	10.	−	91,000
7300	" 13	" 14	*	"	M. F.25	......	676.8	129.2	547.6	57.2	17.6	39.6	B.	1.1	23.1	9.1	14.	.24	.896	.288	.608	2.2	.632	1.568	.034	.92	11.4	8.	5.	−	164,000
7345	" 18	" 19	*	Cons'd	M. F 10	.....	294.4	123.2	171.2	36.4	21.6	14.8	B.	3.8	12.9	7.6	5.3	.112	.32	.176	.144	.856	.536	.32	.02	.72	10.5	10.	10.	+	28,000
7413	" 25	" 26	*	Much	VM.F.30	......	886.	106.8	779.2	46.	18.8	27.2	B.	3.	23.4	7.9	15.5	.004	1.024	.192	.832	2.12	.472	1.648	.025	.92	11.9	15.	25.	+	59,000
7457	May 2	May 3	*	Cons'd	M. F.05	......	474.8	136.8	338.	41.6	23.6	18.	B.	3.8	16.	7.9	8.1	.02	.496	.176	.32	1.06	.36	.7	.012	.64	10.1	20.	23.	+	26,000
7497	" 9	" 10	*	Much	M. F.5	......	599.6	103.2	496.4	43.2	19.2	24.	B.	2.8	18.5	12.9	5.6	.116	.592	.272	.32	1.124	.84	.284	.01	.4	11.4	19.	16.	+	52,000
7545	" 16	" 17	*	Cons'd	M. F.3	......	344.8	140.8	204.	30.8	22.	8.8	B.	3.3	20.6	10.2	10.4	.064	.416	.304	.112	1.284	.452	.832	.017	.32	8.8	24.	29.	+	15,500
7597	" 23	" 24	§	V.Mc'h	M. F.2	......	645.6	147.6	498.	57.2	32.4	24.8	B.	2.9	19.8	7.9	11.9	.124	.56	.112	.448	1.22	.34	.88	.02	.4	8.4	19.	21.	+	22,500
7629	" 30	" 31	*	Much	M. F.05	......	392.8	219.6	173.2	48.4	39.2	9.2	B.	4.6	11.9	8.	3.9	.024	.4	.208	.192	1.12	.52	.6	.014	.8	7.2	21.	25.	+	4,400
7666	June 6	June 7	*	Cons'd	M. F.2	......	320.4	136.	184.4	29.2	22.8	6.4	B.	4.	13.3	8.5	4.8	.028	.4	.112	.288	.8	.154	.646	.011	.36	6.1	24.	26.	+	4,000
7718	" 13	" 14	*	"	M. F.04	......	246.	176.8	69.2	38.	28.4	9.6	B.	4.6	9.5	8.5	1.	.02	.288	.224	.064	1.22	.52	.7	.006	.2	5.2	24.	26.	+	6,000
7755	" 20	" 21	*	"	M. F.1	......	253.4	180.	73.4	26.4	25.6	.8	B.	4.	11.1	8.2	2.9	.04	.272	.144	.128	.58	.244	.336	.004	.04	5.3	23.	25.	....	5,500
7797	" 27	" 28	*	"	M. F.01	......	519.2	172.4	346.8	56.	36.4	19.6	B.	3.2	14.3	6.4	7.9	.064	.384	.176	.208	1.16	.548	.612	.014	.4	7.2	26.	28.	+	8,000
7831	July 4	July 5	*	Little	T. F.03	......	295.2	174.	121.2	34.8	28.8	6.	B.	4.2	11.7	7.5	4.2	.056	.256	.144	.112	.52	.308	.212	.004	.24	5.3	30.	28.	....	5,800
7902	" 11	" 12	*	"	T. F.05	......	296.2	193.8	102.4	40.	36.8	3.2	B.	4.2	9.2	7.3	1.9	.084	.272	.176	.096	.708	.244	.464	.004	.36	4.7	28.	20.	+	2,150
7978	" 18	" 19	*	"	T. F.02	......	242.	159.6	82.4	23.2	21.2	2.	B.	4.6	8.7	6.7	2.	.048	.224	.144	.08	.44	.292	.148	.005	.36	4.5	26.	20.	?	2,300
8074	Aug. 1	Aug. 2	*	Cons'd	M. F.02	......	624.8	131.6	493.2	48.	34.8	13.2	B.	3.8	17.7	8.1	9.6	.060	.608	.16	.448	1.24	.452	.788	.004	.68	6.5	29.	32.	+	14,000
8123	" 8	" 9	*	"	M. F.02	......	270.	145.6	124.4	58.	42.4	15.6	B.	3.8	16.2	11.1	5.1	.102	.416	.288	.128	.92	.436	.484	.008	.4	4.6	31.	29.	?	14,900
8186	" 15	" 16	*	Little	T. F.02	......	210.4	137.2	73.2	36.	34.4	1.6	B.	3.4	12.	8.7	3.3	.066	.416	.16	.256	.76	.332	.428	.001	.12	3.	29.	20.	−	4,050
8270	" 22	" 24	*	Cons'd	M. F.1	......	820.4	128.	692.4	54.4	15.2	39.2	B.	3.4	19.9	6.1	13.8	.146	.72	.24	.48	1.08	.376	.704	.002	.76	5.2	29.	30.	−	4,200
8327	" 29	" 30	*	"	M. F.02	......	380.4	138.4	242.	44.	18.4	25.6	DB.	3.4	13.8	6.8	7.	.150	.48	.16	.32	.984	.252	.732	.001	.6	5.2	28.	30.	?	900
8376	Sept. 5	Sept. 6	§	Much	M.	......	361.2	168.8	192.4	27.2	20.8	6.4	DB.	3.2	17.	8.9	8.1	.072	.352	.304	.048	.92	.03	.89	.003	.4	6.	29.	30.	−	4,200
8448	" 12	" 13	*	"	M. F.45	......	279.2	149.6	129.6	39.6	18.	21.6	DB.	3.8	17.2	10.8	6.4	.078	.4	.24	.16	.792	.576	.216	.005	.32	4.9	27.	......	+	2,300
8502	" 19	" 20	*	Cons'd	M. F.4	......	267.2	152.4	114.8	32.	26.	6.	DB.	2.8	15.3	12.6	2.7	.120	.368	.208	.16	.888	.304	.584	.008	.56	4.	19.	......	−	6,800
8555	" 26	" 27	*	Much	M. F.6	......	315.2	147.2	168.	40.4	25.2	15.2	DB.	2.3	17.8	14.5	3.3	.16	.496	.224	.272	.952	.48	.472	.005	.36	....	....	......	....	....
8600	Oct. 3	Oct. 4	*	"	M. F.1.	......	573.6	137.6	436.	48.4	29.6	18.8	......	2.	27.7	17.2	10.5	.124	.656	.24	.416	1.28	.576	.704	.001	.52	....	....	......	....	....

TURBIDITY—*Decided. §Very Decided. † Distinct. ‡ Very Slight. ǁ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 69.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 400 FEET FROM ILLINOIS SHORE, AT CHAIN OF ROCKS, PUMPING STATION ST. LOUIS WATER WORKS.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Suspnd'd							Tot'l	Dissolv'd	Suspnd'd										
6634	Jan. 5	Jan. 6	*	Cons'd	M. F.05	......	298.	273.2	24.8	38.4	34.8	3.6	B.	16.6	9.6	8.9	.7	1.14	.352	.192	.16	1.	.584	.416	.09	.72	2.3	0.	4.5	+	20,350
6660	" 11	" 12	*	"	M. F.03	......	302.8	241.6	61.2	37.2	30.4	6.8	B.	9.6	11.	8.8	2.2	.64	.448	.176	.272	.88	.64	.24	.013	.72	3.	0.	1.	....	83,850
6717	" 18	" 19	*	Much	M. F.04	......	252.8	212.8	40.	17.2	15.2	2.	B.	6.8	12.	8.4	3.6	.132	.384	.144	.14	1.04	.512	.528	.008	.64	2.6	3.	......	+	20,400
6769	" 26	" 27	*	"	M. F.03	......	374.	194.8	179.2	38.	19.2	18.8	B.	6.8	14.1	7.6	6.5	.42	.464	.272	.192	1.04	.48	.56	.017	1.04	5.6	1.	—1.	?	15,750
6868	Feb. 8	Feb. 9	*	"	M. F.03	......	1402.4	202.	1200.4	48.4	17.2	31.2	B.	9.1	19.7	9.6	10.1	.704	1.04	.256	.784	2.64	.576	2.064	.01	.88	2.7	2.	—4.	....	50,200
6969	" 23	" 24	§	V. M'ch	M. F.05	......	1350.4	160.	1190.4	49.6	23.6	26.	B.	5.8	23.	8.	15.	.448	1.024	.256	.768	2.72	.64	2.08	.012	1.64	8.	0.	4.5	+	176,000
7041	Mar. 8	Mar. 9	§	"	VM. F.06	......	1469.6	149.6	1320.	30.	19.6	10.4	B.	4.8	18.8	6.9	11.9	.352	1.024	.208	.816	2.56	.48	2.08	.013	1.12	15.	1.	10.	+	194,500
7147	" 22	" 23	*	Much	M. F.06	......	822.	126.8	695.2	38.	12.8	25.2	B.	4.6	17.2	5.7	11.5	.256	.64	.224	.416	1.72	.536	1.184	.01	1.28	18.8	2.	13.	+	51,000
7194	" 29	" 30	*	"	M. F.05	......	572.8	150.4	422.4	22.8	7.2	15.6	B.	4.4	14.8	7.8	7.	.32	.448	.256	.192	.984	.536	.448	.014	1.28	15.	5.	7.	—	49,000
7252	April 5	April 6	*	"	M. F.10	......	401.2	153.6	247.6	25.6	16.4	9.2	B.	4.	12.9	6.4	6.5	.24	.32	.176	.144	.888	.472	.416	.022	1.52	14.2	7.	17.	—	26,000
7304	" 12	" 13	*	"	M. F.05	......	432.4	158.8	273.6	37.6	12.4	25.2	B.	4.8	14.2	6.9	7.3	.256	.448	.256	.192	1.24	.536	.704	.022	1.48	15.8	7.	2.	+	15,000
7354	" 19	" 20	*	"	M. F.07	......	330.8	184.4	146.4	26.8	23.2	3.6	B.	5.1	11.9	7.8	4.1	.096	.336	.192	.144	.92	.504	.416	.028	1.6	15.8	12.	22.	+	11,000
7425	" 26	" 27	*	"	M. F.15	......	488.8	166.8	322.	39.2	15.6	23.6	B.	4.8	16.8	7.3	9.5	.064	.576	.176	.4	1.64	.504	1.136	.04	1.52	17.2	15.	24.	+	18,000
7462	May 3	May 4	*	"	M. F.06	......	378.8	191.6	187.2	20.4	11.2	9.2	B.	6.1	13.3	7.8	5.5	.028	.48	.208	.272	1.22	.452	.768	.021	.96	15.3	18.	......	?	11,000
7506	" 10	" 11	*	"	M. F.20	......	487.2	172.8	314.4	49.2	32.4	16.8	B.	5.8	16.7	9.4	7.3	.064	.512	.16	.352	1.46	.26	1.2	.02	.72	16.3	17.	18.	+	24,500
7565	" 17	" 18	§	V. M'ch	M. F.1	......	1152.	222.	930.	42.4	31.2	11.2	B.	9.1	23.2	7.3	15.9	.084	.768	.16	.608	1.54	.356	1.184	.01	.4	15.	23.	23.	+	29,500
7608	" 24	" 25	§	"	VM. F.2	......	700.4	206.4	494.	45.6	40.	5.6	B.	7.2	18.7	8.9	9.8	.044	.448	.16	.288	1.38	.452	.928	.018	.64	14.2	20.	27.	+	21,000
7639	" 31	June 1	§	"	M. F.04	......	1324.8	245.6	1079.2	64.	36.	28.	B.	8.	17.4	6.3	11.1	.024	.656	.16	.496	1.94	.388	1.552	.01	.68	13.2	23.	22.	+	23,000
7680	June 7	" 8	*	Much	M. F.03	......	908.4	220.8	687.6	44.4	29.6	14.8	B.	11.	16.4	6.4	10.	.024	.416	.112	.304	1.62	.308	1.312	.007	.6	12.4	25.	24.	+	8,000
7725	" 14	" 15	§	"	M. F.03	......	2756.4	222.4	2534.	71.6	24.4	47.2	B.	7.8	19.	6.5	12.5	.084	1.152	.16	.992	2.74	.234	2.506	.005	.54	10.7	24.	27.	+	19,500
7761	" 21	" 22	§	V. M'ch	VM. F.05	......	1044.8	207.6	837.2	26.	8.4	17.6	B.	6.7	15.1	5.7	9.4	.048	.4	.16	.24	.84	.244	.596	.004	.48	11.2	25.	27.	....	13,000
7802	" 28	" 29	*	Cons'd	M. F.10	......	1228.	200.	1028.	73.2	42.	31.2	B.	6.4	18.2	5.6	12.6	.062	.8	.16	.64	1.4	.244	1.156	.008	.76	12.9	26.	32.	+	19,000
7843	July 5	July 6	*	"	M.	......	1430.	196.	1234.	46.8	20.	26.8	B.	6.3	17.7	8.9	8.8	.052	.48	.112	.368	1.4	.164	1.236	.003	.48	11.3	28.	......	+	11,000
7880	" 9	" 10	*	"	M. F.3	......	2159.6	193.2	1966.4	30.	26.8	3.2	B.	7.1	16.2	5.2	11.	.092	1.04	.128	.912	3.32	.18	3.14	.001	.48	10.8	....	......	....	25,000
7914	" 11	" 12	*	"	M. F.02	......	1508.4	182.8	1325.6	51.2	21.6	29.6	B.	6.8	17.5	8.5	9.	.1	.176	.128	.048	2.6	.18	2.42	.004	.6	10.6	....	......	....	30,500
7921	" 13	" 14	*	"	M. F.01	......	1473.2	192.	1281.2	50.8	8.4	42.4	B.	6.4	16.1	5.4	10.7	.084	.576	.08	.496	1.64	.244	1.396	.001	.48	10.3	....	......	....	32,000
7950	" 16	" 17	*	"	M. F.02	......	1144.8	195.6	949.2	34.	18.	16.	B.	7.8	15.	5.7	9.3	.052	.496	.176	.32	1.32	.404	.916	.004	.48	10.1	27.	......	....	22,000
7963	" 18	" 19	*	"	M. F.02	......	1305.6	193.2	1112.4	39.6	20.8	18.8	B.	7.4	15.6	5.	10.6	.072	.624	.144	.48	1.48	.292	1.188	.004	.44	9.7	25.	......	?	30,500
7988	" 20	" 21	*	"	M. F.02	......	804.4	191.2	613.2	56.8	32.8	24.	B.	7.4	15.4	6.9	8.5	.08	.528	.176	.352	.92	.26	.66	.006	.4	9.4	26.	......	—	57,000
7999	" 23	" 24	*	"	M. F.02	......	1610.	180.	1430.	56.	26.	30.	B.	5.5	15.5	4.5	11.	.076	.48	.064	.416	1.32	.276	1.044	.003	.56	9.1	26.	......	....	18,500
8026	" 25	" 26	*	"	M. F.02	......	2157.6	189.6	1968.	118.	31.6	86.4	B.	6.	24.4	7.9	16.5	.128	1.36	.096	1.264	2.84	.196	2.644	.005	.84	13.2	26.	......	+	50,000

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White

TABLE 69—Concluded.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 400 FEET FROM ILLINOIS SHORE, AT CHAIN OF ROCKS, PUMPING STATION ST. LOUIS WATER WORKS.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dis-solv'd	Loss on Ig'n. Sus-pnd'd			Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dis-solv'd	Albuminoid Am. Sus-pnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
8040	July 27	July 28	*	Cons'd	M. F.05	......	1020.8	155.6	865.2	46.4	24.	22.4	B.	6.6	21.9	7.9	14.	.02	.896	.144	.752	1.64	.276	1.364	.002	.8	12.8	26.	......	+	16,000
8051	" 30	" 31	‡	"	M. F.01	......	576.2	155.2	412.	59.6	36.	23.6	B.	6.4	14.8	7.2	7.6	.06	.512	.144	.368	1.24	.308	.932	.004	.68	12.2	26.	......	+	8,000
8077	Aug. 1	Aug 2	*	"	M. F.02	......	592.4	148.8	443.6	55.6	31.6	24.	B.	6.4	16.7	8.	8.7	.112	.608	.176	.432	1.24	.404	.836	.003	.76	11.7	27.	......	+	7,500
8092	" 3	" 4	*	"	M. F.02	......	578.3	171.6	406.7	75.5	44.8	30.7	B.	6.8	16.4	7.4	9.	.06	.48	.224	.256	.68	.388	.292	.003	.6	10.9	29.	......	+	6,000
8101	" 6	" 7	*	"	M. F.02	......	333.2	156.	177.2	36.	25.2	10.8	B.	6.6	12.4	11.5	.9	.069	.304	.224	.08	.92	.468	.452	.004	.6	9.8	29.	......	?	5,000
8117	" 8	" 9	*	"	M. F.01	......	330.8	176.8	154.	54.	43.2	10.8	B.	7.4	13.5	8.8	14.7	.1	.352	.288	.064	1.	.34	.66	.005	.52	8.4	29.	......	—	7,000
8150	" 10	" 11	*	"	M.	......	303.6	162.8	140.8	57.2	37.6	19.6	B.	7.	14.7	8.3	6.4	.06	.448	.272	.176	1.48	.348	1.132	.005	.44	7.4	29.	......	....	16,000
8161	" 13	" 14	*	Little	T. F.01	......	289.2	156.4	132.8	50.8	50.8	37.6	B.	7.4	12.2	7.6	4.6	.072	.352	.24	.112	1.	.38	.62	.007	.52	6.1	28.	......	—	8,000
8184	" 15	" 16	*	"	T. F.01	......	332.4	172.	160.4	38.8	35.6	3.2	B.	8.	11.5	6.8	4.7	.104	.416	.16	.256	.76	.396	.364	.006	.36	5.6	28.	......	—	10,000
8198	" 17	" 18	*	"	T. F.02	......	262.8	163.6	99.2	35.6	28.8	6.8	B.	8.	10.4	6.7	3.7	.12	.416	.24	.176	1.08	.3	.78	.007	.44	5.1	29.	......	+	1,100
8223	" 20	" 21	*	"	F.01	......	350.4	191.2	159.2	18.	14.8	3.2	B.	8.8	10.6	6.8	3.8	.112	.544	.224	.32	1.	.3	.7	.008	.36	5.2	29.5	......	+	1,800
8260	" 22	" 23	*	Cons'd	M. F.	......	692.8	150.8	542.	46.8	22.	24.8	B.	6.6	17.3	6.3	11.	.144	.8	.208	.592	1.48	.236	1.244	.004	.8	8.9	29.	......	....	....
8279	" 24	" 25	*	"	M. F.1	......	802.4	149.2	653.2	138.	20.	118.	B.	5.6	19.	6.1	12.9	.14	.608	.224	.384	1.16	.3	.86	.001	.68	9.1	28.	......	....	2,900
8302	" 27	" 28	*	"	M. F.06	......	521.2	145.2	376.	35.2	21.6	13.6	B.	6.	14.8	5.9	8.9	.104	.48	.096	.384	1.4	.332	1.068	.004	.92	8.9	26.	......	+	3,000
8321	" 29	" 30	*	"	M. F.	......	454.4	162.8	292.	34.	16.4	17.6	B.	7.4	12.8	6.4	6.4	.136	.448	.16	.288	.84	.316	.524	.002	.72	8.9	26.	......	+	1,800
8345	" 31	Sept. 1	*	Much	M. F.1	......	560.	174.4	385.6	27.2	23.2	4.	DB.	7.8	15.9	5.8	10.1	.066	.448	.208	.24	.92	.332	.588	.001	.6	8.7	27.	......	—	1,800
8352	Sept. 3	" 4	§	V. M'ch	M. F.15	......	452.4	158.	294.4	31.2	30.	1.2	B.	6.6	16.9	7.8	9.1	.132	.48	.128	.352	.824	.428	.396	.006	.68	10.1	26.	......	+	2,750
8394	" 5	" 6	§	"	M. F.05	......	386.4	188.4	198.	37.2	19.6	17.6	DB.	7.6	13.7	7.2	6.5	.118	.352	.224	.128	.664	.432	.232	.003	.4	10.	27.	......	+	3,600
8413	" 7	" 8	§	Much	M. F.1	......	454.8	167.6	287.2	32.8	11.2	21.6	DB.	10.	15.9	6.9	9.	.13	.48	.208	.272	.664	.416	.248	.004	.6	10.4	27.	......	+	1,500
8424	" 10	" 11	*	"	M. F.15	......	329.6	175.2	154.4	32.4	18.8	13.6	B.	7.4	13.2	7.3	5.9	.128	.416	.24	.176	.92	.512	.408	.006	.76	8.6	27.	......	—	2,550
8443	" 12	" 13	*	"	M. F.3	......	362.	176.8	185.2	26.	24.	2.	DB.	6.8	15.1	8.8	6.3	.114	.512	.224	.288	.856	.576	.28	.008	.52	7.8	26.	......	+	1,450
8465	" 14	" 15	§	"	M. F.2	......	320.4	186.	134.4	31.6	24.4	7.2	DB.	7.2	16.2	9.2	7.	.144	.368	.16	.208	.696	.384	.312	.004	.64	7.1	24.	......	+	1,400
8483	" 17	" 18	§	V. M'ch	M. F.02	......	339.2	177.6	161.6	60.	28.4	31.6	B.	6.4	14.1	9.6	4.5	.142	.416	.192	.224	.6	.464	.136	.007	.52	6.1	20.	......	—	5,400
8497	" 19	" 20	*	Cons'd	M. F.03	......	312.8	173.2	139.6	40.8	24.	16.8	DB.	6.	13.9	9.3	4.6	.08	.384	.176	.208	.668	.384	.284	.013	.52	6.	18.	......	—	3,350
8517	" 21	" 22	*	"	M. F.3	......	315.6	178.8	136.8	28.4	23.2	5.2	B.	5.8	13.8	9.8	4.	.074	.352	.256	.096	.792	.464	.328	.007	.52	6.2	19.	......	+	3,900
8524	" 24	" 25	§	Much	VM. F.35	......	795.6	198.8	596.8	54.4	32.8	21.6	DB.	6.8	17.5	10.9	6.6	.104	.416	.208	.208	1.08	.652	.428	.003	.48	7.5	20.	......	+	9,600
8551	" 26	" 27	*	"	M.	......	383.2	164.	219.2	57.2	30.8	26.4	B.	5.4	16.9	13.	3.9	.17	.448	.192	.256	.952	.544	.408	.005	.6	7.6	22.	......	+	5,100
8569	" 28	" 29	*	Cons'd	M.	......	390.8	154.4	236.4	49.2	22.8	26.4	DB.	4.8	18.3	13.1	5.2	.1	.576	.272	.304	.724	.572	.152	.008	.44	8.	20.	......	+	10,800
8581	Oct. 1	Oct. 2	*	"	M. F.1	......	414.	140.4	273.6	40.	26.8	13.2	DB.	4.	22.1	17.3	4.8	.112	.432	.4	.032	1.024	.592	.432	.008	.52	10.	19.	......	—	1,300
8618	" 4	" 5	§	Much	M. F.1	......	502.4	139.6	362.8	43.6	32.4	11.2	DB.	3.6	24.8	17.8	7.	.136	.608	.352	.256	.....	.502	.....	.001	.6	....	....	......	+	3,300
....	....	....	..	....	....	......	......	......	......	.....	.....	....	....	.....	....	....	....	.....	.....	.....	.....	.....	.....	.....	....	.....	....	....	......	....	....

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 70.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, MIDSTREAM, AT CHAIN OF ROCKS
PUMPING STATION ST. LOUIS WATER WORKS.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
										Loss on Ig'n.									Albuminoid Am.												
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Tot'l.	Dissolv'd.	Suspend'd.			Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Tot'l.	Dissolv'd.	Susp'd.	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
6633	Jan. 5	Jan. 6	*	Cons'd	M. F.03	......	330.	303.6	26.4	24.	17.2	6.8	B.	22.	9.3	6.5	2.8	.304	.256	.176	.08	.84	.52	.32	.012	.32	2.2	0.	4.5	—	13,000
6670	" 11	" 12	*	"	M. F.02	......	442.4	408.	34.4	20.8	18.4	2.4	B.	21.7	8.	6.2	1.8	.068	.272	.128	.144	.64	.32	.32	.007	.44	3.	0.	1.	+	43,500
6716	" 18	" 19	*	Much	M. F.03	......	616.8	335.2	281.6	18.8	7.2	11.6	B.	24.7	10.6	5.3	5.3	.08	.288	.096	.192	.8	.416	.384	.004	.21	2.6	3.	—1.	+	192,000
6767	" 26	" 27	*	"	M. F.02	......	585.2	298.4	286.8	24.4	14.8	9.6	B.	20.2	10.2	5.3	4.9	.06	.352	.144	.208	.96	.224	.736	.008	.68	5.6	1.	—1.	+	31,800
6867	Feb. 8	Feb. 9	§	"	M. F.03	......	1663.6	219.2	1444.4	62.	22.4	39.6	B.	11.	19.6	7.9	11.7	.432	.96	.16	.8	2.64	.48	2.16	.009	.96	2.7	1.	—4.	....	66,800
6968	" 23	" 24	§	"	M. F.04	......	891.6	183.2	708.4	41.6	28.	13.6	B.	9.8	18.6	7.4	11.2	.224	.8	.224	.576	2.08	.512	1.568	.01	.8	8.	0.	4.5	+	123,500
7038	Mar. 8	Mar. 9	§	V. M'ch	VM. F.03	......	1240.	145.2	1094.8	64.8	18.4	46.4	B.	5.	26.3	7.8	18.5	.256	1.44	.176	1.264	3.68	.64	3.04	.012	1.04	15.	1.	10.	+	103,000
7145	" 22	" 23	§	Much	M. F.4	......	782.4	111.6	670.8	34.4	11.6	22.8	B.	4.	20.	7.4	12.6	.32	.672	.24	.432	2.04	.6	1.44	.014	.92	18.8	2.	13.	—	120,000
7195	" 29	" 30	*	"	M. F.04	......	438.8	118.4	320.4	26.4	10.8	15.6	B.	4.2	15.2	6.8	8.4	.352	.48	.272	.208	1.304	.6	.704	.012	.96	15.	5.	7.	—	59,000
7250	Apr. 5	Apr. 6	*	"	M. F.03	......	493.6	141.6	352.	24.	16.4	7.6	B.	4.2	16.2	7.1	9.1	.272	.512	.176	.336	1.24	.504	.736	.02	.64	14.2	7.	17.	—	97,000
7302	" 12	" 13	*	"	M. F.40	......	732.4	182.4	550.	43.6	18.	25.6	B.	3.8	21.2	9.4	11.8	.16	.904	.288	.616	2.12	.824	1.296	.03	.6	15.8	7.	2.	+	69,000
7353	" 19	" 20	*	"	M. F.07	......	1004.	188.4	815.6	31.6	18.4	13.2	B.	5.8	16.1	7.5	8.6	.08	.512	.176	.336	1.16	.44	.72	.018	.8	15.9	12.	22.	+	29,000
7426	" 26	" 27	*	"	M. F.30	......	1017.2	154.	863.2	42.4	32.	10.4	B.	4.4	19.1	7.3	11.8	.064	.736	.192	.544	1.96	.44	1.52	.02	1.52	17.2	15.	21.	+	45,500
7461	May 3	May 4	*	"	M. F.08	......	837.2	163.6	673.6	27.6	19.6	8.	B.	5.6	17.5	7.	10.5	.008	.64	.192	.448	1.62	.388	1.232	.009	.72	15.3	18.	......	+	32,500
7503	" 10	" 11	*	"	M. F.50	......	791.2	172.	619.2	31.2	29.6	1.6	B.	5.2	19.3	12.5	6.8	.048	.752	.192	.56	1.54	.32	1.22	.01	.48	16.3	17.	18.	+	24,500
7566	" 17	" 18	§	V. M'ch	M. F.1	......	1229.2	212.8	1016.4	56.	22.8	33.2	B.	9.	18.8	7.2	11.6	.08	.8	.16	.64	1.54	.324	1.216	.01	.44	15.	22.	23.	+	33,000
7606	" 24	" 25	§	"	M. F.3	......	1301.6	206.	1095.6	61.2	26.	35.2	B.	6.8	18.7	8.5	10.2	.052	.752	.176	.576	2.18	.42	1.76	.006	.6	14.2	20.	27.	?	53,000
7642	" 31	June 1	*	Much	M. F.05	......	1769.2	258.8	1510.4	61.2	30.8	30.4	B.	8.8	17.9	6.3	11.6	.088	.736	.16	.576	2.02	.292	1.728	.011	.72	13.2	23.	22.	+	28,000
7679	June 7	" 8	*	"	M. F.03	......	1281.6	226.4	1055.2	61.6	31.2	30.4	B.	8.2	17.3	6.1	11.2	.016	.608	.112	.496	1.78	.308	1.472	.007	.56	12.4	25.	21.	+	9,000
7726	" 14	" 15	§	"	M. F.03	......	3680.4	238.	3442.4	67.2	23.6	43.6	B.	7.8	19.5	5.6	13.9	.028	1.088	.112	.976	3.22	.74	2.48	.006	.52	10.7	24.	27.	+	37,000
7764	" 21	" 22	§	V. M'ch	VM. F.05	......	1602.4	226.8	1375.6	52.4	10.8	41.6	B.	7.2	17.3	5.9	11.4	.032	.56	.08	.48	1.32	.244	1.076	.003	.44	11.2	25.	27.	....	20,000
7803	" 28	" 29	§	Cons'd	M. F.10	......	2100.4	198.8	1901.6	82.8	30.	52.8	B.	6.4	18.4	5.9	12.5	.122	1.2	.176	1.024	2.92	.244	2.676	.005	.68	13.9	26.	32.	+	20,500
7842	July 5	July 6	*	"	M. F.03	......	2418.8	196.8	2222.	76.8	20.8	56.	B.	6.4	22.4	6.6	15.8	.08	.96	.112	.848	2.68	.516	2.164	.001	.56	11.3	28.	......	?	13,500
7881	" 9	" 10	*	"	M. F.02	......	2776.4	196.4	2580.	68.	16.4	51.6	B.	8.	24.	4.7	19.3	.12	1.2	.144	1.056	2.44	.228	2.212	.001	.64	10.8	27.	......	....	20,000
7912	" 11	" 12	*	"	M. F.03	......	2041.6	177.6	1864.	62.4	13.6	48.8	B.	7.	18.5	7.4	11.1	.1	.176	.112	.064	2.44	.372	2.068	.003	.6	10.6	27.	......	....	25,000
7922	" 13	" 14	*	"	M. F.01	......	1725.6	190.4	1535.2	88.4	35.2	53.2	B.	6.8	16.7	4.2	12.5	.068	.576	.08	.496	1.72	.272	1.448	.001	.52	10.3	26.	......	....	24,000
7928	" 16	" 17	*	"	M. F.02	......	1681.6	189.2	1492.4	41.2	14.8	26.4	B.	7.2	16.3	5.2	11.1	.076	.592	.144	.448	1.8	.18	1.62	.004	.44	10.1	27.	......	+	38,000
7962	" 18	" 19	*	"	M. F.01	......	1542.4	198.4	1344.	57.2	21.6	35.6	B.	9.4	16.	4.2	11.8	.092	.672	.128	.544	1.4	.196	1.204	.004	.44	9.7	25.	......	+	12,000
7991	" 20	" 21	*	"	M. F.02	......	1354.2	178.	1176.2	58.8	23.2	35.6	B.	8.2	17.5	5.3	12.2	.08	1.088	.176	.912	1.64	.212	1.428	.003	.4	9.4	26.	......	+	64,000
7998	" 23	" 24	*	"	M. F.04	......	1817.2	188.	1629.2	41.6	31.2	10.4	B.	5.8	16.4	4.6	11.8	.072	.608	.064	.544	1.64	.292	1.348	.003	.68	9.1	26.	......	....	12,000
8029	" 25	" 26	*	"	M. F.01	......	2605.2	239.6	2365.6	104.	43.2	60.8	B.	6.6	27.8	6.6	21.2	.112	1.36	.112	1.248	1.64	.244	1.396	.005	.8	13.2	26.	......	....	32,000
8039	" 27	" 28	*	"	M. F.05	......	1537.2	152.8	1384.4	80.	32.	48.	B.	7.2	19.6	8.2	11.4	.056	1.024	.24	.784	2.44	.436	2.004	.002	.68	12.8	26.	......	—	23,500

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 70—Concluded.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

SOURCE OF WATER—MISSISSIPPI RIVER, MIDSTREAM, AT CHAIN OF ROCKS, PUMPING STATION ST. LOUIS WATER WORKS.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
										Loss on Ign.									Albuminoid Am.												
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Tot'l	Dissolv'd	Suspnd'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Suspnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
8053	July 30	July 31	*	Cons'd	M. F.02	......	1062.4	148.	914.4	62.	33.2	28.8	B.	4.8	21.7	6.5	15.2	.044	.736	.176	.56	1.64	.348	1.292	.004	.68	12.2	26.	......	+	6,000
8079	Aug. 1	Aug. 2	*	"	M. F.02	......	836.8	149.6	687.2	61.2	30.8	30.4	B.	5.4	20.2	6.9	13.3	.072	.688	.192	.496	2.04	.416	1.624	.003	.68	11.7	27.	......	+	15,000
8089	" 3	" 4	*	"	M. F.02	......	697.6	151.6	546.	74.4	26.	48.4	B.	4.8	18.7	7.5	11.2	.076	.608	.176	.432	1.32	.324	.996	.001	.6	10.9	29.	......	+	10,000
8090	" 6	" 7	*	"	M. F.02	......	506.	161.6	344.4	52.	37.6	14.4	B.	5.3	15.1	11.	4.1	.10	.512	.24	.272	.92	.452	.468	.001	.44	9.8	29.	......	+	4,000
8116	" 8	" 9	*	"	M. F.02	......	538.8	161.2	377.6	62.8	29.6	33.2	B.	6.6	16.	9.	7.	.108	.448	.272	.176	1.24	.452	.788	.001	.44	8.4	29.	......	+	18,000
8149	" 10	" 11	*	"	M.	......	500.	168.8	331.2	45.2	26.4	18.8	B.	5.8	15.7	7.9	7.8	.044	.544	.24	.304	1.	.324	.676	.001	.44	7.4	29.	......	+	16,000
8159	" 13	" 14	*	"	M.	......	552.8	199.2	353.6	55.6	33.6	22.	B.	6.6	13.4	6.9	6.5	.096	.544	.176	.368	1.06	.36	.7	.003	.44	6.1	28.	......	+	6,000
8183	" 15	" 16	*	Little	T.	......	517.6	189.6	328.	54.4	36.4	18.	B.	3.8	12.1	7.	5.1	.1	.416	.112	.304	.76	.332	.428	.004	.3	5.6	28.	......	+	6,000
8196	" 17	" 18	*	"	T. F.01	......	388.4	178.4	210.	45.6	24.	21.6	B.	7.8	11.	6.9	4.1	.132	.544	.176	.368	.808	.316	.492	.003	.36	5.1	29.	......	+	2,000
8224	" 20	" 21	*	Cons'd	M. F.01	......	819.2	214.4	604.8	41.6	17.6	24.	B.	9.2	12.7	6.3	6.4	.116	.448	.288	.16	1.16	.3	.86	.003	.36	5.2	29.5	......	+	1,800
8263	" 22	" 23	*	"	M. F.05	......	839.	134.4	704.6	48.4	23.6	24.8	B.	4.2	18.8	6.2	12.6	.136	.8	.192	.608	1.48	.46	1.02	.003	.76	8.9	23	......	+	1,500
8278	" 24	" 25	*	"	M. F.2	......	804.	130.8	673.2	70.	18.8	51.2	B.	4.8	20.4	6.	14.4	.152	.736	.192	.544	1.336	.22	1.116	.001	.52	9.1	28.	......	+	2,850
8300	" ..	" 28	*	Little	M. F.02	......	785.6	158.	627.6	40.	12.8	27.2	B.	8.6	18.4	5.7	12.7	.08	.48	.16	.32	1.48	.188	1.292	.002	.08	8.9	26.	......	−	2,150
8322	" 29	" 30	*	Cons'd	M. F.02	......	774.4	146.	628.4	42.4	14.8	27.6	B.	9.2	17.2	6.	11.2	.14	.64	.112	.528	1.16	.392	.768	.001	.6	8.9	26.	......	−	1,900
8344	" 31	Sept. 1	*	Much	M. F.05	......	852.	173.6	678.4	38.4	27.2	11.2	DB.	9.	18.3	5.9	12.4	.068	.592	.208	.384	1.48	.268	1.212	.001	.6	8.7	27.	......	+	1,700
8353	Sept. 3	" 4	§	V.M'ch	M. F.18	......	718.4	138.8	579.6	36.4	25.6	10.8	DB.	11.	20.8	7.4	13.4	.124	.608	.112	.496	1.08	.028	.96	.001	.44	10.1	26.	......	+	4,450
8383	" 5	" 6	§	"	M. F.05	......	765.2	180.8	584.4	46.	16.4	29.6	DB.	10.3	21.5	7.1	14.4	.112	.592	.128	.464	1.176	.416	.76	.001	.6	10.	27.	......	+	7,300
8412	" 7	" 8	*	Much	M. F.15	......	785.6	171.2	614.4	40.4	18.4	22.	DB.	9.	17.4	6.7	10.7	.156	.768	.256	.512	1.08	......	......	.002	.6	10.4	27.	......	+	19,400
8423	" 10	" 11	*	"	M. F.2	......	606.8	169.2	437.6	39.6	14.8	24.8	DB.	6.8	18.3	7.4	10.9	.144	.448	.256	.192	1.148	.512	.636	.004	.6	8.6	27.	......	−	1,600
8446	" 12	" 13	*	"	M. F.3	......	604.4	185.6	418.8	37.6	31.6	6.	DB.	8.	16.7	8.6	8.1	.116	.544	.208	.336	1.208	.416	.792	.004	.5	7.8	26.	......	+	2,400
8468	" 14	" 15	§	V.M'ch	VM. F.03	......	513.6	176.4	337.2	36.	18.	18.	DB.	5.8	20.6	11.9	8.7	.188	.448	.336	.112	.984	.352	.632	.003	.44	7.1	24.	......	+	2,300
8481	" 17	" 18	§	Much	M. F.05	......	473.2	182.	291.2	52.8	23.6	29.2	DB.	5.6	17.	9.4	7.6	.068	.48	.208	.272	.696	.384	.312	.007	.24	6.1	20.	......	−	2,100
8498	" 19	" 20	*	"	M. F.02	......	442.8	188.	254.8	43.6	26.	17.6	DB.	6.4	16.2	9.	7.2	.062	.4	.16	.24	.76	.336	.424	.006	.52	6.	18.	......	−	8,800
8516	" 21	" 22	*	"	M. F.2	......	902.4	223.2	679.2	25.6	22.	3.6	B.	8.2	17.	10.3	6.7	.07	.48	.176	.304	1.24	.416	.824	.002	.52	6.2	19.	......	+	60,000
8525	" 24	" 25	§	"	VM. F.35	......	1306.4	229.6	1076.8	59.2	32.8	26.4	DB.	8.4	18.7	9.9	8.8	.1	.64	.128	.512	1.56	.432	1.128	.003	.72	7.5	20.	......	+	9,800
8550	" 26	" 27	§	"	M.	......	825.2	195.2	630.	50.4	26.8	23.6	DB.	11.	21.6	11.7	9.9	.082	.768	.16	.608	1.4	.432	.968	.001	.56	7.6	22.	......	+	29,100
8571	" 28	" 29	*	Cons'd	M.	......	543.6	163.2	380.4	50.8	26.	24.8	DB.	5.	24.8	12.1	12.7	.148	.576	.272	.304	1.184	.62	.564	.005	.56	8.	20.	......	+	12,600
8582	Oct. 1	Oct. 2	§	Much	M. F.8	......	602.4	150.4	452.	54.	31.2	22.8	DB.	4.8	22.3	16.8	5.5	.12	.512	.324	.188	1.264	.528	.736	.005	.52	10.	19.	......	−	2,550
8617	" 4	" 5	§	"	M. F. T.	......	1145.6	170.8	974.8	56.	28.8	27.2	DB.	5.	24.7	12.6	12.1	.212	1.024	.304	.72	2.144	.608	1.536	.001	.52	....	....	......	+	3,400

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ǀ Slight.   COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 71.)

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, AT CHAIN OF ROCKS, INLET TOWER, ST. LOUIS WATER WORKS.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
										Loss on Ig'n.									Albuminoid Am.												
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Tot'l	Dis-solv'd	Sus-pend'd			Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Tot'l	Dis-solv'd	Sus-pend'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
6636	Jan. 5	Jan. 6	*	Cons'd	M. F.04	......	367.2	342.8	24.4	18.8	16.8	2.	B.	24.	6.5	5.5	1.	.144	.208	.144	.064	.84	.52	.32	.008	.36	2.2	0.	4.5	—	15,800
6667	" 11	" 12	‡	"	M. F.01	......	454.8	334.4	120.4	19.6	16.4	3.2	B.	23.5	7.	5.5	1.5	.044	.288	.16	.128	.72	.32	.4	.009	.48	3.	0.	1.	—	35,100
6715	" 18	" 19	*	Much	M. F.02	......	649.6	362.8	286.8	51.2	17.2	34.	B.	28.4	8.1	5.2	2.9	.068	.288	.128	.16	.8	.256	.544	.005	.28	2.6	3.	......	+	216,000
6768	" 26	" 27	*	"	M. F.01	......	653.6	302.4	351.2	21.2	14.4	6.8	B.	21.4	9.9	4.9	5.	.056	.264	.096	.168	.96	.224	.736	.007	.64	5.6	1.	—1.	+	30,200
6870	Feb. 8	Feb. 9	§	"	M. F.01	......	1830.	240.8	1589.2	52.8	18.	34.8	B.	12.6	19.4	5.2	14.2	.32	.88	.208	.672	2.08	......	......	.006	.68	2.7	1.	—4.	....	48,600
6971	" 23	" 24	§	"	M. F.04	......	1015.2	220.	795.2	50.8	36.	14.8	B.	12.2	17.2	6.9	10.3	.192	.576	.24	.336	1.68	.512	1.168	.008	1.04	8.	0.	4.5	+	85,000
7039	Mar. 8	Mar. 9	§	V. M'ch	VM. F.03	......	2604.4	137.2	2467.2	78.4	10.	68.4	B.	5.2	27.2	6.3	20.9	.288	1.44	.192	1.248	3.84	.48	3.36	.015	1.04	15.	1.	10.	+	160,500
7146	" 22	" 23	§	Much	M. F.06	......	957.6	123.2	834.4	21.2	8.	13.2	B.	5.	22.	6.6	15.4	.32	.96	.256	.704	2.36	.6	1.76	.013	.44	18.8	2.	13.	+	142,500
7196	" 29	" 30	*	"	M. F.06	......	511.6	126.	385.6	25.6	9.6	16.	B.	5.	16.4	6.9	9.5	.288	.512	.224	.288	1.368	.536	.832	014	.56	15.	5.	7.	+	73,500
7249	Apr. 5	Apr. 6	*	"	M. F.03	......	748.	182.	566.	35.2	10.	25.2	B.	6.6	16.1	7.	9.1	.24	.496	.192	.304	1.368	.536	.832	.018	.72	14.2	7.	17.	—	80,000
7301	" 12	" 13	*	"	M. F.06	......	1042.8	179.6	863.2	31.2	12.	19.2	B.	6.2	18.9	7.5	11.4	.176	.96	.256	.704	2.12	.472	1.648	.027	.96	15.8	7.	2.	+	81,000
7352	" 19	" 20	*	"	M. F.05	......	1381.6	201.6	1180.	44.8	17.6	27.2	B.	6.4	17.8	8.8	9.	.048	.544	.176	.368	1.4	.44	.96	.012	.36	15.8	12.	22.	+	39,000
7427	" 26	" 27	*	"	M. F.25	......	1474.8	174.8	1300.	138.	26.	112.	B.	6.6	18.4	6.4	12.	.064	.8	.128	.672	2.12	.376	1.744	.018	.88	17.2	15.	24.	+	33,500
7460	May 3	May 4	*	"	M. F.40	......	1371.6	220.	1151.6	60.	25.2	34.8	B.	8.	18.6	6.6	11.5	.016	.912	.144	.768	2.1	.36	1.74	.006	.8	15.3	18.	......	+	46,000
7504	" 10	" 11	*	"	M. F.07	......	1256.	198.	1058.	37.	20.	17.	B.	9.2	19.6	8.7	10.9	.048	.928	.144	.784	2.18	.28	1.9	.006	.68	16.8	17.	16.	+	27,000
7567	" 17	" 18	§	V. M'ch	M. F.08	......	1829.6	243.2	1586.4	64.	24.8	39.2	B.	12.2	26.2	7.2	19.	.036	1.44	.096	1.344	2.02	.324	1.696	.01	.44	15.	22.	23.	+	23,000
7607	" 24	" 25	§	"	VM. F.1	......	2034.4	255.2	1779.2	62.4	31.2	31.2	B.	9.4	23.7	7.2	16.5	.1	.592	.16	.432	4.26	.226	4.034	.004	.64	14.2	20.	27.	?	32,500
7641	" 31	June 1	§	Much	M. F.05	......	2069.6	286.8	1782.8	81.2	29.6	51.6	B.	9.6	18.5	5.7	12.8	.064	.88	.144	.736	2.9	.324	2.576	.01	.68	13.2	23.	22.	+	28,000
7677	June 7	" 8	*	"	M. F.03	......	1820.4	242.8	1577.6	68.8	20.8	48.	B.	11.4	18.3	5.5	12.8	.016	.768	.096	.672	1.94	.308	1.632	.004	.48	12.4	25.	24.	—	27,000
7727	" 14	" 15	*	"	M. F.04	......	4014.4	224.8	3789.6	63.2	16.8	46.4	B.	8.4	23.5	6.4	17.1	.028	1.344	.176	1.168	3.46	.42	3.04	.005	.52	10.7	24.	27.	....	12,000
7762	" 21	" 23	§	V. M'ch	VM. F.05	......	2124.	243.6	1880.4	46.8	28.4	18.4	B.	7.8	17.8	5.2	12.6	.048	.56	.128	.432	2.12	.196	1.924	.003	.4	11.2	25.	27.	....	20,500
7805	" 28	" 29	§	Cons'd	M. F.10	......	3130.4	211.6	2918.8	117.6	42.	75.6	B.	7.	24.5	5.5	19.	.14	1.36	.176	1.184	2.92	.212	2.708	.003	.6	13.9	26.	32.	....	35,500
7841	July 5	July 6	*	"	M. F.03	......	2746.4	196.4	2550.	75.6	21.2	54.4	B.	6.6	24.	5.	19.	.08	1.04	.096	.944	3.56	.148	3.412	.003	.6	11.3	28.	......	—	23,500
7879	" 9	" 10	*	"	M. F.03	......	3081.6	204.4	2877.2	76.4	14.	62.4	B.	8.8	27.5	4.8	22.7	.152	1.52	.144	1.376	3.88	.18	3.7	.001	.64	10.8	27.	......	....	33,000
7913	" 11	" 12	*	"	M. F.03	......	2704.4	180.	2524.4	60.	18.4	41.6	B.	7.4	22.6	8.1	14.5	.1	.176	.096	.08	2.68	.116	2.564	.002	.6	10.6	27.	......	....	71,000
7919	" 13	" 14	*	"	M. F.03	......	2345.2	188.	2157.2	76.8	26.8	50.	B.	8.6	18.3	7.	11.3	.068	.864	.08	.784	1.72	.244	1.476	.001	.52	10.3	26.	......	....	26,000
7959	" 16	" 17	*	"	M. F.02	......	2294.4	201.6	2092.8	46.8	22.	24.8	B.	7.8	17.6	4.9	12.7	.1	.608	.064	.544	1.96	.1	1.86	.004	.44	10.1	27.	......	....	......
7965	" 18	" 19	*	"	M. F.01	......	2321.2	192.8	2128.4	74.8	16.4	58.4	B.	9.2	17.9	4.3	13.6	.064	.864	.128	.736	2.12	.18	1.94	.004	.36	9.7	27.	......	....	......
7990	" 20	" 21	*	"	M. F.02	......	1997.2	194.8	1802.4	82.8	20.	62.8	B.	9.8	19.3	5.1	14.2	.116	.864	.176	.688	1.96	.212	1.748	.001	.28	9.4	26.	......	+	20,500
8000	" 23	" 24	*	"	M. F.02	......	2376.8	194.	2182.8	50.8	19.	31.8	B.	6.8	18.3	4.3	14.	.068	.864	.064	.8	1.8	.1	1.7	.003	.68	9.1	26.	......	....	15,500
8027	" 25	" 26	*	"	M. F.01	......	3296.	267.2	3028.8	153.2	21.2	132.	B.	7.2	29.1	7.1	22.	.156	1.52	.144	1.376	2.28	.372	1.908	.005	.88	13.2	26.	......	....	......

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 71—Concluded.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, AT CHAIN OF ROCKS, INLET TOWER, ST. LOUIS WATER WORKS.

Serial No.	Date of		Turb'y.	Appearance.		Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.		Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Susp'd							Tot'l	Dissolv'd	Susp'd										
8041	July 27	July 28	*	Cons'd	M. F.02	......	2407.6	172.8	2234.8	84.4	20.	64.4	B.	8.4	26.9	5.	21.9	.072	1.76	.096	1.664	2.92	.244	2.676	.002	.8	12.8	26.	......	–	18,000
8054	" 30	" 31	*	"	M. F.02	......	1981.6	166.4	1815.2	71.2	31.2	40.	B.	6.	24.8	5.6	19.2	.07	1.088	.176	.912	2.52	.348	2.172	.004	.08	12.2	26.	......	+	8,000
8078	Aug. 1	Aug. 2	*	"	M. F.02	......	1646.	155.6	1490.4	80.8	20.	60.8	B.	8.6	23.4	5.	18.4	.128	1.04	.104	.936	2.52	.228	2.292	.003	.68	11.7	27.	......	+	3,500
8091	" 3	" 4	*	"	M. F.02	......	1577.2	178.4	1398.8	82.8	25.6	57.2	B.	7.	23.7	4.8	18.9	.084	1.024	.128	.896	2.52	.244	2.276	.001	.68	10.9	29.	......	+	12,000
8100	" 6	" 7	*	"	M. F.01	......	1250.8	195.6	1055.2	52.	27.6	24.4	B.	8.6	20.2	7.4	12.8	.092	.608	.176	.432	2.04	.42	1.62	.001	.68	9.8	29.	......	+	8,000
8119	" 8	" 9	*	"	M. F.02	......	1066.	202.	864.	54.	26.	28.	B.	15.	16.	5.7	10.3	.086	.546	.16	.386	1.32	.276	1.044	.001	.44	8.4	29.	......	+	29,500
8148	" 10	" 11	*	"	M.	......	940.	197.2	742.8	63.6	22.4	41.2	B.	8.6	16.4	5.2	11.2	.072	.544	.272	.272	1.56	.38	1.18	....	.36	7.4	29.	......	+	12,000
8158	" 13	" 14	*	"	M.	......	898.8	211.2	687.6	56.8	20.8	36.	B.	9.	14.1	4.9	9.2	.076	.48	.176	.304	1.08	.268	.812	.004	.44	6.1	28.	......	+	80,000
8185	" 15	" 16	*	"	M. F.02	......	854.8	224.8	630.	40.8	22.	18.8	B.	10.	14.2	5.	9.2	.92	.448	.112	.336	.92	.252	.668	.002	.4	5.6	28.	......	+	29,000
8199	" 17	" 18	*	"	M.	......	367.6	226.8	140.8	25.6	22.8	2.8	B.	10.2	11.4	4.5	6.9	.94	.352	.176	.176	.936	.22	.716	.002	.48	5.1	29.	......	+	1,700
8225	" 20	" 21	*	"	M. F.01	......	1074.4	243.6	830.8	39.2	17.6	21.6	B.	14.	13.6	4.5	9.1	.116	.544	.208	.336	1.16	.332	.828	.002	.4	5.2	29.5	......	+	3,100
8252	" 22	" 23	*	"	M. F.04	......	1370.	206.	1164.	48.8	17.2	31.6	B.	9.	20.9	4.6	16.3	.144	.8	.192	.608	1.48	.3	1.18	.005	.68	8.9	30.	......	+	1,550
8270	" 24	" 25	*	"	M. F.04	......	1307.2	181.2	1126.	62.	14.4	47.6	B.	9.6	22.1	4.7	17.4	.156	.768	.112	.656	1.64	.22	1.42	.001	.56	9.1	28.	......	....	2,500
8301	" 27	" 28	*	"	M. F.	......	1146.8	201.2	945.6	60.4	16.8	43.6	DB.	13.	19.7	4.7	15.	.064	.704	.176	.528	1.64	.38	1.26	.001	.6	8.9	26.	......	–	2,150
8320	" 29	" 30	*	"	M. F.	......	1287.2	201.2	1086.	48.4	11.2	37.2	DB.	15.8	21.3	5.	16.3	.104	.704	.192	.512	1.56	.236	1.324	.002	.6	8.9	26.	......	+	2,350
8346	" 31	Sept. 1	*	Much	M. F.02	M'sty	1398.	168.8	1229.2	40.4	22.	18.4	DB.	11.	23.4	4.4	19.	.145	.672	.064	.608	1.96	.3	1.66	.001	.56	8.7	27.	......	–	3,350
8351	Sept. 3	" 4	§	V.M'ch	M. F.15	......	1236.8	183.6	1053.2	49.6	16.8	32.8	DB.	22.2	23.	5.3	17.7	.128	.736	.112	.624	2.2	.252	1.948	.004	.64	10.1	26.	......	+	3,100
8385	" 5	" 6	§	"	M. F.05	......	1381.2	212.	1169.2	65.6	15.2	50.4	DB.	18.4	23.2	4.9	18.3	.148	.752	.16	.592	1.88	.24	1.64	.001	.72	10.	27.	......	+	7,200
8410	" 7	" 8	§	"	VM. F.15	......	1320.	198.8	1121.2	49.6	18.8	30.8	DB.	15.	24.2	5.5	18.7	.12	1.024	.16	.864	1.96	.464	1.496	.002	.68	10.4	27.	......	+	4,700
8422	" 10	" 11	§	"	VM. F.05	......	1081.2	212.4	868.8	50.8	18.	32.8	DB.	11.6	20.8	5.	15.8	.12	.48	.128	.352	1.208	.384	.824	.003	.64	8.6	27.	......	–	5,300
8444	" 12	" 13	§	"	VM. F.1	......	1054.	209.2	844.8	39.6	20.4	19.2	DB.	12.2	19.6	6.2	13.4	.084	.544	.128	.416	1.176	.432	.744	.003	.48	7.8	26.	......	+	4,500
8466	" 14	" 15	§	"	VM.	......	886.4	228.4	658.	44.	20.4	23.6	DB.	10.2	20.8	7.1	13.7	.144	.48	.112	.368	1.208	.304	.904	.002	.44	7.1	24.	......	+	4,300
8482	" 17	" 18	§	Much	M. F.01	......	872.4	242.4	630.	58.	21.6	36.4	DB.	9.6	14.8	7.1	7.7	.056	.416	.128	.288	1.08	.368	.712	.003	.56	6.1	20.	......	–	3,400
8496	" 19	" 20	§	"	M. F.03	......	800.8	255.2	545.6	30.	18.8	11.2	DB.	11.4	14.7	7.9	6.8	.1	.4	.128	.272	1.144	.4	.744	.006	.56	6.	18.	......	–	19,600
8519	" 21	" 22	§	V.M'ch	M. F.1	......	1362.4	270.8	1091.6	43.6	26.4	17.2	DB.	11.2	20.4	7.3	13.1	.228	.592	.112	.48	1.56	.528	1.032	.002	.52	6.2	19.	......	+	25,300
8536	" 24	" 25	§	Much	VM. F.25	......	1879.2	258.8	1620.4	62.8	26.8	36.	DB.	10.8	19.4	7.9	11.5	.106	.8	.144	.656	1.72	.432	1.288	.003	.68	7.5	20.	......	+	30,900
8553	" 26	" 27	§	V.M'ch	M. F.3	......	1545.6	260.4	1285.2	68.8	18.8	50.	DB.	23.	24.6	8.6	16.	.168	.928	.128	.8	1.64	.32	1.32	.001	.6	7.6	22.	......	+	9,250
8570	" 28	" 29	*	Much	M.	......	1251.6	218.4	1033.2	61.2	18.	43.2	DB.	11.6	26.6	9.4	17.2	.125	.768	.256	.512	1.88	.614	1.266	.003	.64	8.	20.	......	+	11,500
8580	Oct. 1	Oct. 2	*	Cons'd	M. F.05	......	1223.6	207.6	1016.	54.4	23.6	30.8	DB.	11.6	24.8	9.3	15.5	.108	.72	.308	.412	.864	.512	.352	.004	.68	10.	19.	......	–	6,100
8619	" 4	" 5	§	Much	M. F.03	......	2023.2	186.	1837.2	31.2	18.8	12.4	DB.	8.2	19.8	9.8	10.	.152	1.248	.192	1.056	3.424	.432	2.992	.001	.64	....	....	......	–	5,700

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 72.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

SOURCE OF WATER—MISSISSIPPI RIVER, 400 FEET FROM MISSOURI SHORE, AT CHAIN OF ROCKS, PUMPING STATION ST. LOUIS WATER WORKS.

Serial No.	DATE OF		APPEARANCE.			Odor.	RESIDUE ON EVAPORATION.						Color on Ignition.	Chlorine.	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
										Loss on Ig'n.									Albuminoid Am.												
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Tot'l	Dissolv'd	Suspend'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Suspend'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
6635	Jan. 3	Jan. 6	*	Cons'd	M. F.03	......	386.8	348.	38.8	35.2	26.	9.2	B.	26.	5.4	4.4	1.	.108	.128	.08	.048	.44	.36	.08	.008	.36	2.2	0.	4.5	—	6,100
6668	" 11	" 12	*	"	M. F.01	......	491.2	346.8	144.4	30.8	24.	6.8	B.	29.	6.5	5.	1.5	.036	.24	.144	.096	.72	.256	.464	.008	.4	3.	0.	1.	+	1,450
6714	" 18	" 19	*	Much	M. F.02	......	680.8	389.6	291.2	28.	24.8	3.2	B.	31.4	7.8	4.3	3.5	.088	.256	.112	.144	.64	.192	.448	.004	.64	2.6	3.	......	+	186,000
6770	" 26	" 27	*	"	M. F.04	......	730.	338.8	391.2	26.8	17.2	9.6	B.	25.8	8.9	3.8	5.1	.064	.264	.112	.152	.8	.288	.512	.006	.48	5.6	1.	—1.	?	66,150
6869	Feb. 8	Feb. 9	§	"	M. F.02	......	1205.2	271.6	933.6	41.2	14.8	26.4	B.	15.4	17.3	4.6	12.7	.208	.72	.16	.56	1.92	.224	1.696	.007	.6	2.7	2.	—4.	....	46,600
6970	" 23	" 24	§	"	M. F.03	......	1035.6	286.8	748.8	30.	22.4	7.6	B.	19.6	13.8	....	....	.048	.448	.192	.256	1.12	.384	.736	.008	.84	8.	0.	4.5	—	54,000
7040	Mar. 8	Mar. 9	§	V.M'ch	VM. F.04	......	3152.	146.	3006.	57.2	14.8	42.4	B.	5.6	28.5	6.2	22.3	.32	2.08	.128	1.952	4.64	.32	4.32	.016	1.12	15.	1.	10.	+	162,000
7148	" 22	" 23	*	Much	M. F.05	......	1856.4	176.	1680.4	34.8	6.8	28.	B.	9.	22.9	5.4	17.5	.192	1.12	.206	.914	2.92	.504	2.416	.017	1.08	18.8	3.	13.	—	147,000
7197	" 29	" 30	*	"	M. F.03	......	1212.	231.2	980.8	35.2	10.8	24.4	B.	12.4	16.7	4.6	12.1	.008	.576	.144	.432	1.8	.376	1.424	.025	1.48	15.	5.	7.	+	121,000
7251	Apr. 5	April 6	*	"	M. F.04	......	1530.4	298.	1232.4	29.2	10.8	18.4	B.	13.6	16.3	4.	12.3	.128	.56	.096	.464	1.688	.248	1.44	.025	.76	14.2	7.	17.	+	56,000
7303	" 12	" 13	*	"	M. F.06	......	1853.2	303.2	1550.	46.4	11.6	34.8	B.	12.2	16.7	5.1	11.6	.064	.704	.112	.592	1.88	.312	1.568	.013	.48	15.8	7.	2.	+	102,500
7351	" 19	" 20	*	"	M. F.03	......	2148.4	256.	1892.4	44.8	19.2	25.6	B.	9.4	12.8	7.5	5.3	.064	.864	.16	.704	2.12	.376	1.744	.015	.44	15.8	12.	22.	+	48,000
7428	" 26	" 27	*	"	M. F.15	......	1783.6	222.8	1560.8	52.4	21.2	31.2	B.	9.8	16.8	5.4	11.4	.064	.728	.112	.616	1.96	.28	1.68	.009	.88	17.2	15.	24.	+	21,500
7459	May 3	May 4	*	"	M. F.03	......	1875.2	237.2	1638.	38.8	28.8	10.	B.	10.8	19.5	5.3	14.2	.024	1.152	.176	.976	2.66	.36	2.3	.012	.73	15.3	18.	......	?	71,500
7505	" 10	" 11	*	"	M. F.02	......	2014.	273.2	1740.8	56.4	18.4	38.	B.	14.4	27.2	5.1	22.1	.036	1.12	.096	1.024	3.14	.26	2.88	.000	.8	16.3	17.	16.	+	89,000
7568	" 17	" 18	§	V.M'ch	M. F.03	......	2409.6	303.2	2106.4	76.8	21.6	55.2	B.	16.4	26.2	6.1	20.1	.064	1.44	.08	1.36	3.54	.356	3.184	.004	.8	15.	22.	23.	+	33,000
7609	" 24	" 25	§	"	M. F.05	......	2456.	283.2	2172.8	60.	23.2	36.8	B.	12.	28.3	6.5	21.8	.06	1.376	.08	1.296	4.26	.36	3.9	.003	.72	14.2	20.	27.	+	60,000
7640	" 31	June 1	§	Much	M. F.06	......	2422.	304.	2118.	85.6	36.8	48.8	B.	10.8	19.5	5.3	14.2	.04	1.12	.128	.992	2.96	.292	2.668	.01	.68	13.2	23.	22.	....	......
7678	June 7	" 8	*	"	M. F.03	......	2073.6	264.	1809.6	56.8	10.8	46.	B.	12.6	18.7	5.	13.7	.016	.832	.096	.736	2.1	.292	1.808	.005	.44	12.4	25.	24.	+	8,500
7728	" 14	" 15	§	"	M. F.10	......	3906.4	233.6	3672.8	48.	21.6	26.4	B.	8.8	26.7	6.8	19.9	.024	1.472	.176	1.296	3.7	.356	3.344	.006	.6	10.7	24.	27.	....	45,500
7763	" 21	" 22	§	V.M'ch	M. F.05	......	2299.2	248.4	2050.8	47.6	24.4	23.2	B.	8.6	19.1	4.7	14.4	.04	.736	.064	.672	2.12	.292	1.828	.003	.4	11.2	25.	27.	....	39,500
7804	" 28	" 29	*	Cons'd	M. F.10	......	2751.2	210.	2541.2	76.	30.4	45.6	B.	7.4	27.4	5.	22.4	.14	1.84	.144	1.696	4.04	.292	3.748	.005	.64	13.9	26.	33.	+	8,000
7840	July 5	July 6	*	"	M. F.10	......	2901.2	206.	2695.2	93.6	18.4	75.2	B.	7.	23.1	4.9	18.2	.076	1.04	.128	.912	2.92	......	......	.001	.56	11.3	28.	......	—	24,500
7878	" 9	" 10	*	"	M. F.03	......	3541.6	196.8	3344.8	72.8	12.4	60.4	B.	15.2	29.	4.5	24.5	.16	1.68	.144	1.536	3.24	.228	3.012	.001	.68	10.8	27.	......	....	18,000
7911	" 11	" 12	*	"	M. F.03	......	2879.6	179.2	2700.4	60.8	18.4	42.4	B.	10.6	24.9	7.2	17.7	.14	.176	.112	.064	2.44	.18	2.26	.002	.6	10.6	27.	......	....	34,500
7930	" 13	" 14	*	"	M. F.02	......	2461.6	198.	2263.6	80.4	32.4	48.	B.	7.	18.5	4.3	14.2	.072	.832	.08	.752	2.36	.116	2.244	.001	.52	10.3	26.	......	....	24,000
7931	" 16	" 17	*	"	M. F.02	......	2290.4	218.8	2071.6	70.4	36.4	34.	B.	8.	17.7	4.6	13.1	.044	.688	.08	.608	1.8	.244	1.556	.004	.44	10.1	27.	......	+	22,000
7964	" 18	" 19	*	"	M. F.02	......	2420.8	197.6	2223.2	74.8	16.	58.8	B.	9.6	18.5	3.9	14.6	.1	.832	.144	.688	2.52	.148	2.372	.004	.36	9.7	25.	......	—	48,000
7989	" 20	" 21	*	"	M. F.02	......	2202.	195.2	2006.8	60.	32.	28.	B.	11.	19.3	5.3	14.	.108	1.152	.144	1.008	1.88	.18	1.7	.001	.4	9.4	26.	......	+	77,000
8001	" 23	" 24	*	"	M. F.02	......	2944.	200.	2744.	66.4	19.6	46.8	B.	7.2	19.2	4.	15.2	.076	.896	.064	.832	1.96	.148	1.812	.001	.56	9.1	26.	......	....	2,400
8038	" 25	" 26	*	"	M. F.01	......	3653.6	266.4	3387.2	132.	22.8	109.2	B.	8.	29.7	7.2	22.5	.152	1.52	.112	1.408	4.36	.276	4.084	.005	.84	13.2	23.	......	+	1,600

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 72—Concluded.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 400 FEET FROM MISSOURI SHORE, AT CHAIN OF ROCKS, PUMPING STATION ST. LOUIS WATER WORKS.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dis-solv'd	Sus-pad'd							Tot'l	Dis-solv'd	Sus-pad'd										
8038	July 27	July 28	*	Cons'd	M. F.05	......	2005.6	173.2	2432.4	87.6	23.2	64.4	B.	10.	27.7	4.9	22.8	.004	1.84	.112	1.728	2.98	.24	2.68	.002	.78	13.8	26.	......	+	14,500
8052	" 30	" 31	*	"	M. F.01	......	2234.8	168.8	2066.	110.	25.2	84.8	B.	6.6	24.8	4.	20.8	.128	1.548	.08	1.168	3.32	.244	3.076	.004	.08	12.2	26.	......	+	11,000
8076	Aug. 1	Aug. 2	*	"	M. F.02	......	2040.8	170.8	1870.	109.2	20.4	88.8	B.	9.4	24.9	4.6	20.3	.08	1.04	.16	.88	2.92	.356	2.564	.003	.04	11.7	27.	......	....	......
8090	" 3	" 4	*	"	M. F.02	......	1740.8	193.	1547.8	54.	36.	18.	B.	8.	25.1	4.1	21.	.152	1.056	.16	.896	2.6	.228	2.372	.001	.02	10.9	29.	......	+	22,500
8102	" 6	" 7	*	"	M. F.01	......	1384.4	205.6	1178.8	51.6	30.	21.6	B.	9.8	20.9	6.3	14.6	.1	.768	.16	.608	1.96	.308	1.652	.001	.04	9.8	29.	......	—	6,000
8118	" 8	" 9	*	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	8.4	29.	......	—	24,000
8147	" 10	" 11	*	Cons'd	M. F.01	......	1039.6	199.6	840.	66.	21.6	44.4	B.	9.6	16.2	4.3	11.9	.08	.576	.24	.336	1.64	.324	1.316	....	.52	7.4	29.	......	—	36,000
8160	" 13	" 14	*	"	M. F.01	......	976.4	225.2	751.2	63.6	33.6	30.	B.	9.8	15.1	4.3	10.8	.008	.448	.176	.272	1.06	.264	.796	.004	.56	6.1	28.	......	—	6,000
8182	" 15	" 16	*	"	M. F.02	......	918.	233.6	684.4	42.	30.4	11.6	B.	10.6	13.	3.8	9.2	.1	.448	.128	.32	1.06	.220	.844	.002	.52	5.6	28.	......	+	10,000
8197	" 17	" 18	*	"	M. F.01	......	435.6	218.8	216.8	49.2	27.6	21.6	B.	10.8	11.5	4.	7.5	.076	.352	.208	.144	1.08	.252	.828	.002	.44	5.1	29.	......	+	3,050
8222	" 20	" 21	*	"	M. F.01	......	1284.4	270.4	1014.	36.	12.8	23.2	B.	15.2	13.3	4.2	9.1	.112	.576	.16	.416	1.16	.188	.972	.003	.44	5.2	29.5	......	+	2,800
8261	" 22	" 23	*	"	M. F.02	......	1598.4	236.4	1362.	51.2	18.	33.2	B.	11.2	20.2	3.9	16.3	.14	.88	.128	.752	1.88	.156	1.724	.003	.6	8.9	30.	......	....	......
8277	" 24	" 25	*	"	M. F.1	......	1468.8	193.6	1275.2	72.8	12.	60.8	B.	12.	21.4	4.2	17.2	.164	.864	.08	.784	2.12	.204	1.916	.001	.52	9.1	28.	......	+	2,500
8303	" 27	" 28	*	"	M. F.02	......	1300.8	216.	1084.8	47.2	14.8	32.4	B.	15.4	20.1	4.5	15.6	.116	.608	.096	.512	1.64	.284	1.356	.002	.68	8.9	26.	......	+	2,500
8319	" 29	" 30	*	"	M. F.02	......	1405.6	1216.8	188.8	55.2	11.2	44.	DB.	18.4	21.2	4.9	16.3	.148	.416	.176	.24	1.72	.46	1.26	.003	.6	8.9	26.	......	+	5,800
8347	" 31	Sept. 1	*	Much	M. F.03	M'sty	1523.6	205.2	1318.4	33.2	24.4	8.8	DB.	12.8	23.3	3.7	19.6	.224	.704	.224	.48	1.8	.188	1.612	.001	.6	8.7	27.	......	+	6,150
8350	Sept. 3	" 4	§	V.M'ch	M. F.02	......	1424.4	204.	1220.4	52.4	18.4	34.	DB.	20.	24.	4.9	19.1	.2	.8	.096	.704	.6	......	......	.025	.6	10.1	26.	......	+	2,850
8396	" 5	" 6	§	"	M. F.04	......	1580.	228.	1352.	46.4	14.4	32.	DB.	22.2	24.2	4.	20.2	.124	.768	.096	.672	2.04	.24	1.8	.002	.76	10.	27.	......	+	7,400
8411	" 7	" 8	§	"	VM.F.02	......	1608.6	210.	1393.6	35.6	17.6	18.	DB.	18.2	24.6	4.5	20.1	.168	.96	.208	.752	2.44	.656	1.784	.004	.64	10.4	27.	......	+	5,150
8425	" 10	" 11	§	"	VM.F.05	......	1315.2	229.2	1086.	34.8	15.6	19.2	DB.	14.	20.5	4.	16.5	.176	.48	.192	.288	1.04	.252	1.288	.003	.76	8.6	27.	......	—	2,850
8445	" 12	" 13	§	"	VM.F.03	......	1238.	243.6	994.4	36.	24.4	11.6	DB.	16.4	19.	4.2	14.8	.10	.704	.128	.576	1.236	.24	1.096	.002	.52	7.8	26.	......	+	4,000
8467	" 14	" 15	§	"	VM F.02	......	1088.	257.6	830.4	47.2	19.2	28.	DB.	11.8	19.2	6.4	12.8	.156	.496	.124	.372	1.24	.672	.568	.002	.6	7.1	24.	......	+	2,900
8480	" 17	" 18	§	Much	M. F.02	......	1057.6	280.8	776.8	42.4	16.4	26.	DB.	11.6	15.4	5.1	10.3	.064	.4	.096	.304	.92	.32	.6	.004	.04	6.1	20.	......	—	1,000
8499	" 19	" 20	§	"	M. F.01	......	917.2	279.6	637.6	34.8	16.4	18.4	B.	13.8	14.	5.4	8.6	.084	.4	.176	.224	1.08	.396	.644	.006	.56	6.	18.	......	—	10,100
8518	" 21	" 22	§	"	M. F.06	......	1594.	290.8	1303.2	34.	20.	14.	DB.	13.2	16.8	8.1	8.7	.074	.576	.096	.48	1.64	.236	1.404	.002	.08	6.2	19.	......	+	47,950
8537	" 24	" 25	§	V.M'ch	VM.F.25	......	2148.4	285.6	1862.8	65.6	25.6	40.	DB.	12.4	20.7	7.4	13.3	.132	.864	......	......	2.04	.512	1.528	.002	.84	7.5	20.	......	+	27,400
8552	" 26	" 27	§	"	M. F.07	......	1880.	282.4	1597.6	90.	17.2	72.8	DB.	27.6	24.9	7.5	17.4	.18	.864	.128	.736	2.84	.56	2.28	.001	.8	7.6	22.	......	—	3,750
8572	" 28	" 29	*	Much	M.	......	1573.2	242.4	1330.8	53.6	16.	37.6	DB.	15.4	26.4	6.8	19.6	.152	1.12	.24	.88	2.02	.608	1.412	.004	.92	8.	20.	......	+	15,000
8583	Oct. 1	Oct. 2	§	"	M. F.3	......	1673.2	244.8	1428.4	62.8	18.	44.8	DB.	16.2	23.8	6.3	17.5	.188	.864	.224	.64	2.224	.352	1.872	.003	.64	10.	19.	......	—	5,500
8620	" 4	" 5	..	......	......	......	......	....	......	....	......	....	......	......	....	....	....	......	......	......	......	......	......	......	....	......	....	....	......	....	......
....	......	......	..	......	......	......	......	......	......	....	......	....	......	......	....	....	....	......	......	......	......	......	......	......	....	......	....	....	......	....	......

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 73.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSOURI RIVER, FORT BELLEFONTAINE, WEST ALTON, MO.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dis-solv'd	Sus-pnd'd							Tot'l	Dis-solv'd	Sus-pnd'd										
6630	Jan. 4	Jan. 6	*	Cons'd	M. F.01	......	454.4	386.4	68.	26.	23.2	2.8	B.	26.8	3.9	3.3	.6	.068	.208	.112	.096	.36	.232	.128	.008	.32	1.7	1.	3.	−	21,000
6681	" 11	" 13	*	Much	M. F.03	......	578.	370.	208.	23.2	20.4	2.4	B.	33.5	5.2	3.5	1.7	.048	.176	.112	.064	.56	.32	.24	.004	.32	3.3	2.	5.	+	11,200
6726	" 18	" 20	*	"	M. F.01	......	769.	395.6	373.4	18.4	6.8	11.6	B.	35.4	8.	4.3	3.7	.12	.32	.128	.192	.72	.32	.4	.007	.28	4.1	1.	6.	+	309,000
6766	" 25	" 27	*	"	M. F.01	......	773.2	338.	435.2	28.	22.	6.	B.	29.	9.6	3.9	5.7	.08	.32	.16	.16	.88	.32	.56	.008	.64	5.1	2.	3.	+	43,600
6816	Feb. 1	Feb. 3	*	Cons'd	M. F.02	......	533.2	384.8	148.4	24.4	22.4	2.	B.	26.9	5.3	4.1	1.2	.06	.16	.096	.064	.416	.16	.256	.011	.52	2.8	1.	5.	−	40,000
6866	" 7	" 9	†	"	M. F.02	......	548.	347.2	200.8	9.6	7.6	2.	B.	20.4	4.1	3.6	.5	.048	.128	.096	.032	.384	.192	.192	.005	.48	2.	7.	12.	....	75,500
6918	" 14	" 16	*	Much	M. F.03	......	804.8	303.2	501.6	32.8	14.8	18.	B.	22.8	12.1	3.2	8.9	.068	.448	.224	.224	.96	.32	.64	.006	.56	3.4	2.	5.	+	37,200
6965	" 21	" 23	*	Cons'd	M. F.02	......	474.4	321.6	152.8	25.6	25.2	.4	B.	25.	4.9	4.2	.7	.08	.272	.176	.096	.56	.32	.24	.01	.72	3.7	2.	9.	−	7,500
7043	Mar. 7	Mar. 9	§	V.Mc'h	VM.F.04	......	1882.8	180.4	1702.4	100.8	14.8	86.	B.	7.8	23.	6.5	16.5	.216	2.	.16	1.84	4.96	.576	4.384	.015	.64	13.3	2.	5.	+	135,000
7080	" 13	" 15	§	"	VM.F.4	......	3430.8	182.4	3248.4	50.4	14.8	35.6	B.	9.2	27.8	6.7	21.1	.23	1.92	.192	1.728	4.16	.544	3.616	.015	1.4	16.5	5.	13.	+	260,000
7152	" 22	" 24	*	Much	M. F.05	......	1734.8	197.6	1537.2	51.6	14.	37.6	B.	9.6	19.9	5.4	14.5	.16	1.12	.208	.912	2.76	.504	2.256	.02	1.12	10.9	8.	16.	+	206,000
7205	" 29	" 31	*	"	M. F.2	......	982.8	241.2	741.6	42.8	12.	30.8	B.	12.8	16.	5.2	10.8	.068	.56	.192	.368	1.656	.44	1.216	.021	.88	7.9	11.	9.	+	118,000
7228	April 3	April 5	*	"	M. F.04	......	1286.	282.4	1003.6	34.	7.6	26.4	B.	14.1	16.4	5.4	11.	.06	.56	.096	.464	1.64	.304	1.336	.035	.72	9.2	12.	17.	+	84,000
7290	" 10	" 12	§	"	VM.F.03	......	1708.	293.2	1414.8	43.6	12.	31.6	B.	12.8	17.3	4.7	12.6	.024	.64	.096	.544	1.64	.216	1.424	.016	.64	9.3	11.	6.	+	64,000
7333	" 16	" 18	*	V.M'ch	VM.F.03	......	3026.8	258.8	2768.	66.4	15.2	51.2	B.	12.	19.9	4.7	15.2	.016	.992	.096	.896	3.4	.312	3.088	.015	.72	12.5	12.	18.	+	119,000
7403	" 23	" 25	§	"	M. F.	......	1923.6	223.6	1700.	44.4	19.6	24.8	B.	9.4	19.3	5.7	13.6	.02	.96	.128	.832	2.44	.344	2.096	.012	.72	10.6	15.	......	+	41,000
7447	May 1	May 3	§	"	M. F.	......	1626.	237.6	1388.4	56.8	14.4	42.4	B.	15.2	22.4	5.8	16.6	.02	.896	.16	.736	2.66	.42	2.24	.007	1.28	11.	20.	25.	+	92,000
7491	" 8	" 10	*	Much	VM.F.03	......	2290.	245.2	2044.8	64.	18.	46.	B.	10.8	25.6	5.9	19.7	.052	1.6	.128	1.472	3.78	.26	3.52	.008	.8	10.8	21.	26.	+	111,000
7550	" 15	" 16	*	"	M. F.05	......	2855.2	316.8	2538.4	85.2	19.6	65.6	B.	11.4	27.5	4.9	22.6	.104	1.6	.16	1.44	2.9	.256	2.644	.003	.76	11.8	23.	27.	+	14,000
7592	" 22	" 23	§	V.M'ch	M. F.02	......	2697.2	305.6	2391.6	84.8	20.4	64.4	B.	12.8	27.3	4.5	22.8	.052	1.12	.064	1.056	3.14	.484	2.656	.004	.64	11.2	21.	26.	....	55,000
7635	" 29	" 31	§	"	M. F.05	......	2220.	300.	1920.	52.8	39.6	13.2	B.	16.5	19.9	5.3	14.6	.052	1.216	.16	1.056	2.9	.372	2.528	.004	.8	11.6	24.	27.	?	59,000
7669	June 5	June 6	*	Cons'd	M. F.02	......	2176.4	282.	1894.4	56.8	22.	34.8	B.	13.4	18.8	5.8	13.	.016	.768	.112	.656	2.34	.292	2.048	.004	.68	10.8	25.	26.	?	77,000
7719	" 12	" 14	*	Much	M. F.06	......	2180.4	262.8	1917.6	63.2	22.4	40.8	B.	10.6	18.3	7.3	11.	.02	.88	.16	.72	2.98	.8	2.18	.007	.48	10.4	25.	24.	+	113,000
7758	" 19	" 21	*	"	M. F.02	......	2431.6	241.6	2190.	46.8	18.8	28.	B.	9.6	18.5	4.7	13.8	.086	.704	.096	.608	2.92	.188	2.732	.003	.56	11.	26.	24.	+	22,000
7798	" 27	" 28	*	Cons'd	M. F.10	......	3585.2	218.4	3366.8	123.6	20.4	103.2	B.	8.4	28.7	4.8	13.9	.082	1.76	.144	1.616	6.28	.213	6.068	.001	.68	12.9	25.	26.	+	31,500
7833	July 3	July 4	*	"	M. F.03	......	2567.6	199.2	2368.4	44.	20.4	23.6	B.	6.4	22.6	6.2	16.4	.052	.992	.096	.896	2.28	.308	1.972	.001	.28	11.4	28.	......	+	38,000
7907	" 10	" 11	*	"	M. F.02	......	3438.4	201.2	3237.2	116.	27.2	88.8	B.	7.8	28.	8.2	19.8	.166	.324	.16	.164	.642	.346	.296	.002	.68	11.	27.	......	?	48,500
7968	" 17	" 18	*	"	M. F.01	......	2364.8	199.6	2165.2	60.	8.	52.	B.	8.7	18.2	5.1	13.1	.128	.702	.128	.574	2.2	.292	1.908	.004	.44	10.4	29.	......	....	4,000
8022	" 24	" 26	*	"	M. F.01	......	4124.8	207.6	3917.2	514.8	18.	496.8	B.	9.	24.4	6.7	17.7	.114	1.52	.096	1.424	4.2	.212	3.988	.005	.6	11.7	28.	......	?	......
8080	Aug. 1	Aug. 2	*	"	M. F.02	......	2034.	172.4	1861.6	84.8	16.8	68.	B.	7.	25.5	4.5	21.	.102	1.504	.16	1.344	2.92	.228	2.692	.007	.56	9.7	29.	......	+	17,500
8125	" 7	" 9	*	"	M. F.01	......	1305.2	230.	1075.2	89.6	34.4	55.2	B.	18.	18.9	3.8	15.1	.086	.544	.224	.32	1.8	.324	1.476	.001	.44	7.4	31.	......	+	11,400
8179	" 14	" 16	*	"	M. F.02	......	968.4	230.	738.4	58.8	56.4	2.4	B.	11.	13.4	3.9	9.5	.076	.48	.112	.368	1.08	.252	.828	.004	.44	5.8	29.	......	?	16,000
8259	" 21	" 23	*	"	M. F.02	......	1623.2	246.	1377.2	38.4	13.2	25.2	B.	12.0	20.5	3.9	16.6	.134	.88	.128	.752	1.96	.108	1.852	.002	.6	....	....	......	....	......
8328	" 28	" 30	*	"	M. F.	......	1609.6	197.6	1412.	56.4	15.6	40.8	B.	22.0	22.7	4.3	18.4	.158	.896	.08	.816	2.2	.236	1.964	.001	.68	7.3	28.	......	....	4,900
8381	Sept. 4	Sept. 5	§	V.M'ch	M. F.02	......	1662.8	228.4	1434.4	63.2	14.	49.2	B.	28.	25.4	3.4	22.	.154	.8	.064	.736	2.2	.368	1.832	.001	.76	8.5	28.	......	+	7,200
8447	" 11	" 13	§	"	VM.F.02	......	1492.	271.6	1220.4	43.6	19.2	24.4	DB.	23.	20.2	4.	16.2	.096	.656	.112	.544	1.336	.272	1.064	.004	.64	6.3	27.	......	?	4,050
8494	" 18	" 20	§	Much	M. F.01	......	1171.2	342.	829.2	50.4	16.4	34.	B.	15.4	15.	5.4	9.6	.08	.448	.096	.352	1.16	.368	.792	.007	.68	4.7	21.	......	....	11,500
8548	" 25	" 27	§	V.M'ch	VM.F.05	......	2385.6	344.4	2041.2	89.6	17.2	72.4	DB.	34.6	22.5	5.7	16.8	.12	1.056	.144	.912	2.68	.272	2.408	.001	.8	6.1	24.	......	....	78,000
8608	Oct. 2	Oct. 3	§	"	M. F.02	......	2201.6	252.8	1948.8	52.4	17.2	35.2	DB.	15.8	24.9	7.1	17.8	.190	1.28	.192	1.088	3.344	.448	2.896	.001	.76	....	....	......	....	......

COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 74.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

SOURCE OF WATER—MISSISSIPPI RIVER, 100 YARDS FROM ILLINOIS SHORE, JEFFERSON BARRACKS, MO.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
										Loss on Ig'n.									Albuminoid Am.												
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Tot'l	Dissolv'd	Suspnd'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Suspnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
6614	Jan. 4	Jan. 5	*	Cons'd	M. F.03	......	340.8	321.6	19.2	28.4	22.8	5.6	G.	21.2	11.3	9.4	1.9	.7	.4	.256	.144	.92	.584	.336	.02	.72	1.	0.	......	+	1,650
6673	" 11	" 12	*	"	M. F.04	......	270.8	242.4	28.4	26.	25.6	.4	B.	10.2	10.2	8.1	2.1	.32	.48	.224	.256	.88	.544	.336	.011	.28	2.5	0.	......	+	15,000
6712	" 18	" 19	*	Much	M. F.03	......	277.6	226.8	50.8	30.4	27.6	2.8	B.	9.	10.8	9.	1.8	.068	.432	.16	.272	.96	.616	.344	.008	1.04	2.6	3.	......	+	22,000
6761	" 25	" 26	*	"	M. F.2	......	428.8	186.8	242.	31.6	18.	13.6	B.	6.2	14.9	7.7	7.2	.202	.512	.256	.256	1.28	.512	.768	.013	1.	5.9	4.	......	+	38,400
6821	Feb. 3	Feb. 5	*	Cons'd	M. F.3	......	308.8	283.6	25.2	41.6	39.2	2.4	B.	16.	9.3	7.5	1.8	.6	.336	.176	.16	.704	.384	.32	.013	.92	.6	0.	......	+	21,700
6874	" 9	" 10	*	Much	M. F.04	......	1497.6	200.8	1296.8	57.2	15.6	41.6	B.	8.4	19.9	7.5	12.4	.514	1.36	.192	1.168	3.12	......	......	.01	.8	4.7	0.	......	....	62,500
6961	" 22	" 23	*	"	M. F.25	......	840.4	170.	670.4	85.2	23.6	61.6	B.	6.	17.7	8.8	8.9	.48	.864	.272	.592	1.52	.544	.976	.017	1.2	6.4	0.	......	+	132,000
7010	Mar. 3	Mar. 4	†	Cons'd	M. F.3	......	326.	184.4	141.6	34.8	13.2	31.6	B.	6.8	13.9	9.4	4.5	.336	.448	.24	.208	1.04	.64	.4	.02	1.32	6.2	0.	......	+	98,000
7047	" 8	" 9	§	V.M'ch	M. F.04	......	1329.2	148.	1181.2	34.	10.4	23.6	B.	5.	19.1	6.6	12.5	.32	.864	.16	.704	2.72	.32	2.4	.014	1.12	14.	0.	......	+	106,500
7098	" 16	" 17	§	"	VM. F.05	......	1429.2	113.2	1316.	46.	7.6	38.4	B.	3.	23.3	6.7	16.6	.32	1.2	.176	1.024	2.88	.48	2.4	.009	.84	23.5	2.	......	+	136,000
7140	" 22	" 23	§	"	VM. F.04	......	851.6	132.8	718.8	43.6	17.2	26.4	B.	5.5	19.5	6.4	13.1	.328	.8	.192	.608	2.04	.536	1.504	.016	1.28	18.5	2.	......	+	75,000
7191	" 29	" 30	*	Much	M. F.08	......	652.4	134.8	517.6	27.6	10.4	17.2	B.	4.4	15.1	6.8	8.3	.288	.448	.24	.208	1.272	.696	.576	.016	1.08	13.	8.	......	+	133,000
7243	Apr. 5	Apr. 6	*	"	M. F.30	......	447.2	131.2	316.	19.2	9.2	10.	B.	4.3	13.5	6.9	6.6	.272	.384	.192	.192	1.144	.376	.768	.017	1.24	14.8	7.	......	+	36,000
7309	" 12	" 13	*	"	M. F.04	......	572.4	143.6	428.8	50.4	19.6	30.8	B.	4.6	17.	7.1	9.9	.208	.608	.224	.384	1.24	.6	.64	.022	1.32	15.8	8.	......	+	107,000
7377	" 20	" 21	*	"	M. F.03	......	498.8	161.2	337.6	24.8	20.	4.8	B.	4.8	13.	6.3	6.7	.08	.336	.208	.128	1.	.536	.464	.05	1.08	16.	12.	......	+	21,000

TURBIDITY—*Decided. §Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 75.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, EAST OF MIDSTREAM, JEFFERSON BARRACKS, MO.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
										Loss on Ig'n.									Albuminoid Am.												
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Tot'l	Dissolv'd	Suspend'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Suspend'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
6615	Jan. 4	Jan. 5	*	Cons'd	M. F.03	......	234.	318.8	15.2	36.8	34.	2.8	B.	21.2	9.6	8.7	.9	.06	.336	.208	.128	.76	.616	.144	.017	.73	1.	0.	......	+	1,800
6676	" 11	" 12	*	"	M. F.04	......	308.	239.6	68.4	23.	15.8	7.2	B.	10.	11.	8.4	2.6	.34	.576	.192	.384	1.04	.544	.496	.000	.48	2.5	0.	......	+	24,100
6711	" 18	" 19	—	Much	M. F.04	......	309.2	224.8	84.4	21.2	18.	3.2	B.	10.	11.4	8.5	2.9	.076	.432	.16	.272	.96	.416	.544	.008	.72	2.6	3.	......	+	30,800
6762	" 25	" 26	*	"	M. F.06	......	435.2	201.2	234.	39.2	24.	15.2	B.	8.4	14.3	7.1	7.2	.188	.496	.224	.272	1.36	.384	.976	.015	.88	5.9	4.	......	+	36,400
6822	Feb. 3	Feb. 5	‡	Cons'd	M. F.03	......	387.6	294.4	93.2	32.8	28.4	4.4	B.	16.6	10.8	7.8	3.	.6	.332	.16	.192	.736	.384	.352	.012	1.04	.6	0.	......	+	39,200
6959	" 22	" 23	*	Much	VM. F.25	......	635.2	166.8	668.4	89.2	24.8	64.4	B.	6.	18.9	9.	9.9	.496	.832	.256	.576	1.84	.64	1.2	.013	1.4	6.4	0.	......	+	140,000
7012	Mar. 3	Mar. 5	*	Cons'd	M. F.3	......	308.4	192.4	116.	31.2	25.2	6.	B.	7.	13.7	9.1	4.6	.4	.432	.304	.128	1.12	.736	.384	.022	1.2	6.2	0.	......	+	133,000
7048	" 8	" 9	§	V.M'ch	VM. F.08	......	1752.4	146.	1606.4	80.	9.6	70.4	B.	5.6	19.3	5.9	13.4	.304	1.024	.16	.864	2.88	.416	2.464	.013	.76	14.	0.	......	+	187,500
7097	" 16	" 17	§	"	VM. F.03	......	1580.8	121.2	1459.6	41.6	13.6	28.	B.	1.6	22.9	6.6	16.3	.288	1.2	.208	.992	2.88	.416	2.464	.011	.68	23.5	2.	......	+	198,000
7139	" 22	" 22	‡	Much	M. F.3	......	778.4	125.2	653.2	42.8	17.2	25.6	B.	4.	18.3	6.5	11.8	.336	.864	.176	.688	1.88	.6	1.28	.015	1.12	18.5	2.	......	+	75,000
7193	" 29	" 30	*	"	M. F.06	......	548.	150.4	397.6	22.8	14.4	8.4	B.	4.	14.3	7.7	6.6	.32	.448	.192	.256	1.24	.504	.736	.015	.88	13.	8.	......	+	131,000
7244	Apr. 5	Apr. 6	*	"	M. F.08	......	398.8	143.2	255.6	32.4	25.2	7.2	B.	3.9	12.7	6.1	6.6	.256	.384	.192	.192	1.144	.408	.736	.017	1.38	14.8	7.	......	+	81,000
7310	" 12	" 13	*	"	M. F.06	......	562.	141.2	420.8	37.2	15.2	22.	B.	4.3	18.	7.3	10.7	.208	.672	.208	.464	1.64	.536	1.104	.027	1.24	15.8	8.	......	+	36,000
7379	" 20	" 21	*	"	M. F.04	......	620.4	163.2	457.2	31.2	16.8	14.4	B.	4.7	14.	7.2	6.8	.096	.416	.176	.24	1.	.472	.528	.045	1.04	16.	12.	......	+	9,500

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. | Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 76.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, MIDSTREAM, JEFFERSON BARRACKS, MO.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n. Tot'l	Dis-solv'd	Sus-pend'd			Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Dis-solv'd	Sus-pend'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
6617	Jan. 4	Jan. 5	*	Cons'd	M. F.03	......	388.8	332.4	56.4	25.6	20.8	4.8	B.	22.4	9.4	9.1	.3	.06	.32	.208	.112	.76	.448	.312	.017	.64	1.	0.	......	+	2,400
6675	" 11	" 12	*	"	M. F.04	......	325.2	239.6	85.6	36.8	33.2	3.6	B.	11.2	13.4	8.2	4.2	.4	.448	.224	.224	.96	.64	.32	.011	.48	2.5	0.	......	+	15,000
6708	" 18	" 19	*	Much	M. F.03	......	361.6	258.8	102.8	30.4	28.4	2.	B.	13.2	11.5	9.	2.5	.064	.384	.208	.176	.88	.384	.496	.008	.68	2.6	3.	......	+	27,000
6763	" 25	" 26	*	"	M. F.03	......	508	231.2	276.8	34.4	25.6	8.8	B.	11.8	12.9	6.2	6.7	.12	.384	.192	.192	.88	.32	.56	.01	.68	5.9	4.	......	+	26,000
6825	Feb. 3	Feb 5	*	Cons'd	M. F.04	......	386.	300.4	85.6	32.	30.8	1.2	B.	16.8	8.3	6.3	2.	.6	.272	.144	.128	.688	.448	.24	.015	.72	.6	0.	......	+	62,200
6873	" 9	" 10	*	V.M'ch	VM.F.03	......	1076.8	243.2	833.6	44.	18.8	25.2	B.	11.4	17.3	6.6	10.7	.304	.768	.16	.608	2.16	.32	1.84	.008	.88	4.7	0.	......	....	79,000
6956	" 22	" 23	*	Much	VM.F.25	......	756.4	167.2	589.2	74.8	27.2	47.6	B.	6.4	19.	8.9	10.1	.432	.736	.256	.48	1.44	.64	.8	.015	1.12	6.4	0.	......	+	109,000
7007	Mar. 3	Mar. 5	*	Cons'd	M. F.5	......	373.2	214.8	158.4	41.6	28.4	13.2	B.	7.2	13.8	9.	4.8	.304	.432	.248	.184	1.04	.544	.496	.017	1.32	6.2	0.	......	+	51,000
7046	" 8	" 9	§	V.M'ch	VM.	......	1968.	141.6	1826.4	58.8	13.2	45.6	B.	4.4	24.6	5.7	18.9	.24	1.184	.208	.976	3.2	.384	2.816	.011	1.04	14.	0.	......	+	153,500
7101	" 16	" 17	§	"	VM.F.03	......	2166.8	130.4	2036.4	48.8	12.8	36.	B.	5.6	28.7	6.5	22.2	.288	1.2	.192	1.008	3.2	.384	2.816	.014	.92	26.5	2.	......	+	186,000
7143	" 22	" 23	*	Much	M. F.25	......	814.	123.6	690.4	31.2	13.6	17.6	B.	3.8	20.3	6.2	14.1	.32	.8	.24	.56	2.04	.6	1.44	.015	.6	18.5	3.	......	+	103,000
7189	" 29	" 30	*	"	M. F.06	......	518.	130.8	387.2	30.4	11.2	19.2	B.	4.4	14.3	7.	7.3	.288	.432	.176	.256	1.24	.44	.8	.013	1.08	13.	8.	......	+	74,500
7245	Apr. 5	Apr. 6	*	"	M. F.05	......	422.	144.	278.	31.6	12.	19.6	B.	4.	14.	6.5	7.5	.256	.384	.176	.208	1.176	.472	.704	.018	.72	14.8	7.	......	+	37,000
7305	" 12	" 13	*	"	M. F.06	......	672.	143.2	528.8	44.8	18.	26.8	B.	3.8	18.9	7.5	11.4	.208	.768	.24	.528	1.88	.568	1.312	.008	1.16	15.8	8.	......	+	77,000
7375	" 20	" 21	*	"	M. F.06	......	967.2	174.8	792.4	40.8	19.2	21.6	B.	5.4	15.4	7.7	7.7	.048	.448	.176	.272	1.4	.536	.864	.04	.76	16.	12.	......	+	31,000

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. | Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.
COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 77.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, WEST OF MIDSTREAM, JEFFERSON BARRACKS, MO.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n. Tot'l	Loss on Ig'n. Dissolv'd	Loss on Ig'n. Suspnd'd			Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspnd'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
6618	Jan. 4	Jan. 5	*	Cons'd	M. F.03	......	372.4	316.	56.4	29.6	29.6	....	B.	21.2	12.5	9.3	3.2	.72	.432	.24	.192	.92	.496	.432	.08	.8	1.	0.	......	+	20,000
6672	" 11	" 12	*	"	M. F.04	......	382.4	267.2	115.2	31.2	28.	3.2	B.	15.	9.	7.2	1.8	.2	.416	.176	.24	.8	.416	.384	.01	.52	2.5	0.	......	+	28,000
6709	" 18	" 19	*	Much	M. F.03	......	550.8	316.4	234.4	39.2	28.8	10.4	B.	23.2	10.6	7.1	3.5	.072	.352	.112	.24	.8	.384	.416	.007	.64	2.6	3.	......	+	57,200
6760	" 25	" 26	*	"	M. F.03	......	610.	260.	350.	24.	13.2	10.8	B.	15.2	12.	5.5	6.5	.132	.416	.16	.256	.96	.32	.64	.01	.64	5.9	4.	......	+	19,900
6826	Feb. 3	Feb. 5	*	Cons'd	M. F.04	......	398.4	302.4	96.	22.8	21.6	1.2	B.	18.4	8.1	6.3	1.8	.56	.352	.192	.16	.704	.448	.256	.014	.92	.6	0.	......	+	97,200
6903	" 22	" 23	*	Much	VM.F.	......	563.2	213.2	350.	58.4	21.2	37.2	B.	11.	15.6	7.1	8.5	.304	.608	.24	.368	.96	.48	.48	.012	.92	6.4	0.	......	—	104,000
7011	Mar. 3	Mar. 5	*	Cons'd	M. F.03	......	450.	321.6	128.4	18.4	15.6	2.8	B.	17.6	8.8	6.2	2.6	.08	.32	.272	.048	.88	.48	.4	.012	.8	6.2	0.	......	+	55,500
7044	" 8	" 9	§	V.M'ch	VM.F.05	......	2930.4	144.	2786.4	72.	13.2	58.8	B.	5.2	29.	7.1	21.9	.288	1.696	.128	1.568	3.84	.448	3.392	.014	1.08	14.	0.	......	+	125,000
7100	" 16	" 17	§	"	VM.F.03	......	2474.8	143.6	2331.2	50.8	9.6	41.2	B.	7.	29.4	6.8	22.6	.272	1.76	.192	1.568	4.	.448	3.552	.014	1.04	23.5	2.	......	?	216,000
7144	" 22	" 23	*	Much	M. F.2	......	865.2	468.	497.2	49.2	38.	11.2	B.	4.4	19.4	8.7	10.7	.288	.896	.256	.64	2.2	.76	1.44	.018	.84	18.5	2.	......	+	135,000
7190	" 29	" 30	*	"	M. F.06	......	482.	138.8	343.2	25.2	15.2	10.	B.	5.	15.8	7.	8.8	.256	.544	.208	.336	1.336	.536	.8	.016	.88	13.	8.	......	+	46,000
7248	Apr. 5	Apr. 6	*	"	M. F.04	......	748.	196.4	551.6	34.	10.	24.	B.	7.2	14.9	6.2	8.7	.176	.448	.224	.224	1.24	.536	.704	.08	.8	14.8	7.	......	+	49,000
7306	" 12	" 13	*	"	M. F.2	......	1241.6	235.2	1006.4	50.4	19.2	31.2	B.	8.	18.	6.6	11.4	.192	.8	.176	.624	2.04	.408	1.632	.018	.76	15.8	8.	......	+	64,000
7374	" 20	" 21	*	"	M. F.05	......	1517.2	440.4	1076.8	32.8	12.	20.8	B.	7.2	16.8	7.7	9.1	.064	.56	.112	.448	1.88	.352	1.528	.035	.56	....	....	......	....	....
....	....	....	..	....	....	......	......	......	......	....	....	....	......	....	....	....	....	......	......	......	......	.....	.....	.....	....	.....	....	....	......	....	....

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 78

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 100 YARDS FROM MISSOURI SHORE, JEFFERSON BARRACKS, MO.

Report of ARTHUR W. PALMER,
T. J. BURRILL,
University of Illinois.

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ign. Tot'l	Loss on Ign. Dissolv'd	Loss on Ign. Susp'd			Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Susp'd	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
6619	Jan. 4	Jan. 5	*	Cons'd	M. F.03	......	377.6	338.8	38.8	21.2	21.2	....	G.	23.8	11.1	8.	3.1	.7	.336	.176	.16	.84	.552	.288	.018	.72	1.	0.	......	+	16,200
6671	" 11	" 12	*	"	M. F.02	......	423.2	292.	131.2	26.	20.8	5.2	B.	20.2	9.2	7.	2.2	.132	.304	.112	.192	.72	.32	.4	.008	.36	2.5	0.	......	+	9,400
6710	" 18	" 19	*	Much	M. F.03	......	576.5	324.	252.5	20.	15.6	4.4	B.	23.2	11.4	7.1	4.3	.1	.336	.16	.176	.72	.416	.304	.005	.48	2.6	3.	......	+	51,600
6758	" 25	" 26	*	"	M. F.04	......	619.2	272.8	346.4	34.	17.6	16.4	B.	17.6	11.9	4.6	7.3	.104	.336	.128	.208	.8	.256	.544	.013	.68	5.9	4.	......	+	19,300
6824	Feb. 3	Feb. 5	*	Cons'd	M. F.03	......	411.2	312.8	98.4	28.	17.2	10.8	B.	19.4	7.9	6.4	1.5	.44	.24	.144	.096	.616	.352	.264	.013	.72	.6	0.	......	+	21,000
6875	" 9	" 10	*	Much	M. F.02	......	603.2	246.4	356.8	31.2	14.	17.2	B.	12.4	13.8	5.9	7.9	.272	.512	.192	.32	1.2	.288	.912	.011	.8	4.7	0.	......	....	69,000
6963	" 22	" 23	*	"	VM.F.	......	682.	216.	466.	50.	14.4	35.6	B.	12.6	13.5	6.6	6.9	.272	.528	.224	.304	1.12	.512	.608	.01	.96	6.4	0.	......	+	84,000
7008	Mar. 3	Mar. 5	*	Cons'd	M. F.03	......	514.4	321.2	193.2	41.2	18.8	22.4	B.	17.4	9.5	5.7	3.8	.08	.272	.208	.064	.88	.416	.464	.012	.88	6.2	0.	......	+	32,000
7045	" 8	" 9	§	V.M'ch	M. F.3	......	2746.4	149.6	2596.8	52.4	12.8	39.6	B.	6.	20.4	7.	22.4	.352	1.76	.192	1.568	4.	.32	3.68	.012	1.	14.	0.	......	+	134,000
7102	" 16	" 17	§	"	VM.F.1	......	2105.2	141.6	1963.6	60.8	14.	46.8	B.	7.4	29.	7.4	21.6	.24	1.12	.24	.88	3.2	.48	2.72	.015	1.	23.5	2.	......	?	320,000
7142	" 22	" 23	*	Much	M. F.25	......	1338.8	162.8	1176.	34.	12.	22.	B.	7.	22.2	6.2	16.	.39	1.024	.208	.816	2.36	.6	1.76	.016	.96	18.5	2.	......	+	106,000
7188	" 29	" 30	*	"	M. F.02	......	764.8	178.	586.8	31.6	12.4	19.2	B.	9.	16.	6.3	9.7	.224	.576	.224	.352	1.336	.504	.832	.018	.84	13.	8.	......	+	59,000
7246	Apr. 5	Apr. 6	*	"	M. F.30	......	1079.6	278.8	800.8	31.6	9.6	22.	B.	11.5	15.9	6.2	9.7	.144	.464	.16	.304	1.4	.376	1.024	.022	.72	14.8	7.	......	+	55,000
7307	" 12	" 13	*	"	M. F.05	......	1337.2	240.8	1096.4	28.4	20.4	18.	B.	9.2	17.1	5.6	11.5	.16	.768	.16	.608	2.04	.44	1.6	.018	.72	15.6	8.	......	+	84,000
7376	" 20	" 21	*	"	M. F.02	......	1614.8	227.2	1387.6	28.4	20.	18.4	B.	7.6	17.	5.1	11.9	.064	.608	.144	.464	1.96	.312	1.648	.035	.56	16.	12.	......	+	28,000
....	....	....	..	....	....	......	......	......	......	....	.....	....	......	.....	.....	....	....	.....	.....	.....	.....	.....	.....	.....	....	.....	....	....	......	....	....

TURBIDITY—* Decided. § Very Decided. † Distinct. ‡ Very Slight. ‖ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB. Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., White.

TABLE 79 and 80.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ST. LOUIS, MISSOURI, TAP WATER. (Regulars and Extras.)

Report of ARTHUR W. PALMER
T. J. BURRILL,
University of Illinois

Serial No.	Date of		Appearance.			Odor.	Residue on Evaporation.						Color on Ignition.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, Cent.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.	Loss on Ig'n.					Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
										Tot'l	Dissolv'd	Suspnd'd							Tot'l	Dissolv'd	Suspnd'd										
6616	Jan. 4	Jan. 5	*	Little	M. F.03	......	350.4	321.2	29.2	29.6	26.4	3.2	G.	21.	6.4	6.4	0.0	.08	.192	.112	.08	.52	.328	.192	.007	.4	....	....	......	—	1,750
6674	" 11	" 12	*	Cons'd	M. F.03	......	357.6	328.	29.6	20.4	19.6	.8	B.	21.6	5.9	5.	.9	.072	.176	.128	.048	.48	.384	.096	.006	.28	....	....	......	—	3,350
6713	" 18	" 19	†	Little	M. F.04	......	347.2	332.4	14.8	30.4	27.2	3.2	B.	24.2	5.4	5.	.4	.012	.192	.112	.08	.448	.32	.118	.002	.32	....	....	......	—	4,200
6759	" 25	" 26	*	"	M. F.02	......	357.6	308.4	49.2	25.6	19.6	6.	B.	20.2	5.8	4.1	1.7	.016	.176	.144	.032	.48	.288	.192	.008	.36	....	....	......	+	2,575
6823	Feb. 3	Feb. 5	†	"	M. F.02	......	359.2	327.6	31.6	28.8	26.	2.8	B.	22.	5.3	4.9	.4	.02	.128	.112	.016	.32	.256	.064	.008	.56	....	....	......	—	12,450
6845	" 6	" 7	†	"	M. F.03	......	341.2	320.4	20.8	10.8	10.	.8	G.	23.2	4.4	4.1	.3	.064	.16	.128	.032	.416	.32	.096	.005	.64	....	....	......	....	....
6883	" 12	" 13	*	Cons'd	M. F.03	......	336.8	305.6	31.2	14.	13.2	.8	B.	18.	7.9	3.9	4.	.08	.176	.128	.048	.352	.256	.096	.012	.76	....	....	......	....	....
6909	" 14	" 15	*	"	M. F.05	......	326.	276.8	49.2	26.4	20.	6.4	B.	16.2	6.4	4.6	1.8	.08	.224	.112	.112	.56	.384	.176	.013	.76	....	....	......	....	....
6923	" 16	" 17	*	"	M. F.4	......	372.	271.2	100.8	24.8	16.8	8.	B.	15.6	6.2	4.9	1.3	.02	.176	.16	.016	.544	.288	.256	.008	.84	....	....	......	—	10,600
6960	" 22	" 23	†	Little	M. F.25	......	295.2	250.	45.2	47.2	16.	31.2	B.	15.4	6.3	6.2	.1	.032	.256	.208	.048	.576	.416	.16	.014	.84	....	....	......	—	6,000
7009	Mar. 3	Mar. 5	†	"	M. F.3	......	312.	244.	68.	24.	10.8	13.2	B.	13.	9.3	7.1	2.2	.064	.244	.224	.02	.72	.48	.24	.018	1.	....	....	......	—	8,100
7049	" 8	" 9	*	"	M. F.3	......	305.6	280.4	25.2	13.6	13.6	0.0	G.	14.6	8.4	6.8	1.6	.024	.24	.192	.048	.544	.448	.096	.013	.88	....	....	......	—	3,600
7099	" 16	" 17	*	"	M. F.5	......	316.4	226.8	89.6	23.2	11.2	12.	B.	9.8	11.	7.4	3.6	.064	.256	.144	.112	.8	.256	.544	.007	1.	....	....	......	—	9,750
7141	" 22	" 2[illegible]	[illegible]	Cons'd	M. F.25	......	399.6	166.8	232.8	32.	13.2	18.8	B.	8.	13.4	6.	7.4	.03	.4	.176	.224	.92	.472	.448	.011	1.08	....	....	......	—	18,100
7192	" 29	" [illegible]	[illegible]	Much	M. F.5	......	272.	165.2	106.8	22.8	14.	8.8	B.	6.6	8.9	7.1	1.8	.008	.272	.192	.08	.096	.536	.16	.012	1.08	....	....	......	—	9,100
7247	Apr. 5	Apr. [illegible]	[illegible]	Cons'd	M. F.30	......	234.8	150.	84.8	18.8	5.6	13.2	B.	6.3	8.7	6.6	2.1	.03	.224	.176	.048	.6	.408	.192	.006	1.	....	....	......	—	5,300
7308	" 12	" 13	*	"	M. F.40	......	273.6	186.4	87.2	25.2	18.	7.2	B.	6.6	8.3	6.5	1.8	.008	.24	.202	.032	.76	.408	.352	.004	1.	....	....	......	+	6,400
7378	" 19	" 21	*	"	M. F.05	......	341.6	185.2	156.4	23.6	18.4	5.2	B.	6.8	9.	6.2	2.8	.016	.272	.208	.064	.824	.6	.224	.011	.88	....	....	......	—	4,000
7463	May 3	May 4	*	"	M. F.50	......	346.	231.2	114.8	24.4	19.6	4.8	B.	7.8	9.1	7.1	2.	.008	.24	.128	.112	.612	.324	.288	.005	.84	....	....	......	+	5,650
7507	" 10	" 11	†	"	M. F.50	......	451.2	212.	239.2	42.4	24.8	17.6	B.	7.7	11.7	6.5	5.2	.028	.272	.112	.16	1.22	.296	.924	.005	.8	....	....	......	—	4,000
7564	" 17	" 18	§	Much	M. F.	......	394.8	318.4	76.4	37.2	33.6	3.6	B.	7.9	12.7	8.3	4.4	.046	.32	.112	.208	.964	.452	.512	.009	.72	....	....	......	+	5,000
7610	" 24	" 25	§	Cons'd	M. F.	......	326.8	300.4	26.4	32.	18.	14.	B.	9.4	8.6	8.2	.4	.016	.16	.144	.016	.516	.292	.224	.003	.32	....	....	......	+	2,500
7638	" 31	June 1	§	"	M. F.30	......	330.	261.6	68.4	40.4	39.6	.8	B.	9.2	8.	5.4	2.6	.02	.192	.176	.016	.548	.28	.268	.007	.68	....	....	......	+	14,350
7681	June 7	" 8	†	"	M. F.04	......	407.6	264.4	143.2	26.	20.8	5.2	B.	9.6	8.2	5.5	2.7	.016	.208	.112	.096	.68	.308	.372	.006	.56	....	....	......	+	3,400
7724	" 14	" 15	*	"	M. F.03	......	352.4	257.6	94.8	20.4	20.4	....	B.	10.2	6.8	5.9	.9	.004	.128	.112	.016	.52	.388	.132	.004	.6	....	....	......	+	3,250
7766	" 22	" 23	*	"	M. F.	......	332.	286.8	45.2	53.6	47.2	6.4	B.	8.5	6.9	5.1	1.8	.022	.144	.08	.064	.292	.212	.08	.002	.4	....	....	......	....	1,600
7801	" 28	" 29	*	"	M. F.20	......	326.	255.6	70.4	26.	22.4	3.6	B.	8.2	6.7	5.6	1.1	.060	.16	.144	.016	.584	.244	.34	.002	.6	....	....	......	+	2,250
7844	July 5	July 6	*	V. Sl'ht	T.	......	318.8	215.6	103.2	40.	27.6	12.4	B.	7.4	6.3	6.1	.2	.014	.128	.112	.016	.26	.212	.048	.001	.44	....	....	......	—	1,150
7915	" 12	" 13	*	Little	T. F.03	......	286.	198.8	87.2	28.	25.2	2.8	B.	6.9	6.1	6.1	0.0	.032	.144	.096	.048	.324	.18	.144	.001	.52	....	....	......	+	2,200
7984	" 19	" 20	*	"	T. F.02	......	241.2	180.	61.2	22.	22.	0.0	B.	7.3	4.6	4.1	.5	.014	.16	.112	.048	.324	.212	.112	.001	.44	....	....	......	....	....
8033	" 26	" 27	†	"	T. F.01	......	259.2	195.6	63.6	38.8	25.2	13.6	G.	7.9	5.	4.8	.2	.032	.176	.128	.048	.356	.26	.096	.001	.36	....	....	......	—	1,600
8085	Aug. 2	Aug. 3	*	"	T. F.02	......	290.8	176.	114.8	41.6	34.4	7.2	B.	7.3	5.8	4.6	1.2	.048	.16	.144	.016	.484	.228	.256	.001	.52	....	....	......	+	950
8194	" 16	" 17	*	"	T. F.02	......	275.6	198.	77.6	35.6	24.4	11.2	B.	9.4	5.5	4.8	.7	.034	.128	.112	.016	.388	.172	.216	.001	.68	....	....	......	—	3,000
8271	" 23	" 24	*	"	T. F.1	......	265.2	221.6	43.6	25.2	13.6	11.6	B.	10.8	4.6	4.	.6	.064	.16	.08	.08	.284	.204	.08	.002	.44	....	....	......	—	2,85
8337	" 31	" 31	*	"	M. F.05	......	312.4	208.4	104.	24.8	23.2	1.6	DB.	12.3	7.	4.2	2.8	.050	.24	.....	.....	.44	.3	.14	.....	.68	....	....	......	—	1,00
8409	Sept. 6	Sept. 8	*	Much	M. F.2	......	324.	206.4	117.6	24.8	13.6	11.2	B.	14.2	7.4	5.2	2.2	.100	.192	.176	.016	.46	.....	.....	.001	.36	....	....	......	....	....
8460	" 13	" 14	*	Cons'd	M. F.02	......	309.2	206.4	102.8	20.4	15.6	4.8	B.	14.2	6.6	6.1	.5	.056	.16	.128	.032	.376	.352	.024	.002	.48	....	....	......	+	1,45
8515	" 20	" 22	*	Little	M. F.15	......	268.	232.4	35.6	22.8	19.6	3.2	B.	10.6	6.5	6.3	.2	.108	.224	.192	.032	.344	.....	.....	.002	.52	....	....	......	....	....
8568	" 27	" 29	*	Cons'd	M.	......	308.	252.	56.	26.4	17.6	8.8	B.	12.8	7.5	7.	.5	.054	.192	.....	.....	.636	.....	.252	.003	.6	....	....	......	+	18,8
8694	Oct. 4	Oct. 6	*	"	M. F.4	......	412.4	220.4	192.	30.	15.6	14.4	B.	11.	11.5	7.7	3.8	.076	.304	.192	.112	.864	.236	.628	.003	.63	....	....	......	?	7,4

TURBIDITY—*Decided. § Very Decided. † Distinct. ‡ Very Slight. ǁ Slight. COLOR—M., Muddy. VM., Very Muddy. T., Turbid. C., Cloudy.

COLOR ON IGNITION—G., Gray. B., Brown. DB., Dark Brown. LB., Light Brown. RB., Reddish Brown. BG., Brownish Gray. Bh., Brownish. R., Red. Rh., Reddish. W., Whi

MR. JEFFRIES: Let me ask the witness a question.

8297 JUDGE SPRINGER: Certainly.

Q. MR. JEFFRIES: Professor, did you prepare these tables yourself?

A. I did.

Q. They are not the original tables, are they?

A. Yes.

Q. The original sheets upon which the records was made?

A. Not this piece of paper, no.

Q. That is a printed sheet is it not?

A. It is.

Q. And your original was in pen and ink?

A. Yes sir.

MR. JEFFRIES: That's all.

Q. JUDGE SPRINGER: Did you read the proof sheets after they were set up by the printer?

A. I did.

Q. Did you compare them with the papers that you had prepared in the first instance?

A. I did.

Q. Did you make the necessary corrections, if any were required for the purpose of making this table correspond with the sheets that you prepared in the first instance?

8298 A. I did.

Q. Then do you state that these tables as well as the other sheets to which you referred, were prepared by you and and under your direction?

A. I do.

Q. Who received these samples of water at the laboratory at the University of Illinois?

A. I did, I and my helpers.

Q. When the sample was received, what entries were made upon the certificate accompanying the sample in addition to those already on the sample and placed there by the water takers?

A. The date and hour of reception at the laboratory, and a serial number, was placed upon the certificate which accompanied the sample and the number, the same serial number was placed upon the bottle containing the sample.

Q. State where those serial numbers appear in table No. 1, for instance?

A. In table No. 1, and in all the rest of the eighty tables now referred to, the serial number appears at the left hand of the table.

Q. What is contained in the next column to that?

A. In the second column the date of collection which was
8299 put upon the certificate by the collector, has been put upon the table to indicate throughout, the respective dates of collection of the various samples.

Q. And what is contained in the next column after that?

A. The third column contains the date upon which the sample was delivered at the laboratory.

Q. And these various entries appear upon all the tables from 1 to 80?

A. They do.

Q. I see in the columns following, under the head of "Appearance," the words "turbidity," "sediment," "color" and "odor." State how those determinations were reached?

A. Turbidty was determined by inspection of the sample. Note was made of the relative degree of turbidity of this way, and the results recorded under the various terms "decided," "very decided," "distinct," "very slight" and "slight," as appears in the tables.

Q. And the initial letter of these words was used to indicate those conditions, was it?

A. No, an arbitrary printers' sign, the star or asterisk, and so on, were used for indicating the turbidity.

Q. And what does the star indicate?

A. The star indicated a decided turbidity.

8300 Q. And what does the section mark indicate?

A. The section mark indicated a very decided turbidity. That is, greater turbidity than that which was designated as "decided." The dagger indicated a distinct turbidity, which means less than "decided" turbidity.

Q. The double dagger?

A. The double dagger indicated a very slight turbidity. That is, if turbidity was noticeable, but very small, it was indicated as very slight, and the indication recorded in the printed tables by this sign.

The vertical parallel indicated a slight turbidity. No attempt was made to determine the turbidity with great accuracy for the reason that all of these waters are naturally ordinarily quite turbid, and for the purposes of the chemical investigation, any more close determination of the turbidity seemed to be superfluous.

Q. In what manner did you determine the presence of sediment?

A. When the sample was received note was taken of the quantity of matters lying upon the bottom of the bottle, such substances as sand and clay, and so on, which had settled during the course of time of transport to the laboratory, and an idea as to the amount of sediment was made or developed at this time. Again, that portion of the sample which was not immediately taken, after thoroughly shaking, for the determinations of the
8301 nitrites and nitrates and such constituents as are particularly susceptible to change, was left standing over night, and again the relative quantity of sediment deposited during the standing over night was noted. The results of such observations were recorded roughly by the terms "considerable," "much," "very much," "little," "none." A better idea of the amount and nature of the suspended matter is to be had from the figures recorded in the respective columns of the table under the headings, "total solids," "suspended matters," "loss on ignition," "suspended matters," "oxygen consumed by suspended matters," "albuminoid ammonia in suspended matters," "total organic nitrogen in suspended matters."

Q. What did you determine in reference to the color of the water?

A. The color of the water was determined by the method described previously and was recorded in the tables in terms of the quantity of nitrogen as free ammonia, which developed the same color when it was treated with the Nessler reagent by the method indicated under the determination of free ammonia. Thus the color recorded as "1," represents the color as developed by the Nesslerization of a solution containing one cubic centimeter of the standard ammonic chloride solution, diluted
8302 to fifty cubic centimeters with ammonia free water, or in other words, fifty cubic centimeters of the solution which contains ammonic chlorate equivalent, to .01 of a milligram of

nitrogen. The color recorded in the tables above, the figure "1" indicates .1 of the amount just referred to; that is, indicates a color corresponding to that developed by a solution containing .1 of a cubic centimeter of the standard ammonic chlorate solution, diluted to fifty cubic centimeters with ammonia free water and Nesslerized by the method above indicated.

Q. State what determinations were made in these tables under the heading "residue on evaporation?"

A. The residue on evaporation was determined by the methods before described. They include the total residue on evaporation, the total loss on ignition, the residue left on evaporation of the filtered solution, which give a direct determination of the total matters in solution and the loss upon ignition of the same. The determination of the suspended solids being indirect, that is, the figures recorded in the tables being the difference between the figures representing those matters in solution and the figures representing the total solid matters, which latter include of course both the dissolved substances and those which are suspended merely in the water.

8303 Q. I see you have a column here headed "color on ignition." That is indicated by the various letters used in these tables, is it not?

A. The color on ignition, yes.

Q. And the word "the" is explained in the note below, and also the other letters?

A. Yes, sir.

Q. State whether the explanation by certain letters and signs, are correctly explained with corresponding letters and signs in the note at the bottom of each of the tables?

A. They are. Now, with reference to the color there, I should put in the designation. In the column where the record of the color is made, there appears two letters, "M" and "F." The M here refers to the fact that the water was muddy, and that consequently it was necessary to filter it in order that the color be determined. The letter F refers to the fact that the sample so designated was filtered before the color examination was made.

Q. What does the figure .5, for instance, at the top of the first column refer to?

A. This indicates that the color of the filtered sample of

water referred to, was equal to the color developed in 50 cubic centimeters of a mixture of water and ammonic chloride
8304 solution, of which the ammonic chloride solution constituted or consisted of half a cubic centimeter of the standard ammonic chlorate solution used in Nesslerization. The whole entry for this particular sample with respect to the color reads: "The sample was muddy, consequently it was filtered, and the filtered sample had a color corresponding to the half of a cubic centimeter of ammonic chloride as determined by the method just described.

Q. Take the next to the last line in that table which says "M. F. .30." What is the meaning of the figure .30?

A. Here the M means muddy, the F, filtered, and the .30, is in reality .3. Through some oversight, the printer got in an additional figure, the insignificant cipher,—insignificant because here it means nothing.

Q. State whether in all the tables from 1 to 80, inclusive, these letters and figures mean the same?

A. They mean the same throughout the entire set of these tables?

Q. Now, returning to the other columns under the head of "chlorine" you have entered what figures?

A. 102. This shows that the result of our determination, my determination of chlorine in the sample No. 4974 showed the sample to contain 102 parts of chlorine per million parts of sample.

8305 Q. Do the entries succeeding that to the end of these tables indicate the same thing?

A. They throughout indicate similar things. That is, the same sort of things with respect to each sample.

Q. That means the chlorine in different quantities?

A. Yes, sir.

Q. Now, in reference to oxygen consumed, you have three columns, what do they indicate? On the first line we will say of the first table; table 1?

A. In the first column, total oxygen consumed. That is the oxygen consumed in the determination upon the original sample without filtration. It showed in this particular sample, No. 4974, that the quantity of oxygen required or consumed, was 39 parts per million parts of water. Similar figures throughout this and corresponding columns in the other tables show similar facts with respect to the oxygen consumed, by the various different samples of water.

In the next column, under "Oxygen Consumed," that by dissolved substances, the determination was made, in a portion of the sample which had been filtered, thus removing the suspended matters. The determination was made by the same method; the results were entered in the second column, and the figure in the second column shows the amount of oxygen required by a million parts of water. That is, the 21. 8306 shows that 21 parts per milion of ogygen were required for the oxidation of organic matters in solution under the conditions prevailing in the entire series of determinations of oxygen consumed.

The third column contains the figures which represent the oxygen required or consumed by suspended matter, and shows these quantities as determined by the difference between the oxygen consumed by dissolved matters directly determined as indicated above, and the oxygen consumed by all matters contained. That is, by those in solution and those in suspension and recorded in the column under "total." The figure 18 under this column, under oxygen consumed by suspended matters, shows that the suspended matters in a million parts of water require 18 parts of oxygen for their consumption. It is the difference between the figures in the two next preceding columns.

Q. Under the columns headed nitrogen as ammonia you have determinations of free ammonia and albuminoid ammonia. Will you please state what is indicated by the figures in the column headed "free ammonia?"

A. In the column marked "free ammonia" under the general head "Nitrogen as Ammonia," the figures 13.6 shows the results of our determination of free ammonia in sample 4974 by the methods previously described. The figures 13.6 repre- 8307 sents the fact that 13.6 parts by weight of nitrogen as free ammonia, were contained in a million parts of sample No. 4974.

In the next column under the general title "Nitrogen as Ammonia," secondly titled "Albuminoid Ammonia," tertiary title "Total," figure 2.4 represents the quantity of albuminoid ammonia contained in or formed from the matters in solution and in suspension in the sample No. 4974. In the next column under the term "Dissolved" 1.44 the figure represents the quantity of nitrogen as albuminoid ammonia contained in solution. It was determined similarly to the total albuminoid ammonia, but upon a portion of the sample of water which had been filtered before the determination was made, the 1.44 indicates the fact that the sample in question contained in one million parts, 1.44 parts of nitrogen as albuminoid ammonia in solution, or, rather, nitrogenous organic matters corresponding to nitrogen as albuminoid ammonia in solution.

The third column under secondary title "Albuminoid Ammonia," represents the nitrogen as albuminoid ammonia derived from the matter suspended in the sample of water No. 4974, and it is determined indirectly, that is, by the difference between the two direct determinations, namely that of the total nitrogen as albuminoid ammonia and that of the nitrogen as albuminoid ammonia in solution, recorded in the column marked "Dissolved" in the table.

8308 Q. Under the general heading of "Organic Nitrogen" you have prepared three columns of figures, will you please explain what they indicate in reference to the sample about which you have been speaking, the first sample in table 1?

A. The heading "Organic Nitrogen," as it appears in table 1 and the other 79 tables of this set, refers to the total organic nitrogen as determined by the Kjel Dahl method hereinbefore described, and the three columns which appear under this general heading, contain the figures which show the quantities of the total organic nitrogen in the unfiltered sample, which includes the organic nitrogen of substances in solution and also the organic nitrogen of substances in suspension. In the column designated "Dissolved" the figure appearing represents the results of the same determination made upon a portion of the sample of water which had previously been filtered. In the third column under the heading "Suspended" the figures which appear represent the quantity of total organic nitrogen contained in the matters or substances which are held in the water merely in suspension, and not in solution or dissolved. This determination is made indirectly; that is, the figures appearing in this column represent the differences between the figures appearing in the first and second columns, under the general title

8309 "Organic Nitrogen" which two figures have been determined directly and only the last, that is, the suspended matters, determined indirectly or by difference.

Q. Under the general heading "Nitrogen as Nitrites or Nitrates," please explain what these figures indicate in reference to the first sample recorded in table 1?

A. In the column marked "Nitrites" under the general term "Nitrogen as Nitrites" the figure appearing represents the quantity of nitrogen as nitrites appearing in the sample contained in number 4974 and represented in parts per million. That is, the figure .005 represents the fact that in 1,000,000 parts of this sample there were contained .005 of one part of nitrogen as nitrites.

Q. In the next column what have you indicated?

A. In the next column which represents the nitrogen as nitrates, the figure .15 represents the fact that in the sample 4974 there were found .15 of one part of nitrogen as nitrates in one million parts of the original sample.

Q. You have now indicated the significance of the entries made in table No. 1, in reference to sample 4974. Please state whether a similar explanation is applicable to all samples recorded in the tables numbered from 1 to 80, inclusive?

A. This same explanation applies to all of the entries in 8310 this table and the other 79 tables of this set, with the simple exception of the differences in the figures and the letters pertaining to the results obtained for the individual samples as set forth in the tables.

Q. I see upon this table No. 1, certain entries in columns indicating the height of water, temperature of water, temperature of air, presence or absence of the bacillus coli communis, and the number of bacteria per cubic centimeter; will you please state who made those entries upon this table?

A. These entries pertaining to the bacterial examinations were made by Prof. T. J. Burrill, bacteriologist of the University of Illinois, who had charge of the bacterial examinations made at the University of Illinois.

JUDGE SPRINGER: I will state to counsel that we will call him subsequently for the purpose of testifying to these two columns.

A. The entries under "Temperature of Water," "Temperature of Air," "Height of Water," were made partly by me and partly by Professor Burrill, and were transcribed from the original certificates sent in by the various collectors and may all be found by reference to the original certificates which are on file in the possession of the court.

8311 MR. JEFFRIES: Complainant moves to strike out all the testimony of this witness in explanation of the tables just read in evidence for the reasons stated in the objection to the introduction or the reading of the tables into the record, and to strike out all that part of the tables and the explanation of this witness which refers to sediment in the samples of water so examined by this witness, for the reason that it has not been proven by the defense that the question of sediment is not to be considered of moment in passing upon the sanitary condition of the water, unless at the same time the source of sediment be considered. That certain water might contain large quantities of sediment, and yet contain no disease producing organisms, chemically speaking, or speaking from a sanitary standpoint. Upon the other hand it might contain no sediment, and at the same time be teeming with living disease producing organisms. I move to strike out all reference to the color of the samples taken for the same reason and all reference to the column referring to the odor of the water for the reason that water without odor has been known to be teeming with living disease-producing organisms.

I move to strike out the column with reference to residue on evaporation for the reason that the determinations therein made throw no adequate light upon the determination of the sanitary condition of the water. I make the same motion

8312 as to the oxygen consumed, nitrogen as ammonia, organic nitrogen and nitrogen as nitrites and nitrates, for the reason that there is evidence showing that none of these qualities contained in water, are of a disease producing character, and for the further reason that their determination does not correctly portray the sanitary condition of the water with reference to its containing disease producing organisms or living organisms of a disease producing character.

I move to strike out all reference to the tables by this witness for the reason that an insufficient number of samples have been examined for the determination of the sanitary condition of the water at all times and at all seasons of the year, from chemical analysis pure and simple, and that samples so taken and examined have not covered a sufficient length of time to determine exactly the chemical condition as well as the sanitary condition of the water at all times of the year, and for the further reason that in the analyses and by failure to cover the entire year, the question of flood times and low water seasons was not considered, and is not sufficiently considered, and is not shown by the tables, and for the further reason that the evidence on the part of the defense shows that certain chemical changes will be produced and brought about in the time of the transfer from the places 8313 of collecting the samples to the laboratory and before the sample is analyzed chemically, so that the chemical constituents of the water analyzed, at the time the analyses were made do not correctly portray the exact chemical condition of the water at the time the sample was taken, aside from the sanitary condition of the water, at the time and place.

JUDGE SPRINGER: I move to strike out this objection for the reason that it goes merely to the weight of the evidence and not to its admissibility, and for the further reasons stated by me in my motion to strike out the objection of counsel to the reading of these tables in evidence.

MR. TODD: I desire to add by way of answer to the objection, not conceding the conclusions stated in counsel's objection, that the complainant in its original case has introduced several thousand pages of testimony of a chemical and bacteriological character and has also introduced the testimony of Whipple in regard to questions of coloration for the purpose of establishing the unsanitary condition of the water for domestic and drinking purposes, and in view of this enormous amount of tstimony offered by complainant on the same line which they now object to defendants introducing evidence, and without conceding the conclusions mentioned in the objection, this testimony is admissible if for no other purpose than for the 8314 purpose of rebuttal, which is not the sole and only purpose for which it is offered, but is offered as affirmative evidence for the establishment of the contentions set up in the answer of the defendants.

Q. JUDGE SPRINGER: Professor, the tables which you have read in evidence, beginning with table No. 1 and ending with table No. 38, contain, as you have stated, your analyses of water, the samples of which were taken during the year 1899. Will you please state whether you made any general averages of the results of the samples taken for that year?

A. I have made averages of all results of my analyses of the samples collected from each of the points under consideration during the year 1899.

Q. I will ask you to look at the table which has been designated as table "A"—Streams Examinations, Sanitary District of Chicago, Sanitary water analysis, parts per million, averages of results, for the year 1899, and the report of Arthur W. Palmer, of the University of Illinois, and ask you to state whether that table contains the averages made by you of your chemical analyses of the waters under investigation and indicated in the tables which I have mentioned, beginning with 1 and ending with 38?

A. I identify this table as tableA,—which is designated
8315 as table A, as being the one which I prepared, and as
representing the general averages for the year 1899 of the figures appearing in tables 1 to 38, inclusive.

Q. I call your attention to the first line in this table A, and you will please designate or indicate the averages indicated by that line?

A. The first line in table A gives in the first column, the number of the station, that is, the point at which the samples were collected, and indicates also table 1, in the set of 80 which has been hereinbefore described. The point is Bridgeport, Illinois and Michigan canal. This designation appearing in the second column under the caption "Source of Water." In the third column "period covering" for 1899, there appear dates April 27th, December 26. These dates represent the dates of the first and last collections made during 1899 from that particular source.

In the next column, "Average of," there is given the number of samples upon which the average was made. That is, the figures in this column represent the numbers of different samples taken during the period indicated in the year 1899, the results of which are entered in tables 1 to 38, inclusive, referred to above, and upon which the averages were made.

Under residue on evaporation, total, the figures
8316 584.1 represent the general average of the residue on

evaporation determined in the 22 different samples collected at this point.

In the next column figure 499.7 under the term "Dissolved" represents the average content of solid matters in solution in the samples of water collected during 1899, covering the period April 27th to December 26th, from the Illinois and Michigan Canal at Bridgeport.

The figures 85.4 appearing in the third column under "Residue on Evaporation," refers to the suspended matters and shows the average quantity of matters contained in suspension in the 22 samples of water referred to. Under the "loss on ignition" the figures 65.1 in the column designated "Total" and the figures 39.5 in the column designated "Dissolved," and the figures 25.9 in the column designated "Suspended" represent the averages of these different determinations made in the 22 samples of water derived from this source, the details of which appear in table 1 above referred to.

Q. What's that?

A. The details of the analyses of the 22 samples and the other figures in these columns, refer in a similar manner to the averages of the various samples, the analyses of which appear in detail in the tables 1 to 38 inclusive.

8317 Now, in the next column, under the heading "Chlorine" there appear figures representing the averages determined in the same manner for the chlorine, as the entry in this column 124.2 represents the fact that the average content of chlorine in the 22 samples of water collected from the Illinois and Michigan Canal at Bridgeport during the period from the 27th of April to the 26th of December, 1899, inclusive, was 124.2 parts of chlorine in a milion parts of water, and the other figures appearing in this column in table A represent the various averages of the chlorine determinations which appear in detail in the tables 1 to 38, inclusive.

The figures appearing in the column under "Total Oxygen Consumed" show similar averages for this determination. The number 35.1 the first entry in this column represents the average quantity of oxygen consumed by the 22 samples of water collected at the point above repeatedly mentioned during the period April 27th to December 26th, 1899, and the other figures in this column represent similar averages of the total oxygen consumed by the various samples, details of the determinations of oxygen consumed, appearing in the tables 1 to 38, inclusive.

The figures in the column under "Oxygen Consumed by Dissolved Substances and by Suspended Matters" represent similar averages to those heretofore explained.

8318 Under "Nitrogen as Ammonia" the entries in the column under free ammonia refer to similar averages of the free ammonia contained in the various entries as shown in detail in the tables 1 to 38, inclusive.

Under "Nitrogen as Ammonia," secondary title "Albuminoid Ammonia" in the column marked "Total" and in the column marked "Dissolved" and in the column marked "Suspended" the various figures represent similar averages for those various different determinations as given upon the detailed records of tables 1 to 38, inclusive.

Under "Organic Nitrogen" the figures appearing in column marked "Total" and those in column marked "Dissolved" and those in column marked "Suspended," represent similar averages for those different constituents as set forth in detail in the tables 1 to 38, inclusive, but here brought together in the form of general averages, as in the other cases disclosed with respect to this table "A."

Under the columns marked "Nitrogen as Nitrites and Nitrates" the various figures entered represent similar averages for these different constituents which averages were determined from the detailed notations in tables 1 to 38, as indicated above.

8319 Q. State whether the lines of this table A, following the ones to which you have just been testifying and including in that No. 38, Mississippi river at Jefferson Barracks, west shore, contain similar averages for the points mentioned under the head of sources of water, and for the times indicated in the column headed "Period covering 1899?"

A. They do.

Q. Will you please read this table A in evidence?

A. The table—

MR. JEFFRIES: I object to the witness reading the table of averages in evidence for the same reasons stated in my objection to the reading of the table in evidence.

A. The table is as follows:

TABLE A.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

AVERAGES OF RESULTS FOR YEAR 1899.

Report of ARTHUR W. PALMER,
University of Illinois.

No. of Station.	Source of Water.	Period Covering 1899	Average of	Residue on Evaporation.						Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
							Loss on Ignition.								Albuminoid Am.							
				Total.	Dis-solved.	Sus-pended	Tot'l	Dis-solv'd	Sus-pen'd		Total.	By Dis-solved.	By Suspd Matter.	Free Ammonia.	Tot'l	Dis-solv'd	Sus-pnd'd	Total.	Dis-solved.	Sus-pended	Nitrites.	Nitrates
1	Illinois and Michigan Canal—Bridgeport	Apr. 27-Dec. 26	22.	584.1	499.7	85.4	65.1	39.5	25.9	124.2	35.1	17.9	17.2	17.16	2.513	1.158	1.355	4.985	2.282	2.703	.025	.295
2	Illinois and Michigan Canal—Lockport..	" 24- " 26	31.	572.6	495.4	77.2	69.8	44.7	25.1	120.1	37.7	18.7	19.	15.58	2.681	1.147	1.534	5.072	2.373	2.699	.015	.23
3	Desplaines River—Lockport	" 24- " 26	33.	370.8	355.3	15.5	46.1	39.8	6.3	8.47	11.9	10.3	1.6	.077	.467	.374	.093	.986	.776	.21	.007	.29
4	Desplaines River—Joliet	May 23- " 26	30.	568.8	484.4	84.4	60.9	39.	21.2	105.7	28.5	16.2	12.3	14.92	2.195	.831	1.364	4.502	1.732	2.77	.01	.208
5	Desplaines River—Joliet	" 23-Sept. 11	17.	601.6	460.1	141.5	65.9	42.6	23.3	99.8	31.4	16.2	15.2	12.794	1.962	.621	1.341	4.35	2.999	1.351	.009	.26
6	Kankakee River—Wilmington	June 5-Dec. 26	29.	302.7	262.5	39.4	37.8	29.7	5.6	3.9	11.1	9.2	1.9	.047	.372	.266	.106	.886	.643	.245	.011	1.084
7	Illinois River—Morris	May 29- " 26	25.	410.5	381.1	17.6	43.1	36.6	6.	65.7	14.9	12.2	2.7	8.897	.911	.539	.372	1.916	1.116	.8	.026	.537
8	Fox River—Ottawa	" 29- " 28	30.	344.8	295.8	49.	52.8	46.7	7.4	5.84	9.9	8.3	1.7	.056	.416	.27	.146	.94	.556	.384	.008	.373
9	Illinois River—Ottawa	June 19- " 28	27.	395.2	379.9	15.3	41.2	35.7	5.6	59.4	11.3	10.6	1.	4.995	.498	.399	.099	1.111	.824	.287	.497	1.62
10	Big Vermilion River—La Salle	May 24- " 26	32.	1023.1	992.8	30.3	91.5	83.4	8.1	64.9	6.4	4.9	1.5	.254	.244	.159	.085	.639	.406	.243	.022	.845
11	Illinois River—La Salle	" 5- " 26	33.	408.5	369.3	39.2	47.6	39.9	7.7	47.3	12.6	10.1	2.5	2.648	.503	.363	.14	1.216	.808	.408	.413	2.047
12	Illinois and Michigan Canal—La Salle	" 24- " 26	32.	367.6	331.8	35.8	51.2	44.9	6.3	16.95	10.9	8.5	2.4	.751	.499	.323	.176	1 244	.827	.417	.043	.62
13	Illinois River—Henry	" 30- " 19	30.	403.2	363.1	40.1	44.5	38.5	6.	47.2	12.2	9.8	2.4	2.156	.594	.369	.225	1.382	.799	.583	.313	1.745
14	Illinois River—Averyville	" 1- " 26	33.	390.3	359.3	31.	43.8	37.8	6.	41.1	11.1	9.4	1.7	1.016	.49	.327	.163	1.143	.755	.388	.293	1.79
15	Illinois River—Wesley City	" 29- " 28	25.	496.2	359.4	136.8	47.8	42.3	5.5	42.6	12.3	9.9	2.4	1.156	.691	.388	.303	1.603	.901	.702	.287	1.67
16	Illinois River—Pekin	" 24- " 28	32.	391.7	359.2	32.5	46.1	40.2	5.9	41.3	12.5	10.	2.5	1.236	.681	.388	.293	1.532	.87	.662	.294	1.5
17	Illinois River—Havana	" 2- " 20	33.	386.5	343.9	42.6	42.4	36.6	5.8	35.8	12.1	9.6	2.5	1.203	.558	.36	.198	1.331	.816	.515	.227	1.12
18	Sangamon River—Chandlerville	" 31- " 20	23.	351.1	280.9	70.2	40.5	30.	10.5	5.6	7.3	5.	2.3	.115	.262	.154	.108	.72	.38	.34	.043	.62
19	Illinois River—Beardstown	" 24- " 28	29.	383.4	318.	65.4	35.6	32.5	5.7	30.4	10.8	8.3	2.5	.89	.443	.284	.159	1.09	.655	.435	.147	1.08
20	Illinois River—Kampsville	" 2- " 20	33.	382.6	281.6	101.	37.4	29.3	8.1	20.1	10.5	7.99	2.51	.27	.409	.241	.168	1.065	.645	.42	.054	.97
21	Illinois River—Grafton	" 3- " 27	34.	349.5	274.7	74.8	38.7	29.7	9.	18.5	9.9	7.8	2.1	.221	.412	.217	.165	1.037	.609	.428	.051	1.07
22	Mississippi River—Grafton	" 3- " 20	33.	342.4	153.1	189.3	36.1	26.7	9.4	2.6	15.8	10.8	5.	.039	.469	.218	.251	1.142	.489	.653	.01	.295
23	Miss. River—Alton, Illinois Shore	" 3- " 20	34.	351.	197.6	153.4	34.3	25.1	9.2	8.2	13.4	9.9	3.5	.062	.454	.241	.213	1.117	.552	.565	.019	.57
24	Miss. River—Alton, ¼ dis. from Ill Shore	" 3- " 20	34.	313.8	178.3	165.5	34.4	26.1	8.3	5.8	14.5	10.6	3.9	.053	.469	.23	.239	1.147	.525	.622	.014	.422
25	Miss. River—Alton, Midstream	" 3- " 20	34.	381.	164.5	216.5	39.3	27.5	11.8	3.7	15.2	10.6	4.6	.041	.498	.218	.28	1.207	.484	.723	.009	.355
26	Miss. River—Alton, ¼ dis. from Mo. Shore	" 3- " 20	31.	402.9	157.3	245.6	40.8	27.1	13.7	2.7	15.2	10.8	4.4	.031	.512	.219	.293	1.269	.487	.782	.007	.344
27	Miss. River—Alton, Mo. Shore	" 3- " 20	33.	399.8	158.5	241.3	41.5	28.9	12.6	2.6	15.4	10.9	4.5	.032	.505	.232	.273	1.223	.498	.725	.009	.329
28	Missouri River—West Alton	July 8- " 28	23.	1284.6	285.2	999.4	50.3	17.6	32.7	14.9	13.9	4.4	9.5	.03	.475	.102	.373	1.378	.272	1.106	.006	.337
29	Miss. River—Mitchell, Illinois Shore	Apr. 28- " 21	32.	1092.1	190.8	901.3	48.2	21.9	25.4	6.	18.6	8.8	9.8	.039	.677	.201	.476	1.764	.45	1.314	.011	.442
30	Miss. River—Mitchell, Midstream	" 28- " 21	32.	1500.4	228.3	1272.1	57.3	22.2	35.1	8.	19.2	7.5	11.7	.027	7	.162	.538	1.936	.383	1.553	.008	.387
31	Miss. River—Mitchell, Intake Tower	" 28- " 21	32.	1109.6	232.8	876.7	60.2	20.6	39.6	9.1	19.5	6.8	12.7	.028	.726	.142	.584	2.174	.359	1.815	.007	.399
32	Miss. River—Mitchell, Missouri Shore	" 28- " 21	32.	1909.3	247.1	1662.2	61.8	19.9	41.9	9.8	19.9	6.3	13.6	.027	.817	.133	.684	2.358	.327	2.031	.007	.431
33	St. Louis Tap Water	June 6- " 21	28.	336.	239.4	98.5	25.2	20.	5.2	9.7	7.2	5.6	1.4	.022	.19	.125	.065	.57	.323	.247	.005	.342
34	Miss. River—Jeff. Bar., East Shore	May 1- " 21	31.	1104.9	196.2	908.7	49.8	21.3	26.3	6.2	19.1	8.6	10.5	.041	.682	.195	.487	1.789	.45	1.339	.01	.405
35	Miss. River—Jeff. Bar., E. of Center	June 6- " 21	23.	1174.6	197.1	977.5	53.8	22.5	31.3	6.4	19.9	8.6	11.3	.036	.678	.18	.498	1.852	.428	1.424	.008	.36
36	Miss. River—Jeff. Bar., Center	May 1- " 21	32.	1427.7	208.8	1246.3	54.5	21.9	33.1	7.	20.1	8.1	12.	.031	.738	.175	.563	1.977	.396	1.581	.008	.306
37	Miss. River—Jeff. Bar., W. of Center	June 6- " 21	29.	1472.7	225.9	1246.8	55.8	19.2	36.6	9.	19.5	7.2	12.5	.031	.712	.151	.561	1.988	.338	1.65	.007	.367
38	Miss. River—Jeff. Bar., West Shore	May 1- " 21	30.	1578.	239.2	1338.8	54.6	21.5	33.1	9.3	19.8	6.8	13.	.037	.712	.143	.569	1.939	.356	1.583	.008	.35

8321 Q. JUDGE SPRINGER: Professor, I now call your attention to tables Nos. 39 down to and including table No. 80, which you have read in evidence and ask you whether you made similar averages for the samples taken in the year 1900, which are embraced in these tables, as in the table you have just testified in regard to for the year 1899?

A. I did.

Q. I hand you a paper marked Table B, Streams Examination, Sanitary District of Chicago; Sanitary Water Analyses, Parts per million; averages of results for year 1900, report of Arthur W. Palmer, University of Illinois. Please state whether that table contains the averages that you made of chemical analyses taken from samples of water in the year 1900, and to which you have previously testified, and the results of which samples are recorded in tables beginning with No. 39 and ending with table No. 80, inclusive, already read in evidence by you?

A. It does.

Q. Please read the table in evidence.

MR. JEFFRIES: To the reading of which table in evidence complainant objects for the same reasons stated in the objection to the introduction of the tables from which the averages are made.

A. The table is as follows:

TABLE B.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

AVERAGES OF RESULTS FOR YEAR 1900.

Report of ARTHUR W. PALMER,
University of Illinois.

No. of Station.	Source of Water.	Period Covering 1900	Average of	Residue on Evaporation.						Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
				Total.	Dis-solved.	Sus-pended	Loss on Ignition.				Total.	By Dis-solved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dis-solved.	Sus-pended	Nitrites.	Nitrates
							Tot'l	Dis-solv'd	Sus-pen'd						Tot'l	Dis-solv'd	Sus-pnd'd					
1(a)	Illinois and Michigan Canal—Bridgeport	Jan. 2-Oct. 8	29.	449.3	405.8	43.5	38.8	26.6	12.2	118.5	17.7	9.5	8.2	10.614	1.632	.77	.862	3.466	1.436	2.025	.042	.296
1(b)	Sanitary Canal—Kedzie Avenue	" 11- " 8	51.	212.8	172.1	40.7	25.6	18.3	7.3	14.2	9.8	4.9	4.9	1.247	.512	.176	.336	1.151	.398	.753	.015	.272
2	Illinois and Michigan Canal—Lockport	" 2-Sept. 24	36.	518.	451.	67.	42.7	30.	12.7	135.2	20.7	11.1	9.6	13.4	1.814	.791	1.023	3.619	1.58	2.039	.016	.27
3	Sanitary Canal—Lockport	" 2- " 28	58.	264.6	241.5	23.1	30.6	24.7	5.9	12.3	8.9	6.5	2.4	9.986	.415	.232	.183	.918	.502	.416	.007	.39
4	Desplaines River—Joliet	" 2-Oct. 8	41.	265.2	231.9	33.3	29.8	22.4	7.4	30.4	11.1	7.3	3.8	2.971	.707	.402	.305	1.574	.83	.744	.031	.31
6	Kankakee River—Wilmington	" 1-Sept. 27	34.	334.4	259.5	74.9	38.4	31.8	6.6	3.3	11.3	8.2	3.1	.073	.371	.251	.12	.892	.567	.325	.014	2.208
7	Illinois River—Morris	" 5- " 25	39.	287.7	237.2	50.5	29.5	23.9	5.6	23.5	10.4	6.7	3.7	2.374	.549	.275	.274	1.167	.635	.532	.1112	.761
8	Fox River—Ottawa	" 4-Oct. 6	34.	319.2	267.3	51.9	44.6	37.9	6.7	5.3	9.6	7.6	2.	.13	.393	.251	.148	.816	491	.325	.008	.416
9	Illinois River—Ottawa	" 4- " 6	37.	293.3	269.5	23.8	30.5	25.6	4.9	21.4	8.6	6.9	1.7	1.311	.39	.246	.144	.848	.537	.311	.251	1.624
10	Big Vermilion River—La Salle	" 2- " 2	40.	480.7	409.8	70.9	52.3	42.8	9.5	16.4	7.3	4.8	2.5	.112	.259	.146	.113	.595	.314	.281	.018	3.522
11	Illinois River—La Salle	" 2- " 2	40.	292.4	245.4	46.9	32.	25.9	6.1	18.7	10.2	7.2	3.	.963	.392	.251	.141	.944	.611	.333	.153	1.703
12	Illinois and Michigan Canal—La Salle	" 2- " 2	40.	342.8	308.6	34.2	39.7	33.9	5.8	17.7	10.5	7.8	2.7	.944	.475	.327	.148	1.109	.697	.412	.049	1.005
13	Illinois River—Henry	" 9- " 1	37.	293.3	243.8	49.5	31.9	25.1	6.8	16.7	9.9	7.2	2.7	.755	.4	.257	.143	.959	.572	.387	.118	1.551
14	Illinois River—Averyville	" 2-Sept. 25	39.	289.7	245.3	44.4	37.2	26.5	10.7	16.8	9.1	7.2	1.9	.653	.347	.233	.114	.781	.469	312	.085	1.64
15	Illinois River—Wesley City	" 5-Oct. 3	38.	325.1	246.4	78.7	34.9	26.2	8.7	17.5	10.1	6.9	3.2	.608	.386	.239	.147	.928	.547	.381	.07	1.535
16	Illinois River—Pekin	" 5- " 3	37.	297.4	249.3	48.1	33.1	27.4	5.7	17.1	10.2	7.2	3.	.672	.414	.244	.17	.924	.575	.349	.083	1.486
17	Illinois River—Havana	" 11-Sept. 26	34.	308.	203.5	104.5	31.1	21.6	9.5	14.6	9.6	7.1	2.5	.616	.391	.235	.156	.921	.504	.417	.077	1.312
18	Sangamon River—Chandlerville	" 3- " 26	33.	397.7	255.	142.7	39.4	28.3	11.1	5.	9.9	4.7	5.2	.107	.327	.146	.181	.783	.329	.454	.021	1.84
19	Illinois River—Beardstown	" 4-Oct. 4	40.	394.1	239.7	154.4	38.1	28.3	9.8	14.3	11.6	6.8	4.8	.507	.405	.236	.169	.966	.521	.445	.067	1.391
20	Illinois River—Kampsville	" 3-Sept. 26	36.	420.3	228.	192.3	37.4	25.4	12.	13.1	10.3	6.5	3.8	.394	.391	.208	.183	.97	.461	.509	.038	1.398
21	Illinois River—Grafton (*See also below)	" 4- " 26	140.	532.	209.1	322.9	37.6	23.2	14.4	10.3	12.6	7.	5.6	.401	.472	.233	.239	1.138	.481	.657	.021	1.426
22	Mississippi River—Grafton " "	" 4- " 28	90.	440.8	150.5	290.3	39.9	23.8	16.1	3.78	15.8	8.9	6.9	.139	.537	.22	.317	1.208	.472	.736	.0076	.504
23	Miss. River—Alton, Illinois Shore	" 4- " 26	38.	523.3	195.7	327.6	42.1	26.7	15.4	7.9	13.8	7.4	6.4	.269	.483	.212	.271	1.138	.477	.661	.017	1.063
24	Miss. River—Alton, ¼ dis. from Ill. Shore	" 4- " 5	35.	495.4	182.8	312.6	42.9	25.1	17.8	7.1	14.7	7.6	7.1	.259	.508	.196	.312	1.198	.434	.764	.014	.896
25	Miss. River—Alton, Midstream	" 4- " 26	37.	418.3	161.1	257.2	40.7	25.1	15.6	4.8	15.3	8.8	6.5	.21	.514	.205	.309	1.15	.434	.716	.01	.56
26	Miss. River—Alton, ¼ dis. from Mo. Shore	" 4- " 5	35.	449.8	155.	294.8	38.2	24.	14.2	4.1	15.6	8.1	7.5	.175	.535	.21	.325	1.188	.433	.755	.01	.525
27	Miss. River—Alton, Missouri Shore	" 4- " 26	38.	436.3	154.7	281.6	39.1	23.5	15.6	4.1	15.2	9.	6.2	.157	.507	.211	.296	1.144	.468	.676	.009	.535
28	Missouri River—West Alton	" 4-Oct. 9	40.	1866.6	266.1	1600.5	67.5	19.	48.5	16.1	18.6	4.9	13.7	.092	.875	.134	.741	2.279	.325	1.954	.0072	.662
29	Miss. River—Mitchell, Illinois Shore	" 5- " 4	61.	769.7	180.3	589.4	44.7	23.6	21.1	6.86	15.9	7.8	8.1	.153	.542	.193	.349	1.288	.403	.885	.008	.698
30	Miss. River—Mitchell, Midstream	" 5- " 4	61.	1062.9	194.4	868.5	50.	23.6	26.4	7.88	17.9	7.6	10.3	.115	.665	.181	.484	1.561	.411	1.15	.005	.579
31	Miss. River—Mitchell, Intake Tower	" 5- " 4	61.	1545.9	215.3	1330.6	57.5	20.5	37.	10.9	19.6	6.1	13.5	.116	.774	.152	.622	1.938	.327	1.611	.005	.593
32	Miss. River—Mitchell, Missouri Shore	" 5- " 1	59.	1406	241.2	1164.8	55.1	20.9	34.2	13.3	19.7	4.9	14.8	.107	.825	.134	.691	2.131	.297	1.834	.005	.629
33	St. Louis Tap Water	" 4- " 4	40.	340.9	243.6	97.3	28.1	20.6	7.5	11.9	7.5	5.7	1.8	.039	.205	.193	.012	.551	.309	.242	.005	.647
34	Miss. River—Jeff. Bar., East Shore	" 4-Apr. 20	15.	671.4	185.4	486.	38.6	18.6	20.	7.02	15.2	7.6	7.6	.313	.631	.211	.42	1.545	.508	1.007	.017	1.016
35	Miss. River—Jeff. Bar., E. of Center	" 4- " 20	14.	653.4	187.7	465.7	39.4	19.6	10.8	7.6	14.9	7.5	7.4	.262	.604	.201	.403	1.463	.505	.958	.017	.963
36	Miss. River—Jeff. Bar., Center	" 4- " 20	15.	780.2	198.4	581.8	41.	20.9	20.1	8.7	16.	7.3	8.7	.302	.597	.232	.365	1.529	.475	1.054	.016	.853
37	Miss. River—Jeff. Bar., W. of Center	" 4- " 20	14.	977.6	268.8	688.8	38.4	17.5	20.9	11.7	15.7	7.	8.7	.257	.685	.192	.493	1.611	.489	1.122	.015	.797
38	Miss. River—Jeff. Bar., West Shore	" 4- " 20	15.	1013.6	246.8	766.8	35.8	16.	19.8	13.5	15.6	6.3	9.3	.242	.612	.178	.434	1.541	.409	1.132	.015	.76
*21	Illinois River—Grafton	" 4-Sept. 26	39.	434.6	229.1	209.5	38.5	27.3	11.2	12.47	10.9	6.6	4.3	.37	.403	.205	.198	.931	.478	.453	.024	1.362
*22	Mississippi River—Grafton	" 4- " [illegible]	38.	365.	151.4	213.6	37.3	23.1	14.2	3.5	15.1	8.8	6.3	.111	.465	.216	.249	1.075	.453	.622	.007	.445

8323 Adjourned until 2:00 p. m., same day, Tuesday, October 13, 1903.

RECORD

The State of Missouri

vs.

The State of illinois

and

Sanitary District of Chicago

VOL. 6

IN THE

Supreme Court of the United States

THE STATE OF MISSOURI
vs.
THE STATE OF ILLINOIS
and
THE SANITARY DISTRICT OF CHICAGO.

Original,
Docket No.

Before
FRANK S. BRIGHT,
Commissioner of the Supreme Court of the United States.

VOLUME 6.

A—316a

VOLUME 6.

2:00 p. m., Tuesday, October 13th, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further direct-examination by Judge Springer and testified as follows:

Q. Professor, referring again to tables numbered 1 to 80, inclusive, which you have read in evidence, please state whether you made any averages based upon those tables for the years 1899 and 1900, based upon the chemical analyses of water taken from the places indicated in those tables for the months of June, July, August and September, respectively, of those two years?

A. I did, and these averages are given in tables C and D, respectively.

Q. Please look at the tables which I now hand to you and state what they are, in the first place, and what they contain in a general way?

A. Table C contains the averages of results for the period June, July, August and September, 1899; averages made from the detailed analyses appearing in tables 1 to 32, inclusive,
8324 but for only such samples of those tables as were collected during the period mentioned, namely, June, July, August and September.

Q. State whether the respective columns of figures contained in those tables were prepared in the same manner and represent similar results as those contained in the averages which you have read in evidence contained in tables A and B?

A. The columns and the figures which appear in the various columns of table C represent just such averages as I have described in my statement regarding tables A and B, and they were prepared in similar manner, but for the period of four months, June, July, August and September, only, instead of for the entire period of the year 1899.

Q. You will please read those averages then into the record as part of the evidence in this case?

MR. JEFFRIES: To the reading of which table complainant objects for the reasons stated in the previous objection to the reading of tables A and B.

THE WITNESS: This table is as follows:

TABLE C.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

AVERAGES OF RESULTS—For Period June, July, August and September, 1899.

Report of ARTHUR W. PALMER,
University of Illinois.

No OF STATION.	SOURCE OF WATER.	RESIDUE ON EVAPORATION.						Chlorine.	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS	
					LOSS ON IGNITION.								Albuminoid Am							
		Total	Dis-solved.	Sus-pended	Tot'l	Dis-solv'd	Sus-pnd'd		Total.	By Dis-solved	By Suspd Matter.	Free Am-monia.	Tot'l	Dis-solv'd	Sus-pnd'd	Total.	Dis-solved.	Sus-pended	Nitrites	Nitrates
1	Illinois and Michigan Canal—Bridgeport	590.2	505.2	85.	60.8	45.7	15.1	119.	39.9	20.6	19.3	17.23	2.38	1.01	1.37	4.75	2.31	2.44	.078	......
2	Illinois and Michigan Canal—Lockport	572.2	492.7	79.5	74.2	51.6	22.6	116.1	41.1	21.2	19.9	15.2	2.37	1.02	1.35	4.7	2.26	2.44	.0234	......
3	Desplaines River—Lockport	335.6	316.6	19.	52.4	48.	4.4	6.4	14.1	12.9	1.2	.07	.52	.44	.08	1.13	.9	.23	.01	.257
4	Desplaines River—Joliet (above town)	496.5	473.3	23.2	62.6	43.9	18.7	101.6	29.6	17.6	12.	15.8	1.76	.74	1.02	3.81	1.58	2.23	.0124	.217
6	Kankakee River—Wilmington	314.4	259.4	55.	41.5	34.1	7.4	3.7	13.5	10.6	2.9	.06	.45	.29	.16	1.033	.676	.357	.0114	.55
7	Illinois River—Morris	419.3	396.9	22.4	47.5	40.9	6.6	68.5	16.4	13.8	2.6	9.3	.85	.5	.35	1.95	1.11	.84	.0242	.258
8	Fox River—Ottawa	380.9	298.1	82.8	58.8	49.2	9.6	4.9	13.1	10.1	3.	.053	.53	.31	.22	1.28	.665	.615	.012	.4
9	Illinois River—Ottawa	405.9	392.7	13.2	47.3	41.8	5.5	50.8	13.3	12.2	1.1	3.917	.5	.4	.1	1.13	.87	.26	.091	1.79
10	Big Vermillion River—La Salle	746.	708.3	38.1	74.8	65.6	9.2	44.4	7.8	5.4	2.4	.148	.29	.17	.12	.749	.464	.285	.0295	.67
11	Illinois River—La Salle	417.9	372.2	45.7	49.2	43.4	5.8	50.8	14.1	11.2	2.9	1.68	.54	.36	.18	1.31	.81	.5	.5338	2.26
12	Illinois and Michigan Canal—La Salle	346.4	307.1	39.3	50.2	43.9	6.3	14.9	11.9	9.2	2.7	.578	.5	.33	.17	1.231	.86	.371	.0443	.526
13	Illinois River—Henry	407.2	332.8	74.4	45.9	40.1	5.8	43.2	14.6	11.1	3.5	1.02	.64	.38	.26	1.57	.92	.65	.4515	1.74
14	Illinois River—Averyville	389.5	346.2	43.3	46.2	42.1	4.1	36.8	12.4	10.4	2.	.36	.5	.35	.15	1.23	.85	.38	.1906	1.48
15	Illinois River—Wesley City	353.8	340.9	12.9	50.4	44.7	5.7	36.1	13.3	10.6	2.7	.36	.62	.38	.24	1.32	.97	.35	.1528	1.2
16	Illinois River—Pekin	384.6	343.3	41.3	44.8	42.1	2.7	36.7	13.9	11.1	2.8	.702	.64	.39	.25	1.54	.93	.61	.2268	1.053
17	Illinois River—Havana	376.7	330.	46.7	48.9	42.8	6.1	29.9	12.9	10.1	2.8	.74	.5	.34	.16	1.31	.87	.44	.164	.7605
18	Sangamon River—Chandlerville	379.5	273.2	106.3	50.4	36.3	14.1	5.	8.7	4.9	3.8	.033	.28	.14	.14	.851	.388	.463	.0287	.94
19	Illinois River—Beardstown	399.8	291.1	108.7	41.6	34.3	7.3	21.3	11.8	8.9	2.9	.41	.44	.26	.18	1.086	.61	.476	.1257	.8185
20	Illinois River—Kampsville	369.2	268.7	100.5	41.2	33.4	7.8	15.7	10.7	8.4	2.3	.11	.35	.23	.12	1.	.65	.35	.0744	.9
21	Illinois River—Grafton	341.9	268.1	73.8	41.2	34.6	6.6	14.8	10.	8.3	1.7	.1008	.34	.23	.11	.934	.61	.324	.0551	.8815
22	Mississippi River—Grafton	327.1	156.2	170.9	40.9	31.6	9.3	2.2	16.5	11.3	5.2	.0406	.46	.21	.25	1.208	.526	.682	.0058	.339
23	Mississippi River—Alton, Illinois Shore	343.3	198.4	144.9	40.	30.1	9.9	7.02	13.	9.8	3.2	.031	.4	.22	.18	1.066	.541	.525	.0184	.6
24	Mississippi River—Alton, ¼ dis. from Ill. Shore	319.5	174.6	134.9	36.5	28.5	8.	4.34	15.1	10.7	4.4	.023	.43	.22	.21	1.136	.514	.622	.0103	.441
25	Mississippi River—Alton, Midstream	353.5	162.1	191.4	39.7	31.	8.7	2.6	15.7	10.8	4.9	.032	.45	.2	.25	1.211	.475	.736	.0058	.346
26	Mississippi River—Alton, ¼ dis. from Mo. Shore	373.3	159.8	213.5	43.8	30.7	13.1	2.3	15.7	10.8	4.9	.028	.47	.21	.26	1.287	.502	.785	.0042	.385
27	Mississippi River—Alton, Missouri Shore	371.2	162.6	208.6	49.3	34.4	14.9	2.5	15.6	10.8	4.8	.023	.45	.22	.23	1.223	.497	.726	.0041	.332
28	Missouri River—West Alton	2267.6	222.7	2044.9	94.9	20.7	74.2	7.8	21.1	5.7	15.4	.021	.73	.11	.62	2.177	.293	1.884	.0071	.39
29	Mississippi River—Mitchell, Illinois Shore	1437.8	197.9	1239.9	60.7	25.4	34.3	5.1	21.2	8.5	12.7	.024	.77	.19	.58	2.162	.435	1.727	.0087	.458
30	Mississippi River—Mitchell, Midstream	1936.5	216.8	1719.7	75.8	26.3	49.5	5.6	23.	7.9	15.1	.022	.84	.16	.68	2.38	.398	1.982	.0071	.455
31	Mississippi River—Mitchell, Intake Tower	2160.9	213.1	1947.8	74.9	23.7	51.2	6.2	23.5	7.2	16.3	.023	.9	.14	.76	2.66	376	2.284	.0054	.442
32	Mississippi River—Mitchell, Missouri Shore	2338.9	220.8	2118.1	79.3	25.4	53.9	6.4	24.4	7.	17.4	.024	.98	.13	.85	2.86	.356	2.504	.0054	.513

III

8326 THE WITNESS: Table D, made in a similar way and bearing similar relation to tables A and B, and to the tables 39 to 80, inclusive, identified as containing general averages for the period, June, July, August and September, 1900.

Q. Will you please read that table now in evidence?

MR. JEFFRIES: To the reading of which complainant objects for the reasons stated in our objection to the reading of tables from which the general averages contained in this table, were obtained.

THE WITNESS: The table is as follows:

TABLE D.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

AVERAGES OF RESULTS—For Period June, July, August and September, 1900.

Report of ARTHUR W. PALMER,
University of Illinois.

No. of Station.	Source of Water.	Residue on Evaporation.						Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
					Loss on Ignition.								Albuminoid Am.							
		Total.	Dis-solved.	Sus-pended	Tot'l	Dis-solv'd	Sus-pnd'd		Total.	By Dis-solved	By Suspd Matter.	Free Ammonia.	Tot'l	Dis-solv'd	Sus-pnd'd	Total.	Dis-solved.	Sus-pended	Nitrites	Nitrates
1(a)	Illinois and Michigan Canal—Bridgeport	495.2	448.1	47.1	83.8	28.4	55.4	147.2	17.6	8.6	9.	13.84	1.085	.312	.773	2.572	.558	2.014	.0076	.325
1(b)	Sanitary Canal—Kedzie Avenue	201.2	174.3	29.9	26.1	18.5	7.6	13.7	8.9	4.6	4.3	1.174	.45	.158	.292	1.047	.365	.682	.0115	.243
2	Illinois and Michigan Canal—Lockport	572.5	496.6	75.9	45.6	31.3	14.3	168.4	20.9	10.	10.9	16.3	1.372	.475	.897	2.671	.958	1.713	.0017	.181
3	Sanitary Canal—Controlling Works, Lockport	279.1	265.2	14.9	38.1	31.7	6.4	14.2	8.8	7.	1.8	1.235	.426	.218	.208	.902	.435	.467	.0031	.216
4	Desplaines River—Joliet	232.5	210.2	22.3	28.9	22.4	6.5	24.3	7.9	5.3	2.6	2.132	.362	.174	.188	.753	.472	.281	.0037	.255
6	Kankakee River—Wilmington	298.4	251.4	47.	38.3	33.2	5.1	3.24	9.7	7.7	2.	.0901	.273	.218	.055	.694	.485	.209	.0132	1.127
7	Illinois River—Morris	267.2	232.9	34.3	28.1	24.2	3.9	22.8	8.3	5.4	2.9	2.112	.354	.15	.204	.765	.444	.321	.1636	.696
8	Fox River—Ottawa	316.1	282.	34.1	46.8	39.7	7.1	5.68	8.7	7.1	1.6	.105	.339	.24	.099	.662	.444	.218	.0064	.25
9	Illinois River—Ottawa	266.6	242.4	24.2	31.9	25.9	6.	25.9	6.9	5.4	1.5	1.038	.27	.184	.086	.596	.412	.184	.4079	1.601
10	Big Vermillion River—La Salle	484.	438.1	45.9	50.7	44.3	6.4	20.96	6.2	4.4	1.8	.0989	.237	.149	.088	.592	.309	.283	.0125	1.796
11	Illinois River—La Salle	269.9	242.5	27.4	28.9	24.1	4.8	23.3	8.3	5.5	2.8	.772	.286	.173	.113	.699	.459	.24	.2634	1.676
12	Illinois and Michigan Canal—La Salle	336.2	304.2	32.	44.1	40.6	3.5	14.27	9.9	7.1	2.8	.4318	.465	.275	.19	.95	.541	.409	.023	1.796
13	Illinois River—Henry	291.3	249.9	41.4	30.7	25.	5.7	20.9	8.3	5.3	3.	.43	.328	.178	.15	.825	.448	.376	.2058	1.54
14	Illinois River—Averyville	267.4	243.2	24.2	31.9	26.8	5.1	21.2	6.8	5.6	1.2	.268	.265	.175	.09	.6	.425	.175	.1395	1.34
15	Illinois River—Wesley City	300.6	249.1	51.5	33.4	25.6	7.8	21.1	7.8	5.7	2.1	.27	.296	.19	.106	.72	.461	.259	.0996	1.4
16	Illinois River—Pekin	291.	249.2	41.8	32.2	26.8	5.4	21.4	7.5	5.7	1.8	.354	.305	.2	.105	.674	.478	.196	.1259	1.276
17	Illinois River—Havana	298.9	244.3	54.6	37.9	27.9	10.	18.3	7.7	5.6	2.1	.346	.305	.21	.095	.844	.484	.36	.1713	1.29
18	Sangamon River—Chandlerville	403.4	246.5	156.9	41.3	28.2	13.1	4.83	9.7	4.8	4.9	.0818	.316	.17	.146	.75	.381	.369	.027	1.276
19	Illinois River—Beardstown	317.5	241.8	105.7	34.9	28.1	6.8	17.6	8.7	5.8	2.9	.151	.344	.21	.134	.718	.437	.281	.1071	1.26
20	Illinois River—Kampsville	322.8	234.8	88.	36.5	26.3	10.2	16.5	7.5	5.6	1.9	.0977	.275	.188	.087	.652	.403	.249	.0516	1.22
21	Illinois River—Grafton	320.2	234.8	85.4	34.7	26.8	7.9	14.96	7.9	5.8	2.1	[illegible]	.275	.185	.09	.535	.397	.138	.0208	1.089
22	Mississippi River—Grafton	383.4	159.9	223.5	42.8	25.1	17.7	3.49	15.6	9.2	6.4	.0885	.444	.199	.245	.948	.39	.558	.0061	.402
23	Mississippi River—Alton, Illinois Shore	389.1	201.2	187.9	40.3	28.5	11.8	8.8	11.7	7.1	4.6	.0822	.394	.206	.188	.84	.459	.381	.0132	.848
24	Mississippi River—Alton, ¼ dis. from Ill. Shore	380.5	191.9	188.6	41.	25.3	15.7	7.6	12.4	6.9	5.5	.0759	.396	[illegible]	[illegible]	.84	.388	.452	.0068	.77
25	Mississippi River—Alton, Midstream	363.1	168.2	194.9	44.	28.7	15.3	4.8	14.	8.4	5.6	.091	.41	.19	.22	.87	[illegible]	[illegible]	[illegible]	[illegible]
26	Mississippi River—Alton, ¼ dis. from Mo. Shore	366.6	177.5	189.1	40.9	26.6	14.3	3.7	14.3	8.1	6.2	.0759	.41	.222	.188	.86	.33	.53	.0049	.352
27	Mississippi River—Alton, Missouri Shore	329.7	158.1	171.6	38.2	27.2	11.	8.5	13.7	8.7	5.	.0817	.38	.193	.187	.84	.355	.485	.0061	.368
28	Missouri River—West Alton	2226.	241.2	1984.8	95.9	20.8	75.1	14.48	21.3	5.2	16.1	.0979	.879	.123	.756	2.447	.304	2.143	.0033	.591
29	Mississippi River—Mitchell, Illinois Shore	957.1	183.8	773.3	51.9	24.2	27.7	7.12	16.	7.3	8.7	.0829	.56	.173	.387	1.324	.335	.989	.0049	.56
30	Mississippi River—Mitchell, Midstream	1353.6	196.3	1157.3	57.	24.7	32.3	7.25	18.3	7.	11.3	.0864	.705	.163	.542	1.65	.385	1.265	.0033	.542
31	Mississippi River—Mitchell, Intake Tower	1938.9	213.8	1725.1	64.4	22.1	42.3	10.2	20.7	5.8	14.9	.0964	.83	.14	.69	2.06	.295	1.765	.0028	.556
32	Mississippi River—Mitchell, Missouri Shore	2068.1	207.3	1860.8	59.7	21.6	38.1	11.8	21.4	5.1	16.3	.1037	.92	.134	.786	2.27	.301	1.969	.008	.578

8328 Q. Did you make any averages based upon the chemical analyses of waters taken from the streams indicated in tables 1 to 80, inclusive, showing the averages for June, July, August and September, for the two years, 1899 and 1900, in one table, placing the respective determinations in succeeding lines and columns?

A. Table G which you have just handed me is recognized by me as one in which I brought together some of the averages of tables C and D, for the purpose of comparison of the results, covering the two four months periods, namely, June, July, August and September, 1899, and June, July, August and September, 1900, and I also gave in that table the highest and lowest figures of various determinations made during the periods in question. I note one typographical error in that table, namely, Mississippi river at West Alton, should read Missouri river at West Alton, and I now correct this mistake.

Q. State whether the determinations set forth in that table as the result of the chemical analyses to which you have referred are now, after making the correction, the averages of the results which the table purports to make?

A. It is a comparison of some of the averages from the preceding tables of averages, and includes also some in-
8329 dividual data from the tables 1 to 80, inclusive, from which I have selected the highest and lowest figures of the determinations, occurring within this period,—four months in the summers of the two years respectively.

Q. Will you now read that table G into the record?

MR. JEFFRIES: To the reading of which said table complainant objects for the reason that all of the averages are not employed in making the comparison, and for that reason it is incompetent, irrelevant and immaterial and does not purpose to give any information with reference to the continually existing comparative relations between the various streams of waters,—the waters of which were analyzed by this witness.

THE WITNESS: The table is as follows:

TABLE G

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

For Period June, July, August and September, 1899-1900.

Report of ARTHUR W. PALMER,
University of Illinois.

SOURCE OF WATER.	Year.	AVERAGE.	RESIDUE ON EVAPORATION.							Chlorine.	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS	
			Total.	Dis-solved.	Sus-pended	Loss on Ignit'n					Total.	By Dis-solved	By Suspd Matter.	Free Am-monia.	Albuminoid Am.			Total.	Dis-solved.	Sus-pended	Nitrites	Nitrates
						Tot'l	Dis-solv'd	Sus-pnd'd							Tot'l	Dis-solv'd	Sus-pnd'd					
Illinois River —Grafton	1899	Average of 4 mos.	341.9	268.05	73.8	41.3	34.6	6.7	....	14.8	10.05	8.29	1.76	.101	.339	.233	.106	.936	.615	.321	.055	.881
	1900	" " 4 "	320.2	239.8	85.4	34.7	26.8	7.9	....	14.9	7.9	5.8	2.1	.079	.274	.185	.089	.609	.399	.31	.021	1.089
	1899	Highest..........	......	July 19	217.2	....	.....	....	Aug. 2	32.	12.7	June 14	Sept. 27	.396	.512	June 14	....	......	.....	......	.165	July 12
	1900	"	......	Sept. 5	146.4	....	.....	....	Aug. 13	22.	11.9	July 27	Sept. 26	.16	.4	Sept. 5	....	......	.....	......	.035	July 20
	1899	Lowest	......	June 28	.8	....	.....	....	June 7	4.5	8.4	Sept. 20	Aug. 9	.01	.224	June 28	....	......	.....	......	.004	June 14
	1900	"	......	Aug. 6	28.2	....	.....	....	June 6	12.	6.6	Aug. 13	July 6-20	.032	.208	July 6	....	......	.....	......	.007	June 25
Mississippi River —Grafton	1899	Average of 4 mos.	327.1	156.1	171.	40.9	31.6	9.3	....	2.17	16.51	11.33	4.18	.038	.457	.209	.248	1.208	.525	.683	.0088	.339
	1900	" " 4 "	383.4	159.9	223.5	42.8	27.6	14.2	....	3.47	15.6	9.2	6.4	.0882	.447	.191	.256	.941	.389	.552	.005	.399
	1899	Highest..........	......	June 7	540.6	....	.....	....	Aug. 30 Sept. 6	3.5	25.5	June 7	June 14	.044	.88	June 7	....	......	.....	......	.02	July 19
	1900	"	......	July 30	440.8	....	.....	....	July 9	4.8	19.3	Sept. 5	Sept. 26	.162	.544	July 30	....	......	.....	......	.013	June 25
	1899	Lowest..........	......	July 12	12.8	....	.....	....	June 7	.3	10.6	Sept. 6	June 7 Aug. 21	.012	.32	Aug. 2 Sept. 6	..	......	.....	......	.001	Aug. 2
	1900	"	......	Sept. 12	66.6	....	.....	.. .	Sept. 26	2.2	9.4	June 13	June 6	.024	.288	June 20	....	......	.....	......	.001	June 13 July 23
Mississippi River —W. Alton	1899	Average of 3 mos. July, Aug. Sept.	2267.5	222.7	2044.8	94.9	20.7	74.2	....	7.94	21.06	5.66	15.4	.0211	.729	.111	.618	2.177	.293	1.884	.007	.39
	1900	Average of 4 mos.	2225.8	211.2	1984.6	95.9	20.8	75.1	....	14.90	21.38	5.22	16.16	.0979	.878	.1232	.755	2.448	.304	2.144	.003	.591
	1899	Highest..........	......	Aug. 9	3290.6	....	.....	....	Sept. 28	14.8	31.9	Aug. 2	Aug. 31	.028	1.052	Aug 17	....	......	.....	......	.01	July 27 Aug. 17
	1900	"	......	July 24	3017.2	....	.....	....	Sept. 25	31.6	28.7	June 27	July 10	.166	1.76	June 27	....	......	.....	......	.007	June 12 Aug. 1 Sept. 18
	1899	Lowest..........	......	Sept. 28	644.4	....	.....	....	July 27	5.1	11.55	Sept. 28	Sept. 28	.006	.352	Sept. 21	....	......	.....	......	.002	Aug. 31
	1900	"	......	Aug. 14	738.4	....	.....	....	July 3	6.4	13.4	Aug. 14	June 5	.016	.324	July 10	....	......	... .	......	.001	June 27 July 3 Aug. 7, 28 Sept. 4, 25
Kankakee R. —Wilmington.	1899	Average of 4 mos.	314.4	259.4	55.	41.5	34.06	7.4	....	3.687	13.5	10.59	2.9	.0601	.446	.296	.15	.733	.676	.057	.0114	.55
	1900	" " 4 "	298.4	251.48	46.92	38.3	33.2	5.1	....	3.24	9.7	7.73	1.97	.0901	.273	.218	.055	.693	.485	.208	.0122	1.127
Fox River —Ottawa	1899	" " 4 "	380.9	298.05	82.85	58.8	49.15	9.6	....	4.86	13.07	10.11	2.96	.0502	.583	.31	.223	1.28	.665	.615	.012	.399
	1900	" " 4 "	316.1	282.02	23.08	46.8	39.6	7.2	....	5.7	8.68	7.1	1.58	.105	.338	.239	.099	.662	.443	.219	.0064	.253
Big Vermillion River, La Salle	1899	" " 4 "	746.4	708.3	38.1	74.8	65.6	8.2	....	44.44	7.81	5.39	2.42	.148	.292	.172	.12	.749	.464	.285	.029	.675
	1900	" " 4 "	484.	438.11	45.9	50.7	44.3	6.4	....	20.9	6.18	4.36	1.82	.098	.262	.149	.113	.5916	.3087	.2829	.012	1.796
Sangamon R., Chandlerville	1899	" " 4 "	379.5	273.2	106.3	50.4	36.3	14.1	....	4.78	8.74	4.96	3.78	.033	.277	.143	.134	.8513	.3884	.4629	.0287	.945
	1900	" " 4 "	403.3	246.5	156.8	41.3	28.2	13.1	....	4.83	9.74	4.83	4.91	.0815	.3116	.169	.143	.7327	.381	.3517	.0267	1.276
Illinois River —Grafton	1899	" " 4 "	341.9	268.05	73.8	41.3	34.6	6.7	....	14.8	10.05	8.29	1.76	.101	.339	.233	.106	.936	.615	.321	.055	.881
	1900	" " 4 "	320.2	234.8	85.4	34.7	26.8	7.9	....	14.9	7.9	5.8	2.1	.079	.274	.185	.089	.609	.390	.21	.021	1.089

8331 Q. I now hand you a paper, Professor, which is designated as table H. Please state what ascertainments you have made and entered upon that table?

A. Table H comprizes a comparison of the general averages of all the work during the years 1899 and 1900, which appear in tables 1 to 80, inclusive, so far as the entries under the different columns in table H are made, and these averages, together with the individual highest and lowest determinations of a number of constituents, are brought together for the purpose of comparison of the condition of the water as between the two years, so far as these two years are covered by the series of examinations which appear in tables 1 to 80, inclusive.

Q. Will you please read that table in evidence?

A. I will.

MR. JEFFRIES: To the reading of which we object for the reasons stated in our objection to the reading of the previous tables into the record, and also for the reasons stated in our objection to the reading of the tables from which this table of general averages is taken.

THE WITNESS: The table is as follows:

Table H.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

For Years 1899-1900.

Report of Arthur W. Palmer,
University of Illinois.

Source of Water.	Year.	Average.	Residue on Evaporation. Total.	Dis-solved.	Sus-pended	Loss on Ignit'n Tot'l	Dis-solv'd	Sus-pen'd		Chlorine.	Oxygen Consumed. Total.	By Dis-solved.	By Susp'd Matter.	Nitrogen as Ammonia. Free Ammonia.	Albuminoid Am. Tot'l	Dis-solv'd	Sus-pnd'd	Organic Nitrogen. Total.	Dis-solved.	Sus-pended.	Nitrogen as Nitrites.	Nitrates.
Illinois River —Grafton	1899	Average of 34.....	349.5	274.7	74.8	38.7	29.7	9.	....	18.5	9.9	7.8	2.1	.221	.412	.247	.165	1.037	.609	.428	.051	1.07
	1900	" " 39....	438.6	229.1	209.5	38.5	27.3	11.2	....	12.47	10.9	6.6	4.3	.37	.403	.205	.198	.931	.478	.453	,024	1.362
	1899	Highest..........	......	May 31	500.8	....	....	....	Nov. 8	36.6	16.8	May 31	....	.88	Nov. 29	....	....	1.806	Nov. 15	......	......	......
	1900	"	......	Feb. 14	1311.2	....	....	....	Jan. 4	30.	24.7	Feb. 14	....	2.24	Jan. 4	....	....	3.52	Feb. 14	......	......	......
	1890	Lowest..........	......	June 28	.8	....	....	....	June 7	4.5	7.	May 24	....	.006	June 7	....	....	.648	Nov. 1	......	......	......
	1900	"	......	Jan. 10	2.8	....	....	....	Mar. 14	4.2	6.6	Aug. 13	....	.032	May 30 June 6 and 20	....	....	.42	June 20	......	......	......
Mississippi River —Grafton	1899	Average of 33.....	342.4	153.1	189.3	36.1	26.7	9.4	....	2.6	15.89	10.8	5.	.089	.469	.218	.251	1.142	.489	.653	.01	.295
	1900	" " 38.....	365.	151.4	213.6	37.3	23.1	14.2	....	3.5	15.1	8.8	6.3	.111	.465	.216	.249	1.075	.453	.622	.007	.445
	1899	Highest..........	......	May 24	958.8	....	....	....	Oct. 4	6.8	26.9	May 3	....	.184	May 24	....	....	2.65	May 24	......	......	......
	1900	"	......	April 23	1053.2	....	....	....	Jan. 4	9.5	27.6	April 9	....	.42	Mar. 26	....	....	3.52	April 9	......	......	......
	1899	Lowes..........	......	July 12	12.8	....	....	....	June 28	1.	8.9	Nov. 1	....	.001	Dec. 13	....	....	.6	Dec. 20	......	......	......
	1900	"	......	Jan. 10	14.	....	....	....	April 9	1.5	11.2	Jan. 24	....	.012	May 30 June 10	....	....	.616	Sept. 12	......	......	......
Missouri River —West Alton	1899	Average of 23.....	1284.6	285.2	999.4	50.3	17.6	32.7	....	14.9	13.9	4.4	9.5	.03	.475	.102	.373	1.378	.272	1.106	.006	.337
	1900	" " 40.....	1866.6	266.1	1600.5	67.5	19.	48.5	....	16.1	18.6	4.9	13.7	.092	.875	.134	.741	2.279	.325	1.954	.0072	.662
	1899	Highest..........	......	Aug. 2	3299.6	....	....	....	Nov. 16	30.	31.9	Aug. 2	....	.08	Dec. 28	....	....	3.16	Aug. 2	......	......	......
	1900	"	......	June 24	3917.2	....	....	....	Jan. 18	35.3	28.7	June 27	....	.22	Mar. 13	....	....	4.96	Mar. 7	......	......	......
	1899	Lowest..........	......	Dec. 26	180.4	....	....	....	July 27	5.1	6.6	Nov. 30	....	.006	Sept. 28	....	...	.456	Dec. 28	......	......	......
	1900	"	......	Jan. 4	68.	....	....	....	Aug. 1	7.1	3.9	Jan. 4	....	.016	Apr. 16 June 5	....	....	.36	Jan. 4	......	......	......
Kankakee R. — Wilmington	1899	Average of 29.....	302.7	262.5	39.4	37.8	29.7	5.6	....	3.9	11.1	9.2	1.9	.047	.372	.266	.106	.886	.643	.245	.011	1.084
	1900	" " 34....	334.4	259.5	74.9	38.4	31.8	6.6	....	3.3	11.3	8.2	3.1	.073	.371	.251	.12	.892	.567	.325	.014	2.208
Fox River —Ottawa	1899	" " 30.....	344.8	295.8	49.	52.8	46.7	7.4	....	5.84	9.9	8.3	1.7	.056	.416	.27	.146	.94	.556	.384	.008	.373
	1900	" " 34.....	319.2	267.3	51.9	44.6	37.9	6.7	....	5.3	9.6	7.6	2.	.13	.399	.251	.148	.816	.491	.325	.008	.416
Big Vermillion River, La Salle	1899	" " 32.....	1023.1	992.8	30.3	91.5	83.4	8.1	....	64.9	6.4	4.9	1.5	.254	.344	.159	.085	.639	.406	.243	.022	.845
	1900	" " 40.....	480.7	409.8	70.9	52.3	42.8	9.5	....	16.4	7.3	4.8	2.5	.112	.259	.146	.113	.595	.314	.281	.018	3.523
Sangamon R., Chandlerville	1899	" " 23.....	351.1	280.9	70.2	40.5	30.	10.5	....	5.6	7.3	5.	2.3	.115	.262	.154	.108	.72	.38	.34	.043	.62
	1900	" " 33.....	397.7	255.	142.7	39.4	28.3	11.1	....	5.	9.9	4.7	5.2	.107	.327	.146	.181	.783	.329	.454	.021	1.84
Illinois River —Grafton	1899	" " 34.....	349.5	274.7	74.8	38.7	29.7	9.	....	18.5	9.9	7.8	2.1	.221	.412	.247	.165	1.037	.609	.428	.051	1.07
	1900	" " 39.....	438.6	229.1	209.5	38.5	27.3	11.2	....	12.47	10.9	6.6	4.3	.37	.403	.205	.198	.931	.478	.453	.024	1.362

8333 Q. Did you make any ascertainment of the dissolved oxygen in the water of the respective streams mentioned in tables numbered 1 to 80, inclusive, that you have already read in evidence?

A. I did.

Q. State whether you entered those determinations upon any tables, and if so, whether the tables that I now hand to you which contain a designation at the bottom of each page, as 95a, 95b, 95c, 95d, 95e, 95f and 95g, contain the results of those ascertainments?

A. I do identify these tables, 95a, 95b, 95c, 95d, 95e, 95f and 95g, as containing the results of various determinations of dissolved oxygen in samples of water from the various points in the Ilinois river, and some of its tributaries and the Mississippi river.

Q. What period is covered by these determinations?

A. These determinations range over the period from the beginning of the work early in 1899, to the discontinuance of the work in the year 1900. That is, from the latter part of April, 1899, until about the middle of October, 1900.

MR. JEFFRIES: Let me ask the witness a quetsion.

Q. Professor, were these determinations made from the same samples that the other determinations were made from?

8334 A. No.

Q. It was a separate set of samples, then, altogether?

A. Yes, but in most cases collected at the same time. Those which we took on the spot of course, were separate from the others. In some cases they were collected simultaneously with the large samples that were used for chemical analysis, but in all other cases all shipped samples were collected at the same time as the bacterial and chemical samples.

MR. JEFFRIES: I object to this testimony and move to strike out the answers of the witness for the reason that it is not shown that the samples of water were properly taken, or the manner in which they were taken, or the point in the river from which they were taken, and for the further reason that this testimony, on account of the variations in the taking of the samples and the analyses of the water, being different from that with reference to the manner in which, and the time at which the samples were taken with reference to the tables heretofore introduced in evidence, is not comparable and do not accurately portray the condition of the water at the places taken with reference to dissolved oxygen at all times, and further for the reason that there is no evidence showing the extent that dissolved oxygen was affected by means of the 8335 collection of samples, their transportation and their manner of being handled in the laboratory or en route.

JUDGE SPRINGER:

Q. I will ask you, Professor, to look at the tables which I have placed in your hands, numbered at the bottom 92a to 95g, inclusive, and state the manner in which the collections were made, and all the facts which are intended to be conveyed by these tables?

MR. JEFFRIES: That is objected to for the same reasons stated in the previous objection.

JUDGE SPRINGER: Perhaps this statement will remove some of your objections.

A. Most of the samples, determinations upon which are recorded in these tables, 95a to 95g, inclusive, I collected myself, and analyzed myself, following the methods which I have previously described in giving this testimony so far as the determination was concerned. With respect to the manner of collection I may say that the collection in some cases was made by immersing the special pipette referred to in my description of the method, in the water of the stream to be examined, to a depth of eighteen inches, and after the pipette was in this manner filled by closing the cocks to confine within the pipette the full 8336 volume which the pipette might hold, namely, 107 cubic centimeters, and thus withdrawn from the stream within the pipette, shut off entirely from the atmosphere, the sample in which the dissolved oxygen was to be determined. In other cases the collection was made by means of a rubber syringe bulb, so arranged as to draw the water from the stream and force it into and through the bottle in which the sample was to be taken, or into and through the pipette in which the sample was to be analyzed, and where the dissolved oxygen was determined at greater depth than eighteen inches below the surface, there was attached to this syringe a tube which reached to nearly the bottom of the stream, varying in length as the depth of the stream

varied at different places. The samples which were not collected by myself, and they include only a portion of the samples collected at Grafton, that is, part of those collected from the Illinois river at Grafton, and part of those collected from the Mississippi river at Grafton, were collected for me by a collector, who had been specially instructed how to collect, who had helped me collect when I was on the spot doing the work for myself, and who further was the regular collector of the samples at Grafton, both from the Mississippi and the Illinois river, for the regular bacterial and chemical examinations. The collections at all
8337 other points referred to in these tables I made myself.

Q. Will you please explain the object of this determination and the significance of the column where you have indicated the results?

A. Where the results are indicated?

Q. Yes, "M. G.," "temperature," etc.

A. In the series of three columns for which the heading is milligrams per liter, represented by the ordinary abbreviation, capitals "M. G." for milligrams, there appear the results of determinations upon duplicate samples in the first two columns, and the average of these two determinations in the third column, save where in a few cases from lack of time, duplicate determinations were not made.

In the next column is given the temperature of the water, which determination was made by the one who took the sample,—in mose cases myself. In the cases hereinbefore mentioned, by the specially instructed collector.

In the next column after the one in which the temperatures are recorded, there appears under the general heading "Per cent. of saturation," figures which represent that portion of the possible quantity of dissolved oxygen which was actually contained in the water. That is, it is well understood that
8338 under the conditions of exposure to the atmosphere, these will be modified somewhat by atmospheric pressure, modified very largely by the temperature of the water. The proportion of oxygen which the water may hold in solution varies, and the maximum which can be held in equilibrium in solution at any given temperature is called the saturation figure, and when the water is fully saturated it is regarded as holding

100 per cent. of dissolved oxygen, which means all that the water can normally, under the given conditions, retain in solution.

Q. Please state whether the succeeding determinations as to the sanitary canal, Kedzie avenue, Desplaines river, Joliet, etc., down through all the tables, including 95g, were made in the same way as that which you have just explained?

A. They were all made in practically the same manner, except that a few of the analyses or determinations of dissolved oxygen included in these tables were made by the well known Winkler's method.

Q. Have you explained what that method is?

A. Well, I have not done so. I can if it is necessary. The Winkler method for the determination of dissolved oxygen depends upon the fact that dissolved oxygen or free oxygen acts upon manganous hydroxide, oxidizing it to manganic or the higher oxides or hydroxides of manganese, and the higher
oxide of manganese thus produced, re-acting with a solu-
8339 tion containing hydiodic acid, sets iodine free, which sub-
sequently is measured by titration with a standard solution of thiosulphate of sodium. The collection of the sample for dissolved oxygen by the Winkler method is made in essentially the same manner as has been described in the Levy method, with the exception that no special pipette is used in this method, but that a bottle of convenient size, which may hold about a quarter of a liter of water, but of which the capacity must be known precisely, is filled with the water. Then there is introduced a concentrated solution of manganese sulphate or maganese chloride. Next a strong solution of sodium hydroxide, and without permitting air to come into contact with the mixture within the bottle other than merely momentarily with it at the surface exposed in the neck of the bottle. The stopper is inserted excluding all air, and the contents of the bottle mixed. The alkali precipitates manganous hydroxide, which is almost white or pinkish white. Any dissolved oxygen in the water immediately affects this manganous hydroxide, changing some of it into manganic compounds which have in the pure state a dark brown color. The manganous compounds do not affect the solution of hydriodic acid. The manganic do, and set free from such solution iodine in the elemental condition. The dissolved oxygen oxidizes the manganese; the manganese oxidizes the

hydriodic acid, giving free iodine. The free iodine
8340 strikes a blue color with starch paste, which in small quantity is used as an indicator, and then by titrating this mixture with thiosulphate of sodium, a standard solution, from the quantity of this latter solution required, the quantity of iodine, and from it the quantity of dissolved oxygen is readily calculated after the shaking of the mixture in the bottle, after the oxygen has been absorbed by the manganese compounds, the mixture after completion of this reaction, is acidified and potassium iodide added, the acidification sometimes taking place before, sometimes after the addition of the iodide of potassium, but in all cases before the mixture in the bottle is exposed to the air. With waters containing considerable organic matters, nitrites and so on, it is necessary to run a blank determination with the water in order to make corrections for the effect of such impurities upon the different solutions used in making the determination. These corrections were made by treating a measured quantity of the water sample with manganic chloride and noting the amount of reduction that was effected in this solution during the lapse of from two to five minutess, according as it seemed best to vary the times, for reasons determined by the time taken in making the direct determination upon the particular sample, although ordinarily five minutes was the length of time allowed for the action of the
8341 impurities in the sample upon the maganic chloride used
in determining the blank.

Q. In the column headed "Remarks" I find the statement "Test of keeping qualities" opposite certain lines. Will you explain what that means?

A. Why, in some cases, even where the work was done on the spot, and for the reason of getting some information as to what changes take place during transportation from the point of collection to the laboratory, samples collected simultaneously with those in which the determination was made as the water came from the stream, were set aside and kept sometimes ten or twelve hours, sometimes until the next day, sometimes two days. The test of keeping qualities applies to this, for the reason that it is found that waters containing notable quantities of organic matters frequently suffer a loss of dissolved oxygen when the samples are allowed to stand out of their natural environment, that is, taken out from the stream in which they normally are found, or from which they have been collected. If there is a great diminution of the quantity of dissolved oxygen, then the keeping qualities are regarded as being inferior to what they are in case there is less diminution on standing.

8342 Q. How were these samples of water shipped to you, and where did you receive them?

A. These samples of water were collected in self-sealing or quick-sealing magnesium citrate bottles, bottles of heavy glass, provided with a combined metal and rubber stopper, which is so fastened to the neck of the bottle by means of heavy wires, that the bottle can be quickly and securely closed by insertion of the stopper, which the wires keep in place, and subsequently when it is necessary to open the bottle by removing the wires, the stopper is removed and the contents may be easily accessible. The bottles employed held from 350 to 400 cubic centimeters of water and special effort was always made in filling the bottles to exclude totally every bubble of air, that is, to have the bottles entirely filled with water and nothing but water, with its various ingredients. These bottles were packed in small special cases each case holding one dozen bottles, each bottle in its own separate compartment, and the case sealed to exclude light, the case and bottles being shipped together with the case containing the chemical and bacterial samples, and they usually arrived at the laboratory in good condition, with the exception that oc-
8343 casionally bottles were broken in transit from the pressure exerted by reason of increase in temperature of the water during its transit, and oftentimes the expansion caused by decrease in temperature during transit,—from the point of collection to the laboratory.

With reference to my statements concerning saturation of the water with dissolved oxygen, a reference to the column in which the data under this head is given, shows at once that the figures there are in many cases considerably above 100. For instance, under the Illinois river water at Henry above the dam for 1899, under date of August 17th, the first in that series, the percentage shown in the last column under saturation is 220.88. This shows that the water is highly supersaturated, the supersaturation takes place by reason of the fact that the chloriphyl containing organisms with which the river water at such seasons especially abounds, under the influence of sunlight, give off streams of oxygen, which may be seen coming up through the water, and under these conditions the water naturally dissolves much more oxygen than it could under these conditions, dissolve from the atmosphere, and this oxygen for a time remains in the water, although on long standing it undoubtedly would be given off in part into the atmosphere, down to the saturation figure of 100 per cent, and also might in part be utilized by the organic matters in the water, and so the proportion be reduced. 8344

I guess that covers the supersaturation.

Q. JUDGE SPRINGER: Now professor, read the tables to which you have referred Nos. 95a, to 95g.

MR. JEFFRIES: I object to the reading of the tables into the record for the reason that there is no evidence to show that any samples of water were taken in the manner described by the witness or shipped in the manner described by the witness, no water-taker having testified to the taking of any such samples in any such manner, and that while it may be true that the witness took a part of the samples contained in the tables which he is now requested to read into the record, yet the witness has stated that he did not take all of them, that a part were taken by others and shipped to him, and there is nothing in the record to show the manner in which those were taken by other persons, or the manner of shipment and no evidence to show where they were taken, whether from the Illinois river or from some other river.

I object to the reading of the tables for the further reason, because of the failure to show the exact manner in which all of them were taken and the exact places at which all of them were taken; that the examination for the purpose of determining the dissolved oxygen, renders the tables incomparable and unreliable, and as carrying with them no probative force, and for the further reason that they do not disclose the condition of the water of the Illinois river with reference to dissolved oxygen at all times of the year, with reference to the variations in the flow of the stream, the volume of water in the stream, with reference to the various temperatures of the waters in the stream at different seasons of the year. 8345

A. The tables are as follows:

DISSOLVED OXYGEN IN THE WATER OF THE

Date of Collection.	Date of Determination.	Depth of Collection.	Mg. per Liter.			Temp. of Water.	Per cent Saturation.	Remarks.
			1	2	Aver.			
SANITARY CANAL, LOCKPORT.								
1900	1900							
June 29, 5:00 p.m.	June 29, 5:00 p.m.	18" below surface	1.	1.	1.	20°c	10.88	Just above BearTrap dam.
" 29, 5:45 "	" 29, 5:45 "	18" " "	5.1	5.1	5.1	"	55.5	200 yds. bel. dam.
Aug. 14	Aug. 14	18" " "	.55	.55	.55	18°c	5.88	Just above BearTrap dam.
" 14	" 14	18" " "	6.55	6.55	6.55	"	70.05	Below dam.
SANITARY CANAL, KEDZIE AVENUE.								
1900	1900							
Aug. 13, 5:15 p.m.	Aug. 13, 5:15 p.m.	18" below surface	2.7	2.8	2.75	19°c	29.	
" 13, 5:40 "	" 13, 5:40 "	18" " "	2.6	2.7	2.65	"	28.2	
DESPLAINES RIVER, JOLIET.								
1900	1900							
June 30, 5:50 a.m.	June 30, 5:30 a.m.	18" below surface	2.6	2.6	2.6	18°c	27.8	Just above dam No. 1.
" 30, 6:00 "	" 30, 6:00 "	18" " "	7.6	7.6	7.6	"	81.28	Below dam in sluice.
ILLINOIS AND MICHIGAN CANAL, JUST ABOVE CHANNAHAN.								
1899	1899							
Aug. 21, 6:30 a.m.	Aug. 21, 6:30 a.m.	18" below surface	.3	.2	.25	26°c	3.05	
FOX RIVER, OTTAWA.								
1899	1899							
Aug. 20, 5:00 p.m.	Aug. 20, 5:00 p.m.	18" below surface	10.2	10.4	10.3	31°c	136.25	
ILLINOIS RIVER WATER, LA SALLE, ABOVE CANAL.								
1899	1899							
Aug. 16, 2:40 p.m.	Aug. 16, 2:40 p.m.	18" below surface	8.4	8.	8.2	26°c	100.12	
" 16, 3:05 "	" 16, 3:05 "	18" " "	8.2	8.2	8.2	"	100.12	
" 16, 4:00 "	" 16, 4:00 "	18" " "	8.2	8.25	8.22	"	100.36	
" 16, 2:30 "	" 17, 4:00 "	18" " "	6.2	6.2	6.2	"	75.70	Test of keeping qualities.
" 16, 3:30 "	" 18, 9:00 a. m.	18" " "	4.6	4.9	4.75	"	58.00	
ILLINOIS AND MICHIGAN CANAL, UPPER BASIN, LA SALLE.								
1899	1899							
Aug. 16, 4:00 p.m.	Aug. 16, 4:00 p.m.	18" below surface	8.2	8.25	8.22	27°c	102.42	
" 16, 4:00 "	" 17, 4:00 "	18" " "	6.3	6.3	6.3	"	78.45	Kept 24 hours.
" 16, 4:00 "	" 18, 10:30 a.m.	18" " "	5.	5.	5.	"	62.26	" 40 "
ILLINOIS RIVER WATER, HENRY, ABOVE DAM.								
1899	1899							
Aug. 17, 1:15 p.m.	Aug. 17, 1:15 p.m.	1" below surface	17.3	17.6	17.45	22°c	230.88	
" 17, 1:15 "	" 17, 1:15 "	1" " "	16.7	16.7	16.7	"	211.29	
" 17, 1:15 "	" 17, 1:15 "	18" " "	15.8	15.8	15.8	28°c	200.00	
" 17, 1:15 "	" 17, 1:15 "	18" " "	16.6	16.3	16.45	"	208.22	
" 17, 1:15 "	" 17, 1:15 "	18" " "	16.46	......	......	"	208.35	Winkler Method
" 17, 1:15 "	" 18, 1:30 "	18" " "	8.9	8.5	8.7	"	110.12	Test of keeping qualities.
" 17, 1:15 "	" 17, 1:15 "	2' from bottom	10.1	10.2	10.15	"	120.10	
" 17, 1:15 "	" 18, 1:30 "	2' " "	3.7	3.8	3.75	"	47.42	Test of keeping qualities.
ILLINOIS RIVER, AVERYVILLE.								
1899	1899							
July 21, 4:30 p.m.	July 21, 4:30 p.m.	18" below surface	13.2	13.1	13.15	29°c	169.80	
" 21, 5:00 "	" 21, 5:00 "	18" " "	13.3	13.2	13.25	"	171.18	
" 21, 5:30 "	" 21, 5:30 "	18" " "	13.4	13.2	13.3	"	171.88	
" 21, 6:00 "	" 22, 11:00 a.m.	18" " "	9.1	9.0	9.05	"	116.92	Test of keeping qualities.
" 21, 6:00 "	" 22, 6:00 p.m.	18" " "	8.9	Lost	8.9	"	114.08	
" 21, 6:00 "	" 22, 6:00 "	18" " "	9.0	9.0	9.0	"	116.27	
" 22, 8:50 a.m.	" 22, 8:50 a.m.	18" " "	6.6	6.8	6.7	"	87.83	
" 22, 9:26 "	" 22, 9:26 "	18" " "	7.1	7.1	7.1	"	91.73	
" 22, 10:10 "	" 22, 10:10 "	18" " "	7.4	7.4	7.4	"	95.60	
" 22, 12:20 p.m.	" 22, 12:20 p.m.	18" " "	8.4	8.9	8.65	"	111.78	
" 22, 1:10 "	" 22, 1:10 "	18" " "	8.9	8.8	8.85	"	114.34	
" 22, 1:10 "	" 24, 2:00 "	18" " "	2.9	3.	2.95	"	38.11	Test of keeping qualities.
" 22, 1:10 "	" 24, 2:00 "	18" " "	3.02	......	......	"	39.02	Test of keeping qualities, Winkler's.
" 22, 1:10 "	" 24, 2:00 "	18" " "	3.12	......	......	"	40.31	
" 22, 1:10 "	" 24, 2:00 "	18" " "	2.93	......	......	"	37.85	
Aug. 17, 6:30 p.m.	Aug. 17, 6:30 p.m.	18" " "	7.0	6.7	6.85	24°c	80.49	
" 17, 6:30 "	" 17, 6:30 "	2' from bottom	6.3	6.3	6.3	"	74.03	
" 17, 6:30 "	" 18, 7:05 "	2' " "	8.2	8.4	8.3	"	97.52	Test of keeping qualities.

DISSOLVED OXYGEN IN THE WATER OF THE

Illinois River, Averyville.—Continued.

Date of Collection.	Date of Determination.	Depth of Collection.	Mg. per Liter. 1	Mg. per Liter. 2	Mg. per Liter. Aver.	Temp. of Water.	Per cent Saturation.	Remarks.
1899	1899							
Aug. 19, 12:30 p.m.	Aug. 19, 12:30 p.m.	18″ below surface	14.5	14.3	14.4	28.5°c	184.14	
" 19, 3:20 "	" 19, 3:30 "	18″ " "	15.	16.	15.5	29°c	200.25	
" 19, 4:00 "	" 19, 4:00 "	18″ " "	17.2	16.1	16.65	"	215.11	
" 19, 4:25 "	" 19, 4:25 "	18″ " "	16.7	16.7	16.7	"	215.76	
" 19, 5:55 "	" 19, 5:55 "	18″ " "	7.5	7.3	7.4	"	95.6	
Oct. 16, 8:35 a.m.	Oct. 16, 8:35 a.m.	18″ " "	6.8	6.9	6.85	20°c	74.53	
" 16, 9:25 "	" 16, 9:25 "	18″ " "	7.	7.	7.	"	76.17	
" 16, 11:00 "	" 16, 11:00 "	18″ " "	7.	7.1	7.05	"	76.71	
" 16, 2:30 p.m.	" 16, 2:30 p.m.	18″ " "	7.	7.1	7.05	19.5°c	75.97	
" 16, 3:30 "	" 16, 3:30 "	18″ " "	7.2	7.2	7.2	"	77.58	
" 16, 4:20 "	" 16, 4:20 "	18″ " "	6.8	7.	6.9	"	74.35	
1900	1900							
Jan. 4, 8:45 a.m.	Jan. 4, 9:20 a.m.	18″ below surface	11.1	11.1	11.1	1°c	77.78	
" 4, 8:45 "	" 4, 9:20 "	18″ " "	11.1	11.1	11.1	"	77.78	
" 4, 8:45 "	" 5, 10:30 "	18″ " "	10.9	10.9	10.9	"	76.38	Test of keeping qualities.
" 4, 8:45 "	" 5, 10:30 "	18″ " "	10.8	10.7	10.75	"	75.33	
" 4, 8:45 "	" 4, 8:45 "	8′ " "	11.1	11.	11.05	"	77.44	
" 4, 8:45 "	" 4, 8:45 "	8′ " "	11.	11.	11.	"	77.08	
" 4, 8:45 "	" 5, 10:30 "	8′ " "	10.6	10.6	10.6	"	74.22	Test of keeping qualities.
" 4, 8:45 "	" 5, 10:30 "	8′ " "	10.7	10.7	10.7	"	74.96	
" 4, 11:45 "	" 4, "	18″ " "	10.9	11.1	11.	"	77.08	
" 4, 11:45 "	" 4, "	8′ " "	11.2	11.2	11.2	"	78.48	
June 30, 9.00 a.m.	June 30, 9:00 a.m.	18″ " "	5.8	5.8	5.8	25°c	69.46	
" 30, 9:35 "	" 30, 9:25 "	18″ " "	6.	6.1	6.05	"	72.45	
" 30, 9:35 "	" 30, 9:35 "	2′ from bottom	6.2	6.2	6.2	"	74.25	
" 30, 1:45 p.m.	" 30, 1:45 p.m.	18″ below surface	6.5	6.6	6.55	26°c	79.95	
" 30, 2:40 "	" 30, 2:40 "	18″ " "	6.8	6.8	6.8	"	83.02	
" 30, 2:40 "	" 30, 2:40 "	2′ from bottom	6.4	6.6	6.5	"	79.36	
" 30, 3:45 "	" 30, 3:45 "	18″ below surface	6.7	Lost	6.7	"	81.80	
" 30, 3:45 "	" 30, 3:45 "	2′ from bottom	6.7	6.7	6.7	"	81.80	
" 30, 4:35 "	" 30, 4:35 "	18″ below surface	6.8	6.9	6.85	"	83.64	
" 30, 4:35 "	" 30, 4:35 "	2′ from bottom	6.8	6.8	6.8	"	83.03	
Oct. 13, 8:30 a.m.	Oct. 13, 8:30 a.m.	18″ below surface	7.1	Lost	......	18°c	74.34	
" 13, 9:45 "	" 13, 9:45 "	18″ " "	7.1	7.2	7.15	"	74.87	
" 13, 9:45 "	" 13, 9:45 "	18″ " "	7.	7.4	7.2	"	75.39	
" 13, 11:10 "	" 13, 11:10 "	18″ " "	7.1	6.9	7.	18.5°c	74.00	
" 13, 2:00 p.m.	" 13, 2:00 p.m.	18″ " "	7.	7.2	7.1	19°c	75.77	
" 13, 3:10 "	" 13, 3:10 "	18″ " "	7.1	7.4	7.25	"	77.37	
" 13, 3:10 "	" 13, 3:10 "	18″ " "	7.1	7.1	7.1	"	75.77	
" 13, 4:25 "	" 13, 4:25 "	18″ " "	7.	7.	7.	"	74.00	
" 13, 11:10 a.m.	" 15, 2:40 "	18″ " "	6.	6.1	6.05	18.5°c	63.95	Kept 51 hours.
" 13, 11:10 "	" 15, 3:00 "	18″ " "	6.	6.	6.	"	63.42	" 51 "
" 13, 2:00 p.m.	" 15, 3:50 "	18″ " "	5.7	5.7	5.7	19°c	60.83	" 50 "
" 13, 2:00 "	" 15, 4:10 "	18″ " "	4.5	5.	4.75	"	50.69	" 50 "
" 13, 4:25 "	" 15, 4:25 "	18″ " "	6.	6.1	6.05	"	64.56	" 48 "

Illinois River, Wesley City.

Date of Collection.	Date of Determination.	Depth of Collection.	Mg. per Liter. 1	Mg. per Liter. 2	Mg. per Liter. Aver.	Temp. of Water.	Per cent Saturation.	Remarks.
1899	1899							
July 22, 9:00 a.m.	July 22, 9:00 a.m.	18″ below surface	2.	2.4	2.2	28°c	30.28	50 ft. from W. Bank.
" 22, 9:30 "	" 22, 9:30 "	18″ " "	7.2	7.3	7.25	"	91.77	Midstream.
" 22, 10:00 "	" 22, 10:00 "	18″ " "	7.5	7.2	7.35	"	93.03	East Bank, 50 feet from Midstream.
Aug. 18, 7:00 a.m.	Aug. 18, 7:00 a.m.	18″ " "	3.6	3.6	3.6	24°c	43.30	
" 18, 7:00 "	" 18, 7:00 "	18″ " "	2.7	2.7	2.7	"	31.72	
" 19, 6:30 p.m.	" 19, 6:30 p.m.	18″ " "	4.2	3.5	3.85	27.5°c	48.36	
1900	1900							
Jan. 4, 4:00 p.m.	Jan. 4, 4:00 p.m.	2′ below surface	11.1	10.4	10.75	1°c	75.33	East Bank.
" 4, 4:00 "	" 4, 4:00 "	2′ " "	10.7	10.7	10.7	"	74.98	
" 4, 4:00 "	" 5, 12:40 "	2′ " "	10.5	10.4	10.45	"	73.22	East Bank, kept 21 hours.
" 4, 4:00 "	" 5, 12:40 "	2′ " "	10.5	10.4	10.45	"	73.22	

Illinois River, Pekin.

Date of Collection.	Date of Determination.	Depth of Collection.	Mg. per Liter. 1	Mg. per Liter. 2	Mg. per Liter. Aver.	Temp. of Water.	Per cent Saturation.	Remarks.
1899	1899							
Aug. 18, 10:00 a.m.	Aug. 18, 10:00 a.m.	18″ below surface	2.	1.9	1.95	26.5°c	24.04	Midstream.
" 18, 10:00 "	" 18, 10:00 "	18″ " "	2.6	2.6	2.6	"	32.06	
" 19, 5:30 p.m.	" 19, 5:30 p.m.	18″ " "	6.4	6.4	6.4	30°c	84.21	
" 19, 5:30 "	" 19, 5:30 "	18″ " "	6.04	......	......	"	79.74	

Illinois River, Lancaster Landing.

Date of Collection.	Date of Determination.	Depth of Collection.	Mg. per Liter. 1	Mg. per Liter. 2	Mg. per Liter. Aver.	Temp. of Water.	Per cent Saturation.	Remarks.
1899	1899							
Aug. 19, 4:20 p.m.	Aug. 19, 4:20 p.m.	18″ below surface	9.7	9.8	9.75	30°c	128.29	
" 19, 4:20 "	" 19, 4:20 "	18″ " "	9.13	......	......	"	120	Winkler Method

Illinois River, Copperas Creek Dam.

Date of Collection.	Date of Determination.	Depth of Collection.	Mg. per Liter. 1	Mg. per Liter. 2	Mg. per Liter. Aver.	Temp. of Water.	Per cent Saturation.	Remarks.
1899	1899							
Aug. 19, 3:30 p.m.	Aug. 19, 3:30 p.m.	18″ below surface	9.5	9.7	9.6	29°c	124.03	

DISSOLVED OXYGEN IN THE WATER OF THE

ILLINOIS RIVER, HAVANA.

Date of Collection.	Date of Determination.	Depth of Collection.	Mg. per Liter.			Temp. of Water.	Per cent Saturation.	Remarks.
			1	2	Aver.			
1899	1899							
Aug. 18, 3:30 p.m.	Aug. 18, 3:30 p.m.	18" below surface	3.7	3.7	3.7	31°c	49.8	
" 19, 6:00 a.m.	" 19, 6:00 a.m.	18" " "	3.4	3.5	3.45	24°c	40.54	
" 19, 6:00 "	" 19, 6;00 "	18" " "	3.6	3.7	3.65	"	42.89	
" 19, 6:00 "	" 19, 6:00 "	18" " "	3.1	......	......	"	36.42	Winkler Method
" 19, 6:00 "	" 19, 6:00 "	18" " "	3.01	......	......	"	35.37	" "

ILLINOIS RIVER, GRAFTON.

1899	1899							
Apr. 29, 10:30 a.m.	Apr. 29, 10:30 a.m.	1' below surface	11.2	11.3	11.25	22°c	127.27	Midchannel.
" 29, 2:15 p.m.	" 29, 2:15 p.m.	1' " "	11.4	11.4	11.4	"	128.96	
" 29, 3:15 "	" 29, 3:15 "	1' " "	11.1	11.1	11.1	"	125.56	
June 22, 9:00 p.m.	June 23, a. m.	18" " "	5.7	5.5	5.6	27°c	69.73	
" 22, 9:00 "	" 23, a. m.	18" " "	5.4	5.6	5.5	"	68.49	
" 23, 9:00 a.m.	" 23, 9:00 a.m.	18" " "	5.1	5.5	5.3	28.5°c	67.77	
" 23, 4:30 p.m.	" 23, 4:30 p.m.	18" " "	5.7	5.8	5.75	28°c	71.79	
" 23, 4:30 "	" 23, 4:30 "	18" " "	5.7	5.6	5.65	"	71.52	
" 24, 4:30 a.m.	" 24, 4:30 a.m.	18" " "	5.5	5.55	5.52	"	69.87	
" 24, 1:45 p.m.	" 24, 1:45 p.m.	18" " "	6.	6.	6.	"	75.95	
July 27, 3:30 p.m.	July 27, 3:30 p.m.	18" " "	8.2	8.3	8.25	32°c	113.01	
" 27, 3:30 "	" 27, 3:30 "	18" " "	8.21	......	......	"	112.46	Winkler's Method.
" 27, 3:30 "	" 27, 3:30 "	18" " "	8.25	......	......	"	113.01	
" 27, 4:00 "	" 27, 4:00 "	11' " "	6.25	6.25	6.25	31°c	83.89	
" 27, 4:30 "	" 27, 4:30 "	4" " "	9.6	9.7	9.65	34°c	137.85	
" 27, 5:00 "	" 27, 5:00 "	11' " "	5.98	......	......	31°c	80.28	Winkler's Method.
" 27, 5:00 "	" 27, 5:00 "	11' " "	5.86	......	......	"	78.66	
" 27, 5:45 "	" 27, 5:45 "	18" " "	7.7	7.8	7.75	33°c	106.16	
" 27, 8:30 "	" 27, 8:30 "	18" " "	6.4	......	......	"	87.67	
" 27, 8:30 "	" 27, 8:30 "	18" " "	6.63	......	......	"	90.82	
" 28, 6:20 a.m.	" 28, 6:20 a.m.	18" " "	6.	6.	6.	30°c	78.94	
" 28, 6:30 "	" 28, 6:30 "	18" " "	5.91	......	......	"	77.76	Winkler's Method.
" 28, 6:30 "	" 28, 6:30 "	18" " "	5.96	......	......	"	78.42	
" 28, 11:30 "	" 28, 11:30 "	18" " "	6.3	......	......	29°c	81.30	
" 28, 11:30 "	" 28, 11:30 "	18" " "	6.29	......	......	"	81.27	
" 28, 11:30 "	" 28, 11:30 "	18" from bottom	5.32	......	......	28°c	67.34	
" 28, 11:30 "	" 28, 11:30 "	18" " "	5.32	......	......	"	67.34	
" 28, 3:30 p.m.	" 28, 3:30 p.m.	18" below surface	7.15	7.2	7.17	30°c	94.34	
" 28, 3:45 "	" 28, 3:45 "	18" from bottom	6.35	6.35	6.35	"	83.56	
" 28, 4:20 "	" 28, 4:20 "	4" below surface	9.35	......	......	"	123.03	
" 28, 4:30 "	" 28, 4:30 "	2" " "	8.18	......	......	"	107.63	
" 28, 4:30 "	" 28, 4:30 "	2" " "	8.18	......	......	"	107.63	
Aug. 25, 7:50 a.m.	Aug. 25, 7:50 a.m.	18" " "	5.8	5.9	5.85	28°c	74.05	
" 25, 11:40 p.m.	" 25, 11:40 p.m.	18" " "	7.	7.1	7.05	31°c	94.63	
" 25, 3:40 "	" 25, 3:40 "	18" " "	7.	6.8	6.9	"	93.24	
" 25, 8:35 a.m.	" 25, 8:35 a.m.	2' from bottom	5.4	5.4	5.4	28°c	68.35	
" 25, 12:15 p.m.	" 25, 12:15 p.m.	2' " "	5.2	5.2	5.2	29°c	67.18	
" 25, 4:00 "	" 25, 4:00 "	2' " "	4.9	4.9	4.9	30°c	64.47	
Dec. 28, 1:30 p.m.	Dec. 29, 5:00 p.m.	18" below surface	12.9	13.5	13.2	0°c	89.79	Center Channel.
" 28, 1:30 "	" 30, a.m.	18" " "	12.7	12.4	12.55	"	85.37	Opp. side "
" 28, 1:30 "	" 30, a.m.	18" " "	13.1	13.1	13.1	"	89.11	⅓ dist. fr. main shore.
1900	1900							
Jan. 4, 11:00 a.m.	Jan. 5, 12:00 m.	18" below surface	11.7	11.5	11.6	0°c	78.90	
" 4, 11:00 "	" 6, 2:20 p.m.	18" " "	11.	11.1	11.05	"	75.51	
" 4, 11:00 "	" 6, 2:20 "	18" " "	10.9	10.8	10.85	"	73.81	
" 4, 11:00 "	" 6, 11:00 a.m.	2' from bottom	10.9	10.9	10.9	"	74.15	
" 4, 11:00 "	" 6, 11:00 "	2' " "	11.1	11.1	11.1	"	75.51	
" 17, 11:00 "	" 18, 12.00 m.	18" below surface	12.	11.8	11.9	3°c	88.14	
" 17, 11:00 "	" 18, 12:00 m.	18" " "	12.	Lost	......	"	88.88	
" 17, 11:00 "	" 18, 2:00 p.m.	2' from bottom	12.	12.	12.	"	88.88	
" 17, 11:00 "	" 18, 2:00 "	2' " "	12.1	12.	12.05	"	89.20	
" 24, 11:30 "	" 25, 10:30 a.m.	18" below surface	10.8	10.8	10.8	4°c	82.13	
" 24, 11:30 "	" 25, 10:30 "	18" " "	10.9	10.9	10.9	"	82.88	
" 24, 11:30 "	" 25, 10:30 "	2' from bottom	10.8	10.8	10.8	"	82.13	
" 24, 11:30 "	" 26, 10:30 "	2' " "	10.9	10.9	10.9	"	82.88	
" 28, 11:00 "	" 31, 10:25 "	18" below surface	11.3	11.3	11.3	0°c	76.87	
" 28, 11:00 "	" 31, 10:25 "	2' from bottom	11.9	11.7	11.8	"	80.27	
Feb. 7, 11:30 a.m.	Feb. 9, 8:50 a.m.	18" below surface	12.8	12.8	12.8	"	87.07	
" 7, 11:30 "	" 9, 8:50 "	18" " "	12.9	12.8	12.85	"	87.41	
" 7, 11:30 "	" 9, 9:20 "	2' from bottom	12.9	12.9	12.9	"	87.75	
" 7, 11:30 "	" 10, 8:15 "	2' " "	12.5	12.4	12.45	"	84.69	
" 12, 1:30 p.m.	" 14, 8:45 "	18" below surface	11.7	11.7	11.7	"	79.59	
" 12, 1:30 "	" 14, 8:45 "	18" " "	11.5	11.5	11.5	"	78.23	
" 12, 1:30 "	" 14, 9:45 "	2' from bottom	11.6	11.5	11.55	"	78.57	
" 12, 1:30 "	" 15, 9:45 "	2' " "	11.1	11.1	11.1	"	75.51	
" 14, 11:30 a.m.	" 16, 8:30 "	18" below surface	11.8	11.8	11.8	"	80.27	
" 14, 11:30 "	" 16, 8:30 "	18" " "	11.8	11.8	11.8	"	80.27	
" 14, 11:30 "	" 16, 9:20 "	2' from bottom	11.7	11.7	11.7	"	79.59	
" 14, 11:30 "	" 17, 8:25 "	2' " "	11.5	11.5	11.5	"	78.23	
" 19, 11:00 "	" 20, 5:00 p.m.	18" below surface	10.9	10.9	10.9	"	82.88	
" 19, 11:00 "	" 21, 8;15 a.m.	18" " "	10.6	10.6	10.6	"	72.11	
" 19, 11:00 "	" 21, 8:50 "	2' from bottom	9.9	9.9	9.9	"	67.34	
" 19, 11:00 "	" 21, 8:50 "	2' " "	10.4	......	......	"	70.74	
" 21, 11:00 "	" 23, 10:40 "	2' " "	9.9	9.7	9.8	"	66.66	
" 21, 11:00 "	" 23, 10:40 "	2' " "	10.	9.9	9.95	"	67.69	

DISSOLVED OXYGEN IN THE WATER OF THE ILLINOIS RIVER, GRAFTON—Continued.

Date of Collection.	Date of Determination.	Depth of Collection.	Mg. per Liter. 1	Mg. per Liter. 2	Mg. per Liter. Aver.	Temp. of Water.	Per cent Saturation.	Remarks.
1900	1900							
Feb. 22, 10:30 p.m.	Feb. 26, 11:15 p.m.	18" below surface	8.6	8.6	8.6	0°c	58.5	
" 22, 10:30 "	" 26, 11:15 "	18" " "	8.7	8.7	8.7	"	59.15	
" 22, 10:30 "	" 26, 11:40 "	2' from bottom	7.9	8.	7.95	"	54.08	
" 22, 10:30 "	" 27, 8:15 "	2' " "	7.9	8.2	8.05	"	54.76	Test of keeping qualities.
Mar. 2, 1:30 p.m.	Mar. 3, 5:15 p.m.	18" below surface	11.1	11.1	11.1	"	75.51	
" 2, 1:30 "	" 5, 8:30 a.m.	18" " "	10.9	10.9	10.9	"	74.15	
" 2, 1:30 "	" 5, 9:35 "	2' from bottom	10.9	10.8	10.85	"	73.81	
" 2, 1:30 "	" 5, 9:35 "	2' " "	10.4	10.4	10.4	"	70.75	
" 5, 2:00 "	" 6, 12:45 p.m.	18" below surface	11.2	11.3	11.25	"	76.53	
" 5, 2:00 "	" 6, 12:45 "	18" " "	11.2	11.2	11.2	"	76.19	
" 5, 2:00 "	" 6, 1:10 "	2' from bottom	11.3	11.2	11.25	"	76.53	
" 5, 2:00 "	" 7, 8:25 a.m.	2' " "	11.1	11.1	11.1	"	75.51	Test of keeping qualities.
" 7, 11:00 a.m.	" 8, 4:35 p.m.	18" below surface	11.1	Lost	......	"	75.51	
" 7, 11:00 "	" 8, 5:10 "	18" " "	11.7	11.7	11.7	"	79.59	
" 7, 11:00 "	" 9, 8:15 a.m.	2' from bottom	11.2	11.3	11.25	"	76.53	
" 7, 11:00 "	" 9, 8:15 "	2' " "	11.5	11.5	11.5	"	78.23	
" 9, 11:30 "	" 10, 5:00 p.m.	18" below surface	11.7	11.8	11.75	"	79.93	
" 9, 11:30 "	" 10, 5:30 "	18" " "	11.7	11.7	11.7	"	79.59	
" 9, 11:30 "	" 12, 8:25 a.m.	2' from bottom	10.1	10.1	10.1	"	68.71	
" 9, 11:30 "	" 12, 8:25 "	2' " "	10.3	10.3	10.3	"	70.07	
" 12, 11:30 "	" 13, 5:00 p.m.	18" below surface	10.6	10.6	10.6	2°c	76.42	
" 12, 11:30 "	" 14, 8:00 a.m.	18" " "	10.3	10.2	10.25	"	73.90	Test of keeping qualities.
" 12, 11:30 "	" 13, 5:20 p.m.	2' from bottom	10.9	10.8	10.85	"	77.50	
" 12, 11:30 "	" 14, 8:35 a.m.	2' " "	10.5	10.5	10.5	"	75.70	Test of keeping qualities.
" 14, 10:30 "	" 15, 4:30 p.m.	18" below surface	10.3	10.3	10.3	4°c	78.33	
" 14, 10:30 "	" 16, 8:00 a.m.	18" " "	10.3	10.3	10.3	"	78.33	Test of keeping qualities.
" 19, 1:00 p.m.	" 20, 4:15 p.m.	18" " "	11.1	11.1	11.1	0°c	75.51	
" 19, 1:00 "	" 21, 8:15 a.m.	18" " "	11.	11.1	11.05	"	75.17	
" 19, 1:00 "	" 20, 4:45 p.m.	2' from bottom	11.1	11.1	11.1	"	75.51	
" 19, 1:00 "	" 21, 8:40 a.m.	2' " "	10.9	11.1	11.	"	74.83	
" 21, 10:30 a.m.	" 22, 4:30 p.m.	18" below surface	11.1	11.1	11.1	3°c	82.22	
" 21, 10:30 "	" 23, 8:30 a.m.	18" " "	10.9	10.9	10.9	"	80.74	
" 21, 10:30 "	" 22, 5:15 p.m.	2' from bottom	11.	11.2	11.1	"	82.22	
" 21, 10:30 "	" 23, 9:00 a.m.	2' " "	11.	11.	11.	"	81.48	
" 23, 11:00 "	" 24, 4:50 p.m.	18" below surface	11.2	11.2	11.2	"	82.96	
" 23, 11:00 "	" 26, 8:45 a.m.	18" " "	10.3	10.3	10.3	"	76.29	
" 23, 11:00 "	" 26, 8:20 "	2' from bottom	10.1	10.5	10.3	"	76.29	
" 23, 11:00 "	" 26, 8:20 "	2' " "	10.3	10.3	10.3	"	76.29	
" 26, 11:30 "	" 28, 10:20 "	18" below surface	10.	10.1	10.05	4°c	76.42	
" 26, 11:30 "	" 28, 10:20 "	18" " "	10.	10.	10.	"	76.04	
" 26, 11:30 "	" 28, 10:50 "	2' from bottom	10.2	10.2	10.2	"	77.56	
" 26, 11:30 "	" 29, 9:00 "	2' " "	9.9	10.	9.95	"	75.66	
" 28, 11:30 "	" 29, 5:00 p.m.	18" below surface	9.8	9.9	9.85	3°c	72.96	
" 28, 11:30 "	" 30, 8:20 a.m.	18" " "	9.6	9.5	9.55	"	70.74	
" 28, 11:30 "	" 30, 8:50 "	2' from bottom	10.2	10.2	10.2	"	75.55	
" 28, 11:30 "	" 30, 8:50 "	2' " "	10.	10.	10.	"	74.07	
" 30, 11:30 "	April 2, 10:25 a.m.	18" below surface	8.4	8.4	8.4	"	62.22	
" 30, 11:30 "	" 2, 10:25 "	18" " "	8.7	8.7	8.7	"	64.44	
" 30, 11:30 "	" 2, 11:25 "	2' from bottom	9.5	9.4	9.45	"	70.00	
April 2, 11:30 a.m.	" 3, 5:00 p.m.	18" below surface	10.	9.9	9.95	4°c	75.66	
" 2, 11:30 "	" 4, 9:15 a.m.	18" " "	10.2	10.2	10.2	"	77.56	
" 2, 11:30 "	" 4, 8:50 "	2' from bottom	10.	9.9	9.95	"	75.66	
" 2, 11:30 "	" 4, 8:50 "	2' " "	10.	10.	10.	"	76.04	
" 4, 11:00 "	" 5, 4:50 p.m.	18" below surface	9.9	10.	9.95	"	75.66	
" 4, 11:00 "	" 6, 8:50 a.m.	18" " "	9.9	9.9	9.9	"	75.29	
" 4, 11:00 "	" 6, 8:20 "	2' from bottom	9.7	9.7	9.7	"	73.76	
" 4, 11:00 "	" 6, 8:20 "	2' " "	10.	10.	10.	"	76.04	
" 6, 11:30 "	" 7, 4:50 p.m.	18" below surface	9.5	9.5	9.5	5°c	74.10	
" 6, 11:30 "	" 9, 8:00 a.m.	18" " "	8.7	8.7	8.7	"	67.86	
" 6, 11:30 "	" 7, 5:25 p.m.	2' from bottom	9.3	9.3	9.3	"	72.54	
" 6, 11:30 "	" 9, 8:00 a.m.	2' " "	8.6	8.6	8.6	"	67.08	
" 9, 11:00 "	" 10, 5:00 p.m.	18" below surface	8.8	8.8	8.8	11°c	79.56	
" 9, 11:00 "	" 11, 8:00 a.m.	18" " "	8.7	8.7	8.7	"	78.66	
" 9, 11:00 "	" 11, 8:30 "	2' from bottom	8.8	8.7	8.75	"	79.11	
" 9, 11:00 "	" 11, 8:30 "	2' " "	8.7	8.8	8.75	"	79.11	
" 11, 11:00 "	" 12, 4:50 p.m.	18" below surface	9.4	9.4	9.4	9°c	81.17	
" 11, 11:00 "	" 13, 8:10 a.m.	18" " "	9.3	9.3	9.3	"	80.31	
" 11, 11:00 "	" 12, 5:15 p.m.	2' from bottom	10.	9.9	9.95	"	85.91	
" 11, 11:00 "	" 13, 8:10 a.m.	2' " "	9.9	9.9	9.9	"	85.49	
" 13, 11:30 "	" 14, 4:40 p.m.	18" below surface	10.1	10.1	10.1	"	87.22	
" 13, 11:30 "	" 14, 5:10 "	18" " "	10.2	10.3	10.25	"	88.51	
" 13, 11:30 "	" 16, 8:20 a.m.	2' from bottom	9.6	9.6	9.6	"	82.90	
" 13, 11:30 "	" 16, 8:50 "	2' " "	10.2	10.1	10.15	"	87.65	
" 16, 11:30 "	" 17, 5:00 p.m.	18" below surface	9.5	9.6	9.55	10°c	84.43	
" 16, 11:30 "	" 18, 8:25 a.m.	2' from bottom	9.9	9.9	9.9	"	87.53	
" 16, 11:30 "	" 18, 8:25 "	2' " "	9.9	9.7	9.8	"	86.64	
" 20, 11:30 "	" 21, 10:45 "	18" below surface	9.	8.9	8.95	11°c	80.92	
" 20, 11:30 "	" 21, 10:45 "	18" " "	8.9	8.9	8.9	"	80.47	
" 20, 11:30 "	" 21, 11:15 "	2' from bottom	8.8	8.7	8.75	"	79.11	
" 20, 11:30 "	" 21, 11:15 "	2' " "	8.6	8.6	8.6	"	77.74	
" 23, 11:30 "	" 24, 5:00 p.m.	18" below surface	8.	8.3	8.15	14°c	71.91	
" 23, 11:30 "	" 25, 8:35 a.m.	18" " "	8.2	8.1	8.15	"	71.91	
" 23, 11:30 "	" 25, 8:00 "	2' from bottom	7.6	7.6	7.6	"	73.36	
" 23, 11:30 "	" 25, 8:00 "	2' " "	7.3	7.2	7.25	"	69.98	
May 2, 11:30 a.m.	May 3, 11:00 a.m.	18" below surface	8.2	8.1	8.15	20°c	88.68	
" 2, 11:30 "	" 3, 11:00 "	18" " "	8.2	8.2	8.2	"	89.23	

DISSOLVED OXYGEN IN THE WATER OF THE

ILLINOIS RIVER, GRAFTON—Concluded.

Date of Collection.	Date of Determination.	Depth of Collection.	Mg. per Liter.			Temp. of Water.	Per cent Saturation.	Remarks.
			1	2	Aver.			
1900	1900							
May 2, 11:30 a.m.	May 3, 11:25 a.m.	2' from bottom	8.8	8.8	8.8	20°c	95.75	
" 2, 11:30 "	" 4, 10:00 "	2' " "	8.2	8.2	8.2	"	89.23	
" 9, 11:00 "	" 10, 4:45 p.m.	18" below surface	6.7	6.8	6.75	19°c	72.03	
" 9, 11:00 "	" 11, 8:10 a.m.	18" " "	6.3	6.3	6.3	"	67.23	
" 9, 11:00 "	" 10, 5:10 p.m.	2' from bottom	6.9	6.9	6.9	"	73.64	
" 9, 11:00 "	" 11, 8:25 a.m.	2' " "	6.5	6.5	6.5	"	69.37	
" 16, 11:30 "	" 18, p.m.	18" below surface	3.7	3.8	3.75	25°c	44.91	
" 16, 11:30 "	" 18, p.m.	18" " "	3.8	3.7	3.75	"	44.91	
" 16, 11:30 "	" 18, p.m.	2' from bottom	3.7	3.5	3.6	"	43.11	
" 16, 11:30 "	" 18, p.m.	2' " "	3.8	3.8	3.8	"	45.51	
" 30, 11:30 "	" 31, 1:50 p.m.	18" below surface	5.1	5.1	5.1	"	61.08	
" 30, 11:30 "	" 31, 1:50 "	18" " "	5.1	5.1	5.1	"	61.08	
" 30, 11:30 "	" 31, 2:50 "	2' from bottom	5.2	5.3	5.25	"	62.87	
" 30, 11:30 "	June 1, 10:15 a.m.	2' " "	5.1	5.1	5.1	"	61.08	
June 6, 11:30 "	" 7, 4:30 p.m.	18" below surface	4.4	4.4	4.4	"	52.69	
" 6, 11:30 "	" 7, 4:30 "	18" " "	5.2	5.2	5.2	"	62.27	
" 13, 11:30 "	" 14, 4:30 "	18" " "	5.2	5.2	5.2	27°c	64.75	
" 13, 11:30 "	" 14, 4:30 "	18" " "	5.8	5.7	5.75	"	71.61	
" 13, 11:30 "	" 15, 9:00 a.m.	2' from bottom	4.7	4.6	4.65	"	57.97	
" 27, 11:30 "	" 28, 10:00 "	18" below surface	5.3	5.5	5.4	"	67.24	
" 27, 11:30 "	" 28, 10:00 "	18" " "	5.4	5.4	5.4	"	67.24	
" 27, 11:30 "	" 28, 1:30 p.m.	2' from bottom	5.4	5.5	5.45	"	67.87	
July 7, 5:00 p.m.	July 7, 5:00 p.m.	18" below surface	7.3	7.2	7.25	30°c	95.4	
" 7, 5:00 "	" 7, 5:00 "	2' from bottom	7.2	7.2	7.2	"	94.7	
" 7, 5:45 "	" 7, 5:45 "	18" below surface	7.	7.	7.	"	92.8	
MISSISSIPPI RIVER, GRAFTON.								
1899	1899							
April 29, 4:30 p.m.	April 29, 4:30 p.m.	18" below surface	8.9	8.9	8.9	18°c	93.19	
June 24, 3:00 p.m.	June 24, 3:00 p.m.	18" " "	7.	6.8	6.9	27°c	85.9	
July 27, 7:30 p.m.	July 27, 7:30 p.m.	18" " "	8.6	8.8	8.7	31°c	116.7	
" 28, 9:15 a.m.	" 28, 9:15 a.m.	18" " "	7.09	......	......	29°c	91.7	Winkler.
" 28, 9:15 "	" 28, 9:15 "	18" " "	7.1	......	......	"	91.7	
" 28, 2:30 p.m.	" 28, 2:30 p.m.	18" " "	8.9	8.7	8.8	30°c	115.8	
Aug. 25, 10:08 a.m.	Aug. 25, 10:08 a.m.	18" " "	7.3	7.4	7.35	27°c	91.53	
" 25, 2:05 p.m.	" 25, 2:05 p.m.	18" " "	8.	8.1	8.05	28°c	101.89	
" 25, 2:30 "	" 25, 2:30 "	18" " "	8.1	8.1	8.1	"	102.53	
Dec. 28, 1:30 p.m.	Dec. 29, 5:00 "	18" " "	13.7	13.7	13.7	0°c	93.19	Center Channel.
" 22, 1:30 "	" 30, 9:30 a.m.	18" " "	13.1	13.	13.05	"	88.77	Near Dyke.
" 28, 1:30 "	" 30, 9:00 "	18" " "	14.1	14.	14.05	"	95.58	Mo. Shore.
1900	1900							
Jan. 4, 1:30 p.m.	Jan. 5, 12:00 m.	18" below surface	15.5	14.1	14.8	"	100.65	
" 4, 1:30 "	" 5, 12:00 m.	18" " "	16.	16.	16.	"	108.84	
" 4, 1:30 "	" 6, 8:30 a.m.	18" " "	15.6	15.8	15.7	"	106.8	
" 4, 1:30 "	" 6, 10:30 "	2' from bottom	15.4	15.4	15.4	"	104.76	
" 4, 1:30 "	" 6, 10:30 "	2' " "	14.6	14.8	14.7	"	100.00	
" 17, 1:30 "	" 18, 11:00 "	18" below surface	14.6	14.4	14.5	3°c	107.41	
" 17, 1:30 "	" 18, 11:00 "	18" " "	14.6	14.4	14.5	"	107.41	
" 17, 1:30 "	" 18, 11:15 "	2' from bottom	14.6	14.1	14.35	"	106.29	
" 17, 1:30 "	" 18, 11:15 "	2' " "	13.9	14.	13.95	"	103.33	
" 24, 2:00 "	" 25, 11:00 "	18" below surface	12.7	12.9	12.8	4°c	97.33	
" 24, 2:00 "	" 25, 11:00 "	18" " "	12.6	12.5	12.55	"	95.44	
" 24, 2:00 "	" 25, 11:30 "	2' from bottom	12.7	12.6	12.65	"	96.19	
" 24, 2:00 "	" 26, 10:30 "	2' " "	12.8	12.7	12.75	"	96.96	
" 28, 12:15 "	" 31, 11:30 "	18" below surface	11.9	11.7	11.8	0°c	80.27	
" 28, 12:15 "	" 31, 11:30 "	18" " "	12.	11.9	11.95	"	81.29	
" 28, 12:15 "	" 31, 11:30 "	2' from bottom	12.5	12.5	12.5	"	85.03	
" 28, 12:15 "	Feb. 1, 12:45 p.m.	2' " "	12.5	12.4	12.45	"	84.69	
Feb. 7, 2:30 p.m.	" 9, 8:20 a.m.	18" below surface	10.6	10.6	10.6	"	72.11	
" 7, 2:30 "	" 9, 8:20 "	18" " "	10.3	10.4	10.35	"	70.41	
" 7, 2:30 "	" 9, 9:20 "	2' from bottom	9.4	9.6	9.5	"	64.62	
" 7, 2:30 "	" 10, 8:15 "	2' " "	8.2	8.2	8.2	"	55.78	
" 12, 2:30 "	" 14, 9:15 "	18" below surface	13.	13.1	13.05	"	88.77	
" 12, 2:30 "	" 14, 9:15 "	18" " "	12.8	12.7	12.75	"	86.73	
" 12, 2:30 "	" 14, 9:45 "	2' from bottom	12.9	12.8	12.85	"	87.41	
" 12, 2:30 "	" 15, 9:45 "	2' " "	12.8	12.7	12.75	"	86.73	
" 14, 1:00 "	" 16, 8:50 "	18" below surface	13.	13.2	13.1	"	89.12	
" 14, 1:00 "	" 16, 8:50 "	2' from bottom	12.8	12.9	12.85	"	87.41	
" 14, 1:00 "	" 17, 8:25 "	2' " "	13.3	13.3	13.3	"	90.48	
" 19, 2:00 "	" 20, 5:00 p.m.	18" below surface	11.6	11.6	11.6	"	78.91	
" 19, 2:00 "	" 21, 8:15 a.m.	2' from bottom	11.4	11.3	11.35	"	70.41	
" 21, 1:30 "	" 23, 11:10 "	18" below surface	10.8	10.9	10.85	"	73.81	
" 21, 1:30 "	" 23, 11:10 "	2' from bottom	10.9	10.9	10.9	"	74.15	
" 22, 11:30 a.m.	" 26, 10:35 "	18" below surface	9.3	9.4	9.35	"	63.60	
" 22, 11:30 "	" 26, 10:35 "	2' from bottom	9.2	9.2	9.2	"	62.58	
Mar. 2, 11:00 a.m.	Mar. 3, 5:15 p.m.	18" below surface	12.5	12.5	12.5	"	85.03	
" 2, 11:00 "	" 5, 8:30 a.m.	18" " "	12.5	12.5	12.5	"	85.03	
" 2, 11:00 "	" 5, 9:10 "	2' from bottom	12.6	12.6	12.6	"	85.71	
" 2, 11:00 "	" 5, 9:10 "	2' " "	12.5	12.6	12.55	"	85.37	
" 5, 11:30 "	" 6, 11:30 "	18" below surface	12.3	12.5	12.4	"	84.35	
" 5, 11:30 "	" 6, 11:30 "	18" " "	12.3	12.3	12.3	"	83.67	
" 5, 11:30 "	" 6, 1:10 p.m.	2' from bottom	12.4	12.4	12.4	"	84.35	
" 5, 11:30 "	" 7, 8:25 a.m.	2' " "	12.4	12.4	12.4	"	84.35	
" 7, 2:00 p.m.	" 8, 4:35 p.m.	18" below surface	12.6	12.6	12.6	"	85.71	
" 7, 2:00 "	" 8, 4:35 "	18" " "	12.6	12.5	12.55	"	85.37	

DISSOLVED OXYGEN IN THE WATER OF THE

MISSISSIPPI RIVER, GRAFTON—Continued.

Date of Collection.	Date of Determination.	Depth of Collection.	Mg. per Liter. 1	2	Aver.	Temp. of Water.	Per cent Saturation.	Remarks.
1900	1900							
Mar. 7, 2:00 p.m.	Mar. 9, 8:45 a.m.	2' from bottom	13.	13.	13.	0°c	88.43	
" 7, 2:00 "	" 9, 8:45 "	2' " "	13.	12.9	12.95	"	88.09	
" 9, 1:00 "	" 10, 5:00 p.m.	18" below surface	12.7	12.7	12.7	"	86.39	
" 9, 1:00 "	" 12, 8:50 a.m.	18" " "	12.	12.1	12.05	"	81.97	
" 9, 1:00 "	" 10, 5:30 p.m.	2' from bottom	12.6	12.6	12.6	"	85.71	
" 9, 1:00 "	" 12, 8:30 a.m.	2' " "	12.	12.	12.	"	81.63	
" 12, 1:00 "	" 13, 5:00 p.m.	18" below surface	11.7	11.8	11.75	2°c	84.71	
" 12, 1:00 "	" 14, 8:00 a.m.	18" " "	11.2	11.3	11.25	"	81.11	
" 12, 1:00 "	" 13, 5:20 p.m.	2' from bottom	12.	12.	12.	"	86.52	
" 12, 1:00 "	" 14, 8:35 a.m.	2' " "	11.7	11.7	11.7	"	84.35	
" 14, 11:30 "	" 15, 5:30 p.m.	18" below surface	10.5	10.5	10.5	4°c	79.84	
" 14, 11:30 "	" 16, 8:00 a.m.	18" " "	10.1	10.	10.05	"	76.42	
" 14, 11:30 "	" 16, 9:00 "	2' from bottom	10.2	10.3	10.25	"	77.94	
" 14, 11:30 "	" 16, 9:00 "	2' " "	10.1	10.	10.05	"	76.42	
" 19, 2:00 "	" 20, 4:15 p.m.	18" below surface	10.5	10.7	10.6	0°c	72.11	
" 19, 2:00 "	" 21, 8:15 a.m.	18" " "	10.3	10.6	10.45	"	71.09	
" 19, 2:00 "	" 20, 4:45 p.m.	2' from bottom	10.5	10.7	10.6	"	72.11	
" 19, 2:00 "	" 21, 8:40 a.m.	2' " "	10.7	11.	10.85	"	73.81	
" 21, 11:30 a.m.	" 22, 4:30 p.m.	18" below surface	11.8	12.	11.9	3°c	88.14	
" 21, 11:30 "	" 23, 8:30 a.m.	18" " "	10.7	11.1	10.9	"	80.74	
" 21, 11:30 "	" 23, 5:15 p.m.	2' from bottom	11.8	11.8	11.8	"	87.41	
" 23, 1:00 p.m.	" 24, 4:50 "	18" below surface	10.4	10.6	10.5	"	77.77	
" 23, 1:00 "	" 26, 8:45 a.m.	2' from bottom	9.4	9.5	9.45	"	70.00	
" 26, 1:00 "	" 28, 10:50 "	18" below surface	10.6	10.6	10.6	4°c	80.61	
" 28, 1:00 "	" 28, 10:50 "	2' from bottom	10.9	10.8	10.85	"	82.51	
" 26, 1:00 "	" 29, 9:00 "	2' " "	10.2	10.2	10.2	"	77.56	
" 28, 1:00 "	" 29, 5:00 p.m.	18" below surface	10.9	10.9	10.9	"	82.89	
" 28, 1:00 "	" 30, 8:20 a.m.	18" " "	10.7	10.6	10.65	"	80.98	
" 28, 1:00 "	" 30, 9:25 "	2' from bottom	11.1	11.	11.05	"	84.03	
" 28, 1:00 "	" 30, 9:25 "	2' " "	10.8	10.8	10.8	"	82.13	
" 30, 1:00 "	April 2, 11:55 a.m.	18" below surface	10.6	10.6	10.6	"	80.61	
" 30, 1:00 "	" 2, 11:55 "	2' from bottom	10.9	10.9	10.9	"	82.89	
April 2, 1:00 p.m.	" 3, 5:00 p.m.	18" below surface	12.2	12.2	12.2	5°c	95.16	
" 2, 1:00 "	" 4, 8:20 a.m.	2' from bottom	11.5	11.5	11.5	"	89.70	
" 2, 1:00 "	" 4, 8:20 "	2' " "	11.1	11.	11.05	"	86.19	
" 4, 1:00 "	" 5, 4:50 p.m.	18" below surface	10.4	10.4	10.4	"	81.12	
" 4, 1:00 "	" 6, 8:50 a.m.	2' from bottom	10.4	10.3	10.35	"	80.73	
" 6, 1:00 "	" 7, 4:50 p.m.	18" below surface	9.4	9.5	9.45	4°c	71.86	
" 6, 1:00 "	" 9, 8:30 a.m.	18" " "	8.2	8.2	8.2	"	62.35	
" 6, 1:00 "	" 7, 5:25 p.m.	2' from bottom	10.5	10.4	10.45	"	79.46	
" 9, 1:00 "	" 10, 5:00 "	18" below surface	9.5	9.5	9.5	9°c	82.04	
" 9, 1:00 "	" 11, 8:00 a.m.	18" " "	9.4	9.5	9.45	"	81.61	
" 9, 1:00 "	" 11, 9:10 "	2' from bottom	9.7	9.7	9.7	"	83.76	
" 9, 1:00 "	" 11, 9:10 "	2' " "	9.9	9.9	9.9	"	85.49	
" 11, 1:00 "	" 12, 4:50 p.m.	18" below surface	9.9	9.8	9.85	8°c	82.98	
" 11, 1:00 "	" 12, 5:15 "	2' from bottom	9.3	Lost	......	"	78.35	
" 13, 1:00 "	" 14, 4:40 "	18" below surface	10.4	10.4	10.4	"	87.61	
" 13, 1:00 "	" 14, 5:10 "	18" " "	10.5	10.5	10.5	"	88.46	
" 13, 1:00 "	" 16, 8:20 a.m.	2' from bottom	10.4	10.4	10.4	"	87.61	
" 13, 1:00 "	" 16, 8:50 "	2' " "	9.8	9.8	9.8	"	82.56	
" 16, 1:00 "	" 17, 5:00 p.m.	18" below surface	10.5	10.5	10.5	11°c	94.93	
" 16, 1:00 "	" 18, 9:20 a.m.	18" " "	9.8	9.7	9.75	"	88.15	
" 16, 1:00 "	" 18, 9:00 "	2' from bottom	10.	10.	10.	"	90.41	
" 16, 1:00 "	" 18, 9:00 "	2' " "	10.3	10.3	10.3	"	93.13	
" 20, 1:00 "	" 21, 10:00 "	18" below surface	9.6	9.7	9.65	"	87.25	
" 20, 1:00 "	" 21, 10:00 "	18" " "	9.7	9.7	9.7	"	87.70	
" 20, 1:00 "	" 21, 11:15 "	2' from bottom	8.9	8.9	8.9	"	80.47	
" 23, 1:00 "	" 24, 5:00 p.m.	18" below surface	8.6	8.6	8.6	14°c	83.59	
" 23, 1:00 "	" 25, 8:00 a.m.	18" " "	7.7	7.7	7.7	"	74.32	
" 23, 1:00 "	" 25, 9:10 "	2' from bottom	8.6	8.6	8.6	"	83.01	
" 23, 1:00 "	" 25, 9:10 "	2' " "	8.3	8.4	8.35	"	82.53	
May 2, 1:00 p.m.	May 3, 10:30 a.m.	18" below surface	8.5	8.5	8.5	19°c	90.71	
" 2, 1:00 "	" 3, 10:30 "	18" " "	8.2	8.3	8.25	"	88.04	
" 2, 1:00 "	" 3, 11:25 "	2' from bottom	8.9	8.9	8.9	"	94.98	
" 2, 1:00 "	" 4, 10:00 "	2' " "	8.1	8.2	8.15	"	86.98	
" 9, 1:00 "	" 10, 4:45 p.m.	18" below surface	7.3	7.3	7.3	18°c	76.44	
" 9, 1:00 "	" 11, 8:10 a.m.	18" " "	7.2	7.2	7.2	"	75.39	
" 9, 1:00 "	" 10, 5:10 p.m.	2' from bottom	7.9	7.9	7.9	"	82.72	
" 9, 1:00 "	" 11, 8:35 a.m.	2' " "	7.5	7.5	7.5	"	78.53	
" 16, 1:00 "	" 18, p.m.	18" below surface	6.	6.	6.	23°c	69.20	
" 16, 1:00 "	" 18, p.m.	2' from bottom	6.4	6.3	6.35	"	73.24	
" 30, 1:00 "	" 31, 2:30 p.m.	18" below surface	7.2	7.1	7.15	24°c	84.02	
" 30, 1:00 "	" 31, 2:30 "	18" " "	7.1	7.1	7.1	"	83.43	
" 30, 1:00 "	June 1, 10:15 a.m.	2' from bottom	7.	7.	7.	"	82.25	
June 6, 1:00 p.m.	" 7, 5:00 p.m.	18" below surface	5.8	5.8	5.8	25°c	69.46	
" 6, 1:00 "	" 7, 5:00 "	18" " "	6.	6.	6.	"	71.86	
" 6, 1:00 "	" 8, 11:00 a.m.	2' from bottom	6.4	6.4	6.4	"	76.65	
" 13, 1:00 "	" 14, 4:40 p.m.	18" below surface	6.6	6.7	6.65	26°c	81.19	
" 13, 1:00 "	" 15, 9:00 a.m.	2' from bottom	6.4	6.1	6.25	"	76.31	
" 27, 1:00 "	" 28, 12:40 p.m.	18" below surface	6.5	6.3	6.4	27°c	79.70	
" 27, 1:00 "	" 28, 12:40 "	18" " "	6.2	6.2	6.2	"	77.21	
" 27, 1:00 "	" 28, 1:00 "	2' from bottom	5.8	5.7	5.75	"	71.61	
" 27, 1:00 "	" 28, 1:00 "	2' " "	5.9	6.	5.95	"	74.09	
July 7, 5:45 p.m.	July 7, 5:45 p.m.	18" below surface	7.4	7.3	7.35	29°c	94.9	
....	....	....	......	......	......	......	......	

DISSOLVED OXYGEN IN THE WATER OF THE

MISSISSIPPI RIVER, ALTON.

Date of Collection.	Date of Determination.	Depth of Collection.	Mg. per Liter. 1	Mg. per Liter. 2	Mg. per Liter. Aver.	Temp. of Water.	Per cent Saturation.	Remarks.
1899	1899							
June 25, 9:30 a.m.	June 25, 9:30 a.m.	18" below surface	7.6	7.6	7.6	26°c	92.8	Missouri shore.
" 25, 9:45 "	" 25, 9:45 "	18" " "	7.3	7.2	7.25	"	88.5	Midstream.
" 25, 10:00 "	" 25, 10:00 "	18" " "	7.0	6.8	6.9	"	84.2	Missouri shore.
Aug. 26, 7:55 a.m.	Aug. 26, 7:55 a.m.	18" " "	6.9	6.9	6.9	27°c	85.92	100' off Ill. shore.
" 26, 8:30 "	" 26, 8:30 "	18" " "	7.3	7.4	7.35	28°c	93.03	¼ distance from Ill. shore.
" 26, 9:10 "	" 26, 9:10 "	18" " "	7.8	7.9	7.85	"	99.36	Midstream.
" 26, 9:40 "	" 26, 9:40 "	18" " "	7.7	7.8	7.75	"	98.10	¼ distance from Mo. shore.
" 26, 10:10 "	" 26, 10:10 "	18" " "	7.8	7.7	5.75	"	98.10	100' fr. Mo. shore.
" 26, 1:15 p.m.	" 26, 1:15 p.m.	18" " "	7.5	7.5	7.5	29°c	96.80	100' fr. Ill. shore.
" 26, 1:45 "	" 26, 1:45 "	18" " "	7.7	7.8	7.75	"	100.12	¼ distance from Ill. shore.
" 26, 2:15 "	" 26, 2:15 "	18" " "	8.0	8.1	8.05	"	104.00	Midstream.
" 26, 2:35 "	" 26, 2:35 "	18" " "	8.3	8.2	8.25	29.5°c	107.56	¼ distance from Mo. shore.
" 26, 3:05 "	" 26, 3:05 "	18" " "	8.3	8.3	8.3	"	108.21	100' fr. Mo. shore.
" 26, 4:10 "	" 26, 4:10 "	18" " "	7.9	7.8	7.85	"	102.34	100' fr. Ill. shore.

8352 JUDGE SPRINGER: Professor, please state in what capacity you were acting when the samples which were analyzed in these tables just put in evidence, were taken?

A. As collector, as analyst, as investigator of the conditions of the water in the Illinois river and tributaries, and the Mississippi.

Q. At whose instance?

A. Well, I began this work at my own instance, but such portion of it as is included in the tables here under discussion, such portions of the general investigation as are included in the tables 1 to 80 inclusive and the tables of averages, were begun as a result of the conference held March 15th, 1899 at the City Hall, which conference has been described in part by myself and more fully by Dr. Gehrmann, in his testimony. I undertook the work on dissolved oxygen myself, for the purpose of getting information concerning that particular constituent or condition of these waters, as a part of the general investigation in progress, of these various waters.

Q. Did you state who collected the samples that were not contained in the tables 1 to 80 inclusive?

A. You mean those in 95a to 95g?

Q. Yes.

A. Yes, I stated that. I collected most of them. I did
8353 not state before, but I am glad to do so, that some were
collected by Mr. B. F. Robinson of Grafton, Illinois.

Q. State whether Mr. Robinson at Grafton was furnished certificates for the purpose of labeling the bottles, and furnished bottles that had been prepared in the usual way you have described in regard to other analyses, and whether those bottles with the certificates and blanks upon them filled out, came to you from him from time to time, as indicated in these tables, 95a to 95g inclusive.

A. Yes sir. The general certificates for the chemical samples pertain to the bacterial samples also, and further, to the dissolved oxygen samples, but the tags and labels with less detail information were also placed on the individual bottles in which the oxygen samples were collected, that is, the samples of water for determination of dissolved oxygen, but the general features, as the height of the river, temperature of the air, direction of the wind and the recent rain, and the passing of boats and so on, were for all three sets of samples, and put on one certificate.

Q. State whether the bottles that you received from Robinson at Grafton during this period were the same that you had sent to him for the purpose of being filled?

A. They were the same.

8354 Q. Have you any reason to believe that any different method was pursued by him from that which has been indicated on these various certificates?

A. None whatever.

Q. Were you willing to receive those samples from Mr. Robinson, and did you record them as having been taken in the manner that you had instructed him to take the other samples?

MR. JEFFRIES: I object to the question as immaterial, irrelevant and incompetent. It is not a question whether he is willing to receive them or did receive them. His receiving them is no evidence of their being taken in the manner stated, he not being present at the time they were taken and having no personal knowledge of the time and place of taking.

A. I was so willing to receive them and did receive them in the full belief that they were collected, sealed and shipped in accordance with the directions given by me to Mr. Robinson in person.

Q. Please explain the significance which you attach to the ascertainment of dissolved oxygen in the respective waters mentioned in these tables.

MR. JEFFRIES: I object to any question as to their significance for the reason stated in my objection to the reading of the tables into the record.

8355 A. The results of our determinations of dissolved oxygen in some 400 samples of water from the Illinois river have shown that the waters of the Illinois river at all times contained a considerable percentage of the quantity of oxygen which was required for saturation, and that at times it contains much more than the saturation figure; indeed, occassionally at certain points it contains even more than double the saturation quantity. The supersaturation of the water with oxygen, if we may so term it, is due to the liberation of oxygen by the chlrophyl-containing micro-organisms, and other minute plants which are very abundant in the waters of the Illinois at certain seasons of the year. In fact, oxygen-evolving organisms seem to be always present and almost always active in these waters.

Many of the determinations have been made upon the spot, but inasmuch as circumstances rendered it impracticable for us to make very extensive series of determinations in this way, the samples of water were, throughout a considerable portion of the time, shipped to the laboratory and the determinations of dissolved oxygen made there ordinarily in about 24 hours after the time of collection, but sometimes not until 40 or 48 hours had elapsed from the time of collection. These shipped samples
gave results which are always less than the saturation
8356 figure, except on a few occasions, when the original water
was highly supersaturated with oxygen. The exceptions noted from the general diminution of dissolved oxygen during transit, were occassioned by the treatment of some of the samples with mercuric chloride, in which cases there appeared no diminution in the proportion of dissolved oxygen, as the mercuric chloride prevented such changes in the water, as under other circumstances brought about such a decrease of the oxygen contained in solution.

Comparison of the results of determinations made upon the spot with those made upon duplicate samples which were either shipped to the laboratory or kept under similar conditions to those involved in shipping, show that there was in all cases a notable diminution of dissolved oxygen during the time which elapsed between the time of collection, and the time of making the examinations. Consequently, it is certain that the actual content of dissolved oxygen in all these waters was in reality greater than the results here recorded. There was but one case in which a greater percentage of dissolved oxygen was found in the sample which had been kept. This determination is recorded in the bottom line upon table 95a, where a sample of the Illinois river water taken at Averyville, August 17th, 1899 at
6:30 P. M., and examined August 18th, 1899, at 7:05 P.
8357 M., approximately 24 hours after the time of collection.
This abnormal condition will be considered more in detail farther along, when we discuss the conditions at Averyville.

Dissolved oxygen in the water of the Illinois river, at its mouth at Grafton: The series of determinations dissolved oxygen which appear in the tables 95a to 95g, show that during the period January 4th to June 27th, 1900, the percentage of saturation in the Illinois river water ranged from 43.1 to 95.7, the average being 76.47 per cent for the entire series of 141 shipped samples. As is seen in the date columns, the determinations were made upon samples shipped to the laboratory in usually about 24 hours after collection. The minimum 43.1 per cent, was found in the case of four samples collected May 16th, and examined May 18th. In no other case was less than 52.7 per cent found, and indeed, in but five other samples was less than 61 per cent dissolved oxygen found.

Dissolved oxygen in the waters of the Mississippi river at Grafton: A parallel series of determinations of dissolved oxygen in the waters of the Mississippi just above the mouth of the Illinois was made upon samples collected at the same time, that is, within a few minutes and shipped and examined under similar conditions. The details appear upon tables 95e and 95f,
8358 inclusive. The degree of saturation in these samples ranged from 55.78 per cent to 108.84 per cent, the average for the entire series of 127 samples being 82 per cent.

Comparison of the data obtained from these two series of shipped samples, shows that the waters of the Illinois contain 93.2 per cent of the quantity of dissolved oxygen found in the waters of the Mississippi.

Q. Will you explain what you mean by that?

A. I mean by that that in these shipped samples there was little more dissolved oxygen in those which came from the Mississippi river than was found in those which came from the Illinois river, the relation being as 92.2 in the Illinois to 100 in the Mississippi.

Q. What year was this?

A. This was the year 1900. Analyses made upon the spot (see tables 95c, 95d, and 95e) show that both the Illinois river water at Grafton and the Mississippi river water at Grafton frequently contain a greater proportion of dissolved oxygen than is required for saturation, but each of them also frequently contains less dissolved oxygen than the saturation figure required. In general it is true, that the waters of the Illinois do not retain their dissolved oxygen so long as do the waters
8359 of the Mississippi, that is, the dissolved oxygen diminishes more quickly and to a greater extent in the water of the Illinois than it does in the water of the Mississippi although the

difference between the two river waters in this respect is not very great as may be seen by a study of the data of the tables.

Q. Can you give any explanation of this difference?

A. Well, I can when it comes to a discussion of the significance of dissolved oxygen, which I understood we were to consider when we got through with the discussion of the data here on the tables.

Q. All right.

A. The upper Illinois: In the Illinois river at LaSalle just above the town upon August 16th, 1899, we found the water eighteen inches below the surface just saturated with dissolved oxygen, the actual figures being 100.12 per cent to 100.36 per cent in samples taken at different points across the stream.

A. Sample of the water taken at the same time but examined 24 hours later contained but 75.7 per cent of dissolved oxygen, while still another sample collected at the same time as the three above mentioned, but kept 41 hours, contained but 58 per cent of the amount required for saturation. The evidence would seem to show that although during sunshine, oxygen was being evolved by the vegetable life in the water
8360 with sufficient rapidity to keep the water saturated, yet
when the conditions were changed by placing the sample in the dark such action ceased, and the oxygen began rapidly to disappear.

Similar conditions were found with respect to the water of the Illinois and Michigan canal at La Salle. The water at the upper basin at La Salle was, before the opening of the sanitary canal, in better condition ordinarily, than was the water of the Illinois river at this point, for the reason that the canal above LaSalle was fed from the Fox river and other streams. The records with respect to the water in this place, as given in table 95a, show that the water in its original condition contained 102.42 per cent, while after standing 24 hours it was reduced to 62.26 per cent.

Upon August 17th, somewhat striking conditions were found at Henry. The samples were taken above the dam at 1:15 P. M. upon a bright day. The temperature of the water, 32 degrees C. being very nearly as high as that of the air, which in the shade was 34 degrees. A sample of the water taken one

inch below the surface, was found to contain considerably more than twice the amount of oxygen required for saturation, presuming of course, the saturation figure should be that for an equilibrium between the oxygen of the atmosphere and
8361 that dissolved in the water.

The water was full of minute vegetable organisms, and it had a very distinct, yellowish green tint. The temperature of the top inch of water was 32 degrees C., or 89.6 Fahrenheit. The quantities of dissolved oxygen found by the Levy method in this water were 220.9 per cent, and 211.4 per cent respectively. Samples taken at the same time and place, but at eighteen inches below the surface had a temperature of 28 degrees Centigrade, and were found by the Levy method to contain dissolved oxygen corresponding to 200 per cent of saturation, and 208.3 per cent of saturation respectively. While the determinations made upon the same samples by the Winkler method showed 208.35 per cent. A sample collected at the same time and kept until the next day, the analysis being made 24 hours after the time of collection, during which time the sample was kept in the dark, was found to contain 110.1 per cent of the saturation figure. At the same time and place a collection was also made at two feet from the bottom, or ten feet below the surface. At this depth also the water was found to be supersaturated but far less so than the water at the surface; it contained 129.1 per cent. These samples were all taken a short distance above the dam and it is probable that the water at two feet from the bottom was comparatively sluggish in motion, and the conditions of tem-
8362 perature and of illumination by sunlight were not the
same as those prevailing in the strata of water nearer to the surface. The dissolved oxygen in the water very near the bottom disappeared much more rapidly and was reduced far more proportionately than that in the water taken near the surface. The percentage remaining at the end of 24 hours being about 47.42 per cent. This difference as to retention of dissolved oxygen was undoubtedly due to a difference in either the Plankton or the other organic matters contained in the water in these two different stratas.

Averyville: Several visits were made to Averyville, just above Peoria, for the purpose of making determinations upon the spot, and some of these developed quite interesting results, as upon July 21st, 1899, the water eighteen inches below the surface was found late in the afternoon to contain 171 per cent of the saturation figure of dissolved oxygen and the water was still supersaturated with oxygen when samples which were kept in the dark were again examined 18 hours and 24 hours later, after the lapse of this time, the figure being 115 to 117 per cent respectively.

The quantity of dissolved oxygen in the samples collected at the same spot the following morning were found to be only
87.8 per cent, but during the morning it increased slightly
8363 to 95.6 per cent at 10:10, reaching 111.7 per cent at 12:20
P. M., and 114.3 per cent at 1:10 P. M. at which time the examinations were stopped by the necessity for catching a train. Samples collected at the same time were kept over for two days, and it was found that the quantity of dissolved oxygen had diminished in 48 hours from 114 per cent to from 38 to 40 per cent. (See in Illinois river, Averyville, July 22nd, 1899, at bottom of table 95a.)

On August 17th, late in the afternoon the quantity of dissolved oxygen found in the water at the depth of 18 inches at Averyville was 80.5 per cent, while the water coming from about two feet above the bottom in fourteen feet of water contained 74 per cent of the saturation figure. A sample of the water taken eighteen inches below the surface at 6:30 P. M. which was kept until the next day was found to contain a considerably higher quantity of dissolved oxygen than the sample which was examined at the time of collection. The determination on the spot gave 80.49 per cent, and that made 24 hours later gave 97.53 per cent. It may be that this is an error, but it is possible that in this case some more hardy oxygen-envolving organisms than usual were contained in the water, and that during the following day, which was excessively hot, light was not entirely
excluded from the sample; or the original content of
8364 oxygen may possibly have been quite different, for as
is evident from the records for the 19th, when this point was again visited, the water earlier in the afternoon was supersaturated.

Upon August the 19th at 12:30 p. m., a sample taken eighteen inches below the surface contained 184 per cent; another taken at the same time but three hours later contained slightly more than 200 per cent, and a sample collected at four o'clock contained 215 per cent. Another collected at 4:25 contained 215.7 per cent, while the samples of water collected one and one-half hours later at the same point and under the same conditions were found to contain 95.6 per cent, dissolved oxygen.

During the time that these examinations were made, the surface of the water was marked here, there and everywhere, with patches of blue-green scum the size of a man's hand, apparently consisting of masses of filamentous algae. The current was quite rapid and these patches were about two or three feet apart in various directions. The samples were taken under such conditions as to exclude these floating matters from the sample of water upon which the test was made. The sun was shining very brightly and the temperature was very high
8365 These examinations were made at the Averyville bridge
where the river is very narrow and the current rapid. Between this point and Henry, about 38 miles above, the river spreads out to a considerable width, forming a series of so-called pools, lakes or lagoons, in which the current is very sluggish. In these broad stretches the conditions of depth, spread of surface, temperature and rate of movement are in the summer season especially, favorable for the development of plant life and and the water consequently so teems with green and green-blue organisms that oxygen is evolved in great abundance, in fact may frequently be seen coming from the floating plants in streams of minute bubbles. During the middle of the day when the chemical activity of the sun's rays is at the maxium, the evolution of oxygen naturally will be at the maximum, and the water then becomes supersaturated but as the sun sinks towards the West the action slackens, and the excess of oxygen begins to disappear, partly perhaps by diffusion into the atmosphere, but undoubtedly in the main through absorption by the organic matters either living or dead, contained in the water, and in part by the cessation of the evolution of oxygen through the agents just referred to.

The water which was found to be supersaturated at Averyville, doubtless received its oxygen mainly at some distance above, and the rather sudden drop from 215 per cent to
8366 95.6 per cent was in all probability due to the fact that
a new body of water which in the late hours of the after-

noon had not been exposed to such vigorous action as prevailed earlier in the day began to reach the point of collection. This change may have also been due to the fact that as evening approached, the sun was in part obscured from the particular point at which these examinations were made, by dropping below the high wooded bluffs which line the west bank of the river in this vicinity.

Later in the year, that is upon October 16th, 1899, another series of examinations were made in Averyville, but at this time the conditions were entirely different. The quantity of dissolved oxygen reached but 74.5 per cent, to 77.5 per cent.

Examinations which were made during January, 1900, gave similar results to those mentioned for October, 1899.

Examinations made in June, 1900, showed figures which were considerably below those obtained in July and August of the preceding year. It is unfortunate that we did not have an opportunity to make determinations in 1900 upon the same dates as in 1899, for in June the season is not sufficiently advanced to bring about the conditions which are commonly encountered in the latter part of July and the middle of August.

8367 The results obtained in October, 1900, were practically identical with those obtained in October, 1899, which would seem to imply that the opening of the drainage channel has not materially changed the conditions with respect to dissolved oxygen at this point and for this season of the year.

Dissolved oxygen just below Peoria: A few examinations made at Wesley City have always shown that the water of the river at this point contains far less than the saturation quantity of dissolved oxygen, a result due of course to the fact that so much sewage is discharged into the river about two or three miles above. Somewhat similar conditions were found with respect to the water at Pekin. The effect of bright sunlight is strikingly shown by comparison of the figures obtained upon August 18th, in the middle of the morning with those obtained August 19th, late in the afternoon, the figures for the morning being 24 per cent; those for the afternoon averaging about 82 per cent.

Examinations of water collected early in the morning of August 19th at Havana, 30 miles below Pekin showed but about one-third as much dissolved oxygen as would correspond to the saturation figure, while later in the day determinations by both

the Levy and the Winkler method made at Copperas
8368 Creek dam and at Lancaster Landing, points between
Havana and Pekin, showed considerable excess of dissolved oxygen. The weather was hot, 100 degrees to 108 degrees Fahrenheit in the shade, and there was considerable plankton in the water, much of it appearing to consist of filamentous and other algae.

Dissolved oxygen in the water of the Drainage Canal: Several determinations were made of the dissolved oxygen of the waters of the Sanitary Canal itself. Upon August 13th, 1900, an examination was made of the water in the upper end of the sanitary canal at Kedzie Avenue. At 5:15 in the afternoon, a sample taken eighteen inches below the surface was found to contain 29 per cent, and a little further down the canal, that is at the Belt Line Bridge at 5:40 o'clock, it was found to contain 28.2 per cent. Upon June 29th, 1900, at five o'clock in the afternoon, this water just above the Bear Trap Dam at Lockport was found to contain 10.9 per cent of dissolved oxygen, while at 200 yards below the dam, after the water had been agitated with air in its escapes from the higher level of the drainage channel to the bed of the Desplaines river below, the aeration had been sufficient to bring the proportion of dissolved oxygen up to 55.5 per cent of the saturation figure. Upon August 14th,
1900, similar determinations showed, that the water above
8369 the dam contained 5.9, and that below the dam 70 per
cent. of dissolved oxygen.

At Joliet, examinations made upon June 30th, 1900, showed 27.8 per cent. of dissolved oxygen just above Dam No. 1, while just below the dam where the water has fallen 12 or 13 feet the percentage of dissolved oxygen was found to be 81.28.

In making these determinations, due care was exercised to prevent any minute bubbles of air being retained by the water which was made the subject of the examination. The entire pipette was filled with the water and was allowed to stand for a few minutes until such bubbles as were contained in the sample collected in the upper part of the pipette, and were allowed to escape.

The results obtained at Lockport and at Joliet show quite strikingly the effect of agitation of the water with air in falling over the dam.

A single determination made upon the water of the Fox river at Ottawa, August 20th, 1899, showed the water of this tributary to be quite supersatured. It contained 128.35 per cent. of dissolved oxygen. The water of the Illinois and Michigan Canal, just above Channahan was examined upon August
21st and was found to contain three per cent. of the
8370 saturation figure of dissolved oxygen. At this time there
was practically no water flowing in the bed of the upper Desplaines below Joliet, as at Joliet all of the flow both from the Desplaines river above and from the Illinois and Michigan canal was carried down the north bank of the river in the canal itself.

Adjourned until 10:00 a. m. following day, Wednesday, October 14th, 1903.

8371 10:00 A. M., Wednesday, October 14th, 1903.
Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further direct-examination by Judge Springer and testified as follows:

THE WITNESS: I desire to call attention to two errors which are contained in the tables heretofore read in evidence by me, namely, in table 60 concluded, serial No. 8214, the entire analysis belongs in table 61 concluded, at the place indicated by serial No. 8215, since this sample of water was obtained not from the Illinois, but from the Mississippi river, and No. 8215 which is now in table 61 concluded, must be transferred to table 60 concluded, in the place of No. 8214, which has just been removed, and a correction of the chlorine stated for 8215 must be made. In reality it is 20 parts per million instead of 4 parts per million as recorded in table 61 concluded.

There may be other errors in the tables, but such as they are they are certainly very small. I have looked up some of them,
that is, have detected some of them, and doubtless there
8372 are others, but such as they are are certainly too small to
affect seriously any of the general conclusions or the

general averages. These corrections were by me made before the averages went to print, and the changes here made do not consequently affect the figures of averages in tables A to C, inclusive.

JUDGE SPRINGER: Counsel for defendants now desire to put in evidence certain graphic plates which were made by this witness and which exhibit in a compact form the results which are given in the tables numbered Table 1 to Table 80 inclusive.

Q. Professor, I hand you a paper which is designated Plate 1. Will you please state whether you prepared that plate or not, and if so, upon what ascertainments or chemical analyses you base it, and what is its significance. But first state whether this is a plate prepared by you?

A. It is.

Q. And is this plate based upon the averages contained in any of the tables that you put in evidence?

A. It is a representation of certain of the averages which appear in table A, which averages have been made from the detailed data of the tables 1 to 38 inclusive.

Q. You may now read the plate in evidence.

8373 MR. JEFFRIES: I object to the reading of the plate in evidence, or to the witness making any explanation or giving any evidence in connection therewith, for the reason that the same is incompetent, irrelevant and immaterial, and for the reason that it has reference to conditions that existed prior to the opening of the Chicago drainage canal and therefore can be neither relevant, competent or material.

I object to the witness reading the plate into the record or making any statements in connection therewith for the further reason that it is in part based upon certain analyses made of various tributaries of the Illinois river, which analyses and all evidence in relation thereto, is incompetent, irrelevant and immaterial, and samples of water so examined from the tributaries are not and were not of sufficient number to throw any light on the true condition of the water contained in the tributaries, and for the further reason that the samples of water were taken from tributaries without reference to the condition of the water in the rivers at all seasons of the year, and at all stages of the water, and without reference to the volume of water con-

tained and flowing down the tributaries during all parts of the
year, and I object to the reading of the plate into the record
and to the witness making any explanation in reference
8374 thereto for the further reason that the dates that the
samples of water were taken from the Illinois river, the
Mississippi and the Missouri and the dates of analyses are shown by the tables upon which the plate is based, and from which it is made, were such as not to be comparable and these samples were not taken with a view of determining the chemical condition of the water at all seasons of the year in question, and with reference to the condition of the water in flood times, low water times, in winter and in summer, by night and by day, and for the further reason that the samples so taken, because of time consumed in shipment and making analyses, were so changed chemically speaking as not in any way to characterize the true chemical condition or sanitary condition of the waters of the Illinois river at the points and at the times the samples were taken.

JUDGE SPRINGER: Counsel for defendants move to stirke out this objection for the reason that it goes to the weight of the testimony and not to its admissibility or competency.

MR. JEFFRIES: My position is that the samples were so taken without reference to temperature, without reference to day time and night, without reference to flood time and low water stages, without reference to winter and summer seasons, and at such times and such dates, and the analyses made at
variable times after the samples were taken, that renders
8375 any comparison therefrom entirely incompetent, and
therefore the plate is not admissible for any purpose.

JUDGE SPRINGER: I renew my motion to strike out for the same reasons stated before.

THE WITNESS: The plate is as follows:

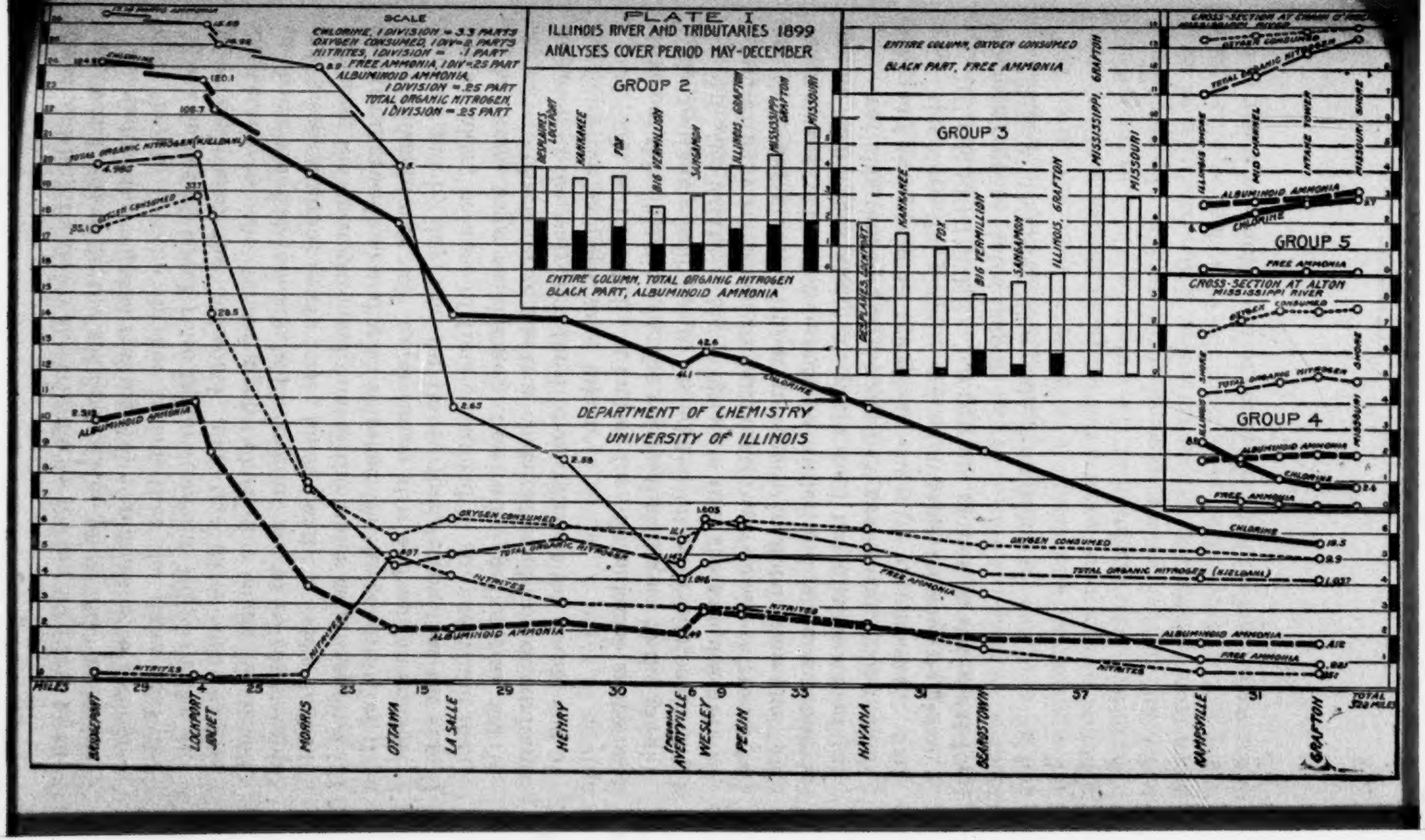
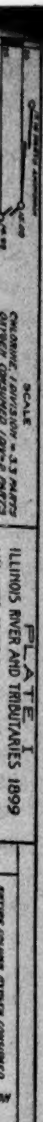


PLATE I
ILLINOIS RIVER AND TRIBUTARIES 1899
ANALYSES COVER PERIOD MAY-DECEMBER

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS



8377 MR. JEFFRIES: Let me ask a question. Professor, explain what the column "Average of" means on Table A, from which the plate in question was made?

A. I explained that in my testimony yesterday, and do so again at your request, to same effect, that the numbers in that column represent the numbers of samples of water analyzed as appears in the corresponding tables Nos. 1 to 38, inclusive, and which were considered in making up the general averages which appear in this table A.

MR. JEFFRIES: Now I move to strike out the plate, and all testimony in reference thereto, by this witness, for the reason that he has stated that column designated as "Average of" in the table of average results, for the year 1899, known as table A, and from which this plate in question was made, respresents the number of samples analyzed and from which a general average was struck, and it appearing from the able A that there was an average made upon 29 samples of water examined from the Kankakee river at Wilmington, 32 samples of water from the Big Vermillion at LaSalle, and 23 samples from the Sangamon river at Chandlersville, while there is no evidence so far introduced, showing that any such number of samples of water were taken from these rivers at these places, and no evidence showing that any such number of samples have ever been examined 8378 chemically; no evidence showing the manner in which the 23 samples in the one instance, the 32 samples in another instance, and the 29 samples in another instance, were taken; no evidence showing the point in the river from which they were taken, and therefore the plate does not accurately characterize and portray the facts that have been shown in evidence, in reference to conditions in the tributaries of the Illinois river in 1899, and therefore such results are not comparable with each other, or comparable with any conditions that exist or that might have existed on the Illinois river during that period.

JUDGE SPRINGER: I move to strike out this motion for the reason that it is principally argumentative, and in so far as it applies in any way to the matter under consideration, it goes to the weight of the evidence and not to its admissibility or competency.

Q. Proceed with your explanation of the plate, professor.

A. Explanation of Plate 1: I identify plate 1 as a chart which I prepared, to show graphically, some of the results which are given in detail in the tables 1 to 80 inclusive, and the averages which are shown in table A.

Q. Heretofore read in evidence in this case?

A. Yes. This particular plate No. 1, shows graphically
8379 the proportions of chlorine, oxygen consumed, nitrites,
free ammonia, albuminoid ammonia, and total organic nitrogen as determined by my analyses, set forth in detail in tables 1 to 80 inclusive, and particularly as shown in the form of averages in table A.

In order that the significance of the figures of table A, as shown graphically by means of the curves and columns of plate 1, may be fairly understood, I will as I proceed, state briefly the general significance which pertains to each constituent there represented, as we proceed with the discussion of the plate.

First, the chlorine. This substance is contained in water in combination with various basic elements, but chiefly in the form of sodium chloride or common salt. Chlorides occur in very small quantities in all soils, and hence are present in small proportions in the waters of streams, ponds, lakes and so on, in their natural condition, and in greater quantity are found also in wells, particularly in many artesian wells, and in salt springs. Most animal matters, and especially various animal secretions, contain more or less chlorides, and chlorides are constant in considerable constituents of sewage. In the sewage they are derived not only from the various animal secretions and particularly the urine contributed to sewage, but also are intro-
8380 duced in various manufacturing wastes, as the wastes
from soap factories, packing houses and so on. They are also contained in kitchen wastes, being derived from the liquids which have been in contact with food during the preparation of foods for the table. The only natural causes of change in the proportions of chlorine aside from such concentration as may result from long continued hot weather during the season of minimum flow, would be its decrease by dilution with waters which contain less, or its increase by mixing with waters and other liquids as sewage, and so on, which contain more. The chlorine introduced into streams in the form of chlorides,

remains unchanged—(if it were at any time introduced in other forms it might change, but it is not ordinarily so introduced). That is, is not in any way removed, absorbed or destroyed, but finds its way finally into the sea into which the stream or streams finally discharge. The determination of the proportion of chlorine consequently is an index to the total quantities of chlorides introduced into the stream from watever source, above the point at which the determination in question is made.

Referring now to the curve for chlorine upon the plate, we note that a very large proportion, namely 124.2 parts per million, was contained in the water of the Illinois and Michigan
8381 Canal at Bridgeport, on the average for the period, May
to December, inclusive, 1899. This period it should be understood is referred to throughout, in the discussion of Plate No. 1. The proportions of chlorine at Lockport and Joliet, respectively, 29 and 33 miles below Bridgeport, respectively, are smaller than the proportion at Bridgeport. The reduction in proportion at Lockport being due to slight dilution along the course of the Illinois and Michigan Canal; that at Joliet being due to the dilution effected by mixing of the waters of the Desplaines river with the discharges from the Illinois and Michigan canal, just above the point at which the Joliet samples were taken. From this point on down to Peoria there is shown continuous and considerable decrease in the proportions of chlorine. The decrease between Joliet and Morris, 25 miles below, due to the introduction of the discharges of various small streams into the Desplaines, but mainly due to the introduction of the waters of the Kankakee river, which latter was found for this period to contain on the average, 3.9 parts of chlorine per million. Below Morris there are small streams discharging water into the Illinois, which brings about a reduction in the proportion on the way to Ottawa. At Ottawa the discharge of the Fox river brings about a very considerable reduction in the proportions of the chlorine, so that at LaSalle the proportion is 47.3, as
8382 against 59.4, the proportion contained at Ottawa. The
Fox river at Ottawa during this period containing on the average 5.8 parts of chlorine per million. There is but slight dilution, as indicated by reduction of chlorine, between LaSalle and Henry, but beyond Henry again, a notable decrease in the

proportion of chlorine occurs, to Averyville, where the proportion is 41.1 parts per million. The decrease resulting from the dilution effected by the discharges of various small streams, and in part by the underground flow of land water into the river. This underground flow is known to be considerable along the entire stretch of the Illinois river between LaSalle and Beardstown, and is particularly considerable between Peoria and Havana, and in times of low water may have quite an appreciable effect in diluting the waters in the stream, an effect which of course was more considerable before the flow and the initial dilution were increased by the inflow of lake water secured by the opening of the Chicago main drainage canal in January, 1900. The increase of chlorine between Averyville and Wesley city resulted from the contribution of Peoria's sewage to the river, and in small part probably was due to the inflow of the water of certain saline artesian wells, and springs. From this point,
that is Wesley City just below Peoria, there was a con-
.8383 tinuous and considerable diminution in the proportions
of chlorine at all points down to the mouth of the river at Grafton, and the final discharge into the Mississippi river contained chlorine in the proportion of 18.5 parts per million.

The next curve which we may consider represents the oxygen consumed. Oxygen consumed is the quantity of oxygen required for the burning of the organic matters contained in the water, or rather the quantity of oxygen required for combination with and oxidation of those organic matters contained in the water which are readily affected by the process used in these determinations, for it is well known that not all of the organic matters are affected or at least are not completely oxidized by the chemical processes employed. It is evident from the curves which merely represent the figures in the table of averages in table A, that the organic matters which at Lockport required a great deal of oxygen for their consumption, namely, 37.7 parts per million, were so affected by dilution and natural oxidation, as to appear in much smaller proportions at Morris and at Ottawa. A notable increase occurs between Ottawa and LaSalle, but the organic matters then below LaSalle diminish in proportion until we reach Averyville, where the proportion was 11.1 parts per million. Below Averyville there occurs an

increase until we pass Pekin, and from there on down to
8384 the mouth of the river at Grafton, occurs a gradual
but definite diminution, the quantity of oxygen consumed by the waters as they pass from the Illinois into the Mississippi being 9.9 parts per million.

Free ammonia, or saline ammonia as it is variously designated, is naturally present in small proportions in surface waters, being introduced into them by the washings of the air by the rain, and from surface soils, by the rain water, which in times of storm flow in part over the surface to the streams. It is contained in comparatively great quantity in fresh sewage or sewage which is in the first stages of putrefaction. In the sewage it has come in part from the sanitary wastes of the household, including the discharges from human beings, but comes also from other household wastes, and from the discharges of other animals. It comes in part from discharges of manufacturing wastes and industrial wastes of various sorts, including stock yards wastes, refuse from gas works, and the decomposition products of the same and so on, and is produced by the putrefactive changes to which organic matters from all these sources are naturally susceptible.

The large proportions of nitrogen as free ammonia contained in the waters of the canal at Bridgeport and Lockport,
respectively, are represented at the left hand of the table
8385 and by the figures 17.16 and 15.58 which appear in table
A of Averages. The diminution in proportion between Lockport and Joliet is due to dilution by the waters of the Desplaines, and between Joliet and Morris, to the dilution referred to above under the discussion of chlorine and oxygen consumed, namely, dilution effected mainly by the introduction of the waters of the Kanakee, and is in part effected by the natural decomposition or changes to which this substance is subject in streams and other surface waters. Between Ottawa and LaSalle, there is a very great diminution, namely from five parts per million to 2.65 parts per million. This diminution being effected in part by dilution with the waters of the Fox river and other but minor tributary streams, and in part due to nitrification which takes place vigorously in the stretch of stream between Ottawa and LaSalle, and it may in part be due also to assimila-

tion by the plant life, which is abundant in this part of the river, and in part due to its conversion into free nitrogen which escapes in part into the air. On the other hand, there may at times be a tendency toward an increase of the proportions of free ammonia as a result of the de-oxidation of nitrates and nitrites, which takes place when these substances in water are in contact with various organic matters.

8386 Between LaSalle and Henry there is further diminution in the proportions of free ammonia notwithstanding the fact that just below LaSalle the sewage of LaSalle is, by the final discharge of the Illinois and Michigan canal, introduced into the Illinois river, and that the sewage and wastes of Peru also are introduced at this point.

Between Henry and Averyville there takes place a more considerable diminution in the proportions of free ammonia, this being undoubtedly due to the natural destruction of ammonia or its oxidation into nitrates and nitrites or its assimilation by the plant life of the river, or to all of these causes together.

Now I notice a mistake in the figure given upon this plate. The figure in the table of averages is correct, and the curve is drawn to proportion all right, but the figure there above Henry, in the plate is put 2.56 and it should be 2.156—perhaps a minor correction, but one it is well to have made.

Beyond Averyville there is an increase in the free ammonia to Wesley City, a slight further increase to Pekin, and from there on down to the mouth of the river, continuous decrease—slight it is true—until we reach Havana, but beyond Havana more considerable in proportion until we reach Kampsville, 8387 where the proportion is only slightly greater than that contained in the water as it is discharged into the Mississippi at Grafton, 31 miles below, where the proportion is .221 parts per million.

MR. JEFFRIES: That is at Grafton?

A. At Grafton, yes.

Nitrites: Nitrites as contained in surface waters may be derived from the washings of the air by the rain; the leachings from the surface soils with which the fallen rain has been in contact on its way to the surface streams, which discharge it into ponds or rivers, and is also produced by the oxidation of nitrogenous organic matters derived from these or other sources and contained in the surface water, be it that of ponds or streams.

The nitrites constitute a stage or represent a stage in the series of decomposition which convert organic matters finally into the comporatively unobjectionable mineral matters which are chiefly carbonic acid and nitrates. The comparatively small proportion of nitrites in the upper river down to the neighborhood of Morris shows that this second stage of natural purification is to this point but beginning, but the great increase below Morris witnesses to the fact that from here on this highly important feature of nature's purification processes is efficiently active. 8388 The gradual diminution of the nitrites on the way down the river from Ottawa to Averyville. would indicate a gradual progressive exhaustion of the food supply for the organisms which are responsible for this oxidation and thus serves as evidence that the purification is proceeding. The proportions of nitrites contained in the water may at times also be increased by the reduction of nitrates, which reduction at times proceeds beyond this stage, and brings about the liberation of nitrogen in the form of nitrogen gas, the element, or may proceed further to the stage of ammonia, and so increase the proportion of the latter. The nitrites decrease in proportions from Pekin on down to Grafton, and this indicates the considerable improvement in the sanitary condition of the water during its pasage from Pekin to the point of discharge into the Mississippi river at Grafton.

Total organic nitrogen: This determination, made by the Kjel Dahl process, represents the total proportions of nitrogen contained in the water in combination in organic matters. The nitrogenous organic matters are contained in all soils in some quantity, but they are the most significant and constant constituents, of sewage, and include all sorts of animal refuse, tissues, fecal matters, constituents of the urine, household 8389 wastes and manufacturing wastes of various sorts, particularly those of animal origin, but also those of vegetable origin. Nitrogenous organic matters too, are essential constituents of all living things, great or microscopic, both vegetable and animal. It is substances of this class in part

which serve as the nutrients upon which bacteria thrive and multiply. The proportions of nitrogen as total organic nitrogen, that is the total nitrogen contained in organic matters, are shown by the figures of table A, and represented by the line upon plate 1 as being very considerable in the waters of the Illinois and Michigan canal, both at Bridgeport and at Lockport, the quantity diminishing between Lockport and Joliet, diminishing again very considerably between Joliet and Morris, and again diminishing on the way to Ottawa, but beyond Ottawa increasing in proportion on the way to LaSalle and Henry, below which there is again a decrease to Averyville. The decrease between Joliet and Ottawa is party due to dilution by the introduction of the waters of various tributaries, but in very large part is due to the natural destruction of these organic matters, and their conversion into more innocuous forms, partly into mineral matters, partly into the organic matters of the vegetation of the river. The increase on the way to LaSalle and Henry is due
to the introduction of sewage by means of the Big Ver-
8390 million river, and the sewage of LaSalle and of Peru.
The increase below Averyville on the way to Wesley City, is due to the introduction of Peoria's sewage and refuse. Below this point, there occurs at first slight, but then a more considerable decrease in the quantities of total organic nitrogen on the way down to Beardstown, below which point there is a very slight decrease down to the mouth, where the proportion contained in the water as it is discharged into the Mississippi was during this period 1.037 parts per million.

Albuminoid Ammonia: The albuminoid ammonia varies somewhat in conformity with the variations of the total organic nitrogen, although the quantity is but from 40 to 50 per cent. that of the latter. Its significance is similar to that of the total organic nitrogen, but the total organic nitrogen represents all of the nitrogen that is contained in the organic matters, that is as constituting part of the tissues, living or dead, as well as various products of vital activities of living organisms, while the albuminoid ammonia represents only the nitrogen. Of such part, about one-half of these substances, as is comparatively easily affected by the chemicals and processes used in the albuminoid ammonia determination.

8391 Comparison of the waters of the Illinois with those of its tributaries and those of the Mississippi and the Missouri are made in groups 2 and 3 of Plate 1. The various columns show the comparative proportions of total organic nitrogen, albuminoid ammonia and free ammonia contained in, and the oxygen consumed by, the waters of the more important tributaries of the Illinois river, the waters of the Mississippi river above the mouth of the Illinois and the waters of the Missouri river just above its mouth. The columns in all cases representing the figures given in table A. It appears that during this period the waters of the Illinois at its mouth at Grafton, contained more free ammonia than those of the Mississippi and the Missouri and considerably more than those of its tributaries, except the Big Vermillion, the Illinois and Michigan canal not being considered. On the other hand, the columns show that the waters of the Mississippi and the Missouri contain considerably more total organic nitrogen and albuminoid matters than did the waters of the Illinois, while the oxygen consumed by the waters of these two streams was nearly twice as great as that consumed by the water of the Illinois. In these respects, too, the columns show that the water of the Illinois river at its mouth compares favorably with the waters of its several tributaries.

8392 The Mississippi at Alton: The curves of group 4, plate 1, referring to the cross-section of the Mississippi river at Alton represent the averages of analyses of samples of water taken at the five points across the Mississippi at Alton, about sixteen miles below the mouth of the Illinois. It is evident from the consideration of the data, tables 23 to 27, inclusive, and the averages of table A, and as graphically shown by the curves of plate 1, that the waters of the Illinois do not mix thoroughly with the waters of the Mississippi, but chiefly pass down along the Illinois shore, and that the proportions of organic matters contained in the Mississippi river water are greater than the proportions of the same substances contained in the Illinois river water. The chlorine and ammonia, on the other hand, being higher in the Illinois river water at Grafton than in the waters of the Mississippi river at Alton or at Grafton.

The Mississippi at chain of rocks, or Mitchel:

The waters of the Missouri river during the period here considered, did not average so high in chlorine as did the waters of the Illinois, but they contain an enormous amount of suspended matters, and notably greater quantities of various objectionable organic matters. From the data of tables 28 to 31 and the averages of Table A, exhibited in group 5, Plate
8393 1, it would seem that at the chain of rocks the waters passing down the west bank and beside the intake tower, consist mainly of Missouri river water and contain much larger proportions of organic matters than do the waters of the Illinois.

Further comparisons: A consideration of the analyses of the individual samples given in tables 28 to 31 shows that the proportions of the nitrogenous organic matters never during the given period were so great in the Illinois river water as they were in the Missouri, and that the minimum proportion of these matters in the Mississippi and in the Missouri river water never reached quite the low point that they did in the water of the Illinois river at Grafton.

The general conclusion from the consideration of these data, which, however, it must be remembered cover simply the period from the beginning of May, 1899, to December 31st, 1899, is that the water discharged from the Illinois river is in these respects in purer condition than the water of the Mississippi river just above Grafton, or the water of the Missouri river at Fort Bellefontaine, or West Alton, and that it is in most respects quite similar to the waters of the larger tributaries of the Illinois. Table G gives the specific data.

8394 Q. Professor, I now hand you papers which are designated as plates II and III. State whether those were prepared by you and what they were based upon?

A. I prepared plates II and III and they are based upon some of the averages which appear in table B.

Q. Heretofore read in evidence?

A. Heretofore read in evidence, and which shows the results of analyses of the water taken at different points in the Illinois river and its tributary streams, the Mississippi and Missouri rivers during the period January 1st to October 1st, or thereabouts, in 1900, the details of which appear in tables 39 to 80 inclusive.

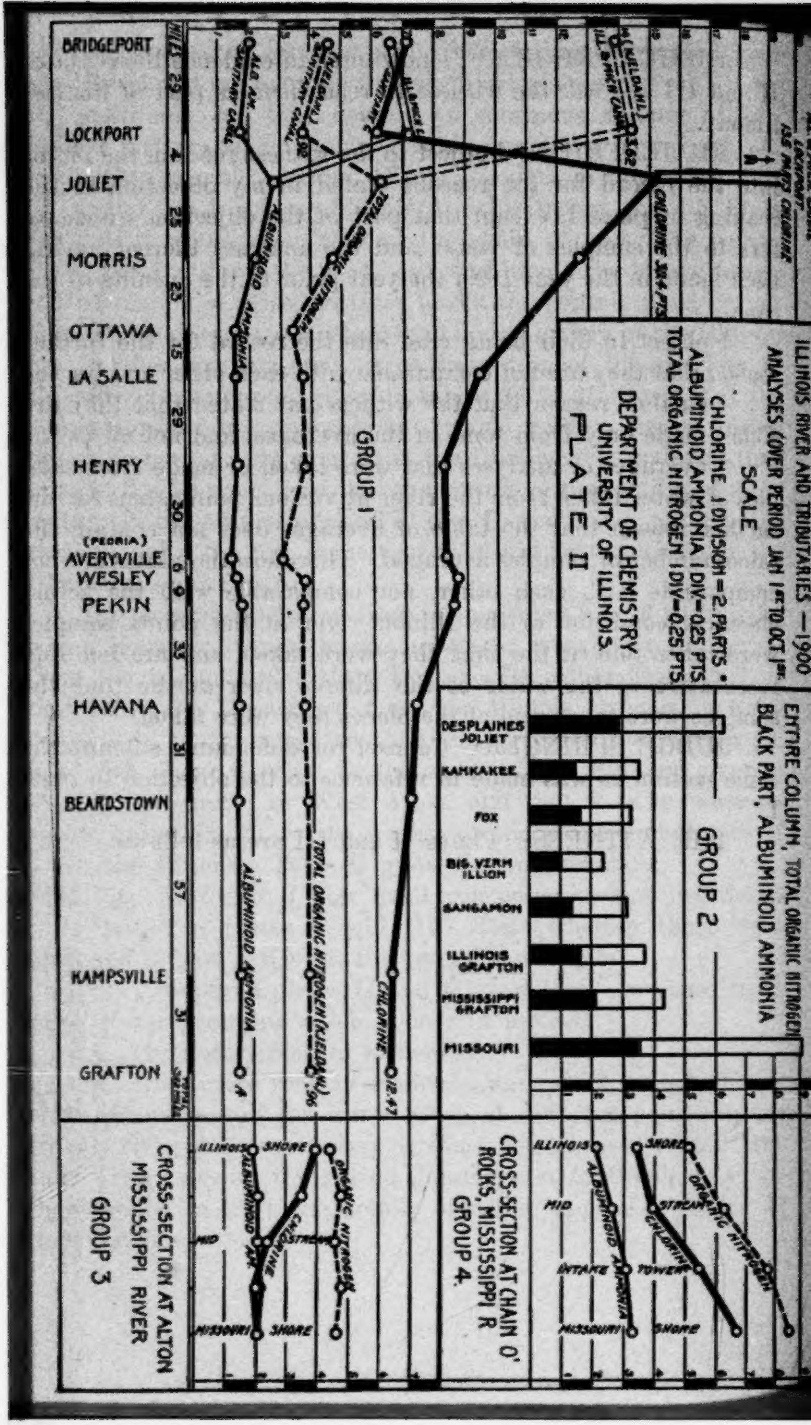
JUDGE SPRINGER: I now offer in evidence these plates II and III and ask the witness to read them as part of his testimony.

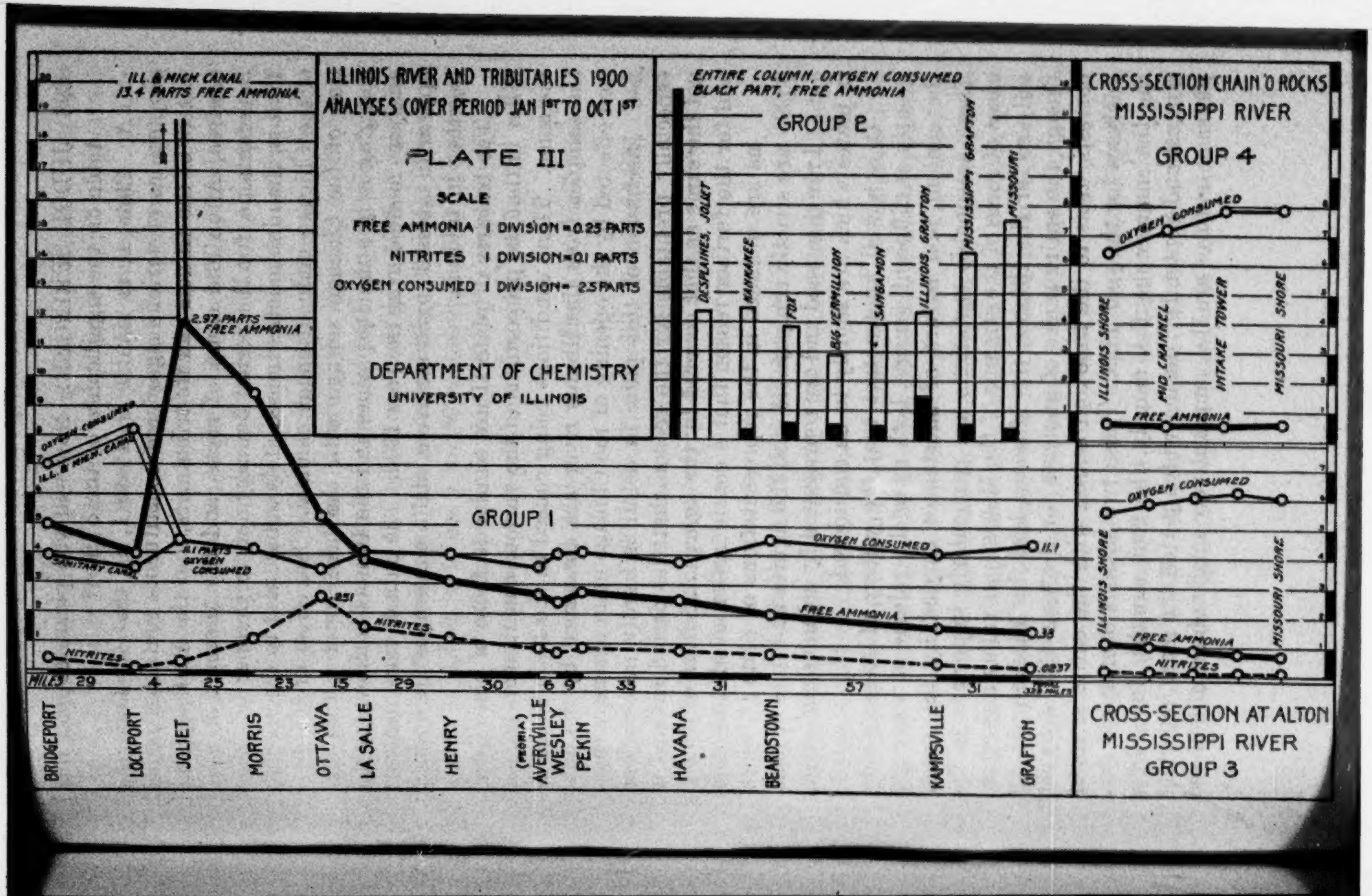
MR. JEFFRIES: I object to the witness reading the plates into the record for the reasons stated in my objection to the reading of plate I, except that part of the objection which refers to the samples of water and the analyses thereof having been made in the year 1899, the year prior to the opening of the canal.

I object to their being read into the record for the further reason that they are not comparable with each other and for the further reason that the witness has stated that they are 8395 made only from some of the averages, and not all of the averages or analyses that were taken or made from samples of water taken from the river at various points, and for the further reason that the table of averages does not contain the same number of samples averaged. Therefore the plates are not comparable with each other, nor comparable with the actual chemical condition of the Illinois river at the points samples were taken and at the time they were taken, and are not representative of the water of the Illinois river at the time the samples were taken and at the places they were taken.

JUDGE SPRINGER: Counsel for defendants submits the same motion as was made in reference to the objection to plate I.

THE WITNESS: Plates II and III are as follows:


ILLINOIS RIVER AND TRIBUTARIES —1900
ANALYSES COVER PERIOD JAN 1st TO OCT 1st
SCALE
CHLORINE 1 DIVISION = 2 PARTS
ALBUMINOID AMMONIA 1 DIV = 0.25 PTS
TOTAL ORGANIC NITROGEN 1 DIV = 0.25 PTS
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS.
PLATE II
GROUP 1
GROUP 2
ENTIRE COLUMN, TOTAL ORGANIC NITROGEN
BLACK PART, ALBUMINOID AMMONIA
BRIDGEPORT
LOCKPORT
JOLIET
MORRIS
OTTAWA
LA SALLE
HENRY
(PEORIA) AVERYVILLE
WESLEY
PEKIN
HAVANA
BEARDSTOWN
KAMPSVILLE
GRAFTON
MILES
29
4
25
23
15
29
30
6
9
33
31
57
31
LOCKPORT
1.5 PARTS CHLORINE
CHLORINE 30.4 PTS
3.62
(KJELDAHL) ILL. & MICH CANAL
SANITARY CANAL
ILL. & MICH. C.
(KJELDAHL) SANITARY CANAL
ALB. AM. SANITARY CANAL
TOTAL ORGANIC NITROGEN
ALBUMINOID AMMONIA
TOTAL ORGANIC NITROGEN (KJELDAHL)
CHLORINE
12.47
.96
.4
DESPLAINES JOLIET
KANKAKEE
FOX
BIG. VERMILLION
SANGAMON
ILLINOIS GRAFTON
MISSISSIPPI GRAFTON
MISSOURI
CROSS-SECTION AT ALTON MISSISSIPPI RIVER
GROUP 3
ILLINOIS
SHORE
MID
STREAM
MISSOURI
ALBUMINOID AM.
CHLORINE
ORGANIC NITROGEN
CROSS-SECTION AT CHAIN O' ROCKS, MISSISSIPPI R
GROUP 4.
ILLINOIS
MID
INTAKE
TOWER
MISSOURI
ALBUMINOID AMMONIA
ORGANIC NITROGEN
CHLORINE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18


ILLINOIS RIVER AND TRIBUTARIES 1900
ANALYSES COVER PERIOD JAN 1ST TO OCT 1ST
PLATE III
SCALE
FREE AMMONIA 1 DIVISION = 0.25 PARTS
NITRITES 1 DIVISION = 0.1 PARTS
OXYGEN CONSUMED 1 DIVISION = 2.5 PARTS
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS
ILL. & MICH. CANAL 13.4 PARTS FREE AMMONIA
2.97 PARTS FREE AMMONIA
OXYGEN CONSUMED
ILL. & MICH. CANAL
SANITARY CANAL
8.1 PARTS OXYGEN CONSUMED
GROUP 1
OXYGEN CONSUMED
11.1
FREE AMMONIA
.38
.851
NITRITES
NITRITES
.0237
MILES 29 4 25 23 15 29 30 6 9 33 31 57 31
BRIDGEPORT
LOCKPORT
JOLIET
MORRIS
OTTAWA
LA SALLE
HENRY
(PEORIA) AVERYVILLE
WESLEY
PEKIN
HAVANA
BEARDSTOWN
KAMPSVILLE
GRAFTON
ENTIRE COLUMN, OXYGEN CONSUMED
BLACK PART, FREE AMMONIA
GROUP 2
DESPLAINES, JOLIET
KANKAKEE
FOX
BIG VERMILLION
SANGAMON
ILLINOIS, GRAFTON
MISSISSIPPI GRAFTON
MISSOURI
CROSS-SECTION CHAIN O' ROCKS
MISSISSIPPI RIVER
GROUP 4
OXYGEN CONSUMED
ILLINOIS SHORE
MID CHANNEL
INTAKE TOWER
MISSOURI SHORE
FREE AMMONIA
OXYGEN CONSUMED
ILLINOIS SHORE
MISSOURI SHORE
FREE AMMONIA
NITRITES
CROSS-SECTION AT ALTON
MISSISSIPPI RIVER
GROUP 3

8398 JUDGE SPRINGER: Now will you please explain this table on the significance of these lines?

A. Plate II is similar to Plate 1, in that it shows the proportions of various significant constituents contained in the waters of the Illinois and its tributaries, and the Mississippi at Grafton, Alton and chain of rocks, and the Missouri at Fort Bellefontaine, for the period January 1st, to October 1st, 1900. That is, the nine months immediately subsequent to the opening of the Chicago main drainage channel. The effect of the dilution of the Chicago sewage with the lake water before discharging it into the Desplaines and the Illinois is shown by the analyses made during the year 1900. The data of these analyses appear in tables 39 to 80 inclusive, and the averages are brought together in table B.

The features of plate II are similar to those of plate I, but differ in that the proportions of the various constituents are not the same. These conditions being caused in the main so far as the samples from the Illinois river are concerned by the dilution effected by the opening of the Chicago main drainage channel. Discussion of this plate in detail is hardly necessary or especially profitable for the reason that the period covered is not the same as that covered by the figures and lines of plate I, and for the further reason that a consideration of all such data as are included in the representations of plate II, which
8399 are strictly comporable with the figures and lines of plate I are discussed and are represented by columns and curves in plates which are shortly to be considered.

It is a well known fact that the waters of streams vary greatly at different seasons, both as to the volume of water and the content and nature of substances carried by the water. These seasonable variations are particularly important in the cases of some of the streams of the Mississippi valley and especially so for the Illinois, the Missouri and the Mississippi. Although the entire series of analyses for the year 1900 does not correspond as to the time and season with the entire series of analyses for the year 1899. These two seasons overlapped during the summer months, namely, the four months, June, July, August and September, during which period the most important physical features are the comparatively small volume of flow and

the comparatively high temperature, not only of the atmosphere but of the water itself, features which are especially important with reference to the Illinois river. In consequence of this overlapping, the data during this period for the two different years, namely, June, July, August and September, 1899, and June, July, August and September, 1900, are fairly and reasonably comparable with each other. For the purpose of
8400 making this comparison, I have prepared averages of the data of the Illinois made during June, July, August and September, 1899, that is before the opening of the main drainage channel and similar averages from data obtained from analyses made during the same four months in 1900 or immediately after the opening of the main drainage channel. The data appear in detail in tables 1 to 80 inclusive, and the particular averages in question appear in tables C and D respectively.

Q. Which have been read in evidence by you?

A. Yes sir.

Adjourned until 2:00 p. m. same day, Oct. 14, 1903.

8401 2:00 P. M., Wednesday, October 14th, 1903.

Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further direct examination by Judge Springer and testified as follows:

Q. Professor, I hand you a paper which is designated as plate IV. Please state whether that plate was made by you and if so where you obtained the data from which it was made?

A. Plate IV was made by me. The data represented upon it appear in the form of averages in tables C and D which were heretofore read in evidence, and the details from which the averages were made appear in tables 1 to 80 inclusive, which tables have heretofore been read in evidence.

JUDGE SPRINGER: I offer the plate in evidence and the witness will please read it as a part of his testimony.

MR. JEFFRIES: To the reading of the plate into the record I object for the same reasons stated in my objection to the reading of plates II and III, and for the further reason 8402 that the plate being now offered in evidence, being based upon tables C. and D. no comparison can be drawn with reference to the chemical constituents in the water that would be relevant in this case, for the reason that table C purports to represent the chemical constituents contained in the water of the Illinois river prior to the opening of the Chicago drainage canal, and table D purports to represent the condition of the water in the Illinois river subsequent to the opening of the canal and no comparisons that would be drawn from these tables would be comparable with each other, or with the conditions prior to the opening of the canal, because of the influence of the addition of water to the volume of water in the Illinois river, and by reason of the increased flow of the water in the Illinois river, and it would therefore have no bearing upon the sanitary condition of the water in the Illinois river as it has existed and will exist, since the opening of the drainage canal.

JUDGE SPRINGER: Counsel for defendants move to strike out this objection for the reason that it goes to the weight of the evidence and not as to its admissibility or competency.

A. The plate when copied into the record is as follows:

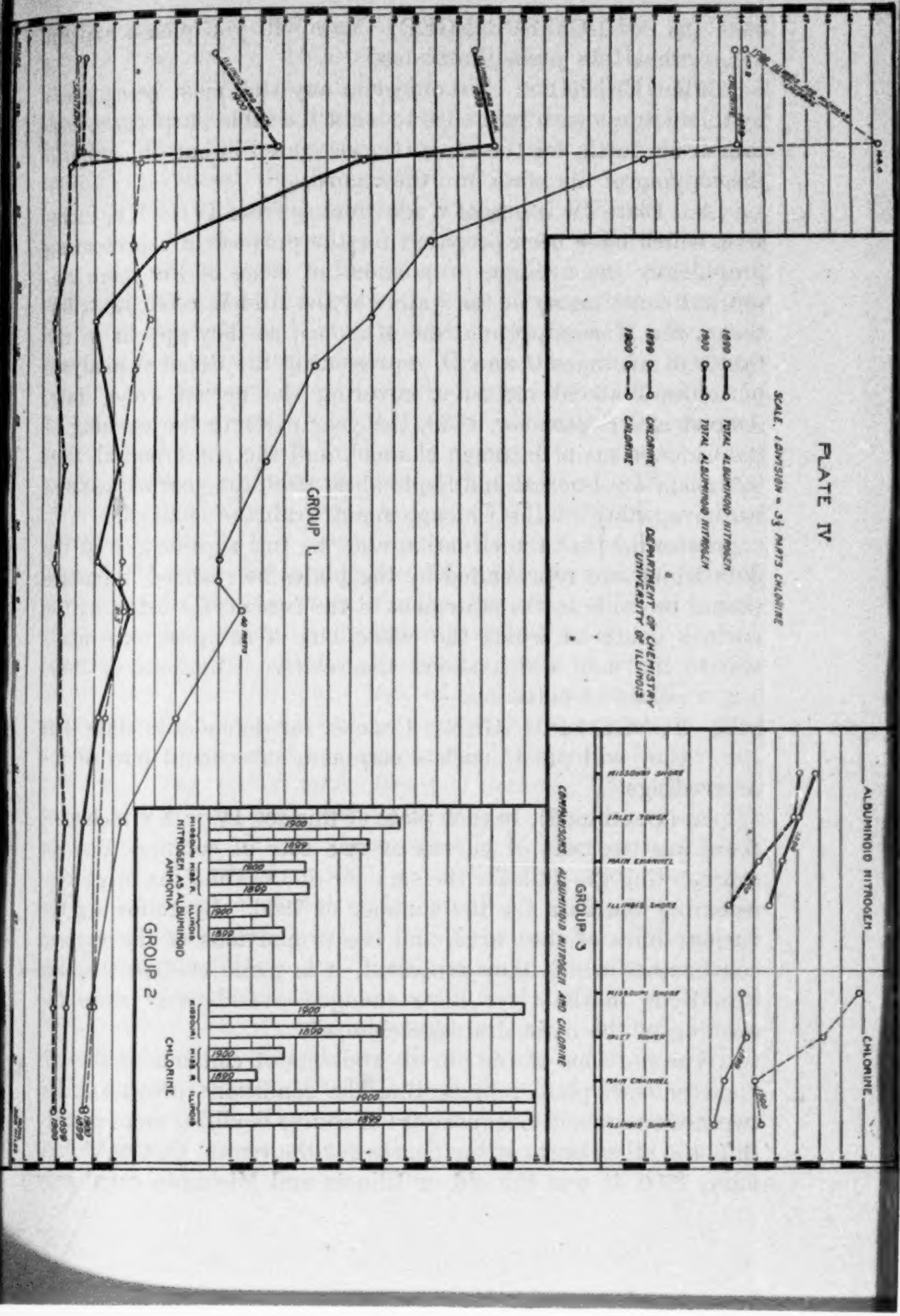


PLATE IV
SCALE, 1 DIVISION = 3½ PARTS CHLORINE
1899 TOTAL ALBUMINOID NITROGEN
1900 TOTAL ALBUMINOID NITROGEN
1899 CHLORINE
1900 CHLORINE
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS
GROUP I.
40 PARTS
GROUP 2
NITROGEN AS ALBUMINOID AMMONIA
CHLORINE
MISSOURI
MISS. R.
ILLINOIS
1900
1899
GROUP 3
COMPARISONS ALBUMINOID NITROGEN AND CHLORINE
MISSOURI SHORE
INLET TOWER
MAIN CHANNEL
ILLINOIS SHORE
ALBUMINOID NITROGEN
CHLORINE

8404 Q. JUDGE SPRINGER: Now will you please explain what this plate illustrates?

MR. JEFFRIES: We object to any statement being made by this witness with reference to what the table purports to contain or set forth, for the same reasons stated in our objection to the copying of the plate into the record.

A. Plate IV is one of a set running from IV to XV, inclusive, which have been prepared for the purpose of representing graphically the average proportions of some of the more significant constituents of the waters of the Illinois river, its tributaries, the Mississippi and the Missouri, as they appear in the tables of averages C and D, representing the detailed analyses of tables 1 to 80 inclusive, covering the period June, July, August and September, 1899, the year prior to the opening of the Chicago main drainage channel, and the same period, that is, June, July, August and September, 1900, the year subsequent to the opening of the Chicago main drainage channel.

In order that the situation and the full significance of the data which are represented by the plates be realized, reference should be made to the statement of the reasons for selecting the various points at which the collections of samples were made and to the map which shows the relative situations of these points of collection—

8405 JUDGE SPRINGER: Counsel for defendants state that they will put in such a map as a subsequent part of the proceedings.

A. (Continued). In each plate of this set, IV to XV inclusive, there are two sets of curves or two sets of columns, one set representing the data for the summer of 1899 and the other representing the data for the summer of 1900. By following the various lines of the curve, and the proportions of the various constituents which they represent, it is made evident that the conditions in the river have changed considerably since the opening of the main drainage channel.

The portions of the curves and sets of columns at the left hand of each plate representing the conditions prevailing between Chicago and Lockport are of course modified more greatly than the other parts of the curves for the reason that until January, 1900, it was the old or Illinois and Michigan canal only

which carried the discharge of Chicago sewage into the Desplaines river valley, while since the opening of the drainage channel the sanitary canal itself carries not merely undiluted sewage and stock yards drainage, but a very large proportion of diluting lake water. Inasmuch as the Illinois and Michigan canal is still mainly fed from a fork of the south branch, which is not yet flushed with lake water, we find that the pro-
8406 portions of the various constituents are still excessive in
the waters of the old or Illinois and Michigan canal, both at Bridgeport and at Lockport. It is to be remembered that the discharge through the Illinois and Michigan canal is now much less than it was formerly, for since the opening of the drainage channel the old canal is used chiefly for transportation and not particularly as a sewer, and the pumps at Bridgeport are supposed to raise only such fluid as is required to maintain a serviceable depth for commerce. The average flow in the Illinois and Michigan canal prior to 1900 was from 35,000 to 36,000 cubic feet per minute. In 1900 it varied during the year, but the average was 26,700 cubic feet a minute. In 1901, the pumps were in operation only during seven months, beginning the latter part of April and reaching to the latter part of November. During this period of seven months, the average rate at which liquids were raised from the south fork of the Illinois and Michigan canal was 23,000 cubic feet per minute; the average for the entire year, which is not a true average for the time of operation, however, being 13,800 cubic feet per minute. The figures of tables Nos. 40 and 41 in which the data of analyses of samples from the Illinois and Michigan canal at Bridgeport and Lockport, for the year 1900, are set forth, reveal occasional
8407 variations of considerable magnitude. These variations
are chiefly due to the fact that the pumps at Bridgeport which feed the Illinois and Michigan canal are situated but a few rods within the mouth of the south fork and that the diluted sewage which, on its way through the south branch to the drainage channel, passes the mouth of the south fork, sometimes enters a short distance within the mouth and is thence pumped into the old canal. The short duration of such occasional conditions during which comporatively dilute sewage is pumped

into the Illinois and Michigan canal, accounts for the fact that the variations are less frequent and less considerable at Lockport, 29 miles below, for the reason that on the way the mixing of the more concentrated sewage ordinarily raised, and the more dilute sewage occasionally introduced by the pumps, is more or less perfected.

At Joliet where the discharges through the two canals and that from the upper Desplaines river have come together, there is frequent and considerable variation in the proportions of organic matter and other impurities contained in the waters of the Desplaines river, partly in consequence of variations in the flow of water from the Illinois and Michigan canal through the use of locks, partly from occasional closing of the gates at the
Bear Trap dam, thus shutting off or reducing the flow
8408 of the more dilute sewage from the drainage channel. The
accumulation of sewage in the Chicago river, which follows a stoppage or reduction of the flow through the drainage channel is another cause of variation, for when the gates are again opened the sewage discharged is for a time necessarily less dilute than it would otherwise have been. The variations at Joliet results in large part also from incomplete commingling of the waters, for the discharge from the old canal entering by the south or east bank at Lockport and at Joliet generally passes down beside that bank for some considerable distance, but at times when the flow from the drainage channel is reduced, it often extends further out into the stream or possibly may entirely cross the river bed. The variations which appear in table 44 are largely due to the facts just above considered.

Upon plate IV, there is shown, first, general curves representing the proportions of chlorine and of nitrogen as albuminoid ammonia in the waters of the Desplaines and the Illinois rivers at different points between Chicago and the mouth of the river at Grafton. For the purposes of this study the Illinois and Michigan canal and the sanitary canal are both regarded as being part of the one system which includes these canals,
the Desplaines river and the Illinois river stretching from
8409 Chicago to the Mississippi at Grafton. Comparison of the
two curves representing the chlorine shows a much more

considerable diminution of the proportions or chlorine contained in the water flowing through the bed of the Desplaines river at Joliet, in 1900 than in 1899. This is obviously due to the dilution of Chicago sewage with lake water which passes through the drainage channel. The continuous diminution in content of chlorine between Bridgeport—(in both years, following the Illinois and Michigan canal as far as Joliet)—and the mouth of the river at Grafton, is of course due merely to dilution. The average quantity of chlorine contained in the natural surface waters of the regions in question has ranged from two to three parts as in the water of Lake Michigan, to as much as five or six parts as frequently found in the waters of such streams as the Fox, the Kankakee, and the Sangamon. The waters which pass through the drainage canal contain a considerably smaller portion of chlorine than is contained in the waters passing through the Desplaines and Illinois river valley, for the reason already noted that the sewage carried by the Illinois and Michigan canal, and discharged by it into the Desplaines river at Lockport, and just above Joliet, is still very concentrated. Moreover, in and about Lockport and Joliet
8410 there are various saline artesian wells. There are sewers
and manufacturing establishments which discharge into the old canal or the river between the collecting point at Lockport and that at Joliet. From Joliet down, the river there is a slight fall in chlorine for 1900 as we reach Morris, and the subsequent apparent increase in the content of chlorine at Ottawa, notwithstanding the inflow of the waters of the Kankakee above Morris, are in some measure misleading, and untrustworthy, for the mixing of the two streams is at these points still incomplete, as subsequent work has shown, and to the incomplete mixing of the main body of water from the drainage channel with the waters of the various tributaries is due many of the variations in both directions which appear in the results for 1900 for the several points between and including Joliet and Ottawa.

Various cross-section determinations made at LaSalle, Averyville and Grafton have shown that at these several points the mixing is complete. Particularly at Averyville and Grafton, which we may regard as critical points, determinations of

chlorine in samples taken at a number of points across the stream have invariably shown that in these localities there is no difference in the chlorine content of the water anywhere between the two banks. At the mouth where the Illinois discharges into the Mississippi river, this water contains less
8411 chlorine than is found in it anywhere between that point
and Chicago, except in the sanitary canal itself. The proportion contained in the water at the mouth of the river in 1900 was very slightly greater than that contained during the corresponding time in 1899.

The curves representing the nitrogen as albuminoid ammonia show for 1899 a very rapid diminution in quantity as we pass from Bridgeport down the stream to Ottawa. Beyond Ottawa there is a notable increase, reaching the maximum at Henry but beyond that point there occurs a considerable diminution to Averyville or Peoria. Below Averyville, that is, at Wesley City and Pekin the quantities of nitrogen as albuminoid ammonia were greatly increased as a result of the discharge of sewage and wastes from distilleries, cattle sheds glucose works and such plants at Peoria and Pekin. Below Pekin again there is a slight but constant diminution until we reach the mouth of the river at Grafton. The curve for 1900 shows that there were much smaller quantities of albuminoid matters contained in the waters of the sanitary canal and in the waters of the Desplaines river at Joliet, and as we proceed down the stream from Joliet there is a decrease which reaches the limit at Ottawa. Beyond Ottawa the albuminoid nitrogen increases until Henry is
reached, beyond which point it diminished to Averyville.
8412 A slight increase occurred as we passed from Averyville
to Wesley, and Pekin and so on to Havana. Beyond Havana there is a gradual but continuous diminution until at the mouth of the river at Grarfton the proportion of albuminoid nitrogen contained in the water discharged from the Illinois into the Mississippi was notably less in 1900 than it was in the year 1899.

Comparison of the Illinois with the Mississippi and Missouri, group 2 on plate IV, represents first, comparison of the chlorine contained in the waters of the Illinois as it discharges into the Mississippi at Grafton, for the summer months of 1899 and for the summer months of 1900—

MR. JEFFRIES: I object to the witness making any comparisons or giving any testimony with reference to the chemical constituents of the water flowing down the Missouri river and the Mississippi river above Grafton, for the reason that the witness has not sufficiently qualified himself in evidence with the source of his information of those streams and for the further reason that the testimony is incompetent, irrelevant and immaterial, having no bearing upon the issues involved in this case and not being the subject at issue in this controversy.

JUDGE SPRINGER: I move to strike out the objection 8413 for the reasons stated in my motion to strike out the previous objections to these plates.

Q. Proceed, professor.

A. The proportions are stated in tables C and D, and represented in plate IV by the two columns at the lower right hand corner. Mere inspection of these columns is sufficient to show the relation of these proportions and to make manifest the slight difference as to chlorine content in the waters of the Illinois at its mouth between these two years.

Second, a comparison of the chlorine contained in the Mississippi above the mouth of the Illinois for like periods in 1899 and 1900. This is shown by the two columns next to the left of those referring to the Illinois river water. Inspection of the figures in the tables make manifest,—and the two columns in the plate show graphically the differences as to chlorine content in the Mississippi river water between these two years, and show that the proportion of chlorine in the Mississippi river water during this period in 1900 was considerably greater than during the similar period of 1899. This difference as to chlorine content between the two years was due doubtless to the fact that the water in the upper Mississippi river was at a lower stage during the summer of 1900 than it was during the 8414 summer of 1899.

Upon plate XVII which will be hereinafter introduced in evidence, the stages of water in the Mississippi river for the years 1899 and 1900 are represented.

Third, a comparison of the chlorine contained in the waters of the Missouri river near the mouth for the same periods. The figures in tables C and D show that the waters of the Missouri river contained a much higher proportion of chlorine during the summer of 1900 than during the corresponding season of 1899, but it must be noted that the period covered in 1899 is somewhat shorter than that for 1900, as in the earlier year the collections from the Missouri began July 10. The facts as represented in the tables of averages are shown in the plate by the columns labeled "Missouri" and serve to represent the considerable difference between the proportions for these two periods.

Fourth: Comparison of the content of albuminoid nitrogen in the Illinois river for 1899 and 1900, referred to in the general statement above, is shown graphically in this group, and these differences appear to the eye at once upon inspection of the columns.

Fifth: Comparison of the content of nitrogen as albuminoid ammonia in the water of the Mississippi river above the mouth of the Illinois. The second set of columns under the title
8415 "Nitrogen as Albuminoid ammonia" shows a slightly smaller proportion contained in the water of the Mississippi for 1900 than was contained during the same period of 1899, and shows further that there was considerably more albuminoid nitrogen in the waters of the Mississippi river during each of these periods,—that is both 1899 and 1900, than was contained in the waters of the Illinois river in either of the seasons in question.

Sixth: Comparison of the content of nitrogen as albuminoid ammonia in the waters of the Missouri. The figures which appear in tables C and D, show that during the summer of 1900 the proportion was greater than during the summer of 1899, and shows further that more than twice as much albuminoid ammonia or albuminous substances was contained in the water of the Missouri river in each of these years as was contained in the water of the Illinois river at Grafton and very considerably more than was contained in the waters of the Mississippi river. These facts as they appear in the tables of the averages, C and D, being represented graphically by the two columns at the left hand of the group 2, in plate IV.

Cross section of the Mississippi at Alton and at Mitchell, or chain of rocks, Group 3 on plate IV, represents the content of chlorine and of nitrogen as albuminoid ammonia in the waters
of the Mississippi river at four points across the stream
8416 at the chain of rocks, opposite the intake tower of the
St. Louis waterworks. From consideration of the curves which represent the averages appearing in tables C and D, it is made evident that the content of chlorine and of albuminoid nitrogen was considerably greater upon the Missouri side of the river than it was upon the Illinois side, and shows further that there was a greater difference between the two sides of the stream at the St. Louis pumping station during the season of 1900 than there was during the same period of the preceding year, that is, the year 1899. These differences between the proportions of chlorine at the different cross section points at the chain of rocks and also the seasonal variations of the chlorine at these points are exhibited in plate XIV which is to be hereafter introduced, and we will give a short description of that hereafter.

That is all in regard to plate IV.

Q. JUDGE SPRINGER: Professor, I call your attention to a paper designated as plate V. Please state whether that plate was made by you and if so, from what data?

A. Plate V was made by me and from the same data that was the basis of the lines and columns upon plate IV.

Q. The description of this differs only in respect to the
fact that in one way the data were illustrated by lines,
8417 and here by columns?

A. That is all right, but there is something more, and also by the fact that upon plate V we show cross-section proportions at Alton as well as cross-section proportions at the chain of rocks, and that the columns upon plate V represent the chlorine only for these various points and not also the nitrogen as albuminoid ammonia.

JUDGE SPRINGER: I now offer in evidence plate V to which you have referred and ask that it may be incorporated in the record as a part of your testimony in this case.

MR. JEFFRIES: Now I object to plate V being copied into the record and object to the witness testifying in relation thereto, or drawing any conclusions or making any determinations from it, for the same reasons stated in my objection to the introduction of plates II, III and IV.

A. Plate V is as follows:

LOCKPORT
LOCKPORT JOLIET
MORRIS
OTTAWA
LA SALLE
HENRY
AVERYVILLE
WESLEY PEKIN
HAVANA
BEARDSTOWN

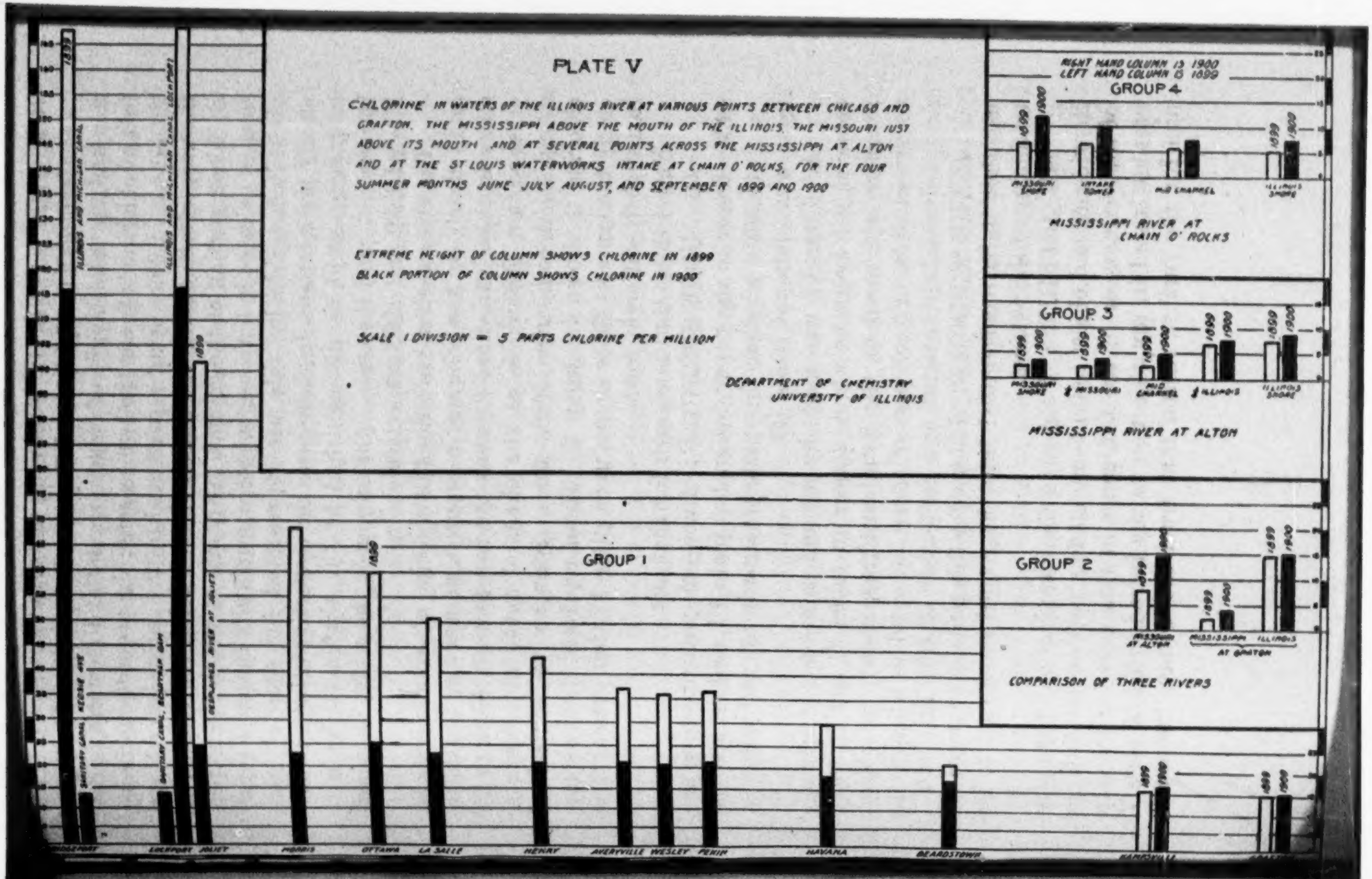


PLATE V

CHLORINE IN WATERS OF THE ILLINOIS RIVER AT VARIOUS POINTS BETWEEN CHICAGO AND GRAFTON, THE MISSISSIPPI ABOVE THE MOUTH OF THE ILLINOIS, THE MISSOURI JUST ABOVE ITS MOUTH AND AT SEVERAL POINTS ACROSS THE MISSISSIPPI AT ALTON AND AT THE ST LOUIS WATERWORKS INTAKE AT CHAIN O' ROCKS, FOR THE FOUR SUMMER MONTHS JUNE JULY AUGUST, AND SEPTEMBER 1899 AND 1900

EXTREME HEIGHT OF COLUMN SHOWS CHLORINE IN 1899
BLACK PORTION OF COLUMN SHOWS CHLORINE IN 1900

SCALE 1 DIVISION = 5 PARTS CHLORINE PER MILLION

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GROUP 1
1899
ILLINOIS AND MICHIGAN CANAL
SANITARY CANAL, KEDZIE AVE
SANITARY CANAL, BEARTRAP DAM
ILLINOIS AND MICHIGAN CANAL, LOCKPORT
DESPLAINES RIVER AT JOLIET
1899
BRIDGEPORT
LOCKPORT
JOLIET
MORRIS
OTTAWA
LA SALLE
HENRY
AVERYVILLE
WESLEY
PEKIN
HAVANA
BEARDSTOWN
KAMPSVILLE
GRAFTON
RIGHT HAND COLUMN IS 1900
LEFT HAND COLUMN IS 1899
GROUP 4
1899
1900
MISSOURI SHORE
INTAKE TOWER
MID CHANNEL
ILLINOIS SHORE
MISSISSIPPI RIVER AT CHAIN O' ROCKS
GROUP 3
MISSOURI SHORE
¼ MISSOURI
MID CHANNEL
¼ ILLINOIS
ILLINOIS SHORE
MISSISSIPPI RIVER AT ALTON
GROUP 2
MISSOURI AT ALTON
MISSISSIPPI
ILLINOIS
AT GRAFTON
COMPARISON OF THREE RIVERS

8419 THE WITNESS: Following down the series of columns from left to right, the differences between the black portion and the total height of column show the differences in content of chlorine between the two seasons; the proportions during the season of 1899 being represented by the entire column, and the proportions during the season of 1900 being represented by the black portion of the column. At points at which the proportions of chlorine in both seasons were practically the same, separate columns side by side are represented for showing more clearly the relations. In these cases the respective columns which ordinarily could be distinguished by the simple blackness in the one case, and the open, light column in the other, have been labeled 1899 and 1900 respectively.

The cross section variations in chlorine at Alton are shown quite clearly by the columns in group 3, as are also the differences in these variations between the two seasons, likewise the cross-section differences at the chain of rocks are shown in group 4. A comparion of the three rivers as to content of chlorine is shown in group 2. These represent features precisely the same as those shown upon plate IV, but present them in a slightly different form.

Now I think that is enough for that one.

Q. JUDGE SPRINGER: I now call your attention professor to the paper designated plate VI, and request you to state whether this plate was made by you and if so, upon what data you based it? 8420

A. Plate VI was made by me and represents graphically some of the averages which appear in tables C and D, which averages are based on the detail analyses, shown on tables 1 to 80 inclusive, or such part of these latter tables as cover the period June, July, August and September of 1899 and 1900.

JUDGE SPRINGER: I now offer this plate in evidence and ask that it be incorporated into the record as a part of the testimony of the witness.

MR. JEFFRIES: I object to the introduction of the plate in evidence and object to its being made a part of the testimony of this witness or of the testimony in this case for the same reasons stated in my objection to the introduction of plate V, and for the further reason that from the witness' statement,

it was only made up from a part of the analyses contained in the table of averages heretofore introduced; and for the further reason that it does not purport to represent or portray the character of the water in the Illinois river at the various points named on the plate during all times of the year, and for the reason also that it only portrays and represents, or purports to represent the character of the water in the Illinois river at the various points mentioned on the plate during the summer
8421 months of June, July, August and September of the years
referred to, while the winter months and spring months are omitted therefrom, so that no conclusion can be drawn from said plate that would represent the condition of the water with reference to the chemical constituents in the places referred to at all times of the year, and for this reason the plate does not represent the true character of the water of the river at all times and seasons of the year and cannot therefore be considered as constituting any evidence whatever, having no probative force and not being comparable with actual conditions existing and liable to exist at any and all times.

JUDGE SPRINGER: I move to strike out this objection for the reasons stated in similar motions in reference to the objections that have been made to the plates heretofore introduced, namely plates I to V inclusive, and for the further reason that it is impossible that one plate should contain all of the data presented in one of these tables of averages, the object in presenting these data graphically being to take portions of the data and graphically illustrate them on separate plates, for the purpose of showing in graphic form or in a pictured form the conditions which exist rather than to rely upon mere inspection of the figures contained in the tables upon which they are based.

Other plates will illustrate other conditions, and when
8422 they are introduced there will be a perfect representation
graphically of the various conditions which the detail analyses show to have existed at the time they were made, and further it is not contended by counsel that these plates represent anything other than the results obtained by the analyses which have actually been made and put in evidence in this case. We are not covering the earth, but we are only covering that part

of which is represented in the tables heretofore put in evidence and referred to upon each of these plates.

MR. JEFFRIES: I suggest to the court that if defendants are in possession of analyses showing the chemical constituents of the water at the various places during the entire year or any period that covers an entire year, that they and they alone will correctly represent the actual conditions, if they can be represented by the science of chemistry, and not by selecting one portion of the year and omitting the remaining portions of that year; and I also suggest to the Court that a plate of this kind and character can only be of service in the determination of the questions at hand when they graphically display the entire situation from one end of the year to the other, taking into consideration the conditions of water in the night time as well as the day, and taking into consideration the temperature of the water in the summer as well as in the winter and the changes and variations with reference to flow and volume of water each day and month throughout the year, and that only such tables can be of service to the court in making determinations, if tables of this character are to be relied upon so that the failure to graphically display from the plates now being offered in evidence the conditions throughout the year, renders them incompetent, irrelevant and of no probative force whatever. 8423

JUDGE SPRINGER: I submit that it is impossible for counsel for defendants to put in all of their testimony at the same time. We are now presenting testimony in detail. We intend before this witness leaves the subject entirely, before he quits the stand, to present other tables and other plates which will give a more extended result as to chemical conditions of the various waters under consideration, and I submit further that if counsel's objection is valid, that nothing would be competent in the way of chemical analyses of these waters unless we could analyze chemically every cubic centimeter of the water of the river that passes every moment at every point in the river between Bridgeport and the St. Louis intake, a task which is impossible, and defendants are not expected to accomplish impossibilities.

8424 MR. TODD: I desire to submit to the court in reply to the objections made by counsel for complainant, that while counsel for complainant in his objection as to the probative force of these charts may apply to the charts introduced in evidence by the complainant, the objection has no weight whatever when being applied to the charts which are being introduced in evidence as illustrating the testimony given by this witness based upon the chemical analyses in the tables heretofore offered in the evidence, and the objection if valid in any particular applies to the weight and not to the form of the evidence.

THE WITNESS: Plate VI is as follows:

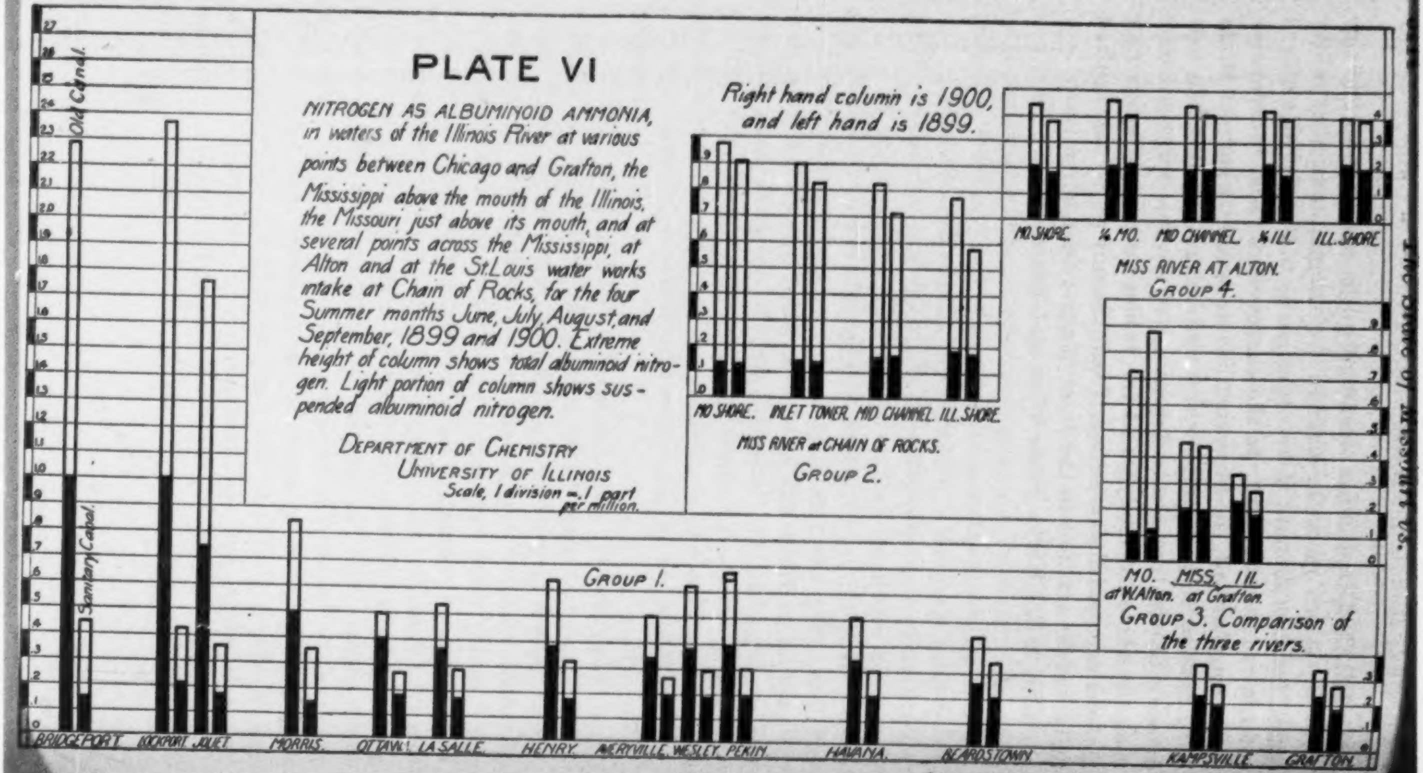


PLATE VI

NITROGEN AS ALBUMINOID AMMONIA, in waters of the Illinois River at various points between Chicago and Grafton, the Mississippi above the mouth of the Illinois, the Missouri just above its mouth, and at several points across the Mississippi, at Alton and at the St. Louis water works intake at Chain of Rocks, for the four Summer months June, July, August, and September, 1899 and 1900. Extreme height of column shows total albuminoid nitrogen. Light portion of column shows suspended albuminoid nitrogen.

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS
Scale, 1 division = .1 part per million.

Right hand column is 1900, and left hand is 1899.

27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Old Canal.
Sanitary Canal.
BRIDGEPORT
LOCKPORT
JOLIET
MORRIS.
OTTAWA
LA SALLE.
HENRY.
AVERYVILLE.
WESLEY
PEKIN.
HAVANA.
BEARDSTOWN.
KAMPSVILLE.
GRAFTON.
GROUP 1.
MO. SHORE.
INLET TOWER.
MID CHANNEL.
ILL. SHORE.
MISS RIVER at CHAIN OF ROCKS.
GROUP 2.
MO. SHORE.
¼ MO.
MID CHANNEL.
¼ ILL.
ILL. SHORE.
MISS RIVER AT ALTON.
GROUP 4.
MO. at W. Alton.
MISS.
ILL. at Grafton.
GROUP 3. Comparison of the three rivers.

8426 JUDGE SPRINGER: Now professor, will you please explain in detail what this plate was intended to illustrate?

A. Plate VI was made by me for the purpose of facilitating a realization of the significance of certain averages which appear in tables C and D, and in this respect is supplementary or rather complementary to that portion of plate IV which represents the proportions of nitrogen as albuminoid ammonia. It has the different lengths of the column to show the differences between the two years. The columns in this plate show in addition to the total albuminoid nitrogen, also that portion of nitrogen as albuminoid ammonia which is derived from albuminous substances contained in solution, and the difference between the black portion and the total height of each column represents the proportion of nitrogen as albuminoid ammonia derived from that portion of the albuminous substances which are in suspension in the waters.

Q. What period does this plate cover?

A. As all of the plates IV to XV inclusive, this plate covers the periods June, July, August and September, 1899 and 1900.

The successive shortenings of the columns as we proceed from near to the left hand side of the plate to the right hand,
shows the successive steps of decrease of nitrogen as
8427 albuminoid ammonia as we proceed down these streams
from the neighborhood of Chicago, that is Bridgeport and Lockport, to the mouth of the Illinois river at Grafton, and shows moreover, the notable increase in the proportions of these substances contained in the waters of the Illinois river just below Peoria.

Moreover, the differences between the two seasons, that is the period June, July, August and September of 1899 and the same months of 1900, readily appear on comparison of the right hand column with the left hand column in each set of two across the bottom of the plate. The very considerable difference between these columns showing the very considerable decrease in proportions of albuminoid nitrogen effected for the season 1900 by the dilution consequent upon the opening of the Chicago main drainage channel, and the discharge of lake water through it into the Desplaines valley. That this has not during the period in question brought about any notable increase in the proportions of nitrogen as albuminoid ammonia in that portion of the waters of the Mississippi, which passes down from the vicinity of Grafton to the chain of rocks near St. Louis toward the Missouri bank, is evident from an inspection of the columns of group 4 and group 2.

Q. Professor, I now hand you two papers, one designated
8428 as Plate VII, and the other as Plate VIII, please state
whether these plates were made by you and if so upon what data they were based?

A. Plates VII and VIII were made by me. They represent certain data which appear in the tables of averages in tables C and D, the detailed analyses of which appear in tables 1 to 80 inclusive, or rather in such portions of tables 1 to 80 as cover the four summer months, June, July, August and September for the years 1899 and 1900.

These two plates VII and VIII represent in general similar features to those already referred to in the descriptions of plates IV and VI, but the particular substances represented upon Plates VII and VIII are the total organic nitrogen, that derived from substances which are in solution, that derived from substances which are in suspension, and the sum of the two for the real total.

JUDGE SPRINGER: I now offer in evidence these two plates VII and VIII and ask that they be incorporated into the record as part of the testimony of this witness.

MR. JEFFRIES: I object to plate VII being incorporated into the record for the reason stated in my objection to plate VI, and for the further reason that it does not show what season
of the year the samples were taken which are graphically
8429 represented by the plate, and I object to the incorporation
of Plate VIII into the record for the same reason mentioned in my objection to the incorporation of Plate VI into the record.

THE WITNESS: Plates VII and VIII are as follows:

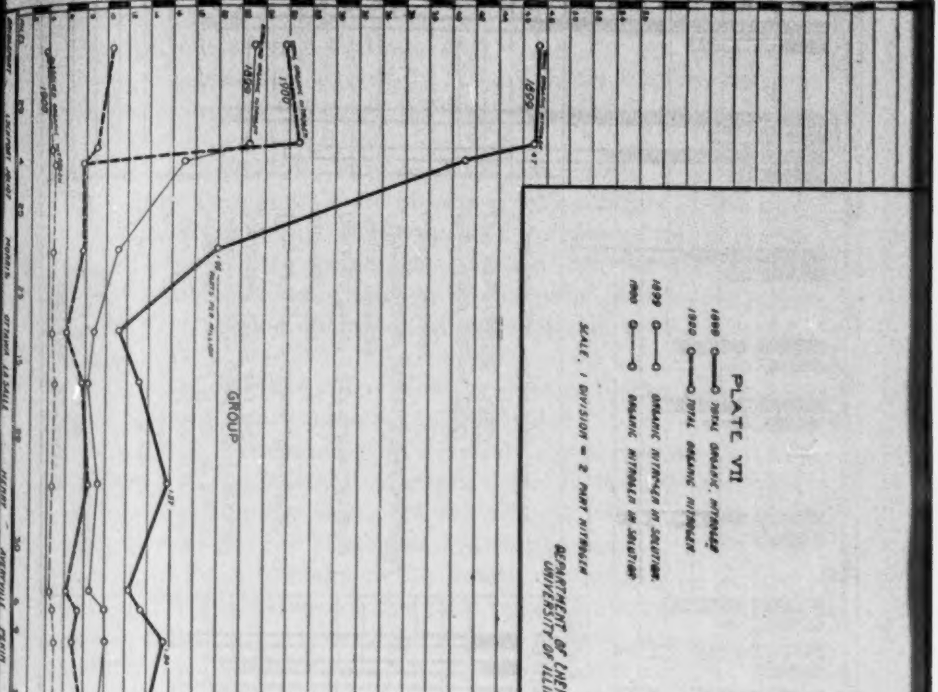


PLATE VII
1899 TOTAL ORGANIC NITROGEN
1900 TOTAL ORGANIC NITROGEN
1899 ORGANIC NITROGEN IN SOLUTION
1900 ORGANIC NITROGEN IN SOLUTION
SCALE, 1 DIVISION = 2 PART NITROGEN
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS
GROUP
CHICAGO
LOCKPORT
JOLIET
MORRIS
OTTAWA
LA SALLE
HENRY
AVERYVILLE
PEKIN
HAVANA
BEARDSTOWN
KAMPSVILLE
GRAFTON
1899
1900
PARTS PER MILLION
GROUP 2
COMPARISONS OF AMOUNTS OF ORGANIC NITROGEN IN WATERS OF ILLINOIS MISSISSIPPI AND MISSOURI RIVERS IN 1899 AND 1900
MISSOURI MISS. R. ILLINOIS
DISSOLVED ORGANIC NITROGEN
TOTAL ORGANIC NITROGEN
GROUP 3
COMPARISONS OF WATERS COLLECTED AT DIFFERENT POINTS ACROSS THE STREAM OF THE MISSISSIPPI RIVER AT ALTON AND AT CHAIN OF ROCKS
ALTON
CHAIN OF ROCKS
MISSOURI SHORE
ILLINOIS SHORE

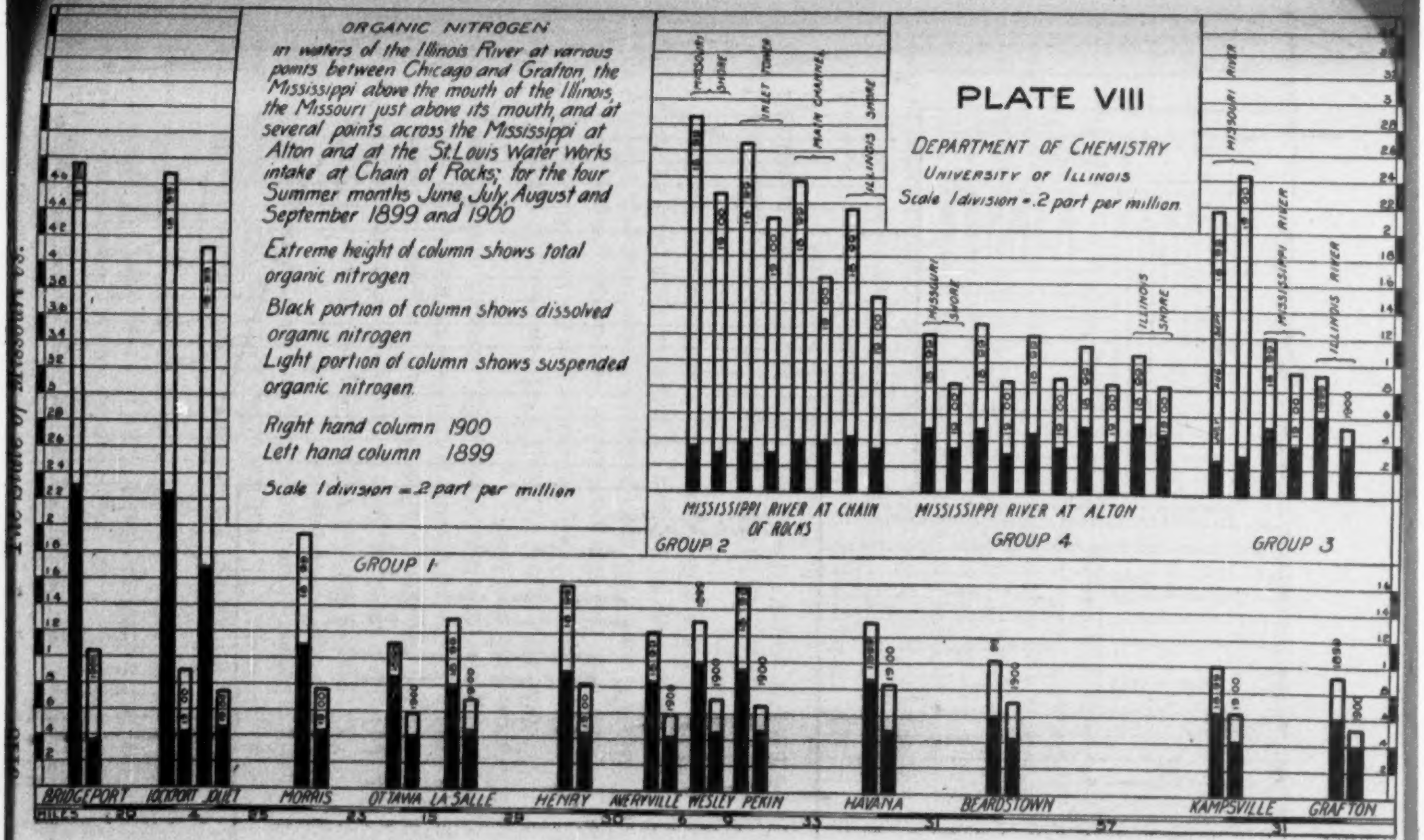


PLATE VIII
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS
Scale 1 division = .2 part per million.
ORGANIC NITROGEN
in waters of the Illinois River at various points between Chicago and Grafton, the Mississippi above the mouth of the Illinois, the Missouri just above its mouth, and at several points across the Mississippi at Alton and at the St. Louis Water Works intake at Chain of Rocks; for the four Summer months June, July, August and September 1899 and 1900
Extreme height of column shows total organic nitrogen
Black portion of column shows dissolved organic nitrogen
Light portion of column shows suspended organic nitrogen.
Right hand column 1900
Left hand column 1899
Scale 1 division = .2 part per million
GROUP 1
GROUP 2
GROUP 3
GROUP 4
MISSISSIPPI RIVER AT CHAIN OF ROCKS
MISSISSIPPI RIVER AT ALTON
MISSOURI SHORE
INLET TOWER
MAIN CHANNEL
ILLINOIS SHORE
MISSOURI RIVER
MISSISSIPPI RIVER
ILLINOIS RIVER
1899
1900
BRIDGEPORT
LOCKPORT
JOLIET
MORRIS
OTTAWA
LA SALLE
HENRY
AVERYVILLE
WESLEY
PEKIN
HAVANA
BEARDSTOWN
KAMPSVILLE
GRAFTON
MILES
20
4
25
23
15
28
30
6
0
35
31
57
31
.2
.4
.6
.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4
4.2
4.4
4.6

8432 Q. JUDGE SPRINGER: Please state professor, the periods covered by Plate VII?

A. The periods covered by Plate VII, are the four summer months, June, July, August and September, 1899, and the same months of the year 1900.

MR. JEFFRIES: In view of the last answer of the witness I withdraw that part of my objection which refers to the table, as not showing the time the samples of water were taken, the analyses of which are graphically set forth on the plate, but I still object to the incorporation of the plate into the evidence for the same reason contained in my objection to the introduction of Plate VI.

JUDGE SPRINGER: Now professor, please state what these two plates are intended to illustrate?

A. They are intended to illustrate, by a representation of the figures of the tables of averages C and D, the changes which take place along the course of the Illinois river and the Desplaines river and the Illinois and Michigan canal and the Sanitary Canal from Chicago to the mouth of the Illinois at Grafton, in the proportions of the total organic nitrogen, and also to show the relative quantities of total organic nitrogen in the water of the three streams, namely, the Illinois river, Missouri river, and the Mississippi river near the point at which
8433 these two streams come together, and to show the variations across the stream of the Mississippi river at Alton, and opposite the intake of the St. Louis waterworks at the chain of rocks, and to represent the difference between these two years for the period indicated.

Q. In reference to what?

A. With reference to the effect of the opening of the Chicago main drainage channel upon the waters of the Illinois and such portion of the Mississipi river as extends from the mouth of the Illinois to the intake tower of the St. Louis waterworks. The considerable differences between the right hand and left hand column in each pair in plate VIII show how much less was the content of nitrogenous organic matters as represented by the total organic nitrogen in the summer period referred to above, of the year 1900 as compared with the same period of the year 1899, the latter being the period before the opening of the Chicago main drainage channel and the former the period subsequent thereto.

Inspection of the two columns at the lower right hand corner of plate VIII shows graphically the relation between the figures which appear in tables C and D, representing the average proportions of total organic nitrogen, and that contained in substances in solution in the waters of the Illinois in 1899
8434 and in 1900.

Inspection of the columns represented in group 3 serves to show that the proportions of total organic nitrogen contained in the waters of the Illinois river at its mouth at Grafton, in 1900 was very considerably less, in fact, but little more than half as much in 1900 as in 1899. Same comparison of the next two columns which represent the proportions in the Mississippi river shows, that in it also the proportions for the summer period of 1900 were considerably less than during the same period in 1899, although the difference is not proportionally so great as in the case of the waters of the Illinois.

The third set of columns in this group represent the conditions with respect to the total organic nitrogen in the waters of the Missouri river. These columns serve to represent figures which appear in tables C and D, and express the fact that in the waters of the Missouri river in 1900 there was a greater proportion of total organic nitrogen than in the preceding year, that is the same period for the year 1899, but to those there must be noted the fact that the period for the Missouri river in 1899 was not so long as the period for the year 1900, for the reason again that the collections in the Missouri river did not begin in 1899 until July 10th.

8435 Cross-sections of the Mississippi at Alton shown in Group 4, show that the proportions clear across the stream in 1900, were considerably less than the proportions of total organic nitrogen contained in the waters of the Mississippi river at this point during the preceding year, the year 1899.

Consideration of the columns of group 2 show that the relative proportions at the different points across the stream at the chain of rocks, wer [illegible]t much different in the year 1900 from what they had been in the year 1899, although the total proportions at each of the four points across the stream were less in 1900 than in 1899.

Plate VII represents similar data by means of lines and curves instead of the columns, and will probably need no further explanation than that just given in respect to Plate VIII.

The total organic nitrogen referred to in these tables and in these plates and in the tables in which the figures represented upon the plates appear, is contained as a constituent of organic matters, particularly such organic matters as are contained in animal substances, and which are essential constituents of all living things, including micro-organisms as well as all
8436 other and irrespective of size, or the animal or vegetable
character, except that in general a greater proportion of nitrogen is contained in animal substances than is contained in most vegetable organisms or the substances in vegetable organisms which in particular contain the nitrogen in organic combination.

It includes that just referred to above and in the earlier plates as nitrogen as albuminoid ammonia, and in general it is from two to three times as much as the latter.

The dissolved organic nitrogen is of course derived from these nitrogenous organic matters which are commonly in solution in the water, while the total includes not only this, but also that which is contained in matters which are suspended in the water. These comparisons further give expression to the fact that the nitrogenous organic matters in solution which are here represented by the term "organic nitrogen in solution" are contained in the Illinois river water in greater proportion than in the waters of the Mississippi or in the waters of the Missouri, but it is noticeable that the difference between these streams has been considerably less during the summer of 1900 than it was during the summer of 1899. In the waters of the Missouri river there was somewhat more in 1900 than 1899, but the difference is slight. For the Mississippi and the Illinois, however,
8437 there are as represented, considerable differences, indicating a better condition of their waters in this respect during the summer of 1900 than during the summer of 1899. The striking differences between these three streams with respect

to the proportions of the nitrogenous organic matters becomes clearly manifest upon inspection of the unshaded portions of the columns of plate VIII.

Q. Professor, I now hand you three papers designated as Plates IX, X and XI. Please state whether these plates were made by you, and if so from what data they were compiled and made?

A. I made these three plates, Plates IX and X, and XI, and they were made as representations of the figures appearing in the tables of averages covering the four summer months, June, July, August and September, 1899 and the same months in 1900, which averages appear in tables A and D, and represent the detailed data which appear for these two four months periods, in the tables 1 to 80 inclusive.

JUDGE SPRINGER: I now offer these three plates in evidence and ask that they be incorporated in the record as part of the testimony of this witness.

MR. JEFFRIES: I object to the introduction of Plates IX, X and XI and to their incorporation into the record as part of the testimony of this witness, for the same reasons stated in my objection to the incorporation into the evidence of plates VI, VII and VIII. 8438

THE WITNESS: The plates, IX, X and XI are as follows:

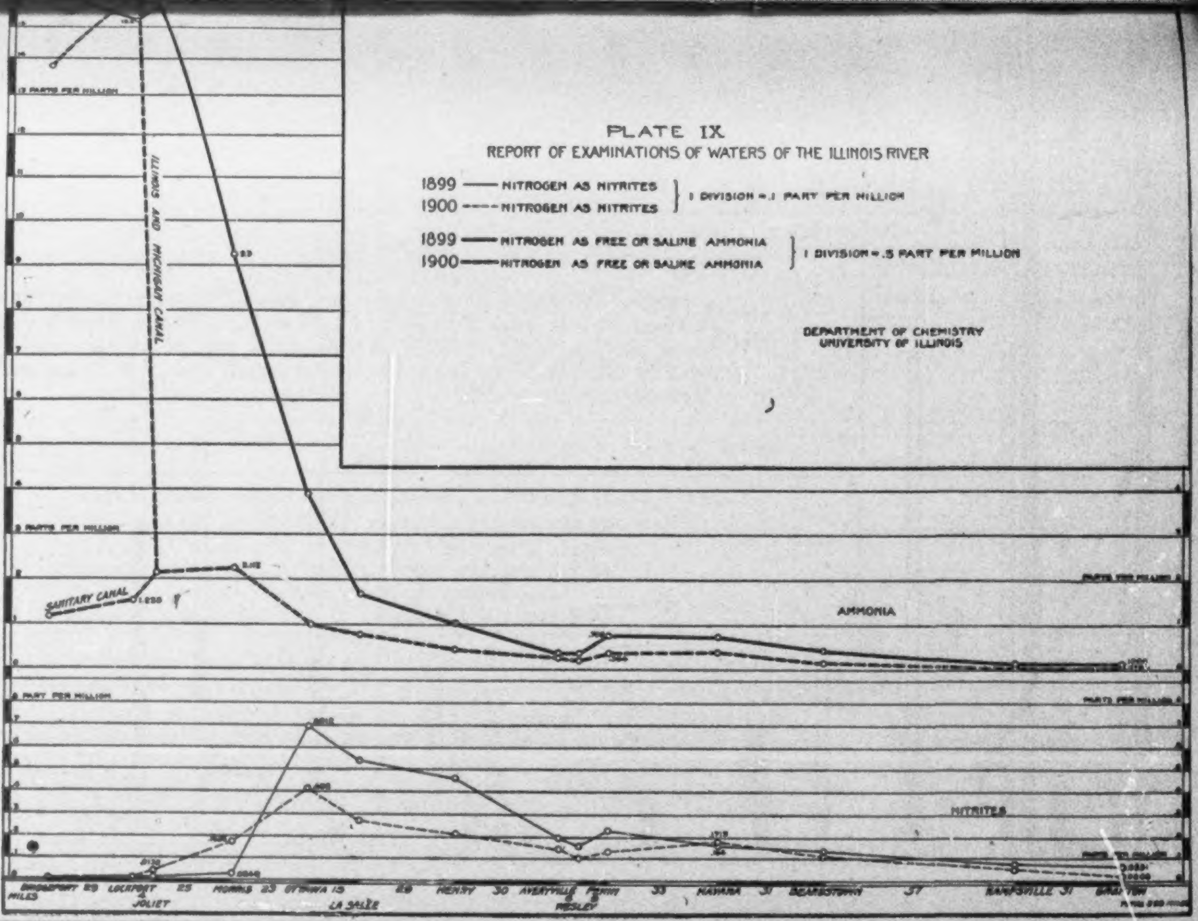
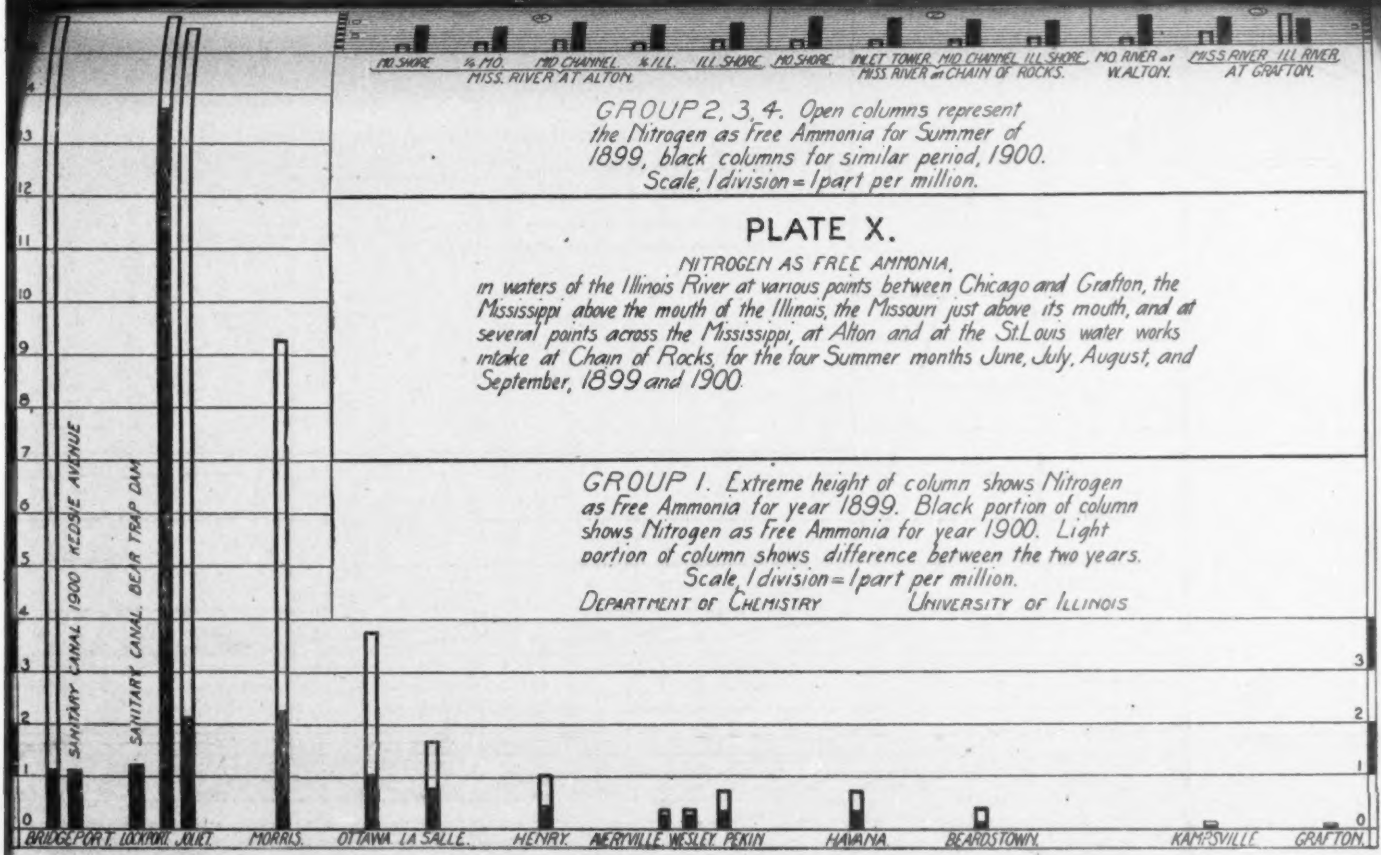


PLATE IX

REPORT OF EXAMINATIONS OF WATERS OF THE ILLINOIS RIVER



GROUP 2, 3, 4. Open columns represent the Nitrogen as Free Ammonia for Summer of 1899, black columns for similar period, 1900.
Scale, 1 division = 1 part per million.

PLATE X.

NITROGEN AS FREE AMMONIA,

in waters of the Illinois River at various points between Chicago and Grafton, the Mississippi above the mouth of the Illinois, the Missouri just above its mouth, and at several points across the Mississippi, at Alton and at the St. Louis water works intake at Chain of Rocks, for the four Summer months June, July, August, and September, 1899 and 1900.

GROUP 1. Extreme height of column shows Nitrogen as Free Ammonia for year 1899. Black portion of column shows Nitrogen as Free Ammonia for year 1900. Light portion of column shows difference between the two years.
Scale, 1 division = 1 part per million.

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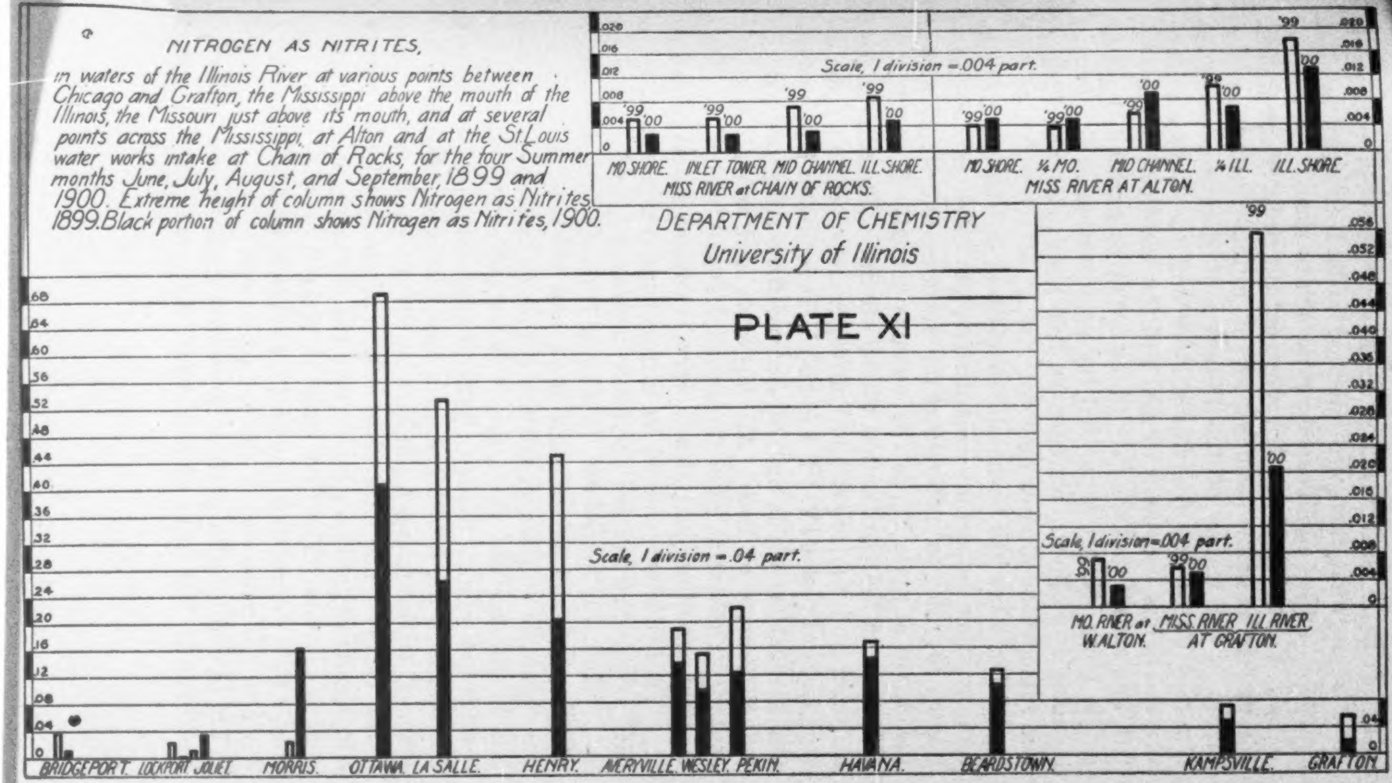

PLATE XI

NITROGEN AS NITRITES,

in waters of the Illinois River at various points between Chicago and Grafton, the Mississippi above the mouth of the Illinois, the Missouri just above its mouth, and at several points across the Mississippi at Alton and at the St. Louis water works intake at Chain of Rocks, for the four Summer months June, July, August, and September, 1899 and 1900. Extreme height of column shows Nitrogen as Nitrites 1899. Black portion of column shows Nitrogen as Nitrites, 1900.

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University of Illinois

Scale, 1 division =.004 part.
.020
.016
.012
.008
.004
0
'99
'00
MO SHORE.
INLET TOWER.
MID CHANNEL.
ILL. SHORE.
MISS RIVER at CHAIN OF ROCKS.
MO SHORE.
¼ MO.
MID CHANNEL.
¼ ILL.
ILL. SHORE.
MISS RIVER AT ALTON.
Scale, 1 division =.04 part.
0
.04
.08
.12
.16
.20
.24
.28
.32
.36
.40
.44
.48
.52
.56
.60
.64
.68
BRIDGEPORT.
LOCKPORT.
JOLIET.
MORRIS.
OTTAWA.
LA SALLE.
HENRY.
AVERYVILLE.
WESLEY.
PEKIN.
HAVANA.
BEARDSTOWN.
KAMPSVILLE.
GRAFTON.
Scale, 1 division =.004 part.
.004
.008
.012
.016
.020
.024
.028
.032
.036
.040
.044
.048
.052
.056
MO. RIVER at W. ALTON.
MISS. RIVER
ILL. RIVER
AT GRAFTON.

8442 JUDGE SPRINGER: Professor, you will now please state what facts are intended to be illustrated by these figures and what significance you attach to them?

A. Plates IX, X and XI, represent the proportions of nitrogen as free or saline ammonia and of nitrogen as nitrites, contained in the waters of the Illinois and Michigan Canal, the Sanitary Canal, the Desplaines river and the Illinois river at various points between Chicago and the mouth of the river at Grafton, except that the data which are given generally upon the single plate IX, are separated for presentation in the form of columns and appear, nitrogen as free ammonia upon Plate X, and nitrogen as nitrites on Plate XI.

After what has been said concerning similar plates representing other important constituents, but little explanation is needed in order to understand the meaning and significance of the curves of plate IX, or the columns of plates X and XI with reference to the purification of the stream. The total organic nitrogen and the albuminoid nitrogen referred to in the descriptions of plates IV, VI, VII and VIII represent largely waste organic matters which may be derived from either vegetable or animal sources or both. All vegetable and animal organisms contain as essential constituents, substances which in their original condition, and also in certain various stages of decomposition are classed as nitrogenous organic matters.

8443 Such matters are included in feces and urine, in waste from the household, in wastes from all industries which utilize plant and animal substances and products as well as in the vegetable substances contained in soils, and which accumulate in swamps and in forests. Those substances which make sewage and animal waste in general offensive to the senses and dangerous to the health are, as a rule, nitrogenous organic substances, either living organisms or the products or wastes of living things. The natural processes of purification of sewage and similar organic wastes involve the oxidation of these nitrogenous matters. The first stage in the purification process includes such a decomposition of these substances and the breaking down of the molecules of the complex proteid bodies, as results in the liberation of a portion of the nitrogen, together with the hydrogen in the form of ammonia. This may remain merely

dissolved in the water, or it may unite with acids, particularly with the carbonic which in these decompositions of the organic
matters may be formed simultaneously with ammonia,
8444 and thus appear as a salt of ammonia, or corbonate of ammonia. Ammonia is not in general contained in the surface waters in considerable proportions except it be derived from the sources above mentioned, or it be formed by the reduction of nitrates and nitrites when these substances under some conditions are in contact with decomposing organic matters.

The proportions of free ammonia contained in the water of the stream or in sewage, indicates on the one hand the relative quantity of refuse matters contained, and shows the stage of decomposition or on the other hand, it may represent the relative proportions of reduction of nitrites and nitrates. In this reduction process a considerable portion of the nitrogen which was at one time present in the water in the form of nitrates or nitrites, may be wholly lost, so far as the possibility of analytical determinations are concerned, by conversion into the element nitrogen, which as a gas may in part remain dissolved in the water, or it may be discharged from the water into the air in a gaseuos state.

8445 Referring to Plates IX and X, we may observe that in 1899 a considerable proportion of nitrogen as free ammonia was contained in the water of the Illinois and Michigan canal, and that although the proportion contained in the Desplaines river at Joliet was considerably diminished through mixing with the waters of the upper Desplaines river, yet considerable proportions of free ammonia were found in the river as far down as LaSalle, but that the diminution still proceeded as we passed down the river until we find the minimum at Averyville. Below Averyville the free ammonia increased in proportion again, reaching the maximum at Pekin, diminishing then more rapidly and continuously until the mouth of the river at Grafton is reached. The curve for 1900 shows of course the effect of dilution with lake water in the sanitary canal, that is the proportions of nitrogen as free ammonia never were so great in the water flowing into the upper end of the canal and past the points between that and Grafton as they were in the preceding year in the Illinois and Michigan Canal and the Desplaines

river and the Illinois river. Otherwise the curves show similar features, that is the very rapid diminution of free ammonia until we reach Averyville shows that the natural decomposition of the organic matters is taking place very vigorously in the upper reaches of the stream, but this action diminishes as we proceed down stream. The indication being that the
8446 diminution of the bacterial action is caused mainly by the exhaustion of the nutrients, that is, the supply of substances which are being converted by bacteria through ammonia into other innocuous forms of matter and which may be regarded as the food supply of the bacteria, is more rapidly diminishing.

It is notable that the proportion of free ammonia increases again below Averyville, but afterwards diminishes until we find at the mouth of the river considerably less than elsewhere along the course of the stream and less during the summer of 1900 than during the summer of 1899.

Upon Plate IX there are two curves, and upon plate X various columns representing the proportion of nitrogen as nitrites. Nitrites are oxidation products derived from the nitrogenous organic matters above referred to. In the conversion of objectionable and harmful nitrogenous organic matters into innocuous substances, the nitrites mark a stage following that which is indicated by the presence of the free ammonia.

The curve for 1899 shows the maximum content of nitrites at Ottawa. From thereon considerable diminution occurs until we reach Averyville and Wesley, but beyond that there is again an increase. We find the maximum at Pekin, beyond which there is a gradual decrease until we reach the minimum
8447 at the mouth of the river at Grafton.

The two maxima indicate the two zones in the river at which the second stage of the natural purifying processes is most vigorously under way.

Referring now to the curve for 1900, it becomes evident that the increase in the proportion of nitrites becomes marked very much nearer the source of the sewage, that is, since most of the sewage has been diluted before it is discharged into the Desplaines river valley, those natural decompositions and oxidations of the organic matters which result in the formation of nitrites and subsequently nitrates, have begun vigorously at a point much nearer Chicago.

The point at which the maximum quantity of nitrites is found during the summer of 1900 is again at Ottawa, as during 1899. From there the curve varies in general in the same direction, but it is notable that the minimum is less than during the earlier season and that the maximum never reaches the high proportion found in 1899.

Consideration of the curves and columns shows that the zones at which the purifying action takes place with the greatest vigor are in the vicinity of Ottawa, and the stretch of river between Pekin and Havana, under both sets of conditions, that is, those conditions prevailing during the summer of 1899 and those prevailing during the summer of 1900 or both before
8448 and after the opening of the drainage canal.

It is evident then that so far as the significance of nitrites is concerned, those purifying processes which effectively destroy the nitrogenous organic matters introduced into the waters of the stream either in sewage or in other ways, enter upon the decomposition earlier in their course of transit between Chicago and the mouth of the river, and the activities which bring about these changes reach their maximum at points no further down the stream since the opening of the Chicago main drainage channel than they did prior thereto.

MR. JEFFRIES: I move to strike out all of the conclusions and statements of this witness as drawn from and placed upon the plates VI, VII, VIII, IX, X and XI for the reasons stated in my objection to the introduction of the plates into evidence, and their being incorporated into the testimony of this witness.

ADJOURNED until 10:00 A. M., following morning, Thursday, October 15th, 1903.

10:00 A. M., Thursday, October 15, 1903.

8449 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further direct-examination by Judge Springer and testified as follows:

Q. Professor, at the time of adjournment on yesterday you were giving an explanation of plates IX, X and XI, which have already been read in evidence. Have you any further statement to make in regard to those plates?

A. I was not quite through with them and will proceed. Study of the various figures of the tables and the curves and columns of the plates reveals the fact that in each of the summers in question, there was less nitrogenous organic matter contained in the water of the Illinois river at Ottawa just above the mouth of the Fox, than was in the Illinois river water at points farther down its course, except at Averyville, and at Grafton. This may in part result from incomplete mixing in
the upper stretches of the river, but is undobutedly due
8450 in part to the fact that organic matters of animal
origin such as constitute the chief organic matters of sewage, are more easily susceptible to the putrefactive and oxidizing influences which bring about the purification of water, while vegetable matters, which constitute the greater part of the organic matters found in the natural waters of swamps and streams, such as are contributed in larger proportion to the Illinois by its tributaries and by the run-off from its own slopes, are less easily decomposed and persist in the water of the lower river in greater proportion.

Moreover, vegetation, particularly of the minuter and floating forms, that is the plankton, is more abundant in the waters of the lower stretches of the river, from LaSalle down. The nitrites and nitrates produced abundantly in the waters of the upper part of the river through the decomposition of the nitrogenous organic matters of sewage are in turn utilized by the vegetation and in part their nitrogen is built up into more stable and less objectionable nitrogenous organic matters which remain floating or dissolved in the water and appear in the analytical results but must be regarded with much less disfavor and objection than would be accorded a like proportion of nitrogenous matters of animal origin.

Q. Professor, I now call your attention to plate XII and plate XIII. Please examine these two plates and state 8451 whether they were made by you and if so, from what data they were made?

A. I identify these plates XII and XIII, as plates which I made, to represent graphically certain averages which appear in tables C and D, which averages were made from those portions of tables 1 to 80 inclusive, which represent analyses of samples collected during the four summer months, June, July, August and September, 1899 and the same months of year 1900.

JUDGE SPRINGER: I now offer these plates in evidence and ask them to be incorporated into the record as a part of the testimony of this witness.

MR. JEFFRIES: I object to the introduction of these plates in evidence, and to their being incorporated into this witness' testimony, or to their being incorporated into the testimony of this case for the same reasons stated in my objection to the introduction into the evidence and the incorporation in evidence of plates VI, VII, VIII, IX, X and XI.

THE WITNESS: The plates are as follows:

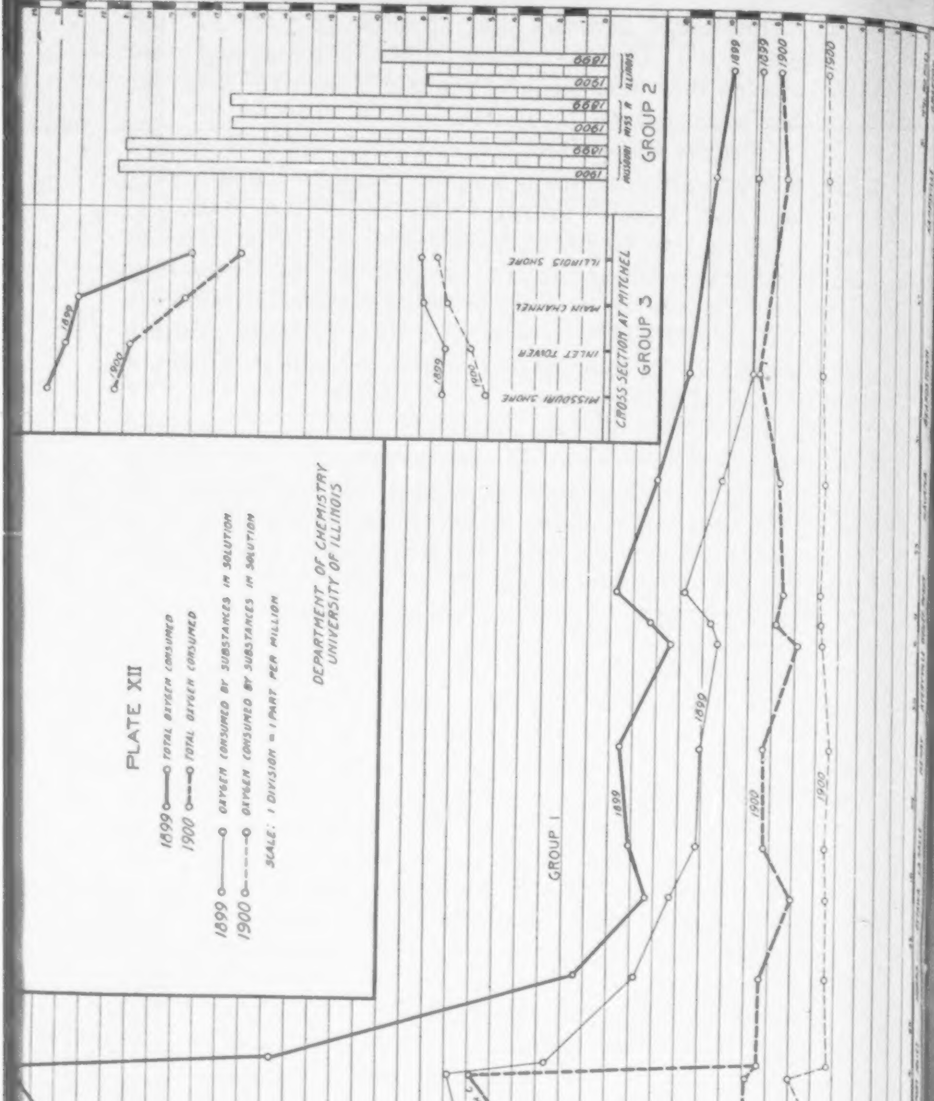
PLATE XII
1899 TOTAL OXYGEN CONSUMED
1900 TOTAL OXYGEN CONSUMED
1899 OXYGEN CONSUMED BY SUBSTANCES IN SOLUTION
1900 OXYGEN CONSUMED BY SUBSTANCES IN SOLUTION
SCALE: 1 DIVISION = 1 PART PER MILLION
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS
GROUP 1
GROUP 2
MISSOURI
MISS R
ILLINOIS
1900
1899
1900
1899
1900
1899
GROUP 3
CROSS SECTION AT MITCHEL
MISSOURI SHORE
INLET TOWER
MAIN CHANNEL
ILLINOIS SHORE
1899
1900
SANITARY 1900
ILLINOIS AND MICH 1900
1899
1900

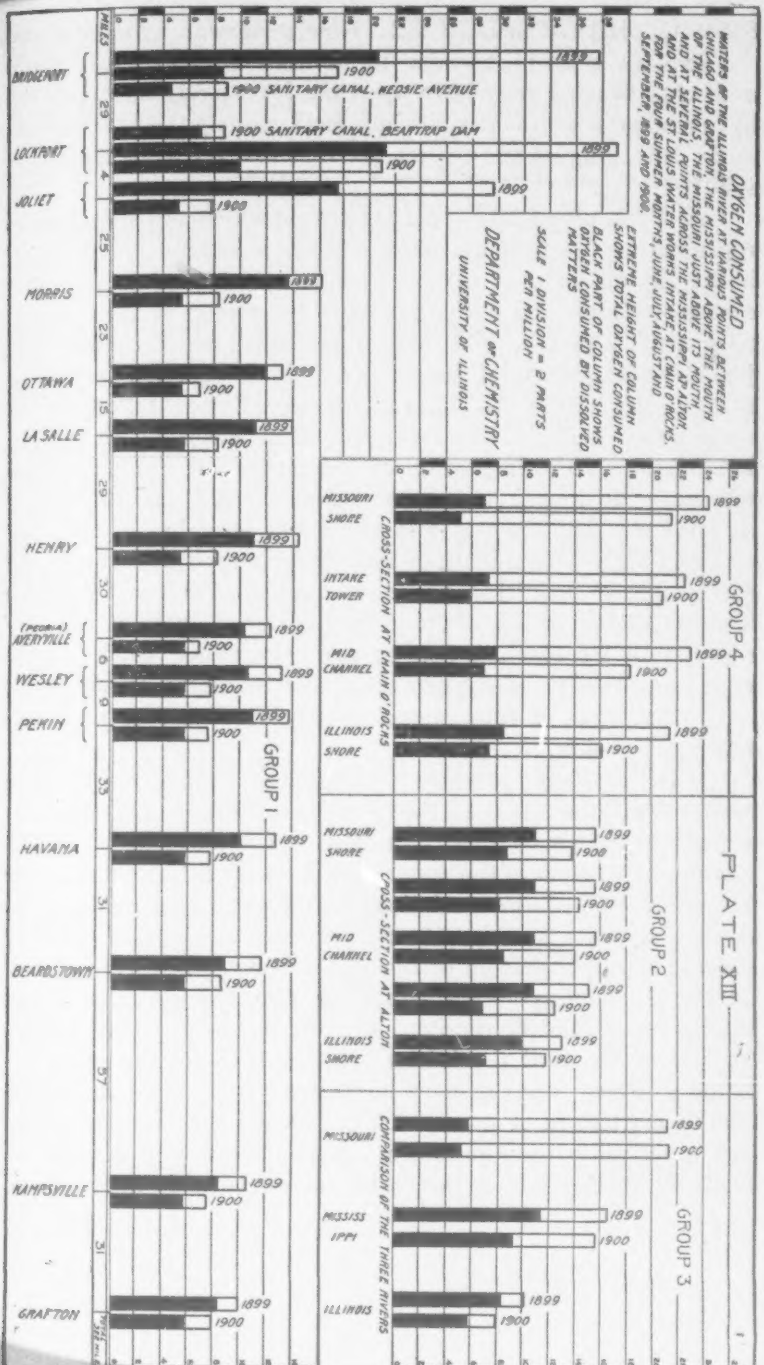

PLATE XIII

OXYGEN CONSUMED

WATERS OF THE ILLINOIS RIVER AT VARIOUS POINTS BETWEEN CHICAGO AND GRAFTON, THE MISSISSIPPI ABOVE THE MOUTH OF THE ILLINOIS, THE MISSOURI JUST ABOVE ITS MOUTH, AND AT SEVERAL POINTS ACROSS THE MISSISSIPPI AT ALTON, AND AT THE ST. LOUIS WATER WORKS INTAKE, AT CHAIN O'ROCKS, FOR THE FOUR SUMMER MONTHS, JUNE, JULY, AUGUST AND SEPTEMBER, 1899 AND 1900.

EXTREME HEIGHT OF COLUMN SHOWS TOTAL OXYGEN CONSUMED

BLACK PART OF COLUMN SHOWS OXYGEN CONSUMED BY DISSOLVED MATTERS

SCALE 1 DIVISION = 2 PARTS PER MILLION

DEPARTMENT OF CHEMISTRY

UNIVERSITY OF ILLINOIS

MILES
BRIDGEPORT
1899
1900
1900 SANITARY CANAL, WEDSIE AVENUE
29
1900 SANITARY CANAL, BEARTRAP DAM
LOCKPORT
1899
1900
4
JOLIET
1899
1900
25
MORRIS
1899
1900
23
OTTAWA
1899
1900
15
LA SALLE
1899
1900
29
HENRY
1899
1900
30
(PEORIA) AVERYVILLE
1899
1900
6
WESLEY
1899
1900
9
PEKIN
1899
1900
33
GROUP I
HAVANA
1899
1900
31
BEARDSTOWN
1899
1900
57
KAMPSVILLE
1899
1900
31
GRAFTON
1899
1900
TOTAL 328 MILES
0
2
4
6
8
10
12
14
16
18
20
22
24
26
GROUP 4
CROSS-SECTION AT CHAIN O'ROCKS
MISSOURI SHORE
1899
1900
INTAKE TOWER
1899
1900
MID CHANNEL
1899
1900
ILLINOIS SHORE
1899
1900
GROUP 2
CROSS-SECTION AT ALTON
MISSOURI SHORE
1899
1900
1899
1900
MID CHANNEL
1899
1900
1899
1900
ILLINOIS SHORE
1899
1900
GROUP 3
COMPARISON OF THE THREE RIVERS
MISSOURI
1899
1900
MISSISSIPPI
1899
1900
ILLINOIS
1899
1900

8454 Q. JUDGE SPRINGER: Now, professor, will you please explain what is intended to be illustrated by these plates and what bearing they have upon the investigations which you have made during the periods indicated, namely the four months, June, July, August and September 1899 and the same months of 1900?

A. Upon plates XII and XIII are shown curves and columns representing the proportions of oxygen consumed by the water in the Illinois river at various points, as indicated on the other charts or plates, and a comparison of the waters of the Missouri river near its mouth, the Illinois at its mouth and the Mississippi just above the mouth of the Illinois, and cross-section determinations at Mitchell or the chain of rocks on Plate XII, and at the same points and also the cross-section at Alton, in Plate XIII. It is obvious from inspection of the curves and columns which represent the figures recorded in tables C and D heretofore read in evidence, that the water in the upper stretches of the river contains a great deal more of such organic matters as are easily susceptible to oxidizing agencies, than does the water in the lower stretches of the river. The diminution in 1899 was very rapid until we reached Ottawa and Averyville, below Averyville the quantity of oxygen consumed increased owing to the discharge of sewage and wastes into the river at Peoria
8455 and Pekin.

Below Pekin there is a continuous diminution in these matters until the mouth of the river is reached. Similar features appear when we consider the total oxygen consumed by the matters in solution in the water, that is in the filtered water. The curve for 1900 shows variations at different points along the river, and make manifest the fact that the proportion of easily effected organic matters in the water is considerably less than during the corresponding season of 1899, though there is not such a great relative diminution along the course of the river, for the reason that the initial dilution through the operation of the sanitary canal at once decreases the proportions or oxidizable matters in or near to Chicago and there is consequently less opportunity for diminution on the way down the river because the proportions at the upper end are already far less than they were in former times, that is times prior to the opening of the drainage canal.

Group 2 of plate XII, represents a comparison of the relative quantities of oxygen consumed by the waters of the Illinois river, those of the Mississippi river and those of the Missouri river. It is evident that the waters of the Illinois river contain considerably less readily oxidizable matter in the summer
8456 of 1900 than in the summer of 1899. In the case of the
Mississipi river water it is evident that the proportion of oxidizable matters far exceeds that contained in the Illinois river water at the mouth, and that the proportion is practically the same for the two seasons, namely, 1899 and 1900.

In the case of the Missouri river water the proportion of oxidizable matters is essentially the same in 1900 as it was in 1899, but in both years it is very much greater than the proportion contained in the water of the Illinois river. On the other hand, comparison of the proportionate quantities of oxygen required by dissolved organic matters shows that there is less required by the waters of the Missouri river than by the waters of the Mississipi river or those of the Illinois river, this appearing from the columns which appear in Plate XIII.

Q. What group?

A. Plate XIII, group 3.

Q. Can you make any further explanation of that then?

A. No, not at present—did you ask me whether I would?

Q. Yes.

A. I can if required.

Q. You may if you desire, make it now, or state it?

8457 A. I wasn't quite through.

Q. Excuse me then, for interrupting you. Proceed then until you reach this point and then you can do so.

A. In 1899, as appears from this same group 3 of table XIII, the quantity of oxygen consumed by the waters of the Illinois river were considerably greater than in 1900, also by the Mississippi river water, more was required during the summer of 1899 than during the summer of 1900, but in each year the quantity required by the Mississippi river water was greater than the quantity required by the Illinois river water.

In answer to the question of counsel, I would say that the smaller proportions of oxygen required by dissolved substances in the Missouri river water, notwithstanding the fact that the total oxygen consumed by the Missouri river water was greater than that required by either the Mississippi or the Illinois river water, was due to the fact that the substances in suspension in the Missouri river water were more considerable in quantity, required more oxygen for their oxidation than did the suspended matters in the waters of the Mississippi river or the waters of the Illinois river.

Now group 3 of Plate XII and group 4 of Plate XIII show the relative quantities of oxygen consumed by water samples collected at the four points across the stream of the Mis-
8458 sissippi river at the chain of rocks or Mitchell. It is evident that the water along the Missouri shore and in the vicinity of the intake tower contains much greater quantities of organic matters than does the water which passes down near the Illinois shore.

On the other hand, in this latter group it is apparent that the dissolved, readily oxidizable matters contained in the water near the intake tower are less in proportion than those contained in the water near the Illinois shore.

Group 2 of Plate XIII, representing the cross-section at Alton, shows that the proportions of oxidizable matters at various points across the stream were greater during the year 1899 than they were during the same period of 1900, both for the totals and for that in solution, and shows further that the proportions of total oxygen consumed and that consumed by matters in susupension, were greater as we pass from the Illinois shore down which the Illinois river water flows, toward the Missouri shore, where the water in greater proportion is that from the upper Mississippi river.

Considering the evidence represented by the columns in group 1, and that of the curves in groups 2 and 3, plate XII, and the columns of group 1 and those of groups 3 and 4
8459 of plate XIII, it appears that the water passing down near the Missouri shore and passing the intake tower of the St. Louis waterworks is much more nearly like the water of the Missouri river than it is like that of the Mississippi river in its upper stretches or the Illinois river in its lower stretches.

MR. JEFFRIES: I move to strike out all the plates and tables of averages and all of the testimony of this witness, based on such tables and plates, for the reason that the table of averages does not properly represent the actual conditions of the water at all times of the year; for the further reason that these tables of averages conceal actual conditions existing at times when the condition of water in the Illinois river is much worse than is shown by the table of averages.

I move to strike the tables and plates out for the further reason that they are of such character as when applied to natural existing conditions are absolutely worthless to the court in the determination of the questions involved in this case, and while certain of the analyses might show a diminution of organic matter regardless of whether it be polluted matter or not, yet at the same time many instances occur where greater quantities of organic matter exist, and it will not do 8460 to say so far as the issues involved in this case are concerned, that the general average of the conditions existing throughout four months of a year can be applied to the river as a whole, and at all times of the year; that the analyses upon which the averages are based, and the plates are based, show at times much larger quantities of organic matter and do not appear to reduce those findings, and conceal them, clouded by a table of general averages made up of analyses of water taken at that time of the year, which is more favorable for the destruction of organic and other matters, and I move to strike out the tables and plates for the further reason that the witness has shown no knowledge in evidence of the sources from which the organic and other polluting matters come, which are found in the waters of the Illinois river, or the character of those polluting substances.

JUDGE SPRINGER: I object to this motion on the ground that it is principally argumentative, and goes to the weight of the testimony and not to its admissibility or its competency as testimony in this case.

8461 Q. Professor, I now call your attention to plate XIV, which I now hand you. Please state whether you made that plate and if so, upon what data you based it?

A. I made plate XIV, and the data which are represented here by means of curves are contained in the tables numbered 1 to 80, inclusive, referring to the points named in the plate, which tables have been heretofore put in evidence.

JUDGE SPRINGER: I now offer this plate in evidence, and ask that it be incorporated in evidence as a part of the witness' testimony.

MR. JEFFRIES: And I object to its being incorporated in evidence of this witness, or into the evidence in this case, for the reason that the defendants have as yet failed to show the purpose and object of the introduction of the plate, and for the further reason that the plate itself shows that it has from its face, no bearing upon the issues in this case.

I object to it also for the reasons heretofore stated in my objection to the introduction of previous plates from I to VI.

JUDGE SPRINGER: I move to strike out this objection for the reason that it is principally argumentative and goes only to the weight of the testimony and not to its admissibility or competency as testimony in this case.

THE WITNESS: The plate is as folows:

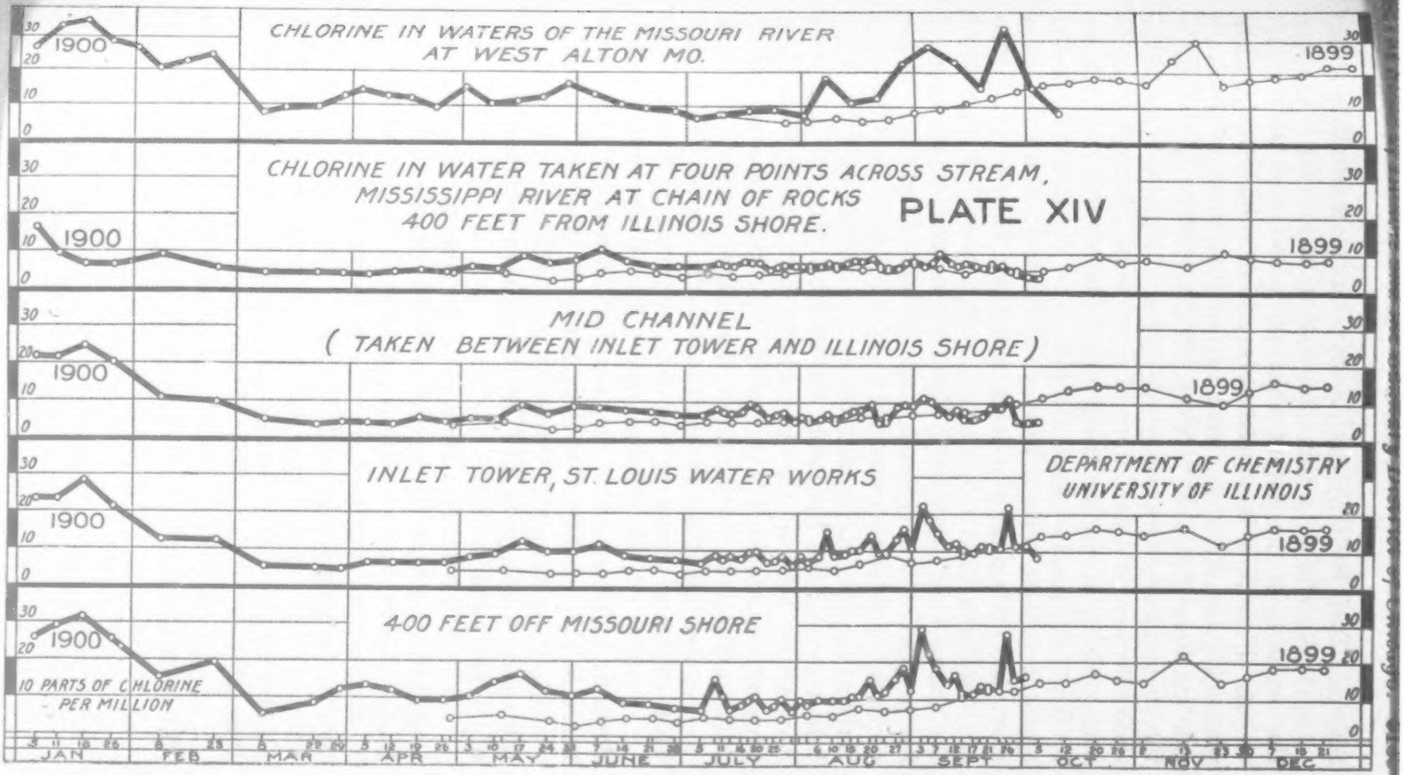

PLATE XIV

CHLORINE IN WATERS OF THE MISSOURI RIVER AT WEST ALTON MO.
CHLORINE IN WATER TAKEN AT FOUR POINTS ACROSS STREAM, MISSISSIPPI RIVER AT CHAIN OF ROCKS 400 FEET FROM ILLINOIS SHORE.
MID CHANNEL (TAKEN BETWEEN INLET TOWER AND ILLINOIS SHORE)
INLET TOWER, ST. LOUIS WATER WORKS
400 FEET OFF MISSOURI SHORE
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS
1900
1899
10 PARTS OF CHLORINE PER MILLION
0
10
20
30
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC

8463 JUDGE SPRINGER: Now, please state, Professor, what is illustrated by this plate and what bearing it has upon the condition of the waters which have been analyzed by you?

A. Plate XIV is supplementary to or complementary with plates IV and V, which were heretofore put in evidence. It exhibits the differences between the proportions of chlorine at the different cross-section points at the chain of rocks, and also shows the seasonal variations of chlorine at these points during such periods, as the tables corresponding refer to, as indicated by the years marked upon the plate and the months and days appearing in the scale at the bottom thereof. The small circles along the lines place the dates, and show also the proportions of chlorine by their relation to the vertical scale at the side of the plate. There appears in these curves seasonal variations in the proportions of chlorine, and differences between the proportions of chlorine contained in the water of the Mississippi river at the four different cross-section points, opposite the intake tower of the St. Louis waterworks. It also institutes a comparison between the proportions just mentioned, and the proportions contained in the water of the Missouri river at West Alton, and serves further to illustrate the point previously discussed, that the water near the intake tower and near the
8464 Missouri shore at the chain of rocks is more like the water of the Missouri river than is the water passing down at mid-channel, or that passing down toward the Illinois shore in this locality, that is opposite the chain of rocks.

Q. Please explain, Professor, any differences that may be disclosed by this plate XIV, at the different seasons or months of the years indicated?

MR. JEFFRIES: I object to the question for the reason that there has been no showing made by the defendants of the taking of samples from December, 1900, to Decmeber, 1901, and no showing of samples being taken in such manner as to authorize characterization on this plate of the actual conditions existing during any one year which may constitute all of 1899 or all of 1900 or a part of both years, and that there is nothing on the plate itself which will justify any such question.

Q. JUDGE SPRINGER: Proceed with your explanation, Professor?

A. Considering the various lines for 1900 which appear upon plate XIV, it is evident that the proportion of chlorine contained in the water of the Missouri river at West Alton, was greater at the dates indicated in January, 1900, than in February, and that in March the proportion is considerably less than in either February or January. Proceeding on through
8465 such portion of the year as this curve represents, we find slight increases and slight decreases from time to time, but that in August there was a more considerable increase in chlorine than during several months preceding, and that after a decrease again in the latter part of August and in the early part of September, the proportions of chlorine increase considerably, to be followed by a decrease near the middle of September which was again followed by a very considerable increase near the end of September, the latter increase being followed by a more considerable decrease to a date early in October, which is stated in the table from which these data have come, but at which date the collection of samples from this river was discontinued.

Q. That is for 1900?

A. 1900 we are referring to there.

Q. Those small figures at the bottom of the line indicate the day of the month which follow just below, do they not, at which the ascertainment was made, is that right?

A. The dates at the bottom of the plate represent the dates at which the collections were made, but in order to avoid crowding at certain points in the scale at the bottom of the plate some dates are merely indicated by lines, and not by figures.
8466 The figures all appear in table 73, which has heretofore been read in evidence.

Q. Now, upon what analyses was the other line, 1899, based?

A. The line marked 1899 represents the data of the analyses for the same river and the same point given in table 32, and covers the period, July 10 to December 29, 1899. It shows similar seasonal variations, the content of chlorine in this case being lowest in the summer months and increasing during the fall and winter.

Consideration of the other lines of plate XIV show that the waters passing down near the inlet tower of the St. Louis waterworks and near the Missouri shore opposite, are subject to the same seasonal variations, as regards content of chlorine, as those just described, with respect to the water of the Missouri river at Fort Belefontaine or West Alton, and show further that the water at these two points is more greatly like that of the Missouri river itself than is the water passing down at mid-channel, or that passing down toward the Illinois shore opposite the intake.

Q. Professor, I now hand you plate XV. Please state whether you made that plate, and if so upon what data it is based?

A. I made plate XV. It is based upon the figures given in tables C and D, which refer to the averages for the four summer months of June, July, August and September, 1899, and
8467 1900, which averages were made from the detailed figures found in tables 1 to 80, inclusive, heretofore offered in evidence, and the columns of this table represent by their proportions the figures of the tables of averages referred to, namely, tables C and D. The particular sets of figures of tables C and D represented upon this plate are those which pertain to the waters of the Kankakee river, the Fox river, the Big Vermillion river, the Sangamon river, the Illinois river at Averyville, and the Illinois river at Grafton for the two periods in question, and have been brought together in this plate for the purpose of rendering easy a comparison of the relative proportions of the different constituents named upon the plate as contained in the waters of the tributary streams, and the waters of the Illinois river at Averyvile and Grafton.

JUDGE SPRINGER: I now offer this plate XV in evidence and ask that the witness incorporate it into his testimony as a part of the evidence.

MR. JEFFRIES: I object to the introduction of plate XV in evidence, and object to its being incorporated into the evidence of this witness, or into the evidence in this case, for the same reasons stated in my objection to the introduction of plates numbered from VI to XIII, inclusive, and for the reasons stated in my motion to strike out all of the plates from I to
8468 XIII, inclusive.

I object further for the reason that the plate is confined solely to a comparison of the tributaries of the Illinois river, with the water in the Illinois river, and it is therefore irrelevant, incompetent and immaterial, having no bearing upon the issues involved in this case, and does not prove or tend to prove any issues involved; and for the further reason that if it should be considered material under any circumstances whatever, a sufficient number of samples were not taken from the tributaries to be comparable with those taken from the Illinois river.

I object for the further reason that it is based upon a table of averages, which as heretofore stated, conceals actual conditions of far greater importance than what may be considered the general average conditions, even if a general average can be obtained, in such manner as to be relied upon, and in such manner as to be of any probative force.

JUDGE SPRINGER: I move to strike out this objection for the reasons stated heretofore in reference to other objections to these plates.

THE WITNESS: Plate XV is as follows:

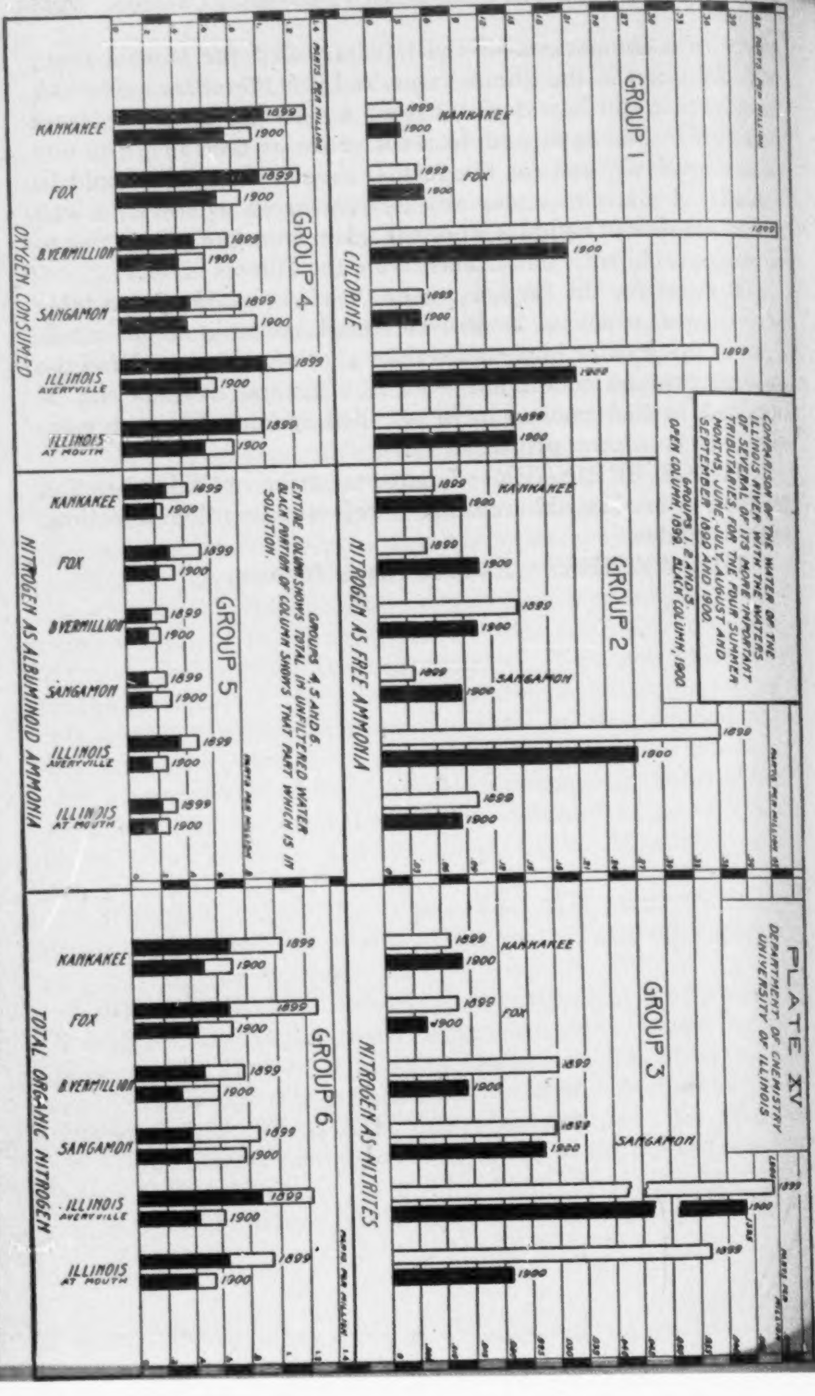
PLATE XV
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS
COMPARISON OF THE WATER OF THE ILLINOIS RIVER WITH THE WATERS OF SEVERAL OF ITS MORE IMPORTANT TRIBUTARIES, FOR THE FOUR SUMMER MONTHS, JUNE, JULY, AUGUST AND SEPTEMBER 1899 AND 1900.
GROUPS 1, 2 AND 3. OPEN COLUMN, 1899. BLACK COLUMN, 1900.
GROUPS 4, 5 AND 6. ENTIRE COLUMN SHOWS TOTAL IN UNFILTERED WATER. BLACK PORTION OF COLUMN SHOWS THAT PART WHICH IS IN SOLUTION.
GROUP 1
CHLORINE
GROUP 2
NITROGEN AS FREE AMMONIA
GROUP 3
NITROGEN AS NITRITES
GROUP 4
OXYGEN CONSUMED
GROUP 5
NITROGEN AS ALBUMINOID AMMONIA
GROUP 6
TOTAL ORGANIC NITROGEN
KANKAKEE
FOX
B. VERMILLION
SANGAMON
ILLINOIS AVERYVILLE
ILLINOIS AT MOUTH
1899
1900
PARTS PER MILLION

8470 Q. JUDGE SPRINGER: Professor, will you please state what facts are intended to be illustrated by plate XV and the several groups mentioned on that plate?

MR. JEFFRIES: The question is objected to for the same reasons stated in my objection to plate XV.

A. Plate XV is intended to represent by means of columns the averages which appear in tables C and D, referring to the proportions of chlorine, of oxygen consumed, of nitrogen, as free and as albuminoid ammonia, and as nitrites, and the total organic nitrogen in the waters of several different tributaries of the Illinois, and to facilitate a comparison of the proportions represented by these figures of tables C and D, with the proportions contained in the waters of the Illinois at Averyville and Grafton.

The comparison of these columns which merely represent the figures in the table of averages, renders evident at a glance the fact that the proportions of organic matters as represented by oxygen consumed, by albuminoid ammonia and total organic nitrogen, are even more considerable in the waters of the larger tributaries of the Illinois than they are in the waters of the Illinois at Grafton. Free ammonia and nitrites, however, are more
abundant in the waters of the Illinois river at Averyville
8471 than in the waters of the tributary streams, but the waters
of the Illinois river at its mouth at Grafton, contain less nitrogen as nitrites than is contained in the water of the Sangamon river, the proportion contained during this period of four summer months, June, July, August and September, 1900, being less than half as much as was contained in the corresponding period of 1899, and about three-fourths as much as was contained in the waters of the Sangamon river during the same period in 1900 and in 1899, and less than was contained in the waters of the Big Vermillion river during the corresponding period of 1899.

The waters of the Illinois river at Grafton contain considerably less nitrogen as free ammonia during these four months in 1900 than was contained during the same period in 1899, and the proportions in both years were less than the proportions contained in the waters of the Big Vermillon river in either year, although the Big Vermilion river water contined less in 1900 than it did in 1899. Moreover, the proportions of free ammonia in the water of the Illinois at Grafton during this period in 1900 is slightly less than the proportion contained in the water of the Sangamon for the same period and year, and still more considerably less than was contained in the water of the Big Vermillion river, the Fox river, and the Kankakee river, during this same period.

8472 Q. Will you please make similar comparisons as to nitrogen and free ammonia and nitrites, of the waters at Averyville in the Illinois river and the Kankakee river for the two years under consideration?

A. The proportions of nitrogen as nitrites and as free ammonia in the waters of the Illinois river at Averyville were very considerably greater than the proportions of nitrogen as nitrites or that as free ammonia in the waters of the Illinois river at Grafton in both years, and very considerably greater than the proportions of these substances contained in the waters of the Kankakee river during these periods and years. Consideration of the columns of group 4 representing the proportions of oxygen consumed, show that the waters of the Kankakee river and the Fox river required more oxygen than did the waters of the Illinois river at Grafton in both of these years, and that the waters of the Sangamon river required more oxygen in the year 1900, than did the waters of the Illinois river at Grafton in the same year. Comparison of the figures of group 5 shows similar facts with respect to the proportions of albuminoid ammonia, namely, that there was a greater proportion in the waters of the Fox river and in the Sangamon river in 1900, than in the waters of the Illinois river at its mouth at Grafton, and that in
8473 the year 1899 the proportions of nitrogen as albuminoid ammonia in the waters of the Kankakee and the Fox were considerably greater than the proportions of these substances in the water of the Illinois river at the mouth. Similar facts appear from consideration of the columns of group 6, referring to the total organic nitrogen. In both years it appears that the water in the Illinois river at its mouth at Grafton contained less total organic nitrogen than did the waters of the Kankakee or Fox river, and that in the year 1900 the water of the Illinois at Grafton contained less total organic nitrogen than was con-

tained in any one of the tributary streams here referred to, namely, the Kankakee, the Fox, the Big Vermillion and the Sangamon.

Q. I call your attention to plate XVI, will you please state whether you made that plate or not, and if so, upon what data it was based?

A. I made plate XVI. It represents the discharge of water of the Desplaines river at Joliet of the Chicago main drainage channel or sanitary canal at Lockport and of the Illinois river over the dam at Kampsville, 31 miles from the mouth of the river. The data relating to the flow of the Desplaines river at Joliet and the discharge of the sanitary canal at Lockport, were furnished me by the engineer of the Sanitary District, Mr.
8474 Isham Randolph, I believe is the name. The data concerning the discharge over the dam in the Illinois river at Kampsville were furnished me by the United States engineer in charge of the Kampsville dam and the improvement of the lower Illinois river, Mr. C. V. Brainard.

JUDGE SPRINGER: I will state to counsel that Mr. Isham Randolph will be introduced as a witness hereafter and will testify to these figures more in detail.

JUDGE SPRINGER: Now, I offer this plate in evidence, being plate XVI.

MR. JEFFRIES: I object to the introduction of the plate in evidence and object to its being incorporated into the evidence of this witness or incorporated into this case for the reason that there has as yet been no proof as to the exact volume of water passing down the river at Kampsville during the year 1900, or of the volume of water passing through the sanitary canal at the Beartrap Dam at Lockport and the Desplaines river at Joliet, and no evidence showing that these curves on this plate represent correctly the discharge of said stream, and I move to strike out the statement of the witness as to the source of his information because it is hearsay and not competent proof. This objection, however, as to the amount of discharges of the vari-
8475 ous streams stands only in the event that the defendants fail to prove the exact discharges of the rivers as represented by the plate.

I object to the introduction of the plate for the further reason that this witness has not qualified as a hydraulic engineer and has not qualified as being possessed of scientific knowledge on stream flows, and the relative effect of added and reduced volumes of water upon any given stream.

JUDGE SPRINGER: I move to strike out this objection for the reason that it goes to the weight of the testimony and not to the admissibility or competency.

THE WITNESS: Plate XVI is as follows:

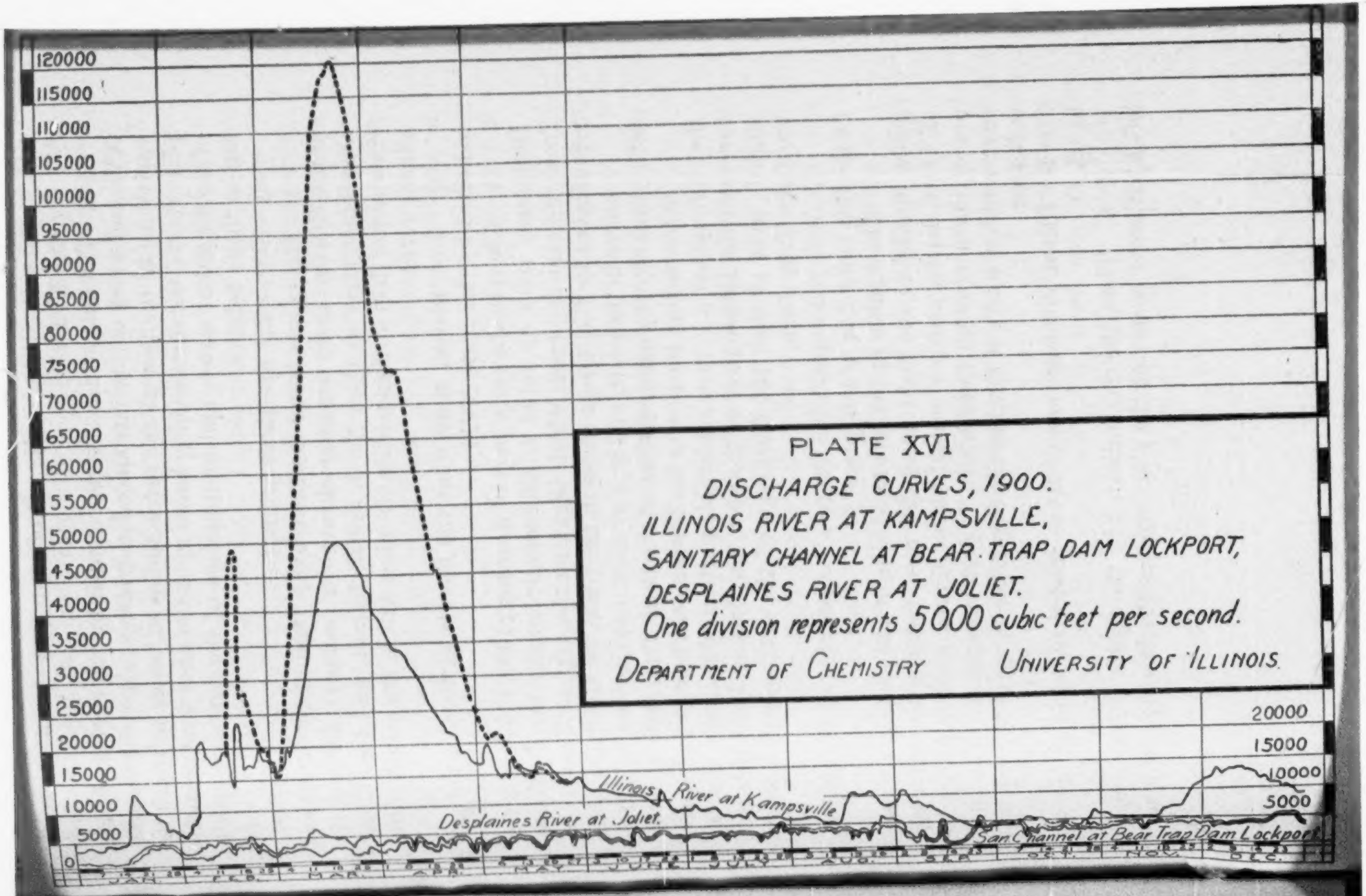

PLATE XVI

DISCHARGE CURVES, 1900.
ILLINOIS RIVER AT KAMPSVILLE,
SANITARY CHANNEL AT BEAR TRAP DAM LOCKPORT,
DESPLAINES RIVER AT JOLIET.
One division represents 5000 cubic feet per second.

DEPARTMENT OF CHEMISTRY   UNIVERSITY OF ILLINOIS

8477 JUDGE SPRINGER: Professor, you will now explain plate XVI.

A. The data which are represented by the curves of plate XVI, and which will be introduced in evidence, show the seasonal variations in the flow of the three bodies of water to which the plate refers, the curves being based upon the total measurements of the height of water, and computation of the flow corresponding to those heights.

Q. Now, what are those points?

A. The points being the Bear Trap Dam at the lower end of the Chicago main drainage channel at Lockport, Illinois, the Desplaines river at Dam No. 1, Joliet, Illinois, and the Illinois river at the dam at Kampsville, 31 miles within the mouth of the Illinois river.

Q. Now, please, state what the flow is at these points as indicated by this plate XVI?

A. Thus, in the early part of January, 1900, the flow in the Desplaines river at Joliet is exceedingly small; the discharge from the sanitary canal which began on the 17th of January is represented by the lowest curve in the plate, by the underneath curve in the plate, and it is evident that the opening of the
8478 canal by the manipulation of the Bear Trap Dam resulted in increasing the flow in the Desplaines river at Joliet, and that throughout a very considerable portion of the year, that is, for much the larger part of the year, the flow at Joliet was but slightly greater than the discharge of the drainage channel at the Bear Trap Dam.

Q. Will you explain the figures, the meaning of the figures on the left hand side of this plate?

A. The figures at the left hand side of the plate and those which appear at the right hand side also, indicate the volumes of water discharged per second, these figures applying to each one of the horizontal lines which is just beneath it. The line representing, where it touches the curve, the flow for the day so indicated.

Q. Please illustrate one of those conditions so as to apply to all.

A. Thus, the line indicated by the figure 10,000 at the left hand lower corner of the plate crosses the line representing the discharge of water in the Illinois river over the Kampsville Dam at about January 16th, the precise date being given in the tables of figures hereafter to be offered in evidence and shows that at or upon this date the discharge of the Illinois river at this point was 10,000 cubic feet per second. That there had 8479 been a somewhat sudden increase of the discharge upon a day or two preceding, and an increased discharge for a day or two following this date. Continuing along the line of the curve, the variations, that is, the increases and decreases are at any point and every point indicated by the position of the curve, with respect to the horizontal lines of the plate, while the dates are indicated by the relative position of the curve with respect to the figures at the bottom of the plate, and certain vertical lines which have been drawn to facilitate the comparison.

Q. At what season of the year is the flow greatest at Kampsville?

A. The flow is greatest at Kampsville in the latter part of March, that is, for this year 1900.

Q. This plate relates to 1900 altogether?

A. Yes, sir. The flow at that time being about 50,000 cubic feet per second.

Q. Then the figures represent the quantity of water going over the dam at Kampsville?

A. Yes, sir.

Q. Please state the volume of water passing over the Bear Trap Dam for the year 1900 as shown by this chart?

A. This chart does not show that. This chart shows by 8480 curves the daily flows, but not the yearly average. The yearly average I have stated somewhere else in figures.

Q. Well, take one of those averages when the lower dark line at the right hand side of the plate, March, 5,000, what does that indicate?

A. That indicates that the discharge from the drainage channel at the Bear Trap Dam was 5,000 cubic feet per second, or 300,000 cubic feet per minute.

Q. Now, Professor, I hand you plate XVII. Please state whether you made that plate, and if so, upon what data it is based?

A. I made plate XVII, and it represents the figures supplied to me by readers of the gauge at the C., B. & Q. bridge across the Mississippi river at Alton, Illinois.

Q. Who were those readers; what were their names?

A. I cannot give their names. Mr. Graham, who used to be superintendent of the Alton terminal line there, but I can look that up and give the exact initials and names. These are the official readings taken at the bridge and kept by the owners of the bridge; I think it is the C., B. & Q. now.

JUDGE SPRINGER: I offer this plate in evidence and ask that it be incorporated as a part of the testimony of this witness, being plate XVII.

MR. JEFFRIES: I object to the incorporation of plate XVII into the record for the same reasons stated in my
8481 objection to the incorporation of plate XVI.

JUDGE SPRINGER: I move to strike out the objection for the reasons stated heretofore in reference to motions of this kind.

MR. JEFFRIES: I move to strike out all of the tables of averages and all the plates based on those tables of averages for the reasons shown in plate XVI; that no reliance can be placed upon the table of averages, the volume of flow in the Illinois river ranging during the year 1900 from 50,000 cubic feet a second to less than 5,000 cubic feet per second.

JUDGE SPRINGER: I move to strike out this objection for the reason that it goes to the weight of the testimony and not to its competency or admissibility.

THE WITNESS: Plate XVII, is as follows:

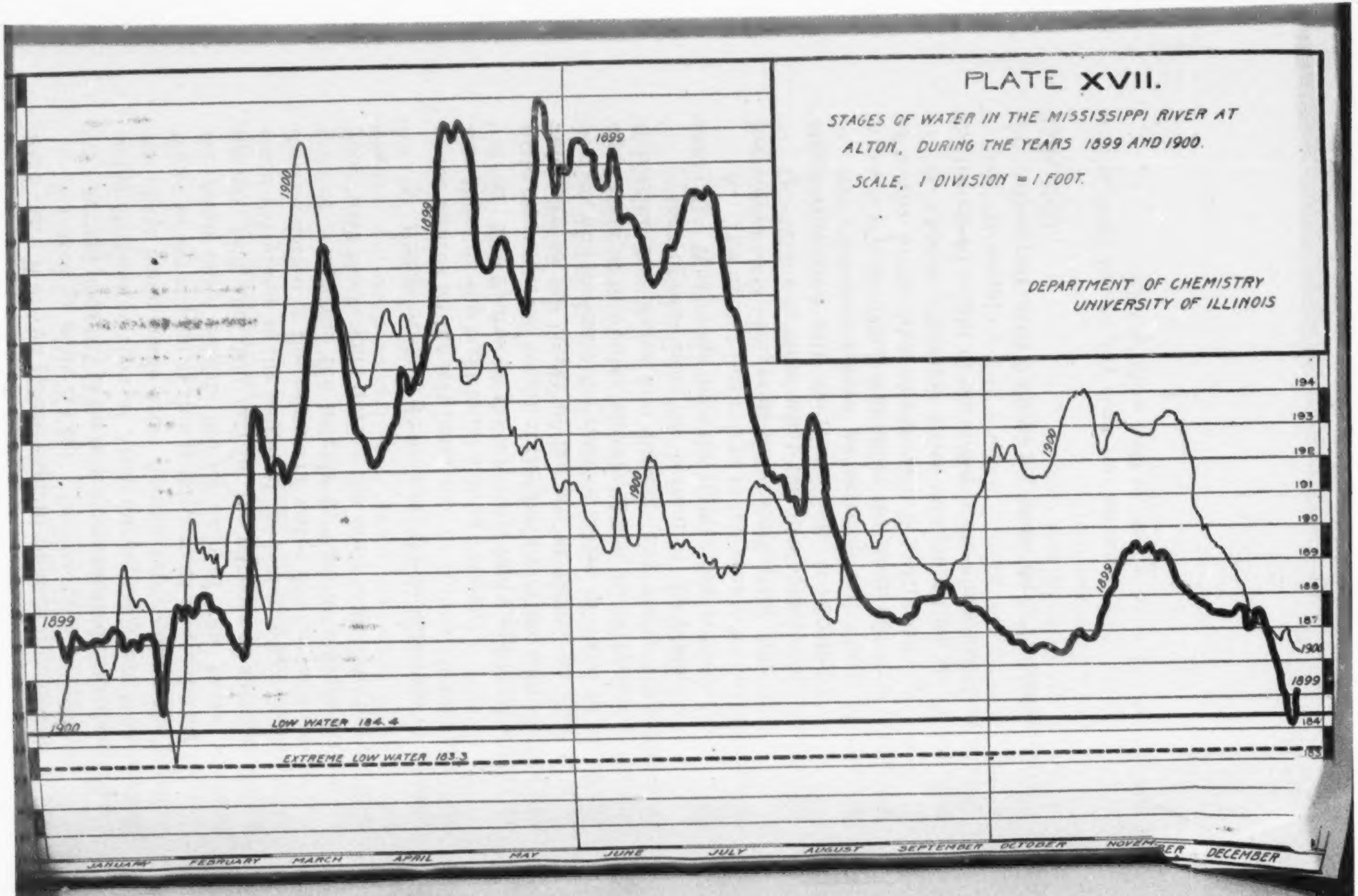

PLATE XVII.

STAGES OF WATER IN THE MISSISSIPPI RIVER AT ALTON, DURING THE YEARS 1899 AND 1900.

SCALE, 1 DIVISION = 1 FOOT.

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS

8483 Q. Will you please explain what is intended to be illustrated by plate XVII?

A. On plate XVII there are represented the stages of water in the Mississippi river at Alton during the years 1899 and 1900, the chart being made from figures representing the height of water in the stream at this point each 24 hours during the year, the mean daily heights during each of the years indicated, namely, 1899 and 1900, and for the purpose of showing the seasonal variations in the height of the water, which figures bear a direct relation to the volume of water flowing, and for the purpose of comparing the heights at various seasons during one year, with the heights during the same season during the other year.

Q. Please explain, Professor, the significance or meaning of the figures on the left hand side or column of this plate, and also those on the right hand side or column?

A. The figures on the left hand and right hand side of the plate represent the height of the surface of the water in feet with reference to the height of the sea at Biloxi, on the Gulf of Mexico, and indicates the relative stages of water in the Mississippi river at this point, namely, Alton, by reference to the lines indicating low water and extreme low water respectively, as they appear near the bottom of the plate.

8484 Q. What year does the lighter line refer to?

A. The lighter line refers to the year 1900, and the heavier line refers to the stages of water during the year 1899.

Q. Will you state what the low stages, the extreme low stages compared with the Biloxi data, is at Alton?

A. That this record as extreme low stage of water at Alton is a point 183.3 feet above the mean sea level on the Gulf of Mexico or the lake, whichever it is at Biloxi.

Q. And the increase above this point then would represent the increased height of the water at the time stated, at Alton?

A. It would.

Adjourned until 2:00 p. m., same day, Thursday, October 15th, 1903.

8485 2:00 p. m., Thursday, October 15th, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further direct-examination, by Judge Springer, and testified as follows:

Q. Professor, have you made any other chemical analyses of the waters of the rivers of Illinois, and especially of the waters which have been under investigation since you took the stand as a witness, in this case, than those about which you have already testified?

A. I have.

Q. Just state, please, the circumstances which brought about those other investigations?

A. Well, as professor of chemistry in the university, it fell to me to examine many waters in connection with the instruction work of students, and also for the information of citizens, and also in connection with the work of the biological station of the university, which just at the time I began this 8486 work systematically, was located at Havana on the Illinois river.

My first work upon the Illinois river with the exception of some few examinations made many years ago when I was a student, began in the summer of 1894, the results of which examinations,—comparatively few samples being examined, were reported by me to the president of the university in 1897.

In the following year provision was made for a somewhat extensive series of investigations of the water supplies of the state, including not merely river waters and other surface waters, but also the ground waters, and the investigations at that time commenced included an attempt at a systematic study of the waters of the Illinois river.

Q. What year was that?

A. I have not mentioned any year yet, except 1894, and referring to the time of report of that work in 1897.

Q. Did the state of Illinois make any provision for more extended examinations of these waters?

A. It did.

Q. In what way?

A. The legislative assembly of Illinois in the spring of 1897, passed an act establishing a survey of the waters of the state and by this act directed the trustees of the univer-8487 sity to establish such survey, and made appropriation for the work in this survey.

Q. Will you cite that act of the Legislature of Illinois?

MR. JEFFRIES: We object to the statement that the witness has just made and object to the citation of the act of the Legislature of the state of Illinois with reference to the examination of the waters of the Illinois river prior to the opening of the Chicago drainage canal for the reason that it is incompetent, immaterial and irrelevant, not proving or tending to prove any issues involved in this case, the condition of the Illinois river water prior to the opening of the drainage canal not being under consideration in this suit.

Q. JUDGE SPRINGER: Please read the title of that act and the first and second sections of it?

A. Title of the Act, University of Illinois Chemical Survey of the Waters of the State of Illinois.

Q. No, that is not the title.

A. An Act to Establish a Chemical Survey of the Waters of the State of Illinois, approved June 7, 1897, in force July 1, 1897.

"Section 1. Be it enacted by the people of the state of Illinois represented in the General Assembly, that the trustees of the University of Illinois are hereby authorized and directed 8488 to establish a chemical and biological survey of the waters of the state in connection with said University.

Section 2. It shall be the duty of the university to collect facts and data concerning the water supplies of the state; to collect samples of waters from wells, streams and other sources of supply, to subject these samples to such chemical and biological examination and analysis as shall serve to demonstrate their sanitary condition, and to determine standards of purity of drinking waters for the various sections of the state; to publish the results of these investigations in a series of reports to be issued annually, or oftener, to the end that the condition of the potable waters of the State may be better known, and that the welfare of the people of the various communities of the state may thereby be conserved."

Q. What is the book from which you read?

A. Laws of Illinois, Radwell, 1897. All the laws of the state of Illinois passed by the Fortieth General Assembly, convened January 6, 1897; adjourned sine die June 4, 1897.

Q. State what steps were taken, if any, by the board of trustees of the University of Illinois for the purpose of carrying that act into effect?

MR. JEFFRIES: I object to the question as incompetent, irrelevant and immaterial, for the reasons stated in my objection to the reading of the act of the Legislature of the
8489 state of Illinois into the record.

Q. (Last question repeated.)

A. I was directed by the board of trustees of the University of Illinois to proceed to carry out the directions in this act of the Legislature.

Q. And what did you do in pursuance of that instruction?

A. I proceeded to make the investigations indicated in section 2 of the act, that is, to obtain data and information concerning the waters of the state; to obtain samples of water from the various different sources, and subject these to examination and to prepare the results thus obtained in the form of reports to the president of the university and the trustees.

Q. Did those investigations cover any point upon the Illinois river, the Desplaines river or the Mississippi or Missouri, or the sanitary canal or the Illinois and Michigan canal?

MR. JEFFRIES: I object to the question for the same reasons stated in the previous objection.

A. The investigations which I at that time began, included the examination of samples of water drawn from Lake Michigan, delivered at tap in the city of Chicago;

Samples of water from the Illinois and Michigan canal at Lockport;

8490 Samples of water from the Kankakee river at Wilmington;

From the Illinois river at Morris;
From the Fox river at Ottawa;
From the Illinois river at La Salle,
From the Big Vermillion river, near La Salle;
From the Illinois river at Averyville, or North Peoria;
From the Illinois river at Havana;
From the Spoon river at Havana;
From the Illinois river at Kampsville;
And later from the Illinois river at Grafton;
From the Mississippi river at Alton, and at Grafton, and at Quincy.

Q. JUDGE SPRINGER: Who selected the persons to take the samples of water at these respective places?

A. I did.

Q. What instructions, if any, did you give them in a general way? I don't want to go into too full details.

A. I gave them written and printed instructions as to the method of collecting samples, the precautions to be observed, and certificates also upon which they were to make certain entries as to the time of collection and other information
8491 concerning the source of supply and conditions prevailng at the time of collection.

Q. Were those instructions similar to those contained upon the certificates which accompanied the samples of water about which you have already testified in this case?

MR. JEFFRIES: I object to the question for the reason that it is incompetent, irrelevant and immaterial and has no bearing upon the issues involved in this case, and for the further reason that a copy of the written or printed instructions, or one of the samples of written or printed instructions is the best evidence, and I object to this character of testimony for the further reason that chemical analysis does not disclose the sanitary condition of water, and that this exaimnation was made without reference so far as this witness is concerned as to the amount of pollution, source of pollution, volume of water, or from a bacterial standpoint.

Q. (Question repeated.)

A. They were similar, but not identical therewith.

Q. Who were the persons selected by you to take these samples of water at the points indicated by you?

A. Do you wish me to name them

Q. No, not necessarily, if you can identify them without naming them?

8492 A. In most cases they were men who were afterwards selected to collect the samples of water for the investigations begun at the instance of the Chicago Sanitary District, the trustees of the Chicago Sanitary District.

Q. About which you have already testified in this case?

A. Yes.

MR. JEFFRIES: I object to the question and move to strike out both question and answer for the reason that none of the witnesses who did take samples for the Sanitary District of Chicago testified to ever having taken any such samples for Professor Palmer or for any one else.

JUDGE SPRINGER: The objection is not pertinent because the question does not embrace that.

MR. JEFFRIES: Read the question and answer?

(Question and answer read.)

MR. JEFFRIES: I will state here to the Court that if defendants are relying upon this testimony, it certainly was proper and competent at the time those witnesses were on the stand, to ask them the manner in which the samples of water were previolusly taken, and forwarded to Professor Palmer, and that the witnesses not having been questioned upon that period of time by defendants who placed them upon the stand, the statement of Professor Palmer with reference to the man-
8493 ner in which the samples were taken with reference to who took the samples, certainly is objectionable because defendants while having the opportunity to prove it, have failed to prove the manner in which the samples were taken.

JUDGE SPRINGER: I desire to suggest in reference to this objection that it was not necessary to ask these witnesses to testify in reference to the samples that were furnished to the University of Illinois, for the reason that those samples were taken in pursuance of an act of the Legislature of Illinois, and were a part of the official ascertainment by the authorities of the state of certain conditions which were provided for in that act, and it is not necessary in order to use the statistics obtained in that way, to prove by every person who took a part, and made a part of them, what he did, any more than it is necessary when you use the census reports of the United States, to prove from the census taker that he correctly enumerated the inhabitants contained in that report. It is a very different case we are presenting. We are presenting to you official data obtained by the authorties of a great state and made evidence by all the rules of evidence.

MR. JEFFRIES: Then I suggest that the evidence is without weight, is incompetent, immaterial and irrelevant, and these questions of a preliminary character are entirely out of 8494 place, assuming that Judge Springer is correct in his statement of the law. We are now dealing with what was actually found to be the conditions at the time and not with reference to what any official of the state of Illinois may have said with reference to conditions ascertained by him under and by virtue of any statute law of the state of Illinois, and in order to be able to place the proper light upon this testimony, we have the right, and the Court is entitled to strict proof upon those propositions, because it entails the sanitary condition of the water during the time the examination was made, and during the time covered by the report which I presume is intended to be introduced.

JUDGE SPRINGER: Counsel for defendants will present their case in such a manner that the Supreme Court will take cognizance of it, and we are responsible for any failure to establish minor conditions which counsel for the complainant may point out.

MR. JEFFRIES: I suggest to the Court that the necessity of proving the names of the water takers and of other preliminary matters in connection with the analysis of water during the period now under consideration, which is assumed by defendants' counsel, is sufficient to warrant an objection which is now made, that strict proof should be made in relation thereto.

8495 JUDGE SPRINGER: Counsel for defendants suggest that we will argue these questions if necessary before the

Supreme Court. We prefer now to put in the testimony in the case, the witness will therefore proceed to state who were the other persons, not engaged in taking the samples about which testimony has already been introduced.

A. I will have to look up those names.

Q. Well, where were they located?

A. At Chicago, the collector from the Chicago city supply was a person not engaged subsequently in collecting for the sanitary district, Henry Enlert was his name.

The collector at Wilmington on the Kankakee river was not the same person as subsequently collected samples analyzed for the sanitary district. I can name the person there if you desire?

Q. Yes, if you can, name him.

A. C. H. Kaehler was collector at Wilmington.

The Hon. A. E. Palmer, mayor of the town, collected samples for me at Morris.

The collector at Ottawa I will name later; I don't recall it at the moment. I have it on record.

The collector at LaSalle was the same, Dr. William Frazer.

8496 The collector at Averyville was the same, and under the direction of the superintendent of the waterworks,—circumstances precisely the same as for the investigation later carried on for the Sanitary District.

The collector at Havana was one of the force of the biological station. I will name him later. Miles Newbury, was his name.

The collector at Kampsville was the assistant United States engineer, C. V. Brainard, who has since collected samples for the sanitary district work.

The collector at Grafton was Mr. B. F. Robinson, the same man that collected for the subsequent investigations for the sanitary district.

Also the collector at Alton was the individual, Mr. George Brooks, who afterward collected samples taken on behalf of the sanitary district of Chicago.

The collector at Quincy was the superintendent of the waterworks, Mr. Dow R. Gwin.

I should have said that the collector at Havana, both from the Illinois river and the Spoon river was the same individual, Miles Newbury.

Q. State whether the bottles were prepared, filled and shipped in the same way as the bottles about which you
8497 previously testified in this case?

A. They were.

MR. JEFFRIES: I object to that question for the same reasons as given in my previous objection to this character of testimony, and while we may not deny that Professor Palmer obtained the chemical results upon the analyses which he says he did and which are contained in his report based upon the act of the Legislature of the State of Illinois, which he has read in evidence, and if this testimony has any bearing upon the questions involved in this case, it is plain to the Court that the fact that those analyses do not correctly describe and represent the sanitary condition of the water in the Illinois river at that time, and it is denied by the State of Missouri, and therefore we are entitled to strict proof upon that proposition with reference to all the formalities of collecting the samples the shipment of the samples and the analyses of the samples.

MR. TODD: I desire to suggest in reply to the objection made by counsel that aside from the admissibility if this evidence being offered under a legislative act of the State, it is admissible for another reason, and that is that in the examinations of Professors Teichmann, Keiser and Ravold, they saw fit to take parts of these reports and refer to them in
8498 their examination for the drawing of conclusions, and under the strict rules of evidence, where the complainant goes into any part of a document without offering it in its entirety, the defendants have a right to offer the entire document or report, and all the analyses upon which that report is made, as the record in this case will disclose by a careful consideration of the testimony of the three witnesses who testified for complainant.

MR. JEFFRIES: I will state to the Court that we have no objection to the defendants reading in evidence the entire articles that were referred to by Prof. Keiser, Dr. Teichmann and Dr. Ravold, or any other witness that the state of Missouri has placed upon the stand, or may place upon the stand. We submit, however, that we have a right to introduce that character of testimony and to refer to anything that the Sanitary District or the State of Illinois has said, because said against itself.

We submit further that there is no evidence that any of the testimony of this witness or the reports of the authorities under the act of the legislature in question, were referred to by any of the witnesses for the State of Missouri.

Q. JUDGE SPRINGER: When those bottles from the Illinois river and the other points that you have mentioned arrived at the University of Illinois, please state what
8499 you proceeded to do with them?

A. They were examined, the samples treated and analyzed in precisely the manner set forth in my testimony of the last three days, respecting the samples examined by me on behalf of the Sanitary District of Chicago.

Q. Did you enter the ascertainments of those analyses upon any records made by you?

A. I did.

Q. Have you those records with you?

A. I have.

Q. Will you please produce them?

A. Yes.

(Witness produces papers).

Witness produced certain tables entitled "Department of Chemistry, University of Illinois, Sanitary Water Analyses, parts per million" which constitutes a part of the report of the State Water Survey as made by the department of chemistry of the University of Illinois under the act of the Legislature of the State of Illinois, approved June 7, 1897, and in force July 1, 1897, heretofore this day read in evidence, which tables were made by witness Arthur W. Palmer, Professor of Chemistry, University of Illinois, and which tables shall be hereafter
8500 known in this evidence as "Department of Chemistry, University of Illinois, A. W. P., Table 1 to table 80 inclusive."

JUDGE SPRINGER: Now I ask that these tables be read into the evidence.

MR. JEFFRIES: I object to the reading of the tables just referred to in evidence for the reason that they are incompetent, irrelevant and immaterial, and for the reason that there is no evidence showing the manner in which the samples of water were collected, or at least showing how all the samples were collected, and no evidence showing the manner of shipment or the manner of packing and no evidence showing time elapsing from the date of collection until the date the analyses were made.

JUDGE SPRINGER: I desire to suggest that the tables themselves furnish the information which counsel assumes is absent, in many respects.

MR. JEFFRIES: And I suggest that the witness himself has stated that persons other than those who have testified, collected samples for him for the purpose of making these analyses, and inasmuch as the Act of the Legislature of the State of Illinois and the conduct of the officials in reference thereto is not binding upon the State of Missouri, and as the State of
8501 Missouri challenges the sanitary conditon of the water
of the Illinois river at the times mentioned in the tables, subsequent to January 17, 1900, we are entitled to all evidence bearing upon the sufficiency, the correctness and the accuracy of the analyses and all witnesses having any connection therewith, in order that they may be cross-examined; and for the further reason that defendants' evidence shows that chemical analysis alone is not to be relied upon in determining the sanitary conditon of water.

JUDGE SPRINGER: I move to strike this objection from the record for the reason that the tables themselves when read in evidence will disclose many of the facts which counsel assumes are wanting, and for the further reason that his objection is argumentative and goes to the weight of the testimony and not to its competency or admissibility.

MR. JEFFRIES: And I object to the introduction of the tables for the further reason that they contain analyses of water made from various other streams than the Illinois river, and therefore they are incompetent, irrelevant and immaterial, the sanitary condition of the water of the Illinois river alone being under determination in this controversy.

8502 JUDGE SPRINGER: I move to strike out the objection for the same reasons stated in my previous motion.

MR. JEFFRIES: And I object to the introduction of the tables for the further reason that it is not shown by this witness that all these chemical results were obtained from his own personal work.

JUDGE SPRINGER: The witness will explain later how these tables were prepared, and I asked for them now to be read in evidence.

THE WITNESS. The tables are as follows:

8503

CHEMICAL EXAMINATION OF WATER FROM LAKE MICHIGAN AT CHICAGO.

(Parts per 1,000,000.)

Serial Number.	1897 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.							Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.		Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Total.	Dissolved.	Suspended	Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
1794	Jan. 4	Jan. 4	s	l	.02.03*	137.2	136.4	.8	5.2	5.2	3.1	3.2	3.	.2	.004	.08	.064	.016	.32	.24	.08	.002	.15
1812	" 11	" 11	s	l	.03.04*	141.6	140.	1.6	9.6	4.	3.4	2.5	2.2	.3	.016	.08	.048	.032	.32	.24	.08	none	.2
1832	" 18	" 18	s	l	.04.05*	148.	142.4	5.6	9.2	8.4	3.5	3.8	3.2	.6	.024	.136	.08	.056	.4	.28	.12	.002	.3
1844	" 25	" 25	s	l	.01.02*	140.8	140.	.8	6.	5.2	3.	3.	2.7	.3	.004	.096	.08	.016	.4	.208	.192	none	.13
1864	Feb. 1	Feb. 1	s	l	.04	142.4	141.2	1.2	6.	4.	3.2	2.4	1.8	.6	.004	.096	.08	.016	.4	.32	.08	"	.15
1893	" 8	" 8	s	l	.01.02*	141.6	140.8	.8	7.2	6.	3.	2.	1.8	.2	.008	.08	.0784	.0016	.304	.272	.032	"	.2
1912	" 15	" 15	s	l	.03.04*	140.4	136.8	3.6	4.4	2.	3.	1.9	1.7	.2	.008	.112	.096	.016	.256	.224	.032	"	.2
1931	" 22	" 22	s	l	.02.03*	146.8	141.2	5.6	14.	10.	3.2	2.1	1.6	.5	.004	.098	.066	.032	.24	.184	.056	"	.25
1953	Mar. 1	Mar. 1	s	l	.01.02*	150.8	144.4	6.4	12.8	10.4	3.	2.1	1.8	.3	.004	.082	.07	.012	.36	.24	.12	"	.25
1972	" 8	" 8	s	vl	.03.05*	158.8	157.2	1.6	34.	27.6	3.	2.6	2.5	.1	.004	.096	.076	.02	.25	.23	.02	"	.18
2000	" 15	" 15	s	vl	.02.03*	136.4	136.	.4	15.2	15.2	2.9	2.2	2.	.2	.002	.096	.08	.016	.23	lost	....	"	.2
2028	" 22	" 22	s	vl	.02.03*	148.	148.6	4.4	18.	15.2	3.1	3.	2.6	.4	.008	.112	.068	.044	.174	.15	.024	.001	.27
2052	" 29	" 29	s	vl	.03.04*	160.	152.	8.	18.8	18.	3.2	3.1	2.8	.3	.008	.086	.064	.022	.24	.2	.04	.002	.27
2069	Apr. 5	Apr. 6	s	l	.03.1*	176.4	163.2	13.2	22.	19.6	3.9	4.9	4.2	.7	.062	.144	.102	.042	.43	.27	.16	.006	.5
2108	" 12	" 12	s	vl	.03.04*	142.	137.2	4.8	12.8	9.6	2.8	3.	2.3	.7	.001	.076	.068	.008	.21	.15	.06	none	.15
2137	" 20	" 21	s	l	.02.05*	179.2	155.6	23.6	20.	19.2	3.	4.5	3.6	.9	.014	.172	.114	.058	.35	.2	.15	.001	.15
2154	" 26	" 27	s	l	.02.04*	152.8	145.2	7.6	12.8	10.	3.	4.3	2.7	1.6	.007	.124	.078	.046	.23	.2	.03	.04	.3
2186	May 4	May 5	d	c	.03	468.	140.	328.	22	14.	2.8	14.7	3.2	11.5	.006	.416	.092	.324	.95	.182	.768	.008	.4
2203	" 10	" 11	s	l	.02.03*	141.6	132.8	8.8	9.2	6.8	2.8	4.3	4.	.3	.001	.094	.074	.02	.23	.094	.136	none	.15
2221	" 17	" 18	s	vl	.03.04*	149.2	145.2	4.	13.2	12.	3.	4.7	4.5	.2	.002	.096	.064	.032	.23	.174	.056	.002	.2
2255	" 24	" 25	vs	vl	.03.04*	142.	141.6	.4	13.2	12.8	2.8	2.5	2.3	.2	.001	.072	.058	.014	.23	.19	.04	none	.25
2276	" 31	" 31	s	vl	.01.03*	142.8	137.6	5.2	6.8	6.4	2.7	1.7	1.5	.2	.002	.1	.072	.028	.27	.21	.06	"	.1
2309	June 9	Jun. 10	s	l	.02.03*	140.8	138.	2.8	9.6	6.	3.1	2.5	2.3	.2	.004	.096	.086	.01	.29	.21	.08	"	.21
2323	" 14	" 15	s	l	.01.02*	144.	141.6	2.4	12.0	11.6	2.7	3.3	3.	.3	.002	.096	.078	.018	.21	.17	.04	"	.2
2350	" 21	" 22	vs	vl	.02.03*	150.	136.	14.	12.8	6.8	2.1	2.4	2.	.4	.004	.076	.062	.014	.25	.17	.08	"	.2
2383	" 28	" 29	vs	vl	.03	145.6	144.4	1.2	17.6	15.2	3.	4.	3.	1.	.004	.09	.078	.012	.29	.19	.1	"	.1
2414	July 6	July 7	vs	vl	......	138.	136.8	1.2	12.	8.	2.9	3.3	3.1	.2	none	.07	.062	.008	.56	.52	.04	"	.1
2433	" 12	" 13	vs	vl	.02.03*	132.2	129.2	3.	7.2	6.	2.9	1.6	1.5	.1	.001	.08	.072	.008	.16	.1	.06	"	.08

CHEMICAL EXAMINATION OF WATER FROM LAKE MICHIGAN AT CHICAGO.—CONTINUED.

(Parts per 1,000,000.)

Serial Number	1897. Date of		Appearance.			Residue on Evaporation.					Chlorine	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Collection.	Examination	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved.		Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Dissolved.	Albuminoid Ammonia. Suspended	Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
2462	July 19	July 20	s	1	.0 .05*	158.	139.2	18.8	16.	12.	2.9	2.4	2.	.4	.002	.102	.078	.024	.28	.24	.04	none	.15
2485	" 26	" 27	s	1	.03	150.8	134.8	16.	11.2	6.	3.	3.8	3.2	.6	.001	.102	.076	.026	.24	.2	.04	"	.1
2518	Aug. 2	Aug. 3	s	1	.01.03*	190	138.4	51.6	14.	11.2	2.8	5.	3.9	1.1	.001	.142	.104	.038	.16	.12	.04	"	.1
2538	" 9	" 10	vs	vl	.02.03*	134.4	127.2	7.2	11.2	10.4	3.	3.2	2.8	.4	.001	.09	.086	.004	.24	.18	.06	"	.1
2563	" 16	" 17	s	1	.02.03*	135.2	127.2	8.	11.6	10.8	2.9	3.8	3.4	.4	.001	.102	.09	.012	.24	.22	.02	"	.35
2584	" 23	" 24	s	1	.02.03*	135.2	134.	1 2	11.2	9.2	2.9	3.1	2.8	.3	.001	.106	.088	.018	.28	.24	.04	"	.1
2610	" 30	" 31	s	1	.02.03*	128.	1 7.2	.8	10.	8.	2.9	3.8	3.6	.2	.001	.094	.082	.012	.22	.2	.02	"	.05
2647	Sept. 7	Sept. 8	vs	1	.02	128.4	123.2	5.2	11.6	10.4	3.	3.2	3.	.2	.002	.086	.08	.006	.156	.148	.008	"	.15
2661	" 13	" 14	s	1	.02.03*	136.	134.	2.	10.	9.6	3.	2.9	2.7	.2	.002	.08	.074	.006	.164	.148	.016	"	.15
2700	" 21	" 22	s	1	.02.03*	134.8	131.4	.4	8.	7.2	3.1	3.2	2.8	.4	.001	.07	.064	.006	.18	.16	.02	"	.1
2716	" 27	" 28	s	1	.03.04*	139.2	138.	1.2	6.	5.6	3.	3.	2.8	.2	.002	.106	.092	.014	.188	.172	.016	"	.1
2750	Oct. 4	Oct. 5	s	1	.03.03*	136.4	129.2	7.2	14.8	14.4	2.9	3.5	3.3	.2	.001	.074	.06	.014	.22	.188	.032	"	.1
2797	" 13	" 14	vs	vl	.02.02*	138.	133.6	4.4	13.2	7.6	2.7	2.65	2.65	...	.006	.07	. 96	....	.172	.252	....	"	.15
2813	" 18	" 19	d	1	.02.03*	146.	140.	6.	10.	9.2	3.1	3.5	3.3	.2	.004	.106	.076	.03	.284	.19	.094	.002	.05
2870	Nov. 1	Nov. 2	vs	vl	.02.02*	135.6	131.2	4.4	12.4	10.8	2.7	3.1	2.9	.2	.0 1	.078	.068	.01	.204	.188	.016	none	.3
2922	" 9	" 10	d	1	.03.05*	149.2	138.	11.2	12.	6.4	3.	3.6	3.	.6	.001	.12	.084	.036	.204	.172	.032	.001	.35
2954	" 15	" 16	s	1	.03.04*	136.8	132.8	4.	7.6	6.	2.9	3.	2.5	.5	.001	.08	.076	.004	.18	lost	....	none	.35
2972	" 22	" 23	s	1	.02.03*	144.	136.	8.	6.	5.2	2.8	2.7	2.6	.1	.001	.098	.09	.008	.188	.172	.016	.001	.2
3002	" 29	" 30	s	1	.02.03*	141.2	132.	9.2	12.4	12.	2.7	2.9	2.7	.2	.001	.74	.064	.01	.178	.162	.016	none	.4
3021	Dec. 6	Dec. 7	d	1	.03.08*	164.4	140.	24.4	6.	4.	2.8	3.8	2.9	.9	.018	.172	.07	.102	.25	.21	.04	.004	.4
3063	" 13	" 14	d	1	.03.06*	148 4	142.8	5.6	12.4	8.	3.1	3.2	2.6	.6	.03	.112	.084	.028	.242	.226	.016	.004	.45
3085	" 21	" 23	s	1	.02.04*	143.2	132.	11.2	8.4	4.	2.9	3.	2.8	.2	.001	.062	.056	.006	.194	.178	.016	none	.25
3094	" 27	" 28	s	1	.02 04*	146.8	146.4	.4	10.	9.2	2.8	2.6	2.4	.2	.001	.068	.054	.014	.21	.162	.048	"	.12
Average Jan. 4–.Dec 27..........						151.7	136.6	15.	11.9	9.6	2.9	3.3	2.7		.005	.102	.076	.036	.268	.196	.073	.005	.2

*Not altered.

CHEMICAL EXAMINATION OF WATER FROM LAKE MICHIGAN AT CHICAGO.

(Parts per 1,000,000.)

Serial Number	1898		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
	Collection.	Examination.							Total.	Dissolved.						Total.	Dissolved.	Suspended					
3120	Jan. 3	Jan. 4	s	l	.02.03*	138.8	130.4	8.4	11.6	10.	2.8	2.1	2.	.1	.001	.07	.064	.006	.194	.162	.032	none	.15
3136	" 10	" 11	vs	vl	.01.02*	144.4	138.8	5.6	13.6	12.8	2.9	2.5	2.3	.2	.001	.114	.084	.03	.220	.152	.068	"	.16
3174	" 18	" 19	s	l	.02.03*	154.	140.	14.	10.4	10.	3.	3.	2.6	.4	.001	.098	.094	.004	.184	.168	.016	.001	.3
3204	" 24	" 25	d	l	.04.07*	171.6	141.2	30.4	7.2	6.	3.1	3.	2.	1.	.002	.11	.09	.02	.216	.15	.066	.001	.3
3225	" 31	Feb. 1	d	l	.4	213.2	146.8	66.4	18.8	14.8	3.	3.6	2.7	.9	.008	.116	.068	.048	.28	.184	.096	none	.3
3241	Feb. 7	" 8	d	l	.04.1*	176.	166.4	9.6	31.2	21.2	3.1	3.	2.7	.3	.01	.102	.09	.012	.18	.16	.02	.001	.1
3268	" 14	" 15	s	l	.02.03*	152.	146.8	5.2	18.2	12.	3.3	3.5	3.	.5	.06	.08	.076	.004	.232	.2	.032	.005	.19
3291	" 21	" 22	d	l	.04.15*	195.6	152.8	42.8	19.2	16.8	3.	3.6	3.	.6	.006	.094	.088	.006	.232	.184	.048	.001	.2
3311	" 28	Mar. 1	d	l	.1.15*	159.2	140.8	18.4	13.2	8.8	3.	3.1	2.9	.2	.002	.096	.088	.008	.184	.152	.032	none	.5
3332	Mar 7	" 8	s	l	.03.04*	147.6	139.2	8.4	9.6	8.4	2.9	2.6	2.	.6	.004	.072	.066	.006	.184	.168	.016	"	.4
3352	" 14	" 15	d	l	.05.06*	184.	167.2	16.8	25.6	22.8	5.8	4.5	4.	.5	.38	.196	.150	.046	.6	.424	.176	.02	.35
3382	" 21	" 22	d	l	.10.20*	181.6	172.4	9.2	24.	21.2	5.4	4.9	4.3	.6	.286	.212	.186	.026	.408	.376	.032	.025	.65
3399	" 28	" 29	d	l	.1.5*	182.	164.8	17.2	16.	13.6	3.4	3.8	3.4	.4	.08	.116	.088	.028	.322	.242	.08	.005	.2
3420	Apr 4	Apr. 5	d	l	.03.3*	204.4	180.8	23.6	22.4	19.6	6.	5.8	4.9	.9	.28	.21	.18	.03	.482	.29	.192	.04	.5
3443	" 11	" 12	s	l	.03.04*	144.8	137.6	7.2	10.4	10.	3.2	2.6	2.5	.1	.004	.102	.08	.022	lost	.21	....	.001	.5
3466	" 18	" 19	s	l	.01.03*	169.2	151.6	17.6	10.4	9.2	3.	3.	2.8	.2	.006	.122	.118	.004	.274	.21	.06	.003	.9
3500	" 25	" 26	s	l	.02.01*	149.2	146.4	2.8	11.2	10.	3.2	4.	3.3	.7	.001	.092	.088	.004	.194	.162	.032	none	.35
3535	May 3	May 4	vs	vl	.02.04*	152.4	138.	14.4	20.	10.8	3.2	2.0	2.5	.4	.004	.088	.082	.006	.22	.18	.04	"	.4
3547	" 9	" 10	vs	vl	.02.03*	143.6	142.8	.8	14.	12.8	3.1	2.7	2.5	.2	.002	.102	.074	.028	.232	.21	.022	.001	.2
3595	" 18	" 19	vs	vl	.02.03*	152.4	146.4	6.	20.	18.	3.	3.	2.3	.2	.006	.094	.086	.008	.14	.116	.024	.01	.4
3603	" 23	" 24	s	l	.01.02*	149.6	147.2	2.4	19.2	18.	3.	2.8	2.6	.2	.002	.08	.074	.006	.228	.196	.032	.001	.3
3637	" 31	June 1	s	l	.02.03*	142.	137.2	4.8	12.	8.4	3.	2.7	2.5	.2	.001	.076	.072	.004	.124	.116	.008	none	.25
3654	June 6	" 7	s	l	.01.02*	142.4	136.	6.4	6.8	16.	3.	3.2	3.	.2	.001	.084	.074	.01	.232	.184	.048	"	.15
3679	" 13	" 14	s	none	.03	150.	136.	14.	10.8	8.4	4.	2.7	2.5	.2	.001	.084	.072	.012	.24	.2	.04	"	.15
3701	" 20	" 21	s	none	.02	126.4	108.8	17.6	11.2	6.8	.1	1.9	1.9		.001	.066	.064	.002	.144	.144	..	"	.20
3751	" 27	" 28	s	l	.02.03*	166.4	132.4	34.	12.	10.	3.5	3.5	3.3	.2	.008	.086	.080	.006	.16	.14	.02	.01	.1
379	July 5	July 6	s	l	.02	136.	130.4	5.6	14	1.	3.1	2.8	2.7	.1	none	.072	.066	.006	.22	.152	.068	none	.2

3883	July 18	July 19	s	1	.01.02*	138.8	137.2	1.6	10.8	10.	3.1	2.	1.9	.1	.001	.06	.056	.004	.16	.128	.032	none	.075
3871	" 25	" 26	s	1	.02.02*	41.9	136.	5.2	14.	12.6	3.1	1.9	2.8	.1	.001	.072	.068	.004	.128	.112	.906	"	.2
3908	Aug. 2	Aug. 3	s	1	.01.02*	134.4	125.6	8.8	11.2	8.	3.	2.8	2.6	.2	.0 2	.068	.054	.014	.112	.096	.016	"	.2
3927	" 8	" 9	s	1	.02.02*	131.2	128.	3.2	12.	11.2	3.	2.7	2.3	.4	.001	.064	.06	.004	.16	.128	.032	"	.05
3952	" 15	" 16	s	1	.02.03*	143.2	139.6	3.6	21.2	20.	3.3	2.7	2.5	.2	.004	.076	.07	.006	.176	.16	.016	"	.15
3976	" 22	" 23	s	1	.01.02*	133.2	129.2	4.	14.	12.	3.1	2.9	2.7	.2	.005	.064	.062	.002	.112	.096	.016	.001	.2
4005	" 29	" 30	s	1	.01.01*	136.4	135.2	1.2	15.2	14.	3.1	2.5	2.4	.3	.002	.002	.078	.014	.144	.112	.032	none	.04
4039	Sept. 5	Sept. 6	s	1	.02.03*	136.8	134.4	2.4	14.	13.2	3.	3.	2.8	.2	.002	.06	.058	.902	.144	.128	.916	"	.05
4063	" 12	" 13	s	1	.02.03*	142.8	138.	4.8	23.2	18.8	2.9	2.5	2.4	.1	.002	.066	.062	.004	.112	.096	.016	"	.05
4085	" 19	" 20	s	1	.02.03*	136.	138.8	3.2	13.2	12.	3.	2.4	2.2	.2	.004	.064	.060	.004	.096	.08	.016	"	.1
4117	" 26	" 27	s	1	.01.02*	139.2	134.8	4.4	16.	14.	3.1	1.8	1.7	.1	.001	.07	.066	.004	.16	.124	.036	"	.04
4150	Oct. 3	Oct. 4	s	1	.02.03*	139.2	132.	7.2	13.6	12.	2.9	2.5	2.3	.2	.002	.064	.058	.006	.16	.128	.032	"	.1
4191	" 1	" 11	s	1	.01.02*	132.	130.4	1.6	24.	13.2	2.9	2.1	1.8	.3	.004	.074	.06	.014	.13	.1	.93	"	.3
4223	" 17	" 18	d	1	.02.05*	153.6	136.4	17.2	12.	11.2	3.	2.6	2.	.6	.006	.088	.07	.018	.194	.146	.048	.001	.2
4244	" 24	" 25	s	1	.02.03*	142.8	134.8	8.	16.8	14.8	3.	2.3	2.	.3	.002	.098	.086	.012	.163	.13	.032	none	.2
4292	" 31	Nov. 1	d	1	.05	190.	142.	48.	18.	16.	3.1	3.4	2.4	1.	.022	.094	.072	.022	.256	.146	.112	.013	.4
4325	Nov. 7	" 8	d	1	.02	158.	138.	20.	12.	10.	3.	2.7	2.	.7	.01	.076	.07	.006	.162	.13	.032	.008	.1
4350	" 14	" 15	d	1	.03	184.4	136.	48.4	13.4	12.	3.3	3.2	2.2	1.	.046	.064	.058	.006	.23	.126	.094	.005	.15
4392	" 21	" 22	d	1	.02	164.8	134.8	30.	16.8	14.8	3.1	2.6	2.3	.3	.008	.062	.0 2	.03	.19	.126	.064	.002	.06
4422	" 28	" 29	d	1	.02	187.2	140.8	46.4	24.	20.8	3.9 3.8	3.6	2.2	1.4	.072	.11	.09	.02	.202	.19	.112	.013	.5
4456	Dec. 5	Dec. 6	d	1	.04	174.	124.8	49.2	22.	16.8	3.1	2.7	2.	.7	.004	.106	.084	.022	.194	.162	.032	.01	.15
4476	" 12	" 13	s	1	.02.04*	136.	129.6	6.4	20.	16.8	3.1	2.6	2.4	.2	none	.06	.05	.01	.18	.13	.05	none	.1
4513	" 20	" 21	s	1	.03.05*	142.	135.6	6.4	28.	22.8	3.2	2.3	2.	.3	.004	.086	.07	.016	.18	.13	.05	"	.1
4531	" 27	" 28	s	1	.03.04*	142.	134.8	7.2	20.	18.	3.	2.8	1.8	.4	none	.064	.052	.0 2	.146	.11	.036	none	.1
Average Jan 3—Dec. 27..........						154.2	137.6	16.6	15.9	13.6	3.2	2.9	2.5	.4	.024	.091	.078	.012	.202	.161	.041	.006	.239

*Not filtered. § Considerable.

CHEMICAL EXAMINATION OF WATER FROM LAKE MICHIGAN AT CHICAGO.
(Parts per 1,000,000.)

Serial Number.	1899		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.
	Collection.	Examination							Total.	Dissolved.						Total.	Dissolved	Suspended					
4567	Jan. 3	Jan. 4	s	1	.02.03*	144.	136.	8.	22.	17.2	3.2	2.4	1.8	.6	.002	.06	.056	.004	.13	.1	.03	.001	.16
4590	" 9	" 10	s	1	.03.04*	153.2	147.6	5.6	16.	14.8	3.3	2.7	2.5	.2	.012	.06	.054	.006	.194	.13	.064	none	.15
4614	" 16	" 17	s	1	.01.02*	133.2	129.2	4.	23.2	20.	3.2	2.2	2.1	.1	.01	.058	.052	.006	.13	.114	.016	"	.1
4639	" 23	" 24	s	1	.01.02*	136.8	129.6	7.2	20.	18.8	3.1	1.7	1.6	.1	.004	.064	.06	.004	.13	.114	.016	"	.1
4676	Feb. 6	Feb. 7	s	1	.01.02*	136.8	132.	4.8	18.	16.	3.2	2.3	2.	.3	.002	.072	.058	.014	.16	.13	.03	"	.42
4697	" 13	" 14	s	1	.01.02*	152.8	144.	8.8	22.	20.	3.3	2.4	2.2	.2	.001	.07	.06	.01	.132	.1	.032	"	.1
4727	" 20	" 21	s	1	.01.02*	140.8	138.	2.8	18.	16.	3.1	2.3	2.1	.2	.002	.01	.056	.014	.132	.1	.032	"	.15
4748	" 27	" 28	s	1	.02.03*	148.	142.	6.	24.	22.	3.2	2.5	2.1	.4	.01	.104	.094	.01	.13	.1	.03	"	.1
4778	Mar. 6	Mar. 7	s	1	.01.03*	160.	139.2	20.8	24.	19.2	3.2	2.4	2.1	.3	.001	.074	.07	.004	.164	.148	.016	"	.15
4798	" 13	" 14	s	1	.01.03*	144.	136.	8.	24.	22.	3.1	2.8	2.2	.6	.006	.096	.076	.02	.148	.116	.032	"	.075
4834	" 20	" 21	d	1	.02.03*	162.8	134.	28.8	22.	18.	3.1	2.6	2.1	.5	.001	.074	.056	.018	.196	.148	.048	"	.15
4857	" 27	" 28	s	1	.02.03*	142.	134.8	7.2	18.	16.	3.	2.	1.8	.2	none	.05	.046	.004	.126	.11	.016	"	.06
4889	Apr. 3	Apr. 4	s	1	.01.02*	134.	132.	2.	18.	16.8	3.	2.1	2.	.1	.001	.058	.054	.004	.126	.11	.016	"	.1
4910	" 10	" 11	s	1	.01.02*	136.	132.	4.	18.	16.	3.	2.1	2.	.1	none	.058	.056	.002	.11	.094	.016	"	.12
4933	" 17	" 18	s	1	.02*	140.	136.	4.	20.	18.	3.1	2.4	2.3	.1	.002	.086	.068	.018	.158	.11	.048	"	.1
4955	" 24	" 25	s	1	.01 02*	139.2	136.4	3.2	18.	17.2	3.	2.3	2.1	.2	.002	.07	.066	.004	.138	.122	.016	"	.12
4981	May 1	May 2	s	1	.01.02*	141.2	140.4	.8	16.	15.2	3.1	2.3	2.05	.25	.001	.076	.062	.014	.13	.106	.024	"	.1
5007	" 8	" 9	s	1	02.03*	138.2	137.2	.8	20.	19.2	3.1	2.1	2.1	.00	.001	.062	.058	.004	.154	....	....	"	.22
5043	" 16	" 17	s	1	.01.03*	143.6	137.2	6.4	8.	7.2	3.	2.9	2.9	.00	.001	.098	.082	.016	.218	.17	.048	"	.23
50 4	" 22	" 23	s	1	.01.02*	154.4	143.6	10.8	17.2	11.2	3.15	2.4	2.4	.00	.001	.076	.064	.012	.22	.2	.02	"	.38
5110	" 29	" 30	s	1	.01.02*	159.6	158.	1.6	27.6	27.6	2.8	2.	1.95	.05	.001	.084	.072	.012	.234	.186	.048	"	.17
5154	June 5	Jun. 6	s	1	.01.03*	141.6	140.	1.6	16.8	15.8	2.9	2.	2.	.00	.001	.086	.082	.004	.154	.122	.032	"	.2
5211	" 13	" 14	s	1	.01.03*	146.8	134.	12.8	19.2	10.4	2.15	1.95	1.75	.2	.001	.074	.056	.018	.328	.248	.08	"	.2
5243	" 19	" 20	s	1	.01.02*	160.	156.8	3.2	26.8	24.8	2.85	2.35	2.2	.15	.001	.072	.062	.01	.232	.152	.08	"	.12
5213	" 26	" 27	s	1	.01.02*	137.2	128.8	8.4	8.	7.2	3.3	1.85	1.8	.05	.001	.06	.058	.002	.2	.176	.024	"	.06
5336	July 3	July 4	s	1	.01.02*	154.	138.4	15.6	44.	14.8	2.9	2.8	2.5	.3	.001	.082	.08	.002	.224	.2	.024	"	.2
5381	" 10	" 11	s	1	.01.02*	1 6.	131.6	4.4	22.	20.8	3.8	1.6	....	...	.001	.068	.064	.004	.224	.176	.048	"	.2
5438	" 18	" 19	s	1	.02.03*	134.	134.		22.4	18.8	3.4	3.1	....	...	.001	.076	.07	.006	.216	.144	.072	"	.16

CHEMICAL EXAMINATION OF WATER FROM LAKE MICHIGAN AT CHICAGO.—CONTINUED.

(Parts per 1,000,000.)

Serial Number	1899 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved.	Suspended	Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
5476	July 24	July 25	s	1	.02.03*	146.8	137.6	9.2	34.4	32.8	3.3	5.	4.5	.5	.001	.092	.072	.02	.192	.16	.032	none	.28
5528	" 31	Aug. 1	d	1	.01.03*	178.8	138.	40.8	70.8	31.2	3.7	6.4	5.7	.7	.007	.108	.1	.008	.256	.184	.072	"	.16
5574	Aug. 7	" 8	s	1	.01.02*	125.6	124.8	.8	27.6	25.6	3.	2.5	2.2	.3	.001	.072	.062	.01	.184	.168	.016	"	.16
5625	" 14	" 15	d	1	.01.02*	124.8	111.6	13.2	27.2	22.8	2.85	3.4	2.8	.6	.001	.072	.056	.016	.184	.12	.064	"	.12
5671	" 21	" 22	s	1	.01.03*	123.6	99.6	24.	20.	6.	3.	3.3	2.9	.4	.001	.074	.06	.014	.2	.112	.088	"	.24
5795	Sept. 5	Sept. 6	s	1	.01.03*	136.4	126.4	10.	20.4	19.2	2.85	3.6	2.	1.6	.001	.08	.074	.006	.2	.184	.016	"	.2
5831	" 11	" 12	s	1	.01.03*	128.4	123.6	4.8	13.2	10.8	2.9	2.	1.8	.2	none	.088	.072	.016	.244	.184	.06	"	.24
5877	" 18	" 19	s	1	.01.03*	127.2	124.4	2.8	15.2	13.6	3.1	1.9	1.7	.2	.001	.11	.072	.038	.232	.2	.032	"	.16
5929	" 25	" 26	s	1	.0 .02*	123.2	124.8	....	4.	5.6	3.1	2.2	2.2	...	.001	.074	.064	.01	.164	.14	.024	"	.12
5993	Oct. 3	Oct. 4	s	1	.01.02*	125.2	124.4	.8	22.	22.	7.1	2.9	2.9		.001	.068	.068	....	.172	.164	.008	"	.08
6041	" 10	" 11	s	1	.01.02*	130.8	125.2	5.6	9.2	8.8	2.8	2.5	2.3	.2	.001	.086	.072	.014	.132	.104	.028	"	.16
6073	" 16	" 17	s	1	.01.02	123.2	120.8	2.4	9.6	6.4	2.9	2.5	2.5	...	.001	.078	.062	.004	.18	.164	.016	"	.12
6141	" 23	" 24	s	1	.01.02	134.	130.8	3.2	9.6	6.	3.	2.5	2.2	.8	.001	.084	.078	.006	.168	.152	.016	"	.16
6191	" 30	" 31	s	1	.01.03*	133.6	118.8	14.8	12.4	11.2	6.	2.2	2.1	.1	.001	lost	.066	....	.212	.2	.012	"	.16
6238	Nov. 6	Nov. 7	s	1	.01.03*	138.8	136.4	2.4	10.	9.6	2.9	1.9	1.8	.1	.001	.076	.066	.01	.304	.18	.024	"	.24
6272	" 13	" 14	s	1	.02.04*	155.2	144.8	10.4	22.	12.	lost	2.6	2.2	.4	.002	.1	.078	.022	.228	.148	.08	"	.12
6330	" 20	" 21	s	1	.01.03*	136.8	132.8	4.	10.4	6.4	3.3	2.5	2.5		.002	.102	.086	.016	.228	.204	.024	"	.8
6394	" 27	" 28	s	1	.01.03*	135.2	126.4	8.8	9.6	8.8	3.2	1.9	...	...	.002	.086	.062	.24	.236	.18	.056	"	.12
6444	Dec. 4	Dec. 5	s	1	.01.04*	134.	125.2	8.8	21.2	14.	3.	2.3	1.7	.6	.001	.082	.072	.01	.228	.204	.024	"	.16
6494	" 11	" 12	s	1	.02.03*	137.2	133.6	3.6	26.4	23.2	3.	2.4	2.2	.2	.003	.086	.08	.006	.236	.156	.08	"	.12
6539	" 18	" 19	s	1	.01.02*	126.4	122.8	3.6	16.	15.6	2.9	4.	3.6	.4	.001	.08	.07	.01	.26	.18	.08	"	.32
6581	" 26	" 27	s	1	.01.02*	124.4	114.	10.4	9.2	8.	3.2	3.9	3.2	.7	.001	.076	.06	.016	.244	.22	.024	"	.28
Average Jan. 3—Dec. 26..............						140.	132.	7.4	18.6	16.	3.1	2.5	2 1	.38	.002	.074	.067	.007	.188	.148	.039	.001	.178

*Not filtered.

CHEMICAL EXAMINATION OF WATER FROM LAKE MICHIGAN AT CHICAGO.

(Parts per 1,000,000.)

Serial Number.	1900		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
	Collection.	Examination.							Total.	Dissolved.						Total.	Dissolved.	Suspended					
6610	Jan. 3	Jan. 4	s	l	.01.03*	142.8	129.6	13.2	21.9	20.1	3.4	3.8	3.6	.2	.002	.084	.072	.012	.22	.156	.064	none	.16
6641	" 8	" 9	d	l	.01.02*	132.	121.6	10.4	20.	14.4	3.	2.9	2.1	.8	.001	.072	.062	.01	.236	.148	.088	"	.2
6667	" 15	" 16	s	l	.01.02*	140.8	130.8	10.	16.	14.4	3.1	2.1	1.9	.2	.004	.082	.07	.012	.184	.12	.064	"	.28
6744	" 23	" 24	s	l	.01.03*	137.2	126.	11.2	13.6	8.8	3.1	2.6	2.4	.4	.004	.074	.07	.004	.2	.16	.04	"	.08
6778	" 29	" 30	s	l	.01.02*	142.4	125.6	16.8	19.6	18.4	3.1	2.	1.9	.1	.002	.06	.054	.006	.144	.12	.024	"	.12
6830	Feb. 5	Feb. 6	s	l	.01.02*	132.	126.	6.	16.	11.6	3.	2.7	2.	.7	.002	.102	.086	.016	.176	.16	.016	"	.12
6931	" 19	" 20	s	l	.01.02*	132.	127.6	4.4	12.	10.	3.2	2.	1.9	.1	.002	.1	.096	.004	.184	.16	.024	"	.08
6980	" 26	" 27	s	l	.01.02*	141.2	125.6	15.6	19.6	10.4	3.2	2.4	2.3	.1	.002	.078	.074	.004	.184	.168	.016	"	.4
7014	Mar.	Mar. 6	s	l	.01.02*	142.4	141.2	1.2	15.6	14.8	3.2	2.	1.8	.2	.002	.08	.076	.004	.2	.176	.024	"	.2
7061	" 12	" 13	s	l	.02	146.8	133.2	13.6	8.8	5.6	3.5	2.1	2.1	..	.002	.084	.08	.004	.168	.16	.008	"	.32
7110	" 19	" 20	s	l	.01.02*	144.4	139.6	4.8	7.2	7.2	3.5	2.9	2.6	.3	.002	.088	.08	.008	.156	.14	.016	"	.2
7159	" 26	" 27	s	l	.01.02*	144.4	144.	.4	15.2	15.2	3.5	2.2	2.2	..	.002	.074	.068	.006	.252	.228	.024	"	.24
7212	Apr. 2	Apr. 3	s	l	.01.02*	145.6	132.4	13.2	10.	6.8	3.5	3.1	2.7	.4	.002	.082	.072	.06	.18	.14	.04	"	.2
7266	" 9	" 10	s	l	.01.02*	142.4	132.4	10.	14.8	12.8	3.4	2.9	2.3	.6	.002	.078	.072	.006	.156	.124	.032	"	.2
7319	" 16	" 17	s	l	.01.02*	133.6	127.2	6.4	19.6	18.	3.3	2.5	2.5	..	.002	.06	.054	.006	.196	.18	.016	"	.2
7394	" 23	" 24	s	l	.01.02*	145.2	131.6	13.6	6.8	5.2	3.5	2.1	2.1	..	.002	.078	.074	.004	.172	.14	.032	"	.4
7435	" 30	May 1	s	l	.01.01*	131.2	124.4	6.8	14.4	8.	3.6	2.4	2.4	..	.001	.068	.06	.008	.114	.1	.014	"	.28
7473	May 7	" 8	s	l	.01.02*	130.8	128.8	2.	23.8	22.	3.5	3.	2.6	.4	.004	.08	.076	.004	.194	.18	.014	"	.32
7521	" 14	" 15	s	l	.01.02*	132.	130.4	1.6	26.	24.8	3.5	2.9	2.5	.4	.022	.066	.066	....	.226	.21	.016	"	.2
7580	" 21	" 22	s	vl	.01.02*	143.2	134.	9.2	20.4	19.6	3.3	3.	2.9	.1	.042	.088	.068	.02	.132	.1	.032	"	.12
7611	" 28	" 29	s	l	.01.02*	130.8	125.6	5.2	26.4	23.6	3.6	2.8	2.8	..	.002	.068	.064	.004	.154	.146	.008	"	.16
7651	June 4	Jun. 5	s	l	.01.02*	144.8	139.6	5.2	22.	31.6	3.5	2.5	2.5	..	.002	.072	.056	.044	.186	.146	.04	"	.2
7697	" 11	" 12	s	l	.01.01*	130.	129.6	.4	20.	20.	6.8	2.9	2.7	.2	.002	.072	.068	.004	.17	.13	.04	"	.24
7732	" 18	" 19	vs	vl	.01.02*	130.2	138.8	.4	17.6	17.2	3.4				.044	.084	.056	.028	.104	.068	.036	.001	.16
7771	" 25	" 26	n	vl	.01.02*	158.	151.2	6.8	34.4	30.4	3.3	2.2	2.2	..	.006	.054	.054	....	.324	lost	....	none	.12
7814	July 2	July 3	vs	vl	.01	150.4	142.8	7.6	26.4	19.6	3.3	2.5	2.3	.2	.013	.074	.066	.018	.34	.306	.032	"	.28
7883	" 9	" 10	vs	vl	.01	139.6	137.2	2.4	14.8	18.6	3.4	2.3	2.2	.1	.012	.07	.07	....	.084	.084		trace	.12
7933	" 16	" 17	vs	vl	.02	152.	142.	10.	17.6	17.6	3.2	2.2	2.2	..	.012	.056	.056	....	.218	.194	.022	"	.12

8004	July 23	July 24	s	vl	.01	143.6	138.8	4.8	16.4	11.6	3.1	2.	2.	..	.012	.056	.058	....	.122	.122	....	trace	.2
8056	" 30	" 31	d	vl	.01	131.2	120.8	10.4	20.8	14.8	3.	2.	2.	..	.006	.054	.034	....	.122	.132	....	none	.2
8104	Aug. 6	Aug. 7	vs	vl	.01	146.4	135.2	11.2	21.2	11.6	3.1	2.5	3.6	..	.024	.066	.064	.002	.146	.148	....	trace	.44
8163	" 13	" 14	vs	vl	....	144.	131.6	12.4	28.8	20.8	3.1	2.8	2.5	.3	.012	.07	.072	....	.162	.196	....	"	.08
8230	" 20	" 21	vs	l	.01	129.6	127.6	2.	16.8	13.6	4.	2.4	2.3	.1	.02	.07	.064	.006	.19	.172	.018	none	.16
8290	" 27	" 28	n	n	.01	140.4	134.8	5.6	11.6	9.6	3.1	2.6	2.4	.2	.028	.084	.08	.004	.15	.14	.01	"	.16
8354	Sept. 3	Sept. 4	c	vl	.01	142.	139.2	2.8	12.8	11.2	3.1	2.2	2.	.2	.04	.094	.16	....	.118	....	....	trace	.24
8427	" 10	" 11	vs	vl	.02.01*	124.	118.4	5.6	17.6	16.	3.1	2.4	2.3	.1	.016	.09	.096	....	.15	....	....	none	.24
8478	" 17	" 18	vs	vl	.01.01*	138.4	134.4	4.	26.4	15.6	3.2	2.6	2.4	.2	.044	.158	.096	.062	.36	.16	.22	"	.2
8534	" 24	" 25	c	vl	.01.02*	141.2	138.8	2.4	22.	18.4	3.2	2.2	...	..	.056	.178	.112	.066	.252	lost	....	"	.48
8588	Oct. 1	Oct. 2	c	vl	.02.03*	140.8	138.	2.8	20.8	19.2	3.2	2.6	2.4	.2	.042	.138	.112	.026	.216	.192	.024	"	.2
8641	" 8	" 9	vs	vl	.01.01*	137.2	130.4	6.8	15.2	12.	2.8	2.4	2.3	.1	.014	.106	.096	.012	.24	.352	....	.002	.28
8662	" 15	" 16	vs	vl	.01.01*	135.2	133.6	1.6	15.2	14.4	3.1	2.7	3.8	..	.008	.056	.064	....	.176	.224	....	.002	.318
8685	" 22	" 23	s	l	....	140.4	138.4	2.	16.8	15.6	3.1	2.3	2.1	.2	.044	.14	.072	.068	.2	.12	.08	.015	.295
8715	" 29	" 30	vs	vl	.01.01*	136.8	131.4	2.4	16.	15.2	3.	3.0	2.9	.7	.076	.144	.088	.056	.432	.388	.144	none	.52
8742	Nov. 5	Nov. 6	vc	vl	.01.01*	132.4	130.8	1.6	10.8	10.4	2.9	2.5	2.5	..	.104	.102	.08	.024	.144	.272	....	"	.24
8770	" 12	" 13	s	vl	.01.02*	130.4	130.4	0.0	10.8	10.	2.8	3.	3.	..	.047	.108	.136	....	.256	.332	....	"	.34
8800	" 20	" 21	s	vl	.01.02*	137.6	130.4	7.2	9.2	8.8	2.7	2.1	3.6	..	.046	.1	.12	....	.168	.184	....	"	.28
8824	" 26	" 27	s	l	.01.02*	140.4	127.2	13.2	16.	14.4	2.8	2.6	2.9	..	.018	.124	.048	.076	.184	.256	....	"	.16
8848	Dec. 3	Dec. 4	vs	vl	.01	126.	125.2	.8	12.8	12.	2.7	2.2	2.6	..	.024	.08	.078	.002	.144	.136	.008	trace	.24
8881	" 10	" 11	s	vl	.01.02*	139.0	131.2	7.4	12.8	11.6	2.7	2.8	3.	..	.006	.076	.068	.008	lost	.088	....	none	.08
8900	" 17	" 18	vs	vl	01.01*	126.4	125.6	.8	8.	7.4	2.8	3.5	3.5	..	.014	.06	.06	....	.208	.108	.04	"	.36
8926	" 26	" 27	s	vl	.01.01*	130.	129.6	.4	16.	15.6	3.	2.5	3.3	..	.012	.08	.08	....	.112	.104	.006	"	.28
Average Jan. 4—Dec. 27..........						138.4	132.2	6.2	17.5	14.7	3.3	2.5	2.4	.17	.018	.065	.076	.014	.186	.155	.034	.004	.237

*Not filtered.

8507

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS AND MICHIGAN CANAL AT LOCKPORT.

(Parts per 1,000,000.)

Serial Number.	1897.		Appearance.			Residue on Evaporation.					Chlorine	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
	Collection.	Examination.							Total.	Dissolved						Total.	Dissolved	Suspended					
1798	Jan. 4	Jan. 5	vd	m	1.	598.	380.4	217.6	26.	16.	59.	25.3	14.5	10.8	2.	1.6	.8	.8	2.24	1.28	.96	.13	4.2
1816	" 11	" 13	d	c	.4	568.4	516.8	51.6	48.	37.6	85.	25.8	17.5	8.3	4.4	1.76	1.28	.48	4.	2.4	1.6	.5	1.5
1843	" 18	" 21	d	c	.3	502.	384.4	117.6	32.	16.	71.	28.6	14.4	14.2	6.	1.92	.96	.96	3.52	1.52	2.	.8	.7
1850	" 25	" 8	d	l	.2	586.4	549.2	37.2	26.	22.8	94.	34.	17.3	16.7	9.2	3.2	1.76	1.44	6.	3.68	.32	.006	.15
1873	Feb. 1	Feb. 3	vd	m	.06	1698.4	1269.2	429.2	52.	24.	505.	68.	12.8	55.2	7.2	5.6	.8	4.8	9.6	1.28	8.32	.07	.2
1897	" 9	" 10	d	m	.3	1202.8	621.6	581.2	116.	24.	151.	88.8	17.4	71.4	13.6	10.8	1.12	9.68	19.2	3.2	16.	.032	.25
1915	" 15	" 16	d	c	.5	715.2	656.	59.2	56.8	37.	170.	45.5	19.1	26.4	16.	4.	2.08	1.92	8.	2.72	5.28	.026	.3
1936	" 22	" 24	d	c	.4	689.6	623.6	66.	131.6	96.8	142.	37.5	17.3	20.2	11.2	3.52	1.76	1.76	6.8	1.92	4.88	.051	.2
1956	Mar. 1	Mar. 2	d	c	.4	624.	573.2	50.8	126.8	94.	146.	37.1	18.1	19.	8.	3.84	1.28	2.56	7.55	1.71	5.84	.03	.075
1974	" 8	" 9	d	c	.2	569.2	501.2	68.	126.	78.8	107.	44.	18.8	25.2	10.	4.	1.92	2.08	6.75	1.71	5.04	none	.1
2008	" 15	" 16	d	c	.2	615.2	541.6	73.6	121.2	98.4	100.	39.3	17.3	22.	8.	3.2	1.28	1.92	6.67	1.71	4.96	.08	.9
2033	" 22	" 23	d	m	.1	677.2	470.4	206.8	96.4	61.2	70.	26.9	13.3	13.6	4.	1.92	.8	1.12	3.5	1.23	2.27	.575	.05
2056	" 29	" 30	d	c	.1	537.2	498.	39.2	92.	88.4	70.	26.	14.3	11.7	3.6	2.08	.72	1.36	3.32	1.	2.32	.017	.3
2087	Apr. 5	Apr. 6	d	m	.5	677.2	553.2	124.	118.	54.4	95.	47.7	19.1	28.6	8.	3.68	1.12	2.56	6.03	1.47	4.56	.03	.3
2116	" 13	" 14	d	c	.5	583.2	503.2	80.	96.	62.	91.	42.6	19.1	23.5	9.6	3.04	1.44	.6	5.07	2.27	2.8	none	.15
2131	" 19	" 20	vd	m	.6	725.2	630.4	94.8	117.2	66.4	137.	48.3	24.3	24.	15.6	3.04	1.76	1.28	5.23	3.4	1.83	.002	.15
2159	" 26	" 28	d	m	.5	698.8	609.2	89.6	110.	78.8	129.	45.7	22.6	23.1	14.4	3.2	1.6	1.6	5.51	3.27	3.24	.005	.25
2181	May 3	May 4	d	m	.5	591.2	502.	89.2	58.	47.2	73.	43.2	21.4	21.8	8.	2.56	1.44	1.12	4.87	2.47	2.4	.04	.15
2207	" 10	" 12	d	m	.4	599.2	512.2	87.	60.	43.2	90.	45.2	23.1	22.1	10.4	2.8	1.6	1.2	5.11	2.63	2.48	.04	.15
2223	" 17	" 18	d	c	.5	530.8	451.6	79.2	78.	60.	80.	44.	20.4	23.6	9.6	2.8	1.12	1.68	4.75	2.03	2.72	.045	.1
2263	" 24	" 26	d	m	.5	588.	509.2	78.8	76.	60.	123.	40.5	19.	21.5	16.8	2.08	1.44	.64	4.35	2.03	2.32	.016	.35
2283	" 31	June 2	vd	c	.4	514.8	424.4	90.4	70.8	42.8	91.	41.7	16.5	25.2	1.9	2.4	1.44	.96	4.35	2.51	1.84	.023	.1
2300	June 7	" 8	d	m	.4	537.2	484.4	52.8	59.2	48.8	119.	39.4	20.	19.4	16.8	3.6	1.76	1.84	3.93	2.33	1.6	.045	.1
2322	" 14	" 15	d	m	.3	813.6	444.8	368.8	134.	34.	109.	58.3	20.3	38.	16.	3.6	.8	2.8	6.73	1.7	5.03	.04	.15
2359	" 22	" 24	vd	m	.5	670.	590.8	79.2	44.	36.	139.	41.2	23.9	17.3	90.	1.9	.96	.96	3.61	2.01	1.6	.018	.3
2396	" 29	July 1	d	m	.....	734.8	509.2	225.6	118.	53.2	120.	32.2	16.8	15.4	16.	2.08	1.04	1.04	3.93	1.85	2.08	.01	.1
• 2416	July 5	" 7	d	m	.2	610.4	474.	136.4	113.6	22.	117.	39.1	14.5	24.6	16.	2.24	.96	1.28	4.76	1.8	2.96	.012	.25

Chemical Examination of Water from the Illinois and Michigan Canal at Lockport. Continued.

(Parts per 1,000,000.)

Serial Number.	1897. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matter		Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
2449	July 14	July 16	d	m	.5	581.6	430.	151.6	46.8	23.	100.	35.7	15.4	20.3	13.2	2.08	1.12	.96	4.28	2.04	2.24	.02	.14
2476	" 20	" 22	d	m	.8	492.8	441.	48.8	44.	30.	112.	28.2	14.5	13.7	13.6	1.6	1.04	.56	2.68	1.96	.72	.003	.25
2500	" 27	" 29	d	c	.2	522.	477.2	44.8	28.	26.	133.	29.5	16.5	13.	15.9	1.44	.8	.64	2.8	1.6	1.2	.003	.25
2549	Aug. 9	Aug. 11	d	c	.6	523.2	428.8	94.4	41.2	23.8	116.	35.4	21.7	13.7	13.6	1.92	1.6	.32	3.96	2.68	1.28	.001	.25
2570	" 16	" 18	d	c	.5	532.8	492.8	40.	52.	28.8	140.	33.	19.5	13.5	18.4	1.92	1.28	.64	3.16	1.88	1.28	.016	.2
2592	" 23	" 25	d	c	.2	520.8	463.8	57.	50.8	34.4	121.	33.	19.7	13.3	16.8	2.16	1.28	.88	3.78	2.5	1.28	.026	.1
2611	" 30	" 31	d	c	.4	509.2	485.2	24.	38.	36.	140.	33.5	21.1	12.4	19.2	1.92	1.28	.64	3.46	2.34	1.12	.01	.075
2639	Sept. 6	Sept. 8	d	c	.2	437.2	399.6	37.6	51.2	40.8	99.	33.	16.8	16.2	10.8	1.92	1.52	.4	3.54	1.78	1.76	.007	.05
2668	" 13	" 14	d	c	.5	492.4	416.8	75.6	46.4	20.8	107.	30.6	18.7	11.9	13.6	1.76	1.44	.32	3.94	2.66	1.28	.02	.1
2689	" 20	" 21	d	c	.3	520.8	450.	70.8	40.8	24.	110.	37.1	17.	20.1	14.4	2.4	1.44	.96	3.94	2.34	1.6	.035	.1
2721	" 27	" 28	d	c	.6	478.	452.8	25.2	38.	32.8	120.	31.3	23.4	7.9	14.4	1.84	1.44	.4	3.34	2.86	.48	none	.3
2751	Oct. 4	Oct. 5	d	c	.5	460.8	432.8	28.	42.	36.8	105.	36.2	23.6	12.6	15.2	2.4	1.6	.8	3.66	2.86	.8	none	.25
2777	" 11	" 12	d	c	.3	465.6	433.2	32.4	58.4	43.6	104.	32.8	21.8	11.	16.8	2.16	1.84	.32	3.58	2.7	.88	.016	.05
2810	" 16	" 18	d	c	.7	482.	444.4	37.6	46.8	35.2	123.	33.5	24.	9.5	17.6	2.08	1.84	.24	3.66	3.18	.44	.006	.1
2835	" 23	" 25	d	c	.4	504.	418.	86.	59.6	38.2	107.	35.5	19.2	16.3	13.6	2.	1.44	.56	3.66	2.7	.96	.002	.12
2867	" 30	Nov. 1	d	m	.3	487.2	397.2	90.	68.8	37.6	97.	44.8	17.3	27.5	13.6	3.04	1.2	1.84	4.44	2.38	2.06	.02	.7
2905	Nov. 6	" 8	d	c	.5	408.8	366.4	42.	48.8	36.8	81.	32.3	18.5	13.8	11.2	2.24	1.6	.64	4.46	2.06	2.4	.014	.45
2945	" 13	" 15	d	c	.6	520.	477.2	42.8	56.	46.8	114.	38.5	23.	15.5	17.6	2.4	1.92	.48	4.46	3.02	1.44	.004	.6
2977	" 22	" 24	vd	m	.6	525.2	477.6	47.6	66.	61.2	110.	35.	22.8	12.2	12.8	1.76	1.52	.24	4.28	2.68	1.6	.05	.25
3006	" 27	" 29	d	m	.3	433.2	373.2	60.	51.2	31.2	76.	32.7	16.5	16.2	10.4	2.08	1.44	.64	3.83	2.39	1.44	.018	.3
3031	Dec. 7	Dec. 8	d	m	.5	522.	470.	52.	88.8	40.	103.	34.2	19.9	14.3	16.	3.28	1.36	1.92	6.37	3.65	2.72	.05	.2
3061	" 13	" 14	vd	c	.6	438.	391.6	46.4	58.8	30.8	87.	30.6	15.8	14.8	12.	2.4	1.52	.88	4.45	2.49	1.96	.05	.25
3076	" 20	" 21	d	c	.6	523.6	485.2	38.4	57.2	32.	111.	39.	27.	12.	12.4	3.2	2.08	1.12	6.05	3.57	2.48	.022	.9
3106	" 28	" 30	d	c	.5	403.2	374.4	28.8	54.4	33.2	85.	34.2	17.5	16.7	11.2	2.4	......	......	4.77	2.64	2.08	.05	.6
Average Jan. 4—June 29..........						684.1	548.0	136.0	84.2	53.1	121.7	42.1	18.4	23.7	10.6	3.2	1.31	1.93	5.79	2.12	3.66	.06	.401
Average July 5—Dec. 28..........						495.7	438.2	57.5	53.6	34.1	108.8	34.3	18.6	15.7	14.3	2.2	1.38	.8	4.05	2.51	1.54	.018	.273
Average Jan. 4—Dec. 28..........						591.8	494.2	97.5	69.2	43.8	115.4	38.3	18.1	20.2	12.4	2.72	1.34	1.38	4.94	2.31	2.62	.039	.339

This water always had a decided odor described as musty or as gassy. The color upon ignition was always brown.

8508

CHEMICAL ANALYSIS OF WATER FROM THE ILLINOIS AND MICHIGAN CANAL AT LOCKPORT.
(Parts Per 1,000,000.)

Serial Number	1898. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Collection.	Examination	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved		Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Dissolved.	Albuminoid Ammonia. Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
3116	Jan. 1	Jan. 3	d	m	.3	479.2	413.2	66.	61.2	49.1	95.	34.	15.5	18.5	11.6	3.04	1.12	1.92	5.57	2.37	3.2	.01	.5
3152	" 10	" 11	d	m	.5	484.4	438.	46.4	70.4	41.2	105.	33.6	22.	11.6	13.6	3.52	1.84	1.68	5.88	4.12	1.76	.02	.8
3182	" 18	" 20	d	c	.5	507.	468.8	38.2	70.8	56.	108.	34.	22.5	11.5	13.6	2.48	2.08	.4	5.4	3.8	1.6	.002	.2
3210	" 24	" 26	d	m	.5	578.8	534.8	44.	80.	56.8	105.	30.	25.	11.	13.6	3.04	1.6	1.44	5.4	3.96	1.44	.05	.7
3222	" 31	Feb. 1	d	c	.7	462.	418.4	43.6	64.	34.4	88.	31.9	21.4	10.5	8.8	3.2	2.16	1.04	5.56	3.8	1.76	.01	.55
3249	Feb. 8	" 9	d	c	.5	471.2	457.2	14.	79.6	58.8	97.	33.3	23.3	10.	12.8	3.4	2.1	1.3	5.56	4.44	1.12	.027	.6
3271	" 14	" 16	vd	vm	.5	3034.	556.	2478.	348.	32.8	88.	350.	15.3	334.7	14.4	18.8	1.12	17.68	36.	1.56	34.44	1.75	1.25
3297	" 21	" 23	d	c	.8	746.	721.2	24.8	80.	60.	110.	45.5	28.2	17.3	12.4	5.2	2.88	2.32	9.16	5.4	3.76	.015	.55
3308	" 28	Mar. 1	d	c	.6	656.8	606.4	50.4	81.6	64.4	114.	45.9	27.5	18.4	10.	5.12	3.36	1.76	8.76	5.72	3.04	.002	.45
3330	Mar. 7	" 8	d	c	.4	627.6	583.8	49.8	80.8	52.8	115.	38.3	27.3	11.	14.4	4.	2.88	1.12	6.68	5.4	1.28	.002	.45
3354	" 14	" 15	d	c	.5	413.2	374.4	38.8	68.4	28.8	46.	19.3	15.1	4.2	3.84	2.24	.88	.4	2.36	1.72	.64	.7	.7
3378	" 21	" 22	d	m	.5	558.	501.6	56.4	58.	41.2	48.	23.7	17.6	6.1	6.72	1.6	.8	.8	3.	1.56	1.44	.875	.9
3408	" 28	" 30	d	c	....	502.8	450.	52.8	66.	41.2	67.	27.9	16.8	11.1	6.88	2.24	.96	1.28	4.77	1.73	3.04	.001	.2
3423	Apr. 4	Apr. 5	d	c	.6	615.2	484.8	130.4	77.2	46.	82.	36.8	29.	7.8	7.6	3.68	1.92	1.76	6.69	2.69	4.	.015	.15
3446	" 11	" 12	d	m	.1	730.8	481.6	249.2	118.8	33.	95.	47.8	19.1	28.7	10.	4.96	1.6	3.36	7.97	2.21	5.76	.012	.4
3473	" 18	" 20	d	c	.25	452.8	395.6	57.2	64.8	53.2	73.	31.	17.	14.	9.2	2.72	1.6	1.12	5.09	2.21	2.88	.003	.5
3493	" 25	" 26	d	m	.25	495.2	414.	81.2	54.4	39.2	80.	33.6	15.5	18.	10.	2.56	1.36	1.2	4.45	2.05	2.4	.003	.65
3528	May 2	May 3	d	c	.4	458.8	394.	64.8	54.4	49.	85.	31.4	16.4	15.	12.	2.4	1.28	1.12	5.22	2.14	3.08	.004	.25
3561	" 9	" 10	d	m	.1	687.2	422.8	264.8	100.4	34.	102.	52.1	20.8	31.3	12.	3.68	1.2	2.48	6.98	1.7	5.28	.016	.3
3581	" 16	" 17	d	c	.25	515.6	437.6	78.	85.6	55.2	92.	38.2	19.8	18.4	14.	2.72	1.68	1.04	4.26	1.86	2.4	.011	.35
3611	" 23	" 24	d	m	.5	629.6	504.8	124.8	96.8	55.6	123.	45.2	23.5	22.7	18.	3.52	2.08	1.44	6.44	2.58	3.76	none	.4
3632	" 30	" 31	d	m	.1	612.8	552.	60.8	68.8	60.	138.	35.8	20.5	15.3	15.2	2.4	1.28	1.12	4.74	2.34	2.4	.005	.4
3659	June 6	June 7	d	m	.05	550.4	433.6	116.8	58.	50.4	112.	43.	19.5	23.5	16.8	2.5	1.12	1.38	4.76	1.4	3.36	.018	.4
3681	" 13	" 14	d	m	....	1501.2	613.6	887.6	879.6	38.4	138.	42.8	21.	21.8	18.4	3.04	1.6	1.44	5.88	1.72	4.16	.009	.3
3703	" 20	" 21	d	m	....	638.8	517.2	121.6	50.	11.2	114.	41.5	17.7	23.8	12.8	2.72	1.12	1.6	5.56	1.8	3.76	none	.4
3747	" 27	" 28	d	c	.5	732.4	678.4	54.	48.	42.	163.	19.8	16.7	3.1	16.	1.92	1.36	.56	3.	1.72	1.28	.013	.1
3771	July 2	July 4	d	m	.5	547.2	478.4	68.8	50.8	46.	88	38 2	19 5	18 7	12	2.24	1.44	.8	3.8	2.68	1.12	.003	5

3810	July 11	July 12	d	m	.4	548.	443.2	104.8	60.	30.8	125.	36.	17.4	18.6	14.4	1.92	1.36	.56	3.96	2.2	1.76	none	.8
3838	" 18	" 19	d	m	.1	515.2	453.6	61.6	52.	38.	125.	32.2	20.8	11.4	16.8	2.4	1.44	.96	3.6	2.48	1.12	.006	.6
3862	" 26	" 27	d	c	.2	510.8	443.6	67.2	53.2	34.	110.	29.7	17.	12.7	15.2	2.24	1.28	.96	3.76	2.32	1.44	.006	.1
3901	Aug. 1	Aug. 2	vd	vm	.6	578.4	482.	96.4	60.	32.	115.	49.5	17.5	32.	15.2	2.72	1.52	1.2	5.28	2.32	2.96	.078	.35
3930	" 8	" 9	d	m	.3	496.8	452.4	44.4	48.	42.4	118.	31.	10.5	29.5	13.6	2.08	1.12	.96	3.24	2.16	1.08	.023	.1
3956	" 14	" 16	d	m	.15	497.2	450.	47.2	53.2	35.2	125.	28.4	19.6	8.8	13.6	1.6	1.12	.48	3.12	2.	1.12	.01	.35
3987	" 22	" 24	d	c	.3	516.	470.8	45.2	48.	42.	122.	35.	14.1	20.9	13.6	3.12	1.2	1.92	3.76	1.76	2.	.003	.4
4007	" 29	" 31	d	c	.05	443.2	417.6	25.6	46.	40.	103.	26.8	12.3	14.5	10.8	2.08	1.28	.8	3.12	1.84	1.28	.03	.05
4041	Sept. 4	Sept. 7	d	c	.4	444.4	407.2	37.2	49.2	46.	113.	27.7	17.5	10.2	13.2	1.28	.96	.32	2.16	1.68	.48	none	.05
4061	" 10	" 12	d	c	.2	419.2	374.8	44.4	58.	48.	83.	26.5	13.8	12.7	10.	1.6	1.2	.4	2.8	1.84	.96	none	.3
4088	" 19	" 20	d	c	.06	701.2	671.2	30.	82.	60.	235.	28.9	16.3	12.6	13.2	2.08	1.12	.96	3.76	1.84	1.92	none	.35
4129	" 26	" 28	d	c	.4	663.6	582.4	81.2	104.	47.2	167.	43.	32.	20.	28.	2.24	1.48	.76	5.2	2.56	2.64	none	.05
4170	Oct. 3	Oct. 5	d	m	.3	640.2	552.4	86.8	80.2	38.	165.	44.4	17.	27.4	22.4	2.24	.64	1.6	4.22	1.98	2.96	none	.9
4190	" 10	" 11	d	c	.1	517.6	458.	59.6	61.2	42.	125.	33.	15.3	20.7	17.6	2.24	.96	1.28	3.76	1.41	2.36	.001	.5
4228	" 18	" 19	d	c	.2	468.	476.	22.	50.	42.	128.	32.	16.8	15.2	11.6	1.76	.88	.88	3.33	1.57	1.76	.018	.9
4254	" 24	" 26	d	c	.5	726.	626.	102.	92.	52.	173.	45.1	25.5	19.6	13.2	2.64	1.2	1.44	5.09	2.93	1.16	.004	.75
4302	" 31	Nov. 2	d	m	....	832.	700.	72.	108.	58.	186.	46.	18.8	27.2	17.2	3.2	1.2	2.	6.05	1.97	4.08	.007	.6
4329	Nov. 7	" 8	d	c	.6	662.8	586.	76.8	92.4	64.	140.	44.	17.7	26.3	13.2	3.2	1.76	1.44	6.51	2.03	4.48	.004	.75
4364	" 14	" 15	d	c	.4	596.8	538.	58.8	62.	40.	81.	29.5	14.8	14.7	6.8	2.24	1.04	1.2	4.27	1.55	2.72	.008	.2
4405	" 21	" 23	d	m	.3	662.8	602.	60.8	88.	64.	135.	36.	17.3	18.7	7.6	2.56	1.36	1.2	4.75	2.11	2.64	.014	.5
4425	" 28	" 29	d	c	.3	662.	606.	54.	96.	52.	190.	38.2	15.8	22.4	10.	3.2	1.6	1.6	5.23	2.59	2.64	.007	.75
4457	Dec. 6	Dec. 7	d	c	.3	550.8	502.8	48.	78.	50.8	145.	29.6	15.6	14.	9.2	2.08	1.24	.84	3.65	2.21	1.44	.001	.15
4478	" 12	" 13	d	c	.5	527.2	460.	67.2	100.	58.	116.	30.5	19.7	19.8	10.8	2.52	2.24	1.28	3.89	3.81	2.08	.008	.25
4506	" 19	" 21	d	c	.7	572.8	470.8	102.	106.	74.	135.	44.7	25.	19.7	7.6	3.36	1.6	1.76	5.89	2.85	3.04	.02	.25
4539	" 26	" 28	d	c	.5	612.8	560.8	52.	93.6	72.	145.	45.	26.2	18.8	12.8	3.52	2.16	1.36	5.89	3.81	2.08	.01	.25
Average Jan. 1—June 27..........						813.1	424.5	318.6	113.9	45.2	90.3	48.2	20.4	27.7	12.1	3.68	1.65	3.02	6.73	2.76	3.96	.137	.47
Average July 2—Dec. 27..........						575.1	518.7	64.4	72.5	47.9	134.3	36.3	17.8	18.3	13.4	2.05	1.82	.72	4.31	22.2	2.06	.01	.36
Average Jan. 1—Dec. 26..........						694.1	503.6	190.5	93.2	48.5	116.8	42.2	19.1	13.	12.7	2.86	1.48	1.38	5.54	24.9	3.02	.072	.41

Odor uniformly gassy, Color upon ignition uniformly brown.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS AND MICHIGAN CANAL AT LOCKPORT.

(Parts per 1,000,000.)

Serial Number.	1899. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
									Total.	Dissolved						Total.	Dissolved	Suspended					
4563	Jan. 2	Jan. 4	d	c	.6	584.8	548.	36.8	98.	74.	140.	46.5	27.	19.5	12.4	3.84	2.64	1.2	6.85	4.77	2.08	.005	.2
4599	" 9	" 11	d	c	.6	851.6	842.	9.6	114.8	100.	275.	42.3	24.7	17.6	12.8	4.16	2.4	1.76	8.77	4.77	4.	.01	.2
4625	" 18	" 20	d	m	.5	610.8	573.2	37.6	112.	70.	170.	44.4	22.	22.4	12.	2.56	1.92	.64	5.25	2.37	2.88	.007	.2
4645	" 24	" 25	d	c	.5	413.2	392.	21.2	76.	64.	77.	36.3	21.5	14.8	11.2	2.72	1.76	.96	5.25	3.01	2.24	.024	.25
4650	" 30	" 31	d	c	.4	580.8	541.2	39.6	108.	76.	118.	43.2	26.5	16.7	12.4	3.84	2.72	1.12	6.69	4.77	1.92	.002	.25
4680	Feb. 6	Feb. 7	d	m	.3	433.2	392.8	40.4	88.	80.	90.	39.5	24.2	15.3	10.8	3.52	2.16	1.36	5.54	3.7	1.84	.007	.2
4724	" 20	" 21	d	m	.3	536.	490.8	45.2	84.	61.	127.	46.	24.3	21.7	12.4	3.2	1.92	1.28	6.02	3.46	2.56	none	.25
4752	" 27	" 28	d	m	.6	832.8	702.	130.8	120.	76.	265.	49.	26.5	22.5	10.	3.68	2.24	1.44	6.66	4.	2.66	.003	.1
4777	Mar. 6	Mar. 7	vd	vm	.5	770.	726.	44.	118.	104.	254.	46.5	25.	21.5	7.2	4.	2.	2.	7.14	3.7	3.44	.006	.2
4804	" 13	" 14	d	m	.5	808.8	648.	160.8	120.	74.	100.	44.3	25.3	19.	14.	5.04	2.56	2.48	10.	5.14	4.86	.006	.25
4830	" 20	" 22	d	m	.4	696.8	612.	84.8	114.	72.	182.	39.8	23.5	16.3	8.	2.76	1.2	1.56	4.67	2.51	2.16	.008	.15
4861	" 27	" 29	d	m	.5	582.8	506.	76.8	124.	76.	192.	45.	28.4	16.6	9.6	3.84	2.	1.84	7.07	4.67	2.4	.017	.1
4887	Apr. 3	Apr. 4	d	c	.4	574.8	472.	102.8	110.	76.	115.	45.	26.	19.	9.2	3.68	1.92	1.76	7.30	3.4	3.90	.016	.1
4912	" 10	" 11	d	c	.1	802.	714.	88.	120.	98.	240.	43.	27.5	15.5	13.2	3.04	1.44	1.6	6.43	3.39	3.04	.002	.15
4937	" 17	" 18	d	c	.5	591.2	534.	57.2	100.	88.	108.	41.5	24.	17.5	11.2	2.72	1.84	.88	4.99	3.39	1.6	.002	.15
4963	" 24	" 26	d	c	.1	609.2	551.6	57.6	102.	60.	121.	41.	24.5	16.5	14.	3.2	1.6	1.6	5.05	2.97	2.08	.002	.2
5072	May 22	May 23	d	m	.3	633.2	558.	75.2	73.6	56.	107.	48.	27.2	20.8	16.2	3.68	1.04	2.64	5.85	1.85	4.	none	.25
5118	" 29	" 31	d	c	.2	826.	688.	138.	74.8	60.	187.5	38.5	18.6	19.9	27.4	3.84	1.06	2.78	6.33	2.09	4.24	.002	.28
5158	June 5	June 6	d	c	.7	740.2	660.	80.2	60.2	48.8	133.	43.3	20.	23.3	9.2	2.95	1.24	1.71	4.57	2.89	1.68	.003	.2
5204	" 12	" 14	d	c	.5	633.2	508.4	124.8	92.8	48.4	100.5	50.5	27.1	23.4	16.	2.95	1.18	1.77	5.96	2.2	3.76	.001	.32
5248	" 19	" 21	vd	vm	.6	675.6	574.8	100.8	84.8	74.	125.	58.	23.5	34.5	20.8	2.88	1.36	1.52	5.08	2.52	2.56	none	.32
5291	" 26	" 27	d	m	.25	590.8	484.	106.8	55.2	30.4	108.	47.	20.5	26.5	15.2	2.64	1.18	1.45	5.08	2.44	2.64	"	.12
5331	July 3	July 4	d	m	.5	562.4	447.2	115.2	71.2	50.	109.	41.4	21.7	19.7	14.6	2.8	.8	2.	5.56	2.68	2.88	"	.2
5387	" 10	" 11	d	c	.6	534.	480.4	53.6	63.2	48.	104.	34.5	15.9	18.6	12.8	2.24	.73	1.51	4.76	1.49	3.264	.001	.24
5434	" 17	" 18	d	c	.9	582.8	511.2	71.6	55.2	44.8	123.	22.6	16.4	6.2	6.72	1.024	.57	.44	2.04	1.27	.768	.45	.24

5483	July 24	July 25	d	m	.7	592.4	510.4	89.	101.6	70.	102.	40.3	21.7	18.6	13.6	2.4	1.04	1.36	4.36	3.	1.36	none	.2
5532	" 31	Aug. 1	vd	c	.5	525.2	451.6	73.6	96.4	78.8	98.	41.	17.	24.	11.6	2.24	1.04	1.2	4.76	1.8	2.96	.006	.2
5577	Aug. 7	" 8	vd	vm	.5	546.8	482.4	66.4	79.3	49.6	130.5	43.4	23.	20.4	20.	2.16	.96	1.2	4.44	2.04	7.4	none	.2
5628	" 14	" 15	d	m	.5	532.8	468.4	64.4	92.	72.4	118.	43.3	23.5	19.8	16.	2.16	.786	1.42	5.76	1.48	4.28	"	.16
5676	" 21	" 22	d	m	.6	504.	439.6	64.4	74.8	51.2	106.	36.3	24.3	12.	15.2	2.56	1.47	1.08	5.24	3.32	1.92	.001	.28
5731	" 28	" 29	d	c	.5	553.6	484.	69.6	71.6	40.	118.	35.4	25.2	10.2	18.	2.4	1.44	.96	4.12	3.	1.12	none	.28
5790	Sept. 4	Sept. 5	d	m	.8	488.	423.6	64.4	52.8	30.4	103.	32.2	17.8	14.4	15.	2.24	.608	1.63	4.76	1.94	2.81	.004	.16
5837	" 11	" 12	d	m	.6	558.	409.4	67.6	81.6	63.6	129.5	36.9	18.8	18.1	17.6	2.32	.704	1.61	4.44	1.24	3.2	none	.16
5882	" 18	" 19	d	m	.5	501.6	441.2	60.4	70.4	44.4	110.	33.2	17.4	15.8	15.4	2.24	.72	1.52	4.28	2.44	1.84	.002	.2
5936	" 25	" 26	d	m	.7	562.	506.4	75.6	68.2	40.	139.	45.6	23.6	22.	18.	2.24	1.44	.8	4.28	2.5	1.76	none	.24
5984	Oct. 2	Oct. 3	d	m	.5	526.	451.6	74.4	61.6	38.4	114.	41.1	21.4	19.7	14.	2.4	1.44	.96	4.74	2.08	2.08	"	.16
6079	" 16	" 17	d	m	.2	480.4	415.2	65.2	52.8	20.4	116.	23.5	11.8	11.7	14.8	2.16	.96	1.2	4.68	2.04	2.64	"	.2
6146	" 23	" 24	d	m	.7	489.2	431.2	58.	36.8	15.6	118.	31.3	16.3	15.	14.8	2.8	.67	2.12	4.68	1.86	2.81	"	.28
6193	" 30	" 31	d	m	.7	532.8	468.	64.8	56.4	30.8	116.5	26.3	12.3	14.	14.8	2.96	.8	2.16	5.48	1.4	4.08	.003	.4
6243	Nov. 6	Nov. 7	d	m	.5	546.	498.4	47.6	45.6	23.2	191.	34.7	14.8	19.9	14.8	2.8	1.28	1.52	5.48	2.12	3.36	none	.28
6279	" 13	" 14	d	c	.4	534.	476.4	57.6	50.2	28.4	lost	28.9	8.9	20.	13.6	2.16	.51	1.64	4.56	1.32	3.24	"	.08
6338	" 20	" 21	d	m	.6	613.6	498.8	114.8	67.2	24.8	125.	35.	12.	23.	16.	3.36	1.92	1.44	6.92	3.4	3.52	"	.2
6400	" 27	" 28	d	m	.3	529.6	460.8	68.8	55.2	22.	123.	35.5	....	....	17.6	2.56	1.28	1.28	4.52	2.6	1.92	.001	.08
6446	Dec. 4	Dec. 6	d	m	.4	531.2	451.2	80.	64.4	37.6	111.	27.3	18.7	8.6	15.2	2.4	1.44	.96	5.	2.34	2.65	.001	.16
6543	" 18	" 20	d	c	.04	553.2	483.6	69.6	81.2	40.8	111.5	27.3	14.6	12.7	14.4	4.32	2.08	2.24	6.76	3.16	3.6	.002	.16
6583	" 26	" " 27	d	m	.6	633.6	562.4	71.2	69.2	44.	167.5	36.6	23.	13.6	20.	4.	2.24	1.76	7.72	5.48	2.24	.005	.2
Average Jan. 2—June 26..........						653.9	578.1	75.8	97.7	70.6	158.3	44.8	24.4	20.4	19.4	3.39	1.79	1.60	6.21	3.36	2.84	.0056	.20
Average July 3—Dec. 26..........						543.1	472.2	70.8	67.6	41.9	117.9	34.7	18.2	16.4	15.2	2.54	1.19	1.42	4.97	2.35	2.61	.0196	.23
Average Jan. 2—Dec. 26..........						596.1	522.9	73.2	82.	55.6	135.2	39.5	21.2	18.4	18.9	2.95	1.44	1.51	5.56	2.84	2.72	.013	.21

Odor uniformly gassy, Color upon ignition uniformly brown.

CHEMICAL ANALYSIS OF WATER FROM THE ILLINOIS AND MICHIGAN CANAL AT LOCKPORT.

(Parts per 1,000,000.)

Serial Number	1900. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
									Total.	Dissolved						Total.	Dissolved	Suspended					
6608	Jan. 2	Jan. 3	d	c	.5	513.6	444.4	69.2	59.6	39.2	107.	34.3	22.8	11.5	10.4	3.36	2.08	1.28	8.52	4.84	3.68	.002	.64
6643	" 8	" 9	d	c	.4	440.4	376.4	64.	43.6	28.8	90.	21.1	14.8	6.3	10.4	2.48	1.04	1.44	4.84	2.44	2.4	.001	.24
6688	" 15	" 16	d	c	.5	531.6	468.	67.6	60.4	21.6	134.	24.6	17.2	7.4	12.8	3.36	2.16	1.2	6.4	3.36	3.04	.001	.2
6738	" 22	" 24	d	c	.5	458.	439.	19.	42.8	31.6	108.	20.6	11.6	9.	9.6	2.24	1.04	1.2	5.28	1.68	3.6	.015	.2
6780	" 29	" 31	d	c	.25	545.2	230.	315.2	55.6	25.6	151.	16.3	13.1	3.2	13.2	2.56	1.76	.8	4.8	2.24	2.56	.009	.2
6841	Feb. 5	Feb. 6	d	c	.6	372.	342.4	29.6	41.2	24.	82.75	18.9	10.6	8.3	6.4	1.92	.46	1.45	4.16	.99	3.16	.017	.16
7022	Mar 5	Mar. 6	d	c	.4	499.2	431.6	67.6	44.4	28.	113.	21.7	11.9	9.8	10.4	3.36	1.76	1.6	7.04	4.	3.04	.014	.36
7069	" 12	" 13	d	c	.3	369.2	255.6	113.6	49.8	38.	58.7	22.	9.4	12.6	15.76	1.84	.04	1.2	4.64	1.18	3.45	.075	.84
7117	" 19	" 20	d	c	.4	434.	384.4	49.6	33.2	32.8	78.3	21.9	11.8	10.1	6.4	2.4	1.21	1.18	4.76	2.52	2.24	.15	.72
7165	" 26	" 27	d	c	.3	399.6	373.	27.6	39.2	32.4	73.2	18.8	11.1	7.7	7.2	1.92	1.02	.89	4.44	2.6	1.84	.17	.4
7217	Apr. 2	Apr. 3	d	c	.5	526.	497.2	28.8	35.2	24.	130.5	22.5	11.3	11.2	11.2	2.88	1.28	1.6	5.24	2.52	2.72	.008	.2
7272	" 9	" 10	d	l	.5	643.6	632.8	10.8	50.	45.2	175.	22.4	14.9	7.5	13.6	2.64	1.68	.96	5.24	3.32	1.92	.003	.12
7328	" 16	" 17	d	c	.4	509.6	482.	27.6	24.8	18.4	117.	18.	11.2	6.8	10.8	1.6	.7	.89	3.48	1.36	2.11	.004	.24
7398	" 23	" 24	d	m	.04	571.6	522.8	488.	38.	32.8	119.8	21.4	10.7	10.7	14.4	2.16	.69	1.47	3.48	1.72	1.76	.004	.2
7438	May 1	May 1	d	c	.15	380.4	271.3	89.2	32.	19.2	53.	18.7	7.9	10.8	5.92	1.35	.43	.92	3.14	1.14	2.	.003	.2
7480	" 8	" 9	d	c	.3	451.2	372.	85.2	28.4	28.	101.	18.8	9.3	9.5	11.2	1.36	.7	.65	2.98	1.14	1.84	.008	.24
7533	" 15	" 16	d	c	....	425.2	397.6	27.6	36.4	21.2	88.	16.6	9.1	7.5	7.2	2.24	.64	1.6	3.14	.74	2.4	.004	.12
7587	" 22	" 23			.1	462.4	448.	14.4	29.6	26.4	120.	16.5	11.2	5.3	15.2	1.47	.53	.94	2.18	.8	1.38	.003	.08
7623	" 29	" 30	d	c	.2	505.2	496.8	8.4	37.2	35.6	152.5	20.6	11.4	9.2	21.48	1.28	.73	.54	2.18	1.22	.96	.02	.4
7654	June 4	June 5	d	c	.5	579.2	539.6	39.6	59.	39.6	105.5	17.4	10.8	6.6	19.2	1.44	.45	.99	2.9	1.86	1.04	none	.24
7703	" 11	" 13	d	c	.3	467.2	440.8	26.4	44.4	29.2	107.	17.2	8.2	9.	12.4	1.36	.45	.91	2.74	1.6	1.14	.011	.2
7739	" 18	" 19	d	c	.2	666.8	640.4	26.4	45.2	39.6	217.	23.1	15.7	7.4	21.6	1.52	1.05	.46	2.74	2.1	.64	none	.18
7781	" 26	" 27	d	m.	.3	722.8	659.2	63.6	56.4	37.6	227.	26.9	12.7	14.2	22.4	1.41	1.15	.25	3.88	1.54	2.34	.002	.2
7822	July 3	July 4	d	l	.01	363.6	319.2	44.4	29.6	17.6	75.	13.2	7.8	5.4	6.4	.88	.24	.64	1:46	.74	.72	.008	18
7893	" 9	" 11	d	l	.2	500.	442.8	57.2	38.	20.	120.5	16.8	8.3	8.5	8.8	.57	.49	.08	.97	.64	.32	.004	.04
7958	" 16	" 17	d	l	.03	437.6	406.4	31.2	37.6	28.4	117.	16.2	7.2	9.	8.8	.88	.35	.52	1.28	.61	.66	tr'ce	.18

8008	July 23	July 24	d	l	.02	418.8	392.	26.8	24.4	24.	117.5	10.7	7.8	2.9	12.	.96	.29	.07	1.8	.61	1.16	.001	.2
8067	" 30	" 31	d	l	.02	582.4	570.4	12.	46.	46.	182.	16.7	14.8	1.9	13.6	1.25	.45	.8	2.52	1.06	1.44	tr'ce	.24
8113	Aug. 6	Aug. 8	d	l	.02	609.2	579.8	30.4	45.6	45.2	193.	21.	8.4	12.6	19.2	1.36	.48	.88	3.32	1.11	2.2	.001	.12
8173	" 13	" 15	d	l	.03	408.	583.6	25.4	44.4	30.4	116.	17.1	6.5	10.5	12.	1.18	.21	.97	1.88	.44	1.44	trc'e	.4
8233	" 20	" 21	d	l	.02	595.2	518.6	71.6	45.2	23.6	188.	27.1	10.6	16.5	19.2	1.68	.33	1.34	3.32	.57	2.74	"	.2
8307	" 27	" 28	d	l	.02	551.2	529.6	21.6	35.6	20.	166.5	18.7	6.8	11.9	9.2	1.09	.37	.72	2.04	.54	1.5	"	.08
8368	Sept. 4	Sept. 5	d	l	.02	595.6	558.4	37.2	38.8	22.8	184.	16.7	7.	9.7	21.6	1.28	.33	84	2.46	.41	2.05	none	.28
8436	" 10	" 11	d	o	.1	565.6	516.8	48.8	58.	31.6	170.	25.3	7.4	17.9	19.2	1.44	.43	1.	2.86	.72	2.14	.001	.16
8491	" 17	" 19	d	c	.2	724.8	281.6	443.2	49.2	45.6	256.5	23.8	11.7	12.1	24.8	1.6	.49	1.1	2.14	.56	1.58	.001	.2
8546	" 24	" 27	vd	vm	...	838.6	605.6	228.	76.	27.2	212.5	41.2	18.1	23.1	20.	2.96	.35	2.6	6.04	.93	5.11	none	.28
8594	Oct. 1	Oct. 2	d	l	.4	613.2	525.2	88.	47.2	18.4	180.	28.3	18.5	14.8	.37	1.76	.72	1.04	2.7	1.1	1.6	"	.08
8673	" 15	" 17	s	l	.01	465.2	421.6	43.6	34.8	27.6	131.	19.	14.2	4.8	.32	1.28	.67	.6	2.75	1.30	1.36	.008	.232
8699	" 23	" 25	d	l	.02	526.8	472.	54.8	36.4	30.8	150.5	22.3	13.2	9.1	19.8	.69	.53	.06	3.07	.48	2.59	.004	.156
8725	" 29	" 31	d	l	...	425.2	380.8	44.4	36.	22.8	112.	20.2	10.7	9.5	14.4	1.57	.51	1.06	2.91	1.23	1.68	.001	.32
8761	Nov. 5	Nov. 10	d	l	.1	411.6	392.	19.6	34.	30.	110.5	16.3	8.1	8.2	12.	.62	.33	.29	2.67	1.47	1.2	.004	.276
8774	" 12	" 13	d	l	.06	511.6	452.2	59.4	34.8	21.6	145.	20.4	11.3	9.1	.3	1.12	.67	.4	3.31	1.33	1.98	.004	1.506
8791	" 19	" 20	d	c	.1	546.	458.4	87.6	35.6	21.6	144.	22.2	13.2	9.	15.2	2.48	.7	1.77	4.75	1.29	3.45	.004	.316
8831	" 26	" 27	d	c	.2	579.2	468.4	110.8	45.6	29.2	135.	23.4	12.3	11.1	18.4	2.24	.49	1.74	3.95	1.23	2.72	.001	.24
8889	Dec. 11	Dec. 12	d	l	.25	449.2	439.2	10.	24.	20.4	121.5	18.1	15.	3.1	.32	1.28	.89	.33	2.91	1.79	1.12	.004	.116
8907	" 18	" 21	d	l	...	515.6	486.4	29.2	54.	42.	149.5	17.8	14.9	2.9	17.6	2.16	1.57	.59	4.27	2.75	1.52	.002	.078
8925	" 26	" 27	d	m	.02	827.6	409.6	418.	78.	30.4	79.5	37.2	13.4	23.8	9.6	3.04	.64	2.4	6.67	1.	5.66	.036	.444
Average Jan. 2—June 26						498.4	441.	57.3	42.2	30.3	120.4	20.8	12.1	8.7	12.51	2.09	1.02	1.06	4.97.	2.04	2.23	.022	.34
Average July 3—Dec. 26						544.	458.5	85.4	42.7	28.3	149.1	21.2	10.9	10.3	12.63	1.42	.52	.9	3.	1.	2.	.023	.254
Average Jan. 2—Dec. 26						521.7	450.	71.7	42.5	29.3	135.	21.	11.5	9.5	12.60	1.77	.77	1.	3.02	1.51	2.11	.023	.289

The odor was uniformly gassy or musty. The color upon ignition was brown.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS AND MICHIGAN CANAL AT LOCKPORT.

(Parts per 1,000,000.)

Serial Number.	1901 Date of Collection.	1901 Date of Examination	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Ammonia. Total.	Nitrogen as Ammonia. Albuminoid Ammonia. Dissolved.	Nitrogen as Ammonia. Albuminoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspeuced	Nitrogen as Nitrites.	Nitrogen as Nitrates.
8966	Jan. 22	Jan. 23	d	1	......	514.4	494.4	20.	34.8	30.	93.5	18.5	18.3	.2	14.4	2.08	1.376	.704	3.584	2.592	.992	.005	.015
9008	Feb. 21	Feb. 21	d	v 1	.4*.4	464.8	462.8	2.	45.2	28.8	56.	14.8	14.	.8	6.	.704	.704	.....	1.552	1.472	.08	.01	.15
9073	Apr. 14	Apr. 17	s	1	.2*.2	512.4	498.	14.4	57.5	50.8	71.	13.1	12.3	.8	13.6	.576	.48	.096	1.424	1.104	.32	.055	.465
9110	May 12	May 15	d	1	.3	504.8	479.6	25.2	46.8	37.2	143.	21.2	15.9	5.3	15.6	.752	.48	.272	2.752	1.52	1.232	none	.12
9168	July 8	July 12	d	1	.2	544.4	515.2	29.2	50.	34.	137.	16.5	12.7	3.8	14.4	1.024	.576	.448	1.744	1.104	.64	"	.04
9200	" 22	" 24	d	1	.08	508.8	486.	22.8	36.	29.2	158.	15.1	14.	1.1	17.8	.992	.48	.512	1.952	.752	1.2	"	.12
9222	" 29	" 30	d	c	.08	458.4	398.8	59.6	35.2	28.8	117.	16.1	15.6	.5	14.4	.72	.352	.368	1.104	.944	.16	.010	.221
9272	Aug. 5	Aug. 6	d	1	.4	601.6	591.2	10.4	31.2	20.8	207.	18.6	15.6	3.	20.8	1. 8	.72	.56	3.552	1.428	2.124	none	.12
9291	" 12	" 13	d	c	.2	380.8	379.2	1.6	27.2	27.2	111.5	13.3	11.6	1.7	13.6	.576	.352	.224	1.424	.704	.72	"	.12
9310	" 19	" 20	d	1	.2	533.2	496.4	36.8	24.	16.	178.	17.5	14.9	2.6	18.4	1.2	.576	.624	2.432	1.112	1.32	"	.08
9322	" 26	" 27	d	c	.3	607.6	587.2	20.4	72.	38.8	206.	18.2	15.2	3.	20.4	1.312	.656	.656	2.352	1.264	1.088	"	.16
9347	Sept. 2	Sept. 3	d	1	.2	482.8	477.2	5.6	34.8	23.6	100.5	15.9	12.9	3.	18.4	1.024	.688	.336	1.952	1.456	.496	"	.08
9480	" 9	Oct. 15	d	c	.2	563.6	532.8	30.4	30.8	18.4	210.	17.8	9.6	8.2	32.	1.6	.56	1.04	......	......	......	.012	.068
9381	" 16	Sept. 17	d	c	.3	652.4	582.4	70.	50.4	35.6	193.	26.3	12.9	13.4	16.	1.28	.992	.288	......	......	......	none	.08
9397	" 23	" 24	d	c	.2	649.2	616.4	22.8	40.	29.2	207.5	23.8	14.7	9.1	16.4	1.152	.64	.512	......	......	......	"	.16
9421	" 30	Oct. 1	d	c	.2	602.	550.	52.	34.4	4.	191.	19.9	16.2	3.7	16.8	1.44	1.056	.384	......	......	......	"	.24
9444	Oct. 7	" 8	v d	c	....	644.	603.6	40.4	31.6	25.2	212.	27.3	15.4	11.9	31.2	1.28	.432	.848	......	......	......	"	.16

9478	Oct.	14	Oct.	15		d	c	.2	628.8	588.8	40.	41.6	27.6	220.	25.1	16.5	8.6	35.2	1.6	1.344	.256	....	....	....	.006	.224
9550	"	21	"	22	v	d	m	.4	694.8	646.4	48.4	60.	25.6	246.	26.2	9	17.2	28.8	1.68	.8	.88	....	....	....	none	.24
9590	"	28	"	28		d	c	.2	676.4	659.6	16.8	46.	37.2	260.	25.8	15.8	10.	22.8	1.6	.8	.8	....	....	....	"	.24
9661	Nov.	4	Nov.	5		d	c	.3	459.2	442.	17.2	29.2	24.	165.	12.4	5.5	3.9	20.	1.04	.896	.144	....	....	....	.008	.077
9722	"	11	"	12		d	l	......	470.	464.	.6	32.	28.8	154.	16.9	11.7	5.2	16.8	1.28	.896	.384	....	....	....	none	.16
9806	"	18	"	19		d	l	.3	724.4	627.6	96.8	42.	32.	240.	23.9	17.7	6.2	14.	2.08	1.68	.4	....	....	....	"	.16
9878	"	25	"	26		d	c	......	616.8	563.6	53.2	62.8	26.	210.	27.6	13.3	14.3	14.4	1.76	.336	1.424	....	....	....	"	.16
9963	Dec.	2	Dec.	3		d	l	.05	423.6	393.6	30.	22.8	18.8	120.	24.2	7.4	16.8	17.6	1.056	.416	.64	....	....	....	"	.08
10031	"	9	"	10		d	l	.05	264.4	260.	4.4	22.	21.6	60.	11.7	6.7	5.	7.2	.48	.32	.16	....	....	....	.015	.205
10090	"	16	"	17		d	l	.02	310.	293.2	16.8	40.	23.2	54.	8.9	7.	1.9	7.04	.64	.32	.32	....	....	....	.03	.53
10134	"	23	"	24	v	d	m	.01	746.4	274.4	472.	88.	22.	43.	48.5	12.1	36.4	6.56	3.2	.288	2.912	....	....	....	none	.4
10153	"	30	"	31		d	l	.05*.1	283.2	282.4	.8	36.	.8	50.	11.	10.2	.8	4.8	.4	.288	.112	....	....	....	.021	.219
Average Jan. 22—May 12..............									498.6	484.2	14.4	53.5	30.7	90.8	16.9	15.1	1.8	18.4	1.028	.76	.268	2.828	1.672	.656	.023	.292
Average July 8—Dec. 30..............									542.7	497.1	45.6	30.8	25.8	161.4	20.1	12.7	7.4	21.	1.256	.650	.507	1.997	1.172	.825	.018	.171
Average Jan. 22--Dec. 30..............									525.1	491.9	33.2	55.3	30.1	133.2	18.8	13.7	5.1	17.6	1.165	.699	.466	2.186	1.457	.729	.013	.209

*Not Filtered.

The odor was uniformly gassy or musty. The color upon ignition was brown.

CHEMICAL EXAMINATION OF WATER FROM THE CHICAGO SANITARY CANAL AT LOCKPORT.

(Parts per 1,000,000.)

Serial Number.	1900		Appearance			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of								Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
7895	July 9	July 10	d	1	.2	272.4	255.2	17.2	44.4	32.8	24.	9.5	7.5	2.	2.08	.68	.176	.504	1.092	.42	.672	.004	.04
7923	" 11	" 14	vs	1	.01	192.8	178.	14.8	15.6	14.4	12.	5.	4.3	.7	1.36	.256	.176	.08	.76	.42	.34	.034	.12
7939	" 16	" 17	d	1	.02	210.4	190.	20.4	22.4	11.6	16.	7.4	4.3	3.1	1.52	.368	.272	.096	.6	.452	.148	.001	.9
7981	" 18	" 19	s	1	.02	176.8	162.	14.8	17.2	14.	17.	5.2	4.2	1.	1.	.324	.16	.164	.....	.....	.....	.005	.16
7993	" 20	" 21	d	1	.02	176.8	160.4	16.4	17.6	11.6	14.	5.4	4.	1.4	1.04	.208	.176	.032	.68	.54	.14	none	.04
8007	" 23	" 24	d	1	.01	190.	164.4	25.6	26.8	18.8	12.	5.7	5.3	.4	1.32	.272	.144	.128	.68	.42	.26	.001	.12
8023	" 25	" 26	d	1	.04	164.4	156.	8.4	19.6	19.6	10.	5.5	4.8	.7	1.36	.272	.112	.16	.68	.392	.288	.007	.9
8045	" 27	" 28	d	m	.01	237.2	208.	49.2	40.4	30.4	19.	7.5	6.1	1.4	2.44	.368	.208	.16	.8	.6	.2	.001	.16
8058	" 30	" 31	d	1	.01	197.2	176.8	20.4	19.6	18.8	15.	5.6	5.4	.2	1.2	.48	.176	.304	1.16	.52	.64	†	.08
8082	Aug. 1	Aug. 2	d	1	.01	197.2	157.6	39.6	35.2	19.2	13.	5.8	5.5	.3	1.6	.288	.192	.096	.76	.44	.32	†	.28
8114	" 6	" 8	d	1	.01	198.	180.8	17.2	36.8	30.	16.	7.5	4.9	2.6	1.28	.352	.256	.096	.84	.712	.128	.001	.52
8136	" 8	" 9	d	1	.01	192.8	174.	18.8	37.6	28.4	14.	6.1	5.3	.8	1.44	.448	.192	.256	1.12	.68	.44	.001	.16
8155	" 10	" 13	d	1	.01	171.2	166.8	4.4	32.4	29.2	16.	6.	4.2	1.8	1.92	.304	.176	.128	.76	.284	.476	†	.2
8174	" 13	" 15	d	1	.01	154.4	154.	.4	29.2	22.4	14.	4.6	3.8	.8	1.36	.272	.176	.096	1.	.504	.496	.001	.28
8192	" 15	" 16	d	1	.01	178.4	165.2	13.2	30.8	26.4	13.	11.	4.4	6.6	2.88	.992	.144	.848	2.52	.33	.216	†	.9
8216	" 17	" 18	d	1	.01	218.	188.8	29.2	41.2	31.6	20.	8.	5.	3.	2.16	.368	.16	.208	.76	.348	.412	.001	.36
8232	" 20	" 21	d	1	.02	218.8	209.2	9.6	32.8	22.	25.	14.9	5.1	9.8	2.	.688	.176	.512	1.4	.284	1.116	†	.2
8264	" 22	" 23	d	1	.....	200.8	174.8	26.	17.8	10.4	16.	7.1	3.4	3.7	1.84	.384	.112	.272	.94	.22	.72	†	.16
8281	" 24	" 25	d	1	.02	230.	205.2	24.8	30.8	17.6	24.	7.7	4.	3.7	2.4	.368	.112	.256	1.	.3	.7	.004	.16
8306	" 27	" 28	d	1	.02	221.6	217.6	4.	20.4	18.8	22.	11.2	4.5	6.7	2.08	.432	.08	.352	1.16	.296	.864	.001	.16
8335	" 29	" 31	d	1	.02	202.4	180.4	22.	19.2	16.4	15.	5.7	4.	1.7	2.08	.32	.16	.16	.76	.3	.46	.002	.24
8349	" 31	Sept. 3	s	1	.02	212.4	169.2	51.2	14.8	12.	15.	7.	3.9	3.1	1.888	.4	.208	.192	.6	.28	.32	.01	.16
8367	Sept. 3	" 5	s	1	.4	173.2	166.8	6.4	12.	10.4	12.	6.	3.	3.	.112	.208	.128	.08	.62	.22	.4	.007	.16
8388	" 5	" 6	s	1	.01*.04	179.2	173.6	5.6	17.6	13.2	14.	6.9	3.	3.9	1.28	.384	.16	.224	.62	.328	.292	.009	.24

8410	Sept. 7	Sept. 8	d	o	.1	203.4	192.8	13.6	29.4	13.2	17.	17.4	5.6	11.8	1.2	.64	.208	.432	1.4	.....	.....	.004	.2
8435	" 10	" 11	d	i	.04*.05	196.	180.4	17.6	19.2	17.2	19.	9.5	4.1	5.4	2.08	.544	.176	.368	1.212	.384	.088	.003	.16
8455	" 12	" 13	d	o	.1	200.	197.2	2.8	18.	16.8	19.	10.2	4.6	5.6	2.52	.652	.124	.528	3.1	.....	.....	.001	.16
8472	" 14	" 15	d	l	.3	216.4	213.2	1.2	22.4	22.	24.	10.6	8.4	2.9	2.8	.688	.208	.48	.62	.336	.224	none	.28
8490	" 17	" 19	d	l	.02	176.8	146.	30.8	14.8	13.2	13.	6.1	4.4	1.7	1.36	.32	.096	.224	.652	.32	.331	.017	.4
8522	" 21	" 22	s	l	.03*.02	199.2	194.4	4.8	19.6	18.4	17.	7.6	5.9	1.7	.192	.336	.124	.228	.6	.4	.2	.001	.8
8547	" 24	" 27	s	l	.02	168.4	166.8	1.6	21.	18.	10.	3.9	3.	.2	1.52	.141	.036	.048	.636	.384	.259	.007	.24
8565	" 26	" 28	d	l	.03*.03	200.8	177.2	23.6	24.8	20.	15.	6.3	3.9	2.4	1.76	.224	.096	.128	.572	.336	.236	.001	.28
8574	" 28	Oct. 1	d	l	.05	184.8	170.	14.8	18.4	13.6	12.	6.	3.8	2.2	.62	.48	.128	.352	.54	.352	.188	.002	.28
8593	Oct. 1	" 2	s	l	.05*.05	188.8	173.6	13.2	16.4	15.2	14.	6.5	5.6	.9	1.12	.544	.224	.32	.928	.496	.433	.001	.04
8615	" 3	" 4	s	l	.03*.05	168.8	164.8	4.	31.2	23.	11.	5.3	4.5	.8	1.12	.304	.272	.032	.592	.496	.096	.001	.16
8627	" 5	" 6	s	l	.01*.03	178.8	163.6	15.9	22.4	18.4	11.	5.5	4.	1.5	1.32	.24	.....	.....	.592	.272	.32	.001	.24
8674	" 15	" 17	s	l	.01*.02	175.6	160.6	6.	23.6	20.4	13.	8.2	6.5	1.7	.064	.008	.368	.24	1.28	.928	.252	.01	.23
8700	" 23	" 25	s	l	.02*.02	173.2	168.8	4.4	19.6	17.6	10.	5.7	5.	.7	.128	.208	.192	.016	.672	.56	.119	.063	.257
8724	" 29	" 31	s	l	.01*.02	170.4	151.6	18.8	15.6	12.8	9.	4.7	4.3	.4	1.36	.272	.096	.176	.672	.56	.112	.001	.24
8762	Nov. 5	Nov. 10	s	v	.02*.02	160.2	168.4	.8	18.8	17.2	10.	5.3	4.6	.7	1.36	.256	.144	.112	.608	.496	.119	.01	.27
8773	" 12	" 13	d	l	.01	177.2	157.3	20.	10.4	10.	10.	5.5	4.4	1.1	1.394	.32	.272	.048	.816	.624	.192	.007	.193
8792	" 19	" 20	d	l	.02	194.8	160.4	34.4	18.	15.6	10.	6.3	4.9	1.4	.96	.48	.24	.48	1.552	.704	.848	.018	.349
8830	" 26	" 27	d	l	.03	188.8	167.6	21.2	18.	16.8	10.5	5.3	4.4	.9	1.056	.368	.192	.176	.976	.655	.32	.036	.204
8868	Dec. 11	Dec. 12	d	l	.1	182.8	166.4	16.4	13.6	12.4	9.	6.9	5.7	1.2	1.024	.272	.128	.144	.848	.384	.464	.019	.141
8906	" 18	" 21	d	l	....	175.6	164.	11.6	22.4	20.	9.	6.6	6.2	.4	.96	.333	.144	.192	.944	.416	.498	.013	.107
8924	" 26	" 27	d	l	.02	198.	177.2	20.8	26.4	20.8	16.	8.	6.7	1.3	1.49	.448	.32	.128	1.264	.528	.736	.016	.384
Average July 9—Dec. 26, ...						206.4	189.	17.4	25.4	17.5	15.6	7.2	5.1	2.1	1.500	.421	.183	.238	.985	.447	.543	.006	.258

* n. f. The water was invariably possessed of the characteristic musty odor of diluted sewage. The residue upon ignition was always either dark gray or brown.

CHEMICAL EXAMINATION OF WATER FROM THE SANITARY CANAL AT LOCKPORT.

(Parts per 1,000,000.)

Serial Number.	1901		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
	Collection.	Examination							Total.	Dissolved.						Total.	Dissolved.	Suspended					
8965	Jan. 22	Jan. 23	d	l	.05	201.2	191.2	10.	12.	12.	17.	7.8	5.5	2.3	2.	.416	.24	.176	.944	.496	.448	.012	.208
9034	Mar. 15	Mar. 18	d	c	.3	233.6	197.2	36.4	24.4	22.8	16.	13.6	9.7	3.9	1.168	.656	.304	.352	1.952	.88	1.072	.038	.362
9072	Apr. 14	Apr. 17	d	l	.01	204.4	189.2	15.2	23.6	23.6	17.	8.	6.3	1.7	1.64	.352	.208	.144	.72	.448	.272	.019	.221
9109	May 12	May 15	d	v l	.1*.2	183.2	173.2	10.	30.4	30.	11.	6.2	5.6	.6	1.248	.4	.224	.176	.784	.512	.272	none	.2
9132	June 11	June 13	d	v l	.1*.2	184.8	183.2	1.6	30.2	37.2	11.	7.6	6.2	1.4	1.408	.432	.272	.16	1.008	.436	.512	"	.28
9167	July 8	July 12	d	l	.1	233.2	224.	9.2	32.	31.2	15.	7.8	6.3	1.5	2.	.48	.288	.192	1.2	.832	.368	"	.08
9210	" 22	" 24	d	l	.02	205.2	178.8	27.4	27.6	18.	13.	7.3	6.7	.5	2.	.256	.128	.128	.624	.432	.192	.004	.12
9271	Aug. 5	Aug. 6	d	l	.04	198.4	167.2	31.2	14.8	8.	14.	8.9	6.	2.9	1.344	.48	.256	.224	1.072	.368	.704	.001	.08
9292	" 12	" 13	d	c	.05	194.4	163.6	30.8	32.4	32.4	12.	8.6	7.1	1.5	1.52	.32	.224	.096	.752	.404	.288	.003	.157
9311	" 19	" 20	d	l	.02*.03	187.2	176.	11.2	18.8	18.8	11.5	9.4	8.2	1.2	1.62	.304	.112	.112	.784	.464	.32	.008	.164
9323	" 26	" 27	d	l	.04	197.6	184.	13.6	16.4	16.4	12.5	9.3	6.9	2.4	1.68	.336	.224	.112	.784	.48	.304	none	.16
9348	Sept. 2	Sept. 3	d	l	.05	179.6	151.2	28.4	13.2	13.2	12.	7.8	7.	.8	1.408	.32	.112	.128	.752	.352	.4	"	.08
9481	" 9	Oct. 15	d	c	.04	188.	154.8	33.2	15.6	13.6	13.	9.2	5.5	3.7	2.8	.224	.144	.08	......	....	......	.2	none
9382	" 16	Sept. 17	d	c	......	190.8	182.8	8.	4.8	....	11.	8.9	7.5	1.4	1.6	.32	.16	.16	......	....	......	none	.08
9390	" 23	" 24	d	c	.01	180.	156.8	23.2	16.4	14.4	10.	6.4	5.9	.5	1.312	.288	.192	.096	......	....	......	"	.2
9418	" 30	Oct. 1	d	c	.01	188.8	146.4	42.4	28.	12.4	15.	12.6	10.	2.6	1.472	.56	.256	.304	......	....	......	"	.16
9443	Oct. 7	" 8	d	l	.04	175.2	160.8	14.4	18.8	12.8	13.	8.2	7.8	.4	1.36	.4	.288	.112	......	....	......	"	.16

*Not filtered.

CHEMICAL EXAMINATION OF WATER FROM THE SANITARY CANAL AT LOCKPORT —CONTINUED.

(Parts per 1,000,000.)

Serial Number.	1901 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved.	Suspended	Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
9476	Oct. 14	Oct. 15	d	c	.05	174.4	156.	18.4	20.	26.4	12.2	11.2	10.3	.9	1.504	.576	.32	.256	....	....	....	.012	.068
9547	" 21	" 22	d	c	.03	198.	175.6	22.4	30.8	20.4	14.	7.1	6.8	.3	1.76	.368	.256	.112	....	....	....	.001	.28
9591	" 28	" 29	d	l	.03	172.8	155.2	17.6	28.4	18.4	12.	7.8	6.3	1.5	1.6	.336	.224	.112	....	....	....	.008	.232
9660	Nov. 4	Nov. 5	d	c	.05	176.	129.6	46.4	33.2	28.	14.	8.	6.1	1.9	1.44	.432	.262	.17	....	....	....	.024	.096
9721	" 11	" 12	d	l	....	164.8	146.4	18.4	28.8	26.8	11.	7.8	4.3	3.5	1.36	.32	.256	.064	....	....	....	.016	.144
9805	" 18	" 19	d	l	.02	176.	138.	38.	10.8	7.6	11.	6.4	5.	1.4	1.184	.288	.192	.096	....	....	....	.01	.19
9875	" 25	" 26	d	l	.02	176.	158.	18.	25.6	19.6	12.	7.2	5.	2.2	1.376	.352	.192	.16	....	....	....	.016	.144
9952	Dec. 2	Dec. 3	d	l	.01*.1	205.6	143.6	62.	16.4	15.2	19.	7.1	6.9	.2	2.88	.336	.256	.08	....	....	....	.01	.23
10029	" 9	" 10	d	l	.03	183.2	182.8	.4	21.2	14.	22.	8.7	5.6	3.1	3.04	.48	.256	.224	....	....	....	.03	.14
10100	" 16	" 17	d	c	.04	258.	216.	42.	26.4	17.2	35.	16.2	7.1	9.1	4.32	.8	.304	.496	....	....	....	.035	.385
10135	" 23	" 24	d	l	.01	192.4	176.8	15.6	23.2	18.8	24.	10.3	9.5	.8	2.68	.528	.224	.304	....	....	....	.016	.384
10156	" 30	" 31	d	c	.05	231.2	224.	7.2	23.6	10.4	21.	9.9	7.2	2.7	3.36	.64	.24	.4	....	....	....	.012	.228
Average Jan. 23—June 11..............						201.4	186.8	14.6	25.9	25.12	14.4	8.6	6.6	1.9	1.402	.451	.249	.202	1.081	.566	.515	.014	.33
Average July 8—Dec. 30..............						194.4	171.1	23.3	22.4	16.8	14.8	9.8	6.8	3.	1.906	.399	.228	.171	.837	.476	.361	.015	.123
Average Jan. 23—Dec. 30..............						197.5	178.1	19.4	24.	21.5	14.5	9.2	6.7	2.5	1.715	.422	.238	.184	.99	.532	.458	.023	.183

*Not Filtered.

The water was invariably possessed of the characteristic musty odor of diluted sewage. The residue upon ignition was always either dark gray or brown.

CHEMICAL EXAMINATION OF WATER FROM THE DESPLAINES RIVER AT LOCKPORT.

(Parts per 1,000,000.)

Serial Number.	1897.		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
	Collection.	Examination.							Total.	Dissolved						Total.	Dissolved	Suspended					
797	Jan. 4	Jan. 6	vd	m	.6	426.	238.	188.	28.8	10.8	13.	17.3	13.4	3.9	2.566	.72	.36	.36	1.52	.88	.64	.062	2.1
1815	" 11	" 13	d	l	....	381.6	364.4	17.2	17.6	12.	9.	12.9	....	....	.07	.32	....	....	.88	....	....	.04	3.4
1851	" 25	" 28	d	l	....	437.6	421.6	16.	14.4	4.8	20.	14.	....	....	2.748	.8	....	....	1.52	....	....	.04	2.1
1874	Feb. 1	Feb. 3	d	l	.1	827.2	810.8	16.4	16.	12.	98.	7.8	....	....	.38	.4	....	....	.72	....	....	.008	2.2
1898	" 9	" 10	s	l	.1	598.4	592.	6.4	20.8	10.	10.	7.3	....	....	.34	.28	....	....	.72	....	....	.023	1.7
1916	" 15	" 16	d	l	.3	373.6	368.4	5.2	12.8	10.	4.6	6.5	....	....	.088	.24	....	....	.72	....	....	.01	1.7
1935	" 22	" 24	d	c	....	422.	195.2	226.8	36.8	27.2	3.8	9.2	....	....	.062	.36	....	....	.72	....	....	.05	1.6
1955	Mar. 1	Mar. 2	s	l	.03	315.2	313.2	2.	38.	38.	4.	8.5	....	....	.242	.44	....	....	.55	....	....	.015	2.2
1975	" 8	" 9	d	l	.15	324.8	322.2	2.6	37.2	36.4	4.6	7.	....	....	.04	.2	....	....	.67	....	....	.018	1.7
2007	" 5	" 16	d	c	....	278.	202.	76.	41.2	34.	3.	16.	....	....	.112	.6	....	....	1.35	....	....	.05	1.8
2032	" 2	" 23	vd	m	.8	509.6	206.4	303.2	76.4	36.8	2.4	35.7	11.4	24.3	.094	1.12	.288	.832	2.83	....	....	.055	1.8
2057	" 9	" 30	vd	c	....	259.2	226.4	33.2	44.	33.2	3.1	10.7	....	....	.066	.36	....	....	.83	....	....	.025	1.7
2088	Apr. 5	Apr. 6	d	c	.5	272.8	245.6	27.2	30.	29.6	3.3	11.	....	....	.012	.4	....	....	.75	....	....	.045	1.8
2115	" 13	" 14	d	l	....	310.	300.	10.	30.	25.6	3.6	9.1	....	....	.014	.36	....	....	.67	....	....	.015	1.2
2130	" 19	" 20	d	l	....	350.8	325.2	25.6	31.6	28.8	4.1	12.1	....	....	.01	.36	....	....	.83	....	....	.02	1.
2158	" 26	" 28	d	c	....	357.2	321.2	36.	47.2	44.	4.	14.1	....	....	.044	.48	....	....	.71	....	....	.034	.7
2180	May 3	May 4	d	l	....	294.	288.8	5.2	23.6	23.2	3.2	14.	....	....	.003	.44	....	....	.67	....	....	.007	1.
2206	" 10	" 12	s	l	.2	328.	316.	12.	34.8	30.4	3.5	9.	....	....	.062	.36	....	....	1.35	....	....	.006	.3
2222	" 17	" 18	s	l	.15	350.8	350.	.8	34.	33.2	4.2	12.3	....	....	.01	.36	....	....	.67	....	....	.002	.4
2262	" 24	" 26	s	l	.3	324.	307.2	16.8	32.	18.4	4.3	8.5	....	....	.018	.4	....	....	.83	....	....	none	.3
2282	" 31	June 2	s	l	.5	345.6	345.2	.4	33.2	28.	5.2	8.5	....	....	.008	.36	....	....	.67	....	....	none	.2
2290	June 7	" 8	s	l	.05	328.8	328.8	0.0	28.	27.6	5.	9.1	....	....	.006	.5	....	....	.65	....	....	none	.15
2321	" 14	" 15	s	l	.2	366.	355.2	10.8	41.2	24.	5.7	13.8	....	....	.008	.52	....	....	.81	....	....	.01	.2
2368	" 22	" 24	d	l	.2	300.4	300.	.4	26.4	18.	4.7	14.	....	....	.022	.52	....	....	.65	....	....	.022	.5
2397	" 29	July 1	d	l	.15	341.2	317.2	24.	22.	18.	4.	9.1	....	....	.03	.44	....	....	.65	....	....	.002	.1
2415	July 5	" 7	s	l	.3	345.2	335.2	10.	47.2	28.4	4.	9.1	....	....	.046	.52	....	....	1.32	....	....	.002	.2
2450	" 14	" 16	d	l	.2	356.	342.	14.	28.	24.	6.	12.2	....	....	.038	.48	....	....	.84	....	....	none	.2

CHEMICAL EXAMINATION OF WATER FROM THE DESPLAINES RIVER AT LOCKPORT.—CONTINUED.

(Parts per 1,000,000.)

Serial Number.	1897.		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
	Collection.	Examination.							Total.	Dissolved						Total.	Dissolved	Suspended					
2475	July 20	July 22	s	l	.3	368.	342.	26.	38.8	21.2	8.5	13.1	...	...	.034	.44	...	...	1.	...	...	.001	.3
2501	" 27	" 29	s	l	.15	361.2	356.	5.2	28.	26.	7.7	14.4	...	...	.024	.88	...	...	1.08	...	...	.001	.2
2548	Aug. 9	Aug. 11	d	c	.15	530.8	508.8	22.	20.6	19.6	55.	14.7	...	...	.352	.64	...	...	1.16	...	...	.11	.25
2571	" 16	" 18	s	l	.1	534.	528.8	5.2	44.	22.8	10.	7.3	...	...	.088	.28	...	...	.56	...	...	.056	.4
2593	" 23	" 25	d	l	.09	539.	537.6	1.4	38.8	22.4	35.	7.1	...	...	1.086	.32	...	...	.62	...	...	.11	.45
2612	" 30	" 31	s	l	.2	376.4	373.2	3.2	30.	25.2	13.	14.5	...	...	.12	.64	...	...	1.04	...	...	.003	.1
2638	Sept. 6	Sept. 8	d	l	.06	482.8	471.6	11.2	28.	24.8	43.	9.5	...	...	.2	.4	...	...	.86	...	...	.2	.05
2669	" 13	" 14	d	l	.1	701.6	685.2	16.4	35.6	33.2	33.	9.3	...	...	1.18	.44	...	...	.58	...	...	.24	.2
2690	" 20	" 21	d	c	.1	695.6	686.8	8.8	30.8	28.	28.	10.8	...	...	.32	.52	...	...	.82	...	...	.125	.3
2722	" 27	" 28	d	c	.1	701.2	572.	129.2	35.2	13.2	25.	9.5	...	...	.56	.52	...	...	1.1	...	...	.225	.4
2752	Oct. 4	Oct. 5	s	c	.06	650.	630.8	19.2	42.8	34.	31.	10.6	...	...	1.8	.44	...	...	.94	...	...	.3	.35
2776	" 11	" 12	d	c	.1	716.8	716.	.8	56.	52.	23.	11.2	...	...	.28	.52	...	...	.94	...	...	.2	.4
2809	" 16	" 18	s	l	.05	682.4	667.6	14.8	48.	45.2	25.	8.4	...	...	.4	.32	...	...	.78	...	...	.25	.6
2836	" 23	" 25	d	c	.1	618.8	608.8	10.	40.	36.	51.	11.6	...	...	4.	.56	...	...	1.28	...	...	.3	.62
2868	" 30	Nov. 1	s	l	.03	704.	696.4	7.6	58.	52.	20.	7.2	...	...	.2	.36	...	...	.7	...	...	.005	.3
2906	Nov. 6	" 8	d	l	.07	729.2	728.8	.4	72.	70.	19.	6.8	...	...	.36	.28	...	...	1.02	...	...	.07	.25
2946	" 13	" 15	d	l	.06	735.6	697.2	38.4	47.2	42.4	22.	11.	...	...	.48	.52	...	...	1.08	...	...	.04	.6
2978	" 22	" 24	s	l	.07	542.	538.	4.	47.2	44.8	8.	8.8	...	...	.032	.24	...	...	.62	...	...	.003	.2
2995	" 27	" 29	d	c	.1	524.8	519.2	5.6	30.	28.8	49.	13.2	...	...	5.8	.8	...	...	1.29	...	...	.04	.65
3030	Dec. 7	Dec. 8	d	c	.1	603.6	589.2	14.4	66.8	29.2	37.	7.	...	...	3.6	.48	...	...	.77	...	...	.05	.6
3062	" 13	" 14	d	c	.1	643.2	629.2	14.	57.2	47.2	20.	8.7	...	...	1.48	.36	...	...	.69	...	...	.1	1.3
3077	" 20	" 21	d	c	.1	702.	680.	22.	68.	56.	38.	8.7	...	...	2.	.36	...	...	1.01	...	...	.065	1.05
3107	" 28	" 30	d	c	.04	621.2	608.8	12.4	37.6	33.6	41.	8.5	...	...	4.8	.6	...	...	1.17	...	...	.2	.75
Average Jan. 4—June 29..........						340.5	334.4	6.0	31.5	24.4	9.4	11.9	...	...	.272	.45	...	...	.92	...	...	.023	1.27
Average July 5—Dec. 28..........						570.6	561.9	8.6	43.8	34.4	25.9	10.1	...	...	1.171	.47	...	...	.93	...	...	.111	.42
Average Jan. 4—Dec. 28..........						459.5	448.2	11.3	37.6	29.4	17.6	11.	...	...	.722	.46	...	...	.93	...	...	.067	.94

There was no perceptible odor. The color upon ignition was brown.

Collections not made at right point.

Chemical Examination of Water from the Desplaines River at Lockport.

(Parts per 1,000,000.)

Serial Number.	1898. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
3117	Jan. 1	Jan. 3	d	c	.08	772.8	762.8	10.	70.8	60.	41.	7.5	......	......	1.6	.36	......	......	.85	......	......	.2	1.2
3151	" 10	" 11	d	c	.04	629.2	621.6	7.6	32.	31.2	21.	5.2	......	......	1.6	.32	......	......	.84	......	......	.045	1.1
3181	" 18	" 20	d	l	.2	696.	686.4	9.6	64.8	46.8	31.	6.7	......	......	.88	.24	......	......	.84	......	......	.04	1.2
3200	" 24	" 26	d	c	.2	548.8	542.	6.8	50.	48.8	19.	7.8	......	......	.88	.32	......	......	.68	......	......	.06	1.75
3223	" 31	Feb. 1	d	c	.6	530.	509.2	20.8	60.	34.	29.	9.	......	......	.56	.48	......	......	.84	......	......	.125	2.25
3248	Feb. 8	" 9	d	c	.08	860.8	841.2	19.6	104.8	98.	60.	8.8	......	......	.7	.4	......	......	.76	......	......	.07	.9
3296	" 21	" 23	d	l	.4	438.8	423.2	15.6	56.4	36.	18.	10.9	.	......	.48	.32	......	......	.84	......	......	.025	.7
3307	" 28	Mar. 1	d	l	.3	396.	388.	8.	37.2	32.	11.	9.2	......	......	.44	.44	......	......	.92	......	......	.022	1.1
3331	Mar. 7	" 8	d	c	.25	555.6	543.2	12.4	54.8	44.8	25.	9.4	......	......	1.08	.6	......	......	1.32	......	......	.03	1.5
3355	" 14	" 15	d	c	....	516.	469.2	46.8	60.8	40.	94.	11.1	......	......	.56	.44	......	......	1.	......	......	.03	.85
3379	" 21	" 22	vd	c	.15	550.	461.2	88.8	62.8	54.4	126.	21.	......	......	.6	.8	......	......	1.4	......	......	.055	.8
3407	" 26	" 30	d	c	.5	395.2	375.2	20.	52.	36.	12.	19.6	......	......	.2	.44	......	......	2.4	......	......	.03	1.06
3422	Apr. 4	Apr. 5	d	l	.4	523.6	519.6	4.	48.	39.2	12.	9.5	......	......	.152	.44	......	......	.93	......	......	.03	1.
3447	" 11	" 12	d	l	.08	665.6	632.4	33.2	73.2	68.4	16.	9.1	......	......	.56	.44	......	......	.85	......	......	.03	.7
3472	" 18	" 20	d	l	.15	628.4	625.2	3.2	69.6	68.8	37.	9.9	......	......	.72	.44	......	......	1.01	......	......	.034	1.25
3494	" 25	" 26	s	l	.05	620.4	616.	4.4	62.	60.	33.	7.6	......	......	.36	.4	......	......	.77	......	......	.03	1.4
3529	May 2	May 3	d	c	.05	612.8	567.2	45.6	76.8	66.	18.	11.8	......	......	.24	.56	......	......	1.26	......	......	.04	.4
3552	" 9	" 10	d	l	.08	736.8	734.	12.8	78.4	72.8	18.	8.3	......	......	.52	.48	......	......	.74	......	......	.045	.4
3580	" 16	" 17	d	c	.06	724.	720.4	3.6	82.	72.	34.	8.7	......	......	.112	.64	......	......	1.14	......	......	.001	1.5
3612	" 23	" 24	d	c	.1	697.6	674.	23.6	72.	66.8	15.	11.	......	......	.2	.44	......	......	1.06	......	......	.02	.4
3633	" 30	" 31	d	l	.04	750.4	709.2	41.2	80.8	78.	35.	8.3	......	......	.16	.36	......	......	.74	......	......	.014	.8
3658	June 6	June 7	d	l	.04	480.	475.2	4.8	48.	42.8	8.	13.	......	......	.056	.4	......	......	.76	......	......	.003	.3
3682	" 13	" 14	d	l	.03	585.6	562.4	23.2	51.2	22.	10.	8.3	8.2	.1	.078	.32	.32	0.0	.68	.6	.08	.008	.3
3702	" 20	" 21	s	l	.02	725.2	734.	1.2	57.2	54.8	16.	7.8	7.3	.5	.08	.36	.32	.04	.96	......	......	.016	.4
3748	" 27	" 28	d	c	.2	386.	303.2	82.8	33.6	32.	14.	15.5	......	......	.76	.64	......	......	1.16	......	......	.034	.3
3770	July 2	July 4	d	l	.7	356.	336.	20.	25.6	25.2	16.	14.	......	......	.56	.48	......	......	.92	......	......	.1	.35
3811	" 11	" 12	d	c	.05	709.6	693.6	16.	48.4	45.2	19.	9.	......	......	.16	.48	......	......	.96	......	......	.03	.25

3837	July 18	July 19	d	1	.04	843.2	832.4	10.8	56.	52.	20.	8.1	......	......	.104	.44	......	......	.88	......	......	.07	.35
3863	" 26	" 27	d	1	.04	788.	784.4	3.6	46.	45.2	22.	9.	......	......	.176	.36	......	......	.84	......	......	.12	.1
3902	Aug. 1	Aug. 2	d	1	.03	765.6	752.	13.6	60.	58.	41.	8.3	......	......	.136	.36	......	......	.88	......	......	.09	.25
3931	" 8	" 9	d	1	.04	573.2	562.	11.2	50.	47.2	21.	9.	......	......	.048	.48	......	......	.8	......	......	.16	.15
3957	" 14	" 16	s	1	.06	722.8	706.	16.8	80.	78.	25.	7.3	......	......	.12	.32	......	......	.68	......	......	.15	.35
3986	" 22	" 24	d	1	.05	699.2	693.2	6.	40.	38.	16.	7.5	......	......	.16	.32	......	......	.64	......	......	.036	.1
4006	" 29	" 30	d	1	.1	384.8	381.2	3.6	44.8	39.2	10.	9.5	......	......	.032	.52	......	......	......	......	......	none	.05
4040	Sept. 4	Sept. 7	d	1	.06	390.	389.2	.8	35.2	34.	11.	12.7	......	......	.064	.56	......	......	.72	......	......	.001	.05
4062	" 10	" 12	d	1	.1	355.2	354.8	.4	40.	40.	11.	8.7	......	......	.032	.36	......	......	.6	......	......	none	.2
4089	" 19	" 20	d	1	.05	374.4	362 4	12.	38.	32.8	10.	8.	......	......	.028	.44	......	......	.6	......	......	.001	.1
4130	" 26	" 28	d	1	.06	385.2	382.8	2.4	73.2	72.	12.	7.8	......	......	.02	.36	......	......	.52	......	......	none	.15
4171	Oct. 3	Oct. 5	s	1	.05	380.8	379.2	1.6	43.2	39.2	11.	7.7	......	......	.032	.36	......	......	.56	......	......	none	.5
4189	" 10	" 11	d	c	....	397.6	375.6	22.	28.8	26.8	15.	9.8	......	......	.022	.44	......	......	.6	......	......	.008	.5
4229	" 18	" 19	d	1	.06	390.8	376.	14.8	40.	34.	12.	8.	......	......	.006	.32	......	......	.61	......	......	none	.2
4255	" 24	" 26	d	1	.1	434.8	424.	10.8	50.	42.	11.	7.7	......	......	.01	.288	......	......	.61	......	......	.01	.25
4303	" 31	Nov. 2	d	1	.3	442.8	441.2	1.6	38.	36.	7.	8.	......	......	.02	.36	......	......	.61	......	......	.012	.4
4328	Nov. 7	" 8	d	1	.2	454.	450.8	3.2	38.	36.	8.	8.	......	......	.01	.28	......	......	.63	......	......	.012	.5
4363	" 14	" 15	d	1	.7	326.8	320.	6.8	30.	28.	7.	9.	......	......	.014	.36	......	......	.67	......	......	.015	.55
4404	" 21	" 23	d	1	.15	402.8	398.	4.8	40.	38.	6.	8.1	......	......	.010	.28	......	......	.59	......	......	.01	.6
4434	" 28	" 28	d	1	.06	482.	461.6	20.4	50.	35.6	6.	7.7	......	......	.06	.236	......	......	.59	......	......	.004	.5
4458	Dec. 6	Dec. 7	s	1	.04	560.	542.8	17.2	48.	46.8	6.6	7.5	......	......	.08	.256	......	......	.01	......	......	.001	.2
4477	" 12	" 13	s	1	.05	707.2	704.8	2.4	65.2	64.	10.	8.	......	......	.01	.292	......	......	.05	......	......	.001	.3
4507	" 19	" 21	s	1	.05	496.8	490.	6.8	60.	59.2	7.5	8.5	......	......	.002	.336	......	......	.65	......	......	.005	.2
4538	" 26	" 28	d	1	....	342.	335.3	6.4	44.	40.	8.5	15.	......	......	.056	.52	......	......	.85	......	......	.017	.25
Average Jan. 1—June 27..........						605.	539.	66.	61.5	52.2	30.2	9.9	......	......	.560	.443	......	......	.19	......	......	.041	.94
Average July 2—Dec. 28..........						506.3	493.4	12.9	46.6	13.5	13.4	8.9	......	......	.078	.374	......	......	.664	......	......	.032	.37
Average Jan. 1—Dec. 28..........						534.7	319.6	35.	53.9	47.8	21.6	9.4	......	......	.315	.406	......	......	.824	......	......	.036	.6

CHEMICAL EXAMINATION OF WATER FROM THE DESPLAINES RIVER AT LOCKPORT.

(Part per 1,000,000.)

Serial Number.	1899 Date of Collection.	1899 Date of Examination	Appearance Turbidity.	Appearance Sediment.	Appearance Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Dissolved	Albuminoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved	Organic Nitrogen. Suspended	Nitrogen as Nitrites.	Nitrogen as Nitrates.
4564	Jan. 2	Jan. 4	d	l	.1	373.2	360.8	12.4	49.6	44.	7.5	13.	......	......	.184	.36	......	......	.77	......	......	.008	.2
4598	" 9	" 11	d	l	.4	380.	377.6	2.4	26.8	24.8	7.8	9.6	......	......	.26	.36	......	......	.69	......	......	.007	.2
4624	" 18	" 20	d	l	.3	348.	346.8	1.2	60.	58.	7.2	8.8	......	......	.21	.32	......	......	.65	......	......	.006	.55
4644	" 24	" 25	d	l	.4	318.8	316.8	2.	40.	40.	5.8	7.8	......	......	.152	.36	......	......	.57	......	......	.006	.3
4660	" 30	" 31	d	l	.1	472.8	468.8	4.	62.	58.	8.7	12.5	......	......	.066	.36	......	......	.77	......	......	.002	.5
4679	Feb. 6	Feb. 7	s	l	.1	544.8	540.	4.8	80.	79.2	10.	9.	......	......	.04	.30	......	......	.57	......	......	.003	1.
4721	" 11	" 20	s	l	.15	916.8	912.	4.8	128.	112.	15.5	13.4	......	......	.14	.52	......	......	.9	......	......	.005	1.4
4725	" 20	" 21	d	l	.05	230.	228.	2.	28.	24.	3.5	7.7	......	......	.236	.36	......	......	.58	......	......	.012	.35
4753	" 27	" 28	d	c	...	284.	196.	88.	54.	44.	5.	18.8	......	......	.64	.68	......	......	1.14	......	......	.013	.4
4776	Mar. 6	Mar. 7	d	m	1.2	206.	170.2	28.8	56.	49.2	4.2	23.8	......	......	.4	.76	......	......	1.38	......	......	.045	.65
4803	" 13	" 14	d	m	......	255.2	220.	35.2	46.	42.	5.	21.	......	......	.44	.66	......	......	1.38	......	......	.02	.1
4838	" 20	" 22	d	m	.5	422.	192.	230.	68.	46.	4.	31.5	17.5	14.	.32	1.	.56	.44	2.67	.95	1.92	.05	.95
4860	" 27	" 29	d	m	......	276.	210.	66.	50.	44.	3.5	17.5	......	......	.32	.6	......	......	1.2	......	......	.023	.55
4888	Apr. 3	Apr. 4	d	m	......	224.	189.2	34.8	42.	40.	3.1	16.	......	......	.36	.48	......	......	.91	......	......	.012	.55
4913	" 10	" 11	d	l	.3	258.8	244.	14.8	42.	30.	4.2	14.2	......	......	.072	.44	......	......	.75	......	......	.014	.4
4938	" 17	" 18	d	l	.4	346.	332.8	13.2	52.	48.	6.4	14.6	......	......	.04	.52	......	......	.90	......	......	.002	.2
4962	" 24	" 26	d	l	.3	400.	386.8	13.2	68.	54.	6.	14.5	......	......	.048	.64	......	......	.81	......	......	.001	.2
5071	May 22	May 23	d	l	.03*.04	369.6	350.8	18.8	27.6	13.6	3.9	15.2	15.	.2	.016	.512	.448	.064	1.21	1.05	.16	.026	.24
5119	" 29	" 31	d	l	.3	375.6	353.6	22.	38.	36.	1.5	17.	14.	3.	.132	.72	.416	.304	1.21	.97	.24	.027	.4
5157	June 5	June 6	d	c	.6	300.	264.4	35.6	36.	28.	2.5	16.7	14.5	2.2	.204	.48	.416	.064	1.29	.89	.4	.07	.48
5203	" 12	" 14	d	c	.5	439.2	358.	81.2	67.2	36.8	3.4	18.3	15.4	2.9	.144	.768	.704	.064	1.16	1.016	.144	.021	.44
5247	" 19	" 21	d	c	.2	418.4	405.2	13.2	56.	52.8	2.5	16.2	13.4	2.8	.144	.544	.448	.096	1.24	1.016	.224	.002	.36
5290	" 26	" 27	d	l	.2 *.25	391.6	352.	39.6	35.6	34.	5.5	15.8	14.3	1.5	.06	.544	.48	.064	1.16	.952	.208	.001	.12
5330	July 3	July 4	d	l	.2 *.3	383.6	369.2	14.4	39.6	38.8	7.3	15.2	15.	.2	.06	.544	.496	.048	1.176	1.112	.064	.001	.16
5388	" 10	" 11	d	l	.4	349.6	342.8	6.8	38.8	30.	6.4	13.7	12.6	1.1	.04	.448	.4	.048	1.08	.76	.32	.008	.4
5435	" 17	" 18	d	c	.5	271.6	194.8	76.8	45.2	40.	3.2	15.8	11.6	3.7	.128	.544	.32	.224	1.24	.824	.416	.00	.52
5482	" 24	" 25	d	c	.4	309.6	284.4	25.2	49.2	48.4	4.1	15.	13.4	1.6	.008	.544	.416	.128	1.24	.92	.32	.012	.36

* n. f.

CHEMICAL EXAMINATION OF WATER FROM THE DESPLAINES RIVER AT LOCKPORT.—CONTINUED.

(Part per 1,000,000.)

Serial Number.	1899 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved.	Suspended	Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
5531	July 31	Aug. 1	d	1	.2	331.2	325.6	5.6	61.2	59.2	5.7	15.5	14.5	1.	.028	.512	.448	.064	.888	.782	.106	.011	.2
5578	Aug. 7	" 8	d	1	.4	338.	324.8	13.2	72.8	70.4	6.8	14.3	13.4	.9	.02	.48	.416	.064	1.16	.856	.304	.003	.2
5627	" 14	" 15	d	1	.15*.2	302.	297.2	4.8	78.4	73.2	7.2	12.8	12.7	.1	.044	.48	.368	.112	1.16	.856	.304	none	.2
5675	" 21	" 22	s	1	.15*.2	346.8	343.6	3.2	68.4	....	10.4	13.7	13.1	.6	.032	.448	.416	.032	1.16	1.08	.08	.002	.16
5732	" 28	" 29	d	1	.25	316.8	313.6	3.2	46.4	46.	9.2	13.7	13.1	.6	.04	.512	.464	.048	.92	.84	.08	.003	.08
5789	Sept. 4	Sept. 5	d	1	.15	310.4	302.4	8.	50.	49.2	8.6	13.1	13.	.1	.092	.576	.416	.16	1.112	.824	.288	.005	.16
5836	" 11	" 12	s	1	.08*.25	300.8	298.8	2.	67.6	66.	8.5	12.6	12.6	0.0	.06	.512	.432	.08	1.16	.888	.272	.001	.12
5883	" 18	" 19	d	1	.05*.06	289.2	288.8	.4	46.	45.6	8.8	8.9	....	....	.062	.512	.432	.08	1.24	.924	.316	.003	.32
5937	" 25	" 26	d	1	.04	304.	304.	0.0	27.2	26.8	7.4	9.6	8.8	.8	.024	.404	.34	.064	.868	.74	.128	.001	.16
5985	Oct. 2	Oct. 3	d	1	.07*.2	315.2	312.8	2.4	54.4	52.8	7.7	10.	....	....	.054	.448	.416	.032	.82	.612	.208	.002	.12
6036	" 9	" 11	d	1	.1 *.15	352.8	343.6	9.2	43.2	41.6	7.9	9.3	9.1	.2	.032	.392	.332	.06	.772	.664	.108	.001	.2
6078	" 16	" 17	d	1	.1	360.4	351.6	8.8	35.6	34.8	9.6	13.1	12.5	.6	.232	.32	.288	.032	.904	.808	.096	none	.16
6145	" 23	" 24	s	1	.15	355.2	351.2	4.	26.	18.	8.4	7.9	7.7	.2	.028	.352	.32	.032	.76	.52	.24	none	.12
6194	" 30	" 31	s	1	.25	406.	397.2	8.8	24.8	22.	8.5	8.1	7.7	.4	.024	.368	.32	.048	.648	.424	.224	.002	.08
6242	Nov. 6	Nov. 7	d	1	.06*.15	438.8	433.	5.8	36.	23.5	12.3	8.1	7.2	.9	.104	.48	.256	.224	.904	.632	.272	.001	.24
6290	" 13	" 14	s	1	.03*.05	475.6	469.2	6.4	47.6	45.2	15.	7.1	7.1	0.0	.06	.512	.288	.224	1.	.584	.416	.006	.4
6337	" 20	" 21	s	1	.03*.04	438.4	428.4	10.	19.6	19.2	18.	6.7	6.6	.1	.032	.432	.32	.112	.744	.584	.16	.001	.28
6399	" 27	" 28	s	1	.02*.04	450.4	446.8	3.6	32.8	31.6	18.5	6.3	....	....	.028	.224	.192	.032	.616	.488	.128	.003	.48
6447	Dec. 4	Dec. 6	s	1	.02*.03	444.	440.	4.	50.	48.4	15.	5.3	5.3	0.0	.044	.208	.192	.016	.68	.552	.128	.001	.32
6495	" 11	" 13	d	1	.1 *.15	377.2	344.8	32.4	36.4	30.4	11.	7.8	4.9	2.9	.048	.32	.16	.16	.68	.424	.256	.003	.32
6544	" 18	" 20	d	1	.03	431.6	421.6	10.	40.	38.	13.7	8.2	8.2	0.0	.84	.368	.352	.016	.776	.68	.096	.003	1.04
6582	" 26	" 27	d	1	.04*.05	538.	514.	24.	65.2	56.4	12.7	8.9	8.9	0.0	.152	.272	.256	.016	.776	.584	.192	.003	.72
Average Jan. 2—June 26						371.7	338.4	33.3	52.6	45.	5.5	15.3	14.9	3.8	.192	.537	.400	.156	1.050	.977	.145	.016	.45
Average July 3—Dec. 26						366.8	355.5	11.3	46.2	42.4	9.2	10.7	10.4	.7	.073	.431	.340	.093	.941	.720	.212	.004	.30
Average Jan. 2—Dec. 26						369.1	347.5	21.6	49.3	43.7	7.7	12.9	11.4	1.4	.129	.481	.379	.102	.907	.782	.262	.01	.38

* n. f.

CHEMICAL EXAMINATION OF WATER FROM THE DESPLAINES RIVER AT JOLIET.—East Side

(Parts per 1,000,000.)

Serial Number.	1901		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved.	Suspeuced	Nitrites.	Nitrates.
	Collection.	Examination							Total.	Dissolved.						Total.	Dissolved.	Suspended					
8964	Jan. 22	Jan. 23	d	l	.05	223.6	194.	29.6	12.	9.2	17.5	8.5	6.7	1.8	2.	.56	.304	.256	1.168	.544	.642	.015	.225
9006	Feb. 20	Feb. 21	d	l	.2*.3	194.	193.2	.8	24.	14.	15.	6.4	6.5	1.9	1.36	.48	.32	.16	1.104	.624	.48	.01	.43
9035	Mar. 15	Mar. 18	d	c	.3	252.8	193.6	60.2	33.6	24.4	13.	15.2	10.3	4.9	1.136	.72	.304	.418	1.632	.816	.816	.026	.974
9071	Apr. 14	Apr. 17	d	l	.01	214.4	202.	12.4	24.	39.	15.	8.6	5.9	2.7	1.6	.256	.208	.048	.608	.304	.304	.014	.306
9107	May 12	May 15	d	l	.1*.3	237.6	220.	17.6	30.8	27.2	32.	7.4	6.9	.5	3.72	.4	.272	.128	.784	.528	.256	.01	.11
9130	June 11	June 13	d	l	.1*.3	272.8	251.6	21.2	47.2	43.2	30.	9.7	7.7	2.	4.8	.672	.336	.336	1.392	.72	.67	none	.28
9170	July 8	July 12	d	l	.3	325.2	288.4	36.8	26.	19.2	45.5	11.4	9.7	1.7	4.8	.464	.288	.176	1.104	.56	.544	"	.44
9206	" 22	" 24	d	l	.02	260.4	238.4	22.	16.	12.8	30.5	9.3	7.5	1.8	4.96	.4	.256	.144	1.168	.528	.64	.001	.12
9223	" 29	" 30	d	c	.04	296.	236.4	59.6	26.4	10.4	42.	13.4	11.9	1.5	5.6	.48	.24	.24	1.104	.536	.568	.01	.11
9273	Aug. 5	Aug. 6	d	l	.04	241.2	220.8	20.4	12.8	9.2	40.5	8.3	6.8	1.5	4.	.336	.304	.032	1.072	.608	.464	.011	.109
9293	" 12	" 13	d	c	.05	289.6	277.2	12.4	33.6	28.	55.	11.5	8.6	2.9	6.	.56	.256	.304	1.008	.528	.48	.5	.06
9306	" 19	" 20	d	c	.02	315.	274.	41.	22.	28.4	52.	11.8	8.8	3.	6.4	.448	.304	.144	.912	.64	.272	.001	.079
9324	" 26	" 27	d	c	.04	300.4	267.2	33.2	27.2	19.6	53.	10.	7.8	2.2	6.7	.352	.24	.112	.816	.496	.32	.009	.16
9349	Sept. 2	Sept. 3	d	l	.03	224.4	205.6	18.8	11.2	11.2	34.	7.9	7.	.9	3.84	.4	.256	.144	.688	.528	.16	.012	.108
9482	" 9	Oct. 15	d	c	.04	238.4	218.	20.4	16.8	9.6	41.8	11.7	7.8	3.9	3.2	.224	.144	.08	.....	....	....	.24	1.52
9379	" 16	Sept. 17	d	c	.1	268.4	237.2	31.2	17.2	16.4	35.	10.9	8.3	2.6	3.44	.336	.176	.16	.....	....	....	.07	.17
9398	" 23	" 24	d	l	.04	247.2	232.8	14.4	20.4	16.4	38.	7.9	6.8	1.1	4.	.288	.256	.08	.....	....	....	.065	.175
9420	" 30	Oct. 1	d	c	.02	231.6	202.4	29.2	22.4	20.8	31.5	9.9	7.6	2.3	3.36	.368	.224	.144	.....	....	....	.12	.24

9420	Sept.30	Oct. 1	d	c	.02	231.6	202.4	29.2	22.4	20.8	31.5	9.9	7.6	2.3	3.36	.368	.224	.144	......	......	......	.12	.24
9442	Oct. 7	" 8	d	c	.03	272.4	247.6	24.8	16.	16.	45.	9.2	7.6	1.6	5.6	.506	.32	.276	......	......	......	.024	.130
9479	" 14	" 15	d	c	.05	258.4	246.8	11.6	18.4	15.2	47.5	13.3	8.8	4.5	5.28	.512	.288	.304	......	......	......	.015	.065
9549	" 21	" 22	d	c	.04	228.	215.6	12.4	28.	14.	34.	8.2	6.2	2.	3.52	.384	.208	.176	......	......	......	.035	.125
9593	" 28	" 28	d	c	.04	227.	208.	19.6	24.8	18.8	35.	7.7	6.5	1.2	4.	.48	.288	.192	......	......	......	.03	.17
9662	Nov. 4	Nov. 4	d	c	.04	186.	164.8	21.2	23.2	19.6	13.	8.	6.1	1.9	1.344	.448	.192	.256	......	......	......	.03	.21
9720	" 11	" 12	d	l	....	196.8	189.2	7.6	35.2	36.8	26.	8.	6.	2.	2.88	.352	.192	.16	......	......	......	.03	.13
9808	" 18	" 19	d	l	.03	221.2	196.8	24.4	23.2	13.6	33.	9.3	5.6	3.7	3.2	.4	.192	.208	......	......	......	.02	.22
9877	" 25	" 26	d	l	.01	220.4	190.4	30.	28.4	23.2	35.	7.9	5.2	.7	3.52	.576	.224	.352	......	......	......	.017	.223
9950	Dec. 2	Dec. 3	d	l	.01*.1	205.6	181.6	24.	20.	19.2	24.	7.9	6.4	1.5	3.36	.336	.288	.048	......	......	......	.017	.223
10030	" 9	" 10	d	l	.05	202.	183.2	18.8	22.8	10.4	22.	8.3	5.4	2.9	2.56	.352	.224	.128	......	......	......	.015	.225
10102	" 16	" 17	d	l	.03	307.6	299.6	8.	31.2	25.6	59.	10.2	6.6	3.6	7.2	.48	.272	.208	......	......	......	.03	.44
10132	" 23	" 24	d	c	.01	277.6	201.2	76.4	32.	18.	23.	14.8	9.2	5.6	3.2	.72	.288	.432	......	......	......	.02	.56
10154	" 30	" 31	d	c	.05	205.6	203.2	2.4	19.2	14.4	21.	10.4	6.4	4.	2.88	.56	.24	.32	......	......	......	.012	.228
Average Jan. 22—June 11............						232.5	209.	23.5	28.6	26.1	21.9	9.6	7.3	2.3	2.436	.514	.29	.224	1.114	.580	.525	.015	.387
Average July 8—Dec. 30............						252.4	226.9	25.5	23.1	18.1	37.5	9.9	7.5	2.4	4.274	.441	.247	.194	.921	.545	.376	.05	.262
Average Jan. 22—Dec. 30............						242.4	218.	24.4	25.8	22.1	29.7	9.7	7.4	2.3	3.355	.478	.260	.209	1.05	.574	.476	.031	.324

*Not Filtered.

The odor was uniformly gassy or musty. The color upon ignition was either dark gray or brown.

8518

CHEMICAL EXAMINATION OF WATER FROM THE DESPLAINES RIVER AT JOLIET.—West Side.

(Parts per 1,000,000.)

Serial Number.	1901		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of								Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved.	Suspended	Total.	Dissolved.	Suspeuced	Nitrites.	Nitrates.
8963	Jan 22	Jan. 23	d	l	.05	218.4	195.6	22.8	14.	9.2	17.	7.5	5.5	2.	1.6	.464	.24	.224	1.036	.528	.508	.017	.183
9007	Feb. 20	Feb. 21	d	l	.2*.3	197.6	185.6	12.	27.6	16.4	15.	7.5	6.	1.5	1.328	.416	.208	.208	.848	.56	.288	.007	.273
9036	Mar. 15	Mar. 18	d	c	.7	207.2	144.8	62.4	35.6	24.	7.8	15.	11.6	3.4	.704	.624	.384	.24	1.488	.752	.736	.022	.976
9070	Apr. 14	Apr. 17	d	l	.01	233.2	210.4	23.2	24.	36.8	13.	9.7	7.3	2.4	1.168	.272	.176	.096	.688	.368	.32	.015	.305
9108	May 12	May 15	d	l	.09*.2	184.8	174.	10.8	31.2	30.4	10.	6.3	5.7	.6	1.472	.288	.192	.096	.704	.496	.208	.02	.14
9131	June 11	June 13	d	l	.1*.2	213.6	190.4	23.2	48.	42.8	14.	9.2	6.9	2.3	1.536	.288	.24	.048	.976	.608	.368	.048	.183
9169	July 8	July 12	d	l	.1	253.6	226.	27.6	28.	26.4	16.	8.7	7.5	1.2	1.44	.272	.256	.016	.752	.432	.32	.06	.1
9211	" 22	" 24	d	l	.01	264.4	233.2	31.2	44.	24.8	33.	8.3	6.5	1.8	3.92	.336	.192	.144	.944	.592	.352	.015	.12
9221	" 29	" 30	d	l	.01	199.6	173.2	26.4	20.8	18.4	12.	10.	9.2	.8	1.66	.4	.192	.208	.656	.4	.256	.015	.065
9274	Aug. 5	Aug. 6	d	l	.04	285.6	260.8	24.8	26.4	22.8	55.	9.1	7.2	1.9	6.08	.544	.336	.208	1.104	.624	.48	.017	.063
9294	" 12	" 13	d	c	.03	187.2	170.8	16.4	39.6	35.2	12.	8.4	7.	1.4	1.6	.32	.224	.096	.624	.336	.288	.04	.2
9300	" 19	" 20	d	l	.02*.02	181.2	166.	15.2	64.4	52.	12.5	8.5	6.6	1.9	1.68	.304	.224	.08	.592	.464	.128	.002	.079
9325	" 26	" 27	d	c	.04	242.4	197.2	45.2	24.4	22.4	15.	9.4	6.4	3.	2.	.32	.224	.096	.816	.432	.384	.03	.09
9346	Sept. 2	Sept. 3	d	l	.02	170.8	163.2	7.6	18.4	18.	11.5	7.4	6.2	1.2	1.408	.288	.208	.08	.528	.384	.144	.032	.048
9483	" 9	Oct. 15	d	l	.04*.04	164.	159.	5.	12.4	12.8	10.3	7.1	4.8	2.3	.082	.128	.096	.032	.....	....	....	.008	1.317
9380	" 16	Sept. 17	d	l	.1	188.	171.2	16.8	13.6	12.	10.	7.4	7.2	.2	1.056	.16	.144	.016	.....	....	....	.125	.235
9400	" 23	" 24	d	l	.01	173.6	159.6	14.	41.2	20.	10.	5.4	5.4	....	1.12	.256	.16	.096	.....	....	....	.11	.17
9419	" 30	Oct. 1	d	l	.01	188.8	173.2	15.6	16.4	20.	11.	7.3	6.7	.6	1.28	.272	.176	.096	.....	....	....	.065	.255

*Not filtered.

CHEMICAL EXAMINATION OF WATER FROM THE DESPLAINES RIVER AT JOLIET.—West Side.—CONTINUED.

(Parts per 1,000,000.)

Serial Number.	1901		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
	Collection.	Examination.							Total.	Dissolved.						Total.	Dissolved.	Suspended.					
9441	Oct. 7	Oct. 8	d	1	.03	184.4	179.2	5.2	16.	16.	13.	7.3	7.3	...	1.6	.304	.144	.16	....	....	....	.065	.135
9477	" 14	" 15	d	1	.04	188.8	169.6	19.	14.8	12.	12.5	8.5	5.9	2.6	2.4	.32	.208	.112	....	....	....	.064	.176
9548	" 21	" 22	d	c	.04	182.8	152.	30.8	17.6	17.6	10.	6.	5.9	.1	.896	.208	.128	.08	....	....	....	.08	.06
9592	" 28	" 28	d	1	.03	180.4	153.2	27.2	35.2	21.2	11.	6.3	5.1	1.2	1.28	.272	.144	.138	....	....	....	.06	.14
9663	Nov. 4	Nov. 5	d	c	.03	172.8	164.4	8.4	28.	23.2	13.	7.1	5.6	1.5	1.184	.32	.224	.096	....	....	....	.034	.166
9807	" 18	" 19	d	1	.03	166.4	146.	20.4	16.8	14.	9.	6.1	4.3	1.8	.656	.308	.128	.18	....	....	....	.03	.21
9876	" 25	" 26	d	1	.01	167.6	157.2	9.4	21.6	30.4	12.	5.4	3.7	1.7	.8	.24	.128	.112	....	....	....	.025	.135
9951	Dec. 2	Dec. 3	d	1	.05*.1	188.	171.6	17.4	16.8	21.6	20.	6.7	4.4	2.3	2.72	.32	.256	.064	....	....	....	.019	.141
10028	" 9	" 10	d	1	.03	188.4	174.4	14.	19.2	14.8	21.	6.6	4.6	2.	2.72	.32	.192	.128	....	....	....	.015	.305
10101	" 16	" 17	d	c	.01	251.2	220.	31.2	30.	26.4	32.	15.6	5.8	9.8	4.48	.72	.288	.432	....	....	....	.05	.36
10133	" 23	" 24	d	c	.01	314.	194.8	119.2	19.6	22.4	22.	10.8	8.8	2.	2.88	.4	.224	.176	....	....	....	.016	.464
10155	" 30	" 31	d	c	.06	200.4	196.	4.4	17.6	18.	21.	10.9	7.	3.9	3.04	.56	.288	.272	....	....	....	.013	.227
Average Jan. 22—June 11...........						200.2	183.4	15.8	30.1	26.6	12.8	9.2	7.1	2.1	1.301	.392	.24	.152	.956	.552	.404	.021	.338
Average July 8—Dec. 30..............						203.5	181.	22.5	25.6	22.1	16.7	8.	6.2	1.8	1.958	.326	.197	.129	.698	.44	.258	.038	.199
Average Jan. 22—Dec. 30.............						206.3	182.2	24.1	27.8	24.3	14.7	8.6	6.7	1.9	1.629	.359	.218	.141	.871	.515	.356	.03	.266

*Not Filtered.

The odor was uniformly gassy or musty. The color upon ignition was either dark gray or brown.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT MORRIS.
(Parts per 1,000,000.)

Serial Number.	1897. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved		Total.	By Dissolved.	By Suspended Matter	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Dissolved	Albuminoid Ammonia. Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
1803	Jan. 5	Jan. 7	7	m	.7	416.4	223 2	193 2	20	10 8	.5.	25.7	11.8	13 9	.48	1 12	64	.48	2.08	.96	1.12	.035	3
1818	" 11	" 13	d	l	....	353 2	315.6	37.6	16.	16.	12.	15 1	....	....	.8	44	....	....	1.2	....	....	.09	3 5
1835	" 19	" 20	vd	m		387 2	241 2	146.	14.	12.	9.	18 5	....	....	.8	.76	....	....	1.6	....	....	.035	2 8
1852	" 26	" 28	d	l	.5	416 8	352 8	64	16 8	9.2	21	13.2	....	....	1.92	.72	....	....	1.41	....	....	.065	3.3
1872	Feb. 1	Feb. 3	d	l	..	380 2	383 6	5 6	8	8	25.	13 9	....	....	3 2	64	....	....	1.44	....	....	15	1.5
1896	" 8	" 10	d	l		375 2	363 2	12.	20 8	12	30.	12 6	....	....	3 4	.64	....	....	1.36	....	....	.115	1.4
1923	" 17	" 18	d	l	.2	322 8	306 8	16.	12.	4.8	18	10 2	....	....	1 76	.44	....	....	1.16	....	....	04	1.7
1938	" 22	" 24	d	c	....	369 6	233 2	136.4	54.8	38 4	9.	13 9	....	....	.64	.52	....	....	1.36	....	....	.04	2.4
1965	Mar. 2	Mar. 4	d	l	.2	313.2	293 2	20	66.	54	17.	10 9	....	....	1.44	.56	....	....	1	....	....	.06	1.7
1980	" 8	" 10	d	c	....	317 2	233 2	84.	48	34.8	11.	13 6	....	....	.88	.52	....	....	1 07	....	....	.03	2.2
2019	" 16	" 18	d	c	..	306	241 2	64 8	58	56.	10.	13 4	....	....	.64	.48	....	....	1 15	....	....	.035	3.4
2042	" 23	" 25	vd	m	2	496.8	229.2	267.6	74.4	41.2	10.	24 9	8.9	16	.64	96	288	.672	2 11	.83	1 28	.15	3.
2063	" 30	Apr. 1	d	l	.5	295.2	238.8	56 4	54 8	40	10.	12.1	....	....	.56	.44	....	....	.91	....	....	.025	2.
2090	Apr. 5	" 6	d	c	..	238.	268	60	60.8	24.	13.	14.7	....	....	1 04	6	....	....	1 23	....	....	.055	1.7
2113	" 12	" 14	d	c	....	324.	262 4	61 6	52	34 8	15	15.	....	....	1 76	.56	....	....	1 07	....	....	.08	1.4
2136	" 19	" 21	d	l	.4	356	325 2	30 8	45 6	40.	19.	14 8	....	....	2.72	56	....	....	1 23	....	....	.095	1.4
2185	May 3	May 5	d	c	....	392.4	346.8	45 6	40 4	16	28	17 3	....	....	2	76	....	....	1 67	....	....	.065	1.6
2215	" 13	" 15	d	l	.3	356	343 6	12 4	32	31.2	24.	13 8	....	....	2 88	52	....	....	1 11	....	....	14	1.
2233	" 17	" 20	d	c	.	350.	343.2	6.8	38.	35 2	30.	16.3	....	....	3 6	.64	....	....	1 31	....	....	25	1.
2260	" 25	" 26	d	l	....	327 6	321 6	6.	24 8	18.8	98.	13	....	....	3 52	.52	....	....	1.15	....	....	.06	.7
2281	" 31	June 2	d	c	.. .	335.2	324.	11 2	35 2	30	32.	15 2	....	....	3.6	52	....	....	1 15	....	....	06	1.6
2305	June 7	" 9	d	c	...	402 8	322	80 8	40	30.8	4'.	26.2	....	....	5 2	1.36	....	....	1 05	....	....	08	.4
2342	" 17	" 19	s	l	.3	328.	324 8	3 2	64.	58.	38	16.4	....	....	5.	.8	....	....	.69	....	....	.17	.16
2361	" 21	" 23	d	m	...	417 2	256 8	160 4	32.	26 4	13.	19.5	....	....	1 28	.64	....	....	1.37	....	....	28	1 9.
2386	" 28	" 30	d	c	.	353 6	333.2	20 4	56.	46 4	18.	17.2	....	....	2.	.52	....	....	1.05	....	....	.38	1.1
2426	July 6	July 8	d	l	.2	336.	323 6	12 4	20.	14 8	35	14.6	....	....	4.	.52	....	....	1 16	....	....	.6	.6
2440	" 12	" 14	d	l	.2	321.6	304 8	16.8	20.	16.	42	16 7	....	....	5 4	64	....	....	1 24	....	....	.25	.4

2469	July 19	July 21	d	l	.5	378 8	322.	6 8	20 8	18	36.	15 4	......	......	4.6	.64	......	......	1 08	......	......	.04	.4
2494	" 26	" 28	d	m	...	340.	304.	* 36.	22	13 2	45.	15.2	......	......	4.6	1 2	......	......	1 16	......	......	.65	1 6
2530	Aug. 3	Aug. 5	s	c	.3	348 4	342.	6.1	21.6	16 8	53	15.3	......	......	5.4	.56	......	......	1.16	......	......	75	1.
2547	" 9	" 11	d	c	.2	353.6	338 8	14 8	21.6	14 8	63.	13.1	......	......	7.	.6	......	......	1 08	......	......	45	.45
2569	" 16	" 18	s	l	.2	380.	358	22.	22.	19 2	77.	13 7	......	......	8 8	.6	......	......	1	......	......	6	6
2590	" 24	" 25	d	l	.3	382.4	380.4	2.	25.2	17 2	82.	14.	......	......	12	72	......	......	1 38	......	......	1 25	.3
2622	" 31	Sept. 2	d	c	.2	388.4	382.	6 4	38.	32	75.	14 3	......	......	9 6	96	......	......	1.7	......	......	.005	.05
2650	Sept 8	" 10	d	l	.5	390.	385.2	4.8	28.	27.2	84	14 3	......	......	10.4	.88	......	......	1.46	......	......	.06	.6
2667	" 13	" 14	d	c	...	395 2	344	51.2	26	20.	87.	16 6	......	......	2.	1:08	......	......	1 86	......	......	001	.1
2692	" 20	" 21	d	c	.15	405.6	401	5.6	18.4	18	92.	12 3	......	......	14	.08	......	......	1 3	......	......	005	.1
2719	" 27	" 28	d	c	2	410.	405 6	4 4	26.	25.2	86.	15 5	......	......	12.	1 2	......	......	2 14	......	......	.01	.1
2754	Oct. 4	Oct. 5	d	c	.	404.	402	2.	44.	40	87.	9	......	......	12	1.6	......	......	2 54	......	......	004	.1
2775	" 11	" 12	d	c		394	384 8	9 2	32.	20.8	81.	16.9	......	......	1.6	1.16	......	......	2 38	......	......	.02	.4
2817	" 17	" 19	d	c	..	390 4	382 8	7.6	25.2	23.6	85	16.	......	......	14.8	.92	......	......	1 82	......	......	.025	05
2840	" 25	" 26	d	c	.15	400.	387.2	12.8	26.8	24.4	88	17.5	......	......	10 8	1 2	......	......	2 14	......	......	none	3
2874	Nov. 1	Nov. 2	d	c	....	404.4	392.4	12	36.4	26.4	83	22.5	......	......	11 6	1.28	......	......	2 62	......	......	008	.1
2926	" 9	" 11	d	c	.	383 6	356.8	26 8	32	20	75.	16.8	......	......	12	1 12	......	......	1.98	......	......	002	.45
2952	" 15	" 16	d	c	..	384 8	359.2	25 6	31 6	20.	74	13.	......	......	9 4	.72	......	......	1 26	......	......	.013	7
2976	" 22	" 23	d	c		420.	399 2	20 8	38.	30.	72	16 4	......	......	9 2	1.32	......	......	1 98	......	......	.015	45
3003	" 29	" 30	d	c	.3	405 6	384.8	20 8	28.	21.8	70.	13.6	......	......	9.	1.	......	......	1.85	......	......	.05	.45
3029	Dec. 7	Dec 8	d	c	..	410.8	396	14 8	48.	34	60.	14 3	......	......	8 4	1.4	......	......	2.77	......	......	.04	.4
3056	" 13	" 14	d	c	...	387 2	362.8	24 4	38 4	30	55.	15.3	......	......	8.	1.44	......	......	2 45	......	......	.06	4
3080	" 20	" 22	d	m	..	679.2	534.	145 2	60	32.	92.	29.5	......	......	9.2	2.4	......	......	4.77	......	......	.06	.35
3098	" 27	" 29	d	c		451.2	436 8	14 4	34	25 2	74.	26.5	......	......	8	2.08	......	......	3.57	......	......	.006	55
Average Jan. 5—June 28			.. .. .			361.1	297.1	64.1	79.3	29.1	19.	15.8	10.3	14.9	2.7	.64	.46	.576	1.28	.89	1.2	.107	1.79
Average July 6—Dec. 27			.... :			395.9	375 7	20 2	30.1	23.2	71.	16.	......	......	9.36	1.07	......	......	1.91		......	.191	.42
Average Jan 5—Dec. 27			.. ..			378.9	337 1	41.7	34 6	26.1	45.	15.9	10.3	14.9	5.78	.86	.46	.576	1.6	.89	1.2	.15	1 09

The odor was generally musty except when the river was high, then the water was usually odorless The color upon ignition was uniformly brown

* n. f.

CHEMICAL EXAMINATION OF WATER IN THE ILLINOIS RIVER AT MORRIS.
(Parts per 1,000,000.)

Serial Number.	1898. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
									Total.	Dissolved						Total.	Dissolved	Suspended					
3128	Jan. 3	Jan. 5	d	c	.25	422.8	406.8	14.	36.8	18.8	42.	14.5	....	....	4.2	1 2	....	....	2.29	....	....	12	1.2
3153	" 10	" 11	d	m	..	432.8	400.	32.8	67.6	56.8	62.	24.4	....	....	6.4	1.92	....	....	4.36	....	....	.004	.8
3178	" 18	" 19	d	c	..	425.8	399.6	25.6	29.2	23.6	51.	23.5	....	....	5 6	2.	....	....	3 96	....	....	.28	.35
3206	" 24	" 26	d	c	....	442.	356.	86.	52.	40	34.	17.	....	....	3.2	1.16	....	....	1.88	....	....	.2	2.35
3221	" 31	Feb. 1	d	c	..	418.	351.2	66 8	41.2	34.8	39.	15.4	....	....	3 4	1.28	....	....	2.2	....	....	.14	2.75
3250	Feb. 7	" 9	vd	m	..	589.6	476	113.6	74.8	37.6	53.	38.	....	....	3 2	3.04	....	....	5.56	....	....	.04	35
3264	" 14	" 15	d	m	....	420.	271.6	148.4	47.2	31.2	27.	28.4	....	....	2.	1.4	....	....	2 28	....	....	.065	2.5
3300	" 22	" 23	d	m	....	351.2	264.4	86 8	36.	27.2	15.	16.7	....	....	1.36	.88	....	....	1 64	....	....	.02	3 25
3318	Mar. 1	Mar. 2	d	c	.5	312.8	297.2	15.6	25.6	23.2	14.	18.6	....	....	12 8	.64	....	....	1.16	....		.04	2.5
3329	" 7	" 8	d	c	.3	359.6	340 4	19.2	40.4	34	27.	13.7	....	....	2.64	.76	....	....	1.64	....	....	.08	.8
3356	" 14	" 15	d	m		405 2	227 6	177.6	66 4	25.6	9.	24.	....	....	1.12	1.08	....	....	2.28	....	....	.075	1 2
3376	" 21	" 22	vd	vm	.1	684.8	236.	448.8	64.8	33.2	7.	35.7	....	....	.64	1.48	....	....	3.08	....	....	.03	.6
3406	" 28	" 30	vd	vm	.6	697.2	181 2	516.	68	30.	4 8	38.	9.3	28.7	.368	1 76	.4	1.36	3.40	.77	2.72	.035	1.35
3432	Apr. 5	Apr 6	d	c	.25	272.	223.6	48.4	46.	32.4	6.	15.	....	....	.48	.66	....	....	1.25	....	....	.02	1.2
3450	" 12	" 13	d	l	.25	249.2	233.6	15.6	28.4	22.8	7.	15.	....	....	.088	.48	....	....	1.25	....	....	.025	.65
3480	" 19	" 21	d	l	.6	268 4	265 2	3.2	39.2	36.8	10.	15.6	....	....	.76	.52	....	....	1.17	....	....	.03	.7
3512	" 27	" 29	d	c	3	306.4	300.4	6.	59.2	50	13.	13.8	....	....	1.28	.48	....	....	1.17	....	....	.035	.95
3536	May 2	May 4	d	c	.3	324.8	319.6	5.2	43.2	40	22.	12.7	....	....	2.64	.52	....	....	1.3	....	....	.045	.5
3555	" 9	" 11	d	l	.1	311.6	284.8	26 8	39.2	36 4	13.	12.8	....	....	1.44	.48	....	....	.98	....	....	.03	.75
3580	" 16	" 18	d	c	.3	314.4	286 8	27.6	46.8	40.	8.	13.8	....	....	.8	.52	....	....	.98	....	....	.025	.6
3613	" 24	May 25	vd	m		626 4	212.4	414.	62.	42.	10.	25.7	....	....	.92	.96	....	....	2.18	....	....	.07	1.

CHEMICAL EXAMINATION OF WATER IN THE ILLINOIS RIVER AT MORRIS.—CONTINUED.

(Parts per 1,000,000.)

Serial Number.	1898. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
3641	May 31	June 2	d	c	...	341.2	289.6	51 6	32.8	27.2	14.	14.	.....	.....	1.52	.56	.....	.....	1.06	.....	.....	.115	.75
3666	June 6	" 8	d	l	.2	357.2	344.4	12.8	45.2	34.4	17.	13.2	.....	.....	2.16	.56	.....	.....	.96	.....	.....	.1	.8
3687	" 14	" 15	d	c		527.2	327.6	199.6	49 6	24.8	30.	16.7	.....	.....	2.8	.72	.....	.....	1.44	.....	.....	.09	.7
3714	" 20	" 22	d	c	.05	353 2	315.2	38.	21.2	20.	24.	10.6	.....	.....	2.56	.4	.....	.....	1.04	.....	.....	.07	.85
3762	" 28	" 30	d	c	...	440.4	400.	40 4	27.2	24.	67.	14.5	.....	.....	6.4	.44	.....	.....	1.16	.....	.....	.065	.25
3792	July 5	July 7	d	c	.2	346.	330 8	15.2	20.	18.8	36.	12.	.....	.....	3.8	.6	.....	.....	.88	.....	.....	.09	.35
3817	" 11	" 13	d	l	.2	372.8	354.	18.8	28.	22.	48.	12.2	.....		6.	.56	.....	.....	1.16	.....	.....	.075	.3
3847	" 19	" 21	d	l	.04	370.8	364.8	6.	16.	14.4	60.	11.5	.....	.....	8.	.56	.....	.....	1.04	.....	.....	.017	.15
3865	" 23	" 25	d	c	.04	352.	347 6	4.4	27.2	26.	57.	10.5	.....	.....	7.6	.6	.....	.....	1.04	.....	.....	.105	.15
3892	" 30	Aug. 1	d	c	.05	379.6	371.6	8.	22.	18.4	77.	11.6	.....	.....	12.	.6	.....	.....	1.04	.....	.....	none	.35
3939	Aug. 8	" 10	vd	vm	.	2065 2	385.2	1670.	282.	33.2	81.	40.8	.....	.....	16.	20.	.....	.....	30.32	.....	.....	.035	.35
3977	" 22	" 23	d	c	.3	365 2	360.	5.2	28.	26.	65.	12.	.....	.....	7.2	.52	.....	.....	.88	.....	.....	.001	.15
4019	" 30	Sept. 1	d	c	.1	379.2	372.	7.2	26 8	23.2	67.	15.	.....	.....	9.6	1.	.....	.....	1.84	.....	.....	.001	.1
4052	Sept. 6	" 7	d	l	.15	340 8	336.8	4.	29.6	24.4	65.	9.6	.....	.....	9.2	.56	.....	.....	.72	.....	.....	none	.05
4095	" 17	" 21	d	l	.08	335.2	328.	7.2	36.	24.	46.	8.2	.....	.....	6.	.44	.....	.....	.88	.....	.....	.04	.25
4115	" 24	" 26	d	c	.04	338.4	318.8	19.6	31.2	26.	58.	7.5		.....	7.4	.4	.....	.....	.64	.....	.....	.06	.3
Average Jan. 3—June 28..........						409.7	308.2	101.5	45.7	32.5	24.	18.9	.....	.....	2.279	.99	.....	.....	1.99	.....	.....	.07	1.14
Average July 5—Sept. 24..........						512.2	351.7	160.5	49.7	23.4	60.	13.7	.....	.....	8.436	2.34	.....	.....	3.67	.....	.....	.037	.31
Average Jan. 3—Sept. 24..........						440.2	304.9	135.3	46.9	29.8	34.7	17.3	.....	..	4.109	.856	.....	.....	1.672	.....	.....	.06	.89

The odor was generally musty except when the river was high, then the water was usually odorless. The color upon ignition was almost always brown, but occasionally gray.

* n. f.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT MORRIS.

(Parts per 1 000,000.)

Serial Number.	1899. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
5112	May 29	May 30	d	c	.4	445.2	419.2	26.	63.2	54.	44.2	19.2	15.05	4.15	8.8	.88	.544	.336	1.93	1.18	.75	.035	.44
5164	June 6	June 7	d	c	.25	402.8	324.8	78.	55.2	52.	32.	15.4	11.4	4.	3.8	.8	.544	.256	2.17	1.23	.94	.06	.64
5209	" 13	" 14	d	c	.5	427.2	420.4	6.8	39.6	34.4	43.5	19.1	15.2	3.9	5.6	.736	.624	.112	1.72	1.24	.48	.06	.44
5290	" 27	" 28	d	c	.25	372.4	355.6	16.8	27.2	24.4	48.	17.6	15.2	2.4	6.8	.672	.512	.16	1.4	.92	.48	.028	.24
5332	July 2	July 4	d	c	.2* 3	403.2	395.6	7.6	33.6	22.8	57.5	15.3	13.5	1.8	7.52	.672	.448	.224	1.72	1.144	.576	.011	.2
5396	" 11	" 12	d	c	....	451.6	445.2	6.4	47.6	40.4	71.	15.8	14.1	1.7	8.8	.768	.528	.24	1.88	1.08	.8	.03	.2
5428	" 17	" 18	d	c	.06	378.2	312.8	60.4	49.6	46.	37.	15.5	11.65	3.85	5.6	.8	.336	.464	1.8	.824	.976	.06	1.08
5484	" 25	" 26	d	l	.25	432.	422.4	9.6	56.6	52.8	58.	14.	12.3	1.7	7.04	.768	.48	.288	.268	1.48	1.2	.035	.24
5529	" 31	Aug. 1	d	c	.04	421.2	401.2	20.	64.4	54.	63.	17.3	14.2	3.1	7.68	.736	.448	.288	1.64	1.16	.48	.018	.2
5570	Aug. 7	" 8	d	l	.04	425.2	420.4	4.8	46.8	43.2	70.2	16.3	11.9	4.4	12.	.72	.48	.24	1.96	.996	.964	.002	.24
5624	" 14	" 15	d	l	.07	394.			54.	52.8	79.	16.3	13.3	3.	11.	.864	.448	.416	1.752	1.048	.704	.005	.28
5672	" 21	" 22	d	l	.15	398.4	395.6	2.8	30.6	38.	75.	15.5	13.	2.5	12.	.832	.48	.352	1.56	1.08	.48	.005	.12
5738	" 29	" 30	d	c	.08	446.4	440.4	6.	96.8	69.2	92.	14.7	12.7	2.	14.	.88	.464	.416	2.12	1.144	.976	.017	.16
5785	Sept. 4	Sept. 5	d	c	.1	434.4	433.2	1.2	44.4	42.	92.7	14.8	13.9	.9	10.4	.64	.448	.192	2.04	1.144	.896	.005	.08
5842	" 12	" 13	d	c	.1	444.	361.2	82.8	40.	39.2	98.	17.5	14.3	3.2	12.8	1.344	.528	.816	2.64	1.144	1.496	.004	.08
5930	" 25	" 26	d	c	.05	453.6	444.4	9.2	35.2	17.6	97.5	18.8	11.8	7.	13.2	1.28	.576	.704	2.18	1.06	1.12	.008	.08
5962	Oct. 2	Oct. 3	d	c	.2	448.4	444.4	4.	36.	31.2	100.	17.2	11.1	6.1	13.6	.96	.608	.352	1.94	1.06	.88	.015	.24
6074	" 16	" 17	d	c	.03	334.8	328.8	6.	20.8	18.	62.5	10.7	9.1	1.6	8.	.512	.384	.128	1.124	8.36	.288	.012	.4
6143	" 23	" 24	d	c	.2	390.4	272.	18.4	21.2	18.	75.	11.7	8.6	3.1	10.8	1.184	.608	.576	1.8	.776	1.024	.002	.28
6190	" 30	" 31	d	l	.15	383.6	370.	13.6	24.4	16.	73.4	11.9	10.9	1.	10.	1.152	.416	.736	1.96	.648	1.312	.004	.08
6235	Nov. 6	Nov. 7	d	c	.2	389.2	382.	7.2	22.8	22.	65.	12.3	10.5	1.8	8.	1.184	.544	.64	2.04	1.064	.976	.014	.32
6294	" 14	" 15	d	c	.06	404.8	398.4	6.4	43.2	40.	51.	11.5	8.6	2.9	6.4	1.04	.832	.208	1.96	1.56	.4	.044	1.84
6329	" 20	" 21	d	c	.13	384.4	372.4	12.	35.6	30.	50.5	11.3	9.7	1.6	6.8	.864	.544	.32	1.64	1.	.64	.06	1.72
6395	" 27	" 28	d	c	.3	401.6	397.6	4.	33.6	28.4	56.5	12.3	11.8	.5	6.4	1.184	.704	.48	1.96	1.44	.52	.05	1.44
6500	Dec 26	Dec. 27	d	c	.3	401.6	389.2	12.4	48.	46.	49.5	12.3	11.9	.4	5.6	1.312	.96	.352	2.28	1.64	.64	.035	2.8
Average May 29—June 27					.....	411.9	382.2	29.6	46.3	41.2	41.9	17.8	14.21	3.61	6.2	772	.556	.216	1.806	1.142	.663	.045	.44
Average July 3—Dec. 26					. ...	886.4	377.4	508.9	42.5	34.	70.3	14.4	11.38	3.04	9.41	.937	.536	.401	3.317	1.111	2.206	.022	.55
Average May 29 -Dec 26..					...	810.5	378.2	432.2	43.1	35.1	65.8	14.7	12.19	2.50	8.91	.911	.539	.372	1.916	1.115	7.90	.036	.53

On July 17th. the odor was grassy; on November 27th, musty; on the other dates the water was odorless. The color upon ignition varied from gray to brown, more often was brown.

* n. f.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT MORRIS.

(Parts per 1.000,000.)

Serial Number.	1900. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.							Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
6637	Jan. 5	Jan. 8	d	c	.3	432.	424.	8.	38.	29.6	63.	22.2	17.6	4.6	7.2	1.6	.896	.704	2.76	1.88	.88	.5	.68
6665	" 10	" 12	d	c	.5	432.	418.	14.	44.4	40.	85.	18.5	12.3	6.2	8.	2.	.8	1.2	3.36	1.84	1.52	.035	.44
6703	" 16	" 18	d	c	.06	364.	355.2	8.8	52.	48.4	50.	11.	9.7	1.3	5.36	.496	.448	.048	1.76	1.04	.72	.015	1.
6773	" 26	" 29	d	c	.04	408.	221.6	186.4	40.4	24.8	23.5	22.9	7.8	15.1	2.4	1.44	.288	1.152	3.04	.672	2.368	.03	.44
6786	" 29	" 29	d	c	.03	306.	254.	52.	31.6	23.	18.	12.1	7.4	4.7	1.76	.528	.256	.272	1.04	.48	.56	.025	.72
6846	Feb. 6	Feb. 7	d	l	.04	246.	220.	26.	16.8	16.4	26.5	7.7	6.2	1.5	3.24	.528	.304	.224	1.04	.64	.4	.02	.33
6893	" 12	" 14	vd	vm	.5	598.	205.	393.	48.	22.8	12.7	21.1	9.4	11.7	1.2	1.088	.304	.784	2.08	.576	1.504	.06	2.6
6942	" 19	" 21	d	c	.04	277.2	239.6	37.6	54.	40.4	24.	8.4	5.9	2.5	1.76	.768	.288	.48	1.68	1.8	.88	.04	.92
6986	" 26	" 28	d	c	.04	265.2	214.	51.2	22.	20.4	21.	9.2	6.8	2.4	1.68	.88	.352	.528	1.84	1.12	.72	.03	1.08
7037	Mar. 7	Mar. 9	d	c	.03	301.2	268.4	32.8	23.6	17.6	29.5	13.7	7.3	6.4	2.8	.8	.288	.512	1.84	.608	1.232	.045	.56
7123	" 19	" 21	d	c	.3	289.6	188.8	100.8	25.2	20.4	13.2	16.1	9.3	6.8	1.28	.96	.336	.624	1.64	.824	.816	.05	1.2
7187	" 28	" 30	d	c	.8	221.6	192.4	29.2	16.8	14.8	12.	15.4	8.8	6.6	1.12	.448	.304	.144	1.144	.824	.32	.04	.88
7220	April 3	Apr. 4	d	c	.15	372.8	190.4	182.4	32.4	20.4	10.1	15.8	8.3	7.5	.72	.656	.352	.304	1.432	.728	.704	.021	2.3
7273	" 9	" 11	d	c	.05	279.2	236.4	42.8	16.4	15.2	19.8	13.5	7.4	6.1	1.76	.48	.32	.16	1.4	.856	.544	.06	.88
7335	" 16	" 18	d	c	.04	333.6	252.	81.6	30.4	14.	26.1	11.	7.1	3.9	2.16	.48	.24	.24	1.304	.664	.64	.03	.68
7393	" 23	" 24	d	l	.03	270.	234.	36.	2.8	19.6	16.7	8.7	7.	1.7	2.4	.496	.272	.224	1.048	.696	.352	.05	.8
7441	" 30	May 2	d	c	.07	334.4	304.	30.4	36.	32.8	18.2	9.3	7.7	1.6	4.32	.48	.32	.16	1.12	.84	.28	.04	.44
7476	May 8	" 9	d	c	.04	215.6	200.4	15.2	20.4	20.	18.	7.7	7.2	.5	2.24	.384	.272	.112	.84	.52	.32	.01	.36
7559	" 15	" 17	d	c	.08	245.2	229.2	16.	29.6	28.	20.1	7.3	6.2	1.1	2.8	.32	.176	.144	.836	.516	.32	.125	.4
7588	" 21	" 23	s	l	.1	272.	249.6	22.4	43.6	33.4	25.	7.8	7.5	.3	2.	.448	.32	.128	.644	.48	164	.125	.6
7620	" 28	" 29	s	l	.04	206.8	191.6	15.2	18.8	18.4	21.	6.2	6.	.2	1.92	.288	.224	.064	.68	.612	.068	.065	.72
7657	June 4	June 6	d	c	.03	257.2	205.6	51.6	34.4	27.6	17.	9.1	6.8	2.3	1.44	.4	.304	.096	964	.68	.284	.125	1.4
7705	" 11	" 12	d	l	.03	264.	254.	10.	20.8	20.4	25.	7.2	6.4	.8	2.04	.32	.272	.048	.8	.48	.32	.2	.96
7743	" 18	" 20	d	c	.04	229.6	227.6	2.	23.6	22.	21.	6.8	5.8	1.	2.08	.272	.128	.144	.58	.388	.192	.06	.32
7790	" 26	" 28	v s	l	.01	258.	235.6	22.4	21.6	20.8	22.	6.9	6.2	.7	2.16	.24	.224	.016	.484	.42	.064	.16	.6
7850	July 5	July 7	s	vs	.02	248.4	226.8	21.6	3.8	30.4	19.5	8.1	4.6	3.5	1.2	.192	.176	.016	.612	.404	.208	.4	.68
7887	" 9	" 11	d	l	.03	343.2	331,2	12.	28.4	28.	......	12.	6.7	5.3	3.68	.288	.208	.08	.516	.42	.096	.23	.52
7944	" 17	" 18	d	l	....	240.4	221.6	18.8	27.2	26.	25.	6.8	6.7	.1	1.64	.288	.144	.144	.74	.484	.256	.275	.72
8012	" 23	" 24	d	l		244.4	216.8	27.6	24.4	23.6	25.	7.7	5.4	2.3	2.04	.272	.096	.176	.76	.42	.34	.18	.32

8002	July	31	Aug.	1		m	.02	337.2	191.6	145.6	44.8	28.	17.	12.5	5.2	7.3	1.216	.432	.192	.24	1.14	.58	.56	.18	.78
8128	Aug.	7	"	9	d	l	.01	254.8	233.6	21.2	43.2	38.8	26.	6.6	4.	2.6	2.56	.288	192	.096	.648	.488	.16	.13	.44
8191	"	14	"	16	d	l	.01	240.8	196.	44.8	20.4	19.6	23.5	7.4	3.6	3.8	1.84	.488	128	.32	.932	.3	.632	.15	.56
8247	"	20	"	22	d	l	.02	260.8	226.	34.8	22.8	22.	18.	5.8	5.1	.7	1.12	.368	.24	.128	.796	.252	.544	.22	1.64
8338	"	30	"	31	d	l	.02	309.6	230.8	78.8	35.2	26.	19.	12.5	4.4	8.1	1.536	.576	.224	.352	1.052	.332	.78	.08	.68
8382	Sept.	5	Sept.	6	d	c	.02	269.6	227.2	42.4	25.6	14.4	22.	8.4	4.	4.4	1.536	.432	.224	.208	.924	.4	.524	.225	.68
8484	"	10	"	11	d	l	*.04 *.2	250.4	246.4	4.	22.	19.6	29.	7.6	4.8	2.8	2.4	.256	.24	.016	.588	.544	.044	.15	.46
8505	"	19	"	20		. . .	.15	266	263.2	2.8	22.	21 6	26.	8.9	6.7	2.2	2.72	.336	.272	064	.54	.576	......	.008	.48
8541	"	25	"	26	d	l	.05	269.2	238.	31.2	27.0	26.	29.	8.	4.	4.	4.48	.544	.112	.432	.924	.4	.524	.08	.36
8626	Oct	4	Oct.	6	d	c	.02	272.4	194.8	77.0	26.	18.4	23.	9.5	4.6	4.9	1.6	.4	.176	.224	.926	.464	.464	.12	.28
8666	"	15	"	16	d	l	.02	272.	199.6	72.4	23.0	18.8	24.	9.7	6.1	3.6	2.88	.512	288	.224	1.44	.624	.816	.25	.27
8691	"	22	"	23	d	l	.02	235.2	197.6	37.6	28.	21.2	22.	8.5	5.6	2.9	2.72	.32	.288	.032	1.168	.72	.448	.15	.61
8718	"	29	"	30	d	l	.01	259.6	209.6	50.	24.4	15.6	17.	8.7	5.2	3.5	1.6	.384	128	.256	.98	.384	.496	.22	.26
8750	Nov.	8	Nov.	9	d	l	.04	254.8	214.	40.8	22.4	21.6	17.	7.5	4.4	3.1	1.56	.352	.16	.192	.992	512	.48	.07	.25
8779	"	13	"	14	d	l	.02	250.8	197.6	53.2	18.8	16.4	24.	8.1	5.2	2.9	.256	48	.272	.208	1.2	.672	.528	.07	.49
8815	"	21	"	23	d	c	.08	296.4	204.8	91.6	30.	18.8	15.	12.	7.4	4.6	1.76	512	.224	.288	1.36	.672	.688	.05	.55
8833	"	27	"	28	d	l	1	275.	236.4	38.6	24.8	20.	20.	8.	6.1	1.9	1.84	.448	.208	.24	.912	.512	.4	.045	.905
8855	Dec.	3	Dec	4	d	l	.05	247.2	223.6	23.6	18.	16.8	18.	8.2	6.1	2.1	1.6	.448	24	.208	.976	.576	.4	.06	.5
8882	"	10	"	11	d	l	.12	224.8	216.4	8.4	23.2	22.	18.	7.3	7.1	.2	1.568	.576	.192	.384	.912	.48	.432	.025	.375
8906	"	17	"	19	d	l	.05	237.6	224.8	12.8	24.4	22.8	15.	8.3	7.5	.8	1.6	.352	304	.048	.848	.592	.240	.013	1.227
8928	"	27	"	28	d	l	.03	229.6	196.	33.6	16.	15.2	15.	8.4	6.	2.4	1.68	.352	.256	.096	.976	.56	.416	.014	.386
Average Ja.	5—June 26						.....	307.1	248.4	58.6	30.8	24.3	26.	11.8	7.9	3.9	2.596	.072	.331	.34	1.413	.767	.646	.061	.848
Average July	5—Dec. 27						....	263.6	232.1	41.4	26.	22.	21.1	12.9	5.4	7.5	1.553	.394	.207	.186	.91	.494	.415	.135	.587
Average Jan.	5—Dec. 27						.....	285.3	235.3	50.	28.4	23.2	23.1	12.3	6.7	5.6	2.075	.535	.269	.265	1.162	.631	.531	.108	.717

During periods of high water and from Jan 5th to July 11th the water was odorless, except Jan. 26th, when it was gassy. From June 19th to end of year it varied, but was generally musty. Color on ignition was nearly always brown.

* n. f.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT OTTAWA.
(Parts per 1,000,000.)

Serial Number.	1899 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved.	Suspended	Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
5342	June 19	June 20	d	l	.3*.4	392.8	383.2	9.6	61.6	53.4	30.	15.9	15.8	.1	1.36	.544	.512	.032	1.24	.984	.256	.5	1.28
5295	" 26	" 27	d	l	.3	402.8	400.4	2.4	24.	23.6	47.	15.5	14.9	.6	3.28	.512	.496	.016	1.24	1.176	.064	.6	.6
5334	July 3	July 4	d	l	.15*.2	392.	374.4	17.6	43.6	26.8	45.	14.5	13.	1.5	3.28	.516	.432	.084	1.16	1.016	.144	.575	1.4
5386	" 10	" 11	d	l	.2*.4	406.	394.4	11.6	46.8	46.8	65.2	14.2	12.9	1.3	5.12	.48	.4	.08	1.24	.96	.28	.75	1.84
5432	" 17	" 18	d	c	.06	394.4	340.4	54.	39.6	30.2	47.	12.6	9.9	2.7	3.76	.384	.304	.08	1.24	.792	.448	.5	.44
5481	" 24	" 25	d	c	.2	408.	374.8	33.2	59.2	54.	36.5	13.4	12.	1.4	.96	.48	.364	.116	1.24	.952	.288	.55	1.72
5534	" 31	Aug. 2	d	c	.2	419.2	396.4	22.8	64.4	64.4	45.	14.3	12.7	1.6	4.48	.592	.432	.16	1.4	.824	.576	.7	2.6
5579	Aug. 7	" 8	d	l	.05	376.8	369.6	7.2	72.8	55.6	54.	12.5	11.5	1.	4.	.512	.304	.208	1.16	.856	.304	.875	2.6
5631	" 14	" 15	s	c	.1*.15	380.4	374.	6.4	60.	....	60.5	11.7	10.8	.9	4.24	.416	.32	.096	.856	.696	.16	.55	1.32
5677	" 21	" 22	s	l	.08*.1	393.2	392.8	.4	51.2	49.2	69.	11.9	11.7	.2	3.08	.448	.416	.032	.76	.68	.08	.95	2.6
5734	" 28	" 29	d	c	.15	432.8	411.2	21.6	47.6	42.8	75.5	14.3	12.3	2.	3.04	.688	.416	.272	1.56	.744	.816	1.25	2.8
5798	Sept. 4	Sept. 6	s	l	.06*.1	438.	436.	2.	51.2	49.6	88.	11.2	10.9	.3	4.8	.364	.352	.012	.856	.824	.032	1.125	3.
5839	" 11	" 12	s	l	.07*.1	436.4	426.	10.4	36.4	29.6	93.5	11.8	11.5	.3	6.08	.48	.368	.112	1.112	.696	.416	.9	2.24
5881	" 18	" 19	s	l	.04*.06	428.4	414.	14.4	33.6	30.	90.7	11.4	8.4	3.	7.08	.496	.288	.208	1.16	.824	.336	.375	1.48
5936	" 25	" 26	d	l	.08	402.4	389.2	13.2	30.4	24.4	82.5	10.2	8.4	1.8	6.4	.512	.448	.064	1.06	.836	.224	.375	2.4
5995	Oct. 3	Oct. 4	d	c	.2	444.	440.	4.	43.6	40.4	97.	11.9	11.7	.2	7.54	.464	.432	.032	.9	.836	.064	.4	3.
6062	" 9	" 10	d	l	.15*.2	438.8	429.2	9.6	37.6	29.2	85.	9.5	9.5	0.0	8.8	.544	.512	.032	1.06	.964	.096	.4	1.48
6084	" 16	" 18	d	l	.04*.2	366.8	319.6	47.2	51.6	44.8	70.	9.4	9.3	.1	8.8	.4	.368	.032	1.	.52	.48	.175	.68
6153	" 23	" 25	s	l	.1*.15	372.	356.4	15.6	20.	19.6	69.5	8.4	8.1	.3	6.08	.384	.352	.032	.92	.68	.24	.625	2.2
6198	" 30	Nov. 1	s	l	.1*.15	370.8	349.2	21.6	19.6	....	61.5	7.	7.	0.0	8.	.384	.32	.064	.744	.648	.096	.225	.88
6241	Nov. 6	" 7	d	l	.05*.25	390.	369.6	20.4	36.	18.	65.	7.7	7.1	.6	7.52	.512	.432	.08	1.064	.712	.352	.15	.64
6277	" 13	" 14	s	l	.06*.1	364.4	358.	6.4	34.8	28.	30.	6.9	6.8	.1	4.8	.448	.352	.096	.68	.488	.192	.225	.56
6335	" 20	" 21	s	l	.04*.06	368.4	360.	8.4	31.6	18.	45.6	7.8	7.5	.3	4.8	.528	.4	.128	1.196	.936	.26	.25	2.2
6401	" 27	" 28	s	l	.03*.04	381.6	373.6	8.	27.6	23.2	47.	8.3	8.1	.2	5.28	.432	.416	.016	.936	.84	.096	.27	2.
6504	Dec. 11	Dec. 14	d	l	.08	371.2	365.6	5.6	35.6	34.4	44.5	11.2	10.9	.3	5.6	.608	.512	.096	1.48	.968	.512	.018	1.2
6575	" 21	" 23	d	c	.05	361.	332.4	28.6	27.2	23.6	36.	15.5	9.9	5.6	3.68	.8	.528	.272	1.48	.84	.64	.055	3.
6595	" 28	" 29	d	c	.04	339.6	327.2	12.4	24.8	23.2	24.5	11.9	10.7	1.2	2.4	.528	.304	.224	1.256	.936	.32	.05	4.
Average June 19—June 26..........						397.6	391.8	6.	42.8	38.5	38.5	15.7	15.3	.3	2.32	.528	.504	.024	1.24	1.08	.16	.55	.94
Average July 3—Dec. 28...... ..						395.	378.6	16.8	41.4	32.5	61.1	10.9	9.7	1.2	5.2	.496	.391	.105	1.1	.803	.297	.492	1.957
Average June 19—Dec. 28..........						395.2	379.6	15.8	41.2	35.6	59.4	11.3	10.5	1.	4.99	.496	.399	.090	1.111	.824	.287	.496	1.857

*Not Filtered.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT OTTAWA.

(Parts per 1,000,000.)

Serial Number.	1900 Date of		Appearance			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
6628	Jan. 4	Jan. 5	d	c	.07	414.4	410.	4.4	39.6	38.	30.	14.8	13.6	1.2	4.8	.656	.464	.192	1.56	.936	.624	.2	2.2
6677	" 11	" 12	d	c	.07	364.4	352.8	11.6	37.2	33.6	40.	11.2	9.4	1.8	4.4	.736	.512	.224	1.44	.56	.88	.13	1.28
6724	" 18	" 20	d	c	.04	351.2	334.	17.2	24.6	24.	31.	9.3	8.5	.8	3.2	.512	.368	.144	.96	.8	.16	.035	1.48
6771	" 25	" 27	d	c	.06	330.4	278.4	52.	38.4	37.6	25.	11.5	6.6	4.9	2.56	1.056	.32	.736	1.92	.672	1.248	.035	1.08
6844	Feb. 5	Feb. 7	d	l	.03	236.	235.2	.8	20.4	19.2	21.	7.4	5.9	1.5	1.76	.416	.256	.16	.88	.544	.336	.02	.72
6949	" 20	" 22	d	c	.2	312.	290.4	21.6	46.4	28.8	17.	9.1	7.9	1.2	1.76	.496	.304	.192	.8	.576	.224	.06	2.6
7024	Mar. 5	Mar. 7	d	l	.3	326.4	324.	2.4	28.4	26.	19.	11.5	10.6	.9	1.76	.384	.32	.064	.896	.704	.192	.044	2.
7077	" 12	" 14	d	m	.04	262.4	166.	96.4	24.	16.8	8.5	12.6	6.3	6.3	.864	.512	.256	.256	1.28	.48	.8	.092	1.48
7127	" 20	" 26	d	c	.02	194.8	184.	10.8	7.2	6.8	3.2	4.1	3.6	.5	.576	.176	.144	.032	.392	.344	.048	.032	1.04
7174	" 27	" 29	d	l	.04*.1	315.6	309.2	6.4	34.8	30.8	8.	15.1	9.4	5.7	1.2	.352	.224	.128	.76	.6	.16	.07	3.2
7231	Apr. 3	Apr. 5	d	l	.03	380.4	368.	12.4	15.6	12.	7.2	8.1	7.9	.2	1.12	.336	.256	.08	.728	.6	.128	.06	1.76
7289	" 10	" 12	d	c	.15	391.6	382.8	8.8	16.8	14.4	8.9	10.3	9.3	1.	1.2	.512	.32	.192	1.112	.792	.32	.09	2.8
7339	" 17	" 19	d	c	.04	422.8	418.8	4.	36.8	33.2	8.3	12.6	11.3	1.3	.608	.768	.44	.328	1.72	1.08	.64	.08	2.4
7407	" 24	" 26	d	c	....	379.2	366.8	12.4	29.2	29.2	7.1	12.2	11.2	1.	.24	.96	.528	.432	1.88	1.016	.864	.07	1.04
7448	May 1	May 3	d	c	.1	336.4	251.2	85.2	26.8	16.4	11.4	14.2	9.1	5.1	.56	.48	.288	.192	1.12	.8	.32	.14	1.48
7488	" 8	" 10	d	c	.03	269.2	228.	41.2	33.6	25.2	16.2	9.1	8.1	1.	1.12	.416	.288	.128	.96	.68	.28	.3	.92
7546	" 15	" 17	..	...	.05	302.	278.	24.	44.4	42.	18.4	9.3	8.	1.3	.576	.416	.224	.192	1.06	.484	.576	.35	1.68
7598	" 22	" 24	d	c	.05	280.	258.8	21.2	42.	35.2	14.2	8.5	7.3	1.2	.48	.24	.128	.112	.804	.612	.192	.02	1.4
7671	June 5	June 6	d	c	.03	259.6	217.2	42.4	42.	36.	18.	8.6	6.	2.6	.704	.288	.128	.16	.74	.468	.272	.55	1.76
7701	" 11	" 13	d	l	.03	308.4	288.8	19.6	42.8	27.2	27.	8.7	7.7	1.	1.04	.288	.16	.128	.74	.48	.26	.5	2.8

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT OTTAWA—CONTINUED.

(Parts per 1,000,000.)

Serial Number.	1900		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
	Date of								Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
7744	June 18	June 20	d	l	.01	257.2	240.	17.2	26.	26.	23.	6.6	6.9	.4	1.36	.224	.192	.032	.532	.372	.16	.18	1.9
7785	25	27	v	m	.01	235.2	230.8	4.4	34.	31.6	23.	5.7	5.4	.3	.656	.256	.192	.064	.528	.484	.044	.45	1.2
7819	July 2	July 4	d	l	.03	249.2	243.2	6.	27.6	22.8	22.5	7.2	5.8	1.4	.21	.208	.16	.048	.456	.28	.176	.8	2.16
7891	9	11	d	l	.1	256.8	243.2	13.6	35.2	25.6	25.	5.7	4.7	1.	.496	.176	.144	.032	.484	.292	.192	.425	1.86
7936	16	17	d	l	.02	417.6	261.2	156.4	40.4	31.6	27.	5.4	4.8	.6	.376	.176	.112	.064	.484	.244	.24	.4	1.64
7987	23	24	d	l	.02	238.4	217.2	21.2	19.2	17.6	22.	6.9	5.1	1.8	.336	.176	.096	.08	.596	.452	.144	.325	1.48
8046	30	31	d	l	.02	261.6	238.4	23.2	28.	28.	20.	7.6	6.9	.7	.704	.272	.192	.08	.628	.42	.208	.4	1.68
8138	Aug. 6	Aug. 9	d	l	....	236.4	217.2	19.2	35.2	....	22.	6.3	5.	1.3	.144	.288	.272	.016	.516	.468	.048	.6	1.72
8170	13	15	d	l	.01	218.4	192.4	16.	36.	19.2	24.	4.8	3.9	.9	.704	.272	.176	.096	.52	.284	.236	.325	1.44
8242	20	21	d	l	....	226.4	224.	2.4	34.8	14.8	22.	6.1	4.3	1.8	.576	.24	.144	.096	.54	.332	.208	.45	1.52
8297	27	28	d	l	....	280.8	250.4	30.4	21.6	20.8	32.	6.9	4.7	2.2	1.8	.192	.192	.00	.732	.62	.112	.475	1.12
8365	Sept. 4	Sept. 5	d	c	.03	234.8	220.	14.8	20.	17.2	20.	6.1	4.5	1.6	.288	.27	.208	.062	.344	.28	.064	.3	1.68
8432	10	11	d	l	.1*.1	300.	282.8	17.2	31.6	27.2	28.	8.7	6.	2.7	.576	.32	.304	.016	.764	.496	.268	.5	1.8
8484	17	18	s	l	.02*.02	248.4	231.2	17.2	28.	19.2	29.	7.7	4.1	3.6	2.24	.4	.192	.208	.764	.32	.444	.017	1.04
8536	24	25	d	c	.08*.1	321.	320.8	.2	38.8	26.	54.	8.1	6.7	1.4	4.8	.48	.224	.256	.7	.64	.06	.3	1.28
8595	Oct. 1	Oct. 2	s	l	.04*.05	223.6	217.2	6.4	20.8	19.6	27.	5.2	4.3	.9	1.52	.288	.128	.16	.528	.368	.16	.275	1.28
8634	6	8	s	l	.03*.08	211.6	198.	13.6	29.4	19.2	22.	5.6	4.6	1.	1.216	.192	....	... .	.512	.304	.208	.25	.87
Average Jan. 4—June 25............						314.9	291.5	23.4	31.4	26.8	17.9	10.	8.1	1.8	1.479	.476	.285	.191	1.036	.641	.395	.156	1.7
Average July 2—Oct. 6............						261.6	237.1	24.5	29.3	23.8	26.4	6.5	5.	1.5	1.07	.263	.186	.076	.571	.386	.185	.369	1.5
Average Jan. 4—Oct. 6............						293.3	269.4	23.8	30.5	25.6	21.4	8.6	6.8	1.7	1.313	.39	.245	.144	.848	.537	.31	.25	1.62

*Not Filtered.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT OTTAWA

(Parts per 1,000,000.)

Serial Number.	1901 Date of Collection.	1901 Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Ammonia. Total.	Nitrogen as Ammonia. Albuminoid Ammonia. Dissolved.	Nitrogen as Ammonia. Albuminoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended	Nitrogen as Nitrites.	Nitrogen as Nitrates.
9202	July 20	July 23	d	1	.05	290.4	283.2	7.2	75.2	73.2	26.	8.6	7.8	.8	1.264	.224	.16	.004	1.072	.688	.384	.5	.9
9203	“	“	d	1	.04	233.6	225.2	8.4	23.2	18.8	25.	7.1	6.	1.1	.288	.192	.16	.032	1.572	.432	1.14	.75	2.13
9204	“	“	d	1	.01*.05	224.8	221.6	3.2	17.2	17.2	26.	6.8	6.2	.6	.288	.224	.16	.064	1.552	.432	1.12	.9	1.96
9205	“	“	d	1	.1	307.2	274.	33.2	79.2	64.	26.	7.4	6.8	.6	.64	.24	.208	.032	1.072	.704	.368	.45	1.11
9278	Aug. 5	Aug. 6	d	1	.08*.1	230.4	216.4	14.	28.8	26.8	28.	6.8	6.6	.2	1.552	.256	.224	.032	.544	.512	.032	.44	.8
9288	“ 8	“ 9	d	1	.05*.05	204.8	204.4	.4	25.6	36.	23.	7.7	6.8	.9	1.216	.24	.208	.032	.576	.368	.208	.4	1.
9305	“ 16	“ 19	d	1	.02	211.2	188.8	22.4	17.2	17.2	20.	6.4	6.1	.3	.192	.224	.144	.08	.56	.448	.112	.625	1.375
9334	“ 29	“ 30	d	1	.04	221.2	198.8	22.4	22.	26.4	24.	6.1	6.	.1	1.28	.24	.16	.08	.656	.512	.144	.5	.94
9355	Sept. 6	Sept. 7	d	1	.01*.02	212.	186.8	25.2	16.4	16.4	21.	5.5	5.1	.4	.48	.208	.16	.048	.48	.48	.....	.45	1.03
9368	“ 12	“ 14	d	1	.01*.02	196.4	184.8	11.6	16.	16.	19.	5.5	4.0	.6	.608	.224	.144	.08	.....	....	.....	.375	1.065
9396	“ 20	“ 21	d	1	.03	239.2	233.6	5.6	24.4	....	28.	6.8	6.5	.3	1.152	.208	.16	.048	.....	....	.....	.35	1.05
9414	“ 26	“ 28	d	1	.03	219.2	206.	13.2	29.2	35.2	20.5	5.7	5.7	...	.752	.224	.128	.096	.....	....	.....	.325	1.155
9433	Oct. 3	Oct. 5	d	1	.1	202.8	190.4	12.4	10.4	20.	20.	6.7	6.4	.3	.101	.224	.224	....	.....	....	.....	.275	.925
9473	“ 10	“ 14	d	1	.04*.05	190.	172.	18.	10.	13.6	20.	6.3	...	...	.208	.176	.144	.032	.....	....	.....	.6	1.8
9537	“ 22	“ 23	d	1	.05	221.6	186.4	35.2	20.8	13.6	20.	6.2	5.3	.9	.8	.24	.192	.048	.....	....	.....	.16	1.12
9615	“ 29	“ 30	d	1	.04	197.6	166.8	30.8	14.	12.8	19.5	6.8	5.2	1.6	.752	.224	.192	.062	.....	....	.....	....	.. ..
Average July 20—Oct. 28.........						225.1	206.7	16.4	20.8	25.4	23.4	6.6	5.8	.8	.97	.223	.173	.06	.808	.508	.39	.454	1.200

*Not filtered.

CHEMICAL EXAMINATION OF WATER IN THE ILLINOIS RIVER AT LA SALLE.

(Parts per 1,000,000.)

Serial Number.	1897 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.							Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.		Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Total.	Dissolved.	Suspended	Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
1802	Jan. 5	Jan. 6	vd	m	.8	420.	271.2	148.8	30.8	8.	10.	21.5	9.2	12.3	.468	.96	.56	.4	1.76	1.42	.34	.08	4.
1826	" 14	" 15	vd	c	5*.8	340.4	314.4	26.	20.8	20.	9.	12.6	9.4	3.2	.4	.52	.4	.12	1.12	.88	.24	.04	3.5
1834	" 19	" 19	vd	c	.2	422.	305.2	116.8	21.6	44.4	8.	14.8	6.9	7.9	.48	.64	.4	.24	1.44	.8	.64	.04	2.8
1876	Feb. 2	Feb. 1	c	l	.1	352.8	349.2	3.6	13.2	6.8	10.	9.1	8.9	.2	.88	.48	.368	.112	1.28	1.4	.24	.045	2.2
1894	" 8	9	s	l	1*.15	346.8	343.2	3.6	14.	10.	13.	10.	7.8	2.2	1.2	.36	.28	.8	.88	.8	.08	.065	2.2
1925	" 17	" 18	d	l	1*.15	311.2	290.	21.2	14.	7.6	9.	10.4	6.8	3.6	.76	.72	.24	.48	1.12	.88	.24	.025	2.2
1943	" 24	" 25	d	c	.4	320.4	283.2	37.2	43.6	36.8	5.2	9.3	6.2	3.1	2.08	.48	.32	.16	.96	.72	.24	.03	3.2
1958	Mar. 1	Mar. 2	s	l	3*.4	288.4	269.6	18.8	48.4	45.6	8.	9.8	7.1	2.7	.56	.52	.48	.4	1.35	.91	.44	.02	3.1
1978	" 8	" 9	d	c	.1	312.	240.	72.	44.8	38.	7.	13.1	7.6	5.5	.64	.56	.4	.16	1.23	.95	.48	.04	2.3
2009	" 15	" 16	d	c	.3	334.	266.4	67.6	39.2	35.6	6.	13.3	7.8	5.5	.46	.64	.24	.4	1.07	.61	.4	.065	3.1
2036	" 22	" 23	d	m	.6	425.2	237.6	187.6	54.	42.8	3.4	22.	7.5	18.5	.112	.96	.32	.64	1.55	.6	.95	.045	3.3
2058	" 29	" 30	d	c	.5	352.	284.4	67.6	46.8	44.	6.	12.	5.7	6.3	.08	.4	.16	.24	.83	.68	.15	.045	2.8
2098	Apr. 5	Apr 7	d	c	.8	346.	296.	50.	43.2	31.6	8.	9.	6.	3.	.176	.48	.176	.304	1.07	.67	.4	.067	3.2
2120	" 12	" 14	d	c	.2	367.2	281.6	85.6	34.4	28.4	8.	13.5	8.9	4.6	.496	.44	.272	.168	.91	.75	.16	.08	2.4
2138	" 20	" 22	d	l	*.15	337.2	366.2	22.	49.2	48.	10.	15.5	8.9	6.6	.8	.48	.336	.144	1.	.69	.31	.12	1.6
2467	" 29	" 30	d	c	1*.2	337.2	315.6	21.6	44.8	37.2	10.	12.8	9.3	3.5	.56	.64	.368	.272	1.35	1.03	.32	.25	2.2
2199	May 10	May 4	d	l	.7	331.2	302.	29.2	36.4	30.	11.	14.1	10.3	3.8	.32	.4	.32	.08	2.15	1.11	1.04	.24	1.7
2228	" 17	" 11	d	c	.15	342.8	303.2	39.6	48.	36.4	12.	13.3	8.6	4.7	.272	.88	.288	.592	1.23	.75	.48	.25	1.9
2256	" 24	" 19	d	l	.3	332.4	318.	14.4	43.6	32.4	18.	11.8	9.2	2.6	.72	.64	.56	.08	1.23	.83	.4	.35	1.9
2277	" 31	May 25	d		.1	342.8	306.4	26.4	26.8	18.	17.	13.2	11.6	1.6	.8	.72	.4	.32	1.4	1.	.4	.32	1.4
2313	June 10	June 1	d	m	.2	340.2	319.2	80.	48.	33.2	20.	13.6	12.	7.6	.8	.8	.48	.32	1.37	1.21	.16	.575	2.
2325	" 15	" 12	d	o	.08	348.	336.	12.	36.	34.	20.	14.8	12.5	2.3	.256	.72	.4	.32	1.85	1.29	.56	.875	1.8
2360	" 22	" 16	d	c	3	345.2	268.	177.2	45.6	32.	11.	15.1	11.3	3.8	.32	.56	.4	.16	1.7	1.05	.65	.6	2.5
2395	" 30	" 23	d	c	.15	372.8	352.	20.8	54.	50.	18.	17.5	11.1	6.4	.4	.4	.32	.8	1.37	1.13	.24	.65	2.7
2428	July 8	July 1	d	c	.15	371.2	308.	63.2	46.	26.	23.	13.7	11.4	2.3	.24	.56	.38	.18	1.32	1.08	.24	1.	1.5

2448	July 15	July 16	d	c	.15	388.	354.	34.	32.	28.	31.	16.9	14.2	2.7	1.28	.88	.608	.272	1.72	1.4	.32	1.	1.7
2477	22	23	d	c	3	344.	305.2	38.8	28.	20.	23.	16.5	14.7	1.8	1.28	.72	.48	.24	1.56	1.24	.22	.675	.7
2510	30	31	d	l	.2	379.9	342.	37.9	48.	34.	39.	14.	11.8	2.2	1.12	.8	.56	.24	1.4	1.	.4	.85	1.6
2531	Aug. 4	Aug. 5	d	c	.1	358.	334.4	23.6	28.	24.4	42.	13.5	12.2	1.3	.48	.72	.416	.304	1.2	1.04	.16	.95	3.
2551	12	13	d	c	.15	440.	404.4	35.6	68.	58.2	60.	12.6	12.	.6	2.24	.56	.416	.144	1 16	1.	.16	.125	2.5
2583	1	23	d	c	.1	433.6	388.8	44.8	62.	56.8	58.	13.2	11.5	1.7	1.31	.8	.384	.416	1.4	1.	.4	.7	2.2
2608	27	30	d	c	.15	421.	402.	19.	46.	40.	71.	13.8	10.8	3.	1.76	.56	.4	.16	1.14	.74	.4	1.6	2.5
2626	Sept. 3	Sept. 4	d	c	.15*.3	388.8	376.	12.8	28.8	28.	66.	13.3	10.5	2.8	2.4	.56	.36	.2	1.06	.98	.08	1.5	1.8
2660	10	13	d	c	.2	363.2	341.2	22.	26.	22.8	55.	12.5	9.8	2.7	.48	.52	.4	.12	1.06	.9	.16	.2	1.
2685	18	20	d	c	.1	469.2	377.6	91.6	33.2	24.8	69.	13.5	9.8	3.7	5.2	.72	.4	.32	1.14	.74	.4	.6	2.
2714	24	27	d	c	.05	410.4	384.	26.4	29.2	24.	67.	12.5	10.7	1.8	2.4	.54	.36	.2	.86	.74	.12	1.	3.5
2738	Oct. 1	Oct. 2	d	c	.05	4 3.2	394.	29.2	47.6	28.	73.	13.3	11.	2.3	3.6	.53	.36	.16	.86	.78	.08	1.375	2.6
2786	12	13	d	l	.15	4 3.8	388.4	34.8	43.2	30.6	68.	12.4	10.7	1.7	5.6	.48	.4	.08	1.02	78	.24	.55	1.9
2820	19	20	d	c	.1	4 1.6	376.	35.6	30.4	29.2	65.	12.9	8.	4.9	5 6	.64	.52	.12	.98	.62	.36	.075	1.7
2866	29	Nov. 1	s	l	.05	379.9	364.	15.2	36.	32.	61.	13.	10.2	2.8	3.	.44	.4	.04	.78	.7	.08	.45	1.5
2907	Nov. 6	8	d	l	.1*.15	365.2	356.8	8.4	36.	28.	59.	10.8	9.	1.8	5.	.44	.36	.08	1.1	.86	.24	.35	1.8
2962	16	18	d	c	.15	344.8	335.2	9.6	24.4	21.2	45.	10.6	8.	2.6	4.	.44	.36	.08	.78	.62	.16	.025	1.2
2993	27	29	d	l	.1	355.6	334.8	20.8	28.4	26.	34.	9.6	7.5	2.1	2.88	.44	.32	.12	1.18	.86	.32	.15	.7
3047	Dec. 10	Dec. 11	d	c	.15	416.	411.6	4.4	26.	23.6	53.	12.3	11.	1.3	4.6	.64	.34	.28	1.57	.81	.76	.13	.8
3070	15	16	d	l	.08*.1	355.2	349.6	5.6	31.2	25.6	39.	9.	7.3	1.7	4.8	.52	.44	.08	.93	.69	.24	.2	.9
3108	29	30	d	l	.15	449.2	440.	9.2	31.2	22.8	51.	13.4	10.9	2.5	6.	.68	.48	.2	1.38	1.05	.28	.2	1.2
Average Jan. 5th—June 30th.......						351.1	299.	52.	37.5	30.	11.3	13.4	8.7	4.6	.507	.6	.334	.246	1.3	.89	.41	.204	2.5
Average July 8th—Dec. 29th.......						394.9	367.2	28.2	36.3	29.8	52.3	12.8	10.5	2.2	3.06	.6	.416	.183	1.16	.89	.269	.095	1.7
Average Jan. 5th—Dec. 29th						272.1	331.4	40.6	36.9	29.9	30.9	13.1	9.6	3.5	1.728	.6	.384	.216	1.23	.39	.343	.441	2.1

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT LASALLE.

(Parts per 1,000,000)

Serial Number.	1898 Date of Collection.	1898 Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Ammonia. Total.	Nitrogen as Ammonia. Albuminoid Ammonia. Dissolved.	Nitrogen as Ammonia. Albuminoid Ammonia. Suspended	Organic Nitrogen. Totol.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspenced	Nitrogen as Nitrites.	Nitrogen as Nitrates.
3127	Jan. 4	Jan. 5	s	l	.1 *.2	387.2	383.6	3.6	34.8	32.8	35.	9.	7.7	1.3	4.	.64	....	....	1.40	.97	.52	.1	.6
3175	" 18	" 19	d	l	.2 *.4	388.8	378.	10.8	18.	16.	26.	9.3	7.7	1.6	2.6	.52	.4	.12	1	.72	.28	.08	1.3
3192	" 21	" 24	d	m	.4	402.	296.	106.	36.	26.	16.	14.3	7.5	6.8	1.6	.6	.32	.28	1.08	.72	.36	.2	1.9
3230	Feb. 4	Feb. 5	d	l	.15*.3	370.8	366.8	4.	34.	31.6	14.	6.8	5.5	1.3	.64	.36	.24	.04	.44	.32	.12	.15	4.8
3262	" 14	" 15	d	c	.2	202.8	155.2	47.6	29.2	28.	2.	13.6	9.2	4.4	.2	.44	.272	.168	1.16	.64	.52	.03	1.1
3365	Mar. 17	Mar. 18	d	c	.2	290.4	255.2	35.2	41.2	34.8	3.6	10.6	8.2	2.4	.2	.4	.36	.04	.92	.72	.2	.035	1.1
3421	April 4	April 4	d	l	.15*.4	297.6	272.4	25.2	37.2	36.	6.	9.8	8.7	1.1	.148	.04	.36	.04	.85	.65	.2	.025	1.4
3439	" 9	" 11	d	l	.15*.4	296.4	286.4	10.	23.2	22.	7.	12.3	11.6	.7	.44	.56	.48	.08	.97	.85	.12	.03	1.
3456	" 15	" 16	d	c	.15*.3	321.2	286.8	34.4	34.8	27.6	9.	13.6	12.6	1.	.72	.56	.48	.08	1.25	.93	.32	.065	.4
3499	" 25	" 26	d	c	.06*.12	324.8	308.	16.8	38.8	36.	15.	13.	11.5	1.5	1.16	.36	.44	.08	1.17	.85	.32	.17	.85
3524	May 2	May 3	d	c	.1	420.	322.4	97.6	40.	36.	16.	14.3	8.6	5.7	.88	.6	.44	.16	1.43	.94	49	.23	.6
3545	" 9	" 10	d	c	.05*.3	345.2	324.	21.2	44.8	42.	16.	12.	8.	4.	.68	.44	.36	.08	1.06	.78	.28	.20	1.
3571	" 13	" 14	d	c	.06*.15	412.	356.4	55.6	70.8	62.8	21.	14.2	9.5	4.7	1.	.52	.44	.08	1.3	.86	.44	.25	.65
3598	" 20	" 23	d	m	.04	984.	273.2	710.8	62.	44.	10.	29.	11.8	17.2	.4	1.2	.52	.68	3.14	.78	2.36	.14	.9
3696	June 16	June 17	d	m	....	408.8	303.6	105.2	41.6	40.4	15.	13.5	8.3	5.2	.48	.52	.32	.2	1.04	.68	.36	.3	.45
3727	" 24	" 25	d	m	....	457.2	298.4	158.8	39.6	26.4	20.	13.	7.2	5.8	.24	.68	.28	.4	1.24	.76	.48	.35	1 85
3777	July 5	July 6	d	c	....	370.4	309.6	60.8	40.	28.8	16.	13.8	8.1	5.7	.016	.64	.36	.28	1.4	.76	.64	.28	.5
3869	" 25	" 26	d	c	.04	410.4	356.	54.4	30.	27.2	82.	14.2	10.8	3.4	.8	.72	.44	.28	1.52	1.04	.48	.8	.5
3917	Aug. 6	Aug. 8	d	c	.04	467.6	379.6	88.	42.	35.2	65.	16.5	8.8	7.7	2.2	.88	.4	.48	1.84	.92	.92	.8	.6
3944	" 11	" 12	d	c	.05	424.4	364.8	59.6	36.8	31.6	60.	14.2	9.1	5.1	2.64	.64	.44	.2	.96	.76	.2	.8	.85
4016	" 30	" 31	d	c	.04	392.	338.8	53.2	43.2	38.	49.	11.	8.2	2.8	1.6	.48	.36	.12	1.04	.68	.36	1.	.3
4079	Sept 14	Sept. 15	d	c	.05	378.	332.4	45.6	42.8	37.2	40.	10.2	7.	3.2	2.	.4	.28	.12	1.04	.56	.48	.25	.4
4143	" 29	" 30	d	c	.06	405.2	356.8	48.4	58.	36.8	43.	10.6	6.3	4.3	1.76	.48	.32	.16	.88	.6	.28	.33	.5
4177	Oct. 6	Oct. 7	d	c	.05	407.2	367.2	40.	53.6	31.2	50.	10.6	7.3	3.3	4.6	.4	.32	.08	.88	.6	.28	.3	.3
4251	" 24	" 25	d	l	.04	356.8	348.	8.8	36.	32.	31.	7.	6.5	.5	2.4	.32	.24	.08	.61	.40	.12	.12	.5
4306	Nov. 2	Nov. 3	d	l	.03	360.6	304	5.6	38.8	36.	21.	8.	6.	2.	1.28	.32	.28	.04	.65	.57	.08	.09	1.35
4342	" 9	" 10	d	l	.15*.2	380.8	380.4	.4	48.	47.6	21.	7.5	7.	.5	1.28	.4	.28	.12	.71	.55	.16	.09	.6
4455	Dec. 5	Dec. 6	d	l	.08*.06	398.	386.	12.	52.	42.	17.	7.5	7.	.5	1.	.304	.208	.096	.77	.57	.2	.042	1.25
4499	" 19	" 20	s	l	.15*.2	437.2	426.8	10.4	67.2	62.	26.	9.1	8.6	.5	2.	.368	.304	.064	.77	.65	.12	.025	.35
Average Jan. 4th—June 24th........						394.3	304.1	90.1	39.1	33.9	14.4	12.1	8.9	3.2	.974	.555	.357	.198	1.22	.76	.46	.15	1.24
Average July 5th—Dec. 19th........						402.1	364.6	37.4	45.2	37.3	40.	10.7	7.7	3.	1.762	.488	.325	.163	1.74	.67	.97	.372	.6
Average Jan. 4th—Dec. 19th........						397.8	331.3	66.5	41.8	35.4	25.9	11.2	8.4	2.7	1.366	.525	.342	.182	1.15	.72	.43	.25	.96

*Not Filtered.

8528

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT LA SALLE.

(Parts per 1,000,000.)

Serial Number.	1899. Date of Collection.		Appearance. Turbidity.			Residue on Evaporation. Total.			Loss on Ignition. Total.		Chlorine.	Oxygen Consumed. Total.			Nitrogen as Ammonia Free Ammonia.	Albuminoid Ammonia. Total.			Organic Nitrogen. Total.			Nitrogen as Nitrites.	
		Date of Examination.		Sediment.	Color.		Dissolved.	Suspended.		Dissolved			By Dissolved.	By Suspended Matt'r			Dissolved	Suspended		Dissolved	Suspended		Nitrates.
4706	Feb. 15	Feb. 16	d	l	.3	416.	410.	6.	58.	56.	31.	12.6	9.8	2.8	3.2	.528	.4	.128	1.26	.9	.36	.14	.75
4760	Mar. 1	Mar. 2	vd	vm	.6	776.	178.	598.	94.	34.	12.	47.	15.	32	.16	1.608	.32	1.288	3.7	.74	2.9	.035	.9
4886	Apr. 3	Apr. 4	vd	c	.2	262.	224.	38.	42.	38.	9.	13.8	9.8	4.	.56	.52	.352	.168	1.15	.75	.4	.045	1.2
5006	May 5	May 6	d	c	.06	414.4	358.4	56.	45.2	44.	22.	14.2	13.9	.3	1.76	.56	.512	.048	1.29	1.17	.12	.25	1.28
5080	" 24	" 25	d		.04	389.2	364.	25.2	19.6	24.8	16.	14.5	12.8	1.7	.8	.48	.352	.128	1.21	.945	.265	.06	1.6
5116	" 30	" 31	vd	vm	.2	507.6	292.8	214.8	83.2	59.2	11.5	22.1	12.1	10.	.8	.656	.32	.336	1.85	.826	1.024	.2	1.24
5160	June 6	June 7	d	c	.3	354.	308.8	45.2	36.	35.2	9.	15.9	12.6	3.3	.36	.48	.384	.096	1.29	.826	.464	.32	1.32
5219	" 15	" 16	d	m	.3	420.4	350.4	70.	40.8	37.6	47.5	19.2	14.9	4.3	1.28	.608	.352	.256	1.56	1.144	.416	.4	1.22
5250	" 20	" 21	d	c	.3	462.	374.4	87.6	72.	52.	27.	14.8	12.9	1.9	.88	.704	.384	.32	1.32	.856	.464	.35	1.84
52 7	" 27	" 28	d	l	.4	451.2	402.	49.	34.8	27.6	43.5	16.3	14.1	2.2	1.92	.576	.422	.154	1.64	1.16	.48	.56	1.76
5339	July 4	July 5	d	c	.15	412.8	376.4	36.4	52.	49.2	42.	17.	12.9	4.1	1.04	.544	.432	.112	1.56	.92	.64	.55	2.4
5390	" 11	" 11	d		.25	412.4	374.	38.4	53.6	46.8	66.	14.	12.3	1.7	2.8	.512	.368	.144	1.16	.984	.176	1.1	2.8
5442	" 18	" 19	d		.15	350.	292.4	57.6	40.6	43.2	80.	13.6	10.5	3.1	2.48	.608	.272	.336	1.4	.728	.672	.38	1.8
5487	" 25	" 26	d	c	.15	411.6	344.	67.6	60.8	57.6	31.5	13.1	9.8	3.3	.24	.576	.32	.256	1.32	.792	.528	.28	1.76
5538	Aug. 1	Aug. 2	d	c	.25	432.4	377.6	54.8	85.2	78.	47.	16.	12.	4.	1.28	.544	.352	.192	1.3	.868	.432	.7	2.4
5585	" 8	" 9	d	c	.07	407.6	374.4	33.2	60.4	53.2	47.5	13.7	11.5	2.2	.80	.528	.304	.224	1.32	.76	.56	.7	2.8
5637	" 15	" 16	d	c	.15	406.4	385.6	20.8	64.	61.2	57.5	13.3	11.4	1.9	1.6	.496	.352	.144	1.208	.664	.544	.6	2.8
5686	" 22	" 23	d	c	.1	420.4	381.6	38.8	51.2	43.6	64.	13.7	10.8	2.9	1.3	.576	.384	.192	1.24	.888	.352	.34	3.2

5736	Aug. 29	Aug. 30	d	c		.06	418.4	397.2	21.2	51.6	43.6	66.	12.3	9.	3.3	.788	.528	.32	.208	1.32	.92	.4	.75	2.6
5792	Sept. 5	Sept. 6	d	c		.06	492.	426.	66.	32.8	28.	75.5	13.3	7.9	5.4	2.8	.544	.48	.064	1.464	.856	.608	1.	3.5
5845	" 12	" 13	d	c		.06	426.4	393.2	33.2	40.	36.	69.5	12.2	11.1	1.1	4.	.416	.32	.096	1.08	.312	.768	.5	2.4
5893	" 19	" 20	d	l		.03	424.4	392.	32.4	33.2	33.2	73.	11.	7.9	3.1	4.4	.448	.368	.08	1.16	.392	.768	.325	2.4
5941	" 26	" 27	d	c		.04	402.	388.8	13.2	28.	24.8	73.	10.1	8.	2.1	.57	.448	.336	.112	.968	.74	.128	.3	1.88
5997	Oct. 3	Oct. 4	d	c		.15	437.2	421.6	15.6	56.4	49.2	84.5	12.	10.8	1.2	5.92	.448	.416	.032	1.14	.804	.336	.175	1.72
6039	" 10	" 11	d	c		.06	432.	424.8	7.2	26.4	25.2	76.	9.7	9.4	.3	6.08	.464	.416	.048	1.06	.9	.16	.225	1.44
6080	" 17	" 18	d	l		.03	400.4	378.4	22.	33.2	29.2	68.	11.6	9.3	2.3	5.92	.416	.384	.032	1.032	.704	.328	.375	1.88
6149	" 24	" 25	d	c		.1	395.6	353.6	42.	23.2	22.4	60.	10.4	7.8	2.6	4.64	.464	.368	.096	.92	.584	.336	.3	2.
6201	" 31	Nov. 1	d	c		.12	387.6	367.2	20.4	38.4	30.4	53.5	7.7	7.7	0.0	4.32	.4	.288	.112	.84	.612	.228	.275	1.44
6244	Nov. 7	" 8	d	l	.07*	.15	403.6	399.2	4.4	39.8	19.6	54.	7.4	7.1	.3	5.12	.512	.272	.24	1.032	.68	.352	.15	1.16
6296	" 14	" 15	d	l		.06	351.2	341.6	9.6	24.	24.	33.	7.2	7.	.2	3.04	.32	.288	.032	.76	.584	.176	1.5	1.12
6340	" 21	" 22	d	c		.04	348.4	345.2	3.2	36.	34.	36.5	7.5	7.2	.3	[illegible].72	.32	.288	.032	1.196	.68	.516	.325	3.
6405	" 28	" 29		l		.04	402.8	389.2	13.6	50.8	49.2	38.	7.9	7.6	.3	3.84	.368	.32	.048	.936	.744	.192	.24	.512
6465	Dec. 5	Dec. 7	d	c		.1	380.	362.8	17.2	48.4	36.8	42.5	9.4	lo't	.	4.32	.416	.32	.096	1.065	.776	.288	.14	2.08
6508	" 12	" 14	d	c		.06	403.6	373.6	30.	45.6	43.2	42.5	10.	9.5	.5	4.32	.56	.448	.112	1.128	.904	.224	.15	1.4
6545	" 19	" 20	d	c		.3	368.	353.2	14.8	37.2	29.2	31.5	12.3	10.7	1.6	3.84	.648	.528	.12	1.48	1.064	.416	.065	2.8
6588	" 26	" 28	d	c		.06	358.	326.	32.	48.4	48.4	21.	13.9	9.8	4.1	1.98	.432	.32	.112	1.	.872	.128	.065	4.
Average Feb. 15—June 27							465.2	326.2	118.9	53.5	40.8	22.85	19.	12.7	6.2	1.17	.672	.379	.292	1.627	.931	.695	.236	1.31
Average July 4—Dec. 26							403.2	374.6	29.6	46.5	39.9	53.21	11.5	9.5	1.9	3.06	.482	.356	.125	1.154	.759	.394	.442	2.2
Average Feb. 15—Dec. 26							414.9	361.1	53.7	49.	40.2	44.77	13.6	10.4	3.1	2.53	.534	.362	.172	1.285	.807	.477	.385	1.955

*Not Filtered.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT LA SALLE.

(Parts per 1,000,000.)

Serial Number	1900. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.							Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
6605	Jan. 2	Jan. 3	d	c	.04	418.8	418.	.8	53.2	52.4	40.2	11.6	11.	.6	3.84	.64	.512	.128	1.32	1.064	.256	.065	3.58
6652	" 9	" 10	d	c	.05	392.8	389.2	3.6	49.6	46.	39.	11.	9.6	1.4	4.16	.672	.448	.224	1.56	.984	.576	.1	2.
6692	" 16	" 17	d	c	.06	359.2	332.4	26.8	34.8	24.4	24.	9.4	8.5	.9	3.2	.528	.416	.112	1.28	1.024	.256	.08	1.72
6741	" 23	" 24	d	c	.15	327.6	270.8	56.8	32.4	22.	21.7	14.2	9.1	5.1	2.24	.704	.384	.32	1.76	.864	.896	.025	1.6
6792	" 30	" 31	d	c	.05	254.8	239.6	15.2	18.4	14.8	14.	9.4	6.9	2.5	1.36	.32	.24	.08	.8	.544	.256	.04	1.24
6852	Feb. 6	Feb. 7	d	l	.03	276.4	270.	6.4	30.8	29.6	17.	6.7	6.7	...	1.28	.288	.256	.032	.608	.544	.064	.05	.76
6897	" 13	" 14	d	m	.3	454.8	198.8	256.	44.8	24.	11.	18.5	8.6	9.9	.896	.8	.336	.464	1.84	.736	1.104	.07	3.
6939	" 20	" 21	d	c	.2	285.6	259.2	26.4	52.8	39.6	14.2	8.9	8.8	.1	1.152	.448	.304	.144	1.12	.736	.384	.035	2.6
6987	" 27	" 28	d	c	.4	276.	222.8	53.2	56.8	30.8	14.7	8.8	7.8	1.	1.04	.448	.32	.128	1.04	.768	.272	.032	2.4
7028	Mar. 6	Mar. 7	d	c	.1	260.	253.6	6.4	20.	16.8	14.	10.6	7.9	2.7	1.088	.352	.288	.064	.896	.8	.096	.023	1.6
7074	" 13	" 14	d	m	.4	436.8	82.	354.8	38.	14.8	3.7	26.6	8.3	18.3	.368	.864	.368	.496	2.08	.64	1.44	.011	.48
7122	" 20	" 21	d	c	.3	242.4	174.8	67.6	20.	20.	3.5	12.6	8.9	3.7	.592	.48	.272	.208	1.16	.632	.528	.03	1.72
7167	" 27	" 28	d	c	.3	237.6	174.4	63.2	23.6	15.6	5.7	13.	9.5	3.5	.384	.432	.32	.112	1.24	.76	.48	.014	1.8
7221	Apr. 3	Apr. 4	d	c	.4	412.4	180.4	232.	33.6	21.2	5 6	16.7	8.5	8.2	.288	.592	.256	.336	1.304	.632	.672	.018	2.4
7276	" 10	" 11	d	c	.16	269.2	217.6	51.6	27.6	26.8	9.1	12.2	8.5	3.7	.576	.384	.256	.128	1.048	.632	.416	.035	1.76
7331	" . 17	" 18	d	c	.1	274.8	236.8	38.	32.	29.2	11.	9.	8.8	.2	.56	.32	.256	.064	.824	.6	.224	.068	1.32
7399	" 24	" 25	d	c	.04	290.	260.8	29.2	29.6	27.2	10.9	9.5	8.4	1.1	.72	.384	.272	.112	1.08	.76	.32	.065	1.6
7443	May 1	May 2	d	c	.2	299.6	262.	37.6	37.6	24.	8.5	14.5	9.6	4.9	.176	.448	.288	.16	1.16	.8	.36	.08	1.52
748	" 8	" 9	d	c	.25	284.	254.4	29.6	32.4	25.6	16.	13.7	8.7	5.	1.12	.48	.4	.08	1.092	.644	.448	.25	1.08
7528	" 15	" 16	d	c	...	276.	268.4	7.6	28.8	26.4	14.2	8.4	8.1	.3	.256	.372	.256	.116	.9	.836	.064	.15	1.6
7581	" . 22	" 23	d	l	.03	277.2	272.4	4.8	36.	35.6	13.9	9.5	8.6	.9	.32	.25	.224	.032	.74	.644	.096	.075	1.12
7617	" 29	" 30	d	l	.04	247.6	226.4	21.2	28.	27.6	18.	8.3	7.2	1.1	.48	.32	.208	.112	.74	.58	.16	.175	1.68
7659	June 5	June 6	d	c	.04	283.2	206.8	76.4	38.4	29.6	16.	9.2	6.5	2.7	.448	.352	.208	.144	.9	.52	.38	.3	2.4

Chemical Examination of Water from the Illinois River at La Salle. Continued.

(Parts per 1,000,000.)

Serial Number.*	1900		Appearance			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
	Collection.	Examination							Total.	Dissolved						Total.	Dissolved	Suspended					
7699	June 12	June 13	d	l	.03	302.8	281.6	21.2	20.8	16.	23.	7.6	6.9	.7	.456	.272	.224	.048	.64	.52	.12	.35	2.6
7747	" 19	" 20	d	l	.15	272.8	252.4	20.4	32.	24.	21.	17.6	6.3	11.3	.532	.32	.224	.096	.484	.452	.032	.021	1.
7777	" 26	" 27	l	l	.05	269.	233.	26.	22.	21.2	19.5	7.7	6.4	1.3	.616	.24	.112	.128	692	.516	.176	.22	1.29
7825	July 3	July 4	d	l	.01	262.8	240.4	22.4	38.8	28.4	20.	6.5	6.3	.2	.176	.192	.16	.032	.648	.484	.064	.25	1.84
7889	" 10	" 11	d	l	.03	279.6	244.	35.6	26.4	22.4	27.	8.5	5.8	2.7	.112	.272	.176	.096	.548	.452	.096	.375	1.84
7942	" 17	" 18	d	l	....	268.	238.	30.	28.	2.4	25.	6.2	5.2	1.	.224	.192	.08	.112	.58	.436	.144	.3	2.
8010	" 24	" 25	d	l	.01	301.2	232.	69.2	22.	22	21.	7.2	4.9	2.3	.144	.288	.112	.176	.612	.42	.192	.17	1.28
8060	" 31	Aug. 1	d	l	.02	258.8	216.4	42.4	42.	40.4	19.5	7.7	5.	2.7	.272	.272	.176	.096	.996	.356	.64	.180	1.32
8111	Aug. 7	" 8	d	l	.01	229.2	227.6	1.6	32.	....	23.	7.	4.9	2.1	.272	.24	.192	.048	.52	.408	.112	.425	1.72
8177	" 14	" 15	d	l	.01	220.4	204.4	16.	23.6	16.	22.5	6.5	4.2	2.3	.256	.272	.192	.08	.644	.348	.296	.35	1.72
8245	" 21	" 22	d	l	.02	248.4	226.	22.4	31.6	8.4	20.	6.9	4.6	2.3	.144	.272	.224	.048	.572	.174	.448	.2	1.44
8311	" 28	" 29	d	l	.02	278.4	240.	38.4	22.8	20.	20.	8.1	4.6	3.5	.352	.304	.096	.208	.7	.38	.32	.475	1.64
8359	Sept. 4	Sept. 5	d	c	.03	258.8	238.8	20.	21.2	18.4	19.	8.1	4.7	3.4	2.08	.256	.192	.064	.392	.232	.16	.3	1.72
8440	" 11	" 12	d	l	.05*.1	278.	266.8	11.2	26.4	24.8	25.	7.8	6.2	1.6	.4	.32	.16	.16	1.24	.592	.648	.325	1.72
8487	" 18	" 19	d	c	.01*.04	252.8	244.	8.8	27.2	17.6	27.	8.	5.9	2.1	2.08	.272	.176	.096	92	.606	.312	.018	1.08
8538	" 25	" 26	d	l	.02*.25	335.2	319.2	16.	38.4	36.4	47.	8.2	6.6	1.6	3.28	.48	.208	.272	.824	.672	.152	.22	1.88
8599	Oct. 2	Oct. 3	d	l	.01*.05	250.8	238.	12.8	27.6	22.	24.	6.	5.2	.8	2.72	.32	.256	.064	.524	.416	.108	.23	1.13
Average Jan. 2d—June 26th					....	306.7	247.7	58.9	33.6	26.7	15.8	11.7	8.2	3.5	1.095	.45	.294	.155	1.082	.712	.369	.088	1.76
Average July 3rd—Oct. 2d					....	285.1	241.1	24.	29.1	24.5	24.3	7.6	5.2	2.4	.718	.282	.171	.111	.687	.423	.264	.272	1.59
Average Jan. 2d—Oct. 2d					....	292.4	245.4	46.9	32.	25.9	18.7	10.1	7.2	2.9	.963	.391	.251	.142	.944	.611	.332	.152	1.7

*Not Filtered.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT AVERVILLE.

(Parts per 1,000,000.)

Serial Number	1897 Date of Collection	1897 Date of Examination	Appearance: Turbidity	Appearance: Sediment	Appearance: Color	Residue on Evaporation: Total	Residue on Evaporation: Dissolved	Residue on Evaporation: Suspended	Loss on Ignition: Total	Loss on Ignition: Dissolved	Chlorine	Oxygen Consumed: Total	Oxygen Consumed: By Dissolved	Oxygen Consumed: By Suspended Matt'r	Nitrogen as Ammonia: Free Ammonia	Albuminoid Ammonia: Total	Albuminoid Ammonia: Dissolved	Albuminoid Ammonia: Suspended	Organic Nitrogen: Total	Organic Nitrogen: Dissolved	Organic Nitrogen: Suspended	Nitrogen as Nitrites	Nitrogen as Nitrates
2153	Apr. 26	Apr. 27	d	l	.2	303.2	289.2	14.	44.	43.6	10.	11.	....	....	.2	.44	......	......	.79	.....	....	.075	2.
2177	May 3	May 4	d	c	.. ..	316.	304.8	11.2	45.2	40.	11.	11.7	.. .	....	.24	.44	......	......	.95	....	....	.18	2.2
2204	" 11	" 12	d	l	.1*.15	316.8	306.	10.8	23.6	19.6	10.	12.	9.	3.	.128	.56	.256	.304	1.19	.79	.4	.11	2.2
2220	" 17	" 18	d	c	.7	327.2	321.3	6.	22.8	22.	11.	13.4	9.4	4.	.08	.56	.48	.08	1.23	.....	....	.14	1.4
2253	" 24	" 25	d	c	.2	352.4	328.	24.4	39.6	36.	14.	11.4	10.2	1.2	.16	.56	.4	.16	1.23	1.	.22	.1	1.5
2278	" 31	June 1	d	c	.15	366.8	328.	38.8	18.8	18.4	16.	12.9	8.9	4.	.32	.64	.4	.24	1.07	.91	.16	.14	1.7
2301	June 7	" 8	d	c	.15	367.6	325.2	42.4	31.2	28.4	20.	13.	11.	2.	.56	.8	.64	.16	1.21	.89	.32	.17	1.8
2357	" 21	" 22	d	c	.15	378.4	352.8	25.6	30.	26.	26.	12.3	11.5	.8	.16	.44	.4	.04	1.13	1.05	.08	.325	3.
2380	" 28	" 29	d	c	......	326.8	302.8	25.	44.	40.	9.	22.2	13.2	9.	.048	.48	.384	.096	1.21	.97	.24	.25	2.1
2412	July 5	July 6	d	c	......	316.4	286.4	30.	28.4	27.2	13.	12.	8.8	3.2	.05	.4	.28	.12	1.16	1.08	.08	.25	1.6
2436	" 12	" 13	d	c	.06	335.2	286.8	48.4	22.4	16.	17.	12.9	8.4	4.5	.048	.64	.24	.4	1.16	.92	.24	.320	2.
2464	" 19	" 20	d	c	.15	350.4	306.	44.4	39.6	20.	20.	12.5	10.4	2.3	.064	.64	.4	.24	1.16	.76	.4	.26	1.5
2488	" 26	" 27	d	c	.06	278.	258.	20.	24.	22.	20.	10.9	10.1	.8	.024	.4	.256	.144	1.	.85	.16	.27	1.75
2519	A 2	Aug. 3	d	c	.15	338.8	320.	18.8	40.	26.	24.	13.8	13.	.8	.224	.48	.416	.064	1.28	.8	.48	.35	1.7
2539	9	" 10	d	c	.08	300.	290.	10.	16.8	15.2	24.	10.2	9.5	.7	.096	.64	.352	.288	1.08	1.	.08	.3	1.8
2566	" 16	" 17	d	c	.07	338.8	322.8	16.	21.6	14.8	32.	11.	10.2	.8	.08	.48	.32	.16	1.16	.92	.24	.2	1.7
2586	" 23	" 24	d	c	.15*.2	334.	322.	2.	24.8	22.	38.	11.7	11.	.7	.4	.56	.416	.144	1.08	.76	.32	.125	1.2
2615	" 30	" 31	d	c	.2	366.4	342.	24.4	24.	22.	44.	12.8	11.3	1.5	.28	.6	.44	.16	1.06	.82	.24	.11	1.1
2631	Sept. 7	Sept. 7	d	c	.1*.2	363.2	342.8	20.4	22.	18.4	53.	11.3	9.2	2.1	.32	.6	.48	.12	.98	.9	.08	.22	1.3
2666	" 13	" 14	d	c	.2	363.2	341.2	22.	26.	22.8	55.	12.5	9.8	2.7	.48	.57	.4	.12	1.06	.9	.16	.2	1.
2691	" 20	" 21	d	c	.1	371.2	364.	7.2	45.2	10.8	59.	10.6	9.	1.6	.4	.44	.36	.08	.98	.82	.16	.27	1.4
2720	" 27	" 28	d	l	.15	371.2	347.2	24.	36.8	8.	60.	11.7	9.7	2.	.32	.5	.36	.24	1.26	.94	.32	.34	1.
2753	Oct. 4	Oct. 5	s	l	.1*.3	376.8	360.	16.8	44.8	40.	61.	13.5	13.	.5	.4	.56	.52	.04	1.18	.87	.24	.525	1.5
2774	" 11	" 12	d	l	.07	397.2	382.8	14.4	36.	27.2	65.	11.2	10.5	.7	.32	.56	.44	.12	.84	.94	.16	.375	1.6
2816	" 18	" 19	d	c	.15	394.8	374.	20.8	32.	30.8	65.	10.6	8.8	1.8	.2	.64	.36	.28	.78	.7	.08	.4	2.3
2839	" 25	" 26	s	l	.08*.1	402.8	394.4	8.4	35.6	32.	71.	10.8	9.6	1.2	.088	.48	.4	.08	.7	.66	.04	.75	.7
2872	Nov. 1	Nov. 2	d	l	.05	397.2	392.4	4.8	30.8	28.8	65.	10.7	8.	2.7	.2	.36	.28	.08	.78	.66	.12	1.	1.45
2914	" 8	" 9	d	l	04*.06	383.6	378.4	5.2	39.2	38.	64.	8.9	8.	.9	.4	.36	.24	.12	.86	.58	.28	.4	3.3
2951	" 15	" 16	d	c	.06	388.	369.6	18.4	31.2	30.4	60.	9.	6.4	2.6	2.	.34	.28	.08	.86	.66	.2	.15	2.3
2975	" 22	" 23	d	c	.06	382.	368.	14.	39.2	33.2	55.	9.9	7.6	2.3	2.64	.4	.32	.08	.46	.38	.08	.15	2.3
3004	" 29	" 30	d	l	.15*.2	364.4	374.	16.8	31.2	28.4	51.	8.	6.8	1.2	3.04	.36	.28	.08	.77	.57	.2	.06	1.7
3024	Dec. 6	Dec. 7	d	l	07*.09	374.8	370.8	4.	35.2	32.4	51.	7.4	7.1	.3	3.36	.4	.32	.08	.85	.77	.08	.125	1.9
3057	" 13	" 14	d	l	.08*.1	366.4	355.6	10.8	30.8	18.8	46.	6.8	6.4	.4	3.2	.3	.20	.04	.73	.69	.04	.055	1.15
3075	" 27	" 21	d	c	.07	397.6	380.	17.6	27.6	22.4	47.	8.5	7.7	.8	4.8	.44	.36	.08	1.01	.89	.12	.03	1.1
3097	" 27	" 28	d	l	.1*.15	387.6	380.	7.6	22.8	22.	42.	8.2	7.8	.4	4.2	.48	.4	.08	1.01	.85	.16	.175	1.1
Average April 26—June 28.					......	339.4	317.5	21.9	33.2	30.4	14.	13.3	10.4	3.4	.21	.54	.423	.154	1.12	.93	.23	.165	1.96
Average July 5—Dec. 27.					....	362.6	345.4	17.2	29.9	24.2	46.	10.6	9.1	1.5	1.062	.46	.353	.134	.97	.79	.18	.285	1.59
Average April 26—Dec. 28.					....	356.7	339.3	18.4	30.7	25.6	37.	11.3	9.4	1.9	.843	.5	.387	.138	1.01	.79	.19	.254	1.69

CHEMICAL EXAMINATION OF WATER IN THE ILLINOIS RIVER AT AVERYVILLE.
(Parts per 1,000,000.)

Serial Number.	1896 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved.	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
3123	Jan. 3	Jan. 4	d	c	.06*.12	402.8	396.8	6.	24.	14.	45.	7.3	6.9	.5	4.4	.48	.4	.8	.93	.77	.16	.01	1.3
3148	" 10	" 11	d	c	.06	448.	425.6	22.4	23.2	16.8	48.	9.	7.3	1.7	4.6	.48	.4	.08	.92	.76	.16	.175	1.1
3169	" 17	" 18	d	c	.06	300.	376.	24.	36.	26.8	37.	11.	7.5	3.5	3.84	.44	.36	.08	1.16	.84	.32	.12	1.4
3206	" 23	" 24	d	c	.2	346.	310.	36.	30.	18.8	26.	12.6	8.2	4.4	2.6	.56	.4	.16	1.08	.68	.4	.1	1.
3220	" 31	Feb 1	d	c	.4	314.8	306.	8.8	28.	24.	17.	10.6	7.8	2.8	1.68	.52	.32	.2	.84	.68	.16	.12	2.75
3265	Feb. 14	" 15	d	c	.2	375.2	283.2	92.	29.2	26.	12.	14.	7.8	6.2	1.44	.8	.68	.12	1.	.72	.28	.05	2.2
3288	" 21	" 22	d	c	.6	277.2	250.	27.2	32.8	30.	8.	10.9	7.8	3.1	.64	.48	.352	.128	.92	.76	.16	.01	2.4
3312	" 28	Mar. 1	d	c	.5	298.8	273.2	25.6	42.	30.4	9.	9.4	8.6	.8	.64	.48	.4	.08	.76	.64	.12	.02	1.15
3328	Mar. 7	" 8	d	c	.4	264.	255.2	8.8	27.2	16.4	9.	10.8	8.6	2.2	.6	.4	.36	.04	1.	.68	.32	.02	1.1
3353	" 14	" 15	d	c	.2	304.4	241.6	62.8	34.	28.	7.	10.7	6.9	3.8	.6	.48	.32	.16	.92	.72	.2	.035	1.05
3377	" 21	" 22	d	c	.6	298.4	225.2	73.2	26.	20.	5.	13.	9.3	3.7	.4	.52	.36	.16	.92	.64	.28	.035	.8
3400	" 28	" 29	d	c	.4	286.	230.4	55.6	36.8	30.	4.6	13.5	8.9	4.6	.24	.52	.36	.16	1.25	.73	.52	.052	1.25
3434	Apr 4	Apr. 6	d	c	.6	298.8	188.4	110.4	32.4	20.	5.	15.8	10.4	5.4	.184	.64	.4	.24	1.09	.65	.44	.02	1.15
3448	" 11	" 12	d	l	.2	257.6	238.	19.6	32.2	29.6	5.	9.9	9.4	.5	.2	.44	.4	.04	.93	.85	.08	.035	.9
3470	" 18	" 19	d	c	......	257.2	246.8	10.4	32.	30.	7.6	11.9	10.9	1.	.208	.416	.384	.032	1.17	.85	.32	.04	1.
3495	" 25	" 26	d	l	.07 .1	285.6	275.6	10.	32.4	30.4	9.	11.6	8.7	2.9	.36	.44	.28	.16	1.01	.73	.28	.06	1.
3525	May 2	May 3	d	l	.06*.1	300.4	292.	8.4	27.6	26.	12.	8.6	8.2	.4	.32	.44	.36	.08	.84	.74	.1	.08	.7
3550	" 9	" 10	d	l	.1*.15	317.2	311.2	6.	54.8	46.8	12.	8.7	8.2	.5	.2	.48	.44	.04	.9	.74	.16	.1	.8
3579	" 16	" 17	d	l	.05	376.4	314.	62.4	82.	78.8	14.	9.	8.1	.9	.24	.48	.36	.12	1.06	.78	.28	.09	1.1
3610	" 23	" 24	d	l	.15	318.4	276.	42.4	48.	46.	10.	11.3	8.4	2.9	.24	.44	.36	.08	.98	.62	.36	.1	.8
3631	" 30	" 31	d	c	.15	284.	270.2	8.8	42.	36.	7.	11.8	8.8	3.	.12	.32	.24	.08	.82	.62	.2	.16	85
3657	June 6	June 7	d	l	.04*.1	288.	278.8	9.2	44.	34.8	9.	8.5	7.9	.6	.16	.34	.32	.02	.6	.52	.08	.16	.5
3685	" 13	" 14	d	l	.08	324.4	286.	38.4	34.	28.4	11.	8.	7.1	.9	.11	.32	.28	.04	.72	.64	.08	.15	.55
3706	" 20	" 21	d	l	.02	323.6	310.8	12.8	33.2	31.2	13.	7.8	7.6	.2	.24	.28	.24	.04	.6	.56	.04	.25	.45
3749	" 27	" 28	s	l	.05	298.4	294.	4.4	28.8	24.	14.	8.4	7.5	.9	.24	.4	.36	.04	.6	.52	.08	.15	.35
3775	July 4	July 5	s	l	.15	260.	201.2	8.8	28.	27.2	15.	7.8	6.7	1.1	.24	.3	.28	.02	.68	.64	.04	.32	.5
3807	" 11	" 12	d	l	.06*.3	313.2	262.	21.2	20.8	17.2	14.	8.8	8.2	.6	.12	.4	.36	.04	.84	.76	.08	.12	.3

3839	"	18	"	19	d	l	.03*	.1	337.2	313.6	23.6	22.	18.	17.	9.5	8.8	.7	.130	.48	.4	.08	1.12	.88	.24	.07	.2
3875	"	20	"	26	d	c	.04*	.3	340.8	313.9	27.2	20.	18.8	24.	12.2	8.8	3.4	.44	.52	.4	.12	1.08	.84	.24	.06	.25
3897	Aug.	1	Aug	2	d	c	03*	.06	371.6	346.8	24.8	18.	17.2	32.	8.3	8.	.3	.104	.36	.28	.08	.96	.68	.28	.105	.4
3928	"	8	"	9	d	c		.04	383.2	359.6	23.6	31.2	26.	42.	8.5	8.	.5	.16	.4	.32	.06	.8	.64	.16	.21	.2
3955	"	13	"	16	d	c		.04	418.8	387.6	31:2	61.6	50..	47.	9.9	8.3	1.6	.28	.4	.36	.04	.8	.72	.08	.4	.3
3978	"	22	"	23	d	c	.04*	.3	392.8	372.8	20.	42.	40.	56.	9.1	8.	1.1	.32	.44	.36	.08	.8	.68	.12	1.	.55
4010	"	27	"	30	d	l	.04*	.1	324.	298.8	25,2	36.	34.	30.	7.1	6.8	.3	.52	.28	.24	.04	.68	.56	.12	.25	.3
4050	Sept.	6	Sept.	7	d	c		......	370.4	322.	48.4	31.2	26.	37.	8.9	6.1	2.8	.32	.4	.28	.12	.72	.52	.2	.2	.65
4068	"	12	"	13	d	c		.04	368.	337.2	30.8	58.	56.	35.	8.3	5.6	2.7	.72	.28	.2	.08	.8	.56	.24	.14	.35
4087	"	19	"	20	d	c		.05	336.	319.6	6.	44.	38.	35.	8.7	6.	2.7	.64	.32	.24	.08	.72	.56	.16	.14	.35
4121	"	26	"	27	d	c		.04	341.2	331.6	19.6	66.	60.	33.	7.4	6.4	1.	.48	.3	.24	.06	.64	.56	.08	.14	.45
4160	Oct.	2	Oct.	4	d	c		.04	355.2	323.2	32.	30.	27.2	30.	7.8	6.	1.8	.24	.36	.3	.06	.64	.44	.2	.15	.6
4187	"	10	"	11	d	c		.08	466.	337.2	28.8	40.	32.	30.	6.9	6.	.9	.16	.28	.23	.06	.56	.4	.16	.36	.6
4225	"	17	"	18	d	c		.04	396.8	364.8	22.	44.	43.6	40.	7.8	5.8	2.	1.2	.32	.224	.096	.65	.53	.12	.13	.75
4202	"	24	"	25	d	l		.04	396.	364.	32.	41.2	38.	42.	7.7	5.7	2.	2.4	.32	.224	.096	.65	.53	.12	.06	.6
4293	"	31	Nov.	1	d	l		.1	342.	324.	18.		30.	27.	6.6	6.	.6	1.48	.32	.24	.08	.61	.49	.12	.05	.6
4327	Nov.	7	"	8	d	l	.06	.1	362.	344.8	17.2	40.	32.	20.	6.7	5.2	1.5	.92	.26	.2	.06	.59	.51	.08	.06	.9
4362	"	14	"	15	d	l		.04	382.	375.0	6.4	30.	28.8	23.	6.9	6.2	.7	1.16	.28	.24	.04	.55	.47	.08	.075	.8
4393	"	21	"	22	d	c		.06	356.	313.8	37.2	30.	24.	13.	8.	6.	2.	.52	.304	.208	.096	.71	.59	.12	.035	1.
4423	"	28	"	29	d	l	.07*	.3	354.	344.	10.	60.	56.	12.	7.3	6.8	.5	.6	.304	.192	.112	.63	.47	.16	.04	1.35
4452	Dec.	5	Dec.	6	d	l	04*	.05	390.8	376.	12.8	48.8	48.	19.	7.7	7.	.7	.86	.24	.144	.096	.69	.53	.16	.035	.9
4479	"	12	"	13	d	l	03*	.05	386.	373.6	12.4	47.2	44.	18.	8.3	7.5	.8	1.08	.32	.24	.08	.69	.57	.12	.026	.3
4498	"	19	"	20	s	l	.1*	.15	397.6	392.4	5.2	60.8	57.2	23.	9.3	8.5	.8	1.68	.368	.304	.064	.77	.65	.12	.02	.25
4028	"	26	"	27	s	l	.1*	.2	396.8	384.8	12.	62.	58.	25.	8.8	8.	.8	2.66	.4	.288	.112	.93	.77	.16	.035	.15
Average Jan. 3—June 27									317.8	286.4	31.4	35.7	29.7	14.2	10.5	8.2	2.2	.98	.463	.365	.098	.92	.69	.22	.084	1.1
Average July 4—Dec. 26............									262.6	341.2	21.4	35.7	20.7	28.4	8.2	6.9	1.3	.745	.344	.268	.075	.74	.59	.14	.162	.59
Average Jan 3—Dec. 26............									340.6	314.3	26.3	38.1	33.1	21.4	9.3	7.5	1.7	.86	.403	.316	.087	.83	.64	.18	.124	.8

*Not filtered. Odor none. Color upon ignition brown.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT AVERYVILLE.

(Parts per 1,000,000.)

Serial Number.	1899 Date of Collection.		Appearance. Turbidity.	Sediment.	Color.	Residue on Evaporation. Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Dissolved.	Chlorine.	Oxygen Consumed. Total.	By Dissolved.	By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Albuminoid Ammonia. Total.	Dissolved.	Suspended	Organic Nitrogen. Total.	Dissolved.	Suspended	Nitrogen as Nitrites.	Nitrates.
		Examination.																					
4561	Jan. 3	Jan. 4	d	l	.1	357.6	342.	15.6	54.4	44.8	21.	12.	8.8	3.2	1.72	.4	.32	.08	.89	.73	.16	.015	.35
4611	" 9	" 16	d	l	.06	316.	295.2	20.8	46.	38.	15.	10.5	8.3	2.2	1.28	.32	.24	.08	.73	.53	.2	.03	1.02
4613	" 16	" 17	d	c	.2	290.8	270.8	20.	54.	46.	14.	12.5	8.7	3.8	1.2	.44	.272	.168	.77	.57	.2	.035	.35
4640	" 23	" 24	d	c	.3	282.8	242.4	40.4	44.8	39.2	10.	13.	8.5	4.5	.88	.4	.256	.144	.93	.65	.28	.025	.85
4661	" 30	" 31	d	l	.2	332.8	310.	22.8	48.	46.	12.	10.5	8.8	1.7	.88	.416	.288	.128	.93	.77	.16	.03	.7
4678	Feb. 6	Feb. 7	d	l	.1*.15	328.	322.	6.	46.	43.2	14.	8.9	7.5	1.4	1.12	.4	.32	.08	.66	.5	.16	.014	1.75
4698	" 13	" 14	d	l	.06*.2	378.	372.	6.	40.	36.	23.	11.8	8.8	.3	1.76	.44	.304	.136	.82	.66	.16	.04	1.3
4726	" 19	" 21	d	l	.3*.4	360.	356.	4.	50.	46.	23.	11.8	9.5	2.3	2.	.44	.36	.08	.9	.74	.16	.045	1.25
4751	" 27	" 28	d	c	.3	401.2	320.	81.2	62.	58.	26.	18.7	12.	6.7	2.56	.68	.44	.24	1.34	.74	.6	.04	.3
4775	Mar. 6	Mar. 7	vd	vm	.5	434.	180.8	253.2	64.	42.	10.	31.7	14.	17.7	.8	.92	.48	.44	2.02	.98	1.04	.025	.9
4802	" 13	" 14	vd	vm	.4	398.	148.	250.	54.	36.	6.	26.5	12.5	14.	.6	.8	.352	.448	1.94	.74	1.2	.015	1.25
4833	" 20	" 21	d	c	.04	350.	188.	162.	50.	42.	6.	16.6	9.	7.6	.48	.48	.272	.208	1.02	.54	.48	.04	1.25
4856	" 27	" 28	d	m	.04	346.	182.7	163.3	50.	38.	5.6	17.	8.8	8.2	.48	.6	.288	.312	1.27	.55	.72	.035	1.3
4885	Apr. 3	Apr. 4	d	c	.3	248.	206.8	41.2	52.	42.	8.	13.5	9.5	4.	.56	.48	.304	.176	.83	.6	.23	.02	1.75
4911	" 10	" 11	d	c	.05	262.	218.8	43.2	42.	36.	9.	12.4	9.	3.4	.56	.4	.32	.08	.79	.59	.2	.035	1.6
4939	" 17	" 18	d	c	.05	284.	256.	28.	52.	35.2	8.	11.	8.7	2.3	.48	.4	.32	.08	.71	.6	.11	.04	1.6
4956	" 24	" 25	d	c	.05*.3	299.6	280.4	19.2	46.	38.8	12.	11.8	8.9	2.9	.4	.56	.32	.24	1.25	.73	.52	.075	1.25
4982	May 1	May 2	d	c	.04	318.	302.8	15.2	50.	49.2	13.	12.5	9.3	3.2	.208	.48	.224	.256	1.05	.53	.52	.084	.95
5039	" 15	" 16	d	c	.2	430.4	374.8	55.6	68.6	60.	19.2	14.	9.4	4.6	.864	.512	.416	.096	1.20	.80	.4	.035	.96
5073	" 22	" 23	d	c	.04	391.2	354.	37.2	31.2	21.2	18.5	14.6	10.	4.6	.96	.416	.352	.064	1.29	.97	.32	.045	.52
5132	" 30	June 1	d	c	.1	394.4	341.2	53.2	58.8	39.2	16.	11.3	10.7	.6	.352	.48	.32	.16	1.06	.90	.16	.08	1.48
5192	June 8	" 9	d	c	.15	415.6	290.	125.6	34.4	32.	17.5	13.1	11.4	1.7	.288	.524	.416	.108	1.24	.986	.254	.25	1.8
5253	" 20	" 21	d	c	.1	365.2	333.2	32.	35.2	32.8	17.5	13.3	11.1	2.2	.088	.448	.384	.064	1.32	.952	.368	.13	1.2
5302	" 27	" 28	d	c	.1	407.6	362.4	45.2	29.6	28.8	25.	14.	12.7	1.3	.256	.512	.432	.08	1.24	1.048	.192	.185	1.68
5333	July 3	July 4	d	c	.2	400.4	356.4	44.	60.6	62.4	26.	14.3	12.3	2.	.144	.528	.368	.16	1.32	.92	.4	.13	1.76
5349	" 10	" 12	d	c	......	396.8	374.	22.8	26.	24.	37.2	13.5	13.2	.3	.352	.544	.336	.208	1.24	.728	.512	.26	1.8
5439	" 18	" 19	d	c	.15	423.2	378.4	44.8	50.8	48.4	46.	12.9	11.3	1.6	1.6	.512	.352	.16	1.32	.824	.496	.46	2.

*n. f.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT AVERYVILLE.—CONTINUED.

(Parts per 1,000,000.)

Serial Number.	1899		Appearance			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of								Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
5488	July 24	July 25	d	c	.1	315.2	294.4	20.8	50.4	48.8	31.	9.1	8.3	.8	.704	.512	.304	.208	1.16	.856	.304	.39	1.76
5536	Aug. 1	Aug. 2	d	c	.2	386.4	323.6	62.8	61.2	50.2	34.	12.7	10.5	2.2	.384	.448	.288	.16	1.16	.728	.432	.25	1.52
5587	" 8	" 9	d	c	.06	392.4	338.8	53.6	49.6	48.	30.	12.2	10.8	1.4	.16	.332	.272	.08	1.06	.856	.224	.15	1.4
5634	" 15	" 16	d	c	.15	400.	352.4	47.6	85.2	76.	38.5	11.9	10.6	1.3	.416	.416	.24	.176	1.016	.728	.288	.22	1.3
5684	" 22	" 23	d	c	.02	387.6	237.2	50.4	58.	34.8	43.	12.5	10.5	2.	.24	.544	.272	.272	1.24	.824	.416	.12	1.4
5741	" 29	" 30	d	c	.15	375.2	345.2	30.	36.8	36.8	44.	13.	9.1	3.9	.272	.576	.288	.288	1.48	.712	.768	.08	1.
5794	Sept. 5	Sept. 6	d	c	.04	392.4	367.6	24.8	36.4	36.4	50.2	10.8	7.2	3.6	.368	.416	.304	.112	1.08	.856	.224	.12	1.08
5840	" 12	" 13	d	c	.1	393.2	360.4	32.8	37.2	34.4	54.5	11.6	10.8	.8	.24	.512	.384	.128	1.4	.76	.64	.09	1.16
5890	" 19	" 20	d	l	.03	390.8	368.4	22.4	58.	54:4	54.7	11.7	7.5	4.2	.168	.64	.336	.304	1.32	.824	.496	.12	1.08
5944	" 26	" 27	d	c	.04	383.6	368.	15.6	45.6	38.	58.	10.1	8.3	1.8	.128	.512	.416	.096	1.028	.804	.224	.17	1.16
5992	Oct. 3	Oct. 4	d	c	.2	392.8	384.8	8.	37.2	36.8	69.	11.	9.3	1.7	.128	.592	.336	.256	1.46	.708	.752	.85	3.2
6037	" 10	" 11	d	c	.1	408.	391.6	16.4	34.	34.	66.5	11.4	9.6	1.8	.192	.688	.336	.352	1.464	.708	.756	.75	1.4
6087	" 17	" 18	d	c	.03	410.	392.4	17.6	39.6	19.8	67.	9.8	8.8	1.	.256	.464	.4	.064	1.32	.808	.512	1.	3.08
6151	" 24	" 25	d	c	.08	444.8	414.8	30.	27.6	14.8	72.5	10.5	8.8	1.7	1.12	.64	.24	.4	1.32	.584	.736	1.5	4.
6197	" 31	Nov. 1	d	l	.03	421.8	407.6	13.6	29.2	....	62.	8.7	8.2	.5	1.44	.48	.304	.176	.968	.52	.448	1.35	3.6
6247	Nov. 7	" 8	d	l	.04*.15	404.8	389.2	15.6	23.6	22.8	55.	6.5	6.1	.4	3.2	.384	.304	.08	.52	.424	.096	.35	2.6
6295	" 14	" 15	d	l	.03	398.8	380.8	18.	45.2	44.8	54.	7.1	6.6	.5	3.9	.416	.288	.128	.672	.552	.32	.1	1.
6339	" 21	" 22	d	c	.03	372.4	354.4	18.	31.2	22.	50.5	7.1	6.4	.7	3.52	.48	.288	.192	.92	.68	.24	.07	1.6
6408	" 28	" 29	d	l	.06	350.4	348.	2.4	45.6	44.8	34.	7.2	7.2	0.0	1.92	.32	.176	.144	.776	.552	.224	.06	1.84
6448	Dec. 5	Dec. 6	d	l	.02	385.6	364.4	21.2	48.4	40.8	36.	7.7	6.7	1.	1.6	.432	.256	.176	.936	.52	.416	.08	2.8
6502	" 12	" 13	d	l	.04	380.	376.4	3.6	44.4	40.8	39.5	9.1	8.3	.8	1.4	.48	.4	.08	1.	.68	.32	.08	2.32
6551	" 19	" 20	d	c	.05	374.4	358.4	16.	41.6	41.6	41.	9.6	8.9	.7	4.	.48	.432	.048	1.	.808	.192	.08	1.4
6577	" 26	" 27	d	c	.04	376.4	372.	4.4	31.2	28.4	33.7	9.9	9.4	.5	3.36	.432	.336	.096	.84	.68	.16	.07	2.2
Average Jan. 3—June 27...........						349.6	285.4	64.2	48.2	40.4	14.5	14.2	9.8	4.4	.865	.497	.332	.164	1.09	.728	.366	.050	1.14
Average July 3—Dec. 28...... ..						390.6	372.9	17.7	43.9	39.3	47.2	10.4	9.	1.4	1.173	.492	317	.175	1.124	.717	.407	.338	1.94
Average Jan. 3—Dec. 28...........						370.9	3 6.9	43.9	46.	39.8	31.5	12.9	9.4	2.8	1.025	.494	.325	.169	1.11	.722	.387	.204	1.55

* n. f. Odor none. Color on ignition generally brown, but in latter part of year sometimes gray.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT AVERYVILLE.

(Parts per 1,000,000.)

Serial Number.	1900		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
	Collection.	Examination.							Total.	Dissolved.						Total.	Dissolved.	Suspended					
6603	Jan. 2	Jan. 3	d	l	.08*1	375.6	370.8	4.8	46.8	40.9	22.5	9.6	8.6	1.	1.92	.352	.272	.08	.904	.584	.32	.04	3.44
6650	" 9	" 10	d	l	.04	369.6	364.4	5.2	60.8	60.4	26.	8.3	1.8	.5	2.	.384	.32	.064	.76	.6	.16	.04	3.4
6695	" 16	" 17	d	c	.06	384.	382.4	1.6	41.2	39.6	32.	9.	8.5	.5	2.96	.432	.368	.064	1.056	.8	.256	.065	2.8
6740	" 23	" 20	d	c	.2	351.2	302.	49.2	41.6	34.4	22.	12.3	8.9	3.4	2.	.4	.32	.08	1.024	.544	.48	.03	1.52
6789	" 30	" 31	d	c	.1	307.6	221.6	86.	37.6	28.4	22.	9.2	8.7	.5	2.48	.48	.336	.144	.96	.608	.352	.025	1.8
6847	Feb. 6	Feb 7	d	l	.04	267.2	265.6	1.6	28.8	28.	18.	6.5	6.3	.2	1.44	.272	.192	.08	.56	.448	.112	.025	1.4
6898	" 13	" 14	vd	vm	.3	476.4	178.8	297.6	48.	24.8	9.	19.4	8.3	11.1	.736	.704	.288	.416	1.76	.416	1.344	.025	2.
6941	" 20	" 21	vd	c	.2	328.4	223.6	104.8	75.2	29.6	10.	12.	9.9	2.1	1.04	.448	.384	.064	1.12	.608	.512	.03	2.2
6995	" 27	Mar 3	vd	c	.03	343.2	281.2	62.	20.8	20.4	12.	12.8	9.4	3.4	1.024	.416	.208	.208	.8	.576	.224	.027	1.6
7023	Mar. 6	" 7	d	l	.4	255.6	242.8	12.8	14.4	10.8	11.7	11.	8.8	2.2	.864	.32	.288	.032	.88	.64	.24	.03	2.2
7078	" 13	" 14	d	m	.4	327.6	189.6	138.	27.2	17.6	8.4	12.6	7.1	5.5	.96	.384	.288	.096	1.12	.544	.576	.016	1.44
7124	" 20	" 21	d	m	.5	292.	115.6	176.4	30.4	16.4	6.7	14.3	11.9	2.4	.384	.48	.272	.208	1.24	.6	.64	.015	1.
7170	" 27	" 28	d	c	.6	200.4	158.4	42.	27.7	14.4	5.2	10.5	8.1	2.4	.48	.288	.256	.032	1.	.632	.368	.014	1.6
7219	Apr. 3	Apr 4	d	c	.4	234.8	176.4	58.4	23.2	14.4	6.2	10.8	8.2	2.6	.432	.352	.288	.064	.824	.684	.14	.016	1.52
7274	" 10	" 11	d	c	.3	268.4	180.4	88.	22.4	19.2	5.6	13.7	7.7	6.	.352	.336	.24	.096	.824	.632	.192	.03	2.6
7336	" 17	" 18	d	c	.2	230.4	214.	16.4	19.2	17.6	8.1	8.7	8.5	.2	.432	.256	.208	.048	.76	.568	.192	.038	2.
7402	" 24	. 25	d	c	....	264.8	246.8	18.	30.8	20.8	9.	9.	8.	1.	.32	.448	.256	.192	1.016	.632	.384	.045	2.12
7442	May 1	May 2	d	c	.07	285.2	266.4	18.8	43.2	24.8	11.	9.	8.	1.	.112	.432	.24	.192	.932	.644	.288	.06	1.76
7478	" 8	" 9	d	l	.2	270.	258.8	11.2	25.6	23.6	11.6	12.9	8.	4.9	.16	.512	.352	.16	1.092	.644	.448	.07	1.08
7549	" 16	" 17	d	....	.1	294.8	267.6	27.2	49.2	38.8	14.7	8.3	9.	.3	.384	.64	.288	.352	1.252	.676	.576	.125	1.08
7589	" 22	" 23	s	l	.1	296.8	268.4	28.4	40.4	28.4	16.	10.8	7.2	3.6	.304	.32	.24	.08	.676	.484	.192	.1	1.28
7621	" 29	" 30	d	c	.15	322.	255.6	66.4	26.	26.	16.	8.6	6.	.6	.24	.416	.24	.176	.84	.64	.2	.07	1.3
7656	June 5	June 6	d	c	.04	256.4	242.8	13.6	42.4	41.6	19.	7.	8.7	.3	.384	.304	.272	.032	.64	.452	.188	.16	1.4
7707	" 12	" 13	d	l	.04	262.8	242.	20.8	18.6	19.9	16.	6.6	6.5	.1	.224	.24	.208	.032	.58	.52	.06	.2	2.08
7742	" 19	" 20	d	c	.01	322.	288.4	33.6	37.6	34.4	20.	9.3	6.5	2.8	.256	.272	.192	.08	.66	.58	.08	.14	1.48
7779	" 26	" 27	l	s	.07	281.6	260.	21.6	25.2	21.2	20.	7.	6.8	.2	.56	.256	.16	.096	.74	....	....	.11	1.16
7818	July 3	July 4	d	l	.03	282.	253.6	28.4	26.	25.2	20.5	7.9	7.	9.	.352	.324	.208	.116	.612	.34	.272	.19	1.48
7896	" 10	" 11	d	l	.1	302.4	260.8	41.6	42.	25.2	30.	6.	5.8	.2	.128	.208	.16	.048	.564	.388	.176	.135	1.44
7945	" 17	" 18	c	l	.02	283.2	256.	27.2	25.2	24.4	27.	6.2	5.8	.4	.288	.176	.08	.096	.....	.....	....	.22	2.
8013	" 24	" 25	d	l	.01	248.8	231.2	17.6	30.4	30.4	23.	6.3	4.5	1.8	.144	.224	.112	.112	.596	.42	.176	.12	1.32

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT AVERYVILLE.—CONTINUED.

(Parts per 1 000,000.)

Serial Number	1900		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of								Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved.	Suspended	Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
8063	July 31	Aug 1	d	l	.01	258.8	234.8	24.	41.2	34.8	22.	5.5	4.4	1.1	.07	.208	.176	.032	.708	.548	.16	.22	.92
8107	Aug. 7	" 7	d	l	.01	219.2	215.6	63.6	40.	40.	19.	6.	.....	...	.176	.272	.176	.096	.708	.468	.24	.12	1.12
8175	" 14	" 15	d	l	.01	344.	135.2	8.4	46.8	36.4	21.	5.3	4.6	.7	.08	.272	.176	.096	.452	.348	.104	.125	1.12
8234	" 21	" 21	d	l	.01	223.6	197.2	26.4	38.	20.4	25.	5.7	4.4	1.3	.32	.272	.192	.08	.54	.284	.256	.13	1.12
8309	" 27	" 28	d	l	.02	250.	220.4	29.6	19.2	18.4	20.	6.7	4.6	2.1	.176	.24	.144	.096	.636	.38	.256	.1	1.12
8358	Sept. 4	Sept. 4	d	c	.02	264.8	260.8	4.	18.	16.8	22.	6.4	4.6	1.8	.175	.272	1.92	.08	.456	.....	..	.23	1.58
8437	" 11	" 11	d	l	.02	264.	299.6	34.4	16.4	15.2	18.	7.4	4.5	2.8	.128	.256	.128	.128	.536	.384	.152	.075	1.04
8486	" 18	" 18	d	c	.01	272.8	253.2	19.6	36.8	15.6	20.	7.5	6.1	1.4	.144	.32	.224	.096	. .	....	...	.01	1.2
8535	" 25	" 25	d	l	.05	318.	286.8	31.2	39.2	38.4	30.	8.5	6.4	2.1	.864	.352	.16	1.92	.636	......	....	.13	1.44
8597	Oct. 2	Oct. 2	d	l	.02	317.6	294.4	23.2	25.6	23.2	37.	6.7	5.8	.9	1.28	.416	.224	.192	.656	.48	.176	.15	1.28
8645	" 9	" 9	d	l	.02	238.	225.6	12.4	25.6	24.	23.	4.6	4.1	.5	.432	.24	.224	.016	.704	.464	.24	.13	1.80
8672	" 16	" 17	v	m	.01	242.8	216.4	26.4	25.6	24.	20.	5.9	5.4	.5	.32	.224	.192	.032	.512	.48	.032	.41	1.45
8697	" 24	" 25	d	l	.01	244.4	226.	18.4	24.4	23.8	20.	6.6	5.8	.8	.616	.256	.192	.064	.704	.542	.192	.03	1.41
8726	" 30	" 31	d	l		250.	234.	16.	25.6	24.4	21.	5.3	4.9	.4	.418	.16	.16	.00	.608	.608	.00	.05	1.51
8743	Nov. 6	Nov. 7	d	l	.02	247.2	232.8	14.4	23.2	21.6	21.	5.4	4.9	.5	.384	.288	.192	.096	.592	.48	.412	.055	1.665
8775	" 13	" 13	d	l	.01* .04	238.8	236.4	2.4	20.8	18.8	22.	5.8	5.4	.4	.704	.32	.288	.032	.656	.024	.032	.1	1.9
8794	" 20	" 20	d	l	.03	220.	215.2	4.8	16.	12.4	17.5	5.3	4.7	.6	.....	.224	.192	.032	.416	..	..	.036	1.044
8832	" 27	" 28	d	l	.05	269.6	250.8	18.8	27.2	23.2	13.	5.6	5.4	.2	.56	.24	.16	.08	.56	.4	.16	.04	1.3
8854	Dec. 4	Dec. 4	d	l	.1	286.8	272.8	14.	26.	23.6	13.	7.2	6.2	1.	.76	.24	.....	......	.528	.496	.032	.04	2.28
8887	" 11	" 12	d	l	.15	270.4	265.6	4.8	23.6	20.	13.	7.4	.....	.....	.272	.224	.192	.032	.528	.48	.04	.034	1.566
8908	" 18	" 19	d	l	.2	269.2	255.6	13.6	26.4	23.2	113.	7.6	7.4	.2	1.12	.204	.288	.016	.688	.64	.048	.024	1.826
8922	" 26	" 26	d	l	.2	267.2	258.	9.2	21.6	17.6	14.	8.3	8.	.3	.912	.16	.152	.008	.752	.64	.112	.015	1.425
Average Jan. 2–June 26						302.6	248.6	54.	34.8	28.6	14.3	10.3	7.7	2.6	.863	.39	.268	.121	.923	.589	.334	.59	1.81
Average July 3—Dec. 24..........						253.6	241.8	11.7	28.1	23.8	20.	6.4	5.5	.9	.434	.257	.183	.074	.507	.448	.149	.1	1.423
Average Jan. 2–Dec. 24						281.9	245.2	36.7	31.4	25.2	17.5	8.4	6.6	1.7	.65	.323	.222	.101	.767	.534	.243	.077	1.532

* n. f. Usually this water possesses no odor, but upon July 17th and Dec. 11th, 18th and 26th a musty odor was noticeable. The color upon ignition was almost always brownish.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT AVERYVILLE.

(Parts per 1,000,000.)

Serial Number.	1901 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved.	Suspended	Total	Dissolved.	Suspenced	Nitrites.	Nitrates.
8937	Jan. 2	Jan. 3	d	l	.05	255.2	243.6	11.6	16.8	12.8	18.	7.5	7.5	...	1.52	.16	.144	.016	.656	.528	.128	.014	.780
8975	Feb. 1	Feb. 2	d	l	.04	246.4	240.8	5.6	22.8	18.4	12.	7.5	7.4	.1	1.008	.208	.192	.016	.72	.656	.064	.009	1.351
9018	Mar. 1	Mar. 2	s	l	.3*.4	232.8	230.8	2.	10.4	6.8	14.	5.9	5.9	...	1.536	.24	.224	.016	.56	.528	.032	.007	.513
9056	Apr. 1	Apr. 2	d	c	.5	252.4	231.6	20.8	36.	36.	5.4	11.8	8.9	2.9	.272	.272	.224	.048	.72	.592	.128	.032	2.088
9098	May 2	May 2	d	l	.5*.3	267.6	256.4	11.2	41.2	40.4	8.8	9.2	8.5	.7	.144	.4	.256	.144	.912	.752	.16	.025	1.215
9124	June 1	June 1	d	c	.1	308.4	296.4	12.	34.8	31.2	16.	10.9	7.4	3.5	.32	.288	.192	.096	.912	.528	.384	.085	1.04
9157	July 3	July 3	d	c	.01	300.8	252.	48.8	20.	15.6	21.	8.5	6.3	2.2	.176	.208	.16	.048	.688	.544	.144	.24	1.36
9184	" 17	" 17	d	c	.1	324.	284.	40.	33.2	34.	23.	9.1	8.5	.6	.16	.288	.224	.064	1.04	.672	.368	.15	1.57
9216	" 26	" 27	d	l	.01	270.	233.6	36.4	24.	16.4	24.	9.2	8.3	.9	.136	.24	.192	.048	.656	.528	.128	.15	.93
9232	" 30	" 30	d	l	.04	251.2	216.8	34.4	13.6	12.8	26.	7.7	6.7	1.	.224	.224	.192	.032	.688	.608	.08	.18	1.28
9283	Aug. 6	Aug. 7	d	c	.03	254.	225.6	28.4	32.	31.6	26.	7.3	7.1	.2	.82	.288	.272	.016	.688	.528	.16	.272	1.725
9296	" 12	" 13	d	c	.05	253.6	215.2	38.4	29.2	49.2	26.	8.5	7.8	.7	.144	.256	.224	.032	.624	.528	.096	.17	1.67
9316	" 20	" 20	d	c	.01	237.2	207.6	29.6	16.4	4.4	22.5	7.3	5.8	1.5	.144	.24	.224	.016	.56	.528	.032	.16	1.54
9332	" 27	" 27	d	c	.04	232.4	214.4	18.	22.4	22.4	22.	6.9	5.5	1.4	.152	.224	.192	.032	.592	.496	.096	.2	1.44
9345	Sept. 2	Sept. 3	d	c	.02	260.	203.6	56.4	38.4	26.8	24.	7.2	5.8	1.4	.192	.224	.16	.064	.592	.528	.064	.22	1.46
9366	" 10	" 12	d	c	.01	249.2	217.6	31.6	20.4	26.	23.5	6.	4.9	1.1	.128	.224	.16	.064	.....	....	....	.15	1.49
9386	" 17	" 17	d	l	.02	234.	210.8	23.2	30.4	29.2	21.	6.	5.4	.6	.16	.208	.208	.....	.....	....	....	.10	1.49
9405	" 24	" 25	d	c	.02	248.4	236.	12.4	30.	29.2	28.	6.9	5.9	1.	.56	.256	.16	.096	.....	....	....	.2	1.6
9422	Oct. 1	Oct. 1	d	l	.02	240.4	209.2	31.2	....	22.8	22.	7.1	6.3	.8	.192	.272	.16	.112	.....	....	....	.06	1.52
9448	" 8	" 8	d	l	.05	233.6	218.8	14.8	12.8	18.6	13.	6.9	6.7	.2	.156	.224	.176	.048	.....	....	....	.15	1.45
9496	Oct. 16	Oct. 16	d	l	.03	226.	210.6	6.4	19.6	16.4	22.	5.8	5.	.8	.006	.208	.192	.016	....	....	....	.12	1.84
9559	" 23	" 23	d	l	.04	227.6	214.	3.6	28.	26.4	24.	5.3	5.2	.1	.272	.24	.192	.048	....	....	....	.125	1.675
9613	" 30	" 30	d	l	.06	230.	202.8	27.2	26.	31.2	22.	5.8	4.8	1.	.16	.224	.192	.032	....	....	....	.105	1.735
9673	Nov. 6	Nov 6	d	l	.03*.1	194.8	190.4	4.4	13.2	12.	20.	5.	4.4	.6	.08	.224	....	....	....	....	....	.106	1.735
9735	" 13	" 13	d	c	.04	218.4	218.4	....	22.4	16.	21.	5.5	5.3	.2	.56	.224	.224	....	....	....	....	.075	1.805
9812	" 20	" 20	d	l	.04*.1	214.	204.	10.	29.6	10.8	21.	5.4	5.	.4	.32	.208	.16	.048	....	....	....	.085	1.775
9884	" 27	" 27	d	l	.01*.2	210.4	201.2	9.2	27.2	27.2	22.	5.6	4.7	.9	.992	.24	.144	.096	....	....	....	.05	1.15
9969	Dec. 4	Dec. 4	d	l	....	222.4	216.4	6.	24.4	42.4	20.	6.1	4.6	1.5	1.152	.256	.224	.032	....	....	....	.035	1.245
10047	" 11	" 11	d	l	.03	194.8	193.6	1.2	21.6	27.2	20.	5.4	5.3	.1	1.344	.224	.176	.048	....	....	....	.045	.955
10106	" 18	" 18	d	v l	.01*.04	230.4	213.2	17.2	26.8	23.2	22.	5.5	5.	.5	1.76	.224	.16	.064	....	....	....	.022	.338
10141	" 26	" 26	d	v l	.03*.1	498.8	245.2	253.6	50.	21.6	24.	7.3	7.	.2	2.48	.272	.256	.016	....	....	....	.018	.742
Average Jan. 2—June 1						260.4	249.9	10.5	27.	24.4	12.3	8.8	7.6	1.2	.8	.261	.205	.056	.746	.597	.149	.028	1.265
Average July 3—Dec. 26						250.6	219.7	30.9	25.8	22.6	22.7	6.7	5.8	.9	.495	.233	.159	.074	.658	.534	.124	.183	1.409
Average Jan. 2—Dec. 26						255.5	234.8	20.7	26.4	23.9	17.5	7.7	6.7	1.	.647	.249	.198	.051	.717	.576	.141	.081	1.337

*Not filtered.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT HAVANA.

(Parts per 1,000,000.)

Serial Number.	1897 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
1800	Jan. 6	Jan. 6	v	m	....	504.4	259.6	244.8	25.2	20.	10.	15.7	8.5	7.2	.6	.56	.36	.2	1.4	.88	.52	.04	2.
1821	“ 13	“ 13	v	c	....	329.6	259.6	70.	25.2	10.	10.	13.7	......	......	.44	.44	......	......	.96	......	......	.035	2.8
1841	“ 20	“ 20	v	c	....	294.4	270.8	23.6	18.	16.8	8.	8.2	......	......	.32	.36	......	......	.8	......	......	.035	3.5
1849	“ 26	“ 27	s	l	.3	294.	293.2	.8	21.2	14.8	4.3	6.5	......	.	.08	.2	......	......	.64	......	......	.025	3.6
1877	Feb. 2	Feb. 3	d	l	....	308.8	307.6	1.2	9.2	9.2	8.	9.7	......	......	.352	.32	......	......	.8	......	......	.022	3.5
1900	“ 9	“ 10	d	l	.2	333.2	321.6	11.6	12.	11.2	10.	10.1	......	......	.68	.4	......	......	.8	......	......	.025	3.
1921	“ 16	“ 17	d	c	....	338.	318.8	19.2	18.	13.2	12.	10.4	......	......	.88	.36	......	......	.8	......	......	.05	2.4
1939	“ 23	“ 24	d	c	....	322.	298.8	23.2	47.2	34.	11.	9.5	......	......	.8	.48	......	......	.8	......	......	.055	2.
1960	Mar. 2	Mar. 3	d	l	....	289.6	256.4	33.2	44.	31.2	8.	8.2	......	......	.48	.28	......	......	.63	......	......	.07	2.9
1981	“ 9	“ 10	d	c	....	283.2	258.8	24.4	48.8	35.6	7.	8.	......	......	.48	.36	......	......	.6	......	......	.03	2.4
2018	“ 16	“ 17	d	l	....	261.2	246.8	14.4	49.6	43.2	7.	9.5	......	......	.32	.32	......	......	.67	......	......	.05	2.8
2040	“ 24	“ 24	d	c	....	274.8	257.2	17.6	42.8	34.8	6.	7.8	......	......	.112	.2	......	......	.51	......	......	.07	3.5
2060	“ 30	“ 31	d	c	....	277.6	256.	21.6	45.6	37.2	4.	6.4	......	......	.048	.2	......	......	.51	......	......	.04	3.5
2095	Apr. 6	Apr. 7	d	c	....	261.6	231.2	30.4	37.6	26.4	4.	10.4	......	......	.168	.32	......	......	.67	......	......	.07	2.8
2117	“ 13	“ 14	d	l	....	259.6	242.4	17.2	37.6	32.	4.4	8.8	......	......	.136	.32	......	......	.67	......	......	.08	2.4
2134	“ 20	“ 21	d	l	.3	292.	270.8	21.2	50.	41.6	7.	8.9	......	......	.064	.36	......	......	.83	......	......	.055	2.2
2162	“ 28	“ 28	d	c	....	315.2	273.6	41.6	39.2	33.6	9.	10.3	..	......	.096	.44	......	......	.95	......	......	.065	2.
2189	May 4	May 5	d	c	....	316.	296.	20.	41.2	39.2	10.	12.	......	. .	.072	.52	......	......	.95	......	......	.095	1.5
2209	“ 11	“ 12	d	l	.15	304.8	283.2	21.6	25.2	22.	10.	10.7	......	......	.07	.44	......	......	.71	......	......	.08	1.8
2232	“ 18	“ 19	d	l	.1	296.8	293.6	3.2	32.	22.8	10.	9.2	.. ..	......	.072	.36	......	......	.83	......	......	.075	1.4
2259	“ 25	“ 26	d	l	....	334.8	320.	14.8	34.	28.	12.	11.	......	......	.28	.44	......	......	1.07	......	......	.1	1.1
2285	June 1	June 2	d	c	....	347.6	314.8	32.8	49.2	22.8	13.	9.	......	......	.52	.52	......	......	1.	......	......	.25	.9
2308	“ 8	“ 9	d	l	....	340.4	326.8	13.6	23.2	19.6	15.	11.9	......	......	.56	.36	......	......	1.01	......	......	.35	1.2
2331	“ 15	“ 16	d	c	....	347.2	328.	19.2	36.	32.	17.	12.5	......	......	1.	.56	......	......	1.05	......	......	.37	.8
2365	“ 22	“ 23	d	c	....	384.	335.6	48.4	30.	28.8	22.	11.9	......	......	.88	.8	......	......	1.17	......	......	.3	1.4
2388	“ 29	“ 30	d	c	....	348.	247.6	100.4	64.	35.2	9.	11.3	......	......	.28	.44	......	......	.93	......	......	.27	1.5
2421	July 6	July 8	d	c	....	391.6	292.	99.6	73.2	35.6	11.	11.2	8.8	2.4	.88	.44	.32	.12	.92	.48	.44	.4	1.6
2443	“ 13	“ 15	d	l	.3	318.	286.	32.	28.	24.	15.	12.7	8.7	4.	.36	.44	.352	.088	.96	.92	.04	.3	1.1

2472	July 21	July 21	d	l	.2	306.	290.4	15.6	32.	29.2	15.	10.8	8.9	1.9	.8	.72	.384	.336	1.8	.68	1.12	.23	.8
2497	" 28	" 28	d	c	.1	369.2	328.	41.2	20.4	18.4	23.	14.	12.7	1.3	.498	.52	.49	.03	1.04	.68	.36	.38	1.1
2527	Aug. 4	Aug. 4	d	c	.07	310.	268.	72.	24.	14.	22.	12.8	9.5	3.3	.4	.4	.352	.028	1.4	1.08	.32	.27	1.
2545	" 11	" 11	d	c	.15	436.	296.8	131.2	20.	17.6	21.	15.8	11.5	4.3	.72	.64	.512	.128	1.4	1.	.4	.24	1.
2574	" 18	" 18		c	.15	317.6	277.2	40.4	17.6	10.	24.	12.5	11.	1.5	.72	.56	.32	.24	1.16	.92	.24	.26	.5
2595	" 25	" 25	d	c	.01	416.4	312.4	104.	16.8	14.4	29.	12.8	11.5	1.3	.48	...	.416	..	1.3	.82	.48	.4	.9
2619	Sept. 1	Sept. 1	d	c	.15	442.4	322.	120.4	26.	24.	33.	13.2	9.5	3.7	.48	.52	.32	.2	1.14	.74	.4	.16	.3
2648	" 8	" 8	d	c	.1	393.2	302.4	90.8	23.2	18.4	35.	12.	10.5	1.5	.48	.52	.36	.16	1.06	.78	.28	.11	.3
2673	" 15	" 15	d	c	.2	365.6	347.2	18.4	23.6	20.	48.	12.7	11.7	1.	.8	.56	.44	.12	.98	.9	.08	.07	.6
2701	" 22	" 22	d	c	.1	384.8	337.2	47.6	14.	13.2	47.	13.	11.4	1.6	.8	.64	.44	.2	1.3	.86	.44	.07	.7
2727	" 29	" 29	d	c	.1	388.4	342.8	45.6	25.2	8.	50.	12.5	10.5	2.	.56	.64	.48	.16	1.26	.94	.32	.37	1.
2761	Oct. 6	Oct. 6	d	c	.15	314.8	313.2	31.6	26.	22.	42.	11.3	9.5	1.8	.56	.6	.4	.2	1.18	1.02	.16	.15	.4
2789	" 13	" 13	d	c	....	414.8	352.	62.8	24.	22.	54.	12.6	12.5	.1	1.	.56	.48	.08	1.1	.94	.16	.15	.2
2825	" 20	" 20	d	l	.05	403.2	360.4	42.8	28.4	28.4	55.	12.	8.8	3.2	.96	.6	.4	.2	1.02	.78	.24	.55	.7
2847	" 27	" 27	d	l	.3 *.2	408.8	377.2	31.6	22.4	20.8	60.	10.6	9.4	1.2	1.08	.52	.4	.12	1.02	.9	.12	1.	1.7
2880	Nov. 3	Nov. 3	d	l	.1	390.	363.2	26.8	32.8	32.	58.	11.8	10.5	1.3	1.16	.44	.32	.12	.94	.7	.24	1.	.8
2921	" 10	" 11	d	l	.07	400.4	374.8	25.6	30.8	26.8	58.	11.4	10.5	.9	1.28	.48	.4	.08	1.1	.94	.16	.9	1.7
2958	" 17	" 18	d	l	.1 *.07	392.	363.2	28.8	40.	38.	58.	9.	8.	1.	1.	.52	.44	.08	.94	.78	.16	.26	2.3
2981	" 24	" 25	d	l	.13*.1	398.	384.8	13.2	43.6	40.	56.	8.7	8.	.7	2.4	.44	.4	.04	1.06	.86	.2	.2	1.8
3008	" 30	Dec. 1	d	l	.1	360.8	359.2	1.6	32.8	31.4	47.	7.7	6.2	1.5	2.8	.48	.36	.12	.85	.77	.08	.09	2.1
3040	Dec. 7	" 9	d	l	.15*.08	386.8	368.8	18.	44.	36.8	47.	8.	7.5	.5	3.28	.6	.52	.08	1.09	.85	.24	.1	.4
3068	" 14	" 16	d	l	.06	368.8	365.6	3.2	32.	22.8	49.	8.2	7.7	.5	3.28	.68	.48	.2	1.17	.93	.24	.13	2.
3084	" 21	" 23	d	l	.15*.1	382.	373.2	8.8	28.	26.	46.	9.5	9.	.5	3.52	.64	.52	.12	1.25	.97	.28	.08	1.2
3100	" 28	" 30	d	l	.2 *.1	405.6	398.8	6.8	20.8	20.	46.	14.	9.	5.	5.6	.8	.56	.24	1.25	.85	.4	.1	1.2
Average Jan. 6—June 29...........						317.6	283.4	34.2	34.1	25.7	9.5	7.6	8.5	7.2	.376	.39	.36	.3	.84	.88	.52	.103	2.2
Average July 6—Dec. 28...........						381.4	340.6	40.7	28.7	23.1	40.2	11.5	9.7	1 8	1.376	.54	.41	.13	1.14	.76	.37	.308	1.
Average Jan. 6—Dec. 28...........						351.4	312.	39.3	31.6	24.9	24.8	9.6	9.6	2.	.893	.46	.416	.118	.98	.71	.42	.203	1.6

* Not filtered. Odor none except on November 30 and December 7 when it was musty. Color on ignition brown.

Chemical Examination of Water from the Illinois River at Havana.

(Parts per 1,000,000.)

Serial Number.	1898 Date of Collection.	1898 Date of Examination	Appearance Turbidity.	Appearance Sediment.	Appearance Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia Free Ammonia.	Nitrogen as Ammonia Albuminoid Ammonia. Total.	Nitrogen as Ammonia Albuminoid Ammonia. Dissolved	Nitrogen as Ammonia Albuminoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved	Organic Nitrogen. Suspended	Nitrogen as Nitrites.	Nitrogen as Nitrates.
3126	Jan. 4	Jan. 5	d	l	.1*.2	391.2	383.6	7.6	26.4	25.2	42.	8.7	8.	.7	4.	.64	.48	.16	1.41	1.25	.16	.165	1.
3163	" 11	" 12	d	c	.15	400.8	395.6	5.2	18.	17.2	43.	9.1	8.4	.7	4.4	.64	.44	.2	1.64	.96	.68	.21	1.
3177	" 18	" 19	d	c	.15	407.2	376.	31.2	20.	20.	38.	11.8	7.8	4.	4.6	.6	.52	.08	1.24	.84	.4	.13	.8
3212	" 25	" 26	d	m	.15	424.4	292.4	132.	39.2	23.2	24.	15.	8.8	6.2	2.72	.64	.36	.28	1.32	.84	.48	.175	1.4
3228	Feb. 1	Feb. 2	d	c	.3	303.6	280.8	22.8	29.6	20.2	16.	9.5	8.1	1.4	1.68	.48	.4	.08	.92	.64	.28	.11	2.4
3252	" 8	" 9	d	l	.3	331.	303.4	27.6	56.	37.2	15.	10.5	8.5	2.	1.44	.55	.32	.23	.92	.68	.24	.125	1.77
3268	" 15	" 16	d	c	.3	454.8	298.4	156.	36.8	26.4	15.	15.1	7.7	7.4	1.6	.6	.32	.28	1.24	.6	.64	.06	1.2
3285	" 22	" 23	d	c	.4	394.4	233.6	160.8	33.2	30.4	9.	15.	7.4	7.6	.73	.68	.28	.4	1.32	.64	.68	.03	3.2
3316	Mar. 1	Mar. 2	d	l	.5	258.	248.	10.	35.2	28.8	10.	10.5	8.	2.5	.68	.44	.36	.08	.84	.68	.16	.045	2.5
3337	" 8	" 9	d	l	.4	281.2	278.	3.2	28.	20.	7.	10.7	8.8	1.9	.6	.44	.36	.08	.92	.76	.16	.02	1.6
3361	" 15	" 16	d	c	......	299.2	256.8	42.4	34.	21.6	8.	10.5	7.5	3.	.72	.44	.32	.12	1.	.64	.36	.055	1.25
3385	" 22	" 23	d	l	.3	260.	238.4	21.6	34.	30.	7.	7.9	7.5	.4	.36	.4	.36	.04	.92	.68	.24	.055	1.25
3404	" 29	" 30	d	c	.7	236.	226.4	9.6	27.6	24.	4.	9.5	8.2	1.3	.152	.4	.32	.08	.93	.61	.32	.08	1.2
3428	April 5	April 6	d	l	.5	238.8	212.8	26.	33.2	24.8	6.	9.5	8.6	.9	.088	.4	.36	.04	.85	.73	.12	.055	1.
3453	" 12	" 13	d	c	......	237.6	194.4	43.2	27.6	23.	4.	12.3	9.2	3.1	.088	.44	.4	.04	1.09	.93	.16	.035	.85
3478	" 19	" 21	d	l	.25	250.8	244.8	6.	44.	40.8	6.	11.8	9.2	2.6	.16	.44	.36	.08	8	.73	.12	.05	.75
3506	" 26	" 27	d	l	.15	335.2	256.8	78.4	27.6	24.8	9.	12.	9.1	2.9	.088	.52	.32	.2	1.01	.77	.24	.035	1.1
3532	May 3	May 4	d	l	.1*.25	316.	287.2	28.8	50.8	40.8	11.	9.1	7.3	1.8	.34	.48	.4	.08	.98	.74	.24	.065	.85
3557	" 10	" 11	d	l	.05	319.2	299.6	19.6	49.2	37.2	11.	11.3	8.1	3.2	.08	.6	.44	.16	1.38	.74	.64	.07	1.
3591	" 17	" 18	d	c	.05	338.8	316.4	22.4	64.	62.5	12.	9.3	8.	1.3	.36	.36	.28	.08	.9	.78	.12	.06	.75
3620	" 24	" 25	d	l	.05*.25	261.2	256.8	4.4	30.8	26.8	10.	9.	7.5	1.5	.128	.4	.32	.08	.74	.58	.16	.075	.8
3638	" 31	June 1	d	c	.1*.4	261.2	255.2	6.	31.6	26.8	7.	8.5	8.	.5	.184	.32	.28	.04	.74	.62	.12	.2	.85
3664	Jnne 7	" 8	d	l	.1*.2	295.	285.6	10.4	39.6	33.8	7.	8.5	7.5	1.	.24	.28	.2	.08	.64	.52	.12	.22	.525
3691	" 14	" 15	s	l	.05*.2	318.8	279.6	39.2	30.2	25.6	9.	7.7	7.5	.2	.16	.28	.24	.04	.68	.64	.04	.14	.45
3709	" 21	" 22	s	l	.1	329.6	318.4	11.2	46.8	18.	14.	8.6	7.7	.9	.32	.36	.32	.04	.84	.72	.12	.2	.45
3754	" 28	" 29	s	l	.03	308.8	.....	.....	18.	.....	11.	7.9	7.	.9	.094	.24	.2	.04	.72	.64	.08	.22	.5
3785	July 5	July 6	d	c	.06	342.5	326.4	16.1	28.	24.	16.	8.5	6.8	1.7	.48	.36	.24	.12	.92	.48	.44	.22	.35

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT HAVANA.—CONTINUED.

(Parts per 1,000,000.)

Serial Number.	1898 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammon a.							
	Collection.	Examination.	Turbipity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved.	Suspended	Totol.	Dissolved.	Suspenced	Nitrites.	Nitrates.
3820	July 12	July 13	d	l	.04*.12	304.4	294.	10.4	16.8	14.	17.	8.5	8.	.5	.28	.44	.36	.08	.88	.76	.12	.13	.4
3843	" 19	" 20	d	l	.03*.04	319.6	297.6	22.	18.	16.	15.	8.4	8.	.4	.32	.4	.32	.08	.8	.68	.12	.13	.3
3884	" 26	" 27	d	l	.03*.05	310.8	309.2	1.6	22.	21.2	16.	9.	8.5	.5	.6	.44	.36	.08	1.04	.8	.24	.04	.2
3905	Aug. 2	Aug. 3	d	c	.03	330.8	308.8	22.	16.	15.2	22.	8.9	7.8	1.1	1.	.48	.366	.114	.88	.68	.2	.04	.3
3937	" 9	" 10	d	l	.15*.2	370.8	354.8	16.	44.	33.6	29.	9.3	8.4	.9	.52	.6	.44	.16	1.28	.92	.36	.2	.15
396	" 16	" 17	d	c	.04	374.	354.8	20.	29.2	26.8	37.	8.5	8.	.5	.36	.4	.36	.04	.96	.8	.16	.17	.15
398	" 23	" 24	d	l	.04*.1	360.8	343.2	17.6	22.	20.	46.	8.1	6.1	2.	.608	.416	.352	.064	.88	.72	.16	.42	.15
401	" 30	" 31	d	l	.04	337.2	316.4	20.8	24.8	20.	40.	8.5	7.5	1.	.76	.52	.36	.16	1.04	.72	.32	.22	.05
4047	Sept. 6	Sept. 7	d	l	.06	331.2	299.6	33.6	28.	24.8	32.	9.5	6.5	3.	1.	.48	.32	.16	1.	.68	.32	.05	.05
407	" 13	" 14	d	c	.03	356.	331.6	24.4	36.	34.	38.	7.5	7.	.5	.84	.32	.28	.04	.88	.68	.2	.25	.25
4092	" 20	" 21	d	c	.04	372.	328.	44.	48.	28.	36.	7.1	6.6	.5	.88	.36	.24	.12	.76	.6	.16	.28	.3
4125	" 27	" 28	d	l	.05	304.8	280.8	24.	39.2	26.8	37.	6.8	5.8	1.	1.16	.32	.28	.04	.68	.52	.16	.29	.45
416	Oct. 4	Oct. 5	d	c	.04	322.	304.	18.	30.8	24.	25.	6.7	5.8	.9	.8	.32	.24	.08	.72	.52	.2	.14	.5
4198	" 11	" 12	d	l	.05*.15	336.4	318.8	17.6	35.2	34.	25.	6.2	5.5	.7	.8	.36	.28	.08	.53	.45	.08	.24	.4
4230	" 18	" 19	d	l	.05*.15	344.	332.3	11.2	32.	28.	29.	7.	5.8	1.2	.76	.288	.24	.048	.73	.57	.16	.32	.65
4257	" 25	" 26	d	l	.06*.1	590.4	360.8	29.6	43.6	36.	34.	8.	6.6	1.4	1.84	.408	.288	.12	.85	.65	.2	.105	.8
429	Nov. 1	Nov. 2	d	c	.04	360.	339.2	20.8	32.	31.2	28.	7.	5.5	1.5	1.76	.36	.28	.08	.69	.45	.24	.04	.45
4334	" 8	" 9	d	c	.07	370.8	336.8	34.	32.	30.	19.	7.4	5.4	2.	.96	.32	.236	.084	.67	.51	.16	.04	.75
4402	" 22	" 23	d	c	.04	400.8	310	90.8	46.	36.	13.	9.	7.	2.	.6	.4	.208	.192	.79	.47	.32	.035	.9
443	" 29	" 30	d	c	.05	360.	342.	18.	37.2	35.	12.	8.	6.2	1.8	.48	.304	.224	.08	.63	.51	.12	.035	1.25
4463	Dec. 6	Dec. 7	d	c	.07	379.2	370.	9.2	47.2	40	16.	7.8	6.8	1.	.92	.336	.224	.112	.69	.57	.12	.04	.35
4485	" 13	" 14	d	c	....	392.8	391.2	1.6	66.	59.2	17.	8.3	8.	.3	1.08	.384	.272	.112	.8	.67	.13	.02	.1
4512	" 20	" 21	d	c	.04*.08	385.6	384.	1.6	56.5	56.	20.	9.1	8.4	.7	1.24	.464	.272	.192	.89	.69	.2	.02	.35
4540	" 27	" 28	d	l	.07*.4	364.	390.	4.	51.2	50.	27.	12.5	9.5	3.	2.4	.48	.4	.08	.89	.77	.12	.0 6	.2
Average Jan. 4th—June 21st........						317.5	270.	47.4	35.	27.7	13.	10.3	8.	2.3	1.	.46	.34	.12	1.	.729	.27	.103	1.17
Average July 5th—Dec. 27th........						362.1	332.9	29.1	35.1	30.5	25.	8.2	7.	1.2	.897	.398	.309	.088	.83	.634	.19	.139	.39
Average Jan. 4th—Dec. 27th........						339.4	300.9	38.4	35.1	29.1	19.	9.3	7.5	1.7	.950	.431	.327	.103	.92	.683	.23	.121	.81

Odor, none. Color on ignition brown. * not filtered.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT HAVANA.

(Parts per 1,000,000.)

Serial Number.	1899		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
	Collection.	Examination.							Total.	Dissolved.						Total.	Dissolved.	Suspended					
4570	Jan. 3	Jan. 4	d	c	.4	334.8	316.8	18.	54.	42.	19.	14.2	12.2	2.	1.72	.52	.384	.136	1.17	.85	.32	.025	.1
4597	" 10	" 11	d	c	.3	328.8	314.8	14.	32.8	30.	16.	12.	8.8	3.2	1.4	.44	.36	.08	.93	.69	.24	.02	.3
4518	" 17	" 18	d	o	.2	317.2	254.8	62.4	50.	48.	11.	14.	8.7	5.3	.72	.52	.304	.216	.97	.61	.36	.035	.85
4643	" 24	" 25	d	c	.25	236.	202.8	33.2	52.	48.	11.	12.	8.1	3.9	1.04	.48	.288	.192	.85	.57	.28	.035	.65
4665	" 31	Feb. 1	d	c	.15	287.2	270.8	16.4	48.	43.	12.	9.4	8.	1.4	.96	.44	.24	.2	.85	.61	.24	.021	.9
4684	F b. 7	" 8	d	l	.1*.45	326.	318.8	7.2	48.	42.	15.	9.	8.	1.	1.12	.4	.288	.112	.86	.58	.28	.024	1.5
4703	" 14	" 15	d		.1*.25	372.	364.	8.	58.	56.	20.	12.2	9.	3.2	1.48	.528	.368	.16	1.02	.74	.28	.03	1.75
4730	" 2	" 22	d		.15*.3	360.	354.	6.	56.	51.2	20.	9.8	9.1	.7	1.76	.512	.416	.096	1.22	.83	.36	.075	1.15
4757	" 28	Mar. 1	d	vm	.6	750.	178.	572.	82.	40.	10.	37.	9.9	27.1	1.12	1.36	.4	.96	2.34	.58	1.76	.042	.75
4781	Mar. 7	" 8	vd	vm	.7	442.	194.	248.	66.	40.	10.	27.3	15.	12.3	.76	.84	.384	.456	1.94	.74	1.2	.04	.95
48 3	" 14	" 15	vd	m	.5	370.	152.4	217.6	58.	33.2	5.8	23.8	13.5	10.3	.6	.72	.32	.4	1.78	.66	1.12	.023	.8
4840	" 21	" 22	d	m	.7	364.	178.8	185.2	52.	42.	5.2	19.8	12.6	7.	.56	.56	.304	.256	1.35	.6	.75	.035	1.25
4846	" 28	" 29	d	c	.5	268.8	242.	26.8	50.	46.	5.8	15.8	11.6	4.2	.56	.48	.32	.16	1.07	.63	.44	.04	1.35
4890	Apr. 4	Apr. 5	d		.4	266.	206.	60.	46.	40.	6.6	13.5	9.3	4.2	.56	.44	.32	.12	.99	.6	.39	.015	1.6
4919	" 12	" 13	d	l	.1	236.	208.8	27.2	38.	34.	7.	12.	9.	3.	.608	.352	.288	.064	.83	.63	.2	.045	1.7
4940	" 18	" 19	d	c	.2	279.6	260.	19.6	52.	50.	7.4	11.	8.7	2.3	.4	.4	.32	.08	.75	.6	.15	.05	1.7
4964	" 25	" 26	d	c	.1	298.8	276.8	22.	50.8	48.8	9.2	12.5	9.	3.5	.24	.64	.352	.288	1.33	.89	.44	.055	1.25
4990	May 2	May 3	d	c	.... ..	324.4	293.2	31.2	50.8	50.	11.	13.	9.	4.	.144	.48	.248	.232	1.29	.85	.44	.065	.5
5011	" 9	" 10	d	c	.04	341.2	305.6	35.6	33.6	32.	13.	11.2	10.1	1.1	.56	.44	.384	.056	1.21	.97	.24	.1	1.6
504	" 16	" 17	d	l	.04*.05	359.2	316.8	42.4	93.6	4.	18.	12.8	12.2	.6	1.024	.48	.352	.128	1.13	.89	.24	.12	1.12
5078	" 23	" 24	d	c	.04	426.	344.4	81.6	47.2	43.2	18.2	15.4	12.8	2.6	.93	.56	.384	.176	1.45	1.114	.336	.075	1.08
5114	" 30	" 31		c	[illegible]	347.6	328.	19.6	28.	26.4	13.2	11.7	10.3	1.4	.72	.448	.384	.064	1.05	.86	.19	.12	1.56
5206	June 13	June 14		c	.1	331.6	317.6	14.	37.6	36.8	15.	12.3	10.5	1.8	.72	.416	.352	.064	1.4	.824	.576	.24	1.2
5246	" 20	" 21	d	c	.15	356.8	343.6	13.2	50.	48.8	14.5	14.3	11.	3.3	.396	.512	.32	.192	1.16	.856	.304	.16	1.12
5303	" 28	" 29	d	c	.1	371.2	324.4	46.8	29.2	28.4	19.	13.1	12.	1.1	.688	.512	.464	.048	1.32	1.016	.304	.14	.76
5352	July 5	July 6	d	c	.03	391.2	318.8	72.4	44.	39.2	21.5	14.1	6.5	7.6	.8	.48	.352	.128	1.48	1.112	.368	.18	.4
5401	" 12	" 13	d	c	.1	389.6	356.8	32.8	72.	68.8	28.	14.5	11.8	2.7	.88	.416	.352	.064	1.16	.888	.272	.23	1.12

5447	July 19	July 20	d	c	.08	358.	340.4	17.6	44.4	40.	36.	12.6	11.7	.9	.784	.48	.288	.192	1.	.724	.276	.3	1.28
5494	" 26	" 27	d	c	.07	306.	292.8	13.2	47.6	47.2	30.	11.	10.9	.8	.96	.416	.272	.144	1.08	.76	.32	.24	.84
5540	Aug. 2	Aug. 3	d	c	.2	345.2	314.	31.2	74.	51.6	30.	12.7	11.7	1.	.64	.448	.384	.064	1.24	.792	.448	.18	.76
5601	" 9	" 10	d	c	.04	370.	320.8	49.2	49.6	42.4	31.	11.7	10.	1.7	.96	.384	.224	.16	.92	.728	.192	.17	.4
5640	" 16	" 17	d	c	.07	410.	341.2	68 8	80.	68.4	30.5	13.4	11.5	1.9	.976	.432	.304	.128	1.32	.728	.592	.23	.6
5695	" 23	" 24	d	c	.05	408.	347.2	60.8	46.4	45.2	35.	13.3	9.8	2.5	.509	.592	.32	.272	1.4	.728	.672	.23	.64
5749	" 30	" 31	d	c	.04	397.2	334.4	62.8	44.8	24.	40.	12.	10.8	1.2	.544	.64	.32	.32	1.4	.84	.56	.11	.36
5803	Sept. 6	Sept. 7	d	c	.06	395.6	340.	55.6	29.6	29.2	41.	13.1	8.6	4.5	.768	.64	.4	.24	1.72	.92	.8	.04	.6
5859	" 13	" 14	d	c	.1	423.2	352.8	70.4	49.2	46.4	44.2	12.9	7.5	5.4	.928	.64	.4	.24	1.56	1.	.56	.05	.32
5897	" 20	" 21	d	c	.04	387.6	294.8	92.8	44.4	44.	35.5	12.9	8.2	4.7	.608	.48	.272	.208	1.4	.824	.576	.08	.6
5962	" 27	" 28	d	m	.06	416.4	352.8	63.6	46.4	40.	50.	12.2	9.3	2.9	.752	.592	.368	.224	1.54	1.06	.48	.09	.64
6008	Oct. 4	Oct. 5	d	c	.08	406.8	351.6	55.2	45.2	21.2	54.	15.	10.3	4.7	.432	.768	.4	.368	1.86	.772	1.088	.24	1.16
6055	" 11	" 12	d	c	.15	443.6	389 6	54.	32.8	26.4	61.5	13.4	11.2	2.2	.64	.56	.4	.16	1.32	.6	.72	.45	1.32
6104	" 18	" 19	d	c	.25	402.4	352.	50.4	21.6	19.2	60.5	14.3	7.1	7.2	1.6	.704	.432	.272	1.96	1.096	.864	.7	.56
6170	" 25	" 26	d	c	.05	417.6	375.6	42.	18.4	17.6	58.2	9.2	7.8	1.4	1.6	.672	.48	.192	1.224	1.	.224	.025	1.76
6211	Nov. 1	Nov. 2	d	c	.04	436.8	415.2	21.6	42.8	24.8	63.5	10.5	9.	1.5	1.472	.624	.368	.256	1.384	.584	.8	.9	2.6
6258	" 8	" 9	d	c	.04	414.4	404.	10.4	49.6	46.4	57.	9.3	8.1	1.2	2.56	.704	.416	.288	1.4	.808	.592	.875	2.8
6317	" 15	" 16	d	c	.04	397.6	374.	23.6	35.6	32.4	43.	8.2	7.9	.8	2.76	.736	.4	.336	1.16	.68	.48	.25	2.
6357	" 22	" 23	d	c	.04	383.2	363.6	19.6	27.6	22.	48.	8.2	7.	1.3	3.36	.48	.288	.192	1.48	.52	.96	.07	1.48
6421	" 29	" 30	d	c	.03	365.6	356.	9.6	41.2	39.6	58.	8.5	7.4	1.1	3.28	.56	.336	.224	1.224	.872	.352	.06	1.28
6469	Dec. 6	Dec. 8	d	c	.03	366.	358.4	7.6	38.4	35.2	34.	9.6	8.4	1.2	1.76	.672	.352	.32	1.88	.808	1.072	.08	1.52
6522	" 13	" 15	d	c	.03	362.8	357.2	5.6	41.6	39.2	35.5	10.8	9.4	1.4	2.56	.96	.432	.328	1.64	.904	.736	.08	2.4
6558	" 20	" 21	d	c	.03	373.2	371.2	2.	31.2	30.8	36.	13.4	9.8	3.6	2.24	.512	.432	.08	1.16	.84	.32	.08	1.76
Average Jan. 8—June 28						351.4	271.	80.9	47.6	40.1	12.5	14.5	10.8	4.3	.832	.539	.341	.197	1.171	.752	.457	.066	1.09
Average July 5—Dec. 20						390.7	351.	38.1	43.9	37.6	42.2	11.8	9.2	9.4	1.376	.563	.359	.224	1.396	.828	.572	.26	1.16
Average Jan. 8—Dec. 20						370.9	314.	60.7	45.8	38.9	27.3	13.3	9.7	8.4	1.104	.561	.35	.21	1.282	.788	.615	.168	1.12

Odor none. Color on ignition generally brown, but occasionally gray.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT HAVANA.

(Parts per 1,000,000.)

Serial Number.	1900. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
6679	Jan. 11	Jan. 12	d	c	.04	361.2	352.8	8.4	51.2	45.2	21.5	8.8	8.3	.5	1.6	.48	.304	.176	1.04	.735	.304	.04	2.4
6752	" 24	" 25	d	c	.04	368.	338.4	29.8	26.8	24.8	26.7	11.2	9.	2.2	2.56	.448	.352	.096	.88	.64	.24	.05	2.
6795	" 31	Feb. 1	d	c	.15	311.2	295.6	15.6	15.2	15.2	23.	9.1	8.8	.3	2.4	.512	.32	.192	1.04	.64	.4	.03	2.4
6861	Feb. 7	" 8	d	c	.06	312.8	266.8	46.	18.	17.2	18.	9.3	7.	2.3	1.76	.464	.24	.224	.96	.64	.32	.027	1.36
6907	" 14	" 15	d	c	.06	302.8	232.4	70.4	36.8	25.6	15.7	9.7	7.	2.7	1.216	.416	.304	.112	.96	.576	.384	.031	1.4
6946	" 21	" 22	d	c	.15	262.8	224.4	38.4	55.6	20.	12.2	10.8	7.6	3.2	.896	.544	.32	.224	.88	.64	.24	.03	1.28
6996	Mar. 1	Mar 3	d	c	.06	290.8	230.	60.8	20.8	20.4	11.	13.	10.9	2.1	.864	.448	.304	.144	.88	.64	.24	.04	1.48
7042	" 7	" 8	d	m	.5	266.4	234.4	32.	37.2	28.4	11.	11.7	10.9	.8	.88	.416	.288	.128	.96	.64	.32	.035	1.8
7081	" 14	" 15	vd	"v"	.4	1067.6	85.6	982.	44.4	11.6	4.	28.2	13.1	15.1	.4	1.44	.24	1.2	3.04	.576	2.464	.01	.4
7149	" 22	" 23	d	c	.4	255.2	138.8	116.4	19.2	10.8	5.5	12.1	6.9	5.2	.528	.416	.224	.192	1.24	.6	.64	.008	1.08
7200	" 29	" 30	d	c	.2	201.2	147.6	53.6	16.4	14.4	4.	8.6	6.1	2.5	.32	.224	.176	.048	.632	.472	.16	.017	1.38
7229	April 4	April 5	d	c	.3	193.6	166.4	27.2	19.6	17.6	5.6	11.2	7.7	3.5	.448	.272	.238	.034	.536	.456	.08	.018	1.68
7282	" 11	" 12	d	c	.3	227.	202.	25.	22.	22.	5.	9.1	7.3	1.8	.256	.224	.192	.032	.6	.536	.064	.03	2.2
7346	" 18	" 19	d	c	.15	229.2	189.6	39.6	34.	32.8	5.3	8.1	6.9	1.2	.24	.224	.176	.048	.504	.44	.064	.035	2.2
7406	" 25	" 26	d	c	...	220.4	202.8	17.6	30.	24.	6.9	9.8	8.1	1.7	.048	.4	.256	.144	1.24	.664	.576	.036	1.68
7446	May 2	May 3	d	c	.1	234.4	216.4	18.	35.6	33.6	9.	10.3	8.4	1.9	.08	.56	.272	.288	1.16	.74	.42	.052	.88
7490	" 9	" 10	d	c	.03	302.8	250.8	52.	22.8	20.	9.8	10.8	8.2	2.6	.16	.448	.288	.16	.9	.612	.288	.05	.8
7548	" 16	" 17	..	.	.1	327.2	264.	63.2	36.	34.8	13.2	14.4	8.5	3.9	.384	.416	.32	.096	1.284	.132	1.152	.075	.76
7591	" 23	" 24	d	l	.05	382.8	294.	88.8	57.6	35.6	13.5	12.2	7.7	4.5	.448	.352	.24	.112	.9	.74	.16	.115	.12
7626	" 30	" 31	d	c	.1	328.4	267.6	60.8	24.8	19.6	16.	11.1	8.5	2.6	.432	.368	.272	.096	1.16	.644	.516	.075	1.2
7711	June 13	June 14	d	c	.03	342.	265.2	76.8	66.8	36.8	14.	9.7	6.4	3.3	.272	.32	.272	.048	1.22	.772	.448	.21	1.84
7847	July 5	July 6	d	m	...	285.6	252.4	33.2	29.2	24.4	18.	7.	6.8	.2	.416	.224	.208	.016	.612	.388	.224	.16	1.52
7909	" 11	" 12	d	l	.02	276.4	248.	28.4	32.	30.8	12.	6.5	6.2	.3	.288	.176	.16	.016	.516	.324	.192	.095	1.12
7958	" 18	" 19	d	l	.02	301.6	244.4	57.2	31.6	27.6	22.	7.5	5.9	1.6	.448	.24	.144	.096	.804	.58	.224	.12	1.24

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT HAVANA.—CONTINUED.
(Parts per 1,000,000.)

Serial Number.	1900 Date of Collection.	Date of Examination.	Appearance. Turbidity.	Sediment.	Color.	Residue on Evaporation. Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Dissolved.	Chlorine.	Oxygen Consumed. Total.	By Dissolved.	By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Albuminoid Ammonia. Total.	Dissolved.	Suspended.	Organic Nitrogen. Total.	Dissolved.	Suspended	Nitrogen as Nitrites.	Nitrates.
8021	July 25	July 26	d	1	.01	310.	233.2	76.8	27.6	27.6	25.	6.5	6.2	.3	.33	.272	.24	.032	.836	.356	.48	.08	1.4
8081	Aug. 1	Aug. 2	d	1	.01	273.2	232.	41.2	25.6	23.6	24.	6.5	5.1	1.4	.24	.248	.204	.044	.546	.356	.19	.13	1.28
8142	" 9	" 10	d	1	.01	269.2	219.2	50.	43.2	42.8	17.	7.2	4.3	2.9	.144	.304	.224	.08	.836	.456	.38	.08	.68
8203	" 16	" 18	d	1	.02	316.2	200.4	115.8	24.8	22.	18.	7.8	4.4	3.4	.416	.304	.192	.212	.836	.38	.456	.1	.76
8258	" 22	" 23	d	1	.02	221.2	203.6	17.6	15.2	13.2	20.	6.6	4.7	1.9	.352	.288	.16	.128	.508	.316	.192	.15	1.04
8313	" 29	" 30	d	1	.01	273.6	228.	45.6	30.	19.2	21.	6.5	4.4	2.1	.448	.368	.176	.192	.668	.3	.338	.16	1.08
8392	Sept. 6	Sept. 7	d	1	.01	290.4	249.6	40.8	21.2	19.2	20.	6.6	4.4	2.2	.176	.32	.192	.128	.536	.384	.152	.13	1.08
8451	" 12	" 13	d	1	.03	252.	234.4	17.6	26.8	24.	16.	6.6	4.5	2.1	.512	.4	.16	.24	.76	.4	.36	.11	1.
8510	" 20	" 21	d	c	.1	294.4	253.2	41.4	29.6	25.6	21.	8.1	5.6	2.5	.392	.4	.192	.208	.76	.384	.376	.19	1.
8543	" 26	" 27	d	c	.2	322.	266.8	55.2	31.2	24.	23.	7.6	5.8	1.8	.584	.352	.176	.176	1.084	....	....	.12	1.08
8613	Oct. 4	Oct. 4	d	c	.02	308.4	254.4	54.	30.	27.6	18.	6.2	4.9	1.3	.528	.304	.272	.032	.88	.592	.088	.12	1.2
8663	" 15	" 16	d	1	.04	268.	231.2	36.8	18.4	17.6	16.	6.5	4.8	1.7	.352	....	.128	....	.....	.624	....	.12	1.32
8696	" 24	" 25	d	1	.01	270.4	239.2	31.2	26.4	20.4	13.	5.9	5.4	.5	.464	.256	.224	.032	.72	.672	.048	.02	1.5
8728	" 30	" 31	d	1	......	270.4	231.2	39.2	26.8	24.4	15.	5.6	5.	.6	.528	.194	.16	.032	.624	.592	.032	.05	1.15
8752	Nov. 6	Nov. 7	d	1	.02	257.2	234.	23.2	16.8	....	17.	5.3	4.9	.4	.56	.224	.208	.016	.704	.512	.192	.065	1.375
8777	" 13	" 14	d	1	.01	307.6	237.2	70.4	20.4	19.6	16.	7.2	5.4	1.8	.368	.4	.208	.192	.88	.672	.208	.045	1.795
8801	" 20	" 21	d	v 1	.03* .05	254.	236.4	17.6	26.8	24.	14.	5.1	...	...	.664	.304	.288	.016	.752	.672	.08	.026	1.134
8823	" 26	" 27	d	1	.05	256.4	229.6	26.8	20.4	18.8	17.	6.4	5.9	.5	.896	.368	.16	.208	.848	.64	.208	.035	1.205
8874	Dec. 5	Dec. 6	d	1	.1	267.2	260.8	6.4	19.6	16.	9.	5.5	5.4	.1	.336	.24	.224	.016	.512	.48	.032	.026	1.254
8880	" 10	" 11	d	1	.15	262.8	258.4	4.4	27.6	18.	12.	7.2	6.8	.4	.24	.304	.144	.16	.64	.448	.192	.03	1.33
8904	" 18	" 19	d	1	.2	268.	264.	4.	27.2	23.	12.	7.2	7.1	.1	.336	.336	.272	.064	.88	.72	.16	.022	1.298
8921	" 24	" 26	d	1	.15	273.6	266.4	7.2	29.2	27.6	12.	8.1	8.	.1	.656	.432	.336	.096	.848	.752	.096	.021	1.019
Average Jan. 11th—June 13th.......						323.2	331.6	91.5	32.8	24.3	12.	11.3	7.8	3.4	.771	.447	.265	.182	1.	.596	.403	.049	1.444
Average July 5th—Dec. 24th........						277.9	240.3	37.6	26.3	23.7	17.1	6.6	5.4	1.1	.428	.392	.216	.086	.704	.5	.204	.088	1.194
Average Jan. 11th—Dec. 24th.......						298.6	236.3	62.2	29.3	24.	14.8	8.7	6.8	2.0	.585	.361	.23	.131	.829	.533	.306	.0701	1.308

Odor on July 5 clayey; August 16 gassy; November 13 and December 18 and 24 musty; at all other dates odorless. Color on ignition brown.

*Not filtered.

Chemical Examination of Water from the Illinois River at Kampsville.

(Parts per 1,000,000.)

Serial Number.	1897 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved.	Suspended	Totol.	Dissolved.	Suspended	Nitrites.	Nitrates.
1819	Jan. 12	Jan. 13	d	c	.2	655.6	254.	401.6	23.2	11.6	8.	15.3	7.4	7.9	.304	.64	.36	.28	1.28	.56	.72	.045	2.3
1839	" 19	" 20	vd	m	.3	768.4	216.	552.4	32.8	14.	7.	15.9	8.2	7.7	.256	.64	.208	.432	1.44	.72	.72	.03	2.4
1853	" 26	" 30	d	c	.1	606.4	284.4	322.	18.8	18.	6.8	14.3	7.8	6.5	.244	.8	.48	.32	1.44	.88	.56	.06	3.1
1875	Feb. 2	Feb. 3	d	l	.07	322.8	291.6	31.2	10.8	10.	6.4	8.3	7.7	.6	.368	.32	.24	.08	1.12	.8	.32	.017	3.2
1902	" 9	" 11	d	c	.2	342.4	272.	70.4	20.8	19.6	6.1	9.4	6.8	2.6	.288	.4	.176	.224	.88	.72	.16	.04	2.4
1919	" 16	" 17	d	c	.2	379.2	284.8	94.4	24.8	14.	8.	11.3	7.4	3.9	.48	.56	.24	.32	1.12	.8	.32	.035	2.4
1933	" 23	" 24	d	c	.3	421.6	254.	167.6	37.2	31.2	7.	11.8	7.	4.8	.544	.64	.32	.32	1.14	.72	.42	.09	2.
1962	Mar. 2	Mar. 3	d	l	.15	331.6	275.2	56.	40.	38.	8.	10.1	6.6	3.5	.464	.4	.24	.16	1.35	.67	.68	.075	2.3
1984	" 9	" 10	d	m	.2	557.6	219.6	338.	48.4	32.	5.	16.5	7.8	8.7	.228	.8	.176	.624	1.23	.67	.56	.04	2.
2021	" 16	" 18	d	c	.15	463.2	229.2	234.	74.	50.	4.6	14.4	7.6	6.8	.24	.56	.192	.368	1.4	.51	.89	.06	2.2
2043	" 23	" 25	vd	m	.15	518.	213.2	304.8	48.8	35.2	5.8	17.3	7.4	9.9	.196	.52	.22	.3	1.15	.51	.64	.05	2.3
2062	" 30	" 31	d	c	.2	326.8	210.	116.8	40.	27.2	4.1	11.7	7.1	4.6	.164	.32	.24	.08	1.07	.75	.32	.06	2.6
2096	April 6	April 7	vd	c	.1	422.	228.4	193.6	26.8	26.8	3.4	16.	7.5	8.5	.068	.56	.24	.32	1.07	.6	.47	.07	2.4
2119	" 13	" 14	d	c	.2	294.4	219.2	75.2	32.4	32.	4.	11.	6.5	4.5	.096	.48	.208	.272	.6	.51	.09	.065	2.4
2141	" 21	" 22	d	l	.2* .3	293.6	266.	27.6	42.8	40.	4.6	11.3	7.4	3.9	.028	.32	.192	.128	.83	.67	.16	.035	2.4
2160	" 27	" 29	d	c	.06	294.8	240.8	54.	35.6	34.	4.8	11.	6.5	4.5	.056	.56	.192	.368	1.19	.8	.39	.03	1.7
2188	May 4	May 5	d	c	.04	274.	262.8	11.2	30.	26.	7.	11.	8.	3.	.084	.56	.304	.256	1.19	.63	.56	.036	1.5
2212	" 11	" 13	d	l	.03	333.2	266.	67.2	21.6	20.8	6.6	10.3	8.1	2.2	.076	.56	.208	.352	1.03	.63	.4	.065	1.6
2236	" 19	" 21	d	c	.03	403.6	298.	105.6	34.	16.	7.6	12.7	7.7	5.	.104	.48	.24	.24	1.23	.75	.48	.084	1.4
2257	" 25	" 26	d	c	.2	406.	300.8	105.2	23.6	20.	8.4	10.7	8.	2.7	.164	.48	.4	.08	1.23	.83	.4	.07	1.1
2284	June 1	June 2	vd	c	.04	425.2	298.8	126.4	28.	22.	10.	12.	9.4	2.6	.168	.64	.48	.16	1.55	.91	.64	.135	.5
2306	" 8	" 9	d	c	.05	402.4	318.8	83.6	28.	22.8	12.	12.1	7.7	4.4	.184	.64	.4	.24	1.21	.81	.4	.22	1.3
2330	" 15	" 16	d	c	.04	402.4	314.4	88.	41.2	32.	13.	11.	7.4	3.6	.084	.48	.264	.216	1.11	.73	.38	.2	1.2
2364	" 22	" 23	d	c	.06	382.8	300.8	82.	26.	24.	12.	10.	...	...	.064	.48	.4	.08	1.07	.73	.34	.225	1.3
2389	" 29	" 30	d	c	......	502.	314.4	187.6	54.	20.	18.	13.1	9.4	3.7	.024	.56	.256	.304	1.13	.67	.46	.23	1.6
2413	July 6	July 7	d	c	......	374.8	280.8	94.	34.	24.4	9.	12.2	8.8	3.4	.01	.44	.3	.14	1.24	.86	.38	.14	1.6
2471	" 20	" 21	d	c	.07	342.8	274.	68.8	28.	20.	12.	8.9	8.	.9	.12	.64	.416	.224	.92	.52	.4	.08	.7

2498	July 27	July 28	d	c	.4	390.	188.	208.	18.	12.	9.	10.5	9.1	1.4	.128	.56	.32	.24	1.16	.84	.32	.18	.4
2525	Aug. 3	Aug. 4	d	c	.08	314.	280.	34.	18.	16.	19.	10.5	9.1	1.4	.024	.56	.416	.144	1.	.76	.24	.2	1.5
2544	" 9	" 11	d	c	.2	315.6	251.2	64.4	16.	14.4	13.	9.7	8.5	1.2	.068	.48	.288	.192	1.72	1.08	.64	.2	1.1
2572	" 17	" 18	d	c	.1	296.8	270.4	26.4	15.6	14.4	16.	10.8	9.9	9.	.032	.56	.256	.304	1.08	.76	.32	.1	1.3
2596	" 24	" 25	d	l	.06	300.8	274.8	26.	15.2	14.	15.	9.5	9.	.5	.058	.64	.224	.416	.9	.66	.24	.06	1.
2623	Sept. 1	Sept. 2	d	c	.15	308.	286.	22.	24.	21.5	15.	9.7	9.2	.5	.148	.44	.28	.16	.82	.54	.28	.06	.3
2646	" 7	" 8	d	c	.1	315.6	.....	.....	19.2	....	20.	12.5	9.	3.5	.358	.56	.44	.12	1.46	.7	.76	.085	1.3
2677	" 14	" 16	d	l	.05	328.	299.6	28.4	18.	15.2	23.	11.9	9.	2.9	.526	.52	.36	.16	1.06	.82	.24	.045	.2
2698	" 21	" 22	d	l	.05	334.	316.	18.	12.8	11.2	28.	9.2	8.5	.7	.4	.36	.328	.024	.9	.62	.28	.1	.3
2732	" 29	" 30	d	c	.06	345.2	310.8	34.4	31.2	14.	34.	11.8	9.7	2.1	.342	.08	.4	.28	1.34	.98	.26	.085	.5
2788	Oct. 12	Oct. 13	d	l	.1	376.4	317.2	59.2	31.6	20.	41.	9.2	8.6	.6	.32	.4	.32	.08	....	.78	...	.07	.2
2828	" 19	" 20	d	l	.15	352.	331.6	20.4	18.	16.	42.	10.2	9.6	.6	.328	.44	.4	.04	.84	.78	.16	.075	.4
2845	" 26	" 27	d	l	.2*.4	357.2	339.6	17.6	28.4	23.6	45.	8.2	7.3	.9	.36	.4	.36	.04	.78	.7	.08	.085	.8
2883	Nov. 2	Nov. 3	d	l	......	377.5	344.8	32.7	34.	32.	47.	9.6	8.5	1.1	.36	.36	.3	.06	....	.....	...	.02	1.
2920	" 9	" 10	d	l	.08	359.2	334.8	24.4	25.6	24.	47.	10.2	7.7	2.5	.4	.4	.32	.08	.78	.62	.16	.035	1.5
2961	" 16	" 17	d	c	.05	386.	354.4	31.6	32.	30.	49.	7.	6.3	.7	.4	.36	.24	.12	.78	.62	.16	.09	1.4
2980	" 23	" 24	d	c	.1	385.2	382.	3.2	42.	38.8	50.	6.8	5.8	1.	.4	.44	.22	.12	.7	.5	.2	.09	1.2
3012	" 30	Dec. 1	d	c	.08	360.8	352.	8.8	44.8	22.	48.	7.6	6.5	1.1	.52	.4	.28	.12	.85	.65	.2	.07	2.2
3038	Dec. 7	" 8	d	l	.07*.1	374.8	366.4	8.4	48.8	28.	47.	7.8	6.6	1.2	1.6	.4	.28	.12	.85	.65	.2	.07	2.
3071	" 14	" 16	d	l	.07*.15	358.	333.6	24.4	39.6	31.6	43.	7.3	6.2	1.1	1.68	.44	.36	.08	.85	.53	.32	.08	1.9
3082	" 21	" 23	d	l	.05*.17	358.	352.4	5.6	20.	18.	43.	8.5	7.5	1.	1.76	.56	.36	.2	1.05	.65	.4	.08	2.
3099	" 28	" 29	d	l	.06*.08	385.2	363.2	2.	32.	31.2	42.	8.8	7.4	1.4	1.88	.48	.4	.08	1.01	.65	.36	.08	1.5
Average Jan. 12—June 29...........						421.1	265.3	155.8	49.7	25.4	7.5	11.5	7.2	4.2	.199	.53	.275	.26	1.16	.7	.46	.081	1.9
Average July 6—Dec. 28............						336.4	330.5	3[illegible].	26.9	20.5	31.5	9.5	8.1	1.3	.509	.48	.332	.147	1.009	.67	.2	.091	1.1
Average Jan. 12—Dec. 28...........						379.6	282.5	97.	38.5	23.	19.3	10.9	7.7	3.2	.351	.5	.303	.205	1.09	.705	.385	.088	1.5

Odor none. Color upon ignition generally brown, occasionally gray.

*Not Filtered.

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Chemical Examination of Water from the Illinois River at Kampsville.

(Parts per 1,000,000.)

Serial Number.	1898 Date of Collection.	1898 Date of Examination	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Ammonia. Total.	Nitrogen as Ammonia. Albuminoid Ammonia. Dissolved.	Nitrogen as Ammonia. Albuminoid Ammonia. Suspended	Organic Nitrogen. Totol.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspenced	Nitrogen as Nitrites.	Nitrogen as Nitrates.
3124	Jan. 4	Jan. 5	d	c	.05*.2	368.8	360.	8.8	32.	20.	37.	7.9	[illegible]	1.2	2.04	.48	.36	.12	.85	.69	.16	.08	1.5
3159	" 11	" 12	v d	vm	.6	538.8	275.2	263.6	46.4	18.4	23.	19.1	7.4	11.7	1.88	.72	.36	.36	1.64	1.	.64	.2	.9
3173	" 18	" 19	d	vm	.8	719.2	258.	461.2	37.2	20.	15.	24.8	10.7	14.1	1.44	1.2	.48	.72	2.52	1.	1.52	.1	.7
3229	Feb. 1	Feb. 3	d	c	....	360.	279.2	80.8	22.8	18.	15.	12.8	8.1	4.7	1.5	.56	.36	.2	.92	.72	.2	.09	1.6
3257	" 8	" 10	d	c	.2	342.8	274.	68.8	36.	33.2	13.	11.	7.3	3.7	1.24	.48	.28	.2	1.	.64	.36	.09	2.5
3296	" 15	" 16	d	c	.6	737.2	204.8	532.4	42.8	22.8	8.	26.	8.4	17.6	.72	.92	.28	.64	1.88	.52	1.36	.05	.85
3298	" 22	" 23	v d	m	.5	697.2	228.4	468.8	30.8	27.2	8.	17.	7.3	9.7	.596	.84	.32	.52	1.4	.56	.84	.04	2.5
3317	Mar. 1	Mar. 2	d	c	.08	452.	232.8	219.2	24.	23.2	8.	14.4	7.2	7.2	.52	.56	.28	.28	1.08	.56	.52	.025	2.9
3335	" 8	" 9	d	c	.2	409.2	256.	153.2	36.	23.8	8.	11.8	6.8	5.	.48	.56	.32	.24	.84	.52	.32	.03	1.5
3363	" 15	" 16	d	m	.5	786.4	242.4	544.	52.8	41.2	6.	24.	8.	16.	.36	.88	.32	.56	1.72	.6	1.12	.045	1.3
3387	" 22	" 24	v d	m	.5	776.	195.2	580.8	50.	24.4	4.5	19.8	6.9	12.9	.144	.8	.32	.48	1.72	.6	1.12	.035	.8
3403	" 29	" 30	v d	m	.6	1397.6	169.2	1228.4	85.2	22.8	3.8	26.6	6.5	20.1	.196	1.44	.36	1.08	3.33	.57	2.76	.04	1.1
3451	April 12	April 13	d	c	.2	294.	211.2	82.8	29.2	25.2	4.	12.	7.9	4.1	.088	.44	.28	.16	.85	.69	.16	.04	1.
3474	" 19	" 20	d	c	.3	342.8	212.	130.8	33.2	30.4	3.8	13.	8.2	4.8	.036	.52	.4	.12	.93	.57	.36	.03	1.15
3504	" 26	" 27	d	c	.04	459.6	198.	261.6	32.4	24.8	4.5	15.2	8.	7.2	.042	.64	.28	.36	1.41	.77	.64	.035	.9
3534	May 3	May 4	d	m	.15	655.2	221.6	433.6	45.2	17.6	5.2	15.5	6.9	8.6	.112	.64	.36	.28	1.34	.66	.68	.04	.8
3556	" 10	" 11	d	c	.4	402.	257.2	144.8	36.8	31.2	7.	12.	6.7	5.3	.056	.52	.36	.16	.98	.54	.44	.035	.9
3594	" 17	" 19	d	m	.04	510.	238.	272.	46.	38.	5.2	15.4	7.5	7.9	.064	.52	.36	.16	1.38	.74	.64	.08	.7
3622	" 24	" 26	d	c	.5	500.	157.2	342.8	39.2	21.2	2.6	17.	9.3	7.7	.086	.64	.36	.28	1.54	.82	.72	.075	.6
3636	" 31	June 1	d	c	.3	513.6	204.4	309.2	25.6	22.	6.	14.4	7.6	6.8	.062	.52	.28	.24	1.22	.62	.6	.1	.55
3689	June 14	" 15	d	c	....	510.	246.	264.	29.6	28.	6.	12.9	6.5	6.4	.04	.32	.24	.08	1.16	.56	.6	.08	.35
3724	" 21	" 23	d	m	....	449.2	280.4	168.8	14.8	10.4	8.	12.2	7.6	4.6	.028	.36	.28	.08	.96	.64	.32	.125	.7
3759	" 28	" 29	d	c	.03	437.2	218.8	218.4	22.	16.8	7.4	10.7	6.	4.7	.003	.36	.24	.12	1.	.6	.4	.08	.2
3789	July 5	July 6	d	l	....	360.8	279.6	81.2	28.8	25.2	12.	8.2	8.	.2	.004	.24	.22	.02	.84	.6	.24	.125	.35
3819	" 12	" 13	d	c	.03*.1	324.4	266.8	57.6	15.2	12.	12.5	7.6	6.6	1.	.014	.32	.28	.04	.76	.6	.16	.12	.25
3846	" 19	" 20	d	l	.03*.1	306.4	279.6	26.8	15.6	13.2	11.	7.2	6.7	.5	.01	.32	.28	.04	.76	.64	.12	.07	.15
3880	" 26	" 27	d	c	.04	286.4	277.2	9.2	19.2	15.6	10.	7.7	6.5	1.2	.022	.38	.32	.06	.68	.48	.2	.035	.1

*Not filtered.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT KAMPSVILLE.—CONTINUED

(Parts per 1,000,000.)

Serial Number.	1898 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
									Total.	Dissolved.						Total.	Dissolved.	Suspended					
3909	Aug. 2	Aug. 3	d	c	.05	288.4	259.6	28.8	16.	15.2	12.	7.1	6.6	.5	.122	.4	.33	.07	.8	.68	.12	.008	.25
3940	" 9	" 11	d	l	.03	284.8	269.2	15.6	24.	22.4	13.	7.1	6.4	.7	.048	.32	.28	.04	.8	.64	.16	.065	.45
3968	" 16	" 17	v d	m	....	566.8	160.8	406.	30.	20.	6.4	13.5	8.2	5.3	.192	.56	.24	.32	1.2	.4	.8	.045	.25
3983	" 23	" 24	d	c	.06	332.	208.	124.	22.	20.	13.	8.5	6.1	2.4	.006	.4	.28	.12	1.04	.56	.48	.165	.2
4022	" 30	Sept. 2	d	c	.03	373.6	320.8	52.8	40.	36.	35.	9.2	6.3	2.9	.024	.36	.24	.12	.8	.6	.2	.22	.3
4045	Sept. 6	" 8	d	c	.05	365.6	295.2	70.4	24.	23.	30.	8.4	6.4	2.	.028	.36	.32	.04	.68	.56	.12	.14	.25
4075	" 13	" 15	d	c	.05	324.	192.	132.	32.	28.	12.	9.5	6.2	3.3	.122	.4	.2	.2	.88	.52	.36	.06	.15
4094	" 20	" 22	d	c	.04	308.8	261.2	47.6	40.	28.	20.	7.6	5.	2.6	.028	.28	.2	.08	.56	.44	.12	.105	.3
4123	" 27	" 29	d	c	.03	396.	188.8	207.2	34.	22.	16.	11.6	6.3	5.3	.006	.48	.2	.28	.96	.48	.48	.09	.65
4166	Oct. 4	Oct. 6	d	c	.03	334.	259.2	74.8	34.	24.	20.	7.7	5.2	2.5	.08	.28	.2	.08	.64	.44	.2	.08	.55
4199	" 11	" 13	d	c	.04	322.8	272.4	50.4	29.2	28.4	17.	7.2	5.2	2.	.096	.32	.2	.12	.53	.41	.12	.065	.5
4232	" 18	" 19	d	c	.04	339.6	282.	57.6	32.8	28.	18.	6.5	5.4	1.1	.222	.24	.192	.048	.73	.53	.2	.08	.45
4260	" 25	" 26	d	c	.05	326.8	296.8	30.	28.8	26.	17.	6.2	5.1	1.1	.27	.24	.192	.048	.57	.45	.12	.09	.65
4304	Nov. 1	Nov. 4	d	l	.04	392.8	312.	80.8	30.	29.2	25.	8.	5.7	2.3	1.034	.34	.28	.06	.65	.41	.24	.035	1.
4335	" 8	" 10	d	c	.1	378.	278.	100.	28.	24.	15.	7.7	5.5	2.2	.6	.36	.24	.12	.63	.39	.24	.04	.65
4366	" 15	" 17	d	c	.03	348.	306.8	41.2	30.	26.	15.	7.3	5.5	1.8	.362	.28	.16	.12	.59	.39	.2	.03	.85
4398	" 22	" 24	d	c	.05	404.	316.8	87.2	44.	40.	15.	9.	6.	3.	.72	.3	.176	.124	.61	.47	.14	.037	.85
4442	" 29	Dec. 2	d	l	.04	348.	314.	34.	38.	34.8	11.	7.	5.4	1.6	.28	.32	.176	.144	.69	.45	.24	.06	1.15
4464	Dec. 6	" 8	d	l	.03	354.	341.2	12.8	68.	47.2	11.	6.5	5.9	.6	.36	.272	.176	.096	.65	.41	.24	.03	.6
4483	" 13	" 15	d	l	.04*.06	374.	366.8	7.2	62.8	54.	16.	6.8	6.	.8	.48	.304	.272	.032	.65	.49	.16	.022	.25
4519	" 20	" 23	d	l	.03*.05	357.2	354.8	2.4	48.4	46.	16.	7.2	6.	1.2	.66	.357	.224	.133	.73	.49	.24	.02	.2
4542	" 27	" 29	d	c	.03	353.2	329.6	23.6	43.2	42.8	15.	9.6	8.7	.9	.72	.36	.28	.08	.89	.65	.24	.02	.1
Average Jan. 4th—June 28th						541.8	235.6	306.2	37.	24.5	9.	15.8	7.5	8.3	.51	.648	.325	.323	1.32	.66	.66	.087	1.13
Average July 5th—Dec. 27th						352.	280.3	71.7	33.	28.1	15.8	8.	6.1	2.8	.25	.338	.236	.101	.74	.51	.23	.071	.44
Average Jan. 4th—Dec. 27th						444.6	259.3	185.3	34.8	26.4	12.6	11.7	6.8	4.9	.372	.483	.278	.205	1.02	.57	.43	.069	.76

Odor none., Color upon ignition generally brown, occasionally gray.

***Not Filtered.**

Chemical Examination of Water from the Illinois River at Kampsville.

(Parts per 1,000,000.)

Serial Number.	1899		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved.	Suspenced	Nitrites.	Nitrates.
	Collection.	Examination							Total.	Dissolved.						Total.	Dissolved.	Suspended					
4572	Jan. 3	Jan. 4	d	c	.4	358.8	325.2	33.6	44.	38.	36.	11.2	8.6	2.6	1.28	.4	.288	.112	.89	.65	.24	.025	.15
4595	" 10	" 11	d	c	.06	338.	296.8	41.2	26.	24.	14.	12.5	8.	4.5	1.12	.48	.36	.12	.93	.69	.24	.02	.25
4616	" 17	" 18	d	c	.15	374.	252.8	121.2	46.	44.	11.	14.8	8.3	6.5	.8	.52	.24	.28	1.05	.61	.44	.03	.6
4641	" 24	" 25	d	c	.15	316.	250.8	65.2	45.2	42.	9.6	12.5	7.3	5.2	.8	.48	.272	.208	.81	.53	.28	.03	.45
4666	" 31	Feb. 1	d	c	.1	288.8	260.	28.8	42.	36.	8.	9.6	7.1	2.5	.6	.52	.24	.08	.73	.53	.2	.022	.9
4683	Feb. 7	" 8	d	l	.1*.5	302.8	292.8	10.	44.	40.	10.2	8.5	7.	1.5	.76	.4	.256	.144	.7	.5	.2	.022	1.9
4701	" 14	" 15	d	l	.05*.2	340.	333.2	6.8	54.	48.	15.	9.7	7.3	2.4	.88	.368	.272	.096	.74	.54	.2	.016	1.65
4729	" 21	" 22	d	l	.1*.2	323.2	318.8	4.4	49.2	42.	15.	7.7	6.6	1.1	.96	.32	.256	.064	.7	.5	.2	.024	1.3
4755	" 28	Mar. 1	v d	vm	.5	692.	120.	572.	62.	28.	4.	26.	9.5	16.5	.32	1.04	.28	.76	1.94	.54	1.4	.016	.55
4780	Mar. 7	" 8	v d	vm	.7	830.	188.8	641.2	74.	44.	5.2	29.7	13.	16.7	.56	1.2	.384	.816	2.66	.86	1.8	.035	1.
4809	" 14	" 15	d	m	.3	1202.8	131.2	1071.6	98.	36.	5.	29.8	11.	18.8	.52	1.4	.336	1.064	3.	.66	2.34	.025	1.1
4843	" 21	" 24	v d	vm	.2	724.	164.	560.	74.	38.	4.2	27.	9.4	17.6	.4	.64	.24	.4	2.03	.55	1.48	.025	.65
4868	" 27	" 30	d	m	.1	430.8	188.	242.8	50.	38.	4.7	18.	11.7	6.3	.48	.64	.256	.384	1.23	.55	.68	.03	1.15
4891	April 4	April 5	d	c	.2	316.8	186.	130.8	54.	38.	5.6	13.5	8.3	5.2	.48	.4	.256	.144	.95	.51	.44	.03	1.35
4916	" 11	" 12	d	m	....	490.	198.	292.	44.	38.	5.4	17.2	7.7	9.5	.368	.56	.24	.32	.123	.51	.72	.033	1.3
4941	" 18	" 19	d	c	.05	418.4	247.2	171.2	48.	44.	6.6	12.7	8.	4.7	.28	.44	.36	.08	.83	.55	.28	.09	1.75
4965	" 25	" 26	d	c	.07	440.	326.	114.	46.	34.	7.	12.2	8.5	3.7	.096	.56	.32	.24	.93	.61	.32	.05	1.35
4986	May 2	May 3	d	m	.4	458.	272.8	185.2	57.2	30.8	7.2	13.7	8.3	5.4	.08	.48	.248	.232	1.21	.63	.58	.075	.45
5010	" 9	" 10	d	c	.05	496.8	280.8	216.	34.8	33.6	8.3	13.1	8.3	4.8	.01	.48	.272	.208	1.21	.81	.4	.075	.84
5042	" 16	" 17	d	c	.08	492.4	286.4	206.	25.6	18.8	8.8	13.9	8.3	5.6	.224	.512	.32	.192	1.37	.666	.704	.1	1.
5075	" 23	" 24	d	c	.03	490.	236.4	253.6	26.4	18.8	6.5	14.	10.1	3.9	.288	.448	.192	.256	1.37	.666	.704	.038	.68
5125	" 31	June 1	d	vm	.1	636.4	176.4	460.	48.4	24.8	4.	20.5	7.5	13.	.128	.672	.224	.448	1.61	.81	.8	.045	.88
5177	June 7	" 8	d	m	.15	536.8	214.8	322.	32.8	25.2	4.	15.4	8.8	6.6	.032	.48	.176	.304	1.53	.858	.672	.065	1.4
5212	" 14	" 15	d	m	.15	548.	305.6	242.4	36.8	35.6	9.	13.5	7.8	5.7	.112	.512	.288	.224	1.24	.664	.576	.032	1.6
5260	" 21	" 22	d	c	.25	601.6	272.8	328.8	48.8	26.	8.5	13.9	9.2	4.7	.048	.416	.204	.112	1.24	.76	.48	.034	1.2
5309	" 28	" 29	d	l	.06	369.6	285.6	84.	35.2	....	10.	11.7	9.6	2.1	.024	.352	.288	.064	1.	.76	.24	.085	1.2
5347	July 5	July 6	d	c	.02	361.2	294.4	66.8	48.4	43.2	13.	11.1	9.4	1.7	.032	.19	.16	.032	1.	.792	.20	.11	1.36

5402	July 12	July 13	d	c	.2	304.8	257.2	47.6	53.2	33.2	10.	9.7	8.9	.8	.004	.384	.224	.10	.84	.536	.304	.1	.92
5445	" 19	" 20	d	l	.1	310.4	285.2	25.2	47.2	42.	16.3	11.6	10.6	1.	.04	.32	.224	.096	.92	.724	.196	.056	1.2
5493	" 26	" 27	d	c	.07	344.4	324.4	20.	33.6	32.	30.	9.6	9.5	.1	.004	.32	.256	.064	.92	.728	.192	.19	.4
5541	Aug. 2	Aug. 3	d	l	.25	316.	278.4	37.6	46.8	46.	22.	10.5	10.3	.2	.024	.24	.192	.048	.696	.6	.096	.1	1.12
5615	" 11	" 12	d	m	.05	372.8	147.6	225.2	44.	22.8	7.9	11.	7.6	3.4	.16	.288	.132	.156	.84	.488	.332	.065	.48
5643	" 16	" 17	d	l	.2	263.6	244.	19.6	62.8	56.	16.5	9.3	8.5	.8	.08	.304	.176	.128	1.	.456	.544	.1	.8
5703	" 23	" 24	d	c	...	328.8	270.8	58.	40.	39.2	18.	8.5	8.	.5	.056	.352	.212	.14	.88	.632	.248	.07	.72
5746	" 30	" 31	d	c	.03	341.2	272.8	68.4	64.	37.6	18.	11.5	9.1	2.4	.04	.4	.192	.208	1.24	.552	.688	.1	.68
5802	Sept. 6	Sept. 7	d	c	.05	309.6	283.6	26.	41.2	40.4	20.	8.4	5.8	2.6	.144	.336	.256	.08	1.	.792	.208	.04	.32
5850	" 13	" 14	d	c	.04	346.4	312.	34.4	34.	25.2	22.3	8.5	6.	2.5	.24	.352	.304	.048	.84	.6	.24	.06	.48
5900	" 20	" 21	d	c	.04	311.6	222.	89.6	21 2	21.2	16.5	8.7	6.9	1.8	.36	.352	.224	.128	1.	.472	.528	.04	.68
5961	" 27	" 28	d	l	.06	305.2	270.4	34.8	20.4	20.4	26.4	8.1	7.4	.7	.3	.336	.272	.064	.82	.58	.24	.03	.6
6000	Oct. 4	Oct. 5	d	l	.03	286.	264.	22.	30.	36.	25.7	9.5	8.7	.8	.324	.32	.288	.032	.676	.628	.048	.03	.48
6051	" 11	" 12	d	l	.04	327.2	308.8	18.4	27.2	26.4	32.	8.9	7.1	1.8	.164	.288	.272	.016	.804	.392	.412	.024	.64
6098	" 18	" 19	d	l	.07	330.4	321.6	8.8	27.2	25.2	38.5	8.2	8.	.2	.16	.368	.272	.096	1.08	.776	.304	.02	.56
6167	" 25	" 26	d	c	.04	344.	309.2	34.8	19.6	17.2	37.1	7.	6.9	.1	.296	.352	.24	.112	.872	.584	.288	.035	1.08
6214	Nov. 1	Nov. 3	d	c	.04	370.4	336.	34.4	21.6	....	38.6	7.3	7.1	.2	.552	.4	.268	.132	.744	.52	.224	.045	1.
6255	" 8	" 9	d	c	.05	365.6	362.8	2.8	30.	28.8	41.	7.1	6.6	.5	.512	.336	.24	.096	.744	.616	.128	.12	1.68
6345	" 22	" 23	d	c	.03	373.6	325.2	48.4	28.8	24.4	34.5	8.	6.4	1.6	.688	.752	.288	.464	1.64	.704	.936	.05	1.6
6411	" 29	" 30	d	c	.02	342.4	316.8	25.6	34.4	31.6	32.	6.9	6.8	.1	1.44	.368	.272	.096	.936	.584	.352	.046	1.32
6463	Dec. 6	Dec. 9	d	c	.03	344.8	342.4	2.4	37.6	37.2	34.	8.6	5.7	2.9	1.184	.56	.24	.32	1.384	.776	.608	.04	1.76
6516	" 13	" 14	d	c	.06	341.6	321.6	20.	37.6	35.6	26.	9.9	7.2	2.7	.368	.752	.208	.544	1.48	.584	.896	.035	1.8
6572	" 20	" 22	d	c	.04	324.8	292.	32.8	34.	32.	19.8	10.5	7.4	3.1	.672	.48	.256	.224	1.	.552	.448	.04	1.08
Average Jan. 3rd—June 28th........						492.9	246.5	246.3	47.9	34.6	8.9	15.4	8.6	6.8	.448	.558	.276	.282	1.274	.635	.639	.041	1.02
Average July 5th—Dec. 20th........						331.9	290.1	41.8	37.1	32.7	24.8	9.1	7.7	1.3	.331	.381	.236	.145	.973	.611	.382	.064	.95
Average Jan. 3rd—Dec. 20th........						415.6	267.4	148.1	42.7	33.7	16.5	12.4	8 2	4.1	.392	.473	.257	.216	1.129	.623	.506	.052	.98

Odor none. Color upon ignition generally brown, occasionally gray.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT KAMPSVILLE.

(Parts per 1,000,000.)

Serial Number.	1900 Date of Collection.	1900 Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Ammonia. Total.	Nitrogen as Ammonia. Albuminoid Ammonia. Dissolved.	Nitrogen as Ammonia. Albuminoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended	Nitrogen as Nitrites.	Nitrogen as Nitrates.
6609	Jan. 3	Jan. 4	d	l	.08* .15	389.6	379.6	10.	45.6	42.	31.5	8.1	8.	.1	2.24	.432	.304	.128	.84	.616	.224	.06	1.68
6704	" 17	" 18	d	c	.03	343.2	338.4	4.8	50.8	47.6	17.	7.2	6.6	.6	1.28	.384	.272	.112	.8	.64	.16	.036	2.6
6755	" 25	" 26	d	c	.2	382.4	218.	164.4	32.8	21.6	10.	13.7	6.8	6.9	1.04	.448	.224	.224	1.12	.32	.8	.03	2.
6794	" 31	Feb. 1	d	c	.05	330.8	305.2	25.6	16.	13.2	10.	8.6	8.3	.3	1.6	.368	.24	.128	.88	.576	.304	.027	1.8
6862	Feb. 7	" 8	d	c	.03	428.8	270.	158.8	28.8	28.8	16.	12.2	7.3	4.9	1.6	.512	.272	.24	1.04	.544	.496	.018	1.84
6908	" 14	" 15	v d	v m	.06	1240.8	193.6	1047.2	71.2	28.	9.	17.8	7.	10.8	.736	1.376	.208	1.168	3.2	.416	2.784	.023	1.72
6964	" 21	" 23	d	m	....	768.8	180.4	588.4	90.8	20.8	7.6	16.9	7.1	9.8	.672	.736	.336	.4	2.32	.608	1.712	.022	2.
7050	Mar. 7	Mar. 8	d	c	.04	917.2	178.8	738.4	43.6	14.8	6.4	17.3	6.4	10.9	.656	.608	.208	.4	1.84	.544	1.296	.015	1.64
7093	" 14	" 16	v d	v m	.3	905.2	136.4	768.8	30.	13.6	4.1	17.2	5.8	11.4	.32	.672	.192	.48	1.92	.32	1.6	.013	1.04
7126	" 21	" 22	d	m	.1	534.8	165.2	369.6	34.8	20.	4.6	16.	8.	8.	.368	.496	.208	.288	1.24	.6	.64	.013	1.2
7181	" 28	" 29	d	c	.4	311.2	147.6	163.6	36.	15.6	4.8	11.5	8.5	3.	.432	.304	.192	.112	.984	.504	.48	.012	1.4
7230	April 4	April 5	d	c	.3	292.	144.4	147.6	24.	8.4	4.9	11.	6.9	4.1	.336	.288	.176	.112	.664	.44	.224	.015	1.32
7301	" 11	" 12	d	c	.3	331.2	166.8	164.4	20.	18.8	5.3	11.6	7.7	3.9	.272	.32	.192	.128	.696	.568	.128	.035	1.04
7347	" 18	" 19	d	c	.3	335.6	180.8	154.8	20.4	26.4	5.4	11.8	6.8	5.	.208	.352	.256	.096	.92	.824	.096	.03	2.08
7414	" 25	" 26	d	c	.2	353.2	224.	129.2	30.2	20.4	6.6	11.3	7.1	4.2	.144	.336	.208	.128	.824	.568	.256	.036	1.12
7452	May 2	May 3	d	c	.03	402.8	251.6	151.2	35.6	20.4	8.6	12.5	7.4	5.1	.096	.512	.224	.288	1.36	.464	.896	.03	1.6
7492	" 9	" 10	d	c	.04	457.6	233.6	224.	31.	24.8	9.	13.	7.7	5.3	.128	.48	.224	.256	1.	.484	.516	.025	1.
7560	" 23	" 24	v d	v m	.05	515.6	268.8	246.8	48.4	44.8	10.9	13.8	8.4	5.4	.096	.416	.224	.192	.984	.56	.384	.04	.8
7634	" 30	" 31	d	m	.05	444.	252.	192.	42.	31.8	14.	12.5	6.8	5.7	.160	.368	.256	.112	1.092	.548	.544	.03	1.36
7668	June 6	June 7	d	c	.03	399.2	248.	151.2	40.0	47.6	14.	11.3	8.2	3.1	.096	.336	.208	.128	.772	.52	.252	.03	1.48
7721	" 13	" 14	d	c	.03	430.8	270.4	160.4	47.6	27.6	15.	9.4	6.4	3.	.048	.32	.224	.096	1.	.5	.5	.06	1.76
7750	" 20	" 21	d	m	.06	377.6	262.8	114.8	44.	26.2	19.	8.7	6.	2.7	.032	.256	.192	.064	.616	.502	.114	.03	1.48
7790	" 27	" 28	d	v s	.1	302.4	205.6	96.8	32.4	30.	15.	8.7	6.3	2.4	.032	.304	.24	.064	.744	.564	.18	.08	1.24
7882	July 4	July 5	d	v l	.05	335.2	248.4	86.8	28.	27.2	16.5	8.9	6.3	2.6	.048	.208	.192	.016	.402	.338	.064	.035	1.08
7910	" 11	" 12	d	l	.08	266.	222.	44.	22.4	17.2	15.	6.	6.	0.0	.096	.176	.16	.016	.432	.372	.06	.06	1.52
7961	" 18	" 19	d	l	.01	281.2	233.2	48.	35.2	18.	15.	7.1	4.6	2.5	.048	.192	.176	.016	.5	.308	.192	.04	1.08
8025	" 25	" 26	d	l	.01	280.8	240.4	40.4	41.2	27.2	20.	6.3	5.2	1.1	.152	.272	.176	.096	.616	.244	.372	.07	1.52

*Not Filtered.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT KAMPSVILLE—CONTINUED.

(Parts per 1,000,000.)

Serial Number.	1900. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
									Total.	Dissolved						Total.	Dissolved	Suspended					
8084	Aug. 1	Aug. 3	d	1	.02	253.6	240.	13.6	28.	24.	20.	5.1	4.6	.5	.112	.224	.208	.016	.74	.58	.16	.04	1.28
8141	" 7	" 10	d	1	.01	282.8	238.	44.8	40.8	25.6	20.	5.1	5.	.1	.144	.24	.224	.016	.728	.36	.368	.045	.92
8193	" 15	" 17	d	1	.01	276.	231.2	44.8	35.2	....	19.	6.9	4.9	2.	.112	.32	.176	.144	.676	.316	.36	.04	.96
8272	" 22	" 24	d	1	.2	348.	61.2	286.8	30.4	16.4	15.	8.8	4.7	4.1	.144	.352	.16	.192	.972	.268	.704	.01	.92
8333	" 29	" 30	d	1	.02	312.8	210.8	102.	29.6	24.	17.	7.8	5.	2.8	.112	.32	.128	.192	.72	.38	.34	.04	1.08
8387	Sept. 5	Sept. 6	..		.02	326.8	221.2	105.6	22.	12.8	15.	7.4	4.4	3.	.112	.288	....	....	.472	.4	.072	.05	1.04
8456	" 12	" 13	d	c	.03	297.2	248.4	48.8	23.6	16.8	18.	7.7	5.8	1.9	.112	.288	.24	.048	.7	.4	.3	.035	1.
8507	" 19	" 20	d	c	.1	294.4	232.4	62.	24.8	22.	16.	7.7	5.4	2.3	.128	.32	.128	.192	.536	.416	.12	.04	1.
8560	" 26	" 27	d	c	...	302.	248.8	53.2	32.4	24.	18.	6.3	5.9	.4	.16	.272	.256	.016	.7	.672	.028	.075	.88
8614	Oct. 3	Oct. 4	d	c	.04	314.8	250.8	64.	37.2	25.6	18.	7.5	5.9	.6	.128	.304	.256	.048	.8	.544	.256	.06	1.28
8652	" 10	" 11	s	1	.03	318.4	262.4	56.	29.6	24.4	23.	6.4	6.2	.2	.28	.272	...	....	.8	.512	.288	.07	1.49
8675	" 15	" 17	d	c	.01	300.8	252.	48.8	28.	24.8	22.	7.	6.3	.7	.4	.304	.176	.128	.672	.432	.24	.06	1.58
8701	" 24	" 25	d	1	.01	278.	236.8	41.2	24.8	22.4	18.	6.1	5.6	.5	.176	.224	.128	.096	.672	.464	.208	.048	1.332
8727	" 29	" 31	d	1	...	265.6	230.	35.6	22.4	20.8	16.	5.7	5.3	.4	.064	.192	.096	.096	.72	.596	.124	.02	1.42
8753	Nov. 5	Nov. 7	d	1	.02	276.8	232.	44.8	25.6	24.	17.	5.6	5.3	.3	.304	.224	.208	.016	.64	.464	.176	.04	1.44
8780	" 13	" 14	d	1	.02	327.6	249.2	78.4	19.2	16.8	18.	6.6	5.2	1.4	.336	.256	.224	.032	.704	.544	.16	.03	1.89
8796	" 19	" 20	d	1	.1	259.6	241.8	14.8	22.4	21.6	19.5	6.2	5.7	.5	.288	.368	.24	.128	1.008	.752	.256	.03	1.65
8829	" 26	" 27	d	1	.04	266.4	236.8	29.6	24.8	23.2	15.	5.1	4.6	.5	.464	.288	.176	.112	.608	.496	.112	.025	1.095
8856	Dec. 3	Dec. 4	d	1	.08	279.2	260.4	18.8	26.	24.	12.	6.2	5.4	.8	.496	.24	.128	.112	.528	.432	.096	.03	1.49
8890	" 11	" 12	d	1	.15	276.	269.2	6.8	24.4	22.8	11.	6.8	6.5	.3	.408	.256	.144	.112	.704	.432	.272	.028	1.932
8901	" 17	" 18	d	1	.2	290.8	272.4	18.4	27.2	26.	11.	7.	6.8	.2	.544	.32	.256	.064	.752	.528	.224	.022	1.978
8922	" 24	" 26	d	1	.05	293.6	276.	17.6	32.	30.4	12.	7.6	7.4	.2	.624	.352	.272	.084	.784	.688	.096	.025	1.455
Average Jan. 3rd—June 27th.......						442.3	231.8	210.5	41.5	27.1	10.8	12.2	7.1	5.1	.54	.461	.229	.232	1.164	.485	.679	.035	1.556
Average July 4th—Dec. 24th........						292.8	236.4	56.3	28.3	23.4	16.8	6.7	5.5	1.2	.232	.272	.181	.091	.675	.453	.222	.041	1.33
Average Jan. 3rd—Dec. 24th........						385.2	234.3	150.9	34.5	25.1	14.	9.3	6.3	3.	.381	.350	.204	.154	.904	.488	.416	.038	1.436

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT KAMPSVILLE.

(Parts per 1.000,000.)

Serial Number.	1901 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved.	Suspended	Total.	Dissolved.	Suspenced	Nitrites.	Nitrates.
8944	Jan. 7	Jan. 8	d	l	.1*.5	270.4	269.2	1.2	15.2	13.6	14.	8.	8.9	....	.784	.32	.256	.064	1.172	.56	.612	.012	1.228
8961	" 21	" 22	d	c	......	295.2	245.2	50.	19.2	18.	11.	8.3	7.4	.9	.72	.32	.272	.048	.944	.816	.128	.016	1.344
8974	" 28	" 29	d	l	.05	289.6	238.8	50.8	18.	16.4	10.	8.	7.3	.7	.64	.304	.24	.064	.816	.596	.22	.016	1.624
8990	Feb. 11	Feb. 12	d	l	.1	258.8	253.6	5.2	13.6	16.	13.	7.	6.5	.5	.744	.272	.256	.016	.544	.528	.016	.01	1.27
8999	" 18	" 19	d	c	.1	805.2	246.4	558.8	15.2	14.	11.	7.2	6.8	.4	.992	.272	.24	.032	.944	.624	.32	.01	.99
9016	" 25	" 27	d	c	.2	264.4	230.4	34.	20.4	13.2	12.	10.6	9.	1.6	.8	.256	.224	.032	.816	.592	.224	.009	.711
9024	Mar. 4	Mar. 6	d	l	.2	258.4	233.2	25.2	31.6	18.	12.	8.1	7.7	.4	1.168	.288	.24	.048	.864	.688	.176	.011	.749
9027	" 12	" 13	v d	v m	.3	1919.6	160.4	1759.2	63.2	23 2	6.6	28.6	11.8	16.8	.608	1.568	.544	1.024	3.504	.56	2.444	.008	.752
9040	" 18	" 19	v d	v m	.2	787.2	168.8	618.4	30.4	14.	6.7	26.1	9.8	16.3	.56	.8	.24	.56	1.744	.464	1.28	.011	1.269
9046	" 25	" 26	v d	v m	.3	561.6	180.	381.6	27.2	17.2	4.8	15.2	8.3	6.9	.4	.48	.16	.32	1.36	.592	.768	.015	1.425
9065	April 8	April 10	d	m	.4	265.	216.	49.	32.	22.2	5.7	11.8	8.8	3.	.208	.304	.192	.112	.752	.544	.208	.03	2.53
9069	" 15	" 16	d	m	.2	318.8	227.6	91.2	34.4	32.4	5.1	10.7	8.6	2.1	.096	.288	.224	.064	.976	.752	.224	.028	2.692
9082	" 23	" 24	d	c	.15	297.2	243.6	53.6	42.4	42.	5.6	11.5	10.3	1.2	.072	.304	.208	.096	.976	.576	.4	.015	1.745
9087	" 29	" 30	d	c	....	344.	250.	94.	45.2	42.4	6.7	10.3	8.5	1.8	.128	.448	.256	.192	1.104	.496	.608	.014	1.226
9101	May 7	May 8	d	c	.2	464.	260.	204.	50.	35.2	7.7	13.3	8.9	4.4	.096	.416	.256	.16	1.136	.512	.624	.022	.818
9106	" 13	" 14	d	c	....	467.6	265.6	202.	56.8	35.6	9.6	15.1	9.1	6.	.112	.416	.256	.16	1.104	.592	.512	.044	.796
9117	" 20	" 21	d	m	....	462.	263.6	198.4	45.6	35.6	11.	12.9	7.8	5.1	.128	.416	.224	.192	1.168	.592	.576	.032	.688
9129	June 10	June 11	v d	m	....	428.8	254.	174.8	70.4	46.	12.	12.5	10.3	2.2	.144	.368	.304	.064	1.008	.72	.288	.052	.908
9136	" 17	" 19	d	c	.05	422.8	256.4	166.4	55.2	46.	14.	9.9	5.9	4.	.064	.336	.224	.112	.88	.592	.288	.046	1.434
9145	" 24	" 25	d	c	.1	355 2	260.4	94.8	36.8	....	14.5	9.	6 2	2.8	.08	.24	.176	.064	.944	.596	.348	.065	.055
9155	July 1	July 2	d	c	.01	345.6	248.4	97.2	28.8	23.6	15.	8.9	6 2	2.7	.056	.272	.224	.048	.816	.544	.272	.05	1.43
9165	" 8	" 9	d	c	.1	352.	248.	104.	45.2	43.2	12.	10.	6.3	3.7	.096	.304	.256	.048	.752	.608	.144	.05	1.31
9185	" 15	" 17	d	l	.1	312.	279.2	32.8	28.8	28.	17.	7.4	7.1	.3	.108	.224	.208	.016	.64	.608	.032	.07	1.53
9206	" 22	" 23	d	l	.05	278.4	256.8	21.6	19.2	20.	20.	7.	6.7	.3	.108	.224	.172	.052	.624	.592	.032	.08	.8
9233	" 29	" 30	d	l	.05	290.8	254.4	36.4	28.8	22.8	20.	7.6	7.5	.1	.097	.272	.256	.016	.608	.528	.08	.06	.86
9295	Aug. 12	Aug. 13	d	c	.05	256.	236.	20.	28.8	24.8	23.5	8.4	7.5	.9	.128	.272	.224	.048	.592	.48	.112	.105	1.135
9344	Sept. 2	Sept. 3	d	c	.03	263.6	227.6	36.	31.6	30.	22.	6.7	5.6	1.1	.12	.192	.128	.064	.56	.368	.192	.1	.11

*Not filtered.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT KAMPSVILLE.—CONTINUED

(Parts per 1,000,000.)

Serial Number.	1901 Date of Collection.	1901 Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Ammonia. Total.	Nitrogen as Ammonia. Albuminoid Ammonia. Dissolved.	Nitrogen as Ammonia. Albuminoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended	Nitrogen as Nitrites.	Nitrogen as Nitrates.
9363	Sept. 9	Sept. 10	d	c	.02	261.6	218.8	42.8	28.8	26.	21.	6.2	6.	.2	.162	.256	.224	.032	.624	.512	.112	.11	1.13
9385	" 16	" 17	d	c	.03	283.2	239.6	43.6	36.8	26.4	22.	6.4	5.6	.8	.224	.208	.192	.016	....	....	....	.06	1.34
9404	" 23	" 24	d	c	.02	259.2	216.4	42.8	26.4	16.	21.	6.3	6.	.3	.192	.16	.144	.016	....	....	....	.075	1.525
9423	" 30	Oct. 1	d	c	.02	234.8	212.8	22.	11.2	10.8	23.	6.7	6.	.7	.128	.24	.16	.08	....	....	....	.07	1.57
9449	Oct. 7	" 8	d	c	.1	258.4	232.8	25.6	21.6	26.	27.	7.8	7.	.8	.112	.208	.188	.02	....	....	....	.09	1.67
9484	" 14	" 15	d	c	.05	240.	219.6	20.4	12.8	12.8	20.	7.4	5.6	1.8	.132	.208	.16	.048	....	....	....	.055	1.01
9553	" 21	" 22	d	c	.04	250.4	218.	32.4	34.8	19.6	22.	5.5	5.4	.1	.16	.224	.192	.032	....	....	....	.09	1.31
9631	" 28	" 31	d	c	.03	242.8	170.	72.	13.	13.2	22.	7.3	4.9	2.4	.136	.288	.176	.112	....	....	....	.035	1.045
9669	Nov. 4	Nov. 5	d	c	.04	242.8	239.8	3.	30.4	29.2	23.	6.2	5.5	.7	.152	.288	.16	.128	....	....	....	.07	1.57
9725	" 11	" 12	d	l	.04	242.8	223.2	19.6	25.6	21.6	20.	7.1	5.5	1.6	.08	.32	.192	.128	....	....	....	.055	1.625
9809	" 18	" 19	d	c	.05	222.4	210.8	11.6	45.6	26.4	20.	7.1	5.7	1.4	.1	.48	.128	.352	....	....	....	.055	1.185
9879	" 25	" 26	d	l	......	237.2	224.8	12.4	34.	26.8	21.	6.5	4.6	1.9	.328	.384	.16	.224	....	....	....	.045	1.755
9954	Dec. 2	Dec. 3	s	l	.02	228.8	228.	.8	24.4	28.	21.	7.6	6.8	.8	.504	.32	.192	.128	....	...	....	.05	1.71
10032	" 6	" 10	d	l	.05	214.4	211.2	3.2	23.6	22.8	19.	6.8	5.8	1.	.832	.288	.16	.128	....	....	.	.03	1.03
10107	" 17	" 18	d	l	.01*.05	230.4	226.	4.4	35.6	26.8	19.	6.3	5.6	.7	1.12	.288	.176	.112	....	....	....	.034	.966
10131	" 23	" 24	d	l	.02*.15	239.6	237.2	2.4	20.	19.6	22.	7.7	7.7	. .	1.44	.24	.224	.016	....	....	....	.032	1.162
10152	" 30	" 31	d	l	.05*.1	240.	236.	4.	6.4	22.4	23.	7.7	7.7	. .	1.44	.288	.192	.096	....	....	....	.02	.88
Average Jan. 7—June 24						476.4	236.1	240.6	35.6	27.4	9.6	12.2	8.4	3.8	.427	.421	.249	.172	1.137	.599	.538	.023	1.212
Average July 1—Dec. 30						262.2	230.3	31.9	24.9	25.5	20.5	7.1	6.2	.9	.331	.267	.191	.076	.652	.53	.122	.062	1.227
Average Jan. 7—Dec. 30						359.7	232.9	136.8	29.8	26.1	15.6	9.4	7.2	2.2	.375	.338	.218	.12	.999	.579	.42	.044	1.221

*Not Filtered.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT KAMPSVILLE.

(Parts per 1,000,000.)

Serial Number	1902		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
	Collection.	Examination.							Total.	Dissolved.						Total.	Dissolved.	Suspended					
10173	Jan. 7	Jan. 9	d	vl	.1.3*	241.6	242.	....	27.2	[illegible]	20.	7.4	6.	1.4	1.68	.272	.256	.016	....	....	....	.015	1.025
10182	" 13	" 14	d	l	.1.2*	231.6	231.6	....	9.6	10.4	18.	7.2	6.8	.4	1.472	.32	.24	.08	....	....	....	.02	1.42
10196	" 20	" 21	d	l	.2.3*	312.	256.	56.	79.6	18.	19.	6.7	6.6	.1	1.6	.288	.24	.044	....	....	....	.017	1.423
10224	" 28	" 29	d	vl	.05.2*	263.6	256.4	7.2	30.	26.8	19.	7.4	lost	...	1.024	.304	.24	.064	....	....	....	.016	.864
10239	Feb. 3	Feb. 4	d	vl	.2.2*	250.	244.	6.	23.6	20.4	22.	7.5	7.3	.2	1.76	.32	.24	.08	....	....	....	.016	.864
10271	" 10	" 11	s	vl	.2.2*	252.8	239.2	13.6	22.	24.	21.	6.9	6.	.9	2.32	.224	.224	....	....	....	....	.015	.625
10278	" 18	" 19	s	vl	.05.05*	252.	248.4	3.6	18.8	18.8	20.	7.4	7.7	...	1.2	.272	.242	.03	....	....	....	.015	.625
10288	" 24	" 28	vs	vl	.05.05*	234.8	234.	.8	9.6	17.8	18.7	6.7	6.2	.5	2.16	.256	.192	.064	....	....	....	.013	.587
10293	Mar 3	Mar. 4	vd	m	‡	398.8	228.	170.8	41.6	19.2	16.	10.7	7.5	3.2	1.44	.336	.224	.112	....	....	....	.015	.545
10310	" 10	" 11	vd	m	‡	327.6	210.	117.6	25.6	23.6	14.	13.6	9.1	4.5	.64	.48	.288	.192	....	....	....	.016	.724
10319	" 17	" 18	vd	m	‡	604.	232.6	368.4	46.8	31.2	8.5	17.2	10.7	6.5	.704	.528	.224	.304	....	....	....	.03	1.57
10331	" 24	" 25	d	m	.3	314.8	244.8	70.	27.6	27.6	9.85	14.1	8.6	5.5	.64	.32	.256	.064	....	....	....	.07	2.33
10340	" 30	Apr. 1	d	m	.3	380.	247.6	32.4	27.6	27.6	9.1	13.6	9.2	4.4	.336	.384	.24	.144	....	....	....	.07	2.97
10347	Apr. 7	" 8	d	c	.3	400.	257.2	142.8	34.	33.2	9.3	15.3	9.4	5.9	.096	.56	.288	.272	....	....	....	.03	2.21
10352	" 14	" 15	d	c	.3	313.6	269.6	44.	33.6	40.8	10.1	12.2	9.3	2.9	.128	.4	.24	.16	....	....	....	.035	1.205
10361	" 21	" 22	d	c	.2	334.8	277.2	57.6	45.2	46.8	9.7	12.	7.8	4.2	.096	.384	.256	.128	....	....		.045	1.955
10370	" 28	" 29	d	c	.15	364.8	270.4	94.4	39.2	40.	10.	13.3	13.2	1.1	.104	.432	.256	.176	....	....	....	.036	1.324
10387	May 5	May 6	vd	m	.1	504.8	254.	340.8	35.6	31.2	10.9	15.8	9.5	6.3	.16	.416	.224	.192	....	....	....	.055	.905
10395	" 11	" 13	d	c	.2	473.6	279.6	194.	28.4	28.4	13.5	12.	8.	4.	.128	.336	.224	.112	....	....	....	.15	1.65
10401	" 19	" 21	vd	m	‡	543.2	278.8	264.4	42.4	34.	11.2	13.8	8.1	5.1	.064	.368	.192	.176	....	....	....	.1	1.74
10418	" 26	" 27	d	m	.2	536.	249.2	286.8	50.	38.4	9.5	13.1	7.7	5.4	.104	.352	.224	.128	....	....	....	.1	1.3
10431	June 2	June 3	d	c	‡	528.8	314.	214.8	57.6	34.	10.	13.7	8.7	5.	.08	.368	.256	.112	....	....	....	.08	1.72
10444	" 9	" 10	d	m	.4	458.4	247.2	211.2	38.4	15.2	10.	14.1	8.8	5.3	.056	.336	.272	.064	....	....	....	.05	1.95
10463	" 16	" 17	vd	vm	‡	868.4	236.8	631.6	70.	24.	6.2	19.6	8.5	11.1	.038	.72	.288	.432	....	....	....	.022	1.298
10472	" 23	" 24	vd	m	.6	478.	243.2	234.8	43.2	43.2	6.9	13.5	9.1	4.4	.08	.368	.36	.008	....	....	....	.042	1.425
10490	" 30	July 1	d	m	.3	842.8	191.6	651.2	64.8	48.	5.3	17.3	9.2	8.1	.106	.312	.224	.088	....	....	....	.03	.77
10494	July 7	" 8	d	c	‡	428.4	243.2	185.2	38.	35.2	5.8	13.6	11.2	2.4	.108	.368	.304	.064	....	....	....	.048	.825

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT KAMPSVILLE.—CONTINUED.

(Parts per 1,000,000.)

Serial Number	1902		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of								Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved.	Suspended	Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
10511	July 21	July 22	..	..	..	242.4	199.6	42.8	28.4	27.2	4.8	9.9	8.3	1.6	.068	.288	.224	.064	....	....	....	.045	.675
10520	" 28	" 29	d	c	‡	252.4	213.6	38.8	35.6	23.2	4.4	10.3	8.1	2.2	.084	.304	.304	....	....	....	....	.048	.595
10532	Aug. 4	Aug. 5	..	..	.5	321.6	198.4	122.2	38.	36.4	4.45	11.3	10.8	.5	.076	.32	.24	.08	....	....	....	.016	.564
10544	" 11	" 12	d	c	.3	265.2	200.	65.2	44.4	35.6	4.3	10.2	10.	.2	.064	.304	.256	.048	....	....	....	.024	.513
10565	" 19	" 21	d	c	‡	716.8	222.	494.8	68.	36.8	3.5	15.5	9.1	16.4	.052	.596	.24	.356	....	....	....	.065	.815
10572	" 25	" 26	d	m	.4	292.	209.2	82.8	40.8	37.2	4.8	10.1	8.8	1.4	.04	.272	.16	.112	....	....	....	.042	.638
10593	Sept. 1	Sept. 2	d	c	.3	331.2	234.4	96.8	30.4	32.8	5.8	9.8	8.9	.9	.084	.256	.192	.064	....	....	....	.024	.616
10606	" 8	" 10	d	c	.2	424.4	268.4	156.	32.	39.2	8.25	11.5	8.3	3.2	.084	.304	.224	.08	....	....	....	.05	.63
10621	" 15	" 16	d	c	.1	376.	271.2	104.8	48.	46.8	9.7	9.7	7.5	2.2	.064	.304	.208	.096	....	....	....	.05	.59
10657	" 30	Oct. 1	d	m	.2	454.8	230.8	224.	46.8	29.2	9.4	10.8	6.8	4.	.072	.336	.144	.192	....	....	....	.125	.755
10685	Oct. 6	" 10	d	c	.1	470.8	228.8	242.	58.	38.8	7.6	12.	8.4	3.6	.064	.352	.224	.128	....	....	....	.065	.895
10700	" 13	" 14	d	c	‡	496.	339.6	156.4	27.2	28.8	7.8	14.	7.8	6.2	.044	.288	.252	.036	....	....	....	.03	1.01
10709	" 20	" 21	d	c	.4	373.6	259.2	113.4	48.	48.	7.4	9.1	6.3	2.8	.056	.368	.192	.176	....	....	....	.018	.942
10718	" 27	" 28	d	c	.2	396.4	266.8	129.6	54.	44.	6.8	8.9	6.2	2.7	.08	.288	.144	.144	....	....	....	.022	.858
10739	Nov. 3	Nov. 4	d	c	.2	380.4	306.4	74.	44.	45.2*	7.5	7.5	6.3	1.2	.132	.272	.192	.08	....	....	....	.02	.82
10754	" 10	" 12	d	c	.2	410.	387.6	122.4	54.8	22.2	7.4	7.8	6.4	1.4	.112	.24	.208	.032	....	....	....	.04	.84
10760	" 17	" 18	d	c	.2	497.6	277.2	220.4	42.8	24.8	8.2	7.4	6.8	.6	.1	.192	.16	.032	....	....	....	.02	1.18
10773	Dec. 1	Dec. 2	d	l	.2	338.4	308.4	30.	52.8	43.6	8.8	6.7	6.	.7	.072	.192	.16	.032	....	....	....	.016	1.264
10792	" 9	" 10	d	l	.2	312.8	308.8	4.	31.2	29.6	9.	6.3	6.2	.1	.136	.256	.192	.064	....	....	....	none	1.2
10812	" 22	" 24	d	m	‡	282.8	256.	26.8	24.8	16.4	8.1	12.6	7.7	4.9	.248	.496	.128	.368	....	....	....	.008	1.232
10827	" 29	" 30	d	m	.1	511.2	334.	177.2	59.6	58.	9.2	13.7	7.	6.7	.32	.528	.288	.24	....	....	....	.01	1.99
Average Jan. 7—June 30..........						423.1	249.8	173.3	37.4	28.9	12.9	12.	8.3	3.7	.699	.371	.246	.125	....	....	....	.043	1.347
Average July 7—Dec. 29...........						389.7	260.6	129.1	42.8	35.4	6.9	10.4	7.8	2.6	.098	.323	.211	.112	....	....	....	.035	1.068
Average Jan. 3—Dec. 27.... ...						407.8	254.7	153.1	39.9	32.3	10.2	11.3	8.1	3.2	.424	.349	.23	.119	....	....	....	.039	1.219

Until the middle of May the water possessed a faint musty odor, after that date in was odorless until December, when it again became musty. The color upon ignition was almost invariably brown; twice in January it was gray.

*Not filtered. ‡ Muddy.

8545

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT GRAFTON.

(Parts per 1,000,000.)

Serial Number.	1890		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved.	Suspenced	Nitrites.	Nitrates.
	Collection.	Examination							Total.	Dissolved.						Total.	Dissolved.	Suspended					
4555	Dec. 31	Jan. 3	d	c	.2	400.	333.6	66.4	58.	40.	13.5	13.7	8.9	4.8	.92	.48	.272	.208	.89	.61	.28	.032	.5
4587	Jan. 5	" 7	d	c	.05	326.8	282.8	44.8	40.	34.	12.8	10.8	8.1	2.7	.92	.36	.256	.104	.89	.49	.4	.017	.3
4629	" 18	" 20	d	c	.05	532.8	238.	294.8	64.	46.	9.	16.5	7.3	9.2	.6	.56	.224	.336	1.29	.53	.76	.025	.6
4647	" 25	" 27	d	c	.2	400.8	248.8	152.	36.	32.	9.4	13.8	8.	5.8	.64	.44	.24	.2	.79	.53	.26	.075	.65
4667	Feb. 1	Feb. 3	d	l	.05	330.	250.8	79.2	44.	42.	7.6	10.2	7.	3.2	.514	.36	.192	.168	.73	.49	.24	.07	.7
4710	" 15	" 17	d	l	.05	337.2	328.	9.2	46.	42.	11.4	7.2	6.8	.4	.68	.288	.224	.064	.74	.54	.2	.021	1.4
4737	" 22	" 24	d	l	.08*.1	336.	326.	10.	48.	40.	12.6	7.	6.6	.4	.84	.304	.24	.064	.62	.54	.08	.03	1.35
4770	Mar. 2	Mar. 4	d	m	1.	958.	187.2	770.8	84.	38.	2.	34.	13.5	20.5	.26	1.39	.384	.936	2.66	.66	2.	.03	.8
4783	" 8	" 10	d	m	.05	1220.	152.8	1067.2	108.	32.	4.6	36.	15.5	20.5	.52	1.48	.32	1.16	3.14	.74	2.4	.027	1.
4825	" 15	" 17	d	m	.4	1242.	144.	1098.	102.	36.	4.6	36.5	10.5	26.	.44	1.4	.256	1.144	2.9	.66	2.24	.025	1.2
4845	" 23	" 25	d	m	.3	1094.8	140.	954.8	104.	38.	4.6	38.3	15.4	22.9	.36	1.24	.32	.92	3.31	.75	2.56	.04	.8
4875	" 29	" 31	d	m	.02	432.8	178.	254.8	48.	34.	5.	15.8	9.	6.8	.32	.52	.224	.296	1.15	.51	.64	.055	1.55
4920	Apr. 12	April 14	d	c	.07	424.	206.	218.	38.	32.	5.6	14.6	7.6	7.	.304	.448	.224	.224	.87	.43	.44	.017	1.7
4945	" 19	" 21	d	c	.04	372.	238.	134.	40.	36.	6.4	11.9	7.5	4.4	.21	.36	.192	.168	.83	.47	.36	.08	1.5
4972	" 26	" 28	d	c	.09	300.	257.2	42.8	36.	33.2	6.8	11.	7.5	3.5	.072	.4	.24	.16	.93	.53	.4	.044	.95
5006	May 3	May 5	d	c	.03	329.3	266.4	62.9	42.	39.2	7.8	10.2	7.2	3.	.096	.44	.272	.168	1.21	.53	.68	.052	1.05
5024	" 10	" 12	d	c	.04	323.2	258.	65.2	25.6	26.8	7.1	9.9	9.14	.76	.128	.352	.288	.064	.89	.7	.19	.08	.72
5059	" 17	" 19	d	c	.04	350.4	300.4	50.	42.8	38.2	9.	10.	8.8	1.2	.08	.32	.288	.032	.89	.73	.16	.02	1.08
5092	" 24	" 26	d	c	.4	332.	231.6	100.4	28.8	25.6	7.1	7.	6.6	.4	.384	.416	.288	.128	.89	.76	.13	.06	1.56
5135	" 31	June 1	d	m	.1	674.8	174.	500.8	51.2	21.4	3.6	16.8	7.9	8.9	.08	.576	.288	.288	1.53	.57	.96	.042	.52
5185	June 7	" 9	d	m	.7	442.4	263.2	179.2	45.2	42.4	4.5	9.4	8.6	.8	.008	.4	.224	.176	1.37	.666	.704	.011	.96
5222	" 14	" 16	d	m	.2	368.	254.4	113.6	25.2	24.	8.	12.7	9.	3.7	.128	.512	.288	.224	1.	.856	.144	.007	1.4
5262	" 21	" 23	d	c	.3	343.6	276.4	67.2	24.	23.2	7.	11.2	8.9	2.3	.036	.352	.176	.176	.92	.6	.32	.019	1.24
5323	" 28	" 30	d	c	.05	300.8	300.	.8	19.6	....	9.4	9.5	9.2	.3	.04	.224	.192	.032	.68	.6	.08	.033	.96
5351	July 5	July 6	d	l	.02	284.	218.	66.2	44.	....	10.7	10.8	9.3	1.5	.06	.32	.256	.064	.92	.64	.28	.054	1.2
5411	" 12	" 14	d	l	.1*.2	316.8	274.4	42.4	34.4	27.2	10.4	8.9	7.8	1.1	.176	.352	.256	.096	.76	.568	.192	.165	.96
5453	" 19	" 20	d	l	.04	503.6	286.4	217.2	86.8	48.	13.9	10.4	9.4	1.	.04	.32	.304	.016	.92	.696	.224	.08	1.04

5498	July 26	July 27	d	l	.1	343.2	314.8	28.4	50.8	46.	22.8	12.	9.9	2.1	.052	.384	.256	.128	1.	.728	.272	.1	.84
5543	Aug. 2	Aug. 3	d	l	.25	348.4	314.4	34.	59.2	52.4	32.	10.9	9.7	.5	.024	.272	.224	.048	.792	.68	.112	.093	1.2
5598	" 9	" 10	d	c	.04	374.	187.2	186.8	54.	34.4	15.	11.3	8.1	3.2	.01	.256	.112	.144	1.08	.36	.72	.07	.72
5642	" 16	" 17	d	c	.15	282.8	178.8	104.	75.6	47.6	6.9	11.9	9.3	2.6	.04	.368	.24	.128	1.08	.504	.576	.07	.64
5696	" 21	" 24	d	c	.05	308.8	273.2	35.6	44.	43.2	16.7	9.1	7.1	2.	.024	.384	.224	.16	.92	.544	.376	.06	.6
5747	" 30	" 31	d	c	.03	297.2	256.	41.2	28.	27.6	14.	10.	9.	1.	.044	.288	.176	.112	.92	.488	.432	.05	.52
5805	Sept. 6	Sept. 7	d	c	.04	324.4	294.	30.4	36.	33.2	19.7	9.1	5.9	3.2	.084	.4	.272	.128	1.08	.76	.32	.009	.4
5852	" 13	" 14	d	c	.04	320.	296.4	23.6	37.6	34.	19.2	7.9	6.	1.9	.24	.352	.24	.112	.84	.552	.288	.05	.52
5902	" 20	" 21	d	c	.03	344.8	287.2	57.6	24.4	24.	22.3	8.4	6.8	1.6	.18	.288	.224	.064	.84	.536	.304	.045	.6
5959	" 27	" 28	d	l	.06	290.	256.	34.	23.6	17.6	22.4	8.6	7.3	1.3	.396	.272	.256	.016	.82	.58	.24	.04	1.
6001	Oct. 4	Oct. 5	d	l	.05	266.8	226.6	40.2	36.8	30.8	19.3	9.1	8.3	.8	.192	.336	.272	.064	.708	.612	.096	.018	.48
6045	" 11	" 12	d	l	.4	331.6	300.4	31.2	33.2	13.6	28.9	8.3	8.	.3	.172	.32	.24	.08	.98	.628	.352	.023	.72
6166	" 25	" 26	d	c	.03	320.8	282.	38.8	82.8	20.6	28.	7.4	6.9	.5	.084	.368	.224	.144	.84	.472	.368	.022	.8
6205	Nov. 1	Nov. 2	d	c	.15	340.	257.6	82.4	22.8	17.6	26.3	8.2	7.4	.8	.404	.368	.256	.112	.648	.52	.128	.03	1.12
6257	" 8	" 9	d	l	.06	362.	334.4	27.6	40.4	32.	36.6	7.8	6.5	1.3	.48	.32	.272	.048	.84	.44	.4	.06	1.48
6306	" 15	" 16	d	c	.03	353.6	318.	35.6	53.6	46.4	42.5	9.3	6.2	3.1	.12	.96	.352	.608	1.896	.584	1.312	.175	1.08
6347	" 22	" 23	d	c	.02	385.2	329.2	56.	29.6	27.2	32.5	9.	7.2	1.8	.16	.752	.224	.528	1.8	.68	1.12	.05	1.6
6412	" 29	" 30	d	c	.02	339.2	306.	33.2	33.6	30.4	27.	8.	6.6	1.4	.88	.352	.304	.048	1.064	.68	.384	.045	1.68
6462	Dec. 6	Dec. 7	d	c	.03	342.	328.	14.	25.6	25.2	31.5	9.4	4.7	4.7	1.12	.512	.224	.288	1.256	.744	.512	.036	1.68
6519	" 13	" 14	d	c	.07	346.4	315.6	30.8	45.2	36.4	24.	10.6	6.4	4.2	.176	.704	.24	.464	1.64	.456	1.184	.025	1.68
6559	" 20	" 22	d	c	.02	364.8	299.2	65.6	33.6	31.6	22.2	11.7	7.7	4.	.432	.672	.24	.432	1.16	.648	.512	.03	1.68
6585	" 27	" 28	d	c	.03	329.2	282.	47.2	27.2	18.	20.2	12.7	8.8	3.9	.88	.512	.224	.288	1.08	.616	.464	.026	1.08
Average Dec. 31—June 28..........						507.1	243.1	264.	50.	34.3	7.7	15.6	8.9	6.6	.361	.564	.254	.31	1.297	.604	.692	.038	1.02
Average July 5—Dec. 27............						336.1	279.1	57.	39.9	32.9	21.7	9.6	7.6	1.9	.264	.394	.24	.154	1.035	.589	.41	.051	1.035
Average Dec. 31—'98— Dec. 27— 99						421.6	261.1	160.5	44.9	33.2	14.7	12.6	8.3	4.3	.313	.489	.247	.232	1.148	.596	.551	.045	1.027

Odor none. Color upon ignition generally brown, occasionally gray.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT GRAFTON.

(Parts per 1,000,000.)

Serial Number	1900.		Appearance.			Residue on Evaporation.					Chlorine. •	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
	Collection.	Examination.							Total.	Dissolved						Total.	Dissolved	Suspended					
6626	Jan. 4	Jan. 5	d	c	.04	395.2	382.	13.2	40.4	38.8	30.	11.8	8.3	3.5	2.24	.416	.288	.128	.92	.552	.368	.07	1.76
6655	" 10	" 11	d	l	.03	368.	365.2	2.8	28.4	28.	26.7	7.5	7.4	.1	2.16	.432	.304	.128	.792	.6	.192	.03	2.28
6705	" 17	" 18	d	c	.03	338.4	329.6	8.8	47.6	44.4	15.5	7.2	6.5	.7	.704	.32	.208	.112	.72	.544	.176	.03	2.4
6751	" 24	" 25	d	m	.2	502.4	216.	286.4	40.	22.4	10.	16.	8.1	7.9	.8	.512	.208	.304	1.12	.704	.416	.13	2.
6802	" 31	Feb. 2	d	c	.02	439.2	311.2	128.	38.	29.2	21.	10.	8.1	1.9	1.6	.352	.208	.144	.88	.576	.304	.032	2.2
6864	Feb. 7	" 8	d	c	.03	326.8	271.2	55.6	18.4	12.4	17.	10.9	7.7	3.2	1.36	.384	.176	.208	.8	.576	.224	018	1.6
6913	" 14	" 15	v d	v m	.6	1481.6	170.4	1311.2	72.4	45.6	5.1	24.7	7.9	16.8	.544	1.376	.288	1.088	3.52	.544	2.976	.013	1.44
6956	" 21	" 23	d	m	.2	762.8	202.	530.8	83.6	29.2	8.	16.9	8.3	8.6	.704	.864	.272	.592	1.28	.64	.64	.023	2.
6992	" 28	Mar. 2	d	m	.3	729.2	218.8	510.4	100.	32.4	7.	16.1	6.2	9.9	.528	.64	.272	.368	1.68	.64	1.04	.018	2.
7035	Mar. 7	" 8	d	m	.05	973.2	178.	795.2	56.8	18.8	6.4	17.6	6.4	11.2	.528	.736	.264	.472	1.92	.544	1.376	.012	1.44
7082	" 14	" 15	d	m	.2	799.2	153.2	646.	45.2	21.6	4.2	16.2	6.2	10.	.32	.608	.208	.4	1.6	.384	1.216	.011	1.4
7130	" 21	" 22	d	m	.15	807.6	133.6	674.	40.8	18.4	4.7	17.9	6.	11.9	.288	.864	.176	.688	1.88	.6	1.28	.011	1.32
7185	" 28	" 29	d	c	.04	544.4	149.2	395.2	34.	13.2	4.3	14.	6.	8.	.256	.416	.176	.24	1.112	.408	.704	.01	1.52
7226	April 3	April 4	d	c	.06	399.2	151.2	248.	13.6	13.2	4.9	12.1	6.1	6.5	.224	.352	.144	.208	.76	.44	.32	.013	1.6
7282	" 10	" 11	d	c	.3	364.	171.2	192.8	12.	10.	4.7	12.	6.9	5.1	.224	.304	.208	.096	.824	.568	.256	.025	1.32
7334	" 17	" 18	d	c	.04	354.8	193.2	161.6	34.4	30.	5.4	10.9	6.7	4.2	.144	.304	.176	.128	1,016	.44	.576	.035	1.72
7423	" 25	" 26	d	c	.2	316.8	216.	100.8	36.	27.2	6.2	10.5	6.7	3.8	.128	.272	.208	.064	.952	.504	.448	.034	1.12
7450	May 2	May 3	d	c	.38	246.	127.6	118.4	24.4	18.8	9.3	12.8	7.5	5.3	.096	.32	.208	.112	.92	.6	.32	.017	.64
7500	" 9	" 10	d	c	.03	368.	229.6	138.4	24.8	22.4	8.4	12.	7.6	4.4	.144	.384	.256	.128	1.38	.548	.832	.03	.96
7561	" 16	" 17	d	c	.02	329.2	253.6	75.6	36.	34.8	10.	10.9	7.5	3.4	.072	.32	.208	.112	.804	.452	.352	.04	.76
7603	" 23	" 24	v d	v m	.05	374.8	265.2	109.6	46.8	37.2	10.5	11.4	9.4	2.	.064	.32	.192	.128	.74	.36	.38	.038	.9
7627	" 30	" 31	d	c	.07	364.	265.6	98.4	40.8	26.8	14.	10.8	7.6	3.2	.032	.32	.208	.112	.84	.52	.32	.024	1.48
7674	June 6	June 7	d	c	.03	352.	243.6	108.4	38.	35.6	12.	9.5	6.6	2.9	.032	.288	.16	.128	.8	.468	.332	.008	1.4
7722	" 13	" 14	d	c	.04	360.8	258.8	102.	37.6	37.2	14.	7.6	5.8	1.8	.048	.272	.176	.096	.9	.58	.32	.008	1.76
7750	" 20	" 21	d	l	.05	308.8	270.8	38.	35.6	35.2	13.	8.	6.5	1.5	.032	.256	.192	.064	.42	.356	.064	.013	1.48
7769	" 25	" 26	d	m	.03	360.8	267.6	93.2	31.2	28.4	13.	8.1	6.7	1.4	.048	.272	.24	.032	.596	.58	.016	.007	1.04
7813	July 2	July 3	d	m	.03	384.8	255.2	129.6	42.8	29.2	14.	8.2	6.4	1.8	.04	.24	.176	.064	.564	.436	.128	.019	1.

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT GRAFTON.—CONTINUED.

(Parts per 1,000,000.)

Serial Number.	1900		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of								Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
7848	July 6	July 7	d	m	.02	343.2	253.2	90.	35.6	31.2	15.	7.7	6.9	.8	.072	.208	.176	.032	.612	.372	.24	.13	1.28
7917	" 13	" 14	d	m	.03	306.8	243.6	63.2	26.4	25.6	13.	6.7	6.6	.1	.096	.24	.16	.08	.568	.35	.218	.015	1.32
7986	" 20	" 21	d	l	.02	347.6	210.4	137.2	31.2	29.2	13.	8.9	6.6	2.4	.018	.272	.176	.096	.452	.276	.176	.035	.88
8035	" 27	" 28	d	l	.02	342.4	228.8	113.6	56.	56.	13.	11.9	7.7	4.2	.048	.352	.176	.176	.644	.372	.272	.018	.88
8096	Aug. 6	Aug. 7	d	l	.01	272.	243.8	28.2	44.4	38.	18.	6.7	5.1	1.6	.112	.256	.16	.096	.644	.452	.192	.014	.92
8157	" 13	" 14	d	l	.01	284.8	232.8	52.	40.8	34.8	22.	6.6	4.7	1.9	.08	.304	.176	.128	.74	.428	.312	.016	1.08
8221	" 20	" 21	d	l	.01	328.	198.8	129.2	28.4	18.4	17.	7.3	4.7	2.6	.08	.304	.224	.08	.6	.316	.284	.019	1.12
8295	" 27	" 28	d	l	.03	302.8	175.2	127.6	31.6	15.6	15.	6.7	4.9	1.8	.096	.352	.128	.224	.668	.188	.48	.013	.96
8372	Sept. 5	Sept. 6	d	m	...	366.	219.6	146.4	23.2	14.	14.	10.6	4.6	6.	.112	.4	.224	.176	.688	.38	.308	.008	1.2
8454	" 12	" 13	d	c	.03	300.4	242.4	58.	26.	20.8	18.	7.1	5.	2.1	.064	.224	.192	.032	.508	.416	.082	.013	.12
8500	" 19	" 20	d	c	.01	302.8	225.2	77.6	23.6	20.4	15.	7.4	5.4	2.	.112	.336	.192	.234	.6	.448	.152	.025	1.08
8545	" 26	" 27	d	c	.15	288.8	218.	70.8	37.2	22.	14.	8.	6.8	1.2	.16	.352	.208	.144	.536	....	....	.034	.76
8603	Oct. 3	Oct. 4	d	l	.05	271.6	246.4	25.2	27.6	25.2	16.	6.	5.9	.1	.16	.24	.224	.016	.544	.524	.02	.015	.96
8649	" 10	" 11			.2	313.2	230.	83.2	29.6	26.4	16.	10.1	7.3	2.8	.128	.368	.224	.144	.768	.56	.208	.04	1.04
8668	" 15	" 17	d	l	.01	295.2	256.8	38.4	23.6	21.6	25.	6.9	6.4	.5	.376	.256	.24	.016	.64	.432	.208	.045	1.635
8689	" 22	" 23	d	c	.6	281.6	187.2	94.4	46.	40.8	11.	16.9	14.2	2.7	.16	.332	.288	.044	.752	.512	.24	.035	1.285
8711	" 29	" 30	d	l	.02	254.8	234.	20.8	23.2	21.6	17.	7.	6.7	.3	.112	.16	....	....	.576	.384	.192	.036	1.397
8737	Nov. 5	Nov. 6	d	l	.03	266.4	228.4	38.	22.4	16.8	16.	5.6	5.4	.2	.272	.24	.192	.048	.624	.528	.096	.03	1.53
8765	" 12	" 13	d	l	.03	267.6	214.8	52.8	27.2	22.	14.	8.3	7.8	.5	.24	.256	.192	.064	.736	.368	.368	.032	1.248
8786	" 19	" 20	d	l	.1	256.8	247.6	9.2	18.	16.4	19.	5.5	5.3	.2	.24	.304	.256	.048	.656	.592	.064	.024	1.696
8816	" 26	" 27	d	c	.06	282.	243.2	38.8	16.4	14.8	17.	7.3	6.8	.5	.184	.336	.176	.16	.88	.56	.32	.024	1.376
8853	Dec. 3	Dec. 4	d	l	.05	279.6	240.4	39.2	15.2	14.8	13.5	7.2	6.8	.4	.552	.272	.224	.048	.656	.432	.224	.024	1.336
8879	" 10	" 11	d	l	.15	354.8	271.2	83.6	30.8	29.2	10.	7.5	6.7	.8	.368	.288	.144	.144	.608	.352	.256	.025	1.035
8890	" 17	" 18	d	l	.1	334.8	279.6	55.2	28.8	26.8	11.	7.2	5.7	1.5	.32	.256	.16	.096	.752	.512	.24	.022	2.378
8920	" 24	" 25	d	l	.04	473.2	278.4	194.8	26.	22.8	11.	9.5	5.8	3.7	.28	.448	.224	.224	.848	.624	.224	.018	1.862
Average Jan. 4th—June 25th.......						497.5	230.5	267.	40.5	27.3	10.9	12.4	7.1	5.3	.512	.457	.216	.241	1.122	.528	.494	.023	1.521
Average July 2nd—Dec. 24th.......						314.2	234.8	79.4	30.	25.1	15.2	8.	6.3	1.6	.173	.297	.196	.101	.648	.432	.216	.028	1.207
Average Jan. 4th—Dec. 24th.......						404.6	232.6	171.9	35.3	26.2	13.1	10.2	6.7	3.4	.342	.379	.206	.173	.885	.481	.404	.025	1.364

8547

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT GRAFTON.

(Parts per 1,000,000.)

Serial Number.	1901. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
9005	Feb. 21	Feb. 22	v d	c	.3	464.4	228.4	236.	32.8	23.2	10.	18.1	6.9	6.2	.72	.48	.272	.208	1.296	.56	.736	.012	.828
9037	Mar. 15	Mar. 19	v d	v m	.4	789.2	156.4	632.8	50.	11.6	5.4	28.4	11.8	16.6	.56	1.152	.304	.848	2.384	.624	1.76	.016	1.184
9079	Apr. 21	Apr. 23	d	c	.4	361.2	109.2	252.	56.	46.4	4.8	12.4	10.3	2.1	.08	.516	.224	.292	.976	.624	.342	.014	1.626
9115	May 20	May 21	d	c	...	402.4	260.8	141.6	55.2	42.	10.	12.7	8.7	4.	.064	.32	.206	.112	1.04	.592	.448	.04	.76
9147	June 25	June 26	d	c	.2	324.8	248.	76.8	54.8	38.	13.	9.3	6.9	2.4	.048	.256	.224	.022	.672	.464	.208	.025	1.015
9179	July 15	July 16	d	c	.1	302.4	248.8	53.6	30.	33.6	13.	8.7	7.2	1.5	.032	.256	.16	.096	.688	.592	.096	.024	1.176
9197	" 22	" 23	d	l	.04	360.	266.	94.	22.4	28.	19	7.6	6.8	.8	.158	.288	.256	.032	.656	.512	.144	.036	1.324
9230	" 29	" 30	d	c	.5	267.2	219.2	48.	29.2	28.	15.	10.1	....	....	.13	.272	.224	.048	.608	.544	.064	.021	.619
2275	Aug. 5	Aug. 6	d	l	.1	263.2	212.4	50.8	35.2	34.8	17.	8.4	7.7	.7	.064	.304	.288	.016	.72	.64	.08	.025	5.975
9299	" 14	" 15	d	c	.1	292.8	231.6	61.2	52.4	44.	22.	8.6	7.2	1.4	.064	.304	.24	.064	.688	.528	.16	.05	1.19
9312	" 19	" 20	d	c	.05	284.4	239.6	44.8	33.2	33.2	21.	7.2	6.8	.4	.106	.224	.208	.016	.528	.512	.016	.075	.845
9321	" 26	" 27	d	c	.05	274.8	220.4	54.4	29.6	28.8	22.	7.9	7.8	.1	.108	.272	.192	.08	.688	.496	.192	.05	.87
9351	Sept. 2	Sept. 4	d	c	.04	277.2	217.6	59.6	21.2	16.8	20.	7.	5.7	1.3	.114	.24	.192	.048	.592	.432	.16	.07	1.21
9361	" 9	" 10	d	c	.01	264.4	218.	46.4	18.8	14.	20.	6.1	5.2	.9	.076	.192	.176	.016	.528	.512	.016	.055	1.025
9384	" 16	" 17	d	c	.02	270.8	218.4	52.4	33.2	20.	21.	7.1	6.3	.8	.112	.224	.16	.064	.....	....	.....	.06	.06
9401	" 23	" 24	d	c	.02	256.8	222.	34.8	36.8	28.4	20.5	6.2	5.7	.5	.171	.24	.128	.112	.....	....	.....	.06	.15
9416	" 30	Oct. 1	d	c	.03	260.4	214.4	46.	36.	24.	21.	6.3	5.6	.7	.056	.208	.144	.064	.....	....	.....	.04	1.68

9446	Oct. 7	Oct. 8	d	c	....	286.	282.	4.	24.	24.	26.	8.2	8.	.2	.046	.192	.144	.048	.....	.....	.....	.065	1.735
9490	" 14	" 15	d	c	.05	274.8	212.	62.8	31.6	22.4	20.5	7.7	6.6	1.1	.164	.224	.224	....	.....	.....	.....	.035	1.405
9545	" 21	" 22	d	l	.03	243.6	219.2	24.4	18.4	18.4	22.	5.3	5.	.8	.164	.24	.224	.016	.....	.....	.....	.075	1.525
9607	" 28	" 29	d	l	.15	.....	215.6	.....	....	25.2	47.	6.	5.1	.9	.108	.32	.192	.128	.....	.....	.....	.03	1.61
9675	Nov. 6	Nov. 7	d	c	.05	257.6	224.4	32.2	20.	17.2	23.	7.	5.7	1.3	.068	.288	.256	.032	.....	.....	.....	.05	1.79
9752	" 13	" 14	d	c	.04*.05	247.2	218.4	28.8	30.	30.4	21.	....	5.6	....	.064	.552	.176	.176	.....	.....	.....	.035	1.405
9796	" 18	" 18	....	...	.06	235.6	220.8	14.8	35.6	30.4	20.4	8.3	5.9	2.4	.052	.56	.192	.368	.....	.....	.....	.05	1.27
9863	" 25	" 26	....	...	.03	244.8	223.6	21.2	38.4	35.2	20.	8.1	5.8	2.3	.064	.448	.176	.272	.....	.....	.....	.05	1.63
9937	Dec. 2	Dec. 3	d	l	.03*.1	223.2	212.4	10.8	28.	21.2	20.	9.2	5.7	3.5	.24	.352	.224	.128	.....	.....	.....	.05	1.75
10020	" 9	" 10	d	l	.03	281.	233.2	47.8	27.2	25.6	19.	7.4	5.9	1.5	.672	.336	.192	.144	.....	.....	.....	.006	.994
10096	" 16	" 17	v d	m	.04	554.	187.6	366.8	45.6	16.	18.	17.5	6.5	11.	.8	.64	.208	.432	.....	.....	.....	.022	.818
10188	" 23	" 25	d	c	.02	255.6	220.8	34.8	56.	44.8	18.	8.9	7.9	1.	1.28	.32	.192	.128	.....	.....	.....	.022	1.018
Average Feb. 21—June 25						468.4	200.5	267.9	49.7	32.2	8.6	15.1	8.9	6.2	.294	.544	.246	.298	1.273	.572	.701	.021	1.062
Average July 15—Dec. 23						281.5	226.	55.5	31.4	27.2	20.9	8.1	6.4	1.7	.204	.303	.236	.067	.623	.521	.102	.043	1.431
Average Feb. 21—Dec. 23						366.4	214.4	152.	39.8	29.5	15.3	11.8	7.5	3.8	.245	.413	.241	.172	1.029	.553	.476	.033	1.273

*Not filtered.

8548

CHEMICAL EXAMINATION OF WATER FROM THE ILLINOIS RIVER AT GRAFTON.

(Parts per 1,000,000.)

Serial Number	1902		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of								Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved.	Suspended	Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
10219	Jan. 27	Jan. 28	d	l	.05	265.2	258.4	6.8	30.	36.4	18.	8.9	8.5	.4	1.44	.304	.288	.016	....	....	....	.012	.908
10284	Feb. 24	Feb. 25	s	n	.1	253.6	246.4	7.2	22.	21.6	17.	6.8	7.2	...	1.6	.224	.208	.16	....	....	....	.012	.548
10332	Mar. 25	Mar. 26	d	c	.3	358.8	241.2	117.6	26.8	25.6	8.8	12.1	9.7	2.4	.608	.352	.304	.048	....	....	....	.055	2.345
10373	Apr. 28	Apr. 29	d	c	.15	478.4	277.2	201.2	47.2	44.4	10.6	14.2	9.3	4.9	.136	.496	.256	.24	....	....	....	.042	1.558
10419	May 26	May 28	d	c	.2	353.2	236.8	116.4	46.	44.8	10.1	10.1	7.3	2.8	.044	.288	.192	.096	....	....	....	.005	1.345
10478	Jun. 26	Jun. 27	d	c	.4	382.8	247.6	135.2	28.	26.8	7.	18.3	11.2	2.1	.048	.336	.256	.07	....	....	....	.02	.78
10526	July 28	July 30	d	c	‡	337.2	215.2	122.	40.8	30.6	4.7	....	9.8	...	.056	.336	.272	.064	....	....	....	.04	.64
10579	Aug. 27	Aug. 28	d	c	‡	334.	215.6	118.4	34.4	21.6	5.1	10.3	8.3	2.	.096	.288	.224	.064	....	....	....	.012	.628
15645	Sep. 26	Sep. 27	vd	m	‡	550.4	234.8	315.6	48.2	32.4	10.4	13.4	7.4	6.	.072	.384	.192	.192	....	....	....	.05	.59
10719	Oct. 28	Oct. 29	d	c	.2	529.6	303.6	226.	45.2	45.2	6.4	9.	6.1	2.9	.112	.32	.144	.176	....	....	....	.022	.778
10770	Nov. 28	Nov. 29	d	c	.3	350.4	300.	50.4	50.8	44.4	8.	7.7	6.3	1.4	.096	.224	.192	.032	....	....	....	.012	1.188
10825	Dec. 26	Dec. 30	d	m	.1	467.6	281.6	186.	52.8	58.6	6.6	11.9	5.5	6.4	.24	.32	.224	.096	....	....	....	.014	1.586
Average Jan. 27 June 26						348.6	251.3	97.3	33.3	33.2	11.9	10.8	8.86	2.5	.646	.333	.251	.082	....	....	....	.039	1.247
Average July 28 Dec. 26						428.4	258.4	169.8	44.5	39.4	6.8	10.4	7.2	3.7	.112	.312	.208	.104	....	....	....	.025	.902
Average Jan. 27 Dec. 26						388.4	354.8	133.6	38.9	36.3	9.3	10.6	8.1	3.1	.379	.322	.229	.093	....	....	....	.032	1.074

‡ Muddy. Odor musty in January and December; at other times the water was odorless. Color on ignition brown.

8549

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT GRAFTON.
(Parts per 1,000,000.)

Serial Number.	1899. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.							Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
4554	Dec. 31	Jan. 3	d	c	*.3	240.	180.	60.	37.2	34.	3.9	14.	9.	5.	.04	.52	.192	.328	.85	.41	.44	.005	.1
4585	Jan. 5	" 9	d	c	.08	226.8	190.8	36.	28.8	24.	5.2	12.3	8.4	3.9	.018	.44	.16	.28	.81	.33	.48	.003	.07
4627	" 18	" 20	d	c	.02	230.	190.8	39.2	40.	28.8	5.	11.	6.2	4.8	.018	.4	.144	.256	.77	.37	.4	.02	.15
4648	" 25	" 28	d	c	.06	216.	196.8	19.2	24.	20.	5.2	9.2	6.5	2.7	.016	.44	.144	.296	.73	.26	.47	.003	.1
4668	Feb. 1	Feb. 3	d	l	.05	236.	214.8	21.2	37.2	28.	7.9	10.3	6.8	3.5	.024	.4	.16	.24	.77	.29	.48	.008	.25
4708	" 15	" 17	d	l	.04	242.8	236.	6.8	32.	28.	5.	8.	6.8	1.2	.03	.368	.16	.208	.74	.3	.44	.004	.15
4736	" 22	" 25	d	l	.07	225.2	203.2	22.	37.2	28.	5.	8.6	7.3	1.3	.01	.384	.176	.208	.74	.22	.52	.001	.1
4771	Mar. 2	Mar. 6	d	v m	.06	470.	134.	336.	40.	28.	3.	19.5	9.3	10.2	.1	.68	.256	.424	1.26	.38	.88	.02	.55
4784	" 8	" 10	d	m	.4	316.8	154.8	162.	46.	30.	3.	19.7	13.5	6.2	.296	.64	.304	.336	1.26	.7	.56	.025	.5
4824	" 15	" 18	d	m	.06	1196.	134.	1062.	92.	32.	3.	34.3	11.2	23.1	.44	1.52	.288	1.232	3.	.62	2.38	.02	.8
4844	" 23	" 25	v d	v m	.15	784.	164.	620.	72.	36.	2.4	25.7	9.5	16.2	.36	.68	.24	.44	2.03	.51	1.52	.035	1.3
4876	" 29	April 1	d	m	.6	352.	124.	228.	46.	34.	3.	22.8	12.8	10.	.48	.72	.32	.4	1.31	.63	.68	.06	.6
4921	Apr. 12	" 14	d	c	.2	658.8	142.8	516.	54.	24.8	3.2	18.8	8.7	10.1	.28	.72	.24	.48	1.68	.47	1.16	.01	.95
4946	" 19	" 21	d	c	.07	474.8	118.8	356.	36.	22.	2.	16.6	8.	8.6	.32	.6	.24	.36	1.31	.4	.91	.04	.55
4973	" 26	" 28	d	c	.3	314.	123.6	190.4	28.	4.6	2.	13.5	7.5	6.	.064	.4	.208	.192	1.17	.41	.76	.048	.5
5004	May 3	May 6	d	m	.3	891.2	130.4	760.8	17.1	6.7	2.	26.9	8.4	18.5	.01	.96	.208	.752	1.85	.49	1.36	.02	.65
5025	" 10	" 13	d	m	.15	348.	127.6	220.4	28.	22.	.69	14.63	10.6	4.03	.036	.416	.256	.16	1.13	.474	.656	.035	.4
5060	" 17	" 19	d	m	.05	287.6	133.6	154.	27.2	16.4	2.4	18.4	13.8	4.6	.06	.448	.256	.192	1.18	.794	.336	.006	.28
5091	" 24	" 26	v d	v m	.3	1097.6	138.8	958.8	50.8	24.4	2.	26.5	13.4	13.1	.184	1.12	.288	.832	2.65	.7	1.95	.05	.16
5136	" 31	June 1	d	m	.3	844.	147.6	696.4	61.6	26.	2.	24.8	10.9	13.9	.052	.832	.192	.64	2.01	.762	1.248	.016	.52
5186	June 7	" 9	d	m	.6	705.2	155.6	549.6	68.4	34.	1.5	25.5	12.1	13.4	.012	.88	.24	.64	2.65	.57	2.08	.007	.6
5221	" 14	" 16	d	m	.6	521.6	181.2	340.4	29.2	21.6	1.5	23.4	13.5	9.9	.044	.672	.256	.416	1.64	.856	.784	.002	.56
5261	" 21	" 23	d	c	.5	403.6	113.2	290.4	32.	19.6	1.5	20.4	13.1	7.3	.028	.512	.256	.256	1.4	.6	.8	.004	.52
5322	" 28	" 30	d	c	.5	395.6	140.4	255.2	24.8	22.	1.	19.3	14.6	4.7	.024	.48	.192	.288	1.08	.52	.56	.002	.48

5350	July 5	July 6	d	l	*.15	286.	182.8	163.2	21.2	20.4	1.2	17.7	14.6	8.1	.036	.4	.224	.176	1.	.728	.272	.004	.36
5410	" 12	" 14	d	c	.5	172.4	159.6	12.8	45.6	45.2	1.3	24.6	12.5	12.1	.024	.576	.256	.32	1.4	.664	.736	.002	.6
5454	" 19	" 20	d	c	.3	282.8	161.2	121.6	52.4	42.4	2.2	16.3	13.3	3.	.04	.416	.24	.176	1.	.568	.432	.02	.32
5497	" 26	" 27	d	c	.08	267.6	165.2	102.4	55.2	45.6	2.2	15.2	13.2	2.	.048	.416	.224	.192	.92	.376	.544	.01	.4
5542	Aug. 2	Aug. 3	d	l	.25	224.	158.	66.	46.	36.	2.4	14.9	12.8	2.6	.024	.32	.176	.144	.76	.536	.224	.001	.2
5597	" 9	" 10	d	c	.04	438.	163.6	274.4	56.6	41.2	2.6	15.2	11.1	4.1	.026	.416	.16	.256	1.32	.328	.992	.005	.12
5641	" 16	" 17	d	c	.15	305.2	152.8	152.4	66.4	48.	2.7	13.9	10.4	3.5	.036	.432	.176	.256	1.32	lost	....	.011	.28
5697	" 23	" 24	d	c	.05	265.2	178.	87.2	41.2	34.	3.1	11.2	7.8	3.4	.012	.336	.192	.144	1.	.44	.56	.004	.16
5748	" 30	" 31	d	l	.02	244.4	182.8	61.6	38.8	36.4	3.5	10.9	9.9	1.	.032	.272	.176	.096	.92	.424	.496	.002	.12
5804	Sept. 6	Sept. 7	d	c	.03	246.4	170.8	75.6	31.6	28.8	3.5	10.6	6.	4.6	.036	.32	.16	.16	1.	.44	.56	.05	.2
5851	" 13	" 14	d	c	.04	270.4	156.	114.4	29.2	14.4	2.4	11.8	6.8	5.	.04	.384	.208	.176	.92	.552	.368	.007	.2
5901	" 20	" 21	d	c	.04	265.6	162.8	102.8	35.2	33.6	2.3	13.	8.6	4.4	.016	.432	.144	.288	1.08	.328	.752	.01	.32
5960	" 27	" 28	d	c	.15	234.8	141.6	93.2	34.4	21.6	2.8	13.5	11.9	1.6	.014	.416	.244	.172	.96	.484	.496	.006	.16
6002	Oct. 4	Oct. 5	d	c	.07	206.8	148.8	58.	32.	25.2	2.8	16.6	15.3	1.3	.032	.4	.224	.176	.868	.372	.496	.005	.2
6044	" 11	" 12	d	c	.15	228.	163.6	64.4	27.6	24.8	2.8	13.7	13.6	.1	.016	.416	.208	.208	.74	.404	.336	.008	.2
6165	" 25	" 26	d	c	.05	230.8	154.4	76.4	25.6	15.6	3.6	9.8	8.7	1.1	.02	.416	.18	.236	.76	.296	.464	.005	.12
6204	Nov. 1	Nov. 2	d	c	.04	232.4	162.	70.4	14.8	12.	3.7	8.9	8.6	.3	.028	.384	.16	.224	.68	.36	.32	.006	.16
6256	" 8	" 9	d	c	.08	244.4	173.6	70.8	30.	22.	2.8	10.2	9.2	1.	.028	.32	.24	.08	.84	.44	.4	.005	.24
6305	" 15	" 16	d	c	.03	303.2	169.2	134.	20.8	17.2	2.5	12.5	12.5	0.0	.088	.368	.32	.048	.68	.424	.256	.006	.2
6346	" 22	" 23	d	c	.3	241.2	150.8	90.4	38.8	33.2	3.2	12.7	12.3	.4	.064	.4	.224	.176	.84	.52	.32	.006	.16
6413	" 29	" 30			....	178.8	156.8	22.	37.6	27.2	3.1	12.	11.6	.4	.096	.336	.272	.064	.936	.52	.416	.006	.16
6461	Dec. 6	Dec. 7	d	c	.15	170.8	146.	24.8	28.8	20.8	3.	14.4	13.5	.9	.048	.32	.208	.112	.84	.68	.16	.006	.32
6520	" 13	" 14	d	c	.15	157.2	134.8	22.4	23.6	22.	3.7	12.5	11.8	.7	.001	.352	.224	.128	.744	.52	.224	.005	.12
6560	" 20	" 22	d	c	.10	169.6	147.2	22.4	23.2	19.6	3.6	12.1	11.9	.2	.032	.32	.208	.112	.6	.296	.304	.006	.16
Average Dec. 31, '98—June 28, '99...						486.5	157.3	329.2	41.2	24.7	3.2	18.5	10.1	8:4	.122	.634	.224	.41	1.413	.502	.911	.017	.48
Average July 5—Dec. 20..............						244.4	157.6	86.8	32.4	26.	2.5	11.4	9.6	2.4	.038	.382	.21	.16	.922	.465	.457	.007	.2
Average Dec. 31, '98—Dec. 20, '99...						365.4	157.4	208.	36.8	25.4	2.8	15.2	9.8	5.4	.077	.508	.217	.291	1.168	.485	.683	.012	.34

*The water of the Mississippi is at all times so turbid or muddy that it has been necessary, invariably, to filter before attempting to determine the color.

Odor none. Color upon ignition brown.

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT GRAFTON.

(Parts per 1,000,000.)

Serial Number.	1900. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.							Albuminoid Ammonia.							
	Collec-tion.	Exami-nation.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dis-solved		Total.	By Dis-solved.	By Suspended Matt'r	Free Ammonia.	Total.	Dis-solved	Sus-pended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
6625	Jan. 4	Jan. 5	d	c	*.05	232.4	210.8	21.6	23.2	21.2	9.4	13.	9.3	3.7	.08	.352	.208	.144	.76	.328	.432	.007	.16
6656	" 10	" 11	d	c	.1	206.4	192.4	14.	20.	16.8	4.8	11.6	9.3	2.3	.012	.48	.176	.304	.792	.344	.448	.003	.08
6706	" 17	" 18	d	c	.06	204.8	178.8	26.	30.2	26.4	4.4	10.7	8.8	1.9	.024	.352	.176	.176	.88	.384	.496	.001	.08
6750	" 24	" 25	d	m	.06	274.4	180.4	94.	30.4	20.	3.8	11.2	5.2	6.	.028	.352	.176	.176	.8	.512	.288	.008	.48
6801	" 31	Feb. 1	d	c	.25	213.6	172.8	40.8	34.8	22.8	4.	13.3	11.2	2.1	.12	.32	.24	.08	.8	.416	.384	.008	.48
6865	Feb. 7	" 8	d	c	.03	248.4	181.2	67.2	24.4	13.6	5.8	13.2	9.2	4.	.09	.368	.24	.128	.96	.32	.64	.006	.4
6912	" 14	" 15	d	m	.4	531.6	148.8	382.2	38.8	26.	3.65	17.	8.6	8.4	.112	.672	.224	.448	1.52	.416	1.104	.006	.72
6957	" 21	" 23	d	m	.5	318.	137.2	180.8	64.	30.4	3.3	19.5	11.3	8.2	.304	.688	.352	.336	1.36	.864	.496	.012	.72
6996	Mar. 1	Mar. 8	d	m	.08	210.	152.4	57.6	37.2	17.6	3.8	13.7	11.2	2.5	.328	.4	.176	.224	.72	.48	.24	.008	.08
7058	" 9	" 12	d	m	.4	499.6	142.8	356.8	25.6	14.4	3.4	14.8	7.4	7.4	.168	.48	.208	.272	1.44	.512	.928	.007	.64
7115	" 19	" 20	d	m	.5	533.6	125.6	408.	34.2	16.4	2.	22.4	8.8	13.6	.352	.736	.256	.48	1.64	.536	1.104	.008	.52
7172	" 26	" 28	d	m	.3	367.2	108.8	258.4	32.	13.6	2.8	17.1	9.5	7.6	.48	.56	.304	.256	1.48	.696	.784	.01	.48
7214	April 2	April 3	d	m	.06	259.6	125.2	134.4	23.4	18.6	3.4	14.	7.3	6.7	.392	.448	.272	.176	.952	.612	.34	.006	.6
7290	" 9	" 10	v d	v m	.3	1084.	116.8	967.2	46.8	32.8	1.5	27.6	9.3	18.3	.272	1.088	.304	.784	2.52	.76	1.76	.017	1.04
7300	" 16	" 17	d	m	.3	302.1	141.3	161.2	39.	21.2	3.5	14.4	8.2	6.2	.14	.432	.272	.16	1.08	.664	.416	.032	.08
7365	" 23	" 24	v d	v m	.4	1171.6	118.4	1053.2	64.	16.8	2.	21.7	6.6	15.1	.044	1.28	.176	1.104	2.92	.44	2.48	.006	.8
7451	May 2	May 3	d	m	.05	311.6	137.2	174.4	32.8	20.8	3.4	14.9	8.2	6.7	.016	.416	.24	.176	1.14	.484	.656	.011	.6
7490	" 9	" 10	d	c	.3	264.8	102.	162.8	30.4	21.2	3.	17.6	11.9	5.7	.04	.4	.272	.128	1.06	.84	.32	.009	.12
7560	" 16	" 17			.2	390.4	128.6	262.8	41.2	23.2	3.	18.5	9.7	8.8	.056	.448	.176	.272	1.09	.336	.704	.001	.2
7604	" 23	" 24	v d	v m	.2	494.8	147.2	347.6	54.4	24.4	3.	17.4	10.9	6.5	.04	.48	.24	.24	.984	.48	.544	.018	1.
7666	" 30	" 31	d	c	.1	270.4	136.4	134.	30.9	24.8	3.4	12.	8.6	3.4	.012	.352	.192	.16	.96	.452	.508	.006	.48
7673	June 6	June 7	d	c	.06	270.6	130.	141.6	38.	20.8	3.9	16.6	8.2	8.4	.024	.352	.128	.224	.8	.324	.576	.006	.2
7720	" 13	" 14	d	c	.15	280.2	105.2	74.	35.6	26.	4.	9.4	8.1	1.3	.038	.32	.16	.16	.708	.28	.428	.001	.16
7749	" 20	" 21	d	l	.06	257.2	181.6	75.6	38.8	22.8	3.7	11.8	7.5	4.3	.04	.288	.128	.16	.8	.392	.608	.004	.12
7770	" 25	" 26	d	m	.08	362.8	104.	258.8	40.4	22.8	3.4	16.	6.9	9.1	.042	.48	.112	.096	1.156	.480	.704	.013	.28
7812	July 2	July 3	d	m	.07	318.	220.	98.	36.8	24.8	4.	9.9	8.8	1.1	.078	.32	.16	.16	.928	.324	.044	.009	.20
7885	" 9	" 10	d	l	.06	348.4	189.2	159.2	32.	17.2	4.8	12.2	6.9	5.3	.08	.32	.176	.144	1.032	.18	.912	.005	.4

*The water of the Mississippi is at all times so turbid or muddy that it has been necessary, invariably, to filter before attempting to determine the color.

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT GRAFTON.—CONTINUED.

(Parts per 1,000,000.)

Serial Number.	1900 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved		Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Dissolved	Albuminoid Ammonia. Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
7927	July 16	July 17	d	l	*.02	280.8	181.2	99.6	20.	17.2	4.2	11.3	6.5	4.8	.08	.336	.176	.16	.9	.308	.592	.008	.36
7984	" 23	" 24	d	m	.02	354.8	138.4	216.4	34.8	20.8	3.3	12.9	6.7	6.2	.074	.336	.192	.144	.68	.212	.468	.001	.36
8048	" 30	" 31	d	m	.02	564.	123.2	440.8	69.2	26.4	2.6	19.	8.	11.	.064	.544	.16	.384	1.224	.388	.836	.004	.68
8097	Aug. 6	Aug. 7	d	c	.01	285.2	142.	143.2	58.4	47.2	2.7	14.7	12.8	1.9	.082	.384	.342	.042	.76	.548	.212	.002	.44
8156	" 13	" 14	d	l	.02	235.2	155.6	79.6	39.6	37.6	3.	15.4	10.	5.4	.08	.32	.24	.08	1.	.43	.57	.004	.28
8220	" 20	" 21	d	l	.01	383.6	148.8	234.8	42.	22.4	3.6	12.7	7.2	5.5	.13	.512	.208	.304	1.	.232	.748	.007	.44
8294	" 27	" 28	d	c	.2	423.2	132.	291.2	36.	20.	3.	16.	7.	9.	.128	.384	.192	.192	1.16	.252	.908	.005	.84
8371	Sept. 5	Sept. 6	d	m	....	309.6	154.8	154.8	24.4	20.4	2.6	19.3	8.8	10.5	.068	.4	.24	.16	.664	.412	.252	.005	.32
8453	" 12	" 13	d	c	.2	216.2	149.6	66.6	34.	24.8	3.	17.5	11.2	6.3	.09	.464	.192	.272	.616	.464	.152	.002	.24
8501	" 19	" 20	d	c	.04	260.8	148.	112.8	40.	27.6	2.8	15.4	11.8	3.6	.068	.4	.288	.112	.888	.592	.296	.004	.32
8544	" 26	" 27	d	c	.8	306.	144.4	161.6	51.6	31.6	2.2	17.6	11.6	5.9	.162	.432	.24	.192	.792	.656	.136	.002	.36
8604	Oct. 3	Oct. 4	d	c	1.2	372.	153.6	218.4	104.	44.8	1.3	27.6	18.3	9.3	.164	.528	.324	.204	1.28	.624	.656	.002	.44
8650	" 10	" 11	d	c	.6	542.4	150.	392.4	42.4	34.4	2.2	24.4	14.4	10.	.174	.608	.224	.384	1.312	.384	.928	.005	.513
8667	" 15	" 17	d	l	.02	296.8	139.6	157.2	44.4	36.4	1.4	23.2	19.	4.2	.12	.464	.272	.192	1.232	.64	.592	.007	.333
8688	" 22	" 23	d	c	.1	317.2	124.8	192.4	43.6	38.8	1.5	26.	19.6	6.4	.101	.576	.368	.208	1.104	.736	.368	.008	.552
8712	" 29	" 30	d	c	1.4	270.8	129.6	141.2	54.8	40.4	1.4	27.2	23.2	4.	.156	.448	.288	.16	.752	.656	.096	.002	.398
8738	Nov. 5	Nov. 6	d	c	.6	233.2	134.4	98.8	30.	23.6	1.9	20.9	17.1	3.8	.164	.448	.256	.192	.912	.56	.352	.005	.395
8766	" 12	" 13	d	l	.4	319.2	140.4	178.8	37.2	30.	1.9	22.2	13.8	8.4	.13	.448	.224	.224	1.056	.608	.448	.01	.59
8787	" 19	" 20	d	l	1.2	181.2	125.2	56.	31.6	28.8	1.7	22.3	17.9	4.4	.164	.384	.352	.032	.912	.688	.224	.007	.393
8819	" 26	" 27	d	c	.1	209.6	136.8	72.8	20.8	18.8	1.9	19.9	16.7	3.2	.106	.352	.192	.16	.816	.576	.24	.006	.514
8852	Dec. 3	Dec. 4	d	l	.4	180.8	145.2	35.6	15.2	12.4	2.4	14.4	14.2	.2	.088	.288	.272	.016	.608	.496	.112	.008	.552
8878	" 10	" 11	d	l	.3	189.2	171.2	18.	26.8	25.6	2.6	12.5	11.9	.6	.056	.224	.128	.096	.6	.352	.248	.011	.469
8898	" 17	" 18	d	l	.6	179.6	172.4	7.2	21.2	20.8	2.6	12.1	11.6	.5	.042	.176	.112	.064	.624	.448	.176	.004	1.076
8919	" 24	" 25	d	l	.6	207.6	179.2	28.4	22.4	20.8	3.	12.3	10.9	1.4	.124	.256	.144	.112	.512	.32	.192	.023	.597
Average Jan. 4—June 25............						383.8	149.1	234.7	36.3	21.2	3.7	15.2	8.8	6.3	.12	.501	.216	.285	1.169	.487	.682	.008	.468
Average July 2—Dec. 24............						299.4	151.1	148.6	38.6	27.8	2.6	17.6	12.4	5.2	.106	.398	.229	.169	.898	.465	.433	.006	.474
Average Jan. 4—Dec. 24............						340.8	150.1	190.7	37.5	24.6	3.155	16.4	10.6	5.8	.113	.448	.222	.226	1.03	.476	.555	.007	.471

*The water of the Mississippi is at all times so turbid or muddy that it has been necessary, invariably, to filter before attempting to determine the color.

Odor none. Color upon ignition brown.

8551

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT GRAFTON.

(Parts per 1,000,000.)

Serial Number.	1901.		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
	Collection.	Examination.							Total.	Dissolved						Total.	Dissolved	Suspended					
9004	Feb. 21	Feb. 21	d	l	.4	272.	183.2	88.8	19.6	14.4	4.7	9.9	8.7	1.2	.76	.272	.208	.064	.592	.496	.096	.011	.709
9038	Mar. 15	Mar. 19	v d	v m	.6	1068.8	124.4	944.4	63.6	18.	3.	29.1	13.6	15.5	.56	1.44	.336	1.104	2.784	.656	2.128	014	1.226
9078	Apr. 21	Apr. 23	d	c	.2	187.6	124.4	63.2	24.8	28.	1.8	11.7	9.5	2.2	.092	.304	.176	.128	.736	.336	.4	.005	.475
9116	May 20	May 21	d	c	...	217.6	137.2	80.4	36.4	29.2	1.9	13.4	10.8	2.6	.064	.288	.16	.128	.752	.352	.4	none	.12
9148	June 25	June 26	d	l	.3	213.2	141.6	71.6	32.4	18.8	2.6	11.7	8.4	3.3	.044	.32	.176	.144	.72	.368	.352	"	.12
9178	July 15	July 16	d	c	.3	251.6	164.	87.6	38.4	37.2	2.2	13.5	12.3	1.2	.06	.32	.192	.128	.912	.384	.528	"	.2
9196	" 22	" 23	d	c	.4	228.4	138.	90.4	33.2	27.2	2.1	15.2	11.1	4.1	.118	.32.	.192	.128	.784	.448	.336	"	.16
9231	" 29	" 30	d	c	.7	210.4	140.4	70.	33.	29.6	1.	15.4	14.3	1.1	.118	.352	.272	.08	.736	.624	.112	"	.12
9276	Aug. 5	Aug. 6	d	c	.5	208.4	139.2	69.2	36.	23.8	2.2	16.4	15.	1.4	.096	.416	.304	.112	.752	.528	.224	"	.08
9298	" 14	" 15	d	c	.5	202.4	150.8	51.6	38.	40.	2.2	14.4	14.1	.3	.08	.336	.24	.096	.688	.352	.336	"	.12
9313	" 19	" 20	d	c	.4	195.6	124.8	70.8	36.4	24.	2.2	14.2	12.6	1.6	.108	.304	.16	.144	.624	.368	.256	"	.08
9320	" 26	" 27	d	c	...	187.2	144.	43.2	22.4	21.2	2.2	15.2	14.3	.9	.096	.336	.192	.144	.752	.368	.384	"	.22
9350	Sept. 2	Sept. 4	d	c	.4	184.8	141.6	43.2	35.2	30.8	2.	15.2	15.2	....	.072	.304	.192	.112	.656	.352	.304	"	.16
9362	" 9	" 10	d	c	.05	186.8	139.6	47.2	32.8	31.6	2.	14.5	12.7	1.8	.15	.336	.24	.096	.656	.352	.304	"	.32
9383	" 16	" 17	d	c	3	201.6	155.6	46.	32.8	31.6	2.9	13.9	12.	1.9	.06	.304	.16	.144	.....	....	.....	"	.08
9402	" 23	" 24	d	c	.2	190.	149.6	40.4	38.	36.4	3.5	13.3	11.5	1.8	.136	.336	.16	.176	.....	....	.....	.001	.2

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT GRAFTON.—CONTINUED.

(Parts per 1,000,000.)

Serial Number.	1901. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination.*	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
9417	Sept. 30	Oct. 1	d	c	.2	204.8	135.2	69.6	28.4	28.4	3.6	9.1	7.2	1.9	.152	.288	.128	.16	....	....	....	none	.16
9447	Oct. 7	" 8	d	c	...	201.2	166.4	34.8	24.8	18.8	3.6	12.6	10.9	1.7	.052	.304	.192	.112	....	....	....	.001	.16
9491	" 14	" 15	d	c	.13	183.2	148.4	34.8	27.2	13.6	3.4	11.6	9.1	2.5	.092	.272	.16	.112	....	....	....	none	.04
9546	" 21	" 22	d	c	.4	186.4	123.2	63.2	23.6	30.8	2.9	12.1	8.6	3.5	.08	.32	.176	.144	....	....	....	.002	.038
9608	" 28	" 29	d	c	.6	167.6	120.8	46.8	26.	20.	2.8	14.1	9.8	4.3	.068	.368	.224	.144	....	....	....	.001	.12
9674	Nov. 6	Nov. 7	d	c	.7	166.4	121.1	45.2	27.6	28.4	2.3	14.1	11.7	2.4	.048	.288	.192	.196	....	....	....	none	none
9753	" 13	" 14	d	c	.3	170.	126.4	43.6	27.6	28.8	3.6	11.7	9.1	2.6	.064	.224	.16	.064	....	....	....	"	.12
9797	" 18	" 19	d	l	.3	147.6	131.6	16.	24.4	21.6	3.5	9.1	8.3	.8	.048	.224	.16	.064	....	....	....	"	.16
9864	" 25	" 26	d	l	.2	150.	138.	12.	32.4	32.4	3.2	11.4	8.6	2.8	.04	.208	.16	.048	....	....	....	"	.12
9938	Dec. 2	Dec. 3	d	l	.2	166.	144.	22.	32.	32.	3.5	11.8	8.9	2.9	.052	.256	.192	.064	....	....	....	"	.08
10021	" 9	" 10	d	l	.3	162.8	157.6	5.2	21.2	18.4	3.1	12.6	8.5	4.1	.06	.288	.16	.128	....	....	....	"	.16
10095	" 16	" 17	d	l	.05	162.8	143.2	19.6	27.6	26.4	3.8	11.8	8.5	3.3	.028	.256	.16	.096	....	....	....	"	.18
10139	" 23	" 25	d	l	.05	182.4	170.	12.4	37.6	26.4	5.4	11.1	10.1	1.	.032	.288	.176	.112	....	....	....	"	.32
Average Feb. 21—June 25						391.8	142.1	249.7	35.3	21.6	2.8	15.1	10.2	4.9	.517	.524	.211	.313	1.116	.441	.675	.01	.53
Average July 15—Dec. 23						188.	143.2	44.8	30.7	27.4	2.8	13.1	11.	2.1	.081	.302	.191	.111	.723	.413	.31	.001	.133
Average Feb. 21—Dec. 23						280.6	142.7	137.9	32.8	64.8	2.8	14.1	10.6	3.5	.279	.403	.202	.201	.969	.431	.538	.006	.314

*The water of the Mississippi is at all times so turbid or muddy that it has been necessary, invariably, to filter before attempting to determine the color.

Odor none. Color upon ignition brown.

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT ALTON.

(Parts per 1,000,000.)

Serial Number.	1897 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
									Total.	Dissolved.						Total.	Dissolved.	Suspended					
1801	Jan. 5	Jan. 6	v d	m	.6	2805.2	167.2	2638.	30.	10.8	4.5	57.	9.2	47.8	.112	2.4	.24	2.16	4.8	.8	4.	.012	.9
1820	" 12	" 13	d	m	.4	2055.2	250.4	1804.8	34.8	11.2	7.	30.2	7.5	22.7	.232	.96	.32	.64	2.56	.64	1.92	.045	2.3
1840	" 19	" 20	d	m	.25	1521.2	224.	1297.2	20.4	16.	7.	24.9	6.9	18.	.196	1.52	.176	1.344	2.88	.72	2.16	.05	2.
1847	" 26	" 27	d	m	.2	833.2	258.4	574.8	14.2	12.	5.4	20.2	7.3	12.9	.188	.72	.4	.32	1.76	.8	.96	.065	3.
1865	Feb. 1	Feb. 2	d	m	.00	1223.2	282.8	940.4	14.4	10.8	6.2	20.1	6.8	13.3	.176	.8	.4	.4	1.44	.72	.72	.055	3.
1890	" 9	" 10	d	c	.09	394.4	258.8	135.6	12.	12.	5.2	12.2	7.3	4.9	.176	.4	.32	.08	1.44	.8	.64	.035	2.8
1920	" 16	" 17	d	c	.15	460.4	274.4	186.	19.2	10.	8.	11.7	7.2	4.5	.336	.48	.224	.256	1.12	.88	.24	.025	2.3
1932	" 23	" 24	d	c	.3	558.4	259.6	298.8	36.	34.	7.	13.5	6.7	6.8	.352	.56	.44	.12	1.44	.8	.64	.085	1.8
1963	Mar. 2	Mar. 3	v d	m	.13	2141.6	254.4	1887.2	80.4	38.	6.	23.8	5.9	17.9	.336	1.12	.32	.8	2.95	.43	2.52	.08	2.2
1983	" 9	" 10	d	m	.2	1013.2	174.8	838.4	88.8	35.6	2.2	25.1	6.2	18.9	.168	.88	.144	.736	2.35	.51	1.84	.08	1.7
2016	" 16	" 17	d	m	.2	1044.	243.2	800.8	88.8	41.6	5.4	24.6	5.9	18.7	.124	.96	.208	.752	1.71	.51	1.2	.05	2.6
2039	" 23	" 24	v d	m	.02	1639.2	243.6	1395.6	82.	33.6	5.8	24.8	6.7	18.1	.108	.88	.208	.672	2.03	.6	1.43	.075	2.7
2061	" 30	" 31	d	c	.14	402.8	268.4	134.4	41.6	29.2	7.6	11.9	6.1	5.8	.064	.32	.16	.16	.91	.51	.4	.065	3.1
2097	April 6	April 7	v d	c	.1	598.8	210.8	388.	40.4	34.8	3.2	16.3	7.3	9.	.04	.64	.24	.4	1.07	.6	.47	.065	2.1
2114	" 13	" 14	d	c	.6	292.	217.2	74.8	35.2	28.	4.	11.2	7.5	3.7	.032	.4	.208	.192	.75	.65	.1	.4	2.3
2135	" 20	" 21	d	l	.5	280.4	223.2	57.2	30.6	24.8	3.8	10.3	7.4	2.9	.008	.24	.176	.064	1.23	.67	.56	.015	2.4
2157	" 27	" 28	d	c	.2	260.8	198.8	62.	35.2	31.2	3.	10.5	7.1	3.4	.028	.48	.192	.288	.87	.63	.24	.008	1.3
2187	May 4	May 5	d	c	.05	241.2	192.8	48.4	24.8	24.	3.	12.2	8.2	4.	.056	.64	.272	.368	1.19	.71	.48	.014	1.1
2205	" 11	" 12	d	c	.2	338.	235.6	102.4	29.2	19.6	5.4	11.1	8.9	2.2	.048	.56	.208	.352	1:35	.71	.64	.048	1.2
2234	" 19	" 20	d	c	.2	415.2	262.4	152.8	30.	22.4	5.6	14.	8.7	5.3	.028	.72	.272	.448	1.07	.67	.4	.075	1.2
2261	" 25	" 26	d	c	.3	653.2	263.2	390.	36.8	29.2	6.2	16.	7.8	8.2	.024	.72	.4	.32	1.71	.51	1.2	.09	1.1
2288	June 2	June 3	d	c	.3	388.	258.4	129.6	31.6	28.	6.	15.5	8.	7.5	.016	.56	.48	.08	1.23	.67	.56	.055	1.
2310	" 9	" 10	d	c	.2	361.2	254.4	106.8	26.8	22.4	6.2	13.	2.3	10.7	.016	.64	.4	.24	1.29	.73	.56	.04	1.
2324	" 15	" 16	d	c	.04	378.8	229.6	149.2	24.	22.	5.6	15.5	9.	6.5	.008	.64	.208	.432	1.21	.65	.56	.024	1.
2362	" 22	" 23	d	c	.2	292.	210.4	81.6	26.8	24.	4.8	13.6	8.8	4.8	.012	.48	.32	.16	.73	.57	.16	.16	.7
2398	July 1	July 2	v d	m	...	1132.8	216.	916.8	26.	16.	8.	22.3	9.1	13.2	.016	.88	.4	.48	2.41	1.21	1.2	.035	1.
2417	" 6	" 7	d	m	...	564.	212.	352.	28.	21.2	5.4	16.5	12.8	3.7	.008	.64	.48	.16	1.72	.68	1.04	.006	1.3

2441	July 13	July 14	d	c	.6	806.8	278.	528.8	28.8	20.	8.	20.7	8.5	12.2	.018	.8	.362	.448	1.88	.84	1.04	.028	1.3
2470	" 20	" 21	d	c	.4	432.8	200.2	243.6	22.8	18.	8.	15.7	8.2	7.5	.032	.8	.288	.512	1.4	.52	.88	.015	.8
2495	" 27	" 28	v d	m	.2	2129.8	146.4	1982.8	60.	14.	2.2	26.4	12.7	18.7	.012	1.36	.224	1.136	2.4	.64	1.86	.03	.4
2526	Aug. 3	Aug. 4	d	c	.4	354.4	181.	173.4	26.4	16.	6.	16.2	13.3	2.9	.01	.86	.256	.104	.84	.68	.16	.01	.9
2543	" 10	" 11	d	c	.6	446.	191.2	254.8	18.4	17.2	6.2	18.	14.	4.	.008	.64	.288	.352	1.88	1.	.88	.007	.4
2577	" 18	" 19	d	m	.5	741.2	188.8	552.4	37.2	25.6	3.6	26.9	17.	9.9	.02	1.04	.448	.592	1.56	.84	.72	.05	.4
2591	" 24	" 25	d	c	.4	260.8	177.2	83.6	28.	24.	3.	17.5	14.9	2.6	.02	.64	.448	.192	.98	.42	.46	.003	.35
2616	" 31	Sept. 1	d	c	.3	278.	202.4	75.6	28.4	24.4	4.	16.5	14.8	2.2	.036	.4	.32	.08	.82	.56	.24	.004	.25
2653	Sept. 10	" 11	d	c	.4*.5	223.2	178.	45.2	22.	20.	3.5	14.8	14.4	.4	.026	.36	.32	.04	.82	.74	.08	.006	.1
2672	" 14	" 15	d	c	.15	240.	184.	56.	16.	14.	4.2	13.5	11.8	1.7	.014	.36	.24	.12	.74	.46	.28	.011	.9
2703	" 22	" 23	d	c	.15	237.2	192.8	44.4	17.2	14.	5.	13.5	10.5	3.	.006	.52	.28	.24	.9	.38	.52	.02	.4
2730	" 29	" 30	d	c	.06	234.4	192.8	41.6	18.4	14.8	7.	12.	10.5	1.5	.032	.44	.36	.08	.7	.5	.2	.017	.2
2759	Oct. 5	Oct. 6	d	c	.2	300.	194.8	105.2	28.	16.8	8.	14.9	10.7	4.2	.016	.52	.24	.28	1.1	.5	.6	.04	.2
2787	" 12	" 13	d	m	.15	492.	204.8	287.2	26.	22.	8.	18.5	10.6	7.9	.018	.68	.32	.36	1.42	.3	1.12	.06	.1
2832	" 20	" 21	d	c	.2	280.8	208.8	72.	22.8	15.6	10.	12.1	8.8	3.8	.02	.36	.24	.12	.7	.34	.36	.017	.3
2850	" 27	" 28	d	c	.15	264.	197.2	66.8	19.2	18.	9.	12.8	8.1	4.7	.006	.4	.24	.16	.86	.5	.36	.008	.3
2885	Nov. 3	Nov. 4	d	c	.06	267.6	210.8	56.8	26.4	23.2	13.	12.	8.3	3.7	.008	.28	.16	.12	.78	.42	.36	.007	.4
2923	" 9	" 10	d	c	.15	245.6	193.2	52.4	18.8	16.	11.	11.	7.	4.	.026	.4	.28	.12	.7	.5	.2	.06	.6
2965	" 23	" 25	d	c	.07*.15	255.2	214.4	40.8	21.2	18.4	16.	12.9	8.	4.9	.012	.36	.28	.08	.78	.42	.36	.015	.5
3007	" 30	Dec. 1	d	c	.15*.3	236.8	212.4	24.4	25.6	24.8	18.	10.6	8.4	2.2	.006	.44	.28	.16	.53	.41	.12	.03	.6
3048	Dec. 10	" 11	d	c	.08	306.4	233.2	73.2	22.	19.2	19.	9.7	8.	1.7	.324	.48	.36	.12	.93	.77	.16	.01	.6
3074	" 17	" 20	d	c	.06	256.4	232.4	24.	24.	20.	15.	8.9	7.5	1.4	.34	.4	.22	.18	.93	.41	.52	.015	.8
3081	" 21	" 22	d	l	.1*.2	261.2	240.8	20.4	19.2	16.8	15.	8.2	7.2	1.	.316	.44	.28	.16	.81	.45	.36	.01	.6
Average Jan. 5—June 22						823.6	236.6	586.9	36.9	24.2	5.3	18.3	7.2	11.1	.115	.74	.277	.471	1.64	.65	.98	.053	1.8
Average July 1—Dec. 21						450.7	203.7	247.	25.1	18.8	8.5	15.2	10.5	4.7	.053	.56	.305	.254	1.11	.58	.53	.019	.5
Average Jan. 5—Dec. 21						637.1	220.1	416.9	31.4	21.5	6.8	16.8	8.8	7.9	.084	.65	.291	.362	1.77	.62	.75	.036	1.

During the years 1897 and 1898 the samples of water came from the Alton City Supply, which was drawn from the river immediately beside the Illinois shore.

*Not Filtered.

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT ALTON.

(Parts per 1.000,000.)

Serial Number.	1898 Date of Collection.	1898 Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Ammonia. Total.	Nitrogen as Ammonia. Albuminoid Ammonia. Dissolved.	Nitrogen as Ammonia. Albuminoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended	Nitrogen as Nitrites.	Nitrogen as Nitrates.
3129	Jan. 3	Jan. 5	d	c	.06* .25	273.2	252.4	20.8	32.	15.6	17.	11.	6.7	4.3	.6	.52	.36	.16	.93	.65	.28	.02	.65
3138	" 6	" 7	d	c	.1	328.8	241.2	87.6	30.4	19.2	14.	9.8	6.2	3.1	.44	.68	.36	.32	1.25	.45	.8	.07	.5
3165	" 13	" 14	v d	v m	.04	1965.2	168.	1797.2	73.2	24.	10.	28.	8.1	19.9	.6	1.68	.32	1.36	3.48	.48	3.	.1	.48
3183	" 19	" 20	d	m	.15	591.2	203.2	388.	43.2	19.2	12.	26.	7.3	18.7	1.8	.88	.32	.56	1.8	.52	1.28	.045	.3
3226	Feb. 1	Feb. 2	d	c	.2	440.	239.2	200.8	28.	15.6	11.	15.7	7.4	8.3	.92	.56	.24	.32	1.32	.56	.76	.06	1.5
3250	" 10	" 11	d	c	.05	483.2	249.2	184.	32.	28.	8.	13.7	8.	5.7	.6	.44	.24	.2	1.	.52	.48	.11	2.4
3275	" 15	" 16	d	m	.05	675.6	224.	451.6	34.8	26.	7.	18.1	6.3	11.8	.56	.8	.4	.4	1.4	.68	.72	.055	1.9
3299	" 22	" 23	v d	v m	.4	940.	189.6	750.4	38.	21.6	4.6	26.2	6.6	19.6	.4	1.36	.32	1.04	2.52	.64	1.88	.04	1.75
3319	Mar. 1	Mar. 2	d	c	.1	542.8	227.6	315.2	28.8	21.2	7.	17.5	6.8	10.7	.314	.68	.28	.4	1.16	.48	.68	.025	2.25
3344	" 8	" 9	d	c	.2	433.6	284.4	199.2	46.8	26.	7.	11.7	6.7	5.	.24	.48	.28	.2	.84	.52	.32	.04	1.
3366	" 16	" 18	d	m	.15	624.4	228.	396.4	44.8	37.6	4.4	19.	8.3	10.7	.2	.88	.3	.58	1.72	.76	.96	.002	1.2
3388	" 23	" 24	v d	v m	.15	3102.4	193.6	2908.8	107.2	24.	3.6	45.6	8.5	37.1	.112	1.84	.28	1.56	4.6	.48	4.12	.08	.85
3410	" 30	" 31	v d	v m	.3	2142.	175.6	1966.4	61.2	18.4	3.2	27.1	6.8	20.3	.072	1.48	.28	1.2	3.75	.45	3.3	.032	1.05
3435	April 5	April 6	v d	v m	.3	2060.	154.4	1915.6	78.	17.6	2.8	28.	8.2	19.8	.02	1.56	.36	1.2	3.17	.53	2.64	.023	1.2
3455	" 13	" 14	v d	c	.1	888.8	189.2	699.6	32.8	20.	3.2	18.	14.	4.	.008	.72	.36	.36	1.65	.69	.96	.035	.84
3479	" 20	" 21	d	c	.25	787.2	202.	535.2	40.	24.	3.6	15.5	8.	7.5	.056	.64	.28	.36	1.25	.57	.68	.02	.9
3503	" 26	" 27	d	c	.1	436.	214.8	221.2	37.6	24.8	4.	14.	7.7	6.3	.008	.56	.28	.28	1.01	.6	.41	.023	.85
3537	May 3	May 4	d	m	.06	572.4	227.6	344.8	28.	26.8	6.	13.7	7.8	5.9	.024	.6	.24	.36	1.14	.62	.52	.025	1.
3554	" 10	" 11	d	c	.3	475.6	282.	243.6	38.4	32.4	6.	13.7	7.	6.7	.004	.52	.4	.12	.98	.5	.48	.025	.5
3586	" 17	" 18	d	m	.04	960.	203.2	756.8	36.	32.8	5.6	16.8	6.7	10.1	.004	.8	.36	.44	1.86	.78	1.08	.02	.55
3615	" 24	" 25	d	c	.09	550.	196.	354.	38.	27.6	3.6	15.8	7.5	8.3	.01	.64	.36	.28	1.38	.66	.72	.03	.5
3640	June 1	June 2	d	m	.04	987.2	192.8	794.4	44.	30.8	4.	19.2	6.5	12.7	.004	.96	.28	.68	2.1	.54	1.56	.048	.4
3669	" 8	" 9	d	m	...	556.8	258.	298.8	44.8	42.4	4.8	14.1	6.8	7.3	.009	.48	.16	.32	1.08	.52	.56	.04	.4
3688	" 14	" 15	d	c	...	518.4	224.	294.	32.	12.	5.	14.1	6.6	7.5	.004	.36	.2	.16	1.04	.52	.52	.05	.4
3715	" 21	" 22	d	m	...	470.4	237.6	232.8	30.4	27.2	8.	11.7	6.8	4.9	.009	.44	.2	.24	1.08	.56	.52	.012	.8
3758	" 28	" 29	d	c	.05	594.	339.6	254.4	22.	21.2	7.	14.	6.8	7.2	.001	.4	.24	.16	1.24	.88	.36	.012	.2
3776	July 5	July 6	d	c	...	332.8	249.6	83.2	20.8	20.	7.8	10.4	7.7	2.7	.001	.3	.24	.06	.76	.64	.12	.001	.25

*Not Filtered.

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT ALTON.—CONTINUED.
(Parts per 1,000,000)

Serial Number.	1898 Date of Collection.	1898 Date of Examination	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Albumihoid Ammonia. Total.	Albumihoid Ammonia. Dissolved.	Albumihoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspenced	Nitrogen as Nitrites.	Nitrogen as Nitrates.
3818	July. 12	July 13	d	c	.05*.25	356.	250.	106.	20.4	16.	9.	8.7	...	...	.008	.32	.24	.08	.8	.56	.24	.004	.3
3841	" 19	" 20	d	l	.04*.3	256.4	214.	42.4	17.2	16.	7.	9.5	8.2	1.3	.06	.32	.28	.04	.56	.48	.08	.002	.1
3881	" 26	" 27	d	c	.1	260.4	182.4	78.	16.	16.	5.	11.4	8.6	2.8	.004	.32	.22	.1	.64	.48	.16	.002	.2
3910	Aug. 2	Aug. 3	d	c	.1	240.4	186.	54.4	15.2	13.2	5.6	9.5	9.	.5	.002	.36	.3	.06	.56	.32	.24	.004	.25
3936	" 9	" 10	d	l	.05*.3	220.	195.2	248.	26.8	22.8	5.2	9.7	8.	1.7	.002	.32	.28	.04	.56	.4	.16	.004	.1
3961	" 16	" 17	d	c	.04	271.2	240.8	30.4	28.8	26.	10.2	8.6	7.6	1.	.005	.32	.24	.08	.56	.4	.16	.012	.2
3990	" 23	" 24	d	c	.06	314.4	179.6	134.8	29.2	23.6	6.6	10.	5.1	4.9	.004	.44	.24	.2	.64	.36	.28	.02	.35
4017	" 30	" 31	d	c	.05	328.8	209.6	119.6	29.6	26.	12.3	10.	6.8	3.2	.006	.4	.32	.08	.8	.44	.36	.006	.15
4042	Sept. 6	Sept. 7	d	c	.08	360.8	212.	148.8	30.8	26.	12.4	11.6	7.	4.6	.004	.44	.24	.2	1.04	.4	.64	.01	.2
4076	" 13	" 14	d	c	.06	341.2	168.4	172.8	32.4	25.2	8.	10.2	6.	4.2	.006	.32	.2	.12	.72	.36	.36	.007	.1
4096	" 20	" 21	d	c	.04	263.2	215.6	47.6	19.2	18.8	13.	7.5	5.3	2.2	.004	.28	.24	.04	.56	.48	.08	.007	.25
4128	" 27	" 28	d	c	.08	380.8	215.2	165.6	44.8	38.	11.3	10.2	5.4	4.8	.004	.4	.24	.16	.8	.36	.44	.017	.45
4163	Oct. 4	Oct. 5	d	c	.08	304.	222.8	81.2	24.	20.8	14.	7.7	5.6	2.1	.006	.32	.16	.16	.64	.4	.24	.035	.35
4200	" 11	" 12	d	c	.04	302.4	225.2	77.6	22.8	22.	13.	7.5	5.4	2.1	.004	.28	.2	.08	.61	.37	.24	.003	.5
4226	" 18	" 19	d	c	.03	364.	224.8	139.2	30.	22.8	10.	7.5	5.7	1.8	.012	.32	.176	.144	.69	.41	.28	.007	.3
4265	" 26	" 27	d	c	.1	338.	228.	110.	24.8	24.	11.	8.9	5.8	3.1	.04	.32	.176	.144	.73	.45	.28	.015	.5
4301	Nov. 1	Nov. 2	d	c	.05	290.8	244.	46.8	28.	24.	15.	8.4	6.	2.4	.222	.32	.24	.08	.69	.43	.26	.035	.4
4367	" 15	" 17	d	c	.04	346.	240.4	105.6	26.	20.	8.6	8.7	6.	2.7	.08	.36	.24	.12	.71	.47	.24	.028	.7
4403	" 23	" 24	d	c	.04	381.2	266.8	114.4	33.2	30.8	11.	8.1	6.6	1.5	.12	.28	.16	.12	.79	.43	.36	.035	.7
4459	Dec. 6	Dec. 8	d	c	.06	321.6	288.	33.6	36.8	25.2	10.	6.7	5.4	1.3	.068	.24	.176	.064	.57	.37	.2	.007	.2
4482	" 12	" 15	d	c	.04	390.8	308.8	82.	48.6	40.	12.	8.	6.	2.	.072	.336	.224	.112	.69	.37	.32	.01	.15
4508	" 20	" 22	d	c	.04	336.8	294.4	42.4	54.	49.2	11.	8.5	6.	2.5	.158	.352	.192	.16	.93	.41	.52	.012	.35
4532	" 27	" 28	d	c	.15	332.8	262.8	70.	44.	40.	9.	9.5	7.2	2.3	.224	.368	.208	.16	.93	.57	.36	.067	.2
Average Jan. 3—June 28						837.6	215.8	641.7	42.4	24.4	6.6	14.5	7.7	6.8	.289	.805	.286	.619	1.72	.58	1.13	.038	.93
Average July 5—Dec. 27						316.8	234.3	82.5	29.1	25.2	9.9	9.	6.5	.4	.046	.324	.226	.108	.71	.43	.27	.013	.32
Average Jan. 3—Dec. 27						596.1	224.4	373.4	35.9	24.8	8.2	11.9	7.1	4.7	.182	.479	.262	.216	1.23	.51	.72	.026	.66

*Not Filtered.

8554

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT ALTON.—100 ft. off Illinois shore.
(Parts per 1,000,000.)

Serial Number.	1899. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
4580	Jan. 5	Jan. 6	d	c	.05	336.	258.	78.	38.	35.2	10.9	12.1	8.2	3.9	.778	.44	.224	.216	.97	.53	.44	.014	.8
4601	" 12	" 13	d	c	.5	336.8	258.8	78.	52.	40.	9.5	12.5	8.5	4.	.68	.52	.272	.248	1.09	.69	.4	.013	.25
4631	" 19	" 20	d	c	.2	358.8	244.	114.8	44.	40.	9.	12.7	7.2	5.5	.6	.44	.224	.216	1.09	.49	.6	.033	.5
4650	" 27	" 28	d	c	.04	394.8	240.8	154.	32.	28.	8.3	12.8	7.7	5.1	.48	.48	.176	.304	.97	.49	.48	.045	.25
4670	Feb. 2	Feb. 3	d	c	.03	297.	250.8	46.2	44.	42.	7.6	11.	7.5	3.5	.44	.36	.208	.152	.69	.45	.24	.065	.75
4688	" 10	" 11	d	c	.06	364.	319.2	44.8	50.	40.	10.	9.8	7.5	2.3	.6	.48	.24	.24	1.02	.58	.44	.013	1.25
4719	" 17	" 18	d	m	.05	610.	300.8	309.2	54.	40.8	9.7	18.5	6.6	11.9	.48	.88	.224	.656	1.82	.58	1.24	.017	1.1
4743	" 24	" 27	d	c	.06	310.8	294.	16.8	56.	50.	10.7	10.3	6.6	3.7	.56	.4	.277	.128	.74	.46	.28	.021	.95
4761	Mar. 2	Mar. 3	v d	v m	...	1064.8	126.	938.8	76.	30.	2.1	34.	12.1	21.9	.24	1.28	.288	.992	2.74	.66	2.08	.05	.6
4796	" 10	" 13	v d	v m	.3	944.	152.	792.	76.	40.	5.1	26.5	9.8	16.7	.44	1.	.288	.712	2.5	.62	1.88	.036	1.
4823	" 16	" 17	v d	v m	.3	1154.8	142.	1012.8	90.8	32.	4.8	36.	11.2	24.8	.44	1.44	.272	1.168	2.66	.7	1.96	.022	1.
4850	" 24	" 25	v d	v m	.1	780.	176.	604.	72.	40.	4.4	24.9	11.	13.9	.44	.64	.256	.384	1.79	.48	1.31	.027	1.2
4874	" 30	" 31	d	m	.25	431.2	190.	241.2	46.	40.	5.	15.7	9.	6.7	.32	.48	.224	.256	1.	.55	.45	.045	1.5
4903	April 7	April 8	d	c	.1	350.	202.	148.	44.	40.	5.2	13.	8.4	4.6	.32	.48	.256	.224	.83	.6	.23	.035	1.2
4927	" 14	" 17	d	m	.04	448.	222.	226.	48.	44.	5.7	14.1	8.3	5.8	.176	.48	.256	.224	.99	.47	.52	.064	1.8
4947	" 20	" 21	d	c	.05	415.6	213.6	202.	48.	33.2	5.4	13.	7.6	5.4	.24	.44	.208	.232	1.07	.47	.6	.07	1.55
4966	" 27	" 28	d	c	.08	298.4	200.	98.4	36.	30.8	5.3	12.	7.2	4.8	.032	.52	.224	.296	.97	.61	.36	.04	.9
5000	May 3	May 4	d	m	.1	590.8	191.2	399.6	46.	33.2	4.5	17.2	9.1	8.1	.022	.76	.288	.472	1.61	.49	1.12	.042	.6
5018	" 10	" 11	d	c	.25	483.6	205.6	278.	44.6	18.4	4.87	15.	8.4	6.6	.06	.512	.256	.256	1.21	.742	.468	.04	.6
5057	" 18	" 19	d	m	.2	509.6	229.2	280.4	34.8	26.4	5.4	19.5	12.1	7.4	.068	.512	.288	.224	1.53	.794	.736	.015	.56
5086	" 24	" 25	d	m	.08	720.	182.8	537.2	38.8	32.8	3.7	24.	12.7	11.3	.12	.88	.24	.64	1.85	.57	1.28	.006	.84
5126	" 31	June 1	d	m	.5	884.8	170.4	714.4	45.6	26.8	3.6	20.	8.9	11.1	.044	.8	.224	.576	2.09	.506	1.584	.133	.72
5180	June 8	" 9	d	m	.3	680.8	193.6	487.2	42.	28.8	3.8	19.8	10.3	9.5	.008	.48	.24	.24	1.85	.73	1.12	.006	1.2
5217	" 15	" 16	d	m	.25	475.2	238.8	236.4	30.4	26.8	6.9	15.5	8.6	6.9	.036	.544	.208	.336	1.24	.696	.544	.005	1.36
5263	" 22	" 23	d	m	.3	373.6	216.8	156.8	28.	22.4	5.1	14.9	10.3	4.6	.016	.512	.192	.32	1.08	.664	.416	.008	.84
5304	" 28	" 29	d	c	.5	349.6	180.4	169.2	23.2	22.8	3.4	15.7	11.7	4.	.02	.448	.224	.224	1.32	.44	.88	.006	.52
5341	July 5	July 6	d	c	.5	282.8	165.6	117.2	48.8	36.4	3.9	16.8	13.8	3.	.02	.384	.24	.144	1.08	.564	.516	.017	.56

5396	July 12	July 13	d	c	.4	331.6	188.8	142.8	56.8	48.8	4.3	15.4	12.4	3.	.05	.448	.256	.192	1.24	.504	.736	.02	.48
5448	" 19	" 20	d	c	.1	269.6	189.6	80.	23.6	20.	5.6	13.6	11.8	2.	.062	.448	.288	.16	.92	.536	.384	.025	.44
5499	" 26	" 27	d	c	.15	309.2	226.4	82.8	57.6	42.4	10.8	12.6	11.3	1.3	.04	.352	.272	.08	.92	.568	.352	.022	.72
5550	Aug. 2	Aug. 3	d	c	.3	300.8	238.4	62.4	40.	39.6	17.4	12.4	11.9	.5	.128	.304	.208	.096	.824	.664	.16	.04	.72
5592	" 9	" 10	d	c	.03	614.	224.8	389.2	60.8	39.6	13.	16.	9.7	6.3	.036	.48	.208	.272	1.32	.468	.832	.066	.88
5648	" 16	" 17	d	c	.3	302.8	158.8	144.	64.8	38.	5.75	12.2	9.	3.2	.028	.32	.192	.128	1.16	.408	.752	.06	.6
5698	" 23	" 24	d	c	.05	251.2	192.4	58.8	40.4	36.8	6.5	10.2	7.2	3.	.016	.32	.192	.128	.84	.632	.208	.013	.32
5750	" 30	" 31	d	c	.04	256.8	211.2	45.6	30.2	24.	6.3	10.	8.9	1.1	.052	.32	.192	.128	.84	.424	.416	.013	.32
5806	Sept. 6	Sept. 7	d	c	.04	242.4	189.2	53.2	24.8	17.6	6.	9.6	6.	3.6	.056	.304	.208	.096	.92	.536	.384	.008	.2
5857	" 13	" 14	d	c	.06	260.8	184.8	76.	36.4	32.4	5.8	10.9	6.3	4.6	.024	.384	.232	.152	.84	.408	.432	.008	.36
5907	" 20	" 21	d	c	.04	294.4	206.8	87.6	36.8	30.	9.9	11.	7.	4.	.032	.384	.176	.208	.84	.376	.464	.014	.36
5958	" 27	" 28	d	c	.08	227.2	173.6	53.6	34.	2.8	7.3	11.4	10.2	1.2	.04	.352	.256	.096	.9	.532	.368	.01	.28
6003	Oct. 4	Oct. 5	d	c	.07	221.2	158.8	62.4	36.	22.8	6.6	13.3	12.3	1.	.032	.384	.24	.144	.804	.472	.332	.008	.2
6050	" 11	" 12	d	c	.15	231.2	170.8	60.4	12.	9.2	7.	11.6	11.3	.3	.016	.4	.24	.16	.664	.472	.192	.008	.2
6095	" 18	" 19	d	c	.08	230.	207.2	22.8	12.8	12.	11.4	9.7	9.6	.1	.028	.352	.24	.112	.92	.424	.496	.005	.28
6160	" 25	" 26	d	c	.04	234.	179.6	54.4	24.	18.	9.2	9.5	8.1	1.4	.044	.432	.352	.08	.92	.536	.384	.000	.2
6210	Nov. 1	Nov. 2	d	c	.08	276.4	194.4	82.	20.4	10.8	11.2	8.9	8.	.9	.084	.368	.256	.112	.712	.564	.148	.016	.52
6248	" 8	" 9	d	c	.06	279.2	214.8	64.4	24.	17.6	15.3	10.	9.4	.6	.096	.336	.24	.096	.904	.552	.352	.016	.48
6311	" 15	" 16	d	c	.5	244.	184.4	59.6	26.8	25.6	11.7	11.3	9.5	1.8	.064	.56	.288	.272	1.032	.584	.448	.03	.36
6348	" 22	" 23	d	c	.25	272.8	217.2	55.6	23.6	14.8	15.8	11.9	10.8	1.1	.06	.64	.24	.4	1.384	.68	.704	.025	.8
6414	" 29	" 30	d	c	.3	233.6	202.	31.6	19.2	18.4	12.1	10.6	10.2	.4	.398	.352	.208	.144	.968	.584	.384	.02	.72
6451	Dec. 6	Dec. 7	d	c	.04	224.4	207.6	16.8	14.	12.8	11.2	11.8	11.1	.7	.244	.448	.32	.128	.872	.552	.32	.015	.8
6510	" 13	" 14	d	c	.1	224.	206.8	17.2	22.	20.8	11.3	12.	9.9	2.1	.064	.448	.272	.176	1.064	.552	.512	.013	.6
6553	" 20	" 21	d	c	.03	253.6	216.	37.6	32.	24.8	11.7	11.2	9.9	1.3	.1	.48	.224	.256	1.32	.52	.8	.018	.8
Average Jan. 5—June 28............						533.3	215.3	318.	47.7	34.	6.1	17.3	9.	8.2	.294	.623	.241	.382	1.412	.585	.826	.034	.9
Average July 5—Dec. 20............						275.5	155.6	119.9	33.3	24.9	9.1	11.3	9.8	1.5	.068	.4	.241	.158	.968	.525	.443	.019	.48
Average Jan. 5--Dec. 20............						406.8	205.6	201.2	40.6	29.5	7.6	14.4	9.4	4.9	.187	.513	.241	.272	1.194	.552	.641	.026	.69

8555

Chemical Examination of Water from the Mississippi River at Alton.—100 ft. from Illinois shore.

(Parts per 1,000,000.)

Serial Number.	1900.		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
	Collection.	Examination.							Total.	Dissolved						Total.	Dissolved	Suspended					
6620	Jan. 4	Jan. 5	d	c	.04	311.6	292.4	19.2	41.2	40.	19.1	11.8	9.6	2.2	1.16	.448	.24	.208	1.02	.616	.404	.035	.92
6657	" 10	" 11	d	c	.06	283.2	216.2	67.	31.6	27.6	11.7	9.5	8.4	1.1	.844	.48	.176	.304	1.08	.472	.608	.014	.92
6698	" 17	" 18	d	c	.04	258.4	252 8	5.6	41.2	40.4	9.3	9.2	8.2	1.	.344	.464	.192	.272	.88	.544	.336	.014	.92
6745	" 24	" 25	d	m	.03	435.6	201.2	234.4	39.6	27.6	6.9	15.1	10.5	4.6	.628	.464	.224	.24	1.2	.544	.656	.036	1.32
6811	Feb. 2	Feb. 3	d	c	.04	316.	258.4	57.6	35.6	34.	12.3	10.4	8.9	1.5	1.228	.368	.208	.16	.8	.544	.256	.013	1.28
6856	" 7	" 8	d	c	.04	302.	239.6	62.4	37.6	35.2	12.3	11.8	7.5	4.3	.992	.368	.176	.192	.8	.48	.32	.015	1.28
6906	" 14	" 15	v d	v m	.2	1483.2	146.	1337.2	80.	20.	4.4	29.7	7.5	22.2	.368	1.44	.288	1.152	[illegible]	.544	2.456	.014	1.12
6950	" 21	" 2	d	m	.2	1552.4	175 6	1376.8	123.6	16.4	6.2	23.3	7.9	15.4	.608	1.184	.272	.912	[illegible]	.576	1.824	.018	1.32
7000	Mar. 2	Mar. 3	d	c	.04	392.	198.	194.	38.	24.4	6.5	14.1	9.6	4 5	.448	.432	.224	.208	.88	.64	.24	.018	1.36
7053	" 9	" 10	v d	m	.3	1438.8	139.6	1299.2	35.2	14.	3.7	24.9	5.7	19.2	.384	.896	.208	.688	2.72	.512	2.208	.015	.92
7085	" 14	" 15	v d	v m	.04	1284.4	142.4	1142.	42.	12.8	3.8	23.1	5.8	17.3	.368	.96	.16	.8	2.4	.384	2.016	.009	1.4
7131	" 21	" 22	d	m	.06	878.	135.2	742.8	42.8	15.2	3.6	18.4	6.	12.4	.272	.672	.16	.512	1.88	.536	1.344	.009	1.2
7180	" 28	" 29	d	m	.06	616.	140.8	475.2	37.2	12.8	4.5	14.6	6.8	7.8	.288	.448	.176	.272	1.08	.472	.608	.013	1.48
7233	Apr. 4	April 5	d	c	.15	417.2	146.	271.2	25.2	17.2	4.2	12.	6.3	5.7	.24	.384	.176	.208	.76	.376	.384	.015	1.68
7286	" 12	" 13	d	m	.4	534.	109.6	424.4	26.	21.2	5.	11.8	7.	4.8	.224	.576	.256	.32	1.06	.388	.672	.031	1.52
7341	" 18	" 19	d	c	.04	374.	185.6	188.4	32.4	24.4	5.3	12.2	6.2	6.	.16	.352	.192	.16	1.08	.536	.544	.03	2.2
7409	" 25	" 26	d	m	.04	340.4	196.4	144.	35.6	28.	5.7	13.6	7.6	6.	.096	.4	.208	.192	1.24	.44	.8	.034	1.72
7453	May 2	May 3	d	c	.03	494.4	224.	270.4	33.2	25.2	7.3	13.7	7.4	6.3	.048	.544	.288	.256	1.348	.484	.864	.02	1.44
7493	" 9	" 10	d	m	.04	606.	205.6	400.4	36.8	20.8	7.7	15.1	7.7	7.4	.088	.528	.256	.272	1.	.58	.42	.025	.8
7542	" 16	" 17	d	c	.05	452.	247.6	204.4	42.8	22.4	8.9	13.9	7.8	6.1	.124	.512	.24	.272	1.316	.292	1.024	.03	.76
7593	" 23	" 24	d	c	.03	516.4	259.6	256.8	52.8	42.4	9.4	14.1	7.8	6.3	.064	.4	.112	.288	.74	.388	.352	.025	.92
7632	" 30	" 31	d	m	.2	284.8	148.	136.8	39.2	34.4	7.5	11.9	7.7	4.2	.024	.384	.192	.192	.8	.388	.412	.013	.52
7664	June 6	June 7	d	c	.03	388.8	216.4	172.4	34.	32.4	7.6	12.7	8.1	4.6	.012	.352	.192	.16	.84	.56	.28	.01	.92
7714	" 13	" 14	d	c	.03	728.8	222.4	506.4	40.4	38.8	8.5	15.4	7.1	8.3	.024	.48	.24	.24	1.7	.52	1.18	.013	1.08
7751	" 20	" 21	d	c	.04	339.6	239.6	100.	36.8	35.6	8.	9.8	6.4	3.4	.046	.272	.144	.128	.692	.356	.336	.01	.92
7796	" 27	" 28	d	d	.01	480.4	201.6	278.8	56.	33.2	7.4	13.6	5.4	8.2	.042	.368	.16	.208	1.	.356	.644	.048	.88
7837	July 4	July 5	d	l	.08	357.2	230.	127.2	45.6	33.6	10.	9.	7.	2.	.11	.24	.176	.064	.552	.484	.068	.012	1.04

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT ALTON.—100 ft. from Illinois shore.—CONTINUED
(Parts per 1,000,000.)

Serial Number.	1900. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
7906	July 11	July 12	d	l	.02	318.	214.8	103.2	39.2	30.	9.4	8.3	6.7	1.6	.084	.272	.16	.112	.52	.276	.244	.013	1.08
7976	" 18	" 19	d	l	.02	301.6	198.8	102.8	26.4	16.	9.4	8.5	6.8	1.7	.032	.224	.208	.016	.6	.42	.18	.011	.76
8072	Aug. 1	Aug. 2	d	c	.02	508.4	180.8	327.6	39.2	38.4	8.4	13.8	6.6	7.2	.056	.208	.176	.032	1.	.436	.564	.008	1.08
8120	" 7	" 8	d	c	.02	272.8	189.2	83.6	45.6	40.	10.	11.	7.8	3.2	.11	.448	.208	.24	.92	.436	.484	.01	.52
8190	" 15	" 16	d	l	.02	276.	190.8	85.2	36.	32.	10.6	9.5	6.4	3.1	.096	.32	.288	.032	.76	.54	.22	.008	.52
8266	" 22	" 24	d	c	.05	645.6	155.6	490.	52.	18.8	8.	14.	5.3	8.7	.112	.72	.24	.48	1.08	.588	.492	.008	.96
8323	" 29	" 30	d	c	.02	373.6	178.	195.6	36.	12.4	9.6	11.2	5.5	5.7	.084	.352	.112	.24	.52	.252	.268	.008	.88
8380	Sept. 5	Sept. 6	v d	m	.04	376.	208.4	167.6	38.	18.	10.2	10.4	5.8	4.6	.078	.304	.24	.064	.6	.432	.168	.008	.92
8450	" 12	" 13	d	m	.25	323.6	193.2	130.4	39.6	22.8	9.4	13.5	8.3	5.2	.07	.272	.192	.08	.728	.512	.216	.011	.72
8504	" 19	" 20	d	c	.15	304.8	188.4	116.4	36.4	27.6	8.	12.7	8.2	4.5	.164	.368	.272	.096	1.3	.576	.724	.015	.56
8557	" 26	" 27	d	c	.4	320.	176.8	143.2	43.2	28.4	6.	16.5	11.7	4.8	.136	.48	.32	.16	.92	.64	.28	.015	.56
8611	Oct. 3	Oct. 4	d	c	.1	405.2	160.8	244.4	39.2	28.8	5.4	25.3	16.5	8.8	.196	.448	....	....	1.216	....	....	.008	.6
8669	" 16	" 17	d	c	.2	340.	187.6	152.4	40.4	33.2	6.5	16.8	14.4	2.4	.272	.4	.24	.16	1.12	.768	.352	.034	1.126
8682	" 22	" 23	d	c	.6	372.4	155.2	217.2	38.4	35.2	6.7	21.2	15.8	5.7	.2	.464	.288	.176	1.232	.72	.512	.023	.777
8715	" 29	" 30	d	c	.7	350.8	170.	180.8	49.2	46.4	6.5	23.8	15.3	8.5	.144	.416	.192	.224	1.04	.448	.592	.018	.702
8739	Nov. 5	Nov. 6	d	c	.4	250.	163.2	86.8	30.8	20.4	7.	16.1	13.5	2.6	.202	.384	.304	.08	.72	.576	.144	.017	.783
8767	" 12	" 13	d	c	.5	273.2	171.6	101.6	32.4	29.2	7.7	15.1	10.5	4.6	.2	.32	.304	.016	.896	.592	.304	.019	.821
8789	" 19	" 20	d	l	.7	217.6	159.2	58.4	23.2	22.	7.3	16.4	14.1	2.3	.188	.4	.304	.096	1.04	.656	.384	.013	.787
8820	" 26	" 27	d	l	.4	239.2	184.	55.2	20.8	19.6	9.3	14.9	12.7	2.2	.268	.352	.192	.16	.848	.672	.176	.014	.786
8851	Dec. 3	Dec. 4	d	l	.25	234.4	202.8	31.6	21.2	19.6	8.6	10.5	9.9	.6	.336	.324	.288	.036	.88	.544	.276	.018	1.262
8877	" 10	" 11	d	l	.2	285.6	241.6	44.	28.4	26.4	6.7	9.6	8.8	.8	.216	.224	.144	.08	.592	.384	.208	.021	1.419
8896	" 17	" 18	d	l	.3	263.6	230.4	33.2	26.8	25.2	6.8	10.1	9.	1.1	.174	.272	.16	.112	.912	.684	.228	.013	1.347
8917	" 24	" 25	d	l	.2	268.8	236.8	32.	21.2	....	7.8	10.5	9.1	1.4	.24	.32	.224	.096	.688	.512	.176	.011	1.269
Average Jan. 4—June 27						596.4	197.7	398.7	43.1	26.7	7.3	14.8	7.4	7.3	.346	.545	.206	.339	1.296	.478	.817	.02	1.184
Average July 4—Dec. 24						328.2	190.3	137.9	36.3	26.	8.1	13.6	9.8	3.8	.165	.355	.218	.137	.861	.506	.355	.014	.886
Average Jan. 4—Dec. 24						467.7	194.1	273.	39.4	26.4	7.7	14.2	8.6	5.6	.259	.454	.211	.242	1.068	.493	.594	.017	1.041

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT ALTON.—¼ distance from Illinois shore.

(Parts per 1,000,000.)

Serial Number	1899 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
4582	Jan. 5	Jan. 6	d	c	.04	287.6	238.	49.6	30.8	28.	9.2	11.8	7.8	4.	.528	.44	.192	.248	.93	.45	.48	.01	.25
4600	" 12	" 13	d	c	.04	326.	250.8	75.2	44.	40.	9.9	12.2	8.8	3.4	.56	.48	.256	.224	.97	.69	.28	.017	.35
4630	" 19	" 20	d	c	.15	340.8	238.8	102.	55.6	42.	9.	13.3	7.2	6.1	.68	.52	.24	.28	1.05	.53	.52	.035	.36
4651	" 27	" 28	d	c	.04	388.	239.2	148.8	38.	28.	8.8	12.6	7.7	4.9	.432	.4	.176	.224	.97	.49	.48	.04	.2
4669	Feb. 2	Feb. 3	d	c	.04	296.	250.	46.	46.	40.	7.6	10.4	7.2	3.2	.48	.36	.224	.136	.69	.49	.2	.05	.55
4689	" 10	" 11	d	c	.08	314.	292.8	21.2	42.	36.	9.8	8.1	7.	1.1	.64	.36	.224	.136	.74	.5	.24	.016	1.2
4718	" 17	" 18	d	l	.06	310.8	291.2	19.6	42.	39.2	9.2	9.5	6.7	2.8	.44	.44	.256	.184	.86	.5	.36	.016	1.2
4744	" 24	" 27	d	c	.05	258.	162.	96.	40.	36.	5.	11.5	6.	5.5	.36	.56	.224	.336	1.14	.5	.64	.008	.6
4762	Mar. 2	Mar. 3	v d	v m	...	1034.	98.	936.	70.	24.	2.	33.	12.3	20.7	.216	1.12	.304	.816	2.66	.66	2.	.045	.55
4795	" 10	" 13	d	m	.2	552.	150.	402.	52.	40.	4.6	23.	11.7	11.3	.4	.8	.32	.48	1.86	.66	1.2	.037	.55
4822	" 16	" 17	v d	v m	.3	1204.	122.	1082.	100.	26.	3.9	34.5	12.5	22.	.44	1.64	.304	1.336	3.14	.86	2.28	.02	.9
4849	" 24	" 25	v d	v m	.4	784.	130.	654.	82.	32.	3.	33.9	15.2	18.7	.4	.96	.32	.64	2.83	.6	2.23	.033	.8
4873	" 30	" 31	d	m	.2	412.	154.8	257.2	48.	34.	4.4	17.8	10.5	7.3	.44	.6	.272	.328	1.31	.59	.72	.08	1.
4902	Apr. 7	April 8	d	c	.4	272.	162.	110.	40.	30.	4.2	13.3	8.7	4.6	.384	.48	.24	.24	.95	.59	.36	.018	.6
4928	" 14	" 17	d	m	.05	452.	192.	260.	46.	36.	4.4	15.6	12.5	3.1	.24	.48	.288	.192	1.07	.51	.56	.062	1.15
4948	" 20	" 21	d	c	.1	408.4	150.4	258.	42.	28.	3.	15.7	7.7	8.	.28	.48	.224	.256	1.23	.51	.72	.035	.65
4967	" 27	" 28	d	m	.12	252.	142.	110.	34.	26.	2.6	11.7	7.3	4.4	.056	.44	.208	.232	.73	.33	.4	.038	.55
4990	May 3	May 4	d	m	.04	638.8	154.	484.8	48.	28.8	3.4	18.2	8.5	9.7	.008	.76	.208	.552	1.53	.49	1.04	.032	.5
5017	" 10	" 11	d	c	.1	404.4	134.4	270.	40.4	20.	1.48	18.3	10.4	7.9	.068	.544	.256	.288	1.29	.54	.75	.02	.36
5056	" 18	" 19	d	m	.3	569.6	243.6	326.	36.8	27.6	4.	21.9	13.	8.9	.076	.608	.224	.384	1.69	.646	1.044	.023	.6
5085	" 24	" 25	d	m	.04	847.6	164.	683.6	52.	33.2	2.5	25.9	13.2	12.7	.092	.96	.24	.72	2.17	.6	1.57	.017	.84
5129	" 31	June 1	d	m	.3	948.	224.8	723.2	70.8	62.	3.	21.7	11.5	10.2	.088	.832	.32	.512	2.25	.826	1.424	.002	.72
5181	June 8	" 9	d	m	.6	624.	181.6	442.4	45.6	35.6	1.8	24.5	11.6	12.9	.016	.727	.208	.519	2.01	.57	1.44	.007	.72
5216	" 15	" 16	d	m	.5	470.	196.8	273.2	32.	19.6	3.4	19.2	7.7	11.5	.032	.576	.208	.368	1.72	.728	.992	.002	1.
5264	" 22	" 23	d	c	.5	348.8	168.	180.8	24.	11.2	2.	19.2	13.4	5.8	.02	.524	.21	.284	1.24	.504	.736	.004	.48
5305	" 28	" 29	d	c	.7	338.	154.4	183.6	12.8	12.	1.6	17.4	12.5	4.9	.012	.448	.256	.192	1.16	.472	.688	.003	.44
5342	July 5	July 6	d	c	.6	262.8	144.8	118.	46.4	38.4	1.8	18.2	16.5	1.7	.016	.352	.272	.08	1.08	.664	.416	.005	.4

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT ALTON.—¼ distance from Illinois shore.—CONTINUED.

(Parts per 1,000,000.)

Serial Number.	1899. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.							Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
5397	July 12	July 13	d	c	.4	443.6	158.	285.6	75.2	50.	2.	21.1	14.6	6.5	.02	.512	.272	.24	1.32	.44	.88	.002	.44
5449	" 19	" 20	d	c	.2	226.8	159.6	67.2	28.	24.	2.6	15.	12.4	2.6	.06	.416	.256	.16	.84	.472	.368	.015	.28
5500	" 26	" 27	d	c	.15	278.8	192.4	86.4	48.8	43.2	5.5	13.9	11.5	2.4	.036	.384	.192	.192	.84	.6	.24	.01	.48
5549	Aug. 2	Aug. 3	d	c	.3	232.	183.6	48.4	30.	29.6	6.6	13.	12.2	.8	.036	.272	.192	.08	.76	.472	.288	.068	.2
5593	" 9	" 10	d	c	.04	422.4	196.8	225.6	56.8	44.4	8.4	14.	10.2	3.8	.052	.352	.208	.144	1.16	.488	.672	.044	.44
5647	" 16	" 17	d	c	.25	297.6	146.4	151.2	53.2	38.8	3.4	13.1	10.8	2.3	.036	.384	.224	.16	1.24	.456	.784	.023	.62
5699	" 23	" 24	d	c	.06	252.	197.2	54.8	38.8	37.6	5.7	10.3	7.5	2.8	.016	.368	.176	.192	1.	.472	.528	.01	.3
5751	" 30	" 31	d	c	.13	250.	190.4	59.6	31.2	30.8	5.7	10.6	9.3	1.3	.04	.32	.16	.16	.92	.456	.464	.011	.28
5807	Sept. 6	Sept 7	d	c	.02	240.8	184.4	56.4	20.4	15.2	5.5	9.9	6.2	3.7	.048	.288	.224	.064	1.08	.552	.528	.005	.4
5856	" 13	" 14	d	c	.05	260.	172.4	87.6	26.	15.2	5.5	11.	6.7	4.3	.028	.352	.216	.136	.84	.392	.448	.008	.2
5906	" 20	" 21	d	c	.04	283.2	189.2	94.	29.2	20.	7.7	11.7	7.	4.7	.036	.432	.16	.272	1.16	.504	.656	.012	.25
5957	" 27	" 28	d	c	.07	233.	160.4	72.6	27.6	27.2	5.6	12.3	11.2	1.1	.016	.4	.292	.108	.82	.5	.32	.007	.2
6004	Oct. 4	Oct. 5	d	c	.06	212.4	158.	54.4	28.	25.6	5.2	13.5	12.3	1.2	.04	.448	.24	.208	.964	.472	.492	.008	.16
6049	" 18	" 19	d	c	.08	229.2	174.4	54.8	16.8	12.4	6.8	13.1	11.5	1.6	.02	.4	.224	.176	.74	.472	.268	.007	.36
6094	" 18	" 19	d	c	.06	250.8	185.2	65.6	15.6	12.4	10.	9.7	8.9	.8	.024	.384	.24	.144	1.	.424	.576	.005	.2
6161	" 25	" 26	d	c	.04	243.6	174.	69.6	25.2	20.	8.2	9.7	8.	1.7	.044	.416	.24	.176	.744	.312	.432	.008	.2
6209	Nov. 1	Nov. 2	d	c	.08	268.8	187.6	81.2	34.	9.6	9.5	9.	7.7	1.3	.068	.368	.24	.128	.616	.44	.176	.013	.48
6249	" 8	" 9	d	c	.06	254.	197.6	56.4	31.2	24.	8.6	9.6	8.8	.8	.076	.352	.288	.064	.936	.456	.48	.013	.36
6310	" 15	" 16	d	c	.4	230.	164.8	65.2	26.	25.4	7.8	12.1	10.3	1.8	.104	.48	.272	.208	.84	.584	.256	.022	.36
6349	" 22	" 23	d	c	.3	234.4	178.4	56.	18.8	14.8	10.6	12.1	11.5	.6	.048	.544	.208	.336	.968	.616	.352	.02	.52
6415	" 29	" 30	d	c	.3	223.2	189.6	33.6	27.2	16.8	10.6	10.1	10.	.1	.28	.352	.208	.144	.904	.584	.32	.022	.48
6450	Dec. 6	Dec. 7	d	c	.08	215.6	192.4	23.2	28.	26.	8.7	11.8	11.4	.4	.18	.432	.272	.16	1.064	.616	.448	.014	.44
6512	" 13	" 14	d	c	.15	220.4	172.4	48.	21.6	19.2	9.8	12.9	11.6	1.3	.072	.48	.192	.288	1.032	.552	.48	.008	.56
6554	" 20	" 21	d	c	.08	224.8	190.4	34.4	25.2	20.4	11.3	11.7	10.7	1.	.064	.48	.208	.272	1.08	.488	.592	.015	.16
Average Jan. 5—June 28						434.6	176.3	258.2	46.1	31.2	4.7	18.7	9.9	8.8	.282	.636	.247	.388	1.467	.56	.908	.027	.64
Average July 5—Dec. 20						259.5	178.	81.5	32.2	25.6	6.5	12.3	10.2	2.1	.057	.398	.227	.171	.957	.496	.461	.012	.34
Average Jan. 5—Dec. 20						358.4	177.1	181.2	39.3	28.5	5.8	15.8	10.1	5.2	.171	.519	.237	.282	1.218	.53	.687	.02	.5

8557

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT ALTON.—¼ distance from Illinois shore.

(Parts per 1,000,000.)

Serial Number.	1900. Date of Collection.	1900. Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Dissolved	Albuminoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved	Organic Nitrogen. Suspended	Nitrogen as Nitrites.	Nitrogen as Nitrates.
[illegible]	Jan. 4	Jan. 5	d	c	.04	293.6	284.	9.6	35.6	35.2	18.	11.7	9.9	1.8	1.04	.4	.24	.16	.84	.488	.352	.01	.72
[illegible]	" 10	" 11	d	c	.05	274.4	254.8	19.6	28.4	26.4	10.9	12.4	8.8	3.6	.712	.44	.224	.256	1.08	.472	.608	.014	.72
[illegible]	" 17	" 18	d	c	.15	242.	[illegible]	13.2	30.0	30.4	8.2	9.5	8.3	1.2	.24	.48	.208	.272	.92	.512	.408	.012	.76
6740	" 24	" 25	d	m	.08	436.4	156.8	280.0	47.2	23.2	6.	14.6	8.6	6.	.16	.448	.16	[illegible]	1.04	.552	.088	.016	.24
[illegible]	Feb. 2	Feb. 3	d	c	.1	316.	244.	72.	46.4	28.4	11.1	12.5	8.8	3.7	1.02	.416	.224	.192	.96	.48	.48	.016	.24
[illegible]	" 7	" 8	d	c	.05	314.8	244.4	70.4	28.	26.	12.2	11.5	7.9	3.6	.88	.416	.16	.256	[illegible]	.576	.304	.014	.2
[illegible]	" 14	" 15	v d	v m	.07	1256.	151.6	1103.4	77.2	22.	4.6	24.3	7.7	16.6	[illegible]	1.44	.272	1.168	[illegible]	.48	2.4	.015	[illegible]
[illegible]	" 21	" 22	d	m	.15	[illegible]	164.	1089.2	117.6	14.8	5.8	21.7	8.4	13.3	.56	1.056	.272	.784	[illegible]	.544	1.776	.018	[illegible]
[illegible]	Mar. 2	Mar. 3	d	c	.05	[illegible]	191.2	173.6	[illegible]	20.	6.3	14.1	9.2	4.9	.408	.48	.200	[illegible]	[illegible]	.448	.432	.018	[illegible]
[illegible]	" 9	" 10	v d	m	.04	1187.2	[illegible]	1034.	[illegible]	21.6	4.4	18.4	6.	12.8	[illegible]	[illegible]	.176	[illegible]	[illegible]	[illegible]	[illegible]	.012	[illegible]
[illegible]	" 14	" 15	v d	v m	.08	1304.	[illegible]	[illegible]	63.6	8.	2.9	25.8	6.8	19.	[illegible]	[illegible]	.224	.344	[illegible]	.448	2.112	.008	[illegible]
[illegible]	" 21	" 22	d	m	.2	744.4	110.6	[illegible]	35.4	10.	3.5	15.8	7.3	[illegible]	[illegible]	[illegible]	.192	.704	[illegible]	[illegible]	1.676	.008	[illegible]
[illegible]	" 28	" 29	d	m	.1	470.8	[illegible]	[illegible]	[illegible]	16.8	4.	14.8	7.	[illegible]	[illegible]	.544	.176	[illegible]	1.112	.472	.64	.011	[illegible]
[illegible]	Apr. 4	Apr. 5	d	c	.2	[illegible]	142.4	[illegible]	[illegible]	10.0	[illegible]	12.8	6.5	6.	[illegible]	[illegible]	[illegible]	.144	[illegible]	[illegible]	.16	.015	[illegible]
[illegible]	" 12	" 13	d	c	.1	442.4	[illegible]	[illegible]	32.8	10.	3.8	16.7	7.3	[illegible]	[illegible]	.576	.224	[illegible]	[illegible]	[illegible]	.616	[illegible]	[illegible]
[illegible]	" 18	" 19	d	c	.04	301.6	164.8	[illegible]	[illegible]	19.6	4.3	18.8	6.8	[illegible]	.176	[illegible]	.176	.144	1.016	.504	.512	[illegible]	[illegible]
[illegible]	" 25	" 26	v d	v m	.2	666.	[illegible]	[illegible]	[illegible]	20.4	10.3	22.9	8.0	14.9	[illegible]	.768	.16	[illegible]	1.6	.44	1.2	.08	.64
[illegible]	May 9	May [illegible]	d	c	.04	294.	[illegible]	130.4	[illegible]	22.4	4.1	14.8	7.9	6.9	[illegible]	.48	[illegible]	[illegible]	[illegible]	[illegible]	.424	.01	.56
[illegible]	" 9	" 10	d	m	.2	441.6	156.4	[illegible]	56.0	20.4	5.4	16.4	10.7	5.7	.08	.536	.272	.256	1.088	.368	.704	.08	.44

7546	May	16	May	17	d	c	.1	379.8	189.	108.8	64.	21.0	8.5	15.9	8.8	7.8	.05	.416	.224	.192	1.48	.048	.012	.025	.4
7594	"	23	"	24	d	c	.05	506.4	192.	814.4	46.	30.4	5.8	16.4	8.1	10.8	.004	.48	.112	.088	1.00	.25	.8	.02	.32
7633	"	30	"	31	d	m	.05	368.2	201.2	162.	100.2	32.8	6.8	13.	7.8	0.3	.016	.352	.198	.16	1.028	.452	.076	.015	1.32
7668	June	6	June	7	d	c	.08	378.	185.2	192.8	34.8	33.6	6.2	13.1	8.1	5.	.024	.368	.16	.208	.8	.52	.28	.009	.78
7715	"	13	"	14	d	c	.02	589.2	218.8	370.4	52.	40.	7.8	18.3	7.4	5.9	.02	.432	.224	.208	1.94	.484	1.456	01	1.
7752	"	20	"	21	d	c	.01	329.2	232.4	96.8	38.4	34.8	6.8	10.6	6.4	4.2	.04	.272	.192	.08	.628	.244	.384	.007	.8
7794	"	27	"	28	d	d	.01	514.	210.4	303.6	69.6	42.	6.8	14.2	5.6	8.6	.042	.368	.192	.176	1.32	.372	.948	.025	.72
7828	July	4	July	5	d	l	.01	344.8	219.6	125.2	37.6	26.	8.5	10.6	7.7	2.9	.092	.304	.16	.144	.532	.42	.132	.012	1.
7905	"	11	"	12	d	l	.02	310.4	213.6	96.8	29.2	16.4	8.3	8.7	7.7	1.	.106	.272	.176	.096	.712	.356	.356	.013	.88
7979	"	18	"	19	d	l	.02	301.2	193.2	106.	26.8	20.	8.6	8.6	7.2	1.4	.062	.272	.192	.08	.84	.308	.532	.012	.68
8071	Aug.	1	Aug.	2	d	c	.08	474.4	152.4	322.	51.2	24.8	6.5	15.8	6.3	9.5	.072	.448	.176	.272	1.08	.336	.724	.004	.68
8121	"	8	"	9	d	c	.02	280.8	188.8	92.	64.2	52.	8.2	12.3	8.4	3.9	.118	.352	.192	.16	.84	.42	.42	.009	.48
8189	"	15	"	16	d	l	.02	276.8	186.8	90.	37.2	35.6	10.1	9.5	6.6	2.9	.108	.416	.176	.24	.68	.348	.332	.009	.46
8267	"	22	"	24	d	c	.1	701.6	138.4	563.2	63.6	20.8	5.4	15.4	5.7	12.7	.086	.72	.16	.56	1.336	.22	1.116	.008	.96
8324	"	29	"	30	d	c	.03	350.4	152.8	197.6	35.6	16.8	6.4	12.8	6.2	6.6	.117	.352	.16	.192	.58	.....	.....	.004	.68
8379	Sept.	5	Sept.	6	v d	m	.05	333.6	182.8	150.8	34.	12.8	7.8	13.8	6.7	7.1	.024	.304	.192	.112	.6	.446	.152	.006	.76
Average Jan. 4—June 27								537.2	183.8	353.4	43.2	25.1	6.9	15.5	7.8	7.6	.316	.552	.203	.248	1.336	.456	.879	.018	.95
Average July 4—Sept. 5								374.8	181.1	193.7	42.	25.	7.7	12.2	6.9	5.3	.094	.382	.170	.206	.795	.359	.436	.008	.73
Average Jan. 4—Sept. 5								495.4	182.8	312.5	42.9	25.1	7.1	14.7	7.0	7.1	.259	.508	.196	.311	1.107	.434	.763	.014	.89

Chemical Examination of Water from the Mississippi River at Alton.—Midstream.

(Parts per 1,000,000.)

Serial Number.	1890 Date of Collection.	1890 Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Dissolved	Albuminoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved	Organic Nitrogen. Suspended	Nitrogen as Nitrites.	Nitrogen as Nitrates.
4578	Jan. 5	Jan. 6	d	c	.04	272.	231.6	40.4	35.2	34.8	8.	12.4	8.1	4.3	.224	.4	.176	.224	.93	.49	.44	.008	.1
4603	" 12	" 13	d	c	.5	309.2	242.8	66.4	40.	30.	8.	11.5	7.9	3.6	.52	.48	.24	.24	.97	.65	.32	.018	.3
4633	" 19	" 20	d	c	.15	366.8	236.8	130.	54.	44.	8.3	13.4	7.3	6.1	.56	.48	.224	.256	1.09	.49	.6	.019	.55
4652	" 27	" 28	d	c	.03	346.	236.8	109.2	32.	28.	7.6	12.5	7.5	5.	.28	.4	.176	.224	1.17	.49	.68	.02	.15
4672	Feb. 2	Feb. 3	d	c	.04	298.	237.2	60.8	45.3	38.	7.7	10.2	7.	3.2	.4	.4	.176	.224	.73	.45	.28	.012	.55
4690	" 10	" 11	d	c	.1	382.	308.	74.	52.	46.	9.8	13.	8.	5.	.48	.6	.352	.248	1.26	.62	.64	.017	1.15
4717	" 17	" 18	d	c	.08	452.	298.	154.	70.	50.8	9.	26.	7.5	18.5	.04	1.52	.272	1.248	3.22	.54	2.68	.015	1.
4745	" 24	" 27	d	c	.08	299.2	266.	33.2	46.	40.	9.1	9.6	6.	3.6	.4	.44	.192	.248	.82	.46	.36	.016	.65
4763	Mar. 2	Mar. 3	v d	v m	...	837.2	118.	719.2	64.	28.	2.5	38.	10.5	27.5	.192	.96	.24	.72	1.86	.5	1.36	.04	.5
4794	" 10	" 13	d	m	.6	350.	154.8	195.2	44.	36.	3.9	21.	12.5	8.5	.336	.64	.352	.288	1.14	.66	.48	.015	.65
4821	" 16	" 17	v d	v m	.2	1318.	130.	1188.	100.	36.	8.1	36.3	12.2	24.1	.44	1.76	.32	1.44	3.4	.74	2.66	.02	.65
4848	" 24	" 25	v d	v m	.5	824.8	128.8	696.	80.	36.	2.5	35.5	15.8	19.7	.4	.88	.32	.56	2.91	.79	2.12	.037	.75
4872	" 30	" 31	d	m	.6	338.8	114.4	224.4	44.	29.2	3.5	23.	13.	10.	.48	.68	.336	.344	1.39	.63	.76	.025	.65
4901	April 7	April 8	d	m	.4	344.	144.	200.	36.	32.	3.7	14.5	8.2	6.3	.288	.52	.288	.232	.83	.55	.28	.08	.55
4929	" 14	" 17	d	m	.3	531.2	165.2	366.	48.	34.	3.6	17.6	11.5	6.1	.304	.6	.24	.36	1.23	.55	.68	.062	.55
4949	" 20	" 21	d	c	.3	470.	128.	342.	32.	21.2	1.9	16.7	8.1	8.6	.24	.56	.208	.352	1.23	.51	.72	.05	.45
4968	" 27	" 28	d	c	.13	244.	122.4	121.6	32.	20.	2.	12.	7.2	4.8	.056	.44	.208	.232	.73	.37	.36	.084	.35
4998	May 3	May 4	d	m	.3	719.2	136.4	582.8	66.	22.4	1.4	18.4	8.7	9.7	.008	.92	.224	.696	1.85	.45	1.4	.034	.45
5016	" 10	" 11	d	c	.3	474.	157.2	316.8	46.	28.4	1.4	16.8	8.8	8.	.04	.64	.256	.384	1.45	.54	.91	.016	.52
5055	" 18	" 19	d	m	.4	787.2	153.2	634.	46.4	20.8	2.3	24.8	14.4	10.4	.08	.96	.32	.64	1.85	.6	1.25	.023	.48
5084	" 24	" 25	d	m	.08	1172.4	146.8	1025.6	72.8	30.	.74	26.2	12.5	13.7	.068	1.04	.256	.784	2.65	.54	2.11	.017	.92
5128	" 31	June 1	d	m	...	1247.6	165.2	1082.4	78.8	26.	.4	26.	12.6	13.4	.044	1.072	.256	.816	2.41	.474	1.936	.019	.56
5182	June 8	" 9	d	m	.6	769.6	167.2	602.4	54.8	34.1	.3	24.2	12.8	11.4	.016	.8	.208	.592	2.65	.57	2.08	.007	.72
5215	" 15	" 16	d	m	.25	481.6	162.4	319.2	33.2	27.2	1.2	19.7	10.7	9.	.028	.64	.224	.416	1.88	.536	1.344	.009	.52
5265	" 22	" 23	d	c	.4	470.8	158.8	312.	21.6	20.	1.5	21.8	13.6	8.2	.032	.576	.192	.384	1.48	.632	.848	.005	.48
5306	" 28	" 29	d	c	.7	415.2	149.2	266.	18.4	12.8	.9	19.6	12.6	6.	.032	.48	.208	.272	1.24	.16	1.08	.004	.4
5343	July 5	July 6	d	c	.7	302.8	140.	162.8	52.8	33.2	1.3	17.	10.8	6.2	.028	.416	.224	.192	1.08	.568	.512	.006	.36

5398	July 12	July 13	d	c	.7	554.4	164.8	269.6	74.	46.8	2.1	22.8	14.2	8.8	.072	.576	.224	.332	1.64	.568	1.072	.005	.56
5450	" 19	" 20	d	c	.2	295.6	161.2	194.4	44.8	39.6	2.6	15.	12.4	3.6	.034	.448	.224	.224	.96	.408	.512	.007	.32
5501	" 26	" 27	d	c	.2	298.4	167.2	131.2	53.2	44.8	2.4	15.1	12.2	2.9	.028	.416	.256	.16	1.08	.488	.592	.024	.4
5548	Aug. 2	Aug. 3	d	c	.3	228.	176.2	51.8	54.8	30.4	1.2	13.6	12.	1.6	.024	.288	.176	.112	.728	.568	.16	.008	.12
5594	" 9	" 10	d	c	.03	288.4	167.6	120.8	46.	36.8	3.6	13.1	10.9	2.2	.044	.352	.176	.176	1.08	.408	.672	.01	.44
5646	" 16	" 17	d	c	.3	309.6	140.8	168.8	46.4	40.4	2.8	13.8	10.6	2.7	.024	.384	.176	.208	1.16	.456	.704	.017	.28
5700	" 23	" 24	d	c	...	241.6	160.4	81.2	28.4	24.8	3.7	10.7	8.	2.7	.012	.352	.172	.16	1.	.44	.56	.005	.16
5752	" 30	" 31	d	c	.02	256.4	183.6	72.8	35.6	33.2	4.4	10.8	9.3	1.5	.056	.288	.16	.128	.92	.44	.48	.006	.2
5808	Sept 6	Sept. 7	d	c	.02	241.2	175.2	66.	20.8	20.4	4.3	9.9	6.	3.9	.04	.278	.144	.144	.76	.392	.368	.003	.2
5855	" 13	" 14	d	c	.04	262.	161.2	100.8	36.8	21.2	3.6	11.3	6.3	5.	.018	.416	.184	.232	.92	.376	.544	.006	.2
5905	" 20	" 21	d	c	.04	272.4	174.8	97.6	28.4	20.	5.7	12.	7.	5.	.016	.32	.144	.176	.99	.472	.448	.009	.28
5956	" 27	" 28	d	c	.08	233.2	149.2	84.	27.2	26.	8.8	18.	11.5	1.5	.034	.432	.244	.188	.9	.532	.368	.004	.16
6005	Oct. 4	Oct. 5	d	c	.08	212.	151.6	60.4	36.4	15.2	4.4	18.7	12.7	1.	.048	.384	.224	.16	1.08	.42	.64	.007	.12
6048	" 11	" 12	d	c	.15	220.8	174.6	46.2	22.8	22.	5.1	12.4	12.1	.3	.02	.432	.176	.336	.74	.404	.336	.007	.16
6093	" 18	" 19	d	c	.1	240.8	174.	66.8	19.2	12.	8.8	11.1	9.2	1.9	.04	.352	.208	.144	.84	.448	.392	.007	.2
6162	" 25	" 26	d	c	.05	228.	166.4	61.6	25.6	13.6	6.3	9.5	8.2	1.3	.024	.4	.224	.176	.84	.38	.48	.008	.2
6208	Nov. 1	Nov. 2	d	c	.1	225.6	184.	41.6	26.	7.2	7.7	9.1	7.8	1.8	.06	.384	.144	.24	.872	.408	.464	.01	.44
6250	" 8	" 9	d	c	.1	256.8	201.6	55.2	29.2	26.8	4.2	12.5	9.9	2.6	.028	.384	.304	.08	.84	.424	.416	.008	.2
6309	" 15	" 16	d	c	.4	222.	147.6	74.4	30.4	28.4	3.2	12.2	11.	1.2	.092	.416	.32	.096	.808	.584	.224	.007	.28
6350	" 22	" 23	d	c	.3	204.8	150.4	54.4	32.4	24.4	5.3	11.8	11.	.8	.044	.448	.224	.224	.808	.488	.32	.007	.28
6416	" 29	" 30	d	c	.25	195.2	176.	19.2	33.6	28.8	7.3	10.5	10.4	.1	.116	.32	.24	.08	.808	.552	.256	.012	.28
6452	Dec. 6	Dec. 7	d	c	.03	205.6	176.	29.6	18.8	18.	6.8	12.5	11.6	.9	.08	.432	.32	.112	.968	.68	.288	.012	.32
6513	" 13	" 14	d	c	.15	193.6	190.	3.6	36.8	37.2	6.6	11.8	9.6	2.	.04	.464	.208	.256	.904	.584	.32	.008	.24
6555	" 20	" 21	d	c	.04	228.8	181.6	47.2	37.2	35.6	7.7	14.6	11.4	3.2	.062	.416	.172	.244	1.	.488	.512	.049	.44
Average Jan. 5—June 28					...	560.9	175.3	385.6	40.7	31.2	3.9	20.	10.1	9.8	.283	.728	.248	.477	1.629	.538	1.091	.023	.561
Average July 5—Dec. 20					...	252.7	167.8	84.8	35.9	28.1	4.6	12.8	10.2	2.5	.048	.392	.21	.181	.939	.478	.461	.007	.28
Average Jan. 5—Dec. 20					...	400.8	173.6	236.2	42.9	29.7	4.3	16.4	10.2	6.2	.141	.562	.23	.332	1.291	.508	.782	.015	.423

8559

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT ALTON.—Midstream.

(Parts per 1,000,000.)

Serial Number.	1900.		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
	Collection.	Examination.							Total.	Dissolved						Total.	Dissolved	Suspended					
6622	Jan. 4	Jan. 5	d	c	.04	282.8	272.8	10.	35.2	33.2	15.5	11.2	9.1	2.1	.72	.352	.272	.08	.76	.616	.144	.02	.6
6639	" 10	" 11	d	c	.06	265.6	235.6	30.	24.8	23.2	8.7	10.5	8.8	1.7	.52	.464	.208	.256	1.016	.28	.736	.012	.52
6700	" 17	" 18	d	c	.05	229.6	206.8	22.8	32.4	22.	6.7	10.2	8.9	1.3	.12	.4	.24	.16	.88	.64	.24	.006	.56
6747	" 24	" 25	d	m	.2	344.	187.6	156.4	45.2	28.	5.3	14.6	9.	5.6	.24	.448	.24	.208	1.04	.64	.4	.013	.8
6813	Feb. 2	Feb. 3	d	c	.1	305.2	230.	75.2	47.6	40.	10.6	12.6	9.4	3.2	.884	.368	.224	.144	.768	.576	.192	.014	.96
6858	" 7	" 8	d	c	.04	290.8	232.4	58.4	26.4	25.6	10.9	9.2	8.	1.2	.72	.384	.24	.144	.8	.576	.224	.013	.76
6904	" 14	" 15	v d	v m	.15	1315.2	152.	1163.2	43.6	20.8	4.1	23.7	19.5	4.2	.336	1.344	.24	1.104	3.04	.448	2.592	.013	1.08
7002	Mar. 2	Mar. 3	d	c	.05	371.6	172.	199.6	22.	21.2	5.4	14.1	9.4	4.7	.384	.432	.208	.224	.72	.48	.24	.011	.4
7055	" 9	" 10	v d	m	.1	892.	133.6	758.4	36.8	11.2	3.6	17.4	6.6	10.8	.288	.672	.208	.464	2.24	.48	1.76	.011	.8
7087	" 14	" 15	v d	v m	.2	1537.6	96.8	1440.8	35.6	12.4	1.	26.8	9.1	17.7	.368	1.216	.208	1.008	3.04	.544	2.496	.007	.6
7133	" 21	" 22	d	m	.3	490.8	105.2	385.6	45.6	13.6	2.4	21.5	8.8	12.7	.416	.96	.288	.672	2.2	.92	1.28	.008	.56
7178	" 28	" 29	d	m	.3	364.4	110.4	254.	27.2	21.2	3.	16.3	8.5	7.8	.4	.576	.192	.384	1.4	.568	.832	.01	.56
7235	Apr. 4	April 5	d	c	.25	314.4	134.4	180.	28.8	12.	3.	14.6	7.8	6.8	.256	.384	.224	.16	.856	.536	.32	.012	.88
7298	" 12	" 13	d	m	.25	571.2	167.2	404.	39.2	24.	1.	19.6	9.	10.6	.224	.864	.304	.56	2.12	.728	1.392	.03	1.
7343	" 18	" 19	d	c	.06	251.2	118.	133.2	25.6	15.6	3.	12.5	7.1	5.4	.128	.368	.144	.224	.84	.504	.336	.02	.72
7411	" 25	" 26	d	c	.2	829.6	104.8	724.8	63.2	9.6	1.	24.	8.9	15.1	.096	.768	.176	.592	1.96	.408	1.552	.024	.8
7455	May 2	May 3	d	c	.04	301.6	125.6	176.	26.8	22.8	3.4	14.6	7.8	6.8	.024	.48	.224	.256	.932	.42	.512	.007	.56
7495	" 9	" 10	d	m	.4	326.8	100.4	226.4	38.4	10.8	2.8	17.1	11.8	5.3	.08	.48	.224	.256	.84	.48	.36	.008	.32
7541	" 16	" 17	d	c	.4	365.2	121.2	244.	38.4	20.8	5.2	17.8	9.7	8.1	.068	.48	.144	.336	.642	.292	.35	.01	.24
7595	" 23	" 24	v d	v m	.05	570.	141.6	428.4	58.	40.4	3.6	16.6	8.1	8.5	.044	.48	.112	.368	1.156	.196	.96	.015	.32
7631	" 30	" 31	d	m	.2	306.	164.	142.	42.4	36.	4.4	12.2	7.4	4.8	.02	.32	.176	.144	.868	.308	.56	.01	.8
7665	June 6	June 7	d	c	.02	327.2	156.8	170.4	31.2	28.8	4.7	14.3	7.9	6.4	.02	.352	.192	.16	.8	.388	.412	.006	.36
7716	" 13	" 14	d	c	.04	338.	188.4	149.6	48.8	29.2	6.3	12.4	7.8	4.6	.032	.352	.176	.176	.98	.52	.46	.008	.48
7753	" 20	" 21	d	c	.04	296.4	210.4	86.	48.4	46.4	4.8	9.1	7.9	1.2	.044	.288	.192	.096	.612	.244	.368	.004	.32
7795	" 27	" 28	d	d	.01	546.	181.2	364.8	60.8	24.4	5.	15.1	5.6	9.5	.054	.496	.144	.352	1.32	.244	1.076	.013	.72
7829	July 4	July 5	d	l	.02	320.	184.8	135.2	40.	21.6	5.4	11.8	6.4	5.4	.078	.32	.128	.192	.68	.356	.324	.007	.24
7904	" 11	" 12	d	l	.02	317.2	212.4	104.8	40.4	36.4	6.5	9.3	6.8	2.5	.079	.272	.16	.112	.692	.26	.432	.012	.6

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT ALTON.—Midstream —CONTINUED.

(Parts per 1.000,000.)

Serial Number	1900		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
	Collection.	Examination.							Total.	Dissolved						Total.	Dissolved	Suspended					
7977	July 18	July 19	d	l	.02	300.	172.	128.	26.	20.	5.8	8.7	7.4	1.3	.062	.272	.176	.096	.58	.292	.288	.008	.36
8073	Aug. 1	Aug. 2	d	c	.02	554.4	135.2	419.2	48.	24.	4.2	16.7	8.4	8.3	.08	.528	.192	.336	1.16	.372	.788	.005	.72
8122	" 8	" 9	d	c	.02	272.4	170.8	101.6	82.8	61.2	4.7	14.	10.7	3.3	.104	.416	.208	.208	.92	.516	.404	.004	.36
8188	" 15	" 16	d	l	.02	230.4	159.2	71.2	39.2	33.6	6.6	10.8	7.3	3.5	.106	.416	.208	.208	.76	.316	.444	.005	.24
8268	" 22	" 24	d	c	.2	884.8	138.	746.8	59.6	22.	3.6	21.3	6.1	15.1	.152	.72	.192	.528	1.74	.316	1.424	.002	.76
8325	" 29	" 30	d	c	.02	375.2	139.6	235.6	42.	20.8	4.	15.2	6.8	8.4	.102	.48	.192	.288	.92	.284	.636	.003	.44
8378	Sept. 5	Sept. 6	v d	v m	...	321.6	160.4	161.2	34.	27.2	3.4	20.7	8.7	12.	.104	.352	.272	.08	.664	.268	.396	.003	.4
8449	" 12	" 13	d	m	.25	284.	140.	144.	34.4	20.4	3.8	17.2	11.6	5.6	.118	.48	.24	.24	.92	.448	.472	.005	.32
8506	" 19	" 20	d	c	.04	270.4	153.6	116.8	37.6	26.	3.4	15.1	12.7	2.4	.19	.48	.224	.256	.728	....	.....	.007	.48
8556	" 26	" 27	d	m	.7	314.8	147.2	167.6	48.8	23.6	2.8	18.	13.9	4.1	.136	.56	.192	.368	.984	.008	.376	.005	.28
8610	Oct. 3	Oct. 4	d	m	.9	504.	135.6	368.4	50.4	29.2	1.6	27.6	17.7	9.9	.17	.592	.288	.304	1.424	.624	.8	.002	.4
8670	" 16	" 17	d	c	.6	310.8	136.4	174.4	40.	26.4	1.6	22.1	17.3	4.8	.094	.432	.272	.16	1.168	.512	.676	.012	.628
8683	" 22	" 23	d	c	.8	326.8	122.	204.4	41.2	30.2	1.7	26.2	18.6	7.6	.23	.544	.288	.256	1.104	.544	.56	.014	.386
8713	" 29	" 30	d	c	1.3	288.8	132.	156.8	43.2	30.6	1.5	25.6	22.2	3.4	.112	.48	.272	.208	.816	.64	.176	.002	.438
8741	Nov. 5	Nov. 6	d	c	.5	261.2	135.6	125.6	37.6	24.	1.9	19.7	15.4	4.3	.18	.448	.288	.16	.912	.496	.416	.007	.353
8768	" 12	" 13	d	c	.7	294.	157.2	136.8	37.6	30.4	1.9	23.5	18.9	9.6	.151	.448	.208	.24	1.168	.656	.512	.009	.831
8790	" 19	" 20	d	l	.1	204.4	122.	82.4	26.4	24.8	1.6	20.8	17.7	3.1	.154	.352	.336	.016	.912	.8	.112	.006	.395
8822	" 26	" 27	d	c	.8	196.4	130.2	56.2	20.	19.2	2.3	19.1	16.3	2.8	.138	.352	.208	.144	.784	.624	.16	.006	.434
8851	Dec. 3	Dec. 4	d	l	.25	234.4	202.8	31.6	21.2	19.6	8.6	10.5	9.9	.6	.336	.324	.288	.036	.88	.544	.276	.018	1.262
8875	" 10	" 11	d	l	.3	239.6	203.6	36.	29.2	21.6	4.2	11.2	10.6	.6	.124	.224	.128	.106	.816	.432	.384	.014	.906
8897	" 17	" 18	d	l	.4	229.2	204.4	24.8	20.4	24.4	5.	11.	10.	1.	.109	.208	.112	.096	.624	.448	.176	.009	1.081
8918	" 24	" 25	d	l	.4	251.2	218.8	32.4	18.	14.	6.1	10.8	9.8	1.	.239	.304	.224	.08	.576	.4	.176	.008	1.072
Average Jan. 4—June 27............						481.3	161.9	319.4	38.8	23.6	5.1	15.5	8.8	6.6	.259	.549	.208	.341	1.273	.481	.791	.012	.62
Average July 4—Dec. 24............						324.5	150.2	165.2	38.5	27.	3.8	16.9	11.9	4.9	.131	.416	.22	.196	.914	.448	.465	.007	.555
Average Jan. 4—Dec. 24............						404.5	160.6	243.8	38.7	25.3	4.4	16.2	10.3	5.8	.203	.464	.214	.27	1.097	.465	.531	.009	.588

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT ALTON.—¼ distance from Missouri shore.

(Parts per 1,000,000.)

Serial Number.	1899. Date of Collection.		Date of Examination.		Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Dissolved	Albuminoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved	Organic Nitrogen. Suspended	Nitrogen as Nitrites.	Nitrogen as Nitrates.
4581	Jan.	5	Jan.	6	d	c	.04	243.2	202.	41.2	33.2	31.2	6.1	11.8	8.2	3.6	.138	.4	.208	.192	.85	.45	.4	.008	.2
4602	"	12	"	13	d	c	.5	280.	226.8	53.2	40.	36.	7.	11.6	7.7	3.9	.4	.44	.24	.2	.89	.57	.32	.007	.3
4632	"	19	"	20	d	c	.2	280.8	215.2	71.6	48.	40.	6.6	11.5	6.5	5.	.28	.44	.192	.248	.93	.49	.44	.026	.4
4653	"	27	"	28	d	c	.03	264.8	214.8	50.	28.	24.	6.2	11.6	7.1	4.5	.08	.44	.16	.28	1.01	.41	.6	.016	.1
4663	Feb.	2	Feb.	3	d	c	.05	286.	243.2	42.8	47.2	40.	8.2	10.1	6.6	3.5	.36	.44	.192	.148	.69	.49	.2	.015	.2
4691	"	10	"	11	d	c	.06	292.8	270.	22.8	44.	36.	8.3	8.5	7.3	1.2	.44	.4	.256	.144	.86	.54	.32	.018	.75
4716	"	17	"	18	d	m	.05	378.	276.8	101.2	52.	48.	8.6	16.5	8.	8.5	.41	.76	.24	.52	2.04	.5	1.54	.014	.7
4746	"	24	"	27	d	m	.1	444.8	266.	178.8	66.	46.	8.7	18.5	7.8	10.7	.44	1.04	.228	.812	2.34	.5	1.84	.012	.75
4761	Mar.	2	Mar.	3	v d	v m	...	598.8	124.8	474.	52.	30.	2.5	21.5	9.5	12.	.176	.8	.192	.608	1.7	.46	1.24	.08	.45
4793	"	10	"	13	d	m	.4	410.	130.2	270.8	44.	38.	3.6	21.2	12.5	8.7	.32	.72	.368	.352	1.38	.62	.76	.06	.65
4820	"	16	"	17	v d	v m	.4	1508.	128.	1380.	116.	32.	2.9	37.5	12.5	25.	.44	2.2	.32	1.88	3.46	.74	2.72	.08	.9
4847	"	24	"	25	v d	v m	.5	909.2	142.	767.2	94.	35.2	2.3	34.6	16.1	18.5	.44	1.12	.368	.752	3.07	.87	2.2	.023	.8
4871	"	30	"	31	d	m	.5	346.	131.2	214.8	46.	31.2	3.2	19.	12.5	6.5	.44	.68	.352	.328	1.31	.6	.71	.018	.6
4900	Apr.	7	April	8	d	c	.3	366.	146.	220.	36.	22.	3.7	14.	8.2	5.8	.272	.56	.192	.368	.87	.47	.4	.021	.8
4930	"	14	"	17	d	m	.3	690.	158.	462.	60.	36.	3.2	18.6	12.5	6.1	.208	.68	.288	.392	1.63	.51	1.12	.076	1.
4950	"	20	"	21	d	c	.1	558.	122.	436.	44.	26.	2.1	17.5	7.8	9.7	.32	.64	.256	.384	1.47	.43	1.04	.04	.55
4969	"	27	"	28	d	c	.3	344.	138.	206.	34.	26.	2.5	13.5	7.8	5.7	.056	.52	.208	.312	1.01	.33	.68	.05	.5
4997	May	3	May	4	d	m	.3	879.2	133.6	745.6	43.6	26.4	1.4	17.3	8.3	9.	.005	.96	.208	.752	2.09	.49	1.6	.034	.5
5015	"	10	"	11	d	c	.15	614.	162.8	451.2	44.	38.4	.8	19.2	9.8	9.4	.056	.64	.224	.416	1.85	.634	1.216	.012	.44
5054	"	18	"	19	d	m	.4	958.	146.	812.	50.4	13.2	1.8	26.	14.	12.	.044	1.184	.288	.896	2.17	.6	1.57	.016	.56
5083	"	24	"	25	d	m	.6	1285.6	150.	1135.6	84.8	30.8	.54	27.7	13.8	13.9	.084	1.12	.304	.816	2.73	.666	2.064	.01	.96
5127	"	31	June	1	d	m	.5	1262.4	139.2	1123.2	84.4	27.6	.4	18.6	11.4	7.2	.068	1.152	.16	.992	2.73	.442	2.288	.02	.56
5188	June	8	"	9	d	m	.6	947.2	151.6	795.6	64.8	22.4	1.2	22.	11.2	10.8	.008	1.12	.24	.88	2.81	.826	1.984	.008	.72
5214	"	15	"	16	d	m	.4	473.6	141.6	332.	29.6	24.	1.3	19.1	10.8	8.3	.04	.672	.24	.432	1.56	.792	.768	.002	.8
5266	"	22	"	23	d	c	.6	578.4	160.4	418.	36.4	25.6	1.4	23.2	12.8	10.4	.036	.576	.288	.288	1.56	.6	.96	.007	.44
5307	"	28	"	29	d	c	.8	449.2	164.	285.2	18.4	8.8	1.3	18.7	12.7	6.	.024	.512	.208	.304	1.4	.504	.896	.008	.44
5344	July	5	July	6	d	c	.8	356.8	142.8	214.	52.4	36.8	1.9	18.8	14.8	4.	.016	.416	.256	.16	2.12	.728	1.392	.004	.52

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT ALTON.—¼ distance from Missouri shore.—CONTINUED.

(Parts per 1,000,000.)

Serial Number.	1899. Date of				Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Collection.		Examination.		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
											Total.	Dissolved						Total.	Dissolved	Suspended					
5399	July	12	July	13	d	c	.3	560.4	154.4	406.	83.2	47.2	2.2	21.8	13.2	10.6	.032	.64	.24	.4	1.656	.44	1.216	.004	.6
5451	"	19	"	20	d	c	.3	324.8	166.8	158.	51.6	41.6	2.9	16.1	12.4	3.7	.036	.48	.256	.224	1.16	.504	.656	.006	.36
5502	"	26	"	27	d	c	.2	303.2	192.8	110.4	60.8	30.	2.2	14.9	12.1	2.8	.024	.384	.176	.208	1.	.504	.496	.004	.4
5547	Aug.	2	Aug.	3	d	c	.3	228.4	168.4	60.	53.2	52.4	1.2	13.4	12.	1.2	.2	.256	.192	.064	.76	.504	.256	.002	.12
5595	"	9	"	10	d	c	.04	266.8	163.6	103.2	44.	35.6	3.	13.	11.3	1.7	.036	.288	.176	.112	.84	.376	.464	.003	.4
5645	"	16	"	17	d	c	.25	301.2	134.	167.2	46.	36.8	2.5	13.6	10.2	3.4	.036	.4	.144	.256	1.24	.408	.832	.02	.44
5701	"	23	"	24	d	c	...	233.6	163.2	70.4	38.8	32.4	3.2	11.	8.2	2.8	.016	.368	.204	.164	1.	.344	.656	.003	.2
5758	"	30	"	31	d	c	.03	235.2	170.2	56.	32.4	30.4	3.6	10.5	9.3	1.2	.048	.24	.176	.064	.84	.424	.416	.001	.24
5809	Sept.	6	Sept.	7	d	c	.04	230.	165.6	64.4	33.6	21.2	3.6	9.9	6.2	3.7	.032	.288	.176	.112	.76	.28	.48	.001	.16
5854	"	13	"	14	d	c	.04	232.4	164.8	67.6	36.4	27.6	2.5	11.	6.6	4.4	.028	.384	.172	.212	.92	.456	.464	.005	.2
5904	"	20	"	21	d	c	.03	264.8	161.2	103.6	32.	28.	3.1	12.4	8.3	4.1	.012	.352	.16	.192	1.08	.248	.832	.01	.2
5955	"	27	"	28	d	c	.07	220.	145.2	74.8	28.4	28.	2.8	13.1	12.25	.85	.044	.4	.304	.096	.82	.516	.304	.005	.2
6006	Oct.	4	Oct.	5	d	c	.07	213.6	147.6	66.	26.8	24.4	3.2	13.25	11.2	2.05	.048	.416	.272	.144	.836	.472	.364	.005	.08
6047	"	11	"	12	d	c	.15	210.8	163.6	47.2	22.4	21.2	3.7	14.3	11.	3.3	.02	.448	.192	.256	1.06	.324	.736	.005	.2
6092	"	18	"	19	d	c	.06	228.8	156.4	72.4	21.2	16.8	4.9	11.6	9.7	1.9	.052	.384	.176	.208	1.	.36	.64	.005	.2
6163	"	25	"	26	d	c	.06	205.6	160.	45.6	24.	16.	4.3	9.6	8.6	1.	.016	.384	.208	.176	.584	.36	.224	.006	.12
6207	Nov.	1	Nov.	2	d	c	.08	244.4	174.4	70.	21.2	7.2	4.5	9.2	8.4	.8	.028	.4	.144	.256	.68	.392	.288	.007	.28
6251	"	8	"	9	d	c	.06	233.2	173.6	59.6	31.6	31.2	2.9	12.9	9.3	3.6	.028	.352	.24	.112	.936	.36	.576	.006	.2
6308	"	15	"	16	d	c	.3	225.2	143.2	82.	34.	23.2	2.5	12.5	11.2	1.3	.044	.368	.272	.096	.744	.552	.192	.005	.2
6351	"	22	"	23	d	c	.3	191.6	143.2	48.4	25.2	17.6	3.3	12.8	12.1	.7	.026	.432	.24	.192	.808	.52	.288	.005	.12
6417	"	29	"	30	d	c	.3	182.8	157.	25.8	32.	24.4	3.8	11.4	11.	.4	.02	.32	.182	.138	.68	.424	.256	.006	.12
6453	Dec.	6	Dec.	7	d	c	.03	176.4	161.6	14.8	36.	23.6	2.7	12.3	11.9	.4	.016	.4	.32	.08	.968	.616	.352	.011	.44
6514	"	13	"	14	d	c	.15	172.	155.6	16.4	32.	24.	4.	12.6	11.5	1.1	.028	.336	.24	.096	.84	.456	.384	.006	.12
6556	"	20	"	21	d	c	.04	191.2	162.	29.2	30.	28.4	5.4	11.9	11.4	.5	.082	.336	.176	.16	.92	.456	.464	.007	.16
Average Jan. 5—June 28								589.3	172.8	416.5	51.5	30.9	3.7	18.8	10.1	8.7	.214	.775	.247	.528	1.673	.550	1.174	.021	.54
Average July 5—Dec. 20								250.1	160.	90.1	37.2	28.2	3.3	13.	10.5	2.4	.029	.378	.211	.167	.97	.44	.529	.005	.23
Average Jan. 5—Dec. 20								428.2	166.5	361.6	44.5	29.6	3.5	15.9	10.3	5.6	.124	.582	.229	.359	1.328	.501	.829	.013	.4

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT ALTON.—¼ distance from Missouri shore.

(Parts per 1,000,000.)

Serial Number.	1900. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
6623	Jan. 4	Jan. 5	d	c	.04	255.2	241.6	13.6	26.8	24.8	12.	10.7	9.2	1.5	.42	.384	.24	.144	.76	.448	.312	.013	.44
6660	" 10	" 11	d	c	.07	244.4	212.4	32.	25.2	18.8	6.3	10.9	9.	1.9	.2	.48	.176	.304	1.12	.448	.672	.006	.2
6701	" 17	" 18	d	c	.05	209.2	189.2	20.	34.2	34.2	5.1	10.9	9.	1.9	.036	.368	.16	.208	.8	.352	.448	.003	.08
6748	" 24	" 25	d	m	.06	322.4	164.8	157.6	31.6	20.	3.95	14.1	9.2	4.9	.08	.416	.16	.256	.96	.576	.384	.008	.76
6814	Feb. 2	Feb. 3	d	c	.1	288.8	227.6	61.2	29.6	28.	9.6	12.8	....	....	.74	.368	.24	.128	.8	.512	.288	.013	1.08
6859	" 7	" 8	d	c	.4	244.	201.2	42.8	20.	20.	8.2	9.3	7.6	1.7	.352	.384	.144	.24	.88	.32	.56	.009	.68
6903	" 14	" 15	v d	v m	.2	796.8	146.	650.8	42.8	14.	3.8	18.8	8.3	10.5	.16	1.04	.208	.832	1.84	.512	1.328	.018	1.
6953	" 21	" 22	d	m	.41	558.	156.8	401.2	84.	30.4	4.6	18.8	9.5	9.3	.416	.88	.304	.576	1.84	.672	1.168	.014	1.08
7003	Mar. 2	Mar. 3	d	c	.4	224.8	164.0	60.8	21.6	20.8	4.2	13.5	9.8	3.7	.352	.448	.288	.16	.88	.64	.24	.008	.64
7056	" 9	" 10	v d	m	.15	670.	112.	558.	40.	16.8	3.2	17.1	6.8	10.3	.208	.512	.208	.304	1.76	.512	1.248	.009	.84
7088	" 14	" 15	v d	v m	.4	1584.	100.4	1483.6	45.2	10.	.6	25.7	8.5	17.2	.24	1.312	.272	1.04	3.2	.544	2.656	.008	.64
7134	" 21	" 22	d	m	.3	577.2	116.4	460.8	38.	15.6	1.3	19.5	9.3	10.2	.464	.928	.288	.64	2.2	.864	1.336	.01	.68
7177	" 28	" 29	d	m	.5	359.2	125.6	233.6	27.6	20.8	2.9	16.3	8.6	7.7	.432	.576	.224	.352	1.304	.6	.704	.012	.4
7234	April 4	April 5	d	c	.06	344.	138.	206.	16.4	14.	3.5	14.2	7.5	6.7	.32	.4	.192	.208	.896	.304	.352	.013	.4
7299	" 12	" 13	d	m	.4	613.2	116.	497.2	37.6	18.	1.4	25.6	8.8	16.8	.224	.8	.256	.544	2.04	.6	1.44	.032	1.08
7344	" 18	" 19	d	c	.05	260.4	132.	128.4	20.8	17.2	3.6	13.	7.2	5.8	.112	.368	.208	.16	.64	.44	.4	.02	.72
7412	" 25	" 26	v d	v m	.3	913.6	110.4	803.2	46.4	16.8	1.1	25.7	7.3	18.4	.08	1.088	.176	.912	2.2	.44	1.76	.025	.72
7456	May 2	May 3	d	c	.05	328.4	168.8	159.6	32.8	22.	5.3	13.9	8.4	5.5	.04	.528	.176	.352	1.028	.42	.608	.014	.88
7496	" 9	" 10	d	m	.4	534.	109.6	424.4	26.	21.2	3.3	17.9	11.8	6.1	.084	.576	.256	.32	1.06	.388	.672	.01	.28

7544	May 16	May 17	d	c	.2	452.8	124.4	328.4	31.2	21.6	3.8	20.8	9.1	11.7	.074	.570	.144	.432	.74	.452	.288	.015	.1
7596	" 23	" 24	v d	v m	.1	649.2	146.4	502.8	58.8	38.4	3.1	21.1	8.1	13.7	.116	.512	.128	.384	1.94	.308	1.632	.022	.4
7630	" 30	" 31	d	m	.3	293.2	150.4	142.8	41.6	34.8	3.7	11.7	8.	3.7	.022	.288	.224	.084	.74	.5	.24	.013	.48
7667	June 6	June 7	d	c	.07	324.4	141.6	182.8	44.4	21.2	3.9	13.3	8.5	4.8	.032	.384	.112	.272	.8	.154	.846	.01	.4
7717	" 13	" 14	d	c	.04	263.6	180.8	82.8	42.4	27.2	4.4	12.5	8.3	4.3	.02	.32	.192	.128	.9	.452	.448	.007	.08
7754	" 20	" 21	d	c	.05	275.6	192.	83.6	40.4	38.	3.6	11.	9.5	1.5	.046	.288	.16	.128	.58	.244	.336	.004	.08
7796	" 27	" 28	d	c	.01	560.4	164.4	396.	56.8	28.	3.7	15.1	5.7	9.4	.074	.528	.304	.224	1.288	.296	.992	.013	.56
7830	July 4	July 5	d	l	.02	311.2	181.2	130.	27.2	24.8	3.8	11.7	7.	4.7	.072	.304	.112	.192	.68	.228	.452	.004	.28
7908	" 11	" 12	d	l	.05	319.6	195.6	124.	46.8	38.4	4.8	10.7	7.1	3.6	.082	.32	.176	.144	.724	.212	.512	.005	.36
7980	" 18	" 19	d	l	.02	279.6	168.	111.6	24.	16.4	4.3	11.3	7.7	3.6	.048	.272	.24	.032	.76	.232	.468	.005	.16
8075	Aug. 1	Aug. 2	d	c	.02	574.4	127.6	446.8	56.	32.	3.3	18.2	8.7	9.5	.062	.598	.208	.32	1.4	.404	.996	.003	.68
8123	" 8	" 9	d	c	.02	270.	145.6	124.4	58.	42.4	3.8	16.2	11.1	5.1	.102	.416	.288	.128	.92	.436	.484	.003	.4
8167	" 15	" 16	d	l	.08	227.6	149.6	78.	46.4	36.	4.6	11.2	8.3	2.9	.098	.416	.208	.208	.76	.412	.348	.002	.24
8209	" 22	" 24	d	c	.1	896.8	126.	770.8	57.2	18.	3.4	21.4	6.	15.4	.134	.8	.192	.608	1.336	.316	1.01	.002	.76
8328	" 29	" 30	d	c	.2	382.	141.6	240.4	39.2	22.	3.	15.7	7.4	8.3	.106	.48	.192	.288	.92	.236	.684	.009	.44
8377	Sept. 5	Sept. 6	v d	v m	...	336.8	160.4	176.4	31.6	21.2	3.	16.5	8.9	7.6	.078	.432	.304	.128	.76	.428	.332	.004	.36
Average Jan. 4—June 27…………						467.1	155.	312.1	36.6	22.7	4.2	15.9	8.1	7.2	.204	.567	.209	.358	1.28	.409	.873	.012	.56
Average July 4—Sept. 5…………						398.6	135.2	243.3	42.9	27.9	3.7	14.7	8.0	6.7	.091	.44	.213	.227	.917	.329	.588	.008	.41
Average Jan. 4—Sept. 5…………						449.7	155.	294.7	38.2	24.	4.1	15.6	8.1	7.4	.175	.534	.21	.32	1.188	.433	.754	.009	.52

8562

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT ALTON.—100 ft. from Missouri shore.

(Parts per 1,000,000.)

Serial Number.	1899.		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
	Collection.	Examination.							Total.	Dissolved						Total.	Dissolved	Suspended					
4579	Jan. 5	Jan. 6	d	c	.08	228.	198.8	29.2	32.8	28.	5.4	12.1	8.6	3.5	.062	.44	.208	.232	.85	.53	.32	.005	.05
4604	" 12	" 13	d	c	.4	230.8	200.	30.8	40.	32.	4.8	11.	7.	4.	.042	.44	.176	.264	.81	.41	.4	.004	.15
4634	" 19	" 20	d	c	.15	231.6	198.8	32.8	44.8	32.	5.4	10.3	7.	3.3	.014	.4	.16	.24	.81	.33	.48	.02	.6
4654	" 27	" 28	d	c	.03	264.	210.8	53.2	32.	28.	5.9	12.2	7.1	5.1	.018	.44	.144	.296	.77	.37	.4	.008	.1
4671	Feb. 2	Feb. 3	d	c	.04	280.8	235.2	45.6	44.	34.4	7.8	10.6	6.9	3.7	.208	.4	.208	.192	.77	.53	.24	.017	.4
4692	" 10	" 11	d	c	.07	288.	264.	24.	40.	34.	7.8	8.2	7.2	1.	.408	.4	.24	.16	.9	.54	.36	.01	.85
4715	" 17	" 18	d	c	.05	338.	273.2	64.8	46.	42.	8.1	12.	7.3	4.7	.372	.44	.224	.216	.98	.46	.52	.012	.65
4765	Mar. 2	Mar. 3	v d	v m	...	528.	108.	420.	52.	22.	2.4	21.4	8.	13.4	.12	.8	.192	.608	1.54	.38	1.16	.03	.05
4795	" 10	" 13	d	m	.3	470.	144.	326.	40.	34.	3.6	21.6	12.2	9.4	.288	.8	.336	.464	1.38	.66	.72	.024	.6
4818	" 16	" 17	v d	v m	.5	1400.4	127.2	1277.2	83.2	30.8	2.7	35.7	12.5	23.2	.4	1.84	.352	1.488	3.4	.7	2.7	.017	.9
4846	" 24	" 25	v d	v m	.4	954.	124.	830.	94.	33.2	2.4	34.	15.	19.	.48	1.2	.336	.864	3.15	.79	2.36	.04	.8
4870	" 30	" 31	d	m	.4	352.	132.	220.	48.	30.	3.1	18.5	13.	5.5	.4	.68	.352	.328	1.39	.55	.84	.02	.65
4899	April 7	April 8	d	c	.2	382.8	138.8	244.	40.	28.	3.5	14.8	8.	6.8	.272	.52	.176	.344	1.07	.43	.64	.05	.55
4931	" 14	" 17	d	m	.4	622.	156.	466.	56.	34.	3.4	18.8	11.3	7.5	.192	.68	.272	.408	1.55	.55	1.	.054	.9
4961	" 20	" 21	d	c	.15	556.	126.	430.	36.	20.	1.8	17.9	7.6	10.3	.32	.64	.24	.4	1.47	.47	1.	.045	.6
4970	" 27	" 28	d	c	.4	312.4	134.4	178.	31.2	22.	2.4	13.8	7.3	6.5	.072	.52	.208	.312	1.01	.37	.64	.048	.5
4996	May 3	May 4	d	m	.3	801.2	136.4	664.8	50.8	29.2	1.6	18.5	8.4	10.1	.01	.92	.304	.616	2.03	.41	1.62	.088	.5
5014	" 10	" 11	d	c	.06	697.6	150.	547.6	26.4	24.4	.8	21.3	10.1	11.2	.056	.736	.256	.48	1.85	.666	1.184	.04	.48
5053	" 18	" 19	d	m	.4	862.4	146.8	715.6	38.8	26.8	1.4	26.	13.5	12.5	.096	1.024	.256	.768	2.11	.474	1.636	.014	.52
5082	" 24	" 25	v d	v m	.5	1064.4	147.6	916.8	72.	29.2	.8	27.1	14.1	13.	.1	1.04	.256	.784	2.41	.7	1.71	.021	1.08
5130	" 31	June 1	d	v m	.3	1412.8	153.2	1259.6	93.2	40.6	.36	24.7	11.9	12.8	.032	1.312	.224	1.088	2.73	.73	2.	.021	.56
5184	June 8	" 9	d	m	.7	1006.	170.4	835.6	78.4	35.2	.5	26.1	13.4	12.7	.024	.96	.288	.672	2.65	.826	1.824	.007	.48
5218	" 15	" 16	d	m	.4	462.8	169.2	293.6	24.	20.	1.6	18.4	10.8	7.6	.036	.608	.224	.384	1.8	.76	1.04	.008	.72
5267	" 22	" 23	d	c	.5	500.	168.8	331.2	35.6	32.	1.6	21.4	12.7	8.7	.04	.64	.248	.392	1.64	.632	1.008	.007	.36
5306	" 28	" 29	d	c	.6	433.2	150.4	282.8	37.2	26.4	1.6	19.8	12.	7.8	.02	.552	.208	.344	1.32	.472	.848	.005	.4
5345	July 5	July 6	d	c	.8	412.8	142.8	270.	62.8	34.8	2.	19.	14.6	4.4	.02	.48	.24	.24	2.04	.536	1.504	.004	.26
5400	" 12	" 13	d	c	.6	618.8	161.6	457.2	88.4	46.4	2.3	22.8	13.2	9.6	.032	.544	.24	.304	1.464	.472	.992	.003	.6

5452	July 19	July 20	d	c	.5	280.2	179.2	110.	53.2	44.4	2.6	15.4	11.6	3.8	.032	.32	.208	.019	.84	.472	.368	.006	.36
5503	" 26	" 27	d	c	.2	267.2	156.8	128.4	51.2	39.6	2.2	14.4	11.5	2.9	.02	.384	.224	.16	.92	.408	.512	.005	.4
5546	Aug. 2	Aug. 3	d	c	.3	229.6	164.8	64.8	54.	45.2	2.6	13.2	11.2	2.	.016	.272	.224	.048	.64	.540	.104	.004	.2
5596	" 9	" 10	d	c	.04	293.6	165.6	128.	64.	38.	3.9	13.4	11.5	1.9	.024	.288	.192	.096	.84	.44	.4	.003	.2
5644	" 16	" 17	d	c	.3	326.	138.8	187.2	63.2	40.8	2.8	13.7	10.5	3.2	.02	.384	.192	.192	1.16	.492	.668	.023	.4
5702	" 23	" 24	d	c	...	217.2	183.2	34.	74.	55.6	3.4	11.	8.2	2.8	.016	.4	.24	.16	1.08	.312	.768	.004	.16
5754	" 30	" 31	d	c	.08	230.8	176.8	54.	40.	38.4	3.4	10.5	9.6	.9	.036	.272	.18	.092	.92	.328	.592	.001	.28
5810	Sept. 6	Sept 7	d	c	.08	228.8	171.6	57.2	26.4	24.4	3.8	9.5	8.1	3.4	.032	.288	.128	.16	.76	.392	.368	.001	.12
5853	" 13	" 14	d	c	.06	222.4	165.2	67.2	28.4	17.2	2.6	9.6	6.5	3.3	.028	.332	.176	.176	.84	.408	.432	.007	.24
5964	" 27	" 28	d	c	.06	216.4	141.6	74.8	37.2	22.	3.1	12.5	11.8	.7	.012	.4	.264	.136	.82	.5	.32	.003	.12
6007	Oct. 4	Oct. 5	d	c	.07	204.	146.8	57.2	31.2	23.6	3.5	12.4	11.8	.6	.032	.368	.272	.096	.74	.372	.368	.004	.08
6046	" 11	" 12	d	c	.15	214.8	162.8	52.	12.	11.6	3.2	12.9	12.8	.1	.02	.432	.24	.192	.772	.404	.368	.005	.08
6091	" 18	" 19	d	c	.06	213.6	161.2	52.4	19.6	12.4	4.1	11.5	9.7	1.8	.044	.352	.192	.16	.92	.36	.56	.007	.16
6104	" 25	" 26	d	c	.06	209.2	158.6	55.6	19.6	14.8	4.	9.9	8.6	1.3	.02	.4	.208	.192	.76	.376	.384	.005	.16
6206	Nov. 1	Nov. 2	d	c	.07	228.8	170.2	49.6	17.2	12.	4.4	9.	8.2	.8	.028	.352	.192	.16	.648	.392	.256	.007	.2
6252	" 8	" 9	d	c	.08	205.2	162.	43.2	16.	14.4	3.2	12.	9.5	2.5	.04	.432	.192	.24	.904	.424	.48	.007	.2
6307	" 15	" 16	d	c	.5	212.4	145.2	67.2	26.	17.2	2.6	12.1	10.9	1.3	.04	.384	.304	.08	.68	.52	.16	.007	.28
6352	" 22	" 23	d	c	...	186.	144.4	41.6	14.4	11.2	3.4	12.8	12.1	.7	.032	.368	.32	.048	.68	.552	.128	.007	.16
6418	" 29	" 30	d	c	.25	168.8	162.4	6.4	25.6	22.8	3.5	10.8	10.8	0.0	.016	.304	.192	.112	.68	.456	.224	.006	.12
6454	Dec. 6	Dec. 7	d	c	.04	189.6	168.4	21.2	38.4	38.	3.6	12.9	11.9	1.	.02	.384	.32	.064	.808	.712	.096	.006	.48
6515	" 13	" 14	d	c	.02	181.6	150.4	31.2	18.8	16.8	3.4	11.8	10.8	1.	.036	.352	.192	.16	.904	.488	.416	.007	.24
6557	" 20	" 21	d	c	.06	168.	153.2	14.8	31.6	30.4	4.6	14.4	11.5	2.9	.036	.368	176	.192	1.	.424	.576	.006	.16
Average Jan. 5—June 28.....						589.1	166.8	416.2	48.2	30.2	3.2	19.1	10.1	6.9	.162	.737	.233	.503	1.615	.549	1.065	.022	.56
Average July 5—Dec. 20..						248.1	159.9	88.1	36.	28.8	3.3	12.8	10.6	2.2	.027	.37	.221	.148	.909	.449	.46	.005	.24
Average Jan. 5—Dec. 20..........						419.	163.5	255.4	32.6	29.3	3.2	15.9	10.3	5.6	.096	.557	.227	.329	1.269	.5	.768	.012	.4

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT ALTON.—100 ft. from Missouri shore.

(Parts per 1,000,000.)

⑥

Serial Number.	1900.		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
	Collection.	Examination.							Total.	Dissolved						Total.	Dissolved	Suspended					
6624	Jan. 4	Jan. 5	d	c	.13	262.8	244.4	18.4	27.2	16.	12.9	10.5	8.9	1.6	.42	.416	.224	.192	1.	.456	.544	.01	.28
6661	" 10	" 11	d	c	.08	222.	200.4	21.6	26.4	19.6	5.1	12.9	10.8	2.1	.028	.464	.208	.256	.92	.448	.472	.003	.12
6702	" 17	" 18	d	c	.05	197.2	190.8	6.4	28.	27.6	4.7	10.8	9.1	1.7	.006	.384	.176	.208	.8	.544	.256	.001	.16
6749	" 24	" 25	d	m	.2	327.6	174.4	153.2	44.	30.	3.6	14.4	9.6	1.8	.048	.432	.192	.24	1.04	.512	.528	.006	.72
6815	Feb. 2	Feb. 3	d	c	.1	276.4	234.	42.4	31.6	23.2	9.2	12.	9.1	2.9	.74	.384	.256	.128	.768	.544	.224	.014	.88
6840	" 7	" 8	d	c	.3	220.2	190.2	30.	38.4	12.8	8.4	9.4	8.5	.9	.352	.336	.224	.112	.72	.544	.176	.006	.68
6902	" 14	" 15	v d	v m	.06	617.6	146.4	471.2	32.4	22.8	3.4	17.9	8.	9.9	.192	.96	.256	.704	1.92	.544	1.376	.011	.88
6954	" 21	" 22	d	m	.3	486.	140.	346.	86.	21.2	3.8	16.2	10.5	5.7	.2515	.768	.256	.512	1.6	.768	.832	.015	.8
7004	Mar. 2	Mar. 3	d	c	.4	213.2	174.	39.2	24.8	24.8	4.2	13.7	11.5	2.2	.208	.336	.288	.048	.72	.64	.08	.01	1.08
7037	" 9	" 10	v d	m	.5	814.	82.4	731.6	41.6	9.2	1.	17.9	6.4	11.5	.176	.64	.192	.448	2.08	.32	1.76	.011	.8
7080	" 14	" 15	v d	v m	.8	1460.	83.2	1376.8	32.8	12.8	.8	23.	7.5	15.5	.224	1.184	.176	1.008	2.72	.384	2.336	.007	.8
7125	" 21	" 22	d	m	.6	590.	130.4	459.6	30.4	14.8	2.6	19.2	13.6	5.6	.416	.896	.32	.576	2.04	.952	1.088	.009	.68
7176	" 28	" 29	d	m	.5	500.	133.2	366.8	34.	14.8	2.4	17.	9.6	7.4	.416	.608	.24	.368	1.268	.564	.704	.012	.56
7237	Apr. 4	April 5	d	m	.2	3 9.2	130.2	220.	22.8	12.4	3.4	14.1	7.4	6.7	.336	.416	.192	.224	.856	.568	.288	.011	.72
7300	" 13	" 14	d	m	.25	676.8	129.2	547.6	57.2	17.6	1.1	23.1	9.1	14.	.24	.896	.288	.608	2.2	.632	1.568	.034	.92
7345	" 18	" 19	d	c	.1	294.4	123.2	171.2	36.4	21.6	3.8	12.9	7.6	5.3	.112	.32	.176	.144	.856	.536	.32	.02	.72
7413	" 25	" 26	d	m	.3	886.	106.8	770.2	46.	18.8	3.	23.4	7.9	15.5	.064	1.024	.192	.832	2.12	.472	1.648	.025	.32
7457	May 2	May 3	d	c	.05	474.8	136.8	338.	41.6	23.6	3.8	16.	7.9	8.1	.08	.496	.176	.32	1.06	.36	.7	.012	.64
7497	" 9	" 10	d	m	.5	599.6	103.2	496.4	48.2	19.2	2.8	18.5	12.9	5.6	.116	.592	.272	.32	1.124	.84	.284	.01	.4
7545	" 16	" 17	d	c	.3	344.8	140.8	204.	30.8	22.	3.3	20.6	10.2	10.4	.064	.416	.304	.112	1.284	.452	.832	.017	.32
7597	" 23	" 24	v d	v m	.2	645.6	147.6	498.	57.2	32.4	2.9	19.8	7.9	11.9	.124	.56	.112	.448	1.22	.34	.88	.02	.4
7629	" 30	" 31	d	m	.06	392.8	219.6	173.2	48.4	30.2	4.	11.9	8.	3.9	.024	.4	.208	.192	1.12	.52	.6	.014	.8
7686	June 6	June 7	d	c	.2	320.4	136.	184.4	29.2	22.8	4.	13.3	8.5	4.8	.028	.4	.112	.288	.8	.154	.646	.011	.36
7718	" 13	" 14	d	c	.04	246.	176.8	69.2	38.	28.4	4.6	9.5	8.5	1.	.02	.288	.224	.064	1.22	.52	.7	.006	.2
7755	" 20	" 21	d	c	.1	25 .4	180.	72.4	26.4	25.6	4.	11.1	8.2	2.9	.04	.272	.144	.128	.58	.244	.336	.004	.01
7797	" 27	" 28	d	c	.01	519.2	172.4	346.8	56.	36.4	3.2	14.3	6.4	7.9	.086	.384	.176	.208	1.16	.548	.612	.014	.4
7831	July 4	July 5	d	l	.08	295.2	174.	121.2	34.8	28.8	4.2	11.7	7.5	4.2	.056	.256	.144	.112	.52	.308	.212	.004	.24

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT ALTON.—100 ft. from Missouri shore.—CONTINUED.

(Parts per 1,000,000.)

Serial Number.	1900 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved		Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Dissolved	Albuminoid Ammonia. Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
7902	July 11	July 12	d	l	.05	295.2	192.8	102.4	40.	36.8	4.8	9.2	7.3	1.9	.084	.272	.176	.096	.708	.244	.464	.004	.36
7978	" 18	" 19	d	l	.02	242.	159.6	82.4	23.2	21.2	4.6	8.7	6.7	2.	.048	.224	.144	.08	.44	.292	.148	.005	.36
8074	Aug. 1	Aug. 2	d	c	.02	624.8	131.6	493.2	48.	34.8	2.8	17.7	8.1	9.6	.05	.608	.16	.448	1.24	.452	.788	.004	.68
8123	" 8	" 9	d	c	.02	270.	145.6	124.4	56.	42.4	3.8	16.2	11.1	5.1	.102	.416	.288	.128	.92	.436	.484	.003	.4
8186	" 15	" 16	d	l	.02	210.4	137.2	73.2	36.	34.4	3.4	12.	8.7	3.3	.096	.416	.16	.256	.76	.332	.428	.001	.12
8270	" 22	" 24	d	c	.1	820.4	128.	692.4	54.4	15.2	3.4	19.9	6.1	13.8	.146	.72	.24	.48	1.08	.316	.764	.002	.76
8327	" 29	" 30	d	c	.02	380.4	138.4	242.	44.	18.4	3.4	13.8	6.8	7.	.1	.48	.16	.32	.984	.232	.752	.001	.6
8376	Sept. 5	Sept. 6	v d	v m	....	361.2	168.8	192.4	27.2	20.8	3.2	17.	8.9	8.1	.072	.352	.304	.048	.92	.3	.62	.003	.4
8448	" 12	" 13	d	m	.45	279.2	149.6	129.6	39.6	18.	2.8	17.2	10.8	6.4	.078	.4	.24	.16	.792	.576	.216	.005	.32
8502	" 19	" 20	d	c	.4	267.2	152.4	114.8	32.	26.	2.8	15.3	12.6	2.7	.12	.368	.208	.16	.888	.304	.584	.006	.56
8555	" 26	" 27	d	m	.6	315.2	147.2	168.	40.4	25.2	2.2	17.8	14.5	3.3	.16	.496	.224	.272	.952	.48	.472	.005	.36
8609	Oct. 3	Oct. 4	d	m	.1	573.6	137.6	436.	48.4	20.6	2.	27.7	17.2	10.5	.124	.656	.24	.416	1.28	.576	.704	.001	.52
8671	" 16	" 17	d	c	.6	329.6	142.8	186.8	42.8	29.6	1.8	21.9	17.4	4.5	.112	.4	.224	.176	1.344	.56	.784	.012	.596
8684	" 22	" 23	d	c	.9	359.6	126.4	233.2	46.8	37.2	1.3	24.8	18.	6.8	.276	.528	.288	.24	1.024	.552	.472	.017	.503
8714	" 29	" 30	d	c	1.3	330.8	139.6	191.2	56.8	50.4	2.4	27.3	21.5	5.8	.16	.448	.272	.176	1.072	.672	.4	.002	.438
8740	Nov. 5	Nov. 6	d	c	.5	296.4	142.8	153.6	45.6	24.8	2.9	21.1	15.6	5.5	.152	.48	.32	.16	1.136	.544	.592	.01	.31
8769	" 12	" 13	d	c	.7	364.4	146.	218.4	39.	29.6	2.3	23.2	11.9	11.3	.184	.448	.32	.128	1.136	.736	.4	.011	.829
8788	" 19	" 20	d	l	.9	226.4	136.	90.4	[illegible]	27.6	2.2	21.	17.3	3.7	.106	.304	.24	.064	.752	.656	.096	.006	.634
8821	" 26	" 27	d	c	.6	233.2	148.8	84.4	[illegible]	22.8	2.1	19.6	15.9	3.7	.14	.352	.224	.128	.784	.624	.16	.015	.465
8850	Dec. 3	Dec. 4	d	l	.3	200.	159.2	40.8	30.8	30.4	2.6	13.9	12.8	1.1	.088	.256	.24	.016	.56	.496	.064	.008	.632
8876	" 10	" 11	d	l	.4	209.2	180.	29.2	27.2	24.	2.4	12.	11.5	.5	.076	.272	.192	.08	.4	.352	.048	.013	.507
8895	" 17	" 18	d	l	.6	193.2	185.6	7.6	23.6	21.2	2.7	11.5	11.2	.3	.03	.208	.112	.096	.688	.448	.24	.004	.716
8916	" 24	" 25	d	l	.5	206.8	186.4	20.4	12.4	12.	3.9	11.6	10.7	.9	.1	.32	.224	.096	.672	.272	.4	.007	.753
Average Jan. 4—June 27						469.9	155.9	313.9	36.8	31.9	4.2	15.5	8.6	6.9	.191	.548	.214	.334	1.15	.519	.631	.012	.587
Average July 4—Dec. 24						328.6	148.2	180.3	37.8	27.1	2.8	17.1	12.1	5.1	.117	.398	.226	.172	.877	.451	.426	.008	.498
Average Jan. 4—Dec. 24						402.	154.2	249.8	38.1	24.4	3.5	16.3	10.4	5.8	.155	.480	.22	.26	1.019	.486	.532	.009	.544

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT QUINCY.

(Parts per 1,000,000.)

Serial Number.	1897		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r.	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
	Collection.	Examination.							Total.	Dissolved						Total.	Dissolved	Suspended					
1917	Feb. 15	Feb. 16	d	l	.3*.4	218.	190.8	27.2	12.8	10.4	3.4	9.1	8.1	1.	.128	.32	.24	.08	.64	.60	.04	.005	1.4
1942	" 24	" 25	d	c	.5	415.2	184.4	230.8	43.6	29.2	3.	15.2	7.3	7.9	.2	.52	.216	.304	1.44	.6	.84	.017	1.
1976	Mar. 8	Mar. 9	d	c	.2	280.6	160.6	120.	30.	30.	3.	12.6	7.5	5.1	.204	.64	.24	.4	1.39	.51	.88	.02	.3
2006	" 15	" 16	d	c	.3	516.8	180.8	336.	49.8	31.2	2.	18.3	7.4	10.9	.352	.8	.24	.56	1.71	.67	1.04	.04	1.1
2034	" 22	" 23	d	m	.5	534.	162.	372.	57.2	20.4	2.	25.3	8.9	16.4	.144	1.28	.32	.96	2.2	.68	1.52	.04	1.
2064	" 29	" 30	v d	m	.4	451.2	163.2	288.	48.	28.2	1.6	26.7	8.	18.7	.264	.56	.4	.16	2.04	.76	1.28	.025	.9
2091	April 5	Apr. 6	v d	m	1.	340.4	146.	194.4	29.2	16.4	1.6	19.8	8.2	11.6	.176	.56	.168	.392	1.4	.67	.73	.04	1.
2110	" 12	" 13	d	c	.3	207.2	144.8	62.4	22.	21.4	2.	11.4	7.5	3.9	.104	.4	.08	.32	1.05	.6	.45	.028	1.1
2130	" 19	" 20	d	l	.5	167.2	116.4	50.8	20.4	17.2	1.4	13.	8.4	4.6	.032	.4	.208	.192	.88	.6	.28	.03	.6
2155	" 26	" 27	d	c	.3	227.2	126.	101.2	32.	26.	1.6	16.	9.2	6.8	.008	.48	.256	.224	1.19	.55	.64	.025	.6
2178	May 3	May 4	d	c	.4	181.6	138.8	42.8	22.	14.	1.	12.5	9.3	3.2	.016	.56	.272	.288	1.11	.55	.56	.035	.35
2201	" 10	" 11	d	c	......	186.8	141.6	45.2	22.8	20.4	1.6	15.2	12.3	2.9	.076	.48	.368	.112	.95	.71	.24	.04	.3
2218	" 17	" 18	d	c	.3	207.	148.4	58.6	24.	17.6	1.4	15.8	12.7	3.1	.04	.72	.224	.496	.91	.67	.24	.025	.3
[illegible]	" 24	" 25	d	c	.3	211.6	161.2	50.4	25.6	16.8	1.2	13.	12.1	.9	.036	.48	.208	.272	1.07	.6	.47	.03	.3
[illegible]	" 31	June 1	d	c	.2	226.4	165.2	61.2	19.2	16.	1.6	15.8	12.1	3.7	.02	.56	.4	.16	.91	.67	.24	.02	.3
[illegible]	June 7	" 8	d	c	.3	198.4	147.6	50.8	26.	22.8	2.	17.2	14.6	2.6	.036	.72	.48	.24	1.37	1.05	.32	.027	.15
[illegible]	" 14	" 15	d	c	.3	206.	150.	56.	26.8	16.8	1.6	16.5	13.2	3.3	.084	.4	.272	.128	1.05	.73	.32	.03	.35
[illegible]	" 21	" 22	d	c	.3	232.	142.	90.	24.4	19.2	1.6	16.6	14.4	2.2	.044	.56	.4	.16	.99	.57	.42	.035	.3
[illegible]	" 28	" 29	d	c	.2	311.2	174.	137.2	24.	22.	1.	17.8	12.1	5.7	.012	.56	.208	.352	.9	.41	.49	.03	.4
2418	July 6	July 7	v d	m	.15	374.8	193.2	181.6	33.2	22.	1.4	20.6	15.	5.6	.016	.76	.272	.488	1.3	1.	.3	.01	.4
[illegible]	" 12	" 13	d	c	.1	248.8	158.	90.8	16.	14.8	2.2	16.	13.3	2.7	.012	.4	.32	.08	1.38	.94	.44	.026	.3
[illegible]	" 19	" 20	d	c	.5	380.	164.4	215.6	28.	23.2	1.4	21.4	14.2	7.2	.016	.72	.4	.32	1.36	.39	.97	.03	.45
[illegible]	" 26	" 27	d	c	.1	280.	175.2	104.8	26.	18.	.8	18.4	14.	4.4	.018	.48	.416	.064	1.24	.68	.56	.01	.2
[illegible]	Aug. 2	Aug. 3	d	c	.6	287.2	222.	65.2	28.	22.	1.	18.8	16.	2.8	.03	.32	.416	.004	1.08	.88	.2	.006	.8

2540	Aug. 9	Aug. 10	d	c	.3	241.2	168.2	73.	19.2	17.2	1.4	18.	16.	2.	.014	.24	.324	.234	1.24	1.	.34	.006	.4
2567	" 16	" 17	d	c	.8	204.	143.2	60.8	20.8	20.	1.2	19.2	18.	1.2	.012	.36	.448	.312	1.	.68	.32	.005	.3
2588	" 23	" 24	d	c	.4	248.	161.2	86.8	20.	18.4	2.	18.3	17.4	.9	.028	.56	.512	.016	1.06	.66	.4	.008	.3
2614	" 30	" 31	d	c	.4	220.	168.8	51.2	23.2	18.8	2.3	17.9	15.3	2.6	.026	.32	.32	.2	.98	.58	.4	.002	.15
2638	Sept. 6	Sept. 7	d	c	.3*.5	212.4	168.4	44.	14.4	12.	2.5	15.2	14.5	.7	.018	.52	.32	.2	.82	.46	.36	.002	.2
2664	" 13	" 14	d	c	.6	233.2	171.6	61.6	13.2	12.8	2.5	14.8	12.3	2.5	.044	.52	.32	.2	.98	.54	.44	.014	.5
2688	" 20	" 21	d	c	.2	223.2	181.6	41.6	13.2	12.	2.5	13.7	11.2	2.5	.008	.4	.28	.12	....	.54	...	.004	.1
2724	" 28	" 29	d	c	.1	244.	178.8	65.2	17.2	14.	2.6	12.4	9.9	2.5	.012	.44	.3	.14	.7	.54	.16	.012	.55
2756	Oct. 5	Oct. 6	d	c	.2	216.4	170.	46.4	21.2	16.8	2.6	13.7	11.4	2.3	.018	.44	.28	.16	.78	.5	.28	.008	.1
2784	" 12	" 13	d	c	.07	247.2	176.8	70.4	21.2	16.	2.4	14.4	8.8	5.6	.006	.4	.32	.18	.86	.5	.36	.02	.12
2815	" 18	" 19	d	c	.1	233.6	180.4	53.2	19.2	16.	2.6	13.	8.5	4.5	.004	.44	.24	.2	.94	.5	.44	.014	.1
2842	" 25	" 26	d	c	.1	234.	178.8	55.2	17.2	13.2	2.5	12.8	10.4	2.4	.003	.44	.2	.24	.7	.5	.2	none	.06
2916	Nov. 7	Nov. 9	d	l	.2*.25	182.8	156.8	26.	28.	19.2	2.3	12.5	10.5	2.	.008	.36	.2	.14	.58	.42	.16	.001	.05
2950	" 15	" 16	d	c	.09	184.8	161.6	23.2	22.8	17.2	2.4	12.6	9.3	3.3	.003	.28	.2	.08	.54	.42	.12	.001	.12
2984	" 22	" 25	d	c	.07*.1	186.8	175.2	11.6	18.	12.8	2.5	9.6	7.9	1.7	.001	.24	.2	.04	.5	.42	.08	none	.45
3005	" 29	Dec. 1	d	c	.1*.2	181.2	179.6	1.6	22.	20.8	2.7	10.2	9.2	1.	.004	.32	.24	.08	.53	.38	.2	.002	.55
3025	Dec. 6	" 7	d	l	.08*.1	238.	224.8	3.2	22.	20.4	3.9	9.2	8.	1.2	.118	.32	.176	.144	....	.41	...	none	.17
3058	" 13	" 14	d	l	.1*.15	200.	194.4	5.6	20.	16.	3.7	8.5	7.	1.5	.05	.28	.22	.08	.60	.37	.32	.004	.4
3078	" 20	" 21	d	l	.1*.2	216.	208.	8.	24.8	21.2	3.2	8.5	7.5	1.	.002	.32	.22	.1	.61	.33	.28	none	.1
3096	" 27	" 28	d	l	.1*.2	219.2	208.	11.2	18.8	17.2	2.8	8.8	7.1	1.7	.002	.28	.144	.136	.61	.37	.24	.006	.24
Average Feb. 15—June 28						283.1	155.4	127.6	20.1	21.	1.8	15.1	10.1	4.9	.098	.59	.311	.279	1.21	.64	.56	.019	.57
Average July 6—Dec. 27						245.7	177.	65.1	20.3	17.1	2.2	14.3	10.9	3.4	.014	.46	.214	.234	.32	.09	.13	.007	.25
Average Feb. 15—Dec. 27						262.	167.7	94.3	24.1	19.2	1.9	14.6	10.5	4.1	.05	.52	.266	.257	.90	.07	.32	.016	.41

The water in all cases was odorless. The Color upon ignition was brown.

*Not filtered.

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT QUINCY.

(Parts per 1,000,000.)

Serial Number.	1896		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved.	Suspeuced	Nitrites.	Nitrates.
	Collection.	Examination							Total.	Dissolved.						Total.	Dissolved.	Suspended					
3121	Jan. 3	Jan. 4	d	l	.06*.1	207.2	193.2	14.	19.2	15.2	2.6	7.1	6.	1.1	.008	.352	.176	.176	.65	.33	.33	.001	.11
3149	" 10	" 11	d	l	.06*.1	208.	197.2	10.8	19.2	18.4	2.6	7.7	6.	1.7	.006	.32	.192	.128	.68	.28	.4	.001	.18
3170	" 17	" 18	v d	v m	.15	374.8	179.2	195.6	40.8	18.	3.4	18.5	7.8	10.7	.078	.64	.224	.416	1.48	.4	1.08	.08	.35
3207	" 24	" 25	d	c	.4	263.6	204.	59.6	27.6	24.	4.5	13.5	8.9	4.6	.212	.44	.32	.12	1.	.56	.44	.06	.45
3218	" 31	Feb. 1	d	c	......	226.8	198.8	28.	30.	28.	3.1	9.3	8.4	.9	.092	.44	.272	.168	.8	.48	.32	.12	.7
3245	Feb. 7	" 8	d	c	.3	218.8	202.8	16.	27.2	25.6	3.4	8.	6.6	1.4	.04	.4	.22	.18	.76	.48	.28	.004	.24
3270	" 14	" 16	d	c	.2	300.8	188.4	112.4	23.6	20.	2.8	13.5	7.1	6.4	.158	.48	.2	.28	1.08	.56	.52	.04	.6
3290	" 21	" 22	d	c	.2	204.8	145.2	59.6	24.	20.4	2.5	12.	8.2	3.8	.25	.48	.32	.16	.92	.52	.4	.006	.4
3310	" 28	Mar. 1	d	c	.3	180.8	149.2	31.6	22.8	18.4	2.8	9.	7.4	1.6	.228	.32	.24	.08	.84	.6	.24	.003	.55
3326	Mar. 6	" 8	d	c	.2	246.8	185.2	61.6	17.2	15.2	2.7	11.5	6.7	4.8	.134	.48	.28	.2	1.	.52	.48	.008	.55
3358	" 14	" 15	d	m	.2	544.	167.6	376.4	34.	21.2	2.6	17.3	7.	10.3	.172	.8	.32	.48	1.72	.52	1.2	.016	.55
3381	" 21	" 22	v d	v m	.4	612.8	167.6	445.2	38.	18.	2.6	24.5	8.1	16.4	.182	.92	.36	.56	2.04	.76	1.28	.035	.6
3424	April 4	April 5	d	c	.1	384.	183.6	200.4	37.2	19.2	2.6	16.	8.5	7.5	.01	.68	.32	.36	1.65	.65	1.	.02	.55
3444	" 11	" 12	d	c	.1	290.4	168.	122.4	32.4	28.8	2.8	15.6	8.	7.6	.024	.72	.24	.48	1.65	.81	.84	.008	.55
3469	" 18	" 19	d	c	.1	257.6	168.8	88.8	29.6	22.	4.8	13.3	8.	5.3	.03	.56	.272	.288	1.25	.65	.6	.003	.5
3497	" 25	" 26	d	c	.06	292.	146.	146.	27.6	16.	2.6	14.7	7.7	7.	.02	.6	.24	.36	1.05	.65	.4	.008	.5
3527	May 1	May 3	d	c	.2	428.	174.4	253.6	35.2	16.	2.8	18.2	10.8	7.4	.044	.72	.4	.32	1.34	.82	.52	.014	.2
3549	" 9	" 10	d	c	.2	219.2	164.	55.2	30.4	24.	2.5	13.2	9.4	3.8	.038	.44	.32	.12	.98	.54	.44	.002	.3
3582	" 16	" 17	d	m	.5	478.8	151.2	327.6	44.	31.2	2.4	18.3	9.1	9.2	.064	.88	.44	.44	1.94	.66	1.28	.02	.4
3609	" 23	" 24	d	c	.2	442.	141.6	300.4	34.	19.2	2.5	17.6	8.5	9.1	.054	.8	.48	.32	1.86	.86	1.	.04	.3
3635	" 30	June 1	d	c	.06	313.6	174.4	139.2	19.6	16.	3.	12.8	7.3	5.5	.054	.4	.24	.16	1.14	.58	.56	.023	.35
3656	June 6	" 7	d	c	.05	337.6	168.	169.6	30.	29.2	2.6	15.2	7.6	7.6	.014	.52	.28	.24	1.16	.72	.44	.065	.25
3684	" 13	" 14	d	c	......	456.4	166.	290.4	28.4	22.8	2.3	16.7	7.6	8.1	.018	.56	.24	.32	1.36	.52	.84	.06	.4
3706	" 20	" 21	d	m	......	341.2	184.8	156.4	22.8	21.6	3.	13.	8.5	5.	.02	.4	.28	.12	1.04	.64	.4	.024	.45
3753	" 28	" 29	d	c	.2	345.2	.....	.....	28.	....	3.	18.3	9.5	8.8	.006	.56	.28	.28	1.	.52	.48	.036	.3
3784	July 5	July 6	d	c	.2	294.8	171.6	123.2	26.	24.	4.4	16.2	13.	3.2	.034	.48	.28	.2	1.28	.6	.68	.03	.2
3809	" 11	" 12	d	c	.1	323.2	166.4	56.8	26.	16.	2.5	15.4	12.3	3.1	.014	.52	.4	.12	.92	.72	.2	.002	.2

*Not filtered.

Chemical Examination of Water from the Mississippi River at Quincy.—Continued.

(Parts per 1,000,000.)

Serial Number	1898 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved.		Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Dissolved.	Albuminoid Ammonia. Suspended	Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
3834	July 18	July 19	d	l	.1*.2	228.4	153.6	74.8	20.8	18.	1.6	14.5	12.2	2.3	.01	.48	.28	.2	.68	.4	.28	.001	.1
3873	" 25	" 26	d	c	.05*.4	201.6	154.8	46.8	16.	14.	2.2	14.2	13.	1.2	.006	.44	.28	.16	.88	.48	.4	none	.15
3899	Aug. 1	Aug. 2	d	c	.04*.2	195.2	158.	37.2	20.8	16.	2.	13.3	12.3	1.	.008	.36	.28	.08	.72	.44	.28	"	.35
3932	" 8	" 9	d	c	.04	228.	160.	68.	20.8	20.	2.5	13.2	8.8	4.4	.004	.52	.36	.16	.88	.48	.4	.001	.075
3953	" 15	" 16	d	m	.04	412.	146.	266.	34.	21.2	2.2	16.	11.5	4.5	.02	.64	.4	.24	1.2	.72	.48	.03	.15
3988	" 23	" 24	d	c	.05	306.8	155.2	151.6	25.2	22.	2.2	11.3	6.1	5.2	.018	.44	.24	.2	.88	.4	.48	.08	.35
4021	" 30	Sept. 2	d	c	.04	245.2	171.2	74.	22.	20.	2.7	10.7	7.5	3.2	.046	.36	.28	.08	.84	.....	.....	.01	.2
4048	Sept. 6	" 7	d	m	.04	603.6	153.2	450.4	29.2	20.	2.6	16.5	7.3	9.2	.028	.64	.28	.36	1.36	.32	1.04	.006	.1
4067	" 12	" 13	d	c	.04	229.2	169.2	60.	22.	18.	2.8	9.9	6.7	3.2	.014	.36	.24	.12	.72	.36	.36	.002	.15
4090	" 19	" 20	d	c	.04	235.2	171.2	64.	28.	20.	2.6	11.	6.8	4.2	.01	.4	.18	.22	.72	.28	.44	.002	.2
4120	" 26	" 27	d	c	.6	392.8	231.2	161.6	26.	18.	2.8	13.4	7.	6.4	.074	.56	.24	.32	1.2	.464	.736	.012	.25
4168	Oct. 4	Oct. 5	d	c	.04	235.6	179.6	56.	26.	22.	3.1	8.6	5.7	2.9	.016	.36	.24	.12	.72	.36	.36	.02	.3
4193	" 11	" 12	d	c	.05	236.	176.	60.	26.	22.	2.7	11.2	6.1	5.1	.016	.4	.2	.2	.73	.33	.4	.013	.25
4247	" 23	" 25	d	l	.08	198.	172.	26.	20.	16.	2.5	7.2	5.3	1.9	.012	.28	.16	.12	.53	.29	.24	.002	.125
4294	" 31	Nov. 1	d	c	.04	198.	168.	30.	22.	18.	3.	6.8	5.	1.8	.012	.304	.144	.16	.57	.258	.312	.004	.25
4337	Nov. 8	" 9	d	c	.06	196.8	172.	24.8	34.	26.	2.6	8.1	6.4	1.7	.022	.32	.192	.128	.55	.35	.2	.003	.4
4369	" 15	" 16	d	l	.08*.07	182.8	174.	8.8	24.	22.	3.	7.3	6.2	1.1	.004	.28	.144	.136	.51	.31	.2	.003	.15
4395	" 21	" 22	d	c	.08	188.	172.8	15.2	20.	16.	3.4	8.6	6.8	1.8	.028	.32	.208	.112	.63	.37	.26	.002	.3
4426	" 28	" 29	s	l	.07*.2	198.8	189.2	9.6	34.	23.2	4.	8.6	7.1	1.5	.014	.32	.176	.144	.59	.35	.24	none	.4
4453	Dec. 5	Dec. 6	d	l	.08	232.	194.	38.	35.2	26.	4.8	8.6	6.7	1.9	.086	.288	.144	.144	.65	.37	.28	.004	.15
4481	" 13	" 14	d	l	.08	228.8	218.	10.8	38.8	32.	3.4	8.7	7.	1.7	.004	.368	.16	.208	.65	.29	.36	none	.1
4505	" 20	" 21	d	l	.03*.06	222.8	212.8	10.	36.	34.8	4.	8.3	6.8	1.5	.016	.352	.144	.208	.61	.37	.24	.001	.1
Average Jan. 3—June 28						327.	166.7	160.3	33.2	20.8	2.9	14.1	7.9	7.7	.077	.556	.286	.27	1.215	.585	.63	.025	.405
Average July 5—Dec. 20						258.9	174.5	84.3	28.	21.4	2.7	11.1	8.2	2.8	.024	.408	.235	.173	.792	.346	.446	.009	.208
Average Jan. 3—Dec. 20						293.6	170.5	123.1	30.6	20.8	2.9	12.6	8.1	4.5	.052	.483	.261	.222	1.008	.488	.519	.017	.31

The water in all cases was odorless. The Color upon ignition was brown.

*Not filtered.

8566

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT QUINCY.

(Parts per 1,000,000.)

Serial Number.	1899 Date of Collection.	1899 Date of Examination	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Ammonia. Total.	Nitrogen as Ammonia. Albuminoid Ammonia. Dissolved.	Nitrogen as Ammonia. Albuminoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspeuced	Nitrogen as Nitrites.	Nitrogen as Nitrates.
4565	Jan. 3	Jan. 4	d	l	.04	225.2	205.2	20.	32.4	30.	3.4	11.5	7.3	4.2	.024	.4	.176	.224	.73	.37	.36	.001	.1
4592	" 9	" 10	d	c	.04	226.8	198.4	28.4	30.	26.4	3.5	8.3	7.6	.7	.02	.336	.176	.16	.69	.41	.28	.006	.15
4699	" 13	" 14	d	l	.05*.3	248.	238.	10.	38.	28.	4.9	8.9	6.5	2.4	.022	.368	.176	.192	.74	.3	.44	.004	.3
4769	Mar. 2	Mar. 3	d	c	....	298.8	160.8	138.	30.	24.	3.4	15.2	8.6	6.6	.154	.44	.24	.2	1.1	.46	.64	.03	.4
4952	Apr. 18	Apr. 19	d	c	.3	238.	141.2	96.8	30.	25.2	3.	12.9	8.2	4.7	.294	.44	.24	.2	.83	.47	.36	.02	.5
5088	May 24	May 25	v d	m	.4	354.2	149.2	205.	30.8	13.2	2.3	21.1	14.4	6.7	.18	.72	.352	.368	1.21	.7	.51	.007	1.04
5196	June 12	June 13	d	c	.5	436.4	166.2	319.2	41.2	18.4	1.8	21.7	11.6	9.5	.018	.64	.32	.32	1.48	.664	.816	.007	.52
5680	Aug. 22	Aug. 23	d	c	.15	248.8	166.8	82.	46.4	30.2	2.7	12.5	10.	2.5	.024	.432	.192	.24	1.	.408	.502	.007	.08
5909	Sept. 20	Sept. 21	d	c	.07	315.6	231.2	84.4	38.	20.2	1.7	13.8	8.2	5.6	.016	.252	.192	.16	1.	.344	.656	.006	.12
6085	Oct. 17	Oct. 18	d	c	.04	204.	154.	50.	20.4	19.2	3.	11.4	10.3	1.1	.124	.304	.24	.064	.872	.392	.48	.005	.16
6518	Dec. 13	Dec. 14	d	c	.3	164.	137.2	26.8	20.	18.8	3.	11.9	10.9	1.	.036	.384	.24	.144	.904	.584	.32	.008	.24
Average Jan. 3—June 12						296.7	179.8	116.9	33.2	23.6	3.1	14.2	9.1	5.	.101	.477	.24	.237	.968	.482	.446	.011	.43
Average Aug. 22—Dec. 13						233.1	172.3	60.8	31.2	26.6	2.6	12.4	9.8	2.5	.075	.443	.216	.227	.944	.432	.512	.006	.15
Average Jan. 3—Dec. 13						273.6	177.1	96.5	31.7	24.6	2.9	13.5	9.4	4.1	.092	.465	.231	.234	.950	.463	.495	.009	.32

Not filtered.

CHEMICAL EXAMINATION OF WATER FROM THE MISSISSIPPI RIVER AT QUINCY.

(Parts per 1,000,000.)

Serial Number.	1900. Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.							Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
6729	Jan. 22	Jan. 23	d	m	.05	254.4	170.8	83.6	30.8	14.	2.4	14.3	9.4	4.9	.072	.48	.192	.288	1.04	.48	.56	.006	.5
7057	Mar. 12	Mar. 13	v d	v m	.08	1248.4	93.2	1155.2	58.4	10.4	.8	24.	5.4	18.6	.24	1.088	.16	.928	2.64	.352	2.288	.007	.48
7326	Apr. 16	Apr. 17	d	c	.3	238.4	125.6	112.8	24.	20.8	.8	12.2	7.6	4.6	.128	.368	.208	.16	1.	.504	.496	.016	.56
7538	May 15	May 16	d	c	.2	266.8	148.	118.8	27.6	26.8	2.6	15.1	10.6	4.5	.062	.448	.16	.288	1.156	.292	.864	.005	.16
8016	July 24	July 25	d	v m	.03	468.4	136.4	332.	56.	26.4	2.2	17.7	9.2	8.5	.102	.56	.16	.4	.98	.292	.678	.001	.6
8248	Aug. 20	Aug. 22	d	c	.2	576.4	144.	432.4	62.4	19.2	3.1	17.6	7.4	10.2	.126	.704	.224	.48	1.34	.332	1.008	.012	1.24
8602	Oct. 2	Oct. 3	d	c	1.3	246.	148.	98.	51.2	22.8	1.	27.2	17.9	9.3	.138	.416	.384	.032	1.216	.576	.64	.001	.24
8679	" 19	" 20	d	c	1.	250.	126.8	23.2	46.8	39.6	1.6	24.7	22.	2.7	.158	.464	.272	.194	.992	.608	.384	.004	.276
8826	Nov. 26	Nov. 27	d	c	.8	161.2	138.4	22.8	27.6	20.4	1.4	17.5	16.5	1.	.076	.288	.208	.08	.592	.48	.112	.007	.353
Average Jan. 22—May 15						502.	109.4	392.6	35.2	18.	1.4	16.4	8.2	8.2	.125	.596	.18	.416	1.450	.409	1.05	.008	.45
Average July 24—Nov. 26						340.4	138.7	101.7	48.8	28.	1.8	20.9	14.6	6.3	.124	.486	.249	.237	1.024	.457	.567	.005	.341
Average Jan. 22—Nov. 26						412.2	125.5	285.6	42.7	24.	1.7	18.9	11.7	7.2	.122	.535	.218	.317	1.106	.436	.67	.006	501

The water in all cases was odorless. The Color upon ignition was brown.

MISSISSIPPI RIVER AT QUINCY—1901-02-03.

DEPARTMENT OF CHEMISTRY, UNIVERSITY OF ILLINOIS.
SANITARY WATER ANALYSIS.—PARTS PER MILLION.—NO. 68.—A. W. P.

Serial number	Date of		Appearance.			Odor	Residue on Evaporation.						Color on ignition	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
										Loss on Ignition.									Alb'minoid Ammonia.							
	Collection	Examination	Turbidity	Sediment	Color		Total	Dissolved	Suspended	Total	Dissolved	Suspend'd			Total	By dissolved	By suspended matter	Free amm'nia	Total	Diss'l'ed	Susp'ded	Total	Dissolved	Suspended	Nitrites	Nitrates
9060	1901. Mar. 28	1901. Mar. 29	Distinct.	Little.	.02	None	30.4	......	......	40.6	.....	.....	White.	.6	4.7	.....	.....	.144	.054	....	....	...	....	....	.005	.155
9357	Sept. 6	Sept. 7	Decided.	Consid	Muddy F.1	"	225.2	165.2	60.	37.6	28.4	9.2	Brown	3.6	15.2	12.6	2.6	.186	.368	.336	.032	.784	.736	.048	.008	.232
9375	13	14	"	"	Muddy F.3	"	185.6	151.6	34.	18.	18.	0.0	"	3.8	13.1	12.4	.7	.168	.32	.176	.144	....	....	....	.000	.034
9731	Nov. 12	Nov. 13	Distinct.	Little.	.4	"	143.2	134.4	8.8	28.	26.8	1.2	"	4.	12.4	9.3	3.1	.064	.304	.192	.112	....	....	....	None	.08
9852	22	23	....	....	....	....	132.4	128.4	4.	32.	26.6	2.4	"	4.45	9.7	8.4	1.3	.036	.256	.16	.096	....	....	....	.001	.12
9987	Dec. 4	Dec. 5	Decided.	Consid	F 2 Muddy	None	170.4	176.	......	26.4	22.4	4.	"	7.55	13.3	9.2	4.1	.144	.384	.224	.16	...	....	....	.005	.2

No. 69.—A. W. P.

10180	1902. Jan. 13	1902. Jan. 14	Distinct.	Little.	F.3 Muddy	None	204.	193.2	10.8	15.2	26.4	....	Brown	4.3	11.	8.9	2.1	.024	.32	.224	096	....	....	....	.001	.08
10231	Feb. 1	Feb. 3	''	''	F.2 .2	''	205.6	196.8	8.8	26.8	24.8	2.	''	4.35	8.1	7.6	.5	.235	.192	.128	.064	....	....	....	.003	.377
10350	Apr. 10	Apr. 12	''	''	Muddy	''	171.6	143.2	28.4	16.	20.8	....	''	2.7 2.9	13.3	8.6	4.7	.084	.336	.208	.128	...	....	....	.001	.15
10354	16	17	Decided.	''	F.3 Muddy	''	161.6	143.6	18.	24.8	24.	.8	''	2.75	10.8	8.9	1.9	.064	.272	.16	.112	....	....	....	None	.16
10381	May 2	May 5	''	Much..	F.05 Muddy	''	333.6	164.8	186.8	30.8	27.6	3.2	''	4.65	12.8	6.7	6.1	.172	.448	.16	.288	....	....	...	.02	.18
10391	9	10	''	''	F.1 Muddy	''	556.8	155.6	401.2	45.6	29.2	16.4	''	2.95	16.6	7.5	9.1	.12	.544	.192	.352	....	....	....	.015	.285
10481	June 26	June 27	''	Consid	F.6 Muddy	''	613.2	167.6	445.6	71.2	34.	37.2	''	2.3	18.7	12.	6.7	.092	.776	.224	.552	....	....	....	.005	.995
10485	27	28	''	Much..	F.5 Muddy	''	352.8	170.4	182.4	42.8	35.6	7.2	''	2.2	17.2	12.6	4.6	.008	.56	.224	.336	....	....	....	.012	.488
10500	July 11	July 12	''	''	F.4 Muddy	''	632.8	168.	464.8	68.	32.	36.	''	2.95	10.5	9.5	10.	.098	.688	.192	.496	....	....	....	.011	.509
10528	July 31	Aug. 1	''	Decid.	F.4 Muddy	''	453.2	183.6	269.6	43.2	39.6	3.6	''	2.925	18.1	7.6	10.5	.06	.576	.272	.304	....	....	....	.009	.711
10550	Aug. 13	Aug. 14	''	Much..	Muddy	''	371.6	186.4	185.2	40.8	35.6	5.2	''	2.725	15.4	10.4	5.	.08	.448	.144	.304	....	....	....	.004	.376
10599	Sept. 5	Sept. 6	''	Consid	F.2 Muddy	''	261.2	200.4	60.8	40.8	36.4	4.4	''	2.85	11.9	9.4	2.5	.088	.352	.208	.144	....	....	....	.001	.34
10651	Sept. 30	Oct. 1	''	''	F.2 Muddy	''	369.6	157.2	212.4	34.	24.4	9.6	''	3.2	13.7	9.5	4.2	.152	.416	.128	.288	...	....	....	.014	.38
10658	Oct. 1	Oct. 2	''	''	F.2 Muddy	''	330.	157.2	172.8	47.2	31.2	16.	''	2.9	9.1	7.4	1.7	.064	.368	.144	.224	....	....	....	.03	.37
10665	3	4	''	''	F.2 Muddy	''	353.6	190.8	162.8	65.6	41.2	24.4	''	2.9	12.8	8.5	4.3	.1	.384	.256	.128	....	....	....	.01	.39
10725	Oct. 31	Nov. 1	''	''	F.5 Muddy	Musty	307.2	211.6	95.6	30.8	30.8	....	''	3.15	10.4	7.	3.4	.064	.376	.144	.192	....	....	....	.003	.397
10757	Nov. 14	Nov. 15	''	''	F.1 Muddy	None	242.	192.8	49.2	30.	28.8	1.2	''	3.2	9.1	8.4	.7	.052	.288	.144	.144	....	....	....	.001	.379
10806	Dec. 18	Dec. 19	''	''	F.5 F.6	''	248.4	238.	10.4	42.	38.4	3.6	''	5.3	9.5	9.4	.1	.252	.288	.192	.096	....	....	....	.002	.5
10829	30	31	''	''	F.4 Muddy	Musty	267.6	250.8	16.8	40.	29.2	10.8	''	4.3	9.6	8.1	1.5	.228	.304	.288	.016	....	....	....	.01	.59

8570

No. 70.—A. W. P.

Serial number	Date of		Appearance.			Odor	Residue on Evaporation.						Color on ignition	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
										Loss on Ignition.									Alb'minoid Ammonia.							
	Collection	Examination	Turbidity	Sediment	Color		Total	Dissolved	Suspended	Total	Dissolved	Suspend'd			Total	By dissolved	By suspended matter	Free amm'nia	Total	Diss'l'ed	Susp'ded	Total	Dissolved	Suspended	Nitrites	Nitrates
10836	1903. Jan. 3	1903. Jan. 5	Decided.	Little..	Muddy	None.........	254.	244.	10.	29.6	28.	1.6	Brown	4.7	9.	7.8	1.2	.248	.256	.192	.064	....	....	....	.01	.71
10842	9	10	....	....	....	....	246.8	249.6	.....	29.6	27.2	2.4	"	4.8	11.4	10.5	.9	.176	.192	.176	.016	....	....	....	.011	.709
10844	10	12	....	....	....	....	240.	242.	.....	43.6	38.4	5.2	"	4.7	9.4	9.3	.1	.24	.224	.192	.032	....	....	...	.011	.829
10850	14	15	Distinct.	Little..	F.4 Muddy	None.........	260.4	256.	6.4	39.2	38.	1.2	"	4.75	8.2	6.6	1.6	.192	.176	.128	.048	....	....	....	.007	.093
10861	Feb. 4	Feb. 5	Decided.	Consid	F.2 Muddy	Decid muddy	224.8	213.6	11.2	26.8	21.6	5.2	"	4.7	10.3	7.1	3.2	.4	.256	.224	.032	....	....	....	.007	.673
10884	6	7	"	"	F.3 Muddy	None.........	223.6	178.8	44.8	28.8	25.2	3.6	"	4.1	9.4	6.1	3.3	.4	.288	.192	.096	....	....	....	.009	.471
10960	Mar. 26	Mar. 27	"	Much..	F.4 Muddy	"	484.8	254.4	230.4	24.4	10.	14.4	"	2.7	18.	9.8	3.7	.128	.64	.256	.384	....	....	....	.016	.544
11048	May 8	May 9	"	Consid	F.4 Muddy	Musty........	254.8	165.6	89.2	24.8	20.	4.8	"	2.3	15.2	12.6	2.6	.052	.4	.304	.096	....	....	....	.003	.24
11151	June 17	June 18	"	"	F.6 Muddy	None.........	270.	170.	100.	45.	33.	12.	"	1.8	18.1	15.8	2.3	.128	.336	.288	.048	....	....	....	.001	.28
11178	July 8	July 8	"	"	FE Muddy	Vegetable....	284.4	196.4	80.0	32.8	22.4	10.4	"	2.8 2.8 2.	12.8	11.2	1.6	.096	.32	.24	.03	....	...	....	.007	.133
11218	22	23	"	"	F. Muddy	None.........	310.	168.4	141.6	36.4	6.8	29.6	"	1.95	16.2	14.5	1.7	.1	.336	.240	.096	....	....	....	.005	.315
11298	Aug. 17	Aug 18	"	"	F.4 Muddy	"	292.	188.	104.	408.	33.6	7.2	"	2.1	14.4	12:4	2.	.02	.368	.208	.160	....	....	....	.002	.36

8571

CHEMICAL EXAMINATION OF WATER FROM THE KANKAKEE RIVER AT WILMINGTON.

(Parts per 1,000,000.)

Serial Number.	1897 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
									Loss on Ignition.						Free Ammonia.	Albuminoid Ammonia.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r		Total.	Dissolved	Suspended	Total.	Dissolved	Suspended	Nitrites.	Nitrates.
1804	Jan. 8	Jan. 9	v d	m	.8	391.6	219.2	172.4	25.2	15.2	2.2	19.7	12.2	7.5	.024	.8	.48	.32	1.44	.88	.56	.033	2.5
1817	" 12	" 13	d	l	...	271.2	251.6	19.6	20.8	14.	2.5	11.7	....	....	.024	.28	....	......	.88	...	....	.02	3.4
1836	" 19	" 20	d	c	...	290.4	244.8	45.6	14.8	12.8	2.2	13.1	....	....	.026	.32	....	......	.8	..	....	.012	2.6
1862	" 30	Feb. 1	s	l	.4	269.6	268.8	.8	12.4	11.2	2.8	12.5	....	....	.022	.24	....	......	.68	...	....	.008	2.2
1905	Feb 10	" 12	s	l	.4	280.	268.4	11.6	14.4	14.	2.5	12.3	....	....	.06	.36	....	......	.88	...	....	.012	1.7
1924	" 16	" 18	d	l	.25	273.2	259.2	14.	9.6	6.8	3.	9.3	....	....	.07	.32	....	......	.64	...	....	.01	1.8
1934	" 22	" 24	d	c	...	422.	195.2	226.8	44.	24.	1.6	14.8	....	....	.046	.56	....	......	1.36	...	....	.055	2.4
1979	Mar. 8	Mar. 10	d	c	...	301.6	182.8	118.8	38.8	30.4	2.	13.9	....	....	.052	.4	....	......	.83	...	....	.035	1.7
1990	" 12	" 13	v d	m	.4	644.	176.	468.	75.2	38.8	2.6	36.	8.6	27.4	.028	1.32	.224	1.096	2.48	.83	1.65	.045	2.4
2020	" 16	" 18	d	c	...	240.4	193.2	47.2	44.	41.2	1.5	12.7	....	....	.028	.4	....	......	.71	...	....	.045	2.1
2045	" 25	" 26	d	c	...	229.2	190.	39.2	34.4	30.	1.8	12.2	....	....	.002	.32	....	......	.75	...	....	.02	2.
2064	" 31	Apr. 1	d	l	.4	214.	193.2	20.8	29.2	28.	1.6	11.9	....	....	.004	.32	....	......	.75	...	....	.003	1.8
2099	Apr. 7	" 8	d	l	.4	222.4	211.2	11.2	35.2	21.2	1.6	12.6	....	....	.018	.36	....	......	.83	...	....	.003	1.4
2200	May 10	May 11	d	l	.2	286.8	261.2	25.6	26.8	21.2	2.	4.9	....	....	.016	.36	....	......	1.03	...	....	.006	1.3
Average Jan. 8—May 10.........						309.	222.4	87.3	30.3	22.	2.1	14.8	10.4	17.4	.03	.45	.352	.708	1.01	.85	1.1	.021	2.09

The water in all cases was odorless. The color upon ignition was brown.

8572

Chemical Examination of Water from the Kankakee River at Wilmington.

(Parts per 1,000,000.)

Serial Number.	1899 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved	Suspended	Nitrites.	Nitrates.
									Total.	Dissolved						Total.	Dissolved	Suspended					
5156	June 5	June 6	d	c	.5	326.8	264.4	62.4	30.4	29.6	3.7	17.1	13.	4.1	.072	.56	.364	.196	1.29	.92	.39	.026	1.32
5200	" 12	" 13	d	c	.5	346.4	289.6	56.8	46.8	42.8	2.	19.5	17.5	2.	.128	.684	.608	.076	1.48	1.176	.304	.009	.76
5255	" 20	" 21	d	c	.4	317.2	299.6	17.6	24.8	22.8	2.	19.5	16.6	2.9	.06	.544	.448	.096	1.32	1.024	.296	.005	.48
5292	" 26	" 27	d	c	.3	350.8	298.4	52.4	24.8	12.8	2.	18.9	16.3	2.6	.042	.48	.368	.112	1.24	.952	.288	.001	.12
5382	July 10	July 11	d	c	.15	292.4	260.4	32.	42.4	32.4	3.9	10.2	7.5	2.7	.044	.384	.24	.144	.92	.6	.32	.01	.52
5424	" 17	" 18	d	c	.05	364.4	332.8	31.6	67.2	60.	3.2	11.8	10.2	1.6	.076	.352	.256	.096	1.016	.824	.192	.06	3.6
5479	" 24	" 25	d	1	.15	298.8	263.2	35.6	39.6	35.2	3.7	11.4	9.2	2.2	.016	.48	.256	.224	.84	.....	....	.008	.32
5530	" 31	Aug. 1	d	c	.05	316.4	250.	66.4	51.6	50.8	3.4	14.2	11.	3.2	.068	.448	.228	.22	.84	.6	.24	.012	.24
5571	Aug. 7	" 8	d	c	.03	372.4	245.6	126.8	100.4	54.	3.2	15.	10.5	4.5	.048	.48	.24	.24	1.16	.504	.656	.004	.24
5626	" 14	" 15	d	c	.1	303.6	230.8	72.8	52.	46.4	4.1	14.	9.4	4.6	.052	.448	.208	.24	.984	.536	.448	.006	.16
5673	" 21	" 22	d	c	.15	297.6	237.2	60.4	30.8	....	3.9	11.8	9.	2.8	.044	.352	.272	.08	.984	.552	.432	.002	.08
5729	" 28	" 29	d	c	.06	312.8	239.2	73.6	23.6	17.2	3.9	11.5	9.2	2.3	.06	.48	.256	.224	1.	.536	.464	.007	.2
5788	Sept. 4	Sept. 5	d	c	.04	303.6	241.2	62.4	28.	22.8	4.6	11.1	9.1	2.	.092	.448	.256	.192	.888	.6	.288	.008	.2
5838	" 11	" 12	d	c	.15	278.	238.4	39.6	36.8	24.8	5.3	11.3	7.8	3.5	.08	.32	.224	.096	.92	.796	.124	.013	.2
5879	" 18	" 19	d	c	.08	286.4	226.4	60.	43.2	32.4	4.8	9.8	6.3	3.6	.044	.416	.272	.144	.84	.648	.192	.007	.2
5932	" 25	" 26	d	c	.04	263.2	234.	29.2	22.4	21.6	5.4	8.9	7.	1.9	.036	.272	.24	.032	.804	.548	.256	.004	.16

CHEMICAL EXAMINATION OF WATER FROM THE KANKAKEE RIVER AT WILMINGTON.—CONTINUED.

(Parts per 1,000,000.)

Serial Number.	1899 Date of Collection.	1899 Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Ammonia. Total.	Nitrogen as Ammonia. Albuminoid Ammonia. Dissolved.	Nitrogen as Ammonia. Albuminoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended	Nitrogen as Nitrites.	Nitrogen as Nitrates.
5981	Oct. 2	Oct. 3	d	l	.07	240.8	232.8	8.	28.4	20.8	4.8	8.3	6.9	1.4	.012	.256	.208	.048	.58	.404	.176	.004	.16
6029	" 9	" 10	d	l	.03	265.6	253.8	12.	22.	....	4.9	7.	6.7	.3	.012	.256	.24	.016	.532	.392	.14	.005	.12
6077	" 16	" 17	d	l	.03	288.4	249.2	39.2	26.	23.2	4.9	7.3	6.8	.5	.028	.176	.096	.08	.68	.36	.32	005	.24
6142	" 23	" 24	d	c	.04	.....	241.2	....	....	14.4	4.7	5.8	4.9	.9	.016	.24	.16	.08	.456	.36	.096	.004	.08
6188	" 30	" 31	d	l	.04	255.2	229.2	26.	31.2	30.	4.7	5.3	4.7	.6	.02	.176	.128	.048	.312	.2	.112	.005	.16
6237	Nov. 6	Nov. 7	d	l	.04*.05	276.	273.6	2.4	16.	15.8	4.8	6.5	5.6	.9	.02	.24	.208	.032	.552	.424	.128	.002	.32
6289	" 13	" 14	d	l	.04*.1	.....	.....	....	.....	.....	4.	7.7	7.7	...	.012	.288	.256	.032	.76	.712	.048	.03	2.4
6332	" 20	" 21	d	c	.1	317.6	300.8	16.8	30.	33.6	3.6	8.4	8.	.4	.036	.288	.256	.032	.808	.616	.192	.02	3.6
6396	" 27	" 29	d	c	.2	310.4	297.6	12.8	25.2	21.2	3.6	9.5	9.2	.3	.054	.32	.288	.032	1.	.84	.16	.024	2.4
6443	Dec. 4	Dec. 5	d	l	.15*.2	296.4	289.2	7.2	39.2	36.4	3.6	8.8	8.8	...	.066	.336	.304	.032	.776	.68	.096	.017	1.68
6498	" 11	" 12	s	l	.07*.15	280.8	279.2	1.6	41.2	41.2	3.7	9.3	9.1	.2	.028	.432	.364	.068	.776	.68	.096	.005	1.48
6541	" 18	" 19	d	c	.2	313.2	280.	33.2	50.	45.2	3.1	11.6	9.7	1.9	.06	.352	.224	.128	1.	.84	.16	.018	6.
6590	" 26	" 27	d	c	.15	297.2	272.	25.2	41.6	36.8	3.5	10.7	9.7	1.	.068	.288	.24	.048	.936	.68	.256	.013	4.
Average June 5—June 26						335.3	288.	47.3	31.7	27.	2.4	18.7	15.8	2.9	.075	.567	.447	.12	1.333	1.018	.314	.01	.67
Average July 10—Dec. 26						273.2	247.9	25.3	38.9	28.9	4.1	9.8	8.1	1.7	.042	.34	.236	.103	.814	.557	.259	.011	1.15
Average June 5—Dec. 26						302.6	262.4	39.4	37.8	32.	3.8	11.1	9.2	1.9	.047	.371	.265	.106	.886	.594	.244	.011	1.08

The water in all cases was odorless. The color upon ignition was either dark gray or brown.

*Not filtered.

8573

CHEMICAL EXAMINATION OF WATER FROM THE KANKAKEE RIVER AT WILMINGTON.

(Parts per 1,000,000.)

Serial Number.	1900 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Collection.	Examination	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved.		Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Dissolved.	Albuminoid Ammonia. Suspended	Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
6601	Jan. 1	Jan. 2	d	l	.06*.1	371.6	361.6	10.	39.6	36.4	4.	14.5	14.5	....	.06	.384	.368	.016	1.164	.936	.228	.015	4.8
6640	" 8	" 9	d	l	.1*.2	370.4	364.8	5.6	51.6	46.8	4.7	11.6	11.	.6	.048	.432	.4	.032	1.16	.936	.224	.017	4.4
6686	" 15	" 16	s	l	.02*.08	314.	313.2	.8	40.4	40.	3.9	8.1	7.9	.2	.04	.224	.208	.016	.704	.64	.064	.013	3.
6733	" 22	" 23	d	l	.15*.3	262.4	262.4	0.0	19.6	19.6	3.	7.6	7.6	0.0	.048	.24	.224	.016	.608	.544	.064	.01	2.4
6782	" 29	" 30	d	l	.06*.07	288.	282.4	5.6	39.6	37.2	3.2	8.4	8.4	0.0	.028	.352	.256	.096	.64	.48	.16	.006	2.8
6832	Feb. 5	Feb. 6	d	l	.1*.15	327.6	327.2	.4	40.8	20.4	3.7	12.3	10.8	1.5	.024	.32	.288	.032	.864	.768	.096	.005	2.2
6887	" 12	" 13	d	m	.15	877.6	173.2	704.4	64.8	22.4	2.6	23.9	8.3	15.6	.16	1.184	.352	.832	2.56	.8	1.76	.02	4.
6928	" 19	" 20	d	l	.15	306.	290.	16.	40.	40.	3.6	9.	8.5	.5	.1	.416	.336	.08	.768	.608	.16	.017	4.2
7052	Mar. 9	Mar. 10	d	c	.04	246.4	167.2	79.2	22.8	22.	2.6	13.2	6.4	6.8	.16	.32	.192	.128	1.04	.544	.496	.017	1.76
7092	" 15	" 16	d	c	.4	612.4	112.	500.4	30.4	16.	1.4	21.2	8.3	12.9	.112	.96	.256	.704	2.4	.48	1.92	.01	1.08
7119	" 19	" 20	d	c	.2	243.2	161.2	82.	26.	13.6	2.8	12.3	8.6	3.7	.112	.384	.24	.144	.92	.568	.352	.009	1.8
7166	" 26	" 27	d	c	.25	199.6	166.8	32.8	22.8	16.	2.4	11.	8.8	2.2	.08	.64	.256	.384	1.08	.824	.256	.007	1.76
7210	April 2	Apr. 3	d	c	.2	369.6	150.4	219.2	31.6	16.	2.7	17.3	9.6	7.7	.072	.512	.24	.272	1.24	.632	.608	.011	2.88
7265	" 9	" 10	d	l	.08	348.8	301.2	47.6	28.8	28.8	1.1	6.1	5.1	1.	.02	.224	.144	.08	.536	.408	.128	.014	5.6
7322	" 16	" 17	d	l	.04	318.	304.8	13.2	42.8	40.4	3.9	4.3	4.8	0.0	.008	.176	.128	.048	.408	.344	.064	.014	3.2
7382	" 23	" 24	d	l	.03	307.6	298.4	9.2	47.2	38.	4.2	7.4	4.4	3.	.006	.112	.104	.008	.6	.472	.128	.016	4.6
7433	" 30	May 1	d	l	.02*.05	336.4	327.6	8.8	67.6	64.4	4.3	4.3	4.3	0.0	.016	.16	.128	.032	.548	.48	.068	.03	2.96
7472	May 7	" 8	d	c	.3	318.8	296.4	22.4	28.	26.	3.7	18.2	13.5	4.7	.044	.512	.464	.048	1.06	.9	.16	.01	1.12
7522	" 14	" 15	d	c	.3	312.	280.4	31.6	42.8	35.2	4.	15.3	10.9	4.4	.064	.544	.32	.224	1.06	1.028	.032	.015	1.24
7579	" 21	" 22	d	l	.3	330.4	292.4	38.	48.8	44.8	3.4	17.1	12.7	4.4	.056	.512	.432	.08	.964	.58	.384	.013	1.22
7613	" 28	" 29	d	l	.2	320.	276.4	43.6	40.4	40.4	3.5	13.8	9.6	4.2	.044	.368	.256	.112	.96	.8	.16	.03	3.
7650	June 4	June 5	d	c	.03	360.4	324.8	35.6	58.	51.6	4.5	7.5	5.5	2.	.024	.24	.208	.032	.52	.452	.068	.005	2.6
7696	" 11	" 12	d	c	.08	363.6	302.	61.6	45.6	44.8	3.5	9.5	6.9	2.6	.072	.272	.144	.128	.612	.452	.16	.03	4.6
7735	" 18	" 19	d	l	.05	316.	194.8	121.2	82.4	14.8	3.5	9.4	6.1	3.3	.048	.304	.192	.112	.74	.356	.384	.008	1.

7773	June 25	June 26	s	l	.03	329.6	294.8	34.8	34.4	30.4	3.4	8.7	7.5	1.2	.042	.24	.224	.016	1.08	.612	.448	.008	.92
7815	July 2	July 3	d	m	.2	261.6	235.6	26.	41.6	38.4	3.	9.	8.7	.3	.074	.24	.176	.064	.676	.58	.096	.013	.96
8108	Aug. 6	Aug. 7	d	l	.01	274.4	225.6	48.8	54.4	36.8	2.2	10.8	8.5	2.3	.144	.304	.256	.048	.644	.224	.32	.008	.76
8162	" 13	" 14	d	l	.01	271.2	231.2	40.	38.	38.8	3.4	10.7	7.7	3.	.12	.336	.304	.032	.644	.412	.232	.013	.6
8226	" 20	" 21	d	l	.02	296.8	229.2	67.1	30.	28.4	4.5	9.	5.7	3.3	.16	.288	.208	.08	.632	.38	.252	.022	.92
8336	" 30	" 31	d	l	.15	288.	194.	94.	34.	32.	2.6	10.3	5.4	4.3	.124	.272	.256	.016	.568	.452	.116	.013	1.04
8391	Sept. 6	Sept. 7	d	c	.2	313.6	266.	47.6	30.8	21.6	2.2	10.3	8.	2.3	.11	.208	.192	.016	.536	.496	.04	.01	.72
8461	" 13	" 14	d	c	.3	329.2	295.2	34.	32.8	31.6	3.	12.7	9.9	2.8	.084	.32	.288	.032	.552	.502	....	.006	.56
8514	" 21	" 22	d	l	.25	295.6	259.2	36.4	25.6	22.8	3.2	11.8	9.9	1.9	.108	.32	.272	.048	1.364	....	....	.002	.16
8564	" 27	" 28	d	c	.3	289.6	264.6	25.	31.2	24.4	3.8	8.4	7.9	.5	.094	.304	.24	.064	.524	.416	.108	.004	.22
8758	Nov. 8	Nov. 9	d	l	.03	285.6	277.6	8.	32.4	30.	3.7	6.1	5.6	.5	.062	.272	.208	.064	.512	.48	.032	.007	.233
8793	" 19	" 20	s	l	.1*.15	276.4	268.4	8.	26.	23.6	5.	6.2	6.1	.1	.12	.256	.24	.016	.72	.688	.032	.005	.735
8838	" 29	" 30	d	l	.3	314.	283.2	30.8	30.8	28.8	2.6	8.8	8.6	.2	.096	.304	.176	.128	.784	.624	.16	.013	4.187
8873	Dec. 6	Dec. 7	d	l	.3	308.8	300.4	8.4	31.2	29.2	2.8	9.1	9.	.1	.1	.24	.224	.016	.672	.576	.096	.016	3.504
8892	" 13	" 14	d	v l	.3	302.4	296.8	3.6	27.6	25.6	2.8	9.8	9.7	.1	.064	.24	.224	.016	.672	.656	.016	.013	3.387
8903	" 19	" 21	s	l	.4	325.6	318.4	7.2	42.	38.	3.	11.3	11.1	.2	.078	.272	.272	....	.816	.752	.064	.006	3.354
Average Jan. 1—June 25..............						350.	245.	85.	34.4	32.2	3.3	11.6	8.3	3.3	.059	.401	.254	.146	.968	.625	.342	.015	2.76
Average July 2—Dec. 19						295.5	263.1	32.4	33.9	30.	3.2	9.6	8.1	1.5	.073	.278	.235	.042	.687	.531	.157	.01	1.43
Average Jan. 1—Dec. 19...........						320.5	264.3	65.2	37.3	31.4	3.2	10.9	8.2	2.7	.731	.355	.247	.107	.613	.576	.036	.013	2.26

The water in all cases was odorless. The Color upon ignition was brown.

*Not filtered.

CHEMICAL EXAMINATION OF WATER FROM THE FOX RIVER AT OTTAWA.

(Parts per 1,000,000.)

Serial Number.	1898		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.
	Collection.	Examination							Total.	Dissolved.						Total.	Dissolved.	Suspended					
3320	Mar. 1	Mar. 3	d	c	.1*.15	296.4	244.4	52.	17.6	14.4	4.	12.	8.	4.	.274	.36	.32	.04	.84	.6	.24	.022	1.5
3350	" 14	" 15	d	m	.2	297.2	184.8	112.4	22.	23.9	2.3	14.3	7.5	6.8	.24	.72	.28	.44	1.16	.52	.64	.025	1.1
3389	" 22	" 24	d	c	.3	296.	212.8	83.2	27.6	26.8	1.8	14.2	8.3	5.9	.128	.6	.4	.2	1.24	.68	.56	.025	1.1
3401	" 28	" 30	d	c	.4	393.2	224.4	168.8	42.	37.2	2.4	19.9	9.	10.9	.096	.84	.48	.36	1.81	.73	1.08	.03	1.1
3433	April 4	April 6	d	c	.1*.4	323.2	265.2	58.	28.	33.2	4.4	14.	10.8	3.2	.08	.56	.4	.16	1.25	.73	.52	.014	1.
3454	" 12	" 14	d	l	.15	314.8	259.2	55.6	30.	29.2	6.	12.4	9.	3.4	.048	.56	.36	.2	.93	.77	.16	.02	.44
3471	" 18	" 19	s	c	.07	387.6	303.6	84.	38.8	33.6	7.4	12.	11.3	.7	.016	.4	.368	.032	1.17	.85	.32	.015	.6
3496	" 25	" 26	d	l	.07	287.2	278.8	8.4	34.	30.	7.	8.4	7.2	1.2	.024	.44	.32	.12	.93	.77	.16	.002	.55
3536	May 2	May 4	d	c	.05*.1	302.8	273.2	29.6	26.8	24.	10.	8.3	7.7	.6	.072	.36	.32	.04	.82	.58	.24	.008	.45
3553	" 9	" 11	s	l	.04	309.2	304.4	4.8	46.4	44.	10.8	7.7	7.4	.3	.034	.4	.36	.04	.9	.66	.24	.015	.45
3587	" 16	" 18	d	l	.08*.05	324.8	324.4	.4	71.6	70.	6.4	7.4	7.1	.3	.02	.32	.3	.02	.66	.58	.08	.019	.25
3614	" 23	" 25	d	l	.03*.05	328.	300.4	27.6	33.2	27.2	4.	8.	7.4	.6	.072	.48	.32	.16	.92	.58	.34	.02	.6
3642	" 30	June 2	d	c	.03	413.6	252.	161.6	31.2	30.	4.6	15.	7.4	7.6	.076	.6	.44	.16	1.14	.66	.48	.06	.4
3667	June 6	" 8	d	l	....	368.4	284.	84.4	42.	30.	21.	7.	6.5	.5	.028	.32	.26	.06	.68	.52	.16	.027	.8
3692	" 13	" 16	d	c	....	423.4	287.2	136.2	41.6	39.2	7.	12.5	7.1	5.4	.08	.44	.36	.08	1.16	.6	.56	.06	.35
3716	" 20	" 22	s	l	.03	340.	332.4	7.6	44.	36.8	14.	6.8	6.3	.5	.036	.32	.2	.12	.6	.4	.2	.036	.35
3756	" 26	" 29	v d	m	.05	371.6	.....	.....	38.2	.....	2.4	19.	7.6	11.4	.01	.8	.76	.04	1.58	.54	1.04	.02	.15
3791	July 6	July 7	d	l	.1*.2	288.2	246.	42.2	18.4	16.8	7.	10.7	8.8	1.9	.036	.44	.34	.10	.744	.644	.1	.01	.6
3816	" 12	" 13	d	l	.04*.1	262.4	249.6	12.8	14.8	14.4	6.6	7.5	7.	.5	.018	.36	.32	.04	.64	.56	.08	.003	.7
3836	" 18	" 19	d	l	.03*.04	259.6	257.2	2.4	16.8	15.2	5.	7.8	7.4	.4	.014	.32	.28	.04	.72	.48	.24	none	.9
3872	" 25	" 26	d	l	.07*.04	260.8	248.	12.8	22.	20.8	9.	7.5	6.9	.6	.08	.36	.28	.08	.56	.48	.08	"	.1
3908	Aug. 1	Aug. 2	d	l	.03*.04	264.8	258.	6.8	25.2	22.8	10.	7.6	7.	.6	.008	.36	.28	.08	.64	.52	.12	.008	.1
3929	" 8	" 9	s	l	.03*.04	257.2	240.4	16.8	26.	22.8	6.4	7.5	7.1	.4	.004	.4	.36	.04	.6	.48	.12	none	.1
3958	" 15	" 16	s	l	.01*.04	298.8	273.2	25.6	40.	29.2	12.	7.2	6.8	.4	.136	.4	.36	.04	.56	.48	.08	.017	.16
3992	" 22	" 23	d	l	.05*.15	287.6	265.2	22.4	42.	40.	11.	8.	6.5	1.5	.184	.4	.24	.16	.64	.4	.24	.07	.3
4030	" 29	" 30	d	l	.03*.06	296.4	273.2	23.2	35.2	29.2	11.	7.4	6.4	1.	.116	.36	.24	.12	.68	.52	.16	.1	.1
4051	Sept. 6	Sept. 7	d	l	.04	294.8	276.	18.8	32.8	30.8	14.	7.5	6.2	1.3	.060	.32	.28	.04	.56	.44	.12	.08	.05

*Not filtered.

CHEMICAL EXAMINATION OF WATER FROM THE FOX RIVER AT OTTAWA.—CONTINUED

(Parts per 1,000,000.)

Serial Number.	1898 Date of		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
									Total.	Dissolved.						Total.	Dissolved.	Suspended					
4078	Sept. 12	Sept. 13	d	c	.04*.06	309.2	294.	15.2	52.	48.8	16.	7.8	6.3	1.5	.124	.36	.28	.08	.8	.52	.28	.045	.2
4104	" 21	" 22	d	l	.03*.04	301.2	288.	13.2	48.	42.	11.	7.7	6.5	1.2	.072	.4	.32	.08	.6	.44	.16	.025	.2
4135	" 27	" 29	d	l	.03*.05	311.2	307.6	3.6	47.2	42.8	12.	7.	5.7	1.3	.074	.32	.2	.12	.52	.36	.16	.04	.5
4169	Oct. 4	Oct. 5	d	c	....	329.2	319.2	10.	57.6	44.	12.	5.7	5.5	.2	.13	.24	.2	.04	.44	.36	.08	.025	.35
4188	" 10	" 11	d	l	.04*.06	328.8	298.8	30.	55.6	52.	11.	6.5	5.8	.7	.116	.28	.22	.06	.48	.4	.08	.056	.4
4237	" 19	" 21	s	l	.06*.08	306.	302.8	3.2	31.2	30.	10.	5.9	5.6	.3	.066	.224	.192	.032	.4	.338	.062	.007	.25
4266	" 26	" 27	d	m	.07	455.6	246.	209.6	44.8	24.	5.	14.9	6.6	8.3	.004	.6	.24	.36	1.17	.49	.68	.012	.8
4315	Nov. 2	Nov. 4	d	l	.02*.04	364.8	352.	12.8	54.	50.	6.	6.5	5.3	1.2	.04	.24	.16	.08	.53	.37	.16	.015	.4
4343	" 9	" 10	d	l	.06*.15	340.	330.	10.	44.	40.	7.	6.1	5.2	.9	.076	.44	.28	.16	.91	.75	.16	.011	.5
4370	" 15	" 16	d	l	.02*.04	350.	332.	18.	38.	36.	4.8	5.3	4.6	.7	.004	.192	.144	.048	.47	.35	.12	.005	.9
4407	" 23	" 24	s	l	.03*.05	392.	374.	18.	44.	42.	6.	6.1	5.3	.8	.01	.224	.176	.048	.63	.43	.2	.014	.9
4439	" 30	Dec. 1	d	l	.03*.04	383.2	370.8	12.4	53.2	49.2	6.8	5.7	5.	.7	.024	.28	.176	.104	.53	.41	.12	.007	.8
4465	Dec. 7	" 8	s	l	.03*.06	392.8	382.	10.8	66.	60.8	7.	7.5	5.4	2.1	.036	.256	.176	.08	.69	.49	.2	.006	.2
4486	" 12	" 15	s	l	.03	434.	422.8	11.2	68.	66.	8.4	6.5	5.6	.9	.026	.224	.208	.016	.61	.49	.12	.01	.25
4514	" 21	" 22	d	c	.4	308.8	270.8	38.	56.	54.	6.	16.5	13.8	2.7	.024	.72	.432	.288	1.37	.97	.4	.035	.2
4537	" 26	" 28	d	l	.1*.2	316.	298.8	17.2	52.	48.	7.	9.4	8.6	.8	.064	.36	.24	.12	.73	.57	.16	.01	.25
Average March 1—June 28..........						370.	259.5	116.4	37.1	31.2	6.7	11.6	7.9	3.7	.072	.501	.34	.16	1.07	.651	.41	.025	.67
Average July 6—Dec. 26............						322.8	299.1	23.7	42.1	37.7	8.6	7.8	6.5	1.2	.050	.346	.254	.092	.662	.49	.172	.028	.33
Average March 1—Dec. 26.........						333.6	281.	52.6	40.1	35.1	7.9	9.3	7.	2.2	.064	.407	.288	.119	.823	.553	.269	.027	.47

*Not Filtered.

Chemical Examination of Water from the Fox River at Ottawa.

(Parts per 1,000,000.)

Serial Number.	1899 Date of Collection.	1899 Date of Examination	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Ammonia. Total.	Nitrogen as Ammonia. Albuminoid Ammonia. Dissolved.	Nitrogen as Ammonia. Albuminoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspeuced	Nitrogen as Nitrites.	Nitrogen as Nitrates.
5113	May 29	May 30	v	v	.06	1060.4	244.	816.4	65.6	30.4	.3	35.5	9.8	25.7	.12	1.92	.32	1.6	5.53	.73	4.8	.05	1.68
5163	June 5	June 6	v	c	.2	459.6	306.4	153.2	44.4	40.8	1.	15.	9.5	5.5	.128	.64	.304	.336	1.61	.826	.784	.08	.92
5207	" 12	" 14	d	l	.1	335.2	306.	29.2	24.	24.	2.	10.5	9.3	1.2	.048	.448	.32	.128	1.16	.952	.208	.015	.72
5241	" 19	" 20	d	l	.1*.15	321.6	306.	15.6	36.	35.2	2.5	9.6	9.3	.2	.048	.352	.272	.08	.68	.536	.144	.001	.2
5294	" 26	" 27	d	l	.05	320.4	311.6	8.8	39.2	30.8	4.	9.4	9.3	.1	.04	.256	.24	,016	.84	.536	.304	none	.08
5335	July 3	July 4	d	l	.05*.8	309.2	305.2	4.	37.6	32.4	5.	7.7	7.4	.3	.04	.312	.212	.1	1.	.652	.348	.002	.16
5385	" 10	" 11	d	l	.1*.15	297.2	184.8	112.4	54.8	54.4	6.2	9.	8.6	.4	.048	.32	.24	.08	.84	.504	.336	none	.24
5433	" 17	" 18	d	c	.3	420.	282.4	137.6	62.	39.2	4.5	16.8	10.2	6.6	.092	.896	.368	.528	1.8	.792	1.008	.045	1.28
5480	" 24	" 25	s	l	.25	238.4	220.	18.4	56.4	49.6	4.1	11.4	10.3	1.1	.016	.512	.288	.224	1.16	.632	.528	.005	.2
5535	" 31	Aug. 2	s	l	.15*.3	282.4	278.8	3.6	130.8	64.8	5.2	10.3	10.3	0.0	.044	.352	.32	.032	.76	.664	.096	.001	.2
5580	Aug. 7	" 8	d	l	.05	296.4	272.4	24.	64.8	61.6	5.3	11.5	10.2	1.3	.012	.448	.288	.16	.92	.536	.384	none	.16
5632	" 14	" 15	s	c	.06*.15	293.6	282.8	10.8	76.	66.	4.8	9.5	8.8	.7	.08	.352	.288	.064	.76	.6	.16	"	.2
5678	" 21	" 22	s	l	.1*.12	285.2	280.8	4.4	58.	....	5.8	10.4	9.8	.6	.036	.448	.416	.032	.76	.68	.08	"	.16
5736	" 28	" 29	d	l	.04	304.	290.4	13.6	55.2	54.8	6.	19.9	19.4	.5	.036	.384	.272	.112	.76	.6	.16	"	.04
5787	Sept. 4	Sept. 6	d	l	.03	311.2	306.8	4.4	50.8	49.2	6.7	8.9	7.1	1.8	.04	.336	.288	.048	.824	.376	.448	.001	.2
5838	" 11	" 12	s	l	.08*.15	279.2	270.	9.2	45.6	38.8	6.1	8.8	8.8	0.0	.02	.32	.288	.032	.728	.536	.192	none	.12
5880	" 18	" 19	s	l	.02*.04	291.6	277.6	14.	62.	60.8	6.15	7.9	6.1	1.8	.024	.352	.256	.096	.76	.6	.16	"	.08
5939	" 25	" 26	d	l	.04	298.8	297.2	1.6	46.	44.	7.2	8.2	7.	1.2	.02	.368	.276	.092	.704	.532	.172	"	.16

5998	Oct. 3	Oct. 4	d	1	.05	308.8	296.8	12.	66.8	57.2	7.7	8.9	7.6	1.3	.046	.304	.192	.112	.548	.42	.128	none	.28
6038	" 9	" 10	d	1	.04*.05	309.2	308.	1.2	38.	38.	7.4	7.1	7.	.1	.02	.264	.236	.008	.644	.596	.048	.001	.12
6083	" 16	" 18	d	1	.02*.04	326.	318.8	7.2	52.4	51.2	8.	7.	6.9	.1	.128	.416	.336	.08	.648	.488	.16	.001	.24
6152	" 23	" 25	s	1	.05*.1	318.	308.8	9.2	37.6	33.2	7.7	6.6	6.6	0.0	.032	.288	.256	.032	.44	.36	.08	none	.44
6199	" 30	Nov. 1	s	1	.04*.05	320.	299.6	20.4	14.	....	7.6	6.2	6.2	0.0	.024	.288	.256	.032	.456	.408	.048	.008	.28
6240	Nov. 6	" 7	d	1	.03*.04	315.2	300.8	14.4	46.	41.6	7.2	5.9	5.8	.1	.032	.304	.272	.032	.584	.52	.064	.002	.24
6278	" 13	" 14	s	1	.03*.05	337.6	328.8	8.8	38.8	32.4	7.	4.6	4.5	.1	.012	.352	.208	.144	.488	.296	.192	none	.08
6336	" 20	" 21	s	1	.02*.03	315.6	312.	3.6	36.	34.8	7.7	5.5	5.3	.2	.024	.304	.256	.048	.616	.552	.064	.008	.24
6402	" 27	" 28	s	1	.02*.03	312.4	309.6	2.8	57.2	56.4	8.	5.	...	...	.02	.224	.16	.064	.456	.36	.096	.012	.4
6505	Dec. 11	Dec. 14	s	1	.02	330.4	326.4	4.	60.4	58.4	7.6	6.2	6.2	0.0	.16	.272	.256	.016	.616	.488	.128	.01	.56
6574	" 21	" 23	d	1	.02*.03	328.4	324.8	3.6	40.4	40.	7.6	6.9	6.8	.1	.168	.224	.224	.00	.6	.48	.12	.01	.72
6594	" 28	" 29	d	1	.02*.03	420.8	418.	2.8	88.	36.8	9.	7.1	6.7	.4	.12	.224	.176	.048	.52	.424	.096	.004	.8
Average May 29—June 26						499.4	294.8	204.6	41.8	32.2	2.	15.9	9.4	6.5	.076	.723	.291	.432	1.964	.716	1.248	.029	.72
Average July 3—Dec. 28						313.9	296.	17.9	55.1	48.1	6.6	8.6	7.7	.9	.051	.354	.265	.088	.735	.523	.211	.004	.3
Average May 29—Dec. 28						344.8	295.8	49.	52.8	45.	5.8	9.9	8.3	1.7	.055	.416	.270	.145	.94	.555	.384	.008	.37

Not filtered.

CHEMICAL EXAMINATION OF WATER FROM THE FOX RIVER AT OTTAWA.

(Parts per 1,000,000.)

Serial Number.	1900		Appearance.			Residue on Evaporation.					Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as	
	Date of		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Loss on Ignition.			Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Albuminoid Ammonia.			Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
	Collection.	Examination							Total.	Dissolved.						Total.	Dissolved	Suspended					
6629	Jan. 4	Jan. 5	d	l	.03	460.	450.	10.	81.2	76.4	9.9	6.8	6.4	.4	.072	.224	.208	.016	.68	.52	.16	.006	.56
6678	" 11	" 12	s	l	.02*.03	318.8	307.2	11.6	49.2	42.4	6.5	4.5	4.3	.2	.084	.176	.16	.016	.56	.352	.208	.009	.32
6725	" 18	" 20	d	l	.02*.03	311.6	310.4	1.2	60.4	60.	7.3	4.5	4.3	.0	.092	.176	.128	.048	.48	.32	.16	.018	.56
6772	" 25	" 27	s	c	.15	292.4	258.8	33.6	44.4	36.4	4.5	8.3	7.6	.7	.32	.352	.32	.032	.88	.672	.208	.022	1.52
7076	Mar. 12	Mar. 14	d	m	.5	202.8	160.4	42.4	29.6	23.2	3.8	11.6	8.2	3.4	.324	.352	.288	.064	1.04	.608	.432	.012	.72
7128	" 20	" 22	d	c	.3	218.	178.4	39.6	19.2	16.4	3.6	9.4	8.7	.7	.332	.352	.256	.096	.84	.728	.112	.014	.84
7175	" 27	" 29	d	m	.3	281.6	173.6	108.	30.8	26.	3.1	15.1	9.4	5.7	.38	.376	.256	.32	1.24	.632	.608	.015	.68
7232	April 3	Apr. 5	d	m	.3	626.8	131.2	495.6	34.	17.2	2.8	23.5	9.4	14.1	.26	1.024	.288	.736	2.2	.792	1.408	.022	1.6
7288	" 10	" 12	d	c	.15	286.4	199.2	87.2	31.2	22.	2.2	11.	9.	2.	.144	.512	.24	.272	1.08	.664	.416	.02	1.16
7340	" 17	" 19	d	c	.08	297.2	226.8	70.4	35.6	33.2	3.8	9.6	9.	.6	.064	.432	.208	.224	1.08	.6	.48	.018	.76
7408	" 24	" 26	d	c	....	302.8	256.8	46.	28.8	28.	4.	11.2	8.8	2.4	.072	.64	.288	.352	1.368	.792	.576	.011	.32
7449	May 1	May 3	d	c	.06	302.8	250.	52.8	36.4	30.	4.8	15.8	9.8	6.	.024	.64	.368	.272	1.188	.708	.48	.001	.2
7489	" 8	" 10	d	c	.04	402.8	251.2	151.6	32.	30.	4.6	15.3	10.3	5.2	.052	.592	.288	.304	1.16	.612	.548	.015	.36
7547	" 15	" 17	..	..	.1	300.8	285.2	15.6	52.8	51.2	6.6	8.9	8.5	.4	.96	.544	.288	.156	.9	.568	.332	.008	.04
7599	" 22	" 24	d	c	.05	294.	266.	28.	53.2	52.	5.3	9.4	8.4	1.	.132	.368	.224	.144	.804	.42	.384	none	.12
7670	June 5	June 6	d	l	.02	299.2	292.8	6.4	47.6	46.8	5.4	7.9	7.7	.2	.088	.256	.224	.032	.68	.468	.212	.011	.32
7702	" 11	" 13	d	l	.03	326.8	312.	14.8	50.4	41.6	5.3	9.3	8.3	1.	.04	.336	.288	.048	.708	.52	.188	.001	.24
7745	" 18	" 20	d	l	.02	322.4	312.8	9.6	47.6	47.2	6.5	6.8	6.8	....	.052	.224	.192	.032	.452	....	.....	.008	.24
7786	" 25	" 27	d	m	.01	301.2	293.2	8.	36.8	30.4	5.6	6.5	6.5	....	.072	.368	.304	.064	.42	.296	.124	.001	.36
7820	July 2	July 4	d	l	.25	321.2	318.4	2.8	42.4	40.	5.4	7.1	7.	.1	.04	.272	.24	.032	.452	.308	.144	.013	.16

CHEMICAL EXAMINATION OF WATER FROM THE FOX RIVER AT OTTAWA.—CONTINUED.

(Parts per 1.000,000.)

Serial Number	1900 Date of Collection.	1900 Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved.	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Ammonia. Total.	Nitrogen as Ammonia. Albuminoid Ammonia. Dissolved.	Nitrogen as Ammonia. Albuminoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended	Nitrogen as Nitrites.	Nitrogen as Nitrates.
7892	July 9	July 11	d	1	.2	304.	300.	4.	52.4	48.8	5.2	7.	6.8	.2	.066	.192	.16	.032	.516	.42	.096	.005	.16
7937	" 16	" 17	d	1	.02	313.6	288.4	25.2	37.6	25.6	7.6	7.	6.3	.7	.072	.272	.208	.064	.564	.452	.112	.005	.12
7996	" 23	" 24	d	1	.02	316.	282.4	33.6	54.4	42.	6.4	7.9	6.5	1.4	.12	.304	.144	.16	.548	....	....	.002	.2
8047	" 30	" 31	d	m	.02	302.	263.	39.	45.2	30.	6.6	9.2	8.1	1.1	.072	.352	.24	.112	.564	.388	.176	.006	.08
8137	Aug. 6	Aug. 9	d	1	.02	358.	286.	72.	64.8	....	6.2	12.1	7.6	4.5	.172	.512	.32	.192	.836	.564	.272	.005	.16
8171	" 13	" 15	d	1	.02	294.8	255 6	39.2	60.4	53.2	5.5	7.9	7.5	.4	.132	.368	.304	.064	.548	.46	.088	.002	.28
8243	" 20	" 22	d	1	.02	301.2	234.4	68.8	43.6	34.4	5.	8.9	6.1	2.8	.168	.352	.224	.128	.796	.212	.584	.036	.68
8296	" 27	" 28	d	1	.02	440.4	266.8	173.6	41.6	24.8	6.2	13.2	6.7	6.5	.186	.384	.144	.24	1.116	.38	.736	.001	.24
8366	Sept. 4	Sept. 5	d	c	.05	297.6	270.	27.6	30.4	22.	4.4	8.9	5.8	3.1	.11	.324	.272	.052	.488	.38	.108	.006	.28
8433	" 10	" 11	d	1	.2	304.4	281.2	23.2	46.	34.8	4.8	8.8	7.2	1.6	.132	.432	.32	.102	.604	.576	.028	.003	.28
8485	" 17	" 18	s	1	.01*.05	271.2	267.2	3.6	47.6	34.8	5.	9.8	7.9	1.9	.064	.4	.224	.176	1.34	.672	.668	.002	.16
8537	" 24	" 25	d	1	.05*.3	296.	280.4	15.6	46.8	41.6	5.4	8.3	7.8	.5	.162	.352	.224	.128	.488	....	....	.008	.24
8596	Oct. 1	Oct. 2	s	1	.2*.1	304.	288.8	15.2	55.6	40.	5.8	8.	7.6	.4	.084	.48	.288	.193	.48	....	....	none	.16
8635	" 6	" 8	vs	v 1	.01*.02	299.6	291.6	8.	46.	35.6	5.6	8.8	7.7	1.1	.142	.432	.416	.016	.64	.512	.128	.002	.038
Average Jan. 4—June 25						323.6	258.7	64.8	42.1	37.3	5.	10.2	7.9	2.2	.142	.428	.257	.171	.934	.54	.394	.011	.57
Average July 2—Oct. 2						308.2	278.1	30.1	47.6	38.7	5.7	8.8	7.1	1.7	.115	.361	.248	.113	.665	.428	.237	.006	.215
Average Jan. 4—Oct. 2						319.1	267.3	51.8	44.5	37.9	5.3	9.6	7.5	2.1	.13	.398	.253	.145	.815	.49	.324	.008	.416

CHEMICAL EXAMINATION OF WATER FROM THE FOX RIVER AT OTTAWA.

(Parts per 1,000,000.)

Serial Number.	1901 Date of Collection.	1901 Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Ammonia. Total.	Nitrogen as Ammonia. Albuminoid Ammonia. Dissolved	Nitrogen as Ammonia. Albuminoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved	Organic Nitrogen. Suspended	Nitrogen as Nitrites.	Nitrogen as Nitrates.
9306	Aug. 16	Aug. 19	d	1	.05	306.	271.2	34.8	53.6	43.6	17.	9.7	9.2	.5	.164	.288	.256	.032	.72	.688	.032	.08	.56
9333	" 29	" 30	d	1	.1	298.4	274.	24.4	44.8	50.	16.5	8.	7.2	.8	.192	.352	.288	.064	.912	.608	.304	.075	.445
9354	Sept. 6	Sept. 7	d	1	.02	288.8	286.8	2.	31.6	44.	18.	8.1	7.4	.7	.144	.32	.16	.16	.944	.688	.256	.055	.425
9369	" 12	" 14	d	c	.02	315.6	271.2	44.4	32.	32.	14.	8.7	7.9	.8	.24	.336	.272	.064	....	....	....	.065	.495
9413	" 26	" 28	d	c	.1	308.8	292.	16.8	51.6	63.6	14.	7.5	7.2	.3	.128	.336	.24	.096	....	....	....	.03	.45
9434	Oct. 3	Oct. 5	d	1	.15	325.6	308.8	16.8	41.6	44.8	19.	8.7	8.6	.1	.128	.352	.336	.016	....	....	....	.017	.463
9474	" 10	" 14	d	c	.04	317.2	304.8	12.4	48.4	55.2	17.	8.3	...	..	.16	.304	.288	.016	....	....	....	.04	.44
9556	" 22	" 23	d	1	.05	332.	299.2	32.8	64.4	50.	15.	7.	6.2	.8	.048	.288	.272	.016	....	....	....	.017	.663
9616	" 29	" 30	d	1	.1	312.	310.4	1.6	68.4	64.4	16.	7.6	6.8	.8	.16	.32	.224	.096	....	....	....	.014	.396
Average Aug. 16—Oct. 29........						311.3	291.1	20.2	48.5	49.7	16.3	8.1	6.8	1.3	.151	.321	.250	.062	.858	.661	.197	.043	.481

CHEMICAL EXAMINATION OF WATER FROM THE SPOON RIVER AT HAVANA.

(Parts per 1,000,000.)

Serial Number.	1897. Date of Collection.	1897. Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Ammonia. Total.	Nitrogen as Ammonia. Albuminoid Ammonia. Dissolved	Nitrogen as Ammonia. Albuminoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved	Organic Nitrogen. Suspended	Nitrogen as Nitrites.	Nitrogen as Nitrates.
1799	Jan. 5	Jan. 6	v d	m	.3	1462.	160.4	1301.6	22.	10.	2.	37.5	8.9	28.6	.232	1.28	.32	.96	6.4	.88	5.52	.027	1.
1822	" 13	" 13	d	c	...	428.	302.	126.	26.	8.	2.6	8.6	....	....	.104	.28	....	....	.56	...	....	.025	3.7
1842	" 20	" 20	v d	m	...	632.8	212.4	420.4	19.6	16.	2.4	16.8	....	....	.336	.6	....	....	1.28	...	....	.085	2.7
1848	" 26	" 27	s	l	.15	315.2	307.2	8.	17.6	11.6	4.2	4.	....	....	.152	.16	....	....	.48	...	....	.018	3.6
1878	Feb. 1	Feb. 3	s	l	.08	353.2	351.2	2.	28.8	24.	3.4	2.8	....	....	.126	.08	....	....	.32	...	....	.004	3.6
1901	" 9	" 10	d	c	...	319.2	203.2	116.	16.4	12.8	2.8	16.8	....	....	.412	.52	....	....	1.28	...	....	.038	1.8
1922	" 16	" 17	d	c	...	367.2	360.4	6.8	16.8	16.	3.5	7.9	....	....	.244	.32	....	....	.72	...	....	.06	2.5
1940	" 23	" 24	v d	m	.5	2285.2	197.6	2087.6	221.2	32.	1.4	82.8	11.1	71.7	.176	3.52	.48	3.04	7.2	1.2	6.	.045	2.3
1961	Mar. 2	Mar. 3	d	l	...	359.6	308.	51.6	36.4	29.2	3.1	5.1	....	....	.162	.2	....	....	.47	...	....	.06	3.
1982	" 9	" 10	v d	v m	.5	1000.8	168.	832.8	75.6	38.	1.2	36.	9.5	26.5	.328	1.36	.304	1.056	2.51	.83	1.68	.055	1.3
2017	" 16	" 17	d	m	.3	699.2	238.4	460.8	80.8	40.8	2.8	27.8	7.3	20.5	.192	1.08	.224	.856	1.95	.51	1.44	.04	2.5
2041	" 24	" 24	d	m	.4	950.8	214.8	736.	111.2	29.2	1.2	46.8	11.	35.8	.152	1.6	.272	1.328	2.83	.83	2.	.06	2.4
2059	" 30	" 31	v d	c	...	258.	229.2	28.8	36.8	29.6	4.3	9.8	....	....	.26	.36	....	....	.67	...	....	.062	2.4
2094	April 6	Apr. 7	v d	m	...	374.	215.2	158.8	39.2	22.	2.8	14.6	....	....	.094	.44	....	....	.91	...	....	.046	2.2
2118	" 13	" 14	v d	c	...	408.4	288.4	120.	89.6	32.2	3.	7.3	....	....	.044	.28	....	....	.51	...	....	.04	3.2
2133	" 20	" 21	d	l	. .	353.2	311.2	42.	55.2	34.	3.	5.3	....	....	.024	.24	....	....	.43	...	....	.06	3.5
2161	" 28	" 28	d	c	...	465.2	261.2	204.	40.8	34.	3.1	15.8	....	....	.014	.52	....	....	.96	...	....	.08	.9
2190	May 4	May 5	d	c	.	321.2	292.	29.2	37.2	34.	3.2	5.4	....	....	.028	.2	....	....	.39	...	....	.034	2.8
2208	" 11	" 12	v d	l	.1	319.2	284.8	34.4	25.6	24.	3.3	5.6	....	....	.064	.36	....	....	.71	...	....	.028	2.3
2231	" 18	" 19	d	l	.15	288.	262.	26.	36.4	29.2	3.7	6.4	....	....	.028	.36	....	....	.67	...	....	.025	1.6
2258	" 25	" 26	d	c	...	311.2	278.8	32.4	36.	34.	3.4	6.3	....	....	.072	.4	....	....	.83	...	....	.035	.8
2286	June 1	June 2	d	c	...	317.2	253.6	43.6	29.6	26.4	3.2	7.5	....	....	.078	.52	....	....	1.	...	....	.035	1.3
2307	" 8	" 9	d	c	...	327.2	283.6	43.6	31.2	30.	3.5	7.	....	....	.08	.44	....	....	.97	...	....	.06	.6
2332	" 15	" 16	d	c	...	351.2	296.	55.2	30.	20.	3.	7.7	....	....	.102	.4	....	....	.97	...	....	.05	.2
2366	" 22	" 23	d	c	...	353.2	296.	57.2	26.	18.	3.6	7.5	....	....	.034	.48	....	....	.93	. .	....	.04	.7
2387	" 29	" 30	d	c	...	338.	306.	32.	27.2	26.	3.4	5.3	....	....	.04	.24	....	....	.65	...	....	.045	.45
2420	July 6	July 7	v d	v m	...	2930.	187.6	2742.4	106.	20.4	.6	35.8	8.	27.8	.068	2.4	.4	2.	4.76	.84	3.92	.12	.24

CHEMICAL EXAMINATION OF WATER FROM THE SPOON RIVER AT HAVANA.—CONTINUED

(Parts per 1,000,000.)

Serial Number.	1897 Date of		Appearance.			Residue on Evaporation.			Loss on Ignition.		Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia	Albuminoid Ammonia.			Organic Nitrogen.			Nitrogen as	
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved		Total.	By Dissolved.	By Suspended Matt'r	Free Ammonia.	Total.	Dissolved	Suspended	Total.	Dissolved.	Suspended	Nitrites.	Nitrates.
2442	July 12	July 14	d	c	.7	361.6	308.4	53.2	22.8	16.4	2.6	11.2	7.4	3.8	.07	.44	.32	.12	.92	.84	.08	.09	1.5
2473	" 21	" 21	d	l	.05	298.	276.	22.	18.	16.	3.5	6.7	5.8	.9	.1	.72	.32	.4	1.	.52	.48	.045	.7
2496	" 28	" 28	v d	m	.9	368.	220.	148.	20.	10.	2.2	13.	7.5	5.5	.036	.48	.384	.096	.84	.68	.16	.19	.9
2528	Aug. 4	Aug. 4	d	c	. .	298.8	236.	62.8	14.	14.	2.2	18.4	...	...	.128	.24	....	....	.8	...	...	.065	.65
2546	" 11	" 11	d	c	...	314.	223.2	90.8	21.2	16.	2.1	12.6	...	...	.186	.8	....	....	1.24	...	...	.25	.8
2573	" 18	" 18	d	c	...	281.2	220.	61.2	13.2	12.	2.5	10.	...	...	.18	.4	....	....	.92	...	...	.095	.65
2594	" 25	" 25	d	c	...	312.	311.2	.8	15.2	9.2	2.5	8.	...	...	.226	.36	....	...	.58	...	...	.015	.3
2618	Sept. 1	Sept. 1	d	c	...	323.4	282.	40.4	20.4	18.	2.7	9.8	...	...	.214	.36	....	....	.82	...	...	.025	.15
2645	" 8	" 8	d	c	...	342.	276.8	65.2	16.	12.8	2.8	11.	...	...	.226	.48	....	...	.74	...	...	.04	.2
2674	" 15	" 15	d	c	...	380.	291.2	88.8	20.	18.	3.4	12.8	...	...	.408	.6	....	....	.98	...	...	.018	.5
2699	" 22	" 22	d	c	...	353.2	.....	.....	18.2	....	4.8	12.2	...	...	.152	.64	....		1.14	...	...	.022	.15
2726	" 29	" 29	d	c	...	356.8	280.4	76.4	20.	6.4	2.9	11.	...	...	.208	.52	....		1.18	...	...	.017	.1
2760	Oct. 6	Oct. 6	d	c	...	340.4	286.	54.4	19.6	16.	2.6	12.8	...	. .	.308	.48	....	....	1.02	...	...	.017	.1
2790	" 13	" 13	d	c	...	342.8	300.4	62.4	27.2	11.6	5.1	8.7	...	...	.38	.4	....		.94	...	...	.011	.06
2824	" 20	" 20	d	c	...	373.6	306.	67.6	20.4	19.6	†16.	11.	...	...	.56	.52	....		.78	...	...	.02	.1
2846	" 27	" 27	d	c	...	344.8	320.	24.8	22.	21.2	†19.	8.5	...	...	.336	.52	....	...	1.1	...	...	.2	.5
2879	Nov. 3	Nov. 3	d	l	...	325.6	290.8	34.8	24.8	24.	8.	7.9	...	...	.138	.4	....	..	.54	...	...	.015	.7
2959	" 17	" 17	d	c	...	303.6	268.	35.6	28.8	16.8	†7.3	8.7	...	...	.056	.44	....	..	.94	...	...	.016	.75
2979	" 24	" 24	d	c	.1	300.	274.8	25.2	23.2	20.	3.	8.3	...	...	.012	.36	....	...	.94	...	...	none	.2
3009	" 30	Dec. 1	d	c	...	275.2	264.8	10.4	26.8	20.	3.5	5.9	...	...	.08	.4	....	....	.61	...	...	.002	.6
3039	Dec. 7	" 8	d	l	.1	326.	324.8	1.2	28.	....	†6.2	7.5	...	...	.002	.52	....	...	.77	...	...	.008	1.
3066	" 14	" 15	d	c	.2	327.6	299.6	28.	30.8	27.2	4.8	7.5	...	. .	.008	.32	....	....	.69	...	...	.015	.6
3083	" 21	" 23	d	l	.3	347.6	333.2	14.4	22.8	20.	6.	7.2	...	...	.012	.4	....		.65	...	..	none	.35
3101	" 28	" 29	d	l	.15	348.	339.2	8.8	20.4	18.8	4.8	7.4	...	...	.066	.32	....	....	.61	...	...	.008	.55
Average Jan. 5—June 29...........						383.	187.8	195.2	37.1	26.1	2.9	15.5	9.5	3.6	.072	.33	.32	1.448	1.06	.85	3.32	.043	2.04
Average July 6—Dec. 28...........						435.7	284.8	170.9	20.5	15.	4.6	10.5	7.1	9.4	.16	.54	.35	.204	1.02	.72	1.12	.061	.49
Average Jan. 5—Dec. 28...........						408.8	225.5	183.2	28.4	20.7	3.7	13.1	8.5	2.4	.148	.58	.33	1.19	1.04	.79	2.36	.047	1.28

'The water in all cases was odorless. ◆The color upon ignition was brown.

†The abnormal data occasionally found result from the backing of Illinois River water into the Spoon River.

CHEMICAL EXAMINATION OF WATER FROM THE SPOON RIVER AT HAVANA.

(Parts per 1,000,000.)

Serial Number.	1898. Date of Collection.	1898. Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Suspended Matt'r	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Ammonia. Total.	Nitrogen as Ammonia. Albuminoid Ammonia. Dissolved	Nitrogen as Ammonia. Albuminoid Ammonia. Suspended	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved	Organic Nitrogen. Suspended	Nitrogen as Nitrites.	Nitrogen as Nitrates.
3125	Jan. 4	Jan. 5	d	c	.3	312.4	301.2	11.2	32.	14.4	4.2	7.4	....	....	.226	.32	...	....	.61	...		.014	.8
3162	" 11	" 12	v d	v m	.5	659.2	273.6	385.6	30.8	18.8	4.	25.3	8.9	16.4	.28	1.12	.44	.68	2.16	.70	1.4	.2	1.03
3178	" 18	" 19	d	m	...	957.2	190.8	766.4	58.	28.	†10.5	54.8	18.	41.8	1.272	1.92	.32	1.6	4.76	.68	4.08	.125	.95
3211	" 25	" 26	d	m	.8	389.6	208.	181.6	34.8	22.8	3.	23.4	15.	8.4	.386	.8	.56	.24	1.84	.84	1.	.18	1.1
3227	Feb. 1	Feb. 2	d	c	.8	282.8	224.8	58.	24.8	17.2	3.8	14.	12.1	1.9	.352	.48	.36	.12	1.	.8	.2	.08	1.6
3258	" 8	" 9	d	c	...	277.2	246.8	30.4	29.2	25.6	8.5	10.6	....	....	.4	.4	...	....	.84	.8	.04	.03	1.25
3267	" 15	" 16	v d	c	.1	906.8	145.6	761.2	44.8	24.4	.8	28.2	8.8	19.4	.26	.1	.44	.56	2.76	.58	2.2	.05	.85
3294	" 22	" 23	d	c	...	358.8	254.8	104.	21.2	14.8	3.3	9.7	....	....	.27	.36	...	....	.84	...	...	.02	.9
3315	Mar. 1	Mar. 2	d	l	.15	305.2	286.4	18.8	24.	22.4	3.7	5.1	....	....	.148	.22	...	....	.36	...	....	.017	2.1
3336	" 8	" 9	d	l	.15	311.6	272.8	38.8	26.8	21.6	4.	5.1	....	....	.2	.16	...	....	.28	...	....	.016	1.
3362	" 15	" 16	d	m	.4	689.2	228.8	460.4	66.	36.8	2.8	23.9	6.2	17.7	.2	.84	.28	.56	1.72	.52	1.2	.04	1.5
3386	" 22	" 23	v d	v m	.5	2106.	178.4	1927.6	164.	22.8	1.	72.1	8.	64.6	.136	6.36	.36	3.	7.16	.68	6.48	.04	1.4
3405	" 29	" 30	v d	v m	.8	1111.2	194.8	916.4	87.2	24.	1.2	34.7	8.3	26.4	.12	1.76	.32	1.44	3.81	.61	3.2	.035	1.05
3427	April 5	Apr. 6	d	l	...	254.4	220.	34.4	30.	25.6	4.1	9.5	....	....	.16	.44	...	....	.85	...	....	.055	1.
3452	" 12	" 13	d	c	.6	241.6	218.8	22.8	25.6	21.2	4.	8.8	....	....	.06	.4	...	....	.85	...	....	.04	1.
3477	" 19	" 21	d	l	...	318.	265.6	52.4	32.	20.2	3.5	7.9	....	...	.044	.36	...	....	.77	...	...	.03	.55
3505	" 26	" 27	d	c	...	356.8	255.6	101.2	34.8	26.4	3.8	9.4	....	....	.022	.36	...	....	.85	...	...	.04	1.1
3533	May 3	May 4	d	m	...	433.2	238.4	194.8	44.8	19.4	3.2	11.2	....	....	.046	.44	...	....	.9	...	..	.085	.85
3558	" 10	" 11	d	c	...	344.	237.2	106.8	37.2	27.0	3.8	7.	....	....	.034	.28	...	....	.58	...		.035	1.2
3592	" 17	" 18	v d	v m	...	2662.	178.4	2483.6	150.	34.	1.2	39.	8.6	30.4	.12	1.44	.44	1.	5.94	.86	5.08	.07	1.1
3619	" 24	" 25	v d	m	...	734.4	184.8	549.6	64.	31.2	2.	25.9	....	....	.046	.96	...	....	1.86	...		.05	.9
3639	" 31	June 1	v d	v m	.5	1553.2	190.8	1362.8	74.4	19.2	1.7	48.	6.5	41.5	.014	2.32	.32	2.	5.14	.5	4.64	.07	1.
3662	June 7	" 8	d	c	.05	378.	320.8	57.2	50.8	43.	3.1	6.5	....	....	.014	.22	...	...	.6	...	...	.065	.4
3690	" 14	" 15	d	m	...	929.6	222.8	706.8	57.6	29.2	2.4	9.3	....	....	.017	1.08	...	...	4.44	...	...	.06	.6
3710	" 21	" 22	d	c	.03	778.4	317.2	461.2	454.8	32.8	3.3	5.3	....	....	.015	.24	...	....	.32	...	....	.03	1.3
3755	" 28	" 29	v d	m	...	676.8	......	......	30.8	....	2.6	18.5	....	...	.008	.64	...	..	1.4	...	...	.04	.75
3787	July 5	July 6	d	l	.05	342.4	302.8	39.6	20.8	20.	3.2	4.5	....	....	.017	.24	...	—	1.16	...	....	.015	.5

3821	July 12	July 13	d	l	.08	298.	244.8	53.2	15.2	12.8	3.2	6.6	....	....	.032	.6	....	....	1.08	....	....	.186	.25
3844	" 19	" 20	d	c	.15	357.2	314.8	42.4	16.8	13.2	5.1	6.5	....	....	.062	.32	....	....	.8	....	....	.017	.2
3885	" 26	" 27	d	c	.	294.4	276.8	17.6	28.	25.2	3.3	5.3	....	....	.088	.36	....	....	.6	....	....	.001	.1
3907	Aug. 2	Aug. 3	d	c	...	326.	280.8	45.2	14.	12.8	3.5	5.8	....	....	.074	.32	....	....	.8	....	....	.02	.1
3938	" 9	" 10	d	c	...	663.6	174.	489.6	34.	19.2	2.8	15.	....	....	.082	.6	....	....	1.44	....	....	.185	.25
3964	" 16	" 17	d	c	...	263.2	212.8	50.4	24.	22.	3.	7.3	....	....	.17	.28	....	....	.64	....	....	.1	.2
3984	" 23	" 24	d	c	.1	320.4	227.6	92.8	25.2	22.8	2.7	7.6	....	....	.016	.28	..	....	.56	....	....	.008	.15
4013	" 30	" 31	d	c	...	338.	242.	96.	25.6	24.	2.9	7.2	....	....	.014	.32	....	....	.6	....	....	.06	.15
4046	Sept. 6	Sept. 7	vd	vm	...	5846.	168.9	5677.9	158.	20.8	3.2	79.	....	....	.0 6	3.6	....	....	8.32	....	....	.034	.4
4072	" 13	" 14	d	c	...	307.	253.2	53.8	25.2	29.	2.9	6.6	....	....	.026	.2	....	....	.48	....	....	.014	.2
4093	" 20	" 21	d	c	.03	329.	236.8	92.2	22.	23.	3.1	6.6	....	....	.014	.24	....	....	.48	....	....	.023	.25
4126	" 27	" 28	d	c	.02	356.4	286.8	69.6	31.2	27.2	3.5	6.	....	....	.016	.2	....	....	.56	....	....	.02	.6
4146	Oct. 4	Oct. 5	d	c	.05	345.2	318.	27.2	29.2	26.	3.5	4.3	....	....	.016	.16	....	....	.36	..	....	.005	.35
4196	" 11	" 12	d	l	.1	327.6	298.4	29.2	32.	27.2	3.2	4.6	....	....	.008	.2	....	....	.33	....	....	.058	.45
4231	" 18	" 19	d	l	.05	326.	312.	14.	32.	31.2	3.5	4.	....	....	.01	.144	....	....	.29	....	....	.004	.25
4259	" 25	" 26	d	l	.1	318	304.8	13.2	28.	24.	4.	3.8	....	....	.016	.144	....	....	.33	....	....	.006	.45
4300	Nov. 1	Nov. 2	d	c	...	320.8	300.	20.8	32.8	30.	4.7	6.3	....	....	.042	.24	....	....	.49	....	....	.017	.3
4333	" 8	" 9	d	l	...	336.8	316.	20.8	30.	28.	3.8	5.2	....	....	.036	.24	....	....	.35		....	.066	.6
4373	" 15	" 17	d	l	...	328.	309.2	18.8	30.	27.2	4.2	5.5	....	....	.02	.208	....	....	.43	....	....	.014	.55
4400	" 22	" 23	d	l	.1	342.	334.	8.	32.	30.	4.5	3.3	....	....	.012	.096	....	....	.33	....	....	.004	.65
4423	" 29	" 30	d	l	.03	335.2	332.	3.2	46.4	42.	3.5	2.8	....	....	.022	.128	....	....	.27	....	....	.007	.8
4460	Dec. 6	Dec. 7	s	l	.02	326.8	326.	.8	40.	36.	3.9	2.2	....	....	.03	.09	....	....	.21	....	....	.001	.3
4484	" 13	" 14	s	c	.02	367.6	360.	6.8	50.8	48.8	4.4	3.	2.7	.3	.02	.078	.074	.004	.29	.21	.08	.004	.25
4511	" 20	" 21	d	c	.06	486.8	338.8	148.	66.	60.	5.2	15.2	....	....	.006	.56	....	....	1.25	....	....	.03	.5
4541	" 27	" 28	d	c	...	330.8	240.8	90.	48.	40.	5.8	27.1	....	....	.28	.88	....	....	1.81	....	....	.02	.25
Average Jan. 4—June 28.....						704.9	224.8	408.	67.7	24.2	3.2	20.	9.5	26.8	.19	.704	.384	1.12	2.02	.69	2.68	.056	1.01
Average July 5—Dec. 27.						558.5	281.1	277.4	32.3	27.4	3.7	9.6	2.7	.3	.047	.413	.074	.004	.03	.21	.08	.023	.34
Average Jan. 4—Dec. 27..........						631.7	253.	378.7	51.9	23.8	3 4	14.6	8.9	24.4	.119	.608	.335	1.018	1.47	.65	2.46	.039	.67

† The abnormally high figures occasionally obtained result from the backing of Illinois river into the Spoon river.
The water in all cases was odorless. The color upon ignition was brown.

SPOON RIVER, AT HAVANA.

DEPARTMENT OF CHEMISTRY, UNIVERSITY OF ILLINOIS.
SANITARY WATER ANALYSIS. PARTS PER MILLION.—A. W. P. No. 80.

Serial Number....	Date of		Appearance.			Odor..............	Residue on Evaporation.						Color on Ignition...	Chlorine........	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen			Nitrogen as	
	Collection....	Examination	Turbidity....	Sediment....	Color..........		Total	Dissolved....	Suspended...	Loss on Ignition.					Total......	By Dissolved	By Suspend'd Matter......	Free Ammn'a	Albumino'd Ammonia.			Total.........	Dissolved....	Suspended...	Nitrites......	Nitrates.....
										Total....	Diss'lv'd	Susp'ded							Total....	Diss'l'v'd	Susp'ded					
4571	1899 Jan. 3	1899 Jan. 4	Distinct	Little	Muddy F.6	None..	334.8	316.8	18.	34.	31.6	2.4	Br'wn	4.6	6.8	....	....	.14	.24	....	.....	.49	....	.....	.004	.55
4596	10	11	V.Decid.	V. Mch	Muddy F.2	'' ..	458.8	220.8	238.	34.	32.	2.	''	4.	35.8	17.	18.8	.56	1.12	.52	.6	2.29	1.09	1.2	.006	.35
4618	17	18	Decided.	Consid	Muddy F.25	'' ..	317.2	254.8	62.4	50.	48.	2.	''	11.	14.	87.	5.3	.72	.52	.304	.216	.97	.61	.36	.035	.85
4642	24	25	''	''	Muddy	'' ..	278.8	258.8	20.	42.	40.	2.	''	4.2	11.6	....	....	.462	.48	....	.....	.77		.....	.022	.45
4662	31	Feb. 1	Distinct	Little	.25	'' ..	326.	316.8	9.2	54.	44.	10.	''	14.	9.6	....	....	.948	.44	....	.....	.81	....	.....	.026	.6
4685	Feb. 7	Feb. 8	''	''	.15	'' ..	363.2	360.8	2.4	58.	54.	4.	''	4.1	3.3	....	....	.222	.112	....	.....	.3	....	.....	.009	1.5
4702	14	15	''	''	.20	'' ..	368.	364.8	3.2	66.	62.	4.	''	11.5	7.5	....	....	.692	.272	....	.....	.66	....	.....	.015	1.55
4731	21	22	''	''	.03 F.10	'' ..	376.8	360.2	7.6	46.	43.2	2.8	''	4.6	3.	....	....	.13	.096	....	.....	.276	....	.....	.013	1.
4758	28	Mar. 1	V.Decid.	V. Mch	Muddy F.1	'' ..	763.2	112.	651.2	74.	36.	38.	''	1.	29.8	16.3	13.5	.44	1.28	.52	.76	2.5	.86	1.64	.035	.6
4782	Mar. 7	Mar. 8	''	''	Muddy F.4	'' ..	1080.8	150.	930.8	132.	44.	88.	''	1.6	46.	18.7	27.3	.502	2.4	.56	1.84	5.54	1.34	4.2	.045	1.
4812	14	15	''	''	V.Mdy F.7	'' ..	1492.	150.	1342.	128.	41.6	86.4	''	6.	38.	15.8	22.2	.64	1.76	.384	1.376	3.38	.86	2.52	.05	1.1
4841	21	22	''	''	V.Mdy F.03	'' ..	2922.	103.2	2818.8	242.	22.	21.	''	1.	105.5	13.	92.5	.56	4.	.368	3.632	11.87	.55	11.32	.04	1.5
4862	28	29	Decided.	Much.	Muddy F.1	'' ..	328.	254.	74.	34.	30.	4.	''	3.8	9.8	...	....	.45	.4	....	.....	.6	....	.....	.022	1.
5012	May. 9	May 10	''	''	Muddy F.06	'' ..	442.8	244.8	198.	39.6	27.2	12.4	''	3.4	17.5	8.	3.5	.118	.44	.256	1.84	1.05	.73	.32	.005	1.56
5124	30	31	''	V.Mch	Muddy	'' ..	1566.8	264.	1302.8	103.6	47.6	56.	''	2.1	35.5	7.	28.5	.144	1.44	.224	1.216	3.45	.81	2.64	.046	1.64

8581 Q. JUDGE SPRINGER: Did you make any investigations as to the waters of the State of Illinois before the passage of the act of the legislature to which reference has been made?

A. Yes, as I have already testified. I began investigations of the water supplies of Illinois in 1889, but did not begin systematic investigation of the Illinois river until the summer of 1894.

Q. What was done then?

A. Then samples were collected at Havana a number of times during the summer of 1894, and in 1895, under the provisions of an appropriation made by the Legislature and assigned by the trustees of the University to the purpose. Analyses of the water supplies of the State were begun and included the examination of samples of water from the Illinois river, and some of its tributaries.

Q. Did you make a preliminary report of those investigations?

A. I did, which report was published by the University in the beginning of 1897, and covered all work done under the provisions heretofore mentioned, up to the end of the year 1896.

Q. Have you that report?

A. I have.

8582 JUDGE SPRINGER: I will offer this report as defendant State of Illinois Exhibit No. 23 for identification.

Said document so marked by the Commissioner.

Q. Professor, did you make any tables of averages based upon the report to which you have just referred?

A. I did.

Q. Have you those tables with you?

A. I have.

Q. Will you produce them?

A. I will. I produce certain tables of averages made from the tables of detailed data just introduced in evidence as Department of Chemistry, University of Illinois A. W. P. Table 1 to 80 inclusive, and State of Illinois Exhibit No. 23 for identification.

Q. Who made those tables of averages?

A. I did.

Q. Based upon the data to which you have referred?

A. Yes.

JUDGE SPRINGER: I offer these tables of averages in evidence and will ask that they be incorporated in evidence as a part of the testimony of this witness, later on.

MR. JEFFRIES: I object to these tables of averages being incorporated into the record as part of the testimony 8583 of this witness or as a part of the testimony in this case for the reasons stated in my objection to the introductions of the tables themselves, and to the State of Illinois Exhibit No. 23 for identification, and I object further for the reason that a table of averages does not correctly represent the conditions of the water in the Illinois river at all times of the year under all conditions and under all circumstances, and that no table of averages such as these appear, can represent the condition, chemically speaking, from a sanitary standpoint of the actual condition of the water of any running stream.

I object for the further reason that the tables of averages conceal certain conditions that are as important for the determination of this case, as those conditions that it reveals, if any it does reveal, and these concealed conditions of the water in a running stream, so far as the experience of the past is concerned, have been the source and the cause of epidemics of water-borne diseases.

JUDGE SPRINGER: I move to strike this out upon the ground that the objection is argumentative and goes to the weight of the testimony and not to its competency or admissibility.

Q. JUDGE SPRINGER: Professor, state whether you have made any charts or plates or diagrams illustrating in a graphic form the data contained in the tables which you 8584 have read in evidence, and also in defendant State of Illinois Exhibit No. 23, for identification?

A. I have.

Q. Will you produce those please?

A. I produce certain charts which are to be known in this investigation as Department of Chemistry, University of Illinois, A. W. P., plates No. V to XLII, inclusive.

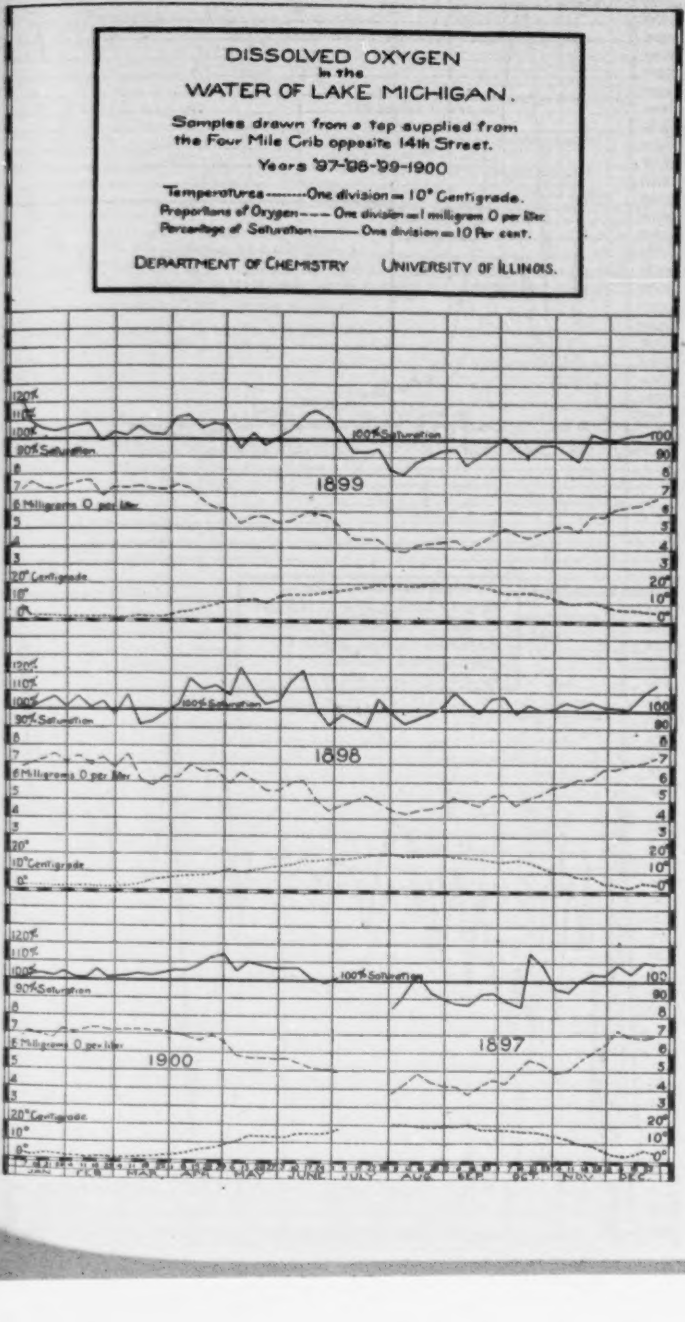
JUDGE SPRINGER: I offer these plates in evidence and ask that they be incorporated in the evidence as a part of the testimony of this witness.

MR. JEFFRIES: We object to the introduction of the plates for the same reason stated in our objection to the introduction and incorporation of tables from which they were made, into the record, and which as I understand it, are the tables that were introduced a few moments ago, and known as "Department of Chemistry, University of Illinois, A. W. P., Table 1 to 80 inclusive."

THE WITNESS: The plates are numbered V to XLV inclusive, and from V to XVII both inclusive are as follows:

8585

Plate V.—A. W. P.



DISSOLVED OXYGEN
in the
WATER OF LAKE MICHIGAN.

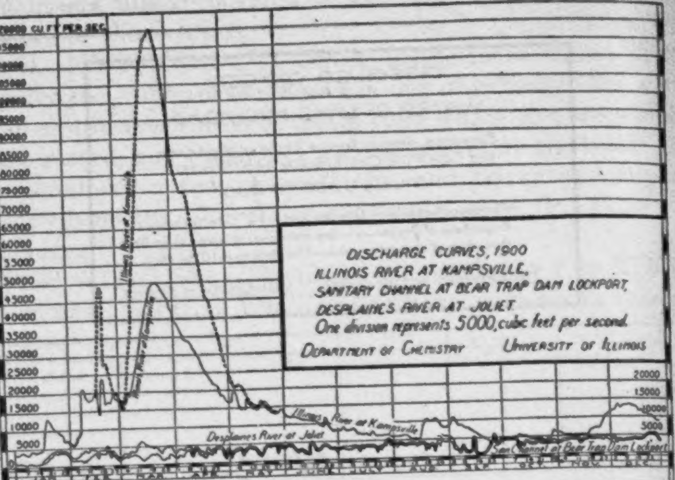
Samples drawn from a tap supplied from the Four Mile Crib opposite 14th Street.

Years '97-'98-'99-1900

Temperatures -------- One division = 10° Centigrade.
Proportions of Oxygen – – – One division = 1 milligram O per liter.
Percentage of Saturation ——— One division = 10 Per cent.

DEPARTMENT OF CHEMISTRY UNIVERSITY OF ILLINOIS.

Plate VI.—A. W. P.


DISCHARGE CURVES, 1900
ILLINOIS RIVER AT KAMPSVILLE,
SANITARY CHANNEL AT BEAR TRAP DAM LOCKPORT,
DESPLAINES RIVER AT JOLIET
One division represents 5000, cubic feet per second.
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS
120000 CU FT PER SEC
115000
110000
105000
100000
95000
90000
85000
80000
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
20000
15000
10000
5000
Illinois River at Kampsville
Illinois River at Kampsville
Desplaines River at Joliet
San. Channel at Bear Trap Dam Lockport
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEP
OCT
NOV
DEC

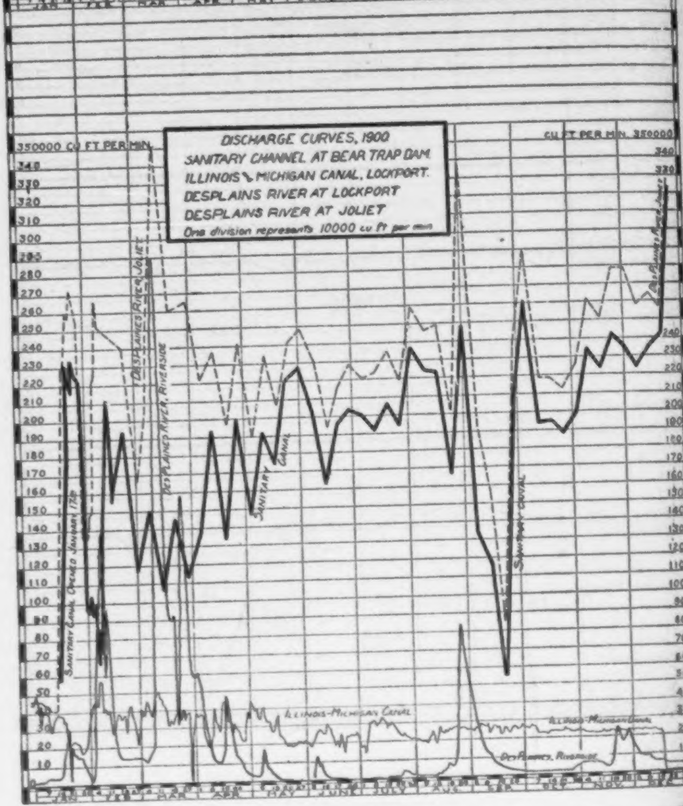
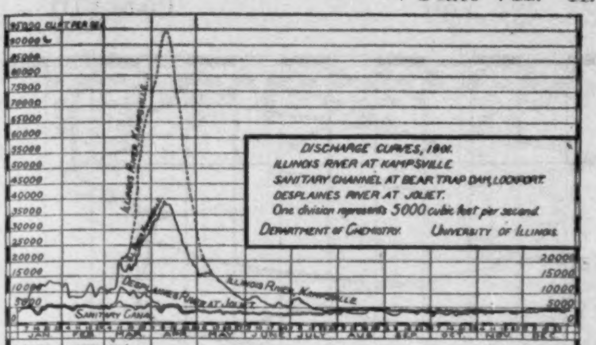

DISCHARGE CURVES, 1900
SANITARY CHANNEL AT BEAR TRAP DAM.
ILLINOIS & MICHIGAN CANAL, LOCKPORT.
DESPLAINS RIVER AT LOCKPORT
DESPLAINS RIVER AT JOLIET
One division represents 10000 cu ft per min
350000 CU FT PER MIN.
340
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
CU FT PER MIN. 350000
340
330
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
SANITARY CANAL OPENED JANUARY 17th
DESPLAINES RIVER JOLIET
DES PLAINES RIVER, RIVERSIDE
SANITARY CANAL
SANITARY CANAL
ILLINOIS-MICHIGAN CANAL
ILLINOIS-MICHIGAN CANAL
DES PLAINES, RIVERSIDE
DES PLAINES RIVER JOLIET
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEP
OCT
NOV
DEC

Plate VII.—A. W. P.



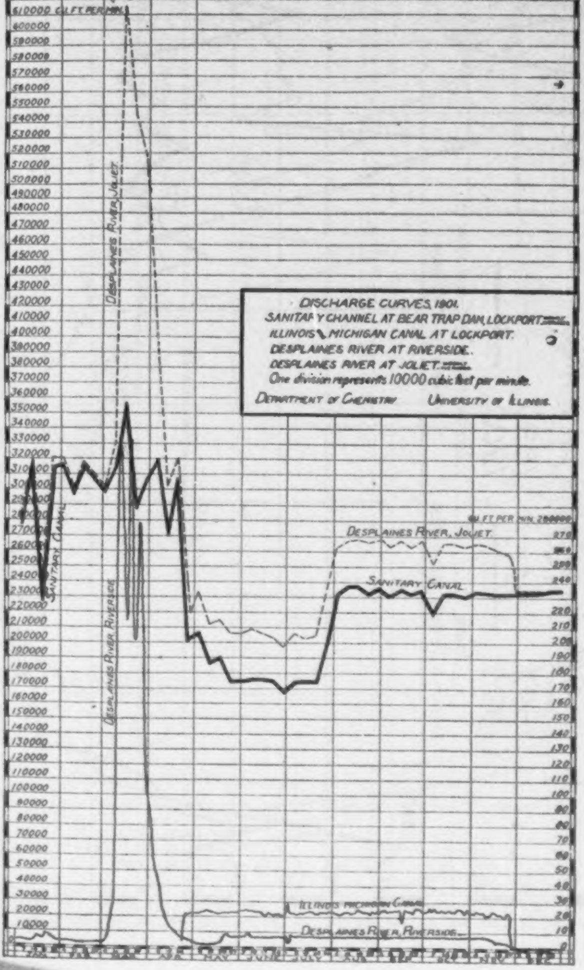
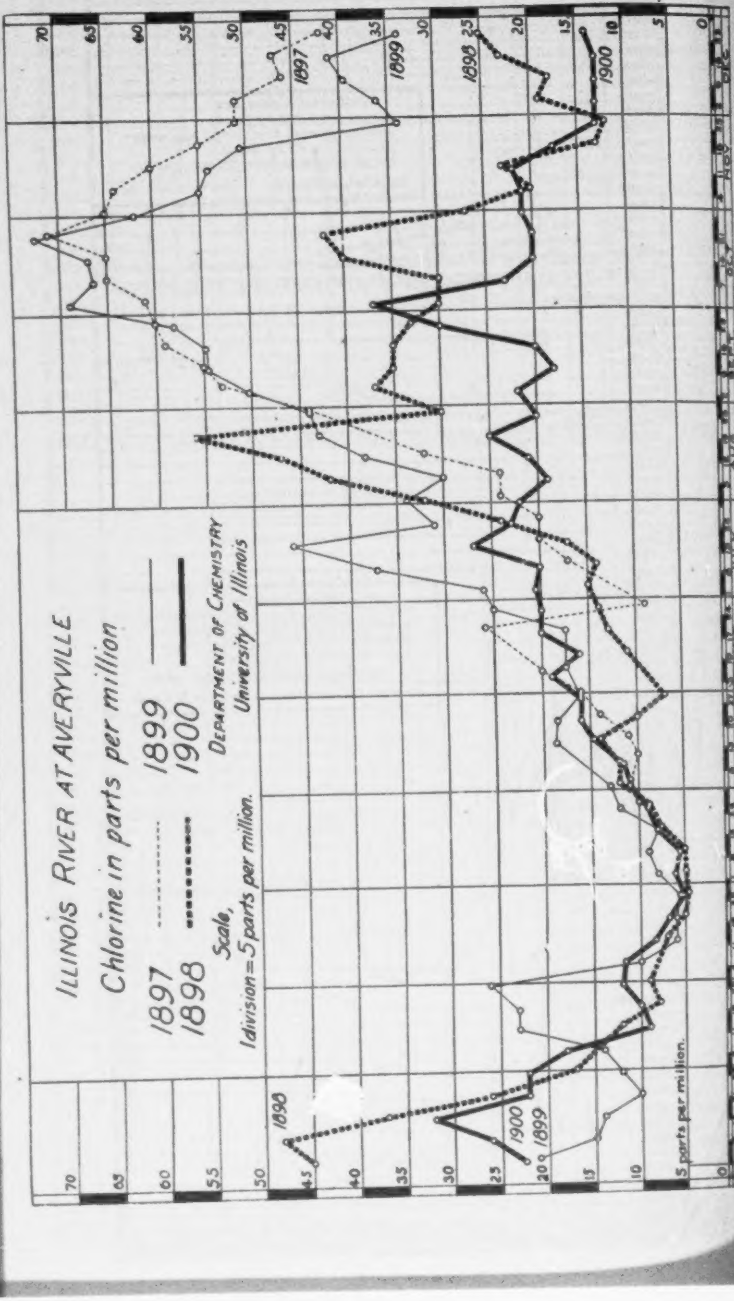
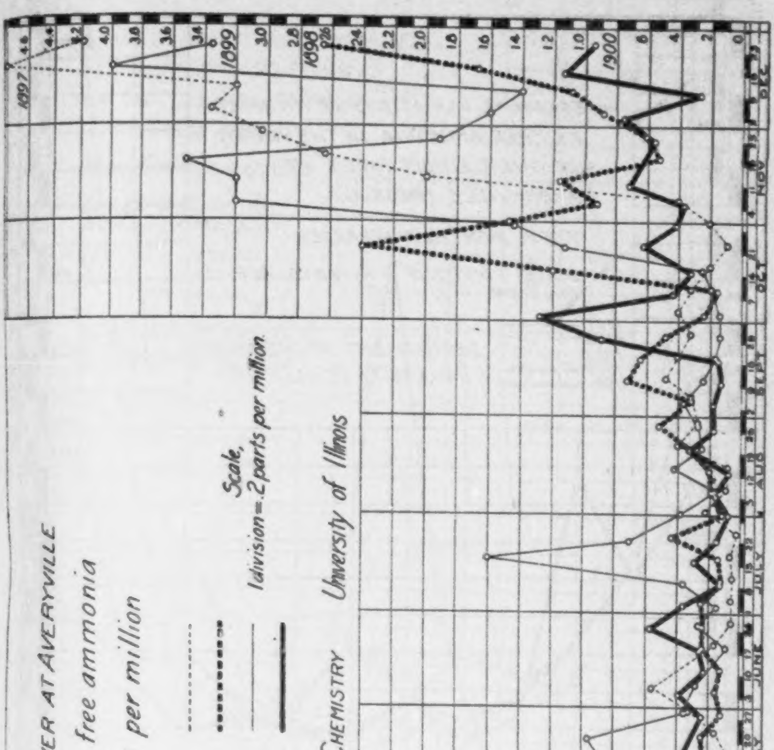


Plate VIII.—A. W. P.



8589

Plate IX.—A. W. P.



—333

Plate X.—A. W. P.

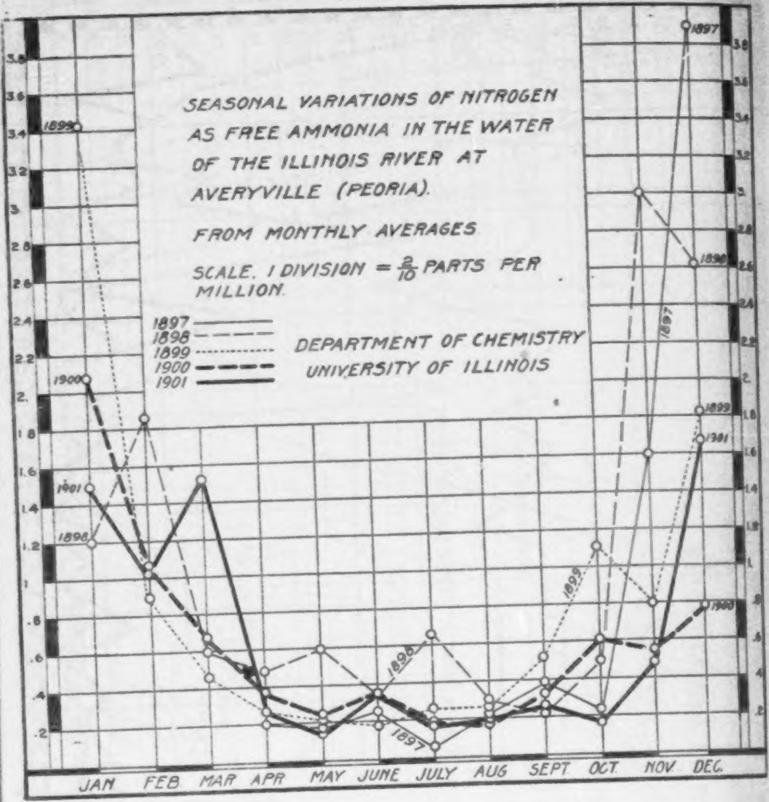

SEASONAL VARIATIONS OF NITROGEN AS FREE AMMONIA IN THE WATER OF THE ILLINOIS RIVER AT AVERYVILLE (PEORIA).
FROM MONTHLY AVERAGES
SCALE. 1 DIVISION = 2/10 PARTS PER MILLION.
1897
1898
1899
1900
1901
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS
3.8
3.6
3.4
3.2
3.
2.8
2.6
2.4
2.2
2.
1.8
1.6
1.4
1.2
1
.8
.6
.4
.2
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC

Plate XI.—A. W. P.

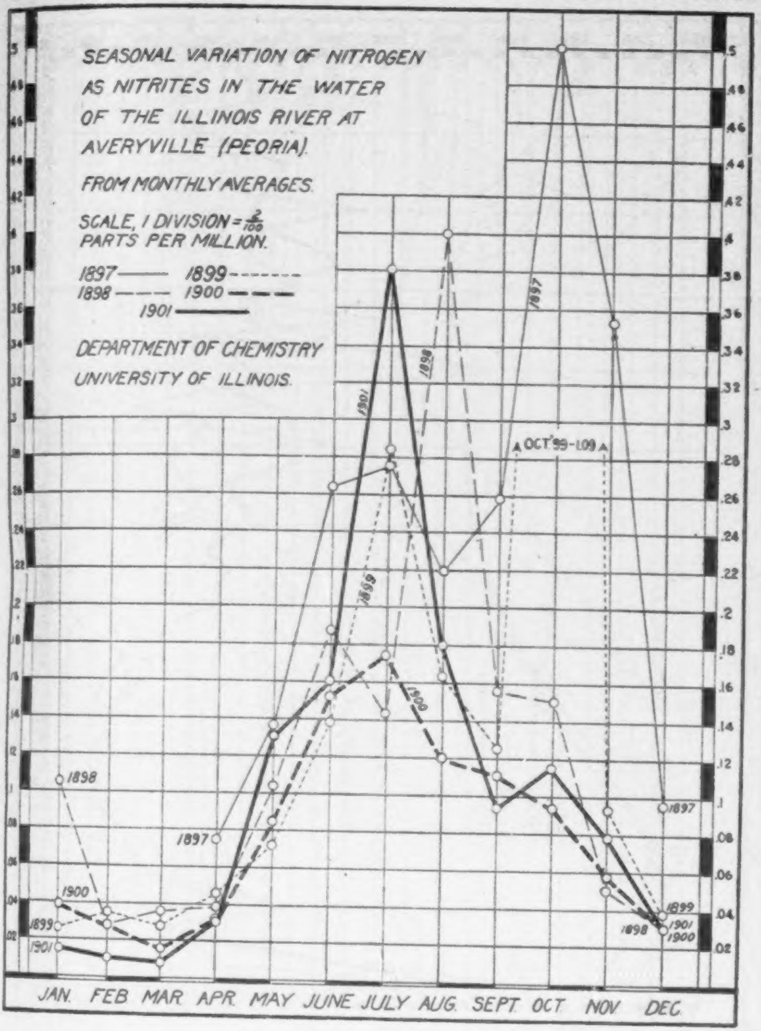

SEASONAL VARIATION OF NITROGEN
AS NITRITES IN THE WATER
OF THE ILLINOIS RIVER AT
AVERYVILLE (PEORIA).
FROM MONTHLY AVERAGES.
SCALE, 1 DIVISION = 2/100
PARTS PER MILLION.
1897
1899
1898
1900
1901
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS.
OCT '99 - 1.09
.5
.48
.46
.44
.42
.4
.38
.36
.34
.32
.3
.28
.26
.24
.22
.2
.18
.16
.14
.12
.1
.08
.06
.04
.02
JAN.
FEB
MAR
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.

Plate XII.—A. W. P.

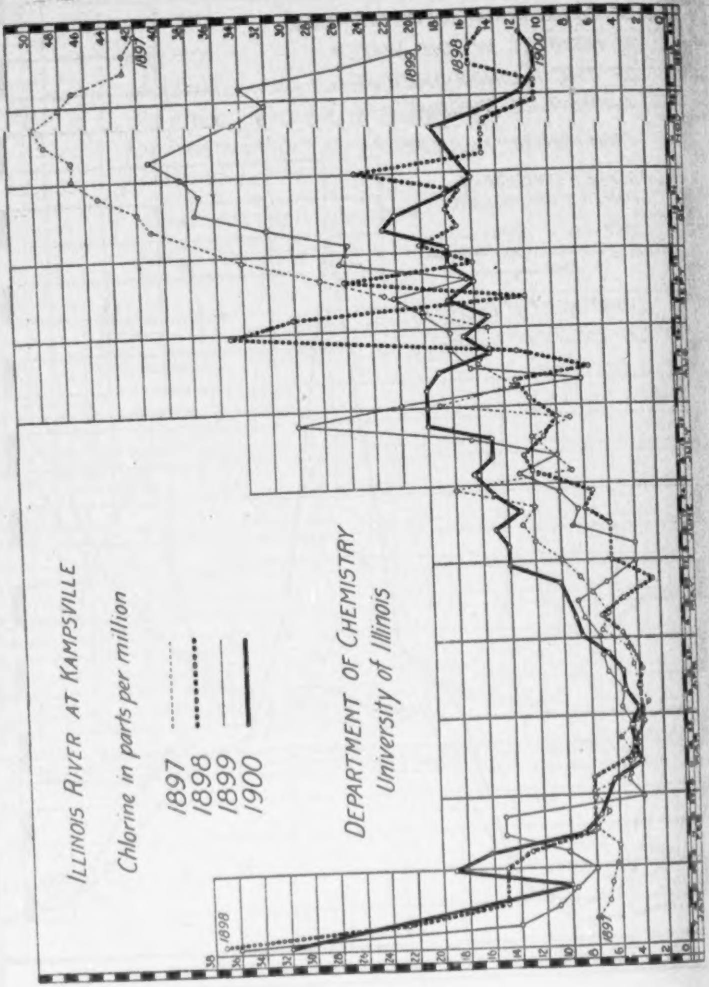


Plate XIII.—A. W. P.

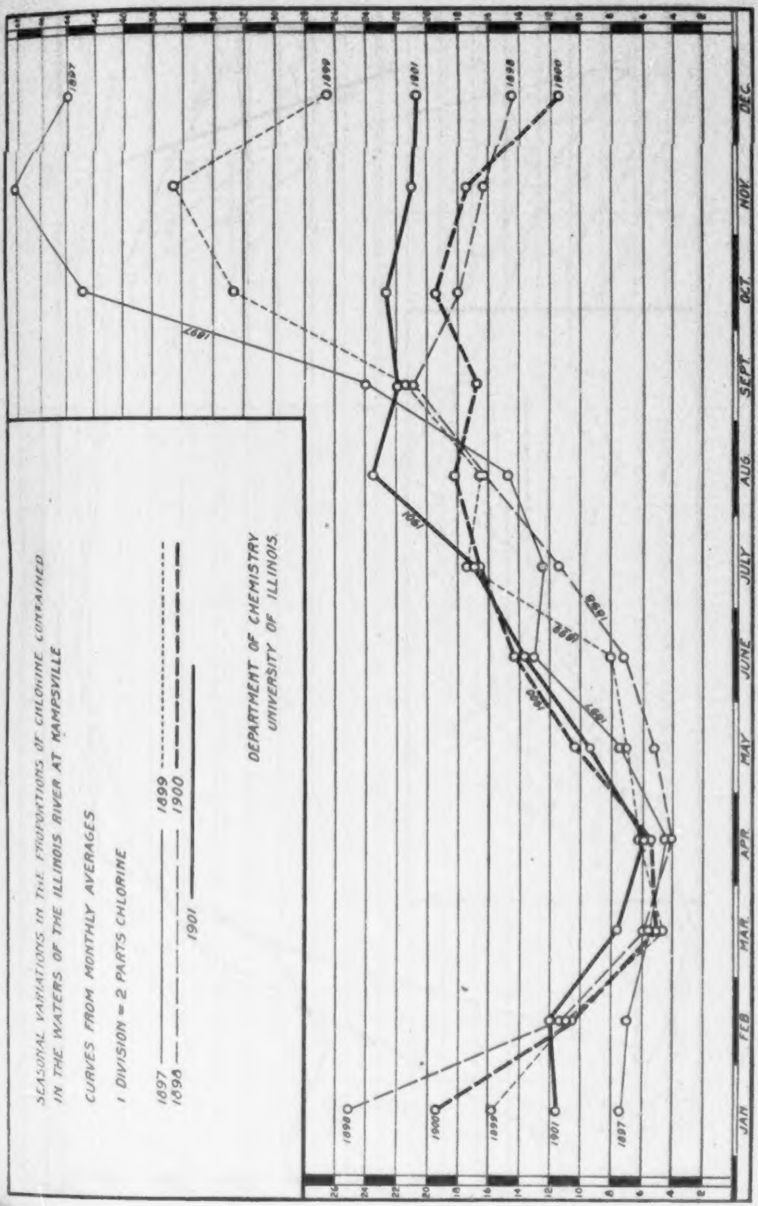
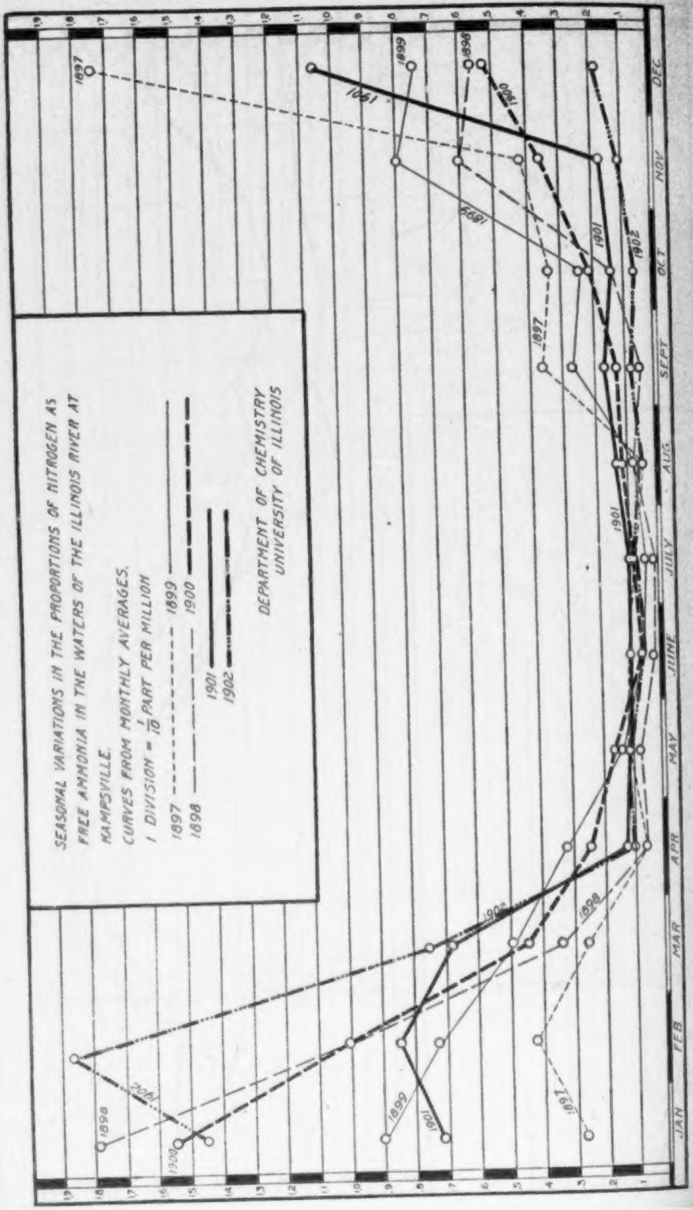
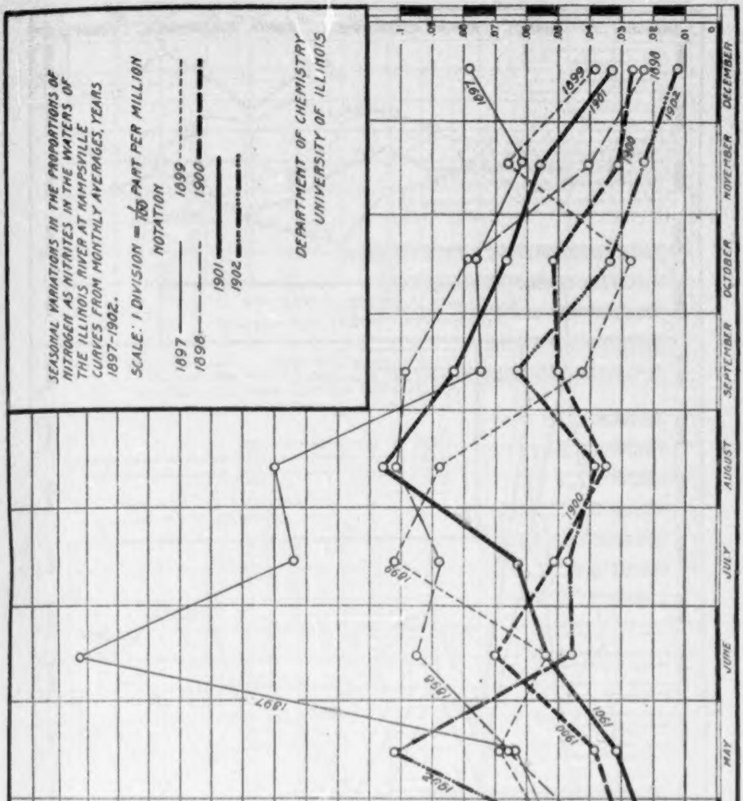


Plate XIV.—A. W. P.



8595 Plate XV.—A. W. P.



8596

Plate XVI.—A. W. P.

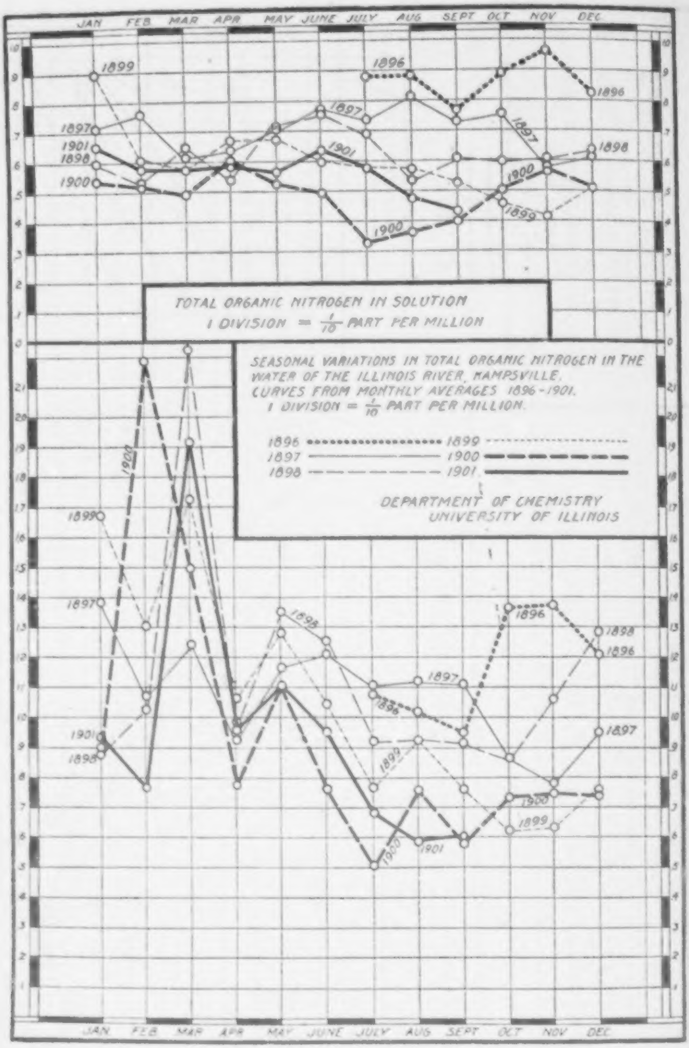
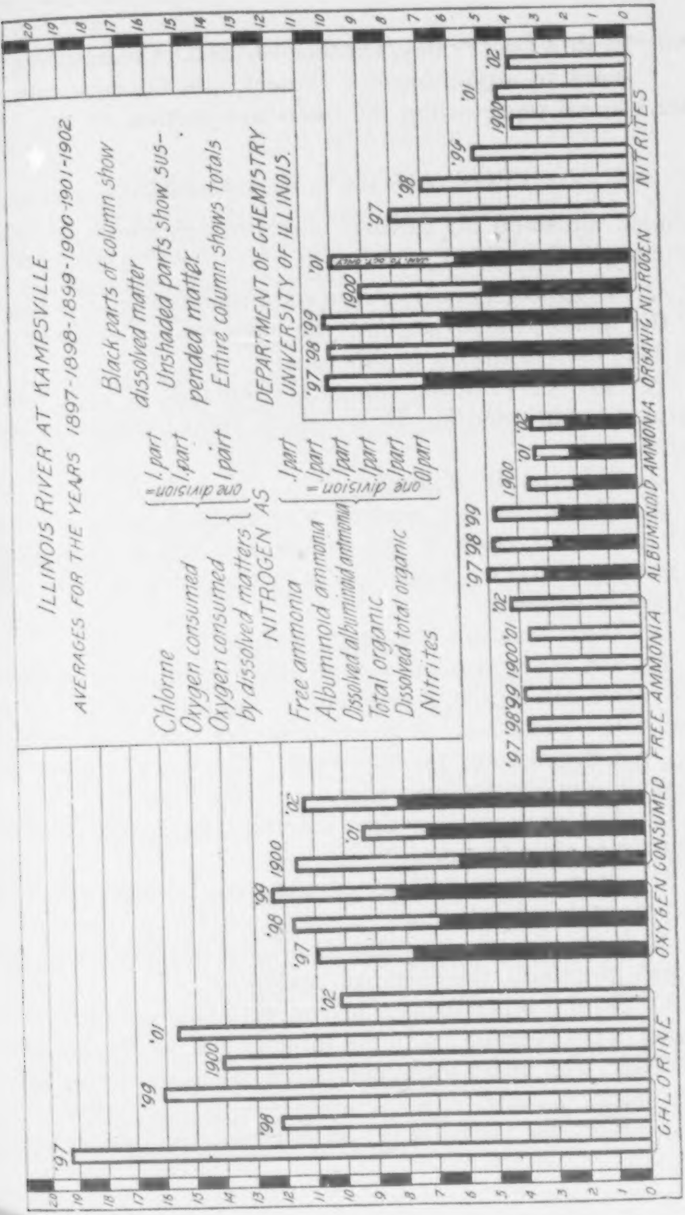


Plate XVII.—A. W. P.



8598 Adjourned until 10:00 A. M. following day, Friday, October 16th, 1903.

8599 10:00 A. M., Friday, October 16, 1903. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further direct-examination by Judge Springer, and testified as follows:

Q. Professor Palmer, please state who assisted you in making the tables of analyses that you have read in evidence since you have been testifying in this case?

A. Mr. C. V. Millar, up to the summer of 1900, now of Joplin, Missouri, and Mr. R. W. Stark, right through the entire series.

Q. Who is Mr. Millar?

A. Mr. Millar is a chemist who assisted me in doing the work of investigation of the waters, and did a great deal of the routine analytical work that is incorporated in these tables that are in evidence.

Q. What part did Mr. Stark perform?

A. Mr. Stark also had charge of a portion of the work and
after Mr. Millar's resignation had chief control of the
8600 work under me. Both of these men were responsible to
me throughout, for the work. The work was all done
under my immediate supervision.

Q. And state whether their ascertainments were submitted to you from time to time?

A. From day to day the results were brought to me and were incorporated into these tables which are in evidence.

Q. Were any other persons than those you have mentioned. engaged in making the chemical analyses?

A. Several other persons helped with portions of the work but they were responsible to me directly and to Mr. Stark and Mr. Millar, who under me supervised some of the minor details of the work.

Q. Were the tables so far as you know, and the ascertainments contained in them made by you three jointly so that you three can determine whether they are accurately made?

A. They were.

(Witness Prof. Palmer temporarily withdrawn from the stand.)

8601 R. W. STARK,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Judge Springer and testified as follows:

Q. State your name, residence and occupation?

A. My name is R. W. Stark, Champaign, Illinois; I am a chemist employed in the State Water Survey.

Q. Where were you educated Mr. Stark?

A. At the University of Illinois.

Q. What courses did you take there?

A. I took the chemical course.

Q. How long were you engaged in that study?

A. I pursued the chemical course for four years, and was graduated in 1895.

Q. Did you attend any other college than this?

A. I have not.

Q. Did you receive any degree?

A. I received the degree of B. S.—Batchelor of Science.

Q. What has been your occupation since that time, since 1895?

A. For two years I did various things; one year was passed upon a farm. In 1897 I was employed upon the Water Survey of Illinois.

8602 Q. What was the nature of your duties in connection with the Water Survey of Illinois?

A. For the first three years I was making chiefly mineral analyses and some clerical work. After Mr. Millar's resignation I was made chief assistant.

Q. Of what?

A. Of the State Water Survey, and I then had charge of the sanitary chemical analyses in the laboratory work.

Q. Have you had any experience, and if so, how much, in making chemical analyses of water?

A. Since June 18th, 1900, I have been employed constantly in making sanitary chemical analyses.

Q. What instructions if any did you have in that line of work and what experience; what was your experience or practice as a chemist?

A. Prior to my employment?

Q. Yes?

A. We have a course, or had a course in the University on sanitary chemical analysis, and I took this course in the University.

Q. Did that embrace the making of chemical analyses of water?

A. It did.

8603 Q. My questions in this case are directed solely to the matter of your knowledge in the making of chemical analyses of water?

A. Yes.

Q. It was that that I desired to call out. Then state what your experience has been in making chemical analyses of water. How long have you made such analyses, and about how many such analyses have you made?

A. About how many of such?

Q. Yes?

A. I have made about between 6,000 and 7,000 I should judge.

Q. State whether you assisted Professor Palmer in making the chemical analyses which he prepared, together with you and Mr. Millar during the years 1897 to 1902?

A. I did.

Q. You heard Professor Palmer's statement a few minutes ago did you?

A. I did.

Q. And you were the person referred to by him as having assisted in making those analyses?

A. I am.

Q. State whether the analyses about which he testified, and in which you participated were entered upon any tables as a matter of record?

8604 A. They were.

Q. Who entered those?

A. Mr. Millar and myself had charge of them; that is the different memoranda as made at the time.

Q. Did Professor Palmer make any of those?

A. Not the sanitary—we made the memoranda.

Q. Of course you don't know all that Professor Palmer has done himself?

A. Oh, no.

Q. You only know what you did?

A. Yes.

Q. State whether the results recorded by you in connection with these analyses were correctly stated in the tables which were prepared by Professor Palmer and yourself and Mr. Millar?

A. So far as I am able to konw, they were.

Q. And so far as you yourself performed the work?

A. They were.

Q. As to that you know that those were correct?

A. Yes sir.

Q. I call your attention to table No. 1, down to and including table No. 80, put in evidence by Professor Palmer; were those the tables that you assisted in making?

A. They were.

8605 Q. I now call your attention to tables made by him, as a part of the sanitary survey of Illinois covering periods from 1897 to the end of 1902, known as Department of Chemistry, University of Illinois, A. W. P. 1 to 80. Do you recognize those tables?

A. I do.

Q. Are those the ones that you participated in making?

A. I did.

Q. And so far as the entires were made by you, they are correct ascertainments of the analyses made by you at the time?

A. They are.

DIRECT-EXAMINATION,

By Mr. Todd.

Q. Now Mr. Stark, you worked under the direction and supervision of Professor Palmer in the laboratory analyses in the University of Illinois, of these water samples as received there, did you not?

A. I did.

Q. And your work was done under his direction and supervision?

A. It was.

8606 Q. You merely worked as an assistant to Professor Palmer in doing this work?

A. Yes sir.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. When you spoke of making sanitary chemical analyses do you mean that you made those from a sanitary standpoint, and as a sanitarian, taking into consideration the source of pollution, extent of pollution, and everything of that kind, or were they made simply with reference to the chemical constituents contained in the samples of water which you analyzed?

A. They were made so far as I was concerned, simply taking into consideration the various chemical constituents.

8607 PROF. ARTHUR W. PALMER,

resumed the stand for further direct-examination by Judge Springer, and testified as follows:

Q. Professor, I now call your attention to the tables of chemical analyses read in evidence by you yesterday, beginning with table "Department of Chemistry, University of Illinois, A. W. P. No. 1." Please explain briefly the nature of the entries upon this, and what the table is intended to illustrate?

MR. JEFFRIES: Now I object to any explanation being made by this witness with reference to what these tables show, for the same reasons stated in my objection to the introduction of the tables themselves.

A. Table marked "Department of Chemistry, University of Illinois A. W. P. 1" shows the results of analyses of samples of water from Lake Michigan at Chicago, drawn from the tap at No. 465 State Street; that is in the building of the college of Pharmacy of the University of Illinois, the water at that point coming from the Four-Mile intake, opposite Fourteenth Street.

8608 The data in this table include the analyses of samples collected regularly every week for the year 1897, reaching from the 4th of January 1897, to the 27th of December of that year. The data which are set forth in this table include all of the usual determinations of various constituents as determined in chemical analyses of waters for sanitary purposes.

The first column at the left hand of the table gives the serial number which was placed upon the sample of water; that is, upon the certificate of the collector, and upon the bottle containing the sample, at the time it was received at the laboratory, by which number the sample of water was identified throughout the analysis, and the tabulations and all discussion which follows:

In the second column there is given the date of collection.

In the third column the date of examination, which examination began immediately upon receipt of the sample at the laboratory.

In the third column, the determination of turbidity is noted.

In the fourth column the sediment.

In the fifth column the color.

In the sixth column the odor.

In the seventh column the total residue on evaporation
560 of a portion of the original sample.

In the eighth column the total residue on evaporation of the filtered portion of the sample.

In the ninth column the suspended matters as determined by the differences between the figures in columns 8 and 7.

In the tenth column the total loss on ignition, that is the loss upon igniting the residue from evaporation of the unfiltered sample.

The eleventh column the loss on ignition of the total residue on evaporation of the filtered water, which appears in the column marked "Dissolved" and numbered 8.

In the twelfth column there are recorded the results of the determination of chlorine.

In the thirteenth the total oxygen consumed.

In the fourteenth the oxygen consumed by organic matters in the filtered portion of the sample.

In the fifteenth column the oxygen consumed by matters in suspension as determined indirectly by the difference between the two next preceding columns.

The sixteenth column contains the figures representing the proportions of nitrogen as free ammonia.

The seventeenth column the nitrogen as albuminoid ammonia,—the total, that is the proportions obtained by the
8610 analysis of an unfiltered portion of the sample.

The eighteenth column contains figures showing the proportions of nitrogen as albuminoid ammonia, derived from the matters held in solution in the water, as determined upon the filtered sample.

The nineteenth column contains figures representing the proportions of nitrogen as albuminoid ammonia derived from matters in susupension and constituting the difference between the figures in columns 18 and 17.

Column 20 contains the figures representing the proportions of total organic nitrogen as determined by the Kjel Dahl process upon the original unfiltered sample.

Column 21, similar determination upon the sample after filtration.

Column 22 the total organic nitrogen derived from matters suspended in the water, and determined by the difference between the figures in columns 20 and 21.

Column 23 shows the figures representing the proportions of nitrogen as nitrites.

Column 24 the proportions of nitrogen as nitrates.

Q. State whether the other tables following in this series contain similar data only differing as to the place from which the water was taken?

8611 A. This table is a typical number of the entire series, and represents the same sort of data in all respects as these appearing upon the other tables included in this series.

Q. Except as to the place where the water was taken?

A. Except as to the source of the sample of water, which, for each given point is noted upon the table in question.

The table also shows upon its lower lines the averages for the first six months, for the second six months, and for the entire year.

Q. The averages of what?

A. Of the analyses above.

Q. You may state what those averages were on this table?

A. What they were?

Q. Yes, the averages recorded there?

A. Well, do you want me to read the averages?

Q. Yes?

A. For this particular table the averages at the bottom show simply the general averages for the entire year, for the reason that variations in the water of Lake Michigan are so slight in the different seasons that there seemed to be no particular object in making averages for lesser periods than the entire year. Most of the other tables referring to the
8612 other points have the three sets of averages above referred to, namely those for the first six months, the second six months and the entire year.

Q. Proceed now and state what the averages were on these ascertainments?

A. We made no attempt to give averages for turbidity and sediment, since these were indicated merely by the terms as herein before testified to,—"Much," "Distinct," "Considerable," "Decided" and so on, which do not readily lend themselves to the preparation of averages. The color too, was not averaged, although expressed in figures in the table. The first averages recorded are those for the residue on evaporation. The average for this particular table representing the total residue upon evaporation is 151.7 parts per million.

The average for the total residue on evaporation of the filtered sample, representing matters in solution was 136.6 parts per million.

The average for the suspended matters, 15 parts per million.

The average loss on ignition, total, 11.9 parts per million.

The average loss on ignition of dissolved substances 9.6 parts per million.

8613 The average for the chlorine 2.9 parts per million.

The average for the total oxygen consumed, 3.3 parts per million.

The average for the oxygen consumed by dissolved substances, 2.7 parts per million.

I note here that the average for the oxygen consumed by suspended matters has not been printed in this table. I will supply it however; it is a mere matter of simple calculation.

The average for the nitrogen as free ammonia is .005 parts per million.

The average for the nitrogen as total albuminoid ammonia was .102 parts per million.

For the nitrogen as albuminoid ammonia yielded by matters in solution .076 parts per million.

The nitrogen as albuminoid ammonia derived from suspended matters, .036 parts per million.

The average for the total organic nitrogen by Kjel Dahl process, .268 parts per million.

For total organic nitrogen, yielded by dissolved substances, .195 parts per million.

For the total organic nitrogen yielded by matters in suspension .73 parts per million.—This is an error, it should be .073,—a typographical error in the plate which I will
8614 verify and get into the record latter.

The nitrogen as nitrites, and it will be observed that in the column for which this average is made, nitrites are frequently recorded as being absent, as indicated by the word "none", in this column, the average was .005 parts per million.

The average of the column giving the data for nitrates is .2 parts per million.

Q. These averages are for what year?

A. For the year 1897. Lake Michigan water at Chicago as described above.

Q. Coming from the Four-Mile crib?

A. Coming from the Four-Mile Crib, opposite Fourteenth Street and drawn at a tap in the College of Pharmacy of the University of Illinois, at 465 State Street.

Q. State whether you have a similar table of Lake Michigan water for the year 1898?

A. I have here before me a similar table, the analyses of Lake Michigan water at Chicago, drawn from the same source, which has just been described, but for the year 1898, which table is designated as No. 2 in the series.

Q. Does that table contain the averages at the bottom of the sheet?

8615 A. It does.

Q. State whether you have a table containing similar data based upon the waters from Lake Michigan at the point you have indicated for the year 1899?

A. I have. It is indicated as No. 3 of this series.

Q. And have you another table of data in reference to analyses of Lake Michigan water from the point you have indicated for the year 1900?

A. I have. It is No. 4 of this series.

Q. Does that table contain also a statement of averages for the year, as table No. 1 did?

A. It does.

Q. Now did you have any ascertainment of dissolved oxygen?

A. Not for the entire series of four tables, as I remember it, but for a portion of them.

Q. State what portion of the time covered by these tables was it during which you obtained results as to dissolved oxygen?

A. The dissolved oxygen determination covered a portion of the year 1897, the entire years, 1898 and 1899, and a portion of the year 1900.

Q. Have you put the plates in evidence heretofore which illustrate the dissolved oxygen to which you have referred? 8616

A. I have.

Q. Where did you obtain the data upon which these determinations were made?

A. The data were obtained by the analyses of samples especially collected for the making of dissolved oxygen determinations, which samples were taken at the same time and at the same place as the samples which were subjected to chemical analyses and the date from which are recorded on tables I to IV of this series, put in evidence yesterday, and just referred to.

JUDGE SPRINGER: Let this data be marked as defendant State of Illinois' Exhibit No. 24 for identification. These are the data which are represented in the curves of the plates already put in evidence, and further explanation of which will be made hereafter. These plates are known as "Department of Chemistry, University of Illinois Plates V to XLV, inclusive."

Q. I will ask the witness to explain the curves in plate V to which reference has just been made, showing these proportions of dissolved oxygen.

MR. JEFFRIES: I object to any explanation of the witness with reference to the curves on Plate V, for the reasons stated in my objection to the introduction of the plate in evidence.

A. An explanation of the meaning of the different lines
8617 upon the plate appears at the top of the plate, and further
I may say that one line represents the temperatures of the water samples as they were collected at the tap. This line being toward the bottom of the plate, or the section of the plate, referring to the year. The next line from the bottom represents the proportion of oxygen contained in the sample in milligrams, of oxygen per liter of water.

The third curve which is at the top of the series in each section represents the percentage of saturation. It will be observed of course that the quantity of oxygen contained in the water varies practically inversely, as the temperature. At lower temperatures the water holds a greater quantity of oxygen in solution; at higher temperatures it holds less. The curve representing the saturation figure, however, varies in a manner which is not precisely similar to the variations of temperature and of content of oxygen in quantity for the reason that the water is at times more than saturated. That is, holds in solution a greater quantity of oxygen than can be held in a state of stable equilibrium at that temperature and which doubtless is slowly diffusing from the water into the air. At other times the percentage of saturation falls below the 100 point, that is
the water is not fully saturated with dissolved oxygen.
8618 Inspection of the lines will show the facts revealed by
the figures in the table, which is offered as an exhibit under State of Illinois Exhibit No. 24 for identification, and it is apparent that in general during the first six months of the year the water is fully saturated or even supersaturated, while during the latter part of the year, particularly in the years 1897 and 1899, the proportion of saturation was less than 100; not at all times, but during most of the time; during the year 1898 the variations from the saturation point are not so marked nor so frequent.

Q. I now call your attention, professor to table 5 of this series which is table "Department of Chemistry, University of Illinois, A. W. P. V." Please state generally what this table is intended to illustrate and what is the character of the data which it contains?

MR. JEFFRIES: I object to any explanation on the part of the witness or any testimony being given by the witness in reference to this table, or with reference to what it shows, for the same reasons stated in my objection to the reading of the tables into the record.

A. Table 5 of this series represents the numerical data of the analyses of waters from the Illinois and Michigan canal at Lockport for the year 1897.

8619 Q. Please state briefly what this table represents?

A. It represents the series of analyses of water from the Illinois and Michigan Canal at Lockport for the year 1897, the different determinations being precisely the same as those heretofore described with respect to table No. 1 of this series, and includes at the bottom, averages not only for the entire year, but for the first six months and the second six months as well.

Q. Will you please state those averages for the first six months?

A. The averages for the first six months covering regular weekly collections from January 4th to June 29th inclusive, are as follows:

Total residue on evaporation,	684.1	parts per million,
Dissolved,	518.	do.
Suspended,	136.	do.
Loss on ignition—total	84.2	do.
Dissolved,	53.1	do.
Chlorine,	121.7	do.
Total oxygen consumed,	42.1	do.
Dissolved—that is, oxygen consumed by dissolved matters,	18.4	do.
Oxygen consumed by suspended matters,	23.7	do.
Nitrogen as free ammonia,	10.6	do.
8620 Total albuminoid ammonia,	3.2	do-
Nitrogen as albuminoid am-		

monia derived from dissolved substances,	1.31	do.
By suspended matters,	1.93	do.
Total organic nitrogen,	5.79	do.
Total organic nitrogen derived from matters in solution,	2.12	do.
By matters in suspension,	3.66	do.
Nitrogen as nitrites,	.06	do.
Nitrogen as nitrates,	.401	do.

8621 Q. Now the next six months please?

A. For the second six months covering the samples collected on the dates indicated in the table ranging from July 5th to December 28th, 1897.

Total residue on evaporation,	495.7	parts per million,
Dissolved,	438.2	do.
Suspended,	57.5	do.
Lost on ignition,	53.6	do.
By dissolved substances,	34.1	do.
Chlorine,	108.8	do.
Oxygen consumed,—total,	34.3	do.
By dissolved matters,	18.6	do.
By suspended matters,	15.7	do.
Nitrogen as free ammonia,	14.3	do.
Total albuminoid ammonia,	2.2	do.
From dissolved substances,	1.38	do.
From suspended matters,	.8	do.
Total organic nitrogen,	4.05	do.
By dissolved matters,	2.51	do.
From suspended matters,	1.54	do.
Nitrogen as nitrites,	.018	do.
Nitrogen as nitrates,	.273	do.

8622 Average for the entire year, that is from January 4th, to December the 28th, inclusive:

Total residue on evaporation,	591.8	parts per million,
Dissolved,	494.2	do.
Suspended,	97.5	do.
Loss on ignition, total,	69.42	do.
By dissolved,	43.8	do.
Chlorine,	115.4	do.
Total oxygen consumed,	38.3	do.

Dissolved,	18.1	do.
Suspended,	20.2	do.
Nitrogen as free ammonia,	12.4	do.
Total albuminoid ammonia,	2.72	do.
From dissolved matters,	1.34	do.
From suspended matters,	1.38	do.
Total organic nitrogen,	4.94	do.
From dissolved matters,	2.31	do.
From suspended matters,	2.62	do.
Nitrogen as nitrites,	.039	do.
Nitrogen as nitrates,	.339	do.

Q. Now for the entire year?

A. That is for the entire year. At the bottom of the table there is a line indicating the general character of the odor
8623 during the year. The statement is that this water always had a decided odor described as musty or gassy, and further the line with color upon ignition is always brown. Similar statements to these are made at the bottom of the various other tables in this series.

Q. I call your attention now to table 6 of this series. Please make a brief statement of the data contained in this table.

MR. JEFFRIES: I object to any statement being made by this witness or any facts being drawn by him from it, for the same reason stated in my objection to the reading of the table into the record.

A. In table No. 6, we have the data for the water of the Illinois and Michigan canal at Lockport similar to the one just described, but for the year 1898.

Q. State whether the averages are computed at the bottom of this table as in other cases?

A. The averages for the first six months the second six months and the entire year have been computed and are recorded at the bottom of the table as in the preceding case.

Q. I now call your attention to table 7 of this series and ask you to explain the character of the data contained in this
8624 table?

MR. JEFFRIES: I desire to make the same objection to table 7 as was made to table 6.

A. Table 7 is precisely similar in all respects to table No. 6, but covers the year 1899.

Q. At what place?

A. At the Illinois and Michigan Canal at Lockport.

Q. Are the averages stated in that table also?

A. They are.

Q. For each six months and the for the whole year?

A. That was covered in my statement "Precisely similar in all respects."

Q. I now call your attention to table 8 of this series and ask you to explain the character of the data contained in that table?

A. Table No. 8 is precisely similar in all respects to tables 5, 6 and 7, but for the year 1900, and table 9 is likewise similar in all respects to Nos. 5, 6, 7 and 8, except that it covers the year 1901 and during a portion of that year the samples were collected monthly instead of weekly as in the other tables in this series.

Q. All taken at what place?

A. All being analyses of the water of the Illinois and 8625 Michigan canal, collected from this canal at Lockport.

Q. Now I call your attention to tables 10 and 11 of this series and ask you to state the character of the data which are embraced in these tables?

A. Tables Nos. 10 and 11, being the data of analyses of samples of water collected from the sanitary canal or Chicago main drainage channel at Bear Trap Dam at Lockport and for the years 1900 and 1901. The collections for some portions of the year being made more frequently than once a week and during a portion of the year 1901 being made once a month.

Q. Now I call your attention to tables 12, 13 and 14 of this series and ask you to explain the character of the data contained in these tables.

A. Tables 12, 13 and 14 of this series contain the results of analyses of samples of water collected from the Desplaines river at Lockport. The samples having been taken beside the old stone bridge which crossed the river at this point before the changes made in the bed of the stream at the time the sanitary canal was finished at this point, or just thereafter.

Q. Did these samples come from the Desplaines river before that river had received any of the discharges from the Sanitary Canal?

A. They did.

8626 Q. I now call your attention to tables 15 and 16 of this series and ask you to explain the data contained in these tables?

A. Tables Nos. 15 and 16 of this series represent the figures obtained from the analyses of the water of the Desplaines river at Joliet, the samples having been taken just above Dam No. 1 in the town of Joliet. These tables are supplementary to the tables and data which have hertofore been placed in evidence in part of the report made by me of analyses made in behalf of the sanitary district of Chicago, and included in the series of tables 1 to 80 heretofore placed in evidence and discussed.

Q. What are the periods covered by these?

A. The period covered by tables 15 and 16 of this series is the year 1901, one table giving the data from the analyses of samples taken at the east side or south side of the stream at the point above indicated, and the other table, No. 16, giving the data of the analyses of samples collected at the west or north side of the stream at this point.

Q. What was the object of taking the samples at the place you have indicated?

A. Observation of the waters at this point flowing through the bed of the Desplaines river and variations in the an-
8627 alyses of samples collected at mid-channel at this point
in the previous year led us to take these two sets of samples, one toward one bank and the other toward the other bank of the stream at Joliet, in order to secure the data respecting the different compositions of the water of the two sides of the stream, and with reference to a study of the mixing of the waters of the upper Desplaines river, of the Sanitary canal and of the Illinois and Michigan canal after they had come together at Lockport, four miles above, and at the point a few hundred yards above that of collection at Joliet.

Q. State whether the points you have indicated were above or below the outlets of the sewers of Joliet?

A. This point was above that at which the sewers of Joliet discharged into the stream, although a portion of the sewage of Joliet and the manufacturing industries, and from the State Penitentiary enters the Illinois and Michigan Canal a short distance above this point, about three miles below the point at which collections were made at Lockport, and above the point where the Illinois and Michigan canal joins with and crosses the Desplaines river; that is a portion of Joliet sewage and manufacturing waste just referred to, mixes with these various bodies of water, occupying the bed of the Desplaines river.

8628 Q. Does this table also contain general averages based upon the two samples or upon the samples separately?

A. The averages at the bottom of these two tables are the averages of the data included in each table respectively.

Q. Did you note any marked difference in the two places in the river and if so you may state where those differences appear?

A. There is a very considerable difference between the averages obtained from the analyses of samples collected at one side of the stream at this point, and the averages obtained from the analyses of the samples collected at the other side, these differences being due to the incomplete mixing of the several bodies of water which are passing down the valley of the Desplaines at this point, or perhaps I had better say the bed of the Desplaines river at this point. The variations being caused at this time by variations in the discharge at the Bear Trap Dam, by variations in the quantities of sewage pumped from the south fork of the Chicago river into the Illinois and Michigan canal and variations in the flow of the upper Desplaines river.

Q. Do these tables embrace the entire year 1901?

A. These data cover the entire year 1901, but in the early part of the year monthly samples only were taken. while
8629 in the latter part of the year samples were collected once a week. I may expain here that in cases of tables of analyses which were not taken uniformly once a week throughout the year, monthly averages were first made, and the years averages made from these for the purpose of securing a greater uniformity in the averages and obtaining figures which were more truly representative of the average condition of the water throughout the year.

Q. I now call your attention to tables 17, 18, 19 and 20 of these series and ask you to explain the data contained in these tables?

A. Tables Nos. 17, 18, 19 and 20 of this series, give the results of analyses of water taken from the Illinois river at Morris, between nine and ten miles below the confluence of the Desplaines and the canal, which by their union form the Illinois river, the tables covering the years 1897, 1898, 1899 and 1900 respectively. The collections were made regularly each week throughout the respective years from the beginning of January to the end of December. In most of the years the entire series of determinations referred to in my description of table No. 1 of this series is made, but in the earlier years, namely, 1897 and 1898 the determinations of albuminoid ammonia and oxygen consumed, and of total organic nitrogen were not
8630 made for matters in solution, only the totals for the original unfiltered water samples being made in this year. For the other years, namely, 1899 and 1900, the entire series of determinations upon both the original sample and the filtered portion were made. At the bottom of each of these tables there appear averages for the first six months, the second six months and the entire year, as in the case of the tables previously described.

ADJOURNED until 2:00 P. M., same day.

2:00 P. M., Friday, October 16, 1903.

8631 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

C. V. MILLAR,

called as a witness in behalf of the defendants, being first duly sworn by the Comissioner, was examined in chief by Judge Springer and testified as follows:

Q. State your name, residence and occupation?

A. C. V. Millar; I reside in Joplin, Missouri; my occupation is that of assayer or chemist.

Q. Where were you educated Mr. Millar?

A. Well I received the common country school education at Mattoon, Illinois; from there I went to the University in the fall of 1889.

Q. Which university?

A. University of Illinois, in the fall of 1889, and went through the four years' course and graduated in 1893, and in 1893 and 1894 I held a fellowship and graduated from the post-graduate course in 1894.

8632 Q. What degrees did you take in the college?

A. In 1893 I received my batchelor's degree, and in 1894 I received my Master's degree besides.

Q. What branches were you studying in the University of Illinois principally?

A. I took the special course of chemistry.

Q. After you finished your courses in college did you pursue any chemical studies or prosecute any chemical work in reference to making analyses of water?

A. Well after I graduated in 1894, I came back in September of 1895, and I was employed by the Water Survey Department.

Q. Of the University of Illinois?

A. University of Illinois, yes.

Q. How long did that employment continue?

A. I remained in that employment until the 15th day of June, 1900.

Q. What have you been engaged in since that time?

A. I went to Joplin, Missouri, where I reside now, and ever since have been engaged in the assay business.

Q. About how many analyses of water have you made during the time you were in college and since that time?

A. Well, when I was in college I only made a few in my senior year, but I studied a branch of chemistry, and in

8633 the Water Survey Department it was between 7,000 and 8,000, as close as I can remember it.

Q. Between 1895 and the year 1900, did you make any chemical analyses of water in connection with Professor Palmer of the University of Illinois?

A. Yes.

Q. What part did you perform in reference to those analyses?

A. I did the chemical analysis of the water.

Q. That is, of a part of it?

A. Yes sir.

Q. Who received the samples and made records of their receipt and what time they were analyzed?

A. I received them.

Q. Did you enter the dates of all the certificates accompanying these samples on the tables containing your chemical analyses?

A. Yes sir. We always dated them when we received them.

Q. And the data in reference to the time it was received,—from what source did you get them—I mean the data as to when the collection was taken?

A. We got that from the men that shipped the samples to us.

Q. Did that appear upon the certificate?

A. Yes sir.

8634 Q. And you entered all those dates correctly from the certificates and the correct date as to the time of making the analysis?

A. Yes sir.

Q. And so far as entered by you they are correct?

A. Yes sir, so far as I know.

Q. In reference to the results of the chemical analyses of the waters during that time, that were analyzed in the University of Illinois, state whether the chemical analyses made by you are correctly reported in the tables that were made at that time?

A. They were.

Q. Would you recognize those tables if you were to see them?

A. Yes sir.

Q. I call the witness' attention to tables 1 to 80 inclusive, in this series—

MR. JEFFRIES: I object to the witness referring to the publication now before him, because it does not constitute, and are not the tables that were made by this witness.

JUDGE SPRINGER: Do you mean that you object to using this book? They are the same ones read into the record. Do you object to the using of the forms that are in this book?

MR. JEFFRIES: I object to this witness referring to 8635 that book because Professor Palmer stated that those tables were made up by himself: In other words, I understood from him that the proof was read by him, and the accuracy and correctness of the tables—now I object to this witness referring to those tables in answer to the question which you have propounded to him.

JUDGE SPRINGER: Let me change my question a little then.

MR. JEFFRIES: My objection goes to this extent; that the witness has no right to speak or to examine the tables from the book or the printed tables which have been incorporated into the evidence in this case, because this witness had nothing to do with their preparation.

JUDGE SPRINGER: My question relates solely to the tables 1 to 80, put in evidence by Professor Palmer, and these are the tables to which I have called the attention of the witness.

MR. JEFFRIES: And which refer to chemical analyses made by Professor Palmer during certain dates.

JUDGE SPRINGER: Which tables refer to chemical analyses of which Professor Palmer has testified, and to the fact that those tables were made by him with the assistance of this witness and of Mr. Stark who testified this morning, and that the three were engaged in making different parts of these analyses, and making these entries.

MR. JEFFRIES: Well Judge you have not connected the
8636 witness with the time he was employed at this work.

JUDGE SPRINGER: Yes I have, 1895 to 1900.

MR. JEFFRIES: Yes, but you haven't connected the tables with the time the witness made these analyses, and therefore my objection is still good.

Q. JUDGE SPRINGER: Will you state the time now that you were engaged, again?

A. From September, 1895 to the 15th of June, 1900.

Q. The tables now before you which were read in evidence by Professor Palmer were made from waters taken during the years 1899 and 1900. During that time were you engaged with Professor Palmer in making chemical analyses of water?

A. Up until June 15th of 1900.

Q. Until June 15th, 1900?

A. Yes sir.

Q. From that time as appears by these tables, you are not cognizant of what was done?

A. No sir.

Q. State whether the chemical results of the analyses made by you were correctly recorded upon those tables during the time mentioned, namely, for the year 1899, and the year 1900 up to June 15th?

A. I recorded them on these blanks correctly, which were
8637 given to me.

Q. Then so far as the part that you performed is concerned, you made the correct entries according to the results of the chemical analyses?

A. Yes sir.

Q. Prior to the year 1899 were you engaged in assisting Professor Palmer in making chemical analyses of water?

A. From 1895 to 1899 I was.

Q. During that time did you participate in the way of assistance to Professor Palmer and under his direction, in making analyses of the waters that came to the University from points taken on the rivers mentioned in the tables to which I have just called your attention?

A. Yes sir.

Q. And from other points that were involved in the tables that were made during the years 1895 to and including 1898?

A. Yes sir, I was connected with him.

Q. Did you make in those tables that were prepared at that time, correct entries of the analyses of waters made by you?

A. Yes sir.

8638 CROSS-EXAMINATION,

By Mr. Jeffries.

Q. These analyses that you made, as I understand it, were made under the supervision of Professor Palmer?

A. Yes sir.

Q. And all that you did was simply to ascertain as best you could the chemical constituents of the samples of water that were placed in your hands for analyses?

A. We had certain determinations which we made on each water, and that was what I did.

Q. Did you determine all of the chemical constituents of the water?

A. No sir.

Q. You made certain chemical determinations of the water that was placed in your hands?

A. Yes sir.

Q. Without reference to the manner in which they came into your hands except through Professor Palmer?

A. What was that question again?

Q. Without reference to how they came into your hands. In other words, without reference to the source of the water or anything of that kind?

8639 A. Yes sir.

Q. You simply made the chemical analyses in the laboratory and recorded them on the sheets

A. Yes sir.

Q. Who else assisted you besides Mr. Stark?

A. There was one gentleman by the name of Edwards that assisted me part of the time and one by the name of Mr. Manhard, and a man by the name of Mr. Koch, and I think that is all. I haven't thought about it.

RE-DIRECT-EXAMINATION,

By Judge Springer.

Q. You knew however, that the work that was done by them in assisting you was correctly entered, do you, in these tables?

A. Yes sir, I entered the work.

RE-CROSS-EXAMINATION,

By Mr. Jeffries.

Q. You don't know though that their chemical results were properly ascertained, as done by these other parties?

A. I have reason to believe they were. They were under my direction.

8640 Q. Being under your direction you don't know of your own knowledge, that they were?

A. No sir.

BY JUDGE SPRINGER:

Q. Were they done in your presence?

A. Yes sir.

By agreement of counsel the signatures of the witness Stark and witness Millar to their evidence, are hereby waived.

Counsel for the complainant and defendants agree that the testimony of witnesses hereafter to be examined need not be signed by them unless the witness desires to do so, or the Commissioner desires to have them, or unless either of the parties shall desire the signature of any particular witness, in which event it shall be made known at the time the witness testifies, and in all cases where witnesses do not sign their testimony the typographical corrections shall be made,, if any are necessary, by the Commissioner and he shall thereupon certify to the evidence as taken.

8641 PROF. ARTHUR W. PALMER,

resumed the stand for further direct-examination by Judge Springer, and testified as follows:

Q. Professor, I now call your attention to tables numbered 21, 22 and 23 of this series, and ask you to state what is the character of the data contained in these tables?

A. The data upon tables 21, 22 and 23, are the results of analyses of the waters of the Illinois river at Ottawa, collected at a point just above the mouth of the Fox River, and covering portions of the years 1899 and 1900, and 1901.

Q. Please state what portions of the years mentioned are covered?

A. For 1899 the series of analyses run from the 19th of June to the 28th of December.

For the year 1900 they extend from the 4th of January to the 6th of October.

And for the year 1901 they extend from July 20 to October 29.

Q. Were they taken at one point in the river or at cross-sections?

A. They were taken at one point.

8642 Q. Where was that point?

A. That point was about a mile north or east of the mouth of the Fox river.

Q. Was it above the point of the outlets of the sewers of Ottawa?

A. It was.

Q. State whether at this point there had been accomplished a mixing of the waters coming from the Desplaines, the Kankakee the Sanitary canal and the Illinois and Michigan Canal?

A. At this point the mixing of the waters of the Kankakee with the waters of the Desplaines, which latter include the discharges from the old or the Illinois and Michigan canal, the sanitary canal, and the waters from the upper Desplaines, is not complete, and this accounts for certain variations in the analytical data. Certain cross section determinations show that this mixing at Ottawa is not complete.

Q. Is this point below or above the outlet of the old Illinois and Michigan canal?

A. It is about eighteen miles above the outlet of the old Illinois and Michigan canal, but at Ottawa and at various other points along the course of the canal there are discharges of water from the canal into the Illinois river.

Q. Do the tables just mentioned contain the averages
8643 of the analyses?

A. They do.

Q. As in the other cases?

A. Yes.

Q. This will appear on the bottom of each page, I presume?

A. Yes sir.

Q. I now call your attention to tables 24, 25, 26 and 27 of this series and ask you to explain the data which are recorded in these tables?

A. The data upon the tables 24, 25, 26 and 27, are the result of analyses of samples of water collected from the Illinois river at LaSalle, during the years 1897, 1898, 1899 and 1900 respectively.

Q. During what portions of the respective years do the tables cover?

A. For the year 1897, the collections cover the period from January 5th to December 29th inclusive, regular collections once a week.

For the year 1898 the collections cover the period January

4th to December 19th, inclusive, but the collections were not made weekly throughout. There were some difficulties about getting the collections made and in some months, as for instance, March, there is but one collection in the month, but the series extend with the breaks I have mentioned, through-
8644 out the year.

For the year 1899, the collections extend from February 15 to December 26.

For the year 1900, they extend from January 2nd to October 2nd.

Q. Are the averages entered upon each of these sheets at the bottom of the page?

A. Upon each of these tables the averages for the first six months, and the second six months and for the entire year, appear at the bottom.

Q. I now call your attention to tables 28 to 32 inclusive, and ask you to explain the character of the data contained in these tables?

A. Tables 28 to 32 inclusive of this series contain the data resulting from analyses of samples of water collected from the Illinois river at the bridge across the Narrows, at Averyville, which is about three miles above the Court House at Peoria.

Table 28 has the data for the year 1897, the collections ranging from the 26th of April to the 27th of December of that year.

Table 29 for the year 1898, has the results of analyses of samples collected regularly each week throughout the
8645 year, beginning January 2 and ending December 26.

Table 30 has upon it the data resulting from analyses of waters taken at the same place, but during the year 1899. Regular weekly collections beginning January 3rd, and ending December 26th.

Q. How many samples a week were there taken?

A. Regular weekly samples, that means one a week.

Table 31 has a record of the results of analyses of samples collected at this same point during the year 1900. Regular weekly collections beginning January 2nd and ending December 26.

Table 32 has the results of the analyses of samples of water collected at the same place during the year 1901, beginning with January 2nd, and ending December 26, but during the first half of this year the collections were made monthly. During the second half of the year weekly collections were made.

Q. State professor, how the samples of water in these series were taken, at what depth below the surface?

A. The samples of water collected at Averyville were taken at midstream, at the bridge over the Narrows, and at a depth of one foot below the surface. They were taken in the manner heretofore indicated, the samples being collected in bottles expressly cleaned and shipped to the collectors for the pur-
8646 pose, and in accordance with printed instructions which accompanied each bottle. The collector recorded the date and such other facts concerning the conditions at that time prevailing as were called for by the instructions as to filling out the certificates, and which have hereinbefore been described.

Q. I now call your attention to tables 33, 34, 35 and 36, of this series and ask you to explain the character of the data contained in them?

A. Tables 33, 34, 35 and 36 contain the data obtained by the analyses of samples of water collected from the Illinois river at Havana, at a short distance above the town, just above the mouth of the Spoon river which enters on the right bank, and above the mouth of Quiver Lake which enters on the left.

Q. What periods do they cover?

A. The periods covered by these tables are as follows:

Table 33 the year 1897, regular weekly collections, beginning January 6th, and ending December 28th.

Table 34 covers the year 1898, regular weekly collections beginning January 4th, and ending December 27th.

Table 35 covers the results of analyses of water samples
8647 collected at this same point during the year 1899; collections beginning on January 3rd, and ending December 20.

Table 36 records the results of analyses of water collected at the same point, that is in the Illinois river at Havana, the collections beginning January 11 and ceasing December 24. Regular weekly collections between these dates.

Q. I now call your attention to tables 37 to 42 inclusive and ask you to state the character of the data contained in these tables?

A. Tables 37 to 42 inclusive contain the data of analyses of samples of water collected from the Illinois river at Kampsville, the collections being made just above the United States Dam.

Q. What periods were covered by them?

A. The periods covered by these tables is that including the years 1897 to 1902 inclusive.

Table 37 contains the data of analyses of samples collected during the year 1897, beginning January 12th and ending December 28th, regular collections, one each week.

Table 38 contains similar data for the year 1898; regular weekly collections beginning January 4th, and ceasing December 27th.

Table 39 of this series contains the data for the year 1899,
8648 regular weekly collections beginning January 3rd, and
ceasing December 20th.

Table 40 of this series contains data of similar sort, but for the year 1900, regular weekly collections beginning January 3rd; ceasing December 24th.

Table 41 contains similar data, but for the year 1901, regular weekly collections beginning January 7th and ceasing December 30th.

Table 42 of this series contains similar data for the same point, as for the five preceding tables, but for the year 1902, regular weekly collections beginning January 7th and ceasing December 29th.

Q. I call your attention now professor, to tables 43, 44, 45 and 46, and ask you to state the character of the data contained in those tables?

A. Tables 43,44, 45 and 46, contain the results of analyses of samples of water collected at Grafton during the years 1899 to 1902, inclusive, samples collected at a point about two miles within the mouth of the Illinois river, where ordinarily there is no mixing of the waters of the Mississippi with those of the Illinois.

Q. What do these tables contain?

8649 A. Table 43 contains the results of analyses of samples of water collected during the period December 31st 1898 to December 27, 1899, regular weekly collections throughout the year, of 1899, assuming the date December 31st, 1898, as pertaining to that year or series.

Table 44 of this series contains the results of analyses of samples of water collected at Grafton from the Illinois river at the point mentioned above, during the year 1900; regular weekly collections, beginning January 4th, and ceasing December 24th.

Table 45 contains the results of analyses of waters collected at the same point, but during the year 1901; collections beginning February 21st, and ceasing December 23rd, being collected somewhat irregularly. During the first half of the year monthly collections were made, but not for all of the months. During the second half of the year collections being made weekly.

Table 46 contains results of analyses of waters collected at the same point as indicated for the three preceding tables, but for monthly collections instead of weekly collections.

Q. I call your attention to tables 47, 48, 49 and 50, of this series and ask you to describe the data contained in those tables?

8650 A. Tables 47, 48, 49 and 50 contain the data of analyses of the waters of the Mississippi river at Grafton, the collections being made at a point about two miles above the mouth of the Illinois, where ordinarily no Illinois water mixes with the water of the Mississippi.

Table No. 47 contains the data for the year 1899, regular weekly collections throughout the year, beginning with December 31st, 1898 and ending December 20, 1899.

Table 48 contains the results of analyses of water samples collected at the same point as for table 47, but for the year 1900, regular weekly collections throughout the year, beginning January 4th and ending December 24th.

Table 49 contains data of analyses of waters collected at the same point, but for the year 1901; collections during the first half of the year made once a month, during the second half of the year each week.

Table 50 contains data of analyses of samples of water collected at the same point as for the three preceding tables, but for the year 1902, monthly collections.

Q. I now call your attention to tables 51 to 62, inclusive, of this series, and ask you to describe the data contained in them?

A. Tables 51 to 62 inclusive contain the data of the an-
8651 alyses of samples of water collected from the Mississippi
river at Alton during the years 1896, to 1900 inclusive. During 1897 and 1898 samples were collected at mid-stream but during the years 1899 and 1900 they were collected at five different cross-section points about one mile above the town of Alton and opposite to the new waterworks filter plant belonging to the city of Alton.

Table 51 contains data of analyses of samples of water taken from the channel of the Mississipi river oposite Alton for the year 1897, regular weekly collections beginning January 5th, and ending December 21st.

Table 52 contains similar data, that is data of analyses of waters taken at the same place during the year 1898, regular weekly collections throughout the year, beginning January 3rd and ending December 27th.

Table 53 contains the data of analyses of samples of water collected at a point 100 feet from the Illinois shore in the near vicinity of the Alton city waterworks, about one mile above the town, the data of this table are for the analyses of samples collected during the year 1899, regular weekly collections beginning January 5th and ending December 20th.

Table 54 contains similar data for water samples collected
at the same point, namely, 100 feet off the Illinois shore,
8652 but for the year 1900, regular weekly collections from
January 4th to December 24th inclusive.

Table 55 contains data of analyses of samples of water collected at the same general locality, but at one-fourth the distance from the Illinois shore, toward the Missouri shore, opposite the pumping station and filter plant of the Alton City water works, the table covers the data for the year 1899, regular weekly collections ranging from January 5th to December 20th inclusive.

Table 56 contains similar data for waters collected at the same point, namely one-fourth the distance from the Illinois shore at Alton, for the year 1900, the samples being collected each week from January 4th to September 5th, inclusive.

Table 57 contains the results of analyses of water samples collected at mid-stream in the line of this cross-section opposite the waterworks of the city of Alton, and about a mile above the town; the data of these tables referring to the analyses of samples collected during the year 1899, regular weekly collections from January 5th to December 20th, inclusive.

Table 58 contains similar data, the analyses of samples of water collected at this same point, namely, mid-
8653 stream in the Mississippi river opposite the Alton water-
works, but for the year 1900, regular weekly collections throughout the year from January 4th to December 24th inclusive.

Table 59 contains the data of the analyses of samples of water collected in the same cross-section line but at a point one-fourth distant from the Missouri shore, or three-fourths of the distance from the Illinois shore, this table having the data for the year 1899; collections beginning January 5th and ceasing after December 20th.

Table 60 contains the data of analyses of samples of water collected at the same point as those referred to in table 59, that is one-fourth distance from the Missouri shore at Alton, but for the year 1900; collections beginning January 4th and being made regularly each week thereafter until and including September 5th.

Table 61 of this series contains the results of analyses of samples of water collected in the same cross-section line, but at a point 100 feet from the Missouri shore; this table giving the data for the year 1899. Regular weekly collections throughout the year, beginning with January 5th, and ceasing after the collection upon December 20th.

Table 62 contains the data of the analyses of samples of
water collected at the same point as is referred to in my
8654 statement concerning table 61, but the collections were
for the year 1900 and extend from January 4th to December 24th, inclusive, regular weekly collections being made during this period.

Q. I now call your attention to tables 63 to 70 inclusive, and ask you to state the character of the data contained in these tables?

A. Tables 63 to 70 inclusive contain the results of analyses of samples of water collected from the Mississippi river at Quincy at a point above that at which any of the sewage of Quincy is discharged into the Mississippi river, and for the years 1897 to 1903 inclusive.

Table No. 63 contains the data of the analyses of samples of water collected from the Mississippi river at Quincy as indicated above, for the year 1897, the collections beginning upon February 15th and ceasing upon December 27th, regular weekly collections throughout the period.

Table 64 contains the similar data of analyses of samples collected at the same point during the year 1898; regular weekly collections beginning January 3rd and ceasing December 20th.

8655 Table No. 65 contains similar data for the year 1899, the collections beginning January 3rd and ceasing December 13th, but being irregular throughout that period, though mainly one a month.

Table No. 66 contains similar data for the same place for the year 1900; samples collected monthly, but not for all months in the year.

Table No. 67 contains results of analyses of samples of water collected at the same point for the year 1900; monthly collections, but not very regular throughout the year.

Table No. 68 contains similar results obtained during the year 1901, there being but six samples collected in that year, being distributed through various months of the year.

Table No. 69 contains similar data for the year 1902; samples collected sometimes irreguarly, but covering the year from January 13th to December 30th.

Table No. 70 of this series contains results of analyses of samples of water collected at the same point, but for the year 1903, the analyses covering, though somewhat irregularly, the period beginning January 3rd and ending August 17th of that year.

Q. I now call your attention professor, to tables 71, 72 and 73 of this series and ask you to explain the data contained in them?

8656 A. Tables 71, 72 and 73 give the data of analyses of samples of water collected from the Kankakee river at Wilmington, for the years 1897, 1899 and 1900.

Table No. 71, referring to the year 1897 contains the results of analyses of samples of water collected during the period ranging from January 8th to May 10th.

Table No. 72 contains data of analyses of samples of water collected at the same place, namely, Kankakee river at Wilmington, but during the year 1899, collections beginning June 5th, and ceasing December 26th, regular weekly collections throughout the period.

Table No. 73 contains similar data for samples of water collected at the same point in the Kanakakee river at Wilmington, but for the year 1900, weekly collections beginning January 1st and ceasing December 19th.

Q. I now call your attention, professor, to tables 74, 75, 76 and 77 and ask you to describe the data contained in those tables?

A. Tables 74, 75, 76 and 77 contain the results of analyses of samples of water collected from the Fox river at Ottawa, collection being made at a point a short distance above the aqueduct which carries the Illinois and Michigan canal over this stream.

8657 Table No. 74 contains the data for the year 1898, samples being collected each week during the period beginning March 1st, and ending December 26th.

Table No. 75 contains similar data of analyses of samples of water collected at the same point, but during the year 1899, the collections beginning May 29th, and ending December 28th.

Table No. 76 contains the data of analyses of samples of water collected at the same place but during the year 1900, collections beginning January 4th, and ceasing October 6th, being made regularly each week during that period.

Table No. 77 contains the data of the analyses of a small number of samples collected from the Fox River at the same point as indicated above, but during the year 1901, collections being made in August, September and October of that year.

Q. I now call your attention to tables 78, 79 and 80, and ask you to explain the character of the data contained in them?

A. Tables 78, 79 and 80 of this series contain data of analyses of samples of water collected from the Spoon river at Havana.

Table 78 contains data of the analyses for the year 1897, of samples taken at a point about half a mile within the mouth of the stream where there ordinarily is little danger of
8658 water from the Illinois mixing with the discharge from the Spoon. The samples were collected regularly each week throughout the year beginning on January 5th and ceasing on December 28th.

Table No. 79 gives similar data concerning samples of water collected at the same point, but during the year 1898, collections beginning January 4th and continuing regularly each week throughout the year, to and including December 27th.

Table No. 80 contains similar data of analyses of samples of water collected at the same point, but during the year 1899, the collections beginning January 3rd, and being made regularly each week up to and including May of that year, the last collection being made May 30th.

JUDGE SPRINGER: This concludes the explanation of the tables in this series.

MR. JEFFRIES: Now I move to strike out all of the explanation and testimony of this witness with reference to the tables which have been read in evidence, and from which he has been testifying,—being "Department of Chemistry, University of Illinois, A. W. P. tables No. 1 to 80 inclusive" for the same reason as contained in the objection to the introduction of the tables in evidence, and to their being incorporated as a part of the testimony of this witness or incorporated
8659 as a part of the testimony in this case.

For the further reason that they include chemical analyses of waters tributary to the Illinois river, and also waters that are not tributary to the Illinois river, while the conditions of the waters of those tributaries, or of those rivers other than the Illinois, are not in issue in this case.

IT IS HEREBY STIPULATED AND AGREED BY AND BETWEEN Counsel, that the samples of water taken by Raymond Hurd at Joliet from the Desplaines river, Denis J. Foley from the Illinois river at Ottawa, and John Egan and Richard

Cullen taken from the Missouri river at West Alton, and Chain of Rocks in the Mississippi river, and carried to the laboratory in St. Louis, were taken in the manner stated and required, as shown by Sanitary Districts' Exhibit No. 11 for identification, which contains instructions as to the manner the samples should be taken, and that all samples taken by these witnesses were taken in accordance with those instructions as near as may be, and said samples of water taken as aforesaid shall be considered as having been taken in the manner aforesaid, when testified to by the analyst who analyzed them.

8660 By agreement of counsel for complainant and defendants, and the Commissioner, an adjournment is hereby taken until Wednesday, October 28th, 1903, at same place, at 10:00 A. M.

8661 SUPREME COURT OF THE UNITED STATES.

State of Missouri,
vs.
State of Illinois
and the
Sanitary District
of Chicago
Original No.

869 The Rookery Building, Chicago, Illinois.

10:00 A. M., October 28, 1903. A continuance was here taken to November 9, 1903, same time and place, by consent of Commissioner and counsel for respective parties, upon motion of complainant.

Same place November 9, 1903, 10:00 A. M. A continuance was here taken to November 16th, 1903, same time and place, by consent of Commissioner and counsel for respective parties, upon motion of complainant.

8662 869 Rookery Building, Chicago, Illinois. 10:00 A. M., Monday, November 16th, 1903.

Continuation pursuant to adjournment. Present:

The Commissioner,
Mr. Jeffries,
Judge Springer,
Mr. Todd.

ARTHUR W. PALMER,

resumed the stand for further direct-examination by Judge Springer, and testified as follows:—

JUDGE SPRINGER: Before proceeding to the examination of Profesor Palmer, I desire to offer at this time in evidence, Defendants' Exhibit A entitled, University of Illinois Chemical Survey of the Water Supplies of Illinois, Preliminary Report, by Arthur William Palmer, S. C. D., Professor of Chemistry, published by the University, 1897.

This is offered now for identification and is marked Defendant's Exhibit A for identification.

This may be used by either party hereafter as evidence 8663 in the case, or it may be referred to by witnesses or counsel, without being printed as part of the record.

MR. JEFFRIES: Professor, this report was made to Andrew Sloan Draper, the President of the University of Illinois, was it?

A. Yes.

JUDGE SPRINGER: And is your official report as the head of this department of the University?

A. Yes, everything that goes to the trustees of the University goes through the President with us. I am a member of the University and everything goes to the President.

Q. At the conclusion of the hearing before the Commissioner on the 16th of October, the witness had briefly explained the contents of certain tables which had been read in evidence beginning with No. 1 of this series, this series being entitled, "University of Illinois, Department of Chemistry, A. W. P., 1 to 80 inclusive." Professor, I now call your attention to tables 1 to 4 inclusive, which contain the chemical examinations of water from Lake Michigan during the years 1897 to 1900 inclusive; will you please state what significance as a chemist, you attach to these tables of the examination of the waters of Lake Michigan?

MR. JEFFRIES: I object to the witness stating what 8664 significance these tables show for the reason that there is no evidence showing the place or point in Lake Michigan where the samples of water from which these analyses were made, were obtained.

JUDGE SPRINGER: I beg your pardon; he stated that in the brief explanation which he gave on the 15th and 16th of October, he stated where each sample was taken from.

MR. JEFFRIES: And I object for the further reason that there is no evidence showing the manner in which the samples were taken and no evidence showing the time of the analyses, after the taking of the samples.

JUDGE SPRINGER: On pages 9, 10 and 11, and subsequent pages of the testimony taken on October 16th, in the morning, you will find all of these matters fully set forth, where they were taken from, etc.

Q. (Last question read).

A. The data of the analyses show the general chemical character of the waters of Lake Michigan, and a comparison of the data for the different years with each other, and the averages for the different years with each other, show that the water of the lake is subject to no great variation as to the proportions of the various substances which are determined in the sanitary chemical analysis. They show that the water contains but a moderate proportion of mineral matters, that the organic
8665 matters are small in quantity as compared with many surface waters, and especially the proportions of nitrogen as free ammonia, as albuminoid ammonia, the total organic nitrogen, nitrites and also nitrates are present in a small quantity. The variations during the four years covered by the tables which have been read in evidence, namely, tables 1, 2, 3 and 4, of this series were in general, comparatively slight, and apparently were mainly caused by conditions which brought about variable discharges from the Chicago river, and from those sewers which empty directly into the lake and pass further out into the lake than they commonly do. They are also in part due to storms which stir up the sediment near the shore of the lake and near the cribs at which the intakes are located. The sediments being in the main such are natural to any considerable body of surface water, but including also a certain amount of refuse from the city and of dredgings from the Chicago river. The variations in no case vary considerably, and on the whole the water of the lake is to be considered as superior in quality to the water of all of the larger streams of Illinois and the vicinity.

The determinations of dissolved oxygen in the water of
Lake Michigan, upon samples drawn at the same time and
place as those which were subjected to the sanitary chem-
8666 ical analyses showed that the waters of the lake were at
all times fairly well charged, that is, generally saturated
with dissolved oxygen.

The data of the dissolved oxygen determinations are included in Defendants' Exhibit No. 24 for identification and are represented by the curves on plate marked "A. W. P. No. V" which has heretofore been placed in evidence.

Q. State whether the averages of these several tables are to be found at the bottom of each table?

A. They are.

Q. Professor, I now call your attention to tables in this series numbered 5 to 9 inclusive, which contain the chemical examinations of water from the Illinois and Michigan Canal, at Lockport. Please state what significance you attach as a chemist to these tables in reference to the waters at this place?

MR. JEFFRIES: I object to any conclusions being drawn by this witness from any of these tables numbered A. W. P. 1 to 80 inclusive, for the reason it is immaterial, irrelevant and incompetent, and for the same reasons stated by complainant in its objection to the introduction of the tables themselves.

A. The tables of analyses No. 5 to 9 inclusive, include the
results of examinations of samples of water taken from
8667 the Illinois and Michigan Canal at Lockport just before
it discharges into the Desplaines river. The periods
covered in these tables are the years 1897 to 1901 inclusive. Throughout the most of the time samples were taken regularly once each week, but during the earlier part of 1901 samples were collected but once a month.

In addition to the data in these five tables, I have made use of the averages for the year 1896; that is for samples of water collected regularly once a week from the Illinois and Michigan Canal at Lockport, during the year 1896, which analyses or the data resulting from them, are recorded in the preliminary report of the chemical survey of the waters of Illinois, which has heretofore been presented for identification as "Defendants' Exhibit A for identification."

The fluid pumped from the west fork of the south branch

of the Chicago river into the Illinois and Michigan Canal at Bridgeport flows sluggishly for a distance of about 29 miles to Lockport, where the first discharge from the canal into the Desplaines river occurs, the discharge being occasioned by the use of canal water as hydraulic power to run the Norton Mills situated at that point. Four miles further down the water from the canal discharges directly into the Desplaines river in the upper part of the town of Joliet, the canal at this point
8668 crossing the river by means of a dam and pool. Before the opening of the Chicago main drainage channel the liquid pumped into the old canal at Bridgeport constituted the major part of Chicago's sewage; it contained then and it still contains both house sewage and manufacturing wastes, the latter including drainage and refuse from stock yards, rendering establishments, soap factories, metallurgical and chemical works, gas works, and so on. Ordinarily no appreciable dilution and no notable additional pollution occurs between Bridgeport and Lockport, but in certain seasons, water from various ditches, and formerly also from the Desplaines river in excessive freshets flowed into the canal and diluted the contents of the same. The concentration of this liquid, flowing in the canal and the nature of the manufacturing and other wastes contained in it, is such that no very considerable change in the quantity or the character of the organic matters appear to take place between Bridgeport and Lockport, a fact demonstrated by comparative analyses made for the sanitary district of Chicago which have heretofore been read in evidence in this case, and also by examinations made on behalf of the State Board of Health, which also have been put in evidence in this case.

The analyses of the water of the Illinois and Michigan Canal at Lockport, serve to show the character of the liqud as it is discharged into the Desplaines valley in the main at
8669 Lockport, but in part at Joliet, four miles further down. The results are given in the details above referred to, and in the preliminary report also referred to above. The data reveal notable variations generally in April and March, the usual season of freshets, but for most of the year they show a somewhat remarkable uniformity in the proportions of organic matters.

Q. Have you prepared any tables of averages based upon the chemical analyses which you made of the waters of the Illinois and Michigan Canal at Lockport during the period under consideration?

A. I have.

JUDGE SPRINGER: Let these be referred to hereafter as "Defendants' tables of averages A. W. P. Nos. 1 to 15 inclusive."

Q. Will you please state what the averages were as appears by table No. 1 of this series of tables of averages?

MR. JEFFRIES: I object to the introduction of these tables of averages, or to the witness stating what they are for the reason that a table of averages does not directly represent conditions that exist at any one time or at all times during the year, and for the reason that they are deceptive in that they fail to disclose conditions that have not occurred and which are of as much importance so far as the issues in this case are concerned as conditions that are disclosed by those tables.

8670 JUDGE SPRINGER: Counsel for defendants suggest that we will only deal with the conditions shown in the tables, the things that are not in these tables are too numerous to be considered.

MR. JEFFRIES: I suggest that my objection does not go to conditions that are not in the tables, but to conditions that are in the tables, and the conclusions that may be drawn from a table of averages are as deceptive as the tables of averages themselves, for the reason that the conditons of the water for sanitary purposes cannot be averaged and should not be averaged; that conditions might exist and do exist of an abnormal character, as shown by the tables, which should not be measured by a general average drawn from those tables.

JUDGE SPRINGER: I suggest that this objection goes simply to the weight of the evidence and not to its admissibility.

Q. Now proceed, professor? (Question repeated).

A. Table No. 1 of this series contains the averages of the analyses of the waters of the Illinois and Michigan Canal collected at Lockport, for the years 1896, 1897, 1898 and 1899, and the general average for the four years period.

Q. Will you read that table No. 1 in evidence?

A. Table No. 1 of averages, is as follows:

8671

DEFENDANTS' TABLE OF AVERAGES NO. 1.—A. W. P.

TABLE III.

CHEMICAL EXAMINATION OF THE WATERS OF THE ILLINOIS AND MICHIGAN CANAL AT LOCKPORT, BEFORE THE OPENING OF THE CHICAGO MAIN DRAINAGE CHANNEL. YEARLY AVERAGES. PARTS PER MILLION.

Year	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
						Albumoid Ammonia.							
		Total	By Dissolved.	By Suspended Matter.	Free Ammonia	Total	Dissolved	Suspend'd	Total	Dissolved	Suspended.	Nitrites	Nitrates
1896	119.1	39.2	14.7	24.5	14.99	2.55	1.17	1.38	5.17	2.19	2.98	.007	.195
1897	115.4	38.3	18.1	20.2	12.4	2.72	1.34	1.38	4.94	2.31	2.63	.039	.235
1898	116.8	42.2	19.1	23.1	12.7	2.86	1.48	1.38	5.62	2.5	3.02	.072	.417
1899	135.2	39.5	21.2	18.3	13.9	2.93	1.44	1.51	5.56	2.84	2.72	.013	.317
Av'e	121.6	39.8	18.3	21.5	13.5	2.77	1.36	1.41	5.3	2.46	2.84	.033	.29

8672 Q. Now what significance do you attach to these tables and to the tables of averages which has just been read in evidence, from a chemical standpoint?

MR. JEFFRIES: The question is objected to for the same reasons stated in the previous objection.

A. Inspection of the yearly averages which appear in table No. 1 of this series shows that up to the time of the opening of the Chicago main drainage channel there were in most respects but slight variations from year to year, such changes as did occur being in the direction of a small but constant increase of the nitrogenous organic matter.

Examination of the data of the analyses for the year 1900, which appear in table 8, and for the year 1901, which appear in table No. 9 reveal much greater and more frequent variations than occurred before the opening of the Chicago main drainage channel. The averages of the analyses of the waters of the Illinois and Michigan Canal at Lockport for the years 1900 and 1901 appear in tables of averages No. 2, A. W. P.

Comparison of the averages for the two periods shows that the relative proportions of organic matters were considerably reduced as a result of the diversion of a part of the sewage, and the new drainage channel, although the proportions of nitrogen as free ammonia became greater than before, a result

8673 which may be due to the effect of the greater dilution in facilitating the more speedy oxidation of the organic matter. The variations are mainly due to the fact that at times when the lake is high, or the discharge from the drainage canal at the controlling works is reduced comparatively pure lake water backs up into the south fork of the Chicago river in such volume that a more dilute sewage than usual is raised by the pumps at Bridgeport into the Illinois and Michigan canal, while ordinarily inasmuch as the south fork is not yet flushed out, the liquid pumped into the old canal, that is, the Illinois and Michigan Canal, still consists mainly of the comparatively concentrated sewage from the stock yards district.

As compared with the analyses of the waters of Lake Michigan as given in tables 1 to 4, the waters of the Illinois and Michigan canal of course show evidence of the enormous quantities of refuse matters which are discharged into the Chicago river, and which thence pass into the Illinois and Michigan Canal, this being revealed by the very much greater proportions of organic matters contained in the canal water as compared with those contained in the lake water.

Q. As you have referred to table No. 2 of these averages, you may now read that table in evidence.

8674 MR. JEFFRIES: The same objection as to the previous table.

A. The table is as follows:

8675

DEFENDANTS' TABLE OF AVERAGES NO. 2.—A. W. P.

TABLE IV.

CHEMICAL EXAMINATION OF THE WATERS OF THE ILLINOIS AND MICHIGAN CANAL AT LOCKPORT, AFTER THE OPENING OF THE CHICAGO MAIN DRAINAGE CHANNEL.

YEARLY AVERAGES. PARTS PER MILLION.

Year.	Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
						Albuminoid Ammonia.							
		Total.	By Dissolved.	By Suspended Matter.	Free Ammonia.	Total.	Dissolved.	Suspend'd.	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.
1900	135.	21.	11.5	9.5	12.6	1.77	.77	1.	3.62	1.51	2.11	.022	.272
1901	133.2	18.8	13.7	5.1	17.6	1.16	.7	.46	2.18	1.45	.73	.025	.208
Av'e	134.	19.9	12.6	7.3	15.1	1.47	.735	.73	2.9	1.48	1.42	.023	.24

8676 **JUDGE SPRINGER:** I now call your attention to tables in this series Numbered 10 and 11, which contain the results of chemical examinations of water from the sanitary canal at Lockport, will you please state whether you made any averages of those two tables?

A. I did.

Q. Will you read those averages into the record at this time as a part of your testimony?

MR. JEFFRIES: I will object to the reading of the tables of averages in question into the record as a part of this witness' testimony for the same reason stated in my objections to the reading of the previous tables of averages into the evidence, and I object to the witness drawing any conclusions or stating any conclusions from these tables, for the same reasons stated in my objection to the reading of the tables of averages and the introduction of the tables themselves into the record.

A. The table of averages is No. 3, A. W. P., and is as follows:

8677

DEFENDANTS' TABLE OF AVERAGES NO. 3.—A. W. P.

TABLE V.

CHICAGO MAIN DRAINAGE CHANNEL, LOCKPORT. YEARLY AVERAGES. PARTS PER MILLION.

Year	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
		Total	By dissolved	By suspended matter	Free Ammonia	Albuminoid Ammonia.			Total	Dissolved	Suspended	Nitrites	Nitrates
						Total	Dissolved	Suspend'd					
1900...	15.6	7.65	5.12	2.53	1.593	.421	.183	.238	.985	.442	.543	.006	.25
1901...	14.5	9.29	6.76	2.53	1,715	.422	.238	.184	.99	.532	.58	.023	.18
Av'e..	15.	8.47	5.94	2.53	1.654	.421	.210	211	.987	.486	.5	.015	.21

8678 Q. **JUDGE SPRINGER:** Now what significance do you attach as a chemist to these analyses as exhibited by the tables to which your attention has been called, and the table of averages?

A. The analyses of samples of water collected from the sanitary canal or the Chicago main drainage channel at the Bear Trap dam at Lockport, have been read in evidence in tables 10 and 11, and they show notable variations. The variations

which appear in these analytical data are due in the main to variations in the volume of flow in the drainage channel, caused partly by differences in the lake level, partly by the partial closing of the gates or the raising of the Bear Trap dam at Lockport and also at certain times by the overflow of water from the Desplaines river at the spillway into the main drainage channel itself. Further, they are caused in part by variations in the pumping at Bridgeport for when the Bridgeport pumps are not in operation a portion of the contents of the south fork enters the south branch of the Chicago river, and passes thence into the main drainage channel, while when the pumps at Bridgeport are kept in operation practically all of the sewage of the south fork is discharged into the Illinois and Michigan canal, and enters the Desplaines river below the point of discharge from the main drainage channel. Comparison of the figures in table of averages No. 3, with the figures appearing
8679 in tables of averages Nos. 1 and 2, show that the waters discharged through the sanitary canal are far more dilute than the waters discharged through the Illinois and Michigan canal, that is, the proportions of the various significant constituents notably those of the nitrogenous constituents, are very much less in the waters of the sanitary canal or main drainage channel, than they were and than they are in the waters of the Illinois and Michigan canal.

MR. JEFFRIES: I move to strike out all that the witness has said with reference to the variations in the analyses being caused by change in the lake level and changing quantities of water passing through the Bear Trap Dam, for the reason that they are not conclusions based upon and drawn from the tables themselves, and therefore not responsive to the question; and for the further reason that there is no evidence introduced along with the tables and shown on the tables, which gives variations in the lake level and the volume of water flowing through the Bear Trap Dam, so as to be comparable with the data contained in the tables of averages themselves.

JUDGE SPRINGER: I will state that the data to which counsel has referred will be given later by other witnesses, but this witness may submit any data that he has upon the
8680 subject bearing upon the points to which counsel has referred.

MR. JEFFRIES: I suggest that this data be furnished counsel before this witness leaves the stand, that is to be introduced by other witnesses, as well as by this witness, so that we may be able to cross-examine on this proposition.

JUDGE SPRINGER: We will furnish you with as much of it as we can.

Q. Have you any plates or tables which will exhibit or show the volume of water in the drainage canal at the various periods covered by these tables?

A. I have.

Q. You will please submit them. Have these been put in evidence heretofore?

A. They have, and are included in the series of plates A. W. P. Nos. V to XLV inclusive, heretofore read in evidence.

Plate VI of this series gives the flow in the Illinois and Michigan Canal at Bridgeport, the Desplaines river at Riverside; the Chicago main drainage channel at Lockport, at the Bear Trap Dam, the Desplaines river at Joliet, where all these various bodies of water have come together, and in the upper part of the plate there are shown curves which reveal the relative proportions of water discharged by the sanitary canal at the Bear Trap Dam, discharged over dam No. 1 at Joliet, 8681 and the volume of water discharged over the dam at Kampsville, that is the quantity of water discharged by the Illinois river at the point 31 miles within its mouth.

Plate No. VII of this series, gives by means of curves a comparison of the relative volume of water discharged by these various streams or agencies at the same points, but for the year 1901. With respect to these plates I may say that the curves have been prepared to show graphically the figures representing the mean daily flow of each one of these streams at the point referred to, except that for convenience, the weekly flow of the Desplaines river at Joliet, and the mean weekly discharge of the sanitary canal at the Bear Trap have been represented. Upon the lower portion of each plate there appear curves representing the discharges of the sanitary canal the Illinois and Michigan canal, the Desplaines river at Riverside instead of Lockport, as printed on the plate; the Desplaines river at Joliet, these all being stated in cubic feet per minute; the upper part of each plate, the comparison between the discharges of the Desplaines river at Joliet and of the sanitary canal at the Bear Trap Dam, with the discharge of the Illinois river over the Kampsville dam, is represented in cubic feet per second, for convenience in getting the curves on a reasonably convenient or small plate.

8682 MR. JEFFRIES: I move to strike out the testimony of this witness and the conclusions that he draws from the plates in question, and the conclusions in particular with reference to the volume of water passing down the various streams at the given points, and his testimony with reference to the change and variations of the lake level and of the variations of the water in the main drainage canal, for the reason that the witness has not qualified himself in the evidence as a hydraulic engineer.

JUDGE SPRINGER: From what source did you obtain those facts?

A. The data from which these curves have been drawn so far as it concerns the sanitary canal, the Desplaines river at Riverside, the Illinois and Michigan Canal at Lockport and the Desplaines river at Joliet, were furnished to me by Mr. Isham Randolph, the engineer for the Sanitary District of Chicago. The data from which the curves representing the flow over the Kampsville dam were made, were furnished me by the Assistant U. S. Engineer who is in charge of that dam, namely, Mr. C. V. Brainard, and these were furnished me as part of the data gathered in my study of the water supplies of Illinois, as part of the work of the State Water Survey, which was in my charge.

MR. JEFFRIES: To the last answer of the witness I renew my motion to strike out, for the reasons stated.

8683 Q. Now you stated that you obtained part of this data from Mr. Isham Randolph—that part of the data will be put in evidence by Mr. Randolph when he is put on the stand, the data in reference to the flow of the Illinois river at Kampsville. That will be offered in evidence at a subsequent place in the proceedings.

MR. JEFFRIES: I still move to strike out the conclusions drawn by this witness from the table for the reason that there is no evidence to show that the information obtained by this witness from Mr. Randolph or from Mr. Brainard or from the other sources represent and is the same that will be testified to by them when they go upon the stand.

JUDGE SPRINGER: When Mr. Jeffries objected to your testimony on acount of the absence of data in reference to the flow of the water, you were proceeding to explain these tables now before you. Have you any further explanation to submit in regard to them?

A. Yes. These were at this time referred to merely in answer to the previous objection of counsel for complainant, namely that the discussion of the absence of the data of analyses was useless because there was no consideration given, to questions of variations in flow in the streams in question. I
have the data in figures upon which the lines of these
8684 plates are based, and they will be introduced in evidence
later.

Q. Have you any further explanation to be made of the chemical results of these examinations at these points?

A. Not at present, although they will be referred to later when we come to consider the problems involved in the present controversy.

Q. I call your attention now to tables Nos. 12, 13 and 14, which contain the chemical analyses of water from the Desplaines river at Lockport. Is that designation correct? At Lockport or was it at Riverside?

A. No this is at Lockport.

Q. Did you prepare any averages of those tables?

A. The only averages of these tables which I prepared appear at the bottom of each table. Further comparative averages of the data in these tables were not made.

Q. What do these tables indicate as to the chemical condition of the waters in the tables to which your attention has just been called?

A. Well the Desplaines river at Lockport is a small stream with an exceedingly variable flow. Variations are shown graphically upon plates VI and VII mentioned above and heretofore
read in evidence. Above Lockport the Desplaines re-
8685 ceives the sewage from various suburban towns. For the
purposes of this investigation an effort was made to have samples of water collected beside the old stone bridge which crosses the river near Lockport at a point above which the dis-

charge from the Illinois and Michigan canal ordinarily enters the stream. Through some misunderstanding of the collectors samples were not always collected at a point which was not reached by the discharge from the Illinois and Michigan canal; consequently there are very considerable and abnormal variations in the data of the chemical analyses, particularly for the years 1897 and 1898. In the years 1899 and 1900 the samples were collected at a point not reached by the discharge from the Illinois and Michigan canal and the data are more uniform in character and more strictly representative of the conditions of the water in this stream except in times of freshet or of prolonged wet weather. The waters of the upper Desplaines have but a slight effect upon the sewage flowing past Joliet.

Q. For what reason?

A. Because of their inconsiderable volume.

Q. I now call your attention to tables of this series Nos. 15 and 16, which contain chemical examinations of water 8686 in the Desplaines river at Joliet during the times indicated heretofore. Will you please state whether you have prepared averages of these other than those contained at the bottom of the tables themselves?

A. I have.

Q. Will you present that table of averages and give its number?

A. The table of averages is No. 4, A. W. P. and brings together the yearly averages of results of analyses of samples of water collected from the Desplaines river at Dam No. 1 in the upper part of the town of Joliet, the averages covering the years 1899, 1900 and 1901. Those for the later year including two sets, representing analyses of one set of samples collected at the east side of the stream at the point given above, and the other including the analyses of a set of samples collected at the other or west bank of the stream.

Q. Will you present that table?

A. Yes, the table No. 4 is as follows:

8687

TABLE VI.

DEFENDANTS' TABLE OF AVERAGES NO. 4.—A. W. P.

CHEMICAL EXAMINATION OF THE WATER OF THE DESPLAINES RIVER AT JOLIET. YEARLY AVERAGES. PARTS PER MILLION.

Year	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
		Total	By Dissolved	By Suspended Matter	Free Ammonia	Albuminoid Ammonia.			Total	Dissolved	Suspended	Nitrites	Nitrates
						Total	Dissolved	Suspend'd					
1899	105.7	28.5	16.2	12.3	14.92	2.195	.831	1.364	4.502	1.732	2.77	.01	.208
1900	30.4	11.1	7.3	3.8	2.971	.707	.402	.305	1.574	.83	7.44	.031	.31
East Side 1901	29.7	9.7	7.4	2.3	3.335	.478	.269	.209	1.05	.574	.476	.031	.334
West Side 1901	14.7	8.6	6.7	1.9	1.629	.359	.218	.141	.871	.515	.356	.03	.258
Mean	22.2	9.1	7.0	2.1	2.492	.418	.243	.175	.96	.544	.416	.03	.296

8688 Now, what explanation can you give of the chemical condition of the waters at these places—you may state first whether the waters at this place contain waters from the Illinois and Michigan Canal, the drainage canal and the Desplaines river?

A. I would like to make a fuller explanation of the average first. I wasn't quite through.

Q. Proceed then.

A. The detailed data of the analyses for the years 1899 and 1900 have not been given in this series of tables, but appear in the tables 1 to 80, inclusive, heretofore read in evidence, said tables being included in the report of the testimony given on behalf of the Sanitary District of Chicago.

JUDGE SPRINGER: Those tables are known as Streams Examination Report, and are consequently not repeated in this series.

A. At this point, namely, Joliet, which is about four miles below Lockport, the I. and M. canal crosses the Desplaines river by means of the valley or basin formed by Dam No. 1 which is located in the upper part of the town; the canal from this point on passing down the side, the west or north bank of the river to its terminus at LaSalle, approximately 100 miles from the beginning of the canal at Bridgeport. It is between this dam

and Lockport that the discharges from the Illinois and
8689 Michigan canal, and since January, 1900, the discharge
from the drainage channel have entered the Desplaines valley and mixed with the waters of the Desplaines river; consequently this is the point at which the initial effect of the discharge of Chicago sewage is at the maximum. Prior to the opening of the drainage channel the seasonal variations in the composition of the water or in the proportions of the various chemical constituents at this place were considerable because of the variations in flow of the diluting waters of the upper Desplaines, during a large or greater part of the year especially the summer and autumn seasons, the dilution of the concentrated sewage discharged from the old canal, that is, the Illinois and Michigan canal is very slight; but in the earlier or flood seasons of the year the flow in the Desplaines at this point would occasionally amount to three or four hundred thousand cubic feet a minute and the dilution of the sewage be correspondingly great; that is, about 10 to one. In the summer season, when the natural flow in the upper Desplaines generally dwindles to almost nothing, there is practically no dilution. The 36,000 cubic feet per minute of sewage raised by the pumps at Bridgeport, in the Illinois and Michigan canal and discharged at Lockport and Joliet constituting the entire flow. Indeed, the river bed below the dam at Joliet would at times be almost entirely dry, the flow for some distance below this point being
8690 entirely carried by the Illinois and Michigan canal. Since
the opening of the drainage channel the volume of water passing this point is much more uniform. The effect of the dilution of this sewage is seen in the very great difference between the data of analyses of samples taken during the year 1899 or before the drainage channel was put in operation and those taken for the years 1900 and 1901, the year immediately subsequent to the opening of the sanitary canal or main drainage channel. During the year 1900 there were found great variations in the proportions of the various constituents of the water. These variations were in part due to seasonal variations of flow in the upper Desplaines river, and in part the result of variations in the flow in either the Illinois and Michigan canal or the main drainage channel or both. If then for any reason the flow in the channel—the drainage channel is reduced or stopped by

manipulation of the gates at Lockport, sewage accumulates in the Chicago river and the discharge into the Desplaines consists then chiefly of the more concentrated sewage of the Illinois and Michigan canal and when the gates are again opened a much less diluted mixture of the accumulated sewage is in time discharged by the main drainage channel. However, many of the variations hitherto noted were due to incomplete mixing of the
several bodies of sewage and water which go together in
8691 this vicinity, a fact that is shown particularly by the re-
sults obtained from the analyses of the two series of samples collected during the year 1901. During this year a sample was taken at each side of the river at Dam No. 1, at Joliet, the averages for the year, and also the mean for the two series of analyses are shown in table No. 4 of averages.

Comparison of the averages for 1900 and 1901 with those for 1899, makes evident the great difference in concentration of the sewage passing Joliet after the opening of the main drainage channel. Most of the sewage of Joliet enters the stream below the point at which Joliet samples were collected.

Comparison of some of the figures in the tables of averages will serve to illustrate or call attention to the conditions referred to above; thus, the average proportion of chlorine in this water in the year 1899 was 105.7 parts per million, while in 1900 the average was 30.4. In 1901 the samples at the east side of the stream gave as an average for the chlorine content, 29.7 parts per million, and for the west side of the stream an average of 14.7 parts per million. The mean for the two series being 22.2 parts of chlorine per million.

The oxygen consumed shows a similar decrease after the
opening of the main drainage channel; thus the average
8692 for the year 1899 for the total oxygen consumed was 28.5
parts per million, and for 1900 11.1 parts per million; for 1901 east side, 9.7 parts per million, and the west side 8.6 parts per million. The average or mean for the two series being 9.1 parts per million.

Similar conditions manifest themselves on comparison of the averages representing the content of nitrogen as free ammonia, that is, for the year 1899, the average proportion was 14.92 parts of nitrogen as free ammonia per million, and for the year 1900 there were but 2.971 parts of nitrogen as free ammonia per million. For the year 1901 on the east side the average was 3.355 parts per million and for the west side 1.629 parts per million, the mean for the two series for 1901 being 2.492 parts per million; thus, the proportion of free ammonia for the year 1899 of 14.92 more than five times as great as the proportions found in the year 1900, namely, 2.971, and for the year 1901, which was 2:492.

The nitrogen as albuminoid ammonia, both the total, the dissolved and the suspended show a similar diminution in proportion on comparison of the data for the year 1899 with the data for the years 1900 and 1901. The total albuminoid ammonia for the year 1899 being 2.195, while for the year 1900 it was .707, and for the year 1901, for the east side it was
8693 .478, and for the west side .359, the mean for the two being .418. The nitrogen as albuminoid ammonia was for 1899, .831; for 1900, .402; for 1901, east side, .269; west side, .218; the mean for the two, .243. Nitrogen as albuminoid ammonia derived from suspended matters was for 1899, 1.364; for 1900, .305; for 1901, east side, .209; west side, .141; mean for the two being .175.

Total organic nitrogen shows similar variations for the year 1899, which was 4.502; for the year 1900, 1.574; for the year 1901, 1.05; for the east side and for the west side, .87; the mean for the two being .96. The organic nitrogen contained in dissolved substances was for 1899, on the average 1.732; for 1900 it was .83; for the year 1901, for the east side, it was .574; for the west side .515; the mean being .544.

Organic nitrogen in suspended matters was for 1899, 2.77; for 1900, .744; for the year 1901, east side, .476; west side .356; the mean being .416.

Nitrogen as nitrites for the year 1899 was .01; for the year 1900, .031; for the year 1901, east side, .031; west side, .03; the mean being .0305.

Nitrogen as nitrates for 1899 was .208; for 1900, .31; for 1901, east side, .334; west side, .268; the mean being .296.

Adjourned until 2:00 p. m., same day, Nov. 16, 1903.

8694 2:00 p. m., Monday, November 16th, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further direct-examination, by Judge Springer, and testified as follows:

Q. I now call your attention, Professor, to tables 17 and 18, 19 and 20, of this series, which give the chemical examinations of water in the Illinois river at Morris. Will you please state whether there were any averages made by you based upon those tables?

A. Averages for the first six months, second six months and the year, for the tables 17 to 20, inclusive, appear at the bottom of the respective tables, but in addition to these I have prepared a table of averages, in which these yearly averages are brought together for the purpose of comparison. This table of averages is known as Defendants' Table of Averages No. 5, A. W. P.

Q. Will you please read that table in evidence?

A. Table of Averages, No. 5, is as follows:

8695

DEFENDANTS' TABLE OF AVERAGES NO. 5.—A. W. P.

TABLE VIII.

CHEMICAL EXAMINATION OF THE WATERS OF THE ILLINOIS RIVER AT MORRIS.
YEARLY AVERAGES. PARTS PER MILLION.

Year	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
						Albuminoid Ammonia.							
		Total	By Dissolved	By Suspended Matter	Free Ammonia	Total	Dissolved	Suspend'd	Total	Dissolved	Suspended	Nitrites	Nitrates
Jan.-Dec. 1896	29.7	14.5	......	......	3.55	.700	......	......	1.44	....	......	.149	1.73
Jan.-Dec. 1897	45.7	15.9	10.3	5.6	5.78	.862	.46	.402	1.006	.895	.71	.15	1.097
Jan.-Sept. 1898	34.7	17.3	......	......	4.109	1.308	......	......	2.491	......	......	.016	[illegible]
May-Dec. 1899	65.6	14.7	12.1	2.6	8.9	.911	.50	.372	1.915	1.115	.8	.026	[illegible]
4 yrs. Av'e.	44.4	15.6	11.2	4.1	5.585	.97	.499	.387	1.9025	1.05	.756	.0965	1.005
1900	23.1	12.3	6.7	5.6	2.075	.535	.269	.266	1.162	.631	.531	.106	.717

8696 Q. Now, what significance do you attribute to these tables, and the table of averages to which you have just referred and which you have read in evidence?

A. Morris is the first station upon the Illinois river proper. At this point the waters of the stream consist of an incomplete mixture of the sewage laden waters of the Desplaines river with the waters of the Kankakee. Prior to the opening of the drainage channel the Chicago sewage discharged into the Desplaines river experienced no considerable dilution before getting the waters of the Kankakee, except when the Desplaines itself was in flood. This, however, was rarely the case at times other than those of the usually short spring freshets. When the Kankakee was in flood, the dilution at this point was of course correspondingly great, as much as 50 to 1; the average dilution for the year being about ten to one, but ordinarily in the summer and autumn the dilution would probably rarely exceed two or three to one, and often fall far short of this. Since the opening of the drainage canal the flow in the lower Desplaines is far more uniform and the average is just about equal to the average flow of the Kankakee, which is about 300,000 cubic feet per minute.

Q. The volume of water therefore added after the opening of the canal to the stream was as great as the volume

8697 which existed before at the mouth of the Desplaines river?

A. Yes, but the average through the two canals is much more uniform throughout the year, while the figure referred to with respect to the Kankakee is an average for the year, and includes volume ranging from a very small minimum flow elsewhere stated in the testimony, and the exceeding great flow of the spring freshets. That is to say, the volume from the Kankakee varies greatly at the different seasons, while the flow in the Desplaines due to the discharges from the main drainage channel and the Illinois and Michigan canal is fairly uniform throughout the year, considering the details of the analyses which appear in tables 17 to 20, inclusive, considerable variations appear, which, however, are not entirely due to variations in the volume of water flowing, but are in part due to the fact that at this point the mixing of the waters from the two general sources, namely, the Desplaines river and the Kankakee river, are quite incomplete, so that individual analyses consequently appear to vary considerably more than the mean composition of this in-

complete mixture warrants, but it is not likely that the variations thus occasioned are for this point sufficiently great to seriously affect the yearly averages and the comparisons instituted between them. The table of averages—this table No. 5,
8698 A. W. P., contains the yearly averages of analyses of the
waters of the Illinois river at Morris for the year 1896, which average is derived from the data in the preliminary report of the chemical survey of the waters of the state, heretofore mentioned and introduced for identification.

The averages for the year 1897, which appear in table No. 17 averages for the year 1898, the detailed analyses for which appear in table No. 18; averages for the year 1899, the detail analyses for which year appear in table No. 19, and averages for the year 1900, the detail data for which appear in table No. 20, so we have thus averages for four years preceding the opening of the main drainage channel, and for one year subsequent thereto. The general averages made up from these yearly averages, and hence representing the four years period before the opening of the Chicago main drainage channel, are as follows:

Chlorine,	44.4
Oxygen consumed,	15.6
Oxygen consumed by dissolved substances,	11.2
Oxygen consumed by suspended matters,	4.1
Nitrogen as free ammonia,	5.585
Nitrogen as albuminoid ammonia, total,	.97
8699 Dissolved,	.499
Suspended,	.387
Total organic nitrogen,	1.8625
Organic nitrogen in dissolved matters,	1.05
Organic nitrogen in suspended matters,	.756
Nitrogen as nitrites,	.0965
Nitrogen as nitrates,	1.0665

The averages for the year 1900 are as follows: Chlorine 23.1, a little more than half as much as the average for the four preceding years, and about one-third as much as for the year 1899, the year immediately prior to the opening of the drainage channel.

The oxygen consumed, the average for the year 1900, was 12.3, as against 15.6, the average for the four preceding years.

Oxygen consumed by dissolved matters, 6.7 as against 11.2, the average for the two preceding years, namely, 1897 and 1899, the only years for which we have the determinations of oxygen consumed by dissolved matters.

The oxygen consumed by suspended matters for the year 1900 is 5.6, as against 4.1, the proportions required of the
8700 average for the two years preceding, that is, the year 1897 and the year 1899.

Free ammonia for the year 1900, the average was 2.075, as against 5.585, the mean for the four preceding years.

The nitrogen as albuminod ammonia, total, .535, as against .97 the average for the four preceding years. The albuminoid ammonia derived from dissolved substances .269 for 1900, as against .499 the average for the years 1897 and 1899.

The albuminoid ammonia derived from suspended matters for 1900 was .2666 as against .387, the average for the years 1897 and 1899.

Total organic nitrogen for the year 1900 was 1.162 as against 1.3625, the average for the four preceding years.

The organic nitrogen contained in dissolved matters was .631 as against 1.05, the average for the years 1897 and 1899.

The organic nitrogen in suspended matters was .531 for 1900, as against .756, the average for the years 1897 and 1899.

Nitrogen as nitrites, the average for 1900 was .108, while the average for the four preceding years was .0965, and
8701 for the year 1899, was .026.

Nitrogen as nitrates, average for 1900 was .717, while the average for the four preceding years was 1.0665.

It is evident that at this point the proportions of chlorine and of organic matters as represented by the oxygen consumed and nitrogen in the form of free ammonia and albuminoid ammonia, the total organic nitrogen, have been considerably less in the waters of the Illinois in the year 1900 than they were during the four preceding years. On the other hand, the nitrogen as nitrites was present in the water of the Illinois river at Morris in more considerable proportion in the year 1900 than in 1899, or than it was on the average during the four preceding years.

Nitrogen as nitrates was present in greater proportion in the year 1900 than in the year 1899, or the average for the four years preceding the opening of the Chicago drainage canal was greater than the proportion contained during the year 1900.

Q. How do you account for these facts as to the nitrates and the nitrites?

A. The nitrites in the waters of the Desplaines river at Joliet have been considerably greater in proportion since the opening of the Chicago main drainage channel than they were prior to that opening, and the same is true at Morris. 8702

It is evident then, that such agencies as bring about the oxidation of the organic matters through ammonia to nitrites, and finally to nitrates, are fully as effective since the sewage has been more extensively diluted at and near Chicago. The fact that the nitrites are now found in greater quantity at Joliet and at Morris indicate that the nitrifying action going on in the river is more active at a point nearer to Chicago; that is, that the oxidizing influences at work upon the organic matters in the waters of these streams are more efficient now nearer to Chicago, this undoubtedly being one of the results of the greater dilution of the sewage with comparatively pure and oxygen saturated lake Michigan water.

Q. I call your attention now to tables in this series numbered 21, 22 and 23, which contain the chemical examinations of water from the Illinois river at Ottawa. Did you prepare any table of averages covering these three tables?

A. I did.

Q. Will you read that table?

A. The table numbered 6, is as follows:

8703

DEFENDANTS' TABLE OF AVERAGES NO. 6.—A. W. P.

TABLE IX.

CHEMICAL EXAMINATIONS OF THE WATERS OF THE ILLINOIS RIVER AND OF THE FOX RIVER AT OTTAWA. YEARLY AVERAGES. PARTS PER MILLION.

Fox Year	Chlorine	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS	
						ALBUMINOID AMMONIA.							
		Total	By Dissolved	By Suspended Matter	Free Ammonia	Total	Dissolved	Suspend'd	Total	Dissolved	Suspended	Nitrites	Nitrates
Mar.-Dec. 1898	7.93	9.3	7.1	2.2	.064	.407	.288	.119	.823	.553	.27	.027	.471
May-Dec. 1899	5.84	9.9	8.3	1.6	.055	.416	.27	.146	.94	.555	.385	.008	.373
Jan.-Oct. 1900	5.3	9.6	7.5	2.1	.129	.398	.251	.148	.815	.491	.324	.008	.416
Av'e.	6.36	9.6	7.63	1.96	.083	.407	.27	.137	.86	.533	.326	.014	.42
ILL.													
June-Dec. 1899	59.5	11.3	10.5	1.13	4.99	.498	.399	.099	1.111	.824	.287	.496	1.847
Jan.-Oct. 1900	21.3	8.6	6.9	1.7	1.311	.39	.244	.147	.848	.537	.311	.25	1.62
July-Oct. 1901	25.5	6.6	5.8	.8	.07	.223	.173	.05	.898	.508	.39	.454	1.209

8704 Will you please explain what is illustrated by these tables and the table of averages based upon them?

A. Now table 6 of this series contains a series of averages of analyses of the waters of the Illinois river at Ottawa and also averages of the series of analyses of the water of the Fox river at Ottawa. The latter we shall not discuss until we come to the consideration of the tributaries.

The collections from the Illinois river at Ottawa were made at a point about a mile above the mouth of the Fox and above the point where the sewage from the town of Ottawa and some discharge from the Illinois and Michigan Canal enters the stream, the detail data are as indicated above, included in tables 21, 22 and 23.

The analyses show the changes which take place during the flow of 24 miles from Morris to Ottawa, without further dilution and without notable addition to impurities, but the mixing of the discharges from the Desplaines and the Kankakee is not yet complete at this point, and some of the variations of the individual analyses are due to this cause. It is to be noted that at this point the nitrites are found in the waters of the Illinois river in greater proportions than at any other point along its course, which fact taken into consideration with the other indi-
8705 cations of the analyses, shows that it is in this stretch of the river that the final oxidation processes which convert the organic matters of the sewage into innocuous mineral substances, the free ammonia, the nitrites and the nitrates and so on, are most active and effective.

Comparison of the averages for the Illinois river at this point for 1899 with those for 1900, and the few for 1901, show how great was the dilution effect of the flow of the Chicago main drainage channel, thus the chlorine for the year 1899 averaged 59.5—this is at Morris—while for the year 1900, it was 21.3.

The total oxygen consumed was in 1899, 11.3; in 1900, 8.6.

Oxygen consumed by dissolved substances in 1899, 10.5, in 1900, 6.9.

That required by suspended matters was in 1899, 1.13, in 1900 it was 1.7.

The free ammonia during the year 1899 averaged 4.99, in the year 1900 it was 1.311.

Nitrogen as albuminoid ammonia, total, for 1899 the average was .498; for 1900, .39.

The albuminoid ammonia derived from dissolved substances was in 1899, .399; in 1900, it was .244.

8706 The albuminoid ammonia from suspended matters was in 1899, .0997; in 1900 it was .147.

The total organic nitrogen was in 1899, on the average 1.111; in 1900 it was .848.

The organic nitrogen in dissolved matters was during the year 1899, .824 and during 1900 was .537.

Organic nitrogen in suspended matters was in 1899, .287; in 1900, .311.

Nitrogen as nitrites in 1899 the average was .495; in 1900 it was .25.

The nitrates in 1899 were 1.857 and in 1900 were 1.62.

Q. I call your attention now to tables of this series numbered 24, 25, 26 and 27. Did you prepare any table of averages based upon the ascertainment contained in these tables, which were the chemical examinations of water in the Illinois river at LaSalle?

A. I did.

Q. Have you that table with you?

A. I have. It is table of averages No. 7 A. W. P. and is as follows:

8707

DEFENDANTS' TABLE OF AVERAGES NO. 7.—A. W. P.

TABLE X.

CHEMICAL EXAMINATION OF THE WATER OF THE ILLINOIS RIVER AT LASALLE. YEARLY AVERAGES. PARTS PER MILLION.

Year	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
		Total	By Dissolved	By Suspended Matter	Free Ammonia	Albuminoid Ammonia.			Total	Dissolved	Suspended	Nitrites	Nitrates
						Total	Dissolved	Suspend'd					
Jan.-Dec. 1896	19.6	12.3	9.04	3.26	.971	.612	.429	.183	1.260	.98	.28	.255	2.51
Jan.-Dec. 1897	30.9	13.1	9.6	3.5	1.728	.6	.384	.216	1.234	.891	.343	.442	2.14
Jan.-Dec. 1898	25.9	11.2	8.4	2.8,	1.396	.488	.357	.131	1.158	.721	.437	.25	9.55
Feb.-Dec. 1899	44.7	13.6	10.4	3.2	2.335	.482	.379	.103	1.285	.807	.478	.385	1.955
4 yrs. Av'e	30.28	12.55	9.36	3.19	1.638	.5455	.387	.158	1.234	.852	.386	.333	1.89
1900	18.7	10.1	7.2	2.9	.963	.391	.251	.141	.944	.611	.333	.152	1.7

8708 Q. State what significance you attribute to these detail tables and this table of averages as to the waters at this point?

A. Tables 24, 25, 26 and 27 contain the data of all analyses of samples of water taken from the Illinois river at LaSalle during the years 1897 to 1900 inclusive. The yearly averages which appear at the bottom of these tables and averages for the year

1896 taken from the preliminary report heretofore referred to and introduced in evidence as defendants' Exhibit A for identification, are brought together in tables of averages No. 7 A. W. P. The samples of water taken at LaSalle were collected beside the wagon bridge at a point three miles below the mouth of the Big Vermillion river, but above the point at which most of the sewage of LaSalle and the final discharge from the Illinois and Michigan canal enter the river.

Between Ottawa and LaSalle the conditons in the river are such as favor the abundant growth of vegetation and the waters at this point consequently become charged with organic matters to a greater extent than at Ottawa. The nitrates also are found at this point in greater proportion than they are found at
8709 Ottawa, and they have not been very notably reduced in
proportion by the dilution resulting from the discharge through the Chicago main drainage channel, a fact which is noted from comparison of the averages for the four years preceding, and those for the year following the opening of the drainage channel.

From Lockport to Ottawa the mixing of the waters seems to be at no point complete, and variations in the analyses due to this imperfect mixing are frequent, but a study of the conditions at LaSalle including analyses of cross-section samples has shown that at this point the waters have ordinarily mingled completely. Just below the town of LaSalle there occurs the final discharge from the Illinois and Michigan Canal which carries most of the sewage of LaSalle and the discharges of sewage and manufacturnig wastes from the town of Peru. It should be noted at several points between Joliet and LaSalle there are minor discharges from the Illinois and Michigan Canal into the Desplaines river and the Illinois river, and that prior to the opening of the drainage channel the old canal, that is, the Illinois and Michigan canal, at times carried practically undiluted Chicago sewage throughout much of the sixty-six miles of its lower course. Indeed, in period of low water, the channel often carried the entire body of Chicago sewage past Joliet and dis-
8710 charged it at various points many miles below that at
which it is now delivered into the river, thus carrying the pollution much farther down stream than the points at which it is now found.

Since the opening of the main drainage channel the diluted sewage which enters the stream between Lockport and Joliet is mainly carried by the Desplaines and Illinois rivers, and the volume discharged from the canal at points below Joliet constitutes a much smaller proportion of the volume of the river. Moreover, the water of the channel is now in far better condition because of its great initial dilution at Joliet and the more thorough-going natural purification thereby occasioned.

Comparison of the averages for the year 1900 with the composite averages for the four preceding years show that the water of the Illinois river at LaSalle contained less than two-thirds as much chlorine. in the year 1900 as it did on the average fo: the four preceding years, the figures being 18.7 for 1900 and 30.28 for the four preceding years; while the averages for the year 1899 was 44.7.

The oxygen consumed for the year 1900 was 10.1, while the average for the four preceding years was 12.55, and for the year 1899 was 13.6.

Oxygen consumed by dissolved substances was 7.2 for 1900 as against 9.36 for the four preceding years, and 10.4 for the year 1899.

8711 The oxygen consumed by suspended matters was 2.9 in 1900 as against 3.19 as the average for the four preceding years, or 3.2 the average for the year 1899.

The nitrogen as free ammonia, was an average, .963 for the year 1900 as against 1.658 the average for the four preceding years, and 2.536 the average for the year 1899.

The albuminoid nitrogen, total, for 1900 was on the average .391, while for the four preceding years it was .5455.

Albuminoid ammonia derived from dissolved substances was for 1900, .251; for the four preceding years it averaged .387.

Albuminoid ammonia derived from suspended matters was for 1900, .141; for the four preceding years it was .158.

Total organic nitrogen for the year 1900 was .944, the average for the four preceding years being 1.234.

The organic nitrogen in dissolved matters was for 1900, .611; for the four preceding years the average was .852.

Organic nitrogen in suspended matters for the year 1900, was .333; for the four preceding years the average was .386, and for the year 1899 the average was .478.

Nitrogen as nitrites, the average proportion for the year 1900 was .152; while for the four preceding years it was 8712 .333.

Nitrogen as nitrates, the average for the year 1900 was 1.7, the average for the four preceding years being 1.89.

It is evident from the comparison of these averages that the proportions of organic matters contained in the waters of the Illinois river at LaSalle have been very considerably reduced as a result of the greater dilution produced by the opening of the Chicago main drainage channel, that the proportions of nitrogen as nitrites is now less than one-half what it was before the opening of the drainage channel, while the proportions of nitrogen as nitrates are but slightly less than they were before that opening.

Q. I will now call your attention professor, to tables in this series numbered 28 to 32 inclusive, which contain the chemical examinations of water from the Illinois river at Averyville. Please state whether you prepared any table of averages based upon these tables?

A. I did prepare such table of averages.

Q. Have you that table with you?

A. I have. It is Defendants' table of averages No. 8, A. W. P. and is as follows:

8713

DEFENDANTS' TABLE OF AVERAGES NO. 8.—A. W. P.

TABLE XII.

CHEMICAL EXAMINATION OF THE WATERS OF THE ILLINOIS RIVER AT AVERYVILLE. YEARLY AVERAGES. PARTS PER MILLION.

Year.	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
		Total	By Suspended Matter	By Dissolved	Free Ammonia	Albuminoid Ammonia.			Total	Dissolved	Suspended	Nitrites	Nitrates
						Total	Dissolved	Suspend'd					
Apr-Dec. 1897	37.9	11.3	9.4	1.9	.843	.503	.367	.136	1.01	.794	.216	.254	1.69
1898	21.4	9.3	7.5	1.8	.86	.403	.316	.087	.83	.646	.184	.124	.807
1899	47.2	12.9	9.4	3.5	1.025	.494	.325	.169	1.11	.722	.388	.204	1.558
3 yr's Av'e.	30.2	11.1	8.76	2.4	.909	.466	.3 6	.13	.98	.72	.262	.194	1.351
1900	17.5	8.4	6.6	1.8	.639	.323	.226	.101	.767	.534	.233	.079	1.384
1901	17.5	7.7	6.7	1.	.647	.249	.198	.051	.717	.576	.141	.081	1.537
2 yr's A've.	17.5	8.05	6.6	1.4	.643	.286	.212	.076	.742	.555	.187	.08	1.46

8714 Q. Now what significance do you attach to these tables and to the table of averages which you have just put in evidence?

A. The tables Nos. 28 to 32 inclusive contain the data of analyses of samples of water taken from the Illinois river at North Peoria or Averyville. That is beside the bridge at the Narrows, three miles above the Peoria Court House, a point where none of the sewage of Peoria finds its way into the waters of the stream.

The analyses were made upon samples which were collected regularly each week throughout the period in question beginning April 26, 1897, and ceasing December 26, 1901, except that during the first half of the year 1901 the collections were made but once a month, the averages however, for such years as are not covered by regular weekly samples have been made first for each month in the year, and the year's average made up from the monthly average. In other cases the averages have been made straight from the various weekly samples.

Between LaSalle and Averyville there is no considerable additional dilution of the waters of the stream and no great amount of impurites introduced except that discharged from the Illinois and Michigan canal just below LaSalle, which discharge contains most of the sewage of LaSalle, and in addition
8715 the discharge of the sewage and manufacturing wastes of Peru, which is just below LaSalle.

The study of the data of the analyses and particularly comparison with those for the other points along the river between Averyville and Lockport show unmistakably that a very great purification of the waters of the stream takes place as they flow along the 125 miles of its course between these two points. The seasonal variations in the water of the river at Averyville as may be seen by study of the detail analyses contained in tables 28 to 32 inclusive, are quite considerable, but the limits of variations are in most respects considerably less since the opening of the Chicago main drainage canal than they were formerly. The variations of the chlorine are shown diagramatically upon plate VIII.

It is quite natural under the existing circumstances, that the proportions of chlorine should be smaller during the high water period, that is, in February, March and April, and that in

the later season of the year, the warmer summer months, when the flow is very much reduced, the contents of chlorine should be much greater than at other periods, and this plate too, shows in general the difference between the first six months and the second six months of the year, for formerly, that is particularly before the opening of the Chicago main drainage
8716 channel there was a much more considerable difference
between high water conditions and low water conditions in the Illinois river with respect to the chlorine contained, as also with respect to the organic matters than is the case since the opening of the main drainage channel.

Plates IX and X show graphically the seasonal variations in content of free ammonia. Plate IX having upon it the data for the weekly analyses represented by curves for the years 1897, 1898, 1899 and 1900, while upon plate X the monthly averages, showing the proportions of nitrogen as free ammonia for the years 1897 to 1901 inclusive are represented.

The curves of both of these plates show the general variations in the content of nitrogen as free ammonia, as it varies with the seasons, the proportion being very great in the cold weather season, that is in January and February, and in general too, in November and December, while the proportions during the warmer seasons, that is the late spring, the summer and the early autumn seasons, are very much less than at other times during the year.

It is very noticeable that both before and since the opening of the Chicago main drainage channel the proportions of free ammonia are much greater in cold weather than at other seasons, and it is evident too, that the proportions of free
8717 ammonia content in the water of the Illinois river at
Averyville are much less since the opening of the Chicago main drainage channel than they were before that time.

Plate XI of this series gives by means of curves the proportions of nitrogen as nitrites contained in the water of the Illinois river at Averyville, these being represented as monthly averages.

The curves of this plate show at a glance that the period when nitrites are most abundant in the Illinois river water at Averyville, is in general the summer time, or early autumn, when the flow is at the minimum and the temperature at the maximum. The conditions with respect to nitrates being just the opposite to those referred to above, with respect to the nitrogen as free ammonia. It is evident from the figures in tables of analyses, and it is shown graphically upon the plate, that the proportions of nitrites since the opening of the drainage channel are in general less throughout the year than they were before the opening of the main drainage channel.

Comparison of the figures of table of averages No. 8, show that as a result of the dilution effected by the opening of the Chicago main drainage channel, or at least subsequent to that opening, the proportions of the various significant constituents of the water of the Illinois river at Averyville are very
8718 greatly reduced.

The data throughout show this. The chlorine has been reduced from 20.2 the average for the three years prior to the opening of the drainage channel, to 17.5, the average for the two years subsequent to the opening. Similar reductions in the proportions of oxygen consumed both the total and that consumed by dissolved and by suspended matters, are evident. That the nitrogenous organic matters are very much reduced in proportion is evidenced at once by comparison of the relative quantities of nitrogen as albuminoid ammonia, and the total organic nitrogen for the two periods, the total organic nitrogen being on the average for the two years of 1900 and 1901 .742, while the average for the three years 1897 to 1899, is .98.

The total organic nitrogen in dissolved matters being .555 for the two years 1900 and 1901 as against .72 for the three years prior thereto. The nitrogen in suspended matters for the two years 1900 and 1901 being .187 as against .262 the average for the three preceding years.

The nitrogen as albuminoid ammonia, the total, was for the years 1900 and 1901 .286, while for the three years preceding the average was .466.

The albuminoid ammonia derived from dissolved sub-
8719 stances being for the years 1900 and 1901 .212, while for
the three years preceding, it was .336.

The albuminoid ammonia derived from suspended matters was on the average for the years 1900 and 1901 .076, and for the three preceding years the average was .13.

The proportion of nitrogen as free ammonia for the years 1900 and 1901 was .643, while for the four preceding years the proportion was .909, and for the year 1899 the proportion was 1.025.

The proportion of nitrogen as free ammonia thus was less than two-thirds as much in the waters of the Illinois river at this point after the opening of the Chicago main drainage channel than it was prior thereto.

Comparison of the proportions of nitrites shows a very great decrease at this point since the opening of the drainage channel, the quantity being less than one-half that formerly contained. Thus the proportions of nitrogen as nitrites on the average for the years 1900 was .079, for the year 1901, .081, and the average for the two years being .08.

The average proportion of nitrogen as nitrites for the year 1897 was .254; for the year 1898 .124; for the year 1899, .204; the average for the three years being .194, considerably more than twice the proportion found in the water at this point since the opening of the drainage canal.

8720 That the reduction of these constituents is not wholly due to mere dilution, but that in part at least it is due to the greater proportional destruction of the organic matters discharged into the stream at Lockport and Joliet would seem to be evident from the fact that the nitrates are found in greater proportions in the water at this point now than they were before the opening of the drainage channel; the average proportion for the three years prior to the opening of the Chicago main drainage channel being 1.351 while the average for the two years subsequent to the opening of the channel was 1.46.

Comparison of the figures of table 8 for Averyville, with those of table 7 for LaSalle, show that there has been a very great decrease in the organic matters during the flow of 60 miles between these two points. The diminution is very considerable in each case, even including the nitrates, but the most significance attaches to the marked diminution in the proportions of nitrites and free ammonia and albuminoid ammonia, and total organic nitrogen. The proportions of nitrites have been reduced about fifty per cent., which would appear to indicate that the nitrification processes are approaching completion; this in turn

indicating that those organic substances which are easily
8721 susceptible to bacterial action have in great part already
been consumed. In fact, it is highly probable that the refuse animal matters introduced in the sewage of Chicago have been completely destroyed, and that the organic matters which are contained in the river water at this point are derived from vegetable and not from animal sources.

MR. JEFFRIES: I move to strike out what the witness says is highly probable, as not having a reasonable foundation upon which to base it.

A. (Continuing) In fact, vegetation of various forms, the plankton, and so on, is exceedingly abundant in the river between LaSalle and Averyville. The water of the river between these points and especially near Averyville may often be seen covered with floating masses of vegetation consisting largely of filamentis and other algae.

Comparison of the averages for Averyville with those for the tributary streams serves to show that the waters of the Illinois river at this point contain considerably less organic matters than are contained in the waters of its chief tributaries, which latter have never been in contact with Chicago sewage, although of course they receive some sewage from comparatively small towns. It is very evident of course that free ammonia and nitrites are still present in the waters of the Illinois river at this point in greater quantities than are
8722 contained in most of the tributary streams but the considerations detailed above and all available data show unmistakably that the character of the water in the streams at Averyville is now far better than it was before the Chicago sewage received its initial dilution at Chicago, and not at the junction of the Desplaines and Kankakee rivers, sixty miles nearer to the point now under consideration.

JUDGE SPRINGER: Q. Professor, you used the words "Highly probable" in reference to the destruction of the sewage matter which has been introduced into the Illinois river from the Chicago drainage canal. State what your opinion is upon that fact.

MR. JEFFRIES: I object to the witness expressing an opinion on the subject for the reason that he is not a sanitarian and has not qualified as such, and for the further reason that the defendants have prided themselves on the proposition that chemistry is an exact science, and therefore if it is an exact science nothing can be probable, but must be certain.

Q. (Question read.)

A. It is my opinion that the animal matters discharged by the two canals, the Chicago main drainage channel and the Illinois and Michigan canal, into the Desplaines river in the vicinity of Lockport and Joliet, and discharged by the Desplaines 8723 into the Illinois river about ten miles above Morris, have been entirely destroyed before the waters of the Illinois river reach Averyville, and the substances of said animal matters have been in part converted into mineral substances, and in part built up into the substance of living vegetation, this opinion being based upon my study of the waters of the streams in question, at the various points enumerated in my testimony in this case, and upon the evidence of the chemical analyses which have been introduced as part of my testimony.

Q. I now call your attention, Professor, to the tables in this series numbered 33, 34, 35 and 36, which contain the chemical examinations of water from the Illinois river at Havana. Have you prepared a table of averages based upon those detail examinations?

A. I have, and it is Defendants' Table of Averages No. 9, A. W. P., and is as follows:

8724

DEFENDANTS' TABLE OF AVERAGES NO. 9.—A. W. P.

TABLE XIII.

CHEMICAL EXAMINATION OF THE WATERS OF THE ILLINOIS RIVER AT HAVANA.
YEARLY AVERAGES: PARTS PER MILLION.

Year	Chlorine	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS	
		Total	By Dissolved	By Suspended Matter	Free Ammonia	ALBUMINOID AMMONIA. Total	Dissolved	Suspend'd	Total	Dissolved	Suspended	Nitrites	Nitrates
1896	15.1	10.9	....	....	.63	.49	......	......	1.17	......	......	.174	2.34
1897	24.8	10.8	9.6	1.2	.860	.46	.41	.05	.988	.717	.271	.269	1.66
1898	19.6	9.3	7.5	1.8	.95	.43	.32	.11	.92	.683	.237	.121	.809
1899	27.3	13.3	9.8	3.5	1.104	.56	.35	.21	1.303	.788	.515	.160	1.133
4 yrs. Av'e	21.7	11.1	8.97	2.10	.894	.485	.365	.12	1.093	.729	.341	.155	1.485
3 yrs. Av'e 97-99	23.9	11.1	8.97	2.16	.982	.484	.366	.12	1.071	.729	.341	.102	1.2
1900	14.8	8.7	6.8	1.9	.565	.361	.23	.131	.859	.533	.306	.07	1.308

8725 Q. State what conclusions you have drawn from an examination of these detail examinations and the tables of averages which you have just put in evidence?

A. Tables 33 to 36, inclusive, give the results of analyses of samples collected during the years 1897 to 1900, inclusive. The yearly averages which appear at the bottom of these tables have been brought together in table of averages No. 9, and together with them there has been included in table No. 9, the year's averages for the year 1896, the details for which appear in the preliminary report several times heretofore referred to as Defendants' Exhibit A for identification.

The collections for Havana were made at a point about a mile and a half above the town, above the mouth of the Spoon river and the mouth of Quiver Lake, between Averyville and Havana. The sewage and manufacturing wastes are introduced into the river at Peoria and Pekin in quantities second only to those introduced through the Chicago main drainage channel and the Illinois and Michigan canal. These, however, consist very largely of refuse from stockyards, from cattle sheds; from some 40,000 to 50,000 cattle which are fed upon distillery slops, and the wastes from large glucose works, and other manufacturing industries.

Prior to the opening of the Chicago drainage channel—

8726 MR. JEFFRIES: Is that per annum—40,000 to 50,000 head per annum?

A. Why, continuously. I don't understand exactly what you mean,—per annum.

MR. JEFFRIES: The cattle that are fed at Peoria during the year?

A. No, during the year; they are constantly fed—there are constantly that number fed there.

8727 Prior to the opening of the Chicago draïnage canal the condition of the river along this stretch of 45 miles was at many places during the summer time practically that of an immense septic tank. The offensive condition of which was striking throughout much of this stretch, but was greatest in the near vicinity of Peoria and Pekin.

The data of the detailed analyses which appear in the tables 33 to 36, inclusive, show the seasonable variations similar to those which were found at Averyvile in comparison of the yearly averages which are brought together in table of averages No. 9, A. W. P., with those for Averyville which appear in table of Averages No. 8, A. W. P., show that notwithstanding the introduction of an enormous amount of filth between Averyville and Havana, the putrefactive and other purifying processes going on in the waters of the stream have sufficiently reduced them to proportions of the various constituents so much that they were but slightly different at Havana from what they were at Averyville, although an analysis of samples taken at Wesley just below Peoria and also at Pekin, show a notable increase in the content of organic matters at these two points, above the quantities found at Averyville and above those found at Havana, thirty miles below Pekin.

Comparison of the figures for the year 1900 with those of the years 1896 to 1899, inclusive, all of which appear in

8728 Table of averages No. 9, shows the effect of the opening of the Chicago main drainage channel in reducing the proportions of the various constituents here considered. With the exception of the nitrates, the reduction of the various constituents is very considerable. The fact that the nitrates are not proportionally lowered seems to indicate that oxidation at this point is more complete since the opening of the sanitary canal than it was previously.

Numerous determinations of dissolved oxygen in the waters of the Illinois river at Havana covering several years show that although at times the water is saturated in general, the content of dissolved oxygen is at this point considerably less than is required for saturation and at all times the dissolved oxygen diminished rapidly upon allowing samples to stand, as will be shown hereafter when a table upon that subject will be presented.

Q. I now call your attention to tables in this series Nos. 37, 38, 39, 40, 41, 42 and 43, which contain detailed chemical examinations of the water taken from the Illinois river at Kampsville, will you please state whether you prepared the table of averages based upon these tables?

A. I did.

8729 Q. Will you produce it, please?

A. It is Defendants' Table of Averages No. 10, A. W. P., and is as follows:

8730

DEFENDANTS' TABLE OF AVERAGES NO. 10.—A. W. P.

TABLE XV.

CHEMICAL EXAMINATION OF THE WATERS OF THE ILLINOIS RIVER AT KAMPSVILLE.

YEARLY AVERAGES. PARTS PER MILLION.

Year	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen			Nitrogen as	
		Total	By dissolved	By suspended matter	Free ammonia	Albuminoid Ammonia.			Total	Dissolved	Suspended	Nitrites	Nitrates
						Total	Dissolved	Suspend'd					
1897…	19.3	10.9	7.7	3.2	.351	.509	.303	.206	1.024	.691	.333	.08	1.553
1898…	12.6	11.7	6.8	4.9	.372	.484	.278	.206	1.018	.579	.439	.069	.764
1899…	10.5	12.4	8.2	4.2	.392	.473	.257	.216	1.129	.623	.506	.032	.988
3 yrs. Av'e..	16.1	11.7	7.6	4.1	.371	.488	.279	.209	1.057	.631	.426	.060	1.101
1900…	14.1	11.5	6.1	5.4	.382	.36	.206	.154	.904	.481	.423	.038	1.436
1901…	15.6	9.4	7.2	2.2	.375	.338	.218	.12	.909	.579	.42	.044	1.221
1902…	10.2	11.3	8.1	3.2	.424	.349	.23	.119	……	……	……	.039	1.210
3 yrs. Av'e..	13.3	10.7	7.1	3.6	.393	.340	.218	.131	.951	.53	.421	.04	1.289

8731 Q. What conclusions have you drawn in reference to these tables as exhibited therein. I mean the table of averages just presented ?

A. The tables numbered 37, 38, 39, 40, 41 and 42, Department of Chemistry, University of Illinois, A. W. P., give details of the analyses of samples of water collected from the Illinois river at Kampsville a few hundred feet above Kampsville Dam, during the years 1897 to 1902, inclusive, the samples being collected regularly once each week throughout this period of six years, three years prior to the opening of the Chicago main drainage channel and three years subsequent to the opening of the Chicago main drainage channel. The comparison of the data of the two three-year periods affords an excellent opportunity of judging of the effects of dilution occasioned by the opening of the Chicago main drainage channel upon the character of the waters of the Illinois river as they are about to flow into the Mississippi river at Grafton thirty miles below Kampsville.

We will consider first some of the data as represented graphically upon plates and then discuss the general averages which appear in table No. 10.

Plates Nos. XII and XIII show that in the usual high water period, that is, the first half of the year, chlorine is contained in the water of the Illinois river at this point in 8732 just as considerable proportions as before the opening of the Chicago main drainage channel but that in the latter part of the year which was formerly a period of extremely low water, the content of chlorine is now found to be considerably less than formerly, the seasonal variations as revealed by regular weekly analyses being represented upon plate XII by lines for the years 1897 to 1900, inclusive, and upon plate XIII, the averages for each month being represented for the years 1897 to 1901, inclusive.

Plate No. XIV represents variations in the proportions of nitrogen as free ammonia, and shows the great difference in respect to proportional content of free ammonia between cold weather and warm weather conditions.

Plate XV represents the seasonal variations in the proportions of nitrogen as nitrites and shows that the nitrites are not contained in the river at this point in so great quantity as they were previous to the opening of the Chicago main drainage channel, but that they follow the same general course of seasonal variations as formerly; that is, they are least in cold weather and greatest in hot weather.

Plate XVI shows by means of monthly averages, the proportions of total organic nitrogen both dissolved and total
8733 and the seasonal variations which took place with respect
to the content of nitrogenous organic matters.

Comparison of the averages for the three years 1897, 1898 and 1899 with each other shows no very great variation in the organic matters, though the oxygen consumed, the free ammonia and the total organic nitrogen increase somewhat from year to year, while the nitrites and the nitrates decrease.

Comparison of the averages for 1900 with those for 1899 show that immediately after the opening of the Chicago drainage channel there was a notable decrease in the proportions of the various constituents with the single exception of nitrates. The decided increase of which, taken into consideration with the 25 per cent. decrease in the proportion of nitrogen as albuminoid ammonia indicates that under the new conditions the oxidation of the organic matters is more complete as the waters of the Illinois flow along its course from the point of initial pollution by Chicago sewage to Kampsville where they are about to discharge into the Mississippi river, that is, within 30 miles of the point at which that discharge into the Mississippi occurs.

The averages for 1901 correspond fairly well with those for 1900 except that the total organic nitrogen appears decidedly higher, but this is due to the fact that the data for this constituent cover but the first nine months of the year
8734 as a press of overwork made it necessary to discontinue
the determination of total organic nitrogen at this time. The higher free ammonia in 1902 over the proportions contained in 1901 and 1900 is chiefly due to the fact that in January and February, when the cold weather conditions are usually accompanied by high free ammonia in the Illinois river, the stage of water in the Illinois was remarkably low and the concentration correspondingly great.

Comparison of the averages for the two 3-year periods makes evident the great diminution in the proportions of the various constituents except free ammonia which is .393 parts per million in the latter period as against .371 parts per million in the earlier period and the nitrates, which have very considerably increased.

Plate XVII exhibits graphically by means of columns some of the facts shown in table of averages No. 10 and facilitates the comparisons between the averages for the separate years.

It is hereby agreed between counsel on both sides that the samples of water taken from the upper Kankakee river near South Bend, Indiana, by George W. Van Schotten, as stated by Professor Long in his testimony, were taken in the manner described by Professor Long as near as may be, and that the
8735 sample of water taken from the upper Desplaines river
near Libertyville by Mr. Clare Sherman were taken as stated by Professor Long in his testimony and in the manner therein stated as near as may be, and that the samples of water taken from the upper Fox river at McHenry as shown by the testimony of Professor Long were taken by Mr. Charles F. Fegers in the manner described by Professor Long as near as may be, and that the samples of water taken from the Mackinaw river at Kappa and analyzed and used by Professor Long in his testimony were taken by Dr. R. E. McKenzie in the manner described by Professor Long as near as may be, and that the samples of water taken from the upper Sangamon at Mahomet by Dr. John H. Gardiner, were taken in the manner described by Professor Long, as near as may be, and that the production of said witnesses is hereby waived. These facts are to be considered in evidence the same as though said persons had been sworn and their testimony produced in evidence, subject to the objections of the complainant in this, to wit, that the taking of samples of water and analyses of these samples from the tributaries of the Illinois river, is incompetent, irrelevant and immateial and has no bearing upon the issues involved in this case.

Adjourned until 10:00 a. m., following day, Tuesday, November 17, 1903.

10:00 A. M., Tuesday, November 17th, 1903.

8736 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further direct-examination by Judge Springer and testified as follows:

JUDGE SPRINGER: Before proceeding with the examination of Professor Palmer, I desire to present a table representing the dissolved oxygen in the Illinois river at Havana. This may be considered as offered for identification, and is entitled "Department of Chemistry, University of Illinois, Defendants' Exhibit B for identification,—A. W. P."

MR. JEFFRIES: Professor, I understood you to say yesterday that this did not comprise the dissolved oxygen for all the samples that were taken by you at this place,—or examined by you at this place?

A. All that were examined for dissolved oxygen except one or two samples that were taken subsequently, but practically all, yes.

Q. Yes, but does it embody the results for dissolved
8737 oxygen of all samples that were chemically analyzed and
taken from this place at Havana?

A. Yes, during the length of time covered by the dates there it does.

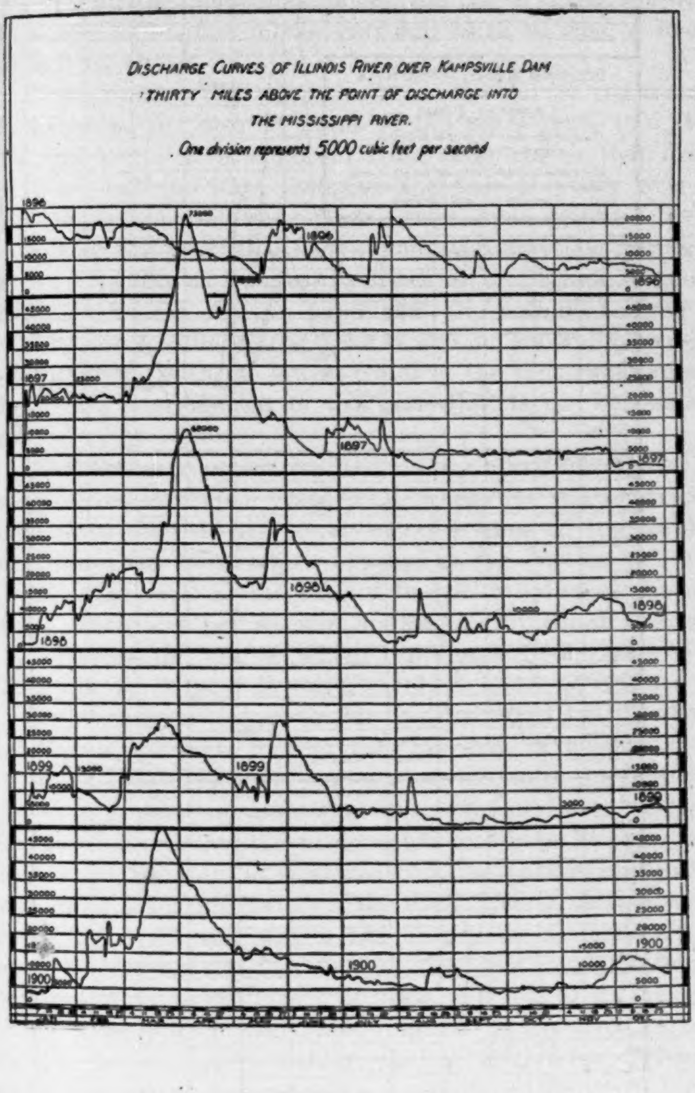
MR. JEFFRIES: I object to the exhibit being introduced for identification for the reason that it relates to a period of time prior to the opening of the Chicago drainage canal and is therefore irrelevant and immaterial.

JUDGE SPRINGER: Professor, will you proceed with your explanation of the chemical examinations of water at Kampsville and table of averages based thereon?

A. With respect to the higher proportion of free ammonia in the water during the second period of three years, that is the period subsequent to the opening of the Chicago Drainage channel it is evident that this is mainly due to the unusually high proportion of free ammonia contained in the water of the stream at this point during the year 1902. The proportions of free ammonia during the months of January and February, 1902, were particularly excessive; the weather being at this time very cold and the volume of water in the stream being unusually small, even for this season of the year, and the proportion,—that is the average proportion for the year is at a higher point for the reason that the year 1902 was on the whole an unusually high water year. The water was 8737a higher, particularly during the ten months following February, than it had been at any time during the six years here under consideration.

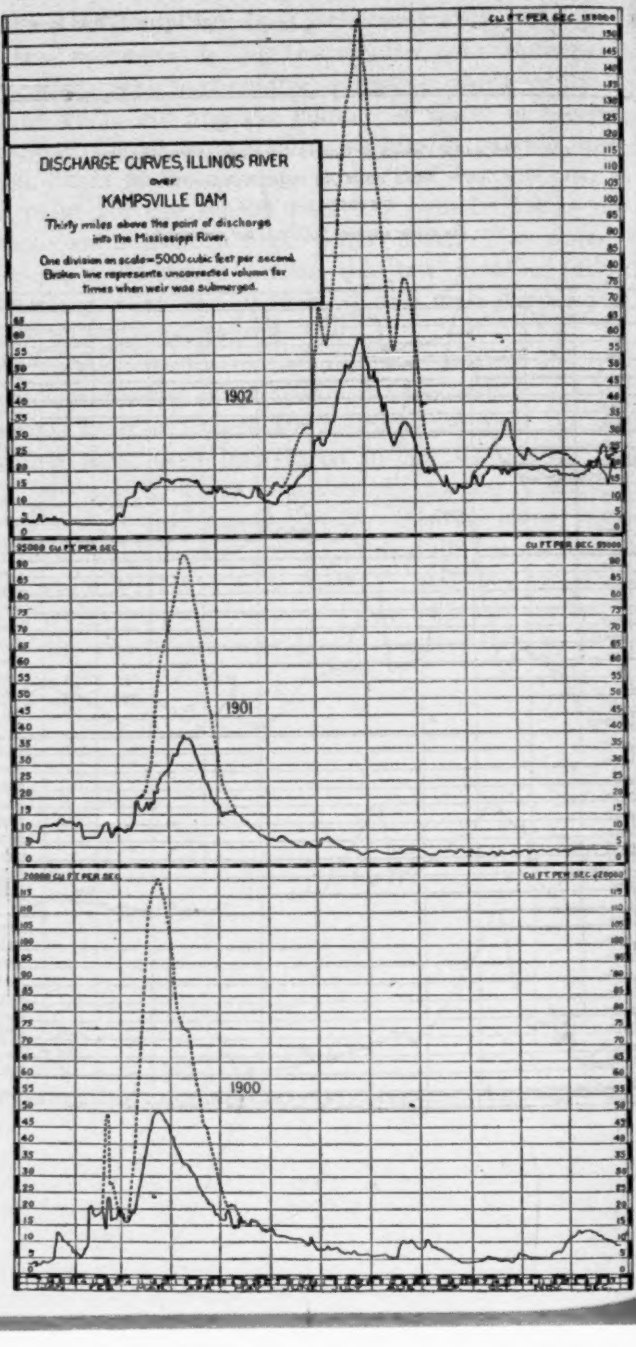
As bearing upon this matter and as a basis for the realization of the significance of the seasonal variations in the waters of the Illinois river at Kampsville as indicated upon the several plates which have been introduced in my testimony, I have prepared two plates, which represent by means of curves the volume of water discharged by the Illinois river over the Kampsville dam during the years 1896 to 1902 inclusive. These are plates Nos. XVIII and XIX, A. W. P., and they are prepared from data which give the mean flow per 24 hours for each day of each of the years here considered, namely, 1896 to 1902, inclusive, and are as follows:

Plate XVIII.—A. W. P.



DISCHARGE CURVES OF ILLINOIS RIVER OVER KAMPSVILLE DAM THIRTY MILES ABOVE THE POINT OF DISCHARGE INTO THE MISSISSIPPI RIVER.

One division represents 5000 cubic feet per second



DISCHARGE CURVES, ILLINOIS RIVER
over
KAMPSVILLE DAM

Thirty miles above the point of discharge into the Mississippi River.

One division on scale=5000 cubic feet per second. Broken line represents uncorrected volume for times when weir was submerged.

Plate XIX.—A. W. P.

8740 Inspection of the plates and comparison of the curve representing conditions in the year 1902 with the curves representing the conditions during the other years, shows the differences as to time in the year and as to volume of flow as referred to above.

Upon Plate XVIII there is shown the curves representing the discharge for each 24 hours of the years 1896, 1897, 1898, 1899 and 1900. It is apparent from these curves that during the years 1897 to 1900, inclusive the flow of water over the Kampsville dam followed much the same general course throughout the year; that is, was comparatively low during the first two months of the year and was at its highest in general in March, and in April. After that the volume became less until by the middle of the year it had in general reached an ordinary stage with the lowest water of the year coming generally in the later months of the year, that is the late summer and the early atumn.

The curves representing the flows during the years 1901 and 1902, appear upon plate XIX, where for the purposes of comparison there is also given at the bottom of the plate the same curve for 1900, which appears at the bottom of plate XVIII. The scale at the side of the plate indicates the number of cubic feet per second, and the point where the curve crosses the line to which the figure in the scale at the
8741 side pertains, indicates the volume of water passing over the dam on the particular day indicated by the vertical line, which intersects the curve to the scale or horizontal line.

Upon plate XIX there is given in addition to the continuous curved line showing the actual flows of water, also a broken line which represents the uncorrected discharge at times when the wier at Kampsville is submerged, the submergence of the weir takes place generally in the early spring or late winter, that is, in April and March, but during the year 1902 it did not occur during the first half of the year, but submergence first took place in the month of June, and was at its maximum in the latter part of July and August. It occurred again in the late fall and early winter; that is in October, November and a portion of December.

The data represented by the continuous lines represent the volumes of discharge computed by wier formula, corrected for submergence of wier; the broken lines represent the volume calculated by wier formula, without correction for submergence of the wier and of course they are far in excess of the actual discharge of water.

Q. Can you explain that wier formula for measuring the water?

A. What do you mean? Tell what a wier is, or—

Q. Yes, what it is?

A. By wier here we mean simply the dam itself, or the
8742 crest of the dam, the particular portion of the dam over
which the water finally passes in its passage from the stretch of river above the dam to the stretch immediately below the dam.

Q. Have you prepared any data in regard to this point that you have not heretofore put in evidence?

A. As I have just stated, the data giving the discharges for each 24 hours of the six years under consideration, are here for introduction.

Q. What was the basis upon which these data were prepared?

A. The United States Engineer who is in charge of improvements along the lower Illinois river, and in residence at Kampsville Dam, which is a part of the government property in his charge, makes readings of the height of water above and below the Kampsville dam three times every 24 hours. These data are published in the reports of the Chief Engineer of the United States Army, and have also been furnished to me privately by the engineer in charge of the work, this latter appertaining particularly to such of the data as have not yet been included in government reports, for government reports frequently are slow in going through the press.

The data covering the volume of discharge have been calculated as above indicated, by use of the wier formula from the
heights of water above and below the dam, as recorded
8743 by the government engineer.

JUDGE SPRINGER: I now offer these tables of discharges in cubic feet per second of water over the Kampsville dam, for the years indicated on each of these plates—

MR. JEFFRIES: Set out the years Judge.

JUDGE SPRINGER: What are the years? You had better identfy them.

A. Years 1896, 1897, 1898, 1899, 1900, 1901 and 1902.

JUDGE SPRINGER: I now offer these tables in evidence. They will be numbered from 1 to 7 A. W. P.—Tables of Discharges of water over the Kampsville dam in cubic feet per second for the years 1896 to 1902 inclusive. The tables are as follows:

8744

Discharge over Kampsville Dam For the Year 1896.

Number of Cubic Feet per Second.

Day	January.			February.			March.			April.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
1	3.68	.55	23300	2.57		17000	2.90	.02	20100	2.20		13450
2	3.80	.55	24500	2.60		17300	2.85	.02	12800	2.15		13050
3	3.78	.55	24400	2.60		17300	2.85	.02	12800	2.10		12500
4	3.67	.55	23200	2.58		17100	2.85	.02	12800	2.05		12050
5	3.58	.56	22200	2.55		16800	2.85	.07	12820	2.05		12050
6	3.50	.56	21300	2.55		18800	2.90	.07	20500	2.00		11750
7	3.50	.50	21000	2.55		16800	2.90	.07	20125	2.00		11750
8	3.45	.42	23000	2.55		16800	2.90	.07	20125	2.02		11875
9	3.40	.37	23250	2.55		16800	2.85	.05	12850	2.10		12500
10	3.35	.31	23000	2.50		16350	2.85	.04	12850	2.10		12500
11	3.30	.30	23200	2.55		16800	2.80	.02	12300	2.15		13050
12	3.30	.30	23200	2.63		17400	2.80		12300	2.10		12500
13	3.25	.26	23375	2.87		20100	2.75		18250	2.10		12500
14	3.23	.25	23000	2.90	.02	20200	2.80		12300	2.10		12500
15	3.13	.22	22150	2.95	.17	20600	2.80		12300	2.10		12500
16	3.10	.20	22100	2.95	.16	20600	2.80		12300	2.05		12050
17	3.05	.17	21750	2.90	.06	20300	2.75		18250	3.05		12050
18	3.00	.12	21300	2.75		18950	2.75		18250	2.05		12050
19	2.95	.06	20500	2.60		17300	2.70	1	18300	2.03		11225
20	2.00		20000	2.40		15400	2.70		18300	1.20		10850
21	2.78		12100	2.20		13450	2.60		17300	2.00		11750
22	2.70		10300	2.50		16350	2.60		17300	1.93		11000
23	2.70		10300	2.45		15200	2.60		17300	1.90		10850
24	2.70		10300	2.52		16500	2.55		16800	1.85		10500
25	2.68		18250	2.72		18550	2.50		16350	1.80		10025
26	2.58		17200	2.80		12300	2.48		16250	1.80		10025
27	2.50		16350	2.81		19350	2.35		14950	1.80		10025
28	2.48		16250	2.85		19875	2.30		14950	1.80		10025
29	2.45		15900	2.90	.06	20300	2.32		14600	1.85		10500
30	2.45		15900				2.25		13950	1.95		11200
31	2.47		16200				2.20		13450			

8745

Discharge in cu. ft. per second over Kampsville dam for 1896, Continued.

Day.	May.			June.			July.			August.		
1	1.90		10850	5.13	.97	19200	1.45		7100	3.10	.14	22050
2	1.90		10850	4.85	.96	18000	1.45		7100	3.10	.24	21600
3	1.90		10850	4.95	.96	18650	1.50		7500	3.12	.30	21100
4	1.85		10500	5.07	.96	19250	1.50		7500	3.15	.36	20500
5	1.83		10350	5.03	.95	19600	1.43		6950	3.15	.41	20400
6	1.80		10025	4.88	.96	18230	1.30		6000	3.10	.37	21300
7	1.80		10025	4.75	.96	17540	1.20		5250	2.95	.27	20500
	1.75		9600	5.02	.96	19050	1.20		5250	2.88	.14	19800
	1.70		9100	5.15	.98	18350	1.20		5250	2.78		19100
	1.67		8800	5.25	.98	18850	1.13		4800	2.68		18250
	1.60		8360	5.05	.97	18720	1.08		4400	2.60		17300
	1.55		7950	4.28	.95	15400	1.05		4150	2.25		16800
	1.48		7400	3.30	.89	12100	1.05		4150	2.50		16350
	1.43		6950	2.50	.74	10400	1.00		3940	2.45		15900
	1.35		6450	2.28	.46	11800	.98		3850	2.35		14950
	1.30		6000	2.20	.20	12550	1.00		3940	2.30		14450
	1.23		5500	2.42	.16	14300	.97		3800	2.25		13950
	1.30		6000	2.37	.11	14800	.88		3100	2.20		13450
	1.88		10700	2.25		13950	1.45		7100	2.20		13450
	2.05	.90	5850	2.20		13450	2.47		16200	2.22		13600
	3.08	.95	9320	2.12		12750	2.58	.06	17100	2.28		13675
	3.97	.97	13050	2.10		12500	2.30	.48	12000	2.13		12850
	4.45	.97	15560	2.02		11875	2.02	.32	11500	2.05		12055
	4.90	.98	17000	1.85		10500	2.20	.19	13300	2.05		12050
	5.20	.98	18650	1.80		10025	3.05	.30	20300	2.03		11920
	5.13	.98	18250	1.75		9600	3.05	.28	20325	1.98		11550
	4.72	.97	16920	1.75		9600	2.75	.11	18700	1.22		11000
	5.10	.98	18075	1.65		8500	2.45		15200	1.20		10800
	5.65	.98	21100	1.60		8300	2.28		14150	1.85		10500
	5.83	.99	21000	1.55		7950	2.20		13450	1.78		9900
	5.45	.98	20000				2.40		15400	1.70		9100

8746

Discharge in cu. ft. per second over Kampsville Dam for 1896, Continued.

Day.	September.		October.		November.		December.	
	1.70	9100	1.20	5250	1.40	6775	1.60	8300
	1.60	8300	1.20	5250	1.40	6775	1.60	8300
	1.60	8300	1.20	5250	1.40	6775	1.60	8300
	1.60	8300	1.32	6150	1.52	7750	1.60	8300
	1.53	7800	1.45	7100	1.60	8300	1.60	8300
	1.45	7100	1.52	7750	1.60	8500	1.60	8300
	1.38	6500	1.55	7950	1.55	7950	1.60	8300
	1.30	6000	1.62	8450	1.40	6775	1.60	8300
	1.28	5900	1.67	8800	1.40	6775	1.60	8300
	1.20	5250	1.72	9300	1.47	7300	1.60	8300
	1.20	5250	1.77	9800	1.48	7400	1.55	7950
	1.20	5250	1.90	10850	1.45	7100	1.55	7950
	1.15	4900	1.90	10850	1.48	7400	1.55	7950
	1.15	4900	1.90	10850	1.42	6850	1.55	7950
	1.20	5250	1.90	10850	1.53	7800	1.55	7950
	1.13	4800	1.88	10700	1.55	7950	1.55	7950
	1.87	10625	1.80	10025	1.60	8300	1.55	7950
	2.08	12350	1.75	9600	1.55	7950	1.50	7500
	1.25	11200	1.72	9300	1.55	7950	1.50	7500
	1.83	10350	1.70	9100	1.60	8300	1.50	7500
	1.75	9600	1.70	9100	1.70	9100	1.50	7500
	1.65	8750	1.68	8900	1.65	8500	1.45	7100
	1.48	7400	1.60	8300	1.65	8500	1.45	7100
	1.38	6500	1.57	8100	1.70	9100	1.45	7100
	1.28	5000	1.50	7500	1.65	8500	1.38	6550
	1.20	5250	1.50	7500	1.65	8500	1.30	6000
	1.20	5250	1.48	7400	1.78	9900	1.25	5000
	1.20	5250	1.40	6775	1.65	8500	1.20	5250
	1.20	5250	1.40	6775	1.65	8500	1.20	5250
	1.20	5250	1.40	6775	1.60	8300	1.15	4900
	1.20		1.40	6775			1.10	4450

8747

Discharge in cu. ft. per second over Kampsville Dam for 1897.

Day	January.			February.			March.			April.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
1	1.10		4450	3.32	.28	22500	3.50	.57	21400	10.75	.98	55200
2	1.73		2300	3.28	.37	21750	3.60	.60	21500	11.42	.98	60700
3	3.40	.36	23450	3.15	.31	21250	3.70	.58	22900	12.12	.98	66200
4	4.05	.84	18600	3.12	.28	21300	3.77	.72	19900	12.50	.98	72000
5	5.40	.94	22750	3.10	.25	21600	4.72	.87	21600	12.80	.98	72000
6	5.28	.96	24800	3.25	.34	22150	5.10	.89	23300	12.95	.98	73200
7	5.83	.95	25100	3.28	.40	21150	5.77	.91	26900	12.78	.98	71800
8	5.13	.93	21600	3.28	.40	21155	5.87	.93	26500	12.50	.98	69300
9	4.17	.85	19000	3.10	.36	20250	5.60	.91	25700	12.22	.97	70600
10	3.68	.71	19600	3.10	.26	21200	5.40	.90	24900	12.20	.98	67000
11	3.60	.59	21700	3.03	.24	20500	5.17	.86	25600	12.10	.98	66000
12	3.60	.57	22300	3.00	.22	20500	5.15	.84	26500	11.88	.98	64200
13	3.62	.56	22600	3.03	.23	20500	5.15	.89	26800	11.57	.98	61800
14	3.75	.57	23700	3.12	.31	21100	5.26	.87	25500	11.23	.98	59000
15	3.80	.59	23600	3.20	.33	21650	5.42	.88	26050	10.85	.98	56000
16	3.85	.62	23500	3.25	.37	21750	5.60	.89	26800	10.48	.98	53100
17	9.08	.70	23200	3.30	.40	21600	5.85	.90	28100	10.13	.98	50600
18	4.27	.77	22600	3.35	.43	22150	6.10	.91	29300	9.85	.98	48500
19	9.90	.82	21750	3.35	.46	21850	6.43	.92	31000	9.85	.98	46300
20	4.53	.84	22000	3.35	.47	21150	6.75	.93	32600	9.40	.98	45300
21	4.55	.84	22100	3.40	.50	21500	7.05	.94	34000	9.27	.98	44400
22	4.58	.84	22250	3.45	.55	21100	7.35	.95	34600	9.18	.98	43600
23	4.63	.84	22500	3.50	.57	21350	7.65	.95	36800	9.20	.98	43700
24	4.58	.83	22700	3.50	.63	20000	7.95	.95	38900	9.20	.98	43700
25	4.42	.78	23500	3.50	.64	19700	8.25	.96	40200	9.30	.97	46880
26	4.32	.75	23800	3.50	.61	20500	8.60	.96	42800	9.30	.98	44500
27	3.95	.70	22100	3.45	.60	20300	8.93	.96	45200	9.37	.98	45000
28	3.72	.67	21200	3.45	.58	20550	9.23	.97	46400	9.55	.98	46300
29	3.50	.60	20500				9.55	.97	48800	10.00	.98	49500
30	3.45	.55	21100				9.88	.97	51280	10.50	.99	50500
31	3.35	.45	21750				10.13	.96	54600			

8748

Discharge in cu. ft. per second over Kampsville Dam for 1897, Continued.

Day.	May.			June.			July.			August.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
	10.95	.99	53800	2.15		13050	2.05		12050	1.15		4900
	11.07	.99	54800	2.08		12400	2.06	.07	12050	1.13		4750
	11.15	.99	55200	1.98		11450	2.07	.37	11500	1.05		6000
	11.00	.99	54200	1.90		10850	2.10	.28	11900	1.10		4450
	10.73	.99	52200	1.83		10350	2.15	.02	13050	1.25		5600
	10.33	.99	49400	1.78		9900	2.50	.18	15100	1.18		5100
	10.88	.99	51000	1.70		9100	2.25	.10	13950	1.08		4400
	9.35	.97	47280	1.65		8500	2.18		13250	1.00		3240
	8.85	.98	41400	1.58		8175	2.10		12500	.95		3500
	8.40	.98	38300	1.55		7250	2.03		11950	.90		3250
	7.80	.97	36040	1.50		7500	2.05		12050	.83		2800
	7.15	.97	31600	1.43		6950	2.18		13250	.75		2350
	6.37	.96	27200	1.40		6775	2.08		12400	.75		2350
	5.58	.95	23400	1.35		6450	1.98		11450	.70		2050
	5.00	.93	20200	1.30		6000	1.90		10850	.68		1900
	4.48	.91	18400	1.23		5500	1.83		10350	.60		1575
	4.00	.88	16600	1.20		5250	1.73		9300	.60		1575
	3.55	.85	15000	1.15		4900	1.65		8500	.60		1575
	3.18	.78	14200	1.10		4450	1.60		8300	.58		1450
	2.95	.68	14630	1.10		4450	1.53		8100	.50		1075
	2.75	.56	15160	1.10		4450	1.43		6950	.52		1250
	2.68	.41	15500	1.20		5250	1.40		6775	.60		1575
	2.65	.30	17000	1.20		5250	1.30		6000	.55		1350
	2.58	.17	16400	1.60		8300	1.47		7300	.90		3250
	2.48	.07	16160	2.10		12500	2.35		14950	1.20		5250
	2.33		14725	1.95		11200	2.17		13250	1.30		6000
	2.32		14600	1.88		10700	1.75		9600	1.32		6150
	2.35		14950	1.85		10500	1.15		7950	1.32		6150
	2.35		14950	2.05		12050	1.35		6450	1.30		6000
	2.28		14150	2.05		12050	1.28		5900	1.30		6000
	2.18		13250				1.20		5250	1.30		6000

8749

Discharge in cu. ft. per second over Kampsville Dam for 1897, Continued.

Day.	September.			October.			November.			December.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
	1.30		6000	1.20		5250	1.25		5600	1.00		3900
	1.30		6000	1.20		5250	1.20		5250	.78		2450
	1.30		6000	1.20		5250	1.15		4900	.60		1575
	1.30		6000	1.20		5250	.93		3350	.50		1075
	1.25		5600	1.15		4900	1.23		5475	.57		1450
	1.25		5600	1.15		4900	1.20		5250	.62		1525
	1.25		5600	1.20		5250	1.25		5600	.68		1875
	1.25		5600	1.15		4900	1.25		5600	.65		1750
	1.25		5600	1.20		5250	1.23		5475	.65		1750
	1.20		5250	1.20		5250	1.20		5250	.75		2350
	1.20		5250	1.20		5250	1.20		5250	.72		2200
	1.20		5250	1.20		5250	1.25		5600	.70		2075
	1.20		5250	1.30		5250	1.30		6000	.77		2425
	1.25		5600	1.13		4750	1.27		5800	.83		2750
	1.28		5900	1.20		5250	1.35		6450	.73		2250
	1.32		6150	1.10		4450	1.35		6450	.82		2700
	1.25		5600	1.13		4750	1.35		6450	.78		2450
	1.20		5250	1.15		4900	1.33		6275	.60		1575
	1.15		4900	1.18		5100	1.30		6000	.65		1750
	1.12		4650	1.20		5250	1.35		6450	.65		1750
	1.10		4450	1.25		5600	1.37		6550	.65		1750
	1.22		5400	1.22		5400	1.40		6775	.65		1750
	1.23		5457	1.20		5250	1.40		6775	.65		1750
	1.15		4900	1.20		5250	1.35		6420	.65		1750
	1.20		5250	1.20		5250	1.23		5475	.65		1750
	1.20		5250	1.23		5475	1.35		6450	.65		1750
	1.25		5600	1.25		5600	1.38		6500	.60		1575
	1.20		5250	1.25		5600	1.20		5250	.60		1575
	1.13		4750	1.20		5250	1.20		5250	.60		1575
	1.13		4750	1.20		5250	1.18		4750	.60		1575
				1.20		5250				.60		1575

8750

Discharge in cu. ft. per second over Kampsville Dam for 1898.

Day	January.			February.			March.			April.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
1	.75	0	22000	1.82	0	10100	3.32	.39	22050	10.75	.97	58000
2	.58	0	1400	1.45	0	9600	3.40	.42	22750	11.10	.98	58000
3	.60	0	1500	1.55	0	8000	3.40	.42	22750	11.25	.98	59100
4	.60	0	1500	1.65	0	8700	3.40	.42	22750	11.45	.98	60000
5	.60	0	1500	1.87	0	10600	3.40	.42	22750	11.55	.98	61800
6	.57	0	1390	2.05	0	12100	3.40	.42	22750	11.62	.98	62000
7	.62	0	1600	2.10	0	12500	3.35	.40	23000	11.63	.98	62100
8	.65	0	1700	2.38	0	15100	3.35	.40	23000	11.45	.98	60900
9	.79	0	1975	2.23	0	13650	3.23	.37	23100	11.25	.98	59100
10	1.27	0	5600	2.20	0	13400	3.15	.36	21000	11.05	.98	57000
11	1.37	0	6500	2.37	0	15000	3.20	.35	21000	10.72	.98	55100
12	1.72	0	9250	2.52	0	16500	3.43	.47	22100	10.35	.96	56300
13	1.90	0	10350	2.55	0	16800	3.52	.70	18600	10.08	.96	54000
14	1.90	0	10350	2.55	0	16800	3.70	.83	16400	9.93	.96	53000
15	1.83	0	10200	2.55	0	16800	3.85	.87	15950	9.58	.96	50200
16	1.70	0	9100	2.50	0	16400	3.85	.87	15950	9.28	.96	47900
17	1.62	0	8400	2.52	0	16600	3.83	.85	16750	8.98	.96	45500
18	1.62	0	8400	2.63	0	17500	3.85	.85	16850	8.65	.94	46250
19	1.70	0	9100	2.85	.04	19500	4.05	.87	17250	8.28	.95	42400
20	1.87	0	10600	3.15	.33	21500	4.42	.89	18850	8.88	.96	31300
21	2.00	0	11500	3.20	.39	17500	4.80	.90	20800	7.35	.98	31300
22	2.07	0	12250	3.15	.37	21200	6.08	.94	27300	7.05	.94	34200
23	2.00	0	11500	3.15	.33	21500	6.85	.98	28100	6.88	.93	33500
24	2.00	0	11500	3.15	.30	20500	7.67	.97	35000	6.58	.92	32000
25	2.10	0	12500	3.15	.30	20500	7.80	.97	36000	6.33	.92	30250
26	2.22	0	13600	3.17	.33	20400	7.52	.96	35000	6.12	.91	29400
27	2.25	0	13800	3.27	.37	21950	7.52	.96	35000	5.75	.91	26800
28	2.20	0	13400	3.30	.39	22100	8.12	.96	38400	5.38	.91	24900
29	2.18	0	13200				8.82	.96	44800	5.00	.90	22200
30	2.15	0	13500				9.67	.97	49600	4.65	.89	20500
31	2.15	0	13500				10.22	.97	54000			

8751

Discharge in cu. ft. per second over Kampsville Dam for 1898, Continued.

Day.	May.			June.			July.			August.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
	4.65	.87	21200	7.05	.94	34150	3.03	.73	14100	.70	.0	2100
	4.75	.89	21000	7.00	.94	33700	2.90	.65	14700	.68	0	1950
	4.68	.88	20900	6.95	.94	33300	2.73	.50	15350	.95	0	3500
	4.48	.88	19600	6.88	.93	33500	2.63	.38	15000	.95	0	3500
	4.35	.88	18750	6.68	.92	32800	2.55	.21	15350	.83	0	2800
	4.28	.88	18300	6.45	.93	30500	2.50	.08	16300	.83	0	2800
	4.18	.88	17700	6.25	.92	29700	2.43	.03	15500	1.00	0	3800
	4.05	.86	17900	6.00	.91	28500	2.40	.23	14200	1.00	0	3800
	3.80	.81	17800	5.83	.90	28000	2.38	.24	14150	1.05	0	2950
	3.55	.76	17400	5.75	.90	27300	2.20	.06	13450	1.00	0	3800
	3.43	.69	18050	5.55	.90	26000	2.08	0	12375	1.00	0	3800
	3.38	.63	18850	5.38	.90	24750	2.00	0	11700	.95	0	3500
	3.22	.56	18800	5.28	.90	24000	1.93	0	11150	1.02	0	4000
	3.20	.56	18600	5.20	.90	23500	1.85	0	10400	1.53	0	7800
	3.60	.69	19500	5.38	.90	24750	1.73	0	9350	2.63	0	17400
	4.03	.83	18800	5.33	.90	24300	1.65	0	8850	2.22	0	13800
	4.20	.89	17450	5.30	.90	24200	1.55	0	8000	1.93	0	11125
	4.27	.91	17200	5.23	.90	23750	1.50	0	7525	1.80	0	9975
	4.57	.92	18300	5.18	.90	23300	1.43	0	7150	1.70	0	9200
	4.98	.92	21100	4.88	.89	21800	1.33	0	6350	1.70	0	9200
	5.92	.95	25600	4.40	.89	18750	1.20	0	5150	1.60	0	8350
	6.92	.96	30800	4.03	.88	16800	1.15	0	4900	1.50	0	7500
	7.68	.97	35200	3.75	.84	16500	1.10	0	4600	1.45	0	7200
	8.00	.97	37400	3.58	.79	16800	1.03	0	4300	1.43	0	7100
	7.95	.97	37140	3.48	.70	18200	.90	0	3200	1.35	0	6300
	7.68	.96	35900	3.37	.70	17350	.78	0	2500	1.20	0	5150
	7.33	.96	33600	3.43	.75	16500	.70	0	2100	1.20	0	5150
	7.15	.95	34000	3.33	.75	15750	.65	0	2000	1.15	0	5000
	7.15	.95	34000	3.23	.73	15500	.70	0	2100	1.10	0	4600
	7.20	.94	35000	3.10	.75	14100	.80	0	2500	1.10	0	4600
	7.13	.93	35300				.70	0	2100	1.03	0	4300

8752

Discharge in cu. ft. per second over Kampsville Dam for 1898, Continued.

Day.	September.			October.			November.			December.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
	.95		3500	1.25		6625	1.57		8100	2.23		13900
	.88		3200	1.25		6625	1.70		9200	2.20		13450
	.80		2500	1.30		6950	1.68		9000	2.20		13450
	.80		2500	1.23		5300	1.67		8900	2.20		13450
	.87		3150	1.20		5150	1.77		9825	2.15		13000
	1.05		3950	1.13		4650	1.97		10950	2.13		12900
	1.45		7200	1.10		4600	1.88		10100	2.03		11900
	1.55		8000	1.10		4600	1.90		10850	1.80		9950
	1.70		9200	1.10		4600	1.97		11450	1.73		9450
	1.55		8000	1.05		4150	2.00		11750	1.55		7900
	1.35		6550	1.15		5000	2.00		11750	1.55		7900
	1.20		5150	1.08		4325	2.00		11750	1.50		7500
	1.20		5150	1.00		3800	1.97		11450	1.50		7500
	1.13		4650	.95		3500	1.88		10825	1.50		7500
	1.20		5150	.93		3350	1.85		10625	1.48		7300
	1.32		6200	.90		3200	1.85		10625	1.45		7200
	1.35		7100	.77		2500	1.87		10725	1.45		7200
	1.28		6700	1.02		4000	2.02		11950	1.45		7200
	1.20		5150	1.12		4150	2.10		12500	1.47		7250
	1.15		5000	1.15		5000	2.12		12250	1.47		7250
	1.15		5000	1.15		5000	2.17		13250	1.60		8350
	1.53		7800	1.15		5000	2.20		13450	1.60		8350
	1.57		8200	1.08		4325	2.28		14250	1.75		9725
	1.60		8350	1.07		4300	2.30		14450	1.75		9725
	1.65		8875	1.15		5000	2.30		14500	1.75		9725
	1.75		9725	1.15		5000	2.28		14250	1.70		9200
	1.70		9200	1.25		5625	2.25		14000	1.70		9200
	1.60		8350	1.45		7350	2.25		14000	1.70		9200
	1.38		6200	1.52		7800	2.25		14000	1.70		9200
	1.30		5950	1.60		8350	2.25		14000	1.70		9200
				1.58		8125				2.18		12800

8753

Discharge in cu. ft. per second over Kampsville Dam for 1899.

Day	January.			February.			March.			April.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
1	1.40		6750	1.85		10500	3.60	.83	14700	5.20	.88	24500
2	1.45		7000	1.85		10500	3.15	.63	13850	5.10	.86	25200
3	1.40		6750	1.83		10200	3.70	.73	19100	4.85	.87	22500
4	1.55		7990	1.80		10000	3.98	.70	22400	4.65	.85	22300
5	2.07		12480	1.75		9650	4.15	.72	23100	4.45	.84	21500
6	1.60		8250	1.70		9120	4.35	.76	23600	4.35	.82	21400
7	1.60		8250	1.70		9120	4.52	.81	23100	4.30	.81	21400
8	1.57		7760	1.70		9120	4.45	.83	21750	4.23	.80	21250
9	1.70		9120	1.65		8750	4.55	.82	22900	4.20	.81	20700
10	1.70		9120	1.60		8250	4.67	.83	23250	4.10	.79	20600
11	1.60		8250	1.55		7900	4.87	.84	24300	4.05	.77	21000
12	1.57		7760	1.50		7500	5.05	.85	25100	3.98	.75	20750
13	1.70		9120	1.45		7000	5.25	.89	24250	3.88	.73	20600
14	1.90		10760	1.43		6900	5.37	.88	25600	3.75	.71	20100
15	2.15		13090	1.33		6100	5.47	.89	25800	3.65	.68	20300
16	2.32		14525	1.25		5600	5.60	.90	26250	3.58	.68	19600
17	2.40		15275	1.25		5600	5.60	.90	26250	3.50	.70	18400
18	2.35		14600	1.20		5250	5.95	.91	28200	3.43	.71	17600
19	2.35		14600	1.15		4370	6.07	.94	27100	3.38	.72	16800
20	2.35		14600	1.15		4370	6.30	.93	29500	3.25	.73	15700
22	2.40		15275	1.30		5970	6.50	.94	30200	3.20	.74	15050
23	2.47		16120	1.35		6250	6.47	.94	30000	3.25	.77	15000
24	2.55		16760	1.40		6750	6.37	.93	29900	3.37	.84	13800
25	2.50		16250	1.47		7300	6.27	.93	29100	3.52	.86	14500
26	2.50		16250	2.65	.57	14000	6.12	.92	28750	3.62	.87	14550
27	2.42		15500	3.45	.86	13950	5.95	.91	28200	3.63	.87	14600
28	2.32		14525	3.73	.88	15100	5.78	.91	27000	3.53	.87	13950
29	1.60		8250				5.58	.90	26100	3.55	.87	14000
30	1.60		8250				5.48	.88	26500	3.75	.93	13500
31	1.82		10100				5.35	.88	25575			

8754

Discharge in cu. ft. per second over Kampsville Dam for 1899, Continued.

Day.	May			June.			July.			August.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
	3.80	.93	13800	6.20	.92	29250	1.85	.87	5360	1.10	0	4500
	3.63	.89	14000	5.83	.93	26250	1.87	.86	5600	1.03	0	3800
	3.40	.89	12700	5.70	.94	24800	1.90	.98	5400	.93	0	3400
	3.03	.85	11700	5.65	.94	24450	2.00	.90	5610	.85	0	2900
	2.72	.78	10650	5.58	.94	24000	2.13	.93	5760	.97	0	3600
	2.58	.77	10550	5.40	.95	22250	2.18	.92	6080	1.00	0	3750
	2.77	.76	11350	5.25	.94	21750	2.13	.92	5900	1.00	0	3750
	3.00	.77	13250	5.04	.92	21500	1.93	.92	5050	1.87	0	10500
	2.90	.78	12250	4.88	.93	20000	1.65	.90	4200	2.27	0	14100
	2.75	.79	11300	4.78	.92	19800	1.43	.82	4000	2.28	0	14150
	2.75	.82	10700	4.55	.91	19100	1.15	.85	2590	1.75	0	9500
	2.58	.79	10200	4.30	.90	17800	1.10	.64	3280	1.35	0	6400
	2.30	.51	11800	4.03	.90	16100	1.10	.21	4200	1.15	0	4950
	2.18	.48	11200	3.73	.84	16400	1.08	0	4500	1.00	0	3750
	2.10	.80	73800	3.43	.82	14900	1.00	0	3750	.95	0	3500
	2.05	.19	14600	3.13	.75	14300	1.00	0	3750	.93	0	3400
	2.27	.39	12550	3.05	.73	14300	1.05	0	4200	.80	0	2500
	2.28	.42	12300	2.80	.71	12960	1.17	0	5000	.75	0	2300
	2.18	.31	11950	2.60	.58	13500	.73	0	2200	1.00	0	3750
	2.35	.59	11350	2.45	.44	13250	1.15	0	4950	.70	0	2000
	2.35	.89	7300	2.33	.37	12940	1.15	0	4950	.77	0	2400
	4.86	.94	19450	2.18	.36	12200	1.15	0	4950	.78	0	2500
	5.58	.97	21800	2.10	.30	12000	1.15	0	4950	.75	0	2300
	6.10	.97	24880	1.98	.28	10250	1.15	0	4950	.75	0	2300
	6.38	.98	25250	1.87	.39	9850	1.10	0	4500	.73	0	2300
	6.63	.97	28200	1.75	.50	8200	1.08	0	4500	.60	0	1500
	6.88	.97	29800	1.70	.65	6620	1.03	0	3950	.50	0	1000
	6.55	.94	30500	1.63	.73	5520	1.00	0	3750	.50	0	1000
	6.95	.95	31750	1.65	.86	4650	1.00	0	3750	.45	0	950
	6.65	.95	29600	1.80	.83	5600	1.02	0	3780	.40	0	750
	6.45	.95	28400				1.05	0	4200	.40	0	750

8755

Discharge in cu. ft. per second over Kampsville Dam for 1899, Continued.

Day.	September.			October.			November.			December.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
	.35	0	525	.40	0	750	.73	0	2100	.90	0	3225
	.35	0	525	.47	0	975	.77	0	2400	.90	0	3225
	.35	0	525	.50	0	1000	.80	0	2500	.90	0	3225
	.35	0	525	.48	0	950	.80	0	2500	.90	0	3225
	.35	0	525	.40	0	750	.80	0	2500	.85	0	2950
	.30	0	400	.42	0	800	.82	0	2700	.80	0	2500
	.35	0	525	.45	0	950	.85	0	2950	.80	0	2500
	.45	0	950	.45	0	950	.85	0	2950	.80	0	2500
	.40	0	750	.45	0	950	.90	0	3225	.80	0	2500
	.45	0	950	.40	0	750	.90	0	3325	.90	0	3225
	.50	0	1000	.45	0	950	.93	0	3575	.90	0	3225
	.50	0	1000	.50	0	1000	.85	0	2950	.95	0	3500
	.45	0	950	.43	0	850	.87	0	2975	1.05	0	3750
	.45	0	950	.45	0	950	.90	0	3225	1.07	0	4350
	.40	0	750	.60	0	1500	.95	0	3500	1.10	0	4550
	.40	0	750	.62	0	1550	.95	0	3500	1.03	0	3950
	.43	0	775	.75	0	2300	.97	0	3625	1.03	0	3950
	.85	0	2950	.70	0	1950	1.05	0	4120	1.13	0	4600
	1.00	0	3750	.70	0	1950	1.05	0	4120	1.20	0	5250
	.85	0	2950	.68	0	1900	1.05	0	4120	1.22	0	5450
	.80	0	2500	.60	0	1500	1.10	0	4550	1.25	0	5500
	.75	0	2300	.60	0	1500	1.22	0	5450	1.25	0	5500
	.77	0	2400	.57	0	1425	1.30	0	5950	1.20	0	5220
	.65	0	1760	.60	0	1500	1.28	0	5825	1.25	0	5500
	.60	0	1500	.60	0	1500	1.20	0	5200	1.25	0	5500
	.60	0	1500	.60	0	1500	1.15	0	4950	1.30	0	5950
	.55	0	1275	.62	0	1550	1.08	0	4500	1.30	0	5950
	.53	0	1200	.77	0	2400	1.00	0	3750	1.30	0	5950
	.45	0	950	.85	0	2950	.95	0	3500	1.25	0	5500
	.40	0	730	.85	0	2950	.95	0	3500	1.18	0	4600
				.83	0	2750				.98	0	3600

8756

Discharge in cu. ft. per second over Kampsville Dam for 1900.

Day	January.			February.			March.			April.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
1	.90		3250	1.35		6450	2.50	.08	16300	8.10	.95	40500
2	.90		3250	1.30		6000	2.50	.04	16350	7.80	.94	39200
3	.92		3325	1.28		3450	2.43		15750	7.57	.93	38600
4	1.00		3900	1.40		6775	2.47		16150	7.38	.93	37200
5	1.00		3900	1.52		7750	2.62	.09	17300	7.30	.93	36000
6	.97		3675	1.57		8100	3.53	.67	19525	7.18	.94	34600
7	.90		3250	1.72		9300	3.93	.82	18500	7.10	.94	34000
8	.90		3250	2.92		20500	4.53	.89	20400	7.10	.94	34000
9	.92		3325	2.96	.13	21000	4.97	.90	22200	7.10	.94	34000
10	1.02		4000	2.75		18950	5.30	.90	24200	7.08	.94	33500
11	1.07		4150	2.68		18250	5.68	.90	26750	6.88	.94	32400
12	1.00		3900	2.62		17500	6.08	.91	29200	6.70	.94	31200
13	1.00		3900	2.67		18100	6.50	.92	31500	6.50	.93	30800
14	1.02		4000	2.70		18300	7.28	.94	35800	6.15	.92	29000
15	1.10		4450	2.80		19300	8.28	.96	40000	5.95	.91	28200
16	1.10		4450	2.80		19300	8.23	.96	40000	5.95	.91	28200
17	1.20		5250	2.77	.12	18800	8.67	.96	43250	5.68	.91	26200
18	1.87		10600	3.70	.90	14100	9.03	.97	44880	5.43	.90	25200
19	2.15		13050	5.17	.90	23300	9.30	.97	46880	5.20	.89	24800
20	2.13		12825	5.63	.95	23500	9.53	.97	48600	5.10	.89	23650
21	2.03		11925	3.63	.80	16800	9.62	.97	49300	5.08	.89	23400
22	1.93		11075	3.65	.80	17000	9.65	.97	49500	4.93	.89	22350
23	1.80		10025	3.60	.78	17200	9.72	.97	50000	4.85	.89	21800
24	1.80		10025	3.45	.74	17000	9.70	.97	49900	4.78	.88	21800
25	1.78		9900	3.25	.62	17900	9.63	.97	49400	4.66	.88	21100
26	1.70		9100	3.05	.49	19750	9.48	.97	48200	4.45	.89	19200
27	1.68		8900	2.90	.41	18100	9.35	.97	47200	4.28	.88	18500
28	1.65		8500	2.90	.41	18100	9.10	.96	46530	4.08	.84	18700
29	1.40		6775				8.90	.96	46530	4.08	.84	18700
30	1.30		6550				8.65	.96	43050	3.58	.78	17100
31	1.30		6550				8.40	.95	42750			

8757

Discharge in cu. ft. per second over Kampsville Dam for 1900, Continued.

Day.	May.			June.			July.			August.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
	3.43	.73	17000	2.15		13050	1.57		8100	1.30		6000
	3.25	.68	16900	2.08		12350	1.60		8300	1.30		6000
	3.15	.63	17000	2.05		12050	1.60		8300	1.30		6000
	3.08	.57	19750	2.05		12050	1.70		4100	1.30		6000
	3.00	.56	19000	2.05		12050	1.60		8300	1.33		6275
	3.05	.62	16500	2.05		12050	1.57		8100	1.35		6450
	3.08	.69	15300	2.05		12050	1.57		8100	1.35		6450
	3.05	.72	14550	2.03		11925	1.60		8300	1.35		6450
	3.03	.69	15000	2.00		11750	1.60		8300	1.30		6000
	2.88	.65	14600	2.00		11750	1.60		8300	1.28		5900
	2.80	.57	17200	2.00		11750	1.53		7800	1.20		5250
	2.68	.43	15900	1.97		11400	1.47		7300	1.20		5250
	2.60	.27	16500	1.95		11200	1.45		7100	1.20		5250
	2.53	.12	16200	1.95		11200	1.45		7100	1.18		5100
	2.45		15900	1.95		11200	1.40		6775	1.15		4900
	2.40		15400	1.95		11200	1.45		7100	1.25		5600
	2.40		15400	1.95		11200	1.45		7100	1.53		7800
	2.45		15900	1.93		11000	1.40		6775	1.72		9200
	2.55		16800	1.87		10625	1.35		6450	1.85		10500
	2.50		16350	1.83		10350	1.50		7500	1.85		10500
	2.50		16350	1.75		9600	1.47		7300	1.80		10025
	2.47		16200	1.75		9600	1.35		6450	1.80		10025
	2.37		15100	1.70		9100	1.35		6450	1.80		10025
	2.35		14950	2.03		11925	1.35		6450	1.85		10500
	2.28		14250	1.83		10350	1.35		6450	1.81		10600
	2.25		13950	1.73		9300	1.35		6450	1.77		9800
	2.25		13950	1.63		8425	1.35		6450	1.73		9300
	2.20		13450	1.60		8300	1.35		6450	1.65		8500
	2.23		13750	1.55		7950	1.35		6450	1.63		8425
	2.27		14150	1.60		8800	1.33		6275	1.60		8300
	2.27		14150				1.30		6000	1.63		8425

8758

Discharge in cu. ft. per second over Kampsville Dam for 1900, Continued.

Day.	September.			October.			November.			December.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
	1.67		8800	1.10		4450	1.30		6000	2.00		11750
	1.70		9100	1.10		4450	1.30		6000	2.00		11750
	1.83		10500	1.08		4400	1.30		6000	2.05		12050
	1.85		10500	1.03		4050	1.20		5250	2.10		12500
	1.77		9800	1.05		4150	1.20		5250	2.20		13450
	1.67		8800	1.02		4000	1.20		5250	2.20		13450
	1.65		8500	1.10		4450	1.20		5250	2.10		12500
	1.65		8500	1.15		4900	1.20		5250	2.15		13050
	1.63		8425	1.20		5250	1.20		5250	2.20		13450
	1.57		8100	1.23		5500	1.20		5250	2.20		13450
	1.55		7950	1.20		5250	1.20		5250	2.20		13450
	1.53		7800	1.20		5250	1.20		5250	2.20		13450
	1.48		7400	1.20		5250	1.20		5250	2.20		13450
	1.43		6950	1.20		5250	1.20		5250	2.15		13050
	1.38		6625	1.20		5250	1.20		5250	2.15		13050
	1.35		6450	1.15		4900	1.20		5250	2.10		12500
	1.30		6000	1.10		4450	1.20		5250	2.10		12500
	1.25		3600	1.05		4150	1.20		5250	2.00		11750
	1.20		5250	1.05		4150	1.33		6275	2.00		11750
	1.20		5250	1.10		4450	1.38		6675	2.00		11750
	1.18		5100	1.10		4450	1.40		6775	1.25		11200
	1.15		4900	1.10		4450	1.45		7100	1.25		11200
	1.15		4900	1.10		4450	1.45		7100	1.25		11200
	1.13		4750	1.08		4400	1.45		7100	1.90		10850
	1.10		4550	1.00		3900	1.45		7100	1.82		10200
	1.05		4250	1.00		3900	1.53		7800	1.80		10025
	1.03		4100	1.15		4900	1.63		8425	1.80		10025
	1.10		4550	1.15		4900	1.73		9300	1.75		9600
	1.13		4750	1.25		5600	1.83		10350	1.70		9100
	1.10		4350	1.38		6625	1.90		10850	1.70		9100
				1.35		6450				1.70		9100

8759

Discharge in cu. ft. per second over Kampsville Dam for 1901.

Day.	January.			February.			March.			April.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
1	1.60		8300	2.03		12000	1.90		10800	6.78	.950	30300
2	1.58		8000	2.00		11700	1.85		10400	6.94	.950	31800
3	1.52		7700	2.15		13000	1.80		10000	7.04	.945	33300
4	1.50		7500	2.10		12500	1.80		10000	7.18	.948	33400
5	1.45		7200	1.75		9600	1.90		10800	7.32	.950	34400
6	1.45		7200	1.57		8000	1.90		10800	7.50	.954	35700
7	1.45		7200	1.60		8300	1.90		10800	7.69	.954	37200
8	1.40		6700	1.60		8300	1.98		11500	7.85	.958	37300
9	1.60		8300	1.60		8300	2.05		12500	7.98	.955	39300
10	1.80		10000	1.60		8300	2.76		18900	8.03	.958	38600
11	2.00		11700	1.60		8300	2.98	.319	19600	8.03	.958	38600
12	2.00		11700	1.60		8300	2.93	.483	17400	8.00	.958	38300
13	2.00		11700	1.60		8300	3.00	.550	17000	7.94	.964	38000
14	2.00		11700	1.60		8300	3.00	.594	16400	7.79	.962	36900
15	2.00		11700	1.60		8300	3.01	.558	16900	7.57	.957	36200
16	2.00		11700	1.75		9600	3.09	.562	17600	7.28	.954	34100
17	2.00		11700	1.90		10800	3.22	.649	18600	7.12	.955	33000
18	2.05		12200	2.00		11700	3.32	.712	16800	6.91	.955	31600
19	2.05		12200	2.10		12500	3.58	.770	17400	6.69	.950	30100
20	2.00		11700	2.13		12800	3.79	.765	18000	6.44	.944	29100
21	2.05		12200	2.00		11700	3.99	.824	18500	6.11	.941	26800
22	2.10		12500	1.70		9200	4.60	.860	21700	5.76	.937	25200
23	2.15		13000	1.60		8300	4.04	.910	21900	5.56	.916	24800
24	2.20		13500	1.08		9000	5.40	.918	24300	5.30	.914	23700
25	2.20		13500	1.85		10500	5.64	.921	25500	5.09	.913	22300
26	2.15		13000	1.95		11300	5.99	.932	26700	4.82	.913	20500
27	2.15		13000	1.98		11500	6.15	.945	27200	4.61	.891	20100
28	2.15		13000	1.90		10800	6.28	.944	28000	4.40	.885	19100
29	2.15		13000				6.35	.946	28400	4.16	.866	18300
30	2.15		13000				6.50	.946	29500	3.99	.840	18100
31	2.10		12500				6.58	.945	30000			

8760

Discharge in cu. ft. per second over Kampsville Dam for 1901, Continued.

Day.	May.			June.			July.			August.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
	3.67	.831	16200	1.50		7500	1.21		5300	1.00		3800
	3.44	.803	15300	1.50		7500	1.39		6600	1.00		3800
	3.22	.763	14700	1.45		7200	1.54		7800	1.00		3800
	3.08	.702	15700	1.45		7200	1.50		7500	1.00		3800
	2.99	.650	15300	1.50		7500	1.54		7800	1.04		4100
	2.86	.570	15800	1.50		7500	1.55		8000	1.08		4300
	2.77	.488	16000	1.57		8000	1.51		7600	1.08		4300
	2.73	.438	16200	1.61		8100	1.44		7100	1.05		4100
	2.64	.366	16100	1.58		8200	1.38		6500	1.03		4000
	2.55	.274	15900	1.62		8500	1.38		6500	1.03		4000
	2.46	.168	15700	1.60		8300	1.35		6300	1.01		3900
	2.40	.1624	15300	1.50		7500	1.30		6000	.98		3600
	2.35		14900	1.47		7300	1.26		8600	.95		3500
	2.30		14400	1.43		7000	1.19		5100	.95		3500
	2.20		13500	1.36		6400	1.18		5000	.90		3200
	2.20		13500	1.36		6400	1.18		5000	.90		3200
	2.15		13000	1.30		6000	1.11		4600	.90		3200
	2.10		12500	1.25		5600	1.11		4600	.90		3200
	2.05		12200	1.23		5500	1.11		4600	.90		3200
	2.00		11700	1.21		5300	1.11		4600	.90		3200
	1.95		11300	1.21		5300	1.10		4500	.90		3200
	1.90		10800	1.20		5200	1.08		4000	.90		3200
	1.85		10500	1.23		5500	1.06		4200	.90		3200
	1.80		10000	1.37		6500	1.03		4000	.90		3200
	1.75		9600	1.38		6600	1.00		3800	.93		3300
	1.70		9200	1.32		6200	.93		3300	1.06		4200
	1.67		8900	1.27		5700	.89		3100	1.10		4500
	1.64		8600	1.23		5500	.85		2800	1.10		4500
	1.60		8300	1.23		5500	.84		2700	1.11		4600
	1.57		8100	1.21		5300	.91		3200	1.10		4500
	1.52		7700				.96		3500	1.06		4200

8761

Discharge in cu. ft. per second over Kampsville Dam for 1901, Continued.

Day.	September.			October.			November.			December.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
	1.02		3900	.95		3500	.94		3400	1.		3900
	1.00		3800	.92		3300	.94		3400	1.03		4050
	.98		3600	.93		3300	1.00		3900	1.05		4250
	.93		3300	.91		3200	1.00		3900	1.05		4250
	.88		3000	.91		3200	.95		3500	1.05		4250
	.85		2800	.91		3200	.83		2750	1.05		4250
	.85		2800	.88		3000	.99		3800	1.05		4050
	.85		2800	.88		3000	.97		3600	1.1		4550
	.83		2700	.88		3000	1.00		3900	1.05		4250
	.85		2800	.87		2900	.95		3500	1.05		4250
	.90		3200	.87		2900	.88		3150	1.05		4250
	1.05		4100	.91		3200	1.00		3900	1.05		4250
	1.02		3900	.92		3300	1.00		3900	1.07		4350
	.99		3700	.92		3300	1.00		3900	1.		3900
	1.00		3800	.86		2900	1.00		3900	.93		3550
	1.00		3800	.87		3000	1.00		3900	1.00		3900
	1.00		3800	.90		3200	.98		3800	1.		3900
	1.00		3800	.80		2500	.96		3000	1.		3900
	1.00		3800	.88		3000	.96		3000	1.		3900
	1.00		3800	1.02		3900	1.00		3900	1.		3900
	.97		3600	.87		2900	1.00		3900	1.		3900
	.90		3200	.88		3000	1.04		4200	1.		3900
	1.02		3900	.88		3000	1.07		4350	1.		3900
	1.05		4100	.88		3000	.98		3800	.9		3400
	1.01		3900	.88		3000	.98		3800	.9		3400
	1.01		3900	.88		3000	1.00		3900	.95		3700
	.98		3600	.90		3200	1.00		3900	.95		3700
	.98		3600	.98		3600	1.00		3900	1.04		4200
	1.02		3900	.90		3200	1.00		3900	1.05		4250
	.98		3600	.90		3200				1.1		4550
				.90		3200				1.1		4550

8762

Discharge in cu. ft. per second over Kampsville Dam for 1902.

Day.	**January.**			**February.**			**March.**			**April.**		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
1	1.10		4500	.96		3650	1.42		6850	2.60		17200
2	1.09		4450	.95		3600	1.45		7050	2.55		16700
3	1.75		9450	.95		3600	1.35		6300	2.50		16200
4	1.17		4950	.95		3600	1.45		7050	2.50		16200
5	1.09		4450	.95		3600	1.77		9600	2.50		16200
6	1.08		4400	.95		3600	1.98		11400	2.60		17200
7	1.10		4500	.93		3500	2.03		11800	2.60		17200
8	1.10		4500	.93		3500	2.05		12000	2.60		17200
9	1.13		4650	.93		3500	2.05		12000	2.60		17200
10	1.26		5600	.93		3500	2.10		12400	2.60		17200
11	1.40		6700	.95		3600	2.42		12600	2.60		17200
12	1.40		6700	.95		3600	2.42		15300	2.60		17200
13	1.10		4500	.95		3600	2.52		16400	2.60		17200
14	1.10		4500	.95		3600	2.52		16400	2.60		17200
15	1.17		4950	.95		3600	2.40		15100	2.55		16700
16	1.20		5150	.95		3600	2.35		14600	2.55		16700
17	1.25		5500	.95		3600	2.35		14600	2.50		16200
18	1.25		5500	.95		3600	2.33		14400	2.45		16650
19	1.23		5350	.95		3600	2.30		14150	2.43		16400
20	1.30		5900	.95		3600	2.35		14600	2.40		15100
21	1.27		5650	.95		3600	2.42		15300	2.33		14400
22	1.20		5150	.96		3650	2.45		15650	2.25		13700
23	1.18		5000	.95		3600	2.50		16200	2.22		13400
24	1.18		5000	1.00		3875	2.50		16200	2.20		13200
25	1.17		4950	.95		3600	2.50		16200	2.15		12800
26	1.17		4950	.95		3600	2.50		16200	2.20		13200
27	1.03		4050	1.02		3975	2.65		17700	2.15		12800
28	.99		3800	1.20		5150	2.63		17500	2 20		13200
29	.98		3750				2.60		17200	2.40		15100
30	.98		3750				2.58		17000	2.33		14400
31	.98		3750				2.57		16900			

8763

Discharge in cu. ft. per second over Kampsville Dam for 1902, Continued.

Day.	May.			June.			July.			August.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
	2.20		13200	2.15	.799	10230	6.40	.432	28850	10.28	.380	52750
	2.33		14400	2.27	.703	9830	6.55	.431	28850	9.95	.385	49800
	2.35		14600	2.37	.645	9610	6.33	.432	28420	9.60	.390	47900
	2.25		13700	2.47	.608	9730	6.05	.448	27575	9.50	.395	47800
	2.20		13200	2.50	.585	9480	5.90	.459	27190	9.53	.408	49500
	2.20		13200	2.42	.644	9780	5.80	.481	27770	9.30	.408	46600
	2.15		12800	2.35	.763	11080	5.88	.485	29600	8.95	.418	47300
	2.15		12800	2.30	.763	11860	6.10	.482	30000	8.68	.412	43550
	2.15		12800	2.35	.860	12550	6.40	.477	31440	8.42	.422	42650
	2.12		12600	2.42	.822	12600	6.75	.477	34600	8.05	.423	39950
	2.15		12800	2.50	.825	13350	7.00	.462	24950	7.65	.431	37750
	2.10		12400	2.55	.760	12720	7.35	.450	36850	7.23	.447	39950
	2.10		12400	2.67	.750	13500	7.80	.439	39510	6.90	.460	34450
	2.15		12800	2.95	.700	14700	8.23	.471	42000	6.85	.460	32050
	2.10		12700	3.26	.590	14070	8.58	.422	43850	6.25	.462	29800
	2.08		12200	3.38	.575	14890	8.85	.421	46950	5.93	.478	28300
	2.05		12000	3.42	.560	14790	9.10	.418	47480	5.68	.487	27100
	2.00		11600	3.57	.571	16090	9.78	.408	48490	5.72	.489	27600
	2.00		11600	3.65	.578	16800	9.80	.408	51750	6.10	.475	29600
	2.00		11600	3.77	.574	17600	10.03	.300	51100	6.27	.468	30300
	2.00		11600	3.85	.570	17940	10.15	.380	50750	6.68	.455	32456
	2.02		11750	3.90	.568	18230	10.27	.380	51600	6.85	.447	33050
	2.25		13700	3.95	.568	18580	10.37	.380	52350	7.02	.440	33730
	2.35	.999	14585	3.95	.578	18870	10.60	.380	54150	7.08	.440	34150
	2.35	.983	14350	3.95	.596	19470	10.85	.380	56000	7.05	.440	34050
	2.10	.992	12300	3.90	.605	19600	11.00	.380	58125	6.98	.435	33100
	2.00	.996	11550	4.17	.558	19600	11.27	.380	59400	6.78	.442	32650
	2.00	.986	11450	4.52	.508	20150	11.30	.380	39650	6.58	.440	30600
	1.98	.939	10725	5.58	.489	26750	11.15	.380	58350	6.33	.453	29806
	2.08	.907	10520	5.72	.482	28700	10.93	.380	56800	6.05	.460	28250
	2.05	.863	10360				10.60	.380	54200	5.72	.480	27100

8764

Discharge in cu. ft. per second over Kampsville Dam for 1902, Continued.

Day.	September.			October.			November.			December.		
	H.	H/H	Q	H	H/H	Q	H	H/H	Q	H	H/H	Q
	5.35	.485	24800	2.30		14150	3.20	.840	20050	3.10	.768	17400
	4.98	.575	24700	2.30		14150	3.15	.860	20080	3.05	.772	17080
	4.35	.531	21300	2.45		15650	3.10	.883	20070	3.05	.784	17360
	4.18	.542	19000	2.68	.941	17040	3.03	.910	20020	3.05	.784	17360
	3.85	.595	18710	2.78	.930	17630	3.22	.860	20000	3.00	.790	16990
	3.65	.638	19620	2.80	.855	16410	3.35	.790	20250	3.00	.812	17460
	3.43	.700	18500	2.85	.775	15230	3.25	.819	20010	2.95	.829	17010
	3.17	.788	19580	2.90	.716	14600	3.20	.831	19830	2.90	.869	17630
	3.12	.842	19400	2.97	.700	14820	3.15	.835	19500	2.85	.907	17830
	3.00	.900	19440	3.03	.723	15650	3.13	.838	19370	2.82	.924	18010
	2.88	.930	18780	3.07	.745	17700	3.10	.856	19420	2.80	.939	18090
	2.78	.978	18670	3.10	.790	17970	3.03	.878	19400	2.82	.949	18480
	2.88	.990	17930	3.17	.793	18620	3.08	.880	19700	2.90	.910	18970
	2.55	.999	16590	3.30	.790	19770	3.10	.878	19900	2.90	.918	11670
	2.45	.000	15700	3.37	.786	20100	3.15	.877	20490	2.90	.932	19000
	2.38		15000	3.47	.750	20250	3.15	.863	20150	2.83	.968	18930
	2.33		14450	3.50	.723	19770	3.20	.848	20200	3.03	.989	21700
	2.63		17400	3.55	.710	19800	3.20	.827	19720	2.90	.976	19920
	2.40		15150	3.57	.713	19400	3.20	.789	19000	2.90	.974	19890
	2.30		14200	3.60	.681	19070	3.25	.778	19020	2.97	.958	20250
	2.23		13500	3.70	.644	18150	3.25	.775	18770	3.30	.861	21550
	2.15		12800	3.85	.575	19610	3.25	.765	18770	3.42	.844	22250
	2.10		12400	4.03	.556	19580	3.25	.769	18800	3.45	.834	19600
	2.10		12400	4.03	.772	18200	3.25	.770	18820	3.52	.701	19410
	2.35		14600	4.10	.530	17490	3.25	.765	18770	3.45	.693	18530
	2.38		15000	3.98	.545	17490	3.25	.765	18770	3.10	.605	14770
	2.28		14000	3.70	.590	18390	3.20	.759	18080	3.20	.710	16920
	2.25		13700	3.48	.678	19590	3.20	.759	18080	3.18	.808	19030
	2.25		13700	3.38	.737	19290	3.18	.760	17970	3.12	.833	10110
	2.27		13900	3.30	.771	19630	3.15	.762	17800	3.38	.859	22200
				3.25	.804	19800				3.20	.835	19920

8765 Q. Now professor, will you explain in detail the tables which have just been put in evidence, and show what relation they have to other data put in evidence in this case by yourself?

A. With respect to table No. 1 of this series, I may say that the first column gives the date of the month, the day of January for instance, beginning with January, 1896. In the second column we have under the letter "H", the height of water above the wier, taking the first figure, it represents the fact that the height of water above the crest of the dam or wier was 3.68 feet. The height of water above the wier, but below the wier,—that is vertical height, above the wier, but measured at a point down stream from the wier, is not given in this table, but the percentage calculated by dividing the one height by the other is given in column 3. This gives the coefficient by which the flow—the actual discharge of water over the wier is to be computed by multiplication into the figure showing the volume of discharge which would have occurred if the height of water down stream from the wier was not higher in the vertical line than the crest of the wier itself. The figures in column four marked "Q" represent the number of cubic feet per second of water discharged over the dam.

The same explanation appertains to the various other columns of figures for this table and also for the other seven of this set.

8766 Q. I understand you to say professor, that these tables were the basis upon which the charts or plates were made?

A. They are.

Q. Professor, I now call your attention to tables 43, 44, 45 and 46 of the series under consideration at the time of adjournment yesterday, containing the chemical examination of water from the Illinois river at Grafton, covering the periods designated in the left hand margin of the tables. Will you please state whether you prepared a table of averages based upon these detail examinations?

A. I did, and it is Defendants' Table of Averages No. 11—A. W. P. and is as follows:

8767

DEFENDANTS' TABLE OF AVERAGES NO. 11.—A. W. P.

TABLE *XVI.*

CHEMICAL EXAMINATIONS OF THE WATERS OF THE ILLINOIS RIVER AND THE MISSISSIPPI RIVER AT GRAFTON, BEFORE AND AFTER THE OPENING OF THE CHICAGO MAIN DRAINAGE CHANNEL.

YEARLY AVERAGES. PARTS PER MILLION.

Year	Chlorine	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS	
						ALBUMINOID AMMONIA							
		Total	By Dissolved	By Suspended Matter	Free Ammonia	Total	Dissolved	Suspend'd	Total	Dissolved	Suspended	Nitrites	Nitrates
Ill. 1899	14.73	12.6	8.3	4.3	.313	.479	.247	.232	1.148	.596	.552	.045	1.063
1900	13.13	10.2	6.7	3.5	.343	.375	.191	.184	.885	.472	.413	.025	1.304
1901	15.3	11.3	7.5	3.8	.245	.413	.241	.172	1.029	.553	.476	.033	1.273
1902	9.35	10.6	8.	2.	.379	.322	.229	.093	......	.....	......	.032	1.074
3 yrs. Av'e	12.6	10,7	7.4	3.3	.322	.37	.22	.149	.957	.512	.444	.03	1.237
Miss.													
1899	2.8	15.2	9.8	5.4	.07	.508	.217	.291	1.168	.485	.683	.012	.34
1900	3.1	16.4	10.6	5.8	.113	.448	.222	.226	1.03	.476	.555	.007	.471
1901	2.8	14.1	10.6	3.5	.162	.403	.202	.201	.969	.431	.538	.006	.314
1902	3.	14.7	9.3	4.5	.095	.464	.189	.275	... ..	......	.....	.01	.496
4 yrs. Av'e	2.92	15.1	10.0	4.8	.116	.455	.207	.248	1.055	.464	.592	.009	.405

8768 Q. Now will you please state what significance you attach to these chemical examinations as illustrated by this and also by the table of averages which you have just put in evidence?

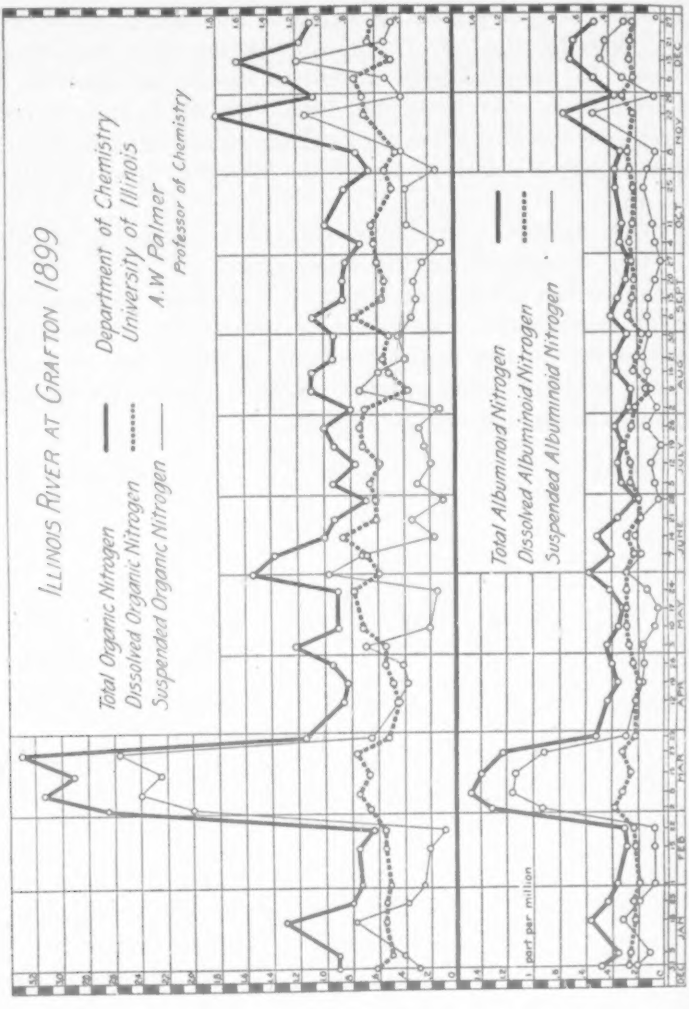
A. The samples of water, analyses of which are detailed in tables 43 to 46 inclusive, were collected from the Illinois river at a point about two miles within the mouth, a place which is not ordinarily reached by water from the Mississippi river. There are several islands in the Mississippi river close to the mouth of the Illinois, lying parallel with and at no great distance from the Illinois shore, and the United States engineers in charge of this section of the improvements of the Illinois and Mississippi rivers have had dikes built between these islands.

which prevent the waters of the Illinois from discharging into the Mississippi at its old mouth and cause them to pass down for at least two miles parallel with the Mississippi river before finally entering the latter immediately opposite the town of Grafton. In times of high water the discharge from the Illinois river flows over these dikes into the Mississippi at points between one and two miles above Grafton, and also at times the waters of the Mississippi flow over the dikes into the Mississippi.

8769 Our samples were collected above the point at which this occasional mixing takes place.

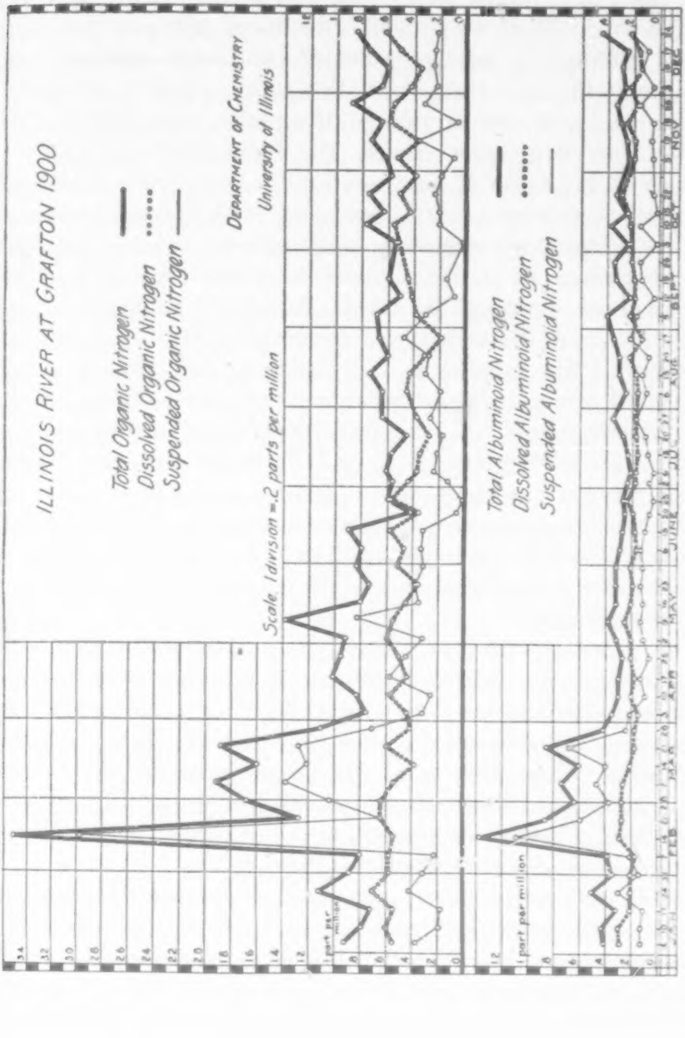
Comparison of the data of the analyses show seasonal variations of considerable magnitude in the waters of the Illinois river at Grafton, the most important of which the albuminoid ammonia and the total organic nitrogen are shown in plates XX and XXI, which are as follows:

Plate XX.—A. W. P.


ILLINOIS RIVER AT GRAFTON 1899
Total Organic Nitrogen
Dissolved Organic Nitrogen
Suspended Organic Nitrogen
Department of Chemistry
University of Illinois
A.W Palmer
Professor of Chemistry
Total Albuminoid Nitrogen
Dissolved Albuminoid Nitrogen
Suspended Albuminoid Nitrogen
1 part per million
DEC
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC

8771

Plate XXI.—A. W. P.



8772 Upon plate XX there is shown by means of curves, the seasonal variations in the content of albuminoid nitrogen, both the total, that derived from dissolved substances, and that derived from suspended substances for each sample collected during the year in question, and by similar curves, similar data with respect to the total organic nitrogen, are shown in the upper section of the plate. Inspection of these curves serves to show clearly the facts which appear in the details of the table of analyses for the year 1899, that is table No. 3 of the series we are discussing, with respect to the nitrogen as albuminoid ammonia and the total organic nitrogen.

Beginning at the left hand side of the plate and following the line representing the total albuminoid nitrogen it is evident that from the last day of December, 1898 to the 5th day of January, 1899, there was a decrease in the proportion of albuminoid nitrogen, while following that to the 18th, there was an increase, which in turn was followed by a decrease in the proportion to January 25th, and February 1st, and February 22nd, after which there was a sudden increase to March 2nd, when the proportions of nitrogen as total albuminoid ammonia amounted to 1.26 parts per million, while it had been but little more than .3 parts per million upon the 22nd of February
8773 preceding.

After the 2nd of March, there was a further increase to the 8th, after which there was a gradual decrease to the 15th and again to the 24th of March, after which a much more considerable decrease took place, between the 23rd and the 29th of March. From this point on the proportions of nitrogen as total aluuminoid ammonia were considerably less than they had been during March, although there were increases and decreases at various times throughout the year.

Similar facts appear when we consider the lines representing the total organic nitrogen, that is there was a notable increase at about the middle of January, which was followed by a decrease in the latter part of January, remaining about stationary during the early part of February. It slightly decreased in the latter part of February, to be followed by an enormous increase between the 22nd of February and the 2nd of March, the curves throughout following substantially the same directions as those above stated, with respect to the total albuminoid nitrogen.

It is obvious from inspection of the curves and is shown definitely by the figures of the tables to which the curves give expression, that during the times when the albuminoid nitrogen and the total organic nitrogen are particularly ex-
8774 cessive in quantity, in the water of the Illinois river at
this point, it is mainly in suspended matters and not in the substances which are in solution, while during the periods of less flow, the organic nitrogen and the albuminoid nitrogen are general chiefly in substances which are in solution in the water, and not in the matters which are merely suspended.

Upon plate XXI, there are shown similar lines for the year 1900. The lines follow much the same general course throughout the year. They represent the various analyses, the details of which are given in table No. 44 of this series.

Study of the figures of the table and inspection of the curves of the plate show that during the year 1900 the variations in the proportions of nitrogen as albuminoid ammonia and of total organic nitrogen follow much the same curves as during the preceding year, that is the year 1899, thus there was during the early part of January a decrease in the proportions which was followed in the latter part of January by an increase, to be again followed by a decrease to the 31st of January, which decrease in the case of the total organic nitrogen continued to the 7th of February, after which there was an enormous increase to the 14th of February, which again was followed by a considerable decrease to the 21st of February, which however was followed by another though less con-
8775 siderable increase to the 28th of February, and on to the
7th of March, after which again a decrease occurred, followed by an increase to the 14th, after which the decrease which occurred again was more considerable, and from that time on to the end of the year the proportions never rose to such considerable amounts as during February and March, and the variations were much less considerable from week to week.

Again with respect to the curves of this plate it may be stated that during the time when the proportions of total organic nitrogen and of total albuminoid nitrogen are at the maximum, or at the higher points, it is mainly due to the excessive proportion of the nitrogen contained in susupended matters, that is the greater proportion of the total organic nitrogen, as also of the nitrogen as albuminoid ammonia is at such times contained in matters which are in suspension in the water and not in the substances which are in solution.

Comparison of the averages for the different years which appear in the table of averages No. 11, above referred to shows that subsequent to the opening of the Chicago main drainage channel, the proportions of the various significant constituents of the water of the Illinois river at Grafton, were in most cases considerably reduced, thus the chlorine was found on the average for the year 1899 to be present to the extent of 14.73 parts per million, while the average for the year 1900 was
8776 13.13 parts per million, and that for the year 1901 15.3
parts per million, for the year 1902, 9.35 parts per million, while the average for the three years subsequent to 1899, was 12.6.

The oxygen consumed for the year 1899 was 12.6 parts per million; that for 1900—10.2; for 1901—11.3; for 1902—11.6.

That required by dissolved substances was, for 1899, 8.3; for 1900—6. 7; for 1901—7.5; for 1902—8, and the average for the three years was 7.4.

That required by suspended matters was, for the year 1899-4.3; for the year 1900-3.5; for 1901-3.8; for 1902-2.6; the average for the three years being 3.3.

The free ammonia was found to the extent of .313 parts per million during the year 1899. It was changed to the amount of .343 parts per million in 1900, and was found in the proportion of .234 in 1901, and in the proportion of .379 during the year 1902; the average for the three years being .322.

Total albuminoid ammonia was for 1899,—.479; for 1900 it was .375; for 1901, it was .413; for 1902 it was .322, and the average for the three years was .37 as against .479 for the year 1899.

The nitrogen as albuminoid ammonia in dissolved matters was, during the year 1899 on the average, .247 parts per million; during 1900 it was .191; during 1901, it was .241;
8777 during 1902-.229.

The nitrogen as albuminoid ammonia derived from suspended matters was, for the year 1899, .232; for the year 1900-.184; for the year 1901-.172; for the year 1902, .093, the average for the three years being .149, as against .232 the average for the year 1899.

The total organic nitrogen was on the average for the year 1899-1.148; for the year 1900 it was .855; a very considerable reduction; for the year 1901 it is given in the table of averages as 1.029, but it is to be noted that these particular determinations were not made after the first of October, 1901, and that the average for the year then appears higher than it would have been if the determinations had been made throughout this year. No determinations of organic nitrogen were made in the year 1902.

MR. JEFFRIES: With that explanation of the witness with reference to 1901, the determinations not having been made throughout the entire year, I object to any testimony or any conclusions being drawn either from the tables themselves or from the tables of averages for the reason that data are insufficient, and any conclusions that might be drawn would be erroneous and of not value for the determination of the issues involved in this controversy.

8778 JUDGE SPRINGER: The objection goes only to the weight of this evidence and not to its competency. Of course it has no further weight than the data upon which it is based.

THE WITNESS: (Contnuing) The total organic nitrogen derived from dissolved substances was, for the year 1899, .596; for the year 1900-.472; and for such portion of the year 1901 as the data of table 45 covers, it was .553.

The organic nitrogen derived from suspended matters was for the year 1899-.552; for the year 1900 it was .413; for the year 1901, or such portion as the data of table 45 covers it was .476.

The nitrogen as nitrites was, for the year 1899-.045 parts per million; for the year 1900 it was .025, a little more than half what it had been for the year 1899. In 1901 it was .033, and for the year 1902 it was .032; the average for the three years subsequent to the opening of the Chicago main drainage channel being .03, or two-thirds the proportion found in the waters of the Illinois river at this point during the year 1899; that is the year immediately prior to the opening of the Chicago main drainage channel.

Nitrogen as nitrates was, for the year 1899-1.063; for the year 1900, it was 1.364; for the year 1901, it was 1.273 and for the year 1902 it was 1.074, the average for the three years
8779 being 1.237, a considerable increase over the proportions found during the year 1899.

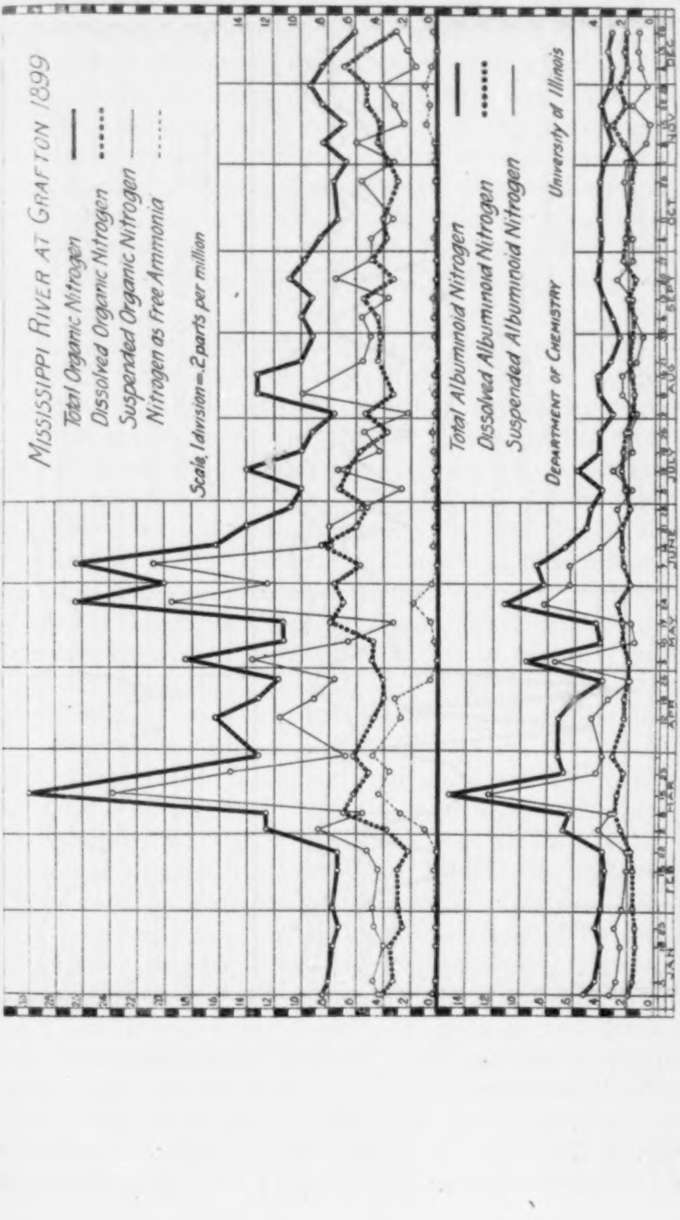
Q. Professor, I now call your attention to tables 47, 48, 49 and 50, of this series, which contain the chemical examinations of water from the Mississippi river at Grafton at the times indicated on these tables. Please state whether you prepared any tables of averages based upon these detail data and if so, will you please read the same into the evidence?

A. I did prepare such a table of averages from the data of tables 47, 48, 49 and 50, and will explain here that table 50 has not yet been printed, and that I put in evidence a manuscript copy of the table for the Mississippi river at Grafton, for the year 1902, the table of averages re-referred to is table No. 11, which we have been discussing for the Illinois River. This one table No. 11 contains not only the averages for the Illinois river, at Grafton, but also the averages of the analyses of samples taken from the Mississippi river at Grafton, those just referred to as being contained in detail in tables 47 to 50 inclusive.

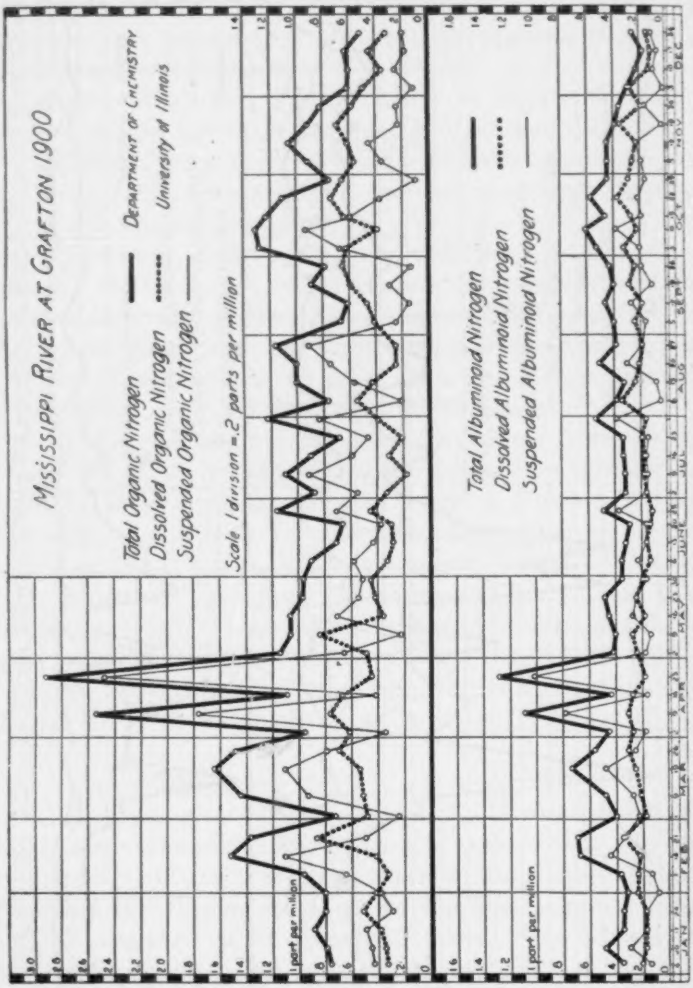
Q. Proceed, professor?

A. The samples of water from the Mississippi river at Grafton were taken at mid-stream, at a point about two miles above Grafton, and above that at which any discharge
8780 from the Illinois river enters the Mississippi. The detail analyses which appear in tables 47 to 50 inclusive, show that seasonal variations in the constituents of the waters of the Mississippi river are in many respects more frequent and more considerable than the seasonal variations in the waters of the Illinois. This is especially true of the albuminoid ammonia and the total organic nitrogen as is evident upon consideration of the features of plates XXII and XXIII, which are as follows:

Plate XXII.—A. W. P.



8782 **Plate XXIII.—A. W. P.**



Upon plate XXII there appear lines representing the 8783 total albuminoid nitrogen; the albuminoid nitrogen contained in dissolved substances, the albuminoid nitrogen contained in suspended substances. These being at the bottom of the plate, while upon the upper part of the plate there are shown lines representing the proportions of total organic nitrogen the organic nitrogen derived from dissolved substances, and that contained in suspended substances. In addition to these, there is a line representing the proportions of nitrogen as free ammonia, in the waters of the Mississippi river during the year 1899.

The plates are in all respects, so far as the scale and dates and general figurations are concerned, similar to tables XX and XXI, which have just been described, and which represent the proportions of these constituents, excepting the free ammonia, contained in the water of the Illinois river at Grafton.

With respect to plate No. XXII, we may follow the lines as we followed those of plates XX and XXI, and note that during the two months in the year 1899, the proportions of albuminoid nitrogen, and of total organic nitrogen vary but slightly, but that at the end of February there was an increase in some 8784 notable degree, which was followed in the early part of March by a slight decrease, this being in turn followed by a very considerable increase up to and upon the 15th of March, after which there was a decrease to the 23rd of March which in turn for the albuminoid nitrogen was followed by a slight increase to the 29th, while the total organic nitrogen decreased to the 29th. After this there was an increase in the total organic nitrogen to the 12th of April, to be followed by decreases until between the latter part of April and the 3rd of May there was again a considerable increase. The decrease which followed this being considerable, but being followed between the 17th and 24th of May by a very considerable increase. This followed by a decrease again to two parts per million, which was again followed by an increase to 2.6 parts per million, after which there was a very considerable decrease, but during the latter part of the year the proportions never rose to similar height to that reached in May, and in March. With respect to the free ammonia represented upon this plate,

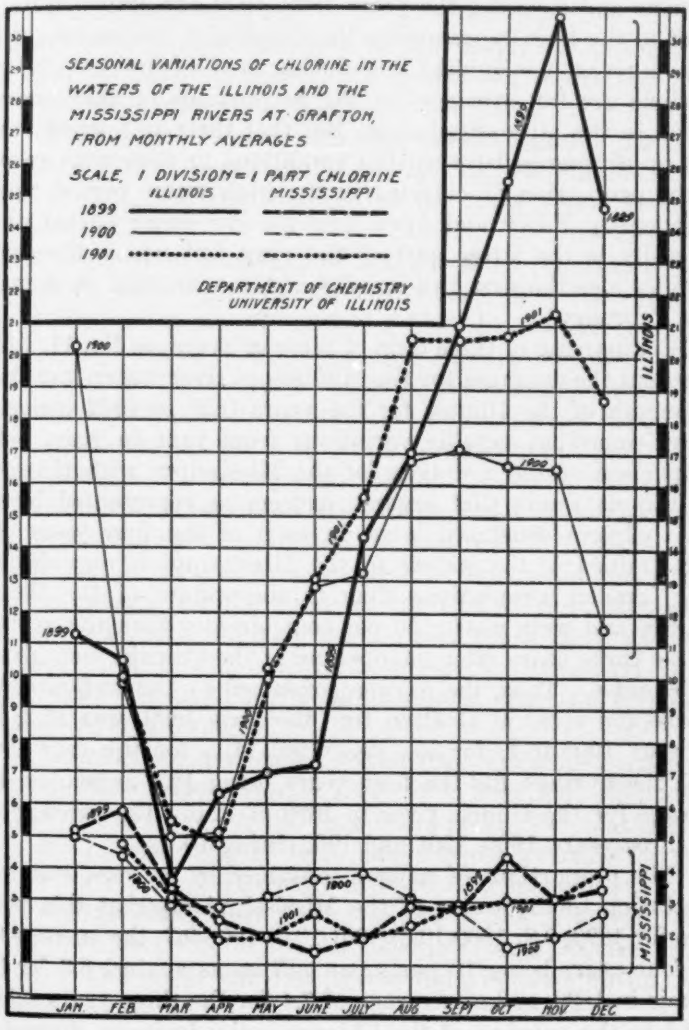
attention may be directed to the fact that the proportions in the water of the Mississippi river were extremely small for the first two months of this year, but that during March and April the proportions were quite considerable, reaching to more than four-tenths parts per million by the middle of March,
8785 and to nearly .5 parts per million at the end of March,
and that this considerable proportion of free ammonia persisted in the waters of the Mississippi until well along toward the latter part of April, after which there was a diminution and the proportions never again during the year reached quite the magnitude they reached during March and April.

In respect to plate No. XXIII in the consideration thereof, attention may be directed to the fact that in the early part of January, the proportions of total organic nitrogen were a little less than .8 parts per million, but there was a gradual increase to the middle of the month, followed by a decrease, but that in the early part of February there was an increase and up to the middle of February, 1900 the proportion of organic nitrogen contained in the waters of the Mississippi at Grafton were something more than 1.5 parts per million, the figure in the table being 1.52. After this there was a decrease in the proportion to the first of March, which was followed by a considerable increase again in March, reaching the maximum on the 19th and followed by a decrease in the early part of April, after which there were successive increases and decreases the maximum for the year being in the latter part of April, when the proportion of total organic nitrogen was found to be 2.92 parts per million. After this, the lines show various in-
8786 creases and decreases throughout the year, but at no
time during the latter part of the year was the proportion nearly so considerable as during the middle of February, the middle of March, and particularly the month of April.

The lines representing total albuminoid nitrogen follow practically the same course as that referred to with respect to the line representing total organic nitrogen and with respect to these two tables representing nitrogen as albuminoid ammonia and the total organic nitrogen in the waters of the Mississippi at Grafton for the years 1899 and 1900 respectively, it should be understood that the lines in the plates represent the figures which appear in detail in tables 47 and 48, and that during the times when the proportions of these constituents are at the maximum it is chiefly the suspended matters which contribute to the high proportion of the nitrogen.

Plate No. XXIV is as follows:

8787 Plate XXIV.—A. W. P.



8788 Upon Plate XXIV there appear lines which represent the proportions of chlorine contained in the waters of the Illinois river near the mouth at Grafton, and similar lines representing proportions of chlorine contained in the waters of the Mississippi at a point just above Grafton, the curves in this plate representing the monthly averages for the chlorine and covering the years 1899, 1900 and 1901. With respect to the lines representing the chlorine in the waters of the Illinois river, it is evident that during most of the year the proportions are far in excess of the proportions of chlorine contained in the Mississippi river, but that there is a great variation or difference between the conditions in this, with respect to the proportion of chlorine in the high water period, which is generally March and April, and the low water period which generally is the latter part of the year, but which frequently includes also the first two months of the year, that is, January and February.

Comparison of these data of table of averages No. 11, which represent the averages for the Mississippi river water just above the mouth of the Illinois for the years 1899 to 1902 inclusive, shows somewhat notable variations from year to year, but a comparison of the averages for the Mississippi with those for the Illinois shows that organic matters as represented by the

8789 oxygen consumed were, in each of the four years contained in the waters of the Mississippi in considerably greater proportions than in the waters of the Illinois in 1899, and were nearly 50 per cent. greater than the average for the three years after the opening of the Chicago main drainage channel. Thus, the oxygen consumed by the waters of the Mississippi river at Grafton for the year 1899, was 15.2; for the year 1900-16.4; for the year 1901-14.1; for the year 1902-14.7; the average for the four years being 15.1 as against the average for the Illinois river in 1899 of 12.6. The average for the three years, 1900, 1901 and 1902, being 10.

The proportions of oxygen consumed by matters contained in solution in the water of the Mississippi river at this point were for 1899, 9.8; 1900-10.6; 1901-10.6; 1902-9.3; the average for the four years being 10 parts per million as against 8.3 for the Illinois in 1899, and an average of 7.4 for the three years subsequent to the opening of the Chicago main drainage channel.

The oxygen consumed by suspended matters in the waters of the Misissippi were in 1899-5.4; in 1900-5.8; in 1901-3.5; in 1902-4.5; the average for the four years being 4.8; the proportion in excess of that required by suspended matters in the water of the Illinois river during 1899, which was 4.3, and also considerably greater than the average for the Illinois 8790 river for the three years, 1900, 1901 and 1902, the figures for that year being 3.3.

The free ammonia contained in the waters of the Mississippi river at Grafton, reached the proportion of .077 for the year 1899, the average for the year 1900 being .133; for the year 1901-.182; for the year 1902-.095; the average for the four years being .116, as against the average for the Illinois river in 1899 of .313, and the average for the three years, 1900 to 1902, being .332.

The albuminoid ammonia in the waters of the Mississippi river for the year 1899 were on the average .508, the average for 1900 being .448; for 1901-.403; for 1902-.464, the average for the four years being .455, a quantity slightly less than that contained in the Illinois river water in 1899, which latter was .479, but considerably in excess of the proportions found on the average in the Illinois river water for the three years, 1900, 1901 and 1902, which average was .37.

Albuminoid ammonia derived from dissolved substances in the Mississipi river at Grafton for 1899 was .217; 1900-.222; 1901-.202; 1902-.189; the average for the four years was .207; the average for the water of the Illinois river for 1899, 8791 was .247, and for the three years subsequent thereto, that is, 1900, 1901 and 1902, it was .22; the proportions in the Illinois river being slightly greater than the proportions in the Mississippi.

The albuminoid ammonia derived from suspended matters was for the Mississippi river in 1899, .291; 1900-.226; 1901-.201; 1902-.275; the average for the four years being .248, as against .232 in the Illinois river in 1899, and .149 the average for the Illinois river for the three years 1900 to 1902 inclusive.

Total organic nitrogen in the waters of the Mississippi at Grafton were for 1899, 1.168; for 1900-1.03; and .969 for such portion of 1901 as is covered by the data in table 49 of this series. The average for these three years or such portion thereof as the data pertains to being 1.0155 as against the average for the Illinois river in 1899 of 1.148, an average for two years, 1900 and 1901, of .957.

Organic nitrogen derived from dissolved substances in the Mississippi river at Grafton for 1899, .485; 1900, 4.76; 1901-.431; the average of these being .464, as against .596 for the Illinois river in 1899, and .512, the average for the Illinois river for the years 1900 and 1901.

Total organic nitrogen derived from suspended matters for the Mississippi river water at Grafton for 1899 is .683;
8792 for 1900 .555; 1901-.538; the average being .592, as against
.552 in the Illinois river water for 1899, an average of .444 for the Illinois river water for 1900 and 1901.

Nitrogen as nitrites in the water of the Mississippi at Grafton were .012, for 1899; and .007 in 1900; and .006 in 1901, and .01 for 1902, the average for the four years being .009, as against .045 in the Illinois river water in 1899, an average of .03 for the three years, 1900, 1901 and 1902.

Nitrogen as nitrates in the Mississippi river water at Grafton was on the average .34 parts per million for the year 1899; for the year 1900 the average was .471; 1901 the average was .314; 1902 the average was .469; the general average for the four years being .405 as against the average of 1.063 in the Illinois river water in 1899, and 1.237, the average in the Illinois river water for the three years, 1900, 1901 and 1902. The data of the tables show in general that the proportions of nitrogenous organic matters as represented by albuminoid ammonia and total organic nitrogen were notably higher in the Mississippi river than in the Illinois river, although in the year 1901 they were slightly higher in the latter stream. On the other hand the oxidation products of nitrogenous organic matters represented by free ammonia, the nitrites and the nitrates, were present in the waters of the Illinois in proportions which
8793 are two to three times those contained in the waters of
the Mississippi, and the total nitrogen, that is, the sum of the total organic nitrogen, the nitrogen as free ammonia and the nitrogen as nitrites and as nitrates was 2.546 parts per million in the waters of the Illinois as against 1.585 in the waters

of the Mississippi. The preponderance of nitrogen in the waters of the Illinois over the proportions contained in the waters of the Mississippi is doubtless due to the fact that the watershed of the former is more extensively and more intensively cultivated than that of the latter, and that the industrial wastes which are discharged into the Illinois are more highly nitrogenous in character than are many of those which find their way into the Mississippi. For example, the refuse matters discharged into the Illinois river at Peoria and Pekin consist largely of the highly nitrogenous wastes from glucose factories and those resulting from the feeding of cattle upon distillery slops, while the organic matters contained in the waters of the upper Mississippi are derived largely from the wastes of the lumber industries and these are not nearly so highly nitrogenous in character. Both streams of course, receive in the aggregate enormous quantities of sewage.

MR. JEFFRIES: I move to strike out the statement of 8794 the witness with reference to the nitrogenous character of the discharges from the glucose factories of Peoria and Pekin, for the reason that the defendants' evidence shows that there are no discharges from these factories, save that of pure distilled water.

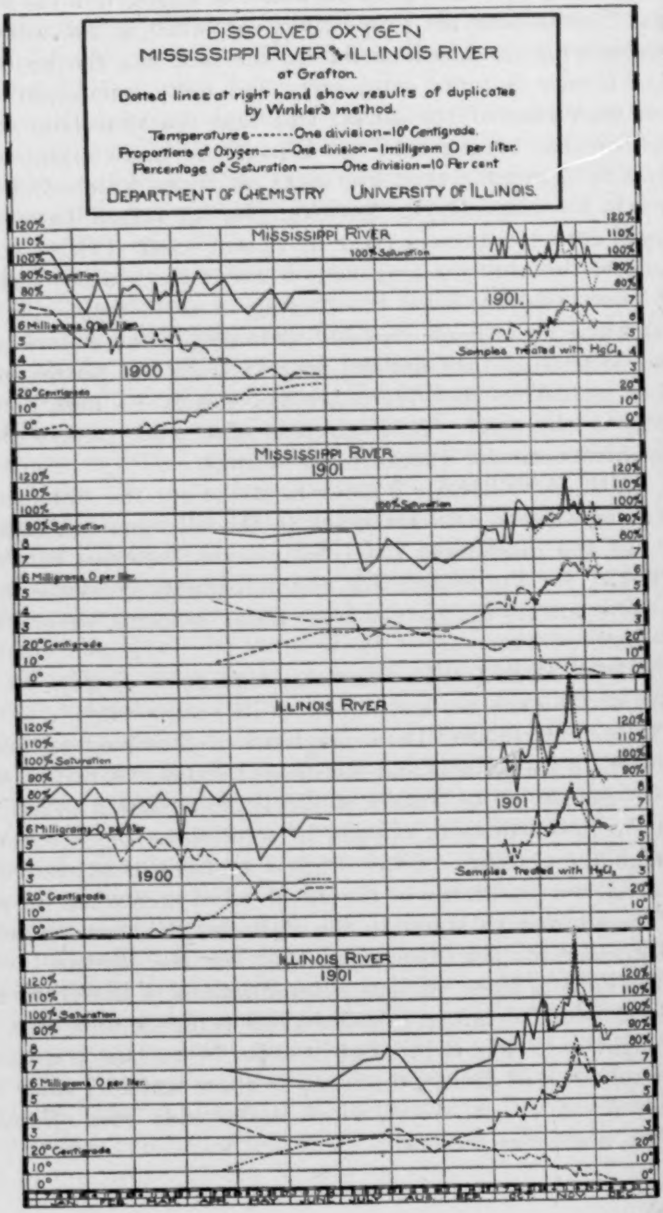
JUDGE SPRINGER: The objection goes simply to the weight of the evidence and not as to its competency.

THE WITNESS: Determinations of dissolved oxygen in the waters of the Illinois and Mississippi rivers at Grafton, show that in general of the waters of the Illinois contain practically the same proportions of oxygen in solution as the Mississippi although the stability of the organic matters as measured by the partial disappearance of the dissolved oxygen when the samples are allowed to stand in the dark for 24 hours, is somewhat greater for the Mississippi than for the Illinois.

The data of these various determinations of dissolved oxygen have been hertofore introduced as evidence and need not be brought in here in detail, but in order to explain graphically the proportions of dissolved oxygen in these waters I refer now to plate No. XXV, A. W. P., which has already been offered in evidence and is as follows: .

8795

Plate XXV.—A. W. P.



8796 THE WITNESS: And I wish to refer to my previous statements regarding dissolved oxygen in the waters of these two streams at this point.

JUDGE SPRINGER: Professor, I now call your attention to tables 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61 and 62, which contain chemical examinations of water from the Mississippi river at Alton, at times indicated in these tables. Have you prepared professor, a table of averages based upon these detail data?

A. I have prepared no tables of averages with respect to these Nos. 51 to 62 inclusive, except the averages which appear at the bottom of each of the tables.

Q. Well, it appears from the head lines over each of these tables, that the samples were taken at cross-sections of the river. Can you explain that part, and also whether they reveal the fact of the mixing of the waters of the Illinois river with those of the Mississippi river?

A. With respect to the data included in the tables 51 to 62 inclusive, I may say that for several years samples of water were collected from the Illinois river at the intake of the old Alton city waterworks, and also a few samples were collected at mid-stream, but that in the fall of 1898, arrangements were made for the collection of a series of samples at a point
8797 opposite the new waterworks nearly a mile above the town. At this place five samples were collected at five different points across the stream for the purpose of determining the differences in composition due to the incomplete mingling of the waters of the Illinois river with those of the Mississippi river. The point at which these samples were taken was 16 to 17 miles below the mouth of the Illinois river at Grafton and six or seven miles above the mouth of the Missouri river or fifteen or sixteen miles above the intake of the St. Louis waterworks at the chain of rocks.

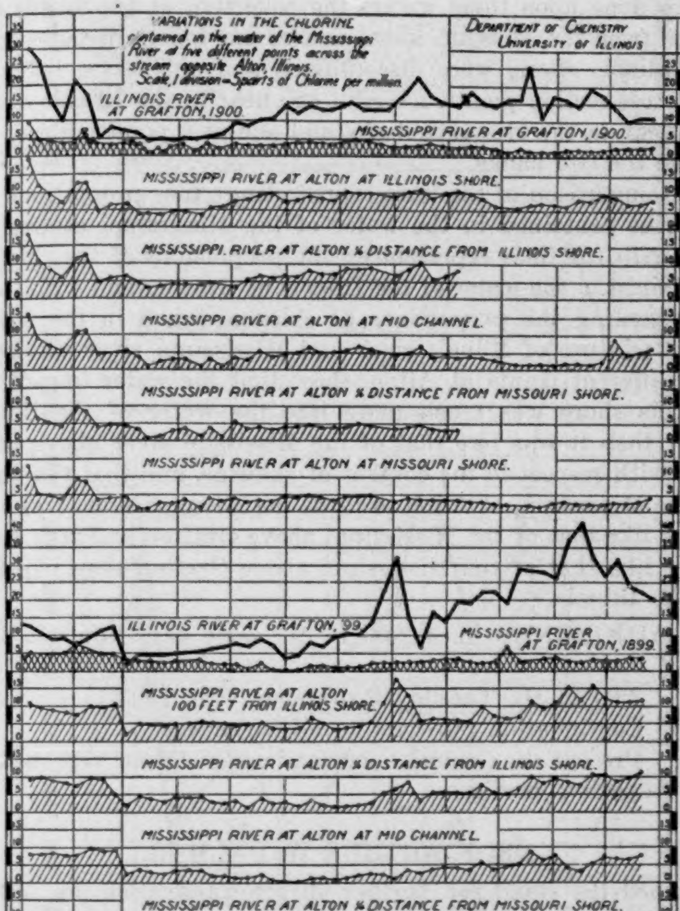
Consideration of the data of the twelve tables shows how incomplete is the mixing of the waters of the Illinois with the waters of the Mississippi, the facts being brought out especially by comparison of the proportions of chlorine contained in the waters of the Illinois river and the Mississippi river above Grafton with those found at different points in the cross-sec-

tion of the stream at Alton. In explanation I will refer to plate No. XXVI which has heretofore been offered in evidence. This plate No. XXVI gives comparative curves representing the results of chlorine determinations in the regular weekly samples collected throughout the years 1899 and 1900, the data appearng in detail in the tables 53 and 62 inclusive. Several times in January and February when because of stationary ice
8798 or floating ice it was impracticable for the collector to reach the proper points, collections were made at the ferry crossing opposite the town, nearly a mile below the point at which collections were at other times made, so that the data for portions of these two months for both years, show the proportions of chlorine, which are not truly representative for the Missouri side of the stream, because the collector who started from the Illinois side couldn't get far enough out toward the Missouri shore.

Plate No. XXVI is as follows. It has heretofore been offered in evidence:

8799

Plate XXVI.—A. W. P.



8800 THE WITNESS: In the latter part of the year 1900, as it was found necessary to contract the amount of work being done upon these waters the collection at one-fourth distance from the Missouri shore and at one-fourth distance from the Illinois shore, were discontinued and only three taken at the cross-section points, namely: one near to the Illinois shore; one near to the Missouri shore, and one at a point midway between the two banks.

Comparison of the lines representing the proportions of chlorine contained in the water of the Mississippi at Grafton and with the lines representing the proportions of the chlorine contained in the water of the Illinois at Grafton and with those representing the proportions of chlorine found in the incomplete mixture of Illinois river and Mississippi river waters at the different points at Alton, show that the water toward the Illinois shore was much more like the water of the Illinois river than it was like that of the Mississipi river above Grafton, with respect to the content of chlorine, and that the water of the Mississippi at Alton towards the Missouri shore was very much like that of the Mississippi above Grafton and very much more like that of the Mississippi above Grafton than like that of the Illinois.

ADJOURNED until 2:00 P. M., same day, Nov. 17. 1903.

2:00 P. M., Tuesday, November 17th, 1903.

8801 Continuation pursuant to adjournment.

Present the Commissioner and same counsel representing the respective parties.

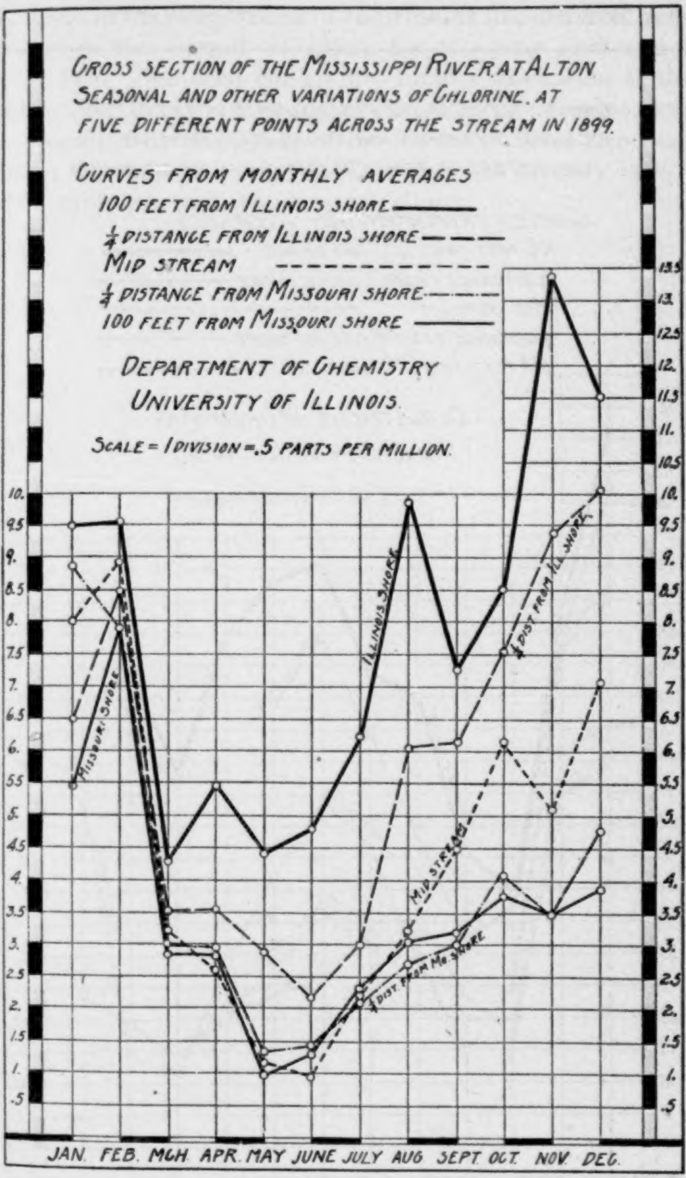
PROF. ARTHUR W. PALMER,

resumed the stand for further direct-examination by Judge Springer and testified as follows:

Q. At the time of the noon adjournment, we had reached consideration of plate XVII. Will you proceed with the explanation of that plate, professor?

A. Plates XXVII and XXVIII, which have already been introduced in evidence, are as follows:

Plate XXVII.—A. W. P.



8803 Plate XXVIII.—A. W. P.

Plate XXVIII.

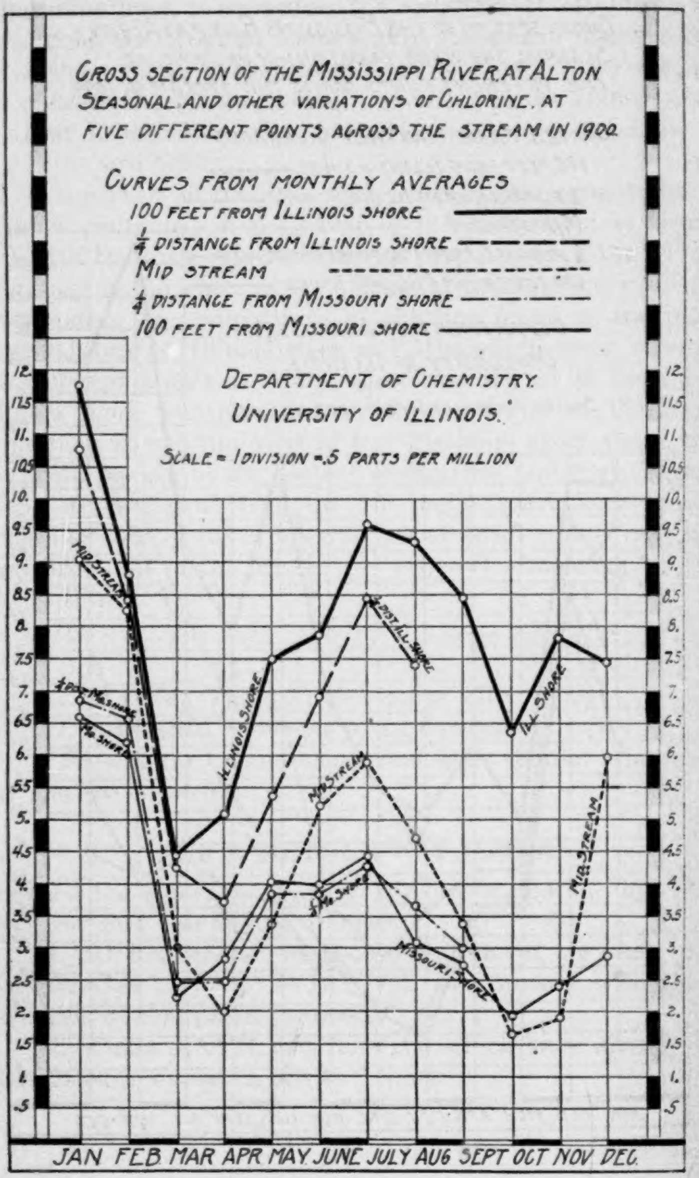


Plate XXVII, represents cross section and seasonal varia-
8804 tions in the proportions of chlorine, at five different points
across the stream, at Alton, for the year 1899 and for
the year 1900. We need not go into further discussion of those
except to say that it is monthly averages of the chlorine, which
are represented by the points of the curves of these two plates.

Next we come to plate XXIX, which has already been offered in evidence, and which is as follows:

8805 Plate XXIX.—A. W. P.

COMMINGLING OF ILLINOIS AND MISSISSIPPI.

CROSS SECTION OF THE MISSISSIPPI RIVER AT ALTON SHOWING THE RELATIVE PROPORTIONS OF UPPER MISSISSIPPI RIVER WATER AND ILLINOIS RIVER WATER AT FIVE DIFFERENT POINTS ACROSS THE STREAM. CALCULATED FROM THE AVERAGE CONTENTS OF CHLORINE AT THE FIVE POINTS, AS DETERMINED FROM WEEKLY ANALYSES THROUGHOUT THE RESPECTIVE YEARS SEE TABLES PAGES 172-191

THE LOCATION IS SIXTEEN MILES BELOW THE MOUTH OF THE ILLINOIS RIVER AND SEVEN MILES ABOVE THE MOUTH OF THE MISSOURI RIVER.

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS

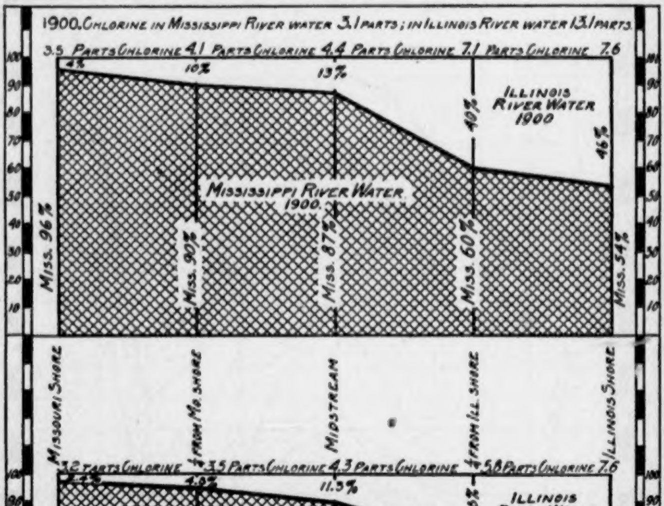


Plate XXIX represents the proportions of Illinois river
8806 water and Mississippi river water which constitute the
mixture at different points across the stream at Alton,
that is opposite the pumping station of the Alton city water
works.

The quantities of water, that is the proportional quantities of Illinois river water and Mississippi river water have been calculated from the average content of chlorine for the year for each one of the five points in the cross section. They show that comparatively little of the water of the Illinois river reaches the Missouri side of the Mississippi at this point. For the year 1899 2.4 per cent. of the water near the Missouri shore came from the Illinois river; the other 97.6 per cent. consisting of water from the upper Mississippi at the point one-fourth the distance from the Missouri shore, the Illinois river water amounted to 4.8 per cent., while the Mississippi river water was 95.2 per cent. of the mixture; at the mid-stream, that is a point midway between the two banks the proportion of Illinois river water was 11.3 per cent; that of the Mississippi, that is the upper Mississippi river water was 88.7 per cent. At a point one-fourth distance from the Illinois shore, the Illinois river water amounted to 23.5 per cent., while the Mississippi river
water amounted to 76.5 per cent. Near the Illinois shore
8807 the Illinois river water preponderated, amounting to 30
per cent. of the water passing down at that point; the
Mississippi water constituting 62 per cent. of the mixture.

For the year 1900, similar facts appear, except that there was a little more of the Illinois river water towards the Missouri shore, the percentage being four per cent. Illinois river water near the Missouri shore; 96 per cent Upper Mississippi river water.

At one-fourth distance from the Missouri shore the Illinois river water constituted ten per cent. of the mixture, while the Mississippi river water constituted ninety per cent. At mid-stream there was 13 per cent. of water from the Illinois river and 87 per cent. of water from the upper Mississippi.

At one-fourth distance from the Illinois shore the mixture consisted of 40 per cent. Illinois river water and 60 per cent. water from the upper Mississippi; while close to the Illinois shore, the mixture contained 46 per cent. of Illinois river water and 54 per cent. of water from the upper Mississippi.

It is evident from the data of the tables 51 to 62 inclusive, and is expressed graphically by the figures and the lines of this plate, that the Illinois river water does not mix perfectly with
the Mississippi river water, but passes down mainly to-
8808 ward the Illinois shore or along side the Illinois shore
on its way down stream [illegible] the bed of the Mississippi river.

Q. How far is the point at which these samples were taken from the mouth of the Missouri river?

A. This point is six to seven miles above the mouth of the Missouri river.

Q. State whether the mixing of the waters of the Illinois and Mississippi rivers is completed by the time they reach the mouth of the Missouri river?

A. From certain analyses of samples of water taken in the Mississippi river about half a mile above the mouth of the Missouri river, it is my opinion that the mixing of the water of the Illinois with the water of the Mississippi is by no means complete by the time these bodies of water reach the mouth of the Missouri.

Q. Upon what basis could you calculate the proportional mixing of the waters of the Mississippi, the Missouri and the Illinois at the chain of rocks where the St. Louis intake is located?

A. In my opinion there is no thoroughly satisfactory basis for a calculation of the relative proportions of Illinois river water, Mississippi river water and of Missouri river water, in
the mixture which pases the intake tower of the St. Louis
8809 waterworks, but for such calculations the chlorine con-
tent would in all cases be the most satisfactory basis because the chorine is not a variable constituent, or rather does not vary from causes which bring about variations of all other constituents which it is customary to determine in sanitary water analysis.

Q. Would it be practicable to calculate the mixing of the waters of the three rivers at the chain of rocks from the proportions of free ammonia?

A. It would not, because free ammonia changes, sometimes rapidly, sometimes slowly, but does change as a result of decomposition of organic matters contained in the water, in a way totally different from chlorine and it could not be assumed with good reason that a quantity of free ammonia found at one point or at one time would not change from processes going on within the water. On the other hand, chlorine does not change from any processes going on within the water itself, but only through the addition of more chlorine by the introduction of liquids or substances foreign to the water itself, or by concentration due to evaporation of the water containing the chlorine.

Q. Would it be practicable to calculate the mixing of the waters of these three rivers from the proportions of
8810 nitrites?

A. It would not for reasons similar to those just stated with reference to the ammonia. The variability of the proportions of nitrites standing in the way of the nitrites constituting a reasonably safe basis for calculation of the quantities of the water and the mixing of waters containing originally different proportions of nitrites.

Q. Would it be practicable then to calcuate the mixing of the waters of these three rivers from the proportions of total solids?

A. It might be; in case the proportions of total solids were sufficiently different in the three streams which were coming together, but even then there would be very great difficulties in the way of making a reasonable approximate calculation or a reasonable approximation of the true proportions, for the reason that the total solids include matters which are in suspension, and which by reason of variations in velocity of the stream, variations in the character of the material lying in the bottom of the stream and constituting the banks of the stream, which cause variations in the proportions of suspended matters even within short distances.

Q. What reliability could be placed upon a calculation as to the mixing of the waters of these three rivers from the proportions of suspended matters?

8811 A. That would be unsatisfactory for the reason just stated in referring to the possibility of calculating the

mixing from the total solids, which total solids of course include the suspended matters. The different velocities at different times in the year and at different points even within short distances of each other, and the different character of the material with which the water is in contact, bring about in many cases a deposition of much of the suspended matters, forming as is well known, sand-bars and other deposits in the stream, and on the other hand, where the character of the banks or of deposits in the bed of the stream are such that they can be easily removed by water, oftentimes the water picks up and holds in suspension considerable quantities of foreign matters which it may derive not from tributaries at some distance, but from localities and deposits quite near to the point at which determinations are made. That is to say, there is no certainty and in this particular case there would be no certainty that the quantities of suspended matters found in the waters of the Illinois at Grafton would proceed down in the Mississippi river to the St. Louis water works. There is no certainty that the quantities of suspended matters contained in the waters of the Mississipi above the mouth of the Illinois would remain in those waters until such time as this body
8812 of water reaches the intake of the St. Louis waterworks,
and there is no certainty that such suspended matters as are contained in the waters of the Missouri river above its junction with the Mississippi remain in that water until such time as it reaches the intake tower of the St. Louis water works; for these reasons: Calculations based upon the suspended solids and upon the total solids which include suspended solids, have no sound basis in fact, and on the other hand, at times the body of water passing down the bed of the Mississippi above the mouth of the Missouri may between the mouth of the Illinois and the mouth of the Missouri pick up and hold in suspension matters which would then be in excess of the quantities found in the waters of the Illinois and of the Mississippi at and above Grafton, and likewise the mixture of the three bodies of water between the mouth of the Missouri river and the intake tower of the St. Louis waterworks, may in this stretch of six or seven miles,—perhaps eight or nine miles, pick up from the sand-bars and the banks of the river, sus-

pended matters which were not contained at this time, at least, in the waters of either the Missouri or the Illinois or the Mississippi.

Hence, in my opinion, it is totally impracticable to calculate the relative proportions of water from these sources contained in the mixture passing down the Mississippi river 8813 beside the intake tower of the St. Louis waterworks, though by general study of all these constituents of the water, it is practicable to get a general idea as to the relative quantities constituting the mixture at this point, that is to say, a rough general approximation may at times be arrived at by consideration of all these constituents, as the basis for a calculation, but only a rough general approximation, can in my opinion be arrived at from these considerations—

MR. JEFFRIES: In view of what the witness has just stated with reference to the uncertainity of the disappearance of nitrogen as albuminoid and free ammonia, and as nitrites and nitrates, and of the suspended matter, and total solids, and the uncertainty of their appearance as well as disappearance, in the various forms, we move to strike out all of the testimony of this witness because it is immaterial, incompetent and irrelevent, and because of the uncertainties to which the witness has called attention and stated in evidence, it is unreliable and can be considered of no value or importance in passing upon the questions at issue in this case.

JUDGE SPRINGER: The objection of the counsel goes only to the weight of the evidence, and it also fails to state what the witness was showing by the statements just made, in reference to the presence of these constituents in 8814 water. They were submitted for the purpose of showing their unreliability as a basis for determining the exact mixing of the waters of the several rivers at the St. Louis intake and not for the purpose of showing their reliability as factors in this case.

MR. JEFFRIES: Then if unreliable for the purposes of showing the relative proportion of water passing down the three rivers, they must necessarily be unreliable as determining the presence or nonpresence of Chicago sewage at Grafton or at any other point where samples were taken and analyzed, for the reason that if they do not at all times correctly show the condition of the water with reference to its chemical constituents then such testimony should not be considered by the Court in determining whether or not the sewage of Chicago passes down the Illinois river and the Mississippi river and thence along the Missouri shore.

JUDGE SPRINGER: Counsel misapprehends the object of this testimony. It is not to show that these elements are not present, but it is to demonstrate the unreliability of these factors in determining how much of the water of one stream is at a particular point in the Mississippi river—at the chain of rocks.

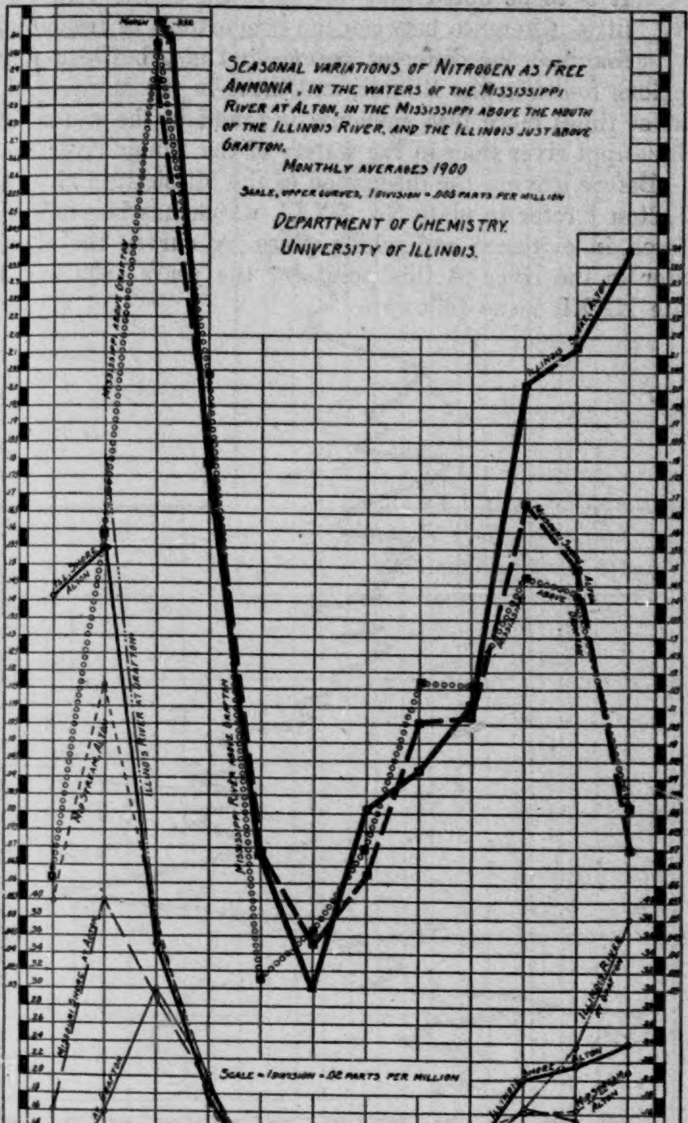
MR. JEFFRIES: For the information of counsel I will state that I understand the question and I understand 8815 the answer of the witness and I state again that if the chemical constituents to which the witness has referred are not of sufficient reliability to determine the proportionate quantities of water at the particular place mentioned in the question and in the answer, they are not of sufficient reliability to determine the chemical condition of the water at any point in the river, and therefore the chemical information that is obtained from the data which the witness has introduced in evidence, is unreliable in that it does not correctly determine the chemical condition of the water at that place.

JUDGE SPRINGER: Counsel's objection is merely argumentative and not available for any purpose. It would only go to the weight of the testimony, and as we are not now weighing this testimony but taking it, we will submit those questions to the Court in the trial of this case.

Q. Professor, proceed with your answer?

A. The seasonal variations of free ammonia and also the cross section variations of free ammonia at Alton are shown in part upon plate XXX, which is as follows:

Plate XXX.—A. W. P.



SEASONAL VARIATIONS OF NITROGEN AS FREE AMMONIA, IN THE WATERS OF THE MISSISSIPPI RIVER AT ALTON, IN THE MISSISSIPPI ABOVE THE MOUTH OF THE ILLINOIS RIVER, AND THE ILLINOIS JUST ABOVE GRAFTON.

MONTHLY AVERAGES 1900

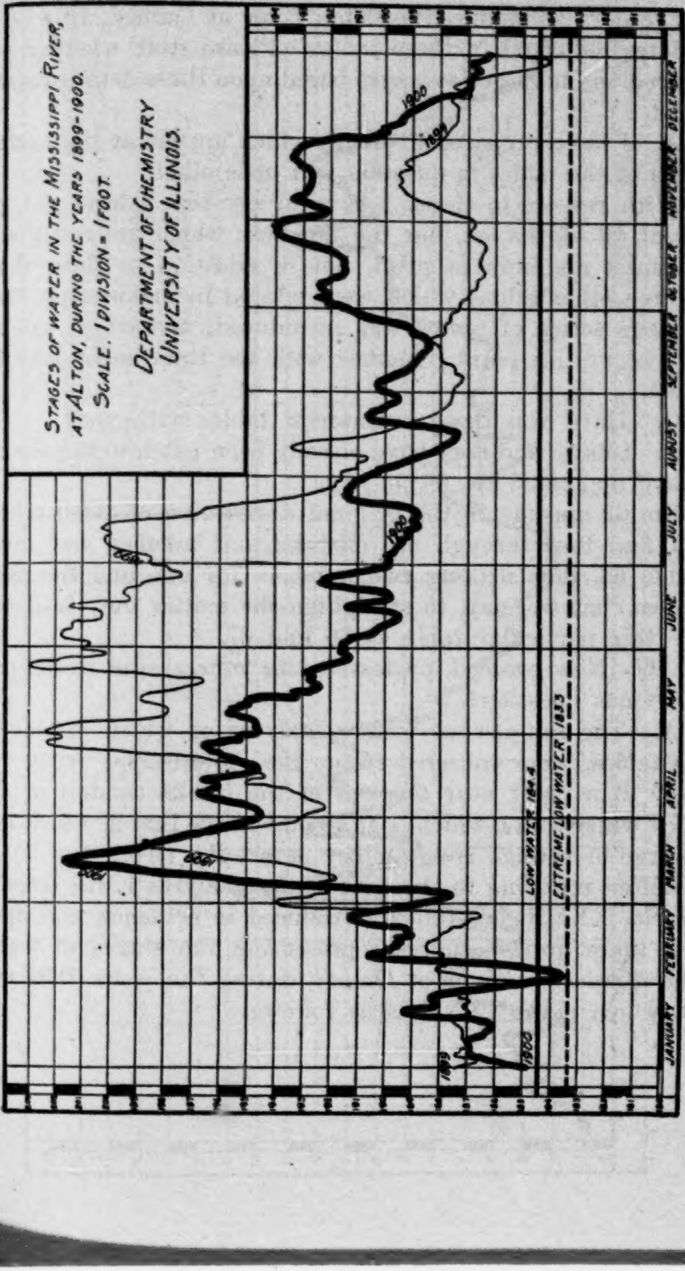
SCALE, UPPER CURVES, 1 DIVISION = .005 PARTS PER MILLION

DEPARTMENT OF CHEMISTRY.
UNIVERSITY OF ILLINOIS.

It is to be noted that during much of the year there is
8817 little difference between the proportions of free ammonia found at the different points, and also between the proportions found in the Illinois, and those in the Mississippi, and that at times more free ammonia is found in the waters of the Mississippi river than in the waters of the Illnois river.

Before leaving the discussion of the Mississippi river water at Alton I refer to plate No. XXXI, which has heretofore been offered in evidence and which gives by curves the stages of water in the river at this point for the years 1899 and 1900; plate XXXI, is as follows:

Plate XXXI.—A. W. P.



Q. Professor, I call your attention to tables Numbered 63,
8819 64, 65, and 66, which contain chemical examinations of
waters from the Mississippi river at Quincy, Illinois at the dates indicated in these tables. Please state whether you prepared any tables of averages based upon these detailed statements?

A. I have prepared averages which appear at the bottom of each of the tables in question, but none other.

With respect to these, I have to say that I have not got in print all of the set, but the numbers which are mentioned by counsel are here in print, but in addition to these there are three other tables which were offered in manuscript when the entire series of plates was introduced, and which are referred to at this point, together with the three mentioned by counsel.

Q. Have you those manuscript tables with you?

A. I have, and they have already been put into the record, and are numbered 68, 69 and 70.

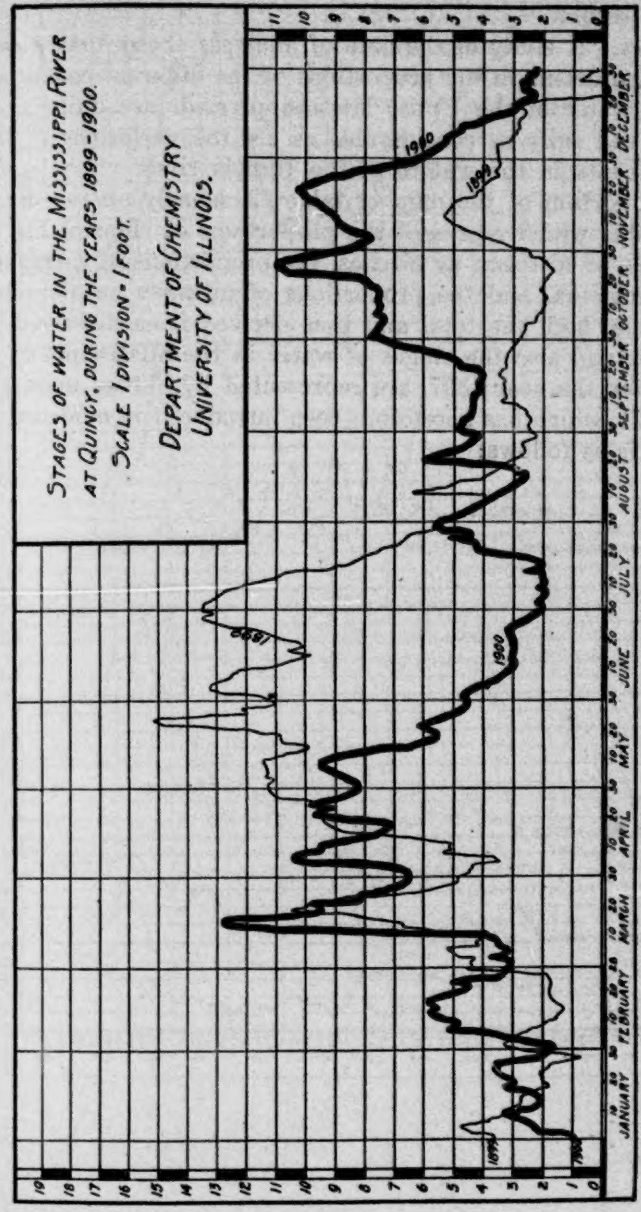
No. 67 appears in the original description of these tables, but I find that through my mistake that number was given to table 66, thus making two numbers for one and the same table, so that we may, to straighten the matter out, designate this particular table as 66 and 67.

8820 Q. Now proceed, professor with your answer to the previous question?

A. The samples of water, analyses of which appear in these tables, were collected from the Mississippi river at Quincy at a point near the end of the intake conduit of the Quincy waterworks, which is at a point above that at which any discharge of sewage from Quincy enters the river.

Before referring to the data of the analyses I will refer to plate No. XXXII, heretofore introduced in evidence, and upon which there appear ~~curves~~ representing the stages of water in the Mississippi river at Quincy during the years 1899 and 1900, which plate XXXII is as follows:

8821 Plate XXXII.—A. W. P.

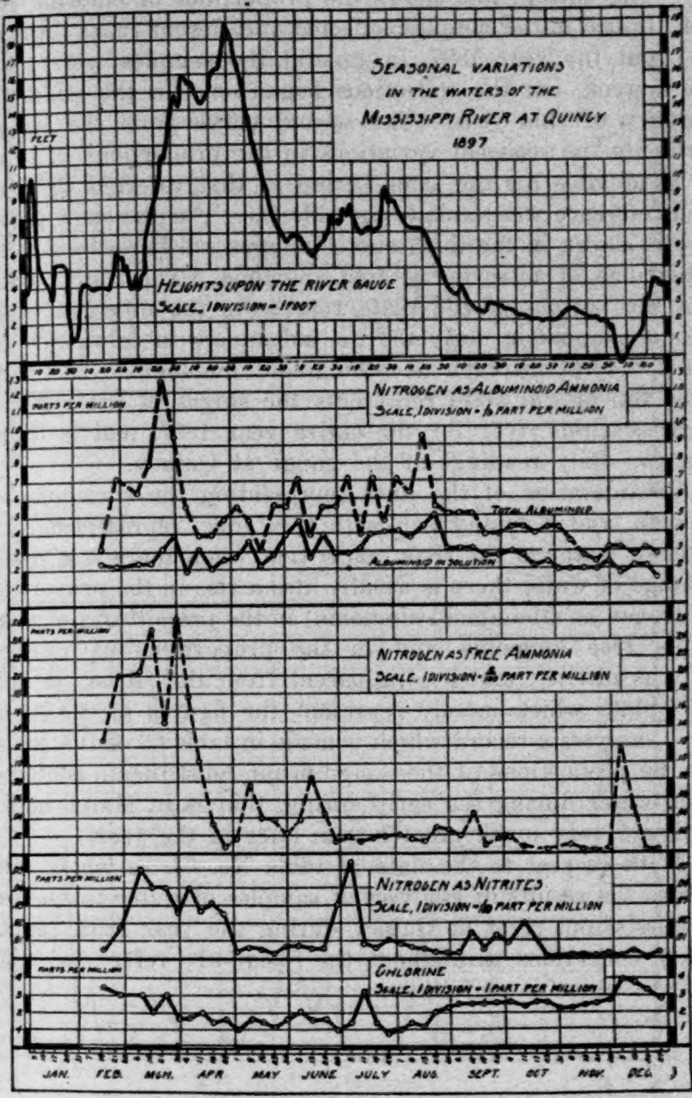


Q. What significance do you attach to these tables, professor? 8822

A. A study of the data of analyses shows that the seasonal variations in the proportions of the different constituents of the water of the Upper Mississippi river are quite as frequent and fully as considerable as are the variations of these constituents in the waters of the Illinois river.

A portion of the data of table 63, namely all the data of that table which represent the proportions of chlorine the proportions of nitrogen as nitrites, the proportions of nitrogen as free ammonia, and the proportions of nitrogen as albuminoid ammonia, both the total and that derived from dissolved substances, and also the stages of water in the Mississippi at this point for the year 1897, are represented by curves upon plate XXXIII, which has heretofore been introduced in evidence, and which is as follows:

8823 Plate XXXIII.—A. W. P.



The bottom line shows the proportions of chlorine con-
8824 tained in the samples collected at different times through-
out the year 1897, in general the samples were taken once a week, but the collections began only in the middle of February of this year. The second curve from the bottom represents the seasonal variations in the proportions of nitrogen as nitrites for the same period as that referred to above when reference was made to the chlorine. For the same period there is shown in the third curve the seasonal variations in the proportions of nitrogen as free ammonia. The fourth curve from the bottom of the plate represents the nitrogen as albuminoid ammonia derived from substances in solution. The fifth the total nitrogen as albuminoid ammonia. The curve at the top of the plate represents the stages of the water in the Mississippi river for the entire year 1897, and is drawn from the daily readings of the gauge at Quincy.

Consideration of the lines representing the chemical constituents, and a comparison with the line representing the stages of water in the river, show that when there is a rise in the stage of water there is usually also a rise in the proportions of nitrogen as albuminoid ammonia; in the proportions of nitrogen as free ammonia and in the proportions of nitrogen
as nitrites, and it is apparent from the lines in this
8825 plate which merely represent the figures of the actual
analyses a record which is made in table 63 of this series, that the proportions of these significant constituents contained in the water during the early spring, that is in March and in April, are very much greater than later in the year.

With respect to the data of table No. 64, in which there is given the results of analyses of samples of water taken from the Mississippi river at Quincy during the year 1898, regular weekly collections throughout the year—I refer to plate XXXIV, which is as follows:

Plate XXXIV.—A. W. P.

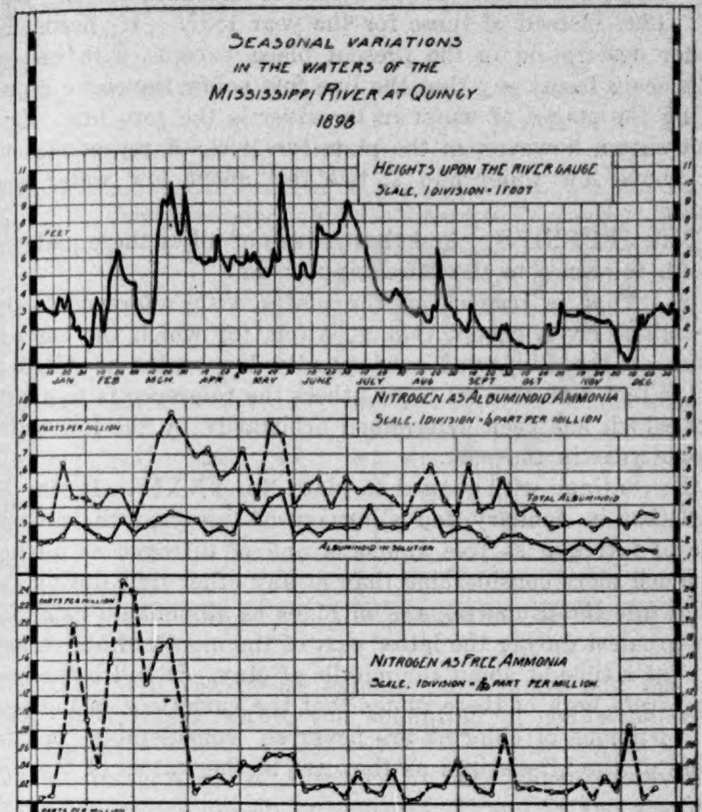


Plate XXXIV is similar in all repects to plate No.
8827 XXXIII, except that it refers to the data for the year
1898 instead of those for the year 1897. It needs no further description in the present place, except—with respect to the scale I may say that the line just below the curve representing the stages of water in the river is the zero line. Zero is not shown however, in the plate for 1898,—1 represents one foot above low water and 2, two feet above low water, and so on.

MR. JEFFRIES: And that is true of all of these plates is it, with reference to the Mississippi river?

A. That is true of all the plates with reference to the Mississippi river, except that at Alton, for which the basis is Biloxi, on the Gulf, and consequently low water at Alton is put 184 feet, but with all these others the reference is to a zero point which has been determined arbitrarily by the low water in some year in the past.

To continue with regard to plate No. XXXIV. It may be noted that in January and February of this year the proportions of nitrogen as free ammonia and of nitrogen as nitrites was much more considerable than at any other time during the year, while the proportions of nitrogen as albuminoid ammonia were greatest during the latter part of the month of March and
at a time at about the middle of May. It will be noticed
8828 from both of these plates that the variations in the proportions of chlorine are never so considerable in the waters of the Mississippi as they are in the waters of the Illinois.

Comparison of the data for the Mississippi river at Quincy with those for the same stream at Grafton show substantially a similarity of the water at these two points, more than 100 miles apart, both as to the proportions of the different constituents and the variations of the same.

Q. JUDGE SPRINGER: Professor, I now call your attention to tables numbered 71, 72 and 73, of the series now under consideration which contain chemical examinations of the waters from the Kanakakee river at Wilmington in the State of Illinois. Please state whether you have prepared any table of averages based upon the detailed data in these tables?

A. I have, and it is defendants' table of Averages No. 12, and is as follows:

8829

DEFENDANTS' TABLE OF AVERAGES NO. 12.—A. W. P.

TABLE VII.

CHEMICAL EXAMINATION OF THE WATERS OF THE KANKAKEE RIVER AT WILMINGTON. YEARLY AVERAGES. PARTS PER MILLION.

Year	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
		Total	By Dissolved	By Suspended Matter	Free Ammonia	Albuminoid Ammonia.			Total	Dissolved	Suspended	Nitrites	Nitrates
						Total	Dissolved	Suspend'd					
Jan.-Dec. 1896	2.4	13.8	....	....	.072	.491	......	......	1.1	......	......	.023	1.95
Jan.-May 1897	2.1	14.8	10.4	4.4	.03	.45	.352	.098	1.01	.65	.16	.0219	2.00
June-Dec. 1899	3.8	11.1	9.2	1.9	.075	.371	.265	.106	.886	.594	.292	.011	.072
Jan.-Dec. 1900	3.2	10.9	8.2	2.7	.059	.335	.247	.108	.863	.576	.287	.013	2.26
Av'e	2.88	12.65	9.3	3.	.059	.419	.288	.104	.965	.607	.249	.017	1.618

Q. Will you please explain these tables and the table 8830 of averages which you submitted in connection therewith?

A. In the table of averages No. 12, I have the averages of the data which appear in tables 71, 72 and 73 and also averages of analyses of waters of the Kankakee river collected at Wilmington during the year 1896, the data for which appear in my preliminary report which has been heretofore presented as defendants' Exhibit A for identification.

With respect to the data of these analyses I would say that the samples of water were collected at Wilmington a point ten or twelve miles from the mouth of the Kanakakee river, and that the data of the analyses may be regarded as fairly representing the condition of the water of the Kanakakee river as it is about to unite with the water of the Desplaines river. Until the Chicago main drainage channel was opened, the sew-

age discharged through the Illinois and Michigan canal met with its first notable dilution, usually only upon mixing with the waters of the Kankakee for although at times the flood flow in the Desplaines would for a few days equal or even exceed the main flow in the Kanakakee, that is, would amount to 300,000 to 400,000 cubic feet per minute, and at times even amount to twice this quantity, and would dilute the
8831 waters discharged from the Illinois and Michigan canal
eight to ten and even sixteen to twenty times, yet the mean flow of the Desplaines for the year is but one-fifteenth to one-tenth that of the latter stream, and the ordinary low water flow is proportionally even less.

Inspection of the figures of the detailed analyses show that there are notable variations in the composition of the waters of the Kanakakee during the year. In general the variations are greatest in the spring of the year when freshets bring down much suspended matters, both mineral and chemical, but it will be noticed that there is a considerable diminution in the proportions of nitrates during the warm summer months; this diminution being in part the result of the growth of vegetation in the flowing waters of the stream; in part the result of the simulation of nitrates by the vegetation of the head waters in the Kankakee marshes, which during this portion of the year constitute the chief source of supply. The higher nitrates during the high water season are in part due also to the leeching of nitrates from the soil by the run-off, and the discharges from tile drains, both of which occur chiefly during the seasons of lower temperature and greater precipitation, which are consequently of course the seasons of
8832 high water.

With respect to these variations in the waters of the Kankakee I refer to plate No. XXXV heretofore offered in evidence, but which has not been made up into a plate and printed, and I have but this one plate. The plate will be made and copies will be introduced. This plate is as follows:

(Copy not subsequently furnished, F. S. B., Com'r.)

Seasonal variations in the Kankakee river at Wilmington; there are two sets of curves upon it; those at the left hand representing the proportions of nitrogen as nitrates; those at the right hand representing the proportions of nitrogen as free ammonia, the bottom curve of each set gives the data, or is drawn from the data in the tables referring to the year 1896. The second set of curves covers but fractions of the years in question, the years 1897 and 1895.

The third set represents these constituents for the year 1899 covering the period from the beginning of June, 1899 to the end of December. In connection with this set of curves, there is given at the left hand of the plate a curve representing the stages of water in the Kankakee river at Wilmington for the first nine months in the year 1900, where the stages of water are represented in feet above the zero.

The fourth sets of curves upon this table, namely those at the top of the plate, give at the left hand the proportions
8833 of nitrogen as nitrates contained in the waters of the
Kankakee river at Wilmington as found by the analyses of samples collected during the year 1900; the curves at the left are two in number.

The continuous line represents the proportions of nitrogen as free ammonia contained in the water of the Kankakee river at Wilmington, as found by analyses of samples collected throughout the year 1900.

The second curve and the broken line represents the temperatures of the water during the first six months of the year 1900. That is the temperature of the water in the Kankakee river at Wilmington at the time the samples for analyses were collected.

The lines upon the plate serve to illustrate the statements made above respecting the variations of the nitrogen as nitrates, and the other constituents of the water of the Kankakee at Wilmington. The organic matters contained in the waters of this stream are almost entirely of vegetable origin, for no considerable amount of sewage is discharged into this stream. That of Kankakee, with a population of nearly 14,000—it is given here 13,995—about 35 miles from the mouth and 25 miles above Wilmington, the point at which collection was made, being the most important place upon the watershed of the
8834 Kankakee river.

Q. Professor, I now call your attention to tables numbered

74, 75, 76 and 77, which contain chemical examinations of water taken from the Fox river at Ottawa, Illinois at the times indicated on those tables. Please state whether you prepared a table of averages based upon these tables?

A. I did, and it is contained in defendants' table of Averages No. 6, which contains also the similar averages for the waters of the Illinois river at Ottawa, and has already been introduced.

Q. Will you please explain these detailed data and also the table of averages based upon them?

A. The Fox river is the largest tributary of the upper Illinois proper and next to that of the Kankakee its discharge is the most important diluting factor of the upper Illinois. Its discharge is more uniform in volume than that of the Desplaines river and is greater in proportion to its water-shed area. The samples for analyses were collected above the town of Ottawa and above the aqueduct which carries the water of the Illinois and Michigan canal across the stream, the reason being that this aqueduct leaks and discharges water from the Illinois and Michigan canal into the Fox river at a point a short distance within its mouth.

8835 The waters of the Fox are rather highly charged with organic matters which are mainly derived from the vegetation which is abundant in this stream, particularly in the marshes and shallow lakes which constitute the chief source of its head water supply. The stream receives the sewage and manufacturing wastes of a number of towns, of which Elgin, with a population of 22,433, and Aurora, with a population of 24,147, are the largest. Between these two towns is the town of Geneva, where there is a large glucose works, and in which 40,000 carloads of corn are used annually, the wastes from which—probably at least 150 tons of highly nitrogenous organic refuse daily, are discharged into the river. Below Aurora, comparatively little sewage and wastes enter the stream and there is considerable opportunity in the flow of 50 miles, between Aurora and the mouth, for the natural purifying processes to exert their influence in bettering the condition of the water. The averages which appear in table 6, contain the data of tables 74, 75, 76 and 77 in the form of general averages, and also an average for the entire three years represented, that is the years 1898, 1899, and 1900.

MR. JEFFRIES: I move to strike out what the witness said with reference to the extent of the pollution in the river at this point for the reason that he has not disclosed the source of his information.

8836 JUDGE SPRINGER: The witness may now state the source of his information if he desires to do so.

A. I was informed by an individual connected with the management of the concern in question referred to, who first told me personally that about 40,000 car-loads of corn were used annually there, and that the refuse was discharged into the river, and he subsequently confirmed his information in Geneva and wrote me to the same effect. I have further been informed by the president of the Fish Commission of the State of Illinois that such quantities of corn are used in the works at Geneva, and that the refuse is discharged into the Fox river and that it kills the fish in the Fox river.

MR. JEFFRIES: I move to strike out all that the witness has said with reference to his source of information for the reason that it is utterly hearsay, and is not based upon facts from the mouths of witness in such manner as to give us an opportunity to cross-examine those witnesses with reference to the correctness of the statements. The witness has clearly disqualified his statement in his testimony in that respect.

JUDGE SPRINGER: State, professor, whether or not these data were collected by you as a part of your duties as head of the chemical department of the University of Illinois.

MR. JEFFRIES: Now I object to the witness making
8837 any such statement or giving any such testimony for the reason that there is nothing included in the statute designating the particular duties of the University of the State of Illinois, or the chemical department of that University requiring the witness to ascertain facts of this character, and for the further reason that even though the witness did embody these statements which he has just read in evidence, in his report, he has by his statement as to the manner of obtaining the information, disqualified such statements so far as being

evidence in this case or so far as the competency of such statements is concerned.

JUDGE SPRINGER: I submit that the authority conferred by the legislature of Illinois upon the University of Illinois, in reference to the examination of the waters of the State, is sufficient to authorize this witness as the head of the chemical department of the University to collect these data from the most reliable sources, and if he deems the sources sufficiently reliable to incorporate them in his official report, he may do so, and that as they are a part of his official report, the objection goes simply to the weight of the evidence and not to its competency, and would more properly have been brought out on cross-examination and not as an objection to the introduction of the evi-
8838 dence.

MR. JEFFRIES: I submit to the Court that the witness was not reading in evidence nor offering in evidence his report, but testifying as to facts concerning the case at issue, and we have a right to have the witnesses who are acquainted with those physical facts, before us, in order that we may cross-examine them and I object to this witness stating what any other person, whether he be an officer or what not, said, or told him with reference to the conditions about which he is testifying, and I will state further that if it is the purpose of the defense to offer the report of this witness to the University of the State of Illinois in evidence, that there is a proper way to do it, but that it is not competent for this witness to read from that report statements in evidence which bear the resemblance of having been collected accurately and personally by this witness without reference to his duties as a member or as one of the faculty of the University of the State of Illinois.

(Last question repeated).

8839 (Question repeated).

A. They were; as a part of my duties as head of the department of chemistry of the University of Illinois and in charge of the survey of the waters of the State of Illinois, the chemical survey of the waters of Illinois.

JUDGE SPRINGER: Go ahead professor.

MR. JEFFRIES: For the reasons just stated I object to the witness testifying to any such facts on the ground that it is not competent testimony.

THE WITNESS: I am through with that.

JUDGE SPRINGER: Now I call your attention professor, to tables 78 and 79 of this series which contain chemical examinations of waters from the Spoon river at Havana, Illinois, at the time indicated in these tables. Please state whether you made the averages or prepared the table of averages based upon these data?

A. I did. There are averages at the bottom of the table in question numbered 78, 79 and 80, the latter of which appears only in manuscript and covers a portion of the year 1899, extending from January 3rd to May 30, this latter, that is table 80, has not been incorporated in the tables of averages No. 14, but there appear in that table in addition to the averages for the Spoon river for the years 1897 and 1898, also the average
for the year 1896, the detail data of which appear in my
8840 preliminary report heretofore offered for identification
as Defendants' Exhibit A.

Collections were made in the Spoon river at a point within about a half a mile of the mouth. Spoon river drains a watershed area of about 1870 square miles, but as there are no very considerable towns situated upon the stream of its watershed, it receives but little sewage and may be regarded as one of the least polluted of the natural streams of the state.

Q. Did you make any chemical examinations of the waters taken from the Big Vermillion river, which is one of the tributaries of the Illinois river?

A. I did. Most of these examinations however, have already been reported in my testimony with reference to the streams examination report. The table of averages No. 13 A. W. P. contain the averages for the years 1899 and 1900, details of which are given in the set of tables 1 to 80 inclusive referred to above as being testified to as part of the streams examination report, and in addition, there is a set of averages for the year 1896, which have been taken from the preliminary report heretofore offered for identification and referred to as defendants' exhibit A.

8841 THE WITNESS: Table 13 is as follows and table 14 follows 13.

DEFENDANTS' TABLE OF AVERAGES NO. 13.—A. W. P.

TABLE XI.

CHEMICAL EXAMINATION OF THE WATERS OF THE BIG VERMILLION RIVER AT LASALLE. YEARLY AVERAGES. PARTS PER MILLION.

Year	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen			Nitrogen as	
		Total	By dissolved	By suspended matter	Free ammonia	Albuminoid Ammonia. Total	Albuminoid Ammonia. Dissolved	Albuminoid Ammonia. Suspend'd	Total	Dissolved	Suspended	Nitrites	Nitr es
Jan.-Aug. 1899.	11.9	4.9	......	......	.03	.245	......	......	.661	......	......	.035	4.5
May-Dec. 1899.	61.9	6.4	4.9	1.5	.254	2.44	.159	.085	.639	.406	.243	.022	.81
Jan.-Oct. 1900.	16.4	7.3	4.8	2.5	.112	.258	.146	.113	.595	.314	.281	.018	3.2

8842

DEFENDANTS' TABLE OF AVERAGES NO. 14.—A. W. P.

TABLE XIV.

CHEMICAL EXAMINATION OF THE WATERS OF THE SPOON RIVER AT HAVANA. YEARLY AVERAGES. PARTS PER MILLION.

Year	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as	
		Total	By Dissolved	By Suspended Matter	Free Ammonia	Albuminoid Ammonia. Total	Albuminoid Ammonia. Dissolved	Albuminoid Ammonia. Susdend'd	Total	Dissolved	Suspended	Nitrites	Nitrates
1896	4.4	7.3	......	......	.119	.351	......	......	.806	......	......	.04	1.6
1897	3.7	13.1	......	......	.148	.58	......	......	1.04	......	......	.047	1.8
1898	3.4	14.8	......	......	.119	.603	......	......	1.47	......	......	.036	.6
Av'e	3.8	11.8	......	......	.129	.511	......	......	1.10	......	......	.041	1.0

The Big Vermillion is a most important tributary be-
8843 tween Ottawa and Peoria; the discharge varies between wide limits, but it is an important factor as a diluting agent, only during the freshet season. In the drier season its flow is practically nothing but sewage, derived mainly from the towns of Pontiac and Streator, and from the drainage of factories and mines upon its banks; the stream is used as a source

of water supply for the towns of Pontiac and Streator, and during much of the year the entire flow of the stream above these towns is used for water supply, and then is discharged again into the stream as sewage below the respective towns. The samples for analyses were collected about a half a mile within the mouth of the stream, the mouth being about three miles above the wagon bridge at LaSalle.

Q. Now professor, you may submit such suggestions as occur to you in comparison of the waters of the tributaries of the Illinois river with the river itself?

A. Comparison of the detailed data of the analyses of the water of the Illinois at Averyville and at Grafton, with the data of the analyses of the waters of the tributary streams, shows that the latter are subject to seasonal variations which in most respects are as great as are those of the Illinois. Comparison of the yearly averages which are given in defendants' tables of Averages No. 15, A. W. P., shows that the proportions of organic matters as represented by oxygen consumed, albuminoid ammonia and total organic nitrogen are even 8944 more considerable in the waters of the larger tributaries than in the waters of the Illinois at Grafton, and the general averages for the six tributaries examined are substantially equal to the averages for the Illinois for 1900, 1901 and 1902.

MR. JEFFRIES: Now I move to strike out that statement for the reason that there is no evidence to show the places at which the samples of water were taken in the Illinois river with reference to the large sources of pollution on this river as testified to by witnesses for the defendants, so that the analyses of water obtained from the tributaries and those obtained from the Illinois river proper were not so taken with reference to the sources of pollution as to be comparable.

JUDGE SPRINGER: I desire to suggest that the samples as appears from the testimony of the witness, were taken in these tributaries at a point so far from the mouth of the respective rivers as not to receive any mixing of the waters of the main stream, and that these points indicate the conditions of the waters of the tributaries as they enter the main bed of the Illinois river.

MR. JEFFRIES: I object to Judge Springer testifying in

this case. The evidence of the witnesses for the defense, shows for itself, that is, the evidence of the witnesses introduced
8845 and sworn in the case is the only evidence that the court has in order to determine the distances from the mouth of the tributaries that the samples were taken and the court is not to be guided by what counsel may say upon that subject.

JUDGE SPRINGER: I was merely calling the attention of counsel to what the witness had already stated.

MR. JEFFRIES: I am much obliged to counsel for calling my attention to it, but I think I understood what the witness testified to about taking the samples, both from the Illinois and the tributaries.

JUDGE SPRINGER: Proceed now with your statement, professor.

THE WITNESS: I should have explained before, that in the tables of averages there is also given averages of analyses of samples collected from the Sangamon river at Chandersville, details of which have been given in the set of tables 1 to 6 inclusive, offered in the report of Streams Examinations for the Sanitary District.

In the table of averages it appears that the free ammonia and nitrites however, are in general more abundant in the waters of the Illinois river than they are in the tributary streams although three of the latter carry practically as much or more in nitrates as does the Illinois, thus, the proportions of nitrites contained in the water of the Illinois at Grafton during the years 1900 to 1902 being .03 parts per million; the aver-
8846 age for the water of the Big Vermillion during the years 1896, 1899 and 1900 was .025, but little less and during the years 1896, 1897 and 1898, the waters of the Spoon river contain nitrogen as nitrites in the proportion of .041 parts per million, while the waters of the Sangamon contained on the average for the years 1890 and 1900, nitrogen as nitrites in the proportion of .032.

A portion of the data included in this table of averages No. 15 A. W. P., have been used in the preparation of plate No. XXXVI, which is the duplicate of the one introduced in an earlier report, and which itself has been introduced in my testimony. The plate represents by means of columns the proportions, or the various constituents as chlorine, oxygen consumed, nitrogen as free ammonia, and nitrogen as nitrates. In the Illinois river at Averyville and at Grafton, in the Kankakee river at Wilmington, the Fox river at Ottawa, the Big Vermillion near LaSalle; the Sangamon river at Chandersville for the four months period, June, July, August and September, 1899 and 1900, and as this has been discussed elsewhere, it is not necessary to do more than to refer to it at this point.

Table No. 15 is as follows:

8847

DEFENDANTS' TABLE OF AVERAGES NO. 15.—A. W. P.

COMPARISON OF THE WATERS OF THE ILLINOIS WITH THE WATERS OF ITS TRIBUTARIES. AVERAGES. PARTS PER MILLION.

Stream.	Chlorine......	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS	
		Total........	By Dissolved...	By Suspended Matter	Free Ammonia	ALBUMINOID. AMMONIA.			Total......	Dissolved......	Suspended......	Nitrites......	Nitrates....
						Total......	Dissolved.	Suspend 'd					
Des P. 1 1899	7.7	12.9	11.4	1.4	.129	.481	.379	.102	.907	.782	.262	.01	.36
Kkk. 2 1896-1900	2.88	12.6	9.3	3.3	.059	.419	.298	.104	.965	.673	.249	.017	1.82
Fox 1898-1900	6.36	9.6	7.6	2.	.083	.407	.27	.137	.86	.533	.327	.014	.42
Big V. 3 '96-99-1900	31.	6.2	4.9	2.	.165	.249	.155	.094	.632	.36	.272	.025	3.
Spoon 1896-7-8	3.8	11.8	......	....	.129	.511	......	......	1.105	......	......	.041	1.19
Sangamon 1899-1900	5.3	8.6	4.9	3.7	.111	.293	.15	.145	.751	.354	.397	.032	1.23
Average	......	10.3	7.6	2.5	.113	.38	.248	.115	.885	.54	.302	.023	1.366
Ill. G. 4 1900-2	12.6	10.7	7.4	3.3	.322	.37	.22	.149	.957	.512	.444	.03	1.237
Ill. G. 4 1899	14.73	12.6	8.3	4.3	.313	.479	.247	.232	1.148	.590	.552	.045	1.063
Ill. A. 5 1900-01	17.5	8.5	6.6	1.4	.643	.286	.212	.076	.727	.535	.187	.08	1.46
Ill. A. 5 1897-8-9	30.2	11.1	8.76	2.4	.909	.466	.336	.13	.98	.72	.262	.194	1.351

1. Desplaines. 2. Kankakee. 3. Big Vermillion. 4. Illinois at Grafton. 5. Illinois at Averyville.

Q. You will please institute any further comparisons
8848 which you may have made based upon these tributaries of the Illinois river for points along the Illinois river itself?

MR. JEFFRIES: I move to strike out all comparisons and inferences that have been drawn by this witness upon the tables of analyses of waters in the tributaries of the Illinois river and the waters of the Illinois river, for the reason that the same is incompetent, irrelevant and immaterial and have no bearing upon the issues involved in this case, and for the further reason that the statement of the witness with reference to these tributaries being diluting factors, is not borne out by the evidence for the reason that the evidence as summed up by this witness shows the tributaries to be as greatly polluted as the Illinois river itself and for the further reason that the tributaries of the Illinois river thus shown in evidence are situated upon the natural water-shed of the Illinois river and there is no complaint alleged in the bill in this case against persons, cities or enterprises polluting the waters tributary to the natural watershed of the Illinois and Mississippi rivers, and that the fact that the tributaries of the Illinois river are thus polluted as stated by the witness is no justification for Chicago to discharge its sewage into the river or burden it with polluted material from its home watershed.

8849 JUDGE SPRINGER: I desire to call the attention of counsel to the fact that Dr. Teichmann in his testimony in this case on the 17th of March I think it was, stated that the condition of the Illinois river was worse in 1897 than before that time, and that its tributaries were not worse than in earlier years. This matter having been overlooked by counsel for the complainant it is competent for us to submit the facts which will rebut statements of their own witnesses.

MR. JEFFRIES: I would suggest that whatever evidence was introduced by complainant upon that proposition was material and not objected to by defendants at the time.

JUDGE SPRINGER: It is in the record nevertheless.

MR. JEFFRIES: The witness might have made, in summing up the evidence the declaration attributed to Dr. Tiechmann, but that does not necessarily justify the defendants in going into a strictly chemical analysis of all the tributaries of the Illinois river. Our proposition is that it is incompetent, irrelevant and immaterial so far as the issues in this case are concerned, what the condition of the tributaries is or was at any previous time.

JUDGE SPRINGER: Counsel for defendants states here that in his opinion this evidence is competent, for the reason that if it should appear from all the evidence in this case, 8850 the Illinois river at Grafton, where it enters the Mississippi river is chemically as pure as the waters of the tributaries of the streams that such testimony tends to show that whatever sewage may have entered the Illinois river from the Chicago drainage canal, has not made the condition of the river any worse than it would otherwise have been at Grafton.

MR. JEFFRIES: With that statement of counsel for defendants I suggest to the Court that all of the evidence with reference to the condition of the Illinois river and its tributaries prior to the opening of the canal is incompetent, irrelevant and immaterial so far as the issues in this case are concerned, for the reason that by the added flow in volume of water and increased rapidity of that flow down the Illinois river, while the dilution may to some extent be increased, the water as a whole is burdened with more infected material than it was prior to the opening of the drainage canal, and it is not a question of pollution merely, but a question of infection that we are dealing with in this case, and is not only burdened with the same infected material that came from the tributaries of the Illinois river and the polluting sources situated upon the watershed of that river, but in addition thereto is burdened with infected material coming from the sewage of Chicago; that is the infecting and polluting material of the city of 8851 Chicago.

JUDGE SPRINGER: By the use of the phrase "Pollutions merely," I assume that counsel still maintains that part of the allegations of the bill of complaint which charge the defendants with polluting the stream.

MR. JEFFRIES: Yes sir.

JUDGE SPRINGER: I had supposed he was about to abandon that part of it from the previous statements he has made, but as the subject of pollution is still pending, I desire to state that in my judgment it is competent to compare the condition of the water in the Illinois river after the opening of the canal with the condition of the water before the opening, for the purpose of determining whether the opening of the canal has increased the pollution or infection of the water.

Q. Professor, can you institute any comparison based upon the tables of analyses of the waters of the Illinois river with the different points on that river?

A. Yes, I have studied the proportions of various constituents as contained in the waters of the Illinois river at various points along its course.

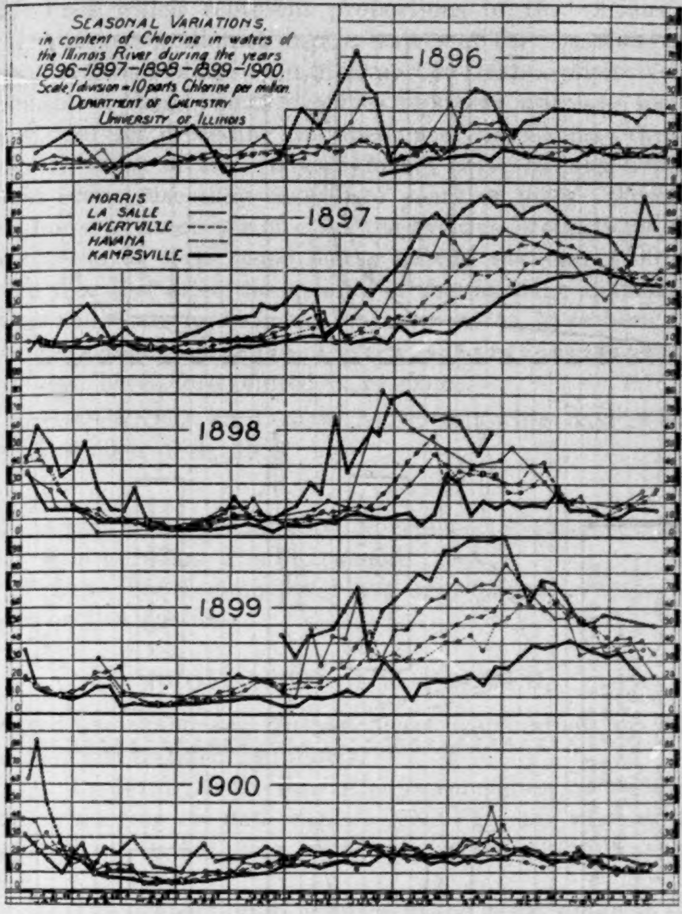
Q. Will you submit those please?

A. And in consideration of this matter, I will refer to plate No. XXXVII, which has heretofore been offered in evidence. It represents seasonal variations in the proportion of chlorine in the waters of the Illinois river at Morris, LaSalle, 8852 Averyville, Havana and Kampsville for the years 1896 to 1900 inclusive. Upon an inspection of these curves, which are representations of all the analyses made in the respective years for the points considered, the great differences in the content of chlorine, as between the first half and the second half of the year is manifest, these figures being due to the greater volume of water flowing during the first half of the year and the consequent greater dilution of the sewage, while in the second half of the year the dilution was in general very small and the proportion of chlorine naturally greater. Comparison of the line for the year 1900 with those for the preceding year shows that after the opening of the Chicago main drainage channel the proportions of chlorine were very much more uniform throughout the year, the reason being that the dilution in the latter half of the year more nearly corresponded to what it was formerly, or to the natural dilution in the earlier part of the year, that is the flow throughout the year was much more uniform in volume, and consequently the concentration of chlorine in the liquid flowing in the Illinois river never rose to such a height as it in general did during the second half of the year in times prior to the opening of the Chicago main drainage channel.

8853 Q. Professor, what plate is that you have been referring to?

A. Plate XXXVII, and it is as follows:

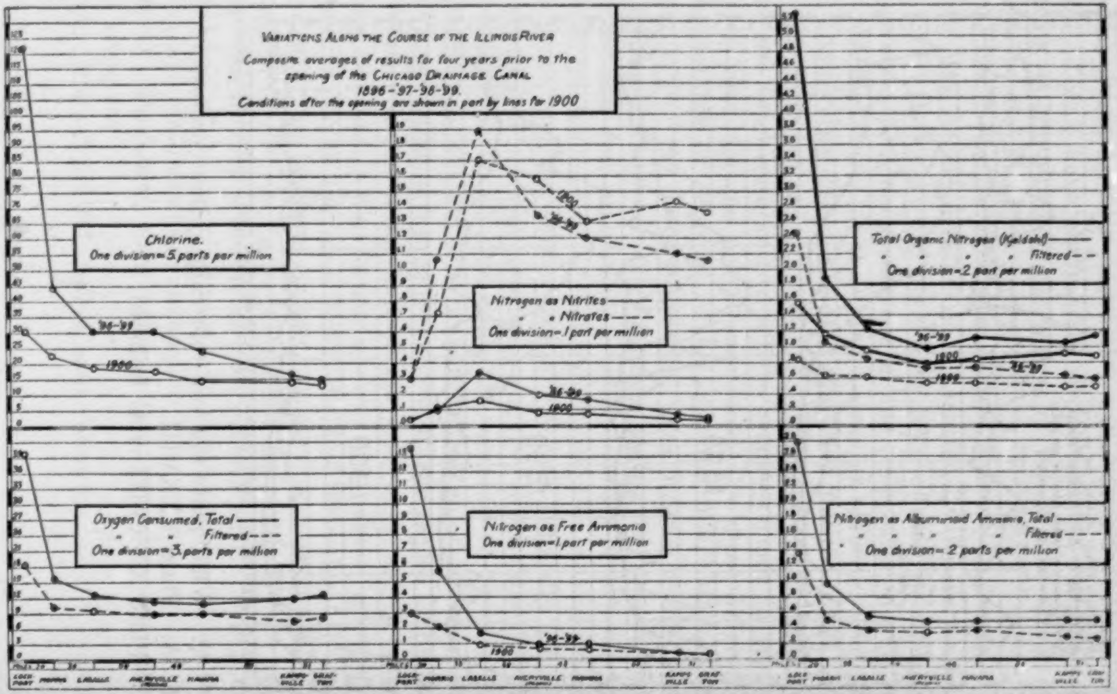
8854 Plate XXXVII.—A. W. P.



Q. What plate are you referring to now, professor?

8855 A. Plate XXXVIII.

Plate XXXVIII is as follows:


VARIATIONS ALONG THE COURSE OF THE ILLINOIS RIVER
Composite averages of results for four years prior to the opening of the CHICAGO DRAINAGE CANAL 1896-'97-'98-'99.
Conditions after the opening are shown in part by lines for 1900
Chlorine.
One division=5 parts per million
'96-'99
1900
Nitrogen as Nitrites ———
" " Nitrates - - -
One division=.1 part per million
1900
'96-'99
Total Organic Nitrogen (Kjeldahl) ———
" " " " Filtered - -
One division=.2 part per million
'96-'99
1900
'96-'99
1900
Oxygen Consumed, Total ———
" " Filtered - - -
One division=3 parts per million
Nitrogen as Free Ammonia
One division=1 part per million
'96-'99
1900
Nitrogen as Albuminoid Ammonia, Total ———
" " " " Filtered - - -
One division=.2 parts per million
MILES
LOCKPORT
MORRIS
LASALLE
AVERYVILLE (PEORIA)
HAVANA
KAMPSVILLE
GRAFTON

THE WITNESS: On plate XXXVIII there are shown
8857 lines which represent proportions of the various constituents contained in the waters of the Illinois river at several different points from Lockport to Grafton inclusive. For a number of these points the lines represent averages for four years' analyses preceding the opening of the Chicago drainage channel. Some of the analyses do not cover so long a period, but in every case they cover two years or more. There are also shown in a number of cases the average proportions of the constituents at these same points during the year 1900; that is, the year just after the opening of the drainage channel. The figures which are represented by these curves, have been taken from the defendants' tables of averages 1 to 15 inclusive, which have been heretofore offered in evidence.

ADJOURNED until 10:00 A. M. following day, Wednesday, November 18th, 1903.

8858 10:00 a. m., Wednesday, November 18, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further direct-examination, by Judge Springer and testified as follows:

Q. Professor, at the time of adjournment on yesterday you were considering the data in plate XXXVIII and were explaining the curves on that plate. Will you proceed with this explanation?

A. The proportion of chlorine in the canal water at Lockport is shown by the figures in the table of averages and represented by the line upon the plate, and is a little more than 120 parts per million. The considerable-drop in the curve between Lockport and the next point, which is Morris, is due in small parts of course, to dilution with the waters of the Desplaines river, but is mainly due to dilution with the waters of the Kankakee between Morris and LaSalle, the next point. There come in the discharges from several minor tributaries, but the most

important diluting factor between these points is the
8859 Fox river. From LaSalle to Averyville there is practically no change in the content of chlorine, for although between these points various smaller tributaries discharge into the river, the stream also receives some sewage and waste waters which are quite highly charged with chlorides, and which consequently, nothwithstanding the increase in volume which occurs, keep up the proportion of chlorine.

Between Averyville and Havana there is a notable diminution in the content of chlorine, and from there on to Kampsville and down to the mouth, at Grafton, a somewhat continuous decrease is apparent. The proportion at Grafton being 15 parts per million.

The curve for 1900 begins at about the same point, but is intended to show the content of chlorine in the mixture at Joliet, since it is at this point that the different discharges of Chicago sewage come together. The proportion is about one-fourth that of the canal at Lockport, for the earlier period, the difference representing approximately the effect of the dilution produced by the use of the drainage channel. From this point down there is a notable diminution in the proportions of chlorine contained in the water, which in a measure keeps step with the diminution which formerly occurred, but is less considerable from
8860 point to point, and finally at the point of discharge into the Mississippi the proportion of chlorine is slightly more than 13 parts per million, which shows the effect of the dilution by the use of the drainage channel as it affected the chlorine content in the discharge from the Illinois river into the Mississippi river during the year 1900.

Oxygen consumed. The lines representing the oxygen consumed both the total and that consumed by the filtered water, show marked diminution between Lockport and Morris, a considerable and somewhat continuous diminution from Morris to Havana, beyond which point the total oxygen consumed increases slightly, so that the proportions required by the water discharged from the Illinois into the Mississippi at Grafton, are greater than they were at either Averyville or Havana, this being in part due to the luxuriant growth of vegetation in the lower stretches of the river, and in part due to the presence of other suspended matters, silt and so on, which during a portion of the year are more abundant in the lower stretches of the river than they are farther up.

Nitrites. Comparisons of the proportions of nitrogen as nitrites show that before the opening of the drainage channel there were but extremely small proportions contained in the water at Lockport, but notable greater proportions at
8861 Morris, the maximum being reached at LaSalle. This argues for the greater activity of the oxidizing processes near this point than at points far above or far below LaSalle, for while the proportions of nitrites below this point are always considerable, there is continuous diminution all the way down to the mouth of the river at Grafton.

The curve for 1900, shows similar relations between the different points, but a very notably smaller proportion of the nitrites at points below Morris. It is evident from the curves however, and these curves represent merely the figures of the tables of averages above repeatedly referred to—it is evident from these curves, however, that the zone in which the greatest activity of the nitrifying processes is reached has not been changed in position by the opening of the drainage channel. That is, it appears unmistakeably from the data of our analyses and is shown clearly in these curves, that the point where the oxidation is most active, and thorough going, is still in the vicinity of Morris and LaSalle. The data of table of averages No. 6 A. W. P. show that the point is somewhere between Morris and LaSalle, probably near Ottawa.

Q. That is to say the point of greatest activity is at or near LaSalle?

A. Ottawa.

8862 Q. Ottawa I mean, yes.

A. Yes. Nitrates. The lines representing the proportions of nitrates show a remarkable increase in the proportions contained as we proceed from Lockport and Joliet to Morris, and so on to LaSalle. The increase of nitrates between Joliet and Morris is due in part to the fact that the waters of the Kankakee river which unite with those of the Desplaines between these two points, are in certain seasons very highly charged with nitrates, but much of it undoubtedly is due to the activity of the nitrifying organisms which in this stretch of the river appear to find the conditions of food supply and dilution most propitious. The great increase of nitrates between Morris and LaSalle must be regarded as practically entirely due to the nitrifying processes which in this stretch of the river complete the destruction, that is the oxidation of the organic matters discharged into the river in the Chicago sewage at Lockport and Joliet. From LaSalle to Averyville there occurs a very considerable decrease in the proportions of nitrates. This is due not to dilution, for no considerable dilution occurs between these points,—but to the utilization of nitrates by the vegetation which is extremely abundant in the broad lake-like stretches of the river between these points.

8863 From Averyville down to the mouth of the river there is considerable further diminution in the proportions of the nitrates, and this also is due to the cause referred to above namely the luxuriant vegetation,—both that of the river banks and bed and the floating forms.

The curve representing the proportions of nitrates for 1900 shows similar sets of conditions, although the proportions of nitrates is not so great at Morris as it was formerly, a fact which is undoubtedly due to the greater dilution. At LaSalle the proportions more nearly approximate those formerly contained, and below this point, although there takes place a notable diminution in the quantity of nitrates on the way to Averyville and Havana, beyond Havana they again increase. Below LaSalle there is no point along the river at which the nitrates are not now present in considerably greater proportions than were found in the river water before the opening of the drainage channel. With respect to these differences in the proportions of nitrates between the two periods in question, it seems evident that the conclusion to be drawn must be that nitrification now takes place at least as completely and it would seem far more completely than before the opening of the drainage channel.

The fact that the proportions of nitrates are less at
8864 Havana than at Kampsville and Grafton is undoubtedly
due to the fact that the great masses of filth which are discharged into the stream in the vicinity of Peoria and Pekin owe their destruction in part to the utilization of oxygen from nitrates which are brought down in abundance by the waters passing Averyville.

Free ammonia. The line representing the proportions of nitrogen as free ammonia for the period prior to the opening of the drainage channel shows excessive proportions of this constituent at Lockport, the diminution on the way to Morris being chiefly due to the dilution, but that between Morris and LaSalle being mainly due to the oxidation of the free ammonia to nitrites and nitrates; to its assimilation by the vegetation of the river and in part undoubtedly to its elimination as free nitrogen gas. Between LaSalle and lower points upon the river the diminution proceeds continuously although free ammonia is contained in notable quantities in the water finally discharged into the Mississippi at Grafton.

The line for 1900 shows a much lower content of ammonia at the point of initial discharge of Chicago sewage, but it also shows considerable diminution on the way down the river, although as is apparent from the plate and also from table of averages No. 10 A. W. P., the proportions contained in the water
as it passes Kampsville, and is discharged at Grafton,
8865 were slightly greater in 1900 than the average for the
preceding years.

Albuminoid ammonia.

The line representing the nitrogen as albuminoid ammonia constitutes for the upper part of the river a curve quite similar to that just discussed for the free ammonia, but below Averyville there is a slight increase on the way to Havana, due to the discharge of the refuse at Peoria and Pekin. Below this point the quantity does not further diminish, but on the other hand very slightly increases. Comparison of the line for total albuminoid ammonia with that for the albuminoid ammonia derived from substances in solution shows that while the latter diminishes markedly between Havana and Grafton, the total very slightly increases, owing to the presence of greater proportions of nitrogenous suspended matters in the waters at this end of the river.

Total organic nitrogen.

The line representing the total organic nitrogen shows much the same features as those just referred to, although the proportions of total organic nitrogen are more than twice as much as those of the albuminoid ammonia.

Comparison of the curves for the period 1897 to 1899, with

the curves for 1900 shows how great an effect the dilution
8866 produced by the opening of the drainage channel has
had, and shows that this effect extends to the mouth of the Illinois river. The fact that the total organic nitrogen and the nitrogen as albuminoid ammonia, do not decrease below Havana, is undoubtedly due to the presence of the enormous masses of vegetation in the waters of the lower river. That the free ammonia does not decrease below the proportions shown for Grafton is doubtless due to its continuous production through the decomposition of the various organisms constituting the plankton, which from time to time complete their life cycles and leave their substances then to enter upon that universal series of transformations to which all organic matters are subject.

Q. Have you prepared tables of monthly averages covering these periods?

A. I have.

Q. Will you now present them?

A. They are upon these ten sheets.

Q. Just read the titles of those please.

A. I will describe them.

Q. That will be better, yes, please describe those tables of monthly averages?

A. These ten sheets contain various tables of monthly
averages which have been prepared from the detailed
8867 analyses given in tables 1 to 80 of this series, Department
of Chemistry, University of Illinois, A. W. P., 1 to 80.

Upon sheet 1, there are the monthly averages for the analyses of the waters of the sanitary canal at Joliet, the west side, for 1901; for the samples taken from the Illinois river at Averyville in 1901; for those collected from the Illinois river at Pekin during the three months, October, November and December, 1901.

On the second sheet, there appear similar monthly averages for the year 1901; samples of water taken from the Illinois river at Kampsville, and at Grafton, and from the Mississippi river at Grafton.

On sheet No. 3 there are data for the year 1902. Monthly averages made from analyses of samples of water taken from the Illinois river at Kampsville.

On sheet No. 4 there are monthly averages for the waters of the Illinois river at Grafton, for the year 1899, and for the year 1900, and also for the Mississippi river water at Grafton for the same years, that is, 1899 and 1900.

Upon sheet No. 5 there are given the monthly averages of analyses of samples of water taken from the Illinois river at Kampsville during the years 1897, 1898, 1899 and 1900.

8868 Upon sheet No. 6, similar data for the Illinois river at Kampsville during the year 1901.

On sheet No. 7, monthly averages of analyses of samples of water taken from the Illinois river at Averyville during the years 1897, 1898, 1899 and 1900.

Upon sheet No. 8 monthly averages of analyses of samples of water taken from the Illinois and Michigan canal at Lockport during the year 1901; from the drainage canal at the Bear Trap Dam at Lockport during 1901; from the drainage canal at Joliet east side, during the year 1901.

On sheet No. 9 there are given the monthly averages of analyses of samples of water collected from the Illinois and Michigan canal at Lockport during the years 1897, 1898, 1899 and 1900.

Upon sheet No. 10 there are given the monthly averages of analyses of samples of water collected from the Desplaines river at Joliet during the years 1899 and 1900.

JUDGE SPRINGER: Let these be designated as Defendants' Exhibit C for identification, sheets 1 to 10 inclusive, A. W. P. They are not to be printed in the record but may be at the request of counsel of either side, incorporated in the testimony hereafter, and are to be held by the Commissioner for reference by counsel on either side if they so desire.

8869 MR. JEFFRIES: I object to the introduction of the exhibit in question embodying the ten sheets referred to as tables of averages for the years 1899 to 1900 inclusive, for the reason that the sanitary condition of the water in a running stream is not to be measured by its average chemical condition throughout the period of one year or two years, or one month or six months, and any table of averages of this character fails to disclose conditions of abnormal character which are as important in the determination of the issues involved in this case as conditions at any other period. In fact such conditions so far as the determinations of the sanitary condition of water are concerned, are the all-important conditions to be ascertained and determined, and if it be found from a sanitary standpoint that the water in a running stream is infected at any one time during any twelve months or six months or three months, its character as a suitable water for domestic and drinking purposes is brought in question, and such water could not be safely used for such purposes, and so far as the issues involved in this case are concerned, the defense are called upon to meet such abnormal conditions and not to show that by a general table of averages the condition of the water is less subjected to infected matter on the average than it is at any one given time during the period in question.

8870 Said documents are marked for identification by the Commissicner, as requested.

JUDGE SPRINGER: The objection of counsel goes merely to the weight of the evidence and not to its admissibility. The abnormal conditions if any, to which counsel has referred, will be found in the tables of detailed analyses which have been put in evidence, namely, tables 1 to 80 of this series, and all other tables heretofore read in evidence in this case.

MR. JEFFRIES: As to whether my objection goes to the weight of the testimony is a question for the court, but I now insist that it goes to the materiality and admissibility of the testimony in this, to-wit; that no table of averages can be relied upon by any sanitarian in undertaking to pass judgment upon the sanitary condition of the water in a running stream or in a given quantity of water.

JUDGE SPRINGER: That is a question for the Court to determine.

MR. JEFFRIES: And for this reason the evidence is inadmissible and my objection does not go to the weight of the testimony and the weight of the evidence as shown by the tables, but to its admissibility, because the tables themselves show from what has been stated in the objection, that conditions
8871 there shown are not to be relied upon and not being reliable, consequently are not admissible.

JUDGE SPRINGER: As before stated, these are questions for the Court to consider and counsel for defendants respectfully submit them to the Court.

Q. Professor, have you any data which show the conditions of the water in the Illinois river just prior to the opening of the sanitary canal as to stages of water, temperature, proportions of constituents, etc.

A. I have.

Q. Will you submit that data at this time?

A. The numerical data, that is, the figures resulting from the analytical determinations, have all been introduced in the detailed tables 1 to 80 which have been referred to above,but some of these data, and the data with respect to stages of water and the temperature of the water, I have represented upon plates Nos. XXXIX and XL, heretofore introduced in evidence and to which I now refer in response to the question of counsel, the

Plates being as follows:

Plate XXXIX.—A. W. P.

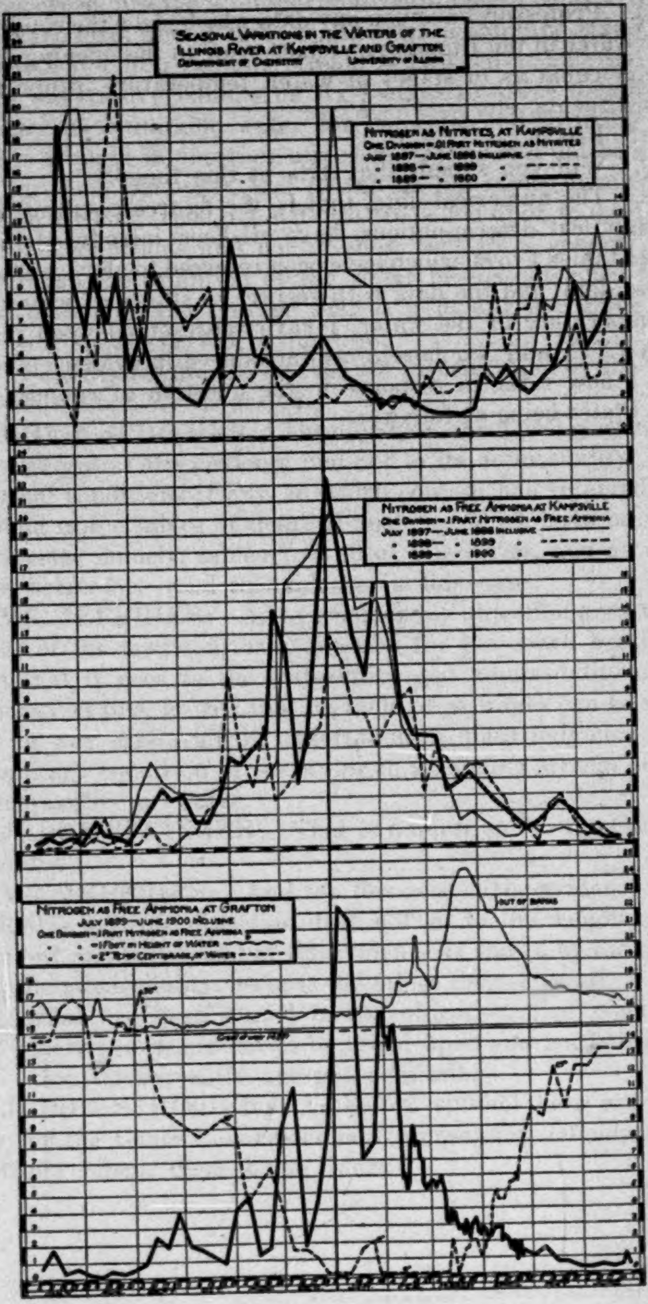
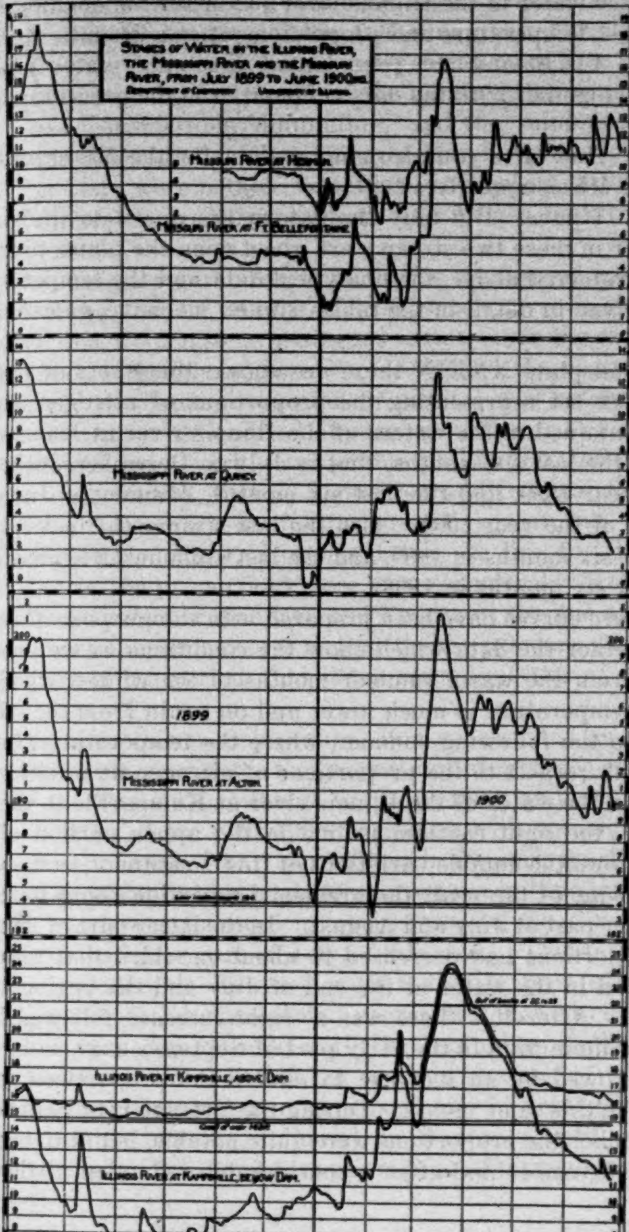


Plate XL.—A. W. P.


Stages of Water in the Illinois River, the Mississippi River and the Missouri River, from July 1899 to June 1900 inc.
Department of Chemistry
University of Illinois
Missouri River at Hermann
Missouri River at Ft. Bellefontaine
Mississippi River at Quincy
1899
Mississippi River at Alton
1900
Illinois River at Kampsville, above Dam
Illinois River at Kampsville, below Dam

8874 Q. Have you also any data which show the condition of the water in the Illinois river just after the opening as to its stages, temperature and proportions of constituents, etc?

A. I have, and have represented them upon plates XXXIX and XL together with the data referred to in the preceding question.

Q. And have you also similar data for the Missouri river and the Mississippi river?

A. I have. But only the data with respect to the stages of water in these two streams are given upon the plates to which I have referred above, the analytical data and the temperatures being given in detail in the tables 1 to 80 inclusive, above referred to.

Upon plate XXXIX there are shown three sets of curves, the upper set representing the proportions of nitrogen as nitrites contained in the waters of the Illinois river at Kampsville during the last six months, that is July to December, inclusive, of the year 1899, and the first six months, January to June, inclusive, of the year 1900. Also the last six months in 1898 and the first six months in 1899, and the last six months in 1897, and the first six months in 1898.

These curves have been prepared with the purpose of bringing together the data which show the conditions as we proceed from the warm summer months to the winter, when the
8875 temperature is much lower and on again from the winter to the following summer, where the temperature rises.

With respect to the proportions of nitrogen as nitrites contained in the water of the Illinois river at Kampsville in the fall of 1897, the light continuous line in the upper portion of the plate shows the notable variations of this constituent, in the various seasons of the year, the greatest proportion being found in the latter part of July and August. In the latter part of August, the proportions had decreased to about one-third that which is contained in the water at the end of July and the beginning of August. After this there was a slight increase followed by a notable diminution in the early part of September, which in turn was followed by an increase to double the proportions found earlier in this same month. During the latter part of September and October the proportions were quite notable, but at the begining of November and after a considerable reduction at the end

of October, they rise again to considerable proportions, which were practically maintained to the end of the year; that is, until the beginning of January of the following year, namely, 1898. In January they rose very considerably, being more than doubled in proportion in the early part of the month, after which there was considerable diminution, and the minimum point
8876 was reached at the beginning of March, from which time on there were notable variations, but mainly in the direction of increases in the proportions of nitrogen as nitrites, to near the end of the year.

Following the curve for 1898, that is the last six months of 1898, and the first six months of 1899, which curve is shown as a broken line, we find some analagous variations in the early part of the year, although in the end of July and the beginning of August the minimum proportion of nitrites was reached, with the maximum for this period appearing at the end of August; this followed by a very considerable diminution, the line for the next two months, that is, September and October, following almost the same course as for the preceding year, but with the beginning of November, dropping below the line for the other year, that is, the proportions were very considerably less during November, December, January and February, the line again following much the same course as that for the previous year in the latter part of the period, that is the second quarter of the year 1899.

The third line in this group,—that represented as a heavy continuous line, represents the proportions of nitrogen as nitrites during the last six months of the year 1899, and the first six months of the year 1900, beginning with notable propor-
8877 tions namely .1 part per million in the early part of July.

There was a drop to about .05 part per million later in the month, which was followed by an increase to .09 of a part per million in the latter part of July of this year. This followed by a very considerable decrease until the early part of August. In August several increases and decreases followed each other, but none very considerable until the beginning of September, when the proportions diminished to about one-half of what they had been in the latter part of August. Later in September, there was a notable increase, followed by decreases until we get a minimum figure .02 of one part per million of nitrogen as nitrites

in the middle of October. In the latter part of October an increase again, reaching the maximum early in November, reaching .12 of one part of nitrogen as nitrites per million; this followed by decreases until the minimum was found in the latter part of December, after which an increase took place to the first of January following, namely January, 1900, and in the beginning of the year 1900, there was considerable diminution in the proportion of nitrites continuously until the early part of February after which there was a very slight increase in the proportions from .018 of one part per million upon February 7th, to .023
of one part per million on February 14th, to .022 of one
8878 part per million on February 21st, this being followed by
diminutions throughout the month of March. The next increase in proportion of nitrites coming in the early part of April, following after which there were the ordinary increases and decreases in the proportions of nitrites similar in character to those which I have referred to above, as taking place in the previous years here considered.

It is evident from these lines, which merely represent the figures in tables 37 to 41 inclusive, that the proportions of nitrites contained in the waters of the Illinois river as they were about to discharge into the Mississippi river, were not during the early months of the year 1900, that is particularly January, February and March, 1900, abnormal. In fact the proportions were very much less than were found in the waters of the Illinois at this same point during the same months of the year 1898, and while somewhat greater in the first part of January than the proportions found at this point in the year 1899, during the latter part of January and during the month of February the figures were almost identical and beginning with March the proportions were almost uniformly less during the year 1900, until the month of June in the early part of which and in the latter
part of May, the proportions rose somewhat beyond those
8879 which had existed in the water of the Illinois at this
point for this time in the year 1899, but were still less than the proportions which had been found in the water at this point in the preceding year at this time, namely, the year 1898.

The second group, that is the group at the middle of plate XXXIX represents the proportions of nitrogen as free ammonia contained in the water of the Illinois river at Kampsville, for the same periods referred to above in discussion of the nitrites.

The light continuous line represents the proportions of nitrogen as free ammonia contained in the water of the Illinois river at Kampsville during the last six months of 1897, and the first six months that is, January to June inclusive of the year 1898. It is very notable from the curves which merely represent the figures which are given in detail in tables 37 to 41 inclusive above referred to, that the proportions of free ammonia are less in the summer time, the months of July and August, that they begin to increase in September, reaching a considerable proportion about the middle of September, after which they diminish somewhat, but remain of notable proportions without much change either up or down, during the months of October and November, until at the beginning of December there is a very remarkable increase in the proportion of nitro-
8880 gen as free ammonia, as the colder weather of the winter season approaches or arrives.

From the early part of December, when the proportion found was 1.6 parts per million, there is again notable increase in the proportions of the nitrogen as free ammonia, to the early part of January when the proportions were somewhat more than two parts per million, after which there is a slight decrease to nearly the middle of January followed by a more considerable decrease to 1.44 parts per million upon the 18th of January, and increase to 1.5 parts per million upon the first day of February, followed by a decrease to 1.24 parts per million on the 8th, and a further decrease to .72 parts per million on the 15th of February, a still further decrease to .956 parts per million upon the 22nd of February, and further decrease to .52 parts per million upon the first of March, after which there was more continuous and more considerable successive diminutions until the minimum was reached in April, and from that time to the end of June the proportions never rose to as much as .01 of a part of nitrogen as free ammonia per million.

Following the broken line of this set, which represents the proportions of the nitrogen as free ammonia for the late months, that is the last six months of 1898, and for the first six
8881 months of the year 1899, we note that in the latter part of the year there were similar variations to those referred to above, but that the proportions did not increase so early in

the year, that is, the proportions found in the water during September were practically similar to those found in the same water in July and August, but that with the beginning of October considerable increase of the nitrogen as free ammonia took place, the maximum being reached early in November, which was followed by a decrease to the middle of November; this in turn followed by an increase to the latter part of November, the minimum for November being reached at .28 of one part per million upon the 29th. After this there were considerable increases until the maximum proportion of nitrogen as free ammonia for the period now in question was reached, upon January 3rd, 1899, the proportion being 1.28 parts per million. After this there were diminutions in the proportions of nitrogen as free ammonia until at the end of January, namely January 31st, 1899, there were but .6 parts per million, which was followed, however, by increases to a maximum of .96 parts per million of nitrogen as free ammonia, upon February 21st. After this there were successive decreases and increases, but on the whole diminutions until the warm weather of the summer period was reached,
8882 when the proportions were as usual for this season of the
year, less than .1 part per million. Following the heavy continuous line which represents the proportions of nitrogen as free ammonia in the waters of the Illinois river at Kampsville during the last six months of 1899 and the first six months of the year 1900, we find nothing particularly unusual in the proportions of the curve. During the first part of the year the lines follow the course above described for the lines for the same months of 1897 and 1898. In the months of September and October it more nearly corresponds to the curve for the year 1897, showing greater proportions than were found during the year 1898, and proportions somewhat less than the considerable proportions found during these months in the year 1897. About the middle of October there was a decrease of nearly 50 per cent in the proportion of nitrogen as free ammonia, followed by an increase more considerable until the proportions .552 parts per million, upon the first day of November, followed by a slight decrease to the next week, and that in turn by an increase to .688 parts per million on the 22nd, and 1.44 parts per million on the 29th of November, 1899. Following this there was a decrease to 1.184 parts per million upon the 6th of December. A further

diminution to .368 upon the 13th of December, and from that time an increase to .672 parts per million upon the 20th
8883 of December. Following this increase in the latter part of December there was further increase to the maximum of 2.24 parts of nitrogen as free ammonia per million upon the 3rd day of January, 1900; from the 3rd of January, 1900, to the 17th of January the same month, there was a decrease in the proportions of nitrogen as free ammonia contained in the waters of the Illinois river at Kampsville, to 1.28 parts per million, and a further decrease between the 17th of January and the 25th of January. The proportion upon the latter date being 1.04 parts per million. From this date to the 31st of January there is a notable increase in the proportions of nitrogen as free ammonia, the maximum of 1.6 parts per million being reached upon January 31st, the same proportion being found a week later, that is, for February 7th. From which time there was a considerable decrease in the proportions of nitrogen as free ammonia, to .736 parts per million, upon the 14th of February; to .672 parts per million upon the 21st of February; to .656 parts per million upon the 7th of March; again to .32 upon the 14th of March, an increase to .368 parts per million, upon the 21st of March, and again to .432 parts per million upon the 28th of March. From this time on there were variations in both directions, but
8884 the general directon of the curve was in the way to represent the diminutions which are shown in the detailed tables of analyses, as occurring during the warmer summer months.

Comparison of this line representing the conditions with respect to the proportions of nitrogen as free ammonia in the waters of the Illinois river at Kampsville during the last six months of the year 1899 and the first six months of the year 1900, show in general great similarity between the conditions during this period of twelve months and the period of twelve months referred to above, that is, the period July, 1897, to June, 1898, inclusive.

The third group of lines upon this plate gives a representation of the proportions of nitrogen as free ammonia contained in the water of the Illinois river at Grafton thirty miles below the point we have been considering, and within two miles of the point where the discharge of the water from the Illinois into the Mississippi occurs. The heavy continuous line represents the proportions of nitrogen as free ammonia. The broken line represents the temperature of the water as taken at the time the samples for analyses were collected. The upper curve represents the height of water as read at Government gauges at Kampsville. The stages are given for Kampsville because at this point there is ordinarily no disturbances due 8885 to variations in height of the water in the Mississippi river.

At times back water from the Mississippi river causes higher water above the dam at Kampsville, but this is only in times of extreme high water in the Mississippi, while ordinarily at Grafton the stages in the Illinois river follow uniformly the variations in the stages of the Mississippi river.

MR. JEFFRIES: You mean extremely high water in the Mississippi?

A. Yes, sir. The line representing the proportions of nitrogen as free ammonia in this group have been compared from the figures which appear in tables Nos. 21 and 60 of the series 1 to 80 heretofore read in evidence. The data for the latter part of 1899 and for the first part of the month of January, 1900, being thus derived from analyses of collections made once a week, but beginning with the 24th of January the collections were made more frequently and from the 28th of January, 1900, on, the collections were made each day, that is, until the end of April, and the data from these daily collections are represented in the curve for this section of the period in question.

The stages of water represented by the upper curve of this group are the daily readings, or, rather, the mean of tri-daily readings, as in the other case the stages of water and 8886 volume of discharge referred to above in my testimony in discussing the conditions at Kampsville.

In the early part of July, 1899, the nitrogen as free ammonia contained in the waters of the Illinois river at Grafton increased from .06 parts per million on the 5th, to .176 parts per million on the 12th, following which there was a decrease to .03 parts per million upon the 19th, after which the proportions were at the minimum until they began to increase in the early part of September, reaching the proportions .24 parts per million upon the 13th, decreasing to .18, and increasing again to .396 upon

the 27th of September, these increases being followed by a decrease to .192 parts per million upon October 4th, to .172 parts per million October 11th, to .084 parts per million on October 25th. The decreases to this point being followed by a considerable increase to .404 upon the first day of November, to .48 upon the 8th of November, these increases being followed by a considerable drop to .12 parts per million upon the 15th. An increase then occurred to .16 parts per million upon the 22nd, to .88 parts per million upon the 29th, to the maximum of 1.12 upon the 6th of December, the increase being followed by a great decrease to .176 parts per million upon the 13th, which is in turn
followed by an increase to .432 parts per million on the
8887 20th, to .88 parts per million of nitrogen as free ammonia
upon the 27th of December, 1899. The increase in proportions of free ammonia continued. The proportion upon January 4th, 1900, being the maximum for the entire period under consideration, namely, 2.24 parts per million nitrogen as free ammonia.

Slight diminution from the 4th to the 10th occurring, the proportion on the latter date being 2.16 parts per million; after this there was a considerable diminution to .704 parts per million upon the 17th day of January, 1900. After this an increase to .8 parts per million upon the 24th of January to 1.6 parts per million upon the 28th, upon the 29th, upon the 30th and upon the 31st of January; then a decrease to 1.24 parts per million upon the first day of February, 1900, the same proportion being found upon the 2nd of February; upon the 3rd day of February the proportion being 1.36; upon the 4th day of February a slight increase again to 1.44 parts per million, an increase again upon the 5th to 1.504, and again upon the 6th an increase to 1.52 parts per million; after this upon the 7th a diminution to 1.36; upon the 8th to 1.28; upon the 9th to .96; upon the 10th to .72; upon the 11th to .576, followed by an increase upon the 12th to .608, and a decrease upon the 13th to
.512. Again upon the 14th a slight increase to .544, fol-
8888 lowed by a greater increase to .8 parts per million upon
the 15th. Upon the 16th the proportion being the same, that is, .8. After this, an increase upon the 16th and 17th to .896 and a decrease to the 18th to .768. From this point on there were various minor increases and decreases, the general

direction or variation, however, being a diminution toward the minimum, which was reached in the warmer months of the year represented in this period, namely, May and June, for the year 1900. The relation of temperature to the proportion of nitrogen as free ammonia is in part illustrated by the curves in this group, for it is notable that as the temperature diminishes in the autumn months, that is, in September, the nitrogen as free ammonia increases in proportion. In this particular year there was an increase in the temperature of the water in the latter part of October, and in conformity with this there appears, or at least in unison with this there appears a decrease in the proportion of nitrogen as free ammonia; then a considerable fall in temperature of the water in the early part of November was accompanied by an increase in the proportion of free ammonia while the increase in temperature of water later in the month was accompanied by a decrease in the proportion of nitrogen as free ammonia. A very considerable further decrease in temperature during the latter part of November and the early 8889 part of December was followed in the early part of December by a considerable rise in the proportion of free ammonia. Toward the middle of December there was again a very considerable diminution in the proportions of the nitrogen as free ammonia, although at this time the temperature of the water remained constant, or but a very slight increase. No other very general relation between the temperature condition and the proportion of free ammonia for this time appears. A further decrease in the temperature of the water to the freezing point, that is, zero degree centigrade, in the latter part of December was accompanied by a very great increase in the proportions of free ammonia contained in these waters. In the latter part of December and the early part of January, a notable rise in temperature of the water from the freezing point, that is, zero centigrade, to four degrees centigrade, just about the middle of January, which rise in temperature was mainly caused by weather conditions, including the precipitation of rain at this time; these were accompanied by a very considerable diminution in the proportions of nitrogen as free ammonia.

Following this [illegible]e was again a drop in the temperature of the water to the freezing point, that is, zero degrees centi-

grade, which was accompanied by another very con-
8890 siderable rise in the proportions of nitrogen as free ammonia and later, although the temperature remained practically the same, that is, zero centigrade, there was a considerable diminution in proportions of free ammonia in the waters of the Illinois at this point which was coincident with a very considerable rise in the stage of water in the river and the volume of flow at this time, which increased very considerably as shown in the various plates upon which the discharges of the Illinois river over the Kampsville dam, have been represented.

From the early part of March on, the temperature of the water was gradually rising until the maximum was reached. Of course in the warm summer months, and step by step with this rise in temperature, there were notable diminutions in the proportions of free ammonia, but the very great diminution in the proportions of free ammonia in February and through March, 1900, corresponded throughout with the diminutions and other variations referred to above in our discussion, and the variations of nitrogen as free ammonia in the waters of the Illinois at Kampsville, and were in part occasioned by the high water naturally produced by precipitation as rain during the latter part of February and March and the early part of April during the year 1900.

MR. JEFFRIES: After having examined Defendants'
8891 Exhibit C for identification composed of sheets 1 to 10, inclusive, I move to strike it out for the reason that the table of averages for the year 1901 and for the other years therein contained is in part upon the result of the analysis of one sample of water or one collection of water, while other parts are based upon averages for 12 and 6 months, and various other periods of time. I move to strike out the exhibit for the reason that the data contained in them are not competent and do not correctly represent the table of averages for the various rivers and at the various places in such a manner as to be comparable.

JUDGE SPRINGER: This objection goes merely to the weight of the evidence. The table shows for itself, what it is.

Q. Professor, what were the relative stages of water in the Illinois, Mississippi and Missouri rivers late in 1899 and early in the year 1900?

A. As I have represented upon plate XL refered to above, the stages of water in the Missouri river, the Mississippi river and the Illinois river were in the latter part of the year 1899 comparatively low, but in the Missouri river at Fort Bellefontaine and in the Mississippi river at Quincy and at Alton the water was remarkably low just at the end of the year 1899, that is, after having been in general low throughout the
8892 later months of the year, that is, throughout the months
of October, November and December, there was a very considerable fall in the stage of water in these streams just at the end of December, and in some cases, continuing into the early part of January following, that is, January of the year 1900. After this there was a very considerable increase in the height of the water in the Mississippi river both at Quincy and at Alton and in the Missouri river both at Fort Bellefontaine and at Hermann; Hermann being some considerable distance higher up the Missouri river where but little effect of the height of the water in the Mississippi river would ordinarily be felt, and Quincy being more than 100 miles farther up the Mississippi river than is Alton and where no effect upon the height of the water in the Mississippi caused by high stages or low stages in the water of the Missouri river would ordinarily be felt.

I have put in this curve for Quincy and the section of a curve for Hermann in order to show that the conditions at Alton for the Mississippi river and at Fort Bellefontaine for the Missouri river were not caused in the one river by the conditions in the other particularly, but that they existed also at points considerably farther up each of these streams respectively.

8893 In January, the latter part, it is notable that the Missouri went from a little less—it is notable that the Missouri at Fort Bellefontaine rose from a little less than two feet upon the gauge, to seven feet, a rise of five feet between the early part of the month and the latter part, while the Mississippi river at Quincy also rose from the end of December, being less than one foot upon the gauge—it rose to a little more than three feet upon the gauge at Quincy in the early part of January, to be followed by a decrease to two feet a little later, and in the latter part of January rising to 3.6 feet. This followed by a decrease to a little less than two feet in the early part of February, an increase from less than two feet to more than five feet, and a rise of over three feet in the stage of water in the river at this point. Later in this month, that is, February, during the middle, the rise came, the stage of water reached six feet, to be followed by a decrease, that is, a fall in the water to about three feet in the end of the month, but in the early part of March there was a sudden and great increase in the height of the water at Quincy, to approximately 13 feet.

The stages of water in the Mississippi at Alton follow the same general course as indicated by the curve, but were more considerable both in the rise and in the fall. In
8894 the end of December, 1899, the water in the Mississippi river at Alton reached the extreme low water stage. From there it rose to three feet in the early part of January following to February but rising again in the latter part of January to more than nine feet upon the guage. From this date to the early part of February there was a very considerable fall in the stages of the water at this point. It went below the extreme low water point but was almost immediately followed by a rise of more than six feet. From this time on there were minor variations in height, the maximum being reached in the latter part of February, followed by a decrease in the early part of March which in turn was followed by a very considerable rise in the stage of the water a little later in March from which time there was a more or less continuous diminution to the end of the period, covered by this plate.

The lines representing the stages of water in the Mississippi river at Alton follow much the same general direction and in general are much similar in proportion to those representing the stages at Quincy, but the rises at this point are more considerable, and the falls in stage of water also more considerable, that is, the variations up and down are more notable at Alton than at Quincy and conform more nearly to the variations both
8895 up and down as shown for the Missouri river at Fort Bellefontaine and at Hermann, than they do with the upper Mississippi at Quincy.

The lower set of curves upon this plate No. XL, represent the stages of water above and below the dam at Kampsville, the crest of the dam being at 14.8 feet upon the government gauge, from which the readings are taken at this point.

A curve representing the stages of water below the dam shows the variations which are in part occasioned by the relative stages of water in the Mississippi, in the vicinity of the mouth of the Illinois, while the curves representing the stages of water above the dam vary somewhat in conformity with these. They are not so much and ordinarily in fact are not at all particularly affected by the stages of water in the Mississippi.

On the upper part of this section of the curve a cross line drawn at the horizontal line marked 22 in the scale at the side, indicates a point at which the water in the Illinois river at Kampsville above the dam begins to go over the banks. It is between stage 22 and 23 feet. The fact that the length of time in the year when such conditions as send the water over the banks and in part around the dam prevail, is short, is apparent by comparison of that section of the curve represented
8896 by the line 22 feet, with the date scale at the bottom of the set of curves.

Adjourned until 2:00 p. m., same day, Wednesday, November 18th, 1903.

8897 2:00 p. m., Wednesday, November 18th, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further direct-examination, by Judge Springer, and testified as follows:

Q. Professor, at the time of the noon recess you had just completed your statement in regard to the stages of water in the Illinois, the Missisippi and the Missouri rivers late in the years 1899 and early in 1900. What effect did these conditions and changes have upon the condition of the waters of each of these streams?

A. The conditions of the water of the Illinois river at Kampsville and at Grafton at this time, and the relation of these conditions to the stage of water in the Illinois river have been discussed somewhat in detail in my testimony of this morning and also incidentally in my testimony with respect to the water at Kampsville and at Grafton given yesterday, and illustrated or rather represented graphically by plates Nos. XII, XIII, 8898 XIV, XV, XVI, XVII, XVIII, XIX, XX, XXI, and XXXIX. The data of the tables series A. W. P., 1 to 80, inclusive, which have been used in preparation of the plates above referred to show that the waters of the Illinois during the first three months of the year 1900, that is, January, February and March, 1900, were in practically the same condition as they ordinarily are in this season of the year as shown by comparison of the data of analyses of the waters collected during these three months of the year 1900, with the data of analyses of samples of water collected at the same points in the Illinois river during the same months of the years 1897, 1898 and 1899.

With respect to the waters of the Mississippi river at this time I would refer to my testimony and discussion of the data of analyses of samples of water drawn from the Mississippi river at Quincy and at Grafton above the mouth of the Illinois river during this period, namely, the months of January, February and March, 1900, and given in the respective tables of series A. W. P., 1 to 80, inclusive, and represented for purposes of illustration and ready comprehension in part in charts XXII, XXIII, XXIV, XXV, XXXIII and XXXIV, respectively.

8899 Consideration of the data of the tables referred to shows that early in January of the year 1900, nitrogen as albuminoid ammonia and the total organic nitrogen were present in the waters of the Mississippi at this point, Grafton, in about the same proportions as in the waters of the Illinois, and that in the middle of February, there was a very considerable increase in the proportions of total organic nitrogen as of nitrogen as albuminoid ammonia in the waters of the Mississippi river above the mouth of the Illinois, which increase in these substances was fully as great in the waters of the Mississippi as in the waters of the Illinois river, and was doubtless occasioned by causes similar to those which at this time brought about these increases in the waters of the Illinois, namely, a rise of notable proportions in the height of water in the stream following upon an unusual fall in the stage of water which in turn had followed a somewhat lengthy period of comparatively low water.

The conditions in the Missouri river as stated in my testimony regarding the stages of water in that stream at the same

time that I discussed the stages in the Illinois and Mississippi were with respect to variations in height of water in the stream similar in character and in extent to those in the Missis-
8900 sippi and similar in character but greater in proportion than those in the Illinois river.

The determinations of the total organic nitrogen and nitrogen as albuminoid ammonia in the samples of water collected from the Missouri river at Fort Bellefontaine show that the variations in height of water in that stream were accompanied by similar variations in the proportions of these constituents of the waters, that is, there was a very considerable increase in the proportions of nitrogenous organic matters contained in the waters of the Missouri river just at this time, the latter part of January and the early part of February, of the year 1900.

While my data with respect to the composition of the waters of the Missouri river at this time are not as numerous as those which I have described concerning the composition and the constituents contained in the waters of the Mississippi and the Illinois, the results of these analyses show similar fluctuations and by reference to the data submitted in this case on behalf of the complainant in the case, that is, the tables of results of chemical analyses of waters of the Missouri river made by Professor Teichmann, we find that his results fully corroborate my own with respect to these conditions in the Missouri river water, and being more numerous than my own, having been taken
8901 daily in the Missouri river, afford a series of determinations which compared from day to day with those which I obtained for the Illinois and the Mississippi rivers, and show even more conclusively than do my own, more meagre data, for this period, a more considerable conformity between the conditions of the water in the Missouri river and the Mississippi river at this time, that is, the complainant's data for this period show a worse condition in this respect in the waters of the Missouri river at Fort Bellefontaine than do my own less numerous data, for the reason that they cover the period more fully and they show complete conformity with the conditions I have stated with respect to the Mississippi river; the data with respect to the free ammonia in the waters of these streams my own for the three rivers, and as corroboative of my data for the Missouri river, and refers to the data already referred to, presented by the

complainant, these show similar conditions, that is, similar fluctuations and increase in the proportion of free ammonia contained in the water of each one of these three streams at the time I have mentioned, that is, coincident with the rises in the height of water in these three streams and particularly in the Missouri and in the Mississippi above the mouth of the Illinois during the early part of February and March, 1900.

8902 Q. What effect did these conditions have upon these waters at the St. Louis intake in so far as these rivers respectively contribute such waters?

A. These conditions involving as they do an increase in the proportions of the various nitrogenous organic matters in the waters of the upper Mississippi and in the waters of the Missouri river, and the increased proportions of these substances and matters which accompany them in the mixture of waters passing down the Mississippi river below the mouth of the Missouri increase them in that mixture, which is drawn into the St. Louis waterworks system at the intake tower at the chain of rocks.

Q. Have the waters in the lower reaches of the Illinois river been more greatly charged with organic matters since the opening of the Chicago drainage canal than they were prior to the opening of the canal?

MR. JEFFRIES: We object to the question for the reason that it is not a question as to whether or not they have been more greatly charged. The question is whether or not it is charged with organic matter coming from the city of Chicago. The question is not whether or not the drainage canal discharges more water into the Mississippi river, but whether or not it discharges more of its sewage or whether or not its sewage 8903 is discharged into the Mississippi river at Grafton by means of the Illinois river, and it matters not whether it be accompanied by a large volume of water or a small volume of water. The question is as to the quantity of pollution and infected material discharged into the Illinois river and thence into the Missisippi.

Q. (Question repeated.)

A. They have not. The data to which I have testified and the various plates representing different portions of the data particularly those referring to the condition of the water in the

Illinois river at Kampsville and at Grafton and testified to somewhat in detail heretofore by me, show that the water in the lower reaches of the Illinois river is now, since the opening of the Chicago main drainage channel, less charged with organic matters than it was previous to that opening.

Q. Have you prepared any data from samples of water taken at cross-sections of the Illinois and Mississippi rivers which you have not heretofore put in evidence? If so, will you please produce them?

A. I have.

Q. Will you please produce them?

A. I will (witness hands papers to counsel).

Q. Will you please describe these data?

8904 A. I present four sheets. On sheet No. 1 there are special cross-sections taken in the Illinois river at Averyville, upon July 21, 1899, and upon November 26, 1901, cross-sections at Wesley City taken July 22, 1899; cross-section at Peoria at the foot of terminal bridge, taken November 26, 1901, and cross-sections one and one-half miles below Pekin taken November 26th, 1901. These do not involve complete analyses in any one case. In the first case mentioned, namely, Averyville, determinations of the chlorine, of the oxygen consumed by dissolved substances; of the free ammonia and the total albuminoid ammonia and the nitrites and the nitrates were made.

Those taken at Averyville in November, 1901, were subjected to determinations of chlorine merely.

Those taken at Wesley City July 21, 1899, were submitted to determinations for chlorine, free ammonia, total albuminoid ammonia, nitrites and nitrates.

The samples collected by the terminal bridge at Peoria and below Pekin were submitted to determinations of chlorine merely.

These cross-sections were taken for the purpose of noting what if any variations there were in the proportions of constituents contained in the waters at these several points in
8905 the Illinois river at different distances across the stream.

Sheet No. 2 represents the results of analyses of special cross-section samples collected in the Mississippi river at Grafton just above the mouth of the Illinois. Samples collected January 5th, 1897, January 18th, 19, February 15, 1899, May 24, 1899, and July 28, 1899, and also cross-section samples collected in the Illinois river at Grafton January 5th, 1899, and July 28, 1899. Most of these samples were subjected to complete sanitary chemical analyses, such as I have testified to heretofore, with respect to the bulk of the work in this investigation. In a few of these samples a fewer number of determinations were made, as is represented upon the sheet here submitted.

Sheet No. 3 has upon it the results of analyses of samples collected at certain cross-sections of the Mississippi river at Hartford, within half a mile of the mouth of the Missouri river, a portion of these samples were subjected to complete sanitary chemical analyses. In another portion of them only the chlorine was determined, and in yet another the chlorine and the nitrogen as nitrites were determined. At the bottom of this sheet No. 3 there are several analyses of samples of water collected below the mouth of the Missouri river at different points across the Mississippi within two miles of the mouth of the Missouri, and one sample collected a quarter of a mile within the mouth of the Missouri river. 8906

Sheet No. 4 of this series contains the results of analyses of special cross-section samples collected in the Mississippi river at Alton and at points below Alton, namely, at Hartford, and at the chain of rocks opposite the intake tower of the St. Louis waterworks.

JUDGE SPRINGER: I now offer these tables in evidence in this case.

MR. JEFFRIES: I object to the reading of the data in evidence for the reason that as witness has stated, they do not contain a complete chemical analysis of the water with reference to the ascertainment of all of the chemical constituents of that water, and as the witness has frequently observed, and as was stated by defendants' witness, Professor Long, that no showing could be made that would or could be relied upon by taking one chemical constituent or ingredient of the water, but that it was necessary to consider all of the chemical constituents of the water with reference to determining the sanitary character of the water under consideration, and that in view of these facts and of the position that the defense has taken with reference to testimony of this character I object to this data being read in evi-

dence because of its being incomplete and not sufficient,
8907 and such data as may appear would at the most be misleading, uncertain and therefore incompetent and irrelevant.

JUDGE SPRINGER: Counsel for defendants suggest that these tables do not purport to state other facts than those shown upon their face; that they are to be considered in connection with all the other data submitted in evidence in this case; that we are making an earnest effort to bring into the case all the data that it is possible to collect.

MR. JEFFRIES: In addition to the objection above stated, I object to the reading of the data in evidence for the further reason that the chemical ascertainments shown therein are not of such character as would be comparable, or is comparable with any other facts introduced in evidence by this witness or by any witness on the part of the defense, and not being comparable it is incompetent and irrelevant to consider them along with the other facts shown in evidence by the defense.

JUDGE SPRIIGER: Counsel for defendants further suggests that both of these objections go to the weight of the testimony and not to its competency, and are more of an argument than they are objections.

MR. JEFFRIES: My objection goes to the competency and not to the weight.

JUDGE SPRINGER: Your objection goes, as you stated, to the competency, but as counsel for defendants insists,
8908 it relates only to the weight of the evidence and as to which is right upon this is a matter to be determined by the Court.

MR. JEFFRIES: It is to be determined by the Court as to whether it goes to the weight or the competency of the evidence, but I submit, however, that it goes to the competency of the evidence itself.

JUDGE SPRINGER: The tables are as follows, and are to be known as Defendants' Special Cross-Sections Numbered 1 to 4, A. W. P., inclusive.

THE WITNESS: The tables are as follows:

3909 DEFENDANTS' SPECIAL CROSS-SECTIONS, NO. 1.

DEPARTMENT OF CHEMISTRY, UNIVERSITY OF ILLINOIS.

SANITARY WATER ANALYSIS.—PARTS PER MILLION.—ARTHUR W. PALMER.

AVERYVILLE.

Serial number	Date of		Chlorine	Oxygen consumed; by dissolved	Nitrogen as Ammonia.		Nitrogen as		Source of Water.
	Collection	Examination			Free Ammonia	Albuminoid Ammonia; total	Nitrites	Nitrates	
5471	1899 July 21	1899 July 24	35.	8.2	.800	.272	.230	1.76	West pier of draw in bridge at Narrows.
5472	"	"	37.	8.3	.800	.288	.270	1.84	East pier near east shore..................
5473	"	"	36.5	8.3	.800	.288	.210	1.84	East pier of draw in bridge at Narrows.
5474	"	"	35.5	8.2	.96	.256	.230	1.68	West bank of river bridge at Narrows..
9885	1901 Nov. 26	1901 Nov. 27	22.	......	......	......	......	......	West bank of river bridge at Narrows..
9886	"	"	21.	......	......	......	......	......	Mid-stream at bridge at Narrows......
9887	"	"	21.	......	......	......	......	......	East bank of river bridge at Narrows..

AT WESLEY CITY.

Serial number	Collection	Examination	Chlorine	Oxygen consumed	Free Ammonia	Albuminoid Ammonia	Nitrites	Nitrates	Source of Water
5467	1899 July 22	1899 July 22	43.	......	.256	.336	.330	1.68	50 feet from east shore....................
5468	"	"	43.	......	.352	.320	.340	1.76	⅓ distance from East shore..............
5469	"	"	41.5	......	.352	.320	.340	1.60	⅔ across from East shore................
5470	"	"	42.	......	2.240	.432	.800	1.04	5 feet from West shore. ....

AT FOOT OF TERMINAL BRIDGE.

Serial number	Collection	Examination	Chlorine	Oxygen consumed	Free Ammonia	Albuminoid Ammonia	Nitrites	Nitrates	Source of Water
9893	1901 Nov. 26	1901 Nov. 27	24.	......	......	......	......	......	West shore......... ....
9894	"	"	22.	......	......	......	......	......	Mid-stream..... ....
9895	"	"	22.	......	......	......	......	......	East shore ....

BELOW PEKIN 1½ MILES.

Serial number	Collection	Examination	Chlorine	Oxygen consumed	Free Ammonia	Albuminoid Ammonia	Nitrites	Nitrates	Source of Water
9888	1901 Nov. 26	1901 Nov. 27	24.	......	......	......	......	......	West shore..................................
9889	"	"	22.	......	......	......	......	......	West of mid-stream.........................
9890	"	"	21.	......	......	......	......	......	Mid-stream..................................
9891	"	"	22.	......	......	......	......	......	East of mid-stream ....
9892	"	"	22.	......	......	......	......	......	East shore........... ....

STREAMS EXAMINATION—O

SANITARY WATER ANALYSI

MISSISSIPPI RIVER AT GRAFTO

Serial number	Source of water.	Date of		Appearance.			Odor	Residue on Evaporation.						Color on ignition
		Collection	Examination	Turbidity	Sediment	Color		Total	Dissolved	Suspended	Loss on Ignition.			
											Total	Dissolved	Suspend'd	
4583	Miss. R., Grafton " " "	1899 Jan. 5	1899 Jan. 9	Deci'd.	Consid	F.08 Muddy	None	232.	195.6	36.4	34.	28.8	5.2	Brown
4585	" " "	5	9	"	"	F.08 Muddy	"	226.8	190.8	36.	28.8	24.	4.8	"
4584	" " "	5	9	"	"	F.05 Muddy	"	231.6	196.8	34.8	32.8	26.	6.8	"
4626	" " "	18	20	"	"	F.3 Muddy	"	228.8	188.	40.8	40.	26.	14.	"
4627	" " "	18	20	"	"	F.02 Muddy	"	230.	190.8	39.2	40.	28.	11.2	"
4628	" " "	18	20	"	"	F.04 Muddy	"	224.	192.8	31.2	42.	32.	10.	"
4707	" " "	Feb. 15	Feb. 17	Dist.	Little	F.04 Muddy	"	238.	228.8	9.2	36.	32.	4.	"
4708	" " "	"	"	"	"	F.04 Muddy	"	242.8	236.	6.8	32.	28.	4.	"
4709	....	"	"	"	"	F.03 .15	"	238.	220.	18.	36.	28.	8.	"
5090	....	May 24	May 26	Deci'd.	Consid	F.04 Muddy	"	369.6	245.2	124.4	38.	33.3	4.4	"
5091	....	24	26	V d'c'd	V m'ch	F.3 Muddy	"	1097.6	138.8	958.8	50.8	24.4	26.4	"
5092	....	24	26	"	"	F. Muddy	"	332.	231.6	100.4	28.8	25.6	3.2	"
F 5594	....	July 28	Aug. 1	....	....	.04	......	......	......	......	....	....	....	......
F.5523	....	28	1	....	....	.04	......	......	......	......	....	....	....	......
F 5522	....	28	1	....	....	.04	......	......	......	......	....	....	....	......
4586	Ill. R., Grafton..	1899 Jan. 5	1899 Jan. 8	Deci'd.	Consid	F.05 Muddy	None	354.	304.8	49.2	42.8	40.	2.8	Brown
4587	" " " ..	5	7	"	"	F.05 Muddy	"	326.8	282.	44.8	40.	34.	6.	"
F.5526	" " " ..	July 28	Aug. 1	....	....	.03	......	......	......	......	....	....	....	......
5525	" " " ..	28	1	....	....	.03	....	......	......	......	....	....	....	......
5527	" " " ..	28	1	....	....	.03	......	......	......	......	....	....	....	......

CROSS-SECTIONS—NO. 2.

CAGO SANITARY DISTRICT.

PARTS PER MILLION.

ABOVE MOUTH OF ILLINOIS. ARTHUR W. PALMER.

Chlorine........	Oxygen Consumed.			Nitrogen as Ammonia				Organic Nitrogen.			Nitrogen as		Remarks.
	Total........	By dissolved.	By suspended matter......	Free amm'nia	Alb'minoid Ammonia.			Total........	Dissolved.....	Suspended.....	Nitrites......	Nitrates......	
					Total....	Diss'l'ed	Susp'ded						
5.2	12.3	8.8	3.5	.012	.440	.240	.200	.77	.45	.32	.004	.075	Collected near Missouri shore.
5.2	12.3	8.4	3.9	.018	.440	.160	.280	.81	.33	.48	.003	.075	Mid-stream.
5.4	12.5	8.1	4.4	.018	.440	.176	.264	.73	.33	.40	.003	.075	Collected near Illinois shore.
5	10.8	6.2	4.6	.018	.360	.160	.200	.85	.37	.48	.035	.25	Missouri shore.
5	11.	6.2	4.8	.018	.400	.144	.256	.77	.37	.40	.020	.15	Mid-stream.
5	11.2	6.2	5.	.022	.360	.144	.216	.69	.33	.36	.026	.10	Illinois shroe.
5	7.7	7.	7.	.020	.352	.160	.192	.66	.34	.32	.003	.15	Missouri shore.
5	8.	6.8	1.2	.030	.368	.160	.208	.74	.30	.44	.004	.15	Mid-stream.
5	8.3	6.8	1.5	.026	.384	.176	.208	.58	.30	.28	.003	.15	Illinois shore.
7	12.1	11.	1.	.352	.48	.384	.096	.97	.70	.27	.07	1.72	Near channel.
4	26.5	13.4	13.1	.184	.112	.288	.832	.265	.7	1.95	.05	.16	Center of channel.
7.15	7.	6.6	.4	.384	.416	.288	.128	.89	.76	.13	.06	1.56	
2.6	13.8	.....	.....	....	....	....	....	.....	....	....	.006	.28	West bank.
2.4	13.0	.....	... .	....	....	....	....	.....	....	....	.005	.28	Mid-stream.
2.4	13.3	.....	.....	....	....	....	....	.....	....	....	.011*	.24	Miss. river channel, near east dyke.
14.	11.5	7.8	3.7	1.	.360	.224	.136	.93	.53	.40	.022	.300	Ill. river Grafton, near east bank.
12.8	10.8	8.1	2.7	.92	.360	.256	.104	.89	.49	.40	.017	.300	Ill. river Grafton, near west bank.
30.00	10.2	.152	.272	....	....	....	....	.....	....	....	.055	1.40	East bank.
30. 30.	10.0	.....	.....	.072	.24	....	....	.... .	....	....	.080	1.48	Mid-stream.
30.	10.0	.....	.....	.228	.272	...	....	.....	....	....	.060	1.44	West bank.

8911

DEFENDANTS' SPECIAL

MISSISSIPPI RIVER. SANITARY WATER ANALYSIS.

Serial Number	Source of Water.	Date of		Appearance.		Odor	Residue on Evaporation.			Loss on Ignition.			Color on Ignition
		Collection	Examination	Turbidity	Sediment		Total	Dissolved	Suspended	Total	Dissolved	Suspend'd	
6455	Mississippi River	1899 Dec. 6	1899 Dec. 7	D'tin't	C'nsid.	None	188.	155.2	32.8	25.6	22.4	3.2	B'wn
6456	" "	6	7	"	"	"	178.4	152.8	25.6	28.	26.8	1.2	"
6457	" "	6	7	"	"	"	182.	164.	18.	23.2	12.4	10.8	"
6458	" "	6	7	"	"	"	211.2	195.6	15.6	24.8	21.6	3.2	"
6459	" "	6	7	"	"	"	208.4	186.4	22.	26.8	23.2	3.6	"
6460	" "	6	7	"	"	"	164.8	152.8	12.	32.	28.	4.	"
7871	Miss. Riv. at Hartford	July, 7	1900										
7870	" " "	7											
7872	" " "	7											
7873	" " "	7											
7875	" " "	7											
7874	" " "	7											
8204	" " "	Aug. 17	1900 18										
8207	" " "	17	18										
8205	" " "	17	18										
8206	" " "	17	18										
8208	" " "	17	18										
8209	" " "	17	18										
8210	" " "	17	18										
8211	" " "	17	18										
8212	" " "	17	18										
4923	Miss. River at Mitchell	Apr. 14	1899 17	Dec'ed	V. Mch	None	1694.8	210.8	1484.	98.	32.	66.	B'wn
4924	" " "	14	17	"	"	"	2265.6	215.6	2050.	116.	30.	86.	"
4925	" " "	14	17	"	"	"	3392.4	250.4	3142.	140.8	24.	116.8	"
4926	" " "	14	17	"	"	"	3502.	254.	3248.	144.	26.	118.	"

CROSS-SECTIONS, NO. 3.

PARTS PER MILLION. ARTHUR W. PALMER.

Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Remarks.	
	Total	By Dissolved	By Suspended Matter	Free Ammonia	Albuminoid Ammonia.			Total	Dissolved	Suspended	Nitrites	Nitrates		
					Total	Dissolved	Suspend'd							
4.9	14.5	13.3	1.2	.016	.0416	.288	.128	1.	.744	.256	.011	.06		
4.4	14.5	13.3	1.2	.016	.384	.24	.144	1.	.744	.256	.008	.44		
6.4	14.8	12.7	2.1	.064	.416	.224	.192	1.	.744	.256	.009	.44		
10.6	13.6	12.6	1.	.242	.448	.224	.224	1.032	.744	.288	.015	.06		
Lst	14.2	12.2	2.	.28	.4	.224	.176	1.	.744	.256	.012	.52		
3.2	14.6	12.8	1.8	.016	.304	.224	.08	.904	.712	.192	.007	.48		
4.4	....	....	....	....	....	....	....	....	....	....	....	....	50 yards from Missouri shore, 5 feet below surface, in 15 feet of water.	
4.8	....	....	....	....	....	....	....	....	....	....	....	....	Mid-channel, 10 inches below surface, in 17 feet of water.	
5.6	....	....	....	....	....	....	....	....	....	....	....	....	Mid-channel, 15 feet below surface, in 17 feet of water.	
8.8	....	....	....	....	....	....	....	....	....	....	....	....	33 yards from Illinois shore, 10 inches below surface, in 33 feet of water.	
11.	....	....	....	....	....	....	....	....	....	....	....	....	33 yards from Illinois shore, 14 feet below surface, in 33 feet of water.	
9.2	....	....	....	....	....	....	....	....	....	....	....	....	33 yards from Illinois shore, 30 feet below surface, in 33 feet of water.	
3.8	....	....	....	....	....	....	....	....	....	....	.005	....	33 yards from Missouri shore, 18 feet from bottom.	
4.0	....	....	....	....	....	....	....	....	....	....	.005	....	¼ distance from Missouri shore, 18 feet from bottom.	
4.1	....	....	....	....	....	....	....	....	....	....	.004	....	Mid-stream, 18 feet from bottom.	
4.2	....	....	....	....	....	....	....	....	....	....	.002	....	" " below surface.	
12.4	....	....	....	....	....	....	....	....	....	....	.008	....	¼ distance from Illinois shore, 18 feet from bottom.	
6.	....	....	....	....	....	....	....	....	....	....	.005	....	¼ distance from Illinois shore, 18 feet below surface.	
8.5	....	....	....	....	....	....	....	....	....	....	.008	....	33 yards from Illinois shore, 20 feet from bottom.	
8.6	....	....	....	....	....	....	....	....	....	....	.005	....	33 yards from Illinois shore, 18 inches from bottom.	
8.6	....	....	....	....	....	....	....	....	....	....	.008	....	33 yards from Illinois shore, 18 inches below surface.	
5.7	26.9	8.7	18.2	.144	.92	.192	.728	2.59	....	....	.08	1.05	300 feet off Illinois shore	2 miles below mouth of Misso'ri river.
5.6	30.	8.6	21.4	.112	1.2	.192	1.008	2.83	.39	2.44	.074	.9	Mid-stream.	
7.8	34.7	6.9	27.8	.056	1.6	.144	1.456	4.27	.35	3.92	.04	.65	300 feet off Missouri shore.	
7.4	34.6	7.4	27.2	.064	1.72	.176	1.544	4.43	.35	4.08	.035	.85	¼ mile within mouth of Missouri river.	

DEFENDANTS' SPECIAL

STREAMS EXAMINATION—CHI

SANITARY WATER ANALYSIS

MISSISSIPPI

Serial number	Source of water.	Date of		Appearance.		Odor	Residue on evaporation.					
		Collection	Examination	Turbidity	Sediment		Total	Dissolved	Suspended	Loss on Ignition.		
										Total	Dissolved	Suspend'd
		1899 Dec.	1899 Dec.									
	Alton—											
6451	Mississippi river, 100 ft. off Illinois shore	6	7	Dist.	Consid	None	222.4	207.6	14.8	14.0	12.8	1.2
6458	Miss. river, 100 ft. off Illinois shore, 8¾ ft. below surface	6	7	"	"	"	211.2	195.6	15.6	24.8	21.6	3.2
6450	Miss. river, ¼ dist. off Illinois shore	6	7	"	"	"	215.6	192.4	23.2	28.0	26.0	2.0
6459	Miss. river, ¼ dist. off Illinois shore, 2½ ft. below surface	6	7	"	"	"	208.4	186.4	22.0	26.8	23.2	3.6
6452	Miss. river, center channel	6	7	"	"	"	205.6	176.0	29.6	18.8	18.0	.8
6457	Miss. river, center channel, 6 ft. below surface	6	7	"	"	"	182.0	164.0	18.0	23.2	12.4	10.8
6453	Miss. iver, ¼ dist. Mo. shore	6	7	"	"	"	176.4	161.6	14.8	36.0	23.6	12.4
6456	Miss. river, ¼ dist. Mo. shore, 6½ ft. below surface	6	7	"	"	"	178.4	152.8	25.6	28.0	26.8	1.2
6455	Miss. river, ¼ dist. Mo. shore, 12 ft. below surface	6	7	"	"	"	188.0	155.2	32.8	25.6	22.4	3.2
6454	Miss. river, 100 ft. off Mo. shore	6	7	"	"	"	189.6	168.4	21.2	38.4	38.0	4.
6460	Miss. river, 100 ft off Mo. shore, 6 ft. 8 in. below surface	6	7	"	"	"	164.8	152.8	12.0	32.0	28.0	4.0
		Dec. 1899	Dec. 1899									
	Mitchel, or the Chain of Rocks—											
6489	Miss. river, 400 ft. off Illinois shore	7	8	Dist.	Consid	None	210.0	168.8	41.2	18.4	16.0	2.4
6484	Miss. river, 400 ft. off Illinois shore, 8 ft. below surface	7	8	"	"	"	216.0	170.8	45.2	37.6	28.8	8.8
6485	Miss. river, main channel, 18 in. below surface	7	8	Decid.	Much.	"	668.4	274.0	394.4	16.8	9.2	7.6
6480	Miss. river, main channel, 8 ft. below surface	7	8	"	"	"	531.6	254.4	277.2	22.8	22.4	.4
6486	Miss. river, Inlet Tower, 18 inches below surface	7	8	"	"	"	689.2	290.0	399.2	34.4	16.4	18.0
6479	Miss. river, Inlet Tower, 7 ft. below surface	7	8	"	"	"	731.6	294.8	436.8	33.2	26.8	6.4
6482	Miss. river, Inlet Tower, 13 ft. below surface	7	8	"	"	"	690.4	286.4	404.0	19.6	10.0	9.
6487	Miss. river, 400 ft. off Mo. shore	7	8	"	"	"	768.4	316.4	452.0	30.8	14.8	16.0
6483	Miss. river, 400 ft. off Mo. shore, 6 ft. below surface	7	8	"	"	"	785.6	310.8	474.8	23.6	12.4	11.2
6481	Miss. river, 400 ft. off Mo. shore, 8 ft. below surface	7	8	"	"	"	780.0	309.2	370.8	19.6	10.4	9.2

CROSS-SECTION NO. 4.

CAGO SANITARY DISTRICT.

PARTS PER MILLION.

RIVER WATER.

Color on ignition…	Chlorine………	Oxygen consumed.			Nitrogen as ammonia.				Organic Nitrogen.			Nitrogen as	
		Total………	By dissolved	By suspend'd matter….	Free ammonia…….	Albuminoid ammonia.			Total…….	Dissolved….	Suspended…	Nitrites…..	Nitrates…..
						Total…	Diss'l'ed	Susp'ded					
Brown	11.2	11.8	11.1	.7	.244	.448	.320	.128	.872	.552	.320	.015	.80
"	10.6	13.6	12.6	1.	.232	.448	.224	.224	1.032	.744	.288	.015	.60
"	8.7	11.8	11.4	.4	.190	.432	.272	.160	1.064	.616	.448	.014	.44
"	Lost…	14.2	12.2	2.	.280	.400	.224	.176	1.00	.744	.256	.012	.52
"	6.3	12.5	11.6	.9	.080	.432	.320	.112	.968	.680	.288	.012	.52
"	6.4	14.8	12.7	2.1	.064	.416	.224	.192	1.00	.744	.256	.009	.44
"	4.5	12.3	11.9	.4	.016	.400	.320	.080	.968	.616	.352	.011	.44
"	4.6	14.5	13.3	1.2	.016	.384	.240	.144	1.00	.744	.256	.008	.44
"	5.0	14.5	13.3	1.2	.016	.416	.288	.418	1.00	.744	.256	.011	.60
"	3.6	12.9	11.9	1.0	.020	.384	.320	.064	.808	.712	.096	.008	.48
"	3.2	14.6	12.8	1.8	.016	.304	.224	.080	.904	.712	.192	.007	.48
Brown	8.2	12.0	10.6	1.4	.108	.512	.240	.272	.968	.648	.320	.008	.28
"	7.9	13.0	10.0	3.0	.112	.480	.272	.208	.968	.616	.352	.009	.28
"	15.9	9.4	6.0	3.4	.056	.368	.160	.208	.904	.360	.544	.007	.28
"	12.5	10.1	6.1	4.0	.032	.384	.192	.192	.872	.360	.512	.005	.28
"	16.2	9.2	5.0	4.2	.064	.368	.144	.224	1.128	.36	.768	.006	.32
"	15.9	8.8	5.3	3.5	.048	.352	.288	.068	.936	.52	.416	.005	.36
"	15.9	9.8	3.8	6.0	.032	.368	.240	.128	1.160	.392	.768	.005	.28
"	18.4	8.3	3.8	4.5	.060	.384	.240	.144	1.160	.360	.900	.008	.20
"	17.5	3.2	3.2	5.0	.056	.384	.144	.240	1.256	.296	.960	.006	.20
"	17.5	8.9	2.8	6.1	.032	.430	.144	.336	.936	.360	.576	.004	.24

8913 Q. Professor, will you now explain the significance of these ascertainments?

MR. JEFFRIES: I object to any explanation of the significance of the ascertainments contained in the defendants' special cross-sections, A. W. P., 1 to 4, inclusive, for the reasons stated in my objection to their being read in evidence.

A. The data of the special cross-sections made at Averyville show that the waters of the Illinois river are of substantially the same composition, that is, contain substantially the same proportions of chlorine and of other constituents at various points across the stream; that the entire body of water passing this point, in the Illinois river is substantially homogeneous as regards those substances, generally determined in the sanitary chemical analyses of waters.

The chlorine determinations alone is sufficient to show the substantial uniformity of composition of the water at the different points in the cross-section, hence the different points across the stream.

The purpose of making such cross-section determinations lies in the fact that when different bodies of water are brought together into one stream, it takes some considerable time for
them to mingle completely, and our data show what has
8914 repeatedly been referred to in giving my testimony, that
at different points in the various streams considered in this investigation the waters from different sources do not mingle completely, so that analyses of samples taken at one point in the stream at such a place would not fairly represent the composition of the entire body of water passing down that stream opposite said point.

The data with respect to the cross-section samples at Averyville show that by the time the waters of the Illinois river containing the discharges from the Illinois and Michigan canal from the Chicago main drainage channel; from the upper Desplaines river, the Kankakee river, the Fox river and numerous other minor tributary streams and containing sewage discharges from various towns situated upon its banks, have by the time they reach Averyville completely commingled so that the waters passing this point at the Narrows at Averyville, is of uniform homogeneous character, with respect to the constituents referred to.

The cross-section at Wesley City, made in July, 1899, in-

volving a determination of chlorine, of free ammonia, of total albuminoid ammonia, of nitrites and nitrates, show that the water at this point is not uniform in character all the way across the stream so far as various significanct chemical
8915 constituents are concerned. The differences in proportions of chlorine at different points here are not great, but the differences in the proportions of nitrogen as free ammonia are very considerable between the two sides of the stream.

The free ammonia at the east shore at this point was but .256 parts per million, while at the west shore within five feet of the west shore the proportion was 2.24 parts per million of nitrogen as free ammonia. At the other points in the cross-section, namely, one-third distance and two-thirds distance across the stream the proportions of nitrogen as free ammonia were greater than near the east shore, but nowhere near so great as the proportions found close to the west shore of the river at this point. This excess of free ammonia near the west shore of the stream at Wesley City is derived from or was at that time, derived from the discharges of Peoria sewage, including industrial wastes and house sewage, distillery slop, cattle shed slop, refuse and so on, passing down mainly along the west bank of the river at this point, so that the condition of the water at the west bank at Wesley City is in these respects far inferior to its condition near the east bank, that is, for the time specified,—July, 1899.

The determinations made near the terminal bridge at Peoria and below Pekin, which determinations involve merely the chlorine, show somewhat notable though not considerable
8916 variations in the proportions of chlorine at the cross-section points; the greater proportion of chlorine being found near the west shore; the smaller proportion being found near the east shore.

On sheet No. 2, defendants' special cross-sections, No. 2, the cross-section samples collected from the Mississippi river just above the mouth of the Illinois at Grafton, were taken for the purpose of determining whether the waters of the Mississippi at this point were substantially of uniform composition across the stream, and it was found that they were, that there were no very notable differences in the composition at the different points in the cross-section,—the cross-section samples being taken at various intervals, ranging from January, 1899, to July 28th, 1899.

Cross-sections taken in the Illinois river at Grafton January 5th, 1899, and July 28th, 1899, show substantial uniformity of the composition of the waters of the Illinois at different points across the stream.

Defendants' Special Cross-section Sheet No. 3, containing data of the analyses of cross-section samples collected in the Mississippi river at Hartford half a mile above the mouth of the Missouri river, which samples were collected December 6th, 1899, and July 7th, 1900, and August 17th, 1900, show 8917 that the waters of the Mississippi river have not commingled perfectly with the waters of the Illinois river by the time these two bodies of water have reached this point where they are about to come in contact with the waters of the Missouri river, and show that even down to this point the waters of the Illinois river pass down mainly along the Illinois shore, while the water passing down near to the Missouri shore is mainly the water of the upper Mississippi river.

The cross-section of the Mississippi river taken two miles below the mouth of the Missouri river merely afford evidence of the incomplete commingling of the three bodies of water at this point, and is corroborative of the more extensive series of cross-section analyses which have heretofore been testified to.

Defendants' Special Cross-section Analyses Sheet No. 4 contains the results of analyses of samples of water collected in special cross-sections at Alton, Hartford and at the chain of rocks. These samples having been collected at the same cross-section points referred to above, but in addition to the ordinary collection, collections were made at different depths below the surface, for the purpose of determining whether the composition at a given point was the same at different depths below the surface of the water in the river.

8918 They show in general that there was at times considerable difference between the proportions of constituents found in the water at eighteen inches below the surface and at depths from six to ten and up to 30 feet below the surface at points where the water reached such depths.

Q. Professor, have you made any special collections in reference to these waters which are not already put in evidence in this case? If so, please state what they are?

A. Oh, yes, I have made a great many special collections of data with regard to water. I have got everything that is published so far as I know and have studied it at various times.

Q. Have you any of that data with you that you could put in evidence?

A. I have not.

Q. Have you made any special collections of waters from these rivers which you have not given in evidence?

A. I have made a few other special collections of waters. I have not got all the data for them here. I made one series of cross-section collections for determinations of chlorine at La Salle during the summer of 1899, which showed that at this point at that particular time, the water at different points across the Illinois river beside the wagon bridge at LaSalle, was of substantially uniform composition all the way across the 8919 stream.

I made also special collections of water from the Illinois river at Grafton for the purpose of noting whether the composition varied at different times in the day, that is, during the 24 hours, and I have that data here on sheet No. 5, Special Collections.

Q. Will you explain that sheet, please?

A. This sheet contains the results of analyses of samples of water collected during 24 hours from the Illinois river at Havana on June 23rd, and 24th, 1899. Again similar collections made November 1st and 2nd, 1899, and similar 24 hour collections of water from the Illinois river at Havana, November 1st and 2nd, 1897, and August 5th and 6th, 1898.

JUDGE SPRINGER: I now offer this sheet in evidence, to be known as Defendants' Special 24 hour collections No. 1, A. W. P.

MR. JEFFRIES: I object to it for the reason that the analyses of water in the Illinois river prior to the opening of the canal, there is no evidence showing the manner and the time it was taken, and for the further reason, that the cause of the chemical changes in the condition of the water as stated by the witness yesterday afternoon with reference to certain ingredients is misleading and indefinite, and does not correctly represent the condition of the water in the river at the time the samples

8920 were taken, and at no time during the date the samples were taken.

8921

DEFENDANTS' SPECIAL 24

DEPARTMENT OF CHEMISTRY,

SANITARY WATER ANALYSIS.—PARTS

Serial number	Date of		Appearance.			Odor	Residue on Evaporation.						Color on Ignition	Chlorine	Oxygen Consumed.		
	Collection	Examination	Turbidity	Sediment	Color		Total	Dissolved	Suspended	Loss on Ignition.					Total	By dissolved	By suspended matter
										Total	Dissolved	Suspend'd					
5288	1899. June 23-24	1899. June 27	Decided.	Consid	F .06	None	332.0	320.4	11.6	48.0	40.0	8.	Brown	8.6	11.1	9.6	1.5
5289	"	"	"	"	F .05	"	345.6	306.0	39.6	40.	34.4	5.6	"	8.6	12.2	9.1	3.1
2882	1897. Nov. 1-2	1897. Nov.	"	Little..	F .1	"	384.8	362.4	22.4	30.	27.6	2.4	"	63.	12.1	10.7	1.4
2880	3	......	"	"	F .1	"	390.	363.2	26.8	32.8	32.	8.	"	58.	11.8	10.5	1.3
3913	1898. Aug 5-6	1898. Aug.	Distinct.	Consid	F .04	"	366.	336.	30.	28.	20.	8.	"	25.	14.9	11.1	3.8
3937	9	......	....	....	....	......	370.8	354.6	16.	44.	33.6	....	....	29.	9.3	8.4	.9

JUDGE SPRINGER: Counsel for the defendants suggests that this objection goes to the weight of the evidence and not as to its competency.

THE WITNESS: The table is as follows:

HOURS COLLECTION—A. W. P. NO. 1.

UNIVERSITY OF ILLINOIS.

PER MILLION.—ARTHUR W. PALMER.

Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Source of water.	Town.	Remarks.
Free amm'nia	Alb'minoid Ammonia. Total....	Alb'minoid Ammonia. Diss'l'ed	Alb'minoid Ammonia. Susp'ded	Total	Dissolved....	Suspended ...	Nitrites	Nitrates			
.064	.352	.288	.064	.84	.76	.080	.022	1.12	Illinois river.	Grafton.	24 hrs. collection, 18 ft below S.
.064	.352	.256	.096	.92	.728	.192	.017	1.12	"	"	" " 18 in "
.132	.48	.32	.16	1.04	.9	.15	1.	.7	"	Havana.	" "
1.16	.44	.32	.12	.94	.7	.24	1.	.8	"	"	Ordinary collection.
Lost.	.88	.48	.4	1.52	.8	.72	.05	.2	"	"	24 hrs. collection.
.52	.6	.44	.16	1.28	.92	.36	.2	.15	"	"	Ordinary collection.

8922 Q. Now, you may explain this further, Professor, if you will ?

A. For the purpose of noting whether the composition of the water in the Illinois river varied greatly during the 24 hours on November 1st and 2nd, 1897, samples of water were collected from the Illinois river at Havana, at a point a short distance above the mouth of the Spoon river and Quiver lake, during both the day and the night. Samples taken from the river every two hours during this time were mixed together, thus yielding a composite sample representing the character of the water during the 24 hours covered by these collections, and the data secured by the analysis of said sample given in this table No. 2, Defendants' Special 24 Hour Collection, A. W. P., show that the composition of the water collected in this manner is substantially the same as that of samples collected upon previous days, for the same period and upon days shortly following those indicating that the ordinary collection of a single sample yields results which are substantially correct for the composition of the water passing during at least the 24 hours in which the period of collection ordinarily falls.

Q. In other words, that the effect of the darkness is not substantially manifest in the ascertainments?

A. So far as chemical contents determined in the sani-
8923 tary chemical analyses of the water is concerned.

Q. State under what circumstances these collections of water were taken. Under what authority?

A. They were taken under my direction and in my presence. I helped but did not do all the work in this particular case.

MR. JEFFRIES: Do you mean to say you sat up for 24 hours?

A. I have done that more than once.

JUDGE SPRINGER: I want to get in what capacity you were acting at the time?

A. As professor of chemistry of the University of Illinois in charge of the chemical survey of the waters of the state of Illinois with which duty I have been charged by the president and trusees of the university, and acting under the provisions of the act of the Legislature before cited in this case.

Q. Were these analyses made at the time the samples were taken or near that time?

A. They were made immediately afterward; they were sent to the laboratory as have been other samples collected, concerning which I have testified.

Q. They were taken then in pursuance of your official duties three years before the pending suit was brought?

A. They were.

Q. Will you please continue your explanation of this plate, Professor?

8924 A. Upon August 5th and 6th, 1898, another similar collection was made at the same point, at Havana, and gave results which were simply corroboative of those referred to above regarding the sample collected at this point November 1st and 2nd, 1897.

On June 23rd and 24th, 1899, some similar 24 hour collections were made in the Illinois river at Grafton. The collection at this time and place, however, was made under somewhat different circumstances by means of a specially constructed galvanized iron boat or tank; the samples were collected continuously during the 24 hours, that is, every hour, every minute and every second of the 24 hours. By means of siphon tube connections the water was kept continuously flowing throughout the 24 hours into the sample bottle into which it was taken for shipment to the laboratory and subsequent analysis. At this time but two samples were taken at the same point simultaneously, one eighteen inches below the surface of the stream and the other eighteen feet below the surface of the stream, or about two feet above the bottom, the water at this point at this time in the Illinois river being about twenty feet in depth. These two analyses compared with other analyses of samples collected at about the same time at this point show substantial uniformity therewith, and comparison of the two 24 hour collections made simultaneously here shows substantial uniformity of the composition of the water at this point throughout the depth 8925 of the stream. The chlorines were identical in proportion; the oxygen consumed was somewhat greater in the sample collected near the surface, than it was in the sample collected near the bottom of the river. The free ammonia was precisely the same in both samples, as was also the total albuminoid ammonia, though the dissolved albuminoid ammonia, that is, albuminoid ammonia derived from dissolved substances, was somewhat greater in the water collected at the depth of eighteen feet than it was in the sample collected at the depth of eighteen inches, the suspended matters being greater in the water near the surface at this time.

Total organic nitrogen was found to be slightly more considerable in proportions in the water taken near the surface than in the water taken near the bottom.

The dissolved total organic nitrogen being somewhat greater at the greater depth, and less near the surface; the suspended matters conversely being greatest near the surface and least near the bottom.

Nitrites were .017 parts per million in the sample taken at eighteen inches below the surface, and were .022 parts per million in the sample taken at 18 feet beneath the surface, while the nitrates were the same,—1.12 in each case.

MR. JEFFRIES: At what point was that, professor?

8926 A. This was the Illinois river at Grafton, in 1899, June 23rd and 24th, 1899.

8927 Q. Were any samples of water taken from the rivers in question in the latter part of the year 1901?

A. There were.

Q. Will you please explain the circumstances under which they were taken?

A. In 1901 a series of examinations of water at points in the Illinois river, the Mississippi river and the Missouri river were made by me on behalf of the Sanitary District of Chicago.

J. Have you the detailed examinations of those waters?

A. I have; they are here upon these sheets.

Q. Please state briefly what these sheets contain so as to advise counsel of their contents.

A. They contain analyses of samples of water collected from the Illinois river at Averyville during October, November and December, 1901. Analyses of samples of water collected from the Illinois river at Pekin for the same months, 1901; collected in the Illinois river at Grafton, October, November and December, 1901. The Mississippi river at Grafton, October, November and December, 1901; the Missouri river at Fort Bellefontaine, October, November and December, 1901; the Mississippi river at the chain of rocks, the Illinois shore, at the mid-channel,

at the intake tower, and near the Missouri show all during
8928 the months of October, November and December, 1901.

Q. Will you explain the circumstances under which those were taken and in what manner they were taken?

A. They were taken in the manner hereinbefore testified to, by various collectors who have been on the stand as witnesses in this case and in accordance with the same directions to which they have testified, the collectors having made out certificates upon the same blanks as those already testified to. In fact the certificates of these analyses I believe are in the possession of the Court together with those covering earlier periods of the investigation, namely the periods from May, to December, 1899, and from January to October, inclusive, 1900.

Q. How many samples in all have you taken?

A. I have not counted them; a good many.

Q. When were those analyses made?

A. These analyses were made by me in the same laboratory as that before referred to, the University of Illinois, at Champaign.

JUDGE SPRINGER: I offer these tables in evidence to be known as Sanitary District series 1901, A. W. P. Sheets numbers 1 to 21 inclusive.

The tables are as follows:

8929

CHEMICAL ANALYSIS.

SANITARY DISTRICT—SERIES 1901—A. W. P.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

REPORT OF ARTHUR W. PALMER.

Serial number	Source of Water.	Date of		Appearance.			Odor	Residue on Evaporation.						Color on ignition	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Nitrogen as	
		Collection	Examination	Turbidity	Sediment	Color		Total	Dissolved	Suspended	Loss on Ignition.					Total	By dissolved	By suspended matter	Free amm'nia	Albuminoid Ammonia.			Nitrites	Nitrates
											Total	Dissolved	Suspend'd							Total	Diss'l'ed	Susp'ded		
9422	Illinois river—Averyville	1901. Oct. 1	1901. Oct. 1	Decided.	Little	F.02 Muddy	Musty.	240.4	209.2	31.2	......	22.8	......	Brown	22.	7.1	6.3	.8	.192	.272	.16	.112	.08	1.52
9448	Illinois river—Averyville	8	8	"	"	F.05 Muddy	None	233.6	218.8	14.8	12.8	13.6	......	"	23.	6.7	6.9	....	.156	.224	.176	.048	.15	1.45
9496	Illinois river—Averyville	16	16	"	"	F.03 Muddy	"	236.	219.6	6.4	19.6	16.4	3.2	Gray	22.	5.8	5.	.8	.096	.208	.192	.016	.12	1.84
9506	Illinois river—Averyville	17	17	......	......	......	......	......	......	......	......	......	......	......	23.	....	......	....	......	......	....	....	......	......
9519	Illinois river—Averyville	18	18	Decided.	Little	F.05 Muddy	None	277.2	264.	13.2	28.4	21.6	6.8	Brown	23.	8.	5.	3.	.08	.224	.192	.032	.12	1.88
9521	Illinois river—Averyville	19	19	"	"	F.05 Muddy	Musty.	......	......	......	......	......	......	......	21.	....	......	....	......	......	....	....	......	......
9530	Illinais river—Averyville	21	21	"	"	F.05 Muddy	"	215.2	214.4	.8	25.2	20.4	4.8	Gray	21.	5.5	5.	.5	.192	.224	.16	.164	.125	1.835
9552	Illinois river—Averyville	22	22	......	......	......	......	......	......	......	......	......	......	......	22.	....	......	....	......	......	....	....	......	......
9559	Illinois river—Averyville	23	23	Distinct.	Little	F.04 Muddy	Musty.	227.6	214.	3.6	28.	26.4	1.6	Brown	24.	5.3	5.2	.1	.272	.24	.192	.048	.125	1.675
9564	Illinois river—Averyville	24	25	......	......	......	......	......	......	......	......	......	......	......	25.	....	......	....	......	......	....	....	......	......
9567	Illinois river—Averyville	25	25	Decided.	Consid	F.04 Muddy	None	232.	216.	16.	26.4	26.4	......	......	25.	6.2	5.6	.6	.32	.32	.192	.128	.25	1.51
9586	Illinois river—Averyville	26	28	......	......	......	......	......	......	......	......	......	......	......	24.	....	......	....	......	......	....	....	......	......
9587	Illinois river—Averyville	28	28	Decided.	Consid	F.12 Muddy	Musty.	236.4	206.6	29.8	22.8	22.8	......	Brown	22.	5.4	5.3	.1	.16	.224	.224	....	.12	1.64
9612	Illinois river—Averyville	29	30	......	......	......	......	......	......	......	......	......	......	......	21.	....	......	....	......	......	....	....	......	......
9613	Illinois river—Averyville	30	30	Decided.	Consid	F.05 Muddy	None	230.	202.8	27.2	26.	31.2	......	Gray	23.	5.8	4.8	1.	.16	.224	.192	.032	.105	1.735
9635	Illinois river—Averyville	Oct. 31	Nov. 1	......	......	......	......	......	......	......	......	......	......	......	20.	....	......	....	......	......	....	....	......	......
9637	Illinois river—Averyville	Nov. 1	Nov. 1	Decided.	Little	F.01 Muddy	None	217.2	205.2	12.	27.6	23.6	4.	Brown	20.	5.7	4.8	.9	.192	.224	.16	.064	.095	1.305
96[illegible]	Illinois river—Averyville	2	4	......	......	......	......	......	......	......	......	......	......	......	21.	....	......	....	......	......	....	....	......	......

9651	Illinois river—Averyville	4	4	Distinct.	Little..	F.03 .15	None..	239.2	227.6	1.6	31.2	27.2	4.	White.	21.	5.6	Lost.	....	.224	.208	.144	.064	.1	1.54
9670	Illinois river—Averyville	5	6												21.									
9673	Illinois river—Averyville	6	6	Distinct.	Little..	F.03 .1	None..	194.8	190.4	4.4	13.2	12.	1.2	Brown	20.	5.	4.4	.6	.08	.224	.256	....	.105	1.735
9690	Illinois river—Averyville	7	8												21.									
9691	Illinois river—Averyville	8	8	Decided.	Little..	Muddy	None..	232.8	214.8	18.	33.2	27.6	5.6	White.	21.	5.8	4.7	1.1	.128	.208	.192	.016	.1	1.9
9707	Illinois river—Averyville	9	11												21.									
9708	Illinois river—Averyville	11	11	Distinct.	Little..	F.03 Muddy	None..	226.4	208.	18.4	24.	23.2	.8	White.	21.	5.5	5.2	.3	.336	.208	.24	....	.095	1.545
9734	Illinois river—Averyville	12	13												21.									
9735	Illinois river—Averyville	13	13	Distinct.	Consid	F.04 Muddy	None..	218.4	218.4	.....	22.4	16.	6.4	Gray..	21.	5.5	5.3	.2	.56	.224	.224	....	.075	1.805
9772	Illinois river—Averyville	14	15												21.									
9773	Illinois river—Averyville	15	15	Distinct.	Little..	F.04 .1	None..	224.	214.	10.	23.2	22.8	.4	Brown	21.	5.5	5.5	....	.448	.192	.144	.048	.07	1.61
9792	Illinois river—Averyville	16	18												21.									
9793	Illinois river—Averyville	18	19	Distinct.	Little..	F.03 .05	None..	204.	219.6	.....	32.8	21.6	11.2	Gray..	21.	5.4	5.1	.3	.384	.224	.16	.064	.06	1.72
9811	Illinois river—Averyville	19	20												21.									
9812	Illinois river—Averyville	20	20	Distinct.	Little..	F.04 .1	None..	204.	214.8	.....	29.6	10.8	18.8	White.	21.	5.4	5.	.4	.32	.208	.16	.048	.085	1.775
9834	Illinois river—Averyville	21	22												21.									
9835	Illinois river—Averyville	22	22	Distinct.	Little..	F.04 .1	None..	209.6	211.6	.....	30.4	29.6	.8	Gray..	21.	5.5	5.2	.3	.432	.192	.144	.048	.075	1.565
9858	Illinois river—Averyville	23	25												22.									
9859	Illinois river—Averyville	25	25	Distinct.	Little..	.1	Musty.	227.2	202.	15.2	28.8	24.4	4.4	White.	22.	5.7	5.1	.6	.864	.208	.16	.048	.06	1.14
9882	Illinois river—Averyville	26	27												21.									
9884	Illinois river—Averyville	27	27	Distinct.	Little..	F.01 .2	Musty.	201.2	210.4	.....	27.2	27.2	.....	White.	22.	5.6	4.7	.9	.992	.24	.144	.096	.05	1.15
9912	Illinois river—Averyville	29	29	"	"	F.01 1.5	" ..	192.6	198.8	.....	23.6	23.6	.....	"	21.	5.4	4.4	1.	1.088	.224	.144	.08	.04	1.16
9931	Illinois river—Averyville	Nov. 30	Dec. 2												20.									
9932	Illinois river—Averyville	Dec. 2	Dec. 2	Slight...	Little..	F.03 .04	None..	223.2	213.2	10.	28.8	21.2	7.6	White.	20.	5.8	5.4	.4	1.184	.24	.144	.096	.05	1.15
8930																								
9949	Illinois river—Averyville	3	3												21.									
9969	Illinois river—Averyville	4	4	Distinct.	Little.	Muddy	None..	222.4	216.4	.6	24.4	42.4	.....	Gray..	20.	6.1	4.6	1.5	1.152	.256	.224	.032	.036	1.245

CHEMICAL ANALYSIS.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

REPORT OF ARTHUR W. PALMER.

Serial number	Source of Water.	Date of		Appearance.			Odor	Residue on Evaporation.						Color on ignition	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Nitrogen as	
		Collection	Examination	Turbidity	Sediment	Color		Total	Dissolved	Suspended	Loss on Ignition.					Total	By dissolved.	By suspended matter	Free amm'nia	Albuminoid Ammonia.			Nitrites	Nitrates
											Total	Dissolved.	Suspend'd							Total	Diss'l'ed	Susp'ded		
9992	Illinois river—Averyville	1901 Dec. 5	1901 Dec. 6												21.									
9993	Illinois river—Averyville	6	6	Distinct.	Little.	F.03 .1	None	208.	221.6		29.6	24.4	5.2	White.	21.	5.5	5.1	.4	1.36	.208	.192	.016	.03	1.37
10011	Illinois river—Averyville	7	9												18.									
10012	Illinois river—Averyville	9	9	Distinct.	Little.	F.02 Muddy	Musty.	205.6	206.4		26.8	20.8	6.	Brown	18.	5.4	4.7	.7	1.024	.224	.144	.08	.05	1.03
10046	Illinois river—Averyville	10	11												20.									
10047	Illinois river—Averyville	11	11	Distinct.	Little.	F.03 Muddy	None	194.8	193.6	1.2	21.6	27.2		White.	20.	5.4	5.3	.1	1.344	.224	.176	.048	.045	.955
10065	Illinois river—Averyville	12	13												20.									
10066	Illinois river—Averyville	13	13	Distinct.	Little.	F.04 Cl'dy	None	209.2	211.2		17.2	16.	1.2	Gray	20.	6.	5.2	.8	1.344	.224	.176	.048	.032	1.008
10085	Illinois river—Averyville	14	16												21.									
10086	Illinois river—Averyville	16	16	Distinct.	Little.	F.01 .05	Musty.	219.6	218.8	.8	29.2	25.6	3.6	White.	21.	6.2	4.8	1.4	1.6	.288			.028	1.052
10105	Illinois river—Averyville	17	18												22.									
10106	Illinois river—Averyville	18	18	Distinct.	Very little.	F.01 .04	None	230.4	213.2	17.2	26.8	23.2	3.6	Gray	22.	5.5	5.	.5	1.76	.224	.16	.064	.022	.338
10118	Illinois river—Averyville	19	20												23.5									
10119	Illinois river—Averyville	20	20	Distinct.	Little.	F.02 .05	Musty.	261.2	256.8	4.4	20.	28.8			28.	10.1	8.6	1.5	2.24	1.152	.8	.352	.024	1.176
10126	Illinois river—Averyville	21	23												24.									
10127	Illinois river—Averyville	23	23	Distinct.	Little.	F.05 .2	Musty.	229.2	225.2	4.	27.6	26.	1.6	Brown	24.	6.8	4.1	2.7	2.08	.288	.208	.08	.022	.778
10142	Illinois river—Averyville	24	26												25.									
10141	Illinois river—Averyville	26	26	Distinct.	Very little.	F.03 .1	Musty.	408.8	345.2	63.6	50.	21.6	28.4	Gray	24.	7.2	7.	.2	2.48	.272	.256	.016	.018	.748

10146	Illinois river—Averyville......	27	27	"	Little.	F.05 Muddy	"	265.6	258.	7.6	18.8	27.6	......	Brown	21.	7.9	6.8	1.1	1.6	.224	.192	.032	.015	.785
10150	Illinois river—Averyville	28	30	....	....	....	....	......	......	......	......	......	......	......	18.	......	......	......	......	......	......	......	......	......
10151	Illinois river—Averyville	30	30	Distinct.	Little.	Muddy	None..	258.4	242.	16.4	18.	22.	......	Brown	18.	7.6	7.6	....	1.6	.24	.224	.016	.015	1.665

8931

9493	Illinois river—Pekin............	Oct. 15	Oct. 16	Decided.	Little..	F.05 Muddy	None..	226.	211.2	14.8	22.8	14.8	8.	Brown	23.	7.1	6.8	.3	.064	.208	.16	.048	.125	1.675
9497	Illinois river—Pekin....	16	17	"	"	"	"	235.6	221.6	14.	14.	11.2	2.8	Gray..	23.	6.2	5.1	1.1	.112	.256	.224	.032	.....	1.68
9517	Illinois river—Pekin............	17	18	....	....	....	....	......	......	......	......	......	......	......	22.	......	......	......	......	......	......	......	......	......
9518	Illinois river—Pekin............	18	18	Decided.	Consid	F.05 Muddy	None..	272.	268.	4.	27.6	19.2	8.4	Brown	23.	6.2	5.2	1.	.128	.272	.224	.048	.1	1.54
9529	Illinois river—Pekin............	21	21	"	Little..	F.05 Muddy	Musty.	215.6	193.2	22.4	5.6	4.4	1.2	"	22.	5.8	5.1	.7	.064	.288	.144	.144	.095	1.705
9551	Illinois river—Pekin............	22	22	....	....	....	....	......	......	......	......	......	......	......	22.	......	......	......	......	......	......	......	......	......
9558	Illinois river—Pekin............	23	23	Decided.	Consid	F.05 Muddy	Musty.	221.2	216.8	4.4	33.6	32.4	1.2	Gray..	22.	6.	5.6	.4	.224	.288	.272	.016	.125	1.675
9565	Illinois river—Pekin............	24	25	....	....	....	....	......	......	......	......	......	......	......	23.	......	......	......	......	......	......	......	......	......
9566	Illinois river—Pekin............	25	25	Decided.	Consid	F.62 Muddy	None..	225.6	219.6	6.	36.	36.	......	White to br'n	23.	7.1	5.3	1.8	.24	.336	.256	.08	.22	1.58
9580	Illinois river—Pekin............	26	28	....	....	....	....	......	......	......	......	......	......	......	25.	......	......	......	......	......	......	......	......	......
9586	Illinois river—Pekin............	28	28	Decided.	Consid	F.1 Muddy	Musty.	239.6	222.8	16.8	20.8	21.2	......	White to br'n	24.	5.9	5.8	.1	.256	.256	.224	.032	.105	1.735
9611	Illinois river—Pekin	29	30	....	....	....	....	......	......	......	......	......	......	......	21.	......	......	......	......	......	......	......	......	......
9614	Illinois river—Pekin............	30	30	Decided.	Little..	F.05 Muddy	None..	243.2	210.4	32.8	26.	22.4	3.6	Gray..	22.	6.5	5.9	.6	.192	.384	.224	.16	.095	1.425
9634	Illinois river—Pekin......	31	Nov. 1	....	....	....	....	......	......	......	......	......	......	......	21.	......	......	......	......	......	......	......	......	......
9638	Illinois river—Pekin............	Nov. 1	1	Decided.	Consid	F.4 Muddy	None..	221.6	210.6	11.	28.4	30.	......	Brown	22.	6.7	4.9	1.8	.192	.336	.192	.144	.095	1.345
9649	Illinois river—Pekin......	2	4	....	....	....	....	......	......	......	......	......	......	......	21.	......	......	......	......	......	......	......	......	......
9650	Illinois river—Pekin.	4	4	Distinct.	Little..	F.03 .15	None..	212.4	210.4	2.	20.4	25.6	.....	White.	21.	4.7	Lost.	....	.224	.24	.144	.096	.1	1.54
9671	Illinois river—Pekin.......... .	5	6	....	....	....	....	......	......	......	......	......	......	......	21.	......	......	......	......	......	......	......	......	......
9672	Illinois river—Pekin............	6	6	Distinct.	Little..	F.03 Muddy	None..	224.4	212.	12.4	17.2	18.4	.....	Gray..	21.	5.7	5.5	.2	.072	.24	.224	.016	.075	1.525
9688	Illinois river—Pekin............	7	8	....	....	....	....	......	......	......	......	......	......	......	21.	......	......	......	......	......	......	......	......	......
9689	Illinois river—Pekin.....	8	8	Decided.	Consid	Muddy	None..	229.6	214.4	15.2	35.2	40.	......	White.	21.	7.	6.	.1	.128	.352	.272	.08	.105	1.535
9709	Illinois river—Pekin............	9	11	....	....	....	....	......	......	......	......	......	......	......	21.	......	......	......	......	......	......	......	......	......
9710	Illinois river—Pekin...	11	11	Distinct.	Little..	F.04 Muddy	None..	228.8	208.	20.8	26.4	23.6	2.8	Gray..	21.	7.	6.4	.6	.192	.368	.24	.128	.085	1.515

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.
SANITARY WATER ANALYSIS—PARTS PER MILLION.

CHEMICAL ANALYSIS.

Serial number	Source of water.	Date of		Appearance.			Odor	Residue on evaporation.						Color on ignition	Chlorine	Oxygen consumed.			Nitrogen as ammonia.				Nitrogen as	
		Collection	Examination	Turbidity	Sediment	Color		Total	Dissolved	Suspended	Loss on Ignition. Total	Loss on Ignition. Dissolved	Loss on Ignition. Suspend'd			Total	By dissolved	By suspended matter	Free amm'nia	Albuminoid ammonia. Total	Albuminoid ammonia. Diss'l'ed	Albuminoid ammonia. Susp'ded	Nitrites	Nitrates
9736	Illinois river—Pekin	1901 Nov. 12	1901 Nov. 13	......	......	......	......	......	......	......	......	......	......	......	21.	......	......	......	......	......	......	......	......	......
9737	Illinois river—Pekin	13	13	Decided.	Consid	F .04 Muddy	Gassy..	241.6	220.	21.6	27.2	19.2	8.	Gray..	21.	7.5	5.8	1.7	.4	.368	.192	.176	.085	1.915
9770	Illinois river—Pekin	14	15	......	......	......	......	......	......	......	......	......	......	......	21.	......	......	......	......	......	......	......	......	......
9771	Illinois river—Pekin	15	15	Distinct.	Little..	F .03 Muddy	None..	225.6	218.4	6.2	26.	23.2	2.8	Gray..	21	6.6	5.6	1.	.512	.368.	176.	192	.05	1.55
9791	Illinois river—Pekin	16	18	......	......	......	......	......	......	......	......	......	......	......	21.	......	......	......	......	......	......	......	......	......
9790	Illinois river—Pekin	18	18	Distinct.	Little..	F .02 .05	None..	218.4	205.6	12.8	25.6	22.	3.6	Gray..	21.	6.2	5.2	1.	.512	.368	.208	.16	.08	1.72
9813	Illinois river—Pekin	19	20	......	......	......	......	......	......	......	......	......	......	......	23.	......	......	......	......	......	......	......	......	......
9814	Illinois river—Pekin	20	20	Distinct.	Little..	F .02 .1	None..	228.8	220.4	8.4	28.8	23.6	5.2	Gray..	21.	6.2	5.2	1.	.48	.288	.144	.144	.085	1,755
9836	Illinois river—Pekin	21	22	......	......	......	......	......	......	......	......	......	......	......	21.	......	......	......	......	......	......	......	......	......
9837	Illinois river—Pekin	22	22	Distinct.	Little..	F .04 .1	None..	214.8	208.4	6.4	32.4	27.6	4.8	Gray..	21.	5.7	5.1	.6	.352	.192	.144	.048	.075	1.565
9856	Illinois river—Pekin	23	25	......	......	......	......	......	......	......	......	......	......	......	21.	......	......	......	......	......	......	......	......	......
9857	Illinois river—Pekin	25	25	Distinct.	Little..	F .03 .1	Musty.	227.2	221.2	6.	28.4	26.	2.4	White.	22.	5.6	5.4	.2	.672	.176	.144	.032	.045	1.235
9881	Illinois river—Pekin	26	27	......	......	......	......	......	......	......	......	......	......	......	21.	......	......	......	......	......	......	......	......	......
9883	Illinois river—Pekin	27	27	Distinct.	Little.	F .04 .2	None..	242.4	206.	36.4	28.4	24.4	4.	Gray..	22.	7.1	5.1	2.	1.12	.368	.176	.192	.05	.95
9913	Illinois river—Pekin	29	29	Slight...	Very little.	F .02 .05	"	205.6	197.6	8.	25.6	34.4	.....	White.	21.	6.4	5.1	1.3	1.12	.288	.16	.128	.045	1.435
9933	Illinois river—Pekin	30	Dec. 2	......	......	......	......	......	......	......	......	......	......	......	20.	......	......	......	......	......	......	......	......	......
9934	Illinois river—Pekin	Dec. 2	2	Slight...	Very little.	F .03 .05	None..	226.4	216.4	10.	36.	35.2	.8	White.	20.	6.2	5.6	6.	1.152	.272	.224	.048	.045	1.195
9970	Illinois river—Pekin	3	4	......	......	......	......	......	......	......	......	......	......	......	20.	......	......	......	......	......	......	......	......	......
9971	Illinois river—Pekin	4	4	Distinct.	Little..	Muddy	Musty.	214.4	202.	12.4	28.4	24.8	3.6	White.	20.	6.9	5.2	1.7	1.536	.336	.16	.176	.04	.132

9994	Illinois river— Pekin	5	6												21.									
9995	Illinois river— Pekin	6	6	Distinct.	Little	F.04	None..	232.	222.4	10.6	31.6	30.4	1.2	White.	21.	6.6	6.1	.5	1.6	.368	.192	.176	.03	1.09
10013	Illinois river— Pekin	7	9												20.									
10014	Illinois river— Pekin	9	9	Distinct.	Little	F.09 Muddy	None..	208.	201.6	6.4	18.4	20.4		White.	19.	6.1	5.2	.9	.896	.272	.208	.064	.05	2.35
10048	Illinois river— Pekin	10	11												18.									
10049	Illinois river— Pekin	11	11	Distinct.	Little	F.04 Muddy	None..	210.4	219.6		24.8	22.	2.8	Gray.	19.	8.	5.9	2.1	.96	.4	.24	.16	.045	.635
10067	Illinois river— Pekin	12	13												21.									
10068	Illinois river— Pekin	13	13	Distinct.	Little	F.01 Cl'udy	Musty.	205.6	187.6	18.	20.4	16.4	4.	Gray.	21.	7.4	5.5	1.9	1.248	.336	.208	.128	.032	.968
10097	Illinois river— Pekin	16	17	"	"	F.01 .04	None..	222.4	215.6	6.8	21.6	21.6		Brown	21.	6.	5.1	.9	.672	.256	.144	.112	.024	.976
10098	Illinois river— Pekin	17	17												21.									
10112	Illinois river— Pekin	18	19	Distinct.	V. Lit.	F.02 .05	None..	226.	224.	2.	24.4	28.4		White.	23.	5.9	5.8	.1	1.68	.288	.24	.048	.026	.894
10113	Illinois river— Pekin	19	19												23.									
10120	Illinois river— Pekin	20	21	Distinct.	V. Lit.	F.03 .05	Musty.	244.8	223.6	21.2	59.2	41.6	17.6	Brown	24.	7.2	6.7	.5	1.68	.224	.224		.024	.776
10121	Illinois river— Pekin	21	21												24.									
10129	Illinois river— Pekin	23	24	Distinct.	"	F.03 .15	Musty.	230.4	222.	8.4	22.4	22.4		Gray.	25.	8.1	8.	.1	2.56	.272	.224	.048	.024	.536
10130	Illinois river— Pekin	24	24												25.									
10144	Illinois river— Pekin	25	26												26.									
10143	Illinois river— Pekin	26	26	Distinct.	Little	F.04 .1	Musty.	252.8	244.4	8.4	27.6	26.4	1.2	Gray.	26.	8.2	7.4	.8	2.8	.304	.288	.016	.02	.78
10148	Illinois river— Pekin	27	30	"	"	F.05 Muddy	"	272.	258.	14.	19.6	21.2		Brown	22.	7.6	6.8	.8	2.08	.272	.176	.096	.015	.745
10149	Illinois river— Pekin	28	30												22.									

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.
SANITARY WATER ANALYSIS—PARTS PER MILLION.

CHEMICAL ANALYSIS.

REPORT OF ARTHUR W. PALMER.

Serial Number......	Source of Water.	Date of		Appearance.			Odor............	Residue on Evaporation.						Color on Ignition..	Chlorine........	Oxygen Consumed.			Nirotgen as Ammonia.				Nitrogen as	
											Loss on Ignition									Albuminoid Ammonia.				
		Collection	Examination.	Turbidity ...	Sediment....	Color...		Total....	Dissolved....	Suspended...	Total ...	Diss'l'ed	Susp'ded			Total..........	By Dissolved.	By Suspended Matter......	Free Am'onia	Total....	Diss'l'ed	Susp'ded	Nitrites......	Nitrates......
9426	Illinois river—Grafton..........	1901 Oct. 2	1901 Oct. 3	V. Dec'd	C'n'ble	F.03 Muddy	Musty.	238.4	214.	44.4	19.2	14.	5.2	Light Brown	21.	6.5	6.6	....	.152	.24	.128	.112	.04	1.56
9435	Illinois river—Grafton..........	4	5	"	Little	F.2 Muddy	"	256.	212.	44.	16.4	12.8	3.6	"	23.	6.6	6.1	.5	.104	.256	.24	.016	.055	1.503
9446	Illinois river—Grafton..........	7	8	"	C'n'ble	"	None.	286.	282.	4.	24.	24.	......	"	26.	8.2	8.	.2	.046	.192	.144	.048	.065	1.735
9455	Illinois river—Grafton.........	9	10	"	"	F.1 Muddy	"	298.4	244.8	53.6	3.2	3.2	......	"	25.2	6.7	7.1	....	.104	.192	.208	....	.06	1.62
9468	Illinois river—Grafton.......	11	12	"	Little.	F.03 Muddy	"	283.2	227.6	55.6	13.2	23.6	......	....	24.7	8.5	9.3	....	.168	.256	.128	.146	.055	1.01
9490	Illinois river—Grafton..........	14	15	"	C'n'ble	F.05 Muddy	"	274.8	212.	62.8	31.6	22.4	9.2	White to Brown	20.5	7.7	6.6	1.1	.164	.224	.224	....	.035	1.405
9508	Illinois river—Grafton..........	15	18	"	"	F.05 Muddy	"	......	......	......	.....	......	......	....	21.	....	......	....	......	......	....	....	......	......
9496	Illinois river—Grafton..........	16	17	"	"	"	Musty.	200.6	201.2	8.4	19.6	18.	1.6	Brown	20.	5.9	5.2	.7	.096	.224	.208	.016	.035	1.365
9510	Illinois river—Grafton..........	17	18	"	"	.. ..	....	......	......	......	......	......	......	....	20.	....	......	....	......	......	....	....	......	......
9522	Illinois river—Grafton....... ..	18	19	V. Dec'd	C'n'ble	F.06 Muddy	None.	250.2	222.8	36.4	1.2	.4	.8	Gray to Brown	20.	6.3	5.4	.9	.128	.104	.104	....	.035	1.525
9526	Illinois river—Grafton..........	19	21	....	....	....	....	......	......	......	......	.....	......	... .	20.	....	......	....	....	......	....	....	......	.....
9545	Illinois river—Grafton..........	21	22	V. Dec'd	Little.	F.08 Muddy	None.	243.6	219.2	24.4	18.4	18.4	......	Gray	22.	5.3	5.	.3	.161	.224	.24	....	.075	1.625
9554	Illinois river—Grafton..........	22	23	....	....	....	....	......	......	......	......	......	......	....	22.	....	......	...	......	......	....	....	......	......
9561	Illinois river—Grafton..	23	24	V. Dec'd	C'n'ble	F.05 Muddy	Musty.	260.8	229.2	31.6	36.4	36.4	......	Brown	22.	5.1	5.3	....	.136	.224	.16	.064	.06	1.62
9568	Illinois river—Grafton..........	24	26	....	....	....	....	......	......	......	......	......	......	....	22.	....	......	....	......	......	....	....	......	......
9570	Illinois river—Grafton..........	25	26	V. Dec'd	C'n'ble	F.04 Muddy	None.	256.	210.4	45.6	22.4	12.8	9.6	Brown	21.	5.7	4.7	1.	.1	.192	.144	.048	.04	1.4

9605	Illinois river— Grafton..........	26	29	....	....	....	....	....	....	....	....	....	....	....	23.	....	....	....	....	....	....	....	....	....
9607	Illinois river— Grafton..........	28	29	V. Dec'd	Little.	F.15 Muddy	None.	Lost.	215.6	....	....	25.2	....	Brown	47.	6.	5.1	.9	.108	.32	.192	.128	.03	1.61
9617	Illinois river— Grafton..........	29	31	....	....	....	....	....	....	....	....	....	....	....	22.	....	....	....	....	....	....	....	....	....
9625	Illinois river— Grafton..........	30	31	V. Dec'd	Little.	F.05 Muddy	None.	240.8	201.8	39.	28.8	20.4	8.4	Light Brown	22.	6.4	4.9	1.5	.064	.32	.192	.128	.03	1.33
9647	Illinois river— Grafton..........	Nov. 1	Nov. 2	"	"	F.03 Muddy	"	221.3	211.6	9.7	30.	27.6	2.4	White	21.	5.9	....	....	.1	.272	.112	.16	.035	1.165
9659	Illinois river— Grafton..........	2	5	....	....	....	....	....	....	....	....	....	....	....	21.	....	....	....	....	....	....	....	....	....
9680	Illinois river— Grafton..........	5	7	....	....	....	....	....	....	....	....	....	....	....	23.	....	....	....	....	....	....	....	....	....
9675	Illinois river— Grafton..........	6	7	V. Dec'd	Little.	F.05 Muddy	None.	257.6	224.4	32.2	20.	17.2	2.8	Gray	23.	7.	5.7	1.3	.068	.288	.256	.032	.05	1.79
9699	Illinois river— Grafton..........	8	9	"	"	F.02 Muddy	"	234.4	224.8	9.6	30.4	24.8	5.6	Brown	22.	6.5	4.8	1.7	.052	.336	.224	.112	.04	1.36
9724	Illinois river— Grafton..........	9	12	....	....	....	....	....	....	....	....	....	....	....	20.2	....	....	....	....	....	....	....	....	....
9754	Illinois river— Grafton..........	12	14	....	....	....	....	....	....	....	....	....	....	....	21	....	....	....	....	....	....	....	....	....
9752	Illinois river— Grafton..........	13	14	V. Dec'd	C'n'ble	F.04 .05	None.	247.2	218.4	28.8	30.	30.4	....	Gray	21.	6.4	5.6	.8	.064	.352	.176	.176	.035	1.405
9775	Illinois river— Grafton..........	14	16	....	....	....	....	....	....	....	....	....	....	....	21.	....	....	....	....	....	....	....	....	....
9782	Illinois river— Grafton..........	15	16	V. Dec'd	C'n'ble	F.03 Muddy	None.	231.6	204.8	26.8	29.2	25.6	3.6	Brown	21.	7.7	5.5	2.2	.052	.496	.16	.336	.035	.84[illegible]
9794	Illinois river— Grafton..........	16	18	....	....	....	....	....	....	....	....	....	....	....	19.5	....	....	....	....	....	....	....	....	....
9796	Illinois river— Grafton..........	18	19	....	....	F.06	....	235.6	220.8	14.8	35.6	30.4	5.2	Gray	20.4	8.3	5.9	2.4	.052	.56	.192	.368	.05	1.27
9815	Illinois river— Grafton..........	19	21	....	....	....	....	....	....	....	....	....	....	....	21.	....	....	....	....	....	....	....	....	....
9817	Illinois river— Grafton..........	20	21	Distinct	Little.	F.02 Muddy	None.	219.6	202.	17.6	38.4	27.4	10.8	Gray	20.	8.3	5.3	3.	.068	.656	.144	.512	.035	.965
9838	Illinois river— Grafton..........	21	23	....	....	....	....	....	....	....	....	....	....	....	19.	....	....	....	....	....	....	....	....	....
9840	Illinois river— Grafton..........	22	23	Distinct	C'n'ble	F.02 Muddy	None.	207.6	204.	3.6	34.	30.	4.	Gray	19.	8.3	5.2	3.1	.028	.48	.16	.32	.045	.955
9861	Illinois river— Grafton..........	23	26	....	....	....	....	....	....	....	....	....	....	....	20.	....	....	....	....	....	....	....	....	....
9863	Illinois river— Grafton..........	25	26	....	....	F.03	....	244.8	223.6	21.2	38.4	35.2	3.2	White	20.	8.1	5.8	2.3	.064	.448	.176	.272	.05	1.63
9896	Illinois river— Grafton..........	26	28	....	....	....	....	....	....	....	....	....	....	....	21.	....	....	....	....	....	....	....	....	....
9898	Illinois river— Grafton..........	27	28	Distinct	C'n'ble	....	Musty.	236.8	219.2	17.6	30.8	28.4	2.4	White	21.	7.8	5.3	2.5	.076	.352	.16	.192	.03	1.37
9921	Illinois river— Grafton..........	28	30	....	....	F.03	....	....	....	....	....	....	....	....	21.	....	....	....	....	....	....	....	....	....
9922	Illionis river— Grafton..........	29	30	Distinct	C'n'ble	F.01 Muddy	None.	229.2	219.2	10.	27.6	25.6	2.	Brown	20.	6.9	5.2	1.7	.176	.336	.16	.176	.05	1.23

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.
SANITARY WATER ANALYSIS—PARTS PER MILLION.

CHEMICAL ANALYSIS.

Serial number	Source of water.	Date of		Appearance.			Odor	Residue on evaporation.						Color on Ignition	Chlorine	Oxygen consumed.			Nitrogen as ammonia.				Nitrogen as	
		Collection	Examination	Turbidity	Sediment	Color		Total	Dissolved	Suspended	Loss on Ignition. Total	Loss on Ignition. Dissolved.	Loss on Ignition. Suspend'd			Total	By dissolved	By suspended matter	Free amm'nia	Albuminoid ammonia. Total	Albuminoid ammonia. Diss'l'ed	Albuminoid ammonia. Susp'ded	Nitrites	Nitrates
9935	Illinois river—Grafton	1901 Nov. 30	1901 Dec 3												21.									
9937	Illinois river—Grafton	Dec. 2	3	Distinct	Little..	F.03	None..	223.2	212.4	10.8	28.	21.2	6.8	Brown	20.	9.2	5.7	3.5	.24	.332	.204	.128	.05	1.75
9975	Illinois river—Grafton	4	5	"	"	.1 Muddy	Musty.	236.4	217.6	18.8	31.2	24.4	6.8	White.	20.	7.5	5.6	1.9	.428	.352	.224	.128	.08	1.8
9996	Illinois river—Grafton	5	7												21.									
9998	Illinois river—Grafton	6	7	Distinct	Little..	F.04 cloudy	None..	222.	216.8	5.2	30.8	24.4	6.4	White.	19.	6.7	5.6	1.1	.54	.384	.16	.224	.06	1.5
10018	Illinois river—Grafton	7	10												19.									
10020	Illinois river—Grafton	9	10	Distinct	Little..	F.03 Muddy	None..	281.	233.2	47.8	27.2	25.6	1.6	Brown	19.	7.4	5.9	1.5	.672	.336	.192	.144	.03	.97
10050	Illinois river—Grafton	10	12												19.									
10052	Illinois river—Grafton	11	12	Distinct	Little.	F.01 cloudy	None..	228.	222.	6.	31.2	21.6	10.6	Gray..	18.	7.2	5.3	1.9	.64	.336	.192	.144	.03	1.21
10081	Illinois river—Grafton	12	16												18.									
10083	Illinois river—Grafton	13	16	Decided.	Consid	F.01 Muddy	None..	238.8	210.4	28.4	22.	16.4	5.6	Brown	18.	6.8	5.1	1.7	.64	.32	.192	.128	.026	.054
10093	Illinois river—Grafton	14	17												18.									
10096	Illinois river—Grafton	16	17	Very Decided.	Much..	F.04 Muddy	None..	554.	187.6	366.4	45.6	16.	28.6		18.	17.5	6.5	11.	.8	.64	.208	.432	.022	.818
10108	Illinois river—Grafton	17	19												18.									
10110	Illinois river—Grafton	18	19	Very Decided.	Much..	F.01 Muddy	None..	273.6	193.6	80.4	39.6	30.	9.6	Brown	17.	10.8	6.2	4.6	.928	.352	.192	.16	.026	1.036
10122	Illinois river—Grafton	19	23												18.									
10134	Illinois river—Grafton	20	23	Decided.	Little..	F.01 Muddy	None..	278.4	223.6	54.8	22.	20.8	1.2	Brown	18.	8.6	6.5	2.1	.864	.288	.16	.128	.03	1.01

10136	Illinois river—Grafton..........	21	25	....	... .	....	... .	......	......	......	.. .	.....	......	... .	18.	....	......	....	......	......	....	....	......	......
10138	Illinois river—Grafton..........	23	25	Decided.	Consid	F.02 Muddy	None..	255.6	220.8	34.8	56.	44.8	11.2	Brown	18.	8.9	7.9	1.	.128	.32	.192	.128	.022	1.018
8935																								
9427	Mississippi river—Grafton..........	Oct. 2	Oct. 3	Decided.	C'n'ble	F.2 Muddy	None	204.4	146.8	57.6	18.8	13.2	5.6	Brown	3.5	13.2	11.1	2.1	.08	.304	.16	.144	None	.24
9436	Mississippi river—Grafton..........	4	5	"	"	F.3 Muddy	"	202.	146.4	55.6	19.6	18.8	.8	"	3.3	13.6	8.8	4.8	.06	.336	.192	.144	.001	.28
9447	Mississippi river—Grafton..........	7	8	"	"	"	"	201.2	166.4	34.8	24.8	18.8	6.	"	3.6	12.6	10.9	1.7	.052	.304	.192	.112	.001	.16
9456	Mississippi river—Grafton..........	9	10	"	"	"	"	198.	169.	29.	20.8	20.4	.4	"	3.	12.8	11.9	.9	.044	.288	.144	.144	None	.08
9469	Mississippi river—Grafton..........	11	12	"	"	"	Pine	202.4	150.8	51.6	13.6	30.8	......	"	3.3	12.3	14.5	....	.32	.304	.128	.176	.007	.153
9491	Mississippi river—Grafton..........	14	15	"	"	F.13 Muddy	None	183.2	148.4	34.8	27.2	13.6	13.6	"	3.4	11.6	9.1	2.5	.092	.272	.16	.112	None	.04
9509	Mississippi river—Grafton..........	15	18	....	....	....	....	......	......	......	......	......	......	....	3.4	....	......	....	......	......	....	....	......	... ..
9499	Mississippi river—Grafton..........	16	17	....	....	....	....	201.2	172.4	28.8	18.	27.6	......	Brown	3.3	9.9	7.5	2.4	.028	.288	.16	.128	.002	.158
9511	Mississippi river—Grafton..........	17	18	....	....	....	....	......	......	......	......	......	......	....	3.3	....	......	....	......	......	....	....	......	......
9523	Mississippi river—Grafton..........	18	19	Decided.	C'n'ble	F.2 Muddy	None	205.2	144.	61.2	2.	.4	1.6	Brown	2.55	11.9	9.2	2.7	.016	.144	.08	.064	None	.08
9527	Mississippi river—Grafton..........	19	21	....	....	....	....	. ....	.....	.....	......	......	......	....	3.1	....	......	...	......	......	....	....	......	......
9546	Mississippi river—Grafton..........	21	22	Decided.	C'n'ble	F.4 Muddy	None	186.4	123.2	63.2	23.6	30.8	......	Brown	2.9	12.1	8.6	3.5	.08	.32	.176	.144	.002	.038
9555	Mississippi river—Grafton..........	22	23	....	....	....	....	......	.....	.....	......	......	....	....	2.8	....	......	....	......	......	....	....	......	......
9560	Mississippi river—Grafton..........	23	24	V. Dec'd	C'n'ble	F.6 Muddy	None	190.2	120.	79.2	32.4	34.4	......	Brown	2.	14.2	12.2	2.	.032	.352	.176	.176	None	.12
9571	Mississippi river—Grafton..........	25	26	Decided.	"	F.3 Muddy	"	205.	169.6	35.4	30.	24.	6.	"	2.8	14.8	12.2	2.6	.036	.32	.16	.16	"	.04
9606	Mississippi river—Grafton	26	29	....	....	....	....	......	......	......	... ..	.. ...	......	....	2.8	....	......	....	......	......	...	....	......	. ....
9608	Mississippi river—Grafton..........	28	29	Distinct.	Little.	F.6 Muddy	None	167.6	120.8	46.8	26.	20.	6.	Brown	2.8	14.1	9.8	4.3	.088	.368	.224	.144	.001	.12.
9618	Mississippi river—Grafton..........	29	31	....	....	....	....	......	......	.....	......	......	......	....	2.8	....	. ....	....	......	......	....	....	......	......
9624	Mississippi river—Grafton..........	30	31	"	"	F.4 Muddy	None	178.	121.2	56.8	30.4	24.	6.4	Brown	2.9	14.3	12.	2.3	.1	.32	.192	.128	.003	.157
9646	Mississippi river—Grafton..........	Nov. 1	Nov. 2	"	"	F.6 Muddy	"	178.8	102.	76.8	28.4	27.6	.8	"	3.1	14.6	12.3	2.3	.056	.288	.112	.176	None	.08
9658	Mississippi river—Grafton.....	2	5	....	....	....	....	......	......	......	.....	......	......	... .	2.8	....	... ..	....	.....	......	....	....	......	......
9681	Mississippi river—Grafton..........	5	7	....	....	....	....	.....	......	......	.....	......	......	....	2.8	....	......	....	......	......	....	....	......	......
9674	Mississippi river—Grafton	6	7	Distinct.	Little.	F.7 Muddy	None	166.4	121.2	45.2	27.6	28.4	......	Brown	3.4	14.1	11.7	2.4	.048	.288	.192	.190	None	.0
9700	Mississippi river—Grafton..........	[illegible]	[illegible]	"	"	F.4 Muddy	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.4	"	[illegible]	[illegible]	11.7	1.8	.056	.272	.224	.048	.001	.08

CHEMICAL ANALYSIS.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.
SANITARY WATER ANALYSIS—PARTS PER MILLION.

REPORT OF ARTHUR W. PALMER.

Serial Number	Source of Water.	Date of		Appearance.			Odor	Residue on Evaporation						Color on Ignition	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Nitrogen as	
		Collection	Examination	Turbidity	Sediment	Color		Total	Dissolved	Suspended	Loss on Ignition					Total	By Dissolved.	By Suspended Matter	Free Am'onia	Albuminoid Ammonia.			Nitrites	Nitrates
											Total	Dis'l'ved	Susp'ded							Total	Dis'l'ved	Susp'ded		
9723	Mississippi river—Grafton	1901 Nov. 9	1901 Nov 12												3.1									
9755	Mississippi river—Grafton	12	14												3.5									
9753	Mississippi river—Grafton	13	14	Distinct.	C'n'ble	F.3 .4	None	170.	126.4	43.6	27.6	28.8	...	Brown	3.6	11.7	9.1	2.6	.064	.224	.16	.064	None	.12
9776	Mississippi river—Grafton	14	16												3.5									
9783	Mississippi river—Grafton	15	16	Decided.	C'n'ble	F.3 Muddy	None	156.	130.8	25.2	26.4	22.8	3.6	Brown	3.	9.4	8.8	.6	.052	.24	.144	.096	.001	.2
9795	Mississippi river—Grafton	16	18												3.4									
9797	Mississippi river—Grafton	18	19			F.3		147.6	131.6	16.	24.4	21.6	2.8	Brown	3.5	9.1	8.3	.8	.048	.224	.16	.064	None	.16
9816	Mississippi river—Grafton	19	21												3.4									
9818	Mississippi river—Grafton	20	21	Distinct	Little.	F.25 Muddy	None	156.	136.	20.	27.2	24.8	2.4	Brown	3.3	9.1	7.9	1.2	.036	.24	.144	.096	None	.11
9839	Mississippi river—Grafton	21	23												3.1									
9841	Mississippi river—Grafton	22	23	Distinct.	Little.	F.2 Muddy	None	137.6	120.4	17.2	32.	29.6	2.4	Brown	3.2	9.3	8.2	1.1	.028	.16	.096	.064	None	.04
9862	Mississippi river—Grafton	23	26												3.1									
9864	Mississippi river—Grafton	25	26			F.2		150.	138.	12.	32.4	32.4	......	Brown	3.2	11.4	8.6	2.8	.04	.208	.16	.048	None	.12
9897	Mississippi river—Grafton	26	28												3.3									
9899	Mississippi river—Grafton	27	28			F.4		136.4	124.	12.4	22.8	28.	......	Brown	3.2	11.7	......	....	.096	.224	.144	.08	None	.08
9920	Mississippi river—Grafton	28	30												3.1									
9923	Mississippi river—Grafton	29	30			F.4		127.6	122.8	4.8	21.6	14.6	7.	Brown	3.3	12.9	8.4	4.5	.016	.256	.144	.112	None	.24
9936	Mississippi river—Grafton	30	Dec. 3												3.3									

8936

9938	Mississippi river—Grafton..........	2	Dec. 3	....	......	F.2	....	144.	166.	.. ..	32.	32.	......	Brown	3.5	11.8	8.9	2.9	.052	.256	.192	.064	None	.08
9974	Mississippi river—Grafton..........	3	5	....	....	....	....	....	....	....	....	....	....	....	3.4	....	....	....	....	....	....	....	....	....
9976	Mississippi river—Grafton..........	4	5	Decided.	Little..	Muddy	None..	148.	150.4	......	28.	24.4	3.6	Black..	3.5	13.6	9.	4.6	.032	.256	.192	.064	None	.08
9997	Mississippi river—Grafton..........	5	7	....	....	....	....	....	....	....	....	....	....	....	3.2	....	....	....	....	....	....	....	....	....
9999	Mississippi river—Grafton..........	6	7	Distinct.	Little..	F.25 Muddy	None..	150.4	159.6	......	33.6	50.8	......	Brown	3.2	12.3	9.3	3.	.068	.256	.16	.096	None	.09
10019	Mississippi river—Grafton	7	10	....	....	....	....	....	....	....	....	....	....	....	3.	....	....	....	....	....	....	....	....	....
10021	Mississippi river—Grafton..........	9	10	Distinct.	Little..	F.3 Muddy	None..	162.8	157.6	5.2	21.2	18.4	2.8	Brown	3.1	12.6	8.5	4.1	.06	.288	.16	.128	None	.16
10051	Mississippi river—Grafton..........	10	12	....	....	....	....	....	....	....	....	....	....	....	3.	...	....	....	....	....	....	....	....	....
10053	Mississippi river—Grafton..........	11	12	Distinct.	Little..	F.02 Muddy	None..	146.8	131.6	15.2	21.2	17.6	3.6	Brown	3.3	12.3	9.1	3.2	.072	.224	.144	.08	None	.08
10062	Mississippi river—Grafton..........	12	16	....	....	....	....	....	....	....	....	....	....	....	3.	....	....	....	....	....	....	....	....	....
10084	Mississippi river—Grafton..........	13	16	Distinct.	Little..	F.06 Muddy	None..	143.2	127.6	15.6	29.2	29.6	......	Brown	3.2	9.4	8.4	1.	.032	.304	.192	.112	.001	.09
10094	Mississippi river—Grafton..........	14	17	....	....	....	....	....	....	....	....	....	....	....	3.3	....	....	....	....	....	....	....	....	....
10095	Mississippi river—Grafton..........	16	17	Distinct.	Little..	F.05 Muddy	None..	162.8	143.2	19.6	27.6	26.4	1.2	Brown	3.8	11.8	8.5	3.3	.028	.256	.16	0.96	None	.18
10109	Mississippi river—Grafton..........	17	19	....	....	....	....	....	....	....	....	....	....	....	3.8	....	....	....	....	....	....	....	....	....
10111	Mississippi river—Grafton..........	18	19	Distinct.	Little..	F.06 Muddy	None..	216.	152.	64.	26.4	18.8	7.6	Brown	4.8	11.4	8.5	2.9	.044	.24	.16	.08	None	.24
10125	Mississippi river—Grafton..........	20	23	"	"	F.05 .2	"	228.8	162.8	66.	29.2	27.2	2.	"	5.6	11.	9.6	1.4	.04	.224	.128	.096	"	.2
10137	Mississippi river—Grafton..........	21	25	....	....	....	....	....	....	....	....	....	....	....	5.2	....	....	....	....	....	....	....	....	....
10130	Mississippi river—Grafton..........	23	25	Distinct.	Little..	F.05 .08	None..	182.4	170.	12.4	37.6	26.4	11.2	Brown	5.4	11.1	10.1	1.	.032	.288	.176	.112	None	.32

8937

9463	Missouri river—Bellefontaine ...	Oct. 11	Oct. 12	Very Decided.	Much..	F.03 V Mud	None..	1610.4	276.	1334.4	59.2	20.	39.2	Brown	12.1	16.6	6.4	10.2	.048	.608	.048	.56	.007	.473
9485	Missouri river—Bellefontain	14	15	Very Decided.	Very Much..	F.05 V Mud	Musty.	1229.2	270.	959.2	36.	9.2	26.8	"	13.3	14.9	4.8	10.1	.028	.416	.048	.368	.001	.519
9492	Missouri river—Bellefontain	15	16	Very Decided.	Very Much..	F.1 V Mud	"	1171.2	276.8	894.4	33.2	6.8	26.4	"	14.45	14.8	5.2	9.6	.02	.416	.096	.32	.003	.317
9500	Missouri river—Bellefontain	16	17	....	....	....	....	1078.3	284.4	794.4	......	1.2	... ..	"	16.5	14.	3.9	10.1	.112	.432	.096	.336	.004	.316
9512	Missouri river—Bellefontain	17	18	....	....	....	....	....	....	....	....	....	....	....	17.3	....	....	....	....	....	....	....	....	....
9520	Missouri river—Bellefontain	18	19	Very Decided.	Much..	V Mud	None..	Lost.	306.4	......	Lost.	44.4	......	Gray ..	16.2	12.5	4.3	8.2	.028	.448	.04	.408	.002	.398
9528	Missouri river—Bellefontain	19	21	....	....	....	....	....	....	....	....	....	....	....	15.5	....	....	....	....	....	....	....	....	....

CHEMICAL ANALYSIS.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

Serial number	Source of Water.	Date of		Appearance.			Odor	Residue on Evaporation.						Color on ignition	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Nitrogen as	
		Collection	Examination	Turbidity	Sediment	Color		Total	Dissolved	Suspended	Loss on ignition.					Total	By dissolved	By suspended matter	Free amm'nia	Albuminoid Ammonia.			Nitrites	Nitrates
											Total	Dissolved	Suspend'd							Total	Diss'l'ed	Susp'ded		
9540	Missouri river—Bellefontain	1901. Oct. 21	1901. Oct. 21	Very Decided.	Much..	F.2 V Mud	None..	1510.4	346.4	1164.	29.2	11.6	17.6	Brown	16.15	14.	4.6	9.4	.044	.448	.096	.352	.003	.597
9562	Missouri river—Bellefontain	23	24	Very Decided.	Very Much..	F.05 V Mud	"	1966.8	321.6	1645.2	66.4	20.	46.4	"	13.8	13.8	4.7	9.1	.036	.704	.096	.608	None	.56
9563	Missouri river—Bellefontain	24	25												13.95									
9576	Missouri river—Bellefontain	25	26	Very Decided.	Much..	F.04 V Mud	None..	1612.4	314.4	1298.	35.6	10.4	25.2	Brown	14.65	18.	4.6	13.4	.044	.72	.096	.624	.003	.637
9581	Missouri river—Bellefontain	26	28												16.									
9600	Missouri river—Bellefontain	28	29	Very Decided.	Much..	F.2 V Mud	None..	1264.	322.4	941.6	45.6	15.6	30.	Brown	17.65	13.7	4.4	9.3	.072	.48	.096	.384	.003	.557
9619	Missouri river—Bellefontain	29	31												19.8									
9626	Missouri river—Bellefontain	30	31	Very Decided.	Much..	F.06 V Mud	None..	1340.	340.8	999.2	44.8	8.	36.8	Brown	20.7	13.4	3.6	9.8	.084	.48	.096	.384	.007	.673
9639	Missouri river—Bellefontain	31	Nov. 2												20.1									
9640	Missouri river—Bellefontain	Nov. 1	2	Very Decided.	Much..	F.04 V Mud	None..	1487.2	350.8	1136.4	59.2	57.2	2.	Brown	18.	14.1	4.	10.1	.028	.464	.08	.384	.003	.597
9664	Missouri river—Bellefontain	2	5												17.1									
9653	Missouri river—Bellefontain	4	5	Very Decided.	Much..	F.05 V Mud	None..	1472.4	348.8	1123.6	35.6	21.6	14.	Brown	17.3	13.8	4.3	9.5	.04	.416	.048	.368	.003	.477
9686	Missouri river—Bellefontain	5	8												15.85									
9687	Missouri river—Bellefontain	7	8	Very Decided.	Very Much..	F.04 V Mud	None..	1281.6	327.6	954.	63.6	22.8	40.8	Brown	17.1	13.	3.8	9.2	.044	.384	.096	.288	.004	.356
9701	Missouri river—Bellefontain	8	9	Very Decided.	Much..	F.02 V Mud	"	1428.	312.4	1115.6	54.4	22.8	31.6	Brown	17.85	12.8	3.3	9.5	.04	.336	.096	.24	.006	.394
9713	Missouri river—Bellefontain	9	12												17.3									
9714	Missouri river—Bellefontain	11	13	Very Decided.	Much..	F.04 V Mud	None..	2039.2	351.2	1688.	46.8	13.2	33.6	Brown	20.4	15.4	4.5	10.8	.06	.592	.112	.48	.007	.553
9745	Missouri river—Bellefontain	12	14												43.6									

9746	Missouri river—Bellefontain	13	14	Very Decided.	Much..	F.05 V Mud	None..	2002.4	352.8	1649.6	46.4	13.2	33.2	Brown	29.5	15.6	4.6	11.	.116	.64	.128	.512	.007	.553
9777	Missouri river—Bellefontain	14	16	....	....	....	....	....	....	....	....	....	....	....	19.3	....	....	....	....	....	....	....	....	....
9784	Missouri river—Bellefontain	15	16	Very Decided.	Much..	F.05 V Mud	None..	1718.	333.6	1484.4	41.6	18.	23.6	Brown	25.	18.	4.2	13.8	.112	.736	.096	.61	.009	.511
9798	Missouri river—Bellefontain	16	19	....	....	....	....	....	....	....	....	....	....	....	28.4	....	....	....	....	....	....	....	....	....
9799	Missouri river—Bellefontain	18	19	Very Decided.	Very Much..	F.07 V Mud	None..	1366.8	314.8	1052.	58.	18.	40.	Brown	17.2	16.	4.2	11.8	.068	.576	.144	.432	.007	.433
9819	Missouri river—Bellefontain	19	21	....	....	....	....	....	....	....	....	....	....	....	15.7	....	....	....	....	....	....	....	....	....
9820	Missouri river—Bellefontain ...	20.	21	Very Decided.	Very Much..	F.05 V Mud	None..	1154.8	319.2	835.6	46.	16.4	29.6	Brown	15.	14.5	3.9	10.6	.04	.48	.064	.416	.005	.315
9842	Missouri river—Bellefontain ...	21	23	....	....	....	....	....	....	....	....	....	....	....	15.6	....	....	....	....	....	....	....	....	....
9843	Missouri river—Bellefontain	22	23	Very Decided.	Very Much..	V Mud	None..	1040.4	330.	710.4	76.4	32.	44.4	Brown	16.9	13.4	3.7	9.7	.052	.32	.096	.224	.04	.32
9865	Missouri river—Bellefontain	23	26	....	....	....	....	....	....	....	....	....	....	....	17.8	....	....	....	....	....	....	....	....	....
9866	Missouri river—Bellefontain	25	26	....	....	F.04	....	947.6	280.8	656.8	44.8	14.8	30.	Brown	17.9	12.1	4.1	8.	.1	.352	.128	.224	.009	.311
9900	Missouri river—Bellefontain	26	28	....	....	....	....	....	....	....	....	....	....	....	17.2	....	....	....	....	....	....	....	....	....
9901	Missouri river—Bellefontain	27	28	....	....	F.05	....	896.	348.4	547.6	29.6	25.6	4.	Brown	18.7	11.2	3.8	7.4	.052	.304	.112	.192	.003	.4
9914	Missouri river—Bellefontain	29	30	....	....	F.02	....	851.6	386.8	464.8	26.4	47.6	....	“	19.4	11.2	3.	8.2	.072	.336	.144	.192	.007	.313
9939	Missouri river—Bellefontain	30	Dec. 3	....	....	....	....	....	....	....	....	....	....	....	20.2	....	....	....	....	....	....	....	....	....
9940	Missouri river—Bellefontain	Dec. 2	3	....	....	F.04	....	859.6	368.	491.6	8.4	2.4	6.	Brown	23.6	10.4	4.1	6.3	.084	.32	.096	.224	.007	.393
9977	Missouri river—Bellefontain ...	3	5	....	....	....	....	....	....	....	....	....	....	....	21.8	....	....	....	....	....	....	....	....	....
9978	Missouri river—Bellefontaine...	4	5	Very Decided.	Much..	F.05 V Mud	None..	838.8	370.8	542.	35.2	20.	15.2	Brown	19.9	12.5	3.8	8.7	.112	.288	.096	.092	.015	.36
10000	Missouri river—Bellefontain....	5	7	....	....	....	....	....	....	....	....	....	....	....	21.9	....	....	....	....	....	....	....	....	....
10001	Missouri river—Bellefontain....	6	7	Very Decided.	Much..	F.05 V Mud	None..	704.8	380.	324.8	23.6	9.2	13.4	Brown	23.	10.3	3.9	6.4	.108	.272	.096	.176	.007	.333
10022	Missouri river—Bellefontain....	7	10	....	....	....	....	....	....	....	....	....	....	....	23.4	....	....	....	....	....	....	....	....	....
10023	Missouri river—Bellefontain....	9	10	Very Decided.	Much..	F.2 V Mud	None..	735.6	362.4	373.2	28.	32.8	....	Brown	24.4	9.7	3.7	6.	.08	.272	.096	.176	.007	.313
10054	Missouri river—Bellefontain....	10	12	....	....	....	....	....	....	....	....	....	....	....	22.5	....	....	....	....	....	....	....	....	....
10055	Missouri river—Bellefontain...	11	12	Very Decided.	Much..	F.02 V Mud	None..	754.	360.8	363.2	36.8	22.4	14.4	Brown	19.9	9.4	3.5	5.9	.072	.224	.064	.16	.01	.31
10069	Missouri river—Bellefontain....	12	14	....	....	....	....	....	....	....	....	....	....	....	22.7	....	....	....	....	....	....	....	....	....
10070	Missouri river—Bellefontain....	13	14	Very Decided.	Much..	F.01 V Mud	None..	730.4	356.4	374.	23.6	18.	5.6	Brown	23.5	8.8	3.6	5.2	.088	.24	.064	.176	.011	.380

CHEMICAL ANALYSIS.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.
SANITARY WATER ANALYSIS—PARTS PER MILLION.

REPORT OF ARTHUR W. PALMER.

Serial number.......	Source of Water.	Date of		Appearance.			Odor..................	Residue on Evaporation.						Color on igniti.n...	Chlorine............	Oxygen Consumed.			Nitrogen as Ammonia.				Nitro-gen as	
		Collection	Examination..	Turbidity......	Sediment.......	Color..........		Total...........	Dissolved	Suspended.....	Loss on Ignition.					Total	By dissolved.	By suspended matter......	Free amm'nia	Albuminoid Ammonia.			Nitrites.....	Nitrates......
											Total......	Dissolved.	Suspend'd							Total....	Diss'l'ed	Susp'ded		
10087	Missouri river—Bellefontain....	1901. Dec. 14	1901, Dec. 17	......	......	......	......	......	......	......	......	......	......	......	21.4	......	......	......	......	......	......	......	......	......
10088	Missouri river—Bellefontain....	16	17	Very Decided.	Much..	F.01 V Mud	None..	754.8	368.8	386.	42.	28.	14.	Brown	22.3	9.5	4.	5.5	.096	.288	.144	.144	.02	.22
9432	Miss. river—Chain of Rocks, Ill. shore	Oct. 3	Oct. 4	Decided.	Much .	F.2 Muddy	None..	892.8	216.	676.8	32.8	12 4	20.4	Brown	9.	18.3	8.5	9.8	.088	.512	.192	.32	.006	.434
9440	Miss. river—Chain of Rocks, Ill. shore	4	5	Very Decided.	Very Much .	F.2 Muddy	"	648.	210.4	487.6	36.4	23.6	12.8	"	7.8	15.7	7.8	7.9	.072	.4	.24	.16	.007	.553
9454	Miss. river—Chain of Rocks, Ill. shore	8	9	Very Decided.	Much .	F.15 Muddy	"	637.6	194.6	443.	19.2	9.6	9.6	"	8.8	14.1	8.	6.1	.052	.352	.144	.208	.008	.432
9460	Miss. river—Chain of Rocks, Ill. shore	9	10	Very Decided.	"	F.15 V Mud	"	650.8	214.4	436.4	29.6	29.6	......	"	8.85	15.3	8.8	6.5	.032	.352	.192	.16	.007	.393
9466	Miss. river—Chain of Rocks, Ill. shore	11	12	Very Decided.	"	F.04 V Mud	"	534.8	204.	330.8	47.2	25.2	22.	"	9.1	12.9	9.6	3.3	.052	.308	.128	.24	.01	.43
9489	Miss. river—Chain of Rocks, Ill. shore	14	15	Decided.	Consid	F.1 Muddy	"	266.	171.6	94.4	.....	21.6	......	"	9.45	10.7	8.6	2.1	.104	.24	.128	.112	.001	.479
9504	Miss. river—Chain of Rocks, Ill. shore	16	17	......	......	......	......	312.	218.	94.	8.4	17.6	......	"	7.6	9.3	7.	2.3	.084	.32	.176	.144	.01	.39
9516	Miss. river—Chain of Rocks, Ill. shore	17	18	......	......	......	......	......	......	......	......	......	......	......	7.9	...	......	......	......	......	......	......	......	......
9538	Miss. river—Chain of Rocks, Ill. shore	19	22	......	......	......	......	......	......	......	......	......	......	......	6.8	......	......	......	......	......	......	......	......	......
9544	Miss. river—Chain of Rocks, Ill. shore	21	22	Decided.	Consid	F.15 Muddy	None..	206.	166.8	41.2	28.4	22.8	5.6	Brown	7.55	9.4	7.1	2.3	.014	.304	.224	.08	.015	.265
9585	Miss. river—Chain of Rocks, Ill. shore	23	25	"	"	F.1 Muddy	"	208.4	141.6	66.8	23.6	27.2	......	"	6.95	9.6	8.1	1.5	.036	.272	.144	.128	.011	.460
9575	Miss. river—Chain of Rocks, Ill. shore	24	26	......	......	......	......	......	......	......	......	......	......	......	7.6	......	......	......	......	......	......	......	......	......
9580	Miss. river—Chain of Rocks, Ill. shore	25	26	Decided.	Consid	F.2 Muddy	None..	222.4	149.6	72.8	20.	16.4	3.6	Brown	7.5	12.6	9.	3.6	.064	.288	.16	.128	.012	.378
9599	Miss. river—Chain of Rocks, Ill. shore	26	29	......	......	......	......	......	......	......	......	......	......	......	7.3	......	......	......	......	......	......	......	......	......
9604	Miss. river—Chain of Rocks, Ill. shore	28	29	Decided.	Consid	F.6 Muddy	None..	Lost.	156.4	.....	Lost.	25.6	......	......	7.75	12.4	8.8	3.6	.072	.336	.192	.144	.01	.43
9623	Miss. river—Chain of Rocks, Ill. shore	29	31	......	......	......	......	......	......	......	......	......	......	......	7.1	......	......	......	......	......	......	......	......	......

9630	Miss. river—Chain of Rocks, Ill. shore	30	31	Decided.	Consid	F.35 Muddy	None..	212.8	137.6	75.2	23.6	13.6	10.	Brown	7.3	12.3	9.	3.3	.072	.336	.176	.16	.011	.389
9644	Miss. river—Chain of Rocks, Ill. shore	Nov. 1	Nov. 2	Decided.	"	F.38 Muddy	"	208.8	154.	54.8	28.8	24.	4.8	"	7.1	12.3	8.8	3.5	.032	.288	.224	.064	.006	.314
9668	Miss. river—Chain of Rocks, Ill. shore	2	5	....	....	....	....	....	....	....	....	....	....	....	7.2	....	....	....	....	....	....	....	....	....
9657	Miss. river—Chain of Rocks, Ill. shore	4	5	Decided.	Consid	F.4 Muddy	None..	197.6	164.	33.6	27.6	8.4	18.2	Brown	8.1	12.4	9.4	3.	.056	.304	.24	.064	.009	.471
9685	Miss. river—Chain of Rocks, Ill. shore	5	7	....	....	....	....	....	....	....	....	....	....	....	7.8	....	....	....	....	....	....	....	....	....
9679	Miss. river—Chain of Rocks, Ill. shore	6	7	Decided.	Consid	F.5 Muddy	None..	180.	138.	42.	33.6	30.4	3.2	Gray..	7.4	12.5	9.7	2.8	.056	.32	.16	.16	.008	.472
9698	Miss. river—Chain of Rocks, Ill. shore	7	9	....	....	....	....	....	....	....	....	....	....	....	7.6	....	....	....	....	....	....	....	....	....
9705	Miss. river—Chain of Rocks, Ill. shore	8	9	Decided	Consid	F.4 Muddy	None..	196.	140.4	55.6	22.	16.8	5.2	Brown	8.75	11.8	8.5	3.3	.056	.304	.224	.08	.014	.426
9718	Miss. river—Chain of Rocks, Ill. shore	11	12	"	"	F.3 Muddy	"	198.	156.8	41.2	36.	16.	20.	"	7.55	11.1	8.5	2.6	.04	.32	.192	.128	.012	.428
9744	Miss. river—Chain of Rocks, Ill. shore	12	14	....	....	....	....	....	....	....	....	....	....	....	7.5	....	....	....	....	....	....	....	....	....
9750	Miss. river—Chain of Rocks, Ill. shore	13	14	Decided.	Consid	F.2 Muddy	None..	Lost.	152.	.....	Lost.	28.	.....	Brown	8.7	10.9	8.6	2.3	.06	.288	.192	.096	.011	.389
9781	Miss. river—Chain of Rocks, Ill. shore	14	16	....	....	....	....	....	....	....	....	....	....	....	7.6	....	....	....	....	....	....	....	....	....
9788	Miss. river—Chain of Rocks, Ill. shore	15	16	Decided.	Consid	F.15 Muddy	None..	171.6	152.	19.6	24.8	20.	.....	Brown	8.1	10.9	7.5	3.4	.112	.272	.16	.112	.014	.346
9803	Miss. river—Chain of Rocks, Ill. shore	18	19	"	Little..	F.2 Muddy	"	174.4	168.	6.4	22.	14.8	7.2	"	7.5	8.4	7.3	1.4	.064	.368	.16	.208	.01	.31
9824	Miss. river—Chain of Rocks, Ill. shore	19	21	....	....	....	....	....	....	....	....	....	....	....	7.5	....	....	....	....	....	....	....	....	....
9827	Miss. river—Chain of Rocks, Ill. shore	20	21	Distinct.	Little..	F.2 Muddy	None..	173.2	169.6	3.6	29.6	21.6	8.	Brown	7.4	8.6	7.3	1.3	.052	.336	.112	.224	.008	.372
9847	Miss. river—Chain of Rocks, Ill. shore	21	23	....	....	....	....	....	....	....	....	....	....	....	7.3	....	....	....	....	....	....	....	....	....
9851	Miss. river—Chain of Rocks, Ill. shore	22	23	Distinct	Little..	Muddy	None..	182.4	169.6	12.8	35.6	38.4	....	Brown	7.2	8.9	7.3	1.6	.014	.288	.16	.128	.009	.311
9870	Miss. river—Chain of Rocks, Ill. shore	23	26	....	....	....	....	....	....	....	....	....	....	....	7.1	....	....	....	....	....	....	....	....	....
9874	Miss. river—Chain of Rocks, Ill. shore	25	26	....	....	F.2	....	167.2	146.8	20.4	32.	24.4	7.6	Brown	7.4	9.	7.1	1.9	.068	.368	.128	.24	.01	.35
9905	Miss. river—Chain of Rocks, Ill. shore	26	28	....	....	....	....	....	....	....	....	....	....	....	8.1	....	....	....	....	....	....	....	....	....
9909	Miss. river—Chain of Rocks, Ill. shore	27	28	....	....	F.15	....	176.8	153.6	23.2	28.8	27.2	1.6	Brown	7.4	9.2	7.4	1.8	.092	.336	.128	.208	.006	.354
9918	Miss. river—Chain of Rocks, Ill. shore	29	30	....	....	F.2	....	210..	154.8	55.2	23.2	25.2	.....	"	7.4	9.2	7.8	1.4	.052	.32	.16	.16	.01	.35
9944	Miss. river—Chain of Rocks, Ill. shore	Nov. 30	Dec. 3	....	....	....	....	....	....	....	....	....	....	....	7.2	....	....	....	....	....	....	....	....	....
9948	Miss. river—Chain of Rocks, Ill. shore	Dec. 2	Dec. 3	Decided.	Little..	F.04 Muddy	None..	192.4	159.6	32.8	22.8	22.	.8	Brown	7.6	11.4	8.1	3.3	.056	.336	.176	.16	.015	.385
9962	Miss. river—Chain of Rocks, Ill. shore	3	5	....	....	....	....	....	....	....	....	....	....	....	7.9	....	....	....	....	....	....	....	....	....

CHEMICAL ANALYSIS.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.
SANITARY WATER ANALYSIS—PARTS PER MILLION.

REPORT OF ARTHUR W. PALMER.

Serial number	Source of water.	Date of		Appearance.			Odor	Residue on evaporation.						Color on ignition	Chlorine	Oxygen consumed.			Nitrogen as ammonia.				Nitrogen as	
		Collection	Examination	Turbidity	Sediment	Color		Total	Dissolved	Suspended	Loss on Ignition.					Total	By dissolved	By suspended matter	Free amm'nia	Albuminoid ammonia.			Nitrites	Nitrates
											Total	Dissolved	Suspend'd							Total	Diss'l'ed	Susp'ded		
9986	Miss. river—Chain of Rocks, Ill. shore	1901 Dec. 4	1901 Dec. 5	Decided.	Little.	F.2 Muddy	None.	186.	169.6	16.4	34.	41.6		Brown	7.8	9.4	8.3	1.1	.032	.336	.16	.176	.016	.624
10005	Miss. river—Chain of Rocks, Ill. shore	5	7												7.7									
10009	Miss. river—Chain of Rocks, Ill. shore	6	7	Decided.	Consid	F.25 Muddy	None.	184.	175.6	8.4	26.4	25.2	1.2	Brown	7.9	9.3	8.5	.8	.104	.304	.176	.128	.008	.472
10059	Miss. river—Chain of Rocks, Ill. shore	10	2												7.6									
10063	Miss. river—Chain of Rocks, Ill. shore	11	12	Distinct.	Little.	F.1 Muddy	None.	158.	164.8		20.8	10.6	1.2	Brown	7.3	9.5	7.5	2.	.12	.336	.144	.192	.01	.27
10074	Miss. river—Chain of Rocks, Ill. shore	12	14												7.6									
10078	Miss. river—Chain of Rocks, Ill. shore	13	14	Distinct.	Little.	F.05 Muddy	None.	162.8	164.8		28.4	26.4	2.	Brown	7.6	9.	8.2	.8	.112	.32	.288	.032	.01	.27
10092	Miss. river—Chain of Rocks, Ill. shore	14	17												6.8									

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Serial number	Source of water.	Collection	Examination	Turbidity	Sediment	Color	Odor	Total	Dissolved	Suspended	Loss on Ignition Total	Loss on Ignition Dissolved	Loss on Ignition Suspend'd	Color on ignition	Chlorine	Oxygen consumed Total	By dissolved	By suspended matter	Free amm'nia	Albuminoid ammonia Total	Diss'l'ed	Susp'ded	Nitrites	Nitrates
9431	Miss. R.—Chain of R., Mid-channel	Oct. 3	Oct. 4	Decided.	Much.	F.15 V Mud	None.	1074.4	208.4	866.	41.2	12.	29.2	Brown	8.6	19.3	8.3	11.	.08	.592	.16	.432	.006	.555
9437	Miss. R.—Chain of R., Mid-channel	4	5	V.Decid.	"	F.2 Muddy	"	1313.6	217.2	706.4	21.2	12.4	8.8	"	8.	19.4	7.9	11.5	.044	.576	.144	.432	.005	.475
9453	Miss. R.—Chain of R., Mid-channel	8	9	"	"	F.15 Muddy	"	923.2	233.6	689.6	20.	32.8		"	8.1	16.	7.8	8.2	.084	.48	.192	.288	.004	.356
9459	Miss. R.—Chain of R., Mid-channel	9	10	"	"	F.15 V Mud	"	706.8	216.8	490.	25.6	14.4	11.2	"	8.5	14.3	9.4	4.9	.08	.384	.144	.24	.006	.314
9465	Miss. R.—Chain of R., Mid-channel	11	12	"	"	F.02 V Mud	"	608.8	207.6	401.2	40.	27.6	12.4	"	9.	14.1	11.1	3.	.104	.352	.112	.24	.009	.321
9488	Miss. R.—Chain of R., Mid-channel	14	15	Decided.	Consid	F.06 Muddy	"	328.8	164.8	164.	20.8	18.4	2.4	"	7.9	11.7	8.6	3.1	.04	.288	.192	.096	.006	.314
9503	Miss. R.—Chain of R., Mid-channel	16	17					456.	182.4	273.6	14.	2.8	11.2	"	8.55	12.	6.3	5.7	.044	.336	.112	.224	.004	.270
9515	Miss. R.—Chain of R., Mid-channel	17	18												7.6									

9537	Miss. R.—Chain of R., Mid-channel	19	22	......	......	......	......	......	......	......	......	......	......	......	5.7	....	6.	....	......	......	....	....	......	....
9543	Miss. R.—Chain of R., Mid-channel	21	22	Decided.	"	F.1 Muddy	None..	269.6	147.6	122.	21.2	12.4	8.8	Brown	5.8	10.6	6.8	3.8	.076	.32	.16	.16	.008	.152
9584	Miss. R.—Chain of R., Mid-channel	23	28	"	Much..	F.15 Muddy	"	1454.4	160.8	1283.6	35.2	16.4	18.8	"	6.1	12.7	8.	4.7	.028	.32	.144	.176	.004	.356
9574	Miss. R.—Chain of R., Mid-channel	24	26	......	......	......	......	......	......	......	......	......	......	......	6.3	....	....	....	......	......	....	....	......	....
9579	Miss. R.—Chain of R., Mid-channel	25	26	Decided.	Consid	F.3 Muddy	None..	255.6	137.2	118.4	31.2	20.	11.2	Brown	5.9	13.1	8.9	4.2	.048	.32	.192	.128	.006	.314
9598	Miss. R.—Chain of R., Mid-channel	26	29	......	......	......	......	......	......	......	......	......	......	......	5.5	....	....	....	......	......	....	....	......	....
9603	Miss. R.—Chain of R., Mid-channel	28	29	Decided.	Consid	F.06 Muddy	None..	Lost.	154.4	..	Lost.	19.6	......	Brown	6.1	13.7	8.6	5.1	.064	.368	.176	.192	.004	.276
9622	Miss. R.—Chain of R., Mid-channel	29	31	......	......	......	......	......	......	......	......	......	......	......	5.9	....	....	....	......	......	....	....	......	....
9629	Miss. R.—Chain of R., Mid-channel	30	31	Decided.	Consid	F.35 Muddy	None..	246.8	144.4	102.4	26.4	20.8	5.6	Brown	5.9	13.2	8.8	4.4	.084	.4	.128	.272	.009	.271
9643	Miss. R.—Chain of R., Mid-channel	Nov. 1	Nov. 2	"	"	F.4 Muddy	"	254.	144.	110.	32.	18.4	13.6	"	5.8	12.8	9.	3.8	.032	.384	.192	.192	.003	.237
9667	Miss. R.—Chain of R., Mid-channel	2	5	......	......	......	......	......	......	......	......	......	......	......	6.4	....	....	....	......	......	....	....	......	....
9656	Miss. R.—Chain of R., Mid-channel	4	5	Decided.	Consid	F.4 Muddy	None..	243.2	158.8	84.4	25.6	18.8	6.8	Brown	6.4	13.3	9.6	3.7	.032	.32	.176	.144	.006	.234
9684	Miss. R.—Chain of R., Mid-channel	5	7	......	......	......	......	......	......	......	......	......	......	......	7.2	....	....	....	......	......	....	....	......	....
9678	Miss. R.—Chain of R., Mid-channel	6	7	V. Decid.	Much..	F.5 Muddy	None..	329.2	177.6	51.6	43.6	20.4	17.2	Brown	6.8	12.9	9.4	3.5	.036	.32	.16	.16	.003	.397
9697	Miss. R.—Chain of R., Mid-channel	7	9	......	......	......	......	......	......	......	......	......	......	......	6.3	....	....	....	......	......	....	....	......	....
9704	Miss. R.—Chain of R., Mid-channel	8	9	Decided.	Much..	F.3 Muddy	None..	431.2	182.8	248.4	24.8	18.	6.8	Brown	7.8	12.5	8.	4.5	.06	.32	.176	.144	.004	.136
9717	Miss. R.—Chain of R., Mid-channel	11	12	"	Consid	F.2 Muddy	"	424.4	105.6	238.8	37.2	20.4	16.8	"	8.1	12.3	8.1	4.2	.044	.336	.176	.16	.008	.362
9742	Miss. R.—Chain of R., Mid-channel	12	14	......	......	......	......	......	......	......	......	......	......	......	8.2	....	....	....	......	......	....	....	......	....
9749	Miss. R.—Chain of R., Mid-channel	13	14	Decided.	Consid	F.2 Muddy	None..	341.2	159.6	181.6	33.6	25.2	8.4	Brown	9.7	11.7	8.2	3.5	.068	.32	.112	.208	.007	.273
9780	Miss. R—Chain of R., Mid-channel	14	16	......	......	......	......	......	......	......	......	......	......	......	8.	....	....	....	......	......	....	....	......	....
9787	Miss. R.—Chain of R, Mid-channel	15	16	Decided.	Consid	F.2 Muddy	None..	298.	159.2	138.8	31.6	21.6	10.	Brown	7.5	11.3	7.9	3.4	.056	.32	.128	.192	.007	.313
9802	Miss. R.—Chain of R., Mid-channel	18	19	"	"	F.1 Muddy	"	419.2	169.6	249.6	32.4	22.	10.4	"	8.4	13.1	7.	6.1	.048	.336	.176	.16	.006	.314
9823	Miss. R.—Chain of R., Mid-channel	19	20	......	......	......	......	......	......	......	......	......	......	......	6.6	....	....	....	......	......	....	....	......	....
9828	Miss. R.—Chain of R., Mid-channel	20	21	V. Decid.	Very Much..	F.15 V Mud	None..	313.2	166.8	146.4	37.0	32.4	5.2	Brown	7.2	11.5	Lost.	....	.032	.32	.096	.224	.006	.194
9846	Miss. R.—Chain of R., Mid-channel	21	23	......	......	......	......	......	......	......	......	......	......	......	6.5	....	....	....	......	......	....	....	......	....
9350	Miss. R.—Chain of R., Mid-channel	22	23	......	......	......	......	285.6	176.	109.6	41.2	38.	3.2	Brown	7.3	9.3	7.4	1.9	.018	.304	.16	.144	.003	.197
9869	Miss. R.—Chain of R., Mid-channel	23	26	......	......	......	......	......	......	......	......	......	......	......	5.8	....	....	....	......	......	....	....	......	....

CHEMICAL ANALYSIS.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.
SANITARY WATER ANALYSIS—PARTS PER MILLION.

REPORT OF ARTHUR W. PALMER.

Serial number	Source of Water.	Date of		Appearance.			Odor	Residue on Evaporation.						Color on ignition	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Nitrogen as	
											Loss on Ignition.									Albuminoid Ammonia.				
		Collection	Examination	Turbidity	Sediment	Color	Odor	Total	Dissolved	Suspended	Total	Dissolved	Suspend'd	Color on ignition	Chlorine	Total	By dissolved	By suspended matter	Free amm'nia	Total	Diss'l'ed	Susp'ded	Nitrites	Nitrates
9873	Miss. R.—Chain of R., Mid-channel	1901 Nov. 25	1901 Nov. 26	......	......	F.2	......	310.	185.2	124.8	34.8	20.8	14.	Brown	7.4	9.1	7.	2.1	.048	.304	.128	.176	.014	.206
9904	Miss. R.—Chain of R., Mid-channel	26	28	......	......	......	......	......	......	......	......	......	......	......	6.5	....	......	....	......	......	....	....	......	......
9908	Miss. R.—Chain of R., Mid-channel	27	28	......	......	Cloudy	......	283.2	192.	91.2	35.2	24.	11.2	Brown	7.7	9.4	7.8	1.6	.062	.304	.176	.128	.004	.236
9917	Miss. R.—Chain of R., Mid-channel	29	30	......	......	F.2	......	165.6	140.	25.6	25.6	24.4	1.2	"	6.1	11.2	7.5	3.7	.048	.288	.16	.128	.006	.272
9943	Miss. R.—Chain of R., Mid-channel	30	Dec. 3	......	......	......	......	......	......	......	......	......	......	......	6.6	....	......		......	......	....	....	......	......
9947	Miss. R.—Chain of R., Mid-channel	Dec. 2	3	Decided.	Consid	F.1 None..	None..	260.4	167.2	73.2	25.2	23.6	1.6	Brown	6.7	11.6	7.8	4.8	.064	.32	.16	.16	.007	.353
9961	Miss. R.—Chain of R., Mid-channel	3	5	......	......	......	......	......	......	......	......	......	......	......	6.5	....	......	....	......	......	....	....	......	......
9985	Miss. R.—Chain of R., Mid-channel	Dec. 4	Dec. 5	Decided.	C'n'ble	Muddy	None	Bottle broken after it was recei'd.						......	9.	....	......	....	.072	.352	....	....	.012	.388
10004	Miss. R.—Chain of R., Mid-channel	5	7	......	......	......	......	......	......	......	......	......	......	......	7.2	....	......	....	......	......	....	....	......	......
10006	Miss. R.—Chain of R.—Mid-channel	6	7	Decided.	Much	F.25 Muddy	None	222.8	183.6	39.2	25.2	27.2	......	Brown	7.2	11.6	8.6	3.	.082	.304	.224	.08	.007	.353
10026	Miss. R.—Chain of R., Mid-channel	9	10	"	C'n'ble	F.15 Muddy	"	318.8	41.6	107.2	33.2	20.	13.2	"	10.9	11.5	7.	4.5	.132	.288	.112	.176	.006	.314
10058	Miss. R.—Chain of R., Mid-channel	10	11	......	......	......	......	......	......	......	......	......	......	......	8.4	....	......	....	......	......	....	....	......	......
10062	Miss. R.—Chain of R., Mid-channel	11	12	Decided.	C'n'ble	F.05 Muddy	None	394.8	237.2	157.6	28.	22.8	5.2	Brown	12.1	9.9	5.9	4.	.056	.304	.112	.192	.008	.232
10073	Miss. R—Chain of R., Mid-channel	12	14	......	......	......	......	......	......	......	......	......	......	......	8.6	....	......	....	......	......	....	....	......	......
10077	Miss. R.—Chain of R., Mid-channel	13	14	Decided.	C'n'ble	F.05 Muddy	None	302.4	201.6	100.8	25.2	14.	11.2	Brown	10.8	10.4	6.8	3.6	.068	.304	.084	.22	.011	.229
10091	Miss. R.—Chain of R., Mid-channel	14	17	......	......	......	......	......	......	......	......	......	......	......	6.9	....	......	....	......	......	....	....	......	......

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9430	Miss. R.—Chain of R., Intake Tower..	Oct. 3	Oct. 4	V. Decid	Much.	F.04 Muddy	None..	2483.6	246.	2237.6	440.4	59.2	381.2	Brown	9.8	22.6	8.9	13.7	084	.992	096	.836	.003	.557
9438	Miss. R.—Chain of R., Intake Tower..	4	5	"	Very much.	F.2 V Mud	"	2038.8	316.	1742.8	60.4	22.	38.4	"	9.3	23.2	7.5	15.7	048	.928	.24	.688	002	.558
9452	Miss. R.—Chain of R., Intake Tower..	8	9	"	"	F.15 V Mud	"	1339.2	254.4	1084.8	22.	30.	......	"	8.6	19.	6.8	12.2	.118	.56	.128	.432	.002	.438
9458	Miss. R.—Chain of R., Intake Tower..	9	10	"	"	F.15 V Mud	"	1380.4	258.4	1122.	20.	13.6	6.4	"	9.2	17.	7.6	9.4	.124	.64	.144	.496	None	.4
9464	Miss. R.—Chain of R., Intake Tower..	11	12	"	"	F.03 V Mud	"	1251.2	260.8	990.4	55.6	16.8	38.8	"	10.4	16.3	8.2	8.1	.048	.56	.064	.496	.005	.315
9487	Miss. R.—Chain of R., Intake Tower..	14	15	"	Consid	F.04 Muddy	"	1093.	248.4	844.6	27.2	15.2	12.	"	11.8	14.8	5.5	9.3	.04	.48	.08	.4	.001	.479
9502	Miss. R.—Chain of R., Intake Tower..	16	17	......	......	......	......	978.	257.2	721.8	22.8	2.4	20.4	"	14.3	13.2	4.2	9.	.144	.384	.096	.288	.004	.396
9514	Miss. R.—Chain of R., Intake Tower..	17	18	......	......	......	......	......	......	......	......	......	......	......	15.	......	......	......	......	......	......	......	......	......
9536	Miss. R.—Chain of R., Intake Tower..	19	22	......	......	......	......	......	......	......	......	......	......	......	13.55	......	......	......	......	......	......	......	......	......
9542	Miss. R.—Chain of R., Intake Tower..	21	22	V. Decid	Much..	F.05 V Mud	None..	1167.2	301.2	866.	32.8	13.2	19.6	Brown	14.	13.1	4.7	8.4	.044	.384	.16	224	.002	.398
9583	Miss. R.—Chain of R., Intake Tower..	23	23	"	"	F.05 V Mud	"	1404.	280.	1124.	32.	11.2	20.8	"	11.45	14.1	5.5	8.6	.028	.576	.096	.48	.003	.557
9573	Miss. R.—Chain of R., Intake Tower..	24	26	......	......	......	......	......	......	......	......	......	......	......	10.95	......	......	......	......	......	......	......	......	......
9578	Miss. R.—Chain of R., Intake Tower..	25	26	V. Decid	Much..	F.05 V Mud	None..	1340.8	274.8	1066.	38.	18.	20.	Brown	12.5	17.5	5.4	12.1	.052	.704	.128	.576	.003	.557
9597	Miss. R.—Chain of R., Intake Tower..	26	29	......	......	......	......	......	......	......	......	......	......	......	12.6	......	......	......	......	......	......	......	......	......
9602	Miss. R.—Chain of R., Intake Tower..	28	29	V. Decid	Much..	F.2 V Mud	None..	1093.2	253.3	779.9	40.8	19.2	21.6	Brown	14.1	14.2	6.1	8.1	.064	.384	.128	.256	.003	.478
9621	Miss. R.—Chain of R., Intake Tower..	29	31	......	......	......	......	......	......	......	......	......	......	......	15.85	......	......	......	......	......	......	......	......	......
9628	Miss. R.—Chain of R., Intake Tower..	30	31	V. Decid	Much .	F.1 Muddy	None..	1096.	302.8	793.2	41.6	24.	17.6	Brown	17.3	13.6	5.3	8.3	.068	.4	.096	.304	.007	.473
9642	Miss. R.—Chain of R., Intake Tower..	Nov. 1	Nov. 2	"	"	F.07 V Mud	"	1206.	287.6	918.4	37.6	13.6	24.	"	15.3	13.4	5.2	8.2	.028	.416	.096	.32	None	.44
9666	Miss. R.—Chain of R., Intake Tower..	2	5	......	......	......	......	......	......	......	......	......	......	......	14.4	......	......	......	......	......	......	......	......	......
9655	Miss. R.—Chain of R., Intake Tower..	4	5	V. Decid	Much..	F.01 V Mud	None..	1198.	293.6	904.4	34.8	12.4	22.4	Brown	14.2	14.1	5.9	8.2	.024	.4	.096	.304	.003	.397
9683	Miss. R.—Chain of R., Intake Tower..	5	7	......	......	......	......	......	......	......	......	......	......	......	13.1	......	......	......	......	......	......	......	......	......
9677	Miss. R.—Chain of R., Intake Tower..	6	7	V. Decid	Much..	F.07 V Mud	None..	1035.2	286.8	748.4	53.2	27.2	26.	Brown	13.2	12.9	5.6	7.3	.104	.368	.112	.256	None	.36
9696	Miss. R.—Chain of R., Intake Tower..	7	9	......	......	......	......	......	......	......	......	......	......	......	14.5	......	......	......	......	......	......	......	......	......
9703	Miss R.—Chain of R., Intake Tower..	8	9	V. Decid	Much..	F.03 V Mud	None..	1020.4	273.6	746.8	46.8	17.2	29.6	Brown	14.8	12.3	4.8	7.5	.04	.336	.096	.24	.004	.136
9716	Miss. R.—Chain of R., Intake Tower..	11	12	"	"	F.15 V Mud	None..	1450.6	296.4	1163.2	64.8	13.6	51.2	"	14.4	15.	5.4	9.6	.06	.496	.112	.384	.006	.394
9742	Miss. R.—Chain of R., Intake Tower..	12	14	......	......	......	......	......	......	......	......	......	......	......	29.1	......	......	......	......	......	......	......	......	......

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.
SANITARY WATER ANALYSIS—PARTS PER MILLION.

Serial number	Source of water.	Date of		Appearance.			Odor	Residue on evaporation.						Color on ignition	Chlorine	Oxygen consumed.			Nitrogen as ammonia.				Nitrogen as	
											Loss on Ignition.									Albuminoid ammonia.				
		Collection	Examination	Turbidity	Sediment	Color		Total	Dissolved	Suspended	Total	Dissolved	Suspend'd			Total	By dissolved	By suspended matter	Free amm'nia	Total	Diss'l'ed	Susp'ded	Nitrites	Nitrates
9748	Miss. R.—Chain of R., Intake Tower	1901 Nov. 13	1901 Nov. 14	V. Decid	Much	F 1 V Mud	None	1700.8	295.2	1405.6	59.2	16.	• 43.2	Brown	28.2	14.9	5.5	9.4	.084	.624	.096	.528	.006	.391
9779	Miss. R.—Chain of R., Intake Tower	14	16												16.6									
9786	Miss. R.—Chain of R., Intake Tower	15	16	V. Decid	Much	F.07 V Mud	None	1548.4	294.8	1253.6	66.8	20.4	46.4	Brown	19.3	17.	4.9	12.1	.076	.576	.096	.48	.007	.553
9801	Miss. R.—Chain of R., Intake Tower	18	19	"	Very much	F.06 V Mud	None	1121.6	275.2	846.4	40.4	15.2	25.2	"	14.7	15.8	4.8	11.	.068	.512	.128	.384	.006	.314
9822	Miss. R.—Chain of R., Intake Tower	19	20												13.7									
9825	Miss. R.—Chain of R., Intake Tower	20	21	V. Decid	Very much	F.05 V Mud	None	945.6	275.6	670.	58.	20.8	37.2	Brown	12.9	14.3	4.5	9.8	.076	.464	.064	.4	.004	.356
9845	Miss. R.—Chain of R., Intake Tower	21	23												12.5									
9849	Miss. R.—Chain of R., Intake Tower	22	23	V. Decid	Very much	V Mud	None	929.6	282.8	646.8	50.8	18.4	32.4	Brown	14.5	13.1	4.5	8.6	.04	.4	.08	.32	.005	.355
9868	Miss R.—Chain of R., Intake Tower	23	26												15.4									
9872	Miss. R.—Chain of R., Intake Tower	25	26			F.01		857.2	319.2	538.	27.6	26.4	1.2	Brown	16.4	12.3	4.1	8.2	.068	.352	.064	.288	.009	.311
9906	Miss. R.—Chain of R., Intake Tower	26	28												15.									
9907	Miss. R.—Chain of R., Intake Tower	27	28			F.04		808.4	306.8	501.6	40.4	16.4	24.	Brown	16.2	11.6	4.1	7.5	.044	.32	.096	.224	.003	.317
9916	Miss. R.—Chain of R., Intake Tower	29	30			F 03		771.6	315.2	456.4	28.8	12.4	16.4		16.7	10.9	3.7	7.2	.084	.32	.096	.224	.007	.353
9942	Miss. R.—Chain of R., Intake Tower	30	Dec. 3	V. Decid	Much										17.5									
9946	Miss. R.—Chain of R., Intake Tower	Dec. 2	8	"	"	F 04 V Mud	None	754.8	353.6	401.2	16.8	16.8		Brown	19.9	10.9	4.6	6.3	.088	.32	.128	.192	.007	.233
9980	Miss. R.—Chain of R., Inlake Tower	3	5												19.3									
9984	Miss. R.—Chain of R., Intake Tower	4	5	V. decid	Much	F.08 V Mud	None	728.4	321.6	406.8	30.4	16.8	13.6	Brown	18.	10.4	5.1	5.3	.052	.32	.128	.192	.012	.306

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10003	Miss. R.—Chain of R., Intake Tower..	5	7	....	....	....	....	....	....	....	....	....	....	....	18.3	....	....	....	....	....	....	....	....	....
10007	Miss. R.—Chain of R., Intake Tower..	6	7	V. decid	Much..	F.04 V Mud	None	704.	330.8	373.2	24.	15.2	8.8	Brown	Lost.	10.5	4.8	5.7	.14	.288	.16	.128	.007	.353
10025	Miss. R.—Chain of R., Intake Tower..	9	10	"	"	F.05 Muddy	"	632.4	342.8	303.6	29.2	20.	9.2	"	21.	9.8	4.7	5.1	.072	.256	.064	.192	.007	.353
10057	Miss. R.—Chain of R., Intake Tower..	10	11	....	....	....	....	....	....	....	....	....	....	....	19.9	....	....	....	....	....	....	....	....	....
10061	Miss. R.—Chain of R., Intake Tower..	11	12	V. decid	Much..	F.05 V Mud	None..	652.4	324.	328.4	34.	22.4	11.6	Brown	18.4	9.2	4.2	5.	.08	.272	.064	.208	.01	.27
10072	Miss. R.—Chain of R., Intake Tower..	12	14	....	....	....	....	....	....	....	....	....	....	....	18.9	....	....	....	....	....	....	....	....	....
10076	Miss. R.—Chain of R., Intake Tower..	13	14	V. decid	Much..	F.01 Muddy	None..	614.	314.8	299.2	26.4	28.	......	Brown	20.6	8.9	4.2	4.7	.008	.256	.096	.16	.01	.23
10090	Miss. R.—Chain of R., Intake Tower..	14	17	....	....	....	....	....	....	....	....	....	....	....	20.3	....	....	....	....	....	....	....	....	....
8945																								
9429	Miss. R.—Chain of R., Mo. shore....	Oct. 3	Oct. 4	V.Decid.	Much..	F.07 V Mud	None..	1134.	259.6	874.4	343.6	47.2	296.4	Brown	10.5	16.8	8.5	8.3	.044	.4	.144	.256	.003	.557
9439	Miss. R.—Chain of R., Mo. shore....	4	5	"	Very Much..	F.15 V Mud	" ..	1145.6	269.6	876.	14.4	9.6	4.8	"	9.6	17.9	6.1	11.8	.088	.416	.208	.206	.002	.588
9451	Miss. R.—Chain of R., Mo. shore....	8	9	"	Much..	F.1 Muddy	" ..	989.6	263.6	726.	16.	12.	4.	"	9.2	16.1	4.7	11.4	.048	.352	.144	.208	.004	.396
9457	Miss. R.—Chain of R., Mo. shore....	9	10	"	"	F.1 Muddy	" ..	1224.4	272.	952.4	21.2	5.6	15.6	"	9.3	15.4	7.3	8.1	.076	.4	.16	.24	None	.36
9467	Miss. R.—Chain of R., Mo. shore....	11	12	"	"	F.04 V Mud	" ..	1010.4	260.	750.4	45.6	9.6	36.	"	11.2	13.2	8.8	4.4	.128	.4	.048	.352	.006	.474
9486	Miss. R.—Chain of R., Mo. shore...	14	15	"	Very Much..	F.04 V Mud	" ..	846.	254.	592.	21.6	10.4	11.2	"	12.6	12.3	....	....	.032	.32	.096	.224	.001	.550
9501	Miss. R.—Chain of R., Mo. shore....	16	17	....	....	....	....	844.	252.4	681.6	18.4	14.8	3.6	"	14.7	12.	3.8	8.2	.048	.336	.064	.272	.003	.397
9513	Miss. R.—Chain of R., Mo. shore....	17	18	....	....	....	....	....	....	....	....	....	....	....	16.55	....	....	....	....	....	....	....	....	....
9535	Miss. R.—Chain of R., Mo. shore....	19	22	....	....	....	....	....	....	....	....	....	....	....	15.2	....	....	....	....	....	....	....	....	....
9541	Miss. R.—Chain of R., Mo. shore....	21	22	V.Decid.	Much..	F.05 V Mud	None..	940.4	331.4	609.	25.6	16.4	9.2	Brown	16.15	10.5	4.2	6.3	.04	.304	.144	.16	.003	.477
9582	Miss. R.—Chain of R., Mo. shore....	23	26	"	"	F.05 V Mud	" ..	1504.	313.6	1190.4	48.4	10.2	38.2	"	14.	15.	5.3	9.7	.028	.992	.10	.832	.003	.557
9572	Miss. R.—Chain of R., Mo. shore....	24	26	....	....	....	....	....	....	....	....	....	....	....	13.	....	....	....	....	....	....	....	....	....
9577	Miss. R.—Chain of R., Mo. shore....	25	26	V.Decid.	Much..	F.04 V Mud	None..	1311.2	318.8	992.4	47.6	18.	29.6	Brown	14.1	16.5	4.6	11.9	.052	.576	.096	.48	.003	.717
9590	Miss. R.—Chain of R., Mo. shore....	26	29	....	....	....	....	....	....	....	....	....	....	....	14.65	....	....	....	....	....	....	....	....	....
9601	Miss. R.—Chain of R., Mo. shore....	28	29	V.Decid.	Much..	F.2 V Mud	None..	990.4	308.8	681.6	36.	16.	20.	Brown	16.1	12.5	4.6	7.9	.064	.352	.112	.24	.002	.598
9620	Miss. R.—Chain of R., Mo. shore...	29	31	....	....	....	....	....	....	....	....	....	....	....	18.	....	....	....	....	....	....	....	....	....
9627	Miss. R.—Chain of R., Mo. shore....	30	31	V.Decid.	Much..	F.06 V Mud	None..	974.8	326.	648.8	37.2	15.2	21.	Brown	20.2	12.6	4.1	8.5	.008	.32	.096	.234	.006	.594
9641	Miss. R.—Chain of R., Mo. shore....	Nov. 1	Nov. 2	"	"	F.06 V Mud	" ..	1099.2	350.	749.2	40.4	13.2	27.2	"	18.2	12.3	4.2	8.1	.028	.32	.096	.224	.001	.439

CHEMICAL ANALYSIS.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

REPORT OF ARTHUR W. PALMER.

Serial number	Source of Water.	Date of		Appearance.			Odor	Residue on Evaporation.						Color on ignition	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Nitrogen as	
		Collection	Examination	Turbidity	Sediment	Color		Total	Dissolved	Suspended	Loss on Ignition.					Total	By dissolved	By suspended matter	Free amm'nia	Albuminoid Ammonia.			Nitrites	Nitrates
											Total	Dissolved	Suspend'd							Total	Diss'l'ed	Susp'ded		
9665	Miss. R.—Chain of R., Mo. shore	1901 Nov. 3	1901 Nov. 5												17.3									
9634	Miss. R.—Chain of R., Mo. shore	4	5	V.Decid.	Much	F.06 V Mud	None	994.8	332.8	662.	39.6	17.2	22.4	Brown	16.3	11.1	4.9	6.2	.024	.262	.048	.214	.003	.437
9682	Miss. R.—Chain of R., Mo. shore	5	7												15.75									
9676	Miss. R.—Chain of R., Mo. shore	6	7	V.Decid.	Much	F.04 V Mud	None	993.2	302.8	690.4	50.8	17.6	33.2	Brown	14.45	10.9	4.1	6.8	.032	.336	.064	.272	None	.36
9695	Miss. R.—Chain of R., Mo. shore	7	9												16.8									
9702	Miss. R.—Chain of R., Mo. shore	8	9	V.Decid.	Much	F.02 V Mud	None	959.2	306.	653.2	35.2	17.6	17.6	Brown	16.9	11.1	3.8	7.3	.048	.272	.096	.176	.004	.136
9715	Miss. R.—Chain of R., Mo. shore	11	12	"	"	F.05 V Mud	"	1443.6	335.2	1108.4	80.4	12.4	68.	"	15.55	13.2	4.5	8.7	.068	.49	.096	.484	.006	.474
9741	Miss. R.—Chain of R., Mo. shore	12	14												30.9									
9747	Miss. R.—Chain of R., Mo. shore	13	14	V.Decid.	Much	F.05 V Mud	None	1380.4	358.	1022.4	44.4	18.8	25.6	Brown	35.2	13.	4.8	8.2	.068	.432	.096	.336	.006	.394
9778	Miss. R.—Chain of R., Mo. shore	14	16												20.25									
9785	Miss. R.—Chain of R., Mo. shore	15	16	V.Decid.	Much	F.05 V Mud	None	2341.2	315.6	2025.6	60.8	48.8	12.	Brown	21.5	16.5	4.1	12.4	.108	.672	.096	.576	.009	.551
9800	Miss. R.—Chain of R., Mo. shore	18	19	"	Very Much	F.06 V Mud	"	1210.8	318.	892.8	53.2	15.6	37.6	"	16.9	15.	4.3	10.7	.132	.576	.128	.448	.006	.474
9821	Miss. R.—Chain of R., Mo. shore	19	20												15.9									
9828	Miss. R.—Chain of R., Mo. shore	20	21	V.Decid.	Very Much	F.04 V Mud	None	1022.8	322.	700.8	49.6	19.6	30.	Brown	14.7	13.7	4.3	9.4	.032	.432	.064	.36	.004	.396
9844	Miss. R.—Chain of R., Mo. shore	21	23												14.5									
9848	Miss. R.—Chain of R., Mo. shore	22	23					954.	322.	632.	50.	21.2	28.8	Brown	15.76	12.0	4.1	8.5	.06	.352	.064	.28	.003	.357
9867	Miss. R.—Chain of R., Mo. shore	23	26												17.									
9871	Miss. R.—Chain of R., Mo. shore	25	26			F.01		873.8	318.8	554.	51.8	59.2		Brown	17.9	12.5	3.7	8.8	.08	.330	.064	.272	.014	.344

9902	Miss. R.—Chain of R., Mo. shore....	26	28	......	......	......	......	......	......	......	......	......	......	......	16.9	......	......	......	......	......	......	......	......	......
9906	Miss. R.—Chain of R., Mo. shore....	27	28	......	......	F.02	......	818.	336.4	481.6	36.4	11.6	24.8	Brown	17.4	10.9	3.5	7.4	.06	.288	.096	.192	.003	.317
9915	Miss. R.—Chain of R., Mo. shore....	29	30	......	......	F.04	......	843.2	348.8	494.4	31.6	26.	5.6	"	19.2	11.3	3.8	7.5	.08	.336	.144	.192	.007	.353
9941	Miss. R.—Chain of R., Mo. shore....	30	Dec. 3	......	......	......	......	......	......	......	......	......	......	......	19.6	......	......	......	......	......	......	......	......	......
9945	Miss. R.—Chain of R., Mo. shore....	Dec. 2	Dec. 3	V.Decid.	Much..	F.02 V Mud	None..	721.6	344.4	377.2	18.	38.4	......	Brown	22.2	8.9	3.9	5.	.108	.288	.096	.192	.007	.393
9979	Miss. R.—Chain of R., Mo. shore....	3	5	......	......	......	......	......	......	......	......	......	......	......	22.	......	......	......	......	......	......	......	......	......
9983	Miss. R.—Chain of R., Mo. shore....	Dec. 4	Dec. 5	V. Decid	Much	F.03 V. Mdy	None	654.	347.6	306.4	40.8	16.8	24.	Brown	20.	8.7	3.8	4.9	.056	.24	.08	.16	.014	.306
10002	Miss. R.—Chain of R., Mo. shore....	5	7	......	"	......	......	......	......	......	......	......	......	......	20.1	......	......	......	......	......	......	......	......	......
10006	Miss. R.—Chain of R., Mo. shore....	6	7	V. Decid	"	F.03 V. Mdy	None	657.2	368.4	288.8	28.4	26.8	1.6	Brown	Lost	9.2	4.1	5.1	.108	.24	.096	.144	.007	.313
10024	Miss. R.—Chain of R., Mo. shore....	9	10	"	"	F.02 Muddy	"	654.	359.6	294.4	36.	23.2	12.8	"	22.4	8.9	4.8	4.1	.08	.24	.128	.112	.007	.233
10056	Miss. R.—Chain of R., Mo. shore....	10	11	......	......	......	......	......	......	......	......	......	......	......	23.4	......	......	......	......	......	......	......	......	......
10060	Miss. R.—Chain of R., Mo. shore....	11	12	V. Decid	Much	F.03 V. Mdy	None	620.	363.2	256.8	29.6	22.4	6.2	Brown	20.5	8.1	3.7	4.4	.088	.224	.064	.16	.01	.27
10071	Miss. R.—Chain of R., Mo. shore....	12	14	......	......	......	......	......	......	......	......	......	......	......	20.5	......	......	......	......	......	......	......	......	......
10075	Miss. R.—Chain of R., Mo. shore....	13	14	V. Decid	Much	F.01 Muddy	None	577.6	346.	231.6	15.2	12.4	2.8	Brown	21.5	7.2	3.7	3.5	.1	.208	.048	.16	.011	.229
10089	Miss. R.—Chain of R., Mo. shore....	14	17	......	......	......	......	......	......	......	......	......	......	......	21.6	......	......	......	......	......	......	......	......	......

CHEMICAL ANALYSIS.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.
SANITARY WATER ANALYSIS—PARTS PER MILLION.

REPORT OF ARTHUR W. PALMER.

Sheet Number	Source of Water.	Date of		Appearance.			No. of Collections	Residue on Evaporation.						Color on Ignition	Chlorine	Oxygen Consumed.			Nitrogen as Ammonia.				Nitrogen as	
		Collection	Examination	Turbidity	Sediment	Color		Total	Dissolved	Suspended	Loss on Ignition					Total	By Dissolved	By Suspended Matter	Free Am'onia	Albuminoid Ammonia.			Nitrites	Nitrates
											Total	Dis'l'ved	Susp'ded							Total	Dis'l'ved	Susp'ded		
1	Illinois river—Averyville	1901 Oct. 1	1901 Oct. 31	Average of			16	235.4 9	218.4	17.	22.1	22.4	......	......	22.5	6.2	5.4	.8	.18	.24	.186	.054 9	.132 9	1.676 9
	Illinois river—Averyville	Nov. 1	Nov. 30	"	"	"	25	214.7 13	210.4	4.3	26.7 13	22.3	......	......	21.	5.5	4.9	.6	.465	.214	.175	.050 13	.079 13	1.534 13
	Illinois river—Averyville	Dec. 2	Dec. 30	"	"	"	24	248.2 13	224.7	23.5	26.1	25.3	......	......	21.2	6.6	5.7	.9	1.597	.313	.241	.073 12	.029 13	1.022 8
	Illinois river—Averyville	Oct. 1	Dec. 30	"	"	"	65	232.4	217.7	14.7	25.3	23.4	......	......	21.5	6.1	5.2	.9	.812	.257	.191	.066	.074	1.381
2	Illinois river—Pekin	Oct. 15	Oct. 31	"	"	"	14	234.8	220.4	14.4	22.8	20.2	......	......	22.5	6.3 8	6.2 8	.1	.16 8	.286 8	.210 8	.07	.128 8	1.027 8
	Illinois river—Pekin	Nov. 1	Nov. 30	"	"	"	25	224.7	211.7	13.	26.9	26.	......	......	21.2	6.3 3	5.4 12	.9	.459 13	.327 13	.186 13	.141	.075 13	1.506 13
	Illinois river—Pekin	Dec. 2	Dec. 28	"	"	"	23	235.4	219.7	15.7	27.8	25.9	......	......	21.8	7.01 12	6.02 12	1.	.762 12	.3 12	.211 12	.089	.031 12	.923 12
	Illinois river—Pekin	Oct. 15	Dec. 28	"	"	"	62	231.1	217.9	13.2	26.2	24.5	......	......	22.	6.6	5.7	.9	.497	.298	.203	.095	.072	1.325
3	Illinois river—Grafton	Oct. 2	Oct. 30	"	"	"	20	200.5 12	222.8 13	37.4 12	18.7 12	17.8 13	......	......	23.2	6.5 13	6.1 13	.9 8	.118 13	.228 13	.178 13	.078 9	.047 13	1.477 13
	Illinois river—Grafton	Nov. 1	Nov. 30	"	"	"	23	233.2 11	215.7 11	17.5	31.3 11	27.5 11	......	......	20.7	7.4 11	5.4 10	2.	.073 11	.416 11	.174 11	.242	.041 11	1.271 11
	Illinois river—Grafton	Dec. 2	Dec. 23	"	"	"	18	279.1 10	213.8 10	65.3	34.4 10	25.5 10	......	......	18.5	9.06 10	6.01 10	3.	.703 10	.308 10	.194 10	.174 10	.037 10	1.116 10
	Illinois river—Grafton	Oct. 2	Dec. 23	"	"	"	61	257.1 33	217.7 34	39.4	27.6 33	23.2 34	......	......	20.9	7.5 34	5.8 34	1.7	.275 34	.330 34	.181 34	.155	.042 34	1.305 34
4	Mississippi river—Grafton	Oct. 2	Oct. 30	"	"	"	19	194.9 13	146.1 13	48.8	22.1 13	21.5 13	......	......	3.	12.8 13	10.6 13	2.2	.057 13	.301 13	.164 13	.137	.0027 7	.127 13
	Mississippi river—Grafton	Nov. 1	Nov. 30	"	"	"	23	153.1 11	125.4 11	28.7	25.9 11	23.2 11	......	......	3.2	11.5 11	9.5 10	2.	.049 11	.238 11	.153 11	.085	.001 2	.123 10
	Mississippi river—Grafton	Dec. 2	Dec. 23	"	"	"	18	167.8 10	152.1 10	28.2 7	28.6 10	27.14 10	......	......	3.7	11.7 10	8.9 10	2.8	.046 10	.259 10	.106 10	.093	.001 1	.153 10
	Mississippi river—Grafton	Oct. 2	Dec. 23	"	"	"	60	173.3	141.1	32.2	25.5	24.4	......	......	3.3	12.1	9.8	2.3	.051	.269	.161	.105	.002	.133

5	Missouri river—Bellefontain....	Oct. 11	Oct. 31	"	"	"	16	1420.3_{9}	305.9_{10}	1114.5_{9}	47.2_{8}	14.7_{10}	......	....	16.1	14.5_{10}	4.6_{10}	9.9	$.031_{10}$	$.515_{10}$	$.081_{10}$	.434	$.003_{9}$	$.504_{10}$
	Missouri river—Bellefontain....	Nov. 2	Nov. 30	"	"	"	24	1360.4_{13}	335.1_{13}	1025.3	48.4_{13}	21.8_{13}	......	....	19.9	13.9_{13}	3.9_{13}	10.	$.063_{13}$	$.456_{13}$	$.103_{13}$	.353	$.008_{13}$	$.426_{13}$
	Missouri river—Bellefontain....	Dec. 2	Dec. 16	"	"	"	13	$768._{7}$	367.6_{7}	400.4	28.2_{7}	18.9_{7}	......	....	22.3	10.1_{7}	3.8_{7}	6.3	$.031_{7}$	$.272_{7}$	$.094_{7}$	.178	$.011_{7}$	$.317_{7}$
	Missouri river—Bellefontain....	Oct. 11	Dec. 16	"	"	"	53	1239.5	333.	906.5	42.	20.1	......	....	19.4	13.2	4.1	9.1	.066	.434	.093	.04	.007	.423
6	Miss. R.—Chain of R., Ill. shore....	Oct. 3	Oct. 30	"	"	"	17	486.3_{11}	181.7_{12}	267.5_{13}	26.9_{10}	20.4_{12}	......	....	7.9	12.7_{12}	8.3_{12}	4.4	$.064_{12}$	$.34_{12}$	$.174_{12}$	.166	$.009_{12}$	$.42_{12}$
	Miss. R.—Chain of R., Ill. shore....	Nov. 1	Nov. 30	"	"	"	23	186.3_{12}	155.3_{13}	30.7_{12}	28.6_{12}	23.2_{13}	......	....	7.6	10.4_{13}	8.1_{13}	2.3	$.08_{13}$	$.316_{13}$	$.172_{13}$	.144	$.009_{13}$	$.376_{13}$
	Miss. R.—Chain of R., Ill. shore....	Dec. 2	Dec. 14	"	"	"	10	176.6_{5}	166.9_{5}	15.8_{5}	26.5_{5}	26.9_{5}	......	....	7.6	9.7	8.1	1.6	$.088_{5}$	$.336_{5}$	$.188_{5}$	.138	$.012_{5}$	$.404_{5}$
	Miss. R.—Chain of R., Ill. shore....	Oct. 3	Dec. 11	"	"	"	50	282.6	167.8	123.6	27.6	22.7	......	....	7.7	11.2	8.2	3.	.069	.337	.172	.155	.009	.398
7	Miss. R.—Chain of R., mid-channel	Oct. 3	Oct. 30	"	"	"	17	$610._{11}$	181.3_{12}	482.4_{11}	26.9_{11}	17.5_{12}	......	....	7.	14.1_{12}	8.3_{12}	7.8	$.063_{12}$	$.394_{12}$	$.154_{12}$	.24	$.005_{12}$	$.334_{12}$
	Miss. R.—Chain of R., mid-channel	Nov 1	Nov. 30	"	"	"	23	315.2_{13}	167.4_{13}	147.8	33.4	23.8_{13}	......	....	7.1	11.6_{13}	8.1_{13}	3.5	$.047_{13}$	$.321_{13}$	$.155_{13}$	.166	$.006_{8}$	$.286_{13}$
	Miss. R.—Chain of R., mid-channel	Dec. 2	Dec. 14	"	"	"	11	299.8_{5}	170.2_{5}	129.6	27.3_{5}	21.5_{5}	......	....	8.6	$11._{5}$	7.2_{5}	3.8	$.079_{6}$	$.312_{6}$	$.138_{5}$	$.165_{5}$	$.008_{6}$	$.305_{6}$
	Miss. R.—Chain of R., mid-channel	Oct. 3	Dec. 14	"	"	"	51	408.7_{29}	178.4	262.6	23.1	20.9	......	....	7.4	12.5	7.8	4.7	.063	.348	.152	.196	.006	.3
8	Miss. R.—Chain of R., Intake tower	Oct. 3	Oct. 30	Average of			17	1385.4_{12}	271.1_{12}	1114.3	69.4_{12}	20.4_{12}	49.	....	12.4	16.5_{12}	6.3_{12}	10.2	$.071_{12}$	$.582_{12}$	$.121_{12}$	.461	$.003_{11}$	$.467_{12}$
	Miss. R.—Chain of R., Intake tower	Nov. 1	Nov. 30	"	"	"	23	1123.3_{13}	292.5_{13}	830.8	46.8_{13}	17.8_{13}	29.	....	16.2	13.6_{13}	4.8_{13}	8.8	$.061_{13}$	$.429_{13}$	$.068_{13}$	.334	$.005_{11}$	$.36_{13}$
	Miss. R.—Chain of R., Intake tower	Dec. 2	Dec. 14	"	"	"	10	612.2_{6}	331.6_{6}	280.6	26.8	19.6_{5}	7.	....	19.5	9.9_{6}	4.9_{6}	5.	$.083_{6}$	$.285_{6}$	$.105_{6}$	.18	$.009_{6}$	$.291_{6}$
	Miss. R.—Chain of R., Intake tower	Oct. 3	Dec. 14	"	"	"	50	1127.2	291.7	835.5	51.7	19.2	32.5	....	15.5	14.1	5.3	8.8	.069	.461	.107	.354	.005	.388
9	Miss. R.—Chain of R., Mo. shore....	Oct. 3	Oct. 30	"	"	"	17	1076.2_{12}	285.8_{12}	790.4	56.3_{12}	15.4_{12}	40.9	....	17.8	14.2_{12}	5.1_{12}	9.1	$.059_{12}$	$.43_{12}$	$.125_{12}$	.305	$.008_{11}$	$.523_{12}$
	Miss. R.—Chain of R., Mo. shore....	Nov. 1	Nov. 30	"	"	"	23	1148.7_{13}	328.2_{13}	820.5	$48._{13}$	22.9_{13}	25.1	....	14.1	12.6_{13}	3.4_{13}	9.2	$.065_{13}$	$.391_{13}$	$.088_{13}$	.303	$.005_{12}$	$.387_{13}$
	Miss. R.—Chain of R., Mo. shore....	Dec. 2	Dec. 14	"	"	"	11	814.1_{6}	354.8_{6}	459.3	$28._{6}$	21.6_{6}	9.4_{5}	....	21.4	8.5_{6}	$4._{6}$	4.5	$.09_{6}$	$.24_{6}$	$.085_{6}$	.155	$.009_{6}$	$.291_{6}$
	Miss. R.—Chain of R., Mo. shore....	Oct. 3	Dec. 14	"	"	"	51	1000.	316.9	683.9	47.3	19.8	27.5	....	17.5	12.4	4.5	7.9	.067	.377	.101	.276	.006	.421

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STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.
SANITARY WATER ANALYSIS—PARTS PER MILLION.

CHEMICAL ANALYSIS.

Serial number	Source of water.	Date of Collection and Examination.	Odor	Residue on evaporation.						Color on Ignition	Chlorine	Oxygen consumed.			Nitrogen as ammonia.				Nitrogen as	
				Total	Dissolved	Suspended	Loss on Ignition.					Total	By dissolved.	By suspended matter	Free amm'nia	Albuminoid ammonia.			Nitrites	Nitrates
							Total	Dissolved.	Suspend'd							Total	Diss'l'ed	Susp'ded		
	Illinois river—Averyville	Oct., Nov. and Dec., 1901	ce 65	35 232.	217.	15.	25.	23.	2.		21.5	6.1	5.2	.9	.812	.257	.191	.066	.074	1.331
	Illinois river—Pekin	" " "	ce 62	34 231.	218.	13.	26.	24.	2.		22.	6.6	5.7	.9	.407	.298	.203	.095	.072	1.325
	Illinois river—Grafton	" " "	ce 61	33 257.	218.	39.	27.	23.	4.		20.9	7.5	5.8	1.7	.275	.336	.181	.155	.012	1.305
	Mississippi river—Grafton	" " "	ce 60	34 173.3	141.	32.3	25.	24.	1.		3.3	12.1	9.8	2.3	.051	.269	.161	.108	.002	.133
	Missouri river—Ft. Bellefontaine	" " "	ce 53	29 1239.5	333.	906.5	42.	20.	22.		19.4	13.2	4.1	9.1	.086	.4004	.093	.304	.007	.423
	Miss. Chain—Illinois shore	" " "	ce 50	28 282.6	167.8	123.6	27.	22.	5.		7.7	11.2	8.2	3.	.066	.327	.172	.156	.0098	.398
	Miss. Chain—Mid-stream	" " "	ce 51	29 446.	173.4	262.6	23.	21.	2.		7.4	12.5	7.8	4.7	.063	.348	.152	.196	.004	.3
	Miss. Chain—Tower	" " "	ce 50	31 1127.	291.	835.	51.	19.	32.		15.5	14.1	5.4	8.8	.069	.401	.107	.354	.005	.388
	Miss. Chain—Missouri shore	" " "	ce 50	31 1000.	317.	6.83	47.	20.	27.		17.5	12.4	4.5	7.9	.067	.377	.101	.276	.005	.421
	Illinois river—Averyville	Oct., Nov. and Dec., 1899		392.	378.	14.	37.	32.	5.		51.1	8.8	7.9	.9	2.06	.476	.314	.162	.437	2.372
	Illinois river—Pekin	" " "		398.	377.	21.	39.	35.	4.		49.6	10.3	8.3	2.	2.053	.73	.38	.35	.385	2.078
	Illinois river—Grafton	" " "		336.	294.	42.	33.	26.	7.		26.9	9.3	7.2	2.1	.428	.463	247	.216	.032	1.272
	Mississippi river—Grafton	" " "		209.	153.6	55.6	27.	21.	6.		3.6	12.6	11.9	.7	.037	.368	.22	.148	.003	.186
	Missouri river—Ft. Bellefontaine	" " "		771.	223.	448.	23.	13.6	9.1		19.7	9.1	3.8	5.3	.037	.301	.098	.203	.007	.284
	Miss. R. Chain—Illinois Shore	" " "		303.	181.	122.	24.	19.	5.		8.2	11.9	9.	2.9	.056	.437	.229	.208	.007	.37
	Miss. R. Chain—Mid-channel	" " "		549.	254.	295.	22.	15.	7.		13.6	10.6	6.5	4.1	.029	.349	.21	.139	.037	.24
	Miss. R. Chain—Inlet Tower	" " "		643.	277.	366.	26.	15.	11.		15.3	10.1	5.8	4.3	.034	.334	.137	.197	.007	.25
	Miss. R. Chain—Missouri Shore	" " "		701.	296.	405.	22.	13.	9.		17.2	9.5	4.5	5.	.034	.311	.123	.188	.007	.27

8950 Q. Professor, will you please explain these tables in detail?

A. Sheets Nos. 1 and 2 contain the results of analyses of 65 samples of water collected from the Illinois river at Averyville, during the period October 1st to December 30th, 1901. Some of the samples were subjected to the ordinary complete sanitary chemical analysis. In a portion of them only the chlorine was determined and from lack of time we made no attempt to determine other constituents, in the samples collected each day. Only the samples collected on alternate days were submitted to complete sanitary chemical analysis.

Sheets 3 and 4 contain results of analyses of 62 samples of water collected from the Illinois river at Pekin covering the period October 15th to December 28th, 1901. In this case as in the case of Averyville only half of the samples, that is, those collected on alternate days were subjected to the complete sanitary chemical analyses, the others having merely the chlorine determination.

Sheets 5 and 6 contain the results of the analyses of samples of water collected from the Illinois river at Grafton, covering the period October 2nd to December 23rd inclusive, in all 62 samples.

8951 Sheets 7 and 8 contain the results of analyses of samples collected during the same period upon the same dates but from the Mississippi river at Grafton just above the mouth of the Illinois.

Sheets 9 and 10 contain the results of the analyses of samples of water collected from the Missouri river at Fort Bellefontaine, 53 samples in all collected, during the period October 11th to December 16th, 1901, inclusive.

Sheets 11 and 12 contain the results of analyses of samples of water collected from the Mississippi river at the chain of rocks near the Illinois shore at the point referred to in the testimony given concerning the earlier series of chemical examination. In all there were fifty samples of water taken at this point and subjected to chemical analyses, the results of these appearing upon these sheets Nos. 11 and 12.

Sheets Nos. 13 and 14 contain the results of analyses of samples of water collected at the chain of rocks, but at mid-channel in the Mississippi river, 51 samples in all covering the period October 3rd to December 14th inclusive, 1901.

Sheets 15 and 16 contain results of analyses of samples of water collected at the chain of rocks taken from the Mississippi river beside the intake tower of the St. Louis waterworks, 51 samples in number, covering the period October 3rd, to December 14th, 1901.

8952 Sheets 17 and 18 contain the results of analyses of samples of water collected from the Mississippi river at the chain of rocks but near the Missouri shore, 51 samples in all covering the period October 3rd to December 14th inclusive, 1901.

Sheets Nos. 19 and 20 contain the averages of the analyses just referred to; the averages for each month, that is, October, November and December, for each point, and the general average for the entire three months period.

Q. Professor, have you prepared any plates graphically illustrating the detailed examinations contained in these tables?

A. I have.

Q. Will you produce them?

A. They are here.

Q. Will you please explain what those plates indicate or show?

A. Plate No. 101, series 1901, A. W. P., represents the averages for the period of three months, October, November and December, 1901, and those for the same three months in 1899 in parallel columns.

The comparison of the three rivers, the Missouri, the Mississippi and the Illinois, exhibits a very great difference between the Illinois and the Missouri on one hand and the Mississippi on the other, during the periods in question.

8953 This plate represents the average proportions of chlorine in the waters of the Illinois river at Grafton, the Mississippi river at Grafton above the mouth of the Illinois, the Missouri river at Fort Bellefontaine and at four points in a cross-section at the chain of rocks, for the months of October, November and December, 1899 and the same months in 1901.

The comparison of the three rivers, that is the Illinois just above its mouth at Grafton, the Mississippi just above the mouth of the Illinois at Grafton and the Missouri river at Fort Bellefontaine, exhibit a very great difference between the Illinois and the Missouri on the one hand and the Mississippi on the other, during the periods in question.

The content of chlorine in the Mississippi is practically the same as in the earlier year, the same in 1901 as in the earlier years.

The content of chlorine in the Mississippi river water was about the same as in the Illinois river. The greater dilution in 1901 has of course manifested itself in somewhat lower chlorine than in the year 1899.

The significance of these features is determined upon the fact that we have demonstrated elsewhere that the water
8954 of the Illinois river does not mix perfectly with the water
of the Mississippi on its way from Grafton down to the chain of rocks, and that the Illinois river water flows mainly close to the Illinois shore, while the water near the Missouri shore consists mainly of Mississippi river water, mixed only slightly with Illinois river water, though at mid-channel there is more or less considerable mixing of the waters of the two streams. That these conditions prevail down to the mouth of the Missouri river, the Missouri river water as it enters the Mississippi deflects the Mississippi river water forcing it toward the Illinois shore, and it passes down chiefly toward the Missouri shore. It mixes of course to some extent with the fluid coming down from the upper Mississippi at this point, but it is substantially but slightly mixed Mississippi river water, which is toward the Missouri shore; that is the main body of water from the Illinois river is toward the Illinois shore and it is water of the Mississippi river mixed with but small proportions of the water from the Illinois, which comes into immediate contact with the discharge from the Missouri river when the Missouri river water enters the bed of the Mississippi and it is quite unlikely that any considerable proportion of Illinois river water mixes at first with the Missouri river water, but rather it is mainly Mississippi river water containing but a small proportion of the water
8955 of the Illinois river.

What we have then, briefly stated is, first, a body of Missouri river water passes down the west or Missouri bank; second, the mixture of Mississippi river water with Missouri river water, containing but a very slight proportion of Illinois river water; third, Mississippi river water containing more Illinois river water in the middle; fourth, Mississippi river water mixed with a more considerable proportion of the water of the Illinois river; fifth, near the Illinois shore the larger proportion of Illinois river water mixes of course with the Mississippi river water and to some extent also with the water of the Missouri river.

To be sure, there is no fixed line of demarkation between any of these mixtures, but the mixing takes place gradually, and we certainly have combinations such as I have indicated at the different points across stream. Water for samples taken at the chain of rocks shows that the water at the Illinois shore contains far less chlorine than does the Illinois river water pure and simple, but far more than does the Mississippi river water above Grafton. There has occurred a somewhat extensive mixing at mid-stream. We find water having almost the same content of chlorine as at the Illinois shore, while at the intake there
is less chlorine than in the Missouri river water at Fort
8956 Bellefontaine and considerably less than at the Missouri
shore. It is to be noted, however, that the collections at
Fort Bellefontaine are not quite so numerous as those at the chain of rocks. They did not begin for some ten days or so after the time when those taken at the chain of rocks began.

The data of the analyses show, and it is evident from the relative heights of these columns that although the Missouri river water did not extend so far across the stream beyond the intake tower in 1901 as it did in 1899, yet, there was no more Mississippi river water and there was no more Illinois river water in the mixture at the intake tower in 1901, that is, after the opening of the Chicago main drainage channel, than there was in 1899.

Upon chart 102 of this series there are represented the proportions of oxygen consumed or required by the waters of the Illinois river at Grafton, the Mississippi river at Grafton just above the mouth of the Illinois; the Missouri river at Bellefontaine just above its mouth and the Mississippi river at four different points across the stream opposite the St. Louis waterworks intake at the chain of rocks.

The columns representing general averages of analyses of
samples collected during three months, October, Novem-
8957 ber and December 1901 and the same three months for
the year 1899.

A comparison of the three rivers shows at once that the total oxygen required was much greater in the Mississippi river water than in the Illinois and was still greater in the Missouri river water than in the Mississippi.

It shows further that the oxygen required by matters in solution in the water, was much greater in the Mississippi water than in the water of the Illinois, and less in the Missouri river water than either the water of the Illinois or the Mississippi. In this respect the Mississippi river water was inferior to both the Illinois river water and the Missouri river water. A cross-section at the chain of rocks shows that in 1901 there was a greater difference between the two sides of the river and particularly between the waters passing down the side of the intake tower and that passing down along the Illinois shore than in 1899.

Comparison of the three rivers shows too a considerable improvement in the Illinois river in 1901 as compared with its condition in 1899, and an improvement too, in the Mississippi river in 1901 as compared with its condition during the same period of 1899.

8958 While the conditions in the Missouri river were worse during this period in 1901 than they were in the same period in 1899.

ADJOURNED until 10:00 A. M. following day, Thursday, November 19th, 1903.

10:00 A. M., Thursday, November 19, 1903.

8959 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further direct-examination by Judge Springer and testified as follows:

Q. Professor, at the adjournment on yesterday afternoon you were considering certain charts based upon the tables of chemical analyses of waters taken from the Illinois and Missouri rivers in the months of October, November and December, 1901, and you had explained the graphic illustrations on chart 102, and had concluded your consideration of that chart. Will you proceed with the other charts based upon those tables?

A. I will. At first I would like to turn over the sheet of averages mentioned yesterday which when the rest of the tables of figures relating to the work of 1901 were introduced, was found to be missing. I found it this morning, and it will be numbered Sanitary District Series 1901, A. W. P. 21.

8960 Q. You may now proceed with your explanation of chart 103.

A. Chart No. 103 of this series represents the average proportions of nitrogen as albuminoid ammonia contained in the waters of the Illinois river at Grafton, the Mississippi river at Grafton just above the mouth of the Illinois, the Missouri river at Fort Bellefontaine, just above its mouth, and at four different points across the stream of the Mississippi river at the St. Louis waterworks intake at Chain of Docks. Data from which these averages represented upon the charts are made, which averages are upon sheet 21 of the series, covering the three months, October, November and December, 1899 and 1901.

The conditions with respect to the proportions of albuminoid nitrogen as revealed by this chart is somewhat similar to those exhibited by chart 102, representing the proportions of oxygen required; that is, the total albuminoid oxygen was greater in proportion in the Missouri river water in 1901 than in either the Mississipi or the Illinois, while the albuminoid nitrogen in solution was less in the Missouri than in the others.

In 1889 the conditions in these respects were much worse than in 1901, although in the Illinois river, and in the Mississippi river, and the cross section at the chain of rocks,
8961 there is shown much less mixing of the water of the Mississippi river with that of the Missouri at the intake tower during the autumn of 1901, than existed in the corresponding season of 1899.

Chart No. 104 of this series represents the total solids, both mineral and organic matters in the waters of the Illinois river at Grafton, the Mississippi at Grafton just above the mouth of the Illinois; the Missouri river at Fort Bellefontaine, and so on, the same points as referred to in the three preceding charts of this series, and is based upon similar averages covering the two periods of three months each, namely October, November and December, 1899 and October, November and December, 1901.

Comparison of the three rivers shows that the total solids in the Illinois river water were notably less in proportion in 1901 than in 1899, and the same is true concerning the water of the Mississippi river. On the other hand the water of the Missouri contained considerably more total solids in 1901, than it did in 1899, the mineral matters in solution too, are very much

greater in quantity in the Missouri river water than in the Mississippi river water, and are notably greater than in the Illinois river water, but the greatest difference between the
8962 Missouri river water on one hand, and the Mississippi and Illinois on the other, is in the proportions of suspended matters, the suspended matters in the Missouri river water during this period in 1899 amounted to about 448 parts per million, while during the season of 1901 they amounted to 906 parts per million. During the same periods the proportions of suspended matters in the Illinois river averaged about 42 parts per million for both years.

In the Missisippi river water in 1899 there were about 55 parts of suspended matters per million. In 1901 about 32 parts per million. It would seem that during these periods the averages representing the quantities of matters in suspension constitute the best basis for calculation of the relative proportions of water from the three streams contained in the mixture at the points where the three have more or less come together.

A comparison of the data at the chain of rocks where we note the relative quantities of the suspended matters at the four different points across the stream, shows at once that there is far less mixing of the Illinois river water with that of the Mississippi and that of the Mississippi with the Missouri in 1901, that is after the opening of the Chicago main drainage channel, than there was in 1899, the season just preceding the
8963 opening of the drainage channel. The relative proportions of suspended matters contained in these waters at the several different points across the stream at the chain of rocks and also in the three different rivers are shown more in detail upon chart 105, that is upon this chart, instead of having the averages for the entire period represented by columns, there are lines, that is, curves, which represent the proportions contained in the water on the day of each collection. The very notable increase in suspended matters in the Illinois river, December 16th, 1901 appears to be due to the fact that the Mississippi and Missouri rivers fell greatly and suddenly at this time, and created a rapid current in the lower Illinois, that is, particularly between the Kampsville dam and Grafton, thus causing a scouring out of the Illinois river along this stretch. The conditions which prevailed during the same season in 1899 are exhibited upon chart No. 106.

Comparison of the two charts shows how much greater were the differences between the Missouri river water on the one hand and the Illinois and Mississipi river water on the other and how much less complete was the mixing of these waters at the chain of rocks in 1901 than it was in the corresponding season of 1899.

The total solids in suspension are shown in detail upon 8964 chart No. 107 of this series, and this again exhibits the great difference between the water at the intake tower and that passing down near the Illinois shore, and also shows that there is comparatively little mixing even so far across the stream as the mid-channel of the Mississippi river; that is a point somewhat to the east of the intake tower.

The fact that the water at the Missouri shore itself frequently contains less suspended matters than that at the intake tower is undoubtedly due to the fact that in times of low water the main current is further out from the shore and beside the intake tower, while the water nearer to the Missouri shore flowing with less velocity does not retain so much matter in suspension as does that farther out, which is moving more swiftly.

The solid matters in solution both at the different points at the chain of rocks and in the three separate rivers, are shown upon chart No. 108. The features exhibited with this chart show again that between the mixture of the Illinois river water and the Mississippi river water, which is passing along the Illinois shore, and the Mississippi river water which hugs the Missouri shore, is a body of water consisting chiefly of upper Mississippi river water which intervenes between that coming down the Illinois shore and the body of water passing 8965 down beside the intake tower, and the Missouri shore, and substantially prevents the Illinois river water from reaching the body of water which enters the intake of the St. Louis waterworks.

The relative quantities of total solid matters that is both the matters in solution and those in suspension, contained in the waters of the different streams are shown on chart No. 109, which simply corroborates what has been stated above respecting the significance of the lines of charts 107 and 108, and the others of this series.

JUDGE SPRINGER: I now offer these charts in evidence as Defendants' Exhibits 5, 6, 7, 8, 9, 10, 11, 12 and 13.

Said charts received in evidence and so marked by the Commissioner.

(Charts not reproduced in print.)

Q. Professor, have the proportions of organic matters in the Illinois river near the mouth been greater or less since January, 1900?

A. They have been less.

Q. Have you any data bearing upon that that you have not presented?

A. Yes, or rather I have it in the form different from that
in which it has already been presented. It has gone in
8966 the detailed tables 1 to 80 inclusive, which we have been
discussing, and it was incidentally contained in the tables
of monthly averages which were introduced yesterday.

I now have in hand certain tables which bring together the averages of the different constituents for the different years in order to facilitate a ready comparison, a comparison which may indeed be made by study of the detailed tables or by study of the tables of monthly averages, but which being here brought together are more easily considered, and their significance more easily grasped.

Q. In what shape is that data?

A. Well, I have it in the form of tables here, typewritten tables much of it; some of it I have only in my original personal note-book.

Q. Well, will you explain those tables and those data?

A. I will. The tables are designated Combined monthly and yearly averages of proportions of certain chemical constituents of the waters of the Illinois river at Kampsville, and are numbered from 1 to 7.

8967 Q. Now professor, will you explain these tables?

A. Table No. 1 of this series gives the proportions of total organic nitrogen as determined by the Kjel Dahl process in the water of the Illinois river at Kampsville during the years 1897, 1898, 1899, 1900, 1901 and 1902, both for the monthly averages and the yearly averages. These represent the monthly averages of anlyses for each year during the period, and the yearly average has been made from all of the detailed analyses made during the year.

The averages for the entire years 1897, 1898 and 1899 have been combined into an average for the three year period, and also the yearly averages for 1900, 1901 and 1902, have been combined into an average for that three year period. The three years average prior to 1900 is 1.0866 parts per million of total

organic nitrogen, and for the three years subsequent to the opening of the Chicago main drainage channel, that is, for the three years 1900, 1901 and 1902; the composite average is .8966. Calculating the percentage difference between these two averages, it appears that there has been a decrease in the proportions of total organic nitrogen in the waters of the Illinois river since the opening of the Chicago drainage channel, amounting to 17.48 per cent. Direct determinations of the total
organic nitrogen were discontinued after September,
8968 1901, and from that time on to the end of 1902, the data
which appear in these tables have been calculated from
the relation between the proportions of nitrogen as total organic nitrogen and nitrogen as albuminoid ammonia, on the basis of the nitrogen as albuminoid ammonia, constituting forty per cent. of the total organic nitrogen.

Table No. 1 is as follows:

8969 PROPORTIONS OF TOTAL ORGANIC NITROGEN IN THE WATER OF THE ILLINOIS RIVER. KAMPSVILLE. MONTHLY AVERAGES.

	1897	1898	1899	1900	1901	1902
Jan.	1.387	1.67	.882	.91	.997	
Feb.	1.065	1.3	1.02	2.19	.768	
Mar.	1.24	1.7	2.23	1.496	1.868	
April	.9225	1.0633	.985	.776	.952	
May	1.17	1.292	1.354	1.109	1.136	
June	1.214	1.04	1.253	.758	.944	
July	1.107	.76	.92	.505	.688	
Aug.	1.175	.928	.9312	.7672	.592	
Sept.	1.116	.77	.915	.6123	.592	
Oct.	.66	.6175	.858	.7328	.6	
Nov.	.7772	.634	1.016	.74	.9	est.
Dec.	.9415	.73	1.288	.692	.065	
Year	1.09	1.04	1.1297	.9043	.869	.872
					est from albu.	

$\underbrace{1897\ \ 1898\ \ 1899}_{1.0866}$ $\underbrace{1900\ \ 1901\ \ 1902}_{.8966}$

1.0866 .8966

Per cent. decrease 17.48.

8970 Upon table No. 2 of this series there is shown similar averages both monthly and yearly, for the dissolved organic nitrogen, that is, the total organic nitrogen held in solution or contained in substances which are in solution in the water. The general averages for the three year periods are given at the bottom; they are .636 for the period 1897 to 1899 inclusive, and .522 for the period 1900 to 1902, inclusive. The percentage difference between these is 17.92 which shows a decrease in the proportions of the organic nitrogen derived from dissolved substances, since the opening of the Chicago main drainage channel, of 17.92 per cent.

Table No. 2 is as follows:

8971 PROPORTIONS OF DISSOLVED ORGANIC NITROGEN IN THE WATER OF THE ILLINOIS RIVER.

KAMPSVILLE—MONTHLY AVERAGES

	1897	1898	1899	1900	1901
Jan.	.72	.8966	.602	.538	.657
Feb.	.76	.61	.52	.523	.581
Mar.	.622	.57	.655	.492	.576
Apr.	.645	.6766	.545	.6	.592
May	.71	.676	.7164	.524	.565
June	.77	.6	.7605	.4265	.636
July	.74	.58	.695	.328	.576
Aug.	.815	.576	.5456	.3808	.48
Sept.	.732	.5	.611	.472	.44
Oct.	.7533	.4575	.595	.5096	.48 est.
Nov.	.597	.622	.606	.564	.6 est.
Dec.	.62	.51	.6373	.52	.5 est.
Year	.705	.5789	.6236	.488	.557
		.636		.522	

Decrease 17.92.

8972 Table No. 3 of this series gives in similar way the monthly averages and yearly averages of proportions of nitrogen as albuminoid ammonia, for the years 1897 to 1902 inclusive, and at the bottom of the sheet there are given also the averages for the first six months and the averages for the second six months. In addition, at the bottom there is given the general average for the three years period, 1897 to 1899 inclusive, and the three year period, 1900 to 1902, inclusive, that is for the three years immediately preceding the opening of the Chicago main drainage channel and the three years immediately following the opening. The general average for the earlier period is .4665 parts per million; for the period immediately following the opening it is .3495. The difference between these two amounts to 25 per cent, showing that the decrease in the proportions of nitrogen as albuminoid ammonia, immediately following and for the three years period subsequent to the opening of the Chicago main drainage channel, is 25 per cent.

Table No. 3 is as follows:

8973 QUANTITIES OF NITROGEN IN THE WATER OF THE ILLINOIS RIVER. TONS DISCHARGED PER 24 HOURS; Calculated from monthly averages of flows and constituents.

Albuminoid Nitrogen; Kampsville.

	1897	1898	1899	1900	1901	1902
Jan.	39.7	17.6	13.7	7.14	9.76	4.
Feb.	27.2	29.3	12.1	37.36	7.47	2.6
Mar.	44.6	59.6	62.6	49.4	39.24	15.2
Apr.	66.2	65.8	24.5	24.6	28.04	19.6
May	40.8	37.	23.3	18.8	15.42	12.2
June	12.7	22.3	19.	8.9	5.65	17.6
July	15.1	7.5	3.8	4.1	3.64	37.6
Aug.	5.4	6.6	3.4	5.9	2.75	36.9
Sept.	7.4	6.3	1.2	5.	1.96	13.6
Oct.	5.7	3.7	1.3	3.3	1.96	15.6
Nov.	6.	10.2	4.5	4.9	3.74	12.2
Dec.	2.4	8.3	6.7	9.3	3.25	18.6
1st. 6 Mo.	38.5	38.7	25.8	24.36	17.59	11.8
2nd 6 Mo.	7.	7.1	3.48	5.4	2.88	22.4
Year	22.7	22.9	14.64	14.88	10.23	17.1

$\underbrace{\text{1897 — 1899}}_{.4665}$ $\underbrace{\text{1900 — 1902}}_{.3495}$

Decrease 25 per cent.

8974 Table No. 4 of this series represents similar facts. The data with respect to the nitrogen as free ammonia in the waters of the Illinois river at Kampsville, that is, the average monthly proportions and the yearly averages for the years 1897 to 1902 inclusive, and contains also the general averages for each of these three year periods, the average for the three years prior to the opening of the Chicago main drainage channel, was .3717; for the three years period subsequent to the opening of the Chicago main drainage channel, the average was .3957, the relation of these to each other being such as to show an increase in the proportions of nitrogen as free ammonia, of six per cent.

Table No. 4 is as follows:

8975 PROPORTIONS OF NITROGEN AS FREE AMMONIA IN THE WATER OF THE ILLINOIS RIVER, KAMPSVILLE MONTHLY AVERAGES.

	1897	1898	1899	1900	1901	1902
Jan.	.268	1.7866	.92	1.54	.714	1.444
Feb.	.42	1.014	.73	1.003	.845	1.86
Mar.	.2584	.34	.49	.444	.684	.752
Apr.	.062	.0533	.306	.24	.126	.106
May	.107	.076	.146	.154	.112	.114
June	.1048	.023	.054	.052	.096	.068
July	.086	.0125	.05	.066	.093	.086
Aug.	.045	.0784	.072	.1246	.128	.058
Sept.	.3548	.046	.261	.128	.165	.076
Oct.	.336	.167	.236	.2096	.135	.061
Nov.	.416	.5992	.798	.33455	.165	.114
Dec.	1.73	.55	.7413	.524	1.067	.194
Year	.3509	.3722	.392	.3821	.375	.124
		.3717			.3937	

.3717

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.0220 = 6 % increase

8976 Table No. 5 of this series gives similar data with respect to the nitrogen as nitrites contained in the waters of the Illinois river at Kampsville, for the years 1897 to 1902 inclusive, both the monthly averages, the yearly averages and the general averages for the three years period prior to and the three years period subsequent to the opening of the Chicago main drainage channel.

The average for the former period is .0672, and for the latter period is .0405, manifesting thus, the fact that there was a decrease of 40 per cent in the proportions of nitrogen as nitrites contained in the waters of the Illinois river at Kampsville on the average for the three years period subsequent to the opening of the Chicago main drainage channel from the proportions contained on the average during the three years period prior to that opening.

Table No. 5 is as follows:

8977 PROPORTIONS OF NITROGEN AS NITRITES IN THE WATER OF THE ILLINOIS RIVER, KAMPSVILLE; TOTAL AVERAGES.

	1897	1898	1899	1900	1901	1902
Jan.	.04166	.1266	.0254	.0385	.014	.017
Feb.	.045	.0675	.0195	.021	.009	.015
Mar.	.057	.035	.02375	.0133	.011	.04
Apr.	.05	.035	.05075	.029	.027	.0415
May	.06375	.066	.0666	.0386	.032	.101
June	.202	.054	.054	.07	.054	.045
July	.133	.114	.114	.0813	.062	.047
Aug.	.14	.087	.087	.035	.105	.037
Sept.	.075	.0425	.0425	.05	.083	.0622
Oct.	.0766	.0275	.0275	.0516	.067	.0337
Nov.	.061	.06525	.06525	.03125	.056	.0266
Dec.	.0775	.0383	.0383	.02625	.033	.0113
Year	.0802	.052	.052	.0385	.044	.039
	.0672			.0405		

Decrease 40 per cent.

8978 Table No. 6 represents by means of monthly averages and yearly averages as in the other tables of this series, the proportions of nitrogen as nitrates, contained in the water of the Illinois river at Kampsville during the years 1897 to 1902 inclusive. There are given also the general averages for the three year period prior to the opening of the Chicago main drainage channel ,and for the three year period subsequent thereto. The relation of these general averages is such as to show an increase in the proportions of nitrogen as nitrates subsequent to the opening of the Chicago main drainage channel of 15 two-thirds per cent.

Table No. 6 is as follows:

8979 PROPORTIONS OF NITROGEN AS NITRATES IN THE WATER OF THE ILLINOIS RIVER, KAMPSVILLE MONTHLY AVERAGES.

	1897	1898	1899	1900	1901	1902
Jan.	2.6	1.033	.47	2.02	1.398	1.183
Feb.	2.5	1.8625	1.35	1.854	.90	.675
Mar.	2.28	1.52	.975	1.32	1.048	1.628
Apr.	2.225	1.0166	1.438	1.54	2.048	1.673
May	1.4	.71	.77	1.19	.767	1.398
June	1.19	.4166	1.35	1.49	.799	1.433
July	.9166	.212	.97	1.37	1.146	.7003
Aug.	1.225	.29	.76	1.032	1.135	.63325
Sept.	.53	.3375	.52	.98	1.155	.647
Oct.	.463	.5375	.69	1.42	1.258	.926
Nov.	1.46	.9	1.4	1.518	1.534	.946
Dec.	1.85	.2875	1.546	1.713	1.151	1.4215
Year	1.553	.7638	.988	1.436	1.202	1.189
		1.103			1.270	

1.270
1.103
———
..173=15 2-3% increase.

8980 Table No. 7 represents the monthly averages of proportions of suspended albuminoid ammonia, that is albuminoid ammonia derived from suspended matters contained in the waters of the Illinois river at Kampsville for the years 1897, 1898 and 1899,and for the years 1900, 1901 and 1902.

The table is as follows:

	1897	1898	1899	1900	1901	1902
January	.349	.4	.28	.26	.256	.244
February,	.244	.31	.266	.272	.24	.224
March,	.214	.32	.304	.2	.296	.246
April,	.209	.32	.294	.208	.22	.26
May,	.288	.344	.251	.232	.245	.216
June,	.36	.253	.264	.216	.234	.28
July,	.345	.275	.216	.176	.223	.277
August,	.296	.274	.181	.179	.224	.224
September,	.363	.23	.264	.208	.169	.192
October,	.36	.196	.268	.164	.179	.203
November,	.292	.206	.267	.212	.16	.186
December	.35	.238	.234	.2	.188	.192
For the year	.3032	.2781	.257	.208	.215	.23

The general average for the three year period before the opening of the main drainage channel is .2794, and for the
three year period subsequent thereto, was .2265, showing
8981 a decrease in the proportions of nitrogen as albuminoid
ammonia derived from suspended matters, of 19 per cent.

Q. Profesor, are the quantities of organic matters in the Chicago sewage discharged into the Desplaines river less or greater since the opening of the Chicago drainage canal than prior thereto.

MR. JEFFRIES: I object to the question for the reason that the witness is not a sanitarian; he has not shown in evidence that he has ever examined the chemical constituents in sewage of any city, or is acquainted with the situation at Chicago either prior to or subsequent to the opening of the drainage canal, or that embodied in the extent of the sewage discharged into the river, or the condition of that sewage.

JUDGE SPRINGER: I submit that a sanitarian would be poorly equipped for his business unless he had taken lessons from a chemist such as Professor Palmer; that the persons who instruct sanitarians ought to be able to know what sanitation is.

MR. JEFFRIES: I suggest in answer to counsel's statement that before the evidence of the existence of the stream can be submitted, that the source must first be established or ascertained.

JUDGE SPRINGER: Proceed, professor.

A. What is the question please?

Q. (Question read).

8982 MR. JEFFRIES: I object to the question for the further reason that it is indefinite.

JUDGE SPRINGER: Perhaps the answer will be a little more definite than the question. It is not intended that the question should suggest all that the witness should state in reference to it.

MR. JEFFRIES: I object to the witness stating anything that will not be responsive to it.

JUDGE SPRINGER: Proceed.

A. They are greater since the opening of the Chicago main drainage channel than they were prior to that opening.

Q. Have you any data bearing upon that point?

A. I have.

Q. Will you produce the data please?

A. I will.

Q. What data have you bearing upon that subject?

A. My data touching this question bears reference chiefly to the quantities of nitrogen in the form of free ammonia and nitrogen held in organic combination, and determined by the Kjel Dahl process, in the waters of the Illinois and Michigan Canal at Lockport, for the years 1896 to 1902 inclusive, and for the waters of the Chicago main drainage channel for the years 1900 and 1901.

8983 The analytical data of defendants' table of Averages No. 1, heretofore introduced in evidence, show that the average proportion of nitrogen as free ammonia in the waters of the Illinois and Michigan canal at Lockport for the four years 1896 to 1899 inclusive, was 13.5 parts per million, and the total organic nitrogen determined by the Kjel Dahl process was 5.3 parts per million.

The average volume pumped into the canal, which was 36,000 cubic feet per minute during these four years, amounts to 1,623,000 tons of water or sewage every 24 hours, which gives us the factor 1.623 for calculating the total weight of nitrogen carried in the canal.

Q. Which canal was this?

A. The Illinois and Michigan canal at Lockport.

We thus find that the discharge of nitrogen as ammonia, that is 13.5 times 1.623 was 21.9 tons per day, that is per 24 hours, and the total organic nitrogen, 5.3 times 1.623, equal to 8.6 tons of total organic nitrogen per day, the sum being 30.5 tons of total nitrogen, that is nitrogen in the form of free ammonia, and nitrogen in organic combination as determined by the Kjel Dahl process. .

I have left out of account the very minute quantities of nitrogen as nitrates for the reason that these are forms of nitrogen in combination with oxygen and hence not regarded
8984 as so nearly allied to organic substances as is the nitrogen as free or saline ammonia. The 8.6 tons of total organic nitrogen represents 53.75 tons of protein or nitrogenous organic matters, and the 21.9 tons of nitrogen as free ammonia if presumed to have been originally in the form of protein or albuminoid matters, would represent 136.9 tons of nitrogenous organic matters. Upon this basis the total quantities of nitrogenous organic matters discharged through the Illinois and Michigan canal, before the opening of the Chicago main drainage channel would amount to 190.7 tons per 24 hours.

It is probable that the population contributing to the sewage which flows into the Chicago river, and was transferred from the Chicago river to the Illinois and Michigan canal during the period in question, excreted 34 tons of urea per 24 hours, corresponding to 15.7 tons of nitrogen, and that the major part of the 21.9 tons of nitrogen as free ammonia contained in the water of the Illinois and Michigan Canal was derived from this source, and not from the more complex nitrogenous organic matters or proteid bodies. The quantities of organic matters contained in the waters of the canal however, were undoubtedly far less than the total quantities of these matters discharged into the river by the proportion of the population considered, the difference being in very large measure, due to the putrefica-
8985 tive changes which begin in the sewers and proceed actively in the river. The changes which formerly oc-

curred in the waters of the Chicago river were similar in most respects to those which take place in the so-called septic tanks, and which serve to destroy much of the organic matter, some of it being converted into comparatively inoffensive sludge, and another portion into gaseous substances which partly escape into the air, some of them characterized by disagreeable odors, but others, as free ammonia, carbon dioxide, nitrogen, hydrogen, and so on, being comparatively inoffensive. The fact that ordinarily there was but very slight difference between the quantities of these matters contained in the water of the canal at Lockport, and the quantities contained at Bridgeport, which has been shown by the comparative analyses of samples collected at these two different points, one at the beginning of the Illinois and Michigan canal at Bridgeport in Chicago; the other at Lockport, the point now under consideration, would appear to indicate that the putrefactive or septic changes which went on in the river proceeded approximately as far as under these conditions it was possible that they should go, and that the matters remaining in the waters of the canal were in a proper condition for the speedy reception of those changes which 8986 mark the next step in the oxidation of the nitrogenous organic matters and their transformation into inocuous products, that is to say, putrefactive changes appear to have approached completion and the conditions become such that no further changes took place, revealed within the canal itself; but the next succeeding step in oxidation and putrefication was facilitated by dilution, of the sewage, and also by introduction of bacterial forms of a different character, derived from or contained in the diluting waters of streams tributary to the Desplaines and the Illinois, or in the waters of the upper Desplaines when these waters were sufficient in volume to have marked diluting effect upon the concentrated, but ripened sewage discharged from the canal into the Desplaines river at Lockport in the main, but in particular at Joliet, three to four miles below.

Since the opening of the sanitary canal of Chicago,—or the main drainage channel, the larger part of Chicago sewage experiences its initial dilution in the Chicago river and passes through the main drainage channel in which the mean daily flow for 1900 was 188,340; for 1901, was 241,323, and for 1902 was 257,006 cubic feet per minute.

The volume of sewage pumped into the Illinois and Michigan Canal which is now intended to subserve purposes of 8987 navigation only, or for purposes of navigation and to supply hydraulic power to the Norton mills at Lockport, was reduced from the former average of 36,000 cubic feet per minute, to 26,700 cubic feet per minute in the year 1900, and to about 23,000 cubic feet per minute during the seven months, May to November, inclusive, in the year 1901; the pumps at Bridgeport standing inoperative during the other months of the year 1901,—the daily and weekly variations in flow of the Illinois and Michigan canal and of the Chicago main drainage channel, as also the daily flow of the upper Desplaines river, measured at Riverside, are shown in plates which have been introduced in evidence.

Throughout 1900 and during such part of 1901 as the pumps were in operation, the Illinois and Michigan canal discharged from 40 to 45 per cent of the nitrogen contained in that part of Chicago's sewage which is conveyed into the Desplaines river, and thence into the Illinois river; the other 55 to 60 per cent during this period passing through the main drainage channel.

That the disposition, that is, the destruction of the organic matters of the sewage by the natural proceses which are in operation in the waters of the sanitary canal, the Des- 8988 plaines river and the Illinois river, are facilitated by the increased dilution affected by the operation of the Chicago main drainage channel, has been demonstrated by the investigation of the waters of the Illinois river at Averyville and Kampsville as heretofore testified to by me.

The data in the following tables have been calculated from the average daily flows for each month, in each canal, and the monthly averages of the analytical data.

Q. Will you put those tables in evidence at this time?

A. Yes sir.

These tables are known as Quantities of nitrogen as free ammonia, and total organic nitrogen, in the Chicago sewage discharged into the Desplaines river, being numbered 1, 2 and 3, and I will put them in as we reach them.

Q. Now professor, will you please explain these three
8989 tables?

MR. JEFFRIES: I object to the introduction of the tables in evidence, or to their being read in evidence, for the reason that the defendants have not as yet shown the average flow of the Illinois and Michigan Canal in 1896 and 1899 or the mean flow, or even shown in evidence the daily flow, weekly or monthly flows of said canal, facts which are material to the proper interpretation of the tables and essential for the purposes of forming a basis for the introduction of this character of testimony, and for the further reason that the tables do not disclose the maximum and minimum flows of the water throughout said canal during the time mentioned in the tables.

JUDGE SPRINGER: The witness may produce as he proceeds, such data as he has, from which these tables have been prepared, and I desire to suggest that a portion of this information has already been put in in the plates heretofore read in evidence.

MR. JEFFRIES: And were put in subject to my objection that there was no evidence disclosed by the plates and charts to show that they were accurate.

JUDGE SPRINGER: You may proceed and produce such of that data as you have, in your explanation of these
8990 tables?

A. Concerning the flow in the Illinois and Michigan canal during the four years prior to the opening of the Chicago main drainage channel there is no detailed evidence, but the engineers of the Chicago Sanitary District and the engineer to the State Board of Health and others who have studied the question, have given as the mean daily flow, during these years, the volume of 36,000 cubic feet per minute. For the year 1900 the flow has been computed by the engineers of the Sanitary District of Chicago, and are printed in the report of streams examinations, which has been discussed in the conduct of the case now being tried.

From the data contained in that publication which has been furnished to me in duplicate by the engineers of the Board, I have computed the monthly average or the mean daily flow for each month in the year 1900, and these are as follows:

January,	35,156	cubic feet per minute,
February,	38,104	do.
March,	37,326	do.
April,	31,921	do.
May,	28,740	do.
June,	23,188	do.
July,	25,616	do.
August,	23,730	do.
8991 September,	25,977	do.
October,	24,060	do.
November,	22,521	do.
December,	13,778	do.

The mean for the year being 26,768 cubic feet per minute.

From these I have calculated the flow in tons, and give data in units of one million tons per 24 hours. These data are as follows:

January, 1.582, which signifies that there were 1,582,000 tons of sewage, or water pumped into the Illinois and Michigan Canal at Bridgeport, on the average for each 24 hours during the month of January, 1900.

February,	1.71468
March,	1.68
April,	1.4364
May,	1.2933
June,	1.0345
July,	1.1527
August,	1.06785
September,	1.168
October,	1.0827
November,	1.013445
December,	.62

8992 From these data as to the flow in weight of water, the unit is 1,000,000 tons of water or sewage or mixture per 24 hours.

ADJOURNED until 2:00 P. M. same day, Thursday, November 19th, 1903.

2:00 P. M., Thursday, November 19, 1903.

8993 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further direct-examination by Judge Springer and testified as follows:

Q. Will you proceed, professor, with the matter under consideration at the time of recess?

A. There was no flow in the Illinois and Michigan canal, that is the pumps at Bridgeport were not in operation until the end of April in the year 1901, and the amount pumped during the months of May, June, July, August, September, October and November are as follows:

May,	23,000	cubic feet per minute,
June,	23,000	do.
July,	23,000	do.
August,	23,300	do.
September,	24,000	do.
October,	24,500	do.
November,	20,100	do.

8994 December there was no pumping done; there was nothing discharged.

Calculated into tons per 24 hours and units of one million tons, these are, for

May,	1.035
June,	1.035
July,	1.035
August,	1.0485
September,	1.05
October,	1.1
November,	.9045

The average for the period of seven months being 1.034.

The flow in the drainage canal, that is the discharge at 8995 the Bear Trap Dam during the year 1901, the mean per 24 hours for each of the twelve months, was as follows:

Month.	Cubic feet per minute.	Tons per 24 hours in units of one million.
January,	295,000	13.27
February,	304,800	13.7
March,	317,700	14.3
April,	275,000	12.37
May,	190,000	8.55
June,	175,000	7.87
July,	180,000	8.1
August,	236,000	10.6
September,	234,000	10.53
October,	230,000	10.35
November,	234,000	10.53
December,	246,000	11.07
Mean for the year,	242,000	10.89

8996 The flow in the Chicago main drainage channel for the year 1900, that is the mean flow per 24 hours for each month and the tons of discharge in units per million, are as follows:

January,	179,682	8.08
February,	138,834	6.36
March,	125,935	5.66
April,	106,644	7.36
May,	161,400	7.46
June,	193,542	8.71
July,	203,447	9.155
August,	224,256	10.19
September,	138,417	6.21
October,	171,490	7.717
November,	228,775	10.3
December,	254,900	11.47

I haven't got the year's average stated here, but I have it somewhere else. I can easily supply that. We will not wait for it now.

Q. Professor, you will now proceed with the explanation of table 1 heretofore referred to and put in evidence?

8997 A. Table No. 1 shows the discharge of nitrogen as free ammonia from the Illinois and Michigan canal and the

Chicago main drainage channel, or sanitary canal, in tons per 24 hours, during each of the months of the year 1900, and the year 1901, the figures in the column opposite each month representing the mean discharge of nitrogen as free ammonia for each 24 hours throughout the month represented. There is shown also the mean discharge in tons per 24 hours for the year both from the Illinois and Michigan canal and from the sanitary canal or drainage channel, and the sum of these, which represents the total amount of nitrogen in the form of free ammonia contained in the sewage discharged by means of these two canals from Chicago or by Chicago into the Desplaines, and thence into the Illinois river, the mean flow in cubic feet per minute for the Illinois and Michigan canal for the year 1900 is stated at the bottom of the column designated "I. & M." The mean daily flow or discharge from the sanitary canal for the year is stated at the bottom of the column designated "Sanitary" for 1900, and is 188,340 cubic feet per minute.

The fourth column in this table contains the sum of the nitrogen as free ammonia discharged by the Illinois and Michigan canal and that discharged by the main drainage
8998 channel or sanitary canal.

The fifth column in this table contains the figures showing the quantities of nitrogen as free ammonia discharged by the Illinois and Michigan canal during the year 1900.

It will be noted that during the first four months nothing appears in this column for the reason that there was no discharge, the pumps at Bridgeport being left inactive during this time, and again during the month of December, the blank is present for the reason that there was no pumping and no discharge from this canal during the month of December, 1901.

The figures for the sixth column represent the quantities in tons per 24 hours of nitrogen as free ammonia discharged by the sanitary canal and in the 7th column there appears the sum of the nitrogen as free ammonia discharged by the Illinois and Michigan canal and by the sanitary canal for each month during the year 1901. The figures in this column representing the total discharge per 24 hours of nitrogen in the form of free or saline ammonia in the Chicago sewage sent through these two canals into the Desplaines and thence into

the Illinois river; the mean flow for the seven months of 1901 during which there was a discharge from the Illinois and Michigan canal, was 23,000 cubic feet per minute; the mean
8999 daily discharge from the sanitary canal during this year being 242,323 cubic feet per minute.

The average flow of the Illinois and Michigan canal during the years 1896 to 1899 is given as 36,000 cubic feet per minute. Upon this basis calculations from the figures representing the average content of nitrogen as free ammonia in the waters of the Illinois and Michigan Canal at Lockport during the years 1896 to 1899 inclusive, which appear in defendants' table of Averages No. 1 A. W. P., show that the average discharge of nitrogen as free ammonia in the Chicago sewage sent into the Desplaines river during the years 1896 to 1899 inclusive, was 21.9 tons per 24 hours and that during the year 1899 the year immediately preceding the opening of the Chicago drainage channel the quantity of nitrogen as saline or free ammonia thus discharged into the Desplaines river in Chicago sewage was 22.5 tons per 24 hours.

The nitrogen as free ammonia represented in the table, that is, for the discharge by the sanitary canal, .2 of one ton per 24 hours, was contained in the diluting lake water drawn through the Chicago river, and not in the sewage discharged into the Chicago river.

9000 Table No. 1 is as follows.

No. 1. A. W. P.

TABLE XXII.

QUANTITIES OF NITROGEN DISCHARGED INTO THE ILLINOIS RIVER IN CHICAGO SEWAGE. NITROGEN AS FREE AMMONIA DISCHARGED IN THE WATER OF THE ILLINOIS AND MICHIGAN CANAL AND THE SANITARY CANAL. TONS PER 24 HOURS.

	1900			1901		
	I. & M.	Sanitary	Sum.	I. & M.	Sanitary	Sum.
Jan.	17.8	25.87	43.67	——	26.54	26.54
Feb.	10.97	20.58	31.55	——	21.62	21.62
Mar.	16.7	15.3	32.	——	16.7	16.7
Apr.	17.94	8.	25.94	——	20.28	20.28
May	15.77	10.	25.77	16.1	10.67	26.77
June	19.71	12.7	32.41	15.9	11.08	26.98
July	11.43	13.5	24.93	15.7	16.2	31.9
Aug.	15.9	19.5	35.4	19.5	16.33	35.83
Sept.	25.1	8.7	33.8	21.9	18.09	39.99
Oct.	9.4	8.9	18.3	35.2	16.1	51.3
Nov.	11.6	11.5	23.1	14.75	14.11	28.86
Dec.	5.69	13.5	19.19	——	35.98	35.98
Year	14.83	14.	28.84	19.86	16.85	30.23
Mean Flow				7 months		
cu. ft. min.	26,768	188,340		23,000	242,323	

Average Illinois and Michigan Canal, 1896-9, 21.9. }
Average Illinois and Michigan Canal, 1899—22.5. } Mean flow 36,000 cu. ft. min.

Of the Nitrogen as free Ammonia above, .2 ton per 24 hours was contained in the diluting Lake water drawn through the Chicago river.

9001 Table No. 2 of this series, has like data with respect to the total organic nitrogen discharged in Chicago's sewage into the Desplaines and thence into the Illinois river. The data with respect to flows is not repeated here because it is the same as that given in my testimony concerning table No. 1.

In column No. 2 there are given the numbers of tons of nitrogen and organic combination as determined by the Kjel Dahl process contained in the waters discharged each 24 hours during the twelve months of the year 1900.

In the third column is given the number of tons per 24 hours discharged in the waters passing through the main drainage channel, and in the 4th column there is given the sum of the quantities represented in columns 2 and 3, which sum represents the number of tons of nitrogen in organic combination contained in all of the sewage of Chicago which is discharged into the Desplaines river and thence into the Illinois for each 24 hours in each of the months respectively.

In column 5 there is given like data for the Illinois and Michigan canal for the year 1901. Here again the blanks indicate the time when there was no discharge through this canal.

9002 In column 6, there is given similar data respecting the number of tons of total organic nitrogen per 24 hours discharged through the main drainage channel or sanitary canal; and in the 7th column of this table there is shown the sum of the quantities stated in tons, of total organic nitrogen discharged in the Chicago sewage by means of the Illinois and Michigan canal and the main drainage channel, into the Desplaines and thence into the Illinois.

For comparison I have placed at the bottom of the table a statement representing the average for the Illinois and Michigan canal for the years 1896 to 1899 inclusive, the analytical data coming from table No. 1, Defendants Averages and the flow being that stated in table No. 1, or rather the flows per month being those given in my testimony heretofore.

The average for the Illinois and Michigan canal during the four years period above referred to was 8.6 tons of total organic nitrogen per 24 hours throughout the year, or the average for the four years. During the year 1899 the average was slightly greater than this, namely, 9 tons per 24 hours.

Now of the total organic nitrogen represented in the table above, it is to be noted that two tons per 24 hours are derived from the lake water, which is drawn in through the Illi-
9003 nois river, and consequently does not originally constitute part of the organic matter of the sewage discharged directly into the Chicago river.

9004 Table No. 2 is as follows:

No. 2. A. W. P.

TABLE XXIII.

QUANTITIES OF NITROGEN DISCHARGED INTO THE ILLINOIS RIVER IN CHICAGO SEWAGE. TOTAL ORGANIC NITROGEN DISCHARGED IN THE WATERS OF THE ILLINOIS AND MICHIGAN CANAL AND THE SANITARY CANAL. TONS PER 24 HOURS.

	1900			1901		
	I. & M.	Sanitary	Sum.	I. & M.	Sanitary	Sum.
Jan.	9.12	7.37	16.49	——	12.52	12.52
Feb.	7.13	5.48	12.61	——	20.71	20.71
Mar.	8.77	5.71	14.48	——	27.91	27.91
Apr.	6.26	6.54	12.8	——	8.9	8.9
May	3.52	6.98	10.5	2.85	6.7	9.55
June	3.2	6.75	9.95	2.25	7.93	9.18
July	1.85	7.38	9.23	1.65	7.39	9.04
Aug.	2.82	10.67	13.49	2.56	8.99	11.55
Sept.	3.94	5.97	9.91	2.11	7.92	10.08
Oct.	3.09	6.09	9.18	2.26	7.79	10.05
Nov.	3.72	10.17	13.89	2.26	7.79	10.05
Dec.	2.85	11.67	14.53	——	17.51	17.51
Year	4.69	7.56	12.25	2.26	11.84	13.08

Average, Illinois and Michigan Canal, 1896-9—8.6.

Average, Illinois and Michigan Canal, 1899—9.

Of the total organic nitrogen above, 2. tons per 24 hours were contained in the diluting Lake water drawn through the Chicago River.

9005 Table No. 3 of this series represents the total nitrogen,—that is the nitrogen in the form of free or saline ammonia, and the total organic nitrogen, since nitrogen in other forms is not present in any considerable quantity ordinarily in these waters, and consequently such other forms have been excluded from this table for reasons which I have already stated in my testimony concerning these particular tables.

Column No. 1 in this table gives the list of months, column No. 2 representing free ammonia. The figures in the columns represent the sum of the free ammonias which appear in table No. 1 under the year 1900.

Column No. 3 contains the figures which appear in column No. 4 of table No. 2, which represents the sum of the total organic nitrogen discharged by the two canals per 24 hours during the year 1900.

Column No. 4 of table No. 3 contains the sum of the quantities of the free ammonias represented in column No. 2 of this table, and the quantities of total organic nitrogen recorded in column No. 3 of this table.

Column No. 5 of table No. 3 contains the figures brought over from the last column in table No. 1, which represent the discharge in tons per 24 hours of nitrogen as free am-
9006 monia conveyed by the two canals into the Desplaines river and thence into the Illinois.

Column No. 6 contains the figures representing the mean daily discharge in tons of total organic nitrogen conveyed by the two canals into the Desplaines river and thence into the Illinois, and is brought over from the last column in table 2.

Column No. 7 of table No. 3, has the figures which represent the sum of the two next preceding columns, which figures give in tons per 24 hours the quantities of total nitrogen, that is nitrogen as free ammonia, and total organic nitrogen determined by the Kjel Dahl process, discharged by the two canals; consequently all that discharged in Chicago sewage through these two canals into the Desplaines and thence into the Illinois.

The average discharge of nitrogen in the form of free ammonia, plus that in the form of the total organic nitrogen by the Illinois and Michigan canal for the four years, 1896 to 1899 inclusive, was 30.5 tons per 24 hours. The average for the year 1899 being 31.6 tons per 24 hours. Of this total nitrogen 2.2 tons per 24 hours came in the diluting water drawn through the Chicago river directly from the lake. Subtracting this from the totals above given, we find that the average
9007 quantity of nitrogen in the form of free or saline ammonia and that designated as total organic nitrogen discharged in Chicago sewage by the two canals, that is the main drainage channel and the Illinois and Michigan canal, into the Desplaines and thence into the Illinois river, was 40 tons per 24 hours, the mean for the two years, 1900 and 1901 or 31.1 per cent more than the average for the four preceding years, and 26.5 per cent more than was discharged by the Illinois and Michigan canal in the year 1899. The increase in the quantities of nitrogen discharged into the Desplaines river through the two canals at Lockport and Joliet is in part doubt-

less due to the increase in population and industries contributing to Chicago's sewage, and in part it is due to the fact that a considerable proportion of the contents of the Chicago river was formerly, from time to time discharged into the lake, but is now through the operation of the drainage channel, sent into the Desplaines and thence into the Illinois.

Table No. 3 is as follows:

9008

No. 3 A. W. P.

TABLE XXIV.

QUANTITIES OF NITROGEN DISCHARGED INTO THE ILLINOIS RIVER IN CHICAGO SEWAGE.
TOTAL NITROGEN: I. e. SUM OF THE NITROGEN AS FREE AMMONIA
AND THE TOTAL ORGANIC NITROGEN DISCHARGED BY THE TWO
CANALS. TONS PER 24 HOURS.

	1900			1901		
	Free Ammonia	Total Organic Nitrogen	Total Nitrogen Sum.	Free Ammonia	Total Organic Nitrogen	Total Nitrogen Sum,
Jan.	43.67	16.49	60.16	26.54	12.52	39.06
Feb.	31.55	12.61	44.16	21.62	20.71	42.33
Mar.	32.	14.48	46.48	16.7	27.91	44.61
Apr.	25.94	12.8	38.74	20.28	8.9	29.18
May	25.77	10.5	36.27	26.77	9.55	36.32
June	32.41	9.95	42.36	26.98	9.18	36.16
July	24.93	9.23	34.16	31.9	9.04	40.94
Aug.	35.4	13.49	48.89	35.83	11.55	47.38
Sept.	33.8	9.91	43.71	39.99	10.03	50.02
Oct.	18.3	9.18	27.48	51.3	10.05	61.35
Nov.	23.1	13.89	36.99	28.86	10.05	38.91
Dec.	19.19	14.53	33.72	35.98	17.51	53.49
Year.	28.84	12.25	41.09	30.23	13.08	43.31

Average, Illinois and Michigan Canal 1896-9—30.5.

Average, Illinois and Michigan Canal, 1899—31.6.

Of the total Nitrogen above, 2.2 tons were contained in the diluting Lake water drawn through the Chicago river.

$\frac{(41.09+43.31)-4.4}{2} = 40.$ tons, the average quantity discharged into the Desplaines and thence into the Illinois river, or 31.1 per cent more than the average for the four preceding years and 26.5 per cent more than in 1899.

9009 Q. Professor, have you any data which show the quantities of organic matters in the Illinois river near its mouth prior to the opening of the Chicago drainage canal and since that time?

A. I have.

Q. Will you please present that data at this time and state in what shape you have prepared the data?

A. I have the data in tables similar to those which we have just been discussing, and which refer to the Illinois and Michigan canal and the Chicago main drainage channel, or sanitary canal, and in addition I have some plates upon which there are lines drawn which show graphically the relative proportions at the different seasons of the year, and at different points along the streams in question.

JUDGE SPRINGER: These will be numbered as the explanation is proceeded with and will be inserted into the record at the time of the explanation. I offer these tables in evidence, to be incorporated in the testimony at the places at which the explanations will be made. The tables will be numbered 4, 5, 6, 7, 8 and 9.

MR. JEFFRIES: I object to the introduction or reading in evidence of tables 4, 5, 6, 7, and move to strike out table 2, which has just previously been read in evidence, for the 9010 reason that it does not correctly disclose the amount or extent of the sewage discharges by comparison or otherwise, from the city of Chicago into the drainage canal and thence into the Illinois river, nor does it disclose by comparison or otherwise the extent and amount of pollution and infection in the Illinois river at Kampsville, in that the chemical constituents used in the table do not reveal all of the chemical constituents and substances contained in the sewage of Chicago and in the polluted and infected matter contained in the Illinois river at Kampsville.

Table 2 undertakes to disclose the total tonnage per 24 hours, of organic nitrogen which passed through the Illinois and Michigan canal and the sanitary canal in 1900 and 1901, when in fact the sewage and total solids of the sewage at that time was not in that state which would enable any correct or reliable determinations therefrom.

And I move to strike out tables 4, 5, 6, and 7 for the additional reason that they refer to the tonnage of organic nitrogen,

nitrates and nitrites, and nitrogen as albuminoid ammonia when, as above stated, these constituents are not correctly represented and from them no reliable conclusions can be drawn as to the amount and extent of the polluted and infected material in the water of the Illinois river at Kampsville
9011 during the period covered by the tables, and for the further reason that the tables which have been read in evidence by this witness disclose that there are yet large quantities of free ammonia and other chemical constituents that have not been reduced to nitrates or nitrites, and are not contained in these tables, so that no comparison and no conclusions as to the extent and volume of polluted and infected material at Kampsville is disclosed by the table in question.

And I object to the tables being read or introduced in evidence for the further reason that as tables of averages they fail to disclose conditions, of more than ordinary consequence, which are correct determinations of the issues in this case, and for the further reason that they fail to disclose both the minimum and the maximum conditions with reference to the subject matter treated.

JUDGE SPRINGER: Counsel for defendants suggest that these objections are argumentative and go merely to the weight of the evidence and not to its admissibility or competency. As an argument, counsel assumes to draw conclusions which only a sanitary expert can submit, and counsel has not qualified as such. The objection as to the failure of these tables to disclose minimum and maximum constituents—those have already appeared in the previous tables as will be explained hereafter.

9012 MR. JEFFRIES: In addition to what has been stated in my objection and in reply to Judge Springer's statement, I suggest to the Court that the objection is not argumentative but may be based as well upon the statement of witness now on the stand and the admission of counsel for the defense, to the effect that the nitrogen ascertainments and the ascertainments of the nitrogenous matter in water is so unreliable in regard to the ascertainment of the mixture of the waters, that it could not be used in that connection, and if unreliable for that purpose, it must also be unreliable for the purpose of determining the extent or amount of polluted or infected material in the water at any given point.

JUDGE SPRINGER: Counsel's objections are still argumentative and comment upon testimony heretofore submitted, giving his conclusion as to the effect of such testimony; but I submit that the testimony is in the record and speaks for itself and it will be considered at the proper time.

Q. Professor, did you prepare any graphic plates in connection with these data?

A. I did.

Q. And in explanation thereof?

A. I have done so.

Q. As you proceed with your explanation of these tables, you may present those graphic plates and at the time of 9013 their presentation I will offer them in evidence, that they may be incorporated in the evidence at the place where the explanation occurs.

MR. JEFFRIES: I object to the witness introducing any evidence of graphic plates, or testifying therefrom, which graphic plates are based upon the tables just offered in evidence, for the same reasons stated in my objection to the introduction and reading in evidence of the tables themselves.

JUDGE SPRINGER: You may now proceed, professor, with the explanation of the tables and also the graphic plates, when you reach them, and make such explanation of them as you desire to submit.

A. These tables numbered 4, 5, 6, 7, 8, and 9 of this series give the mean daily discharge of nitrogen in the form of free or saline ammonia, in the form of albuminoid ammonia, the total organic nitrogen and nitrogen as nitrites, and the nitrogen as nitrates, in the waters of the Illinois river discharged over the Kampsville dam for the years 1897 to 1902 inclusive, and also show the average discharge per 24 hours for the first six months and the second six months in each year referred to, and the average discharge for the entire year. Also the average discharge for the period of three years prior to 1900, 9014 and the average daily discharge for the three year period 1900, 1901 and 1902, inclusive, thus covering the three year period immediately preceding the opening of the

Chicago main drainage channel and the three year period immediately subsequent thereto.

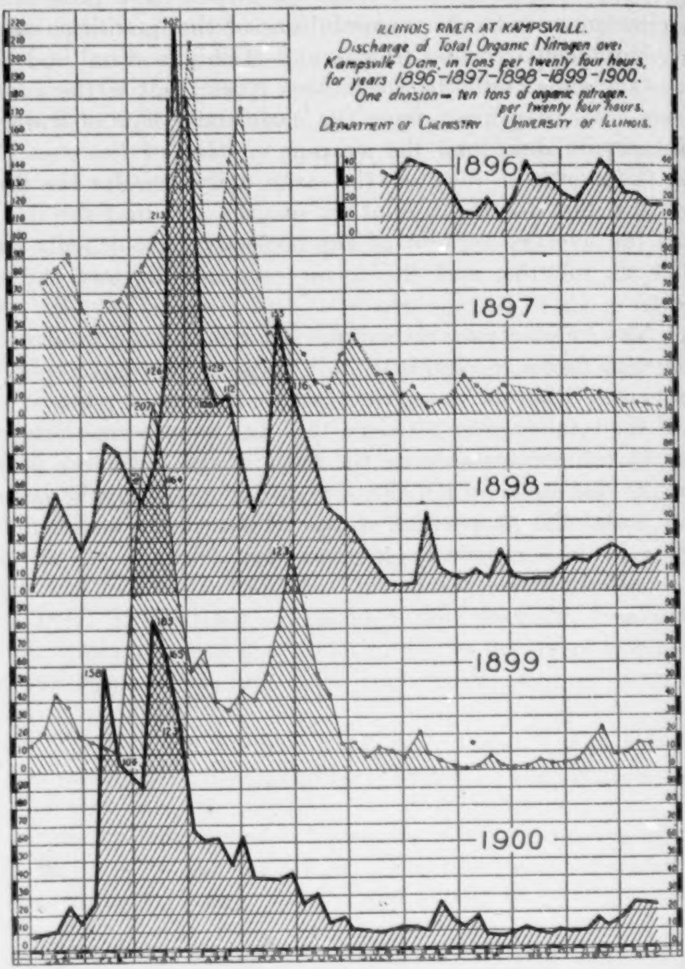
The computations of these quantities have been made in similar manner to the computations of the quantities of nitrogen discharged by the Illinois and Michigan canal and by the sanitary canal into the Desplaines river; that is the computations have been made from the mean daily flow of water over Kampsville dam, and the average content of the constituents for the month in question, the mean daily flow for the first six months, that for the second six months and that for the year, and the average content of the respective constituents for the first six months, and the second six months and the entire year.

The calculations respecting the quantities of nitrogen in different forms of combination in these waters have been made in several different ways, those which appear in plate 41 represent the total organic nitrogen that has been in tons discharged per 24 hours calculated on the basis of the discharge of water for the day upon which the sample for analyses was collected, and the proportion of the total organic nitrogen found
9015 in the sample collected that day.

Plate 41 is as follows:

9016

No. 41.—A. W. P.



9017 The lines of this plate show how considerable were the seasonal variations in the weights of organic nitrogen discharged over the dam at this point during the years 1896 to 1900 inclusive, only the last five months in 1896 being considered because our examinations of the water of the Illinois river at Kampsville began in the latter part of July of that year.

Comparison of these curves with each other shows that during the year 1900, that is, the first year after the opening of the Chicago main drainage channel, the weights of organic nitrogen carried by the water of the Illinois river over the dam at Kampsville, just as they are about to discharge into the Mississippi at Grafton, thirty miles below, were generally less than they were during the preceding years, during both the high water period and the low water period, except that in 1899, during the period ranging from the middle of August to the middle of November, when the flow in the river was extremely low, the quantities of organic nitrogen carried were less than in 1900.

Calculations based upon monthly averages both for the data of the analyses and for the flow of the river show similar but of course less irregular variations throughout the years.

Table No. 4 of this series is as follows:

A. W. P. NO. 4.

9018 TOTAL ORGANIC NITROGEN.

QUANTITIES OF NITROGEN IN THE WATERS OF THE ILLINOIS RIVER AT KAMPSVILLE. TONS DISCHARGED PER 24 HOURS. From monthly averages, average for 1st 6 months; average for 2nd 6 months and yearly averages of flows and constituents. Tons of T. O. N. per 24 hours.

	1897	1898	1899	1900	1901	1902
Jan.	79.47	36.74	27.49	15.9	30.4	10.
Feb.	60.44	54.53	23.28	93.5	21.5	6.6
Mar.	106.51	119.27	143.9	142.1	93.4	38.
Apr.	127.3	131.97	49.39	58.94	79.4	49.
May	91.96	83.94	60.7	47.08	39.25	30.5
June	27.56	67.2	54.2	22.17	17.	44.1
July	31.	18.24	11.43	9.91	9.66	94.1
Aug	11.43	15.12	9.95	15.68	5.99	92.4
Sept.	16.29	12.86	3.14	10.	5.51	34.
Oct.	12.04	8.5	3.4	9.45	5.5	39.1
Nov.	12.08	20.24	10.	12.75	9.	30.5
Dec.	4.91	18.93	14.6	22.02	7.43	46.0
1st 6 mo.	82.2	82.27	59.82	63.28	46.82	29.7
2nd 6 mo.	14.62	15.64	8.75	13.3	7.18	56.1
Year.	48.41	48.95	34.28	38.29	27.	42.9

est.

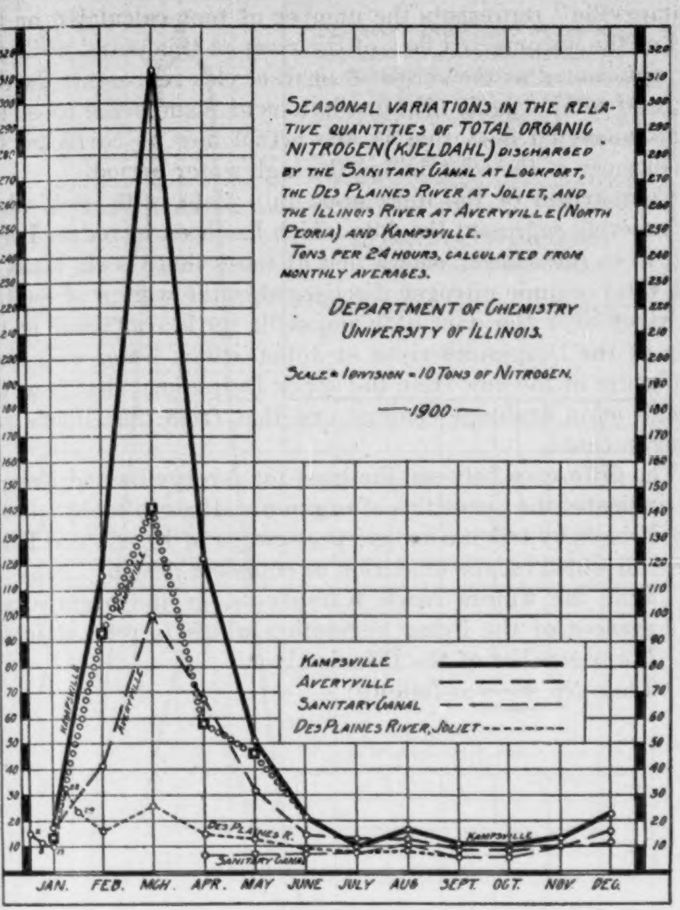
For 1902 calc. from Alb. N. on basis of latter—40% of T. O. N.

9019 Table No. 4 records the discharges of total organic nitrogen in tons in the waters of the Illinois river for each 24 hours of each month during the years 1897 to 1901 inclusive, and for 1902 the data for the last three months in 1901, and for the entire year 1902, having been computed from the tons of nitrogen as albuminoid ammonia discharged on the basis of the latter constituting 40 per cent of the total organic nitrogen.

The figures of this table representing the mean daily discharge of total organic nitrogen for the year 1900 have been represented upon plate No. 42, of this series, together with similar lines referring to the quantities carried by the waters of these streams at certain other points during the same period.

Plate No. 42 is as follows:

No. 42.—A. W. P.


SEASONAL VARIATIONS IN THE RELATIVE QUANTITIES OF TOTAL ORGANIC NITROGEN (KJELDAHL) DISCHARGED BY THE SANITARY CANAL AT LOCKPORT, THE DES PLAINES RIVER AT JOLIET, AND THE ILLINOIS RIVER AT AVERYVILLE (NORTH PEORIA) AND KAMPSVILLE.
TONS PER 24 HOURS, CALCULATED FROM MONTHLY AVERAGES.
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS.
SCALE = 1 DIVISION = 10 TONS OF NITROGEN.
—1900—
KAMPSVILLE
AVERYVILLE
SANITARY CANAL
DES PLAINES RIVER, JOLIET
KAMPSVILLE
AVERYVILLE
SANITARY CANAL
DES PLAINES R.
KAMPSVILLE
JAN.
FEB.
MCH.
APR.
MAY
JUNE
JULY
AUG
SEPT.
OCT.
NOV.
DEC.
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
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310
320

9021 Upon Plate No. 42 there are two lines for Kampsville, for a portion of the year, the heavy continuous line labeled "Kampsville" represents the number of tons calculated on the basis of the uncorrected flow of the river at this point, while the line represented as the series of small circles represents the discharge of total organic nitrogen in tons at Kampsville based upon the corrected flow, that is, the actual flow as corrected for submergence of the wier during the high water period.

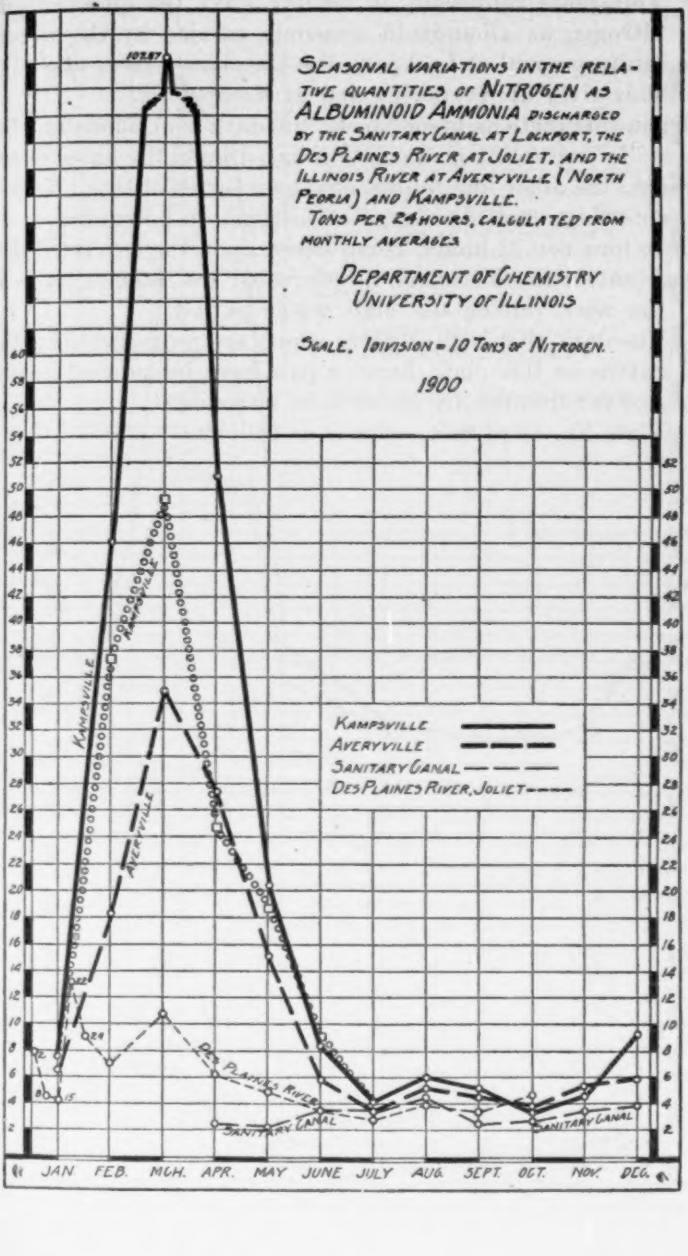
Comparison of the lines upon this plate, with each other, which merely represent the data which has been introduced or is about to be introduced, shows that at times there is six times as much total organic nitrogen discharged in the waters of the Illinois river over the dam at Kampsville as is contained in the water of the Desplaines river at Joliet, which latter comprizes the mixture of the flow from the upper Desplaines, that from the Chicago main drainage channel and that from the Illinois and Michigan canal.

The difference between the lines for Averyville and Kampsville, indicates the quantities of organic matters brought into the lower Illinois by tributaries and the sewage of Peoria and Pekin and so on which escape oxidation or complete destruction by the time the waters reach Kampsville, or the organic sub-
9022 stances of the living vegetation which is present in the lower reaches of the Illinois river.

Plate No. 43 is as follows:

9023

No. 43.—A. W. P.



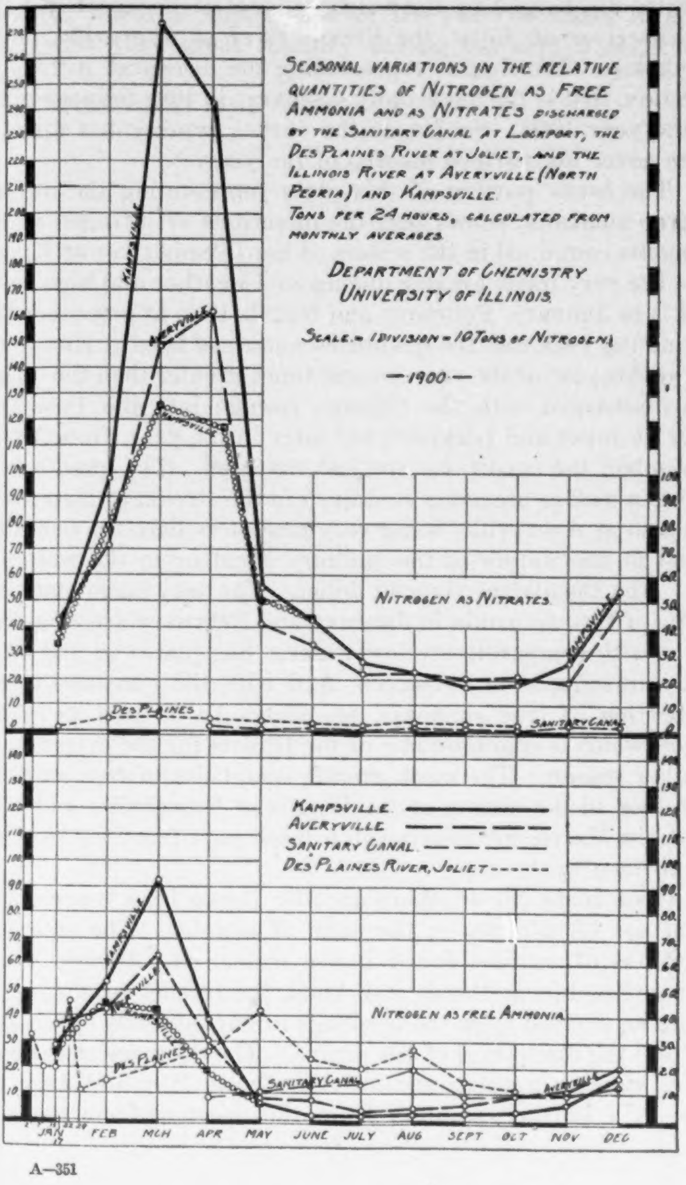
9024 This plate represents in similar ways the quantities of nitrogen as albuminoid ammonia carried by the waters of the sanitary canal at Lockport, the Desplaines river at Joliet, the Illinois river at Averyville and at Kampsville.

Upon this plate as upon No. 42, the dark continuous line for Kampsville represents a calculation based upon the uncorrected discharge; the other line represented as a series of small circles, represents the actual discharge of nitrogen as albuminoid ammonia in tons per 24 hours, being based upon the corrected discharge, that is the discharge as corrected for submergence of the wier, during the high water period.

9025 The data, that is the figures which are represented by the curves on this plate, have in part been introduced in evidence, and for the rest are about to be introduced.

Plate No. 44 of this series is as follows:

No. 44.—A. W. P.


SEASONAL VARIATIONS IN THE RELATIVE QUANTITIES OF NITROGEN AS FREE AMMONIA AND AS NITRATES DISCHARGED BY THE SANITARY CANAL AT LOCKPORT, THE DES PLAINES RIVER AT JOLIET, AND THE ILLINOIS RIVER AT AVERYVILLE (NORTH PEORIA) AND KAMPSVILLE.
TONS PER 24 HOURS, CALCULATED FROM MONTHLY AVERAGES.
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS.
SCALE.—1 DIVISION = 10 TONS OF NITROGEN.
—1900—
NITROGEN AS NITRATES
NITROGEN AS FREE AMMONIA
KAMPSVILLE
AVERYVILLE
SANITARY CANAL
DES PLAINES
KAMPSVILLE
AVERYVILLE
SANITARY CANAL
DES PLAINES RIVER, JOLIET
JAN
FEB
MCH
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

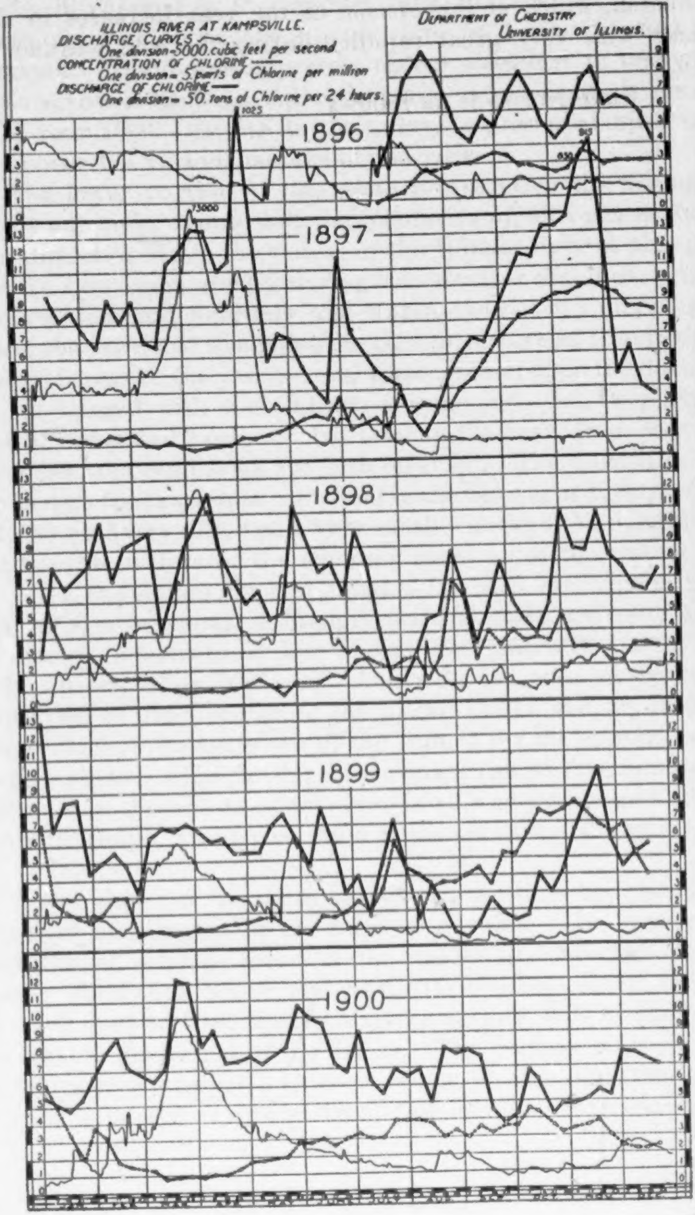
9027 It represents by means of curves, seasonal variations in the relative quantities of nitrogen as free ammonia and as nitrates discharged by the sanitary canal at Lockport, the Desplaines river at Joliet, the Illinois river at Averyville, and at Kankakee. The figures representing the discharge in tons per 24 hours, that is the mean daily discharge in tons for each month in the year 1900. So far as the curves represented upon the plate cover the various months of the year.

The lower portion of this plate representing the nitrogen as free ammonia, shows that the quantities of nitrogen as free ammonia contained in the waters of the Illinois river at Kampsville are very much greater during cold weather and high water, that is in January, February and March, than at any other time during the year, and the quantities contained here at Kampsville are at this part of the year several times greater than the quantities discharged with the Chicago sewage into the Desplaines river at Joliet and Lockport, but later in the year, from May to November, the conditions are just reversed. The quantities of nitrogen as free ammonia contained in the stream at Kampsville and also at Averyville, being very much less than the quantities found in the waters of the sanitary canal or in the waters of the Desplaines river at Joliet. The very large quantities
9028 of free ammonia in January and February are coincident with comparatively low water. See plates 18 and 19 already introduced in evidence. And with the excessively high proportion of free ammonia, see plates 10, 14 and 39 of this series, which is characteristic of the Illinois for the extreme cold weather season. The much greater quantities of free ammonia contained in the waters of the Illinois at Kampsville and other points in March, are derived in a large part from the rain and the surface wash.

Upon plate No. 44, there are also shown lines representing quantities of nitrogen in the form of nitrates. The enormous quantities of nitrates found in the water at Averyville and Kampsville during March and April, the freshet season, are in the main, derived from the leechings or surface soils by the run-offs and the discharges of tile drains. The decrease at the coming of warmer weather and lower water in May and June, results in a partial cessation from this leeching,from the partial oxidation of the supply of nitrates in the soil and from the assimilation of nitrates by the vegetation, especially that of the plankton, which at this season of the year increases in abundance with very great rapidity during the cold weather season.

Plate No. 45 is as follows:

No. 45.—A. W. P.


ILLINOIS RIVER AT KAMPSVILLE.
DISCHARGE CURVES
One division–5000. cubic feet per second
CONCENTRATION OF CHLORINE
One division = 5 parts of Chlorine per million
DISCHARGE OF CHLORINE
One division = 50. tons of Chlorine per 24 hours.
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS.
1025
1896
830
915
13000
1897
1898
1899
1900

9030 It represents by means of curves the flow of water over the Kampsville dam. stated in cubic feet per second. The proportions of chlorine,—and for the years 1896 to 1900 inclusive, also the proportions of chlorine contained in the various samples of water collected during these years, and the data of which are given in tables 1 to 80 inclusive heretofore offered in evidence, and the results of computations of the weights of chlorine carried by the water of the Illinois river at Kampsville as it is discharged over the Kampsville dam, the quantity stated in tons every 24 hours during the day the collection was made and for the mean flow of that day.

Table No. 5 of this series is as follows:

9031 QUANTITIES OF NITROGEN IN THE WATER OF THE ILLINOIS RIVER. TONS DISCHARGED PER 24 HOURS; Calculated from monthly averages of flow and constituents.

Albuminoid Nitrogen; Kampsville.

	1897	1898	1899	1900	1901	1902
Jan.	39.7	17.6	13.7	7.14	9.76	4.
Feb.	27.2	29.3	12.1	37.36	7.47	2.6
Mch.	44.6	59.6	62.6	49.4	39.24	15.2
Apr.	66.2	65.8	24.5	24.6	28.04	19.6
May	40.8	37.	23.3	18.8	15.42	12.2
June	12.7	22.3	19.	8.9	5.65	17.6
July	15.1	7.5	3.8	4.1	3.64	37.6
Aug.	5.4	6.6	3.4	5.9	2.75	36.9
Sept.	7.4	6.3	1.2	5.	1.96	13.6
Oct.	5.7	3.7	1.3	3.3	1.96	15.6
Nov.	6.	10.2	4.5	4.9	3.74	12.2
Dec.	2.4	8.3	6.7	9.3	3.25	18.6
1st 6 Mo.	38.5	38.7	25.8	24.36	17.59	11.8
2nd 6 Mo.	7.	7.1	3.48	5.4	2.88	22.4
Year	22.7	22.9	14.64	14.88	10.23	17.1
		20.08			14.07	

Decrease 30 per cent.

9032 It gives the discharge of nitrogen as albuminoid ammonia in the waters of the Illinois river passing over the Kampsville dam in tons per 24 hours, for each month of the years 1897 to 1903, inclusive, and gives also the average daily discharge during the first six months and during the second six months, and for the period, the three year period; also the average, that is, the period prior to the opening of the Chicago main drainage channel and the average for the three years subsequent to that opening, these averages being 20.08 tons per 24 hours, and 14.07 tons per 24 hours, respectively, showing a decrease in the weight or quantity of nitrogen as albuminoid ammonia discharged by the waters of the Illionis river at Kampsville in the second period of three years, that is, the period following the opening of the Chicago main drainage channel as compared with the three years prior thereto, which decrease amounts to 30 per cent. in weight.

The quantities representing the daily discharge of nitrogen as albuminoid ammonia for each month of the year 1900 appearing in this table, have been represented upon plate No. 43, which has just been in part discussed.

These figures and the quantities represented by them being calculated from the flow corrected for submergence of the wier, at Kampsville, and from the monthly averages of constituents, all of which have heretofore been introduced as evidence
9033 in my testimony.

Table No. 6 of this series is as follows:

9034

NO. 6.

TONS FREE AMMONIA.

	1897	1898	1899	1900	1901	1902
Jan.	15.3	39.3	28.6	27.	22.2	19.5
Feb.	23.8	42.5	16.6	42.8	23.7	18.4
Mar.	22.1	23.8	31.6	42.2	34.2	27.9
Apr.	8.5	6.6	15.3	18.2	10.5	4.7
May	8.4	4.9	6.5	6.5	3.87	3.8
June	2.4	1.5	2.3	1.5	1.73	2.8
July	2.4	.3	.62	1.67	1.3	10.1
Aug.	.44	2.27	.77	2.59	1.29	5.74
Sept.	5.1	.75	.89	2.27	1.53	3.45
Oct.	4.7	2.3	.93	2.98	1.14	2.94
Nov.	6.4	19.1	7.8	6.05	1.68	6.
Dec.	9.	14.2	8.4	16.67	12.16	9.8
1st 6 Mo.	13.4	19.76	16.8	23.	16.03	12.85
2nd 6 Mo.	4.67	6.5	3.57	5.37	3.18	6.34
Year	9.04	13.1	10.2	14.2	9.6	9.6
3 years	10.78			11.1		

9035 It gives similar data respecting the discharge of nitrogen as free ammonia or saline ammonia in the waters of the Illinois river passing over the Kampsville dam during the years 1897 to 1902, inclusive. It gives also the mean daily discharge for the first six months, second six months, and for the year, and the mean discharge for the entire three year period prior to the opening of the main drainage channel, and for the three year period immediately subsequent thereto, which averages are as follows:

For the three years prior to the opening of the Chicago main drainage channel 10.78 tons of nitrogen as free ammonia every 24 hours, and for the three year period, 1900 to 1902, subsequent to the opening of the Chicago main drainage channel, 11.1 tons of nitrogen as free ammonia every 24 hours, thus showing an increase in the quantity of nitrogen as free ammonia discharged by the waters of the Illinois river at this point in the second period over the quantity discharged during the first period, amounting to practically three per cent., the figure on this plate being 2.968 tons per 24 hours.

Table No. 7 of this series is as follows:

9036

QUANTITIES OF NITROGEN IN THE WATERS OF THE ILLINOIS RIVER AT KAMPSVILLE. TONS DISCHARGED PER 24 HOURS. FROM AVERAGE FOR 1st 6 MO., AVERAGE FOR 2nd 6 MO., AND YEARLY AVERAGE OF FLOWS AND CONSTITUENTS. NITRITES.

	1897	1898	1899	1900	1901	1902	Ave.	Ave.	
Jan.	2.4	2.78	.79	.71	.435	.23			
Feb.	2.55	2.83	.44	.89	.253	.15			
Mar.	4.89	2.45	1.85	1.26	.55	1.49			
Apr.	6.9	4.34	2.54	2.2	1.75	1.83			
May	5.	4.29	2.99	1.65	1.1	3.35			
June	4.58	6.14	2.33	2.04	.972	1.88			
July	3.72	2.1	1.41	1.	.871	5.53			
Aug.	1.36	1.64	.93	.7	1.06	3.66			
Sept.	1.09	1.66	.06	.87	.772	2.82			
Oct.	1.07	1.08	.11	.66	.567	1.63			
Nov.	.95	1.29	.64	.53	.57	.76			
Dec.	.4	.6	.43	.83	.377	.57			
1st 6 Mo.	4.38	3.8	1.82	1.45	.843	1.48	3.33	1.264.	62% Dec.
2nd 6 Mo.	1.43	1.39	.59	.76	.692	2.49	1.14	1.31.	15.6% Inc.
Year	2.9	2.59	1.2	1.1	.767	1.98			

2.23 1.282

Decrease 42.5 per cent.

Shift of high water period in 1902 to summer and fall.

9037 It represents the quantities of nitrogen as nitrites discharged into the waters of the Illinois river over the Kampsville dam for the period 1897 to 1902, inclusive. The discharges appearing as the average daily amont carried by these waters for each month of the year indicated respectively, the average daily amount in tons during the first six months, the average daily amount during the second six months and the average daily amount during the whole year, and also the averages for the three year period prior to the opening of the Chicago main drainage channel and the average for the three years subsequent thereto, the figures for these two periods being as follows:

For the first 2.23 tons per 24 hours,
For the second, 1.282 tons per 24 hours,

showing that subsequent to the opening of the Chicago main drainage channel the proportions of nitrogen as nitrites discharged by the waters of the Illinois river at Kampsville were 42½ per cent. less than they were during the three year period immediately prior thereto.

Inspection of the figures representing the data for the year 1902 in this plate, shows the shifting during this year of the high
nitrites period, consequent upon the shifting of the high
9038 water period as shown upon plates 19 and 18 heretofore
introduced in evidence, which plates show the discharges of water by the Illinois river at Kampsville for the years 1896 to 1902, inclusive, and show the fact that is given in detail in the tables of discharge which have been heretofore introduced in evidence, that while usually the high water period in the lower Illinois river comes in March and April, in the year 1902 the highest water of the year came in July and August, and for the last nine months of the year the water was throughout, unusually high, in fact, the discharge for the year 1902, was considerably higher than during any other year of this period, that is, of the years 1896 to 1902, inclusive.

Table No. 8 of this series is as follows:

9039 8. A. W. P.

QUANTITIES OF NITROGEN AS NITRATES IN THE WATERS OF THE ILLINOIS RIVER AT KAMPSVILLE. TONS DISCHARGED PER 24 HOURS. FROM 1st 6 MO.; 2nd 6 MO.; MONTHLY AND YEARLY AVERAGES OF CONSTITUENTS AND FLOWS.

	1897	1898	1899	1900	1901	1902
Jan.	149.	22.7	14.65	31.89	43.48	15.97
Feb.	142.	78.	30.82	79.16	27.8	6.68
Mar.	196.	106.6	62.91	125.4	52.46	60.56
Apr.	307.	126.2	72.06	116.98	170.9	73.95
May	110.	46.13	34.5	50.51	26.5	46.4
June	27.	26.92	58.4	43.58	14.38	59.9
July	25.6	4.08	12.05	26.9	16.11	82.2
Aug.	11.9	4.73	8.12	21.3	11.48	62.7
Sept.	7.74	5.64	1.78	17.	10.75	29.4
Oct.	6.76	7.4	2.72	18.3	10.65	44.7
Nov.	22.7	28.73	13.77	26.15	15.49	49.38
Dec.	9.66	7.46	17.72	54.5	11.17	71.92
1st 6 Mo.	139.19	73.06	43.52	78.54	46.94	40.37
2nd 6 Mo.	15.97	9.43	8.17	26.45	12.99	73.54
Year	68.	32.71	25.12	50.51	31.33	60.24

9040 It represents the discharge in tons per 24 hours of nitrogen as nitrates, contained in the waters of the Illinois river passing over the dam at Kampsville during the years 1897 to 1902, inclusive, and includes also the average daily discharge for the first six months, and the second six months, and the year.

The data of this table touching the year 1900, has been used in making the curve for this point shown upon plate No. 44 heretofore introduced in evidence .

Adjourned until 10:00 a. m., following day, Friday, November 20th, 1903.

9041 10:00 a. m., Friday, November 20, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further direct-examination, by Judge Springer, and testified as follows:

Q. Professor, at the time of adjournment yesterday we were considering table No. 8 of this series, and you had just referred to the data of this table touching the year 1900, and with reference to the curves shown upon plate 44 heretofore introduced in evidence. Will you proceed with the explanation of that table and the plate referred to?

A. Comparison of the data for the various years shows that during the year 1897 the quantities of nitrates discharged into the waters of the Illionis river at Kampsville, were very much greater throughout the year, that is, throughout the high water season, and also in general throughout the low water season, than they were in the years 1898 and 1899.

The proportions discharged during the years 1898 and 9042 1899, were on the average considerably less than during the years 1900 and 1901 and still more considerably less than during the year 1902, though in no one of the years subsequent to the opening of the Chicago main drainage channel were the quantities of nitrates in the water of the Illinois at Kampsville so great as they were during the year 1898.

It is notable that for the year 1902 the quantities of nitrates carried in the waters of the Illinois river at Kampsville were much greater during the latter part of the year than during the first two months, and that during what is ordinarily the low water season in the Illinois, that is, the last six months in the year, the nitrates at this point were present in very considerably greater quantities than during the similar periods of the five preceding years, which fact is in the main due to the high water which existed during this portion of the year 1902, an unusual condition as referred to in my testimony above.

The comparison of the monthly averages of the discharges of nitrogen as nitrates per 24 hours for the two points, Kampsville and Averyvile, shown in the upper part of plate No. 44

heretofore introduced in evidence, shows that during the high water season the discharge of nitrates at Kampsville was less than the discharge at Averyville, while in the latter part
9043 of the year, especially during the months of July, August, September and October, the quantities are approximately equal at the two points, in the latter part, that is, in the months of November and December, there being a somewhat greater quantity of nitrates discharged by the waters of the Illinois at Kampsville and at Averyvile.

Table No. 9 of this series is as follows:

9044

NO. 9.

QUANTITIES OF NITROGEN IN THE WATERS OF THE ILLINOIS RIVER AT KAMPSVILLE. TONS DISCHARGED PER 24 HOURS. FROM YEARLY AVERAGES OF FLOWS AND CONSTITUENTS.

Year	Nitrogen as nitrites.	Nitrogen as nitrates..	Nitrogen as free ammonia ..	Total organic..	Total nitrogen	Albuminoid	Oxygen consumed
1897	3.86	65.83	15.4	47.8	132.89	21.94	478.4
1898	2.97	32.71	16.01	43.91	95.6	20.79	503.7
1899	1.33	25.12	10.05	28.94	65.44	12.12	317.9
Aver.	2.7	41.22	13.82	40.22	97.93	18.28	433.3
1900	1.33	50.51	13.22	31.87	96.93	12.62	327.2
1901	1.12	31.33	9.62	23.	65.07	8.67	241.2
1902	1.996	60.24	20.95	43.1	126.18	17.24	504.
Aver.	1.479	47.36	14.6	32.65	96.06	12.84	357.5

9045 This table shows the discharge of nitrogen as nitrites, nitrates, free ammonia, the total organic and the total nitrogen; also the albuminoid nitrogen and the oxygen consumed by the waters of the Illinois river discharged over the Kampsville dam in tons per 24 hours, during the years 1897 to 1900, inclusive. The figures representing the average daily discharge of the varoius constituents mentioned during each of the years referred to and being calculated from the mean yearly flow and the yearly average of the given constituent.

The total nitrogen referred to, the figures representing the quantities of which appear in column 6, consists of the sum of the nitrogen as nitrites, the nitrogen as nitrates, the nitrogen as free ammonia and the total organic nitrogen, and consequently represent all of the nitrogen contained in the waters in combination with different substances. I explained that to distinguish from nitrogen gas, which may be dissolved in the water and which may be formed by the decomposition of any of these substances, or be dissolved from the air.

In addition to the yearly averages, there are given averages for each of the three year periods.

Table No. 10 of this series is as follows:

9046 NO. 10, A. W. P.

QUANTITIES OF NITROGEN IN THE WATERS OF THE ILLINOIS RIVER AT KAMPSVILLE. TONS DISCHARGED PER 24 HOURS. FROM 1st 6 MO. AVERAGES OF FLOWS AND CONSTITUENTS.

KAMPSVILLE.

Year	Nitrogen as nitrites..	Nitrogen as nitrates..	Nitrogen as free ammonia ..	Total organic..	Total nitrogen	Albuminoid	Oxygen consumed
1897	5.93	139.19	14.57	84.98	244.67	38.82	842.5
1898	4.33	73.06	32.97	85.35	195.71	41.89	1021.6
1899	1.74	43.52	19.11	54.10	118.47	23.8	657.1
Aver.	4.	85.25	22.21	74.81	186.27	34.83	840.4
1900	1.76	78.54	27.91	58.75	166.96	23.27	615.8
1901	.89	46.94	16.53	44.03	108.39	16.30	472.5
1902	1.28	40.37	20.95	27.8	90.40	11.12	386.7
Aver.	1.31	55.28	21.79	43.52	121.90	16.89	491.7

9047 Table No. 10 has similar data but computed for the first six months of the respective years and calculated from the mean daily flow during the first six months, and the average proportions of the constituents during the first six months of the respective years.

Table No. 11 of this series is as follows:

9048 QUANTITIES OF NITROGEN IN THE WATERS OF THE ILLINOIS RIVER AT KAMPSVILLE. TONS DISCHARGED PER 24 HOURS. FROM 2nd 6 MO. AVERAGES OF FLOWS AND CONSTITUENTS.

Year	Nitrogen as nitrites	Nitrogen as nitrates	Nitrogen as free ammonia	Total organic	Total nitrogen	Albuminoid	Oxygen consumed
1897	1.32	15.97	7.39	14.65	39.33	6.96	137.9
1898	1.52	9.43	5.36	15.87	32.18	7.25	171.6
1899	.55	8.17	2.84	8.37	19.93	3.28	78.3
Aver.	1.13	11.19	5.19	12.96	30.47	5.83	129.3
1900	.81	26.45	4.33	12.82	44.41	5.41	133.2
1901	.65	12.99	3.5	6.9	24.04	2.82	75.2
1902	2.54	73.54	6.74	55.58	138.4	22.24	475.1
Aver.	1.33	37.66	4.85	25.1	68.94	10.15	227.86

9049 Table No. 11 contains similar averages to those just referred to, but for the second six months in each of the respective years.

Table No. 12 of this series is as follows:

9050

DEFENDANTS' TABLE OF AVERAGES NO. 12.—A. W. P.

TABLE XVIII.

QUANTITIES OF NITROGEN IN THE WATERS OF THE ILLINOIS RIVER AT KAMPSVILLE. TONS DISCHARGED PER 24 HOURS. YEARLY AVERAGES CALCULATED FROM THE DISCHARGES (IN TONS) FOR EACH MONTH.

Year.	NITROGEN AS					
	Nitrites.	Nitrates.	Free Ammonia.	Kjeldahl Organic.	Total Nitrogen.	Albuminoid Ammonia.
1897	2.9	84.61	9.04	48.41	144.96	22.7
1898	2.59	38.71	13.1	48.95	103.35	22.9
1899	1.2	27.45	10.2	38.29	77.14	14.64
Average	2.24	50.2	10.78	43.88	107.1	20.08
1900	1.1	50.96	14.2	38.29	104.55	14.88
1901	.767	34.26	9.6	27.	71.627	10.23
1902	1.98	50.31	9.6	42.9	104.79	17.1
Average	1.28	45.1	11.1	36.06	93.54	14.07

9051 It gives the quantities of nitrogen in the waters of the Illinois river at Kampsville in tons per 24 hours discharged; yearly averages calculated from the discharges in tons per 24 hours for each month, which appear in the tables which have just been referred to.

Table No. 13 of this series is as follows:

9052

DEFENDANTS' TABLE OF AVERAGES NO. 13.—A. W. P.

TABLE XIX.

QUANTITIES OF NITROGEN IN THE WATERS OF THE ILLINOIS RIVER AT KAMPSVILLE. TONS DISCHARGED PER 24 HOURS; CALCULATED FROM YEARLY AVERAGES OF FLOWS AND YEARLY AVERAGES OF CONSTITUENTS.
(See Table XV, page 86.)

	NITROGEN AS						
Year	Nitrites.	Nitrates.	Free Ammonia.	Kjeldahl Organic.	Total Nitrogen.	Albuminoid Ammonia.	Oxygen Consumed
1897…………………	3.86	65.83	15.4	47.8	132.89	21.94	478.4
1898…………………	2.97	32.71	16.01	43.91	95.6	20.79	503.7
1899…………………	1.33	25.12	10.05	28.94	65.44	12.12	317.9
Average……	2.7	41.22	13.82	40.22	97.93	18.28	433.3
1900…………………	1.33	50.51	13.22	31.87	96.93	12.62	327.2
1901…………………	1.12	31.33	9.62	23.	65.07	8.67	241.2
1902…………………	1.996	60.24	20.95	43.1*	126.18	17.24	504.
Average……	1.479	47.36	14.6	32.65	96.06	12.84	357.5

*Estimated for 1902 on the assumption that the nitrogen as albuminoid ammonia constitutes 40 per cent of the total organic nitrogen.

MEAN ANNUAL DISCHARGES OF THE ILLINOIS RIVER AT KAMPSVILLE DAM. CORRECTED FOR SUBMERGENCE OF THE WEIR.

1897……………………………………………	16,258	cubic feet per second.
1898……………………………………………	15,947	" " " "
1899……………………………………………	9,497	" " " "
1900……………………………………………	13,033	" " " "
1901……………………………………………	9,506	" " " "
1902……………………………………………	18,306	" " " "

9053 Table 13 shows the quantities of nitrogen in the waters of the Illinois river at Kampsville in tons discharged per 24 hours, calculated from yearly averages of flows, and yearly averages of the various constituents, the nitrogen as nitrites and as nitrates, as free ammonia, the total organic as determined by the Kjel Dahl process, the total nitrogen, that is, the sum of that as nitrates, that as nitrites, that as free ammonia and the organic nitrogen, and in addition to these gives similar data regarding the nitrogen as albuminoid ammonia and also the quantities of oxygen consumed by the waters. The averages for the three years preceding the opening of the Chicago main drainage channel and the averages for the three years immediately subsequent thereto, together with general averages for each of these two three year periods.

The organic nitrogen ordinarily as determined by the Kjel Dahl process is for the year 1902, in this table computed from the nitrogen as albuminoid ammonia on the basis of the latter constituting 40 per cent. of the total organic, the Kjel Dahl determination of organic nitrogen. At the bottom of the table there are also given the mean yearly flows or dicharges of water over the Kampsville dam corrected for submergence of the wier, for the years 1897 to 1902, inclusive.

9054 Q. Have you data showing the flows at that time?

A. I have.

Q. Will you please put that in the record?

A. They are as follows?

For the year 1896, the mean daily flow in

January, was	20,538 cubic feet per second,
February,	18,081
March,	18,158
April,	11,711
May,	11,729
June,	14,193

The average for the six months, or the mean daily flow for the six months, is 15,752 cubic feet per second.

In July the flow was 9,337 cubic feet per second,

August,	15,490
September,	7,060
October,	8,292
November,	7,935
December,	7,353

The average for the six months being 9,245, and the mean flow for the year being 12,498 cubic feet per second.

9055 For the year 1897:

January,	21,225 cubic feet per second.
February,	21,109
March,	31,820
April,	51,139
May,	29,117
June,	8,406

The average for the six months being 27,136.

July,	10,394 cubic feet per second.
August,	3,603
September,	5,404
October,	5,188
November,	5,760
December,	1,935

The average for the second six months being 5,381 and the average for the year, 16,256 cubic feet per second.

9056 For the year 1898:

January,	8,157 cubic feet per second.
February,	15,574
March,	25,987
April,	45,980
May,	24,062
June,	23,935

The average for the six months being 23,949.

July	8,919 cubic feet per second.
August,	6,034
September,	6,188
October,	5,098
November,	11,824
December,	9,607

The average for the second six months being 7,945, and the average for the year being 15,947 cubic feet per second.

9057 For the year 1899:

January,	11,546 cubic feet per second.
February,	8,253
March,	23,901
April,	18,570
May,	16,531
June,	16,026

The average for the six months being 15,804 cubic feet per second.

July,	4,602 cubic feet per second.
August,	3,958
September,	1,272
October,	1,459
November,	3,645
December,	4,197

The mean for the six months being 3,189, and the average for the year being 9,497 cubic feet per second.

9058 For the year 1900:

January,	6,497 cubic feet per second,
February,	15,793
March,	35,199
April,	28,133
May,	15,722
June,	10,835

The average for the six months being 18,697 cubic feet per second.

July,	7,270 feet per second,
August,	7,574
September,	6,422
October,	4,773
November,	6,386
December,	11,785

The mean for the second six months being 7,369 and the mean for the year being 13,033 cubic feet per second.

9059 For the year 1901:

January,	11,526 cubic feet per second,
February,	10,400
March,	18,542
April,	30,537
May,	12,803
June,	6,666

The mean for the six months being 15,087 cubic feet per second.

July,	5,210 cubic feet per second,
August,	3,748
September,	3,450
October,	3,137
November,	3,766
December,	4,257

The average for the six months being 3,925 and the average for the year being 9,506 cubic feet per second.

9060 For the year 1902:

January,	5,032 cubic feet per second,
February,	3,667
March,	13,779
April,	16,375
May,	12,296
June,	15,495

The average for the six months being 11,107 cubic feet per second.

July,	43,537 cubic feet per second,
August,	36,670
September,	16,830
October,	17,809
November,	19,360
December,	18,743

The mean for the second six months being 25,506, and the mean for the year being 18,306 cubic feet per second. That is, the monthly and six months averages have been computed from the tables of mean daily discharges of water over the Kampsville dam, which have heretofore been introduced in evidence by me in this case.

Table No. 14 of this series is as follows:

9061

NO. 14.—A. W. P.

TABLE XX.

QUANTITIES OF NITROGEN IN THE WATERS OF THE ILLINOIS RIVER AT KAMPSVILLE. TONS DISCHARGED PER 24 HOURS; CALCULATED FROM THE AVERAGE FLOW FOR EACH PERIOD OF THREE YEARS AND THE AVERAGE PROPORTION OF THE CONSTITUENT FOR SAME PERIOD.

1st period, 1897-8-9, average flow—13,900 cubic feet per second or 37,530,000 tons of water per 24 hours.

2nd period, 1900-1-2, average flow—13,614 cubic feet per second, or 36,750,000 tons of water per 24 hours.

NITROGEN AS	Parts per million.		Tons per 24 hours.		Differences.
	1st period 1897-8-9	2nd period 1900-1-2	1st period 1897-8-9	2nd period 1900-1-2	
Nitrites	.067	.005	2.52	1.49	Decrease 40.8 p. c.
Nitrates	1.103	1.276	41.4	46.9	Increase 13.3 p. c.
Free Ammonia	.3737	.3937	13.95	14.47	Increase 3.7 p. c.
Organic (Kjeldahl)	1.066	.888	40.	32.6	Decrease 18. p. c.
Total Nitrogen	2.6097	2.5982	97.87	95.46	Decrease 2.46 p. c.
Albuminoid Ammonia	.4665	.3495	17.5	12.84	Decrease 30.6 p. c.
Oxygen Consumed	11.7	10.7	438.	393.	Decrease 10.2 p. c.

9062 It represents the quantities of nitrogen discharged in the waters of the Illinois river over Kampsville dam in tons per 24 hours, and is calculated for the first three year period, that is the years 1897 to 1899, inclusive, immediately preceding the opening of the Chicago main drainage channel and for the three year period 1900 to 1902, inclusive, immediately following that opening.

During the first period the average flow was 13,900 cubic feet per second, or 37,530,000 tons of water per 24 hours.

During the second period the flow was 13,614 or 36,750,000 tons of water per 24 hours.

In the table there are given the average proportions of the different constituents and also the average daily discharge in tons of the constituents in question.

The nitrogen as nitrites amounted to 2.52 tons per 24 hours during the first period, and 1.49 tons per 24 hours during the second period, which shows a decrease in the quantities of this constituent discharged by the water of the Illinois river at Kampsville during the second period, as against the first, of 40.8 per cent.

The nitrates are shown by the table to have increased during the second period, the increase amounting to 13.3 per cent.

9063 The free ammonia discharged was found to be greater in quantity during the second period than during the first to the extent of 3.7 per cent.

The organic nitrogen as determined by the Kjel Dahl process was contained in smaller quantity during the second period than during the first, and as represented upon the table the decrease in weight was 18 per cent.

At the bottom of the table similar data show that the quantities of nitrogen as albuminoid ammonia decreased, the decrease as stated being 30.6 per cent.

The oxygen consumed during the first period amounted to 438 tons per 24 hours, and during the second period 393 tons per 24 hours, showing thus a decrease of 10.2 per cent subsequent to the opening of the Chicago main drainage channel.

The evidence shows conclusively that since the opening of the Chicago main drainage channel there has taken place not only a considerable diminution in the proportions of the organic matters contained in the waters of the lower Illinois river, and as they are about to discharge from that stream into the Mississippi, but that a substantial decrease of the actual quantities of the organic matters contained in these waters has oc-
9064 curred, and this notwithstanding the fact which I have testified to, already, that the quantities of organic matters conveyed in Chicago sewage into the Desplaines and thence into the upper Illinois are considerably greater now than they were before the opening of the Chicago main drainage channel.

As it has been shown in my testimony that the organic matters contained in the Chicago sewage discharged into the upper Illinois are practically destroyed or converted into vegetable matters by the time the waters reach Peoria, that is Averyville, where another great influx of sewage and other organic wastes occurs, it will be of importance to compare the condition of the water at Averyville, just above Peoria with its condition at Kampsville, 140 miles below, with respect to the quantities of organic matters carried by the stream at these two points.

The data involved in this comparison have been brought together upon table 15 of this series, which is as follows:

9065

TABLE NO. 15.—A. W. P.

TABLE XXI.

QUANTITIES OF NITROGEN IN THE WATERS OF THE ILLINOIS RIVER AT AVERYVILLE (ABOVE PEORIA.) TONS DISCHARGED PER 24 HOURS; CALCULATED FROM THE MEAN FLOW FOR EACH YEAR AND THE YEARLY AVERAGES OF CONSTITUENTS (SEE TABLE XII PAGE 81).

Year.	Mean Flow of Water.		Nitrogen as						
	Cubic ft. per second	Mil. tons per 24 hrs.	Nitrites.	Nitrates	Free Am'ia.	Org'le Kjeld'l	Total Ni'gen	Albu. Am'ia.	Oxy'n Cons'd
1897	11,173	30.16	7.66	50.97	25.42	30.46	114.51	15.17	340.8
1898	11,923	32.19	3.99	25.97	27.64	23.7	81.3	12.97	299.3
1899	7,378	19.92	4.06	31.	20.41	22.1	77.57	9.84	256.9
Av'e..	10,165	27.44	5.24	36.	24.49	25.40	91.12	12.66	299.
1900	12,026	32.47	2.56	51.4	20.75	24.9	99.61	10.48	272.7
1901	9,757	26.34	2.13	35.2	17.02	16.86	71.21	6.55	172.7
Av'e..	10,891	29.4	2.34	43.3	18.88	20.88	85.41	8.51	222.6
Changes, or differences between the two periods.			55.34 p. c. dec	16.85 p. c. inc	22.9 p. c. dec	17.86 p. c. dec	6.26 p. c. dec	32.78 p. c. dec	25.55 p. c. dec
Averyville 1897-8-9..........			5.24	36.	24.49	25.42	91.12	12.66	299.
Kampsville 1897-8-9..........			2.7	41.22	13.82	40.22	97.93	18.28	433.3
Changes between Averyville and Kampsville..........			-48.47 per ct.	*14.5 per ct.	-43.56 per ct.	*62.15 per ct.	*7.47 per ct.	*44.39 per ct.	*45. per ct.
Averyville 1900-1901..........			2.34	43.3	18.88	20.88	85.41	8.51	222.6
Kampsville 1900-1901..........			1.22	40.92	11.24	27.43	81.	10.64	284.1
Changes between Averyville and Kampsville..........			-47.85 per ct.	-5.49 per ct.	-40.46 per ct.	*31.37 per ct.	-5.16 per ct.	*25.03 per ct.	*27.68 per ct.

*Increase. - Decrease.

9066 Table 15 represents the quantities of nitrogen in the waters of the Illinois river at Averyville, above Peoria, tons discharged per 24 hours; that is, the average for the years 1897 to 1901 inclusive, and with the general averages first for the three year period before the opening of the Chicago main drainage channel and second, for the two year period immediately following, and also there are introduced here once more, for purposes of comparison, similar data with respect to Kampsville.

Comparing the averages for the three year period before the opening of the Chicago main drainage channel with the averages for the two year period subsequent thereto, and I may say here that no analyses of the waters of the Illinois river at Kampsville were made by me for the year 1902, the work at that point was discontinued—comparison of the. general averages for these two periods shows that subsequent to the year 1899 there was a decrease in the weight of nitrogen as nitrites discharged by the waters of the Illinois river at Averyville, from 5.24 tons per 24 hours to 2.34 tons per 24 hours, a decrease of 55 per cent.

The nitrates on the other hand were increased, the increase amounting to 16.85 per cent.

The nitrogen as free ammonia showed a very considerable decrease, amounting to 22.9 per cent, the total organic
9067 nitrogen, Khel Dahl, show a decrease amounting to 17.86 per cent.

The total nitrogen, that is, the sum of those before referred to, show a decrease of 6.26 per cent.

The nitrogen as albuminoid ammonia decreased in quantity 32.78 per cent.

The oxygen consumed by the waters of the Illinois at this point showed a decrease amounting to 25.55 per cent.

Comparing the data for Averyville with those for Kampsville for the years 1897 to 1899, inclusive, the data for Kampsville having been taken from the tables heretofore introduced by me in evidence, shows that between Averyville and Kampsville there is a very considerable decrease in the quantities of nitrites carried by the waters of the Illinois river, this amounting to 48.47 per cent.

That the nitrogen as nitrates during this period increased 14.5 per cent. The nitrogen as free ammonia decreased 43.56 per cent. The total organic nitrogen as determined by the Kjel Dahl process increased 62.15 per cent, this increase being due to the organic matters brought in by the various tributaries of the

Illinois, the discharges of organic matters at Peoria and Pekin, and the wash from the immediate water-shed of the river, and including the vegetation of the river which has subsisted
9968 upon refuse organic matters, introduced at points above
and from the conversion of mineral matters contained in the water, including nitrates, nitrites free ammonia, carbon and so on, into the substances of the vegetation which is so luxuriant in the lower reaches of the Illinois, the total nitrogen is found to increase 7.47 per cent during this period between Averyville and Kampsville.

The albuminoid nitrogen increased between these two points to the extent of 44.39 per cent, considerably less in proportion than did the total organic nitrogen.

The oxygen consumed by the waters increased in quantity between these two points to the extent of 45 per cent.

Comparing the periods after the opening of the Chicago main drainage channel and for the purpose of putting this comparison upon a more reasonable basis I have calculated an average for the content, that is the quantity of these constituents contained in the waters of the Illinois at Kampsville for the two year period following the opening of the Chicago main drainage channel since we have data for Averyville only for this period, we find generally as follows:

A decrease in the quantities of nitrogen as nitrites from
9069 2.34 tons per 24 hours at Averyville, to 1.22 tons per 24
hours at Kampsville, a decrease of 47.85 per cent, which is almost as considerable in percentage as the decrease between these two points in the earlier years, while the actual quantities themselves are about one-half the quantities contained in the water at these two points during the previous period, that is the three years prior to the opening of the Chicago main drainage channel. The nitrates show a change between Averyville and Kampsville, that is, a decrease, amounting to 5.49 per cent, while in the former period between these two points there occurred an increase in the weights of nitrogen as nitrates. The nitrogen as free ammonia were for Averyville during this period 18.88 tons per 24 hours; the quantities for Kampsville being 11.24 tons per 24 hours, showing a decrease of 40.46 per cent between the two points, which is practically the same as the decrease which took place between these two points during the previous period,

which was 43.56 per cent, while the actual quantities contained at both points in the second period were considerably less than they were in the earlier period.

The organic nitrogen as determined by the Kjel Dahl process increased between these two points in this period from 20.88
tons per 24 hours to 27.43 tons per 24 hours, showing an
9070 increase of 31.37 per cent, which is but little more than
one-half as much as the increase which took place between these two points in the period of three years prior to the opening of the Chicago main drainage channel. The figure for that period being an increase of 62.15 per cent.

The total nitrogen contained in the waters shows a decrease of 5.16 per cent in this period as against an increase of 7.47 per cent during the earlier period.

The albuminoid ammonia shows an increase of 25.03 per cent as against an increase of 44.39 per cent during the earlier period, the oxygen consumed showing an increase of 27.68 per cent as against the increase of 45 per cent during the earlier period.

The data of this table No. 15 of this series show that the condition of the water of the Illinois river just above Peoria is very much better since the opening of the Chicago main drainage channel.

The data of this table No. 15 of this series corresponds completely with the data of the various tables I have introduced in evidence, in showing that the condition of the water of the Illinois river just above Peoria is very much better since the
opening of the Chicago main drainage channel, and that
9071 the natural destruction of the organic matters discharged
into the river in the sewage is by the time the water reaches Averyville, is far more complete than it was at this point prior to the year 1900.

A comparison of the data for Kampsville with those at Averyville shows that at the like periods which have been referred to (and no examinations of the water at Averyville were made in 1902,)—the actual weights of nitrites and of free ammonia carried by the water of the Illinois, decreased more than 40 per cent during the flow from Averyville to Kampsville; inasmuch as the waters of the tributaries of the Illinois contained organic material in proportions equal to those of the Illinois itself, and since enormous quantities of nitrogenous organic matters are discharged into the Illinois at Peoria and Pekin, a few miles below Averyville, a considerable increase in the quantities of nitrogenous organic matters in the waters of the lower Illinois might well be expected, but it is to be remembered that the organic matters in the waters of the Illinois below Havana, 45 miles below Peoria and 88 miles above Kampsville, consist of vegetable matters chiefly those of the plankton, as is shown both by observation and by the results of the general investigations which have been introduced in evidence.

9072 Q. Professor, in your testimony in reference to the pollution of the Illinois river by reason of the sewage of Peoria, and the deposits in the river of the matters from the distilleries, you stated that at the time that you desired to make some corrections subsequently as to the amount of organic matters deposited by reason of these distilleries and the cattle fed there. Will you now make that correction?

A. I made a statement that the number of cattle fed at the distilleries and in the stock yards at Peoria and Pekin were 40,000 annually. While this was true of previous times, for previous years, the number have in late years been reduced, and I understand that there are now being fed in the distillery sheds at Peoria and Pekin but 18,000 head of cattle annually.

One other correction I wish to make, with respect to the amount of corn used in the glucose works at Geneva, from which discharges of organic matters are made into the Fox River. I stated that 40,000 car-loads of corn per annum were used in these works, while the correct amount, according to my information is 30,000 carloads of corn per annum, averaging 40,000 pounds of corn per car.

Q. Professor, before you conclude your testimony I wish you would define, for the benefit of those who may read
9073 this record who are not chemists or sanitary experts, some of the words and phrases which have been so frequently used in the testimony in this case. In giving your definitions, please avoid as far as possible the use of technical terms and make it as plain as possible, what the words and phrases mean, and first will you define what is meant by the words "organic matters in water"?

A. By the term "Organic matters" I mean such matters containing carbon in combination as constitute the tissues of living things or organisms, and as are contained in the various secretions or liquids contained in living things of all sorts, great and small, and some of the products elaborated by living organisms, excreted by them, or built up into their tissues, excluding the carbon di-oxide, which is excreted by certain living organisms, and absorbed and utilized by other living organisms, but which is commonly regarded as mineral or inorganic substance.

Q. What is the meaning of the words "nitrogenous organic matters in water"?

A. By the term "Nitrogenous organic matter" we mean to designate those organic matters which contain the element nitrogen as an essential constituent. Not all organic matters
9074 contain this element, but the tissues of living things all
contain or in part consist of, organic matters of which nitrogen is an essential element. Such matters as the substance or flesh, the proteate bodies, stirred up in the seeds of plants known as gluten and so on, and other substances contained in the juices and secretions of living organisms, which are organic in character, and which contain nitrogen as an essential constituent. There are certain nitrogenous organic matters secreted by plants and animals of which the best example perhaps is, the urea excreted by animals in the urine, which contribute in partial proportion to the nitrogenous organic matters contained in sewage.

Q. What is meant by the term "oxidation" used in the consideration of the organic matters in water?

A. By the term "oxidation" I mean the combining or uniting of oxygen with the various organic matters contained in the water, and in a general way also, the union of the elements of water possibly, with these organic matters which latter is frequently called hydrlosis. The effect of this oxidation being in general to convert the organic matters into substances which are regarded as inorganic or mineral in character.

Q. What agencies produce oxidation in water?

9075 A. The chief agencies in bringing about oxidation of
organic matters in sewage are the living organisms present in the water, particularly those of the minuter forms, and which are commonly referred to as bacteria.

Q. How do these bacteria effect or produce oxidation?

A. I don't know.

Q. What is meant by the term "nitrification" as used in this investigation?

A. By the term "nitrification" as I have used it in my testimony I understand such oxidation of the nitrogenous organic matters contained in the water as results in the conversion of the nitrogen of these matters into nitrite and nitrates; that is, essentially finally into saltpeter and nitre. Complete conversion of the nitrogenous organic matters that have undergone nitrification into mineral substances which comparatively are innocuous.

Q. What is meant by the words "turbidity" in water, and what by the word "color," and what is the distinction between turbidity and color in water?

A. The turbidity of water is due to or consists in a certain appearance of cloudiness and partial opacity, which result from the water containing matters in suspension. The color of the
water is distinguished from turbidity in that it results
9076 from the presence of colored matters in solution. A
water may be quite clear and transparent, but have a decided color, and it may on the other hand be both turbid and colored. One is not necessarily associated with the other. Suspended matters which make a water turbid, may impart also a color to the water, but such color is removed by such filtration as takes out these suspended matters.

Q. Will you explain what is meant by the words "total solids", "residue on evaporation" and by loss on ignition", and what significance do you attach to the ascertainment of these factors?

A. By total solids we mean all solid matters which are contained in solution and in suspension in the water, which matters are generally determined together as total solids, by evaporating a measured portion of the water to dryness, so that the water itself is expelled. The residue thus obtained is designated as the residue on evaporation or the total solids. By loss on ignition we mean the loss in weight which takes place when the total solids or residue on evaporation is gently ignited, that is, heated to dull redness, the loss resulting from this ignition is due to the partial burning away of organic matters, and to the

loss of certain inorganic substances, and to the volatiliz-
9077 ation of certain inorganic substances or constituents of
the residue. No very great significance attaches to the loss on ignition today for the reason that it is not practicable to distinguish accurately between such loss, as due to the destruction and removal of organic matters from the loss of inorganic constituents as water, carbon-di-oxide, oxygen from nitrates, salts of ammonia and so on. The significance attaching to the determination of total solids or residue on evaporation, lies in the fact that too great a quantity of such matters contained in water render it unsuitable for domestic use or for manufacturing or steam making purposes.

Q. What does the presence of chlorine in water indicate?

A. Chlorine is contained in the soils in some proportion, but it is a considerable constituent of sewage and of manufacturing wastes. As contained in the water, it may be derived from one or all of these sources. The quantity contained in spring waters, is generally far less than the quantity contained in the waters of deep or artesian wells. The significance which attaches to the proportion of chlorine in the water, depends upon the source of the chlorine, the chlorine itself in such proportions
as are found in ordinary waters is not objectionable. The
9078 proportion in sea water is so great as to render such
water unfit for domestic use. The proportions of chlorine contained in the water of many deep wells is so great as to render the water saline in taste, and to render such water unfit for use for drinking or industrial purposes. It is to be understood in my statements covering chlorine, that it is chlorine in combination with basic matters and not the free substances or element that is referred to, as existing in these waters, that is, in general, it is in the form of sodium chloride, otherwise known as common salt.

Does the presence of chlorine indicate at times the presence of sewage, or might it not indicate the fact that sewage has previously existed, but has now departed?

A. The presence of chlorides in the water is frequently an index to the quantity of sewage that the water does or has contained, but no inference concerning the quantity of sewage contained in the water can be had from a determination of the quantity of chlorine, the chlorides contained, unless other information regarding the water in question previous and subsequent to the introduction of the sewage, is in hand.

Q. What is the meaning of the words "oxygen consumed" and what is the significance of such oxygen in the chemical tables to which you have testified,

9079 A. By the term "oxygen consumed" we mean the quantity of oxygen that the substances contained in the water absorb or unite with in the chemical process used in making this determination. The quantity of oxygen consumed is an index to the quantity of organic matters contained in the water, and affords information concerning the character or, I might say, in some measure affords information concerning the character of the organic matters contained, that is, some organic matters required more, or combined with more oxygen under conditions of the determination than do others. If a considerable quantity of oxygen is required or consumed by the substances contained in a given water, the reasonable inference is that a considerable quantity of organic matters is contained. If on the other hand a small quantity of oxygen is required or consumed by the substances in a given water, the reasonable inference is that the quantity of organic matters contained in that water is correspondingly small.

Q. In the table of chemical analyses to which you have testified in this case, there is an ascertainment designated as "nitrogen as free ammonia, as albuminoid ammonia, as nitrites, as nitrates, and total organic." Will you explain what is meant by each of these designations and what significance you
9080 attach to each of them in ascertaining the quality of water?

A. In my testimony I have already stated what is meant by the term "nitrogenous organic matter." The term "total organic nitrogen" designates the nitrogen contained in combination in the nitrogenous organic matters. It is determined by the Kjel Dahl process, described in my testimony with reference to methods of analysis, and is to be distinguished from the nitrogen contained in the form of free ammonia, that contained in the form of nitrites, and that contained in the form of nitrates, which are regarded as nitrogenous substances, and is also to be distinguisshed from that designated as nitrogen as albuminoid ammonia, although it includes the nitrogen of the latter. It is usually from two to three times greater than the nitrogen as albuminoid ammonia so-called. The nitrogen as albuminoid ammonia is derived from the substances which are designated as nitrogenous organic matter, but the nitrogen which, in the process of chemical examination, is determined under the name of nitrogen as albuminoid ammonia is only part of the nitrogen contained in the organic matters.

ADJOURNED until 2:00 P. M. same day, Friday, November 20, 1903.

9081 2:00 p. m., Friday, November 20th, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further direct-examination, by Judge Springer, and testified as follows:

Q. Professor, will you proceed with your explanation of nitrogen as free ammonia?

A. Nitrogen as free or saline ammonia as recorded in the results of the sanitary chemical water analyses, is the quantity of nitrogen contained in the water in the salts of ammonia or possibly as free ammonia, and as contained in water, is derived from various sources. The rain in falling through the air washes from it small quantities of nitrogen in the form of ammonia, or ammonia salts, and at times the proportion of ammonia and ammonia salts so introduced into water, may be considerable.

It is also derived from the soil or earth with which water comes in contact on its way to the streams, and is derived also from waste organic matters either of vegetable or of 9082 animal origin which may be upon or in the soil and earth with which the waters on their way to the streams in times of fall of rain or the melting of snows, come in contact.

It is also derived from the decomposition of various nitrogenous organic matters which I have described above, both those which are contained in the vegetation, that is, the leaves and stems of grasses, and other plants; of trees, waste vegetable products and waste animal matters of various descriptions, and also from the nitrogenous organic matters contained in sewage and in manufacturing wastes of various descriptions.

It is also produced at times by the reduction of nitrites when these are in contact with decomposing organic matters, when these all are wet or contained in water. The significance which attaches to the presence of free ammonia in a water depends upon the source from whch it has been derived. The ammonia in itself in the proportions in which it is contained in waters is not objectionable, but inasmuch as the free or saline ammonia is a considerable constituent of sewage, the conditions under which it is introduced into or produced in or continues to exist in a given water, must be fully understood and considered in determining its significance in the particular case.

Q. You may proceed with nitrites and nitrates?

9083 A. Nitrogen as nitrites as recorded in the results of the sanitary chemical water analyses refer to the nitrogen contained in combination with oxygen and other substances and constituting salts, which are called nitrites. They are derived in part from the air, being washed from the air usually in the form of nitrites of ammonia by falling rain. They are also derived from the leechings of soils and earth strata with which the fallen rain on its way to the streams comes in contact. They are formed, moreover, in the oxidation of the various nitrogenous organic matters which have been referred to above in my testimony, both those lying upon the surface of the ground or contained in surface soils, in the streets, in barn-yards, in the fields, and from similar changes taking place in the nitrogenous organic matters contained in the water of streams and lakes and ponds; both those derived from or contained in nitrogenous vegetable matters of all descriptions and nitrogenous animal matters, such as are contained in the wastes of habitation, including sewage, barnyard wastes and various manufacturing wastes.

They are also formed by the oxidation of the free or saline ammonia above referred to, as well as by the reduction of nitrates.

9084 The significance of the proportion of nitrites contained in a water depends upon the origin and the amount of the nitrites and the conditions prevailing at the place and time and in the body of water in which they are found.

Nitrogen as nitrates, as recorded in the results of the sanitary chemical analyses of water, represents the quantity of nitrogen that is in combination with basic matters and oxygen, the latter in greater proportion than is contained in the nitrites above referred to. The nitrates, like free ammonia, and nitrites are at times derived in part from the air, being washed from the air by rain and so carried to the earth. They are derived also from the earth strata with which the rain comes in contact and over which or through which it flows on its way to the streams or into the great body of ground water.

The nitrates are derived from the oxidation of the nitrogenous organic matters repeatedly referred to in my testimony above, to the oxidation of free ammonia and to the oxidation of nitrites, both in soil strata and in the water itself. The nitrates constitute the chief final nitrogen containing product of the oxidation of nitrogenous matters of various descriptions, including the nitrogenous organic matters.

9085 A portion of the nitrogen contained in all these various nitrogenous matters, organic and inorganic, is often separated in the form of free nitrogen gas, which may remain in solution in the water or escape from the water and mingle with the air, but generally the major part of the nitrogen of the various nitrogenous matters above referred to is oxidized finally to nitrates.

Nitrates are generally found in notable quantity in the waters of wells, of considerable depth, the so-called shallow wells, and is frequently found in the water of deep wells. It is commonly found in the waters of springs, and is rarely, if at all, absent from surface waters.

It is formed in the oxidation of all sorts of nitrogenous organic matters, both those which are derived from natural vegetation and animal matters, as also from the wastes of habitation, including barnyard refuse, street washings, sewage, and so on.

The significance of the nitrates contained in water depends upon the source and quantity of the nitrates and the conditions under which it has been introduced into or produced in and continues to exist in, the given water.

9086 It is to be noted that the nitrogen passes through a series of conditions, or a cycle of transformations the starting point in which may be regarded as any one of the stages or any one of the conditions or combinations described above, in which it exists in waters. If we consider the nitrogenous organic matters as the first condition or combination in which the nitrogen exists, we may consider the nitrogen in the form of free ammonia as marking the next step or stage in the cycle, this free ammonia being produced in the decomposition or the breaking down of the nitrogenous organic matters, the result of this decomposition being to bring the nitrogen into a sort of combination, namely, the free or saline ammonia, which in the proportions found in water, is not in itself injurious or objectionable.

Following upon the transformation of the nitrogenous organic matters, and the conversion of the nitrogen from organic combination to the inorganic form of free or saline ammonia, the next step in the stage or cycle may be regarded as the partial oxidation of the free ammonia into nitrites which thus constitute the second stage in the series of transformations. The nitrites in turn by further oxidation are converted into nitrates, a comparatively stable form of combination usually regarded as the final stage of oxidation of nitrogenous matters, but the
9087 nitrates are utilized by living organisms, that is, plant life, as a food stuff, and the nitrogen of the nitrates built up into the substance of the plant, that is, converted again into the tissues, and so on, thus being converted into the nitrogenous organic substances of the plant, which nitrogenous organic substances either directly or after digestion and assimilation by animals and conversion into the tissues and secretions of animals may, when in contact with or contained in waters, enter again upon the same series of transformation we have just briefly discussed.

Q. Professor, is it possible to form a reasonably accurate judgment of the condition of a given water from consideration of any one constituent determined in the sanitary chemical analysis?

MR. JEFFRIES: I object to the question for the reason that the word "conditon" is used in its general sense in the question and not with reference to the sanitary condition of the water.

A. No resonably fair judgment regarding the sanitary condition or the potability of a water can ordinarily be drawn from the consideration of any one single constituent determined in the sanitary chemical analysis of a water, but all must be considered together, and with full knowledge of the source of
9088 the water, and of the substances contained in it, and the conditions of time and place and environment, season, and so on.

Q. Professor, tables Nos. 13 and 14 and the tables representing the average monthly flow of the water in the Illinois river, which you read in evidence this morning, show that a greater volume of water passed over the Kampsville dam for the period prior to the opening of the Chicago drainage canal than for the period since that time. What is your explanation of this fact?

MR. JEFFRIES: I object to the witness making any explanation based on the question submitted and growing out of tables 13 and 14, so marked, A. W. P., introduced and read in evidence this morning, for the reason as stated by this witness that the chemical constituents named in those tables and upon which the computation is made, are so uncertain, changeable and unreliable as to give any proper conception of the comparative volumes of water flowing over Kampsville dam during the years in question; this objection being also based upon the definition description and characteristics stated in evidence by this witness with reference to the chemical constituents of nitrogen as nitrites, nitrates, free ammonia, Kjel Dahl organic nitrogen, total nitrogen, albuminoid ammonia and oxygen consumed; and
9089 for the further reason that in these tables the witness has not taken into consideraton the amounts of these chemical constituents that have been drawn into the river from the air, from the rain and from other sources as stated by him; and also for the reason that by the tables no consideration is given the influence of the greater amount of vegetation in the Illinois river prior to the opening of the canal as compared to its condition subsequent to the opening, as shown by defendants' testimony in this case.

JUDGE SPRINGER: The objection of counsel relates to the weight of the testimony and not to its admissibility.

MR. JEFFRIES: I suggest to the court that it is not a question of weight at all. This witness by his definitions of these terms, and by describing their characteristics in water, their appearance and disappearance, has disqualified, and made totally unreliable any conclusions of the character called for in this question.

JUDGE SPRINGER: I suggest that counsel's comments are based upon chemical analyses and tables which can only be correctly interpreted by an expert on water analyses, and he has not qualified to pass judgment as such. We will submit those questions to the court.

MR. JEFFRIES: I suggest that it does not take an expert to understand the definitions of the various chemical 9090 terms described by this witness, and which Judge Springer requested in his question very specifically, that the witness so state and define these terms that a layman may understand them, and believing that I understand the definitions and the description and characteristics of these constituents, as stated by this witness, I again state that from the definitions and characteristics stated by him the testimony is irrelevant, incompetent and misleading, and therefore is of no value so far as the issues in this case are concerned, or so far as the determination of the volume of water passing over the Kampsville dam during the two periods in question, is concerned.

JUDGE SPRINGER: Counsel for defendants regrets that counsel for the complainant has so far failed to understand the definitions given in the testimony of this witness as to make him still incompetent to pass upon the values of chemical analyses of water, and these are questions which must be submitted to the court, and the counsel's objection is merely argumentative.

Q. (Question repeated.)

A. The fact as set forth in my testimony of this morning, relating to the mean monthly flow of water in the Illinois river at Kampsville during the years 1897 to 1902, inclusive, which 9091 showed that at times during the later period, that is, the three years after the opening of the sanitary canal, or Chicago main drainage channel, a smaller volume of water was discharged than was discharged at times during the earlier period, and that the mean or average daily flow during the three years subsequent to the opening of the sanitary canal was slightly less than the mean daily flow during the three years period prior thereto, was due to the fact that in the years 1897 and 1898, the rainfall was considerably greater than it was during the years 1900 and 1901.

The year 1899 was a year of drought and the rainfall during that year was deficient, that is, below the normal, and the flow in the river at Kampsville was very considerably less than it had been during the years 1898 and 1897. In the following year, the year 1900, the drought continued, but there was increased flow in the Illinois river at Kampsville due to the increased discharge of liquid, that is, water and sewage, from Chicago through the Illinois and Michigan canal and the main drainage channel.

The year 1901 was a year of severe drought, deficient rain fall, high temperature and dry winds, and the flow in the river during this year was practically the same as the flow during the year 1899, the year immedately prior to the opening of the main drainage channel. On the other hand, the year 1902 9092 was a year of exceptionally great flow, that is, the greatest flow during the six years here in question was that for the year 1902.

The average for the three year period, because of these variations in the rainfall for the various years was, on the whole a little less than the average for the three years prior to the opening of the main drainage channel.

Q. Professor, wherein does the real value of your data concerning the composition of the waters of the Illinois river before and after the opening of the Chicago Drainage Canal lie?

A. Touching the questions at issue in this case, the real value of the evidence which I have introduced in this case in the way of analytical data lies in the comparison which it institutes between the period prior to the opening of the Chicago main drainage channel and the period subsequent to that opening. For the reason that the various determinations so far as they themselves were concerned, and including the collections of the samples, were made under precisely the same conditions throughout both periods, and that they afford data which are strictly comparable, and which show the conditions pre-9093 vailing in the waters of the streams in question before and after the great change which was co-incident with and produced by the opening of the Chicago main drainage channel.

MR. JEFFRIES: I move to strike out the answer of witness because it is a comment on the evidence. It is for the Court to determine the real value and not the witness.

Q. JUDGE SPRINGER: Professor, you have made numerous examinations of the water of the Illinois river at Kampsville, 30 miles above the mouth of the river. Does Kampsville afford a better opportunity for determining the real character of the water of the Illinois river which is discharged into the Mississippi river than does Grafton, which is at the mouth of the river?

A. The conditons which prevail at the mouth of the Illinois river at Grafton are such that at times water from the Mississippi backs up into the Illinois, and fluctuations in the height of the water in the Mississippi, and indeed, in the Missouri, produce fluctuations in the Illinois below Grafton. For these reasons, and because it was practicable to secure the services of most intelligent collectors, namely, the Assistant United States Engineers who were in charge of the improvements on the lower Illinois, and in residence at the Kampsville dam, Kampsville is the best place on the lower Illinois, near the mouth, 9094
to obtain, samples which should truly represent the character of the water of the Illinois river as it is about to discharge into the Mississippi.

MR. JEFFRIES: I move to strike out what the witness says with reference to the collection of samples by the engineer in charge of the government works at Kampsville, for the reason that the testimony of this witness shows that he did not personally take but two or three of the samples collected at that point.

JUDGE SPRINGER: The objection is not valid for the reason that it is merely a comment on the weight of the testimony and does not go to its admissibility. The testimony heretofore given states exactly how the samples were obtained and the record will speak for itself upon that subject.

MR. JEFFRIES: In consonance with Judge Springer's last remark I move to strike out all that the witness has said with reference to the taking of the samples, for the reason that the testimony of the sample takers themselves shows how the samples were taken, and what the witness says in respect to that is merely a comment on the manner of taking the samples.

JUDGE SPRINGER: The testimony of the sample takers is also in evidence and will speak for itself.

9095 Q. Professor, are you acquainted with the conditions which exist in the water-shed of the Illinois river at this time, and with the conditions which have existed during the past ten years, and especially with the conditions which have existed on the Illinois river and the region near the stream?

A. I have lived upon the watershed of the Illinois river for about 36 years. During a portion of that time living on the banks of the Fox river, one of the chief tributaries of the upper Illinois, and I have been fairly familiar with the conditions prevailing upon the watershed of the Illinois river and with the conditions along the stream itself during the last ten years, and am familiar with the conditions prevailing along that stream and upon much of its watershed today.

Q. Taking into consideration the conditions which exist upon the watershed of the Illinois river, and also the numerous chemical analyses of the waters of the Illinois river which you have made and about which you have testified in this case, what effect in your opinion, has the opening of the Chicago drainage canal in January, 1900, had upon the waters of the Illinois river, and especially upon those waters at Averyville, just above Peoria, and at Kampsville near the mouth of the river, and at Grafton?

9096 A. Taking into consideration my knowledge and information concerning the Illinois river, its tributaries, its watershed, and the conditions prevailing upon and along the same, and taking into consideration the chemical examinations that I have made of the waters of the stream and its various tributaries, both before and after the opening of the Chicago main drainage channel, it is my opinion that the effect of the greater discharge of water resulting from the operation of the Chicago main drainage channel, has greatly improved the condition of the water of the Illinois river all along its course, rendering its waters less offensive to the senses in the immediate neighborhood of the point of discharge of Chicago's sewage into the Desplaines and thence into the Illinois, and reducing the propor-

tions of the organic matters contained in the waters of this stream at Averyville and at other points along its course, and reducing the proportions of nitrogen as free ammonia and as nitrates, and reducing also the quantities of nitrogen as ammonia and as nitrites contained in these waters, and in reducing not simply the proportions, but reducing also the actual quantities of the nitrogenous organic matters contained in the waters of this stream at various points, and particularly at Averyville, to all of which I have testified heretofore, in the evidence
9097 I have presented in this case; and with respect to Kampsville I may refer to my testimony given above in this case, and state it as my opinion here, based upon the considerations enumerated above, that the condition of the water at Kampsville has been greatly improved co-incident with and as a consequence of the operation of the Chicago main drainage channel, in that my evidence shows a great reduction in both the proportions and the actual quantities of the most significant constituents of these waters as determined by the sanitary chemical analyses. And I base this opinion further upon the fact that since the opening of the Chicago main drainage channel, or sanitary canal, although the quantities of organic matters in the sewage now discharged into the Desplaines and thence into the Illinois river, are 30 per cent. greater than before that opening, the proportions of organic matters contained in the waters discharged by the Illinois river into the Mississippi are considerably smaller than they were prior to 1900; and that this decrease of the proportions is not a mere dilution is shown by the fact testified to by me, that the actual quantities of organic matters discharged are now less than they were formerly.

Q. Professor, are you acquainted with the conditions at the mouth of the Illinois river, and at the mouth of the Missouri river, and the conditions which prevail at the place called
9098 the chain of rocks in the Mississippi river, where the St. Louis intake is located, in reference to the water supplies at those points?

A. I have visited these points repeatedly and am somewhat familiar with the state of affairs there, the way the rivers come together, and so on.

Q. From your knowledge of this subject and from your knowledge based upon the numerous investigations which you have made, and about which you have testified in this case, what is your opinion as to the suitablity of the waters of the Illinois river at its mouth, the Mississippi river just above the mouth of the Illinois river, and of the waters of the Missouri river just before they enter the Mississippi river, for domestic purposes, and especially for use for drinking purposes?

9099 A. From a consideration of my knowledge and information concerning these bodies of water, and a consideration of the results of investigations I have made of these waters, and the study of investigations made by others of these same waters, it is my opinion that neither the water of the Illinois river at its mouth, nor that of the Mississippi river just above the mouth of the Illinois river, nor that of the Missouri river just above its mouth, is suitable for domestic use; that is, particularly for drinking purposes without filtering, or without such treatment as shall render it sterile as by boiling or other means.

MR. JEFFRIES: I move to strike out all that the witness said with reference to the Missouri and Mississippi river waters, for the reason that it is immaterial and has no bearing upon the issues of this case. We are not dealing wth the sanitary condition of the water in the Mississippi river above Grafton, or the Missouri river, and so far as the issues here involved are concerned, it matter not whether they are in a sanitary condition or not.

JUDGE SPRINGER: Professor, from your knowledge of
the conditions of the Illinois river and the watershed of that
river and of the flow of the water in the river, the seasonal
9100 changes, the amount of sewage coming from the Chicago
drainage canal and from the amount of water from Lake
Michigan which enters the drainage canal and the sewage which passes through the drainage canal into the Desplaines and Illinois rivers, and from the investigations which you have made of the waters of the Illinois river both before the opening of the drainage canal and since that time, to which you have testified in this case, what effect, if any, in your opinion, has the opening of the Chicago drainage canal in 1900, had upon the waters of the Mississippi river as they flow along the eastern border of the State of Missouri, and has the opening of the Chicago drainage canal, injuriously affected such waters so flowing along the eastern border of the State of Missouri for domestic, manufac-

turing and agricultural purposes, for use by the inhabitants living on the banks of said river in the State of Missouri?

A. From the knowledge and information which I possess concerning these waters and the conditions existing in and about them, and the results of the investigations which I have made of these waters before and after the opening of the Chicago main drainage channel and the knowledge I have of investigations of these same waters made by others before and after the opening of the Chicago main drainage channel, it is my opinion that the effect of the increased flow secured by the opening of the
9101 Chicago main drainage channel has been at times to increase the flow of water in the Mississippi river along the western borders of the state of Illinois and the eastern borders of the State of Missouri, and further it is my opinion that the increased flow secured by the opening of the Chicago main drainage channel containing as it does, increased quantities of organic matters derived from Chicago sewage, does not injuriously affect the waters of the Mississippi along the eastern borders of the State of Missouri so far as the use of such waters for domestic, agricultural and manufacturing purposes is concerned, for the reason that the effect of the increased flow secured by the opening of the Chicago main drainage channel, has been co-incident with or the cause of more complete destruction of the organic matters introduced into the upper Illinois river to such an extent that the waters discharged by the Illinois at its mouth contain less organic matters than they did prior to the opening of the Chicago main drainage channel, and further for the reason that it is my opinion that the organic matters contained in the Chicago sewage conveyed into the Illinois river by the Illinois and Michigan canal and the Chicago main drainage channel, so far as the sanitary chemical analysis can determine, are destroyed completely or converted into mineral matters and
9102 vegetable matter, which as contained in such water are practically innocuous.

Adjourned until 10:00 a. m., Saturday, November 21, 1903.

9103 10:00 A. M. Saturday, November 21st, 1903. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Professor, have you ever had any experience with reference to the examination of water in any other streams than those in the State of Illinois, to which you have testified in chief?

A. With the exception of some samples from the Ohio river and the Mississippi and the Missouri rivers, and a few from the Wabash between Indiana and Illinois. Mr. Jeffries does that include other river waters in Illinois?

Q. No sir.

A. I have examined others besides those testified to.

Q. And your connection with the rivers of the State of Illinois began about when?

A. As a student I did a little work that didn't amount to much, in the years 1880 to 1883, but somewhat system-
9104 atic work was done by me with respect to river waters
in the summer of 1894. I had examined the waters of several streams in the state before that, in 1890 to 1894, though in a small way at that time.

Q. Was anybody else engaged with you in your work, or was anyone other than you engaged in this work in the State of Illinois under the statute which you have read in evidence and which was passed by the Legislature of Illinois in about 1897?

A. No one except my assistants.

Q. And when you speak of assistants, you mean men assisting in your chemical work in connection with these rivers?

A. I do.

Q. That is the full extent of the examination of the waters of the State of Illinois with reference to obtaining their sanitary character under the act in question?

A. It is.

Q. Is it your opinion that you can ascertain the sanitary condition of the water from the analyses which you have made of the various rivers tributary to the Illinois river, and the Illinois river, and that you can obtain and have obtained accurately the sanitary condition of that water and ascertained as to whether or not the waters of those rivers contained
9105 deleterious matters or disease producing elements or organisms?

A. It is my opinion that the analyses which I have made of the waters of the streams of Illinois and to which I have testified in this case throw much light upon the sanitary condition of the waters in these streams but do not directly determine the question as to the presence or absence of disease producing organisms in said waters.

Q. Then you do not say that in these determinations you have ascertained the presence or non-presence at any time of disease producing elements or organisms?

A. I say that in my opinion I have not by my chemical investigations of these waters determined the presence or absence of disease producing organisms. I do not quite understand the meaning which you attach to the term disease producing elements.

Q. The word "elements" for the information of the witness, is used for the purpose of giving the question the broadest possible significance for sanitary purposes.

A. I still fail to discover any precise meaning attached to the word "element" in this question.

Q. State professor, whether or not in your analyses of the waters contained in the Chicago drainage canal at Lockport, or at any other place, you obtained the presence or non-
9106 presence of disease producing organisms or substances or evidence of their presence in that water?

A. My sanitary chemical analyses of the waters of the Illinois and Michigan canal, and of the Chicago main drainage channel were not such as might be expected to determine directly the presence or absence of disease producing organisms, but inasmuch as they were of such a character as to show the presence or absence of sewage, they do indicate the possible presence or absence of substances characteristic of sewage and hence, in some measure, disclose the presence or absence of deleterious substances, substances which as a class are objectionable in drinking waters, for the reason that they themselves or substances which accompany them in sewage, are deleterious to health when introduced into the system through drink.

Q. Do you know professor, and is there anything in the science of chemistry as applied to sanitation which will give you definite information as to the presence, kind and characteristics of the disease producing organisms or substances which as stated in your last answer, accompany certain chemical constituents found in water?

A. It is my opinion that the basis for the detection of
the presence and the kind and the characteristics of the
9107 disease producing organisms and substances which in
sewage and waters at times accompany the chemical constituents found in these fluids, rests mainly upon the various chemical reactions and decompositions which said organisms and substances produce and the chemical substances which result from their action.

Q. Then by your answer, professor, do I understand you to say that from the chemical analyses of the water in the Illinois river and the Chicago Drainage canal, that you can determine and have determined the presence, the kinds and the characteristics of disease producing organisms, which accompany certain chemical constituents found in those waters?

A. No; that is not what I understood and I do not wish you to understand me to say that.

Q. Then referring to my second preceding question, state if it is not a fact that you cannot determine from your chemical analyses made of the waters of the Illinois river and from the Chicago drainage canal and from those chemical analyses, you have not determined the presence, kind and characteristics of disease producing substances which accompany certain chemical constituents referred to by you in the preceding answer?

A. The sanitary chemical analyses which I have made of these waters do not directly indicate the presence or absence of disease producing substances, and I have not deter-

9108 mined directly the presence or absence of said disease producing substances in these waters.

Q. Is there anything in chemistry so far as you know, which recognizes certain disease producing organisms in water as applied to running streams?

A. In my opinion without the science of chemistry, or without a recognition of the chemical changes or the significance of the chemical changes which disease producing organisms bring about, there would be no means of determining their presence or absence in running water, but, the branch of science which is directly concerned in the utilization of chemical and other reactions for the purpose of determining the presence or absence of disease producing germs, is, in my opinion, the science of bacteriology.

Q. Do you as a chemist, aside from any other science, recognize certain organisms contained in river waters subjected to sewage pollution, which are of a disease producing character? I mean by that that the organisms referred to in the question are of a disease producing character.

A. In my opinion, I could become acquainted with said organisms, only through the application of chemical principles and facts to the study of the characteristics and reactions produced by such organisms, but it is customary to desig-
9109 nate that branch of science which applies itself directly to a study of these organisms and their reactions and characteristics and the chemical changes which they effect as bacteriology. To this branch of science I have not devoted much study, and as a chemist pure and simple, in the acceptation of that term in which the question apparently is put, I am unable to recognize disease producing organisms.

Q. Then professor, as a chemist, you do recognize the existence of disease producing organisms in water that has been subjected to sewage pollution. In other words, professor, it seems to me your answer is a little bit inconsistent.

A. As a chemist pure and simple, I do not recognize the presence or absence of disease producing organisms in water in the sense evidently meant by the question.

Q. As a chemist, do you doubt the presence of disease producing organisms or disease producing substances in waters which have been subjected to sewage pollution?

JUDGE SPRINGER: I object to the word "doubt" as used in this question, as not calling for an answer which would be properly recognized as testimony. That is to say, it neither calls for an opinion as an expert or a fact.

A. As a chemist I doubt nothing except in the light of evidence which appeals to the experience and intelligence.

9110 MR. JEFFRIES: Now, as applied to the particular substances or organisms mentioned and referred to in the proceeding questions, what do you say?

A. It is extremely difficult indeed, and I feel it to be impossible, but it is the other side, that side of me which is the chemist, as distinguished from the entire individual.

Q. As a chemist and as an individual, will you state whether or not you doubt the presence of organisms and substances of a disease producing character in the waters of a river which have been subjected to a sewage pollution?

A. As a chemist and an individual, it is my opinion that there can be no doubt but that disease producing organisms and substances are contained in sewage, and in sewage are frequently introduced into running streams.

Q. As a chemist, is it not a difficult matter to determine the quantity of such disease producing organisms and substances which may exist at any given point in a river, which has been subjected to sewage pollution above that given point, and does not the quantity of such disease producing organisms and substances, depend to a large extent upon the extent and amount of polluting substances so discharged into that
9111 river?

MR. TODD: I want to object to the question on the ground that it is improper in form and suggest to the witness that the answer can be divided, as two questions are involved in this one.

A. A chemist pure and simple, does not attempt to determine directly the presence or absence or the quantities of disease producing organisms.

Q. So then, from the standpoint of a chemist as applied to my last preceding question, the quantity of disease producing organisms and substances may be great or may be small, may they not?

A. A chemist who concerns himself with the study of running waters, their pollution and purification, the seasonal variations to which they are subject, as to content and character of various substances does recognize the fact that disease producing organisms and substances are introduced into running waters in sewage and recognize as a fact that the quantities of such disease producing substances and organisms may be greater or less at different points and at different times, although he as a chemist simply, does not ordinarily determine the quantities of such disease producing organisms or substances.

Q. Can he determine the quantity?

9112 A. Not as a chemist pure and simple.

Q. Can he determine their presence as a chemist pure and simple?

A. No.

Q. Or by the usual sanitary chemical analysis?

A. No.

Q. As a chemist, are you acquainted with the kinds of organisms and substances of a disease producing character in a river water which has been subjected to sewage pollution?

A. Not as a chemist pure and simple, if there can be such a thing, but I have some knowledge of these matters incidentally acquired in my study of the problems involved in the pollution of streams and the purification of flowing waters.

Q. Is there anything in the science of chemistry so far as you know which will determine and which does determine the kinds and character of the organisms and substances which produce disease, and which are found in river waters subjected to sewage pollution?

A. I have already answered that question substantially in my answer to an earlier question and see no reason to add to the answer there given.

Q. Is there anything in the sanitary chemical analysis of water as ordinarily conducted, which discloses the kinds and character of the disease producing substances and or-
9113 ganisms contained in polluted waters?

A. There is not.

Q. As a chemist, do you know whether or not these disease producing organisms and substances are dependent for their life and existence upon the present or absence of the various chemical constituents found in polluted waters and obtained or determined by sanitary chemical analyses of the waters?

A. It is my opinion as a chemist and an individual that the substances—

Q. Professor, we are talking chemistry now.

A. I am speaking as an individual concerning the science of chemistry. It is my opinion as a chemist and an individual that the substances, the presence and proportions of which are shown by the sanitary chemical analyses of waters as ordinarily conducted include those substances which serve as the food supply of micro-organisms, and include the substance itself of micro-organisms, both the harmless sort and the disease producing sort.

Q. Is there anything in the science of chemistry alone which enables you to form any such opinion or draw any such conclusion?

A. Yes sir.

Q. Will you please state it.

9114 A. It is this: that the results of the sanitary chemical analysis as it is ordinarily conducted, show the presence of all the nitrogenous organic matters contained in the water, and this includes all nitrogenous organic substances whether it be that of dead matter or living matter.

Q. Is there anything in the science of chemistry which discloses the kind of nitrogenous matter in water which is of a disease producing character as separate and distinct from that nitrogenous matter which is not of a disease producing character?

A. The chemistry of toxins is an exceedingly important chapter of chemistry, and so far as concerns those disease producing substances which are called toxins, chemistry does determine the character of those substances and distinguishes them from other substances which are not disease producing.

Q. Why have you not made such determinations professor with reference to the waters in the Illinois river and the drainage canal?

A. What determinations?

Q. The determinations mentioned by you in the last preceding answer?

A. Because no practicable method is known for separating from each other the substances in the proportions which are found in such waters.

9115 Q. Is it not a fact that such determinations cannot be made from the water in a running stream which has been subjected to sewage pollution?

A. It is my opinion that it is impracticable to make such determinations in the cases referred to in the last question.

Q. Then I understand you still to say that the science of chemistry does not undertake to disclose the kind and character of the disease producing substances and organisms in matter that has been subjected to sewage pollution?

A. It is my opinion that I have substantially made that statement in answer to your previous question.

Q. That is, you are still of the former opinion, that chemistry does not make any such determinations?

A. The sanitary chemical analysis of waters as ordinarily conducted, does not in my opinion make such determinations.

Q. And because of the utter impracticability of it, you have not made determinations with reference to the waters in question?

A. Because in my opinion it is utterly impracticable to determine the character and the quantities of toxins contained in the waters in question, I made no attempt to make such determinations.

Q. Professor, as a chemist, are you able to distinguish 9116 the character of the food supply of the micro-organisms which produce disease, from the character of the other nitrogenous matters or constituents in the water? In other words, are you able to distinguish those nitrogenous organic substances which are food for the micro-organisms of a disease producing character, from other nitrogenous organic substances contained in the water?

A. The chemist pure and simple, does not make the distinction between those nitrogenous organic substances which serve as a food supply for disease producing organisms and those which serve as a food supply for other micro-organisms, but he does make a distinction between those substances which serve as the food supply of micro-organisms and other nitrogenous organic substances, which do not ordinarily serve as such food supply.

ADJOURNED until 2:00 P. M. same day.

2:00 P. M., Saturday, November 21st, 1903.

9117 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further cross-examination by Mr. Jeffries and testified as follows:

Q. (Last question and answer repeated). That is, the chemist can determine what particular character of chemical constituents contained in the water may be used by the micro-organisms of all characters as food, and without reference to whether or not the micro-organisms contained in the water are of a disease producing character or not; is not that true?

A. The chemist can distinguish between those nitrogenous organic matters which are of an albuminous or proteid character and which serve as a food supply for the micro-organisms and other nitrogenous organic matter which are not albuminoid or proteid in character, as for instance, many of the toxins and so on, which are products of the vital processes, or rather which are or may be products of the vital processes of micro-organisms, but which are not in general, food constituents of micro-organisms.

9118 Q. Does the sanitary chemical analysis of the water enable you to make the determination which you have just spoken of?

A. It does not.

Q. Does the sanitary chemical analysis enable you to determine whether or not the disease producing organisms feed upon any of the albuminous or organic nitrogen contained in the water?

A. It does not.

Q. Is there anything in the sanitary chemical analysis of water which enables one to determine whether or not the disease producing organisms in polluted water will live longer in the presence of other organic nitrogen than in the absence of such other organic nitrogen. In other words, is there anything in the sanitary chemical analysis of a water of a polluted stream that enables one to determine as a chemist whether or not the disease producing organisms contained in that water will live longer in the presence of other constituents of sewage in the water, than in the absence of other constituents of sewage in that water?

A. Not as a chemist purely and simply.

Q. Then from the standpoint of a chemist, one is unable to determine from the sanitary chemical analysis of water, whether or not disease producing organisms contained in a polluted stream will live longer in the presence of large quantities of nitrogenous organic matter than in the absence of such
9119 nitrogenous organic matter?

A. The chemist pure and simple is unable to determine this point.

Q. Do your analyses of the water contained in the Illinois river and the drainage canal, disclose any such determination as to the longevity of the disease producing organisms in the presence or absence of other nitrogenous organic matter?

A. They do not.

Q. Do your chemical analyses of the water in the Illinois river and the drainage canal, disclose whether or not the disease producing organisms disappear with proportionate rapidity to the disappearance of the total organic matter contained in that water?

A. They do not.

Q. Do the chemical analyses which you have read in evidence in this case disclose whether or not the disease producing organisms contained in the sewage, of Chicago, disappear to any extent whatever from that water?

A. Considered merely from the standpoint of the chemist. they throw no light whatever upon this question.

Q. What chemical constituent contained in the water would most likely contain the disease producing organisms if such a determination could be made?

9120 A. The nitrogenous organic matters.

Q. Professor, have you examined the water in Lake Michigan taken from the various cribs at times when the water supply of the city of Chicago was producing abnormal typhoid fever results?

A. As to that I am uncertain and can merely refer to the fact as testified to by me heretofore, that I made a series of analyses of samples of water collected at a tap in the city, the supply for which was taken from the lake at the Four Mile Crib opposite 14th Street which data have been introduced in evidence in this case and which cover the period of years from 1897 to 1900 inclusive. I gave no testimony as to the existence or non-existence of typhoid fever in the city with respect to those determinations and cannot state definitely whether or not there were unusual numbers of typhoid cases in the city during such time.

Q. Did you examine chemically the water from Lake Michigan other than from the Four Mile Crib at any time?

A. I did not. Well, I have made other examinations of water other than from Lake Michigan, above the water supply systems of the town of Evanston, Waukegan and other towns along the lake shore, but none others than those I testified to from Chicago.

9121 Q. Professor, I will ask you to state whether or not any of the chemical analyses of the water other than from Lake Michigan from the Four Mile crib, and analyzed by you contained as much organic nitrogen as that contained in the samples of water chemically analyzed by you from the Illinois river during the same period of time?

A. I have on several occasions found greater proportions of organic nitrogen in samples of water taken other than from Lake Michigan at the places heretofore testified to by me, than I have found in numerous samples of water taken from the Illinois river at Kampsville.

Q. Is it not a fact professor, that the water analyzed by you other than from the Four Mile Crib in Lake Michigan at Chicago, did contain smaller quantities of organic nitrogen than the samples of water analyzed by you from the Illinois river at Kampsville, as a general proposition?

A. In general the waters of Lake Michigan analyzed by me contained considerably less total organic nitrogen than I found in the waters of the Illinois river at Kampsville.

Q. If the organic nitrogen contained in the waters of Lake Michigan as analyzed by you contained a certain organism which produced typhoid fever, state whether or not there is anything shown by your sanitary chemical analysis of the water of the Illinois river at Kampsville that showed that the
9122 organic nitrogen contained in the water at that point, did not contain the organisms of such disease?

A. Whether the organic nitrogen contained in the water of Lake Michigan analyzed by me, did or did not contain the micro-organisms which produce typhoid fever, I do not know but assuming it to have been present therein, it is my opinion that there is nothing in my sanitary chemical analysis of the waters of the Illinois river at Kampsville which has determined whether or not a bacillus of typhoid fever was contained in that water.

Q. Assuming professor, the presence of that character or kind of micro-organism which produces typhoid fever in both waters, and that they are present in the organic nitrogen contained in that water, and that the proportionate amount of such micro-organisms in the respective waters corresponds to the respective amounts of total organic nitrogen in these waters, how would the number or amount present in the water of Lake Michigan as analyzed by you, compare with those present and in the water as analyzed by you from Kampsville?

A. Assuming that there was the same relation between the numbers or amounts of micro-organisms mentioned in your question and the total nitrogenous organic matters con-
9123 tained in the waters at these two points, then it is my opinion that the relation the numbers said micro-organisms would have to each other would be similar to the proportions of the total nitrogenous organic matters in each of these two waters.

Q. Knowing as you do from your chemical analyses the approximate relationship existing between the two amounts of organic nitrogen in the waters of Lake Michigan as analyzed by you and those in the Illinois river at Kampsville, what would the relationship of proportionate amounts be with reference to the particular organism producing typhoid fever, as assumed in the preceding question, approximately or as a general proposition?

A. The assumptions in the question in my opinion seem to be absurd, and involve a question of mere arithmetic rather than of chemistry or experimental science, and I fail to see that any particular significance can attach to an answer, but if an answer must be had I would practically reiterate my answer to the preceding question to the effect that the proportions they would bear to each other is a mere matter of arithmetic, but they would bear to each other the same relation as do the proportions of total organic nitrogen.

MR. JEFFRIES: I move to strike out all that the witness has said with reference to the question being absurd, 9124 first, for the reason that it not for him to say, but for the Court to determine whether or not such question is absurd; second, for the further reason that the witness has made the analyses of the water of Lake Michigan and for the Illinois river for the period beginning in 1897 and down to 1900 and even later; that he has determined the total organic nitrogen contained in those waters, that he has drawn conclusions as to the sanitary condition of that water from the various chemical constituents and the witness knows or is presumed to know the relative relationship the various constituents of the waters of Lake Michigan, bear to the same chemical constituents in the waters of the Illinois river.

Q. Now professor, I ask you again to state, first approximately the relative proportions the organic nitrogen contained in the waters of Lake Michigan as analyzed by you, bear to that of the Illinois river at Kampsville, and assuming the presence of organisms producing typhoid fever in the organic nitrogen contained in the waters of Lake Michigan and of the waters of the Illinois river at Kampsville, and assuming that they appear proportionately in amounts to the proportionate amount of total organic nitrogen contained in those waters, how would the number or amount in the one case, correspond with the number or amount in the other?

9125 JUDGE SPRINGER: I move to strike out this question for the reason that the number of micro-organisms which may be found in the water are not comparable with the total organic nitrogen contained in the water; that the presence of such organisms in water is not due to the chemical constituents in water, or to the total organic nitrogen contained in water, but that their presence in water is to be attributed solely to the fact that they have been brought into the water from some human being who had the disease known as typhoid fever, and whether they were brought into the water or not depends upon whether there are typhoid fever patients present or whose dejecta have been placed in such waters.

A The average proportion of total organic nitrogen contained in the waters of Lake Michigan which I analyzed and testified to heretofore in this case, were, for the year 1897, .268 parts per million; for the year 1898 .202 parts permillion; for the year 1899-.188 parts per million, and for the year 1900-.186 parts per million; the average for the four year period being .211 parts per million. The average proportions of total organic nitrogen contained in the waters of the Illinois river at Kampsville analyzed by me during the year 1897 was 1.204; for the year 1898-.1.018; for the year 1899 it was 1.129; the average for these three years being 1.057. The average
9126 total organic nitrogen contained in the waters of the Illinois at Kampsville during the year 1900 as already testified to by me, was .904 and during the year 1901, or rather for the first nine months of the year 1901—for these determination were discontinued at the beginning of October,—in that year the proportion was .999. The average for these two years or one year and nine months being .951, which undoubtedly is higher than would be the average for the nine months of 1901, undoubtedly being higher than would be the average for the entire year if the determinations had covered the entire year. The relation of the proportions of total organic nitrogen found in the waters of Lake Michigan for the four year period, 1897 to 1900 inclusive bears to the proportion found in the waters of the Illinois at Kampsville for the period 1897 to 1899 inclusive,

are as 1 to 5. In other words, 1 for Lake Michigan, and 5 for the water at Kampsville.

Q. Now please state the comparative amounts with reference to this chemical constituent known as organic nitrogen in the waters of Lake Michigan and the Illinois river at Kampsville as shown by your analyses of those waters for the year 1900?

A. The proportions of organic nitrogen found by me in the waters of Lake Michigan for the year 1900 were .186
9127 parts per million, and the proportions found in the waters of the Illinois river at Kampsville for this year were .905 parts per million, these two numbers bearing to each other the ratio of one for the water of Lake Michigan, to 4.86 for the water at Kampsville.

Q. Now professor, assuming that in the year 1899 there were a large number of typhoid fever cases in the city of Chicago, and that in the year 1900 there were a like number of cases of typhoid fever in that city, assuming that in the year 1899 the discharges of the dejecta of those patients in Chicago reached the intake crib and were present in the water analyzed by you from the Four Mile crib during that year; and assuming that for the year 1900 the typhoid dejecta from the patients in the city of Chicago, were discharged into the sewers of that city and thence into the Chicago river, the drainage canal, and through the drainage canal discharged into the Illinois river; is there anything in the science of chemistry or in the chemical analyses which you have made of the waters of the Illinois river at Kampsville, which discloses that these typhoid fever organisms so discharged at Chicago, did not reach and are not contained in the organic matter in the waters of the Illinois river at Kampsville?

A. Granting all these assumptions, there is not.

9128 Q. Professor, during these entire series of examinations of the waters of Lake Michigan, the drainage canal and of the Illinois river, you have used the same method of analyzing, have you not?

A. I have.

Q. Do you know whether or not you used the same method that was employed by Professor Long in his determinations?

A. That I don't know.

Q. Do you know whether or not you used the same method as that used by Profesor Jordan in his chemical analyses?

A. It is my opinion that Professor Jordan and I used the same methods.

Q. Do you know whether or not you and M. Bisbee used the same method?

A. It is my opinion that in general the same methods were used by Mr. Bisbee and by myself.

Q. Why did you need to take more than a single chemical analysis of the water of the Illinois river?

JUDGE SPRINGER: Do you mean at any one place or at all places?

MR. JEFFRIES: At any one place?

A. Because of the seasonal and other variations which take place in those waters, both as to flow and as to content 9129 of the various constituents determined in the sanitary chemical analysis.

Q. Why did you need to make hundreds and even thousands of analyses of samples taken from the river at the various times and places?

A. To cover as long a period in time as was practicable, and to cover such a period as thoroughly as was practicable.

Q. Then professor, is it possible to determine precisely the chemical composition of all parts of a running stream at all times and all places in it?

A. It is not, for the reason that it is not practicable to chemically examine every drop of water in such a stream.

Q. Then is it not a fact that your results strictly speaking show nothing more than the chemical composition of some of the waters of the Illinois river and other streams at some of the places at some times and some seasons?

A. It is my opinion that my analyses give as complete evidence concerning the composition of all of the waters passing the points at which samples of said water were collected, so far as it is possible by a sanitary chemical analysis to do so, for the reason that it is not practicable to analyze at any time, much less at all times, all the water flowing past a given point in a stream, of such a stream as the Illinois and other 9130 streams referred to in my testimony introduced in this case; and I will add further that while it is always desirable to have as many analyses as is possible, and even more than the number which I made for, say the point on the Illinois river at Kampsville, practical reasons, that is, those involved in the time, labor and expense, have prevented my making more analyses of the waters at the given points during the periods covered in my testimony, and it is my opinion that the evidence which I have submitted covers the case reasonably well, and as well as similar cases have been covered at other places and by other people in the examination of the waters of running streams.

Q. May not the water of the Illinois river have been very different at other times and other places, and even at the same place at other times, than as shown from your sanitary chemical analyses of that water?

A. It is my opinion that the water of the Illinois river at Kampsville has not been at other times during the period in question materially different from the condition revealed by the analyses which I have submitted in evidence, and it is further my opinion that the data which I have submitted reveal substantially the true composition of the water of the Illinois river at this point, namely, Kampsville, during the
9131 entire period covered by the analyses, namely, the years
1897 to 1902 inclusive.

Q. May not the samples of water have been taken at the same point by the same collectors, at practically the same time, and afterwards analyzed by different chemists, and show a material difference in the chemical constituents of that water, thus revealing a rapidly changing stream, so far as chemical condition is concerned?

A. In my opinion this is quite possible, but the averages for a considerable number of analyses of samples, taken and analyzed as you have indicated, would not in my opinion be substantially different.

Q. Would the table of averages give a correct and complete representation or picture of the waters of the river at the point the samples were taken during the entire period those samples were collected and analyzed.

JUDGE SPRINGER: What tables are you referring to?

MR. JEFFRIES: I am referring to the tables of averages the witness referred to in the last preceding answer.

(Question repeated).

JUDGE SPRINGER: I object to this question for the reason that the words "representation or picture" have no definite meaning so far as the constituent elements of water are
9132 concerned.

A. It is my opinion that no table of averages would give a complete and correct representation or picture of the water in this stream at all times, and the table of averages is not intended and cannot be expected to be so any more than the table of averages of the height of man gives a complete and correct representation or picture of the heights of all men.

MR. JEFFRIES: Q. Professor, assuming that the samples of water were taken and analyzed one time per week for one entire year, from the waters of the Illinois river, and the chemical constituents so obtained from the analyses be placed upon a table of averages, how would the various ascertainments of chemical constituents compare with the table of averages as the height of all men compare with the average man?

JUDGE SPRINGER: I object to this question for the reason that any answer that possibly can be given to it would not be responsive to the issues in this case.

MR. JEFFRIES: Referring now to the tables of averages made up from the chemical analyses of the waters of the Illinois river during any of the years those waters were examined by you and the results of which you have read in evidence in this case?

JUDGE SPRINGER: I renew my objection to the post-
9133 script.

A. It is my opinion they would compare quite favorably.

MR. JEFFRIES: Professor, if one man is 40 per cent taller or forty per cent lower than the average man in stature, how would you designate in ordinary language the relationship of the one who was taller or shorter in stature than the average man? In other words, would he not be a giant or a dwarf?

JUDGE SPRINGER: I object to this question for the reason that any answer which the witness can possibly give to it would not tend to establish any of the issues involved in this case.

MR. JEFFRIES: The relevancy of this testimony will come later.

A. The one who was forty per cent shorter than the average man would probably in ordinary parlance, be designated a dwarf, and the one who was forty per cent taller than the average man would probably in ordinary parlance, be designated a giant.

Q. Assuming that Mr. Bisbee analyzed a sample of water, the companion of one which you analyzed and both of which were collected by the same man on the same day and practically at the same time, on the 6th day of September, 1899 at Kampsville, and the determination of the constituent known as total organic nitrogen as determined by Mr. Bisbee was either forty per cent less or forty per cent more than the determination made by you; would that sample of water in ordinary parlance as applied to the table of averages which you have read in evidence, represent a dwarf or a giant sample so far as that particular constituent was concerned, and would not such differences in the determination of the chemical constituents of the water, indicate and reveal an extensively changing chemical composition of the stream, and also an enormous variation in the chemical condition of the water in the stream at that point and time? 9134

JUDGE SPRINGER: I object to this question for the reason that the words dwarf or giant as applied to chemical analyses, have no significance whatever, and I object to this question for the further reason that any assumption as to the differences of these analyses in this case, rests solely in the mind of counsel, but the best evidence is the fact which is a statement from the record of the analyses themselves.

MR. JEFFRIES: I will state for the information of the witness that this assumption is based upon the tables introduced by defendants and as having been made up from the examinations of the waters of the Illinois river at Kampsville for the time in question by this witness and the witness Bisbee.

JUDGE SPRINGER: Let the record show what Mr. Bisbee's ascertainment was for the sample examined on that

9135 day, and what the ascertainment was as found by Professor Palmer.

A. So far as the designation of a sample of water as a dwarf or a giant is concerned, I may say that I attach no significance to such terms in such an application and do not as a chemist understand the same, but, with reference to the relation of the figures representing these proportions of total organic nitrogen and the samples of water in which they were found, I would state it as a matter of opinion, that no general conclusion regarding the sanitary condition of a sample of water can reasonably be based upon one determination; that is, upon the determination of one individual constituent, and comparing the entire data of the analyses of the two samples in question, I would further state it as my opinion, that there is here simply an error to which all men are liable and that the fact that the figures representing the proportions of total organic nitrogen indicated in the question are .6 and .1 respectively, do not in the light of what I have just stated, indicate any great change taking place in the water samples collected at this time and at this point.

ADJOURNED until 10:00 A. M., Monday, November 23, 1903.

10:00 A. M., Monday, November 23rd, 1903.

9136 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further cross-examination by Mr. Jeffries, and testified as follows:

Q. Profesor, referring to table No. 20 of the series of tables 1 to 80 inclusive, introduced and read in evidence by yourself, and to table 178, being tables introduced by defendants, and known as Defendants' tables of Streams Examinations, 1 to 196, which constitute a part of the testimony of Mr. Bisbee, we find upon comparison of these tables that during the month of September 1899, there were samples collected by the water takers at that point, and these samples are known in the evi-

dence of these water takers as companion samples, one of each of which was shipped to you and the other shipped to Mr. Bisbee, and of these samples you analyzed four, the analyses of which were made by you September 7th, September 14th, September 21st, and September 28th, and of these samples
9137 Mr. Bisbee analyzed three, to wit, September 7th, September 14th and September 21. These samples were collected on the 6th, 13th, 20th and 27th days of September, 1899. Upon your determination of the chemical constituents of those samples, you found that on September 7th to contain 1.0 of organic nitrogen; of the samples analyzed on the 14th of September, you found .84 of organic nitrogen, and of the sample analyzed on the 21st of September, you found 1.0 of organic nitrogen, and the sample examined by you on the 28th of September, you found .82 of organic nitrogen. Mr. Bisbee in his analyses found contained in the sample analyzed by him on September 7th, total organic nitrogen .60; that analyzed on the 14th of September, organic nitrogen 1.04, and that analyzed by him on the 21st day of September, total organic nitrogen .76; no analyses having been made by him of the sample collected on the 27th of September so far as organic nitrogen was concerned. All these samples were taken from the Illinois river at Kampsville. Now do not these analyses show upon comparison, a material difference with reference to the constituent known as total organic nitrogen in the waters of the Illinois river at Kampsville for the month of September, 1899, comparatively speaking?

A. They do not in my opinion show a substantial differ-
9138 ence in the content of total organic nitrogen in the water of the Illinois river at Kampsville during the month of September, 1899, for the reason that they are in my opinion, partly the result of differences in the details of the method used in the determination of the total organic nitrogen, although the method employed was in general the same in both cases, that is, in the analyses made by Mr. Bisbee and those made by myself, and for the further reason that the averages for the month, that is, the average proportion for the three analyses made by Mr. Bisbee, namely those made upon samples collected upon the 6th, the 13th and the 20th of September, 1899, re-

spectively, and those made by me upon samples collected upon the same days in the same month of 1899, which samples were collected simultaneously with those analyzed by Mr. Bisbee, for I find that the average for the three determinations made by Mr. Bisbee were .8 parts per million, the average for the three samples analyzed by me corresponding to the three examined by Mr. Bisbee, were .95, a much less difference than is indicated between certain of the individual determinations included in these six analyses.

Q. I will ask you professor, if that difference, taking the average difference between the examinations made by Professor Bisbee and those made by yourself, does not amount to 9139 18.8 per cent, counting yours as 100 per cent, or as being accurate?

A. Assuming as the basis for the calculation my own average, .95, the difference between the two averages is 15.78 per cent while taking Mr. Bisbee's average of .8 as the basis of the calculation, the difference is 18.75 per cent.

Q. Now may not these same differences of 40 per cent, 23.8 per cent and 24 per cent, have occurred, even though you had made the analyses in both instances, for the month of September, instead of having been made one by yourself and the other by Mr. Bisbee?

A. In my opinion they would not.

Q. Is it a fact that Mr. Bisbee's results are always higher or lower than yours, or do they not vary first one way and then the other?

A. So far as I am aware, they vary in both directions, some of them being higher and some of them being lower than my own.

Q. Now I will ask you professor, if it is not a fact that a comparison of the analytical results of the samples of water collected in September, 1899 at Kampsville an examined by yourself and by Professor Bisbee, do not show either a very rapid change in the chemical condition of that water or do not show extensive variations, chemically speaking, in the water at that time and place, and even on the dates and at the 9140 hour of collecting the samples?

A. In my opinion these variations in the results of the analyses do not indicate similarly considerable variations in the actual content of the total organic nitrogen in the water samples collected at the same date and hour, nor do they show rapid variations in these substances contained in the water, but in my opinion the variations in the determinations as recorded in the tables you have quoted, are very largely the result of differences in the details of the method employed in making these determinations to which I have referred in my answer to the preceding question.

Q. Do those variations, to wit, variations comparatively speaking, shown between the analyses made by yourself and those made by Mr. Bisbee, result from differences in accuracies or differences in inaccuracies?

A. Doubtless they are in part due to both, but in my opinion in the main they are due to variations in the details of the processes to which I have referred in my answers to the two preceding questions.

Q. Professor, in laboratory experiments, is not chemistry an exact science?

JUDGE SPRINGER: What do you mean by the words "exact science" in this connection?

9141 MR. JEFFRIES: I mean by the words "exact science" that when a certain quantity of various substances have been compounded that chemistry can detect to a certainty the quantity of each of the different constituents in the compound.

A. In many cases the methods of chemical analyses do afford a means of determining accurately the proportions of chemical constituents contained in various mixtures, but whether chemistry as applied to methods of chemical analyses may be defined as an exact science, is a question which is somewhat beyond me. I have been told by mathematicians and physicists at times, that chemistry is not an exact science. Undoubtedly it is not in my opinion, capable of such exactness as are the various processes of mathematics.

Q. It is not a mathematical science is it, professor, that is, in the sense that averages can be used with any degree of certainty based upon the results obtained from a given series of analyses?

A. It is my opinion that the averages based upon a given

series of chemical determinations afford as accurate a basis for comparison and for determination of certain facts, as do the averages computed concerning the height of man, in the determination of the heights of man, or as the averages of the length of life of individual man, and of individuals of a
9142 certain class of men computed by the actuaries of insurance companies, which afford a substantially accurate basis for the determination of the length of life of individual man and classes of men, and thus afford a reasonably accurate basis for conducting the business of life insurace.

Q. Tables of averages as used by life insurance companies are based upon mathematical accuracies, are they not, or mathematically accurate data?

A. They are in my opinion based upon data which are probably mathematically accurate, for the number of individuals which it has been practicable to consider, but in my opinion in no case do they cover all of the individuals in a given class.

Q. Have you had any experience as an actuary in the insurace business?

A. I have not.

Q. So that what you say on that subject is merely an opinion based upon general business information?

A. General business information and information given to me by life insurace agents.

Q. Professor, is it not a fact that if two given quantities of water are taken from the same source at the same time, in the same manner, and analyzed practically at the same time by different analysis, that the results of total organic nitro-
9143 gen contained in that water, should be practically the same, speaking now as a chemist pure and simple, and based upon the experience of chemists in the laboratory?

A. That depends particularly upon the source from which the water samples have been taken, and largely upon the methods employed in the determination of the total organic nitrogen and all the details of the methods, and of course too, in part upon the accuracies and inaccuracies involved in the methods employed, including those of the individuals employing them.

Q. Is it not a fact professor, that yourself, Professor Long, Professor Bisbee, and Professor Jordan had a meeting before the investigations began, in which you discussed and finally determined the manner in which the samples of water should be taken and the method which should be used in making the chemical analyses of those waters, in order that the manner of collecting the samples and the manner of making the chemical analyses should be uniform with reference to all persons making those analyses?

A. It is not.

Q. Did you have any such meeting with anyone?

A. I did.

Q. Who were they?

A. Professor Jordan and Dr. Gehrmann, director of the 9144 municipal laboratory of the City of Chicago.

Q. You and Professor Jordan then, so far as the chemical examination goes, used the same system and the same method?

A. We did.

Q. Was it not your understanding at the time, that Mr. Bisbee was to use the same method?

MR. TODD: I object to what his understanding is unless he has definite information from Mr. Bisbee as to what methods Mr. Bisbee was to pursue, as his understanding is not material to the inquiry in this case. What this man's mental phenomena is as to understanding, is not a matter material in this case, whatever Bisbee's testimony would be.

Q. (Question repeated).

A. It was my understanding at the time that the methods to be used in the three laboratories, namely, the laboratory of Professor Jordan, at the University of Chicago; the municipal laboratory in the City Hall, Chicago, and my own laboratory at the University of Illinois, were to be the same, but at that time I did not know who was to do the chemical work in the municipal laboratory, whether it should be Mr. Bisbee, or anybody else.

Q. Now professor, if the same methods were used, and 9145 if the water on the 6th day of September, 1899, collected by the water taker at Kampsville, was the same and in equal parts, was forwarded to the three laboratories which you have mentioned in your last preceding answer, and the variation in the chemical analyses with reference to the ingredient or constituent known as total organic nitrogen should be 40 per cent, more or less, as determined by Professor Bisbee, than as determined by yourself, is it not a fact that an inaccurate determination was made in one instance or the other, and if no inaccuracies with réference to this constituent, is it not a fact that the sample of water which you examined contained more or contained less of the total organic nitrogen than the sample examined by Mr. Bisbee?

A. If we were to assume that there were no inaccuracies in the details of the methods employed in making the determination of the total organic nitrogen in these two samples collected at the same point, at the same time and analyzed, the one by Mr. Bisbee, the other by myself, then the results of said analyses would indicate a difference in content of total organic nitrogen as between the two original samples, but as I have stated in my answers to the three or four preceeding questions, in my opinion, the variations in the details of the methods employed in making the determination of total organic nitrogen
9146 in these two cases is mainly accountable for the differences which appear in the record.

Q. Then what you have stated with reference to the variation between the analyses with reference to total organic nitrogen as determined by yourself on the 6th day of September, 1899, from the sample of water collected at Kampsville, as compared to a companion sample collected at the same time by the same collector, and analyzed by Professor Bisbee, which shows a variation of 40 per cent, the same answer is applicable to the sample collected on the 13th day of September, which shows a variation of 23.8 per cent, is it not?

A. In my opinion it is.

Q. And the same is also true with the sample collected on the 20th day of September, which shows a variation of 24 per cent?

A. It is.

Q. And the same is also true with reference to the sample collected on the 11th of October, which shows a variation of 5.5 per cent?

A. It is.

Q. And also with reference to the sample collected on the 18th day of October, which shows a variation of 9.2 per cent?

A. Yes, and in my opinion to all the others included in
9147 these records.

Q. That is, it applies to the sample collected on the 25th day of September, 1899, at the same point, which shows a variation of 3.7 per cent; and to the one collected November 1st of the same year, at the same place, which shows a variation of 15.6 per cent, and to the one collected on the 8th day of November of the same year at the same place, which shows a variation of 90.9 per cent, to the one collected on the 22nd day of November, which shows a variation of 9.1 per cent of total organic nitrogen contained in those samples so analyzed by yourself and Mr. Bisbee, all of these calculations with reference to the percentage in comparing the analyses of total organic nitrogen, as determined by Mr. Bisbee and Professor Palmer are based upon the premises that Professor Palmer's determinations should be 100 per cent of the total organic nitrogen contained in the samples of water, and examined at these several times?

A. In most the cases you have mentioned, there is no doubt in my opinion that the variations have resulted from the circumstances I have referred to in my answers, to the five or six preceding questions, but in the case of the sample collected on November 8th, 1899, where the difference is said to be 90.9 per cent, there is no doubt in my opinion that the
9148 difference in that particular case is due to some arithmetical error, not including the result from the original data of the analyses, or a clerical error in putting down the figures in the record, or typographical error in preparing the plates for printing.

Q. Professor, referring to the total solids in suspension as determined by yourself, and Mr. Bisbee on that date, to wit, November 8, from the samples analyzed by you, what is the percentage of difference?

A. The difference between the suspended matters upon the date in question based upon Mr. Bisbee's figure, namely, 26 parts, as of 100 per cent., or 828 per cent. if based upon my own figures, 2.8 parts, as 100 per cent.,—amounts to about 90 per cent.

Q. What is the total residue in suspension in the two instances?

A. The total residue in suspension as given in any data is 2.8 parts.

Q. What is it in Mr. Bisbee's?

A. In Mr. Bisbee's 26.

Q. And what per cent. did you say?

A. Ninety per cent.

Q. Now the variations in nitrates based upon your fig-
9149 ures as 100 per cent, would be 48.8 per cent, would it
not, as between yours and Mr. Bisbee's on the same date, to wit, November 8th, 1899?

A. It would.

Q. And for the same date and same water, calculating yours as 100 per cent, the variations in free ammonia between yourself and those of Mr. Bisbee, would be 30.9 per cent, and of total albuminoid ammonia would be 28 per cent.

A. They are approximately 30.9 per cent and 28. per cent respectively.

Q. Expressed in percentage, professor, what are the limits of accuracy in your analyses of water for the different determinations of organic matter contained in those waters?

A It is my opinion that in all probability the limits of accuracy in my determinations of the organic matters in water are in general, about ten per cent.

Q. Now does that percentage apply in your determinations of the water in the Illinois river, the drainage canal and Lake Michigan, with reference to the total solids, oxygen consumed, chlorine, free ammonia, albuminoid ammonia, albuminoid ammonia dissolved and suspended; total organic nitrogen, and dissolved and suspended organic nitrogen, nitrites
9150 and nitrates?

A. It does not apply equally to all of these, but was stated by me in response to a question concerning the limits of accuracy in determining the proportions of organic matters.

Q. Professor, state the limits of variation as to accuracy in parts per million of all chemical constituents, or of each of the chemical constituents determined by you in your sanitary chemical analyses of the water of the Illinois river at Kampsville; that is to say, what are the limits of variations in the results of the various constituents as determined in your laboratory, and expressed in parts per million?

A. With respect to the limits of accuracy in the determination of total solids in my laboratory, I would say that the determination was ordinarily accurate within two or three per cent. That if we assume the true figure for the content of total solids to be 400 parts per million, the limit of accuracy in the determination as made in my laboratory would come easily within 395 parts per million on the one hand and 405 parts per million on the other, although I have made no special determination of this in the case in question, but base this opinion upon my general experience with the analyses of these and
9151 similar samples.

With respect to the determination of the proportions of dissolved matters there is at times in my opinion a wider variation than this, due to the difficulty of filtering out the suspended matters. With respect to the proportions of suspended matters the proportional variation will be at times even more considerable, dependent upon the degree of completeness with which suspended matter, which are in all cases determined as differences between the total and dissolved matters are removed from the sample in the process of filtration.

With respect to the determination of the loss on ignition, this is less accurate than the determinations to which I have just referred, and in fact today little significance is attached to this determination because of the inaccuracies involved and because it throws little light upon the nature or the amount of organic matter contained in the water, and has been by many chemists, engaged in the sanitary chemical analysis of waters altogether abandoned. The same statement applies to the loss on ignition of dissolved matters. The determination of chlorine as conducted in my laboratory is subject to a variation perhaps of a half of one part per million and in the case of waters containing little chlorine as chlorides this would make a high percentage difference between duplicate determinations if
9152 it were not for the fact that in such cases a greater quantity of water was used in the determination, and the experimental error between duplicate determinations which is practically a constant, was upon these greater quantities considerably reduced in proportion and percentage. That is, in waters which were low in chlorine a greater volume was used

in the determination, but being concentrated to the same volume, namely, 50 cubic centimeters, employed in all of the chlorine determinations, the constant experimental error was reduced in proportion to the quantity of chlorine contained in the original sample.

In the case of the oxygen consumed, duplicate determinations in my laboratory, probably do not in my opinion vary more than five to ten per cent. Stated in parts per million, if there were ten parts of oxygen consumed by the organic matters contained in a water sample, the variation in the determination might make the proportion recorded nine and one-half parts per million or ten and a half parts per million. This would apply proportionally to the oxygen consumed by dissolved and suspended matters, subject of course to the differences due to the difficulties of completely removing suspended matters from the sample as referred to above in my statements regarding determinations of dissolved and suspended solids, but not so great proportionally.

9153 The determination of free ammonia as conducted in my laboratory upon duplicate samples, is subject in my opinion so far as my memory now serves, for I have not expressive data here at the moment, to a variation of perhaps ten per cent, although it will vary in different cases, and the proportion of nitrogen as free ammonia determined in given cases, will be less or greater according as the distillation employed in removing the free or saline ammonia, from the rest of the constituents of the water in the process of determination, is pushed to a greater or less degree, for in the determination of the nitrogen as free ammonia, the albuminous matters, that is the various nitrogenous organic matters contained in the water, suffer a decomposition and yield some of that nitrogen in the form of free ammonia which distills over and is included in the determination of the nitrogen as free or saline ammonia.

On the other hand, there are losses in the condensation of the distillate in which the nitrogen of the free ammonia is to be determined, which losses may amount to as much as ten per cent or even more, but which on the average would not in my opinion, be so great as this. I may say that in the method of determination of the total organic nitrogen, free ammonia contained in the sample was distilled off under precisely the same conditions as those prevailing in the determination of the nitrogen as free or saline ammonia, and the attendant determination of albuminoid ammonia, and that the proportion of nitrogen as albuminoid ammonia thus separated preliminary to the determination of the total organic nitrogen was in all cases determined, and corresponded very closely with the proportion of nitrogen as free or saline ammonia determined in the portion of the sample used, especially for the determination of nitrogen as free or saline ammonia and nitrogen as albuminoid ammonia, thus giving a check upon the determination of total nitrogen contained in the form of free ammonia, and of organic nitrogen as determined by the process of Kjel Dahl. 9154

ADJOURNED until 2:00 P. M. same day, Monday, November 23rd, 1903.

2:00 P. M., Monday, November 23rd, 1903.

9155 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for further cross-examination by Mr. Jeffries, and testified as follows:

Q. You may proceed with your answer to the last question professor, which was asked just before adjournment.

A. The variations in the determination of the proportions of nitrogen as albuminoid ammonia, as between duplicates run upon the same sample, would be probably as great as those upon the nitrogen as free ammonia, and to some extent would be the inverse of the same, that is, where the proportion of nitrogen as free ammonia in a duplicate was found to be greater the proportion of nitrogen as albuminoid ammonia in the corresponding duplicate would probably be smaller, but on the other hand the varying decompositions of the albuminous matters involved in the release of a portion of their nitrogen as free ammonia in the processes of analyses, would bring in other variations. On the whole, however, the determinations in my opinion do not

vary so greatly as those of the nitrogen as free ammonia.
9156 What has been stated in respect to the variations in the proportions of the dissolved and suspended matters in my statement concerning dissolved and suspended solids, and the oxygen consumed by dissolved and suspended matters, would apply to the determination of nitrogen as albuminoid ammonia from dissolved, and the nitrogen as albuminoid ammonia from suspended matters; since variations in the proportions of suspended matters removed by filtration would entail variations in the proportions of nitrogen as albuminoid ammonia derived from these substances in solution and in suspension, which vary as indicated in my statements above, according to the effectiveness of the process of filtration.

TOTAL ORGANIC NITROGEN.

The variations in the proportions of total organic nitrogen as determined by the Kjel Dahl process depend upon the completeness of the removal of the nitrogen as free ammonia, and the degree of decomposition of albuminous substances and other nitrogenous organic matters contained in the water in the process of removal of the free or saline ammonia. In the case of the waters analyzed by me in this series of investigations, the total organic nitrogen as determined, would from these causes probably be a little below the truth, for undoubtedly a small portion of the total organic nitrogen has been con-
9157 verted into the form of free ammonia in the process of distillation and removal of the nitrogen as free or saline ammonia, thus increasing the latter and being lost in the determination of the total organic nitrogen; but there are other sources of variation in the determination of the total organic nitrogen. The process involves the destruction of the nitrogenous organic matters through reaction with hot sulphuric acid, which destruction transforms the organic matters into inorganic substances, namely, carbon dioxide, water and ammonia. If in the digestion with the sulphuric acid the decomposition is not complete a portion of the total organic nitrogen may be left in such form that it does not appear in the subsequent processes as free ammonia, the form in which the nitrogen as total organic nitrogen is subsequently by the Nessler process,

quantitatively determined, thus giving a lower result. In my work upon this determination, care was taken to note so far as is possible, that the organic matters were completely destroyed, and to secure ourselves against the probability of any of the nitrogenous organic matters escaping, this complete destruction, and the complete conversion of the nitrogen contained in them, into the form of free ammonia, the liquids in the Kjel Dahl flask were heated for twenty minutes or half an hour
beyond the time which indicated the complete destruc-
9158 tion of the organic matters, that is, the complete clearing
up of the liquid and its becoming colorless, which ordinarily is regarded as showing the completion of said destruction. When the nitrogenous organic matters have thus been completely destroyed, which is attended by the conversion of the nitrogen contained in them into the form of ammonia, which remains in the form of a salt of ammonia in the sulphuric acid, in the flask. The next step in the process is the neutralization of the sulphuric acid by means of alkali and the addition of sufficient excess of alkali to set free the ammonia from the sulphate, the form in which it remains after the digestion of the sulphuric acid. At this point there is liability to error from loss of free ammonia, that is, the evolution and escape of free ammonia from the flask and later in the distillation there is liability to loss of free ammonia from imperfect condensation of the gas, as it is distilled off from the one flask in order to be condensed together with water as a distillate in another flask. Just how great the final loss and diminution in proportion of the total organic nitrogen from all these sources of variation is, I cannot state, but I am confidently of the opinion that as between any two duplicate determinations upon the same sample
as the determinations have been made in my laboratory,
9159 it is in my opinion not great, probably not beyond from
three to four per cent., and I very much doubt its amounting to as much as this.

The determination of the total organic nitrogen in dissolved and in suspended matters, the former of which is conducted in precisely the manner indicated above will vary from these same causes in the same proportion as does the determination of the total, but the distinction between the dissolved and the suspended matters depends not only upon these variations involved in the method itself, but also upon variations of the proportions of suspended matters removed from the original sample in the process of filtration as indicated in my statements with respect to the determination of other constituents, above.

Variations in the proportions of nitrogen as nitrites are far smaller in general than variations in the determination of the proportions of the other substances I have mentioned. It is true that the nitrites in particular vary from causes other than those mentioned above, often in far greater proportion than any of the variations I have referred to above, but from a given sample examined in duplicate in the laboratory the variations in the determinations between these duplicates will
9160 be extremely small. The sensitiveness in the process is frequently given as one part in 1,000 million, which would correspond to .001 parts per million as it appears in the analytical tables.

In the determination of the nitrogen as nitrates there is considerably greater variation owing to the fact that in the process employed, a portion of the nitrate may escape reduction to free ammonia, thus lowering the proportion found by Nesslerization of the free ammonia reduced in the process used and a further loss of the nitrogen undoubtedly takes place in the process of distillation of the free ammonia produced by reduction in this separation from the other matters present in the liquid, resulting from the reduction, and its conveyance into the distillate in which the free ammonia thus produced is to be determined.

Variations from these causes, as between duplicate determinations upon the same sample made in my laboratory, have amounted to from 2 to 20 per cent., and in general it is my opinion that the methods as conducted in my laboratory give results which in general are accurate to within about ten per cent., the results undoubtedly in all cases being below the truth, the variations from these causes not being such as to show more nitrogen as nitrates than was really present in the
9161 sample.

In considering the limits of accuracy in the determinations of these various substances, I would add that the proportions involved are stated in my testimony as parts per million, and that the quantities involved in all cases of determination of nitrogen in its various forms, are extremely minute. The determination of total organic nitrogen that has been referred to several times in my testimony today, one part per million corresponding to the determination of the presence of one pound of total organic nitrogen in a million pounds of water, and that of Mr. Bisbee referred to in connection with this involving as indicated by his figures, the determination of the quantity .6 of a pound of total organic nitrogen in a million pounds of water.

I would further add that in my opinion the comparison of the data of individual analyses from the various series of analyses introduced by me as evidence in my testimony does not constitute a very important part of said testimony, but that the comparison which I have instituted between the averages for the individual years, and for the three year period prior to January, 1900, and the three year period subsequent to the first of January, 1900, rests upon a reasonably accurate basis in fact, and that these averages made up as they are from the data of analyses of samples collected at regular stated periods, 9162 namely once a week, throughout the six year period mentioned, afford a sound basis for a comparison of the condition of the waters in the Illinois river at Kampsville during the two periods in question.

My opinion further is that the variations in the process of determination in the samples themselves, as they are collected, and which take place during the time that lapses between the actual moment of collection and the time the examination is begun, in the laboratory, are substantially the same for all the various samples taken throughout the entire six year period, and that consequently the data secured by the analyses of all these samples, that is, particularly the averages computed therefrom, are strictly and reasonably comparable for the purpose of showing the condition of the water at this point during the two periods.

It is true that the averages do not show all the variations in both directions which take place in the proportions of these

substances contained in the water, and as I have stated elsewhere in my testimony, they are neither intended to do this, nor can they be reasonably expected so to do any more than a table of the average mortality of men in a certain class of occupations, and of certain age, can be expected to show
9163 the variations in the length of life of said men, although it is made the basis for conduct of the business of life insurance, and I would further add that the variations which may take place during the period covered by the analyses and especially during the intervals of time between the collection of various successive individual samples are by no means so great as the variations in the length of the lives of men of a given class and occupation and age, which are included in the averages used by insurance companies as the basis for the insurance of the lives of men; for in cases where the average life of men of a given class and occupation and age may be 20 years, oftentimes it happens that individuals of this class decease within a few days or perhaps hours, and others live far beyond the average length of time alloted for the life of said individuals as computed by the actuaries of insurance companies in their tables of averages above referred to. On the other hand, there is in my opinion absolutely no probability that any such extreme variations or anything comparable with such extreme variations takes place in the proportions of the various organic substances contained in the waters of the Illinois river at Kampsville between the time of the collection of various successive samples.

With respect to the duplicate determinations of dissolved
9164 oxygen I would say that in general the variations between duplicates are but slight at times, reaching as much as one part per million out of from 15 to 16 parts per million as recorded in the results of the analyses, a variation of about six per cent., but take the entire series of examinations submitted by me in evidence, and it is my opinion that the variation between duplicate determinations for the entire series would fall far short of this, probably not more than .1 of a part per million on the average, although it is true I have prepared no averages from these series, that is, as between the duplicate determinations.

Q. Professor, is it not a fact that organic nitrogen results by the Kjel Dahl process are affected by high chlorine contents due to the formation and escape of tri-chloride of nitrogen?

A. As to that I cannot state definitely, for the reason that I know of no one who has demonstrated the presence of nitrogen tri-chloride in the mixture undergoing this reaction, nor in the products which escape during the action, but it is my opinion that high chlorides together with high nitrates, do result in loss of a portion of the nitrogen contained originally in the water in combination with organic substances.

Q. And may not that loss be a material percentage?

9165 A. I believe it may be.

Q. Professor, what allowances have you made for error in analyses made for organic matter due to changes enroute during the transportation of the samples from the place of collection to the laboratory?

A. I have made no allowances whatever for errors resulting from changes in the organic matters contained in the water samples while enroute between the point of collection and the laboratory, where the analyses were made, but have put in evidence the data precisely as they were obtained, as a result of the analyses in question, and am of the opinion that no allowances for this are necessary or important in this case, for the reason that the conditions as to the collection of samples, shipment and lapse of time between collection and arrival at laboratory and commencement of the analyses were similar throughout the entire six years period, and consequently such changes as may have occurred while the samples were being transported from the river point where they were collected, to the laboratory where they were analyzed, will have equally affected on the average those samples collected during the earlier three years period, and the samples collected during the latter three years period, and so do not militate against the reasonableness of the basis upon which my comparisons of the condition of the water during these two periods was

9166 made.

Q. Was there not a change in the organic matter contained in those samples while enroute from the point of collection to the laboratory?

A. There was undoubtedly some change in the organic matters contained in the samples of water while said samples were enroute from the point of collection to the laboratory, but these changes, as I have repeatedly stated, were undoubtedly similar in character and in amount on the average for those samples collected during the one period and the samples collected during the other period.

Q. How do you know that?

A. In my general experience in the examinations of waters for the purposes of determining their sanitary chemical condition I have made comparisons and comparative analyses of samples which have been kept for longer and shorter periods of time such as to demonstrate to my satisfaction the fact that organic matters in water samples which are allowed to stand for various lengths of time do suffer change in the nature of the proportional content of the organic matters in them, and in the case of the various data which I have introduced in evidence here I know that the conditions of temperature in the water samples, temperature of the air, length of time during which the samples were in transit, passed through the same
variations during the first three year period, that they
9167 did during the second three year period, that is, the first
three year period included the various seasons of the
year with all the seasonal changes as to flow of water in the stream, precipitation, temperature of air and water, variations in the content of the proportions of the different constituents of the water and so on, which were similar to the variations in all these respects which maintained during the second three year period. I have for my own satisfaction made some few determinations directed to the purpose of determining how much change took place during the time that elapsed between the collection of the sample and its arrival in the laboratory, with respect to the dissolved oxygen, this has been set forth in detail in my testimony heretofore given. Some determinations of nitrites in the waters of the Illinois river at Grafton on June 23rd and 24th, 1899, showed that in the water of the Illinois at Grafton on the morning of June 23rd, 1899, at a depth of one foot, there was about .025 parts of nitrogen as nitrites per million, and at a depth of 18 feet the same spot in the same waters

the proportion of nitrites was .028 parts per million, and about 30 hours later, that is, upon June 24th, at the depth of one foot, the proportion of nitrogen as nitrites was found to be .026 parts per million. Unfortunately, data for the nitrite determination upon samples collected at this
9168 time and transported to the laboratory, have been lost
or mislaid, but the data secured from the analyses of waters collected upon days just preceding and other days following, at intervals of one day, on the one hand and of four days on the other, in the time of collection of these samples, show the proportion of nitrogen as nitrites as contained in said samples to be .109 and .033 respectively, which are substantially comparable with the proportions of these constituents found in the samples taken upon the spot.

Upon July 21st, some determinations were made as the water was taken from the river at Averyville. I found the proportion of nitrogen as nitrites to be .25 parts per million in one sample, and .23 parts per million in another sample, while determinations at the laboratory made upon sample collected upon July 18th, showed .46 parts of nitrogen as nitrites per million, and determination upon the sample collected upon the 24th, examined in the laboratory upon the 25th, showed .29 parts of nitrogen as nitrites per million.

Determinations upon the water of the Mississippi river at Grafton made upon June 24th, 1899 practically at the same time, that is upon the same day as those referred to with respect to the Illinois at Grafton, showed a content of nitrogen as nitrites,
of .001 parts per million, while samples collected from
9169 the Mississippi river at Grafton upon the 21st and the
28th of June respectively and examined in the laboratory 48 hours after the time of collection, showed a content of nitrogen as nitrites .004 of a part per million and .002 of a part per million respectively.

Q. Professor, have you taken into account the errors if any, in each constituent analyzed by you from the samples of water during this period of years, due to sampling, that is, the samples of water analyzed not being the representative of all the water in the stream at the time and place of collection?

A. I have taken that into consideration in this respect, that in my opinion variations in the determinations due to variations in the sampling are eliminated in a long series of collections and analyses by the fact that at one time the variation will undobtedly be on the upward side, and at another, upon the downward side, so that in a long series of examinations of waters taken from the same river at the same point, these will neutralize each other, and thus afford a series of results which are strictly comparable in the form of averages.

Q. Then it is a fact professor, is it not, that the nitrogen compounds do change in transportation?

A. There is no doubt in my opinion but that such changes take place during transportation.

9170 Q. Professor, this morning you referred to the fact that certain methods might be used in making chemical determinations of water which would show a percentage of variation such as is shown by a comparison of the results obtained by yourself, with those obtained by Mr. Bisbee from samples of water collected from the same river at the same point by the same collector at the same time. Now I would like you to state in evidence what difference in methods would produce such great variations in results?

A. The differences which were the subject of several questions this morning, bore particularly upon the proportion of total organic nitrogen. In this determination the methods followed by Mr. Bisbee and by me were, in my opinion, in general, of the same sort, and the differences due to variations in the method rest upon differences in detail. So far as I am aware, it is my opinion that Mr. Bisbee gave less consideration to the possible loss of nitrogen contained in the nitrogenous organic matters, during the process of removal of the free or saline ammonia, and on the other hand, to the complete removal of the free or saline ammonia before adding the acid for the determination of the total organic nitrogen.

Then too, as was stated in his testimony, the heating with sulphuric acid was continued until the contents of the
9171 flask became colorless, or a faint straw yellow color. In
my own work, we were very careful, as I have stated above, in answer to questions of yours today, to distill off the free or saline ammonia from the portion which was to be used

for the determination of total organic nitrogen under precisely the same conditions as were maintained in the determination of the nitrogen as free ammonia to be so recorded in the analyses. That is, we collected this distillate and Nesslerized it as a duplicate determination of free or saline ammonia, and thus assured ourselves that such decomposition of the total organic nitrogen as may have occurred in this process was practically the same in the portion used for the determination of free or saline ammonia, and after it, of the nitrogen as albuminoid ammonia, and in that sample used for determination of the total organic nitrogen, and incidental to this, we thus assured ourselves of the fact that the free or saline ammonia was all removed from the portion which was subsequently to be treated by the Kjel Dahl process.

Then too, in the digestion with the sulphuric acid, we, as I have stated above, pushed the digestion beyond the point at which it appeared that the organic matters were all destroyed. That is, when from the appearance of the mixture in the flask we felt assured that the organic matters were act-
9172 ually destroyed, we continued the digestion for from twenty minutes to a half an hour, as a further assurance of complete destruction.

9173 Q. Now Professor, how do you reconcile your last answer with the statement made this forenoon that as to the constituent known as organic nitrogen the analyses determined by yourself, and those determined by Mr. Bisbee, upon comparison showed sometimes you found more of such a constituent and sometimes less than he did in his analyses?

A. The statements which I have made in my answer to your last question covered the variations in both directions.

Q. Professor, is it not a fact that animal matter is a more fruitful source of free ammonia than vegetable matter, other things being equal?

A. In my opinion it is.

Q. Professor, do you know anything about what is known as the septic process?

A. I do know a little.

Q. Is dissolved oxygen as shown by your analyses ever absent from the waters of the drainage canal or the Illinois river since the canal was opened?

A. I made but three or four determinations of dissolved oxygen in the waters of the sanitary canal, but such as I have made did not reveal the absence of dissolved oxygen therefrom, and I have at no time found the waters of the Illinois river in its lower stretches wholly devoid of dissolved oxygen.
9174 However, in the water of the sanitary canal at the Bear Trap Dam on August 14th, 1900, I found but 5.88 per cent saturation with dissolved oxygen and on June the 29th, at the same point, but 10.88 per cent saturation with dissolved oxygen.

Q. Is it possible for a septic operation to be going on in a water where analysis shows nitrogen in the form of nitrates?

A. With respect to that the only information which I have personally upon the subject is the result of examination of sewage entering, and the effluents proceeding from septic tanks which showed the presence at times of nitrates in the effluent of the septic tank, from which it may be inferred that a septic action going on within the tank, went on with the presence of nitrates.

Q. What were the conditions under which those analyses were made?

A. These were somewhat unusual conditions in that septic action was at the time defective, that is, not complete, the flow through the tank being greater than the capacity and condition of the tank really warranted, or in other words, there was too much work for the tank under the conditions.

9175 Q. Then it was more a settling tank than a septic tank wasn't it?

9175 A. In my opinion no septic action was going on evidently in the tank.

Q. How long did it take the sewage to flow through that tank?

A. As to that I could not at present give you the data.

Q. That tank was located at what place?

A. In the town of Urbana, Illinois, the tank belonging to and handling the sewage of Champaign, contiguous to the town of Urbana. Each town has a septic tank and has had for many years.

Q. Is it not a fact that decomposition and putrification reduce to their simplest and most noxious forms, the various compounds contained in sewage, and that they are restored to their natural conditions more rapidly in a septic tank than under any other conditions?

A. It is in my opinion true, that a septic tank affords one of the best and quickest means of resolving the constituents of sewage into simpler and less noxious forms, but the action of the septic tank never completely resolves these matters into the simplest forms, and following upon the series of decompositions which it produces, there must, in order to bring about the oxidation of these products and their conversion into other sets of simpler forms, be a new or other series
9176 of agencies set in operation.

Q. Professor, is it not a fact that during flood conditions in the Illinois river, that weekly samples may fail to reveal sediment of a very objectionable character?

A. Not in my opinion if the samples are collected during the said flood period.

ADJOURNED until Tuesday morning, at 10:00 A. M., November 24th, 1903.

9177 10:00 A. M., Tuesday, November 24th, 1903. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

cross-examination resumed by Mr. Jeffries.

Q. Professor, how do you account for the variations reported by you in the total nitrogen discharged by Chicago sewage into the Illinois river, that is to say, 29.18 tons per day as an average for April, 1901, and 61.35 tons per day for October, 1901, when during 1900, the corresponding figures in your table show 38.74 tons for April and 27.44 tons for October?

A. This difference is very largely due to the fact that during the months of January, February, March and April, 1901, the pumps at Bridgeport, were not in operation, so that there was no discharge of sewage through the Illinois and Michigan canal, thus reducing particularly the quantities of nitrogen as free ammonia discharged in Chicago sewage into the Desplaines river. During the year 1900, on the other hand, the pumps were in operation continuously throughout the year.

8178 During the month of October, 1901 the pumps at Bridgeport were in operation, thus discharging nitrogenous organic matters and nitrogen as free ammonia through the Illinois and Michigan canal into the Desplaines river, in addition to the quantities sent down through the drainage canal. The abnormally high quantity of total nitrogen discharged through the two canals into the Desplaines in October, 1901, was due in the main to an unusually high content of nitrogen as free ammonia in the waters of the Illinois and Michigan canal during the month of October, 1901. Reference to the table of detailed analyses shows that for the four samples which were collected from the Illinois and Michigan canal at Lockport during the month of October, 1901, the following proportions of nitrogen as free ammonia, to-wit: 31.2, 35.2, 28.8 and 32.8 parts per million of nitrogen as free ammonia for the four collections upon the dates as follows: October 7th, 14th, 21st and 28th, respectively. Just what may have been the source of this high proportion of free ammonia in the waters of the Illinois and Michigan canal, I cannot say, but it is a known fact that the liquid raised by the Bridgeport pumps into the Illinois and Michigan canal comes mainly from the south fork of the south branch, which is practically a septic tank, and which
9179 receives the sewage and wastes of the stock yards district, and that in this liquid occupying the south fork of the south branch the content of nitrogenous wastes is subject to considerable variation.

Q. Is it not a fact professor, that the Bridgeport pumps in the Illinois and Michigan canal were in operation during the month of October in both years, that is, 1900 and 1901?

A. It is.

Q. Professor, if it should appear in evidence that a series of cross-section samples of water for chemical analyses give results materially different from the results of your analyses of samples collected at a single sampling station at a given time and place on the Illinois river, would not that affect the accuracy of your results according to the variation between your analytical data and those representative of the entire stream flow at the given time and place, assuming that the methods of analyses in all cases were substantially identical?

A. If the assumptions included in this question were all granted, the effect would not be to show that my analytical data were not correct, but they would show that the data of the analyses made by me for a single sample at the given point, was not fairly representative of the entire body of water
9180 passing down the stream past the cross-section line indicated by your question.

Q. Assuming that samples of water are collected for analyses from a river once a week, or 52 days out of 365 per year, is it not a fact that much deleterious organic matter may pass a given place in the river and escape detection by analyses?

A. That depends very much upon various conditions which are not stated in the question. It depends upon the place and upon the proximity of discharge of said deleterious substances. In the near proximity of the place where such substances are discharged into the river, it is a well known fact that oftentimes the mixing is not complete and that it is not completed for some distance below such point, so that a single analysis taken once a week at one point, at such a locality in a river might not reveal the presence of deleterious substances passing down at that point, owing to the fact of the incomplete mixing to which I have referred, but in cases where such mixing is known to be complete, then the analyses taken once a week at a number of points along the stream below that at which the mixing is complete will reveal the presence of such substances as are contained in the water, so far as the methods of sanitary chemical analysis subserve that purpose.

9181 Q. How do you account for the range of suspended residue on evaporation in 1900 in the Illinois river water at Averyville being from 1.6 to 297.6 parts per million, and in the same river water at Kampsville during the same year the range being from 4.8 to 1047.2 parts per million?

A. The suspended solids at Averyville as recorded in table 53, were 1.6 parts per million on February 6th, 1900, and 297

parts per million upon February 13th, 1900. Between these two dates there was a considerable rise in the Illinois river at various points along its course, due to rains and melting snow, one or both, and the conditions on February 6th at Averyville were those which obtained before this rise in the river, while the next date when samples were collected, namely, the 13th of February, the suspended matters were found to be 297 parts per million. This was just after this sudden rise of three feet as it appeared at Kampsville, but a more considerable rise in the upper part of the river. Naturally when rivers rise from rainfall, much surface wash is carried into the stream, thus adding to the proportions of suspended matters, and a further increased velocity of the stream at such times keeps in suspension other things being equal, a greater proportion of the suspended matters brought into the water and adds to such suspended matters by the erosion of the banks and sand-
9182 bars in the stream.

With respect to the data mentioned for Kampsville, a similar explanation affords the key to the occurrence, namely, the very considerable rise in the river at this point—two of them in fact between the dates of January 17th, 1900, when the figure 4.8 parts of suspended solids per million is given, and the figure 1047.2 parts suspended solids per million for February 14th. I may say too, that along the lower course of the Illinois river there are a number of minor tributaries which are subject to very sudden rise, and which at times bring down enormous proportions of silt and clay, so that the quantities of these matters contained in the waters of the Illinois, and the proportions of them contained in the waters of the lower Illinois are often far in excess of the proportions contained at many points further up the river, that is, towards its source.

Q. Professor, do your analyses show in any way whatever the effect of the sewage and sewage mud coming from Chicago down the Illinois river caused by the opening of the drainage canal, January 17th, 1900?

A. They do not, in my opinion.

Q. From your analyses I understand you to say then there is no evidence of any change so far as the effect of the sewage

and the mud coming from the City of Chicago and the
9183 Chicago river down the Illinois river immediately subsequent to the opening of the drainage canal in January,
1900?

JUDGE SPRINGER: The last question is a very different question. One says, "caused by the opening of the drainage canal, January 17th, 1900," and the other says "immediately subsequent to the opening of the drainage canal in January, 1900."

A. From my analyses there is nothing to distinguish between the various constituents determined by said analyses or such proportion thereof as was derived from the sewage of the City of Chicago and such portion as was washed into the stream in the sewage of other towns, and from the run-off along the tributaries and the banks of the Illinois itself during this period,—this applying to the analyses of the waters of the Illinois river itself. On the other hand there was and is shown in the tables of analyses and upon some of the plates,—one at least,—an effect in the Desplaines river at Joliet in a considerable increase in the proportions of nitrogen as free ammonia; of nitrogen as albuminoid ammonia; of total organic nitrogen as determined by the Kjel Dahl process during the time immediately subsequent to the opening of the Chicago main drainage channel upon January 17th, 1900, but in the
lower river, that is, along the Illinois river, proper, there
9184 is nothing in any analyses that does distinguish between
such matters as were brought at this time in from the sanitary canal or Chicago main drainage channel, and that brought in other ways into the waters of this stream as indicated above, in my answer. So far as the question assumes a great discharge of Chicago river mud at this time, I have serious doubts about such discharge ever having taken place.

Q. Professor, with your knowledge of the Illinois river prior to the opening of the present drainage canal and with your knowledge of both the Illinois river and the drainage canal since the opening of that canal, and assuming that the canal was opened, on the 17th day of January, 1900, and assuming further that immediately subsequent to the opening of that canal and during the latter part of January, the month of February and the early part of March, the water in the Illinois river at Grafton and the Mississippi river below Grafton, assumed a black sewage muddied condition at times, and that that condition pertained throughout the entire stretch of the Illinois river from the drainage canal to the intake tower at the chain of rocks at St. Louis, what if anything do your sanitary analytical examinations of the water of those rivers and of the canal show in reference to the presence of such polluting substance therein contained?

9185 JUDGE SPRINGER: I object to this question for the reason that it does not include in the assumptions contained in the question the assumption that such changes were not produced by the seasonal changes at that season of the year, or by a flood in the river which would have been sufficient to account for these conditions.

MR. JEFFRIES: So far as Judge Springer's objection is concerned, I will state to the Court that it makes no difference what the source of this polluting substance was. The question is based altogether upon the condition of the river at the time mentioned in the question, which was immediately subsequent to the opening of the Chicago Drainage Canal.

JUDGE SPRINGER: Still, the answer which counsel anticipates and desires to bring out, relates to the opening of the canal as the probable cause of the conditions to which he has referred.

MR. JEFFRIES: For the satisfaction of counsel I will state that the evidence thus far introduced as coming from the witnesses for the complainant and the witnesses for the defense is that such condition was caused by the opening of the drainage canal, but that proposition so far as this question is concerned, will not and cannot affect the answer of the witness.

JUDGE SPRINGER: I desire to say further as to what 9186 this record shows, is not for me to state at this time. The record will speak for itself.

MR. TODD: I object to the question for the reason that the assumptions contained in the question have not been proven, and that there is no evidence in this record for the complainant or the defendant that shows that a black sewage muddied condition obtained in the Illinois river at Grafton or the Mississippi river below Grafton during a period of three months as assumed in this question, and that no witness has testified to the presence of sewage from whatever source, as being in the river during these three months at that point, based upon vision, as I assume the question has reference to.

(Q. Question repeated.)

A. So far as the assumption of a black sewage muddied condition of the Illinois river water throughout its length, or at various points along it, and the same condition including Grafton and the Mississippi river between Grafton and the chain of rocks, is concerned, I would state as my opinion that such assumption is altogether beyond the fact, that no such condition was to my knowledge, observed along the course of the Illinois river, nor at Grafton, nor in the Mississippi river between Grafton and the chain of rocks, but that on the other hand, the results of my analyses, particularly those having to do with the appearance and the odor of the water, indi-
9187 cate that no such condition maintained or held except that in the upper stretch of the Desplaines river in the vicinity of Joliet, the odor of the water as recorded in table 44 of the series of analyses I have submitted, as gassy, from January 2nd to March 26th, 1900, and that the water in the Illinois river at Morris, collected upon January 26th, 1900, had an odor which is indicated as gassy. There is nothing else in the series of analyses included in my tables which indicates directly a more than usually large proportion of sewage contained in these waters. On the other hand the variations in color and in the proportions of suspended matters and in the color of the suspended matters contained in the water during this period, were not different from those observed in other years in like seasons.

I would further add that I obtained from the various collectors of water samples along the river, information concerning the appearance of the water at this time and in no case did they note an unusually dark or black sewage colored mud contained in the water. They failed to note anything particularly different from the usual appearance during the season of high water in the Illinois river, in the spring.

9188 Q. Is it not probable that during flood periods weekly analyses of river water taken at the same point may furnish much less accurate data than daily samples from the same river at the same place?

A. Under such conditions, that is, assuming a sudden flood, or a sudden fall during the intervals between collections of samples, such collection would not through the sanitary chemical analysis reveal all the conditions between these times; but several collections, a week apart, taken during a general flood period, will in my opinion, give fairly accurate evidence concerning the condition of the water during the intervals between. I may add that in order to cover such possible differences between the times of weekly collections, we made daily collections from the Illinois river at Grafton throughout most of the period now in question, namely the three months subsequent to the opening of the Chicago main drainage channel, and I have included in my answer above to the preceding question, the inspection of the records covering such daily collections and analyses.

Q. If such flood conditions happening upon your weekly samples should appear then in evidence, it would affect would it not, the accuracy of your average results?

9189 A. It would, as I have stated in my answer to the preceding question, for the other periods covered by such change in conditions of flow as take place between the date of collection of the yearly samples, but it would not affect the general averages for the year in such a manner as to make those for the different years incomparable with each other upon a substantially accurate basis, for the reason that the same variations appear in the flood seasons of different years.

Q. Assuming that on an average deleterious organic matter coming from Chicago sewage and entering the Illinois river, would become innocuous by the time it reaches Averyville, and assuming further that on certain occasions such deleterious organic matter reaches the chain of rocks at St. Louis before it becomes innocuous, would the statement of averages, the average conditions alone, be true and correct when the matter is viewed from a sanitary standpoint, as a practical proposition?

MR. TODD: I object to the question because the assumptions contained in the question have not been proven, and for the further reason that the time between Chicago and St. Louis

as put in the evidence is in excess of a week, and that
9190 the innocuous matter cannot pass from Chicago to the
chain of rocks without being present at some of the points where samples of water were taken from which the analyses were made, for the making of the table of averages.

A. I am not ready to grant the correctness of the second assumption, but the truth and correctness of the tables of averages are independent of any standpoint, whether that of a sanitarian or a chemist of a mathematician, and in my opinion they afford a proper and reasonable basis for the comparisons which I have instituted between the averages for the various years and for the two three year periods.

Q. If the sanitary chemical analysis of the water shows the water in question to be good during 51 weeks in the year and unsafe for drinking purposes for one week, would the average results for the year reveal this feature?

JUDGE SPRINGER: I object to this question because the assumption has not been proven in this case. It is a mere abstraction, and any answer to it cannot be responsive to any of the issues involved in this case.

A. If we should grant the first assumption and the second assumption, the average results for the year could not be expected and would not be intended to show the condition assumed in the second assumption.

9191 Q. Wouldn't it be possible to have several analyses of
the water in question which would be called unsafe for drinking purposes and still not have the facts disclosed by the analyses of such samples covered by the results, as stated in your table of averages, or in the tables of averages?

A. That might very easily be the case, but I wish here to call attention to the fact that all the various analyses are given in the tables together with the averages; that is, at the foot of each table covering a year or a lesser period, in case the whole year was not covered by the analyses and analyzed, the averages appear for such periods.

Q. Professor, assuming that there is discharged into the Illinois river by means of the drainage canal, the sewage from the city of Chicago which contains certain organisms which produce typhoid fever; assuming that those organisms are of

a living character and that they live in the sewage of Chicago the drainage canal and the waters of the Illinois river from five to thirty days or more, disappearing by death gradually at from five to thirty days or more until at the end of thirty days or more, all have become innocuous; assuming further that they flow down the canal to the Illinois river with the water and with the same velocity as the water in the canal and
9192 the river. Assume that the mean velocity from Chicago to St. Louis is eighteen days; assume that the average life of these organisms has expired at some point between Averyville and Grafton, but assume also that as heretofore stated, the extreme life limits will carry them in thirty days or more to a point far below St. Louis. State whether or not a table of averages upon the life limit of these organisms, which shows that such average took place at some point in the river between Averyville and Grafton, can be used by a sanitarian, or by a sanitary chemist, as proof from a practical sanitary standpoint that no such disease producing organisms pass a given point between Averyville and Grafton and do not reach the St. Louis intake at the chain of rocks and pass beyond the city of St. Louis.

JUDGE SPRINGER: I object to this question for the reason that it assumes the existence of a table of averages as to the longevity of pathogenic micro-organisms, which fixes that longevity at from five to thirty days. As no such table of averages has been introduced in this case, any answer which the witness could give as to the effect of such table would not tend to prove any of the issues in this case, and for the further reason that the testimony already submitted in this case by Professor Zeit, based upon actual experiments as to the
9193 longevity of the typhoid fever bacteria, in the water of the Illinois river at Grafton, places the limit of the longevity of said micro-organisms at six days.

MR. JEFFRIES: I suggest to the Court that the testimony of Professor Zeit, does not show any such conditions or any such fact, and I suggest also that it is not a question of what the testimony of any one witness of the defense shows, but of what the testimony of all the witnesses as to the longevity of the typhoid bacilli or any other disease producing germ is in water, such as the drainage canal and the Illinois and the Mississippi rivers.

I suggest to the Court further in answer to Judge Springer's objection, that this witness has stated that the science of chemistry did not disclose the kind, character or characteristics of disease producing organisms in water. That the witness did state that if such disease producing organisms were in water that they would be and appear in the total organic nitrogen, the evidence in this case shows that the organic nitrogen commences in the canal and continues to Grafton in the Illinois river and to St. Louis. I suggest also that the witness is unable to
state that anything in the science of chemistry would dis-
9194 close the fact whether or not disease producing or-
ganisms will disappear in canal water as rapidly as other nitrogenous organic matter, and I suggest the witness has so testified and has made tables of averages and exhibited them in evidence upon the subject of total nitrogenous matters contained in the waters of the Illinois river and as this evidence in this case shows that the longevity of the typhoid bacilli is from five to thirty days or more, varying according to the testimony of the various witnesses, that the question is competent for the purpose of showing that no reliance can be placed upon such table of averages as applied to the science of chemistry, and as applied to the sanitary chemical analysis of water in a running strem.

JUDGE SPRINGER: I desire to suggest to the Court in response to the statements submitted by Mr. Jeffries, that a designation of pathogenic micro-organisms as other nitrogenous matter is not correct as applicable to the nitrogenous organic matter disclosed by chemical analyses. That the presence of pathogenic micro-organisms in water depends solely upon the fact as to whether there has been a human being having the disease of typhoid fever, or a disease produced by other pathogenic germs, and whether the dejecta of such patients has been
deposited in the water, and that whether these chemical
9195 tables disclose the nitrogenous organic matter or not,
does not tend to prove in any way the presence or absence of pathogenic micro-organisms, and that the question in this respect is misleading and improper.

A. It, in my opinion cannot, but the conditions prevailing in the Mississippi river between Grafton and the chain of rocks as to the mixing of the waters in the Illinois with the waters of the Mississippi and the waters of the Missouri, render it, in my opinion, highly improbable that any considerable proportion of such pathogenic germs as may be contained in the waters of the Illinois at Grafton,—that is, if we grant the assumptions of the question passes down the Mississippi to the point below, St. Louis, and is taken into the intake of the St. Louis waterworks.

ADJOURNED until 2:00 P. M. same day, Nov. 24, 1903.

2:20 Tuesday, November 24th, 1903.

9196 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. ARTHUR W. PALMER,

resumed the stand for re-direct-examination by Judge Springer and testified as follows:

Q. Professor, is there in your opinion, any evidence given by your analyses that septic action takes place in the waters of the drainage canal?

A. In my opinion there is.

Q. Will you give your reasons for that opinion?

A. The comparisons of the averages which appear in table D heretofore introduced in my testimony representing the analyses of the waters taken from the sanitary canal at Kedzie Avenue at its Chicago end, and taken at Lockport at the Bear Trap dam, for the four summer months, June, July, August and September, 1900, show a series of changes of the organic matters which are of the same nature as the changes which take place during the passage of sewage through a septic tank.

9197 MR. JEFFRIES: I move to strike out the question and the answer and any further answer that the witness may give to this question for the reason that it is not proper re-direct examination.

JUDGE SPRINGER: I will state in regard to this fact, that the subject of septic action was referrred to, only incidentally, in the direct examination of this witness, but was brought out by cross-examination.

MR. JEFFRIES: Not with reference to the canal nor the Illinois river.

JUDGE SPRINGER: What reference would it have then?

MR. JEFFRIES: The only question was, I asked the witness whether he knew what septic action was, and asked him to explain it, and that was withdrawn, and the only reference made to septic action was that made with reference to a septic tank or tub at Urbana, Illinois, as stated by the witness, and that the cross-examination extended no further than that.

JUDGE SPRINGER: I desire to state in reference to this objection that whatever reference witness made to septic action in the tanks at Urbana, Illinois, had some bearing I assume, upon similar action in the Chicago drainage canal; othewise it would have been incompetent and would not have borne
9198 upon any of the issues in this case.

MR. JEFFRIES: I would like counsel to state whether or not that inference, applied, if it was an inference, to conditions prior to the opening of the drainage canal or subsequent to the opening of the canal. I have never cross-examined the witness on the septic action of the water in the Chicago river prior to the opening of the canal, nor in the canal since the opening, nor in the Illinois river. The question that I asked was a general question with reference to the witness' knowledge upon the question of septic operation, and if it was true that the witness was qualified to speak of the septic conditions of the Illinois river, and of the canal since the opening of the canal it was competent and proper for defendant to have examined the witness in reference thereto, in chief and not have delayed the matter until his re-direct examination. I submit that such manner of examination of the witness is unfair for the reason that it eliminates a large part of the knowledge and information of this witness if he is acquainted with the septic operation of the water in the Illinois river and the drainage canal and the canal prior to the opening, until after the cross-examination has been completed, and for this reason is contrary to all rules

of evidence bearing upon the direct examination, cross-
9199 examination, re-direct and re-cross-examination of witnesses.

JUDGE SPRINGER: If counsel for complainant insists that the reference made in the cross-examination, made to the septic action taking place in the tanks at Urbana, had no bearing upon this case, then I withdraw the question.

MR. JEFFRIES: I will state now that the only object and the only purpose that I had in asking the question of this witness as to whether or not he was acquainted with the septic operation of sewage in a septic tank, was for the purpose of either showing that the witness did or did not know, in order to give the Court an opportunity to determine the credibility of the testimony of this witness, as a whole, and to determine the weight of the testimony coming from the defendants, who placed the witness on the stand and on the examination made in chief.

JUDGE SPRINGER: Then it was for the purpose of affecting the credibility of the witness and not for the purpose of proving the fact?

MR. JEFFRIES: For the purpose of proving the credibility of the witness' testimony and also for the purpose of showing the strength and weight to be given the testi-
9200 mony because of the defense having withheld such examination until after he had been cross-examined.

JUDGE SPRINGER: It seems therefore that the introduction of the subject on cross-examination was for a double purpose, not only to bring the fact into the case, but of testing the witness' credibility, and for this reason, it is competent for the witness to explain fully his opinion upon this subject.

MR. TODD: I desire to suggest that as far as a violation of the rules of proper examination of witnesses is concerned, that that rule has been violated from the very beginning of this case and any question that was asked was objected to and the answer given and recorded in the record, and if the facts appear that counsel interrogated the witness on the question of septic action, the fact that counsel states the limitations he placed upon the object of his cross-examination is not patent from the record, but merely from counsel's statement, and in

view of the statement that the examination went not only to the weight of the testimony, but to the credibility of the witness, and in view of the fact that counsel is not precluded from further cross-examination even if it appears to be new matter to the Court, we deem the question of sufficient importance, in view of all the circumstances, to be competent at this
9201 time, reserving to the complainant all rights which he may see fit to avail himself of. •

(Question and answer read).

THE WITNESS: (Continuing) Thus the average proportion of the total oxygen consumed by the water collected from the sanitary canal at Kedzie Avenue, was, for the four months in question, namely, June, July, August and September, 1900 8.9 parts per million, while the proportion contained in the waters collected at the Bear Trap Dam during the same period was upon the average, 8.8 parts per million, showing a reduction of 1.1 per cent in the proportions of total oxygen consumed. The proportions of oxygen consumed by the dissolved substances in the water at Kedzie Avenue, were 4.6 parts per million, while the proportion required by the water at the Bear Trap Dam was 7 parts per million, showing an increase in the proportion of oxygen consumed by dissolved matters as between the samples collected at these two points on the drainage canal, of 52 per cent.

The proportion of oxygen required for suspended matters was, for the samples collected at Kedzie Avenue 4.3 parts per million, while the proportion required by the waters collected at the Bear Trap dam were 1.8 parts per million, showing a reduction of 6 per cent.

The average proportions of free ammonia found in the waters at Kedzie Avenue, were 1.174 parts per million,
9202 while the proportion found at the Bear Trap dam was 1.235 parts per million, showing an increase in the proportion of nitrogen as free ammonia of 5.2 per cent.

The nitrogen as albuminoid ammonia, that is the total for Kedzie Avenue, was .45 parts per million, while the proportion found at the Bear Trap dam was .426 parts per million, a reduction of 5.3 per cent.

The proportion of nitrogen as albuminoid ammonia derived from dissolved substances was for the Kedzie Avenue sample, .158 parts per million, and for the sample collected at the Bear Trap dam it was .218—showing an increase between these two points in the dissolved albuminous matters in the proportion as against the nitrogen contained, of 38 per cent.

The nitrogen as albuminoid ammonia derived from suspended matters was, in the Kedzie Avenue sample, .292 and for the samples at the Bear Trap dam, .208—showing a reduction between these two points of 28.7 per cent.

The total organic nitrogen for the Kedzie Avenue samples was 1.047, and for the samples taken at the Bear Trap dam, it was .902, a reduction of 12.9 per cent.

The total organic nitrogen derived from dissolved matters was at Kedzie Avenue, .365, and at the Bear Trap dam .435, an increase of 19 per cent.

9203 The total organic nitrogen in suspended matters was, for the samples taken at Kedzie Avenue, .682 parts per million, while the proportions found in the samples collected at the Bear Trap dam were .467 parts per million, showing a reduction of 31.5 per cent.

These changes, which occurred during the time of the passage of the water from the upper opening of, or the entrance to the Chicago main drainage channel, and the out-flow of these waters at the Bear Trap dam are similar to the changes that occur during the passage of sewage through a septic tank in this particular, that the proportion of free ammonia is increased, and that nitrogenous organic matters and other organic matters which were in suspension, have been taken into solution and thus brought into a condition which prepares it for the next process of purification, namely the oxidation which occurs as these waters mix with the waters of the Desplaines and the Illinois, and flow on down the course of the Illinois river; that is particularly the oxidation of the organic matters and the nitrification of the same; these two sets of processes resulting in the destruction of much of the organic matter, part of it being converted into gases, the oxidation process producing mainly carbon di-oxide and water, and from the nitrogen producing nitrites and nitrates.

9204 Q. Professor, to what do you ascribe the fact mentioned in your testimony, that no unusual appearance of black sewage muddiness occurred in the waters of the Illinois river, just after the opening of the main drainage channel upon January 17th, 1900, and that the data of your chemical analyses show no unusual conditions of these waters for the season in question?

MR. JEFFRIES: I suggest that the witness made a complete explanation in answer to the question upon that subject on cross-examination.

JUDGE SPRINGER: I asked him to what he attributes this fact.

MR. JEFFRIES: The fact that it does not show or that it does show?

JUDGE SPRINGER: That it does not.

Q. (Question repeated).

A. In general I ascribe this to two conditions or circumstances. In the first place the waters or the sewage began to flow from the Chicago river into the drainage channel in the early morning of the second day of January, 1900, and slowly passed into the same during the following twelve days, so that the drainage channel was filled with such discharges including water drawn through the river from the lake by the 14th 9205 of January, and that during this period of slow dilution and standing in the drainage canal and the subsequent period of three days during which it stood quiescent in the canal, septic action took place which would tend to destroy much of the organic matters contained therein, and prepared it for the more speedy destruction after it had mixed with the natural waters of the Desplaines and the Illinois, the amount of dilution, taking the whole cubic contents of the Chicago river as the basis of comparison and the cubic contents of the sanitary canal, showing that the dilution during the filling of the sanitary canal amounted to 7.84. That is to say, the water of the Chicago river, which was introduced in the canal amounted to one part as against 6.84 parts of lake water drawn through the Chicago river while the contents of the Chicago river were being drawn into the drainage canal.

The other general condition I referred to previously in my

testimony. It is that just at the time and immediately following the opening of the gates at the Bear Trap dam at Lockport which permitted the first discharge from the sanitary canal into the Desplaines and thence into the Illinois river, namely, upon January 17th, 1900 there was rain, and the stages
9206 of water in the Illinois river throughout its course were
increased, that is, the waters were raised from the volume brought into the stream from its natural watershed, tributaries and its own banks. The rise at Averyville at this time, as between the 17th of January, 1900, and the following days, amounting to .6 of a foot; that is from the stage of 5.1 feet upon the 17th of January, the water rose to the stage of 5.7 upon the 18th; to 6.1 upon the 19th; to 6.6 upon the 20th; to 7.1 upon the 21st; to 7.5 upon the 22nd; to 7.7 upon the 24th; 8.15 upon the 25th; same height for the next two following days, that is the 26th and 27th; it fell to 7.9 feet upon the 28th, a rise of three feet at this point between the 17th day of January and the 25th.

Q. Professor, you have been asked several questions on cross-examination in reference to the limits of accuracy in the determination of the various substances disclosed by your analyses of the waters in question. Taking into consideration all such limits of accuracy and all other data which you have collected in this investigation, and all the environments of the situation, what is your opinion as to whether the condition of the waters of the Illinois river at Kampsville, samples of which you have analyzed and about which you have testified in this case, is substantially shown in your sanitary chemical
9207 analyses of the waters of the Illinois river at that point
for the periods in question and whether these examinations do or do not show substantially the sanitary chemical condition of all the water which passed over the Kampsville dam during the entire six year period from 1897 to 1902, about which you have testified in this case?

MR. JEFFRIES: I object to the question, first because it is not proper re-direct examination; second, for the reason that it shows the inaccuracies and variations in his analyses, with his general information and the purport of the question is directed to the examination of the witness on cross-examination with reference to the inaccuracies in the sanitary chemical analysis of the water; and for the further reason that it is simply an effort on the part of counsel to duplicate in the form of an opinion a conclusion which the witness has already stated in his direct-examination.

JUDGE SPRINGER: In my opinion it is competent cross-examination for the reason that there was no reference made in the examination in chief to these assumed inaccuracies to which the cross-examination was so much directed.

MR. JEFFRIES: I object to the statement of counsel, that the inaccuracies so assumed by counsel—the inaccuracies are an admitted fact as coming from the witness.

9208 Q. (Question repeated).

A. It is my opinion that the data of the analyses which I have read in evidence, and to which I have testified in this case substantially represent the sanitary chemical condition of the waters in the Illinois river at Kampsville during the entire periods covered by the series of examinations, and that in particular the comparison of the averages for the various years and for the two three year periods rest upon a substantial and sound basis.

RE-CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Professor, in any year under consideration, what approximately is the total volume of water in cubic feet, that you have analyzed, with reference now to the Illinois river and the drainage canal?

A. Between 700 and 800 samples—call it 750 though.

Q. How many cubic feet would that be?

A. It would be 100 cubic feet of water.

Q. Now then, what per cent is that of the total flow down the Illinois river, or through the main drainage canal at Lockport in any one examination?

A. The discharge of the sanitary canal at the Bear Trap
9209 dam was, during that year, 188,000 cubic feet per minute.

Q. How much would that be per hour?

A. Sixty times that during the hour.

Q. And that would amount to how much?

A. 270,720,000 cubic feet per 24 hours, if my arithmetic is correct.

Q. And per annum?

A. 98,812,800,000 cubic feet per annum.

Q. Now what per cent of that is the total amount in cubic feet that you analyzed, which was as stated by you, 100?

A. It was 1,198,812,800,000th part of that quantity of water.

Q. Now professor, in your opinion, is there septic operation in the waters of Lake Michigan 100 feet out in the lake at the mouth of the Chicago river, or which was formerly the mouth but which now is the head waters of the Chicago river?

A. I have no direct evidence upon that point, but in my opinion, there have been times in the past when septic action took place in and near the mouth of the Chicago river.

9210 Q. Has there been since the opening of the Chicago drainage canal?

A. I do not know.

Q. What is your opinion?

A. I have not considered the matter at any time.

Q. Then you have no opinion upon that proposition?

A. No.

Q. And as a chemist, having made thousands of sanitary chemical analyses of water from the Illinois river, the main drainage canal and Lake Michigan, you have no opinion upon the proposition as to whether or not there is, since the opening of the canal, septic operation in Lake Michigan 100 feet out in the lake, from the former mouth and now source of the Chicago river?

JUDGE SPRINGER: I submit that the answer to this involves merely a question of fact and not one of opinion, and if witness has obtained no data by analyses of the waters at that point, he is unable of course to answer as to the fact as to whether there is septic action at that point.

MR. JEFFRIES: If the witness does not care to give an opinion he need not do so.

A. In the absence of direct knowledge of the conditions prevailing in the bottom, near and in the mouth of the
9211 Chicago river, I can make no definite statement in answer to this question, but in a general way would state it is my

opinion, that in all probability, at times there is still septic action going on in the sediments in the bottom of the lake in the vicinity of the mouth of the Chicago river.

Q. Then professor, the water that is discharged from Lake Michigan into the canal and thence into the Illinois river, is not at all times the same so far as its chemical constituents are concerned, is it?

A. Not precisely the same. That fact is shown in the tables of analyses which we have put in evidence, which show that the water four miles out is not at all times of precisely the same composition.

Q. Then professor, if you are correct in your opinion that since the opening of the drainage canal there is at times septic operation in the waters of Lake Michigan, 100 feet from the former mouth and now 100 feet from the source of the Chicago river, the water that flows through the Chicago river into the canal and thence into the canal from Lake Michigan is at times polluted, is it not?

A. Not at all. That does not follow from my statement, which was to the effect that lacking evidence, never-
9212 the less I am of the opinion that at times septic action is taking place in the sediments in the bottom of the lake in the vicinity of the mouth of the Chicago river.

Q. If septic operation is taking place in the sediment, would not that operation to some extent be affected by the sediment in the water itself, and from the contents of the water?

A. That is quite possible and probable, even down so far as the drainage channel.

Q. And is it not true that if septic operation is taking place in Lake Michigan at the mouth of the Chicago river, even in the sediment or in the water itself, that it indicates certain quantities of organic matter in course of putrification and decomposition?

A. It certainly does the latter, and everybody who has investigated the matter knows that certain sewers of Chicago still discharge into the lake, and that refuse matter from various places has been at times dumped along the margin of the lake, which afford the basis for the opinion I have given, although lacking chemical analyses in evidence, that septic action does at times take place in the sediments of the lake in the vicinity of the mouth of the Chicago river,--the former mouth of the Chicago river.

9213 Q. Professor, in your compilation of the total amount of the various chemical constituents passing through the main drainage canal at Lockport, you stated, and it is shown in the tables that were read in evidence by you, that there was .2 per cent of those constituents which were due to such constituents contained in the Lake Michigan water that passed through the canal and was mingled and mixed with the sewage of Chicago, did you not?

A. I did.

Q. Did you obtain those percentages from any analyses made of the chemical character of the water in the lake as it passes from the lake into the drainage canal or into the Chicago river?

A. No; those proportions were based upon my analyses of water drawn in at the Four Mile crib, opposite 14th Street.

Q. In your opinion is it a fact or not that there are more of those organic substances contained in the water at the mouth of the Chicago river, as it now is, at its junction with Lake Michigan, than there was in the water analyzed by you which was drawn from the Four Mile Crib?

A. In all probability at times there is a slightly greater proportion of these substances contained in the water as it enters the old mouth of the Chicago river than is contained in the waters of the city supply drawn at the intake crib opposite 14th Street, but such matters have 9214 directly or indirectly been derived from Chicago sewage, and consequently the difference between those quantities contained in the lake water further out, and the quantities found in the waters of the Illinois and Michigan canal, and the waters of the sanitary canal show the sum total of nitrogenous organic matters and nitrogen as free ammonia derived from Chicago sewage.

Q. So then, so far as your data is concerned, it makes no difference and you have taken into consideration also the fact that the sewage from Chicago is discharged into the drainage canal not only by reason of the sewers themselves discharging into the Chicago river, but because they also discharge into Lake Michigan and thence through the mouth of the Chicago river into the canal; isn't that true?

A. I have given very little weight to the latter point, because of its significance as compared with the proportions of Chicago sewage which are directly drawn into the Chicago river and thence into the two canals, which discharge it into the Desplaines.

Q. It is your opinion then that the difference between the condition, chemically speaking, of the water at the Four Mile Crib and the condition of the water at the mouth of the 9215 Chicago river, is of no consequence so far as the percentage of the total amount of tonnage of organic matter that passes over the Bear Trap dam is concerned?

A. Not exactly that. I mean to say that nothwithstanding that difference at the dam which so far as I am aware, has not been specifically determined, that in spite of such differences, the data I have given regarding the quantities and the proportions of these nitrogenous organic matters and nitrogen as free ammonia discharged through the two canals, including that discharged by the Bear Trap dam and that discharged at Lockport and Joliet through the Illinois and Michigan canal represent with substantial accuracy the quantities of these matters introduced into the Chicago river and the two canals and discharged thence into the Desplaines, in Chicago sewage.

Q. Professor, in your opinion, is septic operation going on in Lake Michigan at the point in the lake where are located any one or all of the four intake cribs which furnish the water supply of the City of Chicago?

A. In my opinion it is not.

Q. Then is it not a fact, professor, that the water that passes from Lake Michigan into the drainage canal and down the Illinois river, is more polluted as it comes from Lake Michigan than the water that is drawn by the City Water depart- 9216 ment, from the various cribs located in Lake Michigan opposite Chicago?

A. I have no doubt—in my opinion the water which enters the old mouth of the Chicago river, is inferior in quality in the respects indicated in the question, to the waters drawn into the city supply through the intakes at the various cribs, but it is my opinion further that the difference is not at all to be compared with the difference between the city water which enters the old mouth of the Chicago river and the water which passes out of the Chicago river into the drainage canal, or is pumped out into the Illinois and Michigan canal.

Q. Is it not a fact in your opinion that the water that passes from Lake Michigan into the Chicago river and thence into the canal that as it passes from the lake into the canal it is in an unsanitary condition?

A. It becomes undoubtedly in my opinion of an unsanitary condition as it passes through the Chicago river into the sanitary canal, because of the introduction of Chicago sewage on the way.

Q. Isn't it in an unsanitary condition before it leaves Lake Michigan and passes into the river?

A. I have no doubt that at times it is.

9217 Q. What in your opinion would be the effect upon the people of Chicago if they should obtain their supply of water at the old mouth, now the source of the Chicago river, that supply being obtained 50 to 100 feet in Lake Michigan away from the mouth of the river?

A. In my opinion at times the water if drawn into the city supply system at this point, would be in an unsanitary condition.

Q. Professor, when you stated the average amount of oxygen consumed in the water of the drainage canal in June, July, August and September, 1900, was 8.9 parts at Kedzie Avenue, and 8.8 parts at Lockport, how are you able to state that it shows a reduction of one per cent, when you admit the difference is within the limit of accuracy of your analytical determination?

A. For the reason that these are averages based upon a number of analyses and as I have repeatedly stated in my testimony, the differences being in both directions, the averages eliminate most of the errors of the averages for two sets of analyses made under the same conditions, and are consequently comparable for purposes of representing and showing the differences in proportional content of the various substances. However, that particular difference is not one of any great moment. 9218

Q. In other words, it is not a measurable or an appreciable difference?

A. One per cent is sometimes appreciable. In this case it is of no particular significance.

Q. Then sometimes a difference of one per cent in the limit of accuracy is appreciable, is it not?

A. Sometimes; it depends on what it is. One per cent in the determination of the content of gold in ore, is of more significance than in a case of this sort.

Q. But so far as this case is concerned, it is inappreciable?

A. I say in this particular case the total oxygen consumed referred to in my statements regarding the waters of the drainage channel at Kedize Avenue and at the Bear Trap dam—

Q. Is what? Inappreciable?

A. Insignificant. Or rather I said, not particularly significant.

Q. Then the oxygen consumed represents the carbonaceous matter?

A. To a certain extent it does.

Q. Then there is no appreciable reduction as the water flows through the drainage canal?

9219 A. So far as that determination shows, there is no appreciable reduction in the total oxygen consumed.

Q. Professor, do you not know that the degree of dilution of Chicago sewage by Lake Michigan water in the drainage canal, which degree was investigated at great length by the Hering Commission in 1886 and 1887, and upon which the legislative Act creating the Sanitary District of Chicago was predicated, and upon which the present canal in question was predicated, was for the special purpose of preventing septic action in the main canal and that it was absolutely absurd to denominate the chemical changes in the drainage canal as those of a septic process, as that proces is regarded by sanitary engineers?

JUDGE SPRINGER: I object to the assumption in regard to the reason for the passage of the Act establishing the Sanitary Canal as not being accurately stated.

A. I do not know precisely that the degree of dilution called for by the determinations of the Hering Commission was intended to entirely prevent septic action, but I am of the opinion that those changes in the nitrogenous organic matters contained in the waters of the sanitary canal to which I have testified are of the character of the changes which are produced in such matters in the changes of sewage while passing through septic tanks.

ADJOURNED until 10:00 A. M. Wednesday, Nov. 25, 1903.

9220 (Very shortly after Prof. Arthur W. Palmer completed giving his testimony, he was taken ill and never recovered. His much to be lamented death occurred on the 31st day of January, 1904. He had corrected his testimony up to the beginning of his cross examination. From that point down, such typographical corrections have been made, as were necessary to give the sense of what witness said.

FRANK S. BRIGHT,
Commissioner.)

9221 10:00 a. m., Wednesday, November 25th, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

THOMAS J. BURRILL,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief, by Judge Springer, and testified as follows:

Q. You may state your name, residence and occupation?

A. Thomas J. Burrill; Urbana, Illinois; a member of the faculty of the University of Illinois. I hold now the professorship of botany.

Q. Where were you educated, Professor?

A. Illinois State Normal University.

Q. What courses did you pursue there?

A. It was a course largely for teachers, and I specialized as much as possible in science.

Q. What branches of science?

A. Biology.

Q. When did you quit that institution?

A. 1863.

9222 Q. Have you made any special studies in reference to biology since that time?

A. Yes.

Q. Where, and what were they?

A. Continuously since that time, in the larger field of botany, but more especially cryptogamic botany, and more especially still the group of fungi in which we class the bacteria.

Q. Where were those studies pursued?

A. I took up the subject by myself, as I was forced to do at that day; and at my home in Urbana largely, and elsewhere in the country as I could find opportunity.

Q. Have you attended any other university as a student?

A. Not as a regular student.

Q. How long have you been engaged in teaching at the University of Illinois?

A. Thirty-five years.

Q. Did you teach in any other school or university prior to that time?

A. As an assistant for one year, in the State Normal University. Afterward as principal of a public school—city school.

Q. What branches have you taught in the University of Illinois during the time you have been connected with that
9223 institution?

A. My professorship until three years ago was botany and horticulture, and the branches usually included in those two sciences, I had, at least in supervision, with certain assistants.

Q. How much teaching have you done in reference to biology or bacteriology?

A. Which?

Q. Both?

A. Well, my subjects have been all included under the first term—"Biology," as I understand it. I began studying bacteriology in 1877. I began teaching classes in bacteriology in 1885.

Q. How much time have you devoted to the teaching of biology which includes bacteriology, since that time?

A. All my time teaching and investigating.

Q. Have you ever delivered any course of lectures or lectured before special scientific societies upon these subjects?

A. Yes, sir, several times.

Q. Can you name some of the occasions?

A. The American Association for the Advancement of

Science, beginning in 1880, upon a bacteriological subject, and for a number of years subsequent to that for the same society.

About the same date I gave courses of lectures before the 9224 Natural History Society of Peoria, mostly on subjects connected with fungi and bacteriology. Beginning in 1878 and continuing almost to the present,—or more or less to the present—I have had annual papers in the proceedings of the American Microscopical society. I have during that time had some papers in the proceedings of the Royal Microscopic Society of London, England, and a great number on the more practical side of my general subject before state and American agricultural and horticultural associations.

Q. What was the general character of these various lectures and addresses?

A. The more technical ones were generally upon the diseases of plants caused by fungi and by bacteria. The more general ones upon matters connected with horticulture and forestry.

Q. What was the character of the address you delivered before the London Royal Society?

A. Bacteriological.

Q. When was that?

A. About 1886. This was a paper published; not an address.

Q. What scientific societies are you a member of?

A. American Association for the Advancement of Science, a fellow; American Microscopical Society, of which I am at present president; Western Naturalist's Society.

9225 Q. Any others?

A. No, I believe that is about all of this kind.

Q. What college degrees have you received, if any?

A. The institution at which I graduated gave no degrees. The Northwestern University at Evanston, some time in the seventies, conferred upon me the degree of Master of Arts, as an honorary degree. The old Chicago University upon a thesis bacteriological in kind, in 1881, conferred upon me the degree of Doctor of Philosophy—

Q. Ph. D.?

A. Yes. And the Northwestern University in 1893, I think it was, the degree of Doctor of Laws,—LL. D.—honorary.

Q. Have you ever made any special examinations of water for the purpose of ascertaining the presence of micro-organisms, if so, please state generally and specifically so far as you can remember?

A. I have never published anything upon the examinations of water of my own investigations until this article appeared in this report on Streams Examination. It has been my habit for at least twenty years, to make examinations, partly for the purpose of instruction in the subject; partly for the Illinois state authorities, in some instances the State Board
9226 of Health; partly for the state institutions—all of the state institutions, I think—I have made examinations of water for frequently—I mean all the public state institutions, insane asylums, penitentiaries, and so forth.

Q. Did you make any special examinations at the penitentiary of Joliet, for the prpose of determining whether tuberculosis infected the patients?

A. I did.

Q. Please state what that examination was?

A. In the spring of 1895 I was asked by Governor Altgeld to examine the penitentiary at Joliet for the matter of tuberculosis among the men confined there, and I devoted several days to the examination, especially of the sputum from persons suspected, of having this disease, and during the time I found the tubercle bacilli in the sputum of about 75 of the 1,600 men.

Q. Any action taken by the state authorities upon your report upon that subject?

MR. JEFFRIES: Objected to as irrelevant, incompetent and immaterial.

A. Yes, sir.

JUDGE SPRINGER: I do not desire to ask what the action was.

9227 MR. JEFFRIES: I move to strike out the statement of the witness to the effect that some action was taken, for the reason that it is immaterial.

JUDGE SPRINGER: Simply for the purpose of showing that this was an official matter for the benefit of the State authorities, that is all.

MR. JEFFRIES: I suggest that you have no right, except in a general way of the witness stating his qualifications and his attainments by degrees and otherwise, to corroborate his own evidnece, whether action was taken, for the purpose of strengthening the credibility of this witness' statements or testimony, is entirely incompetent and irrelevant, and contrary to all rules of evidence.

JUDGE SPRINGER: As this was an official matter I think it is competent to state that a report was made, and that some atcion was taken by the authorities for whom this investigation was made. That is all I desire to show.

Q. Did you make any other special examinations for state institutions?

A. No, sir; if I understand your question.

Q. Special examinations?

A. Of the state institutions; not otherwise than of the water supplies.

9228 Q. What did you do, if anything, in regard to their water supplies; what investigations did you make—I mean, in regard to the water supplies?

A. This was almost entirely upon the number of bacteria as revealed by the colony counts, and for the detection of Bacillus coli-communis.

Q. You mean of the water used by the patients in the in stitutions and by the students at the colleges?

A. Yes, sir.

Q. And the inmates of the prisons?

A. These waters in every case were sent to the University of Illinois. They were collected under my directions and usually in bottles sent by me for the purpose, but I did not go to the institutions to make the examinations.

Q. I understand you to say then, that the authorities—that they called upon you to make these investigations for the purpose of determining the character of the water used in the various institutions of the state?

A. That is the statement, yes.

Q. How long have you been engaged in that work?

A. Oh, it began about 1890,—I cannot give the exact date.

Q. Has it continued ever since?

A. More or less, yes.

9229 Q. Can you state approximately how many bacterial examinations of water you have made?

A. No, that would be impossible.

Q. You can give some idea, I presume, a great many of them, or a small number of them, you think?

A. Several thousands.

Q. And running through what period of years?

A. About thirteen years. I suppose I might make that longer, truthfully.

Q. State whether you made any bacterial examinations of the waters of the Illinois river, and its tributaries, and of the Chicago drainage canal in the years 1899 and 1900?

A. Beginning with May, 1899, I made a series of examinations from selected points in the course of that stream, and these were continued until October, 1900, and then in 1901, a series was made extending from October to December, inclusive.

Q. How many samples of water during that period of time did you examine bacterially?

A. These were for the most part weekly collections, from the stations arranged for by Professors Palmer and Jordan. There were two samples in each collection, and in the whole for the two years first named, there were 2800 of these samples; the number of entire cultures made from these samples
9230 amounted to about 7,000.

Q. State whether the samples of water which you examined during the two periods to which you have referred were those which were obtained by Professor Arthur W. Palmer, of the University of Illinois, and Professor Edwin O. Jordan, of the University of Chicago, during that time?

A. They were upon samples taken under their direction.

Q. And state whether those samples were procured at the times and places mentioned in the detailed reports of streams examinations by Professor Palmer?

A. They were.

Q. I call your attention, then, to tables 1 to 80, inclusive, which have been put in evidence by Professor Palmer and that are published in the book known as Streams Examinations, Sanitary District of Chicago.

A. I have them.

Q. Do you recognize the tables before you as the tables made by Professor Palmer and yourself?

A. I do.

Q. What part of these tables numbered 1 to 80, inclusive, was made by you?

A. The last two columns in each of the tables.

Q. What is the heading of those columns?

9231 A. The first one, "Presence or Absence of," as it is placed here, for short statement, "coli." Bacillus coli communis is what is referred to.

Q. And what is the heading of the last column to which you have referred?

A. Number of "Bacteria per Cubic Centimeter."

Q. State, please, what characters were used by you for the purpose of designating the presence or absence of the bacillus coli-communis in these tables, and whether any character was used to designate that you were in doubt as to whether the bacillus coli-communis was present or not?

A. The sign "plus" or an upright cross, is used to indicate the positive presence of this organism, as determined by me. The horizontal line, commonly called "minus," is used to indicate according to our test, the absence of this organism or group of organisms, and the interrogation point is used when the test could not be relied upon to indicate its presence, but the test did give some evidence of its being there; some of the tests, in other words, indicated its presence and others its absence.

Q. I see in some places, there are small dots, what do they indicate?

A. This means that for some reason no examination was made of the samples collected under those particular dates.

9232 Q. Please observe the first column, which indicates serial number, and the second and third columns which indicate the year of collection, and following those the dates in each year. Please state whether those were the serial numbers and the dates of collection and dates of examination of the samples of water which you examined for this purpose during that period?

A. The serial numbers published in this table are those attached to the samples by Professor Palmer. The series in all of this investigation extended from 1 on, the dates of collection were those upon the bottles.

Q. The tags?

A. The tags. And the dates of examination given here are those made by the chemical department, which in 99 per cent. of the cases were the same as the date of the examination by me. There are a few of these dates of examination which vary by one day from my own examinations.

Q. What do the figures in the extreme right hand column of these tables indicate?

A. These indicate the number of bacteria as revealed by our tests in a cubic centimeter of the water.

Q. Of the sample collected?

A. Of the sample that was collected, as I have explained.

9233 Q. Do these explanations which you have given apply to the whole series of tables, beginning with 1 and ending with 80, inclusive?

A. They do. If you will permit me to say, however, that there are some corrections, typographical corrections, to be made in these printed sheets.

Q. Have you made those yet?

A. I have in this copy of mine.

Q. I hand you now, Professor, tables numbered 1 to 80, inclusive, entitled "Streams Examination, Sanitary District of Chicago; Report of Arthur W. Palmer and T. J. Burrill, University of Illinois. Please state whether you identify those as the tables which were prepared by Professor Palmer and yourself?

A. These tables are prints from the manuscript copies prepared by us.

Q. If there are any errors in the copy you hold in your hands, as to the bacterial ascertainments, will you please note them and state them in evidence?

ERRATA AS TO BACTERIAL COUNTS IN TABLES 1 TO 80, ARE AS FOLLOWS:

9234 Table 1, serial number 5878, change "minus" to "no examination" in the next to the last column.

Same table, serial number 6187, change "no examination" to "plus."

Serial number 6333, change "plus" to "question mark."

Table 2, serial number 5790, change "plus" to "no examination."

Insert after serial number 5984, under date of collection, October 9th, and of examination October 10th, "plus" for coli determination, and for colony count, 1,320,000.

After serial number 6446, insert "collection December 11th;" examination same month, "12th;" interrogation mark for coli determination, and colony county, 925,000.

Table 3 for the serial number 6036 add "plus" for the coli determination, and 18,650 for the colony count.

Serial number 6280, change "minus" for coli to "no examination."

For serial number 6495 insert for the colony count, 23,000.

For table 4, after serial number 6024, insert "date of collection October 9th, examination October 10th, "plus" for the coli determination, and for the colony count, 1,175,000."

Table 8, in connection with serial number 5632, strike out
"minus" for coli determination, and 2,700 for colony
9235 count.

JUDGE SPRINGER: I want the record to note that Judge Hugh E. Crea of the Illinois bar, appeared as counsel in behalf of the state of Illinois, in association with General Hamlin.

THE WITNESS: (Continuing)

Table 9, in connection with serial number 5677, insert for coli determination "plus."

Table 15; in connection with serial number 5384, strike out the colony count of 120,000.

In connection with serial number 5739, change the indication "plus" for coli determination, to "no examination."

Next after serial number 5843, insert under date of collection September 19th, and examination September 21, "plus" for coli determination and 745,000 for colony count.

Table 21, insert after serial number 6257, under date of collection November 15th, and of examination November 16th, "minus" for coli determination, and "16,900" for colony count.

Table 22, serial number 5497, change for the coli determination, "plus" to "minus."

In connection with serial number 5542, change for colony count, "1450" to "580."

Table 28 in connection with serial number, 5815, change
9236 "2500" for colony count, to "7,500."

Table 32, in connection with serial number 5369, strike out the interrogation point for coli determination, and "48,500" for colony count. There was no examination there, the figuers got transposed from the year 1900.

Table 40, in connection with serial number 8529, strike out the determinations for coli and for colony counts.

And the same for the serial number 8586, and insert—and after serial number 8586, under dates of collecting October 8th, and of examination October 9th, "plus" for coli determination, and for colony count, "225,000."

Table No. 41, serial number 8594, the last on the page, change colony count "1,240,000" to "1,237,500."

Table 43, in connection with the three serial numbers, 8455, 8472 and 8490, for each of these serial numbers, place the colony count one space down in each case.

Table 49, serial number 7826, in the colony count, change "17,800" to "17,300."

Table 53, next after serial number 6740, insert under date of collection January 30, and of examination January 31, "plus" for coli determination, and "65,200" for colony count.

In table 55, in connection with serial number 7713, insert for coli determination "plus" and for colony count,
9237 "150,000."

Table 59, in connection with serial number 8,141, change "16,650" to "15,650."

Table 60, continued. This is the second continuation of that table. In connection with serial number 7848, change "minus" for coli determination to "no examination" and strike out for colony count, "560."

Table 60 concluded, in connection with serial number 8363, for coli determination, change "no examination" to "minus."

In connection with serial number 8470, change "minus" in coli determination to "plus."

In connection with serial number 8475, change "plus" to "minus" in coli determination.

In connection with serial number 8500, change in coli determination "minus" to "plus."

In connection with serial number 8512, change in coli determination "plus" to interrogation point.

In connection with serial number 8532, change the interrogation point to "plus."

Table 61 continued, in connection with serial number 7326, change in coli determination "plus" to "minus."

In connection with serial number 7350, change coli determination from "plus" to "minus."

In table 62, in connection with serial number 7627, change
9238 in coli determination "minus" to "plus."

In connection with serial number 8295, in coli determination, change "plus" to "minus."

In connection with serial number 8500, in coli determination, change "minus" to "plus."

Table 63, in connection with serial number 7326, in coli determination change "plus" to "minus."

Table 65, insert after serial number 7979, under date of collection July 25th, and date of examination July 26, "minus" for coli determination, and "1,300" for the colony count.

Table 66, in connection with serial number 6747, for coli determination change "minus" to "plus."

In connection with serial number 7055, in coli determination, change "plus" to interrogation point.

Table 67 in connection with serial number 6859, change for coli determination "minus" to "no examination."

Next after serial number 7980, insert under date July 25th for collection, and 26th for examination for coli determination, interrogation point. For colony count, "5,200."

9239 Table 69 in connection with serial number 7930 change for coli determination "no examination" to interrogation point.

Table 70 concluded, in connection with serial number 8278, in coli determination, change "plus" to "no examination."

Table 71, in connection with serial number 7965, insert "plus" for coli determination, and "28,000" for the colony count.

Table No. 71 concluded, in connection with serial number 8041, change for coli determination "minus" to "no examination."

In connection with serial number 8619, for coli determination, change "minus" to "plus."

Table No. 72, concluded in connection with serial number 8038 for coli determination, change "plus" to "no examination."

In connection with serial number 8480, change colony count from "1000" to "1800."

Table No. 75, in connection with serial number 7193, change "plus" to "minus" for coli determination.

Table 76 in connection with serial number 6763, for coli determination, change "plus" to "minus."

9240 Table 78, in connection with serial number 6824, in coli determination, change "plus" to "minus."

That is all.

Q. Professor, with the errors noted by you with reference to tables 1 to 80 of this series, please state whether the ascertainments for the presence of the coli group and for number of bacteria per cubic centimeter, are correctly stated?

A. They are.

Q. Have you made a table of monthly averages of colony counts based upon the detailed examinations found in these tables Numbered 1 to 80 inclusive?

A. I have.

Q. Please look at the table F, contained on two sheets, which I now hand you, and designated Table F, Streams examination, Sanitary District of Chicago, Sanitary Water Analyses, monthly averages of colony counts, report of T. J. Burril, University of Illinois, and state whether this table on two sheets contains the monthly averages of colony counts based upon the tables 1 to 80 to which you have referred?

A. They do sir; subject to one difference. This table of averages was based upon the regular weekly collections from the stream. When there were any extra collections, as
9241 there were at Grafton, and at the chain of rocks and other
places sometimes, those extra collections are not included in these averages.

JUDGE SPRINGER: I offer this table in evidence, to be known as Table F, two sheets, Streams Examinations, Sanitary District of Chicago, Sanitary Water Analyses, Monthly Averages of Colony Counts, report of T. J. Burrill, University of Illinois.

MR. JEFFIIES: I object to the table being offered in evidence for the reason that it does not show the average number of colony counts found at various points in the Illinois river and the canal during all the months of the two years in question, to-wit, 1899 and 1900, and for the further reason that comparative results are only shown for the months of June, July, August and September, which are recognized as summer months, and no comparisons were made for the winter months. I therefore object to it for the reason that the results so obtained from the various analyses are not comparable with each other, and that the results obtained for the years, to-wit, 1899 and 1900, are not comparable.

JUDGE SPRINGER: I desire to state in behalf of the defendants, that the table of averages now offered in evi-
9242 dence, speaks for itself, and indicates upon its face exactly what it is intended to represent; that the objection of counsel merely goes to the weight of this table as evidence and not to its competency.

MR. JEFFRIES: I agree with counsel that the tables show for themselves, but I insist that the comparative averages for the two years are not comparable as shown by the tables themselves, and therefore are not competent.

JUDGE SPRINGER: That is a question for the Court to determine and not for counsel.

THE WITNESS: The table is as follows:

TABLE F.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—MONTHLY AVERAGES OF COLONY COUNTS.

Report of T. J. BURRILL, University of Illinois.

YEAR.	LOCATION.	SOURCE OF WATER.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1900	Kedzie Ave.	Sanitary Canal					1,474,000	377,000	863,8·8	1,233,700	1,186,665			
1899	Bridgeport.	Illinois and Michigan Canal						1,035,500	3,895,555	......	2,483,333	2,150,000	2,497,000	2,151,666
1900	"	" " " "	3,862,000	6,063,333	4,240,000	6,037,500		......	......	1,215,000	315,000			
1899	Lockport	" " " "						3,885,750	5,323,750	3,215,000	696,666	1,335,000	582,000	746,250
1900	"	" " " "	2,256,000	......	4,405,000	3,891,250	1,649,000	997,500	731,250	790,000	3,290,000			
1899	"	Desplaines River						14,912	11,162	38,850	24,160	25,783	9,640	16,300
1900	"	" "	42,370	......	167,500	21,375	5,637	40,162	......	......	......			
1900	"	Sanitary Canal	......	......	......	......	......	......	601,250	1,205,666	651,666	......	......	......
1899	Joliet	Desplaines River						1,445,000	2,848,666	3,220,000	217,000	1,145,000	1,023,000	1,026,250
1900	"	" "	973,000	1,148,333	2,000,000	1,655,000	485,000	18,000	170,000	134,750	203,330			
1899	" S.	" "	......	......	......	......	......	1,309,375	3,201,666	4,611,666	185,000	......	......	......
1899	Wilmington	Kankakee River						22,837	4,720	4,000	5,387	11,075	11,650	25,300
1900	"	" "	5,790	102,000	75,250	52,000	3,300	3,650	950	1,975	4,950			
1899	Morris	Illinois River						909,875	930,750	4,882,375	2,186,100	505,000	747,000	170,000
1900	"	" "	2,737,500	1,731,250	1,593,750	392,500	46,200	246,125	42,375	76,600	624,750			
1899	Ottawa	" "						20,550	9,298	7,512	40,100	33,050	18,070	261,766
1900	"	" "	256,250	228,000	116,750	68,500	15,125	14,237	2,950	18,830	34,875			
1899	"	Fox River						11,027	3,670	4,560	4,822	5,475	5,900	7,000
1900	"	" "	12,275	......	84,166	49,250	5,800	2,412	3,266	2,962	9,375			
1899	La Salle	Illinois River						17,800	6,370	11,875	9,700	27,112	11,910	101,400
1900	"	" "	192,400	278,750	367,666	96,125	13,050	12,275	3,500	13,000	17,412			
1899	"	Illinois and Michigan Canal						170,050	157,766	241,000	166,375	131,250	164,400	223,000
1900	"	" " " "	193,300	169,625	212,000	157,750	25,300	31,062	38,375	17,200	73,775			
1899	"	Big Vermilion River						7,062	4,510	1,480	3,102	3,987	14,050	12,757
1900	"	" " "	13,750	45,912	103,125	33,000	22,270	8,550	5,475	7,000	2,200			
1899	Henry	Illinois River						61,350	22,362	26,350	11,100	8,575	5,880	59,966
1900	"	" "	41,462	160,500	183,625	39,875	14,260	3,487	40,433	1,850	136,700			
1899	Averyville	" "						8,700	9,358	4,000	3,100	3,768	1,640	9,300
1900	"	" "	27,570	129,500	93,375	13,087	15,920	1,637	4,233	8,060	4,466			
1899	Wesley City	" "						1,476,480	3,925,000	2,355,000	481,575	2,373,750	705,000	20,666
1900	"	" "	89,000	95,666	107,750	22,750	70,400	58,625	96,000	99,250	264,375			
1899	Pekin	" "						1,500,000	737,625	1,928,333	391,250	1,047,500	812,000	69,000
1900	"	" "	128,100	84,000	125,125	27,250	106,500	150,625	313,375	286,500	1,061,875			
1899	Havana	" "						6,816	5,950	5,725	6,137	12,433	159,040	301,333
1900	"	" "	124,166	79,575	181,875	26,500	23,850	15,000	24,125	21,362	50,662			
1899	Chandlerville	Sangamon River						7,125	9,900	19,783	20,300	3,683	7,100	10,266
1900	"	" "	10,620	101,433	105,875	13,625	11,850	29,562	13,900	4,150	4,316			
1899	Beardstown	Illinois River						4,400	1,352	10,287	3,039	5,000	26,070	114,100
1900	"	" "	239,750	420,500	145,750	28,375	12,880	7,962	4,275	15,000	5,550	......	......	......

TABLE F—Continued.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—MONTHLY AVERAGES OF COLONY COUNTS.

Report of T. J. BURRILL, University of Illinois.

YEAR.	LOCATION.	SOURCE OF WATER.	January.	February.	March.	April.	May.	June.	July.	August.*	September.	October.	November.	December.
1899	Kampsville...	Illinois River						5,316	3,161	6,225	3,480	1,717	5,065	28,650
1900	“	“ “	36,725	202,666	155,625	15,825	5,038	2,425	1,850	10,700	5,850			
1899	Grafton	“ “						4,155	2,628	1,806	793	743	7,210	40,344
1900	“	“ “	46,600	191,500	159,500	14,550	6,850	6,875	3,911	2,708	5,274			
1899	“	Mississippi River						5,017	915	1,379	2,356	2,406	8,380	15,912
1900	“	“ “	13,750	69,625	227,750	66,750	10,580	3,650	3,027	3,291	3,932			
1899	Alton	Miss. River, 100 ft. from Ill. Shore						2,457	1,242	3,319	3,612	2,775	9,600	23,750
1900	“	“ “ “ “ “ “	20,470	86,500	119,750	18,125	17,620	13,125	3,266	3,180	6,687			
1899	“	“ “ ¼ dist. from Ill. Shore						6,087	809	2,355	3,000	2,112	17,630	23,533
1900	“	“ “ “ “ “ “	18,940	98,125	175,000	46,625	18,180	7,875	4,800	6,180	5,500			
1899	“	“ “ Center of Channel						5,775	2,021	2,465	3,725	2,425	7,160	18,300
1900	“	“ “ “ “	23,380	105,125	166,250	66,000	26,000	4,375	6,966	6,710	8,200			
1899	“	“ “ ¼ dist. from Mo. Shore						5,725	1,753	2,647	2,525	2,375	6,390	8,416
1900	“	“ “ “ “ “ “	19,040	88,500	149,875	48,500	16,040	6,750	9,050	5,640	6,400			
1899	“	“ “ 100 ft. from Mo. Shore						7,250	2,927	2,215	2,562	2,200	5,730	4,183
1900	“	“ “ “ “ “ “	18,620	104,100	144,875	85,500	24,080	5,875	3,862	7,610	4,433			
1899	Mitchell	“ “ 400 yds. from Ill. Shore						19,706	5,737	11,700	5,325	3,075	5,037	9,816
1900	“	“ “ “ “ “ “	35,087	113,100	98 166	17,500	21,800	14,875	26,191	6,110	4,357			
1899	“	“ “ Center						12,883	6,830	15,850	12,063	11,775	25.075	15,183
1900	“	“ “ “	70,075	95,150	97,000	60,125	34,200	21,625	24,250	8,725	13.310			
1899	“	“ “ Inlet Tower						18,100	6,275	20,437	14,737	14,462	26,612	31,650
1900	“	“ “ “ “	76,525	66,800	125,833	58,375	31,300	23,750	27,045	13,300	9,170			
1899	“	“ “ 400 yds. from Mo. Shore						16,650	5,902	32,275	9,250	10,187	30,125	25,233
1900	“	“ “ “ “ “ “	64,925	50,300	143,333	57,500	64,125	25,375	29,275	10,256	12,927			
1899	West Alton...	Missouri River							20,600	32,695	23,417	16,325	28,510	10,475
1900	“ “	“ “	84,960	40,066	179,750	77,000	66,200	63,375		12,450	25,187			
1899	Jeff. Barracks	Mississippi River, East Shore						66,250	10,050	87,825	69,250	59,500	5,750	6,133
1900	“ “	“ “ “ “	19,750	97,500	130,875	54,666								
1899	“ “	“ “ East of Center						37,475	13,400	45,712	43,750	33,625	9,000	9,241
1900	“ “	“ “ “ “	24,460	136,500	145,375	25,500								
1899	“ “	“ “ Center						41,100	6,962	29,837	18,787	11,833	11,600	6,675
1900	“ “	“ “ “	28,720	79,666	129,750	48,333								
1899	“ “	“ “ West of Center						55,350	5,737	54,525	42,125	45,250	25,900	19,067
1900	“ “	“ “ “ “	44,460	79,750	130,500	56,500								
1899	“ “	“ “ West Shore						33,637	12,050	63,125	60,125	52,875	22,562	16,350
1900	“ “	“ “ “ “	23,500	61,666	154,750	55,333								
1899	St. Louis Tap.							14,392	851	810	1,900	1,710	8,952	2,433
1900	“ “		4,865	8,233	10,137	5,233	6,300	2,625	1,650	1,950	10,125			
1900	Chicago Tap.			2,425	850	750	140	88	96	95	213			

9245

ERRATA.

Q. State whether the table as printed above contains any errors and if so, please note them?

A. They do. The number specified for the collection at Kedzie Avenue in June, 1900, here given as 377,000 should be 377,500.

The number given under date of December, 1899, as 12,757, should be 12,787. These are all the corrections.

Q. Professor, please state whether the errata which you have indicated as appearing in tables Nos. 1 to 80 inclusive, were taken into consideration in making up the table of averages contained in table F, just put in evidence?

A. These averages were made from the numbers as now corrected in tables 1 to 80.

Q. Will you please state briefly and generally what this table F of averages shows?

A. This table is intended to show the average number of bacteria as shown by all the determinations from the samples regularly collected each week for the different months of 1899 and 1900, during which the examinations were made.

9246 Q. Will you state, professor, in what manner you plated for these colony counts?

A. The plating for colony counts was made upon standard nutrient agar; this was made from an infusion of butcher's meat, and with phenolphthalin as an indicator was neutralized to represent ten on Fuller's scale or one per cent of normal of acid. We took pains to have the medium made sometime before its use because we found less trouble from it in counting the colonies. There were less over-growths when it was so kept. A cubic centimeter, diluted if necessary beforehand, of the water, so as to have from our experience, from 50 to 100 colonies on a plate, was placed in a test tube of the melted agar, well shaken up and immediately poured into the plates called Petri dishes; these after some preliminary trials were kept in a constant temperature room in the basement of a large building, at 20 degrees centigrade, and were left a uniform time of ten days before counting. In the counting a lens was used when this was helpful.

Q. Is this the usual method for making these ascertainments?

A. It is, sir, except that very frequently gelatin is perferred instead of agar for the purpose. I will say that in our tests, in the examinations of this particular water we found our results more uniform with the use of agar, for the extended
9247 period of ten days, than we could get with gelatin at the maximum period of about four days. The number of colonies were in many instances a little less when agar was used than when gelatin was used in the best manner, but the results proved more uniform, hence the selection of the agar instead of the gelatin.

Q. What attention did you give in making these bacterial examinations for the purpose of ascertaining the presence of the bacillus coli communis?

A. This work was begun in May, 1899, during that month preliminary experiments were made with several methods for detecting this organism or group of organisms. From out previous experience and from these tests, a routine method was adopted, somewhat as follows:

A culture medium made up of five grams of Liebig's meat extract, ten grams of chemically pure lactose; one gram of pure carbolic acid crystals, and 1000 cubic centimeters of distilled water, to which was added sufficient solution of litmus to give it a distinct bluish, purplish or violet color. This was our preliminary culture medium. A cubic centimeter of the water to be examined was placed in each of two tests tubes containing about ten cubic centimeters of this medium, and this was placed
9248 in an incubator at 38 degrees centigrade for 48 hours. Our previous results had shown that when the bacillus coli-communis was present in the water, that this litmus colored medium was changed to a reddish color within the time mentioned, under the conditions in which it was placed. If no such change occurred in this medium, a negative result was at once interpreted, though in some cases of doubt the tubes were left a longer time in the incubator, to determine the results. If the medium became red in color, then plating was resorted to in nutrient gelatin, containing the same quantity of lactose and carbolic acid as in the former medium, with litmus to give it the violet color. After 24 hours incubation at about 22 to 23 degrees centigrade, attempts were made to select colonies from these plates, showing the characteristics of bacillus coli-communis. Microscopic

examinations were made from these selected colonies, and transfers were made from such selected colonies to broth made sugar-free by previous culture for about sixteen hours, of Bacillus coli-communis, and subsequently filtered and sterilized for indol tests; also in two per cent glucose broth for use in ferment tubes, and also into sterilized milk. If in these different media 9249 the reactions characteristic of the bacillus coli-communis were found, a positive interpretation was made for the presence of these organisms; if most of them failed, a negative determination was made. If some of them indicated the presence of the organism and some indicated its absence, a question mark was placed as the result of the finding.

I may say in this connection that I have to present photographs of fermentation tubes thus handled, as we found them after growth from the selected colonies mentioned before.

These photographs, two of them, each give the conditions of things for one week's tests, and show pretty conclusively that the colony examination usually are the *bacillus coli-communis.* We took as an arbitrary standard of determination, 30 to 60 per cent of gas in the closed arm of the fermentation tube, as indicative of the bacillus coli-communis, and if there proved to be more or less than this, we assumed that the organism under test was not this one.

JUDGE SPRINGER: I present these photographs at this time, as defendants' Exhibit Nos. D and E for identification, to be incorporated hereafter in the testimony if counsel on either side so desires, and to be kept by the Commissioner for reference by counsel at any time. The one containing 62 flasks 9250 being marked Defendants' Exhibit D, and the one containing 79 flasks being marked Defendants' Exhibit E.

JUDGE SPRINGER: Will you proceed with this explanation professor?

A. I may say that in this method of procedure, we had more variation in the indol test than in any others, and that we were obliged more frequently to exercise our judgment in this one respect than in any other, as to what mark should be given for the determination.

Q. Will you please consider briefly, the tables to which you have testified, which contain the colony counts as indicated by you and point out the differences which exist in the bacterial content of these waters in the different portins of the stream?

A. The difference in colony counts for different portions of the stream is very marked, and while there is considerable variation for each point, there is for all of our tests very striking agreement in the greater number existing in the course of the stream near its head at Bridgeport, amounting to several millions in a cubic centimeter, and then a more or less gradual decrease to Peoria, and from Ottawa to Peoria, this decreased number is exceedingly marked.

Q. Please point out the differences which are indicated between the colony counts at Bridgeport and Averyville, for the period in question?

9251 A. The colony counts from the tests made from samples taken at Bridgeport on November 7th, 1899, were 4,790,000; November 15th, 1,960,000; November 21st, 3,920,000; November 29th, 315,000, with the average for the four tests of 2,497,000.

At Averyville for the same time, the counts were respectively, 550, 1,100; 1,200; 2,800; an average for the four tests, 1,640.

Q. Now for the year 1900 what do those counts show for these two places?

A. And for the year 1900 in April at Bridgeport, on the 3rd of that month, 5,300,000; on the 10th, 3,725,000; on the 17th, 11,200,000; on the 25th, 3,925,000, with an average for the four tests of 6,037,500.

While at Averyville for the same times, the counts were 28,000; 17,000; 5,500; 1,850, and with an average for the four of 13,087.

Q. In your examinations have you noted any increase in the quantities of polluting matter as sewage from the cities of Peoria and Pekin, and if so, please state what your colony counts indicate in regard to those for the two years mentioned?

A. The colony counts showed a great increase in number of bacteria after the pollutions were received by the river
9252 from Peoria and Pekin. As an illustration of this I will say that in 1899 on November 1st, there were found at Pekin, 2,780,000 bacteria per cubic centimeter; on November the 9th, 170,000; on November 16th, 145,000; on November 24th, 95,000; with an average for the four tests of 797,500.

For the same times at Beardstown, which is 56 miles further down stream, the colony counts were respectively, 6,500; 21,500; 7,150; 35,200, with an average for the four tests of 17,590, for the year 1900.

For July 6th, 1900, there were at Pekin, 38,500; for July the 12th, 555,000; July 19th, 370,000; July 26th, 220,000; with an average of 295,875.

While at Beardstown for the same times there were respectively, 3,500; 4,000; 3,000; 3,600; with an average of 3,700.

I should say that in order to make this tabular statement, the dates given sometimes vary by one day, for one or the other of the numbers given, because the collection was not always made on the same day.

Q. How much greater do these figures show for each period, was the number of bacteria per cubic centimeter at the respective places?

9253 A. The averages in the last figures show respectively, 45 and 71 times as many bacteria in the water at Pekin as at Beardstown, though the distance is 56 miles and the time required for the flow of the water 24 hours.

Q. Please state, professor, whether you prepared any graphic plates based upon the tables of data contained in pages 1 to 80 of the series in question, illustrating graphically the conditions shown by those tables?

A. I did not directly from these tables, but I did from the monthly averages that are exhibited in table F.

Q. And that is based upon what data?

A. That was based upon data as given in tables 1 to 80.

Q. Please examine the plates which I now show you and state whether these plates were prepared by you?

A. These plates were prepared by me.

Q. What do they show, briefly?

A. They show in a graphic presentation, what is shown in figures in table F, which is based upon the detailed data contained in tables 1 to 80 of this series.

JUDGE SPRINGER: I will offer these plates in evidence, being plates numbered 21 to 28 inclusive, and to be known
9254 as plates 21 to 28 inclusive, of the bacteriological laboratory of the University of Illinois.

Plate 21 is as follows:

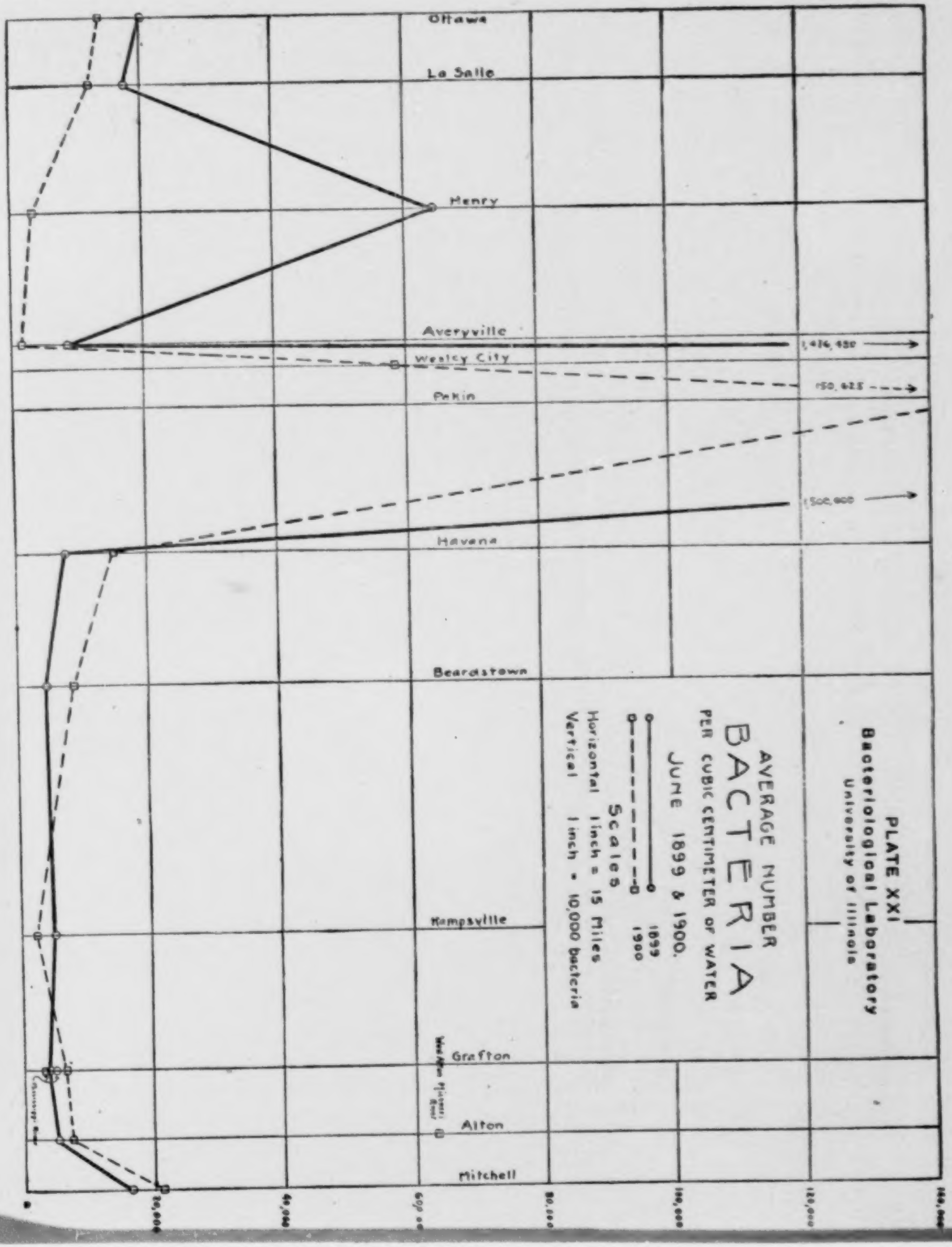


PLATE XXI
Bacteriological Laboratory
University of Illinois

AVERAGE NUMBER
BACTERIA
PER CUBIC CENTIMETER OF WATER
JUNE 1899 & 1900.

9256 Q. JUDGE SPRINGER: Please explain professor, what is shown by plate 21, which is put in evidence?

A. This shows the average number of bacteria per cubic centimeter of water for the month of June, 1899 and 1900, according to all our tests made for these dates.

The whole black line indicates the number forJune, 1899.

The broken line or the line made up of short straight pieces, for the month of June, 1900.

This plate shows the tests made from Ottawa to Mitchell, otherwise known as the chain of rocks, opposite the intake tower of the St. Louis waterworks.

The earlier tests (those from samples taken above Ottawa) were not indicated on this plate because the numbers are so great that they could not be shown on this scale. It will be noticed that at Ottawa the number was 20,000; at LaSalle it was about 18,000; at Henry it was about 64,000; at Averyville it was about 9,000; at Wesley City the number was so great that it could not be shown on the plate. The lines were stopped near the upper part of the plate and the number inserted, 1,476,480. And at Pekin for the same reason the line does not show the number, but the figure is put in, 1,500,000. Now the number drops quickly to Havana, where it is shown to be about
9257 8,000; at Beardstown about 5,000; and at Kampsville about 6,000; and at Grafton about 5,000 again. At Alton about 6,000; and at Mitchell as named on this plate, about 17,000.

It ought to be said that the term "Mitchell" is used here as the nearest railroad station to the place otherwise called the Chain of Rocks. Now for June in the year 1900, at Ottawa, the number is about 14,000; something a little less at LaSalle, and 3,000 at Henry, and 1,500 at Averyville, all of which is below that of 1899, and then at Wesley City, six miles below Averyville and below the reception of the Peoria sewage, 59,000 and at Pekin, 150,625; and at Havana, about 15,000. At Beardstown, 8,000; at Kampsville, 2,000; at Grafton, Illinois river about 7,000; and at Alton, 8,000; and at Mitchell, 21,000.

I wish to say that the showing is for 1900, less than for 1899 in the first part of the stream as here indicated, and more for some distance after Havana, less at Kampsville and more again at Grafton, Alton and Mitchell.

There is further shown on this plate the colony counts for the Mississippi river at Grafton, by a little separate circle, showing about 5,000 for 1899, and 3,000 for 1900; that is, the 9258 showing for the Mississippi during this comparison, is a little lower in each case than for the Illinois river.

ADJOURNED until 2:00 P. M. same day, Wednesday, November 25th, 1903.

9259 2:00 P. M., Wednesday, November 25th, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

THOMAS J. BURRILL,

resumed the stand for further direct-examination by Judge Springer, and testified as follows:

Q. Professor, I now call your attention to plate 22 of this series. Will you please explain what is shown or illustrated by this plate?

A. Plate 22 shows the same thing as plate 21, but represented in a different way, and has in addition the showing for the Illinois and Michigan canal at Lockport; for the Desplaines river at Joliet, and for the Illinois river at Morris. In plate 21, the presentation is shown by oblique lines; in plate 22 the exhibit is made by perpendicular lines.

Q. Please explain the first column on the left hand side,—it seems to be represented by three lines.

A. The solid black line exhibits the counts made for the 9260 month of June, in 1899, and the open line or the light colored line shows the counts for this month in 1900. The total number represented on the perpendicular line is 1,400,000 as seen at the upper right hand corner.

Q. And for the three lines then what would that indicate?

A. Now the entire length of the first black line goes twice across the plate, representing 2,800,000, and again rising to 1,090,000, which, added to the 2,800,000 makes 3,890,000. The light line shows 1,000,000.

Q. Those two counts indicate the differences between the colony counts for the time indicated, for the month of June, 1899, the year before the opening of the canal, and the other column indicates the number found for June, 1900, the year after the opening of the canal?

A. That is correct.

Plate 22 is as follows:

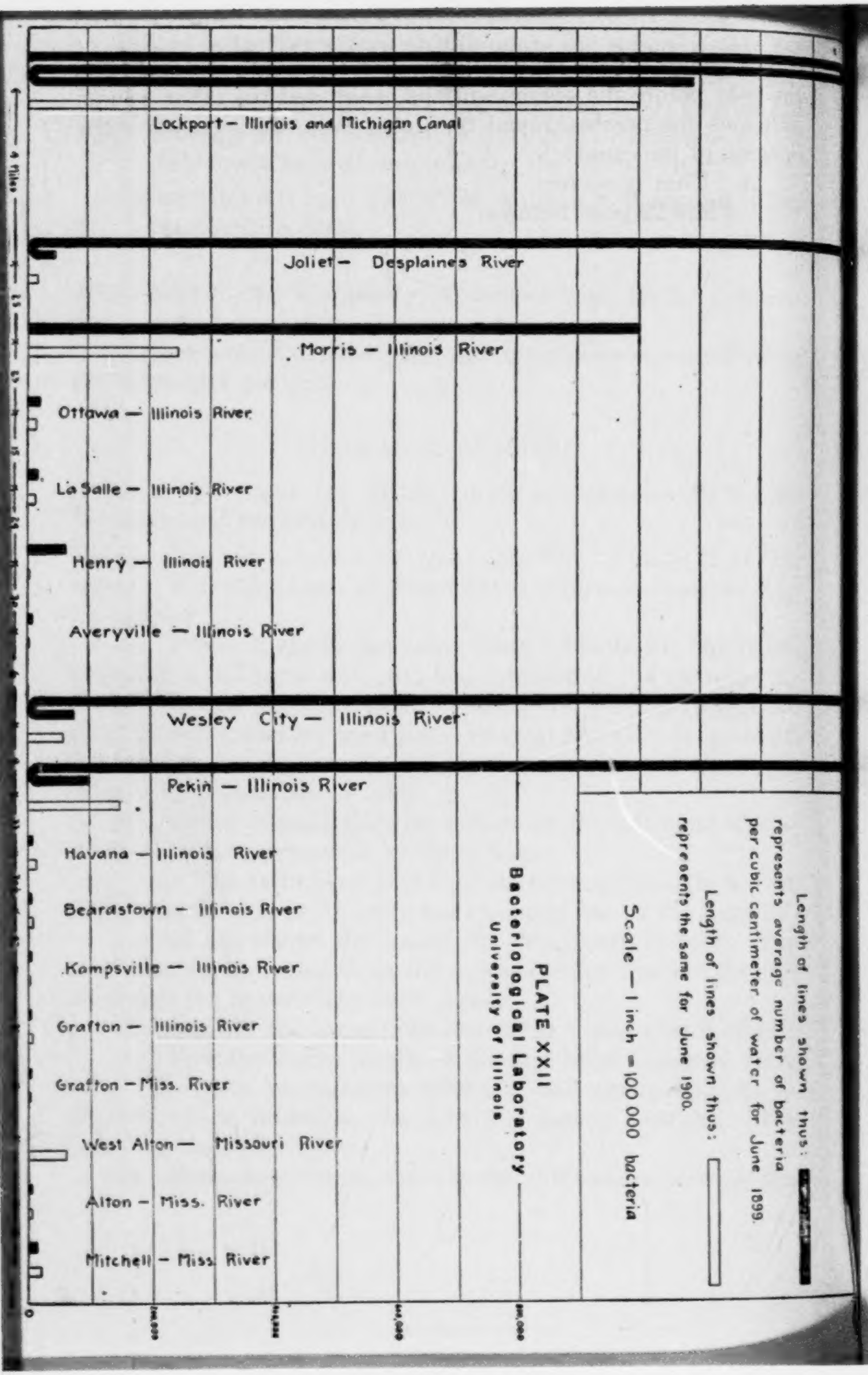


PLATE XXII

Bacteriological Laboratory

University of Illinois

9262 Q. I call your attention professor now to plate 23 of this series. Please explain what is shown or illustrated by this plate?

A. Plate 23 shows the average number of bacteria per cubic centimeter as determined by the tests during July, in 1899, and also for the same months in 1900. The solid black line, exhibits the number for 1899, and the broken line for 1900 of this month.

It will be seen that for the year 1899 we started Ottawa with about 9,000 bacteria. At LaSalle the number sinks to about 7,000, at Henry it rises again to about 22,000; at Averyville it is a little over 9,000; and at Wesley City the line, if drawn would extend beyond the plate, and the figures are given to indicate 3,925,000, and at Pekin, 737,625. At Havana the number rapidly decreases to about 6,000 and at Beardstown to about 1,000. Again at Kampsville it rises somewhat, to about 3,000; slightly sinks again at Grafton, to about 2,500, for the Illinois river, and at Alton to something less than 2,000, while at Mitchell it rises to about 6,000.

Q. Please explain the condition of the Mississippi river at Grafton as indicated by that line?

A. The Mississippi river at Grafton,—the number of
9263 colonies from tests of the water in the Mississippi river is
indicated by the small circle as less than 1,000 for this
year.

Q. And at West Alton in the Missouri river?

A. And at West Alton, it was 20,000. I may say that these places are not connected by slanting lines because they were not on the direct course of the stream.

Q. Now for the next year; for July, 1900?

A. For July, 1900, we have commencing at Ottawa, from 2,000 to 3,000; at LaSalle, 3,000 to 4,000; at Henry, 40,000; at Averyville about 4,000; at Wesley City, about 96,000; at Pekin 313,375; and at Havana 23,000; at Beardstown about 4,500; at Kampsville 2,000; at Grafton about 4,000; at Alton about 6,000 and at Mitchell 26,000.

Q. Is the Missouri River indicated there?

A. The Missouri river for this year at Grafton, is indicated.

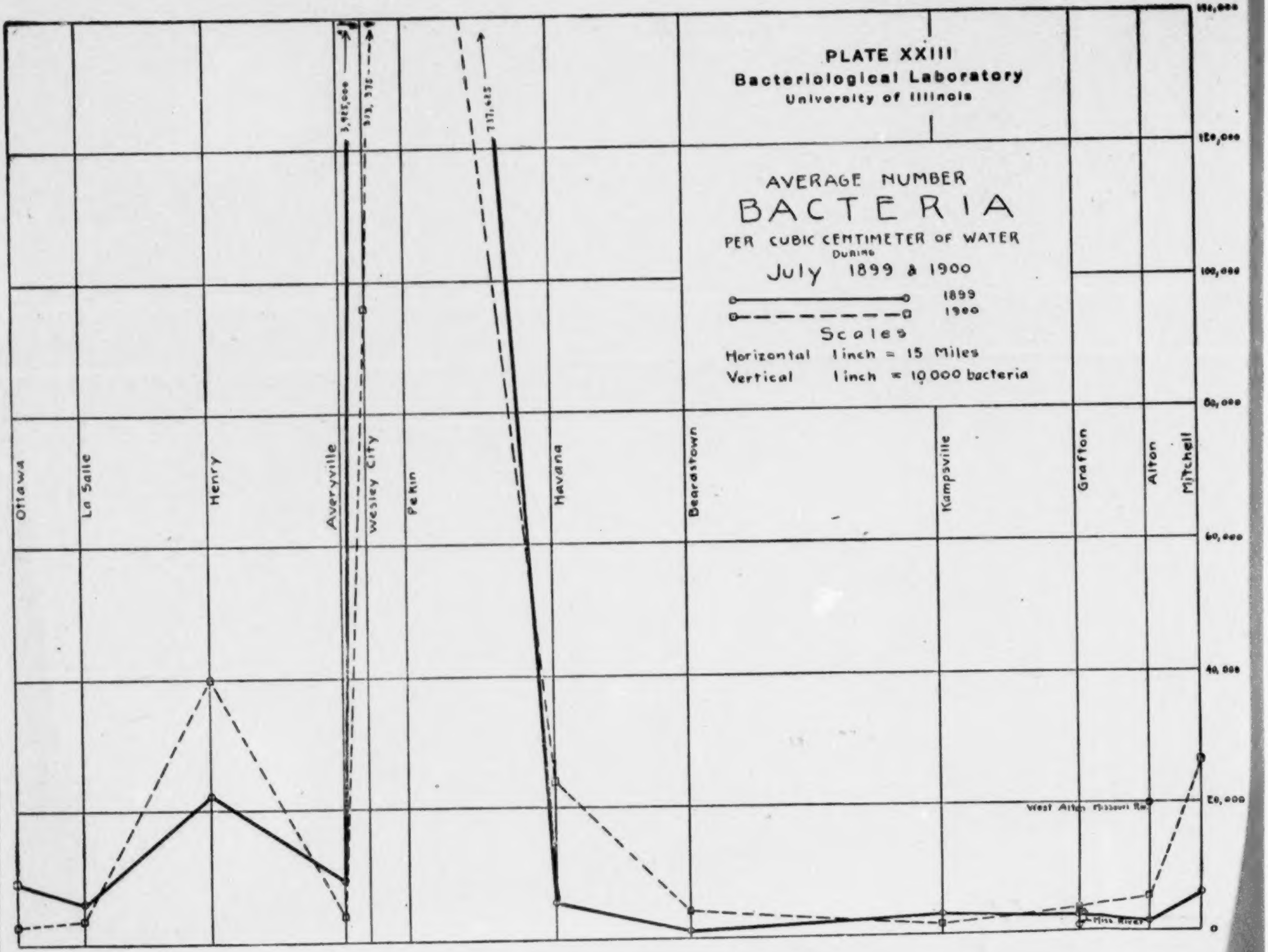
Q. I mean West Alton—the Mississippi river I mean to say?

A. Missouri river is not represented for 1900.

Q. Or the Mississippi river at Grafton?

A. Yes, the Mississippi river at Grafton is about 4,000. Right between the indication for the Illinois river at Grafton for the two years.

Plate 23 is as follows:

PLATE XXIII
Bacteriological Laboratory
University of Illinois
AVERAGE NUMBER
BACTERIA
PER CUBIC CENTIMETER OF WATER
DURING
July 1899 & 1900
1899
1900
Scales
Horizontal 1 inch = 15 Miles
Vertical 1 inch = 10,000 bacteria
Ottawa
La Salle
Henry
Averyville
Wesley City
Pekin
Havana
Beardstown
Kampsville
Grafton
Alton
Mitchell
3,925,000
313,375
717,625
West Alton Missouri Riv.
Miss River
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000

9265 Q. I now call your attention to plate 24 of this series. Please explain what is indicated by this plate?

A. Plate 24 is another way of showing what was contained in plate 23, and with the addition of the exhibit for the Illinois and Michigan canal at Lockport, for the sanitary canal at Lockport, for the Desplaines river at Joliet; and for the Illinois river at Morris. In this plate the indication is made by vertical lines, with the black solid lines for 1899 and the open light lines for 1900.

Q. What is indicated by the line for 1899 at Lockport, the Illinois and Michigan canal?

A. This shows about 5,320,000.

Q. For July, 1899?

A. For July, 1899.

Q. What is shown for the same month in 1900?

A. 740,000.

Q. Now the Desplaines river at Joliet, what does that indicate?

A. For 1899 the black lines show about 2,850,000.

Q. And what for the same place for the month of July, 1900?

A. And for 1900, about 170,000.

Q. What is shown at Morris?

A. At Morris, for 1899, the indications are that there were about 930,000 and for the year 1900, a little less than 45,000. 9266

Q. What is shown at Averyville?

A. At Averyville the exhibit shows very few numbers for both years, about 10,000 for 1899 and rather less than 5000 for 1900.

Q. What does the next column indicate—there are three columns there?

A. That is for Wesley City. Do you wish that?

Q. Yes?

A. For Wesley City the dark lines show about 3,925,000 for 1899, and for 1900 a little less than 100,000.

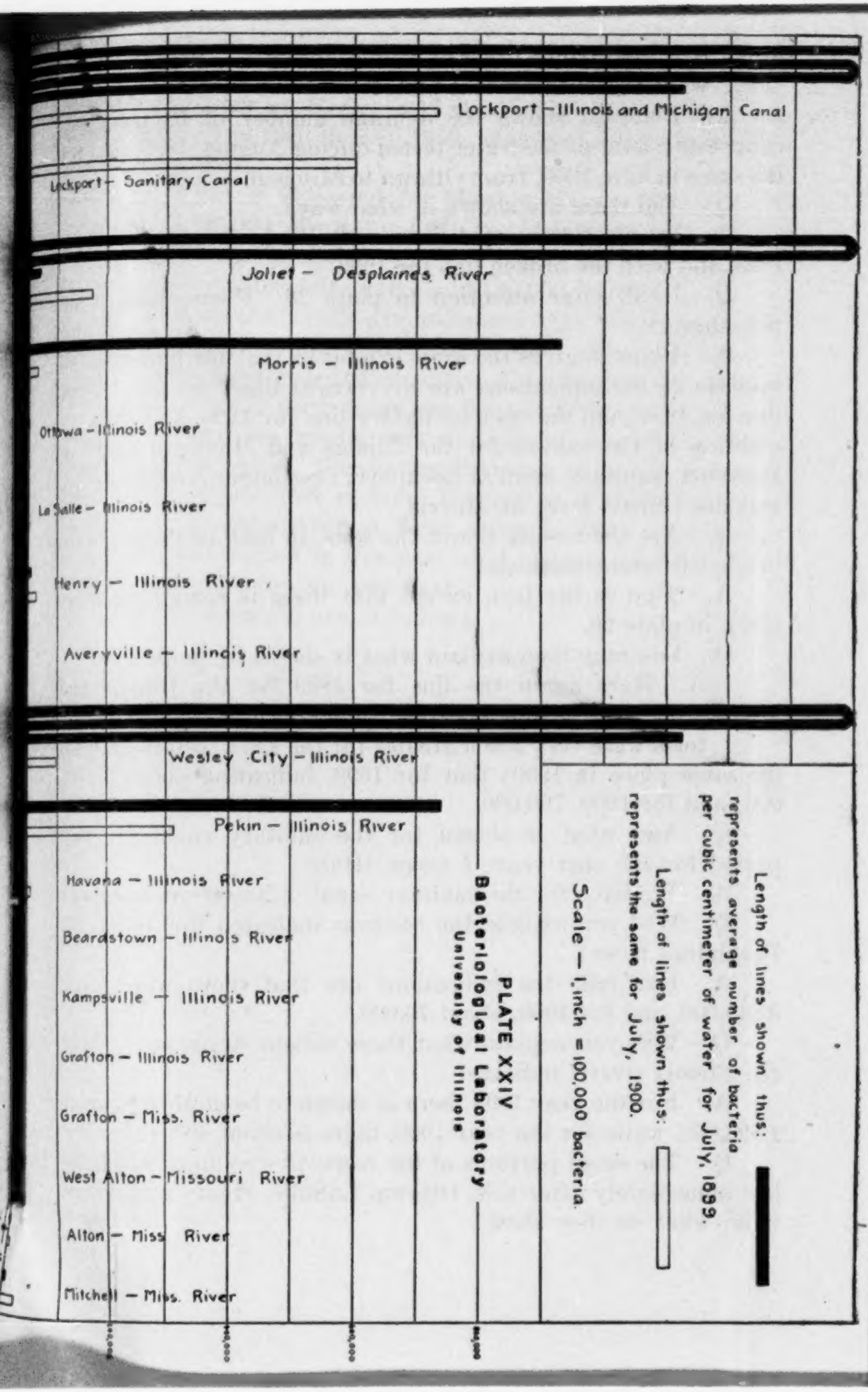
Q. What is the result as to Pekin?

A. For 1899, the indications are that there were about 740,000; and for 1900, 315,000.

Q. What are the ascertainments for the remainder of the river down to Mitchell, or the chain of rocks?

A. From Havana on through the course of the stream the indications show very clearly that the number of bacteria were compared with those already mentioned, exceedingly small.

Plate No. 24 is as follows:



Length of lines shown thus: ■ represents average number of bacteria per cubic centimeter of water for July, 1899.

Length of lines shown thus: ☐ represents the same for July, 1900.

Scale — 1 inch = 100,000 bacteria.

PLATE XXIV

Bacteriological Laboratory

University of Illinois

9268 Q. I call your attention now to plate 25. Please explain what is shown by that plate?

A. Plate 25 shows the average number of bacteria per cubic centimeter of the water tested during August, 1899, and for the same month, 1900, from Ottawa to Mitchell.

Q. And these are shown in what way?

A. By black connected lines, with the heavy dark line for 1899, and with the broken line for 1900.

Q. I call your attention to plate 26. Please state what that shows?

A. Plate 26 gives the same exhibit as that for plate 25, but in plate 26 the indications are by vertical lines, the solid black line for 1899, and the open or lighter line for 1900, and with the addition of the exhibit for the Illinois and Michigan canal at Lockport; sanitary canal at Lockport; Desplaines river at Joliet, and the Illinois river at Morris.

Q. Are the results shown the same in both of these plates, but by different methods?

A. That is the fact, except that there is something more given in plate 26.

Q. You may then explain what is shown by plate 26?

A. Here again the line for 1899 for the Illinois and 9269 Michigan canal at Lockport show that the number of bacteria were very much greater for the same waters than for the same place in 1900; that for 1899, indicating about 3,240,000; and for 1900, 790,000.

Q. And what is shown for the sanitary canal for that period for the next year; I mean, 1900?

A. We have for the sanitary canal, 1,200,000 at Lockport.

Q. Will you explain the columns indicated for Joliet, the Desplaines river?

A. For 1899 the indications are that there were about 3,240,000, and for 1900, about 70,000.

Q. Will you explain what these colums designated "Morris, Illinois river" indicate?

A. For the year 1899 there is shown to be at Morris, about 4,890,000, while for the year 1900, there is about 40,000.

Q. The small portions of the respective columns which follow immediately after this, Ottawa, LaSalle, Henry and Averyville; what do they show?

A. They show that for this month of August the colony counts from Ottawa to Averyville inclusive were very low, but greatest for 1899 at Henry. At Averyville the number was slightly greater in 1900 than in 1899, while at LaSalle they were about equal.

9270 Q. What is indicated for Wesley City?

A. 2,360,000, about, for 1899, and 50,000 for 1900.

Q. And what for Pekin?

A. 1,940,000 for 1899, and about 145,000 for 1900.

Q. The counts which are indicated thereafter beginning with Havana, and ending with Mitchell, show what condition?

A. Here again it is indicated that the comparative number of bacteria found is very much less than at Wesley City and at Pekin, but upon the whole, very similar to those found from Ottawa to Averyville. The largest number represented in this section of the plate, that is, from Havana to Mitchell inclusive, was, in the Missouri river at West Alton, in 1899. The showing is not far different in this part of the plate, otherwise than as mentioned, between the two years.

Plates 25 and 26 are as follows:

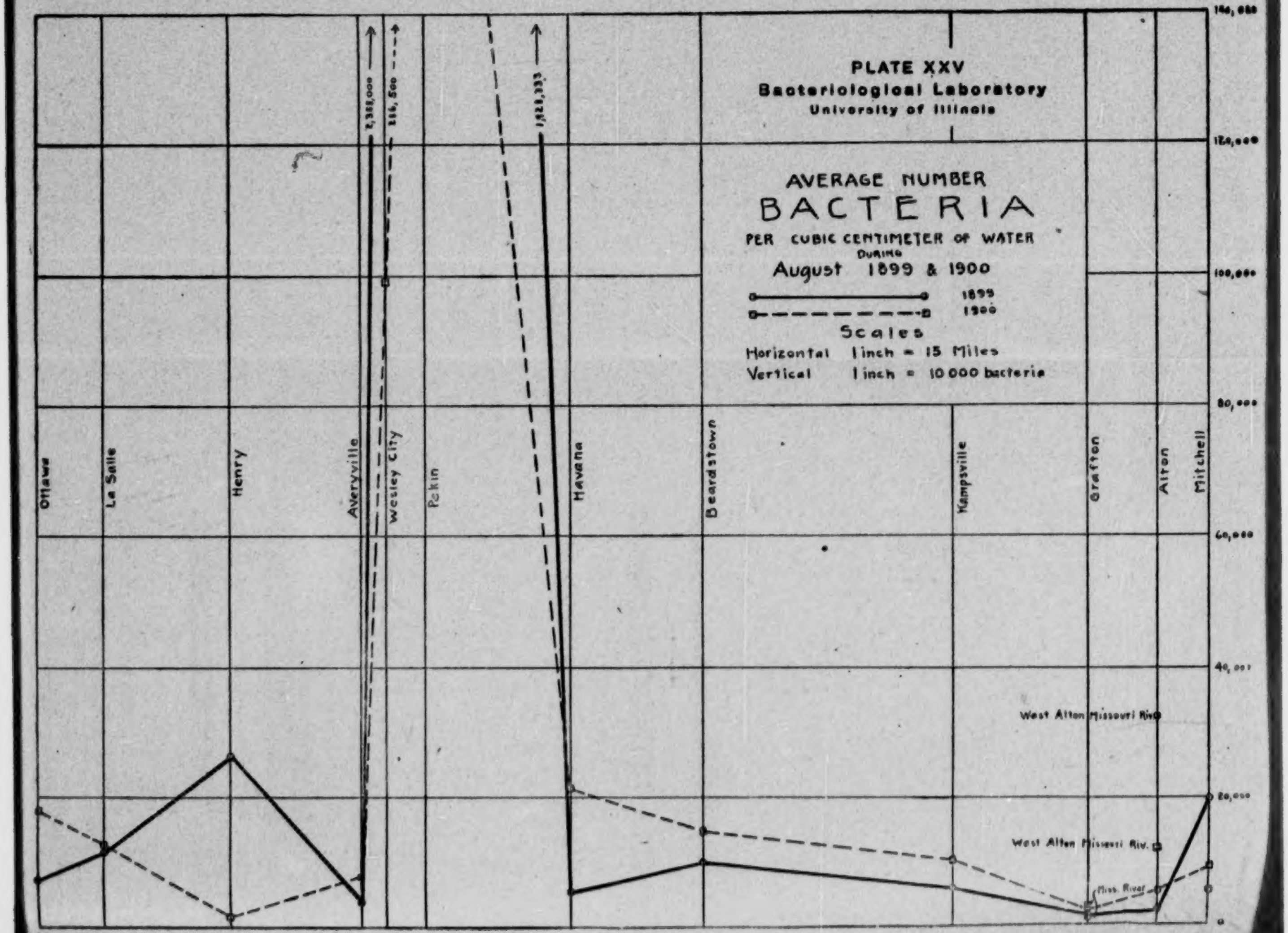


PLATE XXV
Bacteriological Laboratory
University of Illinois

AVERAGE NUMBER
BACTERIA
PER CUBIC CENTIMETER OF WATER
DURING
August 1899 & 1900

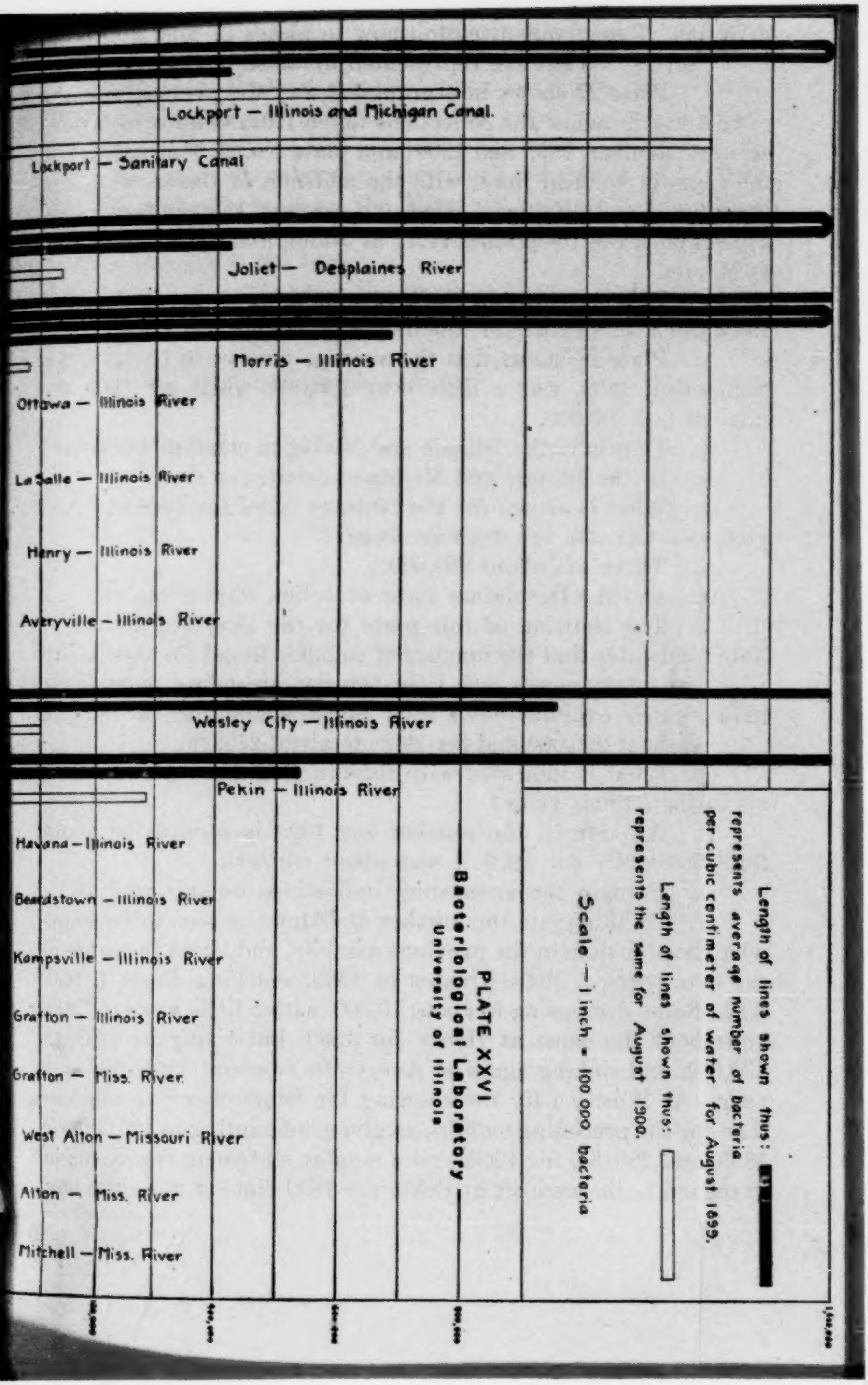


PLATE XXVI

Bacteriological Laboratory
University of Illinois

9273 Q. I call your attention now to plates 27 and 28 of this series. What are represented by these plates?

A. Plate 27 shows in a graphical way the average number of bacteria found at the collections taken from Ottawa to Mitchell in September, 1899 and 1900; and plate No. 28 is an exhibit of the same in vertical lines, with the addition of the showing for the Illinois and Michigan canal at Lockport, the sanitary canal at Lockport, the Desplaines river at Joliet, and the Illinois river at Morris.

Q. What is shown by these two plates as to the condition of the water at Lockport for this month of September, 1899?

A. Plate 28 shows that the average number of bacteria for September, 1899, was a little over 700,000, while for 1900 the number is 3,200,000.

Q. That is in the Illinois and Michigan canal at Lockport?

A. In the Illinois and Michigan canal, yes sir.

Q. What is shown for the sanitary canal for 1900 at Lockport, and the Chicago drainage canal?

A. There are about 650,000.

Q. And the Desplaines river at Joliet, what is shown?

A. The showing of this plate for the Desplaines river at Joliet indicates that the number of colonies found for this month was very much less than for the preceding months for
9274 which exhibits have been given amounting in 1899 to about 220,000 and for 1900, to about 210,000.

Q. What is indicated with reference to the waters at Morris in the Illinois river?

A. At Morris, the number for 1899 is seen to be about 2,190,000 while for 1900 it was about 640,000.

Q. Explain the succeediing indications on this plate?

A. On this plate the number at Ottawa is seen to be somewhat greater than in the previous exhibits, and about the same in the two years, a little greater in 1899, reaching about 40,000. At LaSalle, decreasing to about 10,000, with a little more in 1900, and about the same at Henry for 1899, but rising in 1900, to 130,000, and sinking again at Averyville to about 3,000 for each year. At Wesley City the showing for September is much less than for the preceding months, as given, amounting to 490,000 for 1899, and 280,000 for 1900, and a similar statement can be made in regard to the number at Pekin for 1899 since it is a little less than 400,000; but for 1900 the representation indicates that there were 1,070,000 at this place.

At Havana there were also more for 1900, there being about 70,000, while for 1899 there seems to be less than 2,000.

During the rest of the course of the stream the numbers are again comparatively very much reduced, but are more
9275 than elsewhere from the Missouri river at West Alton,
where the number seems to be about 20,000 and upwards for 1899 and 25,000 for 1900.

At Alton for this year the number is slightly greater for 1900 than for 1899. At Mitchell the numbers were about equal for the two years.

Tables 27 and 28 are as follows:

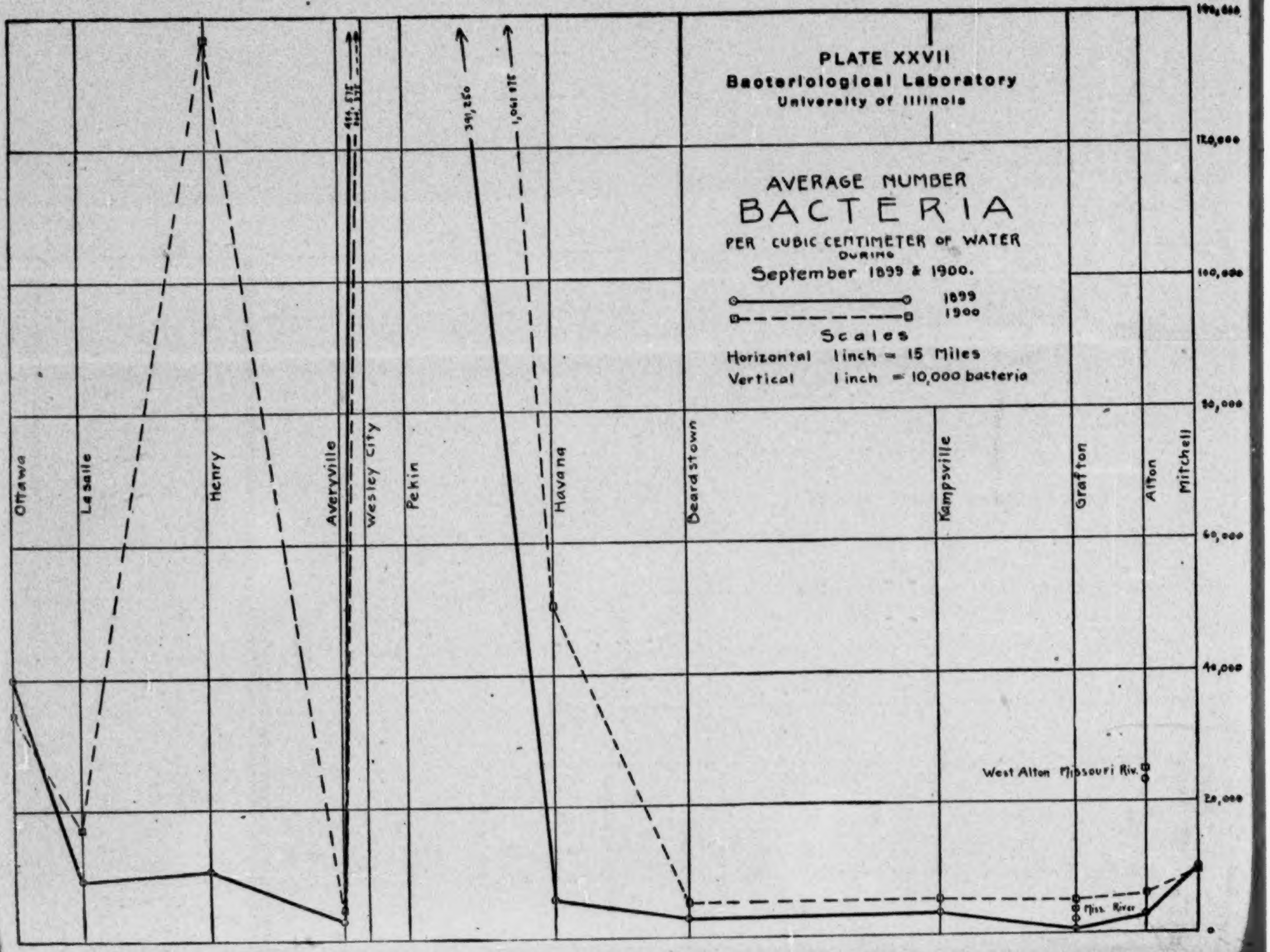


PLATE XXVII
Bacteriological Laboratory
University of Illinois

AVERAGE NUMBER
BACTERIA
PER CUBIC CENTIMETER OF WATER
DURING
September 1899 & 1900.

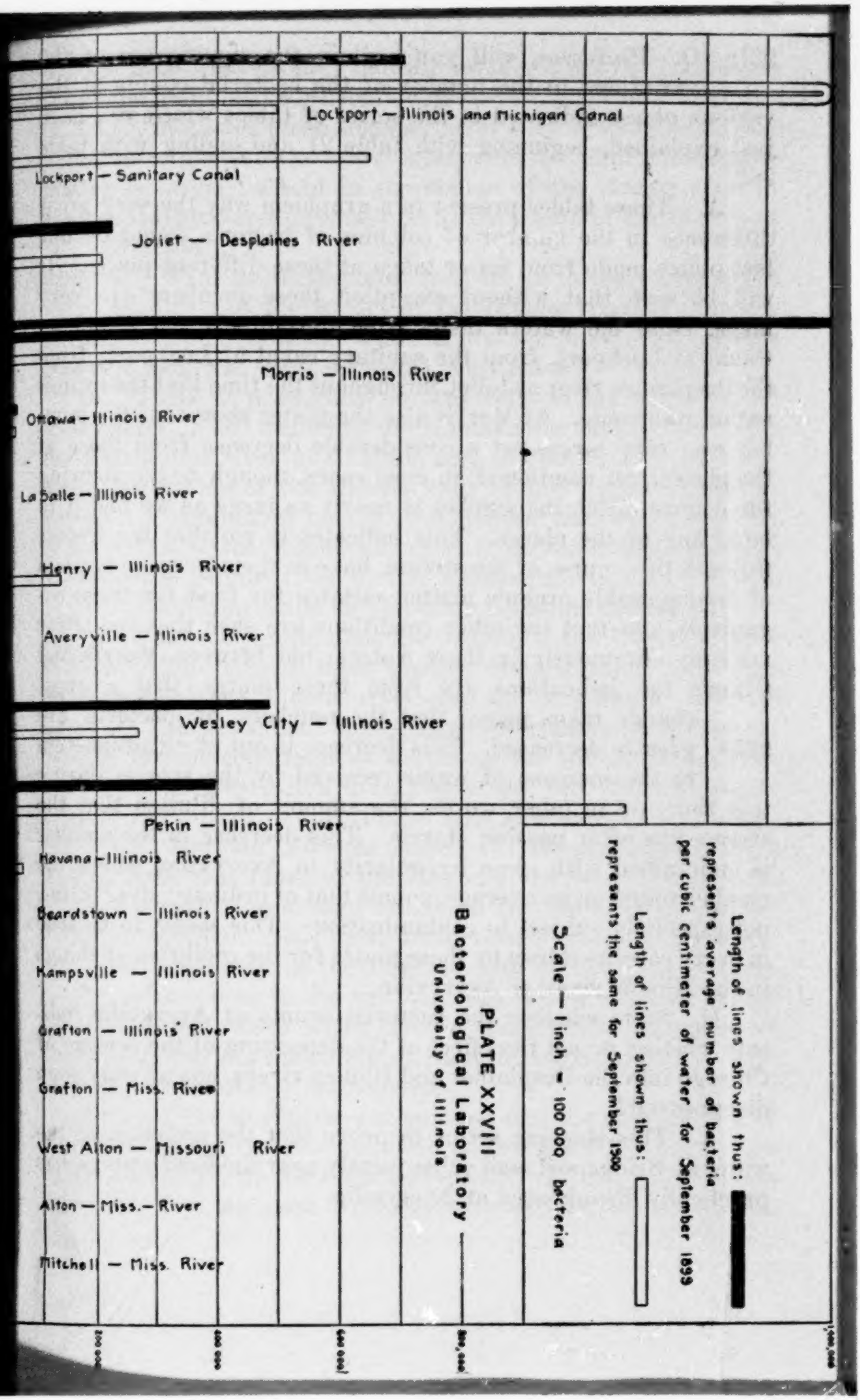


PLATE XXVIII
Bacteriological Laboratory
University of Illinois

9278 Q. Professor, will you explain the significance of the variations in the number of the bacterial counts at the various places indicated in the series of tables which you have just explained, beginning with table 21 and ending with table 28?

A. These tables present in a graphical way the very great difference in the number of colonies of bacteria found on our test plates made from water taken at these different places. It will be seen that without exception these numbers are very large, from the waters taken from the Illinois and Michigan Canal at Lockport, from the sanitary canal at Lockport; from the Desplaines river at Joliet, throughout the time that the examination was made. At Morris also the plates show that the number was very large, yet a considerable decrease from those at the places just mentioned, in most cases, though in the showing for August, 1899, the number is nearly as large as we find it to be at any of the places. This indicates to me that the waters through this course of the stream, have in them great quantities of decomposable organic matter suitable for food for these organisms, and that the other conditions are such that the latter multiply enormously in these waters; but between Morris and Ottawa the indications are from these plates, that a great change takes place; that the numbers of bacteria are 9279 greatly decreased. This decrease is out of all proportion to the increase of water received by the stream during this time, or in other words, the amount of dilution that the stream has after passing Morris. This decrease in the number is maintained with some irregularity to Averyville, where the number found on an average, equals that of ordinary river water, not especially subject to contamination. This seems to be true in every case, as shown by these plates for the condition of things in the Illinois river at Averyville.

Q. State whether the bacterial counts at Averyville indicate whether or not the effect of the depositing of the sewage of Chicago into the Desplaines and Illinois rivers, has already soon disappeared?

A. This showing seems to prove that the pollution of the water at Bridgeport, and subsequently near the head waters, has practically disappeared at Averyville.

Q. And what do they indicate further down at Grafton, so far as the additional contribution of pollution is concerned?

A. The plates taken together show very conclusively great pollution of the stream below Averyville, but that the organic matter is largely absent in the course of the stream after it reaches Havana, and especially so at the mouth of the Illinois at Grafton.

9280 Q. What do these plates indicate as to the comparative condition of the waters of the Illinois river at Grafton, the Mississippi river above Grafton, and the Missouri river just above its mouth at the place called West Alton?

A. There is practically no difference so far as shown by these plates, in the waters of the Illinois river before they enter the Mississippi river at Grafton, and of the Mississippi river above the mouth of the Illinois river at this place. There is, however, a continuous exhibit of a greater number of bacteria in the waters of the Missouri river at West Alton than there are in either the Illinois river or the Mississippi river at Grafton.

Q. What conclusion do you draw from this difference?

A. I can only infer that the waters of the Missouri river at West Alton have in them greater contamination than have the waters of the Illinois river and the Mississippi river at Grafton. I do not think I have enough information of the special reasons for the conditions as shown for the waters of the Missouri river at West Alton to be able to say why the pollution is greater there than in the Illinois and Mississippi at Grafton. I will say, however, that the records of temperature in these waters show that those of the Missouri are for the most part somewhat lower than are those for the Illinois and the 9281 Mississippi. This lower temperature probably has something to do with the lessened rate of decrease in these colder waters, than in the warmer ones, for it must be understood that the waters which have a temperature favorable to the growth and multiplication of bacteria, clear up sooner than those not so favorably conditioned.

I would like to express my opinion, that the greater part of this clearing up from the pollution of the water is directly due to the agency of the bacteria themselves, and this will explain why I say that the more favorable the condition for the growth and multiplication of the bacteria the quicker the pollution disappears.

Q. Will you explain what is the effect produced by these bacterial agencies?

A. The bacteria have in general, as a source of food, dead organic matter. They in this respect have the same influence upon this organic matter as do animals, reducing the compounds from their higher or complicated states to less and less complex conditions, until finally the hydro-carbons are so reduced to water and carbon dioxide and the proteid matters, to ammonia or still further, to nitrites and nitrates ultimately; in other words, the principal role of bacteria in this regard is exactly opposite to that of green vegetation,—the latter are concerned in building up organic compounds from the simpler 9282 states, and the bacteria are reversing the process and ultimately the result is that the operations of the green vegetation are exactly destroyed; and we start over again with the condition of the substances in which we had them at first.

Q. In other words, the bacteria operate upon dead organic matter whether animal or vegetable, and reduce such matters to their original elements, and these original elements are in turn taken up by the chlorophyl vegetation and restored again to the form of vegetable matter, and vegetable matter being used as the food for animals, produce again animal matter?

A. Yes, I think that is correct.

Q. Could there be any reduction of animal or vegetable matter without the agency of such bacteria?

A. As I understand it there is no such reduction of consequence, except through the agency of living beings, and in the operations as a whole upon the earth, the bacteria are the principal of these living agencies, though what they do is not far different from what is accomplished by many plants belonging to the group called fungi, nor far different from the activities in this respect, of animals.

9283 I would say, though, the operations of bacteria are more commonly in graded stages, and by this I mean that the compounds are not at once reduced to their elements, but the more complex are rendered somewhat less complex, and these again still somewhat less complex, until finally the complete reduction is produced. In other words, the bacterial operation is often to a slight extent upon a very large amount of matter, while the operations of animals are generally made to take effect to a greater extent upon a small amount of organic matter.

Q. What role do bacteria perform in producing what is called oxidation of organic matter in water?

A. Oxidation itself is a chemical process, but from my information there is exceedingly little of this taking place without the aid of living organisms—

Q. Of micro-organisms?

A. Not necessarily of micro-organisms, but largely of micro-organisms. In regard to the changes taking place in water I will say that there has been a great deal of discussion upon this point. Formerly it was quite commonly understood to be the fact that oxidation proceeded as a simple chemical operation without any aid from living beings at all. All of my experience in the laboratory, entirely upon the bacteriological side and
9284 not upon the chemical side, indicates that such purely chemical operation is very slight if it takes place at all, while the oxidation of carbonaceous material due to bacteria as the agents, is very prominent; very striking.

If you will permit me, I will say that I have kept in my laboratory for years at a time, beef broth fully exposed to the air, at the temperature of the room, where everything seemed to be favorable for the oxidation of its contents if it could take place without organisms, but so long as these organisms were excluded even over great lengths of time, such reduction did not appear to take place at all.

Q. What do you infer from a bacterial examination of water from the presence of a large number of micro-organisms?

A. It seems to me, if this is natural water, that it is positive proof that there is organic matter there suitable for the food of these organisms.

Q. What kind of organic matter is it that is most suitable for the food of micro-organisms, known as saprophytes, for instance, and water bacteria?

A. Proteid matter is most suitable for many, but carbonaceous compounds are very favorable for numerous other kinds, though some of both would be needed.

9285 Q. Is this organic matter in water coming from sewers suitable for the food of this micro-organism?

A. It is evidently very suitable.

Q. Where you cannot attribute the presence of a large number of micro-organisms in water to natural causes, what inference do you draw of the possibility or probability that such contamination comes from sewage?

A. Sewage is richer food for bacteria than any other that commonly escapes into our river water courses from the land, or from the surface of the earth otherwise. There is rarely found such very large numbers of organisms in river waters except from sewage contamination, and I mean by this when the numbers run into the millions per cubic centimeter.

Q. When in the examinations of water at different points in a river, you discover a material reduction in the number of the micro-organisms found in the water, what inference do you draw with reference to the sewage that may have been in the river?

MR. JEFFRIES: I object to the question for the reason that the witness is not qualified as a sanitarian and for the further reason that he has not stated his qualifications or experience in dealing with sewage and sewage polluted waters.

9286 JUDGE SPRINGER: I think he did. He stated that he has been examining the waters for many years for state institutions for the purpose of determining their sanitary condition.

MR. JEFFRIES: He didn't state where it came from, whether it was well water or not.

JUDGE SPRINGER: He stated it came from the water supplies of the state institutions.

Q. (Question repeated)?

A. I think I am entitled to infer that the matter suitable for food for these bacteria has disappeared, and since, as has just been said, sewage is the richest food commonly in such water, I may further infer that the sewage has disappeared.

Q. Please state, Professor, whether you prepared any plates in reference to the identification of the bacillus coli-communis in the Illinois and Mississippi rivers, and the tributaries covering this period?

A. Yes, sir, I did.

9287 Q. Have you those plates with you at this time?

A. I did prepare plates, but I discover there was some error in them and I will insert them in the record at this place when I have prepared them in the proper form to correspond with the data in tables 1 to 80, of this series.

MR. JEFFRIES: That is perfectly satisfactory to the State of Missouri, or to the complainant, provided of course that if we desire after the plates have been furnished to the Commissioner by the witness, that we have an opportunity to cross-examine him with reference to the plate and the plate alone, in addition to what cross-examination we may see proper to interpose while the witness is now on the stand.

The tables, as corrected by the witness, are as follows:

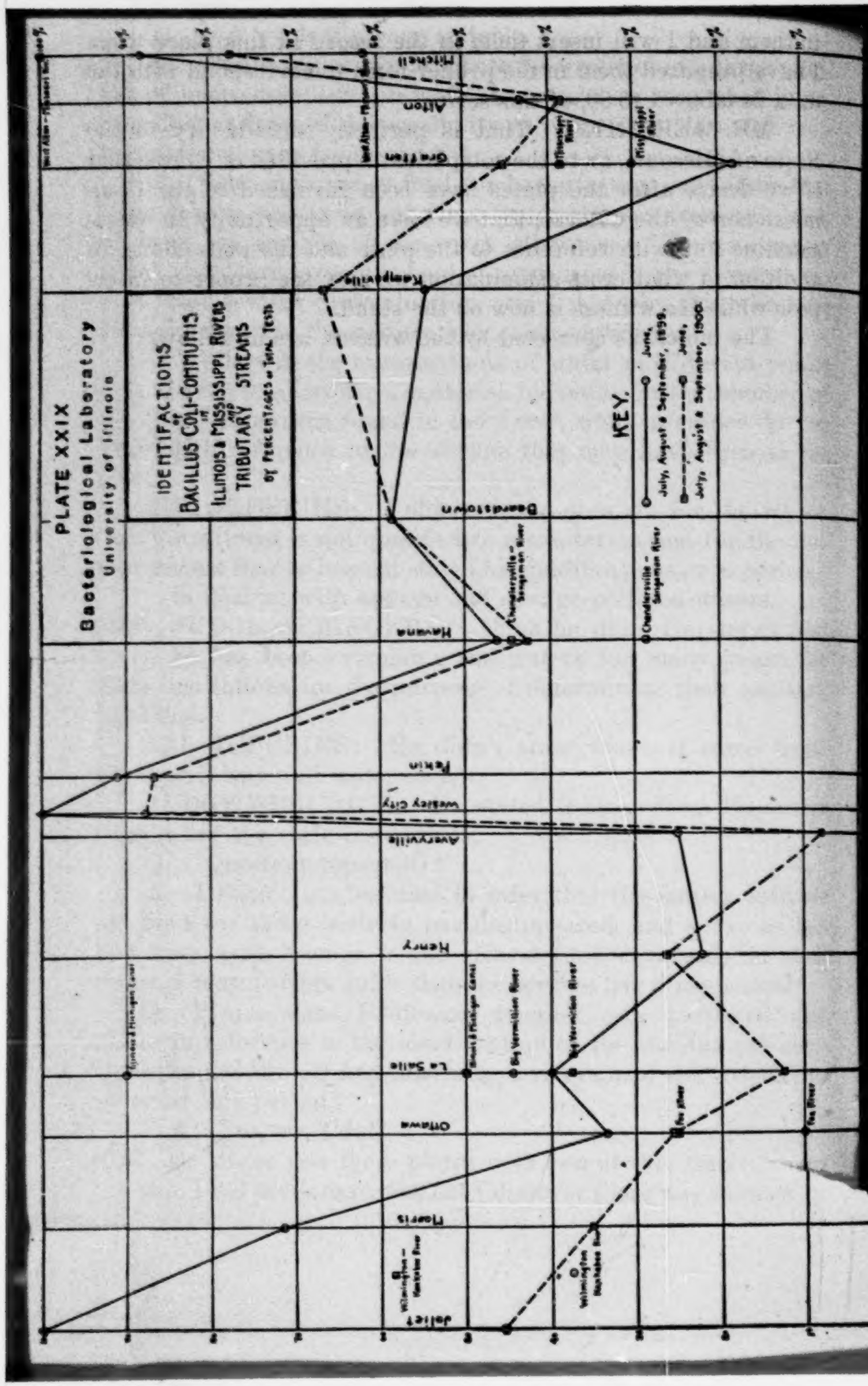


PLATE XXIX
Bacteriological Laboratory
University of Illinois

IDENTIFACTIONS OF BACILLUS COLI-COMMUNIS IN ILLINOIS & MISSISSIPPI RIVERS AND TRIBUTARY STREAMS

BY PERCENTAGES OF TOTAL TESTS

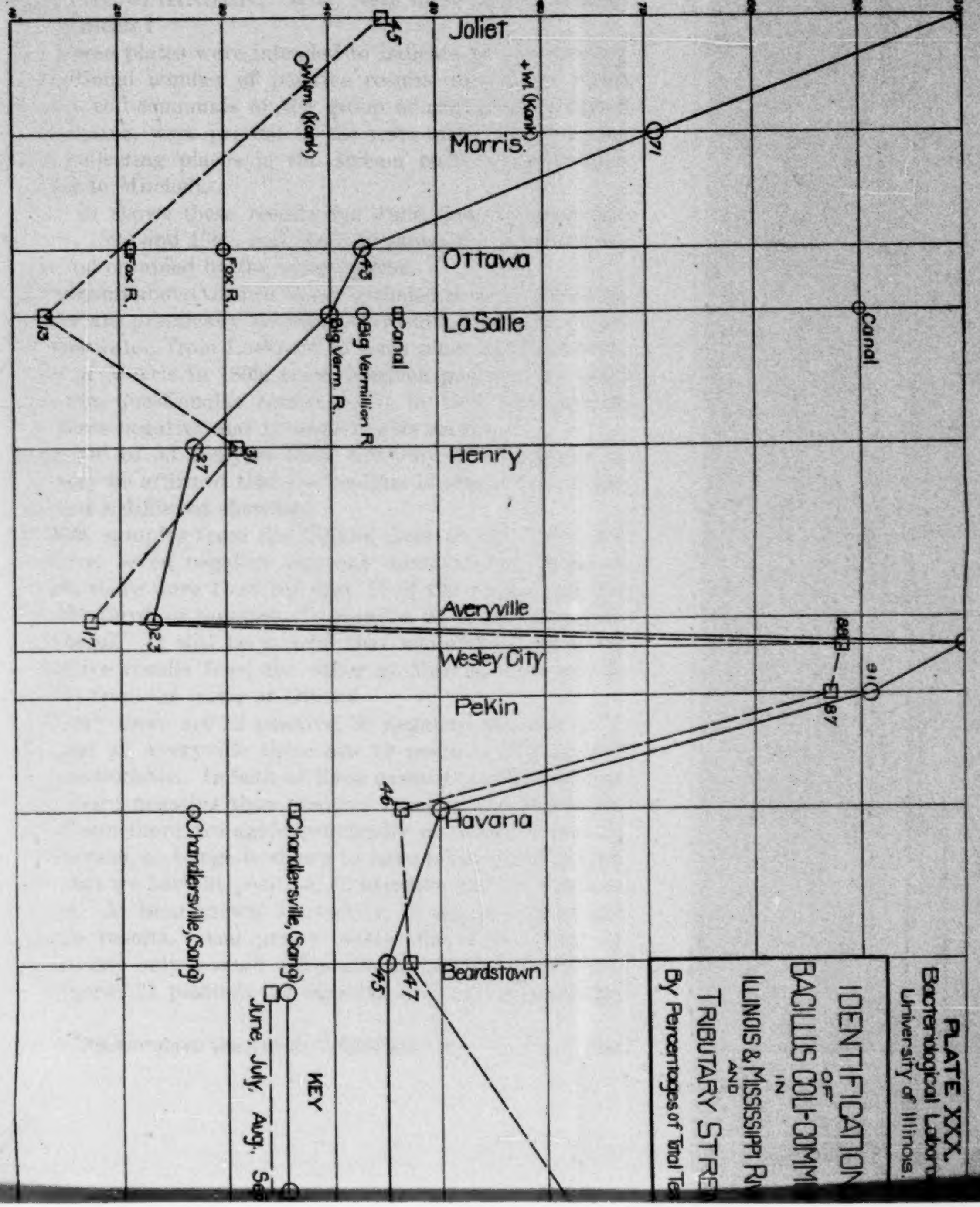


PLATE XXX.
Bacteriological Labora
University of Illinois.

IDENTIFICATION OF BACILLUS COLI-COMM IN ILLINOIS & MISSISSIPPI RI AND TRIBUTARY STRE

By Percentages of Total Te

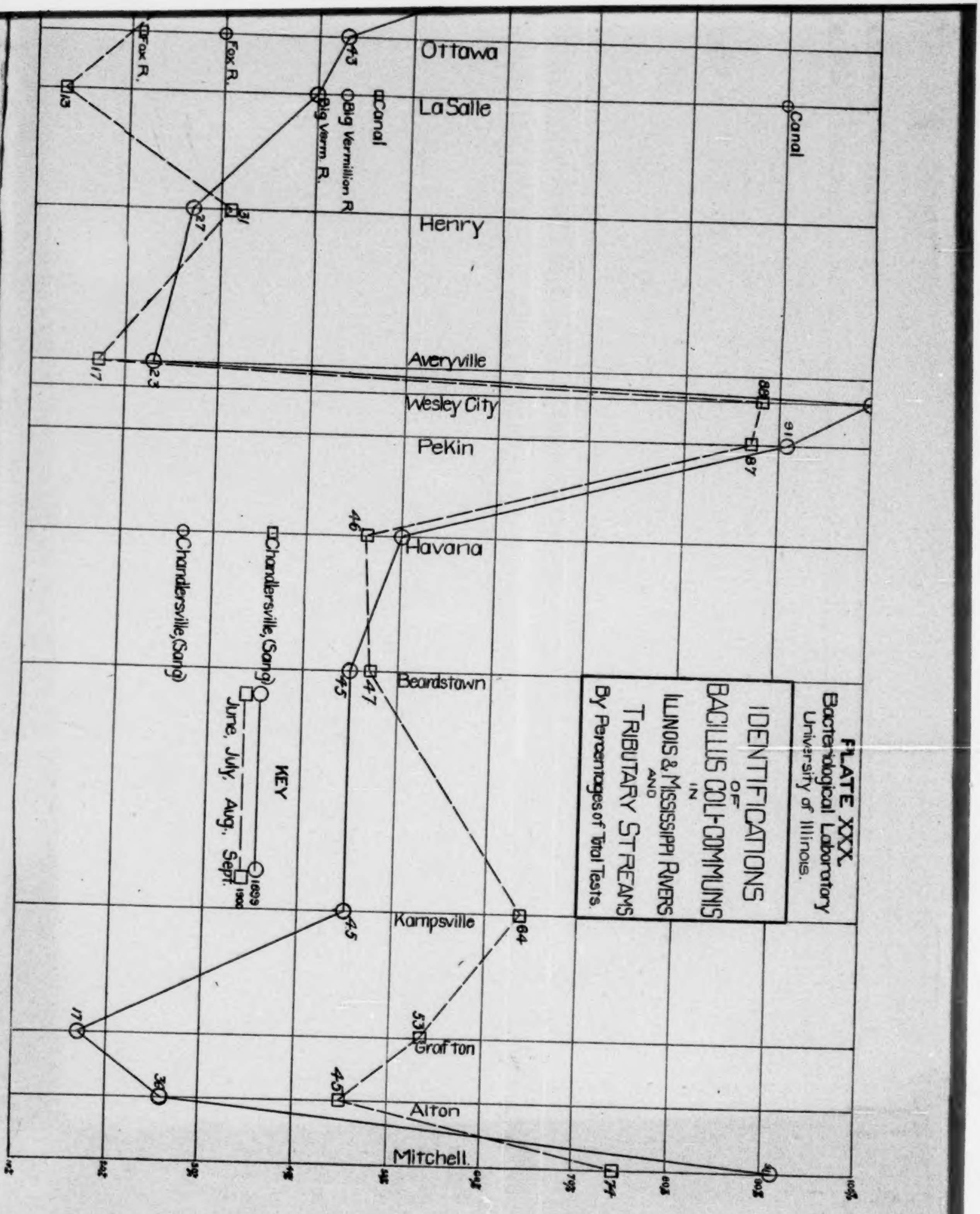


PLATE XXX.
Bacteriological Laboratory
University of Illinois.

IDENTIFICATIONS OF BACILLUS COLI-COMMUNIS IN ILLINOIS & MISSISSIPPI RIVERS AND TRIBUTARY STREAMS

By Percentages of Total Tests.

9290 JUDGE SPRINGER: What were these plates intended to indicate?

A. These plates were intended to indicate by percentages, the proportional number of positive results, that is, in which the bacillus coli-communis or the group of organisms referred to by this name, were present in the tests made by me at the different collecting places in the stream under consideration from Joliet to Mitchell.

Plate 29 shows these results for June, July, August and September, 1899 and 1900, and plate 30 shows the same for the entire period occupied by the investigation.

The stream above Ottawa is not included in this exhibit because there are practically no negative results from any of the tests in this water, from Lockport to some place above Ottawa.

Tests at Morris in 1899, show fourteen positive, no negative, and two questionable results, while in 1900 there are 23 positive, three negative and 11 questionable results.

Thus, out of 53 analyses there are only three samples in which it may be affirmed that the bacillus is absent, but at Ottawa we find a different showing:

In 1899, samples from the Illinois river at this place, ten give positive, seven negative and one doubtful test, while in 1900, there were 11 of the first, 17 of the second and five
9291 of the third, or together, 21 positive, 24 negative and six
doubtful. It will be noticed that while there were but three negative results from the water at Morris, there are 24 such results from the water at Ottawa.

At Henry there are 22 positive, 30 negative and five questionable, and at Averyville there are 19 positive, 21 negative and two questionable. In both of these cases it is observed that there are more negative than positive results; but at Wesley City and Pekin there are again practically no negative results, while at Havana, a change is shown to have taken place in such a manner that we have 31 positive, 12 negative and 14 questionable results. At Beardstown, 37 positive, 18 negative and three questionable results. And pretty closely the same thing at Kampsville, and only a small difference in the Illinois at Grafton, as follows: 31 positive, 23 negative and one questionable result.

If now we compare the results obtained from the waters at the mouth of the Illinois river, with those in a similar way from the waters of the Mississippi above the mouth of the Illinois and of the Missouri at West Alton, we shall have the following exhibit:

In the Illinois river, 31 positive, 23 negative and 9292 one questionable result. In the Mississippi river water, 35 positive, 20 negative, one questionable result; from the waters of the Missouri river 36 positive, 7 negative and seven questionable results.

This indicates that the organism is most often present in the waters of the Missouri river; next in those of the Illinois at the mouth and somewhat less frequently in those of the Mississippi, if we take into consideration the whole time of the investigation.

By reference to the graphical showing in this connection it will be seen that the less number of positive results through the whole course of the stream from Bridgeport to Mitchell was at Averyville, there being a slightly greater per centage of positive results at Grafton than at this last place. The greater number shown for the waters collected near Mitchell, seem to be due to the larger proportion or greater number in the waters of the Missouri river.

Q. Now, in the various bacterial examinations which you made of the waters indicated by you in tables 1 to 80, in those examinations, did you make any effort to determine the presence of the bacillus typhosus?

A. I did not.

9293 Q. Did you make any experiments on live animals for the purpose of testing toxins in the water?

MR. JEFFRIES: For the reasons stated by this witness that no effort was made by him to discover or determine the presence of the bacillus typhosus, in the waters of the Illinois river and the drainage canal as examined by him, I move to strike out the opinion of Professor Long, Professor Palmer and Professor Zeit, which was to the effect that they did not believe, or rather believed that the typhoid bacilli emanating from Chicago did not reach Grafton and the City of St. Louis and the intake thereof, for the reason that it has not been discovered by any of the bacteriologists who have examined samples of the water from those streams, their opinion so expressed being based upon the assumed fact that all examinations so made were with a view to determining the presence of such bacilli.

JUDGE SPRINGER: The examinations made by other witnesses have nothing to do with the examinations by this witness, and I merely desire the fact to go into the record, that he did not enter upon that branch of the case.

MR. TODD: In reply to the objection I want to suggest that no witness who has testified in this case on either side, has found the typhoid bacillus in the running waters of the
9294 Illinois river, and not only have they not found it in this
river, but there are no well authenticated cases on record, with the possible exception of six, where it has been found, and if the fact that this witness did not look for it is any reason why opinions of other witnesses should be excluded, by the application of that doctrine, it would exclude the opinion of every witness who testified in this case for complainant, as none of them found the typhoid bacillus, and the opinions of the gentlemen named in the objection were formed as much upon the testimony of Dr. Ravold, whose testimony they were familiar with, as upon the testimony of other witnesses.

MR. JEFFRIES: I am willing to admit the statement of counsel with reference to the failure to find this particular bacillus in water, and go even further with the statement that if it should be found in any water and be disseminated in the water proportionally, that the number contained in the centimeter examined, and found,—that the water would be condemned beyond question, but my motion to strike out is based on the fact that the opinion expressed by the witnesses, which was heretofore referred to, was premised upon the proposition that they believed that such bacilli did not reach Grafton or St. Louis, because they had not been found by any of the examiners who
had analyzed the water, and this witness having stated
9295 that he did not examine it for the purpose of determining
the presence of such bacilli, it affects the credibility of the opinion so expressed by the witnesses which I have referred to.

MR. TODD: I want to suggest to counsel that if he will review the testimony of Professor Long and Professor Palmer, he will find in their testimony frequently stated that they were not passing opinions as bacteriologists, but that they were strictly chemists.

JUDGE SPRINGER: Did you make any experiments on live animals for the purpose of testing toxins in the water?

A. I did not.

Q. Based upon your bacterial examinations of the waters in the Illinois river and its tributaries, and of the Mississippi river and the Missouri river to which you have referred and which are embraced in the tables and plates which have been submitted in evidence by you, what is your opinion as to the effect produced, if any, upon the waters of the Mississippi river below the mouth of the Illinois river by the opening of the Chicago drainage canal in January, 1900?

MR. JEFFRIES: I object to the question for the reason that the testimony of this witness refers to bacterial counts, without reference to the character of the bacteria, whether they be pathogenic or non-pathogenic, without reference to the 9296 pollutions of the streams of waters examined by him, or the extent of the pollution, and any opinion that the witness might give with reference to what his analyses show, would not disclose the effect of the pathogenic germs passing down the Illinois river coming from the sewage of 2,000,000 of people at Chicago in connection with the sewage from the people living upon the watershed of the Illinois river, as compared with the sewage discharged into other rivers mentioned in the question, the witness not having stated in evidence anything concerning his opinion as to the extent of the sewage pollution of any of the rivers in question, and not having differentiated in his testimony between pathogenic and non-pathogenic bacteria and the effect of the sewage disposals into a running stream, producing larger or smaller quantities of pathogenic germs, than the sewage that ordinarily comes from industrial, domestic and farm wastes.

JUDGE SPRINGER: This objection in my opinion is merely argumentative and goes to the weight of the testimony if it goes to anything, and does not affect its admissibility as the testimony of this witness, and the opinion of the witness are based upon examinations which he himself has made.

9297 MR. JEFFRIES: I submit that it goes to the admissibility of the inferences or conclusions which the witness is now requested to draw from the bacterial analyses of the waters of the Illinois river and of the other streams mentioned in the question, and the witness not having shown in evidence any knowledge of the extent of the pollution from the sewage discharges of the various cities upon the watersheds of the rivers examined by him, and not having differentiated upon the character of the pathogenic germs, the objection goes to the admissibility of the evidence called for by the question, and not to its weight or credibility.

JUDGE SPRINGER: I desire to suggest further that this witness might give his opinion upon any one of the examinations which he has made, and if the opinion is based upon that particular examination, as to what that examination means, and he may give it as to all of them at once.

MR. TODD: I move to strike out all of counsel's statements except so much of it as is a legal objection to the question.

Q. (Question repeated.)

A. In my opinion the very decided reduction of the number of the bacteria found in the course of the stream up to the time the waters reached Averyville, causing the waters at this place to assume the character of a normal river water, indi-
9298 cates that the contaminations from the sewage introduced into the stream from Chicago have disappeared at this point, and I cannot otherwise than conclude that the evidence now presented shows that the water at the mouth of the Illinois river at Grafton is practically free from any such contaminations introduced at Chicago.

I find also that the contamination as indicated in the water at the inlet tower at the chain of rocks, has a larger portion of its contamination from the water of the Missouri river rather than from the combined waters of the Illinois and the Mississippi at this point. I can say that the opening of the drainage canal has had no effect upon the waters of the Mississippi river one way or the other.

JUDGE SPRINGER: Professor, did you make any bacterial examinations of the waters of the Illinois river, the Mississippi river and the Missouri river in the months of October, November and December, 1901?

A. I did.

Q. Under what circumstances were those samples taken?

A. They were taken in the same manner and by the same

9303 Pekin, Illinois River, 1901.

	Coll.	Ex.	Bacteria.	Coli.
October	15,	16,	6,500	—
	16,	17,	81,500	
	18,	18,	1,080,000	
	17,	18,	1,060,000	
	21,	21,	185,000	x
	22,	22,	510,000	—
	25,	25,	286,000	x
	28,	28,	150,000	x
	28,	30,		x
November,	1,	1,	2,400,000	?
	4,	4,	260,000	x
	6,	6,	510,000	x
	8,	8,	60,000	x
	11,	11,	220,000	?
	13,	13,	145,000	x
	15,	15,		x
	18,	18,	90,000	x
	20,	20,	120,000	x
	22,	22,	5,000	x
	25,	25,	35,000	x
9304	Coll.	Ex.	Bacteria.	Coli.
November	27,	27,	10,000	x
	29,	29,	20,000	x
December	2,	2,	4,500	—
	4,	4,	49,500	x
	6,	6,	73,500	x
	9,	9,	60,000	x
	11,	11,	140,000	—
	12,	13,	12,500	x

No. of bacteria, average—299,000.
B. Coli-Com. 7.6 per cent.

9305 Grafton, Illinois River, 1901.

	Coll.	Ex.	Bacteria.	Coli.
October	14,	15,	1,900	—
	16,	17,	750	...
	17,	18,	1,100	...
	18,	19,	5,400	—
	19,	21,	2,750	...
	21,	22,	1,300	—
	22,	23,	1,350	—
	23,	24,	1,350	—
	25,	26,	1,650	—
	28,	29,	4,700	—
	30,	31,		—
November	1,	1,		—
	6,	7,	10,500	—
	8,	9,	6,000	—
	13,	14,	7,500	—
	15,	16,	2,350	—
	18,	19,	4,450	—
	20,	21,	4,200	—
	22,	23,	400	—
	25,	26,	800	—
	27,	28,	2,600	—
9306	Coll.	Ex.	Bacteria.	Coli.
December	2,	3,	17,900	—
	4,	5,	24,000	—
	6,	7,	16,650	—
	9,	10,	22,000	—
	11,	12,	16,050	—
	13,	16,		—
	16,	17,	48,250	x
	18,	19,	11,500	x
	20,	23,	10,500	—
	23,	25,		x

No. of bacteria, average,—8,441.

B. Coli-Com. 10.7 per cent.

9307 Grafton, Mississippi River,—1901.

	Coll.	Ex.	Bacteria.	Coli.
October,	14,	15,	1,500	—
	16,	17,	2,750	
	17,	18,	2,900	
	18,	19,	2,100	—
	19,	21,	3,150	
	21,	22,	2,950	—
	22,	23,	2,250	—
	23,	24,	2,750	—
	25,	26,	3,350	—
	28,	29,	5,100	—
	30,	31,	5,400	—
November,	1,	2,	3,820	x
	6,	7,	7,000	—
	8,	9,	9,000	—
	13,	14,	6,500	—
	15,	16,		—
	18,	19,	3,000	—
	20,	21,	2,450	—
October	22,	23,	150	—
November	25,	26,		—
9308	Coll.	Ex.	Bacteria.	Coli.
November	27,	28,	400	—
December	2,	3,	4,650	—
	4,	5,	32,900	—
	6,	7,	18,600	x
	9,	10,	9,500	—
	11,	12,		—
	13,	16,		—
	16,	17,	2,300	—
	18,	19,	700	—

No. of bacteria, average, 5,407.

B. Coli-Com. 11.5 per cent.

9309 Chain of Rocks, Illinois Shore, 1901.

	Coll.	Ex.	Bacteria.	Coli.
October	14,	15,	4,700	—
	16,	17,	3,700	
	17,	18,	18,500	
	21,	22,		
	19,	22,		
	25,	26,	81,000	—
	23,	28,		
	28,	29,		—
	30,	31,		x
November	1,	2,	15,000	—
	4,	5,	22,000	—
	6,	7,	10,500	—
	8,	9,	9,500	—
	11,	12,	813,500	x
	13,	14,	13,500	x
	15,	16,		—
	18,	19,	3,500	—
	20,	21,	18,000	x
	22,	23,	15,000	x
	25,	26,	2,000	—
	27,	28,	1,000	—

9310

	Coll.	Ex.	Bacteria.	Coli.
November	29,	30,	3,000	—
December,	2,	3,	4,000	—
	4,	5,	16,850	—
	6,	7,	38,850	—
	9,	10,	42,000	—
	11,	12,	3,500	—
	13,	14,	8,500	—

No. of bacteria, average, 52,177.
B. Coli-Com. 21.7 per cent.

9311 Chain of Rocks, Mid-Stream, 1901.

	Coll.	Ex.	Bacteria.	Coli.
October	14,	15,	5,350	x
	16,	17,	950	. . .
	17,	18,	17,000	?
	21,	22,		
	19,	22,		
	25,	26,	34,500	x
	23,	28,		
	28,	29,	116,000	—
	30,	31,		x
November,	1,	2,	37,500	—
	4,	5,	12,000	—
	6,	7,	38,500	—
	8,	9,	28,000	—
	11,	12,	120,000	x
	13,	14,	30,500	x
October	15,	16,		x
November	18,	19,	35,000	x
	20,	21,	3,500	x
	22,	23,	3,500	x
	25,	26,	2,500	—
	27,	28,	5,000	x

9312

	Coll.	Ex.	Bacteria.	Coli.
November	29,	30,	3,000	—
December	2,	3,	53,000	—
	4,	5,	16,850	—
	6,	7,	11,600	x
	9,	10,	276,500	—
	11,	12,	59,000	—
	13,	14,	84,000	x

No. of bacteria, average, 43,185.

B. Coli Com. 50 per cent.

9313 Chain of rocks, Intake Tower, 1901.

	Coll.	Ex.	Bacteria.	Coli.
October	14,	15,	24,300	
	16,	17,	450	
	17,	18,	193,000	
	21,	22,		
	19,	22,		
	25,	26,	304,500	x
	23,	28,		
	28,	29,	23,000	x
	30,	31,		x
November	1,	2,	55,000	x
	4,	5,	85,750	x
	6,	7,	102,000	—
	8,	9,	32,000	—
	11,	12,	58,500	—
	13,	14,		x
	15,	16,		—
	18,	19,	117,000	—
	20,	21,	118,500	x
	22,	23,	7,500	x
	25,	26,	2,000	—
	27,	28,		—

9314

	Coll.	Ex.	Bacteria.	Coli.
November	29,	30,	3,000	—
December	2,	3,	48,500	—
	4,	5,	96,000	—
	6,	7,	312,000	x
	9,	10,	514,500	—
	11,	12,	124,000	—
	13,	14,	459,500	—

No. of Bacteria, Average, 127,862.

B. Coli-Com. 36.3 per cent.

9315 Chain of Rocks, Missouri shore, 1901.

	Coll.	Ex.	Bacteria.	Coli.
October	14,	15,	66,800	
	16,	17,	650	
	17,	18,	65,000	
	21,	22,		
	19,	22,		
	25,	26,	85,000	x
	23,	28,		
	28,	29,		--
	30,	31,		x
November	1,	2,	510,000	--
	4,	5,	28,500	--
	6,	7,	107,000	x
	8,	9,	284,000	--
	11,	12,	485,000	x
	13,	14,	98,500	x
	18,	19,	145,500	?
	15,	16,		x
	20,	21,	269,000	x
	22,	23,	6,000	x
	25,	26,	4,500	x
	27,	28,	11,000	--
	29,	30,	7,000	--

9316	Coll.	Ex.	Bacteria.	Coli.
December,	2,	3,	316,000	x
	4,	5,	102,000	--
	6,	7,	124,750	x
	9,	10,		
	11,	12,	9,000	--
	13,	14,	115,500	x

No. of Bacteria, Average 32,845.

B. Coli-Com. 57 per cent.

Total Average number for the four collections at the Chain of Rocks, of bacteria 63,402.

Total B. Coli-Com. 41.1 per cent.

9317 Ft. Bellefontaine, Missouri River, 1901.

	Coll.	Ex.	Bacteria.	Coli.
October	14,	15,	22,400	
	15,	16,	17,950	
	16,	17,	27,750	
	17,	18,	99,200	
	18,	19,	133,000	
	19,	21,	66,000	x
	20,	22,	98,700	–
	23,	24,	189,500	–
	24,	25,	85,500	x
	25,	26,	163,500	x
	26,	28,	240,500	x
	28,	29,		–
	30,	31,	180,500	x
November	1,	2,	136,000	x
	4,	5,	228,500	–
	7,	8,	154,000	–
	8,	9,	891,500	–
	11,	12,	196,000	x
	13,	14,	155,000	x
	15,	16,	185,000	–
	18,	19,	145,500	x

9318	Coll.	Ex.	Bacteria.	Coli.
November	20,	21,	220,500	x
	22,	23,	14,000	x
	25,	26,	5,000	x
	27,	28,	9,500	–
	29,	30,	4,500	x
December	2,	3,	184,000	–
	4,	5,	276,000	x
	6,	7,	294,000	–
	9,	10,	206,000	–
	11,	12,	64,000	x
	13,	14,	202,500	–
	16,	17,	21,500	x

No. of Bacteria Average, 127,353.

B. Coli-Com. 57.1 per cent.

9319 JUDGE SPRINGER: State whether you computed any averages in reference to these tables, and if so, what these averages show?

A. The averages were computed from the total tests made from the waters collected at each place; and also the percentage of positive results from all tests made for Bacillus coli-communis, were made from the waters in each place.

Q. Now what do those show in each of the tables?

A. The average number of bacteria shown for Averyville in this examination from October 16th, to December 30th, is 13,691 and the percentage of positive tests for the Bacillus coli-communis is 6.2.

The average number of bacteria from the Illinois river at Pekin for the time mentioned, is 299,000; and the percentage of positive tests for the Bacillus coli-communis, is 76.

The average number of bacteria from the Illinois river at Grafton is 8,441, and the percentage of positive results for the tests for the coli-communis at this place, is 10.7.

Of the waters of the Mississippi river above the mouth of the Illinois at Grafton, the average number is 5,407, and
9320 the percentage of positive results in the tests for Bacillus coli-communis is 11.5.

I may state there were four places of collection from the chain of rocks in a cross-section of the river. Those taken from near the Illinois shore averaged 52,177, and the positive results for the Bacillus coli-communis tests was 21.7 per cent.

Those taken from mid-stream averaged 43,185, and the positive results for the tests for Bacillus coli-communis, is 50 per cent.

Those taken near the intake tower, the average number was 127,862, and the number of positive tests for Bacillus coli-communis is 36.3.

The average number of bacteria from the water taken near the Missouri shore amounted to 32,845, and the positive results of the tests for bacillus coli-communis shows 57 per cent of the total number of tests.

Now the general average for all tests at this point was 63,402 bacteria per cubic centimeter, and the positive tests for bacillus coli-communis is 41.1 per cent.

From the waters of the Missouri river at Fort Bellefontaine

the average number of bacteria was 127,353, and the
9321 positive results for tests for Bacillus coli-communis is 57.1 per cent.

ADJOURNED until 10:00 A. M. Friday, November 27th, 1903.

10:00 A. M., Friday, November 27th, 1903.

9322 Present, the Commissioner and same counsel representing the respective parties.

Continuation pursuant to adjournment.

PROF. T. J. BURRILL,

resumed the stand for further direct-examination by Judge Springer, and testified as follows:

Q. Professor, at the time of adjournment day before yesterday, you had put in evidence certain tables showing colony counts and the presence of bacillus coli communis as found in samples of water taken from the Illinois, Mississippi and Missouri rivers, in 1901. Please state whether you have made a table of averages graphically indicated, based upon these tables of ascertainment?

A. I have.

Q. Will you please present it?

A. (Witness produces plate).

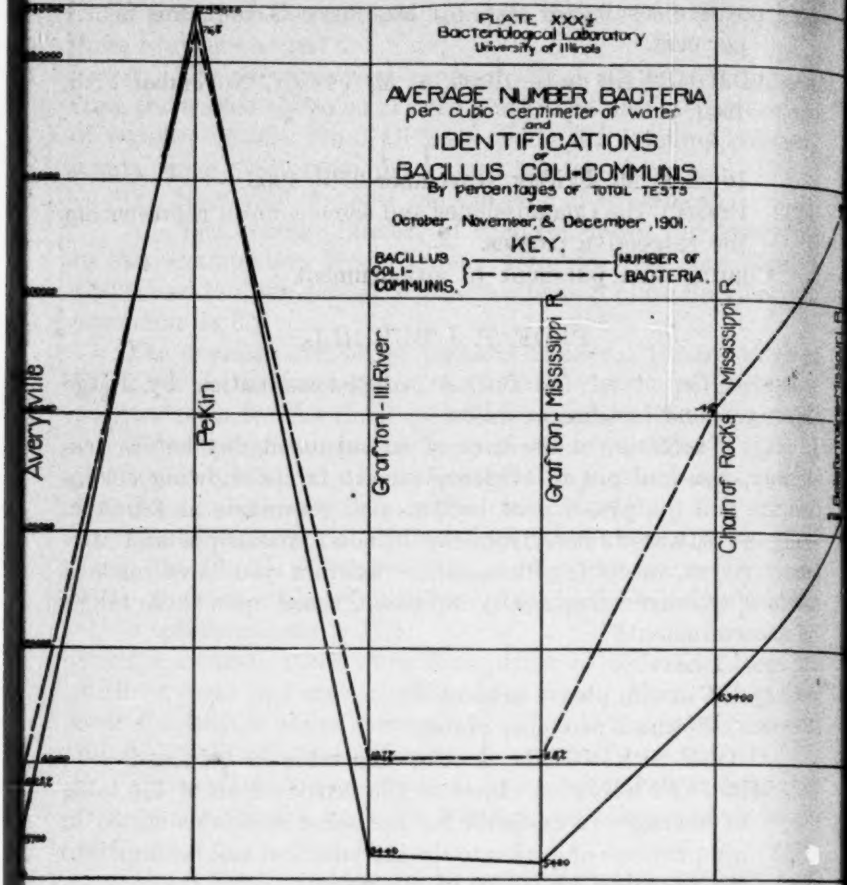
JUDGE SPRINGER: I offer this table in evidence.

MR. JEFFRIES: I object to the introduction of the table of averages in evidence for the same reason as stated in
9323 my previous objection to the introduction and reading into the record of all tables of averages.

JUDGE SPRINGER: This table of averages to be known as plate No. XXX½ of this series.

THE WITNESS: The table is as follows:

9324



Q. Now please state professor, what significance you at-
9325 tach to the colony counts and the presence of the Bacillus coli communis as they appear in the tables which you put in evidence, and also as graphically illustrated by the plate just put in evidence?

A. This series of investigations shows very closely just what was presented in the series for 1899 and 1900, already presented, and gives clear evidence that the water from the stream of Averyville is comparatively pure, or at least free from great numbers of micro-organisms, and also quite commonly free from the bacillus coli communis. The percentages of total tests which were positive in this examination proved to be 6.2

Q. That 6.2 per cent refers to the percentage of times that you found the Bacillus coli communis?

A. Yes sir. If we compare this with the water taken from the Pekin station, we find a very great difference, and it shows local contamination, since there are an average of 299,000 bacteria to the cubic centimeter, and 7.6 per cent of positive tests for the Bacillus coli communis.

This pollution at Pekin seems to have disappeared at the
9326 mouth of the Illinois river at Grafton, since the average
number of colonies is 8,441, and the percentage of positive tests for Bacillus coli communis is 10.7.

If we compare the results from the waters of the Illinois river near its mouth, with that of the Mississippi river above the mouth of the Illinois, we find the result in regard to the number of colony counts slightly in favor of the Mississippi river as was found in the previous case, the average here being 5,407. This difference between 5,407 and 8,441, may or may not show a constant condition of things, as the difference is too small for this purpose, but the tests in regard to these two waters made for the determination of Bacillus coli communis, favor somewhat the Illinois river water as against the Mississippi river water, since the percentage in the former is 10.7 and in the latter 11.5.

At the chain of rocks, where four samples were each time taken across the stream, the indications are that the pollution increases from the Illinois shore to the Missouri shore, as this series of counts show, namely, for the Illinois shore 52,177, for the midstream, 43,185; for the intake tower 127,862 and for the
Missouri shore 32,845. This last is the only count which
9327 does not support the statement just made.

For the determination of Bacillus coli communis in the same water we find beginning with the sample taken near the Illinois shore, 21.7 per cent; from midstream 50 per cent; from the intake tower 36.3 per cent; and from the Missouri shore 57 per cent.

Comparing now these last results with those obtained from the waters of the Missouri River at Bellefontaine, or as it is sometimes called, West Alton, the indications are that this latter stream is considerably more contaminated, since the average number of bacteria per cubic centimeter is 127,353, and the percentage of positive tests for Bacillus coli communis is 57.1.

This means, so far as this evidence can be taken to mean anything, that the waters at the intake tower are largely derived from those of the Missouri river, and to present this a little more clearly, the results of the examinations of the water from the Missouri at Bellefontaine and of those at the intake tower may be placed together. From the former, that is the Missouri, the average number of bacteria per cubic centimeter is 127,353; at the intake tower the average is 127,862. The percentage of positive tests for Bacillus Coli Communis from the Missouri river is 57.1 per cent, and the intake tower 36. 3 per cent.

9328 The whole examination seems to indicate that the water which is comparatively pure at Averyville, becomes very greatly contaminated at Pekin, clears up again at Grafton, and at this point compares favorably with the waters of the Mississippi river above the mouth of the Illinois, and very favorably with those of the Missouri at Bellefontaine.

Q. What significance do you attach in running river water, to the presence of Bacillus coli communis?

A. The presence of this organism means to me more than anything else, that the water is contaminated with sewage, and that this shows its bad quality for drinking purposes.

I will say that since Bacillus coli communis, and Bacillus typhosus is mainly derived so far as they are found at all in water, from the same source, that the very common presence of the former may be held to give some indication, though by no means a positive proof, of the presence of the latter.

Q. Did you have any difficulty in determining the presence of the Bacillus coli-communis in your examinations of the water?

A. I cannot say that we did.

Q. Professor, on day before yesterday, in your testimony in this case, you gave it as your opinion that the sewage from the City of Chicago had not produced any effect either

9329 one way or the other, in the waters of the Mississippi river, covering the months of October, November and December, 1901. Please state whether you still entertain that opinion after taking into consideration the tables which you have given in evidence this morning?

A. I don't think there is anything shown by these later examinations to warrant any change in that opinion.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Professor, you have been studying bacteriology practically ever since there was anything known of the science of bacteriology, have you not?

A. This is the case in reference to the subject of studies that were made in America, or in this country, and to a considerable degree as known anywhere.

Q. Now before you commenced the study of bacteriology what was your line of work?

A. Cryptogamic botany, as a general specially was my line of investigation. I had a wider subject for teaching.

Q. Had you studied biology prior to that time?

A. 1877?

Q. Yes?

A. Why, yes sir.

9330 Q. Was it in connection with biology or botany that you commenced the study of bacteriology?

A. Please let me say that I have been accustomed to use the term "botany" as a branch of biology.

Q. Then what was the character of your work during this time in which you used botany as a branch of biology, and to what character of work and limits did your investigations carry you?

A. Well, the part of my work that had a more special bearing upon the subject now included under the term of bacteriology, was that upon microscopic fungi, especially those kinds of these low organisms which produce diseases in plants. To a less extent for the purposes of comparison of any of the lower forms of plant life included under the general term "fungi."

Q. Now you made bacteriological investigations in connection with agricultural and horticultural experiments?

A. Yes sir. My first studies upon bacteria in the sense of following the course of development of any species were upon the disease of pigs known as cholera, or hog cholera, but this only served as an introduction to the more serious studies, those of much greater extent, upon somewhat similar organisms producing disease in plants, and I may be permitted to state that I worked out and published the first disease known to be 9331 produced by any kind of bacteria on any living plant.

Q. What was that?

A. This was the disease called blight in pear and apple trees,—fire-blight, sometimes.

Q. Now in your study with reference to the disease known as hog cholera, state whether or not it was your purpose to discover if possible any connection between the disease itself, and the food that was used or consumed by the animal?

A. Only in an incidental way. It was mainly my purpose to try to find out whether or not the bacteria found in the diseased tissues of animals were really the cause of the malady or not.

Q. And you made no investigation with the view of determining whether or not those same bacteria were found in the vegetable matter that was used by the animal as food?

A. No sir, except I did endeavor to find out how the suspected organisms entered the body of the animal, whether in the food or through wounds through the skin.

Q. Or by breathing it from the air?

A. Yes, that would be the third method of posisble entrance. Perhaps I should explain further that these studies were made in connection with the first Commissioner appointed 9332 by the United States Department of Agriculture to investigate this disease, and were made for a great part in my laboratory at Urbana, and my studies were largely in connection with his work. That was Dr. H. J. Detmers, now of Columbus, Ohio.

Q. Doctor, has the greater part of your work been along the lines of the diseases of animals or those of human beings so far as your bacteriological examinations have gone?

A. I really never made any serious studies of the bacteriological diseases of human beings, except in the studies of the organisms, themselves. The studies directly upon the living beings which I have made, have been almost altogether from the standpoint of the bacteria, for the purpose of gaining information in regard to their life history and mode of development, and not to any considerable extent from the pathological standpoint.

Q. You have not then studied bacteria particularly with reference to the cause of the disease, but with reference to its life history when you know that a certain bacteria does produce disease?

A. That is the general statement. In a few cases in the diseases of human beings, I have undertaken to find the cause in the discovery of the particular organism to which the
9333 disease might be attributed and to prove that the suspected organism was the cause of the disease.

Q. Have you ever made any experiments for the purpose of differentiating between the effect of the bacteria which comes from human excreta, and those which come from ordinary domestic animal excreta?

A. I have not.

Q. Have you ever made any investigations with reference to differentiating between the effect upon the human system when taken into the system, of bacteria which come from human excreta, and the bacteria which come from the decomposition of vegetable matter?

A. I have not usually made such studies. The main exception to this has been in cases of the suspected presence of Bacillus typhosus.

Q. Those examinations were with particular reference to the effect of the Bacillus typhous, and its source, were they not?

A. They were for the main purpose of determining whether or not a water having a few of the individuals of Bacillus typhosus, or which was suspected to have some individuals of this species, were more deterimental to health than those containing a large number of other organisms, or in other words, to
9334 determine what report should be made upon the results

of an examination of water as to its liability to produce serious diseases.

Q. Now then, aside from the typhoid bacilli, what other disease producing bacteria have you studied?

A. You mean now, human diseases?

Q. Human diseases?

A. The bacillus tuberculosis, and upon this I may state that as soon as the discovery of this organism was made, I devoted very considerable attention to it and as one result found a possibility of detecting the organism through a special stain that has been pretty widely known.

I also at a later time made a considerable study upon the disease commonly called grip. These results were never published.

Q. You made no investigations with reference to any other diseases commonly known as water borne diseases, than the typhoid?

A. I think I may say I have not.

Q. What was the character, professor, of the water supplies of the various institutions which you stated you examined on behalf of the various state institutions?

A. They were almost in every case of local supply, and 9335 mostly from wells.

Q. Did you during that time examine any water from wells that was known to be infected with typhoid?

A. Not that was known to be infected, but was seriously suspected of being infected.

Q. Did you ever find the Bacillus typhosus?

A. In such waters?

Q. Yes?

A. No sir.

Q. Did you find the colon?

A. Yes.

Q. And as you found the colon and from the finding of the colon you reasoned as to the presence or non-presence of the typhoid?

A. So far as I thought it permissible to do so yes.

Q. Now in forming an opinion as to the presence of the typhoid in the waters of those wells from the fact that the analyses show colon, you took into consideration did you not, the physical surroundings and general sanitary conditions of those physical surroundings?

A. An endeavor was always made to do so.

Q. In any instance did you find large quantities of water bacteria?

9336 A. Yes sir.

Q. And of other kinds of bacteria?

A. Such as bacillus coli communis that is frequently found in water, though not commonly classed as water bacteria.

Q. Is there any difference, professor, between the ordinary water bacteria and that bacteria which is produced by decayed animal matter?

A. There is no sharp differentiation between the two groups, though there are certain differences which in detail can usually be pointed out.

Q. Do you know the effect of oxidation upon ordinary water bacteria?

A. Some of the ordinary water bacteria can thrive only in the presence of free oxygen. Others of them can best develop where there is little or no free oxygen, and there are still others occupying an intermediate relation in this respect.

Q. Do you know what effect oxidation has upon the colon?

A. It can live pretty nearly equally well in the presence or absence of free oxygen, provided other conditions are proper for it.

Q. Do you know the effect of oxidation upon the typhoid bacilli?

A. They also can live under both of these conditions.

9337 Q. I will ask you if it is not a fact that larger quantities of bacteria of all kinds are generally found in compositions containing small amounts comparatively speaking, of oxygen?

A. This is commonly true with reference to water.

Q. Is it not a fact that in highly polluted water, the ordinary bacteria at work in that water, have a tendency to overgrow certain kinds of parasitic bacteria which may be contained therein?

A. I believe that to be very generally the case.

Q. And when we say overgrow, we do not mean a disappearance of the parasite, but that greater numbers of the ordinary bacteria have been produced until we become unable to differentiate or to distinguish the parasite?

A. The latter is very thoroughly known to be true; that the ordinary species multiply to such an enormous extent as to make it very difficult to find any other given species, which does not multiply, or does not multiply much. It is also, however, very commonly believed, that the excessive multiplication of those kinds found in great numbers in water, actually tend to kill out those not adapted to the conditions found in the water, as is the case of most parasitic organisms.

Q. Have you ever made any determinations with reference to the life or longevity of the disease producing bacteria?

9338 A. In very numerous instances, such tests have been made in my laboratory, partly by myself and partly by my students under my direction, but probably in no case under such conditions as will be taken certainly to throw light upon their life under their usual circumstances.

Q. As contained in a water supply?

A. As contained in a water supply. My examinations for that purpose have been in closed receptacles.

Q. Is it not a fact professor, that there is nothing in the science of bacteriology which will disclose the exact longevity of pathogenic bacteria in the waters of a lake or river, or of any water supply into which they have been discharged? In other words, has the science of bacteriology been able to produce artificial conditions as would exist in the water itself so as to enable a correct determination of the longevity of the disease producing germs?

A. I must say that so far as I know, all of the tests of which published accounts have been made, are open to criticism when we come to consider the conditions under which these artificial tests were made, and the conditions actually existing in nature.

Q. Do not bacteriologists reason from bacteriological analogy, that pathogenic or disease producing bacteria live
9339 longer in the water while in the running stream than in

the laboratory experiments, for the reason that conditions are more favorable in the river than in the laboratory, in that the bacteria as contained in the laboratory tests are prisoners and to a large extent, are unable to care for themselves as they are while contained in the running water, being living organisms?

A. I cannot say that this is commonly the case. Of course the conditions artificially produced in a laboratory are not only very different in themselves, and are subject to great variations, but they are very different also from those in ordinary running streams; but if I can answer the question in a general way, I think the preponderance of opinion would be that pathogenic bacteria in the open running streams have less advantage than they commonly have in a bacteriological laboratory test.

Q. But as to the exactness of that opinion, what would you say?

A. I cannot say that it is an actual fact.

Q. Professor, do you know whether or not the pathogenic bacteria or any kinds of them are dependent organisms while contained in a polluted water; that is to say, do they depend upon other organisms or material as a food supply for
9340 their existence?

A. There is a great difference in this respect in regard to different kinds.

Q. That is, you mean difference in opinion?

A. No sir, different kinds of species of organisms. Some of the disease producing bacteria are plainly in their main activity, saprophytic, or such as commonly live upon dead organic matter outside of the body, while there are others that are entirely incapable of getting their food supply except from the living tissues, though they may live for a considerable length of time outside of the host, as the subject is called, preyed upon by these organisms.

Q. Now do you know what kind of pathogenic or disease producing bacteria are generally known as saprophytic also?

A. The bacillus of tetanus, producing the disease commonly called lock-jaw is one such. It passes its life for the most part, and multiplies its kind to a very great extent in ordinary garden soil, and can do so perpetually, without at any time in the life of the individual, or of the species being an inhabitant of the living animal, but when once introduced into the tissues it is a virulent, disease producing organism.

Q. Does that particular bacillus known as the bacillus tetanus feed upon other organisms in water, or is there
9341 anything in bacteriology that will disclose that?

A. No species of bacteria feed directly upon other bacteria. No bacteria of any kind are capable of taking into their substance any solid particles, and since however small they may be, all bacteria are solid bodies, it is impossible that the other bacteria should actually feed upon them. They may feed upon the dissolved substance of other bacteria.

Q. But as to whether they do or not—

A. Oh yes. I think that is positively assured, that they do.

Q. Do they propagate?

A. Very largely.

Q. In the water of a running stream?

A. Certain kinds certainly do.

Q. Of pathogenic bacteria?

A. Usually not. I cannot say that there are no pathogenic bacteria which do not propogate in streams.

Q. As a general proposition is it not true that they will not propogate unless the proper temperature has been obtained?

A. There is a great difference in different species of bacteria in this regard.

Q. Yes, but I mean professor, proper temperature has been obtained with reference to each particular class or
9342 kind or species of bacteria?

A. That is true as a general law, though some species are very much more limited in regard to the range of temperature than others, for some can only live and propogate within a few degrees of a certain temperature, while others may have considerable range over a greater number of degrees, but the temperature must come within that range in order that they may grow.

Q. Do the colon bacilli multiply in a running stream?

A. Yes.

Q. At any temperature?

A. No sir. Under favorable conditions.

Q. At what temperature?

A. They multiply freely at the temperature of 20 degrees centigrade up to 41 degrees centigrade.

Q. In Fahrenheit that would be?

A. That would be about 68 to 100, and more. They will multiply to some extent at a lower temperature.

Q. Do they multiply rapidly at the proper temperature?

A. Very rapidly; the growth is very—the multiplication is pretty rapid.

Q. Do they multiply in sterilized water?

A. Yes sir.

Q. At the proper temperature?

9343 A. If other things are favorable.

Q. Will ordinary water bacteria multiply in sterilized water?

A. Yes.

Q. Will the typhoid bacilli multiply in sterilized water at proper temperature?

A. It will if the proper food supply is present.

Q. In other words, if the water is sterilized, then a certain food supply must be introduced with the typhoid bacilli?

A. I may say that I did not understand the reference to sterilized water to preclude its having certain food matters in it for bacteria.

Q. Of a soluble character?

A. Of a soluble character, and so sterilized water may be very fit indeed for the development of bacillus typhosus.

Q. Then professor, a glass of water that is perfectly transparent and clear, colorless and odorless, containing a typhoid bacillus, if raised to a certain temperature, would cause a multiplication of that typhoid bacillus provided it contained the soluble food supply?

A. Yes sir.

Q. Yet a bacterial analysis of the entire glass of water before it was raised to the proper temperature, would disclose only the one bacterium if a bacterial analyses be made accurately? 9344

A. And sufficiently extensive that would be the case.

Q. And the water might be analyzed bacterially and the typhoid bacilli not found?

A. Very easily.

Q. It is more easily believed that it would not be found than to believe that it would be found?

A. That is certainly the case.

Q. Then a bacterial analysis of water does not speak with exactness as to the total number of micro-organisms or bacteria contained in the water?

A. It never can be true that the exact number in any considerable volume of water can be revealed by a bacterial analysis.

Q. There would be more reason to believe that pathogenic bacteria would multiply in a water containing the soluble substances that were produced from the solid particles of pollution, than from those solids themselves, if raised to the proper temperature?

A. I think that would be commonly true. It is certainly true that there must be at least a certain proportion of water in connection with the solid material in order that the
9345 development of bacteria shall take place at all.

Q. What waters are more likely to contain the typhoid bacilli?

A. Those waters that have been recently infected through the medium of excretions from the human body.

Q. Assuming that water has been infected with the typhoid bacilli at a given point, is it within the science of bacteriology to determine the exact point in the river where the water would not be affected by the typhoid bacilli so deposited?

A. If sufficient attention is given to the word "exactness" in the question, I will say it is impossible so to determine.

Q. Professor, have you ever made any examinations with reference to the determination of the proportionate quantity or numbers of the colon bacilli that come from human beings, and those which come from animals?

A. I cannot say that I have, but I have determined that they are very large in the daily evacuation of both man and the higher animals.

Q. Is there any difference in the construction, nature and characteristics of the colon bacilli that come from the intestines of the human being and those that come from the intestines of the lower animals?

9346 A. The colon bacillus seems to be peculiarly subject to some variation. This is true to such an extent that there has been much discussion as to whether the individuals referred to by this name are really members of one species or group of allied species. Now then, there seems to be something of a similar variation in regard to the source of the particular individuals referred to under this name. Sometimes those from a human being have been found to have certain minor variations from those derived from other animals, but I cannot say that there is any clear distinction which can be made or referred to between the races of these organisms in consequence of such difference of origin.

Q. Is it not a fact that those that come from the human intestines live longer than those that come from the domestic animal?

A. This is often asserted to be true, and it probably is true, especially with reference to those which come from herbivorous animals.

Q. Is the distinction or difference between the two such as is recognized by bacteriologists in the examinations of water for sanitary purposes?

A. No sir.

9347 Q. Professor, in your analyses of the water supply of the various institutions to which you have testified, did your opinion as to the sanitary condition of that water depend upon the number of counts or the character of the bacteria that you found in that water?

A. Upon both, but more especially upon the latter, the character of the bacteria, and in this case almost exclusively upon the presence or absence of the Bacillus coli-communis.

Q. When you say this case, you mean the opinion you expressed in the present case?

A. No. I mean in relation to the character of the organism.

Q. Now did you consider the physicial surroundings as well as the sources of pollution?

A. I rarely visited the locality. The opinion given in this case was from correspondence, though an endeavor was made to find out as much as possible of the surrounding conditions and any history that could be given connected with the case in any respect.

Q. Now any knowledge of those conditions that was obtained by you, did you consider such knowledge in forming your opinion?

A. Yes sir.

9348 Q. Is it not necessary, professor, to know the physical conditions with reference to the character of the discharges or deposits in the river, in order to determine the sanitary condition of that water from a bacteriological standpoint?

A. It is certainly true that the interpretation to be made from the bacteriological examinations must be influenced by the knowledge of the physical conditions and all other matter pertaining to the sources of pollution.

Q. In your opinion as to the sanitary condition of the water of the three rivers, the Illinois, the Mississippi and the Missouri, did you take into consideration the extent and the sources of pollution and infection?

A. Not to any very considerable extent, from my own personal investigations, but if reference is made to such knowledge as could be derived from investigations of others, I did take into consideration such sources.

Q. Then your opinion is based in part upon what others have told you with reference to the physical conditions of the three rivers?

A. Yes, I never made any personal examinations as to the quantities of polluted matter which entered the river. I have been in a position to observe in a general way the main pollutions entering the Illinois stream, but not in regard to the Missouri river.

9349 Q. You do not know of your own knowledge, whether the polluted and infected material deposited in the Mississipi river above Grafton is greater or less than deposited into the Illinois river above Grafton?

A. Yes, I think I do know.

Q. Of your own knowledge?

A. Of my own knowledge.

Q. Is it more or less?

A. *That the bulk of the pollutions of the Illinois stream* is greater.

Q. How is it with reference to the Missouri river?

A. I have never had from my own knowledge any opinion in regard to the pollution of the Missouri river, and such general knowledge as I have of the stream I have continually been surprised at my results of the examinations of the water taken at Fort Bellefontaine; surprised that the evidence existed of so great contamination somewhere above that point.

Q. And that was because of the fact that you knew that the sources of sewage pollution were not great, or as great as those upon the Mississippi and Illinois?

A. That the sources of pollution did not seem to be anything like as great as they were at the specially polluted
9350 points of the Illinois stream. Of course I know in a
general way that the Missouri river is previously contaminated from the sewage of St. Joe, Atchison, Kansas City, Kansas, and Kansas City, Missouri, but I have no special information of very great contamination of that stream in its lower courses.

Q. You have no particular information with reference to the number of people residing upon the Missouri and Mississippi river watersheds as compared with those upon the watershed of the Illinois river including the city of Chicago?

A. I am well aware that the population on the watershed of the Illinois including the city of Chicago is very much greater than that affecting the Mississippi above the Illinois and that of the Missouri above its mouth.

Q. You never made any analyses of the Illinois river except those you have introduced here in evidence?

A. Yes sir.

Q. That is an occasional analysis?

A. Yes sir.

Q. But no series of analyses?

A. No sir.

Q. Is there anything, professor, in the science of chemistry that will disclose the effect of saprophytic bacteria upon typhoid bacteria or bacilli?

9351 A. I should be unable to answer very effectively, since I am no chemist. I should suppose not.

Q. But as a bacteriologist I mean.

A. I should suppose not.

Q. In other words, bacteriology does not disclose what effect the presence of the saprophytic bacteria have upon the life or longevity of the typhoid bacillus?

A. You mean now the chemical effect?

Q. No, I mean what effect have they upon them with reference to their disappearance and removal and the elimination of the one or the other from the sewage?

A. I think there is a considerable amount of knowledge on that subject.

Q. Decreasing quantities of saprophytes means increasing opportunity for the longevity of typhoid in water, doesn't it?

A. That is possibly true, but the decreasing numbers of saprophytes is altogether a different matter from the small number of saprophytes originally present. In this latter case there is no doubt but that the Bacillus typhosus other things being equal, has a better chance for survival.

Q. I believe you stated that there was nothing in bacteriology that would disclose the fact that the typhoid bacillus was dependent upon other bacteria, or lived independent

9352 of them in running streams.

A. I do not remember to have so stated.

Q. The temperature not being sufficient to produce a multiplication of the typhoid?

A. I think the evidence is quite conclusive that Bacillus typhosus in ordinary running streams in our country does not multiply very largely, and one of the reasons for this is, the want of a sufficiently high temperature.

Q. In making determinations for the colon bacillus, does a bacteriologist undertake to determine the number of counts of colon, or simply the presence of colon in water for sanitary purposes?

A. Both are undertaken at times, or either result may be prominent in the mind of the investigator in a given case or even commonly. I think ordinarily some attention is given to both of these matters.

Q. Is it not a fact professor, that it is almost impractical to determine the counts of the colon as contained in water?

A. That depends upon the amount or number of the organisms present, belonging to this species. If they are somewhat rare in the water, then it can be approximately determined how many there are in a given quantity of that water.

9353 Q. Do you mean by that, that it depends upon the number of other bacteria present?

A. No sir, I mean if the analyst supposes the organism is in no great numbers in a given water under examination, he may try measurements of the water in such a way as to determine how many of the organisms exist in any certain measure. For instance, he may adopt a method of examining carefully a cubic centimeter of water divided into tenths, and find out in making these tenths any of the organisms existing. If on an average for such tests he finds that five of the divisions of the cubic centimeter, yield positive results and five do not, he concludes that there are at least five of these organisms in that cubic centimeter. The fact that half of the results showed no presence of the organisms, is taken to mean that in that proportion the organisms are absent from certain quantities of water.

Q. But in that method it cannot be accurately determined because the presence of colon in one of the tenths might be shown from the gas that is produced by two or more bacilli?

A. There certainly may be present two or more of these organisms, without the power of the investigator to discover it. 9354

Now, professor, in this connection please explain what bacteriologists mean by masking, and state whether or not the colon is not to a large extent and in a number of instances, masked?

A. That is a term which usually refers to the comparatively larger numbers of other organisms present in a given sample of water, and when these other organisms are of a similar character to the one under special examination, it makes it very difficult to discover the latter.

Q. Now is that true with reference to the colon?

A. Yes, but not by any means so true as in regard to some other organisms, since the colon commonly multiplies.

Q. It is particularly true with reference to the typhoid?

A. Yes it is particularly true with reference to Bacillus typhosus.

Q. Now is it not a fact that the presence of the colon bacillus is more readily detected in water than the typhoid, not only because of its presence in greater numbers, but because of the fact that it produces a certain gaseous substance in the experiment from which the determination is obtained, while the typhoid bacillus does not produce a gas?

A. It is a fact that the production of gas by the colon
9355 bacillus serves as a very critical test of its presence, while
the non-production of gas in the medium gives no indication as to whether or not the Bacillus typhosus is present or absent, because Bacillus typhosus does not produce gas.

Q. Now these determinations of the presence of the colon bacilli are made from the presence or absence of gas in the test?

A. That is one of the tests of about a half a dozen.

Q. Hasn't this test been adopted by bacteriologists as the most perfect of all tests?

A. I think it is true that most bacteriologists consider this the most critical test in the separation of this organism from most others likely to be met with in the analysis of water, though not with respect to certain other organisms.

Q. This is the test which you have employed in your determinations, the results of which you have read in evidence in this case?

A. We have always employed this test but have not neglected other tests also.

Q. But professor, in the determinations which you read
in evidence, those determinations were made by this test,
9356 this gas test which we are speaking of?

A. Not exclusively. I regard the action of the colon bacillus upon milk quite as important in the differentiation of these from other organisms, as the test for gas.

Q. Is there any other organism that will have the same effect upon milk as colon?

A. Yes, very closely the same.

Q. What is it?

A. There is the lactus aerogenes, which has an exceedingly similar effect, except that it is slow in action.

Q. Is that the only one that has the same effect?

A. No sir, there are others also. There are small differences in probably all cases. The Bacillus coli-communis cannot be readily differentiated from all other organisms by any one test or I think, by any two tests.

Q. There are other organisms that produce gas?

A. There are.

Q. But with corresponding percentages?

A. Somewhat closely the same as that of Bacillus coli-communis, but if the number of tests are extended, the production of gas in connection with these other tests becomes a very critical test of the Bacillus coli-communis, or the presence of coli communis.

9357 Q. Now professor, in making a test for the discovery of colon in water, the fact that the test or the examination fails to disclose its presence, does that prove conclusively that it is not present?

A. By no means, since the quantity of water examined by a bacteriologist is small compared with the total volume, and possibly in some cases when, owing to the peculiarities of the life history of the special organism it does not respond to the test applied for it.

Q. Although it may be present?

A. It possibly may be present and its presence not made manifest owing to special effects of development of this particular organism or race.

ADJOURNED until 3:45 P. M., same day, Friday, November 27th, 1903.

9358 3:45 P. M., Friday, November 27th, 1903. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. T. J. BURRILL,

resumed the stand for further cross-examination by Mr. Jeffries and testified as follows:

MR. TODD: Professor, there is one question that was omitted in the direct-examination, that I desire to call your attention to before concluding your cross, with the permission of counsel, and that is this:

Have you made any observations or experiments in regard to the life of the bacillus prodigiosus in water, and if so, please state the results of those observations and your opinion as to the longevity of that bacillus in water?

A. I have made such examinations frequently. This bacillus is well known to all bacteriologists, and is made common use of in bacteriological laboratories for various purposes. In my own work, it has been frequently used in connection with other organisms in various kinds of water contaminated 9359 and otherwise, and the general result has been that this organism soon dies out in any kind of water.

I happen to have the exact results of an experiment made this last summer, and found that when the Bacillus prodigiosus was placed in water entirely sterilized and free from other organisms and kept at about room temperature, though the room temperature at that time varied between 20 and 25 degrees Centigrade, the organism did not last over four days in a living condition. When put in with various other organisms some of which could live continuously in water, it was found that in several instances the bacillus died after a period of three days. In one instance a few of the organisms were found after a period of five days, but in no other case were there any found living up to that length of time.

I think I am entitled to the opinion that under any ordinary circumstance, Bacillus prodigiosus will not live in ordinary tap water or in common river water or in sewage polluted water more than five days.

CROSS-EXAMINATION,

Resumed by Mr. Jeffries.

Q. Professor, from your bacterial analyses of the water of the Illinois river at any point or at any of the points in question, taking into consideration what you know of the 9360 source of the pollution, do you consider the water suitable for domestic and drinking purposes in the condition that you found it at the time of the analysis?

A. I should not consider it proper water to drink.

Q. Did you make bacterial analyses of the water of Lake Michigan at any time?

A. Yes, continuously during the period of investigation from June, 1899 to October, 1900, as taken from a tap in the municipal laboratory at the City building.

Q. Did you make any for 1901?

A. No sir.

Q. Is the data with reference to those analyses contained in any of the tables which you have introduced in evidence?

A. I believe not.

Q. Have you the analyses or data with you which show those determinations?

A. Yes sir.

Q. I will ask you if you know what particular crib this water was drawn from that you analyzed?

A. No sir, I do not.

Q. I will ask you if it was the same water or a representative of the same water that was analyzed chemically by Professor Palmer?

A. It was from the same samples.

9361 Q. I will ask you if it is not a fact that the percentage of the number of bacterial counts in those analyses was not much less than the percentage of the analyses made by you of the water of the Illinois river at Grafton or at other points?

A. It was.

Q. Could you state approximately the percentage of difference?

A. As near as I can remember the results without immediate access to the figures, there were on an average from seven to ten times as many per cubic centimeter in the water taken from the station at Averyville and also from the mouth of the Illinois river at Grafton as were found in Lake Michigan.

Q. And with reference to the colon bacilli, what do the percentages show?

A. This organism was found much more frequently as a common thing, in the water at Averyville and at Grafton, than in the water of Lake Michigan as examined.

Q. Is it not a fact that it was very infrequently found in the waters of the lake?

A. That is my remembrance. Let me say I have those figures in my satchel if you wish them.

Q. No, I don't care for them at all. I think you are right about it. Was there anything in those determinations made by you of the waters of Lake Michigan, that led you to be-
9362 lieve that the water was infected?

A. I don't think we could call it bacteriologically pure water.

Q. Could you bacteriologically call it water suitable for domestic and drinking purposes in the condition in which you found it at the time the analysis was made?

A. I should not consider it to be very desirable; at least as it exists according to these tests in many instances, it should be a good deal better.

Q. I will ask you professor, if the variations of bacterial count and the variations in the determination of the presence of coli are not very much greater in the waters of the Illinois river than in the waters of Lake Michigan as shown by your analyses of the two waters?

A. I think that is the case.

Q. Profesor, referring to your table of bacterial analyses of the waters of the Illinois river at Averyville for the year 1901, I wish you would explain the significance of the colon bacilli, not having ben found in a sample collected on the 9th day of December, which contained 102,200 bacteria per cubic centimeter, while in the sample collected on the 23rd of September and examined on the 23rd, containing 9,500 bacteria per cubic centimeter, the colon was found, and what particular

significance do you place upon the fact that it is often
9363 not found in samples containing large numbers of bacteria while from the same waters it is often found to be present in samples of water containing small numbers of bacteria per cubic centimeter?

A. I will say that a comparison of the tables will generally show that a large number of colonies of bacteria is accompanied by positive determination of the Bacillus coli-communis, but there are frequent variations from this, and the particular circumstances cited by you as shown by the tests of the Illinois river at Averyville, seem to belong to this unexplainable variation in the results. I should have anticipated, after finding 102,000 bacteria from the water taken on December 9th, that there would be a positive determination of Bacillus coli-communis. Our results based upon the particular samples examined, seemed to show that in these samples it was not present. I should by no means take this to mean that it was absolutely absent in the water from that point at that time commonly. I am not at all surprised to find it present on December 23rd, when the number of colonies as made out was 5,900. The greater variation from the ordinary results is in the first instance. But during the fermentive processes continued for some time there is among the organisms present a survival of the fittest and the special water bacteria are likely to be these which ultimately prevail, while Bacillus coli-communis dies out. This may be one of these instances.

I may say if I may speak generally of this series of investigations at Averyville, for the time from October to De-
9364 cember, 1901, that the number of negative results in the tests for Bacillus coli-communis, is upon the whole, to me quite surprising, taken into account with the total number of colonies that were found at that time.

Q. Now professor, I will ask you to state approximately what relationship the variations of total bacterial count per cubic centimeter in the water of the Illinois river at Averyville for 1901, as shown by your analyses, bear to the bacterial counts of the water drawn from Lake Michigan and analyzed by you in any period?

A. The numbers at Averyville are very considerably greater than those found in the waters of Lake Michigan.

Q. Now as to their variation, professor?

A. And the variation is greater.

Q. Now I will ask you if it is not a fact that where large bacterial counts are obtained, the colon may be present, and yet be masked or overgrown by the other bacteria so that it cannot be detected?

A. Not to any very considerable extent. Bacillus coli-communis by the methods in use has so even and distinct characteristics that it can be pretty certainly found, no matter what else is present.

Q. Professor, you examined bacterially the water of the
9365 Mississippi river at Jefferson Barracks, did you not?

A. Yes sir.

Q. I will ask you to state generally how those results in counts compare with the counts which you obtained from your analyses of the water of the Mississipi river taken at the chain of rocks, Jefferson Barracks being at a point below the city of St. Louis and at a point where the Mississippi river had already taken on the sewage of the City of St. Louis?

A. The number found at Jefferson Barracks is very considerably more than the number at the chain of rocks, as reported in tables 69 to 72 inclusive, for the chain of rocks, and tables 74 to 78 inclusive, for the Jefferson Barracks. I have not figured out these averages, but as I now glance at the tables, the number is from ten to twenty times the number in the latter instance, that is the number for Jefferson Barracks.

Q. Professor, what was the extent of the dilution used by you in making your colony tests?

A. From our experience we diluted the original water to such an extent as should give us from 50 to 100 colonies per plate. Sometimes diluted only 1 to 10; sometimes 1 to 100; sometimes 1 to 1000, according as our previous experience assured us we must do in order to get in the neighborhood of from
9366 50 to 100 colonies to a plate.

Q. Then you would dilute it with pure distilled water, so as to limit the number of colonies developed on the plate to about how many?

A. To from about 50 to 100 was our endeavor.

Q. So that the amount of dilution used in the analyses depended upon the presence of large or small numbers of the bacterial counts contained in the water?

A. The dilution depended upon the supposed number of bacterial counts as indicated by former tests; but of course it is not to be understood that we always did dilute to such an extent that the number was actually limited to 100 or less, but that was our aim.

Q. In making the ordinary gas test it would not be necessary to dilute it in order to detect the presence, would it?

A. It would not.

Q. Do your tables show the per cent of the cubic centimeter of water examined for the purpose of determining the presence or non-presence of this Bacillus coli-communis?

A. These tables do not.

9367 Q. Could you state briefly the quantity used at the various places where the water was obtained that you analyzed?

A. As nearly as I remember, as a general thing, the waters taken from the stations near the head waters were diluted from 1,000 to 10,000 times. Doubtless for some of these it was more than that. At Averyville and Grafton about ten times, and at intermediate points, at varying proportions between these. We did not plate any of this water direct.

Q. Then the tables are not comparative in so far as the same amount of water was used in making the particular examination?

A. If the quantity of water actually examined made any difference, then the tables are not comparative. I take it however, that the method used in the dilution was such that the liability of error in this respect is very small.

Q. How long did you say this Bacillus prodigiosus lived under your experiments?

A. At a maximum of five days, under the conditions of these tests as reported.

Q. Are there different species of the prodigosus?

A. There are different varieties to some extent, but one species.

Q. In other words, the prodigiosus is a species of bacteria?

A. Yes.

9368 Q. And of that species there are different varieties?

A. Yes.

Q. Do you know whether or not those different varieties are different in longevity?

A. I don't think the Bacillus prodigosus is subject to very great variation.

Q. You say you don't think?

A. I don't say. Not nearly so much so as some well known organisms, mention of which has been frequently made.

Q. Do you know whether other bacteriologists have been able to keep it alive longer than five days?

A. I think that has been frequently reported, and I have no doubt but that it is true under other conditions.

Q. It depends then on the conditions in the laboratory to some extent?

A. Considerable. I don't think this is notably an inhabitant of the water at all.

Q. Professor, is there any other source of the colon bacilli other than from the intestinal canal of men and animals so far as you know?

A. It has been reported. It has been found where it did not seem to have orginated in the intestinal canal of men and animals. I have never found it where it did not have
9369 abundant chance to be so derived.

Q. Professor, if it should appear from the analyses of the waters of the Illinois river made at Grafton in the years 1899 and 1900, that there was a larger per cent of the colon bacilli passing down the river at that point in 1900 than there was in 1899, and if it should appear that the colon from the tests and the analyses, showed less frequent the appearances in the waters of the tributaries of the Illinois river for 1900 than in 1899, to what would you attribute the increase in the colon passing down the Illinois river at Grafton during the year 1900 over that of 1899?

A. In such a hypothetical case, as I understand this to be—

Q. Yes, altogether?

A. I should seek for the increased pollution of the main stream somewhere in its course, and if I were to begin this search, I would begin at Grafton and follow the stream upward until such extra pollution could be found.

Q. There would be no possible opportunity for its coming from any other source than from men or animals, would there?

A. Oh yes sir. We know that this organism multiplies in water when the conditions favor, outside of the body. If the question means that it does not come from any other
9370 source ultimately, I don't know that I could assign such
place of its origin, but if the immediate place of origin is to be considered, I should not go beyond the first cultivated field that had been some time previously subject to the contents of the intestinal canal of animals, and where the water had been sufficient for the further multiplication of the organism in the soil.

Q. The conditions for the multiplication in the soil as a general proposition, run about the same, one as with another, do they not?

A. Subject to great variations.

Q. At what temperature does the colon multiply?

A. It multiplies from 20 to 40 degrees centigrade, and somewhat considerably even below the first named degree, that is on the Fahrenheit scale from about 68 if I translate the figures, to 104.

Q. You are not a physician are you professor?

A. I am not.

Q. You never examined the sanitary condition of water other than as here stated by you in your examination of the waters of the Illinois river, Lake Michigan, and the canal and the instances referred to with reference to the various state institutions?

A. Yes, I have made from time to time quite a good
9371 number of examinations of various waters of the state
besides those included in these records.

Q. A long series of examinations?

A. No sir.

Q. Just examined a few samples from each particular place?

A. Since the conclusion of the work in October, 1900, I have, as opportunity permitted, examined a good many samples from various points on the Illinois river, but not for the purpose of any comparison of the number of organisms or for finding Bacillus coli-communis, as to these waters.

Q. Now then, professor, as a bacteriologist, what is the best practical test as shown by the analyses alone, of the presence of typhoid and other water-borne diseases which affect mankind?

A. So far as typhoid fever is concerned, I have been led to the belief and understanding that the detection of Bacillus coli-communis was the best practical test that we had of the possible presence of the organism causing this disease of typhoid fever. Of course there are other organisms sometimes carried in the water which can be readily identified by proper examination, and when they can be identified, that is the best evidence as to whether this water is proper for potable purposes in respect to those particular diseases.

9372 Q. And these results of the analyses and tests showing the presence of the organisms known as the colon bacillus, together with the knowledge of the extent and the source of the pollution above the point examined, or from which the water is taken and analyzed, are the basis or premise of an opinion as to the sanitary condition of that water?

A. Yes sir, that has been my practice, and that of many others, though certain bacteriologists include in their inspection as a regular thing, other particular species.

T. J. BURRILL.

ADJOURNED until 10:00 A. M. following day, Saturday, November 28th, 1903.

10:00 A. M., Saturday, November 28th, 1903.

9373 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

Whereupon, an adjournment was taken until 10:00 A. M. Monday, November 30th, 1903.

10:00 A. M., Monday, November 30 1903.

9374 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

FREDERICK WILLIAM SCHULE,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Frederick William Schule.

Q. What is your business?

A. Student at present.

Q. Where?

A. Ann Arbor,—University of Michigan.

Q. Were you connected with the Chicago University at any time?

A. I was connected with it in the way that I got my position through the Chicago University. I had entered the University of Chicago as a student, and immediately afterwards I obtained the position at Peoria.

9375 Q. Did you ever do any work at Peoria under the direction or supervision of Professor E. O. Jordan of the Chicago University?

A. Yes sir.

Q. And at what time was this work done?

A. It was in the fall of 1901, in the months of October, November and December.

Q. Was that the period wherein the State of Missouri and the State of Illinois and the Sanitary District of Chicago were taking samples by agreement at the same places?

A. Yes sir.

Q. You had charge of the laboratory at Peoria?

A. Yes sir.

Q. Under the direction of Professor Jordan?

A. Yes sir.

Q. This work was bacterial entirely, was it not?

A. Yes sir.

Q. Did you do that work under the direction of Profesor Jordan?

A. Yes sir.

Q. And reported all conclusions from the work to him?

A. Yes.

Q. Analytical data and tables?

A. Yes.

9376 Q. At what points were the samples taken from at Peoria?

A. Two samples were brought each morning, one from above Peoria at the small village of Averyville, and one below at the town of Pekin, Illinois.

Q. Now who were the water takers that brought these samples to the laboratory?

A. The one that brought it from Averyville was a man in connection with the water works there; his name was Martin. He had charge of that.

Q. And who was the man that brought it from Averyville?

A. The man that brought it from Averyville, his name was Lautz; he was in connection with the Pekin waterworks.

Q. From Averyville?

A. No sir, from Pekin.

Q. Who was the fellow from Pekin?

A. Lautz.

Q. And what about the man that brought it from Averyville?

A. His name was Martin.

Q. And these samples were delivered in the laboratory in the Y. M. C. A. building at Peoria?

A. Yes sir.

Q. To you?

A. Yes sir.

9377 Q. And received by you for analysis?

A. Yes sir.

Q. And you received certain instructions from Professor Jordan?

A. Yes sir.

Q. And you followed those instructions?

A. Yes sir.

Q. In the work, did you, that you did?

A. Yes sir.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How long had you been studying bacteriology up to that time?

A. Well, practically—fully two years; that was the major subject at Wisconsin.

Q. What was the character of the analyses that you made; what were you looking for?

A. I was taking quantitative analyses and at the same time was taking qualitative analyses, and sending these in to the University of Chicgo; that is, sending samples of the bacteria found, or the cultures.

Q. You were taking both qualitative and quantitative 9378 were you?

A. Yes, I did work in both lines. I determined quantitative cultures at Peoria, and the main work in the qualitative line was done in the University of Chicago, so I understood.

Q. You didn't do any of that then, did you?

A. No sir, very little if any.

Q. I understand you to say then that you made no determinations with reference to the qualitative?

A. Well, I did in so far that I took off the colonies from the plates and shipped them to Chicago for further inspection.

Q. Did you take off the colonies—did you take all the colonies off?

A. All which were different. I tried to take the different colonies off, so as to get a knowledge of the different kinds of bacteria which were found in the waters above and below Peoria.

Q. The different kinds that appeared in the one colony, or different from any that appeared in any of the samples?

A. In any of the samples.

Q. So that if one species or kind appeared in one sample, you would not take that off of the next determination?

A. No sir, about two or three times a week I picked off 9379 samples from the water which was gotten for that day, 9490 Q. State what is shown by table 127 and what is its sanitary significance?

A. Table 127 contains the analyses of samples of water taken from the Illinois river at Morris between January 5th and June 26th, 1900. During the month of January the conditions were not dissimilar to those prevailing during 1899, but the analyses for subsequent days show in several ways the effect of the dilution of the Chicago sewage in the Chicago drainage canal.

The smaller amount of chlorine particularly is evidence of this increased dilution and on several occasions notably in the month of May, the number of bacteria in the Illinois river at this point was lower to a striking degree, than at any time in the preceding period.

Q. How is the great number of bacteria in the month of January and the small number of bacteria in comparison in the months of April, May and June, explained in this table 127?

A. The difference may be in part at least explained by the fact that during the early part of January, 1900, the water from the drainage canal was not flowing into the Desplaines river, but the water from the Illinois and Michigan canal was entering the Desplaines river during that period.

Q. Will you produce table 128 and read it in evidence?

A. Yes sir, table 128 is as follows:

TABLE 128.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—FOX RIVER, OTTAWA.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Suspd Matter	Free Ammonia.	Albuminoid Am Tot'l	Albuminoid Am Dissolv'd	Albuminoid Am Suspnd'd	Total.	Dissolved.	Suspended.	Nitrites	Nitrates					
1173	Jan. 4	Jan. 5	Slight	V. Little	.15	....	448.	448.	0.	6.8	5.7	5.7	.0	.078	.296	.272	.024	....	....	....	.004	.2	3.	2.	2.	......	3,700
1220	" 11	" 12	"	"	.1	....	312.	310.	2.	6.	4.4	4.	.4	.066	.24	.168	.072	....	....	....	.016	.5	3.5	2.	2.	......	30,200
1249	" 18	" 19	"	Little	.3	....	309.	294.	15.	6.	4.1	3.8	.3	.09	.2	.16	.04	....	....	....	.01	.4	3.	3.	3.	......	12,600
1282	" 24	" 26	Much	"	Muddy	....	310.	282.	28.	4.2	7.4	6.2	1.2	.31	.336	.208	.128	....	....	....	.016	.8	4.	4.	4.	......	25,300
1491	Mar. 12	Mar. 13	"	Cons'd.	.3	....	196.	170.	26.	4.2	8.6	7.3	1.3	.256	.384	.224	.16	....	....	..	.014	.9	4.	5.	4.	......	....
1528	" 20	" 21	"	Little	.3	....	230.	200.	21.	3.4	8.5	7.4	1.1	.294	.32	.216	.104	....	....	....	.016	.6	4.	3.	2.	......	1,100
1568	" 27	" 28	Slight	V. Little	.4	....	304.	165.	139.	2.6	15.2	7.8	5.4	.156	.584	.288	.296	....	....	....	.02	.8	5.	2.	7.	......	50,000
1603	Apr. 3	Apr. 4	Much	Much	.5	....	734.	144.	590.	2.2	19.6	8.3	11.3	.244	1.12	.344	.776	....	....	....	.018	1.2	4.	3.	16.	......	200,000
1642	" 10	" 11	"	Cons'd.	.42	....	305.	208.	97.	2.	13.	10.1	2.9	.16	.296	.288	.008	....	....	....	.022	.5	4.	3.	11.	......	5,800
1681	" 17	" 18	Decided	"	.3	....	290.	248.	42.	2.8	2.7	2.7	.0	.02	.416	.232	.184	....	....	....	.044	.0	......	4.	4.	......	7,500
1722	" 24	" 25	Much	"	.4	....	334.	272.	62.	3.	10.	8.1	1.9	.06	.544	.32	.224	....	....	....	.014	.0	4.5	......	27.	......	8,600
1759	May 1	May 2	"	"	.4	....	280.	262.	18.	3.8	12.9	9.	3.9	.016	.624	.304	.32	....	....	....	.002	.05	4.	27.	27.	......	2,100
1790	" 8	" 9	"	Little	.4	....	304.	268.	36.	3.4	14.9	8.9	6.	.048	.504	.296	.208	....	....	....	.006	.0	3.5	19.	19.	......	8,500
1823	" 15	" 16	Decided	"	.4	....	307.	301.	6.	4.	8.6	7.8	8.	.046	.384	.274	.11	...	....	....	.0	.05	3.5	22.	22.	......	800
1859	" 22	" 23	Much	"	.4	....	276.	202.	14.	4.2	8.9	7.4	1.5	.02	.488	.312	.176	....	....	....	.006	.35	3.5	19.	19.	......	800
1930	June 5	June 6	Slight	"	.35	....	314.	312.	2.	3.4	7.8	7.2	.1	.1	.4	.352	.048	....	....	....	.013	.15	3.	23.	24.	......	2,200
1963	" 11	" 12	Decided	"	.4	....	331.	307.	24.	4.6	8.2	7.2	1.	.048	.36	.272	.088	....	....	....	.0	.0	......	25.	23.	......	6,200
1997	" 18	" 19	Distinct	"	.25	....	328.	285.	43.	3.2	6.8	6.2	.6	.038	.232	.224	.008	....	....	...	.0	.0	3.	26.	21.	......	2,600
2035	" 25	" 26	Slight	"	.25	....	296.	276.	20.	5.	5.7	5.5	.2	.07	.256	.224	.032	....	....	....	.036	.05	2.5	27.	32.	......	2,600

9492 Q. State what table 128 shows and its sanitary significance?

A. Table 128 contains the analyses of samples of water from the Fox river at Ottawa between January 4th, and June 25th, 1900.

During the early part of this period the number of bacteria was much higher than in the period of 1899 and much higher than for the latter part of April and for May and June, 1900. This is a phenomenon of common occurrence in river waters and so far as I am aware no adequate explanation for this occurrence has been adduced.

Q. Will you produce and read in evidence table 129?

A. Yes sir, table 129 is as follows:

TABLE 129.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, OTTAWA.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Susp'd Matter	Free Ammonia.	Albuminoid Am Tot'l	Albuminoid Am Dissolv'd	Albuminoid Am Susp'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
1174	Jan. 4	Jan. 5	Distinct	V. Little	.28	....	434.	406.	28.	36.	9.5	8.9	.6	8.	.76	.624	.136	....	....	....	.15	1.45	3.5	2.	2.	......	40,000
1221	" 11	" 12	Much	Little	.35	....	332.	331.	1.	23.	10.8	8.5	2.3	4.2	.74	.44	.3	....	....	....	.1	1.55	3.	2.	2.	......	225,000
1250	" 18	" 19	"	"	.4	....	433.	322.	111.	28.	7.8	7.	.8	3.	.56	.352	.208	....	....	....	.028	.95	3.5	3.	3.	......	173,000
1283	" 25	" 26	"	"	Muddy	Gassy	350.	298.	52.	24.	12.6	5.6	7.	2.96	.7	.336	.364	....	...	....	.03	.65	5.5	4.	4.	......	570,000
1340	Feb. 5	Feb. 6	"	"	.22	....	256.	250.	6.	20.	6.2	5.2	1.	1.6	.32	.216	.104	....	....	....	.026	.15	5.5	0.	3.	......	47,000
1402	" 20	" 21	Decided	"	.5	....	314.	300.	14.	15.5	8.4	7.5	.9	1.6	.44	.296	.144	....	....	....	.62	.38	5.5	3.	16.	......	10,000
1455	Mar. 5	Mar. 6	Much	"	.3	....	316.	310.	6.	15.5	8.	7.3	.7	1.36	.296	.288	.008	....	....	....	.034	1.9	5.	3.	3.	......	32,000
1490	" 12	" 13	"	Cons'd	.4	....	254.	174.	80.	8.	8.9	6.	2.9	.88	.424	.192	.232	....	....	....	.024	.55	6.	5.	4.	......	900,000
1529	" 20	" 21	"	Little	.4	....	208.	199.	9.	3.	3.6	3.4	.2	.48	.128	.04	.088	....	....	....	.032	.6	3.	3.	—2.	......	68,000
1568	" 27	" 28	"	"	.12	....	272.	259.	13.	7.8	6.1	4.6	1.5	.44	.176	.168	.008	....	....	....	.068	2.9	4.	2.	7.	......	210,000
1604	Apr. 3	Apr. 4	Decided	"	.3	....	414.	384.	30.	5.8	7.	6.8	.2	1.14	.28	.176	.104	....	....	....	.07	1.	5.	3.	16.	......	165,000
1643	" 10	" 11	Much	"	.4	....	410.	391.	19.	7.6	11.6	10.2	1.4	1.04	.424	.256	.168	....	....	....	.06	1.2	5.	3.	11.	......	12,000
1682	" 17	" 18	Decided	"	.45	....	424.	410.	14.	7.2	8.6	7.5	1.1	.746	.576	.368	.208	....	....	....	.1	1.	4.	4.	4.	......	6,000
1723	" 24	" 25	"	"	.4	....	375.	375.	0.	5.6	12.9	9.3	3.6	.184	.752	.424	.328	....	....	....	.082	.5	3.5	......	27.	......	5,000
1760	May 1	May 2	Much	"	.4	....	352.	252.	100.	10.4	13.2	8.1	5.1	.424	.48	.248	.232	....	....	....	.18	.8	3.5	27.	27.	......	1,700
1791	" 8	" 9	Decided	"	.4	....	246.	242.	4.	15.8	8.4	7.9	.5	1.024	.304	.216	.088	....	....	....	.18	.42	3.	19.	19.	......	7,300
1824	" 15	" 16	"	"	.4	....	312.	302.	10.	17.	7.8	7.6	.2	.66	.384	.274	.11	....	....	....	.6	.6	3.	22.	22.	......	1,800
1860	" 22	" 23	"	"	.4	....	262.	246.	16.	14.	8.	6.6	1.4	.46	.328	.28	.048	....	....	....	.16	.6	3.	19.	19.	......	2,000
1931	June 5	June 6	"	"	.4	....	273.	240.	33	16.	7.4	6.1	1.3	.96	.344	.328	.016	....	....	....	.3	.0	3.	23.	24.	......	17,300
1964	" 11	" 13	"	"	.3	....	286.	280.	6.	14.	7.6	6.2	1.4	.82	.264	.192	.072	....	....	....	.3	.4	3.	25.	26.	......	29,000
1998	" 18	" 19	Distinct	"	.2	....	258.	214.	44.	21.	6.6	6.2	.4	1.36	.232	.208	.024	....	....	....	.3	.3	3.	24.	25.	......	12,100
2036	" 25	" 26	....	"	.22	....	274.	242.	32.	21.8	6.	5.5	.5	.88	.192	.176	.016	....	....	....	1.	.35	3.5	29.	32.	......	17,000
....	....	....	....	....	....	....	......	......	......	......	....	....	....	......	......	......	......	....	....	....	......	....	......	......	......	......	....
....	....	....	....	....	....	....	......	......	......	......	....	....	....	......	......	......	......	....	....	....	......	....	......	......	......	......	....

9494 Q. State what table 129 shows and what is its sanitary significance?

A. Table 129 contains analyses of samples of water from the Illinois river at Ottawa between January 4th, and June 25th, 1900. The various determinations chemical and bacterial, especially those showing the amount of albuminoid ammonia, free ammonia and nitrates and the number of bacteria per cubic centimeter, indicate that a considerable change in the direction of purification has taken place between Morris and Ottawa as in 1899.

Q. Will you produce and read in evidence table 130?

A. Yes sir, table 130 is as follows:

TABLE 130.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—BIG VERMILLION RIVER, LA SALLE.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l.	Albuminoid Am. Dissolv'd.	Albuminoid Am. Suspend'd.	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
1164	Jan. 2	Jan. 3	....	V. Little	.1	....	609.	581.	23.	22.	3.	2.4	.6	.168	.08	.072	.008	....	....	....	.032	4.5	......	......	......	......	4,000
1204	" 9	" 10	....	"	.4	....	662.	660.	2.	24.	2.4	2.2	.2	.4	.104	.096	.008	....	....	....	.04	2.85	......	......	......	......	5,400
1243	" 16	" 17	Slight	"	.06	....	584.	534.	0.	30.	2.3	2.2	.1	.290	.136	.072	.064	....	....	....	.04	1.7	......	......	......	......	3,900
1271	" 23	" 24	Much	Cons'd	.12	....	420.	338.	82.	8.	6.	2.1	3.9	.128	.248	.104	.144	....	....	....	.32	3.08	......	......	......	......	20,100
1306	" 30	" 31	Slight	V. Little	.12	....	432.	130.	2.	11.	2.6	2.6	.0	.13	.104	.104	.0	....	....	....	.01	2.75	......	......	......	......	6,000
1341	Feb. 6	Feb. 7	"	"	.1	....	570.	563.	7.	22.	5.	2.4	2.6	.202	.88	.072	.808	....	....	....	.026	1.55	......	......	......	......	1,800
1377	" 13	" 14	Much	Much	.2	....	630.	251.	379.	6.	15.2	4.4	8.8	.006	.712	.176	.536	....	....	....	.016	3.4	......	......	......	......	79,000
1403	" 20	" 21	Slight	Little	.2	....	362.	358.	4.	8.	3.	2.3	.7	.106	.128	.104	.024	....	..	....	.012	3.65	......	......	......	......	7,500
1434	" 27	" 28	Much	Cons'd	.6	....	278.	262.	16.	4.5	7.6	6.	1.6	.08	.24	.192	.048	....	....	....	.022	3.	......	......	......	......	50,000
1462	Mar. 6	Mar. 8	"	Little	.4	....	380.	350.	30.	9.4	2.6	2.6	.0	.114	.088	.072	.016	....	....	....	.02	4.85	......	......	......	......	7,500
1495	" 13	" 14	"	Much	.2	....	550.	98.	452.	2.6	19.6	8.8	10.8	.206	1.064	.296	.768	....	....	....	.011	.65	......	......	......	......	150,000
1530	" 20	" 21	"	"	.2	....	396.	220.	176.	4.	8.8	3.4	5.4	.048	.312	.088	.224	....	....	...	.014	2.3	......	......	......	......	30,000
1565	" 27	" 28	"	Little	.12	....	312.	296.	16.	4.8	4.	2.8	1.2	.066	.128	.088	.04	....	....	....	.02	.39	......	......	......	......	10,000
1605	Apr. 3	Apr. 4	"	Much	.3	....	618.	228.	390.	3.	15.5	4.1	11.4	.054	.544	.128	.416	....	....	....	.016	3.05	......	......	......	......	19,000
1644	" 10	" 11	"	Little	.18	....	338.	304.	34.	4.6	5.8	4.6	1.2	.064	.136	.088	.048	....	....	....	.012	.5	17.6	......	......	......	2,700
1683	" 17	" 18	Decided	Cons'd	.1	....	366.	336.	30.	6.2	8.4	8.1	.3	.064	.16	.088	.072	....	....	....	.036	1.4	......	......	......	......	2,100
1724	" 24	" 25	"	Little	.25	....	340.	308.	32.	4.4	4.6	3.5	1.1	.036	.128	.08	.048	....	....	....	.022	5.2	......	......	......	......	7,300
1761	May 1	May 2	Slight	"	.2	....	370.	367.	3.	8.	3.	3.	.0	.016	.112	.096	.016	....	....	....	.016	2.25	14.8	......	......	......	600
1792	" 8	" 9	Much	Much	.35	....	488.	308.	180.	8.1	6.5	4.9	1.6	.106	.4	.184	.216	....	....	....	.028	1.9	......	......	......	......	30,000
1825	" 15	" 16	Decided	Little	.2	....	406.	390.	16.	11.	3.	2.7	.3	.022	.128	.088	.04	....	....	....	.028	1.35	14.	......	......	......	1,300
1861	" 22	" 23	Distinct	"	.3	....	396.	376.	20.	11.4	3.5	3.3	.2	.022	.184	.12	.064	....	....	....	.024	1.65	11.4	......	......	......	1,500
1898	" 29	" 30	Decided	"	.2	....	394.	385.	9.	10.6	4.6	4.1	.5	.12	.2	.128	.072	....	....	....	.28	2.12	......	......	......	......	7,800
1932	June 5	June 6	Slight	"	.3	....	360.	360.	[illegible]	6.2	3.6	3.1	.5	.03	.216	.192	.024	....	....	....	.03	.15	......	......	......	......	3,000
1966	" 12	" 13	Decided	"	.2	....	346.	344.	2.	7.	4.3	3.4	.9	.02	.192	.136	.056	....	....	....	.026	2.15	11.8	......	......	......	3,200
2003	" 19	" 20	"	"	.15	....	434.	386.	48.	13.2	4.	3.4	.6	.026	.128	.112	.016	....	....	....	.026	2.15	......	......	......	......	5,400
2038	" 26	" 27	Much	Much	.4	....	478.	166.	312.	2.4	18.	6.5	11.5	.078	.664	.144	.520	....	....	....	.024	.65	......	......	......	......	40,000

9496 Q. Will you please explain what table 130 shows and its sanitary significance?

A. Table 130 contains analyses of samples of water from the Big Vermillion at LaSalle, the samples being taken between January 2nd, and June 26th, 1900. The number of bacteria during this period is on the whole higher than in the period for 1899. The amount of free ammonia during the first part of this period is much higher than in the latter part of the period.

Q. Will you produce and read in evidence table 131?

A. Yes sir, table 131 is as follows:

TABLE 131.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, LA SALLE.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved	By Suspd Matter	Free Ammonia.	Albuminoid Am			Total.	Dissolved.	Suspended.	Nitrites	Nitrates					
															Tot'l	Dissolv'd	Suspnd'd										
1165	Jan. 2	Jan. 3	Decided	V. Little	.35	....	416.	412.	4.	39.	8.	7.5	.5	3.9	.58	.392	.188	....	....	....	.054	2.9	....	....	....	....	30,100
1205	" 9	" 10	"	"	.4	....	378.	374.	4.	68.	8.	7.5	.5	.4	.6	.56	.04	....	....	....	.072	.6	....	....	....	....	18.200
1244	" 16	" 17	"	Little	.2	....	354.	354.	0.	53.	7.2	6.4	.8	.3	.34	.296	.044	....	....	....	.028	.75	....	....	....	....	154,800
1272	" 23	" 24	Much	Cons'd	.35	Gassy	348.	292.	56.	21.	8.6	6.5	2.1	2.3	.74	.328	.412	....	....	....	....	.62	12.4	....	....	....	317,000
1309	" 30	" 31	"	V. Little	.22	....	292.	274.	18.	14.	5.4	5.4	.0	1.3	.44	.288	.152	....	....	....	.018	.0	12.6	....	....	....	195,000
1342	Feb. 6	Feb. 7	Slight	Little	.27	....	294.	285.	9.	16.	6.4	5.6	.8	1.48	.34	.192	.148	....	....	....	.03	.4	1.	....	....	....	9,000
1378	" 13	" 14	Much	Much	.6	....	472.	218.	254.	9.	17.2	7.6	9.6	.76	.712	.272	.44	....	....	....	.06	1.7	18.3	....	....	....	195.000
1404	" 20	" 21	"	Little	.45	....	270.	254.	16.	13.	8.6	7.3	1.3	1.2	.464	.248	.216	....	....	....	.028	1.85	14.9	....	....	....	53,000
1435	" 27	" 28	"	"	.3	....	279.	252.	27.	12.	9.	7.6	1.4	1.04	.408	.24	.168	....	....	....	.036	1.3	....	....	....	....	200.000
1463	Mar. 6	Mar. 8	"	"	.25	....	274.	249.	25.	12.	7.2	5.8	1.4	1.32	.296	.168	.128	....	....	....	.028	1.55	14.6	....	....	....	28.000
1496	" 13	" 14	"	Much	.5	....	444.	92.	352.	7.	19.4	8.2	11.2	.4	.96	.248	.712	....	....	....	.012	.5	25.5	....	....	....	320,000
1531	" 20	" 21	"	Cons'd	.4	....	248.	188.	60.	6.	8.8	6.7	2.1	.504	.328	.176	.152	....	....	....	.03	1.4	23.	....	....	....	120,000
1566	" 27	" 28	"	Little	.4	....	244.	160.	84.	4.8	9.2	6.8	2.4	.336	.44	.248	.192	....	....	....	.016	1.6	19.6	....	....	....	260,000
1606	Apl. 3	Apl. 4	"	Much	.4	....	430.	186.	244.	4.8	15.2	7.5	7.7	.336	.464	.192	.272	....	....	....	.016	1.3	21.	....	....	....	360,000
1645	" 10	" 11	"	Little	.4	....	276.	230.	46.	8.6	9.6	9.5	.1	.536	.432	.256	.176	....	....	....	.026	1.	17.6	....	....	....	65.000
1684	" 17	" 18	Decided	Cons'd	.3	....	298.	245.	53.	10.	8.8	5.8	3.	.528	.368	.246	.122	....	....	....	.052	.55	15.6	....	....	....	16.000
1725	" 24	" 25	"	Little	.4	....	282.	260.	22.	9.4	8.2	7.8	.4	.504	.36	.288	.072	....	....	....	.076	.1	16.	....	....	....	25.000
1762	May 1	May 2	Much	"	.5	....	276.	260.	16.	5.0	12.8	8.9	3.9	.112	.416	.304	.112	....	....	....	.06	1.	14.8	....	....	....	4,600
1793	" 8	" 9	"	"	.4	....	307.	246.	61.	15.2	9.1	7.9	1.2	.112	.44	.44	.0	....	....	....	.17	.38	15.3	....	....	....	8,500
1826	" 15	" 16	Decided	"	.4	....	282.	266.	16.	12.	7.3	7.2	.1	.176	.22	.208	.012	....	....	....	.36	1.	14.	....	....	....	1,800
1862	" 22	" 23	"	"	.4	....	268.	266	2.	13.	7.7	7.4	.3	.256	.342	.256	.086	....	....	....	.2	1.1	11.4	....	....	....	5,700
1899	" 29	" 30	Distinct	"	.3	....	229.	226.	3.	14.	6.	6.	.0	.128	.232	.168	.064	....	....	....	.14	.86	11.6	....	....	....	8,600
1933	June 5	June 6	Much	"	.35	....	263.	226.	37.	14.	7.9	6.5	1.4	.216	.304	.152	.152	....	....	....	.28	.0	12.8	....	....	....	25,500
1969	" 12	" 13	Decided	"	.4	....	287	258.	27.	19.	6.6	6.	.6	.416	.288	.184	.104	....	....	....	.4	1.5	11.8	....	....	....	9,900
2004	" 19	" 20	"	"	.2	....	260.	225.	35.	16.6	6.5	5.8	.7	.728	.224	.208	.016	....	....	....	.3	1.05	11.6	....	....	....	11,000
2039	" 26	" 27	Distinct	"	.3	....	231.	225.	6.	18.	7.	5.6	1.4	.08	.256	.152	.104	....	....	....	.25	.35	12.4	....	....	....	3,700
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

9498 Q. What does table 131 show and what is its sanitary significance?

A. Table 131 contains analyses of samples of water from the Illinois river at LaSalle between January 2nd, and June 26th, 1900. During the months of January, February and March, the number of bacteria in the rivers is, as in the other river waters that have been considered, much higher than during 1899. The amount of free ammonia is likewise much higher during the first part of this period than during the latter portion.

Q. Will you produce and read in evidence table 132?

A. Yes sir, table 132 is as follows:

Table 132.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

Source of Water—Illinois and Michigan Canal, La Salle.

Report of Edwin O. Jordan,
University of Chicago.

Serial No.	Date of 1900 Collection.	Date of 1900 Examination.	Appearance. Turb'y.	Appearance. Sediment.	Appearance. Color.	Odor	Residue on Evaporation. Total.	Residue on Evaporation. Dissolved.	Residue on Evaporation. Suspended	Chlorine.	Oxygen Consumed. Total.	Oxygen Consumed. By Dissolved.	Oxygen Consumed. By Susp'd Matter.	Nitrogen as Ammonia. Free Ammonia.	Nitrogen as Ammonia. Albuminoid Am. Tot'l	Nitrogen as Ammonia. Albuminoid Am. Dissolv'd	Nitrogen as Ammonia. Albuminoid Am. Susp'd	Organic Nitrogen. Total.	Organic Nitrogen. Dissolved.	Organic Nitrogen. Suspended	Nitrogen as Nitrites	Nitrogen as Nitrates	Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
1166	Jan. 2	Jan. 3	Decided	V. Little	.3	....	560.	540.	20.	51.	8.1	8.1	.0	3.6	.56	.48	.08	....	....	....	.28	2.85	9.6	......	......	......	30,000
1206	" 9	" 10	"	"	.3	....	422.	414.	8.	41.	7.6	7.1	.5	3.32	.58	.408	.172	....	....	....	.2	1.1	9.9	......	......	......	13,000
1245	" 16	" 17	Much	Little	.3	....	494.	492.	2.	28.	9.2	8.2	1.	3.84	.94	.464	.476	....	....	....	.24	.85	10.	......	......	......	3,000
1273	" 23	" 24	"	"	.25	....	418.	385.	33.	31.	11.8	6.5	5.3	3.	.66	.296	.364	....	....	....	....	.34	12.4	......	......	......	113,000
1310	" 30	" 31	"	V. Little	.3	....	338.	336.	2.	22.	6.1	6.1	.0	2.04	.44	.288	.152	....	....	....	.03	.9	12.6	......	......	......	119,000
1343	Feb. 6	Feb. 7	Decided	Little	.25	....	311.	294.	17.	19.	6.	5.9	.1	1.48	.28	.224	.056	....	....	....	.024	.85	11.4	......	......	......	17,000
1379	" 13	" 14	"	Much	.7	....	418.	281.	137.	11.	15.	8.	7.	1.28	.712	.352	.36	....	....	....	.016	.8	18.3	......	......	......	52,000
1405	" 20	" 21	"	Cons'd	.4	....	322.	239.	83.	11.5	9.2	8.2	.1	2.04	.432	.296	.136	....	....	....	.04	.8	14.9	......	......	......	127,000
1436	" 27	" 28	"	Little	.6	....	272.	234.	38.	12.	9.	8.	1.	1.08	.38	.272	.108	....	....	....	.044	1.	15.6	......	......	......	140,000
1464	Mar. 6	Mar. 8	"	"	.6	....	256.	232.	24.	11.	8.4	7.3	1.1	1.04	.384	.192	.192	....	....	....	.036	1.25	14.6	......	......	......	26,000
1497	" 13	" 14	"	Much	.2	....	236.	126.	110.	6.	11.7	6.4	5.3	.72	.496	.184	.312	....	....	....	.026	.8	25.3	......	......	......	149,000
1532	" 20	" 21	"	Little	.3	....	210.	170.	40.	5.	9.	7.5	1.5	1.08	.448	.288	.16	....	....	....	.03	.8	......	......	......	......	85,000
1567	" 27	" 28	"	"	Muddy	....	220.	170.	50.	7.6	7.4	6.2	1.2	.6	.32	.208	.112	....	....	....	.044	1.2	19.6	......	......	......	105,000
1607	Apr. 3	Apr. 4	"	"	.4	....	286.	246.	40.	12.2	7.6	6.2	1.4	.92	.304	.176	.128	....	....	....	.058	1.2	21.	......	......	......	180,000
1646	" 10	" 11	"	Cons'd	.35	....	376.	336.	40.	15.6	8.5	6.4	2.1	1.	.56	.52	.04	....	....	....	.066	2.4	17.6	......	......	......	62,000
1685	" 17	" 18	"	Little	.3	....	372.	338.	34.	15.	7.7	6.8	.9	.6	.352	.176	.176	....	....	....	.074	1.1	15.6	......	......	......	12,000
1726	" 24	" 25	"	"	.25	....	394.	360.	34.	13.	7.9	5.7	2.2	.5	.384	.16	.224	....	....	....	.072	1.3	......	......	......	......	33,000
1763	May 1	May 2	"	"	.25	....	372.	332.	40.	14.2	5.6	5.4	.2	.24	.288	.184	.104	....	....	....	.054	.9	14.8	......	......	......	9,400
1794	" 8	" 9	"	"	.3	....	406.	368.	38.	15.4	7.7	6.3	1.4	.72	.336	.224	.112	....	....	....	.04	.5	......	......	......	......	25,000
1827	" 15	" 16	"	"	.3	....	366.	344.	22.	12.	7.7	7.3	.4	6.	.368	.256	.112	....	....	....	.34	.0	14.	......	......	......	3,900
1863	" 22	" 23	Much	"	.3	....	400.	351.	49.	15.	7.7	7.7	.0	.76	.384	.312	.072	....	....	....	.03	.8	......	......	......	......	5,400
1900	" 29	" 30	Decided	"	.35	....	408.	354.	54.	14.	8.7	6.2	2.5	.72	.496	.296	.2	....	....	....	.066	.0	11.6	......	......	......	24,200
1934	June 5	June 6	Much	"	.3	....	354.	326.	28.	13.	7.8	7.3	.5	.256	.376	.272	.104	....	....	....	.054	.1	12.8	......	......	......	6,700
1968	" 12	" 13	Decided	"	.4	....	347.	318.	29.	12.2	8.1	7.6	.5	.72	.352	.32	.132	....	....	....	.044	.5	11.8	......	......	......	32,000
2005	" 19	" 20	"	"	.2	....	362.	335.	27.	11.	9.2	8.3	.9	.88	.4	.344	.056	....	....	....	.012	.25	11.6	......	......	......	28,800
2040	" 26	" 27	Distinct	"	.3	....	226.	216.	10.	12.	.8	7.8	.2	.312	.4	.264	.136	....	....	....	.024	.35	......	......	......	......	36,400
....	....	....	....	....	......	....	......	......	......	......	....	....	....	......	......	......	......	....	....	....	....	......	......	......	......	......	....

9500 Q. State what table 132 shows and its sanitary significance?

A. Table 132 contains analyses of samples of water from the Illinois and Michigan canal at LaSalle from January 2nd to June 26th, 1900. I should like to strike out in table 131 the height of water in the Illinois river at LaSalle for February 6th, as being obviously a clerical error.

Q. Will you produce and read in evidence table 133?

A. Yes, sir, table 133 is as follows:

TABLE 133.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, HENRY.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved.	By Suspd Matter	Free Ammonia.	Albuminoid Am Tot'l	Dissolv'd	Susp'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
1170	Jan. 3	Jan. 4	Decided	V. Little	.22	....	381.	380.	1.	22.	7.8	7.8	.0	1.92	.352	.304	.048	....	....	....	.048	3.05	7.1	0.	—15.	......	9,400
1207	" 9	" 10	Slight	"	.3	....	348.	338	10.	31.	7.6	7.6	.0	3.32	.416	.296	.12	....	....	....	.06	1.2	7.3	0.	2.	......	1,000
1246	" 13	" 17	Distinct	Little	.35	....	335.	333.	2.	31.	7.8	7.8	.0	2.8	.44	.296	.144	....	....	....	.05	1.	6.5	0.	1.	......	8,500
1274	" 23	" 24	Much	Cons'd	.3	....	320.	290.	30.	18.	7.7	5.6	2.1	1.96	.456	.28	.176	....	....	....	....	.42	8.2	2.	3.	......	266,000
1311	" 30	" 31	"	Little	.3	....	308.	306.	2.	16.	6.1	5.6	.5	1.4	.376	.2	.176	....	....	....	.01	.3	7.6	0.	0.	......	164,000
1339	Feb. 5	Feb. 6	"	"	.3	....	278.	276.	2.	15.	6.3	6.3	.0	1.16	.296	.24	.056	....	....	....	.025	.2	7.4	0.	12.	......	166,000
1374	" 12	" 13	"	Much	.42	....	474.	202.	272.	7.	17.4	8.2	9.2	.64	.672	.272	.4	....	....	....	.096	.15	11.2	0.	4.	......	194,000
1401	" 19	" 20	"	Little	.4	....	326.	218.	8.	11.5	9.4	7.4	2.	.76	.448	.24	.204	....	....	....	.026	.95	10.7	0.	—12.	......	13,000
1433	" 26	" 27	"	Cons'd	.25	....	274.	222.	52.	9.5	8.8	6.8	2.	1.04	.44	.224	.216	....	....	....	.036	1.06	12.6	0.	—13.	......	195,000
1456	Mar. 5	Mar. 7	"	Little	.4	....	273.	248.	25.	11.3	8.2	7.1	1.1	.76	.336	.208	.128	....	....	....	.024	1.7	11.	0.	—11.	......	13,000
1492	" 12	" 13	"	Cons'd	.2	....	250.	207.	43.	10.9	8.3	6.9	1.4	.92	.352	.216	.136	....	....	....	.02	.6	15.8	0.	— 1.	......	60,000
1527	" 19	" 20	"	Much	.2	....	291.	146.	148.	3.6	11.7	5.6	6.1	.4	.416	.176	.24	....	....	....	.012	1.1	13.9	0.	4.	......	120,000
1562	" 26	" 27	"	Little	.3	....	224.	172.	52.	9.2	7.5	6.3	1.2	.44	.32	.208	.112	....	....	....	.012	1.16	16.9	0.	3.	......	260,000
1601	Apr. 2	Apr. 3	"	Cons'd	.4	....	286.	194.	92.	5.2	8.8	6.8	2.	.4	.42	.184	.236	....	....	....	.018	1.1	17.5	4.	3.	......	55,000
1641	" 9	" 10	"	Much	.4	....	286.	193.	93.	4.4	11.9	9.6	1.8	.34	.32	.24	.08	....	....	....	.024	.0	16.	4.	1.	......	30,000
1686	" 16	" 18	"	Little	.32	....	259.	217.	42.	7.	7.4	7.	.4	.34	.32	.288	.032	....	....	....	.064	.85	13.8	4.	2.	......	60,000
1720	" 23	" 24	"	"	.3	....	290.	258.	32.	7.6	8.4	7.3	1.1	.42	.424	.272	.152	....	....	....	.056	.8	13.	10.	10.	......	6,000
1764	" 30	May 2	Slight	"	.35	....	286.	241.	45.	9.8	8.	6.1	1.9	.42	.312	.24	.072	....	....	....	.054	.75	11.6	12.	11.	......	22,000
1785	May 7	" 8	Much	Cons'd	.4	....	318.	267.	51.	12.6	15.6	8.4	7.2	.5	.496	.288	.208	....	....	....	.03	.05	10.	11.	17.	......	3,400
1828	" 15	" 16	Decided	Little	.4	....	304.	270.	34.	14.	8.5	8.3	.2	.3	.312	.232	.08	....	....	....	.26	.6	9.8	22.	28.	......	1,200
1855	" 21	" 22	Much	"	.35	....	300.	248.	52.	14.	7.6	6.5	1.1	.44	.376	.224	.152	....	....	....	.08	1.1	9.	16.	19.	......	3,100
1890	" 28	" 29	"	Cons'd	.4	....	293.	242.	51.	13.4	7.6	5.6	2.	.46	.344	.176	.168	....	....	....	.1	.3	9.	20.	17.	......	3,500
1929	June 4	June 6	Decided	Little	.3	....	314.	282.	32.	12.8	7.	6.	1.	.76	.352	.256	.096	....	....	....	.26	.84	9.5	20.	17.	......	5,500
1965	" 11	" 12	Much	"	.3	....	301.	240.	61.	12.8	8.3	6.2	2.1	.38	.376	.2	.176	....	....	....	.16	.8	9.1	22.	24.	......	1,400
1999	" 18	" 19	"	"	.2	....	380.	272.	108.	19.	8.6	6.	2.6	1.28	.238	.208	.030	....	....	....	.32	.73	7.4	20.	23.	......	1,900
2031	" 25	" 26	"	Cons'd	.3	....	267.	244.	23.	16.2	7.9	7.2	.7	.264	.216	.16	.056	....	....	....	.8	.1	7.5	23.	28.	......	3,300
....	....	....	....	....	....	....	......	......	......	......	....	....	....	......	......	......	......	....	....	....	....	......	......	......	......	......	....

9502 Q. State what table 133 shows and its sanitary significance?

A. Table 133 contains analyses of samples of water from the Illinois river at Henry between January 3rd and June 25th, 1900. Here again is shown the increase in the number of bacteria in the river water during the late winter and early spring. This has already been shown to be a common phenomenon in river water and occurs in the tributaries of the Illinois as well as in the Illinois itself. The diminished chlorine in the latter part of this period shows the effect of the dilution due to the opening of the Chicago drainage canal.

Q. Will you produce table 134 and read it in evidence?

A. Yes sir, table 134 is as follows:

TABLE 134.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, AVERYVILLE.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Suspd Matter	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended	Nitrites	Nitrates					
															Tot'l	Dis-solv'd	Sus-pnd'd										
1167	Jan. 2	Jan. 3	Distinct	V. Little	.22	....	366.	350.	16.	21.	6.6	6.5	.1	1.66	.352	.288	.064	....	....	....	.024	3.	28.1	1.	—2.	......	53,600
1208	" 9	" 10	Slight	"	.3	....	368.	358.	10.	24.	6.4	6.3	.1	1.92	.296	.264	.032	....	....	....	.03	3.4	28.3	2.	3.	......	9,100
1247	" 16	" 17	Distinct	"	.3	....	378.	360.	18.	49.	7.4	7.4	.0	2.56	.352	.26	.092	....	....	....	.07	.85	28.4	2.	3.	......	58,800
1275	" 23	" 24	Much	Cons'd	.3	....	356.	302.	54.	21.	8.	6.	2.	1.84	.416	.272	.144	....	....	....	—.	.45	31.	3.	4.	......	51,000
1312	" 29	" 31	"	Little	.32	....	310.	310.	0.	21.	6.5	6.2	.3	2.4	.44	.296	.144	....	....	....	.01	1.25	31.2	0.	—9	......	147,000
1344	Feb. 6	Feb. 7	"	"	.27	....	296.	288.	8.	17.	6.	5.4	.6	1.48	.28	.184	.096	...	....	....	.024	.5	30.9	1.	—1.	......	48,000
1380	" 13	" 14	"	Much	.6	....	486.	182.	304.	7.	17.2	7.2	10.	.68	.736	.272	.464	....	....	....	.017	1.65	34.6	0.	—2.	......	210,000
1406	" 20	" 21	"	Cons'd	.4	....	338.	214.	124.	9.	9.1	7.2	1.9	.84	.44	.272	.168	....	....	....	.028	1.8	34.6	1.	0.	......	58,000
1437	" 27	" 28	"	"	.35	....	262.	218.	44.	10.5	8.8	7.2	1.6	.96	.352	.248	.104	....	....	....	.031	1.	35.6	0.	—3.	......	175,000
1459	Mar. 7	Mar. 7	"	Little	.3	....	258.	228.	30.	9.4	7.6	6.2	1.4	.84	.28	.184	.096	....	....	....	.026	2.	34.7	0.	3.	......	22,000
1498	" 13	" 14	"	Much	.15	....	330.	166.	164.	8.8	9.	6.	3.	.68	.368	.12	.248	....	....	....	.026	1.1	38.9	1.	5.	......	77,000
1533	" 20	" 21	"	"	.18	....	294.	132.	162.	4.4	13.	5.9	7.1	.4	.488	.176	.312	....	....	....	.012	.6	43.02	1.	—3.	......	110,000
1570	" 27	" 28	"	Little	.22	....	210.	170.	40.	5.4	7.4	6.5	.9	.46	.296	.176	.12	....	....	....	.18	1.07	39.7	2.	3.	......	200,000
1608	Apr. 3	Apr. 4	"	Cons'd	.35	....	242.	182.	60.	4.8	8.	5.8	2.2	.46	.256	.16	.096	....	....	....	.016	1.1	40.1	6.	9.	......	33,000
1647	" 10	" 11	"	"	.35	....	274.	184.	90.	4.6	8.4	6.7	1.7	.32	.72	.384	.336	....	....	....	.026	1.85	29.2	9.	3.	......	23,000
1687	" 17	" 18	"	Little	.3	....	248.	210.	38.	7.4	7.7	7.2	.5	.42	.28	.224	.056	....	....	....	.054	1.1	36.85	10.	14.	......	9,000
1727	" 24	" 25	"	"	.25	....	262.	244.	18.	8	7.6	6.1	1.5	.2	.336	.208	.128	....	....	....	.048	1.	36.1	14.	18.	......	3,600
1765	May 1	May 2	"	"	.3	....	281.	262.	19.	10.	7.8	7.	.8	.176	.296	.192	.104	....	....	....	.054	.7	34.8	18.	23.	......	4,700
1795	" 8	" 9	Decided	"	.35	....	268.	264.	4.	10.4	8.8	7.6	1.2	......	......	......	......	....	....	....	.05	.5	33.3	19.	22.	......	6,700
1832	" 16	" 17	"	"	.4	....	300.	276.	24.	13.8	8.3	8.	.3	.28	.432	.176	.256	....	....	....	.088	1.2	32.75	22.	23.	......	24,500
1864	" 22	" 23	"	"	.4	....	290.	260.	30.	12.6	7.2	7.2	.0	.304	.296	.288	.008	....	....	....	.06	1.	32.1	19.	22.	......	3,000
1901	" 29	" 30	Much	"	.35	....	334.	252.	82.	12.	7.4	6.6	.8	.176	.344	.248	.096	....	....	....	.094	.45	31.9	21.	21.	......	4,800
1935	June 5	June 6	Decided	"	.25	....	266.	250.	16.	15.2	5.8	5.	.8	.4	.256	.168	.088	....	....	....	.16	.0	32.1	23.	21.	......	4,000
1969	" 12	" 13	"	"	.3	....	265.	251.	14.	13.6	7.	6.8	.2	.272	.304	.208	.096	. .	....	.	.2	.9	31.8	23.	22.	......	8,600
2006	" 19	" 20	"	"	.2	....	339.	274.	65.	16.	7.5	6.8	.7	.12	.264	.24	.024	....	....	....	.24	1.16	30.6	22.	19.	......	800
2041	" 26	" 27	Distinct	"	.22	....	259.	250.	9.	16.6	5.9	5.8	.1	.52	.264	.144	.12	....	....	....	.03	.35	30.35	25.	24.	......	2,500
....	....	....	....	....	....	....	......	......	......	......	....	....	....	......	......	......	......	....	....	....	....	......	......	......	......	......	....

9504 State what table 134 shows and its sanitary significance?

A. Table 134 contains analyses of samples of water in the Illinois river at Averyville from January 2nd to June 26th, 1900. Both the effects of purification and dilution are shown in this table, especially during the latter part of the period when the effect of the condition of early spring had disappeared.

Q. Will you produce and read in evidence table 135?

A. Yes sir, table 135 is as follows:

TABLE 135.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, WESLEY CITY.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved.	By Suspd Matter	Free Ammonia.	Albuminoid Am Tot'l	Albuminoid Am Dis-solv'd	Albuminoid Am Sus-pnd'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
1190	Jan. 5	Jan. 6	Decided	Little	.2	....	376.	376.	0.	22.	7.2	6.2	1.	1.08	.48	.24	.24	....	....	....	.032	.3	2.	—12.	.....	......	10,000
1222	" 11	" 12	Much	"	.22	....	371.	354.	17.	24.	7.5	6.6	.9	1.5	.46	.216	.244	....	....	....	.046	1.9	1.	— 1.	.....	......	50,000
1251	" 18	" 19	"	Much	Muddy	....	620.	290.	330.	18.	13.1	7.3	5.8	1.16	.7	.288	.412	....	....	....	.052	1.	2.	.....	—1.	......	23,000
1345	Feb. 6	Feb. 7	"	Little	"	....	311.	304.	7.	14.	7.	6.2	.8	1.16	.38	.184	.196	....	....	....	.016	.85	4.	.....	4.	......	47,000
1387	" 13	" 14	"	Much	"	....	521.	212.	309.	11.	12.2	6.4	5.8	1.	.66	.272	.388	....	....	....	.018	.75	7.	.....	—7.	......	34,000
1411	" 21	" 23	"	Cons'd	.4	....	373.	215.	158.	9.	8.8	7.7	1.1	.76	.52	.224	.296	....	....	....	.034	1.85	7.8	.....	0.	......	31,000
1460	Mar. 6	Mar. 7	"	Little	3	....	256.	228.	28.	9.4	8.4	6.6	1.8	.82	.3	.192	.108	....	....	....	.026	1.65	7.	.....	—4.	......	14,000
1501	" 14	" 15	"	Cons'd	.15	....	316.	220.	96.	9.9	10.6	6.2	4.4	.66	.44	.2	.21	....	....	....	.02	.7	12.	.....	—1.	......	....
1534	" 20	" 22	"	Much	.18	....	274.	162.	112.	4.8	9.	6.	3.	.38	.34	.184	.156	....	....	....	.012	.85	13.6	.....	—6.	......	65,000
1581	" 29	" 30	"	Little	.3	....	232.	154.	78.	4.8	7.2	6.	1.2	.38	.28	.128	.152	....	....	....	.012	1.15	11.	.....	4.	......	91,000
1610	Apr. 4	Apr. 5	"	"	.5	....	222.	199.	23.	5.2	7.7	6.5	1.2	.36	.256	.184	.072	....	....	....	.016	.5	12.	.....	4.5	......	29,000
1648	" 10	" 11	"	Cons'd	.4	....	284.	180.	104.	4.6	8.8	6.6	2.2	.41	.656	.416	.24	....	....	....	.018	1.85	.....	6.	3.	......	17,000
1689	" 17	" 18	"	Little	.4	....	256.	198.	58.	8.6	17.9	4.9	13.	.304	.256	.192	.064	....	....	....	.028	1.35	9.	10.	18.	......	2,000
1728	" 24	" 25	Decided	"	.25	....	236.	230.	6.	7.6	7.3	6.5	.8	.168	.288	.208	.08	....	....	....	.048	1.3	8.4	13.	22.	......	7,000
1767	May 2	May 3	"	"	.35	....	326.	261.	65.	9.4	8.7	7.2	1.5	.176	.416	.192	.224	....	....	....	.034	1.05	7.	16.	21.	......	150,000
1796	" 8	" 9	Much	Cons'd	.4	....	460.	248.	212.	10.2	11.6	7.6	4.	......	......	......	......	....	....	....	.034	.5	6.	17.	23.	......	18,000
1829	" 15	" 16	Decided	Little	.4	....	292.	254.	38.	13.2	8.2	7.2	1.	.216	.368	.168	.2	....	....	....	.1	.45	5.2	20.	29.	......	40,000
1866	" 22	" 23	Much	"	.4	....	338.	276.	62.	13.	7.8	6.7	1.1	.312	.32	.296	.024	....	....	....	.08	1.2	4.1	17.	24.	......	6,100
1902	" 29	" 31	"	Much	.35	....	738.	234.	504.	11.	16.6	7.2	9.4	.288	.696	.248	.448	....	....	....	.064	1.1	5.	21.	28.	......	110,000
1938	June 6	June 7	"	Little	.3	....	324.	240.	84.	14.8	6.3	5.7	.6	.256	.264	.16	.104	....	....	....	.106	.4	4.5	24.	36.	......	3,000
1972	" 13	" 14	Decided	"	.3	....	304.	274.	30.	13.9	9.	7.	2.	.504	.864	.224	.64	....	....	....	.6	.2	4.	23.	26.	......	22,700
1973	" 13	" 14	Distinct	"	.3	....	303.	228.	75.	13.1	5.9	5.2	.7	.144	.248	.16	.088	....	....	....	.24	1.8	4.	23.	26.	......	....
1974	" 13	" 14	"	"	.2	....	300.	233.	67.	14.	6.8	6.3	.5	.168	.24	.176	.064	....	....	....	.16	1.5	4.	23.	26.	......	....
2008	" 20	" 20	Decided	"	.2	....	392.	276.	116.	16.4	7.4	6.3	1.1	.216	.272	.2	.072	....	....	....	.16	1.04	3.	24.	39.	......	10,000
2042	" 27	" 28	"	Cons'd	.25	....	278.	259.	19.	17.6	6.3	5.6	.7	.44	.264	.16	.104	....	....	....	.13	.65	3.1	24.	30.	......	1,400

9506 Q. State what table 135 shows and its sanitary significance?

A. This table contains analyses of samples of water in the Illinois river at Wesley City. The smaller number of bacteria during this period as compared with the 1899 period shows that the pollution entering the Illinois river at Peoria, has been crowded in part towards the western bank and does not make its presence so evident in mid-stream as was the case during 1899.

Q. Will you produce and read in evidence table 136?

A. Yes sir, table 136 is as follows:

TABLE 136.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, PEKIN.

Report of EDWIN O. JORDAN.
University of Chicago.

Serial No.	DATE OF		APPEARANCE.			Odor	RESIDUE ON EVAPORATION.			Chlorine.	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am												
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Susp'd Matter	Free Ammonia.	Tot'l	Dissolv'd	Suspnd'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
1223	Jan. 11	Jan. 12	Much	Little	.3	....	380.	340.	40.	25.	7.4	6.6	.8	1.64	.464	.304	.16	....	....	...	.046	2.1	1.	—1.	.....	......	70,000
1252	" 18	" 19	"	"	Muddy	....	614.	301.	313.	18.	13.8	7.2	6.6	1.04	.848	.344	.504	....	....	....	.052	1.15	2.	....	—1.	......	130,000
1288	" 25	" 26	"	Cons'd	.35	....	444.	320.	124.	22.	10.6	6.4	4.2	1.88	.712	.24	.472	....	....	....	.026	.75	4.	....	—12.	......	20,600
1313	" 30	" 31	"	Little	.32	....	312.	312.	0.	23.	6.8	6.1	.7	2.52	.376	.296	.08	....	....	....	.01	1.25	4.	....	—17.	......	68,600
1346	Feb. 6	Feb. 7	"	"	.3	....	310.	297.	13.	15.	7.5	5.2	2.3	1.4	.4	.168	.232	....	....	...	.017	.8	4.	....	4.	......	64,000
1382	" 13	" 14	"	Much	.3	....	509.	210.	299.	10.	13.6	6.5	7.1	.84	.584	.264	.32	....	....	....	.016	1.15	7.	....	— 7.	......	34,000
1412	" 21	" 23	"	Cons'd	.42	....	368.	216.	152.	8.	12.	7.5	4.5	.88	.464	.288	.176	....	....	....	.028	1.35	7.8	....	0.	......	41,000
1502	Mar. 14	Mar. 15	"	"	.12	....	346.	192.	154.	8.6	8.9	6.2	2.7	.68	.4	.184	.216	....	....	....	.012	1.1	12.	....	— 1.	......	28,000
1535	" 20	" 22	"	Much	.2	....	280.	148.	132.	4.6	9.	5.8	3.2	.32	.44	.136	.304	....	....	....	.61	.75	13·6	....	— 6.	......	34,000
1582	" 29	" 30	"	Little	.3	....	213.	154.	59.	5.2	7.8	6.5	1.3	.34	.232	.16	.072	....	....	....	.012	1.35	11	....	4.	......	85,000
1611	April 4	April 5	"	"	.4	....	224.	188.	36.	5.2	7.7	5.7	2.	.36	.224	.152	.072	....	....	....	.014	1.05	12.	....	4.	......	26,000
1649	" 10	" 11	"	Cons'd	.5	....	262.	184.	78.	5.4	8.4	6.5	1.9	.456	.784	.6	.184	....	....	....	.024	.8	......	5.5	3.	......	20,000
1688	" 17	" 18	"	Little	.4	....	248.	200.	48.	6.2	7.6	7.	.6	.304	.24	.192	.048	....	....	....	.054	.86	9.	10.	18.	......	17,000
1729	" 24	" 25	Decided	"	.3	....	254.	250.	4.	7.4	7.4	6.8	.6	.176	.272	.168	.104	....	....	....	.048	1.5	8.4	13.	22.	......	6,600
1768	May 2	May 3	"	"	.3	....	269.	256.	13.	9.2	8.	6.8	1.2	.12	.416	.192	.224	....	....	....	.021	1.15	7.	16.	21.	......	37,500
1797	" 9	" 9	Much	Cons'd	.4	....	436.	152.	284.	10.2	11.1	7.8	3.3	......	......	......	......	....	....	....	.044	.55	6.	17.	23.	......	14,000
1839	" 15	" 16	Decided	Little	.4	....	294.	251.	43.	13.	8.4	7.1	1.3	.208	.408	.248	.16	....	....	....	.1	1.	5.2	20.	29.	......	40,000
1867	" 22	" 23	Much	"	.35	....	302.	261.	41.	13.	7.7	7.1	.6	.312	.36	.272	.088	....	....	...	.08	.75	4.1	17.	24.	......	26,400
1903	" 29	" 31	"	Much	.3	....	708.	233.	475.	10.	15.8	7.1	8.7	.288	.64	.184	.456	....	....	....	.066	.7	5.	21.	28.	......	90,000
1939	June 6	June 7	"	Little	.22	....	367.	258.	109.	14.4	7.8	5.5	2.3	.384	.264	.208	.056	....	....	....	14	.3	4.5	24.5	35.5	......	250,000
1975	" 13	" 14	Decided	"	.3	....	313.	248.	65.	14.2	6.8	6.2	.6	.24	.256	.224	.032	....	....	....	.22	1.05	4.	23.	25.5	......	190,000
2009	" 20	" 21	"	"	.2	....	330.	256.	74.	17.2	8.	6.4	1.6	.304	.376	.216	.100	....	....	....	.21	.69	3.	24.	39.	......	160,000
2043	" 27	" 28	"	Cons'd	.25	....	295.	239.	56.	17.8	7.	6.7	.3	.704	.28	.2	.08	....	....	....	.13	.7	3.1	24.5	30.	......	110,000

9508 Q. State what table 136 shows and its sanitary significance?

A. This table contains the analyses of samples of water taken from the Illinois river at Pekin from January 11th, 1900 to June 27th, 1900.

The effect of pollution here in the mid-stream sample is more manifest than in the samples from Wesley City owing possibly to a more thorough mixing at this point.

Q. Will you produce and read in evidence table 137?

A. Yes sir, table 137 is as follows:

TABLE 137.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, HAVANA.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am.												
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Suspd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Suspend'd	Total.	Dissolved	Suspended	Nitrites	Nitrates					
1234	Jan. 11	Jan. 12	Slight	Little	.6	....	355.	352.	3.	21.	6.2	5.	1.2	1.32	.344	.256	.088	....	....	....	.046	.5	4.08	0.	1.	....	27,600
1314	" 30	Feb. 2	Decided	"	.32	....	318.	306.	12.	21.	7.	6.1	.9	2.24	.48	.296	.184	....	....	....	.022	1.1	7.1	0.	—15.	....	63,400
1353	Feb. 7	" 8	Much	"	Muddy	....	344.	285.	59.	17.	7.6	6.	1.6	1.8	.424	.256	.168	....	....	....	.024	.45	7.4	1.	9.	....	46,600
1555	Mar. 22	Mar. 23	"	Much	.4	....	262.	131.	131.	6.	8.4	5.6	2.8	.464	.336	.168	.168	....	....	....	.008	.95	17.	3.	9.	....	60,000
1612	Apr. 4	Apr. 6	"	Little	.4	....	214.	180.	34.	4.6	7.3	5.8	1.5	.4	.192	.176	.016	....	....	....	.016	.6	14.0	6.	7.	....	50,000
1651	" 11	" 12	"	"	.5	....	256.	197.	59.	5.	6.4	6.	.4	.32	.488	.392	.096	....	....	....	.032	.05	14.3	9.	3.	....	4,700
1691	" 18	" 19	"	"	.2	....	272.	218.	54.	4.4	3.6	2.4	1.2	.168	.216	.136	.08	....	....	....	.034	1.1	12.9	11.	11.	....	4,000
1730	" 25	" 26	Decided	"	.3	....	234.	219.	15.	5.4	7.9	6.6	1.3	.144	.416	.208	.208	....	....	....	.044	.65	12.	11.5	18.	....	2,900
1769	May 2	May 3	"	"	.3	....	230.	212.	18.	7.6	8.6	6.7	1.9	.144	.464	.216	.248	....	....	....	.02	.8	11.2	20.	23.	....	1,100
1804	" 9	" 10	Much	"	.3	....	328.	253.	75.	9.2	8.	6.5	1.5	......	......	......	......	....	....	....	.02	.6	10.3	17.	17.	....	40,000
1838	" 16	" 17	Decided	"	.4	....	348.	262.	86.	13.	8.6	6.9	1.7	.408	.488	.248	.24	....	....	....	.062	.4	9.1	24.	26.	....	11,300
1874	" 23	" 24	Much	"	.3	....	376.	274.	102.	12.	8.5	7.4	1.1	.408	.328	.208	.12	....	....	....	.092	.51	9.	24.	27.	....	31,000
1904	" 31	" 31	"	"	.3	....	330.	268.	62.	12.	7.9	7.	.9	.344	.336	.192	.144	....	....	....	.04	.7	8.4	27.	32.	....	20,000
1936	June 6	June 7	"	Cons'd	.3	....	346.	268.	78.	12.2	7.5	5.7	1.8	.4	.344	.168	.176	....	....	....	.16	.04	8.4	24.	26.	....	19,000
1971	" 13	" 14	"	Little	.2	....	337.	252.	85.	11.8	7.1	6.5	.6	.288	.296	.168	.128	....	....	....	.24	.6	8.1	25.	23.	....	10,500
2010	" 20	" 21	"	"	.2	....	310.	244.	66.	14.	8.3	6.8	1.5	.344	.344	.208	.136	....	....	....	.13	.42	8.	26.	31.	....	7,400
2044	" 27	" 28	"	Cons'd	.25	....	293.	228.	65.	14.2	7.8	6.2	1.6	.36	.28	.2	.08	....	....	....	.14	.3	6.5	27.	25.	....	10,900

9510 Q. State what table 137 shows and what its sanitary significance is?

A. This table contains analyses of samples of water taken from the Illinois river at Havana, between January 11th and June 27th, 1900. The purification in the river as shown by the amount of nitrates and the number of bacteria is manifest here as well as in the 1899 period.

Q. Will you produce table 138 and read it in evidence?

A. Yes sir, table 138 is as follows:

TABLE 138.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—SANGAMON RIVER, CHANDLERVILLE.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am.												
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Suspend'd	Total.	Dissolved.	Suspended.	Nitrites	Nitrates					
1172	Jan. 3	Jan. 4	Decided	V. Little	.15	....	350.	348.	2.	5.3	4.4	3.9	.5	.142	.184	.136	.048	....	....	....	.016	2.65	3.	0.	3.5	......	900
1215	" 10	" 11	"	Little	.1	....	334.	290.	44.	6.4	2.6	2.4	.2	.168	.112	.088	.024	....	....	....	.008	1.9	3.5	1.	2.	......	4,000
1259	" 17	" 19	"	"	.3	....	306.	290.	16.	5.	2.8	1.8	1.	.192	.14	.088	.052	....	....	....	.008	.45	3.5	4.	7.	......	7,200
1276	" 24	" 25	"	"	.2	....	348.	297.	51.	5.8	4.	2.6	1.4	.228	.192	.128	.064	....	....	....	.014	.75	4.	5.	15.5	......	15,700
1315	" 31	Feb. 2	Slight	"	.12	....	332.	320.	12.	5.5	2.6	2.4	.2	.19	.112	.088	.024	....	....	....	.02	.8	4.	0.	15.	......	900
1355	Feb. 7	" 8	Much	"	.3	....	346.	288.	58.	5.3	4.8	3.6	1.2	.176	.216	.144	.072	....	....	....	.01	1.05	5.	2.	13.	......	29,300
1384	" 14	" 15	"	Much	.2	....	884.	180.	704.	3.	2.5	5.7	19.3	.2	1.28	.16	1.12	....	....	....	.024	1.35	7.	0.	—4.	......	117,000
1438	Mar. 1	Mar. 2	"	Cons'd	.12	....	318.	230.	88.	4.	7.4	5.5	1.9	.144	.272	.128	.144	....	....	....	.018	1.3	6.	0.	1.	......	70,000
1470	" 7	" 8	"	"	.16	....	410.	226.	184.	4.2	8.2	3.5	4.7	.12	.28	.088	.192	....	....	....	.015	2.3	7.	1.	8.	......	45,000
1508	" 14	" 15	"	Much	.4	....	338.	138.	200.	4.	14.3	4.6	9.7	.126	.496	.104	.392	....	....	....	.012	1.15	16.	5.	4.	......	50,000
1544	" 21	" 22	"	"	.22	....	520.	186.	334.	3.8	15.8	5.6	10.2	.162	.96	.64	.32	....	....	....	.016	2.85	12.	5.	4.	......	120,000
1572	" 28	" 29	"	Little	.12	....	345.	251.	94.	3.8	6.	3.	3.	.06	.176	.088	.088	....	....	....	.017	2.6	8.	5.	6.	......	30,000
1613	Apr. 4	Apr. 6	"	"	.12	....	358.	276.	82.	3.8	4.3	2.2	2.1	.062	.128	.056	.072	....	....	....	.016	.95	8.	9.	11.	......	18,500
1652	" 11	" 12	Decided	"	.2	....	330.	282.	48.	5.2	4.4	2.8	1.6	.084	.176	.136	.04	....	....	....	.22	1.68	6.	9.	3.5	......	7,000
1692	" 18	" 19	Much	Cons'd	.4	....	347.	294.	53.	4.6	9.3	8.9	.4	.024	.144	.096	.048	....	....	....	.01	1.45	4.	16.	19.	......	5,600
1731	" 25	" 26	Decided	Little	.12	....	340.	276.	66.	3.8	5.	3.5	1.5	.04	.224	.08	.144	....	....	....	.0	.75	4.	16.	25.	......	3,600
1770	May 2	May 3	"	"	.12	....	336.	265.	71.	4.8	4.2	2.7	1.5	.022	.184	.144	.04	...	....	....	.008	1.15	3.	18.	22	......	1,900
1805	" 10	" 10	Much	Cons'd	.12	....	450.	266.	184.	5.4	6.9	4.3	2.6	......	......	......	......	....	....	....	.0	.6	3.	19.	22.	......	16,500
1839	" 16	" 17	Decided	Little	.2	....	370.	292.	78.	6.4	6.	4.6	1.4	.028	.288	.136	.152	....	....	....	.008	1.05	2.	25.5	31.	......	9,700
1875	" 23	" 24	Much	Cons'd	.3	....	468.	244.	224.	4.	8.5	5.	3.5	.042	.352	.12	.232	....	....	....	.04	1.35	3.	19.	22.	......	8,000
1911	" 30	" 31	"	"	.2	....	503.	285.	218.	5.6	8.5	3.6	4.9	.034	.328	.104	.224	....	....	....	.036	1.35	3	25.5	27.	......	11,300
1945	June 6	June 7	"	"	.25	....	455.	253.	202.	4.6	8.2	3.4	4.9	.02	.344	.12	.244	....	....	....	.032	.55	4.	25.5	30.	......	12,000
1981	" 13	" 14	"	"	.25	....	414.	241.	173.	4.8	9.2	4.4	4.8	.022	.296	.136	.16	....	....	.	.048	.75	5.	25.5	30.	......	8,300
2011	" 21	" 21	"	Little	.2	....	456.	257.	199.	3.8	8.3	4.	4.3	.012	.232	.12	.112	....	....	....	.024	1.5	3.	27.	24.	......	8,800
2051	" 27	" 28	"	"	.2	....	566.	238.	328.	6.	9.1	4.	5.1	.01	.288	.12	.168	....	....	....	.028	.65	3.	28.	30.	......	11,600

9512 Q. What does table 138 show and what is its sanitary significance?

A. Table 138 contains the analyses of samples of water from the Sangamon river at Chandlerville, from January 3rd, and June 27, 1900. The usual spring increase in the number of bacteria is manifest at this point as in the other tributaries of the Illinois and in the Illinois river itself.

Q. Will you produce and read in evidence table 139?

A. Yes sir, table 139 is as follows:

TABLE 139.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, BEARDSTOWN.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Suspd Matter	Free Ammonia.	Albuminoid Am			Total.	Dissolved.	Suspended	Nitrites	Nitrates					
															Tot'l	Dissolv'd	Suspend'd										
1181	Jan. 4	Jan. 5	Slight	V. Little	.23	....	392.	383.	9.	28.	6.8	4.6	2.2	2.8	.408	.32	.088	....	....	....	.046	2.	7.	0.	— 2.	......	10,700
1236	" 11	" 12	"	Little	.22	....	343.	342.	1.	17.	6.4	6.2	.2	1.4	.272	.272	.0	....	....	....	.03	.5	7.	0.	— 1.	......	....
1264	" 18	" 19	Much	Much	.2	....	512.	286.	226.	15.	8.5	5.6	2.9	1.16	.488	.184	.304	....	....	....	.26	.74	8.	0.	1.	......	....
1284	" 25	" 26	"	Cons'd	.3	....	527.	338.	189.	22.	8.8	6.2	2.6	2.2	.52	.256	.264	....	....	....	.044	1.	8.	0.	— 9.	......	25,300
1319	Feb. 1	Feb. 2	"	"	.25	....	354.	326.	28.	19.	7.4	5.8	1.6	2.16	.448	.248	.2	....	....	....	.024	1.15	7.8	0.	—15.5	......	....
1363	" 8	" 9	"	Much	.25	....	1276.	232.	1044.	11.	17.4	6.6	10.8	1.16	.964	.192	.672	....	....	....	.022	.7	9.2	0.	— 1.	......	68,000
1394	" 15	" 16	"	"	.5	....	788.	226.	562.	11.	16.7	6.4	10.3	.96	.736	.2	.536	....	....	....	.018	.06	10.4	0.	—15.5	......	42,400
1428	" 22	" 24	"	"	.4	....	894.	191.	703.	6.5	14.7	6.9	7.8	.7	.96	.216	.744	....	....	....	.012	1.65	11.2	0.	0.	......	58,000
1440	Mar. 1	Mar. 3	"	Cons'd	.5	....	406.	202.	4.	9.	8.2	6.8	1.4	.7	.456	.232	.224	....	....	....	.014	.4	9.8	0.	— 1.	......	37,500
1483	" 8	" 9	"	"	.15	....	394.	204.	190.	9.2	20.	7.	13.	.64	.376	.208	.168	....	....	....	.026	1.05	11.8	0.	— 3.	......	35,000
1513	" 15	" 16	"	Much	.4	....	434.	146.	288.	4.8	12.4	4.4	8.	.44	.592	.144	.448	....	....	....	.016	.5	16.8	0.	— 3.	......	34,000
1557	" 22	" 24	"	"	.2	....	320.	130.	190.	4.8	9.	5.	4.	.456	.4	.176	.224	....	....	....	.011	.55	17.4	0.	7.	......	23,000
1593	" 29	" 30	"	"	.4	....	256.	150.	106.	3.6	8.2	5.6	2.6	.3	.296	.136	.16	....	....	....	.011	.95	15.9	1.	1.	......	70,000
1632	Apr. 5	Apr. 6	"	"	.4	....	388.	162.	226.	4.2	13.6	5.8	8.	.424	.336	.184	.152	....	....	....	.015	.75	14.7	1.	7.	......	20,000
1666	" 12	" 13	"	Cons'd	.4	....	280.	188.	92.	4.2	8.2	7.8	.4	.288	.44	.32	.12	....	....	....	.026	.75	14.7	1.	0.	......	7,700
1710	" 19	" 20	"	"	.4	....	322.	214.	108.	5.8	7.2	6.4	.8	.184	.296	.216	.08	....	....	....	.042	.05	12.8	9.	13.	......	12,300
1749	" 26	" 27	Decided	Much	.4	....	340.	237.	103.	8.	8.3	7.6	.7	.104	.4	.184	.216	....	....	....	.052	.16	12.15	10.	17.	......	7,400
1779	May 3	May 5	Much	Cons'd	.3	....	358.	262.	96.	9.	8.8	8.7	.1	.12	.448	.248	.2	....	....	....	.03	.65	11.	19.	8.	......	....
1813	" 10	" 11	"	Little	.3	....	390.	250.	140.	8.8	18.5	6.6	11.9	......	......	......	......	....	....	....	.03	.4	10.3	18.	8.	......	17,200
1848	" 16	" 18	Little	Much	.35	....	414.	251.	163.	11.4	18.8	7.	11.8	.216	.36	.24	.12	....	....	....	.01	.4	9.5	27.	20.	......	3,200
1887	" 23	" 25	"	Cons'd	.4	....	428.	278.	150.	10.8	8.7	6.9	1.8	.08	.312	.224	.088	....	....	....	.072	.9	9.5	25.5	20.	......	14,000
1919	" 30	June 1	Decided	"	.3	....	403.	268.	135.	11.8	8.2	5.9	2.3	.244	.328	.208	.12	....	....	....	.07	.45	9.1	28.	21.	......	7,000
1953	June 7	" 9	Much	"	.3	....	391.	375.	16.	11.	7.4	5.8	1.6	104	.272	.176	.096	....	....	....	.086	.45	9.	27.	22.	......	17,000
1990	" 14	" 15	"	Little	.2	....	384.	236.	148.	10.4	8.8	5.5	3.3	.16	.416	.192	.224	....	....	....	.102	.5	8.8	24.5	18.	......	5,400
2024	" 21	" 22	"	"	.3	....	477.	372.	105.	9.2	7.9	6.	1.9	.142	.344	.256	.088	....	....	....	.17	.78	8.3	24.5	20	......	3,000
2059	" 28	" 30	"	"	.25	....	506.	225.	281.	12.2	8.6	6.3	2.3	.138	.256	.192	.064	....	....	....	1.5	.35	7.9	24.5	27.	......	13,700

9514 Q. State what table 139 shows and what is its sanitary significance?

A. Table 139 contains analyses of samples of water from the Illinois river at Beardstown from January 4th to June 28th, 1900. Taking into consideration the greater dilution of the water at this point, the analytical data are not materially different from those covering the 1899 period.

Q. Will you produce and read in evidence table 140?

A. Yes sir, table 140 is as follows:

TABLE 140.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, KAMPSVILLE.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved	By Suspd Matter.	Free Ammonia.	Albuminoid Am Tot'l	Albuminoid Am Dissolv'd	Albuminoid Am Suspnd'd	Total.	Dissolved.	Suspended.	Nitrites	Nitrates					
1171	Jan. 3	Jan. 4	Decided	V. Little	.2	....	379.	372.	7.	30.	6.9	6.9	.0	2.336	.4	.296	.104	....	....	....	.034	1.7	15.7	2.	— 2.	......	2,200
1216	" 10	" 11	Slight	"	.3	....	356.	328.	18.	22.	6.6	5.6	1.	1.6	.344	.256	.088	....	....	....	.032	1.5	15.8	......	......	......	18,600
1260	" 17	" 19	Decided	Little	.4	....	344.	238.	106.	14.	6.	5.2	.8	.72	.376	.218	.161	....	....	....	.034	1.15	15.0	8.	6.	......	10,000
1285	" 25	" 26	Much	Much	.35	....	400.	220.	180.	9.	10.2	6.	4.2	.94	.416	.192	.224	....	....	....	.026	1.1	16.6	4.	12.	......	200,000
1316	" 31	Feb. 2	"	Little	Muddy	....	366	312.	54.	18.	7.2	6.	1.2	1.64	.384	.224	.16	....	....	....	.026	1.7	16.2	0.	—13.	......	26,700
1354	Feb. 7	" 8	"	Cons'd	.25	....	455.	280.	175.	15.5	7.2	5.4	1.8	1.54	.432	.216	.216	....	....	....	.018	.25	16.4	......	......	......	17,200
1385	" 14	" 15	"	Much	.35	....	1242.	218.	1024.	8.4	23.5	7.8	15.7	.608	1.2	.288	.912	....	....	....	.024	.55	17.5	1.	— 4.	......	76,000
1407	" 21	" 22	"	"	.2	....	790.	215.	575.	13.	16.4	6.	10.4	.586	.744	.168	.576	....	....	....	.01	.6	18.5	1.	4.	......	31,000
1512	Mar. 14	Mar. 16	"	"	.25	....	1002.	162.	840.	4.2	15.8	4.4	11.4	.344	.64	.12	.52	....	....	....	.012	.6	21.9	3.	2.	......	35,000
1538	" 21	" 22	"	"	.22	....	564.	154.	410.	5.4	11.6	5.	6.6	.216	.448	.148	.3	....	....	....	.012	1.35	24.46	1.5	— 2.	......	32,500
1573	" 28	" 29	"	Cons'd	.3	......	332.	146.	186.	4.8	8.	5.6	2.4	.344	.336	.176	.16	....	....	....	.01	.55	23.9	6.	12.	......	70,000
1614	Apr. 4	Apr. 6	"	"	.5	....	332.	143.	189.	3.6	7.9	5.4	2.5	.256	.224	.144	.08	....	....	....	.017	.5	22.2	8.	6	......	28,000
1653	" 11	" 12	"	"	.35	....	337.	178.	159.	5.	8.7	5.6	3.1	.312	.288	.192	.096	....	....	..	.26	.8	21.8	9.	2.	......	4,800
1840	May 16	May 17	"	"	.3	....	442.	258.	184.	9.8	8.6	6.2	2.4	.168	.52	.184	.336	....	....	....	.03	.55	17.2	20.	22.	......	2,400
1876	" 23	" 24	"	Much	.3	....	520.	250.	270.	10.	9.2	7.2	2.	.16	.44	.192	.248	....	....	....	.04	.4	17.2	19.5	19.	......	5,000
1982	June 13	June 14	"	Cons'd	.3	....	420.	259.	161.	8.4	8.6	5.3	3.3	.012	.288	.168	.12	....	....	....	.072	.6	16.75	26.	30.	......	5,500
2017	" 22	" 22	"	"	.35	....	336.	222.	114.	9.8	7.6	6.1	1.5	.026	.264	.16	.104	....	....	....	.06	1.14	16.65	25.	30.	......	5,800
2052	" 27	" 29	"	"	.2	....	392.	245.	137.	13.	7.6	6.4	1.2	.062	.264	.168	.096	....	....	....	.075	.65	16.45	29.	35.	......	....
....	....	....	....	....	....	....	......	......	......	......	....	....	....	......	......	......	......	....	....	....	....	......	......	......	......	......	....

9516 Q. State what table 140 shows and its sanitary significance?

A. Table 140 contains analyses of samples of water taken from the Illinois river at Kampsville from January 3rd to June 27th, 1900. The usual spring rise in the number of bacteria, the amount of free ammonia and albuminoid ammonia and so on, is manifest here as elsewhere, but during the latter part of the period the condition of the water both chemically and bacterially compares very favorably with that in the 1899 period.

Q. How do the chemical and bacterial constituents of the water at Kampsville, as manifest by this table compare with the conditions for this period at Averyville?

A. The number of bacteria averages less at Kampsville than at Averyville. The amount of free ammonia is on the whole lower. The albuminoid ammonia is very similar; thus, on June 19th at Averyville, the albuminoid ammonia was .264.

And on June 22nd, at Kampsville, the albuminoid ammonia was .264.

And on June 26th at Averyville the albuminoid ammonia was .264.

And on June 27th at Kampsville, the albuminoid ammonia was .264.

The nitrates are on the whole lower at Kampsville than at Averyville during this period.

The nitrites are also lower, and the oxygen consumed
9517 on the whole does not differ materially.

ADJOURNED until 10:00 A. M. following day, Tuesday, December, 1st, 1903.

9518 10:00 a. m., Tuesday, December 1st, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN,

resumed the stand for further direct-examination, by Mr. Todd, and testified as follows:

Q. Professor, will you produce and read table 141 in evidence?

A. Yes, it is as follows:

TABLE 141.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ILLINOIS RIVER, GRAFTON.

Report of EDWIN O. JORDAN, University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am												
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Susp'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
1187	Jan. 4	Jan. 5	Much	Little	.12	....	392.	368.	24.	28.5	6.7	5.9	.8	1.52	.384	.264	.12	....	....	....	.018	.2	2.9	0.	6.	......	2,600
1217	" 10	" 11	Slight	V. Little	.3	....	376.	370.	6.	25.	6.3	5.6	.7	2.16	.32	.256	.064	....	....	....	.024	8.5	4.2	0.	3.	......	3,300
1261	" 17	" 19	Much	Little	.2	....	350.	336.	14.	14.	6.	5.8	.2	.52	.288	.2048	.0832	....	....	....	.028	1.2	3.5	3.	13.	......	29,600
1286	" 24	" 26	"	Cons'd	.4	....	509.	220.	289.	7.6	10.7	5.8	4.9	.712	.52	.208	.312	....	....	....	.019	.9	5.1	4.	16.5	......	58,500
1317	" 31	Feb. 2	"	"	.3	....	478.	330.	148.	18.	8.2	5.6	2.6	1.64	.504	.192	.312	....	....	....	.03	1.4	2.8	0.	—9.	......	22,300
1356	Feb. 7	" 9	"	Little	.22	....	330.	296.	34.	16.	6.7	5.7	1.	1.52	.368	.256	.112	....	....	....	.014	.85	3.8	0.	13.	......	18,700
1386	" 14	" 15	"	Much	.35	....	1420.	192.	1228.	5.	23.	7.2	15.8	.46	1.408	.24	1.168	....	....	....	.024	.25	6.6	0.	2.	......	84,000
1408	" 21	" 22	"	"	.4	....	860.	233.	627.	8.	16.3	6.2	10.1	.56	.68	.192	.488	....	....	....	.016	.55	8.3	0.	5.5	......	16,000
1484	Mar. 7	Mar. 9	"	"	.14	....	1029.	148.	881.	6.4	15.6	5.6	10.	.394	.64	.216	.424	....	....	....	.012	.25	9.3	0.	2.	......	60,000
1509	" 14	" 16	"	"	.4	....	756.	200.	556.	4.2	14.4	3.4	11.	.3	.568	.176	.392	....	....	....	.012	.12	16.3	4.	4.	......	32,500
1536	" 21	" 22	"	"	.4	....	846.	156.	690.	5.6	15.8	4.6	11.2	.24	.672	.168	.504	....	....	....	.01	.9	14.8	0.	4.	......	59,000
1579	" 28	" 29	"	"	.2	....	572.	160.	412.	4.2	14.	5.2	8.8	.296	.424	.136	.288	....	....	....	.017	.9	12.7	3.	17.	......	56,000
1615	Apr. 4	Apr. 6	"	Cons'd	.3	....	426.	170.	256.	3.6	8.	4.8	3.2	.184	.28	.144	.136	....	....	....	.017	.3	11.8	4.	14.5	......	18,000
1654	" 11	" 12	"	"	.33	....	382.	174.	208.	4.8	8.6	5.5	3.1	.216	.288	.192	.096	....	....	....	.3	.8	13.1	9.	2.	......	4,000
1693	" 18	" 19	"	"	.12	....	365.	204.	161.	4.4	8.	6.3	1.7	.112	.304	.184	.12	....	....	....	.028	1.1	10.9	11.	13.	......	3,000
1732	" 25	" 26	Decided	"	.2	....	310.	218.	92.	4.8	7.4	5.5	1.9	.032	.256	.136	.12	....	....	....	.036	.7	12.7	15.	21.	......	3,300
1771	May 2	May 3	Much	Little	.3	....	314.	238.	76.	6.8	8.3	6.3	2.	.06	.34	.136	.204	....	....	....	.008	.55	18.7	20.	24.	......	600
1806	" 9	" 10	"	Cons'd	.3	....	398.	224.	174.	8.	7.6	6.	1.6	......	......	......	......	....	....	....	.016	.9	12.2	18.	21.	......	2,300
1841	" 16	" 17	"	"	.3	....	356.	258.	98.	10.	8.8	5.9	2.9	.012	.368	.24	.128	....	....	....	.028	.55	8.5	25.	30.	......	3,600
1877	" 23	" 24	"	"	.3	....	372.	258.	114.	9.6	8.	6.3	1.7	.096	.312	.208	.104	....	....	....	.032	.55	8.4	20.	27.	......	4,000
1912	" 30	" 31	"	"	.3	....	370.	278.	92.	11.4	7.1	5.9	1.2	.02	.24	.168	.072	....	....	....	.02	1.05	6.5	25.	27.	......	11,400
1946	June 6	June 8	"	Little	.25	....	360.	258.	102.	9.2	7.4	5.6	1.8	.02	.248	.176	.072	....	....	....	.008	.55	6.	26.	32.	......	5,300
1983	" 13	" 14	"	Cons'd	.3	....	332.	247.	85.	10.8	7.2	5.3	1.9	.08	.248	.176	.072	....	....	....	.002	.45	5.2	27.	31.	......	2,300
2018	" 22	" 22	"	Little	.35	....	274.	234.	40.	9.6	6.6	6.	.6	.012	.232	.16	.072	....	....	....	.017	1.3	5.2	27.	28.	......	11,500
2053	" 29	" 29	"	Cons'd	.2	....	410.	226.	104.	10.4	8.1	6.3	1.8	.04	.272	.216	.056	....	....	....	.04	.6	5.7	27.	29.	......	13,700

9520 Q. State what table 141 shows and its sanitary significance?

A. Table 141 contains analyses of samples of water from the Illinois river at Grafton, taken between January 4th, and June 29th, 1900.

A very considerable degree of purification is shown chemically, and in the latter part of the period bacterially also, as compared with the collecting stations in the upper stretches of the river. The increased volume of water in the Illinois river, especially in the months of March and April, is reflected in the lower chlorine content during this period.

Q. Will you produce and read in evidence table 142?

A. Yes, it is as follows:

TABLE 142.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, GRAFTON.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am.												
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Tot'l.	Dissolv'd.	Suspnd'd.	Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.					
1188	Jan. 4	Jan. 5	Much	Little	.25	....	......	......	......	3.1	8.6	8.2	.4	.104	.352	.208	.144	....	....	....	.0	.0	2.9	0.	6.	......	300
1218	" 10	" 11	"	"	.35	....	231.	198.	33.	2.3	9.	7.7	1.3	.032	.416	.176	.24	....	....	....	.0	.1	4.2	.0.	8.	......	2,400
1262	" 17	" 19	"	"	.35	....	197.	192.	5.	3.8	8.6	7.4	1.2	.078	.416	.176	.24	....	....	....	....	......	3.5	3.	13.	......	8,900
1287	" 24	" 26	"	Much	.35	....	286.	176.	110.	4.	10.7	6.8	3.9	.18	.384	.128	.256	....	....	....	.002	.2	5.1	4.	17.	......	15,200
1318	" 31	Feb. 2	"	Little	.6	....	248.	220.	28.	4.	9.	7.8	1.2	.154	.32	.192	.128	....	....	....	.008	.6	2.8	0.	—9.	......	18,900
1357	Feb. 7	" 8	"	"	.42	....	262.	198.	64.	7.8	18.3	6.5	11.8	.08	.328	.144	.184	....	....	....	.006	.25	3.8	0.	13.	......	7,400
1387	" 14	" 15	"	Much	.35	....	540.	216.	324.	3.8	14.3	8.7	5.6	.08	.624	.252	.302	....	....	....	.014	.0	6.6	2.	2.	......	38,000
1409	" 21	" 22	"	"	.45	....	329.	180.	149.	3.3	15.4	8.6	6.8	.234	.56	.296	.264	....	....	....	.008	.55	8.3	0.	5.5	......	33,000
1485	Mar. 7	Mar. 9	"	"	.2	....	799.	112.	687.	3.	14.6	6.6	8.	.28	.616	.156	.48	....	....	....	.002	.05	9.3	0.	2.	......	60,000
1510	" 14	" 16	"	"	Muddy	....	1508.	158.	1350.	2.4	25.9	8.9	17.	.236	1.28	.216	1.064	....	....	....	.006	.45	16.3	4.	4.	......	80,000
1537	" 21	" 22	"	"	Muddy	....	540.	124.	416.	4.8	17.1	8.	9.1	.334	.904	.224	.68	....	....	....	.006	.1	14.	3.	4.	......	170,000
1580	" 28	" 29	"	"	.22	....	350.	124.	226.	3.2	12.4	7.2	5.2	.31	.488	.216	.272	....	....	....	.01	.75	12.7	4.	17.	......	60,000
1616	Apr. 4	Apr. 6	"	"	.35	....	370.	158.	212.	2.6	11.4	6.8	4.6	.346	.416	.168	.248	....	....	....	.011	.15	11.8	5.	14.5	......	140,000
1655	" 11	" 12	"	"	.5	....	738.	122.	616.	2.8	23.6	7.4	16.2	.14	1.12	.264	.856	....	....	....	.018	.6	13.1	8.	2.	......	28,000
1694	" 18	" 19	"	Cons'd	.3	....	274.	144.	130.	2.6	8.	6.1	1.9	.088	.304	.12	.184	....	....	....	.018	.4	10.9	11.	13.	......	5,000
1733	" 25	" 26	"	Much	.3	....	810.	122.	688.	1.6	19.7	6.6	13.1	.008	.96	.128	.832	....	....	....	.018	.65	12.7	15.	21.	......	40,200
1772	May 2	May 3	"	Little	.45	....	322.	139.	183.	2.2	11.9	7.2	4.7	.032	.32	.136	.184	....	....	....	.002	.2	10.7	19.	24.	......	4,500
1807	" 9	" 10	"	Cons'd	.8	....	338.	120.	218.	3.	16.1	13.3	2.8	......	......	......	......	....	....	....	.0	.0	12.2	19.	21.	......	3,800
1842	" 16	" 17	"	"	.5	....	358.	111.	247.	4.6	13.8	8.	5.6	.06	.52	.176	.344	....	....	....	.008	.1	8.5	23.	30.	......	2,100
1878	" 23	" 24	"	Much	.5	....	548.	129.	419.	2.2	8.8	6.7	2.1	.064	.52	.16	.36	....	....	....	.014	.25	8.4	19.	27.	......	13,500
1913	" 30	" 31	"	Cons'd	.35	....	280.	172.	108.	4.4	8.2	6.	2.2	.052	.28	.16	.12	....	....	....	.016	.25	6.5	24.	27.	......	8,700
1947	June 6	June 8	"	"	.4	....	300.	160.	140.	2.8	9.4	9.2	.2	.018	.336	.136	.2	....	....	....	.007	.95	6.	25.	33.	......	6,600
1964	" 13	" 14	"	Little	.4	....	232.	153.	79.	3.6	8.	6.5	1.5	.002	.248	.16	.088	....	....	....	.0	.0	5.2	26.	31.	......	12,000
2019	" 22	" 22	"	Cons'd	.8	....	240.	152.	88.	3.2	9.	7.4	1.6	.024	.256	.136	.12	....	....	....	.0	.35	5.2	26.	28.	......	2,400
2064	" 29	" 29	"	Much	.25	....	560.	147.	413.	3.4	14.6	6.3	8.3	.032	.56	.128	.432	....	....	....	.003	.3	5.7	27.	29.	......	4,000

9522 Q. State what table 142 shows and its sanitary significance?

A. Table 142 contains analyses of samples of water taken from the Mississippi river at Grafton, Illinois, the samples being collected between January 4th and June 29th, 1900.

The amount of albuminoid ammonia in the water of the Mississippi during this period is on the whole somewhat higher than the amount in the Illinois river in samples taken on similar dates.

Q. Will you produce and read in evidence tables 143, 144, 145, 146 and 147, showing the cross-section of the Mississippi river at Alton?

A. Yes, they are as follows:

TABLE 143.

STREAMS EXAMINATION — CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 100 FEET FROM ILLINOIS SHORE, ALTON.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am												
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Suspd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Suspnd'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
1182	Jan. 4	Jan. 5	Much	Little	.22	....	332.	310.	22.	15.9	7.8	7.8	.0	.976	.312	.232	.08	....	....	....	.02	.15	0.	0.	4.	......	1,500
1210	" 10	" 11	"	Much	.3	....	286.	260.	26.	12.	8.	7.2	.8	.728	.4	.256	.144	....	....	....	.01	.55	2.4	0.	0.	......	3,800
1277	" 24	" 25	"	"	Muddy	....	440.	210.	230.	7.	10.8	5.8	5.	.48	.528	.208	.32	....	....	....	.013	.7	3.9	0.	—.	......	33,500
1321	Feb 2	Feb. 3	"	Little	.3	....	328.	258.	70.	13.	8.3	8.	.3	.92	.272	.2	.072	....	....	....	.017	.05	0.	0.	0.	......	21,800
1348	" 7	" 8	"	"	Muddy	....	334.	242.	92.	12.	8.2	6.4	1.8	.816	.288	.184	.104	....	....	....	.009	.4	2.6	......	—.	......	17,000
1389	" 14	" 15	"	Much	.4	....	1494.	160.	1334.	4.6	24.	7.4	16.6	.28	1.456	.208	1.248	....	....	....	.008	.25	5.	......	0.	......	....
1419	" 22	" 23	"	"	.2	....	943.	190.	753.	6.1	17.3	6.6	10.7	.44	.824	.184	.64	....	....	....	.012	.7	5.	......	0.	......	85,000
1441	Mar. 2	Mar. 3	"	Cons'd	.22	....	359.	174.	185.	5.8	8.4	6.6	1.8	.384	.392	168	.224	....	....	....	.008	.3	3.	......	0.	......	59,000
1465	" 9	" 10	"	Much	.18	....	1185.	177.	1008.	5.	18.2	5.4	12.8	.368	.656	.098	.56	....	....	....	.014	1.4	10.	0.	9.	......	100,000
1503	" 14	" 15	"	"	.12	....	1350.	132.	1218.	5.	16.	5.	11.	.28	.96	.104	.856	....	....	....	.01	1.4	17.	4.	6.	......	175,000
1539	" 21	" 22	"	"	12	....	976.	139.	837.	4.4	12.7	5.	7.7	.256	.74	.16	.58	....	....	....	.008	.8	14.1	......	......	......	55,000
1574	" 28	" 29	"	"	Muddy	....	534.	160.	374.	4.6	14.2	5.6	8.6	.224	.456	.128	.328	....	....	....	.01	.7	11.5	6.	......	......	50,000
1617	Apr. 4	Apr. 6	"	"	.3	....	470.	170.	300.	3.4	8.	4.8	3.2	.192	.32	.128	.192	....	....	....	.016	.7	10.1	9.	10.	......	17,000
1667	" 12	" 13	"	"	.4	....	388.	171.	217.	4.2	8.5	5.2	3.3	.128	.44	.192	.248	....	....	....	.026	1.15	11.4	8.	5.	......	15,000
1695	" 18	" 19	"	"	.3	....	380.	196.	184.	4.6	8.8	5.6	3.2	.104	.272	.136	.136	....	....	....	.028	1.3	10.5	10.	10.	......	7,000
1734	" 25	" 26	Decided	Cons'd	.22	....	405.	192.	213.	4.8	8.9	5.8	3.1	.044	.352	.128	.224	....	....	....	.026	.11	11.9	15.	25.	......	18,000
1773	May 2	May 4	Much	"	.3	....	541.	231.	310.	6.8	10.8	5.8	5.	.036	.464	.136	.328	....	....	....	.022	1.	10.1	20.	23.	......	7,300
1799	" 9	" 10	"	"	.4	....	629.	196.	433.	7.2	12.3	6.5	5.8	......	......	......	......	....	....	....	.018	.8	11.4	19.	16.	......	10,700
1833	" 16	" 17	"	"	.3	....	430.	252.	178.	8.	8.9	6.8	2.1	.004	.424	.192	.232	....	....	....	.024	.55	8.8	24.	29.	......	4,400
1868	" 23	" 24	"	Much	.25	....	502.	237.	265.	8.8	9.5	7.2	2.3	.04	.392	.192	.2	....	....	....	.024	.85	8.4	19.	21.	......	5,000
1905	" 30	" 31	"	Cons'd	.3	....	384.	224.	160.	7.2	8.4	6.4	2.	.006	.28	.176	.104	....	....	....	.02	.6	7.2	24.	25.	......	11,600
1940	June 6	June 7	"	"	.3	....	420.	224.	196.	7.2	8.7	5.9	2.8	.034	.32	.2	.12	....	....	....	.006	1.15	6.1	24.	26.	......	6,500
1976	" 13	" 14	"	Much	.3	....	730.	214.	516.	8.6	8.	6.	2,	.028	.568	.16	.408	....	....	....	.018	.5	5.2	24.	26.	......	13,500
2012	" 20	" 21	"	Little	.2	....	342.	220.	122.	8.	8.4	5.4	3.	.02	.264	.192	.072	....	....	....	.01	.85	5.3	23.	25.	......	3,600
2015	" 27	" 28	"	Much	.25	....	499.	172.	327.	6.6	10.8	5.8	5.	.034	.376	.16	.216	....	....	....	.034	.45	7.2	26.	29.	......	7,000

TABLE 144.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

Report of EDWIN O. JORDAN,
University of Chicago.

SOURCE OF WATER—MISSISSIPPI RIVER, ONE-FOURTH DISTANCE FROM ILLINOIS SHORE, ALTON.

Serial No.	DATE OF		APPEARANCE.			Odor	RESIDUE ON EVAPORATION.			Chlorine.	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coll.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Suspd Matter	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspnd'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
1183	Jan. 4	Jan. 5	Much	Little	.25	....	268.	250.	18.	10.8	7.7	7.5	.2	.434	.336	.176	.16	....	....	....	.012	.1	0.	0.	4.	......	1,200
1211	" 10	" 11	"	Much	3	....	278.	242.	36.	11.4	8.	7.	1.	.672	.48	.288	.192	....	....	....	.008	.55	2.4	0.	0.	......	3,200
1278	" 24	" 25	"	"	Muddy	....	436.	198.	238.	6.2	10.6	5.6	5.	.424	.504	.184	.32	....	....	....	.012	.6	3.9	0.	10.	......	93,500
1322	Feb. 2	Feb. 3	"	Little	.3	....	328.	251.	77.	12.2	7.7	6.4	1.3	.888	.352	.2	.152	....	....	....	.018	.65	0.	0.	0.	......	32,800
1349	" 7	" 8	"	"	.4	....	320.	255.	65.	12.	8.2	6.4	1.8	.808	.304	.216	.088	....	....	....	.008	.85	2.6	11.	10.	......	41,000
1390	" 14	" 15	"	Much	.4	....	1082.	154.	928.	4.4	23.8	7.1	16.7	.192	1.12	.176	.944	....	....	....	.007	.1	5.	0.	0.	......	143,000
1420	" 21	" 23	"	"	.5	....	759.	168.	591.	4.4	17.2	7.5	9.7	.36	.664	.224	.44	....	....	....	.012	.85	5.08	0.	0.	......	135,000
1432	Mar. 2	Mar. 5	"	Cons'd	.3	....	237.	152.	85.	4.4	8.7	6.6	2.1	.336	.368	.192	.176	....	....	....	.002	.3	3.04	0.	0.	......	54,000
1466	" 9	" 10	"	Much	.18	....	1180.	164.	1016.	4.8	17.5	5.9	11.6	.352	.656	.152	.504	....	....	....	.01	1.3	10.	0.	9.	......	90,000
1504	" 14	" 15	"	"	.12	....	1400.	128.	1272.	4.6	16.2	5.9	10.3	.272	1.008	.12	.888	....	....	...	.008	.45	17.	4.	6.	......	110,000
1540	" 21	" 22	"	"	.12	....	750.	112.	638.	3.8	16.9	6.2	10.7	.288	1.02	.208	.812	....	....	....	.006	.8	14.1	......	......	......	150,000
1575	" 28	" 29	"	"	.15	....	478.	134.	344.	4.	14.5	5.4	9.1	.304	.456	.128	.328	....	....	....	.01	1.1	11.5	6.	......	......	110,000
1618	Apr. 4	Apr. 6	"	"	.3	....	430.	160.	270.	3.4	8.7	5.2	3.5	.192	.28	.16	.12	....	....	....	.016	.85	10.1	9.	10.	......	35,000
1668	" 12	" 13	"	"	.4	....	477.	138.	339.	2.8	14.9	6.3	8.6	.112	.64	.208	.432	....	....	....	.02	1.15	11.4	8.	5.	......	67,000
1696	" 18	" 19	"	"	.22	....	322.	178.	144.	3.6	8.4	5.4	3.	.08	.272	.136	.136	....	....	....	.03	1.2	10.5	10.	10.	......	15,000
1735	" 25	" 26	"	"	.3	....	698.	150.	548.	2.	18.6	6.2	12.6	.06	.84	.176	.664	....	....	....	.022	.65	11.9	15.	25.	......	38,000
1774	May 2	May 4	"	Cons'd	.3	....	370.	142.	228.	3.	11.	6.9	4.1	.028	.44	.12	.32	....	....	....	.008	.75	10.1	20.	23.	......	13,500
1800	" 9	" 10	"	"	.5	....	468.	130.	338.	4.6	16.	9.	7.	......	......	......	.....	....	....	....	.014	.55	11.4	19.	16.	......	4,000
1834	" 16	" 17	"	"	.45	....	370.	196.	174.	5.8	9.4	6.1	1.3	.034	.44	.176	.264	....	....	....	.024	.3	8.8	24.	29.	......	4,600
1869	" 23	" 24	"	Much	.35	....	492.	170.	322.	4.8	14.9	7.5	7.4	.044	.408	.184	.224	....	....	....	.016	.45	8.4	19.	21.	......	5,700
1906	" 30	" 31	"	"	.3	....	372.	200.	172.	6.	8.3	6.2	2.1	.006	.296	.16	.136	....	....	....	.01	.8	7.2	24.	25.	......	8,000
1941	June 6	June 7	"	Cons'd	.3	....	401.	194.	207.	5.4	9.1	6.4	2.7	.022	.344	.136	.208	....	....	....	.004	.55	6.1	24.	26.	......	7,200
1977	" 13	" 14	"	Much	.35	....	604.	207.	397.	8.2	8.6	6.6	2.	.012	.352	.16	.192	....	....	....	.014	.5	5.2	24.	26.	......	10,000
2013	" 20	" 21	"	Little	.2	....	334.	207.	127.	6.	8.8	5.6	3.2	.052	.280	.136	.144	....	....	....	.0	.4	5.3	23.	25.	......	3,800
2046	" 27	" 28	"	Much	.35	....	519.	166.	353.	6.	9.6	5.7	3.9	.044	.376	.144	.232	....	....	....	.026	.45	7.2	26.	29.	......	4,000

TABLE 145.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, MIDSTREAM, ALTON.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended	Nitrites	Nitrates					
															Tot'l	Dis-solv'd	Sus-pnd'd										
1184	Jan. 4	Jan. 5	Much	Little	.21	....	268.	266.	2.	13.7	7.8	6.9	.9	·53	.296	.2	.094	....	....	....	.016	.025	......	0.	4.	......	2,100
1212	" 10	" 11	"	Much	.3	....	263.	234.	29.	8.8	8.4	7.6	.8	.44	.352	.24	.112	....	....	....	.006	.05	2.4	0.	0.	......	8,300
1279	" 24	" 25	"	"	.3	....	404.	199.	205.	5.6	9.	6.2	2.8	.168	.384	.176	.208	....	....	....	.008	.55	3.9	0.	10.	......	67,000
1323	Feb. 2	Feb. 3	"	Little	.4	....	318.	232.	86.	11.	8.	6.5	1.5	.738	.328	.208	.12	....	....	....	.018	.85	0.	0.	0.	......	18,300
1350	" 7	" 8	"	"	.4	....	296.	238.	58.	13.	10.2	6.8	3.4	.72	.272	.192	.08	....	....	....	.009	.3	2.6	11.	10.	......	11,000
1391	" 14	" 15	"	Much	.4	....	1356.	156.	1200.	4.4	23.7	6.8	16.9	.227	1.312	.168	1.144	....	....	....	.007	1.15	5.	0.	0.	......	111,000
1421	" 21	" 23	"	"	.5	....	514.	166.	348.	3.	16.5	8.3	8.2	.304	.568	.28	.288	....	....	....	.012	.5	5.	0.	0.	......	61,000
1443	Mar. 2	Mar. 3	"	Cons'd	.35	....	263.	170.	93.	4.4	8.7	7.6	1.1	.216	.296	.192	.104	....	....	....	.0	.3	3.4	0.	0.	......	19,000
1467	" 9	" 10	"	Much	.18	....	1146.	141.	1005.	3.6	17.2	5.7	11.5	.272	.656	.112	.544	....	....	....	.01	1.	10.	0.	9.	......	67,000
1505	" 14	" 15	"	"	.25	....	1460.	112.	1348.	4.2	19.3	5.8	13.5	.272	1.08	.176	.904	....	....	....	.008	.6	17.	4.	6.	......	240,000
1541	" 21	" 22	"	"	.2	....	550.	102.	448.	3.6	17.4	7.2	10.2	.376	1.2	.216	.984	....	....	....	.005	.6	14.1	......	......	......	250,000
1576	" 28	" 29	"	"	.3	....	366.	116.	250.	3.2	15.8	7.2	8.6	.304	.52	.216	.304	....	....	....	.01	.55	11.5	6.	......	......	175,000
1619	Apr. 4	Apr. 6	"	"	.3	....	350.	150.	200.	2.6	8.6	6.	2.6	.248	.4	.152	.248	....	....	....	.01	.05	10.1	9.	10.	......	103,000
1669	" 12	" 13	"	"	.5	....	586.	106.	480.	1.6	17.5	7.8	9.7	.13	.856	.432	.424	....	....	....	.026	.6	11.4	8.	5.	......	28,000
1697	" 18	" 19	"	"	.3	....	282.	140.	142.	2.6	8.4	6.	2.4	.064	.272	.136	.136	....	....	....	.026	.55	10.5	10.	10.	......	27,000
1736	" 25	" 26	"	"	.3	....	880.	136.	744.	1.8	19.4	6.5	12.9	.084	.92	.176	.744	....	....	....	.018	.5	11.9	15.	25.	......	61,000
1775	May 2	May 4	"	Cons'd	.4	....	316.	132.	184.	3.	11.6	7.	4.6	.032	.36	.128	.232	....	....	....	.008	.5	10.1	20.	23.	......	10,500
1801	" 9	" 10	Decided	"	.7	....	356.	120.	236.	2.4	17.7	12.6	5.1	......	......	......	......	....	....	....	.0	.3	11.4	19.	16.	......	3,900
1835	" 16	" 17	Much	"	.6	....	365.	142.	223.	2.6	14.4	8.3	6.1	.032	.464	.192	.272	....	....	....	.016	.0	8.8	24.	29.	......	6,200
1870	" 23	" 24	"	Much	.4	....	566.	132.	434.	2.4	16.2	7.9	8.3	.038	.488	.16	.328	....	....	....	.016	.4	8.4	19.	21.	......	5,200
1907	" 30	" 31	"	"	.3	....	297.	164.	133.	5.2	8.8	6.	2.8	.006	.28	.152	.128	....	....	....	.008	.55	7.2	24.	25.	......	2,400
1942	June 6	June 7	"	Cons'd	.3	....	360.	172.	188.	4.	15.8	6.4	9.4	.05	.344	.136	.208	....	....	....	.006	.5	6.1	24.	20.	......	7,100
1978	" 13	" 14	"	Much	.4	....	320.	186.	134.	6.6	7.4	6.2	1.2	.016	.288	.16	.128	....	....	....	.002	.55	5.2	24.	26.	......	3,300
2014	" 20	" 21	"	Little	.2	....	286.	178.	108.	4.6	8.5	6.	2.5	.046	272	.16	.112	....	....	....	.007	.3	5.3	23.	25.	......	4,000
2047	" 27	" 28	"	Much	.25	....	530.	164.	366.	4.6	14.6	6.8	7.8	.028	.456	.136	.32	....	....	....	.019	.45	7.2	26.	28.	......	13,900

TABLE 146.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, ONE-FOURTH DISTANCE FROM MISSOURI SHORE, ALTON.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended	Nitrites	Nitrates					
															Tot'l	Dis-solv'd	Sus-pnd'd										
1185	Jan. 4	Jan. 5	Much	Little	.2	......	303.	290.	12.	15.9	7.6	6.9	.7	.914	.36	.192	.168	....	....	....	.02	.0	......	0.	4.	......	3,500
1213	" 10	" 11	"	Much	.35	......	244.	198.	46.	6.2	8.8	8.	.8	.208	.325	.192	.133	....	....	....	.004	.025	2.4	0.	0.	......	4,500
1280	" 24	" 25	"	"	.3	......	350.	192.	158.	4.	8.6	6.2	2.4	.104	.424	.176	.248	....	....	....	.002	.55	3.9	0.	10.	......	30,200
1324	Feb. 2	Feb. 3	"	Little	.4	......	307.	238.	69.	11.4	8.	6.6	1.4	.656	.352	.184	.162	....	....	....	.016	.5	0.	0.	0.	......	37,500
1351	" 7	" 8	"	"	.4	......	270.	213.	57.	8.	8.2	7.2	1.	.376	.32	.232	.088	....	....	....	.006	.2	2.6	11.	10.	......	9,000
1392	" 14	" 15	"	Much	.4	......	754.	168.	586.	3.8	18.	7.4	10.6	.12	1.016	.192	.824	....	....	....	.007	.2	5.	0.	0.	......	112,000
1422	" 22	" 23	"	"	.5	......	420.	154.	266.	3.6	16.6	8.4	8.2	.28	.624	.224	.4	....	....	....	.01	.25	5.08	0.	0.	......	68,000
1444	Mar. 2	Mar. 3	"	Cons'd	.4	......	223.	142.	81.	4.4	8.6	7.5	1.1	.216	.314	.224	.12	....	....	....	.0	.3	3.04	0.	0.	......	15,000
1468	" 9	" 10	"	Much	.18	......	1042.	111.	931.	4.7	17.2	5.4	11.8	.16	.656	.112	.544	....	....	....	.006	1.	10.	0.	9.	......	75,000
1506	" 14	" 15	"	"	.3	......	1618.	74.	1544.	3.8	19.4	5.2	14.2	.224	1.216	.136	1.08	....	....	....	.008	.9	17.	4.	6.	......	250,000
1542	" 21	" 22	"	"	.2	......	608.	114.	494.	3.4	18.2	7.3	10.9	.376	1.26	.296	.964	....	....	....	.008	.55	14.1	......	......	......	180,000
1577	" 28	" 29	"	"	.2	......	381.	116.	265.	3.4	15.8	7.2	8.6	.216	.536	.216	.32	....	....	....	.001	.6	11.5	6.	......	......	260,000
1620	Apr. 4	Apr. 6	"	"	.3	......	380.	160.	220.	3.8	9.2	5.9	3.3	.192	.416	.152	.264	....	....	....	.01	.1	10.1	9.	10.	......	130,000
1670	" 12	" 13	"	"	.43	......	662.	135.	527.	1.6	19.3	7.2	12.1	.188	.904	.208	.696	....	....	....	.026	.6	11.4	8.	5.	......	60,000
1696	" 18	" 19	"	"	.35	......	302.	134.	168.	2.6	8.8	6.	2.8	.076	.32	.136	.184	....	....	....	.028	.25	10.5	10.	10.	......	20,000
1737	" 25	" 26	"	"	.25	......	914.	133.	781.	2.2	18.9	6.5	12.4	.082	.92	.168	.752	....	....	....	.016	.5	11.9	15.	25.	......	62,000
1776	May 2	May 4	"	Cons'd	.4	......	345.	167.	178.	3.	9.5	6.7	2.8	.042	.304	.136	.168	....	....	....	.009	.5	10.1	20.	23.	......	7,200
1803	" 9	" 10	"	"	.7	......	552.	112.	440.	3.6	16.5	10.8	5.7	......	......	......	......	....	....	....	.002	.35	11.4	19.	16.	......	10,000
1836	" 16	" 17	"	"	.6	......	450.	124.	226.	4.4	15.4	8.	7.4	.034	.512	.192	.32	....	....	....	.014	.15	8.8	21.	20.	......	5,700
1871	" 23	" 24	"	Much	.4	......	634.	122.	512.	1.4	16.7	7.2	9.5	.05	.512	.128	.384	....	....	....	.016	.3	8.4	19.	21.	......	7,500
1908	" 30	" 31	"	"	.35	......	296.	156.	140.	5.2	8.5	6.	2.5	.018	.288	.12	.168	....	....	....	.009	.55	7.2	24.	25.	......	2,600
1943	June 6	June 7	"	Cons'd	.3	......	332.	154.	178.	3.2	16.2	6.6	9.6	.032	.344	.168	.176	....	....	....	.006	.7	6.1	24.	26.	......	5,000
1979	" 13	" 14	"	Much	.4	......	256.	158.	98.	4.8	7.4	6.7	.7	.016	.296	.144	.152	....	....	....	.002	.35	5.2	24.	26.	......	4,100
2015	" 21	" 21	"	Little	.2	......	258.	157.	101.	3.4	8.6	6.1	2.5	.032	.320	.136	.184	....	....	....	.0	.025	5.3	23.	25.	......	2,600
2048	" 27	" 28	"	Much	.2	......	572.	146.	426.	3.2	14.	6.6	7.4	.052	.48	.128	.352	....	....	....	.019	.45	7.2	26.	28.	......	20,000
....	......	......	......	......	......	......	......	......	......	......	....	....	....	......	......	......	......	....	....	....	....	......	......	......	......	......	......

TABLE 147.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 100 FEET FROM MISSOURI SHORE, ALTON.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved.	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspnd'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
1186	Jan. 4	Jan. 5	Much	Little	.25	....	266.	246.	20.	12.2	7.5	6.9	.6	.362	.304	.160	.144	....	....	....	.006	.00	......	0.	4.	......	3,400
1214	" 10	" 11	"	Much	.35	....	227.	188.	39.	5.4	8.9	7.4	1.5	.064	.325	.176	.149	....	....	....	.0	.025	2.4	0.	0.	......	6,600
1281	" 24	" 25	"	"	.3	....	345.	190.	155.	3.8	10.8	6.4	4.4	.054	.368	.176	.192	....	....	....	.004	.5	3.9	0.	10.	......	31,300
1325	Feb. 2	Feb. 3	"	Little	.6	....	282.	220.	62.	10.6	7.8	6.6	1.2	.568	.304	.2	.104	....	....	....	.016	.9	0.	0.	0.	......	21,200
1352	" 7	" 8	"	"	.4	....	260.	213.	47.	8.	7.9	6.6	1.3	.32	.36	.208	.152	....	....	....	.006	.2	2.6	11.	10.	......	14,000
1393	" 14	" 15	"	Much	.4	....	644.	160.	484.	3.8	17.2	7.3	9.9	.136	.72	.216	.504	....	....	....	.007	.15	5.	0.	0.	......	125,000
1423	" 22	" 23	"	"	.5	....	426.	168.	258.	3.9	16.3	8.5	7.8	24	.72	.216	.504	....	....	....	.012	.25	5.08	5.	0.	......	70,000
1445	Mar. 2	Mar. 3	"	Cons'd	.4	....	294.	154.	140.	4.2	8.3	7.2	1.1	.216	.272	.224	.048	....	....	....	.0	.3	3.04	0.	0.	......	10,000
1469	" 9	" 10	"	Much	.18	....	940.	117.	823.	2.4	17.1	5.2	11.9	.136	.056	.088	.568	....	....	....	.006	1.	10.	0.	9.	......	116,000
1507	" 14	" 15	"	"	.3	....	1463.	70.	1393.	2.6	18.6	5.4	13.2	.208	1.08	.136	.944	....	....	....	.007	.75	17.	4.	6.	......	....
1543	" 21	" 22	"	"	.2	....	628.	108.	520.	4.4	17.8	8.4	9.4	.384	.78	.304	.476	....	....	....	.008	.2	14.1	......	......	......	120,000
1578	" 28	" 29	"	"	.22	....	492.	136.	356.	3.2	16.6	7.	9.6	.344	.544	.216	.328	....	....	....	.012	.5	11.5	6.	......	......	120,000
1621	Apr. 4	Apr. 6	"	"	.3	....	400.	146.	254.	3.8	9.4	5.9	3.5	.192	.4	.176	.224	....	....	....	.014	.4	10.1	9.	10.	......	106,000
1671	" 13	" 13	"	"	.4	....	677.	130.	547.	2.2	19.3	5.7	13.6	.114	.856	.192	.664	....	....	....	.026	.85	11.4	8.	5.	......	143,000
1699	" 18	" 19	"	"	.35	....	320.	134.	186.	2.8	8.8	6.1	2.7	.086	.272	.16	.112	...	....	....	.028	.15	10.5	10.	10.	......	43,000
1738	" 25	" 26	"	"	.25	....	900.	134.	766.	2.2	19.	6.3	12.7	.028	.92	.176	.744	....	....	....	.01	.5	11.9	15.	25.	......	34,000
1777	May 2	May 4	"	Cons'd	.4	....	480.	158.	322.	3.4	14.1	8.2	5.9	.022	.488	.176	.312	....	....	....	.009	.5	10.1	20.	23.	......	16,000
1803	" 9	" 10	"	"	.7	....	600.	116.	484.	3.4	17.2	11.8	5.4	.....	.....	.....	.....	....	....	....	.004	.35	11.4	19.	16.	......	10,700
1837	" 16	" 17	"	"	.6	....	344.	132.	212.	4.2	13.4	8.1	5.3	.028	.36	.264	.096	....	....	....	.014	.15	8.8	24.	29.	......	1,800
1872	" 23	" 24	"	Much	.4	....	622.	120.	502.	2.2	16.7	6.8	9.9	.05	.568	.16	.408	....	....	....	.016	.3	8.4	19.	21.	......	4,500
1909	" 30	" 31	"	"	.35	....	291.	164.	127.	5.	6.8	6.3	.5	.14	.28	.144	.136	....	....	....	.009	.55	7.2	24.	25.	......	4,700
1944	June 6	June 7	"	Cons'd	.3	....	334.	148.	186.	3.4	15.8	6.6	9.2	.034	.344	.136	.208	....	....	....	.016	.4	6.1	24.	26.	......	7,000
1980	" 13	" 14	"	Much	.4	....	228.	158.	70.	4.8	8.2	6.8	1.4	.024	.296	.128	.168	....	....	....	.001	.2	5.2	24.	26.	......	2,000
2016	" 20	" 21	"	Little	.2	....	256	162.	94.	3.4	8.6	6.	2.6	.048	.256	.16	.096	....	....	....	.0	.0	5.3	23.	25.	......	3,000
2049	" 27	" 28	"	Much	.2	....	494.	145.	349.	3.4	13.8	7.3	6.5	.03	.408	.104	.304	....	....	....	.024	.35	7.2	26.	29.	......	5,800

9528 Q. State what these tables show and their sanitary significance?

A. Tables 143 to 147, inclusive, show the analyses of a series of five samples taken at approximately equi-distant points, across the Mississippi above Alton, Illinois.

The points of collection were the same as during the 1899 period.

The analyses show that as in the 1899 period, there is a lack of complete commingling of the waters of the Illinois and Mississippi rivers at this point, the water derived from the Illinois river clinging as before, to the left bank of the Illinois shore, as is shown particularly by the chlorine and nitrate determinations.

Q. Will you produce and read table 152?

A. Yes, it is as follows:

TABLE 148.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSOURI RIVER, FORT BELLEFONTAINE, WEST ALTON, MO.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	DATE (	
	1900 Collection.	Ex na
1192	Jan. 5	Ja
1224	" 11	"
1297	" 26	"
1359	Feb. 8	Fe
1424	" 23	"
1472	Mar. 8	Ma
1545	" 22	"
1583	" 29	"
1622	Apr. 5	Ap
1656	" 12	"
1700	" 19	"
1739	" 26	"
1808	May 10	Ma
1843	" 17	"
1883	" 24	"
1915	" 31	Ju
1948	June 7	"
1985	" 14	"
2030	" 21	"
2055	" 28	"
....	....	...

olor.	Odor	RESIDUE ON EVAPORATION.			Chlorine.	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
										Albuminoid Am												
		Total.	Dis-solved.	Sus-pended		Total.	By Dis-solved	By Suspd Matter.	Free Ammonia.	Tot'l	Dis-solv'd	Sus-pnd'd	Total.	Dis-solved.	Sus-pended	Nitrites	Nitrates					
.0	....	448.	388.	60.	24.	2.8	1.8	1	.112	.184	.072	.112	.....	.....	.....	.002	.0	1.7	1.	3.	......	600
.12	....	620.	384.	236.	16.	4.2	2.4	1.8	.078	.136	.088	.048	.....	.....	.....	.002	.55	3.3	2.	5.	......	5,100
.12	....	814.	404.	410.	35.	6.4	3.2	3.2	.146	.28	.096	.184	.....	.....	.....	.0	.3	4.1	4.	6.	......	2,000
.2	....	887.	351.	536.	26.	5.1	1.8	3.3	.088	.256	.032	.224	.....	.....	.....	.007	.6	5.1	2.	3.	......	102,000
.2	....	542.	394.	148.	26.5	3.4	2.5	.9	.096	.192	.08	.112	.....	.....	.....	.006	.35	2.8	1.	5.	......	13,300
.12	....	638.	356.	282.	20.	3.4	1.7	1.7	.088	.84	.048	.792	.....	.....	.....	.004	.2	2.	7.	12.	......	2,000
.2	....	882.	300.	582.	25.	14.	2.4	11.6	.052	.384	.04	.344	.....	.....	.....	.012	.0	3.4	2.	5.	......	38,000
.12	....	542.	336.	206.	23.	4.2	3.2	1.	.052	.16	.088	.072	.....	.....	.....	.006	.55	2.7	2.	9.	......	2,000
.2	....	757.	350.	407.	22.	5.8	3.2	2.6	.044	.216	.072	.144	.....	.....	.....	.008	.5	5.9	1.	4.	......	14,000
.11	....	....	....	....	7.5	30.	3.8	26.2	.132	1.52	.064	1.456	.....	.....	.....	.....	.85	13.3	2.	5.	......	80,000
15	....	3938.	162.	3776.	9.7	28.6	4.3	24.3	.216	1.384	.128	1.256	.....	.....	.....	.01	.9	16.5	5.	13.	......	173,000
14	....	1845.	182.	1663.	8.6	18.8	5.2	13.6	.12	1.12	.208	.912	.....	.....	.....	.016	.85	10.9	8	16.	......	90,000
4	....	1078.	254.	824.	12.	9.6	5.2	4.4	.034	.528	.152	.376	.....	.....	.....	.018	.8	7.9	11.	9.	......	150,000
2	....	1826.	276.	1550.	13.4	9.8	3.	6.8	.052	.536	.088	.448	.....	.....	.....	.026	.5	9.2	12.	17.	......	170,000
25	....	1760.	314.	1446.	13.2	16.3	3.2	13.1	......	.96	.544	.416	.....	.....	.....	.012	.35	9.3	11.	6.	......	40,000
4	....	3248.	300.	2948.	8.8	16.8	6.4	10.4	.056	.96	.088	.872	.....	.....	.....	.01	.55	12.5	12.	18.	......	44,000
22	....	1922.	234.	1688.	8.4	14.8	4.2	10.6	.012	1.016	.08	.936	.....	.....	.....	.016	.0	10.6	......	......	......	26,000
2	....	1880.	230.	1650.	14.6	18.6	4.2	14.4	.034	.96	.176	.794	.....	.....	.....	.0	.7	11.	20.	25.	......	30,000
3	....	2328.	238.	2090.	10.6	19.9	3.9	16.	......	......	......	......	.....	.....	.....	.0	.7	10.8	21.	26.	......	24,000
25	....	3110.	313.	2797.	11.	19.2	5.	14.2	.024	1.2	.088	1.112	.....	.....	.....	.0	.55	11.8	23.	27.	......	13,600
3	....	1758.	300.	1458.	12.6	18.7	3.8	14.9	.022	1.36	.128	1.232	.....	.....	.....	.002	1.	11.2	21.	26.	......	26,000
2	....	2415.	298.	2117.	13.8	17.7	4.7	13.	.042	.8	.104	.696	.....	.....	.....	.0	1.4	11.6	24.	27.	......	9,000
25	....	2313.	279.	2034.	12.2	17.5	3.8	13.7	.026	.8	.072	.728	.....	.....	.....	.004	.8	10.8	25.	26.	......	10,000
2	....	2095.	256.	1839.	10.2	16.	3.8	12.2	.024	.736	.08	.656	.....	.....	.....	.0	.3	10.4	25.	24.	......	5,400
2	....	2535.	236.	2299.	9.2	19.2	5.7	13 5	.052	.8	.08	.72	.....	.....	.....	.0	.5	11.	26.	24.	......	24,000
5	....	3716.	198.	3518.	8.4	20.6	4.5	16.1	.02	1.52	.08	1.44	.....	.....	.....	.004	.65	12.9	25.	26.	......	25,000
...	....	....	....	....	......	....	....	....	......	......	......	......	.....	.....	.....	....	......	....	......	......	......	....

9528 Q. State what these tables show and their sanitary significance?

A. Tables 143 to 147, inclusive, show the analyses of a series of five samples taken at approximately equi-distant points, across the Mississippi above Alton, Illinois.

The points of collection were the same as during the 1899 period.

The analyses show that as in the 1899 period, there is a lack of complete commingling of the waters of the Illinois and Mississippi rivers at this point, the water derived from the Illinois river clinging as before, to the left bank of the Illinois shore, as is shown particularly by the chlorine and nitrate determinations.

Q. Will you produce and read table 152?

A. Yes, it is as follows:

TABLE 152.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSOURI RIVER, FORT BELLEFONTAINE, WEST ALTON, MO.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended	Nitrites	Nitrates					
															Tot'l	Dissolv'd	Suspnd'd										
1189	Jan. 4	Jan. 5	Much	Little	.0	....	448.	388.	60.	24.	2.8	1.8	1	.112	.184	.072	.112	....	....	....	.002	.0	1.7	1.	3.	......	600
1235	" 11	" 12	"	"	.12	....	620.	384.	236.	16.	4.2	2.4	1.8	.078	.136	.088	.048	....	....	....	.002	.55	3.3	2.	5.	......	5,100
1263	" 18	" 19	"	Much	.12	....	814.	404.	410.	35.	6.4	3.2	3.2	.146	.28	.096	.184	....	....	....	.0	.3	4.1	4.	6.	......	2,600
1296	" 25	" 26	"	"	.2	....	887.	351.	536.	26.	5.1	1.8	3.3	.088	.256	.032	.224	....	....	....	.007	.6	5.1	2.	3.	......	102,000
1320	Feb. 1	Feb. 3	"	Cons'd	.2	....	542.	394.	148.	26.5	3.4	2.5	.9	.096	.192	.08	.112	....	....	....	.006	.35	2.8	1.	5.	......	13,300
1358	" 7	" 10	"	Little	.12	....	638.	356.	282.	20.	3.4	1.7	1.7	.088	.84	.048	.792	....	....	....	.004	.2	2.	7.	12.	......	2,000
1388	" 14	" 16	"	Much	.2	....	882.	300.	582.	25.	14.	2.4	11.6	.052	.384	.04	.344	....	....	....	.012	.0	3.4	2.	5.	......	38,000
1410	" 21	" 23	"	Little	.12	....	542.	336.	206.	23.	4.2	3.2	1.	.052	.16	.088	.072	....	....	....	.006	.55	2.7	2.	9.	......	2,000
1439	Mar. 1	Mar. 2	"	Cons'd	.2	....	757.	350.	407.	22.	5.8	3.2	2.6	.044	.216	.072	.144	....	....	....	.008	.5	5.9	1.	4.	......	14,000
1471	" 7	" 8	"	Much	.11	....	......	......	......	7.5	30.	3.8	26.2	.132	1.52	.064	1.456	....	....	....	....	.85	13.3	2.	5.	......	80,000
1499	" 13	" 14	"	"	.15	....	3938.	162.	3776.	9.7	28.6	4.3	24.3	.216	1.384	.128	1.256	....	....	....	.01	.9	16.5	5.	13.	......	173,000
1556	" 22	" 23	"	"	.14	....	1845.	182.	1663.	8.6	18.8	5.2	13.6	.12	1.12	.208	.912	....	....	....	.016	.85	10.9	8	16.	......	90,000
1594	" 29	" 30	"	"	.4	....	1078.	254.	824.	12.	9.6	5.2	4.4	.034	.528	.152	.376	....	....	....	.018	.8	7.9	11.	9.	......	150,000
1609	Apr. 3	Apr. 4	"	"	.3	....	1826.	276.	1550.	13.4	9.8	3.	6.8	.052	.536	.088	.448	....	....	....	.026	.5	9.2	12.	17.	......	170,000
1650	" 10	" 11	"	"	.35	....	1760.	314.	1446.	13.2	16.3	3.2	13.1	......	.96	.544	.416	....	....	....	.012	.35	9.3	11.	6.	......	40,000
1690	" 16	" 18	"	"	.4	....	3248.	300.	2948.	8.8	16.8	6.4	10.4	.056	.96	.088	.872	....	....	....	.01	.55	12.5	12.	18.	......	44,000
1721	" 23	" 25	"	"	.22	....	1922.	234.	1688.	8.4	14.8	4.2	10.6	.012	1.016	.08	.936	....	....	....	.016	.0	10.6	......	......	......	26,000
1766	May 1	May 2	"	"	.2	....	1880.	230.	1650.	14.6	18.6	4.2	14.4	.034	.96	.176	.794	....	....	....	.0	.7	11.	20.	25.	......	30,000
1798	" 8	" 9	"	"	.3	....	2328.	238.	2090.	10.6	19.9	3.9	16.	......	......	......	......	....	....	....	.0	.7	10.8	21.	26.	......	24,000
1831	" 15	" 16	"	"	.25	....	3110.	313.	2797.	11.	19.2	5.	14.2	.024	1.2	.088	1.112	....	....	....	.0	.55	11.8	23.	27.	......	13,600
1866	" 22	" 23	"	"	.3	....	1758.	300.	1458.	12.6	18.7	3.8	14.9	.022	1.36	.128	1.232	....	....	....	.002	1.	11.2	21.	26.	......	26,000
1910	" 29	" 31	"	"	.2	....	2415.	298.	2117.	13.8	17.7	4.7	13.	.042	.8	.104	.696	....	....	....	.0	1.4	11.6	24.	27.	......	9,000
1937	June 5	June 7	"	"	.25	....	2313.	279.	2034.	12.2	17.5	3.8	13.7	.096	.8	.072	.728	....	....	....	.004	.8	10.8	25.	26.	......	10,000
1970	" 12	" 13	"	"	.2	....	2095.	256.	1839.	10.2	16.	3.8	12.2	.024	.736	.08	.656	....	....	....	.0	.3	10.4	25.	24.	......	5,400
2007	" 19	" 20	"	"	.2	....	2535.	230.	2299.	9.2	19.2	5.7	13.5	.052	.8	.08	.72	....	....	....	.0	.5	11.	26.	24.	......	24,000
2050	" 27	" 28	"	"	.15	....	3716.	198.	3518.	8.4	20.6	4.5	16.1	.03	1.52	.08	1.44	....	....	....	.004	.65	12.9	25.	26.	......	25,000
....	....	....	....	....	....	....	......	......	......	......	....	....	....	......	......	......	......	....	....	....	....	......	......	......	......	......	....

9530 Q. State what table 152 shows, and its sanitary significance?

A. Table 152 contains the analyses of samples of water taken from the Missouri river at Fort Bellefontaine, West Alton, Missouri, between January 4th and June 27th, 1900.

The large amount of suspended matter carried by the Missouri river in high water periods is shown by these determinations, especially by the suspended residue on evaporation, by the amount of oxygen consumed by suspended matter, and by the amount of nitrogen present in the form of albuminoid ammonia in suspended matter. Throughout the greater part of this period also the number of bacteria in the Missouri river water was high.

Q. Will you produce and read in evidence tables 148, 149, 150 and 151?

A. Yes; they are as follows:

TABLE 148.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 400 FEET FROM ILLINOIS SHORE, AT CHAIN OF ROCKS, PUMPING STATION ST. LOUIS WATER WORKS.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspend'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
1192	Jan. 5	Jan. 6	Much	Little	.2	....	304.	292.	12.	15.	8.6	7.4	1.2	.096	.44	.232	.208	....	....	....	.017	.85	2.2	0.	4.5	......	3,000
1224	" 11	" 12	"	Cons'd	.25	....	294.	210.	51.	10.	7.6	7.2	.4	.464	.44	.2	.24	....	....	....	.016	.55	3.	0.	1.	......	2,800
1297	" 26	" 27	"	Much	Muddy	....	406.	216.	190.	6.3	11.8	7.6	4.2	.31	.38	.136	.244	....	....	....	.024	.85	5.6	1.	—1.	......	21,400
1350	Feb. 8	Feb. 9	"	"	.23	....	1518.	216.	1302.	9.8	18.3	5.9	12.4	576	.98	.144	.836	....	....	....	.008	.4	2.4	2.	—4.	......	76,000
1424	" 23	" 22	"	"	.4	....	1440.	180.	1260.	6.2	18.7	9.	9.7	.392	1.16	.224	.936	....	....	....	.018	1.15	8.	0.	4.5	......	76,000
1472	Mar. 8	Mar. 9	"	"	.16	....	1632.	152.	1480.	5.	18.9	5.2	13.7	.262	.82	.128	.692	....	....	....	.008	.5	15.	1.	10.	......	150,000
1545	" 22	" 22	"	"	.23	....	880.	140.	740.	4.6	17.2	4.8	12.4	.274	.68	.152	.528	....	....	....	.008	1.1	18.8	2.	13.	......	160,000
1583	" 29	" 30	"	"	.18	....	612.	142.	470.	4.4	9.2	5.	4.2	.316	38	.128	.252	....	....	....	.012	.85	15.	5.	7.	......	80,000
1622	Apr. 5	Apr. 6	"	"	.3	....	460.	155.	305.	4.	8.8	5.2	3.6	.192	.352	.136	.216	....	....	....	.017	.85	14.2	7.	17.	......	23,000
1656	" 12	" 13	"	"	.35	....	450.	162.	288.	4.4	11.8	5.6	6.2	208	.392	.184	.208	....	....	....	.03	1.15	15.8	7.	2.	......	17,000
1700	" 19	" 20	"	Cons'd	.3	....	333.	176.	157.	4.2	8.3	5.6	2.7	.096	.264	.16	.104	....	....	....	.03	.85	15.8	12.	22.	......	7,000
1739	" 26	" 27	"	Much	.25	....	486.	178.	308.	4.	15.	6.2	8.8	.042	.496	.176	.32	....	....	....	.042	.01	17.2	15.	21.	......	21,000
1808	May 10	May 11	"	"	.6	....	506.	172.	334.	5.6	15.9	8.5	7.4	......	......	......	......	....	....	....	.012	.3	16.3	17.	18.	......	9,500
1843	" 17	" 18	"	"	.3	....	1165.	221.	944.	9.4	17.3	7.	10.3	.06	.72	.144	.576	....	....	....	.012	.5	15.	22.	23.	......	10,300
1883	" 24	" 25	"	Little	.3	....	704.	200.	504.	5.8	14.4	5.9	8.5	.002	.464	.264	.2	....	....	....	.02	.7	14.2	20.	27.	......	9,900
1915	" 31	June 1	"	Much	.3	....	1456.	234.	1222.	9.	9.6	4.8	4.8	.022	.576	.136	.44	....	....	....	.006	.25	13.2	23.	22.	......	9,100
1948	June 7	" 8	"	"	.3	....	962.	220.	742.	7.6	14.4	5.8	8.6	.02	.536	.176	.36	....	....	....	.006	.15	12.4	25.	24.	......	6,900
1985	" 14	" 14	"	"	.3	....	2593.	210.	2383.	7.6	18.	6.1	11.9	.022	.96	.088	.872	....	....	....	.008	.35	10.7	24.	27.	......	16,000
2030	" 21	" 22	"	"	.3	....	906.	208.	706.	6.6	13.	6.6	6.4	.014	.442	.096	.346	....	....	....	.005	.0	11.2	25.	27.	......	8,500
2065	" 28	" 29	"	"	.35	....	1235.	270.	1050.	4.6	17.	5.5	11.5	.048	.656	.136	.520	....	....	....	.003	.35	13.9	26.	32.	......	15,600
....	....	....	....	....	....	....	......	.....	......	......	....	....	....	.....	......	......	......	....	....	....	....	......	......	......	......	......	....

TABLE 149.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

Report of EDWIN O. JORDAN,
University of Chicago.

SOURCE OF WATER—MISSISSIPPI RIVER, MIDSTREAM, AT CHAIN OF ROCKS,
PUMPING STATION ST. LOUIS WATER WORKS.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Susp'd Matter	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspend'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
1193	Jan. 5	Jan. 6	Much	Little	.12	......	376.	340.	36.	21.	6.2	4.4	1.8	.284	.28	.136	.144	....	....	....	.009	.35	2.2	0.	4.5	......	1,800
1225	" 11	" 12	"	Cons'd	.3	......	456.	320.	36.	22.	5.2	4.4	.8	.096	.42	.128	.292	....	....	....	.006	.2	3.	0.	1.	......	1,600
1298	" 26	" 27	"	Much	.22	......	654.	311.	343.	19.2	7.8	4.2	3.6	.07	.38	.088	.292	....	....	....	.012	.2	5.6	1.	—1.	......	72,500
1300	Feb. 8	Feb. 9	"	"	.22	......	1678.	242.	1436.	10.	17.8	5.1	12.7	.552	1.02	.144	.876	....	....	....	.005	.4	2.4	1.	—4.	......	54,000
1425	" 23	" 24	"	"	.4	......	984.	202.	782.	9.	16.5	6.6	9.9	.232	.72	.136	.584	....	....	....	.008	1.15	8.	0.	4.5	......	110,000
1473	Mar. 8	Mar. 9	"	"	.16	......	2626.	146.	2480.	5.4	20.	4.6	15.4	.17	1.	.064	.936	....	....	....	.006	.4	15.	1.	10.	......	140,000
1546	" 22	" 23	"	"	.22	......	739.	114.	625.	3.8	17.6	6.3	11.3	.28	.68	.2	.48	....	....	....	.008	.6	18.8	2.	12.	......	130,000
1589	" 29	" 30	"	"	.18	......	440.	132.	308.	3.6	9.4	5.8	3.6	.31	.48	.128	.352	....	....	....	.008	.4	15.	5.	7.	......	115,000
1623	April 5	April 6	"	"	.3	......	590.	158.	432.	4.4	14.4	5.9	8.5	.248	.56	.192	.368	....	....	....	.015	.05	14.2	7.	17.	......	54,000
1657	" 12	" 13	"	"	.4	......	750.	132.	618.	3.8	18.8	7.5	11.3	.102	.96	.304	.656	....	....	....	.03	.6	15.8	7.	2.	......	108,000
1701	" 19	" 20	"	"	.3	......	958.	196.	762.	5.	15.6	5.	10.6	.08	.464	.128	.336	....	....	....	.018	.5	15.8	12.	22.	......	8,000
1740	" 26	" 27	"	"	.3	......	887.	140.	747.	3.2	19.	6.3	12.7	.028	.8	.136	.664	....	....	....	.026	.01	17.2	15.	24.	......	43,000
1809	May 10	May 11	"	"	.5	......	826.	162.	664.	6.	17.5	8.9	8.6	......	......	......	......	....	....	....	.008	.4	16.3	17.	18.	......	14,600
1844	" 17	" 18	"	"	.3	......	1350.	212.	1138.	9.8	18.	7.	11.	.032	.904	.16	.744	....	....	....	.008	.4	15.	22.	23.	......	11,700
1884	" 24	" 25	"	"	.3	......	1478.	208.	1270.	6.4	17.7	6.8	10.9	.046	.856	.12	.736	....	....	....	.006	.7	14.2	20.	27.	......	12,500
1916	" 31	June 1	"	"	.3	......	1855.	249.	1606.	9.8	10.	4.8	5.2	.042	.624	.112	.512	....	....	....	.001	.25	13.2	23.	22.	......	16,200
1949	June 7	" 8	"	"	.3	......	1336.	294.	1042.	8.6	12.8	5.2	7.6	.018	.56	.176	.384	....	....	....	.003	.15	12.4	25.	24.	......	8,300
1986	" 14	" 15	"	"	.3	......	3746.	220.	3526.	8.	19.8	4.3	15.5	.056	1.08	.088	.992	....	....	....	.002	.35	10.7	24.	27.	......	8,800
2021	" 21	" 22	"	"	.3	......	1526.	222.	1304.	7.4	14.3	5.	9.3	.006	.544	.112	.432	....	....	....	.004	.4	11.2	25.	27.	......	13,200
2056	" 28	" 29	"	"	.3	......	2123.	179.	1944.	6.6	18.	5.4	12.6	.046	.96	.112	.848	....	....	....	.003	.45	13.9	26.	32.	......	9,500

TABLE 150.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, AT CHAIN OF ROCKS, INLET TOWER, ST. LOUIS WATER WORKS.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspend'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
1194	Jan. 5	Jan. 6	Much	Little	.1	....	394.	355.	39.	22.	5.	4.	1.	.192	.3	.112	.188	....	....	....	.004	.15	2.2	0.	4.5	....	1,800
1236	" 11	" 12	"	Cons'd	.3	....	528.	343.	185.	25.	5.	3.6	1.4	.08	.36	.104	.256	....	....	....	.006	.5	3.	0.	1.	....	2,000
1299	" 26	" 27	"	Much	.2	....	745.	316.	429.	19.6	7.6	3.8	3.8	.068	.34	.064	.276	....	....	....	.012	.2	5.6	1.	-1.	....	70,000
1361	Feb. 8	Feb. 9	"	"	.22	....	1927.	265.	1662.	13.	17.4	4.3	13.1	.32	1.	.128	.872	....	....	....	.006	.25	2.4	1.	-4.	....	63,000
1426	" 23	" 24	"	"	.3	....	1006.	232.	774.	12.2	15.	6.	9.	.158	.72	.128	.592	....	....	....	.008	.85	8.	0.	4.5	....	45,000
1474	Mar. 8	Mar. 9	"	"	.16	....	3050.	140.	2910.	5.4	20.4	4.4	16.	.148	1.08	.08	1.	....	....	....	.008	.4	15.	1.	10.	....	90,000
1547	" 22	" 23	"	"	Muddy	....	1110.	147.	963.	6.	18.5	7.	11.5	.3	1.04	.2	.84	....	....	....	.014	.6	18.8	2.	13.	....	135,000
1565	" 29	" 30	"	"	.18	....	564.	136.	428.	4.8	9.	6.2	2.8	.288	.52	.136	.384	....	....	....	.01	.5	15.	5.	7.	....	88,000
1624	Apr. 5	Apr. 6	"	"	Muddy	....	830.	200.	630.	6.8	14.6	5.9	8.7	.196	.52	.152	.368	....	....	....	.015	.35	14.2	7.	17.	....	56,000
1658	" 12	" 13	"	"	.25	....	1040.	190.	850.	6.	17.7	6.6	11.1	.136	.846	.184	.662	....	....	....	.028	.55	15.8	7.	2.	....	72,000
1702	" 19	" 20	"	"	.25	....	1344.	196.	1148.	5.8	9.2	4.7	4.5	.032	.536	.112	.424	....	....	....	.02	.4	15.8	12.	22.	....	18,000
1741	" 26	" 27	"	"	.25	....	1310.	186.	1124.	5.1	17.2	5.5	11.7	.052	.688	.136	.552	....	....	....	.006	.01	17.2	15.	24.	....	....
1810	May 10	May 11	"	"	.3	....	1210.	196.	1014.	8.4	18.7	7.1	11.6	....	....	....	....	....	....	....	.0	.4	16.3	17.	18.	....	15,000
1845	" 17	" 18	"	"	.3	....	2018.	242.	1776.	12.	19.3	7.	12.3	.032	1.04	.12	.92	....	....	....	.002	.4	15.	22.	23.	....	18,000
1885	" 24	" 25	"	"	.3	....	2035.	248.	1787.	8.8	19.	8.5	10.5	.046	1.016	.128	.888	....	....	....	.012	.75	14.2	20.	27.	....	13,800
1917	" 31	June 1	"	"	.3	....	2256.	267.	1989.	10.	10.2	4.3	5.9	.024	.648	.168	.48	....	....	....	.005	.15	13.2	23.	22.	....	12,000
1950	June 7	" 8	"	"	.3	....	2054.	247.	1807.	11.4	13.4	4.5	8.9	.028	.696	.12	.576	....	....	....	.005	.15	12.4	25.	24.	....	12,000
1987	" 14	" 15	"	"	.2	....	4198.	229.	3969.	8.2	22.	4.8	17.2	.062	.128	.112	.016	....	....	....	.002	.35	10.7	24.	27.	....	15,600
2022	" 21	" 22	"	"	.25	....	2144.	228.	1916.	8.2	15.2	5.5	9.7	.024	.68	.08	.6	....	....	....	.003	....	11.2	25.	27.	....	17,900
2067	" 28	" 29	"	"	.32	....	2756.	175.	2581.	6.6	19.8	4.7	15.1	.046	1.12	.112	1.008	....	....	....	.002	.35	13.9	26.	32.	....	9,000
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

TABLE 151.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

Report of EDWIN O. JORDAN,
University of Chicago.

SOURCE OF WATER—MISSISSIPPI RIVER, 400 FEET FROM MISSOURI SHORE, AT CHAIN OF ROCKS, PUMPING STATION ST. LOUIS WATER WORKS.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coll.	No. of Bac. per Cubic Centimeter.
															Albuminoid Am												
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Suspd Matter.	Free Ammonia.	Tot'l	Dissolv'd	Suspnd'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
1195	Jan. 5	Jan. 6	Much	Little	.3	....	396.	360.	36.	15.	4.3	3.9	.4	.128	.26	.096	.164	....	....	....	.004	.2	2.3	0.	4.5	......	2,800
1227	" 11	" 12	"	Cons'd	.3	....	524.	358.	166.	30.	4.9	2.9	2.	.101	.24	.096	.144	....	....	....	.006	......	3.	0.	1.	......	12,700
1300	" 26	" 27	"	Much	.2	....	788.	354.	434.	21.2	7.	2.8	4.2	.062	.22	.08	.14	....	....	....	.012	.45	5.6	1.	—1.	......	88,000
1362	Feb. 8	Feb. 9	"	"	.22	....	1278.	284.	994.	14.4	15.5	3.3	12.2	.252	.54	.128	.412	....	....	....	.005	.45	2.4	1.	—4.	......	32,000
1427	" 23	" 24	"	"	.2	....	1092.	310.	782.	18.8	7.8	4.6	3.2	.106	.44	.144	.296	....	....	....	.008	.6	8.	0.	6.	......	16,000
1475	Mar. 8	Mar. 9	"	"	.16	....	4122.	145.	3977.	6.	20.6	4.	16.6	.156	1.44	.064	1.376	....	....	....	.008	.5	15.	1.	10.	......	156,000
1548	" 22	" 23	"	"	.2	....	2970.	182.	2788.	9.4	19.6	4.6	15.	.186	1.2	.096	1.104	....	....	....	.016	1.	18.8	2.	13.	......	270,000
1586	" 29	" 30	"	"	.18	....	1026.	131.	895.	12.	13.2	4.6	8.6	.142	.568	.184	.384	....	....	....	.024	.5	15.	5.	7.	......	140,000
1625	Apr. 5	Apr. 6	"	"	.2	....	1634.	310.	1324.	13.4	12.8	2.7	10.1	.056	.672	.096	.576	....	....	....	.017	.4	14.2	7.	17.	......	65,000
1659	" 12	" 13	"	"	.22	....	1858.	301.	1557.	8.2	13.3	4.4	8.9	.034	.672	.104	.568	....	....	....	.016	.5	15.8	7.	2.	......	36,000
1703	" 19	" 20	"	"	.2	....	2008.	252.	1756.	8.	18.2	3.9	14.3	.022	.624	.088	.536	....	....	....	.017	.4	15.8	12.	22.	......	23,000
1742	" 26	" 27	"	"	.15	....	1724.	230.	1494.	8.2	16.1	4.7	11.4	.058	.608	.12	.488	....	....	....	.014	.3	17.2	15.	24.	......	44,000
1811	May 10	May 11	"	"	.2	....	1882.	272.	1610.	13.8	19.3	4.3	15.	......	......	......	......	....	....	....	.0	.85	16.3	17.	18.	......	21,000
1846	" 17	" 18	"	"	.3	....	2600.	302.	2298.	16.2	19.9	4.4	15.5	.032	1.24	.088	1.152	....	....	....	.002	.4	15.	22.	23.	......	14,300
1886	" 24	" 25	"	"	.3	....	2516.	290.	2226.	10.2	19.6	3.9	15.7	.036	1.12	.128	.992	....	....	....	.001	.7	14.2	20.	27.	......	9,500
1918	" 31	June 1	"	"	.3	....	2558.	294.	2264.	11.8	17.7	3.8	13.9	.008	.856	.072	.784	....	....	....	.005	.15	13.2	23.	22.	......	8,200
1951	June 7	" 8	"	"	.3	....	2227.	279.	1948.	10.8	3.9	4.7	5.2	.014	.68	.12	.56	....	....	....	.004	.15	12.4	25.	24.	......	6,400
1988	" 14	" 15	"	"	.2	....	4032.	220.	3812.	8.5	23.4	4.5	18.9	.064	.128	.096	.032	....	....	....	.002	.35	10.7	24.	27.	......	30,500
2023	" 21	" 22	"	"	.3	....	2462.	240.	2222.	8.8	14.	5.3	8.7	.014	.720	.112	.608	....	....	....	.003	.2	11.2	25.	27.	......	7,900
2058	" 28	" 29	"	"	.3	....	3429.	183.	3246.	7.6	20.4	5.5	14.9	.056	1.344	.112	1.232	....	....	....	.001	.6	15.9	26.	32.	......	11,400
....	....	....	....	....	....	....	......	......	......	......	....	....	....	......	......	......	......	....	....	....	....	......	......	......	......	......	....

9535 Q. State what these tables show and their sanitary significance?

A. Tables 148, 149, 150, and 151 contain analyses of samples of water taken from the Mississippi river opposite the pumping station of the St. Louis waterworks at the chain of rocks between January 5th and, June 28th, 1900, the samples being collected from the same points as were specifically designated for the 1899 period.

The considerable amount of suspended matter, as is shown by the residue on evaporation, which was present in the water of the Mississippi river at the inlet tower and in midstream at this point, when compared with the smaller amount of suspended matter in the Mississippi river above the entrance of the Missouri, indicates that the major part of the water entering the St. Louis water intake during the period covered by these analyses was derived from the Missouri river rather than from the Illinois.

Q. Will you produce and read in evidence tables 153, 154, 155, 156 and 157?

A. Yes, they are as follows:

TABLE 153.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 100 YARDS FROM ILLINOIS SHORE, JEFFERSON BARRACKS. MO.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended	Nitrites	Nitrates					
															Tot'l	Dissolv'd	Suspend'd										
1176	Jan. 4	Jan. 5	Much	Little	.18	....	362.	330.	32.	18.6	7.2	6.1	1.1	.056	.304	.192	.112	....	....	....	.014	.3	1.	0.	......	......	800
1229	" 11	" 12	"	Cons'd	.4	....	286.	250.	36.	9.	8.2	8.2	.0	.352	.400	.264	.136	....	....	....	.006	2.55	2.5	0.	......	......	4,300
1254	" 18	" 19	"	Little	.3	....	292.	236.	56.	2.	8.6	6.6	2.	.004	.544	.176	.368	....	....	....	.008	.3	2.6	3.	......	......	6,600
1290	" 25	" 26	"	Much	Muddy	....	464.	194.	270.	5.8	11.	6.4	4.6	.296	.496	.176	.32	....	....	....	.012	.4	5.9	4.	......	......	40,000
1329	Feb. 3	Feb. 5	"	Little	.2	....	324.	285.	39.	16.	7.	5.6	1.4	.6	.248	.184	.064	....	....	....	.012	.35	6.	0.	......	......	8,400
1365	" 9	" 10	"	Much	.25	....	1536.	206.	1330.	9.8	19.5	5.8	13.7	.64	1.2	.168	1.032	....	....	....	.008	.45	4.7	0.	......	......	102,000
1414	" 22	" 23	"	"	.5	....	873.	176.	697.	5.4	12.7	6.9	5.8	.44	.9	.208	.692	....	....	....	.012	1.15	6.4	0.	......	......	39,000
1449	Mar. 3	Mar. 5	"	Cons'd	.45	....	314.	194.	120.	7.2	9.2	6.6	2.6	.384	.32	.208	.112	....	....	....	.010	.9	6.2	0.	......	......	90,000
1477	" 8	" 9	"	Much	.2	....	1328.	160.	1168.	5.6	19.6	5.6	14.	.19	.96	.064	.896	....	....	....	.016	.4	14.	0.	......	......	125,000
1515	" 16	" 17	"	"	.3	....	1292.	163.	1129.	4.	18.8	5.8	13.	.254	1.12	.136	.984	....	....	....	.006	1.	25.5	2.	......	......	190,000
1550	" 22	" 23	"	"	.2	....	915.	114.	801.	4.4	17.8	6.	11.8	.28	.74	.128	.612	....	....	....	.008	.8	18.5	3.	......	......	210,000
1588	" 29	" 30	"	"	.3	....	692.	158.	534.	4.4	12.8	5.5	7.3	.288	.504	.34	.164	....	....	....	.014	.7	13.	8.	......	......	120,000
1627	Apr. 5	Apr. 6	"	"	.3	....	494.	146.	348.	4.2	9.3	5.2	4.1	.184	.424	.136	.288	....	....	....	.017	1.	14.8	7.	......	......	29,000
1661	" 12	" 15	"	"	.45	....	604.	166.	438.	3.	16.	6.4	9.6	.164	.624	.168	.456	....	....	....	.03	1.1	15.8	8.	......	......	46,000
1705	" 20	" 20	"	"	.4	....	508.	159.	349.	4.6	8.8	6.2	2.6	.048	.392	.144	.248	....	....	....	.03	.0	16.	12.	......	......	7,000
1744	" 26	" 27	"	"	.25	....	687.	164.	523.	4.8	15.6	6.2	9.4	.056	.624	.16	.464	....	....	....	.03	.85	17.4	16.	......	......	32,000

TABLE 154.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, EAST OF MIDSTREAM, JEFFERSON BARRACKS, MO.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	DATE OF		APPEARANCE.			Odor	RESIDUE ON EVAPORATION.			Chlorine.	OXYGEN CONSUMED.			NITROGEN AS AMMONIA.				ORGANIC NITROGEN.			NITROGEN AS		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Suspd Matter.	Free Ammonia.	Albuminoid Am.			Total.	Dissolved.	Suspended	Nitrites	Nitrates					
															Tot'l	Dissolv'd	Suspnd'd										
1177	Jan. 4	Jan. 5	Much	Little	.12	....	344.	336.	8.	19.4	6.9	5.4	1.5	.048	.36	.16	.2	....	....	....	.012	.3	1.	0.	......	......	2,900
1230	" 11	" 12	"	Cons'd	.25	....	330.	226.	104.	9.	7.4	6.2	1.2	.32	.38	.224	.156	....	....	....	.006	.25	2.5	0.	......	......	4,000
1255	" 18	" 19	"	Little	.32	....	326.	230.	96.	9.	8.8	7.	1.8	.048	.44	.16	.28	....	....	....	.002	.2	2.6	3.	......	......	18,000
1291	" 25	" 26	"	Much	.3	....	471.	222.	249.	7.4	10.6	6.	4.6	.196	.46	.128	.332	....	....	....	.008	.85	5.9	4.	......	......	46,400
1330	Feb. 3	Feb. 5	"	Little	.2	....	396.	296.	100.	15.5	6.8	5.	1.8	.592	.64	.144	.196	....	....	....	.012	.85	6.	0.	......	......	11,600
1360	" 9	" 9	"	Much	.25	....	1180.	208.	972.	9.8	18.7	6.2	12.5	.52	1.072	.192	.88	....	....	....	.004	.25	4.7	0.	......	......	56,000
1415	" 22	" 25	"	"	.3	....	844.	188.	656.	5.6	17.8	6.4	11.4	.416	.84	.176	.664	....	....	....	.012	1.15	6.4	0.	......	......	80,000
1450	Mar. 3	Mar. 5	"	Cons'd	.35	....	289.	180.	109.	5.8	9.6	7.3	2.3	.323	.456	.168	.288	....	....	....	.016	.4	6.2	0.	......	......	70,000
1478	" 8	" 9	"	Much	.15	....	1920.	119.	1801.	6.2	20.	5.6	14.4	.186	1.08	.064	1.016	....	....	....	.016	.35	14.	0.	......	......	112,000
1516	" 16	" 17	"	"	.3	....	1634.	136.	1498.	3.4	18.7	6.4	12.3	.254	1.32	.152	1.168	....	....	....	.01	1.	23.5	2.	......	......	180,000
1551	" 22	" 22	"	"	.2	....	850.	120.	730.	3.8	17.7	5.7	12.	.252	.74	.184	.556	....	....	....	.014	.8	18.5	3.	......	......	170,000
1589	" 29	" 30	"	"	.3	....	574.	142.	432.	4.4	12.4	5.	7.4	.31	.416	.38	.036	....	....	....	.012	.8	13.	8.	......	......	115,000
1628	Apr. 5	Apr. 6	"	"	.3	....	436.	150.	286.	3.8	9.	5.9	3.1	.176	.328	.144	.184	....	....	....	.016	1.	14.8	7.	......	......	23,000
1662	" 12	" 13	"	"	.38	....	547.	140.	407.	3.4	15.6	6.2	9.4	.2	.592	.152	.44	....	....	....	.032	.9	15.8	8.	......	......	20,000
1706	" 20	" 21	"	"	.4	....	640.	170.	470.	4.6	8.9	6.3	2.6	.048	.448	.168	.28	....	....	....	.028	.0	16.	12.	......	......	9,000
1745	" 26	" 27	"	"	.25	....	779.	160.	619.	4.6	17.9	6.2	11.7	.064	.648	.168	.48	....	....	....	.036	.5	17.4	16.	......	......	20,000

TABLE 155.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, MIDSTREAM, JEFFERSON BARRACKS, MO.

Report of EDWIN O. JORDAN.
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Suspd Matter.	Free Ammonia	Albuminoid Am.			Total.	Dissolved.	Suspended	Nitrites	Nitrates					
															Tot'l	Dissolv'd	Susp'd										
1178	Jan. 4	Jan. 5	Much	Little	.12	....	403.	339.	64.	21.4	6.4	4.4	2.	.062	.26	.168	.092	....	....	....	.011	.2	1.	0.	......	......	4,300
1231	" 11	" 12	"	Cons'd	.4	....	362.	252.	110.	10.	8.2	7.2	1.	.376	.32	.176	.144	....	....	....	.006	.35	2.5	0.	......	......	3,500
1256	" 18	" 19	"	"	.5	....	418.	256.	162.	12.	8.4	5.8	2.6	.068	.46	.136	.324	....	....	....	.002	.45	2.6	3.	......	......	32,900
1292	" 25	" 26	"	Much	.3	....	569.	251.	318.	12.4	8.2	4.7	3.5	.108	.46	.128	.332	....	....	....	.008	.6	5.9	4.	......	......	40,000
1331	Feb. 3	Feb. 5	"	Little	.2	....	402.	280.	122.	17.	6.8	4.8	2.	.544	.22	.152	.068	....	....	....	.006	.3	6.	0.	......	......	16,200
1367	" 9	" 10	"	Much	.25	....	1102.	246.	856.	11.5	15.7	4.3	11.4	.304	.784	.136	.648	....	....	....	.008	.3	4.7	0.	......	......	39,000
1416	" 22	" 23	"	"	.3	....	729.	186.	543.	5.6	16.7	7.2	9.5	.352	.832	.184	.648	....	....	....	.012	.85	6.4	0.	......	......	75,000
1451	Mar. 3	Mar. 5	"	Cons'd	.35	....	375.	200.	175.	6.6	9.5	7.3	2.2	.286	.456	.208	.248	....	....	....	.012	.5	6.2	0.	......	......	(17,000)
1479	" 8	" 9	"	Much	.15	....	2026.	116.	1910.	5.3	20.	5.	15.	.16	1.04	.064	.976	....	....	....	.014	.35	14.	0.	......	......	100,000
1517	" 16	" 17	"	"	.3	....	2394.	142.	2252.	5.8	19.8	5.6	14.2	.222	1.38	.168	1.212	....	....	....	.016	2.1	23.5	2.	......	......	200,000
1552	" 22	" 22	"	"	.2	....	934.	113.	821.	4.2	18.	5.7	12.3	.252	.82	.168	.652	....	....	....	.012	.75	18.5	2.	......	......	230,000
1590	" 29	" 30	"	"	.3	....	624.	126.	498.	4.2	12.6	5.2	7.4	.236	.456	.34	.116	....	....	....	.012	.95	13.	8.	......	......	130,000
1629	Apr. 5	Apr. 6	"	"	.3	....	489.	156.	333.	4.2	11.1	5.6	5.5	.208	.336	.152	.184	....	....	....	.017	.85	14.8	7.	......	......	19,000
1663	" 12	" 13	"	"	.38	....	689.	134.	555.	3.2	17.2	6.7	10.5	.296	.728	.176	.552	....	....	....	.03	.0	15.8	8.	......	......	104,000
1707	" 20	" 20	"	"	.4	....	904.	194.	710.	5.4	9.5	6.7	2.8	.036	.488	.144	.344	....	....	....	.018	.0	16.	12.	......	......	11,000
1746	" 26	" 27	"	"	.25	....	980.	156.	824.	5.2	18.2	6.1	12.1	.05	.672	.168	.504	....	....	....	.018	.5	17.4	16.	......	......	31,000

TABLE 156.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, WEST OF MIDSTREAM, JEFFERSON BARRACKS. MO.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Suspd Matter.	Free Ammonia.	Albuminoid Am			Total.	Dissolved.	Suspended	Nitrites	Nitrates					
															Tot'l	Dissolv'd	Suspend'd										
1179	Jan. 4	Jan. 5	Much	Little	.12	....	375.	318.	57.	17.	5.6	5.2	.4	.616	.38	.184	.196	....	....	....	.016	.55	1.	0.	......	......	4,900
1232	" 11	" 12	"	Cons'd	.35	....	428.	280.	148.	16.	6.7	5.3	1.4	.212	.26	.096	.164	....	....	....	.002	.35	2.5	0.	......	......	4,500
1257	" 18	" 19	"	"	.5	....	582.	308.	274.	20.	7.8	4.2	3.6	.088	.376	.128	.248	....	....	....	.008	.2	2.6	3.	......	......	42,300
1293	" 25	" 26	"	Much	.25	....	552.	267.	285.	15.9	8.	4.	4.	.122	.296	.112	.184	....	....	....	.008	.75	5.9	4.	......	......	56,400
1332	Feb. 3	Feb. 5	"	Little	.2	....	400.	288.	112.	19.	6.7	4.6	2.1	.480	.288	.152	.136	....	....	....	.007	.3	6.	0.	......	......	9,200
1368	" 9	" 10	"	Much	.25	....	842.	236.	606.	12.5	15.8	4.8	11.	.296	.76	.152	.608	....	....	....	.004	.2	4.7	0.	......	......	49,000
1417	" 22	" 23	"	"	.22	....	676.	228.	448.	10.6	12.	6.4	5.6	.216	.576	.168	.408	....	....	....	.012	.5	6.4	0.	......	......	48,000
1452	Mar. 3	Mar. 5	"	Cons'd	.25	....	478.	318.	160.	19.2	7.1	4.8	2.3	.11	.272	.128	.144	....	....	....	.009	.75	6.2	0.	......	......	24,000
1480	" 8	" 9	"	Much	.15	....	3706.	130.	3576.	5.4	28.6	4.6	24.	.15	1.36	.064	1.296	....	....	....	.014	.25	14.	0.	......	......	140,000
1518	" 16	" 17	"	"	.3	....	2462.	152.	2310.	7.	19.2	5.4	13.8	.19	1.54	.128	1.412	....	....	....	.014	1.	23.5	2.	......	......	300,000
1553	" 22	" 22	"	"	.2	....	1008.	115.	893.	4.2	18.6	5.8	12.8	.274	.94	.168	.772	....	....	....	.012	.7	18.5	2.	......	......	220,000
1591	" 29	" 30	"	"	.3	....	552.	134.	418.	4.6	12.5	5.2	7.3	.256	.44	.36	.08	....	....	....	.012	.9	13.	8.	......	......	150,000
1630	Apr. 5	Apr. 6	"	"	.3	....	899.	218.	681.	8.2	12.3	4.9	7.4	.11	.44	.12	.32	....	....	....	.017	.65	14.8	7.	......	......	35,000
1664	" 12	" 13	"	"	.35	....	1164.	199.	965.	6.2	17.2	5.8	11.4	.082	1.12	.376	.744	....	....	....	.028	.55	15.8	8.	......	......	70,000
1708	" 20	" 20	"	"	.4	....	1544.	222.	1322.	7.	9.6	4.4	5.2	.036	.648	.096	.552	....	....	....	.016	.1	16.	12.	......	......	15,000
1747	" 26	" 27	"	"	.25	....	1574.	214.	1360.	8.4	16.7	4.8	11.9	.048	.656	.136	.52	....	....	....	.018	.75	17.4	16.	......	......	28,000

TABLE 157.

STREAMS EXAMINATION—CHICAGO SANITARY DISTRICT.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—MISSISSIPPI RIVER, 100 YARDS FROM MISSOURI SHORE, JEFFERSON BARRACKS, MO.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli.	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended		Total.	By Dissolved	By Suspd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspnd'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
1180	Jan. 4	Jan. 5	Much	Little	.13	....	384.	340.	44.	18.	5.5	3.5	2.	.529	.26	.176	.084	.....	.....	.....	.012	.5	1.	0.	......	......	4,800
1233	" 11	" 12	"	Cons'd	.2	....	446.	312.	134.	22.	6.6	5.	1.6	.18	.34	.136	.204	.....	.....	.....	.002	.35	2.5	0.	......	......	4,900
1258	" 18	" 19	"	"	.2	....	594.	323.	271.	22.	7.7	4.	3.7	.136	.38	.16	.22	.....	.....	.....	.002	.05	2.6	3.	......	......	27,600
1294	" 25	" 26	"	Much	.2	....	560.	276.	284.	16.8	6.7	3.7	3.	.034	.34	.112	.228	.....	.....	.....	.006	.4	5.9	4.	......	......	28,400
1333	Feb. 3	Feb. 5	"	Cons'd	.2	....	410.	336.	74.	19.	5.8	5.4	.4	.342	.2	.16	.04	.....	.....	.....	.014	.3	6.	0.	......	......	7,400
1369	" 9	" 10	"	Much	.2	....	658.	255.	403.	12.5	8.6	4.3	4.3	.216	.44	.157	.283	.....	.....	.....	.008	.25	4.7	0.	......	......	38,000
1418	" 22	" 23	"	"	.22	....	758.	238.	520.	12.	11.2	6.	5.2	.2	.552	.144	.408	.....	.....	.....	.012	.45	6.4	0.	......	......	....
1453	Mar. 3	Mar. 5	"	Cons'd	.2	....	502.	338.	164.	16.2	7.	4.5	2.5	.094	.224	.096	.128	.....	.....	.....	.006	.75	6.2	0.	......	......	26,000
1481	" 8	" 9	"	Much	.15	....	2865.	114.	2751.	6.4	28.6	4.5	24.1	1.64	1.376	.064	1.312	.....	.....	.....	.014	.25	14.	0.	......	......	130,000
1519	" 16	" 17	"	"	.3	....	2174.	148.	2026.	7.	19.3	5.5	13.8	.188	1.54	.136	1.404	.....	.....	.....	.016	1.	23.5	2.	......	......	200,000
1554	" 22	" 23	"	"	.2	....	1522.	150.	1372.	6.4	19.6	5.5	14.1	.246	.94	.168	.772	.....	.....	.....	.013	.9	18.5	2.	......	......	240,000
1592	" 29	" 30	"	"	.3	....	796.	192.	604.	8.8	14.6	5.5	9.1	.118	.46	.192	.268	.....	.....	.....	.018	.6	13.	8.	......	......	175,000
1631	Apr. 5	Apr. 6	"	"	.3	....	1122.	258.	864.	10.8	14.4	4.2	10.2	.07	.44	.088	.352	.....	.....	.....	.017	.6	14.8	7.	......	......	28,000
1665	" 12	" 13	"	"	.35	....	1250.	246.	1004.	8.	15.6	6.6	9.	.078	.928	.216	.712	.....	.....	.....	.018	.55	15.8	8.	......	......	63,000
1709	" 19	" 20	"	"	.4	....	1756.	232.	1524.	7.2	9.8	4.	5.8	.04	.632	.096	.536	.....	.....	.....	.016	.05	16.	12.	......	......	22,000
1748	" 26	" 27	"	"	.25	....	1603.	216.	1387.	8.4	16.5	4.7	11.8	.052	.68	.136	.544	.....	.....	.....	.018	.75	17.4	16.	......	......	55,000

9541 Q. State what these tables show and what is their sanitary significance?

A. Tables 153, 154, 155, 156 and 157 include analyses of samples of water taken from the Mississippi river at Jefferson Barracks, Missouri, below the City of St. Louis, between January 4th and April 26th, 1900, the points at which the samples were collected being the same as those specified more particularly for the 1899 period. Aside from the changes attributable to the differences already noted in the composition of the Illinois, Mississippi and Missouri river waters, the analyses at this point contained nothing of special significance?

Q. Will you produce and read in evidence table 158?

A. Yes, it is as follows:

TABLE 158.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

SOURCE OF WATER—ST. LOUIS, MISSOURI, TAP WATER.

Report of EDWIN O. JORDAN,
University of Chicago.

Serial No.	Date of		Appearance.			Odor	Residue on Evaporation.			Chlorine.	Oxygen Consumed.			Nitrogen as Ammonia.				Organic Nitrogen.			Nitrogen as		Height of Water.	Temperature of Water, C.	Temperature of Air, C.	Presence or Abs. of Coli	No. of Bac. per Cubic Centimeter.
	1900 Collection.	1900 Examination.	Turb'y.	Sediment.	Color.		Total.	Dissolved.	Suspended.		Total.	By Dissolved.	By Susp'd Matter.	Free Ammonia.	Albuminoid Am. Tot'l	Albuminoid Am. Dissolv'd	Albuminoid Am. Suspend'd	Total.	Dissolved.	Suspended	Nitrites	Nitrates					
1175	Jan. 4	Jan. 5	Much	V. Little	.12	None	378.	328.	50.	19.4	4.2	3.7	.5	.056	.152	.104	.048	....	....	....	.002	.1	....	....	....	....	....
1228	" 11	" 12	"	"	.15	"	374.	328.	46.	21.	4.4	4.4	.0	.064	.192	.104	.088	....	..	....	.002	.6	....	....	....	....	600
1253	" 18	" 19	"	"	.15	"	361.	330.	31.	21.	4.6	3.	1.6	.048	.208	.072	.136	....	....	..	.0	.3	....	....	....	....	670
1289	" 25	" 26	"	"	.2	"	376.	324.	52.	23.	4.8	3.2	1.6	.036	.128	.104	.024	....	....	....	.0	.4	....	....	....	....	9,300
1328	Feb 3	Feb. 5	"	"	.2	"	360.	323.	37.	23.75	3.6	3.2	.4	.036	.128	.08	.048	....	....	....	.004	.3	....	....	....	....	11,200
1347	" 6	" 8	"	"	.2	"	364.	335.	29.	21.	4.	3.8	.2	.062	.128	.104	.024	....	....	....	.007	.25	....	....	....	....	600
1364	" 9	" 10	"	"	.15	"	366.	326.	40.	21.	3.9	2.4	1.5	.074	.136	.128	.008	....	....	...	.005	.25	....	....	....	....	500
1376	" 12	" 13	"	"	.15	"	360.	316.	41.	19.	4.4	3.8	.6	.088	.144	.088	.056	....	....	....	.010	.5	....	....	....	....	1,200
1383	" 14	" 15	"	"	.22	"	348.	300.	48.	14.6	5.5	4.7	.8	.02	.224	.136	.088	....	....	....	.011	.5	....	....	....	....	2,300
1395	" 16	" 17	"	"	.4	"	308.	256.	52.	15.1	6.3	4.8	1.5	.034	.208	.136	.072	....	....	....	.012	.55	....	....	....	....	2,800
1413	" 22	" 23	"	"	.22	"	346.	236.	60.	18.	5.	4.	1.	.046	.176	.096	.08	....	....	....	.015	.6	....	....	....	....	4,500
1448	Mar. 3	Mar. 5	"	Cons'd	.25	"	290.	258.	32.	13.2	7.2	5.	2.2	.03	.208	.168	.04	....	....	....	.01	.25	....	....	....	....	6,500
1476	" 8	" 9	"	Little	.15	"	326.	267.	59.	14.6	5.6	4.4	1.2	......	.104	.048	.056	....	....	....	.016	.35	....	....	....	....	2,400
1514	" 16	" 17	"	Cons'd	Muddy	"	338.	248.	90.	9.9	7.	4.9	2.1	.002	.264	.128	.136	....	....	....	.005	.55	....	....	....	....	7,700
1549	" 22	" 23	"	Much	.18	"	413.	162.	251.	8.4	11.	4.4	6.6	.016	.368	096	.272	....	....	....	.008	1.	....	....	....	....	75,000
1587	" 29	" 30	"	Cons'd	Muddy	"	298.	160.	138.	7.	9.	4.8	4.2	.002	.304	.176	.128	....	....	....	.006	.8	....	....	....	....	8,000
1626	Apr. 5	Apr. 6	"	"	.3	"	266.	156.	110.	6.6	7.3	4.8	2.5	.008	.2	.144	.056	....	....	....	.0	.85	....	....	....	....	16,600
1660	" 12	" 13	"	Much	.4	"	308.	176.	132.	6.2	7.7	5.3	2.4	.008	.248	.136	.112	....	....	....	.004	.7	....	....	....	....	9,500
1704	" 19	" 20	"	Cons'd	.3	"	365.	182.	183.	6.6	7.1	5.	2.1	.012	.224	.192	032	....	....	....	.002	.0	....	....	....	....	1,700
1743	" 26	" 27	"	"	.15	"	410.	200.	210.	6.6	6.3	6.2	.1	.028	.216	.144	.072	....	....	....	.0	.3	....	....	....	....	23,000
1778	May 3	May 4	"	Little	.3	"	356.	198.	158.	7.8	7.2	5.6	1.6	.016	.272	.176	.096	....	....	....	.006	.4	....	....	....	....	3,500
1847	" 17	" 18	"	Cons'd	.3	"	390.	195.	194.	9.2	7.4	4 9	2.5	.008	.272	.112	.16	....	....	....	.002	.4	....	....	....	....	2,900
1879	" 24	" 25	"	Little	.3	"	372.	246.	126.	8.6	6.5	5.7	.8	.003	.184	.104	.08	....	....	....	.003	.45	....	....	....	....	1,200
1914	" 31	June 1	"	"	.3	"	252.	344.	108.	10.6	5.7	4.5	1.2	.022	.192	.136	.056	....	....	....	.004	.25	....	....	....	....	3,000
1952	June 7	" 8	"	Cons'd	.4	"	423.	266.	160.	9.4	6.	4.2	1.8	.002	.176	.096	.08	....	....	....	.004	.15	....	....	....	....	6,100
1989	" 14	" 15	"	Little	.1	"	382.	240.	142.	9.5	5.6	4.5	1.1	.006	.16	.112	.048	....	....	....	.002	.2	....	....	....	....	3,900
2025	" 23	" 23	"	V. Little	.2	"	339.	242.	97.	13.6	4.8	4.4	.4	.004	.16	.136	.024	....	....	....	.002	......	....	....	....	....	7,300
2060	" 28	" 30	"	Little	.2	"	374.	216.	158.	8.2	6.	5.	1.	.016	.112	.112	.0	....	....	....	.0	.35	....	....	....	....	2,400
....	....	....	....	....	....	....	......	......	......	......	....	....	....	......	......	......	......	....	....	....	....	......	......	......	......	......	....

9543 Q. State what table 158 shows, and its sanitary significance?

A. Table 158 contains analyses of samples of water drawn from the tap at St. Louis, Missouri, the samples being collected between January 4th, and June 28th, 1900.

The large amount of suspended matter in the water of the Missouri river during the latter part of this period is reflected in the increased residue on evaporation in suspended matter in the tap water, although the reduction in passage through settling basins is very great.

Q. Professor, you have now read in evidence all the tables containing the analytical results for the two periods, 1899 and 1900, that you made for the determination of such as you have heretofore stated, have you not?

A. I have.

MR. JEFFRIES: I move to strike out tables 81 to 158, inclusive, read into the evidence by Professor Jordan, for the same reasons stated in my motion to strike out the tables introduced and read into evidence by Professors Long and Zeit, my understanding being that these tables cover the same period and the same character of analyses.

I move to strike out all the tables and all conclusions and inferences drawn from the tables which have reference to the chemical and bacterial analyses of the waters of the tributaries of the Illinois river, for the same reasons stated in previous objections to the introduction of testimony with reference to
9544 the sanitary condition of the waters of the tributaries of the Illinois river.

Q. MR. TODD: Professor, will you explain what the different chemical constituents as disclosed by the tables just introduced mean, and their sanitary significance, as well as the physical and bacterial determinations and their sanitary significance, as applied to the streams under investigation?

A. The physical characters of the water have been roughly determined with reference to the amount of turbidity, amount of sediment, the color and odor.

Little or no sanitary importance can be attached to the turbidity, sediment and color in the cases under consideration.

As regards the odor of the water, it is found that, in general, waters containing a large amount of organic matter in the early

stages of decomposition, possess an offensive odor readily perceived by the senses, while less impure waters or waters further advanced in the processes of oxidation possess little odor, or, it may be, none at all. It sometimes happens, however, that waters containing a large number of microscopic forms of life, chiefly algae and infusoria, yield odors that are more or less offensive, and that simulate the odors of decomposition. The death and disintegration of these microscopic forms may likewise be the cause of disagreeable smells. Offensive odors, then, may
9545 or may not be accompanied by dangerous sanitary qualities.

Turning next to the various chemical determinations, we may first consider the residue on evaporation. This determination gives information as to the amount of solid substance remaining after the water in which it was dissolved or suspended has been completely evaporated. During the process of thorough drying, certain substances, organic and mineral, are decomposed and driven off.

In general polluted waters contain a rather high residue on evaporation, but in certain cases the residue on evaporation may have reference simply to harmless mineral matters in suspension. In all cases a distinction was made between the dissolved residue on evaporation and the suspended residue on evaporation, the determinations being made both upon filtered and unfiltered samples, the difference between the two being taken as the weight of the residue in suspension.

The determinations of chlorine may next be considered. Chlorine is present in practically all natural waters in combination with sodium in the form of sodium chloride or common salt. Owing to the large amount of salt in urine and in various forms of household waste, it has been found that sewage contains an amount of chlorine in marked excess of that present in most natural and unpolluted ground and surface waters.

9546 When the amount of chlorine normally present in the unpolluted wells and springs of a given district is accurately known, it becomes possible to determine with a considerable degree of precision the amount of pollution existing in the various ground and surface waters of that region which have received a larger or smaller amount of drainage.

The content of a water in sodium chloride is therefore under some conditions a fairly satisfactory gauge of the sanitary condition of that water. Owing to the permanence of the salt, however, the amount of chlorine in a polluted water does not afford conclusive indications as to whether the pollution is recent or remote. In following the passage of salt down stream in a polluted river, the permanency of this substance renders it a valuable indication of the degree of dilution and mixing, but on the other hand, does not afford a clue to the rapidity and extent with which processes of oxidation and bacterial purification are taking place.

The determinations known as oxygen consumed concerns especially the carbonaceous matter in the water.

The significance of this determination lies in its comparative rather than its absolute value, since the amount of oxygen consumed as determined by the quantity of permanganate solution consumed during heating, is affected materially by the period of heating, and by other factors. Exact uniformity of the analytical processes involved is therefore of great import-
9547 ance, and in order that the results in one and the same
laboratory shall be strictly comparable throughout it is necessary to maintain perfect uniformity of procedure. The changes taking place in carbonaceous matter in a water cannot be followed step by step as is the case with the nitrogenous compounds, since the carbon di-oxide formed in decomposition processes either goes off, or enters into combination with mineral elements.

The most significant organic compounds in a polluted water are those of nitrogenous character. These nitrogenous compounds are usually determined in four different states, as albuminoid ammonia or organic nitrogen, as free ammonia, as nitrites and as nitrates.

If we follow the history briefly of the waste nitrogenous compounds discharged from the animal body it is as follows:

These compounds are at first relatively complex and are chemically highly organized bodies. When subjected to bacterial action free ammonia is liberated from these substances, and enters into loose combination with certain of the elements present in the water or sewage. When a water into which such matters have been received a short time before is heated, the ammonia is driven off in the steam and can be collected and measured with a considerable degree of accuracy.

This is the so-called free ammonia in the analytical tables.

9548 The nitrogen in the more chemically complex substances on the other hand, is for the most part not driven off by this process. This is the so-called albuminoid ammonia, the amount of which, however, can be determined by heating in an alkaline solution in the presence of permanganate, destruction of the albumin or nitrogenous molecule taking place under these conditions. This process results in the liberation of ammoniacal compounds which can then be distilled over, collected and measured by the same method as used for the determination of the free ammonia.

In general it may be said that a fresh sewage contains a relatively large proportion of nitrogen in the form of albuminoid ammonia, while a stale sewage contains a smaller proportion of nitrogen in the form of albuminoid ammonia, bacterial activity having converted the albuminoid ammonia into free ammonia.

These early stages in the decomposition of organic matter are followed by oxidation processes which result in the conversion of the free ammonia of the water into nitrites, nitrites being less highly energized compounds than the ammoniacal compounds from which they have been derived. The reason for this oxidation process resides in the need of bacteria for food. Food being matter containing available potential energy, many kinds of bacteria are able to obtain this energy from the ammonium compounds.

9549 Under favorable conditions the process of oxidation does not stop here, as certain bacteria are able to obtain the energy necessary for their development even from compounds containing so little available potential energy as nitrites, and are able to carry on their vital processes with the aid of the energy derived from the oxidation of the nitrites, which by virtue of this bacterial activity are converted into mineral nitrates, the nitrogen then passing successively through the various stages of albuminoid ammonia, free ammonia, nitrites and nitrates. The oxidation of the free ammonia into nitrites and of the nitrites into nitrates is what is termed the process of nitrification. The importance of these facts from the sanitary side is due to the connection of these oxidation processes with processes of purification.

In general, large amounts of albuminoid and free ammonia, indicate the existence of products of decomposition, while the presence of a large amount of nitrate, together with little free and albuminoid ammonia and little nitrite, characterizes a water which may perhaps in the past have received a considerable quantity of polluting matter, but which after the lapse of time, and through bacterial activity has become relatively stable. It has been found empirically that waters in which these oxidation processes have taken place, less commonly give rise to disease, or are a source of danger, than waters that have received
9550 recent pollution, as indicated by the relatively high amounts of free and albuminoid ammonia.

The number of bacteria in a water is usually determined by mixing an accurately measured quantity of the water with nutrient beef jelly and then pouring the mixture out into a sterilized glass dish. The theory underlying this procedure is that each germ originally present in the water, finding itself in a favorable nutrient medium, grows, multiplies and in a few hours or days has formed about itself a growth or colony large enough to be plainly visible to the naked eye.

Different kinds of bacteria form colonies that can be distinguished, one from another, by various physical characters. The kinds of bacteria in a water vary greatly in their sanitary significance, most being perfectly harmless saprophytic forms, which do not so far as is known, have any injurious effect upon the human system, even when taken into the alimentary tract in large quantities. Others, the poisonous or so-called pathogenic germs, are able when taken into the animal body, under suitable conditions, to produce poisonous substances which damage the organism.

The number of bacteria per cubic centimeter as enumerated in the analytical tables 81 to 158 includes the colonies of
9551 all kinds developing upon the bacterial plates, no distinction being made between the harmless and injurious kinds.

By enumerating the number of colonies occurring on one of these plates of beef jelly or nutrient gelatin, some approximation can be arrived at regarding the number of germs originally present in the water, although the absolute number of bacteria

in a water is not always convincing evidence of the sanitary quality of water, since under certain laboratory conditions, bacteria may be made to multiply in a pure water. At the same time experience has shown that in waters collected under natural conditions from springs, rivers, lakes and reservoirs, the purer waters contain fewer bacteria, while those waters that are polluted with sewage or large quantities of organic matter, contain numbers of bacteria much in excess of those found in purer waters. Under natural conditions, it is in general true, that as the food supply of bacteria diminishes, the number of germs becomes fewer, while an influx of food material favors the longevity of certain bacteria and their further multiplication. Surface waters contain as a rule, larger numbers of bacteria than ground waters, which have been freed of a portion of their bacterial content by filtration through layers of sand or soil. It has been observed that the water of a sewage polluted river may contain large numbers of bacteria just below the source of the pollution, but that these numbers diminish with the pass-
9552 age of the water down stream.

Q. Have you made a table of comparative averages of the different chemical and bacterial analyses from the tables 81 to 158, both inclusive, for the years 1899 and 1900?

A. I have.

Q. Will you produce and read in evidence such table?

MR. JEFFRIES: Now, I object to the production and reading into the evidence by this witness of the table referred to by him and known as table E, which is a table of comparative averages of the chemical and bacterial analyses of the water in question for a part of the year 1899, and part of the year 1900, for the reason that such table of averages is not competent evidence in this case, the averages for the two years not being comparable with each other on account of there being nine months covered for the year 1899, to-wit, April to December, inclusive, and only three months for the year 1900, to-wit, January until March, inclusive, and I object to the table being read into evidence for the further reason that a table of averages constitutes no evidence, for the reason that it fails to disclose the bacterial and chemical condition of the water at certain time, which are as important in the determinations of this case as for the determination of the chemical and bacterial condition of the water at any other

time, and the table of comparative averages cannot be relied upon because it conceals and fails to reveal all of the con-
9553 ditions chemically and bacterially of the waters in question at all times during any one year or any one period of time.

In addition to the foregoing objection I will also state that the table of comparative averages above referred to is incompetent for the reason that analyses chemical and bacterial of the waters in question at the various points mentioned in the table, are not comparable with each other because covering different dates and different periods of time, for the two years.

MR. TODD: Will you produce and read such table in evidence?

A. Yes, this table of averages is designated as table E and table E continued, and is contained on two sheets. The table is as follows:

TABLE E.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

COMPARATIVE AVERAGES, 1899 AND 1900.

Report of EDWIN O. JORDAN,
University of Chicago.

SOURCE OF WATER.	PERIOD COVERING	RESIDUE ON EVAPORATION.			CHLORINE.	OXYGEN CONSUMED			NITROGEN AS AMMONIA				NITROGEN AS		No. of Colonies per Cubic Centimeter.
										Albuminoid Am.					
		Total.	Dissolved.	Suspended		Total.	Dissolved.	Suspend'd.	Free Ammonia	Tot'l	Dissolv'd	Suspnd'd	Nitrites.	Nitrates.	
Illinois and Michigan Canal—Bridgeport	Apr.-Dec., 1899	562.7	481.8	80.9	119.2	30.3	15.2	15.1	15.9	2.64	1.25	1.39	.016	.166	1,245,000
" " " " "	Jan.-Apr., 1900	421.8	389.	33.	93.6	16.6	9.57	7.03	8.65	2.05	1.04	1.05	.0214	.074	631,000
Illinois and Michigan Canal—Lockport	May-Dec., 1899	562.	485.1	76.9	117.4	32.1	17.5	14.6	15.7	2.42	1.29	1.13	.002	.18	650,000
" " " " "	Jan.-June, 1900	491.	451.8	39.4	124.5	18.1	11.1	6.8	10.9	2.07	.962	1.15	.0133	.0664	1,755,000
Desplaines River—Lockport	May-Dec., 1899	371.	353.4	17.6	7.9	10.1	8.8	1.3	.072	.452	.378	.074	.011	.167	9,380
" " "	Jan.-June, 1900	363.8	334.	29.7	6.1	9.08	7.8	1.1	.143	.384	.291	.097	.0138	.3467	12,500
Desplaines River—Joliet (above town)	May-Dec., 1899	561.	480.1	80.9	104.8	25.4	14.4	11.	14.7	2.12	.97	1.15	.007	.12	492,000
" " " " "	Jan.-June, 1900	307.	274.	32.	41.5	10.4	7.1	3.3	4.22	.833	.474	.359	.0215	.086	744,286
Kankakee River—Wilmington	June-Dec., 1899	307.4	271.3	36.1	3.4	8.5	7.	1.5	.054	.352	.290	.062	.010	.733	5,000
" " "	Jan.-June, 1900	343.8	268.	76.	2.9	9.4	7.2	2.13	.099	.327	.222	.106	.174	1.58	16,100
Illinois River—Morris	May-Dec., 1899	413.1	394.2	15.9	68.1	13.2	8.9	4.3	9.33	.863	.533	.330	.025	.31	400,000
" " "	Jan.-June, 1900	313.	242.8	73.	24.46	9.6	6.8	3.2	2.458	.509	.315	.24	.075	.424	445,000
Fox River—Ottawa	May-Dec., 1899	345.	297.7	47.3	4.99	8.3	5.9	2.4	.074	.470	.280	.190	.010	.26	6,500
" " "	Jan.-June, 1900	326.7	264.	62.	3.9	8.97	6.27	2.1	.111	.42	.202	.158	.0136	.345	20,600
Illinois River—Ottawa (above town)	June-Dec., 1899	395.8	380.6	15.2	58.5	9.	7.4	1.6	4.17	.503	.381	.122	.37	.98	27,470
" " " " "	Jan.-June, 1900	320.	292.	28.	15.3	8.5	6.9	1.59	1.555	.414	.277	.1306	.197	.966	116,000
Big Vermilion River—La Salle	May-Dec., 1899	996.6	957.3	39.3	61.2	4.9	3.6	1.3	.224	.247	.153	.094	.017	.57	7,970
" " " "	Jan.-June, 1900	441.	353.	87.	10.1	6.4	3.8	2.5	.1	.285	.12	.104	.044	.227	19,200
Illinois River—La Salle	May-Dec., 1899	417.6	368.1	49.5	46.1	9.4	7.7	1.7	27.72	.496	.364	.132	.32	1.38	8,870
" " "	Jan.-June, 1900	307.7	250.9	56.9	17.5	9.06	6.95	2.1	1.046	.4228	.258	.164	.109	.979	94,000
Illinois River—Henry	May-Dec., 1899	399.1	370.1	29.	44.2	9.9	7.7	2.2	2.008	.548	.376	.172	.255	1.12	13,290
" " "	Jan.-June, 1900	306.	250.	52.	13.26	8.8	6.9	1.9	.916	.378	.235	.142	.102	.8	64,200
Illinois and Michigan Canal—La Salle	May-Dec., 1899	375.6	336.1	39.5	15.6	8.	6.3	1.7	.715	.454	.311	.143	.042	.62	49,550
" " " " "	Jan.-June, 1900	351.	313.	38.8	16.7	8.2	7.	1.4	1.244	.447	.286	.159	.0658	.88	54,000
Illinois River—Averyville	May-Dec., 1899	387.6	360.5	27.1	40.9	8.6	7.1	1.5	.929	.452	.331	.121	.256	1.11	3,670
" " "	Jan.-June, 1900	303.	247.	52.2	13.55	8.1	6.56	1.7	.8147	.366	.226	.139	.064	1.15	51,800
Illinois River—Wesley City	May-Dec., 1899	391.9	362.4	32.5	40.9	10.1	7.7	2.4	1.26	.693	.411	.282	.249	.97	758,000
" " " "	Jan.-June, 1900	348.	241.	101.	11.98	9.1	6.47	2.6	.562	.415	.213	.202	.083	1.03	36,800
Illinois River—Pekin	May-Dec., 1899	388.6	355.4	33.2	38.4	9.2	7.2	2.	1.096	.615	.376	.239	.231	.960	492,300
" " "	Jan.-June, 1900	351.	237.	96.	12.3	6.6	6.5	2.5	.690	.429	.258	.19	.06	.99	68,400
Illinois River—Havana	May-Dec., 1899	390.4	343.7	46.7	36.2	8.6	6.9	1.7	1.235	.529	.353	.176	.194	.87	17,470
" " "	Jan.-June, 1900	303.	243.	58.	11.2	7.5	6.07	1.38	.507	.361	.218	.142	.065	.57	23,100
Sangamon River—Chandlerville	May-Dec., 1899	335.1	267.2	67.9	4.52	5.5	3.4	2.1	.052	.239	.149	.090	.020	.61	5,080
" " "	Jan.-June; 1900	409.	260.	148.	4.75	7.6	3.92	3.68	.096	.308	.135	.174	.026	1.32	24,200
Illinois River—Beardstown	May-Dec., 1899	385.6	326.9	58.7	29.3	7.6	5.9	1.7	.83	.528	.301	.127	.151	.81	14,080
" " "	Jan.-June, 1900	460.	249.	196.1	10.7	10.7	6.28	4.4	.691	.441	.217	.224	.106	.685	28,200
Illinois River—Kampsville	May-Dec., 1899	369.3	296.8	72.5	22.9	7.4	5.6	1.8	.309	.425	.262	.163	.075	.76	4,810
" " "	Jan.-June, 1900	500.5	233.	266.	11.3	9.8	5.9	3.9	.659	.445	.195	.25	.044	.87	33,700
Illinois River—Grafton	May-Dec., 1899	473.1	385.1	88.	18.3	7.8	6.	1.8	.253	.400	.237	.143	.044	.71	10,210
" " "	Jan.-June, 1900	503.	240.	260.	9.8	9.8	5.7	4.1	.463	.423	.1941	.2290	.031	1.06	21,000

TABLE E—Continued.

STREAMS EXAMINATION—SANITARY DISTRICT OF CHICAGO.

SANITARY WATER ANALYSIS—PARTS PER MILLION.

COMPARATIVE AVERAGES, 1899 AND 1900.

Report of EDWIN O. JORDAN,
University of Chicago.

SOURCE OF WATER.	PERIOD COVERING	RESIDUE ON EVAPORATION.			CHLORINE.	OXYGEN CONSUMED			NITROGEN AS AMMONIA				NITROGEN AS		No. of Colonies per Cubic Centimeter.
		Total.	Dissolved.	Suspended		Total.	Dissolved.	Suspend'd.	Free Ammonia	Albuminoid Am. Tot'l.	Dissolv'd	Suspend'd	Nitrites.	Nitrates.	
Mississippi River—Grafton	May-Dec., 1899	407.3	165.8	241.5	2.8	12.7	8.6	4.1	.082	.492	.226	.266	.006	.24	7,600
" "	Jan.-June, 1900	444.	155.	247.	5.3	13.	7.6	5.45	.123	.522	.177	.346	.007	.3	30,600
Mississippi River—Alton, East Bank	May-Dec., 1899	353.2	202.4	150.8	7.6	10.4	7.3	3.1	.076	.417	.249	.168	.042	.45	7,900
" " " " "	Jan.-June, 1900	587.	204.	371.	7.2	10.9	6.1	4.8	.242	.489	.171	.318	.0165	.69	30,300
Mississippi River—Alton, East of Center	May-Dec., 1899	326.2	182.9	143.3	5.4	11.4	8.	3.4	......	.442	.236	.206	.026	.33	7,720
" " " " "	Jan.-June, 1900	535.	178.	357.	5.8	12.1	6.5	5.6	.251	.509	.173	.336	.013	.65	47,000
Mississippi River—Alton, Midstream	May-Dec., 1899	379.2	164.9	214.3	3.7	11.5	8.4	3.1	.054	.465	.228	.237	.008	.38	6,650
" " " "	Jan.-June, 1900	508.	162.	346.	4.9	13.2	7.	6.6	.224	.528	.187	.34	.01	.429	51,800
Mississippi River—Alton, West of Center	May-Dec., 1899	412.	168.	244.	2.7	12.6	7.7	4.9	.047	.482	.222	.260	.004	.23	6,350
" " " " "	Jan.-June, 1900	499.	155.	348.	4.6	13.	6.9	6.3	.194	.544	.174	.365	.0098	.396	55,200
Mississippi River—Alton, West Bank	May-Dec., 1899	391.2	163.8	227.4	2.74	11.9	7.7	4.2	.041	.498	.241	.257	.005	.26	7,700
" " " " "	Jan.-June 1900	489.	153.	336.	4.3	13.	6.6	6.	.150	.495	.179	.316	.0102	.379	42,500
Missouri River—West Alton	July-Dec., 1899	1124.5	294.7	829.8	15.4	8.7	2.9	5.8	.035	.377	.079	.298	.002	.27	8,170
" " " "	Jan.-June, 1900	1756.	294.	1446.	15.4	13.9	3.7	10.1	.065	.754	.111	.643	.0066	.56	43,100
Mississippi River—Chain of Rocks, East Bank	May-Dec., 1899	1203.1	198.6	1004.5	5.1	14.5	6.8	7.7	.057	.697	.199	.498	.011	.42	12,480
" " " " " "	Jan.-June, 1900	917.	199.	723.	6.7	13.7	6.2	7.4	.211	.566	.16	.426	.0151	.58	36,200
Mississippi River—Chain of Rocks, Midstream	Apr.-Dec., 1899	1612.2	224.8	1387.4	7.	15.6	5.8	9.8	.048	.744	.159	.586	.005	.34	18,390
" " " " "	Jan.-June, 1900	1269.	209.	1055.	8.6	14.8	5.7	9.1	.145	.697	.138	.559	.0096	.43	46,600
Mississippi River—Chain of Rocks, Intake Tower	Apr.-Dec., 1899	1945.9	216.4	1699.5	7.8	15.7	5.5	10.2	.051	.806	.147	.659	.002	.35	12,930
" " " " " "	Jan.-June, 1900	1626.	227.	1399.	10.3	14.7	5.4	9.3	.117	.699	.125	.574	.0845	.38	41,000
Mississippi River—Chain of Rocks, West Bank	Apr.-Dec., 1899	1993.2	240.8	1752.4	8.8	15.3	4.6	10.7	.049	.904	.139	.765	.008	.37	11,960
" " " " " "	Jan.-June, 1900	2056.	265.	1791.	12.8	14.9	4.1	10.7	.081	.714	.106	.608	.0083	.46	49,700
St. Louis Tap Water	June-Dec., 1899	342.2	251.6	90.6	8.8	5.8	4.6	1.2	.024	.168	.126	.042	.003	.37	2,330
" " "	Jan.-June, 1900	351.6	254.	101.	13.4	6.	4.4	1.6	.028	.196	.12	.075	.0052	.4	7,700
Mississippi River—Jefferson Barracks, East Bank	May-Dec., 1899	1228.1	202.2	1025.9	5.6	15.	6.5	8.5	.048	.744	.188	.556	.006	.35	17,590
" " " " "	Jan.-Apr., 1900	686.	194.	492.	7.2	12.6	6.3	5.8	.203	.612	.179	.435	.016	.76	65,600
Mississippi River—Jefferson Barracks, East of Center	June-Dec., 1899	1311.7	205.1	1106.6	5.8	15.	6.3	8.7	.045	.729	.190	.539	.006	.37	13,120
" " " " " "	Jan.-Apr., 1900	722.	189.	533.	7.2	12.9	6.65	6.9	.285	.639	.173	.447	.015	.6	59,700
Mississippi River—Jefferson Barracks, Midstream	May-Dec., 1899	1502.2	215.4	1286.8	6.4	15.2	5.9	9.3	.049	.710	.163	.547	.001	.34	13,320
" " " " "	Jan.-Apr., 1900	837.	197.	641.	8.4	12.8	5.8	7.	.223	.607	.167	.44	.013	.565	69,500
Mississippi River—Jefferson Barracks, West of Center	June-Dec., 1899	1633.1	233.3	1399.8	7.9	14.9	4.9	10.	.018	.686	.143	.543	.003	.51	21,650
" " " " " "	Jan.-Apr., 1900	1077.	227.	857.	11.3	12.8	5.	7.7	.206	.647	.1605	.486	.012	.53	74,800
Mississippi River—Jefferson Barracks, West Bank	May-Dec., 1899	1792.5	232.6	1559.9	8.2	15.8	4.8	11.	.058	.838	.148	.690	.005	.43	25,180
" " " " " "	Jan.-Apr., 1900	1087.	248.	776.	12.6	12.3	4.7	7.5	.250	.608	.139	.468	.012	.48	69,900
Sanitary Canal, Kedzie Street	Apr.-June, 1900	215.8	188.	28.7	9.87	8.05	5.01	2.9	1.31	.499	.22	.279	.0296	.289	1,332,000
Sanitary Canal, Dam at Lockport	Apr.-June, 1900	196.	183.	12.9	12.7	6.27	4.97	1.3	1.33	3.47	.185	.161	.0185	.118	1,167,000
Desplaines River, Joliet (below town)	....	597.5	486.7	110.8	97.6	25.5	14.5	11.	12.83	2.45	1.05	1.41	.011	.066	766,700
Joliet, below Rock Island Bridge or Jefferson Street	....	250.	221.	28.	24.5	8.	5.9	1.9	3.37	.521	.255	.266	.0283	.287	1,051,000

ERRATA.

Under free ammonia, next to last line, should be .128 instead of 12.83.

Under free ammonia, last line, should be .337 instead of 3.37.

Under albuminoid ammonia, total, third figure from bottom, should be .347 instead of 3.47.

Under albuminoid ammonia, total, second figure from bottom, should be .245 instead of 2.45.

9556 Q. What do the tables and table of averages read into the record by you show, as to the purification of the waters of the Illinois river for the period of 1899, interpreting the sanitary significance of the different chemical and bacterial constituents which you have heretofore explained?

MR. JEFFRIES: I object to the question for the same reasons stated in my objection to the reading of the table into evidence, and I object to the witness drawing any conclusions or inferences from the tables and stating such conclusions and inferences in evidence, and I object to his drawing any conclusions from the tables of averages because such tables conceal and fail to reveal the condition of the water in the Illinois river both chemically and bacterially at all times during the period analyzed or covered by the table of averages, and I object to his drawing any conclusions or inferences from the tables of analyses which have been read into the evidence for the same reasons stated in my objection to the introduction of such table in evidence.

Q. (Question repeated.)

A. From an examination and consideration of the tables of separate analyses and the tables of averages for this period, the period of 1899, it appears that the water in the Illinois and Michigan canal at Bridgeport and at Lockport, as well as
9557 the water of the Desplaines river at Joliet and of the Illinois river at Morris, contained throughout this period a large amount of nitrogenous organic matter in the early stages of decomposition. It appears also from the large amount of chlorine present in these waters that the initial pollution of the Illinois river reached a considerable height during this period. The large number of bacteria present in these waters shows that the substances capable of serving as food for these organisms were present in great abundance.

The tables and averages also show that by the time the Illinois river reaches Ottawa, being somewhat diluted in its course by the purer waters of the Kankakee, mingling with which is incomplete at Morris, a very great change has taken place in the composition of the river water, a change which is manifested especially by the diminution in the amount of albuminoid ammonia by the increase in the amount of nitrites and nitrates, and particularly by an enormous and significant diminution in the bacterial content.

The oxidation of the organic matter continues with the passage of the water down stream and by the time the flow reaches Averyville the amount of free ammonia is greatly diminished
as compared with the amount at Ottawa. The amount of
9558 albuminoid ammonia is diminished. The amount of
nitrites is somewhat lower than it was at Ottawa; the
amount of nitrates has greatly increased, while the bacteria which were present in such enormous numbers in the waters of the upper Illinois have now sunk to a point where they can be compared with the number present in ordinary surface waters in the United States and with the number present in the tributaries of the Ilinois during this period.

Below Averyville the Illinois river receives a large influx of polluting material from Peoria with its stock yards and distilleries, which is evidenced by the increase in some of the significant constituents in the river water, notably in the free ammonia and the albuminoid ammonia and in the number of bacteria.

At Pekin some additional pollution is received and the mingling of the Peoria sewage with the Illinois river water has become more perfect. From Pekin to the mouth of the river, the purification follows a generally progressive course, until by the time the mouth of the river is reached at Grafton, the amount of free and albuminoid ammonia, the oxygen consumed by the carbonaceous matter and the number of bacteria are again low, while the relatively large amount of nitrates bears witness to
the practically complete oxidation of the enormous amount
9559 of organic matter with which the sewage was laden at
Peoria, as well as that with which it originally set forth
at Lockport.

MR. JEFFRIES: Now, I move to strike out the answer of the witness to the last question for the reason that it can have no bearing upon the issues involved in this case, in that the physical condition of the Illinois river has materially changed by the opening of the Chicago drainage canal. All of the evidence of the defendants' witnesses along the Illinois river showed that during the greater part of the year 1899, and for several years prior thereto, the water in that river from Kampsville to Henry Dam was in a state of practical quiescence, thus affording greater opportunities for the disappearance and destruction of pathogenic bacteria than in any period since 1899.

I move to strike out the answer for the further reason that an opinion based upon such conditions as pertained to the river at that time for the purposes of showing the pathogenic bacteria or disease producing organisms did not reach the Mississippi river and the chain of rocks during that period, is no evidence that such disease producing organisms and bacteria are not now and have not since the opening of the Chicago drainage canal, appeared in the waters of the Mississippi river
9560 at the chain of rocks coming from the sewage of Chicago.

Adjourned until 2:00 p. m., same day, Tuesday, December 1st, 1903.

9561 2:00 p. m., Tuesday, December 1st, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN,

resumed the stand for further direct-examination, by Mr. Todd, and testified as follows:

Q. For the period of 1900?

MR. JEFFRIES: I object to the witness drawing any conclusions or inferences and stating such conclusions and inferences in the testimony from the tables of averages for the year 1900, or during the months the water was analyzed for the year 1900, for the reason that such table of averages does not disclose the actual conditions, chemical or bacterial in the waters of the Illinois river at any and all times during that year or during the time the analyses were carried on.

I object for the further reason that such table of averages is not comparable with any condition that may be shown from one analysis, either bacterial or chemical, or any series of analyses for the reason that the witness has not taken into 9562 consideration in making these determinations the various and varying conditions physical and otherwise of the water in the Illinois river, and I object to the witness drawing any conclusions from the tables of analyses referred to in the question and heretofore introduced in evidence for the same reasons stated in my objection to the reading of such tables into the record, together with the reasons suggested by me in my objection to the drawing of inferences and stating of conclusions from the table of averages made up of the tables of analyses so referred to in the question.

Q. (Question repeated.)

A. The conditions in the Illinois river during the larger part of the period covered by these investigations are shown by analyses of samples collected at the same points and under the same conditions as in 1899, the whole series of analyses from May, 1899, to the end of June, 1900, forming one continuous period.

From April to June, 1900, analyses were made of the water from the Chicago drainage canal at Kedzie street and at Lockport. These analyses show that as compared with the condition of the water in the Chicago river considerable dilution has taken place as witnessed particularly by the chlorine determination, as well as by similar changes in the other constituents of the sewage.

9563 A mingling of the waters coming from the Chicago drainage canal at Lockport and from the Illinois and Michigan canal at Lockport, with the waters of the Desplaines river which is subsequently joined by the Kankakee, took place during this period. The first admixture of the waters of the drainage canal took place on the 17th of January, 1900, after the canal had been filled, and the gates finally opened.

Examination of the separate analyses of the samples of water from the Illinois river at Morris and also of the averages of these analyses, shows that the water of the river at this point was charged with organic matter; that it contained a large amount of nitrogen in the form of albuminoid and of free ammonia; that the amount of oxygen consumed was high, and that the number of bacteria was still large.

The samples of water taken from the Illinois river at Ottawa during this same period showed that considerable purification took place between Morris and Ottawa, the amount of free ammonia and of albuminoid ammonia and of oxygen consumed, being diminished, and the number of bacteria being little more than one-fourth the number in the Illinois river at Morris during this same period.

By the time Averyville is reached, the process of purification had proceeded still farther, both free and albumi-
9564 noid ammonia being notably lower than at Ottawa.

At this station also the amount of nitrate was high, showing that considerable nitrification had taken place in the flow from the drainage canal to this point. The number of bacteria was not half as great as in the Illinois river at Ottawa during this same period.

A further addition of polluting water took place at Peoria and Pekin, with the result that in the lower half of the river the process of purification had again to be completed. How complete this purification was may be seen from the determinations at Grafton for this period, the amount of free and albuminoid ammonia in the water and the amount of nitrates indicating that this purification followed a parallel course to the purification in the upper half of the river.

This second period, the conditions in which have been just described, has been arbitrarily separated from the first period, namely, that for the months May to December 1899, but the analyses show plainly that the essential course of events in the water of the Illinois river is the same, whether a period of two months, or five months or fourteen months, be considered.

In all cases the same phenomenon is noticed. The water at the outset, highly charged with putrescible or-
9565 ganic matter and laden with sewage material, regains in the course of about 130 miles flow the condition usually existing in surface waters in this country.

The entrance for a second time into this stream of a large mass of polluting matter, an event that occurs at Peoria and Pekin as heretofore pointed out, is followed by a second successful attempt on the part of the stream to purify itself of this added load.

The self-purification of the Illinois river during the period covered by this analysis extending from May, 1899, to the end of June, 1900, is notable in character and extent both at high water and at low water, both at low temperatures and at high temperatures, and shows convincingly that under the conditions prevailing in the Illinois valley during the period studied, the self-purification of streams is not an interesting biological myth, but an actual and definite occurrence.

Q. Professor, while these tables have been presented as covering two periods of investigation, as a matter of fact the investigation covers one period, does it not?

A. It certainly does. There was practically no break in the analyses, as they were conducted in my laboratory from May, 1899, to the end of June, 1900, weekly analyses being made throughout this period, with but few exceptions.

9566 Q. Are there any two periods during the course of this examination from May, 1899, to June, 1900, that are comparable with each other as to height of water, temperature and similar conditions?

A. Yes, there are.

Q. Will you point out the periods, give the analytical data and make the comparison?

A. In examining the analytical data for Grafton, Illinois, table 101, it appears that the height of water in the Ilionis river at this point was much greater in May and June, 1899, than in July, August, September, October, Noevmber and December, 1899.

Referring next to table 141 containing the analyses of samples from the Illinois river at Grafton for 1900, it appears that the water was very much higher in the months of March and April than in the months of January, February, May and June.

On comparing the temperatures of the water it appears that the temperature was very much higher in June, July, August and September, 1899, and in May and June, 1900, than it was in October, November and December, 1899, and January, February and March, 1900.

9567 Comparing the analytical data it appears that the free ammonia was very high in January, 1900, and in the latter part of November and early part of December, 1899, and that it was relatively low in June and August, 1899, and May and June, 1900.

It appears further that the oxygen consumed was relatively high in May and June, 1899, and in February and March, 1900, and that the nitrates were relatively high in November and December, 1899, and in January, 1900.

It appears further that the number of bacteria per cubic centimeter as determined by the colony count was high in June, 1899, in the latter part of December, 1899, and from about the middle of January to the last of March, 1900, while they were relatively low in August, September, October and November, 1899, and in early January, and in April, May and June, 1900.

From a comparison of the analytical data therefore, at this point, it is evident that the separation of the two periods on the basis of calendar years, is from the point of view of sanitary water analysis, an arbitrary one, and does not bear any definite relation to any meteorological or biological conditions.

Q. How does the chemical and bacterial condition of the
9568 Illinois river at Averyville, Kampsville and Grafton, for the period covered by this survey, compare with that of its tributaries for the same period?

MR. JEFFRIES: I object to the question for the reason that the issue involved in this case is not the determination of the sanitary condition of the waters of the tributaries of the Illinois river, the sanitary condition of the waters of those tributaries being a matter of no importance so far as the issues in this case are concerned, and I object to the question for the further reason that the subject of infection is eliminated therefrom.

Q. (Question repeated.)

A. So far as the chemical and bacterial determinations show, the condition of the Illinois river at Averyville, Kampsville and Grafton, differs in but slight and insignificant particulars from the waters of the tributary streams, thus the amount of albuminoid ammonia in the water of the Kankakee river at Wilmington for June to December, 1899, is .352.

At Averyville for the same period, it is .447

At Grafton for the same period, it is .400

The oxygen consumed in the Fox river at Ottawa for the
period May to December, 1899, was 8.3
9569 In the Illinois river at Averyville, 8.6
in the Illinois river at Grafton, 7.8

The number of bacteria in the Kankakee river at Wilmington
from June to December, 1899, was, 5,000
In the Fox river at Ottawa, 6,500
Big Vermillion river at La Salle, 7,970
Sangamon river at Chandlerville, 5,080
Illinois river at Averyville, 3,670
Illinois river at Kampsville, 4,810
Illinois river at Grafton, 10,210

For the period January to June, 1900, the albuminoid ammonia
in the Kankakee river at Wilmington, was .327
In the Fox river at Ottawa, .42
In the Big Vermillion river at La Salle, .285
In the Sangamon river at Chandlerville, .239

The amount of albuminoid ammonia in the Illinois river at
Averyville for January to June, 1900, was .366
At Kampsville, .445
At Grafton, .423

While the average number of bacteria in the Kankakee river
at Wilmington from January to June, 190, was 16,100
The Fox river at Ottawa, 20,600
Big Vermillion river at La Salle, 19,200
Sangamon river at Chandlerville, 24,200

9570 While the average number of bacteria per cubic centimeter
for January to June, 1900, in the water of the Illinois
river at Averyville was, 51,800
At Kampsville, 33,700
At Grafton, 21,100

The number of bacteria in the Illinois river at Grafton being lower than the number in the Sangamon river at Chandlerville, and almost exactly the same as the number in the Fox river at Ottawa, and the Big Vermillion river at La Salle for this period; so that considered from the point of view of a comparison of the chemical and bacterial analyses the condition of the Illinois river at Averyville, Kampsville and Grafton, compares favorably with the important tributaries of the Illinois.

Q. How does the condition of the Illinois river at Pekin compare with the conditions that obtain at Averyville?

A. Throughout the period covered by this investigation, namely, from May, 1899, to the end of June, 1900, the water of the Illinois river at Pekin was usually in a more highly polluted condition chemically and bacterially, than the water of the Illinois river at Averyville.

Q. What explanation, if any, have you for that condition at Pekin?

9571 A. The large amount of sewage and refuse that enters the Illinois river at Peoria and at Pekin offers a sufficient explanation in my opinion for the increased pollution of the Illinois river at this point as compared with the condition of the river above Peoria, at Averyville, before this pollution enters.

Q. How far down the river from Peoria does the pollution which the Illinois river takes on at Peoria, disappear?

A. That is a somewhat difficult question to answer, because the conditions undoubtedly vary at different times of the year and with different rates of flow. The water of the Illinois river at Havana is on the whole, considered in the light of the chemical and bacterial examinations given in these tables, in a less satisfactory condition than the water of the Illinois river at Averyville.

The same might possibly be said on some occasions, of the water of the Illinois river at Beardstown; at Kampsville and at Grafton. However, the water of the Illinois river at Grafton is usually in a condition very similar to that obtaining at Averyville.

Q. How far from Peoria is Kampsville?

A. About 124 miles.

Q. How far is Averyville from Lockport?

A. About 130 miles.

9572 Q. During this entire period, do your chemical and bacterial examinations disclose the presence at Kampsville of the sewage from Chicago, whether from the Illinois and Michigan canal for the first part of this period, or from the Chicago main drainage canal for the second?

A. They do not so far as the number of bacteria in the water is concerned, nor do they so far as the various chemical determinations of albuminoid ammonia, oxygen consumed, nitrites and nitrates are concerned. The large amount of chlorine that enters the Desplaines river along with the Chicago sewage, is, however, permanent, and not being liable to destruction by various influences, as is the case with the nitrogenous organic matter and the bacteria, that are added in the Chicago sewage, the chlorine manifests itself at Kampsville and Grafton, and even beyond, into the Mississippi river.

MR. JEFFRIES: I move to strike out the last preceding answer for the reason that the witness has not undertaken to differentiate between the bacteria or germ life of a pathogenic character and those of the non-pathogenic character, and particularly in reference to the longevity of both.

9573 MR. TODD: In reply to that objection I will state that before the witness leaves the stand all questions raised by this objection will be met, but in the sequence of the testimony it is impossible to cover the entire field at once.

Q. Does the presence of chlorine in the water of a river in the absence of the other chemical ingredients or constituents of sewage indicate of itself the presence of sewage pollution?

A. In my opinion the presence of chlorine under those conditions would be absolutely devoid of sanitary significance. It would be possible for a stream in the condition that the Illinois river was in at Kampsville, to be passed around the world several times in a closed conduit, consuming years or decades in the process, without altering materially the amount of chlorine in the water, although it is my judgment that, supposing the water were at the outset injurious to health, in the course of such a passage and in such a time, it would become entirely free from any injurious qualities it might have originally possessed.

Q. Professor, did you prepare any charts based upon the analytical tables for this period concerning which you have testified?

A. Yes, I have prepared five charts.

Q. How are the charts designated, professor, that you
9574 have prepared?

A. The first one "Chlorine, parts per million, in the Illinois river, Edwin O. Jordan."

Q. Was that chart prepared by you?

A. It was prepared under my supervision.

Q. From the tables and analytical data which have been offered in evidence?

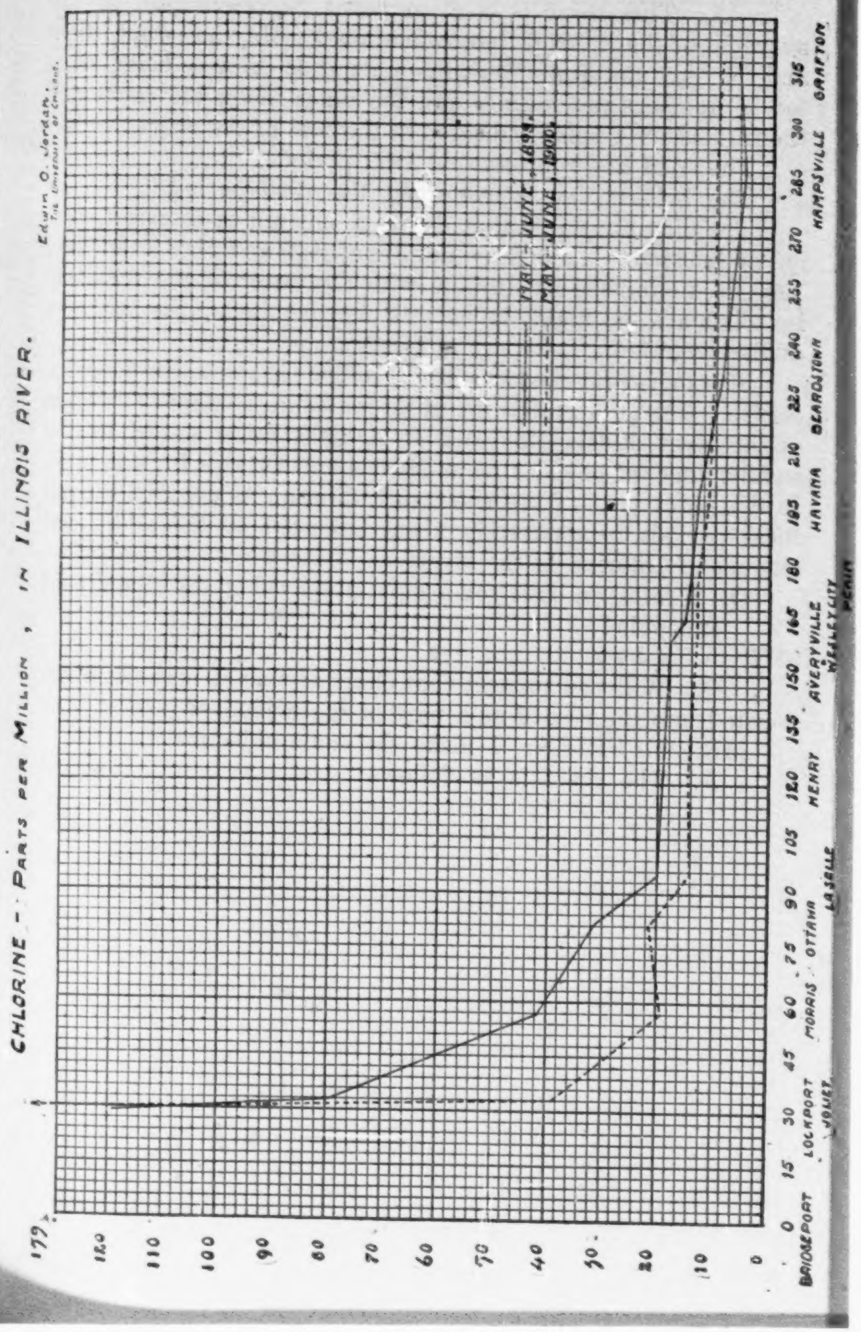
A. Yes sir.

Q. Will you present that chart so that it may be incorporated into the record as a part of the evidence?

MR. JEFFRIES: I object to the chart, to any of the charts which have just been referred to by the witness, being introduced in evidence for the same reasons stated in my objection to the introduction of the tables of analyses upon which the charts are based, or from which they were drawn.

A. The chart is as follows:

9575


CHLORINE - PARTS PER MILLION, IN ILLINOIS RIVER.
Edwin O. Jordan.
The University of Chicago.
MAY - JUNE, 1899.
MAY - JUNE, 1900.
177
120
110
100
90
80
70
60
50
40
30
20
10
0
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210
225
240
255
270
285
300
315
BRIDGEPORT
LOCKPORT
JOLIET
MORRIS
OTTAWA
LASALLE
HENRY
AVERYVILLE
WESLEY CITY
PEKIN
HAVANA
BEARDSTOWN
HAMPSVILLE
GRAFTON

9576 MR. TODD: Q. Will you please explain the chart?

A. This chart is a diagramatic representation of the averages of the chlorine detetrmination for May and June, 1899 and for May and June, 1900, the amount of chlorine being plotted in numbers per million and the miles along the course of the Illinois river being indicated at the foot of the chart.

The solid line representing 1899 period.

The broken line representing the 1900 period.

The diagram shows that the large amount of chlorine present at Lockport during May and June, 1899 and May and June, 1900, is diminished by dilution with the water of the tributaries which are less highly laden with chlorine during the progress of the river from Lockport to Grafton.

The curves for the two periods follow substantially the same course. The greater dilution of the water in the upper stretches of the river during May and June, 1900, being shown by the smaller amount of chlorine at Morris and Ottawa for example. In the lower part of the river such dilution as occured during these periods is apparently about balanced by the additional amount of chlorine in the river.

Q. Professor, have you a chart prepared on the albuminoid ammonia?

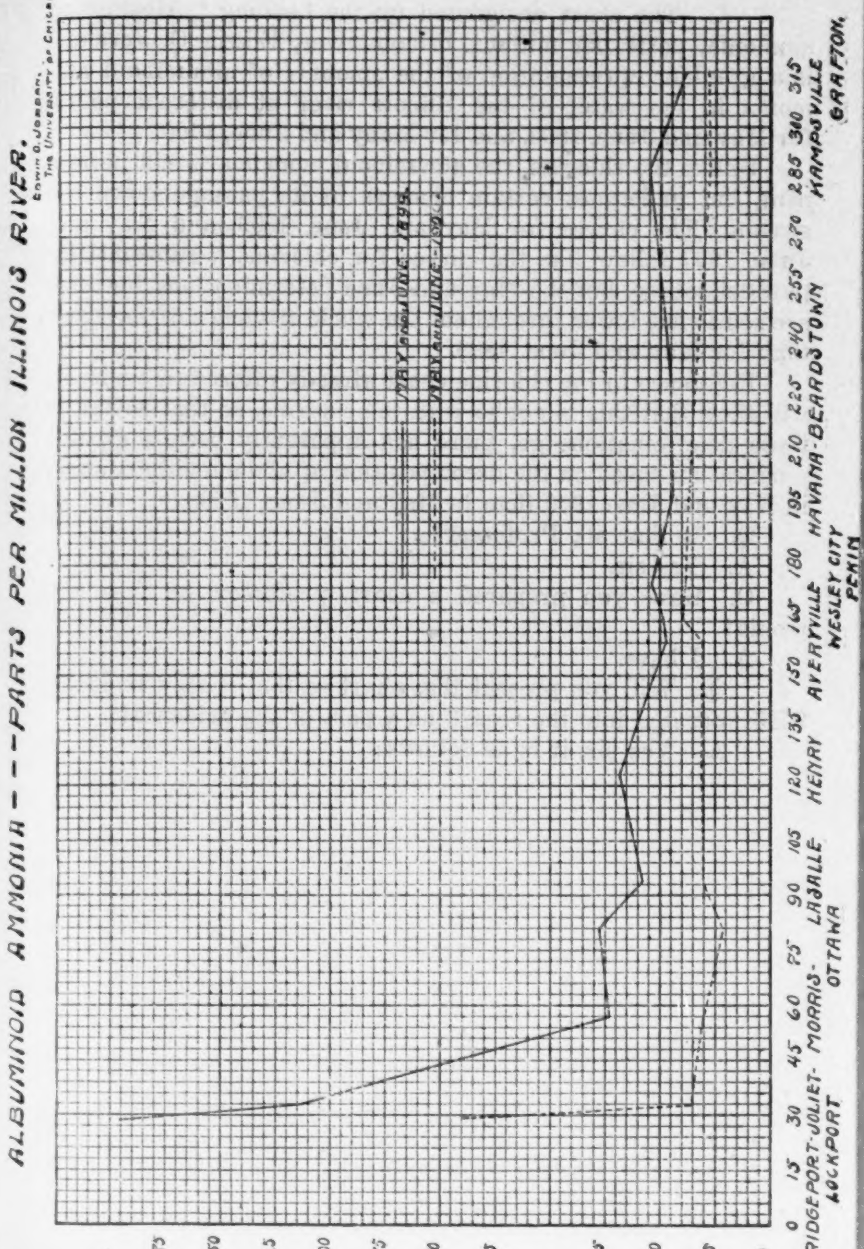
9577 A. I have.

Q. Will you present that chart so that it may be incorporated into the record as a part of the evidence?

MR. JEFFRIES: I make the same objection.

A. The chart is as follows:

9578


ALBUMINOID AMMONIA---PARTS PER MILLION ILLINOIS RIVER.
EDWIN O. JORDAN,
THE UNIVERSITY OF CHICAGO.
MAY AND JUNE 1899.
MAY AND JUNE 1900.
3.
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.
.75
.50
.25
0.0
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210
225
240
255
270
285
300
315
BRIDGEPORT-
LOCKPORT
JOLIET-
MORRIS-
OTTAWA
LASALLE
HENRY
AVERYVILLE
WESLEY CITY
PEKIN
HAVANA-
BEARDSTOWN
KAMPSVILLE
GRAFTON.

9579 Q. MR. TODD: Will you please explain the chart?

A. The chart designated by the heading "Albuminoid ammonia, parts per million, Illinois river, Edwin O. Jordan" is a graphic representation of the amounts of albuminoid ammonia in the water of the Illinois river at different points for May and June, 1899, and for Many and June, 1900.

Unlike the chlorine, the albuminoid ammonia is not permanent, but undergoes certain changes in its passage down the stream. The curves for May and June, 1899, and May and June, 1900 follow like the curves for chlorine, a substantially parallel course, but the May and June determinations for 1900 are somewhat lower throughout the whole stretches of the river than for May and June, 1899.

Reference to the chlorine chart already offered in evidence, will show that this is not so with the chlorine, so that so far as these determinations go, there has apparently been a greater purification based on the decomposition of albuminoid ammonia in May and June 1900 than in May and June, 1899.

Q. Is that all, Professor?

A. Yes sir.

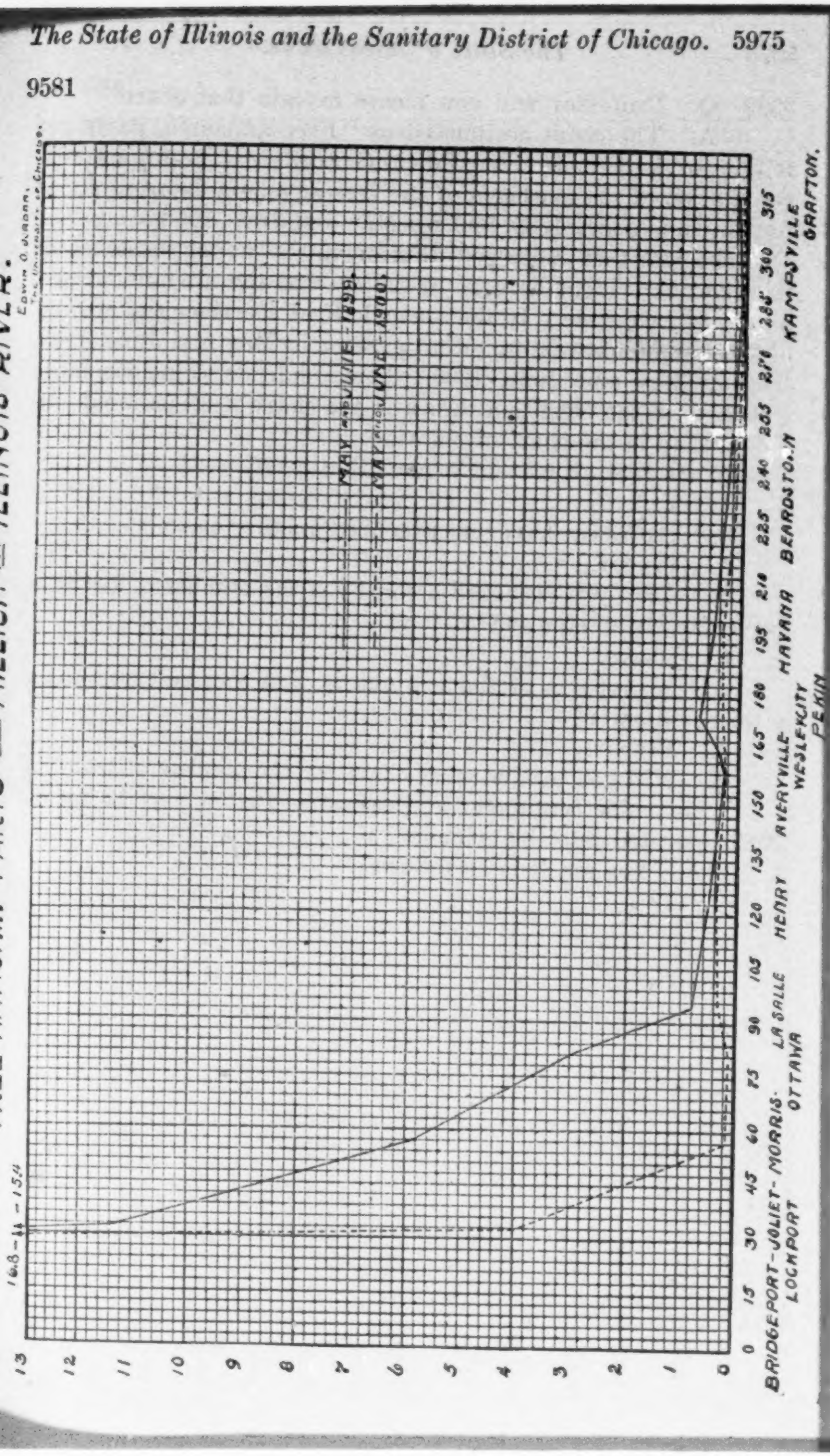
Q. Have you prepared a chart, professor, on free ammonia?

A. I have.

Q. Will you present that chart so that it may be incorporated into the record as a part of the evidence? 9580

A. Yes sir, it is as follows:

9581


RIVER.
EDWIN O. JORDAN,
THE UNIVERSITY OF CHICAGO.
MAY AND JUNE 1899.
MAY AND JUNE 1900.
16.8 – 11 – 15.4
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210
225
240
255
270
285
300
315
BRIDGEPORT-JOLIET-MORRIS-
LOCKPORT
OTTAWA
LA SALLE
HENRY
AVERYVILLE
WESLEY CITY
PEKIN
HAVANA
BEARDSTOWN
KAMPSVILLE
GRAFTON.

9582 Q. Professor will you please explain that chart?

A. The chart designated as "Free ammonia, parts per million in the Illinois river, Edwin O. Jordan" is a graphic representation of the averages of the free ammonia determinations for May and June, 1899, and for May and June, 1900.

The effect of increased dilution in the upper stretches of the river is evident here as in the case of the albuminoid ammonia and chlorine. In the lower half of the river the amount of free ammonia was somewhat greater in May and June, 1899, than in May and June, 1900. This condition coincides more closely with the condition shown in the chart of albuminoid ammonia than in the chart of chlorine.

Q. Is that all of that explanation, professor?

A. Yes.

Q. Professor, have you prepared another chart?

A. Yes sir.

Q. Have you prepared a chart for the number of bacteria per cubic centimeter at Grafton?

A. I have.

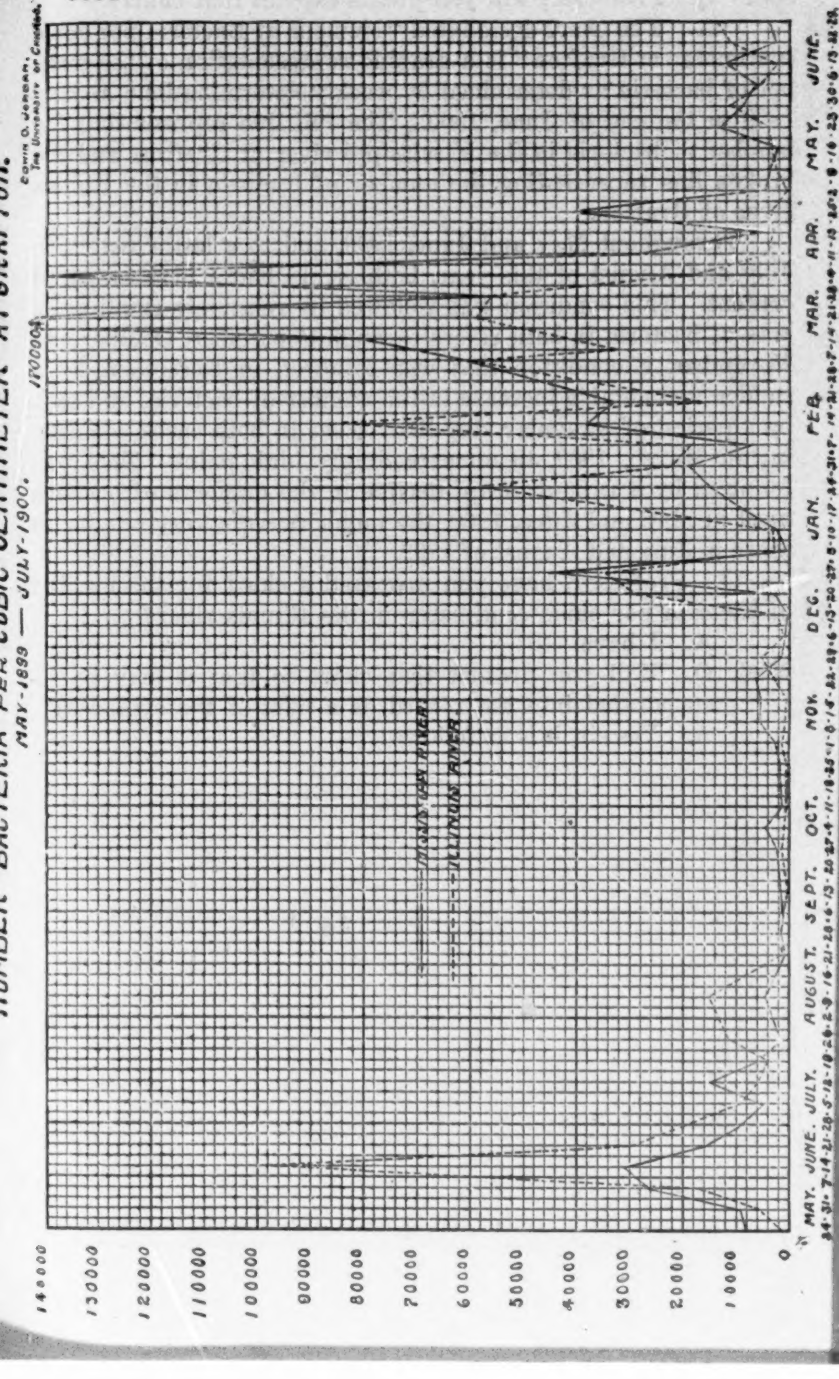
Q. Is that one of the five charts that you referred to in a former answer?

A. Yes sir.

Q. Will you produce that chart for the number of bacteria per cubic centimeter at Grafton so that it may be incorporated into the evidence? 9583

A. Yes sir, it is as follows:

9584


BACTERIA PER CUBIC CENTIMETER AT GRAFTON.
MAY-1899 — JULY-1900.
EDWIN O. JORDAN, THE UNIVERSITY OF CHICAGO.
170000
MISSISSIPPI RIVER
ILLINOIS RIVER
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
MAY. JUNE. JULY. AUGUST. SEPT. OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY. JUNE.

9585 Q. Professor, will you please explain that chart?

A. The chart designated "Number of Bacteria per cubic centimeter at Grafton" is a graphic representation of the number of bacteria as determined by weekly determinations in May 1899 to the end of June, 1900. The full line representing the number of bacteria in the Mississippi river at Grafton, and the broken line representing the number of bacteria in the Illinois river at Grafton.

Throughout May and June, 1899, and to a lesser extent in July and August of this year, both rivers had a high bacterial content. This condition was followed by relatively small numbers of bacteria in both rivers through September, October and November, a condition that was followed in December, by a sudden and notable increase in the number of bacteria, and then by a period of irregular step-like ascent in both cases, amounting in March, 1900, to an exceedingly high point. This was followed by a rather abrupt decline in the numbers of bacteria until in May and June, 1900, the numbers were very similar to those in July and August of 1899.

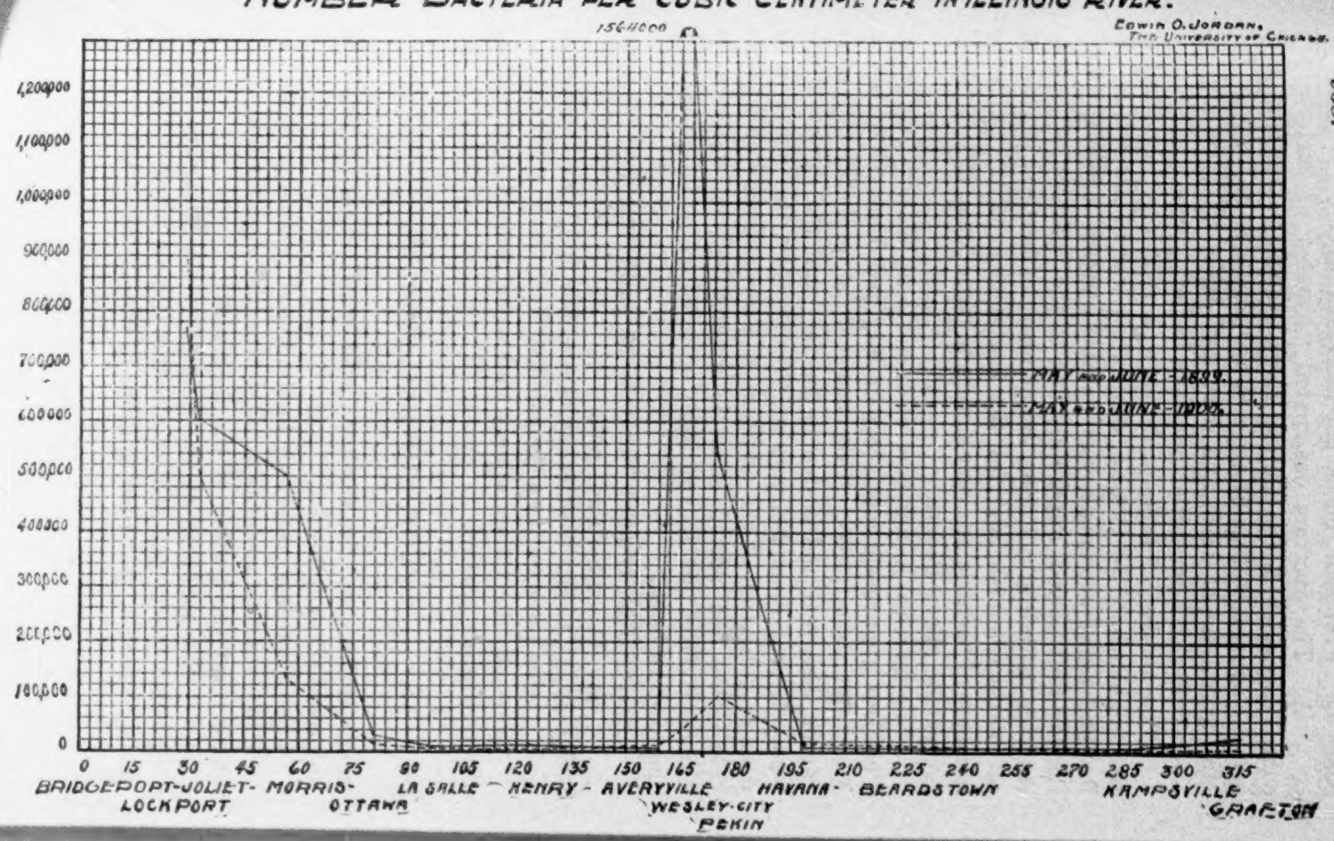
Q. Professor, have you prepared a chart for the number of bacteria per cubic centimeter in the Illinois river?

A. I have.

9586 Q. Will you present that chart so that it may be incorporated into the record as a part of the evidence?

A. Yes sir, it is as follows:

9587


NUMBER BACTERIA PER CUBIC CENTIMETER ILLINOIS RIVER.
Edwin O. Jordan,
The University of Chicago.
1564000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210
225
240
255
270
285
300
315
BRIDGEPORT-
LOCKPORT
JOLIET-
MORRIS-
OTTAWA
LA SALLE
HENRY-
AVERYVILLE
WESLEY-CITY
PEKIN
HAVANA-
BEARDSTOWN
KAMPSVILLE
GRAFTON
MAY AND JUNE - 1899.
MAY AND JUNE - 1902.

9588 Q. Professor, please explain that chart?

A. The diagram designated "Number of bacteria per cubic centimeter in the Illinois river, Edwin O. Jordan" is a graphic representation of the average numbers of bacteria for May and June of 1899, and May and June, 1900, starting at Lockport with high initial numbers in both cases.

The number of bacteria drops to a relatively low point in the neighborhood of Ottawa, continuing low to Averyville, below that point, showing a very notable increase, especially during the first period, apparently due to the pollution of Peoria. As with the initial pollution the numbers of bacteria introduced at Peoria diminish, and for the last stretch of 120 miles the numbers of bacteria are very similar to those found at Henry and Averyville above Peoria.

The increase in numbers of bacteria at Wesley City below Peoria is apparently much less in May and June, 1900 than in May and June, 1899. This however is probably apparent rather than real and is due to the fact that the sample which was collected in mid-stream at Wesley City, did not give as definite indication of the addition of Peoria sewage as was the case in the 1899 period, since the greater body of water in the Illinois river at this time probably crowded the pollution towards the western bank.

ADJOURNED until 10:00 A. M. following day, Wednesday, December 2nd, 1903.

9589 10:00 A. M., Wednesday, December 2nd, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN,

resumed the stand for further direct-examination by Mr. Todd and testified as follows:

Q. Professor, referring to the five diagrams presented by you in evidence yesterday, what was the signification of the numbers at the bottom of the diagrams?

A. The numbers at the bottom of the diagrams headed "Chlorine, parts per Million, in the Illinois river;" "Albuminoid ammonia, parts per million, in the Illinois river;" "Free ammonia, parts per million in the Illinois river," and "Number of Bacteria per cubic centimeter in the Illinois river" refer to the distance in miles from Bridgeport as a starting point, the approximate position of the collecting stations being given below the figures. Thus, the distances from Bridgeport in miles, are as follows:

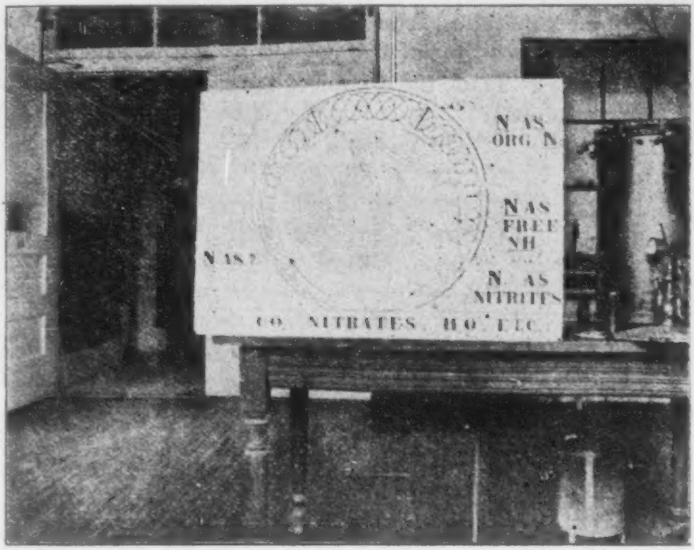
9590	Lockport,	29 miles,
	Joliet,	33
	Morris,	57
	Ottawa,	81
	LaSalle,	95
	Henry,	123
	Averyville,	159
	Wesley City,	165
	Pekin,	175
	Havana,	199
	Beardstown,	231
	Kampsville,	288
	Grafton,	318

Q. Have you any further explanation to give regarding the significance of the four kinds of nitrogen compounds determined in sanitary water analyses?

A. I have here a photograph of a diagram which I would like to explain.

MR. TODD: I offer the photograph as a part of the evidence; it is as follows:

9591



9592 Q. Please read the above question to the witness.

(Question read as follows:)

Have you any further explanation to give regarding the significance of the four kinds of nitrogen compounds determined in sanitary water analyses?

A. This is a photograph of a schematic representation prepared by Professor Sedgwick and myself some fifteen years ago. It is intended to illustrate the various stages in the decomposition and oxidation of nitrogenous organic matter. The circle represents what may be termed the cycle of nitrogen in its relations to the living world. In the upper part of the diagram the large spirals indicate the relative complexity of the organic nitrogenous substances forming the bodies of plants and animals, and excreted from them as waste products. Nitrogen in this stage appears in the analytical tables as so much organic nitrogen or albuminoid ammonia. By the agency of bacteria and other micro-organisms this nitrogenous organic matter is broken down into less complex compounds, the nitrogen in this stage being designated on this chart as nitrogen as free ammonia.

An attempt is made to indicate the less complex condition of these nitrogenous bodies by smaller and less
9593 intricate spirals. The oxidation of the free ammonia to
nitrites is the next step in the process of oxidation, the nitrites being in turn oxidized to the completely mineralized nitrates, which with carbon dioxide, water and other substances devoid of available potential energy, occupy the region of complete mineralization at the bottom of the circle.

Various forms of plant life are able with the aid of sunlight to utilize the nitrogen of the nitrates as food; and through stages of ever increasing complexity, the exact nature of which is unknown, the nitrates are built up again, into the living bodies of plants and animals, and become again organic nitrogen, from which point the nitrogen eventually starts anew on its cycle.

Owing to the effect that the occurrence of nitrogen in the form of organic nitrogen and as free ammonia is associated with the decomposition of substances discharged from the bodies of animals, the presence of nitrogen in these forms indicates relatively recent contamination with organic matters, while owing to the time that must elapse for the process of nitrification to be completed, the occurrence of nitrates in inconsiderable abundance in surface water is taken as indicating that a relatively long period has elapsed since original contamina-
9594 tion took place.

In such a water as the Illinois river, the nitrogenous matter introduced in the Chicago sewage may pass through this complete cycle several times on its way to the mouth of the river. The oxidation of the organic nitrogenous compounds introduced into the river at Lockport may take place under certain circumstances in the upper stretches of the river. The nitrates thus formed may be utilized by microscopic algae for building up their life substances, and thus again pass into the state known as organic nitrogen or albuminoid ammonia. From the advent of cold weather, or from other unfavorable circumstances these organisms may die, and the nitrogen composing their bodies being again decomposed, may reach the mineralized form of nitrate and perhaps again begin the upward part of the cycle.

Under certain circumstances, any river into which an excessive amount of nitrogenous matter is emptied, will contain throughout a large part of its course, an amount of nitrogen in one form or another, in excess of that existing in a stream not so laden at the start. Under such conditions the appearance and reappearance of nitrogen as free ammonia, albuminoid ammonia, or one or another of these compounds, cannot be held to possess the same sanitary significance as under
9595 some other conditions.

Free ammonia at the mouth of the Illinois river for example, may be derived from a decomposition of algae, while free ammonia at Lockport or Bridgeport may be derived from decomposition of waste substances leaving the human or animal body, or discharged into the water in the course of various manufacturing operations.

This diagram I think, serves to illustrate some of these points and to show the complexity of the phenomena attending the decomposition of organic compounds containing nitrogen, and the re-composition of this nitrogen in the bodies of other living forms.

Q. Did you make any hourly bacteriological survey of the water of the Illinois river below Morris?

A. Yes sir.

Q. Please state when this survey was made and describe it in detail?

A. I have made such examinations of the river between Morris and Ottawa, at Wesley City, and at Grafton.

Taking first the determinations made on the Illinois river at Morris. Several series of observations were carried out at this point. The first of these was on October 7th, 1899.
9596 The day was bright and sunny, the temperature of the air being 7 degrees centigrade at six o'clock in the morning, and reaching 20.5 by mid-day. A slight breeze ruffled the surface of the water in the middle of the day, but was at no time strong. The river was very low, the gauge reading for that day being five feet, and the current exceedingly sluggish.

With a view to determining the distribution of bacteria in different portions of the Illinois river at this point, a cross-section was taken across the river from the right to the left bank; three samples being taken at approximately equi-distant intervals from one another and from the shores. The upper cross sections were taken at a point just above the Mazon river, the lower about three-quarters of a mile below the mouth of the Waupecan Creek. This was at a dry period, and little if any water passed into the Illinois from these tributaries at this date. This stretch of river is almost exactly three miles in length. The rate of flow between the two points was determined by weighted floats and by the use of fluorescein solution, and was found to be very close to half a mile per hour.

Four series of cross sections at hourly intervals were taken
at the upper station, which may be designated as Sta-
9597 tion A, and these were followed by a similar series at
the lower station, Station B, beginning six hours later.
These samples were plated immediately after collection, the plating being completed within the hour in each case.

At Station A the river was about 150 yards wide, and at Station B about 125.

The figures given for the number of colonies in the tables that follow are the averages of counts of two separate platings.

9598

UPPER STATION (A).

Hour.		No. Colonies per cc.	Turbidity (Hazen's scale).	Temp. Water °C.	Chlorine (parts per million)
6:15 a. m.	Right Bank	500,000	.16	13.	....
"	Center	378,000	.12	13.	....
"	Left Bank	42,000	.075	13.	....
7:15 a. m.	Right Bank	368,000	.17	13.	....
"	Center	344,000	.125	13.	....
"	Left Bank	35,000	.0775	13.	....
8:15 a. m.	Right Bank	752,000	.16	13.5	91
"	Center	364,000	.11	13.	69
"	Left Bank	30,000	.0675	13.	45
9:15 a. m.	Right Bank	554,000	.16	14.	....
"	Center	472,000	.11	14.	....
"	Left Bank	79,000	.075	14.	....

LOWER STATION (B).

(Three miles below A).

Hour.		No. Colonies per cc.	Turbidity (Hazen's scale).	Temp. Water °C.	Chlorine (parts per million)
12:15 p. m.	Right Bank	480,000	.13	16.	....
"	Center	327,000	.15	16.	....
"	Left Bank	87,000	.05	16.5	....
1:15 p. m.	Right Bank	281,000	.1475	16.	....
"	Center	102,000	.09	16.	....
"	Left Bank	19,000	.042	16.	....
2.15 p. m.	Right Bank	400,000	.13	17.	87
"	Center	249,000	.09	16.	72
"	Left Bank	22,000	.045	16.	52
3:15 p. m.	Right Bank	412,000	.136	17.	82
"	Center	416,000	.12	16.	78
"	Left Bank	11,000	.0433	17.	53

9599 The averages may be tabulated as follows:

		No. Colonies per c. c.			No. of Hourly
	Distance.	Right Bank.	Center.	Left Bank.	Analyses.
Upper Station (A).....	......	543,700	389,700	46,500	4
Lower Station (B).....	3 miles (6hours).	393,250	273,500	34,750	4
Percentage Decrease		27.6	29.8	25.3	

9600 Attention may be directed to the fact that between these collecting stations, a distance of three miles travelled by the stream on this date in about six hours, a great bacterial diminution occurs. The chlorine determinations show that the mixing of the Kankakee water and the Desplaines water is very incomplete both at the upper station which is about nine and one-half miles below the junction of the rivers, and at the lower station as well. This is entirely confirmed by the bacterial count and turbidity cross sections at the two points.

It should be noted that the decline in the numbers of bacteria occurs in almost equal degree throughout the whole breadth of the stream, being as great along the highly polluted right bank of the river as along the comparatively uncontaminated left bank.

A second series of observations was carried out on November 9th, 10th, and 11th, 1899, in similar fashion, upon a longer stretch of river. The distance between the regular collecting station at Morris and the regular collecting station at Ottawa is about 24 miles, and the rate of flow between these points averaged one-half a mile per hour at the time our observations were made. A point midway between Morris and Ottawa was selected, near Seneca, and a three days' series of operations was planned.

9601 The sun was wholly obscured by clouds during these three days, but no rain fell. The results are given as before, in tabular form, as follows:

9602

UPPER STATION (MORRIS).

Hour.	No. Colonies per cc.	Turbidity (Hazen's scale).	Temp. Water °C.	Chlorine (parts per million)
7:15 a. m. Right Bank	433,000	.153	7.	....
" Center	337,000	.13	7.	....
" Left Bank	30,000	.046	7.	....
11:30 a. m. Right Bank	177,000	.17	7.25	67.5
" Center	145,000	.18	7.25	47.5
" Left Bank	17,000	.02	7.25	8.
2:00 p. m. Right Bank	174,000	.15	3.	....
" Center	131,000	.135	3.	....
" Left Bank	49,000	.05	3.	....

MIDDLE STATION (SENECA).

Hour.	No. Colonies per c. c.	Turbidity (Hazen's scale).	Temp. Water °C	Chlorine (parts per million).
9:00 a. m., Nov. 10 Right Bank	134,000	*Less than .09 more than .07	9.5	51
" " Center	47,000		9.5	44
" " Left Bank	23,000		9.5	35
1:30 p. m., Nov. 10 Right Bank	67,000	....	11.	....
" " Center	52,000	....	11.	....
" " Left Bank	52,000	....	11.	....

*Turbidity readings could not be taken accurately at this point and at Ottawa owing to presence of water weeds.

LOWER STATION (OTTAWA).

Hour.	No. Colonies per c. c.	Turbidity (Hazen's scale).	Temp. Water °C	Chlorine (parts per million).
10:00 a. m., Nov. 11. Right Bank	11,000	Less than .04	9.5	49
" " Center	10,500		9.5	46
" " Left Bank	3,900		9.5	43
1:00 p. m, Nov. 11. Right Bank	12,000	....	9.5	....
" " Center	11,000	....	9.5	....
" " Left Bank	18,000	....	9.5	....

The averages are as follows:

	Distance from Morris.	No. Colonies per c. c. Right Bank.	Center.	Left Bank.	No. of Hourly Analyses.
Upper Station (Morris).....	......	261,000	204,000	29,000	3
Middle Station (Seneca)....	12 miles. 24 hours.	100,000	49,000	35,000	2
Lower Station (Ottawa)....	24 miles. 48 hours.	11,500	10,700	13,500	2

9603 During this flow of 24 miles therefore, the Illinois river became nearly free from the great mass of sewage bacteria with which it was originally laden. In fact the bacterial content of the Illinois at Ottawa on this date was not greatly in excess of that of the local tributary streams.

In connection with this series of bacterial determinations may be given the averages of the regular chemical determinations made at the laboratory in Chicago during the period between October 23rd and November 20th, 1899. These determinations, which follow, show that a considerable degree of nitrification takes place in the river between these two points, as witnessed by the increase in the amount of nitrites and nitrates, the diminution in free and especially in the albuminoid ammonia.

9604

Station.	No. Determinations.	Residue on Evaporation. Total.	Dissolved.	Suspended.	Oxygen Consumed. Total.	By Dissolved Matter.	By Suspended Matter.
Morris	5	398	380	18.	10.7	8.4	2.3
Ottawa ...	5	356	353.5	2.5	7.5	7.3	.2

Nitrogen as Free Ammonia.	Albuminoid Ammonia. Total.	Dissolved.	Suspended.	Nitrites.	Nitrates.
7.98	.860	.478	.382	.028	.340
6.6	.364	.315	.049	.382	.648

9605 A third series of similar observations was made between these same points on May 24th, 25th and 26th, 1900. The sun was partially obscured on May 25th, but shone brightly on May 24th and 26th. No precipitation occurred during the period.

The results follow as before, in tabular form:

9606

UPPER STATION (MORRIS).

Hours.		No. Colonies per c. c.	Temp. Water °C.	Chlorine. (Parts per million).
7:30 a. m., May 24.	Right Bank	45,000	15.5	20
“ “	Center	74,000	17.5	13
“ “	Left Bank	42,000	18.	8
9.30 a. m., May 24.	Right Bank	60,000	15.5	....
“ “	Center	34,000	17.	....
“ “	Left Bank	39,000	18.	....
11:30 a. m., May 24.	Right Bank	98,000	15.75	....
“ “	Center	62,000	17.	....
“ “	Left Bank	30,000	18.	....
*2 p. m., May 24.	Right Bank	70,000	16.	21
“ “	Center	63,000	17.	14
“ “	Left Bank	48,000	18.	6

*Samples were taken at this time and submitted to chemical examination with the following result:

	Right Bank.	Center.	Left Bank
Total residue on evaporation	232	246	308
Dissolved residue on evaporation	230	244	285
Suspended residue on evaporation	2	2	23
Chlorine	21	14	6
Oxygen consumed—Total	6.6	7.2	8.8
Oxygen consumed by dissolved matter	6.1	6.0	4.7
Oxygen consumed by suspended matter	.5	1.2	4.1
Free ammonia	2.28	1.08	.24
Albuminoid ammonia—Total	.256	.296	.240
Albuminoid ammonia—Dissolved	.224	.224	.168
Albuminoid ammonia suspended	.032	.072	.072
Nitrites	.072	.050	.040
Nitrates	.4	1.1	.95

MIDDLE STATION (SENECA).

Hours.		No. Colonies per c. c.	Temp. Water °C.	Chlorine. (Parts per million).
7.30 a. m., May 25	Right Bank	13,800	16.5	19.5
" "	Center	11,700	....	16
" "	Left Bank	4,100	....	13
9:30 a. m., May 25	Right Bank	12,700	17	....
" "	Center	14,000	....	....
" "	Left Bank	16,000	....	....
11:30 a. m., May 25	Right Bank	4,500	17.5	....
" "	Center	4,100	....	....
" "	Left Bank	3,000	....	....
1:30 p. m., May 25.	Right Bank	5,500	18.5	16
" "	Center	6,700	18.8	15
" "	Left Bank	13,100	19.7	12

LOWER STATION (OTTAWA).

Hours.		No. Colonies per c. c.	Temp. Water °C.	Chlorine. (Parts per million).
8:30 a. m., May 26.	Right Bank	7,400	18.5	15
" "	Center	10,000	18.5	14
" "	Left Bank	8,300	18.5	13
11:00 a. m., May 26.	Right Bank	8,100	19.	17
" "	Center	6,800	19.2	15
" "	Left Bank	6,400	19.2	14
2:00 p. m., May 26.	Right Bank	9,000	19.5	17
" "	Center	6,300	19.5	16
" "	Left Bank	4,200	20.	14

	Distance from Morris.	No. Colonies per c. c. Right Bank.	Center.	Left Bank.	No. of Separate Analyses.
Upper Station (Morris)...	......	68,200	58,200	39,800	4
Middle Station (Seneca)..	12 miles.	9,100	9,100	10,300	4
Lower Station (Ottava)..	24 miles.	8,200	7,700	6,300	3

9607 This last series of determinations shows that on May 24th, 25th and 26th, 1900, the mixing of the Kankakee and Desplaines rivers at Morris was more complete than on November 9th, 10th, and 11th, 1899. They also show a smaller number of bacteria per cubic centimeter of the water at this time. A diminution in the number of bacteria, however, similar to that noted in the earlier series takes place during the flow from Morris to Ottawa, and there are fewer bacteria per cubic centimeter as shown by the colony count at Ottawa during this period in 1900, than in November, 1899.

I see no escape from the conclusion that in this flow of approximately 24 miles, the Illinois river which at Morris contained a large number of bacteria in all probability derived more or less directly from the sewers of Chicago freed itself from these bacteria to a remarkable and impressive degree in a short distance and in a relatively short space of time. The probable reason for the high mortality among bacteria in this particular stretch of the river will be discussed in another connection.

I should like to state that these three series of observations upon the water of the Illinois river between Morris and Ottawa are not the only series that I have made between
9608 May 1899 and June, 1900.

Q. What other observations have you made professor?

A. I have made several other series of observations between Morris and Ottawa of the same character as those just described. The samples were collected in the same way, the experiments in each case being conducted by my chief assistant, Mr. Irons, and myself.

Q. When were the subsequent experiments made?

A. Between July, 1899 and June, 1900.

Q. That is between Morris and Ottawa?

A. Between Morris and Ottawa.

Q. Can you give the dates?

A. One of these was on September 2nd, 1899. I have memoranda of the others with my papers at the University.

Q. Professor, will you describe how these samples were taken from which the foregoing analyses that have been introduced in evidence were made, and the conclusions drawn?

A. These samples were taken from a row-boat. The floats and flourescein introduced into the water were followed down stream in the boat, so that it was possible to determine very closely the passage of a given body of water from one point to another, the object of the experiment being to observe the changes in one and the same mass of water flowing from
9609 point to point. This was true of the collections of water samples made immediately below Morris; the collections made at Seneca and at Ottawa were also made from a boat at regular intervals, but the entire body of water was not fol-

lowed the whole distance from Morris by boat, the approximate time necessary for the passage of the water from Morris to Seneca, and from Seneca to Ottawa being determined and hourly examinations made at the lower points.

Q. Professor, did you make any cross section experiments at Wesley City?

A. Yes sir. On several occasions cross sections were taken at Wesley City below Peoria to determine the amount of mixing at this point.

Q. When were these experiments made?

A. One of these, of which I have a record here, was made on June 13th, 1900. It gave the following result:

	Free ammonia.	Albuminoid ammonia.	No. of colonies per c. c.
Right bank,	.504	.864	4,340,000
Center,	.144	.248	40,000
Left bank,	.168	.240	2,400

This cross section was not made by me personally, but by Mr. Irons, in pursuance of my directions.

9610 The large amount of pollution entering the river at Peoria on the right bank of the river is clearly shown in this sample. The free ammonia, the albuminoid ammonia, and the number of bacteria per cubic centimeter being immensely greater than on the left bank of the stream. Slight changes in the position of sand-bars and in the height of water deflect the main mass of pollution now to one side, of the stream, now to the other, and so lead to the sudden and marked fluctuations in the analyses which the detailed tables show to be so characteristic of the samples obtained from this point.

Q. Did you make a cross section investigation at Grafton?

A. Yes, on a number of occasions both in 1899 and in 1900, cross-sections were taken of the Illinois river at Grafton. These cross-sections at Grafton dealt simply with the number of bacteria per cubic centimeter. In general it may be said that the results obtained from samples taken midway between the banks of the streams and the center were not materially different from those taken from the center of the stream, mixing of the bacteria, so far as these determinations go, being complete at this point. Slight variations were however, sometimes noticed, the number being sometimes higher in the center than on the sides; sometimes higher on the sides than in the center.

Q. What sanitary significance do you attach to the experiments conducted by you at Morris which have been testi-
9611 fied to by you in evidence?

A. These observations upon the bacterial content of the Illinois river between Morris and Ottawa indicate in my judgment that a very large proportion of the bacteria entering the Desplaines river from the Illinois and Michigan canal and from the Chicago drainage canal do not survive to reach Ottawa. From a sanitary point of view this observation would seem to be of importance in that it renders less probable the passage of disease germs down the river, as far as this point. Since these sewage bacteria disappear in such numbers, it is in my opinion, fair to assume that the various non-spore forming pathogenic bacteria entering the Chicago sewage, die out at least in the same proportion.

MR. JEFFRIES: The opinion of the witness being based solely upon the result of the last experiment just detailed in evidence, I move to strike it out for the reason that the analyses so made were so limited that no reliable conclusions can be drawn therefrom, which would cover all periods, conditions and circumstances, surrounding the Illinois river at the point in question, and characterizing the sanitary condition of that water during the various periods, and at maximum and minimum conditions of pollution and infection, as well as the temperature of the water and the atmosphere at all times.

9612 Q. MR. TODD: In giving the latter part of your opinion, have you taken into account any other knowledge that you possess except the knowledge gained from this experiment?

MR. JEFFRIES: I object to the question for the reason that the witness' opinion is based upon the preceding question and had reference solely to the result of the bacterial analyses of that water and the question just asked the witness partakes of the nature of a question in cross-examination. It is therefore incompetent and improper.

Q. (Question repeated):

A. In giving the last opinion I am of course obliged to take into consideration all the knowledge that I possess on the life of pathogenic germs and their relation to sewage bacteria. I regard however, these observations upon the bacterial content of one and the same body of water as re-inforcing in a remarkable manner all that I have been able to learn in other ways regarding the life of bacteria introduced into water with sewage.

Q. Did you make any determinations for the bacillus coli communis?

A. Yes sir, I did.

9613 Q. Covering what period of time?

A. I have made several series, the first covering the period between May, 1899 and June, 1900.

Q. At what points were these determinations made?

A. These were made upon samples of water collected from the Illinois and Michigan canal at Lockport.

From the drainage canal at Kedzie Avenue.
From the drainage canal at Lockport,
From the Desplaines river at Lockport.
From the Kankakee river at Wilmington.
From the Illinois river at Morris.
From the Fox river at Ottawa.
From the Illinois river at Ottawa.
From the Big Vermillion river at LaSalle.
From the Illinois river at LaSalle.
From the Illinois river at Henry.
From the Illinois river at Averyville.
From the Illinois river at Wesley City.
From the Illinois river at Havana.
From the Sangamon river at Chanderville.
From the Illinois river at Grafton.
From the Mississippi river at Grafton.
9614 From the Mississippi river at Alton, a cross-section.
From the Missouri river at West Alton.
From the Mississippi river at intake tower of St. Louis waterworks.
St. Louis tap water.

Q. Were these examinations made from the same samples sent by the same water takers from these different places as heretofore testified by you in evidence

A. Yes sir; in the tables containing the results of these determinations, this fact is indicated by the serial number accompanying each determination.

9615 Q. Have you a list of tables prepared showing bacillus coli communis determinations?

A. I have.

Q. Were these tables prepared in the same manner as the other tables which you have testified to as to the chemical and bacterial analyses that have been introduced?

A. They were.

Q. Will you give the characteristics of the bacillus coli communis?

A. The bacillus coli communis, or the colon bacillus is, as its name implies, a bacterium inhabiting in large numbers that portion of the alimentary tract known as the colon. It is the bacillus commonly found in this situation.

The colon bacillus grows readily upon the ordinary culture media used in the bacteriological laboratory, in beef tea, upon nutrient beef jelly, made with gelatin and agar; upon potato and in milk. On all these food substances it thrives luxuriantly, producing in many cases characteristic growth effects and chemical changes.

The colon bacillus is one of the rod-shaped bacteria and is sluggishly motile. It is not known to form spores.

Q. Where else in nature is this bacillus coli communis found, except in the colon in man?

9616 A. It is found in the intestinal discharges not only from man, but from many other of the higher animals; it is found also in waters and soils contaminated with animal excreta. It is found sometimes in the dust of streets. Its occurrence in this situation being probably due to the presence of horse droppings. It is sometimes, though but rarely, found in the air, in pure water and in the deeper layers of soil it is found if at all, in very small numbers.

Q. What is the relationship of the bacillus coli communis to the bacillus typhosus?

A. The colon bacillus is exceedingly similar to the typhoid bacillus in many of its morphological and biological characters,

In shape, size, motility, lack of spore formation, it resembles the typhoid bacillus so closely that the most experienced bacteriologists have difficulty in distinguishing between these two organisms on the basis of the characters just enumerated. The growth of these two organisms upon beef broth and gelatin agar, is again so similar that by these characters alone it is not possible to distinguish between the two microbes. The typhoid bacillus and the colon bacillus in fact, belong to a group of bacteria, including a large number of bacteria both pathogenic and
9617 non-pathogenic. The different members of this group, which is known among bacteriologists as the colon typhoid group, differ from one another by relatively slight biological peculiarities. While the typhoid bacillus and the colon bacillus are thus intimately related, there are, nevertheless certain constant characteristics which enable an experienced observer to distinguish between the two forms. Some of the main points of difference are, that the colon bacillus is able to ferment dextrose with gas production, while the typhoid bacillus, although producing acid from dextrose, is not known under any circumstances to produce gas; when grown in milk the colon bacillus produces acid from the milk sugar, curdling the milk. The typhoid bacillus is not able to do this.

These are some of the fundamental distinctions between these two germs. The colon bacillus is in every respect more hardy than its near relation the bacillus typhosus.

In comparative tests that have been made on the relative viability of the bacillus coli, and the bacillus typhosus under certain conditions, the following facts have been demonstrated:

1. As regards sand filtration with the water to which both species have been added, 99.9 per cent of all the bacillus
9618 coli and 100 per cent of the bacillus typhosus were removed by an intermittant filter, and 99.8 per cent of bacillus coli and 99.9 per cent of bacillus typhosus by a continuous filter.

2. As regards the persistence of the two organisms in a filter after infection of the applied water has ceased, bacillus coli was found to continue in the effluent from the intermittent filter for 24 to 36 hours, and the bacillus typhosus only for two to three hours. With the continuous filter the bacillus coli

continued for forty-six days, and the bacillus typhosus for two days.

3. The effect of cold without freezing. In a water subjected to a temperature of 33 degrees Fahrenheit, about 90 to 95 per cent of both species were destroyed within 24 hours. A few organisms of each, however, may live for a considerable number of days.

4. Elimination by freezing and viability in ice. About 50 per cent of the bacillus coli and 75 per cent of the bacillus typhosus, were destroyed by fifteen minutes freezing, after one hour, 95 per cent of the bacillus coli and 98 per cent of the bacillus typhosus were killed, and at the end of 24 hours over 99 per cent of all the organisms had disappeared.

5. Resistance to heat. Both species resisted temperatures
9619 up to 45 degrees for five minutes. And between 45 and
55 degrees centigrade, all but a few individuals of each are destroyed. These few individuals however, resisting temperature up to 85 degrees centigrade, at which temperature all organisms of both species were destroyed.

As bearing further on the question of the relative resistance of these two organisms I may state that some experiments were made by me some years ago a report of which is printed in the Medical News on September 28th, 1895, in which it was found that the typhoid bacillus when introduced into sterilized Lake Michigan water, does not multiply, but may under certain conditions, maintain its vitality for upwards of 93 days. The colon bacillus on the contrary, under the same conditions, undergoes rapid multiplication and may remain alive for upward of 263 days.

ADJOURNED until 2:00 P. M. same day, Wednesday, December 2nd, 1903.

RECORD

The State of Missouri

vs.

The State of Illinois

and

Sanitary District of Chicago

VOL. 7

1272
S.6.

IN THE

Supreme Court of the United States

THE STATE OF MISSOURI
vs.
THE STATE OF ILLINOIS
and
THE SANITARY DISTRICT OF CHICAGO.

Original,
Docket No.

Before
FRANK S. BRIGHT,
Commissioner of the Supreme Court of the United States.

VOLUME 7.

A–375a

VOLUME 7.

2:00 P. M., Wednesday, December 2nd, 1903.

9620 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN,

resumed the stand for further direct-examination by Mr. Todd and testified as follows:

(Witness continues answer begun before adjournment).

From the facts just enumerated, it is clear that while the colon bacillus resembles in many important particulars the typhoid bacillus, it is under all conditions in which the viability of these two organisms has been compared a more hardy and more resistant organism. Its longevity under adverse conditions is greater than that of the typhoid bacillus. This fact, and the ease with which it is isolated and identified, combine to render it a particularly significant organism from a sanitary point of view.

Q. What is the significance of the bacillus coli communis in sanitary water analyses?

A. Owing to the fact that bacillus coli communis leaves 9621 the human body in large numbers in feces, it is one of the prevailing forms in fresh sewage. For this reason the presence and relative abundance of bacillus coli communis in water is regarded as one of the most delicate, precise and altogether significant indications of recent sewage pollution.

As an illustration of the way in which the presence of this organism can be used for demonstrating the existence of pollution of a dangerous character, I may cite from a paper upon Municipal Water Supplies, and Their Examination, by Dr. William G. Bissell, of Buffalo, New York, bacteriologist of the

Department of Health in Buffalo. This paper was printed in the Philadelphia Medical Journal August 30th, 1902.

"Two samples were prepared, each representing one-half gallon of water, one was a sample of water from the Niagra river taken from the tap at Buffalo after it had passed through a sterilized filtering stone of a Pasteur Chamberland filter. To this sample there was added a small proportion of salt. The other was a sample of Niagra river water collected at Niagra Falls (and in which it was easy to demonstrate the colon bacillus in cubic centimeter amounts of the sample) into which there was introduced a small aount of human excreta. No data were sent with either sample, except that they were said to
9622 be river water." " 'Reports came back that the source from which the first sample was obtained was 'unsafe for use on account of the high percentages of chlorides" and that the second sample was 'wholesome for household use.'''

This illustration suffices to show that it is possible by means of the delicate test for colon bacilli to detect a degree of pollution which might be altogether missed by the use of less delicate and less precise methods.

So far as I have been able to discover, it is at the present time, the prevailing opinion among those bacteriologists who deal with sanitary water analysis that the test for the colon bacillus properly applied and interpreted, furnishes one of the most satisfactory clews to the sanitary condition of a water.

In this connection it should be emphasized that it is not so much the presence or absence of bacillus coli communis in a large quantity of water that is significant as it is the relative abundance of this micro-organism.

I will cite a statement from a recent monograph bearing upon this matter. This monograph is by Dr. William G. Savage, lecturer on bacteriology, University College, Cardiff, Wales; bacteriologist to the Cardiff County Public Health Labora-
9623 tory. The article is entitled: "The Significance of the bacillus coli in drinking water." and appeared in the Journal of Hygiene, 1902, Volume 2, page 320, edited by Professor George H. F. Nuttall, and published by the Cambridge University Press. This author gives extended tables of the examinations of waters from various sources for their content in colon bacilli.

On page 321, the author states that

"In such an investigation the three following points must in my opinion always be kept in view:

1. That it is not so much the presence of B. coli which is of possible value but the number present. The consideration of the problem is essentially quantitative, and the number of B. coli in a standard amount of water must be considered. This view is insisted upon by many English bacteriologists, and there can be no doubt of its vital importance in studying the question."

In his conclusions on page 338, the writer states that

"The number of B. coli present is an essential factor but arbitrary standards of the number of this organism allowable per liter, are of but little value, and are fraught with considerable possibilities of error, unless the particular kind
9624 of water and the local conditions are considered in every case."

In further support of the view already expressed as to the significance of bacillus coli in water supplies, I may cite a report of a committee of the American Public Health Association presented at the Washington meeting of this association October 26th to 30th, 1903. An abstract of this report being printed in the Journal of the American Medical Association for November 21st, 1903, page 1292.

This report of the committee on the significance of bacillus coli in water supplies was presented by the Chairman, Professr S. C. Prescott, Assistant Professor of Biology at the Massachusetts Institute of Technology. The abstract is in part as follows:

"To present a statement of the opinion of the committee individually and as a whole, as probably representing the generally accepted views of sanitary bacteriologists as to the significance of B. coli in water, the following questions were sent to each member; the answers appended, except as otherwise stated, were practically as given below:

1. In view of the fact that numerous investigators have found B. coli in nature where it could not be directly traced to sewage or fecal pollution, do you believe that the colon
9625 test of water is as safe an index of pollution as it was formerly regarded to be?

Yes sir.

2. Are you of the opinion that the number of colon bacilli rather than their presence, should be used as a criterion of recent sewage pollution?

Yes.

3. To pronounce a water sewage polluted, would you require as evidence that B. coli was present in a majority of one cubic centimeter samples?

Yes, in general."

These opinions or the opinions expressed by these writers coincide with my own experience based on a considerable number of examinations for the presence of bacillus coli communis. It is my judgment that the relative abundance rather than simple presence of this organism should be considered in sanitary water analysis.

I may add furthemore, that my own opinion as to the significance of the abundance of bacillus coli communis in the waters of a flowing stream, has been greatly strengthened by some recently published investigations in a report on water purification investigation, and on plans proposed for sewerage and waterworks systems published by the sewerage and water board of New Orleans, Louisiana, 1903.

9626 The work included in this report has been largely carried out under the supervision of Mr. G. W. Fuller, of New York, who I understand has already testified as a witness in this case.

I quote from page 47 of this report, paragraph headed "Bacillus coli Communis:"

"In waters which contain unpurified sewage, the test for this intestinal organism is of the utmost importance. In the Mississippi river at New Orleans, however, there is evidently so much self-purification effected by natural agencies, such as dilution, sedimentation, etc., that this normal intestinal bacillus was one of the least common of the forms isolated. In about 100 tests with volume of water varying from one to 300 cubic centimeters, its presence was demonstrated only three times, although the larger samples of water were concentrated in a centrifuge before being seeded into the media contained in fermentation tubes."

The remarkable fact that bacillus coli communis was discovered only rarely in the water of the Mississippi river at

this point even when large amounts of water were tested, illustrates the condition that is likely to prevail in a river water of this character when protected from the entrance of
9627 polluting matters during a considerable part of its course.

I quote further from page 49 of this New Orleans report:

"From what goes before, it will be seen that the Mississippi river at New Orleans as evidenced by the data obtained during this investigation is unusually pure from a sanitary standpoint. For instance, it is believed that if 100 cubic centimeter samples of water were taken from the Merrimac, at Lawrence; the Hudson below the Mowhawk, the Schuylkill, the Potomac, the Ohio at Cincinnati, they would show the presence of bacillus coli communis as a rule. Such is not the case with the Mississippi river water at New Orleans, because as stated above, the opportunities for natural purification are so great during the last few hundred miles of its flow, and the amount of additional pollution received, is so small in comparison to the discharge of the river, that the bacteria which one is accustomed to consider to be the normal inhabitants of surface water effectually crowd out those abnormal bacteria which are carried into the river with the drainage from populated and cultivated areas. It must also be remembered that the banks of the Mississippi above New Orleans are protected by levees. These levees also in turn protect the river from contamination, except where sewers exist..
9628 Since it is usually more convenient for the towns immediately above New Orleans to carry their drainage away from the river almost no local pollution exists."

It is in my opinion certainly a striking and highly remarkable circumstance that the Mississippi river at New Orleans after receiving countless millions of colon bacilli contributed by the cities of the Ohio, Illinois, Mississippi and Missouri valleys, together with those on the many tributary streams and bearing in mind the facts already instanced as to the relatively high longevity of the colon bacillus, should show itself so nearly free from organisms of this class.

This condition furnishes a singular confirmation of the views that have been expressed regarding the sanitary significance of this organism when found in water supplies.

MR. JEFFRIES: I move to strike out all that the witness has read into the evidence from various publications, for the reason that the same is incompetent, and for the further reason that the evidence of the persons writing the articles is the best evidence and their production upon the witness stand should be had in order to give complainants an opportunity to 9629 cross-examine them with reference to the statements made or purported to have been made by them as detailed in evidence by this witness.

Q. MR. TODD: Will you state the methods employed by you in the determination made for the bacillus coli communis?

A. Two methods were employed in these determinations, one consisting in the mixing of a measured quantity of the water sample with broth containing a small amount of carbolic acid. Incubation of this broth was then resorted to and the resulting growth plated out on litmus lactose agar. The red colonies that developed resulting from the fermentation of the lactose, were picked from the plate and studied in regard to further characteristics. This method may be briefly designated as the carbol-broth method.

A second method which may be denominated the fermentation tube method, was also employed in a considerable portion of the work. This method consisted in inoculating a measured quantity of the water into Dextrose broth fermentation tubes (photographs of these fermentation tubes will be subsequently shown).

The use of the fermentation tube depends upon one of the most characteristic properties of the colon bacillus, namely its ability to produce gas by the fermentation of grape sugar. 9630 In some cases plates were made from the tubes showing gas production, and the colonies that developed were studied in detail, and complete identification arrived at. Throughout a large part of the work, however, the adoption of a more speedy method was rendered necessary by the large number of water samples to be examined, and what is known as the presumptive test for the presence of the bacillus coli was applied. The interpretation that I have adopted for this presumptive test is as follows:

Positive reactions—that is those indicating the presence of B. coli were regarded as those tubes showing gas production amounting to over 20 per cent of the tube length, the tubes yielding on absorption hydroxide with sodium, a gaseous residue appreciably in excess of the carbon dioxide absorbed. Negative reactions were those showing:

(a) No gas production, or

(b) gas production less than ten per cent of the tube length.

The doubtful class was made to include:

(a) those tubes yielding only ten to twenty per cent of gas. and

(b) those yielding more than twenty per cent with an ap-
9631 preciable excess of carbon dioxide. Any method susceptible of rapid application, like the one just outlined, leads to occasional misinterpretation, but the following data indicate that where a large number of water samples are treated, the error is not unduly large. The organisms were isolated from a series of 63 fermentation tubes and studied in detail, and complete identification was arrived at. The results summarized, were as follows:

In 39 cases the interpretation was positive, and a typical bacillus coli communis, responding to the most rigorous bacteriological tests, was isolated.

In 7 cases where the interpretation was positive, bacillus coli was not isolated. At least part of these and in my opinion probably all of these negative results were due to the fact that the colon bacillus originally present in the tube was overgrown by other forms and so missed at the plating; that this often occurs when the fermentation tube stands too long is well known to sanitary water analysts.

In 9 cases where the interpretation was doubtful, the bacillus coli was not isolated.

In 4 cases, where the interpretation was doubtful the typical bacillus was isolated.

9632 In 4 cases, where the interpretations were negative, bacillus coli was not isolated, and in addition, some twenty tubes were examined which showed growth in the closed arm, but yielded no gas producing organisms of any kind.

Such a presumptive test must always be open to the possibility of occasional misinterpretation, but in view of the data just cited, I cannot believe that the margin of error from this source is so great as to vitiate in any degree the results obtained.

In support of my opinion as to the value and importance of the presumptive test for the presence of the bacillus coli in water, I may cite some conclusions in a paper by Mr. George C. Whipple, of Brooklyn, who I understand has already testified as a witness in this case. The paper is entitled "On the Practical Value of presumptive tests for Bacillus Coli in Water." It was printed in the "Technology Quarterly, published at the Massachusetts Institute of Technology", volume 16, No. 1, March, 1903. I quote from page 31:

"The methods necessary for the certain identification of bacillus coli in water involved technique so complicated and so time consuming that they are not practical as working tests in connection with the supervision of water supplies.

9633 2. The fermentation of Dextrose broth as first suggested by Dr. Theobald Smith, furnishes the most rapid and most practical test for the presence of bacillus coli in water.

3. The extension of this test to cover different quantities of water in the same samples, thus making the test quantitative, within limits as well as qualitative, greatly enhances its value.

5. But whether or not bacillus coli is simply an intestinal germ, the fermentative test described above is a useful test to determine the sanitary quality of water and is one which gives results that agree well with chemical and biological analyses."

At another point in this same paper, page 22, Mr. Whipple says:

"Speaking broadly the typical reactions offer satisfactory presumptive evidence of the presence of this species (B. coli-communis) or species very closely allied to it. In a subsequent paper I hope to give the data to support this assertion, but at this time will offer as corroborative testimony, the statement of Mr. Irons, who in his paper on some observations of 9634 methods for the detection of the bacillus coli communis in water, states:

"When the Dextrose tube yields approximately 33 per cent of carbon dioxide, bacillus coli communis is almost invariably present."

The work of Mr. Irons here referred to was done in my laboratory in connection with the analyses that are now being considered.

9635 From all my experience upon the value of presumptive tests for B. coli, I am obliged to believe that this test is of high value in sanitary water analysis, and enables conclusions to be drawn as to the presence or absence of the colon bacillus which are in the main thoroughly satisfactory and decisive.

Q. The table of colon determinations which you have prepared regarding the preparation of which you testified to, cover what period of time?

A. They cover determinations made upon samples of water collected between May, 1899 and the end of June, 1900.

Q. From what places were the samples of water collected and by whom, for the colon determination, as evidenced by the tables which you have prepared?

A. These determinations were made from the bacteriological samples collected by the same water takers and at the same times as heretofore specified in my testimony. The colon determinations cover the samples obtained from the following stations:

Illinois and Michigan canal, Lockport,
Drainage canal, Kedzie Avenue,
Drainage canal, Locgkport,
9636 Desplaines river, Lockport,
Kankakee river, Wilmington,
Illinois river, Morris,
Fox River, Ottawa,
Illinois river, Ottawa,
Big Vermillion river, LaSalle,
Illinois river, LaSalle,
Illinois river, Henry,
Illinois river, Averyville,
Illinois river, Wesley City,
Illinois river, Havana,
Sangamon river, Chandlerville,
Illinois river, Grafton,
Mississippi river, Grafton,
Mississippi river, Alton, cross-section,
Missouri river, West Alton,
Mississippi river, Intake tower, St. Louis waterworks, Mitchell.
St. Lous tap water.

The chemical and bacterial determinations corresponding with these colon determinations, may be found by reference to the serial number and date.

9637 Q. Will you produce and read table No. 1?

A. Yes. It is as follows:

TABLE I.

(Illinois and Michigan Canal, Lockport.)

Serial	Date.	.00001 c. c.			.0001 c. c.			.001 c. c.			.01 c. c.			.1 c. c.		
Number.	1899.	+	—	?	+	—	?	+	—	?	+	—	?	+	—	?
523	Aug. 29.	..	..	..	..	..	..	..	..	..	1	0	..	1	0	..
876	Oct. 31.	..	..	..	4	0	..	2	0	..	..	..	..	..	..	..
914	Nov. 7.	0	4	..	1	0	1	..	..	..	..	..	..	..	..	..
950	Nov. 14.	2	2	..	1	0	1	..	..	..	..	..	..	..	..	..
982	Nov. 21.	1	1	..	4	0	..	..	..	..	..	..	..	..	..	..
1011	Nov. 28.	0	2	..	2	1	1	..	..	..	..	..	..	..	..	..
1042	Dec. 5.	0	0	1	1	0	1	..	..	..	..	..	..	..	..	..
1072	Dec. 12.	0	2	..	2	1	1	..	..	..	..	..	..	..	..	..
1110	Dec. 19.	0	2	..	3	0	1	..	..	..	..	..	..	..	..	..
1146	Dec. 28.	0	2	..	4	0	..	..	..	..	..	..	..	..	..	..
	1900															
1168	Jan. 3.	0	2	..	2	2	..	..	..	..	..	..	..	..	..	..
1199	Jan. 9.	0	2	..	3	1	..	2	0	..	..	..	..	..	..	..
1239	Jan. 16.	1	0	..	2	0	..	..	..	..	..	..	..	..	..	..
1269	Jan. 23.	0	4	..	4	0	..	..	..	..	..	..	..	..	..	..
1303	Jan. 30.	0	4	..	1	3	..	..	..	..	..	..	..	..	..	..
1334	Feb. 6.	0	2	..	2	2	..	..	..	..	..	..	..	..	..	..
1457	Mar. 6.	0	4	..	1	3	..	..	..	..	..	..	..	..	..	..
1493	Mar. 13.	0	2	..	2	1	1	1	0	..	..	..	..	..	..	..
1522	Mar. 20.	..	..	..	1	2	..	1	2	..	..	..	..	..	..	..
1563	Mar. 28.	1	2	..	3	0	..	..	..	..	..	..	..	..	..	..
1597	Apr. 3.	0	3	..	1	2	..	..	..	..	..	..	..	..	..	..
1636	Apr. 10.	1	1	..	2	0	..	..	..	..	..	..	..	..	..	..
1675	Apr. 17.	0	2	..	0	1	1	1	0	..	..	..	..	..	..	..
1717	Apr. 24.	1	0	..	1	1	..	0	0	1	..	..	..	..	..	..
1753	May 2.	0	1	..	0	2	..	1	0	..	1	0	..	..	..	..
1786	May 8.	0	1	..	1	0	..	2	0	..	1	0	..	..	..	..
1817	May 15.	0	1	..	1	0	..	1	0	..	..	..	..	..	..	..
1856	May 22.	1	1	..	1	0	1	..	..	..	..	..	..	..	..	..
1895	May 29.	0	2	..	1	1	..	..	..	..	..	..	..	..	..	..
1923	June 5.	0	2	..	1	0	1	..	..	..	..	..	..	..	..	..
1959	June 12.	0	2	..	2	0	..	..	..	..	..	..	..	..	..	..
2000	June 19.	..	..	..	0	1	..	0	1	..	1	0	..	1	0	..
2032	June 26.	..	..	..	0	2	..	0	2	..	..	..	..	..	..	..

9638 Q. Will you explain the results shown in this table, and their sanitary significance?

A. Table No. 1 contains the results of colon determinations made upon samples of water from the Illinois and Michigan canal at Lockport, between August 29th, 1899 and June 26th, 1900. Owing to the large numbers of colon bacilli present in the water of this canal, it was found necessary to examine small quantities of water.

The numbers at the head of the five columns indicate quantities of water used in the several tests, namely, .00001 of a cubic centimeter; .0001 of a cubic centimeter; .001 .01 of a cubic centimeter and .1 of a cubic centimeter.

The sewage was diluted in each case by mixing with exactly measured quantities of sterilized water, one cubic centimeter of the dilution being added to the fermentation tube.

The signs "plus" "minus" and "interrogation point" in each column have reference to the positive, negative or doubtful outcome of the test. The criteria upon which these tests have been based have been already explained in detail. The table shows that in this highly polluted water the bacillus coli was *occasionally* present in so small an amount of water as
.0001 of a cubic centimeter, and that it was *usually* pres-
9639 ent in so small an amount of water as .0001 of a cubic
centimeter.

Q. Will you produce and read table I. B.?

A. Yes sir. It is as follows:

TABLE I-B.

(Drainage Canal, Kedzie Avenue.)

Serial	Date.	.00001			.0001			.001			.01 c. c.			.1 c. c.		
Number.	1900.	+	—	?	+	—	?	+	—	?	+	—	?	+	—	?
1789	May 8.	0	1	..	0	1	..	2	0	..	1	0	..	..	..	..
1816	May 15.	0	1	..	0	1	..	0	1	..	..	..	..	..	..	..
1850	May 21.	..	..	..	0	1	..	0	2	..	0	1	..	..	..	..
1889	May 28.	..	..	..	0	1	..	0	2	..	0	1	..	..	..	..
1922	June 4.	..	..	..	..	..	..	0	0	1	1	0	..	2	0	..
1955	June 11.	..	..	..	0	0	1	2	0	..	1	0	..	1	0	..
1992	June 18.	..	..	..	1	0	..	1	0	..	1	0	..	1	0	..
2027	June 25.	0	1	..	0	2	..	0	1	..	0	0	1	..	..	..

Q. Will you explain the results shown in this table and 9640 their sanitary significance?

A. Table I B contains the results of colon determinations made upon samples of water taken from the drainage canal at Kedzie Avenue between May 8th and June 5th, 1900.

The greater dilution of the sewage in the drainage canal during this period as compared with the condition of the Illinois and Michigan Canal shown in table 1, is manifested by the comparatively rare occurrence of the colon bacillus in .0001 of a cubic centimeter of water, and its occasional absence, even when .001 of a cubic centimeter of the water was examined.

Q. Will you produce and read table I C?

A. Yes sir, it is as follows:

9641

TABLE I-C.

(Drainage Canal, Lockport.)

Serial	Date.	.00001			.0001			.001			.01 c. c.			.1 c. c.		
Number.	1900.	+	—	?	+	—	?	+	—	?	+	—	?	+	—	?
1677	Apr. 17.	..	..	..	0	1	..	0	1	1	1	0	..	..	..	..
1719	Apr. 24.	..	..	..	0	1	..	1	1	..	0	1	..	..	..	..
1755	May 2.	..	..	..	0	1	..	0	2	..	1	0	..	..	..	..
1788	May 8.	0	1	..	1	0	..	1	0	1	0	0	1	..	..	..
1819	May 15.	0	1	..	0	1	..	0	1	..	..	..	..	..	..	..
1858	May 22.	..	..	..	0	1	..	0	1	1	0	1	..	..	..	..
1896	May 29.	..	..	..	0	1	..	0	2	..	0	0	1	..	..	..
1925	June 5.	..	..	..	..	..	..	0	0	1	1	0	..	2	0	..
1961	June 12.	..	..	..	0	1	..	1	0	..	1	0	..	1	0	..
2002	June 19.	..	..	..	0	1	..	0	0	1	1	0	..	1	0	..
2034	June 26.	..	..	..	0	1	..	0	0	1	1	0	..	1	0	..

Q. Will you explain the results shown in this table and 9642 their sanitary significance?

A. Table I C contains the results obtained from the examination of samples taken from the drainage canal at Lockport between April 17th and June 26th, 1900. The dilution shown in the drainage canal at Kedzie Avenue is shown also in the drainage canal at Lockport, the colon bacillus being present in all the samples of .1 of a cubic centimeter that were examined, and in many of those of .01 of a cubic centimeter, but being almost invariably absent in those where .001 of a cubic centimeter was examined.

ADJOURNED until 10:00 A. M., Thursday, December 3rd, 1903.

9643 10:00 A. M., Thursday, December 3rd, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN,

resumed the stand for further direct-examination by Mr. Todd, and testified as follows:

Q. Will you produce and read table II of the colon determinations?

A. Yes, it is as follows:

9644

TABLE II.

(Desplaines River, Lockport.)

Serial Number.	Date, 1899.	.01 c. c.			.1 c. c.			1 c. c.		
		+	—	?	+	—	?	+	—	?
383	Aug. 1	..	..	..	0	1	..	0	1	..
418	Aug. 8	..	..	..	0	1	..	1	0	..
498	Aug. 22	..	..	..	0	1	..	..	..	..
527	Aug. 29	..	..	..	0	1	..	1	0	..
877	Oct. 31	..	..	..	1	0	..	..	..	..
915	Nov. 7	..	..	..	0	0	1	0	0	1
951	Nov. 14	..	..	..	0	1	..	0	0	1
1012	Nov. 28	0	3	..	0	2	..	..	..	..

9645 Q. Will you explain the results shown in this table and their sanitary significance?

A. Table 2 contains the results of colon determinations made upon the water of the Desplaines river between August 1st, and November 28th, 1899.

Q. Professor, I desire to call your attention to the testimony of Dr. Ravold. On page 150 of his testimony given in this case, Dr. Ravold testified that the colon bacillus was found in 72 per cent of the samples taken from the Bear Trap Dam at

Lockport, in the month of March, 1900, and at page 320 of his testimony he testified that the bacillus coli communis was found in 71 per cent of the samples collected from the St. Louis settling basins during the period from May 1st to October 31st, 1900. Would you infer from those statements that colon bacillus was present in the water of these settling basins in St. Louis in anything like the same proportion that it was in the water of the drainage canal at Lockport?

MR. JEFFRIES: I object to the question because it is leading and suggestive.

A. I certainly should not.

Q. Give your reasons?

A. It is very important in making the test for the colon bacillus, especially when a polluted water is being dealt
9646 with to use dilutions of the water high enough to prevent
the overgrowth of the colon bacillus by other sewage forms. I have frequently in my own experience, found that by the use of so large a quantity of water as one cubic centimeter of water, apparently negative results are obtained, while by examination of a smaller quantity of the same water, positive results invariably appear. The explanation for this phenonenon, which may prove very misleading, is that when a large quantity of a sewage polluted water is introduced into fermentation tubes, other forms of bacteria such as some of the anaerobic bacteria, are present. These overgrow the colon forms, leading to an apparently negative result, and thus completely obscuring the true interpretation. I have frequently encountered this difficulty in dealing with highly polluted waters, in using quantities as large as one cubic centimeter. It is my opinion that if the colon determination be carried out properly, with due regard to the difficulties here mentioned, the colon bacillus would be found to be present in every cubic centimeter of the water in the drainage canal. Indeed, my examinations have shown no fewer than several hundred colon bacteria per cubic
centimeter in the water of the drainage canal, and gener-
9647 ally, several thousands, while in the water of the Missis-
sippi river which is pumped into the settling basins at St. Louis, and in the tap water drawn from the tap in St. Louis, the number of colon bacteria never approximate anything like these figures.

For these reasons I am compelled to assume that the statements to which you refer are based on defective analytical methods, and do not indicate that the actual number of colon bacilli in the water of the drainage canal and in the St. Louis settling basins are at all comparable.

Q. Will you produce and read in evidence table III?

A. Yes, it is as follows:

9648

TABLE III.

(Kankakee River, Wilmington.)

Serial Number.	Date. 1899.	.1 c. c.			1 c. c.		
		+	—	?	+	—	?
415	Aug. 7	0	1	..	1	0	..
496	Aug. 22	1	0	..	..	..	..
528	Aug. 29	1	0	..	1	0	..
566	Sept. 4	0	1	..	1	0	..
875	Oct. 30	1	0	..	..	..	..
913	Nov. 6	0	0	1	0	1	..
981	Nov. 20	...	..	..	1	0	..

9649 Q. Will you explain the results shown in this table and their sanitary significance?

A. Table III contains the results of colon determinations made upon samples of water collected from the Kankakee river at Wilmington, between August 7th, and November 20th, 1899. They show that during this period the colon bacillus was frequently present in .1 of a cubic centimeter, and usually present in one cubic centimeter.

Q. Will you produce and read in evidence, table IV?

A. Yes, it is as follows:

TABLE IV.

(Illinois River, Morris.)

Serial	Date,	.0001 c. c.			.001 c. c.			.01 c. c.			.1 c. c.			1 c. c.		
Number.	1899.	+	—	?	+	—	?	+	—	?	+	—	?	+	—	?
879	Oct. 31.	..	..	..	2	1	..	2	0	..	..	..	..	..	..	..
917	Nov. 7.	..	..	..	2	1	1	2	0	..	..	..	..	..	..	..
962	Nov. 15.	0	2	..	3	0	..	3	0	1	..	..	..	..	..	..
985	Nov. 21.	1	2	..	2	3	..	3	0	..	..	..	..	..	..	..
1014	Nov. 28.	0	1	..	4	0	..	4	0	..	..	..	..	..	..	..
	1900															
1196	Jan. 7.	..	..	..	1	0	1	3	0	1	2	0	..	..	..	..
1209	Jan. 10.	..	..	..	1	0	..	1	0	..	..	..	..	..	..	..
1248	Jan. 19.	..	..	..	1	0	..	2	0	..	..	..	..	..	..	..
1296	Jan. 27.	..	..	..	1	2	..	2	0	..	2	0	..	..	..	..
1307	Jan. 30.	..	..	..	0	2	..	2	2	..	2	0	..	..	..	..
1338	Feb. 6.	..	..	..	..	..	..	0	4	..	2	0	..	..	..	..
1373	Feb. 13.	..	..	..	0	2	..	1	3	..	2	0	..	..	..	..
1400	Feb. 20.	..	..	..	0	2	..	1	2	1	4	0	..	..	..	..
1461	Mar. 8.	..	..	..	1	1	..	3	1	..	2	0	..	..	..	..
1500	Mar. 15.	..	..	..	0	1	..	1	1	1	1	1	..	..	..	..
1526	Mar. 20.	..	..	..	0	2	..	1	0	1	2	0	..	..	..	..
1571	Mar. 29.	..	..	..	0	1	..	1	1	..	2	0	..	..	..	..
1602	Apr. 4.	..	..	..	0	1	..	1	1	..	0	1	..	..	..	..
1640	Apr. 10.	..	..	..	1	0	..	2	0	..	1	0	..	..	..	..
1680	Apr. 17.	..	..	..	0	1	..	2	0	...	1	0	..	..	..	..
1715	Apr. 23.	..	..	..	0	1	..	0	1	1	1	0	..	..	..	..
1758	May 2.	..	..	..	..	..	..	0	1	..	0	1	1	1	0	..
1784	May 8.	..	..	..	..	..	..	0	1	..	2	0	..	1	0	..
1822	May 16.	..	..	..	..	..	..	0	1	..	1	1	..	1	0	..
1854	May 22.	..	..	..	..	..	..	0	1	..	0	2	..	1	0	..
1893	May 29.	..	..	..	..	..	..	0	1	..	1	1	..	2	0	..
1928	June 5.	..	..	..	..	..	..	1	0	..	2	0	..	0	1	..
1962	June 12.	..	..	..	..	..	..	0	1	..	2	0	..	1	0	..
1996	June 19.	..	..	..	..	..	..	0	1	..	2	0	..	1	0	..
2037	June 27.	..	..	..	..	..	..	0	1	..	2	0	..	1	0	..

9651 Q. Will you explain the results shown in this table and their sanitary significance?

A. Table IV contains the results of colon determinations made upon samples of water taken from the Illinois river at Morris between October 31st, 1899 and June 27th, 1900. They show that during the early part of this period the colon bacillus was generally present in .001 of a cubic centimeter of the water, while in the latter part of this period, namely from January 30th, 1900 to April 23rd, 1900, it was rarely present in this dilution. In fact, in May and June, 1900, the colon bacillus was even absent in quantities of .01 of a cubic centimeter, and occasionally absent in .1 of a cubic centimeter sample.

Q. Professor, will you explain what the double dots mean as they appear in the tables both preceding the one under consideration, as well as the one under consideration, and the subsequent tables in this series?

A. These dots signify that there were no determinations following under the several heads at these points. Thus, on May 29th, 1900, no examinations were made of the water from the Illinois river at Morris, in dilutions of .0001 and .001; that one examination of .01 was made, resulting negatively. Two examinations of .1 of a cubic centimeter were made, one 9652 of which was positive, one negative. Two examinations of one cubic centimeter of the water were made, both of which were positive. This system of record is used throughout this series of tables.

Q. Will you produce and read in evidence table V?

A. Yes, it is as follows:

9653

TABLE V.

(Fox River, Ottawa.)

Serial Number.	Date, 1899.	.1 c. c.			1 c. c.			5 c. c.		
		+	—	?	+	—	?	+	—	?
384	Aug. 1	0	1	..	0	1	..	..	..	..
420	Aug. 8	0	1	..	0	1	..	..	..	..
500	Aug. 22	0	1	..	..	..	..	..	..	..
529	Aug. 29	0	1	..	0	0	1	..	..	..
881	Oct. 31	0	1	..	1	0	..	..	..	..
918	Nov. 7	0	1	..	0	1	..	..	..	..
953	Nov. 14	0	1	..	0	1	..	..	..	..
986	Nov. 21	0	1	..	0	1	..	..	..	..
1015	Nov. 28	0	1	..	0	1	..	..	..	..
	1900									
1282	Jan. 26	0	2	1	1	2	..	..	..	..
1528	Mar. 21	0	3	..	0	3	..	..	..	..
1568	Mar. 28	.	..	..	0	2	1	2	0	..
1603	Apr. 4	1	0	..	2	0	..	1	0	..
1642	Apr. 11	..	..	..	2	0	..	1	0	..
1681	Apr. 18	0	1	..	0	2	..	1	0	..
1722	Apr. 25	0	1	..	0	1	1	0	0	1
1759	May 2	0	1	..	0	2	..	1	0	..
1790	May 9	1	0	..	2	0	..	1	0	..
1823	May 16	0	1	..	0	2	..	1	0	..
1859	May 23	0	1	..	0	2	..	0	1	..
1930	June 6	0	1	..	0	2	..	0	0	1
1963	June 12	0	1	..	0	1	1	1	0	..
1997	June 19	0	1	..	0	2	..	1	0	..
2035	June 26	0	1	..	1	1	..	1	0	..

9654 Q. Will you explain the results shown in this table and their sanitary significance?

A. Table V contains the results of colon determinations made upon samples of water taken from the Fox River at Ottawa between August 1st, 1899 and June 26th, 1900. They show that in this water the colon bacillus was rarely present in .1 of a cubic centimeter; was often present in one cubic centimeter and usually present in five cubic centimeters of water.

Q. Professor, will you produce and read in evidence table VI?

A. Yes sir. Table VI is as follows:

TABLE VI.

(Illinois River, Ottawa.)

Serial Number.	Date, 1899.	.01 c. c.			.1 c. c.			1 c. c.			5 c. c.		
		+	—	?	+	—	?	+	—	?	+	—	?
385	Aug. 1	..	..	..	0	1	..	0	1	..	..	..	..
421	Aug. 8	..	..	..	0	1	..	1	0	..	..	..	..
501	Aug. 22	..	..	..	0	1	..	..	..	..	..	..	..
530	Aug. 29	..	..	..	0	1	..	0	0	1	..	..	..
830	Oct. 31	0	1	..	1	0	2	..	..	..	..	..	..
919	Nov. 7	0	2	..	1	2	1	1	0	1	..	..	..
934	Nov. 14	0	2	..	2	2	..	2	0	..	..	..	..
987	Nov. 21	1	1	..	1	0	3	2	0	..	..	..	..
1016	Nov. 23	0	2	..	0	3	1	0	0	2	..	..	..
1076	Dec. 13	1	1	..	3	1	..	2	0	..	..	..	..
1130	Dec. 22	1	0	..	1	0	..	1	0	..	..	..	..
1153	Dec. 29	1	0	1	1	0	3	0	0	2	..	..	..
	1900.												
1174	Jan. 5	1	0	..	3	0	1	2	0	..	..	..	..
1221	Jan. 12	0	1	..	2	0	..	1	0	..	..	..	..
1250	Jan. 19	0	2	..	3	0	1	2	0	..	..	..	..
1283	Jan. 26	0	0	2	4	0	..	1	0	..	..	..	..
1340	Feb. 6	..	..	..	1	3	..	2	0	..	..	..	..
1402	Feb. 21	..	..	..	0	2	..	3	1	..	..	..	..
1455	Mar. 6	..	..	..	0	4	..	0	19	1	..	..	..
1490	Mar. 13	0	2	..	2	2	..	2	0	..	..	..	..
1529	Mar. 21	0	1	1	2	0	..	1	1	..	..	..	..
1569	Mar. 28	0	2	..	1	1	..	1	1	..	..	..	..
1604	Apr. 4	0	1	..	0	2	..	1	0	..	..	..	..
1643	Apr. 11	0	1	..	0	2	..	0	1	..	..	..	..
1682	Apr. 18	..	..	..	1	1	..	0	0	2	..	..	..
1723	Apr. 25	..	..	..	0	2	..	0	2	..	..	..	..
1760	May 2	0	1	..	0	2	..	0	0	1	..	..	..
1791	May 9	..	..	..	1	0	..	2	0	..	..	..	..
1824	May 16	..	..	..	1	0	..	0	0	2	1	0	..
1860	May 23	..	..	..	0	0	1	0	0	2	0	0	1
1931	June 6	0	1	..	0	1	..	0	0	2	0	0	1
1964	June 12	1	0	..	0	0	1	2	0	..	1	0	..
1998	June 19	0	1	..	1	0	..	1	0	..	1	0	..
2036	June 26	0	1	..	0	1	..	1	1	..	1	0	..

9656 Q. Will you please explain what is shown by table VI and its sanitary significance?

A. Table VI contains the results of colon determinations made upon samples of water taken from the Illinois river at Ottawa, between August 1st, 1899 and June 26th, 1900. They show that during the greater part of this period colon bacillus was occasionally present in .01 of a cubic centimeter and that it was frequently present in .1 of a cubic centimeter.

Q. Will you produce and read in evidence table VII?

A. Yes sir. It is as follows:

9657

TABLE VII.

(Big Vermillion, La Salle.)

Serial Number.	Date, 1899.	.1 c. c.			1 c. c.		
		+	—	?	+	—	?
388	Aug. 2	0	5	..	0	1	..
423	Aug. 9	..	..	..	0	0	1
502	Aug. 23	0	1	..	0	0	1
533	Aug. 30	0	1	..	0	1	..
882	Nov. 1	1	0	..	1	0	..
920	Nov. 8	..	..	..	0	1	..
959	Nov. 15	..	..	..	0	1	..
988	Nov. 22	0	1	..	1	0	..
1017	Nov. 28	0	1	..	1	0	..

9658 Q. Please explain what is shown by table VII, and its sanitary significance?

A. Table VII contains the results of colon determinations made upon samples of water taken from the Big Vermillion river at LaSalle, between August 2nd, and November 28th, 1899. The colon bacillus was commonly absent in .1 of a cubic centimeter of water, and found only about half of the time in one cubic centimeter samples.

Q. Will you produce and read in evidence table VIII?

A. Yes sir. It is as follows:

9659

TABLE VIII.

(Illinois River, La Salle.)

Serial Number.	Date, 1899.	.1 c. c.			1 c. c.		
		+	—	?	+	—	?
389	Aug. 2	..	..	..	0	0	1
424	Aug. 9	1	0	..	0	0	1
503	Aug. 23	0	1	..	0	0	1
534	Aug. 30	0	1	..	0	0	1
883	Nov. 1	1	0	..	1	0	..
960	Nov. 15	0	1	..	1	0	..
989	Nov. 22	0	1	..	0	0	1
1018	Nov. 28	0	1	..	1	0	..

9660 A. Please explain what table VIII shows and its sanitary significance?

A. Table VIII contains the results of colon determinations made upon samples of water taken from the Illinois river at LaSalle between August 2nd, and November 28th, 1899. The number of colon bacteria found here corresponds very closely with the number found in the Big Vermillion river, it being noted that the samples were taken at these two points on the same dates.

Q. Will you produce and read in evidence table IX?

A. Yes sir, it is as follows:

9661

TABLE IX.

(Illinois River, Henry.)

Serial Number.	Date, 1899.	.01 c. c.			.1 c. c.			1 c. c.		
		+	—	?	+	—	?	+	—	?
107	June 7	..	..	..	..	..	..	0	1	..
134	June 14	..	..	..	..	..	..	0	1	..
173	June 21	..	..	..	0	1	..	0	1	..
212	June 28	..	..	..	0	1	..	0	1	..
583	Sept. 7	..	..	..	0	0	1	0	0	1
616	Sept. 13	..	..	..	1	0	..	1	0	..
652	Sept. 20	..	..	..	1	0	..	1	0	..
690	Sept. 27	0	1	..	0	1	..	..	..	..
1116	Dec. 20	..	..	..	..	..	..	4	0	..
	1900									
1170	Jan. 4	..	..	..	1	1	..	1	0	1
1207	Jan. 10	..	..	..	..	..	..	2	2	..
1246	Jan. 17	..	..	..	1	3	..	3	1	..

9662 Q. Please state what table IX shows and its sanitary significance?

A. Table IX contains the results of colon determinations made upon samples of water taken from the Illinois river at Henry, between June 7th, 1899 and January 17th, 1900.

Q. Will you produce and read in evidence table X?

A. Yes sir, it is as follows:

9663

TABLE X.

(Illinois River, Averyville.)

Serial Number.	Date, 1899.	.01 c. c.			.1 c. c.			1 c. c.		
		+	—	?	+	—	?	+	—	?
119	June 9	..	..	..	..	..	..	0	1	..
136	June 12	..	..	..	..	..	..	0	1	..
174	June 21	..	..	..	0	1	..	0	1	..
213	June 28	..	..	..	..	..	..	0	1	..
387	Aug. 2	..	..	..	..	..	..	1	0	..
580	Sept. 6	..	..	..	1	0	..	1	0	..
617	Sept. 13	..	..	..	0	1	..	0	1	..
663	Sept. 20	..	..	..	0	1	..	0	1	..
691	Sept. 27	..	..	..	0	1	..	0	1	..
	1900									
1275	Jan. 24	0	4	..	0	2	..	..	..	..
1312	Jan. 31	..	..	..	0	2	..	2	2	..
1344	Feb. 7	..	..	..	0	2	..	0	1	3
1380	Feb. 14	..	..	..	0	0	2	3	0	1
1406	Feb. 21	..	..	..	0	1	1	4	0	..
1437	Feb. 28	..	..	..	1	1	..	2	2	..
1459	Mar. 7	..	..	..	0	2	..	2	2	..
1498	Mar. 14	..	..	..	1	0	1	0	2	1
1533	Mar. 21	..	..	..	0	1	2	1	0	2
1570	Mar. 28	..	..	..	0	2	1	3	0	..
1608	Apr. 4	..	..	..	0	1	..	1	0	1
1647	Apr. 11	..	..	..	0	0	1	0	0	2
1687	Apr. 18	..	..	..	0	2	..	0	2	..
1727	Apr. 25	..	..	..	0	1	..	0	1	1
1765	May 2	..	..	..	0	1	..	0	1	1
1795	May 9	..	..	..	0	1	..	0	1	1
1832	May 17	..	..	..	0	0	1	1	0	1
1864	May 23	..	..	..	0	1	..	0	0	2
1901	May 29	..	..	..	1	1	..	2	0	..
1935	June 6	..	..	..	0	1	..	0	1	1
1969	June 13	..	..	..	0	1	..	0	2	..
2006	June 20	..	..	..	0	1	..	2	0	..
2041	June 27	..	..	..	0	1	..	0	2	..

9664 Q. Please explain what table X shows and its sanitary significance?

A. Table X contains the results of colon determinations made upon samples of water taken from the Illinois river at Averyville, between June 9th, 1899 and June 27th, 1900.

The relatively large number of colon bacteria present in the Illinois river at Morris as shown in table IV has been greatly diminished between Morris and Averyville, so that while at Morris the colon bacillus was found almost invariably in .1 of a cubic centimeter of water, at Averyville it was but rarely present in this amount of water, and occasionally absent even in one cubic centimeter of water.

This group of organisms appear to have suffered a great mortality in the water between Morris and Averyville.

Q. Will you produce and read into evidence table XI?

A. Yes sir, it is as follows:

9665

TABLE XI.

(Illinois River, Wesley City.)

Serial Number.	Date, 1899.	.0001 c. c.			.01 c. c.			.1 c. c.			1 c. c.		
		+	—	?	+	—	?	+	—	?	+	—	?
120	June 9	..	..	..	..	..	..	0	1	..	0	1	..
136	June 14	..	..	..	..	..	..	0	1	..	0	1	..
177	June 21	..	..	..	..	..	..	1	0	..	1	0	..
214	June 28	..	..	..	..	..	..	1	0	..	1	0	..
581	Sept. 6	..	..	..	0	0	1	1	0	..	..	..	..
618	Sept. 13	..	..	..	0	0	1	0	0	1	..	..	..
692	Sept. 27	0	1	..	0	1	..	0	0	1	..	..	..
	1900												
1345	Feb. 7	..	..	..	0	2	..	1	3	..	0	0	2
1381	Feb. 14	..	..	..	0	2	..	1	2	1	2	0	..
1411	Feb. 23	..	..	..	0	2	..	1	3	..	2	0	..
1460	Mar. 7	..	..	..	0	2	..	1	1	2	1	1	..
1534	Mar. 22	..	..	..	0	2	..	2	0	..	2	0	..
1581	Mar. 30	..	..	..	0	2	..	0	1	..	1	1	..
1610	Apr. 5	..	..	..	0	1	..	0	2	..	1	0	..
1648	Apr. 11	..	..	..	0	0	1	0	2	...	0	0	1
1689	Apr. 18	..	..	..	0	1	..	0	2	..	..	..	..
1728	Apr. 25	..	..	..	0	1	..	0	0	1	1	1	..
1767	May 3	..	..	..	0	1	..	0	2	..	0	0	1
1796	May 9	..	..	..	0	1	..	1	0	1	1	0	..
1829	May 16	..	..	..	1	0	..	2	0	..	1	0	..
1866	May 23	0	1	..	0	1	..	1	0	..	..	..	..
1902	May 31	1	0	..	1	0	1	1	0	..	..	..	..
1938	June 7	0	1	..	0	1	..	0	2	..	1	0	..
1973	June 14	0	1	..	0	1	..	0	2	..	1	0	..
2008	June 21	0	1	..	1	1	..	1	0	..	..	..	..
2042	June 28	0	1	..	0	2	..	0	1	..	..	..	..

9666 Q. Please explain what table XI shows and its sanitary significance?

A. Table XI contains results of colon determinations made upon samples of water taken from the Illinois river at Wesley City, between June 9th, 1899 and June 28th, 1900.

The increased pollution of the river at this point is shown by the swollen number of colon bacilli, which were found quite often in .1 of a cubic centimeter of water.

Q. Will you produce and read in evidence table XII?

A. Yes sir, it is as follows:

9667

TABLE XII.

(Illinois River, Havana.)

Serial Number.	Date, 1899.	.1 c. c.			1 c. c.		
		+	—	?	+	—	?
115	June 7	..	..	..	1	0	..
138	June 14	..	..	..	1	0	..
178	June 21	..	..	..	1	0	..
221	June 29	..	..	..	1	0	..
589	Sept. 7	1	0	..	1	0	..
625	Sept. 14	0	1	..	0	0	1
659	Sept. 21	1	0	..	1	0	..
699	Sept. 29	0	1	..	0	1	..

9668 Q. Please explain what table XII shows and its sanitary significance?

A. Table XII contains the results of colon determinations made upon samples of water taken from the Illinois river at Havana between June 7th and September 29th, 1899. The colon bacillus was commonly present in one cubic centimeter of water.

Q. Will you produce and read in evidence table XIII?

A. Yes sir, it is as follows:

9669

TABLE XIII.

(Sangamon River, Chandlerville.)

Serial Number.	Date, 1899.	.01 c. c.			.1 c. c.			1 c. c.		
		+	—	?	+	—	?	+	—	?
116	June 8	..	..	..	..	..	..	0	1	..
182	June 22	..	..	..	..	..	..	1	0	..
626	Sept. 14	..	..	..	0	0	1	0	0	1
660	Sept. 21	..	..	..	1	0	..	1	0	..
715	Sept. 29	..	..	..	1	0	..	1	0	..
	1900									
1276	Jan. 25	..	..	..	1	3	..	4	0	..
1315	Feb. 1	..	..	..	0	4	..	0	4	..
1355	Feb. 8	..	..	..	2	0	..	4	0	..
1384	Feb. 15	..	..	..	2	1	1	1	0	1
1438	Mar. 2	..	..	..	0	1	3	3	1	..
1470	Mar. 8	..	..	..	3	1	..	2	0	2
1508	Mar. 15	..	..	..	1	1	1	0	3	..
1544	Mar. 22	..	..	..	3	0	..	3	0	..
1572	Mar. 29	0	2	..	0	2	..	0	1	1
1613	Apr. 5	0	2	..	1	1	..	1	1	..
1652	Apr. 12	0	2	..	0	0	2	2	0	..
1692	Apr. 19	0	1	..	0	1	..	2	0	..
1731	Apr. 26	0	2	..	0	1	1	0	0	2
1770	May 3	0	1	..	2	0	..	2	0	..
1805	May 10	1	0	..	2	0	..	1	0	..
1839	May 17	1	0	..	1	0	..	2	0	..
1875	May 24	1	0	1	2	0	..	2	0	..
1911	May 31	..	..	..	1	0	..	1	0	..
1945	June 7	0	2	..	0	2	..	1	0	..
1981	June 14	0	1	..	0	2	..	1	0	..
2011	June 21	2	0	..	0	1	1	2	0	..
2051	June 28	0	2	..	0	1	1	1	0	..

9670 Q. Please explain what table XIII shows and its sanitary significance?

A. Table XIII contains the results of colon determinations made upon samples of water taken from the Sangamon river at Chandlerville, between June 8th, 1899, and June 28th, 1900. As has before been stated, the Sangamon river receives above Chandlerville the sewage of a very considerable urban population, and this condition is reflected in the relatively high number of colon bacilli, which during the period covered by these determinations, range much higher than the number found in the water of the Illinois river at Averyville, as evidenced especially by the determinations made of .1 of a cubic centimeter samples. The colon bacillus was even found occasionally in .01 of a cubic centimeter of water taken from the Sangamon river at this point.

Q. Will you produce and read in evidence table XIV?

A. Yes sir, it is as follows:

9671

TABLE XIV.

(Illinois River, Grafton.)

Serial Number.	Date. 1899.		.01 c. c.			.1 c. c.			1 c. c.			5 c. c.		
			+	—	?	+	—	?	+	—	?	+	—	?
117	June	8	..	..	..	..	..	..	0	1	..	..		
184	June	22	..	..	..	..	..	..	0	1	..	..	.	..
222	June	30	..	..	..	..	..	..	0	1	..	..	..	..
591	Sept.	7	..	..	..	0	1	..	0	1	..	..	..	..
628	Sept.	14	..	..	..	1	0	..	1	0	..	..	..	..
662	Sept.	21	..	..	..	1	0	..	1	0	..	..	..	..
701	Sept.	29	..	..	..	0	1	..	1	0	..	..	..	..
906	Nov.	23	1	1	..	2	0	..	2	0	..	..	..	..
1025	Dec.	1	0	1	..	1	0	.	1	0	..	..	..	..
1057	Dec.	6	0	1	..	0	1	..	1	0	..	..	..	..
1098	Dec.	15	..	..	..	0	1	..	0	1	1	..	..	..
1127	Dec.	22	..	..	..	0	0	1	1	0	1	..	..	..
1156	Dec.	29	..	..	..	0	1	..	0	0	2	..	..	..
	1900													
1187	Jan.	5	..	..	..	0	1	..	0	2	..	..	..	..
1217	Jan.	10	..	..	..	0	1	..	0	1	1	..	..	..
1261	Jan.	19	..	..	..	0	4	..	0	2	2	..	..	..
1287	Jan.	26	..	..	..	1	1	..	2	1	1	..	..	..
1317	Feb.	1	0	2	..	0	2	..	2	2	..	..	..	..
1356	Feb.	8	..	..	..	0	1	1	2	1	..	..	..	..
1386	Feb.	15	..	..	..	1	0	1	2	0	2	..		
1408	Feb.	22	..	..	..	0	2	..	3	0	1	..	..	..
1484	Mar.	9	..	..	..	1	1	..	4	0	..	..	..	..
1509	Mar.	16	..	..	..	2	0	..	4	0	..	..	..	..
1536	Mar.	22	..	..	..	0	3	..	0	1	2	..	..	..
1579	Mar.	29	..	..	..	0	3	..	2	0	1	..	..	..
1615	Apr.	5	..	..	..	2	0	..	1	0	1	..	..	..
1654	Apr.	12	..	..	..	0	1	..	1	0	1	..	..	..
1693	Apr.	19	..	..	..	0	1	..	1	0	1	..	..	..
1732	Apr.	26	..	..	..	0	1	..	1	1	..	..	..	..
1771	May	3	..	..	..	1	0	..	2	0	..	..	..	..
1806	May	10	..	..	..	1	0	..	2	0	..	..	..	..
1841	May	17	..	..	..	1	0	..	2	0	..	..	..	..
1877	May	24	..	..	..	1	0	..	2	0	..	..	..	..
1912	May	31	..	..	..	0	1	..	0	2	..	..	..	..
1946	June	8	..	..	..	0	1	..	0	0	1	0	0	1
1983	June	15	..	..	..	0	1	..	1	0	..	1	0	..
2019	June	22	..	..	..	0	1	..	2	0	..	0	0	1
2053	June	29	..	..	..	1	0	..	2	0	..	1	0	..

9672 Q. Please state what table XIV shows and its sanitary significance?

A. Table XIV contains the results of colon determinations made upon samples of water taken from the Illinois river at Grafton between June 8th, 1899, and June 29th, 1900.

The colon bacillus was present in .1 of a cubic centimeter samples in about the same proportion as at Averyville, and was present in the majority of one cubic centimeter samples, as is usually found to be the case with unprotected surface waters receiving at more or less frequent intervals the drainage of urban and rural communities.

Q. Will you produce and read table XV?

A. Yes sir, it is as follows:

9673

TABLE XV.

(Mississippi River, Grafton.)

Serial Number.	Date. 1899.	.01 c. c.			.1 c. c.			1 c. c.			5 c. c.		
		+	—	?	+	—	?	+	—	?	+	—	?
118	June 8	..	..	..	..	..	..	0	1	..	..	..	..
185	June 22	..	..	..	0	1	..	..	..	..	..	..	..
223	June 30	..	..	..	..	..	..	1	0	..	..	..	..
592	Sept. 7	..	..	..	0	1	..	0	1	..	..	..	..
629	Sept. 14	..	..	..	0	1	..	0	0	1	..	..	..
663	Sept. 21	..	..	..	1	0	..	1	0	..	..	..	..
702	Sept. 29	..	..	..	0	1	..	1	0	..	..	..	..
1026	Dec. 1	0	1	..	0	1	..	1	0	..	..	..	..
1058	Dec. 6	0	1	..	0	1	..	0	0	1	..	..	..
1099	Dec. 15	..	..	..	0	1	..	1	1	..	..	..	..
1128	Dec. 22	..	..	..	0	1	..	1	0	1	..	..	..
1157	Dec. 29	..	..	..	0	1	..	0	2	..	..	..	..
	1900												
1188	Jan. 5	..	..	..	0	1	..	1	1	..	..	..	..
1218	Jan. 10	..	..	..	0	1	..	1	1	..	..	..	..
1262	Jan. 19	..	..	..	0	4	..	1	2	1	..	..	..
1286	Jan. 26	..	..	..	1	1	..	3	1	..	..	..	..
1318	Feb. 1	..	..	..	0	2	..	0	2	2	..	..	..
1357	Feb. 8	..	..	..	1	1	..	1	1	2	..	..	..
1387	Feb. 15	..	..	..	1	1	..	3	1	..	..	..	..
1409	Feb. 22	..	..	..	0	2	..	2	0	2	..	..	..
1435	Mar. 9	..	..	..	0	2	..	2	1	..	..	..	..
1510	Mar. 16	..	..	..	1	1	..	3	0	1	..	..	..
1537	Mar. 22	..	..	..	1	1	1	3	0	..	..	..	..
1580	Mar. 29	..	..	..	0	3	..	1	2	..	..	..	..
1616	Apr. 5	..	..	..	1	1	..	0	1	1	..	..	..
1655	Apr. 12	..	..	..	0	2	..	1	1	..	..	..	..
1694	Apr. 19	..	..	..	0	1	..	0	2	..	..	..	..
1733	Apr. 26	..	..	..	0	1	..	3	0	..	..	..	..
1772	May 3	..	..	..	0	1	..	1	0	1	..	..	..
1807	May 10	..	..	..	1	0	..	2	0	..	..	..	..
1878	May 24	..	..	..	1	0	..	1	0	1	..	..	..
1913	May 31	..	..	..	1	0	..	0	0	1	..	..	..
1947	June 8	..	..	..	0	0	1	0	0	1	1	0	..
1984	June 14	..	..	..	0	1	..	0	0	1	1	0	..
2019	June 22	..	..	..	0	1	..	0	2	..	0	1	..
2054	June 29	..	..	..	0	1	..	2	0	..	1	0	..

9674 Q. What does table XV show and what is its sanitary significance?

A. Table XV contains the results of colon determinations made upon samples of water taken from the Mississippi river at Grafton between June 8th, 1899, and June 29th, 1900. The colon bacillus was found during this period not infrequently in .1 of a cubic centimeter samples, and in the majority of one cubic centimeter samples, being in this respect like the Illinois river, a typical unprotected surface water.

Q. Will you please produce table XVI and read it in evidence?

A. Yes sir, it is as follows:

9675

TABLE XVI.

(Mississippi River, Cross-Section at Alton.)

Serial Number.	Date, 1899.	.1 c. c.			1 c. c.		
		+	—	?	+	—	?
	East Bank—						
248	July 6	0	1	..	0	1	..
284	July 13	0	1	..	0	0	1
319	July 20	0	1	..	0	1	..
356	July 27	0	1	..	0	1	..
736	Oct. 5	0	1	..	0	1	..
773	Oct. 12	0	1	..	1	0	..
846	Oct. 26	0	1	..	0	1	..
	East Center—						
249	July 6	0	1	..	0	1	..
285	July 13	0	0	1	0	0	1
320	July 20	0	1	..	0	1	..
357	July 27	1	0	..	1	0	..
737	Oct. 5	0	1	..	0	1	..
774	Oct. 12	0	1	..	0	0	1
847	Oct. 26	0	1	..	0	1	..
	Center—						
250	July 6	0	1	..	0	1	..
286	July 13	0	1	..	1	0	..
321	July 20	0	1	..	0	1	..
358	July 27	0	1	..	0	1	..
738	Oct. 5	0	1	..	0	1	..
775	Oct. 12	0	1	..	0	1	..
848	Oct. 26	1	0	..	0	0	1
	West Center—						
251	July 6	0	1	..	1	0	..
287	July 13	1	0	..	0	1	..
322	July 20	0	1	..	0	1	..
359	July 27	0	1	..	0	1	..
739	Oct. 5	0	1	..	0	1	..
776	Oct. 12	0	1	..	0	0	1
849	Oct. 26	1	0	..	1	0	..
	West Bank—						
252	July 6	0	1	..	0	1	..
288	July 13	0	1	..	0	1	..
323	July 20	0	1	..	1	0	..
360	July 27	0	1	..	1	0	..
740	Oct. 5	0	1	..	0	1	..

9676 Q. Please explain what is shown by the table XVI and what is its sanitary significance?

A. Table XVI contains the results of colon determinations made upon samples of water taken in cross section from the Mississippi river at Alton, Illinois, between July 6th and October 26th, 1899.

Q. Will you produce and read in evidence table XVII?

A. Yes sir, it is as follows:

9677

TABLE XVII.

(Missouri River, West Alton.)

Serial Number.	Date. 1899.	.01 c. c.			.1 c. c.			1 c. c.		
		+	—	?	+	—	?	+	—	?
376	July 28	..	..	..	0	1	..	0	1	..
671	Sept. 23	..	..	..	0	1	..	0	0	1
714	Sept. 29	..	..	..	0	0	1	0	0	1
749	Oct. 6	..	..	..	0	1	..	1	0	..
789	Oct. 13	..	..	..	0	1	..	0	1	..
869	Oct. 27	..	..	..	0	1	..	0	1	..
	1900									
1189	Jan. 5	..	..	..	0	2	..	0	4	..
1235	Jan. 10	..	..	..	0	1	..	1	0	..
1263	Jan. 19	..	..	..	1	3	..	1	2	1
1295	Jan. 26	..	..	..	0	2	..	3	1	..
1320	Feb. 2	..	..	..	0	2	..	0	4	..
1358	Feb. 8	..	..	..	0	2	..	2	2	.
1388	Feb. 15	..	..	..	0	2	..	0	3	1
1410	Feb. 22	..	..	..	0	2	..	0	4	..
1439	Mar. 2	..	..	..	0	4	..	4	4	..
1471	Mar. 8	..	..	..	0	2	..	2	1	1
1499	Mar. 14	..	..	..	2	0	..	0	1	2
1556	Mar. 23	..	..	..	0	0	1	2	0	..
1594	Mar. 30	..	..	..	2	0	..	2	0	..
1609	Apr. 4	..	..	..	2	0	..	2	0	..
1650	Apr. 11	..	..	..	1	0	..	2	0	..
1690	Apr. 18	0	1	..	0	1	1	1	1	..
1721	Apr. 25	..	..	..	0	1	..	2	0	..
1766	May 3	..	..	..	0	0	1	1	0	1
1793	May 10	..	..	..	1	0	..	1	0	..
1831	May 16	0	1	..	1	0	1	..	..	..
1865	May 23	1	0	..	1	0	..	1	0	..
1910	May 31	0	1	..	2	0	..	1	0	..
1937	June 7	..	..	..	2	0	..	2	0	..
1970	June 13	..	..	..	1	0	..	2	0	..
2007	June 20	1	0	..	2	0	..	1	0	..
2050	June 28	2	0	..	1	0	..	1	0	..

9678 Q. Please explain what table XVII shows and its sanitary significance?

A. Table XVII contains the results of colon determinations made upon samples of water collected in the Missouri river at West Alton, Missouri, between July 28th, 1899, and June 28th, 1900. During this period the colon bacillus was found quite commonly in .1 of a cubic centimeter of water, especially in the months of May and June, 1900, and was commonly present in the one cubic centimeter of water samples.

Q. Will you produce and read table XVIII?

A. Yes sir, it is as follows:

9679

TABLE XVIII.

(Mississippi River, Intake Tower, St. Louis Waterworks, Mitchell.)

Serial Number.	Date. 1899.	.01 c. c.			.1 c. c.			1 c. c.			5 c. c.		
		+	—	?	+	—	?	+	—	?	+	—	?
295	July 14	..	..	..	1	0	..	1	0	..	..	..	..
330	July 21	..	..	..	0	1	..	1	0	..	..	..	..
373	July 28	..	..	..	1	0	..	1	0	..	..	..	..
743	Oct. 6	..	..	..	0	1	..	0	0	1	..	..	..
850	Oct. 27	..	..	..	0	1	..	0	1	..	..	..	..
	1900												
1299	Jan. 27	..	..	..	1	1	..	1	1	2	..	..	..
1361	Feb. 9	..	..	..	1	0	1	4	0	..	..	..	..
1426	Feb. 24	..	..	..	1	1	..	1	0	3	..	..	..
1474	Mar. 9	..	..	..	0	0	1	1	0	1	..	..	..
1547	Mar. 23	..	..	..	3	0	..	2	0	1	..	..	..
1585	Mar. 30	..	..	..	0	2	..	1	1	..	1	0	..
1624	Apr. 6	..	..	..	0	1	..	1	1	..	..	..	..
1658	Apr. 13	..	..	..	0	1	..	2	0	..	..	..	..
1702	Apr. 20	..	..	..	1	1	..	0	0	2	..	..	..
1810	May 11	..	..	..	1	0	..	2	0	..	0	0	1
1845	May 18	..	..	..	0	0	1	0	0	2	0	0	1
1885	May 25	..	..	..	1	0	6	0	0	2	..	..	..
1917	June 1	..	..	..	1	0	..	2	0	..	..	..	..
1950	June 8	..	..	..	0	0	1	1	0	1	..	..	..
1987	June 15	..	..	..	1	0	..	2	0	..	..	..	..
2022	June 22	1	0	..	1	0	..	2	0	..	..	..	..
2057	June 29	1	0	..	2	0	..	1	0	..	..	..	..

9680 Q. Please explain what table XVIII shows and its sanitary significance?

A. Table XVIII contains the results of colon determinations made upon samples of Mississippi river water collected at the intake tower of the St. Louis waterworks, between July 14th, 1899 and June 29th, 1900.

The results show a general similarity with those obtained from the water of the Missouri river at West Alton.

Q. Will you produce and read in evidence table XIX?

A. Yes sir, it is as follows:

9681

TABLE XIX.

(St. Louis Tap Water.)

Serial Number.	Date, 1899.	.1 c. c.			1 c. c.			5 c. c.		
		+	—	?	+	—	?	+	—	?
265	July 7	0	1	..	1	0	..	..	..	..
298	July 15	0	1	..	1	0	..	..	..	..
333	July 22	0	1	..	1	0	..	..	..	..
365	July 28	0	1	..	0	0	1	..	..	..
781	Oct. 13	0	1	..	0	1	..	..	..	..
	1900									
1289	Jan. 26	1	1	..	1	2	1	..	..	..
1347	Feb. 7	1	1	..	0	3	1	..	..	..
1364	Feb. 10	0	2	..	0	4	..	..	..	..
1376	Feb. 13	0	2	..	0	3	1	..	..	..
1383	Feb. 15	0	4	..	0	4	..	1	0	..
1395	Feb. 17	0	2	..	0	3	1	..	..	..
1413	Feb. 23	0	2	..	0	4	..	1	1	..
1448	Mar. 5	0	2	..	0	3	1	..	..	..
1476	Mar. 9	0	1	..	0	1	1	..	..	..
1514	Mar. 17	0	1	..	2	0	..	1	0	..
1549	Mar. 23	0	3	..	2	0	..	1	0	..
1587	Mar. 30	0	2	..	1	1	..	1	0	..
1626	Apr. 6	0	1	..	0	2	..	..	..	..
1660	Apr. 13	..	..	..	0	2	..	1	0	..
1704	Apr. 21	1	1	..	1	1	..	..	..	..
1743	Apr. 27	0	1	..	0	1	1	1	0	..
1778	May 4	0	1	..	1	1	..	..	..	..
1812	May 11	0	1	..	2	0	..	1	0	..
1847	May 18	0	1	..	0	0	2	1	0	..
1870	May 25	1	0	..	0	2	..	..	..	..
1914	June 1	0	1	..	1	1	..	1	0	..
1952	June 8	0	0	1	1	1	..	..	..	..
1989	June 15	0	1	..	1	1	..	..	..	..
2025	June 23	1	0	..	1	0	1	..	..	..
2060	June 29	0	1	..	1	0	1	..	..	..

9682 Q. Please explain what is shown by table XIX and its sanitary significance?

A. Table XIX contains the results of colon determinations made upon samples of St. Louis tap water taken between July 7th, 1899, and June 29th, 1900.

The smaller number of colon bacteria in .1 of a cubic centimeter samples, as compared with the number found in the Mississippi river at the water intake indicates a considerable diminution in the number of colon bacteria during the passage through the settling basins and water pipes.

Q. Professor, have you a table of summaries of results for the principal stations on the Illinois river?

A. I have. It is as follows:

9683

I. PRINCIPAL STATIONS ON THE ILLINOIS RIVER.

Collecting Stations.	.00001 c. c.		.0001 c. c.		.001 c. c.		.01 c. c.		.1 c. c.	
	No. of days water exam'd.	No. of days B. coli found.	No. of days water exam'd.	No. of days B. coli found.	No. of days water exam'd.	No. of days B. coli found.	No. of days water exam'd.	No. of days B. coli found.	No. of days water exam'd.	No. of days B. coli found.
Illinois and Mich. Canal, Lockport	28	7	32	28	11	8	4	4	2	2
Illinois River, Morris..............	..	..	3	1	20	11	30	20	23	29
Illinois River, Ottawa..............	..	..	..	..	..	..	22	6	34	19
Illinois River, Averyville...........	..	..	..	..	..	..	1	0	27	4
Illinois River, Wesley City........	..	..	..	..	7	1	22	3	26	13
Illinois River, Grafton..............	..	..	..	..	..	..	4	1	35	13

9684 Q. Will you please explain what the table shows?

A. This table summarizes the results obtained from the colon determinations made upon the waters collected at the principal stations along the Illinois river. It shows that in the water of the Illinois and Michigan canal at Lockport the bacillus coli was present in .001 of a cubic centimeter of water on 28 days out of 32 days on which examinations were made. It shows further that in the water of the Illinois river at Morris the colon bacillus was present in .01 of a cubic centimeter of water on 20 days out of 30 days on which examinations were made, while at Ottawa it was present in the same quantity of water on only 6 days out of 22 days on which examinations were made.

At Ottawa the colon bacillus was found in .1 of a cubic centimeter of water on 19 days out of 34 days on which examinations were made, while at Averyville it was found in the same quantity of water on only 5 days out of 27 days on which examinations were made.

The increased pollution of the water at Wesley City is shown by a larger number of colon bacilli as indicated by the fact that the colon bacillus was found in .1 cc of water from this point on 13 days out of 26 days, on which examinations were made, or more than three times as frequently as in the Illinois river at Averyville above Peoria.

9685 At Grafton at the mouth of the river the colon bacillus was found in .1 of a cubic centimeter on 13 days out of 35 days on which examinations were made.

These summaries show that the colon determinations coincide with the results of the routine chemical and bacterial examinations already referred to.

The processes of oxidation of the organic matter, the death of the mass of sewage bacteria and the mortality among the specially significant group of colon organisms appear to run a closely parallel course, and the inference as to the purification of the stream drawn from the chemical analyses and from the count of bacterial colonies, is further emphasized by the mortality shown to occur in this significant class of sewage bacilli.

Q. Have you a table of summaries comparing the Illinois river at Averyville and Grafton with the tributaries of the Illinois, and with the Mississippi river above Grafton and the Missouri river at West Alton?

A. I have. It is as follows:

9686

I.

Illinois River at Averyville and Grafton, Compared with Tributaries and with the Mississippi (Grafton) and Missouri (West Alton) Rivers.

Collecting Stations.	.01 c. c.		.1 c. c.		1 c. c.		....5 c. c.	
	No. of days water exam'd.	No. of days B. coli found.	No. of days water exam'd.	No. of days B. coli found.	No. of days water exam'd.	No. of days B. coli found.	No. of days water exam'd.	No. of days B. coli found.
Illinois River, Averyville	1	0	27	4	31	13	..	..
Ilnois River, Grafton	4	7	35	13	38	26	4	2
Mississippi River, Grafton	2	0	34	10	35	23	4	1
Desplaines River	..	..	8	1	5	2	..	..
Kankakee River	..	..	6	3	5	4	..	..
Fox River	..	..	22	2	23	6	13	10
Big Vermillion River	..	..	5	1	9	3	..	..
Sangamon River	13	4	25	14	27	21	..	..
Missouri River	6	3	32	13	31	21	..	..

II.

Total, Illinois River (Averyville and Grafton)	..	..	62	17	69	39	..	..
Total, tributaries of Illinois River	..	..	66	21	69	36	..	..
Mississippi and Missouri Rivers	..	..	66	23	66	44	..	..

9687 Q. Please explain what this table shows and its sanitary significance is?

A. This table contains a summary of the results of the colon determinations made upon the Illinois river at Averyville and Grafton, compared with the tributaries of the Illinois and with the Mississippi and Missouri rivers.

On comparing the number of days on which bacillus coli was found in one cubic centimeter, samples of water taken from the Illinois river at Averyville, with those taken from the Illinois river at Grafton, from the Mississippi river at Grafton, from the Desplaines river, from the Kankakee river; from the Fox river, from the Big Vermilion river; from the Sangamon river, and from the Missouri river, it appears that so far as the colon content enables one to pass an opinion as to the sanitary quality of these waters the Sangamon river at Chandlerville, is one of the more highly polluted streams.

The Illinois river at Grafton, the Mississippi river at Grafton and the Missouri river at West Alton appeared to be on substantially the same footing with one another in respect to their colon conent, while the Fox river contained a smaller proportion of colon bacilli than any of the streams under consideration.

9688 The Illinois river at Averyville compares in respect to its colon content very favorably with the Illinois, Mississippi and Missouri rivers and is perceptibly less highly contaminated than the water of the Sangamon river at Chandlerville.

Summing up these facts in the second division of this table it is seen that samples of water taken on 69 different days from the Illinois river at Averyville and at Grafton contained bacillus coli communis on 39 days, while the various tributaries of the Illinois river, samples from which were taken on 69 days, contained colon bacillus on 36 days. Samples taken from the waters of the Missouri on 66 days contained colon bacillus on 44 days.

It appears therefore from these tables, that if the opinion that I have expressed regarding the sanitary significance of the colon bacillus in water is correct, the water of the Illinois river at Averyville and Grafton was not materially different from what it would have been if the tributaries of the Illinois, exclusive of the Desplaines river and its sewage content, had alone fed the basins of this stream. The colon content of such a stream at Averyville and at Grafton would have been sub-
9689 stantially what it is at present.

Q. What sanitary significance do you attach to the tables of colon determinations as presented in evidence by you, considering them as a whole?

A. As stated in my testimony of yesterday, my experience leads me to adopt the view that the relative abundance of the colon bacillus in water affords the most satisfactory single analytical indication that sanitary science at present possesses as to the sanitary quality of a natural water.

Basing my opinion upon this I may say that I regard the relative abundance of colon bacilli in the water of the Illinois river at various points, and in the various tributary streams as furnishing a highly important clew to the freshness of the pollution entering, and the amount of real purification undergone by each stream. Considered from this standpoint the water of the

Illinois river at Averyville and at Grafton, is no more impure than the water in the principal tributaries of the Illinois, and certainly no more impure or dangerous than the water of the Mississippi river at Grafton, or the Missouri river at West Alton. The successive and striking diminution in the number of colon bacilli at various points along the Illinois river from Lockport to Averyville, is proof in my judgement of the occurrence of a process of genuine self-purification.

9690 Q. What sanitary significance, do you attach to your chemical, bacteriological and colon determinations heretofore introduced into evidence, as evidenced, by the tables introduced for the period extending from May, 1899 to the end of June, 1900?

A. I regard these determinations as forming a connected and correlated whole, mutually sustaining one another, and all pointing in my judgment, to but one interpretation. The oxidation of the organic matter that was introduced in enormous quantities at Lockport, the more or less complete destruction of the sewage bacteria also introduced at this point, and especially the high mortality among the colon bacteria occuring in the upper stretches of the river, all appear to me to indicate that infectious matters that might have been introduced into the sewage of Chicago and found their way into the drainage canal during this period from May 1899 to the end of June 1900, did not make their way down river so far as Averyville. So far as my interpretation of the results of the chemical analyses, the bacterial counts and the colon determinations is concerned, I have no hesitation in expressing as my opinion that the water of the Illinois river at its mouth is no more liable to convey disease or to produce injurious consequences of any kind than the waters of the Mississippi river at this point, or the water of the Missouri river at West Alton. In expressing this
9691 opinion I am taking into consideration all the knowledge that I have acquired by personal experience and all the information that I have obtained regarding the chemical and bacterial content of these waters during the period under consideration.

MR. JEFFRIES: I move to strike out all the inferences, conclusions and opinions of this witness based upon the tables of analyses with reference to the period from May 1899 to the close of the year 1900, for the same reasons given and stated in my objection to the introduction of the tables themselves.

ADJOURNED until 2:00 P. M. same day.

9692 2:00 P. M., Thursday, December 3rd, 1903. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN,

resumed the stand for further direct-examination by Mr. Todd, and testified as follows:

Q. Professor, did you make any survey of the waters of the Illinois river, the Mississippi and the Missouri rivers, in 1901?

A. I did.

Q. State the circumstances which led up to the making of this survey?

A. So far as I understand these circumstances, an agreement was reached between the authorities of the State of Missouri and the State of Illinois for conducting a joint investigation of the water of the rivers named, at certain points. The aim of this joint examination was as I understand it, to secure that the samples should be taken at specified places, at specified times, and under uniform conditions.

9693 Q. What part did you have in connection with this investigation?

A. I was asked by Dr. Arthur R. Reynolds, director of the Streams Examination to establish and equip three laboratories; one at Peoria on the Illinois river; one at Grafton at the mouth of the Illinois river, and one at St. Louis. At these laboratories samples of water were to be examined bacterially by methods left to my discretion. These laboratories were accordingly established in October, 1901, under my direction, and work continued up to the end of December, 1901.

The laboratory at Peoria was under direct charge of Mr. F. W. Schule; that at Grafton under the charge of Mr. W. S.

Sayer; and that at St. Louis in charge of Mr. E. E. Irons, and Mr. W. G. Sackett. I believe that all these gentlemen except Mr. Irons, have already testified in this case.

Q. They were all under your direction and supervision?

A. Yes. Mr. Irons in addition to carrying out much of the work in the St. Louis laboratory personally had supervision of all three laboratories, visiting them at intervals and reporting to me. In addition, the workers in charge of the three laboratories sent in weekly written reports to me at the University of Chicago, keeping in addition, duplicate copies of these reports in their laboratories, all of which were finally turned over to me for final scrutiny. 9694

The work carried out at these three laboratories consisted chiefly in plating samples of water daily and also in making daily colon determinations. Data were secured regarding the temperature of water and air at the time of collection, the hour of plating, etc. Besides this routine work in the laboratory, the different workers were instructed by me to select from the colonies of bacteria appearing upon the plates, all the different kinds of bacteria that could be distinguished by their growth upon the medium used. These different colonies thus picked off the plates were transferred to agar tubes which were shipped by express to me at the bacteriological laboratory at the University of Chicago, where they were studied in detail. All of the work in all three laboratories was under my supervision. My assistants were given careful and minute instructions regarding all details of laboratory procedure, and so far as I could determine from inspection of the work and its results, these instructions were scrupulously followed.

9695 Q. At what points were samples of water collected for examination in these three different laboratories?

A. The work carried on at the Peoria laboratory comprised examinations of samples of water taken from the Illinois river at two different localities; namely, at Averyville, above Peoria and at Pekin, below Peoria; the precise points of collection were approximately those selected for the investigation of 1899 and 1900.

The laboratory at Grafton dealt with samples of water collected from the Illinois river at its mouth (above the point where any mixing with the Mississippi river water was possible), and from the Mississippi river above Grafton, the precise points of collection being the same as in the 1899 and 1900 series.

In the laboratory at St. Louis examinations of five samples of water were regularly made, namely, from the Mississippi river at the chain of rocks, a cross section of four samples being taken at this point, the points of collection being those specified in the 1899 and 1900 series. The fifth sample was obtained from the Missouri river at Fort Bellefontaine, West Alton.

Q. What instructions were given by you for the planting of these samples relative to the time of collection?

9696 A. The various laboratory workers were directed to plate the samples of water as soon after collection as possible, in every case.

Q. What determinations were made in these different laboratories?

A. The work done during this period was wholly bacteriological in character and may be grouped conveniently under three heads:

(a) The determination of the number of bacteria in the river water as shown by the ordinary colony counts.

(b) The number of germs of the colon group in the river water as shown by the Dextrose fermentation tube test.

(c) Study of the species of bacteria isolated from the river water.

The first two determinations were carried out in the respective branch laboratories, and it is certain that a decided gain in the accuracy of the results was attained by conducting this work at or near the points of collection, upon freshly collected samples, instead of allowing as in the previous work, a considerable interval to elapse while samples were being transported to a distant point. The detailed study of the bacterial species was carried out under more advantageous conditions of-
9697 fered for this kind of work by the University laboratories.

Q. What methods were employed in making all these determinations?

A. The methods used for the numerical estimation of the germs in the river water were those originally recommended by the committee upon Standard Water Analysis, appointed by the American Public Health Association (Science 1900, December 14, pages 906 to 915), together with the conditions and modifications embodied in the report of this committee presented at the Buffalo meeting of this association in 1901, (Reports and papers of the American Public Health Association, 27, page 377). Gelatin of a standard reaction (one per cent acid to phenolphthalein) was employed as the nutrient medium and in order to insure strict comparability between the results obtained in the several laboratories, all gelatin used in the three laboratories was made by Mr. Irons in the St. Louis laboratory. In my opinion it was because of this uniformity in method that the results in the several laboratories sustained a close and constant relation here to one another and can be legitimately compared. The counts of the bacterial colonies appearing on the gelatin plates have been made after 48 hours incubation, at an average temperature of 20 degrees centigrade. Several different decimal dilutions of the water were usually employed, the dilution that was selected for record in the accompanying tables was always, where possible, the one showing from about 25 to 125 colonies on a plate. The method used for estimating the number of colon bacteria in the river was the Dextrose fermentation tube method and was sufficiently described in connection with the 1899 and 1900 series. All the results detailed in the tables that I have prepared were obtained by this method, and the system adopted for recording the results was the same as in the preceding work. The methods used in the study and differentiation of species were those generally employed in the best bacteriological laboratories in this country. 9698

Q. Have you the tables prepared at the different stations where these determinations which you have just described were made?

A. I have.

Q. The data from which those tables were made were obtained in what manner, Professor?

A. From reports made to me by my assistants at the several laboratories.

Q. Were these analyses made at the different laboratories, made under your direction and supervision?

A. Entirely so.

9699 Q. The results of the analyses made by your subordinates located at the different laboratories were communicated to you in what manner?

A. In writing, each report being signed by the man sending it.

Q. Have you these reports with you from which the tables which you have prepared, were made?

A. I have them all here.

Q. Will you produce them?

(Witness produces tables.)

MR. TODD: I offer the original analytical report from the laboratory at St. Louis made by W. G. Sackett, that at Grafton made by W. S. Sayer, and that at Peoria made by F. W. Schule, to Professor E. O. Jordan of the Chicago University, under whose direction and supervision these analyses were made. Also the coli determinations made by the same parties at the three different laboratories for this period and reported to Professor Jordan in the same manner as above indicated. These reports are offered for the inspection of counsel and will be made a part of the evidence if objection is made to their non-introduction.

Q. Have you the tables made by you from the examinations at the Peoria laboratory?

A. I have.

9700 Q. How many tables have you made of the determinations made at Peoria?

A. Two sets, one covering the samples of water collected at Averyville, the other covering those collected at Pekin, below Peoria.

Q. Will you produce and read the table for the determinations made at Averyville in the Peoria laboratory?

A. I will. It is as follows:

22 8.00 9.00 4 -5 29.58 1-10 1) 1600
2) 1650 1600

9701 ILLINOIS RIVER—Averyville (Above Peoria.)

Date 1901 Oct.	Hour of collection.	Plating.	Temperature C.		Height of Water.	Dilution.	No. of Colonies per cc.	
			Water.	Air.				Averages.
9	2.00	3.00	16.5	16.		1-100	1) 10000	
							2) 9700	9800
10	8.10	9.00	14.	11.5	29.32	1-100	34300	34300
11	9.20	10.10	17.	21.	29.30	1-100	1900	1900
12	9.00	10.00	16.5	13.	29.40	1-100	1800	1800
14	8.00	9.00	14.5	10.	29.40	1-100	800	800
15	8.15	9.10	13.	11.	29.38	1-100	1) 1100	
							2) 1000	1000
16	8.20	9.00	13.	7.	29.47	1-100	1) 1100	
							2) 800	1000
17	8.00	9.10	13.	7.	29.43	1-10	1) 540	
						1-100	2) 890	720
18	8.00	9.15	12.5	8.	29.38	1-10	360	360
19	8.00	8.55	12.5	8.	12.38	1-10	1) 320	
							2) 360	340
21	8.25	9.45	13.	8.5	29.48	1-10	1) 780	
							2) 430	600
22	8.10	10.10	13.	9.	29.53	1-10	1) 750	
							2) 810	780
23	8.30	10.10	13.	11.	29.52	1-100	1) 4300	
							2) 3800	4000
24	8.00	10.00	13.5	10.	29.55	1-10	1) 1010	
							2) 1040	1030
							3) 1050	
25	8.00	9.15	13.5	6.	29.56	1-10	1) 1280	
							2) 840	
							3) 1190	1100
26	8.00	9.10	13.5	12.	29.50	1-10	1) 680	
							2) 780	
							3) 1220	890
28	8.00	8.50	13.	6.	29.58	1-10	1) 730	
							2) 730	
							3) 510	660
29	7.50	8.40	12.	17.5	29.50	1-10	1) 1180	
							2) 1130	1150
30	8.00	8.55	14.	19.	29.56	1-10	1) 690	
							2) 760	730
31	7.40	8.45	14.	17.	29.55	1-100	1) 430	
							2) 370	400

9702 ILLINOIS RIVER—Averyville (Above Peoria).

Date 1901 Nov.	Hour of collection.	Plating.	Temperature C. Water.	Temperature C. Air.	Height of Water.	Dilution.	No. of Colonies per cc.		Averages.
1	8.00	9.45	14	6	29.68	1-10	1)	860	
							2)	650	750
2	8.00	9.25	13.5	8.5	29.68	1-10	1)	320	
							2)	240	280
4	8.00	9.10	11	-6	29.69	1-10	1)	980	
							2)	910	950
5	8.00	9.00	9	-3	29.65	1-10	1)	640	
							2)	590	610
6	8.15	9.20	8	5	29.52	1-10	1)	260	
							2)	150	210
7	8.00	9.15	8	3	29.60	1-10	1)	210	
							2)	280	240
8	8.00	9.10	7.5	-1	29.60	1-10	1)	300	
							2)	280	290
9	8.00	9.05	7	3.5	29.68	1-10	1)	230	
							2)	210	220
11	8.00	9.05	8	18	29.50	1-10	1)	240	
							2)	260	240
12	8.10	9.15	8	10	29.70	1-10	1)	1900	
							2)	2500	2200
13	8.00	9.10	8	3	29.63	1-10	1)	1500	
							2)	1240	1400
14	8.00	9.00	6	3	29.63	1-10	1)	1280	
							2)	1320	1300
15	8.00	9.15	4	-6	29.62	1-10	1)	1180	
							2)	980	1100
16	8.00	9.15	4	-6	29.58	1-10	1)	3600	
							2)	3400	3500
18	8.00	9.20	4	-5	29.55	1-10	1)	730	
							2)	930	830
19	9.10	10.15	4	-5	29.50	1-10	1)	1090	
							2)	460	770
20	8.00	9.15	4	-5	29.54	1-10	1)	920	
							2)	970	950
21	8.00	9.00	4	-2	29.55	1-10	1)	530	
							2)	650	590
22	8.00	9.00	4	-5	29.58	1-10	1)	1600	
							2)	1650	1600

9703 ILLINOIS RIVER—Averyville (Above Peoria).

Date 1901 Nov.	Hour of collection.	Plating.	Temperature C. Water.	Air.	Height of Water.	Dilution.	No. of Colonies per cc.	Averages.
23	8.00	9.10	4.	3.	29.70	1-10	1) 860	
							2) 900	880
25	8.00	9.10	4.	3.	29.76	1-100	1) 2400	
							2) 3000	2700
26	8.00	9.00	2.	-2	29.76	1-10	1) 2670	
							2) 2450	2500
27	8.00	9.15	3.	-2	29.78	1-10	1) 1090	
							2) 1440	
							3) 1600	1400
29	8.00	9.10	3.	3.	29.73	1-100	1) 2600	2600
30	8.00	9.20	4.	-1	29.75	1-100	1) 2800	
							2) 2200	2500
Dec.								
2	8.00	9.10	4.	4.	29.73	1-100	1) 2500	
							2) 4200	3400
3	8.00	9.20	4.	1.	29.72	1-100	1) 1500	
							2) 1800	1600
4	8.00	9.20	3.	-3	29.68	1-100	1) 1800	
							2) 2300	2000
5	8.00	9.00	2.	-4	29.63	1-10	1) 1440	
							2) 2150	1800
6	8.00	9.05	2.	0.	29.60	1-100	1) 3200	
							2) 2400	2800
7	8.00	9.20	2.	2.	29.57	1-100	1) 3300	
							2) 3000	3200
9	8.00	9.25	2.	1.	29.70	1-100	1) 4100	
							2) 4600	4300
10	8.00	9.20	2.	0.	29.68	1-100	1) 4100	
							2) 4800	4400
11	8.00	9.10	2.	0.	29.72	1-100	6100	6100
12	8.00	9.00	2	2	29.70	1-100	1) 2900	
							2) 3300	3100
13	8.00	9.00	2	2	29.80	1-100	1) 3500	
							2) 3700	3600
14	8.	9.10	0	-20	29.90	1-100	1) 5200	
							2) 4100	4600
16	8.15	9.20	0	-14	29.85	1-100	1) 7900	
							2) 7100	7500

9704 **ILLINOIS RIVER—Averyville (Above Peoria).**

Date 1901 Dec.	Hour of collection.	Plating.	Temperature C. Water.	Air.	Height of Water.	Dilution.	No. of Colonies per cc.	Averages.
17	8.15	9.15	0.	-16	29.82	1-100	1) 11700	
							2) 14500	13000
18	8.00	9.10	0	-18	30.00	1-100	1) 28100	
							2) 31800	30000
19	8.00	9.10	0	-23	30.15	1-100	1) 28200	
							2) 27000	28006
20	8.00	9.10	0	-20	30.30	1-100	1) 9200	
							2) 10500	9800
21	8.00	9.15	0	-14	30.40	1-100	1) 10200	
							2) 10400	10300
23	8.00	9.00	1	4	30.80	1-100	1) 14500	
							2) 16200	15000
24	8.00	9.00	1	4	30.88	1-100	1) 56800	
							2) 69400	63000
26	8.00	9.20	1	0	30.92	1-100	1) 54400	
							2) 65400	60000
27	8.00	9.05	1	-1	30.92	1-100	1) 16900	
							2) 18400	17000
28	8.00	9.05	1	1	30.90	1-100	1) 9500	
							2) 7800	8600
30	8.00	9.10	1	-30	30.83	1-100	1) 58200	
							2) 46200	52000

General average, 5800.

9705 Q. Will you state what the table that you have just read shows, and its sanitary significance?

A. This table contains the results of daily bacterial determinations made upon samples of water from the Illinois river at Averyville between October 9th and December 30th, 1901. On this table are specified the date of collection, the hour of collection and the hour of plating, the temperature in degrees centigrade of the water and air; the height of water; the dilution in which the sample was plated, the number of colonies per cubic centimeter (two samples in most cases) and the average of these daily determinations. Throughout October and

November the numbers of bacteria in the water as shown by the colony count were low; the counts showing often only a few hundred colonies per cubic centimeter. In December the numbers increased somewhat and in the latter part of December, the numbers are on several occasions in the tens of thousands.

So far as the bacterial count is concerned, these examinations show that the water of the Illinos river at this point was in a condition which considered as a river water, was fully up to the average of river waters in this country.

9706 Q. Will you produce and read the table showing the determinaitons made at the Peoria laboratory for the point at Pekin?

A. Yes, sir. It is as follows:

9707 ILLINOIS RIVER—Pekin (Below Peoria).

Date 1901 Oct.	Hour of collection.	Plating.	Temperature C. Water.	Temperature C. Air.	Height of Water.	Dilution.	No. of Colonies per cc.	Averages.
16	3.15	5.15	13.5	14		1-1000	1) 170000	
							2) 150000	160000
17	7.50	10.00	11.	4.		1-10000	230000	230000
18	8.00	10.15	12	8		1-1000	1) 45000	
							2) 33000	39000
19	8.00	10.00	12	12.5		1-1000	1) 69000	
							2) 47000	58000
21	7.50	10.10	12.5	9.5	2.2	1-1000	1) 57000	
							2) 79000	69000
22	7.50	10.05	12.5	9.5	2.2	1-1000	1) 96000	
							2) 106000	101000
23	7.55	10.00	11.5	10.	2.2	1-1000	1) 163000	
							2) 155000	
							3) 166000	161000
24	7.50	9.55	11.	9.	2.	1-1000	1) 89000	
							2) 73000	
							3) 74000	79000
25	7.55	9.50	13.	9.	2.2	1-1000	1) 149000	
							2) 178000	
							3) 186000	171000
26	7.50	10.05	13.	8.	2.2	1-1000	1) 312000	
							2) 352000	
							3) 302000	
						1-10000	4) 360000	341000
28	7.55	9.50	12.5	8	2.2	1-1000	1) 390000	
							2) 330000	
							3) 420000	380000
30	7.50	10.30	16.	15	2.2	1-1000	1) 275000	
							2) 241000	258000
30	7.55	10.30	14.	13	2.2	1-10000	1) 1140000	

2) 7200 7600
29 8.00 9.50 2.5 4 2.2 1-100 1) 6500
2) 7400 6900

November the numbers of bacteria in the water as shown by the colony count were low; the counts showing often only a few hundred colonies per cubic centimeter. In December the numbers increased somewhat and in the latter part of December, the numbers are on several occasions in the tens of thousands.

So far as the bacterial count is concerned, these examinations show that the water of the Illinos river at this point was in a condition which considered as a river water, was fully up to the average of river waters in this country.

9706 Q. Will you produce and read the table showing the determinaitons made at the Peoria laboratory for the point at Pekin?

A. Yes, sir. It is as follows:

9707 ILLINOIS RIVER—Pekin (Below Peoria).

Date 1901 Oct.	Hour of collection.	Plating.	Temperature C. Water.	Air.	Height of Water.	Dilution.	No. of Colonies per cc.	Averages.
16	3.15	5.15	13.5	14		1-1000	1) 170000	
							2) 150000	160000
17	7.50	10.00	11.	4.		1-10000	230000	230000
18	8.00	10.15	12	8		1-1000	1) 45000	
							2) 33000	39000
19	8.00	10.00	12	12.5		1-1000	1) 69000	
							2) 47000	58000
21	7.50	10.10	12.5	9.5	2.2	1-1000	1) 57000	
							2) 79000	69000
22	7.50	10.05	12.5	9.5	2.2	1-1000	1) 96000	
							2) 106000	101000
23	7.55	10.00	11.5	10.	2.2	1-1000	1) 163000	
							2) 155000	
							3) 166000	161000
24	7.50	9.55	11.	9.	2.	1-1000	1) 89000	
							2) 73000	
							3) 74000	79000
25	7.55	9.50	13.	9.	2.2	1-1000	1) 149000	
							2) 178000	
							3) 186000	171000
26	7.50	10.05	13.	8.	2.2	1-1000	1) 312000	
							2) 352000	
							3) 302000	
						1-10000	4) 360000	341000
28	7.55	9.50	12.5	8	2.2	1-1000	1) 390000	
							2) 330000	
							3) 420000	380000
30	7.50	10.30	16.	15	2.2	1-1000	1) 275000	
							2) 241000	258000
30	7.55	10.30	14.	13	2.2	1-10000	1) 1140000	
							2) 900000	1000000
31	8.10	10.00	14.5	14	2.2	1-10000	1) 730000	
Nov.							2) 670000	700000
1	8.00	10.15	13	8	2.2	1-10000	1) 630000	
							2) 560000	600000
2	8.00	10.15	12.5	8	2.2	1-1000	1) 50000	
							2) 46000	4800
4	8.00	9.50	10	-10	2.2	1-10000	1) 410000	
							2) 360000	380000

9708 ILLINOIS RIVER—Pekin (Below Peoria).

Date 1901 Nov.	Hour of collection.	Plating.	Temperature C. Water.	Air.	Height of Water.	Dilution.		No. of Colonies per cc.	Averages.
5	8.00	10.15	8	-10	2.2	1-1000	1)	69000	
							2)	88000	79000
6	8.15	10.10	7	4	2.2	1-1000	1)	56000	
							2)	51000	53000
7	2.20	4.30	8	6	2.3	1-1000	1)	14000	
							2)	12000	13000
8	8.00	9.50	6	2	2.2	1-1000	1)	20000	
							2)	19000	19000
9	8.15	9.50	7	2	2.3	1-100	1)	11000	
							2)	16000	14000
11	8.15	10.	9	13	2.3	1-1000	1)	30000	
							2)	27000	28000
12	8.00	10.	7	-2	2.3	1-1000	1)	26000	
							2)	19000	23000
13	8.00	9.50	8	2	2.3	1-1000	1)	31000	
							2)	28000	29000
14	8.00	9.50	6	3	2.3	1-1000	1)	16000	
							2)	23000	20000
15	2.45	5.00	5.5	4	2.3	1-1000	1)	37000	
							2)	32000	34000
16	8.00	9.50	4	-6	2.3	1-100	1)	9300	
							2)	9800	9600
18	8.15	9.50	3	-2	2.2	1-1000	1)	21000	
							2)	48000	35000
19	8.00	9.50	3	-2	2.4	1-1000	1)	66000	
							2)	64000	65000
20	8.15	10.15	3	1	2.4	1-1000	1)	23000	
							2)	18000	20000
21	8.10	10.30	3	1	2.4	1-100	1)	13900	
							2)	14800	14300
22	8.20	10.	4	4	2.4	1-100	1)	6900	6900
23	8.00	9.50	4	3	2.4	1-100	1)	7900	
							2)	7100	7500
25	8.15	9.50	4	2	2.4	1-100	1)	4800	
							2)	5300	5100
26	3.40	6.00	4	6	2.3	1-1000	1)	24000	24000
27	8.15	10.	3	-2	2.3	1-100	1)	8000	
							2)	7200	7600
29	8.00	9.50	2.5	4	2.2	1-100	1)	6500	
							2)	7400	6900

9709 ILLINOIS RIVER—Pekin (Below Peoria).

Date 1901 Nov.	Hour of collection.	Plating.	Temperature C.		Height of Water.	Dilution.		No. of Colonies per cc.	
			Water.	Air.					Averages.
30	8.15	10.05	2	0	2.2	1-100	1)	3700	
							2)	4200	4000
Dec.									
2	8.15	10.	4	2	2.2	1-100	1)	14200	
							2)	11000	12600
3	8.15	10.10	3	1	2.2	1-100	1)	15300	
							2)	17000	16000
4	8.15	10.	3	4	2.2	1-100	1)	9700	
							2)	10400	
							3)	8100	9400
5	8.20	10.	2	-4	2.2	1-100	1)	19400	
							2)	19300	
							3)	17800	18800
6	8.10	10.05	2	-1	2.3	1-100	1)	7100	
							2)	6700	
							3)	6900	6900
7	8.15	9.55	2	3	2.3	1-100	1)	6200	
							2)	6900	
							3)	5700	5900
9	8.15	9.55	2	-2	2.3	1-100	1)	4400	
							2)	7400	
							3)	7300	6400
10	8.00	9.55	1.5	-1	2.3	1-100	1)	3200	
							2)	3400	
							3)	3000	3200
11	8.00	9.55	1.5	1	2.3	1-100	1)	9200	
							2)	9800	
							3)	8900	9300
12	8.10	10.10	2	3	2.3	1-100	1)	5600	
							2)	5700	
							3)	6600	6000
13	8.15	10.15	2	2	2.3	1-100	1)	11300	
							2)	9800	
							3)	11100	10700

General average, 90000.

9710 Q. What does this table show and what is its sanitary significance?

A. This table shows the results of colony counts made from samples of water collected from the Illinois river at Pekin between October 16th and December 13th, 1901, the same data being given as in the table for Peoria.

Throughout this period this water is characterized by a much higher bacterial content than the water of the Illinois river at Averyville. On October 26th, for example, the average number of four determinations at Pekin was 341,000, per cubic centimeter, while at Averyville on the same date there were only 890 colonies per cubic centimeter.

Q. Will you produce and read the table for the determinations made of the Illinois river at Grafton?

A. Yes, sir. It is as follows:

9711 ILLINOIS RIVER—Grafton.

Date 1901 Oct.	Hour of collection.	Plating.	Temperature C. Water.	Air.	Height of Water.	Dilution.	No. of Colonies per cc.	Averages.
1	2.00	3.00	21	29	2.7	1-100	1) 1700*	
							2) 1400*	1550
2	2.45	3.45	20.5	18	2.7	1-100	900*	900
3	4.00	5.30	18.5	17.5	2.7	1-100	900*	900
4	8.15	11.	16.5	9	2.6	1-100	900*	900
5	10.	11.30	16.	15	2.6	1-100	1200*	1200
7	8.30	10.30	16.	18.	2.5	1-10	270*	270
8	8.15	10.	17	18	2.5	1-10	210	210
9	8.15	10.	16.5	16	2.6	1-10	490	490
10	8.15	10.	17.	18.	2.6	1-10	350	350
11	8.15	10.	17.5	19.	2.7	1-10	230	230
12	1.45	3.	17.5	15.	2.9	1-100	1) 2200	
							2) 2600	2400
14	9.00	10.30	14.	11.	3.0	1-10	1) 1120	
							2) 840	
						1-100	1200	1090
15	3.20	4.	15.	20.	3.1	1-10	1) 550	
							2) 670	610

*Agar plate counts, 8 days; all others, gelatine, 48 hours.

ILLINOIS RIVER—Grafton.

Date 1901 Oct.	Hour of collection.	Plating.	Temperature C.		Height of Water.	Dilution.	No. of Colonies per cc.		
			Water.	Air.					Averages.
16	3.45	4.30	15.	17.	3.4	1-10	1)	350	
							2)	330	340
17	3.30	4.15	14.	16.	3.7	1-10	1)	430	
							2)	450	440
18	3.30	4.30	14.	20.	3.9	1-10	1)	220	
							2)	210	210
19	3.15	4.15	15.5	22.	4.0	1-10	1)	270	
							2)	190	230
21	3.30	4.30	16.5	18.	4.1	1-10		360	360
22	3.20	4.15	16.	21.	4.1	1-100	1)	600	
							2)	700	650
23	3.15	4.15	16.	28.5	4.1	1-100		500	500
24	3.45	4.45	16.	23.	4.1	1-10	1)	360	
							2)	340	350
25	3.00	3.45	16.	21.	4.1	1-10	1)	540	
							2)	560	550
9712									
26	3.45	4.30	15.	20.	4.0	1-10	1)	330	
							2)	260	300
28	3.30	4.20	15.	22.	4.1	1-10	1)	570	
							2)	540	550
29	3.30	4.30	16.	26.	4.1	1-10	1)	430	
							2)	420	420
30	3.30	4.30	16.5	23.	4.1	1-10	1)	590	
							2)	420	510
31	3.30	4.20	16.	17.	4.1	1-10	1)	590	
							2)	620	600
Nov.									
1	3.30	4.30	16.	23.	4.1	1-10	1)	590	
							2)	550	570
2	3.00	4.00	16.5	18.	3.9	1-10	1)	560	
							2)	630	600
4	3.20	4.14	12.	8.	3.8	1-10	1)	450	
							2)	490	470

ILLINOIS RIVER—Grafton.

Date 1901 Nov.	Hour of collection.	Plating.	Temperature C. Water.	Temperature C. Air.	Height of Water.	Dilution.	No. of Colonies per cc.	Averages.
5	3.30	4.30	11.	9.	3.7	1-10	1) 280	
							2) 260	270
6	3.00	4.00	10.	19.	3.6	1-10	1) 320	
							2) 380	350
7	3.15	4.15	10.	11.	3.6	1-10	1) 240	
							2) 230	230
8	3.15	4.15	10.	15.	3.5	1-10	1) 380	
							2) 360	370
*								
11	3.15	4.15	11.	22.	3.2	1-10	1) 640	
							2) 620	630
12	4.10	4.50	11.	10.	3.4	1-10	1) 950	
							2) 890	920
13	3.30	4.15	10.	18.	3.5	1-10	1) 610	
							2) 520	570
14	3.15	4.15	9.	10.	3.4	1-10	1) 920	
							2) 710	810
15	3.00	3.50	7.	5.	3.4	1-10	1) 1180	
							2) 1170	1180
							(64 hours)	
16	2.45	3.00	6.	4.	3.4	1-10	1) 710	
							2) 770	740
18	3.15	4.00	5.	8.	3.5	1-10	1) 830	
							2) 930	[illegible]30
19	4.00	4.45	5.	7.	3.6	1-10	1) 960	
							2) 1020	990
*9	3.00	4.00	11.	12.	3.4	1-10	1) 450	
							2) 420	430

9713

ILLINOIS RIVER—Grafton.

Date 1901 Nov.	Hour of collection.	Plating.	Temperature C. Water.	Air.	Height of Water.	Dilution.		No. of Colonies per cc.	Averages.
20	3.15	4.15	5.	11.	3.6	1-10	1)	1080	
							2)	1120	1100
21	3.00	3.45	5.	12.	3.6	1-10	1)	1950	
							2)	1740	1840
22	3.20	4.10	5.	11.	3.7	1-100	1)	3100	
							2)	2200	2700
23	3.00	3.45	5.	5.	3.7	1-100	1)	8800	
							2)	9200	9000
25	3.15	4.15	6.	10.	3.7	1-100	1)	2700	
							2)	3600	3200
26	3.20	4.20	5.5	10.	3.5	1-100	1)	2500	
							2)	2900	2700
27	2.45	3.30	6.	10.	3.5	1-100	1)	6200	
							2)	6900	6500
28	1.00	2.10	5.5	11.	3.5	1-100	1)	7400	
							2)	7900	7700
29	2.50	3.45	6.	12.	3.5	1-100	1)	6400	
							2)	6400	6400
30	2.45	3.40	6.	12.	3.5	1-100	1)	4400	
							2)	4300	4300
Dec.									
2	3.00	4.00	5.5	5.	3.5	1-100	1)	3500	
							2)	3700	3600
3	4.00	4.45	5.	4.	3.4	1-100	1)	2100	
							2)	2300	2200
4	2.45	3.45	4.5	3.5	3.3	1-10		1850	
						1-100	1)	1800	
							2)	1900	1850
5	2.30	3.35	3.5	.	3.2	1-100	1)	3800	
							2)	4100	4000
6	3.15	4.30	3.5	4.	3.1	1-100	1)	9600	
							2)	9800	9700
7	2.15	3.10	3.5	7.	3.0	1-100	1)	8500	
							2)	8200	8400
9	3.30	4.20	3.	2.	3.2	1-100	1)	4100	
							2)	4400	4200

ILLINOIS RIVER—Grafton.

Date 1901 Dec.	Hour of collection.	Plating.	Temperature C. Water.	Air.	Height of Water.	Dilution.	No. of Colonies per cc.	Averages.
10	2.45	3.30	3.	5.	3.0	1-100	1) 8600	
							2) 9800	9200
11	2.45	3.30	3.5	4.	3.0	1-100	1) 8800	
							2) 9200	9000
12	2.45	3.40	3.5	14.	2.9	1-100	1) 6200	
							2) 6100	6100
13	2.30	3.20	3.5	-1.	2.9	1-100	1) 11800	
							2) 12200	12000
14	3.00	4.00	1.	-12.	2.8	1-1000	1) 28000	
							2) 31000	30000
16	2.30	3.30	0.	-3.5	1.1	1-1000	1) 124000	
							2) 122000	123000
17	2.30	3.30	0.	-12.	1.0	1-1000	1) 63000	
							2) 62000	62000
18	2.00	3.00	0.	-12.	1.0	1-1000	1) 18000	
							2) 17000	18000
19	2.20	3.20	0.	-8.	.9	1-1000	1) 53000	
							2) 54000	53000
20	2.00	2.50	0.	-13.	.9	1-1000	1) 18000	
							2) 22000	20000
21	1.15	2.15	0.	-5.	1.9	1-1000	1) 13000	
							2) 16000	15000
23	2.00	3.00	0.	12.	2.4	1-100	1) 26000	
							2) 26000	26000
24	1.30	2.30	0.	13.	2.4	1-100	1) 15300	
							2) 13500	14000

9714

General Average 6900

9715 Q. Will you state what the table you have just read shows, and its sanitary significance?

A. This table contains the results of bacterial counts made from samples of water taken from the Illinois river at Grafton, between October 1st and December 24th, 1901. The data specified as given in the Peoria tables are given also in this table.

The numbers of bacteria per cubic centimeter found in the water of the Illinois river at Grafton are very similar to those found in the water of the Illinois river at Averyville.

9716 Q. Will you produce and read in evidence the table for the determinations made of the Mississippi river above Grafton?

A. Yes sir, it is as follows:

9717

MISSISSIPPI RIVER—Grafton.

Date 1901 Oct.	Hour of collection.	Plating.	Temperature C. Water.	Air.	Height of Water.	Dilution.		No. of Colonies per cc.	Averages.
1	2.30	3.00	21.	29.	2.7	1-100	1)	2200*	
							2)	2300*	2300
2	3.30	3.45	20.5	18.	2.7	1-100		1900*	1900
3	4.45	5.30	18.5	17.5	2.7	1-10		1450*	1450
4	9.15	11.10	16.5	9.	2.6	1-100		1700*	1700
5	10.30	11.30	15.5	15.	2.6	1-100		1500*	1500
7	9.15	10.30	15.	19.	2.5	1-10		840*	840
8	9.00	10.00	16.	18.	2.5	1-100		900	900
9	8.45	10.00	16.	16.	2.6	1-10		990	990
10	9.00	10.00	16.	18.	2.6	1-10		1350*	1350
11	8.45	10.00	17.	19.	2.7	1-100		700*	700
12	2.15	3.00	17.	15.	2.9	1-100	1)	2200	
							2)	2000	2100
14	9.30	10.30	14.	11.	3.0	1-10	1)	1060	
							2)	1010	1040
15	4.00	4.15	14.	20.	3.1	1-10	1)	860	
							2)	530	700
16	4.30	5.00	15.	17.	3.4	1-10	1)	610	
							2)	640	620

*Agar plate counts eight days; all others, gelatine, 48 hours.

MISSISSIPPI RIVER—Grafton.

Date 1901 Oct.	Hour of collection.	Plating.	Temperature C.		Height of Water.	Dilution.		No. of Colonies per cc.	
			Water.	Air.					Averages.
17	4.15	4.45	13.	16.	3.7	1-10	1)	920	
							2)	910	910
18	4.00	4.30	13.	20.	3.9	1-10		620	620
19	3.45	4.15	13.5	22.	4.0	1-100	1)	1600	
							2)	1600	1600
21	4.00	4.30	14.5	18.	4.0	1-10	1)	1080	
							2)	960	1020
22	3.45	4.15	14.5	21.	4.1	1-100		1900	1900
23	4.15	4.45	15.	28.5	4.1	1-100	1)	6000	
							2)	5500	5700
24	4.45	5.15	15	23	4.1	1-10	1)	2340	
							2)	2150	2200
25	4.00	4.25	15	21	4.1	1-100	1)	3200	
							2)	3700	3500
26	4.20	5.00	15	20	4.0	1-100	1)	2400	
							2)	2800	2600
28	4.30	5.00	15	22	4.1	1-10	1)	1720	
							2)	1870	
						1-100	1)	2200	
							2)	2500	2100
9718									
29	4.30	5.15	15	26	4.1	1-10	1)	1340	
							2)	1260	
						1-100	1)	1900	
							2)	1600	1500
30	4.00	4.30	15.5	23	4.1	1-10	1)	1020	
							2)	1140	1300
						1-100	1)	1100	
							2)	1900	
31	4.15	4.45	16	17	4.1	1-10	1)	1580	
							2)	1420	
						1-100	1)	1900	
							2)	2300	1800

MISSISSIPPI RIVER—Grafton.

Date 1901 Nov.	Hour of collection.	Plating.	Temperature C.		Height of Water.	Dilution.	No. of Colonies per cc.	
			Water.	Air.				Averages.
1	4.20	5.00	16	23	4.1	1-10	1) 1560	
							2) 1580	1570
2	3.30	4.00	16	18	3.9	1-10	1) 1780	
							2) 1630	
						1-100	1) 1600	
							2) 2100	1800
4	4.30	5.00	11	8	3.8	1-10	1) 1270	
							2) 1230	1250
5	4.50	5.30	9.5	8	3.7	1-10	1) 1260	
							2) 1080	1170
6	4.15	4.45	9.5	19	3.6	1-10	1) 1240	
							2) 1260	1250
7	4.15	4.45	9	11	3.6	1-10	1) 1420	
							2) 1450	1430
8	4.00	4.30	9	15	3.5	1-10	1) 1310	
							2) 1230	1270
9	4.00	4.30	9	12	3.4	1-10	1) 1920	
							2) 1840	1880
11	4.15	4.45	10	22	3.2	1-10	1) 1840	
							2) 1720	1800
12	4.40	5.10	9.5	10	3.4	1-10	1) 1370	
							2) 1680	1500
13	4.20	5.00	9	18	3.5	1-10	1) 1180	
							2) 1160	1170
14	4.10	4.45	8.5	10	3.4	1-10	1) 1070	
							2) 1020	1050
15	3.40	4.20	6.5	5	3.4	1-10	1) 1120	
							2) 11260	
							(64 hrs)	1200
16	3.30	4.00	5.5	4	3.4	1-10	1) 1090	
							2) 1020	1050
18	4.15	4.45	4.5	8	3.5	1-10	1) 980	
							2) 880	930

9719 MISSISSIPPI RIVER—Grafton.

Date 1901	Hour of		Temperature C.		Height of			No. of Colonies per cc.	
Nov.	collection.	Plating.	Water.	Air.	Water.	Dilution.			Averages.
19	4.40	5.15	4	7	3.6	1-10	1)	1220	
							2)	1340	1280
20	4.15	4.45	4	11	3.6	1-10	1)	1350	
							2)	1280	1320
21	3.45	4.15	4	12	3.6	1-10	1)	1450	
							2)	1360	1400
22	4.15	4.45	4	11	3.7	1-10	1)	1620	
							2)	1860	1740
23	3.45	4.30	4	5	3.7	1-10	1)	1720	
							2)	1890	1800
25	4.15	4.40	5.5	10	3.7	1-10	1)	740	
							2)	820	780
26	4.15	5.00	5.	10	3.5	1-10	1)	640	
							2)	580	610
27	3.40	4.15	5.5	10	3.5	1-10	1)	820	
							2)	820	820
28	2.00	2.40	5.5	11	3.5	1-10	1)	940	
							2)	930	940
29	3.40	4.15	5	12	3.5	1-10	1)	760	
							2)	790	770
30	3.45	4.20	5.5	12	3.5	1-10	1)	860	
							2)	880	870
Dec.									
2	4.00	4.40	5	5	3.5	1-10	1)	1080	
							2)	1050	1060
3	4.50	5.20	4.5	4	3.4	1-10	1)	420	
							2)	450	430
4	3.45	4.20	4	3.5	3.3	1-10	1)	720	
							2)	660	690
5	3.50	4.40	2.5	1	3.2	1-10	1)	520	
							2)	580	550
6	4.15	4.45	2.5	4	3.1	1-10	1)	510	
							2)	530	520
7	3.15	3.45	2.5	7	3.0	1-100	1)	600	
							2)	700	650

MISSISSIPPI RIVER—Grafton.

Date 1901 Dec.	Hour of collection.	Plating.	Temperature C. Water.	Temperature C. Air.	Height of Water.	Dilution.	No. of Colonies per cc.		Averages.
9	4.15	5.00	2.	2	3.2	1-10	1)	880	
							2)	760	820
10	3.30	4.00	2.	5	3.0	1-10	1)	580	
							2)	570	570
11	3.30	4.15	2	4	2.9	1-10	1)	860	
							2)	780	820
12	3.45	4.30	2.5	14	2.9	1-10	1)	510	
							2)	480	500
13	3.20	4.00	2.5	-1	2.9	1-100	1)	2100	
							2)	2500	2300
14	4.10	5.00	1.	-12	2.8	1-100	1)	2700	
							2)	2200	2400
16	4.10	4.40	0.	-3.5	1.0	1-10	1)	960	
							2)	930	950
17	3.30	4.30	0.	-12	1.0	1-10	1)	1030	
							2)	1060	1040
18	3.30	4.05	0.	-12	1.0	1-10	1)	820	
							2)	850	840
19	3.30	4.10	0	-8	.9	1-10	1)	580	
							2)		580
20	3.10	3.45	0.	-13	.9	1-10	1)	580	
							2)	520	550
21	2.30	3.15	0.	-5	1.9	1-10	1)	410	
							2)	360	390
23	3.20	4.00	0.	12	2.4	1-10	1)	780	
							2)	730	750
24	2.40	3.20	0.	13	2.4	1-10	1)	820	
							2)	850	840

General average, 1300.

9721 Q. Will you state what the table you have just read shows, and its sanitary significance?

A. This table contains the tabulations of colony counts made from samples of water obtained from the Mississippi river at Grafton between October 1st, 1901, and December 24th, 1901, other data specified in the Peoria tables being also included in this table. Throughout most of the period covered the results correspond rather closely with those obtained upon the Illinois river at its mouth.

Q. Have you a series of tables for the cross-section of the Mississippi river at the chain of rocks?

A. Yes, sir.

Q. Will you produce and read those tables?

A. Yes, sir; the tables are as follows:

9722 MISSISSIPPI RIVER—Chain of Rocks—Illinois Shore.

Date 1901 Oct.	Hour of collection.	Plating.	Temperature C.		Height of Water.	Dilution.	No. of Colonies per cc.		
			Water.	Air.					Averages.
7	8.10	11.30	16	17	79.05	1-100	1)	4000	
							2)	6000	5000
8	8.10	11.30			79.1	1-10	1)	2130	
							2)	2450	2300
9	8.30	11.30			79.15	1-100	1)	2600	
							2)	2200	2400
10	8.20	9.20	17	16	79.15	1-100	1)	1900	
							2)	2000	2000
11	8.30	12.00	18	19	79.1	1-100	1)	2200	
							2)	2600	2400
12	8.30	9.15	64F	59F	79.25	1-100	1)	1900	
							2)	2000	1900
14	8.15	9.00	58F	48F	79.15	1-100	1)	2200	
							2)	2700	2500
15	8.20	8.45	55F	48F	79.1	1-100	1)	2700	
							2)	4700	3700
16	8.15	8.50	54F	50F	79.1	1-100	1)	2700	
							2)	2600	2600
17	8.15	8.45	13C	8C	79.25	1-100	1)	2200	
							2)	1800	2000

MISSISSIPPI RIVER—Chain of Rocks—Illinois Shore.

Date 1901 Oct.	Hour of collection.	Plating.	Temperature C. Water.	Air.	Height of Water.	Dilution.	No. of Colonies per cc.		Averages.
18	8.15	9.00	12.5	9	79.4	1-100	1)	1200	
							2)	1300	1200
19	8.10	9.00	13	18	79.5	1-100	1)	1400	
							2)	1600	1500
21	8.20	9.00	14	12	79.7	1-100	1)	2100	
							2)	2100	2100
22	8.10	8.45	14	11	79.5	1-100	1)	3200	
							2)	3200	3200
23	8.10	9.00	14	13	79.65	1-100	1)	1800	
							2)	1600	1700
24	8.10	8.45	15	16	79.6	1-100	1)	3100	
							2)	2200	2600
25	8.10	8.45	14	10	79.5	1-100	1)	3800	
							2)	2300	3100
26	8.10	8.45	14	12	79.45	1-100	1)	3100	
							2)	2100	2600
28	8.10	9.20	14	10	79.5	1-100	1)	2600	
							2)	2400	2500
29	8.10	8.45	14	14	79.5	1-100	1)	900	
							2)	600	700
30	8.10	9.00	15	14	79.5	1-100	1)	3000	
							2)	2600	2800
9723									
31	8.10	8.50	15	16	79.5	1-100	1)	2100	
							2)	1700	1900
Nov.									
1	8.30	8.45	15	11	79.4	1-100	1)	1500	
							2)	1500	1500
2	8.10	8.45	14	12.5	79.4	1-100	1)	1500	
							2)	1200	1400
4	8.10	8.50	10	-5	79.2	1-100	1)	1800	
							2)	1500	1600
5	8.20	9.00	7	1	79.2	1-100	1)	500	
							2)	500	500

MISSISSIPPI RIVER—Chain of Rocks—Illinois Shore.

Date 1901 Nov.	Hour of collection.	Plating.	Temperature C. Water.	Temperature C. Air.	Height of Water.	Dilution.	No. of Colonies per cc.		Averages.
6	8.10	9.30	7	3	79.1	1-100	1)	1100	
							2)	500	800
7	8.10	9.10	8.5	4	79.1	1-100	1)	1300	
							2)	1000	1200
8	8.20	9.00	8	3.5	79.1	1-100	1)	2100	
							2)	1900	2000
11	8.25	9.45	9	16	79.1	1-100	1)	2300	
							2)	2100	2200
12	8.45	9.40	9.5	3	79.2	1-100	1)	3200	
							2)	2300	2800
13	8.35	9.40	9	9	79.2	1-100	1)	3300	
							2)	2800	3000
14	9.10	9.45	9	8	79.2	1-100	1)	2400	
							2)	2200	2300
15	9.10	9.45	7	0	79.2	1-100	1)	2300	
							2)	2000	2200
16	8.55	9.30	5	-2	79.2	1-100	1)	1300	
							2)	1800	1500
18	9.05	9.50	4.5	1	79.1	1-100	1)	2500	
							2)	2200	2400
19	9.30	10.05	4	1.5	79.1	1-100	1)	2600	
							2)	2400	2500
20	8.40	8.45	4	0	79.	1-100	1)	1400	
							2)	1100	1300
21	9.05	9.35	4	4	79.	1-100	1)	3100	
							2)	1800	2500
22	9.05	9.35	5	5	79.	1-100	1)	2100	
							2)	1600	1800
23	8.40	9.20	5	3	79.	1-100	1)	2900	
							2)	2300	2600
25	8.45	10.10	6	7	79.	1-100	1)	2000	
							2)	1900	1900

9724 MISSISSIPPI RIVER—Chain of Rocks—Illinois Shore.

Date 1901	Hour of		Temperature C.		Height of			No. of Colonies per cc.	
Nov.	collection.	Plating.	Water.	Air.	Water.	Dilution.			Averages.
26	8.45	9.30	5	3	78.9	1-100	1)	3000	
							2)	2200	2600
27	9.40	10.30	6	6	78.9	1-100	1)	2000	
							2)	3000	2500
29	9.20	10.10	5	11	78.8	1-100	1)	4900	
							2)	3000	4000
30	8.45	9.30	5	5	78.8	1-100	1)	3600	
							2)	4500	4000
Dec.									
2	8.15	9.15	7	4	78.7	1-100	1)	3200	
							2)	2500	2900
6	9.00	9.30	3	1	78.5	1-100	1)	2300	
							2)	2200	2200
9	8.40	9.45	3	-1	78.6	1-100	1)	3300	
							2)	3000	3200
10	8.50	9.45	2	2	78.5	1-100	1)	2700	
							2)	2900	2800
11	9.45	10.15	3	2	78.4	1-100	1)	3100	
							2)	2900	3000
12	8.50	9.20	3	5	78.3	1-100	1)	1700	
							2)	1500	1600
13	8.45	9.40	5	4.5	78.4	1-100	1)	1600	
							2)	1600	1600
14	8.50	10.15	0	-15	78.6	1-100	1)	6700	
							2)	6400	6500

General average, 2400.

9725 MISSISSIPPI RIVER—Chain of Rocks—Mid-stream.

Date 1901 Oct.	Hour of collection.	Plating.	Temperature C.		Height of Water.	Dilution.	No. of Colonies per cc.		
			Water.	Air.					Averages.
7	8.23	11.30	16	17	79.05	1-100	1)	7000	7000
8	8.20	11.30			79.1	1-10	1)	3400	
							2)	4000	3700
10	8.30	9.20	17	25	79.15	1-100	1)	3300	
							2)	3200	3300
11	8.00	12.00	18	19	79.1	1-100	1)	4600	
							2)	3200	3900
12	8.35	9.15	64F	59F	79.25	1-100	1)	2100	
							2)	2300	2200
14	8.25	9.00	58F	48F	79.15	1-100	1)	11000	
							2)	9900	10000
15	8.25	8.45	55F	48F	79.1	1-100	1)	7600	
							2)	7800	7700
16	8.20	8.50	54F	50F	79.1	1-100	1)	15700	
							2)	15000	15000
17	8.15	8.45	13C	8C	79.25	1-100	1)	5200	
							2)	6100	5700
18	8.20	9.00	12.5	9	79.4	1-100	1)	2700	
							2)	1700	2200
19	8.20	9.00	13	18	79.5	1-100	1)	2500	
							2)	2000	2300
21	8.25	9.00	14	12	79.7	1-100	1)	6100	
							2)	6000	6100
22	8.20	8.45	14	11	79.7	1-100	1)	7600	
							2)	7800	7700
23	8.20	9.00	14	13	79.65	1-100	1)	9800	
							2)	8800	9400
24	8.20	8.45	15	16	79.6	1-100	1)	6700	
							2)	7000	6800
25	8.20	8.45	14	10	79.5	1-100	1)	5100	
							2)	8600	6800
26	8.20	8.45	14	12	79.45	1-100	1)	6800	
							2)	7000	6900
28	8.20	9.20	14	10	79.5	1-100	1)	7700	
							2)	7300	7500

MISSISSIPPI RIVER—Chain of Rocks—Mid-stream.

Date 1901	Hour of collection.	Plating.	Temperature C.		Height of Water.	Dilution.	No. of Colonies per cc.		
Oct.			Water.	Air.					Averages.
29	8.20	8.45	14	14	79.5	1-100	1)	3100	
							2)	2500	2900
30	8.20	9.00	15	14	79.5	1-100	1)	3700	
							2)	3900	3800
31	8.20	8.50	15	16	79.5	1-100	1)	2900	
							2)	2500	2700
9726									
Nov.									
1	8.20	8.45	15	11	79.4	1-100	1)	1400	
							2)	1500	1500
2	8.20	8.45	14	12.5	79.4	1-100	1)	2500	
							2)	2000	2200
4	8.20	8.50	10	-5	79.2	1-100	1)	1900	
							2)	2000	2000
5	8.25	9.00	7	1	79.2	1-100	1)	2600	
							2)	2600	2600
6	8.20	9.30	7	3	79.1	1-100	1)	2800	
							2)	2400	2600
7	8.20	9.10	8.5	4	79.1	1-100	1)	3000	
							2)	1800	
8	8.25	9.00	8	3.5	79.1	1-100	1)	2500	
							2)	2900	2700
11	8.30	9.40	9	16.	79.1	1-100	1)	10100	10100
12	8.50	9.40	9.5	3	79.2	1-100	1)	7100	
							2)	7400	7300
13	8.40	9.40	9	9.	79.2	1-100	1)	7600	
							2)	5600	6600
14	9.20	9.45	9.	8	79.2	1-100	1)	2800	
							2)	6000	4400
15	9.15	9.45	7	0	79.2	1-100	1)	3200	
							2)	5900	4600
16	9.00	9.30	5	-2	79.2	1-100	1)	2700	
							2)	3100	3400
18	9.10	9.50	4.5	1	79.1	1-100	1)	11500	
							2)	13100	12000
19	9.35	10.05	4	1.5	79.1	1-100	1)	4100	
							2)	3900	4000

MISSISSIPPI RIVER—Chain of Rocks—Mid-Stream.

Date 1901 Nov.	Hour of collection.	Plating.	Temperature C.		Height of Water.	Dilution.	No. of Colonies per cc.		
			Water.	Air.					Averages.
20	8.35	9.45	4	0	79.	1-100	1)	6900	
							2)	6300	6600
21	9.10	9.35	4	4	79.	1-100	1)	6000	
							2)	6900	6500
22	9.10	9.35	5	5	79.	1-100	1)	8100	
							2)	8900	8500
23	8.45	9.20	5	3	79.	1-100	1)	6000	
							2)	2300	4200
25	8.50	10.10	6	7	79.	1-100	1)	4200	
							2)	4100	4100
26	8.50	9.30	5	3	78.9	1-100	1)	3200	
							2)	3900	3500
9727									
27	9.45	10.30	6	6	78.9	1-100	1)	4200	
							2)	6800	5500
29	9.25	10.10	5	11	78.8	1-100	1)	1800	
							2)	2600	2200
30	8.50	9.30	5	5	78.8	1-100	1)	4200	
							2)	4600	4400
Dec.									
2	8.20	9.15	7	4	78.8	1-100	1)	7300	
							2)	8900	8100
6	9.05	9.30	3	1	78.5	1-100	1)	2700	
							2)	2000	2400
9	8.50	9.45	3	-1	78.6	1-100	1)	8300	
							2)	7400	7900
10	8.55	9.45	2	2	78.5	1-100	1)	2400	
							2)	3000	2700
11	9.50	10.15	3	2	78.4	1-100	1)	8500	
							2)	7200	7800
12	8.55	9.20	3	5	78.3	1-100	1)	1600	
							2)	2500	2000
13	8.50	9.40	5	4.5	78.4	1-100	1)	2100	
							2)	2700	2400
14	9.00	10.15	0	-15	78.6	1-100	1)	4000	
							2)	4200	4100
							3)	4	

General average, 5200.

9728 MISSISSIPPI RIVER Chain of Rocks—Intake Tower.

Date 1901 Oct.	Hour of collection.	Plating.	Temperature C.		Height of Water.	Dilution.	No. of Colonies per cc.	
			Water.	Air.				Averages.
7	8.30	11.30	16	17	79.05	1-100	1) 14400	14400
8	8.30	11.30			79.1	1-10	1) 5560	
							2) 5500	5500
9	8.40	11.30	16	17	79.1	1-100	1) 7000	
							2) 8100	7600
10	8.40	9.20	17	25	79.15	1-100	1) 8200	
							2) 13000	11000
11	8.25	12.00	18	17	79.1	1-100	1) 8800	
							2) 9400	9100
12	8.50	9.15	64F	69F	79.25	1-100	1) 4200	
							2) 2900	3500
14	8.35	9.00	58F	48F	79.15	1-100	1) 22500	
							2) 22700	22000
15	8.55	8.45	55F	48F	79.1	1-100	1) 27300	
							2) 31500	29000
16	8.30	9.00	54F	50F	79.1	1-100	1) 32700	
							2) 32600	33000
17	8.20	8.45	13C	8C	79.25	1-100	1) 15500	
							2) 17300	16000
18	8.30	9.00	12.5	9	79.4	1-100	1) 14400	
							2) 12100	13000
19	8:30	9.00	13	18	79.5	1-100	1) 13300	
							2) 9300	11000
21	8.35	9.00	14	12	79.7	1-100	1) 40700	
							2) 37300	39000
22	8.30	8.45	14	11	79.7	1-100	1) 31100	
							2) 18300	18000
24	8.20	8.45	15	16	79.6	1-100	1) 7400	7400
25	8.30	8.45	14	10	79.5	1-100	1) 26900	
							2) 21100	24000
26	8.30	8.45	14	12	79.45	1-100	1) 33400	
							2) 28900	31000
28	8.30	9.20	14	10	79.5	1-100	1) 25400	
							2) 26600	26000

MISSISSIPPI RIVER—Chain of Rocks—Intake Tower.

Date 1901 Oct.	Hour of collection.	Plating.	Temperature C. Water.	Air.	Height of Water.	Dilution.	No. of Colonies per cc.	Averages.
29	8.30	8.45	14	14	79.5	1-100	1) 14100	
							2) 16300	15000
30	8.30	9.00	15	14	79.5	1-100	1) 24100	
							2) 25600	25000
31	8.30	8.50	15	16	79.5	1-100	1) 5600	
							2) 4100	4800
9729								
Nov.								
1	9.00	8.45	15	11	79.4	1-100	1) 6900	
							2) 6700	6300
2	8.30	8.45	14	12.5	79.4	1-100	1) 6600	
							2) 5500	6000
4	8.30	8.50	10	-5	79.2	1-100	1) 7700	
							2) 7400	7600
5	8.30	9.00	7	1	79.2	1-100	1) 4800	
							2) 4800	4800
6	8.30	9.30	7	3	79.1	1-100	1) 5200	
							2) 5200	5200
7	8.30	9.10	8.5	4	79.1	1-100	1) 11400	
							2) 10400	11000
8	8.30	9.00	8	2.5	79.1	1-100	1) 40000	
							2) 13000	27000
11	8.50	9.40	9	16	79.1	1-100	1) 42000	
							2) 44100	43000
12	9.05	9.40	9.5	3	79.2	1-100	1) 68000	
							2) 17000	42000
13	8.54	9.40	9	9	79.2	1-100	1) 62800	
							2) 68800	66000
14	9.30	9.45	9	8	79.2	1-1000	1) 42000	
							2) 42000	42000
15	9.35	9.45	7	0	79.2	1-1000	1) 26000	
							2) 26000	26000
16	9.00	9.30	5	-2	79.2	1-1000	1) 24000	
							2) 19000	22000
18	9.25	9.50	4.5	1	79.1	1-1000	1) 28000	
							2) 36000	32000

MISSISSIPPI RIVER—Chain of Rocks—Intake Tower

Date 1901 Nov.	Hour of collection.	Plating.	Temperature C. Water.	Air.	Height of Water.	Dilution.	No. of Colonies per cc	Averages.
19	9.50	10.05	4	1.5	79.1	1-1000	1) 38000	
							2) 26000	32000
20	9.00	9.45	4	0	79.	1-1000	1) 42000	
							2) 27000	34000
21	9.25	9.35	4	4	79.	1-1000	1) 40000	
							2) 45000	38000
23	9.00	9.20	5	3	79.	1-1000	1) 13000	
							2) 12000	13000
25	9.00	10.00	6	7	79.	1-100	1) 18200	
							2) 18700	18000
26	9.05	9.30	5	3	78.9	1-1000	1) 16000	
							2) 16000	16000
9730								
27	10.00	10.30	6	6	78.9	1-100	1) 14200	
							2) 14300	14000
29	9.40	10.10	5	11	78.8	1-100	1) 50000	
							2) 41000	46000
30	9.05	9.30	5	5	78.8	1-1000	1) 44000	
							2) 49000	47000
Dec.								
2	8.35	9.15	7	4	78.7	1-100	1) 40300	
							2) 31600	36000
6	9.20	9.30	3	1	78.5	1-1000	1) 30000	
							2) 27000	28000
9	9.05	9.45	3	-1	78.6	1-1000	1) 17000	
							2) 12000	14000
10	9.10	9.45	2	2	78.5	1-1000	1) 20000	
							2) 16000	18000
11	10.05	10.15	3	2	78.4	1-1000	1) 10000	10000
12	9.10	9.20	3	5	78.3	1-1000	1) 14000	
							2) 16000	15000
13	9.05	9.40	5	4.5	78.4	1-1000	1) 13000	
							2) 11000	12000
14	9.30	10.15	0	-15	78.6	1-100	1) 5500	
							2) 3100	4300

General average, 21,600

MISSISSIPPI RIVER—Chain of Rocks—Missouri Shore.

Date 1901 Oct.	Hour of collection.	Plating.	Temperature C.		Height of Water.	Dilution.	No. of Colonies per cc.		
			Water.	Air.					Averages.
7	7.55	11.30	16	17	79.05	1-100		5000	5000
8	8.00	11.30			79.1	1-10	1)	4570	
							2)	4800	4700
9	8.20	11.30	16	17	79.15	1-100	1)	5100	
							2)	4400	4700
10	8.07	9.20	17	25	79.15	1-100	1)	9300	
							2)	9700	9500
11	8.00	12.00	18	19	79.1	1-100	1)	3100	
							2)	6600	6900
12	8.40	9.15	64F	59F	79.25	1-100	1)	3100	
							2)	3600	3300
14	8.00	9.00	58F	48F	79.15	1-100	1)	14400	
							2)	15100	15000
15	8.05	8.45	55F	48F	79.1	1-100	1)	30400	
							2)	35900	33000
16	8.00	8.50	54F	50F	79.1	1-100	1)	22100	
							2)	25300	24000
17	8.00	8.45	13C	8C	79.25	1-100	1)	15400	
							2)	15400	15000
18	8.00	9.00	12.5	9	79.4	1-100	1)	9500	9500
19	8.00	9.00	13.	18	79.5	1-100	1)	16300	
							2)	15900	16000
21	8.05	9.00	14	12	79.7	1-100	1)	11100	
							2)	11200	11000
22	8.00	8.45	14	11	79.7	1-100	1)	10400	
							2)	18000	14000
24	8.00	8.45	15	16	79.6	1-100	1)	19000	
							2)	16000	18000
25	8.00	8.45	14	10	79.5	1-100	1)	20000	
							2)	17900	19000
26	8.00	8.45	14	12	79.45	1-100	1)	31000	
							2)	34000	32000
28	8.00	9.20	14	10	79.5	1-100	1)	17900	
							2)	18100	18000

MISSISSIPPI RIVER—Chain of Rocks—Missouri Shore.

Date 1901 Oct.	Hour of collection.	Plating.	Temperature C. Water.	Temperature C. Air.	*Height of Water.	Dilution.	No. of Colonies per cc.	Averages.
29	8.00	8.45	14	14	79.5	1-100	1) 7200	
							2) 6900	7100
30	8.00	9.00	15	14	79.5	1-100	1) 13900	
							2) 19600	16000
31	8.00	8.50	15	16	79.5	1-100	1) 3800	
							2) 3900	3900
9732 Nov.								
1	8.20	8.45	15	11	79.4	1-100	1) 2100	
							2) 2600	2900
2	8.00	8.45	14	12.5	79.4	1-100	1) 4400	
							2) 4100	4300
4	8.00	8.50	10	-5	79.2	1-100	1) 3000	
							2) 3500	3200
5	8.10	9.00	7	1	79.2	1-100	1) 5100	
							2) 4700	4900
6	8.00	9.30	7	3	79.1	1-100	1) 3100	
							2) 2500	2800
7	8.00	9.10	8.5	4	79.1	1-100	1) 5100	
							2) 5000	5100
8	8.10	9.00	8	3.5	79.1	1-100	1) 7900	
							2) 6400	7100
11	8.10	9.40	9	16	79.1	1-100	41700	41700
12	8.30	9.40	9.5	3	79.2	1-100	1) 41200	
							2) 32400	37000
13	8.20	9.40	9	9	79.2	1-100	1) 45400	
							2) 31800	38000
14	8.50	9.45	9	8	79.2	1-1000	1) 25000	
							2) 17000	21000
15	8.55	9.45	7	0	79.2	1-1000	1) 23000	
							2) 25000	24000
16	8.35	9.30	5	-2	79.2	1-1000	1) 18000	
							2) 16000	17000
18	8.50	9.50	4.5	1	79.1	1-1000	1) 54000	
							2) 67000	60000
19	9.15	10.05	4	1.5	79.1	1-1000	1) 30000	
							2) 30000	32000

MISSISSIPPI RIVER—Chain of Rocks—Missouri Shore.

Date 1901 Nov.	Hour of collection.	Plating.	Temperature C. Water.	Air.	Height of Water.	Dilution.	No. of Colonies per cc.	Averages.
20	8.25	9.45	4	0	79.	1-1000	1) 21000	
							2) 22000	22000
21	8.50	9.35	4	4	79.	1-1000	1) 21000	
							2) 41000	31000
22	8.50	9.35	5	5	79.	1-1000	1) 21000	
							2) 14000	18000
23	8.25	9.20	5	3	79.	1-1000	1) 20000	
							2) 24000	22000
25	8.30	10.10	6	7	79.	1-1000	1) 17000	
							2) 14000	15000
26	9.30	9.30	5	3	78.9	1-1000	1) 9000	
							2) 12000	10000
9733								
27	9.25	10.30	6	6	78.9	1-100	1) 25500	
							2) 20200	23000
29	9 [illegible]	10.10	5	11	78.8	1-100	1) 47000	
							2) 33000	40000
30	8.30	9.30	5	5	78.8	1-1000	1) 33000	
							2) 38000	36000
Dec.								
2	8.00	9.45	7	4	78.7	1-1000	1) 18000	
							2) 17000	18000
6	8.45	9.30	3	1	78.5	1-1000	1) 18000	
							2) 18000	18000
9	8.30	9.45	3	-1	78.6	1-1000	1) 18000	
							2) 17000	17000
10	8.35	9.45	2	2	78.5	1-1000	1) 13000	
							2) 15000	14000
11	9.30	10.15	3	2	78.4	1-1000	1) 14000	
							2) 12000	13000
12	8.35	9.20	3	5	78.3	1-1000	1) 3000	
							2) 3000	3000
13	8.30	9.40	5	4.5	78.4	1-1000	1) 1000	
							2) 6000	8000
14	8.35	1.15	0	-15	78.6	1-1000	1) 4600	
							2) 4100	4400

General Average, 17000

9734 Q. State what those tables show and their sanitary significance?

A. These tables contain tabulations of colony counts made from samples of water taken from the Mississippi river at the chain of rocks between October 7th, 1901 and December 14th, 1901, at four points across stream, namely, those specified in the records of the cross section at this point for 1899 and 1900. These tables show that throughout the period covered the number of bacteria contained in the water taken from the Mississippi river at the intake tower and from the Missouri shore contained a noticeably larger number of bacteria than the water on the Illinois shore.

Q. Will you produce and read the tables showing the colony determinations from the Missouri shore at Fort Bellefontaine?

A. Yes sir, the tables are as follows:

9735

MISSOURI RIVER--Bellefontaine.

Date 1901 Oct.	Hour of collection.	Plating.	Temperature C. Water.	Air.	Height of Water.	Dilution.	No. of Colonies per cc.	Averages.
9	9.15	11.30	60F	62F	4.9	1-100	1) 11100 2) 9200	10200
11	9.25	12.	60	62	4.8	1-100	1) 10000 2) 10800	10000
14	9.30	11.30	48	50	4.5	1-100	1) 51000 2) 53000	52000
15	9.30	12.30	45	47	4.3	1-100	1) 34300 2) 32100	33000
16	9.30	1.00	48	50	4.3	1-100	1) 39700 2) 40700	40000
17	9.30	12.30	42	44	4.3	1-100	1) 11100 2) 11900	11000
18	9.30	1.45	52	45	4.3	1-100	1) 35800 2) 28800	32000
19	9.30	1.30	52	58	4.3	1-100	1) 25300 2) 28000	27000
21	9.55	2.40	52	59	4.5	1-100	1) 29200 2) 31200	30000
23	9.55	12.30	15C	16C	4.4	1-100	1) 17300 2) 21200	19000

MISSOURI RIVER—Bellefontaine.

Date 1901 Oct.	Hour of collection.	Plating.	Temperature C.		Height of Water.	Dilution.	No. of Colonies per cc.	
			Water.	Air.				Averages.
24	9.30	12.	16	21	4.3	1-100	1) 13700 2) 13900	13000
25	9.30	1.30	16	17	4.2	1-100	1) 46000 2) 46900	46000
26	9.30	1.30	17	18	4.1	1-100	1) 7100	7100
28	9.30	2.00	16	15	4.1	1-100	1) 5200 2) 5200	5200
29	9.30	11.30	16	18	4.2	1-100	1) 10300 2) 11000	11000
30	9.30	11.30	16	17	4.3	1-100	1) 5900 2) 5800	5900
31	9.30	12.00	16.5	21	4.3	1-100	1) 5700 2) 4800	5300
Nov.								
1	9.30	11.45	18	16	4.2	1-100	1) 5700 2) 5700	5700
2	9.30	11.30	15.5	14	4.2	1-100	1) 7200 2) 9600	8400
4	9.30	12.	10	8.5	3.9	1-100	1) 9400 2) 7500	8400
5	9.30	12.45	8.25	5	3.9	1-100	1) 7600 2) 5200	6400
7	9.30	12.	8	5	3.8	1-100	1) 27600 2) 20300	24000
8	9.30	12.15	8	5	3.8	1-100	1) 36800 2) 40700	38000
9	9.30	12.15	8	7	4.0	1-100	1) 55700 2) 55300	55000
11	9.30	1.00	10.5	21	4.4	1-100	1) 43400 2) 44500	44000
12	9.30	1.20	9	6	4.3	1-100	1) 21000 2) 22000	22000
13	9.30	12.	8	6	4.3	1-1000	1) 44000 2) 43000	43000

9736

MISSOURI RIVER—Bellefontaine.

Date 1901 Nov.	Hour of collection.	Plating.	Temperature C. Water.	Air.	Height of Water.	Dilution.	No. of Colonies per cc.	Averages.
14	9.30	12.30	9	8.5	4.2	1-1000	1) 35000	
							2) 30000	33000
15	9.30	12.30	6	2	4.2	1-1000	1) 31100	
							2) 28000	29000
16	9.30	12.30	6	1	4.1	1-1000	1) 28000	
							2) 27000	28000
18	9.30	1.00	4	1.5	4.0	1-1000	1) 5000	
							2) 9000	7000
19	9.30	1.30	4	1	3.9	1-1000	1) 16000	
							2) 17000	16000
20	9.30	12.30	4	1	3.8	1-1000	1) 14000	
							2) 48000	31000
21	9.30	12.20	4	5	3.8	1-100	1) 38300	
							2) 36300	37000
22	9.30	12.35	5	9	3.8	1-100	1) 7000	
							2) 7400	7200
23	9.30	12.30	5	3	3.7.5	1-1000	1) 6000	
							2) 8000	7000
25	9.30	1.30	5	4	3.8	1-1000	1) 5000	
							2) 7000	6000
26	9.30	1.30	5	4	3.5.5	1-100	1) 3400	
							2) 2900	3100
28	9.30	1.30	5	8	3.5.5	1-100	1) 25000	
							2) 35000	30000
30	9.30	12.40	5	6	3.4	1-1000	1) 17000	
							2) 16000	17000
9737 Dec.								
2	9.30	1.50	5	4	3.4	1-1000	1) 8000	
							2) 10000	9000
3	9.30	12.00	5	4	3.3.5	1-1000	1) 4000	
							2) 4000	4000
4	9.30	10.45	4	2	3.3	1-1000	1) 17000	
							2) 9000	13000
5	9.30	11.50	3	0	3.3	1-1000	1) 4000	
							2) 4000	34000

MISSOURI RIVER—Bellefontaine.

Date 1901 Dec.	Hour of collection.	Plating.	Temperature C.		Height of Water.	Dilution.	No. of Colonies per cc.	
			Water.	Air.				Averages.
6	7.30	12.30	3	1	3.2.5	1-100	1) 11800	
							2) 7900	9900
7	7.30	9.30	3	3	3.2.5	1-100	1) 32000	
							2) 29000	31000
9	12.30	2.30	3	5	3.2.5	1-100	1) 9700	
							2) 11300	10500
10	7.30	12.40	2	0	3.2	1-1000	1) 12000	
							2) 9000	10000
11	7.30	1.50	2	2	3.3	1-1000	1) 11000	
							2) 11000	11000
12	7.30	9.30	2	3	3.2.5	1-1000	1) 30000	
							2) 28000	29000
13	7.30	1.30	2	9	3.4	1-100	1) 2700	
							2) 2200	2500
15	7.30	9.15	1	-4	3.5	1-1000	1) 21000	
							2) 21000	21000
16	7.30	9.50	1	-9	3.5	1-1000	1) 53000	
							2) 111000	82000

General average, 21000.

9738 Q. State what the table shows and its sanitary significance?

A. This table contains tabulations of colony counts made from samples of water collected from the Missouri river at Fort Bellefontaine between October 9th and December 16th, 1901; other data being included as hereinbefore specified. It shows that throughout this period the number of bacteria in the water of the Missouri river at this point was noticeably higher than in the water of either the Illinois river at its mouth, or the Mississippi river above Grafton.

Q. Have you prepared a table of averages from the table just read?

A. I have.

Q. Will you produce and read the table of averages which you have prepared?

A. Yes, sir; the table of averages is as follows:

9739

Collecting Station.	Number determination.	Average number colonies per cc Oct.-Dec., 1901
Illinois River, Averyville (above Peoria)	69	5800
Illinois River, Pekin (below Peoria)	50	90000
Illinois River, Grafton,	73	6900
Mississippi River, Grafton,	73	1300
Mississippi River, Chain of Rocks, Illinois Shore,	54	2400
Mississippi River, Chain of Rocks, Mid-stream,	53	5200
Mississippi River, Chain of Rocks, Intake Tower,	52	21200
Mississippi River, Chain of Rocks, Missouri Shore,	53	17000
Missouri River, Fort Bellefontaine,	51	21000

9740 Q. State what this table of averages shows and what conclusions you draw from it from a sanitary standpoint?

A. This table contains the averages of the colony counts made from the water of the Illinois river at Averyville, at Pekin and at Grafton; from the Mississippi river at Grafton, and in cross-section at the chain of rocks, and from the Missouri river at Fort Bellefontaine. The number of bacteria found at Averyville and at Grafton was not dissimilar. These averages were higher than the average for this period in the Mississippi river. The usual winter increase which occurs in river waters took place this year in the Illinois river before making its appearance in the Mississippi. Up to the middle of December, 1901, the two waters were very similar as regards their bacterial content. Throughout the whole of the period studied, the average number of bacteria as shown by the colony count in the water of the Missouri river at West Alton was several times as great as the water in either the Illinois river at its mouth or the Mississippi river above Grafton. The number of bacteria in the Illinois river at Pekin as shown by these averages was greatly in excess of that found at any other of the collecting stations, as in 9741 my opinion naturally follows from the entrance of the sewage and refuse of Peoria, into the river above this point.

Q. Have you a table of averages for the cross-section of the Mississippi river at the chain of rocks?

A. I have.

Q. Will you produce and read the table in evidence?

A. Yes, sir; the table is as follows:

9742

AVERAGE NO. COLONIES PER CC.

	Mississippi River, Chain of Rocks.				Missouri River.
Date.	Illinois shore.	Mid-stream.	Intake tower.	Missouri shore.	Ft. Bellefountain.
Oct.					
7	5000	7000	14400	5000	
8	2300	3700	5500	4700	
9	2400		7600	4700	10200
10	2000	3300	11000	9500	
11	2400	3900	9100	6900	10000
12	1900	2200	3500	3300	
14	2500	10000	22000	15000	52000
15	3700	7700	29000	33000	33000
16	2600	15000	33000	24000	40000
17	2000	5700	16000	15000	11000
18	1200	2200	13000	9500	32000
19	1500	2300	11000	16000	27000
21	2100	6100	39000	11000	30000
22	3200	7700	18000	14000	
23	1700	9400			19000
24	2600	6800	7400	18000	13000
25	3100	6800	24000	19000	46000
26	2600	6900	31000	32000	7100
28	2500	7500	26000	18000	5200
29	700	2900	15000	7100	11000
30	2800	3800	25000	16000	5900
31	1900	2700	4800	3900	5300
Nov.					
1	1500	1500	6300	2900	5700
2	1400	2200	6000	4300	8400
4	1600	2000	7600	3200	8400
5	500	2600	4800	4900	6400
6	800	2600	5200	2800	
7	1200	2400	11000	5100	24000

9743 AVERAGE NO. COLONIES PER CC, Con.

Date.	Mississippi River, Chain of Rocks.				Missouri River.
	Illinois shore.	Mid-stream.	Intake tower.	Missouri shore.	Ft. Bellefountain.
Nov.					
8	2000	2700	27000	7100	38000
9					55000
11	2200	10000	43000	41700	44000
12	2800	7300	42000	37000	22000
13	3000	6600	66000	38000	43000
14	2300	4400	42000	21000	33000
15	2200	4600	26000	24000	29000
16	1500	3400	22000	17000	28000
18	2400	12000	32000	60000	7000
19	2500	4000	32000	32000	16000
20	1300	6600	34000	22000	31000
21	2500	6500	38000	31000	37000
22	1800	8500		18000	7200
23	2600	4200	13000	22000	7000
25	1900	4100	18000	15000	6000
26	2600	3500	16000	10000	3100
27	2500	5500	14000	23000	31000
28					30000
29	4000	2200	46000	40000	
30	4000	4400	47000	36000	17000
Dec.					(Dec. 4) 13000
2	2900	8100	36000	18000	9000
3					4000
6	2200	2400	28000	18000	9900
					(Dec. 5) 4000
9	3200	7900	14000	17000	10500
					(Dec. 7) 31000
10	2800	2700	18000	14000	10000
11	3000	7800	10000	13000	11000
12	1600	2000	15000	3000	29000
13	1600	2400	12000	8000	2500
14	6500	4100	4300	4400	
15					21000
16					82000
Gen. Av.	2400	5200	21500	17000	21000

9744 Q. Will you state what the table shows and its sanitary significance?

A. This table contains the results of the bacterial counts made upon samples of water taken from the Mississippi river at the chain of rocks. The averages are arranged in their proper relation, namely, the Illinois shore, mid-stream, intake tower and Missouri shore, the count for the Missouri river being contained in the right hand column. These figures show that during the period covered by this investigation the number of bacteria in the water of the Mississippi river at this point was much lower on the Illinois shore than on the Missouri shore. It shows, moreover, that the water of the intake tower during this period partook of the character bacterially of the water of the Missouri river and of the Mississippi river on the Missouri shore. In other words, during these three months of 1901, judging from the bacterial content of the Missouri river and of the Mississippi river at this point, little, if any, water from the Illinois river entered the intake tower of the St. Louis waterworks. It is evident also from the bacterial count, that if any water from the Illinois shore did pass into the water intake, it improved the condition of this water so far as reducing the number of bacteria per cubic centimeter was concerned.

9745 Q. Have you stated in evidence the stages of water in the Illinois, Mississippi and Missouri rivers during the time of this investigation?

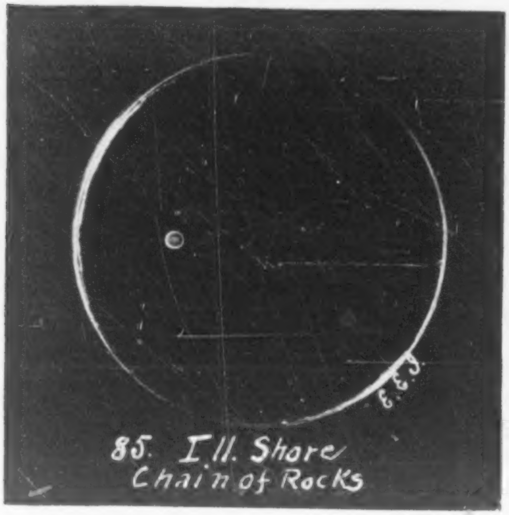
A. Yes, they are included in the detail tables which I have presented.

Q. Have you any photographs illustrating the different cross-sections of the Mississippi river at this point?

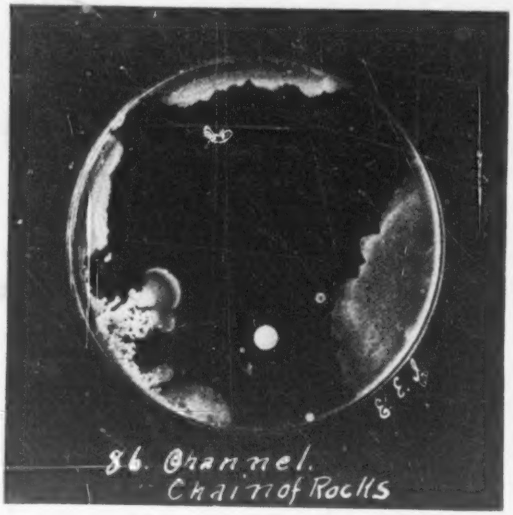
A. I have.

Q. Will you produce and identify the photograph which you hold in your hand so that the same may be incorporated into the record at this point?

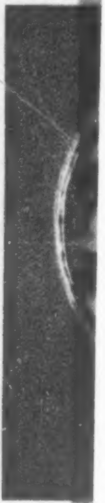
A. The photograph is as follows:



85. Ill. Shore
Chain of Rocks

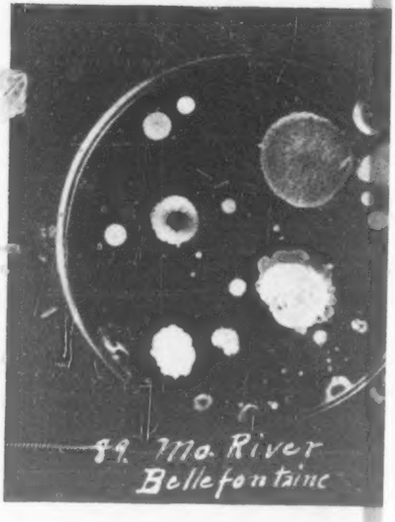


86. Channel.
Chain of Rocks



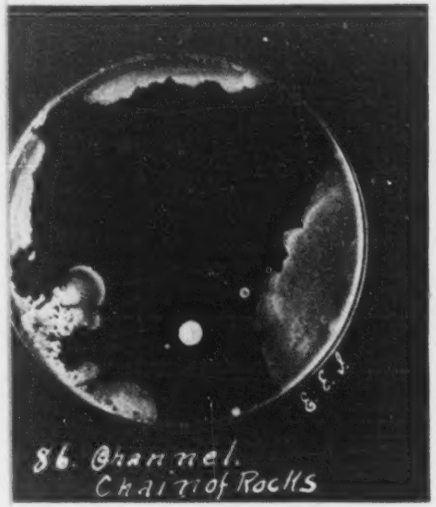
Bacteriological Laboratory.
University of Chicago.

PLATE I.

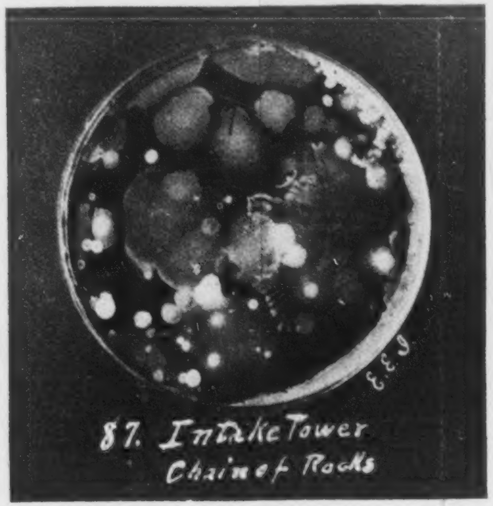


89. Mo. River
Bellefontaine

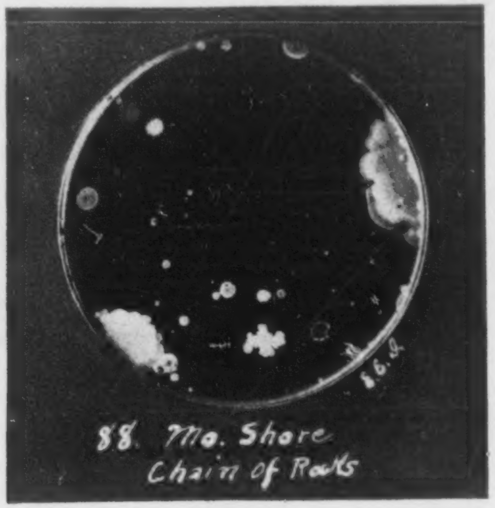
MISSISSIPPI RIVER.



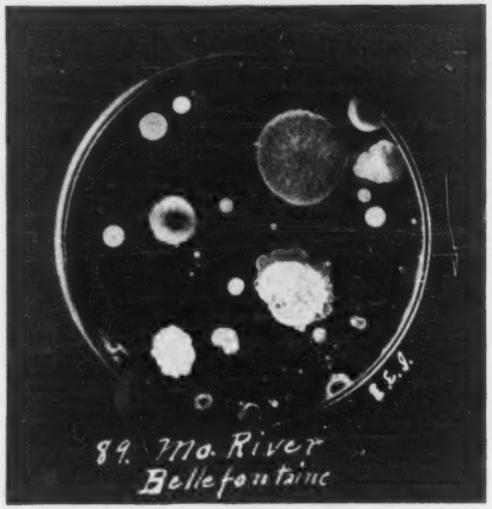
86. Channel.
Chain of Rocks



87. Intake Tower
Chain of Rocks



88. Mo. Shore
Chain of Rocks



89. Mo. River
Bellefontaine

Photographs of Agar Plates
Showing
NUMBER OF COLONIES
in $\frac{1}{10}$ cubic centimeter
Developing in Different
Water Samples.

9747 Q. Will you please explain the photograph just introduced in evidence and made a part of the record and state what it shows?

A. To this card has been affixed five photopraphs of agar plates showing the number of colonies in .01 cubic centimeter, developing in different water samples collected from the Mississippi river in cross-section at the chain of rocks, and also from the Missouri river at Fort Bellefontaine on October 28th, 1901.

This is designated plate 1. These photographs show that the number of colonies appearing in the Mississippi river at the chain of rocks was at this date very much lower than the number in the Mississippi river at the intake tower and the Missouri shore, and also in the Missouri river.

These photographs are thoroughly representative of the results obtained at the chain of rocks throughout this period, October, November and December, 1901, and show clearly that the mingling of the water from the Illinois shore of the Mississippi river with the water of the Missouri river would tend to diminish the number of bacteria per cubic centimeter in the latter water.

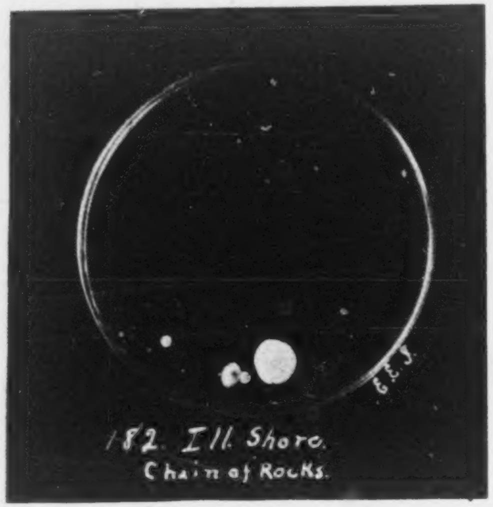
It is also evident from these photographs that the water 9748 entering the intake tower at the chain of rocks, was much more largely composed of Missouri river water than of Illinois river water.

Q. Have you prepared a plate of photographs of other samples taken at the cross-section of the Mississippi?

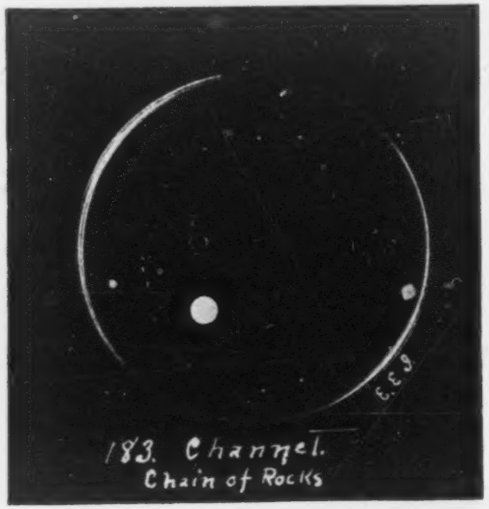
A. I have.

Q. Will you produce plate of photographs No. 2 so as to make it a part of the evidence on record in the case?

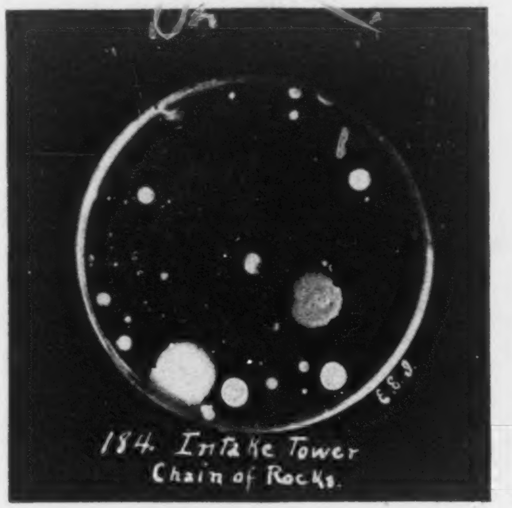
A. Yes, sir; plate 2 is as follows:



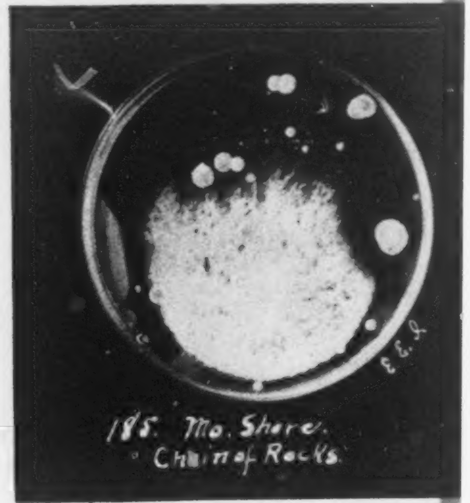
182. Ill. Shore.
Chain of Rocks.



183. Channel.
Chain of Rocks



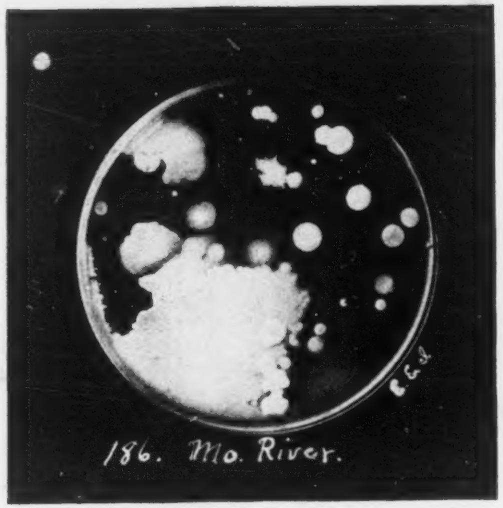
184. Intake Tower
Chain of Rocks.



185. Mo. Shore.
Chain of Rocks.

Bacteriological Laboratory.
University of Chicago.

PLATE II.



186. Mo. River.

Photographs of Agar Plates
Showing
NUMBER OF COLONIES
in $\frac{1}{100}$ cubic centimeter.
Developing in Different
Water Samples.

4749a Q. State what the photographs on plate 2 represent?

A. The photographs on plate 2 are the photographs of agar plates made from samples of water collected on November 20th, 1901. They show the number of colonies in .01 of a cubic centimeter, developing in different water samples taken at cross-section at chain of rocks in the Mississipi river and also from the Missouri river at Fort Bellefontaine. They show a substantially similar condition to that obtained on October 28th, 1901, as shown in plate 1. The water from the Illinois river is much freer from colonies than the water from the Missouri river, from the Mississippi river at the intake tower and from the Missouri shore.

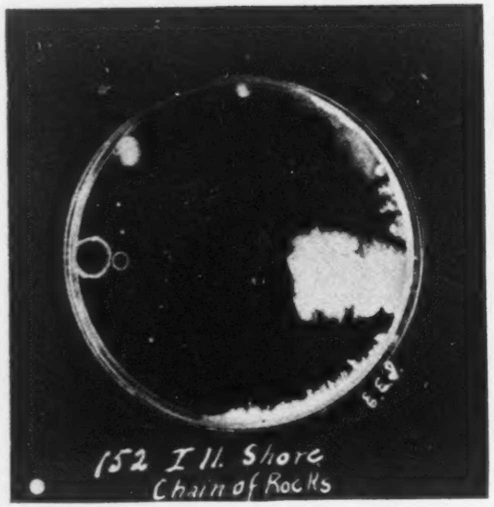
Plate 2 shows again the close similarity between the water from the Missouri river and that taken from the Mississippi river at the intake tower and shows that in the mixing of the water from the Mississippi river along the Illinois shore, that the water from the Missouri river would diminish the number of bacteria per cubic centimeter.

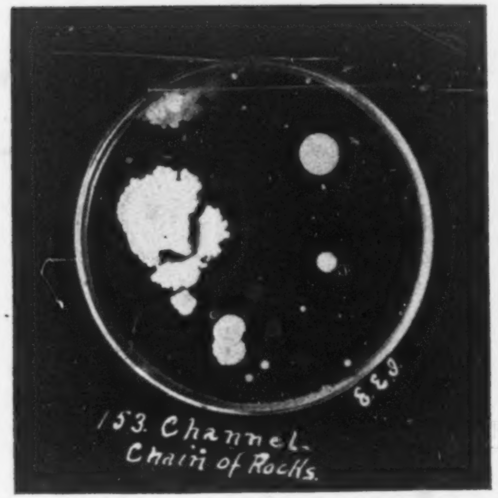
Q. Have you prepared another plate numbered 3?

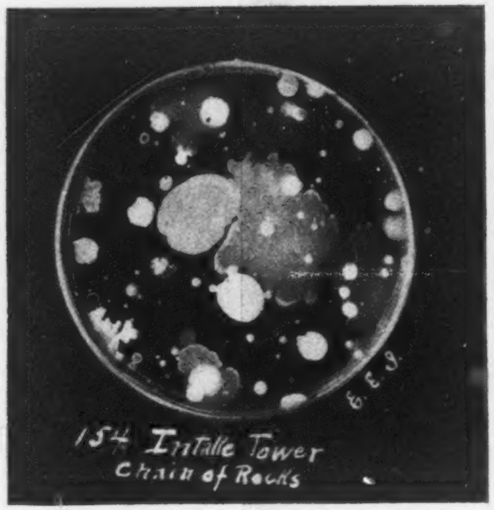
A. I have.

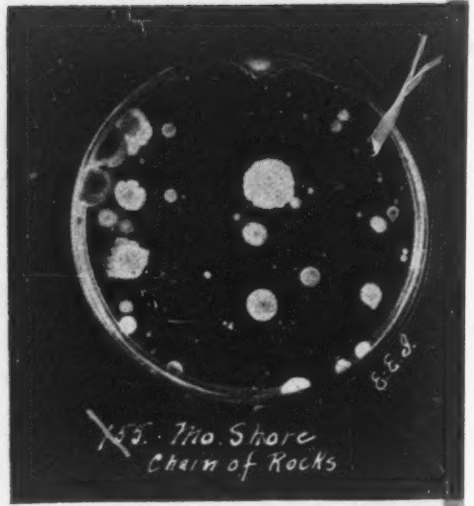
Q. Will you produce that plate so as to make it a part of the evidence in this case?

4749b A. The plate is as follows:


E.E.G.
152 Ill. Shore
Chain of Rocks

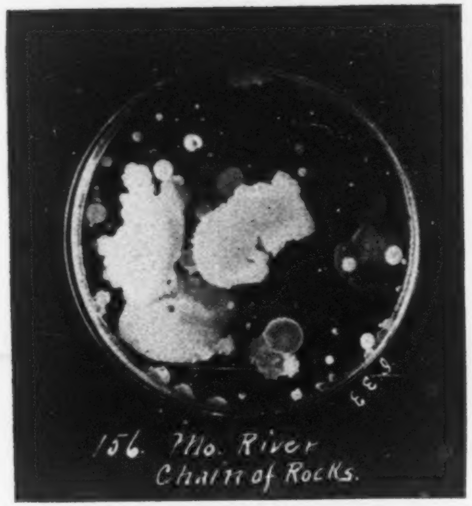

E.E.G.
153. Channel.
Chain of Rocks.


E.E.G.
154 Intake Tower
Chain of Rocks


E.E.G.
155. Mo. Shore
Chain of Rocks

Bacteriological Laboratory.
University of Chicago.

PLATE III.


E.E.G.
156. Mo. River
Chain of Rocks.

Photographs of Agar Plates
Showing
NUMBER OF COLONIES
in $\frac{1}{10}$ cubic centimeter
Developing in Different
Water Samples.

9750 Q. State what plate 3 shows?

A. Plate 3 shows five photographs of agar plates made from samples of water collected from the Mississippi river at chain of rocks on November 13th, 1901. They show the number of colonies in .01 cubic centimeter of water, developing in different samples taken in cross-section at the chain of rocks, and also from the Missouri river at Bellefontaine.

A similar condition to that shown in plates 1 and 2 is also apparent in these photographs, namely, that the water in the Mississippi river on the Illinois shore contains fewer bacteria per cubic centimeter than the water in the Missouri river or the water at the intake tower, Missouri shore. The general similarity of the photographs of samples of water from the intake tower, the Missouri river, from the Missouri shore, the Missouri river and from the Missouri river itself shows that the water entering the intake tower at this date was in a great part, if not wholly, derived from the Missouri river. These photographs show also that in case any water from the Illinois shore of the Mississippi river intermingled with the water of the Missouri river at this date it would decrease the number of colonies developing per cubic centimeter as shown in the table of averages for this cross-section at the chain of rocks during the 9751 period of 1901, which has just been introduced in evidence. These photographs are thoroughly representative of the conditions obtaining in the Mississippi river during this period. The agar plates showing this condition have been selected for reproduction because of this representative character.

MR. JEFFRIES: I move to strike out the photographic plates just introduced in evidence and made a part of the record, for the reason that the samples of water from which the analyses and plates or photographs were made, do not characterize the bacterial condition of the water at all times of the year, and for the reason that they are not representative of the bacterial content of the water at all times at the particular points in the river where the samples of water were collected, and are not representative of the bacterial condition of the water in the river at that point at the time the samples were taken as shown by different results having been obtained by other bacteriologists in analyzing companion samples of water taken at the same time and place as these in question.

And I move to strike out all that the witness has said with reference to these photographs properly character-
9752 izing and representing the bacterial condition of the water in the Mississippi river at the chain of rocks during the entire period of 1901, for the reason that they are not based upon any bacterial or scientific knowledge, but the facts so sought to be stated, and so stated by the witness can be observed by the Court in comparing the number of bacteria contained during the entire period of 1901, with the number of bacteria appearing in the samples from which the photographs were made, and I move to strike out the photographs in question for the reason that they are incompetent, irrelevant and immaterial and throw no sufficient light upon the subject at issue that can be relied upon to any credible extent, and I move to strike out all of the tables with reference to the analyses of water in the Illinois river at Grafton, and the water in the Mississippi and Missouri rivers during the period of 1901 introduced in evidence by this witness for the reason that the same is incompetent in that no sufficient foundation is laid for the introduction of the results of the analyses determined by the persons in charge of the stations at St. Louis, Peoria and Grafton, and I move to strike out the table of averages read into the record by this witness and based upon the analyses of the water at the points in question, during the year 1901, for the reason that the table of
9753 averages conceals and fails to reveal all the conditions that pertain to the waters of the river at the respective points during all times and seasons of the year.

Adjourned until 10:00 a. m., following day, Friday, December 4th, 1903.

10:00 A. M., Friday, December 4th, 1903.

9754 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

THE COMMISSIONER: Gentlemen, I have the sad duty to announce to you that I am just in receipt of a telegram from Captain R. W. Springer, announcing the death last night of his father, the Honorable William M. Springer, one of the counsel in this case.

MR. TODD: Mr. Commissioner, in view of the sad tidings which you have communicated to us in regard to the death of Judge Springer, I believe it fitting and proper as a mark of respect to his memory that the hearing of this case be adjourned. Mr. Commissioner, no man connected with this case was held in higher regard and respect than Judge Springer. I believe I voice the sentiment not only of the attorneys who are associated with him upon the side of the defense, but the sentiment of the attorneys representing the complainant. I believe that his conduct in the trial of this case has impressed upon us all the sincerity and beautiful character of the man. His acts and utterances here have appealed not only to all of the attorneys, but to the witnesses who have been called upon both sides to testify. The witnesses who have testified in this case
9755 are representatives of the highest thought and scientific
opinions, men of unquestioned integrity, lofty scientific learning, who occupy positions of high trust in our different colleges and universities, and these men have held Judge Springer in the highest respect and esteem, and in view of his sad taking off at this time, we can only express our feelings of sympathy for his loved ones that remain.

I move therefore, that this hearing be adjourned until the 28th day of December, and if the Supreme Court shall grant a continuance that then it be continued again until the 5th day of January, 1904.

MR. DRENNAN: I concur sincerely in all that Mr. Todd has said in reference to Judge Springer.

JUDGE CREA: On behalf of the State of Illinois and H. J. Hamlin, Attorney General of the State, I concur entirely with all that has been said with reference to William M. Springer.

MR. JEFFRIES: I want to assure counsel for the defense that the State of Missouri, the complainant in this cause, concurs fully in every word that has been uttered, and I want to join with him and his associates, in asking the continuance requested in this motion.

I want to say further, Mr. Commissioner, that during the time we have been engaged in taking the testimony, I, in con-

nection with counsel upon both sides of the case and in
9756 conjunction with all of the witnesses who have testified,
have not only learned to know Judge Springer, but have learned to love him. We have learned to know him not because of the particular part that he has taken in the production of the evidence here, but by his conduct we have learned to judge of the record that he has made during his life, and through his conduct here, and judging his life as we feel we have a right to do, we have learned to love him. I do not know that more could be said at this time, than the simple statement that by his conduct here, his political and private life, lead us to believe that he realized that by the golden gift of God he was given an opportunity to live but once on earth, and having but the one opportunity, he endeavored to live nobly, and by living nobly his heart was happier, his burdens lighter, and we know that the world and our people are the better for it.

THE COMMISSIONER: It seems particularly sad that Judge Springer should not have lived to complete his part in this great controversy to which he has devoted to my personal knowledge, most of his working hours for the last three years, and to which he brought at its very inception a mind trained and thoroughly qualified to take up the work which he has done. His death, however, is to me a very great personal loss. I had no better friend and no man ever had a truer one than William M. Springer.

9757 Young and old, we can ask nothing more than that when it comes to us to lay down our lives, it can be so truly said of us "He has done his part well."

The motion for continuance until the 28th of December 1903, out of respect to the memory of Judge Springer is granted.

FRANK S. BRIGHT,
Commissioner.

ADJOURNED until December 28th, 1903.

STATE OF MISSOURI,
9758 VS.
THE STATE OF ILLINOIS
and the SANITARY DISTRICT
OF CHICAGO.

Met pursuant to adjournment Monday, February 1, 1904, at 869 Rookery Building, Chicago.

PRESENT:
Frank S. Bright, Esq.,
Commissioner of the Supreme Court of the United States,
Messrs. Todd, Drennan and Crea, representing defendants.
Mr. Jeffries, representing the complainant.

9759 PROFESSOR E. O. JORDAN resumed the stand for further direct examination by Mr. Todd.

Q. Professor, did you make any determinations for colon bacilli in 1901?

A. I did.

Q. These determinations were made in the three laboratories that you have testified to as having been established at Peoria, Grafton and St. Louis?

A. Yes sir, at those three stations.

Q. What stations along the Illinois, the Mississippi and Missouri Rivers were the coli determinations made from?

A. In 1901 from the Illinois River at Averyville and Pekin; from the Illinois River above Grafton, and the Mississippi River above Grafton, from the Missouri River at Bellefontaine and from a cross section in the Mississippi River at the Chain of Rocks. At four places, the Illinois shore, mid stream, intake tower and Missouri shore.

Q. What purpose did you have in view to be subserved in making determinations for the bacillus coli communis?

A. The relative abundance of the colon bacillus in water I consider as affording the most satisfactory indication 9760 of the sanitary quality of such water. In my opinion this is the judgment of most sanitary experts at the present time. In a paper entitled "The Significance of Bacteriological methods in Sanitay Water Analysis," published from the Biological Laboratories of the Massachusetts Institute of Technology by C. E. A. Winslow and C. P. Nibecker, and printed in the Technology Quarterly, Volume 16, number 3, September, 1903 appears the following statement:

"Colon bacilli are either wanting in good waters or are so rare as not to be found in the examination of samples of one cubic centimeter; they are found in a majority of one cubic centimeters of water so polluted as to be dangerous for drinking; between these two extremes their numbers vary with the amount of pollution. Klein and Houston in England, Jordan, and Winslow and Hunnewell in America, and very recently Petruschky and Pusch in Germany have exhaustively studied the distribution of the colon bacillus with uniform results, and that the absence of this organism demonstrates the harmlessness of a water as far as bacterliology can prove it, no one would probably hesitate to acknowledge; and that when present its numbers form a trustworthy measure of its sanitary condition, the observers above quoted have proved beyond
9761 reasonable cavil."

This statement represents my own judgment in the matter as well as what is the prevailing opinion among sanitary experts generally and it is for this reason that in my studies into bacteriological conditions existing in the waters above mentioned, I have paid particular attention to the presence and relative abundance of the colon bacillus.

Q. What methods did you employ in the determination of the coli bacillus in this examination made in 1901?

A. I employed a method known as the Dextrose Fermentation Tube Method. Exhaustive comparative tests were made with the dextrose fermentation tube method, with the neutral red method, with the carbol broth method and other methods sometimes used in making this test with the result that the dextrose fermentation tube method proved the most reliable.

The method consisted in inoculating measured quantities of the water to be tested in fermentation tubes containing ordinary nutrient broth with an addition of one per cent. dextrose.

The interpretations adopted for the changes so produced were as follows:

Positive reactions, that is those indicating presence of B.

coli were regarded as those tubes showing the gas production of over twenty per cent. of the tube length; the tubes
9762 yielding on absorption with sodium hydroxide a gaseous residue appreciably in excess of the carbon dioxide observed. Negative reactions were those showing

(a) No gas production or

(b) Gas production less than ten per cent. of the tube length.

The doubtful class was made to include:

(a) Those tubes yielding only ten to twenty per cent of gas, and

(b) Those yielding more than twenty per cent, before that appreciable excess of carbon dioxide.

A series of fermentation tubes was examined in detail to determine the limits of accuracy of this method, with the result that out of sixty-three tubes examined in thirty-nine cases where the interpretation was positive typical bacillus coli communis was isolated from the tube and identified in all its biological characteristics.

In seven cases where the presumptive test yielded a positive result the bacillus coli was not isolated. This may have been and in my opinion was because the colon bacillus after producing its characteristic fermentation changes was subsequently overgrown by other forms such as the sewage streptococcus.

In nine cases where the interpretation was doubtful the colon bacillus was not isolated.

9763 In four cases where the interpretation was doubtful typical bacillus coli was isolated.

In four cases where the interpretation was negative the bacillus coli was not isolated.

It may be added that these last named cases were those showing less than ten per cent. of gas in which gas forming organisms not B. coli were isolated. In addition some twenty tubes were examined which showed growth in the closed arm but yielded no gas producing organism of any kind.

These results, in my opinion, show conclusively that where a large number of water samples are treated the error due to relying on the presumptive test alone is not unduly large.

The specific application of this method to the problem of self purification of streams depend upon ascertaining in each case the dilution at which the tests give uniformly positive and that at which it gives uniformaly negative results. This method which rests upon the determination of the relative abundance of the colon bacillus is an extremely delicate test for recent sewage pollution.

Winslow and Nibecker in the paper just referred to, on
9764 the significance of bacteriological methods in sanitary
water analyses state, on page 237, "In the second place the bacteriological methods are far more delicate than in the others. Klein showed by experiment with dilutions of sewage that the colon test was from ten to one hundred times as successful as the methods of chemical analysis."

"Studies of the self purification of streams have confirmed these conclusions on a practical scale. Thus, "in the Sudbury River it was found that while the chemical evidence of pollution persisted for six miles beyond the point of entrance the bacteria introduced could be detected for four miles further."

This latter statement refers to the study of self purification in the Sudbury River in Massachusetts carried out by A. G. Woodman, C. E. A. Winslow and P. Hansen, and published in the Technology Quarterly, Volume 15, 1902, page 105.

Q. These analyses which you have made in regard to colon—did you make any tables of the result of your analyses of the waters taken at the different stations which you have enumerated in your previous answer?

A. I did and I have these tables here.

9765 Q. Do those tables correctly tabulate the results of your
coli determinations, made during this period of investigation?

A. They do.

Q. Will you produce and read the coli tables into the record for the station at Averyville?

A. This table designated "Illinois River, Averyville, presence of bacteria of the colon group," includes a record of determinations made on daily samples collected between October 19th and December 30th, 1901, and is as follows:

9766

ILLINOIS RIVER—Averyville.
Presence of Bacteria of the Colon Group.

Date	Serial No.	.001 cc.			.01 cc.			.1 cc.			1. cc.		
1901		+	—	?	+	—	?	+	—	?	+	—	?
Oct. 19	2013		1			2		1					
20	15		1			2		1	1				
21	17		1		1	1		1	1				
23	19					3		1		1			
24	21					3			2				
25	23					3			2				
26	25					2			2				
28	27					3		1		1			
29	29					1				2	1		
30	31					2		2					
31	33					2		2					
Nov. 1	35					2		2					
2	37				1	1							
3	39					2			2				
4	40					1	1	1		1			
5	41				2			1		1			
6	43					2		1		1			
7	45					2		1		1			
8	47					2		2					
9	49					2			1	1			
11	51					1	1	1	1				
12	53					1		1	1		1		
13	55					1		1	1		1		
14	57						1	1	1		1		
15	59				1			1	1				1
16	61				1				1	1	1		
18	63								2			1	
19	65								2				2
20	67								1		1		2
21	69								1		2	1	
22	71								1		1	1	1
23	73								2		2		
25	75								2		1		1
26	77							1			1		1

ILLINOIS RIVER—Averyville.
Presence of Bacteria of the Colon Group.

Date	Serial No.	.001 cc.			.01 cc.			.1 cc.			1. cc.		
		+	—	?	+	—	?	+	—	?	+	—	?
1901													
27	79								1		3		
29	81								2		2		
30	83					1		1		1	1		
Dec. 2	85								1	1	1		
3	87					1			2		1		
4	89					1		1	1		1		
5	91					1		2			1		
6	93					1			2		1		
7	95					1			2		1		
9	97					1		1		1			1
10	99					1		2			1		
11	2101					1		1	1			1	
12	03					1			1	1	1		
13	05					1		1		1	1		
14	07					1		2			1		
16	09					1		1	1		1		
17	11					1		1	1		1		
18	13					1		1	1		1		
19	15					1		2			1		
20	17					1		2			1		
21	19					1				1	1		
23	21												
24	23					1		1	1		1		
26	25					1		2			1		
27	27					1		2			1		
28	29					1			1	1		1	
30						1		1	1				1

9767

	.001 cc.	.01 cc.	.1cc.	1.cc.
No days examination made	3	49	60	41
No. days B. Coli found	0	3	38	34
No determination made	3	72	114	54
No positive results	0	4	49	39
Per cent. positive results	0%	6%	43%	72%

9768 Q. Will you state what the table you have just read shows in regard to colon contents?

A. The table shows that during this period the colon bacillus was never found in .001 cc.

That it was but rarely found in .01 cc (4 positive out of 72 determinations).

That it was found 49 times out of 114 determinations in .1 cc and 39 times out of 54 determinations in 1.cc.

Q. Will you produce and read the coli tables into the record for the station at Pekin?

A. This table headed "Illinois-Pekin, presence of bacteria of the colon group" includes the colon determinations made daily between October 19 and December 30, 1901.

Q. Will you state what the table you are about to read shows in regard to colon contents?

A. It shows that out of 25 determinations made with .001 cc. of river water taken from the Illinois River at Pekin, the colon bacillus was found in 28 per cent. of the samples examined.

In .001 cc in 21 per cent.

In .1 cc 78 per cent.

And in all 100 per cent of the 1. cc samples.

The table is as follows:

9769

ILLINOIS RIVER—Pekin.

Presence of Bacteria of the Colon Group.

Date 1901		Serial No.	.001 cc.			.01 cc.			.1 cc.			1. cc.		
			+	—	?	+	—	?	+	—	?	+	—	?
Oct.	19	2014		1			2		1	1				
	21	16		1			2		2			1		
	22	18		1			1			1	1	1		
	23	20					2		1		1	1		
	24	22					2			2				
	28	28					1	1	2			1		
	29	30		1		2			1					
	30	32	2			2			1					
	31	34	2			1	1		1					
Nov.	1	36	2			1		1	1					
	2	38			2		2							
	4	40	1		1	1	1		1					
	5	42			2		2		2					
	6	44			1	1	1		1					

ILLINOIS RIVER—Pekin.
Presence of Bacteria of the Colon Group.

Date 1901		Serial No.	.001 cc.			.01 cc.			.1 cc.			1. cc.		
			+	—	?	+	—	?	+	—	?	+	—	?
Nov.	7	46			1		2		1					
	8	48			2	1	1		1					
	9	50			2	1	1		1					
	11	52					2		2					
	12	54					2		2					
	13	56					2		2					
	14	58				1	1		1	1				
	15	60					2		1					
	16	62			1		2		1					
	18	64				1	1		2					
	19	66				1	1		2					
	20	68	1	1		2								
	21	70			1		2		2					
	22	72			1		2		1		1			
	23	74		2		1	1							
	25	76		2		1	1							
	26	78			1	1	1		1					
	26	80		2		2								
	29	82							1	1		1		
	30	84					1		1	1		1		
Dec.	2	86					1		2			1		
	3	88					1		2	1		1		
	4	90					1		1	1		1		
	5	92					1		2			1		
	6	94					1		2			1		
	7	96					1		2			1		
	9	98					1		2			1		
	10	2100					1			2		1		
	11	02					1		2			1		
	12	04					1			2		1		
	13	06				1			2			1		
No. days examination made			17			44			44			17		
No. days B. Coli found			4			14			40			17		
No. determinations made			25			75			77			17		
No. positive results			7			16			60			17		
Per cent. positive results			28%			21%			78%			100%		

Q. Will you produce and read the coli tables into the
9770 record for the station at Grafton?

A. The table number 3, entitled "Illinois River, Grafton," presence of bacteria of the colon group includes a record of colon determinations made daily between October 10th and December 24th, 1901, and is as follows:

9771 ILLINOIS RIVER—Grafton.

Presence of Bacteria of the Colon Group.

Date 1901		Serial No.	.001 cc.			.01 cc.			.1 cc.			.1 cc.		
1901			+	—	?	+	—	?	+	—	?	+	—	?
Oct.	10	1017					2		2			1		1
	11	19					2			1				
	12	21				1	1		2					
	14	23				1		1			2			
	15	25					2			2				
	16	27					1	1	1		1			
	17	29					1	1		1	1			
	18	31					2		1		1			
	19	33					2		1					
	21	35					2		1		1			
	22	37					2			2				
	23	39		1			2			2		1		
	24	41		1			1	1		2		1		
	25	43		1			2				2	1		
	26	45					1	1		1	1	1		
	28	47		1			2			2		1		
	29	49		1			2			1	1		1	
	30	51		1		1	1			2			1	
	31	53		1			2			1	1			1
Nov.	1	55		1			2			2			1	
	2	57	1	1			2			2		1		
	4	59		1		1	1			2		1		
	5	61		1			2			2		1		
	6	63		1			2		1		1	1		
	7	65		1			2			2				1
	8	67		1			2			2				1
	9	69		1			2			2				1
	11	71		1			2		1	1				1
	12	73		1			2			2				1

ILLINOIS RIVER—Grafton.

Presence of Bacteria of the Colon Group.

Date		Serial No.	.001 cc	.01 cc			.1 cc. 1. cc.			2. cc.			5. cc.		
1901				+	—	?	+	—	?	+	—	?	+	—	?
Nov.	13	75			1			2			2				1
	14	77			2			2			2				2
	15	79			2			2		2				1	
	16	81			2			2		1	1			1	
	18	83			2			2		2				1	
	19	85			2			2		2				1	1
	20	87			2			2		2				1	
	21	89		1	1			2		1	1		1		
	22	91			2			2		1	1				1
	23	93			2			2		2				1	
	25	95			2			2			2			1	
	26	97			2		1	1		2				1	

ILLINOIS RIVER—Grafton.
Presence of Bacteria of the Colon Group.

Date		Serial No.	.001 cc			.01 cc			.1 cc.			1. cc.			2. cc.			5. cc.		
1901			+	—	?	+	—	?	+	—	?	+	—	?	+	—	?	+	—	?
9772																				
Nov.	27	1099		1			1		2			1	1			1		1		
	29	1103		1			2		2				1			1				1
	30	05		1			2		2				2			1		1		
Dec.	2	07		1			1		2				1	1	1			1		
	3	09		1			1		2				2		1			1		
	4	11		1			1		2			1	1		1					1
	5	13		1			1		2				2			2			2	
	6	15		1			2		2				1			1				1
	7	17		1			1		2			1	1		1					1
	9	19		1			1		1	1		1		1			1			1
	10	21		1			1		1	1		1		1	1		1			1
	11	23		1			1		2					2			1			1
	12	25		1			1		2				2			1		1		
	13	27		1			1		2	1		2				1		1		
	14	29		1			2	1		1		2						1		
	16	31	2				1	1	2			1								
	17	33		2			2		1	1				2						
	18	35		2				2			2			1						
	19	37	1	1			1	1			1									
	20	39		2			2		1	1				1				1		
	21	41		2	1			1		2			1							
	23	43		2			2			1	1			1						
	24	45		2			2			2				1						

No. days determinations made	52	64	64	53	13	16
No. days B. coli found	4	6	12	19	5	8
No. determinations made	72	117	125	71	15	17
No. positive results	5	6	16	21	5	8
Per cent. positive results	7%	5%	13%	30%	33%	47%

Q. Will you state what the table you have just read
9773 shows in regard to colon content?

A. This shows that the colon bacillus was present in 7 per cent. of the .001 cc samples.
in 5 per cent. of the .o1 cc samples.
in 13 per cent. of the .1 cc samples, and
in 30 per cent. of the 1. cc samples.

Q. Will you produce and read the coli table into the record for the station at the Mississippi River above Grafton?

A. Table number 4, headed "Mississippi River, Grafton, presence of Bacteria of the Colon Group" includes a record of colon determinations made daily from the water of the Mississippi River above Grafton between October 10 and December 24, 1901, and is as follows:

9774 MISSISSIPPI RIVER—Grafton.

Presence of Bacteria of the Colon Group.

Date 1901		Serial No.	.001 cc			.01 cc			.1 cc.			1. cc.			2. cc.			5. cc.		
			+	—	?	+	—	?	+	—	?	+	—	?	+	—	?	+	—	?
Oct.	10	1018				1	1		2			2								
	11	20				1	1													
	12	22				1	1		1		1									
	14	24				1	1				2									
	15	26					2		1		1									
	16	28					2		1		1									
	17	30					1	1	2											
	18	32					2				2									
	19	34					2													
	21	36					2				2									
	22	38					2				2									
	23	40		1			2		1	1				1						
	24	42		1			2		1	1		1								
	25	44		1			1	1	1	1		1								
	26	46					2				2	1								
	28	48		1			2			2		1								
	29	50		2			2			2		1								
	30	52		2			2			2		1								
	31	54		1			2		1	1				1						

MISSISSIPPI RIVER—Grafton.
Presence of Bacteria of the Colon Group.

Date		Serial No.	.001 cc			.01 cc			.1 cc.			1. cc.			2. cc.			5. cc.		
1901			+	—	?	+	—	?	+	—	?	+	—	?	+	—	?	+	—	?
Nov.	1	56		1			2		1	1			1							
	2	58		1			2		1		1			1						
	4	60		1		1	1		1		1			1						
	5	62		1			2		1		1			1						
	6	64		1			2		1	1		1								
	7	66		1		1	1			1	1	1								
	8	68		1			2		1		1	1								
	9	70		1			2		1	1		1								
	11	72		1			2		2			1								
	12	74		1			2		1	1			1							
	13	76		1			2		1	1		1								
	14	78		2			2			2			2							
	15	80		2			2			2				1						
	16	82		2			2		2				1							
	18	84		2			2		1	1				1						
	19	86		2			2			2			1							
	20	88		2			2		1		1	1								
	21	90		2			2			2		1								
	22	92		2			2		1	1				1						
	23	94		2			2			2				1						
	25	96		2			2		1	1		1								
	26	98		2			2			2			1							
	27	1100		1			2			2			1					1		
	29	04		1			2			2			2						1	
	30	06		1			1			2			1	1			1	1		
Dec.	2	08		1			1			2		1	1				1	1		
	3	10		1			1			2		1	1				1	1		
	4	12		1			1			2			1	1		1		1		
	5	14		1			1			2		1		1	1			1		
	6	16		1			1			2			1			1			1	
	7	18		1			1			2		1	1				1		1	
	9	20		1			1			1	1			2	1				1	
	10	22		1			1			2		1		1	1				1	
	11	24		1			1			2			2			1			1	

MISSISSIPPI RIVER—Grafton.

Presence of Bacteria of the Colon Group.

Date		Serial No.	.001 cc			.01 cc			.1 cc.			1. cc.			2. cc.			5. cc.		
1901			+	—	?	+	—	?	+	—	?	+	—	?	+	—	?	+	—	?
Dec.	12	26		1			1			2		1	1		1			1		
	13	28		1			1		1	1		2						1		
	14	30		1			1		1				1	1				1		
	16	32		2			2			2			1							
9775																				
	17	1134		2			2			2				1						
	18	36		2			2			2		1		1						
	19	38		1			2			2			1	1						
	20	40		1			2			2			1	1				1		
	21	42		2			2			2		2								
	23	44		1			2			2			2							
	24	46		1			2			2			1	1						

	.001 cc	.01 cc	.1 cc.	1. cc.	2. cc.	5. cc.
No days examination made	52	64	62	54	12	16
No. days B. Coli found	0	6	25	25	4	11
No. of determinations made	69	115	123	74	12	16
No positive results	0	6	29	28	4	11
Per cent. positive results	0%	5%	24%	38%	33%	69%

Q. Will you state what the table you have just read
9776 shows in regard to colon content?

A. This shows that the colon bacillus was present in 5 per cent. of the .001 cc samples,

in 24 per cent. .1 cc samples,

38 per cent. of the 1. cc samples.

Q. Will you produce and read the coli table into the record for the station at Ft. Bellefontaine, Missouri River?

A. Table number 5, headed "Missouri River, Bellefontaine, Presence Bacteria of the Colon Group," contains the result of daily determinations made upon samples of Missouri River water between October 23 and December 17, 1901, and is as follows:

9777 MISSOURI RIVER—Bellefontaine.

Presence of Bacteria of the Colon Group.

Date		Serial No.	.001cc			.01cc			.1 cc			1.cc			5.cc		
1901			+	—	?	+	—	?	+	—	?	+	—	?	+	—	?
Oct.	23	69					2			2			1				
	24	74					1			1	1		1				
	25	79							1	1		1	1				
	26	84					1			1		1	1				
	28	89					1			1		1	1				
	29	94					1			1		1			1		
	30	99					1		1		2		1				
Nov.	1	111													1		
	2	113				1				2			1				
	4	121					1			2			1				
	5	126							1		2		1				
	7	135		1			2			1	1		1				
	8	140		2		2				2			1				
	9	141		1		2				1		1			1		
	11	146		1		2				2			1				
	12	151		1			1		1	2					1		
	13	156		1			2					2	1				
	14	161		1		1	1			2			1				
	15	166		1		1	1			1		1	1				
	16	171		1			2				1	1			1		
	18	176		1		1	1			1							
	19	181		1		1											
	20	186					2			1		1	1				
	21	191		1			1		1	1	2	1	1				
	22	196		1			2			1		1	1				
	23	201		1			2			2			1				
	25	206		1			2			1	1			1			
	26	211		1			2			2			1				
	27	216		1			1		1	1	1		1				
	29	221		1			2				2		1				
	30	226		1		1	1			1	1		1				
Dec.	2	231		1		1	1					2	1			1	
	4	241		1			2				2		1				
	5	246		1			2				1	1			1		1

MISSOURI RIVER.—Bellefontaine.

Presence of Bacteria of the Colon Group.

Date 1901	Serial No.	.001cc +	.001cc —	.001cc ?	.01cc +	.01cc —	.01cc ?	.1 cc +	.1 cc —	.1 cc ?	1.cc +	1.cc —	1.cc ?	5.cc +	5.cc —	5.cc ?
6	251		1			2			1		1					
9	257		1		1	1		1	1		1			1		
10	265		1			2			2		1			1		
11	270		1			2			2		1			1		
12	275		1			1		1	1		1					
13	280	1				2		1	1				1			
14	285		1			2			1		1					
16	286		1	1	1	8	1	8	1	1	2			1		
17	287		1			2		1		1	1			1		
	288		1		1	1		2			1			1		

No. days examination made	32	44	44	43	8
No. days B. Coli found	1	13	31	34	7
No. determinations made	34	84	95	44	8
No. positive results	1	16	48	35	7
Per cent. positive results	3%	19%	50%	79%	88%

Q. Will you state what the table you have just read
9778 shows in regard to colon content?

A. This shows that the colon bacillus was present:

In 19 per cent. of the .001 cc samples,
in 50 per cent. of the .01 cc samples,
in 79 per cent. of the 1. cc samples.

Q. Will you produce and read the coli table into the record for the station at the Chain of Rocks, Mississippi River?

A. These tables, numbers 6, 7, 8 and 9, contain records of the daily colon determinations made upon the water of the Mississippi River at the Chain of Rocks, in cross sections, as previously described in my testimony, viz.: at a point near the Missouri Shore, at the Intake Tower, in midstream and at a point mid way between the Illinois shore and midstream.

These tables contain records of the daily colon determinations made between October 22 and December 14, 1901, and are as follows:

9779

MISSISSIPPI RIVER—Chain of Rocks—Missouri Shore.
Presence of Bacteria of the Colon Group.

Date		Serial No.	.001 cc			.01 cc			.1 cc			1. cc			2. cc			5. cc		
1901			+	—	?	+	—	?	+	—	?	+	—	?	+	—	?	+	—	?
Oct.	22	61					2		1		1	1								
	23	65					2		1		1	1								
	24	70					1		2			1								
	25	75					1		1	1		1								
	26	80					1		2			2								
	28	88					1		1	1		1								
	29	93					1				2	1								
	30	98					1					1								
Nov.	1	110					1			1	1	1								
	2	112				1			2			1								
	4	120					1		1		1	1								
	5	125					1		2			1								
	6	130		1			2			2		1								
	7	134		1			2		1	1		1								
	8	139					1		2			1								
	11	145		1			2				1	1								
	12	150		1			1			2		1								
	13	155		1		1	1		1	1		1								
	14	160		1		1	1			1	1	1								
	15	165		1		2			2			1								
	16	170		1			2				2	1								
	18	175					1			2		1								
	19	180						2			1									
	20	185		1			2			2		1								
	21	190		1			1	1		1	1			1						
	22	195		1			1	1		1	1			1						
	23	200		1			1	1			1		1							
	25	205		1			2		2			1								
	26	210		1			2				2	1								
	27	215		1		1	1		2			1								
	29	220		1			2			2		1								
	30	225	1				2			1	1	1								

MISSISSIPPI RIVER—Chain of Rocks—Missouri Shore.
Presence of Bacteria of the Colon Group.

Date	Serial No.	.001 cc			.01 cc			.1 cc			1. cc			2. cc			5. cc		
1901		+	—	?	+	—	?	+	—	?	+	—	?	+	—	?	+	—	?
Dec. 2	230		1			1	1	1	1		1								
4	240		1			2			2		1						1		
5	245		1			2			2				1				1		
6	250		1			2			1	1	1								
9	256		1		1	1		1		1			1				1		
10	264		1			2		2			1								
11	269		1			2		1		1	1						1		
12	274		1			1		1	1		1								
13	279.		1		1	1			2		1								
14	284		1			2		1	1				1						
No. days examination made,			27			41			41			41						4	
No. days B Coli found,			1			8			24			36						4	
No. determinations made,			27			68			81			42						4	
No. positive results,			1			9			33			38						4	
Per cent. possitive results,			4%			13%			41%			88%						100%	

9780 MISSISSIPPI RIVER—Chain of Rocks—Intake Tower.
Presence of Bacteria of the Colon Group.

Date	Serial No.	.001 cc			.01 cc			.1 cc			1. cc			2. cc			5. cc		
1901		+	—	?	+	—	?	+	—	?	+	—	?	+	—	?	+	—	?
Oct. 22	64				2			1		1	1								
23	68				1	1				2	1								
24	73					1		2			1								
25	78				1					2			1						
26	83					1		2			1								
28	87					1		1	1		1								
29	92				1			2			1								
30	97				1			2					1						
31	102					1			2		1								
Nov. 1	109					1		1	1		1								
2	115					1		1		1	1								
4	119					1		1		1	1								
5	124					1		2			1								
6	129		1		1	1		1		1			1						
7	133		1			2		1	1		1								
8	138						1	2			1								
11	144		1		1	1		2			1								
12	149		1			1	1	2			1								
13	154		1		2			2			1								
14	159		1			1	1	1		1	1								
15	164		1		2			2			1								
16	169		1		1	1		2			1								
18	174						1	1	1		1								
19	179					1							1						
20	184		1			2		2			1								
21	189		1			2				2		1							
22	194		1			2			2		1								
23	199		1		1	1		2			1								
25	204		1			2		2			1								
26	209		1			2		1		1	1								
27	214		1			2			1	1	1								
29	219		1			2			2		1								
30	224		1			2		1	1		1								

MISSISSIPPI RIVER—Chain of Rocks—Intake Tower.
Presence of Bacteria of the Colon Group.

Date	Serial No.	.001 cc			.01 cc			.1 cc			1. cc			2. cc			5. cc		
1901		+	—	?	+	—	?	+	—	?	+	—	?	+	—	?	+	—	?
Dec. 2	229		1			2		1	1				1						
4	239		1			2			2		1			1			1		
5	244		1			2		2			1			1			1		
6	249		1			2		2			1			1					
9	255		1			2		2			1			1			1		
10	263		1			2			2		1			1			1		
11	268		1			2			2		1			1			1		
12	273		1			1		1	1		1								
13	278			1		2			2		1								
14	283		1			2			2			1							

	.001 cc	.01 cc	.1 cc	1. cc	2. cc	5. cc
No. days examination made,	27	43	42	43	5	5
No. days B Coli found,	0	11	30	36	6	5
No. determinations made,	27	71	84	43	6	5
No. positive results,	0	14	48	36	6	5
Per cent. positive results,	0	20	57	84	100	100

9781 MISSISSIPPI RIVER—Chain of Rocks—Mid-stream.

Presence of Bacteria of the Colon Group.

Date	Serial No.	.001 cc			.01 cc			.1 cc			1. cc			2. cc			5. cc		
1901		+	—	?	+	—	?	+	—	?	+	—	?	+	—	?	+	—	?
Oct. 22	63					2				1	1								
23	67							1	1		1								
24	72					1		1	1		1								
25	77					1		1			1								
26	82					1			2		1								
28	86					1			2		1								
29	91					1		2			1								
30	96				1						1								
Nov. 1	108					1		1				1							
2	114				1			1	1		1								
4	118					1			2		1								
5	123					1		1	1		1								
6	128		1			1	1	1		1	1								
7	132		1			2			2		1								
8	137					1		1		1	1								
11	143		1		1	1		1	1		1								
12	148		1			2			1	1		1							
13	153		1			2			1	1	1								
14	158		1			2			2		1								
15	163		1		1	1		1	1		1								
16	168		1			2				2	1								
18	173					1			2		1								
19	178					1		1	1			1							
20	183		1			2		1	1		1								
21	188		1			2			2			1							
22	193		1			2			2		1								
23	198		1			2			2		1								
25	203		1			2			2		1								
26	208		1			2			1	1	1								
27	213		1			2			2		1								
29	218		1			2			2		1								
30	223		1			2		1	1		1						1		

MISSISSIPPI RIVER—Chain of Rocks—Mid-stream. Presence of Bacteria of the Colon Group.

Date 1901	Serial No.	.001 cc			.01 cc			.1 cc			1. cc			2. cc			5. cc		
		+	—	?	+	—	?	+	—	?	+	—	?	+	—	?	+	—	?
Dec. 2	228		1			2			1	1	1								1
4	238		1			2			2		1						1		
5	243		1			2			2				1				1		
6	248		1			2			2			1							
9	258		1			2		1	1		1						1		
10	262		1			2			1	1	1						1		
11	267		1			2				2	1						1		
12	272		1			1			2		1								
13	277		1			2		1	1		1								
14	282		1			2			2			2							

	.001 cc	.01 cc	.1 cc	1. cc	2. cc	5. cc
No. days examination made,	27	41	41	42		7
No. days B Coli found,	0	4	16	35		6
No. determinations made,	27	68	82	43		7
No. positive results,	0	4	18	35		6
Per cent. positive results,	0	6	22	81		86

9782 MISSISSIPPI RIVER—Chain of Rocks—Illinois Shore.
Presence of the Colon Bacteria Group.

Date	Serial No.	.001 cc			.01 cc			.1 cc			1. cc			2. cc			5. cc		
1901		+	—	?	+	—	?	+	—	?	+	—	?	+	—	?	+	—	?
Oct. 22	62					2			1	1	1								
23	66								2			1							
24	71					1			2		1								
25	76						1			2			1						
26	81					1			2				1						
28	85					1			2		1								
29	90					1			1	1			1						
30	95				1			1		1	1								
Nov. 1	107					1			2				1						
2	113					1				2			1						
4	117					1			2		1								
5	122					1		1		1	1								
6	127		1			2			2		1								
7	131		1			2			2				1						
8	136					1			2		1								
11	142		1			2		1	1		1								
12	147		1		1	1		1		1	1								
13	152		1			2		1	1		1								
14	157		1			2			2				1						
15	162		1			2		1	1		1								
16	167		1			2		1	1				1						
18	172					1			2			1							
19	177					1			1		1								
20	182		1			2			1	1	1								
21	187		1			2			2			1							
22	192		1			1	1		2			1							
23	197		1			2			2				1						
25	202		1		1	1					1								
26	207		1			2			1	1	1								
27	212		1			2			2		1								
29	217					2			2		1								
30	222		1			2			2		1						1		

MISSISSIPPI RIVER—Chain of Rocks—Illinois Shore.

Presence of Bacteria of the Colon Group.

Date	Serial No.	.001 cc			.01 cc			.1 cc			1. cc			2. cc			5. cc		
1901		+	—	?	+	—	?	+	—	?	+	—	?	+	—	?	+	—	?
Dec. 2	227		1			2			1		1						1		
4	237		1			2			2		1								1
5	242		1			2		2			1						1		
6	247		1			2		1	1		1								
9	253		1			2			2		1						1		
10	261		1			2			2		1						1		
11	266		1			2			2				1						1
12	271					1			2		1								
13	276		1			2			2		1								
14	281		1			1	1		2				1						

	.001 cc	.01 cc	.1 cc	1. cc	2. cc	5. cc
No. days examination made,	25	41	41	42		7
No. days B Coli found,	0	3	8	25		5
No. determinations made,	25	66	80	42		7
No. positive results,	0	3	8	25		5
Per cent. positive results,	0%	5%	10%	60		71%

9783 Q. Will you state what the table you have just read shows in regard to colon content?

A. These tables show that on the Missouri shore the colon bacillus was present in 13 per cent. of the .01 c. c. sample,

In 41 per cent. of the .1c. c. sample, and,

88 per cent. of the 1. c. c. sample.

At the Intake Tower the colon bacillus was present in 20 per cent. of the .01 c. c. sample, and in

57 per cent. of the .1 c. c. sample, and

84 per cent. of the 1. c. c. sample.

In the samples taken from mid stream the colon bacillus was present in 6 per cent. of the .01 c. c. sample,

In 22 per cent. of the .1 c. c. sample,

81 per cent. of the 1. c. c. sample.

In the water of the Mississippi river at the Illinois shore the colon bacillus was present in

5 per cent. of the .01 c. c. samples,

10 per cent. of the .1 c. c. samples,

60 per cent. of the 1. c. c. samples.

Q. Did you prepare a table of summaries based upon the 9784 coli tables which you have already introduced in evidence?

A. Yes, sir, I have them here.

Q. Will you produce and read the table of summaries prepared by you from the tables of coli determinations already read in evidence?

A. Table A is as folows:

Table A.—Showing Presence of Bacteria of the Colon Group.

Collecting Stations.	0001. cc.		.001 cc.		.01 cc.		.1 cc.		1. cc.		2. cc.		5. cc.	
	No. Days Water Exam'd.	No. Days B. Coli Found.	No. Days Water Exam'd.	No. Days B. Coli Found.	No. Days Water Exam'd.	No. Days B. Coli Found.	No. Days Water Exam'd.	No. Days B. Coli Found.	No. Days Water Exam'd.	No. Days B. Coli Found.	No. Days Water Exam'd.	No. Days B. Coli Found.	No. Days Water Exam'd.	No. Days B. Coli Found.
Illinois river—Averyville	....	....	3	0	49	3	60	38	41	34	....	....	....	....
Illinois river—Pekin	17	4	44	14	44	40	17	17	....	....	....	....	....	....
Illinois river—Grafton	....	....	53	4	64	6	64	12	53	19	13	5	16	8
Miss. river—Grafton	....	....	52	0	64	6	62	25	54	25	12	4	16	11
Miss. Riv.—Chain of rocks, Ill. shore	....	....	25	0	41	3	41	8	42	25	....	....	7	5
Miss. Riv.—Chain of rocks, mid-stream	....	....	27	00	41	4	41	16	42	35	....	....	7	6
Miss. Riv.—Chain of rocks, intake twr.	....	....	27	0	43	11	42	30	43	36	6	6	5	5
Miss. Riv.—Chain of rocks, Mo. shore	....	....	27	1	41	8	41	24	41	30	....	....	4	4
Missouri River—Bellefontaine	....	....	32	1	44	13	44	31	43	34	....	....	8	7

9786 Q. Will you state what the table you have just read in evidence shows?

A. This table shows the presence of bacteria of the colon group in the water collected from the stations just set forth.

This table shows the total number of days on which water was examined during this period and the total number of days on which bacillus coli was found.

Q. Have you made other tables of summaries besides table A?

A. I have here table B showing the presence and percentage of the bacteria of the colon group, based on the total number of determinations made?

Q. Will you produce and read table B in evidence?

A. It is as follows:

Table B.—Showing Presence of and Percentage of Bacteria of the Colon Group.

Collecting Stations.	.0001 cc.			.001 cc.			.01 cc.			.1 cc.			1. cc.			2. cc.			5. cc.		
	No. determinations made....	No. positive results....	Percentage positive results....	No. determinations made....	No. positive results....	Percentage positive results....	No. determinations made....	No. positive results....	Percentage positive results...	No. determinations made....	No. positive results....	Percentage positive results....	No. determinations made....	No. positive results....	Percentage positive results....	No. determinations made....	No. positive results....	Percentage positive results....	No. determinations made....	No. positive results....	Percentage positive results....
Illinois river, Averyville........	25	7	28%	3	0	0%	72	4	6%	114	49	43%	54	39	72%	....	....	....	....	....	....
Illinois river, Pekin........	..	73	......	75	16	21%	77	60	78%	17	17	100	....	....	......	....	....	....	....	....	....
Illinois river, Grafton........	....	....	......	72	5	7%	117	6	5%	125	16	13	71	21	30%	15	5	33	17	8	47
Mississippi river, Grafton........	....	....	......	69	0	0%	115	6	5%	125	29	24	74	28	38%	12	4	33	16	11	67
Mississippi river, Chain of Rocks, Illinois shore........	...	....	......	25	0	0%	66	3	5%	80	8	10	42	25	60%	....	....	....	7	5	71
Mississippi river, Chain of Rocks, mid-stream........	....	....	......	27	0	0%	68	4	6%	82	18	22	43	35	81%	6	6	100	7	6	86
Mississippi river, Chain of Rocks, Intake Tower........	....	....	......	27	0	0%	71	14	20%	84	48	57	43	36	84%	....	....	....	5	5	100
Mississippi river, Chain of Rocks, Missouri shore........	....	....	......	27	1	4%	68	9	13%	81	33	41%	42	37	88%	....	....	....	4	4	100
Missouri river, Bellefontaine........	....	....	......	34	1	3%	84	16	19%	95	48	50%	44	35	79%	....	....	....	8	7	88

9788 Q. State what table B shows?

A. Table B shows the total number of determinations made from samples of water collected from the already specified points in the Illinois, Missouri and Mississippi rivers, together with the number of positive results and the percentage of positive results.

Q. What sanitary significance do you attach to your tables of coli determinations considered as a whole?

A. In my opinion the fate of the colon bacillus in running water furnishes a very satisfactory indication as to the degree and rate of self-purification in such water.

The fact that the colon bacillus is present in but 43 per cent. of the .1 c. c. examinations from the Illinois river at Averyville while it is present in 100 per cent. of the .1 c. c. samples taken from the Illinois river at Pekin and in only 13 per cent. of the .1 c. c. sample taken from the Illinois river at Grafton shows not only the extreme delicacy of this test for sewage pollution but shows a very considerable improvement in the sanitary quality of the water occurs between Pekin and Grafton, notwithstanding the large amount of pollution at Pekin. Comparing the condition of the water in the Mississippi river above
Grafton with that in the Illinois river above Grafton
9789 as evidenced by the colon content of these two waters, it
appears that the colon bacillus was present in 5 per cent. of the determinations made of .01 cc of water from these two places.

It may be mentioned that 117 determinations were made of the Illinois River water above Grafton and 115 of the Mississippi River water above Grafton during this period, so that the substantial agreement in percentage shown in the sanitary character of these waters during this period has a satisfactory statistical basis.

Comparing the examinations made of .1 cc of water during this same period it is shown that 24 per cent. of the samples from the Mississippi River yielded positive results while 13 per cent. of those from the Illinois River above Grafton yielded positive results.

In 1. cc of water from these two stations 38 per cent. of the samples from the Mississippi River and 30 per cent. of those from the Illinois River gave positive results.

In other words, so far as any conclusion as to the sanitary character of these waters can be drawn from the colon determinations—and I have already indicated that in my opinion and in that of sanitary experts generally, the colon test is the most delicate and satisfactory clue that we have to the sanitary condition of the water—the water of the Mississippi River above Grafton during this period was, if anything of a less
9790 wholesome character than the water of the Illinois River above Grafton.

Comparing further the colon content of the Missouri River water above Bellefontaine during this period it is shown that 19 per cent. of the .01 cc samples were positive as compared with 5 per cent. in the Illinois River at Grafton, and that 50 per cent. of the .1 cc samples were positive as compared with 13 per cent. in the Illinois River at Grafton and that 79 per cent. of the 1.cc samples were positive as compared with 30 per cent. in the Illinois River above Grafton.

Comparing the per centages of positive results obtained in the examination of 1. cc. of water in cross section at Chain of Rocks it appears that there was a smaller per centage of colon bacteria in the Mississippi River on the Illinois shore and in mid stream than at the intake tower and on the Missouri shore. This confirms the difference already noted between the colon content of the Illinois River and the Mississippi River at Grafton and that of the Missouri River at Bellefontaine. The higher colon content of the Missouri River betrayed itself in the larger number of colon bacilli found in the Mississippi River at the
9791 Intake Tower and near the Missouri shore at the Chain of Rocks.

The sanitary significance which I attach to these findings is based on what I have been able to learn by my own observation and experiments regarding the significance and relative abundance of the colon bacillus in waters of various kinds as well as that derived from an examination of the available literature on the subject and the opinions of various sanitary experts already referred to in my testimony. It may be summed up by the statement that the water from the Missouri River during this period was distinctly more dangerous and unwholesome than the water of either the Illinois or the Mississippi River at Grafton, and further that the difference between the Illinois

River above its mouth and the Mississippi River above Grafton while not great shows that on the whole the Illinois River was in a less highly polluted condition than the Mississippi.

MR. JEFFRIES:

I move to strike out the last part of the answer where the witness undertakes to form an opinion and draw a conclusion as to the sanitary condition of the water in the three respective rivers for the reason that the same is not based upon all the sanitary and the unsanitary conditions pertaining to the respective waters and ask that the opinion, if it be permitted
9792 to stand be confined solely to the tables that the witness has introduced with reference to the colon test and I move to strike out all of such tables because no proper foundation has been laid for their introduction and for the further reason that they do not represent the condition of the water in the respective rivers so far as the colon bacilli are concerned at all times of the year, and for the further reason that the number of analyses made for these two tests are so limited and indefinite as compared with the great volume of water under consideration, that the evidence is wholy immaterial and is not worthy of credit.

MR. TODD:

Professor, were those examinations made in pursuance of an agreement mutually entered into between the representatives of the complainants and the defendants?

A. I understand that they were.

MR. JEFFRIES:

I object to anything that the witness understands.

A. I will change the answer. In my opinion, yes, they were. Samples of water were taken at points designated, and on days specified by representatives of the bacteriological work undertaken by the City of St. Louis and by representa-
9793 tives of the bacteriological work undertaken in behalf of the sanitary district.

MR. JEFFRIES:

I move to strike out the question and answer for the reason that it is immaterial and move to strike out the answer because of the fact that samples of water taken, as stated by the witness, were not sufficient grounds to authorize any such conclusions as the witness has undertaken to draw from the analyses made by him from the samples of water so taken.

MR. TODD:

Does counsel deny that such an agreement was made between the Sanitary District and representatives of the complainant as to points of collection, the time of collection and the methods to be pursued in these analyses?

MR. JEFFRIES:

In answer to Mr. Todd's question I will say that I can not say that I know any such arrangement was made or that any such arrangement was not made, but, if made, it would not be binding upon the State of Missouri, because the City of St. Louis is not a party to the proceedings here, and for the further reason that if made such an agreement would not warrant
9794 or authorize this witness to draw any such conclusions as
he has undertaken to draw from the analyses alone.

MR. TODD: I want to state for the benefit of the counsel that I am not asking my question as touching upon conclusions but merely to have information as to whether when I, as representing the Sanitary District, met with the representatives from St. Louis, whether they were appearing before us in good faith as representing the State of Missouri or whether they were inpostors.

MR. JEFFRIES: I would like to ask counsel to state when and where the representatives of the State of Missouri or the City of St. Louis appeared during the hearing held by this commission.

MR. TODD:

I would like to state, for the benefit of counsel, that the gentlemen who assumed to represent the complainant in this case appeared before the Board of Trustees of the Sanitary District of Chicago, where it was mutually agreed between the Board of Trustees of the Sanitary District of Chicago and the State of Illinois, represented by the Attorney General, that certain places should be designated for the taking of samples, certain samples should be taken for analysis, and that this
9795 investigation should be conducted jointly, but that each
one could put in the results of their examinations separately as they saw fit and this is the first time it has been intimated to me that such an agreement could possibly have been made with representatives from St. Louis, not in good faith.

MR. JEFFRIES:

Well, I will state for the benefit of counsel that if any such arrangement or any such agreement was ever made between himself and persons purporting or representing themselves as representing the City of St. Louis and the State of Missouri that this is the first intimation that I ever had of any such agreement. I have heard of an agreement between sanitarians and certain witnesses in the case as to the manner in which samples of water should be taken, but who were the parties to that arrangement or agreement I have not yet been able to fully determine.

I will say further that I care nothing about it for the purpose of my objection, whether any agreement of this kind was made either with counsel for the State of Illinois or the Sanitary District of Chicago on the part of certain persons,
9796 citizens of the State of Missouri, but I do object to the
conclusions that this witness has undertaken to draw, wherein he has confined himself solely to the results of the analyses for colon bacilli determination.

MR. TODD:

Q. Professor, did you prepare any photographs?

A. I did.

Q. Photograps of what did you prepare, Professor?

A. In addition to the photographs of plates of colonies which I have already introduced in my testimony I have two plates of photographs of fermentation tubes, showing the differences in amount of gas production in fermentation tubes from samples of water taken from the Missouri River at the Chain of Rocks and from the Missouri River at Bellefontaine.

Q. Are those photographs characteristic of the samples of water which you analyzed at the points from which samples were taken from which photographs were made?

A. They are entirely so and were selected for the reason that they were thoroughly representative of the conditions existing.

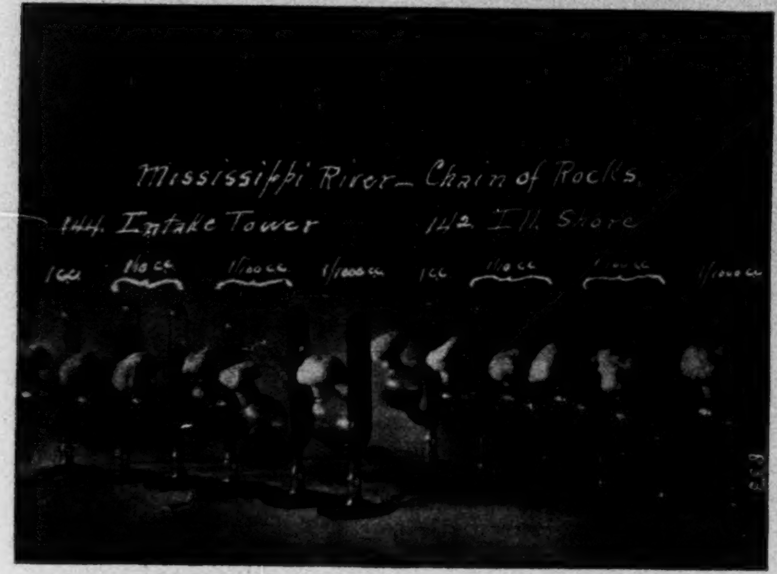
Q. Will you produce plate 4 and make it a part of the record?

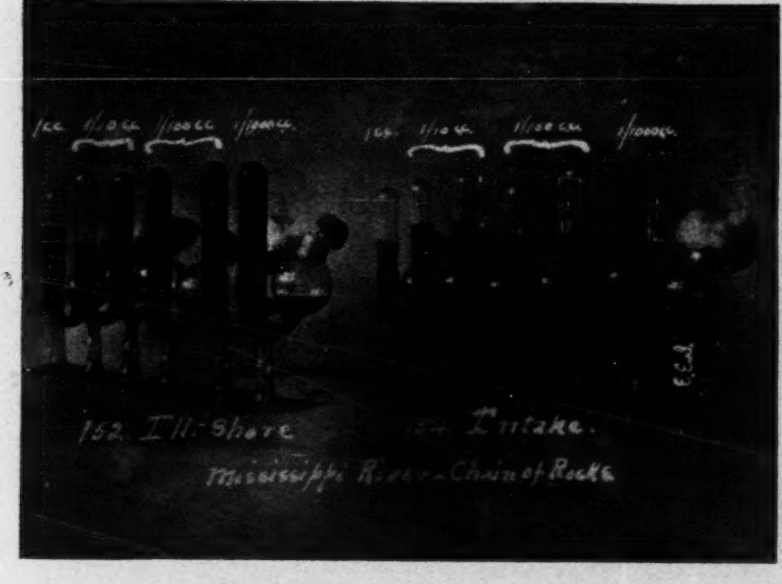
9797 MR. JEFFRIES: I object to the photograph being introduced in evidence for the reason that it represents one

single sample of water taken at the point in question and ca not from the very nature of things be representative of the whole volume of water or the chemical or bacterial conditions of the whole body of water passing down the river from which it was taken.

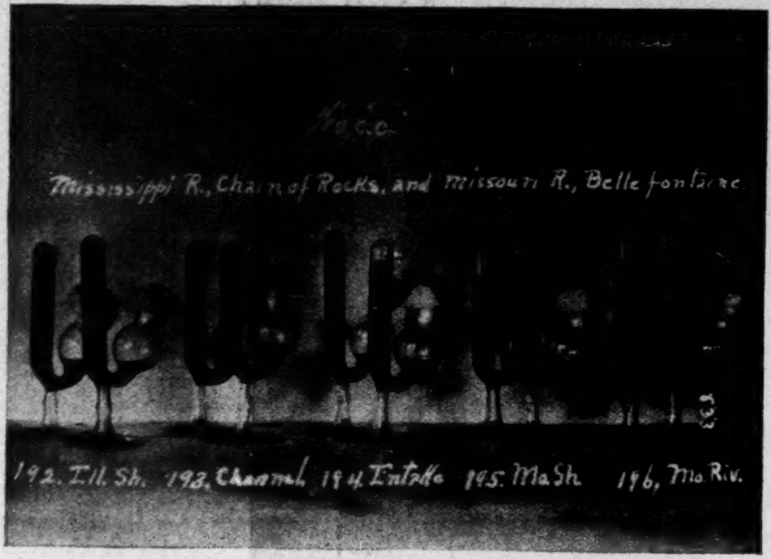
A. Plate Number 4 is as follows:

Showing
Difference of Gas Productio


Mississippi River — Chain of Rocks.
144. Intake Tower
142. Ill. Shore
1cc
1/10 cc
1/100 cc
1/1000 cc
1cc
1/10 cc
1/100 cc
1/1000 cc
E.E.J.


1cc
1/10 cc
1/100 cc
1/1000 cc
1cc
1/10 cc
1/100 cc
1/1000 cc
E.E.J.
152. Ill.-Shore
154. Intake.
Mississippi River — Chain of Rocks

Bacteriological Laboratory.
University of Chicago.


1/10 c.c.
Mississippi R., Chain of Rocks, and Missouri R., Belle fontaine
633
192. Ill. Sh.
193. Channel
194. Intake
195. Mo. Sh.
196, Mo. Riv.

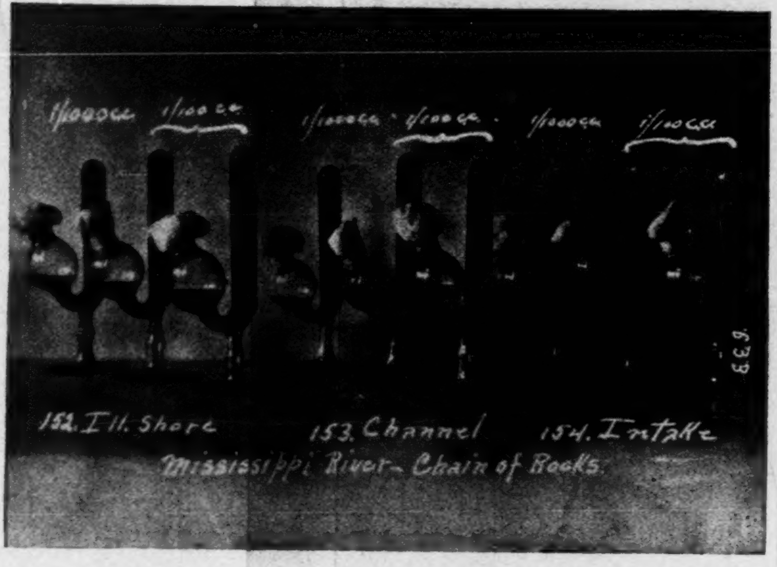

1/1000 c.c.
1/100 c.c.
1/1000 c.c.
1/100 c.c.
1/1000 c.c.
1/100 c.c.
633
152. Ill. Shore
153. Channel
154. Intake
Mississippi River – Chain of Rocks.

PLATE IV.

9799 Q. Will you state what plate 4 shows?

MR. JEFFRIES: I object to the witness making any statement as to what the plate shows for the same reason as stated in my objection to the introduction of the photograph and for the further reason that no chemist, bacteriologist or sanitarian can draw conclusions as to the sanitary condition of the water by the chemical or bacteriological or both analyses of only one sample of that water.

MR. TODD: I am surprised to find that counsel for the complainant did not realize the force of his objections when he placed his own witness upon the stand as by a careful study of the testimony he will find that they drew conclusions from two different samples taken from two different rivers and testified as to the sanitary condition of the water from those two samples, while this photograph is representative of a number of samples taken from the point heretofore indicated.

THE WITNESS: The upper left hand photograph, labeled "Mississippi River Chain of Rocks 144 Intake Tower, 142 Illinois shore," illustrates the difference usually obtaining between samples of water taken from the Mississippi River at the Chain of Rocks. The tubes shown in the photographs were prepared from samples of water collected on November 11, 1901, at the Intake Tower of the St. Louis waterworks and at a point in the Mississippi River half way between mid stream
9800 and the Illinois shore.

The 6 tubes in the left of the photograph show results of inoculating similar tubes with varying quantities of water, viz.: 1.cc at the extreme left (1 tube), .1 cc (2 tubes), .01 cc (2 tubes), .001 cc (2 tubes).

The photograph shows that the gas appeared in the 1. cc tube, in both of the .1 cc tubes, and in one of the .01 cc tubes. There was no gas in the .001 cc tube.

In the right of the photograph are shown the results of inoculating into the tubes the same quantities of water taken from the Mississippi River near the Illinois shore. No gas appeared in the .001 cc tube and no gas appeared in .01 cc tube, and only 1 tube of the .1 cc samples showed gas production.

Since one of the most salient characteristics of the colon bacillus is its production of gas in these fermentation tubes the photograph plainly shows what the detailed tables show on a larger scale, viz: that the colon bacillus, during this period, was not so abundant in the water of the Mississippi River near the Illinois shore as it was in the water of the Mississippi River at the intake tower of the St. Louis water works.

The upper right hand photograph headed 1-10 cc shows
9801 the results obtained by inoculating fermentation tubes on
November 22, 1901, with .1 cc of water taken in cross section at chain of rocks at the usual points, and also from the Missouri River at Bellefontaine.

It shows that no gas appeared when this quantity of water taken from the Illinois shore was inoculated into the fermentation tube while both tubes of water taken from the Missouri river and from the Mississippi River at the Missouri shore showed gas, indicating the presence of some member of the colon group.

The lower left hand photograph, labeled "Mississippi River, Chain of Rocks" 152 Illinois shore, 154 Intake, shows the result obtained by inoculating samples of water taken from the Mississippi River at the Chain of Rocks on November 13, 1901.

The same relation shown to exist in the photograph previously described obtains here also, viz.: more tubes of water from the river at the intake tower show gas than is the case with water taken from the Illinois shore.

The lower right hand photograph, labeled "Mississippi
River, Chain of Rocks" show a similar difference.
9802 Comparing the .01 cc tubes it is shown that no gas was
developed in these tubes on inoculation of samples of water from the Illinois shore and no gas in the sample of water taken from the channel while both tubes containing this quantity of water taken from the Intake Tower showed gas production.

These four photographs illustrate entirely typical conditions in the water of the Mississippi River at the Chain of Rocks and show that as a rule the water from the Missouri River and from the Missouri shore and Intake Tower of the Mississippi River and the Chain of Rocks contains the colon bacillus in larger numbers than the water of the Mississippi River along the Illinois shore.

Q. Have you a photograph known as plate 5?

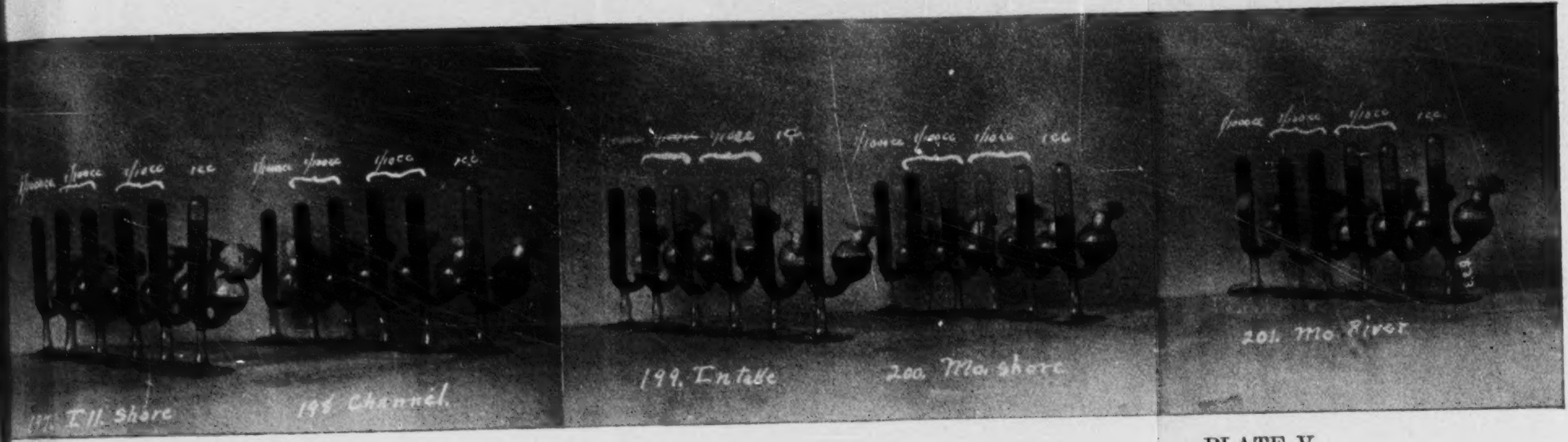
A. I have. This is labeled "Photographs of fermentation tubes showing the difference in gas production, Bacteriological Department of the University of Chicago, Plate 5."

Q. Will you produce and make a part of the evidence Plate 5?

MR. JEFFRIES: I object to the introduction of plate 5 for the same reasons stated in my objection to the introduction of plate 4.

A. Plate 5 is as follows:

Photographs of Fermentation Tubes
Showing
Difference in Gas Production.


1/1000cc 1/100cc 1/10cc 1cc
197. Ill. shore
1/1000cc 1/100cc 1/10cc 1cc
198 Channel.
1/1000cc 1/100cc 1/10cc 1cc
199. Intake
1/1000cc 1/100cc 1/10cc 1cc
200 Mo. shore
1/1000cc 1/100cc 1/10cc 1cc
201. Mo. River

Bacteriological Laboratory.
University of Chicago.

PLATE V.

9804 Q. Will you state what plate 5 shows?

A. Plate 5 shows photographs of a series of 30 fermentation tubes prepared from samples of water collected from the Mississippi River on November 23, 1901, in cross section at the Chain of Rocks and from the Missouri River at Bellefontaine. On the left of the photograph are the samples taken from the Mississippi River, Illinois shore; only one of these, viz.: that in which 1. cc of water was inoculated shows gas production. The same is true of the samples of water taken from the Mississippi River in the channel, although more gas was produced in this case.

The sample of water taken from the Intake Tower shows gas production, not only in the 1. cc tube but in the .1 cc tube, and in one of the .01 cc tubes.

An entirely exact correspondence is shown by sample No. 200 taken from the Mississippi River at the Missouri shore. 4 tubes showed gas production in this case also.

The Missouri River, No. 201, shows a very similar condition, except that no gas was produced in either of the .01 cc tubes.

This close correspondence between the colon content of the Missouri River and that of the Mississippi River along the Missouri shore and at the Intake Tower points in my opinion
9805 unmistakably to the conclusions that the sanitary character of these waters was very similar, and that the water flowing past the Intake Tower at the time at which these samples were collected was derived in a large part from the Missouri River rather than from the Mississippi or the Illinois.

The close agreement between the samples from the Illinois shore and the channel shows the essential uniformity of the body of water from these two sources and shows, furthermore, that from the sanitary point of view the water in this part of the river was less unwholesome less highly charged with objectionable bacteria than the water from the Missouri River or than the water in the Mississippi River at the Intake Tower.

Q. What do the photographs show, professor, as to the mixing of the waters at this point of the three rivers?

A. They show that as far as the bacterial content is concerned the water flowing along the Missouri shore and by the Intake Tower was derived in large part if not wholly from the

Missouri River while the water derived from the Illinois River clings to the Illinois shore and mixes little, if any, with the water of the Missouri.

Q. What is the character of the different waters?

A. The character of these waters during this period as 9806 shown by the colon examinations and as set forth in the tables and illustrated by the photographs is quite different. The colon content of the Missouri River is markedly higher than that of either the Illinois or the Mississippi River at Grafton, and from this I infer that during this period the Missouri River was more highly charged with dangerous bacteria and was distinctly less safe than the water of the Illinois River.

Under these conditions the effect of any mixture of the Illinois River water with the Missouri River water at the Intake Tower of the St. Louis water works would therefore tend to diminish the colon content of the water at that point, thereby rendering it less dangerous for human use. Such mixing of the Illinois and Missouri waters as took place would hence improve the conditions existing during this period in the Mississippi River at the Intake Tower.

Q. What were the stages of the water at the time the photographs were taken and the colon determinations were made?

A. Throughout this period, in the latter part of 1901, the water was low in the three rivers, the Illinois, the Mississippi and the Missouri.

9807 A. The exact figures of the height of the water are given in the detailed tables embodying the colony counts already submitted.

MR. TODD: Professor, Mr. Allen Hazen, on page 4530 of the record, was asked this question "when the mixing begins at the mouth of the Illinois River, by the time it gets to the mouth of the Missouri River, is that mixing complete" and he answered "I do not think it is absolutely complete. It is approximately so; more so at low water than at high water." What do your bacterial analyses show as to whether there is more mixing of these waters at low water than at high water.

MR. JEFFRIES: I object to the question as improper and made for the purpose of discrediting the testimony of Mr. Hazen and contradicting his testimony.

MR. TODD: In reply to counsel I submit that the very purpose included in his objection is correct and a legitimate inference to be drawn from the question and perfectly proper as a matter of evidence.

A. I may state in reply that in my opinion the total number of bacteria in the water at the Intake Tower and near the Missouri shore at the Chain of Rocks as well as the number of colon bacteria in the water at these points shows conclu-
9808 sively that during this period of low water, the water
collected at these two stations was almost wholly if not altogether Missouri River water and was mixed little, if any, with the water from the Illinois. If it be true, therefore, that mixing is more complete at low water than at high water it will certainly follow that the amount of Illinois River water present in the Mississippi at these two points at high water stages must be exceedingly small.

Q. What analyses did you make for species determination?

A. I made an extended examination of species of bacteria taken from the river water at the three stations already described.

Q. That includes the six points?

A. Yes sir. This examination continued through the fall of 1901 and included the study of bacteria found in the samples of water from all the collecting stations.

Q. What methods did you employ in your species determination?

A. The organisms studied in this work were isolated from four different kinds of culture media: (1) from 48 hours gelatine plates, incubated at 20 degrees Centigrade; (2) from 48 hour old dextrose broth fermentation tubes, incubated at 37 degrees; (3) from litmus lactose agar plates 35 degrees
9809 Centigrade, after passage through carbol broth at 37
degrees; (4) from neutral red broth at 37 degrees centigrade. In this way 543 cultures were isolated, studied in great detail and classified.

Q. Will you please read the table of species determination?

A. Yes sir, it is as follows:

Table II.

Type.	Illinois River.			Mississippi River.					Missouri River.	
					Chain of Rocks.					
	Averyv'le	Pekin.	Grafton.	Grafton.	Missouri Shore.	St. Louis Intake.	Channel.	Illinois Shore.	Fort Bellefontaine.	Total.
B. coli communis	3	22	1	7	4	2	1	3	3	46
B. lactis aerogenes	7	8	1	5	....	3	1	1	1	27
B. coli communis and B. lactis aerogenes	6	12	1	....	4	1	....	3	2	29
Proteus	13	4	5	7	2	3	2	2	2	40
B. cloacae	5	1	5	1	2	4	1	2	....	21
B. enteritidis	3	2	....	....	1	....	....	....	....	6
B. fluor. liq	8	3	7	9	1	....	2	3	....	33
B. fluor. non-liq	7	1	2	2	4	1	5	1	2	25
B. subtilis	6	2	12	4	4	6	4	2	6	46
B. gelat.-liquef, milk acid	19	11	10	15	4	6	....	1	8	74
" " milk alk	7	10	7	2	2	1	....	1	....	30
B. non-gelat.-liquef, milk acid	6	8	2	....	3	2	6	4	1	32
" " " milk alk	17	1	1	....	2	1	4	2	1	29
" " " milk amphot	17	6	2	1	....	1	....	1	2	30
Chromogenic Bac.[1]	7	3	1	1	2	1	1	1	....	19
Chrom. Staphylococci	2	2	5	1	1	1	1	1	....	14
Non-chrom. Staphlyococci	4	17	3	2	2	....	4	1	2	35
Sarcinae	2	....	....	1	....	....	....	....	....	3
Streptococci	....	2	....	....	2	....	....	....	....	4
	139	115	65	58	40	33	32	29	30	543

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[1] Two cultures of the red chromogenic group are without data as to place or mode of isolation.

9811 Q. What sanitary significance do you attach to the species determination made by you?

A. This detailed study of species shows that on the whole those forms regarded by bacteriologists as characteristic of sewage pollution are found more abundantly in the water of the Illinois river at Pekin than elsewhere. The Streptococcus forms which are believed by some to be specially characteristic of recent sewage pollution were found in four cases only, viz.: two in the Illinois River at Pekin and two in the Mississippi River near the Missouri shore. The results as a whole confirm the deductions drawn from the study of the colon tables.

ADJOURNED until 10 A. M., Feb. 2nd, 1904.

9812 10:00 A. M., Tuesday, February 2, 1904. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN,

resumed the stand for further direct examination by Mr. Todd and testified as follows:

Q. Do you know whether it is the usual practice in this country among analysts to make daily and hourly determinations of a river water for a long period of time in order to determine the sanitary quality of such water?

A. Reference to some of the recent studies of river water that have been made in this country shows that opinions have been formed and judgments passed on the sanitary character of river water on a smaller number of determinations than would be involved in hourly or even daily examinations.

9813 Thus I find in the report on water purification investigations carried out under the direction of Mr. G. W. Fuller, in behalf of the sewage and water board of New Orleans, Louisiana, the report being published in 1903, a series of tables showing the turbidity, alkalinity and chlorine contained in the Mississippi River water from October 1, 1900 to December 15, 1900 (page 38).

I also find a series of tables showing the composition of the Mississippi River water as determined by its examinations between December 10, 1900 and August 17, 1901.

In another recent investigation of the composition of river water contained in the report of the Filtration Commission of Pittsburg, Pennsylvania, printed in 1889, I find a series of investigations conducted under the supervision of Mr. Allen Hazen who, I believe, has already testified in this case. In Appendix Number 2 of this report, I find the statement "It was desired especially to learn about the character of water obtained from various cribs in the Alleghany river."

9814 In the next paragraph the statement appears: "The samples of the Alleghany River at Brilliant were collected about once a week from the beginning of the work until about March 1, 1898. For the next three months samples were collected twice a week and after June 1, 1898, samples were again collected once a week until the close of the experiments."

From what I know of the work of Mr. Fuller and Mr. Hazen I infer that these gentlemen, who have had large experience in undertakings of this character, would not have had these examinations of river water carried out under their direction at daily and weekly intervals during portions of the calendar year if they had not believed that such determinations actually give a basis for a fairly satisfactory judgment of the character of a river water. Mr. Fuller's examinations at Louisville and at Cincinnati, while extending over a longer period, are substantially of the same character as those in the later investigations.

In European countries, so far as I know, no extended examinations of river water, based on daily and weekly analyses, have been made, which cover so long a period of time as those that have been made in this case.

It is, therefore, my opinion that the usual practice of those experts having to do with the examination of river waters
9815 in this country is based on the belief that an adequate opinion as to the character of the water can be formed by examinations made at intervals as frequent and during periods as long as those indicated in the instances just cited.

MR. JEFFRIES: I move to strike out all the witness said with reference to the instances which he has just cited and all that the witness has read from the reports on the subject, for the reason that the same is not responsive to the question.

Q. What period of time have your own analyses covered throughout this investigation?

A. The examinations which I have made in behalf of the Sanitary District of Chicago cover two periods, the first, one of weekly examinations extending from about the first of May, 1899, to the first of July, 1900. During this period the regular weekly examinations were supplemented by daily and in some instances hourly examinations of the river waters at several points. The second period includes daily examinations made between about the first of November, 1901, to about the first of January, 1902. In all, the examinations that I have
9816 made cover a period of one year and five months.

Q. In your opinion is it possible to pass a competent judgment upon the waters of the Illinois, Mississippi and Missouri Rivers on the basis of the analyses you have submitted in your testimony?

A. It is decidedly my opinion that such is the case. The analytical data, chemical and bacterial, that I have secured by these weekly, daily and hourly determinations, extend over a sufficient interval of time and include sufficiently varying conditions to permit of a satisfactory judgment being rendered as to the general character of the waters dealt with. The separate analyses number many thousands and the results embody the experience gleaned from a study of high water and low water conditions, of summer and winter temperature, and of varying climatic and meteorological factors. It is my judgment that taking into consideration the analyses made concurrently by Professors Palmer, Long, Zeit, Gehrmann and Burrill no such extensive and exhaustive study of river water, in connection with the problem of self purification of streams, has ever been made anywhere in the world as that carried out during this period.

9817 Q. Professor, from your survey of the Missouri and Illinois Rivers, as evidenced by your various analyses heretofore testified to in this case, will you state how the Missouri River compares with the Illinois River before the 17th day of January, 1900, as to its sanitary quality?

MR. JEFFRIES: I object to that as immaterial.

A. During this period the condition of the Missouri River as compared with that of the Illinois River above Grafton was less satisfactory from the sanitary point of view, and was distinctly inferior to the Illinois River at Averyville.

MR. JEFFRIES: I move to strike out the answer as being misleading, indefinite and not responsive.

Q. How did the Illinois River compare with the Missouri River after January 17, 1900?

A. The relative character of the two rivers was not materially different from the 17th of January, 1900, to the first of July, 1900. That is to say, the Missouri River water was more objectionable from a sanitary standpoint than the water of the Illinois River at its mouth or at Averyville.

Q. How did the Illinois River compare with the Missouri River for the period 1901?

A. During the period October-December, 1901, when 9818 daily examinations were made and a large number of results obtained, the sanitary quality of the Missouri River water was, in my opinion, distinctly inferior to the Illinois River water at its mouth and at Averyville, as shown especially by the colon determinations.

Q. What sanitary significance do you attach to your chemical and bacterial analyses including the colon tests, colony counts and species determinations heretofore introduced into evidence, as evidenced by the tables and charts and photographs already introduced by you?

A. Taking into consideration all the analytical data that I have obtained throughout the seventeen months covered by the investigations, I conclude that one of the most remarkable facts, if not the most remarkable, is the entire concurrence of the results derived from the chemical and the various bacterial determinations. The amount and rate of nitrification in the water of the Illinois River at various points along its course, as shown by the tables of chemical analyses, are in line with what the experience of water analysts has shown to accompany a real purification. The large amount of organic matter present in the upper stretches of the Illinois River is oxidized during its passage down stream, and before Averyville is reached 9819 the nitrification of this organic matter has progressed practically to completion.

On the bacterial side, the evidence is wholly confirmatory of this improvement in the quality of the Illinois River water. The enormous number of bacteria poured into the Illinois River in its upper stretches, as shown by the number of bacteria present

in the Illinois River at Lockport and Joliet, is greatly diminished in a flow of less than one hundred miles. Under certain conditions even, and at certain periods of the year, the Illinois River becomes nearly free from the great mass of sewage bacteria with which it was originally laden in as short a distance as 24 miles, as evidenced by the observations between Morris and Ottawa, already introduced. Both at Averyville and above Grafton the bacterial composition of the Illinois River water is about the same as that of tributary streams and as that of the Mississippi River just above Grafton. The colon contents of the Illinois River water is in my opinion, especially significant from a sanitary point of view, and affords evidence in entire harmony with the conclusions derived from the chemical examinations and from the number of bacteria of all kinds shown to be present in these waters. The colon bacteria which are found in great abundance in the waters of the drainage canal and in the
9820 upper stretches of the river practically disappear before
Averyville is reached.

It is clear from the data that I have presented that the water of the Illinois River undergoes a real and very considerable purification. The colon bacteria which are shown to be present in large numbers in Chicago sewage disappear almost completely in less than 150 miles flow. At the mouth of the Illinois River, despite the enormous initial pollution and the very large secondary pollution at Peoria, the number of colon bacteria is certainly no greater than the number in the Mississippi River at this point, and not as large as the number in the Missouri River at Bellefontaine. Since all investigators are agreed that the colon bacillus is more hardy than its relative, the typhoid bacillus, and can live in water for a longer time there is every reason for supposing that the latter microbe dies out with at least the same rapidity. If it be true, as I firmly believe to be the case, that the fate of the colon bacillus in running water furnishes the most satisfactory indication we can secure at present of the continuance of vitality of the typhoid bacillus, there can be no hesitation as to the conclusion to be drawn from this investigation. Since this biological relative of the typhoid bacil-
9821 lus perishes speedily and in large numbers in the course
of the Illinois River, it is my opinion that the typhoid

bacillus itself can not long survive exposure to the same conditions.

Q. Have you made a special study of bacteria?

A. Yes, that has been my main occupation for some fifteen years.

Q. What are bacteria?

A. Bacteria are the smallest and simplest of all living things. They are one-celled organisms, closely related to the lowest forms of plant life.

Q. How are they classified and distinguished?

A. The most general method of classifying bacteria is based on certain differences in form. Three forms of bacteria are generally recognized. The sphere, the rod and the twisted or spiral form. These three kinds of bacteria may be distinguished by the microscope. The spherical bacteria are known as the coccus or the micrococcus forms, the rod-shaped bacteria as the bacillus form, and the corkscrew-shaped forms as the spirillum or vibrio type. The subdivisions of these three groups are distinguished by bacteriologists at the present time by certain structural and functional characteristics. Thus the
9822 position and numbers of the organs of locomotion, the
method of spore formation and other qualities have been used for distinguishing and classifying the various species and varieties. Especial importance has been laid upon the chemical changes brought about by bacteria in the substances in which they grow. Thus, the liquefaction of gelatin, the production of pigment, and the formation of acid or alkali in various food substances are used for distinguishing and differentiating the various kinds of bacteria. The sure and certain differentiation of the numerous species and varieties of these microbes has become a matter involving much time and special skill, and demands special training and experience for its satisfactory accomplishment.

Q. How are they distributed?

A. They are distributed in nature very widely; being found in air, in water and in soil, upon the bodies of living plants and animals and, in short, wherever they can find suitable conditions for growth and multiplication. They are found in large numbers where suitable organic matter is present which serves them as food and enables them to thrive and multiply.

Where the conditions are not suitable owing to improper temperature, to lack of moisture or to insufficiency of food, they are not found so abundantly, and if found at all are likely to be in a dormant rather than an active condition.

9823 Q. What are the characteristics of the bacteria peculiar to waters?

A. Certain species of bacteria are commonly found in pure, unpolluted waters, such as the waters of deep wells, of springs in sparsely inhabited districts, and of lakes and ponds into which no sewage enters. These harmless water bacteria are different from the bacteria found in waters contaminated with organic matters of animal origin, and there is no reason to suspect these water bacteria of possessing any dangerous qualities. Only those bacteria derived from the bodies of human beings or of the higher animals have any special sanitary importance. The so-called water bacteria as a class are simply harmless saprophytes living upon the small amounts of organic matter ordinarily present in pure waters.

Q. Will you distinguish between the so-called saprophytes and parasites?

A. A saprophyte (from Greek corpse-plant) is a name usually applied to those forms of plant life that feed upon lifeless organic matters such as are contained in the dead bodies of plants and animals. Parasites on the other hand are
9824 those forms of life that are able to invade the bodies of some other organism and to obtain their nourishment from the tissues of the host-animal or host-plant. Some bacteria are exclusively saprophytic so far as known; that is, they grow only on lifeless matter and when introduced into the bodies of animals or plants are not able to grow and multiply there.

Some bacteria on the other hand are strict or almost strict parasites. That is, they find the most favorable conditions for their existence in or upon the live bodies of animals or plants, and grow feebly, if at all, outside of the bodies of their respective hosts.

The bacillus of leprosy is a familiar instance of a strict parasite. While it multiplies in the tissues of man it has not yet been cultivated outside of the human body. It is a parasite strictly adapted to the human host.

. Most bacteria, however, are able to live either as saprophytes or as parasites.

Q. Will you distinguish between non-pathogenic and pathogenic bacteria?

A. The pathogenic bacteria are those bacteria that are
9825 able by their presence and products to bring about morbid changes within the bodies of plants or animals. No sharp line can be drawn between pathogenic and non-pathogenic bacteria any more than between saprophytes and parasites. No bacterium is pathogenic for all animals under all conditions. Thus the typhoid bacillus which lives and produces disease in the body of man dies out speedily in the intestinal tract of other higher animals without producing any injurious effect. What is known as the virulence of a bacterium, that is to say, its power to produce disease or morbid changes, varies considerably. A bacterium which under certain conditions is pathogenic for man or other animals may lose its virulence or pathogenic power by long sojourn under natural conditions outside of the animal body. It is well known for example that the tubercle bacillus when freshly isolated from sputum or the animal body is more virulent than when it has been kept under cultivation on lifeless organic matter outside of the body for a considerable period. In other words, it loses its virulence outside of the animal body. The same thing is known to be true of other kinds of pathogenic bacteria. Pathogenicity then
9826 is relative, not an absolute term.

Q. What are the known bacteria pathogenic to man?

A. The list is quite a long one. It includes the typhoid bacillus, the anthrax bacillus, the diphtheria bacillus, the tetanus bacillus, the cholera spirillum, the micrococci causing blood poisoning, septicemia and erysipelas, the bacillus of tuberculosis, the micrococcus of pneumonia and some others.

Q. What pathogenic bacteria are water-borne and find their way into the human body in drinking water?

A. In countries in the temperate zone the typhoid bacillus and its near relative the paratyphoid bacillus are those most commonly entering the body by means of infected drinking water.

It is probable that some members of the group of dysentery bacilli also enter the body in this way.

The cholera spirillum is also commonly conveyed by drinking water in countries where Asiatic cholera is prevalent.

These two diseases, cholera and typhoid, are by far the most important of the water-borne infectious diseases.

Q. What is the bacillus prodigiosus?

A. The bacillus prodigiosus is a name applied to a species of bacterium, or perhaps a group of species, characterized among other things by the production of a red pigment. The group has other well defined biological properties.

9827 Q. What are its characteristics and life history?

A. It is a bacillus with a diameter less than one micron. It is motile, forms no spores, produces turbidity in nutrient broth but no pellicle on the surface, liquefies gelatin rapidly, grows upon potato luxuriantly; grows in the closed arm of the fermentation tube; grows both at body temperature (37°C.) and at room temperature. It does not produce its pigment when grown at body temperature. It is a facultative anaerobe. Liquefies casein and blood serum. Produces gas in dextrose and saccharose broth, but not in lactose. This gas is carbon dioxide and is wholly absorbed by sodium hydro-oxide. It reduces nitrate; does not produce indol; curdles milk with an acid reaction. No fecal odor is produced. Chromogenesis at ordinary temperatures is marked. Some varieties are non-pathogenic for mice, rabbits and guinea pigs, but other varieties have a very marked pathogenic power.

Q. Is it found in river water?

A. Yes, it has been found in the water of rivers and in other bodies of water in various parts of the world.

Q. Have you found it in the waters of the Illinois River?

A. On November 6, 1899, I isolated from the water of 9828 the Illinois River collected at Morris an organism which in all the characters I have described resembles exactly the bacillus prodigiosus.

I have here a sheet of species description in which the biological characteristics of three cultures of bacillus prodigiosus obtained respectively from the University of Michigan Bacteriological Laboratory, from Yale University, and from the Ontario Board of Health, are tabulated. This shows that the characteristics of these three organisms, were similar. The organism isolated from the water of the Illinois River just above Morris on November 6, 1899, possesses all the characters manifested by these three specimens of bacillus prodigiosus and it is in my opinion a member of that group.

Q. Did you find any organism resembling the prodigiosus in the water of the Illinois aside from the one you have already spoken about?

A. Yes. In addition to this form that I have identified as bacillus prodigiosus I found on several occasions organisms which resembled the bacillus prodigiosus very closely, and might on superficial examination be mistaken for it.

Q. In what respect did the organisms resembling the
9829 prodigiosus differ from them?

A. One of these labeled B 210 (a) was isolated from a sample of water taken from the Mississippi River near the Missouri shore near the Chain of Rocks November 16, 1901. It produced red pigment just as the typical bacillus prodigiosus did and on this ground might have been mistaken for it. It did not, however, produce any gas in dextrose broth. It did not liquefy blood serum and did not curdle milk, three very important respects in which this organism differs from the true bacillus prodigiosus type.

Q. Have you charted out upon the diagram alongside the prodigiosus from the University of Michigan, Yale University, and the Ontario Board of Health the one which you separated from the Illinois River at Morris on November 6, 1899.

A. Yes, I have the tables showing these five cultures in comparative form.

Q. What is the significance of the plus sign and the minus sign on the table which you have prepared?

A. The plus sign indicates that the characteristic appearing in the printed form was found upon investigation of the organism concerned. Thus: a plus sign under the head of
9830 "blood-serum" indicates that the organism liquefies
blood serum, and the minus sign under the same head indicates that it did not liquefy blood serum. The same is true

of the caption "gas production in dextrose broth." The same is true also of the signs under the head of "curdling of milk," and so on.

Q. Will you read the table including these five organisms into the record?

A. It is as follows:

9831

BACTERIOLOGICAL LABORATORY,

SPECIES

Name of organism	Source.	Morphology.				Cultural Features.							
						Nutrient broth tube		Nutrient agar tube.		Gelatine plate	Gelatine stab.		
		Bacillus	Diamater greater than 1μ	Motile	Spores	Scum	Turbidity	Dull	Wrinkled	Characteristic appearance	Deep funnel	Surface growth	Needle growth
B. Prodigiosus IV	Univ. of Mich., "Q"	+	−	+	−	+	+	−	−	+	+	+	+
" VI	Yale Univ., (Dr. Rettger)												
" VII	Ontario, B'd of Health												
B. 917	Illinois River, Morris, Nov. 6, 1899	+	−	+	−	+	+	−	−	+	+	+	+
B. 210 A	Mississippi River, Missouri Shore, Chain of Rocks, Nov. 26, 1901	+	−	+	−	+	+	−	−	+	+	+	+

THE UNIVERSITY OF CHICAGO.

DESCRIPTION.

BIOLOGY.																				
			Biochemical Features.																	Pathogenesis.
Potato tube.		Fermentation tube.				Liquefaction.			Gas production.					Milk.				Nutrient agar tubes		Mice.
Visible..........	Luxuriant......	Growth in closed arm...	Grows at body temperature......	Facultative anaerobe..	Affected by range of reaction.	Gelatine.	Casein..	Blood serum.....	Dextrose broth..	Lactose broth...	Saccharose broth	Nitrate reduced.......	Indol produced.........	Curdled.........	Acid............	Alkaline........	Fecal odor.........	Chromogenesis..	Fluorescence....	Intra-peritoneal inoculation...
+	+	+	+	+	+	+	+	+	+	−	+	+	−	+	+	−	−	+	−	−
+	+	+	+	+	+	+	+	+	+	−	+	+	−	+	+	−	−	+	+	−
+	−	+ Pigm.	+	+	+	+	+	−	−	−	−	+	−	− Precip.	+	−	−	+	−	−

ADJOURNED until 2 p. m. Thursday, February 2, 1904.

9832 2:00 P. M., Tuesday, February 2, 1904. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. Professor, did you find, during your analyses of the water of the Illinois River, Mississippi and Missouri Rivers any organisms that resemble prodigiosus, other than the one you have just described?

A. On several occasions we have isolated from the water of the Illinois and Mississipyi Rivers organisms which in many particulars, especially in regard to pigment production, resemble very closely the typical bacillus prodigiosus. These organisms differ oftentimes in very slight degree from the true prodigiosus type. The differences consist, for the most part, in variations in their actions upon milk, gelatin, casein and blood serum and in their action upon the different sugars. Any examination of these organisms, other than a searching and detailed one, might lead to their being mistaken for the true prodigiosus type. 9833

Q. Professor, have you read the testimony of Mr. Ravold wherein he detailed the result of what is known as his prodigiosus experiment?

A. Yes sir, I have read this testimony as it appears in the record of this case.

Q. What importance, as a bacteriologist, do you attach to the value of that experiment as given in the record of the evidence in this case?

MR. JEFFRIES: I object to the witness making any statement as to the value or weight to be placed upon the testimony of Dr. Ravold, that being a question for the court to determine. I object to the question because it is incompetent and immaterial.

A. It seems to me to constitute a demonstration of the power of self purification in streams, from the fact that along the upper collecting stations in the Illinois River this organism was not recovered, although frequent examinations were made of the water at these points and although, according to the testimony, prodigious numbers of this organism were introduced into the water of the drainage canal.

As regards the finding of a few individuals in the water of the Mississippi River, assumed to be of the same variety
9834 as that introduced, I can only say that the identification does not appear from the records to be altogether complete. And, furthermore, assuming that the organisms recovered from the Mississippi River were actually those introduced in the drainage canal, the appearance of so small a number would not in itself be significant. This is true especially since organisms belonging to this prodigiosus group, as has been shown, are sometimes found in the water of these rivers and are saprophytic forms which are evidently rather easily habituated to aquatic life.

Q. Assume that 107 barrels of 40 gallons each of the culture of bacillus prodigiosus, consisting of one hundred million billion to a cubic centimeter, as contained in said barrels, was deposited in the Chicago Drainage Canal at the town of Lamonte, on the afternoon and evening of the 6th of November, A. D., 1901, during a period of from four to eight hours. Assume further that immediately after the said barrels were emptied into the Drainage Canal, the laboratories established at Lockport, Joliet, Peoria, Grafton, on the Illinois River, and the Intake Tower of the St. Louis water works, Chain of Rocks, were notified and that samples were collected at each of these places every hour of the day and night for the purpose of bacterial analyses,
9835 for the ascertainment of this bacillus prodigiosus, and assume that at Lockport these hourly samples taken day and night, were taken from November 7th to November 25th, a period of 18 days, the total number of samples taken being 432. Assume that at Joliet these hourly samples taken day and night, were taken from November 7th to November 25th, a period of eighteen days, the total number of samples being 432. Assume that at Peoria these daily samples, taken day and night, from November 8th to November 30th, a period of 22 days, amounted to a total of 528 samples. Assume that at Grafton these hourly samples were taken day and night from November 12th to December 15th, a period of 33 days, the total number amounting to 792 of which 384 were analyzed by Dr. Ravold.

Assume that the total number of samples taken hourly, day and night, at the Chain of Rocks were 720. Assume that at the laboratory tap these hourly samples taken day and night from November 20th to March 1, 1902, a period of 100 days, amounted to a total of 2400. Assume that the total number of samples analyzed at the different points for the period above mentioned was 5304. Assume further that on December 4th at 8:45 one bacterium bacillus prodigiosus was found at Intake Tower at Chain of Rocks. Assume that on December 5th at 9 A. M. 1 bacillus prodigiosus was found at the Intake Tower, Chain of Rocks. Assume that on December 8th, at midnight, 1 bacillus prodigiosus was found at the Intake Tower, chain of
9836 rocks. Assume that on December 6th, at 8 A. M., at Grafton, 1 bacillus prodigiosus was found. Assume that on December 7th, at midnight, at Grafton, 1 bacillus prodigiosus was found, and assume further that these five organisms were all the organisms of prodigiosus that were found in the examinations made from Lockport to the Intake Tower at the Chain of Rocks and the laboratory tap in the City of St. Louis, which were made during the progress of this investigation, as hereinbefore set forth, and at no time was there more than one single bacterium found at each of these places. Assuming all of the facts as hereinbefore stated to be true, what is your opinion as a bacteriologist as to the value of this experiment as indicating the possible longevity of an infecting bacillus as measured by the longevity of a bacillus prodigiosus or the possibility that a typhoid bacillus entering the drainage canal from the sewers of Chicago would survive the journey down the Illinois River and Mississippi River to the Intake Tower at the Chain of Rocks at St. Louis, based upon all the facts contained in the foregoing hypothetical question?

A. In my opinion this experiment sheds a certain amount of light on the probable longevity of a typhoid bacillus
9837 under the conditions as stated. This is true for the reason that the relatively insignificant findings of bacillus prodigiosus, assuming identification to be correct, indicate that this organism, while in a fairly hardy saprophytic form, does not live long in the river water, and that the typhoid bacillus, which is beyond doubt a more highly specialized parasitic form than bacillus prodigiosus, would not survive as long as the lat-

ter. The experiment, in my judgment, affords strong confirmation of the evidence already derived from a study of the death rate among colon bacilli in the water of the Illinois River. Since bacillus prodigiosus dies off so speedily and in such large numbers, the typhoid bacillus would be less likely to survive exposure to these same conditions.

Q. Will you please give the characteristics and pathological significance of the cholera germ?

A. The cholera germ belongs to the group of spirally twisted bacteria, known as the spirilla. It grows luxuriantly upon our ordinary culture media and liquefies gelatin very rapidly. It is actively motile and forms no spores. It usually finds its way into the human body by way of the alimentary tract, being taken in either in drinking water or by means of contaminated food, such as raw vegetables, fruits, etc. It produces violent fermentation of the intestinal contents and probably
9838 generates powerful toxins or poisonous substances, capable of injuring the body cells. The absorption of these toxins into the body gives rise to many of the general symptoms of Asiatic cholera and if the poisoning is sufficiently intense the infection may result in death. The evidence that the cholera spirillum is the cause of Asiatic cholera in man is convincing and complete. Cases of laboratory cholera have been known to occur among persons working in bacteriological laboratories at a time when no cholera was present in the city or town in which these laboratories were located. Infection in these cases could have come about only through some break in the chain of laboratory precautions and in several of these cases it has been shown that such neglect or carelessness occurred. These cases of laboratory cholera among persons working with the cholera spirillum afford sufficient proof that this germ in pure culture is capable of causing the typical symptoms of the disease, in such intensity even that the outcome may be fatal.

Q. Will you give the characteristics and pathological significance of the tetanus germ?

A. The tetanus bacillus belongs to the class of strict
9839 anaerobes, that is to say it will not grow in the presence of ordinary atmospheric oxygen, but in order for it to thrive free oxygen must be absent from its surroundings. Like

other anaerobes it is spore producing. Under anaerobic conditions it will grow upon the ordinary culture media, such as glucose agar and glucose gelatin. It is usually introduced into the body through some deep wound. It does not, so far as known, infect human beings when taken into the normal ailmentary tract but must find its way into the tissues. It does not spread far from the seat of inoculation but produces a very powerful toxin at the point of growth. The diffusion of this toxin throughout the body, affecting particularly the nervous system, causes the symptoms and lesions peculiar to the malady known as lockjaw or tetanus. The most common form of tetanus in this country at the present time is the so-called Fourth of July tetanus which comes from gunshot wounds, wounds with the toy pistol and similar injuries which result from the forcing into the deep tissue layers a mass of earth or other organic material containing tetanus bacilli or their spores.

Q. Is the tetanus germ a water borne germ?

A. I know of no instance where a case of tetanus has 9840 been traced to water borne infection. The germ is common in street dust, finding it's way there probably from the droppings of horses in which it is usually present in considerable abundance.

Q. Will you give the characteristics and pathological significance of the anthrax germ?

A. The anthrax bacillus is one of the longest known and best studied of pathogenic bacilli. It is a spore forming aerobic bacillus and grows readily upon our culture media. The disease known as anthrax or splenic fever is primarily a disease of cattle and sheep and is sometimes transmitted from them to man, the ordinary modes of transmission being by cutaneous infection through some wound or abrasion, or by inhalation of the spores of anthrax bacilli which may be dislodged into the air from the hides or fleece of infected animals. The affection known in England as wool sorter's disease is the pulmonary form of anthrax due to inhalation of the spores. Cattle are infected by grazing in pastures that have become infected from the presence of diseased animals or where the carcasses of animals dying from anthrax have been superficially interred. The disease in man is not a common one.

Q. Is this germ a water borne organism?

9841 A. There are a few cases on record where the refuse from tanneries has been washed into stream and deposited on fields; and cattle grazing on these fields have been known to become infected. There are also a few cases where the water of a well has become infected in this way and has caused disease among cattle. So far as man is concerned anthrax is not, properly speaking, a water borne disease since infection from this source, if it has ever occurred, is extremely rare.

Q. Will you give the characteristics and pathological significance of the bacillus enteritidis sporogenes?

A. This organism is more commonly known as bacillus aerogenes capsucatus. It is a spore forming anaerobe and is widely distributed, being found in street dust, in sewage, in manured soil and in similar situations. It is found in the contents of the healthy human intestine. This bacillus has been supposed by Klein and some other writers to have some pathogenic property for man. Taken into the human alimentary tract, however, as has been shown by Glynn ((Thompson-Yates Laboratory Report, 1901, Volume 3, Part 2, Page 131) is seems to be harmless. This might, indeed, be inferred from the fact that this bacillus occurs in healthy human evacuations.

9842 Glynn, in the investigation cited, partook of portions of the curd of milk in which this organism was numerous and suffered no ill effects, showing that when taken in this way it can not be called a pathogenic microbe. Inoculated into the circulation of guinea pigs, however, the organism produces pathological changes and death. It appears sometimes when introduced through wounds into the body of man to have some pathogenic properties, producing, oftentimes, accumulations of gas in the tissues and internal organs.

Q. When this germ enters the human system through drinking water will it produce disease?

A. Not so far as is known. The evidence indicates quite the reverse. The experience of Glynn, who, as just described, swallowed large numbers of these bacilli, without suffering any ill effect, shows that this is the case. The mere fact that this bacillus is found in the evacuations of patients suffering from diarrhoea is no proof of its casual relationship with their condition, since the same organism is found in the dejecta of perfectly healthy persons.

9843 Q. Will you give the characteristics and pathological significance of the dysentery bacillus?

A. The dysentery bacillus is a member of the colon typhoid group of organisms and is very closely related to the typhoid bacillus, being distinguished from it by its lack of motility and by its reaction to the serum of dysentery patients. There appear to be several varieties of the dysentery bacillus differing slightly one from another one. The modes of infection with the dysentery bacillus are probably very similar to those in the case of the typhoid bacillus.

Q. Have you made any special study of the typhoid germ?

A. Yes sir, I have on various occasions given rather particular attention to the characteristics of the typhoid bacillus, to the modes of infection with this organism, to its longevity in water and to its other relations with human pathology.

Q. Will you give the characteristics and pathological significance of the typhoid germ?

A. The typhoid bacillus is an actively motile non-spore forming organism. It grows readily upon gelatin, upon potato, in milk, in broth and the other ordinary culture media of the laboratory. It does not liquefy gelatin. It does not curdle
9844 milk although producing a slight acidity in milk which may be transient or may persist permanently. Some varieties of typhoid bacilli produce alkali in milk which may obliterate the original acidity. It does not form gas in dextrose broth although it ferments the dextrose with the production of acid. Upon potato most varieties produce the so called invisible film, a delicate thin growth covering the surface of the potato and so nearly the same color of the potato as to be under most conditions almost invisible.

The typhoid bacillus usually finds its way into the human body through the alimentary tract, being swallowed with infected drinking water or infected food. The bacilli, although invading the body through the alimentary tract, do not remain confined to this location but may spread through the body and be found in the blood, in the spleen and in the internal organs generally. There are some resemblances between infection with the typhoid bacillus and with the cholera spirillum, the toxins produced by the two organisms being not dissimilar, and immunity to these two diseases appearing to rest upon the same biological foundation.

Q. Where are typhoid germs found?

9845 A. Typhoid germs may be found either in the body of the patient or in the discharge from the body of such patient or in waters or soil infected with such discharges. The clothes and bedding of the patient may also become contaminated with the typhoid bacillus unless proper measures of infection are resorted to.

Q. What germs does it resemble?

A. The typhoid bacillus is a member of the so called colon typhoid group of organisms. This is a very large group of bacteria, containing many varieties or species. The colon typhoid group includes bacillus coli communis and its allies, the typhoid bacillus, the paratyphoid bacillus, the desentery bacillus, the hog cholera bacillus, bacilli found in certain cases of meat poisoning, bacilluspsitacosis and other micro organism of more or less pronounced pathogenicity.

Q. Is it related to the colon bacillus, and if so in what way?

A. It is related to the colon bacillus in being a member of this large colon typhoid group. It differs from the colon in being less vigorous. Many of the positive biological qualities of the colon bacillus are represented by negative charac-
9846 teristics of the typhoid germ. Thus, the colon bacillus ferments dextrose, with gas production, curdles milk and produces indol while the typhoid bacillus does not ferment dextrose with gas production, does not produce indol and does not curdle milk. I have already shown that as regards longevity in water, resistance to freezing, to drying and other adverse conditions of life the colon bacillus is a more hardy organism than the typhoid bacillus. The two microbes are, however, biologically very closely related.

Q. What methods can be employed for differentiating and identifying typhoid bacillus?

A. The typhoid bacillus can be differentiated from other members of the colon typhoid group by these qualities that I have just enumerated, viz.: absence of gas production in dextrose broth, failure to curdle milk or to produce any very large amount of alkalinity in milk and especially by the so called serum reaction which enables an investigator to differentiate the typhoid bacillus with certainty from the dysentery bacillus, perhaps its nearest relative in the colon typhoid group. The serum test is generally regarded as a final and precise criterion of the authenticity of a given culture. This test is based on the fact that the blood of an animal such as a rabbit or guinea pig which has been inoculated with the culture of a genuine typhoid 9847 bacillus becomes capable of clumping or agglutinating other strains of typhoid bacilli, irrespective of their sources. By applying serum from an animal that has been inoculated in this way with the typhoid culture to a suspected germ it can be determined with a high degree of certainty whether or not that germ is a genuine typhoid bacillus. This is the method of differentiation and identification commonly employed at the present time.

Q. How does the longevity of the typhoid bacillus in the human body compare with that in soil or in water?

A. From the available data it appears that under certain conditions a typhoid bacillus may remain alive for weeks or even for months in the human body. There are cases on record where even years after an attack of typhoid fever the typhoid bacillus has been found in the bone marrow and other situations in the body of human beings. Outside of the human body on the other hand the life of the typhoid bacillus is comparatively brief. There is no evidence that it can remain alive in water for more than a few days. It may remain alive in accumulations of dejecta in out houses and privies for a much longer time and in the soil also it may retain its vitality for a consideable period.

9848 Q. Will you state the established instances where the typhoid bacillus has been detected in potable water?

Mr. Jeffries: I object to the question for the reason that typhoid bacilli have never been detected in potable water, using the term potable as applied to sanitary science.

Mr. Todd: I use it in the sense in which it was employed by Dr. Teichmann in giving his testimony.

A. Although the evidence which connects polluted water supplies with outbreaks of typhoid fever is entirely convincing both in character and mass, there have been relatively few instances in which bacteriologists have succeeded in isolating a specific typhoid bacillus from suspected waters.

In view of the insufficiency of the data relied on for identification most of the early statements concerning the finding of the typhoid organism must be regarded as of an exceedingly doubtful value. The criteria upon which up to a very few years ago such identification was based would by no means be accepted by bacteriologists of the present time. Especial uncertainty has again been recently introduced into the subject by the discovery of the group of dysentery and pseudo dysentery bacilli, of bacillus fecalis alcaligenes and of a host of related organisms.

9849 A survey of the literature shows that there are very few reported cases of the detection of the typhoid bacilli in water, which conform to present day requirements. Losener (Arbitin a. d. Kais. Gesundheits 1895, 11, p. 207) working in the Hygenie Institute in Berlin, isolated from the laboratory water supply an organism that agreed culturally with the typhoid bacillus in all respects and that also responded favorably to Pfeiffers' immunity test.

Remlinger and Schneider (Ann. de. l'Inst. Pasteur 1897, 11 p. 55) found in various natural waters organisms that possessed the biological qualities of a typhoid bacillus and that agglutinated with typhoid serum and also conformed to Pfeiffers's immunity test.

Some conservatism is shown, however, in accepting the work of these latter authors at its face value both because of their sweeping statements with regard to the "ubiquity of the typhoid bacillus" and because of certain other internal evidence in the paper referred to.

Hankin (Centrable f. Bakt. 1899, 26 p. 554) working in India found a typhoid like bacillus in samples of water derived
from various sources and substantiated his cultural ex-
9850 amination with the observation that agglutination oc-
curred with a 1 to 600 dilution of anti typhoid serum.

Kublar and Neufeld (Zeitschr f. Hyg. 1899, 31 p. 133) related a particularly interesting case of the finding of a typhoid bacillus in the water of a shallow well to which infection had been traced. In the course of the investigation it was noticed that no colon bacilli were present in the water, a fact that in the opinion of the authors pointed to infection with typhoid urine rather than with fecal discharges and that explains the relative ease with which the typhoid bacillus is isolated as well as the unusually long persistence of the organisms in the water. Both the agglutination test and Pfeiffers' test were employed to establish identification.

Genersich (Centralbl f. Bakt. 1900, 27 p. 241) isolated 11 cultures of typhoid like bacillus from the water of incriminated cisterns.| These organisms agglutinated in a dilution of 1 to 50 typhoid serum obtained from a human patient but the serum of animals inoculated with the water cultures failed to agglutinate a control typhoid culture except in a single instance.

Fischer and Flatau (Centralbl f. Bakt. 1901, 29 p. 329)
have reported an apparently unimpeachable case of the
9851 isolation of a bacillus from the water of a well at Rellin-
gen. Both the agglutination test and Pfeiffers' test were
applied with positive results.

There are, therefore, perhaps six cases where undoubted typhoid bacilli have been isolated from ordinary drinking water. If the evidence adduced by Remlinger and Schneider and by Genersich is not regarded as wholly convincing the number of such cases is reduced to four. On the other hand the finding of a paratyphoid bacillus in water by Simon and Negel (Centralbl f. Bakt. Orig. 1902 32 p. 480) may practically be put in the same category with the discoveries of genuine typhoid bacilli.

The meagreness of the findings despite the thousands of examinations that have been made by skilled bacteriologists in every part of the world is in my opinion explained chiefly by the relative short duration of the life of the typhoid bacillus in water. The period elapsing between the moment of infection and the initiation of bacterial investigation is usually at least two or three weeks, owing chiefly to the time occupied in incubation and in the insidious development and perhaps tardy
recognition of the disease. Some time is also consumed by
9852 the preliminaries necessary for the setting on foot of
competent investigation. It is apparently only under exceptional conditions, such for instance as obtained in the case reported by Kubler and Neufeld, that the life of the bacillus can extend throughout any considerable period. The history of most outbreaks of typhoid fever shows that the bacilli have disappeared from the water by the time search is inaugurated and

it is for this reason that a negative finding is the usual result of bacterial examination.

Q. Have you investigated the longevity of the typhoid bacillus in different kinds of water in laboratory experiments?

A. I have.

Q. Will you give the results of those experiments?

A. These experiments were made upon the life of the typhoid bacillus in sterilized waters, kept in glass bottles in the laboratory. They showed, among other things, that the age of the typhoid stock influences a good deal the life of the bacilli introduced into the water, a freshly isolated stock possessing distinctly greater vitality than one that had been under cultivation for some months. The typhoid bacillus when introduced with
proper precautions into sterilized Lake Michigan water
9853 does not multiply but may under certain conditions main-
tain its vitality for upwards of 93 days. The colon bacillus on the contrary under similar conditions undergoes rapid multiplication and may remain alive for upwards of 262 days. In redistilled water the typhoid bacillus perishes much more speedily than in the water of the Lake. It may be noted that all these experiments were made with sterilized water and in glass bottles.

Q. Does the typhoid bacillus multiply and increase in nature?

A. I know of no evidence that this occurs. On the contrary from an examination of literature the evidence appears to me overwhelming that typhoid bacilli once discharged from the human body undergo a constant diminution in number.

Q. Are the conditions of laboratory experiments more or less favorable to the longevity of the typhoid bacillus than the conditions that obtain in nature?

A. In my opinion they are decidedly more favorable.

Q. Will you please state your reasons for that opinion?

A. It has been shown by experiments made by Ficker
(Zeitschr F. Hyg. 1892, 29 p. 1) that water sterilized in
9854 glass bottles brings into solution substances which favor
continued vitality on the part of the various micro organisms. These experiments are well known and show how peculiarly favorable are the conditions in these glass bottle experiments for the long life of the microbes introduced.

Q. Will the germ of typhoid live as long in polluted water as in pure or sterilized water?

A. No sir, I think it will live longer in pure water than in polluted water and it is well known from the experiments of many observers that it lives longer in sterilized water than in unsterilized.

Q. How do you account for this?

A. I attribute the relatively speedy death of the typhoid bacillus in polluted waters as compared with pure and in unsterilized waters as compared with sterilized to the action of the various saprophytic microbes which inhabit these waters. Where the typhoid bacilli are removed from competition with these saprophytic forms as in the case where they are introduced into sterilized waters they live longer than under the conditions where they may be injuriously infected by the products
of other microbes. In the case of the polluted waters the
9855 greater concentration of organic matter may favor a
more intense action of the products of the saprophytic
microbe present in these waters. In other words these products in the polluted water are in more concentrated form than is the case in the pure water, and so bring about the death of the typhoid bacillus sooner. It is therefore to the action of the saprophytic microbes that I attribute the dying off of the typhoid bacillus in polluted waters and in unsterilized waters.

Q. From your knowledge of the character and quality of the waters of the Drainage Canal, the Desplaines River and the Illinois River what is your opinion as a bacteriologist as to the longevity of the typhoid bacillus in these waters?

A. From what I know of the chemical composition and bacterial content of the waters of the Illinois River at various points along its source it is my opinion that the life of the typhoid bacillus introduced into the Illinois River at the upper end of the Drainage Canal would not be more than three or four days.

Q. What reasons have you for the opinion that the life of a
typhoid bacillus in the waters of the Drainage Canal, the Des-
plaines and the Illinois Rivers is shorter as compared
9856 with the laboratory experiments?

A. In the water of the Desplaines and the Illinois Rivers the typhoid bacillus is subjected to the unrestricted action of the products of the various saprophytic microbes that inhabit these waters. The large amount of organic matter in the upper stretches of the river favors the concentration and the consequent intensity of action of these saprophytic products. As compared with the laboratory conditions again the typhoid bacillus can hardly be favored in these rivers by the presence of any such substances as go into solution from the glass bottles used in laboratory tests. These two reasons, therefore, the absence of the favoring laboratory conditions and the free and vigorous action of the products of growth of saprophytic microbes lead me to adopt the opinion that I have just expressed.

ADJOURNED UNTIL 10 O'CLOCK FEBRUARY 3, 1904.

9857 10:00 A. M., Wednesday, February 3, 1904. Continuation pursuant to adjournment. Present, the Commissioner and same Counsel representing the respective parties.

PROF. EDWIN O. JORDAN

resumed the stand for further direct examination by Mr. Todd and testified as follows:

Q. Are you acquainted with the Chicago River, the Drainage Canal, the Desplaines River, the Illinois River and the Mississippi River from Grafton to St. Louis, and the Missouri River as it empties into the Mississippi?

A. In a general way I am.

Q. What opportunities have you had for acquainting yourself with the Drainage Canal?

A. I have been several times by train along the course of the Drainage Canal from Chicago to Lockport. I have several times visited the Bear Trap Dam at Lockport, and I have been by water from near the mouth of the Chicago River to the Bear Trap Dam at Lockport along the full course of the drainage canal.

Q. What opportunities have you had for acquainting yourself with the water course from the Bear Trap dam to Grafton, including the Desplaines and Illinois Rivers.

9858 A. I have been to Joliet and inspected the conditions at that point on the Desplaines River. I have visited Morris during the progress of this investigation on a number of oc-

casions, and have spent some time on the Illinois River between Morris and Ottawa in a boat, carrying out special observations and making hourly examinations of the river water at these points. I have visited Ottawa and examined the conditions prevailing about and below this town. I have observed the point where the Fox River empties into the Illinois at Ottawa. I have been to La Salle and examined the conditions in the Illinois River and the Big Vermillion at this point and have also noted where the old Illinois and Michigan Canal finally empties into the Illinois River at La Salle. I have been to Peoria and have been out on the Illinois River in a boat, above and below this place. I have been to Pekin, to Havana, and to Beardstown. I have visited Grafton at the mouth of the river a good many times, and have spent several days there on various occasions, making examinations of the river water and the conditions prevailing at that point. I have personally made bacterial examinations of the water from the Illinois and the Mississippi
Rivers at Grafton, doing the plating on the spot. I have
9859 also traveled down the Illinois River from La Salle to
Grafton by day light in steamboat and have observed the physical and topographical conditions throughout this stretch of the river. I have been out on the Mississippi River at Grafton and at Alton and have examined the conditions surrounding the mouth of the Missouri River where it empties into the Mississippi below Alton. I have also passed in a steam boat by daylight from Grafton to St. Louis, viewing the conditions existing along the course of the Mississippi River between these points. I have several times been out to the water intake of the St. Louis water works at the Chain of Rocks, have collected samples there myself and am generally familiar with the conditions in this neighborhood.

Q. During what periods were these visits made, as you have indicated?

A. My first trip along the course of the Illinois River was made in March, 1899 and my latest visit in September, 1903. The other visits to the several collecting stations and trips on the river were made at intervals between these dates.

Q. Will you describe the physical conditions of the Illi-
9860 nois River?

MR. JEFFRIES: He is giving his own descriptions!

MR. TODD: His own descriptions of what he personally knows of the conditions.

Q. And its tributaries?

A. From the point where the drainage canal empties into the Desplaines River at Lockport, the fall is quite rapid to a point somewhere below Morris. The lower portion of the Illinois River, especially that part of the River from La Salle to the mouth of the Illinois at Grafton is very sluggish and consists of a series of pools in which the current is very slow and in which opportunities for sedimentation abound. In the lower reaches of the river the current is so slight as to be hardly noticeable. At intervals in the course of the river, dams are located; one at Marseilles, between Morris and Ottawa, one at Henry, between La Salle and Averyville, one at Copperas Creek, some 58 miles below Peoria and two others between this point and Grafton at La Grange and Kampsville. These dams accentuate the tendency of the river to form pools and back waters. At Joliet and above Peoria there are wide expansions of the river known respectively as Lake Joliet and Lake Peoria. In these expanded reaches the current is very slight and the
body of water as a whole is almost entirely quiescent. At
9861 many points along the course of the river, especially be-
low La Salle, the banks of the river are low and an increase in the height of water in the river causes an overflow of the surrounding country, flooding the meadows and low lands adjacent to the river bank. In the lower 225 miles of the Illinois River there is a fall of only about 30 feet and the extremely sluggish current thus produced affords nearly ideal conditions for sedimentation. During the flood stages the valley of the Illinois River becomes virtually a great lake into which flood waters from the upper portion of the valley and tributaries are precipitated, and from the lower end of which they pass out in diminished and equalized volume.

Q. What effect do the lakes along the Illinois River, between Chicago and Grafton, have as a factor for the elimination of the infection and pollution entering the Desplaines River through the drainage canal from the sewers of Chicago?

A. If it were true that any of the infecting and polluting matters from Chicago reached as far down even as Lake Peoria the conditions existing there and further down the Illinois

River would be such as to bring about a further dimin-
9862 ution in the amount of the substances. Under the circumstances of semi-stagnation already enumerated, the settling out of food particles, the entanglement of the bacteria in these, and possibly the slow sinking of the bacteria themselves would all have full effect and would work to diminish the number of suspended bacteria.

Q. From what other sources than that of the drainage canal does the Desplaines and Illinois River receive pollution?

A. The sewage of Joliet, a city with a population of some 29,000, empties into the Desplaines River, as does also the sewage from a number of the suburban towns near Chicago. The Kankakee River, which unites with the Desplaines to form the Illinois, above Morris, also receives sewage from Kankakee of a population of about 14,000, and other communities. On the Illinois River the sewage from Ottawa, a sewered town, with a population of about 11,000, and the sewage of La Salle and Peru, with a combined population of nearly 20,000, also empties into the Illinois River. The Fox River which enters the Illinois above Ottawa, receives the sewage from Aurora, with a population of some 25,000 and of Elgin with a population of about 23,000. The Big Vermillion River, entering the Illinois
9863 above La Salle, also receives drainage from Streator and Pontiac, with a combined population of about 19,000. A very large amount of pollution enters the Illinois River at Peoria, with a population of about 56,000. In addition to the sewage of the town, the drainage from the stockyards and the distilleries enters the river here. At Pekin a sewered town, with a population of about 9,000 considerable sewage and distillery refuse also enter the river. The sewers of Havana also discharge into the Illinois River. The Sangamon River, one of the chief tributaries of the Illinois, receives a considerable amount of sewage from Springfield, with a population of about 25,000, from Decatur, with a population of about 20,000 and Bloomington, with a population of about 24,000. Beardstown, with a population of about 5,000 is the last town upon the Illinois River contributing a very large amount of sewage, the other towns below Beardstown being relatively small communities. All along the course of the Desplaines and the Illinois Rivers and their tributaries, in addition to these urban com-

munities, there is a very considerable rural population often draining directly into the river or small tributary streams,
9864 and this constitutes a source of pollution and possibly infection, not to be ignored.

Q. Considering all sources of pollution and infection entering the Illinois River from its tributaries and towns lying along its shores, and the City of Chicago, as well as its rural population, what importance do you attach to the dams and lakes and physical conditions of the river as a factor in the purification of said stream, at all times and under all conditions that obtain in the Illinois River?

A. I regard the conditions of semi-stagnation prevailing in the Illinois River at most points along its course as an important factor in influencing the fate of polluting and infectious matters added to the water of this stream and to the various tributaries. The exceedingly low gradient in the river which has been already referred to and which is further accentuated by dams at various points, retards the progress of suspended matters down stream and affords highly favorable conditions for purification. This is most marked during period of low water but at high water the flooding of the low-lands and the meadows along the banks of the river also affords opportunity for sedimentation and the retarding influences are still
9865 active. It is my opinion that the conditions prevailing in the Illinois River during summer and winter, during low water and high water, are much more favorable to the self purification of the stream than conditions that exist in a stream flowing over a bed with a steep gradient where any infectious elements introduced might be hurried down without opportunities for sedimentation or for loss of vitality. The considerable time that must be consumed by a given mass of water flowing along the Illinois River affords opportunity for the death and destruction of such infectious and polluting matters as may be introduced into this river, either directly or from the tributaries.

Q. Will clear water afford greater or less opportunity for the sedimentation of bacteria than turbid water containing matter in suspension?

A. Supposing that the velocity of the current is slow enough to allow the settling out of the particles of matter that impart turbidity to the water then any bacteria that might be in suspension, in such a water, would be carried to the bottom more quickly in a turbid water than in a clear water under similar conditions of movement. This has been proven experimentally by suspending in water bacteria together with 9866 clay particles and other substances, and allowing settling to occur. It is found that when there is a considerable amount of suspended matter in the water, bacteria are more quickly dragged down than when the water is relatively clear.

Q. Is the degree of sedimentation in the Illinois River affected by diluting the sewage of Chicago with Lake Michigan water?

A. There is at times a considerable amount of suspended matter in the water of Lake Michigan, near the mouth of the Chicago River, but on the whole the water of Lake Michigan is not a turbid water. In that portion of the Illinois River, however, where most sedimentation obtains, the amount of suspended matter introduced into the water from the tributaries and entering the river directly, is, in my judgment, sufficient to affect the same degree of sedimentation that would occur if the present amount of dilution with Lake Michigan water at the extreme upper end of the river was absent.

Q. If all the sewage of Chicago is turned into the drainage canal, diluted by one million cubic feet of Lake Michigan water per minute passing over the Bear Trap Dam, would that amount of dilution with Lake Michigan water affect the 9867 sedimentation of bacteria in the Desplaines and Illinois River under the conditions that obtain in those rivers?

A. In my judgment such a dilution as that indicated would affect the degree of sedimentation in the Desplaines River and probably in the upper part of the Illinois near the union of the Desplaines and the Kankakee, but in the lower part of the Illinois River, especially in that stretch from La Salle to Grafton, where sedimentation is most active, it is my opinion that such dilution as that described would not materially affect the degree of sedimentation of bacteria.

Q. Why?

A. From what I know of the physical conditions of the Illinois River and of the character of the various tributary streams, it is my opinion that there would be sufficient suspended matter in the water to bring about a mechanical dragging down of bacteria, and, moreover, that such an increase in the body of water as might result from this dilution would result in the spreading out of water of the Illinois River over the low lands, thus affording peculiarly favorable conditions for the sedimentation of bacteria.

9868 Q. What significance does dilution have in considering the problem of the self purification of streams?

A. When polluting or infectious matters are added to a water it naturally follows that the greater the dilution of such matters the less dangerous is a given quantity of such water, such for instance as a quart or a liter. In this sense dilution with a purer water may be said to increase the purity of the stream. So far as the actual destruction of infectious elements is concerned, dilution to such an extent as usually occurs, probably has but little influence.

Q. Is the danger of infection really diminished by dilution?

A. It certainly is.

Q. In what way?

A. Suppose that infectious material was introduced into sewage to such an extent that each tumblerful of the sewage contained one typhoid bacillus. Suppose further that such sewage were diluted with nineteen times its bulk of pure and uninfected water, it would then be true that out of one hundred glasses of this mixture of sewage and pure water only five would contain typhoid bacilli instead of the whole one hundred as was originally the case. In other words the same effect is
obtained as if 95 per cent. of the typhoid bacilli per-
9869 ished. In this way dilution unquestionably diminishes
the danger from infection.

Q. What effect does the dilution of Chicago sewage with the pure water of Lake Michigan have upon the condition of the water in the Illinois River?

A. Considering the conditions at the mouth of the Illinois River above Grafton, I should say that such dilution has little if any effect upon the infectious quality of such water, since whether the sewage be diluted or not, death of any typhoid bacillus originally present therein would occur, in my opinion, long before the mouth of the Illinois River was reached.

Considering the character of the Desplaines River at Joliet, however, such dilution would diminish the danger to any person venturesome enough to partake of the fluid at this point, since the dilution would diminish the number of typhoid germs contained in a given quantity, say a tumblerful of the mixture.

Q. Is the addition of Lake Michigan water to the sewage of Chicago a detriment or benefit to the sanitary condition of the Illinois River, in its upper branches, considered from the standpoint of dilution alone?

9870 A. If by sanitary condition is meant the infectivity of a given measured quantity of the water, such dilution would improve the Illinois River water in its upper stretches. So far as the destruction of typhoid bacilli is concerned, it is my opinion that this dilution has little or no influence upon the longevity of this microbe. The actual number of typhoid bacilli passing a given point would not be materially influenced by dilution, but the proportional number in a given quantity of water would of course be lessened.

As regards the process of decomposition which goes on in such sewage and sewage polluted waters, the river water is rendered much less offensive by dilution with the purer water of Lake Michigan, as I have observed myself to be the case at Morris. An improvement in the quality of the river water is also evidenced by the fact that fish now come up the Illinois River as far as Morris, where prior to this dilution they had not been known for years.

Q. Professor, I will ask you this question which was asked of Professor Sedgewick, on page 3542 of the record: "Professor, assuming the fact that the waters of the Chicago Drainage Canal, taken from points in Lake Michigan at or near the mouth of the Chicago River, were to be conveyed from Lockport to Grafton on the Mississippi River, through a canal or closed conduit, so built as to maintain the same velocity of flow provided in the present canal, built as far as Lockport, and further assuming the contents of this canal or conduit received none of the Chicago sewage except such portion as now reaches Lake Michigan directly, and without entering the Chicago River, do you or do you not consider that the assumed conditions above mentioned would constitute a menace 9871 or danger to the inhabitants of the State of Missouri, and especially of the City of St. Louis, drinking the Mississippi River water in its raw condition, the waters of the drainage canal flowing to the extent of 300,000 cubic feet per minute, emptying into the Mississippi River."

A. Assumming the question as quoted to apply to the passage through a conduit of the water of Lake Michigan, under the conditions stated, from the Lake Front of Chicago to the Mississippi River at Grafton, I would say that I do not consider that it would be a menace or danger to the inhabitants of the State of Missouri and especially to the citizens of St.
9872 Louis drinking the Mississippi River water in its raw condition. I make this answer because in my opinion the typhoid bacillus would not survive exposure to the conditions in such a closed conduit any more than in my opinion it does survive exposure to the conditions existing in the Illinois River. And furthermore, assuming that no greater mixing of such water with the waters of the Mississippi River and Missouri River occurs than is the case at present it is my judgment that a very small portion of such water would reach the intake tower of the St. Louis waterworks, pass through the settling basins and be delivered to the inhabitants of the City of St. Louis.

Q. Would such a volume of Lake Michigan water emptied into the Mississippi River in the manner indicated in General Crow's question, co-mingling with the waters of the Mississippi, and thence with the waters of the Missouri, ever pollute and infect the said waters of the Mississippi and Missouri Rivers as the same should pass along the shore of the State of Missouri and the City of St. Louis, at the St. Louis intake?

A. On the contrary, assuming the conditions in the Missouri and Mississippi River to be as they are at present, it is my judgment that the water issuing from such a conduit,
9873 and experiencing the same degree of purification which now takes place in the Illinois River, would tend rather to improvement and purification of such water so far as it might mingle with it.

Q. How do the physical conditions of the Illinois River compare with the other rivers in the country for the purpose of purification?

A. As compared with rivers of high velocity the conditions for purification in the Illinois River, as already set forth, are especially favorable. The sluggish current which permits a sufficient lapse of time for the death of pathogenic bacteria and which also facilitates and furthers sedimentation constitutes an element wholly favorable to self purification.

As compared with the Mississippi River where the current is swifter and especially as compared with the Missouri River the opportunities for purification in the Illinois River are quite superior.

Any factors that tend to increase the opportunities for sedimentation and that tend to delay the progress of pathogenic microbes down stream further the process of purification. In
these respects the conditions in the Illinois River are
9874 greatly superior to the conditions in the Mississippi and
Missouri Rivers. As compared with some other streams in this country that have been studied with a view to the opportunities for self purification the Illinois River is well adapted for self purification.

I find in the report to the Filtration Commission of Pittsburg, Pennsylvania, published in January, 1899, in a Report upon the Sources of Typhoid fever in Pittsburg, by my friend Professor W. T. Sedgwick, who has testified in this case the following statement: I will quote what he says about the Allegheny River under the heading "The Allegheny River a rapid stream with little or no opportunity for self purification," page 18.

"Any one who will take the trouble to follow the Allegheny River from Oil City to Pittsburg merely as a passenger on the Allegheny Valley Railway, particularly if he is familiar with the streams in the less mountainous parts of the country can not fail to be impressed immediately with the fact that we have in the Allegheny River a peculiar and characteristic stream. Owing no doubt to the character of the rock through which it has cut its way, it exhibits a very regular deep line from Oil City to Pittsburg. There is no mill dam of any consequence between these two cities and the river is therefore narrow as is
not frequently the case with rivers in New England and
9875 elsewhere in which a series of mill ponds containing
slowly moving water, and in which the elements of sluggishness and quiesence are except in period of freshets a chief

characteristic, but rather, even at low water like a brawling brook, making its way rapidly over a stony bed in which are very few pools or other quiet places adapted to purification in which there is little or no evidence of effective sedimentation as is proved by the absence of mud banks, sand bars and the like—but exhibiting everywhere stones polished by the swiftly flowing stream and without effective lodging places for mud or bacteria. An estimate roughly made of the rate of flow shows to the traveller a probable velocity in most places of at least a foot per second and often much more than this even at low water. With high water the velocity must obviously be much more rapid. Clearly the two fundamental elements looking towards self purification in rivers are here wanting, namely time and quiescence. The velocity of the river and the character of its bed are such that foul water introduced for example at Oil City or nearer points may and indeed must arrive at Pittsburg within a very few hours. Fortunately however we do not have to rely on the rough observations of passing travellers but are in 9876 possession of authoritative calculations. According to results obtained from the United States Engineer's office at Pittsburg the average velocity of the Allegheny River even during low water is from one to two miles per hour. During high water it is from 7 to 8 miles per hour and on the average of about three and one-half miles. This means that infectious materials poured in at Oil City of nearer points may arrive at Brilliant within fifteen hours or even at low water must arrive within a few days.

It has just been shown that in the bed of the Allegheny River very little or no opportunity occurs for purification en route by the usual processes which are more or less effected in rivers."

I would say that I entirely agree with Professor Sedgewick that the Allegheny River as he describes it affords few opportunities for the process of self purification, and that I agree in his conclusions as to the rapid march of infectious material under such conditions. The conditions in the Illinois River, however, as hereinbefore set forth are very different from those prevailing in the Allegheny River. In the Illinois River as in other sluggish streams those elements that favor self purifica-

tion in rivers, namely time and quiescence, are present in
9877 force. There are few rivers in the United States with
which I am familiar where the factors making for self purification are so potent as they are in the case of the Illinois River. Both the Mississippi and Missouri Rivers are less favorable in this respect.

ADJOURNED until 2 P. M. same day, February 3, 1904.

9878 MET PURSUANT TO ADJOURNMENT AT 2. P. M, FEBRUARY 3, 1904. Present the Commissioner and same counsel.

PROF. E. O. JORDAN.

resumed the stand for further direct examination by Mr. Todd.

MR. TODD: Mr. Commissioner, have you got the last part of Professor Sedgwick's testimony given in connection with the Washington epidemic, as I would like to have the same for inspection.

THE COMMISSIONER: Professor Sedgwick has that part of the record with him in Boston, it being understood that he is to correct it and when he next returns to Chicago bring it to me to be signed, after we have gone over the corrections which he can make in conformity with the agreement heretofore entered into.

MR. TODD: I have a transcript of his evidence in my possession which has not been corrected or signed by him, and would like to predicate a question upon the testimony as I have it, as I will not have an opportunity to ask this witness this question after you have received the testimony from Professor Sedgwick with his corrections.

Q. Professor Sedgwick on page 369 of the transcript of his testimony, an uncorrected copy of which I have, stated: "The River Commissioners of Great Britain, in a report pub-
9879 lished by them in 1874, state there is no river in England
long enough to purify itself from any sewage admitted to it, even at its source;" that stands as one of the axioms of sanitary science today, that those River Commissioners in 1874 I think it was made that statement that there is no river in the United Kingdom I think they said, long enough to purify itself

of any sewage introduced into it, introduced at its source, and of course some of the rivers of the United Kingdom are very long." And again, on page 4398, this question was asked him: "Do you know how the distance from Cumberland to Washington by river compares with the length of the river Thames in the United Kingdom" answered "The Thames is 209 miles long and is, I believe, the longest river in the United Kingdom, and this epidemic seems to confirm in a very remarkable way that statement of the Rivers Pollution Commission of Great Britain to which I have referred in my previous testimony where they said that there was no river in the world that was long enough to purify itself of any sewage introduced into it, even at its source." I will ask you if you are familiar with the report of the River Pollution Commission of Great Britain for 1874?

MR. JEFFRIES: I object to the question for the reason
that it is not a proper way to impeach, contradict or de-
9880 stroy the credibility of the testimony of Professor Sedg-
wick, but that counsel may introduce a copy of said report in evidence for that purpose, there being no showing that copies of said report are not extant.

A. Yes sir, I have frequently consulted it in connection with my teaching and investigation work.

MR. JEFFRIES: I move to strike out all that part of the question which relates to other than the witnesses acquaintance with the report in question.

Q. Will you state what the River Pollution Commission Report for 1874 did state about river purification?

A. The statement is as follows:

"It will be safe to infer, however, from the above results that there is no river in the United Kingdom long enough to effect the destruction of sewage by oxidation."

Q. What is the difference between the expression "to effect the destruction of sewage by oxidation" and the expression "to purify itself of any sewage introduced into it at its source?"

MR. JEFFRIES: I move to strike out the last preceding answer because it is not the best of evidence, and for the further reason that the witness did not attempt or claim to give all that
was said by said Commission upon the subject of self puri-
9881 fication of water in the rivers of the United Kingdom.

MR. TODD: In reply to the objection will state that when Professor Sedgwick testified to it in regard to what the report stated, he did not produce the report but assumed to testify from memory and the reference to this report is made frequently in his testimony as an axiom of sanitary science.

MR. JEFFRIES: In answer will state that what he has said may be true but that it does not necessarily follow that this board in its report did not say both what is attributed to it by Professor Sedgwick in his testimony and also what is said by this witness because the two statements, that made by Professor Sedgwick and that made by this witness, are not in conflict with each other.

Q. Question read.

A. At the time this report was published in 1874, the knowledge of sanitarians regarding the quality of a water was based on chemical data, this being before the rise of the science of bacteriology. Practically nothing was known at that time regarding the elements in sewage that imparted to it its dangerous character. The fact had, however, been determined empirically that a certain relation existed between the oxidation of sewage and the loss of its dangerous qualities. 9882
It was not known however precisely what this relation was or upon what it depended. At the present time our conception of the purification of a sewage-polluted stream is based rather upon what information we are able to obtain regarding the disappearance and destruction of disease producing bacteria that may be introduced into it rather than upon oxidation processes. There is, therefore, a wide difference between stating that the purification of a stream is effected within a certain distance and that the destruction of sewage by oxidation is accomplished within a certain distance. It does not, by any means, follow that because complete destruction by oxidation of the organic matters contained in a sewage polluted water does not occur within a specified distance, that the real purification of the sewage, that is to say its freedom from dangerous bacteria may not be accomplished within that distance. It is certainly true that the process of nitrification or oxidation and the processes leading to the disappearance of dangerous or suspicious bacteria do not always run in a strictly parallel course either in sewage tanks or polluted rivers.

Q. Does the report of the Rivers Pollution Commission

of 1874 contain anywhere in it the statement that no river
9883 in the United Kingdom is long enough to purify itself of
any sewage introduced into it at its source?

MR. JEFFRIES: I object to the question for the reason that counsel is undertaking to lead the court to believe that the language used by Professor Sedgwick in his testimony is the exact language used by the Commissioners in their report, and I object to it for the further reason that counsel is undertaking to get the witness to state or to relate to the court things that are not contained in the report, and while it is true that witness has stated that certain statements were contained in the report purporting to set out the exact language by the Commissioners in their report, yet the introduction of such statements do not justify this witness in undertaking to tell this court all that the Commission failed to specify, determine or say, and in this connection I suggest that the report must speak for itself as to what it does not contain.

Q. Question read.

A. I have examined this report with some care and have failed to discover in it any statement couched in the language you have just used.

MR. JEFFRIES: I move to strike out the answer because
the question and answer imply and undertake to con-
9884 vey to the mind of the court the impression that Professor
Sedgwick used exactly the identical language contained
in the report.

Q. Is there in that report any language that carries the idea expressed in the sentence "there is no river in the United Kingdom long enough to purify itself from any sewage admitted to it, even at its source?"

MR. JEFFRIES: I object to the question for the reason it is for the court to determine from the report itself whether or not there is any such language used that would convey the impression stated in this question, and not for this witness to determine such fact, and that all of these questions are unfair and irrelevant and incompetent because the report itself is the best evidence.

MR. TODD: I will suggest on the ground of fairness that if counsel who introduced Professor Sedgwick was actuated by the same degree of fairnesss that counsel is in filing his objections he would have had Professor Sedgwick produce the report and there could have been no misunderstanding, as this report has been referred to by several witnesses on the part of the complainant in this case.

9885 MR. JEFFRIES: I will state that whatever counsel may say with reference to fairness of counsel upon either side in this case, that such statements do not justify this witness in undertaking to state to the court whether or not the report contains or promulgates any such propositions as contained in the language expressed in this question, and it is not for this witness to say but for the court to determine upon all the evidence and from the report itself if counsel desires to introduce the report.

Q. Question read.

A. As I have already stated I have made a somewhat careful examination of this report, and the statement that I have found in it that most nearly expresses the idea embodied in the citation from the record, is the statement that I have already quoted.

Q. From your knowledge of the physical conditions that obtain along the Illinois river as well as your analyses of the water, both chemical and bacterial, what effect, if any, does the sewage from Chicago, discharged into the drainage canal, have upon the waters of the Mississippi river as the same passes along the shore of the State of Missouri?

A. The large amount of harmless inorganic chlorine in the
water of the Illinois river at its mouth is derived chiefly
9886 from the sewage of Chicago and Peoria. So far as the
water of the Illinois mingles with that of the Mississippi
along the Missouri shore, so far is the chlorine content of the
water heightened. In respect to the other constituents of the Illinois river water, the sewage introduced at Chicago influences the total amount of nitrogen compounds in said water. This is especially true of the nitrates, which are usually high at Grafton. In respect to the bacterial content of the water, the mixing of the Illinois with the Mississippi does not in my opinion introduce into the mixture any significant number of bacteria derived from the sewers of Chicago. It is my opinion that practically all the bacteria introduced into the drainage canal from the Chicago sewers perish long before the mouth of the Illinois is reached.

I conclude that the sewage from Chicago, introduced into the drainage canal, has no injurous effect upon the waters of the Mississippi as the same passes along the shore of the State of Missouri.

Q. What is your opinion as to whether any pollution, dangerous to public health, entering the drainage canal from the sewers of Chicago, reaches as far down the Illinois river as the town of Grafton?

9887 A. None.

Q. What evidence have you that justifies the conclusion just expressed that no pollution dangerous to public health coming from the sewers of Chicago, reaches as far down the Illinois river as Grafton?

A. All the analytical data that have been introduced by me in evidence justify, in my opinion, the conclusion that I have expressed, the rate of oxidation of the organic matters in the sewage, the enormous death rate among the sewage bacteria in the extreme upper reaches of the Illinois, and especially the high mortality among the colon bacilli, all combined to furnish convincing evidence that pollution dangerous to public health, coming from the sewers of Chicago, does not reach as far down the Illinois river as Grafton.

Q. What is your opinion as to whether any infectious matter coming from the sewers of Chicago, by way of the drainage canal, in a dangerous state reaches as far down the Illinois river as the city of Grafton?

A. I am unable to differentiate clearly between infectious matter and pollution dangerous to public health in this connection, since polluting matters dangerous to the public health are, so far as I am aware, those able to communicate infec-
9888 tion. I, accordingly, would answer this question in the same way as I have answered the preceding, namely, that in my opinion no infectious matter coming from the sewers of Chicago by way of the drainage canal reaches as far down the Illinois river as the city of Grafton.

Q. Is there any evidence, bacterial or chemical, that you know of that would justify the conclusion that polluted and infected matter coming from the sewers of Chicago would reach as far down the Illinois river as the town of Grafton?

MR. JEFFRIES: I object to that as leading and suggestive.

A. I know of no evidence, bacterial or chemical, that would justify such a positive conclusion. On the contrary, as I have stated, the evidence of which I am cognizant points to precisely the opposite conclusion, namely, that such deleterious elements do not reach as far down the Illinois river as the town of Grafton.

MR. JEFFRIES: I move to strike out the answer because the witness has confined himself to the evidence introduced in this case, and to his personal knowledge of the conditions, 9889 and does not state the source of the evidence to which he refers in his answer.

Q. Would a condition of low water in the Missouri river at a time when there was high water in the Illinois river be in any way a factor in carrying infected and polluted matter from the sewers of Chicago to the City of St. Louis?

A. In my opinion it would not. In my judgment the Illinois river at its mouth does not contain infectious matter of a dangerous character, derived from the sewers of Chicago, and so could not be a factor in carrying infectious and polluting matters from the sewers of Chicago to the City of St. Louis.

Q. Professor Sedgwick, in answer to this question (on page 3545 of my transcript of the record), "Professor, will you state whether or not it is within the bounds of human possibility for any competent expert to say that in the period of low water on the Missouri river, such as is likely to occur at next Christmas a thaw on the Illinois river watershed might not endanger the lives of the people using the waters of the Mississippi below the mouth of the Illinois on the Missouri shore and at the City of St. Louis by sending to them in that water the suspended sewage of the sanitary district of Chicago?" answered, "I do not believe that it is, because in my opinion no competent 9890 expert whatever can or will say that any means exist at present by which such unpurified sewage can be warded off from the people on the Missouri shore and the citizens of St. Louis under these conditions." I will ask you to state what is your knowledge in regard to the assumption that low water might exist in the Missouri at a time of flood water in the Illinois, and also state whether you know of any means existing in the Illinois river at present that would permit unpurified sewage from the City of Chicago to become a danger and a menace to the public health of the citizens of Missouri and the citizens of St. Louis using the water of the Mississippi river for drinking and domestic purposes.

A. In reply to the first part of the question I will state that it is of course conceivable that low water may exist in the Missouri at the time of flood water in the Illinois. During the period, however, that I have had a knowledge of the conditions of the water stages in these rivers I have not known such a condition as that described in your question to exist. It seems to me rather unlikely that a period of flood water in the Illinois would coincide with a period of low water in the Missouri.

In reply to the second part of the question I will state
9891 that the natural factors of self-purification that are observed in the Illinois river at present and that in my opinion lead to the death and destruction of pathogenic germs introduced into this river from the sewage of Chicago are sufficient to prevent unpurified sewage from Chicago from becoming a danger and a menace to the public health of the citizens of Missouri and the citizens of St. Louis. I assume that by unpurified sewage is meant sewage containing its original dangerous qualities. It is my judgment that the dangerous elements present originally in Chicago sewage do not pass down the Illinois river far enough to affect the public health of the citizens of St. Louis.

Q. Professor, from your knowledge of all the conditions that obtain along the Illinois river as well as your knowledge of the conditions that obtain in Chicago and the drainage canal, also your knowledge of the water supply of St. Louis, such as is had at the intake tower at the Chain of Rocks—what effect does the sewage from Chicago have upon the water supply of the City of St. Louis or upon the water of the Mississippi river as it passes along the shores of the State of Missouri?

A. From my knowledge of all the conditions indicated in your question, it is my judgment that the sewage of Chi-
9892 cago has no injurious or deleterious effect upon the water supply of the City of St. Louis or upon the water of the Mississippi river as it passes along the shores of the State of Missouri.

Q. Professor, will you please state upon what facts you base your opinion that a typhoid bacillus will not live more than three or four days under conditions as they obtain in the drainage canal, the Desplaines river and the Illinois river?

A. I base my opinion chiefly upon an elaborate experiment that I have recently carried out upon the life of the typhoid bacillus under natural conditions in the water of the drainage canal at Robey street, and at Lockport.

Q. Was this experiment conducted by yourself alone?

A. No, sir; by arrangement with the Sanitary District of Chicago the experiment was conducted under the supervision of Professors Russell of the University of Wisconsin, Zeit of the Northwestern Medical School and myself. It was a co-operative experiment, special features of the work being assigned to each investigator.

Q. Professor, will you give the general plan of the experiment?

9893 A. The experiment was planned with a view to imitating as closely as possible the conditions that would environ a typhoid bacillus introduced into the drainage canal from the sewers of Chicago.

I have already indicated the serious and insurmountable objections to experiments upon the longevity of a typhoid bacillus in glass bottles under laboratory conditions. With a view to removing these objections a different receptacle was planned for imprisoning the typhoid bacillus in the drainage canal under normal conditions of life, temperature, etc. Five different bodies of water were selected for the experiment, namely, the water of Lake Michigan, the water of the Chicago river, the water of the drainage canal at its mouth at Robey street, the water of the drainage canal at Lockport and the water of the Illinois river at Averyville. Professor Zeit carried on the experiments in Lake Michigan water and the water of the Chicago river. Professor Russell carried on the experiments in the water of the Illinois river at Averyville; and under my directions experiments were carried on in the water of the drainage canal at Robey street and Lockport. To avoid the use 9894 of glass in these experiments parchment sacs were employed, one of which I have here. These parchment sacs contained about eight hundred cubic centimeters of water and were suspended in floats which I shall describe presently. These parchment sacs permit the passage of certain substances in solution but do not allow the bacteria to pass through their walls. The conditions under which the typhoid bacilli introduced into the sewage in these sacs are subjected are therefore almost precisely the conditions obtaining in nature, since the bacteria inside and outside of the sacs can not pass through the walls of the sacs, and yet the bacteria are subjected to the action of the toxic products or saprophytic microbes in the sewage. The parchment sac in brief acts as a prison for the bacteria. The bacteria themselves are otherwise under the same conditions as those obtaining in the drainage canal.

Q. Will you describe these parchment sacs in detail which you employed in this experiment?

A. These sacs were made of parchment tubing about two inches in diameter and were prepared from heavy parchment paper such as is used in chemical work for osmotic ex-
9895 periments. The sacs were fastened to a piece of glass
tubing some six inches in length and were firmly tied to this and sealed with a mixture of tallow and rosin. The sac was weighted so as to swing freely in the water when filled with sewage. These sacs were suspended in the water in a frame work covered with a wire screen which permitted free circulation of the water. This frame was made of fine strips of wood and was four feet long and three feet wide and three and one-half feet deep. The bottom, top and lower five-sixths of the sides and ends of this frame were covered with wire screen. The upper six inches of the sides and ends of the box and the sides and ends of the cover six inches deep were of one inch pine fencing. The top opened with a hinge and was fastened in place by a hasp and padlock. The box was balanced in such a way that it floated with the water level up to the height of the lower margin of the upper solid portion of the body. The part above the water was thus of boards and served to break the waves from passing vessels or wind. At Robey street the box
was set between the timbers of a large floating frame.
9896 The wire covering the box had two and one-half meshes
to the inch. At Lockport the box was fastened to the floating dock near the Bear Trap Dam. The wire covering the box is of a three-quarter inch mesh. At both of these places the

floats were situated in such a way as not to prevent free circulation of water through the large wire meshes. And from an observation of the conditions both at Robey street and Lockport I am confident that the water within the frames differed in no essential particular from the open waters of the drainage canal. Inside the box were several coarse strips about an inch above the water level in which slots were cut in intervals of about three inches to receive the glass ends of the tubes. Opposite each slot was a staple through which was passed a cord attached to the tube which was thus securely held in place. To guard further against the tipping of the tubes small slips were fastened across the slots to prevent effectually the accidental removing of the sacs. These boxes were fastened with a padlock and throughout the experiments the key to both boxes was in the possession of my chief assistant, Mr. Irons, no other person having access to those boxes. The lower end of the parchment sac was sealed. It was rolled up tightly and wrapped with thread. Both the upper and lower joints were saturated with a mixture of resin and tallow. The capacity of the sacs ranged from 700 to 800 cubic centimeters. The sacs were tested for cracks or punctures before leaving the laboratory and then again when they were filled in the field. To the lower end of each sac a small weight was attached which served to keep the sac in an upright condition in the water. A cord was also fastened to the lower end by means of which the sac was brought to the surface of the water and the contents agitated at the time of taking samples. The tubes were open to the air at the upper end, allowing a free interchange of the air and gases. Owing to the slight wavy motion that was usually present in the water there was a fairly constant though slight movement of the body of the sacs. After several days in the water the tubes became coated with a dark slimy shag material which on examination was found to consist of a species of bryozoan. It is found on all submerged plants and debris in the vicinity. It was most marked at Robey street, but was seen to a less degree at Lockport. 9897

9898 Q. The description which you have heretofore given applies to the part of the experiment which was conducted under your direct supervision, does it not Professor?

A. It does solely and entirely to that.

Q. The other branches of the experiment were conducted by Professor Zeit and Professor Russell?

A. Yes, sir, in general in the same way, but independently, under the control of those investigators.

Q. Did you three men consult together about the scope of the experiment and the methods to be pursued?

A. Yes, the general plan of the experiments and the details were discussed very fully by us before the work was undertaken. We also held conferences during the progress of the experiment.

Q. You have described now the equipment which you employed for the making of the experiment, have you?

A. Yes, the equipment used in making the experiment has been described.

Q. Will you describe now in detail the manner in which the experiment was made?

A. We considered it important to obtain cultures of typhoid bacilli which had not been weakened or attenuated by artificial cultivation. Since I had already shown in some experiments on the death of typhoid bacilli in water, as previously referred to in my testmony, that freshly isolated cultures lived longer in water than those that had been under cultivation in the laboratory for some time, and since certain individual differences sometimes existed between cultures obtained from different sources we considered it necessary to procure several cultures. Three cultures were employed in the experiments carried out in my laboratory. These were designated respectively as typhoid x 9899

typhoid y and
typhoid z.

Typhoid x was isolated on September 22, 1903, from the blood of a patient suffering from typhoid fever in the county hospital in Chicago. The symptoms of this case which I have here in detail are those of typical typhoid fever. The history of this case is as follows:

Mike L., age 26, laborer, Polish; date of admission 21st of September; date of death 26th of September.

History: Patient is Polish and speaks no English. 9900 No history can be obtained other than that he has been sick one week. By gestures it is learned that he has had pain in his head and neck and has some tenderness in abdomen, has a few drops of blood on his clothing which he says came from his nose.

EXAMINATION. General, young man about 25, medium stature, good physical development, well nourished, expression dull, skin hot and dry; breathing 30, quite shallow; pulse 100, regular; slightly dicrotic.

REGIONAL. Spleen, dullness extends to the ribs in mid sternal line; edge readily palpable beneath costal arch.

ABDOMEN. Rounded, well formed; two or three typical rose spots that disappear on pressure. No tenderness, no distention.

RESUME. September 22, 1903, 5 cubic centimeters of blood were drawn from medium bacillic vein of the right arm 9901 in a sterile manner. With this two flasks of plain bouillon and one of litmus milk each containing 100 cubic centimeters were inoculated. From these flasks the typhoid bacillus was isolated in pure culture.

TEMPERATURE. On the day of blood cultures ranged from 101 to 104, pulse 90, respiration 30.

Leucocyte count September 24, 1903, 8,000.

September 24, patient was transferred to the surgical side and was operated upon.

EXAMINATION. Patient received in condition of partial collapse; abdomen tymponitic and painful; respiration rapid and shallow; pulse rapid and weak; patient conscious but extremely weak.

TREATMENT: Laparotomy.

September 25, 1903, pulse 158 (by stethoscope). Pulse extremely weak, respiration rapid and shallow, abdomen very tymponitic and rather tense. Wound discharging profusely. Wound dressed, dressing saturated.

8:45 p. m. Lowest stitch removed and strip of iodoform gauze inserted. Gas escapes from wound.

September 26, 1903. Death 12:20 p. m.

9902 AUTOPSY. Perforative peritonitis.

Acute splenic tumor.

Ulcerative enteritis (typhoid ulcers).

I should state that these notes were made by Dr. E. C.

Rosenow, working under my direction. In this case was obtained a pure culture isolated from blood.

The history of isolation of typhoid Y which was found in the urine of a typhoid fever patient, was as follows:

Thomas W. S. admitted to the Cook County Hospital September 22, 1903 having been sick five days, age 22.

HISTORY onset. Began with headache, loss of appetite, pains in back and limbs and general feeling of malaise. No history of chill, vomiting, or sweats. Has slept poorly. Bowels had been very loose since taking salts on day of onset. No urinary symptoms. No epistaxis.

EXAMINATION. Reginal, abdomen, distension slightly above normal. Moderate tymponitis and considerable gurgling.

SPLEEN. Palpable. A few pin head sized red spots over abdomen, disappearing on pressure.

September 23, 1903. Temperature 102.8; pulse 84;
9903 respiration 20 at noon day of the disease.

September 25, 1903. Sputum examination negative as to tubercle bacilli.

Blood examination leucocytes 6,000. Widal not positive in one hour, 1 to 40 dilution.

September 28 (12th day). Widal positive.

September 30. General condition good. No complaint. Stomach was disturbed; some diarrhoea.

Examined the abdomen, distended; tymponitic.

Spleen palpable.

October 1, 1903. History contains the following note: Examination of feces and urine by Dr. Rosenow showed typhoid bacilli in both.

October 5, 1903. General condition good. Convalescence uninterrupted.

October 19. Patient is up and around. Clinical diagnosis, typhoid fever.

October 17, 1903. Specimen of urine collected and handed to Mr. Irons."

In regard to this case I want to say that in addition to using
in the experiment a culture of the typhoid bacillus isolated
9904 from the urine of this patient a sample of the urine itself
as collected under natural conditions was obtained from
this patient and added directly to the sewage in some of the sac

experiments, thus imitating as closely as possible the conditions under which typhoid bacilli pass directly from the body of a patient into the sewage in the ordinary urine dscharge.

'Typhoid Z. Mike, O. H. Of Irish descent; age 22 years; admitted to the Cook County Hospital August 28; died September 28th; no postmortem was held. The case was a perfectly typical one of typhoid fever. Typhoid bacilli were isolated from the patient's feces on September 28th.'' These three cultures, typhoid X, typhoid Y and typhoid Z were therefore all freshly isolated cultures obtained for the purposes of this experiment from typical cases of typhoid fever. One of these typhoid bacilli was obtained from the blood of a patient, one from the urine of a patient and one from the feces of a patient. The virulence of these organisms is shown by the fact that in two instances the outcome of the case was fatal.

9905 The aim of isolating these cultures in a fresh condition from the body of patients was to obtain the maximum degree of vitality and virulence, thus making the outcome of the experiment, whatever it might be, as valuable as possible from a scientific point of view and as conclusive as possible on the sanitary side.

Adjourned until 10:00 a. m., February 4, 1904.

9906 10:00 A. M., Thursday, February 4, 1904. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. Professor, will you describe the methods employed by you in developing the typhoid germs which you isolated from the blood, urine and feces of the three persons or patients concerning whom you testified at the close of yesterday's testimony?

A. In each case the material obtained from the patient's blood, urine and feces respectively was mingled with nutrient material in which bacteria are able to thrive. From this they were finally plated out in a solid gelatin or agar medium where each individual germ developed a colony about itself. Separate colonies were examined and the growth obtained in pure culture. The appropriate tests for the typhoid bacillus 9907 were then applied to the microbes so isolated. The growth was tested in gelatin, milk, nutrient broth, dextrose broth, the other usual bacteriological media. The morphology of the organism was then studied, its motility determined and finally the Widal test applied. By these methods it was definitely ascertained that the micro-organisms isolated from the bodies of these several patients were identical with the true typhoid bacillus, and these cultures after such complete identification were used in the experiments that have been referred to.

Q. Why did you select parchment sacs for use in this experiment?

A. For the reason that it was desired to imprison the typhoid bacilli where they might be under observation, and at the same time to imitate as closely as possible the natural conditions. Similar sacs made of celloidin have long been used in bacteriological work; they have been found particularly useful in performing experiments upon animals. Small celloidin sacs, filled with a fluid culture of bacteria, have been introduced into the bodies of animals under aspetic conditions. The advantage of the celloidin sacs used in this way is that it permits the 9908 solube products and toxins generated by the bacteria to pass through the wall of the sac while confining the bacteria themselves and not allowing them to spread through the body. This method has shed a good deal of light upon the action of the poisonous products of bacteria, as distinguished from the changes produced in the body by the presence of bacteria themselves. It was thought that by using similar sacs for these experiments upon the longevity of the typhoid bacillus in sewage, the advantages known to be derived from the use of such sacs in animal experiments would be obtained in the experiments upon sewage. In other words, under these conditions the soluble products of the typhoid bacilli would be free to diffuse into the surrounding liquid, and conversely, similar products of the sewage bacteria outside of the sac could diffuse into the sac. Any action that these products might have upon the typhoid bacilli could then be exerted under these conditions. The parchment sacs are of substantially the same character as celloidin

sacs and the parchment paper of which they are constructed is used commonly in dialysis in the chemical laboratory. The parchment sacs are somewhat stiffer and less fragile than the celloidin sacs and for this reason were used in the ex-
9909 periments in the canal. Parallel tests with large celloidin sacs of the same size and construction as these parchment sacs have given strictly analogous results.

To sum up, parchment sacs confining typhoid bacilli mingled directly with the contents of the drainage canal, represent natural conditions as closely, I believe, as it is possible to represent them.

Q. After the cultures were prepared in the manner you have indicated did any of your associates use these same cultures in similar experiments

A. Yes sir; these three cultures isolated and identified under my direction and designated respectively as typhoid X, typhoid Y and typhoid Z were sent to Professor Russell of the University of Wisconsin, and one of these cultures, typhoid Y, if I remember correctly, was sent to Professor Zeit.

Q. Who assisted you in these experiments?

A. Mr. E. E. Irons who was my principal assistant in a large part of the work that I carried out upon the Illinois River for some three years was assigned the important work of inoculating the sacs placed in the floats in the drainage canal,
9910 and also of obtaining samples from these sacs at times specified by me. After the floats were installed in the drainage canal at Robey Street and at Lockport I visited both these places with Mr. Irons and inspected the results of his work.

In the laboratory I was assisted by Doctors Norman McLeod Harris and Miss Mary C. Lincoln who worked with me and immediately under my supervision.

Q. How many sacs of the character that you have described were employed in making this experiment?

A. At Robey Street 16 and at Lockport 12. These were all inoculated sacs, that is sacs into which typhoid bacilli were introduced. In addition a number of sacs were introduced into the water at both Robey Street and Lockport which were filled with the sewage taken directly from these places and were used as control sacs.

Q. Will you explain what you mean by control sacs?

A. These sacs known as control sacs were not inoculated with typhoid bacilli but contained simply the raw sewage
9911 taken from the canal at the respective points. Samples of water taken from these control sacs were plated at frequent intervals and examined as to their bacteriological content, the aim being to discover what happened to the sewage bacteria, especially the colon bacilli and streptococci present in the sewage. It was thought that in this way some valuable information might be obtained as to the course of events in the sewage itself as it passes on down the drainage canal into the Desplaines and Illinois Rivers. Laboratory experiments with such sewage placed in glass bottles are open to the objection that they are not under natural conditions and so do not afford a true insight into the changes taking place in nature.

Our expectations regarding the value of these control sacs were fully justified by the outcome.

Q. Will you describe the method employed by you for the inoculation of these sacs with the typhoid bacillus?

A. The typhoid bacilli, X, Y and Z were grown upon the surface of nutrient agar, at the body temperature, for twenty-four hours. The surface growth was then scraped off and introduced into sterilized lake water or sterilized sewage,
9912 or in some cases into urine derived from typhoid fever patients. This suspension of typhoid bacilli, as it is technically called, was then introduced by Mr. Irons into the parchment sacs which had been filled with sewage from the drainage canal just prior to inoculation.

In order to determine precisely how many typhoid bacilli were introduced in each case, a measured quantity of the suspension already alluded to was diluted with a known quantity of sterilized water and plated in the usual way. By counting the number of colonies developing upon the plate the number of typhoid bacilli that were introduced into each parchment sac was determined with accuracy. By using a young—24 hours old—culture of typhoid bacilli isolated but a short time before, as already stated, every attempt was made to favor the introduction of the typhoid bacillus into the sewage in a condition of maximum vitality, and thus guard so far as possible the liability that the cultures employed were attenuated or weakened in any degree.

Q. After the sacs were inoculated what was the next
9913 step in the experiment?

A. Samples of water were collected from these sacs in sterilized glass bottles by Mr. Irons, according to my instructions. These samples were brought to the Bacteriological Laboratory of the University of Chicago as speedily as possible.

Q. What were your instructions for the collection of samples from these sacs?

A. Mr. Irons was directed to obtain the samples from certain sacs which I specified to him before leaving the laboratory. He was instructed to obtain the samples according to the most rigorous bacteriological methods and to use all aseptic precautions. Before collecting the samples Mr. Irons was told to agitate the contents of the sacs freely for some time so as to permit thorough mixing of the contents. The sacs were then tilted so that the fluid in them contained passed up in the glass tube and could be easily withdrawn by a sterilized pipette.

Mr. Irons was further told to observe very closely the condition of each sac at the time of collection and to notify me as to its precise condition. I may state here that during the course of the investigation it was found that after about fourteen days some of the sacs would break down owing to maceration and disintegration in the sewage. After the samples were
9914 collected under suitable bacteriological conditions, a procedure in which Mr. Iron's large experience in work of this sort was of great benefit, the samples of water were brought at once by him personally to the University Laboratory.

Q. After these samples were brought to the University Laboratory what was done with them?

A. Accurately measured quantities of the sewage into which typhoid bacilli had been introduced were mingled with special nutrient media of various kinds, and the mixture poured out into sterilized glass dishes. The amount of sewage used was such that a suitable separation of the colonies developing on these plates was arrived at. On the following day these colonies were examined by me and my assistants and any colonies that resembled typhoid colonies were taken from the plates and subjected to a searching examination.

Q. What methods were employed in the identification of the colonies?

A. We considered this from the outset as a most important part of the work. Until recently a considerable obstacle in the way of the isolation of typhoid bacilli in the presence of other organisms has been the difficulty of separating them
9915 readily from allied sewage bacteria. In planning the experiment the whole field of possible methods was canvassed and after many preliminary experiments certain media were found most suitable for the differentiation and identification of the typhoid bacilli.

I will describe simply those media that after many experiments we found to be most useful and to give highly satisfactory results.

9916 "Methods employed in making up the following media:

I. *Medium of Drigalski and Conradi.*

To two litres of sugar free broth were added

Peptone (Witte)	10 grams.
Nutrose	10 "
Sodium Chloride	10 "

and dissolved by the aid of heat. The mixture brought to the boil and sixty grams of agar-agar were added, and the mixture kept boiling until the agar was dissolved. Then the reaction of the mass was made weakly alkiline to litmus by the addition of sodium hydrate (4% sol).

This being done, a mixture of litmus solution (6%) and lactose (c.p.)

Litmus sol	260 cc.
Lactose	30 grams.

were added while both solutions were hot, and the whole boiled gently for five minutes. Then was added a solution of water-free sodium carbonate (10%) in the proportion of 4 cc followed by 20 cc of fresh solution of crystal violet (Grubler's)—o.1 gram in 100 cc water—and the whole mass filtered through cotton, tubed, and sterilized in the Arnold sterilizer for 20
9917 minutes on three successive days.

Ref.: Zeit. f. Hyg., 1902, Heft ii, p. 283.

II. *Medium of Drigalski and Conradi (modified).*

Modification was brought about by leaving out such constituents as nutrose, sodium chloride and solution of water-free sodium carbonate, and by filtering the mixture before adding the litmus lactose solution, a much clearer medium was obtained which scarcely contained any flocculent precipitate after being sterilized in the Arnold sterilizer thrice.

III. *Medium of McConkey, as modified by Grunbaum.*

Twenty grams each of agar-agar and peptone were dissolved in one litre of boiling water, and the whole made alkaline by adding 4 cc of a normal solution of sodium hydrate after having first brought the reaction to the neutral point of litmus.

Then was added while hot

Sodium taurocholate	5 grams
Lactose	10 "
Neutral Red (5% watery solution)	10 cc

9918 When the solution was complete the mass was filtered through cotton, tubed, and sterilized in the Arnold sterilizer once for twenty-five or thirty minutes.

Ref.: Brit. Med. Jour., 1902, Pt. 1, p. 1473

IV. *MacConkey's medium (Second modification)*

The medium having very little restraining power, crystal violet solution (1 gram to 100 cc water) was added in the proportion of 83 cc per litre of medium, and the technique was altered in the following ways:—After the agar and peptone were dissolved, the medium was made 1.8 acid in reaction to phenolphthalein by adding sodium hydrate solution, and the mass was antoclaved for five minutes at 120°C., cooled, cleared with white of egg, and filtered through cotton. This prevented a flocculent precipitate which formerly caused trouble in the original method.

Finally, the other ingredients were added, and also crystal violet solution as mentioned above, and the medium was tubed and sterilized once in the Arnold sterilizer for thirty minutes.

9919

V. *The plating medium of Hiss.*

Agar	15	gms.
Gelatine	15	"
Ext. of meat (Liebig)	5	"
Sodium chloride	5	"
Dextrose	10	"
Water (distilled)	1000	cc

The water being brought to the boiling point, the remaining ingredients were dissolved, reaction left unadjusted, and, after reducing the temperature to 60° C., the mass was cleared with white of egg, filtered, tubed, and sterilized for thirty minutes in the Arnold sterilizer on three successive days.

Ref.: Jour. Med. Research, 1902, v. VIII, No. 1, p. 148 (n. s. v. III, No. 1)

VI. Elsner's Medium.

Five hundred grams of potato, cut small, were put in a flask with 1000 cc. of water, and heated in an Arnold sterilizer for one hour and a half. Then the water was drained off and preserved, the potato mashed and strained, and finally 9920 cast out.

The water and strainings were mixed and brought up to 1000 cc by addition of water. To this fifteen grams of gelatine were added and the mixture boiled for ten minutes gently.

The reaction was made 2.4 acid to phenolphthalein. The mass was cooled at 60° C, cleared with white of egg, and filtered; then potassium iodide was added in the proportion of one per cent. and the medium was tubed and sterilized in the Arnold sterilizer for thirty minutes for three successive days.

Ref.: Zeit of Hyg. 1895, XXI.

HORROCKS GLUCOSE LITMUS AGAR.

Agar-agar	15	grams.
Peptone	10	"
Glucose	20	"
Water (distilled)	1000	cc.

Ingredients combined in the usual manner. Then sufficient aqueous solution of litmus added to give the medium a light blue color. For use the medium is melted, cooled at 42°
9921 C. and then deci-normal sodium hydrate added, so that each 10cc of the medium has an alkalinity equal to 1.8 cc decinormal alkali.

Ref.: An Introduction to the Bacteriological Examination of Water, by W. H. Horrocks, Lond., 1901.

9922 These methods, after careful experimentation and testing with the cultures employed gave satisfactory results and permitted identification of typhoid colonies with readiness.

I have some of the plates prepared by these methods from the infected sacs. I have in my hand a plate prepared in MacConkey's medium, as just described, showing the results obtained by plating sewage, into which typhoid bacillus from one of the X. Y. Z. cultures used in these experiments had been introduced. These plates have all been sterilized with formalin and are sealed with parafine.

The thin light blue colonies in this medium shown by holding the plate up to the light are colonies of typhoid bacilli, the small red colonies being colon bacilli. This medium greatly facilitates the differentiation of the typhoid bacillus, and also suppresses many sewage bacteria not belonging to the colon typhoid group, thus diminishing very greatly the total number of colonies appearing on the plate and rendering the separation of the typhoid colonies a much more simple process. When the plate is freshly prepared the color differentiation is even
9923 sharper than shown in this preserved specimen.

Mr. Todd: I offer this plate in evidence and ask to have it marked as Professor Jordan's Exhibit A.

Which said plate is marked by the Commissioner "Jordan's Exhibit A, Frank S. Bright, Commissioner."

9924 Professor Jordan: I have here also a plate prepared in a similar way, showing the mixture of typhoid bacilli from one of the X. Y. Z. cultures with sewage, this plate being made from the Drigalski Conradi medium, the blue colonies on this plate representing typhoid bacilli.

Mr. Todd: I offer this plate in evidence and ask to have it marked Jordan's Exhibit B.

Which said plate is marked by the Commissioner "Jordan's Exhibit B, Frank S. Bright, Commissioner."

9925 A. I have here a plate showing the same mixing of typhoid bacilli with sewage, this time plated in Hiss's medium. The very thin, delicate watery colonies on the surface of this medium represent typhoid colonies. I have encircled one of these with ink. The hardening of this medium for the purpose of preservation destroys something of the sharpness of differentiation.

Mr. Todd: I offer that plate in evidence and ask to have it marked Jordan's Exhibit C.

Which said plate is here marked by the Commissioner "Jordan's Exhibit C, Frank S. Bright, Commissioner."

9926 A. In the use of these media it was found that after a few days experience it was a relatively simple matter to pick off typhoid colonies from these plates. Mixtures of typhoid bacilli with sewage in the laboratory, showed, as has been stated, a great suppression of the ordinary sewage forms, and a rather sharp distinction between the typhoid bacillus and its near ally the colon bacillus which is always present in sewage in large numbers.

In such mixtures of typhoid bacilli with fresh raw sewage the great majority of colonies that were picked off as resembling typhoid colonies on these plates proved, on thorough examination, to be genuine typhoid bacilli, responding in all their characteristics to the strain of typhoid bacillus originally introduced. In most cases over 90 per cent. of the sewage bacteria were suppressed in these media and from those remaining typhoid colonies could be easily distinguished.

Q. Which one of these methods proved to be most satisfactory?

A. Four of these methods, namely the Drigalski and Conradi, the Horrocks, the Hiss and the MacConkey gave results which were in close harmony.

Towards the latter part of the work we became more expert in identifying the colonies appearing on Hiss medium 9927 than on the others, and some other advantages in the use of this medium also presented themselves, but throughout the investigation the four media were used side by side in practically all cases. Elsner's medium to which we gave a careful examination, did not prove so satisfactory as the others, and was not much used.

Q. Will you describe your method of identification of the typhoid bacillus in this experiment?

A. Typhoid-like colonies appearing on these several media were picked off from each plate. In all cases where it was practicable all of the typhoid like colonies on a plate were transferred to tubes and subjected to further examination, and on several occasions all the surface colonies of every kind appearing on the plate were picked off and transferred to tubes for study. These suspicious colonies were first inoculated into tubes of nutrient agar to which one per cent of sugar (dextrose) had been added.

All those in which gas productions occurred were discarded,
since the typhoid bacillus does not produce gas in this
9928 medium. From those tubes showing no gas production
a second transfer was made to tubes of sterilized milk to
which litmus had been added. The growth of the typhoid bacillus in such litmus milk is highly characteristic, and those tubes that did not show the initial slight acidity in litmus milk produced by the typhoid bacillus were discarded as being not true typhoid organisms.

All organisms passing these tests were then studied as to growth in dextrose broth, in gelatin and in respect to their various morphological characteristics.

Finally those organisms that ran the gauntlet of all these tests were subjected to the Widal test, and a positive reaction in this test established the final identification of the typhoid bacillus.

Q. Will you describe the method employed by you in tabulating the results of this experiment?

A. Particular attention has been paid to recording all the data obtainable in the case of these experiments. The number of ordinary sewage bacteria in the waters of the drainage canal at the respective stations has been determined by the usual colony count method. The number of colon bacilli present in such
waters has been determined and also the number of
9929 streptococcus forms present in these waters. On each oc-
casion a record has been kept of the number of typhoid
bacilli introduced into each sac together with the amount of

sewage contained in the sac so that information was had regarding the number of bacilli in each cubic centimeter of water in the inoculated sac.

The date on which the sample was collected is recorded; each sac was given a number that it retained throughout the experiment. The amount of sewage plated in each case is recorded in the tables. The medium from which the plates were made is recorded in each case and after the first few days the total number of colonies appearing on each plate is recorded. The total number of colonies picked off each plate, and whether these colonies were suspicious typhoid colonies or not, were all questions concerning which we have exact data.

The colony picked off from a plate for further study was given a serial number which allowed its complete identification at any time. Any culture that turned out to be from a genuine typhoid colony could be traced by this method to the exact plate and dilution from which it was obtained.

Thus, to take one instance, at random from the tables
9930 one cubic centimeter of sewage to which typhoid bacilli
had been added, was collected on seven days after the inoculation had been made. This was in Drigalski medium and 120 colonies in all developed on this medium. 25 colonies of these were picked off for further study, none of which proved to be typhoid.

Throughout the conduct of each experiment a record was kept of the temperature of the air and of the temperature of the water in the drainage canal at the point where the float was anchored.

Q. How were the results preserved, the results of this experiment preserved?

A. Typewritten record sheets were prepared, upon which the history of every sample taken, of every plate made, and of every colony studied, was accurately preserved. So that in every case we are able to establish precisely the grounds upon which the colony was discarded or upon which it was determined to be a genuine typhoid bacillus.

Q. Have you prepared tables showing the results obtained from this experiment?

A. I have.

Q. In what manner are those tables prepared?

A. They are typewritten copies, numbered and properly labeled, according to the point at which the experiment was carried out, and the number of the sac used in the experiment. 9931

Q. How many tables have you prepared for the experiment performed at Lockport?

A. I have six such tables.

Q. Will you produce and read table I?

A. Yes sir. It is as follows:

9932

TABLE I*

Drainage Canal at Lockport.

Initial colony count sewage bacteria	……	110000
" colon bacilli	……………………	4000—6000
" streptococci	……… …………	1000

B. typhosus, strain (x), was added to this sewage in such numbers that each sac contained approximately 12000 typhoid bacilli per cc.

Time after inoculation	Sac No.	Amount plated in cc.	Medium	Colonies on plate	Colonies fished		Typhoid colonies found.
1 day	B^1		Drigalski		40)		0
"	"		Horrocks		60)	60	0
2 days	B^2		Drigalski		40)		0
"	"		Horrocks		30)	70	0
3 days	"	1.0	Drigalski		4)		0
"	"	0.1	Drigalski		3)		
"	"	1.0	Horrocks		2)	19	0
"	"	0.1	Horrocks		3)		
"	"	1.0	MacConkey		7)		
5 days	"	1.0	Drigalski	86	8)		
"	"	1.0	Horrocks	50	8)	24	0
"	"	1.0	MacConkey	166	8)		
7 days	"	1.0	Drigalski	120	25)		
"	"	1.0	Horrocks	170	20)	45	0
9 days	"	1.0	Neutral agar		20)		0
"	"	1.0	Drigalski		12)	49	0
"	"	1.0	MacConkey		10)		
"	"	1.0	Horrocks		7)		

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*During the conduct of this experiment, Oct. 5-14 the temperature of the air ranged from 14° C to 19° C and of the water from 14.5° C to 17° C.

9933 Q. Will you explain table I?

A. Table I is the record of an experiment carried out in the drainage canal at Lockport, by the methods hereinbefore indicated, between October 5th and 14th, 1903. The temperature of the air during this period ranged from 14 degrees Centigrade to 19 degrees Centigrade that of the water from 14.5 C. to 17 degrees C. The sewage bacteria in the water of the canal at the time of inoculation was 110,000 per cc. The number of colon bacilli was 4,000 to 6,000 per cc. and the number of streptococcus 1,000 per cc. Bacillus typhosus, strain x, was added to this sewage in such numbers that each sac contained approximately 12,000 bacilli per cc. On the first day 60 colonies were taken from the plates. None of these proved to be typhoid colonies. On the second day 70 colonies were taken from the plates, none of which proved to be typhoid colonies. At three days 19 colonies were taken from the plates, none of which proved to be typhoid colonies. At five days 24 colonies were taken from the plates, none of which proved to be typhoid colonies. At seven days 45 colonies were taken from the
9934 plates, none of which proved to be typhoid colonies. At
nine days 45 colonies were taken from the plates, none of which proved to be typhoid colonies.

Two different sacs, B_1 and B_2 were used in this experiment.

9935 Q. Will you produce and read table II

A. It is as follows:

9936

TABLE II.*

Drainage Canal at Lockport.

Initial colony count	sewage bacteria	110,000
"	colon bacilli	4,000—6000
"	streptococci	1,000

B. typhosus, strain (x), was added to this sewage in such numbers that each sac contained approximately 600 typhoid bacilli per cc.

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*During the conduct of this experiment, Oct. 5-14, the temperature of the air ranged from 14° C to 19° C and of the water from 14.5° C to 17° C.

Time after inoculation	Sac No.	Amount plated in cc.	Medium	Colonies on plate	Colonies fished		Typhoid colonies found.
1 day	C_1		Drigalski		16)		
"	"		Horrocks		4)	20	0
2 days	C_2		Drigalski		20)		
"	"		Horrocks		10)	30	0
3 days	"	1.0	Drigalski	230	30)		
"	"	1.0	Horrocks	130	10)	50	
"	"	1.0	MacConkey	270	10)		
5 days	"	1.0	Drigalski		8)		
"	"	1.0	Horrocks		8)	24	0
"	"	1.0	MacConkey		8)		
7 days	"	1.0	Drigalski		8)		
"	"	1.0	Horrocks		4)	12	0
9 days	"	1.0	Drigalski		5)		
"	"	1.0	Horrocks		4)	10	0
"	"	1.0	MacConkey		1)		

9937 Q. Will you state what table II shows

A. Table II contains a record of experiments carried on in the drainage canal at Lockport on the same days and under the same conditions as the experiment described in table 1, namely, between October 5th and October 14, 1903. The initial number of sewage bacteria, the colon bacilli, and the streptococci were, of course, the same as that described in the preceding table.

A smaller number of typhoid bacilli, strain X, was added to this sewage in each sac. Each sac in this experiment contained approximately 600 typhoid bacilli to 1 cc.

Twenty colonies were taken from plates after one day.

30 after 2 days,
50 after 3 days,
24 after 5 days,
12 after 7 days,
10 after 9 days.

None of these proved to be typhoid bacilli.

Q. Will you produce and read table III?

A. It is as follows:

9938

TABLE III.*

Drainage Canal at Lockport.

Initial colony count sewage bacteria.. 110,000
" colon bacilli 4000-6000
" streptococci 1000

B. typhosus, strain (y), was added to this sewage in such numbers that each sac contained approximately 180 typhoid bacilli per cc. The bacilli were added in 5 cc of urine from a typhoid patient.

Time after inoculation	Sac No.	Amount plated in cc.	Medium	Colonies on plate	Colonies fished	Typhoid colonies found.
1 day	D_1	1.0	Drigalski	10)		
"	"	1.0	Horrocks	3)	13	0
3 days	"	1.0	Drigalski	5)		
"	"	1.0	Horrocks	8)	20	0
"	"	1.0	MacConkey	7)		
5 days	"	1.0	Drigalski	6)		
"	"	1.0	MacConkey	6)	12	0
7 days	"	1.0	Drigalski	8)		
"	"	1.0	Horrocks	6)	20	0
"	"	1.0	MacConkey	6)		

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*During the conduct of this experiment, Oct. 5-14, the temperature of the air ranged from 14° C to 19° C and of the water from 14.5° C to 17° C.

9939 Q. Will you state what table 3 shows?

A. Table III contains a record of an experiment carried out in the drainage canal at Lockport between the same days as those reported in tables I and II, the character of the sewage being the same. In this experiment another strain of the typhoid bacillus, that previously designated as strain Y, was added to the sewage in such numbers that each sac contained approximately 180 typhoid bacilli per cc.

The bacilli were added in this case in 5 cc. of urine obtained from a typhoid fever patient.

13 colonies were picked off after 1 day,
20 colonies were picked off after 3 days,
12 colonies were picked off after 5 days,

20 colonies were picked off after 7 days.

And no typhoid colonies were found among this number.

Q. Will you produce and read table IV?

A. Table IV is as follows:

9940

TABLE IV*

Drainage Canal at Lockport.

Initial colony count sewage bacteria....	
" colon bacilli	1000
" streptococci	2000

B. typhosus, strain (z), was added to this sewage in such numbers that each sac contained approximately 30000 typhoid bacilli per cc.

Time after inoculation	Sac No.	Amount plated in cc.	Medium	Colonies on plate	Colonies fished	Typhoid colonies found.
3 days	L_1	1.0	Drigalski		8)	
"	"	0.01	Hiss		8) 20	0
"	"	1.0	Horrocks		4)	
"	L_2	1.0	Drigalski		8)	
"	"	1.0	Hiss		5) 20	0
"	"	1.01	Hiss		2)	
"	"	1.0	Horrocks		5)	
5 days	"	0.1	Hiss	510	7)	
"	"	1.0	Horrocks		5) 12	0
"	L_3	1.0	Hiss	3180	8)	
"	"	1.0	Drigalski	180	4) 12	0
6 days	L_1	1.0	Drigalski	1860	10)	
"	"	1.0	MacConkey	1320	7) 17	0
8 days	"	1.0	Drigalski		8)	
"	"	1.0	MacConkey		6) 24	0
"	"	1.0	Hiss		10)	
10 days	"	1.0	MacConkey		12)	
"	"	1.0	Hiss		14) 26	0

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*During the conduct of this experiment, Oct. 14-27, the temperature of the air ranged from 10°C to 17.5°C, and of the water from 10°C to 14.5°C.

9941 Q. Will you state what table IV shows?

A. Table IV contains the record of an experiment carried out in the drainage canal at Lockport. The initial number of sewage bacteria was in this case not obtained. The initial number of colon bacilli was 1,000 per cc. and the initial number of streptococcus 2,000 per cc.

During the conduct of this experiment between October the 14th and the 27th the temperature of the air ranged from 10 degrees to 17.5 degrees C. and that of the water from 10 degrees C. to 14.5 degrees C.

The bacillus typhosus, the strain previously designated as strain Z, was added to this sewage in such numbers that each sac contained approximately 30,000 typhoid bacilli per cc. After three days 40 colonies were picked off, none of which proved to be typhoid colonies.

After 5 days 24 colonies were picked off, none of which proved to be typhoid colonies.

After 6 days 17 colonies were picked off, none of which proved to be typhoid colonies.

After 8 days 24 colonies were picked off, none of which proved to be typhoid colonies.

After 10 days 26 colonies were picked off, none of which
9942 proved to be typhoid colonies.

Q. Will you produce and read table V?

A. It is as follows:

9943

TABLE V.[*]

Drainage Canal at Lockport.

Initial colony count sewage bacteria....
" colon bacilli 1000
" streptococci 2000

B. typhosus, strain (z), was added to this sewage in such numbers that each sac contained approximately 1500 typhoid bacilli per cc.

Time after inoculation	Sac No.	Amount plated in cc.	Medium	Colonies on plate	Colonies fished	Typhoid colonies found.
3 days	M_1	0.01	Hiss		5)	
"	"	1.0	Drigalski		5) 10	0
5 days	M_2	0.1	Drigalski	130	2)	
"	"	0.1	Hiss	790	6) 8	0

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[*] During the conduct of this experiment, Oct. 14-27, the temperature of the air ranged from 10°C to 17.5°C, and of the water from 10°C to 14.5°C.

9944 Q. Will you state what table V shows?

A. Table V contains the record of a similar experiment carried out between the same dates as in the preceding case, namely, between October 14th and 27th, 1903, in the same body of water, differing from the experiment reported in table IV, only in the fact that each sac contained approximately 5500 typhoid bacilli per cc. instead of 30,000; 10 colonies were examined after 3 days, 8 after 5 days, none of which proved to be typhoid colonies.

These early experiments gave negative results throughout largely because of the number of typhoid bacilli added in these cases; but especially because in these early experiments the time allowed to elapse after inoculation before a very large number of colonies were examined was in most cases too great, as is shown by the later experiments in which a shorter interval was allowed to elapse between inoculation and examination of the material in these sacs. The experiment, for example, recorded in table IV where no examinations were made of the water of the sac until after 3 days had elapsed is a case in point.

The outcome of these early experiments convinced us that if typhoid bacilli were to be found at all in the waters of 9945 the drainage canal under these conditions it must be by examinations made within a short time after the infection of sacs had been effected.

Q. Will you produce and read table number VI?

A. It is as follows:

9946

TABLE VI.*

Drainage Canal at Lockport.

Initial colony count sewage bacteria......	
" colon bacilli	1000
" streptococci	2000

B. typhosus, strain (y), was added to this sewage in such numbers that each sac contained approximately 360,000 typhoid bacilli per cc.

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*During the conduct of this experiment, Oct. 17-27, the temperature of the air ranged from 10°C to 17.5°C, and of the water from 10°C to 14.5°C.

Time after inoculation	Sac No.	Amount plated in cc.	Medium	Colonies on plate	Colonies fished	Typhoid colonies found.
10 min.	O_1	0.0001	Drigalski	45	14)	13)
“	“	0.001	Horrocks	160	18)	17) 63
“	“	0.001	Hiss	230	36)	33)
2 days	“	0.1	Drigalski	410	15)	
“	“	0.1	Hiss	5700	25) 65	0
“	“	0.01	“		25)	
3 days	“	1.0	Drigalski	268	10)	
“	“	0.1	“		10)	
“	“	1.0	MacConkey	270	10) 63	0
“	“	0.1	“		10)	
“	“	0.1	Horrocks	250	13)	
“	“	0.1	Neutral agar	5840	10)	
5 days	O_2	0.1	Drigalski		3)	
“	“	1.0	“		14)	
“	“	1.0	MacConkey		21) 46	0
“	“	0.1	Hiss		2)	
“	“	0.1	Neutral agar		6)	
7 days	O_1	1.0	MacConkey	126	8)	
“	“	1.0	Hiss	390	11) 19	0
“	“	1.0	MacConkey	32	5)	
“	“	0.1	Hiss	370	18) 23	0
10 days	“	1.0	Hiss	85	85)	0

9947 Q. Will you state what table number VI shows?

A. Table number VI contains the record of an experiment carried out in the drainage canal at Lockport between October 17 and 27, 1903. The temperature of the air during this period was from 10 degrees C. to 17.5 degrees C. and that of the water from 10 degrees C. to 14.5 degrees C.

Initial colony count of the sewage bacteria was in this case not obtained.

The initial number of colon bacilli was 1,000 per cc.

The initial number of streptococcus was 2,000 per cc.

The bacillus typhosus, the strain previously designated as strain Y was added to this sewage in such numbers that each sac contained approximately 360,000 typhoid bacilli per cc.

In this case a particular test was made of the validity of the methods employed in isolation and identification.

10 minutes after the typhoid bacilli had been introduced varying amounts of the mixture of the sewage and typhoid bacilli were plated in three different media. In one of these cases .001 of a cc. was plated and there were 45 colonies
9948 in all on the plate. 14 of these colonies were picked out as looking suspiciously like typhoid colonies and on applying appropriate tests, as already described, 13 of these proved to be genuine typhoid bacilli. From this same sample of water .001 of a cc. of water was plated and 160 colonies in all developed on the plate. 18 of these were picked off as looking like typhoid colonies and 17 of them proved to be genuine typhoid bacilli. Of this same sample .001 of a CC. was plated in Hiss' medium, 230 colonies developed on the plate, 36 of these were picked off as resembling typhoid colonies and 33 of these proved to be genuine typhoid colonies.

The fact that on these three different media 63 out of 68 colonies that appeared to be like typhoid colonies turned out to be genuine typhoid organisms, demonstrates the great aid that these special media were in differentiating the typhoid bacillus in the presence of a multitude of sewage forms.

Continuing the record of this same experiment, after 3 days 65 colonies were taken off from 6 plates, a smaller quantity of water being used, instead of .001 of a cc. .01 of a cc. in one case and instead of .001 of a cc. .1 of a cc. Out of 65 colonies examined none proved to be typhoid.

9949 After three days out of 63 colonies examined, 2 out of 6 plates being from 1 cc. of the sewage, none proved to be typhoid.

After 5 days out of 46 colonies examined none proved to be typhoid.

After 7 days out of 42 colonies examined none proved to be typhoid.

After 10 days out of 85 colonies examined, none proved to be typhoid.

I consider this as one of the most remarkable of all experiments that were made. On the 10th day after inoculation 1 cc. of the contents of the sac was plated in Hiss medium and 85 colonies in all developed on this medium, which is not only very favorable to the growth of the typhoid bacillus but to all other sewage forms, its inhibitive effect being less than that of other media. Eighty-five colonies in all developed in 1 cc. of this sewage, and the whole number of 85 colonies was picked off the plate and examined and not one of these proved to be typhoid although 10 days previously when the sac was inoculated, each cc. in the sac contained 360,000 typhoid bacilli.

9950 This experiment plainly shows an enormous mortality among typhoid bacilli under these natural conditions in the water of the drainage canal. Examination of one whole cc. of the water after 10 days shows that of the 360,000 that it originally contained not one was left alive.

ADJOURNED UNTIL 2 P. M. SAME DAY.

9951 MET PURSUANT TO ADJOURNMENT AT 2 P. M., FEBRUARY 4, 1904.

Present the Commissioner and same counsel.

PROF. EDWIN O. JORDAN

resumed the stand for further direct examination by Mr. Todd.

Q. Do these six tables complete the work so far as typhoid determinations are concerned at Lockport during this experiment?

A. Yes sir, these six tables contain records of the inoculated sacs.

Q. Have you any tables from the Robey Street part of the experiment?

A. Yes sir, tables VII to XV, inclusive, deal with the experiments conducted in the drainage canal at Robey Street.

Q. Will you produce and read table VII?

A. It is as follows:

9952 TABLE VII*

Drainage Canal at Robey Street.

Initial colony count sewage bacteria....390000
" colon bacilli 4000–6000
" streptococci 2000

B. typhosus, strain (x), was added to this sewage in such numbers that each sac contained approximately 11500 typhoid bacilli per cc.

Time after inoculation	Sac No.	Amount plated in cc.	Medium	Colonies on plate	Colonies fished	Typhoid colonies found.
4 days	F₁	1.0	Drigalski		10)	
"	"	1.0	Horrocks		7) 25	0
"	"	1.0	MacConkey		8)	
6 days	"	1.0	Drigalski		10)	
"	"	1.0	MacConkey		5) 20	0
"	"	1.0	Hiss		5)	
7 days	F₂	1.0	MacConkey		2)	
"	"	1.0	Hiss		8) 15	0
"	"	1.0	Neutral agar		5)	
11 days	"	1.0	Drigalski	112	7)	
"	"	1.0	MacConkey	54	4) 19	0
"	"	1.0	Hiss	5590	8)	
12 days	F₃	1.0	Drigalski		9)	
"	"	1.0	Hiss		20) 41	0
"	"	1.0	Horrocks		12)	
14 days	F₂	1.0	Drigalski	510	6)	
"	"	1.0	MacConkey	560	8) 27	0
"	"	1.0	Hiss	940	13)	

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*During the conduct of this experiment, Oct. 9.-23, the temperature of the air ranged from 13°C to 18°C, and of the water from 12.5°C to 14°C.

9953 Q. Will you explain table VII?

A. Table VII contains the record of an experiment carried out in the drainage canal at Robey Street between October 9th and 23rd, 1903. During this period the temperature of the air ranged from 13 degrees C. to 18 degrees C. and that of the water from 12.5 C. to 14 degrees C. The number of bacteria present in the drainage canal at the time of inoculation was

390,000 per cc. The number of colon bacteria from 4,000 to 6,000; the number of strepticocci 2,000. Bacillus typhosus, the strain previously designated as X, was added to this sewage in such numbers that the sac contained approximately 11,500 typhoid bacilli per cc.

This was one of the early experiments and the first examination of the water was made four days after inoculation at which time 25 colonies were picked off. None of these proved to be typhoid. After 6 days 20 colonies were picked off, none of which were typhoid. After 7 days 15 colonies were taken off, none of which were typhoid. After 11 days 19 colonies were picked off, none of which were typhoid. After 12 days 41 colonies were picked off, none of which were typhoid. After 14 days 27 colonies were picked off, none of which were
9954 typhoid.

Q. Will you produce and read table VIII?

A. It is as follows:

9955 TABLE VIII*

Drainage Canal at Robey St.

Initial colony count sewage bacteria.....390000
" colon bacilli 4000–6000
" streptococci 2000

B. typhosus, strain (X), was added to this sewage in such numbers that each sac contained approximately 670 typhoid bacilli per cc.

Time after inoculation	Sac No.	Amount plated in cc.	Medium	Colonies on plate	Colonies fished	Typhoid colonies found.
2 days	G_1	1.0	Drigalski		5)	
"	"	0.1	Drigalski		10)	
"	"	1.0	MacConkey		5) 35	0
"	"	0.1	MacConkey		13)	
"	"	0.1	Hiss		2)	
4 days	"	1.0	Drigalski		6)	
"	"	1.0	Horrocks		3) 15	0
"	"	1.0	MacConkey		6)	
7 days	G_2	1.0	MacConkey		10)	
"	"	1.0	Hiss		8) 23	0
"	"	1.0	Neutral agar		5)	

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*During the conduct of this experiment, Oct. 9.-23, the temperature of the air ranged from 13°C to 18°C, and of the water from 12.5°C to 14°C.

9956 Q. Will you explain table VIII?

A. Table VIII contains a record of an experiment carried out in the drainage canal at Robey Street between October 9 and 23, 1903. During this period the temperature of the air ranged from 13 to 18 degrees C. and that of the water from 12.5 to 14 degrees C. The number of sewage bacteria colon bacilli and streptococcus was the same as that indicated in table VII. Bacillus typhosus, a strain previously described as X, was added to the sewage in such numbers that the sac contained approximately 670 typhoid bacilli per cc. 2 days after inoculation 35 colonies were picked off, none of which proved to be typhoid. After 4 days 15 colonies were picked off, none of which proved to be typhoid.

After 7 days 23 colonies were picked off none of which proved to be typhoid.

Q. Will you produce and read table IX?

A. It is as follows:

9957

TABLE IX*

Drainage Canal at Robey St.

Initial colony count sewage bacteria.....390000
" colon bacilli .... 4000—6000
" streptococci 2000

B. typhosus, strain (3), was added to this sewage in such numbers that each sac contained approximately 18000 typhoid bacilli per cc.

Time after inoculation	Sac No.	Amount plated in cc.	Medium	Colonies on plate	Colonies fished	Typhoid colonies found.
4 days	H_1	1.0	Drigalski		20)	
"	"	1.0	Horrocks		15) 50	0
"	"	1.0	MacConkey		15)	
6 days	"	1.0	Drigalski		8)	
"	"	1.0	MacConkey		5) 19	0
"	"	1.0	Hiss		6)	

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*During the conduct of this experiment, Oct. 9.-23, the temperature of the air ranged from 13°C to 18°C, and of the water from 12.5°C to 14°C.

7 days	"	1.0	MacConkey		9)		
"	"	1.0	Hiss		8)	22	0
"	"	1.0	Neutral agar		5)		
11 days	H_2	1.0	Drigalski		4)		
"	"	1.0	MacConkey	310	5)	14	0
"	"	1.0	Hiss		5)		
12 days	H_2	1.0	Drigalski		13)		
"	"	1.0	Hiss		10)	34	0
"	"	1.0	Horrocks		11)		
14 days	H_2	1.0	Drigalski	102	8)		
"	"	1.0	MacConkey	136	4)	23	0
"	"	1.0	Hiss	1890	11)		

9958 Q. Will you explain table IX?

A. Table IX contains the record of an experiment conducted in the water of the drainage canal at Robey Street, between October 9 and 23, 1903, the temperature of the air and water and the number of sewage bacteria per cc. and the number of colon bacilli and streptococcus being the same as indicated in tables VII and VIII. Bacillus typhosus, the strain previously designated as Z, was added to this sewage in such numbers that each sac contained approximately 18,000 typhoid bacilli per cc.

4 days after inoculation 50 colonies were picked off, none of which proved to be typhoid.

6 days after inoculation 19 colonies were picked off, none of which proved to be typhoid.

7 days after inoculation 22 colonies were picked off, none of which proved to be typhoid.

11 days after 14 colonies were picked off, none of which proved to be typhoid.

12 days after, 34 colonies were picked off, none of which proved to be typhoid.

14 days after, 23 colonies were picked off, none of which proved to be typhoid.

In all, 18 plates were examined for typhoid bacilli 1 cc.
9959 of water being used in making each plate.

Q. Will you produce and read table X?

A. It is as follows:

9960

TABLE X*

Drainage Canal at Robey St.

Initial colony count sewage bacteria.....	390000
" colon bacilli	4000—6000
" streptococci	2000

B. typhosus, strain (z), was added to this sewage in such numbers that each sac contained approximately 900 typhoid bacilli per cc.

Time after inoculation	Sac No.	Amount plated in cc.	Medium	Colonies on plate	Colonies fished	Typhoid colonies found.
2 days	I_1	1.0	Drigalski	5)	35	0
"	"	0.1	Drigalski	10)		
"	"	1.0	MacConkey	5)		
"	"	0.1	MacConkey	10)		
"	"	0.1	Hiss	5)		
4 days	"	1.0	Drigalski	6)	15	0
"	"	1.0	Horrocks	3)		
"	"	1.0	MacConkey	6)		
6 days	"	1.0	Drigalski	5)	17	0
"	"	1.0	MacConkey	2)		
"	"	1.0	Hiss	10)		

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*During the conduct of this experiment, Oct. 9.-23, the temperature of the air ranged from 13°C to 18°C, and of the water from 12.5°C to 14°C.

9961 Q. Will you explain table X?

A. Table X contains the record of an experiment conducted in the drainage canal at Robey Street between October 9 and 23, 1903, the temperature of the air and water and the initial number of sewage bacteria per cc. and the number of colon bacilli and streptococcus being the same as in the three tables just preceding. Bacillus typhosus, the strain previously described as Z, was added to this sewage in such number that each sac contained approximately 900 bacilli per cc.

2 days after inoculation 35 colonies were picked off, none of which proved to be typhoid.

4 days after inoculation 15 colonies were picked off, none of which proved to be typhoid.

6 days after, 17 colonies were picked off, none of which proved to be typhoid.

Q. Will you produce and read table number XI.

A. It is as follows:

9962

TABLE XI*

Drainage Canal at Robey St.

Initial colony count sewage bacteria....113000
" colon bacilli 1000
" streptococci 2000

B. typhosus, strain (y), was added to this sewage in such numbers that each sac contained approximately 25000 typhoid bacilli per cc. The bacilli were added in 50cc of urine from a typhoid patient.

Time after inoculation	Sac No.	Amount plated in cc.	Medium	Colonies on plate	Colonies fished	Typhoid colonies found.
2 days	R_1	0.1	Drigalski		11)	0
3 days	R_2	0.001	Drigalski		6)	
"	"	0.001	Horrocks		7) 19	0
"	"	0.001	Hiss		6)	
5 days	"	0.01	Drigalski		5)	
"	"	0.01	MacConkey		3) 12	0
"	"	0.01	Hiss		4)	

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*During the conduct of this experiment, Oct. 18-23, the temperature of the air ranged from 14°C to 19°C, and of the water from 14.5°C to 17°C.

9963 Q. Will you explain table XI.

A. Table XI contains the records of an experiment conducted in the water of the drainage canal at Robey street, between October 18 and October 23, 1903. During this period the temperature of the air ranged from 14 degrees C. to 19 degrees

C. and that of the water from 14.5 to 17 degrees C. The number of sewage bacteria per cc. at the outset of this experiment was 113,000. The number of colon bacilli 1,000. The number of streptococcus 2,000 per cc. Bacillus typhosus, the strain previously designated as strain Y, was added to this sewage in such numbers that each sac contained approximately 25,000 bacilli per cc. The bacilli were added in 50 cc. of urine from a typhoid patient.

2 days after inoculation 11 colonies were picked off, none of which proved to be typhoid.

3 days after 19 colonies were picked off, none of which proved to be typhoid.

5 days after inoculation 12 colonies were picked off, none of which proved to be typhoid.

Q. Will you produce and read table number XII?

A. It is as follows:

9964

TABLE XII.*

Drainage Canal at Robey St.

Initial colony count	sewage bacteria	113000
"	colon bacilli	1000
"	streptococci	2000

B. typhosus, strains (y), was added to this sewage in such numbers that each sac contained approximately 16,800 typhoid bacilli per cc. The bacilli were added in 50 cc of urine from a typhoid patient.

Time after inoculation	Sac No.	Amount plated in cc.	Medium	Colonies on plate	Colonies fished	Typhoid colonies found.
2 days	S_1	1.0	Drigalski		9)	
3 days	"	0.001	Drigalski		7)	
"	"	0.001	Horrocks		6) 17	0
"	"	0.0001	Neutral agar		4)	
5 days	"	0.01	Drigalski		5)	
"	"	0.01	Hiss		9) 14	0

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*During the conduct of this experiment, Oct. 18-23, the temperature of the air ranged from 14°C to 19°C, and of the water from 14.5°C to 17°C.

9965 Q. Explain table XII?

A. Table XII contains the record of an experiment conducted in the water of the drainage canal at Robey street, between October 18th and 23rd, 1903. The temperature of the air and water, the initial colony count of sewage bacteria, the number of colon bacilli and streptococcus being the same as indicated in table XI. B. typhosus, the strain previously described as Y, was added to this sewage in such numbers that each sac contained approximately 16,800 per cc. The bacilli were added in 50 cc. of urine from a typhoid patient.

2 days after inoculation 9 colonies were picked off, none of which proved to be typhoid.

3 days after inoculation 17 colonies were picked off, none of which proved to be typhoid.

5 days after inoculation 14 colonies were picked off, none of which proved to be typhoid.

Q. Will you produce and read table XIII?

A. It is as follows:

9966

TABLE XIII.*

Drainage Canal at Robey St.

Initial colony count sewage bacteria	.....	240000
" colon bacilli	....	1000
" streptococci	....	1000

B. typhosus, strain (z), was added to this sewage in such numbers that each sac contained approximately 285,000 typhoid bacilli per cc.

Time after inoculation	Sac No.	Amount plated in cc.	Medium	Colonies on plate	Colonies fished	Typhoid colonies found.
1 hour	P_1	0.001	Hiss	430	25)	20)
"	"	0.001	Drigalski	80	6)	4)
"	"	0.0001	"		3) 49	2) 41
"	"	0.001	MacConkey	210	15)	15)
20 hrs.	"	0.001	Hiss	440	37)	13)
"	"	0.001	Neutral agar	610	4)	1)
"	"	0.001	Drigalski	15	6) 54	2) 21
"	"	0.01	MacConkey	1780	7)	5)
28 hrs.	"	0.01	Hiss	1350	33)	24)
"	"	0.001	"		4)	1)
"	"	0.01	Drigalski	60	3) 61	0) 46
"	"	0.01	MacConkey	430	21)	21)
2 days	"	0.01	Hiss	173	59)	1)
"	"	0.01	MacConkey[1]		3) 69	0) 1
"	"	0.1	"	108	7)	0)
3 days	"	0.01	Hiss	182	25)	
"	"	0.1	"		6) 31	0
4 days	"	0.1	Hiss	3400	15)	
"	"	1.0	Drigalski[2]	45	6) 21	0
5 days	"	0.1	Hiss	105	10)	
"	"	1.0	Drigalski	32	6) 16	0
6 days	"	0.1	Hiss	1344	32) 32	0
7 days	"	0.1	Hiss	1130	28)	
"	"	1.0	Drigalski	160	8) 36	0
8 days	"	0.1	Hiss	440	31)	
"	"	1.0	MacConkey	120	4) 35	0

[1] All typhus ahnliche colonies fished on MacConkey.

[2] All typhus ahnliche colonies fished on Drigalski.

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*During the conduct of this experiment, Oct. 25-Nov. 4, the temperature of the air ranged from 6°C to 13°C, and of the water from 9.5°C to 12°C.

9967 Q. Explain table XIII.

A. Table XIII contains a record of an experiment carried out in the water of the drainage canal at Robey street, between October 25 and November 4, 1903. During the conduct of this experiment the temperature of the air ranged from 6 degrees C. to 13 degrees C., and that of the water from 9.5 degrees C. to 12 degrees C.

B. Typhosus, strain Z, was added to this sewage in such numbers that the sac contained approximately 285,000 typhoid bacilli per cc.

One hour after inoculation 49 colonies were picked off from 4 different plates, 41 of which proved to be typhoid.

20 hours after inoculation 54 colonies were picked off from 4 plates, 21 of which proved to be typhoid.

28 hours after inoculation 61 colonies were picked off from 4 plates, 46 of which proved to be typhoid.

2 days after inoculation 69 colonies were picked off from 3 plates, 1 of which proved to be typhoid.

3 days after inoculation —— colonies were picked off, none of which proved to be typhoid.

4 days after inoculation 21 colonies were picked off, none of which proved to be typhoid.

5 days after inoculation 16 colonies were picked off, none
9968 of which proved to be typhoid.

6 days after inoculation 32 colonies were picked off, none of which proved to be typhoid.

7 days after inoculation 36 colonies were picked off, none of which proved to be typhoid.

8 days after inoculation 35 colonies were picked off, none of which proved to be typhoid.

Q. Will you produce and read table XIIIa?

A. It is as follows:

9969

TABLE XIII A.*

Drainage Canal at Robey Street.

Initial colony count sewage bacteria.....240000
" colon bacilli 1000

B. typhosus, strain (z), was added to this sewage in such numbers that each sac contained approximately 285000 typhoid bacilli per cc.

Time after inoculation	Sac No.	Amount plated in cc.	Medium	Colonies on plate	Colonies fished	Typhoid colonies found.
3 days	P_2	0.01	Hiss	1130	14)	
"	"	0.1	Drigalski[1]	229	3) 19	0
"	"	0.01	MacConkey	35	2)	
4 days	"	0.1	Hiss	6120	13)	
"	"	1.0	MacConkey[2]		5) 18	0
5 days	"	0.1	Hiss	1890	23)	
"	"	1.0	MacConkey	97	10) 33	0
6 days	"	0.1	Hiss	1540	15)	
"	"	1.0	Drigalski	83	8) 23	0
7 days	"	0.1	Hiss	1296	11)	
"	"	0.1	Neutral agar	670	5) 18	0
"	"	1.0	Drigalski	44	2)	
8 days	"	0.1	Hiss	1890	18) 18	0
9 days	"	0.1	"	1960	8)	
"	"	0.1	Neutral agar	1460	13) 41	0
"	"	1.0	MacConkey	140	20)	
10 days	"	0.1	Hiss[3]	1820	24)	
"	"	1.0	MacConkey	86	13) 37	3

[1] All typhus ahnliche colonies fished on MacConkey and Drigalski.

[2] All typhus ahnliche colonies fished on MacConkey and Drigalski.

[3] All surface typhus ahnliche colonies fished on Hiss and MacConkey.

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*During the conduct of this experiment, Oct. 25-Nov. 4, the temperature of the ai ranged from 6°C to 13°C, and of the water from 9.5°C to 12°C.

9970 Q. Explain table XIII A?

A. Table XIII A contains a record of an experiment carried out in the water of the drainage canal at Robey street, under precisely the same conditions as those recorded in table XIII.

The sac numbered P^2 was inoculated at the same time and in precisely the same manner as P^1, recorded in table XIII.

3 days after inoculation 19 colonies were picked off, none of which proved to be typhoid.

4 days after 18 colonies were picked off, none of which proved to be typhoid.

5 days after 33 colonies were picked off, none of which proved to be typhoid.

6 days after inoculation, 23 colonies were picked off, none of which proved to be typhoid.

7 days after 18 colonies were picked off, none of which proved to be typhoid.

8 days after inoculation 18 colonies were picked off, none of which proved to be typhoid.

9 days after inoculation 41 colonies were picked off,
9971 none of which proved to be typhoid.

10 days after inoculation 37 colonies were picked off, 3 of which proved to be typhoid.

Q. Will you produce and read table XIV?

A. Table XIV is as follows:

9972 TABLE XIV.*

Drainage Canal at Robey St.

Initial colony count sewage bacteria.....240000
" colon bacilli 1000

B. typhosus, strain (y), was added to this sewage in such numbers that each sac contained approximately 857,000 typhoid bacilli per cc. The bacilli were added in 50 cc of urine from a typhoid patient.

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*During the conduct of this experiment, Oct. 25-Nov. 4, the temperature of the air ranged from 6°C to 13°C, and of the water from 9.5°C to 12°C.

Time after inoculation	Sac No.	Amount plated in cc.	Medium	Colonies on plate	Colonies fished	Typhoid colonies found
20 hrs.	N_1	0.001	Hiss	730	17)	5)
“	“	0.001	Neutral agar	1020	2)	0)
“	“	0.001	Drigalski	118	7) 50	0) 20
“	“	0.01	“		15)	6)
“	“	0.01	MacConkey	960	9)	9)
28 hrs.	“	0.01	Hiss	540	32)	23)
“	“	0.01	Drigalski	380	15) 57	10) 43
“	“	0.01	MacConkey	392	10)	10)
2 days	“	0.01	Hiss		23)	3)
“	“	0.1	Drigalski		14)	0)
“	“	0.01	MacConkey[1]		5) 52	4) 9
“	“	0.1	“		10)	2)
3 days	“	0.01	Hiss[2]	1072	36)	
“	“	0.1	Drigalski	4080	8) 56	0
“	“	0.01	MacConkey	520	12)	
4 days	“	0.01	Hiss[3]	2040	25)	
“	“	0.1	“		10) 35	0
5 days	“	0.1	Hiss	7200	16)	
“	“	1.0	Drigalski	230	7) 23	0
6 days	“	0.1	Neutral agar	1490	4)	
“	“	1.0	Drigalski	180	6) 10	0
7 days	“	0.1	Hiss	1890	25) 25	0
8 days	“	0.1	Hiss	1390	23) 23	0
9 days	“	0.1	Hiss	17400	13)	
“	“	1.0	MacConkey	214	19) 32	0

[1] All typhus ahnliche colonies fished on MacConkey (0.01).

[2] No surface typhus ahnliche colonies on Hiss (0.01) and Drigalski.

[3] All surface typhus ahnliche colonies fished on Hiss.

9973 Q. Explain table XIV?

A. Table XIV contains the record of an experiment conducted in the water of the drainage canal at Robey street, between October 25 and November 4, 1903.

During this period the temperature of the air ranged from 6 to 13 degrees C.; that of the water from 9.5 to 12 C. The number of sewage bacteria in the water at the time of inoculation was 240,000, the number of colon bacilli 1,000 per cc. Bacillus typhosus, the strain previously described as Y, was added to this sewage in such numbers that each sac contained approximately 857,000 typhoid bacilli per cc.

The bacilli were added in 50 cc. of urine from a typhoid patient.

20 hours after inoculation 50 colonies were picked off, 20 of which proved to be typhoid.

28 hours after inoculation 57 colonies were picked off, 45 of which proved to be typhoid.

2 days after inoculation 52 colonies were picked off, 9 of which proved to be typhoid.

3 days after inoculation 56 colonies were picked off, none
9974 of which proved to be typhoid.

4 days after inoculation 35 colonies were picked off, none of which proved to be typhoid.

5 days after inoculation 23 colonies were picked off, none of which proved to be typhoid.

6 days after inoculation 10 colonies were picked off, none of which proved to be typhoid.

7 days after inoculation 25 colonies were picked off, none of which proved to be typhoid.

8 days after inoculation 23 colonies were picked off, none of which proved to be typhoid.

9 days after inoculation 32 colonies were picked off, none of which proved to be typhoid.

Q. Will you produce and read table XV?

A. It is as follows:

9975

TABLE XV.*

Drainage Canal at Robey St.

Initial colony count sewage bacteria......240000
" colon bacilli 1000

B. typhosus, strain (y), was added to this sewage in such numbers that each sac contained approximately 857,000 typhoid bacilli per cc. The bacilli were added in 50 cc. of urine from a typhoid patient.

Time after inoculation	Sac No.	Amount plated in cc.	Medium	Colonies on plate	Colonies fished	Typhoid colonies found.
4 days	N_2	0.01	Hiss	336	6)	
"	"	0.1	Hiss		8) 14	0
5 days	"	0.1	Hiss	2360	15)	
"	"	1.0	Drigalski	280	7) 29	0
"	"	1.0	MacConkey	260	7)	
6 days	"	0.1	Hiss	2640	12) 12	0
9 days	"	0.1	Hiss	3400	8)	
"	"	1.0	MacConkey	592	21) 29	0
10 days	"	0.1	Hiss	3210	35)	
"	"	1.0	MacConkey	468	24) 59	0

9976 Q. Explain table XV?

A. Table XV contains a record of an experiment conducted in the water of the drainage canal at Robey street, between October 24th and November 4, 1903.

During this period the temperature of the air ranged from 6 degrees C. to 13 degrees C.; that of the water from 9.5 degrees C. to 12 degrees C., the initial number of sewage bacteria 247,000 per cc., the number of colon bacilli 1,000 per cc. Bacillus typhosus, the strain designated as Y, was added to this sewage in such numbers that each sac contained approximately 857,000 typhoid bacilli per cc. The bacilli were added in 50 cc. of urine from a typhoid patient.

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*During the conduct of this experiment, Oct. 24-Nov. 4, the temperature of the air ranged from 6°C to 13°C, and of the water from 9.5°C to 12°C.

4 days after inoculation 14 colonies were picked off, none of which proved to be typhoid.

5 days after inoculation 29 colonies were picked off, none of which proved to be typhoid.

6 days after inoculation 12 colonies were picked off, none of which proved to be typhoid.

9 days after inoculation 29 colonies were picked off, none of which proved to be typhoid.

10 days after inoculation 59 colonies were picked off,
9977 none of which proved to be typhoid.

Q. Did you use any control tubes?

A. Yes, sir, I did.

Q. What purpose did you have in using these control sacs?

A. My aim was to discover, if possible, what happened to the sewage bacteria left in such sacs. It is well known that sewage or sewage polluted water removed from its original source and allowed to stand in glass bottles in the laboratory shows a numerous multiplication of bacteria contained in it, thus demonstrating the existence of favorable conditions for the multiplication of sewage bacteria. Under these circumstances, in glass bottles, the number of bacteria in such sewage polluted waters rises into the millions and may even reach tens of millions.

Now, it is well known that in sewage polluted rivers where samples of the water are plated immediately after collection, no such enormous numbers of bacteria are found as in these glass bottle experiments.

In the waters of the Desplaines river and the upper Illinois river, for example, no such numbers of bacteria are observed as in these laboratory observations.

9978 I have already called attention to the fact that an almost steady decline in the number of sewage bacteria and the colon bacteria occurs during the passage of the water down the river, even in the upper stages where the dilution is relatively slight.

In brief, no such multiplication of bacteria is noticed under natural conditions as has long been known to occur in glass bottles in the laboratory.

This is one of the reasons for assuming that the conditions in these glass bottles are more favorable for the life of bacteria generally than in nature, and I have already indicated that one possible reason for this favorable effect is to be found in the nature of the substances dissolved by the water.

It was interesting and important to determine, therefore, whether the sewage bacteria confined in these parchment sacs behaved like those confined in glass bottles or acted more nearly in conformity with what has been observed in natural conditions.

This was the prime object of these control tests. Another reason for making these control tests was to dis-
9979 cover how long the integrity of the parchment sac was
maintained.

Q. Did you prepare any tables showing the result of your analyses of these control tubes for the determination of river bacteria?

A. Yes, sir, I have four tables, tables A, B, C and D, showing the history of such control sacs.

Q. Will you produce and read table A in evidence

A. Yes, sir; it is as follows:

9980

TABLE A.

CONTROLS
LOCKPORT.

No. days in Sac.	Sac No.	Colony count agar 37°	No. B. Coli in 1 cc.	No. Streptococci in 1 cc.
Initial	A_1	470,000	4000-6000	1000
3 days	A_2	2,000	less than 1000	1000
7 days	A_2	660	50	none in 1 cc.
9 days	A_3	2,520	5	none in 10 cc.

9981 Q. Please explain table A?

A. Table A contains the records of the observations upon the bacterial changes occurring in one of these parchment sacs, hereinbefore described, containing water taken from the drainage canal and placed in the drainage canal at Lockport. The initial number of sewage bacteria per cc. was 470,000. In 3 days this number had sunk to 2,000. The initial number of colon bacillus in one cc. was from 4,000 to 6,000. In 9 days the number of colon bacteria had diminished to 5; the number of streptococcus in one cc. was, at the beginning, 1,000; at 9 days no streptococcus was found when 10 cc. of this water was examined.

Q. Will you produce and read table B in evidence?

A. It is as follows:

9982

TABLE B.
CONTROLS
LOCKPORT.

No. days in Sac.	Sac No.	Colony count agar 37°	No. B. Coli in 1 cc.	No. Streptococci in 1 cc.
Initial	K_1	?	1000	2000
3 days	"	8000	10	20
5 days	K_2		6-9	None in 5 cc
6 days	"	1332	6-8	" "
8 days	K_1	11800	7	

9983 Q. Please explain table B?

A. Table B contains the records of observations on one of these parchment sacs. These observations were of the same character as those in the preceding table, containing the water taken from the drainage canal and placed in the drainage canal at Lockport. A decrease in the number of sewage bacteria, colon bacilli and streptococcus was observed.

Q. Will you produce and read table C in evidence?

A. It is as follows:

9984

TABLE C.
CONTROLS
ROBEY ST.

No. days in Sac.	Sac No.	Colony count agar 37°	No. B. Coli in 1 cc.	No. Streptococci in 1 cc.
Initial	E_1	390000	4000-6000	40000
2 days	"	21000	100	20
4 days	"	19500	70-90	1 in 5 cc
6 days	"	70200	50	none in ½ c
7 days	E_2	17200	90-100	none in .1 cc
11 days	"	14600	20	none in 1-5 cc
12 days	E_3	75600	4-10	none in 5 cc
14 days	"	too thick to count	6-10	2

9985 Q. Please explain table C.

A. Table C contains the record of the observations made upon the bacterial changes occuring in one of these parchment sacs containing water taken from the drainage canal and placed in the drainage canal at Robey Street.

I should say, perhaps, that in the case of all of these parchment sacs, both those infected and the controls, the water was taken from the drainage canal at the point where the float was located, and was filled with this water just before inoculation and just before the initial sample was taken.

The initial number of sewage bacteria was 390,000 per cc., the number of B. coli 4,000 to 6,000; the number of streptococcus 40,000.

In 2 days the number of sewage bacteria had fallen to 21,000; the number of bacilli colon to 100; the number of streptococcus to 20.

This sac showed signs of breaking down six days after the beginning of the experiment. This was the earliest that any such change was noticed. The loss of integrity on the part of the sac is first evidenced by an increase in the total number of sewage bacteria and this is followed usually, in several
9986 days by an increase in the number of colon bacillus and streptococcus.

I introduce this table as illustrating the changes taking place in one of those control sacs when the integrity of the sac becomes impaired.

Q. Will you produce and read table D?

A. It is as follows:

9987

TABLE D.

CONTROLS

Robey Street.

No. days in Sac.	Sac No.	Colony count agar 37°	No. B. Coli in 1 cc.	No. Strepto-cocci in 1 cc.
Initial	V_1	240000	800—1000	
20 hrs.	"	327000	700— 900	
28 hrs.	"	326000	800	
2 days	"	122000	100— 200	
4 days	"	17000	20	
5 days	"	16400	7— 8	
6 days	"	17800	5— 6	
7 days	"	7900	8	
8 days	"	5980	9	
9 days	"	7300	6— 8	

9988 Q. Please explain table D?

A. Table D contains a record of the more detailed means of observations upon one of these control sacs containing water taken from the drainage canal at Robey Street and placed in the canal at Robey Street. The initial colony count in this case was 240,000.

Another sample was taken at 20 hours, showing a slight increase in the number to 327,000. In 28 hours the number was 326,000. In 2 days the number was 122,000 and in 4 days the number had fallen to 14,000, and in 9 days to 7,300. The number of colon bacilli in this case remained about the same for the first 28 hours, namely, from 800 to 1,000. In 2 days the number had fallen to from 100 to 200 and in 4 days to 20 per cc.

I regard this experiment as being especially interesting in that it shows a slight initial increase similar to what is observed sometimes in the waters of the drainage canal flowing between Robey Street and Lockport. This very slight initial increase is, however, followed by a rapid decline, and I would call particular attention to the fact that the initial increase does not amount to anything like what is observed in samples of this sewage standing in glass bottles in the laboratory.

To sum up, the conditions shown by these control sacs,
9989 the behavior of the bacteria is shown to be practically
identical with what I have seen reason to believe is the natural course of events in the sewage polluted stream itself. There is at first, perhaps, a slight increase in the number of sewage bacteria, while the colon bacilli apparently hold their own for about 24 hours. There is then a marked and continuous decline in the number of ordinary sewage bacteria as determined by the colony count, and also in the number of colon bacteria and streptococcus, thus simulating in a very precise fashion the changes that take place in the canal and river water.

I regard the evidence presented by these control sacs as confirming altogether the inferences which I have already drawn concerning the naturalness of the conditions in these parchment sacs. The course of events, so far as the death of sewage bacteria and colon bacilli are concerned is precisely the same as what I have been led to consider happens in the river when these sewage bacteria are added to it in Chicago sewage. In both cases there is the same marked diminution in the number of sewage bacteria and in the number of colon bacilli.

9990 Q. Do these tables which you have read into the record
and explained complete the experiment as far as your work is concerned, Professor?

A. Yes sir.

Q. Professor, I show you one of these parchment sacs and ask you to state what it is?

A. It is the sac upon which the observations described in the last table, table D, were made. It was removed from the water at the end of nine days.

Sacs of this character and these dimensions were used throughout the experiment just described.

MR. TODD: I offer this sac in evidence and ask to have it marked "Jordan's Exhibit D."

The sac is marked by the Commissioner as requested by counsel.

9991 Q. When the sac just offered in evidence was taken out
of the water was it intact?

A. It was tested and found intact.

Q. Have you got a table of summaries for the drainage canal at Lockport, based upon the tables that have been offered in evidence?

A. Yes sir, I have.

Q. Will you produce and read the table of summaries?

A. It is as follows:

DRAINAGE CANAL AT LOCKPORT.

Sac. No.	No. typhoid bacilli introduced per cc	10 min.		1 day.		2 days.		3 days.		4 days.		5 days.		6 days.		7 days.		8 days		9 days.		10 days.	
		No. colonies taken in....	No. typhoid found......	No. colonies taken in....	No. typhoid found......	No. colonies taken in...	No. typhoid found.	No. colonies taken in...	No. typhoid found.......	No. colonies taken in...	No. typhoid found......	No. colonies taken in...	No. typhoid found.......	No. colonies taken in...	No. typhoid found......	No. colonies taken in...	No. typhoid found......	No. colonies taken in...	No. typhoid found	No. colonies taken in....	No. typhoid found......	No. colonies taken in....	No. typhoid found......
		c. c.		c. c.		c. c.		c. c.		c. c.		c. c.		c. c.		c. c.		c. c.		c. c.		c. c.	
O_1	360000	0.001-68	63			0.01—25 0.1—40	0 0	0.1—43 1.0—20	0 0							1.0-19	0						
O_2	360000											0.1—9 1.0-35	0 0			0.1-18 1.0—5	0 0					1.0-85	0
B_1	12000			60	0																		
B_2	12000					70	0	0.1—6 1.0—13	0 0			1.0-24	0			1.0-45	0			1.0-49	0		
C_1	600			20	0																		
C_2	600					30	0	1.0—50	0			1.0-24	0			1.0-12	0			1.0-10	0		
D_1	180			1.0-13	0			1.0—20	0			1.0-12	0			1.0-20	0						
L_1	30000							0.01-8 1.0—12	0 0					1.0-17	0			1.0-24	0			1.0-25	0
L_2	30000							0.01-2 1.0—18	0 0			0.1—7 1.0—5	0 0										
L_3	30000											1.0-12	0										
M_1	1500							0.01-5 1.0—5	0 0														
M_2	1500											0.1—8	0										
Total..		68	63	93	0	165	0	202	0			136	0	17	0	119	0	24	0	59	0	110	0

Total colonies taken—902.
Total typhoid found—63.

Total colonies taken after day of inoculation—924.
Total typhoid found after day of inoculation—0.

9993 Q. Will you explain the table of summaries and state what it shows?

A. This table of summaries of the experiment made in the drainage canal at Lockport, on this sheet, headed "Drainage Canal at Lockport," which has just been read in evidence shows the combined results of the several experiments. One sample was taken ten minutes after inoculation, and out of 68 colonies examined 63 were typhoid. One day after inoculation out of 93 colonies examined none were typhoid.

2 days after inoculation out of 165 colonies examined, none was typhoid.

3 days after inoculation out of 242 colonies examined none was typhoid.

5 days after inoculation out of 136 colonies examined none was typhoid.

6 days after inoculation out of 17 colonies examined none was typhoid.

7 days after inoculation out of 119 colonies examined none was typhoid.

8 days after inoculation out of 24 colonies examined none was typhoid.

9 days after inoculation out of 59 colonies examined none was typhoid.

10 days after inoculation out of 110 colonies examined none was typhoid.

9994 The total number of colonies examined after the date of inoculation was 924. In this number no typhoid colonies were found.

Q. Have you a table of summaries for Robey Street prepared from the tables already introduced in evidence?

A. Yes sir, I have.

Q. Will you produce and read the table into the record?

A. It is as follows:

9995

Drainage Canal–

Sac No.		1 Hour.		20 Hours.		28 Hours.		2 Days.		3 Days.		4 Days.	
	No. Typhoid Bacilli Introduced...	No. Colonies Taken in..	No. Typhoid Found.....	No. Colonies Taken in..	No. Typhoid Found.....	No. Colonies Taken in..	No. Typhoid Found.....	No. Colonies Taken in..	No. Typhoid Found.....	No. Colonies Taken in..	No. Typhoid Found.....	No. Colonies Taken in..	No. Typhoid Found.....
		c. c.				c. c.		c. c.		c. c.		c. c.	
P_1	285,000	0.0001- 3	2	0.001-47	16	0.001- 4	1	0.01-62	1	0.01 -25	0	0.1 -15	0
		0.001 -46	39	0.01 - 7	5	0.01 -57	45	1.0 - 7	0	1.0 - 6	0	1.0 - 6	0
P_2	285,000									0.01 -16	0	0.1 -12	0
										0.1 - 3	0	1.0 - 8	0
				c. c.				0.01-28	7	0.01 -48	0	0.01-25	0
N_1	857,000			0.001-26	5	0.01 -57	43	0.1 -24	2	0.1 - 8	0	0.1 -10	0
				0.01 -24	15								
												0.01- 6	0
N_2	857,000											0.1 - 8	0
F_1	11,500											1.0 -25	0
F_2	11,500												
F_3	11,500												
								0.1 -25	0				
G_1	670							1.0 -10	0			1.0 -15	0
G_2	670												
H_1	18,000											1.0 -50	0
H_2	18,000												
H_3	18,000												
								0.1 -25	0				
I_1	900							1.0 -10	0			1.0 -15	0
R_1	25,000							0.1 -11	0				
R_2	25,000									0.001 -19	0		
								1.0 - 9	0	0.0001 4	0		
S_1	16,800									0.001 -13	0		
	Total..	49	41	104	41	118	89	221	10	142	0	196	0

Total colonies taken, 1,658. Total typhoid found, 184.

N. Robey St.

5 Days.		6 Days.		7 Days.		8 Days.		9 Days.		10 Days.		11 Days.		12 Days.		13 Days.		14 Days	
No. Colonies Taken in..	No. Typh. F'd.	No. Colonies Taken in..	No. Typhoid Found....	No. Colonies Taken in..	No. Typhoid Found....	No. Colonies Taken in..	No. Typhoid Found....	No. Colonies Taken in..	No. Typhoid Found....	No. Colonies Taken in..	No. Typhoid Found....	No. Colonies Taken in.	No. Typhoid Found....	No. Colonies Taken in..	No. Typhoid Found....	No. Colonies Taken in..	No. Typhoid Found....	No. Colonies Taken in..	No. Typh. F'd
c. c.		c. c.		c. c.		c. c.		c. c.											
0. 1-10	0			0.1-28	0	0.1-31	0												
1. 0- 6	0	0.1.32	0	1.0- 8	0	1.0- 4	0												
0. 1-23	0			0.1-16	0	0.1-18	0	0.1-21	0	0.1-24	0								
1. 0-10	0			1.0- 2	0			1.0-20	0	1.0-13	3								
0. 1-16	0																		
1. 0- 7	0	0.1- 4	0					0.1-13	0	0.1-35	0								
		1.0- 6	0	1.0-25	0	1.0-23	0	1·0-19	0	1.0-24	0								
0. 1-15	0							0.1- 8	0	0.1-35	0								
1. 0-14	0	0.1-12	0					1.0-21	0	1 0-24	0								
			0									1.0.19	0					1.0-27	0
		1.0-20	0									1.0-10	0	1.0-41	0			1.0-27	0
				1.0-15	0									1.0-41	0				
				1.0-23	0														
		1.0-19	0	1.0.22	0							1.0-14	0					1.0-23	0
												1.0-14	0	1.0-34	0			1.0-23	0
														1.0-34	0				
		1.0-17	0																
0.01-12	0																		
0.01-14	0																		
127	0	133	0	139	0	76	0	102	0	96	8	33	0	75	0	......	....	50	0

Total colonies taken after 2 days, 1,166. Total typhoid found after 2 days, 3.

9996 Q. Will you please explain what that table shows?

A. The table contains the summarized results of the experiment conducted in the water of the drainage canal at Robey Street. Combining the results obtained from the several sacs the following totals appear:

1 hour after inoculation out of 49 colonies taken 41 were typhoid.

20 hours after inoculation out of 104 colonies taken 41 were typhoid.

28 hours after inoculation out of 118 colonies taken 89 were typhoid.

I may say at this point that the reason why a larger proportion of colonies was found in the 28 hour samples than in the 20 hour samples was because a larger quantity of water was examined or plated and this of course resulted in the appearance of a larger number of typhoid like colonies on the plate.

After 2 days inoculation out of 221 colonies examined 10 proved to be typhoid.

3 days after inoculation out of 142 colonies examined none proved to be typhoid.

4 days after inoculation out of 193 colonies examined none
9997 proved to be typhoid.

5 days after inoculation out of 127 colonies examined none proved to be typhoid.

6 days after inoculation out of 133 colonies examined none proved to be typhoid.

7 days after inoculation out of 139 colonies examined none proved to be typhoid.

8 days after inoculation out of 76 colonies examined none proved to be typhoid.

9 days after inoculation out of 102 colonies examined none proved to be typhoid.

10 days after inoculation out of 96 colonies examined 3 proved to be typhoid.

11 days after inoculation out of 33 colonies examined none proved to be typhoid.

12 days after inoculation out of 75 colonies examined none proved to be typhoid.

14 days after inoculation out of 50 colonies examined none proved to be typhoid.

9998 Q. Professor, you have read into the evidence all the tables and the tables of summaries based upon the experiment which you conducted with parchment sacs, infected with typhoid germs, suspended in the drainage canal, have you not?

A. Yes sir.

Q. Did you make any experiments supplemental to the experiments that you have heretofore introduced into evidence?

A. Yes, I have made some experiments comparing the parchment sacs with celloidin sacs.

Q. Will you describe the manner in which this experiment was made in detail?

A. Large celloidin sacs were prepared by my Assistant Dr. Harris who has had special experience in making these. They were made of the same size as the parchment sacs used in the experiments hereinbefore described and for the sake of having a comparison as to the course of events in these sacs some preliminary tests were made in the laboratory. The parchment sac and the celloidin sac were placed under identical conditions in large glass vessels and a stream of lake water from the tap allowed to pass continuously through the glass vessel so that the temperature was kept constant and the conditions surrounding the sacs were the same. Bacillus typhosus,
9999 the strain previously designated as Y, was added to lake water in such numbers that each sac contained approximately 3,080 typhoid bacilli per cc. The original number of bacteria in the lake water as determined by the usual colony count was 65.

1 day after inoculation of the parchment sac 21 colonies were picked off, 19 of which proved to be typhoid.

In the celloidin sac 1 day after inoculation out of 16 colonies picked off 6 were typhoid.

2 days after inoculation of the parchment sac out of 20 colonies picked off the plate 9 were typhoid.

In the celloidin sac 2 days after inoculation out of 20 colonies picked off the plate 2 were typhoid.

3 days after inoculation of the parchment sac out of 20 colonies picked off the plate 5 were typhoid.

3 days after inoculation of the celloidin sac out of 20 colonies picked off the plate none was typhoid.

4 days after inoculation of the parchment sac out of 20 colonies picked off the plate 1 was typhoid.

4 days after inoculation of the celloridin sac out of 20 colonies picked off the plate 1 was typhoid.

On the 5th, 6, 7, 8, 9, 11, 12, 13 and 15th days after inoculation out of 177 colonies examined, an average of about
10000 20 per day and the same number were examined from the
celloidin sac. In no case, however, was the typhoid bacillus found later than the fourth day.

This experiment shows several points of interest.

1. The validity of the methods of isolation used is again demonstrated by the large proportion of typhoid bacilli obtained in the early days from suspected colonies.

The total number of colonies appearing on the plate was very large on the third and fourth day of the experiment reaching to upwards of 120,000 in spite of the fact that a relatively small number of typhoid bacilli had been added originally, namely 3,080. The isolation of the typhoid bacilli did not prove to be difficult. This seems to me a most striking demonstration of the great value of the special media employed.

(2) In the second place it may be noted that the typhoid bacilli lived about twice as long in this experiment in the lake water as they did in the water of the drainage canal at Robey Street.

(3) In the third place the essential similarity between the course of events in the parchment sacs and in the celloidin
10001 sacs shows that the conditions surrounding the bacilli are
substantially the same whether they are imprisoned in parchment or in celloidin. This was perhaps to be expected since both the celloidin and the parchment have long been used for work in dialysis and since both allowed bacterial toxins and other soluble products to pass freely through their walls while strictly confining the bacilli.

ADJOURNED UNTIL 10:00 A. M., FEBRUARY 5, 1904.

10:00 A. M., Friday, February 5, 1904.

10002 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN

resumed the stand for further direct examination by Mr. Todd and testified as follows:

Q. Professor, did you make any other comparative experiments?

A. Yes sir, I compared the behavior of sewage placed in parchment and celloidin sacks and kept under the same conditions.

Q. Will you describe that experiment?

A. Fresh sewage obtained from the 56th Street sewer in Chicago was placed in parchment and celloidin sacks, suspended in running lake water in the laboratory as described in the experiment just cited. The initial number of sewage bacteria, as determined by the colony count, was 500,000, the number of B. coli per cc. from 70,000 to 90,000, the number of streptococcus per cc. about 30,000.

A multiplication of the sewage bacteria occurred in the first day, the number in the parchment and celloidin sacks rising to a little over 2,900,000. This was followed in the next 24 hours by a marked decline in the number of bacteria shown in the colony count. The number of colon bacteria and
10003 streptococci remained about the same through the first
3 days and then diminished very greatly.

After 7 days the count showed in the parchment sacks 64,500 bacteria per cc., 1,000 bacilli coli per cc. and 100 streptococci per cc. In the celloidin sack the total number of sewage bacteria was 10,200; the number of B. coli 500 to 700; the number of streptococci 300.

The other examinations made on the 3, 4, 5, 6, 7, 8, 10, and 12th days showed essential similarity between the course of events in the parchment and celloidin sacks thus confirming what was observed in the preceding experiment.

I conclude that the conditions in the parchment and celloidin sacks are substantially identical.

Q. Did you prepare and send any culture media to Professor Russell?

A. Yes sir, the culture medium used by him in his work at Peoria was prepared in my laboratory and sent to Mr. Hastings who was Professor Russell's assistant in the work at Peoria.

Q. State what kind of medium was sent and how it was prepared, briefly?

10004 A. The medium sent was the Drigalski and Conradi medium, the method of preparation of which was described in full in my testimony of yesterday.

Q. From the results of these experiments what conclusion do you draw as to the longevity of a typhoid bacillus in the water of Lake Michigan?

A. It was found by actual experiment under conditions which I believe to simulate closely those in nature that the typhoid bacillus, introduced into unsterilized Lake Michigan water was recovered four days after inoculation and was not found in subsequent examinations made up to the end of the fifteenth day. It is probable that specially resistant individual cells might survive longer than appeared to be the case in the experiment described in my testimony, but in my opinion even such highly resistant individuals, if they did exist, would not live more than about twice as long as the time recorded in these experiments. So that I conclude that 8 to 10 days would be a maximum period of longevity for the typhoid bacillus in the water of Lake Michigan, under natural conditions.

Q. From the result of these experiments what conclusion do you draw as to the longevity of the typhoid bacillus in

10005 the water of the drainage canal?

A. These experiments, of which a large number were made with varying numbers of typhoid bacilli introduced directly into the water of the drainage canal, gave generally uniform results. It was not difficult to discover typhoid bacilli during the first two days. Later than that they were never found either at Lockport or at Robey Street, with one exception. In this anomolous case, 3 typhoid bacilli were isolated on the 10th day from a single plate in a single sack.

Taking into consideration all of the experiments made in the waters of the drainage canal, and assuming, as before, that specially resistant individual cells might exist, which would live twice as long as those found it is my opinion that typhoid bacilli introduced into the waters of the drainage canal, under natural conditions, would not and do not live in that situation longer than four days.

Q. From the result of these experiments, what conclusion do you draw as to the longevity of typhoid bacilli in the water of the Illinois River?

A. Remembering that the upper stretches of the Illinois River are highly polluted with sewage and that considerable additions of sewage are made to the Illinois River at points along its course, I do not believe that bacilli introduced into the Desplaines or upper portion of the Illinois River would live
10006 under natural conditions more than five or six days.

Q. What in your opinion would be the fate of a typhoid bacillus passing from the sewers of Chicago into the Chicago River and thence into the drainage canal and down the Desplaines and Illinois Rivers?

A. It is my opinion that a typhoid bacillus, discharged from the body of a typhoid patient in Chicago and assuming that such discharges were not disinfected so that the bacillus could pass into the sewers of Chicago and thence into the Chicago River and drainage canal, might live as long as 3 or 4 days after leaving the body of the patient.

From what I know of the rate of flow in the drainage canal and in the Desplaines and Upper Illinois Rivers, in my judgment such a typhoid bacillus would perish long before Averyville was reached, even at a period of low temperature and high water.

Q. From a scientific standpoint what value do you attach to this experiment as showing the longevity of a typhoid bacillus in polluted water?

A. I regard the experiment as described as shedding a great deal of light upon the life of the typhoid bacillus under natural conditions.

The results, in my opinion, show quite conclusively that
10007 if any typhoid bacilli survive later than 48 hours after
they have been introduced into the highly polluted waters of the drainage canal they must be highly resistant and very exceptional individuals.

In the experiments as reported there is one instance where typhoid bacilli were found in a single case, on the 10th day.

The singularity of this finding and its isolation from all the other results that were obtained in the course of examination of a large number of sacks, over a long period of time in my opinion demands a special explanation.

The sudden appearance of 3 colonies in the sack after an interval of 8 days, during which no typhoid bacilli were found, although a large number of colonies were examined, points to some unusual occurrence. The most reasonable explanation seems to me to be that at the time when the contents of the sack were heavily infected with typhoid bacilli, during the process of tilting and agitation previously referred to some concrete particle in the sewage to which typhoid bacteria were adhering, was deposited and became dried upon the walls of the sack above the water line. Under these conditions it is my opinion that the typhoid bacillus might remain alive for some time.

Such a dried particle, containing living typhoid bacilli,
10008 might conceivably be washed off from the place where it
had lodged. These typhoid bacilli suddenly introduced into the sack after an interval of 10 days might appear on the plate and be found as in this case. It is certainly difficult to account otherwise for the sudden apearance of three colonies and for their occurring only on one plate. If these typhoid bacilli had remained alive in the water of the sack throughout this whole period, it would be expected that between the second day and the tenth day other resistant individual germs, straggling survivors of the great multitude originally introduced, would also have appeared on some plates and been picked off and identified.

I am inclined to believe, therefore, that this isolated case was due to an accident occurring under the conditions in which the experiment was conducted, and does not indicate that typhoid bacilli would survive as long as ten days in the water of the drainage canal itself. The outcome of all the other experiments made it distinctly opposite to the latter view.

Answering your question then as to the significance of the whole experiment, I would say that in my opinion it indicates a longevity of the typhoid bacillus in the polluted water of the drainage canal of not more than 3 or 4 days.

10009 Q. Does the experiment shed any light upon the longevity of the typhoid bacillus in the sediment of polluted streams?

A. I think it does in this way, that although some sedimentation of the suspended matter occurs in these sacs the tilting and agitating of these sacks each time before the sample was taken led to a thorough mixing of the suspended and sedimented particles. I found no reason for believing that bacilli lived any longer in the sediment of such sacks than freely suspended in the fluid.

Q. What is the behavior of the colon bacillus in soil as compared with its behavior in water?

A. In my opinion it can live much longer in soil than in water, but there is evidence that a certain destruction of colon bacilli takes place also in the soil although not so rapidly as in water.

Q. Is there such a thing as self purification of soil?

A. Yes. I have here a paper entitled "Self Purification of Made Soil, published by Dr. William G. Savage, Bacteriologist to the Cardiff and County Public Health Laboratory and late lecturer on bacteriology, University College, Cardiff."

This paper was published in the Journal of the Sanitary Institute, Volume 24, part 3, 1903, page 442.

In this paper the writer described the experiments made on the continuance of vitality of the colon bacillus in made soils of various kinds. He finds that the colon bacillus lives for 10010 some time in the soil but disappears as times goes on, the ordinary soil organisms invading the material and taking the place of the colon bacillus. He concludes "that the gradual diminution and disappearance of the B. coli in this refuse is of interest from the point of view of specific contamination. This organism, apparently, rapidly dies out in such material. It is a more resistant organism than the typhoid bacillus. It is a fair assumption from this that the typhoid bacillus, if present in such soils, would also rapidly die out and that the danger of *specific* typhoid contamination from building on such made soil can be neglected."

These observations show that B. coli introduced into soil disappears less rapidly, it is true, than in water, but nevertheless shows a tendency to die out.

Q. Does the experiment which you have introduced in evidence shed any light on the life of the colon bacillus in polluted water?

A. It certainly does. The control experiments I have described show that the colon bacillus dies off in polluted water when imprisoned under natural conditions in parchment
10011 sacs. This confirms what has already been noticed regarding the disappearance of B. coli in the running water of the Illinois River and adds weight to the view that the life of the typhoid bacilli under these conditions is very brief, since the colon bacillus is a much hardier organism than the former.

Q. Does that experiment shed any light on the life of the streptococcus in polluted water?

A. Yes, the controlling experiments show that the sewage streptococci die out very rapidly.

Q. To what do you attribute the death of the typhoid bacillus in water?

A. I attribute the death of the typhoid bacillus in such unsterilized water as I have examined to the poisonous action of the products of other microbes.

It is a well established fact that the typhoid bacillus dies off more rapidly in unsterilized water, that is the water containing a normal number of microbes, than in the same water sterilized, that is containing no other form of micro-organisms.

It is also well established that the products of growth of one microbe are often injurious and detrimental to another microbe.

Q. Why is it that the typhoid bacillus will not live as
10012 long in polluted water as in pure water?

A. In my opinion this is because the products of the microbes are present in more concentrated form in the polluted waters than they are in the purer waters. The action of these toxic products in their concentrated form is naturally more intense than where these products are in a diluted condition.

Q. What is your opinion as to whether the typhoid bacillus will live longer in the sediment of a polluted stream than it would in [illegible] water of the same stream?

A. It is my opinion that there would be little material difference.

Q. Why?

A. In the sediment of running streams the typhoid bacilli are in very much the same surroundings so far as I can picture to myself the conditions obtaining in this sediment that they would be in the water of such streams, except that it is fair to suppose that the organic matters on the bed of the stream in the sediment are more abundant. This latter condition would bring it about that the food substances of the saprophytic bacteria would be present in the sediment more abundantly, and that therefore the products of growth of these microbes 10013 would exist there also in a more concentrated form, so that so far as typhoid bacilli would be differently affected by the conditions obtaining in the sediment they would be exposed to the toxic products of saprophytic microbes more intensely than in the water of the stream above this sediment. This condition would tend if anything to cause their death more speedily in the sediment than in the water of the same stream although I do not believe that the difference would be very great.

Q. Will you differentiate between the conditions that obtain in moist soil and the sediment of a running stream?

A. In moist soil the bacilli are not exposed to the action of the toxic products of the microbes with which they are surrounded for the reason that such soluble toxic products can not act upon the bacilli through the intervening air space. A continuous layer of fluid would be needed for a diffusion of the soluble toxic products of these saprophytes and unless the typhoid bacilli were in contact with these, the conditions in an ordinary damp soil would be very different from the conditions prevailing in the sediment on the bottom of a river or pond.

Q. Does the time that the typhoid bacillus will live in moist soil furnish any criterion for its longevity in the sedi- 10014 ment of a running stream.

A. I do not see how it could, for the reasons just stated.

Q. Are the two conditions comparable?

A. They seem to me very different unless one assumes that by moist soil is meant soil saturated or covered with water, in which case the conditions would be substantially the same as these obtaining in the sediment, and the same result might be anticipated.

Q. How long in your judgment will a typhoid bacillus live in a moist soil?

A. Under such conditions as prevail where the contents of privy vaults are spread upon the surface of fields or vegetable gardens typhoid bacilli may in my opinion live for many months. Under these conditions there is sufficient moisture present for them to retain their vitality, and at the same time, owing to the lack of a continuous layer of fluid, any toxic products of other microbes can not diffuse through the mass and injure the typhoid bacilli.

Q. Would the fact that the typhoid bacillus lived several months in moist soil justify the assumption that it would live for the same length of time in the sediment of a river?

A. By no means.

Q. Will you please give your reasons in full for the answer
10015 you have just given?

A. The conditions in ordinary moist soil and in the sediment of a river differ practically since in ordinary moist soil, if I understand what is meant by that term, there is slight opportunity for the action of the soluble toxic products of saprophytic bacteria upon the typhoid bacilli, and, as I have stated, there is reason to believe that it is the effect of these soluble products upon the typhoid bacillus in water that causes the death of the latter. The poisons of these bacteria could not influence so profoundly the longevity of the typhoid bacillus in soil.

The experiments by Dr. Savage that I have already cited, on the disappearance of the colon bacillus from soil indicate, however, that the typhoid bacillus will probably die out in soil, like its more hardy relative the colon bacillus, although less speedily than in the sediment of a river or in polluted water.

Q. Do you know of any bacteriologist since the beginning of bacteriology that has demonstrated by any experiment that typhoid germs do live in the sediment of lakes or rivers for a long period of time?

A. I do not.

10016 Q. Professor, Mr. Fuller, in his testimony, on page 4218 of the transcript of the record, a copy of which I have, stated that "There were observers over in Switzerland who made such examinations with positive results showing the presence of typhoid germs in the sediment of Lake Geneva, I think also Lake Zurich." Do you know anything about these observations to which Mr. Fuller referred?

A. I know of the observations on Lake Geneva, to which I suppose this statement refers. I have made an examination of the literature to discover something regarding the presence of typhoid germs in the sediment of Lake Zurich but I have found nothing that bears directly on this point.

Q. Will you please state the facts and circumstances as you know them in connection with these observations?

A. The observations on Lake Geneva were reported by an investigator named Lortet at the International Medical Congress in Berlin between the 4th and 9th of August, 1890.

10017 These investigations were published in the Centralbl f. Bakteriologie, 1891, Volume 9, p. 709, entitled "Pathogenic Bacteria of the Deep Mud in Lake Geneva."

The observations as reported covered the examination of slime taken from a depth of 40 to 50 meters, 2 kilometers from the shore. This deep mud was found virulent when inoculated into animals and was more virulent than that taken from near shore. The material taken 200 meters from shore in the water 4 meters deep was sterile, and animal experiments gave negative results. The statement is made that the staphylococcus pysogenes aureus, the tetanus bacillus, the bacilli coli and the bacillus typhosus were isolated from the deep mud 2 kilometers from shore as already alluded to.

No statements are made as to the methods of identification of these microbes. This was before the Widal tests was used for the identification of the typhoid bacillus and in view of the fact that no statements are made by this authority regarding his other methods of identification the mere report of finding these organisms was not a satisfactory one. 10018

It may be added that the author makes a statement that every part of the lake from which material for investigation was taken contained chemically very pure water. Assuming that the pathogenic bacteria isolated were correctly identified, which seems rather a violent assumption in view of all the premises, there are no data as to the length of time that these organisms had been present in the sediment.

I may add that Loeffler in his treatise on Water and Microorganisms, one of the leading German authorities on questions of this sort, in mentioning Lortet's report of the finding of the typhoid bacilli in the slime of Lake Geneva (page 592) puts an interrogation mark after the name typhoid bacillus, indicating his skepticism as to the correct identification of this microbe. Personally I share this skepticism and am unable to assume, in view of the facts given by Lortet in his report, that this identification was correctly and satisfactorily accomplished.

Q. In the light of the present knowledge in regard to bacteriology what importance do you attach to these observations in connection with Lake Geneva?

10019 A. I can attach no importance to them so far as shedding any light upon the logevity of the typhoid bacillus in sediment, since even supposing that the identification were correct there is nothing to indicate how long such bacilli had been present in the sediment of Lake Geneva.

Adjourned until 2:00 P. M. same date, February 5th, 1904.

2:30 P. M., Friday, February 5, 1904.

10020 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. Mr. Fuller, in his testimony, (page 4218 of the transcript of the record, a copy of which I have) in answer to the question "Had it ever been demonstrated by a bacteriologist that typhoid germs have lived in the sediment of a running stream" answered "It has been demonstrated that they have lived for a long time in the sediment of lakes, and I do not consider that there is any weakness in the process of reasoning by which one steps from a lake to a river, provided, of course, that each of

these waters are live waters and not subject to aseptic actions." The further question "By whom has it been ascertained that the typhoid germ has been found to live in the sediment of a running stream or lake" Answer "There are several over in Switzerland who made such investigations with a positive result
showing the presence of typhoid germs in the sediment
10021 of Lake Geneva and I think also Lake Zurich." I will
ask you do you regard the observations in Lake Geneva as quoted by Mr. Fuller as a demonstration that the typhoid bacillus has been found to live for a long time in the sediment of lakes?

A. I certainly do not.

Q. Will you please give your reasons?

A. As already stated there are grave objections to regarding Lortet's investigations in Lake Geneva, first as demonstrating that the genuine typhoid bacillus was found in the slime at the bottom of the lake as alleged. Second, that there are no data as to the length of time such bacilli had remained in the slime, assuming this author's identification to be correct.

Q. Mr. Fuller, in his testimony (page 4219 of the transcript of the record which I have) in answer to the following question "Is not the length of time that a typhoid bacillus will live in a sediment more a matter of assumption than a matter of demonstrated proof? Answer "I consider that it is a very clean cut demonstration where the typhoid fever germs may die and have continued to live in the sediment of running streams."
Question "For what length of time"? Answer "I should
10022 say for a month or more, possibly in cases for years."
Question "Who has demonstrated that it has ever lived a year"? Answer "I think that the conditions existing in a moist soil in many rural places in this country where typhoid fever prevails from time to time is proof that typhoid fever germs in the presence of moisture can live for such a term. If that were not so then there would be an elimination of typhoid fever absolutely through the rural districts of this and all other countries." I will ask you, professor, whether you know of any experiments or observations that have demonstrated that typhoid fever germs may and do and have continued to live in the sediment of running streams for a period of a year and

whether the conditions of moist soil furnish any criteria for the longevity of the typhoid bacillus in the sediment of a running stream?

A. In reply I will say that I do not know of any experiments or observations that demonstrate that typhoid fever can live in the sediment of running streams for a period up to a year.

In my opinion the conditions obtaining in moist soil are very different from those obtaining in the sediment of running streams, and I see no reason whatever for believing that
10023 the typhoid bacillus will live in the sediment of running streams for a similar period.

Q. Do you know of any one who has gone into the question of the life of the typhoid bacillus in natural waters and has made any experiment as extensive as the experiments which you and Professor Zeit and Professor Russell have made and which you have introduced in evidence?

MR. JEFFRIES: I object to the question for the reason that it leaves it to the witness to determine comparatively speaking the length and extent of the investigations that have been had upon the subject in question and does not require of the witness to state or give his understanding as to the extent, duration and limit of the investigations that have been made by others than himself and the persons associated with him in the investigations in question, and that it is for the court to determine and not this witness as to whether or not the investigation made by him and his associates is as thorough or is as extensive and complete as the examinations and investigations that have been made by others upon the same subject.

A. I do not know of any published report of an experi-
10024 ment of this character so extensive in detail as the one that has been introduced.

MR. JEFFRIES: I move to strike out the answer for the reason that it is based upon what the witness has learned from published reports and for the reason that the witness states that in those published reports no investigations which have been made, wherein the details are set out, were such as were made in the investigations by this witness and his associates, and I move to strike it out for the reason that the evidence here shows, and all published reports show, that it has never been considered necessary by competent and reputable and distinguished bacteriologists, sanitarians or epidemiologists to set out in the report published to the world the exact manner and detail in which all of the experiments at the various experimental stages were made, and I move to strike it out for the reason that it is an attempt to reflect discredit upon all reports made by sanitarians and investigators wherein the details of the analyses are not set out, and for the reason that it is incompetent, irrelevant and immaterial and insufficient and is not responsive to the question.

MR. TODD: In reply to so much of counsel's objection
10025 as he claims is based upon the record in this case, I desire to state that the record does not show the facts to be as counsel has stated them to be disclosed by the records.

Q. How near does the experiment named by you approach natural conditions?

A. I have already indicated it as my opinion, and to this I firmly hold, that the conditions under which this experiment were conducted imitate natural conditions as closely as it is possible to imitate them in the present state of bacteriology.

Q. Are the conditions of the experiment which you have introduced more or less favorable to the longevity of the typhoid bacillus than the natural conditions of the water in which the experiment was made?

A. These conditions are, in my opinion, so close to natural conditions that I am unable to say whether they are more or less favorable. The difference is, in my opinion, insignificant.

Q. What reasons, if any, have you for supposing that the conditions described in your experiment, closely simulate natural conditions?

A. The bacteria in the parchment sacks are exposed to
10026 similar conditions of temperature. They are also exposed to the action of the substances present in the sewage and such substances formed by the multiplication of saprophytic bacteria within the sacks. The diffusion that takes place through the walls of the parchment sacks allows soluble substances to pass through, both those inside the sack to pass

out and those outside to pass in where the osmotic conditions are suitable.

These sacks have been tested with solutions of dyes and acid and alkali and have been found permeable. Thus, if a solution of litmus be placed in a glass vessel and a parchment sac containing dilute acid be suspended in this solution of litmus, the acid will pass through the walls of the parchment sac and will cause the blue color of the litmus to change to red. Conversely, if a litmus solution be placed inside the sac and the sac suspended in the acid solution, the acid will pass through the parchment into the sac, changing the litmus to red color. In either case the interchange of substances between the parchment sac and the fluid outside continues until a state of equillibrium is established. So that the contents of the 10027 parchment sac suspended in the water of the drainage canal are in free communication with the waters of the drainage canal itself, and interchange of food substances and other toxic substances being possible.

For these reasons it is my judgment that the conditions of the experiment similate with great exactness natural conditions.

Q. How do the conditions of this experiment differ from those of the glass bottle experiments such as have previously obtained in the laboratory experiments on the longevity of the typhoid bacillus?

A. In the glass bottle experiments substances are dissolved from the glass by the water, and these favor continued vitality on the part of the microbes contained in the water. These substances dissolved from the glass are not found in the case of the parchment sac experiments.

Q. Is there any reason for anticipating greater or less longevity on the part of the typhoid bacillus in the glass bottles than under the conditions of your experiment?

A. I should anticipate that typhoid bacilli would live longer in glass bottles than in parchment or celloidin sacs.

Q. What do the facts show?

10028 A. The experiments on the longevity of the typhoid bacilli that have been made in glass bottles in the laboratory and have been previously published by other investigators, show a generally greater longevity than that found in the conditions obtaining in my experiment.

Q. What is your opinion, based upon all the knowledge which you possess, as to whether typhoid bacilli coming from the sewers of Chicago and entering the drainage canal, could survive the journey from Chicago to St. Louis, a distance of 347 miles, and be a danger and a menace to the inhabitants of the City of St. Louis using the water of the Mississippi River for drinking and domestic purposes?

A. It is my opinion that typhoid bacilli could not survive the journey from Chicago to St. Louis, under the conditions just mentioned, and I do not believe that such typhoid bacilli would arrive in the Mississippi River in a condition that they could be called a menace to the inhabitants of St. Louis.

Q. Are you familiar with the settling basins employed by the City of St. Louis?

A. I have observed these settling basins at the St. Louis waterworks on a number of occasions.

10029 Q. Do the settling basins at St. Louis afford any protection to the citzens of St. Louis against infectious matters in the waters of the Mississippi River at the Intake Tower?

A. In my opinion they do afford a very considerable protection against infectious matters that may be present in the waters of the Mississippi River at the Intake Tower. It appears from the testimony of Professor Ravold in this case that 75 per cent. of the bacteria are removed in the sedimentation basins.

In my opinion the water supplied to St. Louis is much safer than it would be if settling basins did not interpose between the raw water of the Mississippi River and the consumer.

Q. Are the settling basins of St. Louis any protection to the citizens of St. Louis against the sewage of Chicago?

A. I do not believe that any dangerous elements entering the sewers of Chicago reach as far as the Mississippi river and if that is the case I do not see how the settling basins of St. Louis could protect against the sewage of Chicago.

Q. If none of the sewage in its dangerous state reaches the city of St. Louis from Chicago, from what source in your opinion comes the infectious matter which these settling basins eliminated? 10030

A. It comes, in my opinion, from places nearer to St. Louis than Chicago, places situated on the Missouri, Mississippi and Illinois rivers, within five or six days flow from the Intake Tower.

Q. When a settling basin holds a sufficient amount of water to supply the city for a period of thirty days, and as the water is taken out for domestic uses, raw water is immediately supplied, and typhoid fever should prevail among the people using said water, what is your opinion whether such a condition justifies the assumption that because the reservoir holds a supply for a period of thirty days, that a typhoid bacillus will live in that water for such a period

A. In reply I will state that I should wish to investigate thoroughly the conditions surrounding a community so situated and to determine to my satisfaction that the water supply in the settling basin was the source of the typhoid fever prevailing among the people. Some further points would also have to be considered.

As I understand the situation described it is not true that all the water pumped into the settling basin would remain there for a period of thirty days, allowing that length of time for typhoid bacilli to die out, but on the contrary water would be drawn continually from the reservoir during this period of thirty days. 10031

Such being the case it seems to me obvious that not all of the water drawn from the reservoir could have remained in the reservoir for a period of as long as thirty days. Some of it in fact may be drawn from the reservoir within a very short time after its entrance into said reservoir, possibly within 24 or 48 hours of its being taken from the river. Any typhoid germs introduced in this way might be drawn out from the reservoir without having remained in it for a period as long as that mentioned.

It does not seem to me to follow because a reservoir or settling basin holds a thirty days' supply that all typhoid bacilli introduced into the reservoir remain there for thirty days.

Q. Do you know of any experiments dealing with the longevity of cholera and anthrax bacillus in aquaria?

A. Yes sir, I know of some experiments on the longevity of cholera and anthrax bacilli in aquaria.

Q. Will you please give them?

10032 A. These were by Dr. L. Hoeber from the Hygienic Institute at Wurzburg Centralbl f. Bakt., 1895, Bd. XVII, p. 443.

I quote from this paper by Dr. Hoeber:

"The result of my work is therefore as follows: Cholera as well as Anthrax bacilli can remain alive in aquaria, therefore, under conditions which correspond closely to those in nature, no longer, or at least, only a short time longer, than in the different waters in which up till now their longevity has been investigated. Whether by mixing with blood (sewage, drainage), etc., the results would be otherwise, is still to be investigated. In experiments by Professor K. B. Lehmann, where anthrax broth cultures were added to the aquaria, the bacilli perished with accompanying luxuriant increase of green desmids."

Q. Have you had any experience in the investigation of epidemics?

A. Yes sir, I have investigated several epidemics of typhoid fever in this country.

Q. What epidemics have you investigated?

A. Recently I have investigated the epidemic at Ithaca, New York, and at Butler, Pennsylvania.

Q. Professor, have you made a special study of epi-
10034 demics?

A. I am generally familiar with the classical epidemics of cholera, typhoid fever, etc., as described in the literature. I have also known of the conditions surrounding a number of epidemics of typhoid fever occuring in this country and have visited the places where these outbreaks have taken place. I have also, as already stated, investigated in considerable detail the circumstances of several of the most important outbreaks of typhoid fever that have occurred in the United States.

Q. Will you describe the epidemics that you have investigated?

A. The epidemic of typhoid fever that occured at Ithaca, New York, in February and March 1903, was one of the most extensive that has ever been reported in this country.

In a population of about 15,000 inhabitants there occurred during a period of about two months some 1,300 cases and 78 deaths. A large number of these cases and deaths took place among the students of Cornell University.

It was suspected from the natural history of this outbreak that the public water supply was in some way implicated.
10034 The peculiar distribution of typhoid fever in the town at once drew attention to the significant incidents of the infection. That portion of the town supplied with the main public water supply developed a large number of cases of typhoid fever while Cornell University campus and some surrounding houses which were supplied from another source remained entirely exempt from the disease. The rest of the town suffered severely. The University buildings and some 52 houses on or near the campus and about 17 houses at Cornell Heights remained free from the fever, although all through the rest of the town especially in the student boarding houses situated close to the campus many hundreds of cases of typhoid fever developed. With one exception the women students of the Sage college located on the campus numbering over 200 were not affected.

On investigation the distribution of water supply in town it was found that the maximum number of cases of typhoid fever developed in that portion of Ithaca supplied with water taken from a small stream known as Six Mile Creek. The water shed of this creek was found, on investigation, to be in
10035 a very objectionable condition. Loosely constructed outhouses and privies were situated along the bank of this creek and there were a number of opportunities for pollution. It was not found possible to trace the precise origin of the infection of the water supply, although several possibilities existed, any one of which might have given rise to the outbreak. The Ithaca epidemic was undoubtedly a water borne infection as shown by the distribution of cases in strict accordance with the various water supplies.

Q. Were these different sources of infection of an urban or a rural character?

A. They were such sources of infection as one sees frequently in the country districts of this country; over-hanging privies and water closets close to the banks of streams. There seemed to be no supervision of the water shed in the way of guarding against contamination by bands of laborers. I should call the sources of infection in this case distinctively and peculiarly rural.

Q. What other epidemics have you investigated recently, Professor?

A. The one at Butler, Pennsylvania, occurring in November, December and January, 1903 and 1904.

10036 Q. You have investigated that epidemic since you began to testify in this case have you not?

A. Yes sir.

Q. Will you describe the Butler epidemic?

A. The Butler epidemic first became apparent early in November 1903, and has resulted up to the present time in some 1,400 cases and about 110 deaths.

In the number of deaths therefore the Butler epidemic ranks with that at Plymouth, Pa., in 1884, as one of the most extensive reported in the sanitary history of the United States.

The town of Butler contains about 16,000 inhabitants and is supplied with water drawn from Connoquenessing Creek. Owing to the rapid increase in the population of the town, the demand for water has increased very rapidly and the water supply, which is in the hands of a private company, has not been adequate to the needs of the expanding community. The water was pumped from a point in Connoquenessing Creek about a mile and a half above the town and for some time has been filtered by open gravity filters into which a coagulent, basic sulphate of aluminum, was ordinarily introduced. These filters were thrown out of service between October 20th and 10037 31, 1903, in order to permit of some connections being made between the new high service pump and filtered water basin, and also to join some new piping with the old low service piping. These changes necessitated the emptying of the filtered water basin and the shutting down of the filters that supplied it until the changes were completed.

There seems no doubt that that this interruption of the filters during this period in the latter part of October was responsible for the great outburst of typhoid fever that followed.

There are abundant opportunities for infection on the Connoquenessing water shed. No fewer than 17 cases of typhoid were found to have existed on this water shed from the beginning of July, 1903 to the end of the year. Apparently the waters of Connoquenessing Creek and some of its tributaries had been highly charged with infectious matter during a considerable period, and it simply required the putting out of commission of the filters to precipitate the catastrophe.

10038 Here as in the case of Ithaca the water supply was definitely implicated from the outset by the topographical incidence of the disease. That part of Butler lying south of the Baltimore & Ohio Railroad tracks and known locally as Springdale remained almost entirely exempt from the infection throughout the epidemic. This territory forms topographically a part of the town of Butler and apparently differs from it only in the fact that it is not provided by city water, but receives its supply from a number of artesian wells. In this part of the town, with a population of about 2,500, it is stated on high authority that but few cases developed and these among persons attending school or working in that portion of Butler supplied with the Connoquenessing water.

Q. Was the source of infection in the Butler epidemic attributed to urban or rural population?

A. To rural population. These houses on the Connoquenessing water shed in which the cases of typhoid fever occurred were typical small American farm houses and shanties provided with loosely constructed privies. Discharges from the bodies of patients were thrown, with little attempt at disinfection, either into these outhouses or directly upon steep rocky

10039 hill sides where they remained until washed down into the creek by heavy rains. The class and character of the infection were such as pertain distinctively to rural conditions.

Q. What other epidemics are you acquainted with besides the two you have detailed?

A. I was at Lowell for a short time with Professor Sedgewick when he investigated the outbreak of typhoid fever in that city, to which reference has been made in his testimony. I visited Stamford, Conn., during the progress of a considerable epidemic of typhoid fever in that town, due to an infected milk supply. I have also known something about the conditions in the city of Chicago, leading to excessive prevalence of typhoid fever in this city.

Q. Are you acquainted with the Plymouth epidemic?

A. I know of the Plymouth epidemic only from what is found in the printed reports of this outbreak. This is perhaps the most famous epidemic of typhoid fever in the sanitary annals of this country. The severity of the infection as well as the large number of persons attacked and the large number of deaths resulting from the epidemic make it one of the most celebrated epidemics of which there is any record.

10040 Q. Was the Plymouth epidemic an urban or a rural infection?

A. This also was a case of rural infection. The outbreak was traced to an infection of the water supply with the dejecta from a single typhoid patient which had been thrown out on the hillside and allowed to accumulate near one of the feeders of the reservoirs supplying the town with water. There the most of the infectious material remained until washed down into the stream by spring floods and melting snows.

Q. What was the cause of the Lowell outbreak?

A. The Lowell outbreak was traced by Professor Sedgewick to the infection of Stony Brook, a small feeder of the Merrimac River, entering the Merrimac River a short distance above the intake of the Lowell waterworks. Several cases were found by Professor Sedgewick, on investigation, to have been a possible source of the infection of the water of Stony Brook, and the history of these cases corresponded in time and other circumstances with the conditions surrounding the outbreak of typhoid fever in Lowell.

Q. What was the character of that infection as to whether or not it was rural or urban?

A. These also were cases of infection by rural popula-
10041 tion, if as I understand is meant by that, a population not provided with sewers but isloated in character and draining by individual outhouses or by over-hanging privies directly into brooks or other small streams. The infection at

Stony Brook was very similar in character to that already denoted as occurring at Ithaca, Butler and Plymouth.

Q. What other epidemics aside from those you have referred to are you acquainted with?

A. I am familiar with some of the well known instances recorded in the books on sanitary subjects and water supply. One of the very remarkable outbreaks of epidemic disease, due to infected water, was that occurring in Hamburg, Germany, from Asiatic cholera. Although Hamburg itself was .severly afflicted with cholera the neighboring suburb of Altona remained almost entirely exempt although its water supply was derived from the River Elbe below the point at which the sewage from Hamburg entered. The water supply of Altona was, however, safeguarded by the interposition of sand filters which proved effectual against the highly polluted river water. The difference between the two water supplies was so marked
10042 that in streets near the boundary line between Hamburg and Altona supplied partly by Hamburg water (unfiltered) and partly by Altona water that had passed through sand filters, the distribution of cholera cases corresponded exactly with the distribution of the water supply. Cholera cases occurred in houses supplied with the Hamburg water while the houses supplied with Altona water remained exempt from this disease.

This is regarded by sanitarians as one of the most striking demonstrations ever given of the connection between a polluted water and an outbreak of epidemic disease.

Other classical epidemics of water borne disease in Europe are the one at Lausen, Switzerland, where typhoid fever was caused by the polluted spring water; the outbreak of cholera in London due to the use of water from the Broad Street Pump; several outbreaks of typhoid fever in England, namely at Cotterham, at Worthing and in the valley of the Tees.

ADJOURNED until Tuesday, February 9th, 10:00 a. m.

10043 10:00 a. m., Tuesday, February 9, 1904, Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. What does the term epidemiology embrace?

A. As I understand it the term epidemiology embraces the study of vital statistics, the interpretation of these statistics; a consideration of the weight to be placed on the data of bacteriology and chemistry; a study of the modes of causation of various forms of infectious disease; a study of the sources and intensity of infection; a study of the relative incidence of disease upon rural and urban populations and the modes of spread of disease in urban and rural districts; a study of the relative share of urban and rural populations in polluting the public water courses; a study of the vehicles of infection in any given
community, such as food, drink, air infection, etc.; a
10044 study of the character and manner of differentiation of
various infectious diseases.

As I understand these and kindred topics are included within the scope of what is sometimes known as the science of epidemiology.

Q. Is there any distinct difference between an epidemiologist and a sanitarian, or are the terms synonimous?

A. As the terms are used at the present time they are often used interchangeably, epidemiology, as I understand it, being one branch and a very important branch of sanitary science.

Q. Please state what you mean by vital statistics and what sanitary significance do they have to an epidemiologist or sanitarian?

A. By the term vital statistics is meant all the available information regarding the number of persons attacked by various diseases, the number of persons dying of each disease or each class of diseases, the factor involved in the age and sex distribution of the population, and the influence of occupation and the factor so far as these affect the prevalence and fatality of disease:

In short, all the information that can be obtained in a sta-
tistical form regarding the morbidity and mortality in
10045 a given district or population.

As regards the sanitary significance that vital statistics have for the epidemiologist, I may say that it is generally considered that a correct understanding of vital statistics forms the necessary and proper foundation to the science of epidemiology. The accurate collection of facts regarding the prevalence and fatality of disease must perforce constitute the basis for any sound deductions as to the spread, causation and maintenance of epidemic conditions.

Q. Explain what you mean by the interpretation of vital statistics?

A. Assuming that the facts that furnish the basis for a study of vital statistics are accurately collected and tabulated, there remains the very important question of the interpretation of such statistics. It is not a matter of indifference how the figures so collected are viewed by the statisticians. Statistical pitfalls are numerous and certain fallacies of interpretation exist, the introduction of which may vitiate any conclusion drawn from figures in themselves exact.

To give an illustration: It is very commonly assumed that
the death rate in a city, that is the number of deaths per
10046 thousand population annually is a correct measure of
the healthfulness of such a city. The death rate, however, among individuals of different ages and of different nationalities varies so much that the crude death rate, that is the death rate per 1,000 population, without regard to age or sex distribution, or to racial characteristics, is often very far from affording any indication of the healthfulness of a given community.

Thus, that population having in it a large per cent. of infants or of aged individuals would have a larger number of deaths per thousand population than a community having a larger proportion of the individuals between the very resistant ages of say 15 and 40.

So in comparing one section of a city with another, the racial distribution of the population, that is to say the prevalence of persons of American born or German or Irish or Russian, parentage will affect the death rate very profoundly. In the interpretation of vital statistics, therefore, the interpretation of the crude facts observed is a matter of the utmost importance.

Q. In what way do racial characteristics manifest themselves?

A. It is well known that certain races of mankind mani-
10047 fest inborn powers of weakness or of resistance to the onslaughts of various forms of disease.

For example, persons of Irish parentage are much more liable to consumption and pneumonia than Russian and Polish Jews. Any city or any section of a city, therefore, having a large proportion of its population of Irish parentage, will have a higher death rate from consumption and pneumonia than a district containing few Irish and a larger proportion of Russian and Polish Jews.

Q. How much importance do you attach to the proper interpretation of vital statistics?

A. I attach the very highest importance to the interpretation of such statistics. The facts in themselves are meaningless unless correctly interpreted.

Q. What do you understand to be a proper interpretation of vital statistics?

A. An interpretation taking into account all the known factors of every kind that may have had a share in bringing about the conditions observed. Unless these factors are considered there can be no such thing as proper interpretation.

Q. Are you acquainted with the method known as the mortality percentage method?

10048 A. I understand that you mean by the expression "mortality percentage method" the method of representing the prevalence or fatality of a disease by reckoning the ratio of deaths from that disease to the total deaths occurring in that population during the period under consideration.

Q. What is your opinion as a sanitarian and epidemiologist as to the correctness of employing the mortality percentage methods for the purpose of ascertaining the prevalence of a given disease in a community?

A. It is my opinion that the mortality percentage method may and often does fail to give correct information as to the prevalence of a given disease in a community during any specified period.

Q. Is the mortality percentage method the method adopted and approved by the sanitarians and epidemilogists of this country and of Europe?

A. I think on the contrary this mortality percentage method is distinctly not in favor among sanitarians and epidemiologists here and in Europe.

The following is an excerpt from Newsholme's Vital Statistics, published in 1899, page 186.

This book is recognized as the leading authority in the
10049 English language on the question of vital statistics.

The statement is as follows:

"The mortality from any given disease or group of diseases may be stated as a proportion to the deaths from all causes. This method is, however, essentially fallacious, as it constitutes a ratio between two factors, of which both are variable, viz., the mortality from the specified disease, and the mortality from all causes. Dr. Ransome gives the following example of its fallacious character. Suppose a town of 1000,000 with 2,000 annual deaths, of which 500 are caused by phthisis. Here the general death rate is 20 per 1000; the death rate from phthisis is 5 per 1000 living and the death from phthisis forms one-fourth of the total deaths. In another town, having the same population, the total deaths are 4,000, and therefore the death rate 40 per 1,000 inhabitants; the deaths from phthisis are 1,000, and therefore the death rate from phthisis is 10 per 1,000; but the proportion of the phthisical to the total mortality is one-fourth, as before. In the second town, however, there is by the latter test apparently no worse condition, so far as phthisis is concerned, than in the first, though matters are really twice as bad.

In annual reports of medical officers of health the zym-
10050 otic mortality is frequently stated as a percentage of
deaths from all causes. Thus, if in one year the zymotic mortality forms 11 and in the next year 15 per cent. of the total mortality from all causes, it is evident that the relative mortality might be increased either by a diminution in total deaths or an increase of zymotic deaths, though the inference to be drawn in the two cases would be very different.

It is occasionally convenient to know the percentage of deaths due to different causes, in order to estimate the relative magnitude of the different causes of death; but this method can not be employed with propriety in comparing one community with another, or even in comparing the records of the same community in sucessive years."

Then again on page 336 of this book the paragraph headed "Fallacies arising from stating deaths in proportion to total deaths."

Which statement follows:

"These have already received consideration (pp. 124, 186). They present themselves under two heads. The deaths at one age are stated in proportion to the total deaths at all ages; or the deaths from one cause are stated in proportion to the total deaths from all causes. In both cases the same 10051 fallacy is involved. A relationship is attempted to be established between the two factors both of which are variable in value. An alteration in the total deaths on one hand, or in the deaths at one group of ages or from one cause on the other hand, might equally affect the proportion between the two, though the conclusion to be drawn in the two cases would by no means be necessarily identical."

I think that these statements of Dr. Newsholme represent the correct opinion among sanitarians and epidemiologists, regarding the validity of the mortality percentage method. This method involves an obvious fallacy.

Q. Does the mortality percentage method receive your approval as a sanitarian and epidemiologist?

A. For the reasons already set forth I do not consider or regard this method as shedding a true and proper light upon the relative incidence of disease in a community.

Q. What reasons have you for opposing the mortality percentage method as not furnishing the correct rule for the interpretation of vital statistics?

A. I will give an illustration of the fallacious character of this method.

In the city of New York, with a population of 955,921, in the year 1871, there were, according to the records of 10052 health for that City, 26976 deaths, 251 of these being from typhoid fever. The per cent. of the typhoid fever deaths to the total number of deaths was 0.93. The death rate per 10,000 inhabitants from typhoid fever was in this same year 2.62.

In the year 1898, in the City of New York, with a population of 2,048,830, the total deaths were 40,438, of which 376 were typhoid fever.

The typhoid fever deaths were again 0.93 of the total deaths, but the death rate per 10,000 inhabitants was 1.83. In other words, in these two years, 1871 and 1898, the percentage mortality of typhoid fever was the same but there was actually a decrease in the typhoid fever rate from 2.62 per 10,000 to 1.83 per 10,000, or a real reduction of over 30 per cent.

The mortality percentage method fails utterly to show that this reduction of over 30 per cent. has occurred.

A still more striking instance of the failure of the mortality percentage method to reveal such relations is shown in the annual reports of the health department of the City of Boston.

10053 In the year 1871, with a population of 258,032, the total number of deaths from all causes were 5,888, of which 176 deaths were from typhoid fever. The percentage of typhoid fever deaths to those from all causes was 2.99. The death rate per 10,000 inhabitants being 6.82.

In the following year, 1872, with a population of 265,764, the deaths from all causes were 8,090, of which 229 were from typhoid fever. The typhoid fever deaths were in this year 2.83 per cent. of the deaths from all causes. Thus, it would appear from the mortality percentage method that there had been a reduction in typhoid fever in that community, although the actual number of deaths had risen from 176 to 229.

This apparent reduction was of course caused simply by the remarkable increase in the number of deaths from all causes, namely from 5,888 to 8090. The death rate from typhoid fever, reckoned per 10,000 inhabitants, gave, however, a truer indication of the real conditions and showed that instead of diminishing from 1871 to 1872 typhoid had actually increased from 6.82 to 8.62.

Here again the mortality percentage method gives an entirely incorrect and erroneous conception of the real amount of mortality from typhoid fever.

Q. Professor Sedgwick, in answer to this question, page
10054 3540, of my copy of the record: "What method of ascertaining the percentage did you use in fixing the increase in typhoid fever in St. Louis," answered, "I used the method known as that of mortality percentages in which the typhoid fever mortality is compared with the total mortality of any given district. This method is a common one among sanitarians and students of vital statistics and is regarded as on the whole the most accurate, inasmuch as it takes no account of the population, always a dubious and uncertain factor, while the number of deaths is always or is usually more readily determined and also more accurate. It is the same method which I employed in my studies of the typhoid fever statistics of the city of Chicago in 1892, and I have often employed it in my investigations." What is your opinion as to the validity of using the mortality percentage method in estimating the conditions of typhoid fever in the city of St. Louis?

MR. JEFFRIES: I move to strike out all that part of the question which refers to the statement made by Professor Sedgwick or to the question put to him and all the question with the exception of the latter part which asks the direct question of the witness as to the value he places upon mortality percentages, for the reason that that part of the question which I move to strike out is incompetent, irrelevant and im-
10055 material.

A. I have already indicated my reasons for believing that the mortality percentage method is not a valid method. Uncertain as the population factor may sometimes be, the estimation of the death rate on the basis of population does not involve any such fundamental fallacy as that contained in the mortality percentage method, when owing to the fluctuation in the number of total deaths from year to year it is dealing with two variables and the ratio of deaths from one specific cause to the total number of deaths can not give a true indication of the prevalence of mortality from a specified cause. It is, therefore, my opinion that the mortality percentage method is not a valid one to use in estimating the typhoid conditions in the city of St. Louis.

Q. Is the "mortality percentage" method regarded as on the whole the most accurate among sanitarians and students of vital statistics?

A. In my opinion it is not.

Q. What, in your opinion as a sanitarian and epidemiologist, are the correct and proper methods to be employed in estimating the typhoid conditions in a given city?

A. In my opinion the statistics in the health records should be carefully examined and scrutinized as there are con-
10056 siderable differences in the practice of various health boards and organizations in the matter of reporting deaths under various and varying designations.

The ratios of deaths from a specified cause to the population, or what is known among vital statisticans as the death rate, usually considered on the basis of 1,000, 10,000 or 100,000 population, will then give, with a reasonably accurate estimate of the population, a fairly correct conception of the mortality from year to year and from decade to decade.

ADJOURNED until 1:30 p. m. same day.

10057 1:30 p. m. Tuesday, February 9, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. What do you mean by the expression "were to be based on bacteriological and chemical data?"

A. I mean that in my opinion a sanitarian should give such weight to all the evidence that he can obtain from bacteriology, from chemistry and allied science and should even go further and affirm that any information of whatever character, derived from whatever source, that throws light on the questions at issue, should be considered in epidemiological investigations.

Q. What is your opinion as to the value to be placed upon chemical and bacterial analysis of a water course?

A. It is my opinion that such analyses furnish important evidence as to the character of a water, and that while they often supplement and confirm the results of observation, 10058 they also at times reveal conditions that mere ocular inspection or observation would fail to bring to light.

Q. Do chemistry and bacteriology afford any assistance to an epidemiologist or a sanitarian in arriving at a correct judgment to be placed upon the value of a river water, and do they supply facts that are important?

A. In my opinion chemistry and bacteriology often afford very great assistance in arriving at a judgment of the character of a river water. It is sometimes true that chemical and bacteriological data are the only data that one can obtain in regard to the character of a given water and while the inferences from bacterological or chemical data alone are perhaps rarely final, such data are frequently the only available material upon which a judgment can be founded.

In any case an experienced epidemiologist would attempt to secure chemical and bacteriological data regarding the character of a river water as constituting an important element in enabling him to form a judgment of the water.

Q. What light do analyses of a river water shed upon 10059 the problem of self-purification of streams?

A. Here, in particular, analyses offer a material aid in determining the rate and extent of the process of self-purification. Analyses of a river water, polluted at its source, which are made at various points along its course, make it possible to trace the successive changes that take place in the amount and condition of the organic matter in the water, and in the number and kinds of bacteria.

It is my opinion that correct inferences may be drawn regarding the process of self-purification by the study of such analytical data.

Q. Are all these sources of information of which you have spoken about valuable to a sanitarian and epidemiologist?

A. I will reiterate what I have already stated that all sources of information of any kind, tending to shed light on questions in issue, are valuable to sanitarians and epidemiologists and should be investigated and considered.

Q. How is the presence of infectious disease ascertained?

A. In nearly all countries there are regulations requiring physicians to report all cases of certain infectious diseases occurring in their practice, to the health authorities. Some infectious diseases, such as smallpox, are very fully reported in this way, but it is true of many of the infectious diseases, especially the less highly contagious kinds that
10060
such reports to the health authorities are not made uniformly by all physicians.

In most parts of the United States the system of notification of cases of infectious diseases is very imperfect and incomplete. It is perhaps rather the rule than the exception for cases of infectious diseases to be reported promptly and in their full numbers to the health authorities. In too many instances all that the epidemiologist in this country has to depend upon is the mortality returns, the number of deaths recorded by the health authorities rather than the number of cases reported to them. Usually the only clue to the prevalence of typhoid fever in a community during a given period is the number of deaths recorded in the official health reports.

Q. What are the ordinary modes of causation of infectious diseases?

A. The ordinary modes of causation are very different and variable, according to the specific infections. In some cases there is reason for thinking that the infectious matter is air borne, such for example as in the case in tuberculosis and probably in smallpox. In others that the infection is transmitted from one individual to another by more or less
10061
direct contact, as is the case in diphtheria. In still other cases the use of infected drinking water or infected food is the common mode of causation.

Q. What are the chief sources of infection in typhoid fever?

A. The typhoid fever germ usually leaves the body of a patient in the urine or feces. These substances may carry the infection to the sewers, in case proper methods of disinfection are not practiced. The mingling of such infected sewage, containing the discharges from the bodies of typhoid fever patients, with water that is soon afterwards used for drinking purposes is the most common source of infection in typhoid fever, by far the largest number of outbreaks of typhoid fever that have been traced being due to infected drinking water. A considerable number of cases and of epidemics of typhoid fever are however caused in other ways. The milk supply sometimes becomes infected, either directly from a typhoid fever patient or convalescent, or indirectly through the medium of infected water.

Articles of food that are eaten in a raw condition such as oysters, celery and certain fruits may also be the source of infection in this disease.

It may also sometimes happen that the dust from dried
10062 excreta may be blown about and settle upon food and
thus be taken into the alimentary tract.

Insects, too, may play a part in contaminating substances. In the case of physicians and attendants having to do with the treatment of a typhoid fever patient, infection by contact may also occur, and in houses in which there are typhoid fever patients or convalescents, what is known as a secondary infection sometimes results, these cases of secondary infection being due to more or less direct transfer of the discharges of the patient to well persons.

Q. Is it important for the sanitarian and epidemiologist to know the source of infection as well as the results of such infection?

A. It is certainly most important that the source of infection be known since without such information it is impossible to take proper precautionary measures to prevent the spread or recurrence of an epidemic.

Q. Is it a legitimate inference that because typhoid fever increases in a city such increase is due to an increase in the infection of the water supply?

A. By no means, unless other sources of infection are eliminated. An increase of typhoid fever in a city may be due of
course to an increased infection of the public water sup-
10063 ply, but it may also be due to the infection of the milk
supply, to an infection of private wells, to special opportunities for the transmission of the disease by insects or to a change in the character of the population, such as the immigration of a large number of persons of susceptible ages, who had

not previously lived in the city, and acquired a certain degree of immunity.

Q. What other sources of infection are there in a city besides that coming from its water supply?

A. The milk supply; various articles of food; the agency of insects and other factors contribute to an increase in typhoid fever in a given city.

Q. In the case of the city of St. Louis which takes its water supply from the Mississippi River at the chain of rocks, Intake Tower, said river at that point being a mixture of the Missouri, Mississippi and Illinois Rivers—assuming that the reports of the St. Louis Board of Health show an apparent increase of typhoid fever during the years 1900, 1901, 1902, and 1903, as compared with previous years, is there any scientific reason that justifies the conclusion that said apparent increase of typhoid fever in St. Louis is due to infectious matter coming from the sewers of Chicago by way of the drainage canal?

A. Assuming that the reports of the St. Louis Board 10064 of Health show an apparent increase in typhoid fever during the years 1900, 1901, 1902 and 1903, as compared with previous years, it is not in my opinion a justifiable conclusion that said apparent increase of typhoid fever in St. Louis is due to any infectious matter passing into the sewers of Chicago and thence into the Illinois and Mississippi Rivers, by way of the drainage canal. An increase in the infection of the Mississippi River water from points near at hand would seem to me to afford a more satisfactory and scientific explanation of an increase of typhoid fever in St. Louis than the passage of any typhoid bacilli into the intake of the St. Louis waterworks from a point so far removed as Chicago.

Q. What are the instances where the sources of infection that caused epidemics of typhoid fever are known?

A. I have already cited several epidemics in which the evidence seems to me convincing that an infected drinking water was the cause of the outbreak.

Such are the epidemics of typhoid fever at Plymouth, Lowell, Ithaca and Butler, in this country.

An epidemic of typhoid fever traced to infected milk sup-

ply has occurred at Stamford, Conn., and Professor
10065 Sedgwick has described several cases of outbreaks of
typhoid fever in the state of Massachusetts, attributed
to infected milk.

At the time of the Spanish American War in this country outbreaks of typhoid fever among the soldiers in the military camps were traced to infection by flies.

Q. Are there sources of infection which cause typhoid fever epidemics other than drinking water?

A. Yes sir, those that I have already mentioned, namely, milk supply, infected food stuffs, the carriage of the bacilli by flies and perhaps some other agencies.

It has not been recognized until a relatively recent date that the fly can serve as a carrier of the typhoid bacilli. Strong epidemiological evidence for believing that that might be the case was brought out in connection with the occurrence of typhoid fever in the camps at the time of the Spanish American war, as already mentioned.

Since that time it has been definitely proven by Dr. Alice Hamilton, whose results have been printed in an article in the Journal of the American Medical Association for February 28, 1903. Miss Hamilton demonstrated the presence of living typhoid bacilli on the bodies of flies from privies or fences of two
yards, on the walls of houses and in the room of a ty-
10066 phoid patient, and as the result of an extended investi-
gation she concludes that flies played a part in spreading typhoid fever in one section of the city of Chicago in the summer of 1902.

It seems clear from her work that where the discharges from typhoid patients are left exposed in the privy or yards flies may be an important agent in the dissemination of typhoid infection.

Q. What do you mean by intensity of infection as an element to be considered by sanitarians and epidemiologists?

A. The specially severe incidence of disease in one district or in one section of a city might be regarded as a special intensity of infection. If there are 1,000 cases of typhoid fever in one ward in the city as compared with 50 in a neighboring ward, with the same population, the infection might be said to be more intense in one case than in the other.

The word intensity might be used, too, I suppose, to indicate severity of individual cases of disease. If among 1,000 cases of typhoid fever in one ward 200 died while in a neighboring ward with the same number of cases only 50 died, the intensity of infection might be said to be greater in the former case than in the latter.

Q. What evidence have you that the nearer the sources 10067 of infection the more severe the incidence of the disease?

A. It has been observed that where a community is served by an infected water supply there are often fewer cases of typhoid fever in the periphery of the town at a distance from the central source, than they are close to the point where the water is pumped into the mains. In other words, the greater the distance from the source of infection the less the intensity of the disease. The nearer the source of infection the more severe the incidence.

Q. Do you know of any facts or observations that justify the conclusion that the more remote the source of infection the less severe the disease?

A. The observations that I have just alluded to are observations of this character and indicate that the more remote the source of infection the less severe is the incidence of disease.

Q. Is there such a thing as decrease in the virulence of a typhoid fever germ?

A. It is probable that there is a decrease in virulence of a typhoid fever bacillus after its discharge from the human body although the evidence on this hand is scanty and not altogether satisfactory. Such evidence as there is, however, indi-
10068 cates that some decline in the virulence of a typhoid bacillus through a prolonged sojourn in water probably does occur.

Hankin (Centralbl f. Bakt. 1899, 26, p. 544) mentions that on a number of occasions he has found typhoid bacilli in waters at a time when these waters were being used for drinking purposes and that in several such instances no cases of fever developed among the users of such waters.

Indeed, he specifically takes the ground that "My finding typhoid microbes in a water supply gives no proof microbes were then present in a condition in which they could produce infection."

Remlinger and Schneider (Ann. de L'Inst. Pasteur, 1897, II, p. 55).

"Also encountered typhoid bacilli in waters that were not giving rise to fever and that water designated by them as being very pure."

Kubler and Neufeld (Zeitscher f. Hyg., 1899, 31 p. 133).

state that the typhoid bacillus that were first isolated by them from well water would kill a guinea pig in the dose of one-fifth of a loop, whereas a culture isolated later from
10069 the water of the same well did not prove fatal to a guinea pig in a dose five times as great.

There thus seems to be good reason for believing that by prolonged aquatic life typhoid bacilli are rendered innocuous or at least less virulent even where they are able to survive at all. The evidence then as to the decrease in virulence of a typhoid fever germ indicates, such as it is, that the longer a typhoid bacillus remains in water the less likely it is to cause disease.

Q. What do you mean by the decrease in virulence of a typhoid fever germ?

A. By decrease in virulence of a typhoid fever germ, I mean a diminution in its power to invade the human body and bring about pathological conditions.

Q. What is your opinion as to the relative virulence of a typhoid bacillus coming from a remote as compared with a nearer source?

A. It is my opinion, based upon such evidence as exists as to the diminution in virulence of a typhoid bacillus, that the longer such a bacillus sojourns in the water of a lake or river, the less likely it is to cause disease. It follows, consequently, that a typhoid bacillus after making a long journey by
10070 water will be less virulent than after a short journey.

Q. Will you distinguish between the effect of an urban and rural population upon a water shed?

A. I take the question to imply that the sewage and drainage from such urban and rural communities are discharged without purification or special treatment into the streams upon such water shed. It is now true that most urban communities are provided with sewers and it is also true that such sewage often passes directly into the nearest watercourse. The amount of pollution added directly to a river by an urban community is therefore considerable.

In the case of a rural community or of isolated dwellings or scattered farm houses the waste matters due to human life and habitation are not added as a rule so directly to the stream, although, as is well known, in most parts of this country it is a common custom for the outhouses and privy vaults to be located on or near the banks of small brooks or rivulets.

On the whole, however, the total amount of organic matter added to a water course by an urban community 10071 provided with sewers is greater per capita than the amount of similar organic matters added by a rural population of the same dimensions.

Q. Is typhoid fever more prevalent in urban than in rural communities?

A. No sir—just the reverse is true. Typhoid fever is a rural rather than an urban disease.

For example the death rate from typhoid fever in the thinly populated "Adirondacks and Northern" district of New York state in 1900 was 3.9 per 10,000 as compared with 2.0 in the so-called maritime district, including New York and the population thickly settled along the seaboard. This is only one of many instances that might be given as to the greater prevalence of typhoid fever in the country than in the city.

As confirmation of this statement I may quote from an article on typhoid fever in the Journal of the American Medical Association for January 9, 1904, by Dr. John S. Fulton of Baltimore.

According to the figures given by this authority, derived from the 12th census of the United States, typhoid fever 10072 is conspicuously a rural disease. He says "When we examine the rank of typhoid fever among all the causes of death we find that rural typhoid fever is credited with 62 in every 1,000 deaths as against 38 per 1,000 from urban typhoid." This writer gives elaborate diagrams and tables which bring out with great clearness the fact that typhoid fever at the present time in the United States is a rural rather than an urban disease.

Q. Is the danger from a rural population to be given slight consideration by a sanitarian or an epidemiologist?

A. It is my opinion that the danger from a rural population can by no means be ignored by any sanitarian or epidemiologist who wishes to take into account all data bearing upon questions of the spread and transmission of infection.

Q. Is the rural population on the water shed an important factor to be considered in passing upon a water supply of a city using river water for domestic and drinking purposes?

A. In my opinion it is a very important factor since serious infection of a water course may be due to rural infection. I am aware that the significance of rural population in this connection is not always assigned the importance which
10073 in my opinion it deserves.

Q. Professor Sedgwick, in his testimony (page 3,620 of my transcript of the record), stated in reply to the question: "Is it not a fact in sanitary science that the pollution of rivers by what we term the rural population is a very large factor in the consideration of the amount and the degree and kind of pollution," answered, "of pollution, yes sir." Question: "But scientifically considering infection you do not take it into account?" answer, "Not so much because the rural infection to begin with is well known and in the second place, owing to the time factor which is apt to come in, in the partial purification of the pollution the infectious matter may be destroyed." Is it a fact that the infection in the rural population is less common?

A. As I have just stated, typhoid fever is more prevalent in rural than in urban districts. So far from the disease being less common in a rural population the facts, in my opinion, show that it is more common.

MR. JEFFRIES: I move to strike the answer out because it is contained in a previous answer, and the question be-
10074 cause it is repetition, no new facts being brought out either by the question or the answer.

Q. Does the time factor mentioned by Professor Sedgwick really play an important part in preventing rural infection of water courses?

A. It is of course well recognized that in rural communities a longer period may elapse after the discharge of typhoid bacilli from the bodies of typhoid patients before the bacilli enter water courses, than is the case with such discharges in an urban community furnished with a sewage system.

It is also well known that typhoid bacilli in the infections or infectious discharges from the body of typhoid patients, when emptied into a loosely constructed privy vault or outhouse may retain their vitality and virulence for a long period. Such was the case in the Plymouth epidemic already cited.

Typhoid bacilli have been known to retain their vitality for upwards of five months in the contents of privy vaults. It is evident that if the contents of such vaults or outhouses be washed down into a stream by heavy rains or melting snows, or if the contents of said vaults be spread as manure
10075 upon fields near the banks of a river or other stream, the bacilli may find their way into the water course.

Despite the fact, therefore, that a long time elapses after the discharge from the body of the patient, and before such germs find their way into the water, the infectious matter may not be destroyed, owing to the conditions under which it is stored.

The time factor, therefore, would be of less significance in this connection than where bacilli were discharged directly into the stream itself.

Q. Do you know of any important typhoid epidemics in which infection has come from the rural population?

A. The most extensive localized epidemics of typhoid fever in this country, namely those at Plymouth, Pa., Ithaca, N. Y., and Butler, Pa., have been caused by infection from a rural population.

The epidemic at Lowell, Mass., was also due to the infection of the Merrimac River by isloated cases of typhoid fever and not from a population provided with sewers.

Q. Are there any reasons why infection from the rural
10076 population is to be specially feared?

A. It seems to me that there are at least two reasons why infection of a water course by a rural population is especially to be feared.

Q. What are those reasons?

A. The first of these is that, on the whole, disinfection of the dejecta and urine is less carefully and thoroughly carried out in rural communities than in urban, so that in a given number of cases of typhoid fever a larger proportion will be improperly cared for in rural communities than in cities.

In the second place, the storing up or accumulation of infectious material from typhoid cases may result in a very heavy infection of a water course, since the discharges that have collected during the whole course of a case of typhoid fever may be washed, all at once, by a heavy rain into a watercourse.

Still another reason and one that I believe to be very important is that when typhoid bacilli are added to a stream in the sewage of an urban community, they are accompanied by a large amount of organic matter and a large number of saprophytic bacteria.

10077 In rural infection on the other hand, the bacilli from a single case of typhoid fever may pass into a stream unaccompanied by any considerable amount of organic matter. The dilution with pure water of this relatively large number of bacilli and their mingling with the waters of a large stream constitute a peculiarly dangerous kind of infection. The competition of the sewage bacteria in such a case is not nearly so great as in the case of typhoid bacilli passing into the sewers of a large city.

It has been shown previously that typhoid bacilli will live longer in relatively pure water in the presence of a relatively small amount of organic matter than in a polluted water, charged with the sewage of a great city.

For these reasons, therefore, it is my judgment that the infection from a rural population should not only not be ignored but should be especially feared.

Q. What do you mean by character of diseases as an element to be considered by sanitarians and epidemiologists?

A. I mean by that that the vital statistics, the reports of morbidity and mortality should be examined with a view to determining the class and nature of the disease as disclosed by an analysis of the alleged causes of death as reported in 10078 the official publications. The discrepancies in nomenclature and the varying practice of the custodians of public health records in the various parts of the country render such examination necessary if a correct idea is to be obtained regarding the actual character of the disease present or rife in a given community.

Q. Have you examined the typhoid mortality statistics of the city of St. Louis as evidenced by the reports of the Board of Health of the city of St. Louis?

A. I have.

Q. Have you examined the typhoid mortality statistics of the city of Chicago as evidenced by the reports of the Board of Health of the city of Chicago?

A. I have.

Q. Have you prepared a table of typhoid deaths based upon those reports?

A. Yes sir, I have a table of the deaths reported from typhoid fever in St. Louis by months from January, 1890, to December, 1903, inclusive, and I have a similar table for Chicago for exactly the same period.

Q. Will you produce and read the mortality typhoid statistics of the city of St. Louis and the city of Chicago 10079 as compiled by you from the Board of Health reports of those two cities, covering said periods?

A. They are as follows:

10080

TYPHOID FEVER, ST. LOUIS.

Month.	1890	1891	1892	1893	1894	1895	1896
Jan.	11	5	13	36	2	12	4
Feb.	4	9	8	17	7	3	4
March.	6	4	7	8	8	3	3
April.	4	10	9	8	14	7	4
May.	8	9	3	3	5	6	9
June.	8	11	6	2	11	6	6
July.	12	17	15	11	21	9	13
Aug.	19	12	8	42	24	17	29
Sept.	27	32	23	32	32	9	13
Oct.	18	26	45	20	20	15	9
Nov.	16	11	111	25	20	13	7
Dec.	7	16	189	11	7	7	5
	140	162	442	215	171	107	106

10081

TYPHOID FEVER—ST. LOUIS.

Month.	1897	1898	1899	1900	1901	1902	1903
Jan.	7	4	10	19	8	14	15
Feb.	9	6	7	5	14	16	15
March.	7	7	4	16	11	11	20
April.	4	6	5	4	4	14	17
May.	7	2	2	4	8	11	15
June.	9	7	5	8	6	7	16
July.	10	9	9	15	13	14	27
Aug.	18	9	6	20	31	26	37
Sept.	17	14	16	13	24	21	42
Oct.	17	12	15	30	32	32	29
Nov.	15	7	32	13	27	31	24
Dec	5	12	20	19	20	25	31
	125	95	131	168	198	222	288

10082

TYPHOID FEVER—CHICAGO.

Month.	1890	1891	1892	1893	1894	1895	1896
Jan.	53	67	311	41	46	30	87
Feb.	136	61	187	30	26	21	89
March.	103	71	76	41	27	26	65
April.	45	136	56	58	30	30	33
May	82	408	70	56	31	30	31
June	107	167	55	60	31	18	44
July	86	200	211	55	37	36	58
August	115	182	179	76	52	59	64
Sept.	95	198	138	86	71	76	87
Oct.	72	171	92	81	68	90	89
Nov.	67	150	67	43	38	60	60
Dec.	47	186	47	43	34	42	44
Total	1008	1997	1489	670	491	518	751

10083

TYPHOID FEVER—CHICAGO.

Month.	1897	1898	1899	1900	1901	1902	1903
Jan.	38	29	44	23	26	21	97
Feb.	46	32	24	14	16	14	54
March	41	71	18	27	15	20	49
April	19	94	23	23	20	16	33
May	13	67	25	19	24	24	26
June	23	35	28	17	9	22	21
July	27	55	41	26	55	44	29
Aug.	42	45	62	34	83	193	59
Sept.	48	65	58	34	74	165	82
Oct.	61	62	44	38	102	78	45
Nov.	44	56	43	39	54	72	56
Dec.	35	55	32	43	31	132	36
Total	437	636	442	337	509	801	588

10084 Q. What relation do the monthly deaths from typhoid in Chicago bear to those in the city of St. Louis the period from 1890 to 1903, inclusive?

A. From these tables I am unable to discover any relation between the monthly deaths from typhoid fever in Chicago and those in St. Louis.

I have compiled from these tables a statement showing those months of maximum typhoid fever in Chicago and St. Louis and those showing the minimum deaths from typhoid fever in these two cities.

The month showing the largest number of deaths in Chicago precedes the maximum in St. Louis by 11 months in one year (1892),
by 8 months in one year (1903),
by 6 months in one year (1891),
by 5 months in two years (1896 and 1898),
by 3 months in one year (1899),
by 2 months in one year (1902).

The Chicago maximum coincides with the St. Louis maximum in five years, namely: 1893, 1895, 1896, 1897 and 1900.

The minimum typhoid fever in Chicago precedes the
10085 minimum in St. Louis in six years, namely, 1891, 1893,
1898, 1900, 1902. The Chicago minimum coincides with
St. Louis minimum in 2 years, 1892 and 1890, and follows the St. Louis minimum in 7 years, 1890, 1894, 1895, 1896, 1897, 1901 and 1903.

Q. Have you made a study of the typhoid death statistics of the City of St. Louis and Chicago covering that period?

A. Yes sir, I have examined these very carefully and the results are set forth in the tables as just recorded.

Q. Is an increase in the death rate from typhoid fever in St. Louis preceded by a corresponding increase in the death rate from typhoid fever in Chicago?

A. It is not.

Q. Is a decrease in the death rate from typhoid fever in Chicago followed by a decrease in the death rate from typhoid fever in St. Louis?

A. I am unable to discover any relation between the monthly deaths from typhoid fever in Chicago and those in St. Louis.

A decrease in the number in Chicago is not followed by a decrease in the number in St. Louis, nor is an increase in the deaths in St. Louis preceded by a corresponding increase in the deaths in Chicago.

Q. If the typhoid fever in St. Louis, for the period from
10086 1890 to 1903, inclusive, was caused by infection coming
from the city of Chicago, would not some relation exist between typhoid conditions in Chicago and the typhoid conditions in St. Louis?

A. I should certainly expect to find some relation obtaining between the prevalence of this disease in Chicago and that in St. Louis.

I should anticipate that in general if the typhoid fever conditions in St. Louis were dependent upon those in Chicago that a large number of deaths from typhoid fever in the latter city would be followed within three or four months by an increase in the number of typhoid deaths in St. Louis.

No such relation appears in the monthly records of typhoid fever of these two cities as tabulated.

It is therefore my judgment that typhoid fever conditions in St. Louis are unaffected by a large amount or a small amount of typhoid fever in Chicago.

ADJOURNED until 10:00 a. m., February 10, 1904.

10087 10:00 a. m., Wednesday, February 10, 1904. Continua-
tion pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN

resumed the stand for further direct examination by Mr. Todd and testified as follows:

Q. What relation do flood waters in the Illinois River bear to the increase or decrease of typhoid fever deaths in the city of St. Louis?

A. I have prepared a table showing the water gauge readings obtained by the United States engineer at the Kampsville Lock, by months, for the years 1899, 1900, 1901 and 1902. These are the means of tri-daily readings. The readings are referred to the lower miter sill, or 7 feet below low water.

I find on comparing these readings of the heights of water in the Illinois River at the Kampsville Lock, that high water occurred in March, 1899, and low water in September, 1899. The maximum typhoid fever in St. Louis in that year occurred in the month of November and the minimum typhoid
10088 fever in the month of May.

In 1900 the high water period was again in the month of March and the lowest water recorded in January. The maximum typhoid fever in 1900 was in the month of October and the minimum in the months of April and May. In 1901 the maximum height of water occurred in the month of April and the low water period in October. The maximum typhoid fever in St. Louis occurred in the month of October and the minimum in the month of April.

In 1902 the maximum high water occurred in the month of July and the minimum in the month of January. The maximum typhoid fever in St. Louis occurred in the month of October and the minimum in the month of June.

A very interesting comparison may be made between the months of July, August, September, October and November, 1901 and 1902. The water in the Illinois River averaged nearly twice as high in 1902 as in 1901 and yet the typhoid fever at St. Louis was almost exactly the same in the latter part of those years as is shown by reference to the tabulated table of monthly deaths.

Q. When there is low water in the Illinois River what
10089 effect does that stage of water have upon the increase or decrease of typhoid fever in St. Louis?

A. From an examination of the tables just referred to I am unable to discover any connection between the stage of low water as disclosed in the gauge readings at Kampsville and a large amount or small amount of typhoid fever in St. Louis.

In the four years for which record is at hand, absolutely no relation exists between low water in the Illinois River as shown in the gauge readings at Kampsville and an increase or decrease in the typhoid mortality in the city of St. Louis.

Q. Is a high death rate from typhoid fever in Chicago, during cold weather, followed by correspondingly high death rate from typhoid fever in the city of St. Louis, allowing for the period of incubation and distance of flow between Chicago and St. Louis?

A. From an examination of the monthly deaths reported from typhoid fever in St. Louis, I am unable to discover any such relation between a high death rate from typhoid fever in Chicago in the winter months and the typhoid mortality in St. Louis, two or three months later, when allowance is made for the periods of incubation and time of flow between Chicago and St. Louis.

10090 Thus, in December, 1900, the number of deaths reported from typhoid fever in the city of Chicago was the largest reported for any month in that year. In the early months of 1900 in St. Louis no marked increase of deaths appears as a consequence of the large number of deaths in Chicago.

Again, in 1902, the number of deaths from typhoid fever for Chicago in December and also in January, 1903, was very extensive, but the number of deaths in St. Louis in March, April and May of 1903, was not materially in excess of those in the preceding year when the number of typhoid deaths in Chicago for the corresponding months of January and December had not been one-fourth as great.

Q. From a careful study of the typhoid death rate in St. Louis and Chicago, covering the period from 1890 to 1903, inclusive, taking into consideration the seasons of the year and the stages of the water in the Illinois River, is there, in your opinion, any relation existing between the typhoid conditions in St. Louis as evidenced by its mortality statistics and the typhoid conditions in Chicago, as they exist, as evidenced by the mortality statistics of Chicago, showing that the typhoid condition in St. Louis during this period is due as a whole or in part to infection coming from the city of Chicago?

10091 A. From an examination of the monthly deaths reported from typhoid fever in Chicago and St. Louis between 1890 and 1903, inclusive, I am unable to discover any dependence of the mortality in St. Louis upon that in Chicago, as respects extent of mortality, season of year or stages of water in the Illinois River.

Q. Have you made a special study of the so-called germ diseases?

A. Yes sir, in connection with my work in bacteriology I have had to study a number of the so-called germ diseases with considerable care.

Q. Do these diseases caused by germs come within the scope of your study?

A. Yes sir, it is generally conceived that the scope of bacteriology today includes the various diseases due to germs of various kinds, to those closely related to bacteria as well as to bacteria themselves. I refer especially to the so-called protozoan diseases of which malaria is a type. The malaria germ is not a bacterium properly speaking, but a protozoan. Malaria is, however, one of the germ diseases and is studied and investigated by bacteriologists.

Q. Will you distinguish between a protozoan and a bacterium?

A. A protozoan is a one-celled animal; a bacterium a one-celled plant.

10092 The protozoa are of a more complicated sturcture than the bacteria and possess as a rule more intricate life histories. Protozoa are the lowest members of the animal series as the bacteria are the lowest plants known.

Q. What studies have you made upon typhoid fever and malaria fever from the standpoint of a bacteriologist?

A. I have examined the organisms of these diseases and have made blood examinations from cases of typhoid fever and malaria and have examined the literature with reference to the geographical distribution, fatality and general character of these diseases.

Q. In connection with such study as you have detailed, does that lead you into the question of the proper diagnosis of the fevers, the kinds of typhoid and malaria?

A. Yes sir, that has become a very important question in bacteriological laboratories in the last few years. It is now generally recognized that a very important and perhaps the most important means of distinguishing between typhoid fever and malaria is by examinations made in the laboratory.

Q. Have you had any experience with the diagnosis of these fevers?

Yes sir, I have examined and caused to be examined
10093 blood coming from patients suffering from these diseases.

Q. Have you studied these questions sufficiently to give an expert opinion upon them?

A. I think that I have.

Q. What is typhoid fever and its clinical diagnosis?

A. The symptoms of the disease known as typhoid fever are quite various, but the disease is characterized ordinarily by certain well marked peculiarities, such as the temperature curve with its gradual step-like ascent, until the height of the fever is reached, and then its gradual step-like decline. The onset of typhoid fever is often marked by a severe headache, although this symptom may be absent. There is often abdominal pain and tenderness. In a considerable proportion of cases, over 70 per cent., I believe, rose-spots appear on the abdomen. These spots are due to typhoid bacilli in the skin where the spots become reddened. This is a specific eruption due to typhoid bacilli in those cases.

Epitaxis is not an uncommon symptom in this disease. In most cases of typhoid fever a few days after the onset of the
attack an examination of the blood by what is known as
10094 the Widal test affords a highly characteristic mark of
the disease and is one of the most important diagnostic features. The blood of patients suffering from genuine typhoid fever responds positively to this test while the blood of well persons or persons suffering from other diseases than typhoid fever give as a rule negative results.

Q. What is malarial fever and its clinical diagnosis?

A. There are three well recognized types of malarial fever, due to three different kinds of parasites. These different types of fever are characterized by a difference in the periodicity of the well known malarial paroxysm. In the tertian type of malarial fever the parasite completes the cycle of its development every 48 hours. The onset of the paroxysm coincide with the sporulation of the parasite and the disintegration of the blood corpuscles that accompanies this process. The tertian form of malarial fever is much more common in the temperate zone than either of the other phases. It is rarely, if ever fatal in its uncomplicated form.

The quartan malarial fever is caused by a parasite very similar to the tertian parasite, but completing its life cycle in 72 hours instead of 48. The malarial paroxysm occurs every third day instead of every other day, as is the case in
10095 the tertiary fever.

Tropical malarial fever is caused by a parasite with a somewhat irregular cycle of development; the parasite of the tropical fever is not so commonly found in the circulating blood as the others, but carries out a large part of its life history in the internal organs, such as the spleen. This is the most serious of the three types of malarial fever. These parasites, the tertian, the quartan and the tropical parasite can be recognized by a blood examination. The parasites, in each case, invade the red blood corpuscles and pass through the various phases of their development ensconced in the body of the red blood corpuscles.

Q. What is intermittent fever and its diagnosis?

A. The term intermittent fever refers to that type of fever in which the temperature after being high for some time is intermitting, and the temperature of the individual returns completely to the normal. The term is loosely used but is applied often times to various forms of malaria.

Q. Is it a distinct type of fever?

A. It is not.

Q. What is remittent fever and its clinical diagnosis?

10096 A. The distinction between remittent and intermittent fever lies in the fact that the temperature does not return completely to normal in the remittent, but rises and falls.

Q. Is remittent fever a distinct type of disease?

A. It is not. The symptom of remittency may characterize various pathological conditions.

Q. What is typho-malaria fever and its clinical diagnosis?

A. The term typho-malaria fever as ordinarly applied in this country is used for fevers which may be either typhoid or malaria. Most of the cases of so-called typho-malaria are really cases of typhoid fever. It may rarely happen that a mixed infection occurs, that an individual is infected both with the bacilli of typhoid fever and with some one of the malarial parasites, but these cases are so rare as to rank as medical curiosities, and have no far-reaching significance. Typho-malaria fever is not a distinct entity.

Q. What is congestive fever and its clinical diagnosis?

A. The term congestive fever is a vague term, comprising no definitely recognized type of disease. The symptom of congestion of various internal organs such as the liver is what has perhaps given rise to the use of this term.

10097 No such disease as congestive fever is recognized by the best physicians at the present day.

Q. What is simple continued fever and its clinical diagnosis?

A. The term simple continued fever is an old term in medicine which owes its origin to a period when methods of diagnosing diseases were not so far advanced as at present. As the name implies, it refers to a type of fever in which the temperature remains high for quite a long period. Most of the cases that would be likely to be reported as cases of simple continued fever at the present time are simply cases of mild typhoid fever.

Q. Are intermittent fever, remittent fever, typho-malaria fever, congestive fever and simple continued fever distinct types of fevers and so recognized by bacteriologists and clinicians?

A. Most of the affections designated by these different names are either typhoid fever or malaria, and these terms, mentioned in your question, are not generally employed at the present time as representing different and specific types of disease.

10098 Q. What epidemiological and sanitary significance are attached by statisticians to these fevers as above described, when they appear in vital statistics?

A. It is generally considered that these designations relate in almost every instance to cases of typhoid fever and that they should be so regarded.

It is the general opinion among statisticians that the deaths so classed should be transferred bodily to the column of deaths from typhoid fever since they are practically in all cases death from typhoid fever and not deaths from malaria. Malaria in fact, as it occurs in temperate countries is rarely fatal.

Professor William Osler of Johns Hopkins University, in his article on malaria fever in Allbutt's System of Medicine, Vol. III, p. 738, states:

"Unfortunately for many years and in many regions practitioners have been in the habit of labeling as malaria every instance of obscure disease in which they could not make a diagnosis; so that the vital statistics are falsified in a remarkable manner. In the United States Census Report for 1890, which covers the six preceding years, the deaths from 10099 malarial fever in New York and in Brooklyn were more numerous than from typhoid fever. In both these cities it is notorious that a death from true malaria is a great rarity, not more than three or four cases occurring each year in the entire hospital practice of the city of New York."

"In the regular forms of malarial fever the death rate is very slight, and results usually from complications, such as acute nephritis."

In the testimony of Dr. William C. Woodward, who has already testified in this case, page 4602, I find the question:

"In this table marked Exhibit 74, you have what is known as typhoid malaria and typhoid fever. What is the difference between typhoid fever and typhoid malaria"? The answer: "I regard a case of typho-malaria fever as a case of typhoid fever, in which the physician has made a mistake at the beginning and called it malarial fever, and he seeks the best way to get out of the hole. We classify them separately because some people regard them as different diseases, and we furnish our statistics to people and let them use them as they see fit, but I have expressed my opinion."

"There is a very marked distinction between malarial 10100 fever and the other diseases, unless you regard the typho-malarial fever as typhoid fever. When it comes to typhoid malaria and typhoid fever, the best authorities today, I believe, regard them as the same disease."

In a recent article by Dr. John S. Fulton, Health Officer of Baltimore, Maryland, entitled "Typhoid Fever," and appearing in the Journal of the American Medical Association, for January 9, 1904, this matter of the relation between typhoid fever and malaria is exhaustively discussed with a very full statistical presentation. On page 74 of this article is given a series of charts, showing the typhoid mortality and the reputed malaria mortality in different sections of the United States. These charts show that the malaria curve below the line reflects the typhoid curve above as faithfully as the shores are reflected by the surface of a lake, the seasonal apex of the groups corresponding.

Dr. Fulton states his own opinion as follows:

"My personal belief is that fatal malaria intoxication does not happen to one citizen a year in Maryland, though malaria is in some parts of the state a considerable cause of disability."

Then again: "Of all the mortality charged in the South to malaria, death perhaps is due to typhoid fever. The United
States Army experience would indicate that not more
10101 than half is due in fact to typhoid, and certainly more
than 50 per cent. of the mortality so charged is not due to malaria. In the North a much larger part, probably two-thirds of the reputed malarial mortality, represents unrecognized typhoid."

Outside of certain well known areas malaria does not kill citizens of the United States, and within those areas, where malaria is a cause of grave sickness, its right to be considered an important cause of death has not been subjected to the rigid scrutiny which its apparent importance demands."

"Speaking for that part of the United States that I know best, I can say that the terms "malarial" and "typho-malarial" express no definite belief as to the cause or character of a disease,
but are applied to fevers of inderterminate nature."
10102 It is my opinion that these statements represent cor-
rectly the prevailing judgment regarding these designations of intermittent fever, etc., used in mortality records. The great majority of the deaths so reported are due to typhoid fever.

Q. Mr. William C. Woodward, whom you quoted, is the Health Officer of the District of Columbia is he not?

A. I believe that he is.

Q. Does the number of deaths reported as occurring from typhoid fever in the City of St. Louis, according to the reports of the St. Louis Health Department represent, in your opinion, the total number of typhoid deaths actually occurring in that city for the period from 1890 to 1903, inclusive?

A. They certainly do not.

Q. What reasons have you for stating that they do not?

A. I find in the records of the Health Department of the City of St. Louis a very considerable number of deaths under the heading remittent, intermittent, typho-malarial, congestive and simple continued fevers. I have already given what seems to me adequate reasons for believing that the majority of these, if not indeed all of them, were deaths from genuine typhoid fever and properly should be so classed.

10103 Q. To what do you attribute the failure of these statistics to properly disclose the number of typhoid fever deaths occurring in the City of St. Louis?

A. Since there is, in my opinion, no question that a number of deaths reported under the head remittent, intermittent, typho-malarial, congestive and simple continued fevers were undoubtedly deaths from typhoid fever and since there is no precise method of determining just what proportion of these deaths were actually deaths from typhoid fever, it is certainly difficult, if not impossible, to determine how many typhoid fever deaths actually occurred in St. Louis during a given year, particularly since the number of deaths recorded under the heading remittent fever, etc., is so very large in St. Louis.

Since there is no reason to suppose that these figures do not correctly represent the reports received from the physicians of St. Louis, I see no escape from the conclusion that the value of these statistics to properly disclose the number of typhoid fever deaths occuring in St. Louis was due to an improper diagnosis.

Q. Why is it that doctors will apply the terms remittent, intermittent, typho malarial, congestive and simple continued to fevers that are recognized as being typhoid or malaria?

10104 A. These terms that you mentioned have the weight of traditional use behind them. Furthermore it is only in relatively recent years that the sure distinction and differentiation of typhoid and malarial fevers has become possible, through the application of laboratory methods. Many of the physicians who received their medical education before these laboratory methods were in vogue do not habitaually employ such methods in their practice, and without these modern methods, on the basis of clinical symptoms alone, it is often difficult and indeed well nigh impossible to differentiate obscure and indefinite types of fever.

Q. Do you know of any city in the country where the death rate from malaria alone is as high as in the City of St. Louis, as evidenced by the Board of Health reports of that city?

A. No sir, I do not. In my opinion no city in the United States has as large a death rate from genuine malaria as would be indicated by the official records of St. Louis, assuming that all deaths reported under this head of remittent, intermittent fever, etc., were deaths from malaria.

10105 What do the malaria statistics show in cities where careful attention has been paid to malaria fevers?

A. In the city of Baltimore where particular attention has been paid to the study of malaria and typhoid fever and their diagnosis, at the Johns Hopkins University Medical School, the effect of such study is shown in the relatively small number of deaths reported from malarial and typhoid malarial fevers.

I may say that it is the practice in that city to class the deaths reported from typho-malarial with the deaths from typhoid fever rather than with malarial. This seems to be an indication that the health authorities of that city are convinced that the deaths reported by physicians as occuring from typho malarial are in reality cases of typhoid fever.

Q. Is it generally recognized by sanitarians and epidemiologists that classifying typhoid fever in one column and remittent, intermittent, typho malaria, congestive and simple continued fevers in another column in board of health reports is an improper classification from a scientific standpoint of view, as affording a true indication of the prevalence of typhoid fever and malaria?

A. In my opinion the classification is so recognized.

10106 A truer indication of typhoid fever mortality would be obtained by adding the deaths reported under the miscellaneous headings to the deaths reported as occurring from typhoid fever. This confusion of the records of vital statistics is, of course, especially liable to occur in those districts where malaria is prevalent and where a faulty diagnosis on the part of the attending physician is more liable to occur.

Q. Have you compiled from the board of health reports of the City of St. Louis, a table showing the typhoid deaths by each month from 1895 to 1903, inclusive, with a table for the same period, with the fevers indicated at the heading, remittent, intermittent, typho malarial, congestive and simple continued fevers?

A. I have.

Q. Will you produce and read into the evidence, the compilations which you have made?

A. It is as follows:

10107

ST. LOUIS.

	1895		1896		1897		1898		1899	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
Jan.	12	10	4	13	7	7	4	6	10	4
Feb.	3	7	4	10	9	5	6	10	7	8
March.	3	8	3	6	7	11	7	9	4	6
April.	7	7	4	11	4	13	6	8	5	6
May.	6	9	9	10	7	8	2	8	2	12
June.	6	14	6	7	9	18	7	10	5	8
July.	9	8	13	23	10	17	9	13	9	18
Aug.	17	15	29	34	18	20	(9	14)	6	30
Sept.	9	32	13	27	17	31	14	18	16	28
Oct.	15	24	9	20	17	24	12	12	15	16
Nov.	13	8	7	14	15	13	7	13	32	8
Dec.	7	13	5	2	5	5	12	13	20	4

A—Typhoid Fever.

B—Remittent, Intermittent, Typho-malarial, Congestive, and simple continued fever.

10108 ST. LOUIS.

	1900		1901		1902		1903	
	A.	B.	A.	B.	A.	B.	A.	B.
Jan.	19	6	8	5	14	5	15	4
Feb.	5	3	14	0	16	6	15	1
March.	16	9	11	4	11	9	20	4
April.	4	7	4	7	14	3	17	4
May.	4	7	8	7	11	8	15	8
June.	8	12	6	9	7	4	18	8
July.	15	9	13	15	14	12	27	10
Aug.	20	20	31	5	26	7	37	10
Sept.	13	20	24	9	21	16	42	17
Oct.	30	9	32	11	32	17	29	17
Nov.	15	3	27	5	31	9	24	3
Dec.	19	7	20	3	25	6	31	5

A—Typhoid Fever.

B—Remittent, Intermittent, Typho-malarial, Congestive and simple continued fever.

10109 Q. Will you state what this table shows?

A. This table shows the deaths in St. Louis by months from January, 1895, to December, 1903, inclusive, recorded under the headings A typhoid fever, B, remittent, intermittent, typho-malarial, congestive and simple continued fevers.

The table shows a close parallel between the number of deaths reported from these two causes. In the months of July, August, September and October the number of deaths reported under both of these headings is high, while in the months of April and May it is on the whole low.

An interesting change is noted in the latter part of this table. For the first five years of the table the number of deaths under the heading B (remittent fever, etc.), was greater than the number of deaths under the heading A (typhoid fever). Beginning with 1901 the reverse is true. The number of deaths reported under the heading typhoid fever becomes greater than the number reported under the heading remittent fever. To take for example the month of September:

	A (typhoid fever)	B (remittent fever etc.)
1895	9	32
1896	13	27
1897	17	31
1898	14	18
1899	16	28
1900	13	20
1901	24	9
1902	21	16
1903	42	17

10110 Inspection of these figures shows that in the last four years there has been a transfer from the column B, that of remittent fever, etc., to the column A, that of typhoid fever, the effect being to diminish the number of deaths reported as remittent fever, etc., and increase those reported as typhoid fever.

Q. Have you prepared a table from the board of health reports of the City of St. Louis for the years 1890 to 1903, inclusive, showing the number of deaths reported in the typhoid column the number of deaths in the remittent, intermittent, typho-malarial, congestive and simple continued fever column, and the added totals of these two columns for the period above mentioned?

A. I have.

Q. By whom was the table that you have already read in evidence and the one that you now have prepared, and from what source was the information taken that is contained in the tables?

A. These tables were prepared by me personally and the information upon which they are based was obtained 10111 from the official reports of the health department of the City of St. Louis.

Q. Will you read the table last described by you in evidence?

A. It is as follows:

10112 ST. LOUIS. Population 1900, 575,238

Year	Typpus Typhoid Fever	Reported Deaths from Remittent, Intermittent, Typho-malarial Conjestive and simple Continued Fevers.	Total
1890	140	226	361
1891	165	216	381
1892	441	326	767
1893	215	284	499
1894	171	179	350
1895	107	155	262
1896	106	177	283
1897	125	172	297
1898	95	134	229
1899	131	148	279
1900	168	112	280
1901	198	80	278
1902	222	102	324
1903	288	91	379

Q. State what the table you have just read in evidence 10113 shows?

A. This table shows a similar condition to that evidenced in the table of monthly tables just produced. The total number of deaths per year reported under the heading typhoid fever, and under the heading remittent fever, etc., are given in this table.

They show that a much larger proportion of deaths is recorded under the heading remittent fever, etc., before the year 1900 than since that year.

They also show that whereas the number of deaths reported from typhoid fever was generally less during the first 10 years of this period than the number of deaths reported from remittent fever, etc., during the last four years, the case has been just reversed. It is evident that there has been some cause or that there have been some causes at work tending to produce a more accurate diagonsis on the part of the physicians and that a larger number of cases of true typhoid fever have been recognized as such during the latter period than during the earlier one.

Q. Professor Teichmann testified (page 2336 of my transcript of the record) that two circular letters "one issued 10114 in the fall of 1900 and another one issued in the fall of 1901" were "issued by the Health Commissioner of St. Louis, calling the attention of physicians to the fact that the law required them to report all cases of typhoid and all deaths from typhoid" and at the time that letter was sent out the question of opening the drainage canal was being agitated in the public press of St. Louis and there was considerable discussion" and an investigation was going on at that time of the analyses of the samples, etc.," and that attracted considerable attention. From your examination of the statistics of St. Louis for the years 1900, 1901 and 1902, as compared with previous years, does the effect of such a letter, as testified to having been sent to the doctors of St. Louis by the health department of St. Louis, manifest itself in the statistics?

Mr. Jeffries: Objected to for the reason that it is for the court to determine from all the evidence whether any effect whatever was produced by the issuance of the letter as testified to by Professor Teichmann, and not for this witness to draw conclusions therefrom, the question not eliciting expert analysis or testimony.

10115 A. It certainly seems reasonable to suppose that such a letter as that described in your question as having been sent to the physicians of St. Louis would have some effect upon their scrutiny of cases of fever and that it might cause them to pay closer attention to diagnosis and perhaps apply some of the modern methods of differentiating typhoid fever from conditions for which it might be mistaken.

It is certainly in my opinion a significant fact that since 1900 there has been this decided change in the mode of reporting deaths.

Mr. Jeffries: I move to strike out the answer for the reason stated in the question, and for the further reason that the answer is all together argumentative and it is not for this witness to argue this case.

Adjourned until 2:00 P. M same day.

2:00 P. M., Wednesday, February 10, 1904.

10116 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. In what way does the effect of such letters appear on the statistics?

MR. JEFFRIES: Objected to for the same reason as contained in my objection to the last preceding question.

A. Beginning with the year 1900 the proportion of deaths from typhoid fever is much greater as compared with the deaths from intermittent fever than in the preceding decade. This is just the effect that would be expected if the attention of the physicians had been specially directed to the diagonsis and differentiation of typhoid fever in its various forms, including obscure and mild cases.

For the three years, 1899, 1900 and 1901, the total number
of deaths reported from "typhoid fever," and "remittent
10117 fever, intermittent fever," etc., is almost precisely the
same, but the proportion reported from typhoid fever
alone in 1900 and 1901 is much greater than in 1899.

Q. From your examination of the typhoid and typho-malarial group (meaning to include in the latter those deaths reported under the head of remittent, intermittent, typho malarial, congestive and simple continued fevers), what is your opinion as to whether these two tables taken separately correctly show the typhoid condition in the City of St. Louis for the period mentioned?

A. It is my opinion that considering the number of deaths reported separately under the heading typhoid fever, that the total number of such deaths and the average number is not correctly represented by the tables reported under this head alone.

Q. Upon what do you base your opinion that they do not correctly show the typhoid conditions in the City of St. Louis, taking them separately?

A. I base my opinion upon all the facts that are known

concerning the sources of error in the collection of vital
10118 statistics, the possibility of error in diagonsis in this
group; the improvements in methods of diagnosis during
the last few years, and the attention that has recently been
specially focused upon this group of diseases.

There is every reason to suppose that during the first five years covered by these tables a larger proportion of the deaths recorded under the heading "intermittent fever, etc." were genuine typhoid fever than in the latter period owing chiefly to the progress that has been made in the methods of diagnosis.

Q. From your knowledge of the classes of fevers mentioned in these two columns of vital statistics, taken from the board of health reports of the City of St. Louis, how should they be treated by an epidemiologist and sanitarian in order to arrive at the true condition of typhoid fever in the city of St. Louis?

A. That is a difficult question to answer owing to the fact that during the latter portion of the period covered the conditions of record and diagnosis have not been strictly comparable with those in the early portion of this period.

One way of attempting to arrive at the true typhoid mor-
10119 tality in the city of St. Louis during the period indicated
would be by assuming that all the deaths recorded under
the heading "remittent fever, etc." were actually cases of typhoid fever and should be added to those in the column of typhoid fever proper.

Another method would be to assume that a certain proportion of the deaths reported from remittent fever. etc., say 50 per cent. were deaths from genuine typhoid fever and that this 50 per cent. should be added to the deaths reported under the heading "typhoid fever" alone.

It is my opinion that the truth lies somewhere between these two extremes and that for one-half of the deaths reported from intermittent fever to all the deaths reported from this cause should be classed as genuine typhoid fever. The proportion undoubtedly varies somewhat from year to year, the number that should be transferred from one column to another probably being less in the last five years or six years than in the earlier period.

On the whole it is my opinion that most epidemiologists and sanitarians would consider that at rurer conception of the ty-

phoid fever mortality in St. Louis would be derived by transferring all the deaths from the remittent, intermittent
10120 column than by transferring only 50 per cent. of the deaths, but that is a matter of opinion simply.

Q. Have you made any studies of comparisons between the typhoid and typho-malarial groups of the City of St. Louis with those of any other cities?

A. Yes sir, I have examined the deaths reported from malaria fever in the City of Chicago from 1851 to the end of 1902, and have recorded them by months in the accompanying table, and have also examined the figures for typhoid fever during this same period.

The table is as follows:

10121

MALARIAL FEVER.

DEATHS AS REPORTED BY MONTHS; TOTALS BY YEARS

Year.	Jan.	Feb.	Mch.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Totals.
1851								6	4	5	2		17
1852		2		1	1	3		4	10	11	6		38
1853			1	1	1	2	2	2	18	2	1	4	34
1854		1		1	2	11	12	17	10	9	5	2	70
1855	3	1		2	3		1	4	7	5			30
1856			1	4		2		3	3	3	5	1	22
1857			5	1		2	3	13	4	4	10	5	47
1858		1	2	1		1	1	2	3		2	3	16
1859				3	2		1	1	2		1		10
1860		3	1	1	1	4	3	4	7	1			24
1861			2	2	3		2	3	2		1		15
1862				2	2	3		2		3	5		19
1863	1	3	1	2	2	1	4	2	1	7	2	1	27
1864	8	4	6		4	1	2	1	4			2	32
1865		1	1	6	4		3	5	11	8	4		43
1866	1	5	1	2	2	7	1	10	16	17	8	4	74
1867	4	5	9		3	3	1	4	5	3	1	1	39
1868	2	1	2	2		1	3	6	1	4	7		29
1869		1	3	2	1	2	3	1	3	7	4	5	32
1870	2	5	2	4	1	3	5	7	3	5	8	4	49
1871	3	3	5	2	2		3			4	5	8	25

10122

Year.	Jan.	Feb.	Mch.	Apr.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Totals.
1872	3	4	6		3	5	5	1	11	9	6	4	57
1873	5	7	2	2	5	7	10	6	5	8	2	4	63
1874	2	1	2	7	1	4	5	6	1	1	1		31
1875		3	2	8	4	2	4	3	8	3	3	5	45
1876													62
1877		3	1	1		1	4	3	2	3		2	20
1878	3	4	4	6	3	5	3	8	8	9	3	3	59
1879	3	4	2	7	2	2	3	13	5	6	2		49
1880	5	6	8	3	8	2	5	6	9	8	5	6	71
1881	8	8	8	8	11	4	7	13	25	13	10	9	124
1882	13	9	7	6	5	2	4	11	9	10	9	4	89
1883	6	6	7	9	8	13	9	5	12	6	6	8	95
1884	10	4	9	10	8	6	10	8	6	9	12	6	98
1885	3	5	12	5	12	10	19	11	12	8	10	4	111
1886	7	14	8	12	3	5	8	16	12	10	15	8	118
1887	11	5	8	9	6	2	12	6	3	10	11	3	87
1888	4	5	7	12	11	6	9	12	13	6	6	5	96
1889	3	7	7	5	5	3	10	8	7	12	22	16	105
1890	8	11	12	9	15	9	7	16	9	10	7	8	121
1891	7	9	16	18	22	7	10	14	8	12	10	10	143
1892	9	8	9	5	10	16	21	27	13	8	6	7	139
1893	5	4	4	13	8	5	5	5	8	11	8	7	83
1894	5	1	2	4	3	2	1	1	5	4	4	2	34
1895	5	3	4	3	7	2	5	6	3	7	4	7	56
1896	6	3	5	2	2	2	3	3	2	1	2	1	32
10123													
1897	2	2	1	3	5	2	1	2	1	3	1	1	24
1898	5	0	1	2	2	1	2	2	6	3	1	2	27
1899	4	2	2	0	2	2	2	7	3	0	1	0	25
1900	2	2	2	3	2	3	2	2	5	5	0	1	29
1901	1	2	4	0	2	1	3	1	3	3	1	1	22
1902	0	1	0	1	2	5	1	5	3	1	1	1	21

10124 I have also examined the deaths reported from typhoid fever and those reported from malarial diseases in the city of Albany, by months, between January, 1891, and December, 1903.

I have also examined the Baltimore figures as I have already mentioned.

Q. If so, please state how they compare?

A. There is the same general correspondence by months and years that has been noted in the St. Louis records. For example, the largest number of deaths reported from malarial fever in Chicago was in the year 1891, the same year when typhoid fever prevailed in epidemic form in this city and caused the largest number of deaths ever reported from this cause.

In general when the deaths reported from typhoid fever are low those reported from, malarial fevers are low and vice versa.

The proportion of deaths reported from malarial fever is lower in the last ten years than in the earlier portion of this period, owing in large part probably to progress in methods of diagnosis.

A very interesting condition is revealed by the monthly
deaths reported from typhoid fever and malarial dis-
10125 eases in the city of Albany, New York.

As is well known a sand filter was put in operation in Albany on September 6, 1899. During the ten years, 1891 to 1899, inclusive, the total number of deaths reported from typhoid fever was 777, or an annual average of 86. For the four years since the filter was put in operation the total number of typhoid deaths has amounted to 106, or an annual average of 26 since the filter was opened as against 86 preceding.

An exactly similar decline is noticed in the number of deaths reported from malarial diseases. Prior to the opening of the filter the deaths reported from malarial fever amounted to 61, an annual average of 7. In the four years since the filter was opened only two deaths in all have been reported from malarial diseases, or an annual average of ½.

The inference is plain that both reported causes of death, namely "typhoid fever" and "malarial diseases," have been affected by the opening of the filter, and the only conclusion that can be drawn is that the deaths reported as occurring from malarial diseases were really cases of genuine typhoid fever.

The strict parallellism between the deaths reported from typhoid fever and malarial diseases in St. Louis, in Chicago, in Baltimore and in Albany demonstrates conclusively to my mind that the confusion in diagnosis already set forth has existed in widely separated localities. This confusion, however, has been less marked in those regions where malaria is less prevalent and where, therefore, physicians would be less likely to resort to it as an explanation of disease and death. 10126

Q. Have you a table of the death rates from typhoid fever in the city of St. Louis?

A. I have.

Q. From what sources did you obtain the data from which the table which you made were compiled?

A. The figures for population were obtained from the United States Census reports for 1890 and 1900, the population for the intervening years being estimated by Farr's formula, as was also that for the years 1900 and 1903.

Q. What is Farr's formula?

A. Farr's formula is a formula well known to vital statisticians, by means of which the increase of population may be estimated on the hypothesis that the population increases in geometrical progression.

It has been found that this method gives results that closely approximate to actual conditions. It has been thoroughly tested in Europe and in this country.

Taking the population as determined by the United States census as a basis and assuming that the increase between these years has proceeded regularly and by geometrical progression, it is a simple mathematical process to determine the population for each year between the two census years. 10127

Q. Upon what did you make the basis of compilation in the tables that you have prepared?

A. I have estimated the death rate per 100,000 inhabitants based upon the figures of population obtained in the way just described, under three heads, namely: For typhoid fever alone as tabulated in the health reports of the city of St. Louis; for typhoid fever, plus 50 per cent of the deaths recorded under remittent fever, intermittent fever, etc., and for typhoid fever plus all the deaths recorded under the head remittent, intermittent fever, etc.

Q. Will you read into evidence the tables which you have prepared?

A. Yes sir. They are as follows:

10128

TYPHOID FEVER DEATH RATES.

ST. LOUIS.

Death Rate per 100,000.

Year..............	Population..........	Typhoid fever alone.	Typhoid fever plus 50 % of deaths recorded under heading intermittent fever, etc..........	Typhoid fever plus all the deaths recorded under the heading intermittent fever, etc. ...
1890	451,709	30.0	56.67	81.2
1891	462,763	35.6	58.98	82.3
1892	474,077	93.0	127.40	161.7
1893	485,668	44.2	73.52	102.7
1894	497,565	34.3	52.24	70.3
1895	509,740	29.9	30.35	51.3
1896	522,225	20.2	37.37	54.1
1897	533,762	23.4	39.53	55.6
1898	548,590	17.3	29.53	41.7
1899	361,510	23.3	36.49	49.6
1900	575,238	29.2	39.07	48.6
1901	589,315	33.5	40.39	47.1
1902	603,736	36.7	45.21	53.6
1903	618,510	46.5	54.0	61.3

10129 Q. Please state what these tables show as to the death rate in the city of St. Louis from 1890 to 1903, based upon the percentage of population?

A. They show a considerable difference in the death rate according to the number of deaths assumed to be deaths from genuine typhoid fever. Considerable variation is exhibited in the three columns during this period, owing to the transfer of reported deaths from the intermittent column to the typhoid column, as already referred to several times in my testimony.

Q. Will you compare the death rate of typhoid fever in St. Louis from 1890 to 1899, inclusive, with that of 1900 to 1903, inclusive?

A. Assuming that the deaths reported under the heading typhoid fever alone during this period were the only deaths that occurred from this disease in the city of St. Louis, the average annual death rate from 1890 to 1899, inclusive, as shown in the detailed table, excluding, however, the year 1892, as being a year of special epidemic prevalence, was 28.8. On the same basis the average annual death rate from 1900 to 1903, inclusive, was 36.5.

Assuming that only one-half of the deaths recorded under the heading intermittent fever, etc., were deaths from genuine typhoid fever, the average annual death rate from 1890 to 1899,
inclusive, excluding as above the year 1892, was 46.07.
10130 On the same basis the average annual death rate from
1900 to 1903, inclusive, was 44.67.

Assuming that all the deaths reported under the heading intermittent fever, etc., were deaths from genuine typhoid fever, an assumption which in my opinion is not very wide of the mark, the average annual death rate from 1890 to 1899, inclusive, excluding as above the year 1892, was 65.4.

On the same basis that from 1900 to 1903, inclusive, was 52.1.

On either of the latter assumptions the death rate from typhoid fever in the four years, 1900 to 1903, was distinctly lower than in the preceding decade, even when the year of maximum typhoid prevalence in that decade is excluded from the estimation.

Q. Assuming that all the deaths in the typhoid column and the typho-malarial column are typhoid, how does the periods 4 years prior to 1900 compare with the period 4 years since 1900 as to whether there is an increase or decrease in the typhoid fever in the city of St. Louis?

A. The annual death rate on this basis is almost ex-
10131 actly the same, being 52.2 for the period of 4 years prior
to the opening of the canal, and being 52.7 for the period of four years since the opening of the canal. With these figures it would be impossible to assert that there has been either an increase or a diminution in the typhoid fever death rate in this period on the assumption just predicated.

Q. Has typhoid fever increased or decreased in the city of St. Louis since 1900 over the conditions that obtained for the 10 years prior to 1900, in the city of St. Louis?

A. It is emphatically my opinion that the average death rate from typhoid fever in the city of St. Louis has been less in the 4 years beginning with 1900 than the average for the preceding decade, excluding in this comparison the epidemic year of 1892.

Q. How does the typhoid fever death rate in St. Louis compare with the death rate in other American cities during this period?

A. Regarding the typhoid fever death rate as reported in St. Louis, from the figures of typhoid fever alone, the death rate is not very different throughout this 14 year period with the death rate in the city of Boston, omitting in this comparison the epidemic of 1892 in St. Louis. In Boston the average
10132 annual death rate from 1890 to 1902, inclusive, as taken
from the official figures in the health reports in the city of Boston was 29.7, while the death rate in St. Louis, as inserted in the column typhoid fever alone during the 14 year period already mentioned, excluding the year 1892, was 31.1, or almost exactly the same as that in the city of Boston during that period.

The water supply of Boston throughout this period has been regarded as being a fairly satisfactory municipal supply. In the city of Lawrence, Mass., before filtration was introduced, the death rate from typhoid fever averaged 120. The death rate in the state of Massachusetts from typhoid fever during the period 1897 to 1902 was 40, or considerably higher than that in the city of St. Louis, for the period just indicated. In 1894 the death rate in the city of Lawrence was 48 and in 1899 it was 33.

Considering the real death rate in the city of St. Louis from typhoid fever to be represented by the death rate computed on the total of the two headings, typhoid fever and intermittent fever, the death rate in this city throughout nearly the whole period under consideration has been excessive and higher than ought to exist in a city provided with a pure water supply.

10133 Q. Is there any reason other than those you have given for supposing that the number of typhoid fever deaths in St. Louis is higher than that indicated by the figures recorded under heading typhoid fever alone?

A. Yes, I think the fact that I have just instanced regarding the death rate in other American cities is a very strong reason for believing that the actual number of typhoid fever deaths in St. Louis is higher than that indicated under the heading typhoid fever alone. Knowing what I do of the source of the St. Louis public water supply and of the character of the water shed of the Missouri, Mississippi and Illinois Rivers for some distance above the water intake I should expect that a city supplied with a non-filtered surface water of the character of the Mississippi River water at the intake tower at St. Louis would give rise to a higher death rate from typhoid fever than is indicated by the figures under the heading typhoid fever alone in the St. Louis health reports. The death rate from typhoid fever in St. Louis as reckoned on the total of typhoid deaths and typho-malarial deaths is, in my opinion, much nearer what would be anticipated from a consideration of the character of the Mississippi River water than the death rate as reckoned from the so-called typhoid fever deaths alone.

10134 Q. Professor, from a careful analysis of the typhoid and the typho-malarial mortality statistics as they appear in the board of health reports of St. Louis and your knowledge of the conditions that obtain in other cities using a water supply from a river,as well as all other sources of knowledge which you possess upon this question what is your opinion as to whether there has been an increase in typhoid fever in the city of St. Louis since January 17, 1900, over the average typhoid conditions that prevailed in St. Louis for ten years prior to that time?

MR. JEFFRIES: I object to the question for the reason that the number of years to be compared are not the same in point of number, the duration of the periods to be compared are not the same and for the further reason that during a portion of one period, to-wit: from 1890 to 1895 the water supply of the city of St. Louis was not taken at the same point and the manner of taking was not the same as it has been since that period.

A. In consideration of all the facts regarding the mortality of typhoid fever in the city of St. Louis during the period indicated that can be obtained from the official records as published it is my opinion that the average annual death rate from typhoid fever in that city has been lower for the four years 1900 to 1903 than for the preceding decade, excluding the epidemic year of 1892.

10135 Q. Assuming the same conditions in the previous question, what is your opinion as to whether there has been an increase of typhoid fever in the city of St. Louis since January 17, 1900 down to 1903, inclusive, over the general typhoid conditions that prevailed in St. Louis for the 4 years prior to 1900?

A. From the facts already cited which embody all the information that I have been able to obtain, and from a critical analysis of the figures presented in the reports of the health department of the city of St. Louis I conclude that there has been no increase in the annual death rate from typhoid fever in the city of St. Louis since January 17, 1900, as compared with the average annual death rate for the 4 years preceding 1900. As shown in my answer to a previous question the death rate for these two periods computed on the assumption that the typhoid fever deaths and the typho-malarial deaths should be considered as a whole, is almost exactly the same.

Q. What is your opinion based upon all the information and knowledge that you have in regard to the typhoid conditions of the water sheds above the St. Louis intake at the chain of rocks as to whether the typhoid conditions that have prevailed in St. Louis since January, 1900, are due directly to the opening of the Chicago Drainage Canal which took place on January 17, 1900, wherein the sewage of Chicago was emptied into the Desplaines and Illinois River?

10136 MR. JEFFRIES: I object to the question for the reason that the witness has not yet stated what knowledge he has with reference to the conditions of the water sheds above the chain of rocks.

MR. TODD: In reply to the objection I will state that it is a matter for counsel to bring out on cross-examination if he entertains any doubt as to the witness' knowledge of the typhoid conditions as mentioned in the question.

MR. JEFFRIES: I suggest to counsel that ordinarily that might be true, but when this witness undertakes to testify as an expert he must first show sufficient qualification upon which to base his expert testimony and unless that be shown in the evidence the question and any answer given thereto would be incompetent and irrelevant.

MR. TODD: I submit that it is a question for the court to decide whether this witness is qualified to answer the question.

MR. JEFFRIES: That is always a question for the court to decide.

Q. Question repeated.

A. It is my best judgment based upon all the information of which I have become possessed that no portion of the typhoid fever mortality occurring in St. Louis since January, 1900, can be attributed directly or indirectly to the opening of the Chicago Drainage Canal.

10137 Q. Are you acquainted with the typhoid conditions that obtain along the Missouri and Mississippi Rivers above the intake of the St. Louis waterworks as well as those that obtain along the Illinois, the conditions of typhoid in St. Louis and the conditions of typhoid fever in Chicago?

A. I have already submitted the information that I possess regarding the typhoid conditions of Chicago and St. Louis. I have here tables showing the deaths reported from typhoid fever in the principal cities on the Mississippi River above Grafton, the Missouri River and the Illinois Rivers for the years 1893 to 1902, inclusive.

Q. Is there any connection in your opinion between the typhoid condition that has prevailed in St. Louis since the opening of the drainage canal and the discharge of the sewage of

Chicago through the drainage canal since January 17, 1900?

A. In my opinion no such connection exists.

Q. Will running water purify itself so as to be free from pathogenic bacteria that might have been placed therein?

A. Running water, like still water, will rid itself of pathogenic bacteria after a sufficient time. The factor of time rather than distance influences the disappearance of pathogenic microbes. There is satisfactory evidence that a flowing stream becomes freed from large numbers of sewage bacteria that are introduced into it, and since many of these sewage bac-
10138 teria are much more resistant than most pathogenic microbes it follows that the rate of disappearance of the latter is probably more rapid than that of the harmless sewage bacteria. A remarkable instance of the disappearance of sewage bacteria in running water is furnished by the condition of the Mississippi River at New Orleans. Although the sewage of the whole interior of the North American continent enters the Mississippi River and its tributaries the number of colon bacilli, the most characteristic bacteria of sewage at New Orleans is so small that from this standpoint the water compares favorably with many filtered waters and indeed many pure spring waters. The evidence on the whole is overwhelming that running water, like standing water, can and does purify itself.

Q. This question was asked of Professor Sedgwick on page 3448 of my transcript of record, and I desire to ask the same question of you. "State your opinion as an expert on water supplies for cities and towns as to whether or not the waters of the Mississippi River west of the center thread of the main channel of said river below the mouth of the Illinois River and down to the intake tower of the St. Louis waterworks at the chain of rocks is less valuable for drinking purposes and more liable to carry water-born diseases such as typhoid fever and cholera now than it was before the sewage from the sani-
10139 tary district of Chicago was run into the drainage canal and through it into the Illinois River?"

A. It is my opinion that the waters of the Mississippi west of the center of the main channel of the river below the mouth of the Illinois River and down to the intake tower of the St. Louis waterworks at the chain of rocks are no less valuable for drinking purposes nor more liable to carry water-borne diseases than they were before the sewage of the sanitary district of Chicago passed through the drainage canal and through it into the Illinois River. I hold this opinion for the reasons that I have already set forth in considerable detail in my previous testimony, namely that it is my judgment that typhoid bacilli will not live long enough in the waters of the drainage canal or Illinois River to travel from Chicago to St. Louis and furthermore that the change in conditions in the Illinois River since the opening of the drainage canal has not been of a character to justify the assumption that the conditions for the longevity of the typhoid bacillus have been materially improved.

Q. With reference to the quantity of water in the Illinois River do you know what proportion the added volume from the drainage canal will bear to the waters of the Illinois?

A. The proportion of water coming from the drainage canal to the total flow of the Illinois River varies of course considerably from year to year and from season to season,
10140 resulting from the variation in the amount of rainfall and run off. When the Illinois River is high the flow from the drainage canal may amount to not more than one-tenth of the total discharge of the Illinois River, and at times of low water the flow from the drainage canal may amount to possibly as much as one-half of the discharge.

Q. This question, page 3450 of my transcript of the record, was asked of Professor Sedgwick and I desire to ask it of you. "State whether or not an increase in the speed of the current of the Illinois River by reason of the added volume of the water of the drainage canal would affect the amount of sedimentation that might otherwise occur in the Illinois River and if it does effect it, how and in what manner?"

A. I have seen no reason to think that the added volume of water from the drainage canal would materially affect the amount of sedimentation occurring at most seasons in the Illinois River, since the speed of the current in the river appears to be but slightly affected by the increased discharge from the drainage canal. The increased volume leads rather to the spreading out of the river into the low-lying banks and sub-

jacent meadows thus affording additional opportunities
10141 for sedimentation rather than leading to a scouring of
the channel.

Q. This question was asked Professor Sedgwick on page 3450 of my transcript of the record, and I desire to ask you the same question. "What effect, if any, would the increase in the speed of the current in the Illinois River have upon the time within which the sewage from Joliet, Peoria and other towns on the Illinois River might be removed into the waters of the Mississippi (if the same are so removed) as compared with the conditions that existed and the time it might have taken before the added volume of water from the drainage canal was poured into the waters of the Illinois?"

A. The analyses and examinations that have been made of the water of the Illinois River at its mouth do not in my opinion show that the opening of the drainage canal has caused the sewage from Joliet, Peoria and other towns of the Illinois River to be hurried into the waters of the Mississippi River any more rapidly than was the case before the added volume of water from the drainage canal was poured into the waters of the Illinois.

Q. I will ask you this question which was asked of Professor Sedgwick on page 3451 of my transcript of record: "If the water is made more clear and less turbid than it was before the added volume of water being placed therein, will such bacilli
as typhoid have more or less tendency to go down to the
10142 bottom of the stream than they had prior to the water
being rendered less turbid?"

A. There is no doubt that the presence of large quantities of suspended matter in the water of a sluggishly flowing stream tends to facilitate the sedimentation of such bacteria as may be present in the waters of that stream. The life of the typhoid bacillus, however, is so short under the conditions presented in such waters that it makes very little difference whether this organism perishes while suspended in flowing water or dies out in the sediment deposited in the bottom of such stream. Despite the dilution of the water of the Illinois River with the less turbid water from Lake Michigan it is my opinion that the life of the typhoid bacillus would not be increased by such addition.

Q. This question was asked of Professor Sedgwick on page 3452 of the record that I have, and I desire to ask it of you: "If an increased volume of water in the Illinois by the addition of the water of the drainage canal would make an increased speed in the current of the Illinois River would that increase in said current have the effect of increasing or diminishing the typhoid and liability to typhoid and other water-born diseases on the part of the inhabitants of the State of Missouri using the water of the Mississippi River for drinking purposes
10143 below the mouth of the Illinois River?"

A. I do not think that such increased speed as might reasonably be assumed to result from the opening of the drainage canal would increase in any degree the liability to typhoid and other water-born diseases of the inhabitants of the State of Missouri for the reason that such shortening of the time involved as might legitimately be assumed to occur would not come within the range of longevity of a typhoid bacillus under these conditions. It is undoubtedly true that the typhoid bacillus can live longer in relatively pure water such as a lake, well or cistern than in water containing numbers of sewage bacteria. It is generally believed to be true that the rapid mortality of typhoid bacilli in unsterilized water is due to the action of the toxic products of other microbes, which are in sewage polluted water, the toxic products are there present in a more concentrated condition and the typhoid bacillus therefore is acted on by them more speedily.

Q. Professor Sedgwick in answer to this question on page 3453 of my transcript of the record: "What do you say as to the longevity of the germ of typhoid fever as a general proposition in connection with sewage polluted water," answered, "Here also our ideas have undergone some change of late years; my ideas have undergone some late change. Broadly speaking the tendency has been to come to the belief or has been to show or to indicate a greater and greater longevity. Laboratory
10144 experiments have sometimes indicated a short and sometimes a longer longevity. Practical experience has tended to make us believe in a greater longevity than that form-

erly entertained, and having reference to the conditions in the stream, the various conditions in streams, my belief is that in a sewage polluted stream a typhoid germ might live in gradually diminishing numbers for weeks or months or even years." What is your opinion as to the correctness of that belief based upon your knowledge as a bacteriologist and sanitarian?

A. I know of no evidence that indicates that in a sewage polluted stream typhoid bacilli might live for years, months or even weeks. On the contrary all the evidence that I am familiar with regarding the life of typhoid germs in water, even under the very favorable conditions present in sterilized water, in glass flasks in a laboratory shows that this organism is not only not able to multiply under these conditions, but that it diminishes rapidly and steadily. If it were true that the typhoid bacilli could persist for such long periods in the water of reservoirs and settling basins the epidemiological evidence would, I think, indicate that this is true. So far from this being the case a sudden change in conditions such a diversion of sewage away from the water supply usually leads to a
10145 marked improvement in the typhoid fever conditions. An appropriate illustration of this is afforded in the case of the opening of the Chicago Drainage Canal which was followed in the ensuing twelve months by the lowest death rate from typhoid fever ever recorded in the sanitary history of Chicago. This would hardly have been the case if the typhoid germs which had been poured into Lake Michigan in what we must believe to be considerable numbers, during several decades had persisted for any lengthy period in the sediment of the waters of the lake.

ADJOURNED until 10:00 a. m., February 11, 1904.

10146 10:00 A. M., Thursday, February 11, 1904. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. This question was asked of Professor Sedgwick, on page 3454 of the transcript of the record that I have, and I desire to ask it of you. Assuming that the number of bacilli coli communis in the waters of the Illinois River at Grafton are at intervals no greater than the numbers contained in it above the opening of the drainage canal, do you consider for that reason that the water is at all times no more dangerous than formerly?

A. In my opinion, and I believe in that of bacteriologists generally, the presence of colon bacilli in water affords a satisfactory clue to the amount and freshness of sewage pollution.

Since it is true that the number of colon bacilli now found in the water of the Illinois River at Grafton is no greater 10147 than the number found in the water at this same place before the opening of the drainage canal, I am certainly compelled to conclude that the character of the water and its liability to contain typhoid germs has not been materially changed and that the water is no more dangerous than formerly.

Q. Professor Sedgwick, on page 3454 of the transcript of the record which I have, in answer to the following question: "Assuming that the germs of typhoid fever coming from the sewers of Chicago, and passing by way of the drainage canal to Lake Peoria, be in large numbers deposited in the bed of Lake Peoria for the period of a month say, do you consider that typhoid germs would be entirely destroyed at the end of that time, in that deposit" answered "no sir." What do you say as to the assumption that typhoid germs could pass from the sewers of Chicago by way of the drainage canal to Lake Peoria and be deposited there in the bed of Lake Peoria for a period of a month, and as to whether or not typhoid germs coming through the drainage canal, under the conditions as they exist today, would live for a period of a month and not be destroyed before the end of that period?

A. From all that I have been able to learn concerning the life history of the typhoid germ in water, it is my opinion that it is most improbable that typhoid germs would live long 10148 enough in the Illinois River to pass from Lockport to Lake Peoria. In case of such an extremely unlikely occurrence any such typhoid germs deposited on the bed of Lake Peoria would in my judgment be in an extremely weakened condition and would not be likely to live for more than a few hours.

It is my opinion that there certainly would be no accumulation of bacilli under these conditions.

Q. Professor Sedgwick, on page 3455 of the transcript of the evidence which I have, in answer to the question "assuming that typhoid fever germs coming from Chicago sewers are deposited in large numbers in the lakes and slack water portions of the Illinois River above Peoria, do you or do you not consider that flood conditions such as would scour the deposits from the beds of the streams would cause the water leaving Lake Peoria to contain at times more infectious and dangerous pollution than is at present in the diluted sewage entering at the Bear Trap Dam at the foot of the drainage canal" answered "I think that at times it might." Question "Why?" answer "Because if accumulations of typhoid germs were found in the lakes or slack water basins of the river, these might, especially in the case of a large amount of typhoid fever in Chicago, result in the storage of a vast number of germs and with a
10149 sudden flood might sweep out these accumulations and
actually bring it about that sometimes more typhoid fever germs would be flowing in that stream than in the drainage canal itself." What is your opinion, taking into consideration all that you know about the conditions in the drainage canal, the Desplaines river and the Illinois river, as a bacteriologist and sanitarian as to whether such a condition at that time might or does exist?

A. It is my opinion, taking into consideration all that I know about the conditions in the drainage canal, the Desplaines river and the Illinois river, and taking into consideration all the facts that I have been able to obtain by personal investigations and by examination of the leading authorities in the matter, that typhoid fever germs live so short a time under the conditions enumerated that there is no danger that the water that leaves Lake Peoria can at any time contain more infectious material, or, specifically, more living typhoid bacilli than exist in the diluted sewage flowing from the Bear Trap Dam at the foot of the drainage canal.

Q. What is your opinion as to whether typhoid fever germs coming from the Chicago sewage are deposited in large numbers in the lakes and slack water portions of the Illinois river, above Peoria?

10150 A. It is my opinion that typhoid fever germs coming from Chicago sewage rarely, if ever, live long enough to reach Averyville, and it is consequently my judgment that such germs can not be deposited in large numbers in the lakes and slack water portions of the Illinois river above Peoria.

Q. What is your opinion, based upon all the knowledge which you have, as a chemist and bacteriologist and sanitary expert, as to whether at any times of the year under any conditions of water in the Illinois river the number of typhoid fever germs at that point is ever as great as they are at the Bear Trap Dam at the end of the drainage canal?

A. It is emphatically my opinion that the number of typhoid germs in the water of the Illinois river and Lake Peoria is never as great as the number in the drainage canal near the Bear Trap Dam at Lockport, and furthermore that the assumption that they are is not, so far as I am cognizant of the facts, borne out by any data, chemical, bacteriological or epidemiological.

Q. Do you know of any evidence based upon any investigations made by yourself or by any one else that justifies the conclusion that at one time, under any conditions, there are a larger number of typhoid fever germs at Lake Peoria than at the Bear Trap Dam at the foot of the drainage canal?

A. I know of no evidence based upon any investigation that I have made or that have been made by any bacteri-
10151 ologist in any part of the world that justifies the conclusion that there are larger numbers of typhoid fever germs in Lake Peoria than in the water of the drainage canal at the Bear Trap Dam at Lockport. On the contrary, from all the information that I have been able to obtain, I am satisfied that there is a much smaller proportion of typhoid fever germs in the water of Lake Peoria than in the water of the drainage canal at the Bear Trap Dam. In my opinion such typhoid fever bacilli as may be present in the waters of Lake Peoria are not derived from the sewers of Chicago but come from sources much nearer this point.

Q. Do you know of any evidence, scientific or otherwise, that shows that accumulations of typhoid germs are found in lakes or slack water basins of rivers and remain there in storage in vast numbers for any considerable period of time in a virulent state, and are suddenly flooded out by freshets so that greater numbers of typhoid fever germs are present, flowing in a stream a considerable distance from the source of pollution itself than they exist at the source of pollution?

A. I not only know of no evidence that indicates that accumulations of typhoid fever bacteria take place in lakes or
slack water basins of rivers and remain there in storage,
10152 but on the contrary it is my opinion that the evidence
available on this point shows distinctly that no such accumulations take place. It is my belief, as already stated in my testimony, that typhoid germs introduced into sediment under these conditions speedily perish and would not survive so long in a virulent state that they could at some future time be flushed out from such slack water basins.

Q. Has the removal of deposits of sewage matter from the beds of streams resulted in causing typhoid epidemics, and do you know of any well established authenticated case where the cause of the epidemic was established as being due to the removal of deposits of sewage matter from the beds of streams beyond all reasonable doubt?

A. It is possible that where deposits of sewage matter are fresh and recent, as they are, for example, in the bed of the Chicago river, that the sudden flushing out of such a stream might lead to an outbreak of typhoid fever within two or three days distance from such deposits. But where sewage matter has been deposited on the bed of a stream and allowed to remain there for a period of several weeks, without receiving any addition of fresh material, I know of no instance where an epi-
demic of typhoid fever has been traced beyond all rea-
10153 sonable doubt to the removal or flushing out of deposits
of such sewage matter.

Q. Have you studied and are you acquainted with the facts upon which the conclusion has been arrived at that the Detroit epidemic was caused by the dredging of the Black river at Port Huron?

A. I have read the testimony that has been given in this case regarding the dredging of the Black river at Port Huron and its supposed connection with the outbreak of typhoid fever in Detroit.

Q. From your knowledge as an epidemiologist do you consider the cause of the epidemic at Detroit has been established as coming from the Black river at Port Huron beyond a reasonable doubt?

A. I do not for the reason that other sources of infection have not been eliminated, and moreover it is my opinion as a bacteriologist and epidemiologist that under the conditions as described typhoid bacilli could not travel from the Black river at Port Huron to Detroit in sufficient numbers and in a sufficiently virulent condition so that they would be capable of causing an outbreak of typhoid fever in the latter place.

Q. This question was asked of Professor Sedgwick on page 3457 of my transcript of the record, and I desire to ask it of you: "Now, assuming that the only pollution of the Illi-
10154 nois river was that contributed to it by the Chicago Sanitary District and having in mind a large amount of typhoid fever in said district, do you or do you not consider the effects of the time interval, dilution and sedimentation occurring between Chicago and Grafton would be such as to render the water as it reaches the Mississippi at all times free from liability of producing water borne diseases to those who drink it?

A. It is my opinion, assuming that the only pollution of the Illinois river was that contributed by the Chicago Sanitary District, and considering the presence of dilution, of sedimentation and particularly of the time interval occurring between Chicago and Grafton, that these would be factors of sufficient power to render the water of the Illinois river as it empties in the Mississippi river free from the liability of introducing typhoid fever or any other water-borne disease among those drinking such water.

Q. Assuming that no other pollution or infection enters the Illinois river save that which it receives from the Sanitary District of Chicago. From your knowledge as a chemist, bacteriologist and sanitary expert and epidemiologist, have you had any reasons, experience or knowledge which would lead you to believe that the waters of the Illinois river at
10155 Grafton is infected with the sewage from Chicago, and if said water at Grafton enters the Mississippi river, becoming mixed with the latter would the Illinois river water be a menace to the health of the inhabitants of the State of Missouri using said Mississippi river water mixed with the Illinois river

water for drinking purposes at points on the Missouri shore?

A. From all the knowledge that I have, I have formed the opinion that the water of the Illinois river at Grafton does not contain infectious elements derived from the sewage of Chicago, and that consequently such water reaching the Mississippi river and becoming mixed with that water is not a menace to the health of the inhabitants of the State of Missouri, on the Missouri shore of the Mississippi river or to the citizens of St. Louis.

Q. Is there anything, based upon your knowledge as a chemist, bacteriologist and sanitary expert which you know that would lead you to believe that the water coming from the Illinois river at Grafton was infected from the sewers of Chicago, and assume that the waters from the Illinois river mixed with the water of the Mississippi river at Grafton, and subsequently mixed with the waters of the Missouri river at its mouth,
10156 do you consider the water of the Illinois river, thus commingled with the waters of the Mississippi and Missouri rivers a menace to the inhabitants of the State of Missouri, upon the Missouri shore of the Mississippi river, using the Mississippi river water for drinking purposes at points below on the Missouri shore?

A. In reply to this I would state that my position is as already stated in answer to the preceding question, namely, that in my judgment no such effect exists.

Q. Is there any evidence, chemical, bacteriological, or otherwise, that can establish the conclusion that the waters of the Illinois river at Grafton are infected by the sewers from Chicago, eliminating all other sources of infection?

A. I know of no evidence that indicates, directly or indirectly that the waters of the Illinois river at Grafton are infected from the sewers of Chicago, and in view of the large amount of pollution of the Illinois river that takes place at points less remote from its mouth than Chicago, it is my opinion that convincing evidence of such infection coming from Chicago would be very difficult if not impossible to secure.

Q. This question was asked Professor Sedgwick, on page 3463 of the transcript of the record which I have, which
10157 I desire to ask you: "Now, assuming that the only pollution upon the watershed of the Mississippi and its

tributaries above the intake of the St. Louis waterworks was that derived from the sewage district of Chicago, and having in mind a large amount of typhoid fever in Chicago, do you or do you not believe that infection and dangerous pollution might under existing conditions find its way into the water supply of the City of St. Louis?

A. I do not believe that infections or dangerous matter passing into the sewers of Chicago finds its way, under existing conditions, into the water supply of the City of St. Louis for reasons which I have set forth previously in great detail.

Q. This question, on page 3463, was asked of Professor Sedgwick which I desire to ask of you: "Assuming that there was no typhoid fever pollution of the waters upon the watershed of the Mississippi river or its tributaries above the intake of the St. Louis waterworks other than that derived from the sanitary district of Chicago, do you or do you not believe that typhoid fever germs from said district are liable to find their way into the water supply of the City of St. Louis through the intake at the chain of rocks?"

A. Assuming that there was no typhoid fever pollution of the waters of the watershed of the Mississippi river or its 10158 tributaries above the intake of the St. Louis waterworks other than that derived from the sanitary district of Chicago, I certainly do not believe that typhoid fever germs from said district would be liable to find their way under existing conditions into the water supply of St. Louis.

Q. Professor Sedgwick, in answer to the foregoing question, stated: "I believe that they are liable to find their way into the intake" and when asked why, answered, "For the reason that typhoid fever having been frequently abundant in the City of Chicago, I must state with the assumption that a very large number of typhoid germs find their way into the sewage of the city, pass through the sewers and on into the drainage canal and subject to local conditions may, in diminishing numbers, pass out of the Illinois river, mingle with the waters of the Mississippi, pass over to the other side and find their way into the intake at the chain of rocks." I want to ask you, Professor, do you know of any evidence based upon any analysis, experiments or otherwise that justify the assumption that typhoid fever germs will pass from Chicago, out of the Illinois river, into the Mississippi river, thence to the chain of rocks and the intake tower of St. Louis?

MR. JEFFRIES: I move to strike out all that part of 10159 the question except the latter sentence which elicits from the witness whether he knows of any evidence of any character whatever that would lead one to believe that typhoid bacilli pass from Chicago to the intake tower of the water supply of the City of St. Louis, for the reason that whatever this witness may say with reference to that part moved to be stricken out will be merely a comment upon the evidence, and that portion of the question moved to be stricken out is a comment upon the evidence and incompetent, irrelevant and not a proper question.

MR. TODD: In reply, will state that counsel correctly interprets the purpose for which the question is asked as is perfectly competent to ask this witness as to the assumption, not the belief as counsel stated, but the assumption carried in the answer of Professor Sedgwick.

MR. JEFFRIES: I move to strike out the suggestion of counsel for the same reason stated in my objection or motion to strike out the question, that it is for this witness as an expert to give his opinion upon facts as he sees them and for the court to determine the weight of the testimony of the respective witnesses and not for themselves to understake to determine the particular weight or credit that should be given each others testimony.

A. I have myself made a number of analyses, experiments, and observations upon the waters of the drainage canal, 10160 the Illinois and Mississippi rivers, and have examined with some care the reports of analyses, experiments and observations made by others, and I have been unable to discover any evidence that justifies the assumption that typhoid fever germs can or do pass from Chicago out of the Illinois river into the Mississippi river, thence to the chain of rocks and the intake tower of St. Louis.

Q. This question, on page 3465, was asked of Professor Sedgwick, and I desire to ask it of you: "Assuming that an epidemic of Asiatic cholera should occur in the City of Chicago, is it possible that the germs of that disease might find their way into the intake tower of the St. Louis waterworks at the chain of rocks, from the City of Chicago?"

A. The germs of Asiatic cholera are less hardy than the germs of typhoid fever and in view of the conditions that have been shown to exist regarding the life of the typhoid fever bacilli in the waters of the drainage canal, it is my opinion that it is most improbable that germs of Asiatic cholera could travel from Chicago to St. Louis by way of the Illinois and Mississippi rivers.

Q. I want to ask you this question which was asked of Professor Sedgwick, page 3470 of the transcript which I have:

"Now, Professor, considering your personal knowledge as 10161 an expert of typhoid fever conditions in the sanitary district of Chicago, under existing conditions in said district as to sewers and the outfalls there are and the amount of sewage and all the existing conditions of the Desplaines, Illinois, Mississippi and Missouri rivers, and all conditions existing upon the watershed of said streams and the tributaries thereof, and all existing conditions as to the water supply of the City of St. Louis and the general sanitary conditions existing in the City of St. Louis, would you or not beyond a reasonable doubt attribute the principal portion of the increase of typhoid fever in St. Louis, since the opening of the drainage canal, to the infected sewage of the sanitary district of Chicago?"

A. I certainly should not.

Q. Why?

A. Assuming that there had actually been a marked increase in typhoid fever in St. Louis since the opening of the drainage canal, which appears to me to be contrary to the fact, it would, in my opinion, be more reasonable and significant to attribute such an increase in typhoid fever to other causes, such, for example, as an infection of the water supply nearer the water intake, to infection of the milk supply or to some other factor rather than to infected sewage coming from the sanitary district of Chicago.

10162 Q. Professor, do you consider that the Illinois river water, containing the mixed sewage and canal water from the Chicago drainage canal, since the opening of the drainage canal, has rendered less safe and wholesome now than before the opening of the canal, for drinking purposes on the part of the inhabitants of the State of Missouri, the waters of the Mississippi river below the mouth of the Illinois river?

A. It is my opinion and judgment that the chemical, bacteriological and epidemiological evidence is altogether convincing that the water of the Illinois river at its mouth is no more unsafe and unwholesome now than it was before the opening of the canal, and that consequently the water of the Illinois river since the opening of the canal has not rendered less safe and wholesome the waters of the Mississippi river below the mouth of the Illinois river.

Q. This question was asked Professor Sedgwick, on page 3486 of my copy of the evidence, which I desire to ask you: "Now, Professor, I will get you to state whether or not in your opinion the liability to contract typhoid fever or other water borne diseases on the part of the inhabitants of Missouri using the Mississippi river water for drinking purposes, below the mouth of the Illinois river, by reason of the sewage from 10163 the drainage canal infecting the water of the Illinois river is constant, immediate and continuous under all existing conditions upon the Mississippi, the Desplaines, the Illinois and the Missouri rivers, and the tributaries of said streams, under all existing conditions, upon the watershed of the said rivers and the tributaries thereof and the drainage canal and the sanitary district of Chicago?

A. It is my best judgment that the inhabitants of Missouri, using the Mississippi river water below the mouth of the Illinois for drinking purposes are not, under existing conditions, liable to contract typhoid fever by reason of sewage from the Chicago drainage canal infecting the waters of the Illinois river.

Q. Professor Sedgwick, on page 3495, in answer to a question, among other things, answered, "The mere presence of pollution, I mean by that disinfected sewage, that, is, supposing Chicago reduced her typhoid rate and could still put her sewage down there, that sewage as affecting the longevity or growth of germs which go in from Peoria or anywhere else would be an added menace to cities with water supply, even if she did not send typhoid fever germs down, sending the filth alone down is serious." I will ask you what is your opinion based upon your experience as a bacteriologist and sanitarian that the sewage from Chicago favors the longevity or growth of germs from

Peoria or anywhere else, emptying their sewage into
10164 the Illinois river?

MR. JEFFRIES: I object to that because it is incompetent and immaterial.

A. On the contrary, it is my opinion that the introduction of sewage or organic matter of a similar character into the river water is distinctly detrimental to continued longevity or growth on the part of the typhoid fever bacillus. In my judgment the experiments carried out upon the life of the typhoid fever bacillus in the waters of the drainage canal show that the presence of a considerable amount of organic matter or sewage in the water favors the speedy dying out of typhoid fever bacilli, rather than their continued vitality. As I have alread pointed out this is what might be anticipated in view of the greater concentration of the toxic products of saphrophytic microbes in waters highly charged with organic matter than in purer waters.

This being the case it would follow that typhoid fever germs passing into the river from Peoria would not be favored in any respect by the fact that Chicago sewage had entered the Illinois valley 150 miles above. On the other hand they might be actually injured by the products originating from the decomposition of such sewage which were carried down even as
10165 far as Peoria.

Q. Does the presence of sewage in water add to the longevity or growth of pathogenic bacteria?

A. I have already stated that I considered the presence of sewage in water under natural conditions does not add to the longevity or growth of pathogenic germs but favors their speedy dying out.

Q. Professor Sedgwick answered this question, on page 3496, which I desire to ask you: "Do you or not consider that the Illinois river water, polluted and infected by the sewage from the Chicago sanitary district, since the opening of the drainage canal has rendered less safe the water supply of the City of St. Louis as drawn at the intake tower at the chain of rocks and upon what do you base your opinion?"

A. I do not consider that any pollution or infection with sewage from the Chicago sanitary district, since the opening of the drainage canal, has rendered less safe the Illinois river water at its mouth or in consequence the water supply of the

City of St. Louis as drawn at the intake tower at the chain of rocks.

I base my opinion upon all the testimony that I have submitted in this case and upon all the information of every kind chemical, bacteriological and epidemiological, that I have been able to secure.

10166 Q. This question, on page 3497 of my record, was asked of Professor Sedgwick, which I desire to ask of you: "Assuming that the population of the sanitary district of Chicago covers about 3,000,000 people and that the flow through the drainage canal reaches 600,000 cubic feet a minute, what in your opinion would be the effect upon the water of the Illinois river as compared with that water at its mouth as found during the past three years?"

A. I do not believe that the sanitary quality of the Illinois river water at its mouth would be affected by a change in conditions such as that indicated in the question.

Q. This question was asked of Professor Sedgwick, on page 3498 of the testimony, which I have, and which I desire to ask you: "Assuming that the Chicago sewage from 1,500,000 people living in the sanitary district and city of Chicago should be discharged into the Chicago canal and carried from the canal to the Desplaines river and thence into the Illinois river, Chicago being 357 miles from the St. Louis intake, and assuming that a typhoid fever epidemic of extraordinary proportions should become prevalent among the residents of the sanitary district of Chicago at a time when the sewage from said district is being so discharged into the canal, what immediate and impending danger would exist and what effect would it have on the people 10167 of St. Louis and those people living on the Missouri side of the Mississippi river below Grafton, who use the waters of the Mississippi river for drinking purposes?"

A. I know of no reason for believing that typhoid fever germs discharged into the sewers of Chicago, even in immense numbers, could travel down the Illinois river and affect the quality of the water and the health of the people of St. Louis. On the contrary, under existing conditions, the evidence is to my mind strongly in favor of the view that all the typhoid bacilli introduced into the waters of the Chicago river from the sewers of Chicago, perish before the flow from the drainage canal reaches Averyville.

Q. This question was asked Professor Sedgwick, following the last question, which I desire to ask you: "Now, Professor, assuming the same conditions as in the last question you have been answering, and assume that instead of an extraordinary typhoid fever epidemic prevailing in the sanitary district of Chicago, a cholera epidemic should prevail in the sanitary district of Chicago, a severe cholera epidemic should prevail in the sanitary district, would the danger be imminent, impending and immediate to the people of Missouri below Grafton who used the waters of the Mississippi for drinking purposes, as far down as the chain of rocks?

10168 A. The statements that I have already made regarding my opinion as to the life of the typhoid bacillus in the waters of the Illinois river, under existing conditions, apply with even more force to the possible longevity of the cholera spirillum. The danger in my opinion would not be imminent, impending or immediate to the people of Missouri below Grafton who use the waters of the river for drinking purposes, but would on the contrary be imaginary, hypothetical and nonexistent.

Q. What in your judgment was the sanitary character of the water supply at St. Louis after having passed through the settling basins as delivered to the subscribers during the years 1895 to 1899, inclusive, and upon what do you base your conclusions?

A. It is my judgment that the water supply of the City of St. Louis, during the years 1895 to 1899, inclusive, was not a satisfactory municipal supply. I base this opinion upon the great amount of typhoid fever in the city, as shown by the considerable number of deaths reported during this period from typhoid fever or typho malarial fever and other infections which are properly to be classed as typhoid. Taking these into consideration the typhoid fever death rate during the years mentioned was much higher than ought to be the case in a
10169 city having a pure and satisfactory water supply.

Q. What is your opinion as to the satisfactory character of the water of St. Louis since 1899?

A. In my opinion the character has been substantially the same since 1899 as before that year, except that the increasing population in the towns and villages and rural communities immediately above St. Louis, on the Missouri, Mississippi, and Illinois rivers has had the effect of somewhat increasing the degree of pollution.

The mortality from typhoid fever in St. Louis in 1902 and 1903 was somewhat greater than in the years immediately preceding.

Q. State in detail what position the science of bacteriology occupies in regard to the ascertainment of the purity of river waters ?

A. In my opinion bacteriology affords a very valuable service to the sanitarian engaged in the consideration of the character of waters. The colon test represents, in my opinion, the most satisfactory single test for determining the wholesomeness of natural water. The information derived from this and other bacteriological tests should, however, be supplemented by chemical, epidemiological and other data where these can be ascertained.

10170 Q. What position does the science of bacteriology occupy in what is known as sanitary science?

A. Bacteriology constitutes in a sense the foundation and basis of all sanitary science, since the infectious diseases with which sanitary science is particularly concerned are germ diseases. The best known of these germ diseases are due to bacteria of various kinds, and not only the nature of the infecting organism, but the vehicle of infection, the channel of entrance into the body and other factors depend for their distinction upon bacteriological data.

Q. State in detail what place the science of chemistry holds in regard to the ascertainment of the purity of river waters?

A. The data derived from the chemical analysis of river water are often very important in enabling a sanitarian to form an independent judgment as to the character of a water. The various stages of organic nitrogenous matter, the amount of chlorine and other elements furnish oftentimes a very good indication of the changes that have taken place in polluted river waters, and from this as a basis correct inferences can be drawn as to the degree of self-purification that has occurred.

Q. What position does chemistry occupy in what is known as sanitary science?

10171 A. In addition to supplementing the bacteriological examination of river water the study of chemistry affords data that sheds light upon many of the general problems of sanitary science. In general, applications to the problems of bacteriology chemistry has been found particulary useful and important.

Q. In the ascertainment of the quality of river water what aid is chemistry and bacteriology to the sanitarian in forming a judgment of the quality and potability of such water?

A. The data derived from bacteriology and chemistry are often the only data that a sanitarian has for forming a judgment as to the character of a given water. Correctly interpreted these data afford very valuable and significant clues as to the sanitary history of a water and often to its quality at the time the examination is made. For a full and complete understanding of the character of a water such chemical and bacterological examinations are indispensable.

Q. From all the tables and analyses submitted by you in evidence in this case, where is the locality along the Illinois river where practical purification of the sewage of Chicago has taken place?

A. Assuming that by practical purification is meant the death of typhoid bacilli, in my opinion this purification has occurred before the flow of the Illinois river reaches Avery-
10172 vile. The exact point must vary somewhat with rate of flow, temperature, number of bacilli introduced, concentration of sewage, etc.

Q. Has the question of self-purification of running streams received consideration from scientific men?

A. Yes, sir, the question of self-purification of running streams has often been broached and great attention has been given to the problem in Europe and in parts of this country.

Q. Are you acquainted with the views of scientific men expressed upon this subject?

A. I have read the statements on this matter in the leading authorities on water supply and river water published in English, French and German.

Q. What statements are there regarding the process of self-purification, regarding running waters?

A. I have here a quotation from a book entitled "Water and Water Supplies" by Dr. John C. Thresh, Medical Officer of Health to the Essex County Council; Lecturer on Public Health, King's College, London; Editor of the Journal of State Medicine; Hon. Sec. Incorporated Society Medical Officers of Health; Fellow of the Institute of Chemistry; Member of the Society of Public Analysts, etc.

This book is one of the best known and most authoritative treatises in the English language on water supply. 10173

The statement follows:

"The balance of evidence is decidedly on the side of those who uphold the theory of self-purification, and the diverse conclusions arrived at by different observers can be accounted for by the varied and often imperfect character of the experiments, and by the diverse conditions which obtain in different streams. That river water, grossly befouled by sewage in its higher reaches, becomes a few miles lower down so pure, from a chemical point of view, as to be certified by the most eminent analysis to be fitted for all domestic purposes, and is actually so used by millions of our population, is a fact which can not be gainsaid. Whether this process of purification be merely due to sedimentation and dilution, or to those factors, assisted by oxidation, is however, a matter of trifling importance, since it is now fully recognized that the disease producing material is not the dead organic matter in solution, but the living organisms in suspension. The problem is not a chemical one, but a biological one."

The statement above is made by Dr. Thresh in his chapter on the self-purification of streams.

In my opinion this statement in Dr. Thresh's treatise represents correctly the prevailing opinion today among 10174 students of this question. Similar statements appear in other English and in German treatises.

Q. In order to qualify as a sanitary expert is it necessary for such expert to have a knowledge of chemistry and bacteriology?

A. I should consider that some knowledge of chemistry and bacteriology was absolutely necessary for the fundamental principles of sanitary science.

Q. Does not a sanitary expert call to his assistance all the information available from chemistry and bacteriology as well as knowledge of the sources of pollution in passing judgment on the sanitary character of a river?

A. It seems to me self evident that all information of whatever kind that tends to shed any light on the questions at issue should be considered by an epidemiologist in the course of his investigations.

Q. As a sanitary expert, acquainting yourself with all the means of bacterial knowledge which is available to you, what is your opinion as to whether a typhoid bacillus lying in the sediment of a polluted stream for a period of sixty days would be able to cause typhoid when taken in the human system after it had remained in such sediment for that length of time?

10175 A. It is my opinion that a typhoid bacillus that had remained alive for sixty days in the sediment of a stream or a lake,—a supposition in itself extremely improbable,—would not be virulent and capable of causing disease in man. I base this opinion upon the observations on virulence of typhoid bacilli after a long sojourn in water. Meager as these observations are, they indicate that a decline in virulence does occur. I should like to add that from all the information that I have been able to gather it seems to me highly unlikely that a typhoid bacillus could remain alive and virulent in sediment for a period as long as that designated.

Q. What is your opinion as a sanitary expert as to whether polluted or infected matter coming from the sewers of Chicago through the drainage canal, deposited on the bottom of the Desplaines and Illinois Rivers, between Chicago and Peoria, can remain there for a period of from thirty to sixty days and yet contain dangerous matter as well as pathogenic bacteria?

A. As I understand the question the terms "dangerous matter" and "pathogenic bacteria" mean one and the same thing, since the so called dangerous matters present in ordinary sewage may for practical purposes be taken to mean
10176 pathogenic bacteria. As I have already stated I do not
believe that the typhoid bacillus, which is the only one of the pathogenic bacteria that need be considered in this con-

nection, may retain its virulence under the conditions designated.

Q. From your personal knowledge of the Illinois River and your knowledge as a sanitary expert, together with all chemical and bacterial knowledge derived from every source, what is your opinion as to whether the sewage from the City of Chicago, passing through the drainage canal into the Illinois River in the different seasons of the year, and at different stages of the water in the Illinois River would be a danger and menace to the inhabitants of the State of Missouri and the citizens of the city of St. Louis using the water at the intake tower at the chain of rocks, or from the Mississippi River as the same passes along the eastern shore of the State of Missouri?

A. From a long and searching examination of all data, chemical, bacteriological and epidemiological from every source, that I have been able to secure, I am convinced that the citizens of the city of St. Louis and the inhabitants of the State of Missouri are not menaced by or endangered by infectious materials passing into the sewers of Chicago and thence into the
10177 drainage canal.

Q. What is your opinion as a sanitary expert, based upon all the tables of your chemical and bacterial analysis, introduced in evidence, of the waters of the Illinois, Mississippi and Missouri Rivers as represented by such tables, as to which one of these three rivers, from these analyses, discloses the least amount of impurity or pollution?

A. Comparing the Missouri River near its mouth with the Illinois River above Grafton, and the Mississippi River above Grafton, I have no hesitation in saying that I regard the waters of the Mississippi and Illinois, at the point indicated, less dangerous and less unwholesome than the waters of the Missouri River. Between the Illinois and the Mississippi Rivers, at the point indicated, there is, in my opinion, not much to choose from a sanitary point of view.

Q. If the Illinois and Mississippi Rivers disclose from such data as aforesaid the least amount of impurity, what would be the effect of the waters of the Illinois River emptying into the Mississippi River at Grafton and consequently uniting with the Missouri River at its mouth, upon the combined waters of the Mississippi, Missouri and Illinois River at the intake tower and chain of rocks?

A. Such an admixture as occurred of the Illinois River water with the Missouri River water would tend to improve the
quality of the water since the number of colon bacilli
10178 in the waters of the Missouri River are distinctly greater
than those in the waters of the Illinois, and this condition, in my opinion indicates that the Missouri River water, which is more highly charged with these objectionable bacteria, is more likely to be the vehicle of typhoid fever bacilli than the water of the Illinois which does not contain so many bacteria of this type.

Q. Does the mixing of the Illinois with the Mississippi and Missouri Rivers, as indicated in the foregoing question, create any added danger to the already polluted and contaminated waters of the Missouri and Mississippi Rivers below Grafton?

A. In my opinion it does not.

Q. From all your knowledge of conditions that obtain in and below the Illinois River, what is your opinion as a sanitary expert as to whether deleterious substances, infectious matter or pathogenic germs which come from the drainage canal, from the sewers of Chicago, would reach as far down the Illinois River as the city of Grafton?

A. All the analytical data that I have obtained myself and all that I have seen which has been obtained by other investigators indicate both from the chemical changes that take place
and from the diminution in the number of ordinary sewage
10179 bacteria, and especially in the diminution of the number of
bacillus coli communis that under existing conditions, infectious materials introduced into the sewers of Chicago can not and do not pass down the Illinois River as far as Grafton.

Q. Do any of these substances in a dangerous state, reach the intake tower of the St. Louis water works at the chain of rocks in your opinion?

A. In my opinion they do not.

ADJOURNED UNTIL 2:00 P. M., SAME DAY.

10180 2:00 P. M., Thursday, February 11, 1904. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. Assume that in 1890 the increase in typhoid fever in Washington, D. C. was due to an epidemic of typhoid fever in Cumberland, Maryland, and assume that Cumberland, Maryland, is 580 feet above the level of Washington, D. C., and is distant by water 170 miles, or in time 4 days. Assume the above facts to be true, does the typhoid condition in Washington and Cumberland afford any epidemiological or sanitarian basis for a comparison between those cities and the city of St. Louis and Chicago, taking into consideration that the elevation of Chicago over St. Louis is approximately 198 feet and distance 357 miles, or 18 1-2 days the mean average time of flow, together
10181 with all that you know about existing conditions that obtain upon and in the water courses between Chicago and St. Louis?

A. On the assumption just stated it would certainly be impossible to draw a fair comparison between the conditions prevailing on the water sheds of the Illinois and Potomac Rivers. The relatively very rapid flow from Cumberland to Washington and the relatively short space of time within which a body of water can travel this distance represents a very different set of conditions from those prevailing in the Illinois River between Chicago and St. Louis, since in the lower portion of the Illinois River the current is sluggish and the time required for a body of water to pass a mean average flow from Chicago to St. Louis is very much greater than the required time, on the assumption, to pass from Cumberland to Washington. The conditions are, therefore, radically different and it does not follow that if typhoid bacilli have passed from Cumberland to Washington, under the conditions prevailing on that watershed, that typhoid bacilli can also pass from Chicago to St. Louis under the conditions prevailing in the Desplaines, Illinois and Mississippi Rivers.

Q. As a sanitary expert do you consider the sewage of
10182 Chicago entering the drainage canal, the Illinois River,
which in turn enters into the Mississippi River, a menace and a danger to the inhabitants of the State of Missouri and to the citizens of the City of St. Louis, taking their water supply from the Mississippi River and from the intake tower at the chain of rocks from the Mississippi River?

A. I can not regard the discharge of sewage into the Chicago sewers and into the drainage canal under the conditions specified as constituting any danger in the way mentioned to the health of the citizens of St. Louis and the inhabitants of the State of Missouri. In my opinion the dangerous elements in Chicago sewage are eliminated from the Illinois River before the mouth of said river is reached.

Q. What is your opinion as a sanitarian expert as to whether the germ of typhoid fever could lie in the sediment of the drainage canal or upon the bottom of the Illinois River for a period of from one to three years?

A. It is my opinion that the typhoid bacillus could not live nearly as long as from one to three years in the sediment of the river or drainage canal.

Q. Do you know of any instance on record or reference in literature upon the subject of bacteriology where the ty-
10183 phoid bacillus has lived from one to three years in the
sediment of streams?

A. I know of no such case.

Q. What is your opinion as to whether a typhoid bacillus deposited on the bottom of the Illinois River could remain there for a period upwards of five years and then be stirred up by the action of the waves, winds, steamboats or by other means, could continue its journey down to St. Louis in a virile state and be a cause of danger to the inhabitants of the State of Missouri using the water of the Mississippi River and to the inhabitants of the City of St. Louis using the water of the Mississippi River for drinking purposes?

A. The hypothetical case proposed in your question of a typhoid bacillus living as long as five years in the sediment of the Illinois River and retaining its virulence during that period is, so far as I am aware, wholly without basis in observed fact and finds no support in the deductions that can be drawn from my own observations or from the observations of others upon the conditions prevailing in the Illinois River or elsewhere.

Q. What is your opinion as an expert chemist, and bacteriologist, as to whether the pollution and contamination
10184 from the sewers of Chicago, emptying into the Chicago River and thence into the drainage canal, continues to be manifest and persistent as far down the Illinois River as Grafton and at the chain of rocks on the Mississippi River?

A. The pollution that has occurred at Chicago is manifest at the mouth of the Illinois River chiefly in the increased amount of chlorine present in the water of the Illinois River at that point. The introduction of a large amount of nitrogenous organic matter is also betrayed by the large amounts of various compounds containing nitrogen present in the water of the Illinois River at its mouth, but so far as the original polluting matters and pathogenic bacteria introduced into the Chicago drainage canal are concerned, I can find no grounds for adopting the opinion that these substances and these bacteria persist in their original condition as far down the river as Grafton.

Q. From your examination of the waters of the Illinois River what is your opinion as a sanitary expert as to whether any of the original organic matter of the sewage from Chicago finds its way into the intake tower of the St. Louis water works at the chain of rocks?

A. It seems to me quite possible that some of the very stable and slightly oxidizable compounds introduced into the sewage of Chicago may reach the mouth of the Illinois
10185 River but these stable compounds which do not undergo ready decomposition under natural conditions have, so far as is known, no sanitary significance. The unstable and readily oxidizable nitrogenous products are, in my opinion, altered before reaching the mouth of the river to such a degree that it can not be properly said that any of the original organic matter finds it way to the intake tower of the St. Louis water works.

Q. Will you state your opinion as a sanitary expert, basing your opinion on all the information you possess in this case, whether the water supply of St. Louis is contaminated, polluted or injured by the sewage of Chicago entering the drainage canal and from thence into the Illinois River?

A. It is my firm opinion that no such pollution, contamination or infection of the St. Louis water supply, by the sewage of Chicago, occurs.

Mr. Jeffries: I object to the question unless the witness confines his answer to the information which he may have regarding conditions affecting the sanitary condition of the water of the Illinois and Mississippi River as has been detailed by him in his evidence and as is shown by his testimony.

Q. What effect does an increased volume of water in the Illinois River have upon the low lands lying along the 10186 banks of the Illinois River?

A. At such high water periods the low lands along the banks of the Illinois River, especially in its lower stretches, are flooded and large stretches of the river become for days immense settling basins.

Q. If the increased water at flood times from the tributaries of the Illinois as well as the Illinois itself, exclusive of the water of the drainage canal, causes a large area of the land to be overflowed along the Illinois river valley, what effect does this overflow have upon sedimentation of the sewage from Chicago entering the Illinois river through said canal?

A. So far as the current of the river is slackened in these overflowed areas, so far will those elements in the sewage that persist long enough to reach these points be retarded in their passage down the river and perhaps be permanently deposited on these flooded low lands.

Q. What would be the effect upon sedimentation if the volume of water was great, thereby causing a greater area of territory to be overflowed in the Illinois river valley?

A. The larger the amount of territory flooded the greater will be the opportunities for sedimentation of particles, and retarding the flow.

Q. Assume that five dams, one at Marseilles, one at Henry, one at Copperas Creek, one at La Grange and one at 10187 Kampsville, exist in the Illinois river, backing the water up stream for a considerable distance; also there is a lake known as Lake Joliet, a lake above Peoria known as Lake Peoria and many small lakes lying along the Illinois river, receiving their water supply from the Illinois river, what effect do these dams and lakes have as sedimentation basins and also what effect do they have in the elimination and purification of polluted and infected matter, coming into the Illinois river from the Chicago drainage canal?

MR. JEFFRIES: Objected to for the reason that the defendants' testimony shows, and the examination of the witnesses along the Illinois river, that since the opening of the drainage canal there has been and is now a continuous direct and ever flowing current in the Illinois river, from source to mouth, and while it may be true that certain lakes obtain in part their supply of water from the Illinois river, yet the fact remains that the current is often continuous and direct from the source of said river to its mouth, and that the facilities for sedimentation, as elicited by the question, are not affected by or in any way material to the question here involved.

10188 A. These dams and slack water basins or lakes in my opinion materially facilitate process of sedimentation and also serve to retard the current in a not inconsiderable degree.

MR. JEFFRIES: I move to strike out the question and answer for the same reason stated in my objection to the question and for the further reason that defendants' testimony shows that so far as the dams on the Illinois river that were constructed by the State of Illinois, they not being kept in proper condition an effort is being made to have such dams remvoed because the opening of the drainage canal has removed the reason for their construction, and for the reason that the State of Missouri has no assurance upon the part of the Federal Government or of the defendants herein that any of the dams so constructed will be continuously maintained from now on, even though it be conceded that they play an important part in effecting the purification of the sewage from the City of Chicago, and for the further reason that the evidence here shows since the opening of the drainage canal a continuous and ever-flowing current, from one end of the year to the other, both above, below and over said dams, thereby removing the facilities for sedimentation and such purification as necessarily was produced ther[illegible] prior to the opening of said canal when the water immediately and for miles above the dams remained

10189 in practically a quiescent state during the greater part of the year, such conditions as then existed not pertaining to said river on account of said dams since the opening of said canal.

Q. Assuming that the dams at Henry, Copperas Creek, LaGrange and Kampsville, as they exist today, should be removed from the Illinois river, what effect would the removal of these dams from the Illinois river have upon the water supply of the State of Missouri and the City of St. Louis assuming that the sewage from Chicago should enter the drainage canal and thence into the Desplaines and Illinois rivers after the dams were so removed the same as it does under present conditions?

MR. JEFFRIES: Object to the question for the reason that the questions heretofore put by the counsel for defendant assume and take it for granted that said dams to a certain extent are a means of purification and to such an extent a safe guard to the people of the State of Missouri, and for the further reason that it is incompetent, irrelevant and immaterial.

A. So far as the purification of the sewage of Chicago is concerned the assumption of the removal of the dams at the places stated would in my opinion not materially affect such purification, since the elimination of typhoid bacilli takes place, in my judgment, in the upper stretches of the Illinois
10190 river. It is possible that a removal of said dams might have some effect in retarding the purification of the sewage and the elimination of dangerous bacteria discharged by various communities in the lower half of the river.

Q. Would the water supply of St. Louis at the St. Louis intake and the citizens of Missouri taking their water supply from the Mississippi river be endangered or infected by the sewage of Chicago entering the drainage canal if the four dams before mentioned in the Illinois river should be removed?

A. Not so far as the danger of infection in the sewage of Chicago is concerned.

Q. From your chemical and bacterial examinations what parts do the dams in the Illinois river play in the purification of the sewage from Chicago?

A. In my opinion they have little, if any, share in effecting or accelerating the purification of the Chicago sewage.

Q. Will you state as an expert sanitarian and epidemiologist from all sources of knowledge that you possess whether the water of the Mississippi river at the chain of rocks was prior to January, 1900, a safe and potable drinking water fitted for domestic and drinking purposes in its raw state?

10191 A. In my opinion the Mississippi river water at the intake tower at the St. Louis water works at the chain of rocks was unfit and unsafe for drinking purposes during the period mentioned.

Q. Was the Missouri river at Ft. Bellefontaine a safe water for drinking and domestic purposes in its raw state or treated with settling basins prior to the opening of the drainage canal in January, 1900.

MR. JEFFRIES: All these questions are objected to as being immaterial.

A. Assuming that the period of storage of such water in settling basins was not greater than three or four days it is my opinion that such water was not fit or safe.

Q. Was the Illinois River water a safe water for drinking and domestic purposes prior to the opening of the drainage canal in January, 1900, at Grafton?

A. In my opinion it was not.

Q. Has the sanitary condition of the water of the Illinois River at Grafton been improved or damaged by the opening of the drainage canal?

A. In my best judgment the sanitary quality has not been materially affected either in the direction of improvement or in deterioration.

10192 Q. Since the opening of the drainage canal are the waters of the Illinois River at Grafton less sanitary than the waters of the Missouri River at its mouth or the Mississippi River above Grafton?

Mr. Jeffries: I object to the question as immaterial.

A. So far as I can judge from all the analytical data that have come under my observation the Illinois River water at this time was no worse than the water of the Mississippi River, while the water of the Missouri River was distinctly inferior in its sanitary qualities to both the water of the Mississippi and the Illinois.

Q. What effect does the sewage discharged through the drainage canal have upon the waters of the Mississippi River and the Missouri River at the chain of rocks?

Mr. Jeffries: I object to the question as immaterial and a repetition.

A. Beyond increasing the amount of chlorine and perhaps of some other constituents of no sanitary significance it is my opinion that the sewage of Chicago has had no material effect upon the water of the Mississippi River as indicated in the question.

Q. Does the sewage of Chicago, in your opinion, even reach the intake tower of the city of St. Louis at the chain of rocks?

A. If by sewage is meant living pathogenic bacteria I
10193 am firmly of the opinion that it does not. If by sewage
is meant the original, unstable organic compounds of Chicago sewage I am also of the opinion that these do not reach the chain of rocks, at any rate in any quantity possessed of sanitary significance.

Q. Are the waters of the Mississippi and Missouri Rivers, exclusive of the water of the Illinois, safe and suitable water for domestic and drinking purposes, to be used by the citizens of St. Louis in its raw state or treated as now by the City of St. Louis in settling basins?

Mr. Jeffries: I object to the question as immaterial.

A. In my opinion the water of the Missouri River at its mouth and the water of the Mississippi River at the chain of rocks excluding the Illinois River from the latter, are not fit and wholesome waters and would not properly be recommended as a source of municipal water supply in a raw condition.

Q. If the sewage from Peoria and all other towns along the Illinois River and its tributaries as well as the rural population upon the water shed of the Illinois River was eliminated from the Illinois River would all of the sewage of Chicago be eliminated long before it reached Grafton.

10194 Mr. Jeffries: I object to the question as leading.

A. In my opinion it would, so far as the ordinary decomposable and unstable organic substances are concerned. It would also disappear so far as the pathogenic bacteria originally present in said sewage are concerned.

Q. If the typhoid condition in St. Louis since 1900 can not be attributed to the sewage from Chicago beyond a reasonable doubt will you please state what cause in your opinion it should be attributed to and give your reasons for such an opinion?

A. Assumning that the amount of typhoid fever occurring in St. Louis during the period mentioned is in excess of what would naturally exist in a city provided with a fairly pure and satisfactory municipal water supply in my opinion the most rational and scientific explanation of such excess would lie in the infection of the Illinois, Mississippi and Missouri Rivers above the intake tower of the St. Louis water works by communities rural and urban within five or six days flow from the intake tower. Since in my opinion the major part of the water supplied to St. Louis during this period was derived from the Missouri River and inasmuch as it is my opinion the Missouri River is more seriously infected than either of the other rivers mentioned it is my judgment that the infection of the Missouri River has been the main factor in causing such excess of typhoid fever in St. Louis as occurred during the period under consideration. 10195

Q. Professor, taking into consideration all the knowledge which you possess in regard to the chemical, bacterial and physical condition of the waters of the Illinois River and its tributaries; the different towns sewering into the Illinois River and into its tributaries; the population upon the water sheds of the Illinois River, both rural and urban; the stages of the river under all conditions and during all seasons, what is your opinion as a sanitary expert as to the effect of flowing the sewage from Chicago through the drainage canal into the Desplaines and Illinois River upon the inhabitants of the State of Missouri using the waters of the Mississippi River for drinking and domestic purposes?

A. It is my opinion, assigning due consideration to all the facts mentioned, that the discharge of the sewage of Chicago into the drainage canal has had no injurious or detrimental effect upon the health of the inhabitants of St. Louis or the State of Missouri.

Q. Professor, taking into consideration all the knowledge which you possess in regard to the chemical and bacterial and physical condition of the waters of the Illinois, the Mississippi

and Missouri Rivers and their tributaries; the different towns sewering into these three rivers and their tributaries, the
10196 population upon the watersheds of these three rivers, both rural and urban; the stages of the three rivers under all conditions and during all seasons and taking into consideration all the knowledge that you have in regard to the typhoid conditions as they obtain along the water shed of the Missouri and Mississippi and Illinois Rivers, in the City of Chicago and in the City of St. Louis, what is your opinion as to whether the typhoid conditions as they have existed in St. Louis, since January 17, 1900, the date of the opening of the drainage canal, can be attributed to the opening of the drainage canal as the direct, immediate and proximate cause of said typhoid condition existing in said City of St. Louis beyond all reasonable doubt?

A. Summing up all the experience that I have gained in my studies of the Illinois and Mississippi and Missouri Rivers and their tributaries and all the information that I have gained from all sources it is my firm opinion that no relation near or remote, has been traced between the typhoid conditions in St. Louis since January 17, 1900, and the opening of the drainage canal on that date; and it is further my opinion that no such relation exists, and that the opening of the drainage canal was an event entirely unconnected and unrelated with any typhoidal conditions prevailing in St. Louis at that time, and has
10197 remained up to the present time, unrelated and unconnected with the typhoid fever mortality in the City of St. Louis.

Adjourned until 10:00 a. m., February 12, 1904.

10198 10:00 a. m., Friday, February 12, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN

resumed the stand for cross-examination by Mr. Jeffries, and testified as follows:

Q. Professor, have you ever examined water known to be infected with typhoid germs, that was used or being used for domestic and drinking purposes?

A. I am not sure what is meant by the expression "known to be infected with typhoid germs." If by that expression is meant a water which there was reason to suppose was causing on excessive amount of typhoid fever among the community served with such a supply, I would say that I have examined such waters. If by the expression is meant that typhoid germs were known to be in the samples of water at the time the examination was made, I would say that I have not. A given source of supply, as a lake or a river, may, on epidemiological grounds, be suspected of causing typhoid fever, but when an examination of such water is made the typhoid bacilli may have disappeared. It is chiefly for this reason, in my opinion, that the findings of typhoid bacilli are so few in number.

10199 Q. Then I understand you to say, Professor, that you have not examined water known to be infected with typhoid fever germs at the time of the examination, which water was being used or had been used for drinking purposes and domestic purposes?

A. I have never found typhoid bacilli in such water.

Q. But have you made an examination of such water?

A. As stated in my first answer the only proof that such water was infected with typhoid bacilli at the time an examination was made would be the finding of such bacilli in the water. This I have never accomplished.

Q. Then do I understand you to say that there can be no other proof of the existence of typhoid fever germs in water other than the absolute finding of them by the analysis in the water?

A. No sir, that is not a correct inference. The presence of typhoid fever germs in a water might be demonstrated either by finding them in such water or it might be demonstrated by administering such water to a healthy human individual under laboratory conditions, excluding all other sources of infection. These are the only methods I know by which the existence of typhoid bacilli in a given quantity of water could be determined beyond a question.

10200 Q. What is the most general way in which typhoid infected water has been so determined in the scientific world?

A. I know of no royal road to the accomplishment of this end. The question of the sanitary quality of a water can be approached in other ways and by other methods than by a direct search for the presence of a typhoid bacillus in a given quantity of water.

Answering your question directly I would say that in my opinion the most convincing evidence of the presence of typhoid bacilli in a given water during a given period would be the tracing of cases of typhoid fever to that water, it being assumed that other sources of infection were sufficiently well excluded to permit the establishment of the conviction that the particular water under consideration at the particular time stated was responsible for the production of the cases of typhoid fever.

Q. Then, as I understand you, the best evidence as to water being typhoid infected is the result which it produces upon a community using it for domestic and drinking purposes? Is that true?

A. That is true.

Q. Now, Professor, have you, during the pendency of a typhoid epidemic, which was reasonably known to have been caused by the use of a certain water supply examined 10201 that water supply scientifically, chemically and bacteriologically?

A. The long period of incubation in typhoid fever—about 14 days—and the period that elapses before death occurs—an average perhaps of about three weeks—brings it about that at least several weeks elapse between infection with typhoid fever bacilli and the first manifestations of the existence of an epidemic. For this reason examination of the water in such epidemics is not, as a rule, made until after infection has taken place. During this period of four or five weeks elapsing between infection and bacteriological examination the conditions of the water may become so altered that it is no longer infectious. I have made some examinations of water supplies while the epidemic itself was pending, but in all such cases a considerable interval had elapsed since the initial infection that gave rise to the epidemic.

Q. State briefly what water supplies were examined by you as mentioned in your last answer?

A. I made some examinations of the water supply of the city of Chicago in the fall of 1902. I also, a number of years ago, made examinations of the water supply of the city of Lowell, at the time a typhoid epidemic was prevailing there. There was reason in both these cases to think that the water supply was the cause of the outbreak of typhoid fever prevailing in these respective communities. 10202

Q. Did you make any examination of the water supply at Butler, Pa., and Ithaca, New York?

A. No, I did not.

Q. How long in your opinion did this infection at the places mentioned by you continue?

A. At Lowell there seems to have been infection of the water supply by several cases of typhoid fever on several occasions. I do not recall the exact dates on which such infection occurred nor do I know that such exact information was obtainable. I have no means of knowing the period through which infection lasted at Chicago.

Q. Have you any information as to the duration of the infection in the water supply at Ithaca, which you have testified to in your direct examination?

A. I have not.

Q. Do you know how long the epidemic had prevailed prior to your visiting Ithaca, New York?

A. So far as the facts could be ascertained regarding the time of onset and the outbreak it appears that about 14 cases of a low fever, possibly typhoid, occurred between November 17, 1902, and January 15, 1903. Then on January 15, some 5 or 6 cases of fever developed and during the following week several cases each day were reported. After January 25th the number of cases reported daily seems to have increased very materially, and the presence of a serious epidemic began to be recognized. 10203

Q. When did you say you visited Ithaca?

A. I reached Ithaca on March 7th and remained there about a week.

Q. Were there any cases of typhoid fever in Ithaca at the time you were there?

A. There were a great many; several hundred.

Q. Were there any new cases developed while you were here?

A. Yes. Cases continue to develop in every large epidemic f typhoid fever long after the original source of infection has isappeared. This is what is known as secondary infection, hich plays an important part in the spread of every considerble epidemic. This source of infection was very conspicuous oth at Ithaca and at Butler.

Q. In what way did this secondary infection manifest itelf at Ithaca?

A. Cases of typhoid fever occurred in the household of atients already sick with the disease, among the family or mong the nurses, physicians or attendants on the sick. This o-called secondary infection consists in a more or less direct transfer of bacilli from the body of the patients to those
0204 persons in the immediate surroundings of the patient.

Professor Sedgwick has called attention to a very interestng instance of secondary infection in Bondville, Massachusetts.

Q. This secondary infection that you speak of is attribuable to the association of persons with those having typhoid ever is it?

A. Yes sir, that is what is generally meant by secondary nfection.

Q. As a matter of fact, Professor, were there not newly eveloped cases of typhoid fever at Ithaca when you were there, ttributable to the primary infection or cause?

A. I think that that is quite possible. The history of infection of the water supply, so far as it could be gotten at, ndicates that bacilli had been washed from the soil or from acumulations on the banks of the stream in Six Mile Creek which erved as a source of the supply. If any such fountain head of nfection existed, it might continue to be active for a long eriod, owing to the circumstance, which I have already menioned on several occasions, that typhoid bacilli can live for eeks or even months in such accumulations of fecal matter or in soil so that the water supply of Six Mile Creek may
10205 have been fed for a considerable period with typhoid bacilli.

Q. Can you describe the reservoir which contains the water supply or holds the water supply of Ithaca, as it existed at that time?

A. The water supply of the city of Ithaca was considerably mixed. A mixture of the water from the Six Mile Creek and Buttermilk Creek was pumped into a small reservoir, holding, if I remember correctly, hardly more than a day and a half's supply.

Q. Do you know anything as to the depth of the water in that reservoir, and its dimensions, its length and breadth?

A. I have no precise memoranda on those points with me at present. I obtained them at the time I was in Ithaca, but have not them with me at present.

Q. If the first noticeable cases of typhoid fever appeared in Ithaca about the 17th of November, 1902, in your judgment how long prior thereto was the water supply of Ithaca infected with typhoid bacilli?

A. In my opinion the water supply of Ithaca had probably been infected with typhoid bacilli at intervals for some years prior to this date. The previous history of the typhoid fever and the so-called Ithaca fever in the town indicates that the water supply had been more or less infected for some 10206 years. The prevailing opinion among persons connected with Cornell University and who paid attention to matters of this character was that the water supply had been unsafe for such a considerable period, and in many families it had not been used in its raw condition for years before this specific outbreak of typhoid fever. From the best information that I could obtain there seems to have been a certain amount of typhoid fever on the water shed of Six Mile Creek at intervals during a very long time.

Q. With reference to the specific epidemic at Ithaca, which you investigated, how long prior to November 17th was the water supply of that city infected to an abnormal extent, so as to produce and bring about the epidemic at that place?

A. I should not place the outbreak of the epidemic at Ithaca quite as early as November 17th, since there were only 14 cases between November 17 and January 15th. The specific outbreak of typhoid fever at Ithaca seems to have begun about January 15th. The specially heavy infection which gave rise

excessive number of typhoid fever cases appearing on
te may have occurred between 10 and 18 days previously.

Is it not a fact that there had been no cases of typhoid
n the water shed of Six Mile Creek for several weeks
o the outbreak of the epidemic at Ithaca?

A. The exact source of this epidemic has, in my opinion,
not been definitely ascertained, that, is the precise
case or cases of typhoid fever that gave rise to the ex-
ly heavy pollution of the water of Six Mile Creek. Two
e sources of infection were, however, quite conspicuous
ninds of persons in Ithaca. One of these was the presence
e Italian laborers some months previously who had en-
l along the banks of Six Mile Creek during the process
tructing a dam, and the other was the presence of some
y laborers constructing a culvert over the stream. No
of typhoid among the Italian laborers could be obtained.
ling the railway workmen the case was somewhat more
ous. Whatever the source of infection, however, it seems
have been a case of direct water pollution, but a washing
f bacilli from the soil or from fecal accumulations.

Is it not a fact that an effort was made in investigating
al homes upon that water shed and in that investigation
s of typhoid fever were found in those homes for several
prior to this epidemic?

I believe that Dr. Soper, representative of the New
State Board of Health, was conducting such investigation
ime of my visit in Ithaca. I have not seen any published
ent of the outcome of this inquiry.

Q. Was not an investigation of this character going on
at the time you were there?

A. Yes sir. That is the one I referred to as being con-
under the supervision of Dr. Soper.

In the event bacterial analysis had been made at the
at any time within thirty days prior to the epidemic, in
dgment would any such analysis disclose the presence of
l bacilli?

I think that is possible.

Is it probable?

That would depend upon several factors. First, the number of typhoid bacilli in the water; second, the methods used for examination of the water; third, the extent of the examination.

Q. In the event there be one typhoid fever germ for every pint of water, would you consider that as a water supply highly infected or not?

A. I should not.

Q. And such an infection would not, in your opinion create or cause a typhoid fever epidemic?

A. Nothing is known as to the number of typhoid fever bacilli necessary to produce a case of typhoid fever in man.

10209 Q. Based upon your last answer how then can you say that a distribution of typhoid fever germs in the water supply at the ratio of one germ for each pint of water is not to be considered a highly infected water?

A. While nothing definite is known as to the number of typhoid bacilli necessary to produce a case of typhoid fever in man, some light is thrown on this by experiments made upon animals. It is well known that in working experimentally with pathogenic microbes a single germ is rarely able to produce infection. Based upon laboratory experiments with pathogenic bacteria it is my opinion that a single typhoid bacillus would not be capable of causing an infection in a human being, since it is found that in practically all cases of inoculation of animals with specific pathogenic bacteria, not one germ alone but many hundreds must be used in order to produce infection, even when these bacteria are introduced into the most delicate portions of the body.

As indirectly bearing on your question I may mention a case which has recently been published of the attempted suicide by a laboratory worker through swallowing typhoid cultures. Several tubes of broth cultures of typhoid bacilli were swallowed with the aim of committing suicide, but only a

10210 mild case of typhoid fever resulted in spite of the hundreds of millions of bacilli that were taken in in this highly infected broth. It is of course a matter of opinion as to what constitutes a highly infectious water. Personally I should not gard a water containing one typhoid bacillus per pint as a ghly infected water.

Q. This instance of experimental suicide would not in your inion have the same effect if undergone by all persons pro- scuously would it?

A. Certainly not.

Q. So then certain typhoid infected water may be a high ection as applied to certain persons or when taken into the stem by certain persons, when it would not be highly infected en taken into the system by other persons? Is that true?

A. On that point again there is very little data on which to se an opinion. We do not know how widely the susceptibility different individuals in infection with typhoid fever bacillus ries or upon which such susceptibility depends. Individuals tween the ages of 15 and 35 are, as is well known, more liable typhoid fever than younger persons or those of more ad- vanced age, and it is a striking and well recognized fact
211 that robust individuals in apparently excellent physical
condition contract cases of typhoid fever when weaker lividuals do not. Upon what this variation and susceptibility pends, or how great it is, there is, as I have said little informa- n. There are certainly individual differences in respect to ection with typhoid fever just as in the case of other diseases.

Q. What do you understand to be highly infected typhoid ter as applied to sanitary science and to the history of epi- mics with which you are acquainted.

A. I should regard the water supply of Ithaca and Butler the time of the typhoid epidemics pervailing there as a ghly infected water. In these two communities almost ten r cent. of the population was affected.

Q. Is there anything in sanitary science that enables one reach the conclusion that the water supply of either Ithaca Butler was infected to a greater extent than one typhoid rm to each pint of water contained in those suppplies?

A. Only the reasons which I have given, which seem to me fficient.

Q. Is there anything in the science which furnishes absolute d definite assurances that an infection of one typhoid germ one pint of water, when contained in the water supply of a

10212 city such as Ithaca or Butler will not, does not and has not produced typhoid epidemics in those cities?

A. I have aready expressed my opinion that all the experience gained in bacterioligical laboratories from inoculation of hundreds and thousands of animals with many kinds of pathogenic bacteria, under varying conditions has shown that rarely if ever can one germ or two or three germs, even when belonging to highly virulent varieties, produce an infection. So far as I know, this analogy is all that we have to depend upon for forming an opinion on the point indicated in your question.

It is my opinion that swallowing one or two or a half dozen typhoid germs would not produce a case of typhoid fever in man, basing this opinion on the analogies drawn from laboratory experience.

Q. As an epidemiologist will you make any alterations in the conclusions which you have just drawn?

A. If it could be shown by indisputable proof that a community supplied with a water supply containing not more than one typhoid germ per pint of water developed a largely excessive amount of typhoid fever, plainly attributable to the use of such water, I should certainly change my opinion.

Q. This answer then is based upon the fact that there is no way of determinig scientifically or otherwise the cause 10213 of the infection of any water so far as the quantitative infection is concerned is it not?

A. It is based rather upon the fact that we do not know how many typhoid bacilli are necessary to produce a case of typhoid fever in man.

Q. Typhoid fever is contracted by drinking water is it not, professor?

A. That is one of the ways in which it may be contracted.

Q. Is that the most prevalent and general way?

A. Taking the world as a whole I think it is undoubtedly.

Q. While it may be true as stated in your second preceding answer that it has not yet been scintifically determined as to the exact number of typhoid germs necessary to produce typhoid fever in a patient is it not also true that science has thus far been unable to determine quantitatively speaking the extent of the infection of the water known to be infected?

A. Understanding that question to mean the number of yphoid bacilli present in the water at the time that the use of uch water has given rise to an epidemic of typhoid fever I vould say that so far as I am aware the number of typhoid acilli present in such water has never been precisely deternined.

Q. Do you know of any instance where the typhoid fever
0214 germ has been discovered by bacteriologists in their analysis of the water supply of the city?

A. Yes, I have already submitted in my testimony a record f all the cases that I have been able to find in the literature on he subject where a typhoid bacillus has been isolated from water upplies.

Q. And the cases to which you refer are known by you as he six recorded cases?

A. They are, I know of only the six cases that I have reerred to.

Q. And those six cases are the result so far as you know f the work of bacteriologists as applied to the sanitary science or a number of years past, is it not?

A. I should not be willing to make any such a broad statenent. I should simply confine myself to the statement I have lready made that these are the only recorded instances I have een able to find in the literature where the typhoid bacillus as been discovered in water ordinarily used for drinking. The ime that elapses after the infection of water before a cometent bacteriological investigation can be set on foot is one eason why bacteriologists so seldom examine suspicious waters or the presence of typhoid bacilli since experience has shown that when such waters are examined the long period that
0215 has elapsed since infection has permitted the dying out of
bacilli. In one of the cases that I have presented, namely hat by Kubler and Neufeld the evidence indicated that the typhoid bacilli had been introduced in pure culture, so to speak, n the well water in which they were found, namely in the rine of typhoid fever patients containing only typhoid fever erms. The absence of competing fecal bacteria might account or the relative long life of typhoid bacilli in the well water

under these conditions. It is apparently only in such accidental cases that typhoid bacilli survive long enough in water to be found at so late a date as that at which the bacteriological examination is usually undertaken. If one knew just when a given water supply were to be heavily infected with typhoid bacilli and if a proper investigation of such a supply should be undertaken the positive findings would be more numerous than they can possibly be at present, where the stable is not locked until after the horse is stolen.

Q. In water that is infected the typhoid fever germs at the ratio of one germ to each pint of water, could those germs be easily detected by a bacterial analysis?

A. They could not.

Q. If a thousand samples of that water were examined, each sample representing one cubic centimeter, what, in 10216 your opinion, would be the probability of it being detected?

A. It is not likely that it would be.

Q. What in your opinion as a bacteriologists in the examination of water supplies is the necessary distributive number of typhoid bacteria as to guarantee positive typhoid results in the analyses?

A. Assuming in your question that proper methods were used by a bacteriologist, with proper and special experience in this kind of an investigation, and assuming that 10 cc. of water were examined, and that typhoid bacilli were distributed in such a way that there was one in each cc., I think that with water of ordinary bacterial content typhoid bacilli should be found in one-half of the samples. It might be found in them all, and would if a sufficiently detailed examination were made.

Q. And unless the greatest of care would be used it might not be found in any?

A. My answer assumed that the examination was made properly and by a skilled and an experienced observer.

Q. At the rate of one bacilli for each cc. of water how many would that be per pint, Professor?

A. About 500.

10217 Q. Now in making these determinations where the typhoid germ is distributed throughout the water at the rate of one germ to each cc. of water the ability to find these specific germs in that water by the analysis would depend largely upon the presence of other bacteria would it not?

A. Very largely.

Q. In what way would the presence of these other bacteria affect the finding of the typhoid?

A. Their presence would increase the number of plates that must be made in order to bring about a suitable separation of the colonies developing thereon, and would increase the labor in this way.

Q. Would their presence in any way bring about an overgrowth of colonies or by reason of their great number submerge the typhoid colony on the plate?

A. Special media are used for this kind of investigation and these may suppress a very large percentage of the ordinary sewage bacteria, while allowing the typhoid bacillus and some nearly related forms to grow. Where these plates are made properly the colonies are absolutely distinct and separate and there is only a remote chance of the obscuration of the typhoid colony by some other colony.

10218 Q. Is it not a difficult matter, Professor, to distinguish at all times the difference between colon and the typhoid?

A. Not when these special media are used. It is on the contrary very simple. The mere color of the colony, according to the media used, red or blue, enables one to effect an instant and complete differentiation with the naked eye.

Q. Does this special media about which you speak have a tendency to retard the colon or does it develop with the same precision as the typhoid?

A. These media permit the development of the colon colonies, but differentiate their colonies from those of the typhoid bacillus.

Q. Professor, in the analysis of water that is known to have been infected with typhoid germs, and afterwards analyzed, was there any information preserved with reference to the extent of the coli present in any of the cases which you have referred to in your testimony?

A. Yes, I have in several cases the record of the number of colon bacilli. I can get those if you want them.

Q. No, I don't care anything about that. In your opinion does the extent of the coli throw any light upon the extent of the infection so far as the particular cases referred to in the last preceding question are concerned?

A. In reply to that I can only state that at the time I
10219 examined the Chicago water in the autumn of 1902,
shortly after the great epidemic of that year, the number of colon bacilli in the water was higher than I had found it at any previous time. I had made no systematic observation of the Chicago water for any long period but during the ten preceding years I had at occasional intervals and on some occasions for periods of several months made examinations of such water to determine the presence of coli bacilli and at no time had there been as much typhoid fever in the city as in the summer of 1902. At no time also had I found the colon bacilli so abundant in the water as in the fall of 1902, just after the especially severe outbreak of that year.

Q. Do you know whether the water at Butler was being examined by bacteriologists when you were there?

A. It was.

Q. Do you know whether there was an increase in the coli as shown by those examinations over what was shown prior to the epidemic?

A. So far as I know, no examinations had been made prior to the epidemic.

Q. Going back now to the subject of infection would you consider 500 typhoid germs per pint of water and that distribution maintained throughout the water supply as being highly infected?

A. I have not given very careful consideration to establishing a limit for what constitutes a highly infectious
10220 water. I should think that water with 500 bacilli per pint
was certainly much more dangerous than one averaging one typhoid bacillus per pint and that the danger from drinking such water would be much greater in the former case than in the latter.

Q. Is it not a fact that no sanitarian has given the permissible extent of infection much study, but that all efforts so far as sanitarians are concerned has been to the elimination of infection and to a study of its possible presence?

A. I think that is true.

Adjourned until 2:00 P. M., February 12, 1904.

2:00 P. M., Friday, February 12, 1904.

10221 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN

resumed the stand for further cross examination by Mr. Jeffries, and testified as follows:

Q. Professor, there is nothing in sanitary science that undertakes to fix a standard of permissible infection is there?

A. I know of no standard of permissible infection.

Q. What are the elements that enter into the determination of the sanitary condition of a given water supply by an expert sanitarian?

A. The amount of infection entering such supply so far as this can be determined by reference to the population, urban and rural, draining into such supply, together with the conditions as to the probable disinfection of discharges from the bodies of patients; the freshness of such infection as indicated by the nearness of the source of infection to the point where the water supply is obtained; the analytical data, chemical 10222 and bacteriological. All these elements enter into consideration in passing judgment on the quality of a given water

Q. Is there anything in sanitary science that permits or has established an exact, definite and distinct formula, so far as time limit is concerned, from the source of the deposit of the infected material in the water of the stream that is being analyzed or examined?

A. I know of no such formula nor do I believe that it would be wise or feasible in the present state of sanitary science to attempt to advance such a formula inasmuch as a problem of this sort contains certain individual elements which compel it to be considered as an individual case.

Q. The life limit of the disease producing organisms discharged into a running stream or a water supply depend, do they not, upon the character of the organism, the temperature of the atmosphere or water as well as the volume of water?

A. The character of the specific microbe and the temperature of the water would certainly have some influence upon the period of longevity. I am not quite clear as to what is meant by the volume of water in this connection. If a single discharge from the body of a typhoid fever patient was mingled with 1,000 gallons or 10,000 gallons of ordinary city sewage, I do not see how the longevity of typhoid bacilli contained in said discharge could be materially influenced by the volume of the sewage in which it was placed.

10223 Q. I gathered from your direct examination, Professor, that a certain amount of typhoid infected material would survive longer if discharged into a large body of water than if discharged into a small body of water. Am I correct?

A. I think I made the statement that if a given quantity of typhoid infected material were discharged into a body of pure water the bacilli would, in my opinion, live longer in that pure water than if they were discharged into a body of water highly polluted with sewage.

Q. By the use of the term "pure water" in your last answer, do you mean distilled water?

A. I understood the question to refer to a natural body of water and answered it with that understanding.

Q. What is the relation between the chemical operation going on in the purification of water and the bacterial operation that is going on in the purification of water, Professor?

A. The term "purification of water" may be and often is used with reference to distinct processes. What is commonly meant by the chemical purification of a polluted water is the oxidation and nitrification of the organic compounds contained in such water. The phrase "purification of water" may also be used to express the disappearance of pathogenic bac-
10224 teria that may have been introduced into it. In a general way it is found that the processes of chemical and bacterial purification run a parallel course.

Q. Do sanitarians regard that water as safe for domestic purposes which gives unsatisfactory results when examined chemically but fails to disclose unsatisfactory results when examined bacterially, so far as bacterial counts are concerned?

A. There are conceivable and indeed actual cases when light may be shed on the sanitary quality of a water by the chemical examination, when the bacterial count, at the time the examination is made, fails to shed much light. For example, the water of some wells is often found to be high in nitrates and chlorine, under conditions that indicates that such chlorine and nitrates originally proceeded from sewage pollution. The number of bacteria in such well water may be low at the time the examination is made, but owing to the dangerous character of the surroundings of such a well, as indicated by the nitrates and chlorine, such water would be condemned by the prudent sanitarian although the bacterial count was not high. The reason for this is that such a well water showed a bad history. It had been seriously polluted in the past but the pollution had passed away as shown by the bacterial count and the high nitrates. Such a water might be, however, at any time liable
10225 to another influx of pollution and so should be condemned
on the basis of the information revealed by the chemical analysis, although the bacterial count might be so low as to show at the time of the examination it was innocuous.

Q. Is it not a fact that all your chemical analysis of the waters of the Illinois River, the Desplaines River and the drainage canal has indicated bad ancestry of that water?

A. The analysis of the drainage canal and of the Desplaines River, below Lockport, certainly indicates undesirable water. The analysis of the Illinois River water shows in my opinion that the water has not had an unimpeachable sanitary history. The water of the Illinois River at its mouth above Grafton shows, by its chemical constituents, that it has at some point or points along its course, received a large amount of sewage. The condition of such a water as that of the Illinois River at its mouth is, however, very different from that of the well water that I have just mentioned. In forming any judgment as to the character of the Illinois River at its mouth there ought always to be taken into consideration the sources of pollution on the entire water shed of the Illinois River from its source to its mouth.

10226 Q. And in considering whether or not the water in the Illinois River, at its mouth, as shown by the chemical analysis of it is free from pathogenic germs or substances, the sanitarian must take into consideration the question as to whether or not the natural facilities for purification and time limit for death of such pathogenic germs has occurred before reaching the point in question, must he not?

A. It is very difficult, as I have already pointed out, to reason from chemical changes taking place in a flowing stream to the death of pathogenic bacteria in such a stream. We simply know that in general the processes of nitrification and the death of pathogenic bacteria run a parallel course. In other words both require time for their accomplishment. The exact time relations in each case are, however, a matter for experiment. Such factors as temperature, concentration of organic matter, the intervention of algae or other higher forms of life may play a part in influencing either process. In a river like the Illinois, the process of nitrification is a very complicated one. The oxidation of organic nitrogenous compounds to nitrates may be interrupted by the agency of green algae or by the introduction into the stream at various points along its course of fresh organic matter.

Q. Of what particular value then do you consider the
10227 chemical analysis of the water in a running stream in passing judgment upon the sanitary condition of that water?

A. When examinations of a stream are made at several points along its course at different seasons of the year, and with due regard to the introduction of fresh organic matter, such examinations show that a considerable time has elapsed since the introduction of sewage which might presumably have contained pathogenic bacteria. The art of chemical water analysis as I understand it, is based upon experience. Analysis made by many investigators in different parts of the world have shown that waters in which the process of nitrification is far advanced are not so liable to cause disease as waters containing the unstable nitrogenous compounds. It is purely in this empirical way that chemical water analysis is valuable and sheds light upon the sanitary character of a water.

Q. Professor, based upon table 134, introduced by yourself, being a part of the several tables known as Streams examination Chicago Sanitary District, wherein 26 samples of water were analyzed from the 2nd day of January, 1900, to the 26th day of June, 1900, the samples being analyzed weekly, the average chemical constituents for the 26 samples being as follows:

Residue on Evaporation, total 303.1.
Residue on evaporation, suspended, 55.5,
10228 Residue on evaporation, dissolved, 247.6,
Chlorine 13.55,
Oxygen consumed, total, 8.1,
Oxygen consumed by dissolved, 6.6,
By suspended matter, 1.5,
Free Ammonia, .815,
Albuminoid ammonia, total .366,
Dissolved .226,
Suspended .114,
Nitrogen as nitrates .064,
As nitrites 1.15,

Bacterial counts 51,834, the maximum and minimum chemican constituents and bacterial counts of these samples being as follows:

Residue on evaporation, the total,
Minimum 210, Maximum 486,
Dissolved, minimum 132, maximum 358,
Suspended, minimum 0, maximum 304,
Chlorine, minimum 7, maximum 49,
Oxygen consumed, total,
Minimum 5.8, maximum 17.2,
Dissolved, minimum 5, maximum 8,
10229 By suspended matter,
Minimum 0, maximum 10,
Free ammonia, minimum .12, maximum 2.56,
Albuminoid ammonia, total,
Minimum 2.56, maximum 7.36,
Dissolved, minimum .12, maximum .384,
Suspended, minimum .008, maximum .464,
Nitrogen, as nitrates,
Minimum .01, maximum .24,

As nitrites,
Minimum 0, maximum 3.4,
Bacterial counts,
Minimum 800, maximum 210,000.

Knowing that the sewage from about 1,600,0000 people living in the City of Chicago is discharged into the drainage canal thence into the Desplaines and Illinois Rivers, and passes the point on the river known as Averyville, 155 miles from Chicage, the same being the point at which the samples of water in question were taken, I will ask you if in your opinion the water at that point has become freed from the effect of said sewage upon it, as shown by the results of the above an-
10230 alysis?

A. The large amount of chlorine present in the Chicago sewage as in all sewage makes itself evident in the waters of the Illinois River at Averyville, as shown by the analysis cited. So too does in my opinion the large amount of nitrogen introduced in the sewage of Chicago. It is difficult to see how this could be otherwise. The chlorine is in the form of a stable, mineralized compound, common salt, and suffers little if any diminution in the total amount in its passage down the river. The nitrogenous compounds of various kinds are altered more or less in their passage down stream, and the amount of nitrogen appearing under different heads varies from point to point, and some of that oringinally introduced into the stream disappears. There is, however, a large amount of nitrogen in the form of its various compounds, free ammonia, albuminoid ammonia, nitrates and nitrites, in the waters of the Illinois at Averyville which has in my opinion come in a more or less changed condition from Chicago.

Q. What is true with reference to the chemical condition of the water in the Illinois River as shown by table number 134, just referred to, so far as the respective chemical substances are concerned is also true with reference to all other tables introduced by you, containing the chemical analysis of the
10231 waters of the Illinois River is it not?

A. That some effect exists due to the introduction of Chicago sewage, yes sir.

Q. What I have reference to, Professor, is that these various chemical constituents make their appearance in the chemical analysis at the various points on the river where the samples of water are taken, which are afterwards analyzed, and show preceding discharges of polluting material into the river above the points where the samples of water were taken?

A. Yes sir.

Q. Speaking from the science of chemistry alone, as you understand it, can you state that your chemical analysis of the water of the Illinois River at any point is free from disease producing substances, and if not can you as a chemist state with any degree of certainty the exact source of such substances?

A. I can only say that in the light of all the experience that I have had in the chemical examination of water, and all the information that I have derived from a study of the work, of other investigators, the amount and rate of nitrification in the waters of the Illinois River, from Lockport to Grafton, are such as have been found in the experience of water analysts to 10232 accompany the disappearance of disease producing elements.

Answering your question directly I will say that I do not believe it is possible to affirm absolutely from the results of the chemical examinations alone that the water of the Illinois River at any point where I have taken samples and made analysis is free from disease producing elements.

Furthermore, assuming that such disease elements are present in the water of the Illinois River at Grafton, I do not see how it is possible to affirm, on the basis of chemical analysis alone, whether these disease producing elements were derived from Peoria, from Havana, or from some farm house situated two or three miles above the points where the samples were taken. The whole question of chemical water analysis, as I have reiterated, is simply one of deduction made on the basis of past experience. A chemical examination does not disclose the existence or presence of the different disease producing elements in the water. It simply affords a certain kind of evidence that must be weighed in forming a judgment as to the sanitary quality of the water.

Q. Professor in all of the chemical tables or all of the

10233 tables of chemical analyses which you have introduced in evidence, did you perform the work personally yourself?

A. I did not. The work was done by one of my assistants, Dr. Stevens.

Q. And under your superivision?

A. Yes sir.

Q. State whether or not in your opinion, Professor, the chemical analyses so introduced by you are accurate in every respect?

A. The methods used in chemical water analysis are liable to certain sources of error, depending upon the experience of the observer and other factors inherent in the methods themselves so that the results have chiefly a value for purposes of comparison.

Q. What is the percentage of inaccuracy allowed by you in each of the determinations made by you?

A. In the case of the residue on evaporation where the determination is properly performed the limits of error ought not to be more than two per cent. in the hands of an experienced investigator.

In the case of chlorine, where allowance is made for volume, the error perhaps would be 5 or 10 per cent.

The oxygen consumed, the error may be as much as 15 per cent.

10234 The tables of free and albuminoid ammonia ought to be accurate within about 5 per cent.

The nitrite determination is very delicate and the error here may be considerable. Unless strict laboratory precautions are used, the error may be as much as 10 or 15 per cent.

The method for determining nitrates I do not regardl as accurate within 20 or 25 per cent.

Q. Do you know whether the methods that were used by Professor Palmer were the same as those used by you in making the chemical analyses of the water?

A. In general they were the same. Professor Pallmer, I believe made no correction for volume in his chlorine determinations which would make his chlorine results somewhat higher. In general the methods were the same.

Q. State, Professor, whether the samples of water examined by you chemically and also by Profesor Palmer taken at the same time and in the same places should show practically the same result?

A. I do not think that they should for the reason that the time consumed in transporting the samples to the University of Illinois laboratory at Champaign and to the University of Chicago laboratory where the work under my supervision was done, was quite different for different samples of water. The residue on evaporation and chlorine ought to be substan-
10235 tially the same. Errors of analysis would sometimes occur in spite of all precautions. The nitrogenous compounds and the oxygen consumed may show considerable variation owing to the changes taking place during transportation.

Q. And in these nitrogenous compounds you include nitrites and nitrates?

A. I certainly do. Those are compounds that are very liable to change during transportation.

Q. Then the large quantities of nitrites and nitrates appearing in the analyses made under certain conditions may be the result of the delay in transportation and in the delay in analysis after the samples were taken?

A. That may in part account for the conditions observed as regards the nitrites and nitrates but the methods used for the determination of nitrates may also account for some of the conditions observed.

Q. There would be a considerable change would there not in the nitrates and nitrites?

A. There might.

Q. In what way would that change manifest itself?

10236 A. The nitrates might diminish and the nitrites increase in some water or both nitrates and nitrites might diminish owing to the reduction of these contents in the presence of organic matter. Suppose that living algae were taken in a bottle of water and died during transportation, the bacteria present in the waters would flourish upon the nitrogenous matters contained in the body of these algae and in so doing would reduce the nitrates and nitrites and might cause the marked diminution or even disappearance of these compounds.

Q. In the event that the nitrites or nitrates should be in creased or either of them increased from what particular chemical substances would they be drawn?

A. The increase in the amount of nitrates would come from the oxidation of the nitrites.

The increase in the amount of nitrites might come from the oxidation of free ammonia or it might come from the reduction of nitrates.

Q. I notice, Professor, in comparing your results of your analyses made by yourself and Professor Palmer from the water taken at Kampsville January 17, 1900, you find 1.15 nitrates, Professor Palmer finds 2.60 nitrates. Those samples were taken at the same place by the same sample taker. Your analysis 10237 was made on the 19th and Professor Palmer's was made on the 18th the analyses, however, showing a difference of 126 per cent. based upon your analyses as 100 per cent. What do you say as to this variation?

A. This variation may be an analyst's error or it may be due to the method employed for the estimation of nitrates which did not prove altogether a satisfactory one. It may be due possibly to a reduction of nitrates in the samples of water sent to my laboratory owing to the longer period elapsing after collection and before examination was made. I have already mentioned the fact that such reduction of nitrates does sometimes occur. It is my opinion that such a discrepancy as that to which you call my attention did not exist in the original samples of water but that some other explanation must be found.

Q. Have you any other reason to believe that Professor Palmer's analyses of determinations of the nitrates as contained in that sample better represented the actual condition of the water in the river at that point at that time than does your own analysis?

A. I have no means of knowing which of these two figures more correctly represents the original condition of this water.

Q. Professor, comparing your analyses with those of Pro- 10238 fessor Palmer made from water taken from the Illinois River at Kampsville, the samples of water being taken, as shown by the testimony, by the same water taker and shipped to the respective laboratories in the manner described in your testimony I find the result of determination of nitrates of the following samples to be as follows:

Sample taken January 25, analyzed by both you and Professor Palmer on the 26th, in which you found 1.1 nitrates and Professor Palmer found 2.0 nitrates. The sample taken January 31st, examined by you on the 2nd day of February, and by Professor Palmer on the first day of February, you found 1.7 nitrates, and Professor Palmer found 1.8 nitrates. The sample taken February 7th, examined by each of you February 8th in which you found .25 nitrates and Professor Palmer found 1.84 nitrates. The sample collected February 14th and examined by each on the 15th, you found .55 nitrates and Professor Palmer found 1.72 nitrates. The sample collected February 21st, examined by you on the 22nd and by Professor Palmer on the 23rd you found .6 nitrates and Professor found 3.0 nitrates and in these respective determinations in a sample collected on the 25th day of January the variation between the two determination was 81.9 per cent, the variation in the sample taken January 31 was .59 per cent., the variation in the sample taken February 7th is 635 per cent., the variation in the sample 10239 taken February 14th is 213 per cent., the variation in sample taken February 21st was 234 per cent., based upon your figures as 100 per cent. In each instance Professor Palmer found a greater quantity of nitrates than yourself. I will ask you if there is any reason to believe that your determinations represent more actually the condition of the water in the Illinois river at Kampsville, at the time the samples were taken as far as the chemical constituent known as nitrates are concerned, than does the chemical determinations of Professor Palmer for that chemical constituent?

A. On the contrary I should say on examining these results critically that Professor Palmer's examination possibly represent the original condition of the water as regards the nitrates contained more nearly than my own, for the reason that samples of water collected at Kampsville could reach the laboratory of the University of Illinois at Champaign in a shorter time than they could reach the laboratory of the University of Chicago. In the latter case time for reduction of the nitrates would be afforded. Especially if the bottles of water were allowed toremain in warm express offices instead of in a refrigerator in the laboratory. It is true of most of the samples from the lower part of the Illinois river that the time consumed in transportation to Chicago was greater than that consumed in the transportation to Champaign, and changes taking place might be assumed to be greater. This is a possibie explanation of the lower nitrates at Kampsville in the determinations made in my laboratory as compared with the nitrate examinations made in Professor Palmer's laboratory in the University of Illinois. 10240

Q. Is it your opinion that the chemical constituents known as nitrates would make such a radical change from the point of collection to the point of analysis within the time which this examination was made?

A. Such a change might take place within 24 hours under certain conditions.

Q. How do you acount for the variation in such large percentages in those samples that were collected upon the same day and anayzed by each of you upon the same day, especially referring to samples collected on the 25th of January, the 7th of February and the 14th of February?

A. I have already indicated a possible explanation for the low nitrates observed in the determinations made in my laboratory, namely, the changes that takes place after the collection of a sample and before the determination is made.

Q. I notice, Professor, a variation of 42 per cent. in the dissolved residue in the samples collected on the 17th of January, 1900, as shown by the analyses made by yourself and Professor Palmer, his being 42.3 per cent. greater than your own, basing your work at 100 per cent. I will ask you if you can acount in any way for this variation? 10241

A. I can not. Any one who has had experience in water analysis, knows that differences in collection, in transportation and errors in the process of analysis sometimes occur where a large number ot samples are examined in spite of all efforts to obtain uniform and strictly comparable results. Whether this difference to which you call my attention was due wholly or in part to an error during process of analysis I am unable to state.

Q. Should there be any marked difference in the determination of chlorine results?

A. This determination depends upon the reading of color by the different observers. They vary somewhat in their accuracy in making this determination.

Q. I notice in the sample of water collected on the 21st day of February, 1900, a variation in the determinations made for the chemical constituent known as chlorine by yourself and Professor Palmer of 41.5 per cent. Is this an average or an abnormal variation?

A. That is a variation larger than I should expect to occur without some error on the part of someone engaged in the analytical work.

Q. Do you attribute that variation to a difference in the
10242 chemical condition of the water at the time and in the
place where the two samples were taken?

A. It may be due in part to either circumstance. I should personally be inclined to attribute it to the analysis itself.

Q. Is it not a fact, Professor, that the determinations made chemically are of such a delicate character that the exact chemical condition of any water can not be absolutely determined?

A. Referring your question to the determinations usually made in sanitary water analysis—

Q. I intended to put that in.

A. I would say that it is certainly a fact that those determinations are so delicate that even experienced water analysts obtaining samples of water under the conditions in which these samples were collected would be expected to arrive at results that would differ in some cases. These results might differ considerably, as you have shown that the results obtained by Professor Palmer and myself do differ. Regarding the sanitary significance to be attached to such variations, however, is a different matter. Variations of 50 or 100 per cent. in certain constituents of certain waters would have no sanitary importance
whatever. The averages of a considerable series of anal-
10243 yses are more important from the sanitary point of view
than any single analysis and this fact is so generally recognized by water analysts that little weight is attached to a single determination.

ADJOURNED until 10:00 a. m., February 13, 1904.

10244 10:00 A. M., Saturday, February 13, 1904. Continuation pursuant to adjournment. Present, the Commissioner and same Counsel representing the respective parties, also C. D. Corum representing complainant.

PROF. EDWIN O. JORDAN,

resumed the stand for further cross examination by Mr. Jeffries, and testified as follows:

Q. Is it not true that the results of various competent observers differ greatly as to the longevity of the cholera spirillum in natural water?

A. The reported experiments on this matter relate, so far as I am aware, to the life of the cholera spirillum in glass bottles in the laboratory and vary with respect to number of germs introduced, to freshness of isolation and in other respects.

I think it would be anticipated on bacteriological grounds that experiments conducted under these conditions would show considerable variation in the outcome.

Q. It is true then is it that there is a great difference in the results as determined by various competent observers?

A. In these laboratory experiments conducted under different conditions, yes sir.

Q. Do you know of any experiments conducted in any other way for the purpose of determining the longevity of the cholera germ?

10245 A. Experiments in aquaria have been made to simulate natural conditions. I have already referred to the outcome of these experiments in my testimony.

Q. Is it not a fact, Professor, that competent observers have found it to live after 7, 15, or 20 days, or even three months or longer?

A. I am familiar with the experiments to which your question refers, and I would state that in my opinion the conclusions drawn as to the life of the cholera spirillum in such waters under such conditions are by no means valid, for the reason that in the experiments referred to in your question the agglutination test for the identification of the cholera spirillum was not performed, and it has been shown recently that organisms exist in water, especially in polluted water, which simulate the cholera germ very closely in their bacteriological characteristics and which can be distinguished from it only by the application of this agglutination test. Unless this agglutination test be employed we are unable to attach any weight whatever to reported findings of cholera spirillum in waters after the lapse of long periods.

Q. Then you disregard and attach no credit to the determinations made by such observers?

A. In the light of recent discoveries I am compelled to accept the position as stated. The agglutination test is now
10246 recognized by bacteriologists as essential to the identification of these organisms and within the last few months an important paper has been published in the Zeitschrift fur Hygiene, from one of the leading German Laboratories, in which it is shown that organisms formerly classed as cholera microbes, and preserved in various bacteriological laboratories are not cholera germs at all. It seems possible that some of the experiments to which you refer were conducted not with the genuine cholera germ but with some of these sewage bacteria which there is every reason to anticipate would have a greater longevity than the cholera germ itself.

Furthermore, the isolation of a spirillum from a polluted water into which cholera spirilla had been introduced would have little or no significance unless the agglutination test were applied.

Q. Professor, is it not a fact that competent analysts and observers have found the cholera germ able to live in sewage as long as from seven to thirteen days?

A. I have already indicated very clearly my answer to that question in the two preceding answers. I do not believe that it has been so demonstrated.

Q. And your reason for so believing is as stated in your preceding answer?

A. My reasons are as stated.

Q. What in your judgment did you say was the life limit
10247 of the cholera spirillum in ordinary river water?

A. I have no experimental data bearing on the question of the longevity of the cholera spirillum, under truly natural conditions, nor so far as I am aware do such data exist.

Q. So then in your judgment that question has never been answered by sanitary science?

A. The question as to the specific longevity of a true cholera spirillum under natural conditions, no sir.

Q. Professor, are bacteriologists in close agreement as to the longevity of the typhoid bacillus, under various conditions?

A. As I have stated in my answer to a similar question concerning the life of the cholera spirillum, the laboratory experiments that have been conducted in glass vessels have been under such varying conditions of temperature, age of typhoid culture employed, the nature of the water into which such a bacterium was introduced, and other experimental factors that it would be anticipated that the results would show some variation. The experiments that I have introduced in my testimony, which were made with as close an approximation as possible to natural conditions, have given, in my opinion, singularly concordant results, using different strains of typhoid bacilli, different numbers in a given quantity of water, and otherwise attempting to simulate conditions occurring in natural infection.

10248 Q. It is a fact then is it not that they differ widely as to the number of days during which typhoid bacilli may live in water and in sewage?

A. If you refer to these experiments that have been conducted during the last 15 or 20 years by different bacteriologists using different methods, and at different periods in the state of the science, and working under laboratory conditions varying very widely in fundamental and important particulars, it is of course true that the life of the typhoid bacillus has been reported to vary widely. I have myself found that in sterilized water taken from Lake Michigan a freshly isolated culture will live for 93 days, but that a freshly isolated typhoid culture introduced into ordinary sewage under natural conditions, lives but two days.

Q. It is an agreed fact among bacteriologists and sanitarians that typhoid fever germs live in water and in sewage is it not, after such germs have been discharged into such sewage or water?

A. It is, I think, generally conceded that some typhoid bacilli may retain their virulence, after reaching the water or sewage, just as some typhoid bacilli introduced into an antiseptic solution remain alive for a certain period and do not die instantly.

Q. Is it not a fact that a sufficient number of typhoid bacilli when discharged into a water supply by means of the sewers of a city or otherwise do create typhoid epidemics among the people who use that water supply for domestic and drinking purposes?

10249 A. In my opinion the epidemiological evidence that water can be a vehicle for conveying typhoid infection is overwhelming, as I have repeatedly stated in my testimony.

Q. Now, while scientists agree that typhoid fever germs when discharged into a running stream or water supply live and remain virulent in sufficient quantities to produce typhoid epidemics, is it not also generally understood by such scientists that the life of the typhoid germ depends for its duration upon the character of the water into which it is discharged, the natural conditions which surround it and the temperature of the water?

A. I think it is generally conceded that the character of a body of water into which a typhoid bacillus is discharged influences the period of longevity of such bacillus.

Q. May not the conditions in a water supply, such as a running stream, be of such changeable character as to permit at various times the interchangeable shortening and lengthening of typhoid germs which are being discharged into the water?

A. As I have indicated in my previous answers changes in the character of a water may influence within limits the longevity of a typhoid bacillus introduced into it.

Q. What limits do you have reference to, Professor?

A. It is my opinion that from such changes as might ordinarily be expected to occur in a natural body of water that
10250 the life of the typhoid bacillus would not be indefinitely prolonged by such changes. Under the favorable conditions existing in laboratory experiments when the typhoid bacillus is introduced into sterile water in glass bottles it has

been shown that the typhoid bacillus perishes after a short period. In natural waters a similar termination would undoubtedly occur even under the most favorable conditions that would exist in nature.

There is no evidence, bacteriological or epidemiologically that indicates that the typhoid bacillus multiplies in natural waters, but on the contrary all the available evidence shows that from the moment of introduction a diminution in the number of typhoid bacilli takes place. In other words, I do not believe that in natural waters the life of the typhoid bacillus can be indefinitely extended.

Q. What effect has the added volume of water from Lake Michigan upon the typhoid fever germs discharged from the sewers of Chicago as it passes through the Chicago River and the Drainage canal, as applied to the conditions and surroundings of those germs while contained in the sewage proper?

A. I have made no experiments upon the life of the typhoid bacillus in sewage taken directly from the city sewers of Chicago as compared with the life of the same bacillus in such sewage diluted 20 times with Lake Michigan water. I have, however, made some experiments upon the diminution in the number of colon bacilli in ordinary undiluted sewage and
10251 in sewage diluted 1 to 20 with Lake Michigan water,
and I find no difference in the rate of dying off of the colon bacillus in these two fluids, namely raw ordinary sewage and sewage diluted 1 to 20 with the waters of Lake Michigan.

It is conceivable that the life of the typhoid bacillus may be prolonged for a few hours if introduced into a less concentrated medium, owing to a difference in the intensity of the action of the toxic products, but I do not believe that such influences would extend the life of the bacillus more than a few hours.

Q. In expressing the above opinion you do so without having made a personal observation or analysis of the water under the two respective conditions do you not?

A. I have determined, as heretofore related in my testimony, the longevity of the typhoid bacillus in the sewage of the drainage canal. This longevity is so brief that, assuming that the bacillus dies out in concentrated sewage in less than two days, the difference can hardly be more than a few hours. The behavior of colon bacilli in concentrated and diluted sewage has also influenced me in forming the opinion that I have just expressed.

Q. The opinion which you stated with reference to the longevity of the typhoid germ in the drainage canal was fixed at a limit of 2 days was it not?

A. In the experiments that I have recorded in my tes-
10252 timony I did not find typhoid bacilli later than 2 days,
even when enormous numbers were introduced into the sewage, numbers much larger than would be at all likely to exist in the drainage canal under natural conditions.

Q. Assuming, Professor, that the sewage of Chicago be discharged into the drainage canal, as now, and that the water and sewage passes down the canal for a period of two days, at which point it is discharged into a reservoir from which a community obtains its water supply, would you consider that water as being free from typhoid fever germs, assuming also that there is an average rate of from 700 to 1000 deaths from typhoid fever in the City of Chicago per annum?

A. I should not wish to put myself in the position of recommending the introduction of sewage of any degree of staleness into a reservoir from which a public water supply was immediately taken out. The sanitary question is not the only one to be considered in such a connection. The aesthetic side is also worthy to be taken into account.

In discussing the results of my experiments performed in the drainage canal I have already stated that I should not as a sanitarian be willing to place two days as the utmost limit of longevity of typhoid bacillus in such water although this was the extreme limit found in a considerable number of carefully conducted experiments. This time ought at least to
10253 be doubled and possibly trebled in order to insure safety.

So far as the introduction of sewage contained in the Chicago drainage canal is concerned, provided such sewage were from 4 to 6 days old, it is my firm opinion based on the experiments that I have made and all the information, epidemiologically and otherwise that I have been able to obtain that typhoid bacilli would not be alive in such sewage.

I should like to relate in this connection an incident connected with my work at the Lawrence Experiment Station in Massachusetts. Among the experiments conducted there, were some experiments upon the filtration of city sewage through beds of sand. From one of the tanks used in these experiments an effluent was obtained which, chemically and bacterially, was very pure, although it had passed through only 5 feet of sand and was in point of time less than 5 days removed from the original sewage.

The analytical results, chemical and bacterial, obtained upon this effluent were so convincing that a number of those engaged in the experiments at the Lawrence Experiment Station at that time, including Professor Sedgwick, Mr. Hazen and myself, drank of this effluent and suffered no ill effect.

The results of the experiments that have been made by
Professors Russel, Zeit and myself are, in my opinion,
10254 as convincing as those obtained in the Lawrence Experiment, and in my opinion such sewage, under the conditions described, that had been infected 6 days before would be free from typhoid bacilli.

Q. Assuming, Professor, that the canal mentioned in the preceding question was of sufficient length to permit a flow of 6 days, and the other facts being as assumed in the preceding question, would you consider the water as being free from typhoid fever germs?

A. I should not hesitate to consider it as being free from typhoid bacilli.

Q. Professor, have you made any investigations as to the longevity of a typhoid fever germ in the waters of the Illinois River at Averyville?

A. I have not personally made such investigations, but I know of examinations made by Professor Russell in connection with the experiment that has already been described.

Q. That experiment was made in the same manner in which you made your experiments?

A. In substantially the same manner, I believe.

Q. Do you know, Professor, whether typhoid fever bacilli are influenced in death rate more rapidly by the toxin created by themselves or by the toxin created by other forms of bacteria?

A. Those substances that are spoken of in a general way
10255 as toxins have not been isolated as definite chemical
bodies and studied as such.

It is, therefore, difficult to answer your question which, as I understand it, is as to whether the products of the growth of typhoid bacilli are not more detrimental to typhoid bacilli than the products of growth of other micro organisms. The question is one which would have to be investigated with pure cultures and carefully controlled laboratory conditions, and there would be certain experimental difficulties. I know of no data directly bearing on your question.

Q. Do typhoid fever germs create toxin while in an unnatural state?

A. Understanding you to mean by unnatural state the conditions that prevail when typhoid bacilli are confined in glass vessels or other receptacles outside of the animal body, I would say that the meaning of the question, as I understand it, is not altogether clear. I am not sure whether you refer to substances that are poisonous for man or substances that are poisonous for other bacteria or substances that are poisonous for the typhoid bacillus itself.

Q. Are toxins thrown off by typhoid bacilli at any other time than when they are in course of growth and multiplication?

10256 A. Assuming that by your question is meant the formation of any chemical substance, poisonous to any living organism including in this the typhoid bacillus itself and other bacteria, I would say that the cells of practically all bacteria contain within themselves substances, chemical compounds, that are injurious to certain other organisms and there is no reason to suppose that the typhoid bacillus is peculiar in this respect. The disintegration of the cells of typhoid bacilli may give rise to substances in the immediate neighborhood of such disintegrating bacilli which are poisonous for various forms of organic life.

Q. Professor, do you understand the products of decomposing and disintegrating typhoid bacilli to be the toxin usually and naturally thrown off by such bacilli?

A. Assuming that by this question you mean to ask whether the toxin liberated by the typhoid bacillus which is responsible for the peculiar symptoms and lesions of typhoid fever in man originates from dead and disintegrating bacilli rather than from living ones, I will say that I do not.

Q. State, Professor, whether or not typhoid fever germs throw off toxins of any character while contained in water other than the toxins created by disintegration and decomposition of the typhoid cells themselves?

10257 A. Assuming again that by toxin you mean toxic products, I will say that I do not know whether typhoid bacilli contained in water emit, during life, any product harmful to themselves or to other organisms. Nor do I know whether, if such be the case, such products emitted during life are different from those that may pass into water from the disintegrating and breaking up of the cells after death. I do not believe that any accurate information on these two points exists.

Q. I will ask you, Professor, if it is not a generally accepted truth that typhoid bacilli will perish more rapidly from the effects of the decomposing and disintegrating typhoid cells which immediately surround them than from the disintegrating and decomposition of other bacteria?

A. I certainly do not know that to be a generally accepted truth.

Q. May not that, in your opinion, be a fact?

A. I have no opinion to offer on that point. I know of no evidence enabling one to form an opinion one way or another.

Q. Reasoning from the analogy of nature, I will ask you, Professor, if it is not reasonable to believe that typhoid bacilli would perish more rapidly on account of being surrounded and buried in their own filth and the products and by products of its own decomposing matter more rapidly than surrounded by such products and by products and decomposing matter produced by bacilli of a different nature and character? 10258

A. I do not see how such a conclusion can possibly be drawn. For example, to take an instance from bacteriology. In a mixture of bacillus anthracis and bacillus pyocyaneus, the anthrax bacillus will die out much more readily than in a culture where anthrax bacilli are present alone. The products of bacillus pyocyaneus upon bacillus anthracis seems to be much more injurious than the products of bacillus anthracis upon itself.

I know of absolutely no ground for assuming or supposing that the products of one micro organism are more injurious to itself than the products of every other micro-organism are to that particular one.

Q. Professor, with reference to the special analysis which were made by yourself in connection with Professor Zeit and Professor Russell upon the longevity of the typhoid bacilli, I will ask you if these parchment sacks were suspended in the water to their full depth?

A. They were. The glass tube to which the parchment sack was attached alone projected above the water.

Q. How far above the water did the point of the glass tube project?

A. I should say on the average several inches.

Q. How large was this glass tube, that is the opening?

A. About two-thirds of an inch.

10259 Q. On table 1 introduced in evidence by you, Professor, when you testified with reference to those special examinations, was this water that was used taken from the drainage canal at Lockport and the experiment carried on at that particular point?

A. It was. The parchment sack was filled with sewage taken directly from the canal at Lockport and then suspended in the float and typhoid bacilli immediately introduced.

Q. When were these determinations made with reference to the initial colon count of sewage bacteria?

A. The sample was brought immediately to the laboratory and plated at once.

Q. And the determination for the sewage bacteria, the colon bacilli and the streptococcus was then and there made?

A. Yes sir.

Q. And those determinations represented the laboratory determinations of the quantitative amounts or numbers of the respective bacteria contained in that water?

A. Yes sir.

Q. I notice that this table, Professor, says that the approximate amount of typhoid bacilli was 12000 per cc. May that have been greater or less?

A. The number may have been anywhere between 11000 and 13000. The number was determined by plating from a suspension in proper dilution and counting exactly the number of typhoid colonies appearing on the plate. All bacteriologists recognize, however, that where such large numbers are dealt with the determination is an approximate one and not exact to the individual unit. 10260

Q. Now, in plating these samples of water from this parchment sac after it had been suspended in the canal for 12 days or more, is it not a fact that bacteria other than typhoid appeared in large numbers upon the plate?

A. Upon some of the plates, yes, sir. The special media used, however, suppress a very large proportion of the ordinary sewage bacteria while permitting the typhoid bacillus to grow. In some cases over 90 per cent. of the sewage bacteria are suppressed by these special media.

Q. Do not other forms present themselves with the same rapidity as the typhoid?

A. Certainly.

Q. Forms that resemble the typhoid?

A. In some cases, yes.

Q. How many plates did you use, Professor, on an average in making these respective determinations?

A. 2 or 3.

Q. Do you consider that a sufficient number?

A. A sufficient number for what?

Q. To determine the presence or non-presence of typhoid bacilli in these experiments? 10261

A. I am not altogether sure that I understand the question. The details are set forth in each case. Thus, in table 1, on the fifth day after infection 1 cc.. of the water which originally contained 110,000 ordinary bacteria and 12000 typhoid bacteria was examined. This cubic centimeter of water when plated in Drigalski medium developed only 86 colonies in all, it being remembered that there were at the outset approximately 12000. Eight out of the total number of 86 colonies which developed on this plate were selected as the only ones closely resembling typhoid colonies. These were studied in detail and none of them proved to be typhoid bacilli.

In this case, therefore, the presumption is very strong indeed that out of the 12000 typhoid bacilli originally present in that cubic centimeter of water not one had survived for the period of five days.

Q. How much of the water contained in the sac did you analyze on the 5th day, of table No. 1?

A. The table shows that 3 separate cubic centimeters were examined. These 3 cubic centimeters, together contained initially 36000 typhoid bacilli. Not a single typhoid bacillus was found in this quantity of water at the end of five days, and the conclusion is irresistible that these 36000 had perished.

Your question seems to me to ask for an explanation
10262 as to the significance of the examination of small quantities of water. Assuming that typhoid bacilli were originally uniformly distributed throughout the contents of the sac, each cubic centimeter theoretically contained 12000 bacilli. If these typhoid bacilli are found to have vanished completely from 1 or from 3 cc. of the water after 5 days the inference is plain and unescapable therefore that no typhoid bacilli remain alive in the other 600 or 700 cc. in the sac. It is not the absolute disappearance of each individual that is shown in each of these experiments but the relative and absolute death rate.

Q. Professor, what per cent. of the original 12000 would have given the rigid reaction of typhoid in the event they had been plated immediately after being deposited into the parchment sacs?

A. I believe that all of them would have given the typical reaction if they could have been recovered immediately from the sac.

Q. Did you make an effort at such determination?

A. In one case, table 6, a sample was taken from the sac 10 minutes after infection of the sac, and 1-10000 of the mixture plated in Drigalski medium. Out of 14 colonies taken from this plate 13 proved to be typhoid, indicating a typhoid content of this water of at least 130000.

It should be said, however, that in this case not all of the typhoid like colonies on the plate were picked off.

10263 Q. Is it not a fact, Professor, that in all laboratory experiments, there is a certain percentage of shrinkage from the original number of typhoid bacilli placed in the mixture examined?

A. I think that is so. Some of the bacilli die immediately or very shortly after their introduction.

Q. Is it not a fact that because of the delicacy of the determination that a certain percentage of them are not recovered?

A. Assuming that by delicacy of determination is meant the difficulty of procuring the isolation and correct identification of the typhoid bacillus, I would say that by the use of ordinary media that is undoubtedly true. With the use of these special media, however, that we have employed in this experiment, I think the shrinkage from this source is exceedingly slight. The media used gave results that were to me quite surprising in the accuracy with which typhoid colonies could be differentiated and correctly identified in the presence of other forms.

In this particular case, on table 6, where 1-10000 of a cubic centimeter of water was examined 10 minutes after infection and 13 typhoid colonies were found on this plate, not all of the colonies that might have been typhoid were taken from this plate and it seems to me probable that had all the colonies been taken substantially the same number of typhoid 10264 bacilli would have been found as was originally introduced.

Adjourned until 1:30 p. m., February 13, 1904.

10265 1:30 p. m., Saturday, February 13, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. EDWIN O. JORDAN,

resumed the stand for further cross-examination by Mr. Jeffries, and testified as follows:

Q. State whether or not it was impossible according to the plan used by you in making these special determinations for any of the typhoid bacilli to have been suppressed or withheld from development on the plates?

A. I think it is possible that some slight retardation of development may have occurred in the case of Drigalski and Horrock's media, but there was absolutely no suppression, so far as I could determine, on Hiss's medium.

Q. You did not use Hiss's media on tables 1, 2 and 3, did you?

A. No, sir; these were the earliest experiments and we did not find until the experiment had proceeded for a few days that Hiss's medium was especially favorable. It is my opinion, moreover, that such suppression as occurred was due to a weakening or attenuation of typhoid bacilli which was premonitory to death.

Q. All of the colonies which appeared upon the plates were not fished off of the plates and examined afterwards, were they?

A. No, sir; we very soon learned in the progress of the experiments to distinguish sharply between typhoid-like 10266 colonies and those that were not typhoidal. For example on the Drigalski media the colon colonies were red and could not have been mistaken for typhoid colonies by the most superficial observer.

Q. Were all of the blue colonies fished off?

A. On many occasions, yes, sir.

For example, table 14, after 2 days on MacConkey's medium all of the typhoid-like colonies on the plate were fished and this was usually done, especially after the first 24 hours. This was not true as regards colonies taken from the plates through the first day, since the number of typhoid like colonies was so great that the labor of picking off and examining all of them was so great and obviously unnecessary that it was not undertaken. As soon as the number of typhoid germs seemed to be diminishing, all the typhoid-like colonies were taken off. In the later days of these experiments, that is to say especially after four or five days, it was very difficult to find any typhoid-like colonies on the plates at all and only those colonies could be taken that seemed to bear some semblance, however remote, to the typhoid colonies.

Q. Is it not likely that the colonies which were fished off the plates were merely surface colonies and that there were others which were submerged on the plates?

A. The plates were allowed to develop until the colonies that were at first submerged came to the surface. The submerged colonies in these media in many cases presented
10267 typhoid-like appearances, so that it was not necessary for them to make their way to the surface in order to cause suspicion as to their character.

Q. Was it not necessary in order to obtain or determine the presence of typhoid bacilli in these experiments to have plated at least 10 plates in each instance in order to guarantee accuracy?

A. In this case what was aimed at, as I have stated several times, was the proportionate mortality rather than the absolute presence of a lingering typhoid bacillus in a given quantity of the sewage. If the results showed, when 360,000 per cc. were introduced into the contents of a sac originally, that after three days searching, examination of 1 cc. showed no typhoid bacilli the significance of the experiment is apparent. If such a death rate was maintained during the first three days as to cause the disappearance of 360,000 bacilli from 1 cc. of the water it seems fair to assume that substantially the same mortality had prevailed in the other cc. of the sac. And although it is undoubtedly possible that a few straggling bacilli might have remained alive, even these specially resistant forms would, in my opinion, perish speedily since the mortality rate among the typhoid bacilli generally had proved so very great.

Q. Is it not a fact that the tables of these special observations which you have introduced show that you did not make a searching examination of which you speak in your last
10268 answer, by reason of the fact that in certain instances your examinations ranged from 1-10000 to 1-10 part of a cc.?

A. In reply to this question I would call special attention to the fact that these examinations of relatively small quantities of water to which you refer were in the early days of each experiment, and that on the later days it is true in substantially every case that 1 cc. of the water was plated and examined. The numbers of typhoid bacilli introduced in several of these experiments was so enormous that it would have been absurd to examine larger quantities of the water since the typhoid bacilli were readily found in much smaller quantities.

In table 15, for example, after 5 days, 3 examinations were made, one of 1-10 cc. and two each of 1 cc., and although 857,000 bacilli per cubic centimeter were introduced into the contents of this sac on the day of infection none were found after 5 days in a searching examination made of 1 cc.

Q. Professor, even in the examinations where it shows that you discovered the typhoid bacilli by an examination of a small quantity or a small part of a cc., your tables also show that you failed to find it when at the same time you examined a larger quantity of water. Will you explain why such results pertain?

A. On reference to the tables I fail to find any such constant relation as that stated in your question.

10269 Thus in table 13, after 1 hour 1-1000 of a cc. was plated in Hiss's media, and out of 25 colonies fished 20 proved to be typhoid.

From 1-1000 of a cc. plated in Drigalski, out of 6 fished 4 proved to be typhoid.

From 1-10000 of a cc., also plated in Drigalski, out of 3 colonies fished 2 proved to be typhoid.

From 1-100 of a cc. in MacConkey's out of 15 fished 15 proved to be typhoid.

After 20 hours 3 samples of 1-1000 of a cc. were plated and the typhoid bacillus found in all of them. One sample at this same time was plated in 1-100 cc. and typhoid bacilli were found. The same is true after 28 hours. I am unable to discover in the records of the experiment anything suggesting the condition to which you refer.

On table 14, after 20 hours 3 plates were made from 1-1000 of a cc. and the typhoid bacilli were found in one of these plates; 2 were made from ten times this amount of water and the typhoid bacillus was found on both plates.

After 2 days in this same experiment 2 plates were made of 1-100 of a cc. of water and 2 of 1-10. In both 1-100 cc. samples typhoid were found and in one of those of 1-10.

Such a relation as that indicated in your question does not
obtain, as a general rule, although .certain instances
10270 can be selected from the tables in which the typhoid
bacillus was found among colonies selected with plates
made with a smaller quantity of water while none were found among colonies selected from plates made with a larger quantity of water. This may have been because a larger number of colonies were examined in one case than in the other or because they were not there in the larger quantities of water, although by chance a straggling individual might occasionally be encountered in a small quantity of water.

The same occasional variation is noticed sometimes in examinations for the presence of the colon bacillus, as every bacteriologist has had occasion to determine.

Q. How do you explain a discrepancy of this character as shown from the tables that where 1-10 part of a cc. of water was examined and 1 cc. of the same water was examined at the same time, as, for instance, on the second day of table number 10, shows a larger number of colonies fished out as having the appearance of typhoid bacillus or typhoid colonies in the smaller quantities examined than in the larger quantities of water examined?

A. In referring to the table mentioned, I find there is no statement on this table to the effect that only the typhoid-like colonies were fished from these plates, and as the record stands
in the table no such condition is implied as that indicated
10271 in your quesion. I may say that it happened very fre-
quently in the conduct of these experiments that there
was a very small number of typhoid-like colonies on the plate, and in such cases other colonies were taken in order to extend the number of examinations made. This is the condition to which you refer in table 10, and the same thing obtains in many of the other tables. Especially in the later days of these experiments, it was often very difficult to find any typhoid-like colonies at all. Sometimes colonies had to be taken from plates for examination when their resemblance to genuine typhoid colonies was exceedingly remote and problematical.

Q. Were there not more colonies developed upon the plate when a large quantity was used in the observations than when a small quantity was used?

A. More colonies of all kinds, certainly.

Q. And in such cases was it not more difficult to distinguish true typhoid upon the plates developing the larger quantity of water?

A. Not when the plates were made with the proper quantities of water. The dilutions of the water varying by 1-10 presented no material difficulty.

Q. Then why was it necessary to fish off more colonies in one instance than the other?

A. It was not necessary. It was simply a matter of chance that on some plates more colonies were taken than on
10272 another, except in those instances to which I have already referred, when all the typhoid colonies were taken off a plate as happened in the early days of this experiment.

Q. Professor, on table XIII A, the analysis of the water on the 10th day, where you found the 3 typhoid colonies, I will ask you if those three colonies could not be more readily found in that particular observation than if contained in the one preceding it on the same day, with a smaller quantity of water, but wherein there were a large number of colonies found upon the plate?

A. No, sir, quite the reverse is true. The Hiss medium on the whole, as I have stated several times, differentiated more sharply than the MacConkey medium.

Q. Would they not be more liable to be submerged in the one instance than in the other and disappear on the surface of the plate?

A. If these typhoid colonies had developed on the Hiss plate instead of on the MacConkey they would, in my opinion, have been quite as likely to have been detected as on the MacConkey. The differentiation on the Hiss medium is very sharp.

Q. Professor, were there any analyses made of the water contained in the parchment sac, under table XIII A, on the tenth day, than the two samples shown upon the table?

A. There were not.

10273 Q. After having discovered the three typhoid colonies did you subsequently examine the contents of that sac?

A. As will be noticed by reference to the table, this sac, the record of which is tabulated in table XIII A, was a companion to the one tabulated in table XIII. No typhoid colonies had been found in either of these after the second day, and from the way in which the preceding experiments had resulted, it was supposed a continuous negative result would be maintained so that on the day this sample was taken, the sac was removed from the water. It was not known until some weeks later that the colonies taken at this time were genuine typhoid bacilli.

Q. Were any other efforts made thereafter to examine the water contained in these parchment sacs as long as 10 days whereby various quantities of water were examined by plating out 10 or more plates in each instance for the purpose of making a more correct and accurate determination as to the existence or non-existence of the typhoid fever colonies or germs contained in the water up to and longer than the 10th day, or did you rely solely upon what you had previously found, and attribute this finding to the lodgement of some foreign substance to which was attached a typhoid bacillus upon the parchment and above the water line as the only reason why a further and more extended examination along this line should not be made?

10274 A. As the records show the sac referred to was one employed in one of the later experiments of the canal, and soon after the completion of these experiments all the sacs were removed from the water.

I should explain once more the method of procedure adopted in isolating and identifying the typhoid organisms. The plates were made as soon as the samples were brought to the laboratory and incubated for 48 hours. The colonies developing on these plates were then examined by a long and laborious test taking for its completion several weeks. It was not until long after all the sacs had been removed from the water and the series of experiments brought to a termination, that final identification was arrived at in the case of the most of the typhoid colonies. The results were not known until the whole series was finished and tabulated.

As regards the sudden appearance of these three colonies on a single plate late in one of the experiments I can only say that the most plausible explanation for their appearance in this way is, in my opinion, the one that I have given. According to the doctrine of probability if typhoid bacilli were alive in the water in these sacs between the second and the tenth day they should have been found and their presence noted in some of the many hundreds of examinations made. The fact that 10275 they were not so found indicates, in my opinion that they were not present in the water, but found their way into the sac by some such accident as that I have mentioned.

Q. How many observations were made of the water contained in the sac as shown by plate XIII A?

A. Examinations were made on eight different days, and of 207 different colonies. In several instances, as indicated in the notes at the foot of this table, all of the typhoid-like colonies appearing on the plate were fished and examined. That was the case when 1-10 of a cc. of water was examined on the third day of the experiment. All of the typhoid like colonies appearing on the Drigalski medium and all of those appearing on the MacConkey medium on that day were fished and examined, no typhoid colonies appearing among them. If these three typhoid germs whose presence in one plate was manifested on the 10th day, had been alive in the water throughout this period, it would be reasonable to expect that other straggling individuals would have been found in the interval between the third day and the tenth, especially since quantities as large as 1 cc. of the water were examined several times, beginning as early as the fourth day of the experiment, when on this same medium all the typhoid like colonies were fished and examined.

Q. Is it not a fact, Professor, that as shown by table XIII A the initial colony count of sewage bacteria contained 10276 240,000 bacteria per cc. and colon bacilli at the rate of 1000 bacteria per cc. and typhoid bacilli at the rate of 285,000.00 per cc.; that the sac from which the observations were made contained about 700 cc., and that the 207 colonies fished represented the number of colonies examined for typhoid fever bacilli out of the entire initial number of bacteria contained in the parchment sac on the day of its introduction into the water, the examination of the 207 various colonies taking place from day to day for eight days, beginning three days after the introduction of the parchment sac into the drainage canal at Robey street and continuing for eight days or until the 10th day after the submergence as aforesaid?

A. The question seems to me to involve an entire misconception of the conditions under which these experiments were conducted. I should like to point out that on the 7th day the plate made in nutrient agar, developed with 1-10 of a cc. of water contained only 670 colonies per cc. There is, in other words, an enormous decline from the initial content of the water. To the 240,000 sewage bacteria were added, in this experiment, 285,000 typhoid bacilli, making a total of 525,000 of all kinds, per cc. In 7 days only 6700 bacilli of all kinds were present per cc. in the water of the sac, a reduction in other words of from over 500,000 bacteria per cc. to 6700 bacteria of all kinds.

Instead of the initial number of bacteria in the sac being present, therefore, throughout the conduct of the experiment, the number is very much smaller than was originally 10277 the case, and it seems to me only reasonable to suppose that of this 6700 bacteria present in a cc. of the water on the seventh day the larger number belonged to the more hardy sewage bacteria, while the more delicate typhoid bacillus had perished in even greater numbers than shown by the enormous mortality that prevailed among the sewage bacteria themselves.

It is not proper, therefore, to make comparison between the number of colonies examined in the earlier days of the experiment when the number of bacilli in the sac was large, with the number of colonies examined in the later days of the experiment, when the total number of bacilli in the water had shrunk to such relatively insignificant proportions.

Q. I will ask you, Professor, in view of your last answer, how it is that in a case of the neutral agar, as on the seventh day of table XIII as referred to by you in your answer, developed only 670 colonies while on the ninth day, with the same quantity of water observed, the same plate or character of plate developed 1460 colonies, and I will also ask you if in your answer to the last question you have taken into consideration the number of bacteria that are retarded or suppressed by reason of the earlier character of plates used by you and about which you have testified heretofore?

A. Taking the last part of your question first, I would say that I purposely selected for comparison of colony counts

10278 the ordinary neutral agar plate in which no suppression occurs.

I may add that this was the kind of plate used in determining the initial number of sewage bacteria and so is directly comparable with it.

As regards the appearance of a different number of colonies on the agar plate on the seventh day and on the ninth day, I would say that the difference is so small as not to create special interest or concern in the mind of any bacteriologist who has had experience in plating samples of water. It is possible that the sample taken on the ninth day may have been slightly longer in transit, but even supposing that no such difference in time of plating occurred, such differences in number as that shown between 670 and 1460 are sometimes found in duplicate samples of water plated from the same bottle by the same observer at the same time and in the same medium.

Q. Then from your last answer I assume it to be a fact, generally recognized by bacteriologists, that it is not a safe proposition in making these determinations or in making determinations of this character to use in your investigations less than ten plates at one time in order that the bacterial contents of the water may be properly observed?

A. I do not see how such an inference can be properly drawn from the answer that I have given.

Q. As to the agar plate used by you in your determina-
10279 tions that degree of suppression or retardation of ordinary water or sewage bacteria did not take place as was stated by you in your direct examination in reference to these tables and these experiments to be one of the objects of this particular character of work?

A. I made the statement that the Drigalski and MacConkey media, as used by me, suppressed a large number of the ordinary sewage bacteria. I did not intend to make nor do I believe that I made the statement that neutral agar was used for the purpose of suppressing such forms.

I may add that the neutral agar plates that appear in some of the tables were made primarily with a view to determining the correct colony count for exact comparison with the initial number of bacteria, since the initial number of bacteria as given under the head of each table was ascertained by the use of this neutral agar media.

Q. But is it not a fact, Professor, that the 207 colonies fished from the plates as shown by table XIII A are the only colonies developed from the contents of the parchment sac at that place which were specifically examined for typhoid determinations?

A. That is correct. These were the only suspicious typhoid-like colonies that were examined. I would point out, however, that 170 of these were examined before the 10th day, not a single typhoid colony being found among them.

10280 On the 10th day out of 13 colonies taken from one plate 3 proved to be typhoid.

Q. Is it not also a fact that during the 8 days only 7.02 cc. of the 700 cc. contained in the parchment sac were developed, on Table XIII A?

A. I have already pointed out the fallacy of interpretation involved in such a question and any direct answer that could be given to it. The rate and extent of mortality among the typhoid bacilli is the significant thing in these tables rather than the quantity of water examined.

I should, however, like to point out that even viewed in the narrow sense in which your question is asked that this quantity of water, namely, 7.02 cc. contained originally about 20,000,000 typhoid bacilli and that in the course of 8 days examination only 3 typhoid bacilli were found.

Even when looked at in this way which seems to me open to misconstruction it is certainly a highly remarkable and significant fact that out of 20,000,000 bacilli only 3 should be found even assuming what in my opinion is not correct, namely, that these 3 typhoid bacilli had remained alive in the waters of the sac during this long period of investigation.

Q. On the 10th day, Professor, as shown by table XIII A, only the surface colonies were fished, were they not?

A. Yes, sir, according to the statement made in the note.

10281 Q. These sacs, as they were suspended in the water, were well shaken each day, were they not?

A. Yes, sir, Mr. Irons, who had charge of collecting the samples was under specific instructions from me to mix thoroughly the contents of each sac before taking samples, and I have every reason to believe that he followed out these directions.

Q. Did the water in these sacs extend to the glass tube, the upper end?

A. I think in some cases it did. I am not sure about all the sacs.

Q. Could this deposit containing the 3 bacilli of typhoid as shown on table 13, on the 10th day, have remained there any length of time without having been disturbed, as explained by you in your direct examination?

A. I see nothing improbable in that assumption. A particle of organic matter in the sewage with typhoid bacilli adhering to it and lying underneath it, might adhere to the glass and remain there for several days finally to be dislodged by some special accidental occurrence.

Q. Knowing that those conditions would likely pertain should not a more extensive or extended analysis of the water be made than was made, in order to determine its bacterial condition?

A. In reply, I would say that if I understand the question correctly it implies that this source of error might have been foreseen. As a matter of fact it was not foreseen by me
10282 and the possibility of an accident of this character did not occur to me until after the experiments had been closed.

I do not regard, however, the general outcome of these experiments or the deductions to be drawn from them as affected by this accidental occurrence.

Q. Professor, in your direct examination you spoke of the great care urged upon Mr. Irons in shaking each time the contents of the sac and running the water up into the glass tube, so that the water could be drawn with a pipette. In this case would not the sides of the tube and the parchment sac have to be washed down each day, if your instructions had been carefully obeyed?

A. I have already answered that question. It seems to me that a particle of suspended matter present in the sewage at the time a large number of typhoid bacilli were present might adhere with such tenacity to the glass as not to be washed down during a series of examinations.

I should also like to call attention in this conneciton to the fact that no samples were taken from this particular sack until 3 days after the infection of the tube. The washing up of the sewage from the sack into the tube, due to agitation of winds, etc., might have caused some of these particles to dry with such firmness in the first few days, that subsequent motion over them
in the process of agitating the contents of the sac did not
10283 dislodge these firmly adhering particles. An exceedingly
minute concrete particle in the sewage, no larger than the point of a needle, might have clinging to it many thousands of typhoid bacilli.

Q. Professor, how long after these parchment sacs were suspended in the water before they became coated with this bryozoan?

A. This growth was especially noticed in the sacs set in the canal at Robey Street. The coating appeared, as I recall it, in some 8 or 9 days after the sacs were immersed.

Q. Did you not state, Professor, in your direct examination that it appeared upon the sacs within two or three days?

A. There may be some confusion as to the time of appearance of a slime on the walls of these sacs and the appearance of the bryozoan.

Q. How soon did the slime appear after the sacs were submerged?

A. At Robey Street usually within two or three days.

Q. Were these parchment sacs of sufficient strength to hold the water?

A. They were.

Q. Were they air tight—I mean by that, would they permit the diffusion of air through the walls of the sac? Before the water was put into them?

A. I think not, but I am not sure on this point.

Q. Would they hold the water within the sac while sus-
10284 pended in the air?

A. Yes sir, they were tested on that point. I am speaking now of the sacs that were used in the experiment. Some sacs were found defective, having been injured in the process of making, and these were discarded. The sacs used in the experiment were tested in that direction.

Q. What were the differences between the parchment sacs and the celloidin sacs or receptacles?

A. One difference was that the celloidin sacs were a little more fragile and had to be handled more carefully and kept moist to avoid breaking. Diffusion takes place a little more rapidly in the celloidin sacs when they are made properly, otherwise the conditions are very similar.

Q. Did these slimy substances form on both the celloidin and the parchment sacs?

A. In my experiments I had no celloidin sacs in the water of the drainage canal.

Q. Is it not a fact that the formation of the slime and the bryozoan upon the exterior of the sacs prevented diffusion through the walls of the sacs, rendering the conditions exactly similar to a laboratory experiment?

A. I do not see how this could have been the case. The formation of slime may have retarded diffusion in some slight degree, but I do not see how it could prevent it altogether or even hinder it materially. As evidence of the similarity of conditions prevailing in the slime coated sacs in the drainage
10285 canal and sacs not so coated with slime I may instance the
laboratory experiments that I made, when the sacs did not become coated with slime, but the course of events in these sacs ran a parallel course to that obtaining in the slime coated sacs in the canal showing essential identity of conditions as far as the bacterial life was concerned.

Q. Would not that retardation of the diffusion depend upon the extent of the formation of the brazoa upon the exterior of the sacs?

A. It might to some extent, but the sacs were carefully observed with this very point in mind, and no material difference was found in the behavior of sacs rather heavily coated with slime and those relatively free from it. The changes in the bacterial content of the sacs were very much the same at Robey Street and at Lockport, although on the sacs at Lockport there was relatively very little slime.

Q. How can you tell that there was diffusion in those sacs coated with slime and Bryozoa.

A. I have already stated that the events shown to take place in the slime-coated sacs and in those without such slime coating were substantially the same. I see no grounds for assuming that the coating of slime could materially retard diffusion.

Q. Do you understake to say that there was that same diffusion from within and without the sac as there would be and was during that time in the running water of the canal?

10286 A. I believe the conditions to be essentially the same.

Q. In what way do you use the word essentially?

A. So far as products affecting the life of the bacteria are concerned.

Q. Do you believe that the diffusion through the walls of the sac was sufficient to permit the products and by products of the bacterial contents of the water in the sac to pass through the wall and out of the sac, and also the products and by-products of the bacteria in the water itself to pass from the main body of the water into the sac under the same conditions and to the same extent as it would be diffused, distributed and mixed as though in the running stream?

A. Some of the products and substances would in my opinion not be readily diffusible. Assuming, however, that no diffusion whatever occurred, the changes that take place in the content of the sac would be still of the utmost significance since there would be simply a portion of the water of the canal present under similar conditions of temperature, in each of these sacs and whatever took place in such a body of water might be reasonably assumed to take place also in the waters of the canal.

Q. That answer is based altogether upon the proposition that all parts of the water in the canal are equally charged with polluting material from substances and that the bacterial counts are the same at all times at that particular place in the
10287 canal during the 8 days that the parchment bag was suspended in the water, is it not?

A. That is not quite correct for the reason that reference to the tables of the experiment will show that the water into which the typhoid bacilli were introduced varied considerably in bacterial composition in the different experiments.

Q. Professor, if these sacs became coated with slime which you have referred to in your direct examination, is it not a fact that they thus became impervious to all substances and impervious to dissolved oxygen?

A. I do not know that that is so, but assuming that it were true the fact still remains that the changes in the bacterial content of these sacs are the same whether the sac be coated with slime or not.

So far as dissolved oxygen is concerned, there is probably very little if any of this in the waters of the drainage canal and I may further recall the fact that the tubes were open at the top and freely exposed to oxygen.

Q. It is your opinion then that there is very little dissolved oxygen in the waters of the canal?

A. In a water of the character of that in the drainage canal I do not well see how there could be much dissolved oxygen.

Q. And there would be less in the parchment sac used in these experiments, would there not?

A. I have no means of knowing whether there would or would not.

Q. Professor, you analyzed bacterially the waters of
10288 Lake Michigan during the prevalence of typhoid fever in
Chicago did you not, prior to the opening of the drainage canal?

A. Yes sir, I have made a number of examinations of Lake Michigan water as drawn from the tap in the University laboratory.

Q. State, Professor, whether or not there were more bacteria in the waters of Lake Michigan, as shown by the colony counts upon your examination, than there were in the waters of the Illinois River at any point examined by you during this entire investigation?

A. Yes sir, I have several times found more bacteria in water drawn from the laboratory tap than found at Averyville and at Grafton.

Q. As a general proposition was not the reverse true, in this to-wit: that you found more bacteria as shown by the colony counts in the waters of the Illinois River than in the waters of Lake Michigan?

A. I have not made a sufficiently extended examination of Lake Michigan water for a long period covering different seasons of the year, different wind and temperature conditions, etc, to be able to answer that question.

I may also mention that a decline in the numbers of bacteria usually takes place as a water passes from mains and service pipes so that the conditions in Lake Michigan may not be correctly represented by the colony count obtained upon samples of water drawn from a tap.

10289 Q. Prior to the opening of the drainage canal how far out in Lake Michigan was the water of the lake affected by the sewage of Chicago, if you know?

A. I do not know.

Q. Did you make any examination on that subject?

A. I did not.

Q. Professor, assuming that typhoid fever germs pass to the bottom of a body of water, either a river or a lake, and become deposited in the sediment, I will ask you if it is not more likely that such germs would afterwards be washed out and removed from the sediment, if deposited in the bed of a river than if deposited in the bed of Lake Michigan, opposite the mouth of the Chicago River, taking into consideration the average depth of a river, together with the depth of the water in Lake Michigan at the given point?

A. Assuming what seems to me contrary to the fact, namely, that typhoid bacilli can be deposited in such sediment and maintain their vitality for any considerable period, it would of course follow that where changes in the surroundings and velocity were very pronounced such germs would be more likely to be picked up and carried along than in cases where the bottom ooze was not disturbed.

Q. Assuming, Professor, that typhoid fever germs are 10290 carried out into Lake Michigan and deposited in the sediment of the lake would they be afterwards taken up and be carried into the water supply of the City of Chicago as freely and to the same extent as though they had been deposited in such a running stream?

A. Assuming indefinite continuance of vitality on the part of the bacillus I should say that the answer to that question depended upon the extent to which the sediment in the bed of Lake Michigan was infected and the degree to which such infected sediment was disturbed. I do not know how frequently or how profoundly such sediment is stirred up and becomes mingled with the water. The water as drawn from the tap is certainly very turbid at certain times.

RE-DIRECT EXAMINATION,
By Mr. Todd.

10291 Q. Professor, will you distinguish between the terms "presence of sewage" and "effect of sewage" as the terms were used by you in answer to a question of Mr. Jeffries?

A. When I stated that the effect of sewage was present in the waters of the Illinois River at Averyville or Grafton, I referred of course to the fact that the chlorine present in such large quantities in Chicago sewage was manifest in the water of the Illinois River at this point, and also the fact that the large amount of nitrogenous matter introduced into the Chicago sewage was shown by the amount of nitrates and other nitrogenous compounds present in the water of the Illinois River at Averyville. The effect of the addition of sewage to such a river water as shown in the chlorine and the nitrogenous content might persist for hundreds and thousands of miles
10292 irrespective of any change that might occur in the sewage itself. Thus, the chlorine would not disappear from the water of the river if the river were thousands of miles instead of hundreds of miles long.

I should make this distinction between the effect of sewage and its presence.

Q. On cross-examination you were asked several questions pointing to the possibility of the typhoid bacillus being able to swim away from injurious or toxic substances? Do you know how fast this bacillus can move?

A. Some investigations have lately been published on the speed of a typhoid bacillus in the Archiv fur. Hygiene, 1903, 46, page 311, by Lehmann and Fried. These show the results of careful measurements made of the speed of the typhoid bacillus and other bacteria. The mean of the highest and the mean of the lowest observations are given in this paper. Moving at its highest speed a typhoid bacillus was found to move at the rate of four and one-half (4 1-2) inches in an hour, the minimum rate being about one-fifth of this. From one to five inches per hour, therefore, would represent the speed with which a typhoid bacillus could move.

10293 In a river flowing at the rate of half a mile an hour the velocity of the current then would be about 5,000 times as great as that of the typhoid bacillus, so that this organism would be helplessly borne along and brought into contact with various toxic substances without being able to remove itself from their neighborhood.

RE-CROSS EXAMINATION

By Mr. Jeffries.

Q. Do you know of any means of determining accurately and definitely the velocity which may be obtained by the typhoid fever germ in water?

A. These data that I have referred to afford the most recent information that I know of bearing on this subject. The measurements were carefully made with the microscope. It does not seem likely that under natural conditions the velocity would vary more than shown by the figures obtained by these investigators.

Q. There is nothing in those experiments that show that any artificial means was used for the purpose of producing the most rapid probable velocity of these particular germs?

A. The observations on other species of bacteria made
10294 at the same time with those upon the typhoid bacillus
show that even those species of bacteria known to be most highly motile do not vary in their speed very much from the figures thus quoted. The typhoid bacillus itself is a very actively motile organism and a rate of 10 to 12 inches an hour would be an enormous speed for any microbe under any conditions.

Q. Do you know the volume of the particular particles of toxic products that are generally found in polluted waters?

A. In regard to the nature of these so called toxic products in water very little is known, as I have already stated in my testimony. They are, however, doubtless in solution and not in the form of concrete solid particles.

Q. A very short space of removal may only be necessary, to bring the particular bacilli away from the disturbing toxic products into more formidable surroundings, may it not, taking into consideration the size of the particular bacilli?

A. I should think that would not be the case for the reason that the diffusion of dissolved substances through water takes place at a very rapid rate and it seems unlikely that there should be a much greater concentration of these toxic bodies at one point in a mass of water than at another. The diffusion through the water and the mixing caused by the moving
10295 would tend to bring about a very uniform condition of the water within a space of several feet.

Q. Then by the addition of water the diffusion becomes more scattered and less concrete and effective, so far as its deleterious effect upon the bacilli is concerned?

A. I have already stated that that is in my opinion the most plausible explanation for the more rapid disappearance of typhoid bacilli in highly polluted waters as compared with pure waters, namely the greater concentration of the toxins in the sewage polluted waters.

Q. Professor, from your answer to the first question put to you by Mr. Todd, in re-direct examination, in which you described the difference between presence of sewage and effect of sewage chemically speaking, in water, do I understand you to say from that that none of the bacterial counts which may be found in the Illinois River at Averyville come from Chicago, and that all bacteria originating at the city of Chicago have disappeared before Averyville is reached? I mean by that, all bacteria of every kind and character that may be deposited or discharged into the Chicago River or the drainage canal at Chicago?

10296 A. Taking into consideration the enormous number of bacteria and the large number of species discharged into the drainage canal at Chicago and the relatively small number of bacteria found in the water of the Illinois River at Averyville, and taking into consideration also the continuous discharge of bacteria into the Desplaines and Illinois Rivers between Lockport and Averyville, from the sewers of Joliet, La Salle and from the drains of many smaller streams or places, it seems evident that by far the larger number of germs introduced by the Chicago sewage must have perished long before Averyville is reached. Whether every individual bacterial cell entering the drainage canal perishes before reaching Averyville is a matter difficult to determine. There is this indirect evidence, however, gathered from the composition of the various streams tributary to the Illinois. These streams, such for example as the Fox, the Sangamon and others, have not received the drainage from Chicago and yet their bacterial content, so far as numbers is concerned, is almost identical with that of the Illinois River at Averyville.

From my study of species of bacteria isolated from the Illinois River at Averyville as compared with the species
10297 present in the Chicago drainage canal it seems to me
unlikely that any significant numbers of bacteria find their way from the canal to Averyville.

It is impossible to state, however, that some bacteria belonging to saprophytic species adapted to an aquatic life may not survive long enough to pass from the drainage canal to Averyville.

Q. It is your opinion, then, is it Professor that no sewage bacteria or pathogenic bacteria of any kind or character, originating in the sanitary district of Chicago and discharged into the Chicago River or drainage canal pass down the Illinois River as far as Averyville under all conditions that have existed or may exist in the future?

A. I certainly should not be willing to express an opinion as to what might obtain under future conditions.

Using the term pathogenic bacteria in the way which I assume that it is meant, I would say that it is my opinion that few if any pathogenic bacteria pass down the Illinois River under existing conditions as far as Averyville.

10298 Q. But you will not say that they do not pass down as far as Averyville?

A. It is impossible to say that a few straggling individuals may not pass so far, just as it is impossible to affirm that they do pass as far as Averyville.

Q. Now, Professor, in what way do you assume that the term pathogenic bacteria is used in the question and as expressed in your answer?

A. I understood you to mean the pathogenic bacteria ordinarily regarded as pathogenic for man.

EDWIN O. JORDAN.

ADJOURNED UNTIL 10:00 A. M., MONDAY, FEBRUARY 15, 1904.

10299 10 A. M., Monday, February 15th, 1904. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

N. MAC L. HARRIS,

a witness called in behalf of the defendants, having first been duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION BY Mr. Todd.

Q. State your name?

A. Norman Mac Leod Harris.

Q. What is your business?

A. I am employed as an assistant in the Chicago University, Associate in Bacteriology.

Q. Under whom do your duties fall?

A. Under Professor Jordan.

Q. How long have you been connected with the University of Chicago?

A. Since June 15th.

Q. What business were you connected with, prior to that time?

A. I was associate in Bacteriology at Johns Hopkins University.

10300 Q. For how long?

A. From October, 1897, to May, 1903.

Q. Under whom did your duties fall, in the Johns Hopkins University?

A. Under Prof. Wm. H. Welch.

Q. From what institution did you graduate?

A. From the University of Toronto.

Q. Did you take a Post-Graduate degree anywhere else?

A. Yes sir, in London, England, I obtained the diploma of the Royal College of Surgeons, and Licentiate to the Royal College of Physicians, London.

Q. Did you do any work under the direction of supervision of Prof. Jordan, for the Sanitary District of Chicago, in connection with an experiment made in the Drainage Canal?

A. I did.

Q. What part of that work did you perform?

A. The preparation of certain media used for the concentration of the organisms.

Q. Were the preparations of these media done by you according to the directions and under the supervision of Prof. Jordan?

A. By myself, upon consultation with him, upon certain points.

Q. After the media were prepared, what did you do in connection with the experiments?

10301 A. My duties were the identification of the organisms, isolated by Miss Lincoln, who was an assistant.

Q. And were you and Miss Lincoln in the laboratory together?

A. Not in the same room, we were working apart. Occasionally I would go in and see her work.

Q. Miss Lincoln is the lady that Prof. Jordan referred to as being his assistant in his laboratory there?

A. Yes sir.

Q. After the identification of the bacteria was made—this identification was made under the direction and supervision of Prof. Jordan?

A. It was.

Q. After that was made, what else did you do?

A. I simply kept a record of my daily work.

Q. And were these records submitted to Prof. Jordan?

A. They were.

Q. As the work progressed?

A. Yes sir.

Q. And everything you did in connection with the experiment, was done under the direction and supervision of Prof. Jordan?

A. Yes sir.

Q. After you obtained the instruction he gave, in regard to the method to be pursued?

A. I did.

10302 No Cross Examination.

Signature Waived. F. S. B., Com'r.

ERNST E. IRONS,

a witness called in behalf of the defendants, having first been duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION BY
Mr. Todd.

Q. What is your name?

A. Ernst E. Irons.

Q. What is your business?

A. I am assistant in the University of Chicago, in Bacteriology.

Q. Are you employed there now?

A. Not during the present quarter, no.

Q. But do you still retain your connection with the university?

A. I do, at present.

Q. What are you doing now?

A. I am in the Presbyterian Hospital as interne.

Q. When did you graduate?

A. In the University of Chicago, in 1900.

Q. After your graduation, what did you do?

A. I was associated with Prof. Jordan, in bacteriology.

Q. How long were you connected with the university under Prof. Jordan in bacteriology?

A. From January, 1897.

10303 Q. Did you do any work in connection with streams examination, under the direction of Prof. Jordan, in the year 1899 and 1900?

A. I did.

Q. At what place did you do the work?

A. At the University of Chicago.

Q. This work was done in connection with the examination of what rivers?

A. The Illinois river, and the Mississippi and the Missouri.

Q. The results of that examination has been published in what is known as Streams Examination by the Sanitary District?

A. It has.

Q. As well as in the tables introduced in evidence by Prof. Jordan?

A. Yes, sir.

Q. What part of that work, in a general way, did you do?

A. I made the bacteriological examinations.

Q. Did you receive the samples as they came into the laboratory from the water takers?

A. I received part of them in association with Mr. Stevens.

Q. And after the samples were received by you, what was done with them?

A. They were properly labeled, identified and examined.

Q. The examination that you pursued in this matter
10304 was the examination under the direction of Prof. Jordan?

A. Yes, sir.

Q. For that period?

A. Yes, sir.

Q. And all the reports you made were given directly to him?

A. Yes, sir.

Q. This laboratory is his working laboratory that you worked in?

A. It was.

Q. And under the immediate supervision of Prof. Jordan?

A. Yes, sir.

Q. And the results of those examinations that you have heretofore indicated, are the tables that are published and which have been testified to be Prof. Jordan's tables?

A. Yes, sir.

Q. All the work you did in connection with these examinations, was done under the supervision and under the direction of Prof. Jordan?

A. Yes, sir.

Q. Mr. Irons, did you do any work under Prof. Jordan, in connection with the colony count, and the coli determinations, for the period of 1901?

A. I did.

Q. What work did you do?

A. I established laboratories at Peoria, Grafton, and
10305 St. Louis. My chief work was at St. Louis, but from
time to time I was at Peoria and Grafton for a day at a time.

Q. In establishing these laboratories, under whose directions were you acting?

A. Under Prof. Jordan's.

Q. Do you know whether the City of St. Louis had laboratories established at these three points at the time the laboratories were established by you?

A. They did.

Q. Do you know whether water was taken from the same points in the river, that water was taken for the laboratories you have just testified as having been established at these three points?

A. So far as I know, the samples were taken at Peoria, from the same points. At Pekin, I do not know, I am not sure about that. At St. Louis and Grafton, I believe the samples were taken at the same points, so far as I know.

Q. What laboratory did you have charge of?

A. The St. Louis Laboratory.

Q. Who else was there in connection with you?

A. Mr. Sackett.

Q. That is the gentleman that has already testified in this case?

A. I think he has.

10306 Q. At what points was the water taken that was analyzed in the St. Louis Laboratory?

A. From the Mississippi river, Chain of Rocks, four samples, and from the Missouri river, at Bellefontaine.

Q. What determinations were made from the water thus secured from these places?

A. Determinations of the colony count and colon determinations.

Q. How long after the water was taken, was it before they were plated?

A. In the case of the samples at the Chain of Rocks, the samples were examined on the spot in a temporary laboratory fitted out at the Chain of Rocks, that was done by Mr. Sackett. The samples from Bellefontaine, Missouri river, were brought to the laboratory, arriving in about two hours after collection.

Q. All these determinations made by you and Sackett were tabulated?

A. They were.

Q. And the results reported to Prof. Jordan?

A. They were.

Q. Were these examinations made in pursuance to directions given you by Prof. Jordan?

A. They were.

10307 Q. Were these examinations made in pursuance to directions given you by Prof. Jordan?

A. They were.

Q. And under his directions and supervision?

A. They were.

Q. After you had completed the work at St. Louis, what was done with the results of that work?

A. Prof. Jordan had charge of all the results.

Q. They were sent to him?

A. They were.

Q. Those are the results of that laboratory that has been offered in evidence here by Prof. Jordan, and you are the assistant that did the work under his direction, that he has testified to?

A. I am.

Q. Did you do anything under the direction of Prof. Jordan in connection with an experiment made in the drainage canal, for the Sanitary District of Chicago?

A. I did.

Q. State what you did?

A. I had certain boxes constructed and placed in them
10308 parchment sacs containing various cultures, and samples of water.

Q. From whom did you get the parchment sacs?

A. The parchment tubes were bought from a chemical company in the city, and were made into sacs by me.

Q. How did you make the sacs, just describe the process?

A. I cut off sufficient sizes, or pieces of tubing from the roll, and fitted in the upper end a glass tube, about ¾ of an inch in diameter, and rolled up the lower end in such a way as to seal it. The joints at the upper end and the lower end were then saturated in a solution of rosin and tallow, and bound around with twine. After construction, the sacks were tested in the laboratory to see that there were no breaks in them.

Q. Did the sacks come as tubing?

A. They did.

Q. What test did you employ to ascertain the integrity of the sacs?

A. The sacs were moistened, filled with water, suspended, and then observed to see if any minute points of fracture appeared in the outside, which would indicate perforation.

Q. After you had prepared the sacs in the manner that you have indicated, did you use any sacs that gave
10309 evidence of perforation?
No, sir.

Q. After the sacs were prepared as you have indicated, what was then done by you?

A. The sacs were taken out to the drainage canal and filled with the water in the canal. After they were filled they were again suspended and observed to see whether there were any perforations. In case there was a perforation, the sack was thrown out.

Q. Then what was done?

A. The sacs were suspended in the wire cage. Some of them were inoculated with typhoid cultures which had been previously obtained, and some of them were allowed to remain without any inoculation.

Q. What were those sacs called that were not inoculated?

A. They were called control sacs.

Q. The sacs that were inoculated, what were they inoculated with?

A. They were inoculated with suspensions of typhoid bacilli.

Q. What do you mean by suspensions of typhoid bacilli?

A. A colony of typhoid was grown in the incubator for 24 hours in bouillon, then a portion of this culture was
10310 placed in sterile normal salt solution in a flask.

Q. Who prepared these cultures of the typhoid bacilli?

A. Do you mean originally?

Q. Yes, sir?

A. There were three cultures employed, obtained from the bodies of typhoid patients by Dr. Rosenow, at the county hospital.

Q. Did you secure these cultures from Dr. Rosenow?

A. Directly, yes, sir.

Q. After you secured them from him, what did you do with them?

A. I handed them to Prof. Jordan.

Q. And then, when did you get hold of them again?

A. I received them at the laboratory from Dr. Harris, who had examined them in the mean time.

Q. In what form did you receive them from the media?

A. In agar streak cultures.

Q. Then what did you do with them?

A. I made a bouillon culture for each of them as required and inoculated them after 24 hours into a normal salt solution.

Q. How were these typhoid strains designated?

A. As typhoid X, Y and Z.

10311 Q. Now, after you prepared the culture in suspension, as you have described it, what was done with it?

A. A certain amount of the suspensions was placed in certain of the sacs, which had been placed in the wire cage in the canal.

Q. Now, how were the sacs numbered?

A. The sacs were numbered A. B. C, and so on, down the alphabet, the letter designating a certain series, and then a number of similar sacs of the series was made. These were designated A 1, B 1, etc., and A2 B2, and so on.

Q. And after the box was prepared, and the sacs inoculated, and placed in the water, was this in accordance with the instructions given you by Prof. Jordan?

A. That was all under his instructions.

Q. Then what did you do?

A. After inoculating the sacs, and agitating them, samples were removed from the sacs for immediate examination.

Q. Will you describe what you mean by agitating the sacs? 10312

A. Attached to the lower end of each sac was a cord, which is brought up and tied to the rack holding the neck of the sac. The bottom of the sac was alternately brought to the surface and lowered, this was done repeatedly for ten or fifteen times.

Q. Then after you had agitated the sac, what did you do?

A. Samples were taken from the sac.

Q. What means were employed for taking samples?

A. I used sterile 10 c. c. pipettes with a rubber bulb attached to the upper end. The sample of the water was drawn up in these pipettes and placed in sterile 50 c. c. bottles.

Q. After it was placed in the sterile bottles, then what was done?

A. The bottles were sealed and taken to the laboratory at the University.

Q. And after they were taken to the laboratory at the University, what was done with them?

A. They were examined by Miss Lincoln.

Q. And then what was done?

A. That was where my work ended.

Q. Did you keep a record of what you did?

A. I did.

10313 Q. Did you keep a record of the time at which the samples were taken?

A. I kept a record of the time they were inoculated, and the time they were removed, and the time they were delivered at the laboratory, and the condition of the cage, and sacs, at each visit.

Q. What was done with the record that you kept?

A. It was handed to Prof. Jordan.

Q. When you put these sacs in the water, did anything form on them?

A. There was a growth of water organisms which, on examination, proved to be brazoa.

Q. How soon after these sacs were placed in the water, did these brazoa appear on the outside of the sacs?

A. Little small spots began to appear about the third or fourth day, about the fourth day, and these gradually became larger, so that after a number of days there was a coating over the surface of the sac.

Q. About how many days does it take to make a complete coating over the surface of the sacs?

A. I should say about 14 days.

Q. Did the brazoa appear on the sacs at Robey street and at Lockport?

A. At both places.

Q. At the same time and in the same quantity?

10314 A. No, they appeared somewhat earlier at Robey street, so far as I was able to observe.

Q. Did they appear on all the sacs uniformly?

A. Not entirely uniformly, the position in the box seemed to make some little difference, but I was unable to determine just what the reason was.

Q. All of the work which you did in connection with this experiment as you have detailed it, you reported to Prof. Jordan?

A. I did.

Q. And was done under his direction and supervision?

A. It was.

Q. Did you at any time make any examination of the water of the Mississippi river at Quincy, Illinois, for the purpose of determining the presence of the bacilli coli communis?

A. I did.

Q. When did you make this examination?

A. That was in the fall of 1902, in September and October, and in December, 1902, until February, 1903, and a week in March, 1903.

Q. For whom did you make this determination?

A. This determination was made in connection with some
work that I was doing for the American Steel and Wire
10315 Company, in connection with sulphate of iron for the
purification of water.

Q. Have you prepared a table showing the results of your examination of the water of the Mississippi river at Quincy, for that time?

A. Such a table appears in the report that I made.

Q. Was that table made by you?

A. It was.

Q. Who took the samples of water?

A. I took them, myself.

Q. All this work was done by you personally?

A. Yes, sir.

Q. Was the same method pursued in this examination that was made for the coli determinations in the laboratory at St. Louis?

A. Practically the same, yes, sir.

Q. Will you read the table in evidence that you prepared there of the waters of the Mississippi river at Quincy?

A. It is as follows:

10316 TABLE

Showing the relative frequency of occurrence of B. coli communis in Mississippi river water at Quincy.

Date.	No. of samples.	.001 c. c.			.01 c. c.			.1 c. c.			1. c. c.		
		+	—	?	+	—	?	+	—	?	+	—	?
Sept. 27-Oct. 3,	7	1	7	1	4	6	1	12	0	1	7	0	
Dec. 30-Feb. 7,	13	4	17		13	13	1	19	5		8	0	
Mar. 24-Mar. 27,	5	0	7		1	10		9	3		11	0	
Totals,	25	5	31	1	18	29	2	40	8	1	26	0	

Q. Did you examine the results of the coli determination at the station of Grafton?

A. I did.

Q. Were you there at that station?

A. From time to time I was. About every two weeks.

Q. How does the presence of coli bacilli in the Mississippi river at Quincy compare with the coli bacillus at Grafton?

A. Judging from the determinations that I made during the course of my work for the Steel Company, the colon bacillus was much more numerous in the Mississippi river at Quincy than it is in the Mississippi river at Grafton, or of

10317 the Illinois at Grafton.

CROSS-EXAMINATION, by Mr. Corum.

Q. Mr. Irons, from what school are you a graduate?

A. University of Chicago, and Rush Medical College.

Q. Where are you employed now?

A. As interne in the Presbyterian Hospital.

Q. When did you graduate?

A. At the University of Chicago, in 1900.

Q. From Chicago, in 1900?

A. Yes, sir.

Q. Did you attend any school since that time?

A. The Rush Medical College.

Q. And you graduated from that school?

A. Yes, sir, in 1903.

Q. What time in 1903?

A. December, 1903.

Q. How old are you?

A. Twenty-six years old.

Q. Now, these experiments that you made, were made under the direction and supervision of Prof. Jordan?

A. They were.

Q. In each instance you did as you were told to do by him?

A. With the exception of this Quincy matter, yes, sir.

10318 Q. You were then working for the American Steel and Wire Company?

A. I was.

Q. Now, you say you placed some laboratories at Grafton?

A. At Grafton, Peoria and St. Louis.

Q. When did you place this laboratory at Grafton?

A. That was about September 28th.

Q. Of what year?

A. 1901.

Q. How long did that remain there?

A. The Grafton laboratory remained in operation until December 15th, I think.

Q. 1901?

A. 1901.

Q. Did you personally superintend it during its existence?

A. Mr. Sayer had charge of the laboratory.

Q. You were not present there at all times?

A. No, I was not.

Q. At what other point did you place a laboratory?

A. At Peoria and St. Louis.

Q. When was the laboratory placed at Peoria?

A. The first week in October, 1901.

Q. How long did that remain?

A. Until about January 10th, if I remember.

10319 Q. Did you personally superintend that one?

A. Mr. Schule had charge of that laboratory.

Q. You were not there present at all times?

A. I was not.

Q. The other laboratory, did you personally superintend that during its existence?

A. I did.

Q. At all times?

A. At all times except when I was called away on other matters.

Q. Now, you stated that you took four samples from the Chain of Rocks in the Mississippi river?

A. Four samples were taken.

Q. Did you take those?

A. We had collectors who took those samples under the direct supervision of Mr. Sackett.

Q. Now, as I understand, you took some sacs out to the canal, yourself?

A. I did.

Q. How many of those?

A. Between 30 and 40, I should judge.

Q. And where did you place those?

A. They were placed in the canal at Robey street and at Lockport.

Q. Near each other, and how close were they together, those at Robey street?

A. The sacs were placed at Robey street in a box 4 feet long and 3 feet wide.

10320 Q. All in that box?

A. All the sacs were not in the box at the same time. because several of the experiments were repeated from time to time.

Q. Now, those at Lockport, did you say?

A. At Lockport.

Q. Now, how were they placed?

A. They were placed similarly.

Q. In a similar kind of a box?

A. In a similar kind of box.

Q. What sort of sacs were they?

A. They were parchment sacs.

Q. Were they such as to admit the diffusion of air?

A. The upper end of the tube was open to the air.

Q. But would the sacs themselves permit the air to be diffused?

A. The sacs themselves were beneath the surface of the water.

Q. What remained above the water, how about the diffusion of air, what remained above the water?

A. That would allow the diffusion of air, the same as most solids will allow the diffusion of a small amount of gas, if long enough time is allowed, but ordinarily speaking, it would not.

10321 Q. What do you mean when you say ordinarily speaking?

A. There were no punctures in them.

Q. They would not permit it, unless they were punctured, is that the idea?

A. Any parchment membrane will allow the diffusion of a small amount of air if long enough time is allowed.

Q. Now, before these sacs were taken out did you test them thoroughly as to whether they would permit the water to soak through?

A. At the time of removing each sac, it was inspected in the same way, it was inspected when placed there.

Q. I mean prior to placing them in the canal, did you give them a thorough inspection to see whether there was any leakage?

A. I did.

Q. Test them thoroughly?

A. Yes, sir.

Q. Then, when you took them out to the canal they were not tested again?

A. They were.

Q. Why, if they had been thoroughly tested before?

A. As a matter of scientific exactness, they were tested again.

Q. And you did not detect any leakage on either test?

A. If there was a leakage, it was reported at the time.

Q. And then what was done with those sacs?

10322 A. They were thrown out.

Destroyed?

A. Yes, sir.

Q. After these sacs were put in the box, they were permitted to remain there, as I understand, for different times?

A. They were.

Q. How long was it until you removed the first sac?

A. Only a matter of three or four days.

Q. Did you remove the first sac?

A. I did.

Q. What did you do when you removed it?

A. I removed the entire contents for a chemical examination.

Q. What did you do with the contents?

A. Took it to the University.

Q. Take it along in the sacs?

A. It was taken in a chemical bottle.

Q. Was the bottle sealed?

A. The bottle never passed from my possession until it was delivered. The bottle was sealed and did not pass from my possession until it was passed to the person who was to examine it.

Q. You made a chemical analysis of it?

A. No, I made no chemical analysis.

10323 Q. Who did make that?

A. I don't know; that is, I don't remember the man's name.

Q. Did you remove all of those sacs in the box at Robey street?

A. All the sacs that were removed, I removed.

Q. Were they all removed that were placed in there?

A. They were.

Q. And you removed them all?

A. Yes, sir.

Q. How long until you removed the last sac?

A. The last sac was removed at the end of the experiment. The last sac was removed about the 10th of November.

Q. They were placed in there when?

A. The first sac was placed in there, I don't remember the date.

Q. Were all of these sacs intact when they were removed by you from the box?

A. No, they were not.

Q. How many of them were not, if you remember?

A. Well, there were several sacs which remained a matter of about 18 days, as I remember, that were perforated when removed.

Q. Several of those?

A. Yes, sir.

10324 Q. Could you tell how long they had been perforated, Mr. Irons?

A. Indirectly, I could. By judging from the other sacs which I examined that were not perforated, at different periods of time.

Q. Then how long had these been perforated, if you can determine it indirectly?

A. I should judge that the sacs remained intact about on an average of about 17 days.

Q. While these sacs were in the canal, you spoke about a string being attached to them by means of which you would agitate them, what was the purpose of that?

A. The purpose of the string?

Q. Of the agitation?

A. At the time of taking samples, it was decided that the sample should represent the contents of the entire sac, and the agitation was used in order to completely mix the contents of the sac, so that the sample should be a fair sample.

Q. That was done only at times when you took the samples from the particular sac, was it?

A. Yes, sir; or at times when it was decided to inspect the sac possibly without taking samples.

Q. Could you not have inspected the sac without agitating it?

A. It would have to be agitated to some extent,
10325 because it would be impossible to see the sac in the water.

Q. Did you put this typhoid culture in the sac?

A. I did.

Q. Where did you procure that?

A. From Dr. Rosenow.

Q. You simply acted on his statements about where he obtained that culture, you knew nothing about that of your own personal knowledge, did you, Mr. Irons?

A. No, I know nothing except that I obtained the culture from him.

Q. And acted upon what he said, about where he obtained it?

A. Yes, sir.

Q. These bottles that you put your samples in, were they sealed, hermetically sealed?

A. The samples from the sacs were collected in sterile glass stoppered bottles containing about 75 c. c.

Q. And the bottles were sealed?

A. The bottles were sealed with a rubber cloth over the stopper, fastened by a rubber band around the neck of the bottle.

Q. Referring to that agitation again, Mr. Irons, would 10326 not the tendency be in shaking the sac in that manner, to shake down whatever might be attached to the sides of the sac, and it would fall to the bottom as a sediment, would that not be the natural tendency?

A. I do not think it would.

Q. Why would it not?

A. Because, if there is other sediment, by its nature, it will be found at the bottom of the sac, if it is present at all, so that in order to examine that fluid, we agitated it.

Q. Then, anything on the side, or in the bottom, would appear in a liquid?

A. Anything lodging of such a nature, that could float off in the agitation, would appear in the liquid.

Signature waived. F. S. B., Com'r.

10327 MARY C. LINCOLN,

a witness called in behalf of the defendant, having first been duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION, by Mr. Todd.

Q. What is your name?

A. Mary C. Lincoln.

Q. What is your business?

A. Bacteriologist.

Q. Where are you employed?

A. I am employed at the Food Preservaline Company, M. Cohen Brothers.

Q. Chicago, Illinois?

A. Chicago, Illinois.

Q. Did you do any work under Prof. Jordan at the Chicago University, in connection with an experiment made by him on the waters of the Drainage Canal for the Sanitary District of Chicago?

A. I did.

Q. In what capacity were you then engaged?

A. As an assistant doing the laboratory work.

Q. Did you receive the samples that were brought into the the laboratory by Mr. Irons?

A. I did.

Q. And what was done with these samples when they were brought into the laboratory?

A. They were plated by me.

Q. Was the work which you did in connection with these samples done under the direction and supervision of

10328 Prof. Jordan?

A. It was.

Q. This was his private laboratory in which you were engaged?

A. Private laboratory.

Q. And the results of that work was tabulated by him in the tables that have been introduced here in evidence?

A. It was.

CROSS EXAMINATION BY
Mr. Corum.

Q. Did you have anything to do with picking off the typhoid colony?

A. I did.

Q. Did any one assist you in that?

A. Only Dr. Jordan, and Mr. Irons twice, I think.

Signature waived. F. S. B., Com'r.

Adjourned until 2 p. m., same day.

10329 2 P. M. Monday, February 15, 1904. Continuation pursuant to adjournment. Present, the Commissioner, and same counsel representing the respective parties.

F. R. ZEIT,

recalled for further direct examination by Mr. Todd, testified as follows:

Q. Prof. Zeit, since you gave your testimony in this case, last October, have you made any experiment upon the longevity of the typhoid bacillus?

A. I have.

Q. Was this experiment made by yourself, or in conjunction with some one else?

A. It was made in conjunction with Prof. Jordan and Prof. Russell.

Q. Will you state the general plan as outlined for the making of this experiment?

A. The plan outlined was that Prof. Jordan should determine the longevity of typhoid bacilli under the most natural conditions, as would obtain in the drainage canál, both at the beginning of the drainage canal and at its end, and that Prof. Russell was to determine the same question with regard
10330 to the longevity of the typhoid bacillus at Averyville
and that I was to determine the same question in Lake Michigan water, and in the Chicago River.

Q. Did any one assist you in this work?

A. Yes sir, my assistants Dr. Bassett and Dr. West. Dr. Bassett is an assistant and instructor in bacteriology at the Northwestern University Medical School, and Dr. West is my assistant at the Post-Graduate Medical School.

Q. After the stations at which each of you were to do your respective work were selected, what were the general plans which you adopted in carrying on this experiment?

A. I adopted two plans, the first was to use parchment sacs, the second plan was to use celloidin sacs, both intended to allow osmosis, and both to contain the typhoid bacillus in the presense of the normal saprophytes present in the water of Lake Michigan, and the Chicago River.

Q. Will you describe the characteristics of the parchment sacs and the celloidin sacs for the purposes for which they were used in these experiments?

A. Both allow osmosis to take place the parchment sac as well as the celloidin sac. The only object of using them was to allow the saprophytic bacteria in the sacs to multiply 10331 without retaining their excretions in the sacs which might destroy the typhoid bacillus. In this way, there was a free interchange between the excretions of bacteria imprisoned in the sacs, as well as the products of micro-organisms in the free waters of the Lake, as well as the Chicago River.

The principal object was to allow free interchange and to have the conditions in the sac the same that they were outside of the sac, with the one exception that, inside of the sacs there were, besides the usual water bacteria and saprophytes, also typhoid bacilli.

Q. How were these parchment sacs and celloidin sacs prepared?

A. Parchment sacs of a size to contain about 1000 cc. of water were folded at one end twice, and then also folded lengthwise, at the upper end around a glass tube and then tied with a string, after which they were, the folds and string were covered with a mixture of sealing wax, tallow and rosin. In the upper end was inserted a glass tube of the size of about ten mm. which was tied in with a string and sealed with sealing wax, tallow and rosin.

The celloidin sacs were prepared from what is known as Park Davis's Veterinary Capsules, No. 00. These are 10332 made of gelatin, and into each capsule was inserted a glass tube of a diameter of about 5 mm. Then the capsule, which contained 30 cc. of water, was coated over with 6 % celloidin solution. A number of coats of this solution were applied, always allowing drying between each application, and then the sac was filled with water and the gelatin inside allowed to dissolve with heat. It was then repeatedly washed out, so that finally only the celloidin sac together with the glass tube was left. Both kinds of sacs, the parchment sacs as well as the celloidin sacs were tested. We tested them by first blowing into them, the sacs being under water, and looking for air bubbles. Second, we tested them by introducing an albumen solution into the sack and then testing the outside fluid in which they were suspended for 24 hours, for albumen. If these tests were negative the sacs were considered satisfactory and they were used in the experiment.

The sacs were sterilized before use whenever we inoculated the boiled water of Lake Michigan, or boiled Chicago River water with typhoid bacilli. We did this in order to see how long a typhoid bacillus could live if other bacteria were killed 10333 by boiling bacteria normally present in the Lake Michigan water, or in the Chicago river water, were present. The principal experiments that were made were, however, always made by filling the sacs, both parchment and celloidin sacs, with the Chicago river water, or Lake Michigan water, and then inoculating the non-boiled raw water with typhoid bacilli about on an average of 500,000 to the cc. of water in the sac, and then suspending all these sacs in the water according to what water was in the sac. If it was Chicago river water, why, then the sacs would be suspended in a box, and if it was Lake Michigan water, the sacs were suspended in a jar in my laboratory at the Post-Graduate Medical School.

Q. After these sacs were prepared, tested and sterilized in the manner that you have indicated, what method did you pursue in infecting the sacs with typhoid bacilli?

A. The sacs were inoculated with typhoid bacilli which had grown upon agar slants, for 24 hours in the incubator. Of these, coli grown on agar slants enough material was placed into the sac to produce a mixture of about 500,000 typhoid bacilli to the cc. of the water.

Q. Where did you get the cultures of the typhoid fever germs that you planted on the agar slant?

A. We received one strain of typhoid bacillus from Prof. Jordan marked "Bacillus X." These bacilli were obtained from the blood of a typhoid fever patient at the Cook County hospital. The other bacillus we received from Parke, Davis & Co., in Detroit. This bacillus had been used to immunize a horse. With this bacillus we also received the serum of the immunized horse.

Q. After these cultures of bacilli were received by you, what did you do with them?

A. We inoculated many other agar tubes from them, and put them in the incubator over night, and these were the cultures which we used.

Q. After your culture was prepared, what method did you employ for infecting the sacs of parchment and celloidin that you prepared?

A. We suspended these sacs in the Chicago River at the Ashland avenue bridge in a box, and similar sacs were suspended in a jar of water through which fresh Lake Michigan tap water was constantly flowing. At the time they were suspended in these two localities, we plated out upon agar, and, from now on we plated out every day from these sacs which we had 10334 in the Chicago River, and in the laboratory with the tap water, and made agar plates. We made agar plates every day, from both Lake Michigan and also river water, from these sacs.

Q. Will you describe the boxes into which these sacs were suspended?

A. The boxes were prepared in the same manner as Prof. Jordan prepared his. The boxes were suspended in the same manner except that we had inside of the box a cross piece on which were fastened a number of burette clamps into which the glass tubes of the parchment sacs were clamped, the sac being suspended in the water. The celloidin sacs were suspended in the same manner, the open tube closed with cotton, the same as in the parchment sacs and passing out for some distance above the outside water.

Q. What was the purpose of the cotton?

A. The purpose of the cotton was principally to prevent the entrance of other bacteria except those in the water, and second, to allow free access of air. It acts as a germ filter, but does not prevent the entrance of air.

Q. How were the sacs which you have described, infected with the typhoid bacillus that you had prepared?

10335 A. In the parchment sacs we took a suspension of typhoid bacilli in sterile water made by distributing material from colonies grown upon the agar slants for 24 hours. We took these watery suspensions of typhoid bacilli to the Ashland Avenue bridge. The sacs were suspended in the box in the river, under the south side of the bridge. We filled the sacs, first with river water, and then added to the 800 cc. of river water enough of our watery suspension of typhoid bacilli to make in the sac a mixture containing between 200,000 to 1,500,000 typhoid bacilli per cc. We made these experiments numerous times. We used an average suspension of 500,000 typhoid bacilli to the cc. in the sac.

Q. After these sacs were infected in the manner that you have indicated, what was the next step pursued by you in the experiment?

A. We would plate out at once and then go there the next day and remove from the parchment sac by means of a sterile pipette a quantity of the water in the sac after the sac had been shaken. We would always first loosen the burrette clamps, take out the whole sac and see whether it was still patent, and that there was no leak. If there was no leak, we would shake the sac and then remove by means of a sterile pipette, a quantity of water which was placed into a sterile flask which we had 10336 brought along. This flask was immediately taken to the laboratory and here plated out. We would plate out on agar, and we would use for each agar plate .001 cc, .01 cc, .1 and 1 cc, and sometimes larger quantities, as much as 5 cc.

Q. How soon after the sacs were suspended in the drainage canal at Ashland avenue would it be before the samples were taken out in the manner you have just indicated?

A. The first samples were usually taken after 24 hours and after that, daily. We took one sample a day from the moment that we placed the sacs in the river.

Q. Who placed these sacs in the river?

A. Dr. Bassett and myself.

Q. You had personal supervision of this experiment?

A. I did.

Q. And all parts of it?

A. And all parts of it.

Q. Confining yourself now to the experiment at Ashland avenue, how many sacs of parchment and celloidin were placed in the Chicago river at that point by you?

A. There were 8 experiments made at each place, that is, eight experiments at the Ashland avenue bridge in the river water, and 8 experiments made in flowing lake water from the tap of the Post Graduate laboratory.

10337 Q. How many of these 8 sacs at Ashland avenue which you employed in this experiment were celloidin, and how many were parchment?

A. There is some difference between those experiments. In the case of parchment sacs we filled each sac only once, and would take samples daily from the sac. In the celloidin sack experiment we used very many sacs, and took out a whole sac every day and took it to the laboratory. We never took any samples of water out of the celloidin sacs in the river but always took a whole sac. We would take for one experiment as many as 8 or 10 celloidin sacs to the river filled and infect them and suspend them all, and bring home one of these sacs every day, and plate out from it at the laboratory. In other words, we avoided any possible contamination of the specimens to be plated out, and used 8 to 10 celloidin sacs for one experiment, whereas, with the parchment sacs, one sac always made one experiment and we would take out 25-30 CC water from that, daily.

Q. Now, professor, will you explain in detail the definite means employed, the manner in which they were employed, in making the experiment at Ashland avenue?

A. After the parchment sacs were filled and infected with the suspension of typhoid bacilli that we had taken to the place, we then took from the mixture a specimen of water from
10338 the sac into a sterile flask and took that home to the laboratory for control. The next day, and every day following, Dr. Bassett would go to the box and obtain from this sac a quantity of the fluid after examining the sac for holes, nd bring this material in a sterile flask to the laboratory. At he laboratory every day, then, we would plate out this material n a number of plates, using .001; 0.01; .1; 1 cc, and someimes more of this water from the parchment sac. Common gar was used. The agar plates, which were placed into the ncubator over night, were then examined from day to day and ny typhoid like colonies were inoculated into Hiss's medium. This was done for several days, the colonies which in Hiss's ledium proved to be non-motile bacteria, or which proved to e gas producers were thrown aside. Only those colonies in iss's medium which showed no gas but showed a diffuse oudiness due to the motility of the organism that had been

growing there, were then tested with the serum obtained from Parke, Davis & Co. of the immunized horse which would agglutinate typhoid bacilli in a dilution of 1 to 1000, almost instantly. If by this test we found that such a colony was
10339 a typhoid bacillus, we would take it for granted that the typhoid bacillus was still present. When it was impossible to get any positive Widal serum reactions by this means, then we would take that plate in which we were unable to find typhoid bacilli and inoculate from it Hiss's tubes, taking every colony that had grown on it. Then, again, from Hiss's Medium, we would pick out the motile, non gas producers and make a Widal serum test. We would sometimes, also use Litmus milk.

Q. Professor, will you explain the bacteriological significance of the strain of the typhoid bacillus which you used together with the significance and meaning from a scientific standpoint of the serum of the horse, which you employed in this experiment?

A. The object of using preferably the Parke, Davis bacillus "O" was to enable us by means of the Widal test to quickly find colonies of typhoid bacilli if present. In other words, we avoid very much labor in the way of running the colonies
10340 through so many different culture media. We could tell the typhoid bacillus sometimes almost immediately. We could tell it sometimes directly on the plate. I have taken agar plates after they had been in the incubator and right away picked up a typhoid like colony and tested it with the serum of the immunized horse. The reason we preferred this bacillus to the "X" bacillus was because we could do so much more work. We could examine so many more colonies and we would find typhoid bacilli much quicker. We would avoid a great deal of troublesome examination. When we were satisfied that we had a Widal reaction in the dilution of 1 to 1000, we put that down as positive that the typhoid bacillus was present.

The whole method of diagnosis of a typhoid bacillus, that is the most certain and acceptable one is that of being able to agglutinate typhoid bacilli by certain substances which are present in the serum or in the blood of the person who has typhoid fever, or the immunized animal which has been injected with typhoid bacilli. If an animal is injected with typhoid bacilli in a less dose than that which would kill it, the result is that a substance is produced in the animal's serum which agglutinates typhoid bacilli, which clumps them.

10341 The typhoid bacillus is normally a very motile and active bacillus, but when small traces of the serum of an immunized horse or the serum of a typhoid fever case is added to a watery suspension or the fresh bolliuon culture of motile typhoid bacilli, they lose their motility and aggregate in clumps. This constitutes one of the essential points of diagnosis and therefore we preferred to use the Parke Davis bacillus in most of our experiments.

Q. What relations existed between the strain of typhoid bacillus that you used, and the serum of the immunized horse which you used?

A. It was the homologous germ. It was the germ which had been used for immunizing the horse, and therefore the test was more to be depended upon than if we had used the serum of a typhoid fever patient which had been infected with another strain of typhoid bacillus.

Q. Where did you secure the serum which you used, and how did you get it?

A. We received both the typhoid bacillus with which this horse had been immunized as well as the serum of the immunized horse at the same time from Dr. Larned, the Chicago representative of Parke Davis Co. who had told me that they had an immunized horse whose serum would agglutinate the homologous germ in the dilution of 1 to 50,000, or 1 to
10342 60,000.

We found, however, that it would agglutinate it only in 1 to 1000.

Q. What other strain of typhoid did you use in the experiment, or at Ashland avenue, in the Chicago river?

A. We used a strain received of Prof. Jordan's laboratory, typhoid bacillus "X," which was obtained from the Cook County Hospital from the blood of a patient having typhoid fever.

Q. Will you describe the part of the experiment conducted at Ashland avenue with the celloidin sacs?

A. We would take from 8 to 10 celloidin sacs for one experiment to the Ashland avenue bridge together with suspensions of typhoid bacilli in water, which had been grown on agar in the incubator over night, and would then fill all the sacs by

removing the cotton stopper and placing the sacs under water. We would not entirely fill these. We would pour out some of the sacs and we would then infect them with our suspension, to a number of 500,000 typhoid bacilli per 1 cc and then insert the cotton stopper, place their glass tubes into the burrette clamps, suspended in the water, only the glass tubes
10343 sticking out, and we would remove one sac and take it to the laboratory every day, and proceed in the same manner of plating out and differentiating, as we did with the water specimen of the parchment sacs.

Q. What strains of typhoid fever did you employ in these celloidin sacs?

A. In the celloidin sacs we only used the Parke Davis strain.

Q. In the parchment sac?

A. In the parchment sac we used both strains, the bacillus X of Prof. Jordan and the Parke Davis bacillus.

Q. Were these mixed together in the parchment sac?

A. They were not. We either used the one or the other.

Q. How many parchment sacs did you use at Ashland avenue?

A. Six.

Q. How many celloidin sacs did you use at Ashland avenue?

A. 16 to 20, I should say, because some broke. We took 10. We usually took 10, but some accident would occur once in a while. We intended to have 10, and take one out every day after we knew how long the typhoid bacilli lived at Ashland avenue bridge, by the parchment sac experiment. We took 10 sacs of celloidin for one experiment knowing that we would not find them any longer than ten days, but usually some of
10344 them would break, so that probably we had 16 to 18 sacs in all, suspended.

Q. How would this breakage occur?

A. This breakage would occur by dropping one and breaking the glass upon the stone foundation of the bridge. The whole danger of breaking existing at the time that we put them in, not at the time that we took them out, and if one sac would drop, then why, the glass tube which was very long, was broken. We could not use that tube. It was not the sac that broke. The to use the parchment sacs longer than 10 days. That is also the reason why we used the celloidin sacs only 10 days. Feeling certain that we had examined every colony on the plates in one of the first experiments after typhoid bacilli could not be found any more and that the results were negative after 3 days, we thought that 10 days was all that was necessary to follow up the experiment on an average in future experiments.

Q. Have you stated everything connected with the Ashland avenue experiment, now?

A. No, I have not. We have also made experiments in which we have taken the river water and filtered it through a Pasteur filter and then have plated it out to make certain that no water bacteria had passed through the filter. Such raw, filtered river water we infected with typhoid bacilli and found that typhoid bacilli die in this water also in two days, in 10349 some instances, so that it would appear that there is in the water itself something which destroys typhoid bacilli even if no saprophytes are mixed with typhoid bacilli. The reason I mention this is because in some of my former testimony, I laid particular stress upon the fact that I thought the disappearance of the typhoid bacillus in the experiments reported at that time was principally due to the overgrowth of saprophytic bacteria, whereas, as a result of these experiments, I conclude that there are in this river water certain substances, possibly excreted substances of saprophytes, which alone are sufficient to prevent the growth of the typhoid bacillus and even to destroy it within a very short time.

We have also made experiments in which we inoculated a typhoid bacillus into boiled river water. And in these experiments the bacillus lives longer than it did in the raw but filtered river water. In boiled river water containing no living bacteria, into which we inoculated typhoid bacilli, they would live longer than they would in the unboiled, filtered sterile river water.

10350 Q. How much longer, Professor?

A. Three days longer.

Q. In the boiled filtered water?

A. Yes sir.

Q. How long did they live in the parchment sacs and the celloidin sacs which you employed at Ashland avenue?

A. The longest was three days. There is not so much difference between the presence of saprophytes in the sacs and the effect of raw filtered water on typhoid bacilli.

Q. Did you make any other experiments in conjunction with this experiment?

A. I made, in one instance, an experiment by which I added to the water from a parchment sac, immune serum of this horse, and then collected the preciptate in the form of a conical glass tube and added peptone solution to this precipitate, hoping that if I had escaped any typhoid bacilli by the other method, this way I could enrich the number of typhoid bacilli, if any had been left alive. I tried this several times, always adding again serum of the immune horse in that way, hoping to agglutinate and precipitate the typhoid bacilli of the whole quantity of water used, and in that way obtaining all the typhoid bacilli that were present in the water, and getting it to the bot-
10351 tom, pouring off the rest and adding nutrient material to the residue because it is a fact that immune serum agglutinates typhoid bacilli, but will not kill them. So I thought if I used large quantities of the water I might be enabled to find typhoid bacilli later than in the other experiments, where only small quantities of water are used for plating out. I was entirely unsuccessful here in finding typhoid bacilli probably because these experiments were only made after the other experiments showed the disappearance of typhoid bacilli. I am convinced the method is a good one and will enable us to find typhoid bacilli if they are there, much easier because we can use a larger quantity of water for this test. If we have enough serum, we can agglutinate all the typhoid bacilli and they fall to the bottom and can be grown again on plates because the precipitated clumps of typhoid bacilli are not dead.

I was unsuccessful, after the third day, in the river water, by this method, to find any typhoid bacilli.

10352 Q. Did you employ that method before the third day?

A. I experimented on it before I employed it. I added a very small loop full of bouillon culture to a liter flask of water, and of this liter flask full of water took one loop full and added it to another liter glass full of sterile water, and tried the experiment upon this dilution in the second flask and had no trouble in finding typhoid bacilli.

Q. How many cc in a liter?

A. 1000.

Q. What success did you have in agglutinating the X strain sent to you by Prof. Jordan, with the horse serum?

A. That agglutinated, although not in as great dilutions. The best that we could do was to agglutinate a dilution of 1 to 30 or 1 to 40. We also inoculated a few rabbits with this bacillus, the serum of the animals which lived never agglutinated the same bacillus X, in a greater dilution than 1 to 50, or 1 to 100. Feeling that the Widal test was such an important one in our work for the identification of the typhoid bacillus, we preferred to use the Parke Davis culture mostly.

Q. How did the Parke Davis culture compare in vitality with the X strain? 10353

A. The vitality was just as great if not greater. It was more motile than the bacillus "X." It was a great deal more motile than the bacillus X.

Q. In making this experiment at Ashland Avenue how comprehensive was it as far as the known methods of bacteriology for the determination of typhoid in the water was concerned?

A. I would say that the manner employed here of using a membrane that allowed osmosis of the fluids outside of the sac in the river as well as the excretions of the bacteria multiplying inside of the sac to pass freely in and out, conditions were produced which were as nearly those existing in nature as could be artificially produced. This experiment shed more light upon the true conditions of the longevity of a typhoid bacillus in polluted streams than we have known in the past. The opinions of bacteriologists the world over have varied as to the length of time that a typhoid bacillus would live in lake and river waters and I am satisfied now that this variation in their statements as to its longevity is not due so much to the varying vitality of the typhoid bacillus as to the presence in the water of certain substances which in one case will destroy a typhoid bacillus quicker than in another. 10354 I think that these variations can only be explained by such experiments as we have made. The fact that even in the raw filtered river water, free of all saprophytes typhoid bacilli die rapidly is evidence that there is in this water something which destroys the typhoid bacillus quickly. That effect must vary in different rivers, and such variation is due to the greater or lesser presence of substances excreted by saprophytes which explains the greatly varying statements of different authors.

Q. Professor, will you explain in full the experiments which you conducted with Lake Michigan water?

A. With Lake Michigan water we used parchment sacs and also celloidin sacs. The parchment sacs were filled with Lake Michigan water from a tap at my private laboratory at the Post Graduate Medical School, second floor. The infection of the sacs with typhoid bacillus, first the X bacillus, afterwards the Parke Davis Bacillus, was done exactly in the same manner as those in the Chicago River. The sacs were then suspended in a large earthenware jar by burrette clamps, in the same manner as in the river. The sacs were prepared in exactly the same manner and the water from the tap was, by means of a
10355 large rubber tube, allowed to flow day and night, the tube extending to the bottom of the earthenware jar, and the fluid overflowing the top of the jar, so that at all times fresh tap water was flowing through the jar, on the outside of the sacs. After the sacs were placed, small quantities of water were removed from the sacs daily, after removing the sac and testing it for holes, and then shaking the sac. The mixture from the sac was plated out in agar, using for the agar plates .001, .01, .1, 1, 2, 3, and 5 cc. daily. The colonies that appeared upon this agar in the incubator were inoculated into Hiss media. The number of colonies sometimes was very small and every colony on the plates was inoculated into Hiss media.

During the first four or five days we would usually succeed in picking out a typhoid suspicious colony from one of these plates, which immediately gave a Widal test, so that would be set aside. The longest that we found typhoid bacilli here was for 8 days. At the time when they disappeared on the ninth day we would take every colony on all the plates and inoculate every one into Hiss tubes. This was repeated several times to get all the colonies and pass them all through Hiss meria and
10356 then only those which showed motility in Hiss media and which produced no gas were then passed through the usual culture media and were tested with the immune serum.

The longest that we found typhoid bacilli was 8 days. Sometimes we did not find any after 4 days.

Q. Did you employ the celloidin sacs in this experiment?

A. The celloidin sacs were also used. We used possibly some 30 celloidin sacs with lake water and took one celloidin sac out every day.

Q. When you speak of one experiment with the celloidin sacs does that experiment embrace a series of 10 celloidin sacs that were inoculated to the same degree of infection with typhoid bacillus in which you took one of those sacs each day?

A. In the case of Lake Michigan water the series of sacs usually consisted of 15, in some of these experiments for 15 days, once for 20 days. The 20 days was parchment. When I say 30 sacs with the celloidin experiments I mean 2 complete series
of experiments of 15 sacs each. We made six parchment
10357 sac experiments, but one sac broke in taking it out. So
there are two completed experiments with celloidin sacs and five completed experiments with the parchment sacs.

Q. In the waters of Lake Michigan?

A. In the waters of Lake Michigan—tap water.

Q. Did you make any other experiments in conjunction with this experiment in Lake Michigan?

A. We also here inoculated sterilized Lake Michigan water in sacs with typhoid bacilli, and these lived 10 days longer than in raw filtered lake water. They varied a little.

Q. What other experiments did you make?

A. That is all.

Q. What were the results obtained in the experiment of Lake water that you have detailed?

A. In the lake water the typhoid bacillus lived at the longest 8 days, when mixed with the unsterilized lake water. At times we were unable to find the bacillus after the 4th day.

Q. How near in your opinion does the experiment made by you yourself simulate natural conditions?

A. The conditions are as close to natural conditions as it is possible to make them.

10358 Q. Were the conditions of the experiment which you
[illegible]ve introduced more or less favorable to the longevity of the typhoid bacillus than the natural conditions of the water in which the experiment was made would be?

A. I do not think that there is much difference between the conditions in the sac and the conditions outside.

Q. What reasons have you for supposing that the conditions described in your experiment closely simulate natural conditions.

A. Because the surroundings of the typhoid bacillus in the river are the same as those in the sac, by osmosis of the different fluids, and as I have already stated before the principal cause of the death of the typhoid bacillus in water is evidently the presence of some saprophytic products which are outside of the sac just in as large a quantity as inside of the sac, and if there existed any difference these differences would be quickly equalized by osmosis.

Q. Professor, does this experiment which you have made and introduced furnish you with any basis for an opinion as to the life of the typhoid bacillus in the waters of the Chicago River and Drainage Canal and Illinois River?

A. Yes sir. As a result of the experiments which have
10359 been made by all of us, Professor Jordan, Professor
Russell and myself, I am of the opinion that typhoid bacilli can not live in the drainage canal or in the Chicago River or the Illinois River for more than three days.

Q. What is your opinion, based upon all the knowledge which you possess in regard to this experiment, and other experiments made by you, as to whether the typhoid bacilli coming from the sewers of Chicago and entering the drainage canal and from thence into the Illinois River could survive the journey from Chicago to St. Louis, a distance of 357 miles, and be a danger and a menace to the inhabitants of St. Louis using the waters of the Mississippi River at the St. Louis intake, or the residents of Missouri using the waters of the Mississippi River, as it passes along the eastern shore of the State of Missouri, for domestic and drinking purposes?

A. It is my opinion that it offers absolutely no danger to the citizens of St. Louis and that no typhoid bacillus coming from the sewers of Chicago will live to reach there.

Adjourned until 10:00 A. M., Tuesday, February 16, 1904.

10360 10:00 A. M., Tuesday, February 16, 1904. Continuation pursuant to adjournment. Present the Commissioner and same counsel representing the respective parties.

DR. EDWIN C. ROSENOW,

a witness called in behalf of the defendant, having first been duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION by Mr. Todd.

Q. What is you name?

A. Edwin C. Rosenow.

Q. Of what college are you a graduate?

A. Rush Medical College.

Q. When did you graduate from Rush?

A. 1902.

Q. Where do you live, Doctor?

A. Presbyterian Hospital, Chicago.

Q. What business are you in at present?

A. I am an interne at the Presbyterian Hospital.

Q. Before becoming connected with the Presbyterian Hospital were you connected with any other hospital?

A. Why, in a way, I was only secondarily connected, as 10361 Fellow at Rush Medical College in pathology.

Q. Professor Jordan has testified in this case to having received three strains of the bacillus typhosus from you, to be used in the experiments which he made on the life of that organism in the drainage canal. When did you give him those typhoid bacilli?

A. Why, I don't remember the exact date. I have notes that would give the exact date.

Q. About when?

A. Some time last September.

Q. Where did you get them from?

A. I got them from three cases of typhoid fever in the Cook County Hospital.

Q. Did you give to Professor Jordan a clinical diagnosis of the patients from whom these germs were taken?

A. You mean the diagnosis or history?

Q. Yes sir?

A. Why, I copied the history of these three cases of undoubted typhoid fever and handed them to Mr. Irons, who in turn was to hand them to Professor Jordan.

Q. You have heard read the diagnosis of the three patients from whom typhoid bacilli were taken by yourself 10362 and handed to Mr. Irons and Professor Jordan, as testified to by Professor Jordan in his testimony in this case. Are you the doctor who collected these samples?

A. Yes sir.

Q. Are the statements that I have read to you from Professor Jordan's testimony as to the clinical history and diagnosis of these cases the correct history and diagnosis that you gave to Professor Jordan with the samples that you collected?

A. Yes sir.

Q. Doctor, state how these samples were collected from these three patients?

A. Why, the blood of the first patient was collected as given in there, from the medium bacillic vein of the arm with a glass syringe, in a sterile manner. The blood was then used to inoculate the various media from which the typhoid bacillus was isoluated in pure culture. The urine from the second case was collected in a sterile bottle of about the size of 10 ounces. That urine was taken to the laboratory by myself and the various inoculations made from which the typhoid bacillus was isolated and the feces were collected from a sterile bed pan, into a sterile test tube, and also taken to the laboratory and 10363 the inoculations made at once.

Q. And after the typhoid bacillus was separated from these three patients, what did you do with the typhoid bacillus?

A. After proving and testing it every way as being typhoid bacillus, I handed them to Professor Irons.

NO CROSS-EXAMINATION.

Signature waived. F. S. B. Com'r.

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PROF. F. R. ZEIT

resumed the stand for further re-direct examination by Mr. Todd, and testified as follows:

Q. Professor, upon examining your testimony that was given yesterday, I find that you did not state the size of these parchment sacs or celloidin sacs that you employed in this experiment. Will you please state how large they were?

A. The parchment sac was of a size to contain 1000 cc of water. The celloidin sac was of a size to contain 30 cc. of water. The measurements of a parchemnt sac were 24 inches by 3 inches. The size of the celloidin sac is about 3 inches by 1 inch.

Q. Professor, as an expert in bacteriology and clinician, availing yourself of all bacterial knowledge which you possess based upon this experiment, as well as knowledge obtained from other sources, what is your opinion as to whether a typhoid bacillus, lying in the sediment of a polluted stream such as the Illinois River, for a period in excess of 60 days would be able to cause typhoid fever when taken into the human system after it had remained in such sediment for that length of time?

A. It is my opinion that after that length of time there would be no typhoid bacilli present any more. The conditions existing in material on the bottom of rivers and lakes 10365 by sedimentation must contain organic material and saprophytic bacteria which again would produce substances that would destroy the typhoid bacillus if it was present in just as quick a manner as they do in the river or lake water. In fact I should think that being so much closer in contact with the saprophytic bacteria in the presence of organic material that the quantity of these poisonous substances produced by saprophytes would be even greater and cause typhoid bacilli to die at least as quick if not quicker under these conditions than in flowing water.

Q. What is your opinion as a bacteriologist and pathologist as to whether typhoid bacilli coming from the sewers of Chicago, through the drainage canal, deposited on the bottom of the Desplaines and Illinois Rivers between Chicago and Peoria can remain there for a period of 30 to 60 days and yet retain their dangerous qualities as well as their pathogenesis?

A. By what I have learned from the experiments that we have made, that is impossible. Typhoid bacilli die under those conditions in three days.

Q. From your personal knowledge of the Illinois River 10366 and your knowledge as a bacteriologist and pathologist, together with all bacterial knowledge which you possess, derived from every source, what is your opinion as to whether the sewage from the City of Chicago, passing through the drainage canal into the Illinois River at different seasons of the year and at different stages of water in the Illinois River, would be a danger and a menace to the inhabitants of the State of Missouri using the waters of the Mississippi River for drinking and domestic purposes, and to the citizens of the City of St. Louis in particular using the water of the Mississippi River at the intake tower at the chain of rocks for drinking and domestic purposes?

A. It is my opinion that they would never reach the intake of St. Louis alive, because it has been proven by our experiments that they die in three days or less in the water of the drainage canal and the Illinois River, so that they could never reach the lower course of the Illinois River even.

Q. What is your opinion as a bateriologist, based upon your examinations of the waters of the Illinois, Mississippi and Missouri Rivers as to which one of these three rivers disclose the least amount of impurity of pollution?

10367 A. The Illinois River, bacterially speaking, was less polluted during my investigations than either the Missouri or Mississippi. During all of my examinations in the past that has been the case.

Q. If the Illinois River discloses from such examinations made by you the least amount of impurity, what would be the effect of the waters of the Illinois River emptying into the Mississippi River at Grafton and subsequently uniting with the Missouri River at its mouth, upon the united waters of the Mississippi and Missouri Rivers at the intake tower of the chain of rocks?

A. As the Illinois River is bacterially purer than the Mississippi River it could only improve conditions by dilution.

Q. Does the mixture of the Illinois with the Mississippi and Missouri Rivers, as indicated in the foregoing question, create any added danger to the already polluted and contaminated waters of the Missouri and Mississippi River below Grafton?

A. It does not, in my opinion. The very reverse would be true, according to my former answer.

Q. Do you consider the sewage of Chicago emptying into

the drainage canal and the Illinois River, which in turn empties into the Mississippi River, a menace and a danger to the inhabitants of the State of Missouri, using the waters of the
10368 Mississippi River for drinking and domestic purposes and to the citizens of the City of St. Louis taking their water supply from the intake tower at the chain of rocks, from the Mississippi River?

A. I do not for the reasons stated in my former examinations, in which I stated that the Illinois River at Averyville was purer, bacterially, than any part of its course from Chicago to Grafton, and that I considered that absolute purification from saprophytic as well as pathogenic bacteria had taken place above Averyville.

Q. Taking into consideration all the knowledge which you possess in regard to the bacterial and physical conditions of the waters of the Illinois River and its tributaries and the river itself, the different towns sewering into the Illinois River and its tributaries, the population upon the watershed of the Illinois River, both rural and urban, the stages of the river under all conditions, during all seasons, what is your opinion as to the effect of flowing the sewage from Chicago through the drainage canal into the Desplaines and Illinois River, upon the inhabitants of the State of Missouri, using the water of the Mississippi River for drinking and domestic purposes?

10369 A. The contamination produced by the sewage of Chicago would be all practically removed before it reaches Averyville, according to my investigations and answers in this case, in which I have expressed these convictions at some length. I am speaking now, of course, of bacterial purification and not of chemical substances, but I should judge that also chemical purification has taken place so as to convert dangerous organic compounds into non-dangerous ones, as soon as saprophytic life has again decreased and thereby shows that the end products of organic material have been produced by saprophytic multiplication, and I therefore can not consider this a danger or a menace to the citizens of St. Louis or the citizens of Missouri using the water for drinking and domestic purposes.

CROSS-EXAMINATION

By Mr. Corum.

Q. Professor, your experiments consisted in placing these sacks, the parchment and celloidin sacks in the waters of the drainage canal and in the waters of the lake?

10370 A. Yes sir, in the case of lake water we used tap water which was kept flowing continually. The other experiments were made in the Chicago River.

Q. That tap water came from the lake?

A. Yes.

Q. And you did not place any of these sacks in the Illinois River?

A. I did not.

Q. Or in the Mississippi River?

A. I did not.

Q. The only two waters in which these sacks were placed by you were the waters of the canal and the waters of the lake?

A. No sir, in the water of the Chicago River just where the drainage canal begins at Ashland Avenue Bridge. That is still the Chicago River.

Q. How many sacks did you place in there near the Ashland Bridge?

A. Celloidin sacks?

Q. The celloidin sacks first?

A. We placed 6 parchment sacks in the river, and we placed between 16 and 20 celloidin sacks in the river.

Q. Now, who removed these parchment sacks from the river?

A. Dr. Bassett.

10371 Q. How soon after having placed them in there did he remove the first one?

A. 24 hours.

Q. Do you know what course he pursued in removing the sacs?

A. He would loosen the burette clamp, take hold of the glass tube at the top of the parchment sack, lift it out, examine it for leaks after holding it a while, then shaking it and then replacing it. After removing the cotton stopper, he took out, by means of a sterile pipette a quantity of water, placed it in a sterile flask that he had brought with him, replaced the cotton stopper, and brought it immediately to the laboratory and plated it out.

Q. Then he put this same sac back into the box again?

A. Immediately after he had inspected it and had shaken it, it was placed back.

Q. Did he take any further samples from that sac?

A. He took one sample each day from every sac?

Q. From each sac?

A. Yes sir, these sacs were not all put in at the same
10372 time. The celloidin sac experiments followed the parchment.

Q. We are talking about the parchment sac. During the examination of these samples which were removed from the parchment sacs on the first day you found some typhoid germs?

A. Yes sir.

Q. In each sample?

A. The first day we found always typhoid bacilli in the sacs.

Q. Did you examine each of the sacs?

A. In every sac we found them.

Q. On the second day did you find typhoid germs?

A. On the second day we sometimes found the germs and sometimes not. On the third day the same, we found sometimes germs and sometimes not. After the third day we were never able to find any more.

Q. On the first day did you find the germ in considerable amounts?

A. Yes sir, in large numbers.

Q. Have you any means of comparing the number that
1073 you found on the first day with the number that were in the sacs at the time you placed them there?

A. Yes sir.

Q. How was that comparison?

A. Dr. Bassett will be on the stand this afternoon and he has all the counts of every sac, and how many colonies there were. I am not reciting from memory and I should judge that there were about 500,000 of typhoid bacilli to the cc. of river water in the sac, that is every cc. contained a half a million typhoid bacilli, therefore we had no trobule in finding them the first day. When the sacs were seeded very lightly, that is much less than a half a million, we would occasionally find them gone the second day. I am speaking now of heavy seedings in all these experiments, because we found that that was necessary to judge as to when they were really gone.

Q. Suppose that in a certain sac that you found on an examination the second day that there were no typhoid germs in it? Then you examined that sac for the third day and found typhoid germs in it---how do you account for that?

A. That has never happened.

10374 Q. Did it not happen in one of your examinations that in an examination of the samples that were taken from a certain sac on a certain day you did not find any typhoid germs and afterwards, on the following day, or some day following that you would examine the same sac and find typhoid germs in it?

A. That has happened in none of our experiments, simply because when we thought that all typhoid bacilli were gone we would go back to that plate and go over it so thoroughly that we could usually say that we have examined every colony that had grown. We would sometimes find typhoid bacilli on the second day in a plate after we had been unsuccessful in the first attempt not having examined enough colonies. We can say that in no instance did we find typhoid bacilli after a day on which we found none, in our experiments. That holds good for all of them.

Q. After a day when you had examined to see whether there were any typhoid germs, would you take any samples after that?

A. We would take samples for ten days and more in some of the first experiments.

Q. And in no instance did you succeed in finding any germ?

A. In no instance. In the first experiment that we made 10375 we examined the contents of our parchment sac, the first sac that we used, for twenty days. That is when we were getting acquainted with the conditions necessary for the experiment and in that sac also typhoid bacilli had been seeded very heavily, over 1,000,000 per cc. They could only be found for three days. After the third day the whole character of the plate changed suddenly. For three days in succession we would have plates with numerous typhoid colonies, in this first sac, seeded very heavily with typhoid bacilli, and after the third day it was just as though normal water had been plated out. An entire change of the whole character of all the plates took place,

Q. Please state the reason for using the different kind of sacs?

A. The celloidin sacs, we felt, were safer to use. They had proven reliable in bacteriological animal experiments, in which for instance, we would take tetanus bacilli into a celloidin sac, close the sac and place it in the abdomen of an animal. The
animal would die of tetanus, although the bacteria re-
10376 mained in the sac. The bacilli would grow in the sac and
at no time in our laboratory experiments have we ever seen bacteria pass out of the sacs, but only toxic excretions of bacteria would pass out and produce convulsions. In that way we had in the past studied the effect of toxins removing from the experiment the effect that the germ itself might have, and it was principally due to the success of this method, that we used it also here with the water to allow osmosis.

Q. Why did you not use it exclusively?

A. The parchment sac was larger and we could make one sac do for a great many experiments. Cellodin sacs we could use only in smaller sizes, although we made them 20 times as large as they are usually made for animal experiments, by having these big verterinary gelatine capsules. We had to use 8 to 10 of these for one experiment, in the river removing one sac each day, because we could not very easily take water from these celloidin sacs. Now, in the laboratory experiments with lake tap water we did use some of the celloidin sacs several days because we were under less difficulties in removing portions of water from the delicate little sac, but in the river we found it was necessary to always take the complete sac home.

10377 Q. In the lake water I understand that at the expiration of ten days or eight days---

A. In the lake water the first experiment, both with lake water and with river water was 20 days and after that, when we found that bacteria died so much earlier, we would run the experiment 10 days and sometimes 15 days, but always ten days taking cultures every day.

Q. And how long did you find that the typhoid germ survived in the lake water?

A. In the lake water the longest time we found them was eight days. One time we thought we had found them on the ninth day, but further examination proved that this was wrong.

Q. Professor, you stated yesterday that you had found the typhoid germ to survive in boiled river water for the space of three days?

A. In boiled river water? You mean in filtered river water.

Q. I understood you to say boiled and also filtered?

A. No sir. In filtered river water I stated the germs live 2 days only, that is filtered through a Pasteur filter.

Q. How many days?

A. Two days. 2 days is the longest that they live in filtered river water. We have done that numerous times now and
some of the experiments in fact were finished yesterday
10378 and we know that the filtered river water as it exists now
will kill typhoid bacilli in two days, river water containing no bacteria whatever.

Q. I want you to explain the reason for the different length of life of the typhoid bacilli in boiled river water and in filtered river water?

A. Having proven that filtered river water, free of all germs, kills typhoid bacilli within two days, and also knowing that the boiling of such river water allows the same bacilli to live a longer time I conclude that by boiling you destroy certaind poisonous saprophytic products present in the water and that, therefore, in boiled river water the typhoid bacilli will live somewhat longer than they would in filtered river water. Under the same conditions in lake water typhoid bacilli will live eight days in the filtered lake water, and have lived fifteen
to eighteen days in the boiled lake water.

10379 Q. What property is taken from the water by the process of boiling that tends to add to the longevity of a typhoid bacillus?

A. I take it that the saprophytic products that destroy the typhoid bacilli are destroyed by boiling and that therefore the typhoid bacillus which enters boiled water can live longer than in water that has only been filtered, because the saprophytic products filter through the filter.

Q. Now Professor, are these saprophytic products to be found in the waters of the drainage canal?

A. They are.

Q. And in the waters of the Illinois?

A. And in the waters of the Illinois.

Q. Are they to be found in all waters?

A. They are to be found in all waters in which there is any pollution whatever. As soon as the water receives any organic material, such as sewage or other material, saprophytes begin to multiply in the organic material and produce these saprophytic products which are harmful to the disease producing bacteria.

Q. Is there any way of removing these saprophytic products other than by boiling?

10380 A. There is not so far as I know.

Q. Is it eliminated by the running of the stream?

A. I do not think that it is eliminated by the running of the stream, it is simply diluted.

Q. By the addition of other waters?

A. Yes sir.

Q. And if the other waters are infected by the same product why of course there would be no betterment of conditions?

A. If the other streams are polluted with the same material the same saprophytic products are produced which are again harmful to disease producing bacteria. The reason of the saprophytes multiplying more in water than the disease producing bacteria is because the temperature of the water is more favorable to the multiplication of saprophytes than it is to the multiplication of parasites, therefore pathogenic or disease producing bacteria can not multiply in lake or river water. They are not destroyed, if the lake or river water was pure and free of all polluting organic material and therefore free or practically free of saprophytic life. As soon, however, as there is any pollution whatever with organic material you have an increase of saprophytes and an increase of saprophytic products and then the few disease producing bacteria that are
10381 present, and that were unable to multiply, are now destroyed by the saprophytic products. I originally thought that this effect of the disappearance of the typhoid bacteria was really due more to the over growth of saprophytes, making the

conditions of life for typhoid bacilli unfavorable, than to the saprophytic products which are diffused through the water, but I have convinced myself now by these filtering experiments, that there is in the river water sufficient of these saprophytic products present to destroy disease producing bacteria.

Q. Now, Professor, if the boiling of the water destroys the saprophytic products, why is it that a germ will not live indefinitely when placed in water having been boiled?

A. Because some of the saprophytic products are not destroyed by boiling. What I call saprophytic products are substances of a very complicated nature of which we know very little in chemistry or bacteriology. We do not know today even the chemical composition of the diphtheria toxin or antitoxin, and similar products. We know but very little of the chemistry of these products. They are no doubt very complex and very numerous, innumerable. Some are more affected 10382 by heat, some are less. But we can not conclude that all those which are poisonous are destroyed by heat because we know that that is not true. Some of the poisonous products are not destroyed by heat although most of them are.

Q. Now, in making your investigation as to the longevity of the typhoid germ in this boiled water you found sometimes that they lived three days and from that to fifteen days?

A. In boiled water in Lake Michigan they lived as long as 15 to 18 days.

Q. Now, did you make some experiments in which you failed to find any prior to the expiration of 15 days?

A. In boiled lake water we have always found them for 15 days and even more. That is we found them for 15 days and then did not always examine any further. Now, such is not the case in the river. In the river, while they also lived longer in boiled than in filtered water, they disappear sooner so that there must be present in the river water certain substances that are injurious to the typhoid bacillus which are not destroyed by boiling, although river water is not as deadly to the typhoid bacillus when boiled, as when it is only filtered.

Q. Do bacteria living but not multiplying in water produce these saprophytic products?

10383 A. They do not. Saprophytes are non-disease producing bacteria, they do not produce infection, whereas disease producing bacteria are parasites and produce infections. The saprophyte is a germ that lives on dead organic matter. Disease producing germs are germs that live on living organic matter.

Q. Do bacteria, living but not multiplying in water, produce any product?

A. I should judge not. The products of the germ are due to the multiplication of the germ. When the germ finds food and multiplies in a favorable temperature then it also produces excretion products. If, therefore, no multiplication takes place, the food conditions are unfavorable and the temperature conditions are unfavorable, and if it does not multiply it will not produce these excretion products. To illustrate: If you inoculate a nutrient bouillon tube with the diphtheria bacillus and you place that tube in the ice box where the bacillus can not multiply, it will not produce diphtheria toxin in the tube. It will only produce diphtheria toxin if you place it at blood temperature where the bacillus multiplies and uses up organic material in the bouillon and when it multiplies it produces excretion
10384 products which are so poisonous that 1-100 of a cc. can kill an average size guinea pig in 15 minutes. Now, if you prevent that multiplication by lack of food or low temperatures there will be no poinsons in the tube, so I should answer your question by saying that they will not produce such poisonous products when they do not multiply.

Q. You say that the only object of using these parchment and celloidin sacs was to allow osmosis so that excretions would be removed?

A. Yes sir, the excretions of the saprophytes in the sac could be removed. Objections were made to some of my previous experiments in which I had filled liter flasks of the water of the lake or the water of the Illinois River or the Mississippi River or the Missouri River and then infected them with typhoid bacilli and then determined how long typhoid bacilli would live in those bottles. It was stated that in my bottles the saprophytes could multiply more rapidly than the typhoid bacilli and therefore the products of the former would remain in my bottles and kill the typhoid bacilli. I have admitted that to be possible, and that is one of the reasons why we made these experiments so as to exclude and overcome the objection raised by Mr. Jeffries.

10385 Q. Would the toxin products or other bacteria excretions pass through these sacs?

A. Just as well. The toxic products in the sac could pass out and the toxic and other excretion products of the bacteria outside of the sac in the river could pass in, so that there ought to be a fairly free interchange of different bacterial products through the wall of the sac in and out. By osmosis the conditions would eventually become the same in regard to the quality of the bacterial products present outside as well as inside of the sac.

Q. Would the dissolved oxygen of the river or other water used pass through the sac?

A. That would.

Q. Now, in reference to the length of life or longevity of these typhoid germs, Professor Jordan, I think, multiplied the length of life by two in order to be certain and I think probably by three. Now, Professor, as a precautionary measure what do you say about that?

A. I have here given purely the results of my experiments. In those experiments we were careful to take up every colony shown on some of those plates so that I know typhoid bacilli were not there any more. Further, in some of the waters
10386 in which the typhoid bacillus had disappeared after the third and fourth day we would employ the method which I described yesterday of agglutinating and precipitating typhoid bacilli from a large quantity of water—we usually used 50 cc. of water. We would add to that the immune serum, clumping the typhoid bacilli that were present in the water, and then we would take the sediment from this quantity due to the clumping of any typhoid bacilli, if there were any, and plate those out. Now, it has been shown by that method which is one of the most recent ones, that you can detect the typhoid bacilli if there was one part of typhoid bacilli to many thousand million parts of water. It was this method which I quoted yesterday as having experimented with, to first see if I could find them that way. By this method I was unable to find them on the fourth day. I think I may say that the bacilli were not present in that water. Now,

I see no reason why I should extend the time and say that they may be present so much longer or that certain very resistant forms of bacteria might be there so much longer. I simply want to apply the results of the experiment and say that they could be found so long at the longest. Now, sometimes I have found them to live a shorter time for one day. I have stated the longest time for which we were able to find them with the most exhaustive work in detecting them. If we were to
10387 judge that certain resistant forms could live very much
longer then the value of these experiments would be doubtful. If this was simply a matter of speculation as to whether they might not live twice as long or three times as long as the experiment, it might be argued also that they could live ten times as long. I think I want to strictly confine myself to the actual findings that I have given here and say that they live that long and that I know by the experiment on the filtered water of the river that they die in two days or less and in non-filtered river water in three days or less.

Q. Professor, would not the length of the life of these germs depend sometimes upon their virulence and the strength of the particular germ?

A. Some germs are slightly more resistant than others, but we had a very motile and very resistant germ.

Q. To which one do you refer now, strain X or B?

A. The strain "O," the Parke Davis strain, which was used in the immunization of a horse for the purposes of prospective serum treatment of typhoid fever patients.

Q. Was not that a somewhat unreasonable thing, Professor?

A. What?

Q. The treatment of a horse?

10388 A. It was not unusual. Parke Davis & Co. are trying
to produce immune serums for the treatment of infectious diseases, and in doing so they must experiment with many different cultures to obtain the highest immunizing value of the serum in the horse, and they would naturally confine their experiments to one germ that had proven the most efficient, the most virulent germ. That is the one they must use. For their diphtheria anti-toxin, they must immunize horses. They have

to raise the virulence and vitality of the diphtheria bacillus to such a point that the poisons produced by this germ will kill an animal in the dose of .01 cc. The virulence and vitality of the germ is usually increased by passing it through a series of animals, and a horse is then immunized by repeated injections of these filtered poisons. Afterwards the blood serum of the immunized horse is used as anti-toxin for the treatment of patients. In the case of their typhoid bacillus, the high agglutination power of the horse's serum speaks best for the activity and virulence of the typhoid bacillus used in our experiments.

Q. This was the first horse that was ever immunized with typhoid germs within your knowledge, was it not?

A. I do not know how many horses they are immunizing, but this is not the first one.

Q. Do you know of others?

A. Dr. Larned tells me they had numerous horses that are injected continually with all kinds of disease producing 10389 bacteria or toxins.

Q. Now, Doctor, this strain taken from the horse is manifestly different from the strain that would be taken from the typhoid fever patient?

A. All typhoid bacilli come from human cases, not from the horse. We have also used one strain that came directly from the blood of the typhoid fever patient, bacillus X received from Prof. Jordan. Of the horse we used only its serum. The bacillus was used for injecting the horse and producing an agglutinating serum.

Q. Now, there was a difference in those strains, was there not?

A. There was no difference in the results of the experiments between the two germs.

Q. Then in your opinion there was no difference between these two strains?

A. There was no difference in those two strains as far as I could see except in the Parke Davis strain we had, besides the bacillus, the serum of a horse which had been highly immunized with it. That made it so much easier for us to discover the typhoid bacillus in the plates when it was present.

Q. Doctor, did those sacs that you placed in the water become coated with any sort of material?

A. After ten days they had become quite coated and we 10390 found in the first experiment that the sac lasted about two weeks.

Q. After how many days did you say?

A. Ten days.

Q. So that the first you noticed of this coat being formed was after the expiration of about ten days?

A. The coat began to form already after a few days, but it was not very noticeable until five or six days and by ten days the coat was quite thick.

Q. What effect did this have upon the osmotic products of the sac?

A. The osmosis must have been slightly less than it was when the sac was fresh.

Q. Do you not think this coating began to form about the third day?

A. The coating was not noticeable until the third, or fourth or fifth day. It was insignificant the first days and was certainly such as not to prevent osmosis for a week, in the least. This slimy coat does not prevent osmosis. It may make it slightly slower but it can not prevent it. The only objection to the slimy coat was that after two weeks it would produce leaks in the sac and thus spoil the whole sac by that time.

Q. Did you find this same coating in the lake water experiments?

10391 A. In the lake water experiments it was much less although some coat formed also.

Q. Did you find it where you had boiled the water?

A. In boiled water, how do you mean?

Q. Well, after you had boiled this water and put it in these sacs did you find this coating on the sac?

A. We only kept that in bottles for a few days. In the lake water in ten days there is no appreciable coat on parchment sacs. If you keep it for two weeks or twenty days in the river the sac rots. If in the lake water it probably takes three weeks or maybe four weeks for the sac to become deficient by rotting.

Q. Now, you used the agar plates, I believe?

A. Entirely, from the first plating out.

Q. Now, did they show these colonies as clearly as the Hiss medium?

A. That is all a matter of experience. I have been able to detect large numbers of typhoid colonies on the agar plates in the heavily seeded sacs after three days. After three days the whole character of the plate was usually changed, sometimes after two days, and then if we did not find any more typhoid like colonies we would take off every colony on the plates and transfer it to Hiss medium. Every one of the plates from the river where we used 0.001 cc. of water, and in the case of
10392 lake water the plate to which 1-2 cc of water was used,
we found we could get plates with a few hundred colonies only. We would thus inoculate from one plate some 300 colonies, that is, all the colonies on the plate, into the Hiss media. None of these proved to be typhoid bacilli so that I could quite safely say that in that whole plate there was not one typhoid bacillus and this water had been stirred and mixed.

Q. Professor, I think you testified that in one experiment that a typhoid germ lived in lake water eight days and in another experiment a germ lived four days. Now, might not still another germ live for a longer period of time?

A. That depended upon the seeding. If the seeding was very heavy we would find them a little bit longer. If the seeding was light they would disappear in a shorter time. The same holds true also in the river when I gave three days as the longest time we found them in the river. I meant there the heaviest seeding that we used, that is over a million typhoid bacilli to every cc. of water in the sac.

Q. Does not the longevity of the germ depend upon its
10393 strength or virulence.

A. That is one factor.

Q. Then the life or the length of the life of the germ depends upon the hardness of the germ itself?

A. That is only one factor. The more important factors are the surrounding, temperature and food conditions and competitive other saprophytic bacteria present.

Q. What time of the year was it that you made these tests, Professor?

A. October, November, December and January.

Q. Suppose the tests had been made during the hot summer months?

A. I am quite certain that if these tests had been made in the hot summer months that we would have found them to die sooner yet than what we state here, because the saprophytic multiplication in the summer must be a great deal more pronounced than it is during the time of our experiment.

Q. But you made no experiments during the summer months?

A. We did not.

Q. What is osmosis?

A. By osmosis we mean the interchanging of material between fluids on two sides of an animal membrane, until
10394 the contents of crystalloids in the fluid on one side of the
animal membrane is the same as the contents of crystalloids on the other side of the animal membrane, and the equalization of the specific gravity of the fluids on both sides of the animal membrane. Now, to illustrate that still further: If on one side of the animal membrane we have a salt solution of a specific gravity we will say of 1040 and on the other side of the animal membrane we have a salt solution of a specific gravity of 1002, then osmotic pressure causes a passage of the solids through this membrane from the one of higher specific gravity to the lower until the two are equal. That is osmosis. In other words if there is an animal membrane between two fluids of different specific gravities, osmotic pressure is brought about in the direction from the higher to the lower, until the specific gravity of both fluids on both sides of the membrane is the same, and therefore if in our sacs the specific gravity produced by the multiplying of the saprophytes, resulting in excretions, which in my bottles might have destroyed the typhoid bacilli, but which here produce a greater specific gravity than existing in the water outside of the sac, then these increased saprophytic products would pass out through the parchment membrane sac
which acts just the same as an animal membrane, until
10395 the specific gravity outside of the sac were the same as
the specific gravity inside the sac and vice versa if the specific gravity of the contents of the sac was lower than that existing in the outside water, then the crystalizable substances, the so called crystalloids, of which nature are the saprophytic

or disease producing bacterial products, would pass into the sac until the specific gravity of the fluids on both sides were the same. Whenever the specific gravity of fluids separated by such membranes varies, osomotic pressure is set up from the fluid of the higher specific gravity towards that of the lower until the two are equalized.

F. ROBERT ZEIT.

ADJOURNED UNTIL 2:00 P. M., SAME DAY.

10396 2:00 p. m., Tuesday, February 16, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

DR. VICTOR H. BASSETT,

a witness called on behalf of the defendants, first having been duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION, by Mr. Todd.

Q. What is your name?

A. Victor H. Bassett.

Q. Where were you graduated?

A. I graduated from Knox in 1896, from Knox College at Galesburg, Illinois.

Q. After graduation what did you do?

A. I took up a scientific work in the University of Wisconsin, beginning in 1896.

Q. How long were you there?

10397 A. I was there until the fall of 1899.

Q. Who were you under in the University of Wisconsin?

A. I went there in the spring of 1896. For the first two years I was assistant in chemistry under Dr. Daniels, and the following year I became assistant to Dr. Russell and remained with him one year.

Q. After leaving the University of Wisconsin where did you go?

A. I went to Johns Hopkins Medical School.

Q. At Baltimore?

A. Yes, sir.

Q. How long were you there?

A. Four years.

Q. While there what did you do?

A. I took the medical course and acted as an asistant at the same time.

Q. Assistant under whom?

A. I was assistant under Dr. Harris, in Dr. Welch's Pathological Laboratory, specifically in the place of what they call a student assistant.

Q. And did you do anything else in Baltimore except that?

A. During the last two years that I was there, during the summer season, I acted as bacteriologist to the Thomas Wilson Sanitarium where children who have summer diarrhoea are cared for.

10398 Q. After leaving there, what did you do?

A. Following my graduation in June I spent another summer at the sanitarium and on the first of October became an assistant to Professor Zeit of the Northwestern.

Q. Northwestern, what?

A. In the Medical College of the Northwestern University.

Q. Did you assist Professor Zeit in the experiment which he made upon the waters of the Chicago river and Lake Michigan, testing the longevity of the typhoid bacillus?

A. Yes, I did.

Q. What part of the experiment did you conduct?

A. I did what might be called the more active part of preparation and gathering of samples and then together we sought for the organism in the water samples gathered.

Q. Will you explain what you mean by preparation?

A. Well, it was necessary to prepare media, prepare sterile glass ware, to have cultures of the organism to be studied, to seed the waters studied, and place the preparations in the river and in the lake water, and collect the samples.

Q. What means were employed to make this experiment?

A. It was designed by means of placing suspensions of 10399 the typhoid bacillus in river water and in lake water, closed in parchment sacs and in celloidin sacs, suspended in river and lake water respectively, to subject them to the conditions which existed in the river and lake.

Q. At what points were those experiments conducted?

A. The examinations of the river water. The samples of the river water were taken from the Chicago river at the Ashland Avenue bridge. The lake water specimens were specimens of tap water taken in Dr. Zeit's laboratory, in the Post Graduate Hospital.

Q. How many sacs of parchment and how many sacs of celloidin were used in this experiment at Ashland Avenue?

A. I used five parchment sacs for the typhoid organism and one for the dysentry organism. I used one set of celloidin sacs in the river and one set of celloidin sacs for typhoid and one set for dysentery in lake water.

Q. What do you mean by one set?

A. Well, the celloidin sacs were made quite small. It is not easy to make them so large as the parchment sacs, so
10400 that in place of conducting the experiment by taking samples from the sacs, I prepared a number of sacs and subjected them to the same conditions and took one daily as a sample. In the lake water it was possible to take a small portion of the water from one of the celloidin sacs, on account of convenience of working in the laboratory.

Q. How were these sacs tested after being prepared?

A. They were tested first for their integrity, that is for the presence of holes. I did this by blowing them up, that is testing them as one does a bicycle tire by putting air pressure into them and placing them under water, I found that if there was only a minute hole that the escape of air would show its presence. I further tested them by determining whether substances which could not pass through parchment membranes by osmosis would be found in water outside the sac when the sac was suspended and filled with such substances. For this I used egg albumen in water solution. I filled the sac and left it suspended in water 24 hours to 48 hours and then tested the water outside the sac for albumen. In some cases I found albumen, in which case I found holes in the sac and discarded them, and when I did not find albumen and when they did not show
10401 the presence of holes by this air pressure test, I considered that they were intact. The celloidin sacs I tested in the same way. I also tested their osmotic property by placing in them solutions of salts which I might say would pass through permeable membranes, and I found these were

permeable to salts such as sulphate of magnesia. That shows that such substances can pass from them through them, even when there are no holes, and that osmosis could occur readily.

Q. After the sacs were prepared and taken to Ashland Avenue bridge, who placed them in the water?

A. I did.

Q. Just describe the method that you pursued in placing them in the water?

A. I had prepared the box about 3 feet long at first, and I lengthened it a little. The lower 2 feet of the box on each side was covered with a coarse netting, with a mesh about 3-8 of an inch, I judge. Inside the box was a shelf on which there was a series of clamps in which the glass tube in the top part of the parchment sacs could be clamped. The upper part of the box was outside the water, and the lower part underneath the water about 2 or 3 feet.. This box was fastened to the pier of
10402 the Ashland Avenue bridge, about 30 feet out in the river, where the water was said to be about 20 feet deep.
The celloidin sacs I placed in a box which I floated in the river, attaching them to a shelf. I tied them to little pegs.

Q. How were these sacs infected?

A. I prepared 24 hour cultures on agar of the typhoid organisms to be tested and then made suspensions in the first place in the water itself, infecting directly (or suspending the typhoid organisms in salt solution, which I then added to the water). In the earlier experiments I added to the water direct a certain amount of the agar culture of the typhoid organisms, that is of the growth upon the agar. The later samples I infected by preparing suspensions in 100 cc. of sterile salt solutions, and added varying portions of this to the sacs containing the water.

Q. Confining yourself first to the parchment sacs, how many typhoid bacilli were placed in these sacs?

A. In the first series of three sacs I infected heavily. Two of them I infected with about one and one-half million organisms per cc. The third sac I infected exceeding two million
10403 per cc. The water at this time that I used contained about 200,000 organisms per cc.

Q. In doing this work you were acting under instructions from Professor Zeit?

A. Yes, sir, we decided upon the plan of work.

Q. Now, after these sacs were placed in the water who collected the samples?

A. I collected the samples myself.

Q. What method did you employ in the collection of these samples?

A. In making the earlier collections I unlocked the box in which they were placed and carefully took the sacs out, shaking them up somewhat, by tipping them back and forth and then by means of the sterile pipette I withdrew about an ounce of water and let that run in the sterile bottle and carried it to the laboratory.

Q. Before taking the samples out of the sac what was done to the sac, if anything?

A. Well, I first observed the sac to see whether it was intact and then took the end of it and tipped it back and forth, shaking the water to get an even seeding, and usually also
10404 assisted the shaking of the water by drawing up some
of the water in the sterile pipette and letting it flow back.

Q. How were the celloidin sacs seeded and placed in the water?

A. It was necessary to seed those in a somewhat different way. I brought the water to the laboratory and then infected it in a similar way to that in which I infected the water from the parchment sacs and having made plates to determine the seeding then by means of sterile pipettes filled these small sacs from this stock solution of infected water.

Q. Then what did you do with the celloidin sacs?

A. The sacs were then taken at once and placed in the river?

Q. Who took them out of the river to the laboratory?

A. I took them.

Q. How many experiments did you carry on there?

A. I did five experiments in the river with parchment sacs.

Q. On the typhoid?

A. On the typhoid, one on the dysentery organism. I did one experiment, that is, I tested one set of celloidin sacs, infected with the typhoid organism, and one series infected with the dysentery organism.

Q. That made eight experiments?

A. In the river, yes.

10405 Q. Now, how many celloidin sacs in all were placed in the river?

A. I put from 6 to 10, a sufficient number, so that I could conduct the experiment about 10 days. When I used six sacs as I did in one case, I had to take the samples every other day, in the latter part of the experiment.

Q. How were the celloidin samples taken?

A. I brought the sac entire to the laboratory and then removed the water by means of a sterile pipette. I did that in the case of the river water. In the case of the tap water I at times left the sac remain in the water for several days. That is, I often did not remove the sac entirely, but took out a small portion as a sample and replaced the sac in the tap water, taking a second sample the following day.

Q. The typhoid bacilli that were placed in those sacs were typhoid bacilli given you by Professor Zeit?

A. I secured the first culture which we used from Professor Jordan. It was sent by him.

Q. That was the sample that Professor Jordan sent to Professor Zeit, known as strain X?

A. Yes, sir. The second was a culture sent to Professor Zeit from Parke, Davis & Company, taken from a case of 10406 typhoid fever, and known as their culture "O." In addition to that I used in some of my control experiments a third culture which we had in the laboratory and which I isolated from a case of typhoid fever in Johns Hopkins Hospital.

Q. After the samples were taken out of the water and delivered to the laboratory they were tested for the presence or absence of typhoid bacilli?

A. Yes, sir.

Q. When were these sacs first placed into the Chicago river at Ashland Avenue?

A. The first series was placed in the latter part of October, from the middle to the latter part, I should judge about the 20th. I placed a sac about the first of January. That was a celloidin sac, and also another parchment sac about the first of December.

Q. When were they taken out?

A. Well, I ran the experiments about ten days. Some of the sacs I left in, and did not take out at all, that is, I did not remove them from the water.

Q. When was the last sample of water taken from Ashland Avenue?

A. I am still taking it from the celloidin sac series.

What?

10407 A. I am still taking from one series. The last one I took complete was about the middle of January.

Q. That is what I mean, this experiment that Professor Zeit testified about?

A. Yes, sir.

Q. Now, after the samples were taken to the laboratory, analytical determinations made, everything was reported to Professor Zeit as to the results that were made, were they not?

A. Yes, sir; I made cultures and then we worked upon those cultures together, and I reported to him fully in regard to the work.

Q. The dysentry bacillus that was made at this time, was made by yourself?

A. Yes, sir.

Q. Professor Zeit did not participate in that?

A. No, sir.

Q. Will you detail the method that you used in the dysentry bacillus, and how the experiment was made, and when it was made, in full?

A. I tested the longevity of the dysentry bacillus in the river water, beginning the first of December, placing it in a parchment sac. I made a second experiment in the river 10408 water about the first of January, placing them in celloidin sacs. I made a third experiment placing the dysentry organism in celloidin sacs, in tap water, at about the same time. The sacs were prepared and seeded in a method similar to that which I have already described. I used cultures of bacillus dysenterial Shiga. I used two strains, one a subculture of Shiga's original culture, the alkaline form of the dysentry organism, and the second a culture of the acid form of the dysentery organism, isolated from a case of summer diarrhoea at Mt. Wilson in 1903, by myself.

Q. Where did you get the Shiga bacillus that you employed in this experiment?

A. This was a culture which was a subculture of one of the stock cultures at the John Hopkins Pathological Laboratory.

Q. Now, proceed, Doctor, with the experiment, just as you made it?

A. In the first series in December I seeded the river water with several hundred thousand of dysentery organism per cc. The water contained about 8,000 or 10,000 water and sewage organisms at that time. I took samples of the water daily and made plate cultures in agar agar, making a large number
10409 of plates, usually as many as 15 or 20. These plates were
set in the thermostat and at the end of 24 hours the colonies which appeared were marked. I then placed them in the laboratory a second 24 hours, and at the end of that time looked for colonies which had appeared on the second day. This process is one which was developed by Dr. Flexner and his pupils and has been specially valuable for the isolation of the dysentery organism. It depends upon the principle that the dysentery is slow in growing in mixed cultures and colonies usually do not appear in the first day. One is able then to pick out, with certainty, dysentery colonies from the colonies appearing later. I made subcultures from these which appeared in the second 24 hours upon special media making them usually on a slant litmus glucose agar on which dysentery organisms grow in a characteristic manner. I was able to throw out all gas formers, all alkali forms and all other organisms which grew in an unsatisfactory manner unlike the dysentery organism and proceeded then to cultivate the organisms which resembled dysentery and established their identity by the agglutination test with ante-dysenteric serum. In the experiment in the river I was able to find the organism for three days; and even with heavy seeding I found them only three days, and then up to
10410 about the tenth day I was unable to find any.

I made experiments in a similar way, about the first of December, using celloidin sacs, seeding them in a similar way, using, however, a rather smaller number of organisms, about 10,000 per cc. I was able to find the dysentery organism on the first and second days, in lake water, and on the first day only in river water.

Q. Did that complete your experiments on the Shiga?

A. Yes, sir, in connection with these waters.

Q. How long did you find that the Shiga bacillus lived in the waters of the Chicago river?

A. With a heavy seeding, that is, several thousand organisms per cc. I succeeded in finding it on the third day when it was mixed with water which contained a few thousand water bacteria per cc. When it was mixed in the proportion of 10,000 per cc. with water which contained several hundred thousand water and sewage organisms I found it only on the first day.

Q. What means did you employ for determining the presence of the Shiga bacillus?

10411 A. I used the plate method, and the method of marking the colonies and identifying by culture media and by agglutination of the anti-dysenteric serum as described.

CROSS-EXAMINATION, by Mr. Corum.

Q. Will you give the number of days which the typhoid bacillus lived in each of your experiments that were made at Ashland Avenue?

A. Of the first series of experiments made in October I started in with 5 sacs, one on the first day was punctured in taking it out, and I was obliged to discontinue that. One was a control in which I put salt solution infected with the typhoid organism. That became infected on the second day, and so was discontinued as a control. I found the typhoid organisms in there on the third day and not later. And of the other three sacs—these are parchment sacs—one which was infected with over two million organisms per cc. to about 200,000 water organisms, in that I found the organisms on the third day and not later, and I made a single culture as late as the 15th day.

10412 In the other two which were seeded with about one and one-half million organisms per cc., I found the typhoid organisms on the second day and not later than up to the tenth day.

That included all the tests made in October, making five experiments, omitting the one which I was obliged to discontinue.

I made a second experiment in a parchment sac, beginning the first of December. This was inoculated with about 20,000 organisms per cc. to about 8,000 water organisms, and in that I found the organisms on the first, second and third days, and later I did not find the typhoid bacillus, continuing experiments until the ninth day. In this on the fourth and on the ninth day I made a special examination by means of taking off all the colonies on a plate which was seeded with three hundred or four hundred organisms, and also by taking about 50 cc. of water, attempting to precipitate the typhoid organisms, if present, with serum and plating out the precipitate. These were negative on the fifth and ninth days. This method is the method that Schepilewsky described in the Centralblatt fur Bakteriologie, 33rd Volume.

10413 The next series was a series begun on the 30th of December, a series of celloidin sacs, which I inoculated with about 11,000 typhoid organisms per cc. to 640,000 water organisms. In this I found the typhoid organism on the first day, not on the second, fifth or ninth days, using the special methods already described.

I find that I was mistaken in that I had done one celloidin experiment in the river only and two experiments in the tap water, making seven in the river.

Q. Now, in your testimony you have been referring to the experiments in the river?

A. Yes, sir.

Q. In this Chicago river?

A. Yes, sir.

Q. Now, I wish you would refer to your experiments in the lake?

A. I did two experiments in October, suspending the sacs as described in Professor Zeit's laboratory, in one of which I infected with about one and one-half million typhoid organisms per cc. I examined those daily for fifteen days and found the organism on the fifth day. The second one I infected in a similar way and found the organism on the seventh day.

10414 In November, beginning the 18th of November, I did an experiment with the parchment sac, which I infected similar to those described and in that I found the organism on the eighth day and not later, for six days later. In this I determined by the methods described, the absence of the organism. I made a second experiment in which I placed a parchment sac in air and I found the organism on the 5th day and not later to the 12th.

I did another experiment in which I used celloidin sacs, infecting them in a similar manner, and I found the organism on the 7th day and not later to the 14th day.

Q. That was lake water, too?

A. Yes, sir. I did a control experiment in which I used boiled lake water, and I found the organism on the 15th day.

Q. When you speak of organism you mean what?

A. The typhoid organism.

Q. That is all of the typhoid experiments that you performed?

10415 A. Yes, sir, with the exception of some controls.

Signature waived. F. S. B., Com'r.

Adjourned until 10:00 a. m., Wednesday, February 17, 1904.

10416 10:00 A. M., Wednesday, February 17, 1904. Parties met pursuant to adjournment. Present the Commissioner and same counsel representing the respective parties.

There being no witnesses present, an adjournment was taken until 10:00 A. M., Thursday, February 18, 1904.

10417 10:00 A. M., Thursday, February 18, 1904. Met pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. H. L. RUSSELL

a witness called on behalf of defendants, being first duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION

By Mr. Todd.

Q. What is your name?

A. H. L. Russell.

Q. Where do you reside?

A. Madison, Wisconsin.

Q. What is your business?

A. Teacher.

Q. In what capacity?

A. I am in charge of the department of Bacteriology in the University of Wisconsin.

10418 Q. What institution were you graduated from Professor?

A. I received my bachelor's degree from the University of Wisconsin in 1888; remained there as Fellow in Bacteriology until 1890, and then went to Europe and studied in Koch's Institute in the University of Berlin, in the Zoological station at Naples, and in the Pasteur Institute at Paris. I returned to America in 1891 and took my Ph. D. degree at Johns Hopkins University.

Q. When did you assume the professorship in the University of Wisconsin at Madison?

A. 1893.

Q. What experience have you had in sanitary work?

A. I have been connected, since 1894 with the Wisconsin State Board of Health as Bacteriologist, and in that capacity as well as in a private capacity I have had to do with the analysis of waters from a bacterial point of view, for sanitary purposes.

Q. What water courses have you investigated?

A. We have had the examination of all the waters which were submitted for public analysis in the State since that time and have been engaged especially in an examination of
10419 the water supplies of the cities of Superior, Ashland, Marinette, Menominee, Michigan, Merrill, Steven's Point, Warsau, Eauclaire, Portage, Green Bay, Beloit, Baraboo, and Dubuque, Iowa, besides a number of smaller places.

Q. Have you made a special study of sanitary problems?

A. In connection with this work I have carried out investigations on the sanitary nature of waters.

Q. Have you studied any typhoid fever epidemics?

A. Yes sir. The very severe outbreak of typhoid fever in Baraboo, in the year 1901, and I had the examination of the waters at the time of the typhoid outbreak in Ashland, and just subsequent to the typhoid outbreak in Superior, Wisconsin. Also in Menominee, Michigan, and Marinette, Wisconsin. Those are the main outbreaks.

Q. Are you acquainted with the literature bearing upon typhoid fever epidemics?

A. Yes sir.

Q. Are you acquainted with any epidemics other than typhoid fever?

A. Relating to water born diseases?

10420 Q. Yes?

A. In connection with water born diseases I have studied the literature with reference to outbreaks caused by Asiatic cholera, organisms producing gastro intestinal diseases, dysentery, and also anthrax.

Q. Have you made a special study of water analysis?

A. In connection with the work previously mentioned it has been necessary for me to make a bacterial analysis of water in large numbers. I have not studied from a laboratory point of view the chemical side of it so much.

Q. What branch of sanitary science have you given special attention to?

A. Bacteriology.

Q. Have you had any experience in the interpretation of the chemical analyses of water?

A. In the course of our sanitary work in the State the waters are received by me. Samples of the same are taken out for bacteriological analyses and the balance of the samples turned over to the State Chemist. His report comes to me merely as a chemical report, without any interpretation, and it has been necessary for me to combine the results of the bacteriological and chemical examination, and give a proper

10421 interpretation of the coordinated methods of analysis.

Mr. Todd: Mr. Commissioner, have you compared all the tables and charts introduced in evidence with all the tables and charts contained in the book known as reports of Streams Examinations published by the Sanitary District of Chicago? I ask this question for the purpose of simplifying my examinations as I will refer to Streams Examinations instead of to the individual tables that have been introduced in evidence.

The Commissioner: I have made this comparison and have found that all the tables and plates printed in the publication referred to have been copied into the testimony in this case by the witnesses who have hitherto testified.

Counsel for complainant makes no objection to this interrogatory or answer.

Q. Have you examined and studied the bacterial and chemical analysis of the waters of Lake Michigan, the Drainage Canal, the Desplaines River, the Illinois River, the Mississippi River and the Missouri River as made by Professors Jordan, Gehrmann, Palmer and Burrill, the same being published in what is known as "Reports of Streams Examinations," published by the Sanitary District of Chicago?

10422 A. I have.

Q. What opportunities have you had for becoming acquainted with the water course from Chicago to St. Louis?

A. In September, 1903, I made a trip, in conjunction with a number of other individuals, from Chicago to St. Louis, by way of the drainage canal, Desplaines River, Illinois River, Mississippi River and had given me special opportunities for the physical examination of those streams.

Q. How was this trip made?

A. This trip was made by boat from Chicago to Lockport; we then went by rail from Lockport to Joliet, and from Joliet to Peoria on the Rock Island, and then took the Fish Commissioner's Steamer, Illinois, at Peru and made the continuous passage from there to St. Louis, stopping en route during the night so as to give an opportunity for the physical examination of the stream throughout its entire course by day light.

Q. Did you go up the Mississippi?

A. We went up the Mississippi at its junction with the Illinois to Grafton, for the distance of a few miles, so as to observe the physical conditions of this stream before and at its confluence with the Illinois.

10423 Q. Have you made a special study of bacteriology?

A. I have.

Q. What are bacteria?

A. Bacteria are one celled plant structures of the very lowest order of existence. Their methods of reproduction and nutrition ally them with the plants, not possessing green coloring matter, rather than with the animal forms of life.

Q. How are they classified and distinguished?

A. The bacteria are classified primarily on the basis of the form which the cell assumes, there being three fundamental type forms, known respectively as coccus, bacillus and spirillum. The extreme simplicity of the bacteria renders it necessary to bring into the classification of this group of plants a variety of

physiological data, which are not used in the classification of
the more highly organized forms of life. These physiological
data refer to the growth of the organisms on various kinds of
culture media, the reactions which are produced in these media
as a result of this growth, the appearance of the organisms
as grown in masses technically known as colonies and
their relations to other forms of life when artifically in-
10424 troduced into them, such as is the case with the patho-
genic or disease producing bacteria.

Q. How are they distributed?

A. The bacteria are almost universally distributed in nature, being found over the surface of the earth in varying numbers.

Q. What are the characteristics of bacteria peculiar to water?

A. The water bacteria, those that are normally native to this habitat, belong to the group of organisms which are technically known as saprophytes, that is, organisms living upon dead organic matter in contradistinction to the parasitic forms which live upon live organic matter. The water bacteria possess also in addition to this characteristic of growth upon dead material, the ability to thrive in solutions which contain a minimum amount of organic nourishment. So that under natural conditions in waters which are relatively free from organic matter many of these organisms possess the power of multiplication in a very great degree.

Q. Please distinguish between the so called saprophytic and parasitic bacteria?

A. The saprophytic bacteria live upon dead matter. The
parasitic bacteria grow in and on living material. The
10425 parasitic bacteria are divided into two groups one of
which is called the obligatory parasites, when the organ-
ism is unable to grow on any material which is not alive The facultative group possess the power of growing on both live and dead material. This production of pathogenesis is subject to material alterations in intensity, owing to the environmental conditions under which the organism is placed, and it is therefore possible to deprive a normal pathogenic organism of its power of producing a diseased condition in the number of susceptible hosts.

Q. Distinguish between the pathogenic and non-pathogenic bacteria?

A. The distinction of pathogenic and non-pathogenic bacteria is a different classification from the parasitic and saprophytic. The pathogenic bacteria are parasitic, although there are organisms that are capable of producing a pathogenic effect that are not strictly parasites. The non-pathogenic classification is merely a negative one, including all organisms which can not come under the pathogenic or disease producing class.

Q. What are the known pathogenic bacteria to man?

A. The most commonly recognized pathogenic organisms
10426 for man are those which cause the diseases of typhoid
fever, diphtheria, tetanus or lock jaw, Asiatic cholera, Bubonic Plague, dysentery, cerebro spinal meningitis and anthrax.

Q. What pathogenic bacteria are water borne when taken into the human body by means of drinking water?

A. The most common organisms of this class are the organisms producing the diseases of typhoid fever, cholera, dysentery, anthrax, under certain conditions also organisms capable of producing certain gastro-intestinal disturbances. These are the ones most likely to be disseminated through the medium of water.

Q. What is the bacillus prodigiosus?

A. The bacillus prodigiosus is a well recognized harmless saprophyte that is one of the best known of any which are studied in the bacteriological laboratories. The organism is especially easy to recognize on account of its ability to form a, red pigment on certain food media which with other means leads to recognition.

Q. Will you give its characteristics and life history?

A. The characteristics of bacillus prodigiosus are that it
10427 is a short plump organism. On culture material it is capable of liquefying gelatine, producing a funnel shaped liquefication in the test tube, in which there is a slight accumulation of red pigment. On the cut surface of a potato the organism grows luxuriantly forming a thick mass of bacterial growth which possesses a blood red color, changing to a metallic luster with increasing age. These cultures frequently possess a herring brine odor, which is a characteristic of the organism.

Q. Is it found in river water?

A. Bacillus prodigious is occasionally found in river water, as well as other locations of the outside environment.

Q. Have you found bacillus prodigiosus in the water of the western country?

A. Yes sir, in several instances I have found the organism known as bacillus prodigiosus under external conditions. Several of these cases have been in samples of milk which were examined, but in other cases I have found it in water supplies which were reasonably certain to be entirely free from any polluted material.

Q. Are you acquainted with the experiment made with the bacillus prodigiosus, by Dr. Ravold?

10428 A. Yes, I am conversant with the data which has been presented in connection with the case.

Q. Assume that 107 barrels of 40 gallons each of culture of bacillus prodigiosus, consisting of a thousand million bacilli to a c. c., as contained in said barrels was deposited in the Chicago Drainage Canal at the time, and late on the afternoon and evening of the sixth day of November, 1901, during a period of from four to eight hours. Assume further that immediately after the said barrels were emptied into the drainage canal, the laboratories at Lockport, Joliet, Pekin and Grafton on the Illinois River and the intake tower of the St. Louis waterworks, chain of rocks were notified, and that samples were collected at each of these places every hour of the day and night for the purpose of bacteriological analyses for the ascertainment of this bacillus prodigiosus and assume at Lockport these hourly samples, day and night, were taken from November 7th, to November 25th, a period of eighteen days, the total number of samples taken being 432. Assume that at Joliet these hourly samples taken day and night were taken from November 7th to November 25, a period of 18 days, the total number of samples taken being 432. Assume further that at Peoria these hourly samples were taken day and night from November 8th to November 10429 30th, a period of 22 days, amounting to a total of 528.

Assume that at Grafton these hourly samples were taken day and night from November 12th to December 15th, a period of 33 days, the total number amounting to 792, of which 384 were analyzed by Dr. Ravold.

Assume that the total number of samples taken hourly day and night at the chain of rocks was 720.

Assume that at the laboratory tap these hourly samples taken day and night from November 20 to March 1, 1902, a period of 100 days, amounted to a total of 2400.

Assume that the total number of samples analyzed at the different points for the period above mentioned was 5304.

Assume further that on December 4, at 8:45 A. M. 1 bacterium prodigiosus was found at the intake tower at the chain of rocks.

Assume that on December 5th, at 9:00 A. M. 1 bacillus prodigiosus was found at the intake tower, chain of rocks.

Assume that on December 8th at midnight 1 prodigiosus was found at the intake tower chain of rocks.

Assume that on December 6th at 8:00 A. M. at Grafton 1 bacillus prodigiosus was found.

Assume that on December 7th at midnight, at Grafton, 1 bacillus prodigious was found, and assume further that
10430 these five organisms were all the organisms of the prodigiosus that were found in the examination made from Lockport to the intake tower at the chain of rocks and the laboratory tap in the city of St. Louis which were made during the progress of this investigation as hereinbefore set forth and at no time was there more than one single bacterium found at each of these places.

Assuming all the facts as hereinbefore stated to be true, what is your opinion as a bacteriologist as to the value of this experiment as indicating the possible longevity of the typhoid bacillus as measured by the longevity of a bacillus prodigiosus and the probability that a typhoid bacillus entering the drainage canal from the sewers of Chicago would ultimately find its way through the Desplaines and Illinois Rivers to the St. Louis water works at the chain of rocks.

A. Taking into consideration the assumptions as indicated in the question and also considering the question in the light of all the knowledge which I possess with reference to the distribution of the organism known as bacillus prodigiosus under natural and normal conditions, my opinion is that this experiment does not in any way throw any light on the matter
10431 of the probable longevity of the typhoid bacillus as meas-

ured by the longevity of the bacillus prodigiosus, and the assumptions mentioned in the question propounded, leads me to believe it is highly improbable that the organisms reported to have been found on the fourth, fifth and eighth of December at the intake tower, chain of rocks, on the sixth and 7th of December were the same or derived from the organisms which were placed in the waters of the Chicago Drainage Canal at Lemont on the 6th day of November.

This conclusion is based upon the fact that a series of examinations made on the samples taken from the water of the Illinois river at Lockport, Joliet, Peoria and Grafton between the 7th of November and December 15th, amounting in all to 1752, and also samples taken from the intake tower at the chain of rocks, at the laboratory tap in the City of St. Louis, between November 20th and March 1st, amounting in all to 3120 failed to reveal the presence of the bacillus prodigiosus until 28 days had elapsed from the time the cultures were placed in the river at Lemont.

If the organisms which were reported to have been isolated from the waters of the Illinois river at Grafton and the Mississippi at the chain of rocks had been the same or the 10432 progeny of the same as those which were deposited in the Chicago Drainage Canal at Lemont, it would have been natural to expect that in the numerous preceding analyses which had been made, organisms of this species would have been found, as there is reason to believe that the flow of water from Lemont through the Illinois river to the City of St. Louis would not have consumed a period of 28 days.

Assuming that the organisms reported as bacillus prodigiosus, which were found on December 4, 5 and 8th, at the intake tower, chain of rocks, and December 6 and 7 at Grafton, were organisms derived from other sources than those due to the depositing of 107 barrels of cultures of the bacillus deposited on November 6th in the river, and assuming that hourly and daily samples were made at these stations along the course of the Illinois river from Lockport to Grafton, and from the waters of the Mississippi river at St. Louis, said analyses amounting in all to 5304, and assuming that in no case were any organisms belonging to the bacillus prodigiosus found in any of these stations, with the excepiton of the three germs found at the intake tower, chain of rocks, December 4-8, and 2 organisms found in the Illinois river at Grafton on December 6th and 10433 7th, after a period of 28 days after those 107 barrels of culture had been placed in the Illinois river at Lemont, and assuming the well known fact that the bacillus prodigiosus is a saprophytic organism, capable of living in the water under natural conditions a longer period of time than active, vigorous non-spore bearing parasitic bacteria, such as the bacteria of typhoid fever, it is my opinion that the results of the above experiment show that it is highly probable that the saprophytic bacillus prodigiosus had been destroyed in the waters of the Illinois river during the course of its flow from Lemont to Grafton and the City of St. Louis, and, therefore, assuming that such was the case it would be much more probable that the more delicate and easily affected organism of typhoid fever, entering the waters of the drainage canal of Chicago, from the sewers of Chicago, would not have survived a journey down the Illinois river and Mississippi river to the intake tower, chain of rocks, at St. Louis.

Q. What importance do you attach to the experiment as assumed in the hypothetical question?

A. As to throwing light upon the question at issue as to the longevity of the typhoid organisms, I do not consider 10434 the experiment detailed in the foregoing case, where bacillus prodigiosus were placed in the waters of the Illinois river, would be of any direct value, as the selection of this organism would not give conditions which would permit of a proper interpretation of the results obtained.

Q. Are there any other kinds of bacteria resembling the prodigiosus found in this western country?

A. It is not uncommon to find in water and under other conditions in nature, in this region as well as in other places, organisms possessing the characteristic which simulate those belonging to bacillus prodigiosus, by reason of the red pigment which they are capable of producing when grown upon the ordinary nutrient media and which might, therefore, be mistaken for bacillus prodigiosus unless the characteristics of the germs isolated were studied in detail so as to be absolutely certain whether the said organisms belonged to the species bacillus prodigious or not.

Q. Will you give the characteristics and pathogenic significance of the cholera germ?

A. The cholera germs belong to the class known as the spirillum, slightly curved, and therefore receive the name of comma bacillus, on account of its resemblance to the
10435 character comma. This organism is capable of growing on artificial media readily. On nutrient gelatine it is able to liquefy the gelatine, producing a characteristic appearance, both on gelatine plates and in gelatine culture. This is characterized by the formation of gas by products which are rapidly volatilized, causing the formation of a sharply defined pit, in the bottom of which the developing colony is to be noted. The organism upon agar is not especially characteristic. It grows under both aerobic and anaerobic conditions. It is capable of reducing nitrates to nitrites and possesses the well known and well characterized cholera red reaction which enables it to be readily distinguished from other spirillum. It is capable of producing toxic products which are able to produce fatal results in the bodies of experimental animals under certain conditions, although not normally doing so by ordinary means of inoculation.

Q. Of the tetanus germ?

A. The tetanus germ is a bacillus, spore bearing, producing a spore much larger than the mother cell, and therefore giving a drum head appearance to the organism in micro-
10436 scopic examinations, which is very characteristic. The germ is a strict anaerobe, therefore does not develop on ordinary nutrient media, exposed to contact with air. It is capable of growing in artificial media, in the presence of hydrogen or nitrogen, producing in gelatine cultures a very characteristic radiating growth which resembles an inverted fir tree. The germ is capable of producing a very powerful toxin which in exceedingly small quantities produces fatal results in laboratory animals.

Q. Of the anthrax germ?

A. The anthrax germ belongs to the bacillus group, is a very large organism for bacteria, square ended, spore bearing, grows readily upon artificial media; presents in gelatine a well characterized appearance; on agar, less distinct, causes the death of most kinds of laboratory animals upon inoculation of exceedingly small quantities of culture.

Q. The enteriditis sporogenes?

A. Bacillus enteriditis sporogenes is an organism which was discovered by Klein of England. He found it particularly common in sewage and waters polluted with fecal material. This organism is an anaerobic germ, spore bearing, capable of growing upon ordinary culture media; possesses char-
10437 acteristic appearance in milk which enables it to be readily recognized; is toxic for laboratory animals, although it is not usualy associated with disease conditions in man.

Q. Of the dysentery bacillus?

A. The dysentery bacillus is the organism which was discovered by Shiga in Japan, in cases of Japanese dysentery. It has also been recently found by Kruse in Germany, and Flexner in the Phillipines, both of whom have associated it with the production of bacillary dysentery in man. The organism is somewhat allied to the typhoid organism or the colon bacillus. It possesses culture characteristics more nearly related to the typhoid than any other important bacterial form, although it is readily distinguished from the typhoid organism by its reaction towards glucose sugar.

Q. Have you made any special study of the typhoid germ?

A. Yes, sir.

Q. Give the characteristics of the typhoid germ?

A. The typhoid organism belongs to a group of bacteria which is sometimes called the typhoid colon group. The
10438 organism is a germ capable of growing both in the body of animals and in artificial media. On gelatine it is incapable of liquefying the media. Surface colonies present an irregular contour, bluish gray by transmitted light, giving a peculiar lustre, which is quite characteristic on certain media. The organism grows well on agar, in colonies, producing, however, no marked change in the physical properties of the colony. It grows well in broth to which sugar is added, and in these media can be readily distinguished from the varieties of the colon group.

Q. Where are typhoid germs found.

A. Typhoid organisms are found, of course, in cases of typhoid fever, thriving and growing in the intestinal tract, in the lesions produced in the intestinal wall, spreading from thence into the interior tissues of the body where it is found most frequently and in largest numbers in the spleen. It is located in other portions of the body during cases of the disease and may even retain its vitality after convalescence. The organism appears in the feces and the urine of the typhoid patients and retains its vitality in these materials for varying periods of time after the same have been voided from the living host.

10439 Q. What germs do they resemble?

A. The species of bacteria included under the head of the typhoid germ closely resemble a number of other bacteria, not only morphologically, so far as form and structure are concerned, but also as to certain characteristics which they possess similar to other related organisms growing on ordinary nutrient media.

Q. Is it related to the colon bacillus, and if so, in what way?

A. The germ of typhoid fever belongs to a group of organisms which includes, in addition to this specific organism, other bacteria such as bacteria coli communis, or the colon bacillus, and also other bacilli which stand intermediate between the colon bacilli and the typhoid fever organism, which are known as the para colon and the para typhoid organism. The typhoid organism is, therefore, related to the colon bacilli, such relationship being expressed by the morphological similarity of the two organisms as to form and structure, size and arrangement of cells and in a number of growth characters, as exhibited by both organisms when grown on artificial media.

Q. What methods are employed for determining and identifying the typhoid bacillus?

10440 A. The determination and identification of the typhoid organisms is made by isolating the presumptive organism in pure culture from various sources and then transplanting these in various nutrient media in which the organism grows and develops, producing thereby characteristic by products, some of which are peculiarly specific to this organism and permit of its differentiation from other closely related organisms. Such differential tests may be applied as the growth of the typhoid bacillus in milk, to which litmus is added. Its growth in broth to which lactose is added. Its growth in a broth when litmus and dextrose is added, when the acidity of the media is increased by reason of the fermentation which is produced in the added glucose; also recognized by its inability to liquefy gelatine and produces colonies which are more or less characteristic, and is especially recognized by its power to cause an agglutination or a clumping of the blood serum of animals which have been artificially immunized against the typhoid bacillus by repeated injection of cultures of such bacilli in the body cavities of animals.

Q. Please give the longevity of the typhoid bacillus in the human body?

10441 A. The typhoid fever organism grows and multiplies in the human body, and is capable of retaining its vitality even after convalescence for a considerable period of time, as is shown by the continued excretion of the organism in the urine of patients, for weeks and sometimes even months after the disease has run its course, and still longer as has been shown by the isolation of the typhoid fever organisms from portions of the body such as the bone marrow where it has been found in a few cases even years after the disease had disappeared.

Q. Please give the longevity of the typhoid bacillus in soil?

A. The typhoid fever organisms is capable of retaining its vitality in soil for a varying period of time, depending upon the influences to which it is subjected and its environment. When deposited in the soil by burial, the organism rapidly loses its vitality so that at the expiration of a short period, measured by a few days, it can no longer be detected in the upper layers of the soil. When the soil is moist and the organism is deposited in typhoid dejecta, the germ is capable of retaining its vitality for a longer period of time, a period of time which may be measured by months. Some experiments indicate a retention of vitality for five or six months.

10442 Please give the longevity of the typhoid bacillus in water?

A. The longevity of the typhoid bacillus in water is materially shorter than it is under soil conditions, and here again depends largely upon the conditions of exposure. Where the organism is brought in contact with an aqueous medium with normal saprophytic bacteria, such as would naturally be found where the organism was exposed in sewage or polluted waters, the vitality of the typhoid germ is greatly impaired, and its longevity is thereby lessened, so that it is my opinion that under such conditions in waters of this character, the longevity of the organism would not normally be more than three or four days or so, but that in waters of a greater degree of purity where saprophytic bacterial life is not so abundant and therefore the vital concurrence between these native bacteria and the typhoid organisms would not be so great, the longevity of the typhoid organisms, under these conditions, would be increased so that it might be found in waters which would ordinarily be deemed as pure waters, even at the expiration of a longer period, possibly one or two weeks.

Q. Have you made any experiments upon the longevity of the typhoid bacillus in different kinds of water?

A. Yes, sir; I have carried out an extensive series of experiments in connection with this matter of the longevity of the typhoid organism. These experiments indicate that when the organism is exposed in water which is ordinarily pronounced as pure and which has first been sterilized by heat and thus deprived of its germ life and possibly of metabolic products of bacterial activity, this process changes the conditions of the water so that in these waters the germs of typhoid fever are capable of retaining their vitality for a period of time, measured by months. 10443

I have also conducted experiments where such water was deprived of its bacterial life by filtraton rather than by heat, and under conditions where the soluble products of bacterial growth in the water would be brought in contact with the typhoid organism.

Q. Please give the results of those experimnets?

A. The results of these experiments which have been made with waters sterilized by these two processes of heating and filtration indicate consistently that the vitality of the typhoid organism in raw water rendered sterile by filtration was considerably shorter than in the same water which had been rendered sterile by the application of heat. These results obtain not only where the amount of typhoid organisms which were seeded were even light, but also where large numbers, 10444 several thousand per loop, were inoculated. The results of these tests were uniform and indicated that without exception the vitality of the typhoid organism in such raw waters as these was much shorter than in water sterilized by heat.

10445 Q. Does the typhoid bacillus multiply and increase in nature?

A. So far as my experience goes, it is not my belief that the typhoid organism is capable of multiplying and increasing outside of the body under a natural condition. At least this is not the case so far as its relation to water is concerned, and the general opinion among investigators upon this subject is that when discharged with fecal material upon the surface of the ground it is exceedingly questionable whether there is any growth when brought in contact with soil bacteria.

Q. Are the conditions of laboratory experiments more or less favorable than the conditions in nature for the longevity of the typhoid bacillus?

A. The conditions in which laboratory experiments have been performed on the longevity of the typhoid fever organism, are, as a rule, more favorable for the prolongation of vitality of this organism, than would exist where the organism was exposed under natural conditions.

Q. What reason have you for this opinion?

A. This opinion is based upon the well known fact that when the typhoid organism is exposed under natural conditions, in, for instance, flowing waters, it is subjected to a number of factors of a detrimental character, exerting a detrimental influence which often can not be readily simulated under laboratory conditions, and which in the case of the laboratory experiments that have been published relating to the longevity of the typhoid bacillus, in many instances no attempt has been made to overcome. 10446

Q. Will the germ of typhoid fever live as long in polluted water as in pure sterilized water?

A. It has been recognized by practically all investigators on this subject that the organism of typhoid fever lives longer in sterilized water than it does under raw conditions and if such waters are polluted, if normal raw waters are polluted, it is my belief that the longevity of the germ would be much less than in the case of purer sterilized water.

Q. How do you account for this?

A. My opinion that the typhoid organism will not live as long in polluted as in pure waters which have been sterilized by heat, is based upon the fact that there exists an antagonism between the saprophytic bacteria, found in polluted waters, or the bi-products of the growth of these organisms and the typhoid organisms, which exerts a prejudicial effect upon the
10447 development of the typhoid germ, thereby diminishing its vitality and shortening its longevity.

Q. From your knowledge of the quality of the water in the drainage canal, the Desplaines river and the Illinois river, what is your opinion as to the longevity of the typhoid bacillus in those waters?

A. From my knowledge of the conditions which obtain in the water of the Chicago drainage canal and the Illinois river my opinion is that the longevity of the typhoid organism would not be beyond the average more than a few days, at the most, say three to four days.

Q. How do you account for your assumption that the life of the typhoid in the waters of the Illinois river and drainage canal and Desplaines river is shorter as compared to the laboratory experiments?

A. The reason assigned for the diminished vitality of the typhoid organism in the waters of the Illinois river in comparison with those which have been reported in laboratory experiments, is, that under the conditions under which the organism is exposed, in said stream, the germ would be subject to
10448 a number of environmental influences which would exert a prejudicial effect upon the vitality of the organism, and would thereby shorten the longevity of the germ to a period much shorter than would be found in an experimental test carried on in the laboratory conditions where the influence of these detrimental factors was more or less excluded.

Q. Have you made any experiments on the competition existing between the typhoid and the saprophytic bacteria?

A. Yes, I have made a large number of experiments on this very matter, of the vital concurrence or competition which would exist when the typhoid organism was exposed under artificial conditions to the influence of various saprophytic bacteria.

Q. Please state these experiments in full?

A. These experiments have covered a period of four or five years and have been conducted along a variety of lines. One group of these experiments have been made, where cultures of the typhoid organism were placed in celloidin sacs, which were germ tight and therefore would not permit of the passing out of the typhoid organism or the passing in of any extraneous organism, but which will permit of the passing in and
10449 out of the soluble products of the growth of these organisms. These sacs were placed in cultures made of nutrient material, to which material was added such as soil, water, and other matter containing divers forms of saprophytic bacteria. Under such conditions bacterial growth was of course abundant in the outside medium. The results of such experiments indicated frequently that the typhoid organism was unable to grow on the inside of these sacs, even when placed in nutrient medium, such as beef broth. In many instances not only was this inability to grow marked, but the organism was actually killed off. Further experiments have been made to isolate from these impure cultures, the organisms on the outside of these sacs which were capable of bringing about this change. It was possible to demonstrate in this way that there were a number of saprophytic bacteria such as the bacillus flourescencens liquefaciens, a well recognized and well known common water bacterium, that possessed the power of exerting an antagonistic effect against the typhoid organism to such an extent that the typhoid germ placed in nutritive medium inside of the sacs, was incapable of growth. Under such circumstances the typhoid germ itself was only brought in contact with the soluble products of the growth of the saprophytic water
10450 bacteria, which were capable of passing this permeable membrane. The fact that under such conditions the organism lost its vitality, indicates to my mind a specific illustration of the law of antagonism which is konwn to be operative with various organisms among the bacteria and which is undoubtedly a potent agent in the destruction of pathogenic bacteria in the outside environment.

Further experiments have been made where the typhoid

organism has been grown in normal waters, which have been rendered germ free by the processes of sterilization and filtration. In such cases the longevity of the typhoid germ is always shorter in raw water which has been rendered germ free by filtration, than it is in the same water which has been rendered germ free by sterilization. The process of sterilization by heat destroys in all probability certain toxic or prejudicial substances which are naturally present in waters where bacterial growth has previously existed. The direct antagonism between the typhoid organism and certain saprophytic bacteria was shown
particularly well in my judgment in a series of experi-
10451 ments in which boiled water was taken and inoculated
with the colon organism, and also one other well known water bacillus, the flourescence bacillus before mentioned. After these organisms had thrived and grown in boiled water they were then rendered germ free by filtration. This deprived the water of the bacteria themselves but left in the water the soluble products that had been produced by these organisms which were capable of passing the filter. Such filtered waters were then inoculated with typhoid organisms of varying strains, of varying age, with varying amounts, and it was observed that in a large proportion of the cases the typhoid organisms so inoculated into these waters which had previously supported the bacteria life of the saprophytic class, resulted in the early destruction of the typhoid germs. In fact, in two or three days time. Whereas, the same strains of the typhoid organism of the same age of culture in varying amounts similar to those that have been used in the other experiments were inoculated into the same kind of water which had been previously boiled, but which
had not been seeded with these saprophytic organisms.
10452 In these cases the typhoid organism lived longer. The
results of these conclusions lead me to believe that there exists in nature a direct antagonism between various saprophytic bacteria which are normally to be found in water, and the typhoid organism, and that such antagonism results in the loss of vitality of the typhoid germ very much more rapidly than would be the case if the typhoid organism was not exposed to such a prejudicial environment.

Q. Are there any other experiments aside from those you have detailed, which you know of, or have made yourself, touching upon the longevity of the typhoid as compared with the life of other bacteria?

A. These experiments which I have just detailed were not only made by myself, but have been investigated by a number of my advanced students working under my direction and the results have been confirmatory in a general way. The discrepancies in the results, being no more than I would naturally expect would occur where different observers have worked at different times under slightly different conditions.

Q. Are you acquainted with the physical conditions of
10453 the drainage canal, the Desplaines river and the Illinois
river, and the Mississippi from Chicago to St. Louis?

A. I have had an opportunity of examining into the physical conditions of the Chicago drainage canal, the Desplaines river, the Illinois river and the Mississippi river.

Q. Will you describe the dams in the Illinois river?

A. In the trip which was before mentioned I had an opportunity of seeing the dams which have been placed in the lower reaches of the Illinois River, and was able to note the effect these dams would produce upon the physical appearances of the river.

Q. What effect did those dams have upon the problem of sedimentation?

A. The rate of flow in the lower reaches of the Illinois river is much slower than in the upper, causing the river to spread out over a wider cross-section. The damming up of this stream through the construction of the dams on the various points of the river, widens still further the body of water in the river, causing slack water to exist for a considerable distance back to the extent that the height of the dam would
equal the normal fall of the river. As the fall per mile
10454 in the lower reaches of the river is relatively low in comparison to what it is in the upper portion, this damming
back of the stream of low water must amount to considerable. This retarded rate of flow of the current reduces the carrying power of the stream, as to the transportation of the suspended material, and thereby produces marked sedimentation. The subsidence of this matter carries down to the bottom of the stream much of the bacterial life which is present in the river,

thus purifying the water of the river, of its bacteria as well as relieving it of its suspended load of sediment.

Q. How is sedimentation in the Illinois river affected by the higher and lower stages of water?

A. At low water, where the flow is small, the result of the dams must produce slack water to a certain extent, causing sedimentation. At high water the load of suspended sediment in the river is a great deal increased owing to the eroding effect of the surface run off on the land. This increase in the amount of the load carried, naturally increases the possibilities of sedimentation, where there are no variations in the rate of flow of the current. As the flow per mile diminishes from the upper to the lower reaches of the river, the current is naturally retarded and thus has a tendency to deposit
10455 its load. On the contrary, the larger volume of water found in high water increases the rate of flow and tends to retard this rate of deposition.

If the river rises to high stages, where the banks are overflowed, which condition would easily be possible, as the Illinois river flows through a relatively low plain, the water spreads out over the banks and causes deposition by sedimentation.

On the trip taken in September, I noted locations where the water was several miles wide. These locations I would consider as giving favorable opportunity for the production of slack water to a greater or less extent and would therefore permit of the marked deposition of the suspended matter which might be present in the stream.

Q. Will bacteria respond to the law of gravity in the pure water of the running stream?

A. The specific gravity of bacteria is only a trifle above that of water. Hence the sedimentation of bacterial cells themselves cannot well occur in pure water freed from all insoluble sediment except in a state of absolute quiescence.
10456 In this connection I have made a large number of experiments on the vertical distribution of bacteria in lakes such as Lake Mendota, at Madison. In the winter when the lake is covered with ice, and therefore there are no disturbing currents due to wind action and temperature changes, the results of these experiments show that the upper layers of the water, although entirely free from sediment contain a rela-

tively large amount of bacterial life and in fact I am unable to ascertain that there is any material settling out of germ life by mere gravitation in waters which are pure, even in a quiescent condition, and much less so in that of a running stream.

Q. What is it that causes bacteria to settle at the bottom of a running stream?

A. The reason why bacteria settle to the bottom of a flowing stream depends not on the sedimentation of these organisms themselves, but on account of the subsidence of suspended matter in the stream. The small soil particles, which constitute the mud and silt found in running streams, carry
10457 down with them as they fall to the bottom of the stream,
a large part of the bacteria which may be found in such waters. In this way the germ content of the muddy water may be very greatly reduced by the sedimentation of its suspended load.

Adjourned until 2 P. M., the same day, February 18th, 1904.

10458 2:00 P. M., Thursday, February 18, 1904. Continuation
pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. H. L. RUSSELL

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. Could sufficient water from Lake Michigan be carried through the drainage canal into the Desplaines and Illinois Rivers to create a condition of purity and clearness so as to preclude the operation of sedimentation in the Illinois River?

A. I am not familiar with the conditions well enough to know the maximum amount of water which it would be possible to pass through the drainage canal into the Illinois River but I think it extremely improbable that if all the sewage of the City of Chicago was discharged into said drainage canal that a sufficient amount of pure water could be discharged through this channel so as to produce a condition in the waters of the
Desplaines and Illinois Rivers which would preclude the
10459 operation of sedimentation in the latter stream.

Q. Assuming that the entire sewage from the city of Chicago should be diverted into the drainage canal and that one million cubic feet per minute should pass over the Bear Trap dam at Lockport, would that amount of dilution be sufficient after it reached the Illinois River, mingled with the sewage of Chicago, to so separate the matter in suspension in the Desplaines and Illinois River, as to prevent the operation of sedimentation of bacteria?

A. Assuming the present rate of flow to be somewhere in the neighborhood of 300,000 cubic feet per minute with the present amount of sewage discharged, and a condition of turbidity and sediment equal to that reported as existing in the sewage at the time of the analysis as made by Professors Jordan, Palmer, and Gehrmann, and reported in Streams Examination, I do not consider that an increase in the amount of Lake Michigan water to a point that would equal a discharge of a million cubic feet per minute over the Bear Trap Dam, would permit of entire separation of the suspended matter which would be present in the waters of the drainage canal to such a point that the dilution would prevent the sedimentation of such material and the consequent removal in part of the bacterial life in the water.

10460 Q. What sanitary significance does dilution have in considering the process of the problem of self purification of streams?

A. The increase in the volume of water noted in the flow of any stream is due to two causes. First, the water received from surface tributaries which constitute the so called run off from the surface of the land; second, the volume of water which comes from the percolation of the water directly through the soil, seeking a lower from a higher level, and therefore appearing in the drainage channels, either in the form of springs or oozing through the ground. This flow, known as the dry weather flow of a stream, together with the water which finds its way over the surface of the soil, are both factors which cause dilution in a stream, through an increase in the amount of water. The water contributed by the first factor is water which is rich in germ life of a saprophytic nature and those organisms present in the surface of the soil.

The water contributed in the second case is the ground

water supply which has been deprived almost if not entirely of its germ contents by filtration through large or smaller masses of soil, and the introduction of this comparatively sterile water would, therefore, greatly reduce the germ content in any
existing body. Whenever the possibility of disease bac-
10461 teria is present, the admixture of this relatively germ
free ground water, or even the surface run off, diminishes the number of disease organisms materially which would be present in any given body, although it might contribute in a considerable measure numerous water bacteria. The dilution of any polluted water therefore with waters coming from these sources would thereby greatly diminish the danger of contracting disease through the introduction of pathogenic bacteria.

Q. Is the danger of infection entirely diminished by dilution?

A. The infection of the human system from disease bacteria undoubtedly requires in some cases a simultaneous introduction of more than one specific organism of any disease. When water which is infected with disease bacteria is therefore diluted with water not containing these organisms the danger of infection which might arise from the ingestion of such water is really diminished, as the case of a given quantity of such water would permit of the absorption of a smaller number of those specific organisms connected with that disease, and it is entirely conceivable that in this way the amount of water which would be taken might contain less than the lethal dose.

Q. Is it a fact that the greater the dilution of sewage the
10462 less the danger from infection?

A. On the assumption that the danger of infection from sewage comes from the presence of pathogenic bacteria which find their way into the sewage from the fecal discharges, it is true that a dilution of sewage containing those organisms would diminish the number of bacteria of a specific kind, capable of bringing about this infection, and when it is further assumed that it is probably necessary in the case of intestinal diseases that there shall be a simultaneous introduction of more than one organism of a specific disease such as typhoid fever, it therefore follows that the dilution of sewage may reach a point where the danger of infection from sewage which might origially have been dangerous would be brought to such a point as to be relatively harmless.

Q. What effect does the dilution of the Chicago sewage with the water of Lake Michigan have upon the conditions of the water in the Illinois River?

A. The dilution of the Chicago sewage, as found in the drainage canal, with the purer waters coming from Lake Michigan would result in a diminution of the number of disease bacteria which might be present in Chicago sewage in any given volume, and would thus greatly minimize the danger of 10463 infection which might come through the ingestion of the water taken from the Illinois River.

Q. Is the addition of Lake Michigan water to the sewage of Chicago a detriment or a benefit to the sanitary condition of the Illinois River, considered from the standpoint of dilution alone?

A. If we consider this question from the standpoint of dilution alone it is evident that the addition of water from Lake Michigan, relatively low in germ content and of a very much purer quality than would exist in the sewage as found in the drainage canal at Chicago, then the addition of this water would be a benefit to the sanitary condition of the water as found in the Illinois River.

Q. Is the addition of Lake Michigan water to the sewage of Chicago a detriment or a benefit to the sanitary condition of the Illinois River, considered from the standpoint of chemical and bacterial changes taking place?

A. The addition of the waters of Lake Michigan to the sewage of the City of Chicago undoubtedly alters the sanitary condition of the waters of the Illinois River in that it dilutes a very impure and polluted water with waters of a much higher degree of purity. This must of necessity modify 10464 the conditions which would obtain from the standpoint of the chemical and bacterial changes which would take place in the upper regions of the river.

Q. If a sufficient volume of Lake Michigan water should be added to the sewage of Chicago so as to cause the elevation in the waters of the Desplaines and Illinois Rivers, what effect would this increased volume of water have upon the question of sedimentation in the Illinois River?

A. If a sufficient volume of water, Lake Michigan water, should be added to the sewage of the City of Chicago and discharged in the waters of the drainage canal, so as to cause an elevation in the waters of the Desplaines and Illinois Rivers to such an extent as would lead to the overflow of the low lands adjoining these rivers, this increase in the volume of water would undoubtedly facilitate the sedimentation of the suspended matter in such localities where this slack water existed.

Q. How does the physical condition of the Illinois River compare with the other rivers of the country, for the purpose of purification and sedimentation?

A. On account of the fact that the banks of the Illinois
10465 River are relatively low it is therefore possible at high
water stages for these banks to be easily covered and the widening of the stream during such stages of high water would lead necessarily to a retardation of the current and so cause to be deposited on these low lying lands much of the sediment which would be present in the stream and so would lead to a material sedimentation, and by reason of this fact to a material purification of the water in the Illinois River, when compared with other rivers in which the elevation of the shore was such as to prevent the ready overflow of their banks.

Q. From your knowledge of the physical conditions that obtain along the Illinois River as well as from the results of the analysis of the waters, both chemical and bacterial, as they appear in Streams Examinations, what effect, if any, does the sewage from Chicago, discharged into the drainage canal, have upon the waters of the Mississippi, as the same passes along the shore of the state of Missouri?

A. Taking into consideration the conditions which obtain in the Illinois River as to the sedimentation and dilution, and all other conditions that can be observed, which permit of the
production of chemical and bacterial changes in the sew-
10466 age, as revealed by the analyses reported in Streams Ex-
aminations, I do not consider that the sewage of Chicago, as discharged into the drainage canal, can have any material effect upon the waters of the Mississippi River except possibly to increase the amount of such undissolved salts as chlorine which are not taken out of solution and which would therefore find their way down the stream and thus probably

increase the chlorine content of the waters of the Mississippi River as they pass the shores of the State of Missouri.

Q. What is your opinion as to whether any pollution, dangerous to public health, entering the drainage canal from the sewers of Chicago, reaches as far down the Illinois River as the town of Grafton?

A. Basing the results which have been recorded on the self-purification of flowing streams on the fact that the typhoid organism does not thrive in natural waters, and it is only a question of how long it will live in waters of this class, that the time of flow is so great that pollution dangerous to public health would cease to exist in sewage passing from the city of Chicago to the Illinois River, down as far as the town of Grafton, from
the fact that experimental evidence shows that the ty-
10467 phoid organism will not live in highly polluted waters
like those of the drainage canal and upper portions of the Illinois River for more than a brief period of time, measured by three or four days, my opinion is that any pollution which would be dangerous to public health which might arise from the sewers of Chicago and enter the drainage canal would not exert any influence on the character of the waters of the Illinois River at its mouth, at the town of Grafton.

Q. What evidence have you that justifies the conclusion just expressed that no pollution dangerous to public health, coming from the sewers of Chicago, reaches as far down the Illinois River as Grafton?

A. The evidence which can be adduced for the justification of the conclusion just expressed rests upon an experimental evidence which has been adduced, which shows that organisms capable of causing typhoid fever will not live in the waters of the Illinois River for a sufficient period of time so that it would have been possible for them to have been carried from the sewers of the city of Chicago down the Illinois River as far as Grafton.

Q. What is your opinion as to whether any infectious matters coming from the sewers of Chicago, by way of the drain-
age canal, in a dangerous state reach as far down the
10468 Illinois River as the city of Grafton?

A. My opinion is that any infectious matters which may be discharged from the sewers of Chicago by way of the drainage canal, are deprived of their infectious properties by reason of the conditions which exist in the waters of the drainage canal and in the waters of the Illinois River before they have had time to have been carried by the waters of said stream from the city of Chicago down through the drainage canal and the Illinois River to the city of Grafton.

Q. Is there any evidence, bacterial or chemical, that you know of that would justify the conclusion that polluted and infectious matter coming from the sewers of Chicago would reach as far down the Illinois River as the town of Grafton.

A. I have no knowledge or any data whatever of a chemical or a bacterial nature that would justify the conclusion that the pollution brought through the sewers of Chicago to the drainage canal and thus finding its way down the Illinois River would be brought as far down that river as the town of Grafton, in a condition where it could be dangerous.

Q. Would the condition of low water in the Missouri River at a time when there was high water in the Illinois River
10469 be in any way a factor in carrying infected and polluted matters from the sewers of Chicago to the city of St. Louis?

A. If the typhoid fever organism is destroyed under natural conditions which obtain in the Illinois River, in the course of three or four days, the stage of water in the Missouri River and the Mississippi River would exert no effect as I can see on the carrying of infected or polluted water from the city of Chicago to the city of St. Louis.

Q. Professor Sedgwick, in answer to this question, on page 3545 of the record which I have, "Professor, will you state whether or not it is within the bounds of human possibility for any competent expert to say that in the period of low water on the Missouri River, such as is likely to occur at next Christmas time a thaw on the Illinois River waters shed might not endanger the lives of the people using the waters of the Mississippi below the mouth of the Illinois on the Missouri shore and at the city of St. Louis by sending to them in that water the suspended sewage of the sanitary district of Chicago," answered: "I do not believe that it is because in my opinion no

competent expert either can or will say that any means
10470 exist at present by which such unpurified sewage can be
warded off from the people on the Missouri shore and the citizen of St. Louis, under those conditions." I will ask you to state what is your knowledge in regard to the assumption that low water might exist in the Missouri at a time of flood water in the Illinois, and also state whether you know of any means existing in the Illinois River at present that would permit unpurified sewage from the city of Chicago to become a danger and a menace to the public health of the citizens of Missouri and the citizens of St. Louis?

A. From the knowledge which I have of the conditions which would exist if infected and polluted matters entered the drainage canal at Chicago and found their way down through the drainage canal, the Illinois River and the Mississippi River, I would say that I do not regard the assumption that low water might exist in the waters of the Missouri simultaneously with the existence of flood waters in the Illinois would have any effect upon the waters of the Mississippi as would exist at the city of St. Louis so far as the presence of infected and polluted matter derived from the city of Chicago was concerned. Also that the conditions which exist in the waters of the drainage canal and in the waters of the Illinois River under natural
10471 conditions would be such as to destroy infectious matter
capable of producing a disease, which were discharged into the waters and which originated from the sewers of the city of Chicago and that therefore it would be highly improbable that any unpurified sewage from the city of Chicago would pass through the waters of the drainage canal down the Illinois River and Mississippi River and reach the water supply of the city of St. Louis, which would be a danger and a menace to the public health of the citizens of that city.

Q. Professor, from your knowledge of all the conditions that obtain along the Illinois River, as well as your knowledge of the conditions that obtain in Chicago and the drainage canal, also your knowledge of the water supply in St. Louis, such as is had from the intake tower at the chain of rocks, what effect does the sewage from Chicago have upon the water supply of the city of St. Louis or upon the waters of the Mississippi River, as it passes along the state of Missouri?

A. From the knowledge which I have gained with reference to other conditions which exist in the waters of the Chicago drainage canal and in the waters of the Illinois River, together
with the evidence which has been presented as to the
10472 degree of purification which obtains in that stream, as
reported by the chemical and bacteriological examination made of the waters of the drainage canal and Illinois River and the Mississippi River, down to the intake tower at the chain of rocks, at the city of St. Louis, I do not consider that the introduction of the sewage of Chicago into the drainage canal exerts any deleterious effect upon the water supply of St. Louis or upon the waters of the Mississippi River as they pass the State of Missouri.

Q. Please state upon what facts you base your opinion that a typhoid bacillus will not live more than three days or four days under the conditions as they obtain in the Illinois River?

A. The conclusion that the typhoid organism will not live in the waters of the Illinois River for more than a period of three or four days is based upon an extensive series of experiments which were arranged and planned for conjointly with Professors Jordan and Zeit and myself, but carried out independently. These experiments were designed to show how long freshly isolated typhoid organisms would actually live under conditions as they obtained in the drainage canal and in the waters of the Illinois River.

Q. Please give the full details of the experiment made
10473 by yourself, as indicated in the foregoing question and
answer?

A. The experiment was planned at the time that a number of scientific men made the trip from the city of Chicago through the drainage canal, down the Desplaines and Illinois and Mississippi Rivers to the city of St. Louis. It was deemed advisable at that time to make an actual test of the conditions as obtaining in the waters of these rivers, as to just how long typhoid fever organisms would be capable of maintaining their vitality, when exposed to the waters of these rivers under as nearly natural conditions as were compatible with experimental methods. This experiment was planned by Professor Jordan of the University of Chicago, Professor Zeit of the Northwestern University and myself. The work was planned in detail and to each one of the respective parties was assigned certain particular steps to take in the experiment, each one assuming the responsibility for the individual part of the experiment under his own control.

It was designed to expose the typhoid organism to the waters as found in Lake Michigan and in at least three points in the waters along the Chicago River and Drainage 10474 canal, and at least one point along the course of the Illinois River. For the purpose of determining what relation the varying conditions of the water as found in Lake Michigan, Chicago River, drainage canal and the Illinois River would exert upon the mortality of the typhoid organism. The matter of detail and methods was thoroughly discussed at the time this trip was taken and it was decided in order to remove the possible objection which might come from the use of the laboratory stock cultures such as would be found in various bacteriological laboratories the virulence of which might be possibly attenuated to a greater or less degree through their cultivation upon artificial neutrient media for a varying period of time that it would be preferable to employ for the purpose of this experiment strains of the typhoid organisms which had been freshly isolated from the body of patients who were suffering from the disease of typhoid fever.

In order to remove the possible objection which might be urged against the use of merely one strain of the typhoid organism with a knowledge that there is under natural conditions some fluctuations in the virulence and possibly the vital- 10475 ity of different strains of the typhoid bacillus, it was deemed advisable to repeat these experiments and for this purpose said experiments were performed not with merely one culture but with three cultures which were freshly isolated from bodies of persons suffering with typhoid fever, and the use of which would therefore remove any possible objection which might exist, if such experiment had been performed upon only one strain of this organism.

During the time of this trip, when these arrangements were being made, the matter of technique was thoroughly discussed, and it was deemed advisable that in order to remove the objection which might be made to independent experiments conducted by different persons with culture material of possibly varying composition, it would be preferable for the work as outlined to be done in as nearly the same manner, so far as technique was concerned, and upon the same batch of culture material, so far as practicable.

With reference to the detail of the experiment it was decided that Professor Zeit should carry on the experiments in which the typhoid organism was exposed to the waters of Lake Michigan and the waters of the Chicago River; that Professor Jordan would carry on the experiments in at least 10476 two places in the waters of the drainage canal, and for that purpose it was decided to select the entrance and the end of the drainage canal; that I should carry on co-ordinate experiments in the waters of the Illinois River at such point as would represent the greatest possible degree of purification that would be likely to be found.

This variation in conditions of exposure of the typhoid organism was made on the assumption that if the organism was exposed in waters ranging all the way from the strongest concentration of sewage as found in the waters of the Chicago River and at the entrance of the canal, to the point of the greatest degree of purification which could be found in the waters of the Illinois River, and also with the pure waters of Lake Michigan, that this variation in conditions of exposure would be such as would produce the greatest possible range in the results as to the longevity of the typhoid fever organism, when exposed in such waters.

In accordance with this understanding the series of experiments which were allotted to myself were carried out 10477 at the city of Peoria where the conditions of exposure at Averyville were such as was deemed to show the most completely purified stage of the waters of the Illinois River.

For the purpose of this test a laboratory was established at the Bradley Polytechnic Institute, and an assistant placed in charge under my direct supervision for carrying on the detail of this work.

The waters which were infected with the typhoid culture were withdrawn by my assistant and plated out, cultures being taken therefrom and shipped by express to me at Madison, for further study. The cultures which were used in this experiment at Peoria were received by me from Professor E. O. Jordan, and was designated as culture typhoid X, typhoid Y and typhoid Z.

The technique of the experiment was carried out in the following manner:

Recognizing the difficulties which have heretofore obtained in experiments of a similar character in which the typhoid organism was tested as to its longevity in various waters
10478 where such experiments have been conducted in closed vessels made of glass, recognizing the fact that the conditions of such experiments do not accord with the conditions to which the typhoid organism would be exposed when deposited in the waters of a flowing stream, it was deemed necessary to secure information which would present the conditions that would actually obtain when such organisms were exposed in running water and the method was therefore devised of exposing the typhoid organism under such conditions as would permit of the establishment of a state of affairs which would be more nearly in accord with those which existed in the flowing stream. For this purpose a method was used which I had devised and used in similar work in preceding years, where cultures of bacteria could be exposed in permeable sacs which would permit of the ingress and egress of soluble substances on either side of this permeable membrane.

For the purpose of this experiment large parchment sacs were employed, the cubic content of which could be varied at will and could be entirely closed so as to prevent the leakage of bacteria from the inside toward the out or vice versa, but which would permit of the osmotic action of any
10479 soluble substances either to the inside or outside of this permeable membrane. In this way it was expected that many of the defects which have heretofore obtained in experiments which have been made in closed vessels constructed of glass would not obtain where the conditions of the experiment were such as to permit of this free osmotic action. At the same time the conditions of the experiment precluded the possibility of particulate substances such as bacteria from passing either in or out. The conditions then under which this exposure was made was to fill these sacs with water taken from the point in the river where the sacs were to be later immersed, and added to

this volume of water placed in these sacs varying quantities of fresh cultures from these freshly isolated typhoid organisms. In this way the typhoid organism would be subjected to the same conditions as would obtain in the river. The conditions were identical with those which would obtain in any given quantity of river water equal to the capacity of the sacs. If any deleterious effect was to be observed on the typhoid organism due to growth and development of water bacteria which are more habituated to this environment, it would impose itself upon the imprisoned tphoid organisms if the experiment were kept under such conditions as would permit of their isolation.

10480 After some experiments were performed in which the parchment sacs were exposed in the waters of the river in a partially submerged condition, which experiments came to naught through the breaking of the sacs, and the surrounding floats from their moorings, on account of the high winds which existed at such times as when the wind was blowing up the river, it became necessary to vary the original plan of the experiment and entirely immerse the sacs which were filled with river water and inoculated with typhoid bacillus. It was therefore necessary to close the upper opening of these sacs in such a way as to permit of easy access so that samples of water could be removed at intervals for subsequent examination. This was done by making the sacs longer than they would ordinarily be made and folding the same back and forth for at least eight times, placing between the same pieces of soft wood, and binding down this folded parchment by means of strong clamps, slightly wider than the tube on which they were placed. This permitted of the complete immersion of the parchment sac with the opening of the sac closed so tightly that water could neither pass in nor out.

10481 The difficulty of recognizing the typhoid organism when growing in competition with the ordinary water bacteria which are found so abundantly in surface waters led to the necessity of introducing some measures which would tend to repress, as far as possible, these saprophytic water organisms and which would also permit of the differentiation of the typhoid organism from the colon bacillus and other allied forms which might naturally be expected to be found in sewage.

10482 These sacs were then immersed in large galvanized iron cylinders, the top and bottom of which were covered with a removable wire screen. They were immersed at a distance ranging from 6 to 12 inches below the surface of the water. This was done for the purpose of placing the sacs under such conditions as would not permit of their being torn to pieces by the violent wave action which frequently obtained under the conditions of the experiment. These galvanized cylinders containing these sacs were immersed in the waters of the Illinois river immediately above the Averyville wagon bridge at such a point as would permit of their being exposed to the rapid current of the stream, but protected by the false work of this bridge, so as to permit their escaping rupture from contact from passing boats and floating objects of any sort. The galvanized iron receivers which held these sacs were padlocked by the collector carefully each day after removing the requisite sample. As an additional precaution to prevent any tampering with the experiment, the bridge tenders were engaged to watch the galvanized receivers to see that no acident befell them in any way. The samples of water taken from the interior of the sacs were re-
10483 moved from the same day by day, and a quantity of water ranging from 7 to 10 cubic centimeters being taken out for each sample before the sample was removed, the parchment sacs were thoroughly shaken so as to distribute the contents uniformly and thus permit the securing of a proper sample. The samples were removed in sterile containers, taken immediately to the laboratory and culture plates prepared in accordance with the plan previously outlined on the culture material, which was used by Prof. Jordan. The time which elapsed between the securing of the sample and preparation of the culture plates, ranged from one to not more than two hours.

10484 Recognizing the necessity of differentiating readily the typhoid organism, from the water bacteria, and sewage organisms which might possibly be present in the waters of the flowing stream, it was deemed preferable to make the cultures used for the isolation and separation of the presumptive typhoid organism upon media which would, if possible, inhibit the growth of these other than typhoid forms, or at least permit of the more or less ready differentiation of the typhoid bacteria from related organisms. For this purpose, Drigalski's medium was

employed for the differentiation of the typhoid organism. In order to eliminate any possible variation which might come from the use of different batches of such media, I received at my request from Prof. Jordan a batch of the above mentioned media and a part of which was also retained by him, for the purposes of use in the portions of the experiment, which was detailed to him. This permitted of the direct comparison of the organisms as to the numbers and kinds found in the waters of the Illinois river at Averyville in the comparison with the samples
10485 which were taken from the drainage canal by Prof. Jordan.

In making the cultures, wide variations in the amount of culture material was employed until such experience was acquired as would permit of the preparation of plates which would give the maximum amount of bacterial growth without causing a suppression of the organisms on account of their being present in such large numbers as to prevent the proper development of the cultures.

Culture plates were incubated at blood heat for a period of 24 hours. They were then examined and from the resultant growth which was obtained on the same, pure cultures were isolated on agar or glucose agar and prepared for shipment to Madison.

The plates were kept for a certain period of 24 hours at the room temperature in order to permit of the further development of any colonies which might not have appeared during the first 24 hours' incubation of the cultures at the higher temperature. They were then worked over again and in case any organisms were noted which resembled in any way the colonies of the typhoid fever organism, as indicated by their growth
10486 upon the Drigalski's medium, they were isolated, tubed, and also sent to Madison for further study.

Recognizing the fact that a considerable part of the variation in results which have heretofore been reported on the longevity of the typhoid fever organism when exposed in waters which normally contained water bacteria, is due to a variation in the amount of seeding which is present in a given volume of liquid, this series of experiments was extended by seeding duplicate sacs filled with river water, with a varying quantity of a freshly grown typhoid culture. In this series of experiments there were placed 15 different parchment sacs, inoculated with three different strains of freshly isolated typhoid organisms, denominated "X," "Y" and "Z," which had been previously received from Prof. E. L. Jordan .

Sacs 1, 2, 3, 4 and 5 were inoculated with that strain of organism designated as typhoid "X."

Sacs 6, 7, 8, 9 and 10 were inoculated with that strain of typhoid organism denominated typhoid "Y."

Sac No. 11 was a non-inoculated control sac, filled with water from the river.

10487 Sacs No. 12, 13, 14 and 15 were inoculated with strains of culture taken from a culture denominated typhoid "Z."

The amount of seeding of a typhoid organism placed in these sacs ranged in the case of the X cultures, from approximately 1000 typhoid organisms per cubic centimeter in sac 1, approximately 2000 typhoid organisms per cubic centimeter in sac 2, approximately 4000 typhoid organisms per cubic centimeter in sac 3, approximately 10,000 typhoid organisms per cubic centimeter in sac 4, and approximately 20,000 typhoid organisms per cubic centimeter in sac 5.

In the series of sacs inoculated with the culture "Y," the range in seeding was approximately the same: About 1000 typhoid organisms per cubic centimeter being inoculated in sac 6. Approximately 2000 in sac 7, approximately 4000 in sac 8, approximately 10,000 in sac 9, and approximately 20,000 in sac 10.

In the series of cultures, or, rather, in the series of sacs, infected with "Z" culture, sac 12 received 540 typhoid organisms per cubic centimeter. Sac 13 approximately the same
10488 number, sac 14, approximately 5400 typhoid organisms per cubic centimeter and sac 15 approximately 10,800 typhoid organisms per cubic centimeter. This gave a range from the lightest to the heaviest seeding represented in the series of cultures inoculated with "X," "Y" and "Z," from 1 to 20 fold. These seedings were determined by taking an equivalent amount of culture to that which was used in the seeding of the sac, and plating the same upon Drigalski's culture medium so as to determine with approximate accuracy the number of inoculated organisms. In conjunction with this inoculation the number of organisms which were normally present in the uninocu-

lated water was also determined, so as to show the relative number of typhoid bacteria, to those which normally belonged to the water.

These determinations of the water bacteria were also made at first upon Drigalski's medium which does inhibit the growth of a large portion of the water bacteria, but inasmuch as Drigalski's medium was used for the detection of the typhoid organism, it was regarded as essential to know the relative number of typhoid germs which were added to parchment sacs in
10489 comparison with forms normally present in the water.

The number of water bacteria found in each sample in a cubic centimeter of river water were approximately 50 to 80, whereas the number of typhoid organisms which were inoculated in such waters, which gave the strongest growth on Drigalski medium of water bacteria, ranged from the minimum of 540 per cc. to 20,000 per cc. The ratio then of typhoid fever organisms to all other organisms present in the water, was in the lowest case about 11 to 1, and in the strongest seeding about 40 to 1.

In this way, it is evident that the seeding of typhoid bacteria which was placed in the water, would be vastly greater than would be likely to obtain under natural conditions where typhoid material found its way into flowing streams.

For the purposes of comparison of the purity of this water with that of waters taken from any other sources, and particularly with the waters in Lake Michigan, the number of organisms per cubic centimeter as found in the water of the river, was determined upon ordinary nutrient agar as well as upon Drigalski medium.

The results of those analyses made on a number of days, are as follows:

10490 Oct. 13, river water, plain agar, 500 bacteria per cubic centimeter, Drigalski, 80.

Oct. 15, river water, plain agar, 60 bacteria per cubic centimeter, Drigalski, 25.

Oct. 16, river water, plain agar, 240 bacteria per cubic centimeter, Drigalski, 55.

Oct. 19, river water, plain agar, 200 bacteria per cubic centimeter, Drigalski, 40.

Oct. 21, river water, plain agar, 163 bacteria per cubic centimeter, Drigalski, 2.

Oct. 23, river water, plain agar, 102 bacteria per cubic centimeter, Drigalski, 11.

It is thus evident that the use of the Drigalski medium gave us exceptional conditions for the repression of the indigenous water bacteria, and rendered it possible for the easier detection of all typhoid colonies which developed on the medium.

This is a matter of importance, as it frequently happens in experiments of this sort that the number of indigenous organisms is so large in comparison with the adventive organisms, such as the typhoid germ, that the failure to detect the presence of the typhoid germ may easily arise from the overlook-
10491 ing of isolated colonies of this organism when grown in cultures containing large numbers of indigenous bacteri.

The cultures were shipped by express to Madison, where they were subjected to all of the differential tests which are necessary to differentiate the typhoid organism from related bacteria.

Cultures were first made in glucose agar. In this medium the typhoid organism is unable to ferment the sugar. The colon and other sewagic forms, are capable of producing gas.

By an inspection of the cultures frequently for 24, and always after 48 to 72 hours of incubation, it was possible to eliminate all cultures of the colon type by reason of their rapid fermentation of the glucose sugar.

All cultures which showed no signs of gas production, when inoculated in glucose shake cultures, were then inoculated upon nutrient gelatine, litmus milk, and glucose free broth for the production of indol.

Indol cultures were then incubated at blood heat for a period of 3 to 4 days; all milk cultures for not less than 7 days,
10492 and all gelatine cultures, were kept under continuous observation for a period of not less than ten days.

All cultures which showed no tendency to liquefy gelatine in ever so small a degree, or which caused the production of acid in litmus milk, with the decolorization of the litmus solution and the curdling of the milk, and all cultures which showed in litmus milk the production of alkaline reaction, evidenced by the increasing intensity of the color of the litmus solution, were excluded from further consideration.

All cultures which had shown no signs of gas in glucose shake cultures, no signs of liquefaction when grown for a period of not less than 10 days in nutrient 10 per cent. beef broth gelatine, and which were unchanged, or showed only a change to a lilac tint in milk, were still held for examination, as presumptive typhoid organisms, and further tested. Also those which showed a negative reaction for indol were still held for examination and subjected to a test upon litmus dextrose broth made from glucose free media, to which 1 per cent. of glucose sugar and litmus was added.

The results of this series of cultures were then charted,
10493 and all organisms which were practically unchanged on
milk, and which showed negative indol reaction, but which were able to ferment glucose producing acid, thereby changing the color reaction in litmus dextrose broth solution, were still kept for further examination.

These results were then charted in accordance with the well known plan of Fuller, so as to permit of the use of plus or minus signs for ready identification and all organisms which were aberrant, with reference to typhoid characteristics in only one characteristic, were again retested so as to be absolutely certain that the culture characteristics were correct. No organism was eliminated from this series of culture tests unless it departed from the usually expected culture characters given in connecton with descriptions of the typhoid bacillus.

Cultures which had up to this point shown characteristics which brought them within the pale of the culture characters which are found in the case of the bacillus typhosis, were then
subjected to what is known as the agglutinating test,
10494 which is regarded as the most crucial test which any pre-
sumptive typhoid organism can be subjected to.

The agglutinating test was made by using the blood of rabbits which had been previously immunized by repeated and frequent injections of freshly grown agar cultures of the strains of the typhoid bacillus which were used in these experiments for this purpose.

For this purpose rabbits were immunized, with the cultures previously denominated "X," "Y" and "Z," respectively.

The degree of immunization was continued with these cultures until a point was reached were the agglutinating property of the blood of these rabbits was able to cause a sedimentation of a freshly prepared homeogenous emulsion of a 24-hour old agar suspension of the homologous organism in dilution of not less than 1 to 1000.

This degree of dilution is sufficiently high so that any organism which would react positively to blood in this diluted solution, would be regarded, so far as this most crucial test
10495 is concerned, as positively typhoid.

Adjourned until 9:30 a. m., Friday, February 19th, 1904.

9:30 A. M., Friday, February 19, 1904.

10496 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. H. L. RUSSELL

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

10497 Q. Professor, go on and describe the experiment in full which you made at Peoria?

A. In addition to the tests which were made for the use of homologous sera in which the degree of dilution of 1 to 1,000 was reached, further experiments were made with the use of control sera. The purpose of using these control sera, which consisted of taking the blood of normal rabbits, was that in some cases it has been found that organisms are capable of agglutinating the blood of the rabbits when the degree of concentration is very strong.

For this purpose in these control experiments the concentration of the blood serum which was used was increased ten-fold over that which was employed with the homologous sera. That is to say all organisms which gave a positive reaction with the homologous sera in the degree of dilution of 1 to 1,000 were further tested with normal sera of rabbits in the degree of dilution of 1 to 100. In such cases a negative test for aggulutination must be regarded as confirmatory evidence that a positive test in the degree of 1 to 1,000 with homologous sera is indicative of the fact that the organism
10498 tested is a genuine typhoid bacillus.

In addition to these tests with control sera a large number of organisms which were up to this time regarded as negative typhoid on account of their aberrent culture characteristics on nutrient media of the different kinds employed were used for agglutination with the respective sera in the degree of dilution of 1 to 1,000. In such cases organisms should show no agglutination if they had no typhoid affinities.

Further, in addition to the cultures which were tested with the homologous sera, 1 to 1,000, controls tests were likewise made in which the organism was exposed in test tubes to which no blood serum was added.

In such cases the turbidity of the homogeneous suspension which was produced by the mixture of the agar growth with the salt solutions which were used as a menstrum for testing these control tests, should remain unimpaired.

The results of the tests which were made with these different sera will be reported later, in a summary of findings.

As stated before, the number of bacteria which were naturally present in the water of the Illinois River at Averyville was
relatively low when placed upon Drigalski media. The
10499 number of typhoid organisms which were added per cc. to
the water in the parchment sacs was invariably very much
larger than the number of bacteria which appeared upon the Drigalski media. In no case was this ratio of water bacteria to typhoid organisms less than 10 to 1, and in the parchment sacs containing the strongest seeding were as high as 400 to 1.

As a natural consequence of this relation of the number of colonies which appeared upon the culture plates when Drigalski medium was employed for isolation, the large majority showed upon an examination of such plates, characters which allied them to the typhoid bacillus. The use of the Drigalski medium cuts out by far the larger proportions of the water bacteria, even more so than it does the sewage bacteria, and in as such as the colon or sewage bacteria occurs only in limited numbers in the waters of the Illinois River at Averyville, it naturally followed that by far the larger proportion of the appearing colonies under these conditions would be typhoid in appearance. It was, therefore, unnecessary to remove all of
the colonies which appeared upon the plates in every in-
10500 stance. This, however, was done in a number of in-
stances, and it was shown that the selection of representative colonies from the large number of presumptive typhoid

colonies which appeared on the plate gave as positive results for the determination of the presence of typhoid as did the removal of the entire number of appearing colonies.

It should be borne in mind that the work of identifying the presumptive typhoid organisms which were removed from the culture plates at Peoria required the work of several weeks, as these cultures were shipped to Madison and then subcultured at this place, and finally agglutinating tests employed. It was, therefore, impossible, in any case for us to determine whether an organism was going to be proved to be typhoid or not until after a considerable lapse of time, and this in no case was done until after the completion of the experiment at Peoria, so that it was impossible in any way for us to know the actual outcome of these experiments until after the experiment itself had long been completed.

The results of the findings as to the presence and absence of the typhoid organism in the respective parchment sacs which were placed in the water at Averyville will now be given.

10501 The series of cultures which were used in these experiments embraced three different strains, designated as "X," "Y" and "Z." In the series of the cultures made with the organism "X," five different sacs were employed, which were placed in the river on the 8th day of October, 1903.

In the series made with "Y," four were employed; in the series made with "Z" four.

The variation in the amount of seeding ranged from 540 typhoid organisms per cc. to 20,000. The results of the findings of those tests in the case of parchment sac number 1 are as follows:

From the plates made 24 hours after the sacs had been immersed in the water 12 colonies were removed, 1 of which was found to be typhoid.

On the third day 9 were removed, none of which proved to be typhoid.

On the fifth day 11 were removed, none of which were found to be typhoid.

On the tenth day 10 were removed, none of which were found to be typhoid.

In these different series emphasis was placed in the matter of tracing out the two extremes as far as seeding was
10502 concerned, therefore a large number of cultures were

taken of the sacs which contained the lightest and the heaviest seedings, and the intermediate seedings were used as checks or duplicates.

In the sac designated 2, inoculated with the "X" colony, 8 colonies were removed from the plates made on the 4th day. None of these was found to be typhoid.

In sac 3, 12 colonies were taken off on the sixth day, none of which was found to be typhoid.

In sac number 4, 13 (13) colonies were removed, on the 4th day, none of which was typhoid.

On the 5th day 3 colonies were fished. None of these proved to be typhoid.

On the 7th day 8 were removed, none of which was typhoid.

In sac number 5, "X" series which contained the maximum degree of seeding, 20,000 typhoid organisms per cc. the total approximate typhoid contents of the tube being about 4,000,000 typhoid bacteria in the 200 cc. sample used.

6 colonies were taken off the plates made on the first day,
10503 none of which was found to be typhoid.

13 were removed on the second day, two of which were found to be typhoid.

9 were taken off on the 5th day, none of which was typhoid.

8 were taken off on the 6th day, none of which was typhoid.

7 were taken off on the 7th day, none of which was typhoid.

12 were taken off on the 10th day, none of which was typhoid.

12 were taken off on the twelfth day, none of which was typhoid.

11 were taken off on the 14th day, none of which was typhoid.

15 were taken off on the 17th day, none of which was typhoid.

Sacs numbered from 6 to 10, inclusive, inoculated with the "Y" culture were placed in the river on the 10th day of October, 1903. The results of the findings with cultures taken from these sacs are as follows:

10504 Of 8 colonies which were removed from the plates after the organisms had been exposed in the sac in the river water for one day, 3 colonies proved to be typhoid.

Of six removed on the third day 2 proved to be typhoid.

In these particular sacs no further tests happened to be made until the 14th day on which 9 were removed, none of which was typhoid.

In sac 7, 9 colonies were removed on the 4th day, none of which proved to be typhoid.

5 were removed on the 12th day, none of which was typhoid.

5 were removed on the 14th day, none of which was typhoid.

6 were removed on the 16th day, none of which was typhoid.

In sac 8, 8 were taken on the sixth day, none of which was typhoid.

6 were removed on the tenth day, none of which was typhoid.

4 were removed on the 12th day, none of which was typhoid.

10505 8 were removed on the 16th day, none of which was typhoid.

In sac 9, 11 were removed on the 4th day, none of which was typhoid.

7 were removed on the 7th day, none of which was typhoid.

11 were removed on the 10th day, none of which was typhoid.

6 were removed on the 12th day, none of which was typhoid.

In sac number 10, containing the highest amount of seeding 20,000 typhoid organisms per cc., 8 colonies were taken on the first day, 4 of which proved to be typhoid.

16 were taken on the 3rd day, 10 of which proved to be typhoid.

18 were taken on the 5th day, none of which was typhoid.

6 were taken on the 7th day, none of which was typhoid.

7 were taken on the 10th day, none of which was typhoid.

Tube number 11 was used as a control tube, filled with 10506 river water, but not seeded with the typhoid organism.

Cultures were made of this from time to time but no presumptive typhoid colonies were observed.

Series consisting of sacs 12 to 15, inclusive, inoculated with the "Z" culture, and immersed in the river on the 15th day of October, 1903, were found to show the following results:

Tube Number 12, inoculated with 540 typhoid organisms per cc., the lightest seeding which was employed in the case of any of the experiments, showed, 1 hour after the tube had been immersed in the water, 3 positive typhoid colonies out of the 3 colonies which were removed.

After 24 hours immersion in the water 17 colonies were picked off from the colonies of which 15 were found to be typhoid.

On the second day 12 were taken off, 6 of which were found to be typhoid.

On the 5th day 18 colonies were removed, none of which were found to be typhoid.

On the twelfth day 2 colonies were taken off neither of which was typhoid.

Sac 13 showed on the 7th day no typhoid colony of the
10507 3 which were removed.

On the ninth day 4 colonies were fished off, none of which proved to be typhoid.

7 colonies were removed on the 12th day, none of which was typhoid.

Sac 14 one hour after immersion, 3 colonies were removed, all 3 proved to be genuine typhoid.

7th day, 1 colony taken off found not to be typhoid.

Sac 15 24 hours after immersion 15 colonies were removed, 14 of which proved to be typhoid.

On the second day 13 colonies were taken off, 6 proved to be typhoid.

On the 5th day 12 colonies were removed, none of which proved to be typhoid.

On the 9th day 14 colonies were removed, 1 of which proved to be typhoid.

On the 12th day 2 colonies were removed neither of which proved to be typhoid.

Summarizing the results obtained in the foregoing analyses 72 colonies were examined from the different sacs after they had been exposed in the water for 24 hours and of these 43
were found to be typhoid. These 72 colonies were taken
10508 from 8 different sacs, and in these 8 sacs the typhoid
organisms were found in 7 of these sacs.

Of the 25 colonies which were examined on the second day, 12 were found to be typhoid.

These 25 colonies were removed from 2 sacs, both of which contained typhoid.

Of the 44 colonies removed on the third day 14 of them were found to be typhoid.

These 44 colonies were taken from 5 sacs and the typhoid organisms was found in three out of five of these sacs.

41 colonies were taken off on the 4th day, from 4 different sacs, and in none was any typhoid colonies found.

61 colonies were removed on the 5th day from 6 different sacs and in no case was typhoid found.

28 colonies were taken from 3 sacs on the 6th day, and none proved to be typhoid.

32 colonies were taken from 6 sacs on the 7th day, none of which was typhoid.

18 colonies were taken from 2 sacs on the 9th day, 1 of which proved to be typhoid.

10509 On the 10th day 5 sacs were examined, 46 colonies being removed, no typhoid found.

In 7 sacs taken on the 12th day, 38 colonies were examined, none were found typhoid.

In 3 sacs examined on the 14th day, 25 colonies were removed, none were typhoid.

From 2 sacs examined on the 16th day 14 colonies were removed, none of which were typhoid, and in 1 sac examined on the 17th day 15 colonies were taken off, none of which were typhoid.

In these particular series of experiments 459 colonies were examined. The different sacs which were employed were tested 54 times and the typhoid organism was found fourteen times, 70 colonies out of the total 459 belonging to this organism.

During the first 3 days 141 colonies were fished off, 69 of these were found to be typhoid and in the 318 cases which were examined after 3 days only 1 typhoid organism was found.

Q. Have you prepared a table of summaries, based upon this experiment with the typhoid bacilli in the parchment sacs?

A. I have.

10510 Q. Will you produce and read such table of summaries?

A. It is as follows:

10511

DAYS.

Strain of cult used.	Laby. No. Suc.	No. typh. organisms per cc. inoculated..........	1		2		3		4		5		6	
			No. col. fished.	No. typh. col..	No. col. fished.	No. typh. col..	No. col. fished.	No. ty. col....	No. col. fished.	No. ty. col....	No col. fished.	No. ty. col....	No. col. fished.	No. ty. col....
X...	1..........	1,000	12	1	...	....	9	0	....	....	11	0	....	....
X....................	2..........	2,000	....	...	....	....	....	...	8	0	....	....	....	....
X......	3..........	4,000	....	....	....	....	....	....	....	....	....	....	12	0
X....................	4..........	10,000	....	....	....	...	....	..	13	0	3	0	....	....
X....................	5..........	20,000	6	0	....	....	13	2	....	....	9	0	8	0
Y....................	6..........	1,000	8	3	....	....	6	2	....	....	....	....	....	....
Y.	7....	2,000	....	....	. .	. ..	....	....	9	0	...	....	....	....
Y....................	8..........	4,000	....	....	....	....	....	....	....	....	....	....	8	0
Y.........	9..........	10,000	....	....	....	....	....	....	11	0	....	....	....	....
Y..........	10...	20,000	8	4	....	....	16	10	....	....	18	0	....	...
	11..........	Control.	....	....	....	....	....	....	....	....	....	...	....	....
Z..............	12......	540	1 hr 3	3	....	...	....	....	....	....	8	0	....	....
Z..........	13..........	540	17	15	12	6	. ..	....	....	....	....	....	....	....
Z....................	14..........	5,400	1 hr 3	3	....	....	....	....	....	...	....	....	....	....
Z	15..........	10,800	15	14	13	6	....	....	....	....	12	0	....	....
No. col. daily examined from all sacs.....			72	....	25	...	44	....	41	....	61	....	28	...
No. typhoid colonies found on successive days.			....	43	....	12	....	14	....	0	....	0	....	0
Total number sacs examined on different days of exposure			8	....	2	....	5	....	4	....	6	...	3	....
Total No. sacs in which typhoid was found....			....	7	....	2	....	3	....	0	....	0	....	0

DAYS.

7		8		9		A 10 B		A 11 B		A 12 B		A 13 B		A 14 B		A 15 B		A 16 B		A 17 B		Totals ....
No. col. fished.	No. ty. col....	No. col. fished	No. ty. col.....	No. col. fished.	No. ty. col.....	No. col. fished.	No. ty. col.....	No. col. fished.	No. ty. col.....	No. col. fished.	No. ty. col.....	No. col. fished.	No. ty. col.....	No. col. fished.	No. ty. col.....	No. col. fished.	No. ty. col.....	No. col. fished.	No. ty. col.....	No. col. fished.	No. ty. col.....	
....	....	....	....	....	....	10	0	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
8	0	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
7	0	....	....	....	....	12	0	....	....	12	0	....	....	11	0	....	....	....	....	15	0	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	9	0	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	5	0	....	....	5	0	....	....	6	0	....	....	....
....	....	....	....	....	....	6	0	....	....	4	0	....	....	....	....	....	....	8	0	....	....	....
7	0	....	....	....	....	11		....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
6	0	....	....	....	....	7	0	....	....	6	0	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	2	0	....	....	....	....	....	....	....	....	....	....	....
3	0	....	....	4	0	....	....	....	....	7	0	....	....	....	....	....	....	....	....	....	....	....
1	0	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	14	1	....	....	....	....	2	0	....	....	....	....	....	....	....	....	....	....	....
32	....	....	....	18	....	46	....	....	....	38	....	....	....	25	....	....	....	14	....	15	..	450
....	0	....	....	....	1	....	0	....	....	....	0	....	....	....	0	....	....	....	0	....	0	70
6	....	....	....	2	....	5	....	....	....	7	....	....	....	3	....	....	....	2	....	1	....	54
....	0	....	....	....	1	....	0	....	....	....	0	....	....	....	0	....	....	....	0	....	0	14

10512 **Q. Did you make any other experiment, using any other means except the parchment sacs?**

A. Yes sir.

Q. Will you detail the experiments that you made wherein you employed other means, in full?

A. In addition to the series which were made with the parchment sacs, another method was used which approached the problem from a somewhat different point of view. The method which was employed in this case was as follows:

Ordinary commercial agar which is a plant jelly ordinarily employed for bacterial purposes was taken and this was washed in running water for a period of several days so as to remove as far as possible, all soluble products which might happen to be present in this agar substance. This agar was then prepared in the usual manner followed in bacteriological laboratories when such is employed in the preparation of nutrient media and from the prepared agar small rectangular blocks were cut out, which were about a half inch square, and about 2 inches long. These rectangular blocks were inoculated with
10513 freshly grown typhoid cultures by means of a platinum wire. This forced the typhoid organism down into the center of the block; and the top of these agar blocks was sealed from contamination with the exterior by means of searing the surface with a hot iron. The typhoid organism under these conditions was placed in a medium which was incapable of supporting growth as this ordinary agar had had added to it no nutrient substances, and moreover all soluble substances capable of being removed by soaking were taken out. Tests were made upon this non-nutrient agar to see whether the typhoid organism would be able to grow under these adverse conditions. It was found that such was not the case. According to Oswald the eminent German physicist, this soluble agar possesses the property of allowing diffusion to take place quite as rapidly through its substance, as would be the case in water itself. Hence it follows that if typhoid organisms were placed on the interior of an agar mass and then exposed in an aqueous medium containing bacteria of various kinds then the typhoid organism would be subjected to the influences which would arise
10514 from the growth and development of these water or sew-

age bacteria in the surrounding media in which these agar blocks were immersed.

Control experiments were instituted when these agar blocks inoculated with the typhoid bacilli were not exposed in water but kept in air. It was determined, under these conditions, that the typhoid organism was not capable of growing in these blocks, but was capable of retaining its vitality for a period of time which was at least two weeks and in some instances considerably longer.

These agar blocks were inoculated with the three strains of typhoid bacilli, "X", "Y" and "Z", and were placed in considerable numbers in the waters of the Illinois River in small galvanized iron cylinders, the top and bottom of which were covered with a coarse wire mesh. Under these conditions the water had free access to these individual blocks on the inside of which were inoculated these pure cultures of the typhoid organism. The results of the series of tests, 4 in number, which were made with cultures "X," "Y" and "Z," are as follows:

Series 1, inoculated with culture X, was examined on the first day by taking one of these agar blocks from the number which was immersed and paring off the upper surface of
10515 the block and attempting to transfer any material which
was in the line of the inoculation previously made.

It should be said in this connection that the exact point where the typhoid organism was present was known because in making this inoculation the needle was first touched to a mass of sterilized carbon, and then touched to the typhoid culture so that in making the inoculation a streak of black carbon was deposited along the line of the needle track, together with the typhoid organisms which of course would be transferred. In this way the exact location of the typhoid germ could be determnied in every case and in removing the transfer cultures care was always taken to see that the needle traversed the sooty streak which marked the place where the typhoid organisms had been planted. Transfers made from this first series of agar blocks were made on the first, third, fifth, ninth, twelfth, fourteenth, sixteenth and nineteenth days, after their immersion in the river water. In no case did any resultant growth occur in any of the sub-cultures which were made from these
10516 transfers.

Series 2 was inoculated with the same organism and cultures taken immediately, on the first, second, third, sixth, eighth, tenth and thirteenth days and typhoid organisms found in the case of the transfers which were made immediately after the infection, also on the second day.

Series 3, inoculated with the strain of typhoid organisms designated as "Y," were prepared in a similar way and from these cultures transfers were made immediately after inoculation, on the first, third, fifth, seventh, tenth, twelfth, fourteenth and seventeenth days. In no case was any organism found in such transfers except those which were found in the transfers made immediately after insertion, and also on the fifth day.

In the fourth series, inoculated with "Z" culture, cultures were removed immediately after inoculation on the 1st, 2nd, 3rd, 6th, 8th, 10th and 13th days. In this series organisms belonging to the typhoid class were found in those transfers made
10517 immediately after inoculation on the 1st, but at no later date.

These experiments were conducted in the river water of the Illinois River at Peoria. Subsequent to this time another series was made in the lake water of Lake Mendota, at Madison, Wisconsin, in order to increase the amount of data long this line and to determine any possible variation in waters of different organisms. These consisted of two experiments made in a similar manner with non-nutrient agar, and cultures were removed on the 3rd, 7th, 11th, 12th, 15th and 21st days after their immersion in the water. From these sub-cultures were prepared and in no case was the typhoid fever organism found except in the case of the samples removed on the third and seventh days.

A second series was also prepared in which cultures were removed on the 3rd, 7th, 10th, 12th and 15th days, and in no instance was the typhoid organism found, except in the case of the colony removed upon the third day.

The summary of the results of these cultures on the vitality of the typhoid fever organisms, inoculated in numbers, so large that the number of organisms produced turbidity to be
10518 recognizable with the unaided eye, that the exposure of these numerous typhoid organisms in the waters of the

Illinois River and also in the waters of Lake Mendota at Madison, resulted in loss of vitality of this enormous number of typhoid bacteria to such an extent that in no case were any typhoid organisms found after the eighth day and in the case of one series none was found even on the first day. This variation in the vitality of the typhoid cultures, were an indefinite number of organisms were inoculated, under these conditions, and where it was not exposed directly to the competition which exist between water and sewage bacteria and the typhoid organism is more surprising as the organism was not directly exposed to the influences of the competing bacteria themselves but merely to the soluble products which these germs are capable of producing.

Q. Professor, how did the experiment with the agar block differ from the experiment with the parchment sacs?

A. In the case of the parchment sacs the typhoid bacteria were exposed to the direct contact of all of the water or other bacteria which might be present in the samples of water which were placed in the sacs. In the case of the agar blocks 10519 the typhoid organisms were not exposed to this direct contract but were exposed to those products of the metobolic activity of water and other bacteria which might be present in the outside medium and which would find it possible, if in solution, to pass through the agar block, by diffusion, and so possibly act upon the typhoid bacteria themselves which were screened by these agar blocks.

Q. Which method afforded the best opportunity for the life of the typhoid, the agar block or the parchment sacs?

A. I find that the experiment made with the agar blocks gives more favorable conditions for the retention of the vitality of the typhoid organism than was the case in the parchment sacs where the contact of typhoid organisms with other bacteria was rendered possible.

Q. Are you acquainted with the results of that part of this experiment which was made by Professor Jordan on the waters of the drainage canal and Professor Zeit on the waters of the Chicago River and Lake Michigan?

A. Since the practical completion of the experimental work which was done at Peoria, I have had several conferences with

Professors Jordan and Ziet relative to the experiments
10520 which were assigned to them, and am familiar with the
results which they have obtained in these experiments on the longevity of the typhoid organism in the waters of Lake Michigan, the Chicago River and the drainage canal.

Q. From the results obtained in this combined experiment what conclusion do you draw as to the longevity of a typhoid bacillus in the water of Lake Michigan?

Mr. Jeffries: I object to that for the reason there is not a sufficient number of examinations made upon which to base a safe and reliable opinion.

A. I should say from the results of these experiments with which I am familiar, that the longevity of the typhoid organism immersed in the waters of Lake Michigan would be considerably longer than in the waters of the Chicago River, and the organism would probably be able to live for a period of six or eight days.

Q. What conclusion do you draw as to the longevity of the typhoid bacillus in the waters of the Chicago River and the drainage canal, based upon the results of this experiment, conducted by Professors Zeit, Jordan and yourself?

10521 Mr. Jeffries: Let the record show that the complainant
objects to the witness giving any opinion upon any of the determinations made in this joint and concurrent experimental transaction for the same reasons stated in the objection to the previous question.

A. I should consider that the typhoid organisms deposited in the waters of the Chicago River and drainage canal would have a much shorter duration of vitality than in waters of Lake Michigan, and that such vitality would not extend to a period of more than two or three days.

Q. What conclusion do you draw as to the longevity of a typhoid bacillus in the waters of the Illinois River, based upon this experiment?

A. From experiments which I have actually made when freshly isolated cultures of bacillus typhosus were exposed in permeable sacs in varying numbers so that the germ content of the typhoid organism exceeded at least the germ content of the water used in the ratio of 100 to 1 or more, and where the or-

ganisms were destroyed in the course of about three days, with
one possible exception, and that if this was the condition which
was obtained under the conditions in which the experi-
10522 ment was made, when the effect of other environmental
factors were excluded, such as the influence which would
come from sedimentation, dilution, influence of light, vital concurrence with green plant forms which might be found in the waters of such river, I should certainly consider that the life of the typhoid organisms when subjected to the more severe conditions which obtain in the waters of the Illinois River itself than was the case in the experiments with the parchment sacs, that it certainly would be no longer in the waters of the Illinois River and in all probability would be shorter, hence I would conclude from the foregoing data that the vitality of the typhoid organism would not in any case be maintained for more than a period of a very few days, three or four at the outside.

Mr. Jeffries: I move to strike out the answer for the reason that it is not entirely responsive to the question in that it is not based upon the statement of facts contained in the question, not confined to the experiments made by this witness and the experiments made by Professor Jordan and Professor Zeit, jointly, but that the witness has taken into consideration other factors such as sedimentation, dilution and plant destruction of bacteria, and I move to strike out all the testimony of this
witness and Professors Jordan and Zeit with reference to
10523 these particular experiments, for the reason that from the
answer given by this witness other things must be taken
into consideration in determining the life of the typhoid beside the naked experiments themselves, and that any conclusions or opinions that may be based upon these experiments alone as to the life of the typhoid germ are unreliable and untrustworthy as shown by the testimony of this witness in the answer which he has just given to the last question.

Q. What in your opinion, based upon all the knowledge which you possess in regard to typhoid germs would be the fate of the typhoid bacillus passing from the sewers of Chicago into the Chicago River, and thence into the drainage canal, and down the Desplaines and the Illinois Rivers?

A. In view of the facts that have been obtained in the

experiments which have been conducted conjointly by Professors Jordan, Zeit and myself, and in view of my knowledge of the conditions which would obtain where the sewage of Chicago was allowed to flow in to the Chicago River, thence into the drainage canal and down the Desplaines and Illinois Rivers, and in view of the fact that the experimental evidence as to the vitality of the typhoid organism when exposed to the waters as
10524 found in the Chicago River, the drainage canal and the Illinois River, under the conditions of the experiment previously described, and in view of the fact that in my judgment typhoid organisms so deposited in the Chicago River, drainage canal and the Illinois Rivers would be subjected to even more detrimental conditions than did exist under the conditions as recorded in these experiments, and in view of the fact that the sewage of Chicago, deposited in the Chicago River and finding its way through the drainage canal, and down the Desplaines and Illinois Rivers would require a much longer period of time to pass from the city of Chicago down the Desplaines and Illinois River than is required to kill typhoid organisms when placed in such an environment as would exist under these conditions.

I am of the opinion that typhoid organisms finding their way through the sewers of Chicago, into the Chicago River and thence into the drainage canal, down the Desplaines and into the Illinois River would be destroyed before such water had passed the course of the Illinois River.

Q. From a scientific standpoint what value do you attach
10525 to this experiment as showing the longevity of a typhoid bacillus in polluted waters?

A. In comparing numerous experiments which were made under varying conditions as to the longevity of the typhoid organism in the waters of the drainage canal and the Illinois River with the experiments which have been previously reported by other investigators on the typhoid organisms exposed under various conditions, I am of the opinion that the conditions under which the experiments now reported were made approach more nearly to the natural conditions to which the typhoid fever organism would be subjected when exposed in the water of the flowing stream such as would be the case in the Illinois

River in passing from the city of Chicago down the said river, and therefore from a scientific standpoint a greater value is to be attached to the important results of this experiment made by Professor Jordan, Zeit and myself, independently but concurrently, than to the conclusions which have been previously drawn from the experiments of other investigators, and that the results of such experiments show that the longevity of the typhoid bacillus is less in polluted waters than in waters of a pure class.

Q. Does this experiment shed any light upon the longevity of the typhoid bacillus in the sediment of polluted 10526 streams?

A. Pathogenic bacteria exposed in the sediment of polluted streams are brought in contact with even a larger number of bacterial organisms than would be the case if they were exposed to superincumbent water masses and therefore presumably in contact with the increasing amounts of metabolic products, and inasmuch as the pore spaces between the particles of sediment are entirely filled with water, it is my opinion that the conditions which would obtain in the sediment of polluted streams would certainly not be less prejudicial than those which would be found in the water of the stream itself, and therefore I would consider that if the longevity of the typhoid bacillus be impaired by the action of sewage and the water bacteria of a polluted stream that at least the same if not a greater effect would be produced if the typhoid organism was in contact with these bacteria and the products of their growth in the sediment of such a stream.

Q. Had this experiment been conducted in warm weather instead of the season that it was, what effect in your opinion would be manifested in the results?

A. It is a well recognized fact in bacteriology that the 10527 vitality of various organisms, particularly those of a pathogenic class which find unsuitable conditions for their development in the outside environment is profoundly affected by temperature of their surroundings, and the results of many tests upon this point indicate that the vitality of such organisms is retained for a longer period of time during those periods when the temperature is low than is the case when higher temperature prevails.

The reason for this undoubtedly lies in the fact that the characteristic changes which occur in the life history of any organism go on more rapidly with an acceleration in temperature, and therefore if this experiment had been conducted at those seasons of the year when the metabolism of all organisms is at its highest during the period of highest temperature the results of the experiments undoubtedly would have shown that the vitality of the organisms would not have been as long as was the case when the temperature under which the experiments were conducted was materially lower than those which would have prevailed in the height of summer.

Q. What is the behavior of colon bacillus in soil as compared with its behavior in water?

A. The colon bacillus in ordinary soil which is not satu-
10528 rated completely with water is able to live longer than it
is in the water itself.

Q. Is there such a thing as purification of soil?

A. Dead effete organic matter undergoes slow decomposition which universally results in the disintegration of such matter and consequently purification of the soil from such refuse material. Such beneficient operation prevents the surface of the earth from being clogged with the accumulated mass of organic debris and refuse which would result from the death of living forms and which would render continued residence on its surface possible. Inasmuch as we know that this does not occur, it is therefore evident that organic matter discharged on the surface of soil or in soil does undergo a series of changes which result in its destruction and consequently the purification of such soil.

Q. Why is it that the typhoid bacillus will not live as long in polluted water as in pure water?

A. Polluted water is likely to contain a large amount of or-
ganic matter which encourages the rapid growth of sew-
10529 age and other saprophytic bacteria which may find their
way into it, and these bacteria in their growth are capable of producing various compounds or products which I have previously testified to, on the basis of experimental results, as exerting a positive deterimental effect upon other forms of bacterial life. This prejudicial effect is likely to be more marked

upon bacteria belonging to the pathogenic class and which have therefore not habituated themselves to an environment suitable to saprophytic development.

Inasmuch as these conclusions are based upon experimental results which have been previously reported, in my opinion it therefore follows that the typhoid organism would not live as long in waters which were rich in germ life or the products of germ activity, as would be the case in pure water in which these bacteria or their products were not present.

Q. To what do you attribute the death of the typhoid bacillus in water?

A. The typhoid fever organism naturally thrives upon complex organic material and inasmuch as it does not ordinarily find suitable food supply in normal waters which permit
10530 the active cell growth, the starvation of typhoid cells when placed in water must soon set in, and it is a question therefore as to how long such organisms will be able to preserve their vitality in such a medium. The death of an organism of this class is undoubtedly due to the operation of a complex series of conditions.

It is a well known fact that direct sunlight exerts a detrimental effect upon bacteria with which it comes in contact. Particularily is this true in relation to the organisms belonging to the pathogenic class. An exposure of the organisms, such as the typhoid, to the direct rays of the sun will destroy the vitality of these organisms in a short period of time. It has also been demonstrated that another powerful factor which is operative in the destruction of the typhoid organism is that which comes from the effect in which various water and sewage bacteria or the bi-products of which they are capable of exerting have upon the vitality of the typhoid bacillus. When the typhoid organism is brought in contact with large numbers of these organisms it has been demonstrated that it is unable to retain its vitality for more than a brief period of time. In addition to this there should be mentioned the effect which comes from further
10531 competition which may exist between other forms of life which may be present in the waters in which the typhoid organism is exposed, including under this head the microscopic forms of life, both animal and vegetable, such as algae and other

related organisms. The effect of sedimentation in waters more or less heavily charged with suspended material; the effect which comes from the addition of varying quantities of water not containing these organisms in varying numbers has a tendency to place the typhoid organisms in such waters under conditions where this rate of starvation or actual destruction which takes place through the effect of these varying forces will go on. These factors are undoubtedly the main ones which appeared to cause the more or less rapid loss of the vitality of the typhoid organism when exposed in a watery medium.

Q. Will the typhoid germ live as long in the waters of the Illinois River as in the waters of Lake Michigan?

A. I do not think that the typhoid organism would live as long in the waters of the Illinois River under the conditions as there exist in nature as would be the case in the waters of Lake Michigan.

10532 Q. How do you explain the more rapid death of the organism in the waters of the Illinois River than in the waters of Lake Michigan?

A. The waters which are found in the Illinois River are derived from the smaller tributaries to which is added the waters brought from Lake Michigan through the Chicago River and drainage canal. The waters coming from Lake Michigan through the Chicago River and drainage canal receives a very large amount of bacterial life, largely of a saprophytic class, which find it possible to grow and multiply to an enormous extent in these waters. The result is that these organisms are capable of producing various products of growth, some of which are unquestionably soluble as is shown from the results of the previous experiments recorded and these soluble products find their way down the waters of the drainage canal, Desplaines River and into the Illinois River after the organisms which have produced them may have disappeared. The result is that even after the process of self purification has gone on to such an extent as to reduce the germ content from the high numbers
10533 which exist in the drainage canal to the low germcontent which is found at certain points in the Illinois River that the soluble product which have been made by these organisms in the upper reaches of the river pass from the same as would

be the case of any material in solution. It is therefore conceivable that products of this class are present in the waters of the Illinois River in the same way for instance as is chlorine which has been derived from the sewage of Chicago and the presence of which is detected in the waters of the Illinois River even after the organisms which were present in the sewage and therefore in contact with the chlorine of that sewage have entirely disappeared. The presence of these soluble substances has been demonstrated in experiments previously reported, but further proof can be adduced in the experiments which have not yet been detailed, and which were conducted in the following manner:

Cultures were taken and prepared with various saprophytic bacteria planted in agar. These organisms were allowed to grow for a period of 24 hours and then over the surface of these agar plates was streaked cultures from freshly grown subcultures of the typhoid bacillus. A portion of these plates was left free from the growth of the water and saprophytic
10534 bacteria so as to serve as a control which would be indicated by the growth of the typhoid bacillus. In these plates, half of which were seeded with various saprophytic bacteria and half of which were free from any growth of these organisms, the typhoid organism was seeded by drawing an infected wire over the surface of such plates. It was observed that when the needle infected with the typhoid organism was drawn over the sterile agar surface abundant growth occurred, but where the needle was traced over the surface of the plate on which these other organisms were beginning to develop that the typhoid organism was incapable of thriving to any material extent. If the two infections, that is the infection of the plate with the water bacteria and the typhoid organism were made simultaneously, the typhoid organism was able to make a small growth. In case where the water bacteria were inoculated first and the typhoid organism later inoculated say 12 to 24 hours, the growth of the typhoid germ was usually absent. This indicates, in my judgment, that there are products produced by various bacteria indigenous to water and of a saprophytic class, some of which were isolated and found to be representative, common, well recognized water organisms, that this antagonism

between the products of the growth of these saprophytic
10535 bacteria and the typhoid germ are such as prevent the
growth and development of this organism inasmuch as this could only be produced through the action which is caused by soluble products diffusing through the agar medium, and it would indicate that the presence of colonies of bacterial growth would exert a poisonous or an inhibitive effect upon the development of the typhoid organism.

Q. What is your opinion as to whether the typhoid bacillus will live longer in the sediment of a polluted stream than it would in the water of the same stream?

A. If the typhoid organism is imbedded in the sediment of a polluted stream it would be surrounded entirely by a water medium in which there would be present a very large number of bacteria belonging to the saprophytic and probably the sewage class, a number which would ordinarily be much larger than found in the water above. Doubtless the amount of by products thrown off by the activity of these organisms, under the circumstances where these large numbers of bacteria would be found, would also be larger than would exist in the waters of the stream itself, taking into consideration the effect which the proceeding experiments have revealed as to the prejudicial
action of waters rich in bacterial life on the vitality of
10536 the typhoid organism in such waters it can hardly be
considered that the vitality of the organism in the sediment of such a stream would be enhanced; even there are germs in the water itself, and there is no evidence which I know of that indicates that the typhoid organism would be capable of living in the sediment of such a polluted stream for a longer time than it would in the water of the same stream.

Q. Will you differentiate between conditions that obtain in moist soil and the sediment of running streams?

A. The conditions which obtain in moist soil and the sediment of running streams are materially different. In the one case the soil is not completely saturated with water for the soil particles are surrounded by a hygroscopic film which adheres to the particles themselves, but gives a considerable amount of pore space in the interstices which is filled with air. In the sediment found in running streams or lakes this condition would not obtain as these spaces are entirely filled with water.

Q. Does the time that a typhoid bacillus will live in moist soil furnish any criteria for its longevity in the sediment of a running stream?

A. In as much as the conditions which would prevail in a moist soil where the soil interstices were largely filled 10537 with air, and where the amount of water present in such interstices was confined to the thin hyproscopic film which is in contact with the surface of the soil grain itself, and in as much as the conditions herein described are materially different from those which obtain in the sediment found in a running stream, it is my opinion that the conditions which obtain in a moist soil and the results which are here found would not furnish any criteria for the determination of the longevity of the organism as found in the sediment of a running stream.

Q. Are the two conditions comparable?

A. The two conditions as found in a moist soil and in the sediment of a running stream, for the foregoing reasons, are not comparable.

Q. Would the fact that a typhoid bacillus lived several months in moist soil, justify the assumption that it would live for the same length of time in the sediment of a river?

A. In view of the fact that the conditions under which typhoid organisms would be exposed in moist soil are different from those which are found in the sediment of a river, I would not consider that this would justify the assumption that it would live as long in the sediment of a river as would be the case if the exposure was made in moist soil.

10538 Q. Will you give the reasons for the answer you have just given?

A. The reasons which I would assign for the above answer rest upon the fact that the water content of the moist soils is confined to an exceedingly thin film surrounding the moist grain and that the large portion of the pore space between the soil particles is filled with air. These conditions do not obtain in the sediment of streams, .and inasmuch as a prominent factor in the destruction of typhoid bacteria is that which comes from the effect produced by the sewage and water bacteria on the products formed by that growth and inasmuch as the effect of this influence would be much less in the case of a moist soil than it would be in the case where the space between the soil particles was entirely filled with a watery medium, such as would be the case in the sediment in the bottom of a stream, I would not consider that the typhoid organism would be able to live as long in such sediment as would be the case in moist soil.

Q. Do you know of any bacteriologist since the birth of becteriology that has demonstrated by any experiment that typhoid germs do live in the sediment of lakes or rivers for a long period of time?

10539 A. The only experiment which I know of in which the claim is advanced that typhoid fever organism is capable of living for a long time in the sediment of lakes and rivers are those which were made by Lortet of Lyons, France, which were presented to the Tenth International Medical Congress at Berlin, in August, 1890, and published in the Centralblatt fur Bakteriologie, 1891, volume 9, page 709.

Q. From the experiment which you have introduced in evidence as well as the laboratory experiments which you have also introduced in evidence, what is your opinion as a bacteriologist as to the longevity of the typhoid bacillus in the sediment of the Illinois river?

A. On the basis of the experiments which I have been able to perform on the vitality of the typhoid organism when exposed to the waters of the Illinois river, and in view of the facts that the conditions which obtain in the bottom of that stream are such as would undoubtedly bring the typhoid organism in contact with even large numbers of water and sewage bacteria, and the products of their growth, that would often be the case in the waters of the stream itself, it is my opinion 10540 that the longevity of the typhoid organism when exposed in the sediment, as found in the Illinois river, would certainly be no longer than it would in the superincumbent water above, and that it is quite possible that their longevity might even be shortened.

Q. What conclusion do you draw from the experiment which you have introduced?

A. From all of the experiments which I have made on the conditions which obtain where the typhoid organism is exposed in the Illinois river it is my belief that this organism will lose its vitality in the conditions whch would obtain n the waters and in the sediment of such a stream in a relatively short period of time, that period of time not exceeding more than three or four days.

Q. Does the experiment which you have introduced shed any light upon the longevity of the typhoid bacillus in sewage polluted waters?

A. The experiments which I have conducted myself on the longevity of the typhoid organism in the waters of the Illinois river which are known to have received large quantities of sewage pollution, and when compared with similar experiments made by Professor Zeit in the waters of Lake Michigan,
10541 indicate that the longevity of the typhoid organism in such waters is considerably less than it is in the case of pure waters, and from the knowledge which I possess as to the results which have been obtained in the co-operative experiments previously mentioned, the special portion of which has been carried out by Professor Jordan and Professor Zeit, on the conditions which are found as to the longevity of the typhoid organism in the Chicago river and Drainage Canal, I am of the opinion that these experiments, taking them all into consideration, do throw, upon the question as to the longevity of the typhoid bacillus in sewage polluted waters, much light.

Q. Mr. Fuller, in his testimony on page 4218, stated that there are observers in Switzerland who made examinations with positive results, showing the presence of typhoid germs in the sediment of Lake Geneva, and I think also Lake Zurich. Do you know anything about those observations to which Mr. Fuller referred?

A. I do.

Q. What were the facts and circumstances in connection with these observations?

10542 A. These observations which are referred to by Mr. Fuller are, I take it, those which are reported as made by Mr. Lortet, of Lyons, France, and were peresented to the International Medical Congress at Berlin, and published in the journal referred to above.

. It was stated in this paper that samples of the sediment were taken from Lake Geneva, at a distance of a mile and a quarter from shore, and at the depth of 120 to 150 feet, where the temperature of the water was approximately 40 degrees Fahrenheit. It is further stated that the water over the places where these organisms were removed was a chemically pure water. It is further stated that an analysis of the samples of mud taken under these conditions revealed the germs of tetanus or lock jaw, typhoid fever and possibly the tubercular organism.

It is further stated in this paper that other samples were taken from a point 200 meters from shore, and in water 12 feet deep, and that the mud under these conditions was found to be absolutely sterile.

It is further stated that it was commonly observed that when
portions of this lake sediment were injected into labora-
10543 tory animals that it resulted in the production of malig-
nant oedema, and the opinion is advanced that there
may have been an actual multiplication of these disease producing bacteria in this mud for many generations.

Adjourned to 2:00 p. m., February 19, 1904.

10544 Met pursuant to adjournment at 2 p. m., February 19th, 1904.

Present, the Commissioner and same counsel.

PROF. H. L. RUSSELL

resumed the stand for further direct examination by Mr. Todd and testified as follows:

Q. In the light of the present knowledge in regard to bacteriology what importance do you attach to those observations?

A. From the results of the experiments which have been quoted it is my belief that these experiments were either carelessly performed or not carried out with sufficient detail, and under sufficiently stringent precautions to warrant the conclusion which is drawn. The reasons for my belief as indicated are as follows:

It is stated in this paper that samples were taken a mile and a quarter from shore at a depth of 120 to 150 feet, and at a temperature of 40 degrees Fahrenheit and that the water over

these samples was a chemically pure water, and that in
10545 the mud found underneath this chemically pure water
the germs of tetanus typhoid and possibly tuberculosis
were present.

If the sediment in the bottom of this lake contained the pathogenic organisms referred to it would be probable that there would be some evidence of the organic pollution which would have resulted in the deposition of such organism say as typhoid fever. Moreover, he further states that in samples taken 200 metres from shore and in water 12 feet deep the mud was found to be perfectly sterile, a condition which is known and recognized by all bacteriologists of repute to be totally at variance with the actual facts of the case. There is no reference made in these experiments to the length of time which it is supposed that these typhoid, tetanus and tuberculosis organisms had presumably been exposed in the mud of this lake.

The details which are given with reference to the identification of these organisms are exceedingly vague and indefinite.
No bacteriologist who makes the statement that tetanus,
10546 typhoid and possibly tuberculosis organisms are found
under any conditions, can help laying himself open to
the charge of careless manipulation because of the laxity of such statements.

In view of the fact that the majority of the earlier findings with reference to the discovery of the typhoid organism, antedating the introduction of the agglutinating test, are generally regarded as more or less unreliable, and inasmuch as no adequate data are given with reference to the technical methods employed, and the accuracy with which they are carried out, it seems to me plain that the results of these investigations as reported are far from being a satisfactory demonstration of the presence of these pathogenic organisms in the sediment of this lake.

The opinion is further advanced that there has been an actual multiplication of these disease producing bacteria in the mud of the lake, a multiplication which may have continued for many generations. This conclusion is so at variance with the generally accepted opinion of bacteriologists and sanitary experts, that any person advancing the same should 10547 take a special precaution to fortify his conclusions with very carefully controlled experiments and adequate data so that the course of reasoning which would lead him to draw these conclusions might be closely followed.

It is my opinion therefore that the conclusions established in this paper are not justified from the experiments as presented. I find that this opinion is shared by other bacteriologists and discredit is thrown on the same by the well recognized water expert, Prof. Ferdinand Loeffler, of Greifwald, Germany, who, in his book on "water, and water organisms," page 592, refers to Lortet's experiments, and places after them an interrogation point making it evident that he regards the conclusions drawn from his work as not perfect from the facts as stated.

MR. JEFFRIES: I move to strike out the answer for the reason that it is argumentative and not entirely responsive to the question and for the further reason that the witness undertakes to base his criticisms upon the experiments referred to in the question on the fact that nothing is shown in the report as to the character of the examination or the extent or time that the deposits were contained in the bed of the lake, the 10548 presumption being that competent and proper preparations were made in the analysis of such water at that time and the mere statement of failure to set out the character or extent of the examination constitutes no reason for the witness's assumption that proper precautions were not taken and proper examination made.

MR. TODD: Q. Mr. Fuller in his testimony on page 4218 of my transcript of record, in answer to the question, "Has it ever been demonstrated by bacteriology that typhoid germs have lived in sediment of a running stream?" answered, "It has been demonstrated that they have lived for a long time in the sediment of lakes and I do not consider there is any weakness in the process of reasoning, by which one steps from a lake to a river, provided of course that each of these waters are live waters and not subject to septic action." I will ask you, do you regard the observation in Lake Geneva, as quoted by Mr. Fuller, as a demonstration that the typhoid bacillus has been found to live for a long time in the sediment of lakes?

A. From the observations quoted in the question and 10549 to the answer to the preceding question, I do not consider that the result of observations so reported a demonstration sufficiently full and accurate that a typhoid bacillus so found, as to say that it was capable of living in the sediment of the lake so mentioned for a long time.

Q. Mr. Fuller in his testimony, on page 4219, of my transcript of record, in answer to the question, "Is not the length of time that a typhoid bacillus will live in the sediment more a matter of assumption than a matter of demonstrated proof?" answered, "I consider that it is a very clean cut demonstrated fact that typhoid fever germs may and do and have continued to live in the sediment of running water.". "For what length of time?" "A. I should say for a month or more, possibly in cases for years. Q. Who has demonstrated that it ever lived a year? A. I think conditions existing in moist soil in many rural places of this country where typhoid fever prevails from time to time is proof that typhoid fever germs in the presence of moisture can live for such a time. If that were not so, then there would be an elimination of the typhoid fever absolutely through- 10550 out the rural districts of this and other countiries.

Q. I want to ask you whether you know of any demonstration that shows typhoid fever germs may and do and have continued to live in the sediment of running stream for a period of a year?

MR. JEFFRIES: Now I move to strike out all down to the question which refers to Mr. Fuller, for the reason there is nothing to show that this witness is acquainted with all the examinations and observations that were made of which Mr. Fuller is cognizant, or that the two men, this witness and Mr. Fuller have been informed, identically the same of all the examinations and observations that have been made looking to the life of the typhoid fever germ in moist soil or otherwise in the bed of streams.

A. On the basis of the results as reported by Lortet, which were quoted by Fuller in affecting questions of the life and conditions known to exist with reference to the vitality of the typhoid fever organism when placed in moist soil, also 10551 to the fact that the conditions which here obtain are by no means similar to the conditions which would obtain if such typhoid organisms were deposited in the sediment of running streams, in place of moist soil, I should say I know of no demonstration that affords sufficient proof that the typhoid organism is capable of living for the period of a year.

Q. How near in your opinion does the experiment made by you, Prof. Jordan, and Prof. Zeit, approach the natural conditions?

A. In the experiments which have been detailed by myself, and which also have been previously testified to by Professors Zeit and Jordan, it is my opinion that the conditions under which these experiments were performed approach more nearly to the conditions to which the typhoid organism would be exposed in the water of a running stream than do the experiments previously reported by other investigators, so far as I know or have any cognizance of. Further, that the condition of these
streams as reported by Jordan, Zeit and myself, afford
10552 an opportunity for the exercise of the prejudicial effect
which might come to the typhoid bacillus by reason of the action of the soluble products of bacterial growth which would be capable of exerting their influences under conditions in which this experiment was performed. Further, that this experiment differed from the natural conditions to which the typhoid fever organism would be exposed in the waters of the flowing stream, in that the cultures prepared by us were protected from the effect of a number of environmental factors which would also exert a more or less injurious action and would have a tendency to weaken the virulence of and destroy the vitality of the typhoid organism. I refer to those factors the effect of which have been previously amplified under the heads of sedimentation, influence of dilution, influence of light to a greater or less extent, and the influence of organisms which might be present in the waters of the flowing stream other than
those which are ordinarily present in the samples of
10553 water placed in the parchment sacs in the experiments
detailed.

Q. How do the conditions of this experiment differ from those of the glass bottle experiments such as have previously been obtained in the laboratory experiments on the longevity of the typhoid bacillus?

A. The claim has been made by various investigators, and on this subject there has been published a number of papers, that the conditions which obtain when experiments are conducted on the vitality of typhoid fever organisms, where such experiments are made in glass bottles, favor the longevity of the typhoid germ under these experimentally reported conditions as a certain amount of soluble material is dissolved from the glass, which in some way or other affects the vitality of the contained organism.

Q. Is there any reason for anticipating greater or less longevity on the part of the typhoid bacillus in glass bottles than under conditions of your experiments?

A. In the experiments previously referred to, the influence which glass bottles seem to have on the vitality of the typhoid organism, indicate that the vitality of that or-
10554 ganism is enhanced, and it is capable, therefore, of living longer under the conditions as found in glass bottles than would normally be the case in the experiments which have been performed where typhoid organisms were exposed in parchment sacs. The error which would obtain if glass bottles were used, would be avoided, and it is my opinion that the longevity of the organism when placed under such conditions where it is brought in contact with glass surfaces, is greater than under the conditions referred to in the experiment with parchment sacs.

Q. What do the facts show?

A. The opinion which has been previously advanced is one which was made by taking all the facts which I have any cognizance of, into consideration. Subsequent experiments were also made in the case of the agar block experiments where one set of the blocks inoculated with typhoid organisms in accordance with the method previously described was placed in running water, another set inoculated in a similar manner with the same organism, the same batch of media and under
10555 identically the same conditions was placed in a small glass container, the vitality of the organisms as demonstrated by the special cultures made from said agar block shows that organisms exposed in glass containers were able to retain their vitality for a period of 16 days, whereas those placed in

running water were not found in any case for a period longer than 8 days, and in some instances the longevity of the germ was not more than two or three days.

Q. What is your opinion based upon the knowledge which you possess as to whether the typhoid bacilli coming from the sewers of Chicago and entering the drainage canal, could survive the journey from Chicago to St. Louis, a distance of 357 miles, and be a danger and a menace to the inhabitants of St. Louis, using the water of the Mississippi river for drinking or domestic purposes?

A. By reason of the fact that the previous experiments which have been detailed, show that the vitality of the 10556 typhoid organism is destroyed in the course of not to exceed four days, and that the extent or period of flow which would be necessary for the sewage of Chicago, entering the drainage canal, to pass from Chicago to St. Louis, a distance of 357 miles, would be so great that it would be impossible for the typhoid organism to survive this journey, it is my opinion that the diffusion of such bacilli in the waters of the drainage canal would not be a danger and a menace to the inhabitants of St. Louis, using the water of the Mississippi river for drinking and domestic purposes.

Q. Do the settling basins at St. Louis afford any protection to the citizens of St. Louis against infectious matters of the waters of the Mississippi at the intake tower?

A. Owing to the extensive sedimentation of suspended matter which must take place when the turbid waters of the Mississippi river are introduced into the settling basins, and the fact that such sedimentation does eliminate bacterial life and would eliminate much infectious matter if such 10557 were present, it is my opinion that the interposition of these settling basins between the waters of the Mississippi river and the consumers of water in St. Louis, would afford a material protection to them against the infectious matters which might be present in the waters of the Mississippi river at the intake tower.

Q. Are the settling basins any protection to the citizens of St. Louis against the sewage of Chicago?

A. In as much as the typhoid organisms deposited in the city of Chicago and finding their way into the drainage canal would be killed before the waters filled with such sewage would find their way from Chicago to St. Louis, I must say that the settling basins of the city of St. Louis would afford no protection to the citizens of St. Louis against the sewage of Chicago.

Q. Against what sort of protection would the settling basins be a protection?

A. The protection which would be afforded to the citizens of St. Louis by passing water through the sedimentation basins, would be from those places adjacent to St. Louis, in which the typhoid organism would not be killed during the journey from such places to the sedimentation basins of the St. Louis supply. 10558

Q. Where a settling basin holds a sufficient amount of water to supply a city for a period of 30 days and as the water is taken out for domestic uses raw water is immediately supplied from the open river, and typhoid fever should prevail among the people using such water, what is your opinion as to whether such a condition justifies the assumption that because the basin holds a supply for a period of 30 days, that the typhoid bacillus will live in the water deposited?

A. Water in flowing through a reservoir, does not move with a uniform rate of rapidity, owing to the motility of the water molecules. A stream flows fastest in or near the center, because the friction of the water on the sides of the stream is sufficient to retard the rate of flow. The same principle is operative in the waters of the reservoirs. In another connection I have had occasion to test the effect which variation in this rate of flow would have, as in the case of milk flowing in a continuous stream through a Pasteurizing machine. In this case a small column of milk was passed through a winding machine, and the rate of flow was found to vary from one-half a minute to five minutes, indicating a difference of at least 10 fold. If this is true in a machine of a few inches in diameter, it would be true to a much larger extent in a large reservoir into which water was flowing at one point and flowing out at another. If the capacity of the reservoir was sufficient to hold and settle for a period of 30 days, and typhoid fever should prevail among the people using such a 10559 supply of water, in the light of the above well recognized principle of hydraulics, I would not consider that because a basin holds a supply sufficient for 30 days, that the typhoid fever organism lived for that period of time.

Q. What does the term Epidemiology, embrace?

A. Epidemiology is that science which relates to epidemic diseases.

10560 Under the general term would naturally be embraced a general study of the causation of epidemic diseases, ways in which disease organisms are disseminated in nature, and a consideration of all the data of a bacteriological and chemical nature that would throw any light on the question at issue, geographical distribution of diseases, the effect which variable factors exert, such as age, race, sex, etc., on the susceptibility of the human being toward the disease in question, the influences of other predisposing factors such as density of population, whether in city or country, the study of vital statistics connected with diseases in order to ascertain how these varying predisposing factors influence the death rate, the interpretation of these statistics. In fact, the term epidemiology is an exceedingly inclusive term, and one must understand the significance of scientific methods which have been introduced into the study of diseases, especially in recent years, as shown in the development of the bacteriological science as well as in chemistry.

10561 Q. Have you examined the typhoid statistics of the Illinois, Missouri and Mississippi water sheds above St. Louis?

A. I have.

Q. Have you examined the mortality statistics of the City of St. Louis?

A. Yes sir.

Q. How do you interpret the mortality statistics of the City of St. Louis, in connection with the typhoid statistics on the three water sheds?

A. In interpreting the mortality statistics from typhoid fever in St. Louis, it would be necessary to take into consideration the typhoid statistics obtained on or about these water sheds which contribute water finding its way into the Mississippi, past St. Louis, laying special emphasis upon those statistics which are from cities nearest to the city of St. Louis.

Q. Have you studied the typhoid statistics of the City of Chicago?

A. I have.

Q. Have you studied the typhoid statistics of St. Louis?

10562 A. I have, yes sir.

Q. Now, in the matter of the interpretation of statistics, what methods do you employ?

A. There are two methods that are employed, one which is used largely for comparative purposes known as the mortality percentage method, in which the death rate from any given disease is figured and determined in terms of the total number of deaths in that community. The other method, which is more generally used, and considered more reliable, determines the ratio which exists between the number of deaths from any given disease, based upon the actual population from which the death statistics are collected. This is known as the death rate from that disease per unit of population, usually given in terms of 10,000 to 100,000 persons.

Q. Which one of these methods in your opinion the most correctly gives the typhoid conditions in a given city?

A. I regard the latter method as the preferable method to follow in determining the death rate from any given specific disease, and it should be followed wherever possible.

10563 Q. What is your opinion of the validity of using the mortality percentage method in estimating the typhoid condition in a given city?

A. The method of determining the death rate from any given disease by comparing the mortality of that disease with the total mortality of the community instead of the population itself is liable to introduce error into the results which might readily vitiate the accuracy of such statistics to such an extent as to render them all of much less value than otherwise would be the case. The reason for this is, that when you compare the deaths from any disease to the total deaths, in order to study the increase or decrease of any disease in any community, you are using a wrong basis for comparison. What is waated in any given com-

munity is to know whether a disease is increasing more rapidly than the increase in population. When this rate is based on the ratio between that disease and the total death rate the variation which might and often does occur in the total death rate may be subject to many conditions which now enter
10564 into the consideration of the disease in question. Suppose, for instance, that a serious epidemic of some other disease, like the Bubonic Plague, or yellow fever, should break out, it would be manifestly improper to compare the typhoid death rate in that community before and after such an epidemic and compare the actual number of typhoid deaths, with the total number of deaths, and say that the typhoid was increasing or decreasing, where such a fallacious method was employed.

Q. Is the mortality percentage method regarded as on the whole the most accurate among sanitarians and students of vital statistics?

A. No sir. For the reasons which have just been given, where evident fallacies might creep in where the mortality percentage method was used. You are dealing with two variables, and therefore the liability of misinterpretation is greater than where based upon the actual population.

Q. What are the liabilities of typhoid infection of rivers coming from the rural districts?

10565 A. In view of the fact that the urine of typhoid patients often contain bacilli in great abundance, and in view of the fact that this material is not ordinarily looked upon as dangerous, and therefore is frequently thrown upon the surface of the ground, and in view of the fact that in rural communities greater carelesness prevails in regard to the disposition of this excreta, and even solid material, than would be true where special systems of sewage disposal were present, it naturally follows that the liability of the population to the infection of the river is added to considerably from the rural population.

Q. Is the infection from the rural population less common than from the urban?

A. It is a well recognized fact from statistical evidence, that the percentage of infection designated as typhoid fever mortality at least is not less common among the rural population than in urban communities.

Q. Do you know of any important typhoid epidemics in which infection has come from the rural population?

A. There are a considerable number of typhoid epidemics
which have been reported in which the sources of pollu-
10566 tion have been traced specifically to infection arising
from the rural population. Among these may be mentioned
the Swiss case, which is found in many text books, in the small village of Lausanne, Switzerland. The case mentioned by Gaffky, of a troop of soldiers, in the barracks of Wittenburg, Germany.

The best known case here under American conditions, is that which occurred in the small city of Plymouth, Pennsylvania, in 1884. The epidemic of typhoid fever in Lowell. was traced by Prof. Sedgwick to sources of infection, which were rural in origin, and the very recent epidemics which occurred in Ithaca, New York, and also one which has just passed at Butler, Pennsylvania, where in each instance over a thousand cases of typhoid fever occurred, are both of them undoubtedly attributed in their origin to infectious matter which would be designated as rural.

Q. Are there any reasons why the infection of the rural population is to be especially feared?

A. On account of the carelessness which prevails in the disposition of the dejecta and also the fact that disinfection of
this waste is not carried on so frequently in the country
10567 as it is in the city communities, I would consider that
these were features which render the conditions which
would obtain in the rural population a matter of especial danger.

Q. What is your opinion as to the value to be placed upon the chemical and bacteriological analyses of the water course?

A. If I understand your question to mean the relation which these bear to the determination of the purity of the water, I should regard that evidence which is to be adduced from the chemical and bacterioligical study of such waters, affords us the best possible means which we have at our command to determine whether such waters are likely to serve as carriers of contagion.

Q. What light do the analyses of river water shed upon the problem of self purification of streams?

A. The analytical evidence which can be gathered from the analyses of waters taken at frequent intervals for a con-
10568 siderable period of time and at various points along the course of the stream, give us the best possible means which we have at our command at the present time, of showing the progress of the self-purification which occurs in such running streams where organic matter is gradually disposed of and converted into mineral material.

Q. Are all these sources of information valuable to a sanitarian and epidemiologist?

A. I should consider that the data furnished by bacteriological study, and to some considerable extent, that of chemistry, are the foundation on which a sanitarian or epidemiologist must base his conclusions as to the character of any waters and their liability to be a source of danger and menace.

Q. How is the presence of infectious diseases ascertained?

A. Interpreting your question to mean the presence of disease organisms in the outside environment, I would say that bacteriological methods of analyses which permit of the detection of the specific organisms associated with such
10569 diseases, and the growth and study of the characters which are evident upon artificial media, give us a possible basis upon which such study can be carried on, and the reintroduction of the organisms so isolated into bodies of susceptible animals, prove conclusively the presence of infectious disease organisms.

Q. What are the ordinary modes of causation of infectious diseases?

A. If I interpret your question to mean the way in which disease organisms find access to the human body, I would say that air and water, and food supplies, serve as the passive vehicles for the transmission of contagious organisms. To some extent insects, and by the presence or through the medium of wounds, or bruises, organisms are introduced into the body.

Q. What are the chief sources of infection in typhoid fever?

A. The main sources of infection in typhoid fever are dejecta, coming from the intestinal canal, and within recent years the importance of the urine has been much more clearly recognized than formerly. The urine contains the typhoid organisms

10570 in about 25 to 30 per cent. of all cases, and is often found
in large numbers.

Q. Is it important for the sanitarian and epidemiologist to know the source of infection as well as the results of such infection?

A. It is very important in making any study of any epidemiological question that the sources of infection should be taken into consideration as well as the results of the infection, for the distribution of the disease, and its dissemination may depend largely upon how the organism finds its way into the human being.

Q. Is it a legitimate inference, that because typhoid fever increases in the city, that such increase is due to the increase in infection of the water supply?

A. By no means, for it has been abundantly proven in a considerable number of cases, that the organism of typhoid fever is capable of being introduced into the body in other ways than through the medium of infected water.

10571 Q. What other sources of infection are there in the city besides that coming from its water supply?

A. A very important source of infection, which is found in the case of city population, is that which may come from the infection of the milk supply. The typhoid organism is capable of thriving and growing in milk, which is not the case normally in water, therefore if milk is infected with even an exceedingly small number of organisms, the power of multiplication of this germ, which is able to withstand a considerable amount of acid germs, permits of its development even in milk supplies. This has been determined experimentally, and there is bacteriological evidence through the accumulation of a large number of epidemics of typhoid fever, the origin of which has been traced to the infection of milk.

Q. In the case of St. Louis, which takes its water supply
from the Mississippi river, at the St. Louis intake, and the water
at that point being a mixture of the Missouri, the Mississippi
and the Illinois rivers, assuming the reports of the St.
10572 Louis Board of Health show that the apparent increase
of typhoid fever during the years 1900, 1901, 1902 and

1903 as compared with previous years, is there any scientific reason that would justify the conclusion that such apparent increase of typhoid fever in St. Louis is due to infectious matter coming from the sewers of Chicago by way of the Drainage Canal?

A. Assuming that the reports as to the typhoid death rates for the city of St. Louis, for the years mentioned, are true, and taking into consideration the conditions which obtain in the water sheds of the three rivers mentioned, and the fact that there are sources of pollution from which typhoid organisms might arise which were not as far removed from the City of St. Louis, as would be the case of the City of Chicago, and taking into consideration further, the results of the typhoid experiments which have been made, and which have been detailed in the foregoing answers, I should say that there was no scientific reason which justified the conclusion that the increase of
10573 typhoid fever in St. Louis as reported in the Board of
Health reports for the years 1900 to 1903 inclusive, is due to infectious matter which is derived from the sewers of Chicago by way of the Drainage Canal.

Q. Is there such a thing as a decrease in virulence of the typhoid fever germs?

A. A typhoid fever organism is subject to a considerable change in its power of producing disease. The examination of various strains of typhoid organisms taken from different patients indicate that there is a natural variation in the ability of these organisms to produce death in laboratory animals, and it is also possible to demonstrate experimentally that such variations of virulence may be produced where the organism is grown under artificial conditions.

Q. What do you mean by the decrease in virulence of the typhoid fever germ?

A. The decrease in virulence means that the organisms lose wholly or in part their ability to produce an infective con-
10574 dition in the blood of the susceptible host.

Q. What evidence have you upon which to base such an opinion?

A. The evidence which I can adduce to support this opinion, is based upon experimental tests made in the laboratory on the gradual diminution in virulence of such organism when cultivated upon artificial nutrient media.

10575 Q. Have you made a study of the so-called germ diseases?

A. In connection with my studies on bacteriology, it has been necessary for me to make special studies of the various germ diseases caused by bacteria and other lower forms of life.

Q. Do these diseases caused by germs come within the scope of your study?

A. Many of the diseases of man and animals of a transmissible nature are caused by the injection of parisitic organisms belonging to bacteria, and hence in the work of bacteriology, consideration of these diseases and the diseased under which they are introduced, is properly within the scope of my study.

Q. Have you made any study upon typhoid fever and malarial fever from the standpoint of the bacteriologist or clinician?

A. From the bacteriological point of view it has been possible for me to make a study of the diseases of typhoid fever and malaria, and the organisms which are known to possess

10576 a causal relation to those diseases.

Q. In connection with your study as you have detailed, have you taken up the question of the proper diagnosis of fevers known as typhoid fever and malaria?

A. In connection with such studies it is absolutely necessary in order to make a proper diagnosis of such fevers, to take up the study from the laboratory point of view, and determine by examination of the blood whether the disease causes a reaction or not, and in connection with such studies I have performed these tests.

Q. Have you had any experience in the diagnosis of these fevers either in the laboratory or at the bedside?

A. In connection with my studies of these diseases, and also in connection with routine work of the diagnostic laboratory with which I am connected, I have had experience in the study of these diseases and their diagnosis.

Q. Have you studied these diseases sufficiently to give an expert opinion on them?

10577 A. In connection with the diseases previously mentioned this experience has been sufficient, together with the study of the literature relating to this subject to warrant me in giving an opinion as to whether diagnoses of typhoid fever or malaria are correct or not.

Q. What is typhoid fever in its clinical diagnosis?

A. Typhoid fever is a disease which is confined to man, and is widely distributed throughout the temperate zone. The symptoms of the disease are not always specific, but in general it is characterized by the production of fever which often begins in a relatively obscure manner, the temperature rising from day to day until it reaches its maximum, and then gradually declining. The symptoms of the disease most frequently noted are headache, sometimes with more or less tympanitis, the production of rose colored spots on the abdomen, which, however, in some cases do not appear, the enlargement of the spleen, accompanied sometimes with tendernesses, and frequently copious bleeding at the nostrils. The lesions of the disease are 10578 usually manifested in the intestines, affecting peyers patches and the solitary glands, causing an ulceration sometimes through the intestinal wall which may result in the production of a secondary complication of peritionitis.

Q. What is intermittent fever and its clinical diagnosis?

A. Intermittent fever, so called, is a fever which is characterized by a marked variation in the temperature where it falls to a normal after a rising temperature and then a subsequent rise again, which is followed the next day by a fall.

Q. What is remittent fever and its clinical diagnosis?

A. Remittent fever, so called, is one of the older expressions which is used to designate a type of fever in which the variation in temperature does not fall to the normal, but which is marked by frequent and rapid oscillations in temperature.

Q. What is typho-malarial fever and its clinical diagnosis?

A. Typho-malarial fever is again one of those older designations 10579 which is used to designate a type of fever and is employed to include many low types of fevers that with the better diagnostic means which are now available especially since the introduction of the Widal test for typhoid fever can usually be differentiated into genuine typhoid or genuine malarial fever. Rarely does it happen in communities where both of these fevers are universally present, that the organisms capable of producing these specific distinct diseases are found in the same case simultaneously.

Q. What is congestive fever and its clinical diagnosis?

A. Congestive fever again is an indefinite term applied to low fevers that have no well marked characteristic. Its most marked symptom is more or less acute congestion. It has no accurate clinical significance as applied to any specific disease.

Q. What is simple continued fever and its clinical diagnosis?

A. The type of fever in which the course of the febrile changes is more or less continuous. It has no marked characteristic symptom.

10580 Q. Are remittent, intermittent, typho-malarial, congestive and simple continued fevers distinct types of diseases and so recognized by bacteriologists and clinicians?

A. The terms remittent, intermittent, typho-malarial, congestive and simple continued are relics of old methods of description which attempted to differentiate these febrile changes, merely on the basis of the symptoms which are most evident. They are not recognized by working bacteriologists or clinicians of the present time as being satisfactory names for specific types of fevers.

Q. What significance do you attach to these terms as applied to fevers where they appear in vital statistics?

A. The use of the terms remittent, intermittent, typho-malarial, congestive and simple continued as applied to vital statistics collected under present day conditions would in my judgment indicate that the causes of deaths were not
10581 classified as they should be and would therefore lead one to place less reliance on such statistics than would be the case if they were more accurately classified.

Q. Assuming that the number of deaths reported as occurring from typhoid fever in the City of St. Louis as evidenced by the annual reports of the Board of Health in the City of St. Louis Health Department is as follows, from 1890 to 1903:

1890	140
1891	165

1892	441
1893	215
1894	171
1895	107
1896	106
1897	125
1898	95
1899	131
1900	168
1901	198
1902	222
1903	288

10582 and assuming further that the number of deaths reported from the same reports under heading, Remittent, Intermittent, Typho-malarial, Congestive and Simple Continued fevers is as follows, from 1890 to 1903:

1890	226
1891	296
1892	326
1893	284
1894	179
1895	155
1896	177
1897	172
1898	134
1899	148
1900	112
1901	80
1902	102
1903	91

10583 do the number of deaths reported as occurring from typhoid fever alone in the City of St. Louis, properly represent in your opinion the total number of typhoid deaths actually occurring in that city?

A. From the study of the statistics mentioned in the foregoing question and from the general knowledge of the relation which these diseases bear to each other and the liability of making an improper diagnosis between them, I do not consider that the number of deaths reported in the vital statistics of the board of health of the city of St. Louis for the years 1890 to 1903 inclusive, represent the total number of deaths from typhoid fever which actually occurred in that city in that interval.

Q. What reasons have you for stating that they do not?

A. Taking into consideration the fact which is well recognized by sanitarians, that fevers classified under the heads of remittent, intermittent, typho-malarial, congestive and simple continued are in a large measure found to be fevers which by means of modern diagnostic methods would be recognized as typhoid fever, it is my opinion that the statistics which include
a large proportion of fatalities as due to fevers of this
10584 class, do not represent the true condition which obtained
in that city with reference to the total typhoid death rate.

Q. To what do you attribute the failure of these statistics assumed in the hypothetical question, to properly disclose the number of typhoid fever deaths occurring in St. Louis?

A. In my judgment the value of the statistics assumed in the hyphothetical question rests in a large measure on the more or less imperfect diagnosis which has been made by physicians reporting those deaths to the City Health Department.

Q. Why is it that doctors employed the terms, remittent, intermittent, typho-malarial, congestive and simple continued fevers that are recognized as being either typhoid or malarial?

A. Inasmuch as many practicing physicians are not personally familiar with modern diagnostic methods which are now employed in the most advanced practice with the diagnosis of
typhoid fever and malaria, and the differentiation of one
10585 from the other, it frequently follows that the old expres-
sions based upon the symptoms of the fever, which used to be used, are frequently used at the present time by such physicians when reporting the cause of death.

Moreover, it frequently occurs that symptoms noted in cases of fever are not sufficiently distinctive to enable a physician to recognize with certainity whether he is dealing with genuine typhoid fever or malaria, and consequently, owing to the tendency to retain these old terms in the descriptions of diseases, it naturally follows that many of the typical cases, which are more or less obscure in their symptoms, are reported in the cause of death as remittent, intermittent, typho-malarial, congestive and simple continued fevers.

Q. Do you know of any city in the country where the death rate from malarial fever alone is as high as in the city of St. Louis, as evidenced by the total number of deaths assumed in the hypothetical question under the heading intermittent, 10586 remittent, typho-malarial, congestive and simple continued, occurring in the reports of the board of health of the city of St. Louis?

A. Inasmuch as the death rate from such malarial fevers as occur in the United States of America is comparatively insignificant (there being practically no pernicious or tropical malaria which is exceedingly fatal in this country except where imported) it of necessity follows that no city has as high a death rate from pure malaria alone as is represented in the number of deaths reported in the St. Louis statistics and included in the terms, intermittent, remittent, typho-malarial, congestive and simple continued, which are assumed in the foregoing hypothetical question.

Q. What proportion of deaths in the column under the heading, remittent, intermittent, typho-malarial, congestive and simple continued, assumed in the hypothetical question as occurring in the City of St. Louis, as evidenced by the reports of this board of health in your opinion should be classed as typhoid?

A. In my opinion it is practically impossible for any one to give an accurate idea as to what percentage of the 10587 deaths reported under the heading, remittent, intermittent, typho-malarial, congestive and simple continued, assumed in the hypothetical question as occurring in the City of St. Louis, inasmuch as a majority of the cases terminating fatally are now diagnosed as typhoid fever, it is undoubtedly true that a large proportion of these deaths so reported should be classed as typhoid fever.

Q. What proportion is due to malarial fever, of the deaths in the column under the heading, remittent, intermittent, typho-malarial, congestive and simple continued, assumed in the hypothetical question as occurring in the City of St. Louis, as evidenced by the reports of this board of health in your opinion, what proportion should be classed as malarial?

A. Owing to the fact that the disease of malaria as it exists in the United States is a disease resulting in an exceedingly low mortality, it is undoubtedly true that the number of cases reported in the foregoing hypothetical question which should be classed as genuine malaria, is exceedingly
10588 small. This opinion is based upon the fact that the hospital records in southern cities where malaria is more or less abundantly prevalent, and where modern methods of diagnosis are widely used for the recognition of the disease, that the fatality from this disease is so small as to be practically negligable.

Q. What do the mortal statistics of malaria show in cities where careful attention has been paid to malarial fevers as regards the number of deaths occurring from malarial fever?

A. In regions where malaria is known to frequently exist, and where the best modern methods of diagnosis are widely employed, it is noteworthy that the number of deaths reported as due to genuine malaria fever have been greatly reduced since the introduction of these methods. The results of this character are shown directly by the history of malarial cases which have been recorded in the Johns Hopkins Hospital
10589 situated in Baltimore, Maryland. Malaria used to be very frequently reported as the cause of death in the city, but with the introduction of the methods of making blood examinations, the number of cases now reported show that the total number of deaths has been reduced to a mere fraction of what used to be reported.

Q. Is it generally recognized by bacteriologists and clinicians in classifying typhoid fever in one column, and intermittent, remittent, typho-malarial, congestive and simple continued fevers in another column, in the board of health reports of cities, that it is an improper classification from a scientific standpoint as affording a true indication from the mortality from typhoid fever and malaria?

A. Inasmuch as modern methods of diagnosis have enabled the clinician to classify a larger proportion of specific febrile causes under the heads of typhoid fever and malaria, which in

former years, before the introduction of these methods, were generally classified and based on symptoms of the disease under the heading, intermittent, remittent, typho-malarial, con-
10590 gestive and simple continued, it is well recognized by bacteriologists and clinicians that the continuation of the use of these traditional terms is merely to describe the symptoms of the diseases, that indicate their specific character, and is an improper classification from the scientific standpoint, and that where such a classification is followed, it is no true indication of the mortality which exists with reference to typhoid fever and malaria.

Q. Assuming that the reports of the Board of Health of the City of St. Louis, by the month, from '95 to 1903, inclusive, under the heading of typhoid fever, which for the purposes of convenience is designated A, in the table that follows, and that intermittent, remittent, typho-malarial, congestive and simple continued, for the sake of convenience is designated as B, in the table that was prepared by Prof. Jordan and given in his testimony, is based upon said reports of the City Board of
10591 Health of St. Louis, will you please state what construction you place upon this table as showing the relative mortality from typhoid fever, and malarial fever in the city of St. Louis during the period covered by the foregoing table?

A. In view of the fact that the mortality from genuine malaria in the United States is exceedingly small, it is considered that a large number of deaths which are reported in the reports of the board of health of the City of St. Louis in the year 1895 to 1903 and designated as B, in that table, must include in addition to the exceedingly small number of deaths which are caused by the type of malaria which prevails in the United States, and inasmuch as the fevers which are most likely to occur are either malarial or typhoid fevers, and taking into consideration the low mortality which really occurs in malaria, I should consider that it was generally probable that a large proportion of these diseases which are designated for convenience as Column B, for the respective years, should be placed in a column which includes the reports of the fatalities due to typhoid
10592 fever.

Q. Assuming that an added total of deaths from typhoid fevers and deaths from intermittent, remittent, typho-malarial, congestive and simple continued fevers as they appear in the reports of the Board of Health in the City of St. Louis, is as follows, from 1890 to 1903:

1890	361
1891	781
1892	767
1893	499
1894	350
1895	262
1896	283
1897	297
1898	229
1899	279
1900	280
1901	278
1902	324
1903	379

What do these totals as above indicated, represent in your
opinion as to the mortality conditions of typhoid fever in
10593 the City of St. Louis, covering the period as above indicated,
after allowing in said remittent, intermittent, typho-malarial, congestive and simple continued fever column, such proportion as being typhoid fever as in your opinion you should allow. What is your opinion as based upon the statistics as assumed in the foreging hypothetical question, as to the typhoid deaths under remittent, intermittent, typho-malarial, congestive and simple continued fever deaths, in the City of St. Louis, as to whether said statistics show an increase or decrease in the typhoid fever mortality in the City of St. Louis, since '99?

A. Assuming that by far the larger proportion of the deaths which are reported in the reports of the Board of Health of the City of St. Louis, for the City of St. Louis, for the years covered in the foregoing question under the head of intermittent, remittent, typho-malarial, congestive and simple continued fevers, were really deaths which are attributable to the disease of typhoid fever and therefore should be added to the

10594 totals which were actually reported in that city for those years under the caption Typhoid Fever, and taking into consideration the statistics presented in the foregoing question, I should consider that the said statistics do not show material alteration which could be deduced with certainity in the typhoid fever mortality of the City of St. Louis, from the years '99 to 1903.

Q. Assuming that two circular letters were issued in the fall of 1900, another one issued in the fall of 1901 by the Health Commissioner of St. Louis calling attention of physicians to the fact that the law required them to report all cases of typhoid and all deaths from typhoid and at the time those letters were sent out the question of the opening of the Drainage Canal was being agitated by the public press of St. Louis, and there was considerable discussion and investigation was going on at that time in regard to the analyses of the samples so collected, etc., and was attracting considerable attention, from your examination of the statistics of St. Louis, as heretofore assumed in hypothetical questions heretofore asked you, for the years 10595 1901 to 1903, as compared with previous years, does the effect of such letter, assuming that the same had been sent to the doctors by the Health Commissioner of the City of St. Louis, manifest itself in these statistics?

A. In comparing the statistics assumed in the foregoing hypothetical question, I should consider that such data did manifest itself in the statistics.

Q. In what way does the effect of such letter appear from the statistics?

A. Take the statistics as to the mortality from typhoid fever and the mortality from those diseases which are included in what we may call typho-malarial, in the column designated in the previous statistics as Column B, taking into consideration the fact that such statistics show a marked diminution in the number of the cases reported in the typho-malarial column for the year 1900 and the year 1903 inclusive, and that for the same period a marked increase is noted under the head of deaths from typhoid fever. Further taking into consideration the fact that circular letters were issued in the fall of 10596 1900, and 1901 respectively, by the Health Commissioner of the city of St. Louis calling the attention of physicians to the requirements of the law as to the reporting of all cases and deaths resulting from the disease of typhoid fever, it is evident from the data of the report that the issuance of these letters by the Health Department of the city of S. Louis to the physicians of that city does manifest itself in the statistics as reported.

Q. From your examination of the typhoid and typho-malarial group of deaths as assumed in the foregoing hypothetical question, what is your opinion as to whether these two tables taken separately correctly show the typhoid conditions of the City of St. Louis for the period mentioned?

A. If consideration is given to either of the columns designated typhoid and typho-malarial death reports as reported by the board of health of the City of St. Louis, it is my opinion that neither of these reports of the fatalities do express the actual typhoid mortality of the city of St. Louis for the period mentioned.

10597 Q. Upon what do you base your opinion that they do not correctly show the typhoid conditions in the city of St. Louis, taking them separately?

A. This opinion is based upon the fact that it is highly probable that a large majority of the cases reported in the column designated B, in the foregoing questions, really were cases of typhoid fever, and further taking into consideration the effect which would be produced by the issuance of letters mentioned in the foregoing questions, it would lead to a more correct diagnosis of the disease of typhoid fever and the report of the same under the caption of Typhoid Fever, I should consider that the results as presented in the foregoing questions do not correctly represent the typhoid conditions which actually occurred if these tables are considered separately.

Q. From your knowledge of these classes of fever mentioned in the foregoing cloumns in the statistics as heretofore assumed, how should they be treated by bacteriologists

10598 and clinicians and statisticians in order to arrive at the true typhoid fever mortality in the city of St. Louis?

A. Owing to the liability to confusion which must of necessity exist from the use of old traditional terms which are descriptive more of the symptoms than the specific nature of the disease in question, and the direct liability of the confusion of these terms with that of typhoid fever, I should consider that from the standpoint of the bacteriologist, clinician or statistician, in order to get at the true typhoid mortality which would exist in the city of St. Louis, that it would be necessary to add to the statistics which they have reported as typhoid, a large proportion at least if not practically all of the cases which have been reported under the caption which has been designated in previous questions as Column B, to those figures in the given typhoid fever cases.

Adjourned until 10:00 A. M., February 20, 1903.

10599 10:00 a. m., Saturday, February 20, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. H. L. RUSSELL,

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. Assuming that the table testified to in evidence by Professor Jordan, as compiled from the typhoid fever mortality and typho-malaria, etc., of the health reports of the City of St. Louis, and based upon the population of the City of St. Louis, for the years 1890 and 1900, according to the United States Census reports, and the intervening years estimated by 10600 Farr's formula, is given by Professor Jordan. Will you please state what is your opinion, based upon the tables heretofore read, as to whether typhoid fever has increased or decreased in St. Louis since 1900 over the conditions that obtained in St. Louis prior to 1900?

MR. JEFFRIES: I object to the question for whether the table is correct or incorrect it states on its face what it is worth and the court can draw conclusions upon it as well as the witness.

A. Taking into consideration the fact that the circulars issued by the Board of Health of the City of St. Louis have unquestionably had their influence in increasing the accuracy of the typhoid statistics since the issuance of that circular in 1900, and that the great majority, if not practically all of the deaths reported before the year 1900 under the head of remittent, intermittent, congestive, typho-malarial, and simple continued fevers were actually cases of typhoid fver, and, therefore, should have been included in any statistics which showed the total amount of typhoid fever in the City of St. Louis for that time and assuming the accuracy of the compilations which have been 10601 made by Professor Jordan, based on the relative increase of population as determined by Farr's formula when to the typhoid fever death rates there have been added from 50 to 100 per cent. of all recorded deaths which have been reported under the head of remittent, intermittent, congestive, typho-malarial and simple continued fevers, and which in my judgment represent data showing the actual amount of typhoid fever which did occur for the periods mentioned much more correctly than is shown by consideration of the reported deaths, as reported in the board of health reports of the City of St. Louis under the caption of typhoid fever alone, I should consider that the actual number of typhoid deaths which have occurred in St. Louis since the year 1900 shows no increase over the death rate in that city from this disease for the period mentioned prior to that time, with the possible exception of the recognized epidemic which occurred about the year 1892.

Q. From a careful analysis of the typhoid and typho-malarial mortality statistics as they appear in the foregoing hypothetical questions, and from your knowledge of the conditions obtaining in any city using a water supply 10602 from a river, as well as all other sources of knowledge which you possess upon this question, what is your opinion as to whether there is an increase in typhoid fever in St. Louis since January, 1900, over conditions that prevailed in St. Louis prior to that time?

A. Taking into consideration the fact that the typhoid statistics alone, as reported in the board of health report, for the City of St. Louis, do not represent the actual conditions which occur in that city with reference to this disease, but that these statistics should be increased by a large proportion, if not all of the deaths which are reported under the caption of remittent, intermittent, typho-malarial and simple continued fevers, and that when such additions are made for the period which is covered in the foregoing questions, and comparisons are instituted between the typhoid mortality in St. Louis, as modified by the additional deaths which should be computed in the typhoid statistics and now reported under other causes, when these statistics are compared with the typhoid mortality statistics in other cities where similar types of water supply are employed for municipal purposes, it is my opinion that these 10603 statistics show that there has been no increase in the actual number of typhoid deaths which occurred in the City of St. Louis from January, 1900, to 1903, inclusive, when the typhoid death rate for this period is compared with that which actually prevailed in the City of St. Louis for the period embraced between the years 1890 and 1900, inclusive.

Q. Will running water purify itself so as to be free from pathogenic bacteria which may be placed therein?

A. In the operation of natural courses running water undergoes processes of purification, and frees itself from pathogenic organisms in due course of time.

Q. State your opinion as an expert on water supplies for cities and towns as to whether or not the water of the Mississippi river west of the center thread of the main channel of the said river, below the mouth of the Illinois river, and down to the intake tower of the St. Louis waterworks at the chain of rocks, is less valuable for drinking purposes and more liable to carry water borne diseases such as typhoid fever and cholera now than it was before the sewage from the sanitary district of Chicago was running into the drainage canal and through it into the Illinois river?

A. If the typhoid organism is killed out in the Illinois river in the period of time which is less than the necessary time for the flow of the water from the sewers of 10604 Chicago to the City of St. Louis, and assuming that the destruction of the typhoid organism is an index of the destruction of pathogenic organisms in water, and on the basis of the experiments which have been previously detailed in which proof is adduced to show that the vitality of the typhoid organism is destroyed in a much less time than is necessary for the flow of water from Chicago to St. Louis, it is my opinion that the waters of the Mississippi river west of the center of the main channel of the said river and below the mouth of the Illinois river, down to the intake tower of the St. Louis waterworks at the chain of rocks, is not less valuable for drinking purposes and not more liable to carry water borne diseases now than it was before the sewage of the sanitary district was run into the drainage canal and through it into the Illinois river.

Q. State whether or not an increase in the speed of the current of the Illinois river, by reason of the added volume of water of the drainage canal would affect the amount of sedimentation that might and must occur in the Illinois river and if it does affect it how and in what manner?

A. An increase in the speed of the current of the Illinois river, by reason of the added volume of water in the drainage canal would probably alter the manner of sedimentation that would occur in the waters of the Illinois river from what was the case before the addition of such water from the drainage canal occurred. The addition of this added volume of water from the drainage canal carries with it a larger amount of suspended organic matter, and therefore increases the amount of suspended material which would be present in the waters of the Illinois river and consequently the addition of this added drainage canal water would increase the amount of sedimentation which would otherwise occur. 10605

Q. What effect, if any, would the increased speed of the current in the Illinois river have upon the time within which sewage from Joliet, Peoria and other towns on the Illinois river have if emptied into the waters of the Mississippi, if the same are so removed as compared with the conditions that existed at the time it might have taken before the added volume of water from the drainage canal was put into the water of the Illinois?

A. If it did not cause an overflow of the banks of the stream, the increase in the speed of the current would carry suspended matter farther down stream, but it is my opinion that the removal from the river of the sewage from the towns mentioned would be performed before such sewage reached the Mississippi river, so that it would not materially alter the condition of the Mississippi river, except in the case of suspended salts, such as chlorine and nitrates which are not eliminated from the water in the purification of the sewage which might be discharged into such stream. 10606

Q. If water is made more clear and less turbid than it was before the opening of the drainage canal by an added volume of water being placed therein, will such bacilli as typhoid have more or less a tendency to go down to the bottom of the stream than they had prior to the water being rendered less turbid?

A. In case water is made more clear and less turbid by the addition of other volume of water, it would lessen the sedimentation which would normally occur so far as bacteri are concerned.

Q. If an increased volume of water in the Illinois by the addition of the water of the drainage canal would make an increased speed in the current of the Illinois river, would that increase in said current have an effect in increasing or
10607 diminishing the typhoid and liability to typhoid and other water borne diseases on the part of the inhabitants of the State of Missouri using the waters of the Mississippi river for drinking purposes below the mouth of the Illinois river?

A. From the facts of the experimental evidence which has been previously adduced that the typhoid organism would fail to live for a period of time which would be covered by the flow of water from Chicago to St. Louis, it would therefore follow that an additional volume of water discharged by the waters of the drainage canal, which would cause an increased speed in the current of the Illinois river, would not have any effect in increasing or diminishing the typhoid fever or the liability of the inhabitants of the State of Missouri using the waters of the Mississippi river below the mouth of the Illinois river to contract from such waters typhoid or other water borne diseases.

Q. Professor Sedgwick, in answer to this question: "What do you say as to the longevity of the germ of typhoid fever as a general proposition in connection with sewage polluted water?" answered, among other things: "My belief is that in a sewage polluted stream the typhoid germ might live in gradually
10608 diminishing numbers for weeks or months or even years." What is your opinion as to whether typhoid bacillus will live in the sewage polluted streams in gradually diminishing numbers for weeks or months or even years?

A. As it has been shown by experimental evidence that the typhoid organism dies out with a special rapidity in sewage polluted waters, it is my opinion that under the conditions which would exist in a sewage polluted stream that the typhoid organism would not live in gradually diminishing numbers for the period of time which is embraced in the foregoing question.

Q. Assuming that the number of bacilli coli communis in the waters of the Illinois River at Grafton are at intervals no greater than the number contained in it above the opening of the drainage canal, do you consider for that reason that the water is at all times no more dangerous than formerly?

Mr. Jeffries: Objected for the reason that the evidence on the part of the defendants show that since the opening of the drainage canal there has been an added volume of water to the Illinois River at the rate of something like 300,000 cubic feet per minute, that such water was not added to the Illinois River to any such extent prior to the opening of the canal, and
10609 the testimony of the defendant further shows that typhoid fever germs die out much more rapidly in highly polluted sewage material than in the waters of natural streams, and that from the defendant's own testimony the evidence shows that typhoid fever germs will live longer in the waters of the Illinois River since the opening of the canal than prior thereto, and for that reason the question is inconsistent and contradictory and it conflicts with the previous testimony of this witness and all other witnesses introduced by the defendant.

Mr. Todd. In reply I will state that this question, on page 3454 of the transcript of the record which I have, is the identical question which was asked by complainant's attorney of Professor Sedgwick, and I have a right to assume that complainant was as well versed with conditions that obtained upon the Illinois River and all scientific propositions relating to that river at the time this question was asked as he is now.

Mr. Jeffries: It is not a question as to whether or not the complainant thought the question was a competent question for Professor Sedgwick, but whether or not it is competent by taking into consideration all the facts proven in evidence by the defendants themselves.

10610 A. On the assumption of the conditions as stated in the foregoing question that no marked variation in numbers of colon bacteria occurred when comparisons are made of the colon content of the waters of the Illinois River before and since the opening of the drainage canal, I should consider that the results so assumed would indicate that there had been no material change in the water during this time and that it was not more dangerous since the opening of the drainage canal than was the case previous to this opening.

Q. Professor Sedgwick, in answer to the following question: "Assuming that the germs of typhoid fever coming from the sewers of Chicago and passing by way of the drainage canal to Lake Peoria be in large numbers deposited in the bed of Lake Peoria, for the period of a month say, do you consider that typhoid germs would be entirely destroyed at the end of that time in that deposit?" answered "No sir." What do you say as to the assumption that typhoid germs could pass from the sewers of Chicago by way of the drainage canal to Lake Peoria and be deposited there in the bed of Lake Peoria for a period of a month, and as to whether or not typhoid germs coming from the drainage canal, under the conditions as they
10611 exist, would live for a period of a month and not be destroyed before the end of that period?

A. I consider the assumption that typhoid fever could pass from the sewers of Chicago, by way of the drainage canal to Lake Peoria, and be deposited there in the bed of that lake for a period of one month as one that is untenable and in the light of experimental inquiry not in accord with the facts, and it is my opinion that under no normal conditions which could obtain in nature as they now exist that the typhoid germs would be able to pass from Chicago to Peoria and not be destroyed before the end of the period covered by the question.

Q. Professor Sedgwick, in answer to the question "Assuming that typhoid fever germs coming from the Chicago sewers are deposited in large numbers in the lakes and slack water portions of the Illinois River above Peoria, do you or do you not consider that flood conditions such as would scour the deposits from the beds of the stream would cause the water leaving Peoria Lake to contain at times more infectious and dangerous pollution than are at present in the diluted sewage entering the Bear Trap Dam at the foot of the drainage canal?" answered: "I think that at times it might." What is your opinion taking into consideration all that you know about
10612 the conditions in the drainage canal, the Desplaines River and the Illinois River as a bacteriologist and epidemiologist as to whether such a condition at times might exist?

Mr. Jeffries: I move to strike out and eliminate all that was said with reference to Professor Sedgwick and his answer thereto for the reason that the question as put to Professor Sedgwick may be put to this witness without reference to what Professor Sedgwick may have or may not have said.

A. Taking all of the conditions into consideration that obtain in the drainage canal, the Desplaines and the Illinois River, as to the probable longevity of the typhoid bacilli in the waters of such stream, I should consider that at no time under natural conditions would such conditions exist as would cause the waters of the Illinois River leaving Lake Peoria to contain more infectious and dangerous pollution than would exist in the diluted sewage of the drainage canal, passing the Bear Trap Dam.

Q. What is your opinion as to whether typhoid fever germs coming from Chicago sewage are deposited in large numbers in the lakes and slack water portions of the Illinois River above Peoria?

10613 A. Inasmuch as the rate of flow is such that Chicago sewage can not be carried from the city of Chicago to Lake Peoria in a period of time that would be within a period of time that the typhoid organism would be able to retain its vitality, it is my opinion that large numbers of typhoid organisms derived from the Chicago sewage would not be found in Lake Peoria above the city of Peoria.

Q. What is your opinion based upon all the knowledge which you have of conditions at Lake Peoria, as a bacteriologist and sanitary expert, as to whether at any time, under any conditions, the number of typhoid fever germs at that point is ever as great as they are at the Bear Trap Dam, at the end of the drainage canal?

A. Considering all of the conditions involved, and for the reasons previously explained, I should say that my opinion is that at no time, under natural conditions would the number of typhoid organisms even be as great at Lake Peoria as they would be at the Bear Trap Dam.

Q. Do you know of any evidence based upon any investigations made by yourself or by any one else that justifies the conclusion that at any time, under any conditions, there are larger number of typhoid fever germs at Peoria than at the Bear Trap Dam?

10614 A. I know of no evidence whatever that justifies the conclusion that at any time larger numbers of typhoid organisms would be found in the waters of Lake Peoria than would be present at the Bear Trap Dam. On the contrary there is every reason to believe, as a result of the investigations of my own and those made by Professors Jordan and Zeit, that the opposite conditions would prevail and that the organisms of typhoid fever which might be present at the Bear Trap Dam would be destroyed entirely before reaching Lake Peoria, in the natural flow of the river.

Q. Do you know of any evidence scientifically secured or otherwise that shows that accumulations of typhoid germs are found in lakes and slack waters basins of rivers and remain there in storage in vast numbers for any considerable period of time in a virulent state and are suddenly flushed out by freshets, so that greater numbers of typhoid fever germs are present flowing in a stream a considerable distance from the source of pollution in greater quantities than they exist at the source of pollution?

A. Inasmuch as the typhoid organism is incapable of 10615 thriving in normal raw waters or in other waters contaminated with organic matter and therefore they are more or less rapidly destroyed and would therefore be present in diminishing numbers the longer they remain in water, there is no evidence that I know of secured under scientific conditions or otherwise that would show that the vitality of the typhoid organism would be contained in the sediment of streams which are saturated with water and soluble substances dissolved in that water for considerable periods of time, and I do not believe that the conditions would ever obtain under a natural state of affairs so that a large number of typhoid organisms would be found present in a stream a considerable distance from the source of pollution which were larger than would exist under the original source of such pollution.

Q. As a sanitary expert, availing yourself of all chemical and bacteriological knowledge which is available to you, what is your opinion as to whether a typhoid bacillus lying in the sediment of a polluted stream for a period in excess of sixty days would be able to cause typhoid fever when taken into the human system after it had remained in such sediment for that length of time?

10616 A. Recognizing the fact that the typhoid organism is incapable of multiplication in either water of a polluted stream or the sediment of such stream, and recognizing further the fact that this diminishing vitality is undoubtedly coupled with a gradual diminution in the virulence of the organism and recognizing the fact which has been experimentally determined by competent bacteriologists that strains of typhoid bacillus have been found with such low degree of virulence that they were incapable of producing the disease of typhoid fever in the human system, and recognizing, moreover, the inability of the typhoid organism to retain its vitality even for the period of time mentioned, it is my opinion taking all of these facts into consideration, that the typhoid organism exposed under the conditions assumed for the period of time assumed, would not be able to produce typhoid fever.

Q. What is your opinion as a sanitary expert as to whether polluted matter or typhoid bacilli coming from the sewage of Chicago, through the drainage canal, deposited on the bottom of the Desplaines and Illinois Rivers, between Chicago and Peoria, can remain there for a period of from thirty to sixty days, and yet retain its dangerous qualities as well as their pathogenesis?

10617 A. For the reasons which were detailed in the answer to the foregoing question, as to the conditions which would prevail when the typhoid bacillus or polluted matter would be deposited in the bottom of a stream for the period assumed in the foregoing question, it is my opinion that if the organism was deposited for that period, it would not be capable of exerting a pathogenic effect or in any way retain its dangerous qualities.

Q. Now, assuming that the only pollution of the river was that contributed to it by the Chicago Sanitary District and having in mind the large amount of typhoid fever existing in said district do you or do you not consider the effect of the time interval, dilution and sedimentation occurring between Chicago and Grafton would be such as to permit the water as it enters the Mississippi River at all times to be free from the liability of producing water born diseases in those who drink it?

A. Inasmuch as the influence of the particulars which have been assumed in the question would be sufficient to cause the loss of vitality of the typhoid organism which was deposited in the waters of the Illinois River from the sewage of Chicago it would therefore follow that the water which enters the Mississippi River at Grafton would be free from the liability
10618 of producing any water born diseases among persons who should drink such water.

Q. Assuming that no other pollution or infection reaches the river save that which it receives from the sanitary district of Chicago, from your knowledge as a bacteriologist and sanitary expert have you had any personal experience or knowledge which would lead you to believe that the water of the Illinois River at Grafton is infected with the sewage from Chicago, and if the said water enters the Mississippi River becoming mixed with the water of that river would it become a menace to the health of the inhabitants of the Missouri shore of the Mississippi River using that water for drinking purposes at points below, on the Missouri shore?

A. Owing to the fact that the pollution or infection which would be deposited in the Illinois River from the sewers of Chicago would be practically purified by the time it has been carried for a portion of its way down the river on the way from Chicago to Grafton, it would naturally follow that the waters of the Illinois River which entered the Mississippi River
10619 at Grafton would not be a menace to the inhabitants of the Missouri shore on the Mississippi River if such water was used for drinking purposes at points below on the Missouri shore.

Q. Is there anything based upon your knowledge as a bacteriologist and sanitary expert which you know would lead you to believe that the water coming from the Illinois River at Grafton was infected from the sewers of Chicago, and assume that the waters of the Illinois River mixed with the waters of the Mississippi River at Grafton and subsequently mixed with the waters of the Missouri River at its mouth, do you consider the water of the Illinois River, thus commingled with the waters of the Mississippi and Missouri Rivers a menace to the health of the inhabitants of Missouri, living upon the Mississippi River, using the Mississippi River water for domestic and drinking purposes at points below Grafton on the Missouri side of the Mississippi River?

A. I would not consider that the admission of the waters of the Illinois River, in accordance with the conditions as described in the foregoing question would cause any meance to the inhabitants of the Missouri shore when the waters of the Illinois River were discharged into the Mississippi and com-
mingled with the waters of the Missouri River and Mis-
10620 sissippi River, and when the waters of the united streams
was used for drinking purposes by persons living below
Grafton on the Missouri shore.

Q. Is there any evidence, bacterial or otherwise, that can establish the conclusion that the waters of the Illinois River at Grafton are infected by the sewage from Chicago, eliminating all other sources of infection?

A. The chemical and bacteriological evidence which has been secured in this case through the experimental and observational data which have been presented justify, in my judgment, the conclusion that the waters of the Illinois River at Grafton show no indication whatever of unpurified sewage from Chicago that has found its way from Chicago to the latter place.

Q. Now, assuming that the only pollution upon the water shed of the Mississippi and its tributaries above the intake of the St. Louis waterworks was that derived from the sanitary district of Chicago, and having in mind a large amount of typhoid fever in Chicago, do you or do you not believe that infectious and dangerous pollution might, under existing conditions find its way into the water supply of the city of St. Louis?

A. On the basis of my belief that the germs of typhoid
fever would not retain their vitality for a sufficient period
10621 so as to be carried by the waters of the Illinois River
from the city of Chicago to St. Louis, and taking into
consideration all of the data, both chemical and bacteriological, which I have any knowledge of, it is my opinion that under the circumstances hypothecated in the foregoing question infectious and dangerous pollution derived from Chicago would not find its way, under existing conditions into the water supply of the city of St. Louis.

Q. Assuming that there was no typhoid fever pollution of the waters upon the water shed of the Mississippi River or its tributaries, above the intake of the St. Louis water works other than that derived from the sanitary district of Chicago, do you or do you not believe that typhoid fever germs from said district are liable to find their way into the water supply of the city of St. Louis, through the intake at the chain of rocks?

A. Under the conditions assumed when the infection of the Illinois River would be confined to the pollution, typhoid pollution, arising from the city of Chicago and taking into consideration the time of flow and the vitality of the typhoid organism in the waters of such river, I do not believe that the ty-
10622 phoid organisms deposited in the waters of the Illinois River would find their way by the way of the Illinois River to the water supply of the city of St. Louis through the intake at the chain of rocks, for the reasons which have been amplified in the previous answers.

Q. Professor Sedgwick, in answer to the question just propounded to you, answered "I believe that they are liable to find their way into the intake," and when asked why, answered "for the reason that typhoid fever having been frequently very abundant in the city of Chicago, I must start with the assumption that a very large number of typhoid germs find their way into the sewage of the city, pass through the sewers and on into the drainage canal, and subject to local conditions may, in diminishing numbers, pass out of the Illinois River, mingle with the waters of the Mississippi River, pass over to the other side and find their way into the intake at the chain of rocks." Do you know of any evidence, based upon any analysis experiments or otherwise that justifies the assumption that typhoid fever germs will pass from the sewers of Chicago into the drainage canal, in diminishing numbers, out of the Illinois River
10623 into the Mississippi and find their way to the intake tower at the chain of rocks?

Mr. Jeffries: I move to strike out the answer by Professor Sedgwick detailed in the question, and the question put to Professor Sedgwick and all of this question down to that portion which calls for the opinion of this witness, for the reason that the same is incompetent and irrelevant and not a necessary part of the question just propounded, and I move to strike out the whole question for the reason that it has already been answered, and this witness has given his opinion as to the possibility of typhoid fever organisms passing from Chicago to the city of St. Louis, which opinion, I suppose, is based upon all of the scientific knowledge which this witness possesses, and the question now propounded simply calls for the repetition to what the witness has already stated.

A. Taking into consideration the time involved in the flow of water from Chicago to St. Louis, and in view of the evidence which I have previously presented in combination with others that the typhoid organism is incapable of retaining its vitality for the period of time assumed in the foregoing question, I would say that I know of no evidence based upon any analysis, experiments or otherwise that would justify the assumption that typhoid organisms deposited in the Chicago drainage canal will pass by way of the Illinois River into the Mississippi
10624 River and find their way into the water supply of the city of St. Louis at the intake tower at the chain of rocks.

Q. Assuming that an epidemic of Asiatic cholera should occur in the city of Chicago, is it possible that the germs of that disease might find their way into the intake tower at the St. Louis water works from the city of Chicago?

A. In view of the fact that all of the evidence, both analytical and otherwise, indicates that the organism capable of producing Asiatic cholera is more sensitive to the influence of external environments than the organisms of typhoid fever, and from the conclusions which have been presented with reference to the vitality of the typhoid organism and their inability to live for a period of time which would be covered by the flow assumed in the question, I should say that it is impossible for the organisms of Asiatic cholera, should they exist in the city of Chicago, to be discharged into the drainage canal and then to find their way down that stream and into the intake tower of the St. Louis water works, at the chain of rocks.

Q. Considering your personal knowledge as an expert of typhoid fever conditions in the sanitary district of Chicago, and existing conditions in said District as to sewers and the outfalls thereof and the amount of sewage under all the existing conditions of the Desplaines, Illinois, Mississippi and
10625 Missouri Rivers, under all conditions existing on the water sheds of said streams and the tributaries thereof

and all existing conditions as to the water supply of the city of St. Louis and the general sanitary conditions existing in the city of St. Louis, would you or not beyond a reasonable doubt attribute the principal portion of the increase of typhoid fever in St. Louis, assuming there has been an increase in St. Louis since the opening of the drainage canal, to the infected sewage of the sanitary district of Chicago?

A. Taking into consideration the knowledge which I possess with reference to the conditions under which the typhoid organisms would be capable of living when deposited in the waters of the streams mentioned in the foregoing question, and taking into consideration the fact that other conditions exist which are necessary to consider in considering the question of typhoid fever in the city of St. Louis, it is my belief that I would not consider, beyond a reasonable doubt, the typhoid death rates as occurring in the city of St. Louis (assuming that there has been such an increase since the opening of the drainage canal) to any influence which might arise from the introduction
10626 of the sewage of the sanitary district of Chicago into the Illinois River and which would find its way down the channel of the Illinois River to St. Louis.

Q. I will get you to state whether or not in your opinion the liability to contract typhoid fever or other water borne diseases on the part of the inhabitants of Missouri, using the Mississippi River water for drinking purposes below the mouth of the Illinois River, by reason of sewage from the drainage canal infecting the water of the Illinois River is constant, immediate and continuous under all existing conditions upon the Mississippi, the Desplaines, the Illinois, the Missouri Rivers and the tributaries of said streams under all existing conditions upon the water sheds of said rivers and the tributaries thereof and the drainage canal of the sanitary district of Chicago?

A. In view of the facts which have been testified to in answer to the foregoing questions relative to the viability of the typhoid organisms and the conditions which would obtain where typhoid organisms are discharged into the drainage canal and the water flows from Chicago to St. Louis, and taking into consideration all other facts which bear upon the conditions of the question as stated, it is my opinion that the liability of
10627 the inhabitants of the State of Missouri using the Missis-

sippi River water for drinking purposes, below the mouth of the Illinois River, to contract typhoid fever or other water borne diseases is not constant, immediate or continuous, under all existing conditions on the Mississippi, the Desplaines, the Illinois and the Missouri Rivers and the tributaries of said streams under all existing conditions on the water shed of these rivers and the drainage canal of the sanitary district of Chicago.

Q. Professor Sedgwick in answer to a question among other things answered "the mere presence of pollution, I mean by that disinfected sewage, that is supposing Chicago reduced her typhoid death rate and would still put her sewage down there, that sewage as affecting the longevity or growth of germs that get in from Peoria or elsewhere would be an added menace to cities with water supply, even if she did not send typhoid fever germs down, sending the filth alone down is serious." I will ask you what is your opinion, based upon your experience as a bacteriologist as to whether the sewage from Chicago favors the longevity or growth of germs from Peoria or anywhere else, emptying their sewage into the Illinois River?

10628 A. It is my opinion that the deposition of sewage of Chicago into the drainage canal does not increase the longevity of the typhoid organism deposited therein, but on the contrary is a potent factor, toward the more rapid destruction of the vitality of the typhoid organism than would be the case if such sewage was not so deposited.

Q. Does the presence of sewage in water add to the longevity or growth of pathogenic germs?

A. When sewage is added to the water in an unsterilized condition such as would exist when normally deposited in drainage canals, the addition of such sewage does not increase the longevity of the typhoid organism, but on the other hand is a distinct factor in the early death of the typhoid organism.

Q. Assuming that the population of the sanitary district is increased to 5,000,000 of people and that the flow through the drainage canal reaches 1,000,000 cubic feet per minute, what in your opinion would be the effect on the water of the Illinois River at its mouth as compared with the water at that point as found prior to 1900?

A. In view of the fact that under the conditions which
10629 now exist and have existed for the period of the last
three years, it is my opinion that the typhoid organism would have been destroyed in a period of time which would comprise only a small portion of the time necessary for water to pass from Chicago to the mouth of the Illinois River, and assuming the increase in population which must also assume an increase in amount of sewage not containing the typhoid organism which would be deposited in the waters of the drainage canal, and taking into consideration the effect which would be produced by such an increase and the influence of conditions as would exist on the basis of the assumption made, it is my opinion that the addition of the sewage coming from the number of people mentioned, discharged into the amount of water mentioned would not materially alter the conditions which would exist in the waters of the Illinois River at its mouth, so far as these conditions had any effect upon the elimination of those elements in sewage which are of importance in sanitary matters. The addition of this increased amount of sewage would probably alter the amount of soluble substances which would appear in the waters of the Illinois River at its mouth, but these would have no effect upon the sanitary condition of such waters.

Q. Assume that the Chicago sewage from 1,500,000 peo-
10630 ple living in the sanitary district and city of Chicago
should be discharged into the Chicago drainage canal and through the canal into the Desplaines and into the Illinois River, Chicago being situated 357 miles from the St. Louis intake tower, and assuming that a typhoid fever epidemic of extraordinary proportions or a cholera epidemic of extraordinary proportions should become prevalent among the residents of the sanitary district of Chicago at a time when the sewage from said district is being so discharged into the canal, what immediate and impending danger would exist, and what effect would it have upon the people of St. Louis and those people living on the Missouri side of the Mississippi river below Grafton, who use the waters of the Mississippi river for drinking purposes?

A. Taking into consideration the conditions which are operative in nature that lead to the destruction of the typhoid organism when brought in contact with water and sewage organ-

isms such as would exist under the conditions, hypothecated, and also considering the greater sensitivity of cholera to the influences of these conditions in comparison with what happens to the typhoid organism when exposed to such conditions and taking into consideration the distance involved, 357 miles from Chicago to St. Louis, and the time which is necessary for
10631 the sewage containing typhoid or cholera organisms to pass from Chicago to the St. Louis intake, it is my opinion then that no immediate and impending danger would exist to the people of St. Louis or those living on the Missouri side of the Mississippi River below Grafton, and therefore that no effect would be produced upon such people who would use the water of the Mississippi River for drinking purposes.

Q. From your personal knowledge of the Illinois River and your knowledge as a sanitary expert, together with all chemical and bacterial knowledge derived from every source, what is your opinion as to whether the sewage from the city of Chicago, passing through the drainage canal into the Illinois River at different seasons of the year and at different stages of water would be a danger and menace to the inhabitants of the State of Missouri and the citizens of the city of St. Louis, using the water of the Mississippi River for drinking and domestic purposes?

Mr. Jeffries: I object to that as a repetition.

A. Taking into consideration the chemical and bacterial knowledge which has been derived from actual experiment and also all knowledge which I possess with reference to the conditions which would obtain when the sewage of Chicago was
10632 placed in the drainage canal, and taking into consideration the possible variation which would exist at different seasons of the year and the influence which different stages of water would exert upon the vitality of disease organisms which might be present in such sewage, it is my opinion that the introduction of such sewage into the Illinois River would not be a danger and a menace to the inhabitants of the State of Missouri and the citizens of the City of St. Louis who might use the waters of the Mississippi River at the intake tower, chain of rocks.

Q. From all your knowledge of conditions that obtain in and along the Illinois River, what is your opinion as a sanitary expert as to whether deleterious substances, infected matter or pathogenic germs which come from the drainage canal from the sewers of Chicago would reach as far down the Illinois River as the City of Peoria?

A. From the analytical data which has been presented, it is shown that the addition of the sewage of Chicago to the waters of the drainage canal results in such a degree of purification that I do not think that deleterious substances or infectious matters capable of producing disease would be found in the waters of the Illinois River at the city of Peoria, which were derived from the sewers of the city of Chicago.

10633 Q. Would any of these substances in a dangerous state reach the intake tower of the St. Louis water works at the chain of rocks in your opinion?

Mr. Jeffries: Objected to as immaterial and a repetition.

A. For the reasons cited in the foregoing answer and for the reason that the time of flow from Chicago to St. Louis would be greater than from Chicago to Peoria, it is my opinion that none of these substances in the sewage of Chicago would reach the city of St. Louis in a dangerous state.

Q. As a sanitary expert do you consider the sewage of Chicago reaching the drainage canal and the Illinois River, which in turn empties into the Mississippi River a menace and a danger to the inhabitants of the State of Missouri and the citizens of the City of St. Louis, taking their water supply from the Mississippi River.

Mr. Jeffries: Objected to as a repetition.

A. On the basis of the data previously presented it is my opinion that the deposition of the sewage in the drainage canal is not a menace and a danger to the inhabitants of the state of Missouri and the citizens of the city of Et. Louis who take their water supply from the Mississippi River at the intake tower.

10634 Q. What is your opinion as a sanitary expert as to whether the germ of the typhoid fever could lie in the sediment of the drainage canal or the Illinois River for a period of from one to three years?

A. I know of no experiments or data which warrant the conclusion that the typhoid organism would be capable ot retaining its vitality in the bed of a stream for this period. On the contrary, I do not consider that it would be possible for the organism to live for any such period of time.

Q. What is your opinion as to whether the typhoid bacillus, deposited on the bottom of the Illinois River could remain there for a period of upwards of five years and then be stirred up by the action of the waves, winds, steamboats or by other means and continue its journey down to St. Louis in a virile state and be a cause of danger to the inhabitants of the state of Missouri or to the citizens of the city of St. Louis using the water of the Mississippi River, at the city of St. Louis, for drinking and domestic purposes?

A. It is my opinion that the typhoid organism would not be able to retain its vitality for the period mentioned, and therefore could not continue its journey in a virile state and be a source of danger to the inhabitants of the state of Missouri and the citizens of St. Louis who used Mississippi River
10635 water for drinking and domestic purposes.

Q. Will you state as a sanitary expert, basing your opinion upon all the information you possess in this ,case whether the water supply of the city of St. Louis is contaminated, polluted or injured by the sewage of Chicago entering the drainage canal and from thence into the Illinois River?

A. For reasons which have been previously given and amplified it is my opinion that the sewage of the city of Chicago would not be a means of contaminating, polluting or injuring the water supply of the city of St. Louis.

Q. Assuming that five dams, one at Marseilles, one at Henry, one at Copperas Creek, one at La Grange and one at Kampsville, existed in the Illinois River, backing the water up stream for a considerable distance; also there is a lake known as Joliet, a lake above Peoria known as Lake Peoria and many small lakes lying along the Illinois River, receiving their water supply from the Illinois River, what effect would these dams and lakes have as sedimentation basins and also what effect would they have in the elimination and purification of polluted and infected matter, coming into the Illinois River from the different towns sewering into said river?

A. Taking into consideration the well recognized fact

10636 that where a current of a stream is retarded in its rate of flow by an expansion of the cross section of said stream, which condition causes the sedimentation of any suspended matter which may be present in the waters of such stream, it is my opinion that the presence of such expanded portions of the Illinois River would act in a material way in aiding the sedimentation which would occur in the waters of that stream and that such sedimentation would result in the elimination of a large proportion of the total bacterial life, including any disease organisms, if such should happen to be present, that might be present in such waters.

Q. Assume that as the volume of water passing through the drainage canal is increased, the dams at Henry, Copperas Creek, LaGrange and Kampsville, should be removed, would the removal of these dams affect the purification of the sewage of Chicago to such an extent as to be manifest at Grafton?

A. In view of the fact that the sewage of the city of Chicago is practically purified before it reaches a point upon the river where the removal of these germs would exert any appreciable effect upon the conditions which obtain in that river it is my opinion that the removal of these dams, as indicated in the foregoing question, would exert no effect upon the
10637 condition of the waters of the Illinois River at its mouth
at Grafton, so far as the sewage of the city of Chicago is concerned.

Q. Will you state as an expert sanitarian, from all sources of knowledge that you possess, whether the water of the Mississippi River at the chain of rocks was, prior to January, 1900, a safe and potable drinking water, fit for domestic and drinking purposes, in its raw state, after passing through the settling basins?

Mr. Jeffries: Objected to as immaterial.

A. Taking into consideration the fact that surface waters which drain water sheds more or less densely populated, are in a general sense waters which are no doubt more or less incidentally connected with an increased incidence of typhoid fever and other water borne diseases, and taking into consideration the fact which would exist in the question as asked where a water supply might be polluted with dangerous pollution under the conditions which would prevail where the time of flow would not permit of the purification of such water from the sewage which was so discharged, and taking into consideration 10638 the conditions which obtained in the city of St. Louis prior to the year 1900, it is my opinion that such water, furnished under the conditions asked for, is not to be regarded as a thoroughly safe and potable water supply, suitable for all domestic and drinking purposes.

Q. Was the Missouri River water a safe water for drinking and domestic purposes prior to the opening of the drainage canal in January, 1900?

A. The Missouri River draining a large water shed on which there is a large number of people, and into which there is discharged the sewage of such people, would be regarded as a stream which was very liable to carry pollution for varying distances, and it is my opinion that such a stream is not to be regarded as a perfectly safe supply for drinking purposes.

Q. Was the Illinois River water a safe water for drinking and domestic purposes prior to the opening of the drainage canal, in January, 1900?

A. For the reasons given in the foregoing answer I should also state that the Illinois river was not to be regarded as a safe supply.

Mr. Jeffries: I move to strike out the last three preceding questions and answers as immaterial.

10639 Q. Has the sanitary conditions of the waters of the Illinois River at Grafton been benefited or damaged by the opening of the drainage canal?

A. I do not consider that the waters of the Illinois River at Grafton should be looked upon as a perfectly safe supply, regardless of the possible changes which have been made by the opening of the drainage canal.

Q. Is the water of the Mississippi and Missouri Rivers, excluding the waters of the Illinois, a safe and suitable water for domestic and drinking purposes, to be used by the citizens of St. Louis in its raw state or treated as now by the City of St. Louis with settling basins, since January, 1900?

Mr. Jeffries: Objected to as immaterial.

A. I consider that the use of the waters of any drainage system, such as obtained in the Mississippi and Missouri Rivers, is not to be considered as a safe and suitable supply for drinking purposes, as it exists under the conditions which obtain in the foregoing question.

Q. Taking into consideration all the knowledge which you possess in regard to the chemical bacteriological and physical condition of the waters of the Illinois river and its tributaries, and the river itself, the different towns sewering into the Illinois river and its tributaries, the population upon the water
10640 sheds of the Illinois river, both the rural and the urban, the stages of the river under all conditions and during all seasons, what is your opinion as to the effect of flowing the sewage from Chicago through the drainage canal into the Desplaines and Illinois rivers, upon the inhabitants of the State of Missouri, using the water of the Mississippi river for drinking and domestic purposes?

A. Taking into consideration the conditions hypothecated, that the sewage of Chicago is discharged in the drainage canal at such a distance from the State of Missouri that dangerous pollution coming from the sewage of the city of Chicago, so far as that pollution itself is concerned, would be deprived of its dangerous properties during the period of flow which is necessary for the passage of such sewage from the city of Chicago to the State of Missouri, it is my opinion that the sewage of Chicago, discharged into the drainage canal, will have no deleterious effect upon the inhabitants of the State of Missouri using the water of the Mississippi river for drinking purposes.

Q. Assuming all the facts as contained in the foregoing hypothetical question, and in addition from a study of
10641 all the typhoid statistics as they obtain along the water shed of the Missouri, Mississippi and Illinois rivers, and in the City of Chicago and in the City of St. Louis, and assuming that an increase of typhoid fever deaths, as evidenced by the death rate in St. Louis, as disclosed by the board of health reports of the City of St. Louis, and taking into consideration all the knowledge which you possess upon this subject under consideration, what is your opinion as a bacteriologist and sanitarian and epidemiologist as to whether the said increase in typhoid fever in St. Louis, assuming there has been an increase as above indicated, since the opening of the drainage canal can be attributed to the opening of the drainage canal as the direct,

immediate and proximate cause of said increase beyond all reasonable doubt?

A. In view of the fact that the conditions which obtain in the City of St. Louis and the conditions of the watersheds which are immediately adjacent to this city, in view of the fact that the typhoid fever death rate in that city is dependent upon other conditions than those due to the water supply of that city, and may be materially influenced by operation of many other 10642 factors, in view of the conditions which obtain in the Illinois river with reference to the process of purification which would occur in the sewage of Chicago when deposited in the drainage canal, and taking into consideration all the knowledge which I possess with reference to all data which bear directly or indirectly upon the question involved, it is my opinion that the increase in the typhoid deaths, as reported in the City of St. Louis, assuming such increase to be true, which have occurred since the opening of the drainage canal, can not beyond all reasonable doubt be attributed as a direct, immediate and approximate cause for said increase to the opening of that drainage canal.

Adjourned until 2:00 p. m., of same day.

10643 2:00 p. m., Saturday, February 20, 1904. Continuation pursuant to adjournmnet.

Present, the Commissioner and same counsel representing the respective parties.

PROF. H. L. RUSSELL,

resumed the stand for cross-examination, by Mr. Jeffries, and testified as follows:

Q. Are you a practical chemist, Professor?

A. No, sir.

Q. You make no chemical or laboratory experiments?

A. No, sir.

Q. You use it, then, in your work as a sanitarian purely from what you have found to be its import from reading and practice and from your experience in assisting other sanitarians do you not?

A. I use the data which are collected in chemical examinations of water for sanitary purposes as a factor, which together with the bacteriological analysis of the same material is co-ordinated, interpreted together.

Q. Why is it, Professor, that a sanitarian can not pass judgment, reliable judgment, upon the sanitary condition of the water from the chemical and bacteriological observations of that water without taking into consideration the extent and
10644 sources of pollution and population and other natural conditions on the watershed?

A. The chemical examination of the water is entirely an indirect examination. No chemical examination by itself will determine the presence of disease organisms in a water supply. In the development of the subject of sanitary science the chemical methods were first employed and it was necessary where this indirect method of examination was employed for the person who interpreted the findings to take not only the chemical data into consideration but all the data which threw any light on the origin, the nature and conditions of the water. In the bacteriological examination of water supply the attempt may be made to determine the actual presence of disease organisms and if such were found, it would not be necessary to take into consideration the sources of pollution and other conditions mentioned, but if the bacteriological analyses are not made with reference to the direct determination of the presence of pathogenic organisms, but by the indirect method, then the use of these sources in the light of the data collected by both chemical and bacteriological methods are all factors which appertain to the problem in hand.

10645 Q. In passing judgment upon the sanitary condition of a water at a given point is not the number of people residing upon the watershed above this given point one of the prime factors in the determination?

A. I consider that it is possible to arrive at a satisfactory examination of a water supply on the basis of chemical and bacteriological methods without necessarily taking into consideration the matter of population.

Q. In passing judgment upon a sanitary condition of water from a bacteriological standpoint do bacteriologists take into consideration the number of bacterial counts or the character of the counts as shown by the observation?

A. This would depend upon the origin of the water involved in the analyses. In the analyses of certain waters, the determination of the number of organisms present is of minor importance as a general rule. In the determination of the sanitary quality, the qualitative data are regarded as of more value than the quantitative data.

Q. Upon what sources rest, as a rule, the qualitative data found in the sanitary observation of water?

A. Assuming that your question refers to the bacteriological examination, the qualitative data referred to are
10646 secured by determining the absence or presence of organisms which are usually associated with sewage and especially the relative number of those organisms, taking also into consideration the origin of the water as to whether it is water which had been in contact with the upper layers of the soil or is derived from subterranean source.

Q. Is there any graduated rule or formula used by bacteriologists in making these sanitary determinations from a bacteriological standpoint as measured by the population on the watershed above the point in the stream where the water is examined?

A. I know of no such mathematical rule.

Q. Has there been any rule or formula established of a general kind based upon the experience of sanitarians during the past years upon various streams throughout the country by which a basis of determination could be made from the bacterial condition of the water of a given stream as shown by the observation and as compared with previous bacterial observations of streams by sanitarians?

A. It is generally conceded that in surface waters the presence of bacteria belonging to the colon type may be noted on account of the fact that these waters have been brought in contact with the surface of the soil where the opportunities for
10647 the introduction of colon organisms from divers sources may be present and in the determination of the sanitary quality of water of this character, it is therefore especially necessary that emphasis be laid upon the quantitative presence of this type of bacterial life. The water supply containing a large number of colon organisms is therefore one that could be re-

garded by bacteriologists as more or less polluted with sewage at no distant previous date.

Q. Is it not a fact, Professor, that water supplies have been known to have been affected with this disease producing organism that contained small quantities of coli bacilli?

A. I am unable to answer that question unless I know more specifically what you mean by small quantities of colon bacilli and also as to whether the water was of subterranean or surface origin?

Q. Is it not a fact that surface waters, such as lakes and rivers, have been known to have been infected with disease producing organisms which did not contain a sufficient number of colon type to render the water suspicious as shown by the ordinary means of analysis?

A. I do not now recall any cases where under natural conditions the water has been infected with disease pro-
10648 ducing organisms to such an extent as to be able to pro-
duce epidemic disease and where such waters upon examination made at that time failed to reveal the presence of a colon organism in considerable numbers. I can conceive of where an infection was sporadic and discontinuous that the evidence of such infection might not be revealed by bacteriological analysis at some subsequent date and still that water might have previously been the direct cause of epidemic disease.

Q. In your opinion in an examination of the sanitary condition of the water is it necessary to take into consideration the extent of the population residing upon the watershed of the river under examination or form your opinion from the determinations of the bacteriological and chemical analyses regardless of what may be situated upon that watershed, so far as domestic and manufacturing waste is concerned?

A. I think that it would be possible to determine whether a water materially changed from what previous experience had shown to be the case with normal streams which were not infected with sewage or drainage from human beings without taking into consideraton the density of the population on that watershed. The size and area of the watershed and its
10649 nature whether forrested or unforrested and the char-
acter of the soil and numerous other problems which are not directly related with the presence of human life are factors

which are quite as important in determining a matter of this sort as the density of the population itself.

Q. Might not a colon type be found in water unexposed to the excreta or sewage?

A. It might. The colon organism is a normal inhabitant of the intestinal tract of higher mammals and other animal forms, and therefore its mere presence in surface water—this fact taken simply by itself—can not be regarded as direct evidence that its presence had originated from human excreta.

Q. Is it not a fact, Professor, that in the sanitary observation of water, sanitarians become more interested in determining the presence of pathogenic bacteria or organisms rather than in the quantitative presence of those organisms?

A. The ordinary sanitary examination from the bacteriological point of view alone does not attempt to determine the direct presence or absence of specific pathogenic bacteria.

Q. What then is the object of the sanitarian in making the observations of this character?

10650 A. Because of the intimate relation under existing natural conditions which exist between pathogenic organisms capable of producing disease and certain well known bacteria which do not belong to the distinctive pathogenic class, but which can be very much more readily detected in water. The difficulties which confront the bacteriologist in the isolation of pathogenic bacteria are such that under natural conditions the chances of his finding the organism would be exceedingly remote.

Q. The sanitarian then reasons that because of the presence of that class or character of organisms which belong to certain pathogenic bacteria is associated with them that they are present?

A. The methods followed by the bacteriologist are primarily indirect, although not to the degree that the method of the chemist is, and positive findings of this indirect method afford him presumptive evidence which serves as a further basis for investigation and may be supplemented by direct examination for the presence of pathogenic organisms. This provided that the conditions of the test are such as to indicate the probable presence of those organisms at any given time.

Q. So that after all these determinations and observations are made with a view of determining the possible pres-

10651 ence of pathogenic bacteria rather than the extent or quantity of such pathogenic organisms, if present?

A. The conditions to which pathogenic bacteria are subjected in nature are such as to produce a rapid loss in vitality of those organisms and consequently a water may be of such a character as to result in a production of disease and if the examinations are not made in large numbers at that particular time the organisms of a pathogenic character may lose their vitality to such an extent that the determination of their presence and not the number of the pathogenic organisms present may be fairly considered as indicating the probable nature of that water as to the liability of producing epidemic disease.

Q. State whether or not the typhoid bacilli is customarily found by observers in water supplies?

A. It is not. The attempt is not often made to search for the pathogenic organism directly because of the difficulty of the case.

Q. Now, what difficulties are most likely to arise and exist in making these determinations for the pathogenic bacteria in water supplies?

10652 A. When we take into consideration the fact under natural conditions which would obtain in any community that the organism producing typhoid fever requires for its period of incubation a period of time ranging from several days to several weeks; that after the symptoms of the disease appear in the first persons infected, that another period of several days elapses before the excreta of the typhoid patient actually contains typhoid organisms, and that moreover the water supply is rarely brought under suspicion until after a number of typhoid cases have appeared in any given community, that the period of time which may have elapsed between the original infection of the water which would be capable of starting an epidemic of this disease and the time which would elapse before such waters are ordinarily subjected to examination is usually so long that the organism might have entirely disappeared from the water or be reduced to such small numbers that its determinations is rendered very much more difficult it is evident that the difficulties which attend such direct examination are numerous.

Q. Do you in your observations make a practice of looking for the typhoid bacillus and such other pathogenic bacteria in suspected waters?

A. In my routine analytical work the practice is never 10653 followed of making a direct examination of such waters as are ordinarily examined for the purpose of detecting the presence or absence of typhoid organism.

Q. Is there any rule or formula in the science of bacteriology or in sanitary science which measures the life of all classes and kinds of typhoid bacilli virility in sterilized water?

A. The conditions which obtain when we attempt to determine the vitality of any living organism are such that I deem it impossible to formulate with mathematical exactness the period of time which the vitality of any organism could be determined.

Q. Do you deem it unreasonable to undertake the formulation of a rule or system by which the life of the typhoid germ or organism may be measured in running water, in river water, in sewage, in highly polluted water, in sewage polluted water, in sediment, in soil, in moist soil, under all conditions of nature and if so, please state why in your judgment such formula is impossible

A. The conditions to which the typhoid organism would be subjected under the variety of conditions as outlined in the foregoing question, are subject to the influence of so many factors, the effects of which are not directly comparable 10654 and which must be taken into consideration in the different cases involved that I do not consider that one can say with mathematical accuracy just how long it will take for the typhoid organism to be destroyed in those waters, but that in giving an opinion in regard to a matter of this sort one must base his judgment upon the fact that there is some variation to be observed in the influence of these different factors and one could place this limit at such a point as would in his judgment be a safe limit for the destruction of the organism concerned under the variety of conditions which were under consideration.

Q. The conditions of moisture in the soil, the character of the sediment, the character and extent of pollution, the extent of dilution are so variable no rule or formula could be adopted by which the life of the typhoid germ under these various conditions might be accurately observed without taking into consideration the degree of variation that exists in the longevity of the various germs themselves. That is, the extent of their virility, their hardiness and robustness as compared with each other?

A. I do not consider that the data given with reference to the longevity of the organism could be expressed in
10655 terms with mathematical accuracy, and if it were so expressed it would be necessary to take into consideration the effect of these factors mentioned, that the typhoid organism is subject to the influence of these variable factors, and that these might change the rate of destruction and in setting such a limit it must be placed at such a point as in the judgment of the investigator will be sufficient to permit of the operation of all of these factors referred to, and effect the destruction of all organisms of the class concerned.

Q. So that the organisms of typhoid fever like everything else in nature, depend so far as longevity is concerned upon the environments surrounding each particular germ, together with the particular character of the germ itself?

A. The factors which are of import in the destruction of any organism are those which are inherent to the organism itself and also those which relate to the external environment. These may be varied in such a way as to accentuate the rapidity of the process or not.

Q. So that in accordance with the inherent vital qualities of and the external environment of each particular germ the longevity of that germ is measured?

A. So far as any one particular germ is concerned that is true. But it should further be said that experiments which are made under conditions where divers strains of organisms are employed that the validity of the conclusions drawn from
10656 such experiments is very much increased where the experimental conditions are different in each case owing to the fact that more than one strain of the organism is employed.

Q. And thus differences may result from these unobservable differences in the observations brought about because of the extreme delicacy of the observation?

A. The experience of the operator in dealing with matters of this sort is a factor which is of very material significance in interpreting the data of such experiments.

Q. How long have the typhoid bacilli been known to live in sterilized water?

A. Experiments made with typhoid bacilli inoculated into sterilized water have demonstrated the ability of this organism to live for a period measured by a number of months and in some instances upwards of 100 days. The results obtained are widely discordant with respect to the exact time.

Q. That also depends, does it not, upon the inherent quality of the germ itself?

A. In case of tests made on sterilized water the variations reported are undoubtedly due to the effect which is produced
by both sides of variables; first, those which are inherent
10657 to the constitution of the organism in question; second,
those which are produced by the variation in the environments?

Q. This particular germ lives longer in sterilized water than under any other condition in nature other than that of the laboratory experiments or in the human system, does it not?

A. I am uncertain as to what is meant by laboratory experiments, but interpreting that question to be the inoculation of typhoid organisms in culture medium kept in laboratory for stock purposes, stock cultures, I should say that the vitality of the typhoid organism in boiled water but not necessarily sterile water, is marked by a period of duration, longer than exists under natural conditions.

Q. Would it live as long under such conditions as in the soil, or in privy vaults?

A. Interpreting your quesion to refer to the viability of an organism in boiled waters, I am of the opinion that the vitality of the organism might be retained in the water sterilized by boiling, a longer time than would be the case if the organism
10658 was exposed in contact with human dejecta, in a moist
condition.

Q. You stated, I believe, previously, that the typhoid bacilli was a very difficult matter to observe, in the bacteriological examinations of water?

A. I stated it was very difficult to determine its actual presence.

Q. Is it not a fact that it is a difficult matter to find it, even in sewage when the observer knows it had been deposited recently, or discharged, that is, that the typhoid bacilli had recently been discharged into the sewage?

A. When examined under the conditions which would exist in nature, where the typhoid organism would be brought into contact with myriads of sewage bacteria, which themselves are capable of extensive multiplication, it would be a difficult matter to determine the absence of all typhoid organisms, but it is possible by means of the elective media which are now employed in the best laboratories, for the typhoid organism to be differentiated from human feces, and diluted organic matter rich in materials of sewage matter.

10659 Q. Is it not a fact that competent observers have found the typhoid organism to live in sewage for a period of from five to seven days, in the laboratorial experiments?

A. Interpreting your question to refer to the vitality of the typhoid organism when subjected to sewage under perfect natural conditions and normal conditions, I should say that experiments which give such a period of vitality to the typhoid organism, must be tested in the light of the newer methods of differentiation which have been introduced since the agglutining, or Widal test has been devised, and which is now regarded as the most crucial single characteristic which we possess for the differentiating of the typhoid organism from related bacteria.

Q. Has it not been so proven?

A. I do not recall at the moment, any experiments which have been made on the typhoid organism, on raw sewage, 10660 where the identification of the organism has been made on the basis of all the methods which are now employed for the differentiation of the organism from related forms, and in which the vitality of the organism so exposed under natural, normal conditions, was retained for a period as indicated in the foregoing question.

Q. The life of the germ in sewage would depend largely upon the extent of the concentration of the sewage material?

A. It is my opinion that the concentration would not be operative beyond a certain point. That the difference between the sewage containing say, 10 per cent. of solid excreta, and say 20 or 25 per cent. of solid excreta, would not be such as to materially alter the rate of loss of vitality.

Q. These percentages which you have just stated, are within the limits of ordinary sewage?

A. No, those percentages contain more solid matter than are found in normal sewage, but by the previous answer I mean that the rate of death would not be affected, if there was a sufficient amount of the products of other organisms present 10661 in the sewage organisms themselves to accomplish the destruction of the typhoid organism in a period of time.

Q. And as the extent of the dilution in a measure localizes the longevity of the germ?

A. When the degree of concentration is at such a point as to just be able to destroy the typhoid organism in a given period of time, manifestly the dilution of that degree of sewage concentration with water which would reduce the amount of prejudicial substances, would permit of the retention of the vitality of the typhoid organism for a long period of time.

Q. State, Professor, whether or not in your opinion the typhoid fever germs lived longer in the waters of the Chicago river prior to the opening of the Drainage Canal than they will now live in the waters of that river, in the Canal?

A. My opinion is that the changes that have been produced in the Chicago river through the opening of the Drainage Canal, are not such as will greatly modify the death rate of the typhoid organism when exposed under these two conditions.

10662 This opinion is based upon my belief that in either instance the degree of concentration in the water of bacterial by-products, and the presence of saprophytic bacteria themselves would be sufficient to cause an early death of typhoid organisms placed in this water.

Q. If the typhoid organisms rapidly died out, in the waters of the Chicago river, prior to the opening of the Drainage Canal, what effect would the discharge of that water into Lake Michigan, have upon the prevalence of typhoid fever in the City of Chicago, taking its water supply from Lake Michigan?

A. As I understand the conditions which have prevailed in reference to the pollution of the waters of Lake Michigan by sewage of the City of Chicago, a certain proportion of the sewage of Chicago has been discharged into the waters of Lake Michigan, without remaining in the waters of the Chicago river, and such sewage would have found its way into the pure waters of the Lake within a sufficient period of time so that it is probable that the vitality of the typhoid organism would not have been lost during this period, and hence it was possible for the conditions which obtained in nature to serve 10663 as an agent for the production of disease in Chicago even though diluted with the lake water.

Q. It is your opinion, then, is it, that none of the typhoid germs which passed into the Chicago river prior to the opening of the canal, found their way into Lake Michigan, and from thence into the water supply of the City of Chicago?

10664 A. The answer to the preceding question did not state that no typhoid bacteria did find their way through the water of the Chicago river and so into the waters of Lake Michigan, but it is my opinion that the major part of the infection arose from sources where the typhoid organism was not exposed to conditions in sewage for long periods of time.

Q. It is your opinion, then, that the greater part of the typhoid organisms which produced fever in Chicago entered the lake from some source other than the Chicago river?

A. It is quite conceivable that a considerable portion of the organisms which found their way into Lake Michigan may have been carried there by way of the Chicago river, but it is my belief that at such times as the river was flushed by heavy rains which would sweep the sewage out in the lake more rapidly than otherwise would have been the case, that this has been assigned as a potent cause for the incidence of typhoid fever in this city.

10665 Q. Would that not in your judgment cause spasmodic waves of typhoid fever to take place in the City of Chicago?

A. Interpreting your question to mean spasmodic waves of short duration, I should say not necessarily the case.

Q. How many typhoid epidemics have you personally examined, Professor?

A. Interpreting your question to refer to epidemics where I have had anything to do with the analysis of waters at or soon after the time the epidemic occurred, I have examined the conditions which prevailed at the city of Ashland, city of Baraboo, city of West Superior, at Marinette, and Menominee, Michigan.

Q. Were each of these epidemics caused by a typhoid water supply?

A. Each of the epidemics produced in the cities mentioned was caused by impure water supplies.

Q. Can you give the source of infection in each of the three cases, the West Superior, Baraboo and Marionette?

A. In the case at Baraboo, the water supply is drawn from a series of springs and deep wells, situated below the town. The power house for the pumping of the water is situated on the banks of the Baraboo river and for power purposes the 10666 water from the Baraboo river was employed, being derived from the main stream at a point below the town and below the outfalls of the sewers of the city. The water, used in this race, for purposes of pumping the water from the wells by the aid of a water pump, was in a highly polluted condition, owing to the fact that the sewers of the city entered immediately above. The intake pipe from the wells passed from the wells to the pump house directly through this race of highly polluted water, and it was found upon examination that in this intake pipe consisting of short pieces of iron pipe, five leaks were present, so that when the water was pumped by aid of a steam pump, which had a much higher suctional action than the water pump which was used for reserve purposes, the water was drawn in through these leaks from the race into the intake pipe. This intermittent introduction of large quantities of polluted water that would naturally occur when the slower acting water pump was employed was discovered by charting the case rate of the disease as it existed in the city and noting the striking relation which was evident between the use of this steam pump and the wave like outbursts of the fever in the city. Examination of the waters at that time revealed the presence of 10667 the polluted condition and the full examination of the conditions mentioned occurred in my judgment from the pollution of this supply which caused an epidemic of about 150 cases of typhoid fever in a period of six weeks, and in a town of about 5500 population.

The epidemic at Ashland was produced in this way: The sewers of the city of Ashland are discharged into Chequamegon Bay, a shallow arm of Lake Superior. To protect the harbor the government built a breakwater about a half a mile from shore. The current from the lake sets into this bay, passes around the north and the west shore of the bay, receives the sewage of the city of Ashland and then passes out around the two ends of this breakwater. When the water supply for the city of Ashland was introduced, the intake pipe was run out into the bay water and stopped on the land side of the break water, that is between the break water and the land. The result was that with the increasing amount of pollution discharged into the bay, and the flowing of the current around and consequently out past the intake pipe, that the diluted sewage of the city was brought back in the water mains of the town. This resulted in the production of an extensive epidemic of upwards of about 200 cases in a town of 10,000 or 12,000 inhabitants.

Q. How far was the intake of the water supply at Ashland situated from the mouth of the sewer?

A. About three quarters of a mile I should say.

10668 Q. Out in the lake?

A. Out in the lake with the current at times passing directly from these outfalls towards the mouth of the intake pipe.

Q. How deep was the lake at that point?

A. The bay is a shallow bay at this point, varying perhaps from 10 to 15 feet in depth.

The Marinette and Menominee epidemics occurred simultaneously, and typhoid fever had been present there in much larger than usual proportions for several years. The sewers of the city of Marinette are discharged into the Menominee river, and one of the largest sewers of the city of Menominee is discharged into Green Bay. The Menominee river empties into Green Bay. The intake pipe of the water supply is off shore at a distance of about 2,000 feet. The analytical data collected at the time of this epidemic showed that often the water at the intake pipe was normal Lake Michigan water, and at other times, depending upon wind action, would indicate a polluted condition. The presumption is very strong in favor of the view that the sewage of this city was carried out for the distance of 2,000 feet, at times found its way past the intake pipe and was pumped up into the water mains.

Q. Going back to Ashland, state whether or not the city

10669 of Ashland is situated upon an abrupt decline or on a level plain?

A. It is not on a hill slope. I should say that the elevation of the center part of the town ranged from 10 to 30 feet above the lowest.

Q. And that is true with this last place?

A. I have not examined personally the conditions at Menominee and Marinette.

Q. All of these epidemics, however, were caused by sewage pollution, that is each of these that you have just explained, or sewage infection?

A. I should so consider it, yes, sir.

Q. Professor, in the joint and concurrent investigations or observations which were made by yourself, Professor Jordan and Professor Zeit, did you each use strains of culture from the same source?

A. Professor Jordan and myself, I think, used the identical same strains. Professor Zeit, I believe, employed, in addition to the strains which Professor Jordan and myself used, one other.

Q. The strains denominated "X," "Y" and "Z" by 10670 you in your direct examination and as shown on the table which you read in evidence represent cultures from the same strains as those used by Professor Jordan in his examinations, as I understand it?

A. And denominated by him "X," "Y" and "Z."

Q. And denomiated by him "X," "Y" and "Z?"

A. Yes, sir.

Q. In point of inherent vitality, can you from the table which you read in evidence, and your observations made of these three strains, state whether or not they were of different inherent vitality?

A. The analytical data would not enable me to draw such a conclusion.

Q. Why not, Professor?

A. To have determined this point it would have been necessary to have made the observations at very much more frequent intervals than they were made.

Q. Did you make or attempt to make any such determinations from these strains?

A. I did not.

Q. Is it not a fact that the addition of the total number of typhoid seedings deposited in the samples of water used 10671 by you had a tendency to decrease the life of those particular organisms over what the life of any one of those organisms would have been had it been deposited alone in the samples of water used in the determination?

A. It is a well recognized fact by bacteriologists that variation in the amount of seeding does exert a difference in the rate at which loss of vitality occurs, and that the heavier the seeding from a given volume of water the longer will be the vitality of the organisms in that water rather than shorter, so I would conclude from this that so far as this effect was concerned the increase of typhoid seeding would if it had an effect, increase the vitality of the organism over what would have been the case with very light seedings.

Q. How deep under the surface of the water were these parchment sacs placed or suspended?

A. To a depth of about 6 to 12 inches, just sufficient to prevent excessive wave action. We lost a number of the sacs when exposed on the surface, because of breaking from the waves.

Q. The life of the germ as found from your experiments ranged from one to 9 days in the water of the Illinois river, does it not, at Averyville?

10672 A. I do not consider that the life of the typhoid organism as illustrated by the experiment cited, does range for a range of one to nine days.

Q. What significance do you attach to the presence of the organism on the ninth day in sac number 15 of the "Z" strain?

A. Taking all of the data which is incorporated in the table at hand, and taking into consideration the fact that in 141 tests made on the first three days the typhoid organism was found in 69 cases, and further taking into consideration the fact that in 318 analyses conducted subsequent to the third day only one organism was found which was proven to be typhoid in character, and further taking into consideration the fact that the results of the experiment are so overwhelmingly concordant with the exception of this single case, it is my opinion that the conclusion which is to be drawn from this experiment, taken as a whole, warrants the conclusion that typhoid organisms exposed under the conditions of the experiment would be incapable of retaining their vitality in the waters of the Illinois River at Averyville for a period which exceeds that reported in my direct evidence.

10673 Q. Is it not a fact, Professor that of strain Z, sac number 15, as shown on your table, you made an examination of the contents of that sac on five separate days, towit: the first, the second, the fifth, the ninth and the twelfth, and that of those five examinations you found the typhoid bacilli present in the first, the second, and the ninth days?

A. That is true.

Q. Have you any reason to believe that you would not have found it present on the third and fourth days?

A. It is highly probable that if an examination of that particular sac had been made upon the third day after immersion, that the typhoid organism would have been discovered in such an examination.

Q. And how about the fourth day?

A. Taking into consideration all of the analytical evidence which is shown in the accompanying table, where the conditions are all as nearly uniform as can be secured, under the conditions of the experiment, and further taking into consideration the fact that out of twelve colonies examined on the fifth day, none of these proved to be typhoid, or of the 14 examined on the tenth day, 13 of which proved not to be typhoid, and of two examined on the twelfth day, neither of which proved to
10674 be typhoid I believe that I am justified in the conclusion
that if an examination had been made upon the fourth day, the results which would have been obtained would have been in practical accord with the results which are shown as having been obtained in those cultures which were made with the cultures "X" and "Y," when the examination was performed upon the fourth day and where in no case in 41 examinations was the typhoid fever organism found in any instance.

Q. When you speak of 41 examinations, you mean 41 colonies picked off or fished off the plate?

A. I do.

Q. How many platings did you make of each particular sample of water analyzed or observed on each day?

A. In testing the number of organisms found in the tube it was customary to make at least three plates from each sample, and from an inspection of these samples select those organisms which showed presumptive typhoid appearances.

Q. What was the quantity of water plated in each instance?

A. In the outset of these experiments the dilutions which were made ranged from .02 of a cc. to 1 cc. It was found 10675 upon making these tests, that the number of organisms which grew upon the culture medium when we employed Drigalski medium inhibited to such extent the water bacteria which were normally present in the water that by far the large majority of organisms which appeared upon the plate showed, so far as culture examinations were concerned, the typhoid character and this made it unnecessary to employ larger quantities of water because of the great preponderance of the typhoid organism, when cultures were made with large quantities of water.

Q. In making the final test as to whether the colonies fished were typhoid, did you subject them to the Widal test?

A. Yes sir.

Q. State whether or not in your opinion the water contained in these sacs represented the bacterial condition of the water in the Illinois River at Averyville, at the place where the sacs were submerged, during the whole time they were submerged, aside from the change brought about bcause of the additional numbers of typhoid bacilli?

A. The water which was used in the making of these experiments was taken from the river at approximately the point where the sacs were immersed. Inasmuch as the germ 10676 content of a flowing stream is subject to fluctuations, depending upon the amount of sediment and numerous other factors which modify the germ life found in a given body of water, the sample of water placed in the sac would not and could not under any condition, be exactly the same in germ content as was the case in the water flowing past these sacs for the period of time covered by the experiment.

Q. State, Professor, whether or not there was any substance of any kind found on the exterior of the sacs, while they were deposited in the water?

A. After the sacs had been left in the water for various periods of time, a reddish spot appeared upon the sacs. When first observed these were about the size of a pin head, and gradually increased in diameter until they reached a diameter of a half to three-fourths of a cc. These spots never became confluent, that is the surface of each sac never was completely covered with the same, and these spots increased in considerable number, but at no time did the aggregate growth of the fungus cause this spot to equal more than a small fraction of the entire periphery of the sac.

10677 Q. Did you examine this coating or covering of the sac, or these small red spots under the microscope?

A. These were examined and it was found that these were due to fungus which was capable of growing upon the exterior of the sac.

Q. Did not this growth in a measure cause the sac to become impervious?

A. No sir.

Q. To no extent whatever?

A. Not in any way did it produce an impervious condition in the sac.

Q. Did you use any other character of sac except the parchment sac?

A. No sac, no sir. The other series of experiments were made with agar blocks and not sacs.

Q. May not some typhoid fever bacilli, coming from human patients, be possessed of greater inherent vitality than the ones used in the series of experiments conducted by yourself, Professors Zeit and Jordan?

A. It is well recognized that cultures which have been grown upon artificial media gradually lose their virulence and also their power of retaining their vitality, and just in order to meet this objection for the purpose of this experiment freshly isolated cultures were taken from the bodies of three
10678 typhoid patients, one from blood, one from the urine and one from the feces, in order that the possible variations which might occur when such laboratory cultures were employed could be obviated.

Q. May not other cultures have been obtained from human feces, or of the urine which were possessed of greater inherent vitality than those used?

A. It is well recognized that there is a certain variation in the inherent vitality of pathogenic organisms, but it is my opinion that when three cases are taken freshly isolated from the human body, and when these cases are not in any way connected with each other, through the medium of the same outbreak and therefore presumably given as wide a range as would normally be found among typhoid bacilli coming from human sources, then it is quite improbable that typhoid organisms, as they normally occur in man, would ordinarily possess a degree of vitality which would much exceed those which are represented by the three cultures employed.

Q. Taking into consideration the care and precaution that was used by you in making the determinations contained in the tables which you read in advance, in your direct testimony, and assuming that typhoid fever dejecta is deposited into a running stream which flows for a period of nine days, at
10679 which point the inhabitants of a city receive their water
supply, and knowing that you had observed the presence of the typhoid bacilli during the series of examinations which you made in the water at that point—assuming the bacterial contents of that water to remain or be practically as contained in the sacs with which the observations were made, would you recommend that water as free from typhoid bacilli, and therefore suitable for domestic and drinking purposes?

A. Taking into consideration the fact that typhoid organisms deposited in running streams would not be subject, under natural conditions to such conditions as outlined in the foregoing question, for the reason that in such flow there are factors operative and always operative which are not assumed in the foregoing question, and which must be assumed if the conditions are made to refer to conditions that actually do obtain in a flowing stream, and taking into consideration all the knowledge which I possess from a bacteriological analysis of waters so exposed and the conditions which are referred to, it is my belief that waters discharged into a stream, the character of which corresponded to the conditions which are assumed in the question but which under such conditions are affected by
10680 these other factors which are always operative, it is my
opinion that typhoid organisms would not be found in such waters when a period of flow was of nine days duration.

Q. But, Professor, assuming aside from the natural conditions that the water remained in the river as it remained in the sacs for nine consecutive days, and in the ninth day you found typhoid bacilli present as shown in your observations, would you consider that water as being free from typhoid bacilli, at the end of the ninth day?

A. It would be impossible to base a recommendation of such a character unless all the facts which bear upon this question were taken into consideration, and if those facts were in accordance with the facts as represented in the experiment referred to in which analyses were made in large numbers and at daily intervals, and in which out of this series of analyses the typhoid organism was found abundantly the first day, the second day and the third day, but was not found at any subsequent date, although frequent daily examinations were made, except in one single solitary instance, on the ninth day, and was found in no instance thereafter, although examinations were continued for double this length of time, I should under these cir-
10681 cumstances consider that I was warranted in assuming that the typhoid organisms introduced in such water would have disappeared so completely that under no conditions would the water have been able to have produced disease if it had been consumed by human beings.

Q. And under the facts assumed, and at the end of the ninth day, and at the point, the end of the ninth day, you would recommend to the people that they could drink that water with impunity so far as the effect of the typhoid fever germs were concerned?

A. The recommendation as to whether a water supply is pure or suitable for domestic use presupposes conditions which are not assumed in the foregoing question and which must of necessity be taken into consideration before any such recommendation can be made, and a water supply which is known to contain typhoid bacilli must therefore be subjected to exceedingly stringent examination before one would be warranted in making any such recommendation as indicated in the question.

Q. Do you mean a stringent examination for the purpose of determining the presence or nonpresence of typhoid bacilli?

A. I do.

Q. Do you consider the observations and examinations
10682 which you made of the water contained in the sacs, as

shown in your tables, to be a stringent examination of that water, for the purpose of detecting the presence or non-presence of typhoid bacilli?

A. I consider that the examinations which were made of the analysis of this water were sufficiently stringent to have detected the presence of the typhoid bacilli if such had been present.

Q. Then under the conditions assumed in the preceding question that if water in a running stream ran nine days was, during the time in the same bacterial condition as the water contained in the sacs which were used in your experiments, and underwent the same bacterial changes, containing typhoid bacilli which also underwent the same changes, that water would be suitable for drinking purposes at the end of the ninth day and at the place reached at the end of the ninth day?

A. The conditions which were stated in the assumptions named in the question are so entirely foreign to what do exist when waters find their way in a flowing stream that a comparison which is made between the conditions of this experiment and the conditions which would occur when typhoid organisms
were deposited in a running stream for nine days flow,
10683 are such that I am unable to state exactly what would
occur under the conditions assumed, but when I take into consideration the fact that in a case of water containing approximately 5,400,000 typhoid bacteria in a given volume, that an exposure of that water under the conditions as described in the foregoing answers failed to reveal the presence of typhoid organisms in all but one case out of the entire number examined on the ninth day, so that the vitality of this enormous number of organisms had been entirely lost with the exception of the single germ referred to, except in the case of the first three days, when typhoid organisms were demonstrated, I should consider that a conclusion which is based upon the results which were obtained in the case of this single organism alone and not the whole of the results of the experiment are not proper as indicating what the condition of affairs would be which would occur in nature.

Q. Professor, only two examinations were made of all the samples in all the sacs by you on the ninth day. Is that true?

A. It is. Two samples of water removed from two different sacs and from those two sacs a number of separate and individual tests were made, and from these individual tests 18 suspected typhoid colonies were removed and examined.

10684 Q. On the ninth day no samples of water were taken from the sacs except sac number 13 and sac number 15, in which case only one sample of water was taken from each sac and analyzed?

A. The quantity of water that was removed in each instance was much larger than the quantity which is necessary for making a bacterial examination and from this large sample a number of separate and independent tests were made in each case.

Q. State whether or not the water taken from the sacs was diluted before analyzed?

A. I am unable to answer that question specifically, but it was our custom, owing to the relatively small number of water bacteria which appeared in the plates, to use the samples of water for inoculation purposes, directly into the media without dilution.

Q. Is it not a fact that of the water analyzed on the ninth day only 18 colonies were specifically examined?

A. It is a fact that of the water which was analyzed upon the ninth day a much larger number of colonies were examined than is shown in the existing table, but that the 18 colonies which appear in the existing table were colonies which in
10685 a majority of cases were regarded as presumptive typhoid colonies which were therefore selected for this purpose, but it should be kept in mind that these were selections made from a large number of colonies which appeared in the latter plates.

Q. The 18 colonies fished off, that represented the number of colonies that were subjected to the Widal test? Is that true?

A. The colonies of course which were represented upon the culture plates and not fished for further identification were not tested for Widal reaction, but in these cases all the tests were applied to the organism which was sufficient to identify them as typhoid or not.

Q. And on the tenth day 46 colonies were the only ones that were subjected to the Widal test?

A. The number of colonies fished as reported in the table were all of them subjected to the various tests employed to determine their typhoid nature.

Q. And that is true with reference to all the colonies or the various ones shown on the tables?

A. Yes sir.

10686 Q. Professor, what particular significance do you attach to the use of the agar blocks as distinguished from the Drigalski plates, in these experiments?

A. The experiment made with the agar blocks approached the problem from a materially different point of view and one which in my judgment would favor materially the retention of the vitality of the typhoid organism, but recognizing the importance in an experiment of this sort of attacking the problem in hand from as many different points of view as possible, it was deemed advisable to make simultaneous tests with this method of the agar block.

As outlined in the direct examination the typhoid bacteria in these blocks were prevented from coming in contact with the water bacteria by a screen of agar which was in all cases approximately 1-4 to 3-8 of an inch in thickness. This agar screen would permit of the passage of soluble substances, but not the organisms themselves, and so the conditions would in all probability be less prejudicial than was the case in the parchment sacs.

Q. These observations as shown on the table which you read in evidence in your direct testimony represent the only bacteriological analysis of the water in the Illinois River
10687 or the drainage canal that you have personally made or that has been made under your supervision?

A. These represent every independent analysis that was conducted on the water of the Illinois River at Averyville, and in this connection I wish to restate the fact that none of these determinations as to the complete identification of the typhoid organism could be made or was made until all of the samples of the sacs were removed from Peoria and the station at this city discontinued.

Q. Where was the plating done?

A. The plating was done in the bacteriological laboratory of the Bradley Polytechnic Institute at Peoria.

Q. This work was not done, as I understand you, personally by yourself, but by your assistant?

A. The work at the Peoria station was carried out under my direction, by my assistant, Mr. E. C. Hastings, who performed the routine work of packing and shipping the cultures to me at Madison for study and identification.

Professor, in your direct testimony you stated that you were familiar with the typhoid mortality of the various
10688 cities situated on the water sheds of the Missouri River above the city of St. Louis. In making that statement it is a fact is it not that you obtained your information from the certificates or copies of the certificates of the health officials of the various cities exhibited to you by counsel for the defendants, and you did not obtain your information upon a personal inspection of the records in the various offices in the various cities?

A. It was.

Q. You obtained no other information and included no other statistics or mortality records in your testimony than were presented to you by counsel for defendant?

A. The answers to the questions on these subjects assumed the statistics with reference to the typhoid statistics of these cities as previously presented in evidence by other persons.

Q. And those tables have already been introduced in evidence or as you understand it are to be?

A. They are.

Q. Your statement to the effect that you had examined the typhoid statistics of the city of St. Louis was based altogether upon what you obtained from the health reports of the
10689 Health Department of the city of St. Louis?

A. They were.

Q. The published report?

A. They were extracted from the published reports.

Re-Direct Examination
By Mr. Todd.

Q. What are the conditions not assumed in the hypothetical question of Mr. Jeffries to which you referred as existing in nature and not included in the question wherein he asked you if you would recommend water after the flow of nine days from the point of infection, infected and of the quality as contained in the sac used in the experiment?

A. The conditions as I comprehend them from the question asked imposed conditions which I do not think could possibly obtain in the waters of a running stream, inasmuch as the conditions of the experiment precluded the operation of factors which are known to exert a deleterious influence upon the vitality of the typhoid organism, and further that the conditions which do so obtain are conditions which would lessen this vitality in comparison with that which would be obtained in the experiment mentioned, and that the results of the experi- 10690 ment in which the bacteria of typhoid fever were entirely killed in a period of three days, with the exception of the single instance referred to, lead me to consider that no importance is to be attached to the presence of this single organism in determining whether the typhoid organism would be able to exist in flowing water after a period of flow measured for nine days.

Q. With these assumptions supplied as you have indicated, what recommendation would you make, for domestic and drinking purposes, under the conditions obtained in the hypothetical question as to the quality of water after running nine days from its source of infection, assuming that all other sources of infection were eliminated?

Mr. Jeffries: I object to the question for the reason that the witness himself has undertaken to put to himself other assumptions which were not embodied in my question asked in cross examination. I object to the question for the further reason that it is improper redirect examination and if counsel desired the witness questioned upon any such assumptions, it should have been asked in direct instead of redirect.

A. Assuming that all of the sources of infection are eliminated when water was exposed under natural conditions in a flowing stream, I should regard this period of flow as suf- 10691 ficient to result in the destruction of the typhoid organism, and would therefore regard such supply as not capable of producing typhoid disease.

MR. JEFFRIES: I move to strike out the two questions asked in re-direct examination and the answers given thereto for the reason that there is nothing in the assumptions in the questions or in the answers that would preclude the witness from answering the question upon which the first question of this redirect examination is based.

H. L. RUSSELL.

ADJOURNED until 10:00 A. M., Monday, February 22,

10:00 A. M., Monday, February 22, 1904.

10692 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing respective parties. Also Hon. John G. Drennan, representing the Sanitary District of Chicago.

ISHAM RANDOLPH

a witness called on behalf of defendants, after being duly sworn by the commissioner, testified as follows:

Direct Examination

By Mr. Todd:

Q. What is your name?

A. Isham Randolph.

Q. What is your business?

A. Civil Engineer.

Q. How long have you been a civil engineer, Mr. Randolph?

A. I began that line of work in 1868.

Q. Are you a graduate of any technical institution of engineering?

A. I am not?

Q. From what source did you gather your engineering knowledge?

10693 A. From practice, observation and study.

Q. Will you give your engineering experience, commencing with 1868?

A. In 1868 I entered the service of the B. & O. Railroad Company as an ax man, on the Winchester & Strausburg Extension of that line. I remained with that road in the capacity of ax man and later as rodman until its completion in 1870. In 1870 I went to the Washington & Ohio Road as leveller and surveyed from Round Hill in Lowden County through the mountains to Winchester, Virginia. After the surveys and estimates were completed I went into the service of the Lehigh Valley Railroad. My recollection is that that was the fall of 1870, locating the extension of that line from Jugtown Mountain to Perth Amboy, New Jersey. My next engagement was with the B. & O. Railroad. I entered their service in March, 1872, as transit man, on the survey from Syracuse, Indiana, to Chicago. I had charge of the locating party on that line, locating 110 miles of the road; later building 27 miles of it, and building the round house and shops for that company at South Chicago.

After the completion of that work engineering was pretty
10694 dull and the best thing I could get was book keeping and
draughtsman in a plumbing shop in Richmond, Virginia, and I staid there until the first of January, 1876, when I was invited to a position as assistant engineer on the Scioto Valley Railway in Ohio. After the completion of that road I was its roadmaster. In 1880 I was offered the position of Chief Engineer of the Chicago & Western Indiana Railroad and the Belt Railway of Chicago. I took charge of that work on the 1st day of May, 1880, and remained with that company for four years. I then opened an office for general engineering work in Chicago and in 1886 I went into the service of the Illinois Central Railroad to locate and build the Chicago, Madison & Northern Railroad, and the Freeport and Dodgeville Railroad.

After that work I opened an office in Chicago, in 1888, and did general railroad and municipal work. I was consulting engineer for the B. & O., for the Union Stock Yards & Transit Company, the Chicago & Calumet Terminal R. R. Company, and for the Stickney project, the Transfer Yards.

In 1893 I was tendered the position of Chief Engineer of the Sanitary District of Chicago, was elected to that office on the
7th day of June of that year, and have continued as such
10695 Chief Engineer ever since.

In 1893-4 I was the President of the Western Society of Engineers.

Q. What were and are your duties as chief engineer of the Sanitary District of Chicago?

A. As Chief Engineer I am responsible for all the work coming under the general term of engineering, the preparation of plans, the preparation of forms of contract, the supervision of the work of construction and the enforcement of all contracts for engineering work.

Q. Describe the conditions of the Chicago River as they were in 1880 and as they continued to be until 1900?

A. My first familiarity with the Chicago River grew out of the fact that the Western Indiana Railroad Company purchased a considerable length of river front, extending from Stewart Avenue up to Sixteenth Street. This river front I had to re-dock and fill in slips and make available for elevator and railroad yards. This brought me in constant visual contact with the Chicago River. It was at that time and remained for many years thereafter a very foul stream, the water black and ill smelling and often covered with a slime, a black slime, 10696 and in the summer seasons there was a great deal of agitation of the waters due to gases arising from the putrescent matter in the water.

Q. Give the effect upon the Chicago water supply resulting from the pollution of the Chicago River?

Mr. Jeffries: I object to the question because the witness is not a sanitarian and has not qualified as such.

A. The Chicago River at that time was a body of water which sometimes flowed up stream and sometimes down stream. Under ordinary lake conditions there was a very, very slight current to the westward, due to the pumping works at Bridgeport.

When the lake was rising the water came in the river quite rapidly. When the lake was falling the flow was in the opposite direction, towards the lake, and in times of freshet there was a strong flow towards the lake. In times of freshet the Bridgeport pumps had to be suspended, and whenever the flow was towards the lake the foul waters of the river passed out into the waters of Lake Michigan, and when there was a freshet, accumulated filth of the river was swept out into the lake and went out for long distances, and the consequent effect of 10697 putting foul water into pure water was to diminish the purity of the water into which it was put.

Q. Did this condition of the Chicago River, which you have just described, obtain up to 1900?

A. It did.

Q. Will you describe the sewage system of the city of Chicago, the levels of the sewers, the outfalls of the sewers, and at what points these sewers emptied either in the Chicago River or Lake Michigan, up to 1900 and prior thereto?

A. The territory north of Twelfth Street, the business part of the city, all drained by sewers leading directly into the Chicago river. Those sewers did not drain towards the lake. Some of them entered the main river and others the south branch of the Chicago River. As I remember it at that time there was a sewer on Twelfth Street which discharged directly into the lake; the Twenty-second Street sewer discharged directly into the lake. Each one of those had a large contributary population. The West Side sewers also discharged directly into the river, either into the North Branch or into the South Branch. Those that I recall now—I have not a very clear mental photograph of the conditions on the north branch for I never examined any of the sewers entering the north branch. I simply knew in a general way where they came in.

10698 On the south branch there were sewers entering at Randolph Street, at Washington Street, at Madison Street, at Harrison Street, at Polk Street, at Taylor Street, at Sixteenth Street, at Eighteenth Street and Twenty-second Street, and Main or Troupe Street, at Loomis Street, at Ashland Avenue and at Western Avenue.

On the south branch—or rather the south fork of the south branch received all the sewage from the stockyards district and the discharge from two trunk sewers coming in from the south, taking the sewage from the large population on the south of Thirty-ninth Street.

The conditions in the south fork of the south branch were more distressing and more disgusting than any other part of the river. There was more organic matter coming in there from the stock yards than any other branch of the Chicago River.

With regard to Twelfth Street I have no personal recollection of seeing the outlet to that sewer in the lake. I always understood it went into the lake. It is now reversed and flows in the opposite direction, but at Twenty-second Street there is a large sewage entering the lake at that point, and I do not recall the street numbers at which other sewers empty, although

10699 I have seen them, but from Twenty-second Street all the way down to South Chicago there were sewers entering the lake at various points. A part of that territory was so flat that the only way a discharge in the lake could be secured was by putting in sewers which were drained to a central well, where pumping works were established and the sewage pumped from these wells into sewers which were discharged into the lake.

Q. Have you a map in your office showing the location of all sewers in the city of Chicago emptying into Lake Michigan, and those emptying into the Chicago River and its various branches?

A. Yes sir, I have.

Q. Will you describe the map to which you refer?

A. The map to which I refer is published in one of the reports of the Commissioner of Public works of the city of Chicago. It is an uncolored map. It is in black and white and the sewers shown by black lines and with the sizes of the sewers given in figures.

Q. Will you produce the map to which you refer and make it a part of the record?

A. The witness produced the map which is as follows:

FOLD-OUT IS TOO LARGE TO BE FILMED

Q. The map that you have introduced is a correct representation of the sewage system of Chicago is it not? 10701

A. I believe it so to be. When Chicago was a young city the surface was so slightly above the level of the lake, it was impossible to put in sewers, the drainage was all in open ditches, and during Mr. Chesborough's administration of the Engineering Department of the city, he planned a sewage system which required the elevation of the grades of the streets. This street level admitted the putting in of sewers which would have fall enough to produce a flow towards the outlet. That slope is very slight, indeed; in many instances it is as small as half an inch to 100 feet, and I think I recall instances where it is even less than that. The result of this is that there is often an accumulation of organic matter in the sewers which is flushed out in times of heavy rainfall or melting snows.

At one time it was the habit in the city to flush them mechanically. They had very large square tanks, mounted on trucks, that took from four to six horses to haul them around, and they would stop this tank over a manhole and let down a spout in the man hole, open the valve and empty the water from the tank into the sewer and flush it in that way. They were kept flushed for many years in that way. 10702

Q. Are you acquainted with the Illinois and Michigan Canal?

A. I am.

Q. Will you describe the Illinois and Michigan Canal and its source of water supply?

A. The Illinois and Michigan Canal was commenced about the year 1836 and completed in 1848. It extends from a junction of the south fork of the south branch of the Chicago River in the city of Chicago and in a southwesterly direction across the divide between the Lake Michigan watershed and the Illinois Valley watershed, through to Peru Illinois, a distance of about, as I remember it, ninety-six (96) miles. This canal had a navigable depth of about 5 feet and a navigable width of about 60 feet. Its locks were 110 feet long and 18 feet wide. What is known as the summit level extends from the south fork of the south branch of the Chicago River, through to Lockport, a distance of about 29 miles. The summit level since 1884,

I think it was, has been supplied by pumping works
10703 located at Bridgeport in the city of Chicago. The
pumps were under a gauranteed capacity of 60,000 cubic feet per minute. Prior to the erection of the pumps of which I have just spoken the summit level was supplied by water coming in through what is known as the Sag Valley. There was a dam at Blue Island, draining off the Calumet River and dividing its flow, a portion of it through a shallow channel, dug for the purpose, and conveying it into the Illinois and Lake Michigan Canal at Sag Bridge. At a period prior to 1870, the date I do not recall, this supply became inadequate and pumps constructed on the principal of the stern wheel to a stern wheel steam boat were put in at Bridgeport, for the purpose of supplying water for this summit level. At some time prior to 1870 the city of Chicago undertook to deepen the summit level and get a gravity flow from the lake through the canal. This work was in progress at the time of the Chicago fire, and a very large sum of money had been expended by the city, something approximating $1,000,000.00, or a little more, I think, and after the Chicago fire the State of Illinois refunded this expenditure to
the city. This gravity flow proved inadequate because
10704 the channel had not been made deep enough and pumping works were again established at Bridgeport and the pumps that were put in had a guaranteed capacity of 60,000 cubic feet per minute and lift between 4 and 5 feet. As a matter of fact those pumps did not in practice accomplish what they were claimed to do, and the flow fell to in the neighborhood of 50,000 cubic feet. It ranged between 45,000 and 50,000 cubic feet a minute. This supplied the summit level from Bridgeport to Lockport and the intermediate level between Lockport and the upper pool at Joliet. At Joliet the canal and the Desplaines River flowed together through the upper pool as far as dam number 1. At dam number 1 there was a lock called lock number 5, which passed the flow from the upper pool to the middle pool. The middle pool was created by the building of dam number 2 at Jefferson Street in the city of Joliet. At dam number 2 the river and the canal again separated and the canal had an independent course from that point through to LaSalle, where it emptied into the Illinois River. The supply of what

is known as the Chanahan or twelve mile level extending from Joliet to Chanahan was taken from the Desplains River at its junction with the waters coming through the canal from the Bridgeport pumping works. At some seasons of the year the supply of water from the Desplaines was very small indeed, and the canal was almost wholly dependent for its avail-
10705 ability as a navigable stream upon the waters pumped from Bridgeport.

Q. When were these pumps placed at Bridgeport?

A. They were completed in 1884.

Q. By whom were those pumps constructed?

A. You mean what machine company?

Q. Yes sir?

A. They were constructed under a contract with the city of Chicago, and paid for by the city of Chicago.

Q. From what source was the water pumped into the Illinois and Michigan canal by the Bridgeport pumping works?

A. The forebay from which this water was pumped connected directly with the south fork of the south branch or what was known as the Stockyards branch. The water entering the pumps came partly from the stockyards branch and partly through the south branch of the Chicago River from Lake Michigan. There was a certain small flow of water due to sewage discharged into the stock yards branch which met the flow from the lake, and the two mingled and were drawn into the pumps.

Q. Have you a table showing the amount of water pumped from the Chicago River by these pumps at Bridgeport?

10706 A. Our own tables give that pumpage since 1900. Reports of the commissioner of Public Works gave it for previous years.

Q. Are those reports published?

A. Yes sir.

Q. Will you tell of the conditions in the summit level of the pools in Joliet?

A. The water flowing through the summit levels at a very slow velocity, probably a mile an hour, was a black liquid, with a very foul odor, and would leave a greasy black stain on anything that was put into it. The water in the two pools at Joliet was at some seasons of the year as bad as that in the canal proper, because there was so little dilution coming in from the Desplaines River, and it was only bettered by what water came in from the Desplaines river. At some seasons of the year that flow was large, and the conditions were very much improved, but in the dry seasons they were foul, horrible pools.

Q. Were you acquainted with the condition of the water in the Illinois and Michigan canal from Chicago to LaSalle? And if so state how the conditions of the water in the Illinois and Michigan canal at Ottawa and points below compared
10707 with conditions that obtained in the upper stretches of the Illinois and Michigan Canal?

A. I have never traversed that stretch of the Illinois and Michigan canal from Joliet to Ottawa by boat. The stretch from Ottawa south I have traversed by boat. At Ottawa I made a careful investigation with the eye and the nose only of conditions, and at that point I could not detect anything whatever by the eye or the nose, which indicated that the water contained sewage. From there on down the conditions were as good as they were at Ottawa and probably improved continually as we went down.

Q. Will you give the history of the Sanitary and Ship canal?

A. The sanitary and ship canal has been the outcome of Chicago's necessities. The conditions affecting Chicago's drinking water had gotten steadily worse from the days when it begun to be a city. The conditions were such that the public generally was excited and the public men of the city determined to see what could be done to relieve the city.

It reached a period in 1886 that the city council authorized the mayor, the elder Carter H. Harrison, to appoint an expert commission to decide what should be done for the city.
10708 That commission was appointed, I think in January, 1886, and Rudolph Hering, then of Philadelphia, was made the engineer in charge. His associates were Benizette Williams and Samuel J. Artingstall. These gentlemen were authorized to employ expert help, to make surveys and investigations and to prepare a report accompanied by their recommendations. The final report of this commission was never made. The preliminary report I have seen, and in fact there is a copy

of it in the report of Major W. L. Marshall, accompanying his report to the Governor, I think for the year 1889. In 1889 the Sanitary District law was passed, authorizing the formation of drainage districts in the State of Illinois.

Under that law a board of trustees was elected, consisting of nine members, with power to organize, decide upon plans, levy taxes, enter into contracts and prosecute the work as to them seemed best. This board adopted the project for a water way from Chicago to Lockport, this water way to cause a flow of the waters of Lake Michigan through the Chicago River and through the channel which they constructed artificially and discharged in the Desplaines River at or near Lockport, Will county, Illinois.

10709 Q. Will you describe the general outlines of the sanitary and ship canal?

A. The sanitary and ship canal follows the general location of the old Illinois and Michigan canal from Chicago to Lockport. It traverses the territory which is partly tributary to Lake Michigan and partly to the Illinois water shed. It connects with the west fork of the south branch of the Chicago River at Robey Street in the city of Chicago; runs in a southwesterly direction through a clay formation and crosses the divide near the "Summitt Range line." The lowest point in the divide between the water shed of the Illinois, the Desplaines valley and that of Lake Michigan is almost on this summit range line.

Before the building of the "Ogden ditch" the natural surface at its lowest point was 11.72 feet above Chicago datum. Chicago datum is a plane of reference adopted for horizontal elevations by the engineers of the Illinois and Michigan canal when its construction was entered upon. It so happened that this elevation corresponded with the low water of 1847 and hence Chicago's datum is always spoken of as the low water of 1847.

Q. Low water in Lake Michigan?

A. Yes sir. The first seven or eight miles of this chan-
10710 nel is through a clay formation a formation which can
be readily dredged, and the cross-section of this stretch of the channel is now less than what it is to be ultimately. It

is only 110 feet wide on the bottom; the side slopes being 1 foot vertical to 2 feet horizontal, giving a surface width with a minimum depth of water 22 feet, of 198 feet. At the end of this stretch of channel material was encountered which could not be readily dredged. It is described in our specifications as glacial drift. There the full size channel was entered upon. This full size channel is 202 feet wide on the bottom with side slopes as before of 2 feet horizontal to 1 vertical, and the resulting width at the water line is 290 feet with a minimum depth of water 22 feet.

This cross-section of the channel is held for 5.3 miles until Willow Springs is reached; there the rock was encountered. The territory from there on to Lockport is either wholly rock or is underlaid by rock.

The channel contracts at this point to 160 feet in width. The grade is increased from 1 foot in 40,000 feet, which 10711 is equivalent to an inch and 5/8 to the mile, to 1 in 20,000 feet.

The length of this cross-section is 14.95 miles. Seven miles of this distance is through cut in rock, the sides are cut practically vertical with two offsets of six inches each on each side, so that the surface width is 162 feet. Wherever the rock did not come to the surface, walls were built from the rock at the elevation found to a height of five feet above Chicago datum.

It was necessary that perfect control of the flow through this channel should be maintained and to accomplish this, controlling works were erected at Lockport. These works consisted of seven lifting gates of the Stoney type, and one bear trap dam. The gates have an opening of 32 feet each. They are counterbalanced and operated by winches, so constructed that two men can raise or lower the gates under pressure, although each gate weighs 62,000 pounds.

The Bear Trap dam was adopted because it was desirable to have a movable dam which could be raised or lowered to admit of the passage of ice or drift from the channel. The original bear trap dam dates back to 1836 and was invented 10712 by Hazard and White. The one which we are now discussing is the largest ever attempted. It has 160 feet clear water way with possible oscillation of 17 feet. The dam itself is essentially two immense leaves of steel. The down stream leaf hinged at its lower side to massive masonry, the up stream leaf hinged to the down stream leaf like the backs to a book. The up stream leaf plays free upon a masonry barrier or a dam, and is supported at intervals of 2 feet upon wheels which travel on tracks bedded in this masonry dam. The dams fit in between the masonry bulk heads with only sufficient play between them to keep from binding. The space beneath the dams forms a water chamber which is supplied by a tunnel running the full length of the dam. Water is admitted to this channel through valves operated by hand power. There is a discharge conduit beneath the dam to operate the dam. The process is as follows: If it is to be raised the valve controlling the discharge of water from beneath the dam is closed and the intake valve is opened. The water rushes into the chamber below the leaves and forces the leaves up. This is done until the proper height is reached when the discharge valve is opened and the intake valve adjusted so that there should be a steady flow through the tube. The volume of water is kept constant 10713 under the dam. To lower the dam the intake valve is closed and the outlet valve is opened. The water flows out of this chamber beneath the dam and it settles down. The whole mechanism can be operated by one man. It operates so perfectly that the Stoney gates are rarely used. The entire flow can be shut off in five minutes time and in as many more minutes a flow of 400,000 cubic feet per minute can be discharged over the dam.

Q. Will you describe the bridges that have been constructed across the drainage canal and why these bridges were constructed?

A. There are thirteen bridges across the drainage canal, 7 of these are highway bridges and six are railroad bridges. They are all of a movable type. The sanitary law compels this style of construction as it is to be a navigable channel.

The first of these bridges is a double roadway bridge at Western Avenue; one roadway being devoted to the avenue, to commercial traffic and the other to Marshall Boulevard traffic. 600 feet away is an eight track bridge. This bridge is essentially four double track bridges side by side of the Bascule type.

10714 Two tracks crossing this bridge belong to the Chicago Terminal Transfer Railway, two to the Union Stockyards & Transit Company and 4 to the Pittsburg, Cincinnati, Chicago & St. Louis Railway.

The next bridge encountered is the bridge of the Chicago, Madison & Northern or Illinois Central Railroad, a double track railway bridge.

The next is a bridge on Kedzie Avenue and following this is a double track railroad bridge of the 26th Street line of the Santa Fe Railway.

The next bridge is at the city limits, a four track railroad bridge built for the Chicago & Western Indiana Belt Railroad. There are three other double track railroad bridges and six highway bridges.

With the exception of the eight track bridge, all of these crossing the earth channel are center pier structures. The bridges crossing the rock channel are what is known as bob-tail or counter balance drawers. The pivot pier is located on the right bank of the canal and there is no obstruction in the channel.

Q. When was the work first begun on the sanitary and ship canal and when was it completed?

10715 A. Work was begun on the 3rd of September, 1892. The water was let into the channel on the 2nd day of January, 1900.

Q. After the water was let in what was done before the water was turned over the Bear Trap dam?

A. The inspection of the State Commission had extended over nine months prior to this date, and on the 16th day of January, we got the commission together to ask them to recommend to the Governor that we be permitted to open. In fact we did not get them together until the morning of the 17th. We started out after them on the 16th and got them all corralled by the morning of the 17th. The Governor was gotten by telephone, from Joliet, and after considerable parley he authorized the turning on of the water and wired his consent. We then proceeded to Lockport and the president of the commission in the name of the State of Illinois authorized the Board of Trustees of the Sanitary District to lower the Bear Trap dam and caused the waters to flow to the westward.

Q. How long did it take for the water of Lake Michigan to fill the channel?

A. The water was turned in on the morning of the second and it was filled to the level of Lake Michigan by the morning of the 14th.

10716 Q. What was the date that the water flowed over the Bear Trap dam or the time that the dam was lowered for the water of Lake Michigan to flow over the dam?

A. 11:05 a. m., January 17, 1900.

Q. What work has been prosecuted on the Chicago River since the opening of the drainage canal by the sanitary district of Chicago?

A. The work of executing the plans of the district had gone steadily on. The Chicago River as it was in 1898 did not afford an adequate channel to supply the water which the Sanitary District law required us to flow through our channel. Prior to the beginning of work by the Sanitary District the flow through the Chicago River would have been limited to 150,000 cubic feet and the plans of the sanitary district provided for widening the Chicago River uniformly for 200 feet, deepening it for the central 100 feet to 26 feet below the water surface, making the depth at the dock lines 16 feet. This would give the river a capacity of 480,000 cubic feet per minute, and a velocity not exceeding a mile and a quarter per hour.

10717 The district is also engaged in removing center pier bridges from the river and substituting therefor Bascule bridges. We have completed seven Bascule bridges. We have two now under contract. We have the plans under way for four additional bridges, in fact that are partially completed, and we propose to do away with the center pier bridges in the Chicago River.

Q. How many bridges do the plans adopted for the improvement of the Chicago River contemplate?

A. Twenty-two bridges.

Q. In addition to the main drainage and ship canal and improvements of the Chicago River what other work in connection with that improvement has been prosecuted by the sanitary district?

A. The channel of the Desplaines River south of Lockport was entirely inadequate to the demands which would be made upon it by the combined flow of the flood waters of the Desplaines and the discharge from the sanitary and ship canal. It was therefore necessary that the district should deepen and enlarge this channel which it has done to an extent which enables us to carry these combined waters safely through the city of Joliet.

10718 We have made a provision for a flow of 1,500,000 cubic feet of water per minute. For one mile south of the controlling works an entirely new channel was made for the Desplaines River; that brought us to the precipitate slope of the valley. There instead of making a new channel we bought the lands on each side which would be submerged. This method of caring for the water was adopted as far as the E. J. & E. bridge just north of Joliet. From that point into the upper basin we made an entirely new channel for the Desplaines. In the upper basin the width of which was 300 feet we deepened the basin to give a sufficient cross-section to carry the water which I have mentioned as 1,500,000 cubic feet per minute. We were compelled by the Illinois & Michigan Canal Commissioners to rebuild dam number 1 which we did. The middle basin we destroyed, tearing out dam number 2 and maintaining navigation in the Illinois & Michigan canal by building a channel for said canal from dam number 1 to the guard lock located at Jefferson Street. After tearing out dam number 2, which made the second pool, we widened and deepened the river between Jackson Street and Jefferson Street. We continued this
10719 widening and deepening from Jefferson Street through to a point about 800 feet south of the Rock Island bridge. From that point to the mouth of Hickory Creek, we built a massive embankment to prevent the over flow of the adjacent territory by the flood waters. We were compelled by the city of Joliet to build new bridges at Cass Street and at Jefferson Street.

Q. What is the grade from Robey Street to Lockport, through the canal?

A. The grade in the channel falls 5.62 feet, and with the minimum depth, the water surface is supposed to be parallel to that grade so that when there is only 22 feet of water in the nel which may happen sometimes, the fall of the water ce should correspond with the water in the channel, 5.62

Q. How long is the drainage canal from Robey Street to port?

A. 28.05 miles.

Q. How far is it from Robey Street to the mouth of the ago River?

A. Six miles.

0 Q. What is the grade from Robey Street to the Lake?

A. The theory upon which we based our work was that e would be a fall of 2½ feet. That has not been sustained. fall is about 2 feet now and that is being diminished as we ease the Cross-section of the river.

Q. Is the level of Lake Michigan variable?

A. Yes sir.

Q. To what do you attribute this variableness?

A. The widest fluctuations are caused by wind effects. fluctuations have amounted to something over four feet, rly five feet in fact.

Q. How is it that the wind creates this condition?

A. When the wind is from the southwest it drives the er off shore and piles it up on the Michigan side of the lake. en the wind is reversed the conditions are reversed and it s up on this shore of the lake.

Q. What has been the cost to the sanitary district of the itary and ship canal which it has constructed?

Mr. Jeffries: I object to the question as immaterial.

Mr. Todd: Answer the question.

21 A. The construction cost, up to the first of January, 1904, has been.............	$27,179,781.45
e completion account and the maintenance account	548,988.94
ministration account, in all its departments, engineering, clerical, law, treasury, police, and general account....................	3,828,615.45
ght of way, this covers also the buildings which had to be destroyed, etc................	4,808,338.17
terest on bonds	5,395,033.70

Interest on tax warrants	468,453.69
Taxes	24,062.45
Sundry accounts	249,894.95
Making a total of:	$42,503,168.80

ADJOURNED until 2:00 p. m., February 22, 1904.

10722 2:00 p. m., Monday, February 22, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

ISHAM RANDOLPH

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. What were the boundaries of the Sanitary District as first laid out?

A. The original sanitary district took in all of the city of Chicago north of 87th Street, except a part of Roger's Park and Norwood Park, and 42 square miles of the country lying directly west of that portion of the city.

Q. Embracing in all how many square miles?

A. The original was 185 square miles.

Q. By what authority was this sanitary district laid out?

A. Under the general law of 1889.

Q. In the work done by the sanitary district of Chicago 10723 was all the work up to last July done under the law passed in 1889 and the amendments passed by the legislature prior to July last?

A. Yes sir, that is true.

Q. Do you know whether the last legislature of the state of Illinois passed any acts in connection with the sanitary district of Chicago?

A. Yes sir, it passed an act providing for the annexation of territory and for the building of water power by the sanitary district.

Mr. Todd: I offer in evidence a copy of an act to create sanitary districts and to remove obstructions in the Desplaines and Illinois River, approved May 29, 1889, in force July 1, 1889, and all amendatory and subsequent acts passed by the legislature of the State of Illinois since that time relative to the sanitary district of Chicago, and ask that the same be marked Randolph's Exhibit A.

Mr. Jeffries: It is conceded by the complainant that the exhibit is a true copy of all acts of the legislature of the State of Illinois as expressed in the offer of counsel in introducing the bills in evidence.

Which said document is marked by the Commissioner, "Defendant's exhibit, Randolph's exhibit A" so as to identify it as one of the defendant's exhibits.

10724 Q. Under the acts of the Legislature extending the boundary of the Sanitary District, passed at the last Session of the Legislature, what are the boundaries of the Sanitary district as they exist today?

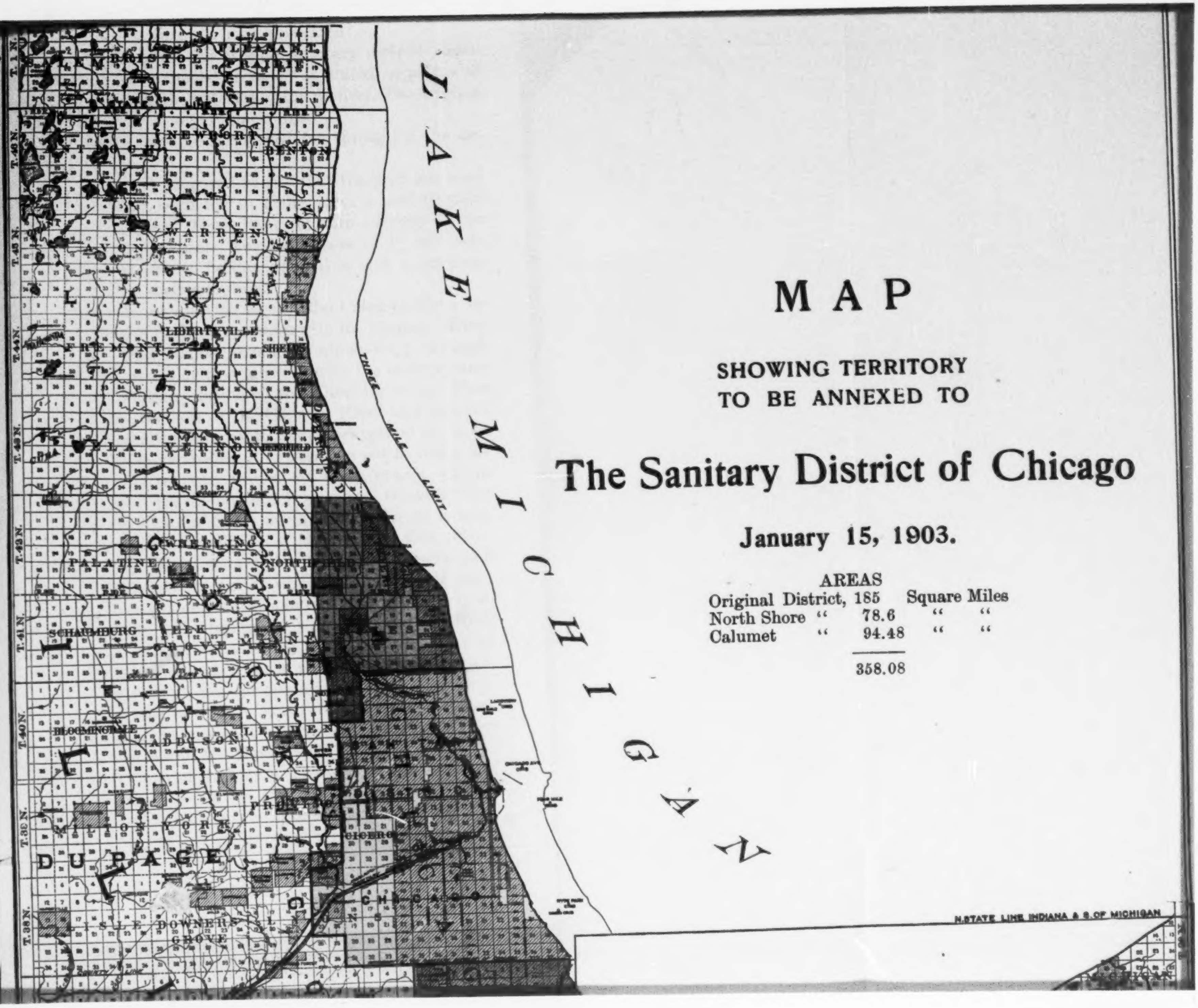
A. Under this bill 78.6 square miles of territory was annexed on the north side, known as the North Shore District, and on the south side 94.48 square miles was annexed, known as the Calumet District. That completes the taking into the sanitary district of all the city of Chicago. The whole city is now in the sanitary district.

Q. Have you a map showing the territory of the sanitary district as it was first laid out and the present territory embraced in the sanitary district?

A. I have.

Q. Will you produce the map in evidence?

A. The map is as follows:


LAKE MICHIGAN
THREE MILE LIMIT
L A K E
ANTIOCH
NEWPORT
BENTON
WARREN
AVON
LIBERTYVILLE
FREMONT
SHIELDS
VERNON
WEST DEERFIELD
DEERFIELD
ELA
WHEELING
PALATINE
NORTHFIELD
SCHAUMBURG
ELK GROVE
BLOOMINGDALE
ADDISON
LEYDEN
PROVISO
CICERO
CHICAGO
MILTON
YORK
DU PAGE
LISLE
DOWNERS GROVE
LYONS
C O O K
N. STATE LINE INDIANA & S. OF MICHIGAN
MICHIGAN

MAP

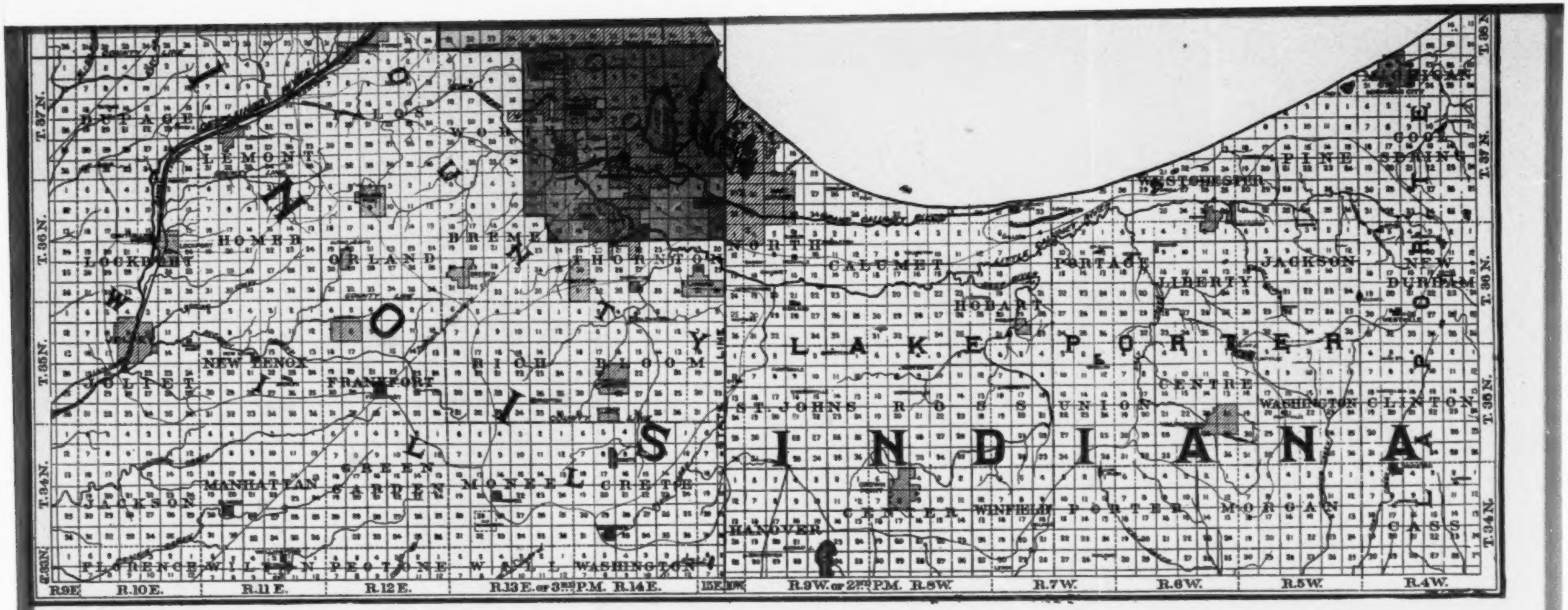
SHOWING TERRITORY
TO BE ANNEXED TO

The Sanitary District of Chicago

January 15, 1903.

AREAS

Original District,	185	Square Miles
North Shore "	78.6	" "
Calumet "	94.48	" "
	358.08	


ILLINOIS
INDIANA
WILL
COOK
LAKE
PORTER
DUPAGE
LEMONT
PALOS
WORTH
HOMER
ORLAND
BREMEN
THORNTON
LOCKPORT
NEW LENOX
JOLIET
FRANKFORT
RICH
BLOOM
GREEN GARDEN
MONEE
CRETE
MANHATTAN
JACKSON
FLORENCE
WILTON
PEOTONE
WILL
WASHINGTON
NORTH
CALUMET
HOBART
ST. JOHNS
ROSS
UNION
HANOVER
CENTER
WINFIELD
PORTER
MORGAN
PORTAGE
WESTCHESTER
LIBERTY
CENTRE
WASHINGTON
JACKSON
PINE
COOL SPRING
MICHIGAN
MICHIGAN CITY
NEW DURHAM
CLINTON
CASS
LA PORTE
T. 37 N.
T. 36 N.
T. 35 N.
T. 34 N.
T. 33 N.
T. 38 N.
R.9E.
R.10E.
R.11E.
R.12E.
R.13E. OF 3RD P.M.
R.14E.
15E.
10W.
R.9W. OF 2ND P.M.
R.8W.
R.7W.
R.6W.
R.5W.
R.4W.

Q. Will you explain the map presented?

10726 A. The map shows the original sanitary district tinted in yellow. The annexed territory is tinted in pink and heavy black lines follow the outlines of the distirct. The original district is bounded by a heavy black line.

Q. What plans have been adopted for caring for the annexed district?

A. Well, I am not prepared to say that the plan has been adopted. I have been istructed to make surveys and prepare plans, which I have done. These have not been adopted by the Board up to the present time, but they seem to be the only things which are feasible to be done, and it is only a question of a short time before their adoption.

It is proposed to reverse the flow of the Calumet River by constructing a channel from a connection with the Calumet River near Blue Island. This channel extends southwesterly, through what is known as Sag Valley to a junction with the sanitary and ship canal at or near Sag Station on the Alton Railroad. This channel will reverse the flow of the Calumet River and prevent the discharge of its waters into Lake Michigan at all times 10727 except in excessive floods. Provision can not be made for taking the entire flood waters of the Calumet region through our channel. On the north it is proposed to extend the north branch of the Chicago River northward as far as Evanston and make a connection with Lake Michigan at that point, at a point almost on the boundary line between Evanston and Winnetka. The lake level being the same at this point of junction as it is at the mouth of the Chicago River, it will be impossible to get a gravity flow through this channel and therefore pumping works will be erected at the north end, designed to pump 60,000 cubic feet of water per minute into this new channel. Into this channel all the sewage arising along the north shore is to be delivered by sewers constructed for that purpose.

Q. The sanitary district as it is at present constructed has a population of how many, Mr. Randolph?

A. The population of the city of Chicago by the census of 1900 was 1,698,575. Making up the population curve, based upon past experiences and future probability, we bring that population down to 1903, as 1,878,000 at the end of the year.

Q. What is the total population of the sanitary district?

A. It is 1,942,000.

10728 Q. Where are the intakes for the water supply of the city of Chicago located and state how many there are?

A. Starting from the south the first intake is located about opposite 61st Street, and is about two miles from shore. The next one is very nearly opposite Taylor Street and four miles out in the lake. The next one is opposite Chicago Avenue—there are two there, one 2 miles out and the other 4 miles out. Then we come up to Lakeview and the intake is about 2 miles out in the lake and about opposite Mount Rose Street. Those are the sources of supply from the lake, and out at Washington Heights there are deep wells from which the water is pumped to supply that village and Morgan Park.

Q. What are the plans established by the Sanitary District for diverting the sewage of Chicago from Lake Michigan?

A. The general plan of the district for providing a means of carrying off the sewage has been described. The city in conjunction with the sanitary district is at work with a system of intercepting sewers both from the north and the south side. The city has built a conduit in 39th street, 20 feet in diameter, and having a capacity of 120,000 cubic feet of water per minute. At the lake end of this conduit a pumping station has been 10729 established in which there are to be six pumps. Four of these are put in by the city for pumping sewage from the intercepting sewers, sewage mingled with lake water. The combined capacity of the four pumps is 40,000 cubic feet a minute. The sanitary district puts in two pumps which take their supply direct from the lake without sewage pollution and each of those pumps has a capacity of 40,000 cubic feet per minute. They are the largest pumps ever attempted in the world. On the north side of the city on Lawrence Avenue, the city is building a conduit to receive the intercepting sewers. That extends from the lake across to the north branch of the Chicago River. The intercepting sewers bring in the sewage from the north and south into these conduits. The pumping station is to be erected at the cost of the city and to be operated by the sanitary district. This pumping station will have a capacity of 35,000 cubic feet of water per minute, with arrangements made for doubling that volume if it is found necessary, but the pumps will only be put in at present for 35,000 cubic feet per minute.

Q. Mr. Randolph, when the improvements contemplated by the sanitary district for the territory on the north and the Calmut on the south, as well as the system of intercepting sewers, and the canal itself in the earth section, and the Chicago River are completed, what will be the maximum capacity of the drainage canal, in cubic feet per minute?

10730 A. About 825,000 cubic feet per minute.

Q. Have you a table showing the flow of the canal as measured at the Bear Trap Dam, since its opening up to the present?

A. I have those tables compiled up to the middle of 1903. The compilation is not complete to date. These compilations come down to the end of June, 1903, from the date of the opening.

Q. Can you give the average flow per week for the year 1900, approximately, over the bear trap dam, through the drainage canal at Lockport?

A. For 49 weeks in 1900 the average was 188,136 cubic feet per minute. The smallest flow was on the 17th of September, 1900, 1863 cubic feet per minute, and the largest was on the 26th day of the same month, 326,791.

Q. During the period of 1900 were the dams at Lockport, entirely closed at any time?

A. My recollection is that they were for a few hours. I think it was on two or three occasions when vessels got stuck here in the channel, and it was shut off long enough to relieve them.

10731 Q. Were they closed for a sufficient length of time to reverse the flow of the current in the Chicago River so that it emptied into Lake Michigan?

A. I have no knowledge of the water ever flowing through to the lake but once since the channel was opened. Once there was a freshet in the north branch—it was a general freshet and it was not watched close enough to take care of it, and that flow began to go towards the lake, and as soon as that was noticed we checked it in a very short time.

Q. How long did that flow towards the lake last?

A. I can not answer that question but it was a very short time, probably two or three hours.

Q. With the exception of shutting down the flow for the purpose of getting off boats that were stuck on the tunnels in the Chicago River has the flow in the drainage canal been shut off for a period equal to a day?

A. No sir.

Q. What was the maximum, mean and average flow through the drainage canal in 1901, 1902 and 1903?

A. On March 16th was the largest flow of the year 1901,
406,227 cubic feet per minute. On October 3rd was the
10732 lowest, 139,427 cubic feet. The average for the year was
242,323.

Now, we will take 1902. For 1902 I find that the lowest flow was on June 3rd when the works were shut down for fourteen hours on account of the flood in Joliet, the Hickory Creek disaster, 107,231 cubic feet was the lowest. There was some water running all the time but not enough to interfere with the flood below. The largest flow was on December 26th, 339,610 cubic feet. The average for the year was 257,006 cubic feet.

For the first six months of 1903 it shows the greatest flow to have been on June 5th, 401,425 cubic feet per minute, the lowest May 30th 248,063 cubic feet, the average 312,692 cubic feet.

Q. Will you give the maximum, mean and average flow through the Illinois and Michigan Canal for the years 1900, 1901, 1902 and 1903.

Mr. Jeffries: Objected to as immaterial.

A. The highest record of the Illinois and Michigan canal was on February 8th, 57,677 cubic feet per minute. The lowest
when there was anything doing at all—there were a few
10733 days when there was nothing doing—was 14,800 cubic
feet. The average was 26,768 cubic feet per minute. That
is for 1900.

The canal appears to have been shut down entirely from the first of January, 1901, to the 24th of April, 1901. The minimum was on April 24th, 3,840 cubic feet: on July 3rd, the maximum was 29,206, and the average for the 26 weeks was 20,073.

In 1902 the pumps were started May 1st. The minimum was 9,200 cubic feet per minute, the maximum 25,080. The pumps were only run for 27 weeks, and the average 22,488.

The first six months of 1903, on January 13th, was the minimum, 1,913. On June 5th was the maximum, 28,114, the average for the 26 weeks 21,996.

Q. What is the per capita consumption of water in the city of Chicago?

A. It is varied, in different years. I have taken the tabulations for 1900, 1901 and 1902. The average per capita for 1900 was 190 gallons. For 1901 it was 195 gallons and for 1902 it was 197 gallons.

10734 Q. Will you state the maximum, minimum and average flow of the Desplaines River for 1900, 1901, 1902 and 1903?

Mr. Jeffries: Objected to as immaterial.

A. There were two periods during 1900 when there was no water flowing past Riverside at all. It was simply a pool, from May 31st to June 5th, and from June 26th to July 7th. The largest volume of water passing was on March 19th, 290,350 cubic feet per minute.

For 1901 there was a period from February 11th to March 2nd when there was only 2,400 cubic feet of water flowing per minute. About March 30th there was 331,680 flowing, and the average for the year was 20,974.

In 1902 there were several periods in the year when there was nothing flowing at all past Riverside and the maximum on May 26th was 37,740 cubic feet. The average was 30,235.

The first six months of 1903, the smallest flow was June 19th and 20th, 1,200 cubic feet per minute. The largest was March 21st, 437,520 cubic feet per minute, and the average was 1,307.

Q. Will you give the mean average flow of the Desplaines,
the Chicago Drainage Canal, the Illinois and Michigan
10735 Canal, at Dam Number 1, where these three waters co-
mingle?

A. The mean for 49 weeks in 1900 was 233,976. The mean for 52 weeks in 1901 was 277,153. The mean for 52 weeks in 1902 was 294,132. The mean for 26 weeks in 1903, ending June 27th, was 385,475.

ADJOURNED until 11:00 A. M., February 23, 1904.

11:00 A. M., Tuseday, February 23, 1904.

10736 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

ISHAM RANDOLPH

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. Mr. Randolph, have you now given the maximum, minimum and mean discharge of the Chicago Drainage Canal, the Illinois and Michigan Canal, and the Desplaines River for the years 1900, 1901, 1902 and 1903, up to July 7.

A. My recollection is that on yesterday I gave the maximum, minimum and mean discharge of our channel. The maximum, minimum and mean discharge of the Desplaines River, but not the maximum, mean and minimum discharge of the combined. I gave the mean discharge of the combined at dam number 1, as I remember it yesterday.

Q. Have you prepared a table showing the pollution at dam number 1, based upon the mean discharge from the drainage canal, the Illinois and Michigan Canal and Desplaines

10737 River, as well as the population discharging sewage, at that point, etc.?

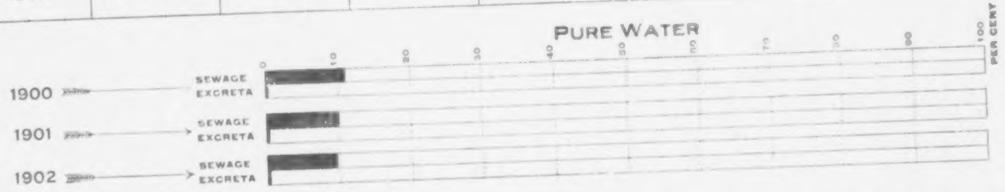
A. I have.

Q. Will you produce and read the table and chart thus prepared in evidence?

A. The table is as follows:

POLLUTION OF SANITARY CANAL BY THE SANITARY DISTRICT.

YEARS	Population discharging Sewage into the Canal	DISCHARGE OF CHANNEL AT DAM NO. 1. IN CU. FT. PER MINUTE FROM WEEKLY AVERAGES			Quantity of Sewage. Gals. per Day same as Water Consumption	Proportion of Sewage to Mean Discharge of Canal	Weight of Urine and Fecal Matter. lbs. per day.	Proportion of Urine and Fecal Matter to Mean Discharge of Canal
		Maximum	Minimum	Mean				
1900	1,443,789	351,088	40,481	233,976	274,209,685	1 : 9.2	3,880,183	1 : 5429
1901	1,494,300	615,392	197,124	277,153	291,391,432	1 : 10.2	4,015,931	1 : 6211
1902	1,545,300	450,328	244,126	295,527	304,386,454	1 : 10.4	4,215,494	1 : 6310



Population of Chicago.

1900	Census..................	1,698,575
1901	Estimate	1,758,000
1902	"	1,818,000
1903	"	1,878,000

Daily Water Consumption of City.

1900..................	322,599,630	gallons.
1901................	342,813,449	"
1902..................	358,101,710	"

Per Capita Consumption.

190 gallons.
195 "
197 "

Proportion using Drainage Canal.

87% by census of 1890.
84% by school census (1898).
85% estimated 1900 1903.

Weights of Excreta.

Fecal matter 3 oz. per capita.
Urine 40 oz. per capita.

Q. Mr. Randolph, will you explain upon what basis the
10739 table just read in evidence is based, and what the table shows in full?

A. The table applies to the years 1900, 1901 and 1902. It is based upon the population discharging sewage into the drainage canal. The quantity of sewage is determined by taking the per capita of water consumed in the city of Chicago as shown by the reports of the Water Commissioner of the city of Chicago for each of the years mentioned. This is taken as the sewage discharge of the city of Chicago in gallons. This sewage is compared with the mean discharge of water of the combined Illinois and Michigan Canal, the Chicago Sanitary and Ship Canal and the Desplaines River where they come together at dam number 1 in the city of Joliet.

The proportion of sewage based on water consumption is then figured out and shown. The absolute weight of urine and fecal matter contained in this sewage is shown, based upon the testimony of Dr. Ravold and other statistics gathered from other sources. The result of these determinations gives us 3 ounces per day per capita of fecal matter and 40 ounces of urine
10740 per capita per day.

Having determined the total weight of urine and fecal matter, this is compared with the total weight of water discharged in 24 hours from the three sources heretofore mentioned, combining at dam number 1. The determinations and results are shown for each year, in figures. We add to this; these determinations and results are shown graphically in a chart for each year. This chart is divided into a scale of 100 parts. The proportion of sewage is shown in solid black, in the first bar of the chart; the proportion of excreta or fecal matter is shown in the second bar of the chart for each year, and it is also in black.

Q. Upon what do you base the quantity of sewage?

A. The quantity of sewage is based upon the water consumption per capita. The population draining into the canal is multiplied by the number of gallons used per day per capita, to determine the sewage.

Q. Is this table based upon gallons or upon pounds?

A. The sewage is based upon the gallons. The flow through the channel is based upon cubic feet. The weight of the urine and fecal matter is determined by multiplying the number of 10741 inhabitants by 43 ounces and dividing by 16 to get the pounds. The proportion of urine and fecal matter to the water is obtained by multiplying the mean discharge per minute by 1440, which is the number of minutes in 24 hours, and multiplying that by the weight of a cubic foot of water, which is 62½ pounds. So the weight of water thus determined, divided by the weight of urine and fecal matter thus determined, gives you the proportion of urine and fecal matter to the total flow of water.

Q. How many gallons are in a cubic foot?

A. There are 7.48 gallons in a cubic foot.

Q. How many pounds in a gallon?

A. 8.3528 per gallon.

Q. What is the proportion of sewage to the mean discharge of the drainage canal as evidenced by your table for the three years, 1900, 1901 and 1902, respectively?

A. The ratio is 1 to 9.2, either expressed in gallons or cubic feet.

For 1901 the ratio is 1 to 10.2.

For 1902 the ratio is 1 to 10.4.

10742 What are the proportions of urine and fecal matter to the mean discharge of the canal for the three years above mentioned?

A. 1 in 5429 for 1900.

1 in 6211 for 1901.

1 in 6310 for 1902, the comparison being made in pounds.

The table which has just been described is table number 1, and is entitled "Pollution of Sanitary Canal by the Sanitary District."

Q. Have you prepared any other tables?

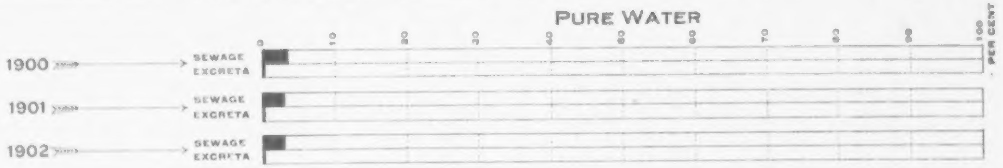
A. Yes sir.

Q. Will you produce and read the table number 2, with a heading "Pollution of Sanitary Canal" in evidence?

A. The table is table number 2 and is marked "Pollution of Sanitary Canal" based on clause on page 12 of the report of the Hydraulic Engineers, and is as follows:

10743 POLLUTION OF SANITARY CANAL. BASED ON CLAUSE ON PAGE 12 OF REPORT OF HYDRAULIC ENGINEERS. See below.

YEARS	Population discharging Sewage into the Canal	DISCHARGE OF CHANNEL AT DAM NO. 1. IN CU. FT. PER MINUTE FROM WEEKLY AVERAGES			Quantity of Sewage based on 60 Gals. per head per day	Proportion of Sewage to Mean Discharge of Canal	Weight of Urine and Fecal Matter. lbs. per day.	Proportion of Urine and Fecal Matter to Mean Discharge of Canal
		Maximum	Minimum	Mean				
1900	1,443,789	351,088	40,481	233,976	86,627,340	1 : 29.1	3,880,183	1 : 5429
1901	1,494,300	615,392	197,124	277,153	89,658,000	1 : 33.3	4,015,931	1 : 6211
1902	1,545,300	450,328	244,126	295,527	92,718,000	1 : 34.3	4,215,494	1 : 6310



The daily quantity of sewage is based on a water consumption of 60 gallons per head per day which the Commission of Hydraulic Engineers reported in 1902 to be all that is necessary.

Page 12 report on the water supply of the City of St. Louis.

"From investigations made upon water systems of cities where the quantity of water used is measured, it appears that in large cities the average volumes needed for domestic, public and manufacturing purposes are respectively, about 30 gallons, 5 gallons and 25 gallons per day for each inhabitant, and that any supply in excess of 60 gallons per day per capita goes to underground leakage or unnecessary waste."

Q. Will you explain upon what data you base this table
10744 and explain its significance?

A. This table differs from the table just described only in the method of determining the amount of sewage per day. The method here used is based upon the clause in the report of the Water Supply of the City of St. Louis, by the Commission of Hydraulic Engineers, 1902, which clause reads as follows:

"From observations made upon water systems of cities where the quantity of water used is measured it appears that in large cities the average volumes needed for domestic, public and manufacturing purposes are respectively about 30 gallons, 5 gallons and 25 gallons per day for each inhabitant and that any supply in excess of 60 gallons per day per capita goes to underground leakage or unnecessary waste."

In this table number 2 the first five columns are identical with table number 1, the first five columns counting from the left. The sixth column gives the quantity of sewage based upon 60 gallons per head per day, and the comparisons thereunder are based upon the substitution of 60 gallons per capita for the gallons per capita used in table number 1. For 1900 the sewage per day was 86.627,340 gallons. The mean discharge, as measured at dam number 1, was, for 1900, 233,976 cubic feet
10745 per minute.

The proportion of sewage to the mean discharge was 1 part in 29.1 parts. That is expressed by measure.

The total weight of urine and fecal matter, in pounds per day, was 3,880,183, and the proportion of urine and fecal matter to the mean discharge of the canal was 1 part in 15,249, expressed in pounds.

These last two divisions are exactly the same as in table number 1, the difference in the table being in the sixth and seventh columns.

In 1901 the mean discharge was 277,153 cubic feet per minute.

The daily sewage discharge was 89,658.000 gallons per day.

The proportion of sewage to mean discharge was 1 to 33 1-3.

The weight of urine and fecal matter in pounds per day was 4,015,931, or 1 part in 6211, expressed in weight.

In 1902 the mean discharge at dam number 1, in cubic feet, was 295,527.

The quantity of sewage per day was 92,718 gallons.

10746 The proportion of sewage to mean discharge was 1 part in 34.3, expressed by measure.

The weight of urine and fecal matter in pounds per day was 4,215,494, or one part in 6310 parts, by weight.

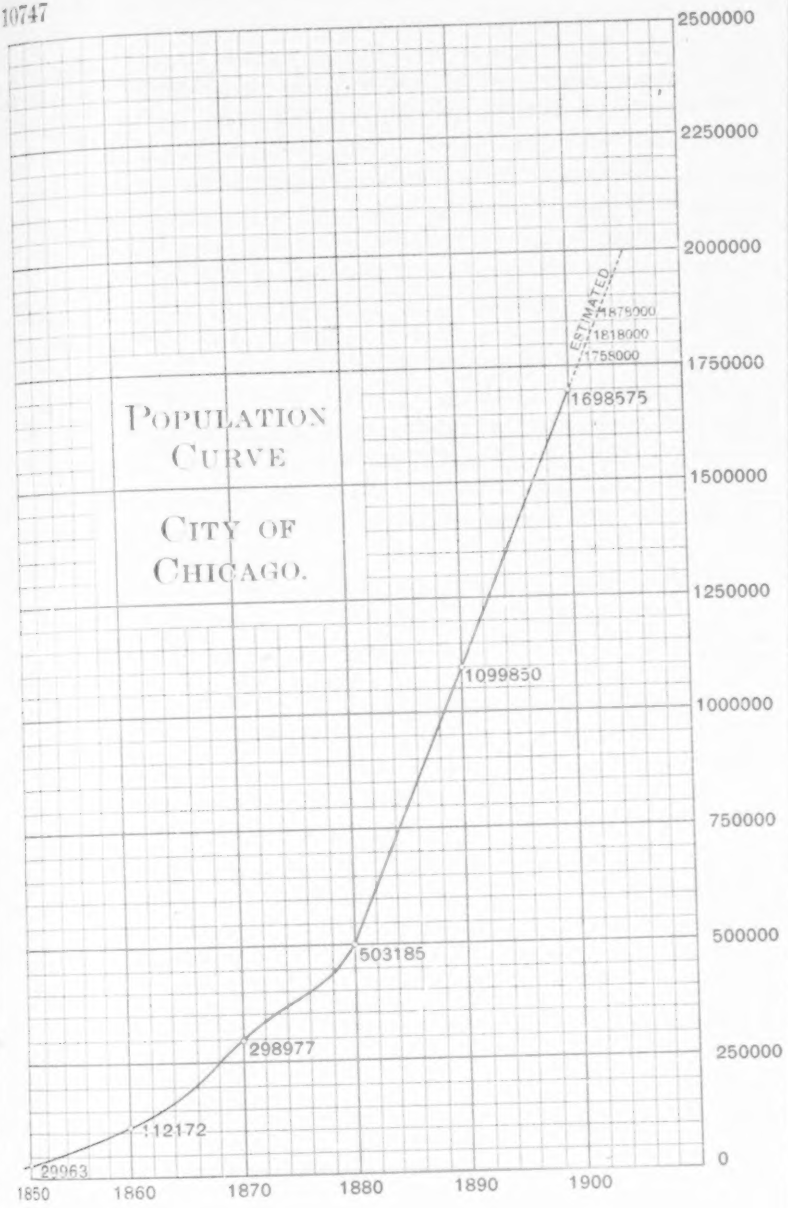
Below the table is a graphic exhibit of the facts set forth in the table. There are two horizontal bars for each year, divided into ten parts, each division representing 10 per cent. In the first bar for each year the sewage is shown in solid black. In the second bar the excreta is shown in solid black, and so for each of the three years covered by the table.

Q. Have you a population curve for the city of Chicago?

A. I have.

Q. Will you produce the chart showing the population curve and make it a part of the evidence?

A. I will. It is number 3 and its title is "Population curve, city of Chicago," and is as follows:


POPULATION CURVE
CITY OF CHICAGO.
2500000
2250000
2000000
1750000
1500000
1250000
1000000
750000
500000
250000
0
ESTIMATED
1878000
1818000
1758000
1698575
1099850
503185
298977
112172
29963
1850
1860
1870
1880
1890
1900

Q. Will you explain the principle upon which this curve
10748 is constructed, as just introduced in evidence?

A. This curve is plated upon what is known as cross-section paper, which is divided up into large squares, and each of these large squares divided into ten parts, the lines crossing each other at right angles. Running across the bottom of this sheet, each one of these squares is assigned to a decade, beginning with 1850 and ending with 1910, passing from left to right. Forming up from the plates on the vertical line, each one of these squares represents a population of 250, running up to a population of 2,500,000. For past years the actual population for each year is dotted upon the vertical line, corresponding to population. All of these dots are joined by a line which a part of the time is undulating, but from 1880 to 1900 is practically straight, very little deviation from a straight line.

From 1900, the line is continued practically straight, showing the census year by year. This line is called the curve of population, and for any year you can ascertain what the population was by looking that year on the bottom of the map,
10749 following the line which corresponds to that year up vertically until it intersects the line of poulation curve, then following the horizontal line from this point of intersecton to the figures indicated on the right of the map, and ascertain what the population was for that year.

Q. Have you prepared a table of the population of Chicago?

A. I have. It is marked Number 4. Its caption is "Population of Chicago."

Q. Will you produce and read the table thus prepared in evidence?

A. The table is produced, and is as follows:

10750

POPULATION OF CHICAGO.

Census 1900.

Ward—	
1	24,724
2	28,547
3	32,989
4	37,029
5	43,315
6	60,216
7	36,844
8	38,742
9	51,539
10	91,097
11	37,533
12	75,507
13	47,327
14	71,528
15	79,944
16	61,859
17	20,713
18	20,503
19	46,929
20	29,577
21	34,103
22	32,767
23	31,424
24	35,830
25	54,588
26	70,757
27	39,131
28	31,013
29	41,214
30	106,124
31	56,576
32	60,202
33	51,892
34	91,145
35	11,795
Total	1,698,575

Census.

1840	4,470
1850	29,963
1860	112,172
1870	298,977
1880	503,185
1890	1,099,850
1900	1,698,575
From curve 1901	1,758,000
" " 1902	1,818,000
" " 1903	1,878,000

Proportion Discharging into Drainage Canal.

87% by census of 1890 (Federal).

84% by " " (School).

85% estimated at present.

1900 85% of 1,698,575=1,443,789

1901 85% of 1,758,000=1,494,300

1902 85% of 1,818,000=1,545,300

Water Consumption of City.	*Divided by Population,*	=	*Amount Per Capita.*
1900..322,559,630 gallons per diem.	1,698,575		190
1901..342,813,449 " "	1,758,000		195
1902..358,101,710 " "	1,818,000		197

Population of District.	*Multiplied by Per Capita Rate,*		=	*Gallons of Sewage.*
1900 1,443,789	190	Or take		274,209,685
1901 1,494,300	195	85% of water		291,391,432
1902 1,545,300	197	consumption		304,386,454

Gallons of Sewage Per Day.	*Gallons Per Minute.*	*Cu. Ft. Per Minute.*
1900 274,209,685	190,423	25,458
1901 291,391,432	202,355	27,053
1902 304,386,454	211,379	28,259

Q. Will you explain the table just introduced?

10751 A. The figures shown under the head of "Census" in the upper left hand corner of the sheet, give the census of 1900, of the city of Chicago, by wards, from ward number 1 to ward number 35, the resulting total is put at the foot of the column. On the right of this census for 1900 are given the successive reports of the census Bureau for the sixty years from 1840 to 1900, inclusive.

Following the data there given the population for the years 1901, 1902 and 1903 are given, and given as taken from the curve of population just described. Beneath the data just described is a statement of the proportion of poulation, discharging into the drainage canal, derived from the Federal Census of 1890, and the school census of 1890, and our estimate of the present time. Then below that comes a further statement for the year 1900, the year 1901 and the year 1902. This information as to population occupies the upper half of the sheet.

Following this is a report of the consumption of water by the city of Chicago for the years 1900, 1901 and 1902. This total consumption per diem is derived from the popu-

10752 lation and the daily consumption per capita is thus determined.

Following this data is an exhibit of the population of the district draining into the channel, measured by the gallons per capita of water consumed to determine the gallons of sewage.

Next follows a statement showing the gallons of sewage per day, the gallons per minute and the cubic feet per minute for the years 1900, 1901 and 1902.

Q. What percentage of population of the district drained into the drainage canal in 1900, 1901 and 1902?

A. Eighty-five per cent.

Q. What was the per capita consumption of water in the city of Chicago in 1900, 1901 and 1902, respectively?

A. The daily consumption per capita for 1900, 190 gallons.

For 1901 was 195 gallons.

For 1902 was 197 gallons.

ADJOURNED UNTIL 2:00 P. M., same day.

2:00 P. M., Tuesday, February 23, 1904.

10753 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

ISHAM RANDOLPH

resumed the stand for further direct-examination by Mr. Todd, and testified as follows:

Q. Have you prepared a table under the caption of "Excreta"?

A. Yes sir.

Q. Will you please produce and read the table into the record?

A. Yes sir, the table is as follows:

10754

EXCRETA.

*Excreta from 100,000 persons per year—

37,610	Men	4,521,664 lbs. Feces	45,217,782 lbs. Urine.
34,630	Women	1,237,040 " "	37,458,512 " "
14,060	Boys	1,239,504 " "	6,423,670 " "
13,700	Girls	274,736 " "	5,041,344 " "
		7,272,944 " "	94,141,308 " "

Daily per capita................	3.2 oz. Feces	41.3 oz. Urine.
†From another..................	2.91 oz. "	34.1 oz. "
From Dr. Ravold..........	3.00 oz. "	40. oz. "

Assume a total of 43 oz. of Excreta.

Total weight of Excreta per day.		Lbs. per minute.
1900............	1,443,789×43 oz.=3,880,183 lbs.	2,694
1901............	1,494,300×43 oz.=4,015,931 lbs.	2,789
1902	1,545,300×43 oz.=4,215,494 lbs.	2,927

Discharge at Dam No 1.		*Proportion of Excreta to Discharge.*
1900..	233,976 Cu.	1 to Ft.=14,623,500÷2,694=5,429
1901..	277,153 Cu.	1 to Ft.=17,322,062÷2,789=6,211
1902	....295,527 Cu.	1 to Ft.=18,470,437÷2,927=6,310

Discharge at Dam No. 1.		*Cu. Ft. Sewage.*	*Proportion of Sewage to Discharge.*
1900..........	233,976 Cu. Ft.	25,458	1 to 9.2
1901..........	277,153 Cu. Ft.	27,053	1 to 10.2
1092	295,527 Cu. Ft.	28,250	1 to 10.4

*First report of Rivers Polluting Commission of Great Britain, page 27. From the Researches of Wolff and Lehman.

†Page 156. Sewage Disposal in the United States. Rafter and Baker.

Q. Will you explain the table that you have just introduced and what it purports to show? 10755

A. It purports to show the amount of excreta from 100,000 persons per year. The first seven lines of this table are taken from the report of the Rivers Pollution Commission of Great Britain, page 27, from the researches of Woolf and Lehman, which give the excreta of 37,610 men, 34,630 women, 14,060 boys, and 13,700 girls, giving the pounds of feces and pounds of urine and as a result they got the average feces of 3.2 ounces and the average urine of 41.3 ounces.

Then another source is page 156 of Sewage Disposal in the United States, Rafter and Baker. They give the average for feces of 2.91 ounces and the average for urine of 34.1 ounces.

Dr. Ravold in his testimony which I heard in St. Louis gave 3 ounces of feces and 40 ounces of urine, and it is the data that I have used in making all of my computations.

Following this on the assumption of 43 ounces of excreta per capita, and taking the population discharging into the sanitary canal, multiplied by 43 ounces we get the results which I have read in the tables heretofore. 10756

The next item of information is the discharge of dam number 1 and it simply gives the process of arriving at that proportion that was used in all the tables. By the two methods one giving the theoretical volume of sewage as shown by the water supply of the city of Chicago, and the other actually as based upon 60 gallons per capita.

Q. Have you a table showing the pollution of the Illinois River prepared under your direction and supervision, Mr. Randolph?

A. Yes sir.

Q. Will you produce and read the table into evidence?

A. Yes sir, the table is as follows:

10757 POLLUTION OF ILLINOIS RIVER.

Drainage basins.	Area square miles.	Population (census) 1900.	Urban Pop., towns of 1,000 and over. 1900.	Estimated water supply, gallons per capita per day.	Estimated total gallons water supplied per day, 1,000 gallons.	Cu. Ft. per second.
DesPlaines........	1,758	124,855	70,748	99.3	7,025	10.83
Du Page...........	....	21,704	6,851	23.1	158	.24
Kankakee.........	5,302	192,226	44,681	53.2	2,377	3.66
Fox................	2,697	175,353	81,743	47.3	3,866	5.96
Vermillion.........	1,413	68,601	27,631	70.1	1,937	2.99
Mackinaw.........	1,182	47,296	10,924	37.1	403	.62
Spoon	1,905	81,782	28,519	40.0	1,141	1.76
Sangamon.........	5,592	303,096	133,632	91.4	11,215	17.28
Crooked	1,286	54,574	14,344	13.9	199	.30
McKee.............	....	16,461	5,624	32.0	180	.28
Macoupin..........	1,000	46,362	15,778	32.0	505	.77
Illinois (directly).	....	379,077	177,189	65.5	11,606	17.89
Peoria industries.	....	....	....	....	15,000	23.11
	....	1,511,387	617,664	65.7	55,614	85.72

Discharge of Illinois river at Kampsville Oct. 20, 1891 (U. S. Engrs.).........1452.7 C. F. S.

" of Illinois and Michigan Canal.. 600.0 "

Natural discharge of river at Kampsville Oct 20, 1891................ .... 852.7 "

Add for basin of Macoupin creek........................ .... 147.3 "

Natural discharge of the Illinois river Oct. 20, 1891.................. .... 1000.0 C. F. S.

Sewage produced by urban population, 85.72 Cu. Ft. Sec., or 57.19 C. F. S., when reduced to a basis of 60 gallons per head per day.

1000÷57.19=17.48 Pollution=1:17.48 as against Drainage Canal Pollution of 1:34.3.

Q. Will you describe the table just read and what it 10758 purports to show?

A. The caption of the table just read is Pollution of the Illinois River. It is divided into seven spaces:

The first space is headed Drainage Basins.

The second space is headed Area in Square Miles.

The third space is population, census of 1900.

The fourth space is Urban Population, towns of 1,000 and over for 1900.

The fifth space is Water Supply in Gallons per capita per day.

The sixth space is the estimated total gallons of a water supply per day.

The last space is the cubic feet per second.

The first drainage basin is the Desplaines, 1758 square miles.

The population is 124,855.

The urban population 70,748.

Water supply in gallons per day per capita 99.3.

Estimated total gallons water supply per day 7,025,000.

10759 The seventh column is cubic feet per second 10.86.

For the DuPage we have not the drainage area.

The population is 21,704.

Urban population is 6,851.

Water supply gallons per capita per day 23.1 gallons.

The water supplied per day 158,000 gallons.

Cubic feet per second .24 of 1 cubic foot.

The explanation given with reference to the Desplaines water shed and the DuPage applies to the Fox, the Vermillion, the Mackinaw, the Spoon, the Sangamon, the Crooked, the McKee, Macoupin and the Illinois, and the last name in the first column is the Peoria industries. For those industries there is no area given, no population, no water supply per capita, but the 1,000 gallons which amounts in this instance to fifteen thousand thousands or 15,000,000 gallons and the cubic feet per second is 23.11. The poulation in all the drainage areas covered in this table amounts to 1,511,387.

The urban population 617,664.

The average water per capita 65.7.

And the total per day 55,614,000 gallons.

The cubic feet per second 85.72.

Following the tables is a statement giving discharges at 10760 various points.

The first gives the discharge of the Illinois River at Kampsville, October 20, 1891 (U. S. Engineers) 1452.7 cubic feet per second.

Discharge of the Illinois and Michigan Canal 600 cubic feet per second.

Subtracting the discharge for the Illinois and Michigan Canal from the report of the discharge given by the United States Engineers giving the natural discharge for Kampsville, for October, 1891, as 852.7 per second.

The discharge from the Macoupin creek must be added. 147.3 cubic feet per second, making a total annual discharge of the Illinois River October 20, 1891, of 1,000 cubic feet per second.

The sewage produced by urban population 85.72 cubic feet per second.

10761 A. Sewage produced by urban population 62.63 cubic feet per second or 57.19 cubic feet per second when reduced to a basis of 60 gallons per head per day; taking 1,000 cubic feet per second as the natural flow at Kampsville and dividing that by 57.19 cubic feet per second, we get, as the result, 17.48 or a pollution of 1 in 17.48 as against the drainage canal pollution of 1 in 34.3.

Q. From the tables which you have introduced, what conclusions do you draw from those tables?

A. I conclude that the natural pollution of the Illinois River is due to the urban and rural population draining into its water shed, exclusive of all sewage coming from Chicago, is more polluted than the waters of the Illinois River are when combined with the discharge from the sanitary canal after the opening of said canal. In the conditions which obtain without considering the discharge from the sanitary canal the pollution is 1 in 17.48. The pollution, considering the sanitary canal, is 1 in 34.3.

Q. Measured in what?

10762 A. In quantity.

Q. Mr. Randolph, have you a map showing the various water sheds of the Illinois River from Chicago to Grafton?

A. Yes sir, I have.

Q. Will you please produce the map?

A. I will.

Q. Is this a correct map of the various water sheds of the Illinois River from Chicago to Grafton?

A. It is essentially correct. It is made up from the best data obtainable from the various sources that we have sought.

Q. Was this map made under your direction and supervision in the office of the Sanitary District of Chicago?

A. It was.

Q. How are the different water sheds indicated on this map?

A. They are indicated by different colors and dotted lines to indicate the summit of the divide between different water sheds. The map shows the number of square miles in each water shed.

Q. Are all the cities and town on the Illinois River located on this map?

10763 A. All the important towns are shown on the map.

Mr. Todd: I offer this map which is known as the Sanitary District of Chicago Map of the Illinois River water sheds scale 4 miles to an inch, and ask to have it marked defendants' Randolph's Exhibit B.

Which map is so marked by the Commissioner.

10764 Q. Will you please state whether the Sanitary District of Chicago is laid out on the map that has just been introduced in evidence?

A. Yes sir, the sanitary district of Chicago is shown on the southwest side of the area marked "Lake Michigan." The general outlines are indicated by heavy border lines and the wording "Sanitary District of Chicago" appear within those borders.

Q. Are you acquainted with the Desplaines River and the Illinois River from Lockport to Grafton?

A. I am.

Q. What opportunities have you had for acquainting yourself with the physical conditions of these streams?

A. I have an intimate knowledge with the Desplaines River growing out of frequent passages up and down the stream from Riverside to the junction of the Desplaines and Kankakee. I have never followed the Illinois River continuously through to
LaSalle, but I have traveled in sight of it and have been
10765 to many points along that river between the mouth of the
Kankakee and La Salle. From La Salle through to the mouth of the Illinois River I have made the trip by boat upon two or more occasions.

Q. What are the physical characteristics of the Desplaines River?

A. The Desplaines River is one of fluctuating volume. In certain seasons of the year it is almost dry. In other seasons of the year it is a stream carrying very large volumes of water, the maximum volume of which I have information being 800,000 cubic feet per minute. The fall of the stream for a distance of about 27 miles southwest from Chicago is slight. The grade is very slight. When it reaches Romeo the valley drops off rapidly and the stream, which follows the trough of the valley, flows very rapidly.

From the controlling works at Lockport to the upper basin at Joliet it has a fall of about 30 feet—the fall in the stream itself is about 30 feet, and at Lockport it enters the basin formed by dam number 1. Passing over that dam it enters a large channel made by the sanitary district and falls quite rapidly to Lake Joliet.

10766 Q. What towns lie tributary to the Desplaines River above Lockport, draining directly into that stream?

A. Since the diversion of the Desplaines River made by the sanitary district in 1893 there is no town draining into the Desplanes between Lyons and Lockport. The Sanitary District canal lies between the towns in the valley and the Desplaines River. Riverside drains into it. Grossdale drains into it, through Salt Creek. The population of Riverside is about 1600. Then the next town draining into it is Maywood on the west, and River Forrest on the east. Then the next town of any consequence is Desplaines.

Q. After leaving Joliet will you describe the physical characteristics of the Desplaines River?

A. There is a rapid fall in the channel from dam number 1 to the head of Lake Joliet, which is about 3½ miles southwesterly of dam number 1. The fall in that distance is approximately 21 feet. Lake Joliet is a widening of the stream and is probably a half a mile wide, and something like five miles long. There is a very slight fall from the head of Lake Joliet which is practically Brandon's road through to the head of Treat's
10767 Island.

For the distance of about a mile from Treat's Island there is a fall of nearly ten feet; from there the fall is gradual until you reach the pool made by the Marseilles dam. The water is backed up by the Marseilles dam for somewhere in the neighborhood of twenty miles. The fall at Marseilles is about 12 feet. At Ottawa, about 8 miles from Marseilles, the Fox River empties into the Illinois and the fall is gradual from there to Peru. Peru is the end of the Illinois and Michigan Canal and is at the head of the back water in Henry dam. The Henry dam is 540 feet long and six and one-half feet high. That backs up 29 miles. The length of that pool is 29 miles.

At Henry there is a lock 75 feet wide and 325 feet long. From the Copperas Creek dam to Henry dam is 59 miles and the back water from Copperas Creek is felt as far back as Henry. Between Henry and Copperas Creek the river forms Lake Peoria, a shallow lake of varying width, probably an average width of a mile and three-quarters, and 8 or 10 miles long, simply an enlargement of the Illinois River.

The next dam after passing Copperas Creek is at La Grange. Its pool is 58 miles long. The back water extends back to Copperas Creek. The height of the dam at La Grange is 7.33 feet, and its width is 818½ feet. The length of the Copperas Creek dam is 640 feet.
10768 From La Grange to Kampsville is 48 miles and that is the last of the dams in the Illinois River. The La Grange and Kampsville dams were built by the United States Government. The width of the Kampsville dam is 1200 feet and its height 7.3. From Kampsville it is 31 miles to the Mississippi River.

Q. Mr. Randolph, prior to the opening of the drainage canal what was the character of the water that went south in the

Illinois and Michigan Canal, by the Bridgeport pumping works?

A. It was water in a highly polluted state.

Q. When did those pumps begin to pump the sewage of the Chicago River into the Illinois and Michigan Canal?

A. The pumps were installed, that is the set of pumps were put in after the deepening of the canal. The canal was deepened between 1865 and 1871 and the flow was only about 9,000 cubic feet per minute. It was insufficient for the sewage and the pumps were put in the latter part of 1884. The operation was commenced about the end of the year 1884.

Mr. Jeffries: I move to strike out the answer and question as immaterial.

10769 Mr. Todd: I offer in evidence an act to provide for the completion of the Illinois and Michigan Canal upon the plan adopted by the state in 1836, approved February 16, 1865, published in the public laws of the State of Illinois in 1865, pages 83 to 84, which is set out in exhibit in the answer to the bill of complainant, filed by the State of Missouri.

Mr. Jeffries: Without objecting to the formality of the proof or the authenticity of the statute in question, I object to the introduction of the statute for the reason that it has no bearing upon the issues involved in this case and constitutes no justification upon the part of defendant, of the Sanitary District of Chicago, committing the nuisance set up in complainant's bill, and for that reason is incompetent, irrelevant and immaterial.

It is agreed that the statute as set out in Exhibit A in the answer of the defendant Sanitary District of Chicago shall be referred to and treated as evidence, subject to the objection presented.

Q. From 1884 to 1900 what was the average volume of sewage pumped from the Chicago River into the Illinois and Michigan Canal? 10770

Mr. Jeffries: Objected to as immaterial.

A. Approximately 50,000 cubic feet per minute.

Q. After this sewage was pumped into the Illinois and Michigan Canal where did it go?

Mr. Jeffries: Objected to for the reason that it is immaterial, and for the further reason that the evidence on the part of the defendants shows that the disease producing organisms more rapidly disappeared in their raw state as contained and existed in the Chicago River prior to the opening of the canal than they do in the drainage canal since its opening by the addition of 250,000 cubic feet of water per minute from Lake Michigan.

Q. Question repeated.

A. It flowed through that canal to Lockport where a portion of it was discharged into the Desplaines River over a waste weir or else passed through the wheels of the water power at that point. What did not enter the river at this point entered it after the Desplaines River reached what is known as the upper basin at Joliet. The complete mingling was in the basin at Joliet.

Q. Have you prepared a map or chart showing the population on the water sheds of the Illinois River, the Mississippi River and the Missouri River above St. Louis? 10771

A. I have.

Q. From what was this data prepared, Mr. Randolph?

A. It was made up from maps of the states through which these rivers flow. The populations were gotten from the Century Atlas, in towns of 500 or over.

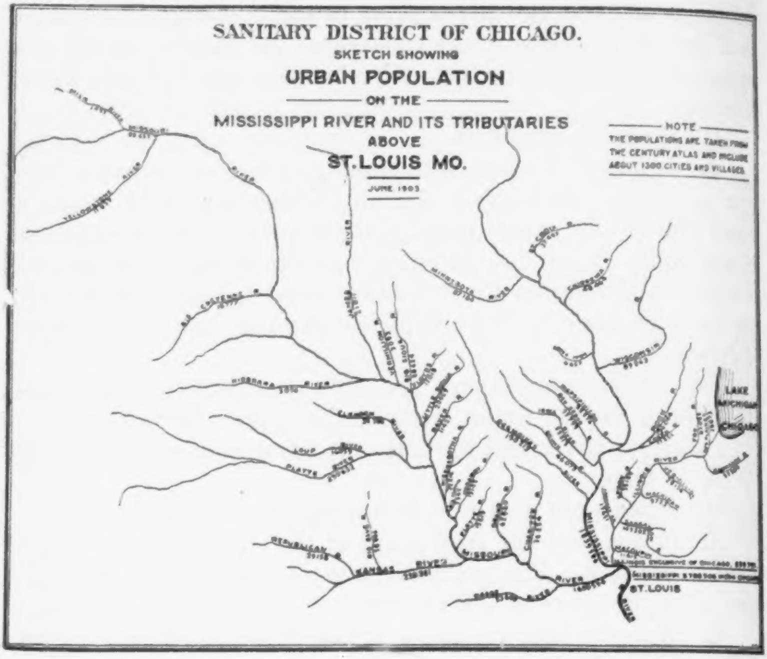
Q. Will you produce this chart or map and make it a part of the evidence?

A. I will.

Mr. Jeffries: I object to the introduction of the map or chart because it is irrelevant and not competent evidence.

A. The chart or map is as follows:

10772


SANITARY DISTRICT OF CHICAGO.
SKETCH SHOWING
URBAN POPULATION
ON THE
MISSISSIPPI RIVER AND ITS TRIBUTARIES
ABOVE
ST. LOUIS MO.
JUNE 1903
NOTE
THE POPULATIONS ARE TAKEN FROM THE CENTURY ATLAS AND INCLUDE ABOUT 1300 CITIES AND VILLAGES.
LAKE MICHIGAN
CHICAGO
MISSOURI
KANSAS
RIVER
ST. LOUIS

10773 Q. From the map that you have introduced, the poulation of the Illinois River, exclusive of Chicago, as evidenced by this map, is what?

A. 599,751.

Q. What is the poulation of the Mississippi River above Grafton?

A. 1,839,586.

Q. What is the population of the Missouri River above its mouth?

A. 1,650,594.

Q. What is the population lying tributary to the Mississippi River upon the three water sheds above St. Louis, including Chicago?

A. 5,788,506.

Q. What is the population on the Illinois River above

Grafton, including the sanitary district of Chicago, as shown by the map just introduced?

A. The population of the Illinois River, including Chicago gives 2,298,326. Substracting the Illinois River from that gives 1,698,575 for the Sanitary District.

ADJOURNED UNTIL 10:00 A. M., February 24, 1904.

10774 10:00 A. M., Wednesday, February 24, 1904. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

ISHAM RANDOLPH

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. Mr. Randolph, have you the gauge readings of the Desplaines River at Lockport, and the Illinois River at Peru, which were asked of you by Professor Van Ornum in a letter, the reply to which was read into evidence in this case, by Professor Van Ornum?

A. I have.

Q. In what way have you those gauge readings?

A. At Lockport I have the daily readings for the month of March and for the whole period since we began flowing water over the Bear Trap Dam, but I suppose it would be sufficient for your purpose to take the mean weekly readings?

Q. Have you the weekly average?

A. I have.

10775 Q. Will you read the weekly averages of the gauge readings at Lockport in the Desplaines River, for the period that you have the data for?

A. The period that he asked for was the month of March, 1903. The weekly average for the first week ending March 7th was —4.74.

Q. What do you mean by minus?

A. I mean that he asked for the gauge reading—that shows the elevation of the water on the gauge, that without having a discharge curve—that gives you no idea of the volume of water flowing at that time. He probably had the discharge curve so that he knew what he wanted it to apply to.

For the week ending March 14th the weekly average was −2.915 feet.

For the week ending March 21st, the average was −2.427.

For the week ending March 28th the average was −2.575.

For the week ending April 4th the weekly average was −2.121.

That covers the period asked for.

10776 Q. Will you give the gauge readings at Peru for the period requested in that letter?

A. I will give the gauge readings as shown upon the gauge records returned to us from that point, which are as follows:

I will preface this statement by saying that the gauge is a little nearer LaSalle than it is Peru, and in our records it is referred to as the LaSalle gauge. The weekly means have not been worked up, but the daily means from March 12th to 25th have been worked up and I will give those.

March 12th the mean for the day was 127.75.

This 127.75 is referred to Chicago datum, and means that that is 127.75 feet below Chicago datum.

	March 13th	128.04
	March 14th	128.42
	March 15th	128.83
	March 16th	129.33
	March 17th	129.73
	March 18th	130.20
10777	March 19th	130.38
	March 20th	129.30
	March 21st	128.68
	March 22nd	128.98
	March 23rd	129.43
	March 24th	129.50
	March 25th	130.28

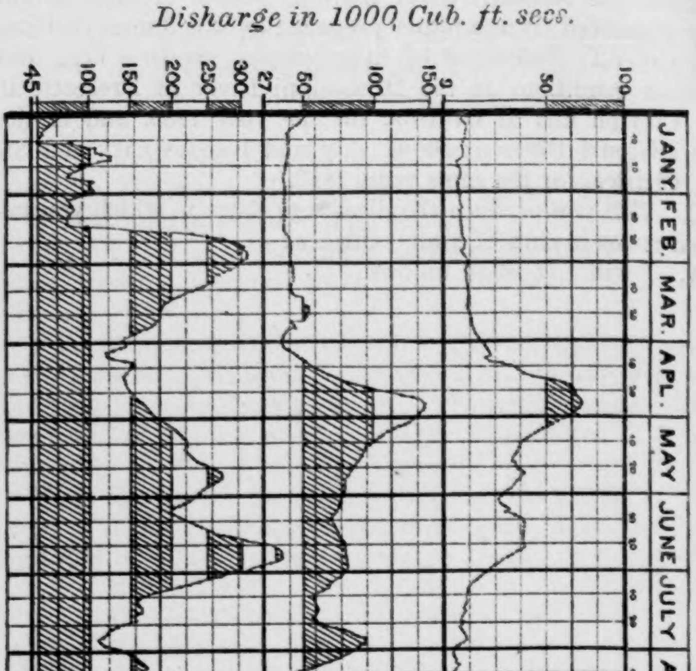
This apparently carried the readings through the flood period. The next record reading is on March 29th, 131.90, and on April 1st, 133.04.

Q. Will you give the volume of flow of the Illinois River at Kampsville, the Mississippi River above Grafton, the Missouri River above its mouth, and the Mississippi River at St. Louis?

A. In determining the volume of flow in the Mississippi River and the Missouri River the only source of information I have is derived from a paper prepared by Mr. James Seddon, which paper is illustrated by hydrographs, showing high and low water conditions in the Mississippi River at Prescott, at Clayton and at Grafton, for the year 1883, and in the 10778 Missouri River at Sioux City and Kansas City and St. Charles, for the same year, 1883.

Q. Will you produce the discharge chart to which you refer and make it part of your evidence?

A. I will. It is as follows:



FLOOD REGIMEN OF THE UPPER MISSISSIPPI

1883

10779 Q. Will you explain that chart and what it represents?

A. The caption of this chart is "Flood Regimen of the Upper Mississippi, 1883." The chart itself is divided vertically and horizontally into squares. The horizontal lines on the left indicate the number of thousands of cubic feet of water flowing, corresponding to the water heights which are shown on the right. The vertical lines indicate the months and the days of the months. Three spaces are alloted to each month beginning with January, 1883. Each space stands for ten days.

With the water at zero at Grafton there was forty-five thousands cubic feet per second flowing. The flood elevations, as before stated, are indicated by the figures on the right and the corresponding flood volumes are indicated by the figures on the left and the intersection of the vertical lines with the lines and depth, connected by broken lines, show the profile of the flood.

With a 4 foot stage at Grafton there was about ninety-eight thousands of cubic feet of water flowing per second. With the water at a 10 foot stage there was one hundred and ninety thousands cubic feet per second flowing. The lines indicating the flood profile which show the dates upon which this
10780 height or these heights occur by their crossing of the date
line. The maximum height of the water for the year 1883 was reached about June 25th, and the minimum about December 28th.

The chart for the Missouri River is constructed in the manner before described.

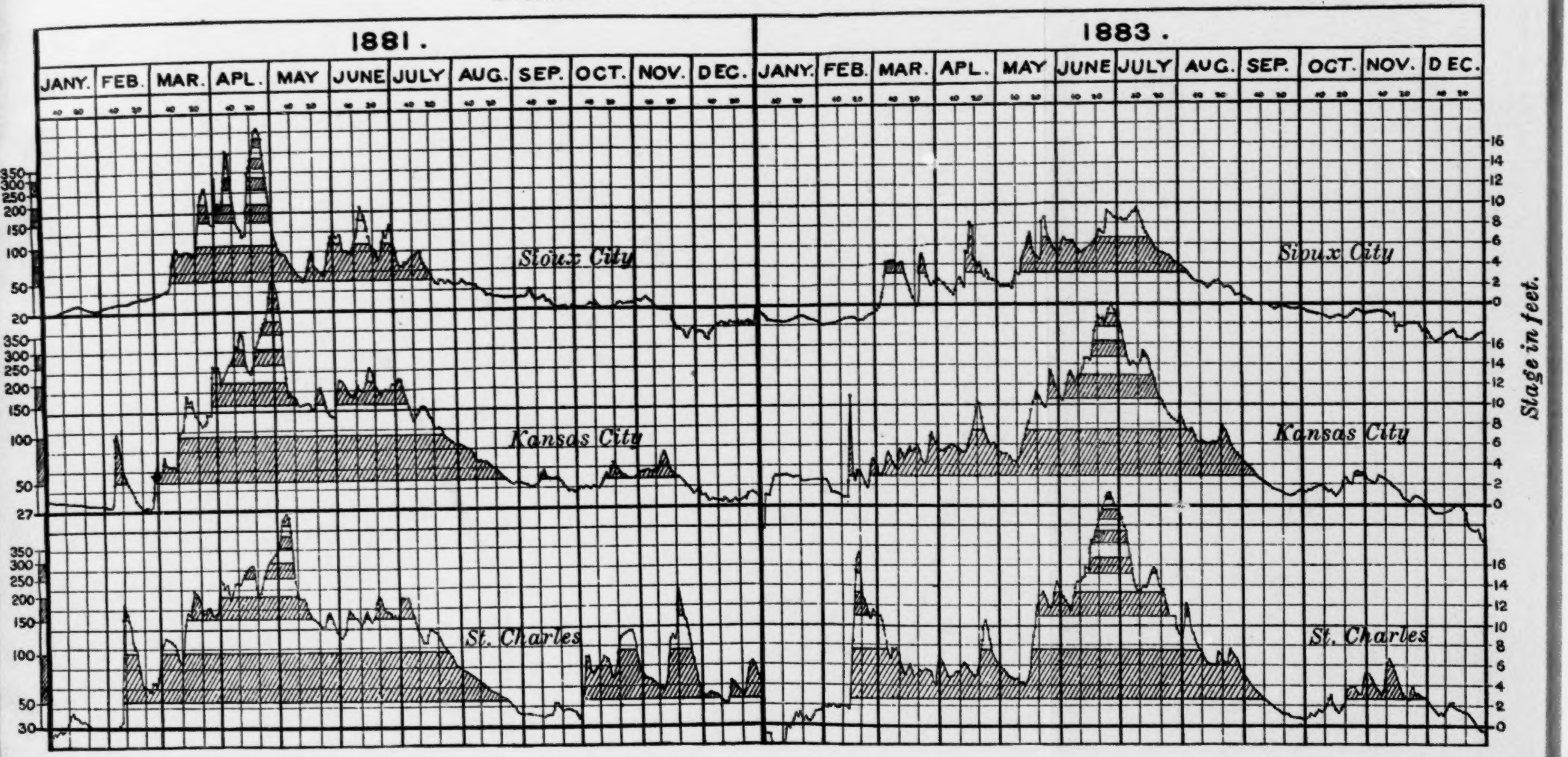
Q. I will ask you if you have a chart of the Missouri River?

A. I have.

Q. Will you produce and make a part of the evidence the chart to which you refer?

A. I will. It is as follows:

EXTREME FLOOD REGIMENS OF THE MISSOURI



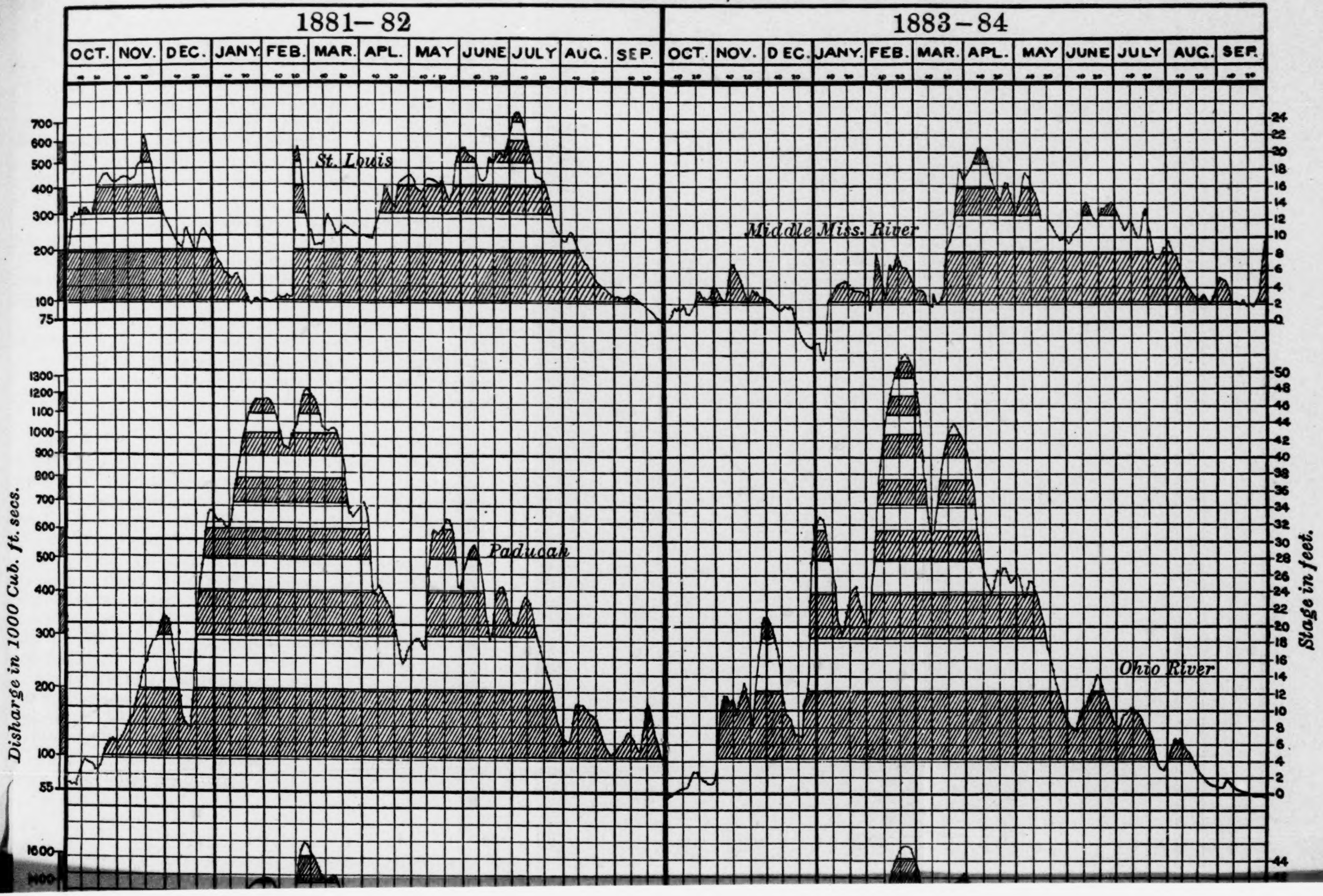
10782 Q. Will you describe the chart just introduced?

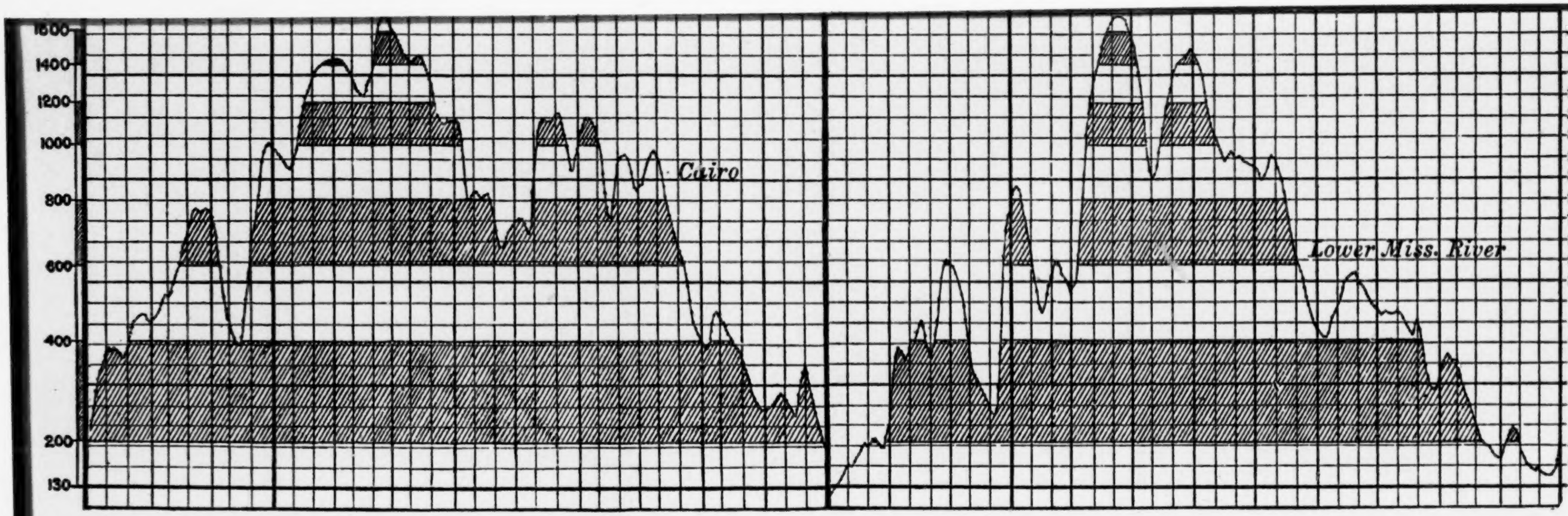
A. The caption of this chart is Extreme Flood Regimen of the Missouri. It covers the years 1881 and 1883, respectively. This chart is constructed in the same manner as the chart previously described, for the Mississippi River. It gives the flood conditions at three points, Sioux City, Kansas City and St. Charles.

I have also a chart showing the flood combinations in the Mississippi River at three points, St. Louis, Paducah and Cairo. This chart is as follows:

FLOOD COMBINATIONS

St. Louis and Paducah equals Cairo




1600
1400
1200
1000
800
600
400
200
130
Cairo
Lower Miss. River
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20
18
16
14
12
10
8
6
4
2
0

10784 It also gives conditions in the Ohio River and in the lower Mississippi.

The caption of this chart is Flood Combinations, St. Louis and Paducah Equals Cairo. It covers the years 1881 and 1882, for St. Louis, Paducah and Cairo, and the years 1883 and 1884 for the middle Mississippi, the Ohio and the lower Mississippi. The flood volumes at St. Louis equal the combined flow of the Mississippi and the Missouri Rivers.

The period covered is October, November and December of 1881 and from January to September, inclusive, of 1882, for St. Louis.

Q. Have you any measurements showing the volume of flow at Peoria?

A. I have several discharge measurements made for the Division of Hydrography, United States Government by one of my own assistants.

Q. Will you give the flow measurements at Peoria, for the period that you have given the dates and the flow?

A. The first discharge reading is March 18, 1903, observation made by E. H. Heilborn, area or cross section 10785 15376.3 square feet. Mean velocity 2.62 feet. Discharge 41218.7 per second.

April 3, 1903, observation made by E. H. Heilborn, area of cross-section 13713.02 square feet. Mean velocity 1.88 feet per second. Discharge 25839.4 feet per second.

April 29, 1903, measurement made by E. H. Heilborn, total area 13712.4 square feet. Mean velocity 1.9 feet. Discharge 26078.8 feet per second.

Observation May 13, 1903, E. H. Heilborn, total area 11072.5 square feet. Mean velocity 1.39 feet per second. Discharge 15337.5 feet per second.

July 5, 1903, E. H. Heilborn, area of cross-section 7768. Mean velocity 1.18 feet per second. Discharge 9424 feet per second.

August 22, 1903, measurements made by E. H. Johnson, area of cross-section 7218. Mean velocity 1.20 feet per second. Discharge 8713 feet per second.

January 30, 1904, E. H. Heilborn, area of cross-section 14874.8 square feet. Mean velocity 1.58 feet per second. Discharge 21124.1 feet per second.

February 14, 1904, E. H. Heilborn. Gauge height was
10786 15.42 on the Peoria gauge. I have not the reference to
Chicago datum. The total area of cross-section was
13639.2 square feet. The mean velocity was 1.2 feet per second and the discharge was 16305.1 feet per second.

February 14, 1904, E. H. Heilborn, area of cross-section 14814.9 square feet. Mean velocity 1.5 feet per second. Discharge 21783.7 feet.

Q. Have you the volume of flow at Kampsville?

A. I have information prepared by Major W. L. Marshall. At the time these observations were made he was Captain Marshall and was in charge of the Illinois river improvements for the United States government.

The first observation which he reports is April 10, 1889, gauge reading 4 feet; area of cross-section 7312 sq. feet. Mean velocity 1.4 feet per second. Cubic feet flow per second 10275.

On April 9th he observes the gauge reading as 4.2, the cross-section 7345, the mean velocity 1.37 feet per second. The volume of discharge 10052 cubic feet.

On April 1st he gives the gauge reading as 4.6, area
10787 of cross-section 7770, mean velocity 1.48, volume of dis-
charge 11548 feet per second.

On July 11th the gauge reading of 7.5 feet; area of cross-section 10859 square feet velocity of flow 2.2 feet per second; volume of flow 23892 cubic feet per second.

June 21st, gauge reading 9 feet; area of cross-section 12901 square feet; velocity in feet per second 2.41; volume of discharge 31068 cubic feet.

One June 22nd gauge reading 9.2 feet; area of cross-section 13084 square feet; mean velocity 2.43 feet per second volume of discharge 31855 cubic feet per second.

Then, he has a note here showing that on May 31st of that year the gauge read 10.5 feet, but it was affected by back water from the Mississippi. The cross-section at that date was 14516 square feet. The velocity was 1.47 feet per second, and the volume of discharge only 21344 cubic feet per second.

For January 18, 1900, he gives the gauge reading at Kampsville 12.8. That is a local gauge. The area of cross-section
is 13069 square feet. The mean velocity in feet per
10788 second 2.55, the resulting volume 33295 cubic feet.

In 1891 we have October 18th gauge reading 00.2; area of cross-section 2321 square feet; velocity per second .81 feet; volume of discharge 1878 cubic feet.

On October 20th the gauge read as above—.2 feet, that is, .2 feet below zero. The area of the cross-section 2224 square feet; the velocity .65 feet per second. The volume mean discharge 1453 cubic feet.

On the same day the same gauge reading he gets a cross-section of 2245 square feet and a velocity of .67 feet, volume of discharge 1505 cubic feet, found in report of Captain W. L. Marshall, for 1889 and 1890 in the report of the Chief of Engineers for 1890, page 2443; report of Captain W. L. Marshall for 1891 in the report of Chief of Engineers for 1892, pages 2263-6.

Q. Have you a profile of the water way from Lake Michigan to Cairo?

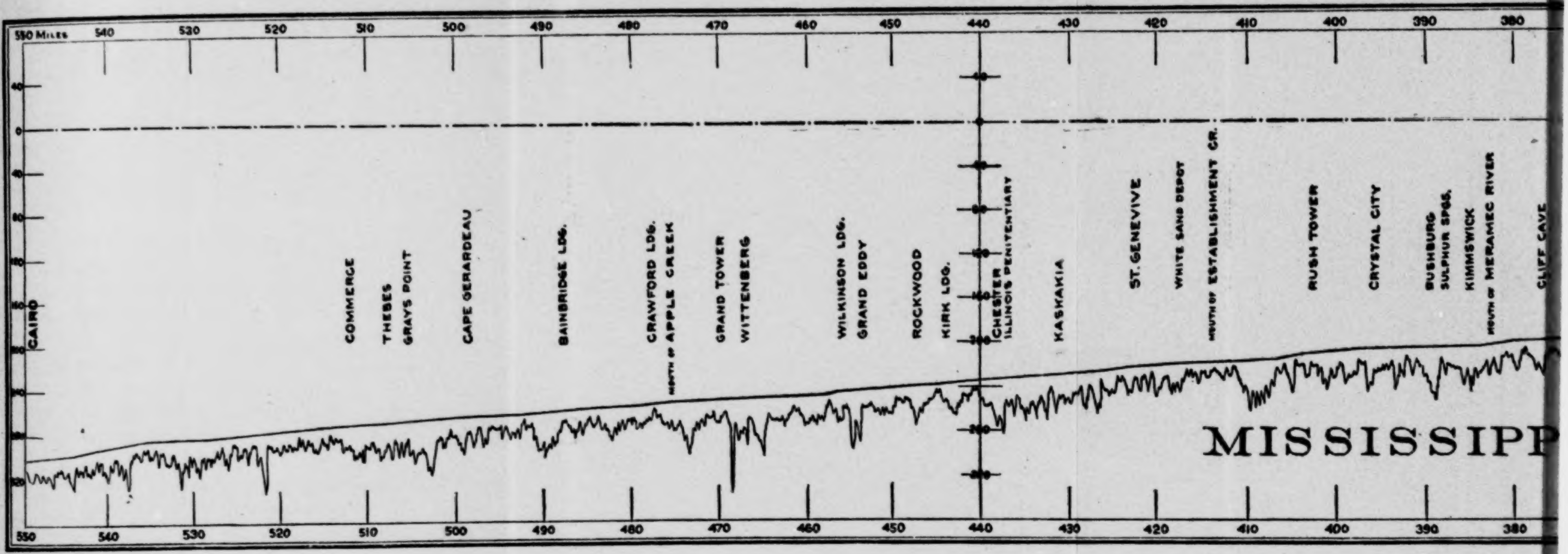
A. I have.

Q. Where was it prepared?

A. It was prepared in my office.

10789 Q. Will you produce and make it part of your evidence?

A. I will. Its title is "Profile of Waterway from Lake Michigan to Cairo," and is as follows: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280
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CAIRO
COMMERCE
THEBES
GRAYS POINT
CAPE GERARDEAU
BAINBRIDGE LDG.
CRAWFORD LDG.
MOUTH OF APPLE CREEK
GRAND TOWER
WITTENBERG
WILKINSON LDG.
GRAND EDDY
ROCKWOOD
KIRK LDG.
CHESTER
ILLINOIS PENITENTIARY
KASKASKIA
ST. GENEVIVE
WHITE SAND DEPOT
MOUTH OF ESTABLISHMENT CR.
RUSH TOWER
CRYSTAL CITY
BUSHBURG
SULPHUR SPGS.
KIMMSWICK
MOUTH OF MERAMEC RIVER
CLIFF CAVE
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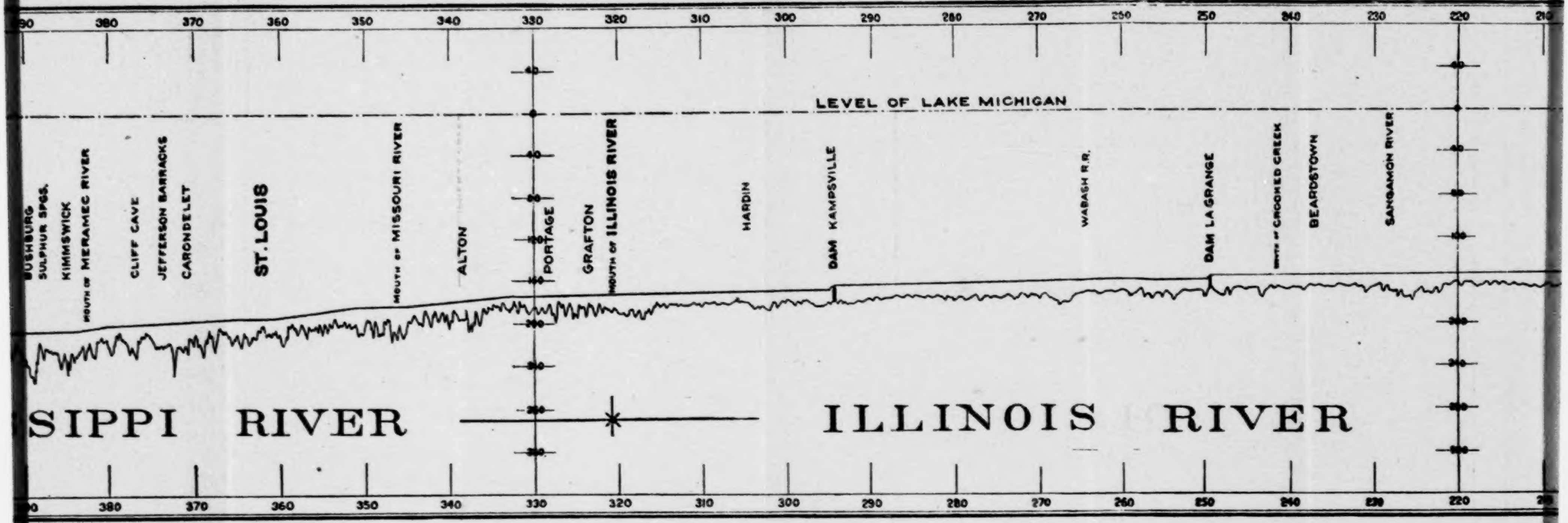
LEVEL OF LAKE MICHIGAN
BUSHBURG
SULPHUR SPGS.
KIMMSWICK
MOUTH OF MERAMEC RIVER
CLIFF CAVE
JEFFERSON BARRACKS
CARONDELET
ST. LOUIS
MOUTH OF MISSOURI RIVER
ALTON
PORTAGE
GRAFTON
MOUTH OF ILLINOIS RIVER
HARDIN
DAM KAMPSVILLE
WABASH R.R.
DAM LA GRANGE
MOUTH OF CROOKED CREEK
BEARDSTOWN
SANGAMON RIVER
SIPPI RIVER
ILLINOIS RIVER
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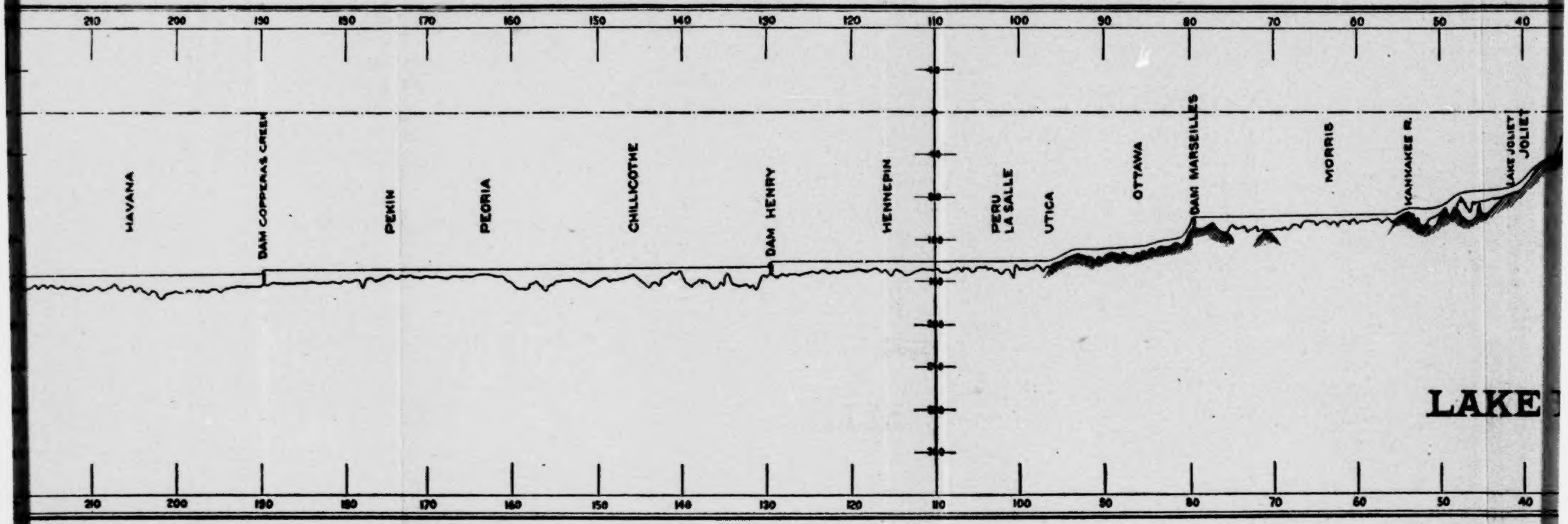
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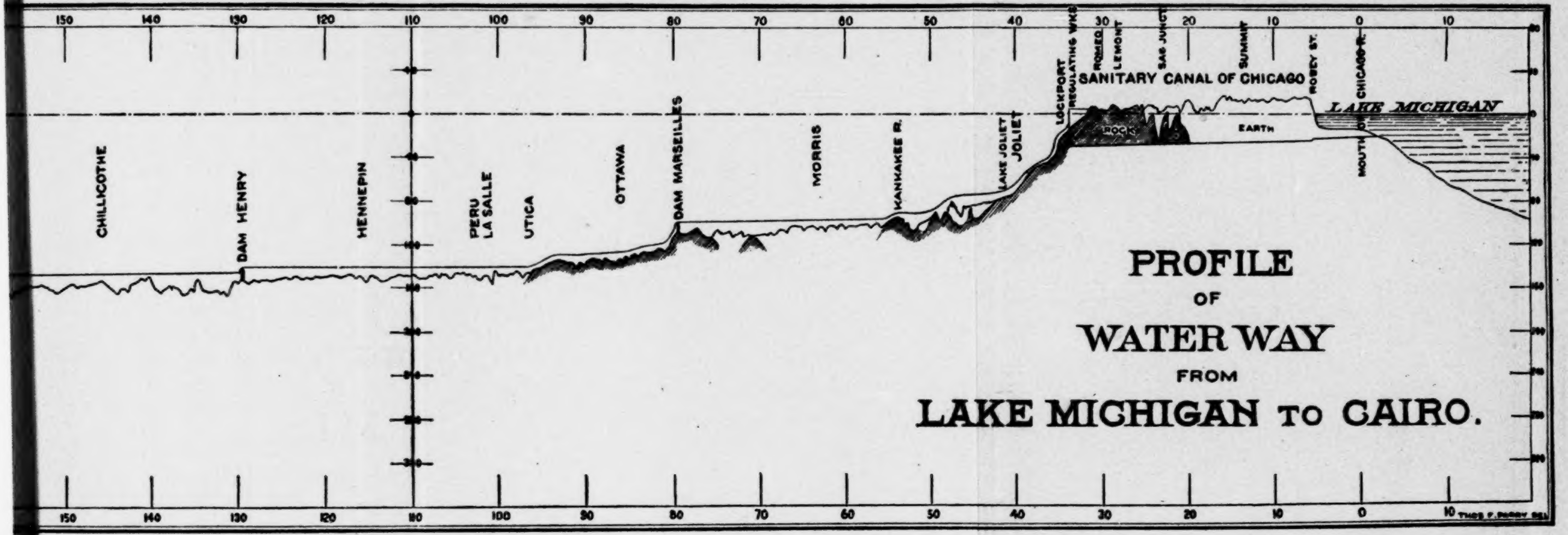
HAVANA
DAM COPPERAS CREEK
PEKIN
PEORIA
CHILLICOTHE
DAM HENRY
HENNEPIN
PERU
LA SALLE
UTICA
OTTAWA
DAM MARSEILLES
MORRIS
KANKAKEE R.
LAKE JOLIET
JOLIET
LAKE

Western Society of Engineers.
Vol. V. No. 4.
Cooley—Reservoirs and the Control of the Lower Mississippi



PROFILE
OF
WATER WAY
FROM
LAKE MICHIGAN TO CAIRO.

10791 Q. Will you explain briefly the plan upon which this profile is made and particularly describe whether the dams in the Illinois river are shown upon the profile?

A. The profile is constructed in the usual manner, the vertical scale being very much exaggerated. It indicates by a broken line the bed of the channel from the best data which we have been able to obtain and where the hydraulic gauge line is not regulated by dams it is shown by a wavy black line.

The pools made by the dams are indicated by straight lines, slightly descending. This profile commences at Lake Michigan, follows the course of the Chicago river and the drainage canal through to Lockport and thence on through the Desplaines, the Illinois and Mississippi rivers to Cairo.

Q. Mr. Randolph, did you calculate the distance between Chicago and St. Louis, as to the velocity of flow between those two points?

A. No, sir, it was done for me by my assistant, Mr. Crane. He prepared the table for me.

Q. What means were employed by you for ascertaining the velocity from Chicago to St. Louis?

A. Floats were used from Lake street to Robey street.
10792 The floats used in this stage of the work were wooden balls, a few of the wooden balls were put in the river at Lake street and allowed to float down to Robey street, a man following in a boat and the time of those balls is what is given in this table.

From Robey street to Lockport the cross-section of the different stretches of the channel being known, and the volume of flow being known, the velocity was easily computed, so for that 28 miles flow measures were not used, because we had a more accurate method of arriving at it, which is by taking the volume of flow as compared with the cross-section. From Lockport to St. Louis floats were used. The floats were of the same general character as complainant's Exhibit 43, except that in place of a 4-flange weight we had a hollow cylinder, suspended by a picture wire from the float.

The float itself was composed of two segments of a sphere, put together, looking like the two tops of a tin pail put together with the convex sides out, with a place on the top side for a flag, and a picture wire attached to the bottom side, the object being to present as little surface to the wind as possible. The flag was pivotal and free to adjust itself to the wind. The floats 10793 were followed by my assistants. For part of the distance they had to follow it on shore because a boat could not get through the rapids, but when it was practicable to follow it in a boat they followed it in the boat, and they were kept going night and day except on such occasions as accident of any kind stopping the work, and they were then taken out and the time noted. Through the rapids wooden balls were substituted for the floats above described, and whenever it was practicable to follow in a boat they were followed in a boat, and the observations were continued night and day, except in case of accident or storm, when the float was taken out, the place noted, and the time noted, and when work was resumed they were put in at the same place and the timing begun from the time of restoration.

Q. Will you produce and read in evidence the table which was prepared as a result of this experiment?

A. I will; the table is as follows:

	Interval.			Corrected Interval.			Total Time.			Total Time.
10794	Days	Hours	Minutes	Days	Hours	Minutes	Days	Hours	Minutes	Days
Lake St. to Robey St.	0	5	30	0	6	52	0	6	52	.3
Summit	0	5	42		5	42	0	12	32	.5
Willow Springs		7	22		7	22	0	19	54	.8
Controlling Works		18	54		18	54	1	14	48	1.6
Joliet		1	58		2	28	1	17	16	1.7
Lake Joliet		1	24		1	45	1	19	1	1.8
Through Lake Joliet		2	15		2	49	1	21	50	1.9
Kankakee Cut-off		3	40		4	35	2	2	25	2.1
Morris		8	11		10	14	2	12	39	2.5
Seneca		7	45		9	41	2	22	20	2.95
Marseilles		6	45		8	26	3	6	46	3.3
Ottawa		3	25		4	16	3	11	2	3.45
Utica		5	55		7	24	3	18	26	3.75
Peru		5	30		6	52	4	1	18	4.05
Henry Dam	1	0	31	1	6	39	5	7	57	5.35
Lacon		8	48		11	0	5	18	57	5.8
Peoria	2	21	15	3	14	34	9	9	31	9.4
Pekin		10	2		12	32	9	22	3	9.9
Copperas Creek Dam		13	43		17	9	10	15	12	10.65
Havana		14	31		18	9	11	9	21	11.4
Louderbach		15	36		18	43	12	4	4	12.15
Frederick		10	0		12	30	12	16	34	12.7
Beardstown		1	58		2	22	12	18	56	12.8
La Grange Dam		10	24		13	0	13	7	56	13.35
Griggsville		12	53		16	6	14	0	2	14
Pearl		16	52		21	5	14	21	7	14.9
Kampsville Dam		12	52		16	5	14	13	12	15.55
Hardin		12	44		15	55	16	5	7	16.2
Hadleys		10	24		13	0	16	18	7	16.75
Grafton		17	47		22	14	17	16	21	17.7
Alton		7	40		9	35	18	1	56	18.1
Merchants Bridge		6	51		8	34	18	10	30	18.45
Eads Bridge			58		1	10	18	11	40	18.5

10795 Q. Will you describe the table just introduced in evidence, and the method employed in its preparation?

A. This table consists of five columns. The first column gives the names of the places passed by the floats. The second column gives the time of passage between points. The third column gives this interval of passage corrected. The fourth column gives the correct total distance traveled by the float, in days, hours and minutes. The fifth column gives the time in days and fractions of a day. The second column of which I have spoken gives the actual observed time of the passage of the float. This time shows practically the surface velocity of the stream. The mean velocity is taken as 0.8 of the surface velocity and the corrections are made upon the basis of .8 of the surface velocity.

Q. What was the mean time from Lake street in the city of Chicago to the Eads bridge at St. Louis?

A. Eighteen days and a half. The term "mean time," as given here applies to the total time consumed in this experiment, from Lake street, Chicago, to the Eads bridge, St. Louis, as corrected in the manner heretofore explained. The correction made is taking .8 of the apparent velocity as the true velocity.

10796 Q. What were the stages of the river at the time this experiment was made?

A. I can hardly call it the mean stage of the river. It was not a flood time, that is, not anything like a maximum flood, nor was it a low water. It was a full river but not a flood.

Q. Was it above or below the mean average flow of the river ?

A. I think it was above the mean average flow of the river.

Q. Will you read the gauges of the river at the time this experiment was made?

A. I have here the gauge readings taken at LaSalle and at Grafton, upon the same days. On July 15th the gauge at La-Salle—the gauges are taken there mornings and evenings, but the averages not worked up, but the variation is so little that I take the afternoon gauges at 5 p. m. The 5:00 p. m. gauge at LaSalle reads as follows:

July 15th,	139.6,	below Chicago datum.
On the 16th,	139.7	
On the 17th,	139.8	
On the 18th,	138.65	
On the 19th,	138.20	
On the 20th,	138.40	
10797 On the 21st,	138.85	
On the 22nd,	139.1	
On the 23rd,	139.55	
On the 24th,	139.5	
On the 25th,	139.65.	

The readings at Grafton are taken from the United States Gauge Reader.

July 14th,	8.55	That is a local gauge.
On the 15th,	9.6	
On the 16th,	10.5	A rising stage of the river.
On the 17th,	11.3	
On the 18th,	12.1	
On the 19th,	12.5	
On the 20th,	12.6	
On the 21st,	12.7	
On the 22nd,	12.7	
On the 23rd,	12.8	
On the 24th,	12.8	
On the 25th,	13.1	

Adjourned until 2.00 p. m.

10798 2.00 p. m., Wednesday, February 24, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

ISHAM RANDOLPH,

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. From your knowledge of the water course from Chicago to St. Louis and taking into consideration all stages of the river during all seasons of the year since 1900, together with the float experiment which you have introduced in evidence, and considering the volume of water discharged into the Illinois river by the drainage canal, and by the tributaries of the Illinois river what is your opinion as to the mean average time it takes water to flow from Lake street in the city of Chicago to the Eads bridge in the city of St. Louis by way of the Chicago river, the Drainage Canal, the Desplaines river, the Illinois river and the Mississippi river?

A. I think that the result of this experiment of floats 10799 comes about as near it on an average as anything that you will ever get.

Q. My question is, what is your opinion?

A. Well, I will substitute, that in my opinion this comes as near to the average as anything that you will ever get.

Q. Have you the annual reports of the Health Commissioner of the City of St. Louis for the years 1893 and 1894, 1895 and 1895-6, known as the 17th, 18th and 19th annual reports of the Health Commissioner, respectively?

A. I have.

Q. Will you turn to page 11 of the report as found in the 17th annual report of the health commissioner of St. Louis for the years 1893 and 1894 and read that part of the report that refers to Illinois river pollution?

MR. JEFFRIES: I object to the form of proof. I object to the reading of the pages in question in evidence for the reason that it constitutes no defense in this case and for that reason is incompetent, irrelevant and immaterial.

A. "ILLINOIS RIVER POLLUTION. The existing 10800 indisputable proof of the contamination of the Illinois river by constant discharge into its channel of a large quantity of sewage and the fact that it joins the Mississippi a number of miles above the site of the intake of the local waterworks suggested the reflection that with the completion of the gravity drainage canal now under construction from the Chicago river to the basin of the Illinois river the sanitary peril attending the unguarded use of the Mississippi water could not in justice be longer unnoticed or ignored. This consideration led to the recommendation that special inquiry be instituted in this regard and resulted in the chemical examination by the department of samples of water taken from the channel of that stream in October."

MR. JEFFRIES: I move to strike out all that part of the report of the City Board of Health of the City of St. Louis just read in evidence, for the reason that it is not binding upon complainant and can not be construed into an admission of any character so far as this complainant is concerned and for the further reason that the conditions now existing and which have
existed since the opening of the drainage canal did
10801 not exist at the time the report was issued or published,
nor at any time prior to the opening of the drainage canal
and for the further reason that such statements are incompetent, irrelevant and immaterial and for the further reason that there was no authority shown that said board had the power or that it is required of said board as one of its duties to embody such determinations or findings in their report.

MR. TODD: Will you turn to page 36 of the same report and read the resolution adopted by the regular meeting of the Board of Health of the City of St. Louis, August 31st, as it appears upon that page?

MR. JEFFRIES: I object to the question for the same reasons stated in the last preceding objection and motion to strike out.

A. "REGULAR MEETING, AUQUST 21st. The following was adopted: Whereas, the present pollution of the Illinois river from a point near Joliet to its mouth by the discharge into its channel of sewage from Chicago seems indisputable from the evidence at hand; and,

Whereas, preparations are now being made by means of
10802 the construction of the drainage canal to pour a still
larger volume of sewage from the same sources into said
river; and,

Whereas, the delivery of this impurity into the Mississippi river so near to St. Louis and the strong probability that the public water supply here will be injuriously affected thereby makes the subject one of interstate importance;

Therefore, be it resolved by the Board of Health of St. Louis, that his honor, the mayor, and the honorable municipal assembly be and are hereby respectfully requested to memorialize Congress concerning this mattter and request that a suitable commission be appointed without grievous delay with powers to fully investigate the subject of the extent of the present and prospective pollution by sewage from Chicago of the Illinois and Mississippi rivers in order that the probable amont of danger to the public health therefrom and all other pertinent facts in regard thereto may be made known."

MR. JEFFRIES: Now, I move to strike out the resolution as read for the same reasons as embodied in my objection
10803 to the question and for the same reasons embodied in my motion to strike out the last preceding question and answer.

MR. TODD: Will you turn to page 38 and read the resolution that was adopted or rather that was offered and referred at the regular meeting of September 28th, as it appears in the same report.

MR. JEFFRIES: I object to that for the same reason previously stated.

A. "REGULAR MEETING, SEPTEMBER 28th. The following resolution was offered and referred: Ordered by the Board that the city chemist be and is hereby directed to proceed to collect samples of water for chemical analysis and such other examination as may by the Board be deemed necessary from the channel of the Mississippi river at the chain of rocks, said samples to be taken in such number and at such times as may be determined by the health commissioner and the results of the analyses of same and such other material information as may be elicited be reported from time to time to this Board."

MR. TODD: Will you please read the proceedings of the Board at the regular meeting of October 16th as appears on page 38 of the same report?

10804 MR. JEFFRIES: I object to the question for the same reasons previously stated.

A. "Regular meeting, October 16th. The following communication from the city chemist was read: I have the honor to report that in compliance with the resolution adopted by the Honorable Board of Health on October 9th, I have collected 22 samples of water from the Mississippi and Illinois rivers on October 11th, 12th and 13th as follows:

October 11th, 9 samples while proceeding on the steamboat Cherokee from the Chain of Rocks to Grafton.

October 12th, 4 samples of Mississippi river water between Grafton and a point 5 miles north of the Illinois river.

October 12th, 4 samples of Illinois river water between Grafton and a point 3 miles north of the mouth of the Illinois river.

October 13th, 5 samples of Mississippi river water between Alton and the chain of rocks, while proceeding from Alton to St. Louis on the steamboat Cherokee.

In conformity with the resolution mentioned above I have begun with the chemical analysis of said samples this day and shall report the result as early as possible, giving the same precedence over all work previously ordered to be executed by the Honorable Board." 10805

MR. TODD: Will you please turn to page 42 of the same report and read the report made at the regular meeting under date of December 4th in said report?

MR. JEFFRIES: I object to the question for the reasons previously stated.

A. "The following report of the city chemist was read: By order of the Honorable Board and under direction of the Health Commissioner I collected 22 samples of water from the channel of the Mississippi river from the chain of rocks to a point 5 miles above the mouth of the Illinois river on October 11, 12th and 13th, and in compliance with my instructions requesting merely a chemical analysis of these samples of water I herewith present my report on the chemical examination of the same.

In conformity with the object of this analysis to ascertain the character of the sewage contamination supposed to exist in the Mississippi river I confined my tests to those usually employed by analysts for such purposes and I have the honor to report the following results on this basis of examination, as presented by the appended table. 10806

In summarizing briefly the facts presented in this report I respectfully call the attention of the honorable Board of Health to the following conspicuous features:

1st. The large amount of free and albuminoid ammonia found at various points of the Mississippi and Illinois river and indicating considerable contamination, largely in excess of the limits adopted by expert analysts and scientific bodies.

2nd. Nitrates and nitrites were identified in all the samples of water, but neither of them exceeding the limits usually considered allowable.

3rd. Organic matter was found in very large proportions, signifying pollution to a certain degree, although a liberal allowance should be made for the presence of organic substances not strictly considered as impurities in river water.

4th. A remarkable fact is the large amount of chlorides present in the Illinois river, being twice as much as good drink-
ing water should contain, unless originating from a
10807 saline subsoil.

In order to ascertain whether or not such sewage pollution takes place in the Illinois and Mississippi rivers, I would suggest that the Health Commissioner be authorized by the Honorable Board to have additional samples collected and analyzed.

MR. TODD: Will you turn to page 43 and read the proceedings at the regular meeting of December 21st in the same report?

MR. JEFFRIES: I object to the question for the reasons previously stated.

A. Regular meeting, December 21st. The Board adopted the following report of committee, to whom was referred the Health Commissioner's communication submitted on the 11th inst.: In their judgment the further examination of the water supplied to this city in the manner and by the methods indicated is quite as important as stated by the Health Commissioner. And such an examination will be absolutely necessary if either of the measures suggested for the protection of the
water supply is to be adopted or advocated.
10808 At the same time it is submitted that such an examina-
tion will not only involve quite a draft upon the resources of the department, but must also for some time engage the attention of the city chemist and his force to the exclusion of all other work mapped out for him.

It is suggested, therefore, by your committee that before finally ordering the city chemist to proceed with the work proposed it may be well to ascertain the attitude or opinion of those city authorities upon whom it will be incumbent to move for the protection of our water supply, either by legal proceeding, petition to Congress or otherwise. The whole matter was then referred to the mayor."

MR. TODD: Will you proceed and read the letter from the mayor of January 6th, on page 45 of the Health Commissioner's Report of the City of St. Louis, in the same report?

MR. JEFFRIES: I object to the question for the reasons previously stated.

A. Regular meeting, January 8th. The following correspondence between the Mayor and Health Commissioner was submitted to the Board. Letter from the Mayor, January 6th:

I have received yours of the 22nd with accompanying reports bearing on the subject of the quality of the water of
10809 the Mississippi river between the chain of rocks and a point 5 miles above the mouth of the Illinois river as recently determined by the city chemist. Also charts illustrating the results arrived at by a chemical examination.

I have examined these charts and reports as carefully as my want of technical knowledge will permit. The result of the work is undoubtedly presented in a very graphic manner; indeed, it seems to me that a technical knowledge is hardly necessary to understand the results as shown by the reports and charts before me, assuming that the work of the city chemist so far as it went was thorough and reliable. I have no reason to doubt that the city chemist, Teichmann's, work can be depended on as representing the true conditions. It is my understanding that this investigation was the result of a suspicion that our water supply was being contaminated by Chicago sewage coming from the Illinois river.

Briefly, then, I find from the charts before me conditions as follows:

Substances supposed to contaminate drinking water in dangerous quantity in the Illinois river, also spots in the Mississippi river between the mouth of the Illinois and the chain of rocks and in the mouth of the Missouri river. I find, however,
10810 that at Grafton, about 1 mile and a half below the mouth of the Illinois the water is purer than at any other point in the river between Grafton and the chain of rocks. That is to say, nothing of the objectionable substances seem to exist in dangerous quantities one mile and a half below the supposed source of contamination, while the pollution increases and diminishes below that point at irregular intervals. This, it seems to me, tends to disprove the theory that the contamination (if there be any) at the chain of rocks comes from the Illinois river and

goes to show that the offensive substances found in spots along the river between the mouth of the Illinois and chain of rocks are due to local causes. The comparative purity of the water at Grafton seems to be inconsistent with the theory that the water below that point is contaminated from the water from the Illinois river. The conditions existing at the mouth of the Missouri river, as shown by the chart, suggest that as a much more probable source of the pollution than the Illinois river.

In view of these conclusions which seem to me necessary upon the facts before me I do not think further superficial investigations would be desirable at this time. In fact, it seems to me the tendency of the work done by our
10811 City Chemist is to give confidence in the purity of the water supply at the chain of rocks so far as influences are concerned within our control affecting the water at that point and I am, therefore, inclined to think that if further work be done the investigation should be conducted by a commission of thoroughly equipped experts, backed by sufficient appropriation of money to enable them to make an exhaustive and final report. The money at command under your present appropriation seems to me, not sufficient to do more than has already been done by Dr. Teichmann with seeming thoroughness. If sufficient funds can be made available to prosecute further work with thoroughness I shall be glad to co-operate with you to a final settlement of this vexed question."

MR. TODD: Will you turn to page 64 of the same report and read that part of Dr. Teichmann's report to the Board regarding the analysis of the Mississippi river water as appearing in the same report on that page.

MR. JEFFRIES: I object to the question for the reason previously stated.

A. "3rd. Regarding the analyses of the Mississippi, Missouri and Illinois river water, by my elaborate report of December 4, 1893, I most earnestly recommended the con-
10812 tinuation of these examinations. Owing to my orders from the Honorable Board, I could only take samples from the mouth of the Illinois river. It was therefore impossible for me to determine the source of contamination found at that point unless additional samples of water along the Illinois river could be analyzed and local conditions inspected personally.

The original purpose of these investigations being to ascertain the extent of present and future sewage pollution of our water supply from the Illinois River, and indirectly from the Chicago drainage canal. I consider the speedy continuation of these investigations a matter of grave importance to our community. A system of thorough chemical and bacteriological examinations conducted at short intervals during a period of two years would contribute much towards the settlement of this great sanitary problem and would very likely encourage national legislation for the purpose of preventing municipal communities from emptying their sewage into potable rivers."

Mr. Todd: Will you turn to the 18th annual report of the Health Commissioner for the year ending March 31, 1895,
10813 and read on page 11 that part of the report under the heading "Federal Rivers Commission."

A. "FEDERAL RIVERS COMMISSION. A movement on the lines suggest in the report for last year was made in January by Hon. Richard Bartholdt, through the introduction into Congress of a bill which reads as follows:

A Bill to appoint a commission for the investigation of the pollution of water supplies where such pollution affects or threatens to affect the sanitary condition of the people of more than one state.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That a Commission shall be appointed to investigate fully the subject of the pollution of rivers and other sources of water supply where the sanitary condition of the people of more than one state is affected or threatened to be affected by such pollution, this commission to consist of three members, to be appointed by the President, by and with the advice and consent of the Senate, whose compensation during the time when
10814 actually engaged in the performance of their duties under this act shall be Ten Dollars per diem each and reasonable expenses.

Sec. 2. That the Commission shall meet in Washington, District of Columbia, within thirty days after the passage of this act to consider the methods to be adopted in the investigation, and it shall have authority to be empowered to make use of the services of chemical, bacteriological and sanitary experts, and such persons as it may judge most competent by reason of their special knowledge and experience to afford it correct information on the subject of its inquiry, as well as in formulating its methods as in carrying them into effect. It shall meet thereafter from time to time at such places as it may consider best suited for the furtherance of this inquiry.

"Sec. 3. That the commission shall report to Congress at its next session the progress made in the investigation undertaken under this act and shall submit such suggestions as may seem desirable, with the view of remedying any unsanitary conditions that have been developed by its work.

Sec. 4. That the sum of .... thousand dollars, or so much thereof as may be necessary, is hereby appropriated, to pay the salaries and expenses of said commission and
10815 carry out the purposes of this act."

The General Assembly at its late session adopted a joint resolution asking the Missouri Congressmen to support this measure and it is to be regretted that its introduction was delayed so long—the bill having died with the session—as, to judge by the expression of the sanitary opinion from the principal parts of the country, the time was ripe for legislation of this kind. Certainly no more important field is offered to progressive science and the thorough investigation as proposed of all streams touching more than one state would yield the data of the very highest practicable value to all concerned in the protection and preservation of the public health.

The defilement of natural water courses has become one of the most conspicuous evils of modern civilization and the harm and wrong are of such magnitude in this country that only the powers of the general government are adequate to deal with them properly. States and municipalities situated near the head waters of potable streams are not so seriously threatened in this respect, but the great bulk of urban population is found on the middle and lower reaches of such water course, hence the necessity for vigilant precaution.

10816 The invasion of this valley by a flood of filth naturally foreign to it, as is proposed by the construction and operation of the sewage canal leading from Chicago to a tributary of the Illinois River, will tend to enormously increase existing danger due to pollution of the upper Mississippi and from other sources and of the Missouri river from the sewage outflow of Kansas City, Leavenworth, St. Joseph, Omaha, etc.

"St. Louis is the focal point of all this drainage and must bear the brunt of the attack as best she may. No place of any considerable size below, drawing public supplies from the channel of the Mississippi River, therefore the means of prevention and correction should be most diligently considered here now."

At page 11 an asterisk at the bottom of the page is in words as follows: "This measure was drafted in December, 1894, by Major Charles Smart, Surgeon United States Army upon the request of the Health Commissioner, later submitted to his Honor, the Mayor and by him forwarded to Washington."

On page 12 a foot note is indicated by an asterisk immediately after the word resolution as heretofore quoted, and it is as follows: "Be it resolved by the General Assembly of the State of Missouri as follows: That our senators and representatives in Congress are requested to vote and urge the 10817 passage of the bill authorizing the National Commission to investigate the pollution of streams, the waters of which flow through or adjacent to more than one state." Approved March 9, 1893.

Mr. Todd: Will you turn to page 25 of said 18th annual report and read what is there stated about a local commission?

Mr. Jeffries: I object to the question for the reason previously stated.

A. "That a local commission be formed under municipal authority to inquire fully into the quality of the water supply of St. Louis."

Mr. Todd: Will you turn to page 43 of the 19th annual report of the Commissioner of Health of the City of St. Louis for 1895-6 and read what is stated there under water supply?

Mr. Jeffries: I object to the question for the reasons heretofore stated.

A. "Water Supply. The question as to the influence of the Chicago Drainage Canal as now in course of construction upon the water supply of St. Louis is one that should not be lost sight of. A bill creating a Federal Commission to investigate and suggest congressional action of a remedial character is now before Congress. It is hoped that such a law be 10818 enacted that selections for membership of the Commission may be made that will recognize and protect the equitable demands of each locality."

Mr. Jeffries: I move to strike out all that has been read of the reports of the Health Department of the city of St. Louis by this witness for the reason that the same is incompetent, irrelevant and immaterial and for the further reason that the conditions complained of are such as existed or may have existed subsequent to the opening of the drainage canal and not such as existed prior thereto and for the further reason that by the opening of the drainage canal conditions were brought about in the Illinois and Mississippi Rivers entirely different from what existed prior thereto, and for the further reason that the defendants' own testimony shows that the longevity of a disease producing germ to be less in highly concentrated sewage polluted waters than in less concentrated or a more highly dilute condition.

Mr. Todd: Who was the sewer Commissioner of the city of St. Louis from 1887 to 1891?

A. The published list of officers shows that Robert E. McMath was Commissioner of sewers.

10819 Q. During the time that he was connected with the municipality of St. Louis do you know of any report made by him upon the question of the Illinois River?

A. I know that he delivered an address of May 30, 1888, before the Engineer's Club of the City of St. Louis and that address appears in the Journal of the Association of Engineering Society beginning on page 316, for the year 1898.

Mr. Jeffries: I object to the question and move to strike out the answer because it is incompetent, irrelevant and immaterial.

Q. Is the paper in which that address was delivered a paper of general circulation?

Mr. Jeffries: I object to the question for the reason that it is an endeavor to introduce statements made by Mr. MacMath without putting him upon the witness stand so that the complainant might have an opportunity to cross examine him.

A. The paper was very generally circulated amongst engineers of the United States.

Mr. Todd: Will you read that part of the address de-
10820 livered by Mr. McMath, the Sewer Commissioner of the
city of St. Louis in the city of St. Louis and published
as you have indicated, in 1888?

MR. JEFFRIES: I object to the question for the reason that Mr. McMath is still living and no effort has been made upon the part of the defendant to place him upon the witness stand in order that the complainant might have an opportunity of cross examining him and for the further reason that whatever might have been said at the time, applied to conditions that existed prior to the opening of the drainage canal and not subsequent thereto, and for the further reason that whatever he might have said would not have been binding upon the complainant, and does not constitute in any way a justification of the defendant in committing the nuisance complained of.

A. The volume containing this publication is in the library of the Western Society of Engineers. I have simply made from it such notations as I thought were necessary.

MR. JEFFRIES: I object to the witness reading into the
record only such parts of the address referred to as he
10821 desires, unless he reads the whole address, and all that
was said upon the subject at the time by the party in
question.

MR. TODD: In reply will state that if the complainant desires the whole document the same will be produced and read in evidence on request made on cross-examination.

MR. JEFFRIES: I would like to have the article present so that I may examine it.

THE WITNESS: He starts out by describing the project—

MR. JEFFRIES: I object to the witness relating in a second hand way what the article contains, for the reason that it is incompetent, improper, immaterial and irrelevant and for the further reason that it is not responsive to the question.

(Question repeated.)

A. I can only read such parts as I made notations of in the book which I hold in my hand: "The project contemplates first a canal from Lake Michigan to the Des Plaines river, Joliet being the objective point, having a capacity to carry the volume of at least 10,000 cubic feet per second, at a velocity consistent

with the use of the canal for navigation. Said Canal to be
10822 the outlet for Chicago drainage. The volume being made
ample to carry sewage without objectionable pollution."

Then follows a discussion of the effect upon Lake Michigan, which I simply put in for my own information, and it does not bear upon this case at all. I skip to where it strikes this question:

"Of the flood discharge of the Illinois River, we have no direct measure. Taking the differences between the gauges of the Mississippi at Hannibal and at Grafton for 1881, maximum difference of 79,000 cubic feet per second appears to be the maximum discharge of the Illinois River. At the lowest stage, the lowest discharge at the mouth of the Illinois River was by measurement in 1866 about 1200 cubic feet, which has now increased to about 2000 cubic feet, by water pumped at Bridgeport."

Skipping to page 319 of the address:

"The normal fall from La Salle to the mouth of the river is equal to .13 per mile, the distance is 225 miles.

On page 320 he begins:

"The treatment of the Sanitary effects, and on page 322,
he states Disinfection may become necessary for all cities.
10823 This is no more applicable to Chicago than to St. Louis."

On page 322: "In 1879, water passing through the Illinois and Michigan canal was 9,000 cubic feet per minute. At Joliet, 33 miles below Bridgeport, the water falling over the dam, gave off odors comparable to those arising when a privy vault was being emptied. Increased volume from pumping works, about 45,000 cubic feet per minute. Sewage in 1886 could not be traced farther than Ottawa."

On page 324 he states: "That the general result is a betterment."

This paper was discussed by Messrs. Seddon, Prof. J. B. Johnson, Messrs. Wheeler, Boughton, and Holdon.

MR. JEFFRIES: I move to strike out the witness's answer to the preceding question in which he undertook to read into the evidence statements made by Mr. McMath in an address delivered by him in 1888 for the same reasons stated in my objections to the question, and for the further reason that the answer is in no way responsive to the question, and for the

further reason that the witness has interjected his own opinion
as to what McMath meant by the use of certain words, when
such evidence, if admissible under any circumstances
10824 whatever, should be admitted as a whole, in order that
the Court might determine the purport, meaning and
spirit of the language used.

10825 Q. Will you turn to page 12 of the Seventeenth Annual
Report of the Health Commissioner of St. Louis, for
1893-4, and read what is said under wells?

Mr. Jeffries: The same objection is interposed here on the part of the complainant to this evidence, and for the same reasons as stated in the objections interposed to previous readings from said reports.

A. "WELLS. The examination by chemical tests of water taken from surface wells in different parts of this city progressed memorably during the year, and a number of these sources of contaminated water supply for households have been condemned. The standard of allowable impurity established for the purpose of this undertaking is quite liberal, but even as thus measured, very many wells were found to contain water utterly unfit for human consumption."

Q. Will you turn to page 63 and read from the annual statement as found in the Seventeenth Annual Report of the Health Commissioner of St. Louis for 1893-4, what is said there about wells?

Mr. Jeffries: Same objection.

10826 A. "Number of samples of well water analyzed 2. Pri-
vate wells, 239; b. public wells, 8. Number of impure
wells reported for condemnation: a. private wells 41. b. pub-
lic wells 5."

Q. Will you turn to the bottom of the same page and read what is said in regard to the analysis of wells, etc.

Mr. Jeffries: Same objection.

A. "Reviewing this work I respectfully venture the following remarks and suggestions:

1. The analyses of well and cistern water were based strictly upon the standard adopted in the month of September, 1893, by the Commission appointed by the Honorable Board, and consisting of Professor Charles O. Curtman, Chairman, Professor Charles R. Sanger, Professor William B. Potter, Dr. Otto

E. Forster, Hon. David W. Caruth, Chief Sanitary Officer, Charles W. Francis, and the undersigned. According to this standard all wells and cisterns are to be condemned as impure and unwholesome which contain: 1. More than 0.05 parts of nitrogen in the form of nitrites, per million parts of water; or second, more than 0.01 parts of nitrogen in the form of nitrites per million parts of water, in conjunction with 0.15 parts nitrogen in the form of free ammonia per million parts

10827 of water and 100 parts of chlorine per million parts of water, or 3rd, nitrogen in the form of albuminoid ammonia to the extent of 0.2 parts per million parts of water, or 4th, phosphoric acid or phosphates as ascertained by the characteristic turbidity produced upon the addition of ammonia molybdate. Although the analyses of wells thus far made do not represent every ward in the city, the comparatively large number of wells found to be impure, averaging about 1 out of 5, fully justify the vigorous continuation of these examinations. The Sanitary Division has already presented a list of nearly 3,000 wells and with proper facilities provided by appropriations I expect to be able to analyze the larger part of this number during the present fiscal year in addition to the other expected work. The principal object of these examinations of wells being sanitary, bacteriological investigations should be included wherever the indications call for them. The last annual appropriation did not provide for the purpose of bacteriological apparatus, therefore such examinations could not be made."

Q. Will you turn to page 215 of the health reports of the

10828 18th Annual Report of the Health Commissioner for May 31st, 1895, and read under the head wells contaminated, total number of wells.

Mr. Jeffries: Objected to for the reason it is incompetent irrelevant and immaterial and has no bearing upon the issues involved in this case, inasmuch as it relates to conditions prior to and not subsequent to the opening of the drainage canal.

A. "Total 59 wells."

Q. Will you turn to page 65 of the same report and read what is there under wells?

A. "Wells. 59 wells have been condemned by the Board of Health and very few have been closed. The standard which was established by the Board of Health in relation to wells should be legalized by the Municipal Assembly. Where City water is on any premises and where it is desired to retain the well for stock or washing purposes, a permit to do so should only be given under certain binding conditions—the Assembly should enact the law."

Q. Will you turn to page 204 of the same report and read the table showing the total number of wells by wards in the city of St. Louis, April 1, 1895?

Mr. Jeffries: Objected to as immaterial.

10829

	Ward	Public Wells on Street.	Total Number of Wells in Ward.
	1	6	19
	2	2	20
	3	2	57
	4	10	148
	5	23	291
	6	46	298
	7	14	541
	8	11	191
	9	14	168
	10	9	256
	11	10	140
	12	26	468
	13	37	435
	14	9	58
	15	9	150
	16	15	199
	17	8	40
	18	29	348
	19	10	58
	20	3	10
10830	21	13	52
	22	5	17
	23	16	147
	24	13	46
	25	6	116
	26	57	210
	27	30	284
	28	4	79
		— —	— —
	Total	437	4848

Q. Will you turn to page 66 of the 19th Annual Report of the Health Commissioner for 1895 and 1896 and 1897, that part of the report of the meeting of August 1, 1895?

Mr. Jeffries: Objected to for the reason it is immaterial and not competent evidence.

A. A communication was submitted by the Health Commissioner in reference to the report of the City Chemist on analyses of the water from seven wells, the water of which is impure according to the standard adoption by the Board of Health some two years ago. The communication was made the basis of the following resolution, which on motion duly seconded was adopted:

"Resolved that hereafter the City Chemist shall make no examinations of well or cistern water unless by special direction of the Health Commissioner."

10831 Mr. Jeffries: I move to strike out all the testimony of this witness wherein he has read into the record excerpts of the reports of the Board of Health of the City of St. Louis, for the reason that the same are immeterial and do not constitute competent evidence.

CROSS EXAMINATION

By Mr. Jeffries.

Q. Mr. Randolph, was there any record kept of the times and periods the water in the Chicago River flowed into Lake Michigan prior to the opening of the canal?

A. No sir, we have no such record.

Q. Is it not a fact that there were periods of several weeks and months in which the water did not pass from the river into the lake but remained as a stagnant pool in the Chicago River?

A. There was no extended period in which there was not some current either to or from the lake.

Q. Can you give any approximation of the time ?

10832 A. No sir, I can not.

Q. Is it not a fact that since the opening of the canal the water from the various cribs in Lake Michigan from which the water supply of Chicago is drawn, is condemned by the Health Department.

A. It is frequently pronounced unsafe by the Health Department.

Q. And citizens using it for domestic purposes are requested to boil that water?

A. That is true.

Q. And such conditions obtain and have obtained regardless of whether there was a freshet which carried the water of the Chicago River back into the lake is it not?

A. That is true.

Q. Do you know whether or not there was any record kept of the number of freshets and the time of their happening prior to the opening of the drainage canal which carried the water from the river into the lake?

A. I have no knowledge of any such record.

Q. You do not know whether they were kept or not?

A. No sir. If they were kept it was by the city of Chicago.

Q. The sanitary district did not keep that?

A. They did not keep that.

Q. Does the sanitary district keep such record since the opening of the canal?

10833 A. No sir. It is a condition which we do not intend should obtain at any time, and all that we do is to keep track of the floods in the north branch and keep the flow from our channel so as to care for those floods.

Q. In fact it is a condition which has rarely happened since the opening of the canal?

A. So far as I have any information or knowledge there is only one occasion when it was notably true.

Q. And that was upon the occassion of the Joliet flood?

A. No sir. I got no complaint of it at that time, strange to say, but it was at a time when there was a flood in the north branch, which was not watched by our people.

Q. And the dam was not lowered to a sufficient depth to permit the necessary flow?

A. To carry it off, yes sir.

Q. At the time of the Joliet flood there was no local freshet at Chicago but the dam was set to a certain height to stop the running of the water through the canal and to carry it to a lake level in order to protect the people below that point, from the local freshet there?

10834 A. Yes sir, that was done.

Q. How long has it been since the 12th Street and the 22nd Street sewers were diverted from Lake Michigan?

A. I have not those exact dates but the best of my recollection is about two and one-half years ago.

Q. They have been diverted from the lake since the opening of the sanitary canal?

A. Yes sir.

Q. And they discharge now into the Chicago River?

A. Yes sir.

Q. And thence into the canal?

A. Yes sir.

Q. What other sewers that you know of besides the 12th and 22nd Streets sewers which formerly discharged into the Lake Michigan have been diverted through some other source?

A. Those are the only two sewers whose diversion I have any knowledge of.

Q. State if you know the extent of population of the territory sewered by the 12th Street and the 22nd Street sewers?

A. I can not give it. I can not differentiate between those sewers and sewers leading from the same general territory which discharged previously into the Chicago River. 10835

Q. Can you give the size of those sewers at the point of discharge?

A. I can not give the 12th Street. The 22nd Street, as I remember it, is a 12 foot sewer.

Q. Those two sewers, to-wit: the 12th Street and the 22nd Street sewers receive the sewage from populous communities do they not?

A. Yes sir, very populous.

Q. How does the population of the territory sewered by these two sewers compare with the population generally throughout the city, in point of numbers?

A. My judgment is that excepting the densely populated business district included within the loop it is the maximum population of anything outside of that area.

Q. How does the population or the territory sewered by the 12th and 22nd street sewers compare with the population sewered by such sewers as have discharged directly into the Chicago

river at and as did directly discharge into the Chicago
10836 river prior to the opening of the drainage canal and
prior to the diversion of the 12th and 22nd Street sewers
from Lake Michigan to Chicago river?

A. There is territory on the north side extending as far north as Chicago avenue, and on the west side parallelling the river, as far west as Halsted street that is of about the same density as the population sewering into the territory about which you have just asked. Those three sections are about on a par as far as population is concerned. Outside of that area the population is less dense. I think that the population draining in the 22nd and 12th Street sewers is about the same density as that draining directly into other sewers which pass into the river between Van Buren street and 22nd street. You see, there are other sewers besides these that also empty into the river, taking sewage from that same territory.

Q. Then it is your judgment that about the same number of people reside in the territory sewered by sewers discharging directly into the Chicago river as are sewered by the 12th and 22nd Street sewers, confining yourself to the immediate territory in which the 12th and 22nd Street sewers are located?

A. That is the ratio of population to area is about the
same for the territory discharging into the 12th and
10837 22nd Street sewers as for the territory discharging
directly into other sewers which pass into the river
between Van Buren street and 22nd street.

Q. In your opinion are there as many people sewered by the 12th and 22nd Street sewers as are sewered by the sewers in that immediate locality, discharging directly into the Chicago river?

A. No, sir; I do not think there are as many.

Q. Now, in these last answers, what is the extent of the smaller sewers that you have taken into consideration with reference to the location of the 12th and 22nd street sewers?

A. There are sewers coming in at Harrison street, at Polk street, at Taylor street, all of them north of Twelfth street, and there is nothing from Taylor street until you come to Twelfth.

Q. Can you give the approximate boundary of the territory sewered by the 12th and 22nd Street sewers?

A. No, sir, I can not. There are small sewers coming into them that I have not in mind.

Q. Can you state approximately the population of the City of Chicago in the immediate vicinity of the 12th and 22nd Street sewers, taking into consideration the population in the
10838 territory sewered by the small sewers in connection with the 12th and 22nd street?

Adjourned until 10:00 a. m., February 25, 1904.

10:00 A. M., Thursday, February 25, 1904.

10839 Continuation purusuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

ISHAM RANDOLPH

resumed the stand for further cross examination by Mr. Jeffries, and testified as follows:

A. The population tributary to the 12th and 22nd Streets sewers I estimate to be from the First Ward 8225, or one-third of the resident ward population; from the second ward 25,692, or 90 per cent of the resident population of the ward. Total, about 34,000. An exact determination can only be had by making a house to house canvass. This answer is based upon the resident population shown by U. S. census and excludes the non-resident business population. In these wards a large area is devoted to railroad yards.

Q. Outside of the territory between the Chicago River and the territory formerly drained by the 12th Street Sewer, the territory of the city of Chicago now drained by the 12th and 22nd street sewers direct into the south branch of the Chicago River and which formerly discharged into Lake Michigan
10840 is about as populous as any part of the city of Chicago?

A. It is as populous as any part of the city of Chicago.

Q. Is there any sewage south of the Chicago river drained directly into the lake today?

A. Yes sir; the 35th Street sewer is draining into Lake Michigan.

Q. Can you give approximately the population of the district sewered by the 35th street sewer?

A. The population tributary to the 35th Street sewer is about 22,000, or 66 per cent. of the resident population of the Third Ward.

Q. Is that the only sewer that drains now directly into Lake Michigan, south of the Chicago River?

A. No sir. The 41st street drains directly into the lake.

10841 Q. What others?

A. The sewer on 43rd street drains directly into the lake. The sewer on 45th street drains directly into the lake. The sewer on 51st street drains into the lake. The sewer on 56th street drains into the lake. The sewer on 71st street did drain into the lake until a short while ago. Whether it does now I can not say. The last time I passed in sight of that pumping station it was apparently abandoned, as the windows were boarded up.

Q. If the sewage from that sewer does not now discharge into the lake where could it discharge?

A. There is a 2 foot sewer passing directly into the lake parallelling the 6 foot sewer which lead from the pumping station, and apparently the only outlet from this sewer would be through this two and one-half foot sewer.

Q. What other sewers south of the Chicago River drain directly into the lake?

A. There is a sewer on 83rd street draining to the pumping station at Mackinaw Avenue, and the sewage is pumped into the lake from that point. That is the most southerly sewer draining directly into the lake.

Q. Will you give the population of the drainage drained
10842 by these respective sewers which you have just named as
discharging their sewage into Lake Michigan?

A. The population sewering into the Lake south of the area tributary to the 35th Street sewer is, approximately, as follows: 6th Ward, 60,216; 7th Ward, 36,844; 8th Ward, 10,000; 33rd Ward, 31,135. Total, 148,195.

Q. Is any arrangement or plan being made by which the sewage from the territory now drained by these sewers into Lake Michigan will be diverted from the lake?

A. An intercepting sewer is nearly completed, extending from 73rd street north to 39th street which will take all of the sewers which have heretofore emptied into the lake between 73rd and 39th. At 39th the accumulated sewage from the intercepting sewer will be pumped into 39th street conduit and flow, west into the south branch of the Chicago River.

10843 Q. How near is that intercepting sewer completed?

A. It will probably be completed within six months from now.

Q. Now, after it is completed, all the sewage of the city of Chicago lying south and east of the Chicago River and the south branch of the Chicago River will be drained directly into either the Chicago River or the canal?

A. Yes sir.

Q. Now, then, Mr. Randolph, will you state whether or not there are sewers north of the Chicago River which discharge directy into Lake Michigan?

A. There are.

Q. Will you please state where those sewers are located?

A. Those sewers begin on the north at the first street north of Diversey Avenue. The next sewer is Belmont Avenue. The next one is on Nevada Street. There is a short one on Addision Street; one on Wavon Avenue; one on Grace Street; one on Irving Boulevard; one on Wilson Avenue; one on 59th Street, North; one on Brin War Avenue; one on the first street south of Greenlake Avenue; one on Grand Avenue.

Q. Now, can you give the population sewered by the sewers that you have just mentioned? I mean the population
10844 of the territory sewered by the sewers you have just mentioned?

A. These sewers are all in the 25th Ward and accommodate about 90 per cent of its population, approximately 49,000.

The answers which I have given are based upon an examination of the ward maps, sewer map and U. S. Census of 1900 covering each ward. An absolute determination can only be made by a house to house canvass to determine the number of people draining into any particular sewer.

Q. All of the sewers north and east of the Chicago River discharge directly into the main river or the north branch?

A. Yes sir. The city is constructing an intercepting sewer from the lake front, extending from Melrose Street on the south to the city limits on the north.

Q. And when that intercepting sewer has been completed it will divert all of the sewage in that part of the city of Chicago lying north of the Chicago River and east of the north branch of the river from Lake Michigan into either the main
10845 river or the north branch?

A. With the exception of two small sewers on Surf Street and on Belmont Avenue.

Q. Is any arrangement being made to divert the sewage from those two streets?

A. Not that I am advised of.

Q. State whether or not it is the intention of the sanitary district to divert all of the sewage that is now being discharged into Lake Michigan from the lake into the river or the drainage canal?

A. The Sanitary District of Chicago has never assumed any jurisdiction over the sewers of the city. They are entirely in the hands of the city authorities. The city has made the arrangements for the intercepting sewers and plans for diverting sewage from the lake into the intercepting sewers. The sanitary district is to operate the pumps or pumping works for ever, which disposes of the sewage which is brought to the pumping works and discharges it in channels provided by the Sanitary District.

Q. So the two corporations together are working to that end?

A. Yes sir.

10846 Q. In giving the amounts of sewage discharges into the river at the present time, and during the past three years as shown in your direct testimony, did you take into consideration the amount of sewage that was discharged into Lake Michigan by means of the sewers which discharged directly into that lake?

A. I do not.

Q. All of the water as used by the people of the city of Chicago, as shown by the records of the water department was used by you in estimating the amount of sewage discharged into and through the drainage canal?

A. No sir, it was not. The per capita of water pumped was used, and the number of inhabitants draining either directly or indirectly into the sanitary canal was multiplied by that per capita to get at the sewage.

Q. Did you use the customary rate of 60 gallons per capita or that which actually existed in the city of Chicago?

A. I presented two tables. In one of these tables the actual pumpage is used and the results based upon that determination are given.

Q. Upon one of these tables you used 60 gallons as the basis and upon the other table what was the number of
10847 gallons used?

A. Upon the other table I used for each year the average consumption per capita for that year, ranging from 190 up to 197 gallons.

Q. What arrangements are now being made to take in the sewage discharges of the Calumet District and the district in north Chicago recently added to or annexed to the Sanitary District of Chicago?

A. Surveys have been made and plans have been perfected under which the sewage of the annexed district will be cared for. On the north it is proposed to build a canal from a point on the north boundary line of Evanston through to a junction with the north branch of the Chicago River at Lawrence Avenue. It is proposed to establish pumping works at the Evanston end of this canal and pump water in the canal sufficient to insure a constant flow.

The authorities of the territory thus drained have in contemplation the reversal of all sewers which now empty into the lake.

10848 Q. And that condition applies not only to Evanston on the north but also to Calumet on the south?

A. The theory is entirely different, but the object is the same.

Q. At the present time the sewage from the Calumet District is drained directly into the lake or into the Calumet River and from thence into the lake?

A. Yes sir, that is true.

Q. The object now is to reverse the channel?

A. To reverse the flow in the same manner as that done in the Chicago River.

Q. Mr. Randolph, state whether or not in your opinion the floats used by you in making your water velocity examination were in any way retarded by the character of the instrument used?

A. No sir, I do not think they were retarded.

Q. What effect had the velocity of the under current over the result of the ascertainment of the surface current as shown by the flow?

A. The floats as constructed were described in my previous testimony, and the hollow cylinder suspended from the surface float was constructed with a view to counteracting wind
10849 effects so that that hollow cylinder would always be feeling the effect of the current to such an extent which the float itself might not feel, if it was opposing the wind. The wind might over come it and I think that the mean result was about what we would have had on the float passing through a still atmosphere. I know it is impossible to get an ideal condition which will give perfect results.

Q. Then why do you take .8 of the actual surface flow in order to get the mean or true velocity?

A. This is unanimously advised by men who have made a business of testing the current of streams. I myself have never made a business of this. It has been an occasional thing with me and from my own actual obervations followed up by enough experiments which convince me in my own mind that it is true, I therefore take what is considered proper practice by men who have made this their business.

Q. Whatever effect the wind might have had upon the surface of the floats themselves would, to a certain degree, be exerted upon the cylinders passing down underneath the surface?

A. Only as transmitted by the string attaching the floats
10850 to the cylinder.

Q. Do you know the directions of the wind during this experiment?

A. I do not.

Q. Do you know whether there was a high wind or a low wind or any wind at all?

A. The wind is noted in the book, but I did not fix it in my mind when I read the report.

Q. I wish you would read from the book what notations were made with reference to the wind, during this experiment?

A. On July 15th a light northeast wind.

5 p. m. of the same day a northeast wind.

On July 17th the floats were not continued during the afternoon on account of severe wind storm.

Q. At what place on the river were these notations made?

A. Right at the Bear Trap Dam on July 15th, and in passing the lower end of Treat's Island at five o'clock that afternoon.

Q. The same afternoon?

A. Yes sir.

Q. Those are the only two places?

A. And when it was discontinued on the afternoon on July 17th on account of the severe wind storm.

Q. Now, when was that? Where was that?

10851 A. That was at Peru Highway Bridge.

Q. And from there on no notations were made?

A. No notations of the wind at all.

Q. Either as to its velocity or its direction?

A. No sir.

Q. Mr. Randolph, how wide approximately and how thick were these floats, or how deep?

A. I think they were about eight inches in diameter and about 2½ inches deep, but we have an exact sketch of them which I can put in.

Q. How far under the surface was this cylinder suspended on the float?

A. I can not answer that question. I was not with the party at any time and I could not say how deep they suspended it.

Q. Was that your instructions to the men who performed the experiment?

A. No sir, I left them uninstructed.

Q. They were to use their own judgment then?

A. Yes sir.

Q. What portion of the river has the most rapid velocity, 10852 with reference to its surface and under currents?

A. In a stream of uniform cross-sections it would be practically the center of such cross-sections, but the streams that I have observed of irregular cross-sections and irregular course you can not lay down any fixed rule as to where the highest velocity would be. I have seen it at times very close in shore and at other times out some distance in the stream. The highest velocity will approach the concave shore in rounding a curve.

Q. But in depth what is the greatest velocity?

A. The greatest velocity is at the surface.

Q. And this calculation of the mean velocity, by taking .8 of the surface velocity, is based upon experiments where only the surface velocity is taken?

A. No, sir, it is not based upon that. It is based upon experiments made partly with floats and partly with current meters, current meters submerged at different depths which will give different resulting velocities.

Q. Without knowing the depth in the water that these cylinders were suspended, how would you know to apply this .8 rule, and what would be the significance in applying it to the observations as found?

10853 A. Why, of course the depth of submergence would bear upon this question of applying the rule. The tables presented by me yesterday were, as stated at the time, prepared by my assistant, Mr. Crane, for me. Mr. Crane paid a great deal of attention to this work during its progress and he visited the work in progress, and had a more intimate knowledge of what went on than I had, as I never went on the work during the time it was in progress.

Q. Did Mr. Crane have it in charge?

A. Yes sir. Mr. Heilborn was the man who was constantly there. Mr. Crane was the man whom I held responsible.

ISHAM RANDOLPH.

10854 LUDWIG HEKTOEN

a witness called on behalf of defendants, being duly sworn, testifies as follows:

Direct Examination

By Mr. Todd:

Q. What is your name?

A. Ludwig Hektoen.

Q. What is your business?

A. Physician and Surgeon.

Q. From what institution are you a graduate?

A. I am a graduate of the College of Physicians and Surgeons, in Chicago.

Q. When did you graduate from that institution?

A. In 1887.

Q. After graduating what did you do?

A. I served as interne in the Cook County Hospital.

Q. For how long?

A. For 18 months. And I served as physician to the Coroner's office of Cook County for three years.

Q. During the time that you served as physician to the Coroner what were your duties?

10855 A. I would make post mortem examinations as required by the Coroner.

Q. How many post mortem examinations did you make during your term as Coroner?

A. I made several hundred, the exact number I do not know.

Q. What were your duties as interne at the Cook County Hospital?

A. Care of the patients in the hospital, passing from one form of service to another at regular intervals.

Q. What wards were you connected with?

A. At that time the services in the hospital were so divided that the interne served for a certain period in all the different wards.

Q. After you ceased your connection with the Coroner's officer, as Coroner's Physician, what did you do?

A. I became connected with Rush Medical College.

Q. How long have you been connected with Rush Medical College?

A. About eight years.

Q. In what capacity are you connected with that institution?

A. As professor of Pathology.

Q. What is the meaning of pathology?

10856 A. Well, pathology is generally defined as the study of disease, more particularly the causes and consequences of disease.

Q. Are you connected with the University of Chicago?

A. I am.

Q. In what capacity?

A. I am professor of Pathology there also.

Q. How long have you been connected with the Chicago University?

A. About four years, between three and four years.

Q. Are you in the general practice of medicine now?

A. No.

Q. To what are you devoting your entire time?

A. My time is devoted to investigation, principally.

Q. In what department?

A. More particularly in connection with the infectious diseases, such as scarlet fever.

Q. How long have you been engaged in that study?

A. During the last two or three years that my work has become limited in this way especially.

Q. Have you made any autopsies in connection with your
10857 work at the County Hospital?

A. I have.

Q. For what purpose?

A. In order to study the changes produced by disease during life.

Q. What class of diseases have you given particular attention to?

A. Well that work in the county hospital will include pretty much all sorts of diseases that are likely to appear in a hospital of that sort.

Q. How extensive has been this work?

A. Well, it has been fairly extensive. The County Hospital is a large hospital and I have been doing a larger share of the post mortems there for many years, about ten or twelve years.

Q. Have you made a special study of the so called germ diseases?

A. Yes sir, I have.

Q. Do these diseases caused by germs come within the scope of your study?

A. They do.

Q. Have you made any study upon typhoid fever and malarial fever from the standpoint of a pathologist and clinician? 10858

A. I have.

Q. Does the subject of pathology include the subject of bacteriology?

A. Yes sir.

Q. Have you given the question of study of bacteriology any consideration?

A. I have.

Q. To what extent, Doctor?

A. Well, to a considerable extent. In the first place I have studied bacteriology considerably, both here and elsewhere, and in the next place our work as pathologists makes it necessary to do bacteriological work all the time.

Q. Have you conducted your studies in any place outside of Chicago?

A. Yes sir, I have studied in Europe.

Q. What places in Europe?

A. In Sweden, and in Prague and in Berlin.

Q. What institutions there?

A. While in Sweden I studied at the University of Upsala. In Berlin I studied in the Hygienic Institute and in Prague in the Pathogical Institute.

10859 Q. How long were you in these different institutions?

A. I remained several months in each place.

Q. Conducting a special study?

A. Partly and partly general studies.

Q. In connection with the studies you have detailed, have you taken up the question of the proper diagnosis of fever of the kinds known as typhoid and malarial?

A. I have.

Q. Have you had any experience in the diagnosis of these fevers, either in the laboratory or at the bedside?

A. I have both.

Q. Have you studied these questions sufficiently to give an expert opinion on them?

A. I think so.

Mr. Jeffries: I object to the question for the reason it is for the court to determine as to the qualifications, as to whether or not he has studied them sufficiently to pass an opinion, and not for the witness.

Q. What is typhoid fever and its clinical diagnosis?

A. Well, typhoid fever is a febrial disease caused by bacillus and characterized by a fairly defined course during
10860 the first part of which the fever gradually rises until it
reaches a certain height at which it remains for a period of a week or two and then gradually declines. There are certain well marked intestinal symptoms, especially dioarhea and frequently also hemorrhage in typhoid fever. The clinical diagnosis of typhoid fever would be based upon the recognition of these symptoms that I have outlined, aided by certain methods of study of the blood and other matters.

In the case of the blood there may be obtained in typhoid fever the so called aggulutination of the typhoid bacillus, and that is used very extensively now as a diagnostic measure. In the early stages of typhoid fever it is possible to cultivate the typhoid bacillus from the blood and that is also becoming used as a means of diagnosis.

Q. What is intermittent fever and its clinical diagnosis?

A. Well, the term intermittent fever, is a rather general term, that indicates the general character of the fever. It means that the fever intermits completely at certain regular intervals, during which the temperature drops to the normal.

Its clinical diagnosis would be determined by regularly taking the temperature of the patient and thus demonstrat-
10861 ing that the fever is intermittent.

Q. What is remittent fever and its clinical diagnosis?

A. Well, in remittent fever which is also a general term the temperature is always above normal, but it falls at certain periods more or less regularly and its diagnosis would be determined by a careful study of the temperature of the patient.

Q. What is typho-malarial fever and its clinical diagnosis?

A. Well, strictly speaking typho-malarial would mean a disease in which there was both typhoid and malarial fever, at the same time, and the diagnosis would be made by demonstrating the presence of the malarial organisms in the blood and the typhoid bacillus in the blood or absolutely indicate that typhoid fever was present at the same time as malarial, but formerly typho-malarial fever was applied to diseases of a more indefinite character, the exact nature of which was not known, the general symptoms of the attack resembling in certain ways malarial fever and in certain ways typhoid fever, and so they called these attacks typho-malarial fever, without knowing whether they were typhoid fever or malarial fever, or both.

Q. Is typho-malarial a common fever in its true type?

10862 A. It is apparently an exceedingly rare disease because, so far as I know, there are only two or three cases recorded in medical literature of typho-malarial fever in which an absolute diagnosis has been made.

Q. What is congestive fever and its clinical diagnosis?

A. Well, I really do not know what congestive fever is. It is a term that has been handed down from the forefathers and it is now very rarely employed, except perhaps in certain parts of the country, more particularly in the south, where it is regarded as a type of the malarial fever but the exact disease meant where the term congestive fever is employed probably varies from time to time, or would probably be different from time to time, and different in one place from another place.

Q. What is simple continued fever?

A. I do not know that there exists any definite disease of that kind. Simple continued fever is another one of those terms that have come down to us and it indicates a rather mild form of fever of some kind, the exact nature not being known.

Q. Are remittent, intermittent, typo-malarial, congestive and simple continued fevers distinct types of disease and

10863 so recognized by pathologists, bacteriologists and clinicians?

A. No, they are not.

Q. What significance do you attach to these terms as applied to fevers when they appear in vital statistics?

A. I think that in a large percentage of the cases they mean typhoid fever.

Q. Assume that the number of deaths reported as occurring from typhoid fever in the city of St. Louis, as evidenced by the annual reports of the Board of Health of the City of St. Louis Health Department is as follows:

	1890	140
	1891	165
	1892	441
	1893	215
	1894	171
	1895	107
	1896	106
	1897	125
	1898	95
	1899	131
	1900	168
	1901	198
10864	1902	222
	1903	288

And assuming further that the number of deaths recorded in the same reports under the heading remittent, intermittent, typho-malarial, congestive and simple continued fevers is as follows:

1890	226
1891	296
1892	326
1893	284
1894	179
1895	155
1896	177
1897	172
1898	134
1899	148
1900	112
1901	80
1902	102
1903	91.

10865 Do the number of deaths reported as occurring from typhoid fever alone in the city of St. Louis properly represent in your opinion the total number of typhoid deaths actually occurring in that city?

A. No.

Q. What reasons have you for saying that they do not?

A. Because of the large number of deaths recorded under the heading of remittent, intermittent, etc.

Q. To what do you attribute the failure of these statistics assumed in the foregoing hypothetical question to properly disclose the number of typhoid fever deaths occurring in the city of St. Louis?

A. For the reason just given in answer to the previous question, namely that the number of deaths attributed to the malarial fevers so called is, in my opinion, excessive and that of course depends upon erroneous diagnosis by the physicians in St. Louis.

Q. Why is it that doctors apply the terms remittent, intermittent, typho-malarial, congestive and simple continued fevers to fevers that are recognized as being typhoid or malaria?

A. Well it is undoubtedly the result of the teaching laid 10866 down from the early periods where these different forms of disease, especially typhoid fever and malarial fever were not distinguished one from the other.

Q. Do you know of any city in the country where the death rate from malarial fever alone is as high as in the city of St. Louis as evidenced by the number of deaths as assumed in the hypothetical question under the heading intermittent, remittent, typho-malarial, congestive and simple continued fevers occurring in the reports of the Board of Health of the city of St. Louis?

Mr. Jeffries: Objected to unless the witness will qualify as being acquainted with the mortality records of the various cities throughout the United States.

A. No, I do not.

Q. Is malarial fever a prominent cause of death in this country?

A. No, it is not.

Q. What proportion of deaths in the column under the heading intermittent, remittent, etc., assumed in the foregoing hypothetical question as occurring in the city of St. Louis as evidenced by the reports of its Board of Health in your opinion should be classed as typhoid?

10867 A. Well, in my opinion it means that between 75 and 90 per cent. of those cases probably ought to be put in the typhoid column.

Q. What proportion as malarial fever?

A. From ten to twenty or twenty-five per cent. Of course this is a general opinion only.

Q. What do the mortality statistics of malaria show in cities where careful attention has been paid to malarial fever, as regards the number of deaths occurring from malarial fever?

Mr. Jeffries: Object to the question for the reason that it does not particularize the cities referred to.

A. They show but very few cases relatively speaking of deaths from malarial fever.

Q. Is it generally recognized by bacteriologists and pathologists and clinicians that classifying typhoid fever in one column, and intermittent, remittent, typho-malarial, congestive and simple continued fever in another column, in the board of health reports of cities, is an improper classification, from a scientific standpoint as affording a true indication of the mortality from typhoid fever and malaria?

10868 A. Yes sir, it is.

Q. Assuming that the reports of the board of health of the city of St. Louis, by the month, from 1895 to 1903, inclusive, under the heading typhoid fever, which for the purpose of convenience is designated "A" in the table and that intermittent, remittent, typho-malarial, congestive and simple continued fever for the sake of convenience is designated as "B" in the table that was prepared and sworn to by Professor Jordan, based upon said reports and is as given by him:

10869 Will you please state what construction you place upon this table as showing the relative mortality from typhoid fever and malarial fever in the city of St. Louis during the periods covered by the foregoing table?

A. Well, the tables appear to show that until the year 1900, when one of these diseases occurred in considerable numbers in a certain month of the year, the other disease occurred to about the same extent at the same time, whereas after 1900 the number of deaths from remittent and intermittent fevers, etc., is on the whole smaller than from typhoid fever.

Q. Assume that the added totals of tables from typhoid fever and the tables from remittent, intermittent, typho-malarial, congestive and simple continued fevers, as they appear in the reports of the board of health of the city of St. Louis is as follows:

	1890	361
	1891	381
	1892	767
	1893	499
	1894	350
	1895	262
	1896	283
	1897	297
	1898	229
10870	1899	279
	1900	280
	1901	278
	1902	324
	1903	379

What do these totals as above indicated represent in your opinion as to the mortality condition of typhoid fever in the city of St. Louis covering the period as above indicated after allowing in said remittent, intermittent, typho-malarial, congestive and simple continued fever column such proportion as being typhoid fever as in your opinion you should allow, what is your opinion as based upon the statistics as assumed in the foregoing hypothetical question as to typhoid death under the remittent, intermittent, etc., tables, in the city of St. Louis as to whether the said statistics show an increase or decrease in the typhoid fever mortality in the city of St. Louis since 1899?

A. The figures do not appear to me to show any increase in typhoid fever mortality.

Q. Assume that two circular letters one issued in the fall of 1900, and another one issued in the fall of 1901, were issued by the Health Commissioner of St. Louis calling the attention

10871 of physicians to the fact that the law required them to report all cases of typhoid and all deaths from typhoid and at the time that that letter was sent out, the question of the opening of the drainage canal was being agitated in the public press at St. Louis and there was a considerable discussion, and an investigation was going on at that time of the analysis of the samples of water collected, etc., and was attracting considerable attention. From your examination of the statistics at St. Louis, as heretofore assumed in the hypothetical question heretofore asked you, for the years 1900, 1901 and 1902, as compared with previous years, does the effect of such a letter, assuming that the same had been sent to the doctors by the health department of St. Louis, manifest itself in those statistics?

A. I think so.

Q. In what way does the effect of such a letter appear from the statistics?

A. It would seem to appear in the prominent increase in the number of deaths from typhoid fever, associated with a corresponding prompt decrease in the number of deaths from remittent, intermittent and other fevers.

Q. From your examination of the typhoid and typho-malarial groups of death as assumed in the foregoing hypo-
10872 thetical question, what is your opinion as to whether these two tables taken separately correctly show the typhoid condition of the city of St. Louis for the period mentioned?

A. In my opinion they do not correctly show the typhoid condition.

Q. Upon what do you base your opinion that they do not correctly show the typhoid conditions in the city of St. Louis taking them separately?

A. For the reason that I believe that a large percentage of the tables include under intermittent, remittent fevers, etc., what really were deaths from typhoid fever.

Q. From your knowledge of classes of fevers mentioned in the two columns of vital statistics as heretofore assumed, how should they be treated by a bacteriologist, a pathologist, clinician and statistician in order to arrive at the true typhoid fever mortality in the city of St. Louis?

A. I think they ought to be consolidated.

10873 Q. In what way should they be consolidated upon what percentage basis?

A. Well, in my opinion I think that the approximate truth could be arrived at by consolidating the two tables and then perhaps substracting ten per cent.

Q. Assuming that the table testified to in evidence by Professor Jordan as compiled from the typhoid fever mortality, the intermittent, remittent, typho-malarial, congestive and simple continued fever mortality, of the health reports of the city of St. Louis and based upon the population of the city of St. Louis for the years 1890 to 1900, according to the United States census reports and the intervening years estimated by Farr's formula, which table was prepared by Professor Jordan and testi-
10874 fied to by him, will you please state what in your opinion, based upon the tables hertofore read and assumed in the hypothetical question as to whether the typhoid fever has increased or decreased in the city of St. Louis since 1900 over the conditions that obtained in St. Louis prior to 1900?

A. Typhoid fever has decreased in the city of St. Louis since 1900.

Q. How did you arrive at that conclusion, Doctor?

A. Why, by studying the figures in the table.

Q. What do they show?

A. Well, they show that up to the year 1895, inclusive, the death rate from typhoid fever appears to be approximately 80 or 90 per cent. whereas after 1896 up to the period 1900 it appears to be between 50 and 55 per cent, that is the death rate appears to be between 50 and 55 per cent., and between 1900 and 1903 the death rate is about the same.

CROSS-EXAMINATION

By Mr. Jeffries:

Q. How long have you been engaged in the practice of medicine and in the work of instructing in colleges?

A. Since 1887.

Q. How many examinations of statistics have you been
10875 called upon to express an opinion as to the relative proportion of deaths from malaria as reported?

A. This is the first one.

Q. What is true with reference to malaria is also true with reference to all of the diseases allied with typhoid fever?

A. Yes sir.

Q. Whether they be remittent, intermittent, typho-malarial, or diseases of that character?

A. Yes sir, this is the first time I have been called upon to express any opinion in regard to questions of that character.

Q. When did you make an examination of the health reports of other cities in the United States so far as these particular diseases which you have testified about are concerned in comparison with the mortality records from those diseases in the city of St. Louis?

A. During the last few days and this morning.

Q. State what mortality records were examined by you?

A. Some of the records pertaining to Chicago, Baltimore and Albany, New York.

10876 Q. Is it not a fact, Doctor, that malaria is more prevalent and more malignant in the warmer climates than in the colder climates?

A. It is.

Q. I understood you to say that about from ten to twenty-five per cent. of the malaria deaths should be transferred to the typhoid deaths in the city of St. Louis?

A. No, that is a misunderstanding.

Q. What did you mean when you used those words?

A. I did not use those words.

Q. What did you mean when you said about from ten to twenty-five per cent. of the malarial deaths so reported were actual typhoid deaths?

A. Will you permit me to explain what I have said, that from 75 to 90 per cent. of the malaria deaths should be transposed, in my opinion, to the typhoid column.

Q. Why do you say that 75 per cent. of the malaria should be removed from the malaria column into the typhoid?

A. I say that in my opinion from 75 to 90 per cent. of the deaths in the malaria column of the St. Louis reports of 10877 health should be removed to the typhoid fever column because it seems to me that represents the actual condition of affairs more accurately.

Q. And that opinion is based upon the examining of health reports of the city of Chicago, Baltimore, Maryland, and Albany, New York?

A. And St. Louis together with such general knowledge of these subjects as I may happen to possess.

Q. And you give that opinion without reference to the source of the disease or the location of the patient?

A. No, those facts are taken into consideration.

Q. To what extent are those facts taken into consideration, Doctor?

A. In so far as on account of the location of St. Louis it occurred to me that it might be reasonable to suppose that the larger number of malignant cases of malarial fever might develop or be imported into St. Louis than into Chicago or Albany.

Q. And if there are importations, in determining the death rate in that city alone, they should not be carried over into the typhoid but should be separated should they not?

10878 A. I have reference to the malarial deaths. I meant that certain cases of malignant malaria might perhaps be imported into St. Louis from farther South, not typhoid.

Q. What percentage did you allow on that?

A. No definite percentage.

Q. You are just guessing at it?

A. Yes sir.

Q. Did you take into consideration the fact that malaria is more malignant and prevalent in the Mississippi River valley than it is at Albany?

A. I did.

Q. And at Baltimore?

A. I did.

Q. And at Chicago?

A. I did.

Q. Did you study the statistics for that proposition?

A. In a general way.

Q. State what you found in making this examination?

A. Well, we found in Albany that the number of deaths reported from malaria decreased very markedly after the establishment of a sand filtration of the water. At the same time there was a noticeable diminution in the number of deaths from

10879 typhoid fever so that it would appear as though sand filtration of the water very materially diminished the death rate from both typhoid fever and malaria. In case of Chicago it was noticeable that in the years of great prevalence of typhoid fever that is to say from 1899 to 1902 the largest number of deaths from intermittent, remittent and other fevers of that general character were reported from 1885 or something like that up to the present time.

Q. You found did you not in Albany, in Baltimore and in Chicago that the intermittent, remittent and the malaria followed in figures to a certain extent the prevalence of the typhoid?

A. It so appeared, yes; whereas in Baltimore, if I may go on and add this to my previous answer the number of deaths from malaria fever as reported, steadily diminished during the last few years.

Q. That is in Baltimore?

A. Yes sir.

Q. Had those fevers diminished in reality or is the decrease simply shown in the report and based upon a better an-
10880 alysis and diagnosis of the case?

A. I think the latter.

Q. And that is true of Chicago and Albany?

A. I could not say as to that.

Q. In making comparisons would you make the same percentage or allowance in a southern city as in a northern or in a city located in territory where malaria was more prevalent than in a city where it was less prevalent?

A. No, I would not.

Q. Have you ever personally examined the condition at St. Louis?

A. I have not.

Q. Have you ever personally made any diagnosis of cases of disease in the city of St. Louis?

A. The only thing I ever did in the city of St. Louis was to make a post mortem.

Q. That was in one particular case?

A. Yes sir.

Q. That was a poison case was it not?

A. I think so.

10881 Q. Do you know whether or not for the years 1897, 1898 and 1899 a similar letter was sent out by the health department as that referred to by Mr. Todd in his question as having been sent out by the Health Department of the City of St. Louis in 1900?

Mr. Todd: I object to the question on the ground that the question that I put was a hypothetical question, assuming what was testified to in this case and the testimony as to whether a similar letter was sent out or not is a matter that is all in the record of this case, in the testimony by Professor Teichmann, and it is not competent as this question put to the witness on cross examination assumes the fact that a letter was sent out.

A. I do not know anything about any such letter.

Mr. Jeffries: In the event that letters of this character were sent out for these years would they have the effect detailed by you in your answer to the question put by Mr. Todd, assuming that a letter of that character had been sent out?

Mr. Todd: I object to the question on the ground that the testimony of Professor Teichmann given in this case states that no such letter was sent out, except the two assumed in 10882 this testimony and it is improper for the counsel to assume in a hypothetical question the sending out of letters when the evidence in the case discloses to the contrary.

A. They might.

Q. And they might not?

A. Yes sir.

Q. And the same is true with reference to the letter referred to by Mr. Todd in his question?

A. Certainly.

Q. Is it not a fact that the physician in charge of each particular case by reason of his ability to observe the symptoms of the disease is better able to determine the nature and character of that disease than a person is who undertakes to diagnose the cases from the statistics?

A. In regard to individual cases, certainly.

Q. And that applies to each and every individual case?

A. Yes, assuming, of course, that the physician uses the modern means of diagnosis exhaustively.

Q. The opinion which you have expressed in your direct testimony upon the actual typhoid conditions in the city 10883 of St. Louis for the last six years are based upon examination of the health report of the four cities just previously mentioned by you, and by making the per cents of them?

A. Yes, and in addition such general knowledge as I have of typhoid and other diseases.

Q. What general knowledge in the main do you refer to?

A. Well, I refer directly to this well known fact, namely, that deaths from malaria fever in temperate climates are exceedingly few and far between and to the further fact that so far as is known the prevalence of fatal malaria in St. Louis and in the vicinity of St. Louis has not been marked for many, many years.

Q. You recognize the fact do you not that people die of malaria fever?

A. I do, yes sir.

Q. But in expressing your opinion upon typho-malaria, intermittent, remittent and other deaths from other diseases in the city of St. Louis, where did you obtain the information or statistics upon which your opinion is based?

A. The statistics which I had are these that have been brought forward here this morning.

Q. You considered only such as that contained in the 10884 question that was put to you calling for your opinion?

A. I interpreted those statistics of course in the light of my general knowledge in regard to those diseases and in the light of what I happened to know about those diseases in other places.

Q. Those statistics that were read to you in the question were the only ones considered?

A. Those were the ones that I was asked to interpret, yes sir.

Q. Now, did you make an examination of the health reports yourself or take for granted such as was given you by the question or shown you by some one else?

A. I did not examine any health reports personally.

Q. Either of St. Louis, Chicago, Baltimore or Albany?

A. No sir.

RE-DIRECT-EXAMINATION

By Mr. Todd:

Q. All the statistics to which you addressed your answers on direct examination were contained in the hypothetical question propounded to you and assumed by you to be true?

A. Yes sir.

Adjourned until 2:00 P. M. same day.

2:00 P. M., Thursday, February 25, 1904.

10885 Continuation pursuant to adjournment.

Present, the Commissioner, and same counsel representing the respective parties.

PROF. E. G. HASTINGS

a witness called on behalf of the defendants, being duly sworn, testified as follows:

Direct Examination

By Mr. Todd:

Q. What is your name?

A. E. G. Hastings.

Q. What is your business?

A. Instructor and investigator in bacteriology.

Q. Where?

A. University of Wisconsin.

Q. How long have you been there?

A. Since July, 1899, with the exception of one year which I was away studying.

Q. Where?

A. In Germany.

Q. At what place in Germany?

A. I studied in Munich.

10886 Q. Where did you graduate before taking up the post graduate course?

A. Ohio State University.

Q. After graduating what did you do?

A. Spent one year in post graduate work in the University of Wisconsin.

Q. And then went abroad?

A. No, I was connected then with the University of Wisconsin for two years and abroad one year. Since then I have been with the University of Wisconsin.

Q. Are you connected in any way with Professor Russell?

A. Yes sir, I am assistant under Prof. Russell.

Q. Did you have anything to do with the experiment conducted with typhoid bacilli by Professor Russel at Averyville?

A. Yes sir.

Q. State what you had to do with this experiment?

A. Why, the inoculations of the tubes which were exposed in the Illinois River at Averyville were made by me and all samples taken by me and the plating of these samples in the nutrient media was made by me and all of these isolations from these plates were made by me.

10887 Q. Was this done under the direction of Professor Russell?

A. Yes sir.

Q. At what point were these tubes placed in the Illinois River?

A. Immediately above the Averyville bridge.

Q. What kind of tubes were these that you employed in this work?

A. They were parchment paper.

Q. By whom prepared?

A. The tubes were prepared by me. The parchment tubing, a portion of it was obtained from Professor Jordan of the University of Chicago, and the rest was obtained from the University of Wisconsin, at Madison.

Q. Just state how these tubes were prepared?

A. The tubing was cut into the desired lengths.

Q. State the length?

A. The tubes were of two sizes, the tubing that we obtained from the University of Wisconsin was about 15 inches in length. The other tubing which we obtained from the University of Chicago was of a greater diameter and the tubes were made shorter, about 10 inches in length. This includes the length of the tube which was to contain the water. The bottom

10888 was folded up and the length would be six inches greater than the dimensions given.

Q. Were the germs that you got from Professsor Jordan ones that have been testified here by Professor Russell and Professor Jordan as strains typhoid "X," "Y" and "Z"?

A. Yes sir, these were the cultures which were sent to me by Professor Jordan and the ones which were inoculated into the tubes and exposed in the river.

Q. Just describe the manner in which this inoculation took place?

A. The typhoid cultures were grown upon media agar for 24 hours and the growth was then removed from these and suspended in water. From this suspension of the organism the tubes were inoculated, each tube containing 200 cc. of the river water and inoculated with varying quantities of suspensions of the typhoid organism.

Q. What quantities of organisms were used in these various tubes, varying between what numbers?

A. Approximately 500 per cc. up to 10,000 per cc.

Q. Now, after the tubes were inoculated, what did you do with them?

A. They were then exposed in the river at the station above named.

10889 Q. How were they exposed?

A. They were placed in the containers in which the tubes were exposed, these were of metal galvanized iron pails.

Q. Describe these containers that you speak of?

A. They were provided with a top of strong wire cloth and also the sides of the pails for about two-thirds of this entire circumference were made up of this wire cloth, to allow the water free access to the tubes. The pails were provided with hasps and pad locks.

Q. What were these containers made of?

A. Galvanized iron.

Q. Just state how they were placed in the water, whether they were completely submerged or not?

A. They were completely submerged.

Q. How many sacs were employed in this experiment, containing typhoid bacillus?

A. 14.

Q. How many sacs were used that did not contain typhoid?

A. There were two control sacs which contained no typhoid There were two sacs that contained a sample of urine which
10890 were sent to me, which at the time that it was sent, they thought contained a large number, but on examination at the University of Chicago contained practically no typhoid.

Q. How were these sacs designated?

A. Well, the pails were marked and the sacs were designated by consecutive numbers from 1 up. There were two containers and each container was marked as I say, and the sacs were designated by the numbers.

Q. They were numbered from 1 to what?

A. 1 to 18.

Q. Now, after the sacs were placed in the water what did you do?

A. The samples were taken from the sacs at intervls.

Q. After the samples were taken from the sacs at intervals what was done with them?

A. The samples were immediately taken to the laboratory and plated out on the medium which was used.

Q. What media did you use?

A. The Drigalski medium entirely.

Q. Now, after plating it out on the media what did you do?

A. The plates were then incubated for 24 hours at 37½
10891 degrees Centigrade.

Q. At the end of 24 hours what did you do?

A. The plates were then removed from the incubator and worked over and the suspicious colonies were marked, and later these colonies were fished off into subcultures and the plates were then incubated at room temperature for 24 hours again and then worked over.

Q. What do you mean by working over?

A. An examination of the plates to pick out the suspicious or typhoid like colonies.

Q. What are the typhoid like colonies that you picked off?

A. Any organic colony which has the appearance of a typhoid colony.

Q. What are the appearances of a typhoid colony?

A. Upon this special media the colonies have a peculiar irridescence, a peculiar granular structure.

Q. Any other marks of identification you employed?

A. The colonies are always blue. They are never surrounded by a red zone. 10892

Q. After these colonies were picked off what did you do with them?

A. They were inoculated in tubes and these tubes immediately sent to Madison, or after an incubation of 24 hours sent to Dr. Russell at Madison.

Q. How was the record kept of these tubes, samples, plates and colonies, and by whom was it kept?

A. The records were kept by me. The tubes were, as I have said, each given a number and upon plating this number was placed upon the label on the plate, and in fishing the colonies from these plates the organism was given a consecutive number, which was followed through each one of the strains, "X," "Y" and "Z."

Q. And after you had done what you have indicated, how did you ship them to Professor Russell?

A. These tube cultures were then shipped to Professor Russell by express. They were packed and shipped to Professor Russell by express.

Q. Did you do anything with the agar blocks?

A. To some extent, yes sir.

Q. At Peoria?

10893 A. Yes sir.

Q. State what you had to do with that part of the experiment?

A. Agar blocks were inoculated with the cultures of the typhoid organisms and were then exposed in small metal containers which were placed in the large metal containers before mentioned and at intervals one of these blocks would be removed and cultures made from it, and the organisms which were isolated were also sent to Madison.

Q. State how these agar blocks were inoculated with the typhoid bacilli?

A. They were simply inoculated with what we call stab culture. A straight platinum wire which contained a growth of the organism on the end was thrust into the agar blocks and they were sealed on top by a nail which was heated so as to melt a small portion of the agar at the place where the stab was made to seal it.

10894 Q. How large were these agar blocks that were employed in this experiment?

A. Oh, they were an inch and a half long and half an inch square, in sections.

Q. After you took samples from the agar block what did you do with them?

A. The cultures were made from these agar blocks and these cultures were sent to Madison for Dr. Russell.

Q. Was any effort made to identify the colonies as typhoid bacilli at the laboratory in Peoria?

A. No sir.

Q. That part of the experiment was conducted at Madison, Wisconsin?

A. Yes sir.

Q. After these sacs were suspended in the water did any formation appear upon the sacs?

A. Yes sir.

Q. Describe the nature and character of that formation?

A. Within two or three days after the sacs were exposed they became dotted with small particles of mud. These gradually increased in size until at the end of about nine or ten
10895 days they would be as large as a half a dollar. At this time some of the sacs broke. This deposit of mud on the sacs was occasioned by the growth of a fungus which gave lodgment for the fine soot which the river water was carrying. This fungus gradually attacked the walls of the tube and weakened it so when the tubes were removed from the water the weight of the contained water was sufficient to break the wall in the weakened places.

Q. How did you ascertain the integrity of the sacs when they were in the water?

A. At the time the sacs were filled and closed they were then tested as to their tightness as to whether they would leak the water.

Q. After a sac disintegrated in the water what did you do with it?

A. After the first of the sacs broke, the remainder were then transferred to fresh sacs.

Q. After they were broken the remainder was transferred?

A. No sir.

10896 Q. Just explain what you mean by that?

A. After the first sac broke this gave evidence that the rest of them would not last very long, so in order to continue the experiment the remainder of the sacks of that series, the water in the remainder of the sacs of that series were transferred to fresh sacs.

Q. And the experiment continued in fresh sacs?

A. In fresh sacs.

Q. Were any of the sacs wherein the water was transferred broken before the transfer?

A. No sir.

Q. And after the transfer of the water from the sacs to the new sacs, did you make an examination of the old sacs to see whether they were intact or not?

A. Yes sir, they were still intact but the walls were very much weakened by the growth of this fungus.

Q. How did you ascertain that that was a fungus?

10897 A. A microscopic examination.

Q. You made an examination of it?

A. Yes sir.

Q. As often as you took samples from each one of those sacs you kept a record of it?

A. Yes sir.

Q. And did you turn over to Professor Russell a correct record of all you did at Peoria under his directions?

A. Yes sir.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. How many sacs did you say you used in the experiment?

A. 18 in all.

Q. During that entire experiment how many sacs were broken on account of deterioration in the water?

A. I could not say.

Q. As many as half a dozen?

A. No sir.

Q. Well, what would you say as to the average?

A. As I recall the first time that any sacs broke was when two of them broke when the container was removed from
10898 the water and the water in the rest of the sacs was then transferred to fresh sacs and the old sacs were destroyed.

Q. Did the control sacs deteriorate more rapidly than the others?

A. No sir.

Q How many days were those sacs in the water before the break was noticed?

A. The first one broke in ten days.

Q. As soon as one sac was broken the contents of all the sacs were changed into new sacs?

A. Yes sir. As I said before we had two samples of tubing, one of which resisted the attack of the fungus longer than the other.

Q. Both samples of tubing were parchment tubing were they?

A. Yes sir.

Q. Any difference in the weight of the parchment?

A. I don't think so; not that I am aware of, any appreciable difference in the weight.

Q. How do you know that one had more resisting power than another?

A. As I say one was a sample of tubing that we obtained
10899 from Madison and broke in nine days while the first one of the sacs was tubing obtained from Chicago which broke in twelve days after they were exposed to the water.

Q. How many days did you carry on the experiment?

A. Cultures "Y" and "X" were continued for seventeen days; "Z" for twelve days.

Q. What was the reason you did not continue the "Z" strain for the full 17 days?

A. The sacs inoculated with the culture "Z" were not put in the water at the same time as the others, but later.

Q. How long did you keep the sacs out of the water when you were transferring the contents from the old to the new?

A. Half an hour.

Q. How long did you keep the sacs out of the water when you were taking the samples of water from them?

A. Fifteen or twenty minutes.

Q. How many samples did you take from each sac?

A. I could not say.

Q. Well, approximately,—you have some idea, have you not?

A. Well, an equal number of samples were not taken from each sac.

Q. On an average how many times was each sac removed from the water?

A. Whenever the container was removed of course the sacs which were exposed in that one container were removed from the water. 10900

Q. Well, how often was the container removed?

A. In the case of "Y" and "X" I should say about ten times and in the case of "Z" it would be about six times.

Q. And those were the only times that it was removed?

A. Yes.

Q. Then in case of "Z," there were only six samples of water taken from the sacs?

A. They were sampled at six different times. More than one sample taken.

Q. How many samples were taken from Strain Z?

A. I should say about 18.

Q. Then there were 3 samples of water taken from strain "Z" each time the container was removed from the river?

A. Yes, approximately.

Q. How much water was contained in each one of those samples?

A. From 7 to 10 cc.

Q. Now, how much of the sample was plated?

A. Varying quantities. At first smaller quantities. Three plates were usually made from each sample. These plates were made with varying quantities. The first series of plates were usually made with 1-20, 1-100 and 1-2000 of the cc. and as the experiment continued the amount of water seeded in each plate was gradually increased as the germ contents of the sac was diminished. 10901

Q. What part of the sample did you use in the plating of the "Z" strain?

A. 1 cc.

Q. And the last plating of the "Z" strain?

A. Yes sir.

Q. Now, was that 1 cc. divided into 3 plates? Or was there 1 cc. on each plate?

A. The largest amount ever used was 1 cc. in the single plate. It was the maximum amount.

Q. And when was that?

A. That was at the end of the experiment.

Q. On strain "Z"?

A. On strain "Z" as well as on strain "X" and "Y."

Q. Why was not 1 cc. of water used in each experiment?

A. Because the germ content of the water was too high; the plates would be so thickly seeded that nothing could be done with them.

Q. Why could not something be done with them?

A. The colonies would be so thick and so small that they could not be seen with the naked eye.

10902 Q. In other words you could not discover them on the plates?

A. Yes, you can see very fine colonies but you can not make subcultures from them.

Q. Does not the character of the plates used by you suppress nearly everything except the typhoid and kindred colonies?

A. I do not know as to that.

Q. Did you at any time make more than three platings from any one sample of water taken from the sac?

A. In a few instances four plates were made.

Q. In what instances were four plates made with reference to the strain and what number if you know?

A. I could not tell as to that.

Q. Why did you make the fourth plate?

A. Sometimes more samples were taken than others. My apparatus was limited and those times in which fewer number of sacs were sampled there were more plates available and more incubator room available for plates.

Q. Do you know of your own knowledge where these strains came from, other than that which you have just stated?

A. No sir.

Q. How long after the sacs were removed from the water and the samples taken from those sacs before the samples of water were plated?

A. From 1 to 2 hours.

10903 Q. In what were the samples of water kept after being removed from the sac and before plating?

A. In glass tubes.

Q. Did you in any instance dilute the samples or the quantities of water plated?

A. Yes sir.

Q. How soon after the samples of water were taken from the sacs was the diluting substance added?

A. From 1 to 2 hours.

Q. The dilution would not be made until just before plating?

A. Just before plating.

Q. Did you examine the interior of the sac to determine whether or not any substance formed upon the wall?

A. Yes sir.

Q. Was there any substance, any formation of any kind upon the wall of the sac upon the interior?

A. Not on the interior, no sir.

Q. How did the interior of the sac compare with the exterior after four or five days submergence in the water?

A. The fungus has begun to grow upon the walls and 10904 these particles of soot begun to find lodgment on the walls of the sac on the exterior while the interior of the sac was still dry.

Q. The water that was in the sac was taken from the river at the point where the sacs were submerged?

A. Yes sir.

Q. Do you know whether that water contained any fungus or any soot of any kind, I mean the water that was contained in the sac?

A. It contained some silt, if the river was slightly turbid at that time.

Q. How did you make those determinations as to the silt contents of the water in the sac?

A. No determinations were made.

Q. You judged that because of the turbidity of the water and because of the silt formation upon the exterior of the sao did you?

A. Yes sir.

Q. You used the same precaution each day in removing samples of water from the sac in the conveyance of those samples to the laboratory and in the laboratory experiments did you not, from one end of the experiment to the other?

A. Yes sir.

10905 Q. How many colonies on an average did you pick off the plates, if you know?

A. I could not say as to that.

Q. Is it not a fact that upon some plates the number picked off was not more than three?

A. Yes sir.

Q. Now, state why only that number was picked?

A. It was largely a matter of chance, as when the plates were worked over suspicious colonies were then fished off and subcultures made.

Q. In making these selections or in picking the colonies off the plate it is a delicate and difficult matter?

A. I do not understand the import of your question.

Q. A delicate and difficult matter in making the selections of those colonies which have the appearance of being typhoid?

A. It is a matter that would require certain experience and judgment, not necessarily delicate.

Q. And often times you are mistaken in your judgment are you not?

A. Yes sir.

Q. And pick off numerous colonies that have the appearance of being typhoid which are not?

10906 A. Yes sir.

Q. And often times great numbers of the same colonies or colonies which have the same appearance as those which have been selected and which in your judgment were characteristic of typhoid colonies remained upon the plates unfished?

A. Yes sir.

Q. About how many colonies would form upon these plates, using 1 cc. in the experiment, at the time 1 cc. experiments were used?

A. From 100 to 200.

Q. At the time .01 of a cc. of water was analyzed how many colonies would appear upon a plate?

A. With these varying quantities of water were used so as to get plates with which it was possible to work.

Q. Then you used varying quantities in every determination, did you?

A. Yes sir.

Q. The first bacterial analysis or plating from the first sample of water that was taken, was made with 1 cc., .1 and .01 of a cc.?

A. No sir, not the first sample.

Q. How was that made?

A. Made with 1-20, 1-100 and 1-2000 of a cc.

10907 Q. Now, how many colonies would appear upon one .002 of a cc.?

A. Well, that would vary, from time to time.

A. Well, approximately, with reference to this experiment, what was the result as shown by the colony counts?

A. At first the samples were taken 24 hours after the sacs were inoculated. The germ content would vary with the different series. I recall they ran about 100 colonies, from 4 to 200 colonies, on each plate.

Q. That is, on the one .002?

A. Yes sir.

Q. And with an increasing number, according to the quantity used?

A. Yes sir.

Q. How large are those plates?

A. They vary in size.

Q. Were not all the plates you used, the same size?

A. Not exactly. The average plate is from 3½ to 4 inches in diameter.

Q. Were any that you used larger than that?

A. Than four inches?

Q. Than four inches square?

10908 A. Four inches in diameter.

Q. That is both ways.

A. The plates are circular.

Q. Are they all circular?

A. Yes sir.

Q. Were those sacs submerged with water all the time except when the samples of water were being taken from them, or whenever the contents were being transferred to fresh sacs?

A. Yes sir.

Q. And were the sacs kept full of water all the time?

A. No sir, they originally contained 200 cc., and as the samples were taken of course the contents diminished by the amount of samples taken.

Q. And that left a vacancy in the sacs?

A. Yes sir.

Q. Was the mouth of the sac tied down, then, so as to keep the contents full and solid, all the time?

A. No sir.

Q. After you removed the sample from the sac, what did you do with the sac?

A. The sac was then closed up, and returned to the container.

Q. Closed in what way, and in reference to the organic contents of the water?

10909 A. They were closed with heavy clamps at the top, and the original length of the sac was maintained, I mean, the portion which was emptied, so as not to shorten it up by that much.

Q. Then it left a portion of the interior of the sac vacant?

A. Yes sir.

Q. Is that true?

A. Yes sir.

Q. How large, at the latter end of the experiment was the space on the sac that was vacant?

A. It would vary, to the amount of water that was removed from under one sac.

Q. Taking the measurement of the stick into consideration, how would the vacant part compare with the part that was filled with water?

A. I should say it would be about half of the water in some of the sacs, or about one-third of the water, in some of the sacs, was removed in the samples taken.

Q. Now, was the clamp in the sac pushed down to the water?

A. No sir.

Q. Were those sacs suspended in the water?

A. Yes sir.

Q. In what way?

A. They were simply suspended from wires which ran
10910 across the top of the metal containers, by clamps, with
which they were closed at the top.

Q. Were they in a position that they could swing in the water, or were they kept stationary?

A. They could swing to a limited extent.

Q. How much?

A. As far as the metal container would allow them to do so.

Q. Well, how much would that container allow them to swing?

A. The containers, I believe, were 13 inches in diameter.

Q. And all those sacs were put into containers?

A. Yes sir.

Q. Well, did the containers swing, or were they stationary?

A. It was somewhat suspended in the air.

Q. Suspended from above?

A. Yes sir.

Q. And how deep in the water was the container?

A. So that the sacks were from 6 inches to a foot beneath the surface of the water.

Q. Well, you don't know whether it remained stationary or not, after it was suspended from the water?

A. There was probably some motion, according to the motion of the water.

10911 Q. What did you put these colonies in, when you fished
them off the plates?

A. In plain nutrient agar, or glucose agar.

Q. Where was that prepared?

A. Madison.

Q. And sent to you?

A. Yes sir.

Q. Or did you take it down there with you?

A. It was sent to me.

Q. What temperature was it kept at, after the colonies were fished and deposited on it?

A. As I said before, some of them were immediately sent to Madison after they were inoculated, and others were inoculated for 24 hours at 37½ degrees before sending them to Madison.

Q. How long was it from the time you picked the colonies off, before they were deposited in this media?

A. A fraction of a minute.

Q. Just as rapidly as it could be done?

A. Certainly.

Q. How long did you keep them there before you started the contents on to Madison?

A. As I say, some of them were inoculated for 24 hours before being shipped, others were started the same day as the inoculations were made. 10912

Q. Were they duplicates?

A. Those were kept there.

Q. Were those duplicates of those that were shipped?

A. No sir.

Q. Some of them you inoculated for 24 hours, and some you did not?

A. Yes sir.

Q. Now then can you state which ones were incubated by you, and which were not?

A. No sir.

Q. Have you any means of telling?

A. No sir.

Q. Did you notify Prof. Russell which had been incubated and which had not?

A. Yes sir.

Q. At the time of the incubation?

A. Yes sir, the time was always 24 hours.

Q. Were those that were incubated sent to him along at the same time as those that were not?

A. No sir.

Q. All different times?

A. Different times.

10913 Q. Now did that rule hold good throughout the entire experiment?

A. Yes sir.

Q. For instance, you were picking colonies from three plates representing a certain sample of water taken upon a certain day. Now, would all those be incubated?

A. They would all be incubated or not.

Q. Do you know how many samples you incubated, or how many plates you incubated?

A. No sir.

Q. Or do you know the number of times that the colonies picked from the plates were incubated?

A. No sir.

Q. Do you know the proportion of the total that were incubated?

A. No sir.

Q. Do you know the proportion of those that were not incubated?

A. No sir.

Q. At the time samples of water from the sac were plated upon from one to three plates, the colonies fished off by you were sent to Professor Russell, without incubation?

A. More than one plate was always made, two at least, never less than two.

Q. The plates representing that particular sample of 10914 water taken from the sac, was picked, or fished off the the typhoid colonies, and those colonies as fished were sent to Dr. Russell without incubation?

A. Yes sir.

Q. How did you send them?

A. By express.

RE-DIRECT EXAMINATION, by Mr. Todd.

Q. Did you send with these colonies, any memorandum to Prof. Russell, showing whether they had been incubated or not?

A. Yes sir.

Q. How did you keep that memorandum of samples that were incubated and those that were not incubated?

A. I simply advised him by letter as to whether the samples had been incubated or not.

Q. Did you keep any memorandum in the laboratory of the samples that had been incubated, and those that were not incubated?

A. Not any data as to that particular point, no sir.

Q. When you communicated with him by letter, how 10915 did you designate the samples that had been from those that had not been incubated?

A. Well, all of the shipment on any one day would either have been incubated, or would not have been incubated.

Q. How was that fact made known to Prof. Russell?

A. I would make a shipment on a certain day and advise him by letter that samples which I had shipped with certain consecutive numbers had been incubated. Each subculture was given a consecutive number.

Q. You haven't those letters with you, have you?

A. No sir.

Q. So that Prof. Russell was advised at each shipment of the samples, those that were incubated, and those that were not?

A. Yes, I say each shipment was either, or rather had been incubated, or had not been incubated.

RE-CROSS-EXAMINATION, by Mr. Jeffries.

Q. In your opinion what proportion of the colonies fished, were incubated by you before shipment to Professor Russell?

A. I should say about one-third.

Q. Were incubated?

A. Were incubated before shipment.

10916 Q. And two-thirds were not incubated?

A. Two-thirds were not.

(Signature Waived.) F. S. B., Com'r.

ELIHU B. SPENCER,

called as a witness in behalf of the defendants, being first duly sworn by the Commissioner, was examined in chief by Mr. Todd, and testified as follows:

Q. What is your name?

A. Elihu B. Spencer.

Q. What is your business?

A. Photographer.

Q. How long have you been in that business?

A. About thirty-five years, I guess.

Q. Are you employed by the Sanitary District?

A. I am.

Q. How long have you been employed by the Sanitary District?

A. A little over three years.

Q. Have you taken any pictures of views on the Illinois 10917 River, from La Salle to St. Louis?

MR. JEFFRIES: I object to it as immaterial.

A. I have.

MR. TODD: Q. When did you make the first set of photographs along the Illinois River?

A. In July, 1902.

Q. Have you prepared an album showing the places where you took the pictures?

A. I have.

Q. Will you produce that album?

A. This one, this series was taken in July, 1902.

Q. At what points were those pictures taken?

A. They are designated on each picture.

Q. Are those pictures true representations and photographs of the places they purport to represent?

A. They are, that section which shows in the picture.

Q. At the time these pictures were taken, what were the stages of the Illinois river high, or low?

A. High.

MR. TODD: I offer this album, containing 39 views, from the Eads Bridge of St. Louis, to Henry, along the Illinois River, and ask to have it marked Defendant's Spencer's Exhibit A.

10918 MR. JEFFRIES. I object to it as incompetent, irrelevant and immaterial.

Said exhibit, received in evidence, and so marked by the Commissioner.

10919 MR. TODD: Q. Did you make any other views?

A. I did, in April, 1903.

Q. What were the stages of the river in April, 1903, when you made these views?

A. High water.

Q. Are those true and correct representations of the places photographed?

A. They are.

Q. Between Hardin, on the Illinois River, and Henry on the Illinois river?

A. They are.

MR. TODD: I offer this album, consisting of 46 photographs, and ask to have it marked Defendant's Spencer's Exhibit B.

MR. JEFFRIES: I object to the offer for the same reason as stated in the objection to the introduction of the preceding album, as incompetent, irrelevant and immaterial.

Said exhibit received in evidence and so marked by the Commissioner.

10920 MR. TODD: Q. Did you make any other views?

A. I did, in July, 1903.

A. At the time in July, 1903, when the photographs were taken, what was the stage of the Illinois river?

A. Lower water.

Q. Are those photographs, 52 in number, in this album, true and correct representations of the places they purport to represent?

A. They are.

MR. TODD: I introduce in evidence this album taken in July, 1903, of photographs along the Mississippi River, from St. Louis to Henry, and ask to have it marked, Defendant's Spencer's Exhibit C.

MR. JEFFRIES: I object to it as incompetent, irrelevant and immaterial.

Exhibit received in evidence and so marked by the Commissioner.

No Cross-examination.

Signature waived.

F. S. B., Com'r.

Adjourned until 10 a. m., February 26, 1904.

10921 10:00 a. m., Friday, February 26, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same consel representing the respective parties.

PROF. ERASTOS G. SMITH,

a witness called on behalf of defendants, being duly sworn, testified as follows:

DIRECT EXAMINATION, by Mr. Todd.

Q. What is your name?

A. Erastos G. Smith.

Q. What is your business?

A. I am now Professor of Chemistry at Beloit College, Beloit, Wisconsin.

Q. How long have you been connected there, Professor?

A. Since 1881.

Q. From what college did you graduate?

A. Graduated from Amherst College in 1877 with the degree of A. B.

Q. After graduating, what did you do?

A. I studied medicine for a year under the private tutilage of Dr. A. F. Reed of Massachusetts.

10922 Q. Then where?

A. I was then called as instructor in chemistry in Williston Seminary, East Hampton, Mass.

Q. How long were you there?

A. Three years.

Q. And from there where did you go?

A. From there I was called to the professorship of chemistry and mineralogy at Beloit College.

Q. And have been there ever since?

A. Yes, sir, except for an absence of about eighteen months when I was in Europe studying at the Georgia Augusta University in Germany, where I took my degree of Doctor of Philosophy in August, 1883.

Q. What line of studies did you pursue in Europe?

A. Chemistry and mineralogy.

Q. Have you been connected with any institutions except those which you have already outlined?

A. I took a course in bacteriology one summer at the Massachusetts Institute of Technology in Boston.

Q. Have you pursued the study of bacteriology since
10923 taking the course at the Boston Institute of Technology?

A. I have.

Q. Where?

A. Not under direction—I studied it at home. I have a laboratory of my own, a private laboratory known as Beloit Sanitary Laboratory, where studies of this kind are carried out. It is particularly devoted to studies of this character.

Q. Have you taught bacteriology?

A. I have not.

Q. What experience have you had in sanitary work?

A. I have given practically all of my available time since about 1885 to the study of sanitary problems, especially water courses.

Q. What water courses have you investigated?

A. In the course of my study and investigations I have been called to the study of many public water supplies, including the study of supplies from the ground or ground wells or artesian wells, rivers and lakes and impounded reservoirs. These would naturally include the lakes and rivers and streams tributary thereto.

I have also done considerable work upon the Platte river, the Missouri river, the Mississippi river, the Schuylkil river, the Delaware river, Beaver river, Pennsylvania, and other smaller streams.

10924 Q. Relate briefly what work you did on these different streams you have investigated?

A. The work done upon these streams has been the observation of the sanitary qualities of the water and its adaptability for drinking and domestic purposes and its suitability for water supply. These embraced both chemical and bacterial work, the bacteriological work having been done the last six or seven years; before that most all, practically all of it, was chemical work.

Q. Have you made a special study of sanitary problems?

A. I have devoted about all of my available time since about 1885 to this class of problems.

Q. Have you investigated any typhoid fever epidemics?

A. I have.

Q. Which ones?

A. I have investigated the typhoid fever epidemics at Baraboo, Wisconsin, Ashland, Wisconsin, West Superior, Wisconsin, Menominee, Michigan, and Rock Island, Illinois, and have frequently been called in where typhoid fever was alleged to be present.

Q. Will you relate the cases and the results of the
10925 investigations of the epidemics which you have made?

A. Two of these were, in my opinion, directly attributable to the character of the water supply, namely the one at Baraboo and the one at Rock Island. In the others the water supply, in my opinion, was not so directly responsible for the outbreak.

In the one at Baraboo, which occurred in 1902, the outbreak was due, in my opinion, clearly to fault in the water serivce. There were some cases of typhoid fever present in the town, and that lead to an investigation of the water supply. Dr. Russell of Madison was called there by the Board of Health, and the Baraboo Water Company asked me to come there and investigate the problem for them. We found that there had been a considerable number of cases in the town and we were at first at a loss to account for their cause. Finally it was agreed upon, by Dr. Russell and myself that we would tabulate results and see what results could be obtained. Upon tabulating these returns of typhoid fever cases we found that they fell into two groups, that upon successive periods there seemed to be an increase in
the number of cases. This lead to inquiry upon our part
10926 and we found that, allowing for the ordinary period of
incubation of the disease, (about 13 to 17 days) upon tracing back from the crest of the wave of the extent of the disease, we found that at a period about two weeks before a steam pump had been started as an auxilliary to the water supply, and we came to the conclusion that the starting of the steam pump had produced an extraordinary draft upon the mains which tended to open some joints in the pipes which lay under the canal, which in turn received the sewage from the city ofBaraboo. It was shown upon further experiments that this was the case, and that lead to the removal of that pipe and its being

replaced by a pipe that was intact, after which the epidemic died down. In my opinion that epidemic was due to the defective conditions of the water pipe over which the canal water flowed, which in turn received the sewage from the city of Baraboo.

I would say that I was upon the ground a part of the time and the details of the work were carried out by my assistant, in consultation with me.

The case at Rock Island was, in my judgment, due to the condition of the water supply. In 1901, I think the last of February, I received a letter from one of my former students, a Mr. Albee, who was at that time instructor in Chemistry 10927 at Rock Island, calling my attention to the prevalence of typhoid fever there. and that they wished some examinations made of the supply. He brought over some samples to my laboratory, and I found that the water was infected or was not suitable for use, being, in my judgment, a water polluted with sewage. This lead to my going down to Rock Island and as the result of a conference held by myself with Dr. Craig, who was the Health Officer for the city, and the Mayor, it was decided to institute a series of experiments to determine whether the supply were really polluted.

At that time there was a filter system installed which was inefficient and unsatisfactory and at the time I was there they were pumping raw Mississippi river water into the mains. Upon investigation I found that the intake from the public supply of the city of Rock Island extended out from a second well, not the main pumping well, but a smaller second well, into the channel of the Mississippi river under the so-called "slough," formerly a branch of the river which divided around Rock Island; at present it is not in the true current of the river, but forms a tail race for the water power at Moline. This slough receives the sewage from Moline and also a considerable portion of that from Rock Island.

10928 I found upon investigation that one of the main sewers from the city of Rock Island, which comes down, I think it is 21st street, empties a few hundred feet, about 400, above the intake pipe, and the sewage from that sewer therefore would naturally pass down over the pipe. It, therefore, seemed to me reasonable that if there were leaks in this intake pipe, or if there were leaks in the rip rap wall which formed the abutment about the well, that this sewage would find its way from the sewer directly into the mains. A series of experiments were inaugurated, taking advantage of the chlorine content of the water, by which we endeavored to see whether that rip rap wall on the intake pipe itself was intact. The experiment consisted in putting in a considerable quantity of salt, along the rip rap wall, distributing it along by the workmen; knowing the chlorine content of the water, both of the slough and of the natural river water, we could, by taking analysis afterwards show whether there would be an increase in the amount of chlorine. The result of this experiment showed that the salt having been added to the water at about 3 in the afternoon, in the course of about two hours the amount of chlorine as salt in the water increased. It increased until evening and did not come back to the normal until late the following morning. This lead 10929 to an investigation of the well and upon the water in the well being lowered it was found that there was abundant leakage from the river through the wall into the well. In the report which was made to me it stated that there were as many as 200 small leaks.

It seemed to me very clear that this sewer was directly responsible for that epidemic and it was certainly true that the sewage from this sewer found its way into the supply. It is of more importance in this connection because upon that sewer was located a hospital which at that time was crowded with typhoid fever patients. I understood there were so many that there were not sufficient rooms and they were placed upon cots along the hall.

Further, in the course of investigation, we made a study of the bacterial content. There was abundant evidence of the colon forms in the water and to the best of my understanding of the problem I believe we isolated a germ of the genuine typhoid bacillus from there, from the water supply. The study of the form, however, was not carried out as far as since then, I wish it had been, but in the best of my own judgment and of my assistant, I believe that that was a typhoid bacillus. We did not apply the Widal reaction to it for we did not have any typhoid fever patients in Beloit. It responded to all the characteristic

10930 typhoid group except that one. We did not have the material to apply any further investigations, and hence they were stopped. I was informed by Dr. Craig, the Health Officer of Rock Island—that at this time about five per cent. of the school children of the town were down with typhoid fever. Those are the essential details, as I recall them after three years.

In the other cases to which I referred, there was typhoid fever in the towns and I had to do with the study of the supply, but I would not lay it wholly to the supply. As for West Superior there was a large use of well water and superficial wells so the problem there is very much more difficult to definitely fix. There might be some question about it.

I could take up Menominee only in a general way. The supply at Menominee, which is right across the river from Marienette, is taken from Green Bay by an intake pipe extending out 2,000 feet. A short distance away (about ¾ of a mile) there is the outlet of a sewer which contains or receives a considerable portion of the sewage of the city. That water varies in quality and while you would expect true normal Green Bay water, that is, essentially Lake Michigan water, it varies at times,
10931 owing to the probable drift of the sewage, owing to the currents generated by the winds, etc. Typhoid fever is undoubtedly partly brought in by lumbermen from the pineries, but I think the water supply there contributes somewhat to it, although I have never found in the supply evidence of a large amount of sewage. I have acted for years as consulting chemsit of that company and from the samples analyzed we have occasionally found colon forms. Sometimes the fermenting forms are found.

There was an outbreak of typhoid fever in Ashland, I think two years ago, and I was called there by the city to investigate that problem for them. I found that the filters which were installed some years before, a system of slow sand filtration, had been improperly operated. The sand had not been renewed for some time and it had thinned down in the process of cleaning. The filters were cleaned in November and the water was very cold, and immediately following this cleaning the waters were unsatisfactory; that is, sewage from the bay undoubtedly found its way in through these filters, and I attributed the conditions then, on the outbreak of typhoid, to that condition of the filters.

After the new sand had been put in—at my order or
10932 suggestion, and the sand increased up to its proper thickness, about 36 inches, after allowing a proper time of the "seeding of the bed," as we say, the bacterial content of the waters came down so that from that time to this, and I have made monthly examinations of that water for the last two years, I have never found a sewage form in the water, until last week from other causes. The typhoid fever epidemic died down and since that time there has been no typhoid in Ashland attributable to the water supply. They have some cases, but they are brought in. The Health Officer informs me there has been none since then.

I was called to Ashland before the filter plant was installed and at that time there were about 400 cases, and I was asked to investigate the condition of the supply. At that time they were pumping raw water into the mains. I was called there when they were pumping raw unfiltered bay water, and there was a serious typhoid epidemic, I think about 400 cases, at that time in the city. At my recommendation the company was asked to change the supply and abandoned the bay supply and adopted a system of artesian wells. This supply was found, upon testing, to be inadequate in quantity, and that lead to the installation of
10933 a system of filters, the slow sand system, and up to this outbreak, which was in 1902, typhoid fever was practically stamped out of the city and only reappeared when the filters had been improperly operated; that is, the sand bed had been thinned down by repeated cleanings, so that at points it was not over eighteen inches in thickness, and if I recall rightly at one point near one of the pillars it was down as low as 12 inches.

In this condition the bed was cleaned in November, in the cold weather; the water was then put through, and immediately after, alowing for the proper period for incubation of the disease, the epidemic of typhoid fever broke out. At my order, that sand bed, after the investigations of the conditions, was thickened back to 36 inches, and filled with properly prepared sand, and since that time, I am informed by the Health Officers, there has been no typhoid fever in the city.

As a matter of fact there was another condition of the bed which was related to me by a friend, an engineer, who went there at the time, and he went down in the well before I went there

and he found that the bed had become clogged, so that the filtration was not sufficiently rapid; on looking down on the
10934 filter bed he observed ridges as though the man operating the bed had been down, and with a rake had broken up this crust, and by so doing let the waters through. That was a thoroughly inefficient operation of the plant. He thus broke the "schmutzdecke," the protection coating, up. He broke that up, because the process of filtration had become clogged so that the water could not get through. That is as I was informed, soon afterwards by one of my friends. Certainly the filter bed had been thinned down to where the filter was imperfect; that was determined by means of bacteriological analysis made by ourselves in the laboratory at home.

Q. Have you had anything to do with the processes of filtration in your sanitary work?

A. In the prosecution of my sanitary work I have had a great deal to do with different systems of filtraton. In fact, I have done work upon filter systems of one sort or another at Davenport, to which water company I have acted as consulting chemist for ten or twelve years, with the filter plant at Rock Island, with the filter plant at Ashland, at Independence, Kansas; at Burlington, Kansas; at Cedar Rapids, Iowa; at
10935 Beaver Falls, Pennsylvania; at Warren, Ohio; at Brooklyn, N. Y.; Binghampton, N. Y.; Denver, Colorado; Kankakee, Ill., Eau Claire, Wis.; Oshkosh, Wisconsin; West Superior, Wis.; Burlington, Iowa.

Q. Describe briefly what connection you had with this filter business?

A. I have been acting under the name of "consulting chemist" to either the company operating the plant or the city.

Q. What were your duties?

A. My duties were to look after the quality of the water, the conditions of the filters and determine the efficiency of filtration, meaning by that the satisfactory character or otherwise, in which they were doing their work.

Q. Are you acquainted with the different kind of filters?

A. I think I have worked practically with every make of the so-called mechanical filters which are made in this country. I have also done work upon the so-called English system. I have once been abroad for the purpose of investigating foreign systems of filtration. I have also been called upon three or four times to recommend types, and in consulting capacity regarding the form of filter to be introduced.

Q. Mention those places?

10936 A. I have been consulted upon the system of filtration introduced at Burlington, Iowa; the system at New Brighton, Pa.; at Ashland. The whole matter of filtration at Menomenee has been up under advisement. The readjustment of the plant at Cedar Rapids. Working over the plant at Oshkosh, Wisconsin, where they had an alarming outbreak of typhoid fever a few years ago. I also made a report upon the proposition of establishing a filter plant for the city of Minneapolis, Minnesota, and elsewhere.

Q. What filter systems in Europe did you investigate?

A. The systems of filtration at London, Paris, Antwerp, Berlin and Hamburg.

Q. What are the characters of those European filters in a general way?

A. The so-called sand filters. They are essentially large basins, excavated, rendered water tight by cement construction, and then filled with the sand to an appropriate depth; this sand being suitably prepared and screened, the whole being supplied with a system of underdrains for receiving the purified water and the necessary apparatus for supplying the raw water.

Q. Briefly, what are the characteristics of filters employed in the places that you have detailed? 10937

A. The system of slow sand filtration is in use at Ashland; at other places the American system is in use which consists in adding a chemical to the raw waters as supplied to the bed; by so doing getting greater speed of filtration, and with efficiency if properly conducted, which is strictly comparable with the best results.

Q. What chemicals?

A. Generally alum or sulphate of alumina; more recently iron in some form, with the addition of lime to assist it.

Q. Are you acquainted with the literature bearing upon the typhoid fever epidemics of this country?

A. I have studied it carefully I think.

Q. Are you acquainted, from the literature, with the epidemics at Plymouth and Lowell?

A. I have read of them several times.

Q. Are you acquainted with any epidemics other than typhoid fever?

A. I have never made any studies of any other epidemics. I have read of them in a general way, but have had no personal study of them.

10938 Q. Have you made a special study of water analysis?

A. I have devoted practically all of my available time to that since 1885.

Q. What branch of sanitary science have you given special attention to?

A. The study of water supplies, their purification when necessary and the adaptability to public use.

Q. Have you had any experience in the interpretation of chemical and bacterial analysis of water?

A. That study includes especially the study of the interpretation of the analyses and their significance from a sanitary standpoint.

Q. In your work as a sanitarian have you done any work in the chemical and bacterial analysis of water?

A. Yes, sir; I have installed at Beloit a private laboratory which is given up practically wholly to the study, and is known as the Beloit Sanitary Laboratory, and I have kept an assistant for some years, working all the time practically upon problems of this kind; in the course of this work we have made about ten thousand analyses of waters. Under my direction another laboratory was established in 1896 or 1897, at Denver, Colorado, where we made in three years about six thousand an-
10939 alyses. These were mostly bacteriological analyses.

Q. Have you examined and studied the chemical and bacterial analysis of the water of Lake Michigan, the Drainage Canal, the Desplaines, the Illinois, the Mississippi and Missouri rivers, as made by Professors Jordan, Gehrmann, Palmer and Burrill, the same being published in what is known as Reports of Streams Examinations, published by the sanitary district of Chicago?

A. I have read them carefully.

Q. Are you acquainted with the Chicago river, the Drainage Canal, the Desplaines, the Illinois and the Mississippi rivers from Grafton to St. Louis?

A. Yes, sir; I know the Chicago river, the Drainage Canal, the Desplaines, the Illinois, the Mississippi from Grafton to St. Louis.

Q. What opportunities have you had for becoming acquainted with the water course from Chicago to St. Louis?

A. Among others was a trip made down the river from the mouth of the Chicago river, in Chicago, during the month of September last, in company with some other gentlemen. The excursion started at the Graham & Morton Docks at Chicago, thence down the Chicago river, out through the canal, 10940 and as far as the bear trap dam, when we went around the river at that point, it not being navigable. From Lockport to Joliet we went on the electric cars, thence on steam car, by the Rock Island road, to Peru, where a boat was taken and then by boat to the mouth of the Illinois river, and thence on the Mississippi river down as far as the Eads bridge at St. Louis.

Q. Was this trip made in the day time?

A. It was made wholly in the day time, that is on successive days.

Q. Have you made a special study of bacteriology?

A. As indicated in my qualification.

Q. What are bacteria?

A. Bacteria are low forms of life, microscopic in character, being one of the lowest forms of vegetable life.

Q. How are they classified and distinguished?

A. There are different systems of classification. I generally think of them as being either saprophytic or parasitic or classified either as pathogenic or non-pathogenic.

Q. How are they distributed?

A. They are distributed widely in nature, being in the soil and in the air, in waters and in animals, and vegetables.

10941 Q. What are the characteristics of bacteria peculiar to water?

A. It is rather a difficult question to answer, but as we ordinarily think of water bacteria they grow generally in a nutrient or gelatine media, quite luxuriantly, at ordinary room temperature, developing colonies that tend to liquefy the gelatine and are not very easily differentiated. Water bacteria are not inclined to grow at elevated temperature or the temperature of the body. We rarely find very many water bacteria growing at the temperature of the living body, 37 degrees centigrade. They have a tendency to grow at about 20 degrees or thereabout.

Q. Please distinguish between the so-called saprophytic and parasitic?

A. The saprophytic are those that live on dead matter; the parasitic those that live upon living matter.

Q. Distinguish between the pathogenic and non-pathogenic?

A. Pathogenic bacteria, I understand, are those which may produce harmful and even fatal effects upon human beings; non-pathogenic those which do not.

Q. What are the known pathogenic bacteria to man?

A. I can not give all, but some of the common ones are those characteristic of typhoid fever, scarlet fever and cholera, of tetanus or lockjaw, and erysipelas. Those are among
10942 the more common ones.

Q. What kind of pathogenic bacteria have you given particular attention to?

A. Especially the typhoid form.

Q. What pathogenic bacteria are water borne, taken that way into the human body by means of drinking water?

A. The two to which most attention has been given are the typhoid germ and the bacillus of cholera. Those are the two important ones. There are others which may produce diarrhoeal diseases.

Q. What is the bacillus prodigiosus?

A. It is a form of organism which is not commonly known as we do not think of it as being widely distributed in nature. It has certain characteristic properties and growth. It does occasionally occur. It was found originally in the south of France, and is especially noteworthy for the peculiar appearance it represents in the growth upon gelatine medium in ordinary temperatures.

Q. Is it found in river waters?

10943 A. I understand it has been occasionally found in river
waters. There are cases where it has been found in the river waters. Franklin speaks of finding it, and he mentions another case where it has been found.

Q. Have you found it?

A. I am not sure whether I have or not. I found a form at Menominee which suggested it. It was very closely allied to it. There was no attempt made to differentiate it and determine whether it was or not.

Q. Are you acquainted with the experiments made with the bacillus prodigiosus by Dr. Ravold?

A. I have read of it.

Q. Assume that 107 barrels of 40 gallons each of culture of bacillus prodigiosus, consisting of one thousand million bacillus to a cubic centimeter as contained in said barrels, was deposited in the Chicago Drainage canal at the town of Lemont on the afternoon and evening of the 6th day of November, 1901, during the period from four to eight hours.

10944 Assume further that immediately after the said barrels were emptied into the drainage canal the laboratories established, at Lockport, Joliet, Peoria, Grafton on the Illinois river and the intake tower of the St. Louis waterworks, chain of rocks, were notified, and that samples were collected at each of these places every hour of the day and night for the purpose of bacteriological analysis, for the ascertainment of this bacillus prodigiosus, and,

Assuming that at Lockport these hourly samples taken day and night were taken from November 7th to November 25th, a period of 18 days, the total number of samples taken being 432;

Assuming that at Joliet these hourly samples taken day and night were taken from November 7th to November 25th, a period of 18 days the total of said samples being 432;

Assume that at Peoria these hourly samples taken day and night from November 8th to November 30, a period of 22 days, amounted to a total of 528;

Assume that at Grafton these hourly samples were taken day and night from November 12th to December 15th, a period of 33 days, the total number amounting to 792, of which 384 were analyzed by Dr. Ravold;

10945 Assume that the total number of samples taken hourly day and night at the chain of rocks was 720;

Assume that at the laboratory tap these hourly samples taken day and night from November 20th until March 1st, 1902, a period of 100 days, amounted to a total of 2400;

Assume that the total number of samples analyzed at the different points above mentioned was 5304;

Assume, further, that on December 4th at 8:45 a. m., 1 bacterium prodigiosus was found at the intake tower, chain of rocks;

Assume that on December 5th at 9:00 a. m. 1 bacillus prodigiosus was found at the intake tower, chain of rocks;

Assume that on December 8th at midnight 1 bacillus prodigiosus was found at the intake tower, chain of rocks;

Assume that on December 6th at 8:00 a. m., at Grafton, 1 bacillus prodigiosus was found,

And assume, further, that these five organisms were all the organisms of prodigiosus that were found in the examinations made from Lockport to the intake tower at the chain of rocks and the laboratory tap in the City of St. Louis, which were made during the progress of this investigation as hereinbefore set forth; and at no time was there more than 1 single
10946 bacterium found at each of these places.

Assuming all of the facts as hereinbefore stated to be true, what is your opinion as to the value of this experiment as indicating the probable longevity of the typhoid bacillus as measured by the longevity of the bacillus prodigiosus, and the probability that a typhoid bacillus entering the drainage canal from the sewers of Chicago will ultimately find its way through the Desplaines and the Illinois river, surviving the journey down the Illinois and Mississippi rivers to the intake tower at the chain of rocks at the City of St. Louis?

A. Why, in my opinion that does not possess value as touching the probable longevity of the typhoid bacillus. The longevity of the bacillus prodigiosus is not necessarily a measure of the longevity of the typhoid bacillus, and it does not contribute to the probability that a typhoid bacillus, entering the drainage canal, etc., would find its way through. But on the contrary, it seems to be an improbability that it would.

10947 Q. What reasons have you for that opinion?

A. Well, in the first place the bacillus prodigiosus is known to flourish under ordinary temperature, given the proper food stuff, and I do not know of any evidence contributory to the knowledge that the typhoid fever organism flourishes and develops in water.

As to the probability that a typhoid bacillus would pass down the canal it seems to me that the experiment first of all does not show that these bacilli were those which were placed in the water, as we have evidence that they are occasionally found, or forms resembling them are found, in our natural waters. Further, upon studying the question it seems to me that if the bacillus prodigiosus had remained in the water for any length of time they would have found them far up the river, but as I understand the results they were not found above Grafton. If they should persist in constantly diminishing numbers it seems to me reasonable to assume that if these organism
10948 were those which actually found their way down the river they would have found them in increasing numbers in the samples taken above; but they did not find them until they reached Grafton, although as I understand from this question numbers of samples were taken, e. g., as 432 samples taken at Joliet. But there is no record they were found there.

Q. Assuming the conditions of this question, they are not found up stream only in 5 cases at the lower part of the course, what importance do you attach to the experiment as assumed in the hypothetical question?

A. Well, as they are operative in that way, it seems to me to be a contribution to the study of the self-purification of that stream. It is an evidence for the stream being rid from them rather than anything else.

Q. Have you made any special study of the typhoid germ in connection with your sanitary work?

A. Yes, sir; I have made such a special study of that organism.

Q. Where are typhoid germs found?

A. Typhoid germs are normally found in the intestinal tract of man and distributed through the body of those suffering with typhoid fever, especially in the spleen, and at other
10949 points in the body as at the abdomen, localized there. They are found in the feces and in the urine discharged from patients suffering from typhoid fever.

Q. What germs do they resemble?

A. The typhoid germ especially resembles the colon bacillus which is the normal and constant inhabitant of the intestinal tract.

Q. What methods can be employed for determining and identifying the typhoid bacillus?

A. It would be a very difficult thing to determine the presence by the methods which have been usually employed for the detection of typhoid bacillus in water. There have been some methods developed very recently, these require special media which I have never used. The typhoid bacillus is very difficult to determine in an unknown water. If I were asked to determine the presence of them I should make the cultures on agar at elevated temperatures and then transfer these growths to other media as the growth on gelatine, the growth in
10950 lactus broth and then apply the so-called Widal reaction for the detection of it.

Q. What significance is attached to the presence of the colon bacillus when found in water?

A. The presence of the colon bacillus in water is very significant, because the colon bacillus is the constant inhabitant of the intestinal tract of man and most of the domestic animals. Now, it is not present, certainly in any numbers, in a natural unpolluted water.

I believe there is a question whether some of the fish do not excrete them in very small numbers, and therefore we do occasionally find the colon bacillus in an unpolluted water. As the colon bacillus is the normal inhabitant of man, if we find the colon bacillus in any amount or quantity or number in a water, it is a presumptive test that fecal matter as such finds its way in that water.

Q. Is a colon test one that is used by sanitarians largely in ascertaining the quality of water?

A. It is one of the most important tests used in the determination of the sanitary quality of a water supply.

Q. What is the probable longevity of typhoid bacillus in the human body?

10951 A. It is present in the body in large numbers at the time of disease and will remain for some months, six months or so, at least, after a person has recovered from typhoid fever. It will then be found in the urine and in the discharges from such persons.

Q. Have you any knowledge of its longevity in soil?

A. Only by reading, not by direct experimentation. Such readings show that certain germs have been found in soil after months, sometimes as high as six months.

Q. What is the longevity of typhoid bacillus in water?

A. That has been the result of a good deal of experimentation, and different observers have set different periods of duration of life of the typhoid bacillus, in water. Mr. Frankland, in his Micro-organisms in Water records a case where it was observed after 100 days in sterilized natural water and this may be taken as the maximum which I have seen recorded in any experiments.

Q. How in unsterilized water?

A. It would tend to diminsh in numbers and disappear after
a few days, some records putting it as six or seven days,
10952 and some as high as 26 days, which is the highest I have
seen recorded, but that would depend upon the quality
of the water used.

Q. Does the typhoid bacillus multiply and increase in nature?

A. No, I understand it does not.

Q. Are conditions of the laboratory experiments more or less favorable than conditions in nature for the longevity of the typhoid bacillus?

A. They are rather more favorable for the longevity than those we meet with in nature.

Q. For what reasons, Professor?

A. I believe one of the reasons given for that is that the glass itself seems to affect the water. Then there are other conditions, the uniformity of temperature, the fact that they are under exactly the same conditions all the time, being different from those than an organism would meet with in a running stream. The change of temperature and change of conditions, owing to change of temperature and the type of water that it comes in contact with, the other micro-organisms which they
meet in the running stream they would not meet with
10953 when they are by themselves in the jar in the laboratory.

Q. Will the germ of typhoid fever live as long in polluted water as in pure sterilized water?

A. Experiments shows they will not live as long in polluted water as in sterilized water. In fact the longest period of life which we have observed in the case of the typhoid bacillus in experimental work is where they have taken natural water and sterilized it.

Q. How do you account for this?

A. The organism in a polluted water is subject to certain enemies. It is subject to the toxins thrown off by the other forms and to the concentration of the toxins and to the varying conditions of the stream. If an organism be placed in polluted water, it will be subject especially to the destructive action of the type of the other organisms more than it is in a natural drinking water.

Q. Are you familiar with the experiment that was conducted by Professors Jordan and Zeit and Russell upon the longevity of the typhoid in Lake Michigan, Chicago River, 10954 the Drainage Canal and the Illinois River?

A. I have read the experiments, especially as conducted by Professor Jordan; also the others, but his more minutely.

Q. Were you present at the time that this experiment was first suggested?

A. I think I suggested it myself first, at the time of the conference. I am quite sure that I first suggested carrying it out and insisted upon it being done as a very important factor to determine the duration in life and the conditions met with in life.

Q. That was on the trip down the river?

A. I think it was brought up the second day after we passed Peoria.

Q. From your knowledge of the quality of the water in the drainage canal, the Desplaines and the Illinois River, and from your knowledge of the experiment that was made or carried out and the results of the experiment, what is your opinion as to the longevity of the typhoid bacillus in those waters?

10955 A. From such a study as I have been able to make of the quality of the waters in the canal and the Desplaines and the Illinois Rivers, and from the study, especially of the work of Prof. Jordan, it is my opinion that the viability or duration of life of the typhoid bacillus must be brief, surviving but two or three days, so far as those experiments show, not extending beyond that. It was recorded in the experiment, that isolated cases were found as late as the ninth day, but out of some

1100 tests, if I recall just right, by Professor Jordan, in only three of those was he able to note the presence of them. All of them were on a single plate, and the same day. It seems that that experiment would tend to show that the duration of life of the typhoid bacillus in the Illinois River must be brief, not more than three days, or so.

Q. How do you account for your assumption that the life of the typhoid in the water of the Illinois River is shorter than as compared with laboratory experiments?

A. I believe it to be largely due to the toxic effect of other organisms upon them. What contributes largely to their disappearance is that their enemies produce these results
10956 by the elimination of these toxins. I believe that to be the prime factor in that experiment.

Q. Are you acquainted with the physical conditions of the drainage canal, the Desplaines River and the Illinois River and the Mississippi River from Chicago to St. Louis?

A. Yes sir, I have been over the ground and have made a study of the surroundings such as could be observed from making this excursion alluded to.

Q. You are acquainted with the dams that are found in the Illinois River?

A. Yes sir, as they were seen that trip.

Q. What effect in your opinion do these dams have upon the problem of sedimentation?

A. These dams are five in number in the river, and they would naturally increase the amount of sedimentation of the river because the dam would check the flow of the water and in the checking of the flow suspended matters would tend to be precipitated. The waters are brought to a more quiescent
10957 condition and as a result matters in suspension go down.

Q. How is sedimentation, in your opinion, in the Illinois River affected by high and low stages of water?

A. Well, a high water always tends to increase the amount of sediment contained in water, but in the Illinois River we meet with physical surroundings which tend to compensate for this increasing of sediment so that in the high water of the river you will have a heavy sedimentation from overflowing and carrying the water out over the low lands.

Q. Will bacteria respond to the law of gravity in pure water of a running stream?

A. Yes sir, they will respond to the law of gravity in the pure water of a running stream, but slowly. The tendency of the bacteria is downward, even in a running stream, but with moderate speed. Of course if you should take a water like that in the South Platte, which I had occasion to study very carefully, there is no sedimentation. The Platte River dashes down the mountain from the South Park, and it is rushed over
10958 those rocks and there is nothing like sedimentation in
that stream. There is no opportunity given for sediment to settle so that we find these bacterial forms down the stream in that river. The sedimentation does not begin until you strike the low lands at the foot of the mountains. This is an extreme case, but if you should have a quiet running stream moving along slowly, you will observe some sedimentation of bacteria and if the water became quiet the bacteria will gradually settle to the bottom in a short time. You may have all grades of deposit between those two experiments so that in my opinion, in a stream running slowly there would be some deposit even in a clear water.

Q. When there is sediment or matters in suspension in a running stream does that assist sedimentation of bacteria?

A. Greatly.

Q. In what way?

A. The bacteria tend to fasten upon these particles of suspended matter and they being much heavier gravity than the water are carried down with the sediment. The sed-
10959 imentation of waters when brought to a quiet condition
differs with different streams. Now, bacteria put into settling basins at Omaha, for instance, are deposited from the water if it be brought to a quiet. You may have an action of silt itself upon the bacteria which, in my judgment, will be not alone, as fastening on of the bacteria, but there will be an action like that of alum in cases of sedimentation, so that a sediment has a tendency to fix or as we say precipitate and carry down these matters. I believe that to be true in our western streams as I have studied them, and if therefore a stream should carry a silt of a hydrous character you will have a direct action of the silt upon the bacteria suspended in the waters. Thus you have

all these elements at work in the case of a sediment in a stream assisting in that purification and tending to throw the bacteria down.

Q. Could a sufficient amount of water from Lake Michigan be carried through the drainage canal into the Desplaines and Illinois rivers, so as to create a condition of clearness in the combined waters of Lake Michigan and the Illinois River so as to preclude the opportunity of sedimentation in the Illinois River, assuming that the maximum amount that could be 10960 carried through the drainage canal was 800,000 cubic feet per minute?

A. In my opinion that amount of water passing into the drainage canal could not produce a condition of clearness to preclude the possibility of the opportunity of sedimentation.

Q. From the Illinois River as you had occasion to observe it, what is your opinion whether if such an amount of water should be carried into the river there would have been a large amount of matter in suspension in the waters of the Illinois River below LaSalle?

A. In my opinion there would be a considerable amount of sediment yet remaining in the waters.

Q. Assuming that the entire sewage from the city of Chicago should be diverted into the drainage canal and that 800,000 cubic feet of water per minute from Lake Michigan should pass over the Bear Trap Dam would that amount of dilution be sufficient after it reached the Illinois River, mingled with the sewage of Chicago to so separate the matter in suspension in the Desplaines and Illinois Rivers as to prevent the opportunity of sedimentation of bacteria?

A. For the reasons given before it is my opinion it would not.

Adjourned until 2 P. M. same day.

10961 2:00 P. M., Friday, February 26, 1904. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

PROF. E. G. SMITH,

resumed the stand for further direct examination by Mr. Todd and testified as follows:

Q. What sanitary significance does dilution have in considering the problem of self purification of streams?

A. The dilution of a water with the water of a better quality is one of the well recognized factors in the problem of self purification of streams.

Q. Manifesting itself in what way, Professor?

A. Manifesting itself in the dilution of a water with the water of a superior quality. It manifests itself in separating objectionable micro organisms and thus diminishing the liability of the same being taken into animal economy.

Q. Is the danger of infection really diminished by dilution?

A. A sewage laden water diluted with the water of a better
10962 quality is thereby rendered less liable to communicate
disease by infection.

Q. Is it a fact that the greater the dilution of sewage the less the danger from infection?

A. It is generally accepted by sanitarians that the dilution of sewage diminishes the danger from infection, the greater the dilution the more the micro organisms are separated and the less the liability of the same being taken in by man.

Q. What effect in your opinion does the dilution of the Chicago sewage with the purer water of Lake Michigan have upon the conditions of the water in the Illinois River?

A. In my opinion the addition of the purer water from Lake Michigan to the sewage improves the quality, that is diminishes the danger from the sewage in that the micro organisms are more separated from each other and also because it gives the river greater area for facilitating the sedimentation of solid matters suspended in the same.

Q. Is the addition of Lake Michigan water to the sewage of Chicago a detriment or a benefit to the sanitary condition
of the Illinois River considered from the standpoint of
10963 dilution alone?

A. It decidedly improves the sanitary condition of the Illinois River, simply on the ground of that dilution for the reasons given that it separates the organisms and thus one receiving the water becomes less liable to infection.

Q. Is the addition of Lake Michigan water to the sewage of Chicago a detriment or a benefit to the sanitary condition of the Illinois River considered from the standpoint of a chemical and bacterial change taking place?

A. In my opinion Lake Michigan water added to the sewage of Chicago is decidedly beneficial to the sanitary condition of the river from the standpoint of the chemical and bacterial changes taking place because so far as the chemical changes are concerned, and the bacterial changes also, there will be an elimination owing to the processes of sedimentation of material carried by the water and therefore the quality of the water would be improved.

Q. If a sufficient volume of Lake Michigan water would be added to the sewage of Chicago as to cause the elevation of the water in the Desplaines and Illinois River what effect would this increased volume of water have upon the question of sedimentation in the Illinois River?

10964 A. It seems to me evident that the raising of the Illinois River level would make an increased volume of the river which would widen the sedimentation area and that this sedimentation of the river would be decidedly increased by this rise of level, and thus the total sedimentation of the river would be greatly increased; and further, this raising of the level would also increase the total volume carried by the river so that relatively there would be a smaller quantity of the sediment in any given volume of the river. Thus, it works both ways, hastening the processes of sedimentation.

Q. How does the physical condition of the Illinois River compare with the other rivers of the country for the purpose of purification and sedimentation?

A. It is my opinion that the physical conditions of the Illinois River are such as to be well adapted to sedimentation as compared with other rivers with which I am acquainted.

In support of this it seems to me that the low shelving banks of the river are such that a slight increase in

10965 the volume of the river and thus a raising of the water above its level tends to broaden out the depositing area for the sediment. For instance, as compared with the Platte River in Colorado which I have studied very carefully, there is no opportunity for sedimentation at all owing to the precipitous sides of the stream. The main bed of the river rushes down between sides practically vertical and rocky, with no opportunity for spreading out and sedimentation. Now, that is far from the conditions in the Illinois River. Here you have the low shelving banks and the sedimentation area of the river therefore is increased.

Along the Mississippi River as I have studied it and had opportunity to see it and study the sanitary quality of its waters in my judgment you do not meet with the same conditions you have here owing to the high bluffs running right down to the river, preventing any spreading out of this river as would obtain if there were low banks bordering its sides and therefore its sedimentation area can not be greatly increased. Now, as compared with the Rock River in Wisconsin with which I am also familiar; there the banks are not low and do not
10966 admit of this sedimentation. There the banks are more precipitous and the river does not have that tendency to widen out. Take many of the rivers up through Wisconsin, for instance the Menominee River does not have these low banks but it tends to be held within its banks and thus dilution would not materially increase the area of deposition for sediment.

The general principle, it seems to me, is that the low lands along either side of the river are quite marked on the Illinois river as compared with others that I have followed along. Cedar River in Iowa would be another that has not this characteristic.

Q. From your knowledge of the physical conditions that obtain along the Illinois River as well as your knowledge based upon the study of the results of the analysis as they appear in Streams Examinations on the water both chemical and bacterial of the Illinois River, what effect, if any, does the sewage from Chicago discharged into the drainage canal have upon the waters of the Mississippi as the same passes along the shore of the State of Missouri?

10967 A. In my opinion all the conditions affect the quality of the Illinois River. Its physical surroundings; the study of the chemical analyses, the comparison of the bacterial analyses; the death rate of the typhoid bacillus; the rate of flow of the river, the Illinois River as discharged into the waters of the Mississippi does not affect its quality as it passes along the State of Missouri, in fact the data probably indicate that the

Mississippi River is not of as good quality as the Illinois River itself in its lower reaches.

Q. What is your opinion as to whether any pollution dangerous to public health entering the drainage canal from the sewers of Chicago reaches as far down the Illinois River as the town of Grafton?

A. In my opinion it seems to me quite clear that there is no pollution dangerous to public health from the drainage canal which received the outfall from the sewers of Chicago which reaches down the Illinois River as far as Grafton.

Q. What evidence have you that will justify the conclusion just expressed?

A. There are several factors in connection with the river and the study of the agencies at work in the self purification of the stream in my opinion would justify that statement.
10968 We have the agencies of dilution of the sewage whereby the sedimentation of the river is augmented for the reasons previously outlined.

We have the experimental work showing the short life probably not exceeding three days of the typhoid bacillus in the waters of the river.

We have the rate of flow of the river showing that the time required for substances to pass from the drainage canal at Chicago to Grafton considerably exceeded the life period of these organisms as revealed by the special experiments upon the typhoid bacillus of this particular river.

We have further the study of the river from a chemical standpoint which shows the purification of the river from that standpoint and we have also the data from the bacteriological investigations all a matter of evidence which show that the waters have purified themselves from the bacterial standpoint. That is, the waters of the Illinois River at Grafton appear from the chemical and bacteriological standpoints as evidenced by these data to be of the quality of other rivers of this sec-
10969 tion.

To sum up these conclusions, in my opinion, the several agencies at work make the Illinois River at Grafton about a normal river water in this section.

Q. When you referred to chemical and bacterial data from what source did you get that data?

A. I understand wherever that word is used, from the chemical and bacterial data, it is from this report of the Streams Examination. It is understood that my conclusions must be based upon these data as I have not done experimental work myself.

Q. What is your opinion as to whether any infectious matters coming from the sewers of Chicago by way of the Drainage Canal, in a dangerous state, reach as far down the Illinois River as Grafton?

A. It is my opinion that infectious matters coming from the sewers of Chicago by way of the drainage canal do not reach as far down the River as Grafton for the reasons I have outlined in my answer previously given.

Q. Would the condition of low water in the Missouri River at a time when there was high water in the Illinois River be in any way a factor in carrying infected and polluted matters from the sewers of Chicago to the city of St. Louis?

A. It is my opinion that it would not enter in as a factor
10970 because in my opinion the waters of the Illinois River
have become purified through the process of self purification and removed the infected and polluted matters and therefore the condition of the Missouri River does not enter into the discussion.

Q. Professor Sedgwick, in answer to this question on page 3545 of the record: "Professor, will you state whether or not it is within the bounds of human possibility for any competent expert to say that in the period of low water on the Missouri River, such as is likely to occur at next Christmas time, a thaw on the Illinois River shed, might not endanger the lives of the people using the water of the Mississippi shore and at the city of St. Louis by sending to them in that water the suspended sewage of the sanitary district of Chicago?" answered "I do not believe that it is, because in my opinion no competent expert either can or will say that any means exist at present by which such purified sewage can be warded off from the people on the Missouri shore and the citizens of St. Louis under these conditions." I will ask you to state what is your knowledge in regard to the assumption that low water might exist

in the Missouri at a time of flood water in the Illinois and
10971 also state whether you know of any means existing in the
Illinois River that would permit unpurified sewage from the city of Chicago to become a danger and a menace to the public health of the citizens of Missouri and the citizens of St. Louis?

Mr. Jeffries: I now move to strike out that part of the question which refers to Professor Sedgwick and what Professor Sedgwick said in answer thereto for the reason that it constitutes no part of the question intended to be propounded to this witness and is incompetent, irrelevant and immaterial.

A. I will answer the first part of that question by saying for reasons given that low water in the Missouri River would not affect the Illinois River and in answering the second part of it would say that I know of no means at present which would permit of this sewage passing. From my point of view the sewage is purified. The agencies of the river tending towards self purification have been at work and have transformed that sewage into harmless forms, so that the impure sewage from the
city of Chicago can not become a danger and a menace to
10972 the public health of the citizens of Missouri and the cit-
izens of St. Louis.

Q. Professor from your knowledge of all the conditions that obtain along the Illinois River as well as your knowledge of the conditions that obtain in Chicago and the drainage canal, also your knowledge of the water supply at St. Louis such as is had from the intake tower at the chain of rocks what effect does the sewage from Chicago have upon the water supply of the city of St. Louis or upon the waters of the Mississippi River as it passes along the state of Missouri?

A. For the reasons given above, the agencies which are at work in the Illinois River tending to the self purification of the stream and the removal of sewage material as such from the river it is my opinion that the sewage from Chicago does not affect the water supply of the city of St. Louis or the waters of the Mississippi River as they pass along the state of Missouri.

Q. What in your opinion would be the fate of a typhoid bacillus passing from the sewers of Chicago into the Chicago River and thence into the drainage canal and down the Desplaines and Illinois Rivers.

10973 A. From the experiments all a matter of evidence it is my opinion that the typhoid bacilli passing from the sewers of Chicago into the Chicago River, thence into the drainage canal are destroyed in a short period, not exceeding more than 3 or 4 days after passage into the Desplaines and Illinois Rivers.

Q. From a scientific standpoint what value do you attach to the experiment made by Professor Jordan and others as showing the longevity of the typhoid bacillus in polluted waters?

A. From a scientific standpoint the experiment of Professor Jordan has great value. It seems to show very clearly that the Illinois River being a polluted water, the typhoid bacillus will not exist in that water for more than three or four days. And this being a polluted water it has a direct bearing upon the general proposition that the typhoid bacilli are short lived in a water thus polluted.

Q. Does the experiment shed any light upon the longevity of a typhoid bacillus in the sediment of polluted streams?

A. It sheds light upon the longevity of a bacillus in the sediment of polluted streams inferentially. The experiment as I understand it did not embrace the actual persistence and
10974 presence of that organism in the sediment itself, but in my opinion it is reasonable to assume that the sediment of the steam would be subjected to essentially the same agency as the water itself, and it is my opinion that the sediment of a stream polluted would not retain the bacilli for a period measurably longer than the polluted water itself.

Q. Is there any such thing as purification of soil?

A. I do not understand that question fully, but as I interpret that question soil tends to have organic material removed from it. The processes of nitrification of soil tend to remove the organic materials and bacteria contained in the soil.

Q. Why is it that the typhoid bacillus will not live as long in polluted water as in pure distilled water?

A. In pure distilled water the toxic effect of other bacteria would be entirely removed. In the case of polluted water the toxins from organisms inimical to the typhoid bacillus would be operative, and to that principal I attribute the short duration of life of a typhoid bacillus in a polluted water, shorter than in pure water.

Q. What is your opinion as to whether the typhoid bacillus
will live longer in the sediment of a polluted stream than
10975 it would in the water of the same stream?

A. In my opinion it would tend to live longer in the sediment than it would in the water itself for the reason that the conditions of change are not so much in the case of the sediment as it is in the case of the water itself. That is a matter of opinion, however.

Q. How much longer would it live in the sediment?

A. We have no evidence bearing upon that.

Q. In your opinion?

A. Well, it would be difficult to fix an exact datum, but of course a bacterium being deposited in the sediment of a stream would have the same agencies at work as the water itself, but probably to a lessor degree so that the absence of these destructive agencies would tend to prolong the life of an organism which went into the sediment of a stream. It would not be my opinion that the organism would live for any great period longer in the sediment than in the water above it.

Q. Will you differentiate between the conditions that obtain in the moist soil and in the sediment of a running stream?

A. Well, in a moist solid the organism is fixed, and new conditions are surrounding the organism. It is open to the air. It is subject to a thin superficial layer near the air. The air percolates through the soil. That condition does not obtain in the sediment of a stream. It is true that the sewage of the stream is the cause of the sediment, and it therefore follows that
whatever toxins of the water have access to the organ-
10976 isms in the sediment of the stream so that the conditions
are entirely separate, one being fixed and the other having the toxic effect of the excretions from other organisms, finding free access to them, and more than that it would be subject to variations in temperature. It might at least.

Q. Does the time that a typhoid bacillus will live in moist soil furnish any criterion for its longevity in the sediment of a running stream?

A. In my judgment conditions are so different that what is true of one should not be applied to the other.

Q. Are the two conditions comparable?

A. In my judgment or opinion they are not comparable.

Q. Would the fact that a typhoid bacillus lives several months in the moist soil justify the assumption that it would live for the same length of time in the sediment of a river?

A. For the reasons I have already stated it is my opinion
that the assumption that it would live for the same length
10977 of time in the sediment of a river as it would in moist
soil is untenable ground.

Q. Mr. Fuller, in his testimony on page 4219 of my transcript of record, in answer to the question: "Is not the length of time a typhoid bacillus will live in a sediment of a stream more a matter of assumption than a matter of demonstrated proof," said "I consider that it is a very clean cut demonstrated fact that typhoid fever germs may and do and have continued to live in the sediment of running waters." "Q. For what length of time? A. I should say for a month or more, possibly in cases for years. Q. Who has demonstrated that it has ever lived a year? A. I think that the conditions existing in a moist soil in many rural places of this country where typhoid fever prevailed from time to time is proof that typhoid fever germs in the presence of moisture can live for such a time. If that were not so then there would be an elimination of the typhoid fever absolutely through the rural districts of this and other countries." I want to ask you, Professor, whether you know of any demonstration that shows that typhoid fever germs may and do and have continued to live in the sediment of running streams for the period of a year?

A. In reply to that question I would say that I do not
10978 know of any demonstration of typhoid fever germs hav-
ing lived for a period of one year in the sediment of a
running stream.

Q. What is your own opinion as to whether a typhoid fever germ will live in the sediment of a running stream for a period of a year?

A. In my opinion the typhoid fever germ would not remain in the sediment of a running stream for that length of time. The agencies of removal would be at work on the destruction of the germ for the reasons stated.

Q. What is your opinion based upon all the knowledge that you possess as to whether the typhoid bacilli coming from the sewers of Chicago and entering the drainage canal could survive the journey from Chicago to St. Louis, a distance of 357 miles, and be a danger and a menace to the people of St. Louis using the water of the Mississippi for drinking and domestic purposes?

A. It is my opinion from all the knowledge that I possess from a study of the analytical data and the conditions surrounding the river that typhoid bacilli coming from the sewage of Chicago and entering the drainage canal could not traverse that distance and survive. This being true, they could 10979 not possibly be a danger and a menace to the inhabitants of the State of Missouri using the waters of the Mississippi for drinking and domestic purposes.

Q. Are the settling basins, or do the settling basins of St. Louis afford any protection to the citizens of St. Louis against infectious matters in the waters of the Mississippi at the intake tower?

A. The use of settling basins for a muddy stream is a well recognized method of treating muddy water, and these are merely an example of that type of construction for the protection of waters and from the experiments which I have made elsewhere on similar construction I am clearly of the opinion that the system does afford some protection to the citizens of St. Louis from polluted matters which may be in the waters of the Mississippi river at the intake tower.

Q. Are the settling basins any protection to the citizens of St. Louis against the sewage of Chicago?

A. The sewage of Chicago, in my judgment, being eliminated from the stream owing to the processes of self-purification before the Illinois river reaches Grafton, the matter 10980 of the settling basins at St. Louis does not enter into the problem of the purification or non-purification of the sewage of Chicago, it not reaching that point as undecomposed sewage.

Q. Where a settling basin holds a sufficient amount of water to supply a city for thirty days and as the water is taken out for domestic use raw water is immediately supplied from an open river and typhoid fever should prevail among the people using said water, what is your opinion as to whether such a condition justifies the assumption that because the basin holds a supply for a period of thirty days that a typhoid bacillus will live in that water for such a period?

A. The fact that a settling basin holds a sufficient amount of water to supply for a period of thirty days, with a constant inflow and outflow of the water as this question supposes, is no evidence that the typhoid bacillus will survive thirty days. It is a well known fact in the study of purification of waters by means of sedimentation that the water must be rendered perfectly quiescent. It must not receive inflow waters in order that the maximum amount of purification may take place.
Now, that being true it can not be assumed that the
10981 period of life of this organism is thirty days, simply because the basin holds that amount.

Q. What is the significance of the term epidemiology?

A. The term epidemiology means primarily the study of epidemics and the factors entering into that cover a wide range in sanitary science, including the proof of prevalence of disease, its distribution, causes leading thereto, the sanitary conditions surrounding the inhabitants of the city, the nature of the food supply, the causes of pollution to which it is subjected, the methods of guarding against pollution of the food supply and the removal of waste products from a community. It embraces a wide study of those as being prominent among the topics discussed.

Q. Have you examined the typhoid statistics of the Illinois, the Missouri and the Mississippi watersheds above St. Louis as compiled in the table I hand you, made up from the certificates of the board of health of the different cities lying on the three watersheds?

A. I have examined such table and studied it carefully.

Q. Does epidemiology in its scope embrace the proper
10982 study and interpretation of the mortality statistics of a given city?

A. The mortality statistics is one of the important factors in the study of epidemiology.

Q. In the matter of the interpretation of the statistics what method do you employ?

A. I have always used in the study of such mortality statistics the number per thousand or the number per hundred thousand.

Q. Why have you taken that method?

A. It forms an accurate, a specific method of determining the rate for any particular city and can be compared with those from any other city.

Q. How does the method that you have employed differ from what is known as the mortality percentage basis?

A. I have not acutally used the percentage mortality basis but have followed the usage of most sanitarians in using numbers, and it seems to give, upon the whole, more accurate results; the mortality percentage basis might be misleading in its conclusion because, for example, you may have a city of 100,000 people and one year there might be 500 deaths, year after
10983 year from typhoid fever, but the deaths in one year
from all causes might greatly exceed those of any other year, for all causes, so that upon the percentage basis you would have a shifting result, whereas if you used the number per 1,000, you would have a constant result and thus make the results which would be strictly comparable.

Q. Is the mortality percentage method regarded as the most accurate among sanitarians and students of vital statistics?

A. I have always used the other method. I cannot answer that question. The other method is the one I have most always seen used, and used myself, believing it to be the most accurate, and gives the most comparable results.

Q. What are the liabilities of pollution and infection of the river coming from the rural districts, the rural population?

A. The liability of pollution and infection of the river from the rural population is very decided. The relation of the rural population is one of the important questions to be considered always in making up our studies of the epidemics of typhoid fever in any given locality.

Q. Is infection from the rural population as common
10984 as from the urban, in causing epidemics?

A. It is a very common cause of epidemics, often epidemics of some of our largest cities have been traced to causes outside of the city, in the rural districts.

Q. Do you know of any important typhoid epidemics in which the infection has come from the rural population?

A. I can think of two or three such epidemics. That historical case of Plymouth, Pennsylvania, is a case in hand, and the very recent one at Butler, Pennsylvania, is another case in hand, the epidemic at Ithaca, New York, was another case in hand. The causes of the typhoid fever in these were chargeable to the rural population. One case I considered historical, whether you would call it an outbreak or not, at Middletown, Conn., students eating oysters from the oyster beds that had received sewage. The oysters were taken and distributed, and students eating such raw oysters came down with typhoid fever. I don't know whether that would be a case in hand or not. Then, in my own experience, I am sure that the conditions of the prevalence of typhoid, in Denver, is due to the conditions
10985 outside of the city, either up the Platte river, or up the
Bear creek canon. As an example of actual experience in studying out the conditions of the water supply at Denver, and source of pollution to which it was subjected, we had occasion to increase the supply along the Bear creek, so-called which is a small stream which debouches from the mountains, about 13 miles from Denver, thence is carried along in ditches and put into Marston Lake, and from there put into the city. Under my direction the Denver Union Water Company spent considerable sums in cleaning up that water shed, buying up farms, and buildings, cutting out the brush and the undergrowth, and especially at Evergreen, a town some twelve miles up the canon, where we found a case of typhoid; it was supposed that the place was thoroughly disinfected, but another case broke out in the same house the following year. In fact, a brother and sister came down, and they were both sick in the
10986 house at the same time with this disease. The house was
upon a little plot of green grass, on the bank of the stream. We went up and had an order executed to take these two patients out of the house, and then burn the house down; we bought the property and made a contract to burn the house down, and cleaned out the place, liming it all down thoroughly. That was all a matter of protection against typhoid fever from a rural district, and because, I believed that the supply was endangered by the presence of those two cases in that house, upon the banks of that stream, the dejecta from those patients

being thrown out, as they were, into the stream, they were removed in that way.

Q. When did you make this investigation at Denver?

A. I cannot give you the exact date; but I would say it was in '97 or '98, at the time I was acting as consulting chemist to the Denver Union Water Company,—it was about that time.

Q. State in detail what position the science of bacteriology occupies in regard to the ascertainment of the purity of the river waters?

10987 A. The development of the study of the purity of river waters requires a knowledge of the science of bacteriology, especially in relation to the presence or absence of sewage. The history of the science of the purification of waters shows that at first the clearness of the water was all that was sought after in selecting and adapting a water supply. Later, the science of chemistry was applied to determine the purity of water, and since about '85, the science of bacteriology was developed, and has been applied to its study, so that to-day a satisfactory opinion upon the healthfulness or unhealthfulness of the water supply cannot be passed without a knowledge covering its bacterial contents. The study of the bacteriology of water has to do with the organisms present, and especially with the presence or absence of the colon forms, and forms like it. To-day, what interests in the study of the river water from its sanitary standpoint, is whether or not that river contains sewage.

10988 It is commonly acepted at the present time, that diseases are caused by certain specific organisms, known as bacteria, and among those bacteria which can be borne by water, those of typhoid fever and of cholera are the most prominent. These are intestinal diseases, and, therefore, it is very important to determine whether or not fecal matters find access to the waters; we can use, therefore, the presenc or absence of the intestinal bacteria as the most important index in determining the purity or impurity of the supply.

Q. What position does the science of bacteriology occupy in what is known as sanitary science?

A. The word Sanitary science is a larger term,—Sanitary science embraces primarily a study of the conditions of good health, and the study of foods, air and water.

I have already outlined the importance of the science of bacteriology in ascertaining the purity of river water. The science of bacteriology also occupies an important place in determining the purity, or demonstrating the quality of food supplies.

It would be self-evident that if food became exposed to impure water, the food will be rendered unsafe and unfit 10989 for use; therefore, bacteriological study is an important factor in determining the characteristics of foods.

Q. State in detail what place the science of chemistry holds in regard to the ascertainment of the purity of the river waters?

A. The science of chemistry as applied to river water, has to do with the detemination of the presence or absence of organic matters in the water. It is necessary that we should know the chemical constituents of water, from a sanitary standpoint, and whether it contains organic matter or not; it may or may not be possible to determine the bacterial forms present in the water, but we can determine the presence or absence of organic matters.

The relation of chemical science to the study of the purity of waters, has to do with determining whether organic matters are present or absent. Another province of the application of chemistry to the study of waters, is to determine what changes those organic matters added to the water undergo, after a period of time, so that we have the definite work of chemistry 10990 in determining the presence or absence of organic matters, and secondly, the changes which such organic matters may undergo.

Q. Docs chemistry occupy an important position in sanitary science?

A. It is fundamental to the proper study of foods, of air, the nature of the food stuffs, and the nature of the water supplies the three great necessities of life.

Q. In the ascertainment of the quality of the river water what aid is chemistry and bacteriology to the sanitarian in forming judgment as to the quality and potability of such water?

A. In my opinion the sanitarian could hardly form a proper opinion regarding the quality of a river water did he not have the chemical and bacteriological data upon which to base such an opinion. As, for example, the Platte river, in Denver, is a bright, clear stream coming down from spring waters out of the parks, up on the mountains. It is bright and clear, colorless and sparkling, pushing down over rocks, and no one would hesitate to drink that water. To look at it you would say that the water was entirely satisfactory, an ideal water, but when the bacteriologist comes to examine that water, he finds that 10991 it contains, and carries fecal matters. When the chemist comes to examine it he finds also that there is evidence of sewage borne in the waters, but the bacteriologist's services would be of the greater use there. The water, to look at would be seemingly perfectly satisfactory, but upon applying these several tests, it becomes evident at once that means of purification must be employed before the same can be delivered with safety to consumers.

Q. From the tables of analyses submitted in evidence in this case, by the witnesses for the defense, and which are published in Streams Examinations, which you have examined, at what points in the Illinois River does the nitrifying and purifying processes of the sewage coming from Chicago reach toward practical completion?

A. In studying the tables it is my opinion that the waters of the Illinois River begin to show a very decided purification at Ottawa, which increases and reaches its maximum at *Averyville, which is above* the City of Peoria. It receives, at Peoria, and at Pekin, a considerable addition of sewage material; another area, or a zone of purification commences at that point, some distance 30 miles or so, below, and is practically completed at Grafton, the river at that point appearing to be water of the quality of rivers of this section.

10992 Q. In order to qualify as a sanitary expert is it necessary for such expert to have a knowledge of chemistry and bacteriology?

A. In my opinion it is necessary for a man to have a pretty thorough working, practical knowledge of chemistry and bacteriology in order to qualify as a sanitary expert.

Q. Does not a sanitary expert call to his assistance all information available from chemical and bacterial knowledge, as well as the sources of pollution, in passing judgment on the sanitary character of a river water?

A. In answer to that question I would say that no man

could pass as a sanitary expert who did not seek, in passing upon the quality of a supply, to avail himself of all information possible, chemical, bacteriological, and knowledge of the sources of a supply and all sources of pollution to which it was exposed. Passing upon a supply includes all of those. A man may pass upon a sample of water submitted but he can not thereby necessarily pass upon the supply as a supply. He can say that that sample of water may be good or bad, but he must have a thorough and accurate knowledge of all the conditions gov-
10993 erning a supply, its pollution, its source and the changes to which it is exposed before he can ultimately recommend it or pass an opinion on it.

Q. As a sanitary expert availing yourself of all the chemical and bacterial knowledge which is available to you, which you possess, what is your opinion as to whether a typhoid bacillus, lying in the sediment of a polluted stream, for a period of or in excess of sixty days would be able to cause typhoid fever, if taken into the human system, after it had remained in such sediment for that length of time?

A. From all the knowledge available, from the standpoint of chemical and bacterial knowledge, it would be my opinion that a typhoid bacillus, lying in the sediment of a polluted stream, for a period of over 60 days woudl not be able to cause typhoid fever; for reasons which I have indicated earlier in my examination, it would probably be destroyed in the sediment.

Q. What is your opinion as a sanitary expert as to whether polluted or infected matter, coming from the sewage of Chicago, through the drainage canal, deposited on the bottom of the Desplaines and Illinois River between Chi-
10994 cago and Ottawa and Peoria, can remain there for a period of from 30 to 60 days and yet retain its dangerous qualities as well as pathogenic bacteria?

A. In my opinion polluted and infected matter coming from the sewage of Chicago through the drainage canal, would have become harmless before reaching Peoria and would have been altered so that it would not be deposited on the bottom as sediment as infectious material. The bacteriological data already submitted in evidence, in my opinion and judgment, show the purification of the stream before reaching Peoria.

Q. From your personal knowledge of the Illinois River

and your knowledge as a sanitary expert, together with all chemical and bacterial knowledge, derived from every source, what is your opinion as to whether the sewage from the city of Chicago passing through the drainage canal into the Illinois River, at different seasons of the year, and at different stages of water in the Illinois River, would be a danger and a menace to the inhabitants of the state of Missouri and the citizens of the city of St. Louis using the water of the
10995 Mississippi River for domestic and drinking purposes?

A. The chemical and bacterial data already a matter of evidence in this case, showing that the waters have become practically purified before reaching Peoria, it would be my opinion that sewage from the city of Chicago could not be a menace to the inhabitants of the State of Missouri and the citizens of the city of St. Louis using the Mississippi River water.

Q. What is your opinion as a sanitary expert, based upon your examination of the tables of analysis introduced into evidence by Professors Long, Palmer, Burrill and Jordan of the waters of the Illinois River, the Mississippi River and the Missouri River as represented by such tables as you have examined as to which one of these three rivers from this analysis discloses the least amount of impurity or pollution?

A. By comparison of the data submitted by Professors Long, Palmer, Burrill and Jordan, it is my opinion that the Illinois River at Grafton discloses the least amount of impurity or pollution of the three rivers, the Illinois, Mississippi or the Missouri.

Q. If the Illinois River discloses from such data as
10996 aforesaid the least amount of impurities what would be the effect of the waters of the Illinois River emptying into the Mississippi River at Grafton and subsequently uniting with the Missouri River at its mouth, upon the combined waters of the Mississippi and Missouri rivers at the intake at the chain of rocks?

A. It would be evident that if the Illinois River is of a better quality or does not show as much impurity as either of the other rivers, it would really benefit them, if anything, and in proportion as the waters became mixed. If the evidence should be that the Illinois River practically hugs the east shore and does not mix, particularly it would not affect them. If, on the other hand, the data should show that there is a gradual mixing then in proportion as this mixing occurred to that degree it would improve, if anything. The differences are not very great, however, between the data as I have examined them.

ADJOURNED UNTIL 10:00 A. M., SATURDAY, FEBRUARY 27, 1904.

10997 10:00 a. m., Saturday, February 27, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. E. G. SMITH

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. Professor have you made any surveys of the waters of the Mississippi River in passing upon the quality of the Mississippi River for drinking and domestic purposes?

A. Yes, in the course of my professional work and the study of the sanitary character of water supplies I have, from time to time, carried out researches or surveys as stated in your question upon the river, the same extending over a period of at least twelve years.

Q. Will you state in detail at what points on the Mississippi River you have made these researches and for what
10998 purpose.

A. The researches have been made from time to time since before 1890 as problems have arisen in connection with water supplies at several points along the river.

The first place where I have made any examinations is at Brainard, Minnesota. These were made for the water company, a private company that supplies the city of Brainard. Brainard is the first town of any importance on the Mississippi River above St. Paul, about 100 miles above Minneapolis, and having I think about 7,000 or 8,000 population. I was called by the management of the company to investigate the supply as there was some complaint made of the quality of the supply, and they wished to know its quality. I made but one set of examinations for this point, but the examinations showed, as I recall them now, the water of the Mississippi River to carry a large amount of organic matter in solution and suspension.

The next point on the river which I have had occasion to examine was at Minneapolis, Minnesota. I think this was about eight years ago. I was called there by the city engineer to make an examination of the quality of the water and report
10999 upon the same to him. There was a complaint made of the quality of the water and about that time there was considerable sickness in the city and this condition had caused complaint to be made as to the supply as they feared the sickness prevalent at that time was attributable directly to the same. I went there and went over the ground quite carefully with the engineer, visiting the different pumping stations at that time. There were two pumping stations, both taking water from the Mississippi River; one of them was located well above the city, I should say three miles or so, and the other was located in the heart of the city, below the falls, located at this point originally because water power was used to pump the water. Samples were taken from various points, at both the upper and lower pumping stations. They were taken from the taps upon the pumps at both stations and at the upper station samples were secured from the stream directly. I do not recall whether any bacteriological examinations were made from the samples taken from the river at this time, but those samples were
11000 subjected to chemiccal analyses in the chemical laboratory at Beloit. The river at that point was highly colored and was very characteristic of the quality of the waters of the Mississippi in its upper reaches. The waters were dark colored, and owing to the source of these waters coming as they do from the drainage of the swamps in Northern Minnesota, they carried a large amount of vegetable extractive matter in solution and in suspension. At that time the condition was aggravated by the large number of logs floating in the river; large mills having been established near the waterworks; further aggravated the conditions in that the booms for retaining the logs had stretched back so that the surface of the river in front of the station and for some distance above was practically covered with logs. The extractive matter from those logs both as they were stored in the river and from the logs floating above,

contributed to the soluble materials carried by the river and was a prominent factor in our study of the quality of the waters. The analyses of samples were made, and a report was made back to the city engineer in which I called attention to the un-
11001 satisfactory character of the water, its unfitness for a public water supply in its present condition and in the report I advocated their establishing a system of filtration by the city of Minneapolis. This report was published and is in print. It is interesting in this connection to note the quality and know of the impurities present in the water, because owing to the location of the city of Minneapolis and the absence of large towns above the city sewage as we understand it was not an important factor. The river water was highly charged with organic matter, but this in my judgment was due, as stated above, to vegetable extractive matters and was not due to sewage in the sense in which we ordinarily use, i. e., representing dejecta and waste from a population. It is true that rural communities above and the isolated homes with their outfalls along the river contributed something in the way of sewage to the river but it was not an important factor to this study.

The next place upon the river which I have made an examination for is St. Paul. It is located about ten miles below the city of Minneapolis; it does not take its supply from the Mississippi River, and I merely mention it in this connection
11002 because of the unsanitary conditions which were found about the supply and which I called attention to and advocated the removal of. The city itself as well as that of Minneapolis sewers directly into the Mississippi River and these two cities together contribute a large amount of pure animal sewage to the river, so that from this point on the sewage becomes a factor in discussion. At the time I did the work for St. Paul, which was, I think, five years ago, there was considerable typhoid fever in the city and complaints had been made to the health officer and also to the secretary of the board of water commissioners; it was in view of these complaints or the presence of typhoid fever in the city that I was asked to make this investigation.

The next city or point upon the river was the town of Winona. These results and analyses were made some years ago and I merely mention it in passing as one of the towns I have examined. I do not remember the conclusions arrived at.

The next point upon the river which I examined and have studied is that at Dubuque, Iowa, which examination and study was made some years ago, about four years ago, I think, and the studies came up in connection with the purchase of the plant owned at that time by the Dubuque Water Company, by
11003 the city. The investigations included an examination of the river water, a system of filters, the artesian supply and other proposed sources.

The next point upon the river where I have made examinations and a study is at Clinton, Iowa, in connection with the water supply and the desirability of using the same as compared with the use of an artesian well supply. At Clinton, Iowa, the waters were considered unsatisfactory; in view of the facts I recommended the use of an artesian well, and a device by which the objectionable features of the artesian well arising from the presence of sulphuretted hydrogen in the water were overcome.

The particular point where I have studied the river is at Davenport, Iowa. The water is supplied to the city of Davenport, by the Davenport Water Company. Originally the water was pumped directly from the river into a reservoir and from there distributed through the mains. About 1890 the condition had become so unsatisfactory owing to the quality of the water supplied, the same being raw river water, it being muddy, and possessing an odor and a disagreeable taste, a demand was made upon the water company that some method should be taken for the purification of the same. About this time a contract
11004 was made with the old American Filter Company to install the type of filters known as the American System of Mechanical filtration to treat the Mississippi River water and render it suitable for public use. After the plant was installed and was in full operation the management of the company decided that they required expert services in connection with the operation of the same, and I was invited by them to come and make an inspection of the plant and some analyses of the waters in their raw condition and as filtered and to report upon the same. This was, I believe, in 1892, and from that until the present I have made frequent examinations of the Mississippi

River water both in its raw condition and after its filtration, both from the chemical and bacteriological standpoint. These examinations had been made practically at least once a month throughout this period and sometimes oftener. Frequently, during bad conditions of the river, they have been made several times a week. The samples have been taken by the company's representative, both from the raw and filtered waters, in suitable receptacles and sent over to Beloit to me for analyses
11005 and study. The samples for the most part have been
but a few hours in transit and have almost always been collected in the morning and received at Beloit and examined later in the same day. The train service between those two places allowing for a period of between five or six hours from the collection of the samples until the examination. The plant has been changed and enlarged and the process improved from time to time, either at my suggestion or in consultation with me, regarding the proper treatment of the waters of the Mississippi River. For the first portion of the time a period covering perhaps five years or thereabouts only chemical analyses were made, but since that period both chemical and bacteriological examinations of both the raw water and the filtered water have been carried out.

From my knowledge of the Mississippi River water at Davenport, a city of about 35,000 population, receiving the sewage of no considerable town below Clinton, which is about 40 miles above, although there are small towns, and the rural population along the river between these places, I am of the opinion that the Mississippi River at that point is unfit for drinking and domestic purposes in its raw and natural conditions. This opinion is based upon a series of chemical analyses and
11006 later upon a continued series of chemical and bacterio-
logical analyses extending from the period first stated up to the present time. The raw Mississippi River water at Davenport always carries a large amount of dissolved organic matter. The organic matters are of vegetable origin though they may have received some limited amount of sewage which might possibly reach the intake from the rural communities stated or mentioned above. The waters of the river are peculiar and differ markedly from that of any other stream with which

I am familiar in this western country in the amount of this extractive vegetable matter which it carries. We always find in this river, in the raw water, a high oxygen consumption and a relatively high amount of albuminoid ammonia. The nitrogen as nitrates is low, the chlorine is low, usually about 2 to 3 parts per million, and the free ammonia is low, ranging in the neighborhood of 8, 12 or 15 one hundredths parts per million. Another peculiarity of the Mississippi River, which has given some trouble at Daveport, in the efficient filtration of the same, is its varying and shifting character. In the spring of the year, at
the break-up there is always a considerable amount of
11007 sediment in the river continuing into the summer
months. In the fall and winter the waters are not highly charged with sediment, but from March until July, or thereabouts, the sediment increasing as it does, and being of a very fine, silty character, is difficult to remove.

Another factor in the Mississippi river water, which I have noted in the study, is the change in character of the soluble contents, usually in the fall. This is due in my opinion to the mixing of the river water with impounded waters near its headquarters; the water differs entirely for an allotted period following the low water, rendering it for a short period more difficult to handle. This is noteworthy in this connection because of these factors, the silting of the river, the increase of organic matters, the entire change of the dissolved matters introduced, the shifting, in the quality of the water, all of which must be taken into consideration in all waters when discussing their quality.

In my opinion the Mississippi River is unfit for drinking purposes and domestic purposes.

Regarding the bacteriological content of the river aside
11008 from any chemical investigations, I have found that
colon forms of organism are generally present in the water, so that in any sample of the raw water submitted for examination from that point—and there are no sewers from the city of Davenport immediately above the intake—I expect to find indications of the presence of the colon form, or of some of its modified forms.

Another point upon the river which I have studied, is the supply as delivered at Rock Island, Illinois, the intake of which is a short distance below the intake of the Davenport Water Company. I have already given in evidence the conditions of the outbreak, or epidemic of typhoid fever at Rock Island, in 1901, and it was shown at that time that the water supply was in bad condition.

It is to be noted further, that the sewers from Moline, from Rock Island, and from Davenport, the three cities closely situated, and representing a population of about 75,000, empty into the river directly or indirectly at this point; the qualities
of the supply at Rock Island, at least, has been seriously
11009 affected by the same. The city of Moline has to take its
supply from the river directly, and I have advised the establishment of a filter plant at that point to purify the same, as in my judgment the river water in its raw state is unfit for public and domestic use. This filter plant is now installed and will be put into operation soon.

The next point upon the river is the city at Muscatine, Iowa, which takes its supply from the river directly, pumping it into a reservoir, subjecting it to the processes of simple sedimentation. Owing to the outbreak of typhoid fever in the city a few years since, I was called there by the Muscatine Water Company, to investigate the supply, and at that time condemned the river water as being unsuitable for public and domestic use, and at that time advised the changing of the supply, or the purification of the same by a process of filtration. Since that time the works have been sold to the city and I have just completed a report to the Board of Water Commissioners, advocating the use of the system of wells, taking the land supply
from the low land below the city, the river at that point
11010 being in my opinion, based upon analyses of the same,
both chemical and bacteriological, an unsanitary supply, unsafe and unwholesome, and not adapted to public use.

The city of Burlington, Iowa, has had a filter plant installed for several years. The water supply is from the Mississippi river, the same being filtered by a system of gravity filters. These have never been operated satisfactorily, and the plant is now being overhauled with plans to make it conform to the more modern types and more perfect types of filtration. I have been acting as consulting chemist to the company for some time and have advised with them, my advice being based upon an investigation of the local conditions and the chemical and bacteriological analyses of the river at that point.

I have been asked by the Pure Water Commission at Keokuk, Iowa, to investigate their supply, and samples are now in the laboratory at Beloit, for both chemical and bacteriological examinations.

We have also made examinations of the water at Quincy, Illinois, but not very extended examinations.

11011 One more general factor regarding the Mississippi river in determining its quality, should be mentioned, the changes of the river and the qualities of the water of the river due to local floods. This is true particularly at Burlington. The heavy local rains produce changes at Burlington, from washing out of a small creek, situated about three miles above the plant, which materially affect the quality of the supply, making the general river water pumped, much more difficult to handle at times than otherwise.

This is also true at Davenport, heavy rain storms washing out the streams above, and throwing into the river quantities of silt which make the operations of the filter, for the time being, much more difficult and out of the ordinary.

Q. Do all the cities mentioned in your previous answer, whose water supplies you have investigated as above detailed sewer into the Mississippi River?

A. The cities of Minneapolis and St. Paul, of Clinton, Davenport, Rock Island, Moline, Burlington and Quincy,

11012 have systems of sewerage which sewer into the river. There are other cities upon the river which I did not mention, whose water supply I did not study, which add also a considerable amount of sewage to the river. There are other smaller towns and cities adding more or less sewer material, though I cannot state positively as to whether they have regular systems of sewage introduced or not, as at Winona and Keokuk.

MR. JEFFRIES: Now I move to strike out all the testimony of this witness with reference to the sanitary condition of the river at the points and places mentioned by the witness, for the reason that the same is incompetent, irrelevant and immaterial.

11013 Q. From the examinations that you have made of the water of the Mississippi River from Brainard on the north to Muscatine on the south, what is your opinion as to whether the water of the Mississippi River is a suitable water in its raw state for drinking and domestic purposes?

MR. JEFFRIES: I object to the question as incompetent, irrelevant and immaterial, and constitutes no defense in this case.

A. From all examinations that I have made of the Mississippi River from inspections at various points from Brainard and Minneapolis, Minn., to Quincy, Illinois, and from chemical and bacteriological examinations from Brainard, Minn., to Muscatine, Iowa, using these as a basis for the opinion, I am of the opinion that the Mississippi River water, in its raw condition unfiltered, and not treated, is not a wholesome or safe water to use nor one adapted for use as a public water supply.

11014 Q. Does the mixing of the Illinois River with the Mississippi and Missouri Rivers, based upon all the knowledge which you have, both chemical, bacterial and otherwise, create an added danger to the already polluted and contaminated waters of the Missouri and Mississippi River below Grafton, to the inhabitants of the state of Missouri, using the waters of the Mississippi River for drinking and domestic purposes?

A. From examinations of the Mississippi River water made at different times throughout a series of years, and at different points reaching from Brainard, Minnesota, as far down the river as Muscatine, it is my opinion that the Mississippi River water in its raw and untreated condition is unfit for use as a public water supply, without treatment, and it is my opinion, therefore, that the mixing of the Illinois River with the Mississippi River water, after it may have received the Missouri River, does not create any added danger to the inhabitants of St. Louis and to the people of Missouri, for public and domestic purposes.

Q. From all your knowledge of conditions that obtain

11015 in and along the Illinois River, what is your opinion as a sanitary expert as to whether deleterious substances, infected matter or pathogenic germs which come from the drainage canal from the sewers of Chicago would reach as far down the Illinois River as the city of Peoria?

A. From all my knowledge of conditions that obtain along the Illinois River, from the inspection of the river throughout its entire length, from a study of the analytical data, both chemical and bacteriological, already a matter of evidence in this case, from the rate of flow of the river, from the data adduced regarding the duration of life of the pathogenic germs the same not living more than three or four days in the waters of the stream, with the processes of self purification at work, notably the process of dilution and sedimentation, and the chemical and bacterial changes shown, it is my opinion that infected matter and pathogenic germs coming into the drainage canal from the sewers of Chicago would not reach as far down the Illinois River as the city of Peoria.

Q. Would any of those substances in a dangerous state reach the intake tower of the St. Louis waterworks at the chain of rocks, in your opinion?

11016 A. In view of my knowledge of the conditions in and along the Illinois River, the results of the bacteriological and chemical examinations made and submitted already in this case, from the rate of flow of the river, the duration of life of the typhoid fever bacillus, as demonstrated, not exceeding three or four days in the waters of this river, from the agencies of self-purification at work on the stream, notably the factors of dilution and sedimentation and the chemical and bacteriological changes established, it is my opinion that substances coming from the sewers of Chicago through the drainage canal would not reach the intake tower of the St. Louis waterworks at the chain of rocks in a dangerous state.

Q. As a sanitary expert, do you consider the sewage of Chicago, entering the drainage canal and the Illinois River, which in turn empties into the Mississippi River, a menace to the citizens of the city of St. Louis, taking their water supply from the Mississippi River?

A. In view of all the knowledge which I possess upon
11017 the Illinois River, and the study of its physical characteristics, from the study of the chemical and bacteriological analyses of the river already a matter of evidence in this case, from the rate of flow of the river and the duration of life of the typhoid bacillus, the same not extending over a period of three or four days, as already a matter of evidence, from the analytical and self-purification operative in the river, notably those of dilution, sedimentation and the bacterial and chemical changes which the river undergoes, it is my opinion that the sewage of the city of Chicago, entering the drainage canal, and thence discharged into the Illinois which in turn empties into the Mississippi River does not constitute a menace and a danger to the inhabitants of the state of Missouri, or to the citizens of the city of St. Louis taking their water supply from the Mississippi River.

Q. What is your opinion as a sanitary expert as to whether the germ of typhoid fever could lie in the sediment of the drainage canal or upon the bottom of the Illinois River for a period of from one to three years?

A. From the experiments already given upon the life
11018 of the typhoid fever germs in the Illinois River, after the same has received the sewage of the city of Chicago, from the fact that the germs which may have been precipitated to the bottom of the river, in the sediment of the river, would be measurably subject to the same agencies, the same tending to its rapid destruction, it is my opinion that there is no probability or possibility of a germ remainng at the bottom of the river for a period of from one to three years.

Q. Do you know of any instances on record or reference in the literature upon the subject of bacteriology, where a typhoid bacillus has lived for a period of from one to three years in the sediment of a polluted stream, or in the water of a polluted stream?

A. I know of no instance on record or in literature on the subject where a typhoid bacillus has lived for a period of from one to three years in the sediment of a polluted stream or in the water of the same, but on the contrary the records of all the

experiments which I have been able to read, and from all information I have been able to gather upon the subject of the duration of the life of a typhoid fever germ in a polluted
11019 water is that it is brief, being limited to that of a few days, six or seven perhaps, at the outside.

Q. Are you acquainted with Sternberg's experiment on the life of the typhoid in a sealed bottle?

A. I have read of an experiment made by Sternberg upon the life of a typhoid bacillus in sterilized water which had been placed and kept in a hermetically sealed bottle, in which statement it appears that it retained its vitality for a period under that condition for upwards of a year.

Q. What is your opinion as to whether a typhoid bacillus deposited on the bottom of the Illinois River could remain there upwards of a period of five years and then be stirred up by the action of the waves, the winds, steamboats or by any other means, could continue its journey down to St. Louis in a virile state and be a cause of danger to the inhabitants of the state of Missouri using the waters of the Mississippi River for drinking and domestic purposes?

A. From my knowledge of the conditions obtaining in
11020 the Illinois River, from the inspection or the physical surroundings and conditions, from a study of the bacterial and chemical tables already submitted as evidence in this case, from a study of the experimental data concerning the duration of life of a typhoid bacillus in the polluted waters of the Illinois River, the same not covering a period of more than three or four days, as already a matter of evidence in this case, from the rate of flow of the river, and from the agencies of self purification operative in the stream, notably those of the dilution, of sedimentation and of the chemical and bacterial changes induced in the stream, I am clearly of the opinion that by no possibility whatever could a germ be deposited on the bottom of the Illinois River at any point and remain there for a period of five years and then be stirred up by the action of the waves, the winds, steamboats or by any other means, and could continue its journey down to St. Louis in a virile state and be a cause of danger to the inhabitants of the state of Missouri

and the citizens of the city of St. Louis, using the waters 11021 of the Mississippi River for drinking and domestic purposes.

Q. What effect does an increased volume of water in the Illinois River have upon the lowlands lying along the banks of the Illinois River?

A. The banks of the Illinois River being low and shelving especially in the lower reaches of the river, the effect of the increased volume of water would be to overflow these low lands to a considerable extent, and thus we have a greatly increased area of sedimentation, the low lands appearing practically thus as a great settling basin for the waters of the river. This particular feature of the river was very noticeable at the time of my journey down the river, and I noted at various points how widely the river had extended, it at that time being quite high, after some storms, and I understood it was above its normal level and thus covered a large area of territory.

Q. If the increased water at flood tide from the tribu- 11022 taries of Illinois River as well as the Illinois River itself, exclusive of the waters of the drainage canal, causing a large area of land to be overflowed along the Illinois River valley, what effect does this overflow have upon entering the Illinois River through the drainage canal?

A. The effect of increasing water at flood tide from the tributaries of the Illinois River, as well as the Illinois River itself, coming in at points below the entrance of the polluted waters of the drainage canal would and do cause, as I have observed personally, a large area of land to be overflowed along the Illinois River Valley, and the effect of this overflow is to greatly increase the area of sedimentation so that the sewage from the city of Chicago entering the river through the drainage canal would have an opportunity for more complete sedimentation; this overflow forms an important factor in estimating the significance to be attached to the element of sedimentation in the purification from the sewage in the stream.

11023 Q. Would sedimentation be greater if the volume of water were greater, thereby causing a greater area of territory to be overflowed in the Illinois River valley?

A. It is my opinion that if the volume of water be increased overflowing this greater area of territory, the waters discharging out, becoming retarded in their course, and giving opportunity thus for the sedimentation, it would follow that the sedimentation would be greater when the volume of water was sufficiently large to cause the overflow of a considerable section of territory adjacent to the Illinois River through the valley.

Q. Are you acquainted with the different lakes and dams between Chicago and St. Louis, along the Desplaines and Illinois River?

A. I have had opportunities for observing different lakes so called, and the dams between Chicago and St. Louis, along the Desplaines and Illinois River. These dams are five in number and they cause a retardation of the flow of the stream, allowing the water to become more quiescent above them. The lakes so called are not true lakes but are practically expansions of the river where through considerable area the river widens out, forming quite an extended body of water,
11024 and offering opportunities for extensive and decided sedimentation.

Q. Assume that the four dams, the one at Henry, Copperas Creek, La Grange and Kampsville were removed from the Illinois River, would the removal of these dams create a condition in the Illinois River that would permit the sewage coming from Chicago to pass down the Illinois River in an unpurified and infectious condition. to the Mississippi, causing it to be a source of danger to the inhabitants of Missouri using the water of the Illinois River for drinking and domestic purposes, taking into consideration all knowledge which you have, of the chemical and bacterial conditions that obtain between Cheiago and Peoria, and from Peoria to Grafton?

A. From all knowledge which I have been able to gather concerning the conditions which obtain in the Illinois River, from my personal inspection of the river, from the chemical and bacteriological tables already a matter of evidence in this case, from the facts concerning the duration of life of the typhoid bacillus, from the rate of flow of the river from the
11025 agencies of sedimentation and dilution and the chemical and bacteriological changes which obtain in the river, it is clearly my opinion that the removal of the four dams namely the dam at Henry, at Copperas Creek, at La Grange and at

Kampsville would not create a condition which would permit of the sewage coming from Chicago through the drainage canal into the Mississippi River to reach the intake of the water works at the city of St. Louis in the Mississippi River and thereby constitute a menace to the health of the citizens of St. Louis and the inhabitants of the state of Missouri, using the water for drinking and domestic purposes.

Q. Will you state as an expert sanitarian and from all the sources of knowledge that you possess whether the water of the Mississippi River at the chain of rocks was prior to January, 1900, a safe and potable drinking water, fit for domestic purposes in its raw state?

Mr. Jeffries: I object to that as immaterial.

A. With all the knowledge which I have been able to gain upon the question, from my personal knowledge of the 11026 water of the Mississippi River from the conditions as revealed by the chemical and bacterial analyses at various points, conforming as they do to data already a matter of evidence as touching the quality of the water of the Mississippi River at Grafton. From the knowledge of the chemical and bacterial nature of the waters of the Illinois River as they are discharged into the Mississippi River at Grafton, and from the prevalence of typhoid fever as shown in tables already submitted in evidence, in the city of St. Louis it is my opinion that prior to January, 1900, the water of the Mississippi River at the chain of rocks was not a safe and potable drinking water fitted for domestic and drinking purposes in its raw state after the same had passed through the process of purification as adopted by the city of St. Louis in their settling basins.

Q. Was the Missouri River water a safe water for drinking and domestic purposes prior to the opening of the drainage canal in January, 1900?

Mr. Jeffries: Objected to as immaterial.

A. In my opinion the waters of the Missouri River were not a safe water for drinking and domestic purposes prior 11027 to the opening of the drainage canal in January, 1900. The analytical data would show the unsafe and unsatisfactory and unwholesome character of the water.

Q. Was the Illinois River a safe water for drinking and domestic purposes prior to the opening of the drainage canal in January, 1900?

A. In my opinion the Illinois River water was not a safe water for drinking and domestic purposes prior to the opening of the drainage canal in January, 1900, this being based upon a study of the analytical data, chemical and bacteriological, already submitted and a part of this evidence.

ADJOURNED UNTIL 2:00 P. M. OF THE SAME DAY.

11028 February 27th, 1904.

2:00 o'clock P. M. Session.

Parties met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROFESSOR E. G. SMITH,

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. Has the sanitary condition of the Illinois River at Grafton been improved or damaged by the opening of the Drainage Canal?

A. From my study of the conditions of the river, especially from the study of the chemical analyses of the supply of water, and also the bacteriological conditions of the water of the river as disclosed by such analyses from before and after the opening of the Drainage Canal, I am of the opinion that the sanitary condition of the water has not been materially changed by the opening of the Canal.

Q. Have you done any work upon the waters of the Missouri River?

11029 A. In reply to that question I would say that I acted as chemist to the American Water Works Company operating the public water plant at the City of Omaha. This was some years since, perhaps eight or ten years, and I made a series of analyses for that company, the same extending over a period I think of about three years, these being made monthly. The American Water Works Company take their supply from the Missouri River at Florence, about seven miles from the City Hall, at Omaha. I have acted in the same capacity for about two years, for the Water Company at Council Bluffs, Iowa, across the river from Omaha, this company also taking its water from the Missouri river, and pumping it into the reservoirs, then distributing from the same.

Q. What effect, if any, does the sewage discharged through the drainage canal, have upon the waters of the Mississippi river and the Missouri River at the Chain of Rocks?

A. From a study of all the data at hand, and the personal inspection of the physical conditions of the Illinois River, from the study of the chemical and bacteriological analyses of
11030 the waters, of the samples of the Illinois River, already submitted as evidence in this case, from the results of the special study upon the vitality of the typhoid fever bacillus in the waters of the Illinois River, after the same have received the sewage of the city of Chicago, through the Drainage Canal, from the knowledge of the length of time required for the water to flow from the Drainage Canal to the mouth of the Illinois River, at Grafton, from the agencies of self-purification which obtain in this river, being those especially of sedimentation and dilution, and the bacteriological and chemical changes in the course of its flow, I am of the opinion that the sewage discharged through the Drainage Canal, has no material effect upon the waters of the Mississippi and the Missouri Rivers at the chain of rocks.

Such changes as it does effect are those due to the mineral salts carried on by the river, as chlorides, and nitrates. It is my opinion that the sewage as such, does not reach the mouth of the Illinois River in an unchanged condition.

11031 Q. Is the water of the Mississippi and Missouri Rivers, exclusive of the waters of the Illinois, a safe and suitable water for domestic and drinking purposes to be used by the citizens of St. Louis and inhabitants of Missouri, in its raw state, already treated as now, in the City of St. Louis, at the settling basins?

A. From my knowledge of the Mississippi River, and the same after it has combined with the Missouri River, from all data available, from personal studies of the Mississippi River both from personal inspection and chemical and bacteriological studies, I am of the decided opinion that the waters of the Mississippi River, after it has received the water of the Missouri

River, not including the waters of the Illinois River, are not a safe water for domestic and drinking purposes, and are unsuitable to be used by the citizens of St. Louis in its raw state

In answer to the second part of the question, "already treated as now, by the City of St. Louis, with the settling basins," from the statistics of the continued prevalence of typhoid fever in the City of St. Louis, and from the in-
11032 spection of bacteriological and chemical data and from the personal observation of the appearance of the water as delivered to the people of St. Louis, after passing through the settling basins, I am of the opinion that the present treatment of the water by the settling basins merely, does not render the same a safe and suitable water for domestic and drinking purposes, to be used by the citizens of St. Louis.

Q. In order to make the water of St. Louis a safe and potable drinking water for domestic and drinking purposes, how should it be treated?

MR. JEFFRIES: I object to the question as immaterial.

A. In my opinion, in order to render the waters of the Mississippi River safe after they have received the waters of the Illinois River, at Grafton, and the Missouri River, at its mouth, the same passing down by the Chain of Rocks, the proper method to treat that water would be by some process of efficient filtration.

MR. TODD: Q. What experience have you had, aside
11033 from what you have already detailed in evidence, in connection with the installation of filter plants?

A. In the course of my studies and investigations upon the purification of public water supplies, I have had to do, as consulting chemist, with some plants already mentioned in my evidence, and in addition to the same, with the filtering plants at Denver, Colorado, at Brooklyn, New York, at Indianapolis, Indiana, and in addition to those plants, I have had to do as consulting chemist with perfecting, and improving the process, and the enlargement of plants at other points.

Q. What other points?

A. Of improving, of operating, or testing the plants at other points, such as Binghampton, New York, Portage, Wisconsin, and Eau Claire, Wisconsin, Kankakee, Illinois, at Stevens Point, Wisconsin, and Oshkosh, Wisconsin.

The nature of the services rendered at these plants has been that of consulting chemist and has had to do with the installation of new plants, to determine the efficiency of those in operation, and advise with the management in the efficiency and operation of the same.

11034 Q. Has your business connection with filtering plants extended to the question of cost of filtration plants and the expense of operating the same?

MR. JEFFRIES: Objected to as immaterial.

A. I think I may say that I have never yet been called into consultation as to any filter plant where the question of cost of operating the same was not raised.

In the matter of the installation of new plants and advising concerning them, the cost of installation and the cost of operating the same is one of the important questions always brought up for consideration, and upon which an opinion is expected.

Q. Did the fact that the Drainage Canal was opened in 1900, create any greater necessity for the filtration of the waters of the Mississippi River at St. Louis, since 1900, than existed prior to that time, in order to secure a safe and potable drinking water for the citizens of St. Louis?

A. From my studies of the Sanitary quality of the waters of the Mississippi River, I am decidedly of the opinion 11035 that the Mississippi River water in its raw condition is unfit for use for a safe and wholesome public water supply without being subjected to processes of purification by filtration. This conclusion is obtained through all my knowledge of the river from personal study and from chemical and bacteriological examination of the same, and that too, not at a single point, but at different points in the river reaching from Minneapolis, Minnesota, where its supply is taken from the river, and where I recommended extensive and efficient filtration of the water.

The introduction of the Illinois River would not cause me to recede from that position, as in my opinion it does not materially affect the quality of the Mississippi River, after the Missouri River is introduced into the Mississippi River.

The known dirty condition of the water from the amount of silt and sediment which it carries would in my judgment only make more desirable and more necessary the purification of the waters of the Mississippi at St. Louis, by filtration.

11036 Q. In the event that a filter plant should be established at St. Louis for the purpose of filtering the water of the Mississippi river, which includes the combined water of the Mississippi and the Missouri rivers, would the installation of such a plant in your opinion cost any more to build and construct and operate, with the waters of the Illinois, since the opening of the Drainage Canal, emptying into the Mississippi river, *than it would prior to the opening of the Drainage Canal?*

MR. JEFFRIES: I object to that as immaterial, and having no bearing upon the issues involved in this case.

MR. TODD: In reply will state that the question of filtration is a matter that has been introduced into this record by the complainant in this case, and has a material bearing on the case as presented by the testimony of the complainant, as evidenced by the testimony of Prof. Sedgwick, Mr. Fuller and Mr. Hazen.

11037 Q. In the event that a filter plant should be established at St. Louis for the purpose of filtering the water of the Mississippi river, which includes the combined water of the Mississippi and Missouri rivers, would the installation of such a plant, in your opinion, cost any more to build and construct and operate with the waters of the Illinois, since the opening of the drainage canal emptying in the Mississippi river than it would prior to the opening of the drainage canal?

A. From my knowledge of the Mississippi river as based upon personal investigations and chemical and bacteriological examinations of the same, and from my study of the analyses of the Illinois river at Grafton, before the waters of the same are discharged into the Mississippi river water I am very clearly of the opinion that the cost of purification of water below the mouth of the Illinois river would not be increased, owing to the waters of the drainage canal finding access to the river, and therefore the cost of installation and operation of a filter plant at the City of St. Louis would not be increased owing
11038 to the admission of waters from the drainage canal.

Q. In the construction of such a filter plant at St. Louis which one of the waters of the three rivers, the Illinois, Mississippi or Missouri, if treated with a filter plant, would cost the most for filtering?

A. The answer to the question can not be made in brief. It involves the whole question of the type of filter most desirable to use, whether a mechanical filter or a system of slow sand filtration, the amount of previous treatment by sedimentation; an exact answer to that question, involving as it does these rivers, could be made only after a series of experiments upon the rivers themselves, and upon a large scale. As an illustration the cost of purifying the Ohio river at Cincinnati was determined only after a large experiment, and also after an elaborate series at Louisville, Kentucky, also after an elaborate series of experiments upon the Alleghany river in determining the treatment of the water supply at Pittsburg, the Alleghany forming one of the tributaries; the proper course to pur-
11039 sue at New Orleans, the type of filtration to be adopted, was determined only after an elaborate series of experimentation. Therefore, the full answer to that question involves data which is not at hand.

Q. If a filter plant should be established at St. Louis to filter the combined waters of the Illinois and Mississippi and Missouri rivers, would such a plant require any change in its construction or management if the drainage canal should be closed?

A. From my knowledge of the quality of the Mississippi river water and the difficulties met with in successfully filtering the same; from personal studies upon filter plants and upon the river; the water of the Illinois river at Grafton being so similar to the waters of the Mississippi river; the waters of the Illinois river at Grafton being, in my opinion, essentially the same as they were before the waters from the sewage of Chicago were delivered from the drainage canal into the Illinois river, I am clearly of the opinion that the role which the drainage canal plays in the Illinois river would not affect the cost of installation, management or operation of a filter plant filtering
11040 the waters of the Mississippi river at St. Louis after the same have received the Illinois river at Grafton and the Missouri at a point below.

Q. If such a filter plant should be established at St. Louis would the cost of operation be increased because of the opening of the drainage canal over conditions that would obtain if the same was not opened, and would it require any more skillful and expensive operators to work the filter with the drainage canal opened than if the drainage canal was closed?

A. From my knowledge of the quality of the Mississippi river water and the difficulties met with in properly filtering the same, from personal study and observation at other points, and from my knowledge of the quality of the Illinois river at its mouth, as disclosed by observations, both chemical and bacteriological, made both before and after the drainage canal was opened, the same showing the Illinois river to be essentially of the same general character as the Mississippi river water, I am clearly of the opinion that it would not cost any more to operate a filter plant or require more skill and expensive management of the same after the sewage of the City of Chi-
11041 cago had passed through the drainage canal into the Illinois river and thence into the Mississippi river water above St. Louis than before the drainage canal was opened.

Adjourned until 10:00 a. m., Monday, February 29, 1904.

11042 10:00 a. m., Monday, February 29, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

No witnesses being present an adjournment was taken until 10:00 a. m., Tuesday, March 1, 1904.

11043 10:00 a. m., Tuesday, March 1, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. E. G. SMITH,

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. Have you made a table of averages, based upon the analytical data presented in evidence in this case, by Professors Jordan, Long and Palmer, from points at Joliet, LaSalle, Averyville, Beardstown, Grafton, the Missouri river at West Alton, the Mississippi at Grafton and the Mississippi at Alton and the Mississippi at the intake tower of the St. Louis waterworks?

A. I have prepared tables showing averages of chemical analyses from samples taken from the Desplaines, at Joliet, the Illinois river at LaSalle, Averyville, Wesley, Beardstown, Grafton, the Missouri river at West Alton, the Mississippi at Grafton and the Mississippi at Alton, 100 feet from shore and at the intake at St. Louis, the same being averages from chemical
11044 analyses, in the reports of Streams Examinations,
the analyses, as stated therein, being made by Mr. Jordan during the months of May and June, 1899, and during the months of May and June in 1900, by Professor Palmer in the months of June, July, August and September, 1899, and during the months of June, July, August and September, 1900, and by Professor Long during the summer months of 1899 and the summer months of 1900, the same being taken as reported by Professor Long in the publication of the Illinois state Board of Health, Sanitary Divisions of the Illinois river and tributaries, dated 1901, the tables from which the data for this table is made having already been introduced in evidence.

In this table there is included the locality, the observer, the nitrogen as free ammonia, the nitrogen as albuminoid ammonia, dissolved, suspended and total; nitrogen as nitrites, nitrogen as nitrates; total nitrogen; oxygen consumed and chlorine.

All of these data have not been determined by all of these three observers.

11045 Q. The data obtained in the tables are taken from the analytical tables heretofore mentioned by you, and general averages made by yourself?

A. The data are made from these tables and the averages made by myself.

Q. Will you please read the table which you have prepared from the analytical data of Jordan, Long and Palmer as heretofore testified to by yourself?

A. The table is as follows:

Locality.	Observer.	Nitrogen as Free N H_3		Nitrogen as Albuminoid Amm'nia						Nitrogen as Nitrites.		Nitrogen as Nitrates.		Total Nitrogen.		Oxygen consumed.		Chlorine.	
				Dissolved.		Suspended		Total.											
		·1899	1900	1899	1900	1899	1900	1899	1900	1899	1900	1899	1900	1899	1900	1899	1900	1899	1900
Des Plaines at Joliet..	Jordan...	10.22	2.81	......	......	......	......	2.62	.413	.022	.048	.107	.15	......	......	29.6	6.4	77.1	27.
	Long.....	16.05	4.66	......	......	......	......	2.88	.85	.015	.09	.014	.02	......	......	......	......	85 49	31.4
	Palmer ..	15.8	2.13	.74	.17	1.02	.188	1.76	.362	.124	.0037	.217	.255	3.81	.753	29.6	7.9	101.6	24.3
La Salle	Jordan...	.824	.313	......	......	......	......	.578	.302	.258	.24	1.10	.80	......	......	14.2	7.87	20.	14.1
	Long.....	4.66	.55	......	......	......	......	.58	.36	.35	.25	1.45	.77	......	......	......	......	41.3	15.8
	Palmer ..	1.68	.77	.36	.17	.18	.138	.54	.28	.534	.2634	2.26	1.676	1.31	.699	14.1	8.3	50.8	23.3
Averyville	Jordan...	.248	.281	......	......	......	......	.475	.307	.14	.108	.90	.69	......	......	12.5	7.3	18.	13.3
	Long.....	.895	.21	......	......	......	......	.572	.34	.141	.12	1.1	.95	......	......	......	......	33.04	15.5
	Palmer ..	.36	.268	.35	.17	.15	.09	.50	.265	.1906	.1395	1.48	1.34	1.23	.6	12.4	6.8	36.8	21.2
Wesley..............	Jordan...	.374	.272	......	......	......	......	.489	.395	.101	.155	.123	.89	......	......	9.8	8.6	15.19	13.3
	Long.....	4.36	1.62	......	......	......	......	3.2	1.34	.026	.11	.106	.72	......	......	......	......	34.97	16.6
	Palmer ..	.36	.27	.38	.19	.24	.106	.62	.296	.1526	.0996	1.20	1.4	1.32	.72	13.3	7.8	36.1	21.1
Beardstown	Jordan...	.348	.150	......	......	......	......	.45	.354	.361	.283	.75	.57	......	...	10.6	10.6	8.71	10.5
	Long.....	......	......	......	......	......	......	......	......	......	......	.59	.87	......	......	......	......	......	......
	Palmer ..	.41	.15	.25	.21	.18	.134	.44	.344	.1257	.1071	.818	1.26	1.066	.718	11.8	8.7	21.3	17.6
Grafton	Jordan...	.132	.030	......	......	......	......	.398	.282	.0302	.019	.706	.72	......	......	10.30	7.6	6.35	9.5
	Long.....	.247	.07	......	......	......	......	.455	.36	.044	.03	......	......	......	......	......	......	17.5	10.6
	Palmer ..	.1008	.079	.23	.18	.11	.00	.34	.275	.0551	.0208	.881	1.089	.934	.535	10	7.9	14.8	14.9
Missouri at West Alton	Jordan...	......	.030	......	......	......	......	......	1.022	...	.001	......	.73	......	......	......	18.6	......	11.4
	Long.....	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	Palmer ..	.021	.097	.11	.12	.62	.756	.73	.879	.0071	.0033	.39	.591	.217	2.447	21.1	21.8	7.8	14.48
Mississippi at Grafton.	Jordan...	.096	.035	......	......	......	......	.707	.380	.010	.005	.55	.28	......	......	20.08	11.96	1.2	3.2
	Long.....	.08	.07	......	......	......	......	.443	.54	.001	.02	.03	.03	......	......	......	......	1.77	2.
	Palmer ..	.0406	.0885	.21	.199	.25	.245	.46	.444	.0058	.0055	.330	.402	1.206	.948	16.5	15.6	2.2	3.40
Mississippi at Alton. 100 feet from shore..	Jordan...	.056	.025	......	......	......	......	.56	.386	.018	.019	.77	.75	......	......	13.9	9.5	4.2	.09
	Long.....	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	Palmer ..	.023	.0822	.22	.206	.23	.188	.45	.394	.0041	.0132	.332	.848	1.228	.84	15.6	11.7	2.5	8.8
At Intake, St. Louis...	Jordan...	.062	.037	......	......	......	......	1.34	.761	.0039	.0039	.68	.36	......	......	27.7	17.2	4.06	9.2
	Long.....	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	Palmer ..	.023	.096	.14	.14	.76	.69	.90	.63	.0064	.0028	.442	.556	2.06	2.06	23.5	20.7	6.2	10.3

Jordan.
1899 May and June.
1900 Same.

Long.
1899 Summer Months.
1900 Same.

Palmer.
1899 June, July, August and September.
1900 Same.

11047 Q. Professor, will you please explain the table that you have just read into evidence and its significance, viewed from the standpoint of a sanitarian?

A. This table was prepared to throw some light upon the condition of the Illinois river in its upper reaches, and also such chemical changes as the river underwent as it passed down at the various points indicated in the first column of the same.

It was also designed to bring out a comparison between the waters of the Illinois river as delivered at the mouth of the Illinois into the Mississippi at Grafton with the quality of the waters of the Mississippi at Grafton, and at two other points down the stream. It was prepared to show what changes the stream underwent, the same being extended over considerable reaches of the river. The data here introduced are taken from the report on Streams Examination, and from Professor Long's report in the Illinois State Board of Health for 1901, and are those which we take in special consideration in determining the sanitary character of the water and the changes it undergoes from a chemical standpoint.

One of the most important data is the consideration
11048 of the presence of nitrogen, and its various stages of oxidation. Sewagic matters are rich in nitrogen and it becomes therefore of the utmost importance to determine not alone the presence of the nitrogen but also any changes the same may have possibly undergone. Nitrogen may be present in nitrogenous organic bodies, and in the process of slow decomposition in contact with air the nitrogenous bodies will break down into ammonia, which may subsequently become oxidized into the condition of nitrous acid and later into the condition of nitric acid. Free nitrous acid may be present in the water, but more probably as nitrites. The nitric acid is present in the waters as the dissolved salts, the so-called nitrates. Therefore, nitrous acid is always stated as nitrogen as nitrites and nitric acid as nitrogen as nitrates.

Chemical analysis, therefore, has to do with the determination of nitrogen present as undecomposed nitrogenous organic compounds; also with the nitrogen which may have undergone its first stage of decomposition into ammonia, with nitrogen as nitrites, and nitrogen as nitrates.

11049 Referring to these particular tables, I find that Professor Jordan uses an expression, "nitrogen as free ammonia." Professor Palmer, "nitrogen as free ammonia." Professor Long in his tabulations speaks of the ammonia as free ammonia. The tables showing this statement, namely of the ammonia, Professor Long's free ammonia or albuminoid ammonia, could be converted easily into nitrogen as free ammonia by diminishing all of his data upon ammonia or albuminoid ammonia by 3-17ths. The present statement, however, does not affect the interpretation of Professor Long's analyses or the significance to be attached to the same.

The study of nitrogen in these various conditions from albuminoid ammonia to free ammonia, to nitrogen as nitrites, and nitrogen as nitrates, therefore, present the condition of nitrogenous organic bodies in the various stages of decomposition of nitrogenous matters which may have been present. The albuminoid ammonia being an index of the undecomposed or partly decomposed nitrogenous matters, the ammonia where the decomposition has gone to such a point as to eliminate the nitrogen as nitrites indicating further change of the free ammonia, and the nitrogen as nitrates representing the ultimate stage of the oxidation of the nitrogen.

11050 The column of total nitrogen which was used only by Professor Palmer would represent the total nitrogen present in these different states of oxidation.

By oxygen consumed we understand the power of a water to absorb oxygen from an oxidizing material. This test for the presence of organic matters in water has been used for many years, and in fact was used before the introduction of the so-called albuminoid ammonia process. Historically the amount of oxidizable matter in the water was taken as an indication of the general purity or impurity and its suitability for public drinking and domestic purposes.

At the present time, however, it does not form the only index of the purity or impurity of the water and the sanitary character of the same, but it is one of the indices we use in valuing the quality of a supply.

The significance of the nitrogen consumed lies in the fact that it represents the amount of the oxygen which would be taken up from oxidizing agents by materials dissolved in the

water. These may be made up of other material capable of oxidation, but inasmuch as the organic matters in our western streams form practically the whole of such oxidizable
11051 matters the oxygen consumed is an index of organic and not inorganic pollution.

In waters from some other sources the oxygen absorbed by the water may point to inorganic contamination, as, for example, in waters from artesian wells which carry considerable amount of sulphurretted hydrogen or of metals in lower state of oxidation, such waters will absorb oxygen from oxidizing agents, but this is not true of waters exposed to the air as in the case of our open streams.

It is a general and important fact to bear in mind that waters may have a high oxygen consumption and yet reveal a relatively low content of nitrogen in its various stages of decomposition. This is true, in a general way, of waters coming from our northern country which require a large amount of potassium permanganate, the agent usually employed in carrying out this test; but strictly sewagic waters carrying a high nitrogen content may also require a large amount of ogygen to oxidize and destroy the organic matters.

Chlorine is taken also from these tables as an important index of the condition of a stream. Chlorine represents, generally, in our streams, common salt, not harmful in and
11052 of itself, but very important in studies of this kind as salt is the constant friend of, and accompanies sewage. The chlorine determinations, therefore, are of importance in estimating the sanitary character of a stream.

With this explanation of the terms employed in the original determinations and their significance, it is of value to note in this table of results which we have, showing the averages of analyses taken from the Desplaines, at Joliet, from the Illinois river, at LaSalle, Averyville, Wesley, Beardstown and at Grafton, from the Missouri at West Alton, from the Mississippi at Grafton, from the Mississippi at Alton, 100 feet from shore, and from the intake at St. Louis, a very high pollution from sewagic matters in the waters of the Desplaines at Joliet, the same gradually diminishing as we pass down the river as far as Averyville, showing an increased pollution at Wesley and again diminishing gradually until Grafton is reached, at the mouth of the Illinois river.

While the data as given by the different men for the periods indicated, namely Palmer for June, July, August and
11053 · September, for the years 1899 and 1900, and Jordan for
the months of May and June, 1899 and 1900, and Long during the summer months of 1899 and 1900, are not strictly comparable, yet in no essential point do they differ the conclusions which can be drawn from any one of these observers pointing clearly to the chemical purification of the waters of the Illinois river by the time they have reached Grafton, as indicated by a diminution in the amounts of free ammonia, in the amounts of albuminoid ammonia, the notable increase in nitrates, the diminution in oxygen consumed and in the diminution in the amounts of chlorine.

Another important fact is that the results of 1900 as compared with those of 1899 show at Grafton a diminution in the amounts of free ammonia, a dimimution in the amounts of albuminoid ammonia, a diminution in the amount of nitrogen as nitrites, but an increase in the amount of nitrogen as nitrates, a diminution in the amount of oxygen consumed and the chlorine showing an increase by Jordan, a decrease by Long and a very slight increase by Palmer.

In a word the important fact brought out is that the waters have undergone a practical degree of purification when
11054 they reach Grafton, and the analytical data clearly show
that the water in 1900 was of a quality superior to that in 1899, for these dates given.

Applying the same principle to the averages of the results of waters taken from the Mississippi river at Grafton, it is my opinion that the waters of the Illinois river at Grafton, as they empty into the Mississippi river, are better than the waters of the Mississippi river taken from the river at a point above Grafton.

Applying the same principles of interpretation of the analyses, it is my opinion that the waters of the Illinois, as delivered into the Mississippi river at Grafton, are of a quality, upon these dates for which these averages are given, and they were the only dates from which data were available, which covered similar periods and similar seasonable fluctuations of the stream), and comparing these data the waters of the Illinois as delivered into the Mississippi at Grafton, are upon the whole a better water, chemically, for drinking and domestic purposes than the samples taken from the intake at St. Louis, the water of the intake of St. Louis being the waters of the Mississippi river after it has received the flow from the Illinois and the Missouri rivers.

11055 Q. Have you examined the bacterial tables introduced in evidence and found in streams examinations, by Professor Jordan, and Professor Burrill?

A. I have studied these bacterial tables as submitted by Professors Jordan and Burrill, and have made a tabulation of results as given by them in their tables, which is already a matter of evidence.

Q. Will you read into evidence the tabulation of results, prepared by you, based upon the bacterial tables of Professors Jordan and Burrill?

A. The table is as follows:

11056

Some data bearing on the bacterial condition of the Illinois river at its worst state, viz., during the four months in the beginning of 1900.

	Morris.	Averyville.		Grafton.		Mississippi River --Grafton.	
	....	2	53,000	......	....	... ..	....
Jan. 10	1,224,000	9	9,100	4	2,600	4	200
16	1,200,000	16	58,800	10	3,300	10	2,400
26	1,230,000	23	51,000	17	29,600	17	8,000
29	290,000	29	147,000	24	58,500	24	15,200
	....	......	....	31	22,800	31	18,000
Feb. 5	215,000	6	48,000	7	18,700	7	7,400
12	320,000	13	210,000	14	84,000	14	28,000
19	520,000	20	58,000	21	16,000	21	33,000
	....	27	175,000	......	....	.....	....
Mar. 7	1,000,000	7	22,000	7	60,000	7	60,000
14	310,000	13	77,000	14	32,500	14	60,000
19	800,000	20	110,000	21	50,000	21	170,000
28	1,000,000	27	200,000	28	56,000	28	60,000
Apr. 3	940,000	3	33,000	4	18,000	4	140,000
9	390,000	10	23,000	11	4,000	11	28,000
16	225,000	17	9,000	18	3,000	18	5,000
23	60,000	......	....	25	3,300	25	40,200
30	22,000	29	3,600	. ....	....	......	....
	99,746,000		1,287,500		470,800		707,000
Average	600,125		75,735		29,375		44,187

11057 Q. Will you state how these tabulations were made and what they indicate?

A. These tabulations were made by myself from Dr. Jordan's tables as given in the report on Streams Examination, and were taken by me from those tables, as covering the worst conditions of the river in its lower reaches, endeavoring to get some view of the water in the conditions which those tables show to be the worst. These were copied off by myself, upon paper, and were then copied by myself on the typewriter, and verified.

There were four points only selected, one of those points being at Morris, Illinois, representing the river in its upper stretches; the second was from Averyville, where the data have shown a sanitary purification. The third was from Grafton, at the mouth of the Illinois river, and the fourth is from the Mississippi river at Grafton, the samples being taken from a point above the outlet of the river into the Mississippi river. These data were taken from the results given by Dr. Jordan during the months of January, February, March and April.

I note upon studying the results that at Grafton and Averyville we had a low count as compared with the waters in the upper part of the stream, the numbers at the beginning
11058 of January being low, a few thousand at Grafton, for instance, in the Illinois river, the lowest count being 2600, and in the Mississippi river at Grafton being 200; the first day at Averyville for the same date being 55,000, that being higher, for the following number on the 9th being but 9,000.

I note also that towards the end of April there was a decided diminution in the number of bacteria, the numbers at Grafton at the end of April having fallen down to the condition they were at the beginning of the year, and at Averyville there being about the same number, and at Morris the numbers having also fallen off.

I took that, therefore, as fairly indicative of the river at the worst period which I have noted bacteriologically, so far as these tables go, being the months of January, February, March and April of 1900.

The averages which I shall give presently seem to me, therefore, to fairly represent something concerning the actual condition of the river throughout this period. It was not subject to seasonal changes, the conditions at that time of the year being much more uniform, and not going beyond the first
11059 of May, it would be evident that it would not be subject to seasonal changes for through this period we have a practically uniform condition, especially of the river in its lower stretches, as at Grafton.

From this table it will be noted that the total number of bacteria at Morris run very high, being over a million the first three days in January and twice in March. The numbers at Averyville reached, one time in February, 210,000. At Grafton a number reached once was 84,000, and in the Mississippi river the number on two different dates, running as high as 170,000 and 140,000, but it will be noted from a study of the tables that in both the cases at Grafton and the case in the Mississippi river we have a small number at the beginning of this tabulation and a small number at the end. The intermediary numbers run uniformly much higher.

By making the averages for this period which in my judgment is comparable, as the condition of the stream was probably quite uniform throughout the period, I find that at Morris there were an average of 609,125 bacteria per cc. and at Averyville there were 75,535; at Grafton there were 29,375 and at
11060 the Mississippi river at Grafton 44,187, this being the
averages of the analyses taken upon sixteen dates from Morris, Grafton, at the Mississippi river, and for seventeen days at Averyville. These are the worst conditions of the river and are interesting as comparing the conditions at that time.

Q. What conclusion, based upon the bacterial table, just introduced, do you draw as to the comparison from a sanitary standpoint of the Illinois river at Grafton with the Mississippi river at Grafton?

11061 A. From a study of these tables, these tables being the results of the investigations of the samples of water on these different dates of the Illinois river at Grafton and the Mississippi river water at Grafton, I am of the opinion that so far as numbers of bacteria are concerned, the waters of the Illinois river at Grafton are of a better quality than the waters of the Mississippi river at Grafton.

Q. Have you examined the reports of Professor Jordan in Streams Examinations, which have been verified and offered in evidence in this case, and the bacteriological data from the tributaries of the Illinois river, the Illinois river and the Mississippi river at Grafton, and have you made a tabulation of the same?

A. I have.

Q. Will you produce and read such tabulation as you have prepared, in evidence?

A. The table that I have prepared is as follows:

11062 Some bacteriological data regarding rivers being averages of the number of bacteria for the first four months for the year of 1900 as given by Jordan in Report of Streams Examination:

Desplaines river, Lockport,	Ave. of	15,625	per c. c.
Kankakee river, Wilmington,	" "	16,162	" "
Fox river, Ottawa,	" "	34,480	" "
Big Vermillion, LaSalle,	" "	23,900	" "
Sangamon, Chandlerville,	" "	33,106	" "
Illinois, at Grafton,		29,375	" "
Mississippi, Grafton,		44,187	

Desplaines,	15,625	
Kankakee,	16,162	
Fox,	34,480	34,480
Big Vermillion,	23,900	23,900
Sangamon,	33,106	33,106
	123,273	91,486
Ave.,	24,656	30,495
Illinois,	29,375	
Mississippi,	44,187	

11063 Q. Will you state what that table shows that you have just read in evidence and what sanitary significance do you attach to it?

A. This table was made up from averages of results as stated by Jordan in his Streams Examination, the average being made by myself, the period covered being from the first of January in 1900 to the end of April of the same year, the same being intended to cover a period similar to that covered by the data introdced in the previous table.

The data in this table are averages of the results as given by him of samples of water taken from rivers tributary to the Illinois. As the results of such analysis I find that the average number of bacteria in the water of the Illinois at Grafton is a little above that of the average of these streams, namely the Desplaines River at Lockport, the Kankakee at Wilmington, the Big Vermillion at LaSalle and the Sangamon at Chandlersville, and the Fox at Ottawa.

It is to be noted that two of these rivers, the Fox river at Ottawa and the Sangamon at Chandlersville, carry a number of bacteria in excess of that of the river at Grafton.

11064 The water of the Big Vermillion is in bacterial content about the average of the five rivers, the Desplaines, the Kankakee, the Fox, the Big Vermillion and the Sangamon, the water of the Desplaines river at Lockport and the Kankakee river being below the average. The waters discharging into the upper part of the Illinois river are therefore lower than those in the lower reaches of the river. Averaging the five rivers together I find that the total number of bacteria per cc. in these waters to be 24,656. I find, averaging the last three, the Fox, the Vermillion and the Sangamon, the average is 30,495 throughout this same period. The Illinois river at Grafton is 29,376, the average of the Mississippi river at Grafton, for the same date, being 44,187. The waters of the Mississippi river are not included in this average. It is my opinion, therefore, that the bacterial condition of the water of the Illinois river at Grafton, from such studies as this, is fairly comparable with the waters emptying into the stream at this season through the same period. It is better bacterially than the average of the waters of the Mississippi river taken at Grafton through this same period.

Adjourned until 2:00 p. m., same date.

11065 2.00 p. m., Tuesday, March 1, 1904. Continuation pursuant to adjournment.

Present, the Commissioner, and same counsel representing the respective parties.

PROF. E. G. SMITH,

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. Have you made a comparison of the bacteria flow of the Illinois river at Grafton with the flow of the Mississippi river at the same point and points below as given in tables submitted by Professor Jordan, in the report of Streams Examinations which have been already introduced into evidence?

A. I have prepared such a table, a table representing the bacterial content of the waters at Grafton, being at the mouth of the Illinois river.

Q. Will you produce and read such table in evidence?

11066 A. The table is as follows:

A comparison of the bacterial flow of the Illinois river at Grafton with the flow of the Mississippi river at the same point and points below as given in the tables submitted by Jordan in the Report of Streams Examination. Average of the counts for the first four months of 1900 when in the worst condition.

Illinois river at Grafton	29,375 per c. c.
Mississippi river at Grafton	44,187 " "
" " " Alton 100′ from Illinois shore	43,906 " "
" " " Alton one-fourth distance from Illinois shore	69,919 " "
Mississippi river at Alton, mid-stream	78,044 " "
" " " Alton one-fourth distance from the Missouri shore	82,294 " "
Mississippi river at Alton, 100′ from Missouri shore	64,233 " "
Mississippi river at Chain of Rocks, 400′ from Illinois shore	53,100 " "
Mississippi river at Chain of Rocks, midstream	69,825 " "
" " " Chain of Rocks, inlet tower	58,309 " "
" " " Chain of Rocks, 400′ from the Missouri shore	73,791 " "
Missouri river at Fort Bellefontaine, West Alton, Mo.	56,035 " "

11067 Q. From the table of bacterial comparison which you have just read, will you state what sanitary significance you attach to this table as showing the comparative pollutions of the Illinois, Mississippi and Missouri rivers?

11068 A. From a comparison of the data submitted in this table, representing the bacterial flow of the Illinois river at Grafton with the flow of the Mississippi river at the same point, and points below, as given in the table submitted by Professor Jordan in the report of Streams Examination, I find from the average of the counts of the bacteria for the first four months of 1900, which months according to my study of the tables represent the rivers in their worst condition, it is my opinion that the Illinois river as indicated by these tables is better in the number of bacteria contained in the same than the Mississippi river at

Grafton or the Mississippi river at Alton, 100 feet from the Illinois river, or at the Mississippi river at Alton, ¼ distance from the Illinois shore, or the Mississippi river at Alton, in midstream, or the Mississippi river ¼ distance from the Missouri shore, or the Mississippi river at Alton 100 feet from the Missouri shore or the Mississippi river at the chain of rocks, 400 feet from the Illinois shore or the Mississippi river at the chain of rocks in midstream, the Mississippi river at the chain of rocks at the intake tower, the Mississippi river at the
11069 chain of rocks 400 feet from the Missouri shore and from Bellefontaine, West Alton, Missouri.

This table indicates the much larger number of bacteria at these points than from the Illinois River at Grafton, this covering, as already stated, the first four months of 1900, taken from the tables; the river appears to be in its worst condition during the period which the table covers.

Q. What is your opinion as an expert chemist and sanitarian basing that opinion upon all the knowledge which you possess as well as interpreting the series of tables offered in evidence by Professors Jordan, Long and Palmer, of the waters of the Illinois River as to whether the pollution and contamination from the sewers of Chicago emptying into the Chicago River and thence into the Drainage canal continues to be manifest and present as far down the Illinois River as Grafton and at the Chain of Rocks on the Mississippi River?

A. From all knowledge available, from a study of the chemical tables in evidence by Professors Jordan, Long and Palmer, of the waters of the Illinois River, as well as all knowledge available to me in passing an opinion, the same
11070 being derived from a personal inspection of the river, from a study of the bacterial as well as the chemical data, I am very clearly of the opinion that pollution and contamination from the sewers of Chicago emptying into the Chicage River and thence into the drainage canal and so out into the Illinois River does not continue to be manifest and present as far down the Illinois River as Grafton, but on the contrary it seems to me that the agencies operating in the self purication of the stream, especially the agencies of dilution and sedimentation, of the bacterial and chemical changes which obtain in the stream, the duration of the life of the typhoid ba-

cillus, the data already being in evidence in this case, and the flow of the river, the combination of these agencies all tending to practically purify the river so that sewage as such does not reach down the Illinois River as far as Grafton; and, further, if for the above reasons in my opinion the contamination, and the pollution from the sewers of Chicago do not obtain in the Illinois River at Grafton, such contamination and pollution cannot be manifest and present from the Illinois River at the chain of rocks in the Mississippi River.

11071 Q. Were you acquainted with the Illinois River at Peoria prior to January, 1900?

A. In the course of my sanitary work I was asked by the Peoria Water Company, at the time of the installation of the new plant in 1892, to assist them in the determination of the best supply available for such new plant, and in the course of the analysis made at the time I made some analyses of the Illinois River and some investigations upon the subject.

Q. What was the condition of the Illinois River in 1892?

11072 A. In the course of the investigation made at that time the river was, in my opinion, unfit for use as a public water supply, and at my advice the company dropped the consideration of the stream for that use.

Q. How does the condition of the Illinois River at Peoria now or since 1900 compare with the conditions that obtained at the time you made these examinations for the Peoria Water Company?

A. In my opinion the water at the present time is of a better quality than it was at that time, in 1892.

Q. Describe the appearance of the water at that time?

A. In the course of those investigations I was upon the river in a boat and went out to and was across the wagon bridge observing the river from time to time, and samples were taken for chemical analysis from the river. It was of a dirty appearance as I recall it, and possessed, in warm seasons, a decidedly disagreeable odor.

Q. When was the last time you observed the Illinois River at Peoria?

A. The last time I observed the river at Peoria was in September of 1903.

11073 Q. In appearance how did the river compare in September, the time that you observed it last, with the conditions that obtained in 1892?

A. At the time I was there in September there had been a rain storm just preceding it, and the river was muddy and so much silt in it I do not think I could institute a comparison, further than that at the time I was there in September it was muddy from previous rains. There was no odor observable, in September, nor was the water offensive to sight or smell, beyond the presence of the mud and silt in the stream.

I remember going across the bridge in 1892, when there was a flood in the river, in the spring time, and the river was dirty and muddy and riley, although I made no chemical analysis or examinations of the water at this particular time, with the mud and silt in the water.

Q. Will you state, as a sanitary expert, basing your opinion upon all the information you possess in this case whether in your opinion the water supply of St. Louis is contaminated, polluted or injured by the sewage of Chicago entering the drainage canal and from thence into the Illinois River?
11074

A. As a sanitary expert, basing my opinion upon all the information which I posses in this case, such information being derived from the study of the physical properties of the stream from a personal examination of the same throughout its entire length, from the mouth of the Chicago River to the mouth of the Illinois at Grafton, from a study of all bacteriological and chemical data which have been submitted in this case, from a knowledge of the experiments regarding the vitality of the typhoid bacillus, the experiments being carried out in the waters of the Illinois River, after the same has received the sewage of the city of Chicago, by way of the Chicago drainage canal, from the rate of flow of the river, from the study of the agencies operative in the self-purification of the stream, consisting of dilution, sedimentation, all chemical and bacteriological changes affected in the same, from the comparison of the data of the waters through the upper reaches of the River after it has received the sewage of the City of Chicago through the drainage canal, the comparison of the results, both bacteriological and chemical, at Averyville and after the river has 11075 received the sewage of the city of Peoria and smaller towns, and the quality of the water of the river as evidenced by the analyses made at the city of Grafton, near the mouth of the Illinois River, and comparing the same with the data at hand regarding the quality of the Mississippi River, and my personal knowledge of the habits of the stream and the sanitary quality of the waters of the same, and from an examination of the data regarding the quality of the Missouri River, I am of the opinion that the water supply of St. Louis is not contaminated, polluted or injured by the sewage of Chicago entering the drainage canal and thence into the Illinois River.

Q. From your examination of all the analytical data in this case as heretofore introduced by the witnesses for the defense, what is your opinion as a sanitary expert and chemist as to whether any of the original organic matter of the sewage from Chicago finds its way into the intake tower at the St. Louis water works, chain of rocks?

A. My examination of all data which I have been able to gather together, which bears upon this case, from a study of the tables submitted by witnesses for the defense in this case, from my knowledge of the conditions of the Illinois River throughout its entire length, derived from the personal inspection 11076 of the same, from the data regarding the viability of the typhoid germ and the period of time necessary for water to flow from Chicago to St. Louis, and from my study of the agencies operative in the sanitary purification of this stream, from the chemical and bacteriological changes which obtain through the course of its flow, it is my opinion that sewage from the city of Chicago becomes practically purified at Grafton and the quality of the Illinois is fairly comparable with that of streams forming its tributaries, and that the sewage of Chicago has become purified practically, the pathogenic bacteria having been eliminated in the process of flow of the stream, and hence the original organic matter of the sewage from Chicago does not find its way into the intake tower of the St. Louis water works at the chain of rocks.

Q. Will running water purify itself so as to be free from pathogenic bacteria that may be placed therein?

A. From studies which I have made upon the question as to self purification of running streams, I am very clearly of the opinion that running water can and does purify itself so as to be free from pathogenic bacteria which may have been placed therein.

11077 Q. Since your opinion as an expert upon water supplies as to whether or not the waters of the Mississippi River was at the center of the main channel of the said river, below the mouth of the Illinois River and down to the intake tower of the St. Louis Waterworks at the chain of rocks are less valuable for drinking purposes and more liable to carry water borne diseases, such as typhoid fever and cholera now than they were before the sewage from the sanitary district of Chicago was run into it, from the drainage canal, and through it into the Illinois River?

A. From all the knowledge which I have upon the sanitary quality of the Mississippi River after the same has received the waters of the Illinois River, from the fact that the agencies of self purification of a running stream obtains in the Illinois River, from the fact that in my opinion the waters of the Mississippi River are not of as good a quality as those of the Illinois River before the Illinois River may have found access to the same, because my study of the Illinois River leads me to consider that the sewage as a factor has been practically eliminated from the Illinois River before it empties into the Mississippi River, at Grafton, I am of the opinion that the 11078 Mississippi River at the intake tower of the St. Louis water works at the chain of rocks is not less valuable for drinking purposes and it is not more liable to carry water born diseases such as typhoid fever and cholera now than it was before the sewage of the sanitary district was run into it.

Q. State whether or not an increase in the speed of the current in the Illinois River, by reason of an added volume of water in the drainage canal would affect the amount of sedimentation that might occur in the Illinois River, and if it does affect it how and in what manner?

A. The volume of water in the Illinois River being increased by water received from Lake Michigan and the speed of the current thereby increased, the sediment being more widely distributed, the amount of sedimentation in any given strip of the river would be diminished over that which it would be without receiving the increased volume of water through the drainage canal, carrying, as it does, the clear waters of Lake Michigan.

Q. What effect if any would the increased speed of the current in the Illinois River have upon the time within which sewage from Joliet, Peoria and other towns on the Illinois River, have if emptied into the waters of the Mississippi, if the same are so removed as compared with the conditions which existed at the time it might have taken before the added volume of water from the drainage canal was put into the water of the Illinois, taking into consideration all that you know about the conditions that obtain in the Illinois River?

A. In my opinion the increase in the speed of the current in the Illinois River would have an effect to remove the sewage from Joliet, Peoria and other towns on the Illinois River, further down the stream, towards the waters of the Mississippi River and this as compared with conditions which existed before this volume of water was added to the river would be to cause sewage to extend over wider reaches of the river.

Q. If water is made more clear and less turbid than it was before, by an added volume of water being placed therein, will such bacteria as typhoid have more or less tendency to go down to the bottom of the stream than they had prior to the water being rendered less turbid?

A. It being my opinion as already stated in evidence that the solid particles carried in the stream are an important agency in effecting the precipitation of the bacteria, it would follow that water being made more clear and less turbid than it was before by the addition of a volume of clear water being placed therein, the bacilli of any form, that of typhoid fever among them, would have a less tendency to be precipitated to the bottom of the stream than they had prior to the water being rendered less turbid.

Q. If an increased volume of water in the Illinois by the addition of the waters of the drainage canal would make an increased speed in the current of the Illinois River, would that increase in the said current have any effect in increasing or diminishing the typhoid and other water born diseases on the part of the inhabitants of the state of Missouri using the waters of the Mississippi River for drinking purposes, below the mouth of the Illinois River?

A. If the volume of water in the Illinois be increased by the addition of pure lake Michigan water to the drainage canal, and the speed of the current of the river thus be increased, such increase in said current, in my opinion, would not have
11081 any effect on increasing or diminishing the liability to typhoid and other water born diseases on the part of the inhabitants of the State of Missouri using the waters of the Mississippi for drinking purposes, below the mouth of the Illinois River; and for this reason, in my opinion, from all studies of the river, from an inspection of the same, and from a study of the analytical data available, both chemical and bacteriological, from a knowledge of the death rate of typhoid fever in the Illinois River, and the rate of flow of the same, of the chemical and bacterial processes operative in the river, tending to its self purification, all sewagic matter as such has been essentially changed and the Illinois River becomes self-purified at Grafton or before reaching Grafton, and the sewagic bacteria have been removed from the water before that point has been reached, the river becoming comparable with the rivers in that section of the state tributary to the same, and thus the bacterial life having been removed, typhoid and other water-borne diseases could not affect the inhabitants of the State of Missouri using the waters of the Mississippi River for drinking purposes below the mouth of the Illinois River.

Q. Assuming that the number of bacilli coli communis in
11082 the waters of the Illinois River at Grafton are at intervals no larger than the number contained in it before the opening of the drainage canal, do you consider for that reason that the water is at all times no more dangerous than formerly?

A. From such studies as I have been able to make of the river noting the data at different intervals so far as they have been submitted to me by the Streams Examination and by witnesses for the defense, I am of the opinion that the water is at all times no more dangerous than it was before the waters from the drainage canal found access to same.

Q. Professor Sedgwick, in answer to the following question: "Assuming that the germs of typhoid fever coming from

the sewers of Chicago and passing by way of the drainage canal to Lake Peoria might be in large numbers deposited in the bed of Lake Peoria for a period of a month say, do you consider that typhoid germs would be entirely destroyed at the end of that time, in that deposit?" answered "No. sir." What do you say as to the assumption that typhoid germs could pass from the sewers of Chicago, by way of the drainage canal to Lake Peoria and be deposited there in the bed of Lake Peoria for a period of a month, and as to whether or not typhoid
11083 germs coming from the drainage canal, under conditions as they exist today, would live for a period of a month and not be destroyed before the end of that period?

A. In regard to the assumption that typhoid germs could pass from the sewers of Chicago, by way of the drainage canal to Lake Peoria and be deposited there in the bed of Lake Peoria for a period of a month it is my opinion from my study regarding the purification of the stream, basing that knowledge upon the analytical data submitted as evidence in this case, which data indicate the removal of sewagic bacteria be-
11084 fore Lake Peoria is reached, it would follow that the typhoid germ from the sewers of Chicago, by way of the drainage canal, do not reach as far as Peoria, and in further support of this view we have the direct evidence secured by the results of the experiment upon the duration of life of the typhoid fever germ showing that in the waters of the Illinois river it does not live for a period of more than three or four days. I am of the opinion, therefore, that the typhoid germ could not pass from the sewers of Chicago by way of the drainage canal to Lake Peoria and be deposited there for a period of a month. And further, experimental data alluded to above indicate that the conditions as they exist today are hostile to the life of the typhoid germ and therefore they would be destroyed before reaching Lake Peoria.

Q. Professor Sedgwick, in answer to the question: "Assuming that typhoid fever germs coming from Chicago sewers are deposited in large numbers in the lakes and slack water portions of the Illinois River above Peoria, do you or do you not consider that flood conditions such as would scour the deposits

from the beds of the streams would cause the water leaving Lake Peoria to contain at times more infectious and dan-
11085 gerous pollution than is at present in the diluted sewage entering at the Bear Trap Dam at the foot of the drainage canal?" stated "I think at times it might." What is your opinion, taking into consideration all that you know about the conditions of the drainage canal, the Desplaines River and the Illinois River as a sanitary expert as to whether such conditions at times might exist?

11086 A. From all the knowledge which I have been able to obtain about the conditions in the drainage canal, the Desplaines River and the Illinois River, the same being based upon personal inspection and analyses, both chemical and bacteriological, already submitted in evidence in this case, from the bacterial purification of the river, as shown by such tables which obtain at Lake Peoria, and especially from the positive results we have in the experiments of Doctors Zeit, Jordan and Russell upon the viability of the typhoid germ in the sewage-laden waters of the Illinois River, the results of such experiments being to show that the typhoid germ lives for a short time in the water of this river, the period being represented by three or four days, it is my opinion that the typhoid fever germs coming from the Chicago sewers would not reach down the Illinois River as far as Peoria, and further, even if such bacteria may be deposited in the sediment of the stream in the course of its passing down the river, the fact that the same has been taken up from the sediment of the river and been subjected to the destructive agencies of the stream, I am further
11087 fortified in the opinion that the typhoid bacillus would not reach as far as Lake Peoria and therefore water leaving Lake Peoria could not possibly contain more infectious and dangerous pollution that are at present in the diluted sewage entering the Bear Trap Dam at the foot of the drainage canal.

Q. What is your opinion as to whether typhoid fever germs coming from the sewage of Chicago are deposited in large numbers in the lakes and slack water portions of the Illinois River above Lake Peoria?

A. From all data available concerning the character of the water in the Illinois River, the agencies at work in the river affecting chemical and bacterial changes, all evidence showing a bacterial purification of the river at Lake Peoria, and added to this the positive results from experiments instituted and carried out by Dr. Zeit, Dr. Jordan and Dr. Russell, I am very clearly of the opinion that typhoid fever germs coming from Chicago sewers do not reach the lakes and slack water portions of the Illinois River above Peoria.

Q. What is your opinion, based upon all the knowledge which you have of conditions at Lake Peoria, as a chemist, bacteriologist and sanitary expert as to whether at any time,
under any conditions, the number of typhoid bacilli at
11088 that point is even as great as it is at the Bear Trap Dam
at the end of the drainage canal?

A. It is my opinion that by no possibility and under no conditions of the river can the number of typhoid fever germs at any point be as great as they are at the Bear Trap dam at the end of the drainage canal.

Q. Do you know of any evidence scientifically secured or otherwise that shows that accumulations of typhoid germs are found in lakes or slack water basins of rivers and remain there in storage in vast numbers for any considerable period of time in a virulent state and are suddenly flushed out by freshets so that great numbers of typhoid fever germs are present, flowing in a stream a considerable distance from the source of pollution in greater quantities than exist at the source of pollution?

A. I know of no evidence scientifically secured which shows that such accumulations of typhoid fever do occur in the slack waters and basins of any river so that greater numbers of typhoid fever germs are ever found floating in a stream within a considerable distance from the source of pollution, and certainly not in greater quantities than they exist at the source of pollution.

11089 A. Assuming that no other pollution or infectious matter or infection enters the river, save that which it receives from the sanitary district of Chicago, from your knowledge as a chemist, bacteriologist and sanitary expert, have you had any personal experience or knowledge which would lead you to believe that the water of the Illinois River at Grafton is infected with the sewage from Chicago, and if said water enters the Mississippi River, becoming mixed with the latter water, would it be a menace to the inhabitants of the Missouri shore of the Mississippi River using the Mississippi River water for drinking purposes, at points below on the Missouri shore?

A. Assuming no other pollution or infection, I have no knowledge which would lead me to believe that the water of the Illinois River at Grafton is infected with the sewage of Chicago and therefore if the said water emptied into the Mississippi River and mixed with the water, it would not become a menace to the health of the inhabitants of the Missouri shore of the Mississippi River for drinking and domestic purposes.

Q. Is there anything, based upon your knowledge as a chemist, bacteriologist and sanitary expert which would lead you to believe that the waters coming from the Illinois 11090 River at Grafton were infected by the sewage of Chicago?

A. I have not, basing my knowledge as a chemist and sanitary expert upon all data which I have been able to gather and from personal knowledge of the course and habit of the stream which would lead me to believe that the water coming from the Illinois River at Grafton was infected with the sewage from Chicago, but on the contrary I believe that the process of natural purification which obtains in this stream, the dilution the sedimentation, the bacterial and chemical changes, the germicidal effect of the waters upon bacteria carried by the same its rate of flow, all contribute to practically purify the waters of the River at Grafton from sewage which may enter at Chicago.

Q. Assuming that the water of the Illinois River mixed with the waters of the Mississippi river at Grafton and subsequently mixed with the waters of the Mississippi River at its mouth, do you consider the waters of the Illinois River thus comingled with the waters of the Mississippi River and the Missouri River a menace to the health of the inhabitants of Missouri living upon the Mississippi River, using the Mississippi River water for drinking purposes at points on the Missouri shore?

A. From my knowledge of the quality of the water as it

issues from the mouth of the Illinois River at Grafton,
11091 before the same becomes mingled with the waters of the
Mississippi, in my judgment being better in quality than either the Mississippi River as it flows by at Grafton or than the Missouri River as it empties below, I am clearly of the opinion that the water of the Illinois River, thus comingled with the waters of the Mississippi and Missouri Rivers is not a menace to the health of the inhabitants of Missouri living upon the Mississippi River using Mississippi River water for drinking purposes at points on the Missouri shore.

Q. Is there any evidence to be secured, chemical, bacterial or otherwise, in your opinion, that can establish the conclusion that the waters of the Illinois River at Grafton are infected by the sewage from Chicago, eliminating all other sources of infection?

A. In view of the extent, quality and kind of investigations bacteriologically, chemically and otherwise that have been made in this case being so extensive and exhaustive as they are, it is my opinion that there is no evidence which could establish the conclusion clearly and decidedly that the waters
11092 of the Illinois River at Grafton are infected with sewage
from Chicago.

Q. Now, assuming that the only pollution upon the water shed of the Mississippi and its tributaries above the intake of the St. Louis water works was that derived from the sanitary district of Chicago, and having in mind the large amount of typhoid fever in Chicago, do you or do you not believe that infected and dangerous pollution might, under existing conditions find its way into the water supply of the city of St. Louis?

A. The evidence as already introduced in this case, both chemically and bacteriologically showing, in my opinion, so conclusively that the agencies of self-purification operative in this stream have practically transformed sewagic matters from the city of Chicago before they reach Grafton, reducing the river at that point practically to the condition of the streams tributary to the same, and the positive results secured from the experiments of Doctors Zeit, Jordan and Russell, upon the viability of the typhoid fever in the polluted waters of this stream, I do not believe that infections and dangerous pollution might under existing conditions find its way into the water supply of St. Louis.

11093 Q. Assumming that there was no typhoid fever pollution of the waters upon the water shed of the Mississippi and its tributaries above the intake of the St. Louis water works other than that derived from the sanitary district of Chicago, do you or do you not believe that typhoid fever germs from said district are liable to find their way into the water works of the city of St. Louis through the intake at the chain of rocks?

A. Eliminating all possibility of typhoid fever infection or other pollution of the waters of the water shed of the Mississippi River above the intake of the St. Louis water works other than that derived from the sanitary district of Chicago, in view of all evidence at hand regarding the quality of the Illinois River at Grafton, the bacterial and chemical agencies at work tending to self-purification of the stream, and the positive evidence upon the viability of the typhoid germ as proved by the experiments of Doctors Zeit, Jordan and Russell already a matter of evidence in this case, I do not believe that typhoid fever from the sanitary district can find its way to the water supply of the city of St. Louis through the intake at the chain of rocks.

Q. Professor Sedgwick, in answer to the question just 11094 propounded to you, stated: "I believe they are liable to find their way into the intake" and when asked why, answered "for the reason that typhoid fever having been frequently very abundant in the city of Chicago, I must start with the assumption that a very large number of typhoid germs find their way into the sewage of the city, pass through the sewers and on into the sanitary canal, and subject to local conditions may, in diminishing numbers, pass out of the Illinois River, mingle with the waters of the Mississippi River and pass over to the other side and find their way into the intake at the chain of rocks." I want to ask you do you know of any evidence, based upon any analyses, experiments or otherwise that justifies the assumption that typhoid fever germs will pass through the sewers and on into the drainage canal and subject to local conditions may, in diminishing numbers, pass out of the Illinois River, mingle with the waters of the Mississippi and pass over to the other side and find their way into the intake at the chain of rocks of the St. Louis water supply?

A. In answer to that question I would say that I know of no evidence to support the assumption thus made, but upon the contrary the analytical data and the results of the ex-
11095 periment which has been carried out decidedly indicate that in the Illinois River the assumption is unwarranted, all evidence both bacteriological and chemical pointing to the bacterial purification of the river at Averyville, a marked chemical purification of the same at that point and completed at Grafton, and the positive evidence which we have from the experiments carried out by Doctors Zeit, Jordan and Russell upon the viability of the typhoid bacillus in the waters of this River, showing that the duration of life is of a short period in this sewage-laden stream in its upper reaches, the same not extending for more than a period of three or four days, and rate of flow of the river being largely in excess of this period. the typhoid fever germs in my opinion can not pass from Chicago through its sewers, out into the drainage canal, thence into the Illinois River, thence into the Mississippi River and across the same and enter the intake tower at the chain of rocks at St. Louis.

Q. Assuming that an epidemic of Asiatic cholera should break out in the city of Chicago, is it possible that the germs of that disease might find their way into the intake tower at the St. Louis water works at the chain of rocks, from the city of Chicago.

A. It is my opinion that in the event of an outbreak of cholera in the city of Chicago, the germs of that disease
11096 could not find their way into the intake tower at the chain of rocks of the St. Louis water works from the city of Chicago, for the reason the bacterial agencies at work, operative in the purification of the stream effect a bacterial purification of the Chicago river before Averyville is reached. Regarding the cholera germ, from such knowledge as I have been able to gather concerning it, it is less resistant than the typhoid fever germ and therefore any agency operating to the removal of the typhoid fever germ would, in my opinion, be more decided than in the case of the typhoid fever germ.

Q. Considering your personal knowledge as a sanitary expert of typhoid fever conditions in the sanitary district of Chicago, and existing conditions in said district as to sewers and outfalls there and of the amount of sewage and all the existing conditions of the Desplaines, Illinois and Mississippi and Missouri Rivers, and all the conditions existing upon the water sheds of said streams and the tributaries thereof, and all existing conditions as to the water supply of the City of St. Louis and the general sanitary conditions existing in the City of St. Louis, would you or would you not beyond a reasonable doubt attribute the principal portion of the increase of typhoid fever in St. Louis, assuming there has been an increase in St.
11097 Louis, since the opening of the drainage canal, to the infected sewage of the sanitary district of Chicago?

A. For reasons which have been given repeatedly in this examination, conditions which obtain in the river from the self-purification of the same, all of which in my opinion contribute to the practical removal of all sewage as such from the river at Grafton, I should not attribute, beyond any reasonable doubt the principal portion of the increase of typhoid fever in St. Louis to the infected sewage of the sanitary district of Chicago.

Q. Professor, do you consider that the Illinois river water containing the mixed sewage and canal water from the Chicago Sanitary District, since the opening of the drainage canal, has rendered less safe and wholesome now than before the opening of the canal for drinking purposes on the part of the inhabitants of the State of Missouri, the waters of the Mississippi river below the mouth of the Illinois river?

A. From the conditions of the river, the agencies operative in the self-purification of the stream, which in my opinion have practically transformed all sewage entering the river from the drainage canal when the river reaches Grafton,
11098 it is my opinion that the drainage canal has not rendered less safe and wholesome the water used for drinking purposes on the part of the inhabitants of St. Louis, using the waters of the Mississippi river below the mouth of the Illinois river than they were before the canal was opened.

Q. Professor Sedgwick, in answer to a question among other things answered: "The mere presence of pollution, I mean by that uninfected sewage, that is, supposing Chicago reduced her typhoid death rate and would still put her sewage down there, that sewage as affecting the longevity or growth of germs that get in from Peoria or elsewhere would be an added menace to cities with water supply, even if she did not send typhoid fever germs down, sending the filth alone is serious." I will ask you what is your opinion based upon a bacteriological, chemical and sanitary experience as to whether the sewage from Chicago favors the longevity or growth of germs from Peoria or anywhere else, emptying their sewage into the Illinois river?

11099 A. From the evidence already given in this case and particularly the positive results of the experiment by Doctors Zeit, Jordan and Russell, in which they have demonstrated that the typhoid germs from the City of Chicago can live but a short period in this sewage laden water, such period covering, according to those observations perhaps three or four days, it is my opinion that the sewage of Chicago does not favor the longevity or growth of germs from Peoria or any other city also emptying its sewage into the river, but on the contrary the same agencies which have operated in this river, which have tended to diminish the viability of typhoid fever would still be operative upon typhoid fever germs coming from points below.

Q. Does the presence of sewage in water add to the longevity or growth of germs?

A. From all knowledge I have been able to gather by study upon this question, and from the study of the experiments, by Drs. Zeit, Jordan and Russell, it is my opinion that the presence of sewage in water tends to diminish the viability of the typhoid bacillus.

11100 Q. Do you consider that the Illinois river water polluted and infected by the sewage from the Chicago drainage district, since the opening of the drainage canal, has rendered less safe waters or water supply of the City of St. Louis as drawn at the intake tower, chain of rocks, at the City of St. Louis?

A. It is my opinion that the Illinois river polluted and infected from the sewage of Chicago Sanitary District, subject as it is to the purifying agencies operative in this stream, tending to transform the same, which according to data is practically complete at Grafton, it has therefore not rendered less safe the water supply of the City of St. Louis as drawn at the intake tower chain of rocks.

Q. Assuming that the Chicago sewage from five million people living in the sanitary district of the City of Chicago, should be discharged into the Chicago drainage canal and carried through the canal into the Desplaines river and thence into the Illinois River, Chicago being situated 357 miles from the St. Louis intake, and assume that a typhoid epidemic of extraordinary proportions should become prevalent among the residents of the sanitary district and at a time when the sewage from said district is being discharged in the canal, what immediate and pending danger would exist and what effect would it have on the people of St. Louis and those people living on the Missouri side of the Mississippi river below Grafton
11101 who use the water of the Mississippi river for drinking purposes?

A. Assuming that the population of Chicago should increase even to the population of five million and the sewage should be discharged into the drainage canal and be carried through the drainage canal to the Illinois river and so pass down the river to the Mississippi river, in my opinion the bacterial or the germicidal effects of the water would still be operative and operative in a degree as efficient as they are at present, and inasmuch as the action of the water bacteriologically and chemically and otherwise, according to the experiments already introduced in this evidence now destroys the typhoid bacillus at a period not exceeding three or four days, in my opinion it would follow that the causes operative in the river would even with a population of five million and with a typhoid fever epidemic obtain so that the sewage from the sanitary district, discharged into the canal would not be an immediate and impending danger upon the people of St. Louis and people living on the Missouri side of the Mississippi river using the water of the Mississippi river for drinking purposes.

Q. Taking into consideration all the knowledge which you possess in regard to the chemical, bacterial and physical conditions of the waters of the Illinois river and its tribu-
11102 taries and the river itself and the different towns sewering into the Illinois river and its tributaries, the population upon the watershed of the Illinois river, both rural and

urban, the discharge of the river under all conditions and during all seasons, what is your opinion as to the effect of flowing the sewage from Chicago through the drainage canal into the Desplaines and Illinois rivers, upon the inhabitants of the State of Missouri, using the waters of the Mississippi river for drinking and domestic purposes?

A. Taking into consideration all the knowledge which I possess regarding the chemical, bacterial and physical conditions of the waters of the Illinois river and its tributaries, such knowledge being secured from an inspection of the same, from the mouth of the Chicago river and the drainage canal, and the river to its mouth at Grafton, in view of all the data available from every source, I am very clearly of the opinion that the effect of flowing the sewage of Chicago through the drainage canal and the Desplaines and Illinois rivers does not militate against the healthfulness of the inhabitants of the State of Missouri using the water of the Mississippi river for drinking and domestic purposes.

11103 Q. Taking into consideration all the assumptions assumed in the last foregoing hypothetical question, and taking into consideration all the typhoid statistics as they obtain along the watershed of the Missouri, Mississippi and the Illinois river, in the City of Chicago and in the City of St. Louis, and assuming that there is an increase of typhoid fever cases in the City of St. Louis since January, 1900, and taking into consideration all chemical, bacterial and other knowledge which you possess, what is your opinion as to whether the increase in typhoid fever, assuming that there has been an increase as above indicated, in the City of St. Louis since the opening of the drainage canal can be attributed to the opening of the drainage canal, as the direct, immediate and approximate cause of said increase beyond all reasonable doubt?

A. From such study as I have given to the conditions stated in the assumption and your question, from my knowledge of the habits of the Mississippi river, it being in my judgment a water unfit to use in its raw state for public water supply, in view of the fact that the pollution existing from the Missouri river, a matter as evidence already given in this case, from my knowledge of the conditions which obtain upon the drainage canal and the Desplaines river and the Illinois river and the agencies of self-purification operative in this stream, 11104 all of these combined tending to effect a practical bacterial purification of the Illinois river at Averyville, I am of the opinion that any increase in typhoid fever, if there has been any increase of typhoid fever since the opening of the drainage canal, can not be attributed beyond all reasonable doubt to the opening of the drainage canal as its direct, immediate and approximate cause.

Q. Assuming that there is an increase in the typhoid conditions in St. Louis over normal conditions due to its water supply, where in your opinion should a sanitarian, studying the question, look for the causes of the infection?

A. For reasons which have been stated repeatedly in this examination, from the knowledge of the Illinois river itself, its surroundings and the chemical and bacterial changes operative tending to the self-purification of the stream, and from the positive evidence of Doctors Zeit, Jordan and Russell, proving that the typhoid bacilli from the City of Chicago, passing through the drainage canal and out in the Illinois river, can not exist in that river for a period extending more than three days or four days, it is my opinion that the typhoid bacillus 11105 from the City of Chicago can not find its way to the intake tower at the chain of rocks, and the intake of the waterworks of St. Louis in the Mississippi river, and therefore the causes for such an increase in typhoid fever must be looked for at points nearer the intake tower than from the sanitary district of Chicago.

Adjourned until 10:30 a. m., Wednesday, March 2, 1904.

10:00 A. M., Wednesday, March 2, 1904.

11106 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. E. G. SMITH

resumed the stand for cross-examination by Mr. Jeffries, and testified as follows:

Q. Professor, if the urine and excreta of a typhoid patient is discharged into 60 gallons of distilled water, will the typhooid fever germs live longer in such condition than if discharged into 197 gallons of distilled water?

A. From my study of the longevity of typhoid fever germs, and from knowledge I have been able to obtain, the general principle is clear that an increased dilution of water tends to increase the longevity of the micro-organism. The conditions of the question could only be answered by applying the general principle that the more dilute the sewage the greater the tendency to longevity of the organism.

Q. Then they would have a tendency to live longer in the larger quantity of water than in the smaller?

11107 A. Applying the above principal it is my opinion that they would.

Q. Professor, assuming that there is a population of 1,545,300 people, the sewage discharged from said population passing into the Chicago drainage canal, and assuming that there are from 700 to 900 deaths per annum from typhoid fever among the population of the territory sewered into the canal and that the urine and fecal matter of that population is daily discharged into 304,686,455 gallons of water, would the typhoid fever germs thus deposited in that quantity of water be of shorter or longer longevity than if deposited in 92 718,000 gallons of water daily?

A. Applying the principle as stated in my first answer it would be my opinion that there might possibly be a tendency to a slight prolongation of the life of the micro-organism.

Q. Would not the natural tendency be to prolong the life of the germ under such circumstances?

A. I think it would a little, but assuming the conditions given, the deposit of fecal matters, of sewagic matters from that population in such waters, the amounts of which are indicated in the question in either case, we would be dealing with 11108 a sewage water which sewage water experiments have shown to be inimical to any prolonged life of the typhoid bacillus.

Q. Professor, were you acquainted with the Chicago River prior to 1900?

A. Yes sir. I have lived in Beloit, Wisconsin, and frequently have been here and observed it in going to and from.

Q. Will you state its condition as you saw it and observed it, generally speaking?

A. Generally speaking it was an exceedingly foul, offensive stream, offensive to sight and to the nostrils. It was more or less turbid, often with a scum floating upon the surface, of a dark color and without very much apparent current.

Q. As compared to conditions that exist in the Chicago River prior to the opening of the canal, in your opinion will pathogenic bacteria discharged into the Chicago River have greater longevity since the opening of the canal and the passage daily of 250,000 cubic feet of water per minute through the Chicago River than they had in the Chicago River prior to the opening of the canal?

A. The influence of dilution by the lake water, tends to
dilute sewagic matters placed in the river, and in so
11109 far tends to prolongation of the life of the bacteria, yet the
river today is decidedly of sewagic character so that in my
opinion the longevity of the typhoid organism would not be very markedly different before the introduction of the quantities of lake water and conditions as we now find them; and in addition to that there is another factor, the river as I formerly knew it and had observed it was quiet, with very little current, and today there is a decided current tending to cause such organisms to pass out of the Chicago River in short periods.

Q. Assuming, Professor, that pathogenic bacteria from Joliet passed down the Illinois River as it existed prior to the opening of the canal, what effect has the addition of 250,000 cubic feet of water per minute into the Illinois River upon the passage of the pathogenic bacteria from Joliet down the Illinois River?

A. The introduction of this large amount of water would tend to increase the speed of the current and therefore tend to push pathogenic bacteria farther down the river than they would prior to the opening of the canal.

Q. Assuming, Professor, that the bacteria counts at
11110 Joliet caused by sewage pollution were much greater
prior to the opening of the canal than they have been
since the opening of the canal, what effect would the discharge of 250,000 cubic feet of water per minute into the river above

Joliet have upon the longevity of the pathogenic germs discharged into the river at Joliet, the waters so discharged not having as great a number of bacterial counts as the water in the river at Joliet prior to such discharge.

A. The waters at Joliet after the addition of the water from Lake Michigan, of waters introduced under the conditions of your question, being yet of a decided sewagic character, and pathogenic germs found therein being subject to the germicidal effect of such sewagic waters, it would be my opinion that this dilution of the water at that point might possibly prolong it, but that it would destroy them in short periods, and the typhoid bacillus would, under these conditions, be subject to the germicidal effect of the diluted sewage.

Q. It is your opinion then that the longevity of the typhoid germ would not be prolonged under the latter conditions over their longevity under former conditions? 11111

A. It would be difficult to make a positive answer to that, but it is clearly my opinion that the pathogenic germs would not be materially increased by such dilution.

Q. Assume, Professor, that the volume of water from Lake Michigan was increased from 250,000 cubic feet per minute to 500,000 cubic feet per minute, with the same amount of sewage discharged into the Chicago River and the drainage canal what effect would such added volume of water have upon the longevity of pathogenic bacteria?

A. It might possibly prolong the life a little, but with 500,000 cubic feet of water pathogenic germs entering the river at Joliet would still be subject to the germicidal action of sewage waters.

Q. It would, however, have an effect to increase the longevity of the germ?

A. Possibly slightly as it is known that this germ will live longer in waters than in sewage, and concentration of sewage affects the life of the germ, but the exact difference would be a matter which could only be determined by actual experiment. 11112

Q. And the longevity of the germ in each instance would depend upon the inherent virility of each pathogenic germ?

A. It is true that different strains, as they are termed of typhoid fever organisms, possess a different degree of resistance to destructive agencies.

Q. From your own personal experience and observations, how long will a typhoid germ live in sewage?

A. I have never carried out observations upon the duration of the life of the typhoid germ in sewage.

Q. And this experiment or observation has never been personally made by you, either in the laboratory experiments or otherwise?

A. No, it has not.

Q. Has such an observation or experiment been made in your laboratory, under your direction and supervision, in sewage?

A. An observation of a study of the vitality of the typhoid bacillus in sewage waters has not been made in my laboratory under my direction.

Q. What, in your opinion constitute, in the main, the environments which affect the longevity of the typhoid
11113 germ after it leaves the human body?

A. There are several elements entering into the longevity of the typhoid germ after it leaves the human body; the matter of temperature, of moisture, the relation to other bacteria, whether these bacteria may be in soil or in sediment of the streams or in running water. I consider those as three of the important factors in the consideration of the environment to which it is subjected.

Q. Professor, assuming that at Joliet there is a daily flow of 271,424 cubic feet of water per minute and that in that water there are 70,000 bacteria per cc., as shown by the bacterial counts upon the plates from the samples of water taken at that point, what effect would the removal or withdrawal of 232,131 cubic feet of water per minute have upon the longevity of pathogenic bacteria contained in that water in the event such bacteria was so contained therein?

A. The removal of 232,000 cubic feet per minute from 271,000 cubic feet per minute would reduce the flow of the river to about 40,000 feet per minute. This would, therefore, tend to concentrate those organisms so that there would be a greater toxic effect from the organism due to concentration of the toxins in the same.

11114 Q. And such concentration would have the effect of shortening the life of the pathogenic bacteria?

A. The special results of the action of the organisms being that of the destruction of the pathogenic bacteria from the toxins eliminated, it would therefore follow that the concentration of toxins would tend to diminish the vitality or viability of pathogenic germs in the same.

Q. State, Professor, if from 250,000 to 500,000 cubic feet of water per minute pass through the drainage canal, the Desplaines and thence into the Illinois River would they not have the effect of more rapidly removing the sewage from the cities of La Salle, Peoria, Pekin and other cities located upon the banks of the Illinois River and carrying such sewage at a more rapid rate on down the river and also have a tendency to increase the longevity of the pathogenic germs contained in the water from the sewage of those cities?

A. The addition of this volume of water, as already a matter of evidence and opinion in this case, tending to increase the rate of flow of the stream, it would be self-evident that solid suspended particles or dissolved matters would be
11115 pushed further down the stream, because of the inflow of such river, and further, the effect of dilution might possibly tend to increase the longevity of the pathogenic germs, but the exact degree of such prolongation could only be determined by a matter of experiments.

Q. Professor, assuming that in 1892 the water in the Illinois River, immediately above the city of Peoria, contained pathogenic bacteria coming from the sewers of La Salle, Morris, Marseilles, Ottawa and Joliet, what effect has the opening of the canal and the discharge of the water from Lake Michigan through that canal had upon the typhoid fever germs that would reach the city of Peoria since the opening of the canal, coming from the cities above mentioned?

A. While it is true that the increase of the flow of the river increases the speed of the current and dilutes the water, tending on the one hand to push the sewage from these cities, somewhat further down the river, and also to dilute the same, yet from all data which I have been able to gather in this case from the experiments made, I am of the opinion that the river at Averyville, above Peoria, has undergone a practical bacterial purification. It would be impossible to say that no germs 11116 from any of these points have never or would never find their way into the river at a point above Averyville, but the data at hand upon the purification of the stream make it, in my opinion, quite certain that there are very few pathogenic germs from any point in the river at that point.

Q. Assuming, Professor, that typhoid germs from the respective cities mentioned in the preceding question, arrive in the Illinois River at a point immediately above Peoria, in a virulent condition, prior to the opening of the canal, what effect would conditions such as are brought about by the opening of the canal have upon the longevity of the typhoid germs contained in the water at Peoria under the assumption?

A. Assuming that typhoid fever germs were in Lake Peoria above the city of Peoria, in 1892, and assuming, as I understand the question to mean, that they are there at the present time, the opening of the drainage canal has not affected the deposit of typhoid fever germs at that point.

Q. What effect would the opening of the canal have upon the longevity of the typhoid fever germs finding their way into the Illinois River at a point immediately above Peoria, as stated in the hypothetical question just put?

A. Assuming that typhoid fever germs were in the river 11117 above Peoria and they are there today, it would be clear that the opening of the drainage canal has not affected the longevity of the germs at that point, assuming they came from the same points.

Q. Assume, Professor, that typhoid fever germs came from the sewers of La Salle, Marseilles, Ottawa and Joliet, prior to the opening of the drainage canal. and found their way in the Illinois River to a point immediately above the city of Peoria in a virulent condition, state whether or not in your opinion the opening of the canal has rendered conditions such that it is less liable for them to continue finding their way there subsequently to the opening of the canal than prior thereto?

A. Assuming that typhoid fever germs in a virulent condition came from the sewers of the cities mentioned and found their way in such virulent condition to the lake at a point immediately above Peoria in 1892, it is my opinion that the conditions which have obtained since the opening of the canal have been such that it would not make it less liable for them to reach that point than they did in 1892.

Q. Under the same assumption as contained in the last
11118 question are they not more liable to find their way into
the Illinois River at a point immediately above Peoria since the opening of the canal than prior thereto?

A. Assuming that in 1892 typhoid germs from the sewers at these points mentioned found their way into and were present in the waters above Peoria, the addition of the larger volume of water increasing the speed of the river and dilution of the same would tend to make them more liable to be found from the same points in the stream.

ADJOURNED UNTIL 2:00 P. M. of same day.

2:00 P. M., Wednesday, March 2, 1904.

11119 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. E. G. SMITH

resumed the stand for further cross-examination by Mr. Jeffries, and testified as follows:

Q. Professor, from your knowledge of the Illinois River is it not a fact that pathogenic and disease producing organisms so far as their facilities for longevity and virility are concerned may be more manifest in the Illinois River immediately above Peoria, since the opening of the drainage canal than prior thereto?

A. Assuming that they were there before the canal was opened, of which we have no positive evidence, it would be true, in my judgment, that the opening of the drainage canal, in-
creasing the speed of the river and the dilution of the
11120 same, would render it more liable for them to be there.

Q. With your knowledge of the Illinois River as you saw it in 1892 at Peoria, could you say that there were no typhoid or other pathogenic bacteria in the water of that river at a point immediately above the city of Peoria, when you observed it?

A. In reply to that question I would say that I have no evidence that there were any pathogenic bacteria there at any time.

Q. Is it not a fact that the same conditions would maintain throughout the entire length of the Illinois River since the opening of the drainage canal as compared to conditions existing prior thereto, as stated in the second preceding question and answer, with reference to conditions at a point immediately above the city of Peoria?

A. It is my opinion that the same conditions would not necessarily obtain throughout the whole length of the river, for the reason that there is in the stream a seasonal variation, in the river at its low period the current being greatly accelerated, and in periods of high water the water not being raised in such proportion or the current therefore increased.
11121 Further, as we descend the river the river continues to receive the inflow from other streams thereby increasing the amount of water, and therefore it would follow that the drainage canal would continue to exert a diminishing influence as we pass down the stream, upon the speed of the river, thus tending to affect the effects of dilution and increased speed of the current, so that it would not obtain throughout the whole length of the river the same as before.

Q. Professor, if advised that prior to the opening of the drainage canal, during a greater period of the year, the Illinois River, for miles above the several dams, was in a quiescent condition, so much so that green scum formed upon its surface, that in rowing in a skiff the skiff would leave behind it a line observable to a great distance, that when blocks of wood were thrown into the river their movements would depend upon the direction of the wind, that since the opening of the canal there has been at all times a continuous current both above and below the several dams, and the green scum formation has not appeared to any great extent, what effect would this change in the

velocity of the stream and the physical conditions of the
11122 stream have upon pathogenic bacteria in waters of that
stream, assuming that they had been discharged into it?

A. The effect of establishing of a current assuming they were there must manifestly be to push them somewhat further down the stream.

Q. Would it not also have the effect of increasing their longevity, vitality and virulence?

A. It would increase their logevity only so far as they might have been pushed further in the short distance which they might have advanced, owing to the increased speed of the current further, in my judgment it would not affect the virulence of the germ.

Q. What would be the difference in the element of sedimentation as contained in the last preceding hypothetical question?

A. In the increase in the speed of the current of a river
or stream, the speed of the current alone being brought into
consideration, the rate of sedimentation would be
11123 diminished. On the other hand if the speed of this cur-
rent be due to an increased volume of water admitted
from Lake Michigan, after the opening of the drainage canal, there would be decided compensation in the loss from sedimentation from the rate of the stream owing to the added area of the waters spreading out over the bottoms by the low shelving banks in the course of the stream so that in my judgment there would not be any very great difference between the total sedimentation in the stream before and after the opening of the drainage canal.

Q. As applied to the conditions of the water in the bed of the stream immediately above and below the dams in question, how would sedimentation be affected by the increased flow?

A. In the bed of the stream the increase of the flow of the current would tend to diminish the rate of sedimentation.

Q. Professor, in your direct testimony you stated that you made an observation of the water in the Illinois River at Peoria in 1892, by being upon it in a boat and went out to and across the wagon bridge, observing the river from time to time that it was of a dirty appearance, as you call it, and possessed in warm seasons of a decidedly disagreeable odor, and that in your opinion it was unfit for use as a water supply.

11124 Please state your opinion as to the cause of this disagreeable odor and dirty appearance of the water which you observed?

A. The cause of the appearance of the water at that time and its unsatisfactory qualities for a water supply was due to the materials in the stream.

Q. What in your opinion was the character of the materials that had been discharged into that stream, producing the effects in question?

A. I did not make any special investigations at that time, as I was simply asked to pass upon it as a desirable or an undesirable supply to pump into the city of Peoria, and I considered it unfit for use and advised the Peoria Water Company not to use the water, and further not to even lay an intake to the river as an emergency supply. I do not know whether that was carried out or not, but the matter was talked over. The water at that time, from its appearance and the analytical data which, as I recall them now, would not justify me as an adviser to the company to recommend their introduction into the public supply in the raw condition.

Q. It was your opinion that the water at that point, at that time, contained substances injurious and harmful to health?

A. It was my opinion at that time that the water was

11125 unsuited for a public water supply, the chemical analysis showing a considerable amount of organic matter contained in the same, and there being some suspended matter, and the waters having some odor and therefore the water was not fit for use in its raw condition.

Q. Now, Professor, if typhoid fever germs had been deposited in the water of the Illinois River at that point, at that time, 1892, what can you say as to the extent of their longevity as compared with typhoid fever germs of the same strength and virulence deposited in the river at that point today, since the opening of the drainage canal?

A. It would be my opinion from the conditions noted in the light of knowledge obtained regarding the action of saprophytic bacteria since that time, that the tendency would be to destroy the typhoid and pathogenic bacteria rapidly at that time, as they would have been subjected to the germicidal effects of the water.

Regarding the effect of the water upon the typhoid germ since the opening of the drainage canal, it is my opinion as has been repeatedly stated in the course of this evidence that the same are eliminated practically at this point, such state-
11126 ment being based upon data, analyses and positive experiments already a matter of record in this case.

Q. From your personal observation of the waters of the Illinois River at a point immediately above the city of Peoria, in 1892, as compared with your personal observation of the water of the Illinois River at the same point in September, 1903, is it not a fact that elements destructive of pathogenic bacteria were more prevalent, apparent and abundant in 1892 than in September, 1903?

A. The waters when I was there in September of this last year 1903, were roily, owing to the recent storms, and so far as personal observation shows therefore I could hardly draw a comparison between the two conditions, there being a large amount of dirt and silt in the river at that time. It could not be based upon any personal observation.

Q. Taking into consideration your personal knowledge of the Illinois River, during the year 1892, and the year 1903, what would you say?

A. From my knowledge of the river and from data and all knowledge which I have been able to gather from the
11127 Illinois River and its characteristics it is my opinion that the agencies tending to destroy bacteria were ample in 1903, and I believe they were as ample to affect the changes in 1892. The current may have been more sluggish at this particular time, but in my opinion the agencies were as effective now as they were then, removing as I believe they do practically the pathogenic bacteria from the stream now.

Q. But were not those agencies of destruction more abundant and more prevalent in the waters of the Illinois River at that point in 1892 than in 1903?

A. That question could hardly be answered positively. They were decided at that time and they are very decided now.

The condition of the stream at that time tended to remove these organisms and it would be difficult to institute a comparison regarding the germicidal effect of the water, dirt and material which might impart an odor to a water need not necessarily be germicidal in its effect. It may be due to the destruction of algae which might impart an odor to the water and yet not be harmful to the same, and yet render it unsatisfactory for use. Some inquiry was made in 1892 as to the source of the disagreeable conditions of the water and its unfitness for the public water supply. 11128

Q. But is it not a fact, Professor, that the saprophytic influence over the pathogenic bacteria per cc. of water was greater in 1892 than in 1903, in the Illinois River immediately above Peoria?

A. That is a difficult question to answer. I do not think I could answer that question off hand.

Q. Is it not a fact that water which emits a disagreeable odor and which has a dirty appearance caused by the discharge of waste and refuse matter into that water contain greater quantities of saprophytic material and agencies for the destruction of pathogenic bacteria than water which emits no disagreeable odor and which has no bad physical appearance?

A. I think as a general proposition that would be true.

Q. And the life of a typhoid fever germ would be shorter when deposited in a water which emits the disagreeable odor and contains the substances thus spoken of in the preceding question than it would be in the water which emits no disagreeable odor and contains but small quantities of such substances?

A. It would be true that water which contains an abundance of saprophytic life would tend to the formation of large amount of the toxins which would prove destructive to bacteria placed therein. 11129

Q. Professor, in passing judgment as a sanitarian upon the condition of water in a running stream, is it not a fact that the population residing upon the water shed of that stream is one of the principle and material elements entering into a consideration of the condition of the water?

A. The population is one of the important factors in passing upon the desirability of a stream for public use.

Q. Is it possible to give an opinion as to the sanitary condition of the water in a running stream for drinking and domestic purposes from a consideration of the bacterial and chemical conditions of the water alone, eliminating therefrom the population residing upon the water shed and all sources of pollution above the point where the water is being observed?

A. Well, that is a very difficult question to answer; opinions might vary. As I stated in the direct examination I believe that a sanitarian should take into consideration everything possible which will help him to interpret the stream, its sources, 11130 its pollution, the changes which it undergoes, in order to give a full opinion of the character and suitability of the same for public use. However, I believe that chemical and bacteriological data can and often do throw light upon the quality of a water which may enable us to pass an intelligent and honest opinion upon the quality of the water and its adaptability to public supply. Almost any one who has had any extended experience of this kind is called upon to do that continuously, and we are frequently called upon to pass upon the quality of a supply from chemical and bacteriological data alone, and in my judgment they do throw very much light upon it. In the determination of the adaptability of a water and the purification of the same we appeal almost exclusively to the chemical and bacteriological data, and we pass upon the supply upon those data alone. Whenever a water is taken from a stream and filtered the adaptability and the safeness of the same, whether it can be used, is determined from the chemical and bacteriological data. It is a scientific proposition. A water may be safe to use and that can be determined by the chemical and bacteriological data. On the other hand an inspection 11131 of the sources of a stream may be entirely misleading and if one should depend upon the personal inspection of a stream and the population upon the same and the sources of pollution which may be above the point examined, from the population and from manufacturing plants, and refuse from establishments of all kinds, one might be easily mislead without having also the chemical and bacteriological data. I consider that the chemical and bacteriological data are very important factors and are absolutely necessary to determine the desirability of a water for use, and whether it can be safely used. The population should be taken into consideration, the changes which the river undergoes and the pollution of the same.

Q. Do you consider that as a sanitary expert you could pass reliable judgment upon the sanitary condition of the water in a running stream at a given point to be used as a water supply of a municipality, without taking into consideration the population residing upon the water shed of that stream, the sources of pollution above the point where the water was being observed?

A. No sir, I could pass upon the quality of a particular sample. I could say that a particular sample from it
11132 was suitable for use but the permanent use of the water supply should involve the study of the surroundings of the same and the pollution to which it should be subjected.

Q. Is it not a fact that the chemical and bacteriological and therefore the sanitary condition of the water in a running stream, such as a river, is continually changing from day to day?

A. It is true that streams are subject to what is known as seasonal fluctuations and that therefore the chemical and bacteriological data necessarily change from day to day.

Q. Is it not a fact that atmospheric changes have an effect upon the bacterial, chemical and therefore sanitary condition of a water?

A. Assuming that by atmospheric conditions you mean rain and snow and cold and heat, it is my opinion that atmospheric conditions do materially affect changes in a running stream.

Q. Is it not a fact, Professor, that sanitarians, in the examination of a water supply are more interested in the character of the bacterial counts than in the number of bacterial counts that appear upon the plates in the bacteriological examination of the water?

A. The numbers of bacteria in waters are important as
11133 showing general conditions in a stream; but it is also true that the character of the bacteria, the species of bacteria, and especially whether any of the bacteria present are of the

so called sewagic types is of great importance in fixing the sanitary character of any given water.

Q. In addition to the number and character of bacteria present in water is not the possible source of such bacteria an important circumstance to be considered?

A. If the analysis shall show the presence of the so called colon forms, especially in water, it becomes a matter of considerable importance to determine from whence they come, and in the study of supplies I have carried that out; particular attention has been given to that phase of the study to determine, if possible, the origin of these colon forms or sewagic forms.

Q. Professor, in the case involving the water supply of the city of Denver, which you spoke of in your direct examination, is it not a fact that while typhoid fever was prevalent in the city of Denver that there was comparatively small number of bacteria in the water as shown by the counts
11134 upon the plates in the bacterological analysis of that water?

A. The number of bacteria in any western water vary, and do not run high in the sense in which we are using it here in this case at least. The investigations in connection with the city of Denver extended, so far as I was concerned, over a period of years, I think about four years, and in the course of those examinations a large number of bacterial and chemical analyses were made, and in general it is to be noted that the numbers of bacteria were comparatively low. The supply at Denver comes from at least four sources, commonly, and each one of these sources was subject to its own conditions. Upon one of them, for instance the Cherry Creek supply the number was very low, under 100, and another supply known as the west side service, the numbers are very low. In both of these supplies the water has undergone a process of filtration. In another source, that of the Marston Lake, the numbers run higher, up to a few thousand, and from the Platte River they would be measured by a few thousand, so that the question needs this amplifying in order not to be misleading.

Of course we have to take into consideration the number of bacteria involved. The Marston Lake and the Platte River

raw waters were high as compared with the others, but
11135 as compared with the eastern streams they are not high, and would be much lower.

Q. Is it not a fact that the bacterial analysis of the water drawn from the supply in the city of Denver, when typhoid fever was prevalent, showed comparatively small numbers of bacteria per cc.?

A. As already stated in the previous answer the number from Cherry Creek were always small and the west side station small, under 100 generally. In testing the west side, the numbers on one occasion suddenly leaped up into the thousands, and it lead to an investigation when we found there was a break in the underground connection. The number from Marston lake ran up into the thousands, and the number from Platte River also were a few thousand.

Q. Are you acquainted with the epidemic which recently occurred in the city of Butler, Pennsylvania?

A. I have read the accounts concerning it as given in the daily press and particularly as stated in the investigations made in behalf of the Engineering News and reported to it by Mr. Soper.

Q. On what stream is Butler situated?

A. I do not know the stream but I understand it is a tributary to the Beaver River.

11136 Q. Are you acquainted with any towns on the Beaver River below Butler?

A. I am. This last summer I was asked by the management of the Beaver Valley Water Company to advise with them regarding the operation of their plant, and I was at Beaver Falls several times rendering services to them.

Q. How far is Beaver Falls from Butler?

A. I do not know.

Q. What is your understanding?

A. I understand about 60 or 70 miles.

Q. Upon hearing of the typhoid epidemic at Butler state whether or not you communicated with your clients at Beaver Falls in relation thereto?

A. Knowing the conditions at Butler, and knowing it was tributary to the Beaver River, at a comparatively short dis-

tance above, I advised the management of the company to be careful in their operation of the plant during the prevalence of the epidemic and the lack of care and disinfecting of the excreta from the typhoid fever patients, and advised that the plant be operated with very great care during this period, and
11137 I understand from letters that they followed that advice.

Q. They have a filtration plant at Beaver Falls?

A. In further explanation of the above question should be added that the Beaver Valley Water Company take their supply from Beaver River, taking it through an intake out in the river. The water is then pumped up to a sedimentation basin where it is treated with alum and then filtered with a so called mechanical filter.

Q. Can you recall the average volume of water flowing down Beaver River?

A. I have no data bearing on that.

Q. Have you ever observed the river?

A. I have been across it several times. It is quite a sizeable stream, emptying into the Ohio a short distance below Beaver Falls. I have been up and down it. I was there in the low stream during the month of August.

Q. How large is Beaver Falls?

A. I am under the impression it must be upwards of 20,000 population. It is one of those iron working towns and is stretched out a long distance. I should judge it was upwards of 20,000 population.

11138 Q. From this letter of advice that you gave your clients at Beaver Falls, it is a fact is it not that the more typhoid material there is deposited in a river there should be greater precautions and more care used in connection with a filter plant there than if there were less of such infection?

A. A filter plant must be worked carefully all the time and the success of any sytem of filtration depends upon the care with which it is operated. Workmen will become careless and this letter was a precaution to them to be sure that the workmen attended to their duty. It was a letter cautioning them to be careful during this epidemic, that no laxity on the part of the service should obtain.

Q. And that precaution upon your part was recommended because of the epidemic which existed on the water shed above, where the water supply was situated?

A. I knew from data at hand and private advices and general knowledge that this river was being polluted at this time, and therefore I cautioned them to be careful in the operation of
the plant. I cautioned them as I should every one to use
11139 due precautions at all times and especially when there was
any reason to suspect that any trouble might arise, from special conditions of the river.

ERASTUS G. SMITH,
Professor Chemistry, Beloit College, Beloit, Wisconsin.

Adjourned until 10:00 A. M., Thursday, March 3, 1904.

10:00 A. M., Thursday, March 3, 1904.
11140 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

JACOB A. HARMAN

a witness called on behalf of the defendants, after being duly sworn by the commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Jacob A. Harman.

Q. Where do you reside?

A. Peoria, Illinois.

Q. What is your business?

A. Civil Engineer.

Q. How long have you been a civil engineer?

A. Since 1887, about 16 years.

Q. Are you a graduate of any institution of learning?

A. I graduated at the Normal University at Lebanon, Ohio, in 1887.

Q. Did you take a technical training at any institution?

A. I took the civil engineering course there.

Q. Have you been connected with any institution of tech-
11141 nical character except that since your graduation?

A. No sir.

Q. What work have you done in the line of civil engineering, briefly?

A. Well, the first two years after graduation I was doing country surveying and drainage engineering and in 1890 I went to Peoria and was assistant engineer in the construction of the water works there for about a year and a half, and the beginning of 1892 I established an office in Peoria for general engineering practice, civil engineering and then in 1893 I was appointed City Engineer of Peoria and continued in that position for two years, and since that time I have been doing general civil engineering work, water supply, sewerage and drainage and general surveying. For the last five years I have been consulting Engineer to the State Board of Illinois.

Q. Are you acquainted with the general physical characteristics of the Illinois River?

A. Yes sir.

Q. Will you give a general description of the Illinois valley, the territory which is drained by the Illinois River, stating the character of the territory drained to what interest it is devoted and the towns situated upon the water shed of the
11142 Illinois River?

A. The Illinois River drains about one-half of the territory of the state of Illinois and a small portion in the southeast corner of the state of Wisconsin and a portion of the northwest corner of the state of Indiana.

The immediate valley of the Illinois River is described in the report on the Water resources of Illinois by L. Everett, of the Geological Survey of the United States. This description is condensed and gives it in about the best form, and I will read quotations from that description:

"The Desplaines and the Illinois River form what has been regarded by geologists as an ancient outlet for Lake Michigan and the other lakes which flow into it, and by that large flow of water from that territory has cut a very much larger channel through the state (now occupied by the stream) than required by the drainage of the territory now drained by the Illinois River." That description is as follows:

I am reading from page 103 of the report of the Illinois

State Board of Health, Sanitary Investigation of the Illinois River and its tributaries, of 1901.

"The Southwestward or Chicago outlet of Lake Michigan, as pointed out some years since by Col. James H. Wilson,
11143 and Wm. Gooding, C. E. by Dr. H. M. Bannister, and by
Dr. Edmund Andrews, entered the present Desplaines Valley immediately west of Chicago, and passed thence down the Illinois. The effect of this outlet upon the size of both the Desplaines and the Illinois, is very marked. The upper portion of the Desplaines, down to the point where the ancient stream entered the valley, is a small channel, 20 to 30 feet in depth and scarcely one-eighth mile in width, cut into soft deposits of glacial drift. Upon entering the outlet the stream finds a valley more than a mile in average width, and cut to a depth of 50 to 100 feet or more, the depth varying with the altitude of bordering uplands. The excavation is mainly in drift, but for a few miles above Joliet it extends 25 feet or more into the rocks."

"The Illinois flows for a few miles in a low drifted basin lying west of the Marseilles Moraine, in which the ancient stream was expanded into a lake which built beeches instead of eroding a channel, but from the Marseilles Moraine, onward, a large valley is cut, having an average depth of more than one hundred feet, and a width of about one and one-half miles
throughout the new course above Hennepin, and nearly
11144 three miles in the old part of the valley below that town."

"To appreciate how small a part of this excavation on the Illinois is due to the present drainage lines, one has only to turn to such tributaries as the Fox, and Vermillion Rivers, and compare the small channels cut by them with the large valley of the Upper Illinois, for they are all cut to about equal proportions, in the drift, and in rock formation of a similar kind. Fox river, which includes about one-fourth of the present drainage of the upper Illinois, has in its lower seventy five miles, a channel with about one-eighth the width and one-half the average depth of the upper Illinois, and is even better favored than the Illinois, in its rate of descent. Instead of 25 per cent of the amount of excavation displayed by the Illinois, this stream has accomplished scarcely one-fourth that amount. It seems probable that at least three-fourths of the excavation of the upper

Illinois, and even more of the portion of the Desplaines occupied by the late outlet, was accomplished by some ancient stream. In the lower Illinois, where the ancient stream worked entirely upon the loose materials of the drift, the excavation was larger in amount, and the valley presents a remarkably low
11145 gradient,—so low that the present stream is silting up
instead of eroding its bed. The fall of the present stream, in its lower 220 miles, is but 30 feet. Whether this very low gradient is entirely due to the lake outlet, or has been brought about in part through the warping of the valley, has not been determined. It is certain, however, that the valley was opened throughout its entire course to a far greater extent than the present stream could have accomplished.

"Of the streams which traverse Illinois, the Illinois is by far the largest, its drainage area being fully half as great as the area of the state and lying mainly between the State's boundaries.

"The drainage or water shed of the Illinois extends in a broad band, averaging one hundred miles in width, in the northeast, southwest direction, directly across the center of the state. From the northeastern extremity of this band there are two projections,—one north into Wisconsin, including the Fox and Desplaines River basins; the other east into Indiana, including the Kanakee and its main tributary, the Iroquois. The name Illinois is appiled to the river from the junction of the
11146 Kankakee and Desplaines. The western side of the water
shed is twenty to forty miles in width, while the eastern side is 60 to 80 miles.

"The Illinois River is a stream showing a marked contrast in the rate of fall. From the junction of the Desplaines and Kankakee westward for fifty miles, being in a new course, its bed usually on the rock, it has an average fall of about one foot per mile; but in the remainder of its course to the Mississippi, a distance of about 225 miles, it is in a pre-glacial channel, and has, as previously stated a very slight fall."

The principal tributaries to the Illinois River are the Desplaines and Kankakee (which by their junction form the beginning of the Illinois River), the Fox River, the Vermillion

River, the Spoon River, Mackinaw River, the Sangamon River, Macoupin Creek and Crooked Creek.

The entire drainage area of the Illinois River is devoted extensively to agriculture, and pasturage. Stock raising is one of the chief pursuits of the rural inhabitants of this territory. A very large urban population also exists upon this terri-
11147 tory, the principal cities being Peoria, Springfield, Pekin, Bloomington, Decatur, LaSalle and Joliet. All of these cities are extensive manufacturing points.

MR. JEFFRIES: I move to strike out all that part of the answer where the witness read into the record quotations from the Report of the Illinois State Board, for the reason that it is incompetent and not proper testimony.

11148 Mr. Todd: Have you made an investigation of the population on the Illinois Water shed as well as in the city of Chicago?

A. Yes sir.

Q. Will you describe the results of that investigation and upon what statistics the investigation was based?

A. The investigation was based upon the United States census report. I have made an investigation of the growth of the population in the city of Chicago, but the details of that are already in evidence in Mr. Randolph's report. I have also made an investigation of the population of all that part of the Illinois water shed except the city of Chicago, the results of which are set forth in detail showing a division of the population into urban and rural population for the two census years 1890 and 1900. This population has been tabulated so as to show the numbers upon each of the subdivisions of the Illinois water shed, as the Desplaines River water shed, the DuPage, the Kankakee, the Fox, the Vermillion, the Mackinaw,
11149 the Spoon, the Sangamon, Crooked Creek and the Macoupin Creek, and the population which is directly tributary to the Illinois and not upon its branches.

This table was prepared as a part of my report to the State Board of Health and is published in the Sanitary Investigation of the Illinois River and its tributaries in 1901, page 119, and is as follows:

Illinois River Drainage Basin Recapitulation Table—Popvlation Various Sub-Basins.

Drainage Basin.	Total Population 1890.			Total Populat'on 1900.			Numerical Increase.			Per Cent. Inc.		
	Urban....	Rural	Total.. ..	Urban....	Rural....	Total.....	Urban....	Rural....	Total.....	Urban....	Rural....	Total.....
*Des Plaines	49,355	51,541	100,896	70,748	54,107	124,855	21,393	2,566	23,959	43.3	5.0	23.8
Du Page	5,844	13,978	19,822	6,851	14,853	21,704	1,507	875	2,382	28.3	6.3	12.3
*Kankakee	35,450	143,263	178,715	44,681	147,545	192,226	9,231	4,282	13,513	26.5	3.0	7.6
*Fox	69,166	93,562	162,728	81,743	93,610	175,353	12,577	48	12,625	18.2	0.05	7.8
Vermilion	21,085	42,227	63,312	27,631	40,970	68,601	6,546	—1,257	5,289	31.0	—3.0	8.4
Mackinaw	8,781	35,407	44,188	10,924	36,372	47,296	2,143	965	3,108	24.4	2.7	7.0
Spoon	22,056	53,322	75,378	28,519	53,263	81,782	6,463	—59	6,404	29.3	—0.1	8.5
Sangamon	101,585	173,105	274,690	133,632	169,464	303,096	32,047	—3,641	28,406	31.6	—2.1	10.3
Crooked Creek	11.853	43,550	55,403	14,344	40,230	54,574	2,491	—3,320	—829	21.0	—7.6	—1.5
McKee's Creek	5,238	11,943	17,181	5,624	10,837	16,461	386	—1,106	—720	7.4	—9.4	—4.2
Macoupin Creek	13,023	32,535	45,558	15,778	30,584	46,362	2,755	—1,951	804	21.2	—6.0	1.8
Population Directly Tributary to Illinois	139,134	193,841	332,975	177,189	201,888	379,077	38,055	8,047	46,102	27.4	4.1	13.8
Totals	482,070	888,274	1,370,344	617,664	893,723	1,511,387	135,594	5,449	141,043	28.2	0.61	10.3

— Indicates Decrease. * Census for Indiana and Wisconsin in 1900 not at hand, and that of 1890 used.

The classification of urban population and rural population
11151 is taken upon the basis of that people living in cities and villages of 1,000 or more are included in the urban population and all others are included in the rural population. This classification has been made for the reason that villages of less than 1000 population seldom have any public water supply or public sewerage system and the villages and cities of more than 1,000 population generally have public water supplies and many of them have public sewerage systems.

Besides the total population for the two census years 1890 and 1900 the table also shows the numerical increase in urban and rural and total populations and the per cent of increase.

The most striking fact brought out by this table is that the rural population during the decade 1890 to 1900 has been practically stationary. The total increase is attributed to the increase in city growth or urban population. The Desplaines territory shows an increase in rural population, and also the Kankakee. The Vermillion, the Sangamon, Crooked Creek, the Mackinaw and Macoupin Creek all show a decrease in rural population.

11152 The total increase in urban population was 135,594 and the total increase in rural population was 5,449.

The greatest per cent of increase of population in any district was on the Desplaines water shed; on Crooked Creek which has no cities there was an actual decrease in total population.

Q. Have you made any calculations upon the rainfall in the different drainage basins in the Illinois River?

A. Yes sir, I have.

Q. How extensive has been your investigation of that question?

A. I have made an investigation of the rainfall for the 11 years of 1890 to 1900, inclusive, using the weather bureau published reports of rainfall as published by the Weather Bureau of the United States. These rainfall records have been compiled for each of the drainage basins of the Illinois River, as described in my testimony regarding the subdivision of the population of the Illinois River basin. My investigation includes the average rainfall by months and for each year during that period of time.

Q. Have you prepared a list of the annual rainfalls in the valleys tributary to the Illinois River?

11153 A. Yes sir, that list comprises ten years, 1890 to 1899, inclusive, and gives the rainfall for each year and the average rainfall in the Desplaines, the Dupage, the Kankakee, the Fox, the Vermillion, the Mackinaw, the Spoon, the Sangamon, Crooked Creek, Macoupin Creek, McKee's Creek and the Illinois River for all these years.

This in tabular form is published, page 159 of the "Sanitary Investigations of the Illinois River and its Tributaries, 1901," by the Illinois State Board of Health, and is as follows:

11154

Resume of Precipitation on Illinois River Basin.

Sub-Basins.	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	Total averages.
Des Plaines	35.82	29.03	35.96	29.03	27.80	30.48	33.74	30.55	37.74	28.03	31.82
DuPage	......	......	......	31.32	27.15	29.94	37.95	34.28	45.32	29.82	33.68
Kankakee	36.74	27.46	36.71	26.06	27.15	29.33	35.05	31.48	42.11	28.18	32.03
Fox	33.63	32.94	44.41	30.37	30.51	28.19	37.14	32.50	42.25	28.14	34.01
Vermillion	32.02	34.18	41.00	27.09	28.85	30.95	36.21	32.96	43.34	28.60	33.52
Mackinaw	26.33	41.70	40.84	33.52	27.80	33.26	35.37	29.13	42.96	29.62	34.06
Spoon	......	......	37.16	29.70	25.32	33.20	35.52	29.70	47.34	31.94	33.74
Sangamon	32.35	36.39	42.37	31.99	27.46	33.61	35.01	34.56	48.31	33.22	35.56
Crooked Creek	29.13	33.49	40.48	31.14	27.84	36.43	41.43	37.08	51.07	37.39	36.55
Macoupin Creek	28.47	28.09	44.24	35.43	28.74	32.65	36.97	37.17	49.46	37.20	35.90
McKee's Creek	29.13	33.49	42.03	36.08	28.52	36.82	39.91	37.95	52.15	37.61	37.37
Illinois River direct	28.19	33.92	40.93	30.61	26.65	32.72	35.05	33.12	46.77	33.05	34.01
Annual averages	31.18	33.13	40.56	31.03	27.82	32.29	36.61	33.42	45.73	31.90	34.36

11155 This table shows in the right hand column the average rain fall for the ten years for each of these water sheds, and in the lower line of figures of annual averages for the entire drainage basin of the Illinois. The average rainfall for the whole water shed for ten years was 34.36 inches.

The characteristic shown by this table is that the average annual rain fall is greater in the southern portion of the Illinois valley than in the northern portion.

The average annual rain fall on the Desplains River was 31.82.

The average annual rain fall on McKee's Creek, the most southern tributary given was 37.37.

This rainfall data included the rainfall and the snow as measured by melting a measured depth of water which it would produce.

Q. What effect is manifest upon the Illinois River itself by this annual rainfall coming from snow and rain as you have indicated?

A. The rainfall data which has gone in evidence is the annual amounts and averages. This rain comes at intervals and frequently raises the rivers to extreme height and especially in the spring when the snow is going off the ground, and
11156 the ground is frozen, the decaying vegetable and other organic matter, especially from the pastures, barn yards, etc., is washed off into the smaller streams and then finds its way into the Illinois River producing a pollution of the stream making it muddy and dirty during flood periods.

Q. Have you prepared any discharge measurements of the Illinois River?

A. I have.

Q. At what point?

A. The discharge measurements were made at Peoria on the Illinois River. The cross-section was taken at the P. & P. U. R. R. Bridge, which is the bridge farthest down the stream at the city of Peoria. At that point the railroad embankments are filled to the bridge abutments so that the entire flow of the river must pass between the piers of the bridge. A cross-section of the river was taken at this place and the velocity of the stream was measured by a current meter and from these measurements of the cross-section and the velocity of flow the discharge of the Illinois River was computed.

11157 Q. Have you the gauge readings of the Illinois River at that point?

A. I have.

Q. Covering what period?

A. From 1890 to 1903, inclusive.

Q. Are these total gauge readings published?

A. Yes sir.

Q. In what report?

A. The daily gauge readings of Illinois River taken at Peoria are published in the weather bureau reports of the United States Government and the daily stages from 1890 to 1900, inclusive, are also published in the Illinois State Board of Health Report of the Sanitary Investigation of the Illinois River and its Tributaries, 1901, pages 167 to 172, inclusive. Since that time the gauge readings which I have here are copied from the original record, and they are published from time to time by the weather bureau.

Q. Have you prepared a table of discharges, based upon the gauge readings, published and found as you have indicated in the Board of Health reports and the reports of the weather bureau?

A. Yes sir, I have. The discharge tables of the Illi-
11158 nois River for the years 1890 to 1900, inclusive, have
been prepared showing the discharge in cubic feet per
second for each month for that period of 11 years. This table
is also published in the Illinois State Board of Health reports
above referred to, pages 177 to 179 inclusive.

Q. Have you prepared, from these monthly reports of the discharges and gauge readings already referred to a table of the annual discharges at Peoria?

A. Yes, I have prepared a table of annual discharges for the Illinois River at Peoria, covering the years 1890 to 1903, inclusive. The table is as follows:

11159

Table of Annual Discharge Data of Illinois River at Peoria.

Year.	Maximum cu. ft. per sec.	Minimum cu. ft. per sec.	Mean cu. ft. per sec.	Average for middle half cu. ft. per sec.	Ordinary cu. ft. per sec.
1890	25,996	723	7,893	6,554	4,438
1891	30,985	786	5,289	2,900	2,135
1892	69,031	1,850	13,396	6,784	4,612
1893	54,570	992	10,906	5,900	3,427
1894	19,277	1,066	4,460	3,222	2,599
1895	30,554	1,066	3,338	2,134	1,843
1896	28,027	1,474	8,099	7,257	6,040
1897	47,019	1,564	11,173	6,955	4,409
1898	52,706	1,387	11,923	8,294	6,043
1899	31,417	1,303	7,378	4,637	3,400
1900	56,401	2,874	12,026	8,204	6,929
1901	43,788	3,648	8,351	6,163	5,338
1902	63,339	5,725	20,634	18,851	14,750
1903	52,706	8,971	20,417	17,216	14,437
Averages for 14 ye'rs	43,281	2,388	10,382	7,498	5,754*
Average without Chicago Riv. flow.	41,663	878	8,761	5,880	4,239

The average discharge for the Chicago river 1890 to 1899, inclusive, taken as 600 cu. ft. per sec.

The ordinary discharge through the Chicago river from 1900 to 1903, inclusive, computed at 4162 cu. ft. per sec., by using the same quantity for 1903 as was found in 1902, i. e., this amount seems to correspond to the conditions existing during time of condition of ordinary flow in the Illinois river.

11160 This table of discharges shows in the first column the year, in the second column the maximum discharge for any date in cubic feet per second, the third column shows the minimum discharge in cubic feet per second the fourth column shows the mean discharge in cubic feet per second, the average for the entire year, the fifth column shows the average discharge for the middle half in cubic feet per second and the sixth column or last, shows the ordinary discharge of the Illinois River in cubic feet per second.

Now, to explain this table, so that the data in these various columns will be understood, I will go back a little and refer again to the observations made to determine the velocity of the river at Peoria and from the velocity the discharge.

Observations were made of the velocity of the river during the years 1889 to 1900 at various stages, ranging from 4.8 inches to 19 feet 3 inches. The gauge readings of which have been referred to.

The record of these observations showing the discharge in cubic feet per second and the average velocity of the stream at the time of each of these observations are also set
11161 out in the table, which is as follows:

Discharge of Illinois River at Peoria, Illinois.

(Computed from Current Meter Observations and Cross-sections.)

Dates.	Stage of River.		Discharge.	Velocity.
	P. & P. U. R'way Bridge.	Bridge Street Bridge.	Cu. Ft. Second.	Ft. per Second.
Oct. 19, 1899	4′ 8″	4.3	2,136	....
Mar. 13, 1900	15′ 11″	15.4	33,797	2.432
Mar. 15, 1900	19′ 3″	19.2	51,086	3.001
Mar. 29, 1900	15′ 8″	16.0	30,483	....
May 23, 1900	8′ 11″	8.8	9,296	1.153
June 27, 1900	7′ 4″	7.2	6,600	1.041
Aug. 29, 1900	7′ 9″	7.7	6,817	1.021
Sept. 27, 1900	5′ 10″	5.8	4,558	0.890

NOTE.—The observation of March 29, 1900, is not accurate on account of the drift material and has been disregarded in preparing the curve of discharge.

11162 From this table of measured discharges a discharge curve or diagram was plated from which to determine the discharges of the Illinois River at stages intervening between the points where the observations were taken. This diagram was plated on paper that was ruled vertically and horizontally.

On the horizontal lines near the bottom at intervals are marked the discharges in cubic feet per second and on the vertical lines the stages of the river, that is from zero stage to 22 feet. Upon this paper was first plated the position of the discharge observation. Through this point was drawn an average curve.

In order to facilitate computations a table of discharges was made up for the stages of the river from 1 foot to 22 feet by tenths of a foot. This table is published in the Illinois State Board of Health above referred to, page 176 and is as follows:

11163

Table of Discharges in Cubic Feet Per Second at Peoria, Ill., for Stages of Two to Twenty-two Feet, by Tenths on Gauge at Bridge Street Bridge.

Stage—Feet.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1	65	....	....	....	....	....	....	....	....	....
2	399	416	496	549	604	662	725	786	852	921
3	992	1,066	1,142	1,221	1,303	1,387	1,474	1,564	1,657	1,752
4	1,850	1,950	2,054	2,160	2,268	2,380	2,494	2,612	2,732	2,854
5	2,980	3,108	3,239	3,372	3,509	3,648	3,790	3,935	4,082	4,233
6	4,390	4.546	4,706	4,868	5,034	5,202	5,373	5,548	5,725	5,906
7	6,089	6,275	6,464	6,656	6,851	7,049	7,251	7,455	7,663	7,874
8	8,087	8,303	8,523	8,745	8,971	9,201	9,433	9,669	9,907	10,150
9	10,393	10,643	10,894	11,149	11,407	11,668	11,933	12,201	12,471	12,746
10	13,025	13,307	13.592	13,880	14,172	14,467	14,765	15,066	15,371	15,678
11	15,989	16,303	16,621	16,941	17,265	17,592	17,923	18,256	18,593	18,934
12	19,277	19,625	19,976	20,329	20,686	21,046	21,408	21,773	22,140	22,511
13	22.880	23,268	23,649	24,034	24,421	24,810	25,203	25,598	25,996	26,397
14	26,800	27,206	27,615	28,027	28,441	28,858	29,278	29,701	30,126	30,554
15	30,985	31,417	31,852	32,290	32,731	33,175	33,623	34,073	34,527	34,984
16	35,444	35,900	36,360	36,825	37,296	37,771	38,250	38,734	39,222	39,717
17	40,217	40,714	41,215	41,720	42,230	42,745	43,264	43,788	43,316	44,848
18	45,384	45,925	46,470	47,019	47,572	48,130	48,693	49,259	49,830	50,406
19	50,985	51,576	52,169	52,766	53,365	53,967	54,570	55,177	55,788	56,401
20	57,020	57,653	58,286	58,918	59,550	60,182	60,814	61,415	62,077	62,708
21	63,339	63,977	64,615	65,250	65,891	66,523	67.154	67,775	68,404	69,031
22	69,655	....	....	....	....	....	....	....	....	....

11164 The discharge diagram used in these computations is as follows:

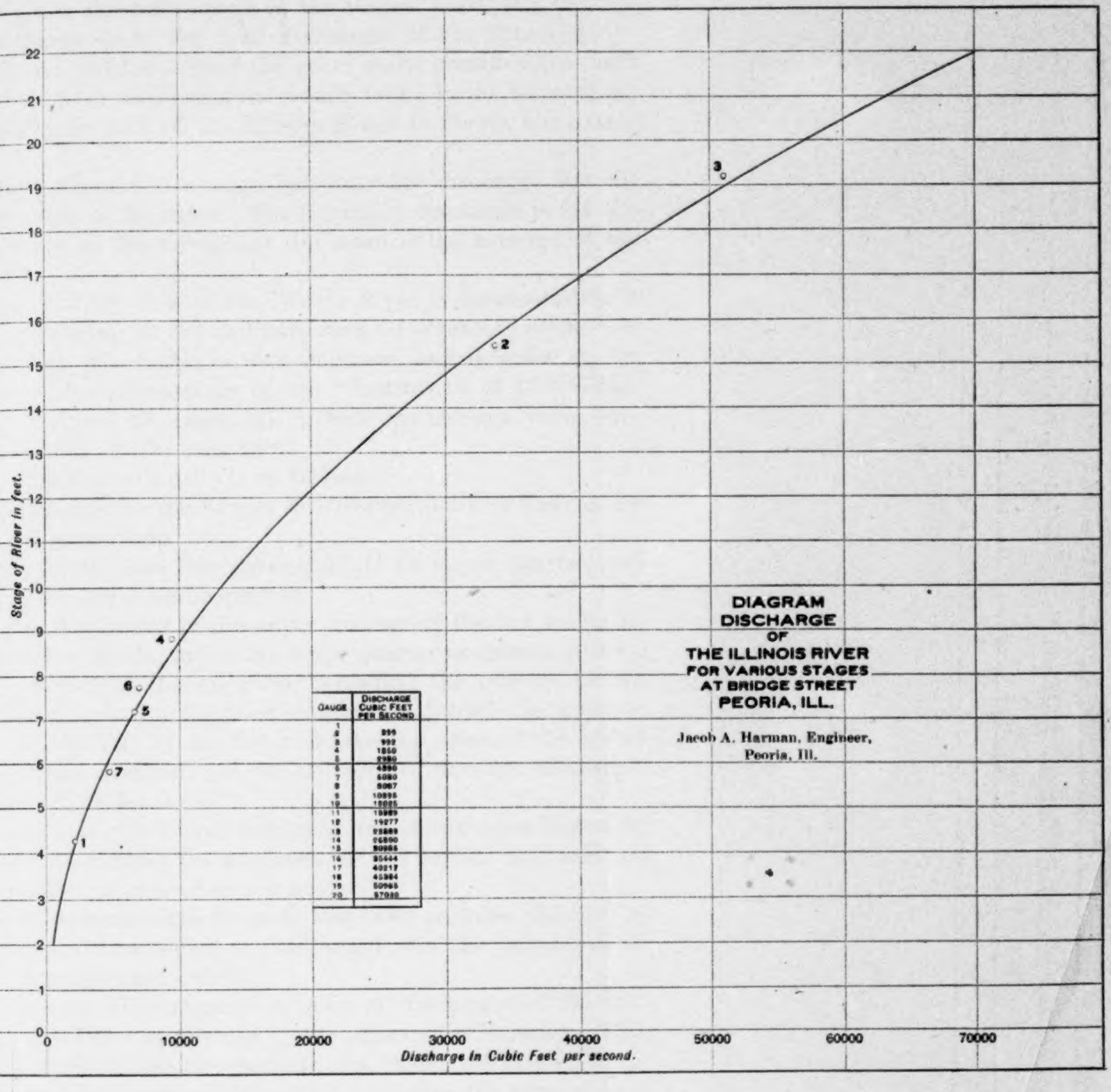


DIAGRAM
DISCHARGE
OF
THE ILLINOIS RIVER
FOR VARIOUS STAGES
AT BRIDGE STREET
PEORIA, ILL.

Jacob A. Harman, Engineer,
Peoria, Ill.

GAUGE	DISCHARGE CUBIC FEET PER SECOND
1	
2	399
3	992
4	1850
5	2990
6	4590
7	6080
8	8067
9	10895
10	13025
11	15989
12	19277
13	22689
14	26590
15	30985
16	35444
17	40217
18	45384
19	50965
20	57030

11165 Using the daily stages of the Illinois River and the discharge table, the total discharges of the Illinois Riv were determined for each of the years under consideration, and from these total discharges the results found in the table of annual discharge data of the Illinois River at Peoria were computed.

The maximum discharge indicates the discharge for the highest stage of the river. The minimum discharge is for the lowest stage of the river, and the mean is the average of the entire year.

The ordinary flow of the Illinois River is determined by a rule for arriving at the ordinary flow of streams, which was proposed by Mr. Leslie, a civil engineer, and is given in the minutes of the proceedings of the "Institution of Civil Engineers," Volume 10, page 327. These poceedings were published, I think, in the year 1851.

The rule of Leslie is as follows:

11166 "Range the discharges as observed daily in their order of magnitude.

"Divide the lists thus arranged into an upper quarter, and middle half, and a lower quarter.

"The discharges in the upper quarter of the list are to be considered as floods, and in the lower quarter as minimum flows

"For each of the gaugings exceeding the average of the middle half, including the flood gaugings, *substitute the average of the middle half of the list,* and take the mean of the whole list, and thus modified, for the *ordinary* or *average discharge, exclusive of flood waters.*"

Using this rule I have computed and shown upon this table of annual discharges the averages for the middle half and the ordinary flow in cubic feet per second.

The discharge data given in this table includes the flow of the Chicago River which is discharged into the Desplaines at Lockport and Joliet.

11167 I have also prepared a table of discharges of the Illinois River as affected by the principal tributaries. This table is divided into two periods, ten years, 1890 to 1899, inclusive, and four years, 1900 to 1903, inclusive, the latter period being since the opening of the drainage canal.

This table is based upon the discharge as measured at Peoria, and the amount contributed by each of the tributaries to the Illinois is estimated as being in same ratio as the area of the tributary bears to the total drainage area above Peoria. The title of the table is as follows: "Table of volume of flow of the Illinois River as affected by its tributaries, based on discharge measurements at Peoria, and ratios of drainage areas," and is as follows:

TABLE OF DISCHARGES OF THE ILLINOIS RIVER AS AFFECTED BY ITS TRIBUTARIES; BASED ON DISCHARGE MEASUREMENTS AT PEORIA AND RATIOS OF DRAINAGE AREAS.

JACOB A HARMAN CE

SUBDIVISIONS OF THE ILLINOIS RIVER DRAINAGE BASIN.	APPROX DISTANCE FROM LOCKPORT MILES	RATIO OF DRAINAGE AREA TO THAT ABOVE PEORIA	SUM OF RATIOS OF DRAINAGE AREAS	DISCHARGE IN CUBIC FEET PER SECOND.											
				FOR ILLINOIS RIVER EXCLUSIVE OF CHICAGO R						FOR ILLINOIS RIVER INCL. CHICAGO RIVER					
				AV. 1890 TO 1899 INCL.			AV 1900 TO 1903 INCL.			AV 1890 TO 1899 INCL.			AV. 1900 TO 1903 INCL.		
				LOW	ORD.	HIGH	LOW	ORD.	HIGH	LOW	ORD.	HIGH	LOW	ORD.	HIGH
CHICAGO RIVER TO LOCKPORT.	0.0									600	600	600	3 801	4 162	4 162
DESPLAINES RIVER TO DUPAGE RIVER.	15.0	.0656		60	214	1141	178	407	1753	660	814	1741	3 979	4 569	5 915
DESPLAINES RIVER TO KANKAKEE RIVER.		.1027	.1027	94	334	1788	280	636	2743	694	934	2388	4 081	4 798	6 905
KANKAKEE RIVER SMALL STREAMS TO FOX RIVER	19.5	3813 .0735	.4840 .5575	444 513	1577 1816	8424 9703	1328 1530	3 000 3 455	12934 14899	1044 1113	2177 2416	9024 10303	5 129 5 331	7 162 7 617	17 096 19 061
FOX RIVER SMALL STREAMS TO VERMILION R.	52.6	2003 .0101	.7578 .7679	697 706	2369 2502	13180 13365	2080 2108	4693 4759	20252 20521	1297 1306	2969 3102	13780 13965	5 881 5 909	8 855 8 921	24 414 24 683
VERMILION RIVER SMALL STREAMS TO PEORIA	62.1	0977 .1333	.8656	796	2820	15066	2376	5364	23137	1396	3420	15666	6 177	9 526	27 294
AT PEORIA SMALL STREAMS TO MACKINAW.	131.6	 .0261	1.0000 1.0261	920 954	3258 3343	17406 17 859	2745 2816	6 198 6360	26 724 27421	1520 1554	3858 3 943	18 006 18 459	6 546 6 617	10 360 10 522	30 886 31 583
MACKINAW RIVER SMALL STREAMS TO SPOON R	140.5	0903 .0400	1 1164 1.1564	1026 1064	3637 3767	19 533 20128	3065 3186	6920 7167	29 834 30 903	1626 1664	4 237 4 367	20 133 20 728	6 866 6 987	11 082 11 329	33 996 35 065
SPOON RIVER SMALL STREAMS TO SANGAMON	171.1	1379 .0104	1 2943 1.3047	1191 1200	4216 4250	22 527 22 708	3552 3581	8021 8085	34 589 34 866	1791 1800	4 816 4 850	23 127 23 308	7 353 7 382	12 183 12 247	38 751 39 026
SANGAMON RIVER SMALL STREAMS TO CROOKED C.	193.6	.4206 .0134	1.7253 1.7387	1587 1599	5621 5665	30030 30262	4735 4771	10692 10776	46 107 46 465	2187 2199	6 221 6 265	30 630 30 862	8 536 8 572	14 854 14 938	50 269 50 627
CROOKED CREEK SMALL STREAMS TO MC KEES CR.	207.8	1027 .0214	1.8414 1.8628	1694 1714	5998 6067	32051 32424	5054 5112	11412 11 524	49 209 49 780	2 294 2 314	6 598 6 667	32 651 33 024	8 855 8 913	15 574 15 686	53 371 53 942
MC KEES CREEK SMALL STREAMS TO MACOUPIN C	225.2	.0350 .0879	1 8978 1.9857	1745 1827	6181 6468	32933 34561	5209 5448	11761 12305	50 716 53 065	2 345 2 427	6 781 7 068	33 533 35 161	9 010 9 249	15 923 16 467	54 878 57 227
MACOUPIN CREEK SMALL STREAMS TO MISSISSIPPI R	268.1	.0738 .0114	2.0595	1894	6710	35 846	5653	12763	55 037	2494	7 310	36 446	9 454	16 925	59 199
JUNCTION OF ILLINOIS RIVER WITH THE MISSISSIPPI RIVER	283.5		2.0709	1904	6747	36045	5681	12 834	55 341	2504	7347	36 645	9482	16 996	59 503

NOTE; IN ABOVE TABLE "LOW" = AVERAGE FOR LOW QUARTER, "ORD" = ORDINARY AND "HIGH" = AVERAGE FOR HIGH QUARTER.

11169 This table shows the approximate distances along the Desplaines and Illinois Rivers, from Lockport to the point of entrance of the various tributaries. The ratio of the area of the various tributaries to the area at Peoria, and the sum of those ratios proceeding down stream. Two sets of discharges are computed for both of the periods referred to. One set of discharges is for the natural flow of the Illinois River, exclusive of that contributed by way of the Chicago River and the other is for the total flow of the Illinois River. The discharge is also given for three stages of the river, that is, low, ordinary and high. The low, as given in this table, is the average flow of the river for the 91 days of the year when the river was lowest or low quarter of the Leslie rule. The high or flood discharges are for the 91 days of the highest discharge of the river, or the average for the high quarter of the Leslie rule. The ordinary is computed by the Leslie rule which has been given before.

For the ten year period, 1890-99, this table shows that the
low flow of the Desplaines River without the Chicago
11170 River contributing, averaged 94 cubic feet per second,
the ordinary 334 cubic feet per second and the high
1788 cubic feet per second.

The flow of the Kankakee and Desplaines jointly was 444 cubic feet, the ordinary 1577 cubic feet, and the high 8424 cubic feet, without the Chicago contributing.

The table shows that the average discharge from the Illinois into the Mississippi for the ten years, 1890-99, inclusive, for the low quarter 1904 cubic feet, the ordinary 6747 and the high 36045 cubic feet, without the Chicago contribution. In these tables the amount of water supplied through the Illinois and Michigan Canal from Chicago has been estimated as 600 cubic feet per second, throughout the entire period.

For the years 1900 to 1903, inclusive, the Chicago drainage canal and the Illinois and Michigan Canal jointly have contributed to the flow of the Desplaines and the Illinois River at the low period, 3801 cubic feet, the ordinary and high periods, 4162 cubic feet per second. The average discharge of the Illinois and its tributaries during the four years, 1900 to 1903, inclusive,

has been considerably in excess of the average discharge for the previous ten years, not taking into account the Chicago
11171 River contribution.

Comparing the discharge of the Illinois into the Mississippi, the low flow for the latter four years, as compared with the former ten years, was nearly three times as great, the ordinary flow at the high or flood flows, about 80 per cent more, these exclusive of the sanitary canal waters.

Q. Have you investigated the city of St. Charles, Missouri?

A. Yes sir, I have made an investigation there.

Q. When was this investigation made?

A. On March 10th and 11th, 1903.

Q. Will you describe the sewage system of St. Charles, briefly, and whether it sewers into the Missouri River?

A. All the sewers of the city of St. Charles, all drain into the Missouri river. The city of St. Charles is located upon the left bank of the Missouri River, above where it empties into the Mississippi River. The distance over land from St. Charles to the business district of St. Louis is about sixteen miles. The land upon which St. Charles is situated rises abruptly from the Missouri River and at a distance of about three or four blocks back from the river the elevation is about 100 feet or more above the stream. The drainage of the business dis-
11172 trict and of nearly all the residence district flows direct
into the Missouri River. The drainage of the remainder of the residence district is north to the Mississippi River, which is only 6 miles away. The streets run parallel with and at right angles to the Missouri River. The business is done on the first two streets, parallel with and near the Missouri River. The population of St. Charles, in 1890, was 6,161, and in 1900 it was 7.982, from the United States census reports. St. Charles is not provided with a complete sewage system. There are four public sewers ranging from three or four blocks in length to eight blocks in length, draining the business districts, and portions of the more populous territories. Besides these there are many private sewers from the hotels and business houses leading to the Missouri River. On Main Street, which is parallel with and one block from the river, there are five hotels and one or two livery stables. There is a public hospital which can

accommodate about twenty patients located four blocks from the river, which has a sewer on Clay Street.

Q. Are you acquainted with the sewage system of St. Louis?

A. In a general way.

Q. Do you know how St. Louis disposes of its sewage?

11173 MR. JEFFRIES: Objected to as immaterial.

A. The sewage of St. Louis is discharged by means of main sewers into the Mississippi River.

Q. Do you know how the garbage and the cleanings of the streets are disposed of?

MR. JEFFRIES: I object to that as immaterial.

A. They are disposed of by dumping into the Mississippi River from city dump boats, stationed at various places along the river line.

Q. Will you look at the photograph on page 1 of defendants' exhibit, Spencer's exhibit C, and state whether that photograph correctly represents the manner of the disposal of garbage in the city of St. Louis?

A. I should say it does.

MR. JEFFRIES: I object to the question as immaterial and to the answer, and I move to strike out the answer for the same reason. Also for the further reason that the photograph does not show that any garbage is being deposited at the place where the photograph was taken.

Q. Describe how the garbage of St. Louis is disposed of along the Mississippi River?

11174 MR. JEFFRIES: Objected to as immaterial.

A. At a number of points along the Mississippi River along the river front of St. Louis, the city maintains what are called dump boats which are scows 30 or 40 feet wide and 80 to 100 feet long, and which are tied near the bank, and the wagons and the teams having the garbage are driven upon these boats, and the garbage is dumped over the edge into the river and it floats off down the stream.

ADJOURNED until 2:00 p. m., same day.

11175 2:00 p. m., Wednesday, March 3, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

JACOB A. HARMAN

resumed the stand for further direct examination by Mr. Todd, and testifies as follows:

Q. Mr. Harman, have you in your possession a copy of a letter addressed to James P. Kirkwood, Esq., chief engineer, from the office of the Board of Water Commissioners of the city of St. Louis, dated December 11, 1865?

MR. JEFFRIES: I object to the question because it is incompetent, irrelevant and immaterial, and has no bearing upon the issues involved in this case, and the letter itself is so antiquated as not to be competent, dated prior to the birth of the science of bateriology and modern sanitary science, and for the further reason that counsel has exhibited to the witness a book which purports to contain a copy or supposed copy of said letter, and such testimony is incompetent, irrelevant and im-
11176 material.

A. Yes sir.

Q. Where does such letter appear?

MR. JEFFRIES: I object to the letter for the same reason and for the further reason that it will have no bearing upon the issues involved in this case and can have no binding force upon the complainant.

A. This letter appears on page 165 of the report on the filtration of river waters for the supply of cities as practiced in Europe, made to the Board of Water Commissioners of the city of St. Louis by James P. Kirkwood, civil engineer, published by permission of the Board by D. Van Nostrand, publisher, 23 Murray Street and 27 Warren Street (up stairs), London. Thubner & Co. 1869.

Q. Will you read into evidence the letter to which you refer?

MR. JEFFRIES: I object to the reading of the letter in evidence for the same reasons stated in the previous objection.

A. Office of Board of Water Commissioners, St. Louis, December 11, 1865.

11177 James P. Kirkwood, Esq., Chief Engineer:

Dear Sir.—At a meeting held this day at the rooms of the Commissioners there were present his Honor, the Mayor, J. S. Thomas, Philip Weigel and Dwight Durkee, President Mayor Thomas offered the following resolution, to-wit:

Resolved, that James P. Kirkwood, Esq., our chief engineer, be requested to proceed at once to Europe and there inform himself in regard to the best processes in use for the clarifying of river waters used for the supply of cities, whether by deposition alone or by deposition and filtration combined, making such an examination in each instance as will enable him to report to this board the general dimensions and special characteristics of the specific works visited by him, so that this board may be able to appreciate how far the same mechanically and the same or similar combinations of materials are likely to be adaptable to the purifying of the Mississippi water at St. Louis.

11178 The following cities which are supplied by river water and which possess works for the cleansing of that water when turbid are indicated as points to be visited, to-wit:

In England, London, Norwich, Preston, Nottingham and South Hampton.

In Scotland: Paisley and Perth,

In Ireland: Dublin.

In France: Lyons, Tours and Toulouse, and Marseilles.

In Germany: Berlin, Hamburg and Brunswick.

In Italy: Leghorn.

And such other cities not above mentioned as may be ascertained to possess works of this class deserving of the examination to be visited, also provided, however, that Mr. Kirkwood shall so arrange his movements as to return to St. Louis by the first day of May, 1866, at the furthest.

Resolved that Mr. Kirkwood be and he is hereby empowered to employ such assistants or interpreter when in Europe, and particularly where foreign languages are spoken, as may be necessary to enable him to get all the information needed.

Above I hand you copy of resolution and to enable you to carry that out I enclose herewith my individual check number 30,009 on the National Bank of North America, New 11179 York, for twenty-seven hundred dollars, which I trust will be sufficient for the full trip.

I have to request that you advise me of the receipt of this, also what day you sail and any other particulars you choose, and further that you will report your arrival on the other side with such observations as your time and inclination will permit.

With the hope that you find an ever ruling Providence will guide and protect you, I remain,

Yours truly,
(Signed) DWIGHT DURKEE,
President.''

MR. JEFFRIES: I move to strike out the letter as read for the reason that it purports to be a duplicate copy and no evidence is shown that it is an exact copy of the original or any such letter was ever written, or any such resolution ever passed or any such authority ever given and it is irrelevant and immaterial testimony and incompetent.

11180 CROSS-EXAMINATION by Mr. Jeffries.

Q. What did you say was the extent of the sewer system in the city of St. Charles, Missouri, as you observed it?

A. There were four public sewers there extending three or four blocks to ten or twelve blocks, from the river, draining the major portion of the business district and considerable of the residence, the more thickly populated residence district, including most of the school houses of the city and the hospital.

Q. Is it not a fact that less than one-third of the city of St. Charles is sewered?

A. In area less than one-third.

Q. In population is it not true?

A. I do not know definitely about that. I do not say it would be less than one-third.

Q. It is a fact that there is not more than one-third?

A. I do not think half of the population.

Q. Do you know the population of the city of St. Charles?

A. As given by the census.

Q. What is it?

A. I do not recall the figures. I gave it in my testimony this morning, nearly 8,000.

11181 Q. What part of the current of the river with reference to its surface and its bed is the most rapid?

A. With reference to the sides of the prominent obstructions in the river, the central portion. With reference to the depth, about from .1 to .2 below the surface is most rapid.

Q. 1.2?

A. From .1 to .2 of the total depth of the stream, below the surface.

Q. From .1 to .2?

A. Yes sir, from .1 to 2. of the depth.

Q. So then if the stream was 10 feet deep the most rapid place would be from 1 to 2 feet below the surface?

A. And in the center of the stream.

Q. And in the center of the stream?

A. Yes sir.

Q. In figuring up the total urban and rural population upon the water shed of the Illinois River what did you include in the urban population?

A. I included the population of all cities or villages of 1,000 or more inhabitants.

11182 Q. And you included all the villages with a population of 1,000 or more that are situated upon the water shed, or what is known as the water shed of the Illinois River?

A. Yes sir, or drainage area.

Q. Or drainage area?

A. Yes sir.

Q. All the remainder of the population as shown by the census was placed in the column known as rural population?

A. Yes sir.

Q. You live at Peoria?

A. I do.

Q. Do you know where the Clark Brothers present distillery is located?

A. I do.

Q. How long have they occupied that present distillery?

A. About five or six years.

Q. Their old distillery is closed down?

A. Yes sir, it is dismantled or closed down, or torn down.

Q. How far is their present distillery located from the Illinois River?

A. About a half a mile.

11183 Q. A wide area of vacant territory between the distillery and the river?

A. Yes sir, it is a river bottom and years of low water it is all farmed.

Q. Cultivated?

A. Yes sir.

Q. This letter that you introduced or read in evidence from the book, where did you get that book?

A. You mean today?

Q. Yes sir?

A. I borrowed it from the Western Society of Engineers' library. I have a copy in my own library at home.

JACOB A. HARMAN.

ADJOURNED until 10:00 a. m., Friday, March 4, 1904.

11184 1:30 p. m., Friday, March 4, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

ROBERT SPURR WESTON,

a witness called on behalf of defendants, being duly sworn, testified as follows:

DIRECT EXAMINATION, by Mr. Todd.

Q. What is your name?

A. Robert Spurr Weston.

Q. Are you a graduate of any technical college?

A. I am a graduate of a college.

Q. What college, Mr. Weston.

A. Amherst.

Q. When did you graduate at Amherst?

A. 1891.

Q. What degree did you take at Amherst?

11185 A. Bachelor of Science.

Q. After graduating from Amherst what did you do?

A. I was employed as chemist for about three years.

Q. Where?

A. With the American Sugar Refining Company, and also on a plantation in Louisiana. After that I was a student in the Institute of Technology and in the University of Berlin, and besides that I have been a volunteer worker in the laboratories of the Massachusetts and the German Imperial Boards of Health. Since then I have been engaged in sanitary work. In 1895 I was connected with the Louisville water purification experiments and subsequently have been connected with water purification experiments at West Superior, Wisconsin, at Washington, D. C., and other places.

In 1900 I was in direct charge of the water purification station at New Orleans and conducted an investigation lasting eight months as to the feasibility of purifying the Mississippi water. I have been in private practice, exclusive of this last period, for six years.

Q. Are you acquainted with the watershed of the Mississippi river above New Orleans?

A. Yes, sir.

11186 Q. Have you prepared a table of distances of the towns lying tributary to the Mississippi river watershed above New Orleans?

A. I have prepared a table of distances.

Q. Will you read the principal cities, their distances from New Orleans, lying on the Mississippi river or its tributaries?

MR. JEFFRIES: I object to the question because it is incompetent and immaterial and has no bearing upon the questions involved in the issues in this case.

A. Baton Rouge, Louisiana, 132 miles.
Natchez, Mississippi, 265 miles.
Vicksburg, Mississippi, 366 miles.
Memphis, Tennessee, 735 miles.
Cairo, Illinois, 965 miles.
Louisville, 1305 miles.
Cincinnati, 1415 miles.
Pittsburg, 1875 miles.

St. Louis, 1159 miles.
Mouth of Missouri river, 1165 miles.
St. Paul, 1823 miles.

Q. Have you figured out the population upon the water-
11187 shed of the Mississippi river above New Orleans?

A. I have.

MR. JEFFRIES: I object to that.

Q. Have you prepared tables showing the urban and rural population on the watershed of the Mississippi river above New Orleans?

A. I have not prepared a table showing the urban and rural population. I have prepared a table showing the population of the cities which have 25,000 or more inhabitants, and the cities having a population of 4,000 or more inhabitants.

Q. That population in cities less than 4,000, that is, the rural population, have you prepared?

A. No, I have not.

Q. For what years have you prepared this table of the urban population in cities of 4,000 or more?

A. For the year 1900.

Q. How was this population for 1900 secured?

A. From the United States census for 1900.

Q. What did the United States census for 1900 show the population to be in towns of 4,000 or more in the Mississippi river valley?

11188 A. About 9,000,000, including Chicago.

Q. Have you prepared an estimate of the amount of sewage sewering into the different rivers which make up the watershed of the Mississippi river?

MR. JEFFRIES: I object to that as immaterial.

A. I have.

Q. Upon what basis have you prepared this data?

A. I have assumed that cities which have a population of 25,000 and over will discharge 175 gallons per capita of sewage per diem. I have assumed that the remainder of the urban population would produce 100 gallons per day per capita of sewage.

Q. Upon what was the assumption based made as to the amount of sewage in large cities as compared with small cities, with small cities having the ratio of 175 to 100 gailons per capita?

A. The assumption was based upon the water supply. In the case of the larger cities it was found, according to tables prepared, by John R. Freedman, in a report presented to Bird S. Coler, comptroller of the City of New York, that the large cities of the country consumed about 100 gallons of water per capita per diem. The 75 gallons per day is added for sewage from the streets, for ground water flowing into the sewers and for contaminated water from any other sources.

11189 In the smaller cities the consumption of water is much lower, approximately 60 gallons per capita. Furthermore, a large percentage of these cities is not sewered and a correspondingly smaller estimate must be made in this case for the difference between the amount of water consumed and the amount of sewage produced.

MR. JEFFRIES: I move to strike out that part of the answer which pertains to the quantity of water, consumption per capita in the large cities and the small cities, for the reason that it is in conflict with testimony already introduced by respondents, to wit: the evidence of Mr. Randolph, and this statement is inconsistent with the complainant's own testimony.

Q. Have you figured out the volume of sewage, based upon the large cities, on a basis of 175 gallons per capita per day as well as those upon the smaller cities?

MR. JEFFRIES: I object to the question for the reason that the counsel does not differentiate between what he terms large and smaller cities.

MR. TODD: In reply will state for the benefit of counsel that the matter has already been differentiated in the previous testimony of this witness, and for that reason I deemed it unnecessary to repeat it. 11190

A. I have. I estimated the amount of sewage from large cities, that is, cities above 25,000 population, to be 1,174,250,000 gallons per day. I estimated the amount of sewage from the remainder of the urban population, that is, the remainder of the population of cities from 4,000 to 25,000 to be 342,000,000 gallons per day, making a total of 1,516,250,000 gallons a day. This is equivalent to a flow of 2310 cubic feet a second at New Orleans.

Q. Have you figured out the dilution of the sewage at New Orleans?

A. I have. These dilutions may be expressed in three different ways:

A. Maximum dilution 1 of sewage to 586 of water.
Minimum, 1 of sewage to 83 of water.
Average, 1 of sewage to 296 of water.

B. Expressed as cubic feet per second of sewage per 1,000 urban population:

Maximum, 150. Minimum, 21. Average, 75 cubic feet per second per thousand urban population for the year 1900.

C. As gallons of water per diem per capita of the urban
11191 population:

Maximum, 16160. Minimum, 2262. Average, 8190.

Q. When you were at New Orleans what branch of the work did you have charge of in connection with the survey of the water of the Mississippi river, at that point?

A. I had the superintendence of the whole work.

Q. Who had charge of the work?

A. I was under the direct supervision of the Chief Engineer of the Sewage and Water Board.

Q. Who was the chief engineer?

A. George G. Earle.

Q. What other engineers were associated with that work?

A. There was an advisory board of six engineers of whom Mr. George W. Fuller of New York was the one with whom I came in direct contact. The advisory board consisted of B. M. Harrod, of New Orleans; Mr. Bell, of New Orleans; Mr. Raymond (deceased); Mr. Rudolph Hering, of New York; Mr. George W. Fuller, of New York, and Mr. Brown, of New Orleans.

Q. What branch of this work did you have charge of?

A. I was in charge of the water purification station.

11192 Q. When was the work done at this water purification station?

A. In 1900 and 1901 an experiment was conducted for eight months and data was collected for somewhat longer time to determine the best method of purifying the Mississippi river water at New Orleans.

Q. What was the character of the data?

MR. JEFFRIES: I object to that as immaterial.

A. The data consisted of analyses, engineering data and reports.

Q. What kind of analyses?

A. Chemical and bacteriological.

Q. Did you have charge of the chemical and bacteriological analyses conducted at this station?

A. I did.

Q. Over what period of time did these bacterial and chemical surveys of the waters of the Mississippi cover?

A. From the last of November until the following September, practically over one flood season.

Q. How often were analyses made of the waters of the Mississippi river?

A. As a rule, daily.

Q. At how many points?

A. At one point.

11193 Q. Where was that point located in the Mississippi river?

A. It was located at the upper confines of the City of New Orleans and where the experiment station took its water for experimental purposes.

Q. Were these analyses that were made daily both chemical and bacterial?

A. They were.

Q. Were the results of the chemical and bacterial analyses for the entire period ever published?

A. They were published in the report on Water Purification, published in New Orleans in 1903, by the Sewerage and Water Board of New Orleans.

Q. Have you prepared a table showing the composition of the Mississippi river water at New Orleans, Louisiana, based upon the chemical and bacteriological data for the months between December, 1900, and August, 1901?

A. I have.

Q. Will you produce and read the table which you have thus prepared?

MR. JEFFRIES: I object to the introduction of the table or to its being read in evidence for the reason that it is incompetent and immaterial and has no bearing upon the issues involved in this case, and for the further reason that it purports to 11194 be a table of averages by months and does not accurately portray or picture or represent the conditions of the water in the river at the point where examinations were made at all times during the term or period of examination, for the reason that it conceals or fails to reveal actual conditions at times.

MR. TODD: Does the objection go to the fact that the daily analyses, or analytical data from which these averages were made was not offered in evidence? I ask this for the reason that if counsel insists I will offer the entire analytical data at the point named in New Orleans, for each day of the examination.

MR. JEFFRIES: My objection principally goes to the competency of the testimony and its relevancy.

A. The caption of the table is "Composition of Mississippi River Water," and the table is as follows:

11195

Composition of Mississippi River Water

(Parts per Million.)

New Orleans, La.

Month. 1901.				Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Tem. Deg. Cent.				....	8.8	8.1	10.8	13.6	19.6	25.0	29.3	29.6
Silica Turbid.				679	187	227	369	630	423	457	515	161
Color				13	11	12	13	14	13	9	11	11
Oxygen Cons.				8.3	4.7	3.5	6.8	11.3	6.9	7.5	7.1	2.9
Nitrogen as'	Ammonia	Albuminoid	Diss.	0.104	0.063	0.056	0.054	0.077	0.060	0.045	0.055	0.046
			Susp.	0.228	0.088	0.140	0.196	0.358	0.185	0.195	0.167	0.032
			Total	0.332	0.151	0.196	0.250	0.435	0.245	0.240	0.222	0.078
		Free		0.017	0.017	0.013	0.013	0.005	0.006	0.004	0.005	0.005
	Nitrites.			0.014	0.010	0.012	0.008	0.001	0.000	0.000	0.001	0.001
	Nitrates.			0.24	0.11	0.12	0.11	0.17	0.12	0.12	0.16	0.13
Chlorine				10.2	9.4	8.5	10.0	7.0	9.3	14.8	8.9	8.3
Incrusting Cons.				19	15	15	11	17	9	11	17	-----
Alkalinity				67	79	70	84	71	75	82	84	98
Residue on evaporati	Dissolved			142	149	127	146	126	137	157	181	226
	Susp.			549	223	294	425	713	436	469	527	....
	Total			691	372	421	571	839	573	626	708	327
Iron				17.0	11.6	14.9	15.6	27.0	12.5	22.6	18.6	10.2
Carbon Dioxide	Free & Half-b.			....	58	68	68	51	66	66	47	33
	Free			....	23	37	31	21	33	32	13	0
Diss. Oxygen				....	10.5	10.7	10.0	8.3	7.0	6.0	6.7	5.9
Bacteria p.c.c.				2020	1315	2870	1790	3590	2150	2010	1835	910

11196 Q. Will you explain the table that you have just introduced in evidence and state what it shows in regard to the purification of the Mississippi river at New Orleans?

A. This table shows that the Mississippi river water at New Orleans is a very muddy stream and varies in character more or less with the character of the contributing tributaries.

The temperature may be passed over without comment.

The silica turbidity is a measure of the resistance of the water to the passage of light—in other words, a measure of the muddiness of the water, the higher the figures the higher the turbidity.

The color is the color of the dissolved matter after the suspended matter is removed. In general it is inappreciable and would not be noticed by the ordinary observer.

The oxygen consumed is a measure of the carbonaceous organic matter in the water and in the case of this water means that the suspended matter contains large amounts of organic matter from swamps which matter had been absorbed by the clay particles.

11197 The nitrogen as albuminoid ammonia shows that leaving the suspended matter out of consideration the water is of exceptional quality.

The nitrogen as nitrates and nitrites in this case are evidences of the transformation of the suspended woody fiber and organic matter which is poured into the Mississippi river water from its own central valley by means of such streams as the Yazoo and which in general course down the valley becomes removed to a great extent, into mineral and gaseous matter.

The chlorine in the water is not due in any appreciable degree to the effect of pollution on the watersheds, but probably to salt deposits.

Stearns, in the report for the Massachusetts Board of Health in 1890, states that 20 people per square miles will increase the chlorine content 0.1 part per million. The Mississippi river basin above New Orleans has about 7.3 people per square mile, equivalent to an increase in the chlorine content of about 0.04 of 1 part of 1,000,000. This is within the limits of accuracy of analytical work. The chlorine at New Orleans is indicative of salt deposits which are situated along the contributing tributaries, especially the southwestern tributaries.

Incrusting constituents and alkalinity are of no sanitary significance, they being harmless mineral matter.

The analyses show that apart from the nitrogen as nitrates and nitrites, that the water is a characteristic of the
11198 non-polluted water of this region. An abundance of oxygen is always present in the water, showing that the organic matter has been decomposed to about the limits, the number of bacteria are very low and are chiefly associated with the suspended matter. When the suspended matter is removed, the water is of excellent quality.

MR. JEFFRIES: I move to strike out the last answer for the same reason contained in my objection to the table.

Q. In the bacterial determinations of the water at New Orleans did you make any coli determinations during the course of this invstigation?

A. Tests were made during the flood season, that is from December, 1900, to April, 1901. These tests were made six times a week in December and the number of tests was gradually decreased in 1901 until April, 1901, when the tests were discontinued. Volumes varying from 1 cc. to 300 cc. were employed.

Q. Will you state in detail the results of these tests for coli?

MR. JEFFRIES: Objected to as immaterial.

11199 A. Bacillus coli was only found on three occasions during the five months of the tests. It was found during the first week of December, 1900. It was not found subsequent to that date. When the bacilli were found in 1900 they were found in a small volume of water, namely 1 cc. They were not found subsequent to the first week in December. The presence of these organisms in the water at this time and not at any other times is explained by the fact that on the bank of the river immediately above the intake of the water purification station a number of house boat men and squatters were quartered. During the low water season these people had thrown their feces on the bank of the river, and during the rise it is easy to account for the presence of bacillus coli in the intake of the water purification station at that time, especially so because the intake was located near the bank of the stream and was suspended from a house boat, but in comparatively shallow water.

Q. About how many coli determinations were made during this investigation?

A. 100.

Q. Covering a period of how long?

A. Five months.

11200 Q. How many times was the coli present in this 100 determinations

A. Three.

Q. What conclusion did you arrive at from the results of these coli determinations?

A. That no unpurified sewage was present in the Mississippi river at New Orleans.

Q. Have you figured out the time flow of water from Baton Rouge to New Orleans?

A. I have. Assuming the velocity of the stream at 4 miles an hour, which is neither the maximum nor the minimum, the sewage from Baton Rouge would reach New Orleans in 33 hours after it was discharged into the Mississippi river.

Q. Are you acquainted with the flow of the water at New Orleans?

A. I am.

Q. What is the velocity of the river at that point?

A. It may be taken as four miles per hour.

Q. From what you know of the Mississippi river, what in your opinion would be a fair average of velocity for that river from Cairo to New Orleans?

A. About four miles per hour. Certainly no more.

11201 Q. Have you figured out the discharge of the Mississippi at New Orleans?

A. I have not figured it out. I have it from the report of the Mississippi River Commission. The estimated discharge of the Mississippi River is as follows, taken from the report of the Mississippi River Commission, 1900, on page 18, of the report for Water Purification Investigation, and on plans proposed for sewage and water works system, published by the Sewage and Water Board, New Orleans, Louisiana, 1903.

Maximum 1,353,000 cubic feet per second.
Minimum 191,000 cubic feet per second.
Average about 685,000 cubic feet per second.

Q. The methods as pursued in your chemical analyses of the waters at New Orleans, and the technique employed in the bacteriological determinations and coli determinations are what are known as the standard methods used by the Massachusetts Board of Health and employed by the different chemists and bacteriologists that have testified in this case?

A. Substantially so, yes sir.

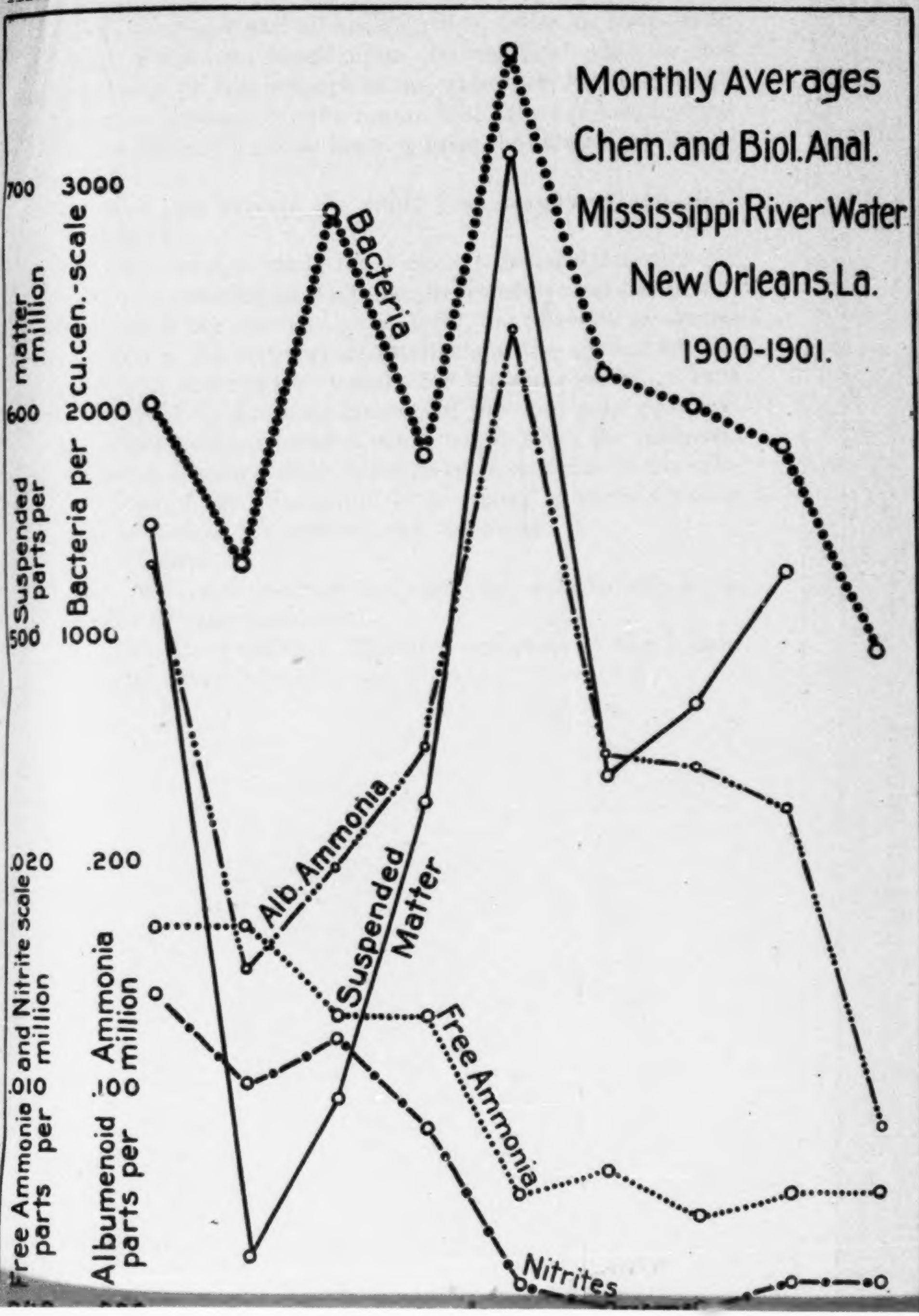
Q. Have you prepared a chart, based upon the monthly 11202 averages of the chemical and bacteriological analyses of the Mississippi river water at New Orleans, Louisiana?

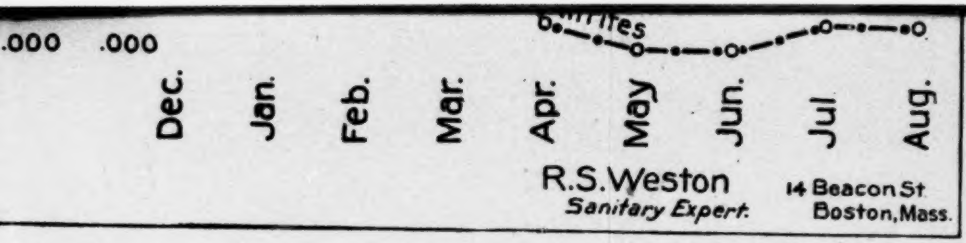
A. I have.

Q. Will you produce the chart and make it a part of your testimony?

Mr. Jeffries: Objected to as incompetent, irrelevant and immaterial.

A. The chart is as follows:


Monthly Averages
Chem. and Biol. Anal.
Mississippi River Water
New Orleans, La.
1900-1901.
Suspended matter parts per million
Bacteria per cu. cen. - scale
700
3000
600
2000
500
1000
Free Ammonia and Nitrite scale parts per million
Albumenoid Ammonia parts per million
.020
.200
.010
.100
Bacteria
Alb. Ammonia
Suspended Matter
Free Ammonia
Nitrites



R.S.Weston
Sanitary Expert.

14 Beacon St.
Boston, Mass.

11204 Mr. Jeffries: Let the record appear that complainant objects to any and all charts, maps, tables or plats being introduced which are based upon the chemical analysis and determinations by this witness in the waters of the Mississippi River at New Orleans, for the reason that they are incompetent and immaterial and have no bearing upon the issues involved in this case.

Q. Will you explain the chart just introduced and state what it shows?

A. This chart is made for a clearer demonstration of the main results expressed in the table previously presented in evidence. It gives the numbers of bacteria, the nitrogen as albuminoid ammonia, the nitrogen as nitrites and the amount of suspended matter averaged by months for the same period of time as was covered by the data presented previously in evidence.

Q. Have you prepared a chart based upon the computations which you have already introduced in evidence of the relative pollution of the Mississippi River water at various points together with data for determining the same?

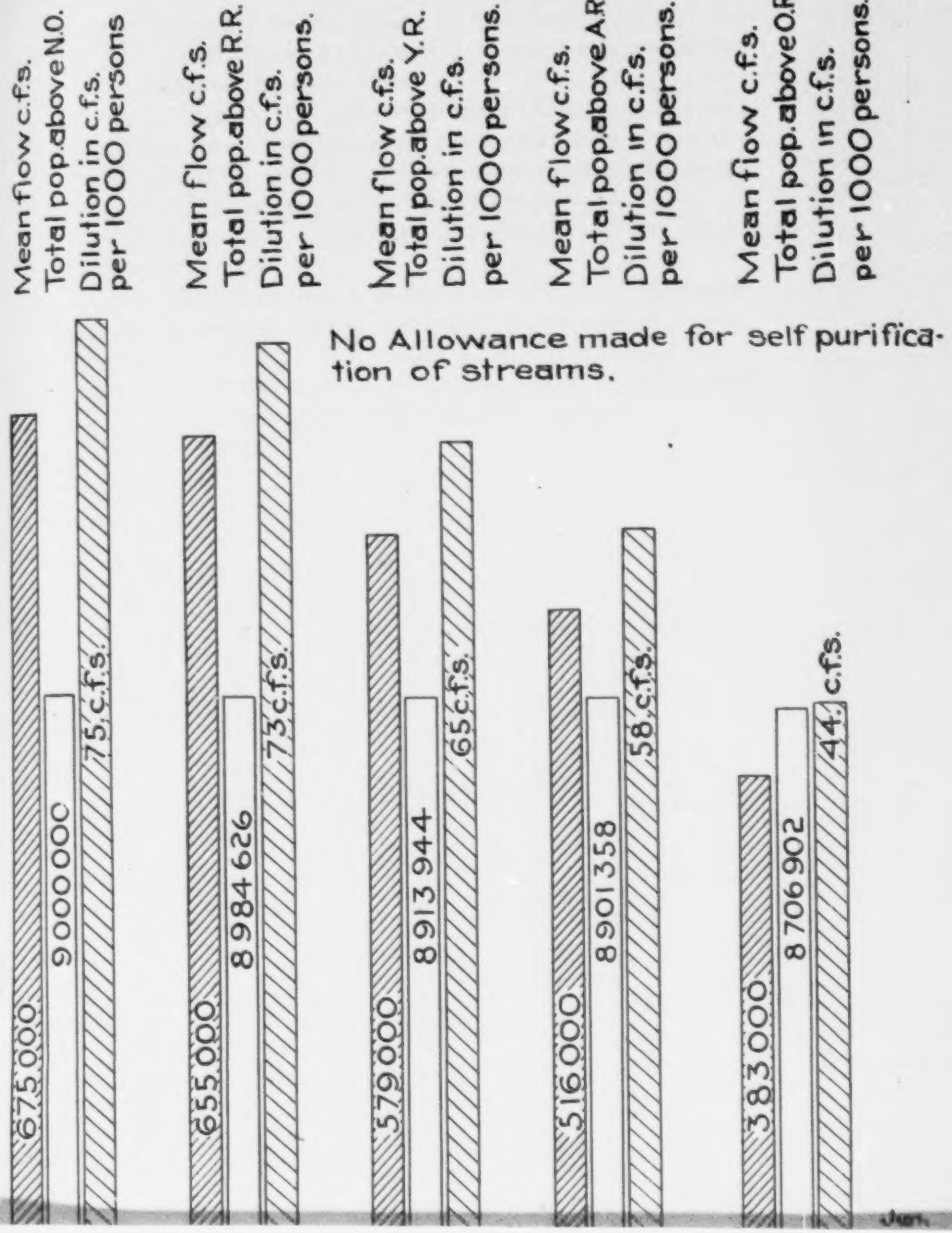
A. I have.

11205 Q. Will you produce and make the data to which you refer a part of your testimony?

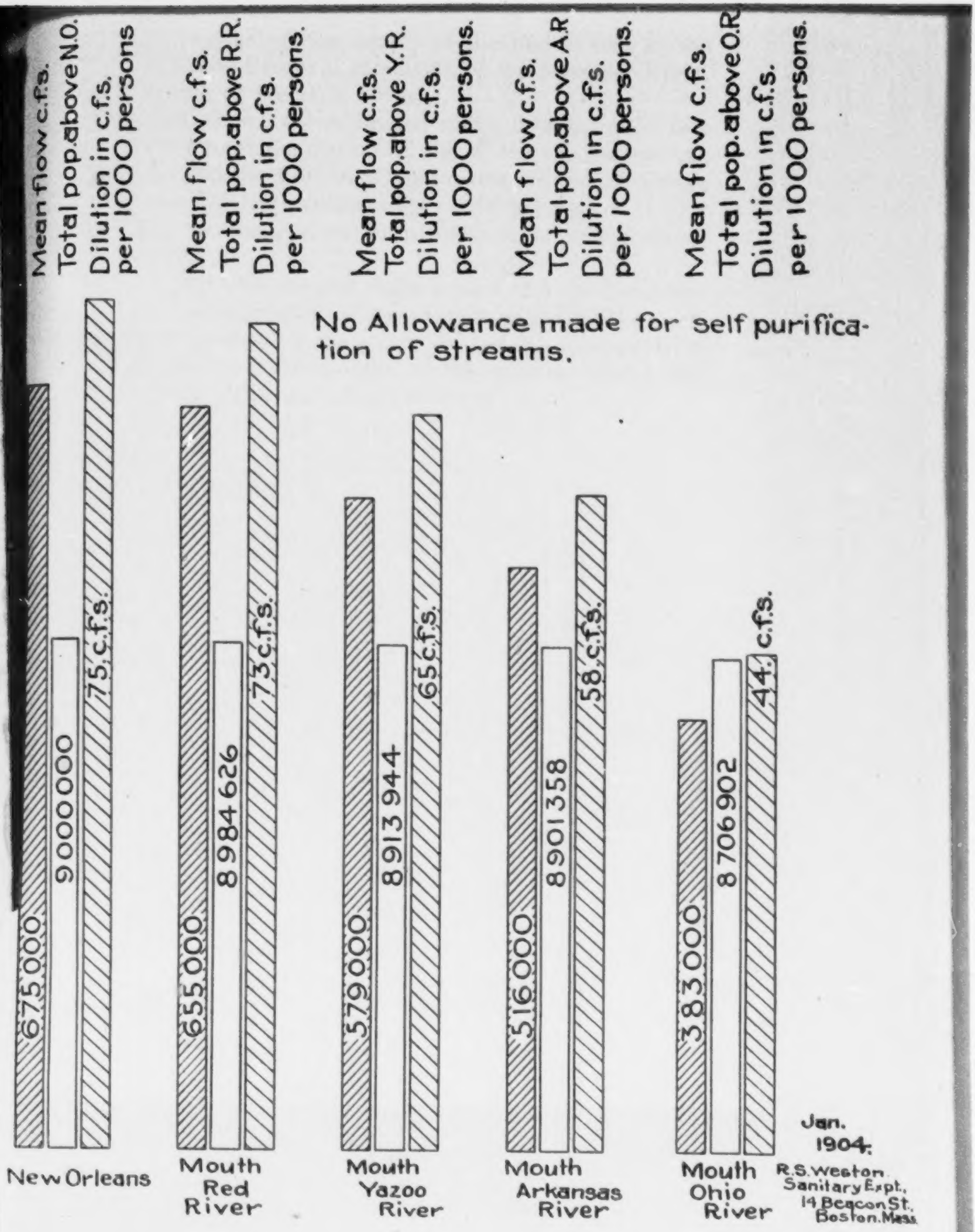
A. The chart entitled "Relative pollution of the Mississippi River Water" is as follows:

Relative Pollution of Mississippi River Water at various points

Together with data for determing the same.



No Allowance made for self purification of streams.



No Allowance made for self purification of streams.

Jan. 1904.

R.S. Weston
Sanitary Expt.
14 Beacon St.
Boston, Mass.

11207 Q. Will you state what that chart is intended to portray?

A. This shows the relative pollution of the Mississippi River water, no allowance being made for self-purification of streams at different points along the course of the stream as follows:

At New Orleans; at the mouth of the Red River; at the mouth of the Yazoo River; at the mouth of the Arkansas River, and at the mouth of the Ohio River.

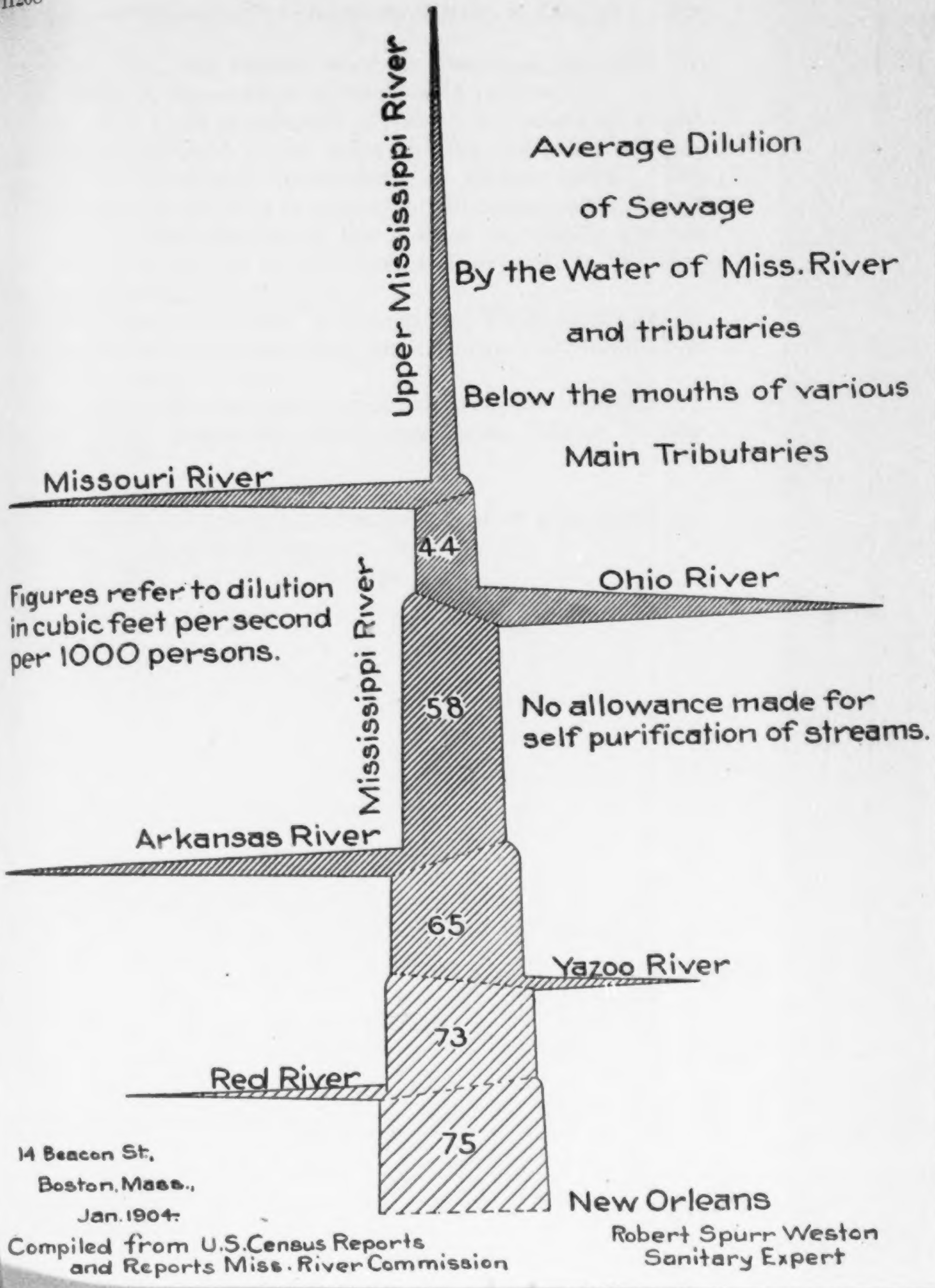
This chart shows the estimated mean flow in cubic feet per second, the total population of the water shed above the various points and the dilution of the present amount of sewage with water in cubic feet per second per 1000 persons.

Q. Have you made a graphical presentation of the same?

A. I have.

Q. Will you produce and make a part of your testimony the graphical representation of the same, based upon the average dilution of sewage by the waters of the Mississippi River and tributaries below the mouths of the various tributaries?

A. I will. The same is as follows:


Average Dilution
of Sewage
By the Water of Miss. River
and tributaries
Below the mouths of various
Main Tributaries
Upper Mississippi River
Missouri River
44
Ohio River
Figures refer to dilution
in cubic feet per second
per 1000 persons.
Mississippi River
58
No allowance made for
self purification of streams.
Arkansas River
65
Yazoo River
73
Red River
75
New Orleans
14 Beacon St.,
Boston, Mass.,
Jan. 1904.
Compiled from U.S. Census Reports
and Reports Miss. River Commission
Robert Spurr Weston
Sanitary Expert

11209 Q. Will you explain what the chart you have just introduced in evidence is intended to portray?

A. This chart is intended to portray the information just previously submitted in the table showing the relative pollution of the Mississippi River water at various points. The width of the shaded area is roughly proportioned to the flow of the stream. The fineness of the shading is roughly proportioned to the extent of the pollution and inversely to the dilution of the sewage.

This table shows that the Mississippi River as it flows to the Gulf dilutes the sewage more and more as it proceeds on its way to the Gulf.

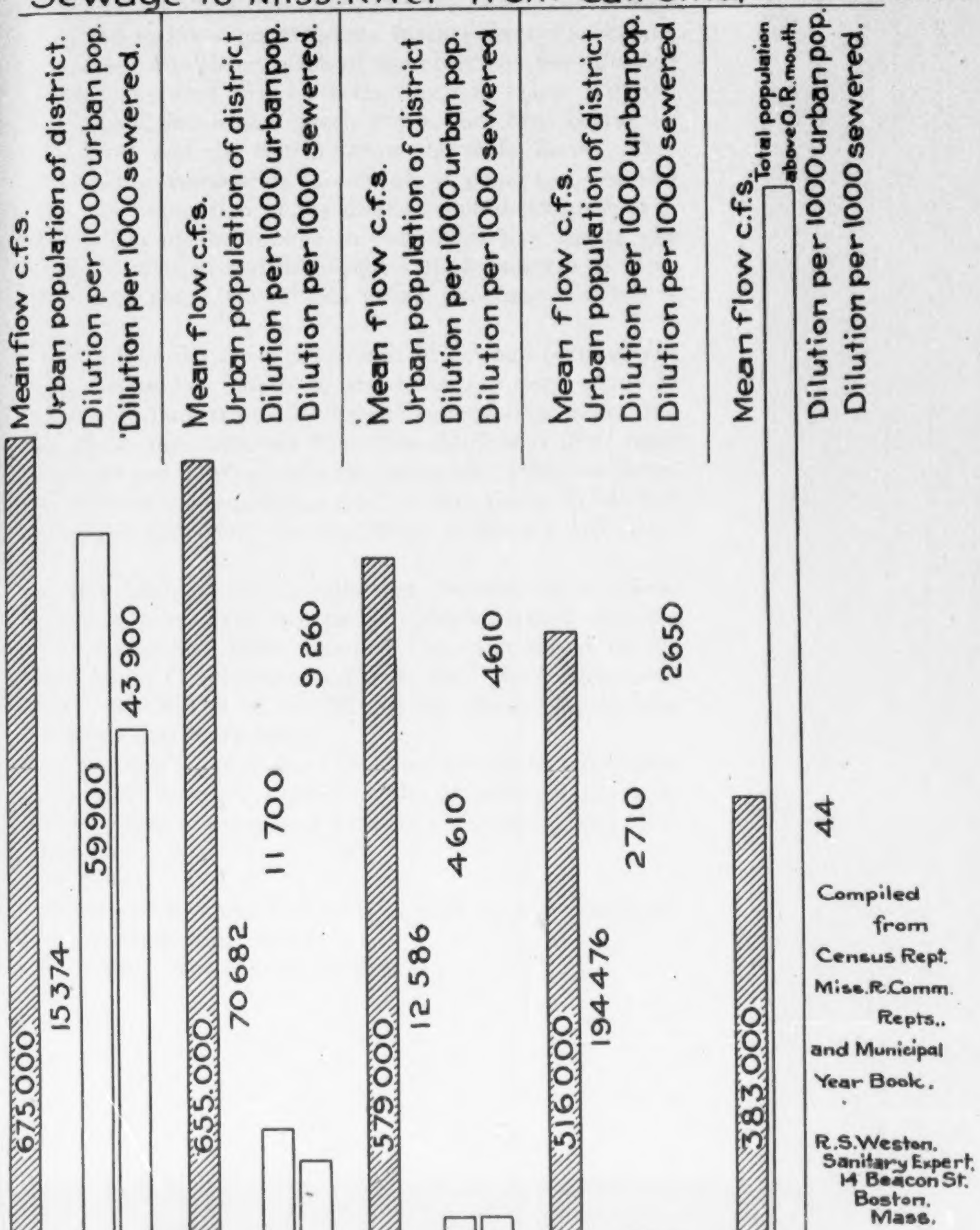
Q. Have you prepared a chart showing the accessions of sewage to the Mississippi River from Cairo, Illinois, to New Orleans?

A. I have.

Q. Will you produce and make a part of your testimony such chart, prepared by you?

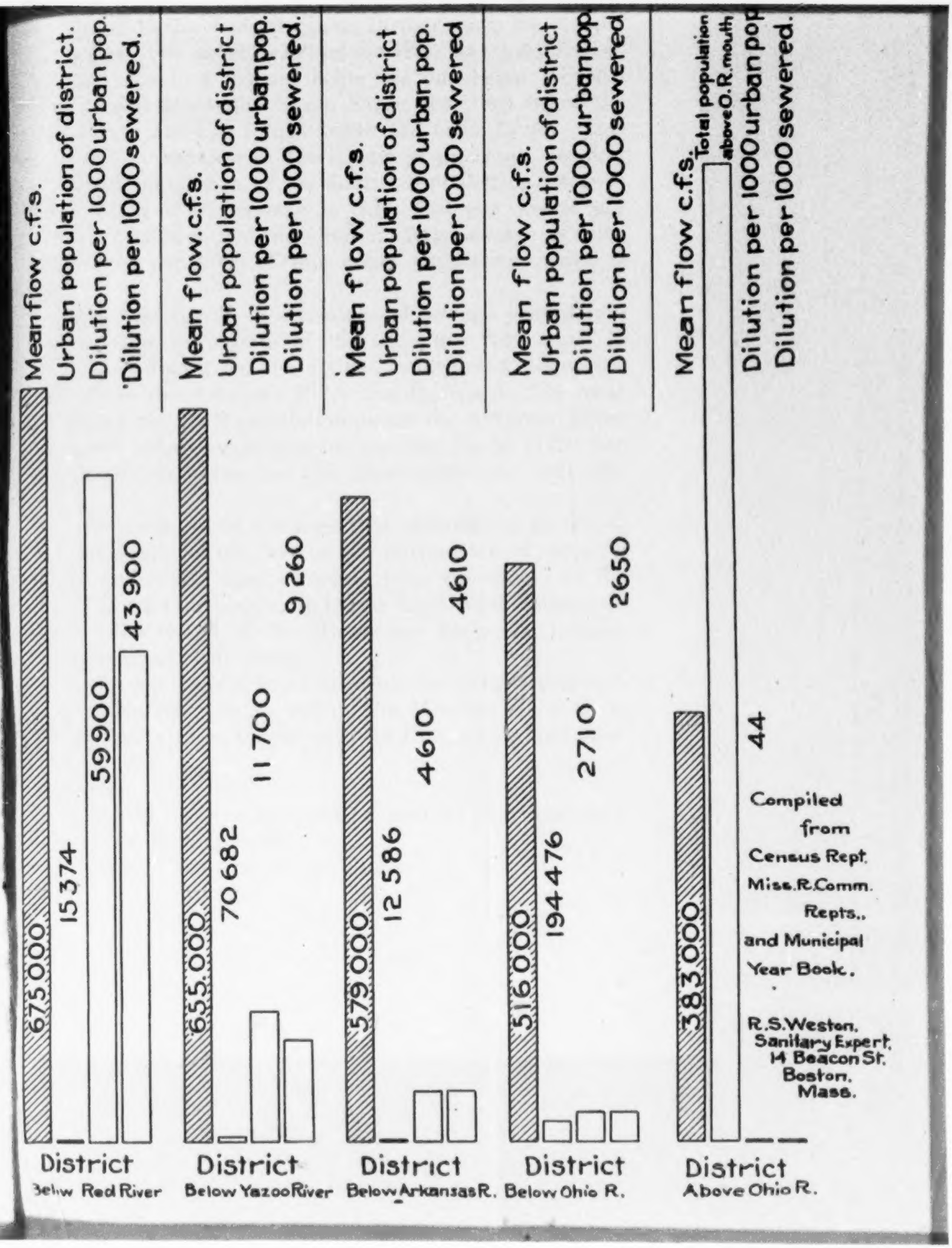
A. The chart is as follows:

Showing Accessions of Sewage to Miss. River from Cairo. Ills., to New Orleans.



Compiled from Census Rept. Miss. R. Comm. Repts., and Municipal Year Book.

R. S. Weston,
Sanitary Expert,
14 Beacon St.
Boston,
Mass.



Compiled from Census Rept. Miss. R. Comm. Repts., and Municipal Year Book.

R. S. Weston, Sanitary Expert, 14 Beacon St. Boston, Mass.

11211 Q. Will you state what that chart is intended to portray?

A. This chart shows the amount of sewage entering the river above the mouth of the Ohio, and the amount of sewage which is added to the river at points further down the stream. For convenience this lower reach of the river has been divided into districts, the first district being the one below the Red River the second below the Yazoo River, the third below the Arkansas River and the fourth below the Ohio River. This table shows the mean flow of the stream in cubic feet per second, the urban population of the district contributing the sewage, the dilution of the sewage in cubic feet per second per 1,000 urban population and the dilution of the sewage in cubic feet per second per 1,000 of this urban population, which is sewered.

It shows that the fresh accessions of sewage poured into the stream below the mouth of the Ohio are very small in amount, namely that from the district immediately below the Ohio and above the Arkansas River the dilution is 2710 cubic feet per second per 1,000 population, below the Arkansas River 4616 per 1000 urban population; below the Yazoo 11700 per 1000 population and below the Red River 59,900 per 1000 population.

11212 In this table as in the ones that preceded it no allowance has been made for the self-purification of streams.

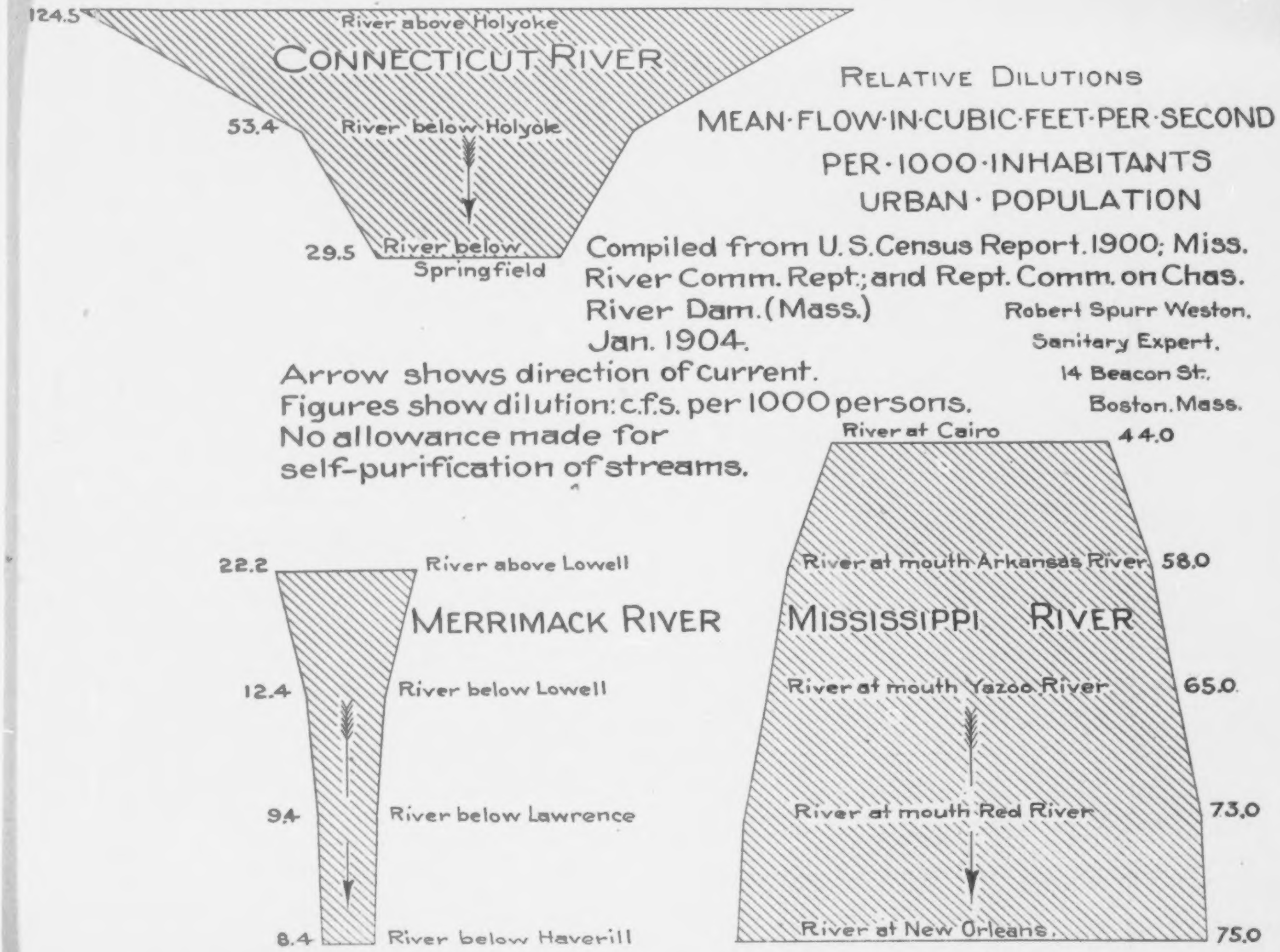
This report has been compiled from the report of the Mississippi River Commission and from the United States census reports—the report of the Mississippi River Commission from the Municipal Year Book.

Q. Have you made a chart showing the relative dilutions of flow in cubic feet per second of the Mississippi River in points of pollution as compared with the Connecticut and Merrimack Rivers?

A. I have.

Q. Will you produce and make a part of your testimony the chart to which you refer?

A. I will. The chart is as follows:



RELATIVE DILUTIONS

MEAN·FLOW·IN·CUBIC·FEET·PER·SECOND
PER·1000·INHABITANTS
URBAN·POPULATION

Compiled from U.S. Census Report. 1900; Miss. River Comm. Rept.; and Rept. Comm. on Chas. River Dam. (Mass.) Jan. 1904.

Robert Spurr Weston.
Sanitary Expert.
14 Beacon St.
Boston. Mass.

Arrow shows direction of current.
Figures show dilution: c.f.s. per 1000 persons.
No allowance made for self-purification of streams.

CONNECTICUT RIVER
124.5 River above Holyoke
53.4 River below Holyoke
29.5 River below Springfield
MERRIMACK RIVER
22.2 River above Lowell
12.4 River below Lowell
9.4 River below Lawrence
8.4 River below Haverill
MISSISSIPPI RIVER
River at Cairo 44.0
River at mouth Arkansas River 58.0
River at mouth Yazoo River 65.0
River at mouth Red River 73.0
River at New Orleans 75.0

11214 Q. Will you explain the chart which you have just introduced in evidence?

A. This chart is a diagramatic one and illustrates the relative dilutions of the sewage at different points along the Mississippi River below Cairo, at three different points on the Connecticut River as it flows through the state of Massachusetts and at four different points on the Merrimack River as it flows through the same state. The arrows show the direction of the current and the figures to the right and left of the different diagrams show the dilutions in cubic feet per second per 1000 population.

In this case no allowance has been made for the purification of streams.

This diagram was made primarily to contrast the two Massachusetts streams with the Mississippi River. The Massachusetts streams receive so much sewage in the form of fresh accessions below the points of observation that the amount of sewage in the river water as it proceeds down the river within the limits named are always in greater proportion as shown by the observations. While on the other hand as sewage
11215 is carried down the Mississippi River below Cairo it is
always in increasing dilution, the fresh accessions of sewage never being of sufficient amount to maintain the concentration of sewage which existed at Cairo. The reasons for this status of affairs are that the Mississippi River below Cairo is levied and that the population is relatively small. The banks slope back from the river for a greater part of the distance, while in the case of the Connecticut and the Merrimack Rivers the streams flow through a country which is higher than the level of the water in the stream and constant fresh accessions of sewage are received. The litteral population is relatively larger.

Q. From your knowledge of the amount of pollution entering the Mississippi River through its tributaries from the population living upon the water shed, and from the chemical and bacterial and coli determinations, the results of which you have offered in evidence in your testimony, what is your opinion of the condition of the Mississippi River water at New Orleans the point where the investigation was made, as to whether the water of the Mississippi River has become free from the sewage and pollution which it has received by the time it reaches New Orleans?

11216 Mr. Jeffries: Objected to as incompetent, irrelevant and immaterial, having so bearing upon the issues involved in this case.

A. In my opinion there is not the slightest evidence that any unpurified sewage exists in the water at New Orleans apart from that small amount which may occasionally have been washed from the banks of the stream outside of the levies and in the immediate vicinity of the water purification station intake during the time when the tests mentioned in your question were made.

CROSS EXAMINATION

By Mr. Jeffries.

Q. Mr. Weston, what do you mean by unpurified sewage?

A. By unpurified sewage I mean sewage which has not undergone the cycle of changes which would obtain when sewage is mixed with an adequate quantity of water in a running stream, and I mean sewage which has not lost its previous bacteriological character.

Q. What effect has dilution upon the purification of sewage?

A. The main effect of dilution is to furnish an adequate quantity of oxygen for the oxidation of the organic mat-
11217 ter contained in the sewage. This can also be obtained by aerating sewage by passing it over dams, but of course not to the same degree.

Q. The way in which you used the term unpurified sewage in your direct examination had reference to the chemical and bacterial composition of the water in the Mississippi River at New Orleans did it not?

A. I used it in a way which I thought would mean that the analysis gave no evidence of the presence of unpurified sewage in the water at New Orleans.

Q. Even though the city of Baton Rouge is situated 132 miles and within a 33 hour flow from the city of New Orleans any sewage so discharged into the river from Baton Rouge has become purified within the time it reaches New Orleans, within thirty-three hours?

A. Evidently.

Q. And regardless of the fact that pathogenic bacteria may live in diluted water of that character longer than the 33 hours, yet that sewage has become purified and the bacteria do not exist in the water, assuming that it does live that long in the water of that character?

11218 A. The facts are as I have stated them that there are no bacterial evidences of sewage at New Orleans, in spite of the fact that sewage reaches the river.

Q. What was the volume of the water analyzed by you for purposes of ascertaining the presence of the colon?

A. The volumes varied from 1 cc. to 300 cc.

Q. And I understand from your examination that 100 examinations were made?

A. Yes sir.

Q. So there would have been examined in the mean 100 times 150 cc. of water?

A. Yes sir.

Q. How much would that amount to in pints or quarts?

A. Thirty (30) pints.

Q. How many of these experiments were based upon the use of 100 cc. of water?

A. I can not give the exact number.

Q. Approximate it?

A. 85 per cent. 300 cc. of water, not 100 cc.

Q. And you found the colon three times?

A. Three times.

11219 Q. Assuming that these colonies of colon came from the dejecta of a typhoid patient, could you say although they were present that typhoid fever germs were not contained in the water?

A. No.

Q. Do you know what the population of Baton Rouge is?

A. 11,269 in 1900.

Q. What is the population of Natchez?

A. 12,210.

Q. Of Vicksburg?

A. 14,834.

Q. Of Memphis?

A. 102,320.

Q. Of Cairo?

A. Less than 25,000.

Q. Of Louisville?

A. 204,731.

Q. Of St. Louis?

A. 575,238.

Q. Now, is it not a fact that the element of dilution has more to do with the small quantities of bacteria contained in the waters of the Mississippi River at New Orleans than other bacterial or chemical elements known in sanitary science?

11220 A. I do not think so. Because in any other river with which I am acquainted, rivers in which the dilution of sewage in some instances have approximated the dilutions of the sewage at New Orleans by increasing the volume of the samples taken, I have been able in all of these other cases to demonstrate the presence of the bacillus coli communis. At New Orleans I was usually unable to do so. Neither was I able to demonstrate the presence of the bacillus coli communis nor, generally speaking, of any of that gas producing type of bacteria.

Q. Is it not a fact that the larger quantities of chlorine found in the waters of the Mississippi River at New Orleans averaging during the month of December, 1900, 10.2 parts per million, January, 1901, 9.4 parts per million, February, 8.5 parts per million, March, 10. parts per million, April, 7.0 parts per million, May, 9.3 parts per million, June, 14.8 parts per million, July, 8.9 parts per million and August, 8.3 parts per million, when taken together with the maps and charts which you introduced in evidence showing the comparisons between the conditions that existed in the Lower Mississippi and the two Massachusetts Rivers, that dilution is the most important element entering into the consideration of the chemical and bacterial condition of the water in the Mississippi River at New Orleans?

A. It is not the most important factor. It has an in-
11221 fluence but it may be seen upon an inspection that the Connecticut River, just above Holyoke has a greater dilution than the Mississippi River at Cairo and the dilution of the river passing down from Cairo to New Orleans is approx-

imately as 1 is to 2, a little less than 1 is to 2. The condition of the river above Holyoke is that of a sewage polluted stream. The condition of the river at New Orleans is that of a purified stream.

Q. Is it not a fact that the chart which you introduced in evidence showing the conditions existing upon the Connecticut River and the Merrimack River and the Mississippi River below Cairo show that dilution is the principal element entering into the chemical and bacterial condition of the waters of those rivers?

A. No sir, I do not think the charts show anything of that kind. I think if they do I have not explained them clearly. This chart shows that the amount of sewage entering into the river between Cairo and New Orleans is relatively, that is, in proportion to the amount of water flowing in the stream,
11222 very much less than the amount of sewage which enters into these other streams.

Regarding the chlorine I would say that according to the best authorities a population of 20 people per square mile would raise the chlorine content about .1 of a part per million. This population of the Mississippi valley is about 7.3 per square mile. In other words we would expect an increase in the chlorine of about 7.3-20 or 0.4 of 1 part per million due to population.

Q. Is it not a fact that the amount of pollution, of polluting material discharged into the Connecticut and Merrimack Rivers and the Mississippi River, as shown by your charts in the volume of discharges of those rivers, when compared with the diluting effect reverse the conditions of the Merrimack and the Connecticut Rivers from what the conditions are in the Mississippi River?

A. The dilution of the sewage increases as it proceeds down the Mississippi River from Cairo to New Orleans; the reverse is true in the other two streams at any particular point.

Q. Taking the elements of oxygen, the current, the ammonias, the nitrogenous matters and the chlorine as
11223 shown by your table of averages in the composition of the Mississippi River water at New Orleans for the month of December, 1900, and January, February, March, April, May,

June, July and August, 1901, do not these constituents show that the water in the Mississippi River at that point is not virgin water?

A. What am I to understand by virgin water?

Q. Does it not show that this water is of a bad ancestry?

Mr. Todd: I object to the question for the reason that it is indefinite, unscientific and contains terms that are misleading.

A. I can not answer this question directly because I do not understand the exact meaning in this connection of the word "bad." Undoubtedly the analyses show that at some previous time the water had received some organic matter and that this organic matter had become changed since its introduction.

Q. Does not this table showing the composition of the Mississippi River water at New Orleans, which you have introduced in evidence, represent a plea of repentance for that water?

A. I do not understand the question.

11224 Q. Mr. Weston, is it not a fact that this table of analyses bears all the evidence of a prior sewage pollution of that water?

A. To a degree.

Q. Is it not a fact that if the chemical and bacterial contents of a volume of water at the point in the Mississippi River where it was examined at New Orleans was concentrated to the same volume of water as existed in the river at Cairo that the chemical constituents which you found in the water at New Orleans would have been greater and larger and more numerous?

A. If the dilution were less the chemical content would be relatively greater to the same degree.

Q. And this relative increase, would that have shown upon a chart made from results of chemical and bacterial determination?

A. Yes sir.

Q. Is it not a fact that the chemical results as shown on the charts or table read in evidence by you, which represents the composition of the Mississippi River water at New Orleans, during the months of December, 1900, and from January to August, 1901, shows conditions less conducive to a puri-

11225 fication of that water during the winter months than in the summer months, and that there is more polluting material in the water of the river at that point during the winter months than in the summer months?

A. The amounts of the constituents which are ordinarily considered as indicative of pollution as a general rule do not seem to vary greatly through the year with the exception of the period immediately preceding and following the first rise of the river after a period of low water. This rise usually occurs in the winter. To that extent the amounts of these constituents are more in the winter than the other times of the year.

It should be said in addition that the amount of suspended matter is the greatest factor influencing the composition of the Mississippi River water at New Orleans as usually determined in other localities. Standards which would apply to the Connecticut River or the upper Mississippi River would not necessarily apply to the Mississippi River water at New Orleans.

11226 Q. Then the increased amounts of chemical constituents contained in the water of the Mississippi River at New Orleans during this investigation in the winter months over the summer months was due to the effect of reduced dilution during the winter months over conditions existing in the summer months, rather than to the effect of the change in the season producing a greater or a less purification of the water?

A. To which chemical constituents do you refer? Some are high in the winter months. Some are lower in the winter months than they are in the summer months of this period.

Q. I am taking the table as a whole together with all of the chemical constituents and the various quantities of the same, and asking you to consider it as a chemist in connection with water sanitation?

A. Due to decreased dilution?

Q. In the winter over conditions in the summer?

A. In the first place dilution of the river in the winter months is greater than it is in the summer. The Mississippi River at New Orleans, as a general rule, has an annual oscillation reaching its height in April and falling again in the
11227 summer. During the low water period there is little suspended matter. In the fall of the year the streams in the

central valley itself with this accompanying low water in the Mississippi River pour in a large amount of highly colored water. This water, usually from unpopulated swampy regions contains a large amount of organic matter which is as a rule immediately absorbed by the suspended matter in the river, therefore increasing the albuminoid ammonia content of the river during the winter especially during the first flood when the suspended matter deposited at the mouths of these contributary streams is poured out in the main river and is carried down with the stream and especially during this same period when the water makes its first rise upon the banks which to a great extent are covered with the drift wood and decomposing vegetation which has followed the previous high water period.

It is not possible for me to establish a relation between the dilution of the river and the amount of organic matter as shown by the analyses, from the fact that at times of high water in one stream we did have in fact a low flow of the Mississippi River at New Orleans and while the amount of constituents which would effect the analyses was proportionately large, the
11228 dilution was proportionately small.

Q. It is a fact then, is it not, that the chemical and bacterial conditions of the water are continually changing on account of flood conditions and weather conditions which produce drains and variations in the volume and velocity of the water?

A. There are slight changes but not so marked changes as on the tributaries of the stream.

Q. And the smaller the volume of water the greater would those changes manifest themselves? Is that not true?

A. Yes sir.

Q. And that condition maintains itself with reference to all rivers and streams comparatively speaking? In other words, these changes that are brought about in the chemical and bacterial condition of the water in a river will be more manifest and vary to a greater degree in a small stream than in a large, long and continuous stream, will they not?

A. They will be more manifest in the tributaries of any stream than in the main stream itself. The volume of water in the latter acts to balance the effects of rises and changes in
11229 the tributary stream to a great degree.

Q. Going back, now, Professor, to this table which was read in evidence in your direct examination, showing the chemical and bacterial pollution of the Mississippi River water at New Orleans, I will ask you if it is not a fact that that table as a whole shows that there is less bacterial and chemical purification going on in that water at low temperature than there is when the water is at high temperature?

A. I am unable to say that the table shows either of these facts.

Q. Is it not a fact that this table does show large quantities of free ammonia and larger quantities of nitrates and nitrites during low temperature than they do during high temperature?

A. Yes sir.

Q. Is it not a fact that the climatic conditions of the territory traversed by what is known as the lower Mississippi is higher in temperature, on an average, from one end of the year to the other, than the upper Mississippi River and its tributaries?

A. Yes sir, that is a fact.

11230 Q. Is it not a fact that during this entire examination bacterially and chemically, the temperature of the water in the Mississippi River at New Orleans on an average was at no time less than 8.1 Centigrade?

A. It was less than 8.1.

Q. The average per month?

A. Monthly average, no sir.

Q. What would 8.1 Centigrade mean expressed in Fahrenheit?

A. About 46 degrees Fahrenheit.

Q. The temperature of the water in the Mississippi River at New Orleans, for the month of February, 1901, averaged what in Fahrenheit?

A. About 46 degrees.

Q. Above or below?

A. Above zero.

Q. During the month of August, 1901, the average was 29.6 Centigrade. What would that be expressed in Fahrenheit?

A. About 86.

Q. Mr. Weston, in making your determinations of the population upon the water shed of the Mississippi River above New Orleans did you take into consideration the population of Denver, Colorado?

11231 A. Yes sir.

Q. Do you know what river Denver is situated upon?

A. The Platte.

Q. Did you take into consideration the cities of Butler and Beaver Falls, Pennsylvania?

A. Yes sir.

Q. In the urban population you took into consideration the population of all towns over the population of 4,000?

A. Yes sir.

Q. And you did that regardless of where they were situated upon what tributaries on the Mississippi River or of the particular tributaries, and regardless of the soil through which the city would flow, or regardless of the manner in which it would be carried away from the city, did you not?

A. Yes sir.

Q. Is it not a fact that a large part of this urban population is contained in small cities of 4,000 and upwards, that are far removed from the main bed of the various tributaries of the Mississippi, although situated upon the water shed of those tributaries?

11232 A. Yes sir.

Q. Is it not a fact that a large number of these small cities are situated so that the sewage discharges, domestic and manufacturing wastes, are discharged into swamps and pools and basins?

A. It is probably true to some extent.

Q. And what is true with reference to urban population is more particularly true of the rural population is it not?

A. I should expect so, certainly.

Q. Is it not a fact that a great quantity of the sewage from the urban population and the rural population is so deposited that it never finds its way into the river upon whose water shed this population is located?

A. The large part of it is deposited in such a way that it never finds its way into the streams of the Mississippi water shed in an unpurified condition. Ultimately all drainage reaches the water course.

Q. Is it not a fact that the major portion of the waste, of the domestic and manufacturing waste of the rural population is so discharged that it passes over and through the earth, soil and sand in such a way that by the time the water therein contained has reached the tributary that it does not approach the condition of sewage?

A. There are no precise data in existence bearing upon
11233 this point. As a general opinion I would say that more
than half the sewage from rural sources is purified before it reaches the stream.

Q. And what is true with the rural population is true to a large extent with a great number of the smaller cities which are unsewered is it not?

A. That depends largely upon the size of the town and the local conditions. Probably all of the greater cities discharge sewage into some water course directly or indirectly. Probably the smaller inland hamlets rarely discharge into streams directly. Between these two extremes it is pretty hard to place the points, which will show the actual conditions of the small cities, but I should say that what is true in the case of rural population is true to a less degree in the case of towns with population varying from 4,000 to 25,000.

Q. Have you made any calculation for the purpose of determining the population residing upon the immediate banks of the tributaries of the Mississippi River above New Orleans as distinguished from the population of those towns that are inland to those tributaries?

A. In Louisiana the whole of the urban population, about
16,000 people, is situated on the river. In Mississippi
11234 27,000 is situated on the river and between 12,000 and
13,000 inland.

Q. That is the urban population upon the water shed of the Mississippi tributary to the Mississippi?

A. In this 13,000 inland population is included the city of Greenville, Mississippi, which because of its non-discharge of sewage in the Mississippi is considered as an inland town. Since the preparation of the above data the city of Greenville has introduced sewers.

Q. Where did you get that information?

A. That was compiled by myself and my assistants.

Q. Have you such data for any other portion of the watershed of the Mississippi river above New Orleans?

A. I am able to give the total urban population in Tennessee only. I can give no comparisons as you wish.

Q. You have never made any such calculation?

A. No, sir.

Q. Is it not a fact that the stream velocity of the lower Mississippi is less than the stream velocity of the upper Mississippi?

A. If I remember correctly, yes, sir.

11235 Q. Do you not know and is it not a fact that the stream velocity of the upper Mississippi from St. Paul to St. Louis is less than three miles per hour?

A. I do not know.

Q. Do you not know that the stream velocity from St. Louis to the mouth of the Mississippi river is less than two miles per hour?

A. I do not know. The stream velocity of the Mississippi river below St. Louis at a time reaches over five miles an hour.

Q. Do you know the average stream velocity of the upper and the lower Mississippi rivers?

A. I do not.

ROBERT SPURR WESTON.

Adjourned until 10:00 a. m., Saturday, March 5, 1904.

11236 10:00 a. m., Saturday, March 5, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

MR. TODD: I desire to offer in evidence a tabulation by the year of typhoid deaths in the cities lying tributary to the Missouri River, in cities lying tributary to the Illinois River, exclusive of Chicago, in cities lying tributary to the Mississippi River, a list by the year of deaths in the cities of Chicago and St. Louis, respectively, these tabulations being made from the certified reports of the Health officer of the different cities; on the Missouri River all towns with the exception of Jefferson

City heretofore offered in evidence by the complainant, and an agreement that such certificate should be considered as evidence without the necessity of more formal proof, have been verified by me and found to be correct, and as to Jefferson City the offer is made subject to the same rebuttal proof on the part of the complainant, that was stipulated in the cities in regard to the testimony offered from the cities which have been verified.

As to the cities on the water shed of the Illinois River the testimony of complainant has been verified by me and is correct.

11237 As to the cities on the Mississippi River the same is true with the exception of the additional cities not offered by complainant but the certificates I possess which are Red Wing Minnesota; Winona, Minnesota; Clinton, Iowa, and Muscatine, Iowa. and to those cities the evidence is subject to rebuttal if the certificates and number of deaths reported by me can be shown to be different, without the necessity of formal proof, which tables I offer in evidence are as follows:

11238 Death Report from Typhoid Fever in Cities lying tributary to the Missouri River.

	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
Lincoln, Neb.	33	21	23	15	14	12	13	4	13	10
Omaha	22	40	29	18	22	32	26	24	23	20
Council Bluffs.	5	7	6	8	8	6	8	11	6	8
St. Joseph, Mo.	20	22	31	19	15	19	37	20	12	13
St. Charles, Mo.							22	5	6	14
Kansas City, Mo.	59	37	34	29	38	49	52	49	58	58
Jefferson City.										16(?)
Totals	139	127	123	89	97	118	158	113	118	139

11239 Deaths Reported from Typhoid Fever in Cities lying Tributary to the Illinois River, exclusive of Chicago.

	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
Peoria				13	18	18	12	33	15	18
Bloomington	12	14	15	9	10	10	9	15	9	15
Springfield								20	10	8
Ottawa	2	5	2	2	4	4	3	3	5	2
Decatur	5	7	2	1	7	5	7	11	5	4
Joliet	12	14	*	12	12	15	15	13	13	21
Pekin								2	1	2
Elgin	5	3	5	14	*	4	5	15	15	8
Aurora	6	12	19	10	5	10	4	17	11	2
Havana	3	7	2	5	*	*	*	*	1	2
Totals	45	62	45	66	56	66	55	129	85	82

* No record.

11240 Deaths Reported from Typhoid Fever in the following cities, according to the public records.

	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
St. Paul	51	32	38	37	22	43	30	36	24	23
Minneapolis	134	107	88	60	148	86	71	79	121	66
Red Wing, Minn.	5	2	2	3	0	4	0	3	2	3
Winona, Minn.	2	2	1	2	2	2	5	5	1	4
La Crosse, Wis.	15	2	5	0	3	8	7	7	5	4
Dubuque, Ia.	6	6	12	8	12	10	12	7	8	10
Clinton, Ia.	10	5	3	7	5	7	7	10	12	5
Rock Island, Ill.	15	13	3	13	*	*	10	14	28	5
Moline, Ill.	7	9	8	11	3	5	20	22	16	7
Davenport, Ia.	5	6	4	3	5	2	12	14	11	11
Muscatine, Ia.	4	8	5	5	2	25	2	13	8	5
Burlington, Ia.	8	10	8	13	3	4	8	13	12	11
Fort Madison, Ia.								5	*	1
Keokuk, Ia.	8	14	3	3	7	10	9	10	4	7
Quincy, Ill.	22	33	24	13	15	6	7	9	12	18
Hannibal, Mo.	7	7	6	8	10	8	4	3	3	2
Louisiana, Mo.								4	2	7
Des Moines.	22	29	30	14	20	17	13	7	22	21
Yearly Totals	321	285	240	200	257	237	217	261	291	210

*No record.

11241 Total Number of deaths reported from Typhoid Fever in cities lying tributary to the Mississippi, Missouri and Illinois Rivers respectively.

	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
Mississippi	321	285	240	200	257	237	217	261	291	210
Missouri	139	127	123	89	97	118	158	113	118	139
Illinois	45	62	45	65	56	66	55	129	85	82
Total	505	474	408	354	410	411	430	503	494	431

DEATHS IN CHICAGO AND ST. LOUIS.

Chicago

1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
1008	1997	1489	670	491	518	751	437	636	442	339	509	801

St. Louis

1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
277	160	488	215	178	106	106	125	95	130	168	198	222

11242 MR. JEFFRIES: I have examined the certificates from these cities obtained by respondent, which were not secured by complainant, and make no objection to the failure of formal proof thereof, and I accept the showing made on those table for those cities as representing correctly the contents of the certificates upon which said tables are based.

I reserve, however, under the previous agreement and under statement of counsel for defendant, in offering the tables in evidence, the right to rebut the report from those cities which have not as yet been introduced in evidence by or examined by complainant.

11243 PROF. W. P. MASON

a witness on behalf of defendant, being duly sworn, testified as follows:

DIRECT EXAMINATION by Mr. Todd:

Q. What is your name?
A. W. P. Mason.
Q. What is your business?

A. I am professor of chemistry in the Rensselaer Polytechnic Institute, Troy, New York.

Q. Please state what institutions of learning you have been connected with?

A. I have been with the faculty of Rensselaer Polytechnic Institute for over twenty years.

Q. In what capacity, Professor?

A. I have been there in the chemical department as Professor of Chemistry and previous to that as Assistant Professor in Chemistry.

Q. Have you made a special study of water analysis?

A. I have.

11244 Q. What branch of sanitary science have you given especial attention to?

A. To the examination of potable water, especially for city supply.

Q. Have you had any experience in the interpretation of chemical analysis of waters?

A. I have; much.

Q. Have you made a special study of sanitary problems?

A. I have made a special study of sanitary problems as related to water supply.

Q. Are you an author of works on water supply and examination of waters?

A. I am.

Q. What works, Professor?

A. "Water Supply," published by John Wiley & Son, and "Examination of Water," published by the same firm.

Q. Have you, as an expert, reported upon and testified in legal cases regarding the water supply of cities or towns of the United States.

A. I have.

Q. Name such cities or towns?

11245 A. New York; Brooklyn; Philadelphia; Washington; Columbia, S. C.; Greenville, S. C.; Danville, Virginia; Birmingham, Alabama; Meridian, Mississippi; Denver, Colorado; Indianapolis, Indiana; Duluth, Minnesota; West Superior, Wisconsin; Buffalo, New York; Elmira, New York; Albany, New

York; Troy, New York; Cohoes, New York; Newark, New Jersey; Newburg, New York; Waterville, Maine; Waterford, New York; Providence, Rhode Island; Bath, Maine; Rennslaer, New York; Erie, Pennsylvania; Hot Springs, Arkansas; Atlantic City, New Jersey; South Hampton, New York; Burlington, Kansas, and sundry others that I can not remember.

Q. Who were the parties in the suits to which you refer?

A. Sometimes these suits were pending between the city and the water company. Sometimes they were between rival filter companies. Sometimes they were investigations in which there were no suits, the city merely wishing to secure the best possible supply and asking advice thereupon.

Q. Were you always on the side of the city or town?

A. Sometimes I was employed by the city as against the water company; sometimes by the water company as against the city.

11246 MR. JEFFRIES: The question and answer are objected to as immaterial.

Q. Have you examined the water supply of any foreign city, if so state what cities they were?

A. I have examined the water supplies of Paris, Hamburg, Copenhagen, London, Liverpool, Hague Stuttgart, Lubeck, Amsterdam and sundry others.

Q. Professor, will you give a brief description of these different European supplies that you have enumerated?

A. In some instances as in that of Paris the supply is partly from the river and partly from springs, the same being piped in double street mains. In some instances as in Hamburg the principal feature of the water plant is the filtration system. I have examined the beds in such places pretty carefully, said beds being upon the English system, commonly called in this country slow sand filtration. In some places the supply has been from deep sources as at Copenhagen, where the water comes from artesian borings. In some instances the water is obtained from surface sources as at Boulogne and is

11247 purified by special devices such as Anderson's process. In some instances as in Naples, the water comes from spring sources, and is chiefly interesting because of the manner in which it is stored. In some instances, as in the water supplies of Spanish cities, which I have not previously referred to, the water supply is principally interesting from the fact that it has been used for a long period of time and is a relic of past civilization.

In some instances, as in the water supply of North Africa, the water is principally interesting in that it represents the renewal of very ancient developments of springs. In the case of the Oasis of Biskra the water supply there is interesting in that it comes from deep sources at the foot of the Atlas Mountains and is conducted to the Oasis and distributed in rather an interesting fashion.

All of these supplies have their own particular points of interest.

Q. Are you acquainted with the literature bearing on typhoid fever epidemics?

A. I am.

11248 Q. Without going into detail you have reference to all the typhoid fever epidemics that are known of in this country?

A. Yes sir, I refer in that answer to both American and foreign typhoid fever epidemics. I am familiar with the literature thereupon.

Q. Have you investigated any typhoid fever epidemics?

A. I have in the instances of water examinations to which I have already testified, some questions involving typhoid fever arose therein, as for instance Bath, Maine; Cohoes, New York; Albany, New York; Buffalo, New York; Waterville, Me., and possibly one or two others. I do not remember which ones now.

Q. Are you acquainted with any epidemics other than typhoid fever epidemics?

A. Yes sir, with those of Asiatic cholera.

Q. What epidemics of Asiatic cholera are you acquainted with?

A. I made more or less of a study of Asiatic cholera in Sicily and Italy, more particularly at Messina.

Q. Was this a personal study?

A. This was a personal study, not during the time of the cholera outbreak. I was not there then but I visited the place in order to obtain the information of an epidemic which was past.

Q. Give the results of your investigation?

A. The investigations resulted in learning of the fact 11249 that cholera was due in that instance to a contaminated water supply, the contamination coming from the washing of infected linen in large water tubs of stone, such infected water afterwards flowing into the mains of the city and being distributed to the people. The facts in the case were that the mains of the city of Messina, Sicily, were pretty badly located and badly laid and opportunity for infiltration of infected water was very great, and as a result cholera broke out in that community. The authorities felt that the water was possibly in fault and they obtained water from the main land and the people were supplied therewith and the cholera epidemic was checked.

Q. Have you examined and studied the bacterial and chemical analyses of the waters of Lake Michigan, the drainage canal, the Desplaines River, the Illinois River, the Mississippi River, and the Missouri River as made by Professors Jordan, Palmer, Gehrmann and Burrill, the same being published in what is known as reports of Streams Examinations, published by the Sanitary District of Chicago?

A. I have.

Q. Are you acquainted with the Chicago River, the drainage canal, the Desplaines River, the Illinois River and 11250 the Mississippi River from Grafton to St. Louis?

A. Yes sir, I am.

Q. What opportunities have you had for becoming acquainted with the water course from Chicago to St. Louis?

A. I went on a boat from the water front to Lockport, down the drainage canal, by day light. I afterwards followed the course of the river in trolley and on train as far as LaSalle and then took a steamer and went from LaSalle in day light to St. Louis, tieing up at night so that no places were passed in the dark. On arrival at St. Louis I visited the settling basins and saw them being cleaned.

Q. Have you made a special study of bacteriology as applied to water investigations?

A. I have.

Q. Are you acquainted with the experiments made with the bacillus prodigiosus by Dr. Ravold?

A. I have read of that experiment. I have read of it in the testimony.

Q. Assume that 107 barrels of 40 gallons each of culture of bacillus prodigiosus, consisting of one hundred million billions to a cubic centimeter, as contained in said barrels,
11251 was deposited in the Chicago drainage canal at the town of Lemont, on the afternoon and evening of the 6th of November, A. D., 1901, during a period of from four to eight hours.

Assume further that immediately after the said barrels were emptied into the drainage canal, the laboratories established at Lockport, Joliet, Peoria, Grafton, on the Illinois River, and the intake tower of the St. Louis water works, chain of rocks, were notified and that samples were collected at each of these places every hour of the day and night for the purpose of bacterial analyses, for the ascertainment of this bacillus prodigiosus, and assume that at Lockport these hourly samples taken day and night were taken from November 7th to November 25th, a period of 18 days, the total number of samples taken being 432.

Assume that at Joliet these hourly samples taken day and night were taken from November 7th to November 25th, a period of eighteen days, the total number of samples taken being 432.

Assume that at Peoria these daily samples, taken day and night, from November 8th to November 30th, a period of 22 days, amounted to a total of 528 samples.

Assume that at Grafton these hourly samples were taken
11252 day and night from November 12th to December 15th, a period of 33 days, the total number amounting to 792, of which 384 were analyzed by Dr. Ravold.

Assume that the total number of samples taken day and night at the chain of rocks were 720.

Assume that at the laboratory tap these hourly samples taken day and night from November 20th to March 1, 1902, a period of 100 days amounted to a total of 2400.

Assume that the total number of samples analyzed at the different points for the periods above mentioned was 5304.

Assume further that on December 4th at 8:45 one bacterium bacillus prodigiosus was found at the intake tower at the chain of rocks.

Assume that on December 5th at 9 A. M. 1 bacillus prodigiosus was found at the intake tower, at chain of rocks.

Assume that on December 8th at midnight, 1 bacillus prodigiosus was found at the intake tower, chain of rocks.

Assume that on December 6th, at 8 A. M., at Grafton, 1 bacillus prodigiosus was found.

Assume that on December 7th at midnight, at Grafton, 1 bacillus prodigiosus was found, and

Assume further that these five organisms were all the 11253 organisms of prodigiosus that were found in the examination made from Lockport to the intake tower at the chain of rocks and the laboratory tap in the city of St. Louis, which were made during the progress of this investigation, as hereinbefore set forth, and at no time was there more than one single bacillus found at each of these places.

Assume all of the facts as hereinbefore stated to be true what is your opinion as to the value of this experiment as indicating the probable longevity of the typhoid bacillus as measured by the longevity of the bacillus prodigiosus and the probability that the typhoid bacillus entering the drainage canal from the sewers of Chicago would ultimately find its way through the Desplaines and Illinois River to the town of Grafton?

A. My opinion is that in view of the large number of the bacillus prodigiosus introduced and the small number found the results of that experiment shows a very considerable death rate of the bacillus prodigiosus and by inference at least as large a death rate of the bacillus of typhoid fever under the same circumstances.

11254 Q. What importance do you attach to the experiments as assumed in the hypothetical question?

A. In my opinion it seems that the importance attached is to show that to the extent that a bacillus prodigiousus represents a bacillus of typhoid fever a very large death rate has been proven as occurring among the bacilli of typhoid fever under those circumstances.

Q. Have you made any special study of the typhoid germ as related to water supply?

A. Yes sir.

Q. Is it related to the colon bacillus and if so in what way?

A. Yes sir, it is quite closely related to the colon bacillus. It has even been mistaken for the latter germ. There is some considerable difficulty in distinguishing between them. The appearance of the germs being somewhat similar, although their flagella are not equally distributed, it is necessary in order to distinguish as between them to make use of differentiation tests.

Q. Please give the longevity of the typhoid bacillus in the human body?

A. Typhoid bacillus may remain a long period in the human body, at least months.

11255 Q. In soil?

A. The bacillus of typhoid fever may remain alive in soil for a period of at least weeks and possibly months.

Q. In water?

A. The question of the longevity of typhoid fever in water may be best stated by saying that it dies out in water more or less quickly en masse, although some individual cells, being more resistant may remain alive for a longer period. I should say that it would be right to limit it to a very much shorter period of time, that is it should be measured by days in water.

Q. Does the character of the water affect the longevity?

A. Yes sir. In the case of a relatively pure water the longevity of typhoid bacillus is greater than in one where it has to fight for existence with saprophytic bacteria.

Q. Does the typhoid bacillus multiply and increase in nature?

A. It does not increase in nature outside of the human body although it may live saprophytically for a greater or longer period of time according to its surroundings. It will multiply rapidly in milk, most milk epidemics having been caused by such multiplication.

11256 Q. Do you know of any milk epidemics?

A. Yes sir.

Q. What are they?

A. Stamford, Connecticut. There are a good many milk epidemics from British sources that have been reported by Harte.

Q. Are conditions of the laboratory experiments more or less favorable than conditions in nature for the longevity of the typhoid bacillus?

A. The laboratory conditions are more favorable for the longevity of the typhoid bacillus.

Q. If more favorable, state what reasons you have for your opinion?

A. The vessels in which the experiments are performed for some reason seem to give conditions favorable to its life, those vessels usually being small vessels of glass but where the conditions resemble more closely those of nature, as for instance where a large tank is employed, the length of the life of the bacillus coli and of the bacillus of typhoid does not seem to be so great. I would quote in support of that some experiments that have been recently made upon thè bacillus coli communis by the Massachusetts Board of Health where the vessel containing the germs, suspended in the Merrimack River water, 11257 was a large one, about 12 feet deep. The reference that I can give you is the report of the Massachusetts Board of Health for 1902, pages 259 and 260. Under those circumstances it was found that the longevity of the colon bacillus was limited to 11 days. It was not found in the tank after that period.

Q. Will the germ of typhoid fever live as long in polluted water as in pure sterilized water?

A. No.

Q. How do you account for this?

A. In the case of polluted water it has to struggle for its existence amid adverse germs in great numbers and it is overgrown.

Q. What do you mean by over-grown?

A. Well, the conditions of its existence are such as to cause it to struggle in the presence of bacteria different from itself, which bacteria are in larger numbers and are producing toxins which are capable of interfering with its growth.

Q. From your knowledge of the quality of water in the drainage canal, the Desplaines River and the Illinois River, what is your opinion as to the longevity of the typhoid bacillus in those waters?

Mr. Jeffries: I assume that the witness is basing his
11258 answer only upon the knowledge which he has shown to
possess of the waters of the canal and the river?

Mr. Todd: I object to counsel assuming anything.

Mr. Jeffries: Unless the answer be limited to the qualifications of the witness, stated by him, I object to the question.

A. I believe that the typhoid bacillus would live in the water of that description for a less period of time than in sterilized water or water of greater purity, from a bacteriological standpoint, and that it would be limited in length of life to a question of days.

Q. How do you account for your assumption that the life of the typhoid in the waters of the drainage canal, the Desplaines and Illinois Rivers is shorter as compared with its longevity in laboratory experiments?

A. I have already touched upon that question, and I base my opinion upon the fact that where the experiment has been upon a large scale, as in the instance in the Massachusetts Report, quoted, we get a shorter period of time during which the
bacillus will remain alive. In other words as we approach
11259 the conditions of nature the opportunities for its destruction seem to be greater than in the conditions obtaining
in the laboratory experiment.

Q. Are you acquainted with the physical conditions of the drainage canal, the Desplaines River and the Illinois River and the Mississippi River to St. Louis?

A. I am.

Q. Will you describe the dams in the Illinois River?

A. The dams in the Illinois River to my knowledge are but four. I am informed that there is a fifth. I did not see it. At the time of passing down the river the water was of sufficient height to permit the steamer to pass over the top of two of those dams and the two other dams we were locked through but they were all submerged dams.

Q. What effect do these dams have upon the problem of sedimentation?

A. They will increase the opportunity for sedimentation in the river although I do not believe that they will increase it to an extent that amounts to very much, acting more as
11260 riffle boards than dams, they being submerged, sedimentation will take place behind them to an extent, not in the immediate vicinity. But, as I have already said, I do not believe that the amount of improvement obtained through the influence of those dams by sedimentation is very great, although I think it to be something. I state that because I have watched the influence of rifle plates or baffle boards upon tanks in a case at Elmira, where I was running the filter plant, under order of the United States court, in a case between two rival filter companies in a patent suit, and I noticed that the aluminum hydrate did gather behind those boards to an appreciable extent.

Q. How is sedimentation in the Illinois River affected by high and low stages of water?

A. The Illinois River when the water is high overflows its banks and the water settles back to the right and left to a very considerable extent. I noticed that as I went down the river, on a boat, that the trees were standing out in the water, trees apparently growing in one or two feet of water, and such overflow represented a considerable acreage.

The effect of such overflow upon sedimentation will be to spread out the water over a large area thereby giving that
11261 particular part of silt the opportunity of reaching the ground after falling a comparatively short distance. Sedimentation is very marked where the water holding the material to be sedimented is spread out in narrow sheets. Advantage is taken of this fact in the construction of certain forms of sedimentation tanks which tanks are divided by horizontal planes placed quite near each other so that the water has to pass backward and forward between successive pairs of these plates on its way from the top to the bottom. A very considerable amount of purification takes place through sedimentation in a device of that kind because of the short distance of fall for any one sedimenting particle before its resting place is reached.

Q. Will bacteria respond to the law of gravity in pure water of a running stream?

A. Bacteria have weight although not much, and of course like other things of specific gravity greater than the water will tend to fall. Whether they succeed in getting down or not will depend upon the local conditions.

Q. What is it that causes bacteria to settle to the bottom of a flowing stream?

A. If the flowing stream referred to in question be a clear one, gravity alone would operate upon the bacteria and
11262 they would settle therefore slowly.

The settlement might be quite easily interfered with by the currents and the eddies of the stream, but if the stream in question be a turbid one the falling particles causing the turbidity will unquestionably tend to drag down bacteria which may be present by attaching themselves to the bacteria or the bacteria being attached to the falling particles and both going down together. I know that bacteria will settle more quickly in turbid water than in clear because I have tried it and have made a determination of the settlement of such bacteria in both turbid and clear waters, the result being that greater settlement took place in the turbid waters. This is entirely in accord with what we know of the precipitation even of chemical substances because every student of quantitative analysis is aware that when a precipitating solid is falling it tends to drag with it other solids in its immediate vicinity and instances are not unknown, and I can quote, if required, where even soluble material will tend to separate and fall with the precipitating solid to an extent, not completely of course.

11263 Q. Will bacteria settle faster in a turbid water than in one that is clear?

A. That I have just answered in the affirmative. They will.

Q. Could sufficient water from Lake Michigan be carried through the drainage canal (assuming that the maximum amount is 800,000 cubic feet per minute) into the Desplaines river and Illinois river so as to create a condition of purity and clearness that would preclude the operation of sedimentation in the Illinois river?

A. No. There is enough turbidity present in the system of the Illinois river to prevent any such condition obtaining. It is true that I believe that a river will empty itself into the sea in order to clear itself of its turbidity in toto, but there is enough turbidity of a coarser character in all turbid waters which continually falls to the botom to provide neuclei around which sedimentation of bacteria can take place.

Q. Assume that the entire sewage from the city of Chicago should be diverted into the drainage canal and that 800,000 cubic feet of water per minute from Lake Michigan
11264 should pass over the Bear Trap Dam would that amount of dilution be sufficient after it reached the Illinois river, mingled with the sewage of Chicago, to so separate the matter in suspension in the Desplaines and Illinois river as to prevent the operation of sedimentation of bacteria?

A. Under the conditions named the turbidity yet remaining in the Illinois river would be sufficient to permit of the sedimentation of bacteria in the manner already referred to.

Q. What sanitary significance does dilution have in considering the process of the problem of self purification of streams?

A. Simple dilution is purification in that it diminishes the chance of the person drinking the water, assuming the water to be polluted, contracting the disease. Assuming that a glassfull of water should contain 100 typhoid germs, the person drinking it would have a risk to run that we shall describe by the number 100. Should conditions obtain whereby 50 per cent. of all germs in the stream were killed, the person then drinking a glass full of that water would drink 50 germs and his risk would be half of what it was before, namely 50. Should
11265 conditions obtain whereby no bacteria were destroyed but the volume of the stream were doubled by the inflow of pure water, then a person drinking a glass full of the mixture would have in his glass 50 germs and his risk would be 50, therefore the dilution of that water has been productive of just as much purification as the killing of half of the disease germs.

Is the danger of infection really diminished by dilution?

A. Unquestionably it is as per the statement that I have just made.

Q. Is it a fact that the greater the dilution of sewage the less the danger from infection?

A. Surely it is a fact, and again I refer to the illustration I have just given.

Q. Is the addition of Lake Michigan water to the sewage of Chicago a detriment or a benefit to the sanitary condition of the Illinois river considered from the standpoint of dilution alone?

11266 MR. JEFFRIES: I object to the question for the reason it cannot be scientifically considered in and of itself alone so far as the application of dilution is concerned in determination of the sanitary condition of the water.

A. The addition of Lake Michigan water to the sewage of Chicago is a benefit to the sanitary condition of the Illinois river considered from the standpoint of dilution alone.

Q. Is the addition of Lake Michigan water to the sewage of Chicago a detriment or a benefit to the sanitary condition of the Illinois river considered from the standpoint of chemical and bacterial changes taking place therein?

A. It is a benefit.

Q. If a sufficient volume of Lake Michigan water should be added to the sewage of Chicago so as to cause the elimination in the water of the Desplaines and the Illinois river, what effect would this increased volume of water have upon the question of sedimentation in the Illinois river?

A. If a sufficient volume of Lake Michigan water should be added so as to cause the Illinois river to overflow its banks in the manner I saw it, under those circumstances there would be a greater opportunity for sedimentation because of such overflow, as per the illustration that I have already given. 11267

Q. How do the physical conditions of the Illinois river compare with the other rivers of the country for the purpose of purification or sedimentation?

A. The physical condition of the Illinois river, inasmuch as the river is one which readily overflows its banks, permit of a better opportunity for sedimentation than woudl obtain in a river like the Hudson where no such overflow of the banks is possible, the banks being very much higher.

Q. From your knowledge of the conditions that obtain along the Illinois river, as well as your inspection and consideration of the results of the analysis of the water, both chemical and bacterial, what effect if any does the sewage from Chicago discharged into the drainage canal have upon the waters of the Mississippi river as the same passes along the shore of the State of Misouri?

A. My opinion is that the waters of the Illinois river do not have any appreciable effect, good or bad, upon the waters of the Mississippi river into which it flows.

Q. Professor, from your knowledge of all the conditions that obtain along the Illinois river, as well as your 11268 knowledge of the conditions that obtain in Chicago and the drainage canal, also your knowledge of the water supply of St. Louis, such as is had from the intake tower at the chain of rocks, what effect does the sewage from Chicago have upon the water supply of the city of St. Louis and upon the waters of the Mississippi river as it passes along the shore of the State of Misouri?

A. It has no appreciable sanitary effect, although it is possible it may slightly improve the mixture inasmuch as if there is any difference between the Illinois river at Grafton and the Mississippi river at Grafton and the Missouri river above the junction, that difference is in favor of the Illinois river at Grafton. At the same time I do not think there is very much choice.

Q. What is the behavior of the colon bacillus in soil as compared with that of water?

A. It is of longer life in soil than it is in water.

Q. What in your opinion would be the fate of a typhoid bacillus passing from the sewers of Chicago into the Chicago river and thence into the drainage canal and down the Desplaines and the Illinois rivers?

A. I believe that typhoid bacillus passing, as stated, 11269 would die in the Illinois river, or to put it differently would die before Grafton was reached. I am now speaking about the great mass of them. It is possible that some resistant germs might make the journey, but the great mass of bacilli of typhoid fever would perish before the Mississippi was reached.

Q. Is there such a thing as purification of soil?

A. Yes sir, there is such a thing as purification of soil, although it is a slow process. The best illustration that I can give of that is to refer you to an article by Savage in the Journal of the Sanitary Institute, October, 1903, page 442, in which he refers to the purification of soil and says the "Gradual diminution and disappearance of bacillus coli is of interest from the point of view of specific contamination. It is a more resistant organism than the typhoid bacillus. It is a fair presumption from this that the typhoid bacillus, if present in such soils, would also rapidly die out and that the danger of specific typhoid contamination from building on such made soil can be neglected."

Q. Why is it that the typhoid bacillus will not live as long in polluted water as in pure water?

11270 A. Simply because in polluted water it has to live in the presence of many saprophytic germs which not only monopolize the food supply, but produce toxic products which are poisonous to it.

Q. To what do you attribute the death of the typhoid bacillus in polluted waters?

A. To the adverse conditions set up by the saprophytic bacilli which are present there in large numbers.

Q. What is your opinion as to whether a typhoid bacillus will live longer in the sediment of a polluted stream than it would in the water of the same stream?

A. My opinion is that there would be no material difference between the lengths of time, although the literature on that subject is scanty. I do not know where you would find a record of any examination of a stream noted. There are British statements made that such a bacillus will live in river-mud for a longer period of time than in the water, but they do not seem to be backed up by anything definite. They seem to be unbased statements. Now, on the other hand, the tank experiment which I quoted a little while ago, made by the Massachusetts Board of Health, said tank being a very sizable one, some 10 or

12 feet deep, I have already stated that that tank showed
11271 the death of the bacillus coli in 11 days. At the end of
15 days the water was removed from such tank, proven to have no bacillus coli present and the sediment of that tank was also examined for bacillus coli with likewise negative results.

Q. Will you differentiate between conditions that obtain in moist soil and the sediment of a running stream?

A. The difference is one of water contents. In one case you have only moisture present and in the other you have water present in quantity.

Q. Does the time that a typhoid bacillus will live in moist soil furnish any criteria for its longevity in the sediment of a running stream?

A. I should not expect that the cases would be parallel. That is my opinion.

Q. Are the two conditions comparable?

A. I think not.

Q. Would the fact that a typhoid bacillus lives for several months in moist soil justify the assumption that it would live for the same length of time in the sediment of a river?

A. I should say that it would not justify that assump-
11272 tion and I refer you again to the Massachusetts Board
of Health tank experiment to which I referred. The bacillus coli communis not having been found in that sediment and it being well known that the typhoid bacillus can not stand averse conditions to the same extent as the bacillus coli, if the bacillus coli could not live then the typhoid could not be there.

Q. Do you know of any bacteriologist since the birth of bacteriology that has demonstrated by any experiment that typhoid germs would live in the sediment of lakes or rivers for a long period of time?

A. I do not.

Q. Mr. Fuller, in his testimony on page 4219, in answer to the question, "Is not the length of time that a typhoid bacillus will live in the sediment more a matter of assumption than demonstrated proof?" answered "I consider that it is a very clean cut demonstrated fact that typhoid fever germs may and do and have continued to live in the sediment of running

waters." Q. "For what length of time?" A. "I
11273 would say for a month or more, possibly in cases for years." Q. "Who has demonstrated that it ever lived a year?" answered, "I think that the conditions existing in a moist soil in many rural places of this country where typhoid fever prevails from time to time is proof that typhoid fever germs in the presence of moisture can live for such a time. If that were not so then there would be an elimination of the typhoid fever absolutely through the rural districts of this and other countries." I want to ask you, Professor, whether you know of any demonstration that shows that typhoid fever germs can and do and have continued to live in the sediment of running streams for a period upwards of two years?

MR. JEFFRIES: I object to the question for the reason it is leading, and I move to strike out all that was said in reference to Mr. Fuller's testimony or as to what Mr. Fuller testified to for the reason that the question can be propounded to this witness without stating what Mr. Fuller said and for the further reason that the question is suggestive in that it contains and is a suggestion of counsel to witness that
11274 counsel expects witness to contradict the statement made by Mr. Fuller.

MR. TODD: In reply will state that counsel has a correct appreciation of the question.

MR. JEFFRIES: In answer to counsel's suggestion I renew my objection to the question because the question is suggestive, as explained by counsel who put the question.

MR. TODD: In reply will state that as to whether it is suggestive is a matter for the court. As to the latter part of the counsel's objection he has a correct appreciation of the purpose of the question.

MR. JEFFRIES: I expect to abide by the decision of the court upon the admissibility of the question.

A. I know of no such demonstration.

MR. JEFFRIES: I move to strike out the question and answer for the reason that this witness is not presumed to know the same discoveries in the bacteriological or scientific questions, the same discoveries that are known to Mr. Fuller, or which are and have been lodged in his memory, which may have entirely escaped the notice or observation of this witness.

Q. What is your opinion, based upon all the knowledge which you possess as to whether typhoid bacilli coming
11275 from the sewers of Chicago and entering the drainage canal could survive the journey from Chicago to St. Louis, a distance of 357 miles and be a danger and menance to the inhabitants of St. Louis or to the citizens of Missouri using the water of the Missisippi river in it raw condition for drinking and domestic purposes?

A. My opinion is that typhoid fever bacilli coming from the sewers of Chicago would not be a danger and a menace to the inhabitants of St. Louis using the water of the Mississippi for drinking and domestic purposes.

Q. Where a settling basin holds a sufficient amount of water to supply a city for a period of thirty days and the water is taken out for domestic uses, raw water is immediately substituted from an open river, and typhoid fever should prevail among the people using said water, what is your opinion as to whether such a condition justifies the assumption that because the basin holds a supply of water for the period of thirty days that a typhoil bacillus will live in that water for such a period?

MR. JEFFRIES: Objected to as immaterial.

A. It is my opinion that merely because the capacity of a reservoir is a thirty-day supply, it is not therefore to be
11276 assumed that water remains in that reservoir for thirty days. Much depends upon the construction of the reservoir. Many reservoirs are of stand pipe type, receiving their water and discharging it through the same orifice. Under such circumstances the pumps deliver to the mains and the reservoir merely takes the surplus of the pumpage. During periods of low pumpage the reservoir receives less, hence in reservoirs of that character it is impossible to say how long any particular volume of water may remain therein.

Adjourned until 2:00 p. m., same day.

11277 2:00 P. M., Saturday, March 5, 1904.

Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. W. P. MASON

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. What does the term epidemiology embrace?

A. The consideration of all those matters dealing with epidemics and vital statistics, matters that deal with a spread of disease among mankind. A general study of epidemics.

Q. Have you examined the typhoid statistics of the Illinois, Missouri and Mississippi water sheds above St. Louis, the same being the table of typhoid statistics which was introduced in evidence in this case just ahead of your testimony?

A. I have.

Q. Have you examined the mortality statistics of the city of St. Louis?

A. I have.

11278 Q. How do you find the mortality statistics of the city of St. Louis in connection with the typhoid statistics on the three water sheds?

A. I notice in the tabulated form of tables reported that for the years 1899, 1900, 1901, 1902 and 1903, the St. Louis deaths are reported as uniformly increasing, being 130, 168, 198, 222 and 288. I notice that Chicago is quite variable.

Beginning with 1899, it is 442 and then dropping instead of increasing, as St. Louis does; 1900 the deaths being 339, rising again for 1901 and 1902 to 509 and 801 and dropping off again in 1903 to 588. I notice, as already stated, that whereas the St. Louis rates uniformly increase, the Chicago rates go up and down in a variable fashion. These statistics are for entire years as given. The relation between Chicago and St. Louis, in the matter of deaths from reported typhoid, would be better given in statistics per month, and I am prepared to show the statistics per month in graphic form, if the counsel so desire.

Q. How does the death rate from typhoid in St. Louis
11279 compare with the death rate from typhoid upon the three water sheds, exclusive of Chicago?

MR. JEFFRIES: I object to the question for the reason that the item of population is not included in the question.

A. I notice that the reported typhoid for 1900 upon the three water sheds, exclusive of Chicago, is 503, which is larger than the preceding year. This is in accord with the reported deaths in St. Louis for that year, the same being larger than the preceding year. It is not in accord with the deaths reported in Chicago, the same being smaller than the preceding year, so that for that one year it would seem that the deaths in St. Louis were not in accord with the water sheds of the three rivers, exclusive of Chicago, that they were with the death rate in Chicago itself, although for the next two years I do not notice that there is the same array of facts, my remarks applying only to 1900.

Q. In the matter of the interpretation of the mortality statistics, what method do you employ?

A. I employ the method of stating typhoid deaths as so many per 100,000 inhabitants.

Q. Why do you employ that method?

11280 A. In my belief that is the more correct method to employ, and it is a very generally employed method. I have at times seen another method employed, and I do not believe that it is a feasible one, namely the percentage of typhoid deaths to total deaths. The reason I do not approve of that method is because, to illustrate, Chicago might have this month much more typhoid than last month, but the total death rate because of some disaster like the Iroquois Theater fire would run up the total deaths so that the typhoid death would apparently improve, whereas really it was worse.

It seems to me that a nearer approach to the truth is obtainable by stating the typhoid rate as so much per one hundred thousand inhabitants.

I can refer you for instance to a recent statement of deaths from typhoid fever in the Engineering News of February 25, 1904, entitled "Cases and Deaths of Typhoid reported at Pittsburg and Alleghany, 1890 to 1903, inclusive." You will observe

that in that table which has been prepared by the Engineering News with the assistance of members of the Board of Health at
Pittsburg that the typhoid is stated in number of deaths
11281 per ten thousand inhabitants. It is also stated as percentage of fatal cases to total cases.

MR. JEFFRIES: I move to strike out all the remarks the witness has made to the Engineering News and particularly to the table cited by him as being contained in the Engineering News, as incompetent and not proper testimony.

Q. Does the percentage of typhoid deaths to total mortality enable the sanitarian to pass judgment upon conditions in a given city as to whether there is an increase or decrease in typhoid fever in such locality?

A. It certainly does not so enable him. Thus, to vary my illustration, should a certain locality have an increase in typhoid, but a very much greater increase in consumption, the report from that place would cause typhoid fever to appear improved whereas it would really be quite the reverse. Typhoid fever would be worse, and consumption would be worse, but the consumption would be at a greater rate.

In other words, you have a comparison between two variables, hence it is difficult to arrive at anything like any
11282 definite opinion thereupon.

MR. JEFFRIES: I move to strike out both the question and answer for the reason that it eliminates the fact that sanitarians in passing judgment upon the increase of typhoid fever on the mortality basis, either on the one hundred thousand per capita basis or on the total death mortality basis, eliminates the proposition that the expert so passing or expressing his judgment may take into consideration the well known fact of which courts take judicial notice as to the population of the particular city being dealt with.

Q. In passing judgment as a sanitarian and epidemiologist upon the mortality percentage basis, what is your opinion as to whether the question of population is involved in that method of calculation?

A. Population is not involved in that. The percentage of typhoid deaths to total deaths.

Q. What method employed by sanitarians takes into account the population figuring out the increase or decrease in a certain community for a given disease?

A. The number of deaths per one hundred thousand method would take it in.

11283 Q. Is the mortality percentage method regarded as the most accurate among sanitarians and students of vital statistics for ascertaining the increase or decrease of a certain disease in a given community?

MR. JEFFRIES: I object to the question for the reason that it shows on its face that under ordinary circumstances and without an absolute increase or decrease in the population there would be very little difference.

MR. TODD: In reply to the objection of the counsel I desire to call the attention of the court to the fact that Professor Sedgwick and Mr. Fuller adopted the mortality percentage method as a correct and proper method for ascertaining whether there was an increase or decrease of typhoid fever in the city of St. Louis since 1900.

A. I will repeat that the percentage method is not the commoner one in use, although it is used, the more common method of stating it being the determination of number of deaths from typhoid per one hundred thousand people.

Q. Is the reporting of non-fatal typhoid cases more general now than it was formerly?

A. Yes sir, it is.

Q. Why?

11284 A. I had occasion to write with reference to that topic to State boards of health of a number of States and I received in reply from them data which showed that there was improvement with reference to the reporting of non-fatal cases of typhoid fever. If the counsel desires I shall be glad to give it much more explicitly.

MR. JEFFRIES: I move to strike out all that the witness has said with reference to the information that he has obtained from the various boards of health, by corresponding, for the reason that it is incompetent.

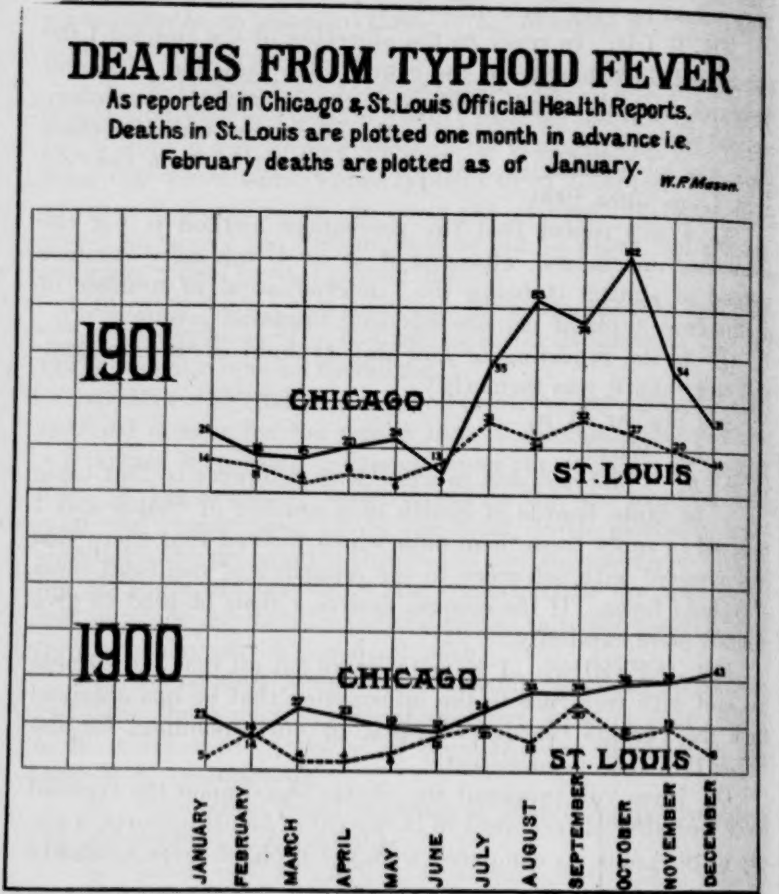
Q. Have you prepared any charts based upon the typhoid fever mortality, as reported in the board of health reports of the city of St. Louis, as compared with the typhoid fever mortality as reported in the Board of Health Report for the city of Chicago by months for 1900 and 1901, and 1902 and 1903?

A. I have prepared those charts.

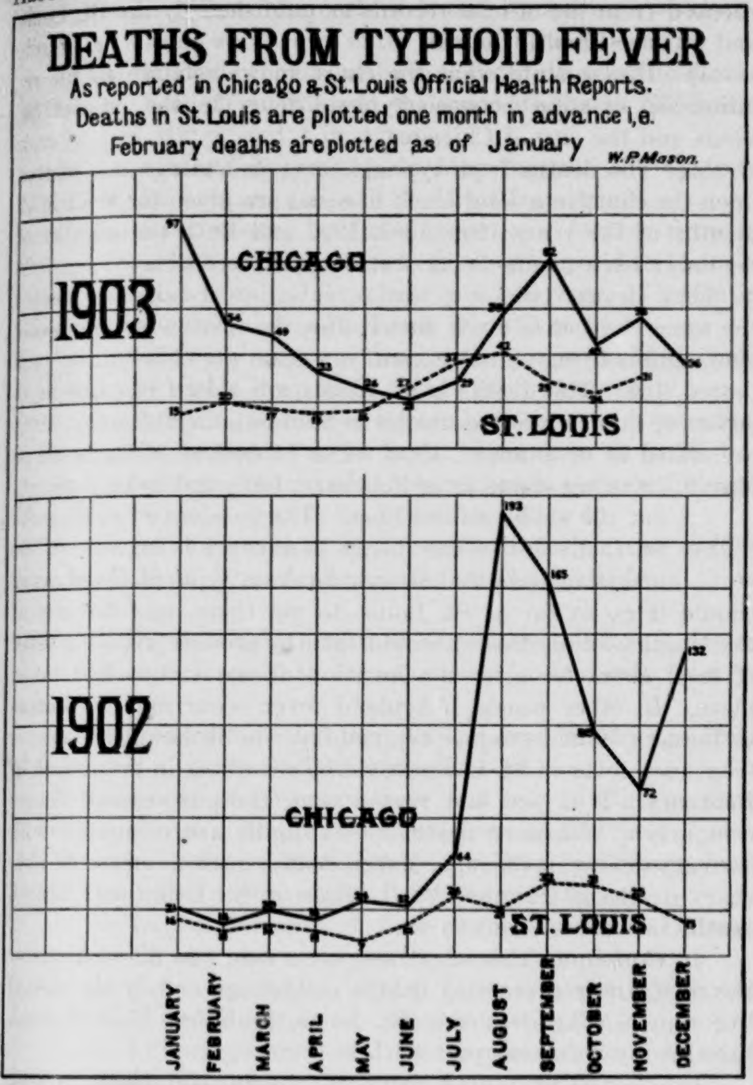
Q. Will you produce the chart for 1900 and 1901, and the one for 1902 and 1903, and make them a part of the evidence?

A. Yes, sir. The caption of these charts is "Deaths from typhoid fever as reported in Chicago and St. Louis official Health Reports." The tables in St. Louis are plotted one month in advance, that is February deaths are plotted as of January.

11285 The charts are as follows:



11286



DEATHS FROM TYPHOID FEVER

As reported in Chicago & St. Louis Official Health Reports.
Deaths in St. Louis are plotted one month in advance i, e.
February deaths are plotted as of January

W. P. Mason.

11287 Q. Will you please state from what data the charts themselves were made?

A. The data from which these charts were made was obtained from Professor Jordan's testimony and afterwards checked from the official records as published by the St. Louis and Chicago Health Boards.

Q. Please state what the chart shows relative to the relationship existing between typhoid fever in the city of St. Louis and the city of Chicago?

A. The deaths from typhoid fever in Chicago are plotted upon the chart in a solid black line and are given for the twelve months of the years 1900, 1901, 1902 and 1903, the number of deaths in each month being stated upon the chart.

The deaths from typhoid fever in St. Louis are plotted the same chart in a black dotted line, the deaths in the successive months being stated in numbers upon the chart along such dotted line. The deaths in St. Louis are stated one month in advance, that is the five deaths in St. Louis in February, 1900, are stated as of January, 1900. The 14 deaths in St. Louis in March, 1900, are stated as of February, 1900, and so on throughout the entire dotted lines. The reason for stating the
11288 St. Louis deaths one month in advance is because of the
length of time that it would take a typhoid fever germ, should it go as far as St. Louis, to get there, and because of the length of time that it would take to produce typhoid fever of fatal character after the invasion of the victim had taken place. In other words, if typhoid fever occurring in Chicago in January should produce typhoid fever in St. Louis, the deaths from such fever in St. Louis would be occurring in the month of February. It is for that reason that, for purposes of future comparison, February deaths in St. Louis are compared with January deaths in Chicago, March deaths in St. Louis with February deaths in Chicago, April deaths in St. Louis with March deaths in Chicago, and so on.

In examining this chart and observing the fluctuations of the solid line representing deaths in Chicago and of the dotted line representing deaths in St. Louis, I observe that the two lines are by no means parallel.

In other words in January, 1900, we have 23 deaths in Chicago corresponding to 5 deaths in St. Louis.

In February, 1900, the Chicago deaths have dropped to 14.

We do not have a corresponding drop in St. Louis. We

11289 have the reverse. We have a rise from 5 to 16.

In the following month of March we have a rise in the deaths in Chicago and a drop in the deaths in St. Louis.

In the following month we have a slight drop in the deaths in Chicago from 27 to 23, and the same deaths in St. Louis, namely 4 in March and 4 in April.

In the next month, namely in May there is a drop from 23 to 19 in Chicago and a rise in St. Louis from 4 to 8.

In the next month, in June, there is a further drop in Chicago from 19 to 17 and a rise in St. Louis from 8 to 15.

In the next month, July, there is a rise from 17 to 26 in Chicago, and also a rise in St. Louis from 15 to 20.

In the following month of August there is a rise in Chicago from 26 to 34 and a drop in St. Louis from 20 to 13.

In the following month of September there is no variation in Chicago, 34 to 34, and a rise in St. Louis from 13 to 30.

In the following month of October there is a rise in Chicago from 34 to 38, and a drop in St. Louis from 30 to 15.

In the following month of November there is a rise in Chicago from 38 to 39 and also a rise in St. Louis from 15 to 19.

11290 In the following month of December there is a rise in Chicago from 39 to 43 and a drop in St. Louis from 19 to 8.

In 1901, there is in January, 1901, a drop in Chicago from 43 to 26, and a rise in St. Louis from 8 to 14.

In the month of February there is a drop in Chicago from 26 to 16, and also a drop in St. Louis from 14 to 11.

The next month of March there is a drop in Chicago from 16 to 15 and also a drop in St. Louis from 11 to 4.

In the following month of April there is a rise in Chicago from 15 to 20 and also a rise in St. Louis from 4 to 8.

In the following month of May there is a rise in Chicago from 20 to 24 and a drop in St. Louis from 8 to 6.

In the following month of June there is a drop in Chicago from 24 to 9 and a rise in St. Louis from 6 to 13.

In the following month of July there is a rise in Chicago from 9 to 55 and also a rise in St. Louis from 13 to 31.

In the following month of August there is a rise in Chicago from 55 to 83, which is a large one, and a drop in St.
11291 Louis from 31 to 24.

In the following month of September there is a drop in Chicago from 83 to 74 and a rise in St. Louis from 24 to 32.

In the following month of October there is a rise in Chicago from 74 to 102 and a drop in St. Louis from 32 to 27.

In the following month of November there is a drop in Chicago to 54 and also a drop in St. Louis, 27 to 20.

In the following month of December there is a drop in Chicago from 54 to 31 and also a drop in St. Louis from 24 to 14.

For the year 1902, for the month of January, 1902, there has been a drop in Chicago from 31 to 21 and a rise in St. Louis from 14 to 16.

For the month of February there has been a drop in Chicago from 21 to 14 and also a drop in St. Louis from 16 to 11.

In the month of March there has been a rise in Chicago from 14 to 20 and also a rise in St. Louis from 11 to 14.

For the month of April there has been a drop in Chicago
11292 from 20 to 16 and also a drop in St. Louis from 14 to 11.

For the month of May there has been a drop in Chicago from 16 to 24 and a drop in St. Louis from 11 to 7.

For the month of June there has been a drop in Chicago from 24 to 22 and a rise in St. Louis from 7 to 14.

For the month of July there has been a rise in Chicago from 22 to 44, and also a rise in St. Louis from 14 to 26.

For the month of August there has been a great rise in Chicago from 44 to 193 and there has been a drop in St. Louis from 26 to 21.

For the month of September there has been a drop in Chicago from 193 to 165 and a rise in St. Louis from 21 to 32.

For the month of October there has been a decided drop in Chicago, from 165 to 98, and a drop also in St. Louis from 32 to 31.

In the month of November there has been a drop in Chicago from 98 to 72 and also a drop in St. Louis from 31 to 25.

In the month of December there has been a rise in Chicago from 72 to 132 and a drop in St. Louis from 25 to 15.

For the year 1903. For the month of January there has
11293 been a drop in Chicago from 132 to 97 and no variation in St. Louis.

For the month of February there has been a drop in Chicago from 97 to 54 and a rise in St. Louis from 15 to 20.

For the month of March there has been a drop in Chicago from 54 to 49, and also a drop in St. Louis from 20 to 17.

For the month of April there has been a drop in Chicago from 49 to 33 and also a drop in St. Louis from 17 to 15.

For the month of May there has been a drop in Chicago from 33 to 26, and a rise in St. Louis from 15 to 16.

For the month of June there has been a drop in Chicago from 26 to 21, and a rise in St. Louis from 16 to 27.

For the month of July there has been a rise in Chicago from 21 to 29 and also a rise in St. Louis from 27 to 37.

For the month of August there has been a rise in Chicago from 29 to 50 and also a rise in St. Louis from 37 to 42.

For the month of September there has been a rise in Chicago from 59 to 82 and a drop in St. Louis from 42 to 29.

For the month of October there has been a drop in Chicago from 82 to 45 and a drop also in St. Louis from 29 to 24.

11294 For the month of November there has been a rise in Chicago from 45 to 56 and also a rise in St. Louis from 24 to 31.

For the month of December there has been a drop in Chicago from 56 to 36, and for St. Louis I have no data because everything has been shoved one month in advance and consequently I am short of data for the month of December for St. Louis.

Q. Professor, from your examination of the monthly mortality from typhoid fever in the city of St. Louis and in the city of Chicago for the years 1900, 1901, 1902 and 1903, what conclusion do you draw as a sanitarian and epidemiologist as to the cause of typhoid fever conditions in the city of St. Louis being attributable to typhoid conditions that exist in the city of Chicago?

A. From an examination of the charts just presented I am of the opinion that no relation whatever exists between the typhoid fever as represented in Chicago and as represented in the city of St. Louis. In other words I am strongly convinced that typhoid in St. Louis is not produced by typhoid fever in Chicago.

11295 It will be seen from an examination of those charts that the curves of typhoid fever are far from being parallel for the two cities. In many instances the rise of the curve from Chicago is coincident with the falling of the curve for St. Louis, particularly so for the month of August, 1902, when the typhoid in Chicago grows from 44 to 193 and the typhoid in St. Louis drops from 26 to 21.

Q. Have you prepared a chart of coli determinations based upon Professor Jordan's tables of coli determinations, made for the year 1901, and introduced by him, and presented and sworn to by him as evidence in this case?

A. I have.

Q. Will you produce the chart thus prepared and make it a part of your testimony?

A. The caption of this chart is "Chart prepared by W. P. Mason based on Professor Jordan's Coli Determinations for 1901," and is as follows:

11296

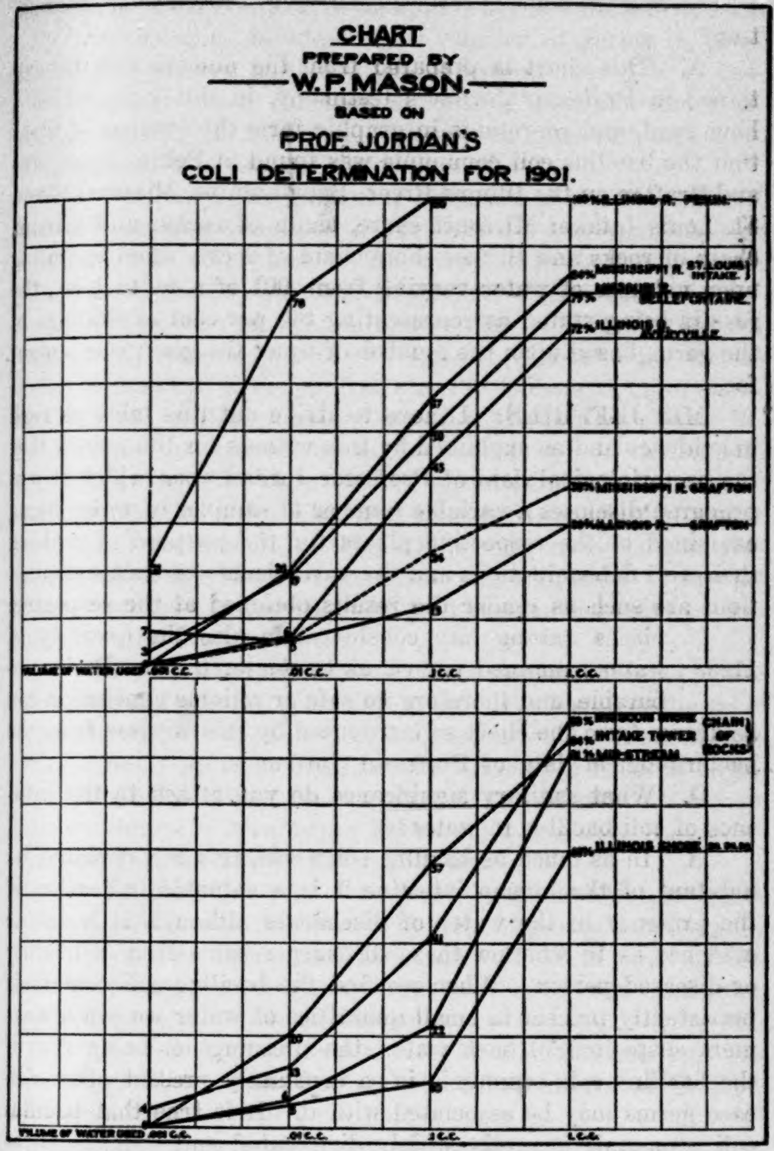


CHART
PREPARED BY
W. P. MASON.
BASED ON
PROF. JORDAN'S
COLI DETERMINATION FOR 1901.

11297 Q. Will you state upon what facts this chart is made and the sources from whence you secured your information?

A. This chart is prepared from the numerical data contained in Professor Jordan's testimony, in this case, which I have read, and represents in graphic form the number of times that the bacillus coli communis was found at Pekin, Averyville and Grafton on the Illinois River; Bellefontaine, Missouri River, St. Louis Intake; Missouri shore, chain of rocks; mid stream, chain of rocks and Illinois shore chain of rocks, when operating upon volumes of water varying from .001 of a cc. to 1 cc., the results being stated as representing the per cent of findings of the germ, based upon the number of times the germ was sought for.

MR. JEFFRIES: I move to strike out this table as read in evidence and as explained by this witness for the reason that the bacteriological data of Professor Jordan upon which it was prepared discloses a variable number of samples of water being examined at the respective places for the purpose of making these coli determinations and the variableness of such examinations are such as render the results obtained at the respective places, taking into consideration also the quantity of 11298 water examined per cc. as to render the results incomparable, and therefore no safe or reliable conclusion can be drawn from the chart so introduced by this witness from the bacteriological data of Professor Jordan.

Q. What sanitary significance do you attach to the presence of coli bacillus in water?

A. In as much as bacillus coli communis is a constant inhabitant of the human intestine it is a valuable indication of the presence in the water of discharges although it bears no evidence as to whether those discharges came from a healthy or diseased person. When we find the bacillus coli communis persistently present in small quantities of water we are always more suspicious of such water, the presumption being that if the bacillus coli communis is so constantly present other disease germs may be associated with it. It is true that bacillus coli communis is pretty widely distributed and that it can be pretty generally found if enough water be examined, therefore we consider it an important matter to have some notion as to the volume of water operated upon in order to obtain from such information an idea of the number of germs in question present in the water. For that reason it is customary to sow different amounts of the water under examination, .001, .01, .1 of a cc., 1 cc. or even more, although 1 cc. is the amount that is usually made use of. 11299

Q. Professor, directing your attention to the chart, based upon the coli determinations of Professor Jordan, what sanitary significance do you attach to that chart as to the comparative pollutions of the Illinois, Mississippi and Missouri Rivers?

A. From an examination of this chart I observe that the bacillus coli communis is more frequently found in the waters of the Mississippi River at Grafton, the Illinois at Averyville, the Missouri at Bellefontaine and the Mississippi at the St. Louis intake and the Illinois at Pekin than it is in the Illinois at Grafton, operating upon 1 cc. of water. Operating upon the same quantity of water I observe that the Mississippi River at the chain of rocks contains the bacillus coli communis most frequently upon the Missouri shore, next in frequency at the intake tower, next in frequency in mid stream and least in frequency on the Illinois shore.

Judging from the bacillus coli communis contents of the several waters, operating upon 1 cc. as stated, the relative purity of the waters in question would stand, first in purity, Illinois River at Grafton. (2) Mississippi River at Grafton. (3) Illinois River at Averyville. (4) Missouri River at Bellefontaine. (5) Mississippi River water at the St. Louis intake, and (6) the Illinois River at Pekin. 11300

Basing upon the same data from the several waters taken at the chain of rocks, the relative degrees of purity would stand, most pure water from the Illinois shore, next in purity from the mid stream, next in purity from the intake tower and least in purity from the Missouri shore.

Q. How does the Missouri river at Bellefontaine and the Mississippi River at Grafton and the Illinois River at Grafton compare as to purity or pollution?

A. Basing my reply upon the bacillus coli communis contents they compare as follows:

The Illinois River at Grafton is the most pure.

The Mississippi River at Grafton is next and the Mis-
11301 souri River at Bellefontaine is the least pure.

Q. What is the liability of pollution and infection of a river coming from the rural population?

A. The source of pollution from a rural population would come from such sewers as it possessed, together with what surface washing might result from its barn yards and from any other source of pollution which there was of surface origin.

Q. Do you know of any typhoid fever epidemics in which infection has come from the rural population?

A. Yes sir. It is very well known that Ithaca typhoid came from such source and Butler, Pennsylvania typhoid from such a source as well. The best known cases are Plymouth and New Haven. The Plymouth and New Haven cases are exceedingly alike.

Q. When considering questions concerning typhoid fever do you regard it as important to note the interval of time elapsing between infection of water supply and the drinking of the infected water?

A. I regard that as very important. That is a topic upon which I have pretty strong opinions and which I have quite an amount of data.

Q. State fully the reasons for your answer?

11302 A. I have made an analysis of 205 British epidemics reported by Harte in a report entitled "Water Born Typhoid made to the Parliamentary Committee of the British Medical Association." A very full report is obtained in that report of Harte's not only of the deaths but of the character of the water supply causing them and I have divided those 205 epidemics into three portions; those that were produced by well water, those that were produced by stream and reservoir water and incidentally those that were produced by milk. Then I had left over some that I could not classify and I have left them out of the count.

In 33 epidemics due to stream and reservoir water I found that the death rate was 9.85 per cent of the cases.

In 75 epidemics due to well water I found that the death rate was 11.83 per cent of the cases, and I found that in 20 epidemics due to milk the death rate was 12.79 of the cases, showing that a well water epidemic was distinctly more serious in character than an epidemic caused by water which had carried the typhoid germ some distance from the point of infection to the point where the water was used for purposes of drinking.

I made an examination of 357 cases of typhoid fever in a typhoid fever epidemic which I examined in Waterville 11303 and I was able there to follow the course more clearly of each case and to get the physician's statement whether the case was a severe one or a mild one. Some of these cases used the city water supply, which was from a contaminated stream. Some of the cases used well water supply and those wells were contaminated. Some of those cases used both sources of water. I found that among the cases that used city water only 41.41 per cent were severe, it not being stated whether they were fatal or not, I rated a fatal case as a severe one naturally.

Among those cases not using city water I found that 61.29 per cent were severe, thus showing that the typhoid fever produced by city water was a milder type, and my explanation of that is that the typhoid germ having to struggle for existence in a river under adverse circumstances, when it arrives at the point where the water is drunk it is not capable of producing so much poisonous material, or in other words not capable of producing so severe a case of fever if it produced one at all.

In the opinion of Mr. George C. Whipple, who testified 11304 in this case, which opinion was given on the witness stand in the case of the Maine Water Company against the city of Waterville. (I was on that case and heard him testify.) He made use of the expression "immediate pollution is very much more dangerous than remote pollution" a view which is entirely in accord with my own views.

Q. Professor, assume that on April 1, 1895, the total number of wells in the city of St. Louis was 4846 and assume that pursuant to an order of the Board of Health of St. Louis, directing the examination of these wells that the city chemist, after an examination of 59 of these wells condemned them as being unsanitary, and assume further that in August, 1895, upon the report of the city chemist condemning 7 more of these wells the board of health of the city of St. Louis passed a resolution to the effect that the city chemist should make no further examination of the wells in question and since 1895 none of these wells has been condemned, what effect would this number of wells in the city of St. Louis have, in your opinion, upon the typhoid conditions existing in the said city, assuming that the water of these wells was used by the inhabitants for drinking and domestic purposes?

11305 MR. JEFFRIES: I move to strike the question out for the reason that the assumptions are not supported by the evidence in the cause.

A. Taking all the assumptions stated in the question I believe that the water of those wells was responsible for a portion of the typhoid fever in St. Louis, because I am a believer in greater danger coming from a polluted well water than from the water of a polluted stream.

Q. What are your reasons for entertaining that belief?

A. My reasons are based upon data such as that which I gave in answer to a previous question, showing that the death rate of well water epidemics was greater than that of stream epidemics, and showing that the intensity of fever from well water epidemics was greater than from stream epidemics.

Such data as I have given I could increase by statistics from Philadelphia, should it be necessary, but the number I have given is already sufficiently large to give accentuation to my opinion.

Q. If the typhoid conditions in part in the city of St. Louis during the last ten years are attributable in part to the
11306 drinking water, and assume that there is typhoid fever existing upon the water shed of the Missouri River water and the Mississippi River water above Grafton, nearer in point of time of flow than the city of Chicago, to what infection would you attribute such proportion of the typhoid in the city of St. Louis as would properly be attributable to its water supply to points having typhoid fever conditions nearer or remote from the St. Louis intake?

A. My opinion is that given points nearer and remote from the St. Louis intake, said points being located upon a water course flowing thereto, and said points all possessing typhoid in their sewer discharges, I would attribute the danger of typhoid fever in St. Louis greater from the nearer points than from those more remote.

Q. Does a sanitary expert call to his attention or assistance all information available from chemical and bacterial sources as well as knowledge of sources of pollution in passing judgment on the sanitary character of a river?

A. A sanitary expert brings to his assistance knowledge of every possible sort that he may possess, bacteriological, chemical and otherwise.

11307 Q. As a sanitary expert, availing yourself of all chemical and bacterial knowledge which is available to you, what is your opinion as to whether a typhoid bacillus lying in the sediment of a polluted stream for a period in excess of sixty days would be able to cause typhoid fever when taken into the human system after it had remained in such sediment for that length of time?

A. I do not think it would produce typhoid fever.

Q. What is your opinion as a sanitary expert as to whether typhoid fever germs coming from the sewage of Chicago through the drainage canal, deposited on the bottom of the Desplaines and Illinois Rivers, between Chicago and Peoria, can remain there for a period of from thirty to sixty days and yet retain their dangerous qualities as well as their pathogenesis?

A. I do not think that they would be able to retain their dangerous qualities after such a discharge in the bottom of the river.

Q. From your personal knowledge of the Illinois River and your knowledge as a sanitary expert, together with all chemical and bacterial knowledge derived from every source, what is your opinion as to whether the sewage from the city of Chicago, passing through the drainage canal into the Illinois 11308 River at different seasons of the year and at different stages of water in the Illinois River would be a danger and a menace to the inhabitants of the State of Missouri and the citizens of the city of St. Louis using the water of the Mississippi?

A. I do not think that it would be a danger and a menace to those people using the water in question.

Q. What is your opinion as a sanitary expert, based upon your examinations of the tables of analysis introduced in evidence by Professors Palmer, Burrill, Gehrmann and Jordan of the waters of the Illinois, Mississippi and Missouri Rivers as represented by such tables which you have examined and are reported in Streams Examinations as to which one of these three rivers from this analysis disclosed the least amount of impurity or pollution?

Mr. Jeffries: Objected to as immaterial.

A. From the data which you have referred to, my opinion is that of the three rivers named the Illinois represents the least impurity although I do not consider that there is any considerable difference between the three, what little difference there is being in favor of the Illinois. I moreover, refer you to the chart which I have in evidence which shows the same result 11309 based upon the colon determination.

Q. If the Illinois River discloses from such data as aforesaid the least amount of impurities, what would be the effect of the waters of the Illinois River emptying into the Mississippi River at Grafton and subsequently uniting with the Missouri River at its mouth upon the combined waters of the Mississippi River at the intake tower at the chain of rocks.

A. The emptying of the Illinois River into the Mississippi River makes no material change in the character of the combined waters. What little change there is is an improvement, but as I have already said the three waters are not widely apart. They are all about the same, any difference being in favor of the Illinois.

Q. Does the mixing of the Illinois with the Mississippi and Missouri Rivers as indicated in the foregoing question create any added danger to the already polluted and contaminated waters of the Missouri and Mississippi Rivers below Grafton?

A. It does not.

Q. As a sanitary expert do you consider the sewage of Chicago entering the drainage canal and the Illinois River which in turn empties into the Mississippi River a menace 11310 and a danger to the inhabitants of the State of Missouri and the citizens of the city of St. Louis taking their water supply from the Mississippi River?

A. It is not a menace and a danger to the people in question.

Q. What is your opinion as a sanitary expert as to whether the germs of typhoid fever could lie in the sediment of the drainage canal or upon the bottom of the Illinois River for a period of from one to three years?

A. I do not think they could and retain their vitality.

Q. Do you know of any instance on record or reference in the literature upon the subject of bacteriology where a typhoid bacillus has lived for a period of from one to three years?

A. I do not.

Q. What is your opinion as to whether a typhoid bacillus deposited on the bottom of the Illinois River could remain there for a period upwards of five years and then stirred up by the action of the waves, the winds, steamboats or by any other means, could continue its journey to St. Louis in a virulent state and be a menace and danger to the inhabitants of the State of Missouri and the citizens of St. Louis using the water of the Mississippi River for drinking and domestic purposes?

A. My opinion is that such a typhoid bacillus could not live for such a period of time and be stirred up as stated, giving the results as stated. 11311

Q. Will you state as a sanitary expert, basing your opinion upon all the information you possess in this case whether the water supply of St. Louis, taken from the intake tower at the chain of rocks, is contaminated by the sewage of Chicago entering the drainage canal and from thence into the Illinois River?

A. My opinion is that it is not contaminated that way.

Q. What effect does an increased volume of water in the Illinois River have upon the low lands lying along the banks of the Illinois River?

A. An increase in the volume of water in the Illinois River floods those low lands. I saw it.

Q. If the increased water at flood tide from the tributaries of the Illinois River as well as the Illinois River itself, exclusive of the waters of the drainage canal, causing a large area of land to be overflowed along the Illinois River Valley, what effect does this overflow have upon sedimentation of the sewage entering the Illinois River through the drainage canal?

A. It increases the opportunity for sedimentation by over flowng those low lands, the principle being entirely simi- 11312 lar to the one which I illustrated in my morning testimony.

Q. Would sedimentation be greater if the volume of water was greater, thereby causing a greater area of territory to be overflowed in the Illinois Valley?

A. It certainly would, for the more acreage that is over flowed by such water the greater number of particles will have a short distance to drop before reaching their final resting place on the soil.

Q. Assume that the five dams which you have described exist in the Illinois River, backing the water up stream for a considerable distance, also there is a lake below Joliet known as Lake Joliet, a lake above Peoria known as Lake Peoria, and many small lakes lying along the Illinois River, receiving water supply from the Illinois River, what effect would these dams and lakes have as sedimentation basins and also what effect would they have in the elimination of the sewage coming from Chicago by way of the drainage canal and the Illinois River?

Mr. Jeffries: Objected to for the reason first that the State of Missouri has no assurance that those dams will be con- 11313 tinued even though they be of any benefit in the way of bringing about the process of sedimentation, and for the further reason that the evidence in this case, taken on behalf of respondents, shows that there is a continuous direct channel from one end of the river to the other during all periods and times of the year since the opening of the drainage canal.

Mr. Todd: I deny the latter part of counsel's objection, unless he means to include the locks as a part of the channel.

Mr. Jeffries: I am relying upon the evidence of respondent's witnesses taken on the river trip.

A. All of those dams and lakes would have an effect in increasing the opportunity for sedimentation, and such increased sedimentation would have a beneficial effect in the elimination and purification of polluted and infected waters coming into the Illinois River from Chicago.

Q. Assume that those dams should be removed at a time when the maximum volume of water was passing through the drainage canal of 800,000 cubic feet per minute, what effect would the removal of those dams have?

A. To the extent the sedimentation of objectionable material would be interfered with, but as I stated this morn-
11314 ing in my testimony I do not think the beneficial effect
of the dams amounts to very much and their removal although it would diminish the purifying power of the stream through sedimentation, such diminution would not be great.

Q. Do you know of any case where dams have improved typhoid rates in cities?

A. Yes sir, there is a recent instance of that in Pittsburg. Pittsburg receives two supplies, one from the Monongahela and the other from the Alleghany. The Monongahela supply is purer water than the Alleghany, and that portion of the city supplied with Monongahela water has a lower typhoid rate than the other. The difference between the two rivers lies in the fact that the Monongahela possesses dams and the Alleghany none, hence the improvement in the typhoid conditions is to be credited to those dams and their opportunities for sedimentation.

Q. Will you state as an expert sanitarian and from all sources of knowledge that you possess whether the water of the Mississippi River at the chain of rocks was prior to January 1900, a safe and potable drinking water, fit for domestic and drinking purposes in its raw state, after passing through
11315 the settling basins?

Mr. Jeffries: Objected to as immaterial.

A. My reply is that it was not.

Q. Was the Missouri River water a safe water for drinking and domestic purposes prior to the opening of the drainage canal in January, 1900, in your opinion?

Mr. Jeffries: Objected to as immaterial.

A. In my opinion it was not.

Q. Was the Illinois River water a safe water for drinking and domestic purposes prior to the opening of the drainage canal in January, 1900, at Grafton?

A. It was not.

Q. Has the sanitary condition of the water of the Illinois River at Grafton been improved or damaged by the opening of the drainage canal?

A. In my opinion it has been improved.

Q. Since the opening of the drainage canal are the waters of the Illinois River at Grafton less sanitary than the waters of the Missouri and Mississippi Rivers?

A. They are not. They are rather better than those other rivers, although as I have said twice before there is very 11316 little difference between them.

Q. What effect does the sewage discharged from the drainage canal have upon the waters of the Mississippi and Missouri River waters, at the chain of rocks?

A. It has no appreciable effect.

Q. Is the water of the Mississippi and Missouri Rivers in your opinion, as a sanitary expert, exclusive of the waters of the Illinois, a safe and suitable water for drinking and domestic purposes, to be used by the citizens of St. Louis in its raw state or treated as now by the city of St. Louis by settling basins?

Mr. Jeffries: Objected to as immaterial.

A. In my opinion the water of the Mississippi and Missouri Rivers, exclusive of the waters of the Illinois, is not a safe and suitable water for use by the citizens of St. Louis in its raw state.

Q. State your opinion as an expert on water supply for cities and towns as to whether or not the waters of the Mississippi River west of the center of the main channel of said river, below the mouth of the Illinois River, and down to the intake tower of the St. Louis water works at the chain of 11317 rocks is less valuable for drinking purposes and more liable to carry water born diseases such as typhoid fever now than it was before the sewage from the sanitary district of Chicago was run into it, from the drainage canal, and through it into the Illinois River?

A. In my opinion it is not less valuable for those purposes.

Q. State whether or not an increase in the speed of the current of the Illinois River by reason of the added volume of water of the drainage canal would affect the amount of sedimentation that might otherwise occur in the Illinois River and if it does affect it, how and in what manner?

A. Under those circumstances as stated, the volume of water in the Illinois River would be increased, thereby causing the river to overflow its banks and submerge the adjacent territory giving the same opportunity for increased sedimentation as under the conditions already testified to.

Q. What effect if any would the increase in the speed of the current in the Illinois River have upon the time within which sewage from Joliet, Peoria and other towns from the Illinois River have if emptied into the waters of the Mississippi
11318 River, if the same are so removed as compared with the conditions which existed at the time it might have taken before the added volume of water from the drainage canal was poured into the waters of the Illinois?

A. So far as particles which were in the main channel were concerned they would doubtless be carried down stream more rapidly; so far as particles which might be contained in the waters which over flowed the low lands were concerned they would not go down so rapidly and there would be a depreciation in the velocity of the current, and there would be an opportunity for sedimentation.

Q. If an increased volume of water in the Illinois by the addition of the water of the drainage canal would make an increased speed in the current of the Illinois River would that increase in said current have any effect in increasing or diminishing the typhoid and liability to typhoid and other water borne diseases on the part of the inhabitants of the State of Missouri using the water of the Mississippi River for drinking purposes below the mouth of the Illinois River?

11319 A. That increase in volume would cause an overflow of the banks and consequently there would be a depreciation in the velocity of the current because of that overflow and that portion of the water which was in the overflow would have low velocity and be given a better opportunity for sedimentation. Some portions of the main channel of the river might or might not have an increased flow in the unit of time, depending very largely upon the amount of water which went over the sides of the river. If the banks were very low as they are in many places, and consequently the river section greatly widened, there would be no material increase in velocity. There might be a decrease. That would have no material influence whatever on the people of the State of Missouri.

Q. Professor Sedgwick, in answer to the question: "What do you say as to the longevity of the germ of typhoid fever as a general proposition in connection with sewage polluted water?" stated among other things: "My belief is that in a sewage polluted stream the typhoid germ might live in gradually diminishing numbers for weeks or months or even years." What is your opinion as to the correctness of that belief, based upon your knowledge as a sanitarian?

11320 A. I do not believe that the typhoid germ would live for such period under those conditions.

Q. Professor Sedgwick, in answer to the following question: "Assuming that the germs of typhoid fever coming from the sewers of Chicago and passing by way of the drainage canal to Lake Peoria be in large numbers deposited in the bed of Lake Peoria for the period of a month, say, do you consider that typhoid germs would be entirely destroyed at the end of that time in that deposit?" answered "No sir." What do you say as to the assumption that typhoid germs could pass from the sewers of Chicago, by way of the drainage canal to Lake Peoria, and be deposited there in the bed of Lake Peoria for the period of a month, and as to whether or not typhoid germs coming from the drainage canal, under conditions as they exist today, would live for the period of a month and not be destroyed before the end of that period?

A. I do not believe that they would live for that period of time under those conditions and I base my opinion very largely upon experiments similar to what I described this morning, the tank experiment which was made by the Massachussets Board of Health, and moreover it is to be remembered 11321 that the burden of proof should be on the part of those who make the statement that the germs will so live.

Q. Professor Sedgwick, in answer to the question, "Assuming that typhoid fever germs coming from Chicago sewers are deposited in large numbers in the lake and slack water portions of the Illinois River above Peoria, do you or do you not consider that flood conditions such as would scour the deposits from the beds of the streams would cause the water leaving Lake Peoria to contain at times more infectious and dangerous pollution than is at present in the diluted sewage entering at the Bear Trap dam at the foot of the drainage canal?" stated "I think at times it might." What is your opinion, taking into consideration all that you know about the conditions of the drainage canal the Desplaines River and the Illinois River, as a sanitary expert and epidemiologist as to whether such a condition at times might exist?

A. I do not believe that such a condition might at times exist. I do not believe that there would be any accumulations of germs taking place gradually, said accumulations afterwards being washed out by flood, and causing wide spread disease in the sections below, and I do not so believe because I observe that we do not have epidemics following floods of that kind. For instance we do not have Spring epidemics of typhoid with us on the Hudson or in the Hudson Valley, although our floods are commonly Spring floods. We have high water resulting from the melting of the northern snows with a great amount of scour following. If the statements above referred to were true there would be deposits of typhoid germs that would gradually accumulate and such deposits would be washed out by these heavy floods and as a result we should have typhod below in the spring time. 11322

We do not seem to have epidemics coming in that order. I can easily understand how you will have typhoid epidemics from the scour such as you have in the Tees river, but that scour is quite different. There you have great deposits of fecal matter in privies and the like in heaps upon the shore, and the high water washes them off from the shore in great masses and the conditions below result in typhoid fever. Such is not a case that is at all comparable with gradual accumulation of river mud, for we know that typhoid will exist for long periods of time in fecal deposits. 11323

Q. What is your opinion based upon all the knowledge which you have of the conditions at Lake Peoria, as a sanitary expert as to whether at any time under any condition the number of typhoid bacilli at that point is even as great as they are at the Bear Trap Dam at the end of the drainage canal?

A. I do not believe they are ever as great as they are at the Bear Trap Dam.

Q. Do you know of any evidence based upon any investigations made by yourself or by any one else that justifies the conclusion that at any time under any conditions there are larger number of typhoid fever germs at Lake Peoria than at the Bear Trap Dam?

A. I do not.

Q. Do you know of any evidence scientifically secured or otherwise that shows that accumulations of typhoid germs are found in lakes or slack water basins of rivers and remain there in storage in vast numbers for any considerable period of time in a virulent state and are suddenly flushed out by freshets so that great numbers of typhoid fever germs are present flowing in a stream a considerable distance from the source of
11324 pollution in greater quantities than exist at the source of pollution?

A. I do not believe that, and for the reasons that I have already stated with reference to the Spring epidemics.

Q. Are you acquainted with the Detroit epidemic?

A. To the extent that I have had information appertaining thereto given me by Professor Williams who has testified in this case. He gave it to me at the time that he was collecting it. I talked the matter over with him and it seemed to me that there might be some doubt with reference to the connection between typhoid fever in Detroit and the dredging of the Black river.

Q. Now, assuming that the only pollution of the river was that contributed to it by the Chicago Drainage canal, and having in mind a large amount of typhoid fever existing in said district, do you or do you not consider the effects of the time interval dilution and sedimentation occurring between Chicago and Grafton would be such as to render the water as it enters the Mississippi River at all times free from the liability of producing water born diseases to the inhabitants of the State of Missouri who use the water for domestic and drinking purposes?

A. I think the water described would not be liable to 11325 produce typhoid fever among those using it.

Q. Assuming that no other pollution or infection enters the river save that which it received from the sanitary district of Chicago, from your knowledge as a chemist and sanitary expert, have you had any experience or knowledge that would lead you to believe that the water of the Illinois River at Grafton is infected with the sewage from Chicago, and if said water enters the Mississippi River, becoming mixed with the latter, would it be a menace to the health of the inhabitants on the Missouri shore of the Mississippi Ricer, using the water for domestic and drinking purposes at points below on the Missouri shore?

A. I have no knowledge of the presence of infected Chicago sewage in the Illinois River at Grafton and I believe that the use of the water of the Mississippi at the chain of rocks, because of the admixture of water from the Illinois River, would not be a menace to the health of the inhabitants of St. Louis.

Q. Is there anything, based upon your knowledge as a chemist and sanitary expert which you know that would lead you to believe that the water coming from the Illinois River at Grafton was infected from the sewage of Chicago, and assuming that the water from the Illinois River, mixed with the 11326 waters of the Mississippi River at Grafton and subsequently mixed with the waters of the Missouri River at its mouth, do you consider the water of the Illinois River thus comingled with the waters of the Mississippi and Missouri Rivers a menace to the health of the inhabitants of the State of Missouri, living upon the Mississippi River using the Mississippi River water for drinking purposes at points below on the Missouri shore?

A. I do not consider that the waters of the Illinois River under the conditions obtaining, comingled with the waters of the Mississippi River are a menace to the inhabitants of the State of Missouri living upon the Mississippi River and using the Mississippi River water for drinking purposes at points on the Missouri shore.

Q. Now, assume that the only pollution upon the water shed of the Mississippi and its tributaries above the intake of the St. Louis water works was that derived from the sanitary district of Chicago, and having in mind a large amount of typhoid fever in Chicago, do you or do you not believe that dangerous infection and dangerous pollution might under existing conditions find its way into the water supply of the city of St. Louis?

A. I do not.

11327 Q. Assuming that there was no typhoid fever pollution upon the water shed of the Mississippi and its tributaries, above the intake of the St. Louis water works, other than that derived from the sanitary district of Chicago, do you or do you not believe that typhoid fever germs from said district are liable to find their way into the water supply of the city of St. Louis through the intake at the chain of rocks, and become a danger and a menace to the inhabitants of the city of St. Louis?

A. I believe that they are not liable to find their way into the water through the intake tower at the chain of rocks and become a danger and a menace to the inhabitants of the city of St. Louis.

Q. Professor Sedgwick, in answer to the question just propounded to you stated: "I believe they are liable to find their way into the intake" and when asked why, answered: "For the reason that typhoid fever having been frequently very abundant in the city of Chicago, I must start with the assumption that a very large number of typhoid germs find their way into the sewage of the city, pass through the sewers and on into the drainage canal, and, subject to local conditions, may, in
11328 diminishing numbers, pass out of the Illinois River,
mingle with the waters of the Mississippi River, pass over to the other side and find their way into the intake at the chain of rocks." Now, Professor, I want to ask you do you know of any evidence, based upon any analysis, experiments or otherwise that justifies the assumption that typhoid fever germs will pass through the sewers and on into the drainage canal and subject to local conditions may, in diminishing numbers, pass out of the Illinois River, mingle with the waters of the Mississippi River and pass over to the other side and find their way into the intake at the chain of rocks of the St. Louis water supply?

Mr. Jeffries: Objected to for the reason it is leading, suggestive, incompetent and irrelevant.

A. I do not know of any analysis or experiments that justify such assumption, but on the contrary I am of the opinion that the charts which I have offered in evidence show that there is no connection between typhoid fever in the city of St. Louis and the city of Chicago, and were it liable that typhoid germs should pass into the water at the intake I should expect that the curves of typhoid fever in St. Louis and in Chicago
11329 would show paralellism whereas they show quite the reverse.

Q. Assuming that an epidemic of Asiatic cholera should occur in the city of Chicago is it possible that the germs of that disease might find their way into the intake tower at the St. Louis water works at the chain of rocks, from the city of Chicago?

A. Germs of Asiatic cholera would be less liable to find their way into the St. Louis water works than germs of typhoid fever for the reason that Asiatic cholera germs are less hardy than germs of typhoid fever.

Q. Now, Professor, considering your personal kuowledge as an expert on sanitary subjects and of typhoid conditions in the sanitary district of Chicago and existing conditions in said district as to sewers and outfalls there and of the amount of sewage under all the existing conditions of the Desplaines, Illinois, Mississippi and Missouri Rivers, and all conditions existing upon the water sheds of said streams and the tributaries thereof, and all existing conditions as to the water supply of the City of St. Louis, and the general sanitary conditions existing in the city of St. Louis, would you or not beyond a reasonable doubt attribute the principal portion of the increase of typhoid
11330 fever in the city of St. Louis, assuming there has been an increase in St. Louis since the opening of the drainage canal, to the infected sewage of the sanitary district of Chicago?

A. On the contrary I would attribute any increase in typhoid fever which might haxe taken place in St. Louis to infection from nearer points because of what I have already testified to as my belief that the nearer the point of infection the greater the danger, and because, further, that the charts which I have offered in evidence shows that there is no relation between the typhoid fever in Chicago and typhoid fever in St. Louis.

Q. Professor, do you consider that the Illinois River water, containing the mixed sewage and canal water from the Chicago sanitary district, since the opening of the drainage canal, has rendered less safe and wholesome now than before the opening of the canal for drinking purposes on the part of the inhabitants of the State of Missouri, the waters of the Mississippi River below the mouth of the Illinois River?

A. I do not.

Q. Now, Professor, I will get you to state whether or not in your opinion the liability to typhoid fever or other 11331 water born diseases on the part of the inhabitants of Missouri using the Mississippi River water for drinking purposes below the mouth of the Illinois River, by reason of the sewage from the drainage canal affecting the waters of the Illinois River is constant, immediate and continuous under all existing conditions upon the Mississippi, the Desplaines, the Illinois and the Missouri Rivers, and the tributaries of said streams, because of the conditions in the water sheds of the said rivers and the tributaries thereof and the drainage canal and the sanitary district of Chicago?

A. Assuming that the question means that the opening of the drainage canal constitutes a constant, immediate and continuous danger under all existing conditions to the inhabitants of St. Louis on the Missouri shore, I shall repeat that in my opinion it does not.

Q. Professor Sedgwick, in answer to a question, among other things, answered: "The mere presence of pollution, I mean by that uninfected sewage, that is supposing Chicago reduced her death rate from typhoid fever, and would still put her sewage down there, that sewage as affecting the lon- 11332 gevity or growth of germs that get in from Peoria or elsewhere would be an added menace to cities with water supply, even if she did not send typhoid fever germs down, sending the filth alone is serious." I will ask you what is your opinion, based upon your experience as a chemist and sanitarian whether the sewage from Chicago favors the longevity or growth of germs from Peoria or anywhere else, emptying their sewage into the Illinois River?

Mr. Jeffries: Objected to as incompetent, leading and suggestive.

A. In reply will state that in my opinion the addition of Chicago sewage as in the question, does not favor growth of the typhoid bacilli introduced at Peoria.

Q. Does the presence of sewage in water add to the longevity and growth of pathogenic bacteria in your opinion?

A. In my opinion it does not.

Q. Do you or not consider that the Illinois River water, polluted and infected by the sewage from Chicago sanitary district, since the opening of the drainage canal, has rendered less safe the water supply of the city of St. Louis as drawn at the intake tower at the chain of rocks, and upon what do you base your opinion?

A. It has not rendered it less safe.

11333 I base my opinion upon the fact that the Illinois River at Grafton furnishes water which is in quality better than it was before the opening of the canal, and better or at least as good as the water of the Mississippi into which it flows.

Q. Assuming that the Chicago sewage from 1,500,000 people living in the sanitary district of Chicago, should be discharged into the Chicago drainage canal and carried through the canal into the Desplaines River and thence into the Illinois River, Chicago being situated 357 miles from the St. Louis intake, and assume that a typhoid epidemic of extraordinary proportions should become prevalent among the residents of the sanitary district at a time when the sewage from said district is being discharged into the canal, what immediate and impending danger would exist and what effect would it have on the people of St. Louis and those people living on the Missouri side of the Mississippi River below Grafton who use the water of the Mississippi River for drinking purposes?

A. It would have no appreciable effect upon them.

Q. Now, Professor, assuming the same conditions as in the last question you have been answering, and assume that instead of an extraordinary typhoid fever epidemic in the sanitary district, a cholera epidemic should prevail in the sanitary 11334 district would the danger be impending and immediate to the people of Missouri below Grafton who use the waters of the Mississippi River for drinking purposes, as far down as the chain of rocks?

A. It would not for the simple reason that the cholera bacillus is less hardy than the typhoid bacillus and what is true with reference to the typhoid dying out is certainly more true with reference to the spirillum of Asiatic cholera.

Q. Taking into consideration all the knowledge which you possess in regard to the bacterial, chemical and physical conditions of the waters of the Illinois River and its tributaries and the river itself and the different towns sewering into the Illinois River and its tributaries, the population upon the water shed of the Illinois River, both rural and urban, the discharge of the river under all conditions and during all seasons, what is your opinion as to the effect of flowing the sewage from Chicago through the drainage canal into the Desplaines and Illinois Rivers, upon the inhabitants of the State of Missouri, using the waters of the Mississippi River for drinking and domestic purposes?

11335 A. It has no materal effect upon the health of the people using the water mentioned for drinking and domestic purposes.

Q. Assuming all the facts in the foregoing hypothetical question, and taking into consideration all the typhoid statistics as they obtain along the water sheds of the Missouri, Mississippi and Illinois Rivers, in the city of Chicago and in the city of St. Louis, and assuming that there is an increase in typhoid fever cases in the city of St. Louis, since January, 1900, as evidenced by the mortality statistics in St. Louis, as disclosed by the Board of Health reports of the city of St. Louis, and taking into consideration all the chemical, bacterial and other knowledge which you possess, what is your opinion as a sanitarian as to whether the increase in typhoid fever as above indicated, assuming that there has been an increase in the city of St. Louis since the opening of the drainage canal can be attributed to the opening of the drainage canal as the direct, immediate and approximate cause of said increase beyond all reasonable doubt

A. I believe that the increase of typhoid fever, if there is an increase of typhoid fever in St. Louis is not due to the opening of the drainage canal.

11336 Q. If the typhoid conditions of the city of St. Louis, since 1900, can not be attributed to the sewage from Chicago, beyond a reasonable doubt, will you please state to what cause it should be attributed, and give your reasons for such an opinion?

A. It should be attributed either to an entirely local cause such as that of well water or milk supply or else to a river carrying infection from points nearer at hand, and the reason that I feel that the points nearer at hand should be held more responsible than those more remote is because of what I have already testified to, namely that the time interval between the point of infection and the point where the water is used is very important.

Adjourned until 10:00 A. M., March 7, 1904.

11337 10.00 a. m., Monday, March 7, 1904. Continuation pursuant to adjournment.

Present, the Commissioner, and same counsel representing respective parties.

PROF. W. P. MASON

resumed the stand for further direct examination, by Mr. Todd, and testified as follows:

Q. Professor, have you had any experience in filter plants and in installation of filter systems for waters in rivers of this country?

A. Yes, sir, I have recommended a good many.

Q. From your knowledge of conditions that obtain at St. Louis do you regard the water at St. Louis as a safe drinking water as it is at present treated with settling basins?

MR. JEFFRIES: Objected to as immaterial.

A. I do not.

Q. How should that water be treated in order to become a safe sanitary drinking water?

A. Sedimentation should be supplemented by filtration.
11338 In this opinion of mine I entirely concur with what has been stated by Messrs. Hazen and Fuller in a report on the water supply for the City of St. Louis, dated 1902, in which Mr. Hazen says, after describing the method of filtration which he proposes, on page 77; "I believe that the hygienic character of the purified water will be entirely satisfactory."

And on the same page: "I believe that the raw water, although polluted far beyond the point where it should be used in its raw state is very much less polluted than many or most of the river waters used by American cities. Purification will remove a very large percentage of the bacteria and the elements of danger in the raw water. So far as there is danger to health in the present water it will be reduced by filtration to an almost inappreciable amount."

Mr. George W. Fuller, in commenting upon Mr. Hazen's statements in this report says, on page 81 of the same report: "With regard to this method of purification for the St. Louis water supply, it is my judgment that it will yield a water of satisfactory appearance and hygienic quality with proper construction and operation of the works and that it
11339 is the best and most applicable method for the conditions existing at and near the chain of rocks."

Q. When was that report gotten out?

MR. JEFFRIES: I move to strike out what the witness read for the reason that the same is incompetent.

A. 1902.

Q. Do you concur in the views expressed by Mr. Fuller and Mr. Hazen, as you have quoted them.

A. I do.

Q. In the installation of a plant for the filtration supply of the City of St. Louis, would the fact that sewage from Chicago entering the Chicago river and the Illinois river, thereafter commingled with the waters of the Missouri and Mississippi rivers create any additional cost in the expense of the plant or in the operation of such a plant over conditions that would exist if the sewage of Chicago was eliminated?

A. My opinion is that the addition of Chicago sewage via the drainage canal to the system of the Illinois river would not add any additional expenses to the purification of the Missis-

sippi water by filtration at the chain of rocks. The installation
and operation of the plant would not be greater in point
11340 of expenses by the addition of the Chicago sewage as it
now is added to the system of the Illinois river.

Q. Have you any acquaintanceship with any rivers more polluted than the waters in the Mississippi at the chain of rocks that have been successfully treated by a process of filtration?

A. Yes, sir.

Q. What are they?

A. As an illustration I shall mention the Elbe river at Hamburg and the Hudson river below Troy, which latter supplies both Rensselaer and Albany.

Q. Any others?

A. There are. I do not recall the analytical data just now. You would have to let me look over a number of them to answer your question.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. Professor, in the examination of water supply, what do
you say as to the sanitary condition of water, the examination
ranging daily for a period of one month, and these examinations
being made at the rate of 24 per day, and in the examina-
11341 tion the germs of typhoid fever should be disclosed upon
the plates three times, what would you say as to the
sanitary condition of that water?

A. I should say that the water contained typhoid fever unquestionably.

Q. Is it not a fact that the germ of typhoid fever is a very difficult thing to find in a water supply?

A. Yes, sir.

Q. Is it not a very difficult matter to discover it in a composition known to contain it?

A. It often has been sought for in a water where it was known to be present and has not been found.

Q. In the hypothetical question propounded to you by Mr. Todd in reference to the bacillus prodigiosus, and assuming that the germs of typhoid fever were contained in the waters of the Mississippi river at St. Louis, when these bacilli prodigiosus were found during that series of experiments, 2 typhoid fever germs had been discovered, and that these discoveries represented a fair distribution of the germs in the waters of that river, what would you say as to the sanitary condition of that water?

11342 A. I should say that if I understand your question right, assuming that your question is for me to draw a parallel between the presence of the prodigiosus and the presence of the typhoid bacillus—

Q. Assuming that the typhoid was there. It assumes that.

A. It assumes that?

Q. Yes, sir?

A. I should say that there was typhoid found there to the extent that it was found. With reference to the death of the typhoid bacillus, its rate of death, I should have to have some notion as to the numbers that have died out between the points at which it was admitted and the point at which it was found.

Q. But assuming, Professor, the actual presence of the typhoid fever germs in the water of the Mississippi river at St. Louis, and that the number of times that it was found in proportion to the number of examinations that were made represented the bacterial condition of the water of the Mississippi river with reference to this particular germ, at the chain of rocks, what would you say as to the sanitary condition of that water?

A. You do not wish me to include in my answer the 11343 number of samples from the laboratory tap?

Q. No, sir, only such samples taken at the chain of rocks from the intake.

A. Which was 720. My opinion would be that a water sampled at the chain of rocks 720 times and the typhoid bacillus was found twice, that it would be a water certainly containing typhoid fever, as the facts show, but not to such an extent as to be prejudicial to a city supply, provided the supply were used after filtration.

Q. If the examination discloses two typhoid fever germs in 700 analyses of a water, would that water be condemned by a sanitarian as an infected water?

A. It would not be condemned by me as a raw water for a city supply. Might I say when I make use of the expression "raw water" that before the water is actually given to the people it must be improved by artificial means and filtered.

Q. But it would be condemned for use in its raw condition?

A. I would condemn that river in its raw condition.

Q. Are sanitarians a unit upon the longevity of the typhoid bacilli?

A. I should judge that they were not.

11344 Q. Upon what does the longevity of the typhoid fever germ depend?

A. It depends upon the conditions under which the germ finds itself after leaving the human body.

Q. And as contained in a running stream are not the conditions which control and regulate, to a large extent, the longevity of the typhoid germ continuously changing?

A. In a general way, no. Very strictly speaking that is true, and it is because of the material which flows into a stream, which, being the drain of a country, takes all kinds of material added thereto, from pure spring water flowing in at its fountain head to polluted material which may flow from its banks.

Q. Is not the life of the typhoid bacillus governed to some extent by local conditions, surroundings and by the effects of dilution, less and greater concentration, and by temperature and floods?

A. Inasmuch as all the conditions which you have named do occur in rivers, there would be variation of course in the longevity of typhoid germs, subject to variation in temperature and in the other items that you have enumerated in your question.

Q. Assuming, Professor, the longevity of the typhoid 11345 germ to be from 1 to 30 days, with gradual diminishing numbers, and that such germs be deposited into running streams would not changes taking place from one end of the year to the other in that stream affect in a general way the longevity of the germ?

A. Under that assumption that the average longevity of a typhoid germ is somewhere between 1 and 30 days, there is no question but that there would be a variation in the longevity, although a small one, as the conditions under which it finds itself might vary.

Q. Now, name some of the conditions which would bring about such variable results?

A. If, for instance, a germ should find itself suddenly immersed in water containing large numbers of saprophytic organisms which would produce conditions adverse to the life of that germ of course the period of longevity would be diminished. On the other hand, if the germ should find itself in a water of greater purity, particularly if the water approached the limit of sterility, the longevity of that germ would be increased.

Q. Would the change in temperature of the water have
11346 any effect upon the germ?

A. Yes, sir. As the water fell in tempertaure the germ would be adversely influenced, especially near the point of freezing, and when frozen in the ice itself the tendency would be to gradually die from such exposure. Alternately freezing and thawing would be particularly adverse to its life.

Q. Taking into consideration your knowledge of the waters of the Illinois river, and from your information upon the variableness of the life of the typhoid germ in a running stream can you, as a sanitarian, designate any particular point in the Illinois river wherein the pathogenic bacteria coming from the sewers of Chicago will not reach during any portion or part of the year or on any day of the year?

A. My opinion is that in consideration of the facts regarding the Chicago sewage being dumped into the Illinois river, as at present, and the facts concerning the conditions of the Illinois river, that the germs of typhoid fever coming from Chicago sewers would be destroyed en masse by the time the mouth of the Illinois was reached, although some resistant organisms
might go beyond that point, such organisms, however,
11347 representing a small number and in my opinion low
vitality.

Q. Is it not a fact, Professor, that the vitality of the typhoid organisms as well as pathogenic bacteria depend largely upon their inherent faculties and qualities for their longevity, and that the longevity of these germs is variable on account of a difference in the inherent qualities or faculties of the respective germs?

A. My opinion is that the longevity of the typhoid germ depends in the first place upon its parentage, but in the second place it depends upon the conditions under which the germ is grown, and the conditions with which it finds itself surrounded.

In the same way, an individual may come from a healthy parentage and live in a healthful form, but, because of conditions surrounding that individual, his vitality may be greatly lowered. Just so with the typhoid germ, should it struggle, for instance, over periods of time it will lose, in my opinion, the vigor of its life, and be incapable of producing its normal amount of poison. My reason for this belief is as I have already shown in my direct testimony that there seems to be a great loss in poison-
11348 ing power of the germ when the period of time is lengthened between the point of infection of a water and the point of time when such water is drunk.

Q. Is it not a fact that the typhoid fever germs from some typhoid patients are possessed of greater vitality than the germs from other typhoid fever patients?

A. That is true with reference to pathogenic germs in general, for the same reason that a crop of turnips grown upon a good soil would be better than one grown upon a poor.

Q. These variations about which we have spoken and commented upon, render it impracticable and impossible for scientists to definitely determine the longevity of the typhoid fever germ within certain limits, under variable circumstances and conditions in nature?

A. My opinion is that it is impossible to tell what shall be the longevity of specially resistant cells. Experimental data have shown that for the general mass the longevity is fairly well fixed, so that a good deal of knowledge has been obtained with reference to the average germ, although we are still in ignorance as to the longevity of specially resistant individuals.

Q. May it not be true that these specially resistant
11349 typhoid fever cells and the specially resistant cells of all pathogenic bacteria are in reality the ones which produce disease?

A. My opinion is that these specially resistant cells at their point of departure from the human body are fully as capable or even more fully capable of producing disease than the greater numbers of their less resistant brethren, with whom they start upon their journey, after leaving the body. Whether they arrive, after the interval that may be chosen for the period of investigation, in a condition to produce disease, may be open to question, because the mere fact of their being resistant enough to arrive living, does not mean that they will have enough toxin producing powers left to form that serious poison which may cause disease.

Q. That, however, is a matter of speculation?

A. That is a matter of speculation.

Q. Professor, is it not a fact that in the examination of water supplies, sanitarians are more interested in making a determination of the actual or probable presence of pathogenic bacteria rather than the quantity or numbers of such bacteria?

A. Whatever their interest may be their practice is not to look for them at all, for the simple reason that it does
11350 not pay. The negative results are so frequent that, taking typhoid fever as an instance, water examiners have given up search for that germ as a routine portion of their water examinations and have fallen back upon the determination of the bacillus coli communis as an indication of bowel discharges without inquiry as to whether those bowel discharges came from bowels that were diseased or bowels that were in a normal degree of health.

Q. But regardless of how the determinations may be made, the possible presence of the pathogenic bacteria is of more concern to the sanitarian in passing judgment upon the sanitary condition of water than the number of pathogenic bacteria that may be present, is it not?

A. Were it possible to tell actually the number of pathogenic germs in a given water at a specified point, why of course it would be desirable to obtain a knowledge of that number, but it is not possible with any degree of accuracy to uniformly make a determination of the number of typhoid germs in a water at any particular point in routine work, and for that reason they fall back upon something that will be indicative of what
11351 has taken place in the water as the determination of the presence or absence and the approximate number of the bacillus coli communis.

Q. Professor, do you know what was the condition of the Illinois river prior to the opening of the drainage canal? In other words, had you ever observed it personally before that time?

A. Never. I made it but one visit.

Q. The only personal observation that you ever made of that river was in 1903?

A. September, 1903.

Q. Professor, assume that a gallon of infected typhoid dejecta be deposited in the waters of Lake Michigan at a point free from sewage contamination, what would be the character of the bacteria that would first disappear from that water which was formerly contained in the composition just mentioned?

A. How is it to be deposited in the water?

A. Deposited in the lake at a point where it is free from any sewage contamination. In other words, take the pure lake water, as near as you can?

A. Under those circumstances the typhoid bacteria would disappear first.

Q. What is your reason for giving that?

11352 A. Because they would be surrounded by myriads of bacteria, ordinary saprophytic bacteria and those bacteria would set up conditions which would be prejudicial to the life of the typhoid germ. Even though it be deposited in the body of the lake, although the period of longevity I should expect to be increased. Nevertheless the typhoid bacillus would disappear before the lake bacteria would disappear.

Q. Would it disappear before the ordinary sewage saprophytes would disappear?

A. Yes, sir, it would.

Q. Do you know anything about the longevity of the ordinary saprophyte in sewage?

A. I could not tell you.

Q. Does not the life of the ordinary saprophyte depend upon its environment also?

A. . It does.

Q. Is it not a fact that as soon as the object or the purpose of the saprophyte has been served and his usefulness exhasuted that he expires?

A. That is his end.

11353 Q. Now, then, whenever he becomes subject to an environment that is of no service in the purification of that water he has run his course?

A. Yes, sir, unless there be food for him he dies.

Q. Do you know how soon he dies after food is removed from him?

A. I could not tell you; probably shortly.

Q. Is it not a fact that the life of the ordinary saprophyte in a composition undergoing purification is indeed very short, and that their decomposition is brought about by the increased numbers of saprophytes that each respective bacterium creates until their course has become exhausted?

A. As a general statement that is true.

Q. So that in that respect the life of the saprophyte in water differs from the life of the typhoid and other pathogenic bacteria in water?

A. In that respect, yes, because the typhoid is merely a foreigner there who has no purpose to fulfill and he is not doing any work.

Q. What effect has dilution upon bacterial life in water?

A. If you have a certain number of bacteria present, in water, and then should dilute the same you would diminish the number of bacteria there because they would be
11354
further separated. I mean, when I say "diminish the number" that you would diminsh the number per gallon.

Q. What effect would that dilution have upon bacterial longevity?

A. I will have to be a little specific, perhaps. Take, for instance, the typhoid fever germ, the dilution would tend to make his longevity greater because it would diminsh the concentration of his adversaries.

Q. Assume, Professor, that prior to the opening of the drainage canal, during a great portion of the year, the Illinois river was a stagnant or quiescent body of water, that if you would cast a chip or a chunk or a piece of board into the water, it would depend altogether upon the wind as to the direction that that board would travel; that there was a green scummy formation upon the water of that river; that since the opening of the drainage canal the volume and velocity had both been increased, and at no time during the year is the river without a current, and at no time is it subjected to the green scummy formation. Is it not a fact that those conditions which existed prior to the opening of the canal were more conducive to the destruc-

tion of pathogenic bacteria than conditions assumed in
11355 the question existing subsequent to the opening of the canal?

A. The conditions as stated in the question, of practically no current and a green scum before the opening of the canal and a decided current and no scum after the opening of the canal, those conditions being as stated, the two waters before and after the opening of the canal being equally infected, by supposition, the conditions obtaining before the opening of the canal would be more favorable to the destruction of typhoid bacilli than those obtaining after.

Q. Assuming, Professor, that there were typhoid fever germs in the waters of the Illinois prior to the opening of the drainage canal, and that the same population resides upon the watershed of the Illinois river, since the opening of the canal as prior thereto, that practically the same number of typhoid cases which would produce typhoid fever germs and from thence be discharged into the Illinois river subsequent to the opening of the canal that existed prior thereto, is it not a fact that the conditions assumed in the last preceding question are such that are conducive to the longer life of the typhoid bacilli thus discharged into that river than they were prior to the opening of the drainage canal?

11356 MR. TODD: I object to the question as assuming that the conditions of stagnation such as assumed in the previous hypothetical question and made a part of this were conditions that obtained at all times throughout the year upon the Illinois river prior to the opening of the drainage canal for the reason that the evidence in this case discloses a contrary condition to exist and the condition assumed exists only for a short period of time.

A. My opinion is that those conditions would, from a practical standpoint, increase the longevity of the typhoid germ, but I do not believe, and it is my opinion in fact, that such increase would be not material from a practical standpoint.

Q. Professor, assume that the dams in the Illinois river were removed, and that the river, so far as the overflowed ground is concerned, was leveed practically from one end to the other, what effect would the removal of the dams and the leveeing of the land have upon the question of sedimentation as effecting the removal of pathogenic bacteria from the waters of the Illinois river?

MR. TODD: I object to the question for the reason it is not proper cross-examination and for the reason that 11357 the assumption that the river is to be leveed, or that it ever will be leveed is based upon no evidence that has been produced in the record so far as has been or will be produced by complainants and for the additional reason it is based upon an impossible, impracticable assumption that never has and never will exist upon the Illinois river, to-wit: that the river will be leveed from one end to the other, and therefore the question is not competent unless counsel is prepared to state that he will offer evidence that such a condition at some future time will be carried out.

MR. JEFFRIES: In answer to counsel's statement I suggest that it is not necessary to prove what the intention of the people owning the overflowed land on the Illinois river is. It is a known fact of which the court will take judicial knowledge that levees are projected for the protection and preservation of overflowed lands along the river streams, and that in view of this public necessity appeals have been made to national and state legislative authority, coming from various parts of the United States, which appeals have not been disregarded and as population grows and increases in the Illinois river valley 11358 the presumption is that the work of leveeing low lands will be continued as they have been until practically every foot of redeemable soil is preserved.

MR. TODD: I move to exclude the statement made by counsel in his reply to my objection for the reason that there is no evidence in this record that justifies the statement which he has made and this case is being tried upon the records and not upon presumptions, either of law or of fact.

Q. Question repeated.

A. The removal of the dams and the leveeing of the river from one end to the other would interfere with sedimentation and its resulting purification by sedimenting bacteria of the pathogenic type.

Q. What effect would it have upon the velocity of the stream?

A. It would increase the velocity of the stream.

MR. TODD: Objected to for the same reasons given.

Q. Professor, in the tables introduced in evidence by Professor Jordan covering the bacterial count examination of the waters in the Illinois river at Grafton, from October 1, 1901, to December 24, 1901, and on the Mississippi at Grafton from October 21, to December 24, 1901, the maximum bacterial 11359 count in the Illinois river at Grafton was 123,000, the minimum 210, the average bacterial count for the period in the Illinois river at Grafton 6900; in the Mississippi river during the same period the maximum bacterial count was 3700; the minimum 360, the average 1300. Taking into consideration your knowledge of the population upon the watersheds of the respective rivers, which would you consider from this bacterial exhibit the better for sanitary purposes?

A. So far as the total count is concerned it shows the Illinois at Grafton to be inferior to the Mississippi at Grafton. Where those bacteria came from is of course important. Is it true that they represent ordinary soil bacteria washed into the Illinois river because of special conditions in the way of local rainfall, or don't they? I don't know. Right on the face of it, judging merely from the count as it stands, the Illinois is inferior to the Mississippi at those points.

Q. Professor, upon examination of the tables 91 and 141, introduced in evidence by Professor Jordan, for the period November 1 to December 24, 1899, as compared with the period from January 4 to March 7, 1900, the average temperature of the water in 1899 being 7 degrees centigrade and in 1900 8.3 degrees centigrade during that period of 1899 the aver- 11360 age bacterial count was 3190 during the period covered in 1900 the average bacterial count was 32,600. Assuming that these examinations were made from water taken from the same river at the same point, although at the two respective periods, what would you say as to the sanitary condition of that water judged from these bacterial counts, so far as the year 1899 being superior or inferior to that of 1900?

A. I should not wish to compare those at all because my experience is that waters in the late fall and early winter are not comparable in the matter of counts with waters in the early spring. You would have a tremendous amount of washing of surface bacteria into the stream in a period of thaw, so I would not wish to compare those waters at all.

Q. Professor, is it not a fact from the tables of analysis as shown in the book known as Streams Examinations, all of which have been introduced in evidence in this case, that since the opening of the drainage canal there has been a reduction of the constituent known as chlorine to a larger and greater extent comparatively speaking than other chemical constituents of the water in the Illinois river at all points where examinations were made, thus showing the diluting effects of the water of the Lake Michigan passing through the drainage canal
11361 upon the chlorine and the effect of the preservation of other chemical constituents that might be contained in that water and is it not a fact that these data also show a preservation of the bacterial counts on the numbers of bacteria that are contained in the water?

A. It is a fact that chlorine has been reduced all along the line by the opening of the canal, but it is also a fact that albuminoid and free ammonia have been reduced as well. Nitrates towards the end of the canal have been increased.

I have made no estimate which would enable me to say whether or not the chlorine has been reduced in the same proportion that the other items have been reduced, such as ammonia, free and albuminoid. All that I can tell you is that they have been reduced, but their relative rates of reduction I can not tell you.

Q. Professor, I show you a copy of table E, which is a copy of a table introduced in evidence by Professor Edwin O. Jordan, entitled "Streams Examination, Sanitary District of Chicago. Sanitary Water Analysis. Parts per million. Comparative averages 1899 and 1900."
11362 Now, based upon your answer to the second preceding question, I will ask you if the chemical and bacterial data disclosed by this table comparatively speaking, for the period from April to December, 1899, and from January to April, 1900, on account of being at different times of the year are comparable with each other?

A. I think that they are not, and for the reason I think so let me take as an illustration, the Illinois river at Grafton. The Illinois river at Grafton in 1899, the results from May to

December—the Illinois river at Grafton in 1900, the results are from January to June, namely the other half of the year. I do not feel that it is wise to compare waters of the same stream at such widely different periods of the year because in one instance you get the benefit of the spring changes and in the other case you get whatever influences may come from the changes of the summer and autumn.

Q. And what is true with reference to table E is also true with all other tables of a like character?

A. When the waters compared have been sampled and analyzed during periods of the year which are not similar.

Adjourned until 2:00 p. m., of same day.

11363 2:00 p. m., Monday, March 7, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. W. P. MASON

resumed the stand for further cross-examination, by Mr. Jeffries, and testified as follows:

Q. Professor, in undertaking to analyze the relationship existing between the typhoid fever mortality in the City of St. Louis with that of Chicago is it not a fact that the physical conditions of the Illinois river, together with the temperature of the water, have some effect upon this relationship—that the variable physical conditions of the Illinois river?

A. No. When I undertook to analyze the typhoid conditions in those two cities I stated them simply as facts and those facts stand out without any question whatever as to what happened to be between the towns. Were there no Illinois river
in existence the facts would stand that the deaths in Chi-
11364 cago were such and such, and the deaths in St. Louis
were such and such, and the charts show the relative tracings.

Q. And those charts are made without regard to the changes in the bacterial and chemical condition of the Illinois river at various times?

A. Surely. Those charts are simply from the reported figures from official sources. In other words, those charts could be made by a man who did not know whether there was any water between Chicago and St. Louis.

Q. In other words, those charts are made as though one city was situated upon the Pacific Coast and the other upon the Atlantic?

A. Certainly. Anybody could have made those. What is between the cities would have no influence upon the way that the man in question drew those charts from the figures given. The charts would appear as they are.

Q. But what is between those cities might have some effect upon actual typhoid conditions?

A. The deaths in St. Louis might be attributable to something existing between those cities. Such does not appear as a fact upon the chart.

Q. In other words, all the factors which materially enter into the longevity of a typhoid germ in passing down stream between two given points is not displayed in those charts?

A. Nothing is displayed in those charts but the number of deaths in those two cities.

11365 Q. Now, in those charts you have removed St. Louis one month in advance of Chicago, have you not?

A. I have.

Q. For what purpose was that done, Professor?

A. Because the deaths of Chicago, due to typhoid fever in one month, if they be related to deaths from typhoid fever in St. Louis, such relation will show in the death rate of St. Louis for the following month. Therefore, I moved the death rate of St. Louis one point to the left merely for the sake of easy comparison. I might have left them where they naturally would fall. Under those circumstances, however, a man in examining the charts would have some little trouble in following the oblique lines, and direct comparison would not be so easy.

Q. Suppose that the period of incubation be two weeks and the duration of illness three weeks, on an average, without counting the time of stream flow, would those charts correctly represent the conditions which they are intended to display?

A. If I were obliged to account for an interval of five weeks it would be necessary to shove those St. Louis records

11366 slightly to the left beyond the point where they were pushed.

Q. And assuming that the stream flow time of the Illinois river was from 10 to 20 days, and on an average of 14 or 15 days, it would be necessary to shove St. Louis still further to the left?

A. Yes, sir; so that it would be shoved perhaps a month and a half all together instead of one month, a difference of perhaps two weeks.

Q. Professor, referring to the chart which you introduced in evidence showing the comparative results of the colon test as made by Professor Jordan for 1901, I call your attention to the Illinois river at Grafton, wherein it was disclosed that 7 per cent. of the determinations made produced positive results of colon when .001 cc. of water was used, and basing that determination, to be accurate mathematically speaking, is it not a fact that if 1 cc. had been used in those determinations that it would have been found in more than 85 per cent. of the examinations?

A. No, sir. I do not think that it is an easy matter to compare .001 determination with 1 cc. determination, because the opportunity for error is quite considerable in so
11367 small a volume of water as that. I attach more value to where the larger quantity of water is used.

Q. Does that chart represent the colon condition of the waters in the respective rivers to a mathematical certainty?

A. Assuming that by mathematical certainty you mean, is it thinkable that in some instances the coli were present, sought for and not found, I should say that it does not represent the results to a mathematical certainty. Such determinations can never be upon a mathematical certainty basis.

Q. Is it not a fact that on that chart, taking the 1 cc. determination, that the water in the Illinois river at Grafton shows a greater pollution than the water in the Mississippi river at St. Louis, the Missouri river at Bellefontaine and the Mississippi river at Grafton?

A. That is true.

Q. Is it not a fact, Professor, that some of these percentages are the result of a less number of determinations than others?

A. That is true.

Q. And that such an extent differs the results does it not, the result of the percentages?

11368 A. Of course the larger the number of determinations
that we get the more accurately can our percentage be stated.

Q. Professor, assume that the average flow of the Illinois River for 1900 at Averyville, or at a point above Peoria known as the bridge, was 2874 cubic feet per second or 248,313,600 cubic feet per day, which equals to 10,249,408,000,000 cc. per day, and in this number of cc. 7,375,573,760,000 contain the bacilli coli communis, representing 72 per cent., as shown upon the chart prepared by you from Professor Jordan's determinations, and that the flow from Bear Trap Dam to Averyville is from 4 days and 8 hours to 6 days and 3 hours, and that the sewage of 1,600,000 people in the sanitary district of Chicago was discharged into the Chicago River and the drainage canal, state whether or not in your opinion any of the bacilli coli communis so existing in the waters of the Illinois River at Peoria originated from the sewers of the city of Chicago; assuming further that the sewage discharges from the city of Joliet, Marseilles, Ottawa, Morris, and Peru are discharging directly into the Desplaines and the Illinois Rivers, and taking into consideration also that the Desplaines River
11369 enters this stream at the city of Joliet?

Mr. Todd: I object to the question for the reason that it is not assumed that the Fox River and the Kankakee River and the Vermillion Rivers upon which are situated large towns also empty into the Illinois River between Lockport and Peoria, and no assumption is made as to the rural water sheds of these rivers draining the rural districts mentioned.

A. In my opinion some of those do come from the Chicago drainage canal. How many I do not know.

Q. In your publications you have used both the percentage of mortality system and the numbers per 100,000 in determining the typhoid and other death rates in cities, have you not?

A. When I have quoted from a man who used percentage methods I have given it as he stated it. I have not used that method myself.

Q. Now is it not a fact that if population runs regularly and no epidemic of any character be prevalent that there is very little difference in the two systems so far as applied to a particular city?

11370 A. Assuming nothing unusual in the death rate, why there would be no particular difference between the two methods, but it would be possible to have very misleading results. For that reason I do not use it. I am speaking now of the mortality percentage.

Q. Assuming, Professor, that the population in the city of St. Louis increased from 1890 to 1900 at a rate less than 3 per cent. per annum, would it not be from that standpoint as inaccurate to use the Farr formula as to use the actual population?

A. I am not familiar enough with the use of that formula to answer your question.

Q. Assume, Professor, that the total deaths from all causes in the city of St. Louis from 1890 to 1903, inclusive, are as follows:

1890	8409
1891	9530
1892	10225
1893	10303
1894	8710
1895	9425
1896	9897

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1897	9554
1898	8908
1899	10023
1900	9847
1901	10601
1902	10348
1903	11138.

That the population of the city of St. Louis for the year 1890, as shown by the census report was 460,000 and that the population for the year 1900, as shown by the census report is 575,200, and assuming that the difference between census report of 1900 and 1890 be divided equally among the various years intervening between those periods which resulted in an

increase in the yearly population between said census taking of 11,520 per year, and that since the census of 1900 that 11,520 be added to the respective years, to wit: 1901, 1902 and 1903, would that showing in your opinion produce any great difference between the two formulas or systems used, to-wit: the percentage of deaths to the total mortality or the number of deaths from typhoid fever per 100,000 population, and
11372 assuming that from the year 1890 to the year 1902, inclusive, are as follows:

1890	227
1891	166
1892	488
1893	215
1894	178
1895	106
1896	106
1897	125
1898	95
1899	130
1900	168
1901	198
1902	222

A. Basing my reply on the numerical data submitted in the question, it is my opinion that there is no material difference between the two methods of stating the result.

Q. Professor, is it not a fact that of the longevity of the
11373 typhoid fever germ, as well as other pathogenic bacteria, in all the various conditions in nature in which it may be found or may exist, taking into consideration climatic influences and all of the elements which affect the vitality of those organisms, scientists have been unable thus far to formulate any rule or formula by which the longevity of the germs may be measured within certain accurately defined limits?

Scientists have thus far been able to determine the longevity of pathogenic germs only within roughly accurate limits.

WILLIAM P. MASON.

ADJOURNED UNTIL 10:00 A. M., TUESDAY, MARCH 8, 1904.

11374 10:00 A. M., Tuesday, March 8, 1904. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

No witnesses being present an adjournment was taken to 10:00 A. M., Wednesday, March 9, 1904.

11375 10:00 A. M., Wednesday, March 9, 1904. Continuation pursuant to adjournment. Present the commissioner and same counsel representing the respective parties.

No witnesses being present an adjournment was taken to 10:00 A. M., Thursday, March 10, 1904.

11376 10:00 A. M., Thursday, March 10, 1904. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

RUDOLPH HERING,

a witness called on behalf of the defendants, after being duly sworn by the Commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. Rudolph Hering.

Q. What is your business?

A. Hydraulic and Sanitary Engineer.

Q. Where is your place of business?

A. New York City.

Q. Under what name are you doing business in New York City?

A. As Hydraulic and Sanitary Engineer.

Q. I mean under what business name?

11377 A. The firm is Rudolph Hering and George W. Fuller.

Q. Composed of yourself and Mr. George W. Fuller who testified in this case?

A. Yes sir.

Q. Are you a graduate of any educational institution? If so, please state which one?

A. I took the course in civil engineering at Dresden, Germany.

Q. When was that—what year?

A. In 1867.

Q. After taking that course what did you do next?

A. I came home and started my engineering work in Brooklyn on Prospect Park and then went to Philadelphia on Fairmount Park and in 1872 was employed on the Geological Survey of the United States Government, making the first survey of the Yellow Stone National Park and in 1873 went back to Philadelphia where I was first assistant Engineer in the Department in charge of bridges and sewers until 1880. In 1880
I went to Europe, commissioned by the National Board of
11378 Health, at Washington, to make an examination of and
to report on European sewerage systems. I spent almost a year on that work, largely on my own account, studying also questions of water supply and other municipal problems.

Q. What cities in Europe did you visit on this occasion, studying the disposal of sewage?

A. All of the large cities of England, France, Germany and Austria.

Q. Did you make a report to the National Board of Health as a result of that visit?

A. I did.

Q. Was that report published?

A. It was in the Annual Report of the Board for the year 1881.

Q. How extensive was that report?

A. It went over the subject of sewerage very fully and answered the question which was one uppermost in the public mind at that time, as to the relative advantages of the separate system of sewerage and combined system of sewerage.

It gave a large amount of statistics from all of those cities, and also maps showing the methods of sewerage and drain-
11379 age practiced there.

Q. After you had completed that work what did you do?

A. I then acted as engineer for a number of cities in an advising capacity or as designer or constructor of works.

Q. What cities?

A. From 1883 to the spring of 1886, I was engaged by the city of Philadelphia to make investigations for a new water supply for that city, and incidentally also for a number of other smaller cities.

In 1882 I was engaged by the city of Cleveland to make a plan of sewerage for the interception of the sewage and cleansing the Cuyahoga River.

After the Philadelphia work was completed, the Mayor of Chicago, Carter H. Harrison, employed me to come here as Chief Engineer of the drainage and water supply Commission and I stayed here about two years.

Then I was appointed Consulting Engineer for the Sewerage works of New York City, by the Commissioner of Public Works and stayed there two years, and since that time I have been engaged by a very large number of cities in the United States and Canada, and also outside, in making plans
11380 and designs for sewerage and water supply works.

Q. What engineering works in this country have you been connected with that dealt with water supply and sewerage disposal of cities in the last ten years?

A. In Philadelphia I was on the Commission to report on a new water supply and recommended filtration of the water, which is now being carried out.

Q. Who made the plans and specifications for the filtration of the waters at Philadelphia—under whose direction?

A. Our commission made the general plans and the detail plans and specifications were carried out by Mr. John W. Hill, who is now the chief engineer of the Filtration Bureau.

I then made a report for the city of Baltimore, also on a commission for the sewerage of that city.

I also made a report, at the request of President Harrison, as Chairman of a Commission to devise a system of sewerage and drainage for the city of Washington, which is being carried out.

I have also been connected with the city of New Orleans for ten years on their works, for a sewerage, drainage and water supply.

11381 Q. Is that New Orleans work being carried out?

A. The works are under construction now.

Q. Are you acting now in any capacity?

A. Yes sir, as consulting engineer.

I was also consulting engineer for the city of San Francisco on their sewerage system, the plans for which were adopted.

I have also been consulted in other cities making a report quite recently on the water supply of Pittsburg, Pennsylvania, together with Col. A. M. Miller, U. S. A., and Mr. John W. Hill, Philadelphia.

I have also made reports on sewerage and water supply works for four or five cities in Canada, St. John, Toronto, Winnipeg and Victoria, and also for Honolulu, Hawaiian Islands, and for Santos, Brazil.

Q. Have you made a specialty of sanitary engineering?

A. I have.

Q. What does the term hydraulic and sanitary engineer embrace in its scope of work?

A. The branch of hydraulic engineering which I have 11382 paid special attention to is the water supply of cities and regulation of small water courses. The branch of sanitary engineering which I have practiced pertains to the collection, removal and disposal of sewage and also garbage of cities.

Q. In passing upon the quality of a water supply for a city, what elements do you take into consideration in arriving at a conclusion, as to whether the water supply is safe or unsafe, proper or improper for domestic and drinking purposes?

A. I take into consideration the quality of the water as judged from the character of the water shed from which the water is derived, from its chemical analysis and bacterial analysis.

Q. Are you a chemist or bacteriologist?

A. I am neither.

Q. How do you utilize chemistry and bacteriologly in your special work?

A. I endeavor to keep posted on the progress made in both sciences so far as they relate to the sanitary condition of the water, and then I take the results obtained by those men in whom I have every confidence and whose ability is unquestioned, and use them in my practice and suggestions for water supply and sewerage works.

11383 Q. When was it that your attention was first called to the sanitary problems of Chicago?

A. In March, 1886, when I received a telegram from the Mayor of Chicago to make him a visit and spend a day here so that he could talk with me.

Q. That was Carter H. Harrison, the First?

A. Yes sir.

Q. Pursuant to that telegram received from Carter H. Harrison, Mayor of Chicago, what did you do, Mr. Hering?

A. I came here and spent a day and returned home.

Q. Then what was the next step?

A. I was engaged as Chief Engineer of the Drainage and Water Supply Commission, and asked to come at my earliest convenience. I was then engaged on the Philadelphia work which was not quite finished, but I see that I entered upon duty on March 28th of that month.

Q. March 28th, what year?

A. 1886.

Q. What did you do after your appointment as Chief Engineer to look into the sanitary problems of Chicago?

11384 A. I made whatever investigations I thought were necessary to answer the resolutions passed by the Mayor and the City Council of the city with reference to obtaining "pure water and scientific drainage."

Q. After your observations were completed did you make any report to the Mayor and the City Council of the city of Chicago as to the conclusions which you arrived at in regard to the sanitary problem of Chicago?

A. I did. In January, 1887, I made a preliminary report, giving the general conclusions which had been reached up to that time.

Q. Will you read that part of the preliminary report prepared by you, which applies to the sanitary problems of Chicago, which you had under consideration?

Mr. Jeffries: I object to it because it is incompetent and irrelevant and immaterial.

A. Witness reads report as follows:

11385 "Chicago, January, 1887.

TO THE HONORABLE MAYOR AND CITY COUNCIL OF THE CITY OF CHICAGO.

Gentlemen: On Jan. 27, 1886, your honorable body passed a resolution authorizing the creation of a drainage and water-supply commission. After being amended Feb. 23, it read as follows:

WHEREAS, Pure water and scientific drainage are necessities of this community, and the people demand a system of water supply and drainage adequate to meet the requirements, not only of the present, but of years to come, nor will any temporary expedient or makeshift satisfy them; and

WHEREAS, A thorough and permanent system of supplying pure water to our citizens and caring for the drainage of the municipality can not be paid for out of current taxation, therefore it is desired that a plan shall be devised and perfected before the next meeting of the legislature, to the end that necessary legislation may be had.

For the purpose of carrying into effect the objects sought, there is recommended the appointment by the mayor of a commission to consist of one expert engineer, whose reputa-
11386 tion is so high that his opinion and report will command
the respect of the community, and with him one or two consulting engineers of like experience in engineering and sanitary matters. The duty of this drainage and water-supply commission, made up as above set forth, should be to consider all plans relating to drainage and water-supply which may be brought to its attention; to make such examinations and investigations and surveys as may be deemed necessary; to collect all information bearing on this problem; to consider all recent developments in the matter of sewage disposal, and their application to our present and future needs; to consider and meet necessity of increasing our water-supply and of protecting the same from contamination; to remedy our present inadequate methods of drainage and sewage disposal; to consider the relations of any system proposed to adjacent districts, and whether there may not be a union between the city and its suburbs to solve the great problem, to determine the great question as to the interest which the state and the United States may have in the

disposal of sewage by way of the Illinois River, and to devise plans to meet any objections thereto, if such system shall be thought best; and in general to consider and report
11387 upon any and all things which relate to the matter of water-supply and drainage of the City of Chicago.

The Commission should report on the whole matter committed to it in the most full and comprehensive manner, with maps, plans, and diagrams complete, and accompany the report with estimates of the first cost and annual requirements for the maintenance of the system proposed.

The report of the commission should be made as early as practicable, and not later than the convening of the next session of the Illinois Legislature in January, 1887.

In consideration of the foregoing, be it

RESOLVED, That the mayor be, and is hereby authorized and directed to employ on behalf of the city one expert engineer of reputation and experience in engineering and sanitary matters, at a salary not to exceed $10,000 per annum, and also to employ such consulting engineers, not exceeding two in number, as may seem necessary, and such assistant engineers as may be required, all to be paid according to services rendered, for the purpose of carrying out the objects set forth
11388 in the preamble hereto. For the fees of said assistant engineers and for all expenses connected with said work there shall be allowed not to exceed the sum of $20,000. All fees, salaries and expenses connected with said work shall not exceed in the aggregate the sum of $30,000, and the same shall be paid from the water fund of the city upon vouchers audited by the mayor and city comptroller.

In accordance with the terms expressed herein His Honor Carter H. Harrison appointed Rudolph Hering as chief engineer, Benezette Williams and S. G. Artingstall as consulting engineers, who, together, should constitute a commission. Mr. Hering entered upon duty March 28, Mr. Williams Sept. 17, and Mr. Artingstall, Dec. 21, 1886.

But the large amount of work alone that was asked for made it impracticable to present a complete report in so short a time. It was expected, however, that results could be reached sufficient to indicate the character of legislation required to carry out any project that might be determined upon, and that

therefore a preliminary report having this end in view could be made at the stated time, leaving to a later date the presentation of a report outlining the detailed features of the
11389 scheme recommended and embracing the minor results of the entire inquiry.

The present communication is to cover the ground indicated for the preliminary report, and besides containing the conclusions reached regarding the main features of the proposed project, it contains also a brief review of the work done during the past year and of what still remains to be done.

The month of April was devoted to a general examination of the subject, of the territory to be investigated, and of the various suggestions that had been made toward effecting a solution of the problem.

The examination disclosed the fact that the city is sometimes greatly suffering from the offensive condition of parts of the Chicago river and its branches, caused by the discharge of sewage into the same, and from the occasional contamination of its water-supply, brought about by the discharge of the polluted contents of the river into the lake. It also disclosed the fact that almost every conceivable way of dealing with these questions had been suggested and in some forms applied during the past thirty years.

The problem therefore demands the attainments of two
11390 ends: the protection of the water-supply and the removal of the river nuisance. As the water must be taken from the lake, it is evident that both its pollution and the objectionable condition of the rivers should be prevented by a better disposition of the sewage. It is therefore the latter question which constitutes the main object of this investigation.

Among the possible methods of getting rid of the Chicago sewage there are but three that have been deemed worthy of an extended consideration, namely, a discharge into Lake Michigan, a disposal upon land, and a discharge into the Desplaines river. The preliminary work has therefore been confined to these three projects, and was classed as topographic, hydrographic, and miscellaneous.

To discharge the sewage from cities into comparatively large bodies of water is not only the usual, but often the best

method for its disposal. Dilution and dispersion thoroughly expose it to the action of the oxygen contained in both the water and the superincumbent air, and it is thereby gradually oxidized. Where the body of water is a large river with a strong current, the best conditions for such purification are found. Where it is a lake in which the circulation is slight and
11391 irregular, the efficiency of the method is less and depends for its success on the character of the currents, and the relative amount of sewage to be discharged into it.

The hydrographic surveys of the lake made during the past season were therefore partly for the purpose of ascertaining, if possible, the laws governing the currents, so that we would know their effect in dispersing the sewage discharged into the lake.

The following results have a bearing on the question of sewage disposal. Where not effected by local conditions the currents practically go with the winds in water of moderate depth, and quickly responded to any change. In deep water also the surface currents run with the wind, but at the bottom and even at mid-depth the direction is usually different. The prevailing current along the shore of Cook county during the past summer has been observed to be toward the north, but it is possible that this result may be different during the winter months. In the open lake wave action seems to be effective in preventing the permanent deposits down to a depth of about sixty feet; inside of the breakwater sewage deposits are found on the bottom.

11392 The general deduction from these results is clear that, as no constant current exists which would carry the sewage away in one direction, it should be discharged into the lake at one end of the future city, while the water-supply should be obtained as far away from it as practicable toward the other end, a conclusion which is being acted upon in the other large lake cities. The proper place from which to bring the water would be opposite Grosse Point, and the sewage discharge should be east of Hyde Park. While it might be practicable to allow the sewage in its crude form to enter the lake under such conditions for many years, the necessity would arise later for clarifying it at least partially previous to its discharge. It could not be allowed to run into the rivers as at present, but the dry weather flow and a considerable amount of storm-water would have to be intercepted and carried to the outfall through many miles of special conduits. And this entire quantity would have to be raised by pumping in order to get sufficient head to empty into the lake, while the diluted sewage during storms, in excess of the capacity of the intercepting sewers, would be allowed to discharge directly into the river.

11393 The water supply would have to be brought from Grosse Point in large conduits to the several pumping stations scattered over the city and its present suburbs. The circulation of the water in the Chicago river and branches would have to be maintained practically as it is at present, because the removal merely of the dry weather flow of sewage would not altogether prevent its pollution.

We shall not at this time enter into a discussion of the principles underlying land purification of sewage or make historical references showing the success or ill-success of the method as practiced elsewhere. We will simply state that with good management under ordinarily favorable conditions, a disposal on land proves satisfactory, so far as the purification of the sewage is concerned, and that with proper conditions in the way of good markets and a favorable soil and climate, sewage farms can be operated on a large scale after the sewage is delivered upon the same, without financial loss.

In speaking of a sewage farm of the magnitude required for the metropolitan area of Chicago, it is not understood as being land devoted primarily to the raising of crops, using the sewage only when and where it would most promote
11394 the growth of vegetation. The primary object would be the purification of the sewage on an area of land as small as could serve the purpose. Technically speaking, the sewage disposal would be by means of intermittent filtration rather than irrigation. To carry out such a scheme for Chicago involves the following:

1. The acquirement of sufficient land suitable for the purpose.

2. A comprehensive system of intercepting and collecting sewers carrying the sewage to the farm.

3. Pumping-works of a capacity to handle all the dry-weather flow of sewage and a certain proportion of storm-water.

4. A thorough underdrainage, leveling, and preparing of beds for the filtration areas.

5. A system of underground conduits and surface carriers for distributing the sewage over the ground, and a system of open ditches for removing the purified water to the nearest water-courses.

6. Buildings, roads, and a complete farming outfit.

7. An organization for properly distributing the sew-
11395 age, for carrying on the farming operations, and for conducting the business of disposing of the crops in the best market.

In making estimates for the size of intercepting sewers, conduits, pumps, and area of land required, we have used as a basis a population of 2,500,000 people, with an average dry-weather sewage discharge of 150 gallons, or 20 cubic feet, per head daily, and made provision for storm-water equivalent to one-fifth of an inch in 24 hours over all portions of the district now drained, or likely to be drained, by a combined system of sewers, allowing surplus-water to escape into the rivers and lakes.

The dry weather flow of sewage would therefore be 50,000,000 cubic feet per day, and the maximum flow of storm-water. 65,000,000 cubic feet per day, making a total maximum discharge of 115,000,000 cubic feet.

It is practicable, however, to exclude the storm-water from the sewers over a large portion of the future city by adopting the separate system of sewerage. The area north of the town of Jefferson and of the middle of Lake View may be treated to advantage in this way, and also a large portion of Hyde
11396 Park, Lake, Calumet, and other adjoining towns.

Assuming that the area which does not allow the storm-water to be entirely excluded is 140 square miles, the average daily amount becomes 10,000,000 cubic feet, which gives, when added to the sewage, 60,000,000 cubic feet, or 24 cubic feet per head of population per day to be provided for on the farm.

As the amount of land required to purify sewage can only be determined by experience, and as this has been very limited in our own country, we are forced to rely mainly upon that of Europe. Without going into details at present, we will simply state that a fair concensus of this experience justifies us in the conclusions that from 10,000 to 15,000 acres of land would be required to dispose of the sewage from the entire metropolitan area.

The only available territory for sewage filtration in the neighborhood of Chicago consists of two sandy ridges in the town of Thornton, extending across the state line into Indiana, and in a sandy ridge crossing the town of Niles. The soil is quite favorable, but the character of the surface is such that the necessary preparation to make it suitable for filtration beds would be comparatively expensive. An enormous cost, is, however, represented by the fact that the sewage would have to be collected by large intercepting sewers, lifted altogether some ninety feet, and carried about twenty miles before reaching the farms. 11397

A third solution of the drainage problem is rendered practicable by the fact that the divide between Lake Michigan and the Mississippi valley lies about ten miles west of Chicago, with so slight an elevation that it is not a difficult matter to carry the sewage from the city westward into the Desplaines river, and thence into the Mississippi river. This method of disposal, as previously explained, is in fact mainly the present one, most of the sewage now being carried across the divide by the Illinois and Michigan canal.

There are two low depressions between the future metropolis and the Desplaines river—the Mud lake valley with the present canal, and the Sag valley west of Lake Calumet. Neither is more than ten feet above the lake, nor do they present any engineering difficulties for canal construction. It is therefore quite feasible to carry all the drainage from the territory ultimately to be occupied by the metropolis, extending from Lake Calumet to Evanston, into the Mississippi valley through these depressions, avoiding thereby all possible lake pollution and permitting the supply of water to be drawn from any number of convenient points in front of the city. 11398

The possibility of this solution was recognized as early as 1856 by Mr. E. S. Chesbrough, and the first step toward its adoption was taken, as already mentioned, by turning the sewage into the Illinois and Michigan Canal. Not until quite recently, however, has it become practicable to consider the construction of a special waterway for sewage removal, because when the pollution was smaller the expense of the undertaking was too great.

The sanitary requirements demand a flow of water large
enough to dilute the sewage sufficiently to make it inoffensive
along the river at all times. Beyond this, any increase in the
size of the channel to provide for the storm-water which naturally
enters it should be kept at a minimum. A glance at the map and
an examination of the ground show the possibility of
11399 diverting the greater part of the storm-water from the
metropolitan district without serious difficulty. Both
branches of the Calumet river can be diverted west of the Indiana state line into Wolf Lake, and thence into Lake Michigan. The Desplaines river can have its flood waters diverted into the North branch near the north line of the town of Jefferson, and the combined waters can be led from Bowmanville directly into the lake.

A second branch of the investigation extends to the elements governing the proper size of the waterway from which a large proportion of the storm-water has been excluded. The area still draining into it will consist largely of paved streets and roofs, allowing of no absorption, and shedding the water rapidly. It requires a careful consideration to determine the maximum quantity of water that may enter the proposed channel, and for which an ample allowance must be made to prevent a back flow of the polluted water to the lake.

The proper degree of sewage dilution in the new channel
demanded a careful investigation. When sewage is
11400 mingled with a sufficiently large quantity of water it not
only becomes inoffensive but readily finds the oxygen
which gradually purifies it. When the surface is covered with ice a greater dilution is necessary for this purpose than at other times when there is a constant replenishment of oxygen from the air. The proposed waterway should of course provide immunity from offense at all times.

The information upon which definitely to decide this question will be given in the final report, as the data have not yet been all collected, owing to the necessity of making actual tests of the oxidation of the canal water under the ice, which is being done for the use of the commission by Dr. J. H. Rauch, Secretary of the State Board of Health. The summer conditions are presented in his late report on the Water-supply and Sewage Disposal of Chicago. The result of these analysis will be compared with those of other streams that are also polluted with sewage in order to show the rate of oxidation with varying degrees of dilution and aeration.

For the purpose of estimating the cost of the water channel we have assumed 3,600 square feet for the cross section and a velocity of the water 3 feet per second, or 2 miles per hour.
11401 This gives a discharge of 600,000 cubic feet of water per minute, or 24,000 cubic feet for each 100,000 persons, which we believe equal to the maximum requirements of a population of 2,500,000 people.

A third branch of the inquiry covers the selection of routes for the proposed canals.

A fourth branch of the inquiry relates to the study of such data as have reference to securing a proper circulation for the waterways within the city.

In the foregoing we have outlined the main features of the only three feasible methods of disposing of the metropolitan sewage, and have given the results of the investigation reached to date. A general conclusion as to the preferable method may be given at present, and also an approximate estimate of cost. But we are not able as yet to give either conclusions or detailed statements of the probable expense regarding all parts of the proposed work, and must defer them until the final report.
11402 In comparing the projects we will first mention their probable cost and then their relative advantages.

The discharge of the sewage into the lake from a population of 2,500,000 in the manner described above, including the extra expense, otherwise not necessary, of taking the water supply at Gross Point, would cost at least $37,000,000, with an annual expense for interest and operation of at least $2,400,000. It would require an immediate investment of about $20,000,000.

To dispose of the entire metropolitan sewage by filtration on land would require an investment of about $58,000,000, with an annual expense of over $3,000,000, for interest, pumping and maintenance, after deducting the profit from the sale of crops. It would be necessary to invest at once about $34,000,000. Land disposal for the sewage from the Calumet region alone, with a future population of 300,000, would require an investment of about $4,000,000, and an annual expense of at least $250,000.

11403 Finally, the cost of the Desplaines project is approximately estimated as follows:

1. A channel from the South fork to Joliet of the capacity heretofore given, will cost between $17,000,000 and $21,000,000.

2. A diversion of the flood waters of the Desplaines, the North Branch, and Salt Creek will cost between $2,500,000 and $2,800,000.

3. Pumping works and locks for the North branch will cost about $150,000.

4. A separate system of sewers to collect the sewage now discharged directly into the lake, and to carry it into the river will cost about $600,000.

5. A channel from Lake Calumet to Sag will cost between $2,500,000 and $3,000,000.

6. A diversion of the flood waters of the Calumet river will cost between $350,000 and $400,000.

The total cost of the Desplaines drainage project would therefore be for the main district between $20,250,000 and $24,550,000; for the Calumet district, between $2,850,000 and $3,400,000. The annual cost, including interest, etc., is
11404 estimated at about $1,300,000 per annum.

It therefore appears that this project is decidedly the least expensive one for the present as well as for the future.

Besides the economical advantage of the Desplaines scheme, its superiority is still further emphasized by advantages of another kind. The proposed canal will, from its necessary dimensions and its regular discharge, produce a magnificent waterway between Chicago and the Mississippi river, suitable for the navigation of boats, having as much as 2,000 tons burden. It will establish an available water-power between Lockport and

Marseilles fully twice as large as that of the Mississippi river at Minneapolis, which will be of great commercial value to the state. The Calumet region will be much enhanced in value by having a direct navigable channel to the Desplaines river, and by a lowering of the flood heights of Calumet lake and river. Within the City the water of the Chicago river and its South branch will get a much better circulation if it flows by gravity than if it has to be pumped, the necessity for which could
11405 remain even if the sewage should be discharged through intercepting sewers either into the lake or upon the land. Under either of the latter conditions an occasional overflow from the sewers into the river during heavy rains would be more objectionable than a constant discharge of sewage into a more rapidly flowing stream. Flood-waters entering the lake by way of the Chicago river would carry into it much filthy matter, either suspended or deposited, notwithstanding the existence of intercepting sewers; but the proposed diversion of such waters before reaching the populated districts will for all time obviate this undesirable occurrence. Lowering the level of the North Branch at Bowmansville by its diversion to the lake will be equivalent to raising the low prairie extending toward Evanston and Niles and greatly benefit parts of these towns.

Respectfully submitted,

(Signed) Rudolph Hering, Chief Engineer.
Benezette Williams,
Samuel G. Artingstall,
Consulting Engineers."

11406 Q. After the report was filed which you have just read, what did you do in connection with this problem?

A. A subsequent report was made in detail covering the proposition to divert water from the north branch near Bowmansville, which is the same as the Lawrence Avenue project. This, I believe, was not printed.

The final report which required the appropriation of some $15,000.00 in addition to the money that had been spent was never made because it was stated that if the preliminary report contained our conclusions and the final report was merely to give the information which lead up to these conclusions, such information could be subsequently published from appropriations made for the proposed sanitary district, and the work was then dropped.

Q. Subsequent to the preliminary report the legislature of the State in 1889 passed a law for the construction of the Sanitary Districts in Illinois did they not?

A. They did.

Q. Since the passage of the sanitary district act in 1889 have you kept in touch with the progress of the drainage
11407 canal and its construction as originally outlined by you in your preliminary report to the elder Carter H. Harrison?

A. In a general way I have. My first visit to the territory after I left Chicago, was during the World's Fair. I have since visited the drainage works on several occasions.

Q. Have you seen the work known as the drainage canal since its completion?

A. I have.

Q. Will you state briefly what were the facts upon which you based your conclusions as found in the preliminary report as already read in evidence, that the drainage canal was the proper solution of the sanitary problem in Chicago?

A. The proposition was a somewhat novel one, and in order to get a safe conclusion regarding the size and other conditions necessary for the proposed drainage canal I was obliged to study into all facts which would point to the best conclusions. Such facts were to be found in Europe and in America. There had been a number of cases of sewage discharged into water courses carefully observed in Europe and in the East as well as at Chicago. This information was carefully collected, weighed and laid the foundation for the recommendation which fixed the size of the proposed channel.

11408 I found that the problem of water pollution and of setting up a standard of purity of the minimum allowable proportion of sewage, or perhaps the necessity of its entire exclusion, required a distinction to be drawn at the outset. If the water is to be used for potable purposes it should evidently be considered in a different light than if a mere inoffensiveness is required.

In view of the absence of such information as we have today, the engineer was confronted with great difficulties for the want of reliable evidence regarding the real danger from pollution. In many cases there was the question whether he should recommend a palatable water, and by far the most economical source of supply, when some hundreds of miles above another community discharged sewage into it. The question was whether he should be governed by the degree of dilution and by the number of days or weeks since the polluted water had a chance to convert the sewage into inorganic and harmless compounds.

The question was different then from what it is now, and
it was necessary to be very careful in the recommendation
11409 of the investment of so large a sum of money as the solution of the Chicago problem involved.

The best information which was available for the purpose, and the most direct, was the observation of Dr. John Rauch, Secretary of the State Board of Health of the State of Illinois, who had been making very careful investigations on the gradual change in the water of the Illinois and Michigan Canal after the water had entered the Illinois River. He fixed a unit of measure which, from a sanitary point of view, he considered sufficient to obviate any substantial injury to the State of Illinois on below. This measure was a flow of water equal to 180 cubic feet per minute for every thousand persons draining in the river at Chicago.

Examinations which I made with reference to the Blackstone River in Massachusetts, which is quite foul at its upper end, and receives much additional sewage on its way, resulted in my conclusion that after a flow of about 140 cubic feet per thousand persons was observed in the river, the character of the water had become entirely inoffensive.

11410 Similar investigations were made from the results obtained in the river Seine, receiving the sewage of Paris, France. The sewage there does not include fecal matter, because this is otherwise removed. It was found on the Seine that where the dilution was 60 cubic feet per thousand people, and after a flow of 14 miles the river was considered unobjectionable to sight or smell.

Also some German Rivers were considered, the Elbe and the Ober, and similar data were secured.

The result from these and still other investigations made me conclude that for the Chicago sewage canal there should be a recommendation that the size is sufficient to carry water at the rate of 240 cubic feet per second for each thousand persons, as stated in the preliminary report.

Q. Have you given the subject of dilution any consideration?

A. I have ever since I was engaged on the Chicago work.

Q. State what facts you have investigated in regard to the question of dilution and what conclusion you have made upon the subject?

A. The practical necessity for utilizing rivers polluted by
sewage from communities in this country has caused the
11411 engineering profession to look into the question of dilu-
tion and my conclusions are as follows:

If the foul water or sewage of a community is liable to enter a stream from whence water is taken for drinking purposes, it is imperative either to purify the water or the sewage. Whereever the stream is not subsequently used for water supply, such a purification may not be required, and it is necessary simply to prevent a nuisance. It is impossible to prevent all disease germs from getting into a water course. We can guard it only against a serious pollution. We can not prevent rain from washing the streets, the fields, the forests and discharging the water into streams, and along with this water must go [illegible] dust of the air and the myriads of bacteria, including disease germs which are sometimes contained in the same. There must go with it also parts of the intestinal discharges of animals, birds and insects, and parts of the manure with which the fields are covered. Therefore much injurious matter is carried into the water courses by the rain water and as it is impossible to
prevent water subsequently to be used for drinking pur-
11412 poses all surface water supplies must in my opinion be
purified.

This is the common opinion now prevalent in some of the countries in Europe. A disposal of the sewage by dilution is still very common and it must remain so for a long time.

Over in Europe we find cities situated on the large rivers discharging their sewage into them with entire impunity. The city of Hamburg discharges its sewage into the Elbe which is a tidal stream at this point. The adjoining city of Altona does the same, and both cities take their water supply from this stream receiving the sewage of over 1,000,000 of people but both cities carefully filter it.

After the preliminary report of the drainage and water supply was published and other papers on the subject of sewage dilution in water courses, the Massachusetts State Board of Health made some investigations with this method as published in their report for 1890. From that information I have compiled a table which I have used since in my professional work, based upon a flow of water in cubic feet per second per 1,000 persons and chemical constituents of sewage in parts per 100,000 which table is as follows:

11413

CALCULATED COMPOSITION OF SEWAGE OF DIFFERENT DEGREES OF DILUTION IN A RUNNING STREAM.

Flowing water.		Ammonia.		Dissolved solids.	Chlorine.	Remarks.
Cubic feet per second per 1000 persons.	Gallons per capita per day.	Free.	Albuminoid.			
		(In parts per 100,000.)				
0.062	40	4.50	.90	65.4	12.6	Dilution is offensive.
0.077	50	3.60	.72	52.3	10.1	
0.093	60	3.00	.60	45.3	8.4	
0.108	70	2.57	.52	37.4	7.2	
0.124	80	2.25	.45	32.7	6.3	
0.140	90	2.00	.40	29.1	5.6	
0.155	100	1.80	.36	26.2	5.0	
0.186	120	1.50	.30	21.8	4.2	
0.232	150	1.20	.24	17.4	3.4	
0.310	200	.90	.18	13.1	2.5	
0.386	250	.72	.14	10.5	2.0	
0.465	300	.60	.12	8.7	1.7	
0.5	323	.5580	.1114	8.10	1.56	
1.0	646	.2790	.0557	4.05	.78	
1.5	969	.1860	.0371	2.70	.52	
2.0	1,292	.1395	.0278	2.02	.39	
2.5	1,615	.1116	.0223	1.62	.31	
3.0	1,938	.0930	.0186	1.35	.26	
4.0	2,584	.0697	.0139	1.01	.19	
5.0	3,230	.0558	.0111	0.81	.16	
6.0	3,876	.0465	.0093	0.67	.13	
7.0	5,522	.0399	.0080	0.58	.11	
8.0	5,168	.0349	.0070	0.51	.10	Dilution is not offensive.
9.0	5.814	.0310	.0062	0.45	.09	
10.0	9,463	.0279	.0056	0.40	.08	
15.0	9,694	.0186	.0037	0.27	.05	
20.0	12.926	.0139	.0028	0.20	.04	
30.0	19,380	.0093	.0019	0.13	.03	
40.0	25,852	.0070	.0014	0.10	.02	
50.0	32,315	.0056	.0011	0.08	.02	
100.0	64,630	.0028	.0006	0.04	.01	

11414 It hardly need be said that in applying the table it is necessary to take into consideration each specific case because no single rule applies to the great differences that we find hydrographically. It is necessary to use careful judgment.

Two lines have been drawn across this table. Above the upper one conditions are indicated where the dilution is practically in all cases offensive. Below the lower one the dilution has never been found to give offense. These two lines are indicated by a dilution of sewage from 2 1-2 cubic feet per second per thousand persons to 7 cubic feet per thousand persons.

It is the duty of the engineer to select between these limits that dilution which conforms to the local conditions of the problem.

Q. In considering this question of dilution what standard did you adopt for the drainage canal?

A. I adopted the standard of 4 cubic feet per second per thousand persons because in the state of knowledge at that time I did not feel justified in recommending a less dilution.
11415 Subsequently, I understand, the number was reduced to 3 1-3 cubic feet per thousand persons, and on that basis the canal was constructed. The dimensions were not altered but it was considered that a larger population than the one which I had figured on would be served by this canal by assuming a less dilution.

Q. From your knowledge of conditions as they obtain in the sanitary district of the drainage canal, as applied to the table that you have already introduced in evidence, what conclusions do you draw as to the dilution?

A. I believe that the dilution which it is intended to give the water at all times is sufficient to prevent offensiveness and in view of what I have said above also improve conditions below.

Q. Have you made any calculations upon the question of dilution of the sanitary canal?

A. I have.

Q. Have you prepared a table of dilution, based on population and flow for 1900, 1901 and 1902 of the drainage canal?

A. I have.

Q. Will you produce and read such table?

A. Such table is as follows:

Years.	Population Discharging Sewage into the Canal.	Maximum.		Minimum.		Mean.	
		Cu. Ft. per Min. Weekly Ave.	Cu. Ft. per Sec. per 1000 Inhab.	Cu. Ft. per Min. Weekly Ave.	Cu. Ft. per Sec. per 1000 Inhab.	Cu. Ft. per Min. Weekly Ave.	Cu. Ft. per Sec. per 1000 Inhab.
1900	1,443,789	351,088	4.05	40,481	0.46	233,976	2.70
1901	1,494,300	615,392	6.86	197,124	2.19	277,153	3.09
1902	1,545,300	450,328	4.85	244.426	2.63	295,527	3.18

11417 Q. Will you please explain the table just read into evidence by you?

A. The table shows the dilution in cubic feet per second per thousand inhabitants which the drainage canal has affected during those three years, and conditions of maximum, minimum and mean flows.

It shows that in 1900 the maximum flow was slightly over 4 cubic feet per second per one thousand inhabitants.

The minimum was less than ½ cubic feet per second per thousand inhabitants, and the mean was 2.7 cubic feet per second per thousand inhabitants. The minimum was caused by the fact, as appears in the table, that the average weekly discharge during that year, which was the first one after the canal was opened, was but 40,481 cubic feet a minute. The canal was not yet in full operation.

In the year 1901 the dilution per thousand inhabitants in cubic feet per second was 6.86, as a maximum, 2.190 a minimum and 3.090 a mean.

These three conditions for the year 1902 are given respectively as in cubic feet per thousand inhabitants per second for a maximum 4.85, for a minimum 2.63 and for a mean 3.18.

11418 Q. How does that dilution come within the table which you have introduced in evidence, prepared by you in 1898, prior to the opening of the drainage canal?

A. The table indicates that the mean discharge during each of the three years was above the line which limits the offensive dilution, therefore, indicating that there should be no offense.

It indicates that during the year 1900 the minimum was much below the standard line above indicated in my table of 1898, heretofore introduced in evidence.

This was due to the fact that the discharge was not yet of the quantity intended.

In 1901 the minimum was 2.19, which is also somewhat below the standard limit, but here also the discharge was not yet the discharge that was intended, and it was due, as I am informed, to the diminution of the velocity in the canal required by the United States Government.

In 1902, when the Chicago river had been somewhat widened, the minimum discharge was 2.63, or above the minimum figure in my table.

It might be added that the conditions of the drainage canal are most favorable to the dilution of sewage because it is 11419 of very uniform section, comparatively all with a regular perimeter, and because the mean hydraulic radius or mean depth is great, all of which would indicate that a less dilution would answer the same purpose that a greater dilution would, in irregular and shallow water courses in which sewage is now often discharged, and where the upper limit of my table is required.

Q. In figuring out the question of dilution as the same applied to the drainage canal dilution being considered from the standpoint of the removal of objectionable qualities and character of the water, what points did you have under consideration in establishing this ratio?

A. I had first and foremost the habitations and cities which lie along the drainage canal and the Desplaines and the Illinois rivers in front of which this water was to pass. As the dilution would become greater by the affluents of the Desplaines and the Illinois rivers on a downward course it was of course assumed that what would be satisfactory with a smaller dilution would be and was generally satisfactory with the greater dilution.

11420 Q. Have you investigated the question of sewage disposals in Europe and in this country since the filing of your preliminary report?

A. I have.

Q. How extensive have been your investigations upon that subject since the recommendations contained in the preliminary report which has already gone in evidence?

A. They have been quite extensive. I must have had surely 50 cases of sewage disposal under consideration myself, and I have examined the principal European works every time I have been there which has been three or four times since then.

Q. Have you kept in touch with the progress of the drainage canal and the work done by that canal for the purification of sewage and the water supply of the city of Chicago since it was opened in 1900?

A. I have.

Q. From what you know of the question of the disposal of sewage and from all the knowledge which you have in regard to the drainage canal, the manner in which it is operated, the purposes served in its operation, and taking into consideration the experience which you have had since you made your preliminary report, what changes would you recommend for the sewage disposal of the city of Chicago today, if the same problem was submitted to you now that was submitted to you in 1886, as a sanitary hydraulic engineer? 11421

Mr. Jeffries: Object to the question as incompetent and immaterial.

A. In considering the several possible ways of disposing of the sewage of Chicago from present knowledge and experience my recommendation today would be that the sewage of Chicago should be disposed of by dilution through a channel substantially like that which has been constructed with a subsequent discharge into the Desplaines and Illinois rivers.

MR. TODD: In the study of this problem have you discovered anything that would change the views expressed by you in the preliminary report at that time?

A. I have not.

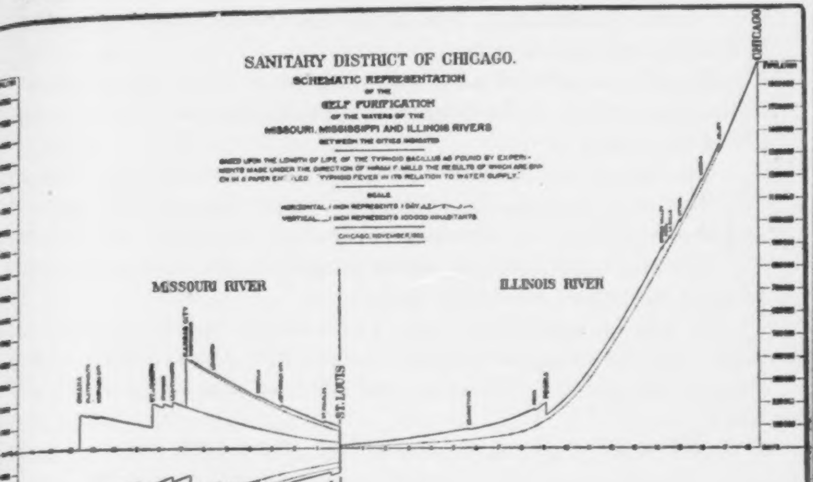
Q. Have you a chart showing the comparative pollutions of the Illinois, Mississippi and Missouri rivers?

A. I have.

11422 Q. Will you produce and make such chart a part of your testimony?

A. Yes. The chart, with the caption "Sanitary District of Chicago, Schematic representation of the self-purification of the waters of the Missouri, Mississippi and Illinois rivers between the points indicated, based upon the length of life of the typhoid bacillus, as fixed by experiments made under the direction of Hiram F. Mills," the results of which are given in the paper entitled "Typhoid fever in its relation to sewage supply," is as follows:

11423


SANITARY DISTRICT OF CHICAGO.
SCHEMATIC REPRESENTATION
OF THE
SELF PURIFICATION
OF THE WATERS OF THE
MISSOURI, MISSISSIPPI AND ILLINOIS RIVERS
BETWEEN THE CITIES INDICATED
BASED UPON THE LENGTH OF LIFE OF THE TYPHOID BACILLUS AS FOUND BY EXPERIMENTS MADE UNDER THE DIRECTION OF HIRAM F. MILLS THE RESULTS OF WHICH ARE GIVEN IN A PAPER ENTITLED "TYPHOID FEVER IN ITS RELATION TO WATER SUPPLY."
SCALE
HORIZONTAL 1 INCH REPRESENTS 1 DAY
VERTICAL 1 INCH REPRESENTS 100000 INHABITANTS
CHICAGO, NOVEMBER
MISSOURI RIVER
ILLINOIS RIVER
ST. LOUIS
KANSAS CITY
ST. JOSEPH
OMAHA
PEORIA
CHICAGO
MISSISSIPPI RIVER
PROFILES
OF THE
MISSOURI, MISSISSIPPI AND ILLINOIS RIVERS
ABOVE
ST. LOUIS.
SCALE
MISSOURI RIVER
MISSISSIPPI RIVER
ILLINOIS RIVER
KANSAS CITY
ST. LOUIS
CHICAGO
LAKE MICHIGAN

11424 Q. Will you state in detail upon what facts this chart was constructed, how constructed and what information it is intended to convey?

A. The chart contains two diagrams. The lower one exhibits the profiles of the Missouri, Mississippi and Illinois rivers above St. Louis.

The upper line indicates the Missouri river as far as Omaha.

The next line the Mississippi river as far as Minneapolis and the third line the Illinois river as far as the city of Chicago.

The three profiles are plated relative to their elevations and to their distances above St. Louis.

It will be seen from these profiles that the Missouri river is the steepest of the three, that it falls from Omaha at an elevation of 960 to St. Louis at an elevation of about 380 above sea level.

The Mississippi river falls from Minneapolis at an elevation of 794 to the elevation above mentioned at St. Louis.

11425 The Illinois River and Sanitary District Canal fall from an elevation of Lake Michigan which is about 578 to Grafton where it enters the Mississippi river. The elevation at Grafton is slightly over 400 feet above sea level.

The distance of Omaha and Minneapolis to St. Louis by water is about 680 miles.

The distance from Lake Michigan to St. Louis by water is about 400 miles.

It will be seen that the Missouri river is the steepest one and the velocity of the water in the river is the greatest. The Mississippi river is the less steep and the velocity would be less great. Therefore, it will take the water longer to flow from Minneapolis to St. Louis than from Omaha to St. Louis, although the distance is nearly the same.

The Illinois river is the flattest of the three rivers and the water has a less rapid velocity.

The upper diagram on the chart exhibits certain deductions made on the basis indicated in the title with reference to the longevity of the typhoid bacillus as found by Mr.

11426 Miram F. Mills. In the above mentioned report it is stated "to prove whether typhoid fever germs would survive in the Merrimack river water, when at the low temperature of the month of November, long enough to pass from the

Lowell sewers to the service pipes in Lawrence, a series of experiments was made by the Board by inoculating water from the service pipe with typhoid fever germs and keeping the water in a bottle surrounded by ice at as near freezing as practicable for a month, and each day taking out 1 cc. and determining the number of typhoid fever germs. The number continually decreased but some survived 24 days:

On the first day there were 6120 germs.

On the fifth day there were 3100 germs.

On the tenth day there were 490 germs.

On the fifteenth day there were 100 germs.

On the twentieth day there were seventeen germs.

On the twenty-fifth day there were no germs.

The ordinates of the curves presented on the diagram represent the relative number of typhoid bacilli still living at towns indicated in terms of population of such towns, it being assumed in the absence of other information at hand that the number of germs is directly proportioned to the population. 11427

From an inspection of the diagram it will appear that Chicago is situated, so far as the average flow of water is concerned, about 18½ days from St. Louis. Kansas City, on the Missouri, on the same basis is situated about 6¾ days and Omaha about 11.6 days from St. Louis.

On the Mississippi river, Minneapolis and St. Paul are situated about 15 days from St. Louis on the same basis. The other cities indicated are at shorter distances.

The conclusions of the chart as indicated by the ordinate at St. Louis is that the relative proportion of typhoid bacilli arriving at St. Louis from the populations situated on the Illinois, the Missouri and the Mississippi rivers, between the limits of Chicago, Omaha and Minneapolis, are about as 13 to 96 to 107, respectively. These figures are merely the proportions. They indicate the relative frequency of the still virulent typhoid bacilli at St. Louis, arriving there from various cities on these three rivers, based on the population of the cities, and also based on the examinations made by Hiram F. Mills as to the longevity of the typhoid bacilli.

Adjourned until 2:00 p. m., same day, March 10, 1904.

11428 2:00 p. m., Thursday, March 10, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

RUDOLPH HERING

resumed the stand for further direct examination, by Mr. Todd, and testified as follows:

Q. Were you acquainted with the Illinois system and Missouri rivers prior to the opening of the drainage canal in 1900?

A. I was in a general way.

Q. What is your opinion as to whether the Mississippi river above Grafton was a safe water for drinking and domestic purposes, in its raw state, prior to 1900?

MR. JEFFRIES: I object to that as immaterial.

A. I consider that the Mississippi river, in its raw condition was not a fit supply for drinking water for any modern community.

Q. Was the Illinois river at Grafton?

A. It was not.

11429 Q. Or the Missouri river at its mouth?

A. It was not.

Q. Is the Missouri river, today, in your opinion, a safe drinking water in its raw state ?

A. It is not.

Q. At its mouth?

A. It is not.

Mr. Jeffries: I object to that as immaterial.

Q. Is the Mississippi river above Grafton a safe drinking water in its raw state?

MR. JEFFRIES: Objected to for the same reason.

A. It is not.

Q. Is the Illinois river at Grafton a safe drinking water in its raw state, in your opinion?

A. It is not.

Q. Is the water of the Mississippi river at the chain of rocks which consists of a mixture of the Missouri, the Mississippi and the Illinois rivers, today, in your opinion, a safe drinking water in its raw state or as treated in the settling basins of St. Louis?

A. According to the present views on water supplies held by engineers and sanitarians, it is not.

11430 Q. How should the water of the Mississippi river at the chain of rocks be treated in order to make it a safe drinking water for drinking and domestic purposes by the citizens of St. Louis if at present it is not a safe drinking water, in its raw state?

A. It should be artificially purified.

Q. In what way?

A. By filtration.

Q. Have you given the question of filtration of the Mississippi river at the intake any consideration?

A. I have given it some consideration.

Q. To what extent, Mr. Hering?

A. I have read a report which was made by a commission of hydraulic engineers upon the water supply of St. Louis to the mayor of the city in 1902.

Q. Who made the report to which you refer?

A. A commission of engineers consisting of Mr. Benezette Williams, George Y. Wisner and Allan Hazen.

Q. In that report to which you referred did your firm have anything to do with?

A. My associate, Mr. George W. Fuller, was asked to consider some features and he made a report which is added

11431 to the report of the Commission.

Q. You have read the report of Mr. Fuller that is published in the document to which you refer in regard to the question of filtering the water of St. Louis as advocated by Mr. Hazen in that report?

MR. JEFFRIES: Objected to as immaterial and incompetent.

A. I have.

Q. What are your personal views and opinions in regard to the treatment of the water of the Mississippi river as it passes by the city of St. Louis at the intake tower at the chain of rocks?

A. My personal views are that this water in order to be supplied to the city of St. Louis for domestic consumption should be purified by mechanical or rapid filtration as the best, most rational and least expensive method of purifying this particular water.

Q. What experience have you had in the filtration of water and the construction of filters for municipalities?

11432 A. I have taken considerable interest in the matter from the time I first visited some European filters in 1881. I was acquainted with Mr. Hyatt who invented the first rapid or mechanical filter and introduced the same in this country, and always anticipated some advantage to be gained from such a method of rapid filtration, and have followed the advances of mechanical filtration ever since. I studied the methods of slow filtration on the ordinary European method and in connection chiefly with the water supplies of Philadelphia and New York, in both of which cases I recommended the slow sand filtration for adoption. I was also asked to pass upon the method of filtration to be adopted at Washington, D. C., in connection with Mr. George W. Fuller and Mr. Allen Hazen, we three making the report. I have gone into the subject of filtration as thoroughly as I know how.

Q. Are you acquainted with the cost of building filter plants?

A. I am.

Q. Are you acquainted with the cost of operating filter plants?

A. I am.

Q. What is your opinion as a sanitary engineer whether it would cost any more to filter the water of the Mississippi river at the chain of rocks, which consists of the combined 11433 waters of the Illinois, Mississippi and Missouri rivers with the sewage from Chicago emptying into the drainage canal and from thence into the Illinois river than it would if such sewage was eliminated from the sanitary drainage canal?

A. In my opinion it would make no practical difference in the construction method or cost nor in the method and cost of operation.

Q. As a sanitary engineer passing upon the quality of the water of the Mississippi river as it passes St. Louis and the chain of rocks, what facts would you take into consideration in passing upon the quality of that water in its raw state?

A. The chief object that would first appeal to me to which I would have to get some satisfactory answer and solution is the turbidity of the water because that affects the manner of treatment more than anything else, and then of course I would also consider the pollution of the river by the number and kind of bacteria contained in the water.

I would also be governed by the hardness of the water or any mineral content of different kinds. I would have to know what the water was, both chemically and bacteriologically 11434 and physically before I would feel that I was completely and satisfactorily solving the problem.

Q. Taking the data which you have introduced in evidence, what help would that data be to you in considering such a problem?

A. These data would indicate to me that first and foremost a filtration of the water was necessary, due to the probability that typhoid bacilli would reach St. Louis to a large extent from the Mississippi and Missouri and to a less extent from the Illinois river.

Q. What consideration would you give to the sewage coming from Chicago?

A. I should give no consideration at all because it was a small factor in the problem. It was too small a factor in the problem to materially affect any recommendation.

Q. In the operation of such a filter plant that would be established to meet the demands of the people of St. Louis for a pure and safe water supply, would the operation of such a plant require a higher degree of skill or more expensive men to manage and operate such a plant with the sewage of Chicago emptying into the Illinois river than it would if such sewage was not present in the Illinois river through the drainage canal?

A. It would not.

(Witness temporarily withdrawn.)

11435

ALBERT S. CRANE,

a witness called on behalf of the defendants, after being duly sworn by the Commissioner, was examined in chief by Mr. Todd, and testified as follows:

Q. What is your name?

A. Albert S. Crane.

Q. What is your business?

A. Civil engineer.

Q. What institution are you a graduate from?

A. Cornell University.

Q. After graduating at Cornell where did you go?

A. I spent the summer of 1891 with Mr. Hering in Europe.

Q. What doing?

A. Visiting sewage purification and water filtration works, principally.

Q. After coming back to this country what did you do?

A. I went to work with the city engineer of Newton, Massachusetts, and occupied various positions from inspector to assistant engineer and finally division engineer. In December of 1894 I went to Washington and was engaged 11436 in the United States Engineer's office on sewerage plans for Fort Monroe.

In April, 1895, I accepted a position as assistant engineer in the Department of Sewers in the city of Brooklyn and remained in that department and the department of city works until October, 1898.

From October, 1898, until March, 1900, I was chief assistant engineer of the Michigan & Lake Superior Power Company.

Q. Where is that company located?

A. Sault Ste. Marie, Michigan.

Q. Briefly, what work did you do at the Sault?

A. The first two years I was on water power construction. The last two years I was chief engineer of the Lake Superior Power Company in charge of the waterworks, electric light plant and mill construction and operation.

Q. Since leaving the Sault what have you done?

A. I have been principal assistant engineer of the sanitary district of Chicago.

Q. Did you prepare the chart introduced in evidence by Mr. Hering under the caption "Sanitary District of Chicago, schematic representation of the self-purification of the 11437 waters of the Missouri, Mississippi and Illinois rivers, between the cities indicated, based upon the longevity of the life of the typhoid bacillus, as found by experiments made under the direction of Hiram F. Mills, the results of which are given in a paper entitled "Typhoid fever in relation to water supply?"

A. I did.

Q. Was this chart made under the direction of Mr. Hering?

A. It was.

Q. Will you state in detail the sources from which you got the information and state facts relating to the method of constructing this chart?

A. The data for the profiles, including the Missouri river, Mississippi river and the Illinois river were taken from a paper published by the Department of the Interior, entitled "Water Supply and Irrigation Papers of the United States Geological Survey, Number 44."

These figures I used entirely in the profiles excepting on the upper part of the Illinois river where other figures were taken in order to make the profile more in detail. These latter figures were taken from a report by L. E. Cooley, 11438 entitled "Waterway from the Lakes to the Gulf" and are part of the archives of the Sanitary District.

Q. Will you state what the distance is from St. Louis to Chicago, and where you get the data for the distance?

A. On page 39 of the report referred to the distance from St. Louis to the mouth of the Illinois river at Grafton is given as 38 miles. On page 60 the distance from the mouth of the Illinois river to the upper dam at Joliet is given as 325 miles. The distance from dam Number 1 at Joliet to Lake Michigan is 38.6 miles.

Q. Will you explain the upper part of the chart, of the plat introduced by Mr. Hering, and upon what you constructed it?

A. The figures on the horizontal line represent days time of the flow of water from the various towns to St. Louis. In the case of the Illinois river they were obtained from actual float

experiments made during the summer of 1903, by Mr. Heilborn, under the direction of Mr. Randolph. The actual time of flow as representing the minimum time has been corrected for mean time of flow. The minimum time flow was taken as .8 of
11439 the mean. 15 days was the quickest time that we could get that float down. We called that 18½ days, or in other words, the actual time was divided by .8.

Q. Why was .8 taken?

A. That has generally been considered to be the relation between maximum velocity and mean velocity in an open stream.

Q. By whom?

A. Prony was the first man that gave that. Trautwine gives that. It is generally conceded by engineers. The time for the Missouri and Mississippi rivers were computed. First the mean discharges of these two streams was obtained on the Mississippi river at Grafton and the Missouri river at St. Louis.

Q. What were they?

A. Being 57,000 and 120,000 cubic feet per second, respectively.

Q. Where did you get that data from?

A. The data were obtained by using the reports of the Mississippi River Commission, entitled "Tabulated results of discharge measurements of the Mississippi river and its tributaries and outlets for the years 1838 to 1898," and plotting these to form a discharge curve.

In the case of the Mississippi river, the average
11440 gauge readings at Grafton was taken for the years 1890 to 1894, inclusive, and then for the Missouri River the years 1895 to 1899, inclusive. After these average stages were obtained the average discharge was obtained directly from the curve.

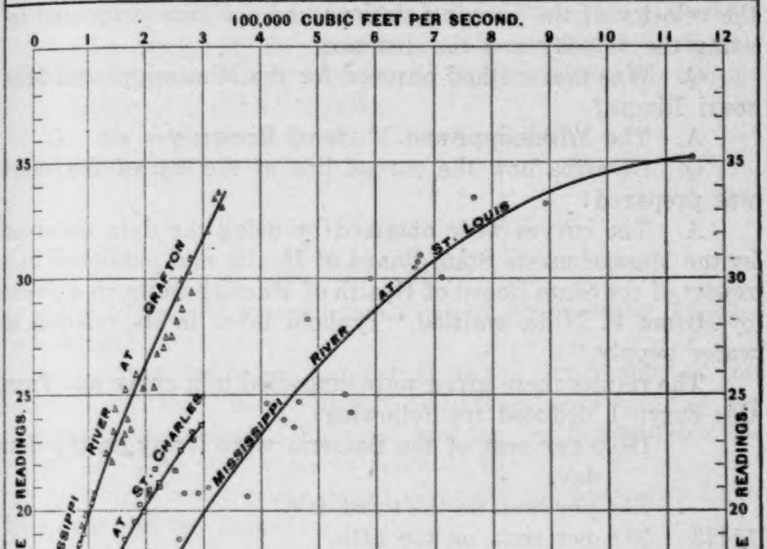
Q. Have you a curve?

A. Yes sir.

Q. Will you produce and make the curve to which you refer a part of your testimony?

A. I will. The chart is as follows:

APPROXIMATE
DISCHARGE CURVES
BASED ON
DISCHARGE MEASUREMENTS
MADE BY THE
MISSISSIPPI RIVER COMMISSION
1838 TO 1898.



11442 Q. How did you figure the time between these points?

A. In the tabulated results of the Mississippi River Commission above referred to are given a large number of discharge measurements, together with the gauge readings, mean and maximum depth, width of the river and velocity in feet per second. The discharges at the various towns along the river were then computed, and by looking in the table the velocity at these towns or a part of them were found. The velocity of the rivers between the different towns was taken as the velocity at the gauging stations and the time computed by using the velocity and the distance.

Q. Was that method pursued for the Mississippi and Missouri Rivers?

A. The Mississippi and Missouri Rivers, yes sir.

Q. Describe how the curved line at the top of the chart was prepared?

A. The curves were obtained by using the data obtained by the Massachusetts State Board of Health and published in a report of the State Board of Health of Massachusetts, in a paper by Hiram F. Mills, entitled "Typhoid fever in its relation to water supply."

The results there given were embodied in a curve and from this curve I deduced the following:

100.0 per cent of the Bacteria were living on the first day.
73.4 per cent. on the third day.
11443 50.8 per cent. on the fifth.
30.8 per cent. on the seventh.
14.1 per cent. on the ninth.
5.2 per cent. on the eleventh.
2.5 per cent. on the thirteenth.
1.6 on the fifteenth.
1.0 on the seventeenth, and
0.4 per cent. on the nineteenth.

Assuming that the number of typhoid bacilli contributed was proportional to the population, the curves were started at the extreme from St. Louis. Working towards St. Louis the results for the first, third, fifth, etc., days were plotted. These curves were plotted for each city in turn.

Q. How was it represented at St. Louis?

A. The results at St. Louis were so arranged that the result for the Illinois River was placed opposite the combined results of the Missouri and Mississippi Rivers so that they might be directly compared.

Q. What does the variation between the Illinois, the Mississippi River and the Missouri River, as indicated upon this chart represent as to the comparative populations at St. Louis, of these three rivers?

A. This would show that the Illinois River has the effect
of a city of 13,000 situated immediately above St. Louis,
11444 the Missouri River of a city of 96,000 and the Mississippi
River of a city of 107,000.

Q. Or a relationship of 13 to 96 and 107?

A. Yes sir.

CROSS EXAMINATION

By Mr. Jeffries.

Q. Where did you get this table of distances on the Illinois River?

A. From the report number 44 of the Department of the Interior, entitled "Water Supply and Irrigation Papers of the United States Geological Survey," and the few figures from the report of L. E. Cooley above referred to.

Q. Mr. Cooley in his report gives 360 miles between Lake Michigan and St. Louis?

A. It comes out 364.7, as I have it here.

Q. From Lake Michigan to St. Louis?

A. Yes sir.

Q. In this chart and these surveys which you have drawn
representing the Illinois, Mississippi and Missouri Rivers
11445 what populations did you take into consideration?

A. The populations of the cities and towns of about 5,000 inhabitants, and over, located on these rivers.

Q. That is immediately on the banks of the rivers?

A. Yes sir, not on the tributaries.

Q. What rivers did you take into consideration on the Missouri River—have you a list of them?

A. Yes sir.

Q. Just name them?

A. Omaha, South Omaha, Council Bluffs—

Q. Have you the population?

A. Yes sir.

Q. Put the whole thing in?

A. Omaha, including South Omaha and Council Bluffs, 154,000

	Plattsmouth	4,964
	Nebraska City	7,380
	St. Joseph	103,000
	Atchison	15,700
	Leavenworth	20,700
	Kansas City	215,000
Q.	That is both of them?	
	A. Yes sir. Independence	6,974
11446	Lexington,	4,190
	Boonville,	4,377
	Jefferson City,	9,664
	St. Charles	7,982
Q.	The Mississippi River?	
A.	Minneapolis and St. Paul, combined,	365,783
	Red Wing	7,525
	Winona	19,714
	La Crosse	28,895
	Dubuque	36,297
	Galena	5,005
	Clinton	22,698
	Davenport, Rock Island and Moline	71,995
	Muscatine	14,073
	Burlington	23,201
	Ft. Madison	9,278
	Keokuk	14,641
	Quincy	36,252
	Hannibal	12,780
	Louisiana	5,131
	Alton	14,210
11447 Q.	Now, the Illinois River?	
A.	Chicago	1,698,000
	Joliet	29,353

Morris	4,273
Ottawa	10,588
La Salle	10,446
Peru	6,863
Spring Valley	6,214
Peoria	56,100
Pekin	8,420
Beardstown	4,827

Q. Where did you get the velocity of the waters in the Mississippi and Missouri Rivers?

A. From the tabulated results of the discharge observations Mississippi River and its tributaries and outlets, published by the Mississippi River Commission.

Q. What year?

A. Years 1838 to 1898.

Q. Published in what year?

A. There are three parts published in 1895, 1897 and 1898 respectively.

Q. Does that include the Illinois River?

A. There are one or two observations in the Illinois River.

11448 There were a few observations at Grafton.

Q. As to the velocity?

A. Yes sir.

Q. You did not use any of the velocities published in the Geological Survey on the Illinois River?

A. No.

Q. Now, do these velocities that you obtain from the Geological Survey represent the velocity of the Missouri and Mississippi Rivers from Omaha and St. Paul to St. Louis?

A. At some points; not at all points.

Q. What points were taken?

A. On the Mississippi River at Winona, Burlington and Hannibal. On the Missouri River at Omaha, Nebraska City, Atchison, Kansas City and St. Charles, those being the only discharge stations.

Q. And those determinations as made by you and which are displayed upon the chart represent conditions which would exist in the event the effects of the sewage discharges into the respective rivers were converted into three respective cities

upon the Mississippi River immediately above the city of
11449 St. Louis?

A. Yes sir.

Q. Now, in what connection did you use the population of the respective rivers with reference to the velocity of the water in those rivers?

A. The populations were plotted on the chart directly above the number giving the number of days distance which they were from St. Louis, the effect of this population decreasing according to the curve plotted from the data on which the chart is based.

Q. Now, assume that the time flow from the mouth of the south fork or south branch of the Chicago River to the city of St. Louis was ten days, how would that effect the result of your determination, and what would be the determination figured on a flow of ten days?

A. It would have the effect of a town of about 160,000.

Q. It would have the effect of a town located upon the Mississippi River, immediately above the city of St. Louis, of about 160,000 population?

A. According to the chart.

Q. And as the velocity increased and decreased from the figures which you have given the results, comparatively speaking, would change at the city of St. Louis?

11450 A. They would.

Q. These floats that were used in making the experiment of the velocity of the water in the Illinois River, could you describe them?

A. I can.

Q. Then just describe them in a plain way?

A. The upper part of the float consisted of two tin segments of a sphere, soldered together, so that the horizontal diameter of the float was six inches and its height 1 1-2 inches. On top of this was constructed a small ring in which a cork and flag were placed. Attached to the lower part of the upper float, by means of brass picture wire, was a hollow cylinder, 8 inches high, and 8 inches outside diameter.

Q. How deep under the surface of the water was the cylinder suspended?

A. The cylinder was generally suspended 2 or 3 feet below the surface. That varied, however.

Q. Did you personally supervise this work?

A. I did not.

Q. What portion of a body of water in a running stream is the most rapid?

A. Generally the part near the center of the stream, and
11451 a little below the surface.

Q. What was the obect in having these cylinders suspended from 2 to 3 feet under the surface of the water?

A. So they would get the effect of the current and not have the wind effect. In other words that they would show the current rather than the wind.

Q. Did the wind effect have any control or influence over the velocity of the cylinders as they passed down stream?

A. It probably had a very slight effect.

Q. What particular place in the Illinois River, with reference to the current on the surface or the bed of the stream did you get the velocity of by means of the cylinder?

A. Generally it was pretty close to maximum velocity.

Q. Is it not a fact that engineers recognize that the greatest velocity in a running stream is about 2 feet underneath the surface, when the stream is about 10 feet deep and that it graduates according to depth upon that basis?

A. I should say between 2 feet and the surface is the maximum.

Q. Why is it that the surface is not taken as the greatest velocity?

11452 A. On account of the wind and the friction of the air.

Q. The whole subject is a good deal a matter of speculation is it not, except that you know that such distinctions exist?

A. Depends upon the stream.

Q. These charts about which you have testified in evidence are the same charts that were testified about by Mr. Hering this forenoon?

A. Yes sir.

REDIRECT EXAMINATION

By Mr. Todd.

Q. If at maximum flood time the distance in time from Kansas City was 3 days instead of 6.8, as shown by this chart, what would it show?

Mr. Jeffries: I object to the question as immaterial.

A. 230,000. That is the effect of the cities on the Missouri River would be that of a city of 230,000 directly above St. Louis.

ALBERT S. CRANE.

ADJOURNED UNTIL 10:00 A. M., FRIDAY, MARCH 11, 1904.

IN THE

Supreme Court of the United States

THE STATE OF MISSOURI
vs.
THE STATE OF ILLINOIS
and
THE SANITARY DISTRICT OF CHICAGO.
} Original, Docket No.

Before
FRANK S. BRIGHT,
Commissioner of the Supreme Court of the United States.

VOLUME 8.

VOLUME 8.

11453 10:00 A. M. Friday, March 11, 1904. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

RUDOLPH HERING

resumed the stand for cross examination by Mr. Jeffries and testified as follows:

Q. State exactly when your connection with the Sanitary Commission of the city of Chicago commenced?

A. I started upon my duties on March 28th, 1886.

Q. That was long before any work had begun on the construction of the canal?

A. Yes sir.

Q. The real object of this drainage canal was and is to remove the sewage material from the Chicago River in order to prevent deleterious substances being swept out into Lake Michigan and thereby affecting the water supply of the city
11454 of Chicago, as well as to remove the offensive odors which
arose continuously from the contents of the river, was it not?

A. That was the chief and primary object.

Q. As a matter of fact that was the basis of your being called into the investigation?

A. I believe so.

Q. You reported upon no other proposition, did you?

A. Yes, I did. I reported upon the disposal of the sewage of Chicago by the other methods which were known to accomplish a proper purification or inoffensive disposal of the sewage.

Q. You reported upon nothing except upon methods with respect to the disposal of the sewage of Chicago, and the ultimate protection of the water supply of Chicago?

A. That was all I reported upon.

Q. And in this report you presented two or three means by which this protection could be brought about?

A. Yes.

Q. One of those was the construction of the canal?

A. Yes sir.

11455 Q. Another was the pumping or removal of the sewage from the city upon land adjacent to the city of Chicago, in order that it might then be purified?

A. Immediately adjacent and extending around the southern end of the Lake, yes sir.

Q. And a third was a continuation of the discharge of the sewage into Lake Michigan?

A. Under very much improved conditions, yes sir.

Q. What were some of those improved conditions going with the recommendation as to its discharge into the Lake?

A. They were that the discharge of sewage and the intake for the water supply should be as far apart as practicable. It was proposed, if I remember rightly, to take all the water for Chicago from a point out in the lake opposite what is called Grosse's point. The sewage was to be discharged as far towards the southern end of the lake as practicable. It was also intended to strain and so deprive the sewage of the grosser pollutions when discharged into the lake, so that it would be diluted and therefore in as unobjectionable condition as that method of disposal would make it.

Q. You still recognize that a method of that character would be objectionable?

11456 A. If the sewage were discharged in a raw state at a distance from the water intake, which would necessarily be limited, I would consider that method of disposal not the best possible.

Q. What difference would there be in a discharge of that character directly into the Lake and a discharge into the Chicago River, as it then existed?

A. As it then existed the Chicago River was loaded with an accumulation of organic matter during such times when the flow was very slight. Whenever there was a heavy rainfall or a freshet all this accumulated matter would be carried out into the

Lake and immediately to one of the water intakes of the city. In the method of lake dilution examined there would be a continous discharge and therefore no long accumulation of foul matter which could at once be driven out, and there would also be a very much greater distance between the sewer outlet and the water intake. There would also be the chances during approximately one-half of the year of having the sewage polluted water near the sewage out-fall carried away from the water works intake and therefore the other half of the year would entirely free the proposed intake from possible effects of
11457 such a disposal.

Q. On account of the immense amount of organic matter contained in the Chicago River at that time there was much deleterious substance contained in that case was there not which would be swept into Lake Michigan?

A. Kindly explain what you mean by deleterious.

Q. Substances detrimental to a water supply and injurious to public health?

A. I am not able to tell you how far this matter would be injurious to public health, because that is not a question of engineering.

Q. Is it not a fact that it was so considered injurious to the water supply and detrimental to public health by the engineers who made the report, and that you took such fact into consideration in making your observations and in presenting your report?

A. Engineers take their data on sanitary matters originally from the physicians and sanitarians who investigate such matters and it was their supposition that the discharge of river sediment resulting from the entrance of sewage into the river would be not only offensive but also injurious to health.

11458 Q. You are a sanitary engineer are you not, Mr. Hering?

A. I am a sanitary engineer.

Q. As a sanitary engineer was it not necessary for you to take into consideration the fact that the discharge of sewage of Chicago into the Chicago River and thence into Lake Michigan was a menace, a danger and a detriment to the water supply and to the public health of the city of Chicago at the time this report was made by you?

A. It was.

Q. What was that condition?

A. The condition was that the sewage of Chicago was discharged into Lake Michigan, partly along the shores of the city and partly through the river and when rain fell in large quantities the water from the Chicago River, laden with sewage matters, was forced out into the lake and at times surrounded the then existing intake of the water supply.

Q. Is it not a fact that you took into consideration also the immense amount of filth, sewage and organic matter which had been contained in the Chicago River for weeks and months between the freshets as containing large quantities of
11459 deleterious substances?

A. This accumulated matter was of course flushed out at such times of heavy rainfall and polluted the lake water.

Q. And you took into consideration then the fact that such matter in the Chicago River at that time contained large quantities of objectionable and deleterious material?

A. I did take this into consideration. These were facts that I was speaking about, that this water did go out there and pollute the water supply to such an extent that in my bath room on the north side, not very far from the pumping station, I staid up one night to watch the entrance or the delivery of the polluted water. For instance we followed the river water on the afternoon, until dark, about five o'clock, and then I computed that within an hours' time, approximately, this water would reach the intake crib, then go to the pumping station and be delivered to the residences. It was early in the morning when this foul smelling water ran into my bath tub.

Q. Then in your observations made of conditions existing in Lake Michigan at the time this report was made with
11460 reference to the sanitary conditions of the water in Lake
Michigan at Chicago, you took into consideration the fact that the organic matter contained in the Chicago River and which remained therein for weeks and months, between the freshets, contained substances objectionable to the water supply and deleterious to the public health?

A. I did.

Q. Which, in your opinion, was the more objectionable, the sewage discharged into the Chicago River, and thence into Lake Michigan, or sewage discharged directly from the shores of the lake, under conditions which existed at the time these observations were made?

A. I would answer to that question that in the light of knowledge at the time this investigation was made, I will say, that it was then considered more objectionable to the water supply when the river water reached the cribs than when the sewage discharged at the lake shores entered the same.

Q. Now, why?

A. Because, in the first case there was an offensive odor, clearly recognizable by the senses. The water was not only turbid, but had an offensive odor, whereas the sewage dis-
11461 charged at ordinary times along the Lake Shore did not
affect the water supply in a manner to be distinguished by the senses. Today we know more about the life of the bacilli which are known to cause typhoid fever, and I would hardly know how to answer your question in the light of today's knowledge as to the relative injury to health with special reference to typhoid fever.

Q. Could you express an opinion?

A. No sir.

Q. That is you could not express an opinion upon the present light of sanitary science?

A. I should not like to. It is beyond my sphere of investigations.

Q. Is there a current in Lake Michigan along the west shore, near the city of Chicago?

A. There is, almost at all times.

Q. What is the direction of that current?

A. The current varies with the winds. We found it by investigations during the summer of 1886 that the prevailing current along the shore of Cook County was towards the north, but we recognized from the wind records that it is prob-
11462 able that that result would be reversed during the winter
months, and it was the general opinion of the crib care taker, who was located out in the lake, that the currents were about evenly divided during the year.

Q. Do you know anything about the velocity or rapidity of that current?

A. That current sometimes is observed, if I remember right, to be as much as 2 and 3 feet per second, but generally, of course, less.

Q. How much would that be per hour, figuring at 2 feet per second?

A. That would be 7,200 feet.

Q. That would be more than one mile per hour would it not?

A. Yes sir.

Q. Practically 1 1-3 miles per hour?

A. Yes sir.

Q. Do you know how far the city of Milwaukee is situated on the shores of Lake Michigan from the city of Chicago?

A. I am making a guess if I say 90 miles.

11463 Q. Assuming that the current in the lake, when flowing from the north to the south, makes a velocity of 2 feet per second, how long will it require the water in the lake to flow from Milwaukee to Chicago, the same being a distance of approximately 90 miles?

MR. TODD: I object to the question on the ground it is not proper cross examination of anything that has been brought out on direct, and for the reason that it is incompetent, irrelevant and immaterial.

A. If I understand you right, 70 hours or 3 days.

That is figuring it 1 1-3 miles per hour, but if I may state I do not admit this is a possible condition, because I never knew that this current had such a rate, and that such a rate would be maintained substantially or constantly for three day.

Q. Assuming that typhoid bacilli are discharged into Lake Michigan from the sewers of Milwaukee, and assuming that there is a current flowing past the city of Milwaukee to the south, with the velocity of 2 feet per second, which velocity is maintained for a period of three or four days, is it not a fact that such typhoid bacilli would reach a point in Lake Michigan opposite the city of Chicago?

11464 MR. TODD: I object to the question for the reason it is not proper cross-examination, for the additional reason that the assumptions contained in the question are not proven in evidence, and for the further reason that it is incompetent, irrelevant and immaterial to the issues inovlved in this case.

A. With the assumptions you make I can not answer otherwise than that they would, but it is hydrographically impossible for such a current to flow from Milwaukee to Chicago intake.

Q. Now, why is it impossible?

MR. TODD: I object to the question for the same reasons as heretofore stated to the previous question.

A. Because the water in the lake does not move near the shores in a parallel direction to those shores. There are cycloidal motions and the water passing the Milwaukee sewage outlet would be so dispersed, even though the winds were favorable to a general southern current, that the particular water from the Milwaukee outfalls would not reach the Chicago intake for, to make a rough guess, weeks and possibly months.

11465 Q. Is it not a fact that sanitary engineers must, in their work, take into consideration the longevity of pathogenic bacteria contained in sewage which is discharged into a stream or body of water from which a water supply is taken?

A. Since the longevity of such disease germs has become known it is the duty of the sanitary engineer to consider the question.

Q. In your opinion as a sanitary engineer, taking into consideration your experience in dealing with sanitary questions involving engineering features, and from what you have learned in this connection, how long will pathogenic bacteria live and exist in the waters of a running stream when discharged therein from the sewers of a city?

MR. TODD: I object to the question for the reason it is not proper cross-examination of anything that was brought out in chief, and therefore incompetent, irrelevant and immaterial.

A. When I entered into the study of this case the best information that I was familiar with regarding the longevity of the typhoid bacillus, which is the most important one to consider in cases of this kind, was that contained in the reports of

11466 the Massachusetts State Board of Health and which I used in preparing the chart entitled "Sanitary District of Chicago, schematic representation of the self-purification of the waters of the Missouri, Mississippi and Illinois rivers between the cities indicated," etc.

Since having been engaged on the case I have become acquainted with similar investigations which have recently been made by witnesses in this case, which information is much more exact and practicable and in accordance with actual facts, in my opinion, than the Massachusetts experiments. Had I asked this diagram or this chart to be prepared later I should have used the later and better information contained in the recent testimony in this case.

Q. Generally speaking, Mr. Hering, taking all the observations of bacteriologists and sanitary scientists the world over, what in your opinion is the longevity of pathogenic bacteria coming from the sewers of a city when discharged into a running stream?

MR. TODD: I object to the question for the reasons already stated in my former objections.

A. I consider that every disease bacterium has presumably a different length of life under the same conditions, and 11467 presumably also under different conditions, and as I have not studied concerning any other bacteria than the typhoid bacillus, I could not make such a general answer.

Q. As applicable to typhoid bacillus what would you say?

MR. TODD: I object to the question on the same grounds as heretofore stated.

A. As applicable to the typhoid bacillus my opinion is that particularly with reference to this case the experiments made by Doctors Russell, Jordan and Zeit would guide my opinion on this question.

Q. As a sanitary engineer would you consider a water as being free from typhoid bacilli contained in a river at a given point when you knew that there was a city located upon that river within from four to six days flow, although bacterial observations had been made as to the longevity of the typhoid in that water, the results of which showed that their longevity was limited to two days?

A. As I have already stated in my opinion every surface water supply should be filtered because of the many uncertain elements controlling the sanitary condition of this water, and I would therefore consider such water, under the conditions you state, only with the proviso that it be filtered. The fact 11468 of the life of the typhoid bacillus being two days or twenty days would not cut much figure in my practical recommendation.

Q. Would you consider the water stated in the last question as being free from typhoid bacillus from the city mentioned in that question, which contained 1,600,000 people?

A. As a sanitary engineer I would not be able to answer that question because I would have to take this information from somebody else.

I will further say that if there was an absolute guarantee that a water supply was free from all disease germs I would then state that so far as the water pollution was concerned I should not insist upon filtration, but we are not sure that many disease germs, including typhoid, are not carried by the winds, by air, by insects—in fact, we know that they are so carried, therefore, as in the recent status of an important case, although the evidence indicated an almost impossible pollution by typhoid bacilli, I should still insist that the water be filtered as a safeguard to public health.

Q. If it is a fact that you must depend upon absolute assurance from others as to the presence or non-presence of pathogenic bacteria in a water supply, what then is the necessity of obtaining the opinion or recommendation of a sanitary 11469 engineer upon the sanitary condition of a water?

A. A sanitary engineer is employed for the practical purpose of carrying out sanitary works with the funds of the people. The engineer is a medium between the sanitarians and the money of the people. He must advise a work which is reasonable, economical and at the same time guard the people against all reasonable dangers in a sanitary way. His judgment, therefore, must be independent, and he takes into consideration all the work done by the chemists and bacteriologists and weighs this evidence in the light of the financial condition of the city which employs him, and makes that recommendation which, in his opinion, is best under the circumstances.

Q. As a matter of fact is not the work detailed in your last answer the work of a civil engineer and work which a civil engineer may execute as well as a sanitary engineer, as defined in that answer?

A. The words "civil engineer" is generic. It comprises the work of sanitary, hydraulic and other engineers. If you mean a purely constructing engineer, then I admit that the constructing engineer pays no attention to anything about the scientific purpose of his works. Whether they answer their
11470 work or not is only secondarily his province.

My own work in this country has been to take into consideration all the progress that has been made in matters where the engineer must take such progress into consideration in designing his works, and by that progress in this particular instance I mean the influences upon public health.

Q. Mr. Hering, is there any instance in your whole career as a sanitary engineer, or an instance coming under your observation as to the work of other reputable sanitary engineers or sanitary scientists where the water in a running stream has been recommended as free from the typhoid bacilli of a large and populous city existing on that watershed with a stream velocity of from 10 to 20 days?

A. Without filtration I do not know of any case exactly answering your description.

Q. The table prepared by you, or used by you, rather, giving the results of the experiments of Hiram T. Mills on the longevity of the typhoid germ is the one that you have heretofore used in your experiments and work as a sanitary engineer?

A. Whenever I was called upon to consider the question of longevity of the typhoid bacillus I have had those Massachusetts experiments in mind.

11471 Q. Is it not a fact, Mr. Hering, that you, as a sanitary engineer, when called as a member of a commission or as a consulting engineer have invariably been called upon to give an opinion with reference to the presence or non-presence of deleterious substances contained in the water?

A. No, sir.

Q. And that you have taken such observations into consideration in expressing your opinion or making your recommendations?

A. Whenever that question was pertinent, I, of course, always gave it consideration.

Q. Mr. Hering, what is it that enters into the cost of a filtration plant and the precautions that are to be used in connection with its operation as applied to the character of the water that is to be filtered?

A. The first question usually related to the turbidity of the water, that is as to the amount of suspended matter carried by such water, because the system of filtration to be recommended largely depends upon the turbidity of the water. The next chief question relates to the relative expense 11472 and the topography, the conditions, the availability or non-availability of sand, which sometimes throws the scale one way or another in deciding upon the method of filtration to be adopted.

Q. In the construction of a filtration plant do you as a sanitary engineer take into consideration the sources of pollution, of infection, of substances deleterious to public health in the construction of that filtration plant which substances and sources of pollution exist upon the river above the point where the water is to be filtered?

A. I always take those matters into consideration and have in some instances made what is called a sanitary survey of the entire watershed which yields the water to be used.

Q. In the event a filtration plant was established for the purpose of filtering the water of a certain city, and that at some point above that city a typhoid epidemic should be prevalent, why has it been deemed necessary for the management of the filtration plant to use extra precautions during such epidemic?

A. The running of a filter plant, like the running of any plant, can be somewhat variable, owing to the fact that human beings are required to take care of the management. When there exists a special danger, in that instance, as well as in all other instances where danger threatens a community or a 11473 smaller body of persons extra precautions are taken to avoid anticipated possible trouble. It is quite natural, therefore, and if I should manage a filtration plant myself, I should give the orders myself, that if a known epidemic exists there should be every reasonable precaution taken for special care to be exercised during that period.

Q. Is there an artificial filtration plant in existence which removes 100 per cent. of the bacterial contents of the water?

A. In the records which are published, and which I have seen, there are not infrequent ones where the bacteriological results give a removal of 100 per cent. of the bacteria. I remember seeing those in Europe and I believe also within a few weeks ago in Philadelphia.

Q. What is the cause in the variation in percentage of bacterial removal by these filtration plants?

A. The cause is both to be sought in irregularity of construction and irregularity of operation. It is impracticable if not impossible to make a perfect construction and it is likewise impracticable to demand of the average laborer or artisan or inspector or superintendent an absolute adherence to perfect conditions. 11474

Q. And as the degree of precaution in the management of the filtration plant increases so also the percentage of absolute removal of bacterial contents in the water is approached?

A. Theoretically I will admit the truth of that position, but practically I should say that in the ordinary operation of filter works, particularly throughout Europe where they have been managed for so many years, so far as we know typhoid fever germs have been entirely excluded. The remnant of cases that still appears in those cities is due to other causes than those of water pollution. It has been found in Europe as well as in this country that after the introduction of filter plants the typhoid fever rate has dropped generally to about one-fourth of the rate that previously existed. Some cities more and some cities less.

Q. Those cities which you have just referred to have slow sand filtration plants, have they not?

A. They have.

Q. In the construction of a filtration plant is it not a fact that sanitary engineers take into consideration the extent of the infecting material discharged into a stream above in determining the character of the plant to be recommended?

11475 A. We do take that fact into consideration.

Q. In recommending the construction of a filtration plant for the filtering of a water supply of a city which is taken from a running stream sanitary engineers would recommend the use of larger quantities of sand, if it be that character of a plant, where the water of a river was subjected to the sewage of a city of 100,000 population than if such waters were subjected to the sewage of a city of 1,000 population, would they not?

A. The population would cut no figure in my mind. We would, under practical conditions, possibly recommend one system of filtration for a highly polluted water when we would be satisfied with another system of filtration in a very slightly polluted water.

Q. Polluted or infected water?

A. In this case it is either polluted or infected water.

Q. What would be the difference in the character of the filter plants in the two cases mentioned in your last answer?

A. My personal opinion, not speaking for the profession in general, when the water is highly polluted and infected I should prefer the slow filters to the rapid filters, for the reason that the chances for infection passing the slow filter 11476 would be very much reduced as compared with the chances of passing through a rapid filter. For the same reason that I would rather be on a slow moving train than on a rapidly moving train, if this train met with an accident. It is always possible in any public work to have something go amiss, although we try to make such works upon which not only a large expense but also the health of people depends as nearly as practicable what we call fool proof.

Q. The slow sand filtration plants are more expensive than the others, are they not?

A. As a total expense generally not, sometimes less expensive but sometimes more. The facts are these: The slow sand filter almost invariably costs more to build but less to operate than the rapid or mechanical filter. By adding the interest on the investment to the cost of operating expenses the two methods cost very nearly the same, but in some instances where sand in large quantities is not readily available but must be brought from afar and where the territory is not suitable for large extensive beds, there the mechanical or rapid method is usually found more economical.

Q. Assuming, Mr. Hering, that over the conditions that existed in 1900 at St. Louis, since that time a city con- 11477 taining a population of 160,000 has grown and been built on the Mississippi river immediately above the city of

St. Louis, at the intake tower at the chain of rocks, would not conditions brought about by the discharge of the sewage from this city into the Mississippi river be considered in an item of using extra precaution, greater responsibility, more accurate and perfect means of operation in the construction or recommendation of the construction of a filter plant for that city than if such a city did not exist?

A. I should say there would be a necessity for as careful a management as is practicable in such plants, and the filter plant should be so constructed and operated to allow of as careful an operation as is practicable.

Q. Now, assuming that at all times the filtration plant thus constructed at the city of St. Louis did not remove all of the pathogenic bacteria, that the percentage of removal varied from day to day, week to week and month to month—assuming that the removal of pathogenic bacteria from the water ran in the same proportion, that is that the percentage of the removal of such bacteria ranged at different rates from day to day, week to week and month to month. Under those assumptions is it not true that a greater number of pathogenic germs would pass through the filtration plant with a city of 160,000 population existing upon the Mississippi river immediately above the chain of rocks and the intake tower of the St. Louis waterworks than there would in the event that such city was not so situated upon the Mississippi river, under conditions in both instances which existed at St. Louis prior to 1900? 11478

A. If your assumptions are correct I will be obliged to answer yes, but the conditions are such which would influence my recommendations as a sanitary engineer regarding the water supply of that city. I question very much whether I would put a filter plant immediately below so large a city, receiving the sewage of the city.

Q. Where would you put that filtration plant?

A. I would first look for another source of water supply.

Q. If possible you would put it above the city mentioned in the question, would you not?

MR. TODD: I object to the question on the ground that no such city as assumed in the question exists, and for the reason that the assumption of such a city does not simulate

11479 conditions that obtain at St. Louis at the present time.

A. I could not answer that question without knowing the local conditions.

Q. If conditions were such that you would recommend the filtration plant at the chain of rocks, without the city of 160,000 population being located immediately above, would you not consider that the filtration plant be placed above said city in the event it so existed, conditions being equal, in the event it was possible to extend it above said city?

A. If you are speaking about the chain of rocks, you are speaking about St. Louis?

Q. Yes, sir.

A. And my knowledge of the conditions there would lead me to recommend no change in the intakes of the St. Louis waterworks, under the existing local conditions.

Q. Mr. Hering, assuming that prior to 1900, a recommendation was made for the construction of a filtration plant for the water supply of the city of St. Louis at the chain of rocks, that before that plant was constructed a large and populous city of 160,000 grew up on the Mississippi river immediately above the chain of rocks, you would recommend that the location of the filter plant be changed to a point above this city which has gone up since 1900, if it was possible to do so, would you not? 11480

MR. TODD: I object to the question for the reason that no such condition as is assumed in the question can, does or will exist at the city of St. Louis, and the hypothesis sheds no light on the issues in this case.

A. My answer would be as above that I would be obliged to look into the local conditions before I could answer such a question.

Q. Under the assumptions contained in the question, taking into consideration no other element would you consider that the filtration plant remain as first located by you?

A. I must say the same thing, that I would be obliged to know the local conditions, and I will give you an instance.

Q. Mr. Hering, does a—

MR. TODD: He should be allowed to answer.

11481 Q. Assuming, Mr. Hering, that the dejecta from the typhoid patients which ordinarily exists from one end of the year to the other from a city containing a population of 13,000 people, be deposited in the Mississippi River immediately above the city of St. Louis, that prior to the existence of this discharge a recommendation had been made to construct a filtration plant at the city of St. Louis at the chain of rocks, this dejecta being deposited in said stream 38 miles above the chain of rocks, if it were possible to do so, would you not change your recommendation and recommend the establishment of the filtration plant above the place or point of discharge of the dejecta from the typhoid patients above stated?

A. Under the conditions you state I would not, and if I can now instance the case to which I had reference a moment ago I will say that two large cities, adjoining each other so that you do not know when you pass from one to the other, and both cities situated on one of the largest rivers of Europe, near its mouth, both discharged all their sewage into this stream, the upper one which is Hamburg, having a population of one million, or thereabouts, both cities on this tidal stream
114682 where the sewage of the lower city, Altona, is likely to
reach Hamburg and the sewerage of the upper city, Hamburg, is likely to reach Altona. In both cities the water supply is filtered and with excellent results, and under those conditions being well familiar with both cities for many years I would not, if I had an opportunity to do so, recommend any other method of water supply than the river water after it has been filtered.

Q. Assuming, Mr. Hering, that a certain per cent. of the pathogenic bacteria pass through the filtration plant into the water supply, would not that percentage increase on account of the discharge of the typhoid dejecta from typhoid patients in the city of 13,000 population, situated upon the Mississippi River, immediately above the intake of the St. Louis water works—the percentage that passed through the filter would increase?

A. They might. I do not know. The difference would probably be small compared with the material difference in the exclusion of bacteria even if such a city did not exist.

Q. Taking the water in its raw condition what effect would the typhoid dejecta of the typhoid patients in a city of 13,000 population, situated immediately above the city of St.

11483 Louis on the Mississippi River have upon the sanitary condition of that water supply?

Mr. Todd: I object to the question for the reason that no such city as described exists, as the only cities that exist immediately above the intake of the St. Louis water works are the towns of Alton and St. Charles, and approximate the population assumed.

A. I do not consider myself as an engineer competent to answer that question. If I wished to know it myself I would consult a bacteriologist well versed in such matters.

Q. From your experience as a sanitary engineer and in conferring with others of the profession and based upon the information which you possess, and upon which you testified as a sanitary engineer, taking into consideration the history of sanitary science, its development, the growth of bacterial science and of the science of chemistry and all that pertains to the pollution and infection of water supplies, what effect would you say that the deposit of the typhoid dejecta from the typhoid patients of a city of 13,000 population have upon the sanitary condition of a water supply when deposited in that water supply immediately above the intake, that supply being taken from a running stream?

11484 A. You ask me as to the effect that such a discharge would have?

Q. Yes sir?

A. And then I must repeat what I said before, that as an engineer I am not able to tell you what such effect would be. I would get such information, if I wanted it myself, from others especially qualified to know what such effects would be.

Q. Would it in your opinion as a sanitary engineer, taking into consideration your knowledge of the science of bacteriology and chemistry as applied to sanitary science, as stated in your qualifications of yesterday, have a deleterious or wholesome effect upon that water supply?

A. As a sanitary engineer and taking into consideration what I could learn from others regarding the question of effect, I would state that under the conditions assumed that it would make no difference with me in my recommendations, regarding a plant to be constructed for St. Louis.

Q. But particularly with reference to the sanitary condition of the water in its raw condition, what effect would it have? In other words, would such a discharge have the effect of rendering that water in its raw condition in a less wholseome state or render it more unwholesome?

A. Irrespective of the filter?

11485 Q. Irrespective of the filter—we are speaking of the water in its raw condition?

A. Then I would say that presumably the more infection contained in the water the less wholesome it would be as a self-evident proposition.

Adjourned until 2:00 p. m., same day.

11486 Met pursuant to adjournment at 2 p. m., March 11th, 1904.

Present, the Commissioner and same counsel representing the respective parties.

RUDOLPH HERING

resumed the stand for further cross-examination by Mr. Jeffries and testified as follows:

Q. Mr. Hering, one of the methods suggested by you in your report was to remove the sewage of Chicago from its water supply by conveying it upon land situated south of the city, wasn't it?

A. It was.

Q. Did you make any estimate as to the cost and amount of power necessary for the elevation of sewage upon this land?

A. I did.

Q. State whether or not a power plant constructed upon the canal at Lockport would create sufficient power to make this elevation?

MR. TODD: I object to the question as not proper cross-examination and for the further reason it is incompetent, irrelevant and immaterial to the issues in this case.

A. I took no account of such power, in regard to lifting the sewage, but estimated the usual cost for pumping the same, and in doing this I considered the fact that if there were such

power created by the waters of the canal, that this could
11487 be sold at a price which I believe is indicated in the report, or at least was in our notes from which the same was prepared, and that therefore the same amount of expenditure in one case would be balanced by the receipts in another. Therefore, the expenses would be practically the same whether the water was pumped by coal or by water power.

Q. As a matter of fact, Mr. Hering, could not the power generated by the plant mentioned by you in your report be used to facilitate the elevation of the sewage of Chicago, upon the land referred to by you in your report?

MR. TODD: Object to the question for the reason that it is not proper cross-examination and for the further reason it is incompetent, irrelevant and immaterial to the issues involved in this case.

A. It could be used, but on account of the great distance which it would be necessary to transport the power there would be a material loss in the same and that branch of engineering was not sufficiently developed at the time to enter into such a subject further than we did.

Q. Is it not a fact that the same loss would be entailed in the sale of the power as well as in its use in the particular
11488 matter mentioned?

MR. TODD: Object to the question for the reason it is not proper examination and the additional reason that it is incompetent, irrelevant and immaterial to the issues involved in this case.

MR. JEFFRIES: Is it not a fact that the same loss would be entailed in the sale of the power as well as in its use in the particular manner mentioned, and the extent of this loss would depend upon the distance of the point where the power has to be utilized from the power plant?

MR. TODD: I object to the question for the reasons stated and for the additional reason that there is no water plant or power plant.

A. The loss would depend upon the distance of transmission; the greater the distance the greater the loss.

Q. What is the percentage of loss in distance?

MR. TODD: I object to the question for the same reason.

A. I am not an expert electrical engineer and cannot tell you.

MR. JEFFRIES: Q. Why was not the proposition to continue the discharge of the sewage of Chicago into Lake
11489 Michigan recommended in preference to other propositions and especially preferable to the one which was adopted?

A. The discharge into the Illinois river under the conditions stated in the report was recommended because of the assurance that the sewage of Chicago would be sufficiently diluted to avoid offensiveness along the river at any point, and also to do no other injury, while a discharge into Lake Michigan, ascertained to be much more expensive, was at the same time surrounded with some doubt as to the character of the dispersion of the sewage by the lake currents.

The discharge into the Illinois river in the first place assured a positive removal of the sewage from Lake Michigan, the only possible source of Chicago's water supply, and the dilution which was recommended was so large that no objectionable results could be seen. The greater economy of this project and the incidental value of the works, as a navigable waterway between the lakes and the Mississippi river, made the project, while safer from a sanitary point of view, also less expensive from a financial point of view, and of greater
11490 advantage from a commercial point of view.

Q. Were you not called upon to investigate the commercial side of the cost?

A. No, sir; but this was an incidental question which entered into the consideration.

Q. It was a very remote incidental consideration, was it not?

A. It was not remote while considering the Illinois river project. It was remote, if the business project had appeared to be the purification of sewage on sand around Lake Michigan, but considering the proposition of dilution, which meant practically the establishment of a large river between the Great Lakes and the Mississippi, it would have been unfortunate, had not this large river been so designed and constructed that it would be of the greatest use to the country. For that reason, the Sanitary District Canal was built almost on a level, so as to allow the

water to assume a velocity not inconsistent with the demands
of navigation. If it had not been for that consideration it would
have cost less money to have built a tunnel from Lake
11491 Michigan directly to Joliet, giving the water a very much
larger velocity, and consequently the channel a much
smaller cross-section.

Q. But the dilution would not have been as great?

A. Assuming the dilution just the same. I might add that a proposition was considered of taking the sewage to Joliet without such dilution and below Joliet, purifying the sewage and discharging the effluent into the Illinois river, but this project was found to be so much more expensive than the others under consideration at that time in view of the limited time and funds at our disposal it was not considered in detail.

Q. That even could be done yet, could it not?

A. That could be done at a very large expense, which I approximated in a general way.

Q. But it could be done?

A. It is physically possible. It would represent, if I remember rightly, an investment of nearly eighty millions of dollars.

Q. In making these examinations, or these observations
upon which this report of yours is based, did you reach
11492 the conclusion that the sewage of Chicago could not
be discharged a sufficient distance in Lake Michigan so
as not to effect the water supply, or that the water supply could
not be extended and drawn from the lake at a sufficient distance
to be free from the sewage pollution of the city of Chicago?

A. The question was involved in sufficient doubt and the expense was so much greater than the project recommended, that in view of the limited funds and time, it was not considered necessary to remove such doubtful points.

Q. Then you mean to say, that an expenditure of $50,000,000 that with that amount the water intake cribs could not be extended a sufficient distance in lake Michigan so as to be free from the contaminating effect of Chicago sewage?

A. The question of extending the intakes ten to 20 miles into the lake was considered, but the means available at that time for estimating the cost, in connection with all other con-

siderations that I have mentioned, did not allow us to get sufficient information to cause us to reduce the estimates
11493 of costs which were given, which estimates must exceed
the cost of the proposed object, and the assurance of the direct and indirect advantages of the lake disposal were not as great as the assurance of the disposal into the Illinois river diluted as recommended.

Q. You mean to say, Mr. Herring, that there were no means at that time of determining from the standpoint of a sanitary engineer the exact cost that it would require to extend the intakes of the Chicago water-supply from 20 to 22 miles into Lake Michigan?

A. I would not say that such an estimate could have been made within 20 per cent or more of the probable cost. We have the example in the construction of the 4 mile tunnel in Chicago and of the construction of a 4 mile tunnel at Cleveland, both of which cost very much more than the estimated amount. But it is not altogether the cost, it was the doubt which necessarily prevailed in our minds, after the current observation as to whether the Chicago sewage would be transported by the current, so as to free the water delivered to the city from pollution.

Q. And that conclusion was reached by the commission
11494 regardless of where or how far into Lake Michigan the
intakes might be extended? A. No, it was reached after a general consideration of all the information available to the commission, at that time.

Q. And, in addition to those facts, you also considered the necessity of getting rid of the offensive organic material deposited in the Chicago river of the City of Chicago?

A. Certainly. The deposit of material in the Chicago river at that time was the accumulation of many years. It was not considered that there could be such a deposit to any extent after the Drainage Canal would be in operation. Therefore, as soon as these deposits had been removed by dredging them, as they were then dredging them, or in some other way, the condition of the river would be much better and would practically be free from this accumulated deposit which would be constantly taken up and carried down with the water into the Canal.

Q. Then, during these freshets which you speak of, occur-

ring in the Chicago river, in which you spoke of this
11495 forenoon, all of the deposits were not washed out thereby into Lake Michigan, were they?

A. I think not.

Q. Mr. Hering, then the result of this whole transaction is that by the opening of the Canal, the city of Chicago has avoided the deposits of organic matter coming from the sewers of Chicago, and manufacturing wastes in the city of Chicago, in the Chicago river, and while such matters are not now deposited in the Chicago river, they are carried by the waters of Lake Michigan out of the river into the Canal and thence into the Desplaines and the Illinois river?

A. There is no doubt of that.

RE-DIRECT EXAMINATION BY Mr. Todd.

Q. In the operation of a filter, what relationship do the bacteria bear to matters in suspension?

A. In very turbid waters, such as in the southern part of our country, and Missouri, it has been found that the chief desire of the engineer, in order to produce a satisfactory water, is to remove the turbidity, that is, the suspended matter in the water.

It has been found that if a very turbid water is thoroughly
11496 clarified, that incidentally thereto, the bacteria are also removed; that therefore, if we give consideration in the construction of works to the economical and complete removal of the suspended matter which caused the turbidity, we accomplish all that is desired, even to the removal of the bacteria, and, including the diseased bacteria, judging from the effects of such filters upon the occurrence of such disease.

Q. Is there any validity to the assumption that a city of 13,000 inhabitants exists upon the Mississippi river immediately above St. Louis, based upon the chart which you have introduced in evidence.

MR. JEFFRIES: I object to the question for the reason counsel has no right to impeach or discredit the testimony of his own witness, or to impeach or discredit the testimony introduced by himself.

MR. TODD: In reply to counsel I will state that there is no intention on the part of counsel for the defendants to impeach the testimony of any witness for the defense, but on the contrary to shed light upon the charts which it is evident from the questions asked by counsel of this witness, that he himelf has 11497 not demonstrated that he has a clear idea of what these charts purport to convey, and that it is for the enlightenment of counsel and the court, and not for the purposes of the impeachment of any witness.

MR. JEFFRIES: I object to counsel stating what his object is or may be, and I ask that under the rules of evidence he be bound by the questions that he has asked and the answers that he has solicited from this and other witnesses in this respect, and still insist that the question is irrelevant and incompetent because it is in effect an impeachment of his own witness and discrediting his own testimony.

MR. TODD: If counsel's conclusions are correct I know of no interest in this litigation that would more cheerfully welcome the casting discredit upon the defendant's witness than counsel himself. And I submit that the very fact that he urges this objection is a refutation of his reasons for the objection.

A. The information which the chart was intended to convey in my opinion was the relative amount of infection that would be contained in the three rivers upon reaching St. Louis, irrespective of any population residing immediately above St. Louis.

11498 MR. TODD: And this relationship is expressed by the numbers 13, 96, 107, for the three rivers respectively?

A. Yes sir.

RE-CROSS EXAMINATION by Mr. Jeffries.

Q. Now, in this chart which you have just referred to in your re-direct examination is included the population of the city of Chicago? A. It is.

RUDOLPH HERING.

ADJOURNED until Monday, March 12th, 1904, 10:00 a. m.

10:00 A. M., Saturday, March 12th, 1904.

11499 Continuation pursuant to adjournment.

Present the Commissioner and same counsel representing the respective parties.

PROF. GEORGE DOCK,

a witness called in behalf of the defendants, after being duly sworn by the commissioner, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. George Dock.

Q. What is your business?

A. I am a physician and teacher of medicine, and have the Chair of Theory and Practice of Medicine in the University of Michigan.

Q. How long have you been connected with the University of Michigan?

A. This is my 13th year.

Q. Where were you educated before taking up the study of medicine?

A. In Harrisburg, Pennsylvania.

Q. Did you graduate from that institution there?

A. I graduated in medicine at the University of Pennsylvania. 11500

Q. What year?

A. In 1884.

Q. After graduating, what did you do?

A. The next year I spent in a hospital in Philadelphia, St. Mary's Hospital in the worst typhoid fever district of Philadelphia, in Kensington, Philadelphia, where I saw a good deal of typhoid fever and I spent a year at that.

Q. What were your duties there?

A. I was an interne, and had charge of various classes of patients, and part of the time I was in the dispensary where I had to examine a great many patients and go out and see a great many patients in houses.

Q. What next did you do?

A. After that I went to Germany, to prosecute my studies in medicine, internal medicine, especially; I went to Leipsic at that time, which was very full of typhoid fever. My experience in Philadelphia, where I expected to settle, had increased my interest in the disease and I paid a great deal of attention to typhoid there. That was before they had improved the water supply and sewage of Leipsic, and there was a great deal there. I spent part of the year there, then I went to Berlin and 11501 saw a great deal of typhoid fever there. I studied the bacteriology of it in both those places and spent altogether two years over there, in the study of pathology and internal medicine.

Q. At what institution?

A. At the Universities of Leipsic, Berlin, Vienna, and in the Pathological Institute in Frankfort.

Q. After getting through there what did you do?

A. I went back to Philadelphia, where I was assistant to Dr. Osler, and Dr. Musser, in the University Hospital. I also had charge of the part of the Medical Dispensary in the University of Pennsylvania, and practiced there too. I saw a great many cases of typhoid fever, and there I began the study of malaria. Dr. Osler was then the first man in America, studying malaria. He had a great many cases brought in to him from the outside. I spent a great deal of time working on them and became very much interested in the practical diagnosis of malarial disease.

Q. Who is Dr. Osler?

A. He is now Professor of Medicine at the Johns Hopkins Hospital.

Q. Then what did you do?

11502 A. After that I had an offer to go down to Galveston, Texas, to teach medicine and pathology. I went there chiefly on account of my interest in malaria. I went down there and stayed three years. I was professor of pathology in the Galveston Medical school and physician to the Hospital connected with the medical school and the last two years I was there, practiced. In Galveston I found they were diagnosing practically no typhoid fever at all and yet I saw lots of typhoid fever patients there. I was able to see that cases that were diagnosed as malaria and typho-malaria were typhoid fever, and my experience showed me that none of these cases had malaria. I did, however, see fatal cases of malaria. They were all cases that either came from the Tropics, Nicaraugua, or Panama, or else cases from the interior of Texas, where they occasionally have very severe forms of malaria. I became very much interested in the practical diagnosis of so called malarial diseases, continued malaria, and various local names that are given to this disease, and did some work on it, wrote an article, read a good many papers on the subject before medical 11503 societies.

On one occasion I made an offer to visit any patient having typho-malaria, or continued malaria, and examine the blood free, in order to settle whether it was malarial fever or could be diagnosed as typhoid. I never had occasion to have my offer accepted.

Q. Well, in Texas did you study the characteristics of malarial fever as they obtained in the southwestern part of the country?

A. Yes, very extensively.

Q. How extensively?

A. Well, I saw many cases and examined them all very thoroughly, wrote several papers on the subject that have been widely quoted and became looked upon as somewhat of an expert in malarial diseases.

Q. After leaving Galveston what did you do?

A. I went to Ann Arbor, and there I had the same experience I had in the south. I found that the doctors were diagnosing many cases of typho-malarial fever. My interest, of course, was still alive. I examined many of those cases post mortem as well as in life, and I was able to show the same thing, cases that were diagnosed as typho-malarial and con-
11504 tinued malarial were all cases of typhoid fever. In Michigan I did not see any fatal cases of malaria at all. Since then I have examined a great many cases every year. I have cases sent in under the diagnosis of typho-malaria or some similar name and I have frequent occasion to clear up the diagnosis.

Q. Have you acquainted yourself with the characteristics of malarial fever as they occur in the Mississippi valley?

A. Yes sir.

Q. What attention have you given to the study of malaria and typhoid as it occurs in the Mississippi valley?

A. Well, now, the Mississippi valley is of course a great point in both of these diseases, and in studying the features of typhoid fever and malaria I studied the conditions and talked with many doctors throughout there, and when I lived in Galveston I always came through St. Louis two or three times a year and usually stayed over a day and had opportunities for looking around the town from a malarial standpoint. This with the eye of a malarial searcher. I was looking for malaria everywhere.

Q. Are you acquainted and have you information in regard to malarial diseases as they occur in cities along the Mississippi river? 11505

A. From conversations with doctors, not from my own observation.

Q. Have you given any attention to the questions of malaria in St. Louis and have you formed any opinion about the character of malarial fever in the City of St. Louis?

MR. JEFFRIES: I object to the question for the reason the witness said he had no experience of his own, but relied upon what others told him and therefore anything he might say would be based upon hearsay testimony.

A. Yes, as I say, in going through St. Louis I was always interested in the question of malaria. I examined the outskirts of the city, and formed the opinion that I have, which was not based upon examinations of my own, of patients but I had some correspondence with doctors in St. Louis, because I was writing on malaria, and the doctors there wrote me as to their methods of examining, and various questions connected with malaria, and I gathered some information that enabled me to form the idea, on evidence that we couldn't see with our own eyes.

Q. Are you acquainted with any literature bearing upon the subject of malaria in St. Louis?

11506 A. Yes, I have tried to read all I can find. There isn't much, the doctors there have not written much on it, but I have read some of them.

MR. JEFFRIES I object to the witness stating he has read the literature unless he states what it is.

MR. TODD: Q. Will you state what you have read on the subject?

A. Well, I have read a number of articles in the local journals. It would be hardly necessary for me to mention the articles, but I might mention an article by Dr. Bremer, a well known physician of St. Louis.

MR. JEFFRIES: I object to the witness stating anything the doctor has said in the magazine article for the reason it is incompetent, and I object to the production of the magazine for the reason it is no evidence that it is the opinion of Dr. Bremer, and that it is incompetent evidence.

MR. TODD: Q. Have you got that article with you?

A. Yes sir, I have.

Q. Will you produce it?

11507 A. Yes. I have here a medical journal known as the Medical Review, a weekly journal of medicine and surgery published in St. Louis and the number I have is the number for August, '95. In this article Dr. Bremer states as follows:

"In our part of the country and probably throughout the larger part of the United States, physicians are apt even today to look upon many ailments as due to malaria, which in reality have nothing to do with this disease either directly or indirectly." There is a foot note, which is as follows:

"This means St. Louis and environments in particular, and the Mississippi valley in general, but it probably applies to the whole United States."

In another place he states as follows:

"Peoriodic chills, followed by high temperatures, which mark the initital stages of so many cases, are generally interpreted as due to malaria, hence the erroneous and mischievious diagnosis, malaria, remittent fever, or typho-malaria, under which names so many cases of typhoid figure in the reports of our city Boards of Health."

11508 Also the following: "Now, a practical question, to what extent does malaria exist in our part of the country (The Mississippi valley) and particularly in St. Louis, basing my opinion on the examination of about five hundred individual cases of all sorts of individuals, many of whom were examined over and over again within the last seven or eight years, I have come to the conclusion that in our city at least, malaria is an extremely rare disease, so rare indeed is this disease, at least in its pronounced forms, that when about four years ago I went to the City Hospital for a number of months in the hope of finding a good, plasmodium infected subject, my efforts were unsuccessful for a long time. The cases pointed out to me by attending physicians as malaria and treated as such, proved to be infections which had nothing in common with that disease."

MR. JEFFRIES: I move to strike out the matter which the witness has just read into the evidence, as being an article purporting to be written by Dr. Bremer, of the City of St. Louis, for the reason that there is no evidence showing that this Dr. Bremer is not within the legal jurisdiction of the Com-
11509 missioner, and therefore there is no reason why he should
not be called upon the subject matter, so that the complainant might have an opportunity to cross-examine.

MR. TODD: In reply to the objection will state, that the same rule applying to the admissibility of this class of testimony, if made to apply to the same class of testimony offered by the complainant, in nearly every witness, with few exceptions, as having testified on complainant's side of the case, is invoked, I have no objections.

A. I might say that this bears out the experience I have had myself in various places, having the general climatic conditions of St. Louis in mind, and especially with the experience I had in 1898, in some of the army camps. I was asked by the Surgeon General—

Q. State what experience you had in the army camps to which you referred, in detail?

A. I was asked by Surgeon General Sternberg, of the United States Army, at that time, to visit certain army camps in order to examine the blood of patients diagnosed largely as malaria. In accordance with that, I examined the Sternberg general hospital at Chickamauga, the hospital at Knox-
11510 ville, and at Camp Meade, Pennsylvania. At that time
most of the cases of typhoid in the army camps were

diagnosed malaria. In the Sternberg hospital, for example, there were 400 patients when I got there, and practically all of them had a diagnosis of malaria, in one form or another, typho-malaria, bilious remittent, or some such name. I examined most of these patients individually. I examined their blood and examined their clinical features with the result that I found only one case out of the whole 400 had malarial fever.

I also made some autopsies on patients dying with so-called malarial fever, and found that they had typhoid fever, without malarial.

Then I went to Camp Meade, Pennsylvania, where the conditions were practically the same. When I got there 80 per cent of all the fever cases had a diagnosis on their bedsides of malarial fever with various modifications of the malarial part. Within a few days those diagnoses were changed just around, 80 per cent typhoid, and 20 per cent malaria. I examined all the suspected malaria patients, many of those who had been suspected as having malaria, and there, too, I found only one patient out of several hundred that really had mala-
11511 rial fever. The disease was in practically all the cases typhoid.

At Knoxville, I was not able to find any malarial cases.

I reported this matter to the surgeon general, but my report has not yet been made public.

Q. What other experience have you had, outside of the army camp, and what you have already given, in regard to the question of malaria and typhoid?

A. Well, such experience as a doctor has treating patients in general hospital work, where people are likely to be sent in with local diagnoses, and even in Michigan, I still see physicians who are giving wrong diagnoses for typhoid fever.

Q. Have you made a special study of typhoid fever?

A. Yes sir.

Q. How extensive have been your studies upon the subject of typhoid fever?

A. Well, I have been studying it persistently for about 20 years. I have made several hundred autopsies on patients who died from typhoid fever, not all of them my own patients,

however—and on a great many patients diagnosed as
11512 either having typhoid fever or having some other disease. In such cases, the diagnoses were often wrong. For example, that of typhoid fever would be mistaken for some other disease or some other disease would be mistaken for typhoid fever. From such experiences I think I have seen a good deal of typhoid fever.

Q. Have you made a special study of the so-called germ diseases?

A. Yes sir.

Q. Do those diseases caused by germs come within the scope of your studies?

A. Yes, very intimately.

Q. Have you made any study upon typhoid fever and malarial fever from the standpoint of a bacteriologist, or clinician?

A. Yes sir.

Q. In connection with such study as you have detailed, have you taken up the question of the proper diagnosis of fevers of the kind known as typhoid and malarial?

A. Yes, very particularly.

11513 Q. Have you had any experience in the diagnosis of these fevers either in the laboratory or at the bedside?

A. Yes, very extensive.

Q. What is typhoid fever in its clinical diagnosis?

A. Typhoid fever is an infectious disease caused by the germ known as the typhoid bacillus, characterized by certain swellings in the lymphatic glands, especially in the alimentary canal, and the mesentery glands, and the spleen, and sometimes in the other organs, like the kidneys, the lungs, and the nervous system, and also in the blood, characterized clinically by fever, by certain eruptions, by enlargement of the spleen, and a tendency to diarrhoea, a tendency to the swelling of the abdomen, to a certain change in the nervous system associated with delirium, and varying very much, so that, in its automical and clinical features, in many cases there may be very little fever, and in some cases all common symptoms are absent, and the ordinary clinical picture of typhoid may not be seen. Among

the most important tests of the disease is the so-called Widal reaction, which consists in a change produced on the ty-
11514 phoid bacilli, by subjecting them to the action of the blood of a patient with typhoid fever, and another very important test is the finding of the typhoid bacilli in the blood.

Q. What is intermittent fever and its clinical diagonsis?

A. Intermittent fever is a name formerly used largely as a synonym for malarial intermittent fever and the name is still used by many people for a common form of malarial fever, but it is a very unsatisfactory name because there are a great many diseases that have intermittent fever. This is a fever that at certain intervals disappears leaving the temperature about normal.

Q. What is remittent fever and its clinical diagnosis?

A. Remittent fever is another unsatisfactory term. Some malarial fevers are remittent, but a great many other fevers are remittent. Diseases like typhoid fever, tuberculosis, various kinds of blood poisoning, frequently have remittent fever. This is a fever in which the temperature does not reach normal, but that has remissions, that are more marked than those that occur normally. That is to say more than about two
11515 degrees Fahrenheit a day.

Q. What is typho-malarial fever and its clinical diagnosis?

A. Typho-malarial fever is a name that is no longer used by any careful clinician or pathologist or bacteriologist, because it has been so loosely applied. There is no definite disease now known as typho-malarial fever. The name, as we find it in practice, usually is applied to typhoid fever.

MR. JEFFRIES: Q. Mild cases?

A. Not always mild, some of them severe. But the word is also used very largely as a cover for diagnostic difficulties. Various diseases that are not more accurately diagnosed have the name of typho-malarial given to them.

MR. TODD: Q. What is congestive fever and its clinical diagnosis?

A. There is no definite disease known as congestive fever. Any fever that can be recognized by the thermometer is some-

times spoken of as congestive fever. It does not mean any definite disease at all. It is merely a symptom, but the
11516 name is given to various diseases.

Q. What is simple continued fever and its clinical diagnosis?

A. Simple continued fever is a name given to various diseases, and the name as given has not been more accurately diagnosed. It is applied in cases of mild fever. All sorts of fevers that doctors cannot trace down to any more definite cause.

Q. Are remittent, intermittent, typho-malarial, congestive and simple continued fevers distinct types of disease and so recognized by bacteriologists and clinicians?

A. No sir. Usually all such names are included by careful boards of health under the heading of typhoid fever.

Q. What significance do you attach to these terms as applied to fevers when they appear in vital statistics of health reports?

A. As I have just said, they usually refer to typhoid fever. My own experience with them among doctors and in the hospitals and in the post mortem room is that they are applied to typhoid fever in the majority of cases.

11517 Q. Do the sypmtoms of typhoid fever closely simulate the symptoms characterized under these headings?

A. Sometimes rather closely, yes. Especially if one is not particularly educated on the finer diagnostic points. An examination of the blood of the malarial organs, on one hand, or the typhoid reaction on the other, usually clears them up very quickly, but, to a casual glance, the diseases may be very much alike.

Q. Assume that the number of deaths reported as occurring from typhoid fever in the city of St. Louis as evidenced by the annual report of the Board of Health of the city of St. Louis Health department is as follows:

1890	140
1891	165
1892	441
1893	215
1894	171
1895	107
1896	106

	1897	125
	1898	95
	1899	131
11518	1900	168
	1901	198
	1902	222
	1903	288

And assuming for the sake of the question that the number of deaths for the respective years correctly represent the typhoid condition in the city of St. Louis, what is your opinion based upon the statistics as assumed in the foregoing question as to whether there has been an increase in typhoid fever in the city of St. Louis during the last ten years?

MR. JEFFRIES: I object to the question for the reasons that the conditions existing prior to '95, are different from the conditions subsequent thereto and subsequent to the opening of the Drainage Canal and therefore the typhoid statistics for the city of St. Louis, for a date prior to '95, on account of the change in the waterworks of that city are not comparable with the typhoid data of a subsequent date or period.

A. The figures show an increase.

(Question repeated.)

A. I should say there has been an increase, but not a great increase.

11519 MR. TODD: Q. How is it manifested from the statistics and give the reasons for your answer?

A. Well, the increase, say, for the last five years, or even six years from 1895 to 1903, is a steady and gradual increase. There is no one point, there, where one can see a sudden increase out of proportion to the general line. I am particularly struck by this increase since 1898 because in 1898 the doctors all over the country had their attention very strongly called to the wrong diagnoses that were formerly made in the so-called typhoid diseases, and the attention of the public has been very strongly called to it.

Q. In what way?

A. As shown in the army camps, especially. That there soldiers were dying of typhoid, that were supposed to have malaria. The people found out it was possible to make a more

accurate diagnosis, and doctors in my experience in various parts of the country have been more careful in their diagnoses since '98. They have been using more accurate means of diagnosis, such as the microscope, and the bacteriological test, so that, while I see an increase I wouldn't call it a great
11520 or a sudden increase.

Q. Assuming the statistics in the foregoing question as above indicated and assuming further that the number of deaths reported in the same reports under the headings remittent, intermittent, typho-malarial, congestive and simple continued fevers, is as follows:

1890	226
1891	296
1892	326
1893	284
1894	179
1895	155
1896	177
1897	172
1898	134
1899	148
1900	112
1901	80
1902	102
1903	91

Do the number of deaths reported occurring from typhoid fever alone in the city of St. Louis properly represent in
11521 your opinion the total number of deaths actually occurring in that city in the period in question?

A. No.

Q. What reasons have you for stating that they do not?

A. The most important reason is that the death rate from malarial diseases is altogether too high, too high for every year. Take an exceptional year for typhoid, when there was an accidental condition, the malaria there is 50 per cent higher than it was two years before. In 1890 there were 226 cases of the malarial disease. I include all these various diseases in malaria. In 1892 there were 326. Now, from studying malaria very carefully at that time, I say there was no reason why malaria should increase in a city like St. Louis to that extent at that time. The death rate in every year is altogether too high in a city like St. Louis. It is higher than I believe possible.

Q. What is malarial fever?

A. Malarial fever is a disease caused by certain animal parasites that live in the blood, and, that are characterized clinically by different kinds of symptoms. In the first place, 11522 cases with intermittent fever, a fever that varies from normal, or about normal, to several degrees above, every day or every other day, or every third day, sometimes by remittent fevers, where the temperature does not reach normal, but varies more than about two degrees Fahrenheit, every day, and sometimes by rather irregular fevers, and sometimes causes a condition known as malarial cachexia, where the patient is weak, anaemic, and has various symptoms that might not strike one as being due to malarial disease originally.

Q. Are there different, distinct types of malarial fever?

A. Yes sir.

Q. What are they?

A. In the first place there is the tertian type in which the patient has a paroxysm every other day, and the quartan type, with a paroxysm every third day or at intervals of 72 hours, and then there may be combinations of these types so that the patient may have the fever every day and may even have more than one paroxysm in a day, or other combinations of the various paroxysms. Then, there are remittent fevers that 11523 are caused by a different kind of parasite in which the fever may go as high as it is in the intermittent fever and even higher, but the temperature does not fall to normal during the course of the disease. These are the more dangerous kinds of malarial fever. They are often spoken of as tropical fevers because they are especially common in the tropics. And these are the chief types. All other types are combinations, or varieties of these.

Q. Are those types found in this country?

A. Yes.

Q. To any extent?

A. No, not above the latitude of Arkansas. They may occur sporadically as far north as Baltimore, or Philadelphia or Chicago. In such cases they occur very sparingly, so sparingly that even a very experienced malarial student may not see a case of this kind.

Q. What is the type of malaria that is common in the central states of the Mississippi Valley?

A. The intermittent form.

Q. Have you had any experience with that type of malarial fever?

11524 A. Yes sir.

Q. Is that type of malarial fever considered a fatal type of fever?

A. Practically never. Nobody ever dies of it unless he has had some previously exhausting disease.

Q. To what do you attribute the failure of these statistics assumed in the foregoing hypothetical questions, to properly disclose the number of typhoid fever deaths occurring in the city of St. Louis?

A. To the use of the term "malarial fever, typho-malarial fever," etc., applied to certain cases of typhoid fever.

Q. Why is it that the doctors employ the terms remittent, intermittent, typho-malarial, congestive and simple continued fevers to fevers that are recognized as being either typhoid or malarial, or some other disease?

A. There are different reasons. In the first place, very often the doctor has an incomplete idea of the diagnosis of typhoid fever. That is, his idea of typhoid fever is not correct. Then, he does not use the methods of diagnosis necessary. Very often, possibly, it is done for what might be termed business reasons or social reasons, a doctor does not like to give out the impression that his town has a lot of typhoid fever
11525 in it. Or, he may even have an intimation from the
health authorities not to give it out. In the army camps, surgeons were frequently ordered by superior officers not to make out a diagnosis of typhoid fever. All these reasons apply in various towns to different degrees, health reports, for example, the diagnosis of typhoid fever is always very unpopular. They

fall back on some other word, especially tpho-malarial. Cities that are going to have World's Fairs in them always object to having such a name used. In places where people might be frightened by the diagnosis of typhoid, there is an instinctive feeling on the part of doctors that they ought to use some other word.

Q. Do you know of any city in the country where the death rate from malarial fever alone is as high as in the city of St. Louis, as evidenced by the number of deaths as assumed in the hypothetical questions under the heading intermittent, remittent, typho-malarial, congestive and simple continued fevers occurring in the reports of the Board of Health of the city of St. Louis?

A. Well, the only city that I could find that gives out such a rate is New Orleans, where, in the first place, the
11526 probability of getting malaria is much better than in St. Louis, and where also the typhoid diagnosis is very often wrong.

Q. Have you any particular knowledge upon the condition at New Orleans in regard to typhoid?

A. Well, I have taken pains, and especially when living in the South, to find out about the conditions there. I made no examinations myself, there.

Q. What proportionate deaths in the column under the heading remittent, intermittent, typho-malarial, congestive and simple continued fevers, assumed in the foregoing hypothetical questions as occurring in the city of St. Louis as evidenced by the Board of Health, in your opinion should be classed as typhoid?

MR. JEFFRIES: Object to the question for the reason that any answer the witness may give would be speculative, not knowing more of the conditions at St. Louis than the witness has testified to, and therefore any opinion he might express would be uncertain and unreliable.

A. From the statistics that have been furnished, and from my experience in the diagnoses of typhoid fever, and typho-malarial fever, I should say it would be impossible to say exactly how many cases, but anywhere between 50 and 90

11527 per cent of the so-called malaria ought to be called typhoid. At least 50 and probably as many as 90.

MR. TODD: Q. What proportion as malarial fever?

A. That would be speculation, too, but probably not more than 2 or 3 per cent. For a city like St. Louis a death rate of 2 or 3 per cent from malarial fever would be very high.

Q. What do the mortality statistics of malaria show in cities where careful attention has been paid to malarial fevers as regards the number of deaths occurring from malarial fever?

A. Well, there are no cities in this country that have actual statistics on that point. The best places to get statistics are in hospitals, where they pay special attention to malaria, and an experience of a hospital like the Johns Hopkins Hospital, where they have climatic conditions, rather more favorable for malaria than those of St. Louis, might be taken. In ten years, they were able to get only three deaths from malarial fever. That is practically nothing at all in comparison to what St. Louis has in one year.

Q. Is it generally recognized by bacteriologists, clinicians and pathologists that classifying typhoid fever in one
11528 column, and intermittent, remittent, typho-malarial, congestive and simple continued fever in another column, in board of health reports of cities, is an improper classification from a scientific standpoint as affording a true indication of the mortality from typhoid fever and malaria?

A. It is generally recognized, and most careful boards of health refuse to accept such classification, because all such diseases should be put in the typhoid table.

Q. Have you in mind any board of health?

A. The board of health of Michigan, for instance, orders that all typho-malaria be classified under typhoid, and the new classification recommended by the United States census makes that same recommendation.

Q. Assuming that the reports of the board of health of the city of St. Louis, by the month, from 1895 to 1903 inclusive, under the heading, typhoid fever, which for the purpose of convenience, is designated A, in the table as follows, and as intermittent, remittent, typho-malarial, congestive and simple continued fevers for the sake of convenience is designated as B, in the table of columns, which table was prepared and sworn to by Prof. Jordan, is based upon said reports, and is as follows:

11529 ST. LOUIS.

	1895		1896		1897		1898		1899	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
Jan.	12	10	4	13	7	7	4	6	10	4
Feb.	3	7	4	10	9	5	6	10	7	8
March	3	8	3	6	7	11	7	9	4	6
April	7	7	4	11	4	13	6	8	5	6
May	6	9	9	10	7	8	2	8	2	12
June	6	14	6	7	9	18	7	10	5	8
July	9	8	13	23	10	17	9	13	9	18
Aug.	17	15	29	34	18	20	9	14	6	30
Sept.	9	32	13	27	17	31	14	18	16	28
Oct.	15	24	9	20	17	24	12	12	15	16
Nov.	13	8	7	14	15	13	7	13	32	8
Dec.	7	13	5	2	5	5	12	13	20	4

A—Typhoid Fever.

B—Remittent, intermittent, typho-malarial, congestive and simple continued fever.

11530 ST. LOUIS.

	1900		1901		1902		1903	
	A.	B.	A.	B.	A.	B.	A.	B.
Jan.	19	6	8	5	14	5	15	4
Feb.	5	3	14	0	16	6	15	1
March	16	9	11	4	11	9	20	4
April	4	7	4	7	14	3	17	4
May	4	7	8	7	11	8	15	8
June	8	12	6	9	7	4	18	8
July	15	9	13	15	14	12	27	10
Aug.	20	20	31	5	26	7	37	10
Sept.	13	20	24	9	21	16	42	17
Oct.	30	9	32	11	32	17	29	17
Nov.	15	3	27	5	31	9	24	3
Dec.	19	7	20	3	25	6	31	5

A—Typhoid fever.

B—Remittent, intermittent, typho-malarial, congestive and simple continued fever.

11531 Will you please state what construction you place upon this table, as showing the relative mortality from typhoid fever and malarial fever in the city of St. Louis during the periods covered by the foregoing table?

A. The chief conclusion I draw is, to conform to what I said before, as to statistics regarding malarial diseases, that they are not altogether faulty. It comes out more clearly when one studies the reports of malarial diseases by months, where the death rate is altogether impossible for malaria, in the latitude of St. Louis. For example, the typhoid deaths reported for the months including January, February, March and April, nobody dies of malarial fever in that latitude in those months. Severe malarial disease cannot occur then. It might occasionally happen that a man would die of Bright's disease who had malaria years before, and his death might be reported as from malaria, but that would not be such a case as we are speaking of now. Even in such a malarial country as the Philippines, malaria does not kill all the year round. In several months, the months corresponding to our winter season, they do not have any deaths from malarial fever.
11532 A study of this table would be enough to show that the whole malarial statistics of that town are seriously faulty.

Q. Assume that the added totals of tables from typhoid fever and the tables from remittent, intermittent, typho-malarial, congestive and simple continued fevers as they appear in the reports of the Board of Health of the city of St. Louis, is as follows:

1890	361
1891	381
1892	767
1893	499
1894	350
1895	262
1896	283
1897	297
1898	229
1899	279

1900	280
1901	278
1902	324
1903	379

11533 What do these totals as above indicated represent in your opinion, as the mortality condition of the typhoid fever in the city of St. Louis, covering the period as above indicated, after allowing the said remittent, intermittent, typho-malarial, congestive and simple continued fever column such proportion as being typhoid fever as in your opinion you should allow, what is your opinion as based upon the statistics as assumed in the foregoing hypothetical question as to the typhoid deaths under the remittent, intermittent, typho-malarial, congestive and simple continued fevers, tables, in the city of St. Louis, as to whether the said statistics show an increase or decrease in the typhoid fever mortality in the city of St. Louis, since 1899, eliminating the year 1892, which was the year of a special epidemic?

A. They do not indicate a marked increase, though they indicate a slight and gradual increase from the year '98. An increase that I would explain partly from the fact that the diagnosis of typhoid fever has become broader, all over the country. More cases are being included. There is a tendency everywhere to increase the proportion of typhoid cases in that way. There has been a slight and gradual
11534 increase.

Q. Is the increase as marked under this interpretation of the statistics as it is taking the typhoid fever column as heretofore assumed as the measure of typhoid conditions in St. Louis?

A. It is not as great, no.

Q. Is there anything in the statistics as they appear, to show any explosion of typhoid fever, as due to any particular cause manifested in these statistics?

A. Not at all. The increase for example is slightly more marked for the year 1901, but even there it is not at all striking. It is not such a thing as we find, for example, in the case of Butler, Pennsylvania, or in the case of Cornell College, in the town of Ithaca.

Q. Assume that two circular letters, one issued in the fall of 1900 and another issued in the fall of 1901, were issued by the Health Commissioner of St. Louis, calling the attention of physicians to the fact that the law requires them to report all cases of typhoid and all deaths from typhoid and at the time that the letters were sent out, the question of opening the Drainage Canal was being agitated in the public press of the city of St. 11535 Louis, and there was considerable discussion and an investigation was going on at that time of the analysis of the samples of water collected, etc., and was attracting considerable attention. From your examination of the statistics of St. Louis as heretofore assumed in the hypothetical question heretofore asked you for the years 1900, 1901, and 1902, as compared with previous years, does the effect of such a letter, assuming that the same had been sent out to the doctors by the Health Department of St. Louis, manifest itself in those statistics?

A. I think the sending out of such a letter would explain the rise that has occurred in the last five years. Of course we have to stick to the last two years, on account of the letter, but the increase is not so great as one might expect. Such an order or such a letter, calling attention of physicians to the fact that the law required them to report all cases of typhoid, has been carried out in many other cities, and the increase has always been marked, I mean, has been distinct. Here there is an increase, too, but it does not strike me as being very much greater than it was in the three years before.

Q. These are deaths, not cases.

11536 A. I should say deaths.

Q. How does it manifest itself in the typho-malarial column?

A. That goes down, as one might expect. Doctors having their attention called by the notification would report more cases as typhoid, and less as typho-malarial. than they had before.

Q. From your examination of the typhoid and typho-malarial group of deaths as assumed in the foregoing hypothetical questions, what is your opinion as to whether these two tables taken separately, correctly show the typhoid conditions in the city of St. Louis for the period mentioned?

A. My opinion is that the two tables taken separately do not correctly show the typhoid condition.

Q. Upon what do you base your opinion that they do not correctly show the typhoid conditions of the city of St. Louis, taking them separately?

A. For the reasons I think I have mentioned before, that the diagnoses of malarial diseases were almost entirely erroneous and should have appeared largely under the head
11537 of typhoid.

Q. From your knowledge of these classes of fevers mentioned in the two columns of vital statistics as heretofore assumed, how should they be treated by clinicians and statisticians and pathologists in order to arrive at the true typhoid fever mortality in the city of St. Louis?

A. The safest way would be to look upon all these anomolous fevers as typhoid. It would not be accurate to say—one could not use them accurately because there is not enough evidence to make an accurate conclusion.

Q. Assuming that the following table testified to in evidence by Prof. Jordan, as compiled from the typhoid fever mortality, and typho-malarial, etc., mortality of the health reports of the city of St. Louis and based upon the mortality of the city of St. Louis for the years 1890 and 1900 according to the United States census reports and the intervening years estimated by Farr's formula, which table is as follows:

11538

TYPHOID FEVER DEATH RATES.
ST. LOUIS.

Year.	Population.	Death rate per 100,000 of typhoid fever alone.	Typhoid fever plus 50 per ct. of deaths recorded under heading intermittent fever, etc.	Typhoid fever plus all the deaths recorded under the heading intermittent fever, etc.
1890	451,709	30.0	56.67	81.2
1891	462,763	35.6	58.98	82.3
1892	474,077	93.0	127.40	161.7
1893	485,668	44.2	73.52	102.7
1894	497,565	34.3	52.24	70.3
1895	509,740	29.9	30.35	51.3
1896	522,225	20.2	37.37	54.1
1897	533,762	23.4	39.53	55.6
1898	548,590	17.3	29.53	41.7
1899	361,510	23.3	36.49	49.6
1900	575,238	29.2	39.07	48.6
1901	589,315	33.5	40.39	47.1
1902	603,736	36.7	45.21	53.6
1903	618,510	46.5	54.0	61.3

11539 Will you please state what is your opinion based upon the tables heretofore read, as to whether typhoid fever has increased or decreased in the city of St. Louis since 1900 over the conditions that obtained in St. Louis prior to 1900?

MR. JEFFRIES: I object to the question for the reason that it does not restrict the answer to periods subsequent and prior to January 7, 1900, and they are not comparable with each other.

A. The table does not show that there has been a marked increase; on the contrary, a slight increase. Such an increase as I would ascribe rather to increased care in diagnosis, rather than to any outside conditions.

MR. TODD: Q. What effect would local conditions have upon an increase such as you have defined it to be?

A. The figures are compatible with such slight increase, as we find here, and typhoid fever, in most places, like most other diseases, runs cyclicly, without any fresh conditions from

the outside, or any marked condition in the matter of water supply or drainage. I should think in the last two years there would have been conditions in St. Louis which would
11540 have increased the typhoid incidents. The fact that
many people were going there, people not accustomed to the climate, perhaps living carelessly. In nearly all such times we see such epidemics breaking out.

Q. What effect do wells in a city have upon the typhoid conditions?

A. One of the most serious sources of typhoid fever where they have surface drainage and wells both, the conditions are especially dangerous. In cities that have a good water supply, but still have wells, they always have a distinct amount of typhoid fever. The wells in small cities and in rural districts are very serious causes of typhoid fever.

Q. Assuming that on April 1, 1895, the total number of wells in the city of St. Louis was 4,846, and assuming that pursuant to an order of the Board of Health of St. Louis, directing an examination of these wells, that the city chemist, after examining 59 wells, condemned them as being unsanitary, and, assume further that in August, '95, upon the report of the city chemist condemning seven more of these wells, the Board of Health of the city of St. Louis, passed a resolution that
11541 the city should make no further examination of the wells
in question, and since August, 1895, none of these wells has been condemned, what effect would this number of wells in the city of St. Louis have in your opinion upon the typhoid conditions existing in the said city, assuming that the water of these wells was used by the inhabitants for drinking and domestic purposes.

A. It would be a very serious source of typhoid fever.

Q. From a consideration of the statistics that have been assumed in the foregoing hypothetical question, and the condition of typhoid fever in the city of St. Louis, for the period referred to, what in your opinion is the cause of such slight increase in typhoid fever in St. Louis, as you have stated? Give in full your reasons for your opinion?

A y opinion is that the increase indicates rather a change in the conditions of the city of St. Louis itself rather than in the main water supply, supposing that the main water supply comes from a river.

A change in the condition of the river water is always indicated in such cases by a more marked increase. As to such an increase as we have here, it is altogether compatible with changing local conditions, such as wells, and the ordinary
11542 course of typhoid epidemics.

ADJOURNED until 2 p. m., same day, March 12, 1904.

11543 2:00 o'clock p. m., March 12, 1904. Continuation pursuant to adjournment.

Present, the Commissioner, and the same counsel representing the respective parties.

PROF. GEORGE DOCK

resumed the stand for cross-examination by Mr. Jeffries, and testified as follows:

Q. Are you now engaged in the active practice of medicine?

A. Yes sir.

Q. What school of medicine do you belong to?

A. The regular school.

Q. Do you know what school Dr. Bremer belongs to?

A. No. I imagine he belongs to the regular school, too.

Q. Don't you know it to be a fact that he is a specialist, and not engaged in fever practice of any kind?

A. Well, along about that time he was very actively engaged in the examination of the blood, made quite a reputation for himself, as a blood expert.

Q. His practice, though, was not extended to typhoid
11544 and other fevers at that time, and has not been since that time?

A. Well, I don't know what his practice has been since then. While his practice might not include those diseases, I see no reason why he should not be credited with having worked on the subject.

Q. Did you ever practice medicine in St. Louis?

A. No sir, I never did.

Q. What was the extent of your examination in typhoid fever mortality in St. Louis, that you made?

A. Well, the only investigations of the mortality have been those of the figures submitted to me.

Q. What was the character of your examination, with reference to the particular disease known as malarial fever, at St. Louis?

A. This included a study of the reports that have been published by the doctors, and the literature. I had to read up on the literature of malarial diseases, and tried to read what the doctors there had published about malarial conditions.

Q. Did you examine malarial fever patients while there?

11545 A. No sir.

Q. Made no examination except what you found from the reports?

A. I examined some written descriptions at one time, sent me by a doctor who was investigating malaria, there, a doctor who is now dead, Dr. Blickhahn. Blickhahn began writing me on account of having seen some of my papers on malaria. I gave him a good deal of assistance in working up the subject. He used to send me his preparations, to see whether he had the right thing or not, and he wrote me at one time, after he had been working at the thing about two years, that he had never been able to see a certain form of malarial organism, that is, the so-called crescent. I was rather surprised at that, because I would have rather supposed, I would have thought that he would find crescents in St. Louis. Crescents are found in the more severe form of malarial fever. The severe types have these bodies associated with them. Blickhanhn wrote me that he had not been able to find them and asked me to send him one of my specimens. I sent him some specimens that I had brought from Texas. I supposed he had simply overlooked them, 11546 but he wrote back and said he had really not seem them, up to that time. That was additional evidence that severe forms did not occur frequently there, although of course they might occur now and then. I have paid little more attention to the conditions in St. Louis, than I have a good many other towns.

Q. When was that?

A. That was during 1903 and 1904.

Q. You never visited St. Louis, for the purpose of making any special determination?

A. No sir.

Q. You only speak of such observations as you had while passing through, or in discussing the matter with other physicians?

A. And reading the articles.

Q. What diseases, Doctor, are fatally allied, of a fatal character with typhoid fever?

A. I do not think I understand your question.

Q. Well, are there any diseases?

A. I don't think I understand your question, in reference to the word, "allied."

11547 Q. What fevers known as fevers which would produce death, may in a sense be associated with typhoid fevers?

A. Well, in this country there are practically none, especially in the northern latitudes.

Q. You mean, then, in this latitude, that every death that is attributed to fever, is from typhoid fever?

A. No, not that. I mean to say that any disease that sets up any very great infection, in a large number of cases, is typhoid. There are in some other countries, such fevers, typhus fever, for example, even that, at the present time, that we cannot distinguish quite positively from typhoid.

Q. How does typhus fever differ from typhoid fever?

A. Well, the chief point in their diagnosis is that it does not give a Widal reaction. You do not get the typhoid germs out of the blood. They are very difficult to distinguish without those tests.

Q. Is that disease common in this country?

A. Typhus?

Q. Yes?

A. Very rarely. They are only brought in at long intervals.

Q. From what country?

11548 A. Particularly from Russia, nowadays. Sometimes from Ireland, and sometimes possibly from Mexico.

Q. Is there anything in the natural conditions of this country that would prevent its spread or distribution in this country over those of countries where it is known to be prevalent?

A. Yes sir, very distinctly. Typhus fever is a disease of extremely bad sanitation and poor feeding. It can hardly exist without those conditions.

Q. And in that respect it differs from typhoid?

A. Yes. Of course that is not a clinical difference, though.

Q. What cities have you examined the mortality record of, with reference to making a distinction between the various fevers, and typhoid fever?

A. Well, I have examined such places as New Orleans, Baltimore, Washington, New York, and Philadelphia.

Q. How do those cities compare with St. Louis?

A. I cannot give you a definite answer, because my information of the mortality reports was not very great. I would not look on it as being very useful evidence. I found, 11549 however, in Baltimore, just about the same climatic conditions, if anything a little bit worse than in St. Louis. I found that their reports of deaths from malaria were lower, proportionately to the population than they were in St. Louis. In Washington they were about the same, but the statistics in Washington have been shown by some doctors, some of the leading doctors there, to be extremely faulty, and in that respect they have shown that practically all the cases represented as dying from malaria, were cases of typhoid.

Q. From your examination of the mortality records of St. Louis, you have arrived at the conclusion that physicians of that city are not competent to make the determination as to the character of the disease?

A. I would not say that all the physicians, but I have already put myself on record as saying that a large number of the physicians are not making correct diagnosis in these diseases, and I have no hesitation in repeating it here.

Q. And you have expressed that opinion altogether from the record?

A. Partly from the record and partly from the facts bear- 11550 ing upon the occurrence of this disease, and partly from my experience in certain definite places where I have investigated the actual cases, and partly by becoming familiar with a good many doctors, from all over the country. In the army camps, for example, I saw doctors from every state, and saw how they made their diagnosis, and I was able to see that a large majority of them were making faulty ones, and I was able to demonstrate that they were.

Q. And in that way you observed that these physicians had been instructed by the government to report the disease as something else than typhoid fever?

A. Not by the government, no.

Q. Where did these instructions come from?

A. They were not wide-spread, or general instructions. And they were not medical officers, but military officers.

Q. Will you name some of them?

A. Well, I do not believe I could recall their names, now.

Q. At what place?

A. At Chickamauga.

Q. What time?

A. In September, '98.

11551 Q. Who was in charge?

A. At the time I was there, Dr. Giffin was in charge of the hospital. He, however, was not a military officer. General Brooks had been in charge and left soon after I got there.

Q. You don't know whether Gen. Brooks gave that order or not?

A. I don't believe Gen. Brooks did.

Q. Do you believe that his successor did?

A. No, I think it was some inferior officer.

Q. Well, if you cannot name the officer who gave the instruction, or the order, how did you know that the order was made?

A. I had a statement from persons that I thought were reliable, and in such repeated form, and so pointedly expressed, I had no doubt about it, at all.

Q. Tell some of those persons that gave you that information?

A. Well, I have not any record of their names. I could not give you the names, now.

Q. Have you the means of ascertaining their names?

A. I could ascertain some of them, if I had access to the record. One of them is a surgeon now, for the United States army. I can give you his name, Dr. Charles F. Craig.

11552 Q. Did he tell you where he got his information, or orders?

A. I do not think he got orders; he got information, I think he mentioned the names at the time, but of course I wasn't interested in remembering those things. My duties were simply to diagnose the cases.

Q. Then it is from what you obtained from those army officers who were not in superior power, that you speak of, that you believed that such orders had gone out, did you?

A. I did, yes sir. I did not understand, however, those were formal orders that were given over every large command, but I believe that such orders were given, and influenced certain doctors in making certain reports.

Q. After obtaining this information, did you call upon those doctors and see whether or not there was any truth in the statement?

A. No, but I examined their patients.

Q. But you said nothing to them, at all?

A. Well, I was too busy to discuss the matter with them.

Q. What were your duties?

A. I was examining the patients.

11553 Q. Who for?

A. For the Government.

Q. Did you say anything to the government about these instructions that had gone out?

A. No.

Q. That orders had been given to withhold typhoid statistics?

A. No, I simply reported my results.

Q. You made no report upon that proposition at all, as to what you had heard?

A. That was not a part of my duty.

Q. What you heard reported among the army officials, that was not a part of your duties?

A. That was not a part of my duty at all.

Q. On the contrary, it was your duty to keep still, was it?

A. No sir, I had nothing to do with the case at all. I was there to examine certain patients and I did that.

Q. What patients were you there to examine?

A. Any patient that might be said to have malarial fever.

Q. At that time?

A. At that time, yes sir.

Q. How many patients did you examine, there, in round numbers?

A. Four hundred. And there were really more than four hundred, but actually about four hundred patients in the
11554 beds at one time.

Q. All of whom had typhoid fever?

A. Not all of whom, but most of whom.

Q. Now, is there any other instance in your experience where such orders have been given, by army authority?

A. I do not recall any similar statements in the other camps.

Q. Do you know of any such authority having been given?

A. No.

Q. That is the only instance you have in mind at Chickamauga?

A. Yes sir. But I would not say that is an isolated instance, because there were a large number of separate, small camps.

Q. But I mean the instance of Chickamauga, and the conditions that existed there with reference to this particular character, or order, is the only camp, army camp, that was subjected to an order of that character?

A. That is the only one where I have a distinct recollection of such a thing having been talked about.

Q. Upon the tables which were read to you, this morning, and which tables were introduced in evidence by Prof. Jordan, I will ask you if a comparison of the strict report of ty-
11555 phoid fever cases, based upon the number of deaths, per 100,000 population, for the year '96, 22.22; '97, 23.4; '98, 17.3; '99, 23.3; 1900, 29.2; 1901, 33.5; 1902, 36.7; 1903, 46.5, making an average for the four years immediately prior to the opening of the canal, of 22.8 per 100,000 and the four years immediately following the opening of the canal, 36.5 per 100,000,

I will ask you if that does not show, based upon the tables reported, an increase of about 74 per cent?

A. You ask me whether the tables show?

Q. Yes?

A. Well, I could only tell by calculating it, and I am not here as a calculating expert.

Q. From the face of the tables, themselves, can you make any estimate of the approximate increase?

A. I could if I calculated it, but I say it shows an increase on the face of the figures.

Q. Doesn't it show a very large increase?

A. It shows a considerable increase, yes sir, I would not call it a very large one.

Q. Taking one-half of column B, or one-half of the intermittent, remittent, typho-malarial, congestive and simple 11556 continued fevers, for those years mentioned in the last preceding question, I will ask you if it does not show a very decided increase?

A. No, I don't think it shows as much of an increase as the first column, for typhoid, alone.

Q. No, but it shows a decided increase?

A. It shows an increase, yes sir.

Q. Going back to the straight typhoid, as reported, I will ask you if 74 per cent increase would not be considered by you as a great increase?

A. It would be a great increase for the town, for the people who were sick, but it would not indicate necessarily a radical difference in the question of infection.

Q. That based upon the population, of cases per 100,000, would not an increase of 74 per cent be considered by you as a physician, a great increase?

A. No.

Q. It would be an increase, then of no material difference, and of very little consideration?

A. I say it would be a very important difference to the people who were sick, and for the town, but it would not 11557 mean that there was a very radical change in the mode of infection. Where a change takes place in the method of infection in a town that always has typhoid, the change is much greater than the fraction of 100, it is several hundred per cent, or at least more than 100 per cent, that is what I mean.

Q. You mean, in cases of epidemics?

A. In the case of an epidemic. For example, the difference of 70 odd per cent might easily occur in a place like Chicago, or a place like Philadelphia.

Q. And when you as a physician realize that the typhoid fever in your town is increasing at a rate of 74 per cent, would you consider that of any importance, and would you make any effort to observe the cause, or ascertain the cause?

A. Yes sir, I would.

Q. And bring about conditions that would eliminate the increase?

A. I have just said I think it would be very important for the town, but I would not look for an outside cause.

Q. Would you look for a milk epidemic, or something of the kind?

11558 A. I would look for a well, or a milk infection, or some other local cause of epidemic.

Q. And you would make that observation for the entire four years, or eight years,—four years preceding and four years subsequent, would you?

A. I don't think the time would have any bearing on the question.

Q. If it came from a milk epidemic it would be localized, wouldn't it?

A. Milk epidemics usually do not get so broad, and do not last so long. I would not think of it as a milk epidemic.

Q. If a milk epidemic, it would likely last a long while and it would be localized?

A. It depends on what you mean, by localized.

Q. Localized in the vicinity, would be an infected well?

A. If there were a number of wells, each well would serve as a focus.

Q. And you would expect more typhoid in a district where there were more wells?

A. Yes sir.

Q. What would you say if you found out that there was 11559 less increase in typhoid in a district where there was a greater number of wells, than there was in a district where there were no wells?

A. I would look for some change in the treatment of the epidemic, then, the people might have been more careful in the use of the wells, might have the necessity to boil their water.

Q. And they might have had a different physician?

A. Yes sir, a different physician.

Q. You take those things into consideration?

A. Very much.

Q. Of more consideration than you would the water supply, regardless of what character that water supply was?

A. Of course I would suppose that the water is being examined all this time.

Q. Examined for what?

A. For its bacterial purity or the reverse.

Q. Doctor, confining yourself to the four years preceding and the four years subsequent, I will ask you if there hasn't been tables introduced by you, or by Prof. Jordan, referred to by you, in your examination which show an increase in the typhoid fever, in the city of St. Louis?

11560 A. There has been an increase.

Q. Even though you transfer all the remittent, intermittent, congestive, etc., fevers, into the typhoid column?

A. There has been an increase, yes sir.

Q. Based upon the number of cases per 100,000 of poulation?

A. Yes sir.

Q. What are the conditions in New Orleans, so far as climatic influences over various fevers are concerned, that do not pertain to the city of St. Louis?

A. New Orleans is in a much more malarial climate.

Q. Now how far does that malarial climate extend to the north, from New Orleans?

A. Well, it gets weaker as it goes north. The same climate does not extend any appreciable distance. It becomes weaker as you go up.

Q. It extends into Arkansas. I believe you said this morning?

A. Yes sir.

Q. Up as far as what?

A. Red River.

Q. Doesn't it extend through the bottoms of the Mississippi river, throughout the entire area of the State of Arkansas?

11561 A. Yes sir, you could even go further and say it extended all through the whole Mississippi valley, but it gets weaker as it goes further north.

Q. It is more effective in the summer time, than in the cooler seasons?

A. Yes sir.

Q. Is it not a fact that it is very prevalent throughout the entire state of Arkansas?

A. My information on that is not very complete. There is a good deal of difference of opinion among the local doctors, I find, from talking to them, and writing to some of them.

Q. Is it not a fact that it was more prevalent throughout the entire state of Arkansas three years ago and prior thereto than it has been since?

A. I do not know.

Q. You made no investigation of that character?

A. Not of that actual point, no.

Q. Is it not a fact that it was more prevalent prior to 1900, throughout the entire Mississippi Valley, than it has been since?

A. I do not know, myself. I would be very skeptical
11562 about any statements that were made on that point.

Q. You made no examination of that kind?

A. No sir.

RE-DIRECT-EXAMINATION BY

Mr. Todd.

Q. Doctor, in figuring out the percentage of figures, assume that the average for '95-6-7-8, of the percentages for the four years before 1900, was 21.05, and for the four years subsequent 36.5, and that the difference between these averages was 15.45, in figuring out the percentages by dividing 15.45 by 21.05 gives a percentage of practically 73 per cent, does that 73 per cent in your opinion, figured upon the basis that I have indicated in arriving at it, express a large increase in typhoid fever?

A. No, but I should say that I consider your method of getting at the result, very faulty. For example, the increase did not occur in a single year, but spread over a series of years, and it is not a figure that varies, up and down in those years,
but goes up steadily. If the 73 per cent had occurred be-
11563 tween '99 and 1900, I should say that either there must
have been a new focus of infection, or else that the old
focus must have been extremely badly handled but as it is spread over four years, and the ascent is gradual, and really began a year before the point of deviation, I still adhere to my former statement that it is not a great increase.

Q. You understand that the figures you are now testifying to are figures based upon the estimation that the typhoid fever death rate as reported in the house statistics, and estimated, do not include the other heading of typhoid fever?

A. Yes sir.

Q. In figuring out the per cent of increase does the average give as correct an idea as to the relationship existing between each year?

A. No.

Q. Will you figure the per cent of increase from 1898 to 1899, in percentages?

A. 34.7.

Q. Will you figure the per cent of increase from 1899 to 1900, in percentages?

A. 25.3.

11564 Q. Will you figure the per cent of increase from 1900 to 1901, in percentages?

A. 14.7.

Q. Will you figure the per cent of increase from 1901 to 1902, in percentages?

A. 9.5.

Q. Will you figure the per cent of increase from 1902 to 1903, in percentages?

A. 26.7.

Q. From these percentages of increase, taking it by the year, which year shows the greater increase over the previous year?

A. The first one.

J. Taking these percentages of increase by the year, what is your opinion as to whether they are large increases, or not?

A. No, they are not large increases.

Q. What is your opinion as to the validity of figuring the increase of typhoid fever in a community, in basing the percentage of increase upon the average per cent of increase for a given period?

11565 MR. JEFFRIES: I object to the question, because the witness is not an epidemiologist, or a sanitarian.

A. Well, I think I can answer that as a clinician. The percent for periods of time is an artificial one. There might be local conditions in any one year that would offset the average too much. In all such statistics there is a very serious error, depending upon the comparatively limited number of cases that we have to deal with, so that the difference in any one year would offset the average too much. So that I always work those things out on scales, because the scale, taken year by year, gives a better idea of the course of the diseases than a bunch of years, even reduced to a scale.

Q. These statistics which have been assumed as coming from the column of typhoid deaths, and not the typho-malarial, etc. deaths, in St. Louis, do you regard as correctly giving the typhoid deaths in the city of St. Louis?

A. The reports of typhoid deaths, alone?

Q. Yes sir.

A. No sir.

11566 RE-CROSS-EXAMINATION BY

Mr. Jeffries.

Q. Taking the number of typhoid deaths per 100,000 population for 1897, at 23.4, as the highest number reported during any one of the four years immediately prior to 1900, compared with the average number of deaths for 100,000, for the four succeeding years, 1900, 1901-2 and 3, please state the percentage of increase or decrease?

MR. TODD: I object to the question as affording no proper method of comparison, to compare one year with the average per cent of four years not separate, and wherein three years have intervened.

MR. JEFFRIES: I will admit that by taking the highest number occurring in any one of four comparative years prior to 1900, that no proper conclusion could be drawn, but that an error in that conclusion or result reached would be in favor of defendants and not the complainant, and therefore, as a precautionary measure will afford a more liberal application of the probable results of the two periods.

A. I get an increase of 55.99 per cent.

Q. What is the percentage of increase or decrease in the number of deaths reported per 100,000 population for the
11567 highest year during the period of '96 to '99 inclusive, and from 1900 to 1903, inclusive?

A. 98 per cent increase.

Q. Now, what years did you employ in that calculation?

A. The years 1897 and 1903.

Q. I will ask you if the result shown on this table for the four years from '96 to '99, does not show that there was an alternate increase and decrease year by year in this to wit, '96, 20.2; '97, 23.4; '98, 17.3; '99, 23.3, and that since 1899, to wit, the years 1900 to 1903 inclusive, there has been a continual increase?

A That is right.

RE-DIRECT-EXAMINATION BY

Mr. Todd.

Q. If the percentage of increase in '99 over '98 was 34.7, in 1900 over '99 was 25.3; in 1901 over 1902 was 14.7; and in 1902 over 1901 was 9.5; in 1903 over 1902 was 23.7, would the fact that the Exposition in the city of St. Louis was going on in these years, in any measure account for the difference in increase of 1903, over 1902?

MR. JEFFRIES: I object to the question for the reason 11568 that it calls for an answer impeaching the testimony of this witness in his direct examination in which he stated that it was a fact, and it is conceded by counsel to be a fact in this instance, that enterprises such as World's Fairs have the effect to cause physicians to fail to report typhoid fever as true typhoid, and causes them to report it in some other column.

MR. TODD: In view of counsel's explanation, I will not press the question.

GEORGE DOCK.

ADJOURNED until 10:00 o'clock A. M., March 14th, 1904.
March 12th, 1904.

STIPULATION.

It is hereby stipulated between the parties to this action, that the evidence heretofore taken in said action, before John A. Bishop, a Notary within and for the City of St. Louis, and State of Missouri, on the 24th day of October, A. D., 1903, being the evidence of LewIllys F. Barker, and consisting of 327 typewritten pages; and also the evidence taken on the 9th day 11569 of November, A. D., 1903, before Fred A. Burton, a Notary Public in and for the County of Cook and State of Illinois, being the evidence of C. D. Cassingham, Frank L. Stevens, and Walter George Sackett, consisting of twenty-eight typewritten pages, which was taken before Notaries instead of before the Commissioner, for the accommodation of the witnesses named, all of which said testimony is this, the 12th day of March, A. D., 1904, presented to the Commissioner herein, shall be received in evidence upon the trial of this action, the same as though such evidence had been taken before said Commissioner, Frank S. Bright, appointed by said Supreme Court, it being understood that each party reserves all objections to said evidence, which were made and noted at the time said evidence was taken, and that this stipulation is not to be regarded as a waiver of any such objections, and further, that in the printed record of said case, such evidence shall be incorporated.

SAM B. JEFFRIES,
Ass't Att'y Gen'l of Mo. for Complainant.
JAMES TODD,
Solr. for Sanitary District of Chicago.

Which said evidence is as follows:

Southern Hotel, St. Louis, Missouri.
11570 10:00 A. M., Saturday, October 24, 1903.

Parties met pursuant to agreement.

Present:

Attorney-General Crow,
Mr. Jeffries,
Attorney-General Hamlin,
Mr. Todd.

11571 LEWILLYS F. BARKER,

called as a witness in behalf of the defendants, being first duly sworn by John A. Bishop, a Notary Public within and for the city of St. Louis and State of Missouri, testified as follows:

DIRECT-EXAMINATION,

By Mr. Todd.

Q. What is your name?

A. Lewellys F. Barker.

Q. Where do you reside?

A. Chicago, Illinois.

Q. What is your business?

A. I am a profesosr in the University of Chicago.

Q. How long have you been connected with the University of Chicago?

A. A little more than three years.

Q. In what capacity are you connected there as a professor?

A. I am professor in the medical faculty, temporarily in charge of the department of anatomy, pending the establishment of a research department of internal medicine.

Q. How long have you been in charge of that department?

A. Ever since I came to Chicago.

11572 Q. What did you do prior to coming to Chicago?

A. I was nine years associated with the medical faculty of Johns Hopkins University at Baltimore, Maryland.

Q. In what capacity?

A. My first year I was an assistant to Professor William Osler of the department of internal medicine; then for two years I was fellow in pathology and bacteriology with Professor Welch, and then I was appointed to an associateship in anatomy with Professor Mall; then to assistant professorship in anatomy, and during my last period in Baltimore I was made associate professor of pathology with Dr. Welch of Johns Hopkins.

Q. Prior to your connection with Johns Hopkins University, what did you do?

A. I was a year as interne or house physician and surgeon in the Toronto general hospital, immediately after my graduation in medicine.

GENERAL CROW Toronto, Canada?

A. Toronto, Canada, yes sir.

Q. MR. TODD: From what school of medicine did you graduate?

A. The University of Toronto.

Q. Did you take an academic course prior to that?

A. No, I had a summer college course, but not the A. B. course. 11573

Q. After you graduated from the medical school at Toronto where did you go?

A. I went for one year in this hospital in Toronto, as the acting house physician and surgeon, then I went immediately to Johns Hopkins and was there for nine years and then came to Chicago; but I was away from Baltimore at various periods studying in Germany and on various commissions.

Q. What schools in Germany did you attend?

A. I spent most of my time at the University of Leipsic.

Q. Any other school?

A. I visited other schools, but did no special work in other places.

Q. What commissions were you on while connected with the Johns Hopkins University?

A. The first commission was one established by the State Board of Health of Maryland. Dr. Flexner and I were sent to the Loona County Valley to study an epidemic of a peculiar disease, the diagnosis of which seemed uncertain, but which turned out to be epidemic cerebral spinal meningitis. Then in 1899—

Q. Just before going to that, describe what you did in the investigation of that epidemic—briefly?

A. We proceeded to the district and found a large number of people of various ages ill of the disease, examined 11574 them clinically, made microscopic and bacteriological examinations of the blood and feces and urine and were successful in getting autopsies of some of the cattle dead of the disease and of making bacteriological examinations of the tissues after death,—examinations which resulted in an absolute determination of the nature of the infection.

Q. From where did the infection come?

A. In the epidemic of cerebral spinal meningitis?

Q. Yes?

A. No one knows. It is due to a micro-organism, but just how the micro-organism gets into the membranes of the brain and spinal cord, no one is just quite sure. There are theories about it but it is not settled.

Q. Not established?

A. Not absolutely established.

Q. Then what other commissions have you been on?

A. In 1899 the Johns Hopkins University sent Dr. Flexner and myself as special commissioners to study the tropical diseases in the Philippine Islands, and incidentally to study the epidemics of plague and beri beri in Hong Kong, India 11575 and Japan.

Q. How long were you on this commission?

A. We were six months on that commission.

Q. Relate what you did and what the results of that investigation were?

A. In Japan we were fortunate enough to visit Gute's laboratory and meet there Shiga who worked out the bacillus of acute dysentery in Japan. That proved to be a very important visit for us, for later in Manila we were able to isolate some of the cases of dysentery in those islands, with apparently the same bacillus as Shiga had isolated in Japan. In Manila too, we had an opportunity of studying an epidemic of 200 cases of beri beri, at Cavite, seven miles from Manila.

Q. What is beri beri?

A. Beri beri is a disease which occurs in two forms, the dry form and the wet form, so-called, the dry form being characterized by degeneration of the nerves or paralysis and loss of sense. The wet form being characterized by dropsical confusions in different parts of the body, a very curious disease the nature and etiology of which are not clearly established as yet.

In Manila there was abundant opportunity for the study of the three diseases very prevalent in the Island, namely, typhoid fever, malaria and the acute tropical dysentery, and
11576 we were able also to not only study a large number of
cases of leprosy, but to make biological examinations and autopsies of a number of lepers dead in various stages of the disease.

Q. Give the details of the investigations, doctor made in the Philippines, and the conclusions arrived at, if any were arrived at by you?

GENERAL CROW: With reference to what?

FR. TODD: To the diseases which he investigated there.

GENERAL CROW: There is no use in encumbering the record with all these other diseases; he can state the facts of his investigation. Do you want to put it all in?

MR. TODD: I want to put it in. Make it brief.

A. Well, in brief, through the courtesy of the Surgeon-General of the Army and of the Navy we had access to all the army and naval hospitals, and also to the native hospitals and Spanish hospitals, and the studies were clinical, including microscopic and bacteriological studies, and when deaths occurred we made autopsical and bacteriological examinations. The most important result of the trip is the special work of my colleague, Dr. Flexner, who was getting out the serum for the treatment of infections with this dysentery bacillus which we all hope may be helpful in abating that infection.

Q. What was the result of the investigations in regard to the typhoid fever made there?

11577 A. The result was the confirmation of the studies of typhoid elsewhere. Nothing especially new came out of our study of typhoid in Manila.

Q. What other investigation did you make in Manila aside from this that you have stated?

A. I think those were the principal investigations.

Q. Where else did you make investigations?

A. When we were at Hong Kong we were permitted to make autopsies on cases of plague and also bacteriological studies of cases of plague, but we had a far better opportunity in India where we saw eight hundred cases of plague in one day at Poona.

Q. What are the characteristics of the disease known as plague?

A. In the majority of cases a swelling occurs either in the groin or in the arm pit or neck, due to an infection of the lymphatic glands with the bacillus of the plague—the plague bacillus.

Q. Is that a contagious disease?

A. Yes, a very contagious disease.

Q. And how is the bacillus transmitted?

A. The absolute details are not established, though the probability is that insects transfer it from infected animals, especially rats to human beings.

11578 Q. What kinds of insects?

A. Possibly fleas, but it is not established.

Q. To what extent was the investigation carried on in India?

A. In India we spent six weeks—five weeks visiting various cities. It was a combination of pleasure trip with an investigating trip and our observations in India were chiefly clinical and a viewing of autopsies. The main benefit of the trip in India was to see the really great epidemic, which was the first great epidemic we had ever seen,—800 cases every day, with a patient coming in at the front door every eight minutes, and a dead one being carried out the back door every ten minutes.

It was an impressive sight rather than anything else. One could realize what a great epidemic would be.

Q. Have you been appointed on any other commissions except those by the Johns Hopkins University?

A. Yes, the first year I came to Chicago I was appointed by the Secretary of the Treasury in Washington, along with Professor Flexner of the University of Pennsylvania, and Professor Novy of the University of Michigan, to proceed to San Francisco and investigate the disease prevalent there among the Chinese, and to ascertain whether or not it was bubonic plague.

Q. Did you make a report upon your investigation?

11579 A. Yes, an extensive report was made to the Surgeon General of the Marine Hospital service in the department of the treasury, establishing the existence of the plague in San Francisco. We saw several cases of the disease during our visit, and made pathological and bacteriological examinations, and animal experiments and proved absolutely that the disease was bubonic plague.

Q. Have you investigated any other epidemics that those that you have described?

A. Well, in Baltimore of course, during the whole nine years, I had the opportunity of studying the epidemics of typhoid that existed in the city. Typhoid is quite prevalent at various times of the year, especially in the spring and autumn, as was also malaria in Baltimore, so that I had the opportunity there of becoming very familiar with both diseases.

Q. To what extent did you investigate the typhoid disease and malarial conditions in the city of Baltimore?

A. To the extent of one giving all his time to scientific work in a pathological line, and the investigation of cases coming into autopsies and coming into the wards of a hospital, which was given over largely to the search.

Q. Will you describe the conditions that obtained in Baltimore and the conclusions that you arrived at as to the cause of the typhoid?

11580 A. There seemed to be no doubt from observation of the conditions that the water supply of Baltimore is a polluted supply, and that at any rate a majority of the cases of infection was water-borne. Doubtless some of the cases were cases of so-called secondary infection of typhoid from contact or from environment or food stuffs.

Q. Have you made any studies of the question of typhoid fever?

A. Yes sir.

Q. What is the cause of typhoid fever—cause or causes of typhoid fever?

A. The reception into the body of a susceptible individual of a sufficient number of virulent typhoid bacilli.

Q. What are the means by which these bacilli are transmitted into the body of a human being as determined by scientific investigations as of today?

A. In a majority of cases through the mouth—by far the majority I should think—more than ninety-five per cent of the cases through the mouth.

Q. Through what means?

A. Through the drinking of polluted water, or of infected food or through the contact of fingers or other objects contaminated with typhoid bacilli.

11581 Q. What are the means by which the food becomes infected?

A. The food might be infected either from water which was already infected, or by contact of other materials, like fingers that had come into contact with typhoid excreta, typhoid urine or typhoid feces or typhoid infected dust.

Q. Do you know whether flies are in any way responsible for the spread of typhoid fever?

A. Yes, there is a great deal of evidence that flies can carry typhoid bacilli from one place to another; flies alighting upon typhoid excreta can contaminate their legs with typhoid bacilli and alighting upon food can leave typhoid bacilli upon the food.

Q. Do you know of any instances where epidemics have originated from that source?

A. Yes, it seems extremely probable that some of the more localized groups of cases in the city of Chicago have been due to infection by flies. The studies of Dr. Alice Hamilton point in that direction.

Q. Are you acquainted with the results of the investigation of Dr. Hamilton?

A. Yes.

Q. When were these investigations made?

A. Within the last two years, in the city of Chicago.

11582 Q. What are the facts connected with that investigation?

A. Our investigation was an experimental investigation, proving in the first place that flies can carry the organisms from one place to another and cause infection of nutrient media in that way. Then she demonstrated the possibility of flies having come in contact with typhoid excreta in the city of Chicago in the region infected—

MR. JEFFRIES: Is the witness testifying from a publication now?

MR. TODD: Yes.

MR. JEFFRIES: It would be well to have him state the publication and the source of his information, and show the probability of food infection in this way.

Q. Where did you get the information from?

A. From conversations with Professor Hektoen of the department of pathology under whose direction the work was done.

GENERAL CROW: Is that all the source of your information?

A. That is my source of information. I consider it the best possible one.

GENERAL CROW: Well, we move to strike all that with reference to experiments made by Dr. Hamilton, out of the record, for the reason that it is simply hearsay testimony.

MR. TODD: Q. Has her investigation been published,
11583 do you know—the result of her investigation?

A. Yes sir.

Q. Do you know where?

A. I cannot give you the reference. It would be very easy to get it though.

Q. Dr., will you state what is remittent fever, intermittent fever, typho-malarial fever, congestive fever and simple continued fever?

A. Those are all clinical rather than pathological terms, and date back to the time when classifications had to be made on symptomology rather than upon pathology and etiology.

The remittent fever was the term given to a fever which had exacerbations and declines without reaching the normal, as a rule, while intermittent fever—

GENERAL CROW: Without the temperature reaching normal?

A. Without the temperature reaching normal.

And intermittent was the term given where the temperature went up high and came down to the normal, then up high again and down to normal.

Typho-malarial fever was a term given to cases which were believed to be by many, a fever distinct from typhoid, and distinct from malaria, a fever which ran the course of typhoid, but which had many symptoms resembling those of malaria
11584 while congestive fever was a very vague term used in different ways by different clinicians and was usually associated with the idea of congestion of the head, rush of blood to the head, along with the fever, while simple continued fever was a term applied by, as a rule, the less well-educated physicians, to mild forms of fever running over a considerable period, generally over more than ten days or two weeks. It was a term used by people who believed that such fevers were not typhoid and not malaria, but simple continued fever. They didn't know exactly what it meant. Now all of those terms are given up by good clinicians at the present time; there is no such thing as a remittent fever as a clinical entity any more. It is either typhoid or malaria, or acute tuberculosis, or some other infection, and usually it is possible during life to determine that a case of so-called remittent fever, or intermittent fever in the same way, may be one of several diseases perhaps. Most often what is designated intermittent fever is malarial fever, but cases of typhoid fever are often mistakenly designated as malaria, intermittent, etc. The congestive fever might be one of

various things; sometimes it is typhoid and sometimes it is malaria. Sometimes it is something else.

Simple continued fever may be typhoid. I think perhaps most often it is—

11585 G9NERAL CROW: Mild cases?

A. A mild case of typhoid fever. It may be something else. None of those terms would be used now by a skilled clinician.

Q. Have you made a special study of fevers?

A. In as far as that a man working in internal medicine a large part of his time, and in pathology must make a study of fevers.

Q. Have you examined the statistics of typhoid fever in St. Louis as given by the health reports of St. Louis?

A. I have.

GENERAL CROW: For what time?

MR. TODD: For the period of—from 1890 to the present time.

A. I have. I have an excerpt from the reports here giving the figures of the Board of Health.

Q. Are those figures taken from the official publications of the Board of Health of the city of St. Louis?

A. They are.

Q. Have you the statistics of typhoid malarial fevers?

A. I have the statistics under the head "remittent, intermittent, typho-malarial, congestive and simple continued fevers. They are grouped together under one head in the official report.

11586 Q. Will you read these statistics for the different years that you have them, as taken from the official reports of the Board of Health of St. Louis?

GENERAL CROW: For what disease; for typhoid fever?

MR. TODD: For the different fevers—these two groups.

A. (Reading):

Year.	Typhoid fever.	Remittent, Intermittent, Typho-malarial, Congestive and simple continued fevers.	Total.
1890	140	226	366
1891	165	216	381
1892	441	326	767
1893	215	284	499
1894	171	179	350
1895	107	155	262
1896	106	177	283
1897—the figures vary slightly in different reports; in one report:	125	173	—Total 297 or 298 according to the report.
1898	95	134	229
1899	131	148	279
1900	168	112	280
1901	198	80	278
1902	222	102	324

11587 Then I have the death rates—the typhoid fever death rate in St. Louis as estimated from the official reports.

GENERAL CROW: Estimated?

A. As figured out from the official reports—or calculated, if you like. It is simply a mathematical case.

GENERAL CROW: Those were cases and not deaths you gave?

A. These are actual deaths. This is the death rate.

GENERAL CROW: For what?

A. For the city of St. Louis.

GENERAL CROW: Yes, but for what diseases; do you mean total mortality?

A. For typhoid fever alone, and total mortality as compared in parallel columns:

11588

ST. LOUIS.

		Death rate per 100,000.	
Year.	Population.	Typhoid alone.	Total death rate.
1890	451,709	30.9	81.2
1891	462,753	35.6	82.3
1892	474,077	93.	161.7
1893	485,568	44.2	102.7
1894	497,565	34.3	70.3
1895	509,740	29.9	51.3
1896	522,225	20.2	54.1
1897	533,762	23.4	65.6
1898	548,590	17.3	41.7
1899	561,510	23.3	49.6
1900	575,238	29.2	48.6
1901	589,315	33.5	47.1
1902	603,736	36.7	53.6
1903	618,510		

The figures of course are not available for the death rate, and I have for comparison the report of deaths from Baltimore during four or five years under these two similar groups of diseases.

In the year 1899, typhoid fever alone, 153; remittent, intermittent, etc., 48,—total, 201.

1900, typhoid fever alone, 182; remittent, intermittent, etc., 51; total, 233.

The population in that year was 508,957.

In 1901, typhoid 141; remittent group, 35; total, 176.

In 1902, typhoid 220, remittent group, 31; total, 251.

11589 MR. TODD: Where were those statistics from Baltimore secured from?

A. From the health reports of the city of Baltimore.

Q. Do these reputed causes of death which you have read into the record appear in the vitality statistics of the Board of Health reports of the city of St. Louis?

A. Yes.

Q. With the exception of Baltimore?

A. Yes.

Q. What is your opinion as to the justification of including these under one head as is done in the St. Louis health reports?

A. Well, I think that under the circumstances the medical practitioners, trained as they are, there is nothing for the Health Board to do but to include them as they do, under that heading, at the same time—

GENERAL CROW: Under which head?

A. I mean the remittent, intermittent, typho-malarial, congestive and simple continued fevers. Those reports are sent in by the physicians to the Board of Health as deaths from those causes, and the Board of Health cannot very well do anything but tabulate them in that way. Of course from what I have said, it is clear that in my opinion those cases are nearly all cases of something else, cases of some disease that could 11590 be diagnosed by skilled physicians—

GENERAL CROW: Mostly typhoid?

A. Mostly typhoid, and some of them perhaps acute tuberculosis, but chiefly typhoid. In fact I think the addition of the two columns, the typhoid column and the remittent, intermittent, typho-malarial, congestive and simple continued fevers, would give a truer typhoid death rate in the city of St. Louis than any other of the statistics that we could get.

Q. MR. TODD: Is it probable that any of the deaths reported from these causes during a series of years might with modern methods of diagnosis appear under some other heading?

A. Yes, I think that the majority of those under the heading of remittent, intermittent, typho-malarial, etc., if examined carefully, by skilled clinicians would be definitely diagnosed as specific diseases which we know about.

Q. Are there any other reasons on the clinical side for confusion of diagnoses in dealing with these diseases?

A. Yes, there are reasons especially where men are not trained in the most modern methods of diagnoses where it would be extremely difficult for a practitioner who has not been trained in the recognition of the malarial parasite, to decide between many cases of malaria and many cases of typhoid fever.

It would be extremely difficult for a man who is not 11591 familiar with the modern agglutinative and bacteriolytic tests to distinguish between many cases of typhoid fever and cases that are not typhoid, but resemble it.

Q. What is the final and distinguishing differential test for typhoid fever and for malaria?

A. The most important clinical test we have for typhoid fever if I may say, a single test, the most important single test though no one test is sufficient in my opinion to rely upon always in the diagnosis of typhoid, the most important single test is the Widal reaction or agglutinative test. More important still is the symptom complex along with the presence of the Widal reaction.

GENERAL CROW: You mean the condition of the patient?

A. The whole condition of the patient, the temperature, apistaxis, the mental condition, the abdominal distention, the tenderness and gurgling in the abdomen, the character of the stools, the enlargement of the spleen, the rose spots on the abdomen, the character and time of disappearance of the headache, the onset of the delirium when it occurs, and so forth.

Q. For malaria what is the final distinguished differential test for that fever?

A. For malaria, the one test above all others, is the
11592 demonstration in the blood or tissues of the patient of
the malaria parasite, by microscopic observation.

Q. What is the cause of malarial fever?

A. There are three great varieties in malarial fever, each due to a specific protozoan parasite, easily recognizable under the microscope; three varities easily distinguishable from one another. The nature of the symptoms being easily predicable by one familiar with the life history of the parasite by simply an examination of the blood—microscopical examination of the blood.

Q. Are these tests always applied by physicians?

A. Unfortunately not, for only a comparatively small percentage of physicians are trained in the method of making the examination.

Q. Are the symptoms of these diseases baffling so that even an experienced physician might sometimes be deceived in his diagnosis unless modern tests were applied?

GENERAL CROW: We will admit all that.

A. Yes sir, that is true.

MR. TODD: In view of all these facts as you have related them, does it appear from the figures given in the report of the St. Louis Health department, that there has been an in-
11593 crease of typhoid fever in the years 1900 to 1902 inclusive as compared with the ten preceding years, in the city of St. Louis?

A. It is absolutely certain if these statistics are reliable, that there has been no increase.

Q. What do the statistics show?

A. The statistics show that the total number of deaths reported from typhoid and the remittent group together, run along at a tolerably constant figure. The figures, however, show in the typhoid fever column alone an increase in the number of typhoid cases; quite a marked increase during the last three years, from 1900 to 1902. They also show quite a marked diminution in the remittent and intermittent group during the last three years. There has evidently been simply a transfer from the remittent column to the typhoid fever column. In other words, typhoid fever has been diagnosed more often during the last three years, than it has in the last preceding years. There has been no greater number of cases, but the diagnosis appears to have been better. That the diagnosis is not yet good by many of the physicians in St. Louis is obvious from the large number of cases still reported in the remittent group.

GENERAL CROW: Are you talking about cases or deaths?

A. Deaths. When I say cases here I mean deaths every
11594 time. And I have no doubt that the discrepancy of cases existing would be infinitely greater than the death report shows.

Q. MR. TODD: Will you read into the record the statistics upon which you base that information, calling particular attention to the conditions before 1900 and since 1900?

A. Well, whereas, with the exception of obvious epidemic years the typhoid from 1890 to 1899--the death rate varies between 95 and say 215.

GENERAL CROW: That is per 200,000?

A. No, this is the total number of deaths in the years.

MR. TODD: You say the epidemic years. What years do you have reference to?

A. The year 1892 was obviously an epidemic year of typhoid fever as there were 441 deaths reported from typhoid fever in St. Louis that year.

Q. Excluding that year?

A. Excluding that year the death rate runs along and varies between 95 and 215, and there are two years with 106 and 107 deaths from typhoid.

Now in 1900, the deaths from typhoid are 168;

1901	198
1902	222

And whereas in the remittent group the lowest number
11595 of deaths before the year 1900, in that group, is 134,
the highest number of deaths being in the epidemic typhoid year, 326, just where we would expect it to be, but in 1900 these numbers drop away down to 112 for 1900; and to 80 for 1901, almost one-half what it was in any year preceding 1900, and in 1902, to 102. The total numbers, however, for the whole ten years run along in a fairly constant way.

GENERAL CROW: In the two groups?

A. The total numbers for the two groups added together run along in a fairly constant way, indicating clearly to one who is familiar with the way these deaths are diagnosed, that there has been a transfer during the last three years from the remittent group to the typhoid group, a transfer which is most commendable because it shows that a more accurate diagnosis has been made of typhoid fever during the last two or three years. I mean by that, the physicians have reported to the health department more cases of typhoid and fewer cases of remittent, but that there are still far too many cases being reported by the physicians of St. Louis as remittent, intermittent, typho-malarial fever, congested, etc., is clearly shown by comparison with the Baltimore typhoid death rate. The conditions of the two cities are
not dissimilar, and typhoid and malaria exist in all prob-
11596 ability in about the same proportions in the two cities,
but whereas in Baltimore the typhoid fever is very much more abundant, as compared with the remittent group, the explanation in my opinion, is that typhoid fever is better diagnosed

in Baltimore than it is in St. Louis, and that is not surprising because very important studies have been made durng the last ten years in Baltimore on typhoid, and on malaria, perhaps the most important studies in the country, and the city is being repeatedly filled with young practitioners who have been trained under the men who have made these special investigations in typhoid and malaria, and nearly all young men who go out into practice in Baltimore from the Johns Hopkins University, have a skill in making the diagnoses between the two diseases so that I feel sure that there is still a large number of cases in this city being put in the wrong list; that physicians are not yet diagnosing typhoid fever as they ought to do.

Q. From your investigations and consideration of the vital statistics of the city of St. Louis, has there been an increase in your opinion, in the typhoid death rate since 1900 over the death rate that existed in St. Louis for the period of five years prior thereto?

A. No, there has not been an increase.

11597 Q. Assume, professor, that in 1900, or the latter part of 1899, the Board of Health of the city of St. Louis sent out a specific circular to all the practitioners in the city of St. Louis, calling particular attention to the typhoid conditions existing here, and asking for a special report upon cases of typhoid fever, would that in your opinion have any influence—

A. Yes, I think it would—

MR. JEFFRIES: Wait a minute. I object to the question for the reason that it is not one based upon the judgment of an expert, or calling for an expert opinion, but one which the court can understand and take into consideration without being interpreted by a layman or any other person.

MR. TODD: Answer the question, professor?

A. I think it would for this reason, that it is not an uncommon practice among physicians to designate cases that they regard as typhoid fever themselves, as remittent or continued, or typho-malaria, or malarial fever, for the express reason of not exciting too much the fears of their patients. I know that that has been done by physicians. Patients are afraid of typhoid fever, and they naturally beg of their physician to tell

them what the disease is, and sometimes when one actually feels
that the case is one of typhoid, he will say to the patient
11598 that it is remittent fever, or typho-malaria or something
of that sort, because he uses a clinical term which is
true. Typhoid fever has a remittent chart sometimes.

Q. Is there such a fever recognized by modern physicians equipped with modern researches, as typho-malarial fever?

A. The best clinicians avoid the term altogether for this reason: that it is now possible to tell in every case practically, whether we are dealing with real typhoid fever or real malarial fever, or as occasionally it has happened, a mixture of the two infections. There are a few cases in which the typhoid fever bacillus is invading the body at the same time that the protozoan malarial parasite is invading the body. If any case deserves to be called typho-malarial fever it is such a case which is a mixed infection, but the term as used formerly and as used generally, referring to the clinical course of the disease, a course that ran several weeks, like typhoid, but that had had marked exascerbations and diminutions of temperature, and associated sometimes with chills, is improper.

Q. How does the death rate from typhoid fever in the city of St. Louis as you interpret the vital statistics, compare with the statistics of Baltimore and other cities?

A. The death rate in St. Louis is not excessive as com-
11599 pared with Baltimore and corresponding cities.

Q. With what other cities have you compared them?

A. I have compared them with figures from Philadelphia, Boston and New York; and especially as compared with Philadelphia, the figures in St. Louis are very moderate.

Q. Are you acquainted with the epidemics caused by the water-borne diseases, such as typhoid?

A. In a general way, I am, yes.

Q. How far has the contagion of typhoid fever been shown to travel in a flowing stream?

A. Well, if one takes the extreme statement of one investigator, the maximum distance is about seventy or seventy-five miles. That view and assertion has not met with general acceptance, however.

Q. Are you acquainted with the general conditions which obtain from Chicago, the drainage canal, the Illinois river, the Mississippi and Missouri rivers, down to St. Louis, at the St. Louis intake?

A. Yes, in a general way.

Q. Have you given the subject of bacteriology any study?

A. Yes, I have studied it and taught it in Baltimore, but no special study since I came to Chicago.

11600 Q. What position does the science of bacteriology occupy in regard to the ascertainment of the purity of waters?

A. A most important position, for it has to deal with the presence or absence of disease producing germs in water.

Q. What position does chemistry occupy in what is known as sanitary science?

A. A very important position also, for it permits one to draw conclusions as to the extent of contamination with organic matters, including sewage.

Q. Are you acquainted with the life of the typhoid bacillus?

A. Yes, I may say that I am. I have worked a good deal with it myself, and I am more or less familiar with what has been written about it.

Q. What is your opinion as an epidemiologist and pathologist as to whether a typhoid bacillus lying in the sediment of a stream for a period in excess of sixty days, would be able, if taken into the human system after that period, to cause typhoid fever, if said bacillus should be removed and placed in the drinking water used by a person?

A. In my opinion it would be harmless.

Q. Assume that the distance between Chicago and the intake tower of the St. Louis waterworks, at the chain of rocks, is 357 miles; the intake tower of the St. Louis waterworks being located about ten or eleven miles above the Eads bridge, 11601 and that the St. Louis intake tower is 1,500 feet from the Missouri shore in the Mississippi river; what is your opinion as an epidemiologist and pathologist as to whether the sewage entering the drainage canal at Chicago, assuming that the same was typhoid infected, after traversing that distance of 357 miles, as to whether the pathogenic bacteria in the sewage of Chicago would be able to survive the journey from Chicago to the intake tower at the chain of rocks, as indicated heretofore, and be a menace and a danger to the inhabitants of the city of St. Louis?

A. In my opinion they could not be.

Q. What is your opinion as to whether typhoid bacilli could survive the journey from Chicago to St. Louis, a distance of 357 miles, passing down the Illinois river, passing by Peoria, and Pekin, which receives a large discharge of sewage from the cattle sheds of the cities of Peoria and Pekin, Peoria being a city with a population of about 75,000 inhabitants, and getting into the water supply of St. Louis, and causing typhoid fever?

MR. JEFFRIES: We object to the question for the reason that the witness is left to assume in his answer any amount of discharges into the Illinois river at Peoria from the cat- 11602 tle sheds of that city, the question not containing the number of cattle fed or the amount of matter discharged into the river at that point.

MR. TODD: I will change that. What is your opinion as to whether typhoid bacilli could survive the journey from Chicago to St. Louis, a distance of 357 miles, passing down the Illinois river, passing by Peoria and Pekin, which receives a large discharge of sewage from the cattle-sheds of the cities of Peoria and Pekin, wherein 18,000 head of cattle are fed annually, and the excreta from these cattle, aggregating 1,080,000 tons of feces and urine, thrown into the Illinois river at these two points, besides the sewage from the city of Peoria, which is a town of about 75,000 inhabitants, and getting into the water supply of St. Louis and causing typhoid fever?

MR. JEFFRIES: That is objected to for the reason that there is no evidence showing that there are 18,000 head of cattle fed at Peoria and Pekin in any one year since the opening of the canal, and for the further reason that the evidence does show that there are less than 12,000 cattle fed, and that the number is decreasing from year to year.

MR. TODD: In reply to that I desire to state that the 11603 testimony of Wolfner, a distiller at Peoria, was to the effect that there were 12,000 head of cattle fed in the city of Peoria, and the mayor of Pekin testified that there were 8,000 head of cattle being fed at Pekin this year.

Q. (Question read).

A. There is no evidence in the literature which would make it seem probable indeed. All the evidence that I know would oppose the probability or even possibility of that occurring, and moreover, the proof that it did occur could not be brought unless every typhoid bacillus now entering the stream between say Lockport and St. Louis, could be excluded from the river. In my opinion typhoid fever bacilli would not survive the journey.

MR. TODD: Q. As an epidemiologist and pathologist, do you consider the sewage of Chicago entering the drainage canal and the Illinois river, which in turn empties into the Mississippi river, a menace and a danger to the inhabitants of the State of Missouri, and the citizens of the city of St. Louis taking their water supply from the intake tower at the chain of rocks, in the Mississippi river?

A. In my opinion, no.

Q. Assume that an epidemic of Asiatic cholera should break out in the city of Chicago, and the sewage of Chicago should enter the drainage canal and the Illinois river, what is your opinion as to whether or not the germ of Asiatic cholera would survive the journey from Chicago to the intake tower at the chain of rocks, a distance of 357 miles, and be a menace and a danger to the inhabitants of the citizens of St. Louis? 11604

A. In my opinion it would not.

Q. What causes in your opinion would lead to the death of the typhoid bacillus in river water?

A. In my opinion there would be two main factors, the oxidation that occurs along with sedimentation, and the unfavorable food relations—three factors—and the third, perhaps the most important factor of all, the influence of saprophytic bacteria in the stream.

Q. Would the introduction of this mass of organic material from the stock yards and distilleries of Peoria favor or hinder the disappearance of the typhoid bacillus in your opinion?

A. In my poinion it would favor the disappearance.

Q. If the disease of tetanus should appear in Chicago, what is your opinion as an epidemiologist and pathologist, as to whether the inhabitants of St. Louis are in danger of infection from tetanus by reason of the operation of the Chicago drainage canal?

A. In my opinion there would be no danger of infection
11605 by tetanus. It doesn't occur in such a way at all.

Q. From anthrax?

A. In my opinion there would be no danger.

Q. From the bacillus enteriditis sporogenes?

A. There would be no danger in my opinion.

Q. What is this bacillus enteriditis sporogenes?

A. I take it that by that you mean the bacillus which is identical with the bacillus aerogenes capsulatus of Welch and Nuttall, a facultative anaerobe which is capable of causing infection in human beings, cases of which I have studied, but which is not, as far as we know, a water-borne disease, and moreover, is a rather rare disease. The bacillus is a spore-producing bacillus, but I cannot conceive of cases of the disease occurring in Chicago being a menace in any way to the citizens of St. Louis.

Q. Do the figures on typhoid fever and related diseases in the St. Louis health reports admit of tracing any relation between the prevalence of these diseases and the opening of the Chicago drainage canal?

A. The only possible relation that I can see is the difference in diagnosis during the years mentioned, as concerns these two groups, of typhoid fever and the remittent group. As far as
the total number of deaths in those two series is con-
11606 cerned I can see no connection between the opening of
the drainage canal and the figures.

Q. What in your opinion from the standpoint of epidemiology would be the probable length of life of the typhoid bacillus introduced by way of the drainage canal into a sluggish river such as the Illinois river, flowing through a more or less densely populated country, and receiving successive increments of organic matter together with the associated saprophytic bacteria?

A. I should think from five to seven days.

Q. Does the death rate from typhoid fever in St. Louis indicate the use of an excessively polluted water supply in your opinion?

A. If you mean excessively as compared with the water supply of many American cities, I should say "No." If you mean excessively as compared with ideal conditions, I should say "Yes."

Q. How does the death rate from typhoid fever in St. Louis compare with that in other American cities using a well protected surface water as a source of supply?

A. The death rate in St. Louis is lower than in a number of such cities, if you mean by the term "well protected" what is ordinarily meant by that term in this country.

11607 Q. Assume, professor, that in the year 1900, the number of typhoid deaths reported from typhoid fever in all the cities lying tributary to the Mississippi river from St. Paul to the mouth of the Illinois river, was 311 deaths, on the Missouri river from Lincoln, Nebraska and Omaha, Council Bluffs, St. Joseph, St. Charles, Kansas City and Jefferson City, lying tributary to the Missouri river, was 108 deaths, and on the Illinois river and its tributaries exclusive of Chicago was 129 deaths, making an aggregate of typhoid deaths on these three rivers, exclusive of Chicago, of 548 deaths, and that the number of deaths in the city of Chicago for the year 1900 was 339 deaths, and assume that in point of distance Omaha is fourteen days, representing the average mean flow of the river from Omaha to St. Louis, from St. Paul the average mean flow of the river is seventeen days, and from Chicago to St. Louis intake on the Illinois river, is eighteen and a half days, representing the average mean flow, and assuming that the typhoid condition in the city of St. Louis for that year is due to a contaminated drinking water in large part, what would you say as an epidemiologist as to whether the cause of typhoid fever in the city of St. Louis could be attributed to the sewage of Chicago, in view of the vital statistics, assuming in this hypothetical question 11608 the typhoid fever existing upon the water-sheds of the three rivers, exclusive of the typhoid conditions in Chicago?

A. In my opinion it could not.

MR. TODD: I want to introduce into the record a tabulated statement of those statistics based upon the death report of typhoid fever in the cities on the Illinois river and its tributaries exclusive of Chicago, the Mississippi river and its tributaries, above Grafton; the Missouri river from Omaha to St. Louis, and the typhoid statistics annually from 1890 to 1902, of the city of Chicago and the city of St. Louis, most of these statistics having been proven by complainant, and verified by defendants, and the table will be verified by the sworn testimony of John J. McLaughlin, a witness sent by defendants to investigate the typhoid conditions in all the towns not testified to by witnesses for the complainant.

The purpose of introducing this into the record at this time is to get the typhoid statistics along the three watersheds and Chicago and St. Louis, in a concise form for reference, as well as to predicate a question to this witness.

The tables are as follows:

11609

Death Report from Typhoid Fever in Cities Lying Tributary to the Missouri River.

	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
Lincoln, Neb........	33	21	23	15	14	12	13	4	13	10
Omaha.........	22	40	29	18	22	33	26	24	23	20
Council Bluffs......	5	7	6	8	8	6	8	11	6	8
St. Joseph, Mo......	20	22	31	19	15	19	37	20	12	13
St. Charles, Mo.....	....	....	....	....	....	....	22	5	6	14
Kansas City, Mo....	59	37	34	29	38	49	52	49	58	58
Jefferson City.	....	....	....	....	....	....	....	....	.....	16(?)
Totals.	139	127	123	89	97	118	158	113	118	139

11610

Deaths Reported from Typhoid Fever in Cities lying Tributary to the Illinois River, exclusive of Chicago.

	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
Peoria	.....	.....	.....	13	18	18	12	33	15	18
Bloomington	12	14	15	9	10	10	9	15	9	15
Springfield	.....	.....	.....	.....	.....	.....	.....	20	10	8
Ottawa	2	5	2	2	4	4	3	3	5	2
Decatur	5	7	2	1	7	5	7	11	5	4
Joliet	12	14	*0	12	12	15	15	13	13	21
Pekin	.....	.....	.....	.....	.....	.....	.....	2	1	2
Elgin	5	3	5	14	*0	4	5	15	15	8
Aurora	6	12	19	10	5	10	4	17	11	2
Havana	3	7	2	5	*0	*0	*0	*0	1	2
Totals	45	62	45	66	56	66	55	129	85	82

*No record.

11611

Deaths Reported from Typhoid Fever in the Following Cities, According to the Public Records.

	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
St. Paul	51	32	38	37	22	43	30	36	24	23
Minneapolis	134	107	88	60	148	86	71	79	121	66
Red Wing, Minn	5	2	2	3	0	4	0	3	2	3
Winona, Minn	2	2	1	2	2	2	5	5	1	4
La Crosse, Wis	15	2	5	0	3	8	7	7	5	4
Dubuque, Ia	6	6	12	8	12	10	12	7	8	10
Clinton, Ia	10	5	3	7	5	7	7	10	12	5
Rock Island, Ill	15	13	3	13	*0	*0	10	14	28	5
Moline, Ill	7	9	8	11	3	5	20	23	16	7
Davenport, Ia	5	6	4	3	5	2	12	14	11	11
Muscatine, Ia	4	8	5	5	2	25	2	13	8	5
Burlington, Ia	8	10	8	13	3	4	8	13	12	11
Fort Madison, Ia	.....	.....	.....	.....	.....	.....	.....	5	0	1
Keokuk, Ia	8	14	3	3	7	10	9	10	4	7
Quincy, Ill	22	33	24	13	15	6	7	9	12	18
Hannibal, Mo	7	7	6	8	10	8	4	3	3	2
Louisiana, Mo	.....	.....	.....	.....	.....	.....	.....	4	2	7
DesMoines	22	29	30	14	20	17	13	7	22	21
Yearly totals	321	285	240	200	257	237	217	261	291	210

*No record.

11612

Total Number of Deaths Reported from Typhoid Fever in Cities Lying Tributary to the Mississippi, Missouri and Illinois Rivers, Respectively.

	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
Mississippi	321	285	240	200	257	237	217	261	291	210
Missouri	139	127	123	89	97	118	158	113	118	139
Illinois	45	62	45	65	56	66	55	129	85	82
Total	505	474	408	354	410	411	430	503	494	431

Deaths in Chicago and St. Louis.

	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
Chicago	1008	1997	1489	670	491	518	751	437	636	442	339	509	801
St. Louis	277	160	488	215	178	106	106	125	95	130	168	198	222

11613 MR. TODD: Doctor, have you examined the tables of typhoid statistics which have been read in evidence, showing the number of typhoid deaths on the water-sheds of the Mississippi river from St. Paul to Grafton, and on the Missouri river from Omaha to St. Louis; and on the Illinois river and its tributaries exclusive of Chicago, and the typhoid death rate in the city of Chicago and the city of St. Louis?

A. I have.

Q. From an examination of those typhoid statistics as above indicated, what is your opinion as an epidemiologist as to the question of probable infection in the city of St. Louis from the typhoid conditions existing on the water-sheds of those three rivers, exclusive of Chicago and the infection from Chicago, assuming that the distance of the mean flow from Omaha is fourteen days; from St. Paul seventeen days, from Chicago eighteen and one-half days, as to the probability of infection from the different towns, upon the question of distance as to flow, rather than distance as to miles?

MR. JEFFRIES: I want to ask counsel if he means by probable infection the probable infection of the waters of the

Missouri and the upper Mississippi, or the probable infection of the waters of the Mississippi by the sewage of Chicago?

MR. TODD: I mean the infection in the water supply of
11614 St. Louis from the three rivers in question exclusive of
Chicago and the infection from Chicago.

A. In my opinion the probability of infection or pollution of the water supply of St. Louis, assuming the above, would be largest from those places within the mean flow of five to seven days. I don't know how to express that—from those places where the average flow or the mean flow is within five to seven days of St. Louis. I think the probability of infection or pollution from the great distances requiring more than twelve days for example, would be remote.

CROSS-EXAMINATION, by Mr. Jeffries.

Q. I understood you to say, doctor, you are now connected with the Chicago University?

A. Yes sir.

Q. And have been connected with that institution how long?

A. Three years.

Q. What position do you now occupy?

A. Professor and head of the department of anatomy.

Q. Professor and head of the department of anatomy?

A. Yes sir.

Q. How long have you occupied that position?

11615 A. Since I came to the University.

Q. And before you came to that university you occupied what position?

A. I was associate professor of pathology in Johns Hopkins University.

Q. With Dr. who?

A. William H. Welch.

Q. And how long were you there?

A. In Baltimore?

Q. Yes?

A. I was in that position only one year.

Q. Now before that you were with Dr. Osler?

A. Yes, I was with Dr. Mall for a while, then with Dr. Welch for two years before that, and then with Dr. Osler one year.

Q. Now explain, doctor, what position you occupied and what relation you bore to these three gentlemen that you mentioned, in Baltimore?

A. With Dr. Osler I was an assistant in the Johns Hopkins hospital, mostly during clinical examinations in the out patient department, chiefly, and while with Dr. Welch in the first two years, my work was all bacteriology and pathology, and again while I was with Dr. Mall I was teaching anatomy, but my research work was largely in pathology and medical subjects and then in the last year in Baltimore my work was all in
11616 pathology and bacteriology again.

Q. Now your study and work in reference to pathology pertained practically to the study of the nature and character of diseases, did it not?

A. Nature, character, mode of spread and origin of diseases, yes sir.

Q. In your work in these institutions both as to the Chicago University and at Baltimore, your time was occupied in the laboratory was it not, and hospitals?

A. Laboratory and hospital almost entirely.

Q. You were not required in your work, while connected with these institutions, to visit various sections of the country to determine the source of any particular infection were you, or the source of the disease with which the patient was afflicted while in the hospital?

A. When working with Dr. Osler it was our custom, especially when a typhoid case or malaria case came in to search out if possible the origin of it, and we often went to the house from which the patient came and examined the conditions and tried to find out the origin.

Q. Now doctor, how many of those cases did you go to the house and search for the origin of the disease?

A. During my year with Dr. Osler?

11617 Q. Yes sir?

A. I haven't any idea.

Q. Well, can you approximate it?

A. Well I should say not less than ten and not more than forty times.

Q. And when you did search for the source of the disease you simply ascertained whether or not it was on account of being associated with some other patient or coming in contact with some other case, or whether or not it was caused by food supply or water supply, without reference to the source of the food or the source of the water, was it not?

A. We tried to ascertain all the conditions bearing on the case. It wasn't always possible to get at all of the conditions.

Q. Now did any of those cases come to your observation while connected with the institution at Baltimore from an epidemic of the particular disease then being studied?

A. Yes, typhoid fever is epidemic in Baltimore nearly every year.

Q. What is the great source of the typhoid epidemic in Baltimore that occurs annually?

A. The water supply is believed to be responsible for it.

11618 Q. Where does Baltimore get its water supply doctor?

A. There are different parts of the city which get different water supplies. The part that I was interested in particularly came from Lake Roland.

Q. How far is Lake Roland from Baltimore?

A. In exact miles I don't know. It takes about half or three-quarters of an hour to go out by the trolley.

Q. Would you say fifteen or twenty miles?

A. Oh no, not nearly so far. I should think five or seven miles perhaps.

Q. Do you know how large a body of water that lake is?

A. No.

Q. You have seen it?

A. Yes sir.

Q. Well in making an examination or study of that water as applied to the particular disease that you had under consideration and which was attributed to that water, did you take into consideration the volume of the water contained in the lake that furnished the supply to the particular locality that was infected with the disease?

A. The volume of water was discussed.

Q. Well now in that discussion—

A. But I took no part in it myself.

11619 Q. How is that?

A. I took no part in the discussion myself.

Q. Well in passing upon the question as to the cause or source of the infection and in exercising your judgment, was it not necessary for you to take that fact into consideration?

A. At that time I was merely an aider and helper in the laboratory.

Q. Then you made no examination with the view of determining for your own satisfaction?

A. The volume, no.

Q. As to whether or not the source of the infection that you were then examining, could be attributed to that lake?

A. I made no personal examination, no, of the waters. .

Q. So you cannot say then of your own personal examination, as an epidemiologist, that the water from that lake was the source of the infection, or of the epidemic?

A. It would not be necessary for me to make a personal examination to have that opinion.

Q. You formed that opinion from the effect of the water upon the people using it?

A. And the testimony of reliable witnesses as to the pollution of the water—as to the possible pollution of the 11620 water.

Q. Well, are you able to state from the information which you received, that that was in your judgment, as an epidemologist, the source of the epidemic, and that the water in that lake was infected?

A. It was my opinion that the cases of typhoid fever occurring among those who drank of the water from that district, from that water supply were due to the pollution of the water supply by typhoid bacilli.

Q. In other words that the epidemic occurring among the people who drank the water or who used the water from the lake it is your opinion then that the water in the lake was infected with typhoid fever germs?

A. Yes sir.

Q. Now you are of the opinion you say that that was the source of the epidemic?

A. Well I am of the opinion that that could have been responsible for it.

Q. But doctor, I understood you to say that you had examined conditions surrounding Baltimore, and had studied and that the study that you had given the situation was sufficient to enable you to form an opinion as an epidemiologist, as to the cause of the epidemic, and you attributed that cause to the pollution or infection of the water in the lake, is that
11621 true?

A. I don't know that I should have called myself an epidemiologist then; I was a very young man and beginning my studies in medicine and studying in a very modest way under directions at that time.

Q. Then doctor, you have never examined as an epidemiologist the origin or source of the typhoid epidemics that occur annually in the city of Baltimore?

A. If you mean personal examination of the shores of the lake and the rivers, that is true.

Q. I mean doctor, an examination such as would enable you to form an opinion which you yourself would be willing to rely upon as a reputable epidemiologist, as to whether or not the infection of the lake was the cause of the typhoid epidemics that appear annually in the city of Baltimore?

A. If I wished to pass as an epidemiologist on such a question I should certainly make a more careful examination than I did at that time.

Q. Well you do pass as an epidemologist, do you not?

A. Yes, I do now.

Q. Well, when was that that you made the little examination you did make of the typhoid epidemics at Baltimore?

A. Well, my examinations of the typhoid epidemics were
11622 chiefly of course clinical and pathological; they were being made all through my stay in Baltimore all through the nine years, and with that side of the pathology I am most familiar.

Q. That is with the clinical side?

A. Bacteriological and pathological side.

Q. Pathological and bacteriological side, without reference to the exterior physical facts that might surround the situation?

A. My study of that has been from the literature chiefly.

Q. In fact has been entirely from the literature, except the few instances which you mentioned in your direct examination with reference to conditions at Manila and other places?

A. Yes, as to the epidemics that I studied elsewhere.

Q. I believe you stated that you would not consider the information that you had with reference to the physical condition of the lake, its dimensions and volume of water, sufficient to enable you to form an opinion as to whether or not the water in the lake was the real source of the epidemic?

A. I would not require any such knowledge to form an opinion as to the source of an epidemic if I found that people were dying from typhoid fever who drank that water in large quantities.

11623 Q. And that, doctor, would be true without reference to whether or not the lake contained a sufficient volume of water to supply the city or that part of the city which was supplied with the water from that lake, with water, for one, two, three, four or five days or longer as the case may be?

A. I don't quite understand the question.

Q. In other words, I mean with that opinion that condition would hold good without reference to the fact that the lake might be sufficient to contain only a sufficient water supply for that particular district, for one or two days, or five or ten or twenty days. In other words, the volume of water would be of no material consequence?

A. I should put it this way; that the distribution of the cases of typhoid from a given water supply connected with a good water supply, would be sufficient to say that that water supply was responsible for the cases of typhoid. As to just what portion of the water supply was responsible, there would need to be special investigation made. One would have to find out where the typhoid bacilli came in, and how it was most likely that the typhoid bacilli got there, and just what the source was. That would require special study.

Q. Now did you have any information as to the source of the infection of the water in the lake?

11624 A. We had at that time, but I cannot recall the details of it. I remember it was all discussed at the time.

Q. How long have you been acquainted with that particular water supply,—that paticular lake?

A. Well I am not well acquainted with it, as I told you, personally. Of course I have heard of it.

Q. Well, you are personally acquainted with the district supplied by the lake?

A. Yes.

Q. And have been for how long a time?

A. Since twelve years ago.

Q. Now then during the entire twelve years, have they been able to determine the source of the infection of the water in the lake each year, and trace it on down from year to year and from time to time?

A. You mean the exact source?

Q. Yes?

A. I cannot tell you the details of that either; I don't know I have no doubt I could find out.

Q. Did you make any bacteriological analyses of the water of that lake?

11625 A. I never did, no. I should hope little from such an examination so far as typhoid bacillus is concerned. It would be extremely difficult to demonstrate.

Q. Would you not expect very little, of any bacterial analyses so far as the actual discovery of pathogenic bacteria is concerned?

A. I should be much more influenced by the biological test, as represented by the number of cases that occurred in the distribution of the water supply, than by an analysis, though much light can be thrown upon the qualities of a drinking water by the number of bacilli present.

Q. You think the number of the bacilli present is of any particular importance in and of itself?

A. Not considered alone, no. It must be considered along with all the other conditions.

Q. What are those conditions?

A. Well, the way the water is taken, the way the test is made, the chemical condition of the water, at the same time, the possibilities of explanation of the number from contaminations other than sewage contamination; the character of the bacilli or the character of the bacteria present. All would be factors that would have to be considered in a given case.

Q. What do you mean by the character of the bacilli?

A. Well, if I found or if anyone found a large number of 11626 bacilli of the colon group for example, that would be evidence,—other things being equal—of probable sewage contamination.

Q. Now doctor, getting back to conditions at Baltimore, this particular district supplied by lake Roland, is the only district in Baltimore that is affected annually, is it?

A. No indeed; I think; I don't recall the details of the different parts of the city today, I couldn't tell you about it. My opinion is that all water supplies of Baltimore are infected, but that some parts are more infected than others, but I cannot tell you which one was the most infected.

Q. Now doctor do you know the source of the water supply in that lake, Lake Roland?

A. No.

Q. Take the rivers around it, or anything of that kind, that empty into the lake?

A. I cannot tell you.

Q. Have you ever rowed over the lake?

A. No, I have been on its edge.

Q. How large a body of water did it appear to you to be?

A. My visual memory is not good enough to—

Q. Well, approximate it, as you best remember it?

A. I am afraid it would not be worth while, giving you a statement.

11627 Q. A body of comparatively still water?

A. Yes, not a large lake.

Q. Now from what other sources does Baltimore get its water supply?

A. Well, as I recall it, there is Gunpowder River—isn't there a Gunpowder river there? I don't know.

Q. How large a river is it?

A. I don't know at all; my opinion there is not valuable to you.

Q. Have you been on this river?

A. No.

Q. You don't know then whether there is any visible source of pollution on the banks of the river or not?

A. Not from my personal observation.

Q. You don't know whether there was on the lake or not?

A. No, I have heard rumors of all sorts of things, and statements—no, nothing from personal observation.

Q. Now is there any other source of water supply for the City of Baltimore excepting this lake and river?

A. I don't know.

Q. Those are the only two sources that you have any knowledge upon?

11628 A. Yes.

Q. And with those you are not familiar with the physical facts?

A. No, it is a side of epidemiology that I was not specially—

Q. And all that you have studied is the nature and character of the typhoid cases which came under your observation?

A. And parts of the city that they came from.

Q. And the parts of the city of Baltimore that they came from?

A. Yes.

Q. Without reference to the character and conditions of the water supply?

A. Well, at that time we discussed that, but the details of it of course have escaped me now.

Q. Now what other experience have you had in the study of epidemics?

A. Epidemics of typhoid, or epidemics in general?

Q. Of typhoid?

A. I had while house officer in the Toronto general hospital a considerable experience with typhoid cases. There was a large epidemic that year, larger than usual.

Q. But you had nothing to do with the actual source of or cause of the epidemic?

11629 A. No.

Q. Your experience was confined solely to hospital work?

A. Yes, and the pathology after death.

Q. Now you know doctor, I suppose, that the source of this epidemic was attributed there to the water supply there, was it?

A. In Toronto?

Q. In Toronto?

A. Yes it was; it was supposed I believe it was definitely proven but I am not sure, that there was a leak in the intake pipe. The pipe went out to an island, it passed through Toronto Bay, and they found out afterwards that there was a hole in the pipe, going across the bay, and that the real sewage mixed water was taken directly into the water supply of the city.

Q. How large is that bay, how wide?

A. Toronto Bay?

Q. Yes?

A. I should think it was about—again my knowledge of distances is very vague. I should think three-quarters of a mile across from the city to the island.

Q. Now was there any current along down the bay?

A. The water is tolerably stagnant there I imagine.

11630 Q. But there is a small creek or river or something of that kind going in from the land running out from the bay, into the lake?

A. The Don, but it is rather a small stream and a rather slow stream.

Q. And that would carry some current, would it not?

A. How much I don't know.

Q. It would be very small?

A. I should think rather small.

Q. Now where is that bay located with reference to the city of Toronto?

A. The city is directly on the lake front, I should think it extended a mile along the lake front.

Q. Is all the sewage of Toronto discharged into the Bay?

A. Whether it is now or not I don't know, as I recall it it was then.

Q. Now with reference to this water main that passed across the bay where was the sewage discharged, above or below?

A. How do you mean, above or below—I think on both sides.

Q. On both sides?

A. I think so; I think it ran right across the bay, and sewage was being poured out at various places along the lake front, for a mile as I recall it.

Q. Now do you remember what particular place in this
11631 water main it was broken?

A. No, I do not.

Q. How far it was from shore?

A. No, I haven't any information about that.

Q. It may have been a considerable distance?

A. From the shore?

Q. Yes.

A. Yes, I think it might have been anywhere in the bay, for all that I know; I don't know about it.

Q. And you say the bay is about three-quarters of a mile wide?

A. I should think so; it may be twice as broad; it may be less broad, but not more than twice.

Q. Do you know how deep the water is in the bay?

A. No, but it is deep enough for quite large steamers to come in.

Q. Do you know doctor, whether or not—or don't you know it to be a fact that they are now considering methods for disposing of or treating their sewage at Toronto?

A. I don't know.

Q. You don't know?

A. I hope they are; I don't know.

Q. Why do you hope they are?

11632 A. Because I think it is a pity for them to drink a polluted water supply when it might be possible by educating the people. and getting proper methods, to avoid the death rate from typhoid.

Q. Well, how far from the city does Toronto get its water supply?

A. That I don't know.

Q. How far did it at that time?

A. I don't know that.

Q. Do you know the typhoid death rate?

A. In the city of Toronto?

Q. Yes.

A. No.

Q. Do you know how far out they would have to go—

A. In Toronto?

Q. Yes, to get good water?

A. I do not, I am afraid.

Q. As an epidemiologist, what would be your judgment?

A. For them to get good water?

Q. To get good water that you would consider reasonably safe?

11633 A. How far out in the lake you mean?

Q. How far out in the lake in front of the city?

A. Oh, well, I cannot say off-hand, to get it absolutely pure and free from typhoid bacilli, they ought to go some distance of course.

Q. Well, about what distance would you say?

A. But even then a passing ship might pollute it temporarily. I don't think that they could be absolutely sure of excluding typhoid anywhere in the lake when ships are passing all the time.

Q. Well, aside from the ships?

A. But you cannot go aside from the ships because they are always there.

Q. Well, we will now assume that the ships and shipping interests are eliminated from the lake at Toronto, how far in your judgment would it be necessary for that city to extend its water mains into the lake in order to get a good water supply and free from sewage pollution?

A. Well, I should think that they would have to be absolutely sure of it, or to be tolerably sure, by assuming this impossible condition, that you suggest, that they ought to go out about one hundred miles.

Q. About a hundred miles?

11634 A. Yes, but that would be past the middle of the lake wouldn't it? I don't know how broad the lake is.

Q. Now what would be your object doctor in extending the water mains out into the lake?

A. One hundred miles?

Q. Any distance?

A. Well, it would be to diminish the amount of pollution of the water.

Q. Pollution from where?

A. From the sewage of the city.

Q. Of the city front?

A. Especially of that.

Q. Do you know how large Toronto is?

A. I think about 200,000 inhabitants.

Q. About 200,000?

A. I should think so.

Q. Now Toronto is situated on the breast of the lake, is it not?

A. Yes, right on the edge of the lake. Toronto bay comes
in a little but it is not a deep indentation. The island is prac-
tically the shore line. Do not understand me to say that I would
recommend putting a pipe out 100 miles. There is a much easier
way of getting a water supply than that, but if you tried
11635 to get it in that way, assuming an impossible condition,
that would be the purest water that you could get, I
should say, into the middle of the lake, farthest from the shore
would be the place to draw your water in case you had to get it
from the lake.

Q. The question though, doctor, was with reference to obtaining a reasonably safe water supply, a good water supply?

A. The best method of doing it?

Q. Yes, that is, how far it would be necessary to extend the mains into the lake to get a good water supply?

A. It would be much better to put in a sand filtration, and then take it from anywhere, provided you could educate the people there to conduct such a filtration plant in the proper way.

Q. Your idea however, is that the water would be polluted from the sewage of the city for quite a considerable distance?

A. I think it would undoubtedly be polluted for quite a distance out if typhoid fever were occurring in the city.

Q. And that was your object in saying that you would extend the main 100 miles out?

A. I say I would extend it to get the purest water, to the middle of the lake, which of course is not practicable.

Q. In other words then you mean that the pollution and
11636 polluting matter would pass from the city to the center of the lake?

A. Certainly the chemical polluting matter would.

Q. And how about the bacteriological?

A. I don't know how broad the lake is. I should think very few bacteria would pass directly out to the middle of the lake.

Q. If the chemical properties of sewage will pass doctor, why will not the bacterial properties also pass and is it not a fact that the chemical properties are largely made up of the bacterial qualities?

A. I think not.

Q. You think not?

A. Yes. The main difference of course, is that the chemical substances that I refer to are in solution, while the bacteria are in suspension, a totally different proposition.

Q. But the chemical analysis always takes into consideration totals in suspension and solution, do they not?

A. Yes sir.

Q. Do they pass through in filtration?

A. It all depends on the kind of filter one uses of course.

Q. Then the chemical analyses are of very little assistance, aren't they?

11637 A. Well, they are helpful. There are certain special substances that are very interesting.

Q. Well, if all these smaller bacteria pass through the filter, will not the small disease producing germs pass through the filter sheets as well?

A. You mean into the fluid?

Q. Into the fluid yes, and not be found either in suspension or solution?

A. I don't quite get your trend. If they pass through they must be there in suspension or solution.

Q. (Previous question repeated).

A. It depended on the kind of filter used.

Q. Well, won't these small bacteria whether they be pathogenic or non-pathogenic, appear somewhere in the chemical analysis, won't they have an effect upon the chemical result, or upon the result of the chemical analysis of the water?

A. Yes, but not a disturbing effect.

Q. What do you mean by a disturbing effect?

A. I mean by it this: that in the chemical analysis of water certain chemical substances are bad often, but particularly for instance the amount of chlorine, the amount of ammonia and so on. The bacteria would play a very little part in the 11638 amount of chlorine, for example.

Q. Yes, but don't bacteria play a very important part in the amount of ammonia, either free or albuminoid ammonia?

A. Yes.

Q. They play a very important part, don't they?

A. Yes, I think so, in certain factors, chemical analysis, they would; in certain other factors they would not.

Q. Then if they do play an important part, doctor, in the chemical analyses, why do you say that the chemical properties or constituents would pass from the sewers of Toronto out into the lake for a considerable distance, for instance, 100 miles, while the bacterial properties will not?

A. Because the bacteria would largely be destroyed before they went out there, and their chemical equivalents might pass out.

Q. You say largely destroyed?

A. Yes, possibly altogether destroyed before passing that distance, it would be difficult to prove.

GENERAL CROW: Difficult to prove their destruction?

A. Yes, there are bacteria out there, but it would be very difficult to determine the exact origin of the bacteria that are there; they might have come from passing ships.

MR. JEFFRIES: Then doctor, assuming that they do disappear and that they are the cause of the water-borne 11639 diseases, such as typhoid fever, and other like diseases, why would it be necessary to pay any attention to the chemical constituents and therefore why necessary to extend the mains so far out?

A. It would not be necessary to extend them further than there are pathogenic bacteria, but it might be difficult to determine just how far.

Q. And for that reason you recommend the extension as far as the chemical constituents can be traced?

A. I think I said that I would not recommend such an extension at all, because I don't think it is the easy way to get good water, but if you wanted to get a pure water,—as pure a water as possible in this way, by extending the mains, of course the further you go from the source of pollution, the safer you are.

Q. Now is it possible to determine whether or not the pathogenic germs or bacteria have disappeared?

A. Yes.

Q. In that distance?

A. It would be possible by giving a great many thousand people who hadn't had typhoid fever, that water to drink, and making them drink it, and if a lot of them developed the fever, and other sources of typhoid were excluded, that would
11640 prove that it was.

Q. And that is the only way that it can be determined?

A. You could be pretty sure probably, but that would be the safest test.

Q. But if I understand you correctly doctor, you take the position that it would be necessary in your judgment, to extend the mains so far as you could trace the chemical impurities because of the likelihood of the bacteria being present?

A. No, I do not intend to leave that impression at all, because chemical impurities will go wherever the water goes, being in solution; they can go ultimately a thousand miles.

Q. Do you know that the bacteria won't go a thousand miles?

A. All the evidence is against it.

Q. What is the evidence with reference to the longevity of pathogenic germs, doctor?

A. Well, I should refer you to the quickest way to get at the evidence,—to Baumgarten's Jahreskricht.

Q. Have you ever had any experience with the longevity of the typhoid germs in water?

A. I have worked with the typhoid bacillus. I made no special experiments dealing with longevity, no, but I have

worked the typhoid bacillus, and had it die out on me in
11641 media.

Q. Because of some inattention or something of that kind?

A. No, probably through exhaustion of the food supply.

Q. Or by extreme heat?

A. No, they were not submitted to too much heat.

Q. State doctor, your experience with reference to the life history of the typhoid bacillus in the laboratory?

A. Well, do you wish me to tell you how I have seen it behave on culture media, what it does? That is part of the life history of course.

Q. No, I want you to state brefly the experience that you have had studying the character of the typhoid bacilli with reference to the longevity of the typhoid bacillus in water, in the laboratory?

A. Oh, I told you that I had not worked especially on the longevity of the typhoid bacillus in the laboratory.

Q. Then so far as you know it maye live three weeks, and it may live ten weeks?

A. From my own personal researches?

Q. From your own personal researches?

A. One has to limit his own personal researches in the field.

Q. So that when you speak of the longevity of the typhoid
germs, and when you apply their longevity to the water
11642 of the Illinois river, you borrow the experience of other
men and do not speak from actual personal experience of
your own?

A. Entirely, yes, I am very glad to acknowledge that, as everything else that I have not worked on myself.

Q. Now doctor, you have stated, have you all that you know about conditions that existed at Toronto while you were there?

A. By no means.

Q. How is that?

A. By no means. I am afraid it would take a long time to state all that I know about that.

Q. With reference to the physicial facts surrounding Toronto and the water supply?

A. Yes, the general facts.

Q. The remainder that you may know, or if you know anything else, it was confined to the hospital?

A. To the that particular case, yes.

Q. Now then, doctor, state what other epidemics of typhoid you have studied?

A. In a clinical and pathological way, or in seeking the source of the water supply?

Q. In any way?

11643 A. Well, practically the only other typhoid epidemic that I have worked in is the one in Manila.

Q. In Manila?

A. Yes, in the Philippine Islands, but my attention there was directed entirely to the clinical and pathological side.

Q. You mean—

A. I didn't seek the source outside.

Q. That was in the laboratory?

A. That was in the laboratory and the hospital.

Q. And your attention and work there were directed entirely to the treatment of the disease?

A. No indeed; largely to the diagnosis, the symptomology, the clinical history and course, and the post mortem appearance.

Q. Now then, doctor, explain just exactly as near as you can what you mean by the various terms that you have used in your work at Manila, and the object that you had in making whatever determinations were made?

A. In Manila?

Q. Yes?

A. My object in the study of typhoid there was not to add anything new to our knowledge of the disease, unless it turned up in the routine. My object in studying typhoid at that 11644 time there was to set a high order of routine up at the beginning of the American medical work in the Philippines. Our work with malaria and dysentery and beri beri was the more original work that we undertook there.

Q. GENERAL CROW: You have not defined those terms yet.

A. Well the diagnosis means differentiating the disease from other disease, that might be confounded with it. By symptomology I mean the symptoms presented by the individual suffering by the disease, by the clinical course of the disease. I mean studying the changes from day to day in the symptoms, and comparing them with known descriptions of the disease, and other appearances of the disease taught by post-mortem. I mean growth and microscopic appearance of the organisms in the individuals dead of the disease.

MR. JEFFRIES: Now you didn't study the source of this epidemic at Manila?

A. No, it really was not interesting to us; it wasn't a profitable thing to study at the time.

Q. You didn't go there for that purpose?

A. No.

Q. Then doctor, I understand you that you have not studied the source of the epidemics in any case except in a casual way, as you have stated?

11645 A. Not typhoid.

Q. In typhoid?

A. That is quite true in plague and epidemics of cerebral spinal meningitis, and in beri beri. We tried very hard to ascertain the origin and mode of spread.

Q. And you have not?

A. But I am familiar with a large part of the work that has been done along those lines, and have to be, as a clinician has to be, familiar with the mode of the spread, to be a scientific clincian.

Q. But you obtained that simply by reading the publications of men who have studied it?

A. As every other scientific man does, yes.

Q. Including the literature on the longevity of typhoid germs?

A. Yes, I have read the literature of them.

Q. Was it necessary to read that as well as other things?

A. Yes, but not absolutely necessary to remember it or to read it,—unless you happen to be interested in it at the time.

Q. And you have not studied the longevity of the typhoid germ yourself?

A. I have studied it to a certain extent, but I have not
11646 made a specialty of it.

Q. You have studied it only as you have read about it?

A. No; I have studied it as I grew it in the laboratory in nutrient media.

Q. I understood you to say that you had made no studies as to its longevity?

A. I have not carried on a series of special researches, dealing with the longevity alone, but in my general work with the typhoid bacillus I have gotten certain first hand ideas about the way the typhoid bacillus will live, the length of time and in different media, and so on.

Q. In any water?

A. Yes, I have done it in distilled water.

Q. Have you ever tried it in the river water?

A. Sewage polluted water, no.

Q. How long did it live in distilled water?

A. I don't know; I couldn't tell you.

Q. You can't tell because you don't remember; is that it?

A. Yes, I don't remember.

Q. Well do you know how long it will live in distilled water?

A. No.

Q. Do you know how long it will live in river water?

11647 A. It will vary in river water according to the conditions under which it is—

Q. Do you know that from your own experience?

A. No, from reading.

Q. What particular portion of the literature did you take into consideration when you expressed an opinion that typhoid germs would live only from five to seven days?

A. In river water?

Q. Yes?

A. I took into consideration particularly the work that has been done upon the purification of streams in Germany.

Q. In Germany?

A. Yes sir.

Q. What was that investigation in Germany that was made?

A. Well it is some time since I have looked over the literature, but I could recall perhaps some of the publications that have been made on the subject. One of the earliest and one of the most interesting publications was that of Frank, who studied the water of the river Spree in connection with the water supply of Berlin.

GENERAL CROW: Give the date of that if you can.

A. I think it was before 1890. The same water supply
77648 was studied later by other investigators, and in a large
part the work of Frank was confirmed. Then the study of the waters from Paris to Rouen was another investigation that was made; the study of the Izar river in connection with the city of Munich was one of the important studies; also that was made of the studies of the water at Cologne,—are very important studies in connection with the purification of streams. I mean the water from the river Rhine between Cologne and Dusseldorf.

Q. Now doctor, don't you know that you are now giving the results that were obtained from an examination of the river Seine, and other rivers in Europe in reference to the determination of what they then characterized as the zone of bacterial purification, without reference to the appearance or disappearance of disease producing germs?

A. The studies dealt particularly with the number of bacteria.

Q. And not with reference to the life of the typhoid germ?

A. Without particular reference to the life of the typhoid germ, yes and with reference to the life of bacteria in general above and below.

Q. But have you ever made any study of any literature
that dealt exclusively with the life of the typhoid fever
11649 germ in river water?

A. No, no special study of that.

Q. Then doctor, not having made an examination or a study either of the literature, or from practical experience, of the life of the typhoid fever germ in river water, how can you express an opinion and confine your opinion as to the life of the typhoid fever germs to from five to seven days in river water?

A. For two very good reasons. One, that I have read of the life of bacteria, many of which are more resistant than the typhoid bacilli, to environmental destructive influences, and the other that I have taught with eminent men and bacteriologists in whom I have confidence, who have worked directly upon this problem, and they have given me the results of their experience, in conversations.

Q. So you mean to express an opinion that is neither based upon a study of the literature, and all writings of men who have made it a study, nor based upon practical experience, but based solely upon what people have told you with reference to it?

A. I do, and I am very glad to do it, because I don't think I could give you a more reliable source.

Q. Now then, doctor, state who told you how long typhoid 11650 fever germs would live in river water?

A. Among others, Dr. Jordan of the University of Chicago.

Q. Did Dr. Jordan tell you that he had been able to preserve the life of the typhoid fever germ in Lake Michigan water for ninety days.

A. I don't recall that he did.

Q. When did you talk to Dr. Jordan about it?

A. Off and on during the last three years.

Q. Since the opening of the Chicago drainage canal?

A. Yes.

Q. Who else did you talk to doctor?

A. Dr. Hektoen.

Q. From where?

A. Also professor of pathology in the University of Chicago.

Q. When did you talk to him?

A. I have talked with him at various times; also during the last three years.

Q. Do you know whether this Dr. Hektoen had any practical experince?

A. I don't know; he has worked a great deal with all kinds of bacteria.

Q. But you don't know as to whether he has had any practical experience of his own with reference to the life of 11651 the typhoid in the river water?

A. No.

Q. Anybody else that you talked to?

A. No, I don't recall any one, especially.

Q. Then you have derived your information from these two men?

A. No, I can give you another source of information; my own opinion derived from the literature dealing with the effects of river water upon bacteria in general, and the inference that I drew from that with regard to the typhoid bacillus.

Q. Doctor, your experience in analyzing river water—

A. I have no experience in analyzing river water.

Q. You have no experience?

A. No.

Q. The literature that you have read upon the subject and all the literature that there is upon the subject so far as you know, has reference simply to the appearance and disappearance of the numbers or counts of bacteria per cubic centimeter, or in a known quantity of water, did it, without reference—

A. I didn't say it—

Q. I am saying it. Without reference to the character
11652 and kind of the bacteria that are present?

A. No, I know that there are articles dealing with the life of special bacteria.

Q. As found in the running stream?

A. As found in running streams.

Q. State some of those doctor?

A. I could not.

Q. You know of no article that you could recall to memory now?

A. I do not; I could easily get them for you.

Q. Now isn't it a fact that there is no publication dealing with that fact, undertaking to give the exact longevity of disease producing bacteria in running water, because they cannot produce in the laboratory like conditions that exist in the water?

A. Oh, that is perfectly true; I thought you said river water.

Q. Well, river water, then?

A. Well life in water in water from natural sources has been studied.

Q. And studied in the laboratory?

A. And studied in the laboratory.

Q. Now doctor, I want you to give us one?

11653 A. I cannot give you a single article.

Q. Can you name us one?

A. No, but I could look it up for you.

Q. We can look it up ourselves.

A. I have an index memory, and the older I get the more it has to be an index memory.

Q. Do you class yourself as a pathologist?

A. In the sense in which the term has been used in this examination today, I do.

Q. Do you mean to class yourself as an epidemiologist when you say that the typhoid fever germs will live in the Missouri, the Mississippi, and the Illinois river only from five to seven days?

A. I do not say that. I didn't say that they had lived in those rivers only from five to seven days.

Q. How long did you say that they would live?

A. I didn't say how long they would live.

Q. How long will they live?

A. I do not know, nor is there any way at present of finding out.

Q. Then if they are once deposited in the water, is there any way of determining when they will disappear?

11654 A. In a river water that is being contaminated along the banks with other typhoid bacilli—

Q. After they are deposited in a given stream of water, is there any way of determining when those particular disease-producing germs will disappear from that water?

A. It would all depend upon the conditions of the individual stream. As a rule it would not be possible. You might make certain probable statements.

Q. Doctor, in view of what you have said that it would depend upon the condition of the stream—

A. And its banks of course.

Q. Yes. I will ask you how you can say that it would depend upon the condition of the water in the stream when you have never made an examination as to the longevity of the typhoid fever germ in water or in river water, or in running water, when you are unable to give but the names of two men who have ever given you any information upon that subject, when you have not studied the source of the epidemics about which you have testified, and the pollution of the water, or the infection of the water?

A. Well my answer would be that one gets, after years of work with bacteria and disease, and after years of perusal of the literature, a capacity for passing judgment upon
11655 literature and experiments, and opinions, that does permit him to come to a conclusion just as satisfactory as anyone can get under the circumstances.

Q. From a study of the literature?

A. General literature of bacteriology and pathology.

Q. What experience have you had in studying the general literature of bacteriology, doctor?

A. Well—

Q. I want to ask you this question: If your study of the literature of bacteriology, has not been confined to the characteristics of the disease itself?

A. By no means.

Q. And not with reference to the life of the germ after it leaves the infected body and passes away?

A. By no means; indeed, in teaching, one has always to give his students the life history of each germ.

Q. Do you teach your students that typhoid fever germs will die in five to seven days?

A. I have not taught students bacteriology for some time now, but if I were teaching them now I would not teach them that they would die in five to seven days; I have not said so.

Q. Will they die in five to ten days?

A. I said that I thought that in all probability in sew-
11656 age they would largely die out before ten days.

GENERAL CROW: In pure sewage?

A. Or in a water strongly mixed with sewage, such as in the Chicago Drainage Canal.

MR. JEFFRIES: Well they didn't die out in the Chicago river prior to the opening of the canal, did they?

A. In five to seven days?

Q. They didn't die out in the river prior to the opening of the canal?

A. Why, great numbers of them died, of course.

Q. Well, did they die out?

A. All of them?

Q. Yes?

A. They were constantly being put in there every day.

Q. And the current was very slow and sluggish, wasn't it?

A. Yes, if the typhoid bacilli were to be deposited there—

Q. But the chances for them to get out to the Four Mile crib in Lake Michigan was very slim as to their chances of getting down the Illinois river now, weren't they?

A. How is that question again?

Q. Their opportunity for getting out to the Four Mile Crib at Chicago, was far less prior to the opening of the canal than their opportunity to get into the river Desplaines and the 11657 Illinois river now, wasn't it?

A. I don't know the exact conditions at that time; that was before I came to Chicago.

Q. Assuming, doctor, that the conditions in the Chicago river were such that the sewage of that city was discharged into the river, which had practically no current, remained in the river until it became a putrid mass, offensive to the smell and sight, and that it finally and gradually passed out into the lake and infected the water in the lake to a distance of four miles out; what would say as to the opportunity for the destruction of the typhoid germs in the Cihcago river, and in the lake as compared with their destruction in the canal today,—the drainage canal today, and the Illinois river?

MR. TODD: I object to the question on the ground that it assumes a condition that did not and never did exist in regard to the Chicago river, and that is that all the sewage of Chicago emptied into the Chicago river, and it was the Chicago river sewage that contaminates the water four miles from shore, for the reason that other sewers of the city empty into the lake directly and not through the Chicago river.

MR. JEFFRIES: Go ahead and answer the question doctor.

A. May I have the question again?

Q. (Question repeated).

11658 MR. TODD: And in addition, the question assumes a fact to exist which did not exist except during times of freshets when the current in the Chicago river tended towards the lake, and when as a matter of fact in times when there were no freshets the Bridgeport pumping works operating as they did, kept the current from going into the lake.

A. My answer would be that if it remained a long time in the river without going out into the lake, without any movement whatever, it would soon die out, and I should think would die out just about as quickly as in the drainage canal, provided there was no access of new typhoid bacilli daily or at intervals, to it.

GENERAL CROW: You didn't answer that question. Read the question.

Q. (Question read).

A. My answer to that would be that you have two things in your assumption which are incompatible as I understand it. You say that the bacteria remain in the river without current, until they are a putrid mass, then you further assume that they go out and infect the lake with typhoid infection. I do not think they would.

GENERAL CROW: We will say the sewage remained, 11659 instead of the bacteria.

A. The assumptions seem to me to be incompatible.

MR. JEFFRIES: Well, doctor, wouldn't they pass further down the running stream before they would perish than they would pass into the lake before they would perish?

MR. TODD: You mean since the opening of the canal?

MR. JEFFRIES: I mean any stream.

Q. Would they not pass farther down the drainage canal, the Desplaines and the Illinois rivers, before they perished, than they would pass into lake Michigan before they would perish?

A. You mean distances?

Q. Distances, yes?

A. Or time?

Q. I am talking about distance now?

A. Evidence is in favor of the view that the greater the dilution with pure water, the longer the life of the typhoid bacillus, and the greater the mixture of sewage, the greater the percentage of sewage, the greater the number of saprophytic bacteria present the quicker the typhoid bacillus dies out. Other thing being equal.

Q. Then doctor going back to the other question—

A. Other things being equal.

11660 Q. Then doctor, with the addition of 250,000 cubic feet of water per minute into the canal, passing through the canal, the river Desplaines and the Illinois river, would have a tendency to prolong the life of the typhoid germ would it not?

A. I think so.

Q. And as the water is added, the life is continually prolonged,—the life limit?

A. While the dilution, as I understand it—

Q. Well, we are talking about the life, doctor; we are not on dilution now.

A. I was about to say that this refers to the life of the bacillus as I understand it, the dilution is not great enough to interfere with the killing off of typhoid bacilli by the saprophytic bacteria.

GENERAL CROW: That is not answering the question. Just answer the question as he asked it, please.

A. Read that question please.

(Question read)

A. Over its life in pure sewage, yes.

Q. And over its life at this time in the canal?

A. Yes, I think that it wouldn't die out quite so quickly but that it probably would not make a very great difference.

11661 Q. Then the greater the pollution the less time they live, is that it? The greater the pollution the less the life limit?

A. With saprophytic bacteria.

Q. We are speaking now of disease producing bacteria, typhoid germs, for instance.

A. In the presence of sewage, yes, other things being equal.

Q. The greater the sewage pollution the less the life limit of the typhoid germs?

A. Other things being equal in my opinion, that is true.

Q. Then the greater the sewage pollution in the Chicago river, prior to the opening of the canal, the less chance for the disease producing bacteria to live?

A. For a long time, yes.

Q. How long, doctor will typhoid germs live in typhoid feces?

A. I do not know.

Q. Don't you know that they will live for several months?

A. I do not know; I have never made the experiment. I know of reports in literature of the typhoid bacilli having lived much longer time in the body of human individuals, but there has always been a question as to the interpretation of the observations of the reporters.

11662 Q. As a biologist and bacteriologist, and pathologist of the disease of typhoid fever do you mean to say that you have never undertaken the study of the life or the longevity of the typhoid germ in the typhoid feces?

A. That is quite true.

Q. Now to what extent in literature does your knowledge go?

A. About that particular point?

Q. Yes?

A. I have no recollection of the statements in the literature. If I wanted to find out, I should just refer to my library and see what had been done on it. I never have been interested in working it out myself.

Q. Now doctor, if the greater the sewage pollution the quicker the destruction of the typhoid germs, why is it necessary to divert the sewage of Chicago from the Chicago river and the lake front in order to protect the water supply of the city of Chicago?

A. For the reason that every source of pollution should be removed as quickly as possible—every source of pollution of a water supply should be removed as quickly as possible.

GENERAL CROW: That is the only reason for it, isn't it?

A. And the nuisance of course.

11663 Q. That is all, is it?

A. The only reason for—please read that question again.

Q. (Question read).

A. Yes, as far as I can say, that is the only reason.

MR. JEFFRIES: Then doctor, would it not have been better yet to have turned the sewage right into the lake than to have run the lake water into the canal? In other words, wouldn't the dilution have been greater?

A. But the water that runs into the canal does not go into the drinking water, whereas, if it were turned into the lake it would run down towards the drinking water; isn't that a great difference?

Q. Is that all the difference that you want to make?

A. It seems to me the important difference.

Q. How is that?

A. That seems to me the important difference.

Q. Then doctor, would it not have been better for the people living below, for Chicago to have discharged their sewage into the lake or have turned the Chicago river into the Illinois river without the lake water, than to have mixed the lake water with it?

A. I think that if there were—if down within fifty miles they were drawing their water supply from that river, it 11664 certainly would have been reprehensible to have turned the sewage into the river—drawing their water supply unfiltered from the river.

Q. Doctor would it not have been better for the destruction of the typhoid fever germs to have turned the sewage of Chicago into the river Desplaines and thence into the Illinois river without mixing it with the water from Lake Mchigan, than to have mixed it with the water of Lake Michigan as they have; would it not have been better for the quality of the water in the Illinois river below the point of discharge?

MR. TODD: I object to the question on the ground that it is not proper cross-examination of this witness, and on the further ground that it does not touch upon any of the issues in this case as alleged in the bill of complaint filed herein.

A. My answer would be that I am sorry to say that I do not know enough about the engineering difficulties to know whether or not your alternative plan would have been a feasible one.

Q. Well, I will ask you this question, doctor: would not the disease producing germs, typhoid germs for instance, disappear much more rapidly if the sewage of Chicago was turned into
the drainage canal unmixed with the water from Lake
11665 Michigan, than it will now as it is being mixed with the
water from Lake Michigan?

A. I should think that that was probably true.

Q. Well, isn't that true from what you have read about bacteria, and their behavior in sewage,—and from reading the literature?

A. Yes, in my opinion, it is true.

Q. Then from a sanitary standpoint, applied to the condition of the water in the Illinois river below the point of discharge of the Chicago sewage into that river, it would have been better to have eliminated the Lake Michigan water from the canal would it not?

A. Of course there are other—

MR. TODD: I object to the question unless the question of being better applies to Missouri and not to the towns in Illinois, for the reason that the issues in this case as defined by the bill, do not raise the question of the effect of the Chicago sewage upon the towns in Illinois, whether diluted or otherwise, because prior to the opening of the drainage canal the sewage of Chicago was pumped into the Illinois and Michigan canal in its crude state, but the issues apply to the effect of the sewage of Chicago upon the citizens of Missouri, and not upon the citizens of Illinois.

11666 A. With regard to the one sanitary feature of destruction of the typhoid bacillus, I should say Yes; with regard
to other sanitary features of the river, I should not say Yes.

Q. MR. JEFFRIES: Doctor, I want to ask you this question, if it is not a fact that the discharge of 250,000 cubic feet of Lake water per minute through the canal, passing on down the Illinois river, has had a tendency to prolong the life of the disease producing germs that are deposited in the Illinois river; not only in the sewage of Chicago, but in the sewage of all other towns and cities situated upon the banks of the Illinois river, over and above what it would be, and what it was prior to the opening of the canal, when the 250,000 cubic feet per minute was not discharged into the canal?

A. I don't see how it would be possible to answer that question in the absence of examinations made before the water was put through.

Q. Doctor, in the laboratory you know what effect an added amount of water will have upon the bacterial contents of a certain amount of other water, don't you, in order to obtain information as to the longevity and appearance and disappearance of the saprophytic bacteria? Now applying that test to the waters of the Illinois river, I will ask you if the addition of 250,000 cubic feet of water per minute coming from 11667 Lake Michigan, through the canal into the Illinois, has not only had a tendency to prolong the life of the disease producing germs found and contained in the Chicago sewage, but also of the disease producing germs contained in the sewage of other cities—of every other city situated upon the banks, and drainage area of the Illinois river, and which is discharged into the Illinois river?

A. I can only repeat that it would be impossible for me—

Q. Answer my question, doctor.

MR. TODD: I submit that he is answering the question.

A. As it would be impossible for me to make a definite statement with regard to that in the absence of data concerning the conditions in the river before the opening of the drainage canal,—my opinion on the matter would not be worth anything without that data, because the conditions vary for each stream; the conditions vary so much that tests would have to be made.

Q. Then doctor if that be true and you cannot tell how is it possible for you to express an opinion as you did in your examination in chief, in answer to Mr. Todd's question, that the typhoid germs will not come, or will not pass the journey and survive from Chicago to St. Louis?

11668 A. My opinion is formed on the total mass of evidence there, but that is a very different proposition. The conditions are very different.

Q. What mass of evidence is your opinion formed on? Was not this very thing that we are talking about—does not that enter into—

A. That was one factor only.

Q. And that factor was eliminated was it not, the addition of the 250,000 cubic feet of water?

A. Was eliminated?

Q. Was eliminated?

A. How do you mean was eliminated?

Q. From your opinion, from the total mass of facts and circumstances and information upon which you base your opinion as to whether or not the typhoid germs would go down and survive the journey?

A. No, it wasn't at all.

Q. It was not a factor?

A. It was not eliminated.

Q. Then if it is not eliminated, doctor, why is it that you cannot state whether or not the addition of the water would have a tendency to prolong the life not only of the disease producing germs, that are contained and found in the sew-
11669 age of Chicago, but in the sewage of every other city along the Illinois river?

A. I have already said that I thought it did prolong the life immediately below Chicago, but I would not be prepared to make any statement with regard to the effect of that water down at St. Louis, or far down the Illinois river.

Q. Now if the added volume of water at Chicago will have an effect upon prolonging the life of the typhoid germ, why will not that added volume of water have a like effect upon all other germs that find their way into the Illinois river below Chicago?

A. I should like to think about that before offering an opinion on it.

Q. All right, go ahead.

A. I should think that would extend the percentage increase of pure water added at various points; it would increase the longevity of the typhoid bacillus correspondingly.

Q. I don't think you understand the question. I don't mean the addition of water by the tributaries of the river; I mean the addition of the 250,000 cubic feet of water per minute at Chicago.

A. Yes.

Q. Now then, if that additional volume of water will
11670 have the effect at Chicago of prolonging the life of the typhoid fever germ, will not that same added volume of water also prolong the longevity of the typhoid germ, that is discharged into the Illinois river, from all of the points below Chicago?

A. Now I do understand it. I think that it would, but in a progressively diminished manner, because the relative percentage of increase would grow progressively less owing to the contents of the tributaries coming in below.

Q. Now doctor, with no other discharges from the tributaries subsequent to the opening of the canal than there was prior to the opening of the canal, with the volume of the water flowing from the tributaries into the Illinois river, practically the same now as prior to the opening of the Chicago drainage canal, I will ask you if the discharge of the 250,000 cubic feet of water per minute through the canal not only prolongs the life of the typhoid fever germs contained in the sewage of Chicago and discharged into the canal, but also prolongs the life of the typhoid fever germs deposited and discharged into the Illinois river from all the towns and cities on the Illinois river below Chicago as well?

A. I think I understand that. As the evidence is that the life of the bacillus is not very much prolonged, even at
11671 Chicago, I should doubt that it would be measurable, of course far down the river, that the longevity would be measurable, if we could submit the thing to experiment, which we cannot do.

Q. You say if the evidence is that it is very much prolonged?

A. Yes.

Q. What do you mean by that?

A. At any rate the evidence is that it dies out more quickly under the present conditions.

Q. Have you made any examination?

A. No, but doctor Jordan has told me of his examinations.

Q. You are taking Dr. Jordan's word for it, and not your own?

A. Yes, again.

MR. JEFFRIES: We move to strike out everything that this witness obtained from Dr. Jordan.

Q. The increased volume of water must necessarily have a great effect upon the life of the germ, does it not, doctor?

A. It has an effect.

Q. It has a great effect, hasn't it?

A. I don't know the comparative statement before and after in this particular case, but I know in a general way that the longevity is increased by the addition of pure water to the sewage.

11672 Q. But you don't know as to the extent of the increase?

A. Similar work was done on the Zurich water, by Tiemann, in 1900, at high water and low water, and comparison was made there, but the exact details of that research I have not in my mind.

Q. Then doctor, in view of that I want to ask you this question again. Would it not have been better from a sanitary standpoint and for the sanitary condition of the water in the Illinois river, to have turned the water and sewage of Chicago from the Chicago river, as it originally existed, into the Illinois river, without any lake water, than to have turned the lake water and sewage at the rate of 250,000 cubic feet per minute through the canal into the river?

MR. TODD: I object to the question on the ground, first, that it is not proper cross-examination; second, that it does not concern any issue in this case as raised by the bill of complaint, in regard to the sewage of Chicago affecting the inhabitants of the State of Missouri. And another reason as to whether the turning of the sewage into the canal without lake water, and the ability to do that being an engineering proposition that does not in any way affect the questions at issue in this case, and for the further reason that the question does not state whether it was better for the citizens of Chicago or for the citizens

11673 along the Illinois valley, or the citizens of Missouri, and unless it is confined to the citizens of Missouri it is not a proper question.

MR. JEFFRIES: The question is confined to the sanitary condition of the water in the Illinois river.

A. Does originally existing mean—

MR. JEFFRIES: Prior to the opening of the canal?

A. Yes, with the pumping going on? Give me the question again please.

(Question read.)

A. My answer to that would be that it might have been better for the upper part of the river, but that I doubt if it makes any appreciable difference with the lower part of the river.

Q. Have you any reason why it would not make any difference in the lower part of the river?

A. For two reasons, that I think the stream would purify itself so thoroughly at the lower end of the river, that the pollution would be inappreciable; and the other reason that the increase in volume of water relatively, would be so slight in the lower part of the river, owing to the access of so many tributaries in between, that any increase in the longevity of pathogenic bacteria would be doubtful, immeasurable.

11674 Q. Doctor, do you take into consideration in your answer that the volume of water flowing down the Illinois river at Grafton during certain seasons of the year since the opening of the Chicago drainage canal is less than the total volume of water passing through the Chicago drainage canal?

MR. TODD: I object to the question if it is stated as a fact.

MR. JEFFRIES: It is stated as a fact and shown by Professor Palmer's charts.

GENERAL CROW: All the testimony shows that,—that less water passes through the Illinois river than comes through the canal now, in cubic feet.

MR. TODD: I don't recollect that, but I reserve my objection just the same. Since the opening of the canal when they are throwing 250,000 cubic feet at Lockport, there has been less than 250,000 cubic feet passing at Kampsville.

MR. JEFFRIES: Yes, and at Grafton.

(Question repeated).

A. Assuming the fact I should think that Grafton was so far below Chicago that it was a matter that had very little bearing upon the question.

MR. JEFFRIES: Why, because of the time, or because 11675 of the volume of water?

A. Because of the self-purification of the stream.

Q. And what makes that?

A. The lack of nutritive materials and the sedimentation.

Q. Now what causes the loss of the nutritive materials?

A. Saprophytic bacteria largely.

Q. And as the nutritive materials disappear the saprophytic bacteria disappear?

A. Yes, that is true.

Q. But do you know doctor, that the typhoid fever germs do not depend upon the nutritive material in any way for their life?

A. I know that they can live a long time without nutritive material.

Q. And don't you know that they live longer without nutritive material than they do with it, unless confined in their native stage in the human system?

A. I think I simply have no opinion to offer on that. I do not know enough about it to offer any opinion.

Q. Now it is your opinion, is it, that the sewage material kills it?

A. My opinion is that they die out quicker when there is a great deal of sewage than when there is not. That is 11676 rather different from the way you put it.

Q. Now do you think there is enough of that sewage goes down to Grafton to kill the typhoid germs?

A. Which typhoid germs?

Q. That are deposited in the water at Chicago—in the river at Chicago?

A. I am not sure that any typhoid germs get as far as Grafton from Chicago.

Q. Well, do you know that they do not?

A. I don't think that they do. I don't think anybody could say that they did not. My opinion is that they do not.

Q. Well now, on what do you base that opinion? You say they don't—your opinion is that they do not?

A. I do not say that they do not, because I don't think anybody can say that, but my opinion is that they do not.

Q. Now on what do you base your opinion that they do not?

A. On the way bacteria die out in river water.

Q. Now then, on that question you have reference to the manner in which bacteria in general die out, without reference to the kind or the character?

A. And the statements that have been made to me by bacteriologists regarding the death of the typhoid bacillus, itself.

11677 Q. Now then, doctor, what is it in the water that causes them to die out?

A. That causes typhoid bacilli to die out?

Q. Yes?

A. I believe myself that a great many different factors are concerned, and that probably the factors are very different in every two rivers; that it is not the same thing in one river that it is in another, and that there might be great differences in individual rivers. In my opinion sedimentation and oxidation processes together with the influence the saprophytic bacteria, and exhaustion of food supply are the most important factors.

Q. Doctor, did you ever make any experiments with reference to the effect of oxidation upon typhoid bacilli?

A. No.

Q. Don't you know as a fact that they do not oxidize?

A. Well, they would if they were dead or sedimented.

Q. If they were dead they would oxidize?

A. I have oxidized typhoid bacilli, yes, when they were dead.

Q. But as long as they can live oxidation has no effect on them, does it?

A. I don't know that that has ever been determined.

Q. Now isn't that the general opinion, that oxidation has no effect upon the typhoid germ unless life is extinct?

11678 No, I am sure it would have some effect.

Q. They live in the earth, don't they?

A. Yes, for a time.

Q. They live in the winter time, don't they?

A. Yes, they can live in ice.

Q. They live many months in the earth, don't they?

A. I don't think there is evidence in favor of that; I don't know of any evidence in favor of that.

Q. Have you never read any of that kind of literature?

A. I have never read that point, no. I know that they have been said to live in dust for as long as ten days.

Q. Haven't they been said to live in dust as long as thirty days?

A. I don't know.

Q. Did you ever read about the case there in Plymouth, Pennsylvania, where they laid there for months?

A. That was a winter case, and it was the spring floods that brought it down. Yes, that is all reported in the Pennsylvania State Reports.

Q. They lived in the earth there, didn't they?

A. I though it was on the surface of the earth.

Q. Well, that is the same.

A. Under the snow. I may be wrong; it is a long time
11679 since I have read it.

Q. How long did they live there under the snow?

A. I don't know the length of time.

Q. Four weeks?

A. I don't know at all, how long it was after they were deposited from the typhoid patient. It was one case of typhoid and if I recall—well, I don't know about one dejecta, but it was from one case anyway, that that whole epidemic of 1100 odd cases developed.

Q. Didn't they live six weeks there and longer?

A. I don't know at all.

Q. If they did live there six weeks, in the snow, couldn't they live six weeks under the ice in the Illinois river?

A. I should think the conditions under ice in the river would be very different than conditions under snow on the ground.

Q. You should think they would be?

A. I shouldn't like to say that the same thing would happen in the two instances.

Q. Do you mean to say that they would disappear as rapidly under the ice as they would during the summer season of the year without ice?

11680 A. I don't think they would disappear so fast in the winter, on account of the saprophytic growth.

Q. There would be a very radical difference, would there not?

A. I should think so.

Q. But you don't know?

A. It would be my opinion that there would be.

Q. What causes that saprophytic growth?

A. The presence of food stuffs suitable to saprophytic bacteria and the presence of enough bacteria to spread the growth.

Q. Now then, doctor, do you know—I will ask you this question, if you don't know that the saprophytic growth does not destroy the typhoid germ; that it simply overgrows it and has no effect upon its life other than what little toxin it might cast off, but that as you add additional volume of water to the stream they have a better opportunity to swim away from those toxins, and therefore better opportunity to live, and do live longer; isn't that true?

A. The evidence is that they die out in the presence of saprophytic bacteria. Just what the reason is, I don't know.

Q. Don't you know that there is no evidence showing that they do die out in the presence of saprophytic bacteria any sooner than they die out in ordinary river water, or drinking water?

11681 A. But ordinary river water and drinking water contains saprophytic bacteria.

Q. But not so many as sewage water?

A. Not so many, no.

Q. In other words, doctor, don't you know this, that they die out just as quickly in ordinary safe drinking water as they do in sewage polluted water, and that the difference in distinguishing the duration of life in the two experiments is caused by the great increase or growth in the saprophytic bacteria in the sewage polluted water, so it has a tendency to cause the saprophytes to overgrow and render the conditions such that you cannot discern the typhoid because of their failure to multiply?

A. Well, it is obvious that there could be two interpretations of the results of such experiments. One interpretation would be this; the other would be the one that I put upon it.

Q. Now isn't it a fact that scientists, or men reputed as scientists, in discussing that in the literature, have given that as the reason for the disappearance of the typhoid germ in the sewage polluted water, in making their analyses bacteriologically in the laboratory, that the typhoid does not disappear any more rapidly in that water than it would in the natural water, 11682 but that the saprophytes overgrow it so that they cannot discern it—they cannot discern or distinguish the typhoid. It is obscured but not destroyed?

A. Yes, I think both opinions are held. It is obvious that one could not say which was right when the doctors disagree.

Q. And it may be either?

A. Yes, although my opinion leads to the other view, that they do die out.

Q. What evidence have you that they do die out?

A. The evidence that .one cannot find them. I feel that we could find them if they had not died out.

Q. Isn't that true of all water, that you cannot find them?

A. I know of no cases of where it has definitely been present.

Q. Don't you know doctor, that they have not been found even in sewage?

A. That is what I say. I know of no case where they have been definitely demonstrated in water, but the biological test shows its presence.

Q. Now doctor, you say temperature would have something to do with their life?

A. I should think it might, yes.

Q. Do you believe, doctor, in the old doctrine of self-purification of streams?

11683 A. Well, if you will formulate the old doctrine I could give a better answer to that.

Q. The Pettenkofer theory for instance?

A. I don't know it under that name. I know who Pettenkofer was, but I don't know his formula of that theory. If you would give me the exact—

Q. Will running water in the absence of sewage pollution eliminate pathogenic bacteria?

A. Yes, it will. I think it will. The sedimentation leads to the disappearance of the pathogenic bacteria. I say I think, because it must be only think, because the conditions do not exist. There is no such condition as far as I know, of running water without saprophytic bacteria.

Q. Do you know that they die in the course of sedimentation?

A. I think all the evidence favors that view.

Q. What evidence do you have reference to?

A. The fact that typhoid—that we have great typhoid epidemics, and that they disappear and die out again, the stream does purify itself. We have typhoid epidemics even from pond waters, and they die out. If they didn't die out, and all the people who are susceptible had not been infected, then the typhoid bacilli would have caused so many more people to

11684 have the disease that it would not have died out.

Q. Then it would be most liable to produce bad results, low water or high water?

A. To produce which?

Q. Bad results from a sanitary standpoint?

A. You mean as regards sedimentation or as regards the influence of saprophytic bacteria? I don't quite see what you mean.

Q. I mean in the conveyance of typhoid fever germs?

A. Down a river?

Q. Yes.

A. Without regard to the swiftness of the current; simply the height of the water, the depth of the water?

Q. Well, a given stream, under the assumption that at high water the current is more rapid than it is in low water, taking into consideration all the conditions that naturally arise between high water and low water in a given stream?

A. The studies of Thomann of Zurich refer to that particular point. He studied the river at Zurich at high water and at low water, and as I recall it, his results went to show that there was less purification of the water in general from bacteria when the water was high than when it was low.

11685 Q. Then the more water you put in a stream the more dangerous it is?

A. Other things being equal I should say so.

Q. Then the more water you put in the canal at Chicago, the Chicago drainage canal, the greater the danger is increased below, down the Illinois river?

A. For a certain distance.

Q. If there is more water comes out of the river at Grafton than there was prior to the opening of the canal, wouldn't the danger be increased?

A. If it were due to the opening of the canal and there were a great increase in volume, I think there would be some increase.

Q. Well suppose it was doubled at certain seasons, as to what it was in like seasons of prior years?

MR. TODD: I object to the question for the reason that the doubling of the flow of the drainage canal does not carry with it the increase of sewage which is thrown into the water when it is increased.

Q. (Question repeated.)

A. Other things being equal, I think that the longevity of the bacteria would be increased.

Q. Now doctor, you say you don't know how long typhoid germs will live in river water?

11686 A. In ordinary river water or sewage contaminated river water?

Q. Well, either or both?

A. I don't know absolutley, no. I have an idea of about how long.

Q. Do you know, doctor, how far the effects of the sewage of Chicago can be discerned in the Illinois river?

A. You mean bacteriological or chemical or both?

Q. Both, yes?

A. In the absence of data before the opening of the canal I don't know what the effect has been definitely.

Q. You don't know whether the sewage of Chicago would have an appreciable effect upon the water in the Illinois river at Kampsville, or not?

A. You mean in the dangerous character of the water?

Q. Yes?

A. I should think it very improbable that it had any effect on the water at Kampsville.

Q. Now on what do you base that?

A. On the distance that Kampsville is from Chicago.

Q. You judge altogether by distance?

A. No, I judge also by the fact that there is so much sewage in the water just below Chicago that I think the water would be robbed of its dangers very quickly. 11687

Q. Is there as much water in the Illinois river below Chicago now as there was water in the lake front before the canal was opened?

A. You mean in volume?

Q. Yes?

A. And how far out on the lake front would you go.

Q. Or dilution.

A. At what point in the river?

Q. Whatever point you mentioned.

A. Kampsville?

Q. No you mentioned it would be much farther above that.

A. Well, just below—

Q. The imaginary point that you have in your mind, whereever that may be, that you claim purification has taken place, and the water has been robbed of the pathogenic germs. Now where is that point?

A. Well, that is a vague point. Of course we have no means of determining.

Q. Why is it vague?

A. Because our information is not definite enough to permit us to locate it.

11688 Q. Now we will take Henry for instance, you know where that is?

A. Henry is above Peoria, yes.

Q. Now are the dilution and the opportunities for dilution as great at Henry as they were in the waters at the lake front prior to the opening of the canal?

A. Why I should think that it would be purer at a place like Henry, but I don't know.

GENERAL CROW: No, that is not the question. Is there more or less water in proportion to the sewage?

MR. JEFFRIES: In other words, is the dilution greater at Henry than it was at the intakes in the lake at Chicago?

A. The percentage composition—that the percentage composition at Henry of sewage and water, is what you mean?

Q. Yes.

A. I am afraid that any opinion I could offer on that would be too vague to be of any service.

Q. What would be your judgment about it? You understand the physical circumstances—all the points that are necessary?

A. I should think that chemically the water at a place like Henry would look like a more contaminated water than the water out at the intake, but I don't know.

11689 Q. Do you believe that the water at Henry is purer bacterially?

A. Pure, free from bacteria?

Q. No, do you believe that it has less bacteria in it at Henry since the opening of the canal than the water in Lake Michigan had at the Four Mile crib prior to the opening of the canal?

A. I don't know anything about the sewage relations of LaSalle, Ottawa and Morris, if they are pouring sewage into the river above Henry, then I should think the water would be much more polluted.

Q. You know about the population of those towns, don't you?

A. I have the data here.

Q. You may add that to Chicago and see what the per cent would be?

A. The point would be—the places like LaSalle and Ottawa being close to Henry, would contaminate the water dreadfully, if they are close. I do not recall just how close they are, but I should think that LaSalle was within thirty or forty miles of Henry.

Q. What is your opinion as to the sanitary condition of the water at Henry above Peoria?

A. Well, it is relatively very good.

11690 Q. What do you mean by relatively?

A. Well, I mean as compared to the water at Lockport, or the water below Peoria.

Q. Is it fit to use for domestic purposes?

A. Not ideally domestic purposes; I think it ought to be boiled.

Q. Is it reasonably safe?

A. I should think it was as safe as the water perhaps at Kampsville or a little above Kampsville.

Q. Would you recommend the water in the Illinois river at Henry as an epidemiologist, for domestic purposes?

A. No, nor anywhere else in the Illinois river, nor in the Missouri river, nor in the Mississippi river.

Q. What in your opinion is the difference in the effect of, or would be the difference in the effect of the sewage of Chicago upon the water in the Illinois river at Henry now, as compared to what it would have been prior to the opening of the canal if the Chicago river alone, containing the sewage of Chicago, had been turned into the Illinois river instead of the present drainage canal, with the 250,000 cubic feet of water per minute?

A. I don't know the engineering situation, but I should doubt if there would be very much difference.

11691 I would not be surprised if there were a difference in the volume—some difference in the volume of water, but I would be surprised if there were much difference in the dangerous qualities of the water.

Q. Do you think, then, that a flow of 29 miles in the canal purifies the water in the canal of the sewage from Chicago?

A. Is it only 29 miles to Henry?

Q. No, the canal is 29 miles long.

A. I should think it certainly did not, but I do not know how many pathogenic bacteria would be present there without getting—

Q. Well, you are figuring now as an epidemiologist?

A. Yes.

Q. And considering Chicago sewage as you would consider the sewage of any other city of like population?

A. Yes.

Q. Now then, if it does not purify itself in a running of 29 miles, through the canal, would all the effects of the sewage be removed in ten miles distance from the mouth of the canal?

A. That would be 39 miles from Chicago. Would all of the sewage be removed?

Q. Yes.

A. I shouldn't think so.

11692 Q. Would all of the pathogenic germs be removed?

A. I don't know.

Q. Well, would you think they would?

A. I wouldn't like to trust the water at that distance.

Q. Well, at a distance of 49 miles would you say they are all removed?

A. I should think they might be if there were no new excess with water.

Q. You would be willing to trust the water, would you?

A. No, I would not be willing to trust the water at 150 miles, because I should avoid it under all circumstances, on account of other contamination on the way.

Q. Cutting out all other contamination, eliminating that, we are dealing now with the effects of Chicago sewage upon that water; would you be willing to recommend it for domestic purposes in its raw condition at a distance of sixty miles from Chicago?

A. I shouldn't recommend it without filtration, or any river water.

Q. Would you recommend it at 75 miles from Chicago?

A. I would not recommend it any distance from Chicago without filtration.

Q. Cutting out now all the sources of pollution other 11693 than Chicago?

A. Oh, but that is an impossible condition, isn't it?

Q. That is a supposition, and that is an assumption and I want the answer. Would you consider that the water—

A. I don't think there is any possible way of telling for sure.

Q. —Became free from all pathogenic germs?

A. In my opinion it would be, but I don't think one could be sure.

Q. Would you recommend it as an epidemiologist, 150 miles away from Chicago?

A. I should want to have a biological test made.

Q. In the absence now of any biological test, we are talking about the river itself, and your knowledge of epidemiology?

A. I think it would be safe.

Q. Would you recommend it?

A. No.

Q. Would you now recommend it at Grafton?

A. No, nor at New Orleans.

Q. Removing all sources of pollution other than Chicago, from the Illinois river, would you recommend, as an epidemiologist, the water in the Illinois river at Grafton, knowing 11694 that the sewage of 2,000,000 of people at Chicago had been discharged into that river by means of the drainage canal, would you recommend it in its raw condition, as an epidemiologist, and suitable for domestic purposes?

A. In the absence of all contamination on the way, I think it would be safe.

Q. Would you recommend it?

A. No.

Q. Would you recommend it at St. Louis?

A. No, though I think it would be safe.

Q. Well, if you think it would be safe why are you not willing to recommend it?

A. Because we have ways of making absolutely sure. My opinion on safely is an opinion. We have methods of being absolutely sure, about our drinking water.

Q. But your opinion is not of sufficient weight with yourself to justify you to recommend the use of that water without filtration?

A. Not when we have a method that makes us absolutely sure.

Q. Taking conditions now as they exist in this civilization, with the means of ascertaining bacterially, chemically and every other way, the sanitary condition of water, your opinion that it is safe is not sufficient to justify you in recommending its use for domestic and drinking purposes, in its raw condition at Grafton and at St. Louis? 11695

MR. TODD: I object to the question as I do not believe the witness has stated that with the biological test having been made that he wouldn't use it.

MR. JEFFRIES: Cut the biological test out.

Q. (Question repeated, eliminating the word "biologically.")

MR. TODD: I still object to the question because the witness has not said "any other way."

A. That is the exact point of course, if we could make the test bacteriologically, chemically and in every other way, then I would recommend it.

Q. Now then, in the absence of all those tests, and with your knowledge as an epidemiologist, assuming that all sources of pollution are removed from the Illinois river, save and except the sewage from Chicago, discharged into the canal, with the 250,000 cubic feet of water per minute; thence into the Illinois river, would you recommend the water of the Illinois river at Grafton for domestic and drinking purposes, and would you recommend the water at St. Louis at the chain of rocks as suitable for domestic and drinking purposes in the condition that it would be in in arriving at those places?

11696 A. In the absence of all tests.

MR. TODD: Do you mean whether or not at St. Louis, as it now exists?

GENERAL CROW: Oh no we are assuming now that the water comes down and goes into the intake.

A. And that there is no water comes into the intake. Is that the question?

Q. Yes.

A. You assume that in that event St. Louis gets no water except that that came from Chicago?

Q. Yes.

A. I would of course make tests in such a case, and I think it would be safe to recommend it.

GENERAL CROW: But without the test would you recommend it?

A. I don't think one would have the right to recommend any water without making a test.

Q. But with that specific proposition would you recommend that water?

A. That is included in my answer.

Q. Excuse me; that question is susceptible of an answer "yes" or "no."

MR. TODD: I submit that the witness has answered that question.

11697 MR. JEFFRIES: Well, he has passed judgment upon this water without making tests as I understand it; now this is a hypothetical question and we ask the witness to answer the hypothesis.

MR. TODD: I submit that the witness has answered the question.

GENERAL CROW: No, he says he would make tests, and that is what our question excluded.

MR. JEFFRIES: You have recommended water without making tests, have you not?

A. I have recommended it?

Q. Yes.

A. I don't know that I have.

Q. Have you not stated that the sewage of Chicago had no effect upon the water at Grafton?

A. I said that in my opinion it had not.

Q. And that statement was made without having made a test of that water?

A. But I didn't recommend its use. I said in my opinion it would have very little if any effect, but that is a very different thing from recommending its use.

Q. Now you say that you think the water would be safe under the hypothesis that was just propounded to you?

11698 A. In my opinion, it would be, but I should—

Q. Now is that opinion such that would enable you in your judgment to recommend the use of that water for drinking and domestic purposes?

A. Without making tests?

Q. Without making tests.

A. No.

Q. Now then, what character of tests would you make?

A. Probably the test would have been already made when my opinion was asked, by people having drank the water, and if typhoid existed among them, and there were no other opportunities for typhoid infection of those people, I should be very suspicious of the water.

Q. Is that the best test?

A. I think so, yes.

Q. The use of the water?

A. I think it is the best test in the long run.

Q. Now doesn't the sanitary condition of the water depend largely upon the flow, the volume, the rate, the temperature the condition of the river with reference to flood times and low water stages, winter seasons and summer seasons?

A. It depends upon all those things.

11699 Q. And isn't it absolutely impossible for anyone to determine the exact place in the river where the water can at all times be recommended for domestic and drinking purposes, after the water of that stream has once been polluted with sewage discharges?

A. My answer to that is that as the water is continually being contaminated at a great many different points, it is safe to recommend that it be not used at all without filtration.

Q. Doctor, is it not absolutely impossible to determine at all times of the year the exact place where you would recommend the water passing through the drainage canal, the Illinois river and the Mississppi river, that it would at all times be safe for domestic and drinking purposes?

A. My opinion is that it is never safe at any time for domestic purposes.

Q. Now what makes that opinion?

A. The fact that typhoid fever cases are occurring among the people who drink the water.

Q. What makes the water unsafe?

A. Typhoid bacilli in the water.

Q. And where does it come from as a rule?

A. From the excreta poured into the rivers all along the banks.

11700 Q. Into the sewers?

A. Into the sewage, yes.

Q. Then the more sewage deposited into a river or discharged into a river the more danger?

A. For the places within a certain distance below that point, yes.

Q. Now then, can you name those distances?

A. No.

Q. Can you place them?

A. No.

Q. On any stream?

A. I don't think so. I don't know how it is.

Q. Can you, doctor, determine the point of safety in the Illinois river, and the point where the sewage of Chicago has lost its effect upon the waters of the Illinois river so far as pathogenic germs are concerned?

A. Only in a probable way.

Q. Can you ascertain it in such a way as would enable you to form an opinion that would be reliable?

A. It can be ascertained in a way that would make an opinion very probably reliable.

Q. Would it be an opinion upon which you would be able to make a recommendation?

11701 A. Oh yes, I could make a recommendation.

Q. For the use of the water for domestic and drinking purposes?

A. I think I have answered that question before.

Q. Well I know, but I want you to answer it again. You didn't answer just exactly that as I understood the case to be.

A. I think that considering the state of the education of the people and the state of politics and the possibilities of sanitary engineering, and the introduction of filtration plants satisfactorily, and so on, in this country, one would be justified in recommending the use of the water at certain places.

Q. Can you locate any place on the Illinois river where you would recommend it?

A. Assuming that—

MR. TODD: Under the present conditions?

MR. JEFFRIES: Under the present conditions where the water of the Illinois river has freed itself from the sewage contamination of Chicago?

A. And assuming that it got no other contamination since, do you mean?

Q. Yes, that is really assumed, but I am taking conditions as they stand. At what point in the Illinois river 11702 in your opinion has the water of the Illinois river freed itself from the sewage of Chicago or from the dangerous disease-producing germs contained in the sewage discharged into that river at Chicago?

A. I should think that for instance to take a definite point at which it would be, I think, safe, a place like Averyville, above Peoria, would be very safe as far as the sewage of Chicago is concerned.

Q. Now then do you know how far Averyville is from Chicago?

A. I think it is about 150 miles perhaps.

Q. About 150 miles from Lockport?

A. It is 159 miles from Chicago.

Q. Do you know how long it takes water to go from Chicago down to Averyville?

A. I don't know exactly, no.

Q. Now doctor, I want to know if that wouldn't have something to do with it?

A. I would go more by the bacteriological analysis at that place.

Q. Now then I want to ask you this question; if you were called upon to pass upon the sanitary condition of the 11703 water in the Illinois river at Averyville, knowing that the sewage of Chicago had been turned in, regardless of the fact that sewage from other cities upon the water-shed above Averyville had also been turned in, and the fact that Chicago had discharged its sewage through the drainage canal into the Illinois river above Averyville, would that have any effect upon you in passing upon the question as to whether or not that water was in good sanitary condition?

A. Certainly I would consider it, but I don't think that it would have any effect. I would certainly consider the—

Q. Then you would recommend it?

A. No, not without considering the whole situation.

Q. Now then, we are at Averyville, and we remove all of the sources of pollution—would you still recommend it?

A. If there were no typhoid in Averyville among people who were drinking the water, I would recommend it.

GENERAL CROW: But remove your test; we are going to supply that water.

A. Yes, I have in mind to supply the water.

Q. That is not the point. It is what we are doing in this proposition. You come in here and state that this water was safe at Averyville—

11704 A. I would not recommend what was not safe.

Q. You wouldn't recommend anything that was not safe?

A. I have not said so. I said in my opinion.

MR. JEFFRIES: Is that opinion of sufficient strength to authorize you to advise people to use it for domestic and drinking purposes in the houses, taking it bodily from the river?

A. Not without tests, no.

Q. What kind of tests do you mean?

A. Observation of the whole situation, especially of people who drink the water.

Q. Then, doctor, you don't undertake to say that you can determine from what little information you have with reference to the physical character of the Illinois river, the source and extent of pollution at Chicago, that the effects of the Chicago sewage are not carried throughout the entire length of the Illinois river, having never made a test?

A. All the evidence is against such a view as you state.

Q. Well now, what evidence do you have reference to?

A. The chemical and bacteriological studies of the river that have been made show great purification of the river—

Q. You have examined them, have you?

A. I have examined the record, yes.

11705 Q. How did the bacteriological and chemical examinations of the water in the Illinois river compare with those taken at the Four Mile crib in Lake Michigan, which was known to be infected with typhoid fever germs?

A. I do not know.

Q. Did you make any comparisons there?

A. No, I have not compared it.

Q. Don't you know, doctor, that the water at lake Michigan that was known to be infected with typhoid fever germs contained only one to 300 bacteria per cubic centimeter?

A. I have not read the account.

Q. Which is less than one-twentieth of that contained at any time in the waters of the Illinois river, the Illinois river being subjected to the same source of pollution, to wit, the city of Chicago with its nearly 2,000,000 inhabitants, as was the Four Mile Crib in Lake Michigan at Chicago. Do you know that?

A. No.

Q. Did you take that into consideration in passing upon the sanitary condition of the water in the Illinois river?

A. I had not heard that it bears upon the sanitary condition.

Q. It has nothing to do with the sanitary condition of the water whatever?

11706 A. What we have to deal with, then, is how does the water of Lake Michigan bear upon the problem of the water in the Illinois river—

Q. Don't you know that the water has been condemned in Chicago, the water taken from the Four Mile Crib, when it did not contain more than one to three hundred bacteria per cubic centimeter in amount?

A. I know that people in Chicago have died of typhoid fever.

Q. Don't you know, doctor, that one cubic centimeter of water taken from a river may contain 10,000 bacteria in amount and another cubic centimeter of water may be taken from another river containing only about 300 or 100 or 10 bacteria per cubic centimeter in amount, and the water in the one river containing the less number of bacteria would be condemned, while that in the other would be recommended?

A. That is just the reason why I have been insisting on a biological test, as the most important one all through, exactly for that reason.

Q. Then you cannot express any judgment or any opinion as to the exact time when the disease producing bacteria or germs deposited in the Illinois river by the sewage of Chicago will disappear?

A. Yes we can, because there is no evidence of any
11707 typhoid infection being carried by water further than
75 miles, as far as I know.

Q. Further than 175?

A. No, seventy-five miles.

Q. Now doctor, doesn't that depend altogether upon the volume, source of pollution, amount of pollution, and the rate of flow?

A. Taking in all the conditions that have ever been witnessed, there is no evidence as far as I know of the typhoid infection being carried further than seventy-five miles by water.

Q. How far is Cumberland from Washington, D. C.?

A. I do not know.

Q. Where is your seventy-five mile case, doctor?

A. I put seventy-five miles as a limit, because all the cases I know about fell within that.

Q. Don't you know, doctor, that it has been traced by reputable epidemiologists and scientists from the city of Cumberland to the city of Washington, D. C., a distance of 175 miles, and that a typhoid epidemic in the city of Cumberland—the sewage of that city being discharged into the Potomac river, found their way into the—that the typhoid germs found their
way into the water supply of the city of Washington,
11708 and created and caused a typhoid epidemic at that city?

MR. TODD: I object to the assumption for the reason that the only evidence in this case is the evidence of Professor Sedgwick, and in his testimony he didn't know, and made no investigation as to whether there were any cases of typhoid between Cumberland and Washington City.

A. I didn't know that Professor Sedgwick had made that statement and I am surprised that so eminent and accurate a man as he should do so.

MR. JEFFRIES: The question is, do you know that it has been traced that far?

A. No.

Q. Doctor, the best sanitary test of the water in the Illinois river would be its use for domestic and drinking purposes would it not?

A. At any given place, yes.

Q. Do you know whether or not the people living on the Illinois river use the water for domestic and drinking purposes, from Grafton to the city of Chicago?

A. I should hope that they did not. I do not know.

Q. Now why should you hope that they did not?

A. Because I understand that typhoid exists in all those towns, and that the sewage passes into the river.

11709 Q. Doctor, without the sewage of Chicago is there any reason to believe that the water in the Illinois river would not be as reasonably safe for domestic and drinking purposes, as the water in any other river of that size in this western country?

A. Why, I should think there must be very great differences in the pollution of different rivers in this western country, and that some would be polluted much more than others, and that therefore one could not make a statement of that sort without knowing the typhoid conditions along such rivers.

Q. It is your judgment is it, doctor, that the sewage from Chicago with the 2,000,000 of people, has no effect upon rendering the water flowing down the Illinois river unsanitary from source to mouth?

A. No, I have not said anything like that; I am sure that I never said anything like that.

Q. It is your judgment then, it has no effect upon it at its mouth; is that it?

A. You mean at Grafton?

Q. At Grafton?

A. In my opinion the effect would not be appreciable.

Q. Do you know how many people live on the Illinois river between Lockport and Grafton?

11710 A. No, I do not.

Q. Do you know how many people reside upon the whole water shed tributary to the Illinois river between those points, exclusive of the city of Chicago?

A. No.

Q. Now then, exclude Chicago and the sewage thereform, from the Illinois river, would you recomend the water of the Illinois river at Grafton for domestic and drinking purposes in its present condition the population of towns and cities and the various industries upon its water shed?

A. I think it would be tolerably safe to use, but I would not recommend it.

Q. Why wouldn't you recommend it?

A. Because I would want to make tests and find out whether it was really pure or not.

Q. Why would you want to make the tests?

A. Because I think a test ought always to be made before any water is recommended.

Q. Tests for what, now?

A. Tests for—especially of the presence of typhoid bacilli, as shown by the occurring of cases among people who drank of the water.

11711 Q. Then you recommend that the people drink it to determine whether or not it contained infected matter?

A. No, they always do those things, or nearly always it has been done for you.

Q. What is it then that makes the water suspicious and unfit for domestic use without a test?

A. Without any test whatever?

Q. Yes?

A. Well, there would be no suspicion if we had not had tests made. Our suspicions have come from tests and from our knowledge of the way disease is propagated. The Eve man had no suspicion about the water. He drank it wherever he could get it.

Q. What is it that renders waters in rivers unfit for domestic purposes?

A. Ordinarily—

Q. Sewage and pollution, isn't it?

A. Ordinarily the presence of pathogenic bacteria.

Q. And they come from sewage?

A. Yes sir.

Q. And the more sewage the more pollution, isn't that true?

A. Yes.

11712 Q. Then if there are more people living in Chicago than there are upon the entire water-shed of the Illinois river below Lockport, the pollution in the Illinois river would be doubled by reason of the condition of the sewage from Chicago, would it not?

A. Not throughout the whole river, no. In my opinion the presence of ten typhoid cases at Peoria would be more dangerous for the river water at Pekin than the presence of 10,000 cases of typhoid in Chicago.

Q. If you knew that there were 10,000 cases of typhoid fever in Chicago and that the discharges of those patients were passed into the canal, would you recommend the water at Grafton?

A. No, not without—I wouldn't recommend it under any circumstances.

Q. Now if there were one thousand cases?

A. Under any circumstances, except those due to the lack of education and to politics of the country.

Q. If you knew that there were 100 cases of typhoid fever during the months of May, June, July, August and September in the city of Chicago and that the excreta of those patients were discharged into the sewers of Chicago, and thence into the
canal, and from the canal into the river, would you use the
11713 water of the Illinois river at Grafton, for drinking and
domestic purposes yourself?

A. I would boil it until we had more knowledge. I think it would be safe, but I would boil it until we had more knowledge about it. Boil it or filter it.

Q. Now then what is your reason for saying that you would boil it until you had more knowledge?

A. My reason is—

Q. I will ask you this: If your reason for saying that you would boil it is because of the uncertainity of ascertaining just how far the germs will travel and how long they will live, and because of the fact that the science has been unable to determine the length of life and the distance they will travel, and the conditions under which they live in a running stream?

A. My answer to that is that I always use the most perfect method whenever I can, in technique.

Q. Any thing then that added to the character of the water in the way of creating a suspicion in the way of creating a deleterious effect upon that water, in the way of giving an opportunity for the presence of disease producing germs, would render that water less valuable for domestic and drinking purposes, would it not?

11714 A. You mean commercially?

Q. Financially, commercially, sanitarily and every other way in which water is used?

A. Exactly in the degree I should think, in which the suspicion was believed to be well founded.

Q. How long do you think that the typhoid germ will live in a running water?

A. Under what conditions?

Q. Well, the ordinary river water?

A. Without any special sewage contamination?

Q. Without any special sewage contamination?

A. I don't know how long they will live.

Q. You have no idea upon the subject?

A. Well, I should think—it would be only a case—it would be a mere opinion. I should think that they would or might live as long as ten days. I don't think they would live longer than thirty days.

Q. Well, do you think they would live longer in the running water than they would in a sample of that water kept in the laboratory?

A. No, I think they would live longer in the sample.

Q. Don't you know that the general opinion of all bac-
11715 teriologists and epidemiologists and scientists upon that
subject is that they will live longer in the running stream or in a large body of water than they will confined in prison where they are kept from oxygen to a large extent, in a bottle in the laboratory?

MR. TODD: I object to that question for the reason that it calls upon this witness to pass judgment upon the testimony of other witnesses who have already testified to the contrary in this case.

MR. JEFFRIES: That is true.

Q. I will ask you this question, if the literature upon the subject and the writings of scientists, bacteriologists and epidemiologists do not hold they will live longer in the running stream or in a large body of water like a lake, than they will in the sample of water contained in the laboratory?

A. I do not recall direct statements about the matter.

Q. I will ask you now if you yourself do not believe that reasoning from analogy, that the typhoid bacteria will live longer in the Chicago drainage canal than they will in a sample of water taken from the Chicago drainage canal and placed in the laboratory, for the reason that while it is contained in
the canal, fresh water is continually being added to it,
11716 and it washes the deleterious matter, the objectionable
matter away from it—the toxins away from it; it is able to swim itself; it is motile and swims away from its objectionable influences, while in the laboratory sample of water it is a confined prisoner, and if the literature upon that subject does not reason from analogy in that way and take the position that they will live longer in the running stream than they will in the sample?

A. I have heard very conflicting statements about this, but I have never gone into the subject enough to offer an opinion on it.

Q. Now whom have you heard make conflicting statements?

A. I have heard someone say, I do not know who it was, at the moment, that substances dissolved out of the glass in bottles that are helpful in keeping bacteria alive. It has been proven of course that chemical substances do dissolve out of glass when fluids are kept in bottles for a while; but in my opinion on this—I have no opinion on it.

Q. I thought you stated a moment ago that you were of opinion that they would live longer in the laboratory sample?

A. Well, it is not a strong opinion. I have that idea about it. It is not a strong opinion.

Q. Then you do not care to express an opinion on it?

11717 A. I would rather not.

Q. You don't care to express an opinion as to how long they will live in the Illinois river?

A. No, I do not like to—a definite opinion.

Q. They might live five days? They might live thirty days?

A. I don't think they would live more than thirty days. I don't think in the Illinois river they would live that long, if they started in the upper part of the river.

Q. What is the difference between the Illinois river and any other river that you are imagining now?

A. The amount of sewage in the river.

Q. What is the cause of that amount of sewage?

A. At Chicago it is sewered into the river, and they die very quickly where the sewage is abundant.

Q. Would that be true in winter?

A. I should think so.

Q. They would die just as fast in the winter as in summer?

A. No, I think they would die faster in winter in sewage contaminated water, than they would in water not contaminated by sewage.

Q. Well, would they die faster in sewage contaminated water in the drainage canal in the winter time than in the summer time in that same water? 11718

A. No, I think they would die faster in the summer.

Q. Then they would disappear more rapidly from the canal in the summer time than in the winter time?

A. That would be my opinion.

Q. Now that is your opinion with reference to disease producing germs in the summer time and winter time?

A. Based on the mean, between the two.

Q. Is that the correct way of basing opinions—would a mean be proper?

A. No, it would not.

Q. Is there any fairness in mean opinions?

A. No, it ought to be based upon the worst possible circumstances.

Q. It ought to be based upon the worst possible circumstances?

A. Yes.

Q. And can you say that under the worst possible circumstances, that the sewage of Chicago will in no wise affect the water in the Mississippi river at Grafton?

A. I think it very improbable that it would.

Q. Will you say that under no circumstances it will not
and cannot affect the sanitary condition of the water in
11719 the Mississippi river at Grafton?

A. I didn't make any definite statement.

Q. Well, do you say that now?

A. No, I said in my opinion it would not.

Q. Well, the saprophytic bacteria would not grow in the drainage canal in the winter time, would they?

A. Some would, I imagine.

Q. It would be a very slow growth though, wouldn't it, and as the water approached the freezing point it would be less would it not?

A. Yes, certain kinds.

Q. And when the water was frozen there would be no growth?

A. Of some kinds of saprophytic bacteria; some are influenced much more than others.

Q. What kinds?

A. I don't know.

Q. You know this, that there is a certain kind of water bacteria that grows faster in winter time than in summer time, but the saprophytic bacteria that come from sewage, and that are caused by sewage grow more rapidly in the summer time than they do in winter. Do you know?

A. I do not know.

Q. Don't you know that to be a fact?

11720 A. I don't know.

Q. You have never seen that?

A. I don't recall it at the moment.

Q. Doesn't it seem reasonable to believe that they would?

A. It might be reasonable.

Q. Well, isn't it reasonable?

A. I think either view could be reasonable.

Q. If that is a fact would it affect your opinion in any way?

A. I think the typhoid bacilli would die less quickly when the saprophytic bacteria,—one of the important factors—are slow in growing.

Q. But there are practically no saprophytic bacteria present when the water is frozen over with ice, are there?

A. Why, I think that they are present, and I believe that I would have included water bacteria among the saprophytic bacteria as a classification. Of course that is simply a matter of differentiation.

Q. But the water bacteria have no tendency to destroy the sewage?

A. Is that true? I did not know that.

Q. I am asking you. I am not a bacteriologist.

A. I suppose that they do.

11721 Q. I don't want you to think that I am a bacteriologist now; I am asking you?

A. Well, it is my opinion that they do.

Q. That the ordinary water bacteria destroy sewage?

A. Yes.

Q. And it is your opinion also that the ordinary water bacteria have a very extensive effect upon the life of the typhoid bacillus?

A. Yes.

Q. Now then, will you tell me how the water bacteria destroy the sewage, and how they destroy the life of the typhoid bacteria?

A. Well, the details of the process are not known. We know it happens; we know that they die out, and chemists and bacteriologists are working on the problem, trying to find out just how it happens.

Q. Then you don't know that they do?

A. Because waters do get purer.

Q. Well, how do you know that the water bacteria kill them?

A. I do not; it is only my opinion that they do; that they along with the—

Q. Does anyone else share that opinion with you?

A. I don't know.

11722 Q. Did you ever read it anywhere?

A. I do not recall having read it; but it seems to me probable.

Q. Is that not an important factor in forming your opinion?

A. Well, I have only thought of it at this moment.

Q. Then you didn't take that into consideration?

A. I had not separated the water bacteria particularly in my mind, from the bacteria in the sewage, but I do now, as you call my attention to it.

Q. But that would be a factor and while the water bacteria might increase very rapidly in the winter, certain kind of them, yet there would be another kind of bacteria that comes from the sewage itself, that would not increase in winter time?

A. It is a most interesting problem to investigate, I think.

Q. And as they fail to increase, the unpurified sewage would go further down the stream?

A. Unpurified sewage?

Q. Unpurified sewage?

A. I think so. How much further, I don't know.

Q. If the river was completely frozen over with ice for six to eight weeks of the year, they could probably travel very comfortably under the ice at a temperature of 32 to 33

11723 degrees could they not,—pathogenic germs?

A. Against the view that they do is the fact that typhoid is rare in winter and most abundant in the autumn and spring, when everything is melted up.

Q. You don't mean to say that there is no typhoid in the winter time?

A. No, but it is far less abundant.

Q. Is that true generally?

A. Yes, generally.

Q. Haven't some of the greatest epidemics in the history of this country occurred in the month of February?

A. Oh, there might be a great epidemic in any month of the year.

Q. Isn't it true as a matter of fact that nearly all of the epidemics do occur in the winter time or in early spring?

A. The spring and autumn are the two times.

Q. The autumn has the greater number of cases?

A. There are more cases in the autumn than in the spring.

Q. More cases because they occur generally all over the country?

A. More cases where they are much infected.

Q. More cases of epidemics?

11724 A. An explosive epidemic might occur at any time, but where it is due to continual pollution of the water supply the autumn cases are the most numerous.

Q. You mean to say then that they would not pass down under the ice and produce an epidemic?

A. You mean to St. Louis?

Q. Yes.

A. In my opinion it would not occur.

Q. What is it that makes you believe that?

A. I think that sedimentation alone would not be sufficient.

Q. If the sedimentation in the Illinois river was sufficient to remove them—by the way, is it not true that this lake at Baltimore that you spoke of, and the Lake Michigan at the Four Mile Crib and the lake at Toronto, would not be sufficient to eradicate them by sedimentation?

A. There would be if there were a continual access of new bacilli.

Q. Aren't there new and continual accesses here in the Illinois river?

A. Yes, but they have to go so far that the opportunity for sedimentation is very great, whereas, in these other instances they do not have to travel so far.

11725 Q. Is it the distance or the water that causes sedimentation—the condition of the water,—the distance traveled by the water or the condition of the water?

A. Why, sedimentation is going on all the time, and as water goes along, sedimentation is occurring. The further it goes, naturally the more is droped out.

Q. And these motile bacilli are continually settling, even in a running stream?

A. Yes, the motility of the typhoid bacillus would have comparatively little effect upon this.

Q. How would that be in flood time? Sedimentation would take place there too, wouldn't it?

A. To a certain extent; it would not occur so quickly.

Q. Assuming now that in a river it has been known to pass a distance of 175 miles, so that an epidemic at one point created an epidemic at a point below 175 miles, is it not reasonable to believe that it might be carried much further than the 175 miles, provided the time of travel is within the life time of the typhoid bacillus?

MR. TODD: I object to the question on the ground that it assumes that an epidemic originated at a distance of 175 miles.

A. The fact that we have no evidence that I regard as reliable—

11726 MR. JEFFRIES: We are not talking about having evidence; I am talking about this question now.

MR. TODD: I submit that you ought to let him answer the question.

A. That is what I am basing my opinion on.

MR. JEFFRIES: I beg your pardon for disturbing you, but I thought you didn't understand.

A. The fact that we have no evidence that I regard as reliable that an infection has been water-borne, for a distance of 175 miles, makes me think that the sedimentation process would be sufficient to eliminate it before it got—

Q. When you mention that you have no evidence of it, you simply mean that you have not observed it?

A. No evidence with which I am familiar in the literature, which I regard as reliable.

Q. Now doctor, assuming that a town situated upon the banks of a river is affected with a typhoid fever epidemic; that the sewage of that town is discharged into the river, and that the sewage so discharged affects the water supply of another town 175 miles below, and creates a typhoid epidemic among the people using that water of the river at that point for domestic and drinking purposes; is it not reasonable to believe that 11727 the typhoid germs thus carried a distance of 175 miles might not be carried to any other distance down the river so long as the distance did not exceed the life of the germ; isn't that true?

A. I don't think it would be reasonable to believe it until we had evidence that it happened.

Q. Assuming that it happened?

A. I don't think that we have any reason to believe that it would go further unless there was evidence that they had gone further.

Q. If it had gone 175 miles and it is not dead, isn't it reasonable to believe that if it is in that water, it will go further?

A. Yes, it is reasonable to believe it might go somewhat further, but how far one could not guess.

Q. If it has gone 175 miles down the river and is still alive in five days, isn't it just as reasonable that if it lives ten days, it may travel another 175 miles?

A. Assuming what you say, I don't think it would be unreasonable to believe.

Q. It is entirely reasonable to believe that if it has gone 175 miles, that it would, if it lives, long enough, travel another 175 miles under the same conditions?

A. Yes, that is a fact.

11728 Q. Doctor, what practical experience have you had in reference to the water supply of cities and investigation of those water supplies, and in the formulation of the water system for a city?

A. None at all.

Q. Have you had any practical experience in the study of any particular water supply for the purpose of determining whether or not that water was in a sanitary condition and suitable for domestic use?

A. I have made an analysis of private water supplies at Baltimore.

Q. You made the analyses of the water in the laboratory?

A. Yes.

Q. But as I understood you yesterday your work at Baltimore was not of sufficient scope to take in all the circumstances and physical facts surrounding the water supply?

A. Of the city of Baltimore as a whole?

Q. Yes?

A. No, I never investigated the city water supply of Baltimore as a whole, but I did examine the water for Mrs. Garrett,—private water supply, bacteriologically.

Q. Then you never examined the water supply of any city with the view of determining whether or not it was suitable for domestic and drinking purposes? 11729

A. No.

Q. Now you say you have examined a private water supply at Baltimore?

A. Simply bacteriologically—a bacteriological examination.

Q. Do you know the source of the water that you examined?

A. I know that it was sent to me in a bottle.

Q. But you don't know whether it was sent from a lake, river or well?

A. I knew at that time.

Q. You didn't go and collect the sample yourself?

A. No, it was collected for me by a medical man with the request that I make the bacterial examination.

Q. And he didn't tell you whether it came from a well or a spring?

A. Yes, he did, but I do not recall now.

Q. From that bacteriological analysis did you determine whether or not the water was suitable for domestic and drinking purposes?

A. Oh, I told him the number of bacteria per cubic centimeter in the water, and compared that with statements in the literature as to what was regarded as an over-polluted water
supply; but I pointed out to him at that time that such an
11730 analysis in the absence of a biological test, in my opinion,
was not sufficient to permit one to pass finally.

Q. Do you remember how many bacteria there were in that water?

A. No.

Q. You expressed no opinion as to the sanitary condition of the water at the time?

A. I expressed a relative opinion at the time.

Q. Do you know what that opinion was?

A. No, I do not recall.

Q. You don't know whether you told him the water was safe or unsafe?

A. As I recall it, it was, as compared with other waters, a safe water, but I do not recall the details.

Q. Now might it not have been doctor, that that sample that you examined, was taken from a well subjected to sewage leaking, and was highly contaminated with sewage, and yet have no large number of bacteria?

A. No, I don't think so.

Q. Isn't it a fact doctor, that water is often condemned that contains a very small number of bacteria, while other water containing a large number is recommended?

MR. TODD: I object to the question, as it is the identical question that was asked yesterday.

11731 MR. JEFFRIES: That is true, but in view of what
he has already said I want to determine just the character of the witness' opinion on the subject.

A. I think I answered that in the affirmative yesterday.

Q. You did not examine the water with the view of determining the character of the bacteria that you found in it?

A. Yes, I examined it especially for the bacilli of the colon group.

Q. Doctor, why do you examine water particularly for the purpose of ascertaining the colon bacilli?

A. Our experience has shown that if there are large numbers of the bacilli of the colon group present, it makes one very suspicious of sewage contamination.

Q. Now the more the sewage there is in the water, the more coli, is that true?

A. If the sewage be largely human excreta that would be true.

Q. Now the more coli that you discover in the water the more dangerous the water would be considered, would it not?

A. Not necessarily. There again, everything would depend upon the number of really pathogenic organisms in the sewage.

Q. But in expressing an opinion, you cannot find the pathogenic—the real pathogenic germs in the water, can you—
11732 you are not likely to find them?

A. The biological test is the best way.

Q. We are cutting out the biological test. We are speaking bacteriologically—the more coli bacilli that you find in the water the more the sewage pollution is apparent from the analysis, is it not?

A. Other things being equal, I should say that was true.

Q. Now, what other things being equal?

A. I mean to say, fairly constant conditions with regard to the destruction of bacteria in the water.

Q. Well, the same conditions that would destroy other bacteria would destroy the colon, would they not?

A. Well, that is what I mean, that if there happened in the particular stream to be something that would kill off colon bacilli, there might have been greater sewage pollution.

Q. Now, we are talking about the analysis of a particular sample of water, where you obtain a large number of the colon bacilli, that water is to be assumed—or condemned as sewage polluted?

A. The water is to be suspected of sewage pollution.

Q. Doctor, isn't it a fact that if you find a large number of colic bacilli in water, you condemn it as sewage polluted? If that is not true, why is it necessary to take into considera-
11733 tion the number of colon bacilli that is found in the samples of water, for the purpose of determining its sanitary condition?

A. I am not sure that the presence of colon bacilli is absolute proof of sewage pollution. I think colon bacilli might be in the water without—

Q. I understood you to say, Doctor, that when you found large quantities of colon bacilli in water, it was not as a general proposition, safe water to be used?

A. I said I would regard it as suspicious of sewage contamination.

Q. Well, I will ask you this question: if it is not a fact that the more the sewage the more the colon; the more sewage you have deposited into a stream, the more colon bacilli you will find in analysis of the water in that stream?

A. As a general statement, I think that would be true, but scientifically you would have to modify your statement by a lot of proportions. There is sewage and sewage, and there are waters in which sewage comes, and there are all sorts of environments and circumstances that would alter it.

Q. Then your judgment is that that is absolutely worthless?

A. Not at all. I think it is one of the most valuable
11734 means of giving us ideas with regard to sewage.

Q. Now, what other kinds or character of bacteria in sewage, speaking as a bacteriologist, do you consider in passing upon the sanitary condition of the water?

MR. TODD: I object to the question, as the witness has not qualified as a bacteriologist, and is not placed on the stand as a bacteriologist.

MR. JEFFRIES: He was qualified as a bacteriologist; he taught bacteriology.

MR. TODD: I submit that that is not born out by the record. He is an epidemiologist and pathologist, and every question I asked was along those lines.

GENERAL CROW: Do you base the objection on the proposition that he is not a bacteriologist?

MR. TODD: No, I base the objection on the fact that he was not put upon the witness stand as a bacteriologist and cross-examination as such is improper.

Q. (Question read).

A. Well, if I am to answer that question, I would say that I would consider especially the bacteria of the bacillus lactus aerogenes group, and of the proteus group.

Q. MR. JEFFRIES: Which of the three would you consider the more important?

11735 A. I would consider the colon bacillus the more important.

Q. Then it is true, isn't it, Doctor, that if you find a large number of colon bacilli in the water, that water is condemned at once by a bacteriologist, as being sewage polluted water?

A. I think it ordinarily would be. I think there might be waters with large numbers of colon bacilli in them, that would not be dangerous.

Q. Then the more sewage, the more colon?

A. In a general way.

Q. Then I understood you to say yesterday that the more sewage the more rapid would the pathogenic bacteria decrease. Now, how do you reconcile the two statements, that the more the colon bacilli the greater the probability of sewage pollution, and also that the greater the sewage pollution the greater the destruction of pathogenic germs?

A. Well, we were talking of particular pathogenic germs, and especially of the typhoid bacillus.

Q. Is not colon bacillus considered a pathogenic germ?

A. It is a very mildly pathogenic germ, and is classed by many as non-pathogenic.

Q. Who classes it as non-pathogenic?

11736 A. In the literature this was often referred to as a non-pathogenic germ, of course we know that it is pathogenic at times.

Q. Then the water would not be condemned because it contained the colon bacilli?

A. I think it would be regarded as very suspicious.

Q. And suspicious because the presence of the colon meant the presence of pathogenic bacteria?

A. Because it would make it probable that if it came from a typhoid infected city, that typhoid bacilli were present.

Q. Now, Doctor, the presence of the colon indicates the presence of sewage pollution, and the presence of typhoid bacilli?

A. Not necessarily, no.

Q. In the event it comes from an infected district?

A. It makes it probable.

Q. It makes it probable. Then, how do you reconcile the statement that the more sewage is discharged into a certain quantity of water, the greater the destruction of the pathogenic germs, such as typhoid bacilli, with the statement that the presence of the colon bacilli is indicative of the presence of the typhoid?

A. I say it is not indicative absolutely, but it arouses suspicion of the presence of typhoid. As I said before, there
11737 might be many colon bacilli with no typhoid bacilli present.

Q. You condemn the water because it contains colon bacilli, and the reason you condemn it on account of the presence of colon bacilli, is because it is sewage polluted and contains typhoid germs?

A. Might contain typhoid germs.

Q. Might contain typhoid germs?

A. I did not say that I condemned it; I said that I would be suspicious of it.

Q. And the more colon the more likelihood of typhoid germs?

A. No, I don't think that would follow at all. That would not follow.

Q. And the more sewage the greater the opportunity for the destruction of the typhoid germs?

A. That is a matter of relative proportion in the water; as I understand it, it is the percentage of sewage to water. It would not matter about the total bulk of sewage and water, but the percentage of the sewage and water in any given bulk.

Q. Doctor, supposing twice the amount, twice the number of the colon bacilli was found in the Chicago river prior to the opening of the Chicago drainage canal, that are found in the drainage canal today, what would you say as to the sanitary condition of that water?

11738 A. I do not know of any special inference that could be drawn from that.

Q. Would you say that there were less or more pathogenic germs in the water?

A. I don't think one could make a statement about that.

Q. Well, the condition of the water, you said yesterday, I believe, had a tendency to prolong the life of the typhoid germs, and the condition of the water would have a tendency to dilute the colon and render the number per cubic centimeter less, would it not?

A. But—

Q. Now, might not and would not, under those conditions there be more danger in a sample of water that contained the less number of colon than there was in samples containing a greater number of colon?

A. But I did not assume that the colon was the only saprophytic bacillus.

Q. Well, wouldn't that be proper?

A. I don't think it would.

Q. Isn't it a fact that if large quantities of colon bacilli were found in the Chicago river prior to the opening of the drainage canal, and that since the opening of the canal smaller quantities have been found in the water in the drainage 11739 canal than were found in the Chicago river prior to the opening of the canal, would not that indicate from the colon contained, that there was less danger since the opening of the canal than prior to the opening, and would it also not indicate from what was said yesterday, with reference to the condition of water, that there is more danger since the opening of the canal because the life of the germ has been prolonged by the addition of water, than there was prior thereto?

A. In other words, you mean that the one factor would diminish the danger and not in any other way was there an increase of danger?

Q. Now, is that true?

A. I think that could be argued.

Q. Now, if it appears, Doctor, that prior to the opening of the canal there were a larger number of colon in the waters of the Illinois river, and that since the opening of the canal there has been a decrease in the numbers; what significance would you give to those conditions, from what you have just said upon that subject?

A. I think very little significance could be given to it. It might mean that there was less sewage.

Q. Might it not mean this, and does it not mean this, Doctor,
that the failure to find the large numbers of colon bacilli in the
Illinois river since the opening of the canal, does not
11740 mean that they are not present, but means by the ad-
dition of the water that they have been further removed,
and that by that addition of water they themselves—their life
has been prolonged, and the life of the typhoid germ, and of
other bacteria in the water has been prolonged, and that there
is more danger in the diluted condition than there was in the
extremely polluted condition, prior to the opening of the canal?

A. It might.

Q. Well now, isn't that a fact?

A. It might mean that there has been increased destruction of the colon bacillus.

Q. What would bring about the increased destruction?

A. The various bacteriological influences that operate.

Q. What do you mean by the various bacteriological influences?

A. Any influence that will kill bacteria.

Q. Now I understood you to say yesterday that the more sewage you added in any quantity of water, the greater would be the destruction of the bacteria in that water?

A. Of the typhoid bacillus.

Q. And the more water you added the longer they would live?

A. Other things being equal.

11741 Q. What other things do you have reference to?

A. All the environmental circumstances.

Q. What are the environmental circumstances—

A. Chemical and physical.

Q. Name some of them?

A. I have done that before. I will gladly do it again. Physical influences, include air, light, temperature, electrical influences, chemical influences, and so on.

Q. Well now, those conditions were all the same after as before?

A. I am not sure that they are.

Q. Do you know anything about it?

A. I don't know the details of it, but I should think that there might be some differences.

Q. Then if you do not know the details of it and don't know that the conditions have been changed, why do you undertake to pass an opinion on the sanitary condition of the water in the Illinois river, and why do you undertake to designate a particular point in the Illinois river where it has become pure and has lost all of the pathogenic germs that have been discharged into that river by the sewage of Chicago?

A. In the first place I have not designated as you indicate.

Q. Did you not designate Averyville?

11742 A. And in the second place my opinion is based upon my general experience as a physician and epidemiologist.

Q. Did you not designate Averyville as the place where the water in the Illinois river, since the opening of the canal had lost all of the pathogenic germs, and was a safe water for domestic and drinking purposes?

A. I did not.

Q. So far as Chicago is concerned, did you not?

A. I said that in my opinion it would be a safe water at Averyville, if everything could be eliminated except the Chicago sewage.

Q. Would you recommend that water?

A. No.

Q. Eliminating all other sources of sewage?

A. No.

Q. Now then, if you don't know anything about these physical facts, including light, air and volume of water and other surrounding circumstances, which you stated were necessary, why is it that you formed an opinion as to that—why do you designate Averyville as the point where it would be a safe water?

A. From the chemical and bacteriological status of the water, and comparison in general with the purification of streams. 11743

Q. What are the chemical and bacteriological results there at Averyville?

A. Well, I haven't them with me, but I have examined them.

Q. Well, can you tell about what they are?

A. Well, in general the self-purification has gone on to a very remarkable extent.

Q. Are you a chemist?

A. I have done chemical work, but I would not designate myself as a chemist.

Q. What one particular chemical constituent in water is considered by you in your laboratory, and as a physician, as being the most suggestive of sewage pollution?

A. I don't think that I ought to be questioned on chemical analyses of water. It is not my fach.

Q. Then doctor, if you don't care to be questioned upon the chemical situation, why do you say that it is necessary to take into consideration the chemical analyses of the water in passing judgment upon the condition of that water, and if it is necessary to have the chemical analyses of the water or chemical tests in order to express judgment, why have you expressed judgment upon the sanitary condition of the water in the Illinois river?

11744 A. For the reason that I believe in getting all the facts together bearing upon the subject when one is passing a judgment upon it.

Q. Doctor, do you believe that you as a layman, would probably appreciate the significance of the chemical results obtained from the analysis of the water in the Illinois river or any other water, not being a chemist yourself?

A. I think that I know enough chemistry and know enough eminent chemists, to be able to appreciate the work of a chemist; to be able to find out how good a chemist's works are.

Q. Now isn't it a fact that chemists who examine water for the purpose of determining its sanitary condition, have designated certain chemical constituents in water which are the most indicative of sewage pollution?

A. Yes, there are differences of opinion even among the chemists.

Q. Now then what class of opinions do you accept?

A. I at any one time try to find out the opinion of the men who are recognized as the leaders in the subject.

Q. Who do you recognize as the leaders on that subject?

A. The way I would find out at the moment, because the leaders change from year to year, and the men whose opinion should be regarded--

11745 Q. Who are the leaders of this day?

A. I would go to my friends in chemistry, and men whom I know are eminent in chemistry, and talk to them about it.

Q. Is that the way you did at Averyville?

A. I talked to an excellent chemist.

Q. And you have expressed your opinion altogether on what an excellent man has told you?

A. No.

Q. So far as the chemical situation is concerned?

A. So far as the chemical situation at Averyville is concerned, yes.

Q. Just what he told you, you have relied upon that?

A. Yes sir.

Q. Now wasn't that Professor Long?

A. He was one of the men.

Q. Who else?

A. Dr. Jordan.

Q. Is Dr. Jordan a chemist?

A. I don't know how much chemical work he has done, but I think he has made chemical analyses.

Q. Well, do you know whether he is a chemist or not?

A. I don't know that he would be called a chemist.

Q. Why do you rely upon his chemical analysis?

11746 A. I would regard his opinion of other men's chemical analyses.

Q. Then I understand you to say that you are undertaking to give what Professor Long believes in references to the situation at Averyville chemically speaking?

A. Particularly the Averyville situation, yes.

Q. Is that true?

A. Yes.

Q. And you know nothing of the conditions at that point other than what you have learned from them?

A. With regard to the chemistry, no.

Q. You have talked it over with them and they agreed on that, that that was the point which you should determine and should designate, as the water being chemically pure?

A. I have not designated that the water was chemically pure there.

Q. (Question repeated)?

MR. TODD: The question is, did they agree that you should?

A. No, they have not told me to do anything.

Q. MR. JEFFRIES: Did not both of those men tell you that that was the point where the water, chemically speaking, was safe?

A. No, not in those words at all.

Q. So far as the Chicago sewage was concerned, and did you not go to them directly to get that information for
11747 the purpose of using it in your testimony here?

A. No; I got it before I had any idea of testifying in this case at all.

Q. Why did you get it?

A. Because I meet these men socially and talk over the general sanitary conditions, and medical conditions from time to time; because I am interested in these problems. I had no idea that I should testify in the case at all at that time.

Q. Have you talked with them since you had an idea that you would be called upon to testify in the case?

A. I have talked with Jordan, but not with Professor Long.

Q. What did you talk to them about?

A. About the general situation of the problem.

MR. TODD: I suggest that in view of his last answer, that he has only talked to one, as he stated, the question assumes that he talked to both since the time referred to.

MR. JEFFRIES: Well, he did talk to both of them.

THE WITNESS: Not since.

Q. Since you have been called upon you only talked to one, but you talked to both of them before?

A. Yes.

Q. Then doctor, you are simply expressing Professor Jordan's views on the situation, are you not?

11748 A. Not at all. In addition to his views we have all the evidence with regard to self-purification of streams which is in the literature to guide us.

Q. And the self-purification in the literature is just such as you referred to yesterday?

A. Yes sir.

Q. And all the purification had reference to the bacteriological purification and not with reference to the purification from the pathogenic bacteria?

A. I referred to my work that has been done on the subject.

Q. Well, isn't that true now, doctor?

A. It includes pathogenic as well as non-pathogenic.

Q. Isn't it a fact that those works pay no attention whatever to the appearance and disappearance of pathogenic germs, but deal entirely with the total number of counts of bacteria contained in the water?

A. If you will turn up the journals it will be possible for you to see exactly what they deal with. I can give you the references.

Q. Isn't that true?

A. I wouldn't want to make definite statements as to the exact nature of those articles, without having them by me. There are too many to carry in one's head.

11749 Q. Do you know of any one article that undertakes to state so far as the purity situation is concerned that they have determined from a bacterial standpoint, the particular place in the river where it is free from pathogenic germs when sewage from a city has been discharged into it?

A. As I pointed out yesterday, I do not think it is possible to do that under any conditions.

Q. I asked you if you know of any one article or any one man who has written an article upon the situation of purity, who has observed from his examination a complete disappearance of the pathogenic germs from the river after the sewage had been discharged into it above?

A. It seems to me that I have answered that question several times.

Q. Well, I want it answered again. I want to know if you know of any man that has written a book—I want to know what book it is, what article it was and where it is, and where it can be found?

A. All the literature bearing on that subject will be found referred to in Baumgarten's Jahresbericht.

Q. I want to know if you know of any piece of literature, either in pamphlet form or in book form, being published, or any man who has undertaken to investigate, and his investiga-
11750 tion shows or discloses a complete disappearance of pathogenic germs from a running stream below the point at which the sewage was discharged into that stream? Do you know or do you not know?

A. As I have said already, all the literature on the subject would be revealed in Baumgarten's Jahresbericht. I am giving you the name of the book and the name of the man.

Q. Well, does he undertake to say that he has made any such investigation and made any such determinations?

A. I cannot tell you what he says without turning up the volume.

Q. Then doctor, you haven't given that sufficient importance to impress it upon your mind, although you are a pathologist, and bacteriologist and an epidemiologist; is that true?

A. There are a great many things that I do not carry in my mind.

Q. Don't you think that as an epidemiologist, that that is a very important question, and don't you know that if it could be determined accurately and safely, that there would be no difficulty in naming the men who had made the determination; isn't that true?

A. If it could always be determined accurately and safely, it would be of course very valuable.

11751 Q. Now I want to know, doctor, if there is any man, epidemiologist, biologist or bacteriologist, that has ever made that character of a determination with reference to the pathogenic or disease producing germs?

A. With regard to the cholera, or any pathogenic germs?

Q. Of pathogenic germs being removed from the stream after the sewage discharges had been deposited in it?

A. I don't suppose any such research has ever been made, determining the complete absence of any pathogenic germs, from a stream.

Q. Doctor, with the addition of 250,000 cubic feet of water per minute in the water of the Illinois river, what is your judgment as to there being a greater number or a less number of bacteria per cubic centimeter, since the opening, than there was prior to the opening of the canal, in the Illinois river?

A. At all points in the Illinois river?

Q. At any point and all points?

A. I should think that there must be some pollution.

Q. What do you mean by that; less or more?

A. That would mean fewer bacteria.

Q. Fewer bacteria since the opening of the canal, is that true?

A. I am speaking theoretically now. I am merely offering 11752 an opinion.

Q. Well, you are speaking theoretically based upon your laboratory experience, are you not?

A. Yes, and reading.

Q. Now do you know as a fact whether or not the bacteriological results show that?

A. I don't know the comparisons between individual points before and after the opening of the canal.

Q. You made no comparisons?

A. No.

Q. Did you not state doctor, that the water at Averyville was in good condition because of the comparisons that you had made?

A. Before and after the opening of the canal?

Q. Yes?

A. No, sir.

Q. Then all that you know is what was done after the opening of the canal and what has been told you by Professor Jordan and Professor Long?

A. And what has been written about it, yes.

Q. What was written about it after the opening of the canal or before the opening of the canal?

A. After the opening of the canal.

11753 Q. And which related solely to conditions after the opening of the canal?

A. Well, there were references to the conditions before the opening of the canal in some of the articles.

Q. Did you consider those?

A. Yes, but there were no data as to the actual number of bacteria at any particular spot in the stream that I recall.

Q. Wasn't that important?

A. That would be very desirable.

Q. Isn't it important to know this?

A. Certainly if they are available. Are they available?

Q. Do you know that they conducted experiments for a year and a half before the opening of the canal—Professor Jordan and Professor Long? Do you know that?

A. I wasn't familiar with it at the time.

Q. Well, didn't you ask for that information when you were talking to Jordan and Long, and before you went upon this stand?

A. I didn't talk to Professor Long before coming on the stand.

Q. But when you found that you were coming on the stand?

A. I only had two or three days notice.

Q. You made no demand for those facts?

11754 A. No.

Q. Not deeming them necessary at the time, but now you say that it is necessary?

A. I have not said that it was necessary for my opinion.

Q. Wasn't it an important matter?

A. There are a great many things that would be desirable and important, but I am here to give evidence on what I am familiar with.

Q. Now just state what you are familiar with?

A. I am familiar with the clinical and pathological phenomena in typhoid fever and malarial fever, with a great deal of knowledge regarding epidemics.

Q. Now then doctor, basing your judgment upon your clinical and pathological experience, in the laboratory and hospital, I will ask you if you consider the analysis of water made by a chemist and bacteriologist, sufficient to give you information to determine as an epidemiologist, the sanitary condition of water?

A. I think they, together with the biological observations offer the most important axercerviates we have for making such determinations.

Q. Can your biological observations indicate to you what is likely to happen in the future?

11755 A. Well, as that is a very general question, my answer would have to be very general. In a general way, yes.

Q. And all conditions that might arise in the future?

A. Your question is so general that I do not think a specific answer—

Q. Well, I make it general so that you will answer it.

A. My biological observations in the past would hardly determine the character of the sun spots in future. I think your question is too general.

Q. But we are applying conditions to the Illinois river or to any river about which you are speaking. We are not talking about the spots on the sun.

A. I think that the biological features will always be very important; very important.

Q. And you can determine by the biological evidence just what the conditions are going to be in the future? I am asking you now for the sanitary results that are liable to happen in the future?

A. I would not be rash enough to make any prophecy as to the future, no; the past is the best guide we have to the future,—and the present.

Q. Now there is, as I understand you doctor, by the addition of the 250,000 cubic feet of water per minute, a less 11756 number of all kinds of bacilli per cubic centimeter or per given quantity of water, or in the Illinois river?

A. There would be the moment the water was mixed.

Q. Would not their opportunity for destruction be less by the addition of the water, than it would be prior thereto?

A. The oportunity for the typhoid bacillus to be destroyed immediately would be lessened possibly. I don't know whether the dilution is great enough to make much difference there.

Q. Did you study the amount of dilution?

A. No.

Q. The ratio?

A. No.

Q. Or proportion?

A. I cannot give you that.

Q. Is that not important?

A. Yes, that is not a part of the evidence which I am called here to give.

Q. Then doctor, if there had been nothing except Chicago river water turned into that canal, would it be safe at Averyville under existing conditions?

A. Under existing conditions?

Q. Yes?

A. I should not think so.

11757 Q. Then the addition of the water must have had some effect upon it?

A. I have said that river water is never quite safe, haven't I, to be recommended, at any rate.

Q. I understood you to say that in your opinion the water in the Illinois river had lost all the pathogenic germs by the time it reached Averyville—I mean pathogenic germs from the city of Chicago?

A. If all others on the way had been excluded?

Q. If all others on the way had been excluded?

A. I said in my opinion it would be safe, though I would not recommend it.

Q. And I not only understand you to say that, doctor, but I believe you said that under the present conditions, that the water in the Illinois river at Averyville in your judgment was free from the sewage of Chicago and was reasonably safe, did you not?

A. As far as Chicago itself is concerned.

Q. Taking into consideration conditions as they now exist, with the cities of Joliet and LaSalle and Henry and other places on the Illinois river, did you not say yesterday that in your opinion the water of the Illinois river was reasonably safe at 11758 Averyville?

A. I don't recall what I said yesterday on that point.

Q. Well, what do you say now?

A. Well, I should say that considering the existing conditions of towns along the bank, an unprotected water-way, that the water ought to be filtered or boiled before it is used.

Q. Would the sewage of Joliet have any effect upon it?

A. How far is Joliet from Averyville?

Q. You testified about the conditions, doctor; you ought to know the distance of Joliet?

A. Well, I have it here, but I don't carry those things in my head absolutely.

Q. Well now, I ask you, would the sewage of Joliet have any effect upon the water at Averyville?

A. You mean in the way of making it pathogenic?

Q. In the way of making it pathogenic or in the way of affecting its sanitary condition?

A. 125 miles, I should think it would have a very limited effect if any.

Q. Would the sewage from the city of LaSalle have any effect?

A. I should think it might.

Q. Do you know how large LaSalle is?

A. No, I do not know the population.

Q. Well, isn't it essential?

11759 A. No, not so essential I think. If there were ten or twenty or fifty cases of typhooid fever there it would be more important than if the city had 2,000,000 inhabitants, and no typhoid.

Q. Do you mean to say that Chicago has no typhoid?

A. Not at all. It has a great deal of typhoid. Much too much.

Q. Then why do you undertake to eliminate Chicago, or a city of 2,000,000 of people with no typhoid?

A. Well, the position of LaSalle is not the same as Chicago.

MR. TODD: I submit that he has not eliminated Chicago as a city of two million with no typhoid.

THE WITNESS: I did not have Chicago in my mind.

MR. JEFFRIES: What did you have in your mind?

A. I didn't have any great population.

Q. Do you know of any city of two millions of people that don't have typhoid fever? As an epidemiologist, have you ever heard of a city of 2,000,000 of people that had no typhoid fever?

A. Cities of course like Berlin and Munich. They are very large cities, but they have very little.

Q. But they have typhoid fever?

A. Yes, a very little—very little.

Q. And that typhoid fever is reduced there because of 11760 the protection of their water supply, is it not?

A. It is.

Q. Do you know, doctor, the total population of the sewered cities upon the Illinois river above Averyville?

A. The total population of the cities?

Q. Yes.

A. No, I haven't them. I have looked them over, but I have not the data in my mind.

Q. Name the towns then?

A. Well, some of the principal towns would be Lockport and Joliet—

Q. Well, the sewered towns I mean.

A. I don't know about the physical conditions.

Q. Do you know whether LaSalle is a sewered town?

A. No, I do not.

Q. Would not that make a great difference?

A. It makes a difference whether sewage comes into the water or not.

Q. Does not it make a difference as to the manner in which it is discharged into the water, whether it runs through the earth, over the earth, deposited in private vaults or directly sewered into the river; isn't that important?

A. The more direct—

11761 Q. Is not the total population of the sewered towns and the information as to whether the towns are sewered necessary in order to enable you to determine the sanitary condition of the water below those towns?

A. I think it would be a desirable thing.

Q. As an epidemiologist do you mean to say doctor, that you will undertake to express an opinion as to the sanitary condition of the water at Averyville without having first, as an epidemiologist, examined the physical conditions of the country and the river above Averyville for the purpose of determining the number of people living upon the water-shed, the various towns located on the water-shed, and with reference to whether or not those towns and cities are sewered or not, and the amount of typhoid fever prevalent on the river?

A. I am here to give you any information that I can and if you care to give me other data to use with those I have, I should be glad to give you my further opinion on that.

Q. Well, what data have you?

A. I have data with regard to the clinical course and pathology of typhoid fever and malaria, and general knowledge of infectious and epidemic diseases.

Q. Now then, answer my previous question, doctor. Will you undertake to express an opinion, and why have you
11762 undertaken to express an opinion as to the sanitary condition of the water in the Illinois river at Averyville without having first examined the physical condition of the river above Averyville, and examined the towns and cities situated upon its water-shed, to determine whether or not they were sewered directly into the river, the number of people living in those towns, and cities, and also examined the typhoid fever statistics of those cities?

A. The opinion I have given you is based—

Q. And also examined as to whether or not they had any sewers at all?

A. The opinion I have given you is based upon the data I have.

Q. On the data that you had?

A. That I have.

Q. The clinical and biological?

A. And general, and the data that I have collected in various ways with regard to the conditions here, without going into certain of the points that you have mentioned.

Q. Now what data have you collected, doctor. I want to know what specific data you have collected, that would enable you to determine and express an opinion as an epide-
11763 miologist now, upon the sanitary condition of the water in the Illinois river at Averyville?

A. Well, I have collected a great deal of data upon the self-purification of streams. I have a good deal of general knowledge of bacteriology. I fear this is rather an immodest sort of a statement, but I must do it, as you asked me to.

Q That is all right. I want you to make it.

A. I have gradually accumulated general conceptions about water supplies and sanitation in the course of the last fifteen years in medical work. I have read some of the literature bearing upon the researches upon the conditions of the Illinois river. I have talked with friends before I had any idea of dealing with this case, with regard to the situation and have formed judgments upon the situation. From all those together, and from my general knowledge of disease, clinical and pathologic, mode and spread of typhoid; from the fact that I have received what I regard as reliable information concerning the existence of typhoid in cities below Chicago on the river, and that the sewage from some of those cities at least, in which typhoid fever exists, is poured into the river. On all these taken together I have formed my opinion.

Q. Do you know, doctor, whether there is a town on the
11764 Illionis river that uses the water of that river for drinking purposes or domestic purposes, between Chicago and Grafton?

A. I should hope that there was not any that did not filter or boil the water.

Q. Don't you know doctor, that they don't use it filtered or in any other way?

A. I am very glad to hear it.

Q. Well, do you know it, and did you know it?

A. No.

Q. Now doctor, you spoke of this general information that you had received with reference to conditions above Averyville. Please state what conditions you have found from your examination of those conditions?

A. Well, I have a map here that gives some information.

Q. What is that, doctor, that you are examining now?

A. This is a map of the Illinois river and its principal tributaries,——Journal of Experimental Medicine.

Q. One of Professor Jordan's papers, is it?

A. It accompanies one of his papers as an illustration.

Q. Gotten up by Professor Jordan?

A. I imagine it was copied from some map. I know he

would be sure to get a good map if he used one. I have
11765 also here the Rand-McNally map of Illinois, which I will
use if you prefer that I use it. This is a little more easily looked over. It would take too long to give you all the data that I have collected, that I stated———

Q. I want to know just exactly what you did get.

MR. TODD: Give all details.

A. Well, as I understand it, the Illinois river receives a number of tributaries, including the Desplaines river, and the Fox river and the Kankakee river and the Vermillion river, and the Sangamon river, and other streams of various sizes and that these streams come into the river of course at different points. I understand that before the drainage canal was constructed that sewage was pumped from the Chicago river into the Illinois and Michigan Canal—I think that is the name of it—and that that canal then emptied that sewage into the Illinois river, but that since the drainage canal was built the Chicago river is more directly connected, without the aid of the pumping station. The sewage is poured into the canal at the upper part of the river. I should know that there are three or four locks on the river; that the stream is not a rapidly flowing stream; that in many parts of the river the rapidity of flow is very slow. I have understood that it is as low as half a mile in some places,
and that the conditions of flow in the stream are different
11766 at different times of the year. I have been given to
understand that not all the sewage of the city of Chicago goes into the drainage canal at present. Part of it still goes into the lake, but that an intercepting sewer is being built to lead more of the sewage into the drainage canal. I understood that the current into the lake from the Chicago river before the drainage canal was built was a very slight one, and sometimes it almost tended to run the other way, and that the smell from the sewage became objectionable, to the city, and that it was believed that the pouring of the Chicago river and its sewage into the lake was a deteriment and menace to the city's health, and that the drainage canal was built in order to protect the city from this danger, and also from the nuisance. I understood that this cost a great deal of money, many millions of dollars,—more than thirty millions, perhaps of dollars, and I have learned that on the banks of the river there are a number of towns which I have

already mentioned. I learned that typhoid fever exists in at least some of those towns, and I have been told by men upon whose opinions I rely that the sewage from some of those towns in which typhoid exists, is poured into the Illinois river, and that there is no adequate protection to either the river bank or the banks of the tributaries of the river, from contamination;
11767 that in fact the whole Illinois river is a drainage canal—in one sense it might be regarded as a drainage canal, and a drainage canal that is polluted at a great many different places. Then I have learned that the sewage deposited into the drainage canal and in points below it, had decreased with great rapidity in the number of bacteria which it contains, and that of course that agrees with observations in other places under similar conditions.

I have learned further that the stream as far as chemical and bacteriological analyses permit of a judgment to be formed, purifies itself gradually on the way down, from Chicago to Peoria; that at Lockport and Joliet the contamination of the stream is still very great, probably still great from the city of Chicago, and at Morris there is still a good deal of contamination in the stream, but that from that point on there is a tolerably rapid, though gradual diminution in the contamination of the stream as judged by bacteriological and chemical studies of the stream; that when Ottawa is reached there is far less contamination than at Morris. At LaSalle the contamination is still less, and that at Henry it is very slight, whereas, at Averyville the conditions are those of an ordinary river water that
11768 would ordinarily be regarded as a fairly good water, but that suddenly, below Averyville, at Peoria, the river again becomes very badly polluted from the sewage of that city. Indeed, while at Averyville a few miles above Peoria, the stream is a tolerably pure river water, even under present conditions, at Wesley, which is just below Peoria, the conditions are practically as bad as they were at Lockport, only thirty miles from Chicago; that this condition is also very bad at Pekin, and in all probability is exagerated by the sewers poured into the river at Pekin, and below Wesley, the river again tends to purify itself, and at Havana there is a remarkable diminution in the phenomena which chemists and bacteriologists regard as polluting phenomena; and at Beardstown, still less, and at Kampsville, still less,

and when Grafton is reached, the conditions are very much again like those at Averyville, as far as chemical and bacteriological studies are concerned, and the river compares quite favorably with ordinary river waters.

Q. That is all the information you obtained, is it?

A. I have here the number of deaths from typhoid fever in some of the towns along the banks of this river. They have already been put in evidence.

Q. It is all hearsay with you, isn't it?

A. I have introduced no hearsay except that that I regard as reliable. 11769

Q. But it is in fact, all hearsay, is it not?

A. Hearsay and reading. If you call reading hearsay.

Q. In other words, doctor———

A. It is not personal investigation.

Q. And therefore is hearsay?

A. It comes through the eyes.

MR. TODD: I submit that that interpretation is not exactly correct because statistics and health reports and matters of that kind would not be characterized as hearsay in the strict sense.

GENERAL CROW: Well, when you repeat them it is clearly hearsay, when you go to repeat them. If you introduce that as original it is not, but he repeats what he has read and what people have told him.

MR. TODD: Well, we differ with you.

MR. JEFFRIES: You did not ascertain the population of Joliet, LaSalle, Ottawa and Morris?

A. I looked over the population of those places, but I confess, I cannot recall them.

Q. You don't know whether they were sewered towns, or whether they had any sewers emptying into the Illinois river or not, do you?

11770 A. I was told that some of them were sewered towns.

Were you told which ones were sewered?

A. No, I don't recall that I was.

Q. So you based your judgment as a bacteriologist upon just what you have stated here in evidence, and that is the only reason upon which you state that in your judgment the water at Averyville is safe for domestic and drinking purposes?

A. I have not given you the details of the experimental work which I have studied.

Q. Well, we understand that you did give us the details of your experimental work which you have studied elsewhere, and we also understand that you took that into consideration in passing judgment upon the sanitary condition of this water, doctor?

A. I have done no experimental work on this river myself.

Q. I understand, but you are insisting on taking into consideration the experimental work that you have done in hospitals and other places?

A. And what I have read, and the experiments of others.

Q. Then I understand you that from your experience as a bacteriologist and biologist, and from what you have read, and from what you have just stated with reference to the
11771 physical conditions in the Illinois river, as having been obtained by you in talking with others and in reading articles written by others, you as an epidemiologist, undertake to express an opinion that the water in the Illinois river at Averyville, after receiving the sewage of Chicago and of other cities situated upon that river above Averyville, is in a reasonably safe sanitary condition?

A. I do.

Q. And you think, doctor, that you have stated in evidence sufficient information to enable you to make that statement?

A. I do.

Q. Doctor, do you know how long it takes the water to travel from Chicago to Averyville?

A. No, I don't know the exact time.

Q. Do you know whether it takes as much as five days?

A. I should think it would take that much.

Q. Now in expressing an opinion as to the sanitary condition of the water at Averyville, and the effect of the Chicago sewage upon that water, is it not essential to take into consideration the stream flow, the velocity of the stream above Averyville and between Averyville and the point of the sewage discharges?

A. If you hadn't evidence that the water at Averyville
11772 were relatively pure in other ways, it would be desirable to have that fact too. It is desirable to have all information on all factors that you can get of course.

Q. Well, doctor, supposing that the bacterial analysis of the water in the Mississippi river at the chain of rocks disclosed certain bacterial counts, and that the analysis of the water of the Mississippi river at Jefferson Barracks, a distance of twelve to fifteen miles below the Eads Bridge, or the central portion of the city,—Jefferson Barracks, being below the sewage discharges of the city of St. Louis, and assuming that the bacterial counts observed and obtained in the analysis of the water at Jefferson Barracks, was not materially different from those obtained at the chain of rocks, and assuming that the water at the chain of rocks was fairly safe for domestic purposes, what in your judgment would be the sanitary condition of the water in the river at Jefferson Barracks, and what would be the sanitary significance of the similarity of bacterial counts in the samples of water examined from the two points, the sewage of the city of St. Louis, containing 600,000 people, having been discharged into the Mississippi river from seven to fifteen miles above Jefferson Barracks, and the point thereat where samples were taken?

A. Assuming all the things that have been assumed, the
11773 proximity of Jefferson Barracks to the sewage out-pour
from the city of St. Louis, would even then render the water suspicious, I should think.

Q. Now then, what effect, doctor, has proximity to the place of the source of pollution upon the sanitary condition of water at a given point?

A. Well, given a certain rate of flow, and then the nearer the place to the source of pollution the less the opportunity for self-purification.

Q. Then you mean by that that because of the flow the impurities discharged into the river are carried by the current and by the volume of water down the river below the point of discharge, is that true?

A. Yes, that would be true.

Q. And the greater the volume of the water, the more rapid the current, the greater the zone of pollution will become and exist in the river; is that true?

A Yes, I think that is true, although the dilution would have an important——the greater the dilution the less the pollution at the point where the dilution takes place, of course.

Q. But the pollution is there nevertheless?

A. Yes.

11774 Q. Although in a more diluted state?

A. Yes, and in a given quantity of water it would be less dangerous than undiluted.

Q. But by reason of the greater quantity of water mixed with the same quantity of sewage, the zone of pollution is more extensive as the water flows down the stream?

A. That would depend of course upon the quantity of dilution. I don't know of my knowledge that the extent of pollution and longevity of pathogenic bacteria is directly proportionate to the volume of water. I imagine it is not.

Q. Doctor, assuming that the bacterial counts at Averyille were from 33 to 100 per cent greater in the analyses of the water in the Illinois river at Averyville made prior to the opening of the Chicago drainage canal, than is contained and found in the analysis of the same water or the water from the same river since the opening of the canal; what significance do you attribute or would you attribute to the relative differences in bacterial counts?

A. I think the significance would depend largely upon the volume of water passing through as compared at the two times.

Q. Well, would it have any significance at all?

A. It might not.

Q. Under what conditions would it not?

11775 A. If there were no pathogenic bacteria among them, it would not be significant.

Q. Well, now assuming that there were pathogenic bacteria deposited in the river at Chicago in both instances?

A. No, but I mean at Averyville.

Q. Assuming that the sewage from Chicago passed down the Illinois river prior to the opening of the canal and that since the opening of the canal the same sewage passes down the river, or the sewage from the same city, diluted with 250,000 cubic feet of water per minute, and assuming further that the bacterial counts were from 33 to 100 per cent more at Averyville prior to the opening of the canal, than they are at Averyville since the opening of the canal, what significance would you give that?

A. It might not have any significance.

Q. Why not?

A. And especially unless the counts were made at different times of the same day, and at every day, for a very long period of time.

Q. Well, assuming that that condition existed, with the counts having been made and the analyses having been made of the waters at both periods, for some two to three months, continuously, once or twice a week, and that the average
11776 conditions were as assumed in the previous question?

A. And the bacteria were less numerous?

Q. Yes, since the opening of the canal than prior thereto?

A. Do you mean that the total number of bacteria or the bacteria per cubic centimeter?

Q. The total number of bacteria per cubic centimeter obtained from the samples of water analyzed bacterially?

A. Well, I think it would depend largely upon the volume of water.

Q. Isn't it a fact doctor, that the addition of the 250,000 cubic feet of water per minute to the Illinois river, mixed with the sewage of Chicago, has had a tendency to preserve the life of the pathogenic germs, and carry them much further down the Illinois river than they were carried prior to the opening of the canal when they were discharged into that river without being mixed with the water from Lake Michigan?

A. I don't think that it can be regarded as a fact; I don't think such a fact has been established.

Q. Assuming that it was established, isn't it a fact that the pathogenic bacteria would disappear much more rapidly in the smaller stream containing the same sewage than it would in the larger stream containing the same sewage?

11777 A. I am not sure that it would. I don't know that the percentage comparisons are so different as to make any material difference in the rapidity of death.

Q. Well, what are you sure of?

A. Of things I am convinced of.

Q. Well, do you say that it would make no difference?

A. No, I say I do not know.

Q. You do not know whether it would or not?

A. No.

Q. Didn't I understand you to say yesterday that the more water you add to sewage, the longer the pathogenic germs contained in that sewage, so mixed with the water, would live?

A. I said that the typhoid bacilli would live longer in pure water than in sewage contaminated water.

Q. Didn't I understand you doctor, to say yesterday that in sewage polluted water, water strongly impregnated with sewage, there would be greater saprophytic action, and consequently a greater reduction of the pathogenic bacteria, and that in proportion to the added volume of water to the sewage, the saprophytic action was decreased, and the life of the typhoid and other pathogenic bacteria prolonged.

A. I don't think that I said in proportion, and if I did, I
11778 should not have said so.

Q. Well, if it is a fact that dilution does increase the life and longevity of the typhoid and other pathogenic germs, isn't it a fact that it can be proportioned?

A. Not until the fact is established.

Q. By the establishment of the fact?

A. By actual experiments, and actual knowledge, and as far as I know that has not been established.

Q. Well, would it not be necessary to establish that in order to make the determination?

A. It may not be very easy to establish it.

Q. As a bacteriologist, what effect has the discharge of 250,000 cubic feet of water per minute into the drainage canal, had upon the bacterial action of the sewage of Chicago when discharged into that canal?

A. Well, I am not testifying as a bacteriologist, but rather as an epidemiologist and pathologist. My opinion with regard to that would be based entirely upon actual observations, as far as possible, and without actual data, though, I think that would be unwise, to give a very definite opinion. I think it might be different in the two streams.

Q. Has it had any effect?

A. I should think it probably had.

11779 Q. It has had the effect, has it not, of prolonging the life of the typhoid germ?

A. I don't know that it has.

Q. Well, if it has had any effect that would be the effect, would it not?

A. Yes, I should think that would be the effect if it had any effect.

Q. Does your experience and your information furnish you any support or any aid in forming any opinion?

A. My opinion is formed on the data that I have given you.

Q. I will ask you, Doctor, if it is not a fact that by the discharge of the sewage of Chicago into the Desplaines and Illinois rivers, without being mixed with water from Lake Michigan to any extent whatever that the conditions for the disappearance of the pathogenic germs would be far greater and they would much more rapidly disappear under such conditions than they will by being discharged into the Illinois river as now, mixed with the water from Lake Michigan at the rate of 250,000 cubic feet per minute?

A. I don't know that to be a fact.

Q. Well, what is your opinion?

A. My opinion is that there is probably very little difference.

11780 Q. Then you are of a different opinion from what you were yesterday when you testified?

A. No, I don't think so.

Q. Then you think the addition of the volume of water would not be conducive to the destruction nor would it be conducive to the preservation of the life of the typhoid and other pathogenic bacteria,—the addition of the 250,000 cubic feet of water per minute?

A. I am not sure that the quantity of water mentioned, as mixed would make any very great difference either way, but I think the tendency would be to increase the life of certain bacteria.

Q. I will ask you, Doctor, if the quantity of 250,000 cubic feet per minute, running 24 hours per day, passing through the same channel that the sewage of Chicago is passing, would not have a very great influence upon the activity of the saprophytic bacteria?

A. With the amount of sewage that there is, I could not be sure that that is true; it would have some influence undoubtedly, but how much, I don't know.

Q. Then, Doctor, I suppose you take the position that as it

would have no practical effect, that the drainage canal as
11781 it exists today, composed of the sewage from Chicago
and Lake Michigan water, is an open sewer?

A. I have not said that it had no practical effect.

Q. What effect has the water from Lake Michigan, coming at the rate of 250,000 cubic feet per minute through the canal, had upon the saprophytic activity of that water when mixed with the sewage from Chicago?

A. I have made no experiments to determine that question.

Q. Well, what is your opinion?

A. Without experimental data behind it?

Q. As an epidemiologist, that proposition is presented to you now?

A. As an epidemiologist I don't think that the opinion would be valuable.

Q. Well, what is your opinion, we will see whether it is valuable or not?

A. I have not any very confirmed opinion about it.

Q. Now, is that opinion equally true at Averyville?

A. The opinion about the purification?

Q. Yes?

A. I am of very much the firmer opinion about the conditions at Averyville.

Q. And why?

11782 A. Because the data that I have about Averyville are
such as to permit me to form an opinion.

Q. You mean to say that you have data about Averyville and yet no data about conditions existing in the drainage canal, and at the same time are willing to express an opinion upon the one and not upon the other?

A. I have data about both but the opinion is about two entirely different things.

Q. You say that you have no data upon the conditions existing in the drainage canal?

A. No, I said that the data I had were not sufficient to let me form an opinion about the particular question that you ask.

Q. Is the data sufficient to let you form an opinion as to the saprophytic action in the water at Averyville?

A. I said that from the distance that Averyville lies from

Chicago, that I doubted if there would be any appreciable difference at that distance.

Q. And in that opinion you have taken into consideration the question of distance then?

A. Yes.

Q. And distance alone?

11783 A. Distance and bacteriological and chemical analyses.

Q. You mean time instead of distance?

A. I mean taking into account all of the information that I have, as given to you this forenoon.

Q. Do you think that you have sufficient information to form an opinion and to recommend to a large city which is calling upon you for an opinion as to the sanitary condition of the water at Averyville, for the purpose of constructing a waterworks, and supplying that city with water, that the information that you have would enable you to say to that city that the water at Averyville is in a sanitary condition and reasonably safe, and is not affected by the sewage from Chicago?

A. I have sufficient information to say that in all probability it is reasonably safe, but that tests should be applied, before it should be recommended.

Q. Would you recommend to a city the use of the water in the Illinois river at Averyville, and would you in your recommendation state to that city that the water at that point was not affected by the sewage of Chicago as it exists today?

A. As I have said before, I would not recommend any river water for use in cities.

11784 Q. Would you recommend to that city that the water in the Illinois river at Averyville was not affected by the sewage of Chicago?

A. I would say that in my opinion it was not materially affected.

Q. And would you recommend to them that they could use it without fear of receiving any harmful results from Chicago; is that true?

A. As I have said, I would not recommend any water without tests.

Q. Well, you have not tested the water at Averyville, have you?

A. No.

Q. And yet you stated in your examination in chief that at that point it was reasonably safe, and that you would recommend it?

A. No, not that I would recommend it.

MR. TODD: I submit that all through his examination while he has given his opinion as to the waters of the Illinois river at certain points as being reasonably safe, at no point has he stated that he would recommend the water of the Illinois or any other river which receives sewage, for domestic and drinking purposes, without making preliminary tests, or the use of a filter system.

11785 MR. JEFFRIES: Doctor, if you knew that it did not take the water five days to come from Chicago to Averyville, would that have any effect upon your opinion?

A. Yes, it would.

Q. What way would it affect it?

A. I shouldn't be sure that in five days absolutely every typhoid bacillus would be dead.

Q. Doctor, if you were called upon to recommend that water at Grafton from the Illinois river, pass your judgment as an epidemiologist upon the sanitary condition of the water at Grafton for domestic use, and assuming that some city had called upon you to render an opinion as a scientist and as an epidemiologist, as to the sanitary condition of the water in the Illinois river at Grafton, with the information that you have, knowing that the city of Chicago is situated upon that watershed, or that the sewage of Chicago rather was discharged into the river, knowing also that the city of Chicago had a population of two millions of people, would you say to that city that the water at Grafton was not affected by the sewage of the city of Chicago?

A. I would say that in my opinion there was no evidence that is was.

Q. And that opinion would be of sufficient strength to 11786 enable you to say to the people, "You may use it without deleterious effects?"

A. I would advise them not to use it without filtration or boiling.

Q. And you would do that regardless of the fact that they were calling upon you to pass upon no question other than the effect of the sewage of Chicago upon the waters of the Illinois river at Grafton?

A. Yes, because you could never be sure of the protection between any two places.

Q. That is not the question, Doctor. A city calls upon you to give them an opinion as an epidemiologist, as to whether or not the sewage of the city of Chicago will affect the water in the Illinois river at Grafton; now, I want to know if in your opinion you could recommend to that city that the water at Grafton was in no wise affected at any time in the year by the sewage of Chicago?

MR. TODD: I object to the question for the reason that it does not take into account the conditions of pollution from the different towns upon the tributaries entering into the Illinois river, but asks for an opinion as to the sewage from Chicago without including the other conditions which obtain upon the river and are proper for consideration.

11787 MR. JEFFRIES: I suggest to the Court that counsel for defendants in his examination in chief, asked this witness his opinion as to the effect of the sewage of Chicago upon the waters of the Illinois river at Grafton, and that this question is directly in line with the question propounded to the witness in his examination in chief.

Q. (Question repeated.)

A. I would give them that as my opinion.

Q. You would?

A. Yes.

Q. Now, Doctor, what would that opinion be based upon?

A. Upon the information which I have obtained.

Q. That you have?

A. I have obtained,—and of course if I were asked in a case of that sort, I should get all the additional information I could about it.

Q. But remember, you have been asked that question with just what information you have, and no more, and you have not called upon either the defendants or the complainant in this case for additional information before you answered the question: you are answering it now upon just the information that you possess today, and do you still say that you would recommend it?

11788 MR. TODD: I object. He hasn't stated that.

GENERAL CROW: Let him state what he has stated.

MR. JEFFRIES: He has stated that it would have no effect.

THE WITNESS: In my opinion.

MR. TODD: Your question embraces two propositions; one was whether his opinion was that it was safe, and whether he would recommend it. His answer was that his opinion was that it was safe, but that he would not recommend it without further consideration.

MR. JEFFRIES: The answer to the last question as I understood you, Doctor, was that you would recommend that city as your opinion,—or rather would recommend to that city as your opinion, that the water at Grafton was in no wise affected by the sewage of Chicago.

A. Why, I would simply recommend that as my opinion.

Q. Your recommendation would be nothing more than your opinion, would it?

A. I would not put myself in the position of recommending my opinion. I would give my opinion.

Q. Well, of stating your opinion then?

A. Yes, that is all right.

Q. Now, Doctor, would you recommend that water, if 11789 you knew that the literature which you had been reading, stated that the germs of typhoid fever would live in running water and in sewage, and in sewage polluted water from five to thirty days, when you knew that the mean time from one end of the year to the other was eighteen and a half days from Chicago to St. Louis, and that a larger part of the year it was less than fifteen days, and at times less than ten days, would that have any effect upon your opinion, or upon you in expressing an opinion?

A. I would not recommend the water under any circumstances.

Q. Well, would that have any effect upon you in giving your opinion in making the recommendation which you said you would make, that the sewage of Chicago had no effect upon the water at Grafton?

MR. TODD: I submit that the words "recommendation" and "opinion" should not be confounded, as the witness has stated repeatedly what he would give as his opinion and what he would not recommend, and as the use of these words interchangeably creates confusion.

MR. JEFFRIES: Would you recommend, Doctor, that the water at Grafton was unaffected by the sewage of Chicago, knowing that the rate of flow from Chicago to the city of St. Louis was in the mean, eighteen and a half days; that
11790 during a greater part of the year it is less than fifteen, and oftentimes less than ten days, and knowing at the same time that the current literature of epidemiologists and bacteriologists, as they have observed the life and character of the typhoid bacillus, is from five to thirty days or more, and that it had not been accurately determined as to exactly how long they would live; knowing all those things, would that have any effect upon you in forming your opinion as to whether or not the water at Grafton was affected by the sewage of Chicago?

A. All information that I can gather, or could gather, would have an effect upon the formation of my opinion, and upon the information that I received, I would be willing to state it as my opinion that the water at Grafton is probably safe, as far as the city of Chicago is concerned,—as far as the sewage of the city of Chicago is concerned, but I would not recommend its use.

Q. Because why?

A. Because I do not recommend any river water for use.

Q. But, Doctor, if you were told that the water came from Chicago to St. Louis on an average of eighteen and a half days, and that it oftentimes came in less than fifteen days, and sometimes in less than ten days, would those facts have any tendency to change your opinion?

11791 MR. TODD: I object to the question for the reason that in the rate less than ten days, the height of the water is not included, the amount of area of inundated land in the valley of the Illinois river is not stated, and for the further reason that all conditions that actually obtain under the conditions of time flow, are not included.

Q. MR. JEFFRIES: (Question repeated).

A. In answer to that I would say that considering those facts if they were assumed to be facts, in connection with all the other conditions, they would not change my opinion.

Q. They would not?

A. Would not change my opinion.

Q. Well, if the water came from Chicago to St. Louis in ten days, and the sewage of Chicago was turned into the canal, and was typhoid infected, would you say that the water would be safe at Grafton or at St. Louis?

MR. TODD: I object to that question for the same reasons stated in the previous objection.

A. Considering all the conditions of the river, I would state it as my opinion that as far as the typhoid bacilli coming from Chicago are concerned, Grafton and St. Louis would not be menaced.

Q. When it comes within ten days?

11792 A. If it comes within ten days, with all the conditions of the river such as we know them, I should not regard the city as menaced.

Q. Do you mean by that, Doctor, that in your opinion the typhoid germs would not come from Chicago to St. Louis in the ten days, with the water?

A. Under all the conditions of the river, I do not think that they would.

Q. Would they under any conditions come?

A. To St. Louis?

Q. Yes?

A. No conditions that will ever be realized in my opinion.

Q. What conditions would there be under which they would come?

A. I think if you had a sterilized tube of distilled water leading from Chicago to St. Louis, coming down there in ten days, you could carry live typhoid bacilli from one city to the other.

Q. And they would come in no other way?

A. No, I would not say that.

Q. Would they come as far as Averyville?

A. Do you mean in ten days?

Q. In five days or ten days?

11793 A. Under the present conditions of the river?

Q. Yes?

A. In my opinion they would not.

Q. They would not?

A. No.

Q. Doctor, if a typhoid bacillus will die out in a running stream in five days, why has it become necessary for the large cities to build large filtration plants to protect their water supply, and why is it that the discharge of the sewage into the river has had such a grave effect upon the sanitary condition of the water in the river?

A. I have not said that the typhoid bacilli would always die out in five days in running river water.

Q. You said they would die out if it didn't take the water longer than five days to come to Averyville?

A. I said that in my opinion under the special conditions that exist in the upper part of the Illinois river and Desplaines river and the Chicago drainage canal.

Q. Well, what are those special conditions?

A. I have referred to them in my evidence of this morning.

Q. Doctor, didn't you tell me a few moments ago that you could not tell what effect the water of Lake Michigan had upon the saprophytic action in the water and the sewage of Chicago? 11794

A. I said that I could not state exactly what effect.

Q. And you cannot tell what effect it has from Chicago on down to Averyville, can you, so far as the pathogenic germs are concerned?

A. I cannot be absolutely sure of it.

Q. Can you be absolutely sure of it at Grafton?

A. Why, in my opinion it would have no appreciable effect at that distance.

Q. Would it have any appreciable effect at Averyville?

A. I don't know.

Q. What do you mean by appreciable effect?

A. Anything estimable by our present methods.

Q. In other words, you cannot determine typhoid anyway, can you, in the water?

A. I can determine it by the biological test.

Q. And that is all?

A. Yes.

Q. And, Doctor, isn't that all that you know about it; just simply what you could get from studying the biology of the disease in the patient?

A. I have given you whatever information I can in an-
11795 swer to your questions.

Q. Isn't that biological test the only test that you could rely upon at Averyville?

A. It is the best of all the tests. There are other axercerviate tests that are extremely valuable for throwing light upon the mode—

Q. Well, if there are other tests that you can rely on, why don't you say what those tests are and limit it to those tests? In other words, I have been trying to find out by what tests you can determine the sanitary condition of water.

MR. TODD: I object; the witness is not called upon to limit his tests.

MR. JEFFRIES: He has evaded it every time.

MR. TODD: I submit that his answers stand in the record, and the Court will say whether he has evaded it or not.

Q. (Question repeated.)

A. As an epidemiologist one utilizes all information he can, and all kinds of tests that are applicable and he bases his opinion—

MR. JEFFRIES: And the biological test is the best test?

A. In my opinion it is the most important.

Q. Did you have the biological test at Averyville?

A. It was impossible to apply it there.

11796 Q. Now, then, what experience have you had with any other test than the biological test?

A. No personal experience.

Q. Do you know of anybody else that has made any test biologically at Averyville?

A. As far as the city of Chicago is concerned, that cannot be applied.

Q. Cannot be applied in what way?

A. To Averyville, for if typhoid exists in Averyville, there would be no evidence that it came from Chicago necessarily.

Q. Not unless they used the water.

A. Nor even then, it would not, on account of the contamination between Chicago and Averyville.

Q. In your opinion, though, it would have no effect upon them even if they did use the water?

A. In my opinion it would be reasonably safe.

Q. Although the water came down there in less than five days?

A. Less than five days.

Q. Doctor, I will ask you this question: If you do not know that the Lawrence typhoid epidemic it was shown that germs passed through a reservoir holding fourteen days' water supply for the city of Lawrence?

A. The conditions are very different.

11797 Q. Specify the difference in the conditions.

A. As I understand it, the reservoirs contained water such as is used for drinking purposes, whereas, the typhoid bacilli coming from Chicago toward Averyville are subjected to the tremendous influences of the sewage in the drainage canal.

Q. Doctor, didn't you tell me that you had no means of ascertaining just what effect the addition of 250,000 cubic feet of water coming from Lake Michigan, had upon the saprophytic influences of the sewage?

A. I said that I had no way of measuring the exact effect.

Q. And it might increase the saprophytic influences, and it might decrease them, is that right?

A. I have forgotten just how I answered the question, but I think I said, at any rate, I think now, that without definite data it would not be wise to express an opinion on an increase or decrease.

Q. Well, unless you can ascertain what effect that additional water has had upon the sewage of Chicago, how is it, doctor, that you can form an opinion as to the sanitary condition of that water at any point below the discharge of the Chicago sewage?

A. Because the evidence that I have gathered thus far indicates a high degree of purification in the upper part

11798 of the Illinois river approaching Averyville.

Q. Well, that is not the question.

(Question read.)

MR. TODD: I submit that the answer is responsive to the question.

MR. JEFFRIES: I will ask you this question, doctor: did you not state yesterday that the saprophytic activity in the sewage was far greater than it is in the sewage polluted water?

A. I do not recall that I did.

Q. Well, is it so?

A. I think it would all depend upon the percentage composition relations of the sewage, their differences in proportions.

Q. I will ask you this question: What is the difference, doctor, between the saprophytic activity or action in the sewage that is discharged at the mouth of the sewer into the river, and the saprophytic activity of the contents of the canal itself, after the sewage has been discharged into it?

A. I don't know that the dilution is great enough to make any difference.

Q. You don't know that it is?

A. No.

11799 Q. But you have no information upon that subject?

A. I have not.

Q. Doctor, how many of the typhoid germs that come from the sewers of Chicago are dead before they go over the Beartrap Dam?

A. I don't know the exact position of the Beartrap Dam.

MR. TODD: That is located at Lockport; that is the end of the canal.

A. How many of them are destroyed?

Q. Yes?

A. I haven't any idea.

Q. Well, what percentage of them?

A. How long does it take? Can you tell me how long it takes? I don't know how long it takes to go that distance.

Q. Well, assuming that it takes 24 hours?

A. Well, I should think a great many were killed.

Q. Well, what percentage?

A. I don't know.

Q. Would it be ten or ninety?

A. I am not prepared to offer an opinion on that at all.

Q. Well, by the time they get to Joliet, what percentage of them would be killed, or would be dead, do you know?

A. I don't think one could answer a question like that.

Q. What percentage of them would be killed by the
11800 time they get to LaSalle?

A. Could you give me the time relation?

Q. Well, we will say two days,—two and one-half days.

A. I should think a very great many more.

Q. Well, what percentage of them?

A. I could not give you a percentage.

Q. Could you tell what percentage would be dead by the time they got to Averyville?

A. I should think that probably they would all be dead at that time.

Q. That is just a think upon your part?

A. It is my opinion based upon my studies and information.

Q. What did you study upon the life of the typhoid germ?

A. I have given you the source of my information, this morning.

Q. Is there any authority, doctor, within your knowledge, that says that or that holds that the sewage of the city of two millions of people discharge into a running stream, will disappear within five days?

A. There is evidence that at any rate the majority of typhoid bacilli will.

Q. Where is the evidence? Name your authority.

A. Well, from experimental work that has been done.

11801 Q. Where?

A. In Chicago.

Q. Where?

A. In connection with the drainage canal.

Q. Anywhere else?

A. Not that I know of.

Q. Well, now, don't you know that there has been no such examination and experiments made in the water of the drainage canal?

A. Experiments on the life of the typhoid bacillus?

Q. Yes, where it was limited to five days?

A. I have not said that the life is limited to five days.

Q. Well, where is the evidence doctor, that it was limited to five days?

A. I have not said that there is evidence that it was limited to five days.

Q. Well then, if you have no evidence limiting it to five days, how is it that you can say that the water at Averyville has purified itself of typhoid bacteria and other pathogenic germs, when the water comes to Averyville within five days and purification being one hundred per cent, while coming from Chicago to Averyville?

A. The evidence drawn from all the sources that I have 11802 mentioned makes me have that opinion.

Q. Now doctor, coming back, will you give me one author, a reputable, scientific bacteriologist who has stated editorially that the life of the typhoid germ in sewage is limited to five days?

A. I haven't any references. I don't know that it occurs in literature.

Q. Does it not occur in literature editorially stated by men who have made the actual experiments of the life of the typhoid germ in sewage, that it would live longer than five days in that sewage?

A. That might be true.

Q. Then is there any reason why, doctor, if it will live in the sewage five days, that it will not live in the Illinois river and in the drainage canal five days?

A. Yes, I think the conditions are very different again.

Q. What are the conditions that have changed,—what changed conditions?

A. The conditions of sedimentation are very different for one thing.

Q. Does that affect the life of the germ, and do you mean to say that typhoid fever germs deposited in a running stream will disappear in the course of sedimentation entirely, in five days?

A. I have not said so.

11803 Q. Well, do you not inferentially say so when you say that they have all disappeared by the time the water gets to Averyville, and give sedimentation as the cause?

A. I have not said that they all disappeared at Averyville.

Q. Did you not say it was 100 per cent removed?

A. I did not.

Q. You said it was safe?

A. I said that I regarded it, in my opinion, that it was reasonably safe but that I would not recommend it for use.

Q. Then they all ought to be practically removed before you would recommend it?

A. I think so.

Q. But you would not say that they were all removed by sedimentation, would you?

A. No, I would not say so.

Q. Would you say that they had all been removed by death?

A. I would say that in my opinion, in all probability, the water would be reasonably safe at Averyville.

Q. What do you mean by reasonably safe?

A. As safe as most water supplies in this country.

Q. Knowing that there was a city of 2,000,000 people with
the sewage of that city discharged into the river 150 miles
11804 above and the water coming down there in five days, and
still would you say it was reasonably safe?

A. As reasonably safe as many of the water supplies in this country, as far as that particular factor is concerned, of course.

Q. Would it be reasonably safe for domestic use?

A. As reasonably safe, in my opinion as many of the supply systems.

Q. Well, what water supply?

A. Well the water supply of the city of Philadelphia, for example.

Q. Is not the water of Philadelphia a notoriously bad water supply?

A. It is about the same water supply apparently, about as bad as the city of St. Louis.

Q. Is it not much worse than the city of St. Louis, and isn't it notoriously so?

A. The mortality from typhoid is just about the same.

Q. Well, give the rate?

A. The mortality from typhoid in Philadelphia is about 33 per 100,000.

GENERAL CROW: For what year?

11805 A. I cannot give you the exact year, but the year that
I estimated it.

MR. JEFFRIES: And what is it for St. Louis?

A. Not more than 34.

Q. That is according to your figures?

A. According to the figures of the St. Louis Health Reports.

Q. According to your figures, that you figure there, and get from the St. Louis Health report?

A. According to the figures of the St. Louis Health Report which I have here.

Q. Do you mean the figures as grouped by you or as put up originally by the St. Louis Health report?

A. I mean the figures on page 424 of the 24th Annual Report of St. Louis.

Q. Is it the figures that they class as typhoid or the figures that you class as typhoid?

A. Figures that they class as typhoid for the year 1901.

Q. Now doctor, I want to know if in your opinion, or if I understand you to say that in your opinion the water at Averyville is safe for domestic and drinking purposes, after the sewage of Chicago, of 2,000,000 of people have been discharged into it, through the drainage canal?

11806 A. I have not said so. I said that in my opinion it is reasonably safe.

Q. Well, is it safe?

A. No.

Q. Is the Chicago sewage an element of danger?

A. In my opinion it is not.

Q. At any season of the year?

A. So far as my information goes, my opinion is that it is not.

Q. And you are applying the information that you have to all seasons of the year—summer and winter?

A. Yes.

Q. Is that true?

A. Yes sir.

Q. Now then, what causes the removal of the pathogenic germs from that river, that are deposited in it by the sewage of Chicago?

A. The same things which are concerned in the removal of pathogenic bacteria from sewage contaminated river water in general and which I have designated in my evidence heretofore.

Q. Now then, state what evidence, what that is. In other words, is it sedimentation or is it the effect of the sewage upon the pathogenic germs themselves?

11807 A. I gave it as my opinion that the principal influences concerned were the effect of saprophytic bacteria, the effect of sedimentation, and the processes that go along with sedimentation, and the effects upon the food, nutrient supply. Of course there are many other influences.

Q. What do you mean by the food nutrient supply?

A. I mean the food supply of pathogenic bacteria.

Q. Do you know that the typhoid bacilli require to feed upon anything when found in sewage and in running water?

A. It is my opinion that they do.

Q. Don't you know that it is the opinion of the best bacteriologists that they do not feed upon anything unless the media is of sufficient temperature to permit their multiplication?

A. That might be true.

Q. Isn't that true?

A. They have a right to their opinions.

Q. And you are of the reverse opinion although you have made no bacterial analyses or experiments with reference to the life and growth of typhoid germs?

A. I have not said that I was of the reverse opinion.

Q. Well, are you of that opinion?

A. I am of the opinion that the typhoid bacillus, while it lives, is undergoing changes all the time, and that where 11808 there is a destructive metabolism there must be also some catabolism.

Q. Is that true when they lie dormant in ice?

A. I think there would be some change. I doubt if they could lie absolutely dormant. Where there is life there is change.

Q. But as to the extent of that change either in ice or in the water, you know nothing about it?

A. I know very little about it.

Q. You know they do live in ice for three months?

A. I know they live in ice a long time.

Q. And you know that they live in river water a long time?

A. And they live in distilled water longer.

Q. Which is the greatest factor of the removal of typhoid and other pathogenic germs in the Illinois river water, the action of the saprophytes or sedimentation?

A. I would put the two together, as the most important influences.

Q. Well, of the two which is the more important?

A. I don't know.

Q. Isn't it true that there is no sedimentation occurs in the river at the time of high water, and isn't it true also that as the current flows, with the continuous current, that sedimentation is a very small factor?

A. In my opinion it would always be an important factor. 11809

Q. Even when there is a scouring action?

A. The scouring action would not be uniform over a great distance, in my opinion.

Q. It would be constant over a great distance, would it not?

A. Constant in degree?

Q. Yes?

A. I should think not.

Q. Well, it would be continuous then?

A. It might not be.

Q. Well, the scouring action to a large extent would follow the rise in the river, would it not?

A. That would depend very largely upon the geological conditions.

Q. Don't you know from the amount of sediment that is carried in the river, that scouring action must take place?

A. Some scouring action I have no doubt.

Q. At all times?

A. I have no doubt that it does at times, but my opinion is that parts of the river have a very clean bottom instead of having the sort of bottom that one expects where much sewage is being carried down.

Q. And that is accounted for by reason of the fact that it is continually scouring out?

11810 A. Not at all. By the fact that it is destroyed before it gets to these places.

Q. How about the mineral matters that are washed in?

A. Where do they come from?

Q. Where do they go to? Are they not scoured out?

A. They are gradually carried down.

Q. Isn't that what makes the turbidity of the water, and goes to make up the total solids in the chemical analysis?

A. A large part of the turbidity is due to the plankton and not to mineral material.

Q. Isn't that true, that a large part of these total solids found in the chemical analysis, is due to the carrying down by the current of the polluted matter, that is deposited in the river above, whether it be mineral earth or vegetable, or what not?

A. In many analyses and in certain portions of the river at certain times, that is true; at other times it is not true.

Q. At what times would it not be true?

A. When there is less floating matter in the water.

Q. Assume that a small particle of clay equal in size to the typhoid bacillus, should start from Chicago and come down to the Mississippi river at Grafton, how would its behavior compare with the typhoid bacillus coming, and what effect
11811 would sedimentation have upon it?

A. Why, it would not be exposed, or though exposed to similar influences, its reaction would be totally different on account of its chemical constitution.

Q. Well, assume that its settling action would be the same?

A. That its settling action would be the same?

Q. Yes, the action of sedimentation, or its conduct concerning sedimentation would be the same?

A. What would be the difference in the results?

Q. Yes.

A. It would not be easily acted upon by the chemical influences on account of its chemical constitution, while the typhoid bacillus would.

Q. Well, do you think those mineral matters, such as small particles of clay and dirt, would come down from Chicago to St. Louis?

A. I don't know how far they would be carried. I have never looked into that, but I know that materials are carried by rivers down to the mouths.

Q. As an epidemiologist, have you ever studied the question of sedimentation?

A. By personal experiment, no.

11812 Q. By personal observation of rivers?

A. No.

Q. What have you studied in connection with sedimentation, as applied to epidemiology?

A. Only the observation of sedimentation in cultures in the laboratory, and literature bearing upon the subject.

Q. What literature have you studied?

A. The literature of the ordinary text-books, a long time ago.

Q. You have not studied it recently?

A. No.

Q. How long has it been since you have studied it, doctor?

A. Oh, I have not studied it since 1895.

Q. That was before you came to Chicago?

A. Yes.

Q. And while you were in Baltimore?

A. Yes.

Q. And then only in the school room, in the class room?

A. Well, in the laboratory, and in my work rooms, yes.

Q. Do you remember what you studied?

A. No, the ordinary text-books. I am not an authority on sedimentation.

Q. Did you ever write any article upon sedimentation?

11813 A. None, I have no special --

Q. Did you ever write an article upon any other subject connected with the sanitary conditions of water, and water supplies?

A. No.

Q. Did you ever make a report as to the sanitary conditions of any water?

A. No, except in connection with the cerebral spinal meningitis epidemic at Loona county. We pointed out the mode of pollution of the town by water running down from the streams on the side of the hill.

Q. I understood you to say that it was not accurately determined what was the source of that epidemic?

A. No, it certainly was not from the water in my opinion.

Q. So you made a report that it was not a water-borne disease?

A. No, we made quite an elaborate report about it; but we referred to the water current in the streets and sewage, and contamination of water running down into the streets, as one of the unwholesome influences.

Q. I understood you to say doctor, that you never made any chemical analyses?

11814 Of a river water. I have made of course, many chemical analyses, but not of river water.

Q. And no bacterial analyses?

A. No, not of river water.

Q. And you have never made any report of the water supply or sewage disposal involving the expenditure of money, have you?

A. No.

Q. Have you ever taught hygiene or sanitary science?

A. Only in connection with other subjects; not as a subject by itself.

Q. Did you ever teach sanitary science?

A. I teach it every day in a general way, but not under that heading.

Q. Under what heading do you teach it?

A. Under the heading of personal and individual hygiene.

Q. But not municipal hygiene?

A. No, I know nothing about it.

Q. And you have never written a book on any of the subjects connected with water supplies or sewage discharges, or disposals?

A. No.

Q. Have you ever contributed anything to the science of sanitation in reference to the supply of water?

11815 A. Any literature?

Q. Yes?

A. Have I published anything on water supplies?

Q. Yes?

A. No, nothing.

Q. Doctor, I understood you to say in your direct examination that you limited the life of the typhoid germ from five to seven days. Am I correct in that?

A. No.

Q. Now, then, have you any idea—

A. I said that in sewage contaminated water, it was my opinion that the majority of typhoid bacilli died before from five to seven days.

Q. Well, that is not a very large reduction, is it, a majority in from five to seven days?

A. It is a reduction of more than fifty per cent.

Q. Well, assuming that there were millions and millions, discharged into the sewers of Chicago, and thence into the canal, and thence into the Illinois river, and they would flow down the Illinois river, there woudl be a majority, which would be fifty per cent., disappear in from five to seven days?

A. I think that the more there were, the quicker they would die out.

11816 Q. What reason have you to believe that?

A. On account of the exhaustion of the pabulum more quickly.

Q. Exhaustion of the food?

A. Either exhaustion of the food or the production of substances inimical to their life.

Q. But with the addition of the water from Lake Michigan, at the rate of 250,000 cubic feet per minute, that would have a tendency to spread them, furnish them fresh water, and as they are motile, to enable them to swim anway from the objectionable substances, would it not ?

A. But I am not of the opinion that it would be sufficient—

Q. Don't you think that is important to know whether it is sufficient or not?

A. Yes.

Q. Well, then, if it is important to know the effect of the added volume of water upon the typhoid bacilli, and you have not obtained the comparative relationship existing between the sewage and the volume of water added, how can you express an opinion as to when the typhoid will disappear?

A. My opinion is expressed on the information I have; not upon anything else.

Q. Then your opinion could not be relied upon because you have not been furnished proper information on all sub-
11817 jects bearing upon the controversy?

A. I should have to leave it to others to decide as to the value of my opinion.

Q. Well, would you not consider it valuable to know the relation existing between the sewage and the added volume of water, 250,000 cubic feet per minute?

A. It, like many other facts, would be valuable to know, but I cannot know everything.

Q. You think there is no way of determining that at all?

A. I think perhaps some time we shall be able to determine that.

Q. How would that determination be made?

A. I think a great deal of light could be thrown upon it by trying percentage relations of lake water and sewage,—different percentage composition relations, and make laboratory tests.

Q. Now, I understood you to say that you have no information or knowledge as to the longevity of the typhoid germ except that which you obtained from literature?

A. And from conversations with —

Q. Bacteriologists?

A. With bacteriologists and my observations in the laboratory, on the duration of the life of the bacilli in various kinds of media. 11818

Q. Now, I will ask you this question, if it is not a fact that bacteriologists disagree, or, rather, all agree that the exact time of longevity of the typhoid bacilli cannot be and has not been determined?

A. Under all conditions, yes.

Q. Under all conditions—and cannot be determined under all conditions, and do they not further agree that the life of the typhoid germ in a running stream ranges from ten to ninety days?

A. No, I don't think they all agree on that.

Q. I will ask you if Professor Jordan has not stated that upon examining the life of the typhoid in Lake Michigan water, he has found that it lived ninety days in that water?

A. I do not recall his statement.

Q. Did he not publish that statement?

A. May be, I do not recall it.

MR. TODD: I object; the publication is the best evidence of what Professor Jordan says.

MR. JEFFRIES: You put a witness on the stand that speaks in no other way except what he understands from publications.

MR. TODD: I submit the statement of counsel is not borne out by the testimony of the witness.

MR. JEFFRIES: I will ask the witness now at this 11819 point in the record, if he has had any experience in testing the longevity of the typhoid bacilli in water?

A. Yes, I have in water in the laboratory.

Q. But that was distilled water and not river water?

A. It was pure water, sterilized water.

Q. How long did they live there, Doctor?

A. I do not recall.

Q. More than three months?

A. It is so long since I have worked with the—

Q. What is your opinion now; what is your recollection; it was more than three months, wasn't it?

A. My opinion is that they died out before that time.

Q. Before three months?

A. Yes.

Q. All of them?

A. Yes.

Q. Before two months?

A. My memory about that is worth nothing.

Q. And that is your only practical experience?

A. On that particular point.

Q. Is that not the most important point in self-purification of streams?

A. The longevity of the typhoid bacillus?

11820 Q. Yes, the longevity of typhoid bacillus?

A. The longevity of its life under the especial conditions of each individual stream, I think is one of the most important points.

Q. And that is true with reference to the Illinois river, is it not?

A. It is true of all rivers.

Q. You said something yesterday, Doctor, that in your opinion 10,000 cases of typhoid fever in Chicago were less harmful than ten cases at Peoria; what do you mean by that?

MR. TODD: I will state that you did not give all that he said. He said that ten cases at Peoria would affect Pekin—

MR. JEFFRIES: Well, yes, all right.

A. I think it was Peoria and Pekin, or Averyville and Wesley. Two places close together, at any rate, very close together. I meant that I thought the menace would be greater to the health of the people drinking the water a short distance from the place where the dejecta of ten typhoid cases were being poured into the water than it would be from 10,000 cases 125 or 150 miles away.

Q. What percentage of removal of typhoid germs did you have in mind when you made this statement?

A. I had no percentage in mind.

11821 Q. It was an off-hand statement, then, was it?

A. It was a general statement.

Q. Based upon any scientific knowledge?

A. Based upon all my scientific knowledge.

Q. On no practical experience, though?

A. On all my practical experience.

Q. Would 15,000 cases of typhoid at Chicago be equal to ten cases at Peoria so far as Pekin is concerned?

A. I should think that 15,000 cases would be less dangerous. The more typhoid bacilli beyond a certain number the quicker in my opinion they would die out.

Q. How do you know?

A. I don't know; it is my opinion.

Q. Do you know of any standard authority by which that opinion can be verified?

A. I should have to leave that to you to compare with them.

Q. Well, you have nothing to say on that?

A. I have nothing to say on that.

Q. Well, do you know of anyone else that has the same opinion?

A. I think that the best informed minds in the country, dealing with this problem, would have the same opinion.

11822 Q. Now, who are they?

A. Well, I am of the opinion that Professor Welch of Johns-Hopkins would have the same opinion.

Q. Did Professor Welch ever have any experience in water supplies of cities?

A. I do not know that he has worked out any water supply.

Q. Don't you know that he has not?

A. I don't think he has; but I don't think that would make any difference with regard to the formation of the opinion in his case.

Q. You think, then, that anybody could make use of the same expression and it would be of as much value as though made by an epidemiologist?

A. Dr. Welch is an epidemiologist. I don't think that anyone having less brain capacity could give as good an opinion as Dr. Welch.

Q. We are speaking now about this opinion that you gave with reference to the 10,000 cases at Chicago and the ten cases at Peoria, and their effect upon the water at Pekin?

A. I am inclined to think that Dr. Welch would give that opinion, but I could not speak for him.

Q. Well, has he ever given an opinion of that character?

11823 A. Not in any special typhoid cases, though, it is in accord with his general views.

Q. Has he written a book on the subject?

A. No.

Q. Has he ever given a professional opinion upon water supply matters?

A. In Court do you mean?

Q. In Court or anywhere else?

A. Oh, he has given private opinions on water supplies. I don't think he has ever testified in Court.

Q. He has given private opinions, just as you have, by examining the water in the laboratory?

A. On the basis of his general epidemiological knowledge.

Q. He is a pathologist, is he?

A. He is a pathologist and bacteriologist, and in the highest sense of the word an epidemiologist—erste klasse.

Q. Doctor, how many typhoid epidemics have you personally studied?

A. I have been interested in typhoid epidemics in three cities—four cities really, but in the sense of studying the water supply relations, as I told you yesterday, I have not studied any personally.

11824 Q. Then you have no personal experience along that line?

A. No personal experience, no.

Q. Doctor, is not sedimentation more extensive in the lake, and in lake water, than it is in a running stream? In other words, is it not much greater; doesn't sedimentation take place much faster in the lake?

A. You mean at all times?

Q. Yes, as a general proposition, now.

A. I don't think it would be true at times when the lake is badly disturbed.

Q. Well, Doctor, the same character of motion that permits sedimentation in a lake, will permit it in a river, won't it, and if the movement of water in the lake will permit sedimentation in that lake, will not the movement of water down stream in a river permit sedimentation in the river?

A. There are very different movements in a lake and in a river.

Q. How so?

A. You might have in the lake some of the same movements that you have in the river, but you have in the lake movements at times that are quite different—for instance, disturbances from the wind and waves, that you do not get in the river to such an extent.

11825 Q. Well, cut out the wind action in both instances.

A. I have made no especial study of current in lakes and rivers and am not prepared—

Q. Therefore, you don't know what effect sedimentation would have, whether it would have any or not?

A. I think it would have a very marked effect in both places.

Q. Do you know how long typhoid germs will live in the sediment of Lake Michigan?

A. No.

Q. How?

A. I do not. I don't think very long.

Q. Well, how long?

A. I should doubt if they lived—it would all depend on what part of the lake they were in, and how much sewage contamination there was where they entered the lake.

Q. Well, in the sediment of the lake?

A. That is the point in the sediment where there is much sewage dumping, at the same time they would be destroyed very rapidly, whereas in pure water, with little sewage, it would, I think, live longer.

Q. What would destroy them in the sediment?

A. The chemical processes going on there.

Q. What chemical processes?

A. They are unknown to us.

11826 Q. Well, now, do you know that they are destroyed?

A. Well, I don't know about the sediments in Lake Michigan, but I am judging on the basis of my general experience as an epidemiologist.

Q. Well, generally are they destroyed?

A. Yes, I think so.

Q. Well, give us some instances?

A. I cannot give you any instances.

Q. Did anybody ever pretend to give an instance?

A. I don't know how much experimental work has been done.

Q. Don't you know that there has been a great deal of experimental work done on that subject and yet they have been unable to ascertain that fact?

A. The conditions of the experiment of course are very difficult, but we have to judge by the biological results.

Q. Don't you know that typhoid germs will live for more than a year in soil and in sediments, and that it is on record?

A. It has been known that they live as long as thirty days; at least it has been asserted that they have lived as long as thirty days, and endorsed.

Q. Do you know that it is on record that they live in earth as long as a year?

A. I know of no such record. It may be there.

11827 Q. If it should appear in this German book that you have stated—what is that book?

A. Baumgarten's Jahresbericht.

Q. Would that have any effect upon your opinion?

A. Not unless the man who made the observation was a reliable man. Baumgarten's to some extent is just a review of all the opinions expressed along these lines, and I would base my opinion entirely upon the ability of the investigator who did the work.

Q. Have you ever taken the trouble to look up the literature?

A. Not on that particular point.

Q. Can you tell us some of the men whose experiments are found in that book, that are reliable?

A. In general on bacteriology?

Q. Yes?

A. Yes, I can tell you.

Q. You have been looking them up since yesterday, have you?

A. Oh, I know quite a few of the reliable bacteriologists,—Koch and Pasteur would be two very reliable men.

Q. How about Frankland, of England?

A. I would regard his opinion as a very valuable opinion.

Q. I will ask you, Doctor, if it isn't a fact that typhoid fever germs have been found in the sediment of Lake
11828 Geneva, a long distance from the source of pollution?

A. I didn't know that that had been demonstrated.

Q. Would it modify your opinion in any way if that should appear and be shown to you, as to the effect of sedimentation upon the water in the Illinois river?

A. No, the conditions in Lake Geneva are quite different from the conditions in the Illinois river.

Q. What are the differences in the conditions?

A. Lake Geneva is a mountain lake, situated under the Dendu midi, and at the outlet of the Roan valley; the Roan river empties into it. It is surrounded by a number of clean cities and all over are high hills; it is a typical Alpine lake.

Q. Its water is polluted, if it contains typhoid, is it not?

A. If the water contains typhoid fever bacilli, it is polluted, certainly.

Q. Doctor, in talking of the water at Lawrence, which was held in the reservoirs for fourteen days before use, containing typhoid fever germs, that water was polluted, was it not, as well as the water in the Illinois river that we are talking about, and sewage polluted at that?

A. Relatively slightly polluted, so far as general sewage is concerned.

Q. Was it not very greatly polluted so far as the ty-
11829 phoid is concerned?

A. Yes, it must have been.

Q. Being infected with typhoid fever germs, Doctor, the source of that infection was sewage, was it not?

A. I should think it was.

Q. Then why is there any difference?

A. Because the water there was a drinking supply water—a much purer water, as I understand it.

Q. And still it produced the worst typhoid epidemic that science records?

A. Well, I don't know that that is true, but it produced a very bad epidemic, and I think that that is one of the most significant things about this whole question, that even the water that looks to be of the purest of water, might be the most dangerous.

Q. And that is one way why you cannot definitely determine that the Illinois river at Grafton does not contain these germs?

A. I certainly would not recommend its use without submitting it to all possible tests.

Q. And what happened at Lawrence, Massachusetts, with fourteen days' sedimentation, is liable to happen to any city using water that has been sewage polluted, and being 11830 within fourteen days' travel from the source of pollution?

A. No, I don't think that would be true. I think any water existing under the same conditions as that at Lawrence, is liable to give exactly the same results.

Q. Do you know what the conditions were, existing there?

A. Not exactly, no.

Q. Well, how do you know that the conditions there are not similar to the conditions here?

A. Because you have told me so, for one thing, and I have read of the epidemic myself, and know about the reservoir.

Q. How do you know, Doctor, that the sewage pollution in the water in the reservoirs at Lawrence, was no less than the sewage pollution of the water in the Illinois river at Averyville, or at Grafton?

A. I have no absolute knowledge on the fact; it is simply my opinion that it was not.

Q. Then, Doctor, I will ask you again if it is not your opinion that the more sewage that you deposit in a running stream, the less danger there is from pathogenic germs?

A. The more sewage?

Q. The more infected sewage that is deposited into a running stream the less danger there is from typhoid fever.

A. Where?

11831 GENERAL CROW: Anywhere on the running stream?

MR. JEFFRIES: Anywhere below the point the sewage is discharged into the river?

A. But of course that is not true. That would be in utter opposition to all our knowledge. It would be true for distant points in the stream, but it would be very untrue for points nearby.

Q. Now, then, why would it be true for distant points?

A. Because in my opinion the typhoid bacilli would be killed off earlier, the greater the amount of sewage turned into the river at the initial point.

Q. Then you mean by that, Doctor, that they would be killed or die out quicker and near the source of pollution, where it was largely polluted with sewage, than they would where there was less sewage pollution?

A. Yes, but the exact percentage relations again, I don't know about of course.

Q. Well, Doctor, assume that the sewage of Chicago, containing two millions of people, was discharged into a running stream that received no other water, how far would it run before it would be free from typhoid and other pathogenic germs?

A. Received no other water except what water?

11832 Q. Except the sewage?

A. Pure sewage.

Q. Pure sewage flowing down the stream, a stream of sewage, an open sewer?

A. Wouldn't that dry up quickly?

Q. Well, that is for you to say.

A. I have never seen the experiment tried. I don't know what would happen.

Q. You don't know how long, or how far it would travel?

A. No.

Q. Nor how long the typhoid germs would live, nor how long any other bacteria would live?

A. No.

Q. Have not there been experiments made with reference to the longevity of pathogenic germs in the sewage?

A. Yes, experiments have been made, but in my opinion the results are so conflicting and the experiments are so difficult that the data are very unsatisfactory.

Q. Now will you name some of the men that have given conflicting opinions?

A. I cannot. I would again look them up in the same journals.

Q. Now, doctor, assuming that there was an equal amount
of water added to the sewage discharges of a city of
11833 2,000,000 of people, such as Chicago, how long would that
mixture be required to run in a stream before the pathogenic bacteria are destroyed, such as typhoid fever germs?

A. I have already said that it was very desirable that percentage relations be experimented with and I know of no definite experiments of that sort. My opinion would be that the typhoid bacilli in such a mixture would die out within five days.

Q. Now supposing you double the quantity of water again?

A. I am of the opinion that that would make no difference.

Q. Supposing that you would increase that water until you had 250,000 cubic feet per minute?

A. I am not sure that that would make any great difference.

Q. Suppose you would increase it until you had a million cubic feet per minute?

A. I think if you increased it until it approached a pure water it would increase the longevity of the typhoid bacillus.

Q. Can it be increased until it would reach a stage of pure water? Isn't that an absurdity?

A. I think as it approached the stage of the purer water—

Q. Well, could you by the addition of water into that sewage of any volume whatever, render it so that it would be recognized as a pure water, by mere addition of water?

11834 A. Well, what I meant by pure water there would be a
water that chemically would be within the domain of pure

water; of course it would not be pure if it had typhoid bacilli in it.

Q. It might not show in the chemical analysis, doctor?

A. That is true.

Q. It might not appear in the bacteriological analysis?

A. Oh, I think if the saweage were diluted so that chemically the water appeared pure, that at that stage at any rate, and probably before, the longevity of the typhoid bacillus would be increased.

Q. But you do not know to just what extent it would be increased?

A. No, I don't think we have data sufficient to tell that.

Q. Then I want to ask you, doctor, if acording to your theory it would not have been better for Chicago to have turned their sewage into the Chicago river, and the Chicago river into the river Desplaines and thence into the Illinois river, instead of constructing a canal and discharging the sewage mixed with 250,000 cubic feet of water per minute, in the river?

MR. TODD: I object to the question unless it applies to the State of Missouri.

MR. JEFFRIES: That is, wouldn't it have been better
11835 for the disappearance and disposal and death and destruction of pathogenic bacteria?

MR. TODD: I object to the question, unless the question is limited to the effect of the discharge of the sewage of Chicago into the river in either of these waters, upon the inhabitants of Missouri, as that is the only issue raised in the pleadings in this case, and what effect it may have upon the inhabitants of Illinois immediately below Chicago, on the Desplaines and Illinois rivers, is not material or competent in this inquiry, and for the further reason that as to the methods employed by Chicago in the disposal of its sewage or the purification of its water is a matter that is not competent to be inquired into in this controversy, as the question involved in this case is the discharge of the sewage through the drainage canal a danger and a menace to the inhabitants of the State of Missouri?

A. My answer to the question would be that I do not know enough about the engineering part of the problem to pass judgment.

MR. JEFFRIES: Has the engineering anything to do with the destruction of the typhoid bacilli?

A. Yes, the rate of flow, and the physical conditions of the river would have a great deal to do with it.

11836 Q. And those you have not studied?

A. I have a great deal of information which I have given you about it.

Q. There is not a particle of difference, doctor, in the supposition that is assumed in this question, and in the condition from which you have previously testified, the canal is; they are just the same?

(Question repeated). (No answer).

Q. Would it not have been better for the destruction of the pathogenic bacteria from the city of Chicago to have turned the Chicago river into the canal?

A. Into the Illinois and Michigan canal?

Q. No, into the canal as it now is, into the drainage canal, without turning the lake water in?

A. I am not sure that it would have made any difference as far as the destruction of bacilli was concerned.

Q. Well, do you know whether it would or would not?

A. I don't know.

Q. What is your opinion on it?

A. My opinion is that it probably would not make much difference, but I should like to see experiments conducted on percentage composition relations.

11837 Q. Then it was unnecessary to turn the water in, was it?

A. My opinion on that particular point might not meet with general approbation; I don't know.

Q. Does septic action obtain in the canal?

A. What do you mean by septic action, if I may ask?

Q. Well, do you know anything about septic action?

A. Do you mean septic processes in a septic tank?

Q. Yes.

A. Yes I should think so.

Q. Does it in the present canal?

A. I have not examined into that at all.

Q. You have seen it, have you not?

A. Yes, I have seen it.

Q. You know that there is being constantly added every minute, 250,000 cubic feet of water passing through the canal and the sewage of Chicago going into it?

A. Yes.

Q. You know that it is about 27 miles long?

A. Yes.

Q. And you know about its depth and its width?

A. Yes.

Q. Now I will ask you if in your opinion as an epidemiologist it has any septic operation?

11838 A. Corresponding to what goes on in a septic tank?

Q. Yes?

A. Yes, I think there is undoubtedly many of the same processes going on.

Q. Is it not true that dissolved oxygen is always present in the Chicago drainage canal?

A. I don't know; I should think it was true.

Q. Did Professor Long or Professor Jordan tell you that they, in their examinations, had shown that dissolved oxygen was present at all times and at all seasons of the year in the drainage canal?

A. No.

Q. You made no inquiry on that point?

A. No.

Q. Either before or after you knew that you were to be a witness in this case?

A. No.

Q. Isn't it a fact that septic operation cannot take place in the presence of dissolved oxygen?

A. It all depends on your definition of the term septic operation.

Q. Well as currently applied to a septic tank and septic operation in sewage disposal?

A. I should think that some of the same processes

11839 would certainly go on, even in the presence of oxygen.

Q. On what do you base that opinion?

A. On my general knowledge of chemistry.

Q. You are a chemist?

A. I utilize chemistry in my work; I am not a specialist in chemistry.

Q. Can oxidizing action and reducing action go on at the same time?

A. In different parts of the same organism, yes.

Q. In simply the organic matter in the canal?

A. Some organic matter might be oxidized while other organic matter was being reduced.

Q. That is not true as a general proposition, is it?

A. Yes, it is.

Q. On what do you base that opinion?

A. On the general law of chemical equilibrium.

Q. Isn't it a fact that the present dilution was provided for with reference to the Chicago sewage, in order to avoid the very thing that you have been testifying to?

A. I don't know.

Q. You don't know?

A. No.

Q. If it would appear that it was so, would it modify 11840 your views in any way?

A. No.

Q. Then you would not give septic action any credit or weight in your opinoin,—any consideration in your opinion?

A. What is that?

Q. You would not give septic action—you do not consider it of any consequence in giving your opinion?

A. Why of course I consider it of great consequence.

Q. Isn't it a fact, doctor, that this canal was constructed and this added volume of water introduced for the purpose of preventing septic operation and putrefactive changes?

A. I have no definite information.

Q. And isn't it a fact that it does prevent?

A. I had supposed that the canal was produced to protect the city's water supply.

Q. And no other purpose?

A. And to remove a nuisance from the immediate neighborhood of the city.

Q. And what created that nuisance, putrefaction, was it not, the destruction of the organic matter?

A. Near the city, very close to the city.

Q. And the water was introduced for the purpose of carrying it on away from the city?

11841 A. As I understand it.

Q. And has it carried it away—has it carried the organic matter in its original condition further away?

A. No, not in its original condition, because it was changing all the time, as it flowed.

Q. What changes are there in it, up to Lockport?

A. It is still much contaminated at Lockport, as I understand it.

Q. Is there any reduction in organic matter between Chicago and Lockport?

A. I have not the details by me.

Q. You don't know, do you?

A. No, I don't know.

Q. Well then, you don't know whether septic operation takes place or not?

A. From my general knowledge of what occurs in septic operations I should say that a great deal had taken place before reaching Lockport.

Q. Didn't you know, doctor, that as applied to conditions for treating sewage by the septic tank process and by septic operation, that there is no such condition exists in the Chicago drainage canal?

A. That depends upon your definition, as I said before,
11842 of septic operation. Certainly great changes have taken place.

Q. As applied to sewage disposal, I will ask you?

A. My answer would be that great changes certainly do take place.

Q. They are not septic, though?

A. I would call them septic, but perhaps others would not.

Q. Did you ever see a septic tank?

A. Yes.

Q. For sewage disposal?

A. Yes.

Q. Where?

A. I have seen experimental ones; not in actual operation, for cities.

Q. Doctor, do you know anything about the population upon the drainage area of the Illinois river?

A. I think in the statistics that were put in there, there was data as to the population of the principal towns, but the total number I don't know.

Q. Do you know anything about the population upon the upper Mississippi?

A. The same remark applies to the Mississippi and Missouri rivers.

Q. Did you ever study those towns and cities with reference to their sewage disposal? 11843

A. No.

Q. As to whether the towns were sewered or not?

A. I know that some of them were sewered.

Q. Do you know whether Louisiana is sewered?

A. No.

Q. Quincy?

A. No.

Q. Keokuk?

A. No.

Q. Davenport?

A. No.

Q. Rock Island?

A. No.

Q. Any of those large cities?

A. No.

Q. That would have a very large effect upon the water in the Mississippi river?

A. Nearby, near the source of pollution, yes.

Q. Do you know of any town that pollutes the water supply of St. Louis?

A. I know that some town pollutes the water supply of St. Louis.

11844 Q. Well, do you know any particular town?

A. No, I know the water supply is polluted by the amount of typhoid that is occurring.

Q. But you don't know the source of that pollution?

A. No, I do not.

Q. Is it Peoria?

A. I shouldn't think so. I should look for it tolerably close by.

Q. What distance?

A. Well, I should look for it within twenty-five or thirty miles.

Q. And you would take no cognizance of any city above twenty-five or thirty miles?

A. Oh, I don't say that, but I should look first very assiduously within thirty miles.

Q. How far up the Mississippi river or any of its tributaries would you go to look for the source of pollution, if you found the water at St. Louis to be polluted.

A. I don't think that I would consider anything beyond 75 miles as important, counting ordinary rate of flow.

Q. What in your opinion is the effect of the Cincinnati sewage upon the Louisville water supply?

A. I don't know about it.

11845 Q. Have you ever read the literature upon that subject?

A. I have been looking at the very high death rate from typhoid fever in Cincinnati. I know that it is a very high death rate.

Q. Have you examined the death rate in Louisville?

A. In Louisville, Kentucky, I have the figures here before me. I have been looking over these figures today. We had 121 deaths with a population of 217,000 in the year 1901.

Q. Isn't it true that that water at Louisville passes through a reservoir holding five to seven days' supply?

A. I don't know.

Q. Well, you know that that is sewage polluted water, do you not?

A. The Louisville water supply?

Q. Yes?

A. I should think it would be from the number of typhoid cases. My attention has not been called to it.

Q. Standing from three days to thirty, from the source of pollution, and yet knowing that the water supply at Louisville was obtained from that source, what would you say as to its sanitary condition—three days for the water to flow from the source of pollution to Louisville, in the river itself, and five days additional in the reservoir, and yet that water 11846 when taken into the reservoir produces typhoid fever and is a polluted water.

A. Is there no chance of contamination on the way?

Q. No sewered towns within ninety miles.

A. Is the water guarded and protected all the way from contammination? Unless it is guarded and protected entirely from contamination, an opinion as to the more distant city would not be very valuable.

Q. Would you take the judgment of reputable men who had examined into it, and who had stated as epidemiologists that that was the source of pollution, as true?

A. It would all depend upon who those men were.

GENERAL CROW: Would it depend upon your personal acquaintance with them?

A. My own opinion would depend upon information I could get as to their reliability, information in which I had confidence.

MR. JEFFRIES: Your opinion, however, is that if a man says that typhoid germs will travel longer than five days and further than 150 miles, that it is not very valuable?

A. No, I would not put it quite that way.

Q. I will ask you, doctor, if the time factor is not more important than distance?

A. I think they are both very important.

Q. Well isn't the time factor more important than distance? 11847

A. Other things being equal, I should say yes.

Q. Well, what do you mean by other things being equal? Don't you know that the time factor is a most important question to be considered by an epidemiologist in determining the source of pollution of water?

A. No, I am not sure that it is. I think that other influences, for instance, the amount of saprophytic bacteria, the amount of sedimentation, are just as important factors to consider.

Q. Then if you saw opportunities for saprophytic operation, and you saw opportunities for sedimentation, whether they would be fancied or not, that would be a justification in stating that the source of pollution was not above a certain point; is that true?

A. If the opportunities for saprophytic action and sedimentation were fanciful, I don't think that one could—

Q. Cut out the "fancy;" I didn't mean to put that in there? (Last question repeated.)

A. The question is not clear to me; I don't quite understand it.

Q. In the examination for the purpose of determining the source of pollution, you were told that the source of pollution was from a town or city situated 150 or 200 miles above
11848 the point affected, you would find that before you reached that point supposed to have been the source of pollution, that there were opportunities for saprophytic action, and also opportunities for sedimentation, as soon as you found that there was an opportunity for the saprophytes to get in their work and an opportunity for sedimentation, you would say at once, there is no need of going any further. That is the end of this controversy; that could not be the source of this infection?

A. Provided the time for those influences were great enough.

Q. Now then, the time for those influences to act, depends altogether upon the longevity of the disease producing germs, does it not?

A. Under the particular conditions.

Q. Under what particular conditions, doctor?

A. Under the particular conditions of the case. They vary in every instance.

Q. Doctor, do you know about the typhoid conditions at Covington, Kentucky?

A. No.

Q. Do you know that the water is held in settling basins for thirty days and yet it is typhoid infected after it is held in that basin thirty days and distributed to the people?

11849 A. I do not know the conditions at Covington.

Q. Now then, doctor, if it could be held in a settling basin for thirty days, with the opportunities for sedimentation there, are not there more facilities for sedimentation in that basin than there would be in the Illinois river coming from Chicago to St. Louis in less than thirty days?

A. I should think there would be more opportunities for sedimentation.

Q. Then on the question of sedimentation, if it remained in a settling basin thirty days at Covington, and still carried the typhoid germs into the water supply, to the people and produced typhoid, would not and are there not strong reasons to believe that they would be carried free from sedimentation, from Chicago to St. Louis?

MR. TODD: I object to the question for the reason that there is no evidence in the record that the water supply of Covington remains thirty days in a settling basin, and is a cause of typhoid fever in Covington.

MR. JEFFRIES: We can prove it by some of this literature that counsel admits that this witness has read, when the witness bases his experience and his qualifications altogether on literature that has been read by him, as entirely compe-
11850 tent.

MR. TODD: I submit counsel's statement as to his qualifications is not borne out by the evidence of the witness.

MR. JEFFRIES: And I suggest further that the testimony for the complainant shows that this particular instance was shown in evidence with reference to conditions existing at Covington, Kentucky.

MR. TODD: I suggest that it is not.

Q. (Last question read).

A. My answer to that is that I don't know enough of the conditions at Covington, Kentucky, as related to me here, to pass any opinion on that.

Q. MR. JEFFRIES: Well, doctor, if they would remain in a settling basin for thirty days and not be sedimented, would they not pass down a running stream the whole distance, for thirty days, or in less than thirty days, and not be sedimented?

MR. TODD: I object to the question for the reason that the assumption of thirty days is not borne out by anything in evidence, and on the contrary it has been proven here by the complainant that in the settling basins of St. Louis, that the water in there for three days, ninety per cent. of the bacteria disappears in those three days from the water supply of St. Louis.

11851 MR. JEFFRIES: That was not shown under all conditions.

THE WITNESS: My answer to that is that I have no opinion to offer on that subject.

Q. Will you state that they would not come from Chicago to St. Louis and not be subject to sedimentation or not be sedimented?

A. In my opinion they would not pass from Chicago to St. Louis alive?

Q. Because of sedimentation?

A. Partly because of sedimentation.

Q. Speaking now of sedimentation alone, doctor, eliminating everything else?

MR. TODD: I submit that the question is improper, to confine the witness to one fact when there are other facts, as heretofore testified by the witness, that have been repeatedly stated as the reasons.

MR. JEFFRIES. I submit that the witness has yet failed to give all of the causes of disappearance, and therefore I have the right to confine him to each one, and limit it to each source of disappearance, in order that I may determine.

A. My answer then to that would be that I don't know whether sedimentation alone would account for the disappearance of the typhoid bacilli or not.

11852 Q. What is your opinion?

A. I am not prepared to offer an opinion on that.

Q. Have you an opinion?

A. No fixed opinion.

MR. TODD: That is as to sedimentation alone.

A. Sedimentation alone. That is what I said.

MR. JEFFRIES: Doctor, what is it that contaminates the water supply, or pollutes it?

A. A great many different things, the most important being bacteria capable of producing disease.

Q. And where do those bacteria come from?

A. Usually from the bodies of infected individuals.

Q. And how do they get into the water supply?

A. Usually through sewage.

Q. Then sewage pollution is the principal cause of infected water supplies?

A. Yes, I should say so.

Q. You say you have examined none of the cities on the upper Mississippi with the view of determining the extent of their sewage disposal?

A. Yes.

Q. You have not?

A. I say that I have not.

11853 Q. You don't know what effect they would have upon the waters of the Mississippi river?

A. I would have an opinion corresponding to the distance they are away, and the time that that water takes to come down.

Q. Now, then, it is a question of distance and time, is it?

A. No, together with the physical conditions of the river, physical and biological conditions of the river.

Q. What do you have reference to,--the biological conditions of the river?

A. The life phenomena of the river.

Q. What do you mean by the life phenomena of the river?

A. Everything living in the river, animal and vegetable.

Q. You are not able then to express an opinion as to where the source of pollution in the Mississippi river at St. Louis is?

A. No, I have not examined into it thoroughly enough to have any opinion.

Q. What towns are there that you know of within what you would consider the limit of pollution of the water at St. Louis?

A. I have made no special examination of that point. I would look first for towns within twenty-five miles of the city, 25 to 30 miles of the city, and I should expect to find it somewhere there. 11854

Q. How far would you have to go, doctor, before you would eliminate the towns and cities on the river, and the sewage disposal thereof, from your consideration?

A. I should think it very improbable that any place within seventy-five miles, was responsible,—any place further away than 75 miles was responsible.

Q. Then it is your opinion, is it, that if all the sources of pollution for a distance of 75 miles from the city of St. Louis, by water, were removed, there would be no danger from typhoid fever or other water-borne diseases?

A. From the water supply?

Q. Yes, is that your opinion?

A. Yes, that is my opinion.

Q. Now, would that water be equal to the water in the river in its primal condition, after it had traveled seventy-five miles, without having received any additional sewage?

A. Would it be exactly in its primal condition?

Q. Yes?

A. I don't know.

Q. But would it be equal to it from a sanitary standpoint?

A. There is no evidence that it could produce typhoid, in my opinion, which is the point which we are interested in.

11855 Q. Then, doctor, in these cases in the literature, where it has been stated that the sources of typhoid epidemics have been traced a distance from 100 to 175 miles up a river, you don't credit them, do you?

A. I do not—

MR. TODD: Wait. I want to put an objection in there as there is no evidence and none has been produced that there is any case in the literature of typhoid fever coming a distance of 175 miles.

MR. JEFFRIES: Well, I will show you some.

A. My answer will be the same. I do not credit it.

Q. You don't believe that it can come that far?

A. All the evidence is against it, in my opinion.

Q. Can you imagine any circumstances under which it could come except that it be put in as you stated a while ago, in distilled water?

A. I might imagine other methods.

Q. Can you determine, doctor, the exact distance that the water polluted with sewage will travel before it becomes relieved of that sewage?

A. The exact distance, no, because it varies in every river—

Q. Now, what are the variations?

MR. TODD: Let him finish.

11856 A. Because it varies in different rivers, and in the same river at different times.

Q. What are the variations?

A. The variations correspond to variations in the various influences, physical, chemical and biological and atmospheric.

Q. But it cannot be determined just exactly what those variations are, or the extent of the pollution or the extent of the purification?

A. They are not constant.

Q. They are not constant and therefore it cannot be determined the exact limit, is that true, and the differences in that limit depend upon the longevity of the disease producing germs?

A. This limit of purification depends upon the presence or absence of pathogenic germs.

Q. Upon the longevity of?

A. Under particular circumstances.

Q. Does it not depend upon the longevity of pothogenic germs under all circumstances?

A. It depends in each case upon the longevity of the germs in that particular instance.

Q. And the longevity in no particular instance can be applied to all conditions and all periods as applied to that one river?

A. It can be applied generally, but not exactly.

11857 Q. Can it be applied so that it can be relied upon and so that you might pass judgment upon a water as being safe for sanitary purposes?

A. It is sufficient to permit you to form an opinion.

Q. An opinion that can be relied upon?

A. An opinion that is the best one that can be formed under the circumstances.

Q. But is it an opinion which can be relied upon and is it a condition that you could recommend?

A. I would not recommend the use of any water that wasn't filtered or boiled.

Q. Does that apply to waters in their primal condition?

A. I think it would be sufficient in their primal condition. There might be some pathogenic amoebae in there or something of that kind.

Q. Do you consider freezing temperatures in fixing the limit?

A. In fixing a limit to the life of pathogenic bacteria?

Q. Yes, and in ascertaining the point in the river at which purification has taken place and pathogenic germs have disappeared?

A. Pathogenic germs can live in ice, some of them, for a very long time.

11858 Q. If ice should freeze in the Illinois river above Averyville and there would be typhoid fever in the water that is frozen and that ice should float down to the Mississippi and melt on its way from Grafton to the Chain of Rocks, typhoid fever germs would be distributed in the water of the Mississippi river, would they not?

A. Assuming that the typhoid bacilli were alive when the piece of ice melted, there would be typhoid bacilli in the river water.

Q. Well, if it came down within thirty days, they would be likely to be alive, would they not?

A. They might be. We know that typhoid bacilli can live some time in ice. I don't know the exact time it has been proven they can live.

Q. Would a block of ice coming from Lockport be more dangerous than one from Averyville?

A. I think it would, provided the typhoid bacilli lived in it.

Q. Doctor, do you know of any city in this country with two millions of people, similarly situated as Chicago, discharging its sewage into the river like that?

A. I don't think there is any city situated in the same way as Chicago.

MR. TODD: Of that population?

11859 A. Of course, of that population.

MR. JEFFRIES: With two millions of people?

A. Yes.

Q. Well, now, doesn't the number of population and the sewage discharges of a city of that population have a great deal to do with the extent of the pollution in the river?

A. With the amount of sewage poured into the river?

Q. Yes?

A. Yes.

Q. And as the amount of sewage is increased the pollution continues further down the stream?

A. As I said this morning, it is conceivable that typhoid bacilli might be killed off more quickly with a large amount of sewage than with a smaller amount of sewage.

Q But I understood you to say that you refused to express any opinion on that subject.

A. I have not expressed an opinion. I have said it is conceivable.

Q. Of what value is it to you in passing upon the sanitary condition of water?

A. Of what value is that conception?

Q. Yes.

A. Well, it is one of the things one thinks about, of 11860 course, in forming an opinion; one tries to draw all ideas together.

Q. Doctor, have you studied the characteristics of the saprophytes in water?

A. In river water?

Q. Yes?

A. No.

Q. Isn't it a fact that you have no actual experience with saprophytic life in water?

A. Oh, I have had laboratory experience with saprophytes.

Q. But not with water taken from the rivers and lakes in connection with the longevity of the typhoid fever germ?

A. No.

Q. And from this river that we are talking about—the Illinois river?

A. No actual personal experiments have I made.

Q. And all that you know is just simply what you have read?

MR. TODD: I submit that that question has been asked three times and been answered twice.

MR. JEFFRIES: It never has been answered.

MR. TODD: I submit that it has, and the record will show.

A. I pointed out this forenoon the sources of my knowledge and information upon which my opinions are based.

Q. Now, all that you know of the saprophytic action of 11861 the water in the Illinois river, and in the Chicago drainage canal is not obtained from any personal examination of that water, but has been obtained from your conversations with Professor Jordan and Professor Long?

A. And my general knowledge of subjects relating thereto.

Q. To that river?

A. To the whole problem of rivers.

Q. You stated, Doctor, that those saprophytic conditions would be different in the various waters, did you not?

A. Yes, I pointed out that only general conclusions could be drawn, and that the special circumstances of each river should be studied in themselves.

Q. If each river should be studied for itself, and if you cannot tell the effect of the added volume of water in saprophytic life in a particular stream without studying those conditions, and those conditions are necessary, and saprophytic action is necessary to determine the sanitary condition below the point of sewage discharge, why is it that you have undertaken to express an opinion as to the sanitary condition of the water in the Illinois river at points below the city of Chicago?

A. I have already given my reasons for expressing my opinion.

Q. And you don't care to express any other opinion?

11862 A. No.

Q. Or to give any other reason?

A. No.

Q. But you have not in that opinion taken into consideration the saprophytic action in the Chicago drainage canal, have you?

A. No personal experiments.

Q. And it is necessary to have—

A. I do not consider—

Q. It is necessary to have the conduct of the saprophytes in that particular stream in order to express an opinion that would be reliable, is it not?

A. It is desirable to have all the information possible, but not necesary to have it to give the expression of opinion which I have given.

Q. Is it not necessary, Doctor, to have it?

A. I have answered that, haven't I?

Q. Doctor, do you—how do you reconcile your statement that you can determine or can express an opinion as to the effect of the added volume of 250,000 cubic feet of water per minute, to the sewage of Chicago, and discharged into the Illinois river, when at the same time you express an opinion as to the sanitary condition of that water, and at the same time state that the saprophytic conduct of the water is different in different rivers and is not the same in all waters? 11863

A. I base my opinion upon my knowledge as an epidemiologist, the foundations of which I have already given you.

MR. TODD: Read that question.

(Question read.)

THE WITNESS: My answer to that is, because there is no discrepancy between the two statements.

MR. JEFFRIES: One is not depending on the other; one has no connection with the other?

A. I say there is no discrepancy between the two statements.

Q. Then, Doctor, why can't you tell the effect and express an opinion as to the effect of the added volume of water upon the life of the typhoid bacilli in the Chicago drainage canal and the Illinois river?

A. Because I think actual experiments with percentage composition relations ought to be undertaken in order to get real knowledge on that particular point.

Q. Well, you admit that it has an effect?

A. I have admitted that it might have some effect.

Q. Then might it not have considerable effect at Averyville?

A. I don't think so; it is my opinion that it would not at Averyville.

11864 Q. And also your opinion that it would have no effect at Chicago in the drainage canal?

A. I have not said that; I said that I didn't know about that.

Q. Then it might and it might not?

A. Yes.

Q. Have you ever testified as an epidemiologist in a suit before?

A. Never.

Q. Have you ever been called upon to give an opinion as to the sanitary condition of a water supply as an epidemiologist?

A. I was called upon to pass upon private water supplies in Baltimore.

Q. That is the one you mentioned this forenoon?

A. Yes.

Q. And you stated, I believe, this afternoon, that you never had been connected with the construction of a water system in any way?

A. Yes.

Q. And your labor has been confined to the laboratory and to the hospital and to the literature with the exception of the few instances that you mentioned, when you went to California and Manilla and the Philippine Islands?

A. And India.

11865 Q. In all those cases you had nothing to do with tracing the origin of the disease but studying its character and its nature and its biology, in the hospital and among the persons who were affected by it?

A. We were tracing the origin of diseases.

Q. But not with relation to the water supply?

A. No, not in relation to the water supply.

Q. Doctor, have you examined the health statistics of the city of St. Louis?

A. I have examined certain parts of them.

Q. You examined them from the health reports?

A. I did.

Q. You made no other examination than that contained in the reports of the health department?

A. I have run across references to the health relations in literature.

Q. But with reference to the city of St. Louis now?

A. My statistics are drawn from the health reports.

Q. You have not gone to the health department and made any examination?

A. I have not.

Q. Have you examined any of the physicians or talked with any of the physicians of the city of St. Louis that had reported typhoid cases or malarial cases?

11866 A. I have not.

Q. With reference to the character of those diseases?

A. I have not.

Q. I understood you to say symptomology was the best way of determining the nature of the disease, particularly with reference to typhoid fever?

A. The detailed symptomology, in the broad sense of the word, including the physical signs and symptoms, and bacteriological tests.

Q. What do you say as to the accuracy of the Widal test?

A. I think it is one of the most reliable of the single tests, but as I pointed out, we depend upon the total symptom complex for our diagnosis rather than upon any one.

Q. You don't know, do you, the qualifications of the physicians of the city of St. Louis and the rules of the State Board of Health, do you?

A. You mean, have I read those rules?

Q. Yes?

A. I have not read the rules, no.

Q. You don't know of the circumstances which bring about the reporting of the cases of deaths from diseases, do you, in the city of St. Louis?

A. I made no special study of that point with regard to the city of St. Louis. 11867

Q. And you are of the opinion, are you, that observation of the symptoms in cases of typhoid fever, especially in cases which die, is the best of evidence, do you, to determine the cause of the death?

A. By symptoms; now, I mean including the bacteriological test and physical signs that I have mentioned above. I think that that is the only way we have during the life of the patient, of determining the nature of the disease. Of course after the patient is dead we have a still more reliable method.

Q. Isn't it a fact, Doctor, that the attending physician is best able to judge of that matter, or in other words, that the attending physician is best able to judge of the cause of the death or the nature of the disease?

A. It is not a fact when large bodies of statistics are concerned, that the statistics are always as reliable with regard to the causes of death, as the opinions of men who are particularly skilled in internal medicine.

Q. Do you know anything about these different groups of fever in Baltimore prior to 1899?

A. You mean the actual figures?

Q. Yes?

A. I know about the occurrence of cases, but I haven't any figures with me with regard to the years. 11868

Q. Why have you eliminated those figures, Doctor?

A. Because I simply wanted to compare the last three or four years with St. Louis.

Q. Did you ever practice medicine?

A. Yes.

Q. In actual practice?

A. Yes.

Q. Where?

A. I took the practice of my preceptor for a while in the country in Canada during one summer. I practiced medicine in the Toronto general Hospital for one year; I practiced medicine during the three months as head of the children's hospital at Mount Airy, Maryland. I practiced medicine in the Johns-Hopkins hospital the first year that I was there, and I practiced medicine in the Philippines, and in Chicago. I occasionally see interesting and rare cases in consultation.

Q. How long were you in the Philippines?

A. I was in the Philippines from May 5th to some time in July.

Q. That was while you were on this Commission?

A. Yes.

Q. And you practiced then?

A. To a certain extent, yes; I saw especially some sick 11869 Americans who needed attention.

Q. Did you ever make a study of the typhoid statistics in general, as a physician, and as applied to water supplies?

A. In a general way, but not in a particular way. I have never made any publications, or any special research.

Q. You have never made any investigation then but ordinary investigation as an ordinary physician, and as would ordinarily be made by a physician?

A. Upon typhoid?

Q. Yes?

A. Yes, I think my studies were scarcely comparable with those of the average physician. I think they were rather more extensive studies than the average physician makes.

Q. How about your practice?

A. My practice has, I think, been unusually interesting and helpful in developing me scientifically.

Q. Has it been as extensive as the average physician's?

A. If you mean the average physician, who has not a hospital appointment, I should say that it was more extensive.

Q. Doctor, you stated something about the existence of typhoid fever where pure water was used in cities, what do you mean by that, and where were they?

A. I do not recall exactly the statement to which you refer.

11870 MR. TODD: It is the town where filters had been put in.

MR. JEFFRIES: He said protected surface water.

A. I do recall speaking of a few cases of typhoid in Berlin and Munich and Hamburg.

Q. New York and Boston?

A. I have the statistics here of the New York and Boston and Philadelphia typhoid conditions.

Q. Have you this group of fevers in those statistics that you read?

A. No, only typhoid in the statistics I have with me here.

Q. Are those typhoid statistics that you have sufficient to form an opinion as to the sanitary condition of the water supply in New York?

A. Why, they permit me to form an opinion, but of course a limited opinion.

Q. What is it?

A. The statistics I have here, for instance, for New York, and I have two sets of them, are the deaths from typhoid fever in New York from 1870 to 1900, and from the comparative mortality of New York with other cities from typhoid fever, they show a remarkable and interesting decerease in the number of cases, from 1870.

Q. How do they compare with St. Louis, for the last ten 11871 years?

A. Well, from 1890 on, the death rate of New York is lower from typhoid per 10,000 inhabitants—

Q. Is that for ten years or by years?

A. This is by years. They are decidedly lower in New York than in St. Louis.

Q. Now, do you know whether or not this group of fevers, such as intermittent, malarial, etc., have been included in the typhoid fever statistics of Chicago?

A. In the Chicago statistics?

Q. Yes.

A. I think I have the Chicago statistics here.

Q. Do you know whether they have been separated?

A. I don't know; I have not looked up that point.

Q. Did you ever look them up for any other city?

A. I have looked them up for St. Louis and Baltimore.

Q. And that is the sum total of all your investigations?

A. My experience in Baltimore was so interesting in that connection that I have repeatedly spoken in medical societies about the confusion that the physicians make in these two groups.

Q. You think, then, that St. Louis and Baltimore are the only two cities in which this confusion has been made?

11872 A. Not at all. I think it has been made in nearly every city in the country, but more particuarly in southern cities, and I have warned practitioners in medical societies, urging them to more sharply diagnose.

Q. That has been continually practiced right along, in the cities?

A. It has been very much better in some cities than others, where the physicians have been better educated, and where their attention has been particularly drawn to it.

Q. The deduction from that is, that the doctors and physicians in the southern cities are not as well educated as those in the northern cities?

A. That is not a necessary deduction. The incidence of malaria is so much greater in southern cities than in the northern cities, that the opportunity for making the mistake is greater.

Q. What do you know about the distribution of malaria in the Mississippi valley?

A. I have made no especial study about the distribution of the malaria in the Mississippi valley.

Q. What do you mean by the incidence of malaria?

A. The occurrence of cases of infection with malaria.

Q. Is there any more malaria in southern cities--

11873 A. Yes.

Q. And not incidence of malaria?

A. That simply means the number of cases occurring.

Q. So, then, the difference is in the number of cases and not in the locality, to particularly call the attention of the physicians in the localities where the fevers occur, is that it?

A. Well, in the main I think that the difficulty is due to lack of education in modern methods in diagnoses. In some southern cities where the men are better educated with regard to these points, as in Baltimore, the statistics are more reliable, though even in Baltimore there are so many physicians who cannot make a correct diagnosis, that the statistics are still very faulty, I am sure.

Q. Well, now, is it your opinion, Doctor, that physicians generally are not able to make a correct diagnosis unless they be specially learned in the different specialties covering these different diseases?

A. I think that it is very easy for a physician who can examine blood microscopically, and who can make the Widal reaction, or have it made for him, to make a mistake.

Q. And that is in cases where the person dies?

A. No, where they live, too.

11874 Q. Well, how would it be where the person dies, would they be able to make a correct diagnosis?

A. At autopsies?

Q. Yes?

A. Very few physicians are able to make correct diagnoses at autopsies. A man must be a pathologist.

Q. Without an autopsy can they?

A. After death?

Q. Yes?

A. I think it would be very hard.

Q. In case of fevers?

A. You mean, if he could not diagnose during life, could he make one after death, without an autopsy?

Q. Yes, so far as malarial fever is concerned?

A. I don't see how he could.

Q. What relation does malarial fever bear to water supplies?

A. The relations of the water supply to a mosquito would be the only relation so far as the drinking water is concerned. There is absolutely no relation to malaria.

Q. A water that is used for domestic purposes, then, has no bearing?

A. No bearing whatever.

Q. Do you care to go on record as saying that a mosquito is the only thing that produces malaria? 11875

A. I am willing to go on record as saying that there is no evidence that malaria is ever obtained by human beings except through the bite of a mosquito.

Q. And that is the only way it can be obtained, and if there were no mosquitoes there would be no malaria?

A. In my opinion there would not.

Q. How do you explain the malaria in the Rocky Mountains in the west, and in Blue Ridge?

A. If there was no mosquito there, there would be no malaria.

Q. Suppose that you were told that there was malaria there and no mosquitoes?

A. I would not believe it, and I am sure that if I went there and examined the field there would be mosquitoes about there.

Q. Don't you know as a matter of fact that there is malaria in those mountains, and that there are no mosquitoes?

A. While there are no mosquitoes there, there are mountain fevers and mountain fevers.

GENERAL CROW: There is but one mountain fever.

A. There are several mountain fevers that have been described, and they may not be all identical, but there is no malaria without the mosquito so far as we know, and we know a great deal about it now. 11876

MR. JEFFRIES: And the mosquitoes are liable to be more prolific in stagnant water than in running water, are they not? isn't that true?

A. Yes. Little bits of pools are more responsible than great bodies of water. A little hole in a stump is often a breeding spot for enormous numbers of mosquitoes, a little pool near a well, near a cistern, and if we could do away with these little breeding pools we would do away largely with mosquitoes and with malaria.

Q Doctor, is malarial fever as a general proposition regular from one year to another in a community?

A. It appears to be in some communities tolerably regular.

Q. Don't you know in the Mississippi valley for the last three years, there has been very little malarial fever for the Mississippi valley?

A. The letters I have had from a doctor in St. Louis have not said anything about that. He told me that malaria was occurring all the time.

GENERAL CROW: Who was that doctor?

A. Dr. Roland Hill. He was a fellow interne with me in the Toronto General Hospital in 1890.

11877 MR. JEFFRIES: You don't know whether it is or not, occurring regularly from year to year?

A. From my own personal observations?

Q. Yes. In the Mississippi valley around St. Louis and in St. Louis?

A. Not from personal knowledge.

Q. I will ask you if these tables which you have read in evidence do not indicate that there has been a falling off in malarial fever?

A. They do not to me.

Q. I will ask you if the tables on their face in the health report,—taking it for granted that they were correctly reported, which you have no reason to doubt—

A. No.

Q. —does not indicate that there was a falling off in malarial fever, and I want to ask if you mean by that to impeach the integrity of the physicians of St. Louis?

A. I do not mean to impeach the integrity of the physicians of St. Louis, but I do mean to intimate that there have been improper diagnoses made in the city of St. Louis.

Q. Doctor, do you know of your own knowledge or from any information which you have received, that you can 11878 state in evidence here, that there has not been a falling off in the typhoid malarial cases in the city of St. Louis in the Mississippi and Missouri valleys, in the last three years, as compared to what it was three, four, five or six years prior thereto?

A. My answer to that would be—I have here the statistics of two groups of cases from St. Louis, typhoid fever and the so-called remittent, intermittent, typho-malaria, congestive and simple continued fever—

Q. But, Doctor, those groups apply to different periods, do they not, one group from 1900 down, and the other, 1900—

A. I have divided them.

Q. Now, then, you don't know that there has been or has not been a falling off of malarial fever cases in the Mississippi valley, the Missouri valley, and in the city of St. Louis in the last three years, or since 1899, do you?

A. I do know that malaria has caused no such death rate at any time as is reported by the column headed "Remittent, intermittent, typho-malarial, congestive and simple continued fevers."

GENERAL CROW: That does not answer the question. You must answer the question.

(Question repeated.)

11879 A.. I have no definite information on that point.

Q. Now, have you any personal knowledge of the intermittent and the continued fever, as to whether it has increased or decreased?

A. I know that no disease should be classed under that name at present, it is a misnomer.

Q. And that means one or two things?

A. No, not always, but one generally; one of two things, either typhoid or malaria. There are very few deaths from malaria, and one can say from his knowledge of malaria and typhoid, that the deaths in that column were due chiefly to typhoid. Some of them to other things like dysentery, acute tuberculosis, but scarcely anything would be termed really malaria, which the terms remittent, intermittent, typho-malaria, and simple continued, indicate.

Q. Doctor, have you noticed any increase in the typhoid death rate in St. Louis for the year 1902, as compared with that of the years 1900 and 1901?

A. The reported death rate from typhoid alone in St. Louis, that is in the group under "typhoid alone" in the city health reports, is 27.90 per 100,000 in 1900, and is 34.90 for 1901. The figures for 1902 are 36.7. But on comparing the total 11880 cases, or taking the total cases of deaths from the two groups together, typhoid fever and that other group,—remittent, intermittent, typho-malaria, etc., the number of deaths in 1900 is 280—168 in the typhoid fever group; 112 in the other group.

In 1901 the total number of deaths from the two groups together is 278, of which 198 are in the typhoid fever column and 80 in the remittent, intermittent, typho-malaria, congestive and simple continued fever column.

In 1902, the total number of deaths of the two together, was 324, of which 222 were typhoid alone and 102 in the remittent, intermittent, etc., column.

Q. So there has been an increase in the typhoid alone?

A. In 1902 over 1900 and 1901.

Q. Yes, in other words there is an increase in 1901 over conditions existing in 1900?

A. No. There is in typhoid alone, but not in the two groups together.

Q. In typhoid alone?

A. Yes, but in 1902 there is a distinct increase in typhoid alone, and in the combined groups.

Q. And in the combined?

A. Yes.

Q. How do you explain that increase, Doctor?

11881 A. The increase is not so great but what it might be—it might occur in any year. For instance, if you examine the statistics further back, you find in the years 1890 and 1891, 1892, 1893 and 1894, more cases in the combined group.

Q. Then, Doctor, attributing the typhoid in all instances to the pollution of the water supply, it simply means that the conditions in the water are not the same from year to year, although the source of the water supply is the same, is that true?

A. That is true.

Q. And the water at the intake is different one year from what it would be another year?

A. Assuming that all the deaths are due to water pollution?

Q. Yes?

A. It would indicate either that there were differences from year to year in the pollution of the water supply, or that for some reason or another the people were more susceptible one year than another.

Q. But as an epidemiologist now, which would be considered as most likely to occur?

A. There is a third possibility, if I may mention it, and

that is that there might be just the same degree of pollution,
but the bacilli might be more virulent in one year than
11882 in another, corresponding to the cases from which they
had been derived. I don't think that it would be easy to
say where the difference is so slight as it is here, which factor
was most concerned.

Q. But it would be one of the factors, and as likely to be one as another?

A. In my opinion it would be, yes. I would be inclined to lay more weight on the water pollution than on the other two factors.

Q. Doctor, do you know what towns or cities are situated on the Mississippi river watershed, which includes both the Missouri and the Illinois rivers, above the chain of rocks, that have a population of more than 5,000 inhabitants, and that are within seventy-five miles of St. Louis?

A. If I may refer to those statistics that I have already put in.

Q. Yes,—well, I will ask you this question, Doctor, isn't it a fact that Alton and St. Charles are the only towns of that size, and that St. Charles has not a complete sewer system, and that Alton also is not completely sewered? In other words, a very large portion of both of those towns is unsewered?

A. I understood that St. Charles poured some sewage into
the river, and that typhoid was occurring in St. Charles,
11883 and that seemed to me very important in connection—

Q. Is it your understanding, Doctor, that the typhoid fever in St. Charles has been occurring in more than normal conditions for the last six years?

A. I have no information about that.

GENERAL CROW: You fix no time?

A. I can fix no time, no.

MR. JEFFRIES: And you have no information on that subject that it was prevalent in St. Charles any more than its normal condition for the year 1902?

A. You mean more than its average condition?

Q. Yes?

A. I have no information on the point except what is on those statistics that I have introduced.

Q. Of 1900 and 1901?

A. No.

Q. Or that there was more typhoid in St. Charles in 1902 than there was in 1901 or 1900?

A. I have no information on that.

Q. Now, does your information with reference to Alton correspond with the information that you have with reference to St. Charles?

A. I have no information with reference to Alton.

Q. You have no information with reference to Alton?

11884 A. No, but I would say that if typhoid were occurring in those two towns and the sewage was being poured into the river and those two towns are within seventy-five miles of St. Louis, I should think a slight difference in the number of cases in two or three years in St. Louis, might easily occur without any change in the amount of typhoid being put into the river.

Q. Now, Doctor, I will ask you this question: if you consider that the sewage from St. Charles and from Alton, which are the only towns on the Mississippi river watershed above the chain of rocks within seventy-five miles of the chain of rocks, do you consider that those towns are the source of all the objectionable pollution in the Mississippi river at the chain of rocks?

A. I would not at all suppose that the towns must necessarily have 5,000 inhabitants in order to pollute the water. I think a single typhoid case occurring near the intake in a village or a hamlet of twenty houses, would be more significant; much more significant than the sewage from a town of 5,000 a great deal further away.

Q. Even if there were no sewers?

A. If the excreta from the typhoid patient got into the river in any way.

Q. But that, Doctor, would come in the shape of epi-
11885 demics, would it not, being so close to the city that it would not be continuous?

A. I regard typhoid fever as being epidemic in St. Louis all the time; not a great epidemic, but still, epidemic.

Q. Have you ever examined the distribution of typhoid deaths in St. Louis by the months?

A. Yes, part of my statistics were based on adding up those together.

Q. Do you know anything about the typhoid conditions in St. Louis this year, 1903?

A. I have looked over the pamphlets that come out, giving the statements, but I have not them with me.

Q. And you haven't included them in your statement in evidence with reference to those dates?

A. No.

Q. Do you know, or don't you know, that St. Charles and Alton are the only towns that are sewered and situated upon the Mississippi river and its tributaries within one hundred miles of St. Louis, and that contain as much as 5,000 population?

A. I did not—I do not know the cities; I don't know the number of cities of that population. I am not familiar with that.

Q. I will ask you, Doctor, if there would not be more
11886 typhoid in St. Louis if this water was taken absolutely
in its raw condition from the river at the chain of rocks,
before it went into the settling basins of the water supply of the city?

A. May I ask about those settling basins? I am not familiar with them. How many are there and what is the arrangement?

Q. Well, the water remains in these settling basins from two to three days.

GENERAL CROW: There are four of them at one place and two in another.

A. I should think if the settling basins were properly conducted that they would diminish the typhoid bacilli.

MR. JEFFRIES: You don't know, then, how much sedimentation is effected by them?

A. No.

Q. You have not considered that, have you, in your statements in evidence with reference to the typhoid situation in St. Louis?

A. I have not considered the water to any great extent below the Illinois river, because I did not deem it necessary in the case.

Q. Doctor, have you ever examined an anthrax epidemic?

A. In human beings?

Q. Or in stock?

11887 A. I have never examined an epidemic. I have made
an autopsy on one human case of anthrax, and of course

on a number of animals, in the laboratory, dead of experimental anthrax.

Q. Those examinations were made upon the dead body and not with reference to any examination of an epidemic?

A. No.

Q. And causes of the epidemic?

A. Well, in the animals we caused it ourselves by experimental inoculation.

Q. Anthrax is a spore forming bacilli, is it not?

A. Anthrax forms spores.

Q. Do you know how long they will live in water or in earth?

A. I cannot give you the exact length of time, but I know that they will live a very long time; that they are most resistant.

Q. I will ask you if they won't live as spores from three to seven years or more?

A. I think that they will live at least years when they are kept dry.

Q. And also wet?

A. If they were wet I should think they would grow out into bacilli—the spores would grow out into bacilli.

11888 Q. They would not grow out into bacilli if they were wet unless the moisture in which they were placed reached the proper temperature, would they?

A. No, if the temperature were at the freezing point I should not think they would grow out.

Q. In other words, as long as they remained in water or in earth and did not get into the proper media as to temperature, they would not grow out into bacilli?

A. Unless they had the proper temperature and media, they would not grow out into bacilli.

Q. Have you had any experience in examining the causation of tetanus?

A. Yes, I have worked with the tetanus bacillus, and with experimental tetanus inoculations, and I have studied human cases of tetanus.

Q. The germs of tetanus form spores, do they not?

A. They do.

Q. And how long will they live?

A. They, too, will live a considerable length of time; I don't know how long; they are very resistant.

Q. From one to three years or longer?

A. I don't know; they are present in garden earth all the time.

Q. And very resistant?

11889 A. And very resistant.

Q. Doctor, do you know, or, rather, isn't it a fact that scientists have recently discovered that the germs of tetanus are prevalent in the intestines of all cattle?

A. I know that they are present in the intestines of animals. I am not sure about particular animals; and they are present in the earth, in the soil, very widely distributed.

Q. Isn't it a fact that some scientists of recent date have taken the position that they are the natural inhabitants of the intestines of cattle?

A. I am not familiar with that point; it may be true.

Q. It may be rue?

A. That might be true. I would not be surprised if it were true.

Q. Then, if they are the natural inhabitants of cattle, the offal and washings from stockyards and slaughter pens at Chicago, discharged into the drainage canal—is there any reason that you know of, Doctor, why they would not be carried down the Illinois river?

A. I know of no reason why they might not, along with the tetanus bacilli of thé soil on the banks of the river all the time.

11890 Q. That would be an additional source?

A. An additional source.

Q. Of tetanus spores?

A. I think those spores would grow out into bacilli under favorable conditions.

Q. That is, if the proper temperature and the proper media was obtained?

A. Yes, but tetanus is not a water-borne disease, as far as I know, in human beings.

Q. Anthrax is though, is it not?

A. I have always associated anthrax with contact in skin infection, although feeding experiments in animals will produce anthrax infection.

Q. Well, may it not be produced either way?

A. In animals, yes; whether or not enough of it could be introduced into a human being by the alimentary tract to set up anthrax, I am not prepared to say.

Q. You are not prepared to say because no experiment has ever been made?

A. I know of no experiments.

Q. Now how is tetanus contracted?

A. Generally by a wound of the skin, a deep wound of the
skin; inasmuch as the bacillus is anaerobic, it does not
11891 grow and survive in the air.

Q. I will ask you, doctor, if the germs of tetanus were discharged into the canal at Chicago by means of the sewers of Chicago, and find their way down the Illinois river to St. Louis, and carried into the intake, and thence into the water supply of the city, and a house servant should be washing vegetables or cleaning vegetables with the water drawn from the tap, and should accidentally inflict a wound in her finger, or in her hand and one of those tetanus spores be carried into the wound, if it would not cause the disease?

A. There would be a thousand chances that in such a case the infection came from the dirt on the vegetables, to one chance that it came from the river water.

Q. The opportunity, however, would be there, would it not?

A. I have never known of a case occurring from water-borne bacilli of tetanus.

Q. In the cases that you have known, how were you able to determine whether it came from the earth or from the water?

A. By far the majority of the cases of tetanus are Fourth of July tetanus cases, due to injury of the hand with a toy pistol, and it has been shown that the percussion caps connected with those toy pistols are very frequently infected with tetanus;
and other cases, nearly all, are punctures with rusty nails
11892 of the bare feet,—children going bare-foot, with dirt on
their feet and getting a puncture wound.

Q. Could not a rusty nail be moistened in water from a sprinkler drawn from the water supply, and a tetanus germ carried in that water?

A. I don't think there is any evidence in favor of that theory.

Q. It is possible, is it not?

A. I would not deny the possibility of it, but I think it very improbable.

Q. Well, is it not as probable that it should be carried that way as to be carried by the dirt in the earth?

A. No, not nearly.

Q. Do you know whether or not there has been the germs of spores of tetanus found in the waters of the Illinois river since the opening of the canal?

A. I don't know; I should think it very probable that there might.

Q. Do you know whether or not the germs of anthrax or the spore of anthrax has been found in that water since the opening of the canal?

A. I have not heard of its being found.

Q. And would you be surprised if you should hear that?

11893 A. Yes I would, because the anthrax is the least resistant when it is not in a spore form,—of any of the bacteria almost; it is killed off more easily than most any other form when it is not in spore condition.

Q. But in its spore condition would you be surprised at its being found in the water of the Illinois river?

A. I would not expect it to be found in spore condition, because I think the spores would grow out into the less resistant bacilli in the water.

Adjourned.

11894

Chicago, Illinois, November 9, 1903.

STATE OF MISSOURI
vs.
THE STATE OF ILLINOIS AND THE SANITARY DISTRICT OF CHICAGO.

It is hereby stipulated and agreed between Samuel B. Jeffries, respresenting the State of Missouri, and James Todd, representing the State of Illinois and the Sanitary District of Chicago, that the testimony of C. D. Cassingham, Frank L.

Stevens, and Walter G. Sackett may be taken before Fred A. Burton, a notary public in and for Cook county and State of Illinois, and they may give their testimony in the case of the State of Missouri vs. The State of Illinois and the Sanitary District of Chicago, and be examined and cross-examined in the same manner and to the same effect as if said testimony was taken before Frank S. Bright, Commissioner of the United States Supreme Court.

And it is also stipulated and agreed that said testimony when so taken and reduced to writing, may be incorporated in the record of this case, with the same force and effect as though the same had been taken before Commissioner Frank S. Bright.

11895 C. D. CASSINGHAM,

called as a witness in behalf of the defendants, after first being duly sworn, was examined in chief by Mr. Todd and testified as follows:

Q. What is your name?

A. C. D. Cassingham.

Q. Where do you live?

A. Wilmington, Illinois.

Q. Mr. Cassingham, did you ever collect any samples of water from the Kankakee river?

A. Yes sir.

Q. When did you collect those samples?

A. I cannot give the dates, I kept no record of it.

Q. About when.

A. About the year 1899 was the first I think.

Q. Did you collect any in 1900?

A. I think I did, yes sir.

Q. For whom did you collect those samples?

A. Professor J. H. Long.

Q. From what river did you collect the samples of water?

A. The Kankakee.

Q. At Wilmington, Illinois?

11896 A. At Wilmington.

Q. In what manner did you collect the samples?

MR. JEFFRIES: I object to the testimony with reference to the taking of samples in the Kankakee river for the same reasons stated in my previous objections to the taking of samples in the tributaries of the Illinois river.

A. They were collected at that time. I was a teamster or drayman and I drove right out into the river so that I could reach the water. I collected it in a bottle. I put my hand over the mouth of that bottle until I got it down probably a foot below the top of the water and then I filled the bottle.

Q. Which side of the wagon did you collect it, up stream or down?

A. The upper side of the wagon,—up stream.

Q. Where did you get the bottle from?

A. That was sent from Mr. Long to me.

Q. By express?

A. By express. I got them out of the express office.

Q. Were the bottles sealed when you received them,—I mean stoppered. Was there a stopper in the bottles?

A. Yes sir, and sealed after the water was taken.

Q. Now after you received the bottles with the stoppers—
11897 what sort of a stopper did the bottles have in them?

A. What did they have in them?

Q. What sort of a stopper, cork or glass?

A. I think it was glass.

Q. Now after you got the bottles and went out into the river, did you remove the cork or the stopper from the bottle before you submerged the bottle under the water?

A. Yes, I took the stopper out before I submerged it under the water.

Q. After you had filled the bottle, in the manner you have indicated, you put the stopper back in, did you?

A. Yes sir.

Q. After you put the stopper back, what did you do with the sample of water collected?

A. After I corked the bottle, a piece of cloth,—I think it was cloth—was put right over this stopper and I tied a string around it and sealed it, and I took a tag with directions as to the temperature of the air and the water and delivered it to the expressman at Wilmington.

Q. How long from the time of taking the water was it, before the sample was delivered to the expressman at Wilmington?

A. Probably twenty minutes or half an hour at the outside.

Q. Now, on the tag that you used, will you describe that
11898 tag clearly and briefly?

A. Why the tag was probably a little longer than that (indicating), probably that width, in the shape of a common shipping tag that is used by business men.

Q. Give it in inches?

A. It was probably two and a half by three and a half.

MR. TODD: It is agreed that the cards used on these samples of water by this witness, are the same kind of a card and envelope as has been testified to here by other witnesses, as being attached to all samples of water collected by Professor Long.

Q. How often did you take these samples of water?

A. I think it was twice a month; I don't know the number of months.

Q. Well your card should show the number of samples taken?

A. Yes sir.

Q. And the date of the taking?

A. Yes sir, and the temperature.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. Where were the samples taken from?

A. Wilmington, Illinois.

Q. How deep was the water in the Kankakee at that time?

11899 A. It would vary from a foot and a half to three feet.

Q. How many samples did you take?

A I couldn't tell; I kept no record of it.

Q. About how many,—three or four?

A. A great many.

Q. What part of the year, what time of the year?

A. It might be the first or second—about August I think, I am not positive.

Q. When did you finish?

A. I think probably the first year I collected only about three different months.

Q. Did you take any other samples than those in the large bottles?

A. Yes, one small bottle.

Q. How did you take them? In the same way?

A. In the same way.

Q. You pulled the cork out, put your hand over the mouth of the bottle and submerged it?

A. Yes sir.

Q. About a foot?

A. Yes, about a foot below the surface.

Q. Then you removed your hand and let the bottle fill with water, then you drew it out of the water and put the cork back in?

11900 A. Yes sir.

Q. You did that with both large and small?

A. The same, both with the large and the small.

Q. Did you rinse the bottles?

A. Yes sir, I did.

Q. How did you do that?

A. By submerging them, taking them out and shaking the bottle.

Q. What did you do with the cork while you were rinsing the bottle?

A. Laid it on the wagon until the bottle was rinsed and filled.

Q. What kind of a wagon was it?

A. It was a dray, something similar to those used in Chicago, or stake wagons, some call them.

Q. Did you lay it down in the bottom of the wagon?

A. Yes, laid it down in the bottom of the wagon.

Q. Have any particular way of laying it down?

A. No sir.

Q. The bottom of the wagon was dirty wasn't it, or dusty?

A. No sir.

Q. There was dust lying around?

11901 A. Probably some dust. I didn't wash it off.

Q. You didn't wash it off.

A. No sir.

11902 **FRANK L. STEVENS,**

called as a witness in behalf of the defendants, being first duly sworn, was examined in chief by Mr. Todd, and testified as follows:

Q. What is your name?

A. Frank L. Stevens.

Q. Where do you live?

A. Raleigh, North Carolina.

Q. What is your business?

A. Teaching.

Q. Where?

A. At the Agricultural-Chemical College of Raleigh.

Q. Where were you before you went to Raleigh, North Carolina?

A. I was in Europe.

Q. And before going to Europe?

A. At the University of Chicago.

Q. Are you acquainted with Professor E. O. Jordan of the University of Chicago?

A. Yes sir.

Q. Did you ever do any work under the direction and supervision of Professor Jordan of the University of Chicago?

11903 A. Yes sir.

Q. Where?

A. At the University of Chicago.

Q. In connection with the analyses of water?

A. Yes sir.

Q. What position did you occupy in the laboratory there, Mr. Stevens?

A. I was Professor Jordan's Assistant in the chemical work.

Q. Covering what period were you there?

A. Beginning in the spring of 1899, until the summer of 1900.

Q. While in the laboratory there under Professor Jordan did you receive samples of water which came there by express from the express company?

A. I did, yes sir.

Q. How were those samples of water marked or labeled?

A. There was a piece of rubber cloth covering the stopper, and that cloth was wired and sealed, and the tag was fastened on with the same wire.

Q. Was that a tag that had printed on it Sanitary District of Chicago; Streams Examinations?

A. I couldn't tell without identifying the tag.

MR. TODD: It is agreed that the cards on these samples were the same kinds of cards that have been testified 11904 to and introduced in evidence here by the different witnesses who collected the water, and sent them to Professor Jordan of the Chicago University.

Q. Now after you received this water, what was done with it?

A. It was opened. The bottle was opened and the water was analyzed.

Q. Did you keep the tags?

A. Yes, we kept those as long as I was in the laboratory.

Q. And they were turned over to Professor Jordan?

A. Yes sir.

Q. And under his control and supervision?

A. Yes sir.

Q. And you only had to do with the chemical samples?

A. Yes sir.

Q. And did those samples extend from St. Louis up to Bridgeport, received from the different water collectors that have been heretofore examined in this case?

A. Yes sir.

Q. Now after taking those samples or receiving them there, they were turned over to Professor Jordan, were they not, I mean under his superivision. The samples came in under his supervision?

A. After they got in the laboratory, yes.

Q. You worked under his direction and supervision?

11905 A. Yes sir.

Q. And was the work that was done by you done under the direction and supervision of Professor Jordan?

A. Yes sir.

Q. And was that all done correctly in accordance with his directions and instructions?

A. Yes sir.

Q. Who was assisting you there? I mean who was working with you in that work?

A. Mr. W. G. Sackett.

Q. How long was he working there?

A. I think it was from October until I left the work.

Q. He was working under the direction and supervision of Professor Jordan at the time?

A. Yes sir.

Q. And Professor Jordan was in the laboratory there?

A. Frequently or constantly.

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. When did you say you commenced this work?

A. It was in the neighborhood of the first of April, 1899.

Q. And how long did you work there?

A. Until in the neighborhood of June, 1900.

11906 Q. Now what was the character of your work, bacterial or chemical?

A. Purely chemical.

Q. Did you undertake to make a complete chemical analysis for all chemical constituents in the water?

A. No sir.

Q. What particular constituents did you look for?

A. We analyzed for the turbidity, sediment, color, odor, total residue on evaporation, dissolved residue on evaporation, suspended residue on evaporation, chlorine, total oxygen consumed; dissolved oxygen consumed; suspended matter, oxygen consumed; nitrogen as free ammonia and nitrogen as albuminoid ammonia; total, dissolved, suspended; nitrogen as nitrites and as nitrates. I think that was all.

Q. The other chemical constituents—are there other chemical constituents in these samples of water, that were not taken?

A. Yes sir.

Q. Of what character?

A. The inorganic matter. We did not analyze for the magnesia calcium and other things.

Q. That is the inorganic?

A. Yes sir.

Q. You were a student in the University of Chicago?

11907 A. Yes sir.

Q. How soon after these samples came into Professor Jordan's office were they analyzed?

A. The analysis was in nearly every case begun the same day they came in.

Q. What part or relative quantity of the water in these large bottles did you examine and analyze?

A. Why, I suppose we would use three-quarters of what was contained in the bottle.

Q. But you wouldn't determine the chemical constituents of any particular part of the water in its entirety?

A. Yes, we filtered it and we analyzed the filtrate. We analyzed the water unfiltered also.

Q. But you would use a certain quantity of a sample of water for one particular analysis or determination, and then another part for other determinations?

A. Yes sir.

Q. You would shake the bottles before you commenced the determinations?

A. The bottles were checked—did you say checked?

Q. I said shaken?

A. Yes sir.

11908 Q. You would determine the turbidity of the water by observing the sediment in the bottom of the bottle, or by disturbing it?

A. The turbidity was determined after it had settled.

Q. After it had settled?

A. Yes, and we determined also the sediment.

Q. Both in the same way?

A. Yes. The turbidity was due to the part that didn't settle; the water after the sediment had formed.

Q. How long had you been engaged in this character of work before you commenced to do this particular work for Professor Jordan?

A. I had been teaching chemistry and studying chemistry for ten years I suppose.

Q. And are still doing so?

A. No, I am not working in chemistry now.

11909 WALTER GEORGE SACKETT,

called as a witness in behalf of the defendants, being first duly sworn, was examined in chief by Mr. Todd, and testified as follows:

Q. What is your name?

A. Walter George Sackett.

Q. Where do you live?

A. Raleigh, North Carolina.

Q. What is your business?

A. Teacher.

Q. Where?

A. Baptist Female University.

Q. How long have you been teaching there, professor?

A. This is my second year.

Q. Where were you before going there?

A. University of Chicago.

Q. How long were you in the University of Chicago?

A. Three years and a half.

Q. Did you ever do any work under Professor Jordan in connection with stream examinations?

A. Yes sir.

Q. In what department?

11910 A. I was under him in chemistry and also in bacterial work.

Q. How long were you in the chemistry work?

A. In the chemical work from October 1st, 1899 to the end of the work.

Q. And was Mr. Stevens with you in that work part of the time?

A. Yes sir.

Q. Now confining yourself to the chemistry work. Did you receive any of the samples of water that were sent to the laboratory from the different water takers?

A. Yes sir.

Q. Who else received samples there besides yourself?

A. Dr. Stevens.

Q. When Mr. Stevens didn't receive them you did?

A. I did.

Q. Nobody else received them but you two?

A. That's all.

Q. They were received in the manner in which Mr. Stevens just testified.

A. Yes sir.

Q. And they had a card attached to them such as we have stipulated they had?

11911 A. Yes sir.

Q. Did you work under the direction and supervision of Professor Jordan in this chemical work?

A. I did.

Q. And in that ascertainment, you made the same ascertainments that were made by Professor Stevens, as he testified a few moments ago?

A. I did.

Q. When did you start in the bacteriological work?

A. It was in October of 1901.

Q. Where?

A. St. Louis.

Q. Did you have a laboratory in St. Louis?

A. Yes sir.

Q. And that was a laboratory established by Professor Jordan?

A. Yes sir.

Q. And where was that laboratory located?

A. Eleventh and Locust.

Q. What was the number there?

A. 1023 Locust Street.

Q. And that was what year?

A. 1901.

Q. Was this laboratory established for the analysis of 11912 samples that had been agreed on to be taken at certain points by the State of Missouri and the defendants in this case together?

A. Yes sir.

Q. And how long did you work there?

A. Until about the 16th of January,—three months.

Q. And where were the samples taken from which you analyzed in that laboratory?

A. There were four from the Mississippi river, chain of rocks; one from Bellefontaine in the Missouri river.

Q. Who took those samples?

A. Mr. Cullon took them from the Mississippi river and Mr. Egan from the Missouri river.

MR. TODD: Those are the water takers that we have stipulated in regard to their testimony, Mr. Jeffries.

MR. JEFFRIES: All right.

MR. TODD: Q. How many samples of water were taken?

A. Five.

Q. How often were they taken?

A. Every day except Sundays.

Q. And at what points in the Mississippi river were those samples taken?

A. There was one sample taken from the Missouri shore;
11913 one from the Illinois shore; one from mid-stream; one
from the intake tower, and one from Bellefontaine in the Missouri river.

Q. Where was the sample from at Bellefontaine, Missouri, did it purport to be taken from the Missouri river at Bellefontaine?

A. That's right.

Q. Did you ever personally visit the chain of rocks?

A. Yes sir.

Q. Did you see the samples collected?

A. Yes sir.

Q. Was there any work done at the chain of rocks?

A. Yes sir.

Q. Where; at what point at the chain of rocks?

A. We had a laboratory fixed up at the chain of rocks where the plating was done.

Q. Was anybody else working on the samples there at the same time, with you?

A. Yes sir.

Q. Who?

A. Mr. Damon for St. Louis.

Q. He was representing St. Louis?

A. Yes sir.

Q. And this work was being done in the same room, together?

A. Yes sir.

11914 Q. This laboratory was the St. Louis laboratory at the chain of rocks, wasn't it, fixed up there?

A. I think it was mutually agreed that we were to use the same room; it was the property of the St. Louis waterworks.

Q. It was extended to us by courtesy of St. Louis, the use of that room?

A. Yes sir.

Q. These samples were then taken where?

A. After I had made a bacteriological analysis, as far as the plating was concerned, they were taken back to the St. Louis laboratory.

Q. And then the work was completed there?

A. Yes sir.

Q. Under the direction and supervision of Professor Jordan?

A. Yes sir.

Q. How long after the samples of water were taken out of the river was it before they were plated?

A. Immediately.

Q. And at Fort Bellefontaine?

A. About an hour.

Q. There would be an hour between the time of taking the sample and the plating of the samples?

A. It would require that long to come from Bellefontaine to St. Louis.

11915 Q. How many samples of water were taken and analyzed at that laboratory?

A. 280 I believe.

Q. And was this work done under the direction and supervision of Professor Jordan?

A. Yes sir.

Q. And these results that were obtained there, have all been turned over to Professor Jordan?

A. Yes sir.

Q. You were simply doing detail work in connection with this, under his direction?

A. Yes sir.

Q. And where else did you do any work, Mr. Sackett, except at the laboratory at Chicago in chemistry, and the laboratory in St. Louis?

A. Do you mean as far as student work is concerned?

Q. In connection with this investigation?

A. At the chain of rocks, St. Louis.

Q. Those were the only three places that you did any work under Professor Jordan in connection with this inquiry?

A. Yes sir.

11916

CROSS-EXAMINATION,

By Mr. Jeffries.

Q. How long did you work with Professor Jordan here in Chicago in that particular work?

A. From October, 1899, until the end of June of the next year, in the chemical work. From October, 1901 to the end of that year on the bacterial work in St. Louis.

Q. Now what part of the bacteriological work did you do here in Chicago?

A. None at all.

Q. It was all chemical?

A. Yes sir.

Q. What part of the bacteriological work did you do in St. Louis?

A. All of it.

Q. At the chain of rocks?

A. All of it.

Q. Now what was the character of that work with reference to the ascertainment of certain facts?

A. At the chain of rocks, the work was entirely quantitative work, in which we plated samples. In the St. Louis laboratory we plated the samples from Bellefontaine for quantitative determinations, and we made analyses of all five samples 11917 for gas fermentation, and the determination of the presence of coli communis.

Q. That was the extent?

A. As far as I was concerned.

Q. Was anyone else working there for you at St. Louis, working with you, for Chicago?

A. Mr. Ernest E. Irons.

Q. Did Mr. Irons work under you or you under him, or were you working together?

A. We were working together.

Q. Were the St. Louis people working at the chain of rocks with you?

A. Yes sir.

Q. And also at the laboratory in St. Louis?

A. Not in our laboratory.

Q. You say you turned over the results of all these analyses to Professor Jordan?

A. Yes sir.

Q. And those results contained the number of bacteria per cubic centimeter?

A. Yes sir.

Q. Together with the presence of coli communis?

A. Yes sir.

11918 Q. And the gas-producing bacteria?

A. Yes sir.

Q. But nothing else?

A. Those sheets also have a record of the turbidity as recorded by the collector and the temperature of the air and the temperature of the water.

Q. You say the collector would record the turbidity?

A. Yes sir.

Q. And you incorporated that into your record?

A. Yes, it was a blank form the same as we have here (indicating paper).

Q. You used the report of the collector in determining the turbidity, and in making your determinations?

A. I made determinations myself, but merely copied his record on turbidity. That is, for the bacterial sample, I am speaking for the St. Louis work entirely.

Q. You made no determinations for the turbidity of the water yourself?

A. Not in St. Louis.

Q. Or at the chain of rocks?

A. No sir.

Q. You did chemical work there too, did you?

A. No sir.

11919 Q. Bacterial only?

A. Yes sir.

Q. Did anyone that was with you do chemical work?

A. No sir.

RE-DIRECT-EXAMINATION,

By Mr. Todd.

Q. Did you take off any of the coli communis from the plates and send them to Chicago?

A. No sir.

Q. You don't know whether Mr. Irons did or not?

A. Mr. Irons did.

Q. He handled that end of it?

A. Yes sir.

ADJOURNED until 2:00 P. M. same day.

2:00 P. M., Monday, November 9th, 1903.

11920 Continuation pursuant to adjournment.

Present, same as before.

MR. TODD: It is hereby agreed between counsel on both sides that the samples of water taken from the upper Kankakee river near South Bend Indiana, by George W. Van Benschotten, as stated by Professor Long in his testimony, were taken in the manner described by Professor Long as near as may be, and that the samples of water taken from the upper Desplaines river near Libertyville, by Mr. Clare Sherman, were taken as stated by Professor Long in his testimony and in the manner therein stated as near as may be, and that the samples of water taken from the upper Fox River at McHenry, as shown by the testimony of Professor Long, were taken by Dr. Charles F. Fegers in the manner described by Professor Long, as near as may be, and that the samples of water taken from the Mackinaw River at Kappa, and analyzed and used by Professor Long in his testimony, were taken by Dr. R. E. McKenzie in the manner described by Professor Long as near as may be, and that the samples of water taken from the upper Sangamon at Mahomet by Dr. John H. Gardiner were taken in the manner described by Professor Long as near as may be, and that the production of said witnesses is hereby waived.

11921 These facts are to be considered in evidence, the same as though said persons had been sworn and their testimony produced in evidence, subject to the objections of the complainant in this, to wit: that the taking of samples of water and the analyses of those samples from the tributaries of the Illinois river, is incompetent, irrelevant and immaterial and has no bearing upon the issues involved in this case.

ADJOURNED.

10:00 A. M., Monday, March 14, 1904.

11922 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

THEOBALD SMITH

a witness on behalf of the defendants, being duly sworn by the Commissioner, testified as follows:

Direct Examination

By Mr. Todd:

Q. What is your name?

A. Theobald Smith.

Q. What is your business?

A. Professor in the Harvard Medical School and Pathologist of the State Board of Health of Massachusetts.

Q. How long have you been connected with the State Board of Health of Massachusetts?

A. Since 1895.

Q. What did you do prior to that?

A. I was bacteriologist and in charge of the investigations in the Department of Agriculture at Washington upon infectious diseases of animals.

Q. How long were you engaged in that work?

11923 A. And if you will allow me—at the same time I was professor in bacteriology in the Columbian University, Medical Department at Washington, D. C.

Q. What institution are you a graduate of?

A. Cornell University and Albany Medical College.

Q. When did you graduate from Cornell?

A. 1881.

Q. After graduating from Cornell what did you do?

A. I spent two years in the study of medicine.

Q. Where?

A. At the Albany Medical College.

Q. After that what did you do?

A. I spent about six months in special work at Cornell, then I went to Washington in the fall of 1883.

Q. And what was chiefly your work in Washington?

A. It was the study of infectious diseases of animals in the Agricultural Department, and Professor of Bacteriology in the Medical Department of Columbian University.

Q. How long were you there, engaged in that work?

A. Until 1895.

Q. And since 1895 what have you done?

A. I have been Professor in the Harvard Medical School 11924 and Pathologist of the State Board of Health of Massachusetts.

Q. Have you done any work on the bacteriology of water?

A. Yes, I began to be interested in that question in 1886, when I made observations upon the bacteriology of the Potomac River water. That was at a time when we simply determined the total numbers of bacteria. In 1891 I was engaged for a number of months on a sanitary survey of the Hudson River between Schenectady and Albany. In view of the pollution of the river there and the prevalence of typhoid in Albany and New York. Last year I was engaged in looking over the bacteriology and the general sanitary status of the Charles River basin around Boston, with reference to the building of a fresh water basin.

Q. In connection with this work have you given the question of typhoid fever any consideration?

A. Yes, because that is the main question involved in our climate, the bearing of drinking water upon typhoid and other intestinal infections.

Q. Have you ever given particular attention to the more suitable method of determining the sanitary condition of water?

A. Yes, I think that has been the main question before us —of finding a method that would particularly estimate the relative danger of water to the public health.

11925 Q. In connection with your work with the Massachusetts Board of Health, what has been its scope?

A. The scope of the Massachusetts Board of Health is to take charge of the water supply of the whole state and its business is to examine into the relative purity of waters in the state and also to determine the best methods of sewage disposal.

Q. Have you given the subject of bacteriology any consideration and if so to what extent?

A. The subject of bacteriology as a whole?

Q. As applied to water and pathogenic bacteria?

A. Yes, I have given considerable attention to that aspect of bacteriology.

Q. What work have you done in connection with bacteriology?

A. I have published about 60 or 70 papers on the subject of bacteriology, not exclusively in relation to drinking water but in relation to diseases generally.

Q. What diseases have you considered?

A. I have studied practically all the pathogenic bacteria that are accessible, except the plague bacillus.

Q. In considering the more suitable method in determin-
11926 ing the sanitary condition of water on what have you based your opinion?

A. In considering the sanitary condition of a water I have taken it for granted that the most important indication would be the presence of fecal matter because the typhoid bacillus, the bacillus of dysentery, the bacillus of Asiatic cholera and the bacteria of all various diarrhoeal diseases, are contained in relatively large numbers in the feces, in the discharges during,

and perhaps some time after these diseases, and hence any test that would indicate the relative number of fecal bacteria would bring us as near to the exact determination of the sanitary condition of the water as we could get. In the study of the fecal bacteria there is one group of bacteria which is present not only in the human feces in large numbers but also in the feces of domestic animals, of the warm blooded animals, and this group of bacilli is very closely related to and probably a progenitor of the typhoid bacillus, and any means of revealing the relative numbers of this particular bacillus, the bacillus coli communis and its various varieties, I inferred would enable us to judge as accurately as we can without being able to actually isolate the typhoid bacillus itself. It would enable us to judge as accurately as possible of the sanitary quality of the water
11927 with reference to fecal pollution.

Q. What are the characteristics of water that in your opinion afford the most convincing evidence as to the possibility of such water being infected with typhoid bacilli?

A. In view of the fact that our methods are still unsatisfactory in the isolation of the typhoid bacillus, at least not practicable on a large scale, the colon bacillus affords us the best indication of the possible presence of the typhoid bacillus.

Q. What is the colon bacillus?

A. The colon bacillus is a bacillus which is a parasite of the mucous membrane of man and the higher mammals. It is probably adapted to live on the mucous membrane more perfectly than any of the other bacteria that we are able to handle or study.

Q. Will you differentiate between the colon bacillus and the typhoid bacillus?

A. The colon bacillus and the typhoid bacillus have so many characters in common that for years before certain tests were brought out they were confused and this can be easily traced in the medical literature of the subject. In fact, when I was at Washington I sent to one of the most prominent medical schools of the country for a specimen of the typhoid bacillus and I received a colon bacillus in return. The method I
11928 devised enabled me at once to tell the difference. For at least a good many years these two bacilli were confounded

because they were so closely allied in their biological characters. But there are certain tests that enable us to distinguish them now without any difficulty.

Q. How does the longevity of the typhoid bacillus compare with the longevity of the bacillus coli communis?

A. The typhoid bacillus is probably more perishable than the colon bacillus under a variety of conditions. The colon bacillus is a more vigorous organism than the more highly parasitic typhoid.

Q. What tests do you regard as the most useful for determining the presence and relative abundance of the coli?

A. There are a number of tests that can be applied to determine the presence; by using agar plates which enable us to determine whether certain acid-forming bacteria are present. But this method is not a final method, and we have to examine such acid-producing colonies subsequently to determine their nature, but the method which perhaps leads us more directly to the quantitative determination of bacillus coli is the fermentation test.

Q. Will you describe those tests?

A. The fermentation test is one from which we are able
11929 to distinguish the colon from the typhoid bacillus and
it is based upon the fact that the typhoid bacillus does not produce gas in culture media, such as beef broth, to which a certain quantity of dextrose has been added. The colon bacillus produces a certain amount of gas in this culture fluid in the fermentation tube, and this amount of gas consists quite invariably of a certain per cent of two gases, hydrogen and carbon dioxide. This fermentation test is perhaps the most satisfactory of those we have for determining rapidly and promptly, and within certain narrow limits of error the presence of colon bacillus in any organic fluid or any water.

Q. By whom were those tests devised and when?

A. The production of gas was determined as far back as 1885, by the discoverer of the bacillus, by Escherich, and it was in 1889 that I first came upon the idea of using the fermentation tube as a ready method of identifying certain pathogenic bacteria, and it occurred to me that the same method could be used for identifying the colon bacillus after I had found out that the colon bacillus acts like the pathogenic bacteria in the fermentation tube. That was in 1889.

Q. Have those tests devised by you been used extensively for colon determinations?

A. The fermentation test, with the fermentation tube, is
11930 used universally in this country for the recognition of
this species. It has not been used so extensively in Europe in the bacterial tests for fecal pollution because I think they are simply so far somewhat behind us in the application of these methods.

Q. Do you know whether it has been used as a test for the efficiency of filters anywhere?

A. It is used as the chief test by the Massachusetts State Board of Health in their filtration experiments.

Q. When was it that you first introduced this test, Professor?

A. I first published the method in the report of the State Board of Health for 1891, I think, of New York, and it was extensively employed by the engineer, Mr. Brown, and his assistants in 1891 and 1892 on the Hudson River for determining the relative fecal pollution of the water.

Q. Have the results of other investigators given general confirmatory evidence as to the value of this test as a criterion of the purity of water?

A. I think they have.

Q. In what instances?

A. I can not specify instances but I am under the impression that it is always used at the present time.

11931 Q. Is this in your opinion a satisfactory method for
determining the purity of a water supply?

A. It is the best that we have at the present time, and probably will not be superceded because there is no indication at present that we are any nearer to a direct determination of the typhoid bacillus than we were perhaps ten years ago.

Q. Is this method applicable to the problem of the self purification of streams?

A. It seems to me it is, if by the self-purification you mean the sanitary purification of a water for drinking purposes.

Q. Will you please explain in what way the method can be used?

A. Simply by determining the number of colon bacilli in a given quantity of water. Do you wish me to go into the technique?

Q. Yes.

A. If we take a small quantity of water, say 1 cc., and add it in fractions of 1-10 cc. to a number of fermentation tubes, say 10, and place these in a thermostat where only the colon bacillus and the related pathogenic bacteria can multiply and where the miscellaneous water bacteria are suppressed, then, if after 24 or 48 hours, in the fermentation tube, we have a certain per cent of gas, say in 5 out of 10 tubes, we can infer that
in the cubic centimeter of water added there were 5
11932 colon bacilli. The test is made more accurate by reducing the amount of water that is placed into each
tube. This, of course, must be done, when the relative pollution is very high and where the number of colon bacilli are very great, and in those instances the smaller the quantity of water used the more accurate the determination will be, because if we use a large quantity of water we may have two or three or a larger number of colon bacilli added to each tube, in which case the method fails to give quantitative results.

Q. What is the validity in your opinion in using a cubic centimeter of water and tenths, hundredths and thousandths of a cubic centimeter of water in making this test? I wish you would explain that answer in full, Professor.

A. If we had relatively pure water and should add a cubic centimeter of water to each of a number of tubes (10) and only a certain percentage of those tubes (50-60 per cent or 5 or 6 tubes) would show gas production we should infer that in the 10 cubic centimeters of water there would only be 5 or 6 colon bacilli, consequently there would not be a colon bacillus in each cubic centimeter of water. If we take a water which is much more highly polluted and we obtain a gas test with colon bacilli
in every tube our test may be inaccurate in that we may
11933 have added several colon bacilli to each tube. Then, by
taking smaller quantities of water, by taking .1 of a cc. of water for each tube, and we only have a fraction of the tubes

showing gas production, our test then becomes accurate. (If, in taking 1-10 cc. of water all our tubes still show gas production then it is necessary for us to use a still greater dilution or a smaller quantity of water in order that only a fraction of the number of tubes to which water is added show the colon bacillus.)

This is based on the old dilution method that was introduced some 20 or 25 years ago by Buchner of Munich, I think, in separating bacteria before the plate method came into use. And, it is a fairly accurate and satisfactory method of determining the number of certain classes of bacteria, as the colon bacillus, in a given quantity of water, provided we use water in sufficiently small doses so that the possible error of adding more than one bacillus to each tube is eliminated.

Q. What do you understand is meant by the bacterial self-purification of streams?

A. It consists in a reduction in the number of bacteria in a stream which reduction is not due to an increase in the lower strata of the water, that is to say, not due simply to an imperfect or perfect sedimentation, but to a complete disappearance (or destruction) of the bacteria from the water
11934 under examination.

Q. Do you know of any established principles of bacteriology and sanitary science that determine how far a stream can flow before purification is effected?

A. I do not know of any general principles that are involved, but I think each stream has certain special local conditions that need be looked into, which conditions depend on a variety of factors that vary from stream to stream, and what might be true for one stream might not necessarily be true for another.

Q. Then, each stream is an individual problem and should be considered separately and independently in arriving at a conclusion as to the self-purification from a bacterial standpoint?

A. I think each stream under consideration must be investigated by itself.

Q. Do you know of any case where the question of self-purification has been studied where the conditions as to distance and time are at all comparable with those prevailing in the Illinois River between Chicago and Grafton, a distance of 350 miles?

A. I do not recall any investigations of a similar problem extending over such a distance.

Q. Is the colon test in your opinion applicable to such a problem as that presented in the Illinois River?

11935 A. I think so.

Q. Do you know of any instance where a stream becomes practically free from colon bacilli in flowing through a country where no additional contamination from this organism occurs?

A. I believe that has been worked out by Mr. Weston in the Mississippi River, below New Orleans. I think there the colon bacillus disappears completely and no additional sewage enters.

Q. The failure to find the colon bacillus at New Orleans would lead you to what conclusion in regard to the water at New Orleans and its purification?

A. It would lead me to think that all other bacteria that are closely related to the colon bacillus, such as the typhoid and dysentery bacilli and the various modifications, the paracolon and para-typhoid had also disappeared.

Q. Will you explain in what way the life history of the colon bacillus sheds light upon the life of the typhoid bacillus?

A. The colon bacillus as stated a few moments ago is very closely related, biologically, to the typhoid bacillus, so closely that up to within a certain number of years the two were confused by many prominent bacteriologists, but with the 11936 introduction of additional tests the typhoid bacillus can now be usually recognized, but it is so closely related to the colon that its growth on the various culture media can scarcely be distinguished from that of the colon bacillus. Its growth in bouillon is very much like that of the colon. The growth of the typhoid on gelatine is very much like that of the colon bacillus. Its growth on potato is very much the same. These are the common media we use in the differentiation of bacteria. It is only when we come to certain chemical tests that the divergence begins. The typhoid bacillus does not produce indol, which means that it does not split up certain nitrogeneous substances

in the way that the colon bacillus does. The typhoid does not ferment certain sugars that the colon does, and this difference I have generally regarded as being due to a loss of function of the typhoid as it becomes more and more parasitic and this loss of function is expressed by its loss of power to ferment these sugars and to produce indol. There are thus very few differences between the typhoid and the colon bacillus, and we are justified, I think, in inferring that whatever changes the colon undergoes are undergone in nature outside of the human body also by the typhoid. Whatever degenerative changes the colon undergoes are also undergone by the typhoid. But per-
11937 haps more rapidly under certain conditions because the typhoid is more parasitic. It has probably lost certain defensive properties, that is to say as a parasite it becomes more adapted to the human body and less adapted to life outside of the human body, and that the reduced power to live will also favor the increased destruction of the typhoid bacillus in nature, a destruction which we generally assume is much more rapid than that of the more vigorous intestinal colon bacillus.

Q. Does the typhoid bacilli multiply and increase in nature that is in ordinary water?

A. It does not. Not unless we were careless and added enough culture material to give the water a temporary nutrient value which would only be so very temporarily.

Q. Will a typhoid bacillus grow in milk?

A. It will grow rapidly in milk, but before the milk becomes very acid. If other bacteria are growing in milk, the acid-acidifying bacilli for instance, then the typhoid would become promptly checked because of the increasing acidity of the milk. But generally speaking the typhoid bacillus does not increase and grow in conditions outside of the human body excepting possibly in milk under favorable conditions.

11938 Q. Do you know of any other bacteria except the colon whose life in water is more likely to furnish an index as to the life of the typhoid bacillus?

A. I know of no other group of bacilli but the colon.

Q. Have you examined the data introduced by Professor Jordan in this case relative to the abundance of the colon bacillus in the waters of the drainage canal and upper Illinois River?

A. I have.

Q. This data was colon determination for 1901, made by Professor Jordan at the laboratories at Peoria, Grafton and St. Louis and introduced in evidence in this case?

A. I have examined those figures.

Q. Are you familiar with the results obtained by him upon the colon contents of the Illinois River at its mouth and of the Mississippi and Missouri Rivers?

A. I made a particularly careful examination of his tables.

Q. What would you infer from this data assuming the method of examination to have been accurate and the results to have been reported exactly?

A. I should assume that the colon bacilli had very largely disappeared in their passage down the Illinois River and that
the colon content of the Illinois River at Grafton is
11939 therefore less than that of the Missouri and the Missis-
sippi Rivers or at least about the same. That is to say, the colon content of the Illinois at Grafton is not to any material degree superior to that of the tributaries of the Illinois River, and it is on the whole less than the colon content of the Mississippi River and the Missouri River according to these tests.

Q. Interpreting the colon determinations as to pollution, what conclusion would you draw as to the comparative pollutions of the Illinois River, the Mississippi River and the Missouri River at their mouths as indicated by these colon determinations?

A. It would seem that the condition of the water at the mouth of the Illinois River was certainly not inferior, if not superior to that of the Mississippi River and the Missouri River, at these points, as I read the testimony in these tables.

Q. On the whole from the colon determinations would you conclude that the Missouri River was more or less polluted than the Illinois or Mississippi?

MR. CORUM: I object to the question as immaterial.

A. The Missouri river is on the whole more polluted than the Illinois River. According to these figures there is not

11940 very much difference but the benefit of the doubt rests with the Illinois River without any question. Basing myself upon the colon tests as I certainly should in all such examinations I should make the table speak for itself.

Q. So far as these colon determinations go then and so far as the inference drawn from the colon contents of streams are warranted, what do those results show as to the sanitary condition of the Illinois River at its mouth as compared with the Mississippi River above Grafton and the Missouri River at Ft. Bellefontaine?

A. I should say that the Illinois River was superior in its sanitary quality to either of the other rivers, the Mississippi and Missouri.

Q. Assuming that the typhoid bacilli introduced into the drainage canal died off with the same rapidity as the colon bacilli what would you infer from the colon content of the Illinois River at Averyville and at Grafton as compared with the colon content of the various streams tributary to the Illinois?

MR. CORUM: I object to the question for the reason that the tables speak for themselves, and it is not necessary for this witness to state them.

11941 MR. TODD: In reply will state that counsel for defendant has no assurance that the Supreme Court of the United States will thoroughly understand the significance of colon determinations, and the purpose of the question is to elucidate the colon determinations for the enlightenment of the Supreme Court.

A. It seems to me that in carefully studying the colon results obtained by Professor Jordan that some of the tributaries are slightly better than the Illinois at that point and some are worse.

Q. Assuming that the typhoid bacilli were introduced into the drainage canal and that they died off with the same rapidity as the colon bacilli, what conclusion would you draw in regard to the typhoid bacillus, based upon the colon determinations at Averyville, as evidenced by Professor Jordan's tables as to their dying off?

A. According to these tables there is an enormous destruction of colon bacilli down to Averyville in the Illinois River, and basing myself upon these I should say that a similar if not greater destruction of the typhoid bacilli had taken place down to that point.

11942 Q. Do these colon determinations made by Professor Jordan taken as a whole warrant one in expressing an opinion as to the probability of the virulent typhoid bacilli passing from the sewers of Chicago to the mouth of the Illinois River at Grafton?

A. It seems to me that if virulent typhoid bacilli should actually pass from Chicago to the mouth of the Illinois River that it would be according to conditions and laws that we know nothing about, but that basing ourselves upon the close relationship of the colon to the typhoid bacillus and to this entire group of disease germs we are at present justified in saying that the virulent typhoid bacilli would be very largely destroyed at that point.

Q. Assuming that there should be no other source of contamination or infection between Chicago and Grafton except that which gets into the Illinois River from the sewers of Chicago, do these colon determinations made by Professor Jordan warrant one in expressing an opinion as to the probability of virulent typhoid fever germs passing through the sewers of Chicago to the mouth of the Illinois River? Assuming the absence of contamination as aforesaid at intermediate points?

11943 A. It would seem to me that the disappearance of the colon bacilli indicates that excluding a large amount of sewage which enters below Chicago the typhoid bacillus would probably be entirely eliminated during that long course from Chicago to the mouth of the Illinois River of three hundred and fifty odd miles.

Q. Is there any bacteriological evidence that in your opinion affords you more suitable indications than the one in question, to-wit, the colon determinations?

A. I know of none.

Q. Is there any particular method in your opinion by which it is possible to demonstrate that the typhoid bacillus actually does pass from Chicago to St. Louis?

A. There is no direct bacteriological method by which that could be done and if it were done it would be largely a matter of accident. As I say, if the typhoid bacillus were discovered it would be rather an accidental discovery because of the difficulty inherent in the isolation of the typhoid bacillus in the presence of so many other bacteria.

Q. Then, if a typhoid bacillus should be discovered in the water supply or the water of the Mississippi River at St. Louis is there any way of tracing it to the city of Chicago, assuming that other points along the rivers, the Mississippi, the Illinois and the Missouri emptied infection into those rivers?

11944 A. It would be utterly impossible to identify the source of such typhoid bacillus. The presumption would be that the typhoid bacillus would come from the nearest sewage-discharging town.

Q. Then the question as to whether the typhoid bacillus can pass from Chicago to St. Louis is one of probability only?

A. It seems to me wholly so and my opinion is based upon the index of the disappearance of the bacillus which is so closely related to it that for many years it had been mistaken for it. That is the colon bacillus.

Q. Assuming that the life of the colon bacillus in water affords the nearest approach to determining the life of the typhoid bacillus under similar conditions is it true that the colon determinations made by Professor Jordan that you have just referred to furnishes as direct evidence as can be obtained that the life of the typhoid bacillus in the Illinois River water is too brief to permit of passage down this river as far as St. Louis?

A. It seems to me that considering the enormous destruction of the colon bacillus from Chicago down to Averyville, the very great influx of sewage at Peoria, that the presump-
11945 tive evidence is very strong that the typhoid bacillus
from Chicago would not reach St. Louis because it is highly probable that the colon bacilli at the mouth of the Illinois River are probably those that have been introduced further down the stream, say at Peoria and other sewage-discharging places.

Q. What effect would polluted water have upon the life of the typhoid germ?

A. That is a very difficult question to answer categorically. It would depend upon the temperature, probably, and depend upon the amount of pollution. It is possible and probable that if the pollution is very great that these pathogenic bacilli under favorable temperature might begin to multiply for a very short period of time and in the course of this multiplication would become destroyed, because they thereby would render themselves vulnerable to destruction. That is to say it is possible that the sewage might afford enough stimulus for these pathogenic bacteria to induce them to multiply and then become destroyed. Of course if that is so, sewage would be extremely dangerous just at that time, but if we pass beyond that period it would become less dangerous because of the increased destruction of these pathogenic bacteria.

Q. Will typhoid germs live as long in pure water as in sewage polluted water?

11946 A. I have no precise data upon that subject but it would seem that some of the epidemics that have occurred in the past have been due to relatively pure water which accidentally carried the typhoid bacillus a short distance or a relatively short distance, such as the epidemics at Ithaca, New York, and at Plymouth, Pennsylvania. Such carriage, of course, is greatly favored by low temperatures, which inhibit the multiplication of bacteria, and this inhibition probably preserves the typhoid bacilli for some longer time than it would if they were attempting to multiply in the water that contained a certain amount of nutrient matter as that in polluted water. Hence, it is quite possible that sewage polluted water may under certain conditions be more destructive than pure water at certain times and within certain limits.

Q. Professor, assuming that no typhoid germs should enter the drainage canal but that the pollution from the sewers of Chicago mingled with the waters of Lake Michigan and thence emptied into the Desplaines and Illinois river would such a mixture of sewage and water add to the longevity of the typhoid germs which should enter the river at the point of Peoria, taking into consideration the chemical changes that have taken
11947 place in the water and also the amount of pollution that is added at Peoria?

A. The history of typhoid epidemics in the past has shown that the typhoid bacili can be carried by relative pure water.

Whether the polluted water is a hindrance to the destruction or favors it is a question which I think has been only recently approached experimentally by Professor Jordan and I do not feel quite competent to make any statement as to that. If I did, it would be merely in the form of an opinion.

Q. If it were true that a relation obtained between typhoid fever in Chicago and typhoid fever in St. Louis, would you not expect this relationship to be shown in an indication between typhoid rates in Chicago and in St. Louis?

A. I should think that the two curves of typhoid would be very much alike and the St. Louis curve would be slightly retarded in time.

Q. I call your attention to two charts entitled "Deaths from typhoid fever as reported in Chicago and St. Louis Official Health Reports. The deaths in St. Louis are platted one month in advance, i. e., February deaths are platted as of January, W. P. Mason," which chart was offered in evidence by Professor Mason, and shows the monthly death rate from typhoid fever for the years 1900, 1901, 1902 and 1903. Assuming that the facts from which those charts are made to be true what is your 11948 opinion as to whether or not there is any relationship or connection between the typhoid rates in Chicago and in St. Louis, as evidenced by these charts?

A. I am unable to see any direct connection between the typhoid curve of Chicago and that of St. Louis from these diagrams. The upward curve in the St. Louis charts is one which seems to correspond with the usual summer and fall increase in typhoid which is manifested throughout the civilized world, but I fail to see any direct relation between the two.

Q. Is there a rise in typhoid in the fall in other cities in this country aside from Chicago and St. Louis?

A. I think it is generally conceded that typhoid fever in our hospitals grows in August, September and October, each year. That is the time when cases are looked for.

Q. Have you examined the typhoid statistics which have been introduced in evidence in this case showing the typhoid fever upon the three watersheds of the Illinois, Mississippi and Missouri rivers, the typhoid fever conditions in St. Louis and the typhoid fever conditions in Chicago?

A. I have looked over the figures as presented to me.

Q. Knowing what you do regarding the watersheds of the
Mississippi and the Missouri rivers and the number of
11949 deaths from typhoid fever occurring in the cities draining
into those rivers would in your opinion the water of
the Mississippi River at the chain of rocks be suitable for a public water supply without filtration, supposing that the sewage of Chicago were entirely eliminated?

A. From the colon determinations of the Mississippi River at that point I should hardly consider the river water a satisfactory water for public use without previous preparation or previous filtration.

Q. Knowing the typhoid condition in the city of St. Louis. and assuming that the same was due to water supply, where would you look for the source of infection, to points as far away as the city of Chicago or to points nearer than the city of Chicago?

A. I should first look to the points nearer by all means, and if those could be eliminated then I think I should look to the city of Chicago.

Q. From a consideration of the typhoid fever upon the water shed tributary to St. Louis would it be reasonable to eliminate the points near at hand in looking for the source or cause of infection in St. Louis, assuming that it came from a water supply?

11950 A. I think it would be highly important to locate the
nearest sources first because of the vulnerability of the
typhoid bacillus in water. The further the area of infection the less the danger of the typhoid bacilli reaching the water supply. A few bacilli discharged into a stream near by would be much more dangerous than a large number discharged at a much greater distance.

Q. Are you acquainted with the experiment on the viability of a typhoid bacillus conducted in the water of the drainage canal, Lake Michigan, the Chicago River and the Illinois River by Professors Jordan, Zeit and Russell?

A. I am acquainted with them. I have heard of them.

Q. Professor, basing your knowledge upon the conditions as they exist, what is your opinion as to whether typhoid fever germs entering the drainage canal could survive the journey of 357 miles to St. Louis, assuming that the mean rate of flow is about 18 1-2 days from Chicago to St. Louis, and become a danger and a menace to the inhabitants of the city of St. Louis and the State of Missouri, taking the water of the Mississippi River in its raw state?

A. The results of Professors Jordan, Zeit and Russell have introduced a new factor into the problem in that they 11951 have defined for us, perhaps for the first time, the viability of the typhoid bacillus in polluted water. Before that time of course the results were not very definite unless we took into account the viability of the colon bacillus, but now it seems that the typhoid bacillus is fairly rapidly destroyed in polluted water, more rapidly than we have believed, and that rapidity of destruction would indicate what I suggested a moment ago, that possibly the typhoid bacillus is stimulated enough to multiply in sewage polluted water to be promptly destroyed whereas in water which contains very little organic matter its life is preserved a longer time because of a condition of latency and absence of that stimulation to multiply which I assume is very destructive to bacteria in general. If these experiments are correct, and I feel quite prepared to take the risk of accepting all of those experiments of Professors Jordan and the other gentlemen—if they are correct—then I think it would be physically impossible for the typhoid bacillus to reach St. Louis, starting at Chicago.

Q. Have you made a special study of the so-called germ tests?

A. I have for twenty years.

Q. Have you made any study of typhoid fever and ma- 11952 larial fever from the standpoint of a bacteriologist and clinician?

A. I have made very extensive studies in the agglutination tests for typhoid which is one of our newest and most reliable tests in the diagnosis of typhoid fever, and I have for a number of years studied conditions that favor malaria in the State of Massachusetts.

Q. In connection with such study as you have detailed, have you taken up the question of the proper diagnosis of the fevers, of the kinds known as typhoid and malaria?

A. We have in our state. The diagnosis for typhoid and malaria is made free by the state, at the State Laboratory, and any physician can send any specimens of blood, prepared in certain ways, for diagnosis, and we advise all physicians to use these methods of diagnosis in order to increase the accuracy of their diagnostic work.

Q. How about malaria?

A. Malaria can, as a rule, be recognized by the examination of the blood by a microscope. Now and then this is impossible, but it is usually impossible where the cases are chronic and where the patients have had repeated attacks of malaria. As a rule the diagnosis by means of the microscope is successful.

Q. Is malaria a fatal disease north of the tropics?

A. It is not so in our state. There were only two cases
11953 which I recall during my eight years of observations in
Massachusetts. There may have been others but those two I recall because I was investigating cases at the time. One was that of an old miser who lived by himself. He had been thoroughly neglected for some time and died without any medical care, and the other was the case of a girl who died in convulsions, I think, and the blood sent to me after death showed malaria parasites, although the blood examination after death is not so satisfactory as that in life. Those are the only two cases I recall in the state of Massachusetts.

Q. Are remittent, intermittent, typho-malaria, congestive and simple continued fevers distinct types of disease and so recognized by bacteriologists and clinicians?

A. It is very rare that typhoid fever and malarial fever co-exist and these cases are so rare as generally to go on record in medical publications. These terms and especially the term remittent fever figured quite extensively in medical publications about twenty years ago, but since that time it has almost wholly disappeared because of the more accurate means of diagnosis.

Q. Is it generally recognized by bacteriologists and clinicians that classifying typhoid fever in one column and intermittent, remittent and typho-malaria, congestive and simple con-

tinued fevers in another column in boards of health re-
11954 ports of cities is an improper classification from a scientific standpoint as affording a true indication of the mortality from typhoid fever and malarial fever?

A. It is at least a very indefinite form of classification because we would assume that under the terms, remittent and simple continued and typho-malarial we would have either one or the other disease, either typhoid or malaria or, a mixture of the two, which rarely occurs.

Q. Where such classifications occur showing almost an equal number of cases under the typho-malarial group with those in the typhoid column, would such a classification furnish a correct idea of the prevalence of typhoid fever in a given community?

A. I do not think that it would. The classification as you have mentioned it would indicate that the best means of diagnosis were not resorted to in determining the nature of those diseases.

ADJOURNED until 1:30 same day.

1:30 P. M., Monday, March 14, 1904.

11955 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

THEOBALD SMITH

resumed the stand for cross examination by Mr. Corum, and testified as follows:

Q. Professor, did I understand you to state that you had made an examination of the purification of the waters of the Potomac River?

A. No, not that, it was an examination of the tap water of the Potamac River through an entire year. It was one of the earliest observations made on the application of bacteriology to drinking water. It was in 1886 that that work was done. At that time I studied the variations in the bacterial life of the Potomac River water.

Q. Then you did not study the question of the purification of the stream?

A. No sir, that question did not come up excepting in this way. The relative pollution was entirely dependent upon the turbidity and it became easy to tell by looking at the 11956 water in the test tube after a little experience how many germs there were from the depth of the turbidity.

Q. Now, at what points did you make this examination in reference to the turbidity of the stream?

A. In Washington the water was drawn from one of the taps in one of my laboratories.

Q. Now, at any other points than that?

A. No.

Q. Now, what examination did you make of the water of the Hudson River?

A. The water was collected during the month of August from Schenectedav to some distance below Albany, and the water was collected according to the usual method and plated, and the bacterial count determined over this territory from day to day, and the year after that the method of the fermentation tube was extensively employed, I think it was in 1892, for the purpose of studying sedimentation and the destruction of bacteria in the Hudson River between the points mentioned.

Q. Did you investigate the purification of the Hudson River?

A. Yes. Specimens of water were collected, I think, about 18 miles below Albany, and the number of bacteria in that 11957 space of 18 miles had fallen from an average of about 10,000 to 300 or 400.

Q. You did not determine whether or not the Hudson River had purified itself at any point, did you Professor?

A. Well, that was determined to this extent that the number of bacteria dropped from an average of 10,000 per cc. to about 300 per cubic centimeter within this distance of about 18 miles, I think. I do not remember the exact number of miles.

Q. Now, was there any point where the typhoid could certainly be lacking or wanting?

A. I do not quite understand the question.

Q. Now, did you examine the waters of that river at any point where the typhoid bacillus was lacking?

A. Well, the typhoid bacillus was not looked for specifically. Simply to determine the change in the bacterial content and the object was to determine the actual sanitary or unsanitary condition of the water owing to the fact that Albany was taking the sewage polluted water and had had a high typhoid rate.

Q. Well, from your investigations could you recommend the water as being free from typhoid?

A. Well, that was not exactly the object at that time,
11958 and I should want the colon determinations of the water
18 miles below Albany before I could venture to say that it was safe for drinking water.

Q. Now, you stated that the purification of streams was local and depended upon each particular stream?

A. That the conditions under which the purification takes place would vary more or less from stream to stream.

Q. Now, have you made any examination of the waters of the Illinois River?

A. None personally.

Q. I understand you made no examination of the waters either before or since the opening of the drainage canal?

A. None.

Q. You spoke this morning of the fermentation test. Is not that test frequently rendered inaccurate by the more rapid multiplication in the tube of other saprophytic forms, such as the streptococci?

A. No. The advantages result, from the fact that the colon bacillus is an organism that multiplies very rapidly at high-temperature and when these tubes are inoculated they are put at once into an incubator and that suppresses the bulk of the water bacteria, so that the test is not injured by the presence of
these water bacteria, but if there are a large number of
11959 colon bacilli it becomes necessary to use minute quanti-
ties of water as I mentioned this morning, as Professor Jordan has done in using quantities as low as .001 cc.

Q. The colon bacilli were found at New Orleans when large amounts of water were examined?

A. Can you tell me what amount was examined?

The Commissioner: He asked you the question.

The Witness. Was the colon bacillus found?

Mr. Corum: Yes.

A. I understand it was not found even with the use of a large amount of water, although I am prepared to be corrected on that point by printed evidence.

Q. Professor, you spoke in the direct examination of the complete removal of the colon bacillus at New Orleans. When you consider the enormous dilution at this point do you not think that it was this factor rather than any other that made its detection impossible?

A. The difficulty of finding the colon bacillus in 300 cc. of water practically means the same thing as purification from a sanitary point of view. That number of colon bacilli means an exceedingly small percentage of colon bacilli as compared with other pure spring and surface waters, and whether the water had been diluted or whether the river had been
11960 purified the result practically is the same.

Q. I understand in your opinion the typhoid germ does not increase in ordinary water?

A. It does not, I should say.

Q. But in water containing nutritive matter as sewage it does increase in short periods does it not?

A. If the temperature is high enough. The temperature must be at least probably 70 degrees Fahrenheit, and the nutrient matter must not be mixed with poisonous substances, like factory waste or acids or other injurious agents, then a slight multiplication might take place.

Q. Do you not find typhoid bacilli in water that is grossly polluted?

A. Typhoid bacilli have been repeatedly found in the intestinal tract of human beings and I think in three or four instances it has been found in water which was suspected of conveying typhoid. I think these instances occurred in Germany where the discovery of the typhoid fever bacillus was made by a bacteriologist so competent that we can not doubt his authority.

Q. Have you made any examination as to the amount of sewage that is emptied into the Illinois River at Peoria?

A. None further than to read the records of the bacterial
11961 count as made by Professor Jordan for 1900 and 1901.

Q. And from that source of information I believe you stated that you would be of the opinion that much of the typhoid germs if found at the chain of rocks in the city of St. Louis came from Peoria and other cities instead of Chicago?

A. Rather than farther up.

Q. Now, assuming that the sewage of Peoria was infected with these germs and that the Chicago drainage canal being turned into the Illinois River would not the fact that this canal was made a tributary to the Illinois River, hasten the flow from Peoria to St. Louis?

A. Do you mean increase the velocity?

A. Yes?

Mr. Todd: I object to the question on the ground that it is not proper cross examination as it embraces the question of engineering and hydraulics, a subject not touched upon by this witness who has not qualified as to knowing the facts in regard to the hydraulic condition that obtained along the Illinois River.

A. Of course it is impossible for me to say to what extent the current would be increased from Peoria down on account of such increase of the volume from above. This increase 11962 in volume might be caused by any freshet or any increase in the rainfall.

Q. It might also be due to the flowing of the waters of any tributary of the Illinois River into the river would it not?

A. It might be. The current might be increased by any increase in volume.

Q. Then it follows as a logical sequence that it would carry the typhoid from Peoria down to St. Louis in a shorter space of time does it not?

A. It does logically. It also follows there would be a great deal more dilution of the Peoria sewage.

Q. Now, Professor, based on the knowledge which you have with reference to this subject are you prepared to state that the coli bacilli are not present at Grafton?

A. I am not prepared to state that because it is given here in the table that it is present at Grafton and we should expect the colon bacilli to be present in almost any surface water. It depends upon the number of colon bacilli per unit of volume upon which our judgment of the sanitary quality of a water is based.

Q. Your table also shows that it is present at the city of St. Louis does it not?

A. It does.

Q. Have you anything in the table or any other source of information that indicates the source from which this
11963 colon bacillus emanates?

A. The original source?

Q. Yes.

A. It would be of course difficult to distinguish a colon bacillus that came from the intestinal tract of higher animals from the colon bacillus that came from the intestinal tract of man, but so far as we know the colon bacillus is essentially a parasite of the intestinal tract of man and higher mammals and that the colon bacillus responding to the temperature test does come from fecal contamination, either directly or through the survival of a certain number of days in a water.

Q. But you are not prepared to state here that this colon bacillus emanates from the sewage of Chicago or some other intermediate point between here and St. Louis?

A. The colon bacilli discovered at St. Louis?

Q. Yes?

A. The evidence upon which I am basing my statement, and I think it is perfectly reliable, shows that the colon bacilli largely disappear at Averyville or before they reach this second source of contamination,—the group of towns at Peoria,—consequently it would be inferred that the colon bacilli which are at St. Louis are largely recruited from the places further down and that the colon bacilli which have almost disappeared
11964 at Averyville would have completely disapeared at the mouth of the Illinois River.

Mr. Todd: I do not care to ask any questions on re-direct examination.

THEOBALD SMITH.

11965
VICTOR C. VAUGHAN

a witness called on behalf of the defendants, after being duly sworn by the Commissioner, testified as folows:

Direct Examination

By Mr. Todd:

Q. What is your name?

A. Victor C. Vaughan.

Q. What is your business?

A. I am a physician and a teacher.

Q. Where do you live?

A. I live at Ann Arbor, Michigan.

Q. What institution of learning?

A. I am connected with the University of Michigan.

Q. From what institute did you graduate?

A. The University of Michigan.

Q. When did you graduate there?

A. I took a Master's degree there in 1875, Doctor of Philosophy in 1876 and Doctor of Medicine in 1878.

Q. After graduating from the University of Michigan in 1878, in medicine, what did you do?

A. I taught in the University of Michigan and practiced 11966 medicine. I have also studied abroad to some extent.

Q. What institutions abroad have you attended?

A. I studied with Robert Koch in the University of Berlin.

Q. How long were you there?

A. Well, I have been there two or three times. The longest time I was there was for about three months in 1888.

Q. Have you been connected with the University of Michigan ever since?

A. I have been teaching in the University of Michigan since 1876.

Q. What branch of science do you teach?

A. I teach hygiene and physiological chemistry.

Q. Have you made a study of the so called germ diseases?

A. I have. As a teacher of hygiene it would be necessary for me to study the germ diseases.

Q. Have you had anything to do with the study of those diseases outside of the institution at Ann Arbor?

A. Yes, I have been a member of the Michigan State Board of Health. I am serving my third term now as a member of that board. I have been called upon frequently to examine into epidemics in the state and I served on the Government Commission and am still serving on the United States Government 11967 Commission for the study of typhoid fever.

Q. When did you begin your service for the United States Government?

A. I was enlisted in the Army June 9, 1898, and I think the Special Commission appointed to study typhoid fever was some time in August, 1898.

Q. Will you relate your experience in connection with the study of typhoid fever as it related to the army?

A. In August, 1898, after my return from Santiago, there was a commission appointed to investigate the causes and spread of typhoid fever in the camps of the United States. This commission consisted of the late Major Walter Reed, the late Major Shakespearre and myself, and we inspected the camps.

Q. Name them, Professor?

A. We went to camps Alger, Fernandino, Jacksonville, Huntsville, Alabama, Chickamagua, Georgia; Knoxville, Tenn.; Camp Meade, Pennsylvania, and the other members of the Commission went to Montauk. I did not. I was sick at the time. Those were the ones I went to.

Q. How many cases of typhoid fever came under your observation during this experience in the army?

A. Well, it would be hard to say. I think I must have 11968 seen several thousand cases of typhoid fever, four or five thousand probably.

Q. Have you had any other experience with typhoid fever besides that which you have related?

A. As a member of the commission I have been engaged practically ever since that time in writing up the statistics and studying the spread of typhoid fever and I have also been called upon frequently to investigate outbreaks of typhoid fever in different parts of the country, in Michigan and other states as well.

Q. Have you made a special study of the so-called germ diseases?

A. I have.

Q. Do these diseases caused by germs come within the scope of your study?

A. Yes sir.

Q. Have you made any special study upon typhoid fever or malarial fever from the standpoint of a bacteriologist and a clinician?

A. I have.

Q. In connection with such study as you have detailed have you taken up the question of the proper diagnosis of fevers, of the kind known as typhoid and malarial?

11969 A. I have.

Q. How extensively, Doctor?

A. Our Commission had charge of all the diagnoses that were made in the army camps after the appointment of the commission, that is we selected the men and put them to work and overlooked their work in the various camps in the United States.

Q. Have you had any experience in the diagnoses of these fevers either in the laboratory or at the bed side?

A. I have had experience both in the laboratory and at the bed side.

Q. What is typhoid fever and its clinical diagnosis?

A. Typhoid fever is an acute septecimia, due to infection with a specific germ known as bacillus typhosus.

Q. What is malarial fever and its clinical diagnosis?

A. Malarial fever is a disease due to infection with a malarial parasite of which there are at least three well known varieties.

Q. What is intermittent, remittent, typho-malarial, congestive and simple continued fever and their clinical diagnosis?

A. Most of the cases diagnosed under those different heads are forms of typhoid fever. Malaria is sometimes called remittent fever but the majority of the cases in this country
11970 that are diagnosed under those heads, especially in the
northern parts of the United States are really cases of typhoid fever.

Q. Are remittent, intermittent, typho-malaria, congestive and simple continued fevers distinct types of disease and so recognized by bacteriologists and clinicians?

A. They are not.

Q. What significance do you attach to those terms as applied to fever when they appear in vital statistics?

A. They almost invariably—there are some exceptions, but almost invariably they mean typhoid fever.

Q. Assuming that the number of deaths reported as occurring from typhoid fever in the city of St. Louis as evidenced by the annual report of the board of health of the city of St. Louis, Health Department, are as follows:

	1890	140
	1891	165
	1892	441
	1893	215
	1894	171
	1895	107
	1896	106
	1897	125
11971	1898	95
	1899	131
	1900	168
	1901	193
	1902	222
	1903	288

What is your opinion, based upon your knowledge of the different kinds of fever as to whether these reported deaths from typhoid fever in the city of St. Louis health reports correctly state the true typhoid conditions existing in the city of St. Louis for the years mentioned?

A. I dare say there were more deaths from typhoid fever than are reported here.

Q. Assuming further that the number of deaths reported in the same reports under the heading remittent, intermittent, typho-malarial, congestive and simple continued fevers is as follows:

1890	226
1891	296
1892	326
1893	284
1894	179

11972	1895	155
	1896	177
	1897	172
	1898	134
	1899	148
	1900	112
	1901	80
	1902	102
	1903	91

Do the number of deaths reported as occurring from the typhoid fever alone in the city of St. Louis properly represent in your opinion the total number of typhoid deaths actually occurring in the city for the period in question?

A. They do not.

Q. What reasons have you for stating that they do not?

A. My experience shows me that malaria is not a common disease in Missouri or in that section of the country. The disease itself is rare and death from the disease is exceedingly rare, so rare that practically it does not occur. You may ask me what I base that statement on. Missouri sent six regiments to the war in 1898. I have studied the records of all of these regiments and although in some of them many cases were 11973 diagnosed by the surgeon as malaria, more careful examination was instituted by our board showing that these were not malarial cases but they were cases of typhoid fever. One of these regiments remained, if I remember correctly—I can tell positively by looking at the records in Jefferson Barracks, practically a part of St. Louis, until July, 1898. While malaria was frequently reported by the medical officers in charge of these regiments, more careful examination showed that they were cases of typhoid fever. For instance the Sixth Missouri developed 286 cases of typhoid fever and had 19 deaths from typhoid fever. The sixth Missouri was stationed at Jefferson Barracks until early in August. I have not the exact date. It then went to Jacksonville, Florida, and there our board inspected the Sixth Missouri and studied the cases clinically, and bacteriologically. They were cases of typhoid fever and not cases of malaria.

Q. How many cases of malaria were recorded?

A. I can not tell you exactly now.

Q. That turned out to be typhoid?

A. I can not tell you from that regiment but I can tell you from some other regiment.

Q. I wish you would?

11974 A. Well, of 83 cases of so called malaria from the Fifth Maryland that were sent to the hospitals in Baltimore, 80 cases proved to be typhoid fever. I think that is just about right. It was about that per cent. I have not the figures exactly here. That is substantially correct.

Q. To what do you attribute the failure of these statistics assumed in the foregoing hypothetical question to properly disclose the number of typhoid fever deaths occurring in the city of St. Louis?

A. For the reasons just given that malaria is certainly a very rare disease in Missouri and death from malaria is much rarer, in this section of the United States.

Q. You are acquainted with the conditions in St. Louis are you not?

A. Very slightly. I can not say that I know very much about the local conditions existing in the city of St. Louis.

Q. In the State of Missouri?

A. Somewhat. I was born and reared in Missouri. I know something about it. I go back there nearly every year. I know something about the conditions existing in Missouri.

Q. Why is it that the doctors employ the terms, remittent, intermittent, typho-malaria, congestive and simple continued fevers to fevers that are recognized as being either typhoid or malaria? 11975

A. There are many reasons why doctors do this. In the first place typhoid fever in its earliest stages is often a remittent disease, that is it is a disease where fever exists for a few hours and then there is no fever. In its earliest stages it is a remittent disease. That is one reason why it is done. The second reason why it is done is that doctors really think they are dealing with malaria when they have typhoid fever, and I have no doubt the third reason that actuates doctors in using these terms is that they are less likely to frighten the patient and friends of the patients. It does not seem quite so dreadful a thing to have malarial fever as to have typhoid fever, and the fourth reason is that the means of accurately distinguishing between malarial and typhoid fever have been discovered only within recent years, and even now are not always in the hands of practicing physicians. These, I think, in sum and substance are the reasons why doctors so frequently use these terms remittent, intermittent, typho-malarial, congestive and simple continued fevers when actually they have typhoid fever to deal with.

Q. Do you know of any city in the country where the death rate from malarial fever alone is as high as in the city
11976 of St. Louis, as evidenced by the number of deaths as assumed in the hypothetical question under the heading intermittent, remittent, typho-malaria, congestive and simple continued fevers, occurring in the health reports of the Board of Health of the city of St. Louis?

A. I am sure there is no city in the United States where there are so many deaths from malaria fever as there reported. Of course there may be cities where the deaths reported are equal to those in St. Louis, but there are no cities where there are that many malarial deaths.

Q. What proportionate deaths in the column under the heading, remittent, intermittent, typho-malaria, congestive and simple continued fevers assumed in the foregoing hypothetical question as occurring in the city of St. Louis as evidenced by the report of the Board of Health in your opinion should be classed as typhoid?

A. I think 100 per cent. of them should be so reported. Now, of course, there may be a few of them that were not typhoid fever; they may have been something else.

Q. What proportion as malarial fever?

A. None.

Q. What do the mortality statistics of malaria show in
11977 cities where careful attention has been paid to malarial fevers in regard to the number of deaths occurring from malarial fever?

A. Well, there are practically no deaths from malaria in this country unless it is in New Orleans or some other extremely southern city. Of course, there may be two or three in a year in a large city. In Albany 5 cases were reported in the last year from malaria, but it is very doubtful that those were really malaria.

Q. Is it generally recognized by bacteriologists and clinicians that classifying typhoid fever in one column and intermittent, remittent, typho-malarial, congestive and simple continued fevers in another column in board of health reports of cities is an improper classification from a scientific standpoint as affording a true indication of the mortality from typhoid fever and malaria?

A. It certainly is.

Q. Assuming that the reports of the board of health of the city of St. Louis by the month from 1895 to 1903, inclusive, under the heading typhoid fever, which for the purpose of convenience is designated "A" in the table that follows and as remittent, intermittent, typho-malaria, congestive and simple continued fevers, for the sake of convenience designated as "B" in the table as follows, which table, prepared and sworn to by Professor Jordan, based upon said reports, is as fololws:

11978

ST. LOUIS.

	1895		1896		1897		1898		1899	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
Jan.	12	10	4	13	7	7	4	6	10	4
Feb.	3	7	4	10	9	5	6	10	7	8
Mar.	3	8	3	6	7	11	7	9	4	6
Apr.	7	7	4	11	4	13	6	8	5	6
May	6	9	9	10	7	8	2	8	2	12
June.	6	14	6	7	9	18	7	10	5	8
July.	9	8	13	23	10	17	9	13	9	18
Aug.	17	15	29	34	18	20	9	14	6	30
Sept.	9	32	13	27	17	31	14	18	16	28
Oct.	15	24	9	20	17	24	12	12	15	16
Nov.	13	8	7	14	15	13	7	13	32	8
Dec.	7	13	5	2	5	5	12	13	20	4

A—Typhoid fever.

B—Remittent, intermittent, typho-malarial, congestive and simple continued fever.

11979

ST. LOUIS.

	1900		1901		1902		1903	
	A.	B.	A.	B.	A.	B.	A.	B.
Jan.	19	6	8	5	14	5	15	4
Feb.	5	3	14	0	16	6	15	1
Mar.	16	9	11	4	11	9	20	4
Apr.	4	7	4	7	14	3	17	4
May.	4	7	8	7	11	8	15	8
June.	8	12	6	9	7	4	18	8
July	15	9	13	15	14	12	27	10
Aug.	20	20	31	5	26	7	37	10
Sept.	13	20	24	9	21	16	42	17
Oct.	30	9	32	11	32	17	29	17
Nov.	15	3	27	5	31	9	24	3
Dec.	19	7	20	3	25	6	31	5

A—Typhoid fever.

B—Remittent, Intermittent, typho-malarial, congestive and simple continued fever.

11980 Will you please state what construction you place upon this table as showing the relative mortality from typhoid fever and malarial fever in the city of St. Louis during the period covered by the foregoing table?

A. I think the total deaths there as reported from all of these cases more accurately give the number of deaths from typhoid fever.

Q. From a careful consideration of the tables which have just been assumed in the hypothetical question, what conclusion would you draw as to whether the outbreaks of typhoid fever in the city of St. Louis were of an epidemic during this period or the normal death rate due to local causes or otherwise?

A. Well, without knowing anything about the local conditions in St. Louis, simply as a student of epidemiology, and looking at the distribution of these diseases according to months I should say that the probabilities are that typhoid fever in St. Louis, with the possible exception of the year, 1892, was due to local causes rather than to any infection of the general water

supply. When there is an infection of the general water supply as a rule the outbreak of typhoid fever is explosive in character, that is there are a great number of cases which occur within a short time. They are not distributed along so evenly
11981 through the months. That is the rule. Of course there may be possible exceptions as to this. I do not know about the local conditions but when there are positive infections, (certain infections of the water supply) the outbreak of typhoid fever is of an explosive character as happened at Grand Forks, North Dakota, some years ago; Duluth, Minn., at Butler, Pennsylvania, recently; Plymouth, Pennsylvania, some years ago; Ithaca, New York, recently, and as now occurring at Watertown, New York. That is the general rule of epidemics due to the infection of the water supply.

Q. Assume that on April 1, 1895, the total number of wells in the city of St. Louis was 4846, and assume that in pursuance to an order of the board of health of the city of St. Louis, directing an examination of these wells, that the City Chemist, after an examination of 59 of these wells condemned them as being unsanitary, and assuming further that in August, 1895, upon a report of the city chemist condemning 7 more of the wells, the board of health of the city of St. Louis passed a resolution to the effect that the city chemist should make no further examination of the wells in question, and that since 1895 none of these wells have been condemned. What effect would the pres-
11982 ence of such wells of known pollution have in affecting the typhoid condition in a city such as St. Louis?

A. As I stated a moment ago these figures as given here showing the distribution of typhoid fever render it highly probable that the local conditions, such as infected or polluted wells indicated the distribution of typhoid fever by contact were the causes of the spread of typhoid fever in St. Louis rather than the infection of the general water supply. I should answer your question then specifically by saying polluted wells, if they were specifically polluted with typhoid fever, the use of the water from such wells, would undoubtedly cause typhoid fever.

Q. Assume that the added totals of tables from typhoid fever and the tables from remittent, intermittent, typho-malaria, congestive and simple continued fever, as they appear in the reports of the board of health for the city of St. Louis are as follows:

1890	361
1891	381
1892	767
1893	499
1894	350
1895	262
11983 1896	283
1897	297
1898	229
1899	279
1900	280
1901	278
1902	224
1903	379

What do those tables as above indicated represent in your opinion as the mortality condition of typhoid fever in the city of St. Louis covering the period as above indicated, after allowing the said remittent, intermittent, typho-malaria, congestive and simple continued fever column such proportion as being typhoid fever as in your opinion you should allow. What is your opinion as based upon the statistics as assumed in the foregoing hypothetical question as to typhoid deaths under the remittent, intermittent, typho-malaria, congestive and simple continued fevers tables in the city of St. Louis as to whether said statistics show an increase or a decrease in the typhoid fever mortality in the city of St. Louis since 1899?

A. If you take the years from 1890 to 1899, inclusive, you have total deaths of 3708 for ten years. That would given an average death rate of 370. If you take the four years since
11984 1899 it would give you 1261 deaths or an average of 315
deaths so there would be if you included all the years from 1892 to 1903, inclusive, then the average would be greater before 1900 than since 1900. If you cut out the years 1892 and 1893 it would be smaller.

Q. Assume that two circular letters one issued in the fall of 1900, and another issued in the fall of 1901, were issued by the health commissioner of St. Louis calling the attention of physicians to the fact that the law required them to report all cases of typhoid fever and all deaths of typhoid, and at that time that letter was sent out, the question of opening the drainage canal was being agitated in the public press of St. Louis, and there was considerable discussion and an investigation was going on at that time of the analysis of the samples of water collected, etc., and was attracting considerable attention. From your examination of the statistics of St. Louis, as heretofore assumed in the hypothetical questions, heretofore asked you, for the years 1900, 1901, 1902, as compared with previous years, does the effect of such a letter, assuming that the same has been sent out to the doctors by the health department of St. Louis manifest itself in those statistics?

11985 A. It probably does. I should assume that the object in sending out such a letter was to get a more perfect report of deaths from typhoid fever and I should judge from the decrease you see here in the deaths from malaria that such object was accomplished.

Q. In what way does the effect of such a letter appear from the statistics?

A. By an increase in the number of deaths reported from typhoid fever.

Q. Is there any proportionate loss from the typhoid malarial column manifested in the statistics?

A. I believe there is, yes sir. While in 1901 there were only 80 cases, the smallest number in any one year, from and including 1900. In fact all three years, 1901, 1902 and 1903, the number of deaths reported as being due to malaria is less than any year preceding that.

Q. From your examination of the typhoid and typho-malarial deaths as assumed in the foregoing hypothetical question, what is your opinion as to whether these two tables taken separately correctly show the typhoid condition of the city of St. Louis for the period mentioned?

A. The two tables taken separately do not correctly show the death rate.

Q. Upon what do you base your opinion that they do not
11986 correctly show the typhoid condition in St. Louis, taking them separately?

A. My opinion is based upon the fact which is well known to most physicians and certainly I have special reasons for knowing it, that malaria is not a frequent disease in this country and is certainly a very rare cause of death.

Q. From your knowledge of these classes of fevers mentioned in the two columns of vital statistics as heretofore assumed, how should they be treated by a bacteriologist, statistician and clinician in order to arrive at the typhoid fever mortality in the city of St. Louis?

A. They should be combined, that is the two tables should.

Q. Have you made any study of comparisons between the typhoid and typho-malarial groups of the city of St. Louis with those of any other city?

A. I have made some studies of the comparison between typhoid fever in St. Louis and typhoid fever in other cities. I have here the number of cases reported and the number of deaths in each year from 1896 to 1902, inclusive, for New York City, Minneapolis, Philadelphia, Richmond, Buffalo, Albany and
Cleveland, and it is rather interesting to note that the
11987 death rate in Buffalo has increased quite markedly since
1899.

Q. That is the year of the opening of the canal is it not?

A. I believe so. Shall I give you the figures.

Q. I wish you would?

A. In 1896 there were 274 cases in Buffalo, reported, with 68 deaths.

In 1897	201	cases	reported,	63 deaths.
In 1898	280	"	"	98 deaths,
In 1899	212	"	"	88 deaths,
In 1900	322	"	"	90 deaths,
In 1901	405	"	"	98 deaths,
In 1902	385	"	"	125 deaths.

Of course in New York there has been a big increase in typhoid fever. I imagine, however, that is due to the enlarging of the city rather than to any other cause, but the cases there jump from 1950 in 1899 to 2658 in 1900, and in 1902 getting up to 3871.

In Minneapolis there has been an increase, if we exclude the year 1897, when there was an epidemic of typhoid fever in Minneapolis.

11988 Q. What has been the general tendency in regard to typhoid fever during the last five years?

A. Do you mean so far as its location is concerned?

Q. As to increase or decrease?

A. I have an idea and I think most epidemiologists have an idea that typhoid fever has been more widely disseminated over the country and there are more cases and more deaths from typhoid fever. I do not mean that the per cent of deaths has increased, but the number of cases has increased and consequently the number of deaths has increased, and I dare say that this is in part due to the distribution of typhoid fever from the camps in 1898. That is probable.

Q. Does St. Louis occupy a different position in regard to this increase in your opinion than the other cities you have referred to?

A. No, there are other cities which show some increase. Of course I might have picked out cities that showed marked increase, but these are cities which I had already looked up in making my Government report and I simply took them as I had them.

Q. Assuming that the following table testified to in evidence by Professor Jordan, as compiled from the typhoid 11989 fever mortality and the remittent, intermittent, typho-malaria, congestive and simple continued fever mortality of the health report of the city of St. Louis and based upon the population of the city of St. Louis for the years 1890 and 1900 acording to the United States Census reports and the intervening year by Farr's Formula, which table is as follows:

11990 TYPHOID FEVER DEATH RATES.

ST. LOUIS.

Death Rate per 100,000.

Year.	Population.	Typhoid fever alone.	Typhoid fever plus 50 per ct. of deaths recorded under heading of intermittent fever, etc.	Typhoid fever plus all the deaths recorded under the heading intermittent fever, etc.
1890	451,709	30.0	56.67	81.2
1891	462,763	35.6	56.98	82.3
1892	474,077	93.0	127.40	161.7
1893	485,668	44.2	73.52	102.7
1894	497,565	34.3	52.24	70.3
1895	509,740	29.9	30.35	51.3
1896	522,225	20.2	37.37	54.1
1897	533,762	23.4	39.53	55.6
1898	548,590	17.3	29.53	41.7
1899	361,510	23.3	36.49	49.6
1900	575,238	29.2	39.07	48.6
1901	589,315	33.5	40.39	47.1
1902	603,736	36.7	45.21	53.6
1903	618,510	46.5	54.0	61.3

Will you please state what in your opinion, based upon
11991 the tables heretofore read, as to whether typhoid fever has
increased or decreased in the city of St. Louis since 1900,
over the conditions that obtained in St. Louis prior to 1900,
and state your reasons for your answer?

A. Well, there certainly has been some increase, unless we go back to the epidemic years of course, and take in 1890 and 1891. Typhoid fever, if we take that alone, then there has been an increase, if we leave out 1892 and 1893. With the exception that in the year 1898 there was a drop, I believe. There was also a drop in 1896 compared with 1895 and a drop in 1895 compared with 1894.

Q. Is there such an increase as you observed as would be characterized as an epidemic?

A. No. An epidemic of typhoid fever, and especially a water epidemic of typhoid fever is where the increase in typhoid fever amounts up to 100 per cent. or more, and even 200, 300 or 400 per cent.

Q. What is the character and nature of the increase that you observed from a study of these statistics?

A. On the whole a gradual increase such as you might ex-
11992 pect would be due to local conditions, especially if wells
were getting more and more filthy and were not condemned.

Q. Have you seen the charts offered in evidence by Professor Mason, which charts have the caption "Deaths from typhoid fever as reported in Chicago and St. Louis, by said health reports. Deaths in St. Louis are platted one month in advance, i. e., February deaths are platted as of January, W. P. Mason." That is where the typhoid deaths of St. Louis and of Chicago are platted by the month?

A. Yes, I have seen those charts. I saw them this morning.

Q. From a study of the typhoid conditions as assumed in the hypothetical questions put to you in regard to St. Louis and the conditions in Chicago as evidenced by these charts, what is your opinion as to whether or not the typhoid conditions in St. Louis bear any relationship to or are consequent of the typhoid conditions that exist in Chicago for the last four years?

A. These charts certainly would indicate that there is no casual relation between typhoid fever in Chicago and typhoid fever in St. Louis because if there was the charts should have the same general curve, charting the typhoid fever in St. Louis
one month later than the typhoid fever in Chicago and
11993 such a relation is not shown by these charts.

Q. If from a consideration of the typhoid conditions as they exist in St. Louis, as evidenced by the typhoid statistics assumed, both the typho-malarial and typhoid death columns you were called upon to attribute a cause for that typhoid condition where would you look for the cause?

A. I should look for the cause certainly in St. Louis in the local conditions. It is generally assumed that typhoid fever is carried altogether by means of drinking water. This is wholly an erroneous assumption. I have some charts here which illustrate that if you care to have me exhibit them. Here is a chart of a regiment, which happens to be the 15th Minnesota, as they were in camp upon the fair grounds at St. Paul, and at Fort Snelling. These men were drinking the same water exactly and still some companies remained practically free from typhoid fever while other companies were largely affected. Typhoid fever if it once starts often spreads by contact from person to person, infection of houses, clothing, bedding, etc. Especially is this likely to be the case in crowded parts of cities and it is certainly true or was true among our troops. Typhoid fever was spread largely by what we call tent or comrade infection.

Q. Does the typhoid fever condition in St. Louis since
11994 January, 1900, as assumed in the tables differ from the
typhoid conditions in other cities in the country for that same period?

A. Certainly not from some other cities. Of course there are certain cities in which there has been a decrease in typhoid fever and other cities in which there has been an increase and in some of these a much more marked increase than in St. Louis.

Q. Would you associate the increase of typhoid fever in St. Louis during the last four years, such as you have indicated it to be, based upon statistics as assumed with the opening of the drainage canal in January, 1900?

A. I think that there is no evidence so far as I can see from these figures that the drainage canal has had anything to do with the typhoid fever in St. Louis for the following reasons:

In the first place, as I have already stated, the distribution of typhoid fever in St. Louis as shown in these tables, is indicative of local contamination and spreading by contact rather than of any general water infection.

In the second place there are certain cities in the list that I have given here where the increase in typhoid fever has been more marked than in St. Louis, and in these cases notably that of Buffalo, the drainage of Chicago has been turned away from Buffalo rather than to it.

I think that there has been a gradual increase of typhoid
11995 fever throughout the country for the last few years, and
the increase in St. Louis has been gradual. It has been slow and I do not think that there is any evidence from the figures that there has been any great contamination of the water

supply of St. Louis. There has been no explosive outbreak of typhoid fever there.

Q. Do you know of any instances where typhoid fever has been spread by contact? If so, please give the instances.

A. I have already shown the table illustrating the spread of typhoid fever in the Fifteenth Minnesota where it was spread by contact. There are still more striking illustrations, probably. In 1898 the Seventh army corp was stationed at Jacksonville, Florida. An army corps in round numbers is 30,000 men. The number of deaths from typhoid fever in the Seventh Army corps was 421. Now, this army corps was at Jacksonville only during the summer. Some regiments a shorter time and some a longer time, some nearly three months and some only a few weeks. The population at Jacksonville at that time was in round numbers 30,000. The soldiers and the people at Jacksonville drank
the same water from the same artesian well. There were
11996 during the whole year of 1898 nine deaths from typhoid
fever if we take those reported as only typhoid fever. If we take all those that were reported as due to typhoid fever, remittent, malaria, typho-malaria and intermittent fevers, the total number of deaths among the people of Jacksonville was 21. In other words there were 400 more deaths from typhoid fever among the 30,000 soldiers there and they were there for only about three months, than there was for the whole year among the 30,000 people of Jacksonville and all drinking the same water. This illustrates that typhoid fever is often spread by other means than by drinking water. There was one division encamped at Knoxville, and we spent some time investigating the conditions at Knoxville, but we could find no case of typhoid fever in Knoxville. There might have been a case but we went with the health officer and tried to find a case of typhoid fever among the cititzens of Knoxville at that time but we were not able to do so. At the same time there were many hundreds of cases among the soldiers and they were drinking the same water.

11997 CROSS-EXAMINATION by Mr. Corum.

Q. But the fact remains, does it not, Professor, that typhoid fever may be scattered or contracted from the use of polluted drinking water?

A. Certainly that is true. That is one way in which it is spread.

Q. Where did you obtain the statistics purporting to show the typhoid death rate in the cities mentioned by you, to-wit: in the city of New York, the city of Buffalo and the city of Minneapolis?

A. I obtained them from the health officers of those cities.

Q. Did you get them directly from the health officers?

A. I did and the original papers were signed by the health officers.

Q. You are not acquainted, I believe you stated, with the local conditions existing in St. Louis?

A. No sir, except as an occasional visitor to St. Louis.

Q. How recently have you been there?

A. I was there a little over a year ago.

Q. At that time did you make any investigation as to the local situation?

11998 A. No sir, of course I know something about it by hearsay.

Q. Assume it to be a fact that the St. Louis intake was removed to its present location in 1895 because local pollution traced to it had passed the old location, would it not be a fair test to compare the conditions in St. Louis between the years 1895 and 1903 rather than between the years 1890 and 1903?

A. Why, yes, I think so.

RE-DIRECT EXAMINATION by Mr. TODD.

Q. You have instituted a comparison for the five years or four years previous and the four years after have you not, in giving your answers to my questions?

A. I have, yes sir. I have omitted the epidemic years.

VICTOR C. VAUGHAN.

ADJOURNED until 10:00 a. m., Tuesday, March 15, 1904.

11999 10:00 a. m., Tuesday, March 15, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and C. D. Corum, Esq., representing complainant; James Todd, Esq., representing the defendants.

EBEN J. WARD,

a witness on behalf of the defendants, being duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION, by Mr. Todd:

Q. What is your name?

A. Eben J. Ward.

Q. What is your business?

A. Civil Engineer.

Q. How long have you been a civil engineer?

A. Since 1880.

Q. Are you a graduate of any technical institution?

A. I took my second degree at Sheffield Scientific School at Yale, in 1880.

Q. Since then what have you done?

A. Been practicing my profession most of the time.

12000 Q. Have you ever made a survey of the Illinois River for the purpose of ascertaining the number of acres that were inundated on the bottoms of the Illinois River?

A. I made a cognizance in 1890 and again in 1892.

Q. Between what points did you make this survey?

A. In 1890 between Lake Joliet and the mouth of the Illinois River and in 1892 between Lake Joliet and the La Grange dam.

Q. Did you figure out the number of acres that were overflowed or subject to overflow between those points in the Illinois valley?

A. Yes sir, for each of those years I estimated that.

Q. Will you please state what your surveys showed as to the number of acres of land subject to overflow between Lake Joliet and the mouth of the river for 1890?

A. The flood of 1890 was what we would call an upper river flood. By that I mean that as far as Peoria the low lands were considerably inundated but from Peoria down the water was confined almost entirely to the channel proper of the river, and slight rises along the bayous and inlets. That was in 1890. That was the condition in 1890.

12001 Q. How did 1892 differ?

A. In 1892 there was a general overflow throughout the entire Illinois River, that is the river below Peoria, it overflowed practically from bluff to bluff. In 1890, below Peoria, the water was confined to the channel proper of the river, but in 1892 it overflowed from bluff to bluff, clear to the mouth of the river.

Q. Will you state the number of acres along the Illinois River valley that is subject to overflow?

A. From the eastern line of Grundy county to the La Grange dam, my estimate for 1892 is 200,000 acres. Now, below the La Grange dam in 1892 the water overflowed from bluff to bluff. I followed the overflow line below the La Grange dam clear to the mouth of the Illinois River, therefore I know it overflowed from bluff to bluff. The drift wood was all the way down there and to come at an estimate or a guess, I would estimate that below there, there was as much more overflowed, probably 200,000 acres below there, although I did not trace the water line on the map below the La Grange dam for 1892. Therefore, there are times when that river overflowed from bluff to bluff below the La Grange dam.

12002 Q. How many acres would you estimate the amount of lands subject to overflow along the Illinois valley from Lake Joliet to the mouth of the river?

A. In the neighborhood of abot 400,000 acres.

CROSS-EXAMINATION, by Mr. Corum.

Q. Did you make a survey of this water in 1890?

A. I made a recognizance of it, one form of a survey.

Q. How many acres at that time according to your estimate?

A. From the eastern line of Grundy county to the mouth of the Illinois River, 150,000 acres.

Q. Between 1890 and your next survey in 1892, had a good portion of this river been levied?

A. There had been one or two levee districts in there.

There was one at Pekin, that was started, I think. No sir, not a good portion of it.

Q. About what portion of it then?

A. There were small levee areas, comparatively small.

Q. How many levee districts are there now?

A. There is one opposite Pekin.

Q. About how many miles does that one at Pekin include?

12003 A. About 2 miles long or something like that—1½ miles long. If I had my maps here I could show you.

Q. Approximately?

A. I should think 1 1-2 or 2 miles long.

Q. That is opposite Pekin?

A. Yes sir, then there is one opposite Beardstown, that I should think was perhaps 2 miles or 2 1-2 miles long, and there is now, which was not in 1892, there is one opposite Havana. That was not there in 1892. It has been put in since. I should think that is perhaps a couple of miles long. There is one above Kampsville, on east side of the river.

Q. Was that erected since 1892?

A. No sir, that was prior to 1890. That is a low levee, however, and in 1892 it was all over flowed, went over the top of it. I know that district very well because I stopped at the house with the party who owns the land. It overflowed there in 1892 but not in 1890. I think that is all that I can recollect.

Q. Is there a general effort being made by the people along the banks of the Illinois River to erect those levee districts?

A. Only at certain places. I would not consider it was 12004 profitable for them to at other places.

Q. In making your estimate as to the number of acres of land subject to overflow along the banks of the Illinois River or contiguous to the banks of the Illinois River what do you mean by the phrase "subject to overflow?"

A. That which would at any time be overflowed. That which has in the past been overflowed.

Q. At times of an unusual freshet?

A. Yes sir, that is what I took it to be.

Q. There is a vast volume of water in there?

A. Yes sir, such as 1892.

Q. At that time the water was very high all over the country?

A. Yes sir, an unusual flood at that time.

Q. And in making your estimate you take those matters into consideration, that of an unusual volume of water?

A. Yes sir, 1892 was an exceptional flood in the Illinois River.

Q. Not only in the Illinois River but in its tributaries?

A. But in its tributaries.

Q. And in all parts of this country?

A. Yes, sir, 1892 was an exceptional flood year.

12005 RE-DIRECT EXAMINATION, By Mr. Todd:

Q. Do you know whether the Pekin Levee Company washed out in 1902?

A. The levee broke and all that country was overflowed.

Q. And was turned into a carp pond?

A. I believe it did. That is my recollection of it. In 1902? It broke in 1892. I do not know about 1902. I had reference to 1892. My impression is it broke in 1892.

Q. These several levee districts to which you refer have they withstood the floods along the Illinois River?

A. No sir. No sir, they did not withstand the flood of the Illinois River. The one opposite Beardstown is the best one I know of along the river. That is the heaviest.

Q. Has that withstood the floods since its construction?

A. I believe it has broken once. I do not know which year. That is only hear say.

Q. These levee districts contain about 1,000 or 2,000 acres which are levied off from the bottom lands do they not?

A. I think the one opposite Beardstown contains more.

Q. How much more?

12006 A. This is mere calculation. I think they have something between 3,000 and 4,000 acres. I could give all that more accurately if I had my maps here.

Q. I only want it approximately. From your knowledge of the Illinois River do you know of any concerted movement to levee that river from its mouth to La Salle?

A. No sir, the levees have been erected, as I understand it, only by private parties, for the purpose of tilling the ground within the levee area.

Q. As a practical proposition do you believe the Illinois River could be levied for the purpose of creating any value to the land lying behind such levees that the cost of the levees would not exceed the cost of the land?

A. I would not consider it a good commercial proposition to levee the Illinois River for tillable purposes except here and there, just as they have selected and placed locations.

Signature waived.

12007 LEONARD P. KINNICUTT.

a witness on behalf of the defendants, being duly sworn by the Commissioner, testified as follows:

DIRECT EXAMINATION, By Mr. Todd:

Q. What is your name?

A. Leonard P. Kinnicutt.

Q. What is your business?

A. Director of the Chemical Department of the Worcester Polytechnic Institute.

Q. Where located?

A. Located in Worcester, Massachusetts.

Q. Where were you educated, Professor?

A. I graduated at the Massachusetts Institute of Technology, in 1875, with the Degree of Bachelor of Science. I studied in the University of Heidelberg, for two years, under the direction of Professor Bunsen. I then studied two years at the University of Bonn, Germany, in the laboratory of Professor Kekule. I then studied for four months at Johns Hopkins University, then at Harvard University, where I obtained the degree of Doctor of Science.

12008 Q. Since graduation what have you done?

A. Since graduation, or since receiving my Doctor of Science degree I was instructor in Chemistry in Harvard University for three years. I was then appointed Assistant in Chemistry at the Worcester Polytechnic Institute. After three years I was appointed full Professor of Chemistry and then Director of Department of Chemistry in the Worcester Polytechnic Institute, which office I now hold.

Q. Have you had any positions with any Boards of Health or societies for the development or advancement of science?

A. I have been consulting chemist to the Worcester Board of Health since 1885. I was the consulting chemist to the Connecticut Sewage Commission, appointed by the Legislature. I have been for fifteen years fellow of the American Association for the Advancement of Science, of which I am now one of the vice-presidents. Member American, English and German Chemical Societies; member American Bacteriological Society, etc.

Q. Have you made a special study of sanitary problems?

A. I have made a special study of sanitary problems, beginning in the year 1882, which study I have continued from that time.

Q. Have you made a special study of the analysis of water?

A. I have made a special study of the analysis of water,
12009 both chemical and bacterial analysis of water, and I am
continually employed in making such determinations.

Q. Have you had any experience in the interpretation of bacterial and chemical analysis of water?

A. I have, as all water analyses require the interpretation of both chemical and bacterial results.

Q. What experience have you had in passing upon the water supply of cities?

A. I have had experience in passing on the water supply of numerous cities, among which I can name Gardner, Mass.; Quincy, Mass.; Bristol, R. I.; Warren, R. I., and various other towns and cities in the East.

Q. Have you made a special study of bacteriology as applied to water investigations?

A. I have made a special study of bacteriology as applied to water investigations, as such study is necessary for determining the character of a water.

Q. Have you made a study of the typhoid bacillus as related to the water supply?

12010 A. I have made a study of the typhoid bacillus as related to water supplies of the coli bacilli, and also the typhoid fever death rates of cities whose water supplies I have examined.

Q. Have you studied the colon bacillus?

A. I have studied the coli bacillus in the determination of the character of water supplies as that is one of the most important single determinations that we make.

Q. Is the typhoid fever bacillus related to the colon bacillus, and if so in what way?

A. The typhoid bacillus is very closely related to the coli bacilli, both belonging to the colon group, and can only be distinguished from each other by special tests.

Q. Are you acquainted with the physical conditions of the Chicago River, the Drainage Canal, the Desplaines and the Illinois Rivers and the Mississippi River, from Chicago to St. Louis?

A. I am.

Q. What opportunities have you had for becoming acquainted with the water course between Chicago and St. Louis?

12011 A. In September of last year I passed through the drainage canal on a tug boat, that went as far down as Joliet, noticing the Desplaines River. Took the train to Peru, then took the boat at Peru and journied down the river as far as St. Louis. I have my notes with me.

Q. Will you describe briefly the physical conditions of the Illinois River as you saw it?

A. The Illinois River as I saw it was a river without swift current, containing a large number of lakes. Below Peoria the shores were low and below Havana the lower part of the river looked like a series of lakes.

Q. Will you state in full what experience you have had in passing judgment upon water supplies of cities?

A. I might state that I make continuous analysis of the Worcester water supply, determining the number of coli in the laboratory each day. Then, I have been employed in determining the character of the water supplies of Quincy, of Bristol and Warren, of Gardner, of the character of the water in Lake Quinsigamond, which is near Worcester, to see if it was suitable for water supply in an emergency.

12012 I have also made numerous examinations of various rivers as the Nashua River between Lancaster and Worcester, of the Blackstone River which is possibly one of the most polluted rivers in the United States, and I am continually making analyses and giving opinions regarding the drinking water of various towns in Massachusetts.

Q. Have you made a special study of the problem of sewage disposal?

A. I have.

Q. Have you studied these problems in the United States and elsewhere?

A. I have both in the United States and in England.

Q. Will you state in full what observations you have made and what studies you have carried out on the problems of sewage disposal?

A. My investigations on the sewage disposal problem began in 1882, when I was asked to give my advice to the city of Worcester regarding the disposal of the city sewage.
12013 Since that time I have devoted a great deal of my attention to the subject of disposal of sewage. I have conducted experiments of my own lasting through periods of over two years, on the question of purification of sewage by the septic tank, having a tank in continuous operation, holding over 1,500 gallons. I have visited all the sewage purification plants in Massachusetts, and have visited most of those in England.

Q. Just describe the plants you have visited in England?

A. I studied the disposal of the London sewage by chemical precipitation. I have studied the system of septic tank treatment and contact bed treatment as carried on at Manchester. I have studied the system of chemical treatment and land irrigation as carried on at Birmingham, etc., etc.

I visited, the first year it was put in operation, the first septic tank in England at Exeter and carefully studied its operation.

Since 1896 I have visited England every other year, studying what was being done in England regarding the methods of treatment of sewage.

Q. What have you done in this country in applying the knowledge which you obtained about the problems of the
12014 purification of sewage?

A. The principal application that I have made of my knowledge is at the Worcester Purification Plant, and describing and writing regarding the treatment of sewage for various scientific societies and scientific papers.

Q. Have you conducted a septic tank yourself?

A. I have. I have conducted an experimental septic tank which I already stated contained 1,500 gallons, making very careful experiments continuously for two years. I have also conducted experiments on a practical scale, in a large open septic tank holding over 250,000 gallons, analyzing the sewage, the effluent, the gas that was given off and studying the processes that took place in the septic tank.

Q. Will you describe a septic tank?

A. A septic tank is merely a tank through which sewage is allowed to pass slowly, the rate of flow of the sewage being regulated. As a rule the sewage as it enters the tank enters below the surface of the liquid and the outlet for the effluent is also beneath the surface of the liquid. These tanks can be either open or closed. By closed I mean covered by a
12015 roof either made of wood or of cement concrete. That is essentially what we mean by a septic tank.

Q. Will you describe the processes which take place in a septic tank?

A. The action of a septic tank is what is commonly known as hydrolysis, the breaking down of complex organic compounds by absorption or addition of water which in the case of a septic tank is brought about by the action of bacteria.

The organic substances contained in the sewage can roughly be divided into three classes, the albuminoids, the fats and the carbo-hydrates.

The albuminoids are organic nitrogen compounds of very complex composition. These compounds by hydrolysis are first resolved into peptones which are soluble in water and then further broken down, giving organic substances containing nitrogen and organic compounds, free from nitrogen.

In this process of breaking down of the albuminoids gaseous products carbon dioxide marsh gas, hydrogen, ammonia, nitrogen and probably more or less sulphide of hydrogen are formed.

The fats, by the same process are resolved into organic acids and glycerine, while the carbo-hydrates break up into alcohol and carbon dioxide.

12016 By this process of hydrolysis the complex organic compounds are broken down into simple compounds with the result that a certain amount of insoluble organic matter contained in the sewage is rendered soluble. A certain amount is removed from the sewage and the organic matter which remains is more easily acted upon by what are called the nitrifying bacteria.

The processes which take places in the septic tank might be called the process of putrefaction. The chief object of the septic tank is the breaking down of these complex compounds, of rendering part of the insoluble compounds soluble and removing part of the organic compounds by resolving them into the gases named and by making the organic compounds which remain, more easily acted upon by the nitrifying bacteria.

I might say the purification of sewage can be divided into two processes, the first process which can be described under the name of putrefaction being brought about by anaërobic bacteria; the second process, the nitrification process, being the further breaking up of these organic compounds and
12017 completely changing the organic into inorganic or mineral matter.

Q. In the operation of a septic tank, will septic operation take place in an uncovered tank?

A. The operation will take place, I believe, fully as well in an open tank as in a closed tank, and illustrating this I might state that at Birmingham, England, which has the largest installation of septic tanks, over 20 in number, all are uncovered and the opinion at the present time regarding the construction of the septic tanks is that open septic tanks will be used in the place of closed septic tanks on account of the difference in cost of construction, the process taking place fully as well in an open as in a closed tank. I might add that the only advantage of the closed tank is as regards the giving off of odor. There is less danger of nuisance from odors from a closed septic tank, than from an open septic tank.

As a rule in an open septic tank a crust forms over it which

acts as a cover. In a great many cases, however, this coat-
12018 ing does not appear or where it does appear it is thin and
is easily carried from one part to another part of the tank.

I might say that in the Worcester tank that a crust first appeared after the tank had been in operation one month. It increased in thickness for about two months and then during a wind storm it was borne to the further end of the tank, and carried away in the effluent, and no crust appeared on the top of the tank for over six months. At the present time in the Worcester tank the first portion of the tank is coated and the lower two-thirds are free from crust.

I would like also to add to that, that during the time that the Worcester tank was perfectly free from crust, no difference could be seen in the action that took place in the tank from the analysis of the sewage and the effluent.

Q. Will you differentiate between the processes that take place in the septic tank in the purification of sewage and the processes which take place in the running stream?

A. In the processes which take place in a septic tank are the processes which may be discribed under the general term of putrefaction which are brought about by anaerobic bacteria.

If sewage is delivered into a running stream and there
12019 is in the stream an excess of oxygen, two processes will
take place, the anaerobic putrefaction and then the nitrification of the sewage, or in other words, if sewage be delivered directly into the running stream both processes are taking place more or less at the same time, while in the septic tank only the first process is taking place.

Q. Have you studied the drainage canal from the standpoint of the septic tank?

A. I have.

Q. What studies have you made upon the drainage canal in its operation as a septic tank?

A. As I passed along the sanitary canal in a tug boat from Chicago to Lockport I took particular notice of the indications of the sanitary canal acting as a septic tank. Among the chief indications that it was so acting was that gas was being given off and I noticed bubbles of gas given off from the liquid as far as Lemont. After passing Lemont I noticed no further gas de-

velopment taking place. The odor from parts of the sanitary canal, especially near Chicago, remind you of the odor
12020 from the septic tank. Further down there was the odor that you obtain where the effluent of a sedimentation tank passes over or is allowed to fall over rocks or passes over a dam.

Q. Have you prepared any table showing the septic operation taking place in the sanitary canal?

A. I have.

Q. Will you state in what manner the tables were prepared?

A. I will. They are tables A., B., C,. D. and E., and follow here the explanation of them:

12021 In studying the action that takes place in the sewage during its passage through the canal, it is necessary to compare the analyses made at Kedzie Avenue or at Western Avenue Bridge with those made during the same period of time at the Controlling Works at Lockport. The averages of weekly examinations made by Prof. Palmer and those made by Prof. Jordan at these two points, and printed in "Streams Examinations, 1903," do not, as made out, give the required data.

Prof. Jordan's Table 119, "Streams Examination," gives the results obtained at Kedzie Avenue from April 30th to June 25th, and his Table 123, "Streams Examination," gives the results obtained at Bear Trap Dam, Lockport, from April 15th to June 25th. Leaving out of this last table, the results of analyses made before April 30th, comparable data are also obtained. These data are given in Table A. Table 39, Palmer's, gives the average results of examinations made at Kedzie Avenue from Jan. 11th to Oct. 8th, 1900, while Table 43, Palmer's, gives the average results only from July 9th to Oct. 5th. By omitting the results obtained at Kedzie Avenue from Jan. 11th to July 9th, and determining the average results obtained from
12022 July 9th to Oct. 5th, data are obtained for comparison of the effect on the sewage during its flow through the canal. (These data are given in Table B.)

Prof. Long's Table 43, page 48, "Illinois State Board of Health, 1901," the analyses of water at Drainage Canal at Western Avenue from June 4th to Sept. 4th, 1900, and Table 44, the analyses of water of canal at Lockport, both covering the same periods of time, were taken as given. These data are also given in Table C.

(Table D is computed from tables A. B. & C.)

12023

TABLE A.

Analyses Showing the Changes Which Took Place During the Passage of the Sewage of Chicago Through the Sanitary Canal.

Jordan's Analyses. April 30—June 25, 1900.
Tables used, 119 and 123 Streams Examination.

Constituents.	Parts per million.	
	Kedzie Ave.	Lockport.
Solids.		
Total	216.8	193.8
Soluble	188.1	180.6
Suspended	28.7	13.2
Oxygen Consumed.		
Total	8.0	6.1
Soluble	5.1	4.65
Suspended	2.92	1.34
Nitrogen.		
Free ammonia	1.31	1.35
Total Alb. Ammonia	0.49	0.34
Soluble Alb. Ammonia	0.22	0.17
Suspended Alb. Ammonia	0.27	0.17
Nitrites	0.029	0.010
Nitrates	0.28	0.08

Taken from Table 119—April 30 to June 25.
Taken from Table 123—April 16 to June 25.

12024

TABLE B.

Analyses Showing the Changes Which Took Place During the Passage of the Sewage of Chicago Through the Sanitary Canal.

Long's Analyses, June 5—September 4, 1900.
Tables used, 43 and 44, Illinois State Board of Health Report, 1901.

Constituents.	**Parts per million.**	
	Western Ave.	**Lockport.**
Solids.		
Total	203	212
Soluble	178	193
Suspended	25	19
Oxygen Consumed.		
Total	6.28	5.29
Soluble	4.42	4.34
Suspended	1.86	0.95
Nitrogen as		
Free Ammonia	1.10	1.77
Total Alb. Ammonia	0.78	0.62
Soluble Alb. Ammonia	....	....
Suspended Alb. Ammonia	....	....
Nitrites	0.11	0.06
Nitrates	0.12	0.00

Taken from Table 43—June 5 to September 4.
Taken from Table 44—June 4 to September 4.

12025

TABLE C.

Analyses Showing the Changes Which Took Place During the Passage of the Sewage of Chicago Through the Sanitary Canal.

Palmer's Analyses, July 9—Oct. 5, 1900.
Tables used, 39 and 43, Streams Examination.

Constituents.	**Parts per Million.**	
	Kedzie Ave.	**Lockport.**
Solids.		
Total	* **201.2**	**196.4**
Soluble	**171.6**	**179.6**
Suspended	**29.6**	**16.8**
Oxygen Consumed.		
Total	**9.5**	**7.4**
Soluble	**4.8**	**4.7**
Suspended	**4.7**	**2.7**
Nitrogen.		
Free Ammonia	**1.2**	**1.59**
Total Alb. Ammonia	**0.47**	**0.40**
Soluble Alb. Ammonia	**0.18**	**0.16**
Suspended Alb. Ammonia	**0.29**	**0.24**
Nitrites	**0.012**	**0.004**
Nitrates	**0.30**	**0.21**

Taken from Table 39, Jan. 11 to Oct. 8.
Taken from Table 43, July 9 to Oct. 5.

12026

TABLE D.

Mean of Jordan's, Long's and Palmer's Analyses Compiled from Tables 1, 2 and 3, Showing the Changes, Parts Removed and the Per Cent. of Purification That Took Place During the Passage of the Sewage of Chicago Through the Sanitary Canal.

Constituents.	Parts per million.		Parts removed.	Per cent removed.
	Kedzie Ave & Western Ave.	Lockport.		
Solids.				
Total	207.0	200.7	6.3	3.0
Soluble	179.2	184.4	+5.2	+2.9
Suspended	27.8	16.3	11.5	41.3
Oxygen Consumed.				
Total	7.93	6.26	1.67	21.
Soluble	4.77	4.63	0.14	2.9
Suspended	3.16	1.63	1.53	48.4
Nitrogen.				
Free Ammonia	1.20	1.57	+0.37	+30.8
Total Alb. Ammonia	0.58	0.45	0.13	22.4
Nitrites	0.050	0.024	0.026	52.
Nitrates	0.23	0.097	0.133	57.8
Mean of Jordan's and Palmer's results, Long not determining soluble & suspended alb. ammonia.				
Total Alb. Ammonia	0.48	0.37	0.11	22.9
Soluble Alb. Ammonia	0.20	0.165	0.035	17.5
Suspended Alb. Ammonia	0.28	0.205	0.075	26.7

12027

TABLE E.

Table Showing the Action of the Septic Tank on Removal of Substances Contained in Sewage.

	Per cent removed.						
	Birmingham.....	Exeter......	Leeds..........	Manchester......	Worcester Kinnicutt 1900 & 1901..........	Lowell Clark 1900 & 1901......	Sanitary Canal..
Solids.							
Total.....	26	24	34	27	22	....	3.0
Soluble	8	7	12	15	21	....	+2.9
Suspended	60	60	70	57	26	....	41.3
Oxygen Consumed.							
Total	33.6	—	—	—	36	45	21.0
Soluble	25.4	—	—	—	29	—	2.5
Suspended	57.1	—	—	—	44	—	49.3
Nitrogen.							
Free Ammonia	+24	—	22	—	+20	0	+32.7
Alb. Ammonia	41.6	17	59	—	33	55	21.8
Total Albuminoid.							
Ammonia	—	—	—	—	33	—	22.8
Soluble	—	—	—	—	8	—	17.5
Suspended	—	—	—	—	43	—	26.7

12028 In regard to table D, I would like to state that I was unable to obtain the mean of Jordan, Palmer and Long's results regarding soluble and suspended albuminoid ammonia, as Long made no determinations of suspended and soluble albuminoid ammonia. Further, that the total amount of albuminoid ammonia removed 22.9 per cent. as declared from the mean of Jordan and Palmer's analyses does not agree exactly in the per cent of total albuminoid ammonia removed, as given by mean of Long, Jordan and Palmer's analyses. The difference, however, is only one per cent.

Q. Will you state what conclusion you draw from the tables which you have introduced in evidence as to the septic action that takes place in the sanitary canal?

A. If analyses are made of the crude sewage, and of the effluent from the septic tank we find that as a rule the amount of free ammonia in the effluent is greater than in the sewage; that the amount of total or soluble albuminoid ammonia and of suspended albuminoid ammonia is less in the effluent than it is in the crude sewage; that the amount of nitrogen as nitrates and nitrites is very small in the effluent and as well as in crude
12029 sewage, but there is a reduction of nitrogen as nitrites and nitrates.

From the analysis that I have made showing the character of the water at Lockport and the character of the water in the canal at Kedzie Avenue, these results indicate very strongly that the septic action has taken place during the passage of water containing sewage through this canal, as shown by the increase in free ammonia, the decrease in albuminoid ammonia, soluble albuminoid ammonia, also in the decrease in oxygen consumed, soluble and suspended; that the results agree in their general characteristics with results that have been obtained by the examination of crude sewage and the effluent from the septic tank in the various places that I have given in table E. The changes are exactly the same in character, the difference only being in amount.

Q. Have you made any comparisons between the action which takes place in the sanitary canal with that which takes place in septic tanks at other places?

A. I think the answer to this question I have just given in referring to table E. i. e., that the action seems to be the same as the action which takes place when sewage is passed through a septic tank.

12030 Q. What effect does this septic action, as you have described it, have upon the sewage of Chicago as it passes through the drainage canal?

A. It has a purifying effect. It also renders the substances which still remain in the sewage more easily acted upon when the sewage enters the river, and it purifies the sewage by removing a part of the solid matter that was in the sewage by throwing it down to the bottom of the canal and by the removal of part of the solid matter by changing it into gas.

Q. What effect does the septic action which you have described as taking place in the drainage canal have upon the bacterial life of the sewage, both the pathogenic and non-pathogenic?

A. Very little work, as far as I know, has been done regarding the action of the septic tank on bacterial life. The best experiments which I know of which are reported are given in the second report of the Royal Commission on Sewage Disposal, 1902, appointed in 1898, which inquired and reported what methods of treating and disposing of sewage may be properly adopted.

The report of Professor Boyce upon the treatment of
12031 Manchester, England sewage by means of bacterial beds,
pages 11 and 12 of the report quoted states "experiments made in Manchester show that B. coli diminshes during the stay in the septic tank, and experiments conducted in the laborartory show, that the septic tank liquid is inimical to B. coli, and therefore to other more delicate bacteria."

He also gives some experiments made by him showing that B. coli diminish in the septic tank.

Thus in one series of observations at Manchester the average number of B. coli was, December 15, 1900, crude sewage 5011; the septic tank 2130.

The Cameron tank which is merely a closed septic tank is 2099.

Experiments on April 3, 1900, he gives crude sewage 45,600; septic tank 7433; septic tank liquid after 2 days 2025; Then he gives quite a series of experiments and a table showing the effect of B. coli at Manchester and Leeds which, show a reduction of the coli in the septic tank.

I will say that my own opinion is that it diminishes the number of B. coli and the more delicate pathogenic germs and
12032 that the total number of bacteria is diminished by ten
or fifteen per cent.

Q. Have you given special attention to the chemical analysis of water for the purpose of ascertaining the sanitary quality of water?

A. I have made many such investigations of waters to determine the sanitary character of such waters.

Q. What determinations do you employ in your chemical analysis for ascertaining the sanitary quality of water?

A. The total solids; the suspended solids; the soluble solids; the nitrogen as free ammonia; the nitrogen as albuminoid ammonia; the nitrogen as soluble albuminoid ammonia and suspended albuminoid ammonia; the nitrogen as nitrites; the nitrogen as nitrates; oxygen consumed; the chlorine; the hardness and some times the total nitrogen. From the total of solids in connection with the hardness, the character of the water for household use, not including drinking or cooking purposes--from the suspended solids the amount of sediment in the water.

Q. What conclusions do you draw from the presence of these different chemical elements when found by your determinations?

12033 I draw the following conclusions:

CHLORINE

Contained in water, chiefly as salt occurs in small quantities in all soils and is consequently present in all waters, streams, ponds, lakes, wells, etc. Most animal matters, especially animal secretions as urine, contain salt. It is also contained in the kitchen waste, in the waste products of many manufacturing processes, and is therefore a constant constituent of sewage. When it enters a stream it does not undergo any decomposition or change, and the only natural causes of change in the proportion of chlorine in a water is through evaporation of the water by the sun's heat, the addition of water containing larger amounts of chlorine as sewage water or by dilution with water containing less chlorine than the water in the stream. The determination of chlorine is an index to the total chlorides introduced into a stream from whatever source above the point at which the determination is made. A sudden increase in chlorine in a stream tends to show the addition of sewage. A sudden decrease, the dilution of the water of the stream by purer water. Normal chlorine of Lake Michigan is 2 parts of some of the rivers, as the Fox, it is 4 parts per million. The chlorine

12034 serves as an index to the past history of the water.

ALBUMINOID AMMONIA.

Albuminoid ammonia indicates the amount of decomposable nitrogenous substances like albumen or protoids in a water. These substances are contained in large amount in sewage and serve as food material for bacteria. These nitrogenous substances are also contained in vegetable matters like dead leaves, grasses, algae, etc., and the amount of albuminoid ammonia not only indicates that the undecomposed matters from sewage are contained in a stream, but also may indicate these other named substances. Something regarding the character of the water must be known before a perfectly correct idea of the significance of albuminoid ammonia is arrived at. In the examination of any given stream it can be said that the decrease of albuminoid ammonia shows that purification is taking place, and that the decrease of albuminoid ammonia shows a decrease of bacterial food, and is in general co-incident with bacterial purification.

FREE AMMONIA.

Free ammonia or saline ammonia is found in small quantities in all waters coming from rain, snow, and the wash-
12035 ings of the soil. In fresh sewage it is contained in com-
paratively large quantities and often in still larger quantities in sewage in which the first changes of putrefaction are taking place, i. e., decomposition of nitrogenous organic matter by anaerobic bacteria. It comes into sewage from the urine and dejecta of men and animals, from manufacturing waste and from the decomposition of these compounds. It also comes into water from the decomposition of micro-organisms and from green plant life like algae. An increase in the free or saline ammonia in the stream may be due to the entrance of sewage or to the decomposition of plant life. A decrease to dilution by its being changed by nitrifying bacteria into nitrites and nitrates. A study or knowledge of the water shed of a stream is often necessary for the proper interpretation of free ammonia results.

NITRITES.

Nitrites in a water usually indicate that the ammonia is being changed into nitrogen as nitrites, though it is contained in small amounts in rain and snow, and to a certain extent comes

into the water in this way, or from washings from surface
12036 soil. It may also be derived from the reduction of nitrates
in water by certain bacteria. Nitrites to any amount in a stream indicate that the purification process is actively taking place. A decrease in nitrogen as nitrites with increase of nitrogen as nitrates shows that the final stage or removal of organic matter is taking place.

NITRATES.

Nitrogen as nitrates in a water are usually formed from the nitrites in the water and indicate the last stage in the removal or oxidation of organic matter in a stream. A water may be sanitarily a perfectly pure water and yet contain a large amount of nitrates. Nitrates in a water taken by themselves indicate the past history of the water. If in an examination of a stream we find nitrogen as albuminoid ammonia decreasing and nitrogen as nitrates increasing, it shows that self-purification, so-called, of the stream is taking place. Decreasing nitrates may be due to algae life.

TOTAL ORGANIC NITROGEN.

The amount of nitrogenous matter in a water is also indicated by what is called total organic nitrogen. This is the
total amount of nitrogen contained in the nitrogenous
12037 substances in the water, and from it an idea as to the
amount of nitrogenous matter in the water can be determined. The general factor used to multiply the amount of total organic nitrogen to obtain the amount of total nitrogenous matter is 16.3. The nitrogen as albuminoid nitrogen gives as a rule only one-half the total nitrogen contained in nitrogenous matter.

OXYGEN CONSUMED.

By oxygen consumed is meant the amount of oxygen used for the destruction of or oxidation of substances contained in water. It serves as an index as to the amount of carbonaceous matter in the water, and in stream examinations it shows the amount of oxidizable matter contained in the water.

12038 The so-called nitrogen cycle is a representation of the changes that take place in the nitrogenous products when contained in water, the albuminoid ammonia being first changed into free ammonia, the free ammonia then being changed into nitrogen as nitrites and nitrates. The green plant life which is always contained in stream water decomposes the nitrates, taking part of the nitrogen to build up their own tissues, part of the nitrogen being given off in a free state. These algae undergo decomposition and give again albuminoid ammonia. The albuminoid ammonia is then changed into free ammonia, and the cycle so continues. This may take place a number of times in a river water.

Q. Have you studied the chemical data prepared by Professor Long and published in the Board of Health reports of the State of Illinois, which have been introduced in evidence in this case, and the chemical and bacterial data prepared by Professor Jordan, Professor Palmer, Professor Burrill and Professor Zeit?

12039 A. I have.

Q. Have you examined the tables prepared by Professor Long and published in the Board of Health reports of the State of Illinois, which have been introduced in evidence in this case?

A. I made a careful examination of the tables of Professor Long as given in the Illinois State Board of Health reports, in 1901, and introduced in this case.

Q. Will you state what conclusions you draw as a chemist and sanitarian from the analytical data presented in such tables by Professor Long?

A. I have taken the analytical data as given by Professor Long in the Illinois State Board of Health, 1901, which are the results of his examinations of the water at the various stations from Chicago to Grafton on the Illinois River, both for 1899 and 1900. The results of his analysis from June to December, 1899, with the conclusions drawn from those results are as follows:

12040 Table 1.—Analyses of Lake Michigan tap water, July 17—Nov. 27, 1899. The total solids are 144, suspended 2, and soluble 142 per million. The free ammonia is 0.05, the albuminoid ammonia 0.103 and it contains no nitrogen as nitrites or nitrates, total oxygen consumed 1.05, chlorine 1.77. Two analyses in July, one in August and two in November.

Table 2.—Bridgeport. Pumping station, July 1st to Nov. 27, 1899, weekly examinations. The results are such as would be obtained from dilute sewage. Total solids 536.5, soluble solids 473, suspended solids 63.5; free ammonia 19.84, albuminoid ammonia 3.32, nitrogen as nitrites 0.03, nitrates 0.0, oxygen consumed 26.65, chlorine 95.47.

Table 3.—Lockport Canal, July 3rd—Nov. 29th. The results obtained at this point are very similar to the results obtained at Bridgeport during the same period, and show that during its passage through the canal little change has taken place in the sewage.

Total solids 558, soluble 491, suspended 67; free ammonia
12041 19.85, albuminoid ammonia 3.37, nitrogen as nitrites 0.03,
nitrates 0.03, oxygen consumed 27.90, chlorine 96.97.

Table 5.—Joliet. Illinois and Michigan Canal, July 3rd—Nov. 6th. Total solids 591, soluble solids 487, suspended solids 104; Free ammonia 16.05, albuminoid ammonia 2.88, nitrogen as nitrites 0.015, as nitrates 0.014, oxygen consumed 25.69, chlorine 85.49. The distance of Joliet from Lockport is only four miles, and the results show that but little change has taken place in the sewage in its flow from Lockport to Joliet. The chief difference in results at this point from those obtained at Lockport, being due in my opinion to dilution by water of the Desplaines River which at this point is mixed with the waters from the canal.

Table 7.—Morris. Illinois River, July 5--Nov. 28. Total solids 445, soluble solids 420, suspended solids 25, Free ammonia 10.99, albuminoid ammonia 1.20, nitrogen as nitrites 0.18, nitrogen as nitrates 0.07, oxygen consumed 9.16, chlorine 61.8.
12042 Morris is about 24 miles from Joliet. The Kankakee
river enters the Desplaines River about nine miles above Morris and its diluting effect is shown by the reduction of chlorine from 85.49 to 61.8. The water of the Kankakee River is a much purer water than that of the Desplaines River at the point of junction, and so the water of the Desplaines is purified to a certain dgree by dilution. That the organic matter in the water has begun to undergo decomposition is shown by the de-

crease in free and albuminoid ammonia and increase in nitrogen as nitrites and nitrates. There has also been a decided deposition of suspended matter, a large part of which was oxygen consuming substances, as the suspended oxygen consumed at Joliet is 10.59, while at Morris it is only 1.09.

Table 8—Ottawa. Illinois River, July 5th—Nov. 27th.
Total solids 445, soluble solids 434, suspended solids 11, Free
ammonia 6.23, albuminoid ammonia 0.62, nitrogen as nitrites
0.61, nitrogen as nitrates 0.74, oxygen consumed 7.13,
12043 chlorine 57.4. There has been a very decided change in
the purity of the water in the river between Morris and Ottawa, a distance of about 24 miles. The chlorine shows that there has been very little dilution of the water of the river between these points, and the very decided decrease in free and albuminoid ammonia with increase of nitrogen as nitrites and nitrates shows that bacterial decomposition of the organic matter is rapidly taking place, changing the organic matter into mineral matter. There has also been a certain amount of deposition of suspended matter. Between Morris and Ottawa there is a dam, the Marseilles dam, I believe, but this would have little effect in the character of the water beyond bringing about the removal of suspended matter, there being, according to Prof. Palmer's results, dissolved oxygen in the water.

Table 10.—La Salle, Illinois River, July 13—Dec. 6. Total
solids 436, soluble solids 415, suspended solids 21, Free
12044 Ammonia 4.66, albuminoid ammonia, 0.58, nitrogen as
nitrites 0.35, nitrogen as nitrates 1.45, oxygen consumed
6.99, chlorine 41.3. These samples were taken about 600 feet above the mouth of the Big Vermillion, and although there has been some dilution as shown by the reduction in chlorine, the very decided decrease in free and albuminoid ammonia with corresponding increase in nitrogen as nitrates and the decided decrease in oxygen consumed shows that during the stretch of river between Ottawa and La Salle the processes of purification have been very active.

Table 12.—Henry. July 10—Dec. 4. Sample taken above the dam. Total solids 451, soluble solids 426, suspended solids 25, Free ammonia 3.28, albuminoid ammonia 0.553, nitrogen as nitrites 0.517, as nitrates 1.39, total oxygen consumed 7, chlorine

43.2. The slight increase in chlorine would indicate a slight
addition of sewage to the river, probably from La Salle and
Peru, total population 20,000. There has, however, been
12045 only slight changes between.

Table 13.—Peoria Narrows. July 5—Nov. 23. Total solids 422, soluble 398, suspended solids 24, Free ammonia 0.895, albuminoid 0.572, nitrogen as nitrites 0.141, nitrogen as nitrates 1.10, oxygen consumed 6.86, chlorine 33.04.

The chlorine shows that there has been more or less dilution between Henry and the Narrows, but the great change has been in the removal of free ammonia and nitrogen as nitrites. This shows that the principle change between Hanry and the Narrows has been the last process in the changing of the organic matters of sewage into mineral matter.

Table 14.—Wesley City. July 5—Nov. 29. Total solids 493, soluble solids 438, suspended solids 55, Free ammonia 4.36, albuminoid ammonia 3.20, nitrogen as nitrites 0.026, nitrogen as nitrates 0.106, oxygen consumed 17.44, chlorine 34.97. The increase in all the above constituents, especially the free ammonia, albuminoid ammonia and oxygen consumed, shows that a large amount of organic matter has been added to river between Peoria Narrows and Wesley City, a distance of only about six miles. This adition from my knowledge of the river is from the town of Peoria, 50,000 inhabitants, with its large cattle sheds and distilleries.

12046 Table 15.—Pekin. July 18th—Nov. 30th. Total solids 419,
soluble solids 393.0, suspended solids 26, Free ammonia
1.39, albuminoid ammonia 0.828, nitrogen as nitrites 0.273, nitrogen as nitrates 0.71, oxygen consumed 7.81, chlorine 34.76.

The distance to Pekin from Wesley City is about ten miles, yet in this stretch a great amount of purification seem to have taken place much more than I should have expected. This is shown by the very great decrease in free and albuminoid ammonia, oxygen consumed, and increase in nitrites and nitrates. There is no marked dilution as shown by the amount of chlorine.

Table 16.—Havana. July 6th—Dec. 14th. Total solids 432, soluble solids 381, suspended solids 51, Free ammonia 1.69, albuminoid ammonia 0.695, nitrogen as nitrites 0.21, nitrogen as nitrates 1.02, oxygen consumed 7.18, chlorine 29.17. The distance

from Wesley City to Havana is about 24 miles. Between the two places is a dam, known as Copperas Creek dam and a stream known as Mackinaw Creek enters the river. The samples were taken above Spoon River. There appears by the chlorine figure some dilution between Pekin and Havana. There is a slight increase in the free ammonia and in the nitrogen as nitrates, while the nitrogen as nitrites is slightly lower. We see here,
12047 as at Peoria Narrows the final changes of organic matter
into mineral matter taking place.

Table 26.—Grafton. July 10—Nov. 28. Total solids 362, soluble solids 306, suspended solids 56, Free ammonia 0.247, albuminoid ammonia 0.455, nitrogen as nitrites 0.044, nitrogen as nitrates 0.59, oxygen consumed 5.61, chlorine 17.5.

The distance from Havana to Grafton is 119 miles. There is a dam between Grafton and Havana and the water of the river is diluted by the Spoon and Sangamon Rivers, both of which enter the Illinois between Havana and Grafton. The water at Grafton, as shown by the analyses, has been so purified between Havana and Grafton that it now closely resembles the water at Peoria Narrows. It shows only in the chlorine and nitrogen as nitrates evidence of part pollution.

Table 21.—Grafton on the Mississippi, July 10—Nov. 20. Samples taken above the junction with the Illinois. Total solids 278, soluble solids 169, suspended solids 109. Free ammonia 0.08, albuminoid ammonia 0.443, nitrogen as nitrites 0.001, nitrogen as nitrates 0.03, oxygen consumed 8.52, chlorine 1.77. The river differs greatly from the Illinois in the amount of chlorine it contains, 177 against 17.5, and while it contains a less amount of solid substances in solution than the Illinois, it contains a greater amount of suspended matter. The amount of or-
12048 ganic nitrogenous matter and carbonaceous matter in the
two rivers is about the same, as shown by the albuminoid ammonia and oxygen consumed.

12049 I have also prepared tables from the results of Professor
Long's analyses at the various stations from Chicago to Grafton, from June to October, 1900, and they are as follows:

Table 41—Chicago City water, June 5—Sept. 4, 1900.
12050 Total solids 148, soluble solids 148, suspended none. Free
ammonia 0.016, albuminoid ammonia 0.094, nitrogen as ni-

trites none, nitrogen as nitrates trace, oxygen consumed 2.93, chlorine 2.17. Four analyses in June, five in July, four in August and one in September. These analyses would indicate that the water was not quite as pure in 1899 as 1900, but are results that would be obtained with a potable water.

Table 43.—*Western Avenue Bridge*, Drainage Canal, June 5—Sept. 4. Total solids 203, soluble solids 178, suspended solids 25, Free ammonia 1.34, albuminoid ammonia 0.95, nitrogen as nitrites 0.11, nitrogen as nitrates 0.12, oxygen consumed 6.28, chlorine 9.2.. If this is compared with the analyses of the water in the Illinois and Michigan canal in 1899 at Bridgeport it is seen that it is a very much more dilute sewage, or sewage mixed with a much larger amount of water.

Table 44.—Lockport Canal, June 4—Sept. 4. Total solids 212, soluble solids 193, suspended solids 19, Free ammonia 2.16, albuminoid ammonia 0.76, nitrogen as nitrites 0.06, nitrogen as nitrates, 0.00, oxygen consumed 5.29, chlorine 12.6. This analysis when taken in connection with table 43, as I have already pointed out, shows that the dilute sewage has undergone
12051 very decided changes in its passage through the canal.

Table 45.—Joliet, Desplaines River, June 4—Oct. 1. Total solids 280, soluble solids 245, suspended solids 35, Free ammonia 4.66, albuminoid ammonia 0.85, nitrogen as nitrites 0.09, nitrogen as nitrates 0.02, oxygen consumed 6.97, chlorine 31.4. This analysis shows that the water is not as pure as it been up there, but when compared with the analyses made in 1899, shows that it contains very much less organic matter than it did at that time.

Table 46.—Morris. June 4—Oct. 3. Total solids 251, soluble solids 222, suspended solids 29, Free ammonia 2.84, albuminoid ammonia 0.63, nitrogen as nitrites 0.27, nitrogen as nitrates 0.17, oxygen consumed 6.4, chlorine 17.8. The dilution by the waters of the Kankakee is here shown by the chlorine as in 1899. The water is very much purer than in 1899.

Table 47.—Ottawa, June 4—Oct. 16. Total solids 266, soluble solids 238, suspended solids 28, Free ammonia 0.81, albuminoid ammonia 0.39, nitrogen as nitrites 0.37, nitrogen as nitrates 0.92, oxygen consumed 5.94, chlorine 17.2. There has been even more marked purification of the water in its run of

24 miles in 1900 than 1899, as shown by the reduction of free albuminoid ammonia, and oxygen consumed, and by increase of nitrites and nitrates.

12052 That there has been little if any dilution is shown by the chlorine. The water is much purer than in 1899.

Table 49.—La Salle. June 4—Oct. 3. Total solids 278, soluble solids 252, suspended solids 26, Free ammonia 0.55, albuminoid ammonia 0.36, nitrogen as nitrites 0.25, nitrogen as nitrates 0.77, oxygen consumed 5.6, chlorine 15.8. The purification which was noted at Ottawa has continued. The chlorine shows the effect of slight dilution. River much purer than in 1899.

Table 51.—Henry, June 7—Oct. 1. Total solids 283, soluble solids 248, suspended solids 35, Free ammonia 0.41, albuminoid ammonia 0.4, nitrogen as nitrites 0.22, nitrogen as nitrates 1.06, oxygen consumed 5.86, chlorine 16.9. The results similar to those obtained in 1899, the slight increase in chlorine, indicates the addition of the sewage of La Salle and Peru. Slight changes as regards organic matter. River purer than in 1899.

Table 52.— Peoria Narrows, table 52, June 7—Oct. 9. Total solids 265, soluble solids 244, suspended solids 21, Free ammonia 0.21, albuminoid ammonia 0.34, nitrogen as nitrites 0.12, nitrogen as nitrates 0.95, oxygen consumed 5.05, chlorine 15.5 The change
as was the case in 1899, is the decrease in free ammonia,
12053 albuminoid ammonia and nitrogen as nitrites. Water much
purer than in 1899.

Table 53.—Wesley City, May 30—Oct. 10. Total solids 333, soluble solids 262, suspended solids 71, Free ammonia 1.62, albuminoid ammonia 1.34, nitrogen as nitrites 0.11, nitrogen as nitrates 0.72, oxygen consumed 9.91, chlorine 16.6. The analyses show the addition of the sewage of Peoria.

Table 54.—Pekin, May 30—Sept. 12. Total solids 326, soluble solids 250, suspended solids 76, Free ammonia 0.39, albuminoid ammonia 0.46, nitrogen as nitrites 0.17, nitrogen as nitrates 0.74, oxygen consumed 7.01, chlorine 15. As in 1899, a great amount of purification seems to have taken place between Wesley City and Pekin, a distance of 9 miles. River much purer than in 1899.

Table 55.—Havana, June 7 to Oct. 10. Total solids 322,

soluble solids 245, suspended solids 77, Free ammonia 0.41, albuminoid ammonia 0.41, nitrogen as nitrites 0.18, nitrogen as nitrates 0.77, oxygen consumed 6.46, chlorine 15. We have here in the 24 miles similar results to 1899, a very slight increase in free ammonia and in nitrates, and a slight decrease in albuminoid ammonia. Mackinaw Creek enters the river above
12054 Havana.

Table 58.—Grafton, June 7 to Sept. 24. Total solids 331, soluble solids 243, suspended solids 88, Free ammonia 0.07, albuminoid ammonia 0.36, nitrogen as nitrites 0.03, nitrogen as nitrates 0.87, oxygen consumed 5.85, chlorine 10.6. The water between Havana and Grafton has been so purified that the nitrates and chlorine are the only indications of the pollution of the river at Peoria.

12055 Table 59. Grafton on Mississippi River, July 31—Sept. 24. Total solids 347, soluble solids 152, suspended solids 195, Free ammonia 0.07, albuminoid ammonia 0.54, nitrogen as nitrites 0.02, nitrogen as nitrates 0.03, oxygen consumed 11.73, chlorine 2. The great difference in the Mississippi at Grafton from the Illinois at Grafton in 1900, as in 1899, was in the amount of chlorine 2 against 10.6, and in the suspended matter. The Mississippi, as shown by the albuminoid ammonia, and oxygen consumed contained in 1900 more organic matter than the Illinois in 1900 and figures for oxygen consumed show a greater amount of organic matter both in solution and suspension.

The data are, oxygen consumed.

	Total	Soluble	Suspended
Mississippi	11.73	7.08	4.65
Illinois	5.85	4.82	1.03

Q. Have you prepared any table from the chemical and
12056 bacterial analysis of Professors Jordan, Palmer, Burrill and Zeit, as they appear in Streams Examinations, which have been introduced in evidence in this case, and the tables of Professor Long as they appear in the Board of Health report of the State of Illinois, which also have been introduced in evidence in this case?

A. I have.

Q. Will you state in a general way the method employed by you in preparing the table which will subsequently be introduced in evidence by you at its proper time from the chemical and bacterial analysis of Professors Jordan, Palmer, Burril and Zeit?

A. Yes sir. The general method was to obtain the mean of the average of the analyses made by these various named persons during given periods of examination, as given in Streams Examination and the report of the State Board of Health of Illinois for 1901, which tables have already been introduced in evidence, and during times which were comparable with each other.

Q. In the examination of these tables did you strike an average for similar periods in different years of the analyses whose tables have already been introduced in evidence? 12057

A. I did.

Q. And where that method was not pursued your tables show it?

A. My tables show it.

Q. Have you prepared a table from the analytical data of Professor Jordan and Professor Palmer from May to January, 1899, and from January to May, 1900?

A. I have. I have prepared tables 41 to 52, inclusive, which are the mean of Jordan's and Palmer's results, May to December, inclusive, 1899.

Q. Will you produce and read the table prepared by you and as above described?

A. The tables are as follows, numbered 41 to 52, both inclusive

12058

TABLE 41.—ILLINOIS RIVER, 1899.

Illinois River.—Joliet, N. of Jackson St., 1899.

Mean of Jordan's and Palmer's Results, May-December,.

	Parts per Million.
Total Solids	564.9
Soluble Solids	482.2
Suspended Solids	82.7
Total Oxygen Consumed	26.9
Soluble Oxygen Consumed	15.3
Suspended Oxygen Consumed	11.6
Chlorine	105.2
Free Ammonia	14.81
Albuminoid Ammonia	2.15
Nitrogen as Nitrites	0.006
Nitrogen as Nitrates	0.16
Bacteria per cubic centimeter	1,164,240

Jordan's S. E. 1901, Table 84, May 4-Dec. 26.
Palmer's S. E. 1901, Table 4, May 23-Dec. 26.
S. E.—Streams Examination.

12059

TABLE 42.

Illinois River.—Morris, 1899.

Mean of Jordan s and Palmer's Results for May-December.

	Parts per Million.
Total Solids	411.8
Soluble Solids	387.6
Suspended Solids	16.7
Total Oxygen Consumed	14.0
Soluble Oxygen Consumed	10.5
Suspended Oxygen Consumed	3.5
Chlorine	66.9
Free Ammonia	9.11
Albuminoid Ammonia	0.88
Nitrogen as Nitrites	0.025
Nitrogen as Nitrates	0.42
Bacteria per cubic centimeter	1,015,214

Jordan's S. E. 1901, Table 87, May 29-Dec. 26.
Palmer's S. E. 1901, Table 7, May 29-Dec. 26.

12060

TABLE 43.

Illinois River.—Ottawa, 1899.

Mean of Jordan's and Palmer's results for June—Dec.

	Parts per million.
Total solids	395.5
Soluble solids	380.2
Suspended solids	15.3
Total Oxygen Consumed	10.1
Soluble Oxygen Consumed	9.0
Suspended Oxygen Consumed	1.3
Chlorine	58.9
Free Ammonia	4.58
Albuminoid Ammonia	0.50
Nitrogen as Nitrites	0.43
Nitrogen as Nitrates	1.30
Bacteria per cubic centimeter	39,080

Jordan's S. E. 1901, Table 89, June 19—Dec. 28.
Palmer's S. E. 1901, Table 9, June 19—Dec. 28.

12061

TABLE 44.

Illinois River.—LaSalle, 1899.

Mean of Jordan's and Palmer's results, May—Dec.

	Parts per million.
Total Solids	413.0
Soluble Solids	368.7
Suspended Solids	44.3
Total Oxygen Consumed	11.0
Soluble Oxygen Consumed	8.9
Suspended Oxygen Consumed	2.1
Chlorine	46.7
Free ammonia	2.70
Albuminoid Ammonia	0.49
Nitrogen as Nitrites	0.36
Nitrogen as Nitrates	1.71
Bacteria per cubic centimeter	17,412

Jordan's S. E. 1901, Table 92, May 24—Dec. 26.
Palmer's S. E. 1901, Table 12, May 5—Dec. 26.

12062

TABLE 45.

Illinois River.—Henry, 1899.

Mean of Jordan's and Palmer's Results, May-Dec.

	Parts per Million.
Total Solids	401.1
Soluble Solids	366.6
Suspended Solids	34.5
Total Oxygen Consumed	11.0
Soluble Oxygen Consumed	8.7
Suspended Oxygen Consumed	2.3
Chlorine	45.7
Free Ammonia	2.08
Albuminoid Ammonia	0.57
Nitrogen as Nitrites	0.28
Nitrogen as Nitrates	1.43
Bacteria per cubic centimeter	19,863

Jordan's S. E. 1901, Table 93, May 30-Dec. 27.
Palmer's S. E. 1901, Table 13, May 30-Dec. 19.

12063

TABLE 46.

Illinois River.—Averyville, 1899.

Mean of Jordan's and Palmer's results, May—Dec.

	Parts per million.
Total Solids	388.9
Soluble Solids	359.9
Suspendid Solids	29,0
Total Oxygen Consumed	9.8
Soluble Oxygen Consumed	8.2
Suspended Oxygen Consumed	1.6
Chlorine	41.0
Free Ammonia	0.97
Albuminoid Ammonia	0.47
Nitrogen as Nitrites	0.27
Nitrogen as Nitrates	1.45
Bacteria per cubic centimeter	4,756

Jordan's S. E. 1901, Table 94, May 30—December 26.
Palmer's S. E. 1901, Table 14, May 1—December 26.

12064

TABLE 47.

Illinois River.—Wesley City, 1899.

Mean of Jordan's and Palmer's Results, May-Dec.

	Parts per Million.
Total Solids	445.5
Soluble Solids	360.9
Suspended Solids	84.6
Total Oxygen Consumed	11.2
Soluble Oxygen Consumed	8.8
Suspended Oxygen Consumed	2.4
Chlorine	42.2
Free Ammonia	1.30
Albuminoid Ammonia	0.66
Nitrogen as Nitrites	0.288
Nitrogen as Nitrates	1.38
Bacteria per cubic centimeter	996,503

Jordan's S. E. 1901, Table 95, May 29-Dec. 28.
Palmer's S. E. 1901, Table 15, May 29-Dec. 28.

12065

TABLE 48.

Illinois River.—Pekin, 1899.

Mean of Jordan's and Palmer's Results, May-Dec.

	Parts per Million.
Total Solids	390.1
Soluble Solids	357.3
Suspended Solids	32.8
Total Oxygen Consumed	10.8
Soluble Oxygen Consumed	8.6
Suspended Oxygen Consumed	2.2
Chlorine	39.8
Free Ammonia	1.16
Albuminoid Ammonia	0.64
Nitrogen as Nitrites	0.262
Nitrogen as Nitrates	1.33
Bacteria per cubic centimeter	722,682

Jordan's S. E. 1901, Table 96, May 24-Dec. 28.
Palmer's S. E. 1901, Table 16, May 24-Dec. 28.

12066

TABLE 49.

Illinois River.—Havana, 1899.

Mean of Jordan's and Palmer's Results, May-Dec.

	Parts per Million.
Total Solids	388.4
Soluble Solids	343.8
Suspended Solids	44.6
Total Oxygen Consumed	10.3
Soluble Oxygen Consumed	8.2
Suspended Oxygen Consumed	2.1
Chlorine	36.0
Free Ammonia	1.21
Albuminoid Ammonia	0.54
Nitrogen as Nitrites	0.21
Nitrogen as Nitrates	0.99
Bacteria per cubic centimeter	43,892

Jordan's S. E. 1901, Table 97, May 30-Dec. 20.
Palmer's S. E. 1901, Table 17, May 2-Dec. 30.

12067

TABLE 50.

Illinois River.—Beardstown, 1899.

Mean of Jordan's and Palmer's results, May—Dec.

	Parts per million.
Total Solids	384.5
Soluble Solids	322.4
Suspended Solids	62.1
Total Oxygen Consumed	8.9
Soluble Oxygen Consumed	7.1
Suspended Oxygen Consumed	1.8
Chlorine	29.8
Free Ammonia	0.96
Albuminoid Ammonia	0.48
Nitrogen as Nitrites	0.149
Nitrogen Nitrates	0.94
Bacteria per cubic centimeter	19,922

Jordan's S. E. 1901, Table 99, May 24—Dec. 28.
Palmer's S. E. 1901, Table 19, May 24—Dec. 28.

12068

TABLE 51.

Illinois River.—Kampsville, 1899.

Mean of Jordan's and Palmer's results, May—Dec.

	Parts per million.
Total Solids	375.9
Soluble Solids	289.2
Suspended Solids	86.7
Total Oxygen Consumed	8.9
Soluble Oxygen Consumed	6.7
Suspended Oxygen Consumed	2.1
Chlorine	21.5
Free Ammonia	0.28
Albuminoid Ammonia	0.41
Nitrogen as Nitrites	.064
Nitrogen as Nitrates	0.56
Bacteria per cubic centimeter	7,457

Jordan's S. E. 1901, Table 100, May 31—Dec. 20.
Palmer's S. E. 1901, Table 20, May 2—Dec. 20.

12069

TABLE 52.

Illinois River.--Grafton, 1899.

Mean of Jordan's and Palmer's results, May—Dec.

	Parts per million.
Total Solids	411.3
Soluble Solids	329.9
Suspended Solids	81.4
Total Oxygen Consumed	8.8
Soluble Oxygen Consumed	6.9
Suspended Oxygen Consumed	1.9
Chlorine	18.4
Free Ammonia	0.23
Albuminoid Ammonia	0.40
Nitrogen as Nitrites	0.047
Nitrogen as Nitrates	0.89
Bacteria per cubic centimeter	9,402

Jordan's S. E. 1901, Table 101, May 10—Dec. 27.
Palmer's S. E. 1901, Table 21, May 3—Dec. 27.

Q. Will you please state how these tables were prepared?

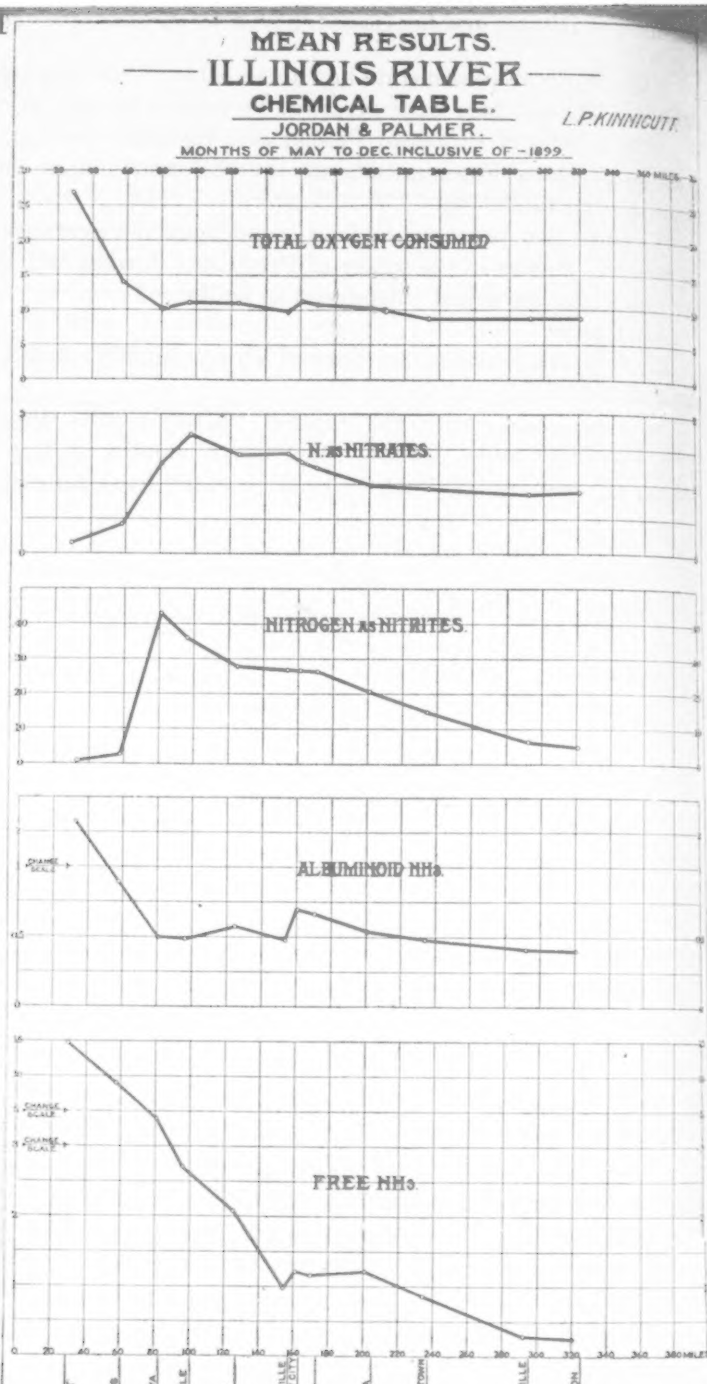
12070 A. These tables were prepared by taking the average of the results of Professor Palmer and Professor Jordan, as given in Streams Examination, at the different places mentioned in each table.

Q. Have you prepared a chart based upon the averages of the chemical results in the tables of Professors Jordan and Palmer which you have just introduced in evidence?

A. I have.

Q. Will you produce the chart which you have prepared, as above stated?

A. The chart, with the caption "Mean results Illinois River, Chemical table, Jordan and Palmer, months of May to December, inclusive, of 1899, L. P. Kinnicutt" is as follows:


MEAN RESULTS.
ILLINOIS RIVER
CHEMICAL TABLE.
JORDAN & PALMER.
MONTHS OF MAY TO DEC. INCLUSIVE OF 1899.
L.P. KINNICUTT.
TOTAL OXYGEN CONSUMED
N. AS NITRATES.
NITROGEN AS NITRITES.
ALBUMINOID NH3.
CHANGE SCALE
FREE NH3.
CHANGE SCALE
CHANGE SCALE
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380 MILES
JOLIET
MORRIS
OTTAWA
LA SALLE
HENRY
AVERYVILLE
WESLEY CITY
PEKIN
HAVANA
BEARDSTOWN
KAMPSVILLE
GRAFTON

Q. Will you state what the chart you have just introduced 12072 in evidence shows?

A. The chart that I have just introduced in evidence shows the amount of free ammonia, shows the amount of nitrogen as free ammonia, albuminoid ammonia, nitrogen as nitrites, nitrogen as nitrates and oxygen consumed as shown by the mean of the analyses taken at Joliet, north of Jackson Street on the Desplaines River, at Morris; at Ottawa; at LaSalle; at Henry; at Averyville; at Wesley City and Pekin; at Havana; at Beardstown; at Kampsville and at Grafton on the Illinois River, from May to December, inclusive, 1899, the mean results of Professors Palmer and Jordan. The abscisse gives the distance in miles of the various places from Chicago. The co-ordinates the part per million of the various substances.

Q. What sanitary significance do you draw from the chart just introduced?

A. At Joliet the high free ammonia, the high albuminoid ammonia the high oxygen consumed, the low nitrites and low nitrates show that at this point we have a water very badly polluted by organic matter or sewage. The rapid decrease in the amount of ammonia, free ammonia and albuminoid ammonia, and the oxygen consumed, from Joliet to Morris, and at the same 12073 time the increase in nitrogen as nitrites and nitrates shows the amount of purification that has taken place between these places. The most active zone of decomposition seems to be in the neighborhood of Ottawa. This is shown not only by the falling curves denoting free albuminoid ammonia and oxygen consumed but by the rising curves denoting nitrogen as nitrites and nitrates, the nitrite curve reaching its maximum at this point. As we proceed down the river from Ottawa to La Salle the curve shows continued purification. The slight fall in the curve from nitrogen as nitrates being due to the removal of nitrates from the water by green plant life. From La Salle to Henry the curve for the free ammonia and nitrogen as nitrites still descend. The slight rise in the curve for albuminoid ammonia and oxygen consumed indicates a slight addition of organic matter to the water of the river between La Salle and Henry. Below La Salle the purification continues down to

Averyville as shown by the gradual decrease of free and albuminoid ammonia, nitrogen consumed and nitrogen as nitrites.

At Averyville the chart shows, as was shown by Professor Long's table, the result of the final change of the organic 12074 to inorganic matter; low free ammonia; low free albuminoid ammonia; low nitrogen consumed with high nitrates. The results obtained by Long at Averyville from July 5th to November 25th, agree closely with the mean of Jordan's and Palmer's results from May to December, as is shown in the following table:

	Palmer—Jordan.	Long.
Total solids	388.9	422.0
Soluble solids	359.9	398.0
Suspended solids	29.0	24
Total oxygen consumed	9.8	6.86
Soluble oxygen consumed	8.2	5.46
Suspended oxygen consumed	1.6	1.2
Chlorine	41	33
Free ammonia	.97	.734
Albuminoid ammonia	.47	.47
Nitrogen as nitrites	.27	.141
Nitrogen as nitrates	1.45	1.1

Long's figures changed to nitrogen.

From Averyville to Wesley City we notice the effect of 12075 the contamination at Peoria by the rise in free ammonia, albuminoid ammonia, oxygen consumed and the decrease in nitrites and nitrates.

Jordan's and Palmer's results show less effect from this contamination than do Professor Long's analysis. This may be due to the possibility that at the point where Professor Long collected his samples, there may not have been complete mixing of the sewage of Peoria with the river water, or that where Palmer and Jordan's samples were taken there was not a complete mixing of the river water with the sewage.

Between Wasley City and Pekin the purification again begins and this purification is continued all the way down to Grafton where the low albuminoid ammonia, low nitrogen as nitrites, low oxygen consumed, shows the removal of the polluted matter entering the river at Peoria. If we again compare the results of Professor Long with the mean of Professor Jordan and Palmer we find a close agreement as regards the condition of the water at Grafton.

	Jordan and Palmer May to Dec., 1899.	Long July 10 to Nov. 28, 1899.
Total solids	411.3	362
Soluble solids	329.9	306
Suspended solids	81.4	56
12076 Total oxygen consumed	8.8	5.61
Soluble oxygen consumed	6.9	4.6
Suspended Oxygen consumed	1.9	.96
Chlorine	30.4	17.5
Free ammonia	.23	.20
Albuminoid ammonia	.40	.37
Nitrogen as nitrites	.047	.044
Nitrogen as nitrates	.89	.59

ADJOURNED until 2:00 P. M. of same day.

2:00 P. M. March 15th, 1904.

12077 Continuation pursuant to adjournment.

Present: The Commissioner and same counsel representing the respective parties.

LEONARD P. KINNICUTT,

resumed the stand for further examination by Mr. Todd, and testified as follows:

Q. Have you prepared tables based upon chemical analyses of Professors Jordan and Palmer, for the months from January to June, inclusive, for 1900?

A. I have.

Q. Were those tables prepared in the same manner as the tables already introduced in evidence by you?

A. They were.

Q. Will you please produce and read the tables which you have prepared?

A. The tables that I have prepared are numbered from 53 to 64 inclusive, and are as follows:

12078 TABLE 53.—ILLINOIS RIVER, 1900.

Illinois River.—Joliet, N. of Jackson St., 1900.

Mean of Jordan's and Palmer's results, Jan.—June.

	Parts per million.
Total Solids	296.6
Soluble Solids	261.2
Suspended Solids	35.4
Total Oxygen Consumed	11.6
Soluble Oxygen Consumed	7.9
Suspended Oxygen Consumed	3.7
Chlorine	37.9
Free Ammonia	3.09
Albuminoid Ammonia	0.85
Nitrogen as Nitrites	0.028
Nitrogen as Nitrates	0.20
Bacteria per cubic centimeter	11,642

Jordan's S. E. 1901, Table 124, Jan. 2—June 25.
Palmer's S. E. 1901, Table 44, Jan. 2—June 25.
S. E.—Streams Examination.

12079 TABLE 54.

Illinois River.—Morris, 1900.

Mean of Jordan's and Palmer's results, Jan.—June.

	Parts per million.
Total Solids	310.0
Soluble Solids	245.6
Suspended Solids	65.8
Total Oxygen Consumed	10.7
Soluble Oxygen Consumed	7.3
Suspended Oxygen Consumed	3.5
Chlorine	24.9
Free Ammonia	2.51
Albuminoid Ammonia	0.63
Nitrogen as Nitrites	0.078
Nitrogen as Nitrates	0.63
Bacteria per cubic centimeter	710,980

Jordan's S. E. 1901, Table 127, Jan. 5—June 26.
Palmer's S. E. 1901, Table 46, Jan. 5—June 26.

12080

TABLE 55.

Illinois River.—Ottawa, 1900.

Mean of Jordan's and Palmer's results, January—June.

	Parts per million.
Total Solids	317.4
Soluble Solids	291.7
Suspended Solids	25.7
Total Oxygen Consumed	9.2
Soluble Oxygen Consumed	7.5
Suspended Oxygen Consumed	1.7
Chlorine	16.6
Free Ammonia	1.51
Albuminoid Ammonia	0.44
Nitrogen as Nitrites	0.176
Nitrogen as Nitrates	1.33
Bacteria per cubic centimeter	111,169

Jordan's S. E. 1901, Table 129, January 4—June 25.
Palmer's S. E. 1901, Table 48, January 4—June 25.

12081

TABLE 56.

Illinois River.—LaSalle, 1900

Mean of Jordan's and Palmer's results, January—June.

	Parts per million.
Total Solids	307.2
Soluble Solids	249.3
Suspended Solids	57.9
Total Oxygen Consumed	10.3
Soluble Oxygen Consumed	7.5
Suspended Oxygen Consumed	2.8
Chlorine	18.6
Free Ammonia	1.06
Albuminoid Ammonia	0.43
Nitrogen as Nitrites	0.098
Nitrogen as Nitrates	1.33
Bacteria per cubic centimeter	120,577

Jordan's S. E. 1901, Table 131, January 2—June 26.
Palmer's S. E. 1901, Table 50, January 2—June 26.

12082

TABLE 57.

Illinois River.—Henry, 1900.

Mean of Jordan's and Palmer's Results, Jan.-June.

	Parts per Million.
Total Solids	303.1
Soluble Solids	248.4
Suspended Solids	54.7
Total Oxygen Consumed	9.9
Soluble Oxygen Consumed	7.6
Suspended Oxygen Consumed	2.3
Chlorine	13.6
Free Ammonia	0.86
Albuminoid Ammonia	0.40
Nitrogen as Nitrites	0.09
Nitrogen as Nitrates	1.19
Bacteria per cubic centimeter	65,987

Jordan's S. E. 1901, Table 133, Jan. 3-June 25.
Palmer's S. E. 1901, Table 52, Jan. 9-June 25.

12083

TABLE 58.

Illinois River.—Averyville, 1900.

Mean of Jordan's and Palmer's Results, Jan.-June.

	Parts per Million.
Total Solids	302.7
Soluble Solids	248.3
Suspended Solids	52.4
Total Oxygen Consumed	9.2
Soluble Oxygen Consumed	7.3
Suspended Oxygen Consumed	2.0
Chlorine	13.8
Free Ammonia	0.80
Albuminoid Ammonia	0.37
Nitrogen as Nitrites	0.082
Nitrogen as Nitrates	1.48
Bacteria per cubic centimeter	46,313

Jordan's S. E. 1901, Table 134, Jan. 2-June 26.
Palmer's S. E. 1901, Table 53, Jan. 2-June 26.

12084

TABLE 59.

Illinois River.—Wesley City, 1900.

Mean of Jordan's and Palmer's Results, Jan.-June.

	Parts per Million.
Total Solids	343.9
Soluble Solids	246.3
Suspended Solids	97.6
Total Oxygen Consumed	10.2
Soluble Oxygen Consumed	7.1
Suspended Oxygen Consumed	3.1
Chlorine	13.2
Free Ammonia	0.66
Albuminoid Ammonia	0.42
Nitrogen as Nitrites	0.068
Nitrogen as Nitrates	1.28
Bacteria per cubic centimeter	60,240

Jordan's S. E. 1901, Table 135, Jan. 5-June 27.
Palmer's S. E. 1901, Table 54, Jan. 5-June 27.

12085

TABLE 60.

Illinois River.—Pekin, 1900.

Mean of Jordan's and Palmer's Results, Jan.-June.

	Parts per Million.
Total Solids	346.6
Soluble Solids	242.9
Suspended Solids	94.6
Total Oxygen Consumed	9.2
Soluble Oxygen Consumed	6.1
Suspended Oxygen Consumed	3.1
Chlorine	13.0
Free Ammonia	0.76
Albuminoid Ammonia	0.44
Nitrogen as Nitrites	0.054
Nitrogen as Nitrates	1.29
Bacteria per cubic centimeter	86,731

Jordan's S. E. 1901, Table 136, Jan. 11-June 27.
Palmer's S. E. 1901, Table 55, Jan. 5-June 27.

12086

TABLE 61.

Illinois River.—Havana, 1900.

Mean of Jordan's and Palmer's results, Jan.—June.

	Parts per million.
Total Solids	313.1
Soluble Solids	237.3
Suspended Solids	74.8
Total Oxygen Consumed	9.2
Soluble Oxygen Consumed	7.1
Suspended Oxygen Consumed	2.1
Chlorine	11.4
Free Ammonia	0.68
Albuminoid Ammonia	0.40
Nitrogen as Nitrites	0.056
Nitrogen as Nitrates	1.00
Bacteria per cubic centimeter	51,840

Jordan's S. E. 1901, Table 137, Jan. 11—June 27.
Palmer's S. E. 1901, Table 56, Jan. 11—June 11.

12087

TABLE 62.

Illinois River.—Beardstown, 1900.

Mean of Jordan's and Palmer's results, Jan.—June.

	Parts per million.
Total Solids	443.0
Soluble Solids	265.3
Suspended Solids	100.2
Total Oxygen Consumed	12.1
Soluble Oxygen Consumed	6.9
Suspended Oxygen Consumed	5.2
Chlorine	11.4
Free Ammonia	0.68
Albuminoid Ammonia	0.43
Nitrogen as Nitrites	0.074
Nitrogen as Nitrates	1.98
Bacteria per cubic centimeter	82,775

Jordan's S. E. 1901, Table 139, Jan. 4—June 28.
Palmer's S. E. 1901, Table 58. Jan. 4—June 28.

12088

TABLE 63.

Illinois River.—Kampsville, 1900.

Mean of Jordan's and Palmer's results, January—June.

	Parts per million.
Total Solids	405.3
Soluble Solids	232.4
Suspended Solids	263.2
Total Oxygen Consumed	11.0
Soluble Oxygen Consumed	6.5
Suspended Oxygen Consumed	4.4
Chlorine	11.1
Free Ammonia	0.60
Albuminoid Ammonia	0.45
Nitrogen as Nitrites	.039
Nitrogen as Nitrates	1.18
Bacteria per cubic centimeter	40,781

Jordan's S. E. 1901, Table 140, January 3—June 27.
Palmer's S. E. 1901, Table 59, January 3—June 27.

12089

TABLE 64.

Illinois River.—Grafton, 1900.

Mean of Jordan's and Palmer's results, January—June.

	Parts per million.
Total Solids	496.9
Soluble Solids	234.9
Suspended Solids	260.5
Total Oxygen Consumed	11.1
Soluble Oxygen Consumed	6.4
Suspended Oxygen Consumed	4.6
Chlorine	10.4
Free Ammonia	0.48
Albuminoid Ammonia	0.43
Nitrogen as Nitrites	0.027
Nitrogen as Nitrates	1.29
Bacteria per cubic centimeter	45,960

Jordan's S. E. 1901, Table 141, January 4—June 29.
Palmer's S. E. 1901, Table 62, January 4—June 25.

Q. Have you prepared a chart based upon the chemical results of Jordan and Palmer as they appear in the tables just introduced? 12090

A. I have prepared such a chart from the tables just introduced.

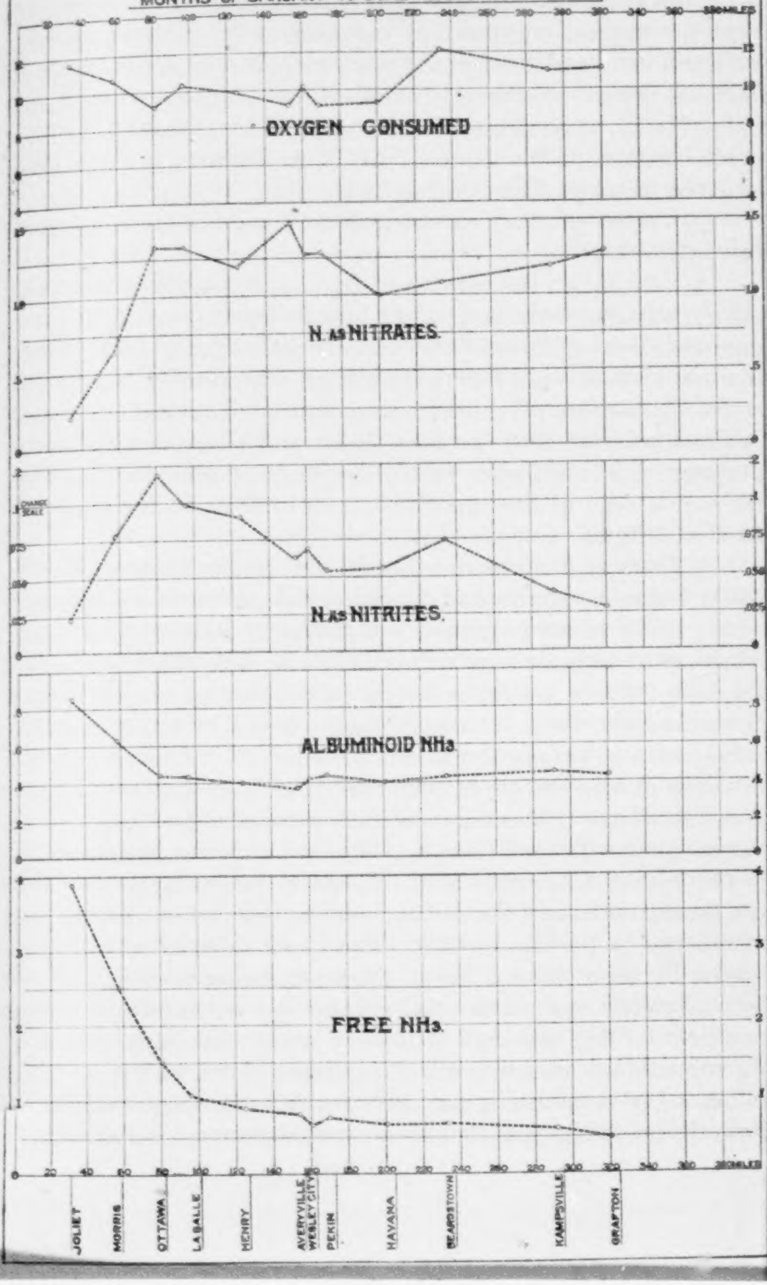
Q. Will you produce and make a part of your testimony such chart?

A. Such chart, with the Caption, "Mean results Illinois River Chemical Table, Jordan and Palmer, Months January to June inclusive, 1900, L. P. Kinnicutt," is as follows:

MEAN RESULTS.
ILLINOIS RIVER
CHEMICAL TABLE.
JORDAN & PALMER.

L.P. KINNICUTT.

MONTHS OF JANUARY TO JUNE INCLUSIVE OF 1900.



Q. Will you state what the chart shows?

12092 A. Chart 2 shows the amount of free ammonia, albuminoid ammonia, nitrogen of nitrites, nitrogen of nitrates, and oxygen consumed, as shown by the mean of the analyses made by Prof. Palmer, and Jordan, of samples taken at Joliet north of Jackson street on the Desplaines River, Morris, Ottawa, La Salle, Henry, Averyville, Wesley City, Pekin, Havana, Beardstown, Grafton, on the Illinois river, from January to June, 1900, as given in tables 53 to 64, inclusive.

Q. What sanitary conclusions do you draw from the chart just introduced?

A. At Joliet, the amount of free ammonia, albuminoid ammonia, oxygen consumed, is not half as great as in 1899, showing much less pollution of the water in 1900 than in 1899. There is, as in 1900, a rapid fall in the curves representing the amount of free ammonia, albuminoid ammonia, and oxygen consumed, in the stretch of river between Joliet and Ottawa, with corresponding rise in nitrogen as nitrites and nitrates, showing that the active zone of decomposition is as in 1899, in the neighborhood of Ottawa.

There is a slight increase in the oxygen consumed curve

12093 between Ottawa and La Salle. The albuminoid ammonia curve remaining nearly stationary, indicating a slight addition of organic matter to the water between Ottawa and La Salle. There is then a steady elimination of organic matter from the river down to Averyville, as shown by the gradual decrease of the curves for free ammonia, albuminoid ammonia, nitrogen as nitrites, oxygen consumed, with an increase of nitrogen as nitrates. The curve of free ammonia does not rise between Averyville and Wesley City, but the rise is noticed between Wesley City and Pekin. This may be due to the fact that the decomposition of the nitrogenous matter did not begin quite as quickly in 1900 as in 1899. The slight delay, a delay represented by about nine miles on the river, being probably caused by the lower temperature of the water in the winter and spring months of 1900, and it is also to be noted that the increase in the albuminoid ammonia curve continues down to Pekin, while in 1899 the decrease began between Wesley City and Pekin. From Pekin to Havana, there is a gradual decrease in the organic

nitrogenous matter, as shown by the free ammonia and albuminoid ammonia curve. From Havana to Kampsville the
12094 free and albuminoid ammonia increased very slightly and then decreased to Grafton. The nitrogenous nitrites and the oxygen consumed also rise slightly from Havana to Beardstown, then decrease between Beardstown and Grafton. The nitrogen as nitrites increased continuouslly from Havana to Grafton. The purification of the River from Havana to Grafton is indicated on the curves by the gradual increasing amount of nitrogen as nitrates. The decrease in free ammonia and albuminoid ammonia not being so evident on account of spring thaws and freshets.

Q. Taking the two charts which you have introduced, in consideration, the first for the months from May to December, inclusive, of '99, the second from January to June, inclusive, 1900, based upon the chemical results of Jordan and Palmer, as hereinbefore named by you, what sanitary conclusions do you draw from the comparison of the results as they appear upon these two charts?

A. The curves on the chart representing the river from June to January, '99, closely resemble the curves given
12095 on the chart representing the river from January to June, 1900, showing that the general character of the purification that took place is the same for the two years, the small differences being chiefly due to the effect of dilution and to seasonable variations that take place in the river. Both charts show by the rapid decrease of free ammonia, albuminoid ammonia and oxygen consumed, and increase of nitrogen as nitrites and nitrates, the purification that takes place between Joliet and Ottawa, in both years, and that the zone of the most active decomposition of organic matter has not been shoved, or been pushed further down the river by the increasing volume of the river, due to the opening of the Sanitary Canal. The purification is then shown to continue in both years as the river flows to Averyville, as shown by the decrease in the free ammonia, albuminoid ammonia, oxygen consumed and nitrogen as nitrites. The chart for June to January, '99, shows by the slight increase in albuminoid ammonia and oxygen consumed between La Salle and Henry that a certain amount of organic matter enters the

river at this point, but the continued decrease of free ammonia and nitrogen as nitrites indicates that it is either not very 12096 large in amount, or of a character not easily decomposed.

In both periods between La Salle and Henry, the nitrogen as nitrites shows a slight decrease, the nitrogen as nitrates also decreasing. The decrease of nitrogen as nitrates at this point is probably due to algae or green plant life. Between Henry and Averyville, the nitrogen as nitrites still decreasing, the nitrogen as nitrates shows an increase more marked between January and June, 1900, than between June and January, 1899. The reason for less increase in nitrogen as nitrates between Henry and Averyville between June and January than between January and June, is due to the larger amount of green plant life living in river waters in the summer and autumn months, than in the winter and spring months. The rise in free ammonia, albuminoid ammonia, and oxygen consumed, between Averyville and Wesley City show the pollution which enters the river between these two points in both years, which is removed in both years, as shown by the decrease in these substances as the river flows downward to Grafton. The river in both years, as shown by the curves, purifies itself again between Wesley City 12097 and Grafton, as it did between Joliet and Averyville.

The slight rise in free and albuminoid ammonia between Beardstown and Kampsville from January to June, 1900, is probably due to seasonal variations, as the river and pond waters contain more free albuminoid ammonia in the winter and spring than at any other time. In the lower stretches of the river in 1899 we find by the charts decreasing nitrites and nitrates; in the chart for 1900, we find, however, that while the nitrites decrease, the nitrates increase. This difference in nitrates in the lower stretches of the river is due to green plant life. This green plant life being more abundant in the summer and autumn months of 1899 than in the winter and spring months of 1900, removed, therefore, the nitrates to a much larger extent in 1899 than in 1900.

Q. Have you prepared a chart based upon the bacterial tables of Professors Burrill and Jordan, for the months of May and December, inclusive, for 1899?

A. I have.

Q. Will you produce and make a part of your evidence the chart thus prepared?

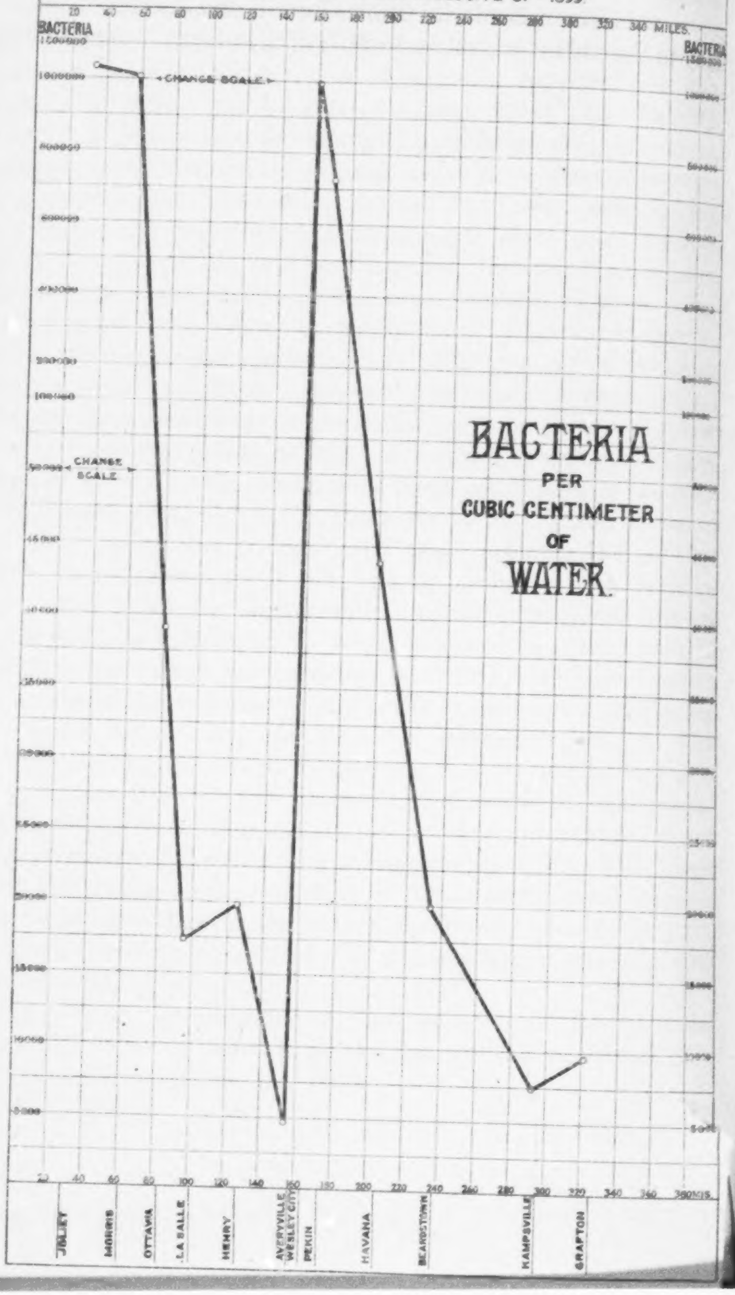
12098 A. The chart with the caption, "Mean Results, Illinois River, Bacterial Table, Burrill and Jordan, months of May to December, inclusive, 1899, L. P. Kinnicutt," is as follows:

12099

MEAN RESULTS.
ILLINOIS RIVER
BACTERIAL TABLE.
BURRILL & JORDAN.

L.P. KINNICUTT.

MONTHS OF MAY TO DEC. INCLUSIVE OF – 1899.



12100 Q. Will you state what the chart you have just introduced in evidence, shows?

A. This chart shows the number of bacteria as given by the mean of the analyses of Professors Burrill and Jordan of samples taken at Joliet, north of Jackson street, on the Desplaines, at Morris, at Ottawa, at La Salle, at Henry, at Averyville, at Wesley City, at Pekin, at Havana, at Beardstown, at Kampsville and at Grafton on the Illinois River from January to June, 1899. The abscissae give the distance in miles of various places from Chicago, the co-ordinates, the number of bacteria in one cubic centimeter of water.

Q. Will you state what sanitary conclusions you draw from the chart which you have just introduced in evidence?

A. The study of this chart, in connection with the chart for the chemical data of the same period, show a striking agreement between the chemical and bacterial data. The bacteria, which number over 1,000,000 per cc. at Joliet, decrease very rapidly to La Salle. In this distance, of about 62 miles, the number
has fallen from 1,000,000 to 17,412 per cc. This shows,
12101 as did the chemical results, that the zone of the great-
est purification is near Ottawa. There is a slight rise in the number of bacteria of only 2,000 per cubic centimeter between La Salle and Henry, a rise coinstant with the rise for albuminoid ammonia in the chemical chart for the same period. From this point the number falls steadily until Averyville is reached, the number there being 4,756 per cubic centimeter. Then on account of the pollution entering the river at Peoria, the number rises immediately to 995,503. This sudden rise in the number of the bacteria shows how quickly sewage pollution can be detected by bacterial examination. From this point the number of bacteria rapidly falls and at Kampsville there are only 7,457 per cubic centimeter, showing the great amount of purification that has taken place between Wesley City and Kampsville. Between Kampsville and Grafton there has been, as was the case between La Salle and Henry, a very slight increase in the number of bacteria, 2,005 per cubic centimeter. This increase is not at all significant, as a slight increase at this
point, after the rapid decrease between Wesley City and
12102 Kampsville is absolutely without significance as regards
the problem of stream purification.

Q. Have you prepared a chart based upon the bacterial tables which you have prepared from Burril and Jordan's tables, and which you have already introduced, for the months of January to June, inclusive, 1900?

A. I have.

Q. Will you produce the chart which you have thus prepared, making it a part of this evidence?

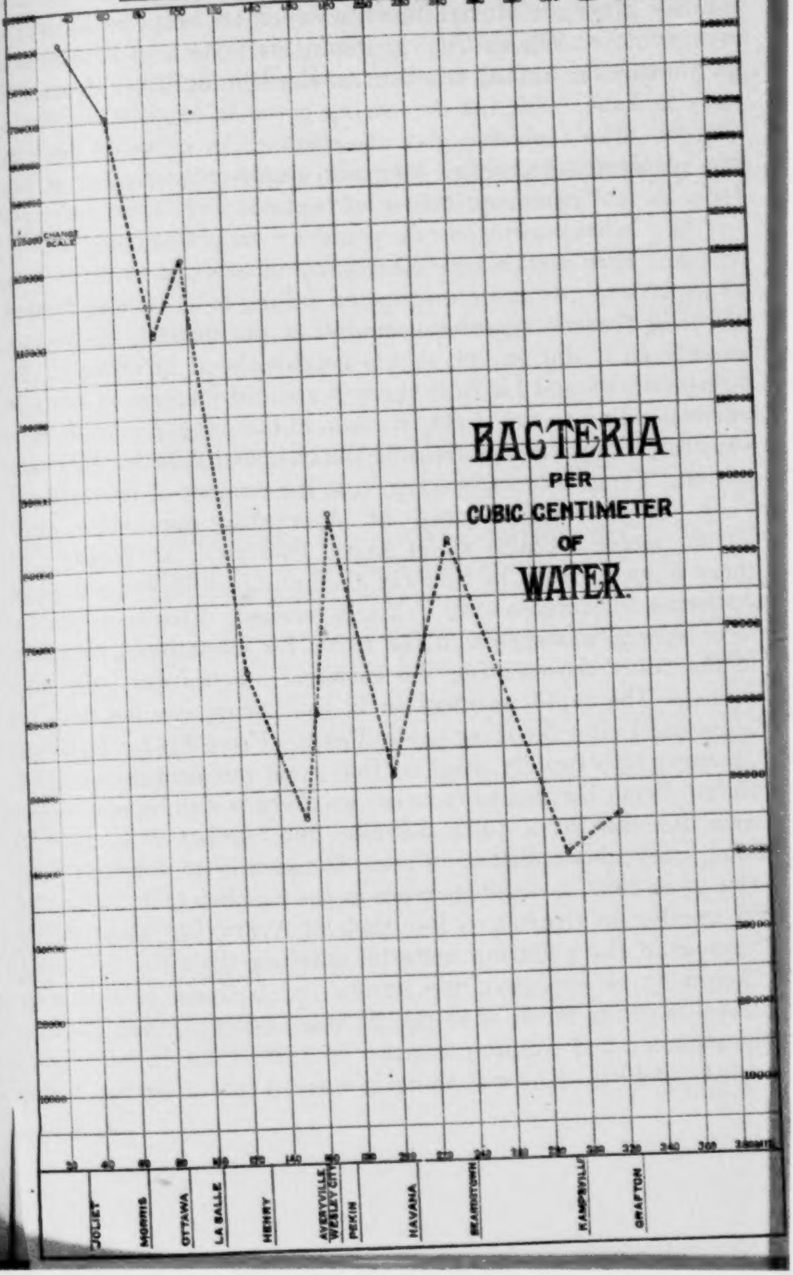
A. The chart with the caption, "Mean Results, Illinois River, Bacterial Tables, Burrill and Jordan, Months, January to June, inclusive, 1900, L. P. Kinnicutt, is as follows:

MEAN RESULTS.
ILLINOIS RIVER
BACTERIAL TABLE.

BURRILL & JORDAN.

L.P. KINNICUTT.

MONTHS OF JANUARY TO JUNE INCLUSIVE OF 1900.



12104 Q. Will you state what this chart shows?

A. This chart shows the number of bacteria as given by the mean of the analyses of Professors Burrill and Jordan, of samples taken at Joliet, north of Jackson street on the Desplaines River, at Morris, at Ottawa, at La Salle, at Henry, at Averyville, at Wesley City, at Pekin, at Havana, at Beardstown, at Kampsville, and at Grafton, on the Illinois River, from January to June, 1900, the data being given in tables 53 to 64, inclusive. The abscissae give the distance in miles of the various places from Chicago, the co-ordinates the number of bacteria in one cubic centimeter of water.

Q. What conclusions do you draw from this chart?

A. This chart shows the amount of bacteria at Joliet to be about 900,000 per cubic centimeter, falling to 110,000 at Ottawa, showing that the greatest amount of purification took place, exactly as it did in '99, in the neighborhood of Ottawa. Between Ottawa and La Salle there is a slight increase in bacteria, corresponding to the slight increase in the oxygen consumed, as shown in the chart representing the chemical data for this same period. From Ottawa to Averyville the number of bacteria rapidly decreases until at Averyville one cubic centi-
12105 meter contains about 45,000 bacteria. At Wesley City there is an increase in bacteria amounting to 60,000 and which continues to increase until Pekin is reached. This increase, due to pollution, was shown in the curve for albuminoid ammonia, in the chart representing the chemical curves for the same period. The rapid purification in the spring months does not begin until after the river passes Pekin. From Pekin to Havana the curve falls rapidly, showing that great purification has taken place. From Havana to Beardstown there is an increase in bacteria, followed by a quick decrease, the number at Kampsville being only about 40,000. From Kampsville to Grafton there was, as in 1899, a slight increase in the number of bacteria, but the number at Grafton is less than at Averyville, showing the removal of the polluting material entering the river at Peoria. As was to be expected, the number of bacteria in the lower stretches of the river, as shown by this curve, is greater during the summer and autumn months of 1899, than in the spring months of 1900. The soil bacteria washed into a stream during

the late winter and early spring months, always increases largely the number of bacteria in a river during that period.

12106 Q. Have you prepared tables showing comparisons of the sanitary character of the tributaries of the Illinois River, based upon the chemical results at their mouth, with the Illinois river, at Grafton, based upon the tables of Professors Jordan and Palmer, for the months of June to December, inclusive, 1899?

A. I have

Q. Were those tables prepared in the same manner with the other tables you have introduced in evidence?

A. They were, sir.

Q. Will you produce and read the tables which you have thus prepared

A. The tables are as follows, numbered from 65 to 72, inclusive.

12107

TABLE 65.–TRIBUTARIES TO THE ILLINOIS RIVER.

Desplaines River, 1899, *Lockport.*

Mean of Jordan's and Palmer's results for June–Dec.

	Parts per million
Total Solids	370.9
Soluble Solids	354.3
Suspended Solids.	16.6
Total Oxygen Consumed	11.0
Soluble Oxygen Consumed	9.5
Suspended Oxygen Consumed	1.5
Chlorine	8.18
Free Ammonia	0.074
Albuminoid Ammonia	0.459
Nitrogen as Nitrites	0.000
Nitrogen as Nitrates	0.228
Bacteria per cubic centimeter	14,382

Jordan's S. E. 1901, Table 83, June 5–Dec. 26.
Palmer's S. E. 1901, Table 3, June 5–Dec. 26.
S. E.–Streams examination.

TABLE 66.

12108 TRIBUTARIES TO THE ILLINOIS RIVER.

Kankakee River, Wilmington, 1899.

Mean of Jordan's and Palmer's results, June—Dec.

	Parts per million
Total Solids	303.0
Soluble Solids	269.9
Suspended Solids	33.1
Total Oxygen Consumed	9.8
Soluble Oxygen Consumed	8.1
Suspended Oxygen Consumed	1.7
Chlorine	3.6
Free Ammonia	0.05
Albuminoid Ammonia	0.302
Nitrogen as Nitrites	0.01
Nitrogen as Nitrates	0.909
Bacteria per cubic centimeter	8,691

Jordan's S. E. 1901, Table 86, June 5—Dec. 28.
Palmer's S. E. 1901, Table 6, June 5—Dec. 26.

12109 TABLE 67.—TRIBUTARIES TO THE ILLINOIS RIVER.

Fox River at Ottawa, 1899.

Mean of Jordan's and Palmer's Results, June-December.

	Parts per Million.
Total Solids	344.9
Soluble Solids	296.7
Suspended Solids	48.2
Total Oxygen Consumed	9.1
Soluble Oxygen Consumed	7.1
Suspended Oxygen Consumed	2.0
Chlorine	5.4
Free Ammonia	0.06
Albuminoid Ammonia	0.463
Nitrogen as Nitrites	0.009
Nitrogen as Nitrates	0.356
Bacteria per cubic centimeter	6,294

Jordan's S. E. 1901, Table 88, June 5-December 28.
Palmer's S. E. 1901, Table 8, June 5-December 28.

12110 TABLE 68.—TRIBUTARIES TO THE ILLINOIS RIVER.

Big Vermillion River, LaSalle, 1899.

Mean of Jordan's and Palmer's Results, June-December.

	Parts per Million.
Total Solids	1009.8
Soluble Solids	975.0
Suspended Solids	34.8
Total Oxygen Consumed	5.6
Soluble Oxygen Consumed	4.2
Suspended Oxygen Consumed:	1.4
Chlorine	63.0
Free Ammonia	0.23
Albuminoid Ammonia	0.245
Nitrogen as Nitrites	0.019
Nitrogen as Nitrates	0.707
Bacteria per cubic centimeter	7,511

Jordan's S. E. 1901, Table 90, June 6-December 26.
Palmer's S. E. 1901, Table 10, June 6-December 21.

12111 TABLE 69.—TRIBUTARIES TO THE ILLINOIS RIVER.

Sangamon River, Chandlerville, 1899.

Mean of Jordan's and Palmer's results, June—December.

	Parts per million.
Total Solids	343.1
Soluble Solids	274.0
Suspended Solids	69.1
Total Oxygen Consumed	6.4
Soluble Oxygen Consumed	4.2
Suspended Oxygen Consumed	2.2
Chlorine	5.0
Free Ammonia	0.08
Albuminoid Ammonia	0.25
Nitrogen as Nitrites	0.121
Nitrogen as Nitrates	0.61
Bacteria per cubic centimeter	8,083

Jordan's S. E. 1901. Table 98, June 7—December 20.
Palmer's S. E. 1901, Table 18, June 7—December 20.

12112 TABLE 70.—TRIBUTARIES TO THE ILLINOIS RIVER.

Mississippi River, Grafton, 1899.

Mean of Jordan's and Palmer's results, June—December.

	Parts per million.
Total Solids	304.6
Soluble Solids	100.1
Suspended Solids	204.5
Total Oxygen Consumed	13.8
Soluble Oxygen Consumed	9.5
Suspended Oxygen Consumed	4.3
Chlorine	2.7
Free Ammonia	0.05
Albuminoid Ammonia	0.180
Nitrogen as Nitrites	0.007
Nitrogen as Nitrates	0.298
Bacteria per cubic centimeter	5,044

Jordan's S. E. 1901, Table 102, June 7—December 27.
Palmer's S. E. 1901, Table 22, June 7—December 20.

12113 TABLE 71.—TRIBUTARIES TO THE ILLINOIS RIVER.

Missouri at Alton, 1899.

Mean of Jordan's and Palmer's Results, June-December.

	Parts per Million.
Total Solids	1204.5
Soluble Solids	290.9
Suspended Solids	914.6
Total Oxygen Consumed	11.3
Soluble Oxygen Consumed	3.6
Suspended Oxygen Consumed	7.7
Chlorine	15.1
Free Ammonia	0.08
Albuminoid Ammonia	0.430
Nitrogen as Nitrites	0.004
Nitrogen as Nitrates	0.303
Bacteria per cubic centimeter	15,996

Jordan's S. E. 1901, Table 112, July 27-Dec. 28.
Palmer's S. E. 1901, Table 32, July 10-Dec. 28.

12114 TABLE 72.—TRIBUTARIES TO THE ILLINOIS RIVER.

Illinois River, Grafton, 1899.

Mean of Jordan's and Palmer's Results, June-December.

	Parts per Million.
Total Solids	361.7
Soluble Solids	279.3
Suspended Solids	82.4
Total Oxygen Consumed	8.8
Soluble Oxygen Consumed	6.8
Suspended Oxygen Consumed	2.0
Chlorine	18.4
Free Ammonia	0.23
Albuminoid Ammonia	0.401
Nitrogen as Nitrites	0.047
Nitrogen as Nitrates	0.89
Bacteria per cubic centimeter	9,463

Jordan's S. E. 1901, Table 101, June 7-Dec. 27.
Palmer's S. E. 1901, Table 21, June 7-Dec. 27.

12115 Q. Have you prepared a chart based upon the tables which you have just introduced?

A. I have.

Q. Will you produce the chart and make it a part of your evidence in this case?

A. The chart with the caption, "Mean Results, Comparison of the Sanitary Character of the Tributaries of the Illinois River at their mouths with the Illinois River at Grafton—Professors Jordan and Palmer, Months of June to December, inclusive, 1899," is as follows:

MEAN RESULTS.

COMPARISON OF THE SANITARY CHARACTER
OF THE TRIBUTARIES OF THE

ILLINOIS RIVER

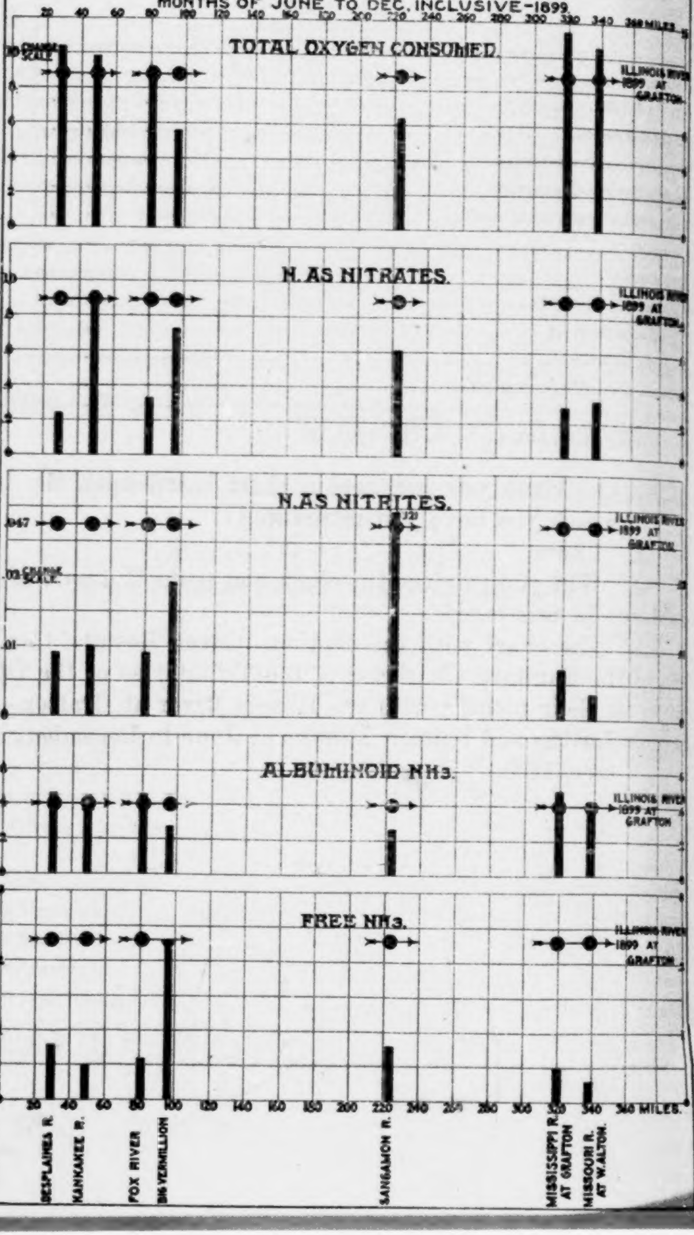
AT THEIR MOUTHS WITH THE ILLINOIS RIVER
AT

GRAFTON.

JORDAN & PALMER.

L.P. KINNICUTT.

MONTHS OF JUNE TO DEC. INCLUSIVE-1899.



12117 Q. Will you please explain the construction of the chart just introduced, and what it shows?

A. In this chart the amounts of free ammonia, albuminoid ammonia, nitrogen as nitrites and nitrogen as nitrates, total oxygen consumed, as found at the mouths of the Desplaines, Kankakee, Fox,. Big Vermillion, the Sangamon, the Mississippi river at Grafton, and the Missouri River at West Alton, are represented by columns, the top of the column representing the amount of the various chemical substances that I have just named in these various rivers. On this chart is also given by means of arrows the amount of free ammonia, albuminoid ammonia, nitrogen as nitrites, nitrogen as nitrates, total oxygen consumed at the mouth of the Illinois river, at Grafton, being the mean results of Prof. Jordan and Palmer's examination during the months of June to December, 1899, inclusive.

Q. What sanitary conclusions do you draw from the chart which you have just introduced, and the construction of which you have just explained?

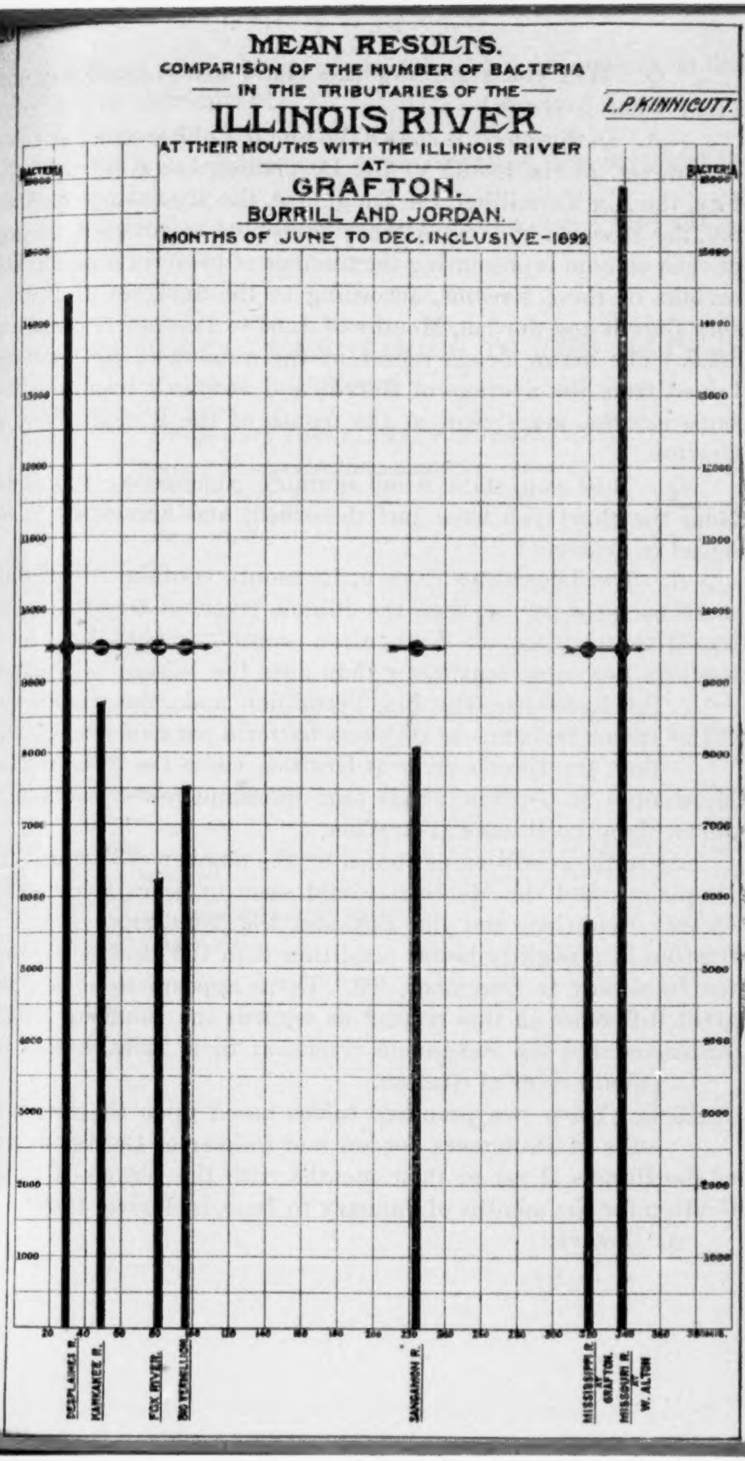
A. The chart requires very little explanation, as it is seen by the eye, that the waters of the Desplaines, the Kan-
12118 kakee, the Fox at their mouths, the Mississippi at Grafton, the Missouri at West Alton, contained in 1899 as much or more albuminoid ammonia and oxygen consumed than the Illinois at Grafton. The higher nitrogen as nitrates in the Illinois river, shows that the Illinois river at Grafton contained at one time higher up on the stream more organic matter, which has undergone decomposition, than did the other rivers. The free ammonia and nitrogen as nitrites is slightly higher in the Illinois at Grafton than in these other streams mentioned, with the exception of the Sangamon, but the amount in the Illinois is low, about 0.23 parts free ammonia and 0.047 parts nitrogen as nitrites, and is without any particular significance. As regards the purity of these streams, as shown by chemical charts and data, and by these curves, I should say that the waters of these various rivers were about in the same condition in 1899 as the Illinois river at its mouth, with the exception of the Missouri River at West Alton, which contains more organic matter.

Q. Have you prepared a bacterial chart from the same tables which you have just introduced, based upon the results of Professors Burrill and Jordan, for the months of June to December, inclusive, 1899?

12119 A. I have.

Q. Will you produce the chart thus prepared and make it a part of your testimony?

A. The chart with the Caption, "Mean Results, comparison of the number of bacteria in the tributaries of the Illinois river at their mouths, with the Illinois River, at Grafton, Burrill and Jordan, Months of June to December, inclusive, 1899, L. P. Kinnicutt," is as follows:



MEAN RESULTS.

COMPARISON OF THE NUMBER OF BACTERIA
IN THE TRIBUTARIES OF THE

ILLINOIS RIVER

AT THEIR MOUTHS WITH THE ILLINOIS RIVER
AT

GRAFTON.

BURRILL AND JORDAN.

MONTHS OF JUNE TO DEC. INCLUSIVE-1899.

L.P. KINNICUTT.

Q. Will you state how this chart was constructed, and
12121 what it shows?

A. In this chart is shown the number of bacteria per cubic centimeter, at the mouth of the Desplaines, the Kankakee, the Fox, the Big Vermillion, the Sangamon, the Mississippi at Grafton, the Missouri at West Alton, represented by columns, the top of each column representing the number of bacteria found at the mouths of these streams, according to the analyses of Professors Burrill and Jordan, Months of June to December, inclusive, 1899. The arrow heads represent the number of bacteria obtained from the average of Burrill and Jordan's results of the same months, same year, at the mouth of the Illinois river, at Grafton.

Q. Will you state what sanitary conclusions you draw from the chart you have just described, and heretofore introduced in evidence?

A. The Desplaines river at its mouth contains about 6000 more bacteria per cc. than the Illinois river, at Grafton, while the Missouri river, at West Alton, contains about 7000 more bacteria per cubic centimeter than does the Illinois at Grafton, the Kankakee, the Big Vermillion and the Sangamon
12122 rivers, from one to 2000 less bacteria per cubic centimeter than the Illinois river at Grafton, while the Fox, and the Mississippi at Grafton, about four thousand fewer bacteria to the cc. than the Illinois at Grafton.

As to the condition as shown by the number of bacteria, the Desplaines and the Missouri would seem to be in a less satisfactory condition, and the Fox and the Mississippi rivers at Grafton in a slightly better condition than the Illinois at Grafton from May to December, '99. There appears to be not any great difference in this respect as regards the condition of the Kankakee and the Sangamon rivers, at their mouths, and the Illinois river at Grafton.

12123 Q. Have you prepared tables based upon the mean results of Professors Jordan and Palmer of the tributaries of the Illinois River at their mouths with the Illinois River at Grafton for the months of January to June, inclusive, 1900?

A. I have.

Q. These tables were prepared in the same manner as the other tables introduced?

A. They were.

Q. Will you produce and read the tables thus prepared in evidence?

A. The tables are numbered 73 to 80, inclusive, and are as follows:

1212½ TABLE 73.—TRIBUTARIES TO THE ILLINOIS RIVER.

Desplaines River, 1900, *Lockport.*

Mean of Jordan's and Palmer's results, Jan.—June.

	Parts per million.
Total Solids	357.1
Soluble Solids	326.3
Suspended Solids	30.8
Total Oxygen Consumed	10.3
Soluble Oxygen Consumed	8.3
Suspended Oxygen Consumed	2.0
Chlorine	6.59
Free Ammonia	0.156
Albuminoid Ammonia	0.403
Nitrogen as Nitrites	0.012
Nitrogen as Nitrates	0.498
Bacteria per cubic centimeter	32,444

Jordan's S. E. 1901, Table 123, April 16—June 25.
Palmer's S. E. 1901, Table 42, Jan. 2—June 26.
S. E. Streams Examination.

12125 TABLE 74.—TRIBUTARIES TO THE ILLINOIS RIVER.

Kankakee River, Wilmington, 1900.

Mean of Jordan's and Palmer's results, Jan.—June.

	Parts per million.
Total Solids	340.9
Soluble Solids	260.5
Suspended Solids	80.4
Total Oxygen Consumed	10.3
Soluble Oxygen Consumed	7.7
Suspended Oxygen Consumed	2.6
Chlorine	3.12
Free Ammonia	0.347
Albuminoid Ammonia	0.364
Nitrogen as Nitrites	0.004
Nitrogen as Nitrates	2.17
Bacteria per cubic centimeter	22,236

Jordan's S. E. 1901, Table 126, Jan. 2—June 23.
Palmer's S. E. 1901, Table 45, Jan. 1—June 25.

12126 TABLE 75.—TRIBUTARIES TO THE ILLINOIS RIVER.

Fox River, 1900, *Ottawa*.

Mean of Jordan's and Palmer's results, January—June.

	Parts per million.
Total Solids	325.1
Soluble Solids	261.3
Suspended Solids	63.8
Total Oxygen Consumed	9.5
Soluble Oxygen Consumed	7.3
Suspended Oxygen Consumed	2.2
Chlorine	4.46
Free Ammonia	0.129
Albuminoid Ammonia	0.424
Nitrogen as Nitrites	0.012
Nitrogen as Nitrates	0.457
Bacteria per cubic centimeter	26,515

Jordan's S. E. 1901, Table 128, January 4—June 25.
Palmer's S. E. 1901, Table 47, January 4—June 25.

12127 TABLE 76.—TRIBUTARIES TO THE ILLINOIS RIVER.

Big Vermillion River, 1900, *LaSalle.*

Mean of Jordan's and Palmer's results, January—June.

	Parts per million.
Total Solids	446.7
Soluble Solids	356.3
Suspended Solids	90.4
Total Oxygen Consumed	7.3
Soluble Oxygen Consumed	4.5
Suspended Oxygen Consumed	2.8
Chlorine	10.40
Free Ammonia	0.104
Albuminoid Ammonia	0.274
Nitrogen as Nitrites	0.033
Nitrogen as Nitrates	2.51
Bacteria per cubic centimeter	27,724

Jordan's S. E. 1901, Table 130, January 2—June 26.
Palmer's S. E. 1901, Table 49, January 2—June 26.

12128 TABLE 77.—TRIBUTARIES TO THE ILLINOIS RIVER.

Sangamon River, Chandlerville, 1900.

Mean of Jordan's and Palmer's results, Jan.—June.

	Parts per million.
Total Solids	404.5
Soluble Solids	259.5
Suspended Solids	145.0
Total Oxygen Consumed	8.9
Soluble Oxygen Consumed	4.3
Suspended Oxygen Consumed	4.6
Chlorine	4.92
Free Ammonia	0.10
Albuminoid Ammonia	0.32
Nitrogen as Nitrites	0.023
Nitrogen as Nitrates	1.72
Bacteria per cubic centimeter	32,357

Jordan's S. E. 1901, Table 138, Jan. 3—June 27.
Palmer's S. E. 1901, Table 57, Jan. 3—June 27.

12129 TABLE 78.—TRIBUTARIES TO THE ILLINOIS RIVER.

Mississippi River, Grafton, 1900.

Mean of Jordan's and Palmer's results, Jan.—June.

	Parts per million.
Total Solids	413.9
Soluble Solids	152.0
Suspended Solids	261.9
Total Oxygen Consumed	14.1
Soluble Oxygen Consumed	8.2
Suspended Oxygen Consumed	5.9
Chlorine	4.49
Free Ammonia	0.121
Albuminoid Ammonia	0.511
Nitrogen as Nitrites	0.007
Nitrogen as Nitrates	0.38
Bacteria per cubic centimeter	41,108

Jordan's S. E. 1901, Table 142, Jan. 4—June 29.
Palmer's S. E. 1901, Table 63, Jan. 4—June 25.

12130 TABLE 79.—TRIBUTARIES TO THE ILLINOIS RIVER.

Missouri at Alton, 1900.

Mean of Jordan's and Palmer's Results, June-December.

	Parts per Million.
Total Solids	1737.4
Soluble Solids	289.3
Suspended Solids	1448.1
Total Oxygen Consumed	15.3
Soluble Oxygen Consumed	4.3
Suspended Oxygen Consumed	11.0
Chlorine	16.0
Free Ammonia	0.068
Albuminoid Ammonia	0.587
Nitrogen as Nitrites	0.008
Nitrogen as Nitrates	0.62
Bacteria per cubic centimeter	64,630

Jordan's S. E. 1901, Table 152, Jan. 4 June 27.
Palmer's S. E. 1901, Table 73, Jan. 4-June 27.

12131

TABLE 80.—TRIBUTARIES TO THE ILLINOIS RIVER.

Illinois River, Grafton, 1900.

Mean of Jordan's and Palmer's Results, January-June.

	Parts per Million.
Total Solids	496.9
Soluble Solids	234.9
Suspended Solids	262.0
Total Oxygen Consumed	11.1
Soluble Oxygen Consumed	6.4
Suspended Oxygen Consumed	4.7
Chlorine	10.4
Free Ammonia	0.519
Albuminoid Ammonia	0.436
Nitrogen as Nitrites	0.027
Nitrogen as Nitrates	1.29
Bacteria per cubic centimeter	48,891

Jordan's S. E. 1901, Table 141, Jan. 4-June 29.
Palmer's S. E. 1901, Table 62, Jan. 4-June 25.

Q. Have you prepared a chart based upon the tables just introduced? 12132

A. I have.

Q. Will you produce and make the chart to which you refer a part of your testimony?

A. The chart, with the caption, "Mean results comparison of the sanitary character of the tributaries of the Illinois River at their mouths with the Illinois River at Grafton, Jordan and Palmer, months January to June, inclusive, 1900, L. P. Kinnicutt" is as follows:

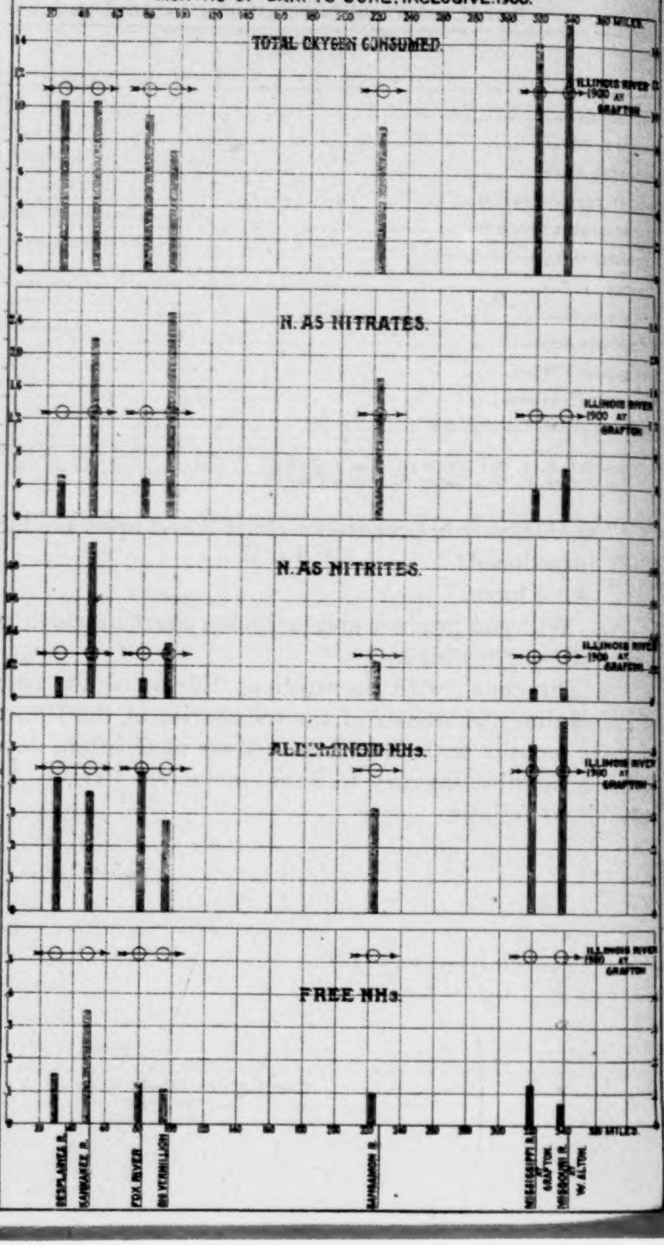
MEAN RESULTS.

COMPARISON OF THE SANITARY CHARACTER
OF THE TRIBUTARIES OF THE

ILLINOIS RIVER

AT THEIR MOUTHS WITH THE ILLINOIS RIVER
AT
GRAFTON.
JORDAN AND PALMER.
MONTHS OF JAN. TO JUNE, INCLUSIVE. 1900.

L. P. KINNICUTT.



Q. Will you state how this chart is constructed and what
12134 it shows?

A. This chart is prepared the same as the chart with the caption "Mean results, comparison of the sanitary character of the tributaries of the Illinois River at their mouths, with the Illinois River at Grafton, Jordan and Palmer, months June to December, inclusive, 1899, L. P. Kinnicutt."

Q. Will you state what sanitary conclusions you draw from the chart just introduced?

A. This chart shows that the Mississippi at Grafton and the Missouri at West Alton contained from January to June, 1900, more albuminoid ammonia and oxygen consumed than the Illinois River at Grafton, that the Desplaines, Kankakee and the Fox contained nearly the same amounts and the Big Vermillion and the Sangamon Rivers at their mouths less amounts. Or, in other words that the Mississippi at Grafton and the Missouri at West Alton contained more undecomposed organic matter than the Illinois at Grafton; that the Kankakee and the Fox contained about the same amounts and the Big Vermillion and the Sangamon less undecomposed organic matter. The free ammonia in all the streams is higher than in the autumn of 1899, but
12135 the relative ratios is not greatly changed, and in the autumn of 1899 as in the spring of 1900 the Illinois at Grafton contained more free ammonia than its tributaries. The nitrogen as nitrites is much less in the Illinois at Grafton in 1900 than in 1899, .027 parts against .047 parts, while the amount in the Mississippi, the Missouri, the Desplaines and the Big Vermillion is about the same in the two different parts of the year.

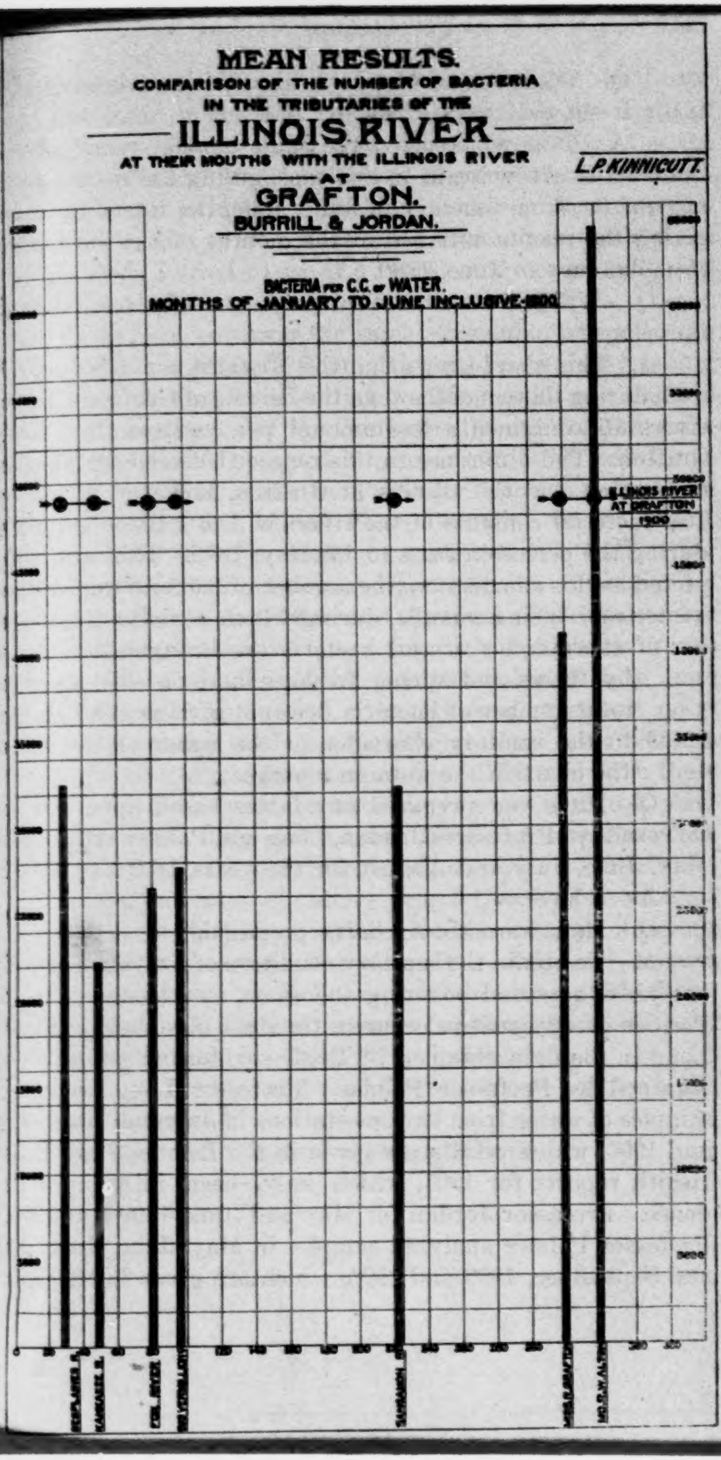
Q. Have you prepared charts comparing the number of bacteria in the tributaries of the Illinois river at their mouths with the Illinois River at Grafton, based upon the bacterial results of Burrill and Jordan for the months of January to June, inclusive, 1900, as they appear in the tables 73 to 80, inclusive, which have just previously been introduced in evidence?

A. I have.

Q. Will you produce the chart and make it a part of your testimony?

A. The chart, with the caption, "Mean results, comparison of the number of bacteria in the tributaries of the Illinois River

at their mouths with the Illinois River at Grafton, Burrill
12136 and Jordan, bacteria per cc. of water for the months of
January to June, inclusive, 1900, L. P. Kinnicutt," is as
follows:



MEAN RESULTS.
COMPARISON OF THE NUMBER OF BACTERIA
IN THE TRIBUTARIES OF THE
ILLINOIS RIVER
AT THEIR MOUTHS WITH THE ILLINOIS RIVER
AT
GRAFTON.
BURRILL & JORDAN.

L. P. KINNICUTT.

BACTERIA PER C.C. OF WATER.
MONTHS OF JANUARY TO JUNE INCLUSIVE-1900.

Q. Will you state how this chart is constructed and what
12138 it shows?

A. It is constructed the same as the second preceding chart. The arrow heads in this case, giving the results obtained at Grafton, from January to June, 1900, the top of the columns giving the results obtained at the mouths of the various rivers from January to June, 1900.

Q. Will you state what sanitary conclusions you draw from this chart?

A. This chart shows that the Missouri contained more bacteria during these months than the Illinois at Grafton. The other rivers all contained a less amount per cc. than the Illinois at Grafton. The difference in this respect between the Mississippi at Grafton and the Illinois at Grafton, however, is not great. The bacterial contents of the rivers is 3 to 4 times greater than during the period in June to January, 1899. This was to be expected as this chart shows the number of bacteria during the late winter and spring months, during which period a greater number of saprophytes or soil bacteria are brought into the river by thaws and spring freshets, and on this account the total number of bacteria does not give as good an idea as
12139 to the sanitary character of the water of the rivers as
the chart in the autumn months.

Q. Have you prepared any tables based upon the chemical results of Professors Jordan, Long and Palmer for the months May, June, July and August for the years 1899 and 1900?

A. I have.

Q. How were those charts prepared?

A. To obtain the sanitary condition of a river in two different years a period covering the same months must be taken. Periods of comparison occur in the data obtained by Professor Long in the data obtained by Professor Jordan and in the data obtained by Professor Palmer. Professor Long analyzed the samples of water from various stations in July and August, 1899, and 1900, which results are given in the Illinois State Board of Health reports for 1901, which have been introduced in evidence. Professor Jordan for May and June 1899 and 1900, and Professor Palmer analyzed samples in May, June, July, August and September, 1899 and 1900, which are given in Streams Ex-

amination which have been introduced in evidence. Professor Palmer has made tables and curves representing the state of the river in June, July, August and September, for the
12140 years 1899 and 1900, which set of curves have been introduced in evidence. Wishing, however, to also make a study of the same question, and to include as many analytical data as possible, I tried to see if a table could not be made out including the results obtained by all three observers, Long, Jordan and Palmer, covering the same seasonable period in the two years, 1899 and 1900. I found this could be done by taking the data given by Professor Jordan for May and June, 1899, in Streams Examination, and by Professor Palmer for the same months for 1899, and obtained the mean for May and June, 1899, taking the data given by Professor Long for July and August, 1899, from the Illinois State Board of Health report for 1901, tables 5 to 22, and the data of Professor Palmer for July and August, 1899, in Streams Examinations. I obtained a mean for July and August, 1899, and the mean of the two sets of data thus obtained gave the mean from which changes in the condition of the river during the months of June, July and August, 1899, could be studied. By the same process a mean could be obtained for studying the changes that took place in the months of May, June, July and August, 1900, and from these comparisons could be drawn between the changes that took place in May, June, July and August, 1899, and those that took
12141 place in May, June, July and August, 1900.

In acordance with the above description I have obtained the tables 1 to 24, inclusive, which give the mean of Jordan's Long's and Palmer's results for May, June, July and August, 1899, being tables 1 to 12, inclusive, and the mean of Professor Jordan's, Long's and Palmer's results for May, June, July and August, 1900, being tables 13 to 24, inclusive.

Q. Will you produce and read the tables that you have just described in evidence?

A. Tables 1 to 24, inclusive, are as follows:

12142 TABLE 1.—ILLINOIS RIVER, 1899.

Illinois River.—Joliet, N. of Jackson St., 1899.

Mean of Jördan's, Long's and Palmer's results, May, June, July and August.

	Parts per million.
Total Solids	560.0
Soluble Solids	483.5
Suspended Solids	76.5
Total Oxygen Consumed	32.4
Soluble Oxygen Consumed	19.8
Suspended Oxygen Consumed	12.6
Chlorine	86.8
Free Ammonia	12.06
Albuminoid Ammonia	2.34
Nitrogen as Nitrites	.095
Nitrogen as Nitrates	.15
Bacteria per cubic centimeter	1,374,320

Long's I. S. B. H. 1901, Table 5, July 3—August 28.
Jordan's S. E. 1901, Table 84, May 4—June 27.
Palmer's S. E. 1901, Table 4, May 24—June 27 and July 4, August 29.
I. S. B. H.—Illinois State Board of Health.
S. E.—Streams examinations.

12143 TABLE 2.

Illinois River.—Morris, 1899.

Mean of Jordan's, Long's and Palmer's results, May, June, July and August.

	Parts per million.
Total Solids	420.0
Soluble Solids	390.9
Suspended Solids	29.1
Total Oxygen Consumed	14.6
Soluble Oxygen Consumed	12.1
Suspended Oxygen Consumed	2.5
Chlorine	55.0
Free Ammonia	7.4
Albuminoid Ammonia	0.79
Nitrogen as Nitrites	0.175
Nitrogen as Nitrates	0.5
Bacteria per cubic centimeter	1,136,167

Long's I. S. B. H., 1901, Table 7, July 5—August 29.
Jordan's S. E., 1901, Table 87, June 3—June 27.
Palmer's S. E., 1901, Table 7, May 30—June 24, July 4—August 30.

12144

TABLE 3.

Illinois River.—Ottawa, 1899.

Mean of Jordan's, Long's and Palmer's results, May, June, July and August.

	Parts per million.
Total Solids	403.9
Soluble Solids	391.5
Suspended Solids	12.4
Total Oxygen Con4umed	12.2
Soluble Oxygen Consumed	11.1
Suspended Oxygen Consumed	1.1
Chlorine	43.5
Free Ammonia	3.1
Albuminoid Ammonia	0.57
Nitrogen as Nitrites	0.65
Nitrogen as Nitrates	1.01
Bacteria per cubic centimeter	19,426

Long's I. S. B. H. 1901, Table 8, July 5—Aug. 29.
Jordan's S. E., 1901, Table 89, June 20—June 27.
Palmer's S. E. 1901, Table 9, June 20—June 27, July 4, Aug. 29.

12145

TABLE 4.

Illinois River.—La Salle, 1899.

Mean of Jordan's, Long's and Palmer's results, May, June, July and August.

	Parts per million.
Total Solids	420.5
luble Solids	373.8
Suspended Solids	46.7
Total Oxygen Consumed	13.1
Soluble oxygen Consumed	10.5
Suspended Oxygen Consumed	2.6
Chlorine	34.5
Free Ammonia	1.6
Albuminoid Ammonia	0.54
Nitrogen as Nitrites	0.39
Nitrogen as Nitrates	1.61
Bacteria per cubic centimeter	17,388

Long's I. S. B. H. 1901, Table 10, July 13—Aug. 30.
Jordan's S. E. 1901, Table 92, May 25—June 28.
Palmer's S. E., 1901, Table 12, May 6—June 28, July 5—Aug. 30.

12146

TABLE 5.—ILLINOIS RIVER.

Henry, 1899.

Mean of Jordan's, Long's and Palmer's results, May, June, July and August.

	Parts per million.
Total Solids	425.3
Soluble Solids	372.2
Suspended Solids	53.1
Total Oxygen Consumed	13.0
Soluble Oxygen Consumed	10.5
Suspended Oxygen Consumed	2.5
Chlorine	31.0
Free Ammonia	0.81
Albuminoid Ammonia	0.60
Nitrogen as Nitrites	0.27
Nitrogen as Nitrates	1.16
Bacteria per cubic centimeter	66,189

Long's I. S. B. H. 1901, Table 12, July 10—August 28.
Jordan's S. E., 1901, Table 93, June 1—June 28.
Palmer's S. E., 1901, Table 13, May 31—June 23, July 6—August 30.

12147

TABLE 6.—ILLINOIS RIVER.

Averyville, 1899.

Mean of Jordan's, Long's and Palmer's results, May, June, July and August.

	Parts per million.
Total Solids	394.0
Soluble Solids	353.8
Suspended Solids	40.2
Total Oxygen Consumed	11.2
Soluble Oxygen Consumed	9.3
Suspended Oxygen Consumed	1.9
Chlorine	25.3
Free Ammonia	0.36
Albuminoid Ammonia	0.67
Nitrogen as Nitrites	0.14
Nitrogen as Nitrates	1.15
Bacteria per cubic centimeter	7,033

Long's I. S. B. H., 1901, Table 13, July 5—August 30.
Jordan's S. E., 1901, Table 94, June 1—June 28.
Palmer's S. E., 1901, Table 14, May, 2—June 28, July 4—August 30.

12148

TABLE 7.—ILLINOIS RIVER.

Wesley City, 1899.

Mean of Jordan's, Long's and Palmer's results, May, June, July and August.

	Parts per million.
Total Solids	400.0
Soluble Solids	353.9
Suspended Solids	46.1
Total Oxygen Consumed	12.3
Soluble Oxygen Consumed	10.2
Suspended Oxygen Consumed	2.1
Chlorine	24.3
Free Ammonia	0.56
Albuminoid Ammonia	0.72
Nitrogen as Nitrites	0.10
Nitrogen as Nitrates	1.06
Bacteria per cubic centimeter	1,630,877

Long's I. S. B. H., 1901, Table 14, July 5—Aug. 30.
Jordan's S. E., 1901, Table 95, June 1—June 28.
Palmer's S. E., 1901, Table 15, May 31—June 28, July 5—Aug. 30.

12149

TABLE 8.—ILLINOIS RIVER.

Pekin, 1899.

Mean of Jordan's, Long's and Palmer's results, May, June, July and August.

	Parts per million.
Total Solids	399.1
Soluble Solids	356.7
Suspended Solids	42.4
Total Oxygen Consumed	12.3
Soluble Oxygen Consumed	10.2
Suspended Oxygen Consumed	2.1
Chlorine	25.1
Free Ammonia	0.71
Albuminoid Ammonia	0.62
Nitrogen as Nitrites	0.19
Nitrogen as Nitrates	0.86
Bacteria per cubic centimeter	929,527

Long's I. S. B. H., 1901, Table 15, July 18—Aug. 30.
Jordan's S. E., 1901, Table 96, May 25—June 29.
Palmer's S. E., 1901, Table 16, May 27—June 29, July 7—Aug. 30.

12150

TABLE 9.—ILLINOIS RIVER.

Havana, 1899.

Mean of Jordan's, Long's and Palmer's results, May, June, July and August.

	Parts per million.
Total Solids	385.3
Soluble Solids	337.6
Suspended Solids	47.7
Total Oxygen Consumed	10.6
Soluble Oxygen Consumed	9.0
Suspended Oxygen Consumed	1.6
Chlorine	20.4
Free Ammonia	0.76
Albuminoid Ammonia	0.86
Nitrogen as Nitrites	0.14
Nitrogen as Nitrates	0.91
Bacteria per cubic centimeter	17,741

Long's I. S. B. H., 1901, Table 16, July 6—Aug. 31.
Jordan's S. E., 1901, Table 97, May 31—June 29.
Palmer's S. E., 1901, Table 17, May 3—June 29, July 6—Aug. 31.

12151

TABLE 10.—ILLINOIS RIVER.

Grafton, 1899.

Mean of Jordan's, Long's and Palmer's results, May, June, July and August.

	Parts per million.
Total Solids	384.0
Soluble Solids	270.8
Suspended Solids	113.2
Total Oxygen Consumed	9.3
Soluble Oxygen Consumed	7.5
Suspended Oxygen Consumed	1.8
Chlorine	10.7
Free Amonia	0.10
Albuminoid Amonia	0.85
Nitrogen as Nitrites	0.04
Nitrogen as Nitrates	0.79
Bacteria per cubic centimeter	11,163

Long's I. S. B. H., 1901, Table 20, July 10—Aug. 28.
Jordan's S. E., 1901, Table 101, May 10—June 30.
Palmer's S. E., 1901, Table 21, May 5—June 30, July 6—Aug. 31.

12152

TABLE 11.—ILLINOIS RIVER.

Beardstown, 1899.

Mean of Jordan's and Palmer's result, May and June.

	Parts per million.
Total Solids	490.1
Soluble Solids	289.5
Suspended Solids	200.6
Total Oxygen Consumed	12.7
Soluble Oxygen Consumed	9.6
Suspended Oxygen Consumed	3.1
Chlorine	6.2
Free Ammonia	0.33
Albuminoid Ammonia	0.49
Nitrites	0.22
Nitrates	0.77
Bacteria per cubic centimeter	5,525

Jordan's S. E., 1901, Table 99, May 25—June 20.
Palmer's S. E., 1901, Table 19, May 26—June 20.

12153

TABLE 12.—ILLINOIS RIVER

Kampsville, 1899.

Mean of Jordan's and Palmer's results, May and June.

	Parts per million.
Total Solids	564.3
Soluble Solids	251.7
Suspended Solids	312.6
Tôtal Oxygen Consumed	14.1
Soluble Oxygen Consumed	8.5
Suspended Oxygen Consumed	5.6
Chlorine	6.2
Free Ammonia	0.084
Albuminoid Ammonia	0.51
Nitrites	0.14
Nitrates	1.01
Bacteria per cubic centimeter	6,953

Jordan's S. E., 1901, Table 100, June 2—June 22.
Palmer's S. E., 1901, Table 20, May 3—June 29.

12154 TABLE 13.—ILLINOIS RIVER, 1900.

Illinois River.—Joliet, N. of Jackson St., 1900.

Mean of Jordan's, Long's and Palmer's results for May, June, July and August.

	Parts per million.
Total Solids	[illegible]
Soluble Solids	[illegible]
Suspended Solids	24.1
Total Oxygen Consumed	8.4
Soluble Oxygen Consumed	6.1
Suspended Oxygen Consumed	2.3
Chlorine	31.3
Free Ammonia	3.30
Albuminoid Ammonia	0.40
Nitrogen as Nitrites	0.47
Nitrogen as Nitrates	0.14
Bacteria per cubic centimeter	[illegible]

Long's I. S. B. H., 1901, Table 45, July 2—Aug. 27.
Jordan's S. E., 1901, Table 124, May 7—June 25.
Palmer's S. E. 1901, Table 44, May 7—June 25, July 2—Aug. 27.
I. S. B. H.—Illinois State Board of Health.
S. E.—Streams Examination.

12155 TABLE 14.—ILLINOIS RIVER.

Morris, 1900.

Mean of Jordans, Long's and Palmer's results for May, June, July and August.

	Parts per million.
Total Solids	250.1
Soluble Solids	[illegible]
Suspended Solids	[illegible]
Total Oxygen Consumed	7.35
Soluble Oxygen Consumed	5.51
Suspended Oxygen Consumed	1.84
Chlorine	21.1
Free Ammonia	2.0
Albuminoid Ammonia	0.38
Nitrogen as Nitrites	0.18
Nitrogen as Nitrates	0.46
Bacteria per cubic centimeter	[illegible]

Long's I. S. B. H., 1901, Table 46, July 2—Aug. 27.
Jordan's S. E., 1901, Table 127, May 7—June 26.
Palmer's S. E., 1901, Table 46, May 2—June 28—July 7—Aug. 31.

12156

TABLE 15.—ILLINOIS RIVER.

Ottawa, 1900.

Mean of Jordan's, Long's and Palmer's results for May, June, July and August.

	Parts per million.
Total Solids	259.7
Soluble Solids	229.8
Suspended Solids	29.9
Total Oxygen Consumed	7.16
Soluble Oxygen Consumed	5.88
Suspended Oxygen Consumed	1.27
Chlorine	19.1
Free Ammonia	0.70
Albuminoid Ammonia	0.28
Nitrogen as Nitrites	0.30
Nitrogen as Nitrates	1.14
Bacteria per cubic centimeter	14,092

Long's I. S. B. H., 1901, Table 47, July 2—August 27.
Jordan's S. E., 1901, Table 129, May 2—June 26.
Palmer's S. E., 1901, Table 48, May 3—June 27, July 4—August 28.

12157

TABLE 16.—ILLINOIS RIVER.

LaSalle, 1900.

Mean of Jordan's, Long's and Palmer's results for May, June, July and August.

	Parts per million.
Total Solids	268.5
Soluble Solids	241.3
Suspended Solids	27.2
Total Oxygen Consumed	7.72
Soluble Oxygen Consumed	5.94
Suspended Oxygen Consumed	1.78
Chlorine	17.3
Free Ammonia	0.33
Albuminoid Ammonia	0.29
Nitrogen as Nitrites	0.24
Nitrogen as Nitrates	1.21
Bacteria per cubic centimeter	13,286

Long's I. S. B. H., 1901, Table 49, July 2—August 27.
Jordan's S. E., 1901, Table 131, May 2—June 27.
Palmer's S. E., 1901, Table 50, May 2—June 27, July 4—August 29.

12158 TABLE 17.—ILLINOIS RIVER.

Henry, 1900.

Mean of Jordan's, Long's and Palmer's results for May, June, July and August.

	Parts per million.
Total Solids	294.3
Soluble Solids	251.9
Suspended Solids	42.4
Total Oxygen Consumed	8.08
Soluble Oxygen Consumed	5.99
Suspended Oxygen Consumed	2.09
Chlorine	17.4
Free Ammonia	0.43
Albuminoid Ammonia	0.22
Nitrogen as Nitrites	0.20
Nitrogen as Nitrates	1.14
Bacteria per cubic centimeter	16,028

Long's I. S. B. H., 1901, Table 51, July 3—Aug. 28.
Jordan's S. E. 1901, Table 133, May 8—June 26.
Palmer's S. E. 1901, Table 52, May 1—June 26, July 4—Aug. 28.

12159 TABLE 18.—ILLINOIS RIVER.

Averyville, 1900.

Mean of Jordan's, Long's and Palmer's results for May, June, July and August.

	Parts per million.
Total Solids	271.3
Soluble Solids	244.3
Suspended Solids	27.0
Total Oxygen Consumed	6.74
Soluble Oxygen Consumed	5.93
Suspended Oxygen Consumed	0.81
Chlorine	17.00
Free Ammonia	0.22
Albuminoid Ammonia	0.29
Nitrogen as Nitrites	0.12
Nitrogen as Nitrates	0.97
Bacteria per cubic centimeter	30,600

Long's I. S. B. H., 1901, Table 52, July 10—August 28.
Jordan's S. E., 1901, Table 134, May 2—June 27.
Palmer's S. E., 1901, Table 53, May 2—June 27, July 4—Aug. 28.

12160

TABLE 19.—ILLINOIS RIVER.

Wesley City, 1900.

Mean of Jordan's, Long's and Palmer's results for May, June, July and August.

	Parts per million.
Total Solids	339.7
Soluble Solids	250.5
Suspended Solids	89.2
Total Oxygen Consumed	8.9
Soluble Oxygen Consumed	6.05
Suspended Oxygen Consumed	2.85
Chlorine	16.6
Free Ammonia	0.41
Albuminoid Ammonia	0.48
Nitrogen as Nitrites	0.11
Nitrogen as Nitrates	1.09
Bacteria per cubic centimeter	170,654

Long's I. S. B. H., 1901, Table 53, July 3—August 28.
Jordan's S. E., 1901, Table 135, May 3—June 28.
Palmer's S. E., 1901, Table 54, May 4—June 28, July 6—August 30.

12161

TABLE 20.—ILLINOIS RIVER.

Pekin, 1900.

Mean of Jordan's, Long's and Palmer's results for May, June, July and August.

	Parts per million.
Total Solids	326.4
Soluble Solids	243.3
Suspended Solids	83.1
Total Oxygen Consumed	8.4
Soluble Oxygen Consumed	6.1
Suspended Oxygen Consumed	2.3
Chlorine	16.6
Free Ammonia	0.39
Albuminoid Ammonia	0.35
Nitrogen as Nitrites	0.11
Nitrogen as Nitrates	0.91
Bacteria per cubic centimeter	163,180

Long's I. S. B. H., 1901, Table 54, July 5—August 29.
Jordan's S. E., 1901, Table 133, May 3—June 28.
Palmer's S. E. 1901, Table 55, May 4—June 28, July 6—August 30.

12162

TABLE 21.

Illinois River.—Havana, 1900.

Mean of Jordan's, Long's and Palmer's results for May, June, July and August.

	Parts per million.
Total Solids	309.1
Soluble Solids	267.5
Suspended Solids	60.6
Total Oxygen Consumed	8.0
Soluble Oxygen Consumed	6.1
Suspended Oxygen Consumed	1.9
Chlorine	14.5
Free Ammonia	0.20
Albuminoid Ammonia	0.81
Nitrogen as Nitrites	0.12
Nitrogen as Nitrates	0.78
Bacteria per cubic centimeter	57,400

Long's I. S. B. H., 1901. Table 55, July 2—Aug. 29.
Jordan's S. E. 1901. Table 137, May 3—June 28.
Palmer's S. E., 1901. Table 56, May 3—June 14, July 6—Aug. 30.

12163

TABLE 22.

Illinois River.—Grafton, 1900.

Mean of Jordan's, Long's and Palmer's results for May, June, July and August.

	Parts per million.
Total Solids	331.5
Soluble Solids	250.4
Suspended Solids	82.1
Total Oxygen Consumed	7.78
Soluble Oxygen Consumed	5.94
Suspended Oxygen Consumed	1.83
Chlorine	12.0
Free Ammonia	0.05
Albuminoid Ammonia	0.53
Nitrogen as Nitrites	0.02
Nitrogen as Nitrates	0.80
Bacteria per cubic centimeter	5,300

Long's I. S. B. H., 1901, Table 56, July 3—Aug. 28.
Jordan's S. E., 1901, Table 141, May 3—June 29.
Palmer's S. E., 1901, Table 62, May 3—June 26, July 3—Aug. 28.

12164

TABLE 23.—ILLINOIS RIVER.

Beardstown, 1900.

Mean of Jordan's and Palmer's for May and June.

	Parts per million.
Total Solids	402.1
Soluble Solids	272.6
Suspended Solids	129.5
Total Oxygen Consumed	11.8
Soluble Oxygen Consumed	7.0
Suspended Oxygen Consumed	4.8
Chlorine	11.6
Free Ammonia	0.17
Albuminoid Ammonia	0.36
Nitrites	0.15
Nitrates	0.88
Bacteria per cubic centimeter	10,878

Jordan's S. E. 1901, Table 139, May 15—June 30.
Palmer's S. E. 1901, Table 58, May 4—June 29.

12165

TABLE 24.—ILLINOIS RIVER.

Kampsville, 1900.

Mean of Jordan's and Palmer's for May and June.

	Parts per million.
Total Solids	424.7
Soluble Solids	254.2
Suspended Solids	170.5
Total Oxygen Consumed	9.7
Soluble Oxygen Consumed	6.6
Suspended Oxygen Consumed	3.1
Chlorine	11.2
Free Ammonia	0.09
Albuminoid Ammonia	0.36
Nitrites	0.05
Nitrates	1.00
Bacteria per cubic centimeter	4,159

Jordan's S. E., 1901, Table 140, May 17—June 29.
Palmer's S. E., 1901, Table 59, May 3—June 28.

Q. Have you prepared two charts based upon the tables
12166 just read in evidence?

A. I have prepared two charts of the tables just read in evidence, 1 to 24, inclusive.

Q. Will you produce the charts and make them a part of your testimony?

A. I will. The two charts with the caption "Mean results Illinois River, Chemical Table, Jordan, Long and Palmer, months of May, June, July and August of years noted. L. P. Kinnicutt," are as follows:

MEAN RESULTS.

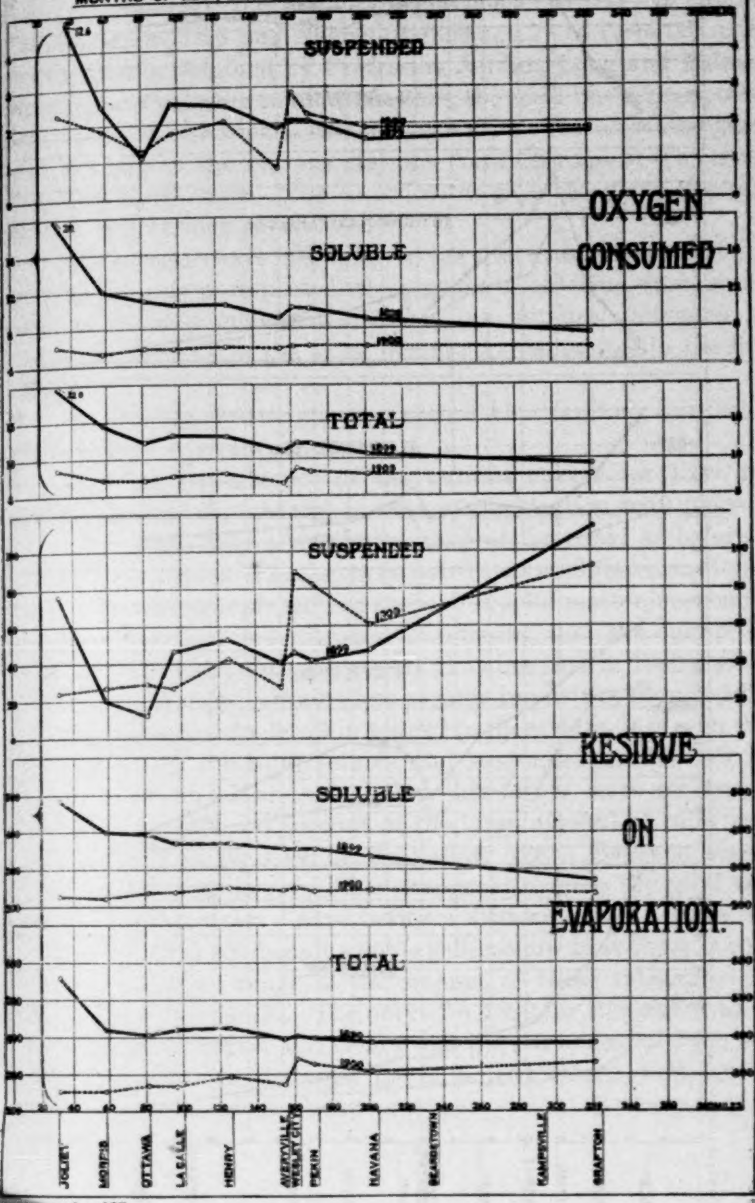
ILLINOIS RIVER

CHEMICAL TABLE.

JORDAN, LONG & PALMER.

L.P. KINNICUTT

MONTHS OF MAY, JUNE, JULY AND AUGUST OF YEARS NOTED.



MEAN RESULTS.

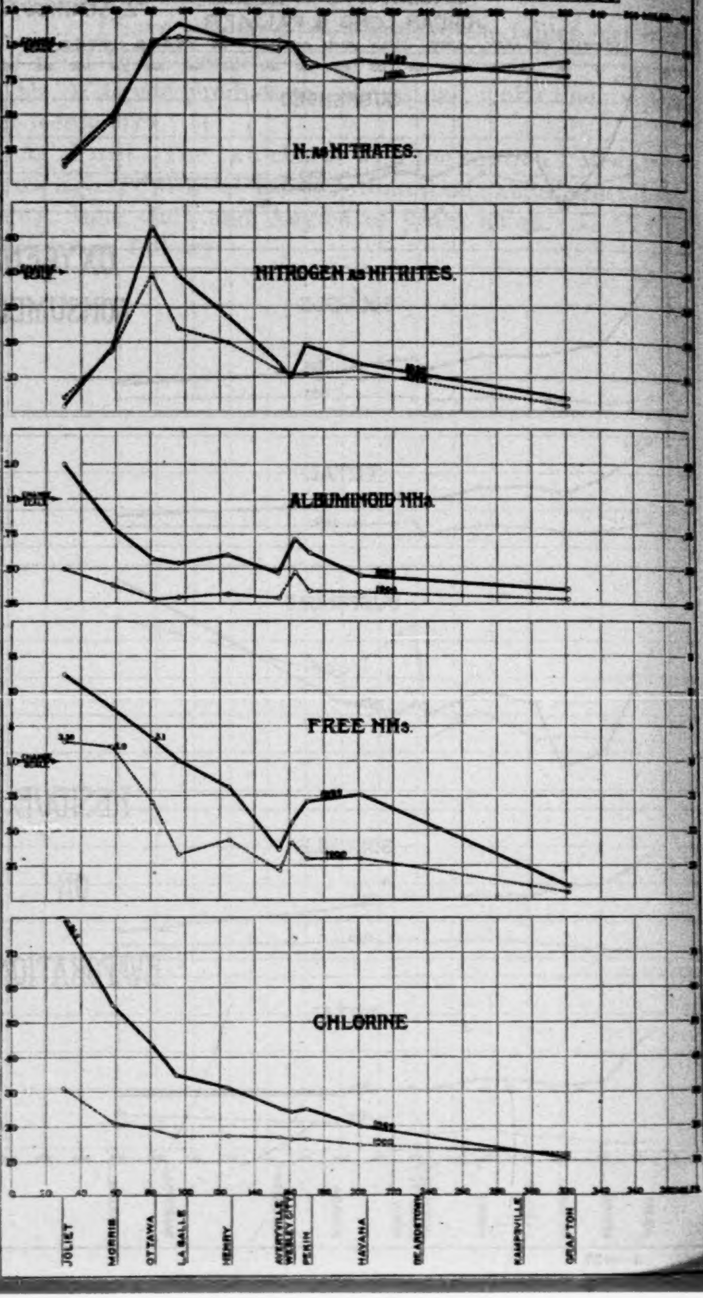
——ILLINOIS RIVER——

CHEMICAL TABLE.

JORDAN, LONG & PALMER.

L.P. KINNICUTT

MONTHS OF MAY, JUNE, JULY AND AUGUST OF YEARS NOTED.



Q. Will you explain the construction of these two charts 12169 just introduced, and what they show?

A. The first chart gives the curve representing the amount of the total solids, suspended solids, soluble solids; the total oxygen consumed; the soluble oxygen consumed for the months of May, June, July and August of 1899 and 1900, from the mean of the results obtained by Professors Jordan, Long and Palmer, for the months in the two stated years, the solid line representing the year 1899, the broken line the year 1900. The abscissae gives the distance of the various stations from Chicago at which the analyses were made. The co-ordinates give the parts per million of the various substances.

The second chart is similar to the first one, except that the curves there given represent the amount of chlorine, free ammonia, albuminoid ammonia, nitrogen as nitrites, nitrogen as nitrates, obtained in the same manner as the curves in the first chart.

Q. Taking the two charts together what sanitary conclusion do you draw from them?

A. The resemblance of the various curves for 1899 and 1900 show that the general process of purification took place in the same way after the opening of the canal as before it 12170 was opened. It is also to be noted that with the exception of the curves representing suspended solid matter, suspended oxygen consumed and nitrogen as nitrates, that the curves for 1900 are below the curves for 1899, showing that in 1900 a given volume of the river contains less organic impurities than in 1899.

To go more into detail in regard to these data, it is seen that the curves for the total soluble and suspended matter fall between Joliet and Morris, and that this fall is more marked in 1899 than in 1900, on account of the large amount of solid matter contained in the river in the former year. Between Morris and Ottawa there is very little change as regards the solid substances in the river. Also between Ottawa and La Salle the curves for total solids and soluble solids show that there is comparatively little change in the amount of these substances between these two places. The curve for 1899 for suspended solids rises between Ottawa and Henry and the curve for 1900 for suspended solids rises between La Salle and Henry, both curves falling again between Henry and Averyville. Between Averyville and Wesley City the curves in both years show an increase in the solid matter in the river. It is shown from the 12171 curve representing albuminoid ammonia to be of an animal and vegetable character.

From Pekin to Grafton the curves show very little increase or decrease in total substances in the river, but the curves for solid substances while showing little change for 1900 shows a slight decrease in 1899. In both years the curves show an increase in the suspended matter in the lower stages of the river, but that this matter is mineral rather than organic is shown by the curve representing oxygen consumed, which runs almost a straight line from Havana to Grafton. The curve representing oxygen consumed shows a large amount of organic matter at Joliet which they show is removed to great extent in both years before the river reaches Morris.

Between Averyville and Pekin the rapid rise in these curves shows an increase in organic matter between these points, and the decrease in the curves between Pekin and Grafton shows a removal of organic matter taking place in exactly the same way in both years.

The curves represeting the free and albuminoid ammonia show a very large amount of organic matter in both years at Joliet, a sharp decrease to Ottawa and then a gradual decrease to Averyville.

The curves, especially the curve representing the albuminoid ammonia rises slightly between Averyville and Pekin, showing the effect of a pollution at Peoria, and then both gradu-12172 ally falling until Grafton is reached, where the minimum amount of both free and albuminoid ammonia is shown by the curves to be present.

The nitrogen curves, especially the nitrogen as nitrites, show that the zone of greatest decomposition in the upper stages of the river, in both years, is in the neighborhood of Ottawa, and that the added volume due to the opening of the sanitary canal has not pushed this zone of decomposition further down the river. Beyond Averyville the rapid rise in the curve for free albuminoid ammonia, nitrogen as nitrites, and the decrease in the curve for nitrates, show the addition of polluted waters in both years at Peoria. This, as shown by the curves is more marked in 1899 than in 1900. The effect of this pollution is shown by the curves to extend to some degree to Havana, but at Grafton, the only curve to show that the water has been polluted at Peoria, is the nitrogen as nitrates.

The curves also show that a given volume of the river water contained less organic nitrogenous matter in 1900 than in 1899.

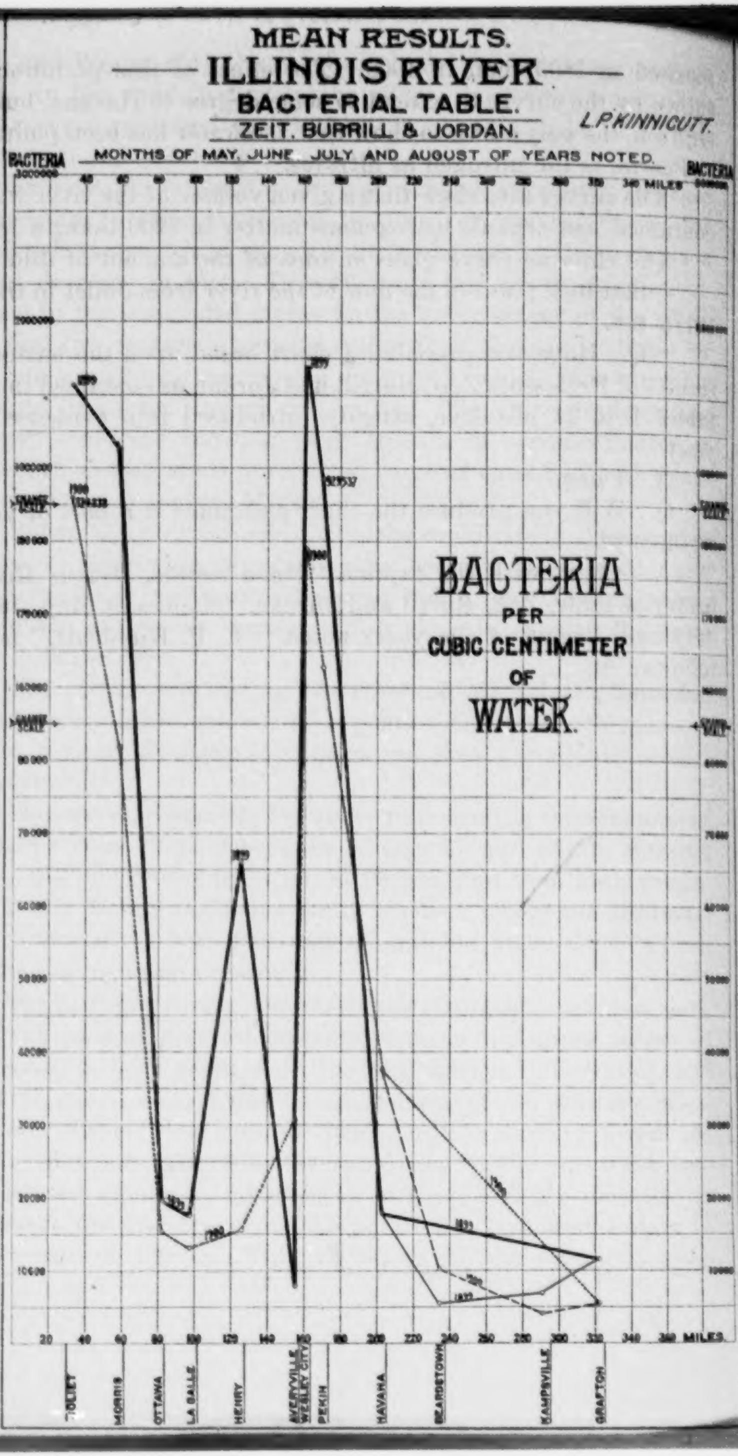
The chlorine curve gives an idea of the amount of dilution that took place in the flow of the river from Joliet to Grafton. 12173

Q. Have you prepared a chart based upon the bacterial results of Professors Zeit, Burrill and Jordan as contained in the tables 1 to 24 inclusive, already introduced into evidence by you?

A. I have

Q. Will you produce the chart and make it a part of your testimony?

A. Chart with the caption "Mean results, Illinois River, bacterial table, Zeit, Burril and Jordan. Months of May, June, July and August of the years noted. L. P. Kinnicutt," is as follows:



MEAN RESULTS.

ILLINOIS RIVER

BACTERIAL TABLE.

ZEIT, BURRILL & JORDAN.

L.P. KINNICUTT.

MONTHS OF MAY, JUNE JULY AND AUGUST OF YEARS NOTED.

BACTERIA PER CUBIC CENTIMETER OF WATER.

Q. Will you state what the chart just introduced in evi-
12175 dence shows?

A. The chart shows the bacterial contents of the river between Joliet and Grafton as obtained from results of Burrill, Jordan and Zeit, for the months of May, June, July and August, 1899 and 1900. The light lines between Havanna and Grafton represent only the months of May, and June, being the mean of Burrill and Jordan's results for May and June, Zeit making no determinations at these points. Consequently it is impossible to obtain a curve at these points representing the four months.

Q. Will you state what sanitary conclusions you draw from the chart just introduced in evidence?

A. Both curves show a great number of bacteria per cc. at Joliet. They then show a great decrease between Joliet and La Salle, a distance of 65 miles. The curves for 1899 show that between La Salle and Henry the number of bacteria increase rapidly, owing principally to the sewage of La Salle and Peru, but decrease almost as rapidly between Henry and Averyville.

The curve for 1900 shows also a slight increase from bac-
teria between La Salle and Henry and also a further in-
12176 crease between Henry and Averyville, due probably to
some local cause. Between Averyville and Wesley City the two show an increase of bacteria in both years, greater, however, between Wesley City and Pekin, in 1899 than in 1900. In both years the curves show a very great decrease between Wesley City and Havana, a distance of 40 miles, and the decrease continued though not so rapidly between Havana and Beardstown.

The curve for 1900 shows this decrease continues to Kampsville, while the curve for 1900 shows a rise between Beardstown and Kampsville. In both years they show an increased number between Kampsville and Grafton. The curve shows only three places in the river where the bacteria was greater in 1900 than in 1899, namely, at Averyville, Havana and Beardstown. The number of bacteria at Grafton is shown to be about 6,000 less per cc. in 1900 than in 1899.

Q. Have you prepared tables based upon the analytical data of Professors Jordan and Palmer on the tributaries of the Illinois River at their mouth, with the Illinois River at Grafton, for the months of May and June, 1899 and 1900, inclusive?

12177 A. I have.

Q. Will you produce and read the tables which you have prepared?

A. These tables are numbered from 25 to 40, inclusive, and are as follows:

12178 TABLE 25.—TRIBUTARIES TO THE ILLINOIS RIVER.

Desplaines River.—Lockport, 1899.

Mean of Jordan's and Palmer's results for May and June.

	Parts per million.
Total Solids	383.0
Soluble Solids	340.6
Suspended Solids	42.4
Total Oxygen Consumed	15.6
Soluble Oxygen Consumed	13.9
Suspended Oxygen Consumed	1.7
Chlorine	3.31
Free Ammonia	0.097
Albuminoid Ammonia	0.572
Nitrogen as Nitrites	0.023
Nitrogen as Nitrates	0.27
Bacteria per cubic centimeter	9,500

Jordan's S. E., 1901, Table 83, May 5—June 28.
Palmer's S. E., 1901, Table 3, May 22—June 26.
S. E—Streams Examinations.

12179 TABLE 26.—TRIBUTARIES TO THE ILLINOIS RIVER.

Kankakee River.—Wilmington, 1899.

Mean of Jordan and Palmer's results for May and June.

	Parts per million.
Total Solids	324.5
Soluble Solids	288.2
Suspended Solids	36.3
Total Oxygen Consumed	17.3
Soluble Oxygen Consumed	15.2
Suspended Oxygen Consumed	2.1
Chlorine	2.05
Free Ammonia	0.077
Albuminoid Ammonia	0.558
Nitrogen as Nitrites	0.014
Nitrogen as Nitrates	0.67
Bacteria per cubic centimeter	13,742

Jordan's S. E., 1901, Table 86, June 5—June 26.
Palmer's S. E., 1901, Table 6, June 5—June 26.

12180 TABLE 27.—TRIBUTARIES TO THE ILLINOIS RIVER.

Fox River.—Ottawa, 1899.

Mean of Jordan's and Palmer's results for May and June.

	Parts per million.
Total Solids	492.0
Soluble Solids	291.5
Suspended Solids	200.5
Total Oxygen Consumed	15.4
Soluble Oxygen Consumed	8.3
Suspended Oxygen Consumed	7.1
Chlorine	2.19
Free Ammonia	0.087
Albuminoid Ammonia	0.87
Nitrogen as Nitrites	0.034
Nitrogen as Nitrates	0.692
Bacteria per cubic centimeter	13,713

Jordan's S. E., 1901, Table 88, May 29—Jnne 26.
Palmer's S. E., 1901, Table 8, May 29—June 26.

12181 TABLE 28.—TRIBUTARIES TO THE ILLINOIS RIVER.

Big Vermillion River.— LaSalle, 1899.

Mean of Jordan's and Palmer's results for May and June.

	Parts per million.
Total Solids	465.3
Soluble Solids	422.6
Suspended Solids	42.7
Total Oxygen Consumed	5.9
Soluble Oxygen Consumed	4.5
Suspended Oxygen Consumed	1.4
Chlorine	15.22
Free Ammonia	0.081
Albuminoid Ammonia	0.22
Nitrogen as Nitrites	0.021
Nitrogen as Nitrates.	1.42
Bacteria per cubic centimeter	5,167

Jordan's S. E., 1901, Table 90, May 24—June 27.
Palmer's S. E., 1901, Table 10, May 24—June 27.

12182 TABLE 29.—TRIBUTARIES TO THE ILLINOIS RIVER.

Sangamon River.—Chandlerville, 1899.

Mean of Jordan's and Palmer's results for May and June.

	Parts per million.
Total Solids	378.5
Soluble Solids	248.4
Suspended Solids	130.1
Total Oxygen Consumed	11.3
Soluble Oxygen Consumed	6.8
Suspended Oxygen Consumed	4.5
Chlorine	2.82
Free Ammonia	0.043
Albuminoid Ammonia	0.369
Nitrogen as Nitrites	0.058
Nitrogen as Nitrates	1.82
Bacteria per cubic centimeter	7,200

Jordan's S. E. 1901, Table 98, May 31—June 21.
Palmer's S. E. 1901, Table 18, May 31—June 21.

12183 TABLE 30.--TRIBUTARIES TO THE ILLINOIS RIVER.

Mississippi River.—Grafton, 1899.

Mean of Jordan's and Palmer's results for May and June.

	Parts per million.
Total Solids	775.2
Soluble Solids	147.4
Suspended Solids	627.8
Total Oxygen Consumed	20.8
Soluble Oxygen Consumed	11.8
Suspended Oxygen Consumed	9.0
Chlorine	1.4
Free Ammonia	0.0615
Albuminoid Ammonia	0.794
Nitrogen as Nitrites	0.011
Nitrogen as Nitrates	0.57
Bacteria per cubic centimeter	10,733

Jordan's S. E. 1901, Table 102, May 10—June 28.
Palmer's S. E. 1901, Table 22, May 3—June 28.

12184 TABLE 31.—TRIBUTARIES TO THE ILLINOIS RIVER.

Missouri River.—West Alton, 1899.

Mean of Jordan's and Palmer's results for May and June.

No data given in Streams Examinations.

12185 TABLE 32.—THE ILLINOIS RIVER.

Grafton, 1899.

Mean of Jordan's and Palmer's results for May and June.

	Parts per million.
Total Solids	450.4
Souble Solids	255.5
Suspended Solids	194.9
Total Oxygen Consumed	10.6
Soluble Oxygen Consumed	7.9
Suspended Oxygen Consumed	2.75
Chlorine	6.34
Free Ammonia	0.092
Albuminoid Ammonia	0.4135
Nitrogen as Nitrites	0.028
Nitrogen as Nitrates	0.925
Bacteria per cubic centimeter	17,219

Jordan's S. E. 1901, Table 101, May 24—June 28.
Palmer's S. E. 1901, Table 21, May 24—June 28.

12186 TABLE 33.—TRIBUTARIES TO THE ILLINOIS RIVER.

Desplaines River.—Lockport, 1900.

Mean of Jordan's and Palmer's results for May and June.

	Parts per million
Total Solids	395.2
Soluble Solids	357.4
Suspended Solids	37.8
Total Oxygen Consumed	10.6
Soluble Oxygen Consumed	8.8
Suspended Oxygen Consumed	1.8
Chlorine	7.7
Free Ammonia	0.073
Albuminoid Ammonia	0.44
Nitrogen as Nitrites	0.040
Nitrogen as Nitrates	0.229
Bacteria per cubic centimeter	14,568

Jordan's S. E. 1901, Table 122, April 30—June 25.
Palmer's S. E. 1901, Table 42, April 30—June 26.
S. E.—Streams Examination.

12187 TABLE 34.—TRIBUTARIES TO THE ILLINOIS RIVER.

Kankakee River.—Wilmington, 1900.

Mean of Jordan's and Palmer's results for May and June.

	Parts per million.
Total Solids	328.9
Soluble Solids	288.6
Suspended Solids	40.3
Total Oxygen Consumed	11.0
Soluble Oxygen Consumed	8.8
Suspended Oxygen Consumed	2.2
Chlorine	3.3
Free Ammonia	0.089
Albuminoid Ammonia	0.342
Nitrogen as Nitrites	0.02
Nitrogen as Nitrates	1.48
Bacteria per cubic centimeter	8,161

Jordan's S. E. 1901, Table 126, April 30—June 23.
Palmer's S. E. 1901, Table 45, May 7—June 25

12188 TABLE 35.—TRIBUTARIES TO THE ILLINOIS RIVER.

Fox River.—Ottawa, 1900.

Mean of Jordan's and Palmer's results for May and June.

	Parts per million.
Total Solids	311.6
Soluble Solids	283.5
Suspended Solids	28.1
Total Oxygen Consumed	9.5
Soluble Oxygen Consumed	7.8
Suspended Oxygen Consumed	1.7
Chlorine	4.7
Free Ammonia	0.032
Albuminoid Ammonia	0.408
Nitrogen as Nitrites	0.005
Nitrogen as Nitrates	0.15
Bacteria per cubic centimeter	3.650

Jordan's S. E. 1901, Table 128, May 1—June 25.
Palmer's S. E. 1901, Table 47, May 1—June 25.

12189 TABLE 36.—TRIBUTARIES TO THE ILLINOIS RIVER.

Big Vermillion River.—LaSalle, 1900.

Mean of Jordan's and Palmer's results for May and June.

	Parts per million.
Totals Solids	415.8
Soluble Solids	346.1
Suspended Solids	69.7
Total Oxygen Consumed	6.5
Soluble Oxygen Consumed	4.2
Suspended Oxygen Consumed	2.3
Chlorine	9.4
Free Ammonia	0.045
Albuminoid Ammonia	0.240
Nitrogen as Nitrites	0.037
Nitrogen as Nitrates	2.78
Bacteria per cubic centimeter	13,241

Jordan's S. E. 1901, Table 130, May 1—June 26.
Palmer's S. E. 1901, Table 49, May 1—June 26.

12190 TABLE 37.—TRIBUTARIES TO THE ILLINOIS RIVER.

Sangamon River.—Chandlerville, 1900.

Mean of Jordan's and Palmer's results for May and June.

	Parts per million.
Total Solids	437.7
Soluble Solids	264.9
Suspended Solids	172.8
Total Oxygen Consumed	9.1
Soluble Oxygen Consumed	4.4
Suspended Oxygen Consumed	4.7
Chlorine	5.1
Free Ammonia	0.033
Albuminoid Ammonia	0.29
Nitrogen as Nitrites	0.026
Nitrogen as Nitrates	1.48
Bacteria per cubic centimeter	14,363

Jordan's S. E. 1901, Table 138, May 2—June 27.
Palmer's S. E. 1901, Table 57, May 2—June 27.

12191 TABLE 38.—TRIBUTARIES TO THE ILLINOIS RIVER.

Mississippi River.—Grafton, 1900.

Mean [illegible]ordan's and Palmer's results for May and June.

	Parts per million.
Total Solids	343.0
Soluble Solids	143.0
Suspended Solids	200.0
Total Oxygen Consumed	12.7
Soluble Oxygen Consumed	8.3
Suspended Oxygen Consumed	4.4
Chlorine	8.3
Free Ammonia	0.022
Albuminoid Ammonia	0.36
Nitrogen as Nitrites	0.006
Nitrogen as Nitrates	0.30
Bacteria per cubic centimeter	7,106

Jordan's S. E. 1901, Table 142, May 3—June 29.
Palmer's S. E. 1901, Table 63, May 3—June 26.

12192 TABLE 39.—TRIBUTARIES TO THE ILLINOIS RIVER.

Missouri River, West Alton, 1900.

Mean of Jordan's and Palmer's results for May and June.

	Parts per million.
Total Solids	2456.2
Soluble Solids	264.2
Suspended Solids	2192.0
Total Oxygen Consumed	20.8
Soluble Oxygen Consumed	4.8
Suspended Oxygen Consumed	16.0
Chlorine	11.7
Free Ammonia	0.039
Albuminoid Ammonia	1.03
Nitrogen as Nitrites	0.002
Nitrogen as Nitrates	0.73
Bacteria per cubic centimeter	41,749

Jordan's S. E. 1901, Table 152, May 1—June 27.
Palmer's S. E. 1901, Table 73, May 1—June 27.

12193 TABLE 40.—THE ILLINOIS RIVER.

Grafton, 1900.

Mean of Jordan's and Palmer's results for May and June.

	Parts per million.
Total Solids	347.2
Soluble Solids	244.5
Suspended Solids	102.7
Total Oxygen Consumed	8.8
Soluble Oxygen Consumed	6.5
Suspended Oxygen Consumed	2.3
Chlorine	10.5
Free Ammonia	0.040
Albuminoid Ammonia	0.23
Nitrogen as Nitrites	0.019
Nitrogen as Nitrates	0.93
Bacteria per cubic centimeter	6,741

Jordan's S. E. 1901, Table 141, May 2—June 26.
Palmer's S. E. 1901, Table 62, May 3—June 26.

Q. How were these tables prepared?

12194 A. These were prepared in the same manner as the other tables.

Q. Have you prepared a chart based upon the tables just read in evidence?

A. I have.

Q. Will you produce and read the chart which you have prepared?

A. The chart with the caption "Mean results, comparison of the sanitary character of the tributaries of the Illinois River at their mouths, with the Illinois River at Grafton, Jordan and Palmer, months of May and June, 1899 and 1900, L. P. Kinnicutt," is as follows:

MEAN RESULTS.

COMPARISON OF THE SANITARY CHARACTER
OF THE TRIBUTARIES OF THE

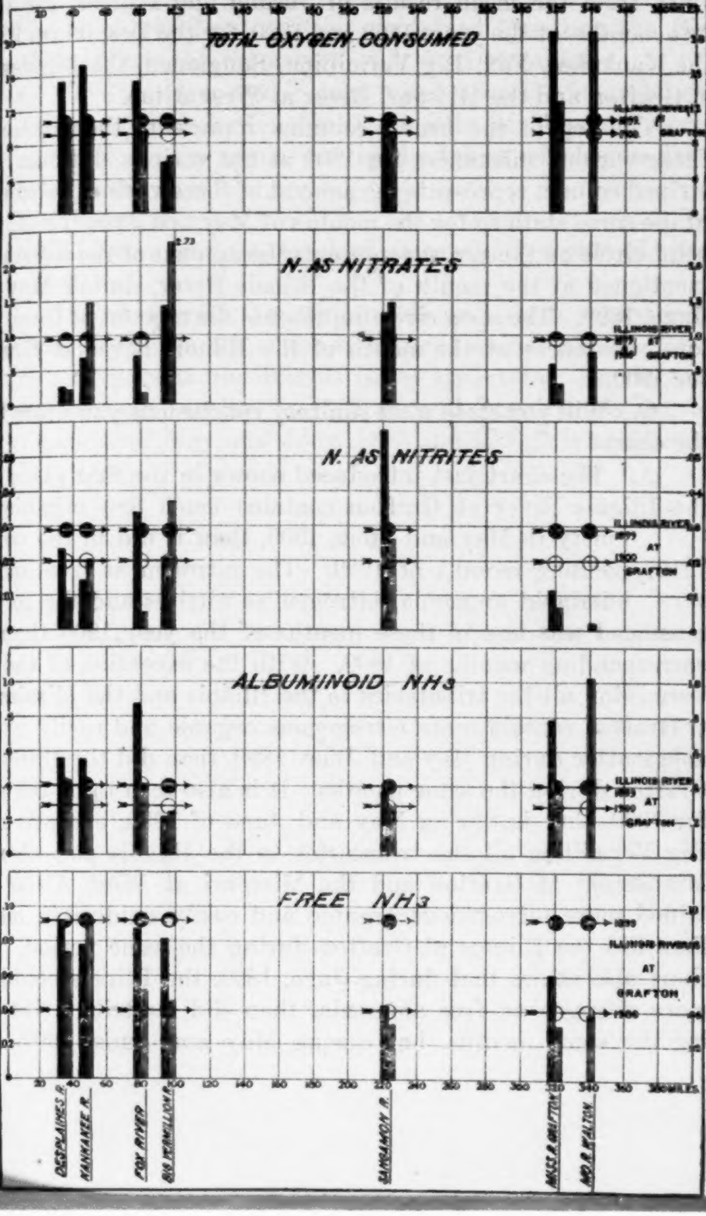
ILLINOIS RIVER

AT THEIR MOUTHS WITH THE ILLINOIS RIVER
AT

GRAFTON.

JORDAN AND PALMER.
MONTHS OF MAY AND JUNE, 1899 AND 1900.

L.P. KINNICUTT.



Q. State how this chart was constructed and what it
12196 shows?

A. In this chart is given the amount of free ammonia, albuminoid ammonia, nitrogen as nitrites, nitrogen as nitrates, oxygen consumed, for the months of May and June, 1899 and 1900, from the mean results of Jordan and Palmer, for these two months, of the years 1899 and 1900, for the Desplaines River, the Kankakee, Fox, Big Vermillion, Sangamon, the Mississippi at Grafton and the Missouri River at West Alton.

The top of the heavy columns represents the amount of these various substances for 1900 at the various stations. The striped column represents the amount of these various substances at the same stations for the months of May and June, 1900. The solid circle on the arrow represents the amount of the substances mentioned at the mouth of the Illinois River, during May and June, 1899. The open circle represents the amount of these various substances at the mouth of the Illinois River at Grafton for 1900.

Q. Will you state what sanitary conclusions you draw from the chart?

A. The chart just introduced shows in the first place that the Illinois River at Grafton contains much less organic impurity in May and June, 1900, than it did in the corres-
12197 ponding months of 1899. The nitrogen as free and albuminoid ammonia, nitrogen as nitrites and the oxygen consumed was less in these months of the year 1900 than the corresponding months of 1899. With the exception of the Big Vermillion all the tributaries to the Illinois and the Mississippi at Grafton contain more nitrogenous organic and easily oxidizable matter during May and June, 1899, than did the Illinois at Grafton during the same months. It is also seen to be the same for 1900, that is during May and June of 1900, excepting the Big Vermillion all the tributaries to the Illinois and also the Mississippi at Grafton and the Missouri at West Alton contained more nitrogenous organic and easily oxidizable matter than did the Illinois at Grafton during the same period. The chart also shows that during June, 1899, the Illinois contained more nitrogen as free ammonia, than did its tributaries during the same months, but during May and June, 1900, it is

seen that it contains less than the Desplaines, the Kankakee, the Fox and the Big Vermillion and practically the same amount as the Missouri.

In May and June, 1899, the Illinois contained more nitrogen as nitrites than any of its tributaries excepting the Fox and the Sangamon.

12198 In May and June, 1900, it contained less than the Big Vermillion, the Sangamon and the Desplaines.

Q. Have you prepared a chart based upon the bacterial results of Burrill and Jordan for the months of May and June, 1899 and 1900, which results are in the tables which you have just introduced?

A. I have.

Q. Will you produce the chart and make it a part of your testimony?

A. The chart with the caption "Mean results, comparison of the sanitary character of the tributaries of the Illinois River at their mouths with the Illinois River at Grafton, Burrill and Jordan's bacterial tables, L. P. Kinnicutt bacteria per cc. of water, months of May and June, 1899 and 1900," is as folows:

12199

MEAN RESULTS.

COMPARISON OF THE SANITARY CHARACTER
OF THE TRIBUTARIES OF THE

ILLINOIS RIVER

AT THEIR MOUTHS WITH THE ILLINOIS RIVER
AT

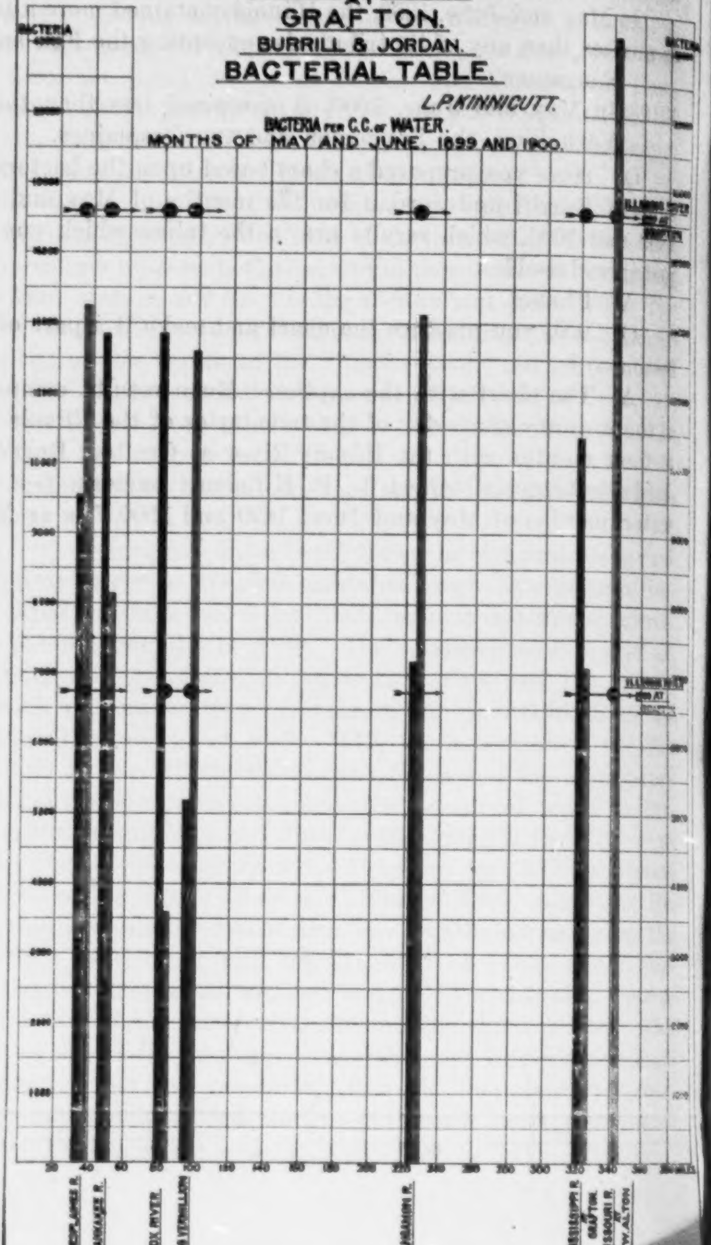
GRAFTON.

BURRILL & JORDAN.

BACTERIAL TABLE.

L. P. KINNICUTT.

BACTERIA PER C.C. OF WATER.
MONTHS OF MAY AND JUNE, 1899 AND 1900.



Q. Will you state how this chart is constructed and what 12200 it shows?

A. This chart is constructed similar to the last chart the four columns representing the number of bacteria per cc. at the mouths of the various rivers whose names are given at the bottom of the chart.

The solid ball and arrow at the top of the chart give the number of bacteria per cc. during the months of May and June, 1899, at Grafton, at the mouth of the Illinois River. The open ball and arrow in the middle of the chart represent the number of bacteria per cc. during May and June, 1900, on the Illinois River at Grafton.

Q. Will you state what sanitary conclusions you draw from the chart just introduced in evidence?

A. This chart shows that the Illinois River at Grafton during the months of May and June, 1899, contained over 10,000 more bacteria per cc. than during the same months of 1900. It also shows that the Illinois River at Grafton, during the months of May and June, 1899, contained more bacteria per cc. than did any of its tributaries, and more than the Mississippi at its mouth, during the same months.

During May and June of 1900 the Illinois River at Grafton contained, excluding the Fox River, not only less bac- 12201 teria per cc. than any of its trbutaries, less than the Mississippi at Grafton and the Missouri at West Alton, during the same months in 1900, but also contained a less number of bacteria than did any of its tributaries with one exception, the Big Vermillion, during the corresponding months of 1899. The Missouri at West Alton is shown by the chart to contain over 40,000 more bacteria per cc. during May and June, 1900, than the Illinois at Grafton. The Illinois at Grafton containing only 8,740 per cc.

There were no data from which the number of bacteria contained in the Missouri at West Alton in May and June, 1899, could be determined. The Missouri at West Alton during the months of May and June, 1900, was from bacterial representations, much more polluted than the Illinois at Grafton.

Q. Professor, in preparing these charts and tables why did you take the mean?

A. The reason that I took the mean was because it is my opinion that in taking a mean of the analytical data obtained by the various observers at the various stations on the Illinois River more accurate information can be obtained of the changes that take place in the river than by studying the data of any one person.

12202 Further, I did this because it is a method commonly employed in all scientific investigations, as for instance what are now considered as the figures representing the correct amount of hydrogen and oxygen in water were obtained not from the results of a single observer but by combining the data of many different experiments made by many different observers.

LEONARD P. KINNICUTT.

ADJOURNED until 10:00 a. m., Wednesday, March 16, 1904.

12203 10:00 a. m., Wednesday, March 16, 1904. Continuation pursuant to adjournment. Present, the Commissioner and same counsel representing the respective parties.

L. P. KINNICUTT

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. Professor, will you state the steps of purification of Chicago sewage as the same passes out of the sewers of Chicago into the Chicago river, thence into the drainage canal and from thence to the Desplaines and Illinois rivers as you have shown by the tables and charts which you have offered in evidence in this case?

A. The sewage of Chicago as it enters from the sewers into the drainage canal undoubtedly contains a small amount of oxygen and the first action that takes place is undoubtedly anaerobic action in which part of such substances like urea are decomposed, ammonia being given off. The action in the sanitary canal is an anaerobic action, or very similar to that which takes place in the septic tank. By this action about 20 per
12204 cent. of the organic matter, as measured both by the loss in the albuminoid ammonia and by the loss in oxy-

gen consumed is removed from the sewage. Also a certain amount of suspended matter is removed and a certain amount of suspended matter has been rendered soluble and a certain amount has been converted into gases and into simpler products.

By this action the sewage is not only purified, but changed so that further purification will take place more easily. The next stage in the purification is the aerobic stage. Undoubtedly in the upper stretches of the river near Joliet we have both aerobic and anaerobic action taking place. Further down as at Ottawa we have principally an aerobic or nitrifying action. At about this point both in 1899 and 1900 is the zone of greatest decomposition. From this point the action, in my opinion, is entirely anaerobic or nitrifying action continued purification going on until we come to Averyville.

Between Averyville and Wesley City the tables and diagrams that I have made show that a large amount of organic polluted matter is added to the river. At Pekin or between Peoria and Pekin, we have also again more or less anaerobic action with aerobic action taking place.

The purification continues and between Pekin and Havana the action that takes place is aerobic or a nitrifying
12205 action. The aerobic purification then goes on until at Grafton, all the original organic matter which was in the sewage at Pekin has been decomposed and changed.

Q. From a careful consideration of all the tables and charts introduced into evidence by you, and consideration of it as a whole, what conclusions do you draw as to the effects of emptying the sewage of Chicago into the drainage canal and from thence into the Desplaines river and the Illinois river as to the effects of said sewage upon the waters of the Illinois river?

A. The effect of emptying the sewage of Chicago into the drainage canal into the Desplaines river at Joliet and then into the Illinois river is to increase the amount of organic matter in the upper stretches of the river.

The effect, however, of adding this organic matter to the upper stretches of the river is not noticed at Averyville except in the increased nitrogen contents of the river and the high chlorine and the same can be said at Grafton, at the mouth of the Illinois river. At that point the effect of the addition of the sewage to the Illinois river is seen only in the high chlorine and

the nitrogen as nitrates. This nitrogen content of the river is very different from the nitrogen content of the river at
12206 or above Ottawa. It is nitrogen which has been changed over and over again from the original character in which it occurred at Joliet. How this change takes place I have tried to show in my description of the nitrogen cycle.

Q. Are conditions worse or better in the Illinois river since the drainage canal was opened, carrying the sewage from Chicago into the Illinois river, than they were prior thereto, when the Chicago sewage was pumped into the Illinois river by way of the Illinois and Michigan canal?

A. I think the chart representing the Illinois river, May, June, July and August, 1899 and 1900, which was produced in evidence yesterday, shows clearly the conditions in the Illinois river in comparable months in 1899 and 1900. This chart compared the state of the river in corresponding periods in 1899 and 1900 and showed that the purification took place almost exactly in the same way during those two periods. Great amount of decomposition of organic matter between Joliet and Ottawa, the zone of greatest decomposition being in both years in the neighborhood of Ottawa. That purification in both years took place in a very similar way, is shown by the close corre-
12207 spondence of the various curves for the two periods. The rapid rise in free ammonia, albuminoid ammonia and nitrogen as nitrites between Averyville and Wesley City showed in both periods, the pollution entering the river between these points. The curves then show a repetition of what took place between Joliet and Averyville, the re-purification of the river. All the data as given by the two charts showed that the purification of the river in the two years took place exactly in the same way and also that the river at all points was purer during May, June, July and August in 1900 than in 1899.

Q. From all the analytical data which you have studied in this case, as well as your tables and charts offered in evidence, what are your conclusions as to whether or not the Illinois river purifies itself of sewage of Chicago before Grafton is reached?

A. My opinion is, as has been shown by my answers to the previous questions, that I believe that the sewage of Chicago is entirely decomposed before Grafton is reached, and that the only effect that we perceive in the river at Grafton is the nitrogen contents and in high chlorine.

12208 Q. Are the nitrogen contents and the chlorine such as are found in the river at Grafton of themselves elements dangerous to public health?

A. Not in the slightest degree. The chlorine and nitrogen content as found in the river at Grafton, have, as far as we know, absolutely no effect upon the human system.

Q. Have you studied the coli determinations made by Professor Jordan as the same appear in Streams Examinations, as well as his 1901 determinations, made at the laboratories at Peoria, Grafton and St. Louis, which tables have been introduced in evidence in this case?

A. I have studied the coli determinations as given by Professor Jordan in Streams Examinations, also his coli determinations made in 1901, and introduced in evidence in this case.

Q. Have you acquainted yourself with the experiments made upon the viability of the typhoid germ by Professor Jordan, Professor Zeit and Professor Russell?

A. I have.

Q. Taking into consideration all knowledge, chemical and bacterial, which you have, together with your personal knowledge of the conditions that obtain upon the water course, from Chicago to St. Louis, what is your opinion as to whether or not the deleterious and infectious properties of the sewage of
12209 Chicago, entering the drainage canal reach as far down the Illinois river as the town of Grafton?

A. Taking into consideration all the data that I have presented and all the data that I have studied regarding the Illinois river, and assuming that you mean by deleterious matters any matters that were in the sewage of Chicago that were deleterious to human health, and by infectious matter that you mean typhoid bacilli, I do not believe that they reach down the Illinois river as far as Grafton.

Q. Please give your reasons in full for your answer?

A. My reasons in full for this answer are that in my opinion all of the deleterious substances which may have been considered to have been contained in the Chicago sewage meaning by deleterious substances not bacterial life, have been entirely decomposed and rendered absolutely harmless long before the river reaches Grafton, and that the infected matter, meaning by that typhoid bacilli, which enters into the drainage canal from the sewage of Chicago would not survive the passage from Chicago to Grafton.

Q. State your opinion as an expert on water supplies
12210 for cities and towns as to whether or not the waters of the Mississippi river west of the center of the main channel of said river below the mouth of the Illinois river and down to the intake tower of the St. Louis water works at the chain of rocks is less valuable for drinking purposes and more liable to carry water-borne diseases, such as typhoid fever and cholera, now than it was before the sewage from the sanitary district of Chicago was run into the drainage canal and through it into the Illinois river?

A. All of the data that I have presented show that the Illinois river at Grafton does not contain undecomposed matter derived from the sewage of Chicago and it is my opinion that the typhoid bacilli from Chicago would not survive the journey from Chicago to Grafton, and therefore it is my opinion that the water of the Mississippi river west of the center of the main channel of said river below the mouth of the Illinois river and down to the intake tower of the St. Louis water works at the chain of rocks, is not less valuable for drinking purposes and not more liable to carry water-borne diseases, such as typhoid fever and cholera, now than it was before the sewage from the sani-
12211 tary district of Chicago was run into the drainage canal.

Q. If an increased volume of water in the Illinois river by the addition of the water of the drainage canal would make an increased speed in the current of the Illinois river would that increase in said current have any effect in increasing or diminishing the typhoid and liability to typhoid and other water-borne diseases on the part of the inhabitants of the State of Missouri using the water of the Mississippi river for drinking purposes below the mouth of the Illinois river?

A. I do not believe that any increased speed of the current of the Illinois river that would be caused by the addition of the water of the drainage canal would have any effect in increasing or diminishing the typhoid and liability to typhoid and other water-borne diseases on the part of the inhabitants of the State of Missouri using the waters of the Mississippi river for drinking purposes below the mouth of the Illinois river, and my opinion is based upon the character of the Illinois river.

Q. Professor Sedgwick, in answer to the question "What do you say as to the longevity of the germ of typhoid
12212 fever as a general proposition in connection with sewage polluted water" stated among other things, "My reason is that in a sewage polluted stream the typhoid germ might live in gradually diminishing numbers for weeks or months or even years." What is your opinion as to the correctness of that belief, based upon your knowledge as a sanitarian, and whether or not a typhoid fever germ might live in a sewage polluted stream for weeks, months or even years?

A. My opinion is that the typhoid fever could not live for weeks or months or even years in gradually diminishing numbers under such conditions, for all the experiments with which I am familiar show that the typhoid germ will live a less time in a polluted water than in a pure water.

Q. Professor Sedgwick, in answer to the following question: "Assuming that the germs of typhoid fever coming from the sewers of Chicago and passing by way of the drainage canal to Lake Peoria, be, in large numbers, deposited in the bed of Lake Peoria for the period of a month say, do you consider that typhoid germs would be entirely destroyed at the end of that time in that deposit," answered, "No sir." What do you say as to the assumption that typhoid germs could pass from the sewers of Chicago, by way of the drainage canal, to Lake Peoria, and be deposited there in the bed of Lake Peoria for a
12213 period of a month and as to whether or not typhoid germs coming from the drainage canal, under conditions as they exist today, would live for a period of a month and not be destroyed before the end of that period?

A. From the experiments that have been made I do not believe that the typhoid bacilli would live until it entered the slack waters at Peoria, and even assuming that it would survive the passage from Chicago to Peoria, and be deposited in the bed of Lake Peoria for a period of a month, I do not believe that it would live for a period of a month in such a deposit, and in this connection I would like to call attention to the experiments made by the Massachusetts State Board of Health, which are reported in the 34th Annual Report of the Massachusetts State Board of

Health in which the experiments of Mr. H. W. Clark and Stephen DeM. Gage are given.

In this experiment they show that when coli bacilli were placed in a storage reservoir once polluted but allowed to stand stagnant without further pollution, that the number of coli bacilli rapidly decreased and after 11 days bacilli coli were found in only one sample, this being collected near the bottom of the tank.

12214 On the 12th day and afterwards no B. coli were found in the water of any portion of the tank, and on emptying the tank on the 15th day the analyses from the scrapings of the bottom of the tank showed complete absence of this organism, showing it did not exist in the mud more than a day or two longer than it did in the water itself.

I would also like to cite in this connection an article on the investigation of the River Severn in the Shrewsbury District of England, given in the Second Report of the Royal Commission on Sewage Disposal appointed in 1898 to inquire and report what conditions of treatment and disposal of sewage may properly be adopted, in which report are given the analyses made of the mud of that river which show that the analysis of the mud 18 miles below where the sewage of Shrewsbury enters the river contained no more coli than the mud taken near the water works intake which is above where the sewage enters the river.

MR. CORUM: Complainant moves that the answer of the witness in reference to what the health reports of the State of Massachusetts show, and in reference to the table showing the bacterial examination of the River Severn be stricken from the evidence on the ground that his evidence is purely hearsay.

12215 Q. Professor Sedgwick, in answer to the question: "Assuming that typhoid fever germs coming from the Chicago sewers and deposited in large numbers in the lakes and slack water portions of the Illinois river above Peoria, do you or do you not consider that flood conditions, such as would scour the deposits from the beds of the streams would cause the water leaving Lake Peoria to contain at times more infectious and dangerous pollution than are at present in the diluted sewage entering at the Bear Trap Dam at the foot of the drainage canal?" stated: "I think at times it might." What is your opinion taking into consideration all that you know about the conditions in the drainage canal, the Desplaines and the Illinois rivers as a bacteriologist, chemist and sanitary expert as to whether such a condition at times might exist?

A. From all the data that I possess and from all the knowledge that I have acquired regarding the life of the typhoid bacilli, I do not think it is possible that the waters leaving Lake Peoria would contain at times more infectious and dangerous pollution than is at present in the polluted sewage entering at the Bear Trap Dam at the foot of the drainage canal.

Q. What is your opinion, based upon all the knowledge 12216 which you have of conditions at Lake Peoria, as a chemist and sanitary expert and a bacteriologist, as to whether at any time, under any conditions, the number of typhoid fever germs at any point is even as great as they are at the Bear Trap Dam at the end of the drainage canal?

A. I am very firmly of the opinion that the waters of Lake Peoria can not at any time contain as much infectious and dangerous material, as the waters at Bear Trap Dam, and I know absolutely of no data that would warrant any such assumption.

Q. Do you know of any evidence scientifically secured or otherwise that shows that accumulations of typhoid germs are found in the lakes or slack water basins of rivers and remain there in storage in vast numbers for any considerable period of time in a virulent state and finally flushed out by freshets so that the number of typhoid fever germs are carried by the stream a considerable distance from the source of pollution in greater quantities than they exist at the source of pollution?

A. I know of no evidence scientifically secured or otherwise that would show such a condition of affairs.

Q. Now, assuming that the only pollution of the river was that contributed to it by the Chicago Sanitary District, and having in mind a large amount of typhoid fever existing in said district, do you or do you not consider the effect of the time interval, dilution and sedimentation occurring between Chicago and Grafton would be such as to render the water as it 12217 reaches the Mississippi river at all times free from producing water-borne diseases in those who drink it?

A. Knowing the character of the Illinois river and bearing in mind the amount of sedimentation, the amount of dilution and the amount of purification that occurs between Chicago and

Grafton, and especially bearing in mind the time element, I do believe that the time interval would render the Mississippi river water at all times free from liability of producing water-borne diseases from pathogenic bacteria entering the Illinois river by way of the drainage canal.

Q. Is there anything based upon your knowledge as a chemist, bacteriologist and sanitary expert, which you know that would lead you to believe that the water coming from the Illinois river was infected from the sewage of Chicago, and assume that the water from the Illinois river mixed with the water from the Mississippi river at Grafton and subsequently mixed with the waters of the Missouri river at its mouth, do you consider the waters of the Illinois river thus commingled with the waters of the Mississippi and Missouri rivers a menace to the health of the inhabitants of Missouri living on the Missouri shore, 12218 using the Mississippi river water for drinking purposes, and those below on the Missouri shore?

A. From all the knowledge that I possess as a sanitary expert, I do not believe that the water of the Illinois river at Grafton is infected from the sewage of Chicago, meaning by infection typhoid bacilli which came into the Illinois river from the Chicago sewage, and this being my opinoin I do not consider that the water from the Illinois river mixed with the water of the Mississippi river at Grafton and subsequently mixed with the waters of the Missouri river at its mouth, thus commingling with the waters of the Missisippi and Missouri rivers is a menace to the health of the inhabitants living upon the Mississippi river, using the Mississippi river water for drinking purposes at points on the Missouri shore.

Q. Assuming that there was no typhoid fever pollution of the waters upon the water shed of the Mississippi river or its tributaries above the intake of the St. Louis water works, other than that derived from the sanitary district of Chicago, 12219 do you or do you not believe that typhoid fever germs from said district are liable to find their way into the water supply of the city of St. Louis through the intake at the chain of rocks?

A. It being my opinion that typhoid fever bacilli from Chicago entering the Illinois river do not survive the journey from Chicago to Grafton, and assuming that there were no typhoid fever pollutions of the waters upon the water shed of the Mississippi river or its tributaries, above the intake of the St. Louis water works, except that which came from Chicago, my opinion is, for the reasons stated above, that typhoid fever germs from said district are not liable to find their way into the water supply of the city of St. Louis through the intake tower at the chain of rocks.

Q. Professor Sedgwick, in answer to the question just propounded to you, answered: "I believe that they are liable to find their way into the intake," and when asked why, answered: "For the reason that typhoid fever having been frequently very abundant in the city of Chicago I must start with the assumption that a very large number of typhoid germs find their way into the sewage of the city, pass through the sewers and into the
drainage canal and subject to local conditions may in
12220 diminishing numbers pass through the Illinois river,
mingle with the waters of the Mississippi river, pass over
to the other side, and find their way into the intake at the chain of rocks." I want to ask you, do you know of any evidence based on your analyses, experiments or otherwise that justifies the assumption that typhoid fever germs will pass from Chicago, out into the drainage canal, through the Illinois river, into the Mississippi and thence to the chain of rocks and the intake tower of St. Louis?

A. I can find no evidence that shows that the typhoid bacilli does or can pass from Chicago out into the Illinois river, thence to the chain of rocks and the intake tower at St. Louis.

Q. Professor, do you consider that the Illinois river water containing mixed sewage and canal water from the Chicago drainage canal has rendered less safe and wholesome now than before the opening of the canal, the waters of the Mississippi for drinking purposes on the part of the inhabitants of the State of Missouri, the waters of the Mississippi river below the mouth of the Illinois?

A. From all the data that I have studied, and from all
12221 the knowledge that I have been able to obtain regarding
the Illinois river I find not the slightest evidence that
the Illinois river, containing the mixed sewage and canal water from the Chicago drainage district since the opening of the drainage canal renders the waters of the Mississippi river below

the mouth of the Illinois river less safe and wholesome than it was before the opening of the canal, for drinking purposes on the part of the inhabitants of Missouri.

Q. Professor Sedgwick, in answer to a question, among other things, said: "The mere presence of pollution, I mean by that uninfected sewage, that is supposing Chicago reduced her typhoid death rate and would still put her sewage down there, that sewage as favoring the longevity and growth of germs that get in from Peoria or elsewhere would be an added menace to the cities with water supply, even if she did not send typhoid fever germs down, sending the filth along is serious." I will ask you what is your opinion, based upon your experience as a chemist and bacteriologist and sanitarian as to whether the sewage from Chicago favors the longevity or growth of germs from Peoria or anywhere else, emptying their sewage in the
12222 Illinois river?

A. From various experiments that have been made it has been shown that the vitality of the typhoid bacilli is greater in pure water than in water polluted by sewage, and basing my opinion on these facts, it is my opinion that the sewage from Chicago does not favor the longevity or growth of germs from Peoria or anywhere else emptying their sewage into the Illinois river.

Q. State in detail what position the science of bacteriology occupies in regard to the ascertainment of the purity of river waters?

A. Bacteriology enables us to determine the number of bacteria in a water and to isolate and determine the number of certain species of bacteria. It enables us to tell indirectly something regarding the condition and amount of organic substances in a water and also to determine the vitality of certain species of bacteria. For studying the sanitary character of the water a knowledge of bacteriology is absolutely necessary.

Q. What position does chemistry occupy in what is known as sanitary science?

A. Chemistry tells us the amount of salts in the water, the amount and condition of the organic matter. It enables us to tell something regarding the past history of a water and in-
12223 directly gives us an idea as to the bacterial condition of the water. It also enables us to understand how the com-

plex organic compounds such as occur in the food products and nature when placed in water are broken up, decomposed and gradually changed into gas and mineral substances.

Q. In the ascertainment of the quality of the river water what aid are chemisty and bacteriology to the sanitarian in forming a judgment of the quality and potability of water?

A. It is absolutely necessary to employ both chemistry and bacteriology, and it is impossible to form a correct judgment as to the quality and the potability of a water without the aid of both of these sciences.

Q. Does not a sanitary expert call to his assistance all the information available from chemical and bacterial sciences as well as knowledge of the source of pollution in passing judgment upon the sanitary character of a river?

A. In passing judgment on the sanitary character of a river it is almost absolutely necessary to have a knowledge of the sources of pollution and a knowledge of the water shed. Without a knowledge of the nature of the water shed it is almost impossible to form a correct idea of chemistry and bacteriology alone, of the changes that are taking place in the river.

1224 Q. From the tables of analyses submitted in evidence by the chemists and bacteriologists who have testified in this case, whose tables you have examined, and from the tables and charts which you have introduced, where is the zone of greatest decomposition located in the Illinois river?

A. From all the tables that I have studied and the various analyses that have been made upon the waters of the Illinois river, all indicate that the zone of the greatest decomposition in both 1899 and 1900, before and after the sanitary canal was opened in the upper stretches of the river was in the neighborhood of Ottawa. In the lower stretches of the river there is in both years another zone of decompostion somewhere between Pekin and Havana.

Q. Will you differentiate between the zone of greatest decomposition and of greatest purification?

A. In my opinion the zone of greatest decomposition is shown principally by the nitrogen as nitrites. The zone of purification is shown by the change of the nitrites into nitrates, that being the last change which organic matters undergo, it being transformed into mineral substances. The zone of purification immediately follows the zone of greatest decomposition.

12225 Q. As a sanitary expert, availing yourself of all chemical and bacterial knowledge which is available to you, what is your opinion as to whether a typhoid bacillus lying in the sediment of a polluted stream for a period in excess of sixty days would be able to cause tphoid fever when taken into the human system after it had remained in such sediment for that length of time?

A. My opinion is that if it was possible for a typhoid bacillus to remain in the sediment of a polluted stream for a period in excess of sixty days the virulence of the typhoid bacillus would be so greatly diminished that when taken into the human system, in all human probability it would not be able to cause typhoid fever.

12226 Q. What is your opinion as a sanitary expert, as to whether pollution, or typhoid fever bacilli, coming from the sewage of Chicago through the drainage canal, and deposited on the bottom of the Desplaines and Illinois rivers, between Chicago and Peoria, can remain there for a period of from 30 to 60 days, and yet retain its dangerous qualities as well as its pathogenesis?

A. If by polluted matter you mean the organic matter that is contained in sewage, I believe that it could be deposited in the upper stretches of the Illinois river and remain there from 30 to 60 days. As regards infected matter, meaning especially typhoid bacilli, I do not believe that it could remain for a period of from 30 to 60 days and yet retain its dangerous qualities.

Q. From your personal knowledge of the Illinois river, and your knowledge as a sanitary expert, together with your chemical and bacterial knowledge derived from every source, what is your opinion as to whether sewage from the city of Chicago passing through the drainage canal into the Illinois river, at different seasons of the year and at different stages of

12227 the water, in the Illinois river, would be a danger and a menace to the inhabitants of Missouri and to the citizens of the city of St. Louis, using the water of the Mississippi river at the intake tower at the chain of rocks?

A. From my knowledge of the Illinois river, flowing as it does at high water over a very large amount of territory, and the fact that the river is studded with lakes, nearly all the way from Upper Peoria Lake to its mouth, I do not believe that even at the different stages of water of the Illinois river, the sewage from the city of Chicago, passing through the drainage canal into the Illinois, at different seasons of the year, would be a danger or a menace to the inhabitants of Missouri and the citizens of the city of St. Louis, using the water of the Mississippi river at the intake tower, at the chain of rocks.

Q. What is your opinion as a sanitary expert, based upon your examinations of the tables of analyses introduced in evidence by Professors Long, Palmer, Burrill and Jordan of the waters of the Illinois, Mississippi and Missouri rivers,
12228 as represented by such tables as you have examined, as to which one of those three rivers, from those analyses. discloses the least amount of impurity or pollution?

A. From the chemical and bacterial analyses introduced in evidence by Professors Long, Palmer, Burrill and Jordan, together with my study of the tables and charts that I have prepared and introduced as evidence, it is my opinion that the Mississippi and the Illinois rivers practically contain about the same amount of impurity, while the Missouri river contans a larger amount of impurity than either of the other two rivers named.

Q. If the Illinois river discloses from such data as aforesaid a less amount of impurity than the Missouri, what would be the effect of the waters of the Illinois river emptying into the Mississippi river at Grafton, and subsequently uniting
12229 with the Missouri river at its mouth, upon the combined waters of the Mississippi and the Missouri rivers at the intake at the chain of rocks?

A. The effect under the conditions stated would be one of purification upon the combined waters of the Mississippi and the Missouri rivers, and would render those waters less harmful.

Q. Does the mixing of the Illinois with the Mississippi and the Missouri rivers, as indicated in the foregong question, create any added danger, or pollute or contaminate the waters of the Missouri and the Mississippi rivers, at Peoria, or at Grafton?

A. It does not.

Q. From your knowledge of the conditions that obtain in and along the Illinois river, what is your opinion as a sanitary expert as to whether deleterious substances and infected matter, or pathogenic germs, which come through the drainage canal from the sewers of the city of Chicago, would reach as far down the Illinois river as the city of Grafton? 12230

A. It is my opinion as a sanitary expert, and with a knowledge of conditions that obtain in and along the Illinois river, and from the evidence that has been submitted in this case, that such infected matter or pathogenic germs which come into the drainage canal from Chicago, do not reach as far down the Illinois river as the city of Grafton.

Q. Would any of these substances in a dangerous stage from Chicago reach the intake tower at the St. Louis water works, at the chain of rocks, in your opinion?

A. If they would not reach as far down the Illinois river as the city of Grafton, it is impossible that any of these substances in a dangerous state would reach the intake tower of the St. Louis water works at the chain of rocks.

Q. As a sanitary expert do you consider the sewage of Chicago, entering the drainage canal, and the Illinois river, which in turn empties into the Mississippi river, a cause of danger to the inhabitants of the State of Missouri, and the citizens of the city of St. Louis, taking their water supply from the Mississippi river? 12231

A. For the reasons which I have already stated, which are based upon all the knowledge which I have been able to obtain, regarding the Illinois river, I do not consider that the sewage of Chicago, entering the drainage canal, and the Illinois river, which in turn empties into the Mississippi river, a menace and a danger to the inhabitants of the State of Missouri or to the citizens of the city of St. Louis, taking their water supply from the Mississippi river.

Q. What is your opinion as a sanitary expert as to whether the germs of typhoid fever could lie in the sediment of the drainage canal, upon the bottom of the Illinois river, for a period of from one to three years?

A. As stated in answer to a previous question, where I refer to experiments made by the Massachusetts State Board of

Health, it is my opinion that the germ of typhoid fever could not lie in the sediment of the drainage canal, or upon the bottom of the Illinois river, for a period of from one to three
12232 years.

Q. What is your opinion as to whether the typhoid bacillus deposited on the bottom of the Illinois river could remain there for a period of upwards of five years and then be stirred up by the action of the waves and wind, steamboats or any other means, and continue its journey down to St. Louis in a virulent state and be a cause of danger to the inhabitants of the State of Missouri and the citizens of the city of St. Louis, using the waters of the Mississippi river for domestic and drinking purposes?

A. Believing that it could not exist for three years in the mud of the Illinois river. I certainly do not believe it could exist for five years.

Q. What is your opinion as an expert chemist, as to the chemical tables brought in evidence by Professors Long, Palmer, Burrill and Jordan, of the waters of the Illinois river, as to whether the pollution and contamination from the sewers of Chicago, emptying into the Chicago river, thence into the drainage canal, could be manifested and present as far down the Illinois river as Grafton, and at the chain of rocks, on the Mississippi river?

12233 A. In my opinion, the only effect the pollution and contamination from the sewers of Chicago, entering into the Chicago river, thence into the drainage canal, that could be noticed at the chain of rocks on the Mississippi river, is a higher chlorine and nitrogen contents of the river.

Q. From your examination of the different tables, what is your opinion as an expert chemist as to to whether any of the original organic matter of the sewage from Chicago finds its way into the intake tower of the St. Louis water works, at the chain of rocks?

A. From a study of the analytic data, which has been submitted in evidence in this case, it is my opinion that all this analytical data shows that this organic matter of the sewage from Chicago has been decomposed before it reaches Grafton. Consequently, none of the organic matter from the sewage of

Chicago finds its way into the intake tower of the St. Louis water works at the chain of rocks.

Q. Will you state as a sanitary expert, basing your opinion upon all the information which you possess in this case, whether the water supply of St. Louis is contaminated
12234 and polluted or injured by the sewage of Chicago entering the drainage canal and thence into the Illinois river?

A. In my opinion it is not.

Q. What effect does the increased volume of water of the Illinois river have upon the lowlands lying along the banks of the Illinois river?

A. The effect of the increased volume of water in the Illinois river is to cover with water the low lands lying on the banks.

Q. If the increased water at flood times, from the tributaries of the Illinois river, as well as the Illinois river itself, exclusive of the waters from the drainage canal, causes a large area of land to be overflowed along the Illinois river flats, what effect does this over-flow have upon the contamination of the sewage from Chicago, entering the Illinois river through the said canal?

A. It is a well known fact that the larger amount of surface over which the water spreads, the greater will be
12235 the amount of deposition, consequently the increased water at flood times, causing a larger area of land to be overflowed along the Illinois river, would tend to cause a greater deposition of the suspended matter coming from the sewage of Chicago and entering the Illinois river through its canal.

Q. Will you state, as an expert sanitarian, from all sources of knowledge which you possess, whether the water of the Mississippi river at the chain of rocks, was prior to January, 1900, a safe and potable drinking water, fitted for domestic use and drinking purposes in its raw state.

A. From the examinations that have been made, and the finding of the coli bacilli in the majority of one cubic centimeter samples, I do not believe that the Mississippi river at the chain of rocks was prior to 1900 a safe and potable drinking water, fitted for domestic and drinking purposes in its raw state.

Q. Was the Missouri river water a safe water for drinking and domestic purposes, prior to opening of the drainage canal, in 1900?

12236 A. For the same reasons, this is my opinion that the Missouri river was not a safe water for domestic purposes prior to the opening of the drainage canal in 1900.

Q. Was the Illinois river a safe water for drinking and domestic purposes prior to the opening of the drainage canal in 1900?

A. In my opinion for the same reasons as stated above the Illinois was not a safe drinking water for domestic purposes prior to the opening of the drainage canal in 1900.

Q. Have the sanitary conditions of the water of the Illinois river at Grafton been improved or damaged by the opening of the drainage canal?

A. It is my opinion all the examinations that I have studied, as well as my own tables and charts show, that the waters of the Illinois river at Grafton are in a purer state since the opening of the drainage canal.

Q. Since the opening of the drainage canal are the waters of the Illinois river less sanitary than the waters of the Missouri and the Mississippi rivers?

A. They are certainly not less sanitary than the waters of the Mississippi river, and they are in a better sanitary condition, as shown by the bacterial and chemical analyses than the waters of the Missouri river. 12237

Q. What effect does the sewage discharged through the drainage canal have upon the Missouri and the Mississippi river waters at the chain of rocks?

A. The only effect in my opinion that the sewage discharged through the drainage canal has upon the Missouri or the Mississippi river waters at the chain of rocks, is in the increase in the amount of chlorine and also in the quantity of nitrogen contents, neither of which elements as far as known, has any effect upon the human system.

Q. Does the sewage of Chicago, in your opinion, ever reach the intake tower of the city of St. Louis, at the chain of rocks?

A. The sewage of chicago as sewage in my opinion never reaches the Mississippi river at the chain or rocks, at the intake tower.

Q. Is the water of the Mississippi and the Missouri rivers, exclusive of the water of the Illinois river, a safe and suitable drinking water for domestic purposes to be used by the citizens of Missouri in its raw state? 12238

A. I do not consider that either the waters of the Mississippi or the Missouri are a safe and suitable water for drinking by the citizens of Missouri.

Q. If the sewage of Peoria and all the other towns along the Illinois river and its tributaries were eliminated from the Illinois river, would all the original organic matter of the sewage of Chicago be eliminated before it reaches Grafton?

A. In my opinion, it would.

Q. Taking into consideration all the knowledge which you possess in regard to the chemical, bacterial and physical conditions of the water of the Illinois river and its tributaries, and the river itself, the different towns sewering into the Illinois river and its tributaries, the population upon the water shed of the Illinois river, both rural and urban, the stages of the river under all conditions, and during all the seasons of the year, what is your opinion, as a sanitarian, as to the effect of flowing the sewage of Chicago through the drainage canal, into 12239 the Desplaines and Illinois rivers, upon the inhabitants of the State of Missouri and the citizens of St. Louis, using the waters of the Mississippi river for drinking and domestic purposes?

A. It is my opinion that all of the organic matter contained in the sewage of Chicago has been entirely decomposed and changed before the river reaches Grafton, and it is also my opinion, based upon all the knowledge that I possess, that the infected matter, meaning by that, the typhoid bacilli, have not been able to survive the journey from Chicago to Grafton. Taking into consideration all the analytical data I have examined and studied, including the chemical and bacterial analyses made upon the waters of the Illinois river and its tributaries, and my own tables and charts, and at the same time taking into account certain towns sewering into the Illinois river and its tributaries, and taking also into account the rural and urban population upon this water shed, my opinion is that there is no evidence that the flowing of the sewage of Chicago from the drainage canal into the Desplaines river has any effect upon the

inhabitants of Missouri, using the waters of the Mis-
12240 sissippi river for drinking and domestic purposes.

LEONARD P. KINNICUTT.

Adjourned until 10:30 a. m., March 17th, A. D. 1904.

10:30 A. M., Thursday, March 17, 1904.

Present, the Commissioner and same counsel representing the respective parties.

Complainant not being ready to proceed with cross-examination of L. P. Kinnicutt an adjournment was taken until 2 p. m. of the same day.

2 P. M., Thursday, March 17, 1904.

Met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

Complainant not being ready to proceed with cross-examination of counsel, by consent, an adjournment was taken until March 26, 1904, at 9 a. m., at the Stafford Hotel, Baltimore, Maryland.

THE STATE OF MISSOURI
12241 VS.
THE STATE OF ILLINOIS and
SANITARY DISTRICT OF CHICAGO.

Met pursuant to adjournment, Saturday, March 26, 1904, 9:00 A. M., at the Stafford Hotel, Baltimore, Md.

Present: Frank S. Bright, Esq., Commissioner United State Supreme Court, S. P. Jeffries, Esq., and James Todd, Esq. representing the respective parties.

WILLIAM S. THAYER

called as a witness in behalf of the defendants, State of Illinois and the Sanitary District of Chicago, being duly sworn by the Commissioner and upon examination in chief by Mr. Todd testified as follows:

Q. Please state your full name?

A. William S. Thayer.

Q. What is your business?

A. Physician.

12242 Q. Where do you reside?

A. 406 Cathedral Street, Baltimore.

Q. Where did you graduate, Doctor?

A. At Harvard University.

Q. When did you graduate at Harvard University?

A. In medicine, in 1899, in the academic department, A. B., 1885.

Q. After graduating in medicine what did you do?

A. I spent a year as house physician at the Massachusetts General Hospital. I should say that that year was the year 1888-1889. It was the rule that one accepting the position of house physician should not take his degree until the year following the date of his graduation so that my degree dates from 1889. After that I spent a year abroad in studying in Berlin and Vienna and in the fall of 1890 I came to Baltimore as assistant resident physician in the Johns Hopkins Hospital. In the fall of 1891 I was appointed resident physician in the fall of 1895 I was made associate in medicine at the Johns Hopkins University and in '96 or '97 associate professor of medicine, which I have 12243 been since then. I lived in the hospital as resident physician from 1891 to 1898.

Q. Have you pursued your study in Europe?

A. I studied in Paris for three months during the fall of 1893.

Q. What positions do you hold?

A. I am one of the physicians in chief of the Johns Hopkins Hospital Dispensary, associate in medicine at the Johns Hopkins Hospital, associate professor of medicine in the Johns Hopkins University and visiting physician to the Union Protestant Infirmary.

Q. What branch of medicine have you given particular attention to?

A. To internal medicine.

Q. Have you made a special study of the so-called germ diseases?

A. Yes sir, I have, in regard particularly to malarial fever and typhoid fever and in a general way to those infectious dis-

eases which come into the practice of a practitioner of
12244 general medicine; I have made a special study of malarial
fever and a number of phases of typhoid fever.

Q. Do the diseases caused by germs come within the scope of your study?

A. They do. At least I may perhaps say, most of them.

Q. Which diseases have you made a special study of, i. e., germ diseases?

A. Malarial fever and typhoid fever particularly.

Q. Have you made any study upon typhoid fever and malarial fever from the standpoint of a bacteriologist or clinician?

A. I have been studying them clinically, steadily, since the beginning of my practice, and I have made special investigations with regard to the parasites of malarial fever.

Q. In connection with such study as you have detailed, have you taken up the question of the proper diagnosis of fevers of the kinds known as typhoid and malarial?

12245 A. Yes, I have.

Q. Have you had any experience in the diagnosis of these fevers, either in the laboratory or at the bed side?

A. I have had continued experience both at the bed side—more particularly at the bed side and also in the laboratory for the last—since 1889—since the summer of 1888, really.

Q. What is the meaning of clinical diagnosis?

A. Clinical diagnosis is bedside diagnosis—at the bedside of the patient. It is bedside diagnosis in contradistinction to pathological or post mortem diagnosis.

Q. What is typhoid fever and its clinical diagnosis?

A. Typhoid fever is a disease due to the entrance into the organization of a specific bacterium, the typhoid bacillus. That organism enters into the body in all probability in the vast majority of cases through the gastro intestinal tract, passes into the general circulation and causes a septicaemia, in other words,
a general blood poisoning. It furthermore is associated
12246 with certain anatomical changes more particularly a
swelling of Peyers patches and the solitary follicles of the small intestine, enlargement of the retroperitoneal glands and an enlargement of the spleen, together with certain widespread degenerative changes in various organs throughout the body.

This results in a clinical picture, the more important features of which are due—not to the local changes, but to a poisoning produced by certain products of the growth of this bacillus. Those symptoms are in the first place a fever of usually rather gradual onset preceded often by a week or ten days or so of sensations of malaise and headache, not infrequently nose bleed, a gradually rising fever which reaches its height at the end of from several days to a week as a rule and lasts on an average of about three weeks falling gradually to noraml. It may last a short time and it may last a very much longer time. This fever is associated ususally with certain other symptoms which are
1227 of considerable importance, a generally dull apathetic condition of the patient, which is spoken of as the typhoid condition and which though it may be present in other intoxications, is rather particularly characteristic of this disease. The appearance of the eruption, which is present in the majority of cases, though not always; this appears usually about the end of the first or beginning of the second week, an eruption of small so-called "rose spots." Very often there is a slight bronchitis. A palpably enlarged spleen. There are not infrequently associated with these symptoms others which are due more particularly to the local lesions, such for instance as diarrhoea, the result in most cases of severe intestinal involvment, abdominal distention, or of other complications such as hemorrhage of the bowels due to ulcerations through a large vessel, or perforation of the intestine, which occurs in a small proportion of cases. Towards the end of the first week or by the tenth day as a rule there appears in the blood serum, a substance, which, when the serum is added to cultures of the typhoid bacillus, even
1248 though the serum be diluted to a high degree, produces a clumping and loss of motility of the bacilli—the phenomenon known as the Widal reaction. This reaction when positive, after proper precautions have been taken in the procedure, is specific of typhoid fever.

It is fair to say that it sometimes does not appear until very late and it is not impossible that there may be cases of typhoid fever though very rarely, in which it does not appear, but this is probably of the utmost rarity.

With regard to the diagnosis of typhoid fever I might say one word more. In contradistinction to what is true in fevers due to or associated with local inflammatory processes, the white corpuscles of the blood are diminished in number in typhoid fever while in all diseases due to local inflammatory process they are increased—sometimes an important diagnostic point.

But the diagnosis of typhoid fever depends upon a careful consideration of the whole situation. It is often impos-
12249 sible to make a positive diagnosis of typhoid fever before the end of the first week, but it is rarely the case that one is not able to recognize typhoid fever if the disease is carefully observed.

Q. Are all the symptoms which you have indicated in your answer always present in a case of typhoid fever?

A. No, there is not a single one of the symptoms of typhoid fever which might not be absent from a given case. While one can draw a good average picture, such as one reads in a text book of medicine, the individual who learns to recognize typhoid fever only from such a picture is bound to make many mistakes. The diagnosis can only be made by a careful consideration of all the different symptoms putting them together and drawing proper conclusions, and in cases which are not typical, proper diagnosis demands experience. There is no disease in which experience is more important than in typhoid fever.

Q. What experience have you had and what studies have you pursued with malarial fever?

12250 A. Shortly after coming to Baltimore in 1890—the fall of 1890, I began to devote myself especially to the study of the malarial fevers as here observed. After five years study—Dr. Hewetson and I published a report on the subject in the Johns Hopkins Hospital Reports in which we gave the results of our studies of the malarial fevers and the malarial parasites. I continued my work afterwards, working principally on malaria up to 1900 and during that time published a number of papers. I published a text book "Lectures on the Malarial Fevers" in 1897; in the spring of 1900, I delivered an address before the Congress of American Physicians and Surgeons on the recent progress in our knowledge concerning malarial fevers. I have, also, I may say, looked into the matter personally in other parts of this country having made trips to Memphis, to New

Orleans, to certain parts of Eastern North Carolina and Virginia, to look up special points.

Q. What is malarial fever and its clinical diagnosis?

A. Malarial fever or more properly the malarial fevers,
12251 for there are several distinct types, are due to the entrance into the blood of specific micro organisms. These belong to the lowest order of animal parasites. They enter into the red blood corpuscles of the infected individual and pursue their cycle of existence in the red corpuscles producing characteristic symptoms in the patient. Here as all over the world there are three types of malaria. Tertian fever, Quartan fever and what is called Aestivo-Autumnal or Tropical fever. The regular intermittent Tertian and Quartan fevers are characterized by chills or febral paroxysms occurring at regular intervals. In infections with the Tertian parasites they occur every other day, in infections with the Quartan parasite, every fourth day. Each paroxysm is associated with the ripening of a group of parasites. The parasites in these regularly intermittent malarial fevers exist in the blood in great groups. All the members of each group pursuing their development in unisen and reaching their maturity at practically the same time.
12252 When a group of parasites reaches maturity each parasite breaks up into a larger number of fresh young organisms which attack new corpuscles and begin again their development. The febral paroxysms correspond to the period during which the full grown parasites are breaking up into the new brood. In Tertian fever this period occurs every other day. In Quartan every fourth day. In either instance if multiple groups of parasites be present—groups which reach maturity on successive days, the chills will occur at more frequent intervals.

In infections with the third form of malarial parasite—the Aestivo-Autumnal parasite, the symptoms are somewhat different. These parasites are not as a rule arranged so regularly in groups. The stage of maturity with the liberation of the new group of parasites, does not occur at such regular intervals. Small groups of parasites may be segmenting almost continually. As a result of this one sometimes sees continued fevers

or fevers with irregular intermissions or remissions. The
12253 malaria fevers are recognizable and diagnosticable by
the examination of the blood under the microscope and
the demonstration of the parasites and need never be confounded with typhoid fever. They are also recognizable by the fact that they are curable by quinine. The only patients with malarial fever properly treated, who ever die are certain cases of extremely pernicious Aestivo-Autumnal malarial cases which die within forty-eight hours perhaps of the beginning of the treatment. No case of continued malaria which could be confounded with typhoid fever need ever be fatal. They always clear up under treatment with quinine and no case of continued fever which lasts more than—well to be most generous four or five days after treatment with quinine, is malaria. That is a statement which in my experience can be positively made.

Q. What are the known means of conveying the parasites of malaria whereby the disease is contracted?

A. The only known way by which malaria can be carried
12254 is by the bite of a mosquito. The malarial parasites of
all three varieties posses two cycles, one of which they
pass in the stomach wall, and in the salivary glands in certain types of mosquito-members of the genus anopheles. The other cycle they undergo in the human being. So far as known and so far as believed by all who have particularly devoted themselv to the subject of malarial parasites, they do not exist outside of the human being or the mosquito. If a mosquito of the genus anopheles at a fitting time of the year when the temperature is warm enough, bites a patient whose blood contains certain forms of malarial parasites, at the end of seven or eight days that mosquito will be capable of transferring the infection by bite to another human being. After careful investigation during the last six years——since this discovery has been made—there has not been revealed a single instance where malaria has originated
except in the presence of this type of mosquito. And
12255 furthermore most interesting experiments have shown
that even in the most malarious districts, the disease
may be kept away by thoroughly protecting individuals from the bites of mosquitoes. And on the other hand it has been shown that by taking a given population and treating them

with quinine in such a way that human beings are never allowed to have parasites in their blood, so that the mosquitoes can get them, the disease may be wiped out. Koch has done that in several places, and most striking were his experiments in a town of seven hundred inhabitants in New Guiana or West Africa. He went there before the beginning of the malarial season and put every one who had parasites in the blood under treatment; paid no attention to mosquitoes but watched the people and as a result there was no epidemic. So far as known the parasite does not live in the mosquito for more than several weeks or a month.

Q. Have you ever found the parasite of malaria in the mosquito?

A. Yes, I have. I have fed mosquitoes on patients
12256 whose blood contained malarial parasites and demonstrated intermediate stages in the mosquitoes stomach.

Q. Do you know of any recorded instance where the mosquito has been employed in transmitting malarial fever from one country to another?

A. Yes, that was done in the case of Dr. Manson, the son of Dr. Patrick Manson in London. The Italians—a number of Italian observers had demonstrated beyond a possibility of contradiction the fact that the disease could be transmitted by the bites of mosquitoes with mathematical accuracy and Patrick Manson of London wishing to demonstrate this more impressively arranged that Dr. Bignami of Rome should send him, I think, two mosquitoes which had bitten a case of malarial fever at such a stage that they ought to be capable of transferring it shortly after arriving in London. These mosquitoes were forwarded to London and his son allowed himself to be bitten by them. His son had never had malarial fever which does not exist in London today except as in so far as it is im-
12257 ported; and he developed after a proper period of incubation the characteristic symptoms of Tertain malaria of the same type as that which the patient had who was bitten by the mosquito in Rome. It was simply a dramatic illustration of what the Italians had definitely shown before.

Q. Is malaria as prevalent in the center of a large city as in the suburbs of a large city?

A. No, there are probably very few if any large cities with proper drainage in which the mosquito capable of transferring malaria is found except in the suburbs for the reason that this class of mosquito lives and breeds in shallow pools containing certain sorts of algae for food and does not breed in other standing water in wells and cans and that sort of thing in which the ordinary house mosquito thrives. In Baltimore which is surrounded by a malarious country, especially on the side of the bay, the disease never breaks out in the middle of the town except in individuals who have been exposed in the
suburbs, and with a pretty wide experience, I have never
12258 found the anopheles except towards the outskirts of the
city where there are slowly running streams and pools in which these mosquitoes breed.

Q. How long do mosquitoes live?

A. That varies very much, and just how long a mosquito may live is not definitely known, but mosquitoes hibernate and live through the winter. The anopheles for instance I have found in winter in enormous numbers hanging from the ceiling of cellars and the roofs of barns where they spend the whole winter. In hot weather unless you keep proper food for a mosquito and give him plenty of room to fly about he may die pretty quickly, but I have kept mosquitoes alive for—I think the longest I have ever kept mosquitoes alive was two months. A mosquito has to be fed as a rule about every other day in warm weather. In winter they will hang upon the wall or in a dark place for months, hibernating.

Q. This answer you have just given applies to the malarial mosquito?

12259 A. Yes.

Q. What is intermittent fever and its clinical diagnosis?

A. That is not a very easy question to answer. Intermittent fever is a term—a purely clinical term—describing a form of fever; a fever which has intermissions. Such fevers occur under a great variety of circumstances. The term is very commonly used to describe the regularly intermittent malarial fevers, but used as such it is not an exact scientific term.

Q. What is remittent fever and its clinical diagnosis?

A. The same answer really applies to that as to the last question; it describes a type of fever which may exist under all manner of circumstances. It has been used pretty largely to describe fevers occurring in malarious districts, long continued with occasional remissions and non-resistant to quinine, which were once by a great many people supposed to be malarial in nature, but which are now known to be non-malarial and in a vast majority of instances probably typhoid. The term itself merely describes a type of fever—not a disease.

12260 Q. What is typhoid malarial fever and its clinical diagnosis?

A. Typhoid malarial fever is an incorrect term which was introduced shortly after the Civil War by Dr. Woodward. I am not perfectly sure, it was not introduced during the war—by Dr. Woodward who edited a valuable part of the Medical and Surgical History of the War of the Rebellion. It was used to describe fevers which were supposed to be due to a combination of the malarial and typhoid poison—fevers which were non-resistent to quinine. At the time when the term first came into use neither the cause of malarial or of typhoid fever was known and we did not possess anything like the means of diagnosis which we now have. The term has been entirely abandoned by all competent observers and it is now generally recognized that the disease called typhoid malarial fever—that is the symptoms classed under the name of typhoid malarial fever represent in the vast majority of instances simply un-
12261 complicated typhoid fever. In the statistics of city health departments which are most carefully looked after, all diagnoses of typho-malarial fever are classed as typhoid fever.

Q. What is congestive fever and its clinical diagnosis?

A. I don't know what is meant by congestive fever exactly. That is also purely a symptomatic term. If a person told me that his father or his relative had died of congestive fever, I should think—had he lived in a malarial district—I should suspect that it meant acute pernicious malaria, that is, an acute malignant type of malaria associated with unconsciousness. But congestive fever is a term which means nothing to me—it would simply set me guessing as to what the individual who used the tem, meant.

Q. What is simple continued fever and its clinical diagnosis?

A. Simple continued fever is simply a term used to describe a fever which is not accounted for by the man who uses the term. It is a wholly unscientific term and is a
12262 cloak for ignorance.

Q. Are remittent, intermittent, typho-malarial, congestive and simple continued fevers distinct types of disease and so recognized by bacteriologists and clinicians?

A. No, they are not. They are simply terms describing symptoms.

Q. What significance do you attach to these terms as applied to fevers when they appear in vital statistics?

A. I should regard them as representing in the vast majority of cases typhoid fever.

Q. Assuming that the number of deaths reported as occuring from typhoid fever in the city of St. Louis, as evidenced by the annual reports of the Board of Health of the city of St. Louis Health Department, is as follows:

	1890	140
	1891	165
	1892	441
	1893	215
	1894	171
12263	1895	107
	1896	106
	1897	125
	1898	95
	1899	131
	1900	168
	1901	198
	1902	222
	1903	288

and assuming further that the number of deaths reported in the same reports under the heading remittent, intermittent, typho-malarial, congestive and simple continued fevers, is as follows:

	1890	226
	1891	296
	1892	326
	1893	284
	1894	179
	1895	155
	1896	177
12264	1897	172
	1898	134
	1899	148
	1900	112
	1901	80
	1902	102
	1903	91

do the number of deaths reported as occurring from typhoid fever alone in the city of St. Louis, properly represent in your opinion the total number of typhoid deaths actually occurring in that city?

A. No, I should say unquestionably they do not.

Q. What reasons have you for stating that they do not?

A. I should say in the first place that a considerable personal experience with cases in which these very diagnoses have been made, has shown me that in almost every instance thy represent typhoid fever. I should say furthermore that in an experience of fourteen years in the Johns Hopkins Hospital—I have never made, and I know that there does not stand
12265 on the books a single diagnosis such as appears in the
list which you gave of the remittent, typho-malarial fever and so forth; and further from the fact that the deaths from malarial fever itself in this city and in this neighborhood which is a malarious neighborhood, occur in extremely small proportion as compared with those of typhoid fever—I should say that in view of all these facts as well as in view of the fact that in other cities in which these diagnoses used to be made, they have now been abandoned entirely, these cases all being classed as typhoid fever—in view of all those facts I should

feel perfectly certain in my own mind that the great majority of those cases represent typhoid fever.

Let me say that in my own experience in the Johns Hopkins Hospital since the opening of the Hospital—I have not been here since the opening of the Hospital, I came here the year after it was opened, but I have the statistics of that year—there have been a hundred and thirty deaths from typhoid
12266 fever, just four deaths from malaria, and no deaths ascribed to any of these other causes. Then again the observations of all men of competence who looked into the conditions during the Spanish-American War, show that the diagnoses of typho-malaria, of simple continued fever, of remittent fever as well as the vast majority of the diagnoses of malarial fever, were incorrect; that the condition was purely and simply typhoid fever. And let me add just one more word in regard to the question of malarial fever in particular, and the diagnosis of remittent fever, and all that sort of thing. When a man hands in a diagnosis of remittent fever it is perfectly safe to say that in the great majority of instances he believes its nature to be malarial. Now, those fevers are—anybody who knows anything about practice in this country knows that a case of remittent fever so diagnosticated, is never allowed to go through its course without treatment with quinine; and anybody who has had any sufficient experience with malaria and sufficient
12267 knowledge of its nature, knows that if those cases were malaria not one of them would die; they would all recover.

Q. To what do you attribute the failure of these statistics assumed in the foregoing hypothetical question, to properly disclose the number of typhoid fever deaths occurring in the city of St. Louis?

A. I should attribute it to wrong diagnoses made by physicians in reporting deaths.

Q. Why is it that the doctors employ the terms remittent, intermittent, typho-malarial, congestive and simple continued fevers, for fevers that are recognized as being either typhoid or malarial?

A. The answer to that will be rather long; it is rather hard to answer in a few words: It seems to me that in the first

place it is fair to preface this answer by saying that our knowledge of the nature of malaria and typhoid fever dates in the former instance from '80, and in the latter from '85—that while the discovery of the malarial parasite was made in 1880
12268 and of the typhoid bacillus in 1885, these causes were not generally recognized until at a considerably later period so that many men in the practice of medicine who are in parts of the world or under conditions where they do not follow well the advances of medicine, and many other men who have begun early to grow mentally old, in parts of the world where they could perfectly well keep up with the times, are not familiar with the advances that have taken place. I think however that the great cause lies in the fact that we have in this country no fixed laws governing medical education. In only a very small proportion of the medical schools of this country are men required to have actual clinical experience in the diagnosis of these diseases before they graduate; and I think it is perfectly safe to say that the great majority of young men graduating from medical schools today, in this country, have never followed a case of typhoid fever from beginning to end.

Now, it is perfectly impossible to correctly learn to rec-
12269 ognize typhoid fever without actual bedside experience. In the great majority of medical schools in this country medicine is taught practically by lectures and by books. The students do not have the necessary clinical or pathological experience—they don't know the nature of the disease and they have no experience in observing its clinical course. When they go out into practice a large proportion of the physicians of this country have not been trained and are not able to reason out the nature of the problems before them. When they approach the question of diagnosis of a case of typhoid fever, it is to such men simply a question of matching pictures—they are comparing the pictures they see in bed before them with a picture which has been impressed upon their minds by the lectures or by books which they have read. Now, a man fifteen years ago who was told by his instructor that typhoid fever had certain characteristics and these various other kinds of fevers which, with the advances of our knowledge we know do

not exist as entities, have other characteristics, and has
12270 had few opportunities to control the statements is very
likely to go through his life comparing all that he meets with these pictures impressed upon his mind, fifteen years before. An example of this sort of thing—and it is an example for the necessity of having proper clinical experiments—I have mentioned in an address which I made before the Massachusetts Medical Society a few years ago. A young man, who was not stupid, had graduated at one of the better medical colleges of this country—he had been taught the technique of the physical diagnoses very well—he knew how to detect a patch of pneumonia as well as the next man. He entered into the service of a large hospital in one of the largest cities in this country immediately after graduation. He had never in the medical school followed a case of pneumonia from beginning to end—although he had seen a fair number of cases, of typhoid fever, he had never followed one from beginning to end. Shortly after the
beginning of his services a patient was brought in very
12271 ill who on examination showed a patch of consolidation
in one of his lungs clearly pneumonia. The patient was dull, had oedema of the lungs and was passing a very small quantity of urine, which contained a considerable amount of albumen. The young man had recognized the patch of pneumonia, but the clinical picture which was characteristic was unfamiliar to him. The small quantity of urine and the albumen present lead him to believe that it was an instance of Bright's disease and that the pneumonia was a secondary affair. He was unfortunately left to himself in the treatment of the case and pursued a course of treatment which certainly did not tend to prevent the death of the patient, which occurred shortly afterwards. Now, the picture presented by that patient was perfectly characteristic. Had that student been obliged, as students in England, France and Germany are, to spend a year of his school work practicing in the wards of a hospital, he would have recog-
nized the conditions as easily as possible; as it was he
12272 could not grasp the general picture and was lead astray.

Our standards of medical education are gradually improving, but it is still true in many instances, that young men are turned loose upon the public without the practical experience which is necessary—not only for treatment, but for the recognition of disease.

Q. Do you know of any city in the country where the death rate from malarial fever alone is as high as in the city of St. Louis, as evidenced by the number of deaths, as assumed in the hypothetical question, under the heading, intermittent, remittent, typho-malaria, congestive and simple continued fevers occurring in the reports of the Board of Health of the city of St. Louis, assuming the fevers under those headings to be malaria and not typhoid.

A. In connection with that question I may say that I looked up a few days ago the statistics of several cities with regard to that point and have found some rather interesting facts.
12273 I looked up the statistics of the cities of New York, Brooklyn, Philadelphia and of Baltimore. I obtained these from printed copies of the reports of the boards of health of these cities which I obtained from the Surgeon General's library in Washington.

The mortality for Brooklyn shows some very interesting points. I have here the records of mortality from typhoid and malaria for every year from 1876 to 1903. In 1876 there were reported 97 deaths from typhoid, and from malaria one hundred and thirty seven. Gradually the number of deaths from typhoid tended to increase while those from malaria tended to diminish. In 1889 for instance, there were one hundred and sixty-one deaths from typhoid and one hundred and eighty-two from malaria. In 1890 there were one hundred and eighty-two deaths from typhoid and one hundred and sixty-eight from malaria. In 1896 there were one hundred and sixty-three from typhoid and one hundred and forty-eight from malaria. In 1898
12274 two hundred and seventy from typhoid and ninety from malaria, and finally in 1903 I find two hundred and sixty-seven from typhoid and thirty-six from malarial fever, showing that while in years past, the deaths from malarial fever were relatively as high as those reported in St. Louis, gradually the deaths from typhoid have increased and the deaths from malaria have diminished. The proportion of deaths from typhoid to the deaths from malaria was in 1890 as 1.08:1.; in 1903 7.4:1.

Now, in the city of New York we find a similar change though there the deaths from all cases reported as typho-malaria in 1890 were classed as typhoid. In New York in 1890 there were 352 deaths from typhoid and one hundred and seventy-six from malaria—in 1900 342 from typhoid and 68 from malaria—in 1901 380 from typhoid to 49 from malaria—in 1902 366 from typhoid to 52 from malaria, and in 1903 317 from typhoid to 27 from malaria.

12275 That is the proportion of deaths from typhoid as compared with the proportion of deaths from malaria was in 1890 as 2: 1, and in 1903 as 11.7 : 1.

Now, in Baltimore a very similar state of things exists. In Baltimore I was unable to get the statistics for 1890. In 1891 there occurred one hundred and fifty deaths from typhoid fever, from malarial fever twenty-six, and from these other classes of fevers, including thirty-nine "typho-malaria," sixty-five. Since 1897 all the "typho-malarias" have been classed as typhoid. I do not believe I am justified in saying that positively; I think that is the case. Since 1898 all these nondescripts supposed to be malarial fevers have been classed under the bad heading of intermittent fever. I find in 1899 the proportion of typhoids to these nondescripts is one hundred and fifty-three to forty-eight. There is no special heading of "malarial fever." 1900 one hundred and eighty-nine to fifty-four—1901 one hundred and forty-one to thirty-six—1902 two hundred and 12276 twenty to thirty-one. I was unable to get the statitstics for 1903. You see there again the same change; relatively more diagnosis of typhoid fever and very much less of the others.

Lastly I looked up the statitstics of the city of Philadelphia. These are interesting in that in Philadelphia the statistics have been much more carefully controlled. The fevers there are included under three headings: the typhoids, the malarias and another group which are entered in their records as "remittent fevers," "catarrhal," "gastric fevers," and so forth. There are one or two deaths every year under these headings. These are, I believe—I am personally convinced, typhoid fever; however, I have made these three hadings. In 1890 there were six hundred and sixty-six deaths from typhoid fever to thirty-four from malaria and twenty-four of these indeterminate fevers, including fourteen cases of remittent fever.

12277 In 1901 there were four hundred and forty-four cases of typhoid fever, fifteen of malaria and twelve of indeterminate fevers. The relative proportion between the diagnoses of typhoid and of the indeterminate fevers, including malaria, was as 11.4 : 1, in 1890 and as 16.4 : 1, in 1903.

During the whole of the fourteen years since the opening of the Johns Hopkins Hospital—or nearly fifteen now, there have occurred, as I stated before, one hundred and thirty deaths from typhoid fever, and four from malaria, the relative proportion being as 32.5 : 1.

As one compares these statistics with the statistics of St. Louis, it will be found that those of Brooklyn show at certain times even a larger proportion of the so-called malarial fevers than were present in St. Louis, but that the same change has taken place here as has occurred in St. Louis—the diagnoses of malaria have diminished, and the diagnoses of typhoid fever relatively increased.

12278 MR. JEFFRIES: I move to strike out all the tables this witness has read into the record for the reason that the same are incompetent and irrelevant.

MR. TODD: Q. Were the tables which you read into evidence taken from the official records of the different Boards of Health?

A. They were.

MR. JEFFRIES: I object to the question and renew my motion to strike out the answer.

MR. TODD: Q. What proportion of the deaths in the column under the heading "typhoid, intermittent, remittent, conjestive and simple continued fevers" assumed in the foregoing hypothetical question as occurring in the city of St. Louis as evidenced by the report of the Board of Health in your opinion should be classed as typhoid?

A. Well, I should say that a perfectly safe estimate would be at least seven-eighths. Seven-eighths of those were typhoid fever. If one desired to get the relevant frequency of typhoid fever from year to year I think that the adding together of the two columns would give as correct an idea as any other method.

Q. What proportions would you class as malarial fever?

12279 A. That is of course a very difficult question to answer positively. From the comparisons of these statistics with those of other cities—from the general conditions which exist so far as I know them, I should think it would be fair to take the proportion as shown by the statistics in the Johns Hopkins Hospital. That is proportionately or approximately 30 to 1 in favor of typhoid—that is, out of the total statistics added together.

Q. What do you do with the difference between the one-eighth and the one-thirtieth which you class as malarial?

A. I should think that would be a fair allowance, a very fair allowance for the cases of general tuberculosis, or ulcerative endocarditis and other general septicemias of various orgin.

Q. What do the mortality statistics of malaria show in cities where careful attention has been paid to malarial fevers as regards the number of deaths occurring from malarial fever?

A. There are no cities I believe in this country which give really an accurate representation of the proportion of deaths from malaria. The city of Philadelphia would seem to me to give the fairest representation of this question and that I have already quoted where the deaths from typhoid fever in
12280 1901 were 444; from malaria 15, and from various other
indeterminate conditions 12. I believe that the proportion, the proportion of deaths included under malaria, is too large even there, but it approaches the correct figures much more there, I believe, any other city which I have examined.

In Baltimore we have, 1902, 220 deaths from typhoid fever and 31 from "intermittent fever," which is supposed to be malaria. I am sure from my observations here that that is an over estimate of the deaths from malaria—from my observations which have been made in connection with the Johns Hopkins Hospital where we get a fair general run of cases as they enter the hospital.

Q. It is generally recognized by bacteriologists and clinicians that classifying typhoid fever in one column, intermittent, remittent, typho malaria, congestive and simple continued fevers in another column in board of health reports of cities is an improper classification from a scientific standpoint as affording a true indication of the mortality from typhoid fever and malaria?

A. It is recognized by all competent observers that such a method of representing the mortality from typhoid fever is entirely incorrect.

Q. Assuming that the reports of the board of health of 12281 the city of St. Louis by the month from 1895 to 1903, inclusive, under the heading typhoid fever, which for the purpose of convenience is designated A in the tables as follows, and as intermittent, remittent, typho malaria, congestive and simple continued fever for the sake of convenience is designated as B in the table that follows, which table prepared and sworn to by Professor Jordan is based upon said reports and is as follows:

12282

ST. LOUIS.

	1895		1896		1897		1898		189	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
Jan	12	10	4	13	7	7	4	6	10	[illegible]
Feb	3	7	4	10	9	5	6	10	7	[illegible]
Mar	3	8	3	6	7	11	7	9	4	[illegible]
Apr	7	7	4	11	4	13	6	8	5	[illegible]
May	6	9	9	10	7	8	2	8	2	[illegible]
June	6	14	6	7	9	18	7	10	5	[illegible]
July	9	8	13	23	10	17	9	13	9	[illegible]
Aug	17	15	29	34	16	20	9	14	6	[illegible]
Sept	9	32	13	27	17	31	14	18	16	[illegible]
Oct	15	21	9	20	17	24	12	12	15	[illegible]
Nov	13	8	7	14	15	13	7	13	22	[illegible]
Dec	7	13	5	2	5	5	12	13	20	[illegible]

A.—Typhoid fever.

B.—Remittent, intermittent, typho-malarial, congestive and simple continued fever.

12283

ST. LOUIS.

	1900		1901		1902		[illegible]	
	A.	B.	A.	B.	A.	B.	A.	B.
Jan	19	6	9	5	14	5	15	[illegible]
Feb	5	3	14	0	16	6	15	[illegible]
Mar	16	9	11	4	11	9	20	[illegible]
Apr	4	7	4	7	14	3	17	[illegible]
May	4	7	8	7	11	8	15	[illegible]
June	8	12	6	9	7	4	19	[illegible]
July	15	9	13	15	14	12	27	[illegible]
Aug	20	20	31	5	26	7	37	[illegible]
Sept	13	20	24	9	21	16	42	[illegible]
Oct	30	9	32	11	32	17	[illegible]	[illegible]
Nov	15	3	27	5	31	9	24	[illegible]
Dec	19	7	20	3	25	6	21	[illegible]

A.—Typhoid fever.

B.—Remittent, intermittent, typho-malarial, congestive and simple continued fever.

12284 Q. Will you please state what construction you place upon this table as showing the relative mortality from typhoid fever and malarial fever in the city of St. Louis during the periods covered by the foregoing table?

A. I should regard these tables as indicating that the mortality from typhoid fever had fluctuated more or less from year to year. That gradually in the last thirty years an improvement in the accuracy of the reports from the general physicians had taken place so that cases of typhoid fever which had previously been included in column B had been properly reported as typhoid fever. As to the relative frequency of typhoid fever and malaria it would seem to me that it would be impossible to draw definite conclusions from these tables, though as to the prevalence of typhoid fever I should think that one might draw good conclusions.

I should think that the mortality from typhoid fever had varied from time to time, from year to year; had risen slightly during the last two years, but that the fluctuations were no more than such as had previously occurred and were not such as to justify any direct assumptions in regard to the cause.

12285 Q. From a careful consideration of the tables which have just been assumed in the hypothetical questions, what conclusions would you draw as to whether the outbreaks of fever in St. Louis were of an epidemic during this period or of a normal death rate due to local causes or otherwise?

A. In the year 1892 I should suspect that there had been some definite epidemic, but since that time the variations shown are not such as to suggest to me any striking special cause. They are variations such as occur in most cities in this country from time to time without explanation.

Q. Assume that the added totals of tables from typhoid fever and the tables from remittent, intermittent, typho-malarial, conjestive and simple continued fevers, as they appear in the report of the board of health of the city of St. Louis, as heretofore given in evidence are as follows:

12286 ST. LOUIS.

Population 1900, 575,238.

Year	Typhus........ Typhoid Fever .	Reported deaths from Remittent, Intermittent, Typho-malarial, Congestive and Simple Continued Fevers.	Total ....
1890	140	226	361
1891	165	216	381
1892	441	326	767
1893	215	284	499
1894	171	179	350
1895	107	155	262
1896	106	177	283
1897	125	172	297
1898	95	134	229
1899	131	148	279
1900	168	112	280
1901	198	80	278
1902	222	102	324
1903	288	91	379

12287 What do those totals as above indicated represent in your opinion as to the mortality condition of the typhoid fever in the city of St. Louis, covering the period as above indicated after allowing the said remittent, intermittent, typho malaria, congestive and simple continued fever column, such proportion as being typhoid fever as in your opinion you should allow? What is your opinion, based upon the statistics as assumed in the foregoing hypothetical question as to typhoid deaths under the remittent, intermittent, congestive and simple continued fever tables in the city of St. Louis as to whether the said statistics show an increase or decrease in the typhoid fever mortality in the city of St. Louis since the year 1899; eliminating the year 1892 which is a year of special epidemic?

A. I should regard this table as indictaing only variations in the typhoid mortality, such as I stated a moment ago might and do occur in many cities without any definite explanation being found.

The typhoid mortality I should say had rather decreased, tended on the whole to decrease from 1893 down to 1901. During the two years following 1901 there has been a
12288 slight increase, but that increase is not, it seems to me, more than might occur without any special change in the pre- existing conditions.

Q. Assume that two circular letters, one issued in the fall of 1900 and another issued in the fall of 1901 were issued by the health commissioner of St. Louis calling the attention of physicians to the fact that the law requires them to report all cases from typhoid and all deaths from typhoid, and at the time that letter was sent out the question of opening the drainage canal was being agitated in the public press of St. Louis and there was considerable discussion and an investigation was going on at that time of the analysis of the samples of water collected and was attracting considerable attention. On your examinations of the statistics of St. Louis as heretofore assumed in the hypothetical question heretofore asked you for the years 1900, 1901 and 1902 as compared with previous years, does the effect of such a letter, assuming that the same had been sent out to the doctors by the health department of St. Louis, manifst itself in those statistics?

A. Yes, I should say that it certainly did.

Q. In what way does the effect of such a letter appear from the statistics?

12289 A. It appears in the relative increase in the number of deaths reported in the typhoid column as compared with those in the column of remittent, intermittent, malaria, congestive and simple continued fevers. It would indicate to me that, stimulated by the advice of the board of health, the physicians had made more accurate and careful diagnoses.

Q. From your examinations of the typhoid and typho-malaria group of deaths as assumed in the foregoing hypothetical question what is our opinion as to whether these two tables taken separately correctly show the typhoid conditions of the city of St. Louis for the period mentioned?

A. No, I do not think taken separately they show at all satisfactorily.

Q. Upon what do you base your opinion that they do not correctly show the typhoid conditions in the city of St. Louis, taking them separately?

A. Upon the facts that I have already mentioned, namely, that everything in my experience and study go to show that the diseases included under such headings as these are in a vast majority of instances typhoid fever.

Q. From your knowledge of these classes of fevers mentioned in the two columns of vital statistics as heretofore assumed, how should they be treated by a bacteriologist, clinician and statistician in order to arrive at the true typhoid fever mortality in the city of St. Louis? 12290

A. Well, as I said a little while ago I should say that a safe estimate of the typhoid fever mortality might be gotten by adding to the typhoid column seven-eighths of the cases coming from the other causes. I should say that a fair estimate might be obtained probably from the comparison of the number of deaths from year to year by adding the two columns together.

Q. What are the sources of infection generally obtaining in large cities which accounts for the prevalence of typhoid fever in cities?

A. I should say that the introduction of the typhoid bacillus into large cities occurs probably in most instances through the water supply, dairy products, uncooked vegetables, such as lettuce, celery and other articles of food; that in cities in which drainage is not good, in which water closets or wells into which the drainage goes, are open, typhoid fever may readily spread after it has started; doubtless this is largely through the instrumentality of flies, while on the other hand, if there are wells from which the water is drunk, the disease might easily spread and does spread in a great many instances by the infection of those wells. 12291

Q. Assume that in the city of St. Louis in 1895 there were in the neighborhood of 4800 wells, and assume further that the board of health of the city of St. Louis authorized an examination of those wells by the city chemist and after an examination of about 50 of those wells, all of which were found to be contaminated, and were condemned by the city chemist, that the board of health passed an order instructing the city chemist to stop the examination of city wells until further ordered, and assume that the water from those wells was used by the citizens of St. Louis, would the presence of such a number of wells in a city in your opinion have any effect upon the typhoid conditions of such city?

A. Yes, I should think that the chances were that they would; that such wells would be a menace to the health of the city and that it would be very possible that certain of the wells might become infected and serve to spread the disease.

Q. Where typhoid fever is due to infected water supply,
12292 how does it manifest itself in its vital statistics?

A. In those cases in which infection of water supplies have been definitely or fairly definitely proven, it is always, I think, to my knowledge, manifested by an explosive epidemic.

It is common to assume in cities, such, for instance, as the city of Baltimore, where we know our supply is open to contamination, it is common to assume that cases are dependent upon the water supply, but as a general rule where it can be proven that the water supply going to a whole city is infected there is an explosive outbreak and it seems to me it would be very difficult to prove the instrumentality of a general water supply to a city in producing typhoid fever unless such an epidemic occurred. I should expect with seriously infected water supply such an epidemic to occur.

Q. From your study of the typhoid statistics of St. Louis as assumed in the foregoing hypothetical question, do those statistics indicate an explosive epidemic within the meaning of the answer which you have just given?

A. No, I think not.

Q. Have you made a study of comparisons between typhoid and typho-malarial groups of the city of St. Louis with
12293 those of any other city?

A. I have.

Q. Assume that the following table testified to in evidence by Professor Jordan is correct as compiled from the typhoid fever and typho-malarial columns of mortality statistics of the health reports of the city of St. Louis for the years 1890 to 1900, according to the United States census report, and the intervening years estimated by Farr's Formula, which table is as follows, and based upon the population of the city of St. Louis:

12294

ST. LOUIS.

TYPHOID FEVER DEATH RATES.

Year..............	Population	Death Rate per 100,000.		
		Typhoid Fever alone	Typhoid Fever plus 50 per cent of deaths recorded under heading intermittent fever, etc.	Typhoid Fever, plus all the deaths recorded under heading intermittent fever, etc.
1890	451,700	30.0	56.67	81.2
1891	462,763	35.6	56.98	82.3
1892	474,077	93.0	127,40	161.7
1893	485,668	44.2	73.52	102.7
1894	497,565	34.3	52.24	70.3
1895	509,740	29.9	30.35	51.3
1896	522,225	20.2	37.37	54.1
1897	533,762	23.4	39.53	55.8
1898	548,590	17.3	29.53	41.7
1899	561,510	23.3	36.49	49.6
1900	575,238	29.2	39.07	48.6
1901	589,315	33.5	40.39	47.1
1902	603,736	36.7	45.21	53.6
1903	618,510	46.5	54.0	61.3

12295 Will you please state what is your opinion, based upon the tables heretofore read as to whether typhoid fever has increased or decreased in the city of St. Louis since 1900 over the conditions that obtained in St. Louis prior to 1900, eliminating 1892 a year of special epidemics?

MR. JEFFRIES: I object to the question for the reason that the table shows for itself.

A. I should say this table indicated that during the past two years there has been a slight increase in the typhoid mortality, but that this increase had been preceded by a diminution and on the whole a gradual diminution from 1892 down to 1901.

I should hesitate from these figures to assert that the mortality had permanently increased or I might say that to look at such table I should not regard it as having greatly increased, and I should want to see what happened in 1904 before expressing any opinion.

The increase in 1902 and 1903 seems to me not more than might occur with fluctuations such as are observed in the tables which I have mentioned from New York, Brooklyn and other cities.

12296 Assuming that during the last two years in the city of St. Louis that a great number of laborers and visitors came to the city for the purpose of assisting in the construction and building of the World's Fair at that point, would the presence of such a number of people in a city the size of St. Louis afford any explanation for the seeming increase of typhoid fever in 1903 over 1902?

MR. JEFFRIES: I object on the ground that the question is speculative.

A. It seems to me that that is a question that would be difficult to answer positively.

If those individuals came from regions where they had not been subjected to typhoid fever at all to a town in which the relative typhoid mortality was rather high, they would probably add to the death rate.

If on the other hand they came from cities where they had been for years exposed to an actual chance of infection I can not see that it would have any effect.

Q. Assume that the typhoid deaths as reported in the typhoid fever column of the city of St. Louis are correct, and assume that
in 1899 the increase over 1898 was 34.7 per cent.,
12297 and in 1900 the increase over 1899 was 25.3 per cent.,
and in 1901 the increase over 1900 was 14.7 per cent.,
and in 1902 the increase over 1901 was 9.5 per cent.,
and in 1903 the increase over 1902 was 26.7 per cent.,
and assume that the increase of 1903 over 1902 is less than the increase in 1899 over 1898, and assume that from 1898 to 1902 there has been a gradual decrease in the percentage of increase during these three years, would you say the increase as indicated by the percentages assumed in my question were abnormal or normal increases for a city the character of the city of St. Louis and the size of the city of St. Louis?

MR. JEFFRIES: I object to the question for the reason that the table shows for itself.

A. You were speaking not of the number of deaths, but of the death rate, were you not?

MR. TODD: Q. Yes, the death rate per 100,000.

A. It does not seem to me that any increase in death rate can be regarded as normal. I should say that such figures as these would perhaps not suggest any striking change of the conditions for the worse, but I should regard any increase nevertheless as a change of conditions for the worse.

12298 Q. Would you regard the conditions obtaining between 1898 and 1899 as better or worse than those conditions obtaining in 1900 and 1901?

A. Assuming all the time that the figures of typhoid mortality are correct, the figure depending upon the single column—

Q. (Question repeated.)

A. It seems to me the conditions between 1898 and 1899 are worse than those between 1900 and 1901.

Q. Do you know how the typhoid fever death rate in St. Louis compares with the death rate of other American cities during this period, eliminating from the St. Louis records the year 1892, which was conceded to have been a year of special epidemic?

A. I made no extended investigation on this point, but I have here a list of the typhoid mortality taken from the special report on the statistics of the cities of the United States of 30,000 population and upward compiled by the United States Department of Labor. This is taken from the public health reports issued by the Treasury Department, public health and marine hospital service, Volume 19, No. 1, pages 4 and 5. This table
includes the death rates for the year 1901, the last avail-
12299 able year at that time for 100,000 population. It in-
cludes all cities with a population above 30,000 excepting the city of Chicago, from which the data were not to be secured at that time.

These rates run from 9.7 per 100,000 at Savannah, Georgia, to 124.7, Pittsburg, Pennsylvania.

Taking those 69 cases, we find that beginning with Pittsburg, the highest mortality, the 34th town, Evansville, Indiana, has a mortality of 26.6 per cent. and Providence, Rhode Island, 26.4, the 35th town.

It would be seen therefore that the death rate from typhoid fever in St. Louis for that year,—the reported death rate, was 33.3 per cent.,—is relatively high, though St. Louis at that time stands 24th, that is, the 24th city in the list, beginning at the end of highest mortality.

The death rate would seem to me, then,—particularly in view of the conditions existing before and after,—would seem to me to be relatively high as compared with the reported death rates of other cities.

Q. From a careful analysis of the typhoid and typho-malaria
mortality statistics as they appear in the foregoing hypo-
12300 thetical question and from your knowledge of conditions
that obtained in other cities, a water supply from a
river, as well as all other sources of knowledge which you possess upon this question, what is your opinion as to whether there has been an increase of typhoid fever in the city of St. Louis since January, 1900, over typhoid conditions that prevailed in St. Louis for ten years prior to that time? Basing your estimate of typhoid conditions upon your judgment as to the typhoid conditions as evidenced by the typhoid death rate column and the typho-malaria column heretofore assumed?

A. There seems to me to have been an increase. Not a great increase but an increase.

Q. Is there such an increase as you would attribute to any special cause?

MR. JEFFRIES: I object to the question for the reason that the witness has not acquainted himself with the local conditions of St. Louis so as to be able to express an opinion as to whether it should be attributed to any one or more causes.

A. There is nothing in these figures to suggest to me any definite special cause.

I may say there is enough to make me feel I should want
12301 to look around for something but there is nothing in
these figures that would suggest a definite cause to me.

Q. From a consideration of the statistics heretofore assumed in evidence what is your opinion as to whether the typhoid conditions in the city of St. Louis has been epidemic in their character since 1900 over the conditions that obtained there prior to 1900, eliminating 1892?

A. I must say that I should be inclined—perhaps this is quibbling—to regard in any city with a typhoid mortality such as that St. Louis has or that which we have in Baltimore,—to regard typhoid fever as epidemic, but I should not consider the conditions in the last several years in St. Louis such as to suggest that any striking change had taken place in the general conditions that obtained prior to that time.

I think it is fair to say that any increase occurring two years in succession should always make one look for something, but I should not regard it as particularly suggestive if the assumptions made in the earlier question in regard to the condition of wells in the city of St. Louis are true.

12302 CROSS-EXAMINATION, by Mr. Jeffries.

Q. Doctor, I understood you to say that in your opinion seven-eighths of the intermittent, remittent, typho-malarial, etc., reported in the health reports of the city of St. Louis and other cities should be taken as the typhoid fever and considered as such?

A. Well, I think I said that in regard to the St. Louis statistics, not of other cities necessarily, because they vary.

Q. Now, prior to 1900 there was a greater number, according to your testimony, of cases of malarial, remittent, intermittent, etc., fevers reported in that city per 100,000 population than since that time, Is that so?

A. As I remember my testimony here the proportion of deaths under column B as compared with the deaths under column A was in the earlier years a little higher than it was in the later years.

Q. Do you know that that difference in the reporting of the cases was not caused by a diminution in number of deaths from fevers other than typhoid in the city of St. Louis, or do you base your answer altogether upon an opinion which you formed from an examination of the statistics which were presented to you? 12303

A. Well, I base my answer on the statistics as they are presented to me, on what I have seen, and in view of the conditions elsewhere. I was influenced very largely by the fact that with the exception of the two years, 1892 and 1893, the general totals of the cases reported in column A and column B were pretty nearly the same, while the relative proportions were different.

Q. Assuming, Professor, a patient takes ill with fever and remains so for several months and finally dies, and the death is reported as intermittent or remittent fever, would you say that was malarial fever or typhoid fever?

A. Of course, the points which you assume there are hardly enough to justify a very definite opinion. I should, if that case had been treated with quinine, and the fever had not broken, assume that it certainly was not malarial fever.

Q. Would you assume that it was typhoid fever?

A. I should not have grounds enough for a definite assumption, and I should have one ground for thinking that it
12304 might not be typhoid, that it lasted for several months.
Typhoid fever often does last as much as eight weeks, but it is not the rule.

Q. Is it not a fact that when typhoid fever does last as long as eight weeks it is a very severe case of typhoid?

A. Not necessarily. There may be cases that are not especially severe in themselves, but with relapses—where there is a rise in temperature before the fever has quite reached normal—of which there may be several, without the development of any very severe symptoms. Such a case may last several months. It may be long but not necessarily very severe.

Q. And those cases are very rare, are they not?

A. They are not very common lasting as long as that, lasting for several months.

Q. Assume, Professor, that a person should have malarial fever, or what was commonly diagnosed as malarial fever, running through a period of months, and finally died, and the physician would diagnose that death as of congestive chill, would you determine that as typhoid fever?

A. That again is rather a hard question to answer definitely. What do you mean by having a disease commonly diagnosed as malaria which has lasted through this long period of time?

Q. I mean that the malaria occurs at intervals, for
12305 weeks, for days at a time, in which there would be days
there would be no malaria present and the patient apparently relieved of the disease, but afterwards occurring again?

A. I should have to know more of that individual case to express an opinion.

Q. Might not a death of that kind occur and be reported as a death caused by congestive chill which would not be typhoid fever?

A. Yes, and I should be glad to say one thing more, that I do not believe the majority of deaths reported from congestive chill are typhoid fever. I believe that typhoid fever accounts for few, if any, deaths, with that particular diagnosis.

Q. In order that the subject of congestive chills, that the subject of congestive malaria—might not the words chill and malaria be given the same meaning?

A. It may mean that and it may mean something else.

Q. Now, then, what else may it mean?

A. That is a question to which the answer must be purely speculative. The term congestive chill is popularly supposed to mean pernicious malaria, comatose malaria. It seems to me it would be rather idle to speculate what else it might be.
12306 I do not remember ever to have seen an autopsy on a case which the diagnosis, congestive chill, was made. I can conceive that the term congestive chill might be used in connection with certain very acute infections and especially in connection with acute cerebro-spinal meningitis. Those are two conditions I should imagine it might be employed for, but it is purely speculative.

Q. Then, as to whether or not a death which is reported as being caused by congestive chill was typhoid fever or not depends a good deal upon the history of the case, does it not?

A. Very much and I am perfectly frank to say that I should not be inclined to interpret the diagnosis of congestive chill as typhoid fever. If there was any reason for doubting its being malaria I should be much more inclined to think that it was a very malignant attack of cerebro-spinal meningitis or something else, not typhoid.

Q. Now, then, may not certain cases of malaria fever reach a condition that after some other complications had set in that death might be produced, then they would be reported out as malaria fever?

A. Do I understand you to say that some case of malaria fever might have another complication?

Q. Yes, which would produce death and yet at the same
12307 time be reported as malaria fever?

A. It does not seem to me to be possible to deny that such a thing might occur.

Q. In cases of malarial fever and other fevers, such as intermittent and remittent which are not thoroughly understood, in which other complications are liable to arise which would produce death and the deaths reported under the heading which the physician had believed the patient to be infected with?

A. I should think that would be very unlikely.

Q. You think that does not occur in any instance?

A. No, I should not say that. I should think it was possible, but in cases of that sort which are supposed to be malaria, which are treated with quinine and react quickly it would be very likely to be recognized if a complication occurred.

Q. Do you know whether all physicians use quinine for malaria or not?

A. I never heard of a physician who did not use quinine for malaria.

Q. Do you know whether or not there are physicians who do not prescribe quinine for anything?

A. There are physicians who do not prescribe quinine for anything?

12308 Q. Yes, and absolutely refuse to do it?

A. I can not imagine a man in his right mind doing such a thing,—a man with a reasonable education.

Q. Have you ever examined the mortality records of the city of St. Louis personally?

A. Only those which have been presented to me as sworn to by Professor Jordan.

Q. Have you ever examined any original records of the city of Baltimore?

A. Well, I have examined the health reports.

Q. The published reports?

A. Yes, sir.

Q. And that was true with all of your testimony?

A. Yes, sir.

Q. Why did you exclude the one-eighth of the column B, known as remittent, intermittent and malaria, from the typhoid list?

A. That was done purely as an approximate estimate and based on my experience and general information.

Q. Does that one-eighth apply to all the cities in the United States?

A. No, I do not think it does. As I endeavored to show by
the statistics there are very great differences, for in-
12309 stance, between the cities of Philadelphia, Brooklyn and
New York. Now, the surroundings of Philadelphia are
certainly more malarious than the surroundings of New York,
and yet the reported deaths from malaria are materially greater

in New York, until very recently, than they have been for the last ten years in Philadelphia.

Q. What other fevers produce death besides typhoid fever?

A. A very long list of general septicemias of all sorts and kinds. Most infectious diseases produce fever and death may occur in all the more serious. For instance, pneumonia, which is a septicemia—general infections with streptococci and staphylococci, all the contagious diseases which we believe to be infectious and which we believe to be due to infectious agents, such as smallpox, diphtheria, scarlet fever, measles, acute rheumatism, cholera—

Q. And a long list of miscellaneous fevers?

A. Yes, sir, a long list.

Q. In all cities, Doctor, typhoid statistics vary, do they not, from year to year regardless of how perfect the water supply may be, to some extent?

A. So far as I know they do and I should certainly
12310 think they would.

Q. And these variations are shown from month to month and year to year, are they not?

A. Yes, sir, with, as a rule, certain general points in common each year; in that ordinarily typhoid fever is more frequent in the late summer and fall months.

Q. This variation may be due to a variation in sanitary condition of the water supply, may it not, as well as other things?

A. I think it would be difficult to deny that it might not.

Q. The water supply is liable to vary in its sanitary condition as well as in other conditions?

A. Yes, sir.

Q. Wells do not necessarily produce typhoid fever?

A. Only when they are infected.

Q. The best way to determine whether or not wells do produce typhoid fever or have an effect upon the typhoid mortality of the city is by comparing the health of the community where these wells are located with the health of the people using the public water supply, is it not?

A. Yes, provided, of course, it can be shown that the water from the wells is drunk more by people in the neighbor-
12311 hood than by people coming from the outside.

Q. They usually are, are they not?

A. I should say that they usually were and yet I can conceive an instance, a case in point. There is a well out here in the western part of Baltimore at which every electric car used to, and I suppose still does stop, and the motormen and conductors get off and take a drink. I fancy if you take it day in and day out the well is more drunk from by car conductors and motormen than by people in that neighborhood.

Q. That is a violent exception to the general rule, is it not?

A. Well, I should think that it might be.

Q. Including, Professor, all of the fevers, typhoid, remittent, intermittent and malaria which occur in the city of St. Louis as shown by the health reports and assumed by the hypothetical questions asked you by Mr. Todd in your direct examination I will ask you if it is not a fact that from 1893 to 1899, inclusive, that the general tendency of the typhoid fever mortality of the city of St. Louis is towards a reduction rather than an increase?

A. Yes, excepting between the years 1898 and 1899, there
is no striking increase. Between the years 1896 and 1897
12312 there is an increase of a little over 1 per cent., but of
course between the years 1898 and 1899 there is a distinct increase.

Q. Speaking generally of conditions that existed in the city of St. Louis from 1893 to 1899, inclusive, taking into consideration the typhoid fever death rate and including as typhoid remittent, intermittent, malaria, etc., occurring in that city, based upon the number of deaths per 100,000 as reported in the hypothetical question put to you by Mr. Todd there has been a gradual decrease, has there not?

A. Yes, with one exception, that between 1898 and 1899, there is an increase which is comparable with that which occurs between 1902 and 1903.

Q. And for that year there is a very great reduction to what there was in 1893, is there not?

A. Yes, materially.

Q. How great a reduction?

A. Well, in 1893 the death rate was 102 for the two columns put together, 102.7 per 100,000, and in 1899 49.6.

Q. Now, then, I will ask you if from 1900 to 1903, inclusive, taking the same column into consideration, the same mortality record, to wit: the typhoid remittent, intermittent, malaria, and counting them all as typhoid if there has not been a 12313 gradual increase or rather the tendency has not been to an increased rate per 100,000?

A. It has been in the last two years, yes. Between 1900 and 1903 the rate has increased. Slightly decreased between 1899 and 1901.

Q. The tendency in one instance, however, has been to increase and in the other to decrease, taking the table as a whole and looking at it?

A. Yes, as far as it goes I should say it had been.

Q. Have you ever examined the death report of the mortality record of the city of Chicago?

A. I have not.

Q. Is there any such thing as congestive fever, pure and simple?

A. Well, I do not know what that means. The term congestive is a physiological term, meaning the filling of vessels, and congestive fever does not mean anything to me.

Q. It does not mean typhoid, does it?

A. Congestive fever as such—I should not have any idea what it meant.

Q. It may mean one thing and it may mean another?

A. Yes, sir.

12314 Q. In other words, as far as the medical science is concerned then it is an unknown quantity?

A. As far as the name alone goes, congestive fever, yes.

Q. And what is true with reference to congestive fever is also true with reference to remittent and intermittent fever?

A. No, I do not think it is.

Q. Now, what is remittent and what is intermittent fever?

A. Remittent and intermittent fever describe a long continued fever as a rule, and as used in the medical profession mean a fever that is rather continued in the one instance with remissions which do not quite go down to normal and in the other with the temperature actually reaching normal and going up again?

Q. Might not also they be malaria, either of those remittent or intermittent?

A. Yes, remittent or intermittent fever terms may mean

malaria. I should like to make one addition—*Not,* I should say with regard to death reports. I think it makes a material difference. I have seen cases of remittent and intermittent fever which were so diagnosticated and were malaria, but people do not die of it; they are cured by quinine. And I have seen such cases that do not react with quinine; in a great majority
12315 of instances these have been typhoid fever and never malaria.

Q. It may be something else besides typhoid fever, may it not?

A. Yes, sir.

Q. It may be a different complication altogether?

A. Yes, there may be infections of another sort.

Q. As a general proposition, Doctor, how long does a case of typhoid run?

A. As a general rule about three weeks.

Q. And the duration of its running is largely limited by the severity of the attack?

A. Well, I think that depends a little upon how one uses the term severity. As I said a moment ago you may have a case of prolonged duration which never manifests any symptoms which give you any alarm. It may be a mild case, but one of long duration, and you may have a case which will last not more than three weks and yet for a week of that time or even more may give you the gravest apprehension. As a general rule, I think it is fair to say that long cases are apt to be severer than others, but there are many exceptions to it.

12316 Q. A good deal then depends upon the resistant force of the patient?

A. Very much.

MR. TODD: I have no re-direct examination.

W. S. THAYER.

Adjourned until Monday, March 28, 1904, at 9:00 a. m., room 710, City Hall, Philadelphia, Pennsylvania.

12317 State of Missouri
vs.
State of Illinois and Sanitary District of Chicago.

Parties met pursuant to adjournment.

Room 710, City Hall, Philadelphia, Pa.

Monday, March 28, 1904, 9:00 a. m. Present the Commissioner, S. B. Jeffries, Esq., representing complainant, James Todd, Esq., representing defendants.

JOHN W. HILL,

a witness called on behalf of the defendants, after being duly sworn by the Commissioner, was examined in chief by Mr. Todd, and testified as follows:

Q. What is your name?

A. John W. Hill.

Q. What is your business?

A. I am an hydraulic engineer.

Q. Where are you engaged?

12318 A. At the present time I am employed by the city of Philadelphia as chief engineer of the Bureau of Filtration, a bureau that is conducting the general improvement of the water supply of that city.

Q. In what manner is this bureau attempting to improve the water supply of Philadelphia?

A. Chiefly by filtration of the Delaware and Schuylkill River waters which now and hereafter will form the sources of public water supply for Philadelphia and partly by reducing the consumption of water from the Schuylkill River, and increasing the consumption of water from the Delaware River.

Q. How large is the plant over which you preside as chief of the Bureau of Filtration that is being constructed for the city of Philadelphia?

A. If by magnitude is meant the extent of the works, it embraces as a first proposition the filtration of 320,000,000 gallons of water per day of 24 hours, the transfer of the chief source of supply from the Schuylkill to the Delaware River, and a general re-organization of the distribution system brought about by reason of the principal volume of water in the future coming from the Delaware instead of the Schuylkill River. It

will involve a cost of about $26,000,000.00. Of that amount
about $17,000,000.00 worth of work has been accom-
12319 plished at the present time. Part of the system of fil-
tration is now in daily operation and has been for a
period of twenty months.

Q. When did you first begin the study of sanitary problems?

A. At the time when I first engaged in the planning and building of works of public water supply, I should say about 32 years ago. From that time up to the present date information touching the hygienic quality of water supply has always been interesting and as a rule an essential part of my work.

Q. What work have you done or been actively connected with in connection with sanitary problems?

A. I have been associated with about 60 works of public water supply, including different questions looking either to the general construction or improvement of municipal waterworks. Wherever my engineering association with public water supply has touched the question of a water quality, investigations have been made to determine the desirability of available sources.

Prior to coming to Philadelphia four years ago my prin-
cipal work along this line was in behalf of the city of Cincin-
nati, where I was chairman of the original board of en-
12320 gineers that made an investigation and furnished the
plans upon which the present improvements at that point
are being constructed. As a part of the Cincinnati work and for other cities for which I have done engineering along the Ohio River, investigations have been made at Parkersburg, Madison and Jeffersonville, Indiana, to determine the desirability of drawing water from the Ohio River for drinking and other domestic uses. The same investigations have been made in behalf of the city of Clarksburg, W. Va., and in behalf of many smaller cities on streams, in the states of Ohio, Indiana, Michigan and Illinois, which were to be drawn upon as sources of public water supply. Mentioning some of these cities where streams have been discussed as sources of water supply are Findlay, Ohio,

Greensville, Ohio;
Eaton, Ohio;
Marion, Ohio;

Zanesville, Ohio;
Bellefontaine, Ohio;
Huntingdon, Indiana;
Lebanon, Indiana;
Greenville, Indiana;
Indianapolis, Indiana;
12321 Aurora, Indiana;
Decatur, Illinois;
Peoria, Illinois;
Oshkosh, Wisconsin;
East Saginaw, Michigan;
Buffalo, New York;
Saratoga Springs, New York;
Chester, Pennsylvania;
Nashville, Tennessee;
Chattanooga, Tennessee;
Birmingham, Alabama;
Mobile, Alabama;
Denver, Colorado;
Trinidad, Colorado;
Pueblo, Colorado.

All of the cities mentioned have submitted either in the course of my work as engineer planning new works or improvement of old works, questions including the availability of different or single sources of water supplies. I say single source especially with reference to towns along the Ohio River where it is rare that any other source can be had than that of the main stream.

12322 Q. In pursuing the work which you have indicated in the foregoing answer to the previous questions what cities have you taken up for consideration as applied to sanitary problems and what methods were pursued by you in your investigations?

A. Aside from purely engineering investigations of water sheds where rivers or ponds have been the sources of public water supply, I have taken up the subject of bacteriology and attempted to qualify myself as an amateur in this line not with a view to pursuing bacteriology as a profession, but with a view to gain information as to the bacteriological condition of water supplies with which as an engineer I would be required to deal. Such work was pursued during leisure time, uninterruptedly from 1894 to 1899. It has been interrupted since coming to Philadelphia, because of lack of time to indulge in the experimental or technical work.

I have also studied the chemistry of water supplies not with a view to chemical analyses but with a view of informing myself as to the true interpretation of chemical analysis of water samples, in connection with my work as engineer in charge of the improvement of the water suppply of Philadelphia.

Q. In connection with the water supply of Philadelphia
12323 are you conducting a laboratory, bacterial and chemical?

A. We do.

Q. Is that laboratory under your direct supervision and direction?

A. Yes sir, it is.

Q. Have you ever investigated any typhoid fever epidemics?

A. Yes sir, several. Two that I now recall, one at Eaton, Ohio, and one in the Cumberland Mountain regions of Kentucky. Both as a part, however, of investigations looking to the improvement of the water supply for the city of Cincinnati. In addition to the investigations noted I have sought information where it has been obtainable in the English or German publications of epidemics that have been reported on in the United States and Europe.

Q. You are acquainted, are you not, with the epidemics from typhoid fever in this country as they appear in the literature such as at Plymouth, Lowell and the others?

A. The records of all these have been read, that is the records of all that I have come in contact with, have been read as the printed documents have been received. It would probably be difficult to recall in detail all the epidemics that have been considered.

12324 Q. Are you acquainted with any epidemics other than those of typhoid fever as they appear in the literature, such as cholera?

A. Yes, the history of the cholera epidemic first in Hamburg and next in the very large compilation of statistics gathered by Dr. Edwin O. Shakespearre of Philadelphia upon cholera in India has been read, studied and noted so far as they seem to contain information that would be of advantage to me as a waterworks engineer.

Q. Have you investigated the sanitary problems as they occurred in Europe?

A. If by investigation is meant an inquiry into the recorded facts as conveyed in public documents, I have.

Q. Have you made a special study of water analysis?

A. I have.

Q. What branch of sanitary science have you given special attention to?

A. Public water supply.

12325 Q. Have you had any experience in the interpretation of chemical analyses of water?

A. I have.

Q. How extensively?

A. Well, really it has gone through the whole period of thirty odd years. The first set of analyses that I can recall from memory were made for the city of Sidney, Ohio, by Professor Chauncey R. Stuntz, analytical chemist of Cincinnati, as early as 1872 or 1873. Of course it must be understood that the sanitary analyses made thirty years ago are not the same as those made today.

Q. In the work here in Philadelphia what have you to do with the interpretation of chemical and bacterial results?

A. It is part of my duty to pass upon the technical investigation of our water samples coming to and from our filters and from them to determine the efficiency of our work of filtration, to do this it is necessary to assign proper values to the results reported from day to day from the technical laboratory.

12326 Q. Have you examined and studied bacterially and chemically the analyses of the water of Lake Michigan, the drainage canal, the Desplaines River, the Illinois River, the Mississippi River and the Missouri River as made by Professors Jordan, Palmer, Burrill and Long, the same being published as reports of Streams Examination which have already been introduced in evidence and the reports of Professor Long appearing in the published health reports of the Board of Health of the State of Illinois, the same having also been introduced in evidence in this case?

A. I have examined the tables of chemical and bacterial determinations contained in the reports mentioned in the question, and have studied them especially with reference to four months during the years 1899 and the corresponding four months during the year 1900.

Q. Are you acquainted with the Chicago River, the drainage canal, the Desplaines, the Illinois and the Mississippi Rivers from Grafton to St. Louis?

A. I am in the main so far as it is represented in published documents and in hydrographic maps published by the United States Government and by the city of Chicago. I have not made a personal examination of the drainage canal

12327 or of the Illinois River excepting of the Illinois River at Peoria during the year 1882 when I was employed on the Peoria water works.

Q. Have you made a special study of bacteriology as applied to water investigations?

A. I have.

Q. Will you distinguish between pathogenic and non-pathogenic bacteria?

A. Pathogenic bacteria are those known or supposed to be the cause of disease in man and other animals. Non-pathogenic bacteria are those that are supposed to be harmless to man and other animals.

Q. What pathogenic bacteria are water borne?

A. The typhoid bacillus, the cholera spirillum, the bacilli coli communis, the bacillus of rabbit septicemia, or the bacillus mesentericus, I think is the term descriptive of it, the proteus vulgaris, the micrococcis of blood poisoning, the staphylococcis pyogenes aureus, the staphylococcus pyogenes albis; there are other pathogenic bacteria found in water which I can not recall from memory.

12328 Q. Are you acquainted with the bacillus prodigiosus?

A. I am.

Q. Have you ever found the bacillus prodigiosus in this country?

A. I think I found it twice in the investigations of the Ohio River water during 1895 and 1896, at least it was differentiated as the bacillus prodigiosus. Comparison was made of its morphology and life history growing on or in different media with a so-called bacillus prodigiosus that I obtained from Dr. Cameron, professor of bacteriology at the Ohio Medical College.

Q. Have you made any special study of the typhoid germ as related to water supply?

A. I have within the limitations of my opportunities.

Q. Is it related to the colon bacillus and if so in what way?

A. It comes into a water supply from the same source as the colon bacillus and resembles the colon bacillus in a number of respects having very nearly the same size when examined under the microscope and having many other qualities quite like the colon bacillus. There are some distinct differences however. The typhoid organism is motile when examined,
12329 while the colon bacillus is nonmotile. Flagella can be developed by staining on the typhoid bacillus, while flagella are not developed on the colon bacillus. Its capacity to resist an acid media is about the same as that of the colon bacillus.

Q. Have you made any experiments upon the longevity of the typhoid bacillus?

A. I did several years ago. In 1895, in sterilized Ohio River water and in unsterilized Ohio River water. These tests on sterilized river water indicated that the typhoid organism would grow without apparent reduction of virility for 60 days. A test made 90 days after the flask had been inoculated with the typhoid organisms failed to reveal its presence and I am unable to state at what time between 60 and 90 days it perished.

The tests made in unsterilized Ohio River water gave negative results. I was never able to find it after the inoculation of the flask of water. I ascribed this not to the nonexistence of the organism some time after the inoculation, but to my inability to demonstrate it on the gelatine plates or to isolate
12330 it on the gelatine plates.

Q. Have you made any other experiments upon the longevity of typhoid bacillus?

A. I have in connection with the work now going on in Philadelphia. Two years ago last fall with a view to determining what, if any, influence the amount of chlorine in the Delaware River might have on the longevity of this organism, at that time I outlined plans that were subsequently put into effect by Mr. Copeland, bacteriologist in charge of the technical laboratory, to show how long the typhoid organism and the colon bacillus would live in unsterilized. Delaware River water with the quantities of chlorine varying from 25 parts per 1,000,000 to 300 parts per 1,000,000 and this test which extended over a number of days, in fact over a number of weeks, revealed the fact that the amount of salt in the Delaware River water had little or no influence upon the longevity of the organism and that its life history was limited to from 5 to 8 days under the most favorable conditions. It also revealed the fact that the colon bacillus would live longer in the unsterilized Delaware River water with the different degrees of salt than would the typhoid organism. 12331

Q. What is the character of the Delaware River water and its sanitary qualities?

A. The Delaware River water is a sewage polluted water which receives the sewage of Trenton, Burlington, Bristol and other towns on the river below Trenton, the sewage thrown into the river from Easton and other towns on the Lehigh River, and the sewage of Phillipsburg, in New Jersey, and from other towns above Phillipsburg as far north as the Delaware Water Gap. It is known to be a distinctly sewage polluted stream below Trenton and the investigation mentioned in my answer to the previous question was with a view to determine what, if any, influence the increased chlorine in the water at the Torresdale Filtration station would have on the typhoid fever germs that might come into the water from points north of our point of intake, which is located about ten miles up stream from the Market Street Wharf.

Q. How were the chlorine tests made?

12332 A. By adding to the normal water common salt until the chlorine was increased first to 25, then to 50 then to

75, then to 100, then to 200 and then to 300 parts per 1,000,000 of water.

Q. Why was it that you made this experiment with chlorine?

A. Because of the probability of an increase of chlorine content in the water to 50 parts per 1,000,000 at a time when the city of Philadelphia is drawing 350,000,000 gallons of water per day from the Delaware River at Torresdale and when the stream flow is at the lowest recorded flow for that river. The excess of chlorine at that time being due to the influence of tidal water coming up the river from Delaware Bay.

Q. What is the population of the towns sewering into the Delaware River and also what is the size of the Delaware River as to volume of flow?

A. I have not made a definite statement of the population of the towns, but what I have made is a statement of the total population gathered on the Delaware watershed exclu-
12333 sive of the Schuylkill.

MR. JEFFRIES: Does that include both rural and urban populations?

A. It is the total population excluding all population collected on the Schuylkill watershed. In my answer of course I would like to correct my figures which are approximate only. I should say that the polluting population from sewered urban centers above the point of intake at Torresdale is about 200,000. I will give the exact figures later on.

Q. What is the size of the Delaware river as measured in volume of flow?

A. In considering the Delaware river and so in considering any river as a source of water supply the lowest stream flow is usually taken into account. Very little or no thought is given to flood volumes or even to mean flow. The lowest recorded flow of the Delaware river is about 1,000,000,000 gallons in 24 hours. The lowest gaugings which I have been able to obtain during the past four years from the station established at Trenton give the lowest stream flow at over two thousand million
12334 gallons per day of 24 hours.

Q. In the making of the experiment which you have detailed state how this experiment was made?

A. The experiment on the stream flow

Q. On the typhoid bacilli?

A. This experiment was made by taking flasks of the Delaware river water from our point of collection at Torresdale testing station and inoculating one of such flasks with a culture of the typhoid fever organism obtained from the health bureau; inoculating another flask with the colon bacillus obtained from fresh feces and carrying one or more flasks as a control in order to compare from time to time the normal water bacteria with the bacteria growing in the flasks which were charged with varying rates of chlorine from 25 parts per million to 300 parts per million. Each test for the longevity of the typhoid bacillus and for the longevity of the colon bacillus was made on eight different flasks including the control flask.

Q. What was the control flask?

12335 A. That contained water with no chlorine whatever.

Q. Was that seeded with typhoid fever germs?

A. In the same manner as the other flasks.

Q. Have you prepared a table showing the results of the experiments to determine the longevity of the bacillus typhosus which you have just recounted in evidence?

A. I have.

Q. Will you produce the table and make the same a part of your testimony?

A. The tables are as follows:

12336

Table showing Results of Experiments to determine the Longevity of B. typhi abdominalis in Sterilized Raw Water of Schuylkill and Delaware Rivers under Various Conditions of Chlorine Content.—Spring Garden Testing Station, Spring Garden Waterworks, Philadelphia, Pa.

Numbers given are Bacteria per Cubic Centimeter.

Number of Test.	Date of Inoculation of Test Flasks.	Average Temperature during Experiment.		Est. Organic Matter introduced into Test Flasks in Parts per Million.	Kind of Water.	Chlorine added to Water in Parts per Million.	Numbers of B. typhi abdominalis in Test Flasks after incubating at given Temperatures for Periods in Days as follows:—									Temperature of Incubation of Plates.	Kind of Medium.	Number of days of Incubation.
		Test Flasks.	Schuylkill Water at Entrance to Bld'g.				0	1	2	3	5	8	12	14	22			
4	Oct. 7 1901.	73°F.	64°F.	0.25	Schuylkill River	0	130	120	27	7	0					39°C.	Lactose Agar.	1
				do.	Delaware River	0	150	100	12	0	0							
				do.	do.	25	150	140	100	55	0							
				do.	do.	50	150	65	12	0	0							
				do.	do.	75	140	80	6	1	0							
				do.	do.	100	150	60	11	1	0							
				do.	do.	200	140	75	6	1	0							
				do.	do.	300	130	80	26	4	0							
5	Oct. 16 1901.	63°F.	62°F.	50	Schuylkill River	0	110,000	43,000	25,000	4,200	1,000	3	—	0		39°C.	Lactose Agar.	1
				do.	Delaware River	0	110,000	38,000	25,000	6,200	1,200	1	0	0				
				do.	do.	25	110,000	41,000	28,000	8,100	1,800	1	0	0				
				do.	do.	50	80,000	34,000	22,000	4,900	1,000	1	—	0				
				do.	do.	75	85,000	35,000	26,000	7,500	1,700	0	—	0				
				do.	do.	100	100,000	36,000	24,000	9,800	2,000	3	—	0				
				do.	do.	200	74,000	63,000	27,000	12,000	2,500	4	—	0				
				do.	do.	300	62,000	34,000	28,000	2,200	600	0	—	0				

12337

Table Showing Results of Experiments to Determine the Longevity of B. coli communis in Sterilized Raw River Water of Schuylkill and Delaware Rivers under Various Conditions of Chlorine Content.—Spring Garden Testing Station, Spring Garden Waterworks, Phila., Pa.

Numbers given are Bacteria per Cubic Centimeter.

Number of Test.	Date of Inoculation of Test Flasks.	Average Temperature during Experiment.		Est. Organic Matter Introduced into Test Flasks in Parts per Million.	Kind of Water.	Chlorine added to Water in Parts per Million.	Numbers of B. coli communis in Test Flasks after incubating at given Temperatures for Periods in Days as follows:—									Temperature of Incubation of Plates.	Kind of Medium.	Number of days of Incubation.
		Test Flasks.	Schuylkill Water at Entrance to Bld'g.				0	1	2	3	5	8	12	14	22			
4	Oct. 7 1901.	73°F.	64°F.	0.25	Schuylkill River	0	180	230	1,700	Too thick to count	← contaminated →					39°C.	Lactose Agar.	1
				do.	Delaware River	0	180	140	61	49	—	15						
				do.	do.	25	180	140	16	2	—	0						
				do.	do.	50	160	100	9	4	—	1						
				do.	do.	75	170	120	13	5	—	2						
				do.	do.	100	160	130	22	6	—	2						
				do.	do.	200	200	140	18	3	—	1						
				do.	do.	300	190	180	33	7	—	2						
5	Oct. 16 1901.	63°F.	62°F.	50	Schuylkill River	0	41,000	18,000	2,500	2,000	1,400	800	400	400		39°C.	Lactose Agar.	1
				do.	Delaware River	0	35,000	13,000	2,200	350	70	30	11	8				
				do.	do.	25	61,000	16,000	4,900	1,200	240	120	63	44				
				do.	do.	50	35,000	15,000	4,300	1,400	650	110	52	37				
				do.	do.	75	46,000	9,200	2,100	750	300	110	17	19				
				do.	do.	100	45,000	17,000	6,200	650	200	43	17	8				
				do.	do.	200	35,000	12,000	1,600	700	80	35	8	2				
				do.	do.	300	42,000	13,000	4,300	1,400	550	100	55	34				

12338 Q. Will you state what the tables show that you have just introduced in evidence?

A. One of these tables contains a caption as follows: "Table showing results of experiments to determine the longevity of B. typhi abdominalis in sterilized raw water of Schuylkill and Delaware rivers under various conditions of chlorine contents."

The other table contains caption as follows: "Table showing results of experiments to determine the longevity of B. coli communis in sterilized raw river water of Schuylkill and Delaware rivers under various conditions of chlorine content."

Q. Will you state what the tables show that you have just introduced in evidence?

A. The first table shows the results of test number 4, typhoid fever organism conducted October 7, 1901, the temperature at which the test flask was maintained in the incubator, the chlorine added to the water in parts per million, and the number of typhoid fever organisms found on the plates for various times from the time of inoculation to the third or eighth day of the test. It also shows the kind of medium used in
12339 making the test, and the number of days of incubation before the first test for numbers was made.

The test number 4 in the first column of tables shows that the typhoid organism rapidly diminished in numbers from the day of inoculation to the third day of the test.

Test number 5, made on the 16th day of October, shows that there was a rapid diminution of numbers on the agar plates from the day of inoculation until the fifth day of the tests, but a small number was found on the eighth day of the tests.

I would like to state that this test was made not for the purpose of showing the longevity of the organisms but rather to show what, if any, influence varying quantities of chlorine content would have upon the growth of the organisms in Delaware river water.

Q. What does the second chart show?

A. The second table shows the same numbers as those given above with reference to the bacillus coli communis, the test being made upon the same day and in the same manner and with the same kind of water for the latter organism as for the typhoid fever organism and this table reveals the fact that the 12340 colon bacillus will live longer in the Delaware river water with varying degrees of chlorine content than does the typhoid fever organism.

Q. What conclusions did you arrive at from the results of this test as to the effect of chlorine upon the longevity of the typhoid bacilli?

A. Briefly it seemed to have no effect. The purpose of this test was to determine whether the increased chlorine which is anticipated when the draft of water from the river at Torresdale becomes large, due to low stream flow and the influence of tidal water coming up the river from Delaware Bay. As to first whether the increased chlorine would permit the growth of the typhoid organism in river water. Next whether it was calculated to increase its longevity both of which factors were under consideration with reference to the establishment of the filter station at Torresdale at the time these tests were made in 1901.

Q. Aside from the question of the longevity of the typhoid germ as affected with the presence of chlorine does this 12341 test afford you any information or a fact upon which to base and predicate an opinion as to the life or longevity of a typhoid in polluted river water?

A. Yes sir, it does. In the absence of information to the contrary I should assume the longevity of the typhoid organism in lake or river water where the sewage pollution was no less than that of the Delaware river at Torresdale would be substantialy the same as that found here. I give this opinion in view of the fact that the temperature of incubation doubtless would be the same for unsterilized or sterilized water taken from any other suspected source of water supply, and in the case of special information collected at some other point from some other stream or source of water supply I should be governed in expressing an opinion on the longevity of the typhoid organism in unsterilized polluted river or lake water by the results of the tests made on the Delaware river water at the Torresdale testing station and the results of tests also made on the Schuylkill river water at the Spring Garden testing station. The tests with the sterilized Schuylkill water being given in the first line of each of the tables, and the next seven are sterilized Delaware river water.

12342 Q. Was this test made on the sterilized or unsterilized water?

A. On sterilized water.

Q. Why was sterilized water selected?

A. Because it was thought to be more favorable to the growth of the organism than unsterilized water, and because it eliminated the danger of our failure to detect the typhoid organisms after a few days of growth, no other organism growing in the water excepting that due to the inoculation of the test flasks.

Q. Would this experiment made on sterilized water furnish you with a basis for an opinion as to the longevity of the typhoid germ in the raw water of these rivers?

A. It would because such data as has come under my observation indicates that the typhoid organism or any specific water bacteria will live longest in sterilized water, due to the fact that sterilization does not remove the food material and possibly increases its availability as food for the bacteria and such food material is consumed only by the organism with which the experiment is being made.

Q. What is your opinion based upon the experiment which you have just introduced in evidence as to the longevity of the typhoid fever germ in the raw waters of these two rivers

12343 at a point where the experiment was made?

A. I should feel safe in expressing an opinion that the organism would certainly not live longer in the unsterilized than it did in the sterilized water, and probably would have a shorter life history. The greatest length of time that a typhoid fever organism lived as shown by the tables is 8 days. I should anticipate that its life in the unsterilized water would certainly be no longer than 8 days and probably less than 8 days, by reason of the facts stated in answer to a previous question with reference to the influence of sterilized water on the life history of the organism with which it may be inoculated.

Q. Are the conditions of laboratory experiments more or less favorable than the conditions in nature for the longevity of the typhoid bacillus in your opinion?

A. I regard the laboratory test usually made and certainly

all that I have made or caused to be made as more favorable to the growth of the typhoid organism than it would be in the normal water with which the experiment was being conducted, as the desire is to show the greatest possible longevity
12344 under the conditions of the test. This is brought about by maintaining a constant temperature of the flasks in which incubation is being carried on and by observing all other conditions conducive to the maintenance of life of the organism.

Q. From your knowledge of this organism what is your opinion as to the longevity of the typhoid bacillus in ordinary river waters which are receiving sewage from urban centers?

A. I should put the life of the typhoid organism in a sewage polluted river water under normal conditions which prevails with the majority of the rivers of the United States drawn on as the sources of public water supply as from 5 to 8 days. I am now referring to the typhoid organism that would come in from a definite point. That organism would probably be not found in the water at the end of five to eight days.

MR. JEFFRIES: Does that now apply to all waters and all characters and conditions or are you referring now to the Schuylkill river?

A. It would be rivers where the normal temperatures were about like those of Philadelphia. I would not like to apply that to the St. Lawrence river for example because I am not quite sure about it, but I think the colder the stream the longer
12345 the organism would live and the warmer the stream the quicker it would perish.

Q. Now, with reference to the degree of pollution, would that have any effect?

A. Yes, it would. But I am assuming as a general proposition that the rivers, when they are the source of public supply as the Delaware, the Schuylkill, the Merrimack, the Hudson, the Missouri and the Mississippi at points of intake for large cities are not largely different with reference to sewage pollution, that is it is more intense in some cases than in others, but nevertheless there is a distinctive sewage pollution in all those streams that would have some modifying influence on the longevity of the organism.

MR. TODD: Would the Illinois river be found in the class of rivers which you have referred to in your previous answer?

A. It would.

Q. To be specific, what is your opinion as to the longevity of the typhoid fever germ in the waters of the drainage canal, the Desplaines and the Illinois rivers?

MR. JEFFRIES: I object to the question for the reason
12346 that the witness has not shown that he possesses proper
information as to the extent of pollution in the Illinois river and the stream flow of that river.

MR. TODD: In reply to counsel will state that the witness has stated that he has familiarized himself with the chemical and bacterial data already introduced in evidence and counsel submits that that information is sufficient upon which to predicate an opinion. The conclusions from these different analytical data will be developed at a later period in the examination.

Q. To be specific, what is your opinion as to the longevity of the typhoid fever germ in the water of the drainage canal, the Desplaines and the Illinois rivers, based upon all the knowledge which you have as to the longevity of the typhoid fever germs in similar waters?

A. From such information as I have of the bacteriological and chemical contents of the Illinois river as disclosed in the volume entitled Streams Examination, prepared by the Sanitary District of Chicago, and of the physical conditions with reference to slope, of their being slack water pools formed in the river at
different points, I should not anticipate a greater longe-
12347 vity of the typhoid organisms in the waters of the Illi-
nois river than I have found in the waters of the Schuylkill and Delaware rivers.

Q. Are there any other experiments aside from those you have detailed which you know of or have made yourself touching upon the longevity of the typhoid bacillus as compared with the life of the other bacteria

A. I have a table which I have made to determine the longevity and follow the life history of the typhoid organism in sterilized and unsterilized river waters.

Q. Are you acquainted with the physical conditions of the drainage canal, the Desplaines river and the Illinois river and the Mississippi river from Chicago to St. Louis?

A. I am so far as information can be obtained from the publications of the hydrographic journals of the Coast Survey,

which has undertaken to show in detail all physical and hydrographic conditions affecting the principal streams of the United States, and which I have accepted as indicating correct conditions as far as they could have been stated with reference to the principal streams of this country. My personal
12348 knowledge of the Illinois river is limited to my association several years ago for a short time with the water works of Peoria, Illinois, when that city was drawing its water from the so-called Lake Peoria.

Q. Assuming that there are four dams in the Illinois river, one at Henry, one at Copperas Creek, one at LaGrange and one at Kampsville, what effect do those dams have upon the problem of sedimentation?

A. The dams, whatever the number may be in the Illinois river, particularly in view of the flat slope of the stream bed will create pools corresponding in number to the dams in which sedimentation is bound to take place. Each of these pools acts very like a sedimentation basin when operated upon the so-called continuous plan, that is to say a sedimentation basin where the water is pumped in at one end and removed at the rate from some other end or point, usually at the opposite end of said basins. I regard the 25 or 26 pools formed in the Schuylkill river between Fairmont dam and Port Clinton, a distance of about 96 miles from Fairmont dam, as active auxiliaries in the purification of the polluted Schuylkill water and I believe that if those dams were removed and only Flat Rock dam at
12349 the Shawmont pumping station and the Fairmont dam at the Fairmont pumping station remained, that the condition of the water coming through our intakes at Shawmont, Belmont, Queen Lane, Spring Garden and Fairmont would be worse that it is now, and the same condition with reference to sedimentation would apply by the maintenance of the dams in the Illinois river, but with greater force by reason of the flatter slope of the stream and the longer the pools formed by each of the dams.

Q. Are you acquainted with the conditions in the Illinois river in regard to its banks as to whether the banks are high or low?

A. I am acquainted with the general topography of the

State of Illinois and acquainted with the channel conditions of the Illinois river at and in the neighborhood of Peoria, and I know that as a rule the banks are low.

Q. What effect do the flood waters in the Illinois river have upon the bottom lands lying in the Illinois river valley?

A. Flood conditions should take the river out of its channel in many places and spread the water over the bottom land, largely widening the channel at such points.

12350 Q. How is the sedimentation in the Illinois river affected by high stages of water overflowing the banks?

A. The percentage of sedimentation would probably be increased by the river rising to such a stage as would overflow the bottom lands, producing over such lands a shallow depth of water moving at a low velocity, both of which would favor precipitation of suspended solids.

Q. Assume that there are in the neighborhood of 400,000 acres of land inundated and subject to overflow in the Illinois river, what effect would this overflowed area have upon sedimentation?

A. It would be to increase the rate of sedimentation during that time when the stream was out of its banks for the reason given in the answer to the previous question.

Q. Will bacteria respond to the law of gravity in the water of a running stream?

A. The specific gravity of bacteria is slightly greater than that of water and in quiescent water bacteria will slowly settle to the bottom. The rate of flow of the water would determine the time required for the bacteria to settle. However, it is known that in a turbid stream carrying considerable silt, sand and other solid matter that there is an engulfing or en-
12351 veloping, rather, of the bacteria by the suspended matter which, when it precipitates, carries the bacteria with it, and in a stream carrying considerable soil, washed from its drainage area, the precipitation of the bacteria is rapid, and is supposed to be due to the agglomeration of bacteria, solids and other suspended matter in masses until a gravity is acquired that will carry it to the bottom of the stream.

Q. Could sufficient water from Lake Michigan—assume that the maximum flow through the drainage canal is 800,000 cubic feet per minute—be carried through the drainage canal into the Desplaines and Illinois rivers so as to create a condition or permit a clearness to such an extent as to preclude the operation of sedimentation in the Illinois river?

A. I do not think that the quantity of water mentioned would impede sedimentation, but it might diminish the rate at which sedimentation would occur during stream flow.

Q. Assume that the entire sewage from the city of Chicago should be diverted into the drainage canal and that 800,000 cubic feet of water per minute from Lake Michigan should pass over the Bear Trap dam, would that amount of pollution be
12352 sufficient if it reached the Illinois river to make the Chicago sewage separate matter under the circumstances in the Desplaines and Illinois river so as to prevent the operation of sedimentation?

A. No, it would not. It might modify the rate of sedimentation, but it would not prevent it.

Q. What sanitary significance does dilution have in considering the problem of self-purification of streams?

A. Dilution of a sewage polluted stream means or should mean dilution with purer water than that flowing in the stream. It operates in two ways, first, self-purification, in a mechanical way by increasing the volume of flow in the main stream and reducing the percentage of pollution; next, to increase the rate of oxidation of organic matter by adding to the polluted water a water higher in dissolved oxygen, and it is probable that with reasonable limitations the addition to a sewage polluted stream of a stream of purer water high in dissolved oxygen, would facilitate the oxidation of organic matter.

Q. Is the danger of infection really diminished by dilu-
12353 tion?

A. Yes, it is.

Q. In what way?

A. By reducing the percentage degree of pollution when referred to the total volume of water flowing. Dilution of the sewage polluted water would act exactly in the same manner as the dilution of a poison. The degree of pollution finally may be reduced to such a small amount as to eliminate all danger.

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12351 veloping, rather, of the bacteria by the suspended matter which, when it precipitates, carries the bacteria with it, and in a stream carrying considerable soil, washed from its drainage area, the precipitation of the bacteria is rapid, and is supposed to be due to the agglomeration of bacteria, solids and other suspended matter in masses until a gravity is acquired that will carry it to the bottom of the stream.

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A. Yes, it is.

Q. In what way?

A. By reducing the percentage degree of pollution when referred to the total volume of water flowing. Dilution of the sewage polluted water would act exactly in the same manner as the dilution of a poison. The degree of pollution finally may be reduced to such a small amount as to eliminate all danger.

Q. Is it a fact that the greater the dilution of sewage the less danger from infection?

A. It is.

Q. What effect does the dilution of the Chicago sewage with the water of Lake Michigan have upon the sanitary quality of the water of the Illinois river?

A. The water drawn from Lake Michigan is probably purer than the water normally flowing in the Illinois river, and the addition of water from Lake Michigan should improve the quality of the water flowing in the Illinois river in proportion
12354 to the relative volumes of original stream flow and flow derived from Lake Michigan.

Q. Is the addition of the Lake Michigan water to the sewage of Chicago a detriment or a benefit to the sanitary condition of the Illinois river considered from the standpoint of dilution alone?

A. The water flowing into the Illinois river from Lake Michigan should be regarded as a benefit to the Illinois river.

Q. Is the addition of Lake Michigan water to the sewage of Chicago a detriment or a benefit to the sanitary condition of the Illinois river considered from the standpoint of the chemical and bacterial changes taking place?

A. Basing an opinion upon the tables giving the chemical and bacteriological determinations for the months of June, July, August and September, 1899, and for the same months for the year 1900, it does not appear that the addition of the sewage of Chicago to the Illinois river is a detriment. Generally speaking a comparison of the data for the four months of the two years mentioned, the condition of the river below the city of Peoria is better for 1900 than it was for 1899. The nitrites are de-
12355 creased, considering the river below Peoria, and the nitrates increased, showing self purification going on in a greater degree during the year 1900 than during the year 1899. In giving this answer some account must be taken of the difference of stream flow for the two years, but notwithstanding that the stream flow, according to the evidence of Mr. Jacob A. Harmon, was greater for 1900 than for 1899, I still think the indications are that the chemical conditions or at least some chemical conditions indicate that self purification is better for the latter year, and having no better data before me than that quoted in

the answer or that mentioned in the question it does not appear that the addition of the sewage in Chicago has injured the quality of the water of the Illinois river south of Peoria.

Q. If a sufficient volume of Lake Michigan water should be added to the sewage of Chicago so as to cause an elevation of the waters in the Desplaines and Illinois rivers, what effect would this increased volume of water have upon the means of sedimentation in the Illinois river?

12356 MR. JEFFRIES: I object to the question for the reason that it is indefinite.

A. The addition of water to the Illinois river from Lake Michigan would increase the current and increase, to some extent, the time required for sedimentation. If the increased volume of water was such as to overflow the banks it might upon the whole have the opposite effect by reason of the large degree of sedimentation that would take place outside of the defined channel of the river on the bottom lands. If, however, it should be shown that the mean velocity of the stream was not materially increased by the addition of water from Lake Michigan it would probably have no marked effect on the rate of sedimentation. The chief factor that would govern in this case would be the mean velocity of the flow of river before and after the addition of water from the lake.

MR. TODD: Q. How do the physical conditions of the Illinois river compare with the other rivers of the country for the purposes of purification and sedimentation?

A. The sedimentation and oxidation of organic matter during stream flow is favored by a low channel and surface slope of the stream. Self purification of a flowing stream would
12357 depend upon time and distance and in two cases where
the distances were the same, but the time of flow for one, between the upper station and the lower station on such a stream would be greater than for the other, the degree of self purification should be greatest with that stream where the time of flow would be greatest, or where the number of hours and days that pass between the upper and lower stations would be the greatest. There is probably very little self purification in rapidly flowing mountain streams, and a very large degree of self purifictaion in streams of slow current in the low lands.

Q. From your knowledge of the physical conditions that obtain along the Illinois river as well as the inspection of the results of the analyses of water, both chemical and bacterial, what effect in your opinion, if any, does the sewage from Chicago discharged into the drainage canal have upon the waters of the Mississippi river, as the same passes along the shore of the State of Missouri?

A. Basing an opinion upon the technical investigations that have been made of the water of the Illinois river at Grafton during the four selected months of 1899 and the four
12358 corresponding months of 1900 it does not appear that the sewage of Chicago has materially changed the conditions, and such changes as are shown would indicate from a chemical point of view an improvement in the quality of the water at Grafton, since the opening of the drainage canal.

Q. What is your opinion as to whether any pollution dangerous to public health entering the drainage canal from the sewers of Chicago reaches as far down the Illinois river as the town of Grafton?

A. Basing an opinion on the technical data contained in the book entitled Streams Examination which has been referred to before in my testimony, there is nothing to indicate that the danger to public health has been increased since the opening of the drainage canal. In making this statement I wish it understood that I do not believe that the water flowing in the Illinois river at Grafton before the opening of the drainage canal was fit for drinking and some other domestic uses, and my answer must be construed as showing only that the conditions are no worse during the months of 1900 which I have under consideration than they were during the corresponding months of
12359 1899 prior to the opening of the canal.

Q. What evidence have you that would justify the conclusions just expressed in your previous answer?

A. I have a compilation of chemical and bacterial data taken from the tables prepared by the chemical and bacteriological experts acting in behalf of the city of Chicago as they appear in the book entitled Streams Examination, previously referred to.

(Let the record show that when the witness refers to the book known as Streams Examination he also includes Professor Long's chemical analyses as shown in the report of the Illinois

State Board of Health, unless such analyses are eliminated specifically by the witness in his answer; all of which have been introduced in evidence and the witness says he has examined).

A. The figures which I now refer to are taken entirely from the book entitled Streams Examination and they show the following numbers of the percentages of decrease or increase for the bacteria or suspended matter or total solids or total oxygen consumed, nitrites and nitrates and finally chlorine, which tables purport to be made as above indicated, and are as follows:

12360

March 18, 1904.

Station	Source of Water.	Bacteria.		Percentage.	
		1899.	1900	Decrease	Increase.
1	Illinois and Michigan Canal, Bridgeport........	2,881,738	1,061,686	63	....
2	" " Lockport...........	3,452,533	1,295.000	62	....
3	Desplaines River, Lockport........................	22,044	738,723	....	3251
4	" " Joliet..........................	2,459,429	169,929	93	....
6	Kankakee River, Wilmington........	9,494	3,525	63	....
7	Illinois River, Morris............................	2,247,353	237,412	18	....
8	Fox River, Ottawa...	5,825	4,787	18	....
9	Illinois River, Ottawa............................	19,957	18,788	6	....
10	Big Vermillion River, La Salle....................	4,007	5,906	....	32
11	Illinois and Michigan Canal, La Salle	185,533	38,756	79	....
12	Illinois River, La Salle	11,192	11,691	....	4
13	" " Henry	31,040	39,482	....	27
14	" " Averyville	7,105	4,011	43	....
15	" " Wesley City.............................	1,381,845	151,462	88	....
16	" " Pekin	1,137,427	470,933	59	....
17	" " Havana.......	6,113	30,738	....	403
18	Sangamon River, Chandlersville....................	16,044	12,796	20	....
19	Illinois " Beardstown	4,855	8,624	....	78
20	" " Kampsville.........	10,263	43,850	....	327
21	" " Grafton...........................	2,346	4,048	....	73
22	Mississippi " Grafton..........	2,471	3,662	....	48
23	" " Alton, Illinois Shore............	2,614	6,559	....	151
24	" " " ¼ district from shore ..	3,068	5,077	....	66
25	" " " Midstream................	3,497	6,547	... .	87
26	" " " ¼ dist. from Mo. shore.	3,348	5,196	....	55
27	" " " Missouri shore	3,988	5,673	....	42
	St. Louis Water Works.				
28	Mississippi River, Illinois Shore	9,328	12,101	....	30
29	" " Midstream.	11,325	14,784	....	31
30	" " Intake....	16,181	16,112	0.4	....
31	" " Missouri Shore	16,544	16,947	....	2
32	Missouri " West Alton, Mo.....	29,948	32,970	....	10

12361

Station.	Suspended matter.		Percentage.	
	1899	1900	Decrease.	Increase.
1	77.8	46.6	40	
2	79.4	72.9	8	
3	19.6	16.7	15	
4	73.5	22.6	69	
6	55.0	51.7	6	
7	22.5	34.2		52
8	48.3	33.4	31	
9	15.1	24.8		64
10	38.4	44.8		17
11	38.6	37.3	3	
12	45.0	28.1	38	
13	48.4	42.1	13	
14	42.2	26.2	38	
15	39.2	51.4		31
16	40.2	41.4		3
17	49.7	49.8		0.2
18	100.6	154.0		53
19	89.2	104.3		17
20	101.8	88.5	13	
21	74.2	86.1		16
22	168.4	210.2		25
23	143.7	195.6		36
24	146.9	208.2		42
25	186.0	206.4		11
26	206.3	226.7		10
27	209.1	200.6	4	
28	1275.2	614.9	52	
29	1756.3	967.4	45	
30	1985.7	1484.7	25	
31	2162.1	1643.2	24	
32	1759.0	1.943.9		11

12362 March 18, 1904.

Station.	Total solids 1899.	Total solids 1900.	Percentage.	
			Decrease.	Increase.
1	575.7	485.2	16	
2	571.4	566.0	1	
3	331.2	222.0	33	
4	548.6	231.8	58	
6	314.4	306.9	2	
7	418.6	267.3	36	
8	314.4	315.9		0.5
9	406.9	267.7	34	
10	745.9	483.6	35	
11	344.3	336.2	2	
12	417.9	270.1	35	
13	407.5	291.5	28	
14	389.1	267.9	31	
15	378.1	306.9	19	
16	383.4	289.7	25	
17	380.5	287.7	24	
18	374.3	405.2		8
19	380.4	345.1	9	
20	368.9	321.0	13	
21	340.8	315.6	7	
22	325.2	364.3		12
23	342.5	394.7		15
24	322.0	399.1		24
25	348.3	372.0		7
26	366.3	370.9		1
27	373.4	356.2	5	
28	1479.7	789.6	47	
29	1966.9	1149.4	42	
30	2198.5	1607.3	27	
31	2449.2	1892.6	23	
32	1995.2	2183.6		9

12363 March 18, 1904.

Station.	Total Oxygen Consumed.		Percentage.	
	1899	1900	Decrease.	Increase.
1	37.7	16.5	56	
2	40.8	20.5	50	
3	14.1	7.9	44	
4	29.6	7.8	74	
6	13.5	9.8	28	
7	16.3	8.4	48	
8	10.9	8.6	21	
9	13.0	6.9	47	
10	7.8	6.1	22	
11	11.9	9.9	17	
12	14.1	8.2	42	
13	14.5	8.3	43	
14	12.3	6.8	44	
15	13.3	7.8	41	
16	13.9	7.4	47	
17	12.9	7.2	44	
18	8.5	9.7		14
19	11.1	8.6	23	
20	10.7	7.6	29	
21	10.1	7.8	23	
22	16.3	14.9	9	
23	13.4	11.9	11	
24	15.0	12.4	17	
25	15.5	14.4	7	
26	15.5	14.2	8	
27	15.7	14.0	11	
28	21.5	15.7	27	
29	23.3	18.2	22	
30	23.8	20.6	13	
31	24.8	21.0	15	
32	19.4	21.3		10

12364 March 18, 1904.

Station.	Nitrites.		Percentage.		Nitrates.		Percentage.	
	1899	1900	Decrease.	Increase.	1899	1900	Decrease.	Increase.
1	.078	.007	91		.348	.256	26	
2	.0562	.0028	95		.254	.188	26	
3	.011	.0045	59		.261	.214	18	
4	.0123	.0382		211	.220	.252		15
5	.0114	.0132		15	.550	1.166		111
7	.0245	.1689		589	.285	.693		143
8	.019	.0064	66		.30	.247	18	
9	.705	.4116	42		1.89	1.61	15	
10	.0290	.0126	57		.71	1.82		156
11	.0449	.0227	49		.511	.369	28	
12	.5385	.2635	51		2.29	.168	27	
13	.4471	.2103	53		1.74	1.55	11	
14	.1891	.1415	25		1.48	1.35	9	
15	.1526	.1059	31		1.23	1.40		14
16	.2301	.1272	44		1.055	1.272		21
17	.165	.1311	21		.7275	1.1443		57
18	.0250	.0251		0.4	.84	1.37		63
19	.1327	.1073	19		.7613	1.2529		65
20	.0751	.0512	32		.89	1.21		36
21	.0582	.0200	66		.8706	1.0611		22
22	.0086	.0048	44		.329	.401		22
23	.0194	.0130	33		.60	.84		40
24	.0115	.0095	10		.415	.757		82
25	.0065	.0062	5		.341	.442		30
26	.0052	.0049	6		.336	.369		10
27	.0053	.0050	6		.338	.385		14
28	.0091	.0048	47		.468	.559		19
29	.0061	.0029	52		.461	.538		17
30	.0055	.0026	53		.473	.567		20
31	.0054	.0027	50		.521	.590		13
32	.0060	.0032	47		.382	.582		52

12365 March 18, 1904.

Station.	Chlorine.		Percentage.	
	1899	1900	Decrease.	Increase.
1	115.9	143.4		24
2	115.6	165.6		43
3	6.34	15.0		136
4	100.6	24.5	76	
6	3.7	3.3	11	
7	67.6	25.2	63	
8	4.86	5.68		17
9	61.92	25.80	58	
10	44.4	20.9	53	
11	14.9	14.3	4	
12	51.1	33.0	35	
13	43.6	20.8	52	
14	37.9	21.3	44	
15	34.14	21.10	38	
16	37.3	21.5	42	
17	31.8	19.4	38	
18	5.16	4.42	14	
19	23.1	17.7	23	
20	15.8	16.6		5
21	14.91	15.30		3
22	2.22	3.48		57
23	7.17	8.80		22
24	4.41	7.50		70
25	2.68	4.70		75
26	2.31	3.82		66
27	2.44	3.50		43
28	5.08	7.00		38
29	5.48	7.16		31
30	16.10	10.70	34	
31	6.28	12.40		97
32	8.37	14.50		73

12366 Q. What do these tables show?

A. This table shows in the following order:

1. An increase in the bacterial content of the water from Havana, Illinois, to Grafton.

A decrease in the suspended matter from Wesley City to about one-fourth the distance from the Missouri shore into the Mississippi river, at Chain of Rocks.

An increase in the total solids from Chicago to Grafton.

A reduction in the total solids from the Mississippi river at Grafton to one-fourth the distance from the Missouri shore, at Chain of Rocks.

An increase in the total solids from the Missouri shore of the Mississippi river to the Missouri shore at the St. Louis water works.

A reduction in the total solids of the Missouri river at West Alton.

It shows, with two exceptions, a material reduction in the total oxygen consumed, which is, in my opinion, significant as indicating self purification by natural processes during stream flow past the thirty-two stations named in the table.

Number 18, Chandlersville, Sangamon river, shows an
12367 increase in the total oxygen consumed.

Number 32, the Missouri river at West Alton, and all the other stations from the Illinois and Michigan canal at Bridgeport, down to the Missouri shore of the Mississippi river at the St. Louis waterworks, show a reduction.

Considering the nitrates and nitrites which in my opinion are always significant factors in showing changes taking place in the quality of polluted waters, and which where purification is being effected by sedimentation or filtration or any other of the known practical means not including sterilization by heat, the nitrites should diminish as the water is reduced in sewage pollution and the nitrates should increase.

Considering the table before me with the exception of four stations, namely, the Desplaines river at Joliet, the Kankakee river at Bloomington, the Illinois river at Morris and the Sangamon river at Chandlersville, the nitrites are largely decreased, and omitting nine stations, namely, the Illinois and Michigan canal at Bridgeport, the same canal at Lockport, the Desplaines river at Lockport, the Fox river at Ottawa, the Illinois river at
Ottawa, the Illinois and Michigan canal at LaSalle, the
12368 Illinois river at LaSalle, the same river at Henry and
the same river at Averyville, there is everywhere else a marked increase in the nitrates. If I was applying the information contained in the sheet showing the nitrates and nitrites for 1899 and 1900 and the percentages of decrease and increase to the work of filtration I should have no hesitation in claiming the same degree of purification by the filters as is here shown by self purification or sedimentation in the channel of the river. Referring to the tables showing the chlorine this has increased for all stations from the Illinois river at Kampsville down to the Missouri river at West Alton excepting the intake of the St. Louis water in the Mississippi river where the tables show a diminution of chlorine. Taking all the data together and particularly that relating to the total oxygen consumed, and the nitrates and nitrites, I consider that the condition of the water flowing in the stream at Grafton has been improved.

Q. In the tables which you have just introduced, on the first page appears at the head of the column "Station" with consecutive numbers following, with the names of the
12369 places which such consecutive numbers indicate, and in the following tables only the consecutive numbers are indicated. Do these consecutive numbers in the first column of the table indicate the name of the station as are set forth in the first table?

A. They do.

Q. What is your opinion as to whether any infectious matters coming from the sewers of Chicago by way of the drainage canal in a dangerous state reach as far down the Illinois river as the city of Grafton?

A. Basing the opinion upon the technical data collected by others for the purposes of this investigation, I do not think that the sewage of Chicago in its original condition is manifested in the waters of the Illinois river at Grafton.

Q. Upon what do you base this opinion?

A. Chiefly upon the tables containing a record of the determinations of nitrates and nitrites at the 32 stations under consideration.

Q. Would the conditions of low water in the Missouri river at a time when there was high water in the Illinois river be in any way a factor in carrying infected and polluting mat-
12370 ters from the sewers of Chicago to the city of St. Louis?

A. I do not think that it would because the question of high or low water of the Missouri river would have no influence on the amount of water flowing in the channel of the Illinois river at or near Grafton. It might increase the surface slope of the stream, but considering the length of the stream, its flat slope, and the number of dams, it is doubtful if the change in the stages of water in the Missouri river would have much influence upon the flow of the Illinois. It certainly would not have a tendency to increase the current throughout its length.

Q. Professor, from your knowledge of the conditions that obtain along the Illinois river as well as your knowledge of the conditions that obtain in Chicago and the drainage canal, and your knowledge of the water supply of St. Louis, such as is to be had from the intake tower at the chain of rocks, and all other sources of knowledge which you may possess, what effect does the sewage from Chicago have upon the water supply of the city of St. Louis or upon the water of the Mississippi river as the same passes along the State of Missouri?

12371 MR. JEFFRIES: I object to the question as a repetition.

A. Considering the technical data already referred to in previous answers and contained in the book entitled Streams Examination and considering the relative drainage area of the Illinois river and the Mississippi river above St. Louis and of the Missouri river, I do not think that any marked effect would be felt in the combined waters of the three rivers by reason of the combined discharge of sewage and Lake Michigan water into the head waters of the Illinois river at Joliet.

Q. Why is it that the typhoid bacillus will not live as long in polluted water as in pure water?

A. Because of the presence in much larger numbers of the stronger bacteria of putrefaction and fermentation which find a normal habitat in polluted water.

Q. How does the typhoid bacillus behave in moist soil?

A. I have no information upon that matter that has come to me in a way to be conclusive and I can not answer the question for that reason.

Q. What is your opinion as to whether a typhoid bacillus will live longer in the sediment of a polluted stream than
12372 it would in the water of the same stream?

A. I have no data upon that proposition either. I should think that the organism would perish more quickly in the sediment of the stream where the destruction of organic matter is actively going on by the agency of the putrefactive bacteria than it would in the water above such sediment. Proof along this line, however, I am not able to offer.

Adjourned until 2:00 p. m., same day, March 28, 1904.

12373 2:00 p. m., Monday March 28, 1904.

Met pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

JOHN W. HILL

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. What is your opinion, based upon all the knowledge that you possess, as to whether a typhoid bacillus coming from the sewers of Chicago and entering the drainage canal could survive the journey from Chicago to St. Louis, a distance of 357 miles, and be a danger and a menace to the inhabitants of the city of St. Louis and the inhabitants of Missouri, using the water of the Mississippi river for drinking and domestic purposes?

A. In the light of such information as I have upon the longevity of the typhoid bacillus in unsterilized waters and of the special knowledge with reference to the conditions subsisting along the Illinois river I should not expect a typhoid
12374 organism introduced into the Illinois river together with the sewage of Chicago and Joliet to pass the entire length of the stream. Upon the contrary I should expect it to perish somewhere in transit and probably before it reached the city of Peoria, and the reason for this opinion is based upon the evident rate of reduction of organic matter in the river between the point of discharge into the canal and the city of Peoria, the typhoid bacillus like other bacteria being a part of this organic matter.

Q. Are you acquainted with the settling basins of the city of St. Louis?

A. I am as they are described in the reports of the water commissioners of St. Louis which reports I have had on file for the past twenty years: I have never personally visited the settling basins that form a part of the St. Louis water works. My information with reference to those is refreshed by reading the report of the Commission of Hydraulic Engineers upon the subject of new water supply for the city of St. Louis, which report was published about two years ago.

Q. How long have you been acquainted with the water
12375 supply of the city of St. Louis?

A. By means of the annual reports of the water commissioners for twenty years and taking into consideration the report of Mr. J. T. Kirkwood, made in 1866 or 1867, which was the basis for the general reorganization of the water works of

St. Louis for a period of thirty-six or thirty-seven years, because Kirkwood's work was one of the early works that I studied in connection with public water supplies.

Q. Who was Mr. Kirkwood to whom you refer?

A. Mr. Kirkwood was one of the most eminent hydraulic or water works engineers in the United States, and in 1865 or 1866 was employed by the city of St. Louis to develop plans for the general improvement of the water supply.

Q. Did you know Mr. Kirkwood?

A. I met him once some twenty years or more ago in New York.

Q. Is that the Mr. Kirkwood that visited Europe and made a report on filtration to the city of St. Louis?

A. The same.

Q. And that report has been published?

A. Yes sir. He made what was the earliest and for
12376 many years considered as the most elaborate report on
the filtration works of Europe, that was printed in the English language.

Q. Do you regard the settling basins at St. Louis as they are at present constituted a complete guarantee against infection coming from the waters of the Mississippi river?

MR. JEFFRIES: I object to the question on the ground that it is immaterial.

A. I do not.

MR. TODD: Q. For what reason?

A. Because it is not possible with such limited sedimentation as can be carried on in the St. Louis reservoirs to so purify an ordinarily polluted water as to fit it for domestic uses. Settling basins such as would be required to eliminate 99 or 99½ per cent. of the bacteria and bring about a corresponding reduction of turbidity, things that are desired in potable water would be of such enormous size as to make them prohibitory by reason of the cost and by reason of the area occupied.

Q. Are you acquainted with the settling basins in the city of Covington, Kentucky?

A. I am.

12377 Q. What acquaintance have you with those settling
basins?

A. I was familiar with the construction at the time they

were being built by reason of temporary employment by the contractors and by reason of further connection with the suit brought by the contractors, Casparis & Co., against the trustees of the Covington Reservoir, for alleged extras in connection with the work of construction. Later on I renewed my acquaintance with these works in connection with the plans for the improvement of the water supply of Cincinnati at which time samples were taken from the Covington reservoirs to determine how much, if any, purification was going on by reason of long sedimentation. At that time the two distributing basins carried about thirty days' supply, that is to say when operated upon the continuous sedimentation plan it would take about thirty days to empty the reservoirs or rather to discharge the original volume of water and have it replaced with unsedimented water pumped from the Ohio river. The result of those investigations is recorded in the report of the Engineering Commission of the city of Cincinnati published March, 1896. And as I now recall upon some occasions the bacterial tests of the water in
12378 Covington reservoirs compared with the tests of the water in the river flowing past the intake of the Covington pumping station, revealed at times a reduction of the bacteria by as much as 97 per cent. I think the average of the tests that were made (perhaps a dozen or more during the months of January, February and March, 1896), indicated more than 90 per cent. bacterial reduction by simple sedimentation for thirty days.

Q. Where the settling basins such as existed at Covington, Kentucky, held a sufficient amount of water to supply the city of Covington for a period of thirty days and as the water was taken out for domestic uses is immediately supplied from the open river and typhoid fever should prevail among the people of Covington using such water what is your opinion as to whether such a condition of typhoid fever existing in Covington, Kentucky, justifies the assumption that because the basins hold a supply for thirty days that the typhoid bacillus will live in that water for such a period?

A. I do not think that it does justify such an assumption. The circumstances with reference to Covington and the
12379 sister city of Newport, which also has a large sedimentation basin, and the city of Cincinnati is this: a large part

of the population of each of the two smaller cities in Kentucky do business or are otherwise engaged daily in Cincinnati, and from investigations of the typhoid fever rates of the three cities from 1890 to 1896, there is satisfactory evidence to my mind that the larger part of the typhoid in Covington and Newport is chargeable to the Cincinnat water, that is to water that was used by the people who were either attending school or looking after business or doing their shopping in the larger city, and a fair test of the influence of thirty days' sedimentation on the Ohio river water is not made in the daily experience of Covington because of this constant change of population from Covington to Cincinnati every day excepting Sunday. Notwithstanding the conditions which reflect upon the action of the Covington reservoir, the typhoid fever rates are much lower in Covington than they are in Cincinnati.

Q. Have you the typhoid rate of Covington and Cincinnati?

A. I have for the years 1890 to 1896. Quoting the rates 12380 of Cincinnati for the years 1890 to 1896, inclusive, by years they run as follows per 100,000 of population.

1890	67
1891	62
1892	40
1893	43
1894	50
1895	36
1896	48.
	——
Average	49.4

For Covington for the same years and upon the same basis:

1890	43
1891	45
1892	40
1893	27
1894	42
1895	27
1896	32.
	——
Average	36.6

With the exception of the year 1892 the typhoid fever rates
per 100,000 population were always lower in the city of
12381 Covington than in the city of Cincinnati, both taking
water from the Ohio river.

Q. What was the character of the water supply of Cincinnati during this time?

A. In general terms it was bad because at that time and now no attempt had been made at improvement of the quality of the water after it was taken from the river, excepting such as may take place in passing through the Eden Park reservoir which holds ordinarily about one and one-half days supply.

Q. From what you know of the typhoid conditions existing in Covington, Kentucky, what is your opinion as to the validity of attributing the typhoid conditions to the water from the reservoir of the city of Covington?

A. Having investigated the typhoid fever rates at Covington it never occurred to me that it was chargeable to the local water, but that it was chargeable to the very considerable daily consumption of unsedimented water that the people of Covington drunk or some of them drunk in the city of Cincinnati daily. There are other sources of typhoid infection that
must be taken into consideration, namely the drinking of
12382 water during travel of the members of an organized
community, and importing cases which will be charged to
the city of residence. I do not believe that all typhoid in Covington was due to the Cincinnati water, but I do believe a large portion of it was. In Covington also there is considerable drinking water used from old-fashioned dug wells, and it is possible that some of the typhoid may be chargeable to that cause.

Q. What effect do wells have upon the public health as regards typhoid in large cities?

A. It is I believe a common opinion of sanitarians today and it is certainly my opinion that an open well is not a safe source of drinking water in an old and well built up urban community, by reason of the fact that soil in due times will become polluted with the wastes from privy vaults and cess pools and that pathogenic bacteria and perhaps other objectionable matter from such cess pools and vaults may by the ordinary means find a way into the well, and render such water unfit for drinking purposes.

Q. In the interpretation of typhoid statistics of a city what method do you employ?

A. My custom in stating typhoid fever cases and deaths 12383 is to relate the rates to the unit of one hundred thousand population living.

Q. Are you acquainted with the mortality percentage method?

A. Yes sir.

Q. What is your opinion as a sanitarian as to the validity of that method being employed in the interpretation of typhoid statistics?

A. It does not as easily convey to the ordinary mind the true relation of the typhoid fever statistics of the population as the method of relating deaths or case to some unit of population, for example 10,000 to 100,000. For the reason that relating the typhoid fever deaths or cases to the deaths or cases from other causes, if the general mortality rate was low and the typhoid fever rate referred to population unchanged, it will create an impression in the ordinary mind that the typhoid rate had been increased while it had remained unchanged, whereas if the comparison is made on the unit of population whatever that unit may be, the ordinary mind can follow more easily as to whether the typhoid fever rates were increasing or diminishing or maintained at some constant rate.

12384 Q. Is the mortality method regarded as on the whole the most accurate among sanitarians and students of vital statistics in ascertaining typhoid conditions of a given community?

A. I do not think it is. The custom in Germany and England is to state the typhoid fever rates and the rates from other infectious diseases upon some unit of population, occasionally 10,000 and sometimes 100,000.

Q. What are the liabilities of pollution and infection of a river coming from the rural population?

A. The danger of infection is not so great from the rural population as from the established centers of urban population because the opportunities of sewage from the rural population reaching some water course are not so great as in established centers where systems of sewerage are in vogue.

The element of time enters into the probability of infection from rural soures. There is an exception that can be made to that in the case of an epidemic of typhoid fever at Wesleyan University some seven or eight years ago at which time there was an epidemic of typhoid fever among the students of the University which finally was traced to oysters eaten by one of
the college fraternities at their annual banquet. In this
12385 case the infection of the oyster bed was traced to a rural
residence, that of the oyster grower where his wife or daughter or both had typhoid fever and where the little drain that carried the sewage from the privy emptied into a neighboring creek and in that creek at some distance below the mouth of the drain was located the oyster growers bed. This is one authentic case of rural infection of typhoid, and is quite recent.

Q. Are not the Plymouth and Lowell epidemics of rural origin?

A. The Plymouth is distinctly rural, because the residence of the parents of the young man who was supposed to be the cause of the Plymouth epidemic was isolated on the water shed of the impounding reservoir that furnished the water supply to Plymouth. My recollection is that it was a suburban factory or a small establishment on a little creek emptying into the Merrimack river below Lowell that furnished the foundation for the Lowell epidemic some thirteen or fourteen years ago. The details of the Lowell epidemic I cannot recall quite so well, but it is reported in detail in the reports of the Massachusetts State Board of Health. I remember, however, the report on it by Professor Sedgwick, and it came either from a small establish-
ment or factory a short distance from the point of en-
12386 trance of the little stream which discharged into the
Merrimack river.

Q. When you consider the question of the condition of typhoid fever in a given community do you regard it as important to note the interval of time elapsing between the infection of a water supply and the drinking of the infectious water by the people?

A. Yes, if the time is known when the water supply is infected due regard is had for the condition between the time of infection and the time of the outbreak of the fever. It is customary to allow as between the time, however, when the infected water is used, and the outbreak of fever a period of at least two weeks.

Q. If upon a water shed where the water is polluted there should be many sources of pollution and infection and typhoid fever should break out in a given community, where would you look for the source of infection?

A. At the nearest possible point of pollution above the source of water intake or above the point of water intake.

Q. Why would you do that?

A. Because the nearer the cause or source of infection the more certain and more virulent would be the outbreak of
12387 typhoid. I can illustrate it by example. There would be as much danger to the city of Philadelphia through an infection of the water of the Schuylkill river by an outbreak of typhoid fever in Norristown, a city distant ten miles and having a population of about 16,000 or 17,000, as there would be from an outbreak of typhoid fever in Reading, a city distant about 70 miles and having a population of 80,000. The element of distance from the point of infection to some extent balances the size of the community, that is or might be the cause of the infection. A large city on a given water shed might be so far removed from the point of water works intake as to render practically remote the possibility of infection from typhoid developing in that city, and a small city may be so near the point of the water works intake as to render it very dangerous to the water supply of a given city if typhoid should develop in that smaller center. In other words, the distance of a center where the infection arises is certainly an element in determining the probability of a source of typhoid. And, in seeking the cause where this typhoid that is supposed to be due to polluted water supply the usual step taken is to begin at the water
12388 works intake and carefully exploit the causes up stream until one is reached, if it be reached at all.

Q. State in detail what position the science of bacteriology occupies in regard to the ascertainment of the purity of river water?

A. Bacteriology is a very important factor in determining the sewage pollution of a water supply, first in determining the number of bacteria per unit of volume of samples so collected for the purposes of analyses, but more especially in showing the presence, if they be present, of what are known as sewage bacteria, namely the bacillus coli communis, the several organisms of the proteus vulgaris variety or the stronger putrefactive and fermentative organisms that are usually associated only with decomposing organic material and are always accompanied or are always found in sewage polluted water.

Q. State in detail the place the science of chemistry holds in regard to the ascertainment of the purity of river water?

A. Chemistry is also another important factor in determining the degree of the pollution of a water supply in showing the condition of the nitrogeneous matter; to some extent the condition of the organic matter; the chlorine present
12389 which is a direct index of sewage contamination; and in showing changes taking place, especially in the nitrates and nitrites from time to time in the water.

Q. In the ascertainment of the quality of a river water what aid are chemistry and bacteriology to the sanitarian in forming a judgment of the quality and potability of a water?

A. It furnishes information on the quality of water that can not very well be had in any other way. It furnishes direct information along certain lines that can not be obtained in any other so called practical manner.

Q. In order to qualify as a sanitary expert is it necessary for such expert to have knowledge of chemistry and bacteriology?

A. I think it is. I think that a sanitary expert in passing on the value of a water supply should be able at least to interpret the bacteriological and chemical analyses and form an opinion as to the meaning of the different data that are given.

Q. Does not a sanitary expert call to his assistance all information available from chemical and bacterial sources
12390 as well as the knowledge of the sources of pollution in passing judgment on the sanitary character of a river?

MR. JEFFRIES: Objected to as leading.

A. When such information is to be obtained he does. There are times where hasty investigations are made of sources of water supply where a sanitarian may be compelled to rely entirely upon his knowledge of the water shed, of the population on that water shed, of the general slope of the water shed and of the probable rainfall, all of which factors may be readily gathered from the statistics of the United States Census Bureau or of the United States Geological or Coast Survey. Whereas analytical data showing the bacteriological and chemical conditions required to be of value should extend over a considerable period of time and take into consideration the usual seasonal changes that occur in the quality of the water supply that will take place in rivers or other proposed sources.

Q. As a sanitary expert availing yourself of all chemical and bacteriological knowledge which is available to you, what is your opinion as to whether a typhoid bacillus lying in the sediment of a polluted stream for a period of sixty days
12391 would be the cause of typhoid fever when taken into the human system, if it had remained in such sediment for that length of time?

A. I have no opinion whatever upon a proposition of that sort and do not like to offer an answer to the question. There is no data with which I am familiar indicating any such condition as is recited in the question, and I do not know that I could offer any better reason upon this than that given before with reference to the probable longevity of the typhoid organism in the sediment of a stream or in the water of a stream above the sediment, having stated in that answer that the chances were in my opinion that the longevity of the organism would be less if found in the sediment of a stream where the processes of organic decomposition were in progress.

Q. What is your opinion as a sanitary expert, based upon your examination of the tables introduced in evidence by Professors Long, Palmer, Burrill and Jordan, of the waters of the Illinois, Mississippi and Missouri rivers as represented by such tables which you have examined as to which of these three rivers from these analyses discloses the least amount of impurity or pollution?

MR. JEFFRIES: I object to the question as immaterial.

12392 A. Basing an opinion upon the technical data in the volume entitled Streams Examination previously referred to in my testimony I should regard the quality of the water of the Illinois River at Grafton as no worse and in some respects better than the mixed waters of the Illinois, Mississippi and Missouri Rivers at the point in the Mississippi River, below Grafton as shown by the data in the tables of technical data previously offered as a part of my testimony.

Q. How does the Missouri River at Ft. Bellefontaine or West Alton compare with the Mississippi River above Grafton and the Illinois River at Grafton?

Mr. Jeffries: I object to the question as immaterial.

A. From a bacteriological point of view the water of the Illinois River at Grafton is decidedly better than the water of the Missouri River at West Alton. Considering the suspended matter the water of the Illinois River at Grafton is superior to the water of the Missouri River at West Alton.

The same statement may be made with reference to total solids.

12393 The same statement may be made with reference to the nitrates and nitrites. The degree of nitrification being shown as greater for station 21 at Grafton, at the mouth of the Illinois River than for station 32, West Alton on the Missouri River.

Considering the chlorine alone the water of the Illinois River at Grafton would not be considered as good as that of the Missouri River at West Alton.

Q. If the Illinois River discloses a less amount of impurities than the Missouri what would be the effect of the water of the Illinois emptying into the Mississippi River at Grafton and subsequently uniting with the Missouri at its mouth upon the combined waters of the Mississippi and Missouri Rivers at the intake tower at the chain of rocks?

A. Considering the relatively small natural stream flow from the water shed of the Illinois River when compared with the stream flow of the Mississippi River above St. Louis and the stream flow of the Missouri River, and ignoring or setting aside the fact of the water of the Illinois River being either better or worse than that of the two larger streams the addition of the ordinary stream flow from the Illinois River to the combined stream flow of the other two rivers would not have much effect either way. In order to reduce this to a more

12394 definite statement I have prepared a table showing the relative areas of the drainage basins of the three rivers mentioned in the question, and assuming for the present that the mean rain fall would be the same over the combined drainage area of the Illinois, Mississippi and Missouri Rivers upon this basis, and omitting all flow of Chicago sewage or of water from Lake Michigan, of each 100 gallons of water flowing in the Mississippi River opposite the chain of rocks, 75 1-4 would come from the Missouri River water shed, 20 1-3 from the Mississippi River water shed and the remaining 4 4-10 from the Illinois water shed.

As a matter of fact, however, the mean rain fall over the whole area of the Missouri River watershed is not so great as that over the water shed of the Illinois and of the Mississippi Rivers and it is probable that of the total flow of water in the Mississippi River opposite St. Louis 70 per cent. can be charged or credited to the Missouri River water shed; 20 or 22 per cent. to the Mississippi water shed and the remaining 6 or 7 per cent. to the Illinois River water shed. In this case it is assumed that no water falls in the Illinois River except that due to the rainfall on its drainage basin.

12395 Q. Have you figured out the results, adding the flow from the drainage canal?

A. I have upon the assumption only that the mean annual rain fall is substantially uniform over the entire Mississippi River basin embraced in the water shed of the Illinois and Mississippi River above St. Louis and the Missouri River which is not as stated in the answer to the previous question, quite true, but for this purpose may be accepted as true. Allowing the least stream flow of the Illinois River at Grafton as reported by the U. S. Engineers in October, 1891, of 1,000 cubic feet per second and assuming the discharge from Lake Michigan through the drainage canal of 300,000 cubic feet per minute or 5,000 cubic feet per second and allowing for the discharge of sewage based upon 90 per cent of 85 per cent of the total water consumption of Chicago which produces a discharge of 424 cubic feet per second, the percentage of volume flow with the least recorded stream flow of the Illinois River at Grafton would be seven (7). Taking this flow into consideration and also taking into consideration the flow of sewage from Chicago plus the flow from Lake Michigan. Of the water flowing in the Mississippi River
12396 opposite St. Louis, 20 per cent would be credited to the

Mississipi river, 75 1-2 per cent. to the Missouri River and 2.96 per cent to the Illinois River, and 1.54 to the influence of the discharge of the Chicago sewage, or such water as is carried with the sewage into the drainage canal exclusive of the diluting water drawn from the Lake.

Q. Will you state upon what basis you base these calculations and the sources of your information?

A. The information with reference to the least stream flow of the Illinois River is obtained from a blue print furnished by Judge Springer at one time counsel for the Sanitary District of Chicago, in this case, and purporting to have been made up in the office of the trustees. The information with reference to the drainage area of the three rivers under considerations is supplied by the United States Census Bureau and checked against drainage areas furnished by the United States Coast Survey in water supply and irrigation papers. The information with reference to the discharge of 300,000 cubic feet per minute from Lake Michigan is obtained from the blue print supplied by Judge Springer as previously mentioned, and in like manner the per second sewage discharge is obtained from the same source with this difference that in the blue print the statement is made that 85 per cent. of the total sewage of Chicago is discharged into the drainage canal. I have seen fit to reduce this by ten per cent. because 85 per cent. is shown to be 85 per cent. of the total water consumption of the city in which is included the water used for street sprinkling and water used for other purposes, which will not probably find its way into the city sewers and will not be a part of the flow of the sewers. Therefore, in discussing the proportion of water consumed by the city which would be found in the sewers, I have been accustomed to limit it to 90 per cent. of such consumption for the reasons above given. 12397

This modification has been made in the volume of sewage discharged in order to allow for the per second discharge in the drainage canal.

That the data furnished from the United States Census Bureau for the purpose of my testimony consist of four sheets and shows the total drainage area of the water shed of the Missouri River, the total population distributed on that water shed and in addition to these also shows in answer to a request for such information the population of the principal cities 12398 and the distances from St. Louis of each of these cities.

This, then, is again divided for each branch of the main stream, as, for example of the Missouri River, the Big Sioux River, the Yellowstone, the Platte, the Kansas and the Osage River. The same data is supplied for the Mississippi River and its principal tributaries and among its tributaries is included the Illinois River, and for the purposes of comparison it also includes the total water shed and distribution of the population on the Deleware River above the city of Philadelphia, excepting the Schuylkill River and finally shows the drainage area of the Schuylkill River and the distribution of the population on its water shed.

I requested Mr. S. B. North, the Director of the Census to make this compilation from the statistics in his Bureau, indicating the line of investigation which I desired to pursue and the state of facts which were requested in order to enlighten me upon the problems embraced in this investigation.

Q. Will you produce and read the compilation concerning which you have just testified?

A. Yes sir, it is as follows:

12399 DRAINAGE BASIN OF THE MISSOURI RIVER.

Missouri River (including all tributaries)—

Area of water shed in square miles	520,088
(a) Population of water shed	5,120,607

Distance of principal cities from St. Louis and their population:

Cities.	Distance from St. Louis	Population.
Jefferson City, Missouri	110 miles	9,664
Kansas City, Missouri	261 "	163,752
Leavenworth, Kansas.	290 "	20,735
Atchison, Kansas	305 "	15,722
St. Joseph, Missouri	322 "	102,979
Omaha, Nebraska	440 "	102,555
Council Bluffs, Iowa	441 "	25,802
Sioux City, Iowa	530 "	33,111

Big Sioux River—

Area of water shed in square miles	10,000
Population of water shed	179,000
Distance of mouth from St. Louis	500

No large cities on this tributary.

12400

Yellowstone River—

Area of water shed in square miles	70,119
Population of water shed	49,002
Distance of mouth from St. Louis	1,165

No large cities on this tributary.

Platte River—

Area of water shed in square miles	89,742
Population of water shed	727,009
Distance of mouth from St. Louis	422

Distance of principal cities from St. Louis and their population:

Cities.	Distance from St. Louis.	Population.
Denver	980 miles.	133,859

Kansas River—

Area of water shed in square miles	60,496
Population of water shed	1,014,772
Distance of mouth from St. Louis	265

Distance of principal cities from St. Louis and their population:

Cities.	Distance from St. Louis.	Population.
Kansas City, Kansas	265 miles.	51,418
Topeka, Kansas	308 "	33,608

12401

Osage River—

Area of water shed in square miles	16,254
Population of water shed	531,765
Distance of mouth from St. Louis	107

No large cities on this tributary.

DRAINAGE BASIN OF THE MISSISSIPPI RIVER— ABOVE ST. LOUIS, MISSOURI.

Mississippi River (including all tributaries except Missouri river)—

Area of water shed in square miles	171.698
Population of water shed	8,409,076

Distance of principal cities from St. Louis and their population:

Cities.	Distance from St. Louis.	Population.
Quincy, Illinois	110 miles.	36,252
Burlington, Iowa	178 "	23,201
Rock Island, Illinois	241 "	19,493
Davenport, Iowa.	242 "	35,254
Clinton, Iowa	270 "	22,698
Dubuque, Iowa	325 "	36,297
LaCrosse, Wisconsin	423 "	28,895
St. Paul, Minnesota	545 "	163,065
Minneapolis, Minnesota	557 "	202,718

12402

Illinois River—

Area of water shed in square miles	32,081
Population of water shed	3,433,845
Distance of mouth from St. Louis	37

Distance of principal cities from St. Louis and their population:

Cities	Distance from St. Louis.	Population.
Peoria, Illinois	162 miles.	56,100
(c) Ottawa, Illinois	227 "	10,588
Chicago, Illinois	357 "	1,698,575

Rock River—

Area of water shed in square miles	10,231
Population of water shed	564,972
Distance of mouth from St. Louis	241

Distance of principal cities from St. Louis and their population:

Cities.	Distance from St. Louis.	Population.
(d) Rockford, Illinois	342 miles.	31,051
Beloit, Wisconsin	360 "	10,436
Janesville, Wisconsin	375 "	13,185

12403

Wisconsin River—

Area of water shed in square miles	12,823
Population of water shed	326,197
Distance of mouth from St. Louis	380

No large cities on this tributary.

Chippewa River—

Area of water shed in square miles	8,616
Population of water shed	107,096
Distance of mouth from St. Louis	490

Distance of principal cities from St. Louis and their population:

Cities.	Distance from St. Louis.	Population.
(e) Eau Claire, Wisconsin	530 miles.	17,517
Chippewa Falls, Wisconsin	542 "	8 094

St. Croix River—

Area of water shed in square miles	7,693
Population of water shed	128,023
Distance of mouth from St. Louis	510

No large cities on this tributary.

12404

Minnesota River—

Area of water shed in square miles	16,100
Population of water shed	396,770
Distance of mouth from St. Louis	545

Distance of principal cities from St. Louis and their population.

Cities.	Distance from St. Louis.	Population.
Mankato, Minnesota	615 miles.	10,599

Cedar River—

Area of water shed in square miles	12,037
Population of water shed	470,365
Distance of mouth from St. Louis	290

No large cities on this tributary.

Des Moines River—

Area of water shed in square miles	14,635
Population of water shed	513,516
Distance of mouth from St. Louis	140

Distance of principal cities from St. Louis and their population:

Cities.	Distance from St. Louis.	Population.
Des Moines, Iowa	283 miles	62,139

12405 DRAINAGE BASIN OF THE DELAWARE RIVER—ABOVE TRENTON, NEW JERSEY.

Delaware River (including all tributaries except Schuylkill River)—

Area of water shed in square miles	9,217
Population of water shed	1,430,367

Distance of principal cities from Trenton and their population:

Cities.	Distance from Trenton.	Population.
(f) Easton, Pennsylvania	42.5 miles.	25,238
Phillipsburg, New Jersey	42 "	10,052

DRAINAGE BASIN OF THE SCHUYLKILL RIVER—ABOVE PHILADELPHIA, PENNSYLVANIA.

Schuylkill River (including all tributaries)—

Area of water shed in square miles	2,008
Population of water shed	382,192

Distance of principal cities from Philadelphia and their population:

Cities.	Distance from Philadelphia.	Population.
Norristown, Borough, Pennsylvania	6 miles	22,265
Reading, Pennsylvania	43 miles	78,961
12406 Pottsville, Pennsylvania	89 "	15,710

Q. In making this request of the Census Bureau what
12407 was the basis upon which the population of the water
sheds of the respective rivers was computed from?

A. The drainage area was first established as accurately as possible on maps in the Census Office. After the lines had been laid down showing the extent of the river basins the Census Records for 1900 were then appealed to to determine the population falling within it. Then the counties were divided pro rata upon the proportion that fell either within or without the drainage basin. Of course the population of urban centers was easily obtained. The distance of those centers above St. Louis on the river, was obtained with dividers in the usual way.

Q. Does the mixing of the Illinois with the Mississippi and Missouri Rivers as mentioned in the foregoing answer, create any added danger to the already contaminated and polluted waters of the Missouri and the Mississippi Rivers at the St. Louis intake, in your opinion?

A. In my opinion it does not for two reasons. 1. The an-
alytical investigations reported on by Professors Palmer
12408 and others in Streams Examination and the other in re-
lation to the total flow of the Illinois River, including Chicago sewage and water drawn from Lake Michigan, the first indicating that the condition of the Illinois River at Grafton was no worse during the four specified months of 1900 than the same four months for 1899, prior to the opening of the drainage canal; and the second indicating that the total volume of flow of the

Mississippi River opposite St. Louis by far the smallest percentage comes from the Illinois Drainage basin even while considering the flow of the sewage of Chicago and the water from Lake Michigan as a part of the discharge from that river. Under these conditions it would be difficult to conceive of a pollution of the Mississippi River at a point below the confluence of the three rivers of junction of the three rivers, excepting the pollution of the Illinois River was very great with reference to the pollution of the two other streams which contributed to the body of water moving past the city of St. Louis.

Q. From all of your knowledge of conditions that obtain in and along the Illinois River what is your opinion as a sanitary expert as to whether the deleterious substances, infected
12409 matter, or pathogenic germs would come from the drainage canal, and the sewers of Chicago and reach as far down the Illinois River as the city of Grafton.

A. The information which I have with reference to the Illinois River and the quantity and quality of the stream flow, its physical characteristics and the technical data obtained from an examination of the water samples does not warrant the belief that infected matter from Chicago would be found in the Illinois River as far South as Grafton.

Q. Assuming that typhoid fever germs should be found in the Mississippi River at the chain of rocks, do you know of any way of determining from what sources such germs originated?

A. Taking into consideration all the facts and considering the three drainage basins, namely the Illinois, the Mississippi and Missouri upon each of which are found many cities, some of considerable population, like Peoria and Chicago on the Illinois drainage basin, and Dubuque, Davenport, Burlington, Des Moines, Rock Island, Moline and Quincy on the Mississippi River basin—Kansas City, Topeka, St. Joe and Omaha on the Missouri basin, in all of which cities it is probable that typhoid fever prevails during the usual season of typhoid fever and in some of these cities prevails at all times, and especially keeping in
12410 mind the larger cities close to St. Louis, it would be wholly impossible in my opinion to say from what city the typhoid fever organism found in the Mississippi River op-

posite St. Louis would come. If it were true that any one of the cities on either of the water sheds not too far removed from St. Louis had typhoid fever while the other cities on the other watersheds did not have it, after allowing for the usual time between the infection of the stream and the discovery of the organism at St. Louis it might be charged to that city, whichever one it might be, but statistics show that in all the larger cities of the country typhoid fever always prevails, and where the drainage of three water sheds combined as in the Mississippi River in front of St. Louis I know of no process whereby the typhoid fever organism there found could be assigned to the probable locality from which it came.

Q. What is your opinion, as a sanitary expert, as to whether the germ of typhoid fever could lie in the sediment of the drainage canal or upon the bottom of the Illinois River for a period of from one to three years?

A. I have no data that would bear out such an assumption. And I do not know of any experiments ever made that 12411 would furnish reasonably exact information upon the matter similar to that embraced in the question.

Q. What is your opinion as to whether a typhoid bacillus deposited on the bottom of the Illinois River could remain there for a period of upwards of five years and then be stirred up by the action of the waves, wind, steamboats, or by any other means and continue its journey down to St. Louis and be a cause of danger to the inhabitants of the State of Missouri and the citizens of St. Louis using the water of the Mississippi River for drinking and domestic purposes?

A. In my opinion such conditions could not exist. I do not think that a typhoid organism would live for five years in the sediment of a river. A fact calculated to fortify this view can be offered in connection with the investigation of what is known as the Dayton Sand Bar in the Ohio River north of Cincinnati, which for many years was regarded by many intelligent people in Cincinnati as the proper source of water supply for the city. At the time the investigations were going forward looking to the development of plans for the improvement of the water supply of Cincinnati, wells were sunk for a depth of 70 feet, in

this sand bar, and samples of water drawn from the bot-
12412 tom of such wells. The organisms found in samples of such
water indicated that organic matter deposited ages before the investigation mentioned was still undergoing decomposition for all of the bacteria found upon the plates cultivated from the samples of water were of the putrefactive variety, but there was nothing to indicate the presence of pathogenic bacteria in the water found at the bottom of these test wells. The results of this examination will be found briefly reported in the report of the engineering commission for the extension and betterment of the water works of Cincinnati, previously mentioned in this testimony.

Q. Was the Missouri River, in your opinion, a safe water for drinking and domestic purposes prior to the opening of the drainage canal in 1900?

Mr. Jeffries: I object to the question as immaterial.

A. Basing my opinion upon my knowledge of the investigations conducted by the city of St. Louis in the filtration of the water supply of that city and reported from time to time in the reports of the water commissioner for the past ten years; upon the data collected by the Commission of Hydraulic Engineers
appointed to report a plan for a new water works or for
12413 the improvement of the present water supply of the city
of St. Louis in 1902, and from my knowledge gained by personal investigation of the waters from rivers not materially unlike that of the Mississippi River at St. Louis I do not believe that the water was fit for drinking and other domestic uses prior to the opening of the drainage canal nor for many years prior to that event.

Q. Was the Illinois River water a safe water for drinking and domestic purposes prior to the opening of the drainage canal in January, 1900?

A. I would give the same answer to that question also.

Q. Was the Mississippi River above Grafton a safe water for drinking and domestic purposes prior to the opening of the drainage canal?

A. I would give the same answer to this question, excepting, of course, with reference to the investigation of the water supply for the city of St. Louis.

Q. Do you regard any river that receives the sewage of 12414 rural and urban population as a safe drinking water without mechanical treatment of some kind?

A. I do not.

Q. Has the sanitary condition of the water of the Illinois River at Grafton been improved or damaged by the opening of the drainage canal?

A. Basing an opinion upon the technical data before me applicable to this question, upon the whole the condition of the water appears to be improved.

Q. Since the opening of the drainage canal are the waters of the Illinois River less sanitary than the waters of the Missouri and the Mississippi River?

A. No.

Q. What effect, in your opinion, does the water discharged through the drainage canal have upon the waters of the Mississippi and Missouri Rivers at the chain of rocks?

A. Assuming that the opinion which I have given as to the quality of the Illinois River at Grafton is no worse after the opening of the drainage canal than it was (as shown by the technical investigations) before the opening of the drain- 12415 age canal it would have no marked influence on the quality of the combined water of the Mississippi River passing the chain of rocks.

Q. Taking into consideration all knowledge that you possess in regard to the chemical, bacterial and physical conditions of the water of the Illinois River and its tributaries by the towns sewering into the Illinois River and its tributaries above, upon the water shed of the Illinois River, both rural and urban, the stages of the river under all conditions and during all seasons, together with the conditions that obtain or seem to occur upon the Missouri and Mississipi Rivers, what is your opinion as to the effect of flowing sewage from Chicago to the drainage canal into the Desplaines and Illinois River, upon the inhabitants of the State of Missouri using the water of the Mississippi River for drinking and domestic purposes?

A. Assuming that the bacteriological and chemical investigation applied to a water supply are acceptable as showing

whether it is or is not fit for domestic uses, and assuming
12416 further for the purpose of answering these questions that
no objection existed as to the quality of the water supply prior to the opening of the drainage canal, but that it was regarded as a suitable drinking water and for other domestic uses, I can see no reason to doubt its present suitability, notwithstanding the flow of sewage through the drainage canal plus the flow of water from Lake Michigan. In this answer I do not wish to be understood as indicating that the water from the Mississippi River at the chain of rocks has been for many years, if it was ever suitable for drinking and other potable uses, and I wish to be understood simply as stating that there is no evidence before me showing such change having occurred in the quality of the water as to render it less desirable for potable purposes or more deleterious to health than existed prior to the opening of the drainage canal.

Q. From a study of all the typhoid statistics as they obtain along the water shed of the Missouri River, the Mississippi River, the Illinois River, the city of Chicago and the city of St. Louis, and assuming that the increase of typhoid fever cases as
evidenced by the death rate in St. Louis, and disclosed by
12417 the Board of Health reports of the city of St. Louis,
under typhoid fever deaths there reported and taking into consideration all chemical, bacterial and other knowledge which you possess, what is your opinion as to whether such increase in typhoid fever, assuming there was an increase as above indicated in St. Louis, since the opening of the drainage canal, can be attributed to the opening of the drainage canal, as the direct, immediate and approximate cause of such increase beyond all reasonable doubt?

A. If the typhoid fever statistics of St. Louis show an increase in the rates per unit of population since the opening of the drainage canal and the investigation clearly indicates that there is no other possible source of infection and the rates in St. Louis rise correspondingly with the rates in Chicago and fall correspondingly with the rates in Chicago, it might be held that such increase in the unit rates for typhoid fever in St. Louis could be charged to the flow of sewage through the drainage canal, but in view of the possibility of infection from other

urban centers than Chicago, and especially in view of the possible infection of the St. Louis water supply from typhoid fever prevailing in Peoria, I should hesitate to charge to the flow
12418 of Chicago sewage through the drainage canal any increased typhoid rates shown in the city of St. Louis since the opening of the canal unless the evidence clearly disclosed the fact that as the rates raised in Chicago they raised in St. Louis and as they declined in Chicago they also declined in St. Louis. In other words, unless the rates in St. Louis showed that they corresponded with the rates of the city supposed to be the cause I am lead to this opinion by the much nearer source of infection in the city of Peoria, where typhoid fever prevails during the usual season of typhoid and doubtless is found prevailing to some extent throughout all the months of the year. Or, in other cities of large population upon the water shed of the Mississippi and Missouri Rivers. While one can not positively say that the sewerage of Chicago might not contribute to this or certainly does not contribute to this, it is equally out of the question to assert that a single city discharging its sewerage into one of the rivers constituting the drainage area of the river which went in front of the St. Louis intake is the sole cause or at all the cause of the increase of rates in the city of St. Louis. Too many factors enter into the proposition such as is contained in the question to justify one in asserting that typhoid fever is due
12419 to any one of several possible centers of infection lying on the drainage basin above the city of St. Louis.

Q. Assume that the city of St. Charles located within 47 miles of the intake tower of the St. Louis water works containing a population of 7,000 with more typhoid fever present than in the city of Peoria, which city of Peoria is located 286 miles above the city of St. Louis, what would be the comparative effect of these two cities upon the water supply under the conditions assumed?

A. The smaller city, namely, St. Charles, being nearer the point of intake above the city of St. Louis in my opinion would constitute a greater menace to the water supply of that city than would the larger city of Peoria, situated five times as far away in point of distance from the intake of St. Louis even though the normal rate of typhoid fever were the same in the two cities.

I have always believed and can point to no evidence that contradicts this belief, that the nearness of the point of infection rather than the size of the urban or rural center is the chief factor in determining infection. That the little city near by in which typhoid fever prevails is more to be feared than a large city far distant even though the same unit rate of typhoid is found in each.

12420 Q. I call your attention to two charts introduced in evidence and sworn to by Professor W. P. Mason under the caption "Deaths from typhoid fever, as reported in Chicago and St. Louis Official Health Reports, the deaths in St. Louis platted one month in advance, i. e., February deaths are platted as of January," and ask you to look at these charts assuming them to be based upon correct statistics and properly platted and ask you to state whether the typhoid deaths in St. Louis bear any relationship to the typhoid conditions that obtain in the city of Chicago?

Mr. Jeffries: I object to the question for the reason that in the compilation of the charts shown to this witness Professor Mason did not take into account variations in the temperature of the water, the velocity of the water, the volume of the water and other natural conditions which would exert a material influence upon the sanitary condition of the water in the Illinois River and for that reason the charts so referred to do not properly display the actual conditions existing at all times through the year and which must be taken into consideration in determining the effect of the sewage of Chicago upon the mortality of the city of St. Louis, and the effect of such variation in the sanitary
12421 condition of the water produced by the variations heretofore referred to, is as important to be considered as the determination that such increase in the typhoid death rate in the city of St. Louis has increased because of the opening of the drainage canal.

A. An examination of the diagrams for the year 1900 to 1903, inclusive, in which the solid lines show the charted deaths by months for the city of Chicago and dotted line the same data for city of St. Louis for each of the years embraced, and which in the legend at the top of each of the pair of diagrams a statement is made, and considering the statement in the legend at the head of the two pages before me, showing that the deaths in St. Louis are platted one month in advance, namely that February deaths are platted as of January, presumably for the purpose of comparison of the deaths in St. Louis directly with the deaths from typhoid fever in Chicago, it does not appear that the typhoid fever death rates from St. Louis are coincident in intensity with the typhoid fever death rates of Chicago. This is especially true for the years 1901 and 1902 and 1903. For which years the diagrams show that when the rate is rising in Chicago it is declining in St. Louis and when it is declining in Chicago it is sometimes rising in St. Louis, and that the wide 12422 ranges in the typhoid fever death rate as shown in the diagram for the city of Chicago are not reproduced in the diagram showing typhoid fever death rates for the city of St. Louis, and it would not be possible in my opinion to connect the rates in one city with the other. In fact there might be just as close an agreement between the typhoid fever rates of the city of Chicago and Philadelphia if plotted together in this manner as there is between the typhoid fever death rates of the cities of Chicago and St. Louis, and clearly the typhoid fever rates of Chicago can have in this manner no influence whatever upon the typhoid fever rates of Philadelphia. There is nothing on the face of the four diagrams to indicate a connection between the typhoid fever death rates of the two cities.

Q. Assume that in the city of St. Louis there existed in 1895 4,800 wells and assume that the city chemist after an examination of about 50 of these wells condemned them as being unsanitary and polluted and assume further that the board of health of the city of St. Louis ordered the city chemist to desist from the examination and condemning of wells and that such wells still exist in the city of St. Louis, what, in your opinion would be the effect upon the typhoid conditions in St. 12423 Louis as attributed to wells in that number in a city the size of St. Louis?

A. As a general proposition wells in built up communities like the city of St. Louis, unless they are deep artesian wells or wells driven to a great depth in rock are always open to suspicion as possible sources of illness and disease. This is due to the fact, as previously stated in this examination, that the soil will in due time become polluted from organic waste, from leaky sewers and connections to sewers, from leeching cess pools and privy vaults where these exist and it is possible that where a well is open to infection from the faeces of a typhoid fever patient it may become the center of infection and cause of wide spread disease. This fact is so well recognized in the large cities that there are few cases where wells are still used as sources or drinking water, provided the city is able to supply mains to carry the water to such localities, and the condemnation of open shallow wells or wells sunk in the drift by the local health boards is a matter of frequent occurrence in the larger cities where such wells are known to be still open to use.

12424 Personally I should regard every such well in the city of St. Louis the water of which is liable to be used for drinking as a menace to the public health excepting the well is so far removed from possible sources of pollution as to be reasonably safe from the contents of vaults and cess pools leeching through the surrounding soil.

ADJOURNED until 9:30 A. M. the next day, March 29, 1904.

Tuesday, March 29, 1904, 10:00 A. M., City Hall.

12425 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

J. W. HILL

resumed the stand for further direct examination by Mr. Todd, and testified as follows:

Q. If in your opinion the water supply at the chain of rocks which consists of the combined waters of the Illinois, Mississippi and Missouri Rivers is an unsafe and unfit water for drinking and domestic purposes in its raw state, or as treated at the present time by the settling basins of St. Louis, what is your opinion as to how said water should be treated in order to get a safe and wholesome water for drinking and domestic purposes?

Mr. Jeffries: I object to the question as immaterial.

A. By filtration.

Mr. Todd: Q. In passing upon the question of filtering the water at St. Louis, assuming that as an engineer having
12426 this problem under consideration, what consideration would you give to the sewage entering the drainage canal from Chicago in passing upon the question of filtration at St. Louis?

Mr. Jeffries: I object to the question as immaterial.

A. No special consideration would be given the sewage of Chicago running into the head waters of the Illinois River which forms one of the tributaries of the Mississippi River.

Mr. Todd: Q. Have you made any investigations touching upon the population living upon the three water sheds above St. Louis, of the Illinois, Mississippi and Missouri Rivers?

A. I have.

Q. What investigations have you made, Mr. Hill, and what was the purpose of this investigation?

A. The purpose of the investigation following the usual custom in determining the probable degree of pollution of water flowing in a stream that is drawn upon or is about to be utilized as a source of public water supply was to show first, the
12427 distribution of population on the three water sheds per square mile, next to locate the center of gravity, next to relate the urban population on each water shed to St. Louis as a point of water intake. The first step in the investigation was to divide the total population on the water shed by its area from which is derived the distribution of population per square mile of drainage basin.

Next the population of each urban center was divided by the distance of the center from the St. Louis intake. The quotients thus obtained were averaged and the total population divided by the sum of the quotients, fixing thus the center of gravity of the population on each water shed. The effect of this operation was to give a numerical value showing the relative probable degree of pollution of the water flowing past St. Louis from each of the respective drainage basins. The next step was to take the mean of all quotients obtained by dividing the population of the urban centers by the distance of each center from St. Louis, and this gave a factor that fixed the probable center of pollution on each drainage basin.

Further investigations were made along this line comparing St. Louis with Philadelphia and with Hamburg in Germany.

12428 Comparisons were subsequently made with reference to the city of Philadelphia by drawing its water partly from the Delaware and partly from the Schuylkill rivers to determine the relative degrees of pollution in those two streams.

A further step along this line was made in the following manner: The total drainage area of each of the three water sheds was stated and added together. The water shed then of each of the drainage basins was divided by the total water shed of the three drainage basins, to obtain a factor which would show what proportion of the water flowing in the Mississippi River below the confluence of the Illinois and Missouri Rivers with the Mississippi came from each of the respective drainage basins. Upon the assumption that there was a uniform amount of rainfall over the entire area stated in evidence yesterday, which is not strictly true. The amount of rainfall on the Missouri water shed as an entirety would be less than on the Mississippi River water shed above St. Louis and on the Illi-

12429 nois water shed and would modify the figures that were thus obtained.

Mr. Jeffries: That is it would be proportionately less?

A. It would be a good deal less and it would reduce this proportion, that is to say instead of seventy-five per cent. of the water flowing past St. Louis coming from the Missouri water shed it would be more nearly correct to state it as from 70 to 72 per cent., and this would correspondingly raise the discharge of the Illinois and the Mississippi Rivers.

Following the several methods above mentioned to arrive at the probable pollution on each of the several water sheds contributing water to the Mississippi River at St. Louis, the following results are obtained:

The distributed population per square mile of water shed of the Missouri River is 9.94.

The distributed population per square mile of the water shed of the Mississippi River above St. Louis is 43.21.

The distributed population per square mile of the water shed on the Illinois River is 107.00.

The urban population collected in the cities on the Mis-
12430 souri water shed is 2.00 per square mile.

The urban population collected in the cities on the Mississippi water shed is 9.00 per square mile.

And the urban population collected in the cities on the Illinois water shed is 72. per square mile.

Referring especially to that part of this answer in which the statement is made that the respective population of the urban centers on each of the urban centers of 4,000 or more people are divided by the distance of such centers from the intake of the St. Louis water works and in which the total population has been divided by the mean of the quotients thus obtained, a factor is obtained for each stream, as follows:

For the Illinois water shed	209.2
For the Mississippi water shed	122.47
For the Missouri water shed	106.56

The relation of these numbers to each other indicates inversely the relative value of each stream as a source of water supply with respect to sewage pollution from all sources.

That is to say the Missouri water shed would have the
12431 highest value; the Mississippi water shed next and the
Illinois water shed the lowest value as a source of water supply for the city of St. Louis.

Mr. Todd: Q. In figuring out the value you take into consideration in answering the question, and in the answer just given, the volume of the three rivers and the relations in which they each stand to the other as they pass St. Louis?

A. In the calculations just mentioned no consideration is given to the flow of water in the stream whatever. This statement is entirely independent of the flow in each river. That is with reference to the figures which were obtained to show the relative value of the different water sheds as sources of supply. because it deals alone with the population gathered in urban centers and the distance of said centers from St. Louis.

Q. What effect would the volume of flow have upon the question involved in the last answer given by you?

A. It would have this effect, if the flow of each of the several streams was as an average the same, it would not change the relation established showing the relative value of the 12432 water sheds as sources of public water supply.

If, however, the flow was greatest from the Missouri River drainage area which normally would be the most available source of supply and least upon that water shed which by the previous showing is the least desirable, namely the Illinois River, it would mitigate the objections to the greater degree of normal pollution by reason of larger population and shorter distances from St. Louis on the Illinois River drainage basin. For example, if the flow of the Illinois River was one per cent. of the total flow of the Mississippi River in front of St. Louis, then notwithstanding the fact that this is the most objectionable drainage basin to draw from its influence when compared with the other 99 per cent. of water derived from the Missouri River and the Mississippi River it would probably not be appreciable.

Q. Applying the information just introduced from the evidence by you from the three water sheds to the question of filtration of the water supply at St. Louis, what bearing would that information have upon that subject?

Mr. Jeffries: I object to the question as immaterial.

12433 A. It would have none at all because any investigations preceding the development of a scheme of filtration of water for the city of St. Louis or of any other city would be mainly devoted to the collection of data with reference to the water flowing past the proposed point of intake and no serious considerations would be given to the sources from which the pollution found in such water came.

Mr. Todd: Q. From your investigation of the water supply at St. Louis which takes its water from the co-mingling of the Illinois, Mississippi and Missouri rivers at the intake tower at the chain of rocks what conclusion do you draw as to how that water supply compares with the other water supplies of the cities of this country and in Europe with which you are acquainted?

Mr. Jeffries: I object to the question as immaterial.

A. I have made a comparison of the conditions of the three cities, namely, St. Louis, and Philadelphia with reference to the Schuylkill River alone, and Hamburg, Germany, drawing its water supply from the Elbe River?

A. Assuming that the city of St. Louis drew its water sup-

ply wholly from the Illinois River drainage basin. I have considered the total drainage area of each of the three
12434 drainage basins. That is I have considered the urban and total population on each of the drainage basins and I have finally developed the factor in the manner explained in the answer to the previous question, which in my opinion shows the relative advantage or disadvantage of the source of water supply of the three rivers mentioned with respect to the three cities drawing their water supply wholly or partly from the sources under consideration. The size of the numbers thus obtained indicates the objection to each source of water supply as follows: For the city of St. Louis on the assumption that the water supply is drawn only from the Illinois River basin there is 209.20; of the city of Philadelphia upon the assumption that the source of water supply is drawn from the Schuylkill River 330.63; and for Hamburg which draws its entire water supply from the Elbe River 698.12. The lower figure by this method of comparison would indicate the best source of water supply, and if my method of reasoning is correct it would show that under the present conditions the Illinois River would be a safer source of water supply for the city of St. Louis than is the Schuylkill River for Philadelphia or the Elbe River for Hamburg. The water
12435 of the Elbe River at Hamburg is now and has been for 11 years past all filtered. Preparations are going forward to filter the water supply at Philadelphia from the Schuylkill as well as from the Deleware River.

And by the same process of reasoning it seems to me that the water supply of St. Louis should be filtered in order to remove any natural objections that exist to the sources from which its water is taken.

Q. Would it cost any more to filter the water of the Mississippi River at the chain of rocks with the water of Chicago entering the drainage canal as it now does than it would if the said sewage of Chicago was eliminated?

A. It would make no difference whatever, either in the cost of construction or the cost of operation of a system of filters for the city of St. Louis. From a reasonable experience in constructing and operating works of filtration on a large scale it is clearly shown that the sewage pollution of a river is not the feature that

increases the cost of filtering a polluted water. That material which rapidly clogs the filters requires their cleansing from time to time is mud and silt flowing in the river and repre-
12436 sented in the analysis as suspended matter, of which the bacteria from sewage sources constitute by weight or volume an infinitesimal part. It is not known that what we term mud, excluding bacteria, is in itself a particularly objectionable element in water, at least it is not known that it is the cause of disease or disorders in the human system and is chiefly if not wholly objectionable from an aesthetic point of view.

I feel that the experience at Philadelphia with the filters that have been operating at the Roxborough stations, some of them for 21 months and others for a period of nine months, in daily service, dealing with upwards of 23,000,000 gallons of water per day, showing clearly that the varying degrees of pollution in the Schuylkill River as determined by the bacteriological and chemical analyses have no influence whatever either upon the efficiency of the filters, of their cost of operation, but when the Schuylkill River is in flood and large quantities of clay and soil are being brought down from its drainage basin to Philadelphia, this material does have an influence in effecting the cost of operating the filters, and to a limited extent has some influence on the efficiency, at least with reference to the
12437 turbidity of the water filtered.

Q. Applying the experience which you have had with the Schuylkill to the waters of the Mississippi River as the same pass the intake and the knowledge which you have of the three rivers, the Illinois, the Mississippi and the Missouri, which one of the three rivers thus mentioned would create the largest percentage of cost in operating a filtration plant at St. Louis?

Mr. Jeffries: I object to the question as immaterial.

A. The Missouri river, by reason of the very large amount of suspended matter brought from its water shed and contributed to the suspended matter of the mixed waters of the two other rivers opposite St. Louis; and the difficulty of filtration of the St. Louis water will be found to be wholly due to the silt and other suspended matter in the Mississippi water at St. Louis, obtained very largely from the Missouri River drainage basin. The sewage condition at St. Louis, I should regard as involv-

ing no special difficulty whatever and I base this opinion upon careful study of the report of the last commission of en-
12438 gineers appointed to investigate the water supply of that city.

Q. That was the Merrimack commission?

A. Yes sir.

Q. Who made that report?

A. That report was made by a commission consisting of Benezette Williams of Chicago, Mr. George Y. Wisner of Detroit, and Allen Hazen of New York.

Q. That is the report where Mr. Hazen filed a minority report, defending the filtration of the Mississippi River?

A. Yes sir, that is right. The majority of the commission recommended the Merrimack scheme.

Q. Would the Mississippi and Illinois, exclusive of the Missouri River cost as much to filter as the Missouri?

A. No, they would not for the reason, that the percentage of suspended matter is lower in each of the two rivers, namely the Illinois and Mississippi river than it is in the Missouri River.

Q. Question repeated.

A. No. It would not cost as much because of the lower
12439 percentages of suspended matter in the two rivers mentioned.

Q. Would the amount of infection in the river, meaning by that sewage infection, create an added cost to the operation of the filters?

A. No, it would not. If the water through a system of filters was free from sand and silt and soil that can be charged to the wash of the banks of the river or of the water shed of the river what we would term city sewage could be filtered provided it was mixed with the same volume of water as that flowing in the stream into which it is discharged. In cleaning filter beds such as are in use in the city of Philadelphia and elsewhere it is found that practically all the material moved from time to time would be classed as mud, and if it were possible to so separate this mud at the surface of a sand bed into organic and inorganic material, and include the bacteria as a part of the

organic material, the organic matter would bear such a small relation to the total amount of material collected that the cost of filtration prorated on this would be an insignificant
12440 amount, and after all the real cost of operating filters is represented by the efforts to remove from a polluted water the suspended matter exclusive of the bacteria, and that matter which usually imparts turbidity to the water.

Q. If a water should be highly infected with typhoid germs would the fact that the water was highly infected create any added cost in the construction or operation of a filter?

A. None whatever.

Q. Assume that a filter plant should be established at the city of St. Louis sufficient in size and suitable for the demands required, would the fact that the Mississippi River at the chain of rocks vary from time to time from slight infection to large infection, create any added cost in the operation of such filter?

A. None whatever.

Q. Would it require any more skilled and expensive operators to handle a filter that would meet the demands of the city of St. Louis under low infection than it would under a high infection existing in the waters of the Mississippi River under present conditions?

A. The dgree of sewage pollution or of infection of water
12441 coming to the filters would not be a factor either in determining their cost of construction or cost of operation. Evidence along this line is best shown, in my opinion, by the regular tests which I am having made of the raw waters applied at our Roxborough filter station, and of the filtered water afterwards to determine the presence of the colon bacillus, deeming this a more delicate test of the operation of sand filters than the comparison of numbers of bacteria in the water before and after filtration. These tests which are regularly made two or three times each week reveal the fact that upon exceedingly rare occasions is the colon bacillus found in the filtrate of any filter while we seldom fail to find it in the applied water. Reducing the operation of the filters with respect to the colon bacillus to percentages, it shows that under the worst conditions of the operation of our filters we have removed from 96 to 99 per cent.

of the colon bacillus and in making this determination I am excluding from consideration altogether a great majority of the times when it is not found at all in the filtrates.

Q. In passing judgment upon the value of a water supply as based upon the population does that judgment take into consideration the condition of the river as determined by
1242 the chemical and bacterial condition of the water and the volume of flow?

A. No, it does not and is based solely upon the factors noted, namely the area of water shed population on the water shed considered as an entirety, population gathered in the urban cities of 4,000 or more people and finally the distances of each of these centers from the water the intake.

Q. How does that method which you have just indicated compare with the chemical and bacterial examination covering a long period of time of the waters of the river and the volume and size of the river?

A. Excluding the soil, grains of sand and silt which are found in varying quantities in different rivers, and excluding the difference in the volume of flow of such rivers, it must be held and is held at times that the chemical condition or bacterial condition of the several rivers so compared would be sub-
1243 tanially the same. That is to say that the sewage pollution of the stream would depend upon the number of people contributing to it, other things equal. 2,000 people would be a greater objection upon a given water shed than 1,000 people and the probable sewage going into the stream would be twice as great from 2,000 people as from 1,000 people. By this process of reasoning it would be fair to assume the sewage pollution of any stream bears a just relation to the population gathered upon its water shed when modified by the distance of center of population from a proposed point of water intake.

Q. Question repeated.

A. The chemical and bacteriological investigations show in reference to the city of St. Louis that the Illinois River is the better source of supply, while the physical investigation that has been described show that it is the least desirable source of supply. If we had no chemical and bacteriological data and

were approaching the problem as a new proposition we
12444 would fix the center of population of the Illinois River water shed nearer the St. Louis intake than that of the Mississippi and Missouri water sheds. This mode of comparison of water sheds wholly ignores the volume of flow in each stream.

Q. Where the information is obtainable showing the chemical and bacterial conditions of the river, and its volume of flow and the information is also obtainable showing the population upon the water shed in the methods here described of a given river, which method furnishes the most accurate way of arriving at a correct judgment of the quality of such a river?

A. The technical analyses of the water itself at any definite point?

Q. In considering the question of filtration as applied to St. Louis, would the percentage of water passing over
12445 the Bear Trap Dam at Lockport, which represents the mixed sewage of Chicago and the water of Lake Michigan, as the same arrives at the chain of rocks at St. Louis comingling with the waters of the Illinois, the Mississippi and the Missouri Rivers be a factor of expense either in maintenance or operation or installation of a filter established for the filtration of a municipal water supply of the city of St. Louis?

Mr. Jeffries: I object to the question on the ground that it is immaterial.

A. It would not.

12446 CROSS-EXAMINATION, by Mr. Jeffries.

Q. What are the elements of cost so far as the condition of the water is concerned in the construction and operation of a filtration plant?

A. The element of cost in the construction will be the area of filters required to deal properly with the given water. The element of cost in operation would be represented by the period of operation of the filters between successive cleanings and the amount of material to be scraped and cleaned from the filters at the end of each such period, that is to say, with a water carrying large amounts of suspended matter, the rate of filtration per unit of surface would be less than with a water carrying smaller amounts of suspended matter.

Q. Why is it necessary to clean the filters?

A. Because of their becoming clogged at the end of what is termed the period of operation.

Q. What would be the result if they were not preperly cleaned?

A. The filter would fail to deliver the required amount of water by reason of the clogging of the sand bed at the surface.

Q. Would this clogging in any way produce a perversion of the sand bed?

12447 A. No, it would not; it would simply create a mass of matter in the interstices of the sand bed at and near the surface such as to prevent the usual rate of flow per unit of sand area.

Q. Is this unit of sand area graduated by the amount of infection that is supposed to exist in the water?

A. No, it is not. It would be graduated entirely by the total amount of suspended matter found in the water as an average through the year of operation.

Q. The more suspended matter—

A. The larger the area to filter a given amount of water, because of the smaller rate of percolation per square foot of sand.

Q. As to the depth of the sand bed what bearing has the infection upon the necessary depth?

A. None whatever. In fixing the thickness of sand beds I do not know that the possibility of infectious matter in the water has been a factor, if taken into consideration at all. As a matter of fact the sand beds are of varying thickness in filters built by different cities. They are likewise of a varying size of sand grains within reasonable limits. The custom is when a new filter has been constructed to furnish it with the maximum thickness; a sand bed which for this purpose may be put at
12448 40 inches in depth. Such sand bed is scraped from time to time as the filter is taken out of service until the least thickness is seldom less than twenty inches, such a filter is once more scraped and the entire bed of sand is restored to the original thickness of say forty inches.

It is believed, and I think proven by my personal experience, that filtration is as well accomplished with a twenty inch sand bed as with a forty inch sand bed, but it is doubtful to my mind as to whether thicknesses of less than twenty inches could be used in order to insure at all times a satisfactory quality of filtered effluents.

Q. Is it not a fact that water sometimes becomes very greatly infected and requires double filtration?

A. There are examples, notably at Bremen in Germany, where the water is run first through one filter and then through another filter of the same size, in which the rate of percolation is maintained the same as in the former filter. This is with a view to improving the quality of the filtrate. The same method or custom prevails in the waterworks at Schiedan, Holland. In our waterworcks at the Lower Roxborough station all the water is twice filtered, once at the high rate through roughing 12449 filters and a second time at a low rate through the plain sand filters. In the Philadelphia experience, however, this is done in order to admit of a reasonable and a normal rate of percolation in the second set of filters and not primarily with a view to guarding against unsatisfactory filtration of the water in the second set of filters. It may be said with reference to the Philadelphia experiments that the water from the primary or preliminary filters is not regarded as satisfactory for use at any time.

Q. In the construction of a filter plant do you take into consideration the character of the watershed, the volume of water in the stream, together with the chemical and bacterial determinations of that water?

A. In fixing the preparations and method of operation in filters, no consideration is given to the area of the watershed or to the population gathered upon it. And this condition would form a factor only for the purpose of comparing conditions as between two proposed sources of supply. The final factors that would enter into consideration of the size and method of operation of filters would be determined by the chemical and bacteriological analyses of samples of water taken from the 12450 selected stream or other source of supply at the proposed point or existing point of intake.

Q. In the operation of filtration plants is it customary to entirely eliminate all bacteria from the water?

A. Eliminate all from the filters?

Q. Yes.

A. Upon rare ocassions it has been shown that the entire number of bacteria have been eliminated from the filter effluents. That experience has been had with our own filters here in Philadelphia and has also been had with the filters in London. As a general proposition, however, there is remaining in the water after filtration very rarely more than one or one and a half per cent. of the original number of bacteria found in the applied water.

Q. And that percentage varies according to the efficiency of the plant and its operation?

A. It does.

Q. The more infected a water becomes the more important it is for a thorough and efficent construction and operation of a filtration plant, is it not?

A. The degree of infection in the water would not affect
12451 the cost of construction but it would affect the grade of
sand used in charging the filters with filtering material. If the source of supply is known or believed to be materially infected it should call for greater care and vigilance in the operation of the filters. That is to say if filtration has for its object the removal or material reduction of sewage pollution in the applied water it would require denser beds of sand and more care in the operation than if the sole purpose was to remove suspended matter not of a deleterious character, or for the purpose of removing simply mud from the water, but this does not necessarily involve either increased cost of construction or increased cost in operation.

Q. It may do so, however?

A. It is not likely, Mr. Jeffries. The result would be to reduce the size of sand in the bed, that is to say it would be a denser bed, not quite so coarse, and it would demand closer attention on the part of the filter manager who should keep in close touch with the daily operation of the filters.

Q. And as you reduce the size of the grains of sand, or as you

employ denser beds of sand, the slower the process of
12452 filtration becomes does it not?

A. That would be true provided there is no preliminary filtration of the water such as we have made a part of the system of filtration for Philadelphia.

Q. Is it not true that water would percolate through rough grains of sand more rapidly than through dense grains of sand?

A. It will.

Q. A given quantity of water will pass through a bed of sand consisting of coarse grains more rapidly than through a bed of sand composed of fine grains?

A. It will. The rate of percolation will be most rapid in the more porous bed of sand.

Q. And as the degree of diminution in the character or size of the sand grains, the slower the process of filtration upon a given area?

A. That is true.

Q. The population of the area drained by the Illinois River including the city of Chicago is greater per square mile than that of either the Missouri or Mississippi, is it not?

12453 A. It is.

Q. Now then taking into consideration the center of population, I understand you to say that the waters of the three rivers, and that was the Illinois, the Missouri and the Mississippi, are represented by the figures 209.2 for the Illinois; 122.47 for the Mississippi, and 106.56 for the Missouri. That, I understand, is the relative value that the waters bear towards each other at a given point in the stream at St. Louis?

A. Yes sir.

Q. That takes into consideration the entire population, both rural and urban.

A. The total population on each drainage area of each river basin.

Q. And is based upon a population and drainage area of the respective rivers?

A. It is.

Q. I understood you to say yesterday that typhoid fever germs would live longer in less polluted water than in more highly polluted water. Is that correct?

A. That is correct.

Q. From the stand point of population and area of 12454 water shed, state whether or not the waters of the Schuylkill at Philadelphia are more greatly polluted than the waters of the Illinois, the Mississippi and the Missouri at St. Louis?

A. The pollution of the Schuylkill River at Philadelphia, based upon the area of the drainage basin and population is much more polluted than the combined waters of the Illinois, the Missouri and the Mississippi Rivers at St. Louis. Indeed the figures show that the probable pollution of the Schuylkill River by this method of investigation is about fifty per cent. greater than the pollution of the Illinois River at its mouth, and in the absence of other data the Illinois River would be regarded as a better source of public water supply than the Schuylkill River and the combined flow of the Illinois and Mississippi and Missouri would largely improve this condition with reference to the city of St. Louis, so far only as the probable sewage pollution is concerned. I would like to add to that, this investigation excludes all chemical data and all consideration of the amount of suspended matter flowing in the streams.

12455 Q. In the chart which you introduced yesterday, which is a table showing the results of experiments to determine the longevity of the bacillus typhosus in the waters of the Schuylkill and the Deleware Rivers, please state again where the samples from which these tests were made were taken?

A. The samples from the Delaware River, which was the stream really under consideration, were taken opposite Harrison Mansion at the site of the Torresdale Filter Station, at a point about ten miles north of Market Street Wharf, and from the same point that the water was taken for a period of nearly two years during the test of experimental filters with the Delaware water. The sample from the Schuylkill River was taken from the forebay of the Spring Garden Pumping Station.

Q. The tests made on October 16th or rather test number 5—how many observations were made?

A. An observation was made each day and usually three plates were made up from each sample each day. The observations were continued until no growth of the typhoid organisms

was found on the agar plates and referring to the test of
12456 October 16th, the last attempt to demonstrate the presence
of the typhoid organism in the sterilized water was
made on the fourteenth day after the observation with negative
results.

Q. Was there any tests made on the thirteenth day?

A. No, there were none. They were only made on the days shown on the table, the first, second, third, fifth, eighth, twelfth and fourteenth.

Q. None were made on the ninth and tenth?

A. No sir.

Q. Not having been made on the ninth and tenth you can not say then whether they would appear?

A. Only by inference comparing the result of the last two days of observation where some of the plates showed no marks at all, no growth at all and the others a very small number compared with the numbers found on the previous day of the tests.

Q. If the water frrom the Schuylkill and Delaware rivers
from where these samples from which those tests were made
were taken should run down the stream with no added polluting
or infecting material and should contain typhoid fever germs
state whether or not it is your opinion that all of the typhoid
fever germs would die out within eight days from the
12457 time they were deposited in that water?

A. If the water was of normal sewage pollution I believe they would.

Q. Then would you recommend the water of the Delaware and Schuylkill after it had passed down the stream for eight days from the time the typhoid infecting material was discharged into it and it received no additional infecting material as being free from typhoid fever germs?

A. I believe that it would be.

Q. Would you recommend it for domestic purposes as being free from typhoid fever germs?

A. No, I would not because there are other things than typhoid fever organisms, other pathogenic bacteria.

Q. Would you recommend it as being free from typhoid although it was found to exist at the end of eight days and no determinations were made on the ninth and tenth day while it was not found on the twelfth day?

A. Yes, I should by reason of the fact that on the eighth day referring to the test of October 16th, compared with the fifth day the numbers were so largely reduced as to suggest
12458 their total disappearance within a short time after that observation, certainly within less than a day.

Q. Why, then, was it necessary, to make platings on the twelfth and fourteenth days?

A. To set aside any doubt of the total elmination of the organism at or near the eighth day of the test.

Q. Would it not have been better and more satisfactory to have made out determinations on the ninth and tenth days?

A. I am not sure that it would. Two of the tests show no growth whatever on the eighth day. Three others show only one organism found on the plates after the eighth day. It would be a fair inference that there would be no growth thereafter, but as a precaution the test was made on the twelfth and fourteenth days and then discontinued. It will be observed that in the preparation this test was to be continued for three weeks if there was any indication of a growth for so long a time, so that the column under the twenty-second day has no figures in it whatever, upon the theory that if the organism was not found on the twelfth and fourteenth days it certainly would not be found on the twenty-second.

12459 Q. Assuming that typhoid fever germs lived in the water of the Schuylkill and Delaware eight days what effect would the addition of a double quantity of water in that river have upon the longevity of the typhoid?

A. It might have the effect of slightly prolonging the life of the organism. These tests that we are now discussing of course were made on sterilized water, and there was no other live organism in the water excepting the typhoid organism or the bacillus coli communis. I do not believe that it would live as long in unsterilized water as it will in sterilized water, for the reason that the entire food material in the latter water will be appropriated to maintenance of life of that one organism.

Q. Each organism, whether it be the typhoid bacillus or the bacillus of some other character, is independent in and of itself is it not?

A. Each has its independent life history so far as we know.

Q. What effect has the diminution of organic matter in compositions containing typhoid fever germs upon these germs, such as the addition of greater quantities of water, or by
12460 the clearing up and purification of the substance in which these germs are contained?

A. By the addition of other water assumed to be pure there would be a reduction in the percentage of organic matter, and a reduction in the total numbers of bacteria per cubic centimeter of water, but there would be no reduction in the total amount of organic matter and it would be a little difficult to predict just what would happen unless the dilution was very great. If to one quart of polluted water was added one quart of unpolluted water the amount of organic matter would be just the same and the number of bacteria the same, and they might go on and perform their operations quite the same by reason of the fact that some of the organisms of fermentation and decomposition flourish best in a strong atmosphere of oxygen. Some will not develop at all in the absence of oxygen and others will develop either with it or without it, and then there are still others that can only develop as anaerobes in an atmosphere that is devoid of oxygen, so that it would not be safe to state positively that the reduction of the organic matter and the destruction of the bacteria themselves might not be quite as great with the double volume as with a single volume, and that probably would be due to the addition of dissolved oxygen to the water by the
12461 purer water.

Q. Sewage concentrated to that extent which produces septic operations is more destructive of pathogenic bacteria than it is in any other condition is it not?

A. I think it is for the reason that the acidity of fermenting sewage is calculated to quickly destroy the more delicate organisms like the typhoid bacillus and some other pathogenic bacteria.

Q. Then as the degree of concentration becomes greater the shorter the life of the pathogenic bacteria and as the degree of concentration becomes less, the degree of sewage concentration becomes less, the longer the life of the pathogenic bacteria?

A. I think that is the true condition, that the pathogenic organisms, those that are not spore bearing, like anthrax for example, would have the shortest life in a very highly concentrated sewage.

Q. The temperature of the water has something to do does it not upon the longevity of pathogenic bacteria, in fact of all bacteria?

12462 A. It does; it has a marked influence. Those bacteria that are indigenous to water or find their normal habitat in water perish when the temperature of the water is raised even to body heat for a reasonable length of time. Upon the other hand it is doubtful if some of the pathogenic bacteria propogate freely when the water is at normal or low temperature.

Q. Mr. Hill, is it not a fact that diminution in the chemical constituents of water have a tendency to bring about conditions of that water such as will prolong the life of the pathogenic bacteria by reason of the fact that such bacteria live longer in unpolluted water than in polluted water?

A. Some of the dissolved solids in water undoubtedly contribute to the life of some of the bacteria and may have an inhibiting effect on the growth of other bacteria.

Q. As a general proposition if sufficient food and material are supplied of the proper kind what would be termed pure water should guarantee the greatest longevity to some of the bacteria?

A. It would not be true of all. In all cases, of course, it is assumed that there is food material in the water. It may be taken as a settled proposition where there is no food material that bacteria will not live.

Q. What significance does a sanitarian give to the total 12463 oxygen consumed in the chemical determination of a water?

A. That is generally looked upon as showing the relative amount of organic matter in the water. Independently considered it is not worth much, but we regard it as of value in determinations of the operation of filters, for example as showing what percentage change has taken place in the total oxygen before and after filtration.

Q. Can that be influenced by reason of an added volume of water?

A. That would have an effect upon it, and I mentioned in my testimony in chief yesterday that some consideration must be given to the fact that the average stream flow for the Illinois River was somewhat greater for the year 1900 than for the year 1899.

Q. Assume then that typhoid fever germs are deposited into a river, have these chemical constituents or determinations such as total oxygen consumed, etc., show a decrease. It is reasonable to believe is it not that the longevity of the typhoid germs contained in that water will be extended?

12464 A. The change in the chemical constituents as between two periods or tests or as between two points of observation is usually not great enough to suggest any material increase in the longevity of the typhoid organism. If the change was very great suggesting an almost complete removal of organic matter, and probable extinction of the stronger species of bacteria by reason of lack of food material to support life, and the typhoid organism was then supposed to be in such water, undoubtedly there would be some prolongation of its life by reason of the fact that the water had reached a considerable degree of purity. In that way, Mr. Jeffries, it is not possible by taking ordinary changes as between two stations in a stream or as between tests made at different dates where the changes are not great, to suggest any material modification in the opinion of its longevity.

Q. If there is any effect at all it is to increase?

A. Or you can assume a condition where you might purify by some process the water, still leaving some organic matter in it, and then import into it the typhoid germ, which would then be an element of danger. For example, we should greatly fear the inoculation of clear water basins with the typhoid or-
12465 ganism because there is still enough organic matter left in the filtered water to support some bacterial life and it would be a very serious condition if such a thing should happen.

Q. Referring now to the table introduced in evidence by

you yesterday made up from the reports of Professors Jordan, Zeit, Palmer and Burrill, as shown by Streams Examination which has been referred to in the evidence here, I will ask you if that is a table of bacterial determinations for the years 1899 and 1900 with the percentage of decrease and increase in the bacterial count? And if it does not show that the number of bacteria in 1900 from the Desplaines River at Joliet and the Illinois River at Ottawa and La Salle and Averyville, Wesley City and Pekin, immediately below the city of Peoria, this last city being immediately below the city of Peoria, if it does not show that such decrease is due to the fact of greater dilution in that stream and that the increase for the year 1900 over 1899 in the Illinois River at Havana, at Beardstown, at Kampsville and at Grafton is due to the fact that the bacteria contained in tht water is longer preserved by reason of the diluting effect caused by the discharge of Lake Michigan water to the drainage
12466 canal?

A. The fact of there being a smaller bacterial content in the water of the Illinois River at Ottawa and La Salle and at Wesley City, can probably be ascribed to the increased dilution of the water flowing in the channel of the river and partly perhaps to a greater rate of oxidation by reason of the added dissolved oxygen obtained from diluting the sewage with Lake Michigan water. I can not see clearly why this should cause an increase in the numbers at points below Pekin. In studying the table giving the bacterial content of the various waters discharged into the Illinois River and of the water of the Illinois River I thought that the increased bacterial content below Peoria was probably due to the sewage discharged at and below that point, and that it could not be connected with the increased flow of water in the Illinois River by reason of the draft on Lake Michigan through the drainage canal, because of the total numbers given in the table by far the larger percentage are the stronger and more hardy organisms of putrefaction and fermentation, organisms that would flourish only in polluted water, and some special cause of pollution must have occurred in the neighborhood of Pekin or Havana to bring about the considerable increase in numbers below that point, and this cause
12467 cannot be ascribed to the increased flow of water from Lake Michigan through the drainage canal.

Q. It cannot be ascribed to the Sangamon River as a tributary of the Illinois for the reason that the table shows that there is a decrease in bacterial count upon that river in 1900 over 1899?

A. No, I would not ascribe it to the flow of the Sangamon River.

Q. It can not be ascribed to the fact that the added volume of water producing the diluting effect has prolonged the life of the bacteria in the water?

A. I do not think this could be conceded as the cause, otherwise its effect should have been shown nearer the point of discharge of the drainage canal than Joliet. If it had been proved for the whole length of the Illinois River after receiving the discharge of Lake Michigan water to the drainage canal that there was an increased growth of bacteria, this might be assigned as the cause, but considering the fact that there seems to have been a considerable diminution in the bacteria between Joliet, Peoria and Pekin, it would be hard to ascribe the
12468 growth below Pekin to the same cause, that probably produced the diminished growth above Pekin. In other words the effect of the increased volume of water, if it had a tendency to increase the growth should have been manifested before the city of Pekin was reached in the flow of the river.

Q. I will ask you, Mr. Hill, if this table does not show that there was a greater percentage of reduction in the Illinois River from Morris to Ottawa in 1899, than there was in that river between those points for the year 1900?

A. That is true that the percentage of reduction was greatest in former years.

Q. Is it not a fact that between La Salle and Henry the increase was greater during 1900 than 1899?

A. It is slightly so.

Q. Below the city of Peoria is it not a fact that the percentage of reduction was much greater during 1899 than it was during 1900?

A. As a matter of fact, comparing the bacterial contents of the river at the various points from Havana down, the numbers were greater for the year 1900 than 1899 showing an
12469 increase in the content.

Q. Did you make any tables showing the comparative results of ammonias as shown by the Streams Examination?

A. No, I did not.

Q. Do you consider that important?

A. No, I do not because the essential conditions with reference to the nitrogen is probably shown by the nitrites and nitrates. A great number of tests can be made perhaps with greater precision on the nitrites and nitrates and are less liable to be in error, than the tests for ammonias, but aside from that the final tests of change of nitrogenous matter is shown in the numbers mentioned.

Q. Is it not a fact that the nitrate and nitrite test as shown in your table introduced yesterday shows that there has been a greater deposition of nitrogenous matter in the Illinois River than in either the Mississippi or Missouri Rivers?

A. That is true for both years under consideration, that the nitrogenous matter in the water is higher in the Illinois River than in the other rivers represented in the tables, and further that the degree of nitrification is correspondingly greater in the Illinois River than in the others.

12470 Q. What is the most fruitful source of nitrogenous matter in a running stream?

A. Sewage wastes contribute very largely to the nitrogen in the water. It can also come from decaying vegetable matter in the run off from the water shed, and probably the bulk of it may be charged to other sources than sewage.

Q. That, however, is a prolific source of such matter where a river runs through a highly or thickly populated community?

A. It is a constant source. Where the cause is vegetable detritus it does not come in to the water with the same daily regularity.

Q. Assume that typhoid dejecta of a certain city deposited into a river from which a city below obtains its water supply which produces typhoid fever in the second city mentioned or the city below, is it not a fact that the frequency of the occurrence of typhoid fever in the city below caused from the typhoid dejecta from patients in the city above is governed considerably by the temperature of the water, the stage of the water in the river, the velocity of the water and other natural conditions which affect the sanitary condition of that water?

A. It is.

12471 Q. Assume that typhoid fever germs discharged in the drainage canal at Chicago from typhoid patients in the city of Chicago reached the city of St. Louis and produced typhoid fever in that city by reason of the fact that the inhabitants of that city used the water of the Mississippi River for drinking and domestic purposes. Is it not a fact that local conditions upon the Illinois River such as the temperature of the water, variation in stream flow, etc., affect in a large measure the variations in the occurrence of typhoid fever from that source in the city of St. Louis, taking into consideration this one important fact that the variations in the stream flow in the Illinois River range from eight to twenty days?

Mr. Todd: I object to the hypothetical question on the ground that there is no evidence in this record of eight days between Chicago and St. Louis.

A. Assuming that typhoid fever organisms entering the drainage canal at Chicago may be the cause or are the cause of typhoid fever in St. Louis, then undoubtedly the temperature of the water flowing in the Illinois River, the variations in the rate of stream flow and other physical conditions in and along the river would have an influence on the resulting rates of typhoid in St. Louis. High temperature of water in the Illinois

12472 River should favor the longevity of the typhoid and other pathogenic bacteria; low temperature in the water of the river should have the opposite effect. A high current would naturally shorten the time for deposition of suspended matter in the water in travelling from Chicago to St. Louis, and a low current would have the opposite effect. The contribution of waste matter to the river along its length between the lower end of the drainage canal and the mouth of the Illinois river might contribute to the longevity of pathogenic bacteria, including typhoid, and it might have an inhibiting effect on this growth, for example the acid waste from certain factories along the stream might kill the bacteria.

Q. Is it not a fact that sanitarians are not only interested in the purification of water by filtration as a water supply but are also interested in the proposition of prohibiting pollution of water supplies?

A. They are.

Q. Is it not a fact that in various parts of the civilized world the pollution of rivers utilized as water supply is prevented although filtration plants are established?

A. It is a fact.

12473 Q. What effect will the increasing population upon the water shed have upon the subject of filtration from the standpoint of a sanitarian?

A. It will stimulate the extension of filtration because in my opinion it would be difficult to create a sentiment in the large communities of the United States at the present time in favor of such treatment of sewage as would render it innocous when delivered into running streams or lakes, and the only other remedy we now see is the filtration of such polluted waters, attempting to render them potable by this means. The time may come after filtration has been thoroughly exploited and is regarded as an established feature of water works which draw their supplies from polluted sources, and when a higher degree of purity of public water supplies is demanded, that a step will then be taken in the direction of protection from sewage pollution of streams and lakes from which municipal water supplies are now taken. At the present time, however, I do not look for any strong public movement along the line of effective sewage disposal at the hands of the larger cities, with a view of course of defending the waters of streams or lakes which are used as sources of city
12474 water supply.

Q. Will not an increased population upon a water shed have a tendency to increase precautionary measures used in the operation and construction of filtration plants and require by reason of the increased undertaking towards slower processes of filtration?

A. No, I don't think so. Our experience with the filters in Philadelphia shows that we are able to successfully maintain unusual rates of filtration with an entirely satisfactory quality of effluent, when measured by standards that prevail abroad for filtered water, provided that efficient measures are adopted to previously rough filter the water or to prepare it before it is

passed on to the final filters. There are a few cases in Europe where plain sand filters have been operated at rates in excess of three million gallons per acre per day of twenty-four hours. The two exceptions that I recall are Zurich, Switzerland, and Schiedam in Holland. In the latter place preliminary filters are used. At Zurich the water obtained from Lake Zurich is very free from suspended matter excepting Plankton. With the filters that are now in operation at lower Roxborough and other filters that have been used in the experimental investigations during the past four
years, the rates have been maintained at from six to ten
12475 million gallons per acre of sand surface per day of 24
hours without impairing the quality of the filter effluents; and as a result of the several months practical test of filters on a large scale at Lower Roxborough, and a longer test of experimental filters on the waters of the Delaware and Schuylkill Rivers the normal rate of filtration has been fixed at six million gallons per acre per day. Knowing that filter effluents at this rate are quite as good as those of lower rates adopted for similar filters now in use at Albany, New York, and elsewhere I do not think, if the source of supply is known to be polluted with sewage or is known to have a higher degree of such pollution than some other source, that this would involve an increased cost of construction or increased cost of operation. It should, of course, involve increased vigilance on the part of the manager of the filters, but this does not necessarily entail increased cost of operation.

Q. Assuming, Mr. Hill, that for several years prior to 1900, the Illinois River during the greater part of the year was a sluggish stream, scarcely any current, having a green scum for-
mation upon its surface, that when rowing in a skiff the
12476 path of the skiff could be seen for considerable distance
behind by reason of the formation upon its surface; that by throwing a chunk of wood into the water the direction in which it would travel depended altogether upon the way in which the wind would blow; that for miles above the four dams in that river there was practically no current and that since January 1900 this green scum has disappeared; that there has been a continuous current from one end of the river to the other both above and below the dams. Is it not a fact that the con-

ditions existing in the river prior to 1900 were more conducive to the destruction of pathogenic bacteria, assuming that they were contained in the water both prior and subsequent to 1900 than under the conditions which have existed subsequent to that time?

A. I do not think that is necessarily true in view of the fact that the introduction of a considerable volume of relatively pure water from Lake Michigan with a corresponding considerable increase in the dissolved oxygen in the waters flowing in the river might contribute to a more rapid oxidation of the organic matter than if it depended entirely upon the processes formerly going on in the pools formed by the dams 12477 in the river or by the formation of sand bars, a situation that would happen in a river of a very sluggish current. It is altogether possible, and this fact would depend upon the relation of the flow from Lake Michigan to the total flow of the Illinois River, and would probably be most favorable when the two volumes of water were very nearly alike, that the addition of lake water from Lake Michigan would stimulate the reduction of organic matter and with it the reduction of the bacteria. There is certainly some point between the septic conditions of slow flowing sewage in the stream, and that of a rapidly flowing stream where the self purification as you may so term it or the oxidation of organic matter will be at its optimum point, and I do not think that the addition of such a volume of water to the stream flow of the Illinois River as would produce a flow over the dams at all times would be calculated to prolong the life of the pathogenic bacteria.

Q. It is true is it not that typhoid fever germs will live longer in water that is highly oxidized than in water which contains no oxygen?

12478 A. That is true, provided there is sufficient organic matter to furnish proper food.

Q. Do typhoid fever germs require food for their subsistence in waters of a running stream?

A. It is a question whether their known longevity in water is due to food material obtained from the water or whether it is due to other causes. It is just possible that such food material as they find that may be acceptable to some extent prolongs their life, but they do not find, of course, the food necessary to propagate or multiply in water. Neither is it known that they are concerned in any of the putrefactive and fermentative processes going on in the decomposition of organic matter.

Q. With proper food supply there is no reason to say they should not propagate if the temperature is right, is there?

A. There is no evidence to show that the proper food material for the typhoid organism is found in water; on the contrary all evidence indicates that it is not found there, but it would not be safe to say that some portions of the life history of the typhoid organisms in water might not be due to
12479 the use of some food materials found in water. The fact that we can grow typhoid organisms in flasks specially prepared indicates that there is food material upon which they flourished for a limited length of time, and some such material or its equivalent may be found in water.

Q. Assuming that there is a city situated upon the Mississippi River immediately above the intake of the St. Louis water works with a population of 13,000 people in which typhoid fever is continually prevalent from one end of the year to the other, the extent of such fever being as much as is ordinarily found in a city of that size in this country, would not such a city be a danger and a menace to the people of the city of St. Lous taking their water supply from the Mississippi River immediately below the sewage discharges of said city of 13,000 population?

A. There would be, and the measure of this danger would be the population of such city stated as 13,000, its distance from St. Louis to the point of water intake and the rate of stream flow between the city and the intake.

Q. And as the population of that city increases from thirteen to one hundred and sixty thousand the danger would increase would it not?

12480 A. The danger would increase directly with the increase of population.

Q. When was the last edition of your work on water supply published, Mr. Hill?

A. 1898.

Q. What is the title of that book?

A. The Purification of Public Water Supplies.

Mr. Todd: I desire to prove at a latter date that Jefferson City, Missouri, is a sewered town and sewers in the Missouri River, unless it is admitted.

With the above reservation the defendants, the State of Illinois and the Sanitary District of Chicago, rest their case.

Adjourned subject to notice.

JAMES W. HILL.

12481 Room 282, Southern Hotel, St. Louis, Mo. 10:00 a. m., Monday, May 23, 1904.

Continuation pursuant to agreement for complainant's rebuttal evidence.

Present, the Commissioner and Hon. S. B. Jeffries representing complainant, and James Todd, Esq., representing defendants.

DR. EDWARD W. SAUNDERS,

a witness called on behalf of the complainant in rebuttal, being duly affirmed by the Commissioner, testified as follows:

DIRECT EXAMINATION, by Mr. Jeffries.

Q. Doctor, what is your profession?

A. Physician.

Q. Where do you practice your profession?

A. In St. Louis.

Q. You reside in St. Louis?

A. Yes, sir.

Q. How long have you practiced in St. Louis?

A. Twenty-six years.

Q. What schools of medicine did you attend?

A. The University of Virginia.

Q. When did you attend this school?

A. I graduated in 1875.

Q. What has been the character of your practice, Doctor?

12482 A. General practice.

Q. What is the street number of your office now?

A. 3003 Lafayette avenue.

Q. Are you acquainted with the disease known as typhoid fever?

A. Yes, sir.

Q. Have you treated that disease?

A. Yes, sir.

Q. Or patients afflicted with that disease?

A. Yes, sir.

Q. Are you acquainted with what is known as the Widal test?

A. Yes, sir.

Q. As a professional man, Doctor, what is the real object and use of the Widal test?

MR. TODD: I object to the question on the ground it is not rebuttal and has already been gone into in chief by the complainant, and for the further reason it is incompetent, irrelevant and immaterial.

A. Well, it is to assist the physician in making an early diagnosis of typhoid fever.

Q. What advantage is this early knowledge as to the character of the disease in the treatment that is given typhoid patients?

12483 A. It enables a physician to treat it very much more effectively.

Q. Is it of any assistance to the physician in preventing the disease becoming fatal in the particular patient?

A. Yes, sir.

Q. This Widal test is used for the discovery or rather to ascertain whether or not the patient is afflicted with typhoid, is it?

A. Yes, sir.

Q. State, Doctor, whether or not it is used for determining the cause of death or only in the aid of making the early diagnosis of the disease.

A. I should say only in making an early diagnosis of the disease, practically. It might be used for determining the cause of death, but practically, I should say, for making an early diagnosis.

Q. When patients die of typhoid fever, is it ordinarily necessary or general for the attending physician to use the

Widal test for determining whether or not death was caused from that disease?

A. No, sir.

12484 Q. What influence has this test had upon you in your practice in making out death certificates to the health department of the city of St. Louis?

MR. TODD: Object to the question for the reasons stated in my previous objection, to a previous question.

A. None at all, I think.

Q. You have treated cases of typhoid fever in your practice in St. Louis?

A. Yes, sir.

Q. State whether or not you have been called in consultation with reference to diseases of this character?

A. Yes, sir.

Q. State whether or not these consultations were frequent or infrequent?

A. Well, I should say—it is rather hard to answer the question at all. You mean in the course of a year?

Q. During the last seven or eight or ten years of your practice?

A. I should say quite often.

Q. Are you acquainted with your profession or with the members of your profession in St. Louis, generally?

A. A large number of them, yes, sir.

12485 Q. Do you know whether or not the Widal test is in general use by the profession in St. Louis?

MR. TODD: I object to the question for the reason that it is incompetent, irrelevant and immaterial.

A. I consider that it is.

MR. JEFFRIES: I suggest to the court that the counsel has lost sight of the testimony of Dr. Barker, Dr. Thayer and Dr. Dock.

MR. TODD: In reply to counsel's suggestions would state that defendant's counsel's vision is very clear upon the testimony of these men and it is not competent for this witness to tell what other witnesses are doing as it would be mere hearsay and therefore incompetent.

MR. JEFFRIES: I suggest that the whole of Doctors Barker, Dock and Thayer's testimony was as to what other men had done and for that reason counsel must be bound by his own statement.

A. Yes sir, I consider it so.

Q. How long has this test been in use in St. Louis?

A. I can not answer that question with any certainty,
12486 but I should say about six or seven years.

Q. As a professional man and knowing the profession as you do, state what effect if any the Widal test has had upon the profession in signing and making out death certificates to the mortuary office of the health department?

MR. TODD: Object to the question for the reasons heretofore stated in my previous objections.

A. I should say that it has taken a number of cases from the typhoid list, and added a number to it, because cases of nondescript fevers which before that time were assigned to the malarial list after that were assigned where they properly belonged, to the typhoid. On the other hand, there were quite a conglomeration of cases, patients dying in what the older writers called the status typhosus, or the typhoid state, which typhoid state had nothing to do with true typhoid fever, and these cases were taken out of the typhoid list.

MR. JEFFRIES: Q. State whether or not the Widal test or any other practice has resulted in taking from the malarial list and placing them in some other list besides typhoid?

A. I hardly think so.

12487 Q. State whether or not some deaths supposed to be
malarial have not failed to react under the typhoid test and therefore have been placed under some other head?

A. You mean deaths?

Q. Yes sir?

A. I will answer that by saying I can conceive of a case where a physician has treated a case for malaria and sees death approaching and makes the Widal test and finds it is not typhoid and that leads him to make a more careful examination and finds the patient is dying of nephritis or something he had not found before. Yes, I can conceive of that case occurring.

Q. So then in that event the death would be reported as nephrites instead of malaria or typhoid?

A. Yes sir.

Q. Under such cases prior to the Widal test, the death might have been reported as caused by malaria?

MR. TODD: Object to the question as this witness is not competent to pass upon what might be done by some other physician of a different standing than himself and as purely
12488 speculative and incompetent, irrelevant and immaterial,
and not rebuttal of anything that has been put in by the defense in this case.

A. It seems to me that this question only bears out what I said before, that the Widal test has conduced to the accuracy of the diagnosis, and in that way has taken a number of deaths out of the typhoid list that heretofore was under the head of typhoid before the introduction of the Widal test.

MR. JEFFRIES: Q. So that these cases of malaria to which you referred in your previous question, and the attending physicians finding death approaching, and failure of the reaction of the Widal test taking place it resulted in keeping that death out of the typhoid list which might otherwise have found place there?

A. Yes sir.

Q. I understand you to say then that since the Widal test has come in vogue, where patients believed by the attending physician to be afflicted with malaria and finding death approaching have applied the Widal test which has resulted in the death being recorded under some disease other than either malaria or typhoid?

12489 A. Yes sir.

Q. What in your opinion has been the effect of the Widal test upon the relative number of deaths from typhoid fever in St. Louis since its use, as compared to the same period prior to the use of such test by the physicians in St. Louis?

A. I am not able to answer that question because I have no clear idea in my own mind as to what number have been taken out of the typhoid list and what number have been added to it by the test.

Q. Doctor, taking into consideration the value of the Widal test in making an early diagnosis of typhoid fever, and taking into consideration the fact also that it is a disease, which, if properly treated in its early stages, is less likely to become fatal, what, in your opinion, has been the effect upon the typhoid mortality in St. Louis since its use as compared with conditions existing prior to its use?

A. The relative mortality?

MR. TODD: Object to the question for the reasons heretofore stated.

MR. JEFFRIES: Q. Yes.

A. Relative to the number of cases?

12490 Q. Yes sir?

A. I should say very favorable.

Q. By that you mean what?

A. That a given number of cases occurring since the Widal test will afford a much better mortality rate than the same number of cases occurring before the Widal test.

Q. What, then, would be the effect of such test upon the total number of deaths occurring from typhoid fever in St. Louis?

A. It would be favorable.

Q. Assuming that all conditions were similar, both subsequent to the use of the said test, as existed prior thereto, how would the conditions compare with reference to the mortality record from typhoid fever?

MR. TODD: Object to the question for the reasons heretofore stated.

A. Assuming all other conditions tending to recovery were the same, those in which the Widal test is used for an early diagnosis are found to show a better mortality rate.

MR. JEFFRIES: Q. Then if conditions, locally and other-
wise for counteracting the disease are the same, that
12491 period of the time during which the Widal test is em-
ployed in the early stages of the disease would show a
better mortality record from typhoid fever than that period
when such tests are not employed?

A. Yes sir.

MR. TODD: Object to the question for the same reasons heretofore stated in my objection.

MR. JEFFRIES: Q. State whether or not there is such a thing as trichinosis or other similar diseases which resemble typhoid and which might be confounded with, and deaths from which might be reported as typhoid were it not for the Widal test?

A. Yes sir.

Q. Such diseases, without the use of the Widal test, might be confounded with typhoid?

A. Yes sir.

Q. And without that test having been employed, during sickness, if death occurred it might be reported as typhoid?

A. Yes sir.

Q. But with the use of the test it would not be reported
12492 as typhoid?

A. Yes sir.

Q. Doctor, did you receive any circulars from the time of the opening of the drainage canal from the board of health or any one connected with the board of health urging you to report all cases of typhoid to them?

A. I think I did. I am not sure about the time, but I remember receiving a circular with reference to reporting typhoid fever.

Q. Do you know whether that circular was received generally by the profession?

A. I do not know whether it was or not. I suppose it was.

Q. Did you hear the circular discussed by the members of your profession?

A. No sir.

Q. What effect has the fact that you had received such circular had upon you in reporting cases of typhoid to the health department?

A. Cases or deaths?

Q. Deaths?

A. None at all.

12493 Q. Were you in any way influenced in your action in making such report by receiving these circulars?

A. No sir, I never thought of it in that light. It never occurred to me that was the object of it.

Q. Did you ever hear the profession discuss the object of those circulars?

A. No sir, I never did. I do not think it ever occurred to any of them.

MR. TODD: I move to strike out the last part of his answer as not competent to what might have occurred to some body else. If it did not occur to him it is a matter that he is not competent to pass upon.

MR. JEFFRIES: Q. Were you in a position to have heard any such discussion had it taken place?

A. Yes sir.

MR. TODD: Object to that question as incompetent, irrelevant and immaterial, and not rebuttal.

MR. JEFFRIES: State, doctor, whether or not in your opinion any of the physicians in St. Louis have been in any way influenced by reason of having received these circulars, 12494 about the time of the opening of the drainage canal or any other time?

MR. TODD: Objected to as incompetent, irrelevant and immaterial.

A. I think not.

MR. JEFFRIES: Q. State whether or not, in your opinion, physicians generally have been influenced by these circulars to report a greater number of deaths from typhoid fever than they would have otherwise reported as due to that disease in the event such circulars had not been sent out by the health department?

A. I think not.

Q. Do you remember the occurrence of the opening of the drainage canal?

A. Yes sir.

Q. State what effect, in your opinion, the opening of the drainage canal at Chicago, thence in the Desplaines and thence in the Illinois river, had upon the physicians of St. Louis, in making the reports from deaths from typhoid in St. Louis?

MR. TODD: Object to the question as incompetent, irrelevant and immaterial.

A. I have no reason to think it would influence them.

12495 MR. JEFFRIES: Q. Assume that a physician certifies that one of his patients died of congestive fever, what would you understand by that term?

A. I would not have any clear understanding of the case at all. I would not know what it meant.

Q. Would it necessarily mean typhoid fever?

A. Not necessarily, no sir.

Q. Might it mean anything else besides typhoid fever?

A. Yes sir. Yes, it might. I do not know really what a man would mean by it. I have really no clear conception.

Q. Should a physician certify that one of his patients died of typho malaria, what would you understand by that term?

A. I would understand that he died of typhoid complicated with malaria.

Q. If a case be reported as remittent fever, what would you understand by that term?

A. I would suspect that he died of typhoid because indigenous remittent fevers are not fatal.

Q. Has the age of the patient anything to do with passing judgment upon that point? 12496

A. Ye sir.

Q. What effect has the age of the patient upon the making of the determination?

A. Malarial fevers do carry off the very young and the very old.

Q. Suppose that a remittent fever patient died in infancy?

A. Then I would believe that that was the true cause of death.

MR. TODD: If he died of remittent fever, you would assume that that was the true cause of death?

A. If the infant patient died in convulsions at the onset of the attack, but not if it died after a protracted illness inasmuch as quinine is a specific remedy for all malarial fevers of this locality, and only those taken off such as the very young, in convulsions, or the old in the first onset, those that are liable to be taken off by that cause.

MR. JEFFRIES: Q. State whether or not the same would be true with reference to intermittent fever?

12497 A. Yes sir.

Q. How about bilious fever, doctor?

A. I have no more clear conception of bilious fever than I have of a congestive fever.

Q. Is the same true with reference to malaria and simple continued fevers?

A. The same is true of malaria, but of simple continued fevers I would say that they were all in the typhoid class.

Q. Unless the patient be an infant?

A. Well, no, I would not even make that qualification, for the reason that a fever which continues any length of time, if it be malaria, is amenable to quinine and if not amenable to quinine I believe in the Osler dictum that any fever that continues a week and is not amenable to quinine and is not anything else, is typhoid.

Q. Might it not be something else besides typhoid?

A. The simple continued fever, do you mean?

Q. Yes sir?

A. In speaking of deaths?

Q. Yes?

12498 A. I hardly think so.

Q. Do infants and old people often die of typhoid fever, doctor?

A. No sir.

Q. At what age are persons most likely to have typhoid fever?

A. Young adults.

Q. At what seasons of the year is typhoid fever most prevalent in St. Louis?

A. In the latter part of the summer and fall.

Q. And it is more frequent in the summer and fall than in the winter or spring?

A. Yes sir.

Q. Doctor, state whether or not you have observed more or less typhoid within the winter and spring months within the last few years than formerly in St. Louis?

MR. TODD: Object to the question as it is not rebuttal as this whole subject was gone into in the plaintiff's case in chief and is therefore incompetent, irrelevant and immaterial.

A. I have.

12499 MR. JEFFRIES: Q. Doctor, do you remember a typhoid condition in St. Louis in 1892 and 1893?

A. Yes sir.

Q. What were those conditions?

MR. TODD: Object to the question as it is not rebuttal and has been fully explained by Dr. Ravold as a year of spring epidemic and has not been contradicted by the defendant in the case.

A. Severe epidemic.

MR. JEFFRIES: Q. Was it general over the city, or localized?

A. It was pretty general.

Q. Do you remember any epidemic since that time?

A. Yes sir, I remember one in the fall of 1899, just before the opening of the canal.

Q. Was that general over the town or local?

A. That was local.

Q. Where were those cases mostly?

A. In the west end, the better quarters of the city.

12500 CROSS EXAMINATION.

By MR. TODD:

Q. Doctor, are you connected with any institution of medicine in St. Louis?

A. Yes sir, the medical department of the Washington University.

Q. How long have you been connected with that department?

A. Since the consolidation of the Missouri Medical with the Washington University.

Q. What branch of medical science do you teach?

A. I teach diseases of children and clinical obstetrics.

Q. In the diagnosis of typhoid fever do you regard the Widal test as the only true test?

A. No sir.

Q. May not a patient have typhoid fever and yet the doctor fail to get the Widal reaction?

A. Yes sir.

Q. In order to properly diagnose typhoid fever it must be based upon the totality of the symptoms?

A. Yes sir.

Q. How many doctors in the city of St. Louis are practicing medicine?

12501 A. I think the last report is some sixteen hundred. I am not accurate about that.

Q. How many of those doctors have you a personal acquaintanceship with?

A. I do not know.

Q. Well, approximately?

A. Well, now, I really could not approximate it.

Q. Ten per cent.?

A. That would be one hundred sixty. Yes sir.

Q. Twenty per cent.?

A. Yes sir, I should say so.

Q. This acquaintanceship which you have with the number of doctors would not exceed twenty per cent., would it?

A. I could not state that whether it would or not. Really, I do not feel that without a careful computation—if I had the list before me, the catalogue, I could tell you in half an hour just how many I do know.

Q. Well, assuming—I am not trying to bind you by a definite answer on this proposition, but the purpose of what I want is to inquire the acquaintanceship which you have with the doctors in St. Louis—is that an acquaintanceship which extends to the bedside of the patients which they treat, 12502 and their methods of diagnosis?

A. With all of them?

Q. Yes sir?

A. No sir.

Q. The doctors that you have an intimate acquaintanceship with their method of treatment of diseases, are those you are called in consultation with?

A. Yes sir.

Q. What per cent. of the doctors would you be called in consultation with?

A. You mean at any time?

Q. During the year.

A. Or during my whole profession?

Q. Take it by the year, an average of the year, say?

A. How many in a year that I would be called in consultation with?

Q. Yes, just generally, doctor?

A. You do not mean how many consultations a year, but how many different physicians?

Q. Different physicians?

12503 A. Well, I will just venture a guess. I should say from fifty to one hundred.

Q. How many cases of typhoid fever do you treat in a year, on an average?

A. I could not answer that question without looking it up.

Q. Approximately?

A. Without looking up my records.

Q. Approximately—could you give an approximation?

A. You mean by treating, that I treated and saw in consultation all together?

Q. Yes sir?

A. That I have seen?

Q. Yes sir?

A. Well, I should venture, just as a guess, the nearest approximation that I could make, I should say from thirty to fifty, or some where along there.

Q. What percentage of those that you have seen are fatal cases?

A. Well, inasmuch as I see some of them in consulation and in a very bad condition, I see perhaps a larger mortality that would seem proper, but the percentages of mortality in cases that I see would bear no ratio to the percentage of mortality in typhoid fever in the city. I remember seeing
12504 two deaths in two hours, from hemorrhage.

Q. Out of thirty cases of typhoid fever, assume that that approximates the number of cases treated by you, in consultation and otherwise, would there be as many as ten deaths during the year?

A. Well, sir, I should say outside of that that I saw three in consultation in one afternoon. That was during the last epidemic.

MR. JEFFRIES: Q. In 1899?

A. Yes sir, in 1899. I should say that I saw anywhere from two to three or four or five deaths in a year.

MR. TODD: Q. What importance do you attach to the Widal test?

A. I think it is a very valuable means of diagnosis.

Q. Of the 1,600 doctors practicing medicine in the city of St. Louis, how many of those doctors are homeopaths?

A. I have no idea of that. I never looked it up.

Q. There are quite a number of homeopathic physicians in town?

A. Yes sir.

Q. Do you know whether they employ the Widal test or
12505 not?

A. I do not know.

Q. What is your opinion as to whether the sixteen hundred doctors in the city of St. Louis are employing the Widal test?

A. Well, I do not know whether the homeopathic doctors employ it at all. You mean outside of them?

Q. Outside of the homeopaths?

A. Well, I should say that all of them, if they are in doubt, would be liable to appeal to the Widal test in a case.

Q. Do physicians, as a general proposition, the ordinary physicians, and I assume you have those in St. Louis?

A. Yes sir.

Q. Do they employ the Widal test?

A. I think they do, yes sir. Whenever they are in doubt they do.

Q. Well, are there not some physicians here that are never in doubt?

A. Yes sir, that is right.

Q. All of these sixteen hundred physicians are not experts on typhoid fever, are they?

A. No sir.

Q. Are you acquainted with the board of health statistics of the city of St. Louis, the board of health mortality sta-
12506 tistics of the city of St. Louis?

A. No sir, I have not looked at them for some time.

Q. If it should appear in the board of health statistics of the city of St. Louis during the last ten years that they have a group of deaths reported as remittent, intermittent, typho malaria, congestive and simple continued fever, and that those deaths amount to something like 200, would that be any reflection upon the doctors of St. Louis in their diagnosis of diseases of that character?

A. Read the list, will you, of diseases, just the list of diseases.

Q. Remittent, intermittent, typho-malaria, congestive and simple continued fevers?

A. Yes sir, I think the number is a reflection on the diagnosis.

Q. And does not the number of deaths so characterized in the board of health report reflect upon the diagnosite ability and carefulness of the doctors who make those reports?

A. Yes sir.

Q. And if the number of deaths appearing in the typhoid death column, and the number of deaths appearing in the
12507 remittent, intermittent, typho malaria, congestive and simple continued fever column were about the same, what value would you attach to the statistics as giving evidence of the typhoid condition in St. Louis, based upon the typhoid fever death column, as they appear in those statistics?

A. Well, I should say that the majority of those cases belonged in the typhoid column.

Q. Would you say that the doctors in St. Louis were employing the Widal test generally if such a condition obtained as evidenced by the compilation of the board of health of the city?

A. At present, you mean?

Q. During the last six or eight years?

A. Since the Widal test?

Q. Yes sir?

A. No sir, I should say they were not.

Q. Is it not a fact that these practitioners wedded to the calomel and quinine are obstinate in acepting new treatment for diseases?

A. That is the tendency.

Q. And does not that manifest itself in the health statistics of the city?

12508 A. Do I understand you to say that the deaths are about equal here in typhoid and in all these others?

Q. Approximately.

A. Approximately. Yes, that proves it; they do not.

MR. JEFFRIES: I move to strike out the answer and the question for the reason that the column known as typho malaria, intermittent, remittent, congestive and simple continued fever, not only contains deaths from such diseases, but other diseases as evidenced by the fact that in the health report the persons who compiled it have placed other deaths in that column and that the question is not fair, and all statements based thereon incorrect, can not be relied upon, because the column itself calls attention to the fact that deaths from other diseases are placed therein.

MR. TODD: In reply will state that the witnesses on the side of the complainant in this case, especially the epidemiologists, predicated their argument that the drainage canal was responsible for the typhoid condition in the city of St. Louis
upon the board of health reports of the city of St. Louis,
12509 and that the injury which St. Louis sustained by virtue
of the opening of the drainage canal was manifest in the board of health reports in the city of St. Louis, and there has been no other evidence offered in this case to sustain the claim except that of the board of health reports of the city of St. Louis.

MR. JEFFRIES: In answer to the counsel, I will state that we accept the truthfulness of what is shown in the board of health reports from the deaths from typhoid fever, but that such deaths contained in the published board of health reports is the only statistics that were offered by the plaintiff. I suggest also that the counsel himself has used the columns with reference to the remittent, intermittent, congestive and other diseases and was introduced by him and not by the complainant, and that the column so introduced by him especially calls attention to the fact that deaths from other diseases are included therein.

MR. TODD: In reply counsel for defendant admits the truth of every word counsel has just uttered, but complains that complainant should have offered the remittent, intermittent,
typho malaria and congestive fever columns in order to
12510 arrive at a correct conclusion as to the typhoid condi-
tions in the city of St. Louis, and complainant's failure to do so can not militate against defendant having done what counsel charged us with having done.

MR. JEFFRIES: I will state for the benefit of counsel that the complainant did not introduce in evidence the published report of the board of health wherein the statement is made that certain number of deaths occurred each year under the head of remittent, intermittent, typho malaria, congestive and simple continued, because it would have been unfair and would have misrepresented the fact, that colmun stating and calling attention to the fact that other diseases were included therein.

MR. JEFFRIES: I object to the question for the reason the witness has stated he is not acquainted with the health statistics as made up by the health department for the last few years.

MR. TODD: Q. Assuming that the mortality health reports of the city of St. Louis disclose the number of deaths from remittent, intermittent, typho malaria, congestive and
12511 simple continued fevers during the last ten years to be
about equal to those of the typhoid deaths, is there, in your opinion, any more integrity in the reports of the physicians as to the typhoid deaths than there would be upon the remittent, intermittent, typho malaria, congestive and simple continued fever death columns?

MR. JEFFRIES: Object to the question for the reason it is for the court to determine as to the integrity and not for this witness.

A. Well, that is a hard question to answer. I would say perhaps the typhoid column is as inaccurate as the other column. That is just a guess or opinion.

MR. TODD: Q. If the typhoid column is as inaccurate as the other column, to what do you attribute the inaccuracies?

MR. JEFFRIES: Object to the question for the reason that the published report of the board of health is not compiled by the physicians who make the report, and therefore such facts are not competent to use in passing upon the credibility and integrity of the physicians in St. Louis.

MR. TODD: If counsel eliminates the board of health
12512 reports of the city of St. Louis in this case as being in-
competent, then the entire case of complainant has failed, as I am ready to show to the court.

MR. JEFFRIES: I will state to counsel that the board of health reports as published shows on its face what it represents but that counsel is imposing upon his own good judgment when he undertakes to assume that under the column of intermittent, remittent, etc., there are not deaths included which have occurred from other diseases.

MR. TODD: In reply, counsel for defendants will state that he assumes nothing that can not be found in the board of health reports of St. Louis, and makes no assumption as to its accuracies, for the defendant will not be bound in this case by any such reports that have been characterized in the manner that counsel has characterized them in his previous arguments this morning to my question.

Q. Question read.

A. To failure in diagnosis.

MR. TODD: Q. Do you recognize, doctor, intermit-
12513 tent, remittent, typho malaria, congestive and simple continued fevers, as distinct types of the disease?

A. I would say that what is generally called intermittent fever in medical nomenclature and in the nomenclature of the boards of health, is a malarial fever characterized by the presence of a certain organism in the blood. I would say that remittent fever is also a malarial fever characterized by the presence of a different organism in the blood.

I would say that typho malaria fever is a typhoid fever complicated by the presence of a malarial organism in the blood.

I would say that as to congestive fever, I do not know what that means. I do not know what a man means when he uses that term, and simple continued fever I would say that that nobody knows what that is, but it is not supposed ever to be fatal.

Q. Is it not a fact that intermittent, remittent and simple continued fevers are characteristic of malarial or typhoid and are not distinct types of fever in themselves, so recognized by clinicians and diagnosticians?

12514 A. The characteristics of malaria or typhoid?

Q. Yes sir.

A. Well, I would say that intermittent and remittent fevers are now a days recognized as characteristic germs of malaria.

Q. Are remittent, intermittent, typho malaria, congestive and simple continued fever recognized by the leading authorities, such as Osler, Welch and other men of equal standing, as distinct types of disease today?

A. Well, I would say some of them are not recognized in the sense of being types of disease apart from the organism.

Q. They are terms that have grown up?

A. Yes sir.

Q. And have been employed by physicians of the past, but are not today employed by the advanced schools in medicine in the United States and Europe, are they?

A. That is true.

Q. Malarial fever differs from typhoid fever in what way?

A. Malarial fever is a fever caused by the presence in the blood of a parasite, a malaria parasite of which there are
12515 two well recognized species in this country, and typhoid fever is caused by the introduction into the organism of the typhoid bacillus.

Q. Is there any difficulty among competent physicians to diagnosticate a case of malaria by the use of the microscopic?

A. Yes sir, there is.

Q. And other means?

A. Yes, there is some difficulty.

Q. That requires a good deal of skill?

A. Yes sir.

Q. Are the doctors in the general practice in the city of St. Louis possessed of that degree of skill necessary to make that diagnosis?

A. No sir.

Q. That is true of typhoid fever, is it not?

A. Yes sir, it is true of typhoid fever.

Q. So that in diagnosing malaria and typhoid fever it requires an expert knowledge on the part of the diagnostician to correctly differentiate those fevers, does it not?

12516 A. Yes sir, in a great many cases. I would not say in all.

Q. And that knowledge is not possessed equally by the physicians in the larger cities, such as St. Louis?

A. That is true.

Q. And that is true of other cities?

A. Yes sir.

Q. Does not the fatality of typhoid fever depend largely upon the amount of poison taken into the system by the patient that has it?

A. Yes sir. You mean by poison—you mean the germs?

Q. Yes sir?

A. Yes sir.

Q. The nearer the source of infection, the more dangerous the disease, is that not true, rather than the early diagnosis of the case of typhoid?

A. Well, I hardly know how to answer that question, Mr. Todd. Of course, if you mean geographically nearer the source of infection.

Q. No, point of time?

12517 A. I am not competent to answer that question.

MR. JEFFRIES: I move to strike out the question for the reason that the defendant's own experts on the stand testified that it is not a question as to the remoteness of the source from which the germ diseases came from, that it depends largely upon the resistant forces of the system of the patient into which the germs of disease were taken, and that the question of remoteness was considered only upon the probability or improbability of the germ being virulent or taken into such system.

MR. TODD: The evidence which counsel quotes is before the court for the court's consideration, and it is not necessary for me to construe it.

MR. TODD: Q. Would the fact that a patient was known to have typhoid fever at the beginning of the disease by the Widal test be any security against the mortality of that patient provided he was treated by a competent physician?

A. Yes sir, it would.

Q. Assume that the other symptoms of the disease, such as the rose spots, the enlargement of the spleen, epitaxis, and the other well known symptoms were present before the Widal
test was made, would the fact that these symptoms were
12518 supplemented by the Widal test change the treatment?

A. No sir, not at all.

Q. The fatality of the disease in the hands of an expert physician depends largely upon the resistance of the patient as well as the amount of typhoid bacilli carried into the system of the patient does it not?

A. Yes sir.

Q. When was the Widal test generally introduced into St. Louis?

A. I can not speak accurately on that question, but somewhere in the late 90's.

Q. Not to exceed six years ago, would it be?

A. No, I don't think so.

Q. What value would you attach to the statistics of the health department of St. Louis, in regard to its typhoid fever condition prior to six years ago, assuming that those statistics are based upon the diagnosis of the physicians of St. Louis.

A. Well, I think they can be taken to represent fairly the presence of typhoid fever. There are a great many
12519 errors undoubtedly.

Q. If it should appear that prior to six years ago they were more or about equal remittent, intermittent, typho malaria, and congestive fever deaths in St. Louis than typhoid death rates, would the death rate column fairly represent the typhoid condition in your opinion, excluding the year of special epidemics?

MR. JEFFRIES: Objected to because it is a repetition.

A. No sir.

MR. TODD: Q. Do you know of any case where a physician treated a case of malaria fever and after the treatment of that case made the Widal test and failed to find the Widal reaction, and then diagnosticated the case as some other disease before death?

A. I do not know of any such case, no sir.

Q. If the patient had malarial fever, in the hands of an expert physician, would he not be able to diagnose that case properly as malaria?

12520 A. I think so.

Q. Do you know of any case that came under your observation where the malaria parasite has been found in the same patient with a typhoid bacilli?

A. Yes sir, I have had two such cases.

Q. And respond to the Widal reaction?

A. Yes sir. Well, in one of them it responded to the Widal and the other one died of what I knew, as well as I could know, of what was typhoid, and had the malarial parasite. That was before the Widal test. The other was since the test of the Widal, and had both.

Q. Those cases are exceedingly rare, are they not, doctor?

A. They are rare, I should say, yes.

Q. And the fatality from those cases are rare, too, are they not?

A. Really, I could not say from personal observation. I can say what Professor Flint says in his book, that hopeful cases of typhoid are lost through malaria not being recognized in the late or convalescent stages.

12521 Q. But the number of deaths from typho malaria is a
very small number as compared with typhoid fever?

A. Yes sir.

Q. How does the fatalty from malaria fever compare with typhoid fever, in your practice?

A. In my practice, well I do not think that I have ever written a death certificate from any sort of malarial fever except in the very young when a convulsion carried off the patient in the onset, or in the aged where malaria carried off a very weak person. I do not believe I have otherwise made a single death certificate.

Q. In a case, such as you have just described, the old and the young, would you assign the cause of death as malaria?

A. Under what conditions?

Q. The old or the young?

A. Either of those symptoms?

Q. Yes, as the primary cause?

A. In the very young I would put it down as convulsions,
probably, or if I found the plasmodia before death as
12522 caused by malaria.

Q. Have you studied the statistics of the board of health of St. Louis since 1900, the date of the issuing of the circular?

A. No sir, I have not even looked at the items before.

Q. Assume that a circular should have been sent out from the board of health of the city of St. Louis to all of the sixteen hundred local practicing physicians, and assume also that the public press was discussing the question and the effect of the drainage canal upon the water supply of the city of St. Louis, and assume that the remittent, intermittent, typho malaria, congestive and simple continued fever columns immediately decreased during the three years and the typhoid column increased, would the effect of such an increase be manifest in the statistics of the board of health, in your judgment.

A. Well,—

Q. Assuming what I have stated to be true.

MR. JEFFRIES: Object to the question for the reason it is a conclusion that the court may draw from the facts introduced in evidence, and is not competent expert testimony from an opinion by the witness. Objected to for the further 12523 reason it assumes that the public press and the public mind was in an agitated condition upon the opening of the drainage canal which fact has not been proven in evidence, and which is not true.

Q. Question read.

A. If those are all the facts upon which I am to base a judgment, I would say yes. I do not know that I have all the facts.

MR. TODD: Q. Did you ever receive a circular of that kind prior to the opening of the drainage canal from the board of health of the city of St. Louis?

A. I have received circulars urging me to report typhoid fever I think, with other diseases, to awaken our minds to the importance of reporting those cases, but I do not remember ever receiving one in which it treated of typhoid alone, assuming that this did treat of typhoid alone. I do not say that it did for my memory is not accurate.

Q. While a circular of that kind would not have any effect upon you, doctor, because you always, I assume, reported your cases correctly, based upon your great experience in diagnostic work, are you prepared to say that it would not have any 12524 effect upon these doctors who had been diagnosing cases as trichinosis and other diseases?

MR. JEFFRIES: I suggest it could have no effect upon such fellows referred to in the question if the statement of counsel was true, physicians were dishonest and were attempting to make a concerted move towards securing a showing of more typhoid deaths occurring in St. Louis subsequent to the time of receiving the circular and prior thereto, and there is no evidence of such fact before the court.

MR. TODD: In reply will state that it is not a question of dishonesty, inasmuch as it is a question of ignorance that is responsible for the health statistics showing deaths from remittent, intermittent, typho malaria, congestive and simple continued fevers, and that a physician may be ever so honest and yet at the same time make wrong diagnosis not only at the peril of his patient, but to such an extent as to destroy the integrity of the sttatistics.

MR. JEFFRIES: If it is a question of ignorance solely I suggest that the fact of receiving the circular does not or would not eradicate the failure of any ignorance that existed 12525 upon their part after receiving the circular as well as prior thereto and that the reports would be, if incorrect, as incorrect subsequent to as prior thereto, based upon the question of ignorance alone.

MR. TODD: If that condition that counsel speaks of is true, it is a matter for the board of health of the city of St. Louis and not for the defendant, as we are not bound by any such conditions.

MR. TODD: Q. Doctor, what is trichinosis?

A. A disease characterized by a parasite taken in with uncooked or partly cooked pork, causing a diarroherea and even in severe symptoms the trichina migrate in the system and sometimes death.

Q. How many cases of trichinosis would you estimate to be in the city of St. Louis a year?

A. I do not know. I have never seen one.

Q. How many cases of trichinosis do you know of as being treated by the doctors of your acquaintance in the city of St. Louis?

A. I only know of one family a good many years ago.

12526 Q. That is an exceedingly rare disease, is it not, doctor?

A. Yes sir.

Q. And in order to guard against that disease the United States Government has an expert stationed at all the slaughter houses in St. Louis to inspect the meats?

A. Yes sir.

Q. Foreign governments have men here for that purpose?

A. Yes sir.

Q. And is there any difficulty in determining meat that is infected with trichina, by an expert specially selected?

A. No sir.

Q. So that the amount of disease, the number of deaths from trichina in the city of St. Louis would be so small that you would not consider it as an element of mistaken diagnosis of typhoid fever would you?

A. From my present statement, together with my present knowledge I would so say. I have never gone into an investigation, but that is just my experience without any investigation.

Q. Your experience is the common experience of the physicians? Your experience is the common experience of the physicians with whom you are associated, is it not?

A. Yes sir.

Q. You stated that you were acquainted with the epi-
12527 demic in the fall of 1899. Is your acquaintanceship with
that epidemic sufficient to enable you to state what the cause of that epidemic was?

A. I never came to any conclusions about it at all.

MR. JEFFRIES: Q. When you say the Government has their inspectors stationed at St. Louis, you mean to inspect the live stock coming into the slaughter pens?

A. Well, after the slaughtering I understand the meat has to be submitted to them.

Q. But the cured meats that are sent away are not inspected by the government here?

A. Brought from elsewhere?

Q. Any where?

A. No sir.

Q. And what kind of meat is more likely to contain this trichinosis?

A. Pork.

Q. Cured pork?

A. Fresh pork.

Q. Fresh pork?

A. Yes sir.

12528 MR. TODD: Q. Doctor, is it not a fact that the govern-
ment inspector not only inspects the cattle and the hogs or the hogs bought and in the slaughter houses, after the hogs are split open?

A. Yes sir.

Q. And before they are permitted to go into the cold storage and inspected, and whenever they find a hog that is diseased they put a tag on it that throws it out?

A. That is what I understood. I never saw it.

E. W. SAUNDERS.

12529 DR. WASHINGTON E. FISCHEL,

a witness called on behalf of the complainant, being duly sworn by the Commissioner, was examined in chief by Mr. Jeffries, and testified as follows:

Q. Doctor, state your name?

A. Washington E. Fischel.

Q. State your residence and occupation?

A. St. Louis is my residence, and I am a physician.

Q. How long have you resided in St. Louis?

A. All my life. I was born here.

Q. How long have you been practicing medicine?

A. I have been practicing medicine since 1874.

Q. Where were you educated in medicine?

A. In St. Louis, Berlin and Vienna.

Q. What schools in St. Louis?

A. The Medical Department of the Washington University.

Q. What schools in Berlin and Vienna?

A. The University of Berlin and the University of Vienna.

Q. You first graduated at the medical department of Washington University?

A. It was then the St. Louis Medical College.

12530 Q. And afterwards took the post graduate course in the Berlin and Vienna Colleges?

A. Yes sir.

Q. Or University?

A. Yes sir.

Q. What is the character of your practice?

A. I am devoting myself entirely to internal medicine.

Q. Do you treat typhoid cases?

A. Yes sir.

Q. How long have you treated typhoid cases?

A. From the first time I had the good fortune to have a patient with typhoid consult me.

Q. Are you connected with any of the hospitals in St. Louis?

A. Yes sir.

Q. What one?

A. St. Luke's Hospital, and I am consultant to the city hospital and I lecture to my classes in the city hospital once a week.

Q. What do you lecture on?

A. On medicine—clinical medicine.

Q. With reference to what character of diseases?

A. Internal medicine.

12531 Q. Is typhoid fever included?

A. Yes sir.

Q. In those lectures?

A. Yes sir.

Q. Are you acquainted with what is known as the Widal test?

A. Yes sir.

Q. How long has that test been used in St. Louis?

A. I should say about eight years. I may be wrong about that, but quite a number of years.

Q. You are acquainted with the disease known as typhoid fever?

A. Yes sir.

Q. Are you familiar with this Widal test for typhoid fever?

A. Yes sir.

Q. For what purpose is this test used, doctor?

A. To establish beyond a reasonable doubt the diagnosis of typhoid and to establish it as early as possible.

Q. What object is there in establishing this fact as early as possible?

A. The sooner you establish the diagnosis, the sooner will 12532 your treatment become an intelligent treatment.

Q. Doctor, state whether this test is used for determining the cause of the death or for the aid of the physician in making the early diagnosis?

A. It is used primarily in making the early diagnosis.

Q. And that is its principal object?

A. That is its principal object. When they die of the typhoid you do not ordinarily need the Widal to establish the cause of death.

Q. Is the disease of typhoid fever more easily treated and less likely to become fatal by reason of the fact that the physician learns early in the history of the case that it is true typhoid?

A. I think that is entirely probale, sir.

Q. Then, doctor, taking into consideration the value of the Widal test in making an early diagnosis of typhoid fever and also taking into consideration the fact that typhoid is a disease if properly treated in its early stages is less likely to become
fatal, what effect has the ability of the physicians to give
12533 their typhoid patients early treatment upon the mortality
record from typhoid?

A. I should think it would lessen it, lessen the mortality.

Q. Then the effect of the Widal test is to enable the physician to lessen the number of fatalities in their practice, so far as typhoid fever is concerned?

A. Yes sir, I think so.

Q. There would naturally be more deaths from typhoid when the Widal test was not employed than where it is properly employed?

A. I think that is entirely probable.

Q. Doctor, do infants and old people die of typhoid fever?

A. Yes sir, that does happen.

Q. Is it prevalent among infants and old people?

A. No.

Q. At these ages?

A. Not as compared to other ages?

Q. At what ages are persons most likely to have typhoid fever?

A. I should say between the ages of eighteen and forty or forty-five.

Q. Then persons between the ages of eighteen and forty-five are more susceptible?

12534 A. Yes sir.

Q. They are more susceptible to typhoid fever?

A. Yes sir, than infants.

Q. What season, doctor, is typhoid fever most prevalent in St. Louis? What season of the year?

A. I can not answer that because in my own practice I have had typhoid one year in the spring more prevalent than in the fall and then in the fall more prevalent than in the spring. I am not here in the summer time and do not know.

Q. You do not stay here in the summer time?

A. No sir.

Q. Then you do not know whether it is more frequent in the summer and fall than in the winter and spring?

A. No.

Q. State, doctor, if it is not a fact that you have observed more typhoid during the winter and spring months within the las few years than formerly?

A. Yes sir, I am very sure of that.

12535 Q. Doctor, state whether or not you know of any circulars ever having been sent out by the health department of the city of St. Louis to physicians practicing in St. Louis, urging them to make proper reports to the board of all typhoid fevers?

A. Circulars have been sent out by the board of health for the period of fifteen years at least, and perhaps longer, which make it obligatory upon the part of physicians to report a number of the infectious diseases, and among them typhoid, and add a punishment, a fine, I think, when the physicians neglect to respond to their questions.

Q. Why is it that physicians make these reports to the board of health and have so made them for the last fifteen or twenty years?

A. I think chiefly because it was demanded of them according to law.

Q. Because it is a matter of law?

A. Yes sir.

Q. And also a matter of city fines?

A. Yes sir.

Q. And has been?

A. Yes sir.

12536 Q. Did you receive a circular such as is just referred to about the time that the drainage canal was opened?

A. I do not recall it if I did. If all physicians received such a circular, I was probably not forgotten.

Q. You are acquainted with your profession in St. Louis?

A. Very well.

Q. You are in frequent communication with them and have been for years past?

A. Yes sir.

Q. State whether or not you ever heard members of your profession dicussing the reception of a circular about the time, from the city board of health, about the time of the opening of the drainage canal?

A. I do not recall that, do not recall that distinctly.

Q. Doctor, state what effect the fact that you have received these circulars from the board of health has had upon you in reporting cases and deaths in typhoid fever?

A. Personally?

Q. Yes sir?

A. None.

12537 Q. What in your opinion is the effect that it has had upon the physicians generally in the city?

A. I believe that many cases of deaths from typhoid have not been reported as typhoid for the reason that if the physicians had reported these deaths as typhoid the board of health would have at once demanded an explanation of them why they had not been reported as typhoid before the death of the patient.

Q. That is true and has been true so far as your judgment is concerned ever since circulars have been issued in St. Louis.

A. Yes sir, I believe that is true ever since.

Q. And is now true?

A. And is now true.

Q. Doctor, supposing that a physician certifies that one of his patients dies of congestive fever, what would yo understand by that term?

A. I should not know. I would fail to give an explanation.

Q. Would you consider the true cause of death to necessarily be typhoid fever?

A. If they pronounced it congestive?

Q. Yes sir?

12538 A. No.

Q. It might be something else besides typhoid?

A. Yes sir.

Q. Suppose a physician certifies that one of his patients dies of typho malaria, or remittent, or intermittent, or malaria, or bilious fever, or simple continued fever or any other of the nondescript fevers sometimes assigned by physicians as causing death, would you consider that such deaths so assigned were caused by typhoid fever?

A. It would depend a good deal upon the physician who returned the cause of death.

Q. When a death is reported as caused by a remittent or intermittent fever, it is not necessarily typhoid fever is it?

A. No sir.

Q. What else may it be?

A. Any of the diseases which have a fever as a symptom.

Q. Such as what?

12539 A. Oh, such as consumption.

Q. Ordinarily called tuberculosis?

A. Yes sir. That would perhaps explain it best for tuberculosis has fever—has a clinical symptom. You may have pneumonia with remittent fever.

Q. Or an intermittent fever?

A. Yes sir, that is possible. Any infectious disease that has fever as a symptom may have a remittent fever type. Meningitis is an infectious disease?

Q. Diphtheria?

A. Yes sir, that may have a remittent fever. It is more apt to be remittent than intermittent.

Q. Suppose the death be reported as being caused by typho-malaria, what would you say to that?

A. I should say that in my judgment there is no such thing as typho malaria. There may be a typhoid plus a malaria, and if he chooses to describe that as a typho malaria, that is his own
choice of nomenclature, but there is no specific organism
12540 to produce it. There must be two organsims, the typhoid
and the malaria organisms. Of course that is possible.

Q. Do infants and old people die of typhoid fever?

A. I think that is entirely possible, yes sir.

Q. Are they as likely to die as middle aged people?

A. If they get typhoid they are more likely.

Q. They are not as likely to get it?

A. They are not as likely to get it.

Q. What influence, if any, doctor, had the opening of the drainage canal on the 17th day of January, 1900, upon you in certifying deaths due to typhoid fever in St. Louis?

MR. TODD: Object to the question for the reason that there is no charge made by the defendant that the opening of the drainage canal has had any effect upon Dr. Fischel in making any incorrect diagnosis, and it is therefore not rebuttal, and that it is immaterial, incompetent and irrelevant.

Q. Question read.

A. I am quite sure that it made me extremely careful of my diagnosis, because naturally I felt that there was
12541 great danger of the sewage of Chicago contaminating our
water supply, and I wanted to make it at least clear to myself whether in my experience that danger existed, and therefore never reported a case as typhoid when the Widal was not positive. And if I may go on, I believe that before that time it was entirely possible that I reported cases typhoid that were not typhoid. Of one such case I have a very clear recollection, when I made the mistake in diagnosis, and the post mortem proved the fact that I was mistaken. I do not think that has happened to me since the opening of the Chicago canal.

Q. Doctor, what effect, in your opinion, has the opening of the drainage canal had upon your profession in St. Louis in the way of influencing it in the reporting of deaths from typhoid fever to the board of health?

MR. TODD: Object to the question on the ground it is incompetent, irrelevant and immaterial.

A. I think it made them more careful.

MR. JEFFRIES: Q. In what way, doctor?

A. In excluding the possibility of death from other
12542 diseases.

Q. In what way does the difference exist now, since the opening of the canal as compared prior thereto in the reporting of these deaths?

A. So far as I know in no way at all. We simply had to report the cause of death, if I understand your question.

Q. In other words, what was the difference in the precautions used in the reporting?

A. At present I report no death as due to typhoid in which the Widal agglutination test has not been found positive. Previous to the issuing of the circular and the penalty which it conveyed to physicians neglecting to report typhoid cases, the cause of death was frequently reported as typhoid when it might have been due to other diseases.

CROSS-EXAMINATION, by Mr. Todd.

Q. And the converse of the proposition is true, is it not, 12543 that many deaths from typhoid were reported as other diseases that should have been reported as typhoid prior to the opening of the drainage canal?

A. I think that is entirely possible. I think mistakes in diagnosis were made before we had the positive test for the given disease.

Q. Then if the typhoid conditions as to deaths in St. Louis prior to the opening of the drainage canal had been made with that same degree of care by the physicians that has been made since, there would have been a larger number of deaths reported than were reported to the health department?

A. I should be inclined to say no to that because after all the rule is that the clinical picture of typhoid is no clearer. We can make a positive diagnosis in the majority of cases without the Widal reaction, and I think therefore that typhoid is more readily recognized than many other diseases that in a way simulate it in a clinical course.

Q. How would you account, Doctor, for the number of deaths under the heading remittent, intermittent, typho-malaria, congestive and simple continued fever as evidenced by the board of health reports prior to January, 1900?

12544 A. That would be purely speculation if I answered that.

Q. Give me your best opinion as a physician in St. Louis?

A. I think many of these cases may have been tuberculosis. Tuberculosis is not always recognized,—the fever symptoms misleading one is accounted for otherwise. It is entirely possible that any one of the diseases which you have mentioned, and which after all mean only symptoms of fever, may have been tuberculosis. However, I know nothing about this—the answer to your question is merely speculative. I know nothing definite about that.

Q. Would not a good many typhoid deaths be classed under that heading?

A. Not now.

Q. Before?

A. Some, but you remember I told you before that typhoid runs a course that is so peculiar to typhoid that the diagnosis of the majority of cases is simple. Some were misdiagnosed and may have been tuberculosis.

12545 Q. It is simple to a physician skilled in diagnosis, but is it simple to the ordinary physician that is turned out from the medical schools during the last ten or fifteen years?

A. As simple as the diagnosis of any disease or as complicated as the diagnosis of any disease would be. It ought to be very simple. Whether it is or not, I do not know.

Q. Taking the number of intermittent and remittent and typho-malaria deaths that have appeared in the board of health reports in the city of St. Louis during the last six or eight years, would you say that those did not represent more typhoid than consumption?

A. I believe they represent more typhoid than consumption. Yes, sir, I think that would represent more typhoid than tuberculosis.

Q. The number of deaths as represented by typhoid would be a very small percentage of those prior to 1900 that would not be typhoid in your opinion, would it not?

12546 A. Yes, I think that is probably correct.

Q. Now, if the circular after the opening of the drainage canal should have an effect upon you, a doctor of recognized standing, in the profession, to be more careful in your diagnosis of typhoid, would it not have an equal effect upon doctors less qualified and competent than yourself, in reporting typhoid cases?

A. I think on the whole it has made the physicians of this city more careful in reporting the typhoid cases.

Q. And if the board of health report should disclose that the number of typhoid fever deaths have increased since the opening of the drainage canal, and the number of intermittent, remittent, typho-malaria, congestive and simple continued fever deaths have decreased since the opening of the canal, that would evidence the effect of that letter after the opening of the canal upon the physicians of the city in making more careful diagnosis not only of typhoid fever, but of other diseases, would it not?

A. It certainly would of typhoid fever and I think of

12547 other diseases. I think physicians are more careful than they have been.

Q. And if that effect is manifest since the opening of the canal in more careful diagnosis of typhoid fever and other diseases, it shows that the physicians prior to the opening of the drainage canal were not as careful in their diagnosis as they should have been?

A. I think in regard to typhoid fever the chief reason for their having become more careful was the penalty attached by the board of health in case physicians did not report typhoid fever.

Q. Do you know of any case of a physician within the last ten years that has been prosecuted, convicted and fined for not reporting typhoid fever?

A. I know of one who has been called to account and that is myself when I did not report a case of typhoid fever because there was absolutely no evidence that satisfied me that the case was typhoid until perhaps three days before the patient's death when the Widal reaction became positive. I was then
12548 summoned before the board of health to give my reasons for not having reported that case as typhoid before. I was not fined for I think my explanation was satisfactory.

Q. Do you know of any other times?

A. I do not know of any other.

Q. Do you know of any case prior to the opening of the drainage canal in January, 1900, where the board of health invoked the ordinances in compelling doctors to report cases of typhoid fever?

A. I do not know from my own knowledge.

Q. Doctor, is it not a fact that the fatality of typhoid fever cases is mitigated largely by the ability of the physicians who attend the cases?

A. That is a mooted question, sir. I should not feel competent to determine that.

Q. What I mean is if you have a competent first-class physician treating a typhoid case, is not that case more likely to recover than if it is in the hands of a less skilled physician?

A. I should say yes.

12549 Q. And the number of deaths from typhoid fever may decrease or increase in a given community, depending upon the skill of the physicians that are handling those cases, other things being equal?

A. Yes sir.

Q. It is necessary for any intelligent physician to know what his patient is suffering from in order to treat him intelligently?

A. Yes sir.

Q. That is the aim of the advanced schools in medicine, to simply diagnose so that the doctors with less opportunity can avail themselves of that broader experience?

A. Yes sir.

Q. And the Widal test is one of the tests that doctors employ for the proper diagnosis of typhoid fever?

A. As early as possible, yes sir.

Q. As early as possible?

A. Yes sir.

Q. There are other symptoms of typhoid fever that a 12550 skilled physician would act upon, even though he did not receive the Widal reaction in the treatment of a typhoid case, would he not?

A. I do not believe that any physician now would be willing to accept the diagnosis of typhoid without having obtained the positive Widal reaction. I should have in mind everything else.

Q. But would your treatment be radically different as long as you had the symptoms to direct you towards the condition of typhoid?

A. I should say no.

Q. Buf you recognize the fact that in other physicians, young men that have limited educational experience, that have gone through medical colleges and just simply been turned out as a great many of them are turned out, would not have the experience in interpreting symptoms that an old practitioner would?

12551 A. Certainly that is true.

Q. And in cases of that kind the patient is the one that suffers?

A. He might suffer; yes sir.

Q. To what would you attribute the number of deaths reported in the board of health reports of the city of St. Louis under the heading intermittent, remittent, typho-malaria, congestive and simple continued fevers, to a faulty diagnosis?

A. In many of these cases certainly, yes sir.

Q. And do you recognize intermittent, remittent, typho-malaria, congestive and simple continued fevers as distinct types of disease?

A. No.

Q. They are terms that have grown up in the profession and are employed today by doctors who are not up with the progress of the medical profession?

A. I think that must be true.

Q. Is not that true?

A. I believe that is true.

Q. And when you find a number of deaths aggregating in the neighborhood of 200 in a city the size of St. Louis, 12552 reported under the heading of intermittent, remittent, typho-malaria and congestive fevers, does not that lead you to the conclusion that there is a great number of doctors in the city of St. Louis, the same as in any other city that are not abreast to the profession?

A. Certainly.

W. E. FISCHEL.

ADJOURNED until 2:15 p. m., same day, May 23, 1904.

12553 2:15 p. m., Monday, May 23, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

DR. LUDWIG BREMER

a witness called on behalf of the complainant, being duly sworn by the Commissioner, was examined in chief by Mr. Jeffries, and testified as follows:

Q. State your name?

A. Ludwig Bremer.

Q. State your residence and profession?

A. 3723 West Pine Street, St. Louis; physician.

Q. How long have you been a practicing physician?

A. About thirty-four years.

Q. When did you graduate and where?

A. I graduated in 1870.

Q. From what school?

A. The St. Louis Medical College, now the Washington University.

Q. Were you then or afterwards connected with the city hospital of St. Louis?

12554 A. Yes sir, I was interne at the city hospital.

Q. Were you in any way connected with the quarantine?

A. Yes sir, I was resident physician of that hospital which was a part of the city hospital. It was then a general hospital which received the superabundant patients of the city hospital. It was not the small pox hospital as it is now.

Q. What was the length of time you were connected with the city hospital?

A. I was there about a year.

Q. Doctor, state whether or not you have ever practiced medicine in the country?

A. Yes sir, I practiced about nine or ten years, general practice in the country, that is, in a small town, Belleville, Illinois.

Q. Have you ever studied abroad?

A. Yes sir.

Q. Where?

A. I studied at Strasburg and Zurich, Switzerland, and Paris.

Q. What subjects did you study there?

A. Internal medicine and pathology.

Q. State whether or not you studied at Berlin?

12555 A. Yes sir.

Q. At Vienna?

A. No sir. I was in Berlin, and in Vienna later on.

Q. Have you ever taught in any medical school?

A. Yes sir.

Q. What subject, Doctor?

A. Histology, pathologic anatomy; microscopy; biology and nervous diseases.

Q. State whether or not you have lectured at the city hospital?

A. Yes sir, I did.

Q. Have you ever made any discoveries, Doctor, with reference to the blood tests for any particular disease or germ?

A. Yes sir, I am credited with the discovery of the blood test for diabetes.

Q. Have you ever written or published any scientific medical articles?

A. Yes sir, a good many.

12556 Q. In your general practice, Doctor, have you treated typhoid fever patients?

A. Yes sir.

Q. State whether or not you have been called in consultation with other physicians in the treatment of this particular disease?

A. Yes sir, I have been called into consultation to make the diagnosis in cases that were suspected of typhoid, especially in the ante Widal days.

Q. Are you acquainted with the Widal test, Doctor?

A. I am acquainted with it, yes sir.

Q. Have you used it?

A. I have used it, I should say not particularly in my own practice, but in order to verify its scientific significance, quite a number of times, a number of years ago.

Q. What in your judgment, Doctor, has been the effect of the use of the Widal test upon the relative number of deaths in typhoid fever in St. Louis since its use as compared to the same period of time prior to the use of the test by the physicians?

A. I do not know of any effect.

12557 Q. What is the purpose of the Widal test?

A. To make an early diagnosis.

Q. What particular advantage in the treatment of the disease of typhoid is obtained by being able to make this early diagnosis?

A. I don't understand.

Q. What particular advantage is there in reference to the treatment of this particular disease in making an early diagnosis and ascertaining at an early stage of the case that it is true typhoid?

A. Well, I should think the earlier one knows that, that has to deal with the case of typhoid, the sooner proper measures were resorted to and the more powerful drugs such as quinine and so on will be avoided.

Q. And therefore the mortality from typhoid will be reduced?

A. Well, I do not know that it would be reduced, but the patient is placed under more favorable conditions for recovery.

Q. Are you acquainted with the medical fraternity in St. Louis, in the profession, in general?

12558 A. I know a good many doctors.

Q. Frequently called in consultation by them?

A. Rather so.

Q. And have been for years past?

A. Yes sir, for a number of years.

Q. Do you attend any medical associations in St. Louis now?

A. Yes sir.

Q. Meetings and conventions?

A. Yes sir, I attend the St. Louis Medical Society, for instance.

Q. Have you been an officer of that Association?

A. Yes sir, I was president.

Q. In those meetings do the physicians of the city discuss the various diseases that they have in their practice?

Mr. Todd: I object to the question as incompetent, irrelevant and immaterial and not proper rebuttal.

A. Are such diseases discussed?

Mr. Jeffries: Q. Yes sir?

A. Why certainly; yes sir.

Q. With reference to typhoid and other infectious disease, is the prevalency of those diseases discussed by the medi-

12559 cal fraternity of St. Louis at these meetings?

Mr. Todd: Objected to for the same reasons.

A. Well, I do not remember that any paper has been read or a formal discussion has been had, but physicians talking socially.

Mr. Jeffries: Q. They talk promiscuously about conditions?

A. Yes sir.

Q. I will ask you to state, Doctor, whether or not since January, 1900, there has been an increase in the death rate from typhoid fever in St. Louis, as you gather it from this professional talk among the members of your fraternity in St. Louis?

Mr. Todd: Object to the question for the reason that it is not proper rebuttal, and for the reason that complainant has gone into the typhoid condition in St. Louis on direct examination, and for the further reason that whatever was said at an informal discussion at a Medical Society is not competent evidence, but purely hearsay, and for the further reason that the question is incompetent, irrelevant and immaterial.

Q. Question read.

A. I gathered from the talk with the physicians and from 12560 hearing my patients talk about it and the cases occurring in their family. I could not state that there has been an increase positively, but that is my impression, that there has been an increase. This is my impression that there has been.

Mr. Todd: I move to strike out the answer for the same reasons given in my objection to the question.

Mr. Jeffries: Q. Now, upon what do you base your impression, Doctor?

Mr. Todd: Object to the question for the reason that the impression of this witness is not competent evidence, and for the further reason it is not rebuttal and therefore is incompetent, irrelevant and immaterial.

Q. Question read.

A. I base my impression upon conversation with physicians and conversation with the relatives of the sick of typhoid fever patients and conversations with druggists.

Mr. Todd: I move to strike out the answer for the same reasons that are assigned as an objection to the question.

Mr. Jeffries: Q. Based upon these conversations which 12561 you have held with the members of your profession, and from what you have learned from them at the various meetings which they held in St. Louis, and upon the conversations that you have had with the druggists and all other persons coming in contact with you as a physician, state, Doctor, what your opinion is with reference to the question as to whether there is or has been an increase in the rate of typhoid death mortality in St. Louis since January, 1900?

Mr. Todd: Object to the question for the reason that it is incompetent, based upon hearsay; for the further reason that complainant went into the question of increase of typhoid fever in the city of St. Louis, in chief, and therefore is not competent in rebuttal, and for the further reason it is incompetent, irrelevant and immaterial.

Q. Question read.

A. I think it is the general consensus of opinion that there has been a gradual increase in the number of cases of deaths from typhoid fever since the opening of the canal.

Mr. Todd: I move to strike out the answer for the reasons given in my objection to the question.

12562 Mr. Jeffries: Q. That is your opinion is it Doctor?

A. It is my opinion, yes sir.

Mr. Todd: I object to the question for the same reason and move to strike out the answer for the same reasons.

CROSS-EXAMINATION

By Mr. Todd:

Q. Doctor, do you know how many cases of typhoid fever were in the city of St. Louis prior to the opening of the drainage canal for a period of four years?

A. I do not.

Q. Do you know how many cases of typhoid fever were in the city of St. Louis during the last four years?

A. I do not.

Q. Have you made any comparison of the typhoid fever statistics of the city health department of the city of St. Louis for the last eight years?

A. No sir.

Q. Is typhoid fever in St. Louis generally distributed in 12563 all localities alike?

A. Not always.

Q. That may appear in some localities more frequent and be absent in others may it not?

A. Yes sir, comparatively absent.

Q. Typhoid fever may be due to local causes may it not?

A. So it would seem.

Q. Is your practice general throughout the entire city or confined to special localities?

A. Throughout the city.

Q. Have you ever taken up this question of typhoid fever in any of your meetings and discussed it with a view of ascertaining whether it is on the increase or decrease?

A. I don't remember that.

Q. That has never been made a subject of discussion at any one of the meetings that you have attended at the associations has it?

A. Not of those that I have attended.

12564 Q. In figuring out the question of increase of typhoid fever based upon your impressions, did you take into consideration the increase in population during the last four years, due to the influx of people here attending the Louisiana Purchase Exposition?

A. I did not take that into consideration.

Q. Would not that be an element to figure out, whether there is an increase or decrease?

A. It might be included as a factor, I think.

Q. Have you observed whether or not, since the Spanish-American war there has been a general increase in typhoid fever throughout the country on account of the returning soldiers from the fever camps at Chickamauga, Tampa, Florida and Mountain Point, etc.?

A. Well, I have read of very severe epidemics, but what part the soldiers play I do not know.

Q. I am not speaking of epidemics. I am speaking of a general rise in typhoid fever throughout the country.

A. I am not aware of it, not personally, not from my reading.

12565 Q. In the diagnosis of typhoid fever do you use the Widal test in all cases that you treat?

A. I never employ the Widal test myself, now. I used it simply for scientific research to find whether there was something in it, when it was new.

Q. Is it a test that is universally adopted by the physicians of St. Louis in the diagnosis of typhoid fever, as far as you know?

A. Yes sir, universally. Well, there may be exceptions.

Q. Why did you abandon it, Doctor?

A. I was at the time very intensely engaged in microscopy and in pathological anatomy and made original investigations. For that reason, when this test was first published, I tried to verify it. Since then I have never had an opportunity or have never had an occasion to use it because there are so many people to do that. At the board of health it is done, and I would not take time for that.

Q. Do the doctors perform this test themselves or turn it over to the board of health of the city of St. Louis to do it for them?

A. There are a number of gentlemen here who have private
12566 laboratories that do it, but I suppose the greater number
of the tests are made at the bacteriological institute, the City Institution.

Q. Do all the older practitioners in the city of St. Louis who are not connected with medical colleges rely upon the Widal test?

A. I do not know.

Q. In the diagnosis of fevers, is it not a fact that the doctors with a few exceptions fail to resort to the Widal test?

A. Is it not a fact that they fail to resort to the Widal test in the diagnosis?

Q. Yes sir, the typhoid fevers?

A. Well, I am not sufficiently familiar with the ways of the general practitioner, and therefore I could not answer that question.

Q. How many doctors have you in St. Louis?

A. It is variously estimated from twelve to fifteen or sixteen hundred.

Q. Among those twelve or fifteen hundred doctors a great

12567 proportion of them are young doctors that have been turned out of the medical schools in the last three or four years, are they not?

A. I do not know the proportion, but I should think there were quite a number, but how many there are I do not know.

Q. In the diagnosis of typhoid fever it requires a skilled physician to make an accurate diagnosis in most cases does it not?

A. I do not know, a general country practitioner that has not had much medical training can make out a case of typhoid fever after the second week, even if that man has not had much medical training. You mean is it very difficult? Well, I say it is not, from the general appearances and the symptoms of the disease; but that is my private opinion.

Q. Doctor, in the diagnosis of malarial fever, does it require a skilled physician to make that diagnosis?

A. Of malarial fever you ordinarily could make a diagnosis easily if it is not complicated. The typical case it certainly does not require a skilled physician.

Q. Do you recognize such fevers as are characterized by
12568 the names intermittent, remittent, typho-malaria, congestive and simple continued fevers as distinct types of disease?

A. They used to be. They are not now.

Q. Are they right now or were they right formerly?

A. Well, what is right and what is wrong, we don't know. Just at the present time such cases as remittent and intermittent and congestive fevers are not recognized any more in the classification, that is in the scientific classification.

Q. Those fevers which are called by doctors as remittent, intermittent, typho-malaria, congestive and simple continued fevers, if diagnosticated according to modern conditions and advanced medical learning would be classified either as malaria or typhoid fever would they not, in the majority of cases?

A. I would not say that with such a precision. I would say that, no doubt, a number of these cases have been typhoid, being entirely unrecognized cases or mistaken cases of ty-
12569 phoid. I do not know what percentage.

Q. So that it is only in exceptional cases that it requires great medical skill to properly diagnose malarial fever?

A. Yes sir.

Q. And that is true of typhoid?

A. True of typhoid, yes sir.

Q. In the absence of the Widal test, what are the symptoms of typhoid fever that are generally recognized?

A. There is the fever curve. Then there is the peculiar drowsiness, and pain on pressure on points in the abdomen, and the eruptions peculiar to typhoid and what is generally called the habitus of the patient, that is, as the impression one gathers from looking at the patient and by the peculiar nature of the feces.

Q. May not a patient have all the symptoms that you have indicated and yet not give the Widal reaction, and still have typhoid fever, all or any one that you mention?

A. May all these symptoms be present by that you mean in combination or single?

Q. Present in patient?

12570 A. And not be typhoid?

Q. And yet not get the Widal reaction?

A. Well, although these symptoms may be present the reaction may be wanting; I mean the positive reaction.

Q. Would the fact that the disease of typhoid fever, if properly diagnosed immediately after the patients contracted the disease reduce the mortality of the typhoid patients?

A. Well, this is a hypothetical question which I do not think I am able to answer.

Q. Is there any specific for typhoid fever in medicine?

A. No sir.

Q. The same as quinine is in malaria?

A. Not that I know of.

Q. In the treatment of typhoid fever patients, it is as much in the nursing and care as it is in the medicine, is it not Doctor?

A. Principally in the nursing.

Q. The cure does not depend upon the medicine that is given does it in a majority of cases?

A. Some doctors are strong believers in medicine. I do not
12571 personally believe much in medicine.

Q. It is a generally recognized fact is it not, that the best treatment for typhoid fever patients is good nursing and little medicine?

A. That is the trend of the present state of medicine.

Q. So that the advantage in making a proper diagnosis of a patient is to prevent the treatment of that patient for some disease that requires medicine which would be to the detriment of the patient if it was given?

A. Yes sir.

RE-DIRECT-EXAMINATION

By Mr. Jeffries:

Q. Doctor, do you remember the slight epidemic of typhoid fever in St. Louis in November and December, 1899?

Mr. Todd: I object to the question on the ground that that has already been testified to by Dr. Ravold and Dr. Teichmann in the original case, and not proper rebuttal, and therefore incompetent, irrelevant and immaterial.

12572 A. I remember it very well.

Mr. Jeffries: Q. State whether or not that epidemic, Doctor, was confined to any particular part of the city?

A. It seemed to be confined to the part of the city where I live, out in the west end. I do not know the number of the districts, it is along West Pine and on Lindell Boulevard, and in that region towards Forest Park.

Q. Doctor, do you know anything about the history of the use of private filters in the city of St. Louis?

Mr. Todd: Object to the question as incompetent, irrelevant and immaterial, and not proper rebuttal.

A. Well, the use of the private filters has increased very materially, on the advice of the physicians.

Mr. Jeffries: Q. Since when?

A. During the last six or seven or eight years. I do not know whether they are still on the increase, but I know that a year or two ago I heard it from the physicians generally they recommended filtered water and boiling the filtered water afterwards.

Q. State in a general way, Doctor, the changes in the

12573 recommendation and the changes in the water that have been brought about by the recommendation of the physicians in St. Louis during your practice here?

Mr. Todd: I object to the question as not rebuttal and therefore incompetent, irrelevant and immaterial.

A. When the fact became generally known among the profession that typhoid fever was principally a water born disease the physicians recommended the boiling of the water and in this city the filtering of water, in order to get rid, presumably, of the germs. There were a good many articles published a number of years ago by the Sunday papers recommending the boiling of water, and I remember that there was quite a crusade against unfiltered water and the physicians were interviewed in regard to the importance of filtering and boiling afterwards, and I know that since in all well regulated households in this city it has been the custom, and I think the invariable custom, 12574 to drink nothing but filtered and boiled water, filtered first and boiled afterwards, and when a case of typhoid arises the question is always asked, did you boil your drinking water, or did you go anywhere where you could get or drink water that was not filtered. I believe that at the present time among educated people, and with even a number of the people of the lower walks of life, that now they know that they have to boil the water in order to protect themselves from causative agents of typhoid fever. I think that idea is pretty generally spread among the population.

Mr. Todd: I move to strike out the answer for the same reasons as stated in my objection to the question.

Mr. Jeffries: Q. State, Doctor, whether or not this education on the part of the people with reference to filtered and boiled water has not been increased and extended considerably within the last three or four or five years?

A. I think it is. I do not know whether it has increased in the three or four last years, but I know this that every physician of common sense, the family physician, recommends 12575 the boiling and filtering.

Q. Today?

A. Today. That is one of the maxims of the medical profession now, and especially since preventitive medicine is given the first place in the practice of medicine. Of late years every doctor is more or less of a hygienist, which they did not use to be in former times, while now, by the teaching of bacteriology in the colleges, hygiene is very much promulgated; and one of the very first things in the practice of medicine is the prevention of infectious diseases, especially in the case of typhoid is this progess that we are talking of.

Q. And this recommendation from a hygienic standpoint on the part of the physicians of St. Louis is one of gradual growth is it not?

A. I think it is.

RE-CROSS-EXAMINATION,

By Mr. Todd:

Q. Are you acquainted with the epidemic of 1892?

A. Yes sir.

12576 Q. That epidemic afforded a stimulus to the physicians to advise the boiling of the water of the Mississippi River did it not?

A. It afforded a stimulus to me.

Q. Did it not afford it to any well informed doctor?

A. Well, I believe it did. To what extent, I do not know, but then there was a crusade in about 1896 or 1897 when bacteriology was a much more recognized branch of medicine than it was at that time; since it was recognized even by the daily press, the papers took it up and that matter became public property.

Q. From 1896 to 1900 the medical fraternity of St. Louis recognized the fact it was unsafe to drink the water in its raw state as supplied to the citizens?

A. There were a good many that did not recognize it, for they looked upon bacteriology as a snare and a delusion.

Q. There are some today that hold to that view?

A. Very few.

Q. There are some?

A. Yes sir.

12577 Q. They still stick to that?

A. Yes sir. I do not know any at the present time but I did in former years.

Q. From 1896 to 1900 it was generally recognized that the water supply of the city of St. Louis was an unsafe water for drinking purposes in its raw state?

A. I should think it was about that time that the suggestion began and since then it has been kept up.

Q. In other words the medical association of St. Louis has kept abreast of the bacteriological researches and the sanitary problems have also advanced on the line of getting a safe, pure drinking water for domestic uses?

A. The medical profession has been gradually improving and with the younger element coming in, the bacteriological truths, or so called truths, have been more and more recognized.

Q. Is it not a fact that the doctors and citizens of St. Louis, since 1865, have recognized the fact that the water supply of St. Louis required filtering?

Mr. Jeffries: Objected to as immaterial.

A. No sir.

Mr. Todd: Q. Do you know that the city council of the city of St. Louis sent a man to Europe, by the name of Kirk-
12578 wood, to investigate the filtration plants of Europe, and
that he came back and published the results of his investigations in the most elaborate work on the subject that is extant today and is recognized by all authors on filtration?

Mr. Jeffries: Object to the question for the reason that it is incompetent in this connection, the city of St. Louis, the City Council and people residing therein not having accepted this report made by this gentleman mentioned in the question, the recommendations of the report, and not having acted upon them.

A. I must plead my ignorance, in regard to the sending of this expert to Europe, but I know in regard to the infection of the water, in the cases that I have read, that not many years ago, and I do not know at present whether there are any such—there were many parties in St. Louis that said that the unfiltered water of the river was healthy and they would not drink it in any other form because the filtered water to them tasted stale and
they wanted it in the natural state, and that has been the
12579 case. I do not know whether they are still in existence,
but five or six years ago there were certainly a good many. Whether there are any now or not I do not know. There

were a good many physicians who didn't believe at all in the filtering of water, but that is a gradual process and now it has reached probably to the climax that everyone believes in filtering and boiling, principally boiling.

Mr. Todd: Q. The medical fraternity of the city of St. Louis recognized the necessity for filtering and boiling the water before 1900, did they not?

A. Oh, yes. Then the sentiment was growing and the education was going in that direction, but that was certaintly not a sudden process. I think it took years to accomplish that in the case of the general public. The public was very conservative.

Q. It took years to stop physicians from bleeding patients?

A. Yes sir.

Q. The water supply of St. Louis has always been turbid has it not?

Mr. Jeffries: Object to the question for the reason it is not competent cross examination.

12580 A. As long as I remember it has been turbid, that is since 1866, but it used to be of a different color. It used to have a sandy complexion, and now it has an inky one. It used to look sandy. That was the Missouri river water, and that had a different taste in the late 60's—it was only water—but then the sewage of the city, from Mill Creek, a little rivulet in the northern part of the city, that polluted the city water, and then came epidemics, and people were afraid to drink it, and it lost its good taste. It lost its good looks too.

L. BREMER.

12581 DR. ALBERT E. TAUSSIG,

a witness called on behalf of the complainant, being duly sworn by the Commissioner, was examined in chief by Mr. Jeffries, and testified as follows:

Q. State your name?

A. Albert E. Taussig.

Q. How long have you lived in St. Louis?

A. All my life.

Q. How long have you been practicing medicine?

A. I have been practicing medicine at my present location for eight years, but I had service in the City hospital previous to that.

Q. How long had you been at the city hospital?

A. One year.

Q. Now, what is your office number?

A. 2647 Washington Avenue.

Q. Where did you receive your education, Doctor?

A. I graduated from the Smith Academy, a branch of the Washington University, in St. Louis, and took the degree of Bachelor of Arts at Harvard University, and then I took
12582 the degree of M. D. at the medical department of the Washington University and served a year as interne at the city hospital, and a year and a half in the University of Berlin, taking both clinical and laboratory work.

Q. That was at Berlin, Germany?

A. Yes sir.

Q. What was the character of your work at the city hospital?

A. I was an interne, served in all the various divisions of the hospital and took everything that came.

Q. State whether or not typhoid fever cases came under your observation at the hospital?

A. Yes sir.

Q. Doctor, what connections have you now in a professional way with any medical college or institution?

A. I am lecturer in medicine and Senior Instructor in clinical chemistry and microscopy in the medical department of the Washington University, and chief of one of the two medical clinics in the same University, and I am on the staff of St. Luke's Hospital.

12583 Q. State whether or not in your general practice in St. Louis that you have been called upon to treat typhoid fever?

A. Yes sir, I have.

Q. Do you have any specialty in your practice?

A. Internal medicine.

Q. And in that is included typhoid fever?

A. Yes sir.

Q. Are you acquainted with the typhoid epidemic that occurred in St. Louis in November and December, 1899?

Mr. Todd: Object to that question on the ground that it is incompetent, irrelevant and immaterial, and not proper rebuttal.

A. I had a number of cases at that time.

Mr. Jeffries: Q. Can you state whether or not this epidemic was general over the city or whether it was localized in a community?

A. It was rather sharply localized, I think in about the central part of what is called the west end.

Q. It was not general over the city?

A. Not general over the city.

12584 Q. Doctor, do you know whether or not the use of private filters in the houses and the process of boiling water for drinking purposes is in vogue in St. Louis or not?

Mr. Todd: Objected to as incompetent, irrelevant and immaterial and not proper rebuttal.

A. Yes sir, both boiling and filters are used a good deal, considerably more, in my opinion, than they were in past years. The use of both of boiling for sterilizing water and filters is steadily on the increase. These families whose regular physician I am, all boil their water. I insist on that and most of them filter their water.

Mr. Jeffries: Q. State whether or not the recommendations which you give in this respect are those that are generally given by the practitioners in your profession in St. Louis?

Mr. Todd: Object to the question for the reason it is incompetent, irrelevant and immaterial and not proper rebuttal.

A. Yes sir, I think practically all physicians advocate that very strongly.

12585 Mr. Todd: I move to strike out the answer for the reasons given in my objection to the question.

Mr. Jeffries: Q. You are acquainted with the advice and recommendations that the profession give to their patients in the city?

Mr. Todd: Object to the question as hearsay and not competent.

A. Those matters are discussed when physicians meet socially and we know pretty well what the others are doing.

Mr. Todd: Move to strike it out for the reasons stated in the objection.

Mr. Jeffries: Q. And from these discussions which you have in the medical associations, etc., what are your observations with reference to the use of private filters and boiling water for drinking purposes?

Mr. Todd: Objected to for the same reasons as heretofore stated.

12586 A. Both boiling and the use of filters are becoming more and more universal.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. State whether or not from the observations and the recommendations which you personally give that these precautions are always observed by the citizens?

Mr. Todd: Object to the question for the same reason.

A. They are not always observed, of course, but one tries to have them observed as well as possible. There are always some people that are careless and others that are careful.

Mr. Jeffries: Q. Are you acquainted with the general use of private filters in St. Louis, about the time that you commenced to practice, as to the number?

A. Not at all; only in a general way. We get a general sort of an impression. I do not know the statistics.

12587 Q. State whether or not you have observed the use of private filters in the private houses in St. Louis have increased during the last four years over conditions existing prior thereto?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. While I have not the statistics, my impression is that they have increased.

Mr. Jeffries: Q. Upon what do you base this impression or opinion?

Mr. Todd: Objected to for the same reason.

A. Simply that a greater number of families about whom I know something have put in filters.

Mr. Todd: I move to strike out the answer for the same reason as stated in my objection to the question.

Mr. Jeffries: Q. Doctor, you received circulars from the city board of health admonishing you to report promptly all deaths from typhoid and other infectious diseases, what effect, if any, did such circulars have upon you in making these reports, deaths or cases?

A. They might make me a little more observant of my
12588 duties where otherwise, if I had a case of typhoid fever I
might neglect to report it as such and the effect would be doubtless, that I should report a greater number of cases of typhoid fever. I do not think it could possibly have any influence on the death certificates that I should write, for that depends upon my own diagnosis. I have to report those. If it had any influence, though I do not think I should yield to the temptation, it might tempt me not to report a case that I had lost as typhoid, if I had neglected to report it as typhoid before death. Do you care for any instance of that kind?

Q. You might, if you care?

A. I had one case of typhoid fever some years ago, in which I did not make the diagnosis until the patient was moribund, so that I had not reported it as a case of typhoid fever. When the patient was dead I put typhoid fever on the death certificate. The next day I got a very sharp note from the health commissioner calling attention to my neglect in not having reported the case before and threatening me with punishment unless I could make a satisfactory explanation.

Q. How many years has it been since this particular in-
12589 stance that you have reference to occurred?

A. Perhaps four or five years or something like that.

CROSS-EXAMINATION

By Mr. Todd:

Q. How long has the necessity for the boiling and filtering of the water in the city of St. Louis, in your opinion, Doctor, existed?

A. I think it always has been a wise precaution to boil the water, or at least since it seemed probable that typhoid was a water born disease.

Q. How long has it been since it has been known that typhoid fever was a water born disease?

A. I do not know. It was a knowledge that has come rather gradually and only gradually spread through the profession.

Q. It has covered a period of over ten years?

A. I am not certain about the dates.

12590 Q. So then the condition that obtained in the city of St. Louis during the last ten years was such as to require the water to be boiled and filtered to prevent typhoid infection?

Mr. Jeffries: Objected to as immaterial.

A. During at least that time it has been a wise precaution.

Mr. Todd: Q. That precaution was emphasized by the epidemic in 1892 when the intake tower was situated at Bissel's Point, and the great epidemic broke out in the city which was directly traceable to the water supply at Bissell's Point?

A. Yes sir, that caused a great many people to begin the systematic boiling of water who had not done so before.

Q. Now, in the letter sent out by the Board of Health in 1900, to the physicians, calling attention to reporting typhoid fever, did not that letter have an influence to stimulate the doctors to more careful diagnosis of typhoid fever?

Mr. Jeffries: Objected to, for it assumes that such a letter was sent out, and the question is not proper.

A. I do not remember very distinctly about such a letter.

12591 I should think that such a letter, if received, might have made a person more careful.

Q. Assume that the chemist to the board of health, Dr. Teichmann, testified in this case that such a letter was sent out to all the doctors, would such a letter stimulate the doctors in St. Louis to a more careful diagnosis of typhoid fever?

A. Those that needed such a stimulus probably might be stimulated. The man that had been in the habit of being careful and conscientious in diagnosing all his cases of typhoid would not be affected. It would certainly have the effect of causing a greater proportion of all cases to be reported, and as I understand it that was the object of the letter, whether it would have any influence on the diagnosis is a very different question.

Q. You understand, Dcotor, that laws are not passed for the purpose of reaching the people that naturally observe the laws, but for those that have a tendency to break them?

Mr. Jeffries: Objected to as incompetent, irrelevant and immaterial.

Mr. Todd: And the same is true of doctors?

12592 Mr. Jeffries: Objected to for the same reasons.

A. Yes sir, I supose that is true. I do not know.

Mr. Jeffries: Object to the question and move to strike it out and also strike the answer out for the reason it is putting a legal proposition to the witness, when he is not a lawyer and therefore not supposed to know.

Mr. Todd: Q. You do not regard doctors as a class different from any other profession as a class, do you, as far as the conscientiousness in the performance of duties is concerned?

A. Yes sir, I think on a whole they are apt to be a little more conscientious.

Q. Do you really think that?

A. Well, there is a certain amount of self sacrifice that is unavoidable in the practice of medicine and I think a man gets to be pretty conscientious on the average. There are some black sheep.

Q. A letter of that kind sent out to doctors who are careless in reporting typhoid deaths would have a stimulus with them in making them more careful in reporting typhoid fevers, would it not?

12593 A. Would make them more careful in reporting typhoid deaths?

Q. Deaths, I mean.

A. The assumption you made, as I understood it, referred to the reporting of typhoid cases.

Q. I am dealing entirely in deaths. If anything is said to the contrary before on the statement, I mean deaths.

A. Do I understand you to say that if a circular had been sent out asking them to be more careful in reporting typhoid deaths, that would have had an effect on the physicians?

Q. Yes sir, in making more careful diagnosis?

A. I do not think that any one could have the nerve to send out a circular asking the physicians to be more careful in reporting the typhoid deaths. He can not unless he makes a diagnosis. Generally, if the patient is dead, he can not make any further diagnosis. Such a letter could only affect the reporting of cases before death. When the patient is dead, that case is closed unless there is a post mortem.

Q. But if a patient who is being treated by a physician for a disease which the physician has wrongfully diagnosed
12594 as typhoid fever or some other disease, if the patient
dies, then his report, whatever they have diagnosticated the case to be, is that not in the absence of post mortem examination?

A. If they are perfectly honest about it, otherwise, as I have stated, if they had a case that at the last moment they recognized as typhoid, and if they had received a letter threatening penalties for failure to report such cases they might be very strongly tempted to report the case as something else on the death certificate.

Q. The diagnosis of typhoid fever, does that require any skill?

A. In a certain proportion of cases it does.

Q. If it should appear in the board of health statistics of the city of St. Louis—

A. May I ask—you said in the diagnosis of typhoid cases?

Q. Cases, typhoid fever cases?

A. Yes sir.

Q. If it should appear in the board of health reports of the city of St. Louis that there were only about 200 cases reported under the head of remittent, intermittent, typho-malaria and congestive fever and simple continued fevers, and it was
12595 not recognized by the advanced physicians in medicine
that these diseases so named are distinct types of disease, to what would you attribute the deaths so recorded?

A. I do not think that any man can possibly tell, assuming to a certain extent that is probably true that a large proportion or a certain proportion of these cases are so diagnosed because the physician in charge does not know what he is about, then I do not think anybody can say what they were. Some were typhoid and some consumption and some probably still other diseases, but I could not say what they were.

Q. If such a proportion of deaths should be wrongfully diagnosed, as intermittent, remittent, typho-malaria, congestive and simple continued fevers, as is evidenced from the board of health reports, would not such a diagnosis reflect upon the ability of the physician sending in such causes of deaths from diseases which could be properly diagnosed, if they had sufficient skill to do it?

A. Assuming that these are not proper causes of death—some of them are.

Q. Assuming that they are not?

A. Why certainly.

12596 Q. Do you recognize intermittent fever as a distinct type of disease?

A. Intermittent fever is rather the name of a symptom than of a disease in itself, a symptom which can characterize a number of different diseases.

Q. Do you recognize remittent fever as a distinct type of disease?

A. The same holds true of remittent fever.

Q. Do you recognize typho-malaria as a distinct type of disease?

A. Typho-malaria is an ambiguous word. It may mean two well recognized diseases, a combination of typhoid and malaria which is rather rare, or it may mean a malaria with typhoid symptoms, with coma and that sort of thing, or again it may mean a fever that probably has been wrongfully diagnosed. It is an ambiguous word.

Q. But if the disease represents, by proper diagnosis, the malarial parasite and the typhoid bacilli present in the same patient, that would be a rare condition would it not?

12597 A. I hear of its occurring perhaps once or twice a year, and probably I get to hear of most of the cases that are recognized. How many remain unrecognized, because not every physician makes a blood examination, can not be stated at all.

Q. What proportion of the physicians in St. Louis make blood examination?

A. I do not know.

Q. Rather a small per cent. of them?

A. No, I think now there are a good many; just what per cent. I have not any idea.

Q. You think fifty per cent. of the doctors practicing in St. Louis go to the trouble of making the blood examination, either the Widal test or the other?

A. I am sure I do not know. Among the physicians whom I personally meet, the per cent. who use the microscope is greater. These are men that do the university work. How many of those physicians that I rarely hear of make such examinations I have not the faintest idea.

Q. Do you regard congestive fever as a distinct type of a
12598 disease, and if so what is congestive fever?

A. In the old days before malaria was accurately diagnosed, the term congestive fever and congestive chill were applied to a disease which almost certainly was pernicious or fatal malaria, and when the term is used correcly that is what it means now.

Q. Do you know of any advanced scholar or authority in medicine today that recognizes congestive fever as a distinct type of disease, and pretends to tell what it is?

A. I have not got my authorities at my fingers' ends, but I am sure that any one who writes on that subject of pernicious malaria would have to mention the fact it was at one time called congestive fever.

Q. I am speaking of the science as it is viewed today?

A. And then what is the question?

Q. Do you know of any one, any expert or authority that recognizes congestive fever as a type of disease, or is able to tell what it means?

12599 A. Well, I think they would all prefer to use the word pernicious malaria as being less ambiguous.

Q. Who are some of the authorities on the question that would use terms of that kind in connection with congestive fever doctor?

A. You mean that would use the term congestive fever?

Q. That is that it would have any meaning to?

A. Well, it would have a meaning for everybody if you used it in that way, because formerly the term pernicious malaria was not used, and the term congestive fever was used. Anybody that knows the history of medcine, when he hears congestive fever mentioned, knows that it is either an old term being used or a term that means little or nothing. It might be either of those things.

Q. Is it not a fact that it conveys no meaning today when employed by physcians to the doctors who represent the advanced authorities in medicine?

A. It is ambiguous as I have stated, because the listener can not know what the speaker means.

Q. Does the speaker himself know what he is talking
12600 about, when he uses the term?

A. Perhaps so and perhaps not.

Q. Who are some of the authorities on fevers and so recognized by the medical profession in this country?

A. It is a little hard to answer that question because medicine does not go by authority. There are a great many first rate men and the men that you hear about and those that one naturally thinks of are those that happen to have written text books.

Q. Well, some of the people that have written text books?

A. There is Osler and Thayer.

Q. Have they treated in their books on congestive fever?.

A. Pernicious malaria.

Q. I am speaking of congestive fever?

A. Well, if that means anything it means pernicious malaria.

Q. I am confining my question to congestive fever?

A. And you mean whether they use the term?

Q. Whether they recognize congestive fever as a term that means anything to them?

A. From memory I should not like to say whether they
12601 use that term in their work or not.

Q. Do you recognize simple continued fever as a distinct type of disease?

A. Personally I am inclined not to, though I recognize that there are men who have practiced longer than I and have seen more fever than I who still do recognize it as a distinct type of disease.

Q. Is it not a fact that the farther away you get from the

Universities of orginal research, such as Johns Hopkins and other recognized medical schools, that the more frequently you come across the terms intermittent, remittent, typho-malaria, congestive and simple continued fevers among the practitioners?

A. I do not know. I should not think so. Of course the less educated the physicians are the more apt they would be to hedge in the matter of a diagnosis in that fashion. Whether there are more here than places in the east where the facilities for medical traning are no better, I do not know.

Q. Is it not a fact that the intermittent, remittent, and simple continued fevers are terms which are employed to 12602 characterize the nature of fevers known as either malaria or typhoid, and are not distinct types of fever so recognized by diagnosticians and clinicians?

A. I think it is likely that in the majority of cases in which these terms are used they are simply descriptive of the symptoms, but they may mean much more than merely typhoid and malaria. A great many diseases might, upon a superficial examination, produce the same sort of an impression.

Q. In the diagnosis of malaria, three distinct types of malaria are recognized by the advanced students of malaria, are they not?

A. At least three.

Q. And in the diagnosis of malaria it requires quite a degree of skill and experience to differentiate between these three types, does it not?

A. Yes sir.

Q. The ordinary practioner, by that I mean a man not connected with a hospital, or a clinician, is not as well qualified to make that diagnosis as the man who has the means at hand for doing it, like the laboratory, is he?

12603 A. Well, that portion of the diagnosis does not require a laboratory. At the medical department of the Washington University for quite a number of years, we have been turning out classes, every member of which has been trained in the ordinary methods of clinical examination, of which the microscopic diagnosis is one.

Q. How long ago has that been?

A. Well, it is a little hard to say but we have been doing it more and more thoroughly every year, but very thoroughly from four to six years.

Q. Then the doctors who were turned out prior to that time are practicing medicine without any facilities for diagnosis that the young man of today has, that is turned out? Is not that true?

A. Yes sir, they have had to acquire that skill either by means of a post graduate course or through their own efforts.

12604 Q. With a class that is turned out of a medical school what proportion of the class goes into post graduate work and what proportion starts out to practice medicine?

A. I should say that less than half went in the post graduate course.

Q. And the other half start out to practice?

A. Yes sir.

Q. So that if in the health statistics of a city the size of St. Louis there should appear in any one year as many as 200 deaths reported by physicians under the heading intermittent, remittent, typho-malaria, congestive and simple continued fevers, that would be evidence in itself of a wrong diagnosis would it not, on the part of the physicians that so reported the deaths?

Mr. Jeffries: Object to the question for the reason it is for the court to say what would be evidence.

A. Well, it is a little hard to answer that question because some of those terms to my mind can not be called diagnosis at all.

12605 Mr. Todd: Q. What would you say a doctor meant when he turned in a death certificate that the patient died from congestive fever—what did he mean by that?

A. Well, he either meant pernicious malaria or he did not know what was the matter with his patient and which of the two he meant I could not tell. If it was a good man that turned it in, a man that I knew to be good, I should assume that he had been using the old fashioned term for pernicious malaria.

Q. In the city of St. Louis do you have any cases of pernicious malaria?

A. Yes sir.

Q. How many?

A. I do not know. I have had occasion to see a number; how many more have occurred I do not know.

Q. Is pernicious malaria the tertian, the quartan or the tropical malaria?

A. That is a question that is still unsettled. It is most apt to be the tropical.

Q. Is it not a matter that has been settled?

A. No sir. There are some first rate observers who still maintain that there are five kinds of malaria, the tertian, the quartan, the tropical and two kinds of pernicious, and that the
two kinds of pernicious malaria are distinct types. I think
12606 the general trend of medical opinion is against that, but
still they have grounds for their belief. It is a question that is still open.

Q. Would the mortality from pernicious malaria in the city of St. Louis, in your opinion, be as high as fifty annually?

A. I could not say. I should be surprised if I learned that from a reliable source.

Q. Are you acquainted with the conditions of Baltimore as compared with St. Louis as to climate?

A. Not in detail. In general I know something about it, but not accurately.

Q. Do you doctors ever diagnose cases as typhoid fever and report the death as such, when as a matter of fact the patient died of something else in the city of St. Louis?

A. Do you mean I know of such a case?

Q. Yes sir.

A. I do not know of any such case, and I do not think I know of anybody who would knowingly do it. We are all apt to make mistakes.

Q. I do not mean that any doctor would diagnose a case intentionally wrong. I am assuming that of all the professions
the doctors are the most conscientious, but do doctors
12607 make mistakes of that kind?

A. I should think it would be conceivable. I do not know of any such case. I should say that that would happen rather rarely. It unquestionably could happen. Ordinarily when a patient dies of typhoid fever, unless it was an infant, the diagnosis is plain. However, I think there must be some cases where the diagnosis remains obscure to the last.

Q. Don't you think there are cases that where patients died of typhoid fever that have been diagnosed as remittent, intermittent and congestive and simple continued fevers?

A. Why, I think it is possible. I do not know.

Mr. Jeffries: You mean diagnosed and reported.

Mr. Todd: Q. You mean diagnosed and reported?

A. When a patient dies of typhoid fever he usually dies of a hemorrhage or a perforation of exhaustion; the disease has dragged on so long it has run through all its phases. It is a pretty poor diagnostician that can not in a vast majority of cases diagnose typhoid under those circumstances. Mistakes in the diagnosis of typhoid fever occur frequently, but chiefly where the disease runs a mild course and the patient does not die.

Q. What other disease could be diagnosed as intermittent, remittent and continued and congestive fevers aside from
12608 malaria?

A. Well, a great many cases of turberculosis are so diagnosed some time or other, and I have seen myself at least two cases of luekemia that were for a number of years diagnosed as malaria.

Q. If the doctors would diagnose tuberculosis under the heading of intermittent, remittent, congestive and simple continued fevers why would they not diagnose typhoid fever under that head, Doctor, the same class of doctors?

A. Oh, they would. You were speaking of deaths?

Q. I mean deaths?

A. I do not think they are very apt to diagnose deaths from tuberculosis under those heads.

Q. What heads would they diagnose tuberculosis under?

A. Ordinarily when a patient dies of that, it is pretty clear.

Q. If a patient dies of leucemia would they diagnose that death as remittent, intermittent, congestive and simple continued fever?

A. Yes sir, that might happen.

Q. What is leukemia?

A. It is a disease of the blood, producing an extraordinarily

12609 great increase in the white blood corpuscles, and accompanied by a swelling of the spleen and very frequently by a fever which may run almost any sort of a course.

Q. Is that a frequent disease, as malaria?

A. No sir.

Q. How does the mortality from leukemia compare with other diseases?

A. Well, al cases of leukemia end fatally.

Q. How does it compare with the deaths in other cases, the number of deaths?

A. I do not know. I have not looked it up.

Q. Do you have many deaths from leukemia in St. Louis, per annum?

A. There is a certain number.

Q. Well, about how many?

A. I do not know.

Q. As many as 100?

A. Well, I hardly think so, but I do not know.

Q. If there should be 100 deaths from leukemia, do you think that out of 100 doctors there would be more than one or two that would fail to diagnose it?

12610 A. Yes sir, it would be very easy to fail to diagnose that.

Q. I am taking the medical profession as it exists in the city of St. Louis?

A. Just how many cases of that would escape diagnosis I can not say. Some would certainly escape and many would be liable to.

Q. What other diseases would be characterized by the terms intermittent, remittent, congestive and continued fever, except leukemia and tuberculosis, if the patient died?

A. Well, almost any fever. I should say that in a considerable number of cases, these terms might mean the grip infection or influenza.

Q. Then when leukemia and tuberculosis and grip are reported as deaths from intermittent, remittent and simple continued fevers and congestive fever, by physicians, that is evidence of the fact of the unskillfullness of the diagnostician in making these reports is it not?

A. Not necessarily. Every one now and then one has a case that dies, and that he has not been able to diagnose. We can write on our death certificates "don't know." We do not want to make it a coroner's case, and you have to put on 12611 some diagnosis, and I suppose one might be tempted to put on a term of that sort, even if he knew it was not very specific, just because his diagnosis was not very specific.

Q. Does that practice obtain generally among physicians in St. Louis?

A. I hope not. I do not think so. I do not really know about that. It has not often been my misfortune to be put in that sort of a quandary.

Q. If the physician should make the mistake of calling tuberculosis leukemia and grip, remittent, intermittent and congestive and simple continued fevers would not those same physicians be liable to call typhoid fever, intermittent, remittent, congestive and simple continued fevers?

A. If they had a case that was obscure to the end certainly. There are cases of typhoid deaths, that remain obscure to the end but they are apt to be less frequent than deaths from those other less typical diseases. There are a great many other 12612 disease that I have not mentioned that might be called remittent, intermittent or simple continued. Any fever might be characterized in that way.

Q. Well, take a first class, up to date clinician and diagnostician, would he be fooled on tuberculosis, leukemia, grip or any of these other distinct disease, and call them intermittent, remittent, congestive and simple continued fevers?

A. I hardly think that any really first rate man would be apt to use those terms, for he would be conscious of their ambiguity.

Q. It is the careless physician that employs those terms?

A. Well, the physicians that are less up-to-date are most apt to use them, yes sir.

Q. And all physicians in St. Louis are not up-to-date?

A. Not all physicians in St. Louis are up-to-date.

RE-DIRECT-EXAMINATION

By Mr. Jeffries.

Q. Doctor, in the case of death, would typhoid fever be more or less likely to be confounded with the nonde-
12613 scripts than such as intermittent, remittent and malarial and congestive fevers?

A. More apt than what? I don't catch the question.

Q. Than grip and leukemia and nephritis?

A. I think on the whole they would be less apt to be confounded with those things than those others which are less typical in their course.

Q. Why?

A. When a patient dies from typhoid fever he usually dies frrom a hemorrhage or a perforation or from a generally exhausted condition, or a few other complications. When those occur in typhoid fever the symptomology is usually so typical in the great bulk of such cases, that the diagnosis can easily be made. The cases that are extremely difficult to diagnose, and they often escape diagnosis, are the cases that are comparatively mild. They are less apt to be typical and give the observer few points on which to base a diagnosis.

Q. That has reference to the cases and not deaths?

A. Yes sir. Those are the cases that do not die.

12614 Q. Would not the Widal test aid you in making this determination, as far as the typhoid is concerned?

A. The Widal helps in making the diagnosis.

Q. That is the obscure cases?

A. Yes sir, there are many cases in which the Widal is unnecessary, for you can make the diagnosis without.

Q. Now, if a practitioner was confounding the obscure typhoid case with malaria, intermittent, remittent and congestive fever, the Widal test would come to his assistance in making the proper diagnosis?

A. Yes sir, no question about it.

Q. Now, then, would this Widal test throw any light upon that case in the event that the patient was afflicted with any of these other diseases, such as leukmia and grip and nephritis?

A. I did not say anything about nephritis.

Q. I mean tuberculosis?

A. Yes sir, in such a case the Widal reaction would be apt to be negative and typhoid could be disregarded as one of the possibilities. Is that what you meant?

12615 That is it exactly.

Q. So then instead of by the use of the Widal test of its being typhoid it may be something else?

A. Oh, certainly, when we do the Widal test in our general work, I should say the result is negative ten times to where it is positive once. As it is comparatively a simple thing to do, the Widal test is made in all cases, where there is the faintest suspicion of typhoid. I do a far greater number of negative Widals than of positive ones.

Q. In that case you have to look to some other source for the disease?

A. Either that or perhaps the blood was taken in too early a stage of the typhoid. At any rate, so far as it goes, a negative Widal speaks against positive diagnosis of typhoid. Usually it means there is something else wrong with the patient.

Q. At what ages are persons most likely to contract typhoid fever?

12616 A. On the whole it is a disease of maturity and middle age, though both the very old and the very young do have it. Just how frequent it is in infancy is still a matter of considerable dispute.

Mr. Todd: Q. In regard to the symptoms of the disease of typhoid, that depends largely upon the skill of the physician that is attending in order to properly interpret that, does it not?

A. Yes sir, the more skillful the physician the less difficulty he would have in interpreting the symptoms of a disease.

Q. Assume that a patient had typhoid fever, and it was wrongly diagnosed as intermittent fever, and the doctor permitted that patient to eat solid food which resulted in perforation followed by peritonitis, would that doctor be skilled enough to say that that patient died with typhoid fever because he happened to die with a hemorrhage and peritonitis?

A. I can not tell because I do not know how skillfull a hypothetical physician might be. It is hard for me to conceive of a man who has a case of fever of an obscure type such as such a diagnosis would presuppose, that lasts for some time, and then ends in death by perforation, and still at the very last 12617 could not diagnose typhoid. I do not know of any such physician. There must be few.

Q. Do you really think there are few?

A. Yes sir.

Q. Are you acquainted with the report made by Dr. Vaughan of the typhoid condition at Chickamauga during the Spanish-American War, in the hospitals there?

A. I read it at the time, but I do not remember it very precisely.

Q. When the physicians diagnosed something like 400 soldiers as being afflicted with intermittent, remittent, typho-malaria and congestive and simple continued fevers, and by a clinical diagnosis conducted by Professor Vaughan of Ann Arbor the 400 turned out to be typhoid fever?

A. No, I did not read that.

Q. If such is the fact as sworn to by Professor Vaughan and also reported to the United States Government?

A. Well, I should say perhaps in a thing of that sort, 12618 with everything crowded, and the physicians worked within an inch of their lives, perhaps they could not give proper attention to diagnosis.

Q. Did you ever know of a case of typhoid fever where the patient was permitted to eat solid food?

A. Yes sir, some of the best men do that. Dr. Shattuck of Boston permits his typhoid patients to eat solid food and he is one of the leaders of the medical profession in this country.

Q. For treatment?

A. Yes sir, he cuts out the most indigestible food, but he permits such patients to eat solid food right along; however, he keeps them quiet.

Q. Is that accepted by experts of the medical profession as the proper food to give a typhoid patient?

A. There is a good deal of divergence of opinion on that point. I should say that perhaps the majority incline the other way, but certainly some of the very good men agree with Shattuck.

Q. If there is a perforation of the bowels of a typhoid patient that causes peritonitis does it not?

A. Yes sir, that is unless the bit of the gut happens to be 12619 lying over the perforation and closes it up. When it is fatal it is because it causes peritonitis.

Q. Is it your opinion that the ordinary doctors, generally speaking, are sufficiently skilled as to make very few mistakes in the diagnosis of the deaths from typhoid fever?

A. Yes sir, I think I can answer that by yes. I think the mistakes must be few. Certainly as compared with many other diseases.

ALBERT E. TAUSSIG.

ADJOURNED until 10:00 A. M., Tuesday, May 24, 1904.

10:00 A. M., Tuesday, May 24, 1904.

12620 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

DR. CHARLES H. GOODMANN,

a witness called on behalf of the complâinant, being duly sworn by the Commiessioner, was examined in chief by Mr. Jeffries, and testified as follows:

Q. Doctor, state your full name, residence and profession?

A. Charles H. Goodmann; 3329 Washington Avenue, physician.

Q. Where were you educated in your profession, Doctor?

A. In St. Louis, and Philadelphia.

Q. Had you previously received an academic training?

A. I graduated at Yale.

Q. What year?

A. 1867.

Q. That is Yale University?

12621 A. Yes sir, it was Yale College at that time.

Q. And what colleges in St. Louis and Philadelphia?

A. At the Homeopathic Medical College of Missouri in St. Louis, and the Hahnemann Medical College in Philadelphia.

Q. How long have you been practicing medicine in St. Louis?

A. About thirty-five years.

Q. Have you occupied a chair in any medical college?

A. Yes sir, I have taught Theory and Practice for about five years at The Homeopathic Medical College of Missouri.

Q. What was your position in that college?

A. Professor of Theory and Practice.

Q. Are you connected with any hospital in St. Louis?

A. St. Louis Children's hospital. I am attending physician and member of the staff.

Q. How long have you been connected with that hospital?

A. Since its foundation, about twenty years any way. Twenty-two years or maybe twenty-three, I have for-
12622 gotten; between twenty and twenty-five years.

Q. Are you a member of any medical Society?

A. State and local, as well as the National.

Q. Have you been an officer of any of the medical societies?

A. City Medical Association.

Q. What was your office?

A. President.

Q. And the St. Louis Medical Association?

A. The St. Louis Homeopathic Medical Association.

Q. Are you acquainted, Doctor, with the disease known as typhoid fever?

A. I have some knowledge of it.

Q. Do you treat that disease in your private practice?

A. I do.

Q. The general practice?

A. I do.

Q. Are you acquainted, Doctor, with what is known as the Widal test?

12623 A. Yes sir.

Q. Do you use that in your practice?

A. I do.

Q. Doctor, what is the real object of the Widal test?

A. To establish the diagnosis.

Q. With reference to the particular disease known as typhoid fever, what is the necessity of obtaining a diagnosis?

A. Because it might be confounded with other diseases in the beginning.

Q. And the real object is to obtain an early diagnosis?

A. An early diagnosis, in order to secure a proper treatment of the case.

Q. Is typhoid fever such a disease as requires early treatment in order to better insure favorable results?

A. Yes sir, I think so.

Q. Doctor, taking into consideration the fact that by the use of the Widal test an early diagnosis may be made which will determine whether or not the disease is true typhoid, and taking also into consideration the fact that typhoid is a 12624 disease which if treated in its early stages is less likely to become fatal, what effect, if any, has this Widal test had upon the typhoid mortality cases or list?

A. I think it has enabled physicians who have had those cases to distinguish between deaths from typhoid and deaths from other causes.

Q. Cases of death?

A. Cases I mean.

Q. By reason of this ability to give proper early treatment, has it had any effect in lessening or increasing the number of deaths from typhoid in your judgment?

A. I think it has enabled physicians perhaps to place the causes of death to typhoid that possibly they might not have done otherwise.

Q. Would it not also have enabled physicians to have ascribed deaths to some other cause than typhoid?

A. Yes sir, that is true too.

Q. And therefore to have eliminated deaths as caused by typhoid from the typhoid list?

A. Yes sir.

12625 Q. Going back now, Doctor, to the results that are actually obtained by reason of the physician being able to treat the case as typhoid in the earlier stages of that disease, state whether or not in your opinion this earlier treatment upon the part of the physicians who have used the Widal test has brought about conditions which resulted in a less number of deaths from typhoid than would have resulted had the Widal test not been used, and the cases treated alone, without the knowledge on the part of the physician as to the true disease with which the patient was afflicted?

A. Do you mean the recognition of the disease or the mortality?

Q. I mean being able to recognize the disease in its earlier stages, the physician has been enabled to give the patient such treatment which otherwise would have been a malignant case?

A. I believe that.

12626 Q. And therefore the death rate would be, by means of the use of the Widal test, as the fatality of the typhoid has been somewhat reduced?

A. Yes sir, I believe that.

Q. Doctor, state whether or not the Widal test as a general proposition is used for determining the cause of death, or to aid the physician in making an early diagnosis of the case?

A. In making an early diagnosis.

Q. State whether or not as a general proposition when a patient dies of typhoid fever there is any difficulty in making out the cause of death?

A. No sir, not as a general thing.

Q. What is your reason, Doctor, for stating as a cause of death from typhoid fever there is very little trouble in properly diagnosing the cause of that death?

A. That might be a matter of experience. I do not think I should have any trouble in diagnosing a case that had died of typhoid fever, after death, if I had the history of the case, and the general run of the symptoms, such as the continuance of the
fever, the duration, the temperature curve, and the at-
12627 tending symptoms that go with it. I believe I could
diagnose a case of typhoid fever even without the test, after death.

Q. Are not the symptoms of the patient, a few days before death, such as would enable the ordinary physician to determine it was typhoid, if the patient died with the disease?

A. Yes sir, if he died with the disease. Then I should include under the general run of the symptoms the course of the symptoms.

Q. Doctor, what effect has the fact that letters and circulars have been sent out to you by the health department of

St. Louis, asking you to report promptly all deaths from typhoid and other contagious diseases had upon you in making these reports?

MR. TODD: Object to the question for the reason that it is not rebuttal and therefore incompetent, irrelevant and 12628 immaterial, and no charge is made against this physician in defendants' case.

A. It made no difference at all with me.

MR. JEFFRIES: Q. Are you acquainted with the members of your profession in St. Louis, generally?

A. Pretty generally.

Q. Have you heard them discuss in a general way the fact that they had received these circulars, and that the circulars had been sent out, of the character mentioned?

A. No sir.

Q. What effect had the opening of the drainage canal had upon you in making these reports?

MR. TODD: Object to the question for the same reasons as heretofore stated.

A. None at all. I simply watched with curiosity to see what the increase in typhoid might be at the time, but I do not even remember now what the results were.

Q. State whether or not in conversation with the members of your profession in the meetings and societies which 12629 were held, that it was generally discussed among the members of the fraternity that they should be very prompt in the future in sending out these reports from the health department?

MR. TODD: Objected to for the reason that whatever took place in any of the societies of doctors is not competent evidence and is not rebuttal of anything that has been introduced in defense and is therefore hearsay which makes it incompetent, irrelevant and immaterial.

A. No, I heard no such discussion at all.

MR. JEFFRIES: Q. Doctor, are you acquainted with the development in the recommendations on the part of the physicians and the use of domestic filters in the city of St. Louis?

MR. TODD: Object to the question for the same reason that it is not rebuttal and is therefore incompetent, irrelevant and immaterial.

12630 A. Yes sir, in a general way. During the times that we have had epidemics or had an increase of typhoid fever here, there has been a general upheaval in the families where I visit, and a great deal of talk about the water being a source of typhoid fever, and physicians recommend filtration at first, and then that did not seem to satisfy the people, and they were advising them to boil the water and that was done, and it did create quite a little talk I know among my own circle of patients. I was appealed to a number of times to know what they should do, whether filter the water or boil it, and it did create some discussion at two or three periods where we had an increase of typhoid here.

MR. TODD: I move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. State whether or not the physicians generally throughout the city of St. Louis recommend to their patients and families under their care the filtration and boiling of water?

MR. TODD: Object to the question for the same reasons as heretofore stated. 12631

A. Yes sir, they did so far as my acquaintance with the physicians goes.

MR. TODD: I move to strike out the answer for the same reason.

MR. JEFFRIES: Q. Is it not a fact, Doctor, that this recommendation on the part of the physicians of St. Louis is more general now than it was six or eight years ago?

A. Yes sir.

MR. TODD: I object to the question for the same reasons as heretofore stated, and move to strike out the answer for the same reason.

MR. JEFFRIES: Q. State whether or not it is a fact that the domestic filters are in more general use now than six or eight years ago?

MR. TODD: Object to the question for the same reason as heretofore stated.

A. Unquestionably so.

MR. TODD: I move to strike out the answer for the

12632 same reason.

MR. JEFFRIES: Q. State whether or not the boiling of water is more generally practiced now than it was six or eight years ago, for drinking and domestic purposes?

MR. TODD: Object to the question for the same reasons as heretofore stated.

A. It is.

MR. TODD: Move to strike out the answer for the same reasons.

MR. JEFFRIES: Q. Doctor, state whether or not domestic filters have proven satisfactory in all events?

MR. TODD: Object to the question for the same reasons as heretofore stated.

A. So far as the mere clearing of the water is concerned, they are satisfactory, but as to the clearing it of the germs or rendering it any more safely drinkable, I have my doubts.

MR. TODD: Move to strike out the answer for the same reasons.

MR. JEFFRIES: Q. Doctor, are you acquainted with what is known as the epidemic in November and De-

12633 cember, 1899, in St. Louis?

A. I am.

Q. That was a typhoid epidemic?

A. Yes sir.

Q. Do you know, Doctor, whether or not that was localized or general throughout the city?

A. Localized.

Q. In what locality did that epidemic occur?

MR. TODD: Object to the question on the ground that the epidemic of 1899 has been gone into in chief by complainant's witnesses, and it is not rebuttal of anything that has been offered by the defendant, and is new matter as far as this rebuttal evidence is concerned, and is incompetent, irrelevant and immaterial.

Q. It was in the west end portion of the city.

MR. TODD: I move to strike out the answer for the same reasons stated in the objection to the question, MR. JEFFRIES: Q. Did it extend to any other portion of the city?

12634 MR. TODD: Object to the question for the same reasons as heretofore stated.

A. Not in general. It was a subject of remark at the time that it was confined to the west end, in the better resident portion of the city.

MR. TODD: Move to strike out the answer for the same reason heretofore stated.

MR. JEFFRIES: Q. In other words, physicians expressed surprise that it was not general?

A. Yes, it was not general.

MR. TODD: Object to the question as leading and incompetent, irrelevant and immaterial, and move to strike out the answer for the reasons stated.

MR. JEFFRIES: Q. Doctor, at what age are people most susceptible to typhoid fever?

A. From ten years up.

Q. Do children and old people—are children and old people as subject to that disease as middle aged people?

A. Not as far as I have observed.

12635 Q. State whether or not, Doctor, typhoid is more prevalent in this latitude during the summer months or the winter months?

A. Of the two seasons I should say, if you express it that way, the winter months. We have it more in the fall or early spring, although the worst cases I have seen personally have been in the middle of winter.

Q. As a general proposition it is in the warmer seasons?

A. Yes sir, the change of seasons, summer to fall and spring to summer.

CROSS-EXAMINATION, by Mr. Todd:

Q. Doctor, are homeopathic physicians regarded as physicians in good standing?

MR. JEFFRIES: Object to the question.

MR. TODD: You have one witness on your side that swore they were not, and I wanted to prove they were.

MR. JEFFRIES: It was drawn out on cross-examination. It was his individual opinion.

12636 A. That is a hard question to answer, Mr. Todd, because there is so much involved in it. By the more liberal men of the opposing schools, I believe that they today have a proper recognition. Among the mass, I believe they are not so regarded.

Q. By the mass, what do you mean?

A. I mean the average physician, the old school physician. That is where the opposition comes from.

Q. Do you mean the alopaths?

A. I mean the alopaths, the alopathic schools of medicine.

Q. In homeopathy, the diagnosis of disease is based upon the totality of the symptoms?

A. Entirely.

Q. And in the treatment of diseases, the symptoms are treated?

A. Certainly; that is the basis of our prescriptions and the totality of the symptoms, for the treatment as well as the recognition of the disease.

Q. Do homeopathists recognize the germ theory of disease?

12637 A. They are divided on that.

Q. In what way, Doctor?

A. Some assert that the germ is the result of the disease and not the cause of it, or an accompaniment of the disease and not the cause of it.

Q. Is that view held exclusively by homeopathists?

A. No sir, I have seen statements in old school journals that certain members hold to that belief too.

Q. When you state that you would have no trouble in determining a death from typhoid fever, do you mean that the determination of typhoid fever deaths is a matter that all physicians, that any persons, regardless of their qualifications, so long as they possess a license to practice medicine, can determine?

A. That might be assuming a good deal for myself.

Q. I am asking you for your opinion as a doctor?

A. No, I do not think—

Q. Without fear of offending the fraternity?

A. I do not care anything about the fraternity, but I do believe that a young practitioner, a man who had a lim-
12638 ited experience, possibly could be mistaken. It is only an individual opinion of mine, that I might be able to recognize it.

Q. Do you believe that experience is valuable to a doctor in diagnosing typhoid fever?

A. I do believe experience is.

Q. In the number of doctors turned out from our medical schools, what proportion enter practice with any clinical experience in hospitals?

A. A comparatively small proportion.

Q. Would not the doctors that are turned out from our medical colleges be truer diagnosticians if they had supplemented their medical education by an experience in hospital work?

A. Undoubtedly.

Q. When a young doctor starts out to practice medicine and has had no experience in hospital work, in carrying cases of typhoid fever from their inception to the convalescent stage, how are they able to properly diagnose a case of typhoid fever except by mere pictures in the medical books, with a case?

A. They can not in any other way.

12639 Q. Is it not the common experience of older physicians that young doctors when turned out of a medical college while they are able to pass the examination from the text books, are inexperienced in the treating of cases?

A. That is undoubtedly so.

Q. Inexperienced?

A. Yes sir.

Q. Doctor, when you mean that any ordinary physician can diagnose a death from typhoid fever, do you include in that men of equal standing with yourself, or the young men that have gone out from the medical college without any hospital experience in the last five or six years?

A. Only men of equal standing with myself.

Q. It is a difficult matter for the very best of doctors to diagnose a case of typhoid fever, is it not?

A. At times.

Q. Are you acquainted with Senator Hanna's case?

A. Only what I have read in the paper about it and that was very desultory.

Q. He had typhoid fever three or four weeks before it was pronounced so by the leading doctors that treated him?

12640 A. Yes sir.

Q. In the beginning there was a difference of opinion as to whether or not he had typhoid, is that not true?

A. Yes sir.

Q. And if a case of typhoid fever would confound men of the standing of those doctors, is it not reasonable to suppose that among the ordinary practitioners in the city of St. Louis that cases of typhoid fever would confound the local doctors?

A. Yes.

Q. Do you recognize as a distinct type of disease intermittent fever?

A. Yes.

Q. Do you recognize, as a distinct type of disease, remittent fever?

A. I do not.

Q. Do you recognize typhoid malaria as a distinct type of a disease?

A. I do not. That is a term that is very obscure. I do not recognize that as a distinct form of disease.

12641 Q. Do you know of any case that came under your experience where the malarial parasite and typhoid germ have been found in the same patient at the same time?

A. Not in my own personal experience.

Q. Do you recognize congestive fever as a distinct type of a disease?

A. No sir, I do not.

Q. What does the word congestive fever convey to your mind?

A. I should understand that form of fever which might be characterized by local congestion of any portion of the body that was subject to it.

Q. Do you recognize simple continued fever as a distinct type of a disease?

A. No. No sir, I do not.

Q. These terms are characteristic of certain diseases rather than the diseases themselves, is that not right?

A. That is true.

12642 Q. It may be typhoid, it may be malaria, or some other disease which has a remittent, intermittent, congestive or continued fever symptom?

A. Yes sir.

Q. What other diseases are as prevalent in the city of St. Louis as malaria and typhoid, which possess these symptoms?

A. None that I know of.

Q. You would not regard trichinosis as a prevalent disease in the city of St. Louis, would you, Doctor?

A. No sir.

Q. In the diagnosis of tuberculosis, is there any more difficulty in diagnosing that disease than the disease of typhoid fever?

A. You mean in the early stages?

Q. From its beginning to its fatality?

A. No sir.

Q. Would a doctor be more likely to confound tuberculosis with typhoid fever than typhoid fever with tuberculosis?

A. I do not see how he could do that.

Q. Would the inexperienced physician, without hospital training, be liable to confound typhoid fever with malarial fever?

12643 A. He might; yes sir.

Q. You stated that you were acquainted with the epidemics in the city of St. Louis?

A. I am.

Q. Have you studied the mortality statistics of the city of St. Louis?

A. No sir, not to any extent.

Q. If in the health reports of the city of St. Louis there should appear tabulated as deaths occurring from intermittent, remittent, typho-malaria, congestive and simple continued fevers, a number of deaths in excess of the number of deaths from typhoid fever, and as you stated you do not regard intermittent, remittent, typho-malaria, congestive and simple continued fevers as distinct types of disease, what, in your opinion, did the people so charged with dieing under that head of remittent, intermittent, typho-malaria, congestive and simple continued fevers die of?

A. They might have died of typhoid fever. They must have been confounding the terms, or confounded the
12644 diagnosis of cases, I should think.

Q. Do you know of any such fatality from malarial fever as to justify placing those deaths under the head of malarial fever?

A. No sir, I do not.

Q. You are acquainted with the epidemic of 1892, are you not?

A. 1892?

Q. When the contagion is supposed to have come from Bissell's Point Creek up above the waterworks?

A. Yes sir, I remember that.

Q. In 1891, the year before that, there were 165 deaths in the city of St. Louis from typhoid fever, and 296 deaths under the heading intermittent, remittent, congestive, typho-malarial, and simple continued fevers; in 1892, the year of special epidemic, there were 441 deaths from typhoid fever and 326 deaths from intermittent, remittent, typho-malarial, congestive and simple continued fevers; in the year 1893, following the epidemic there were 215 deaths from typhoid fever and 284 deaths from intermittent, remittent, typho-malaria, congestive and simple continued fevers. Comparing the number of deaths from typhoid with the number of deaths from intermittent, re-
12645 mittent, congestive, typho-malarial, and simple continued fevers, do not those statistics show that the doctors in reporting typhoid conditions in the city of St. Louis reported cases of typhoid deaths under the remittent, intermittent, typho-malarial, congestive and simple continued columns?

A. Yes sir, I believe they did at that time.

Q. That was before the day of the Widal test?

A. Yes sir.

Q. Then the board of health reports showed that in 1894 there were 171 deaths from typhoid fever and 179 deaths under the typho-malaria column; in 1895 there were 107 and 135, respectively; in 1896 there were 106 and 177 respectively, in 1897 there were 125 and 172, respectively; in 1898 there were 95 and 134, respectively. In the number of deaths appearing as being reported by the physicians of St. Louis to the health department under the heading of intermittent, remittent, typho-malaria, congestive and simple continued fever be accounted for in any other way than that typhoid fever deaths were wrongfully diagnosed as something else, and so reported, in your opinion, assuming that the figures that I have quoted have 12646 been sworn to and verified as true in the record in this case?

A. Well, so far as they are true, I certainly do. On the supposition that these figures were correct, I will say that the reports may have confounded diseases. Those that were reported as typho-malaria might have been typhoid, or typho-malaria, congestive, remittent or intermittent.

Q. But assuming that these statistics which I have quoted are properly compiled from the reports of physicians placed in the health department of the city of St. Louis, and published in their official reports?

A. Yes sir.

Q. And assume that the board of health of the city of St. Louis only had the compiling of the statistics, not making out the diagnosis—that came from the doctors—can 12647 the number of deaths reported under the heading intermittent, remittent, typho-malaria and congestive fever column be accounted for in any other way than that typhoid fever has been wrongfully diagnosed under these various headings?

A. No sir.

Q. In the year 1899, since the Widal test—if in those same health reports that have been verified here in evidence and admitted without question on both sides, there should appear 101 deaths from typhoid fever and 148 deaths under the typho-malaria group, notwithstanding the Widal test, can you account for the 148 deaths from typho-malaria under any other supposition than that typhoid fever has been wrongfully diagnosed under some of these different headings?

A. No, I can not unless that possibly those physicians might have been mistaken in their diagnosis and not used the Widal test.

12648 Q. Is the Widal test used by all the doctors practicing medicine in the city of St. Louis?

A. It is used by some. I do not believe it is used by all.

Q. Eliminate the doctors in St. Louis connected with hospitals and medical schools and medical associations, do you believe that the rest of the doctors employ that test in the differentiation of disease?

A. I can not answer that. I do not know, but I believe all reputable physicians, by that I mean physicians of any standing, who have a practice among intelligent people, do. I think they are compelled to do it.

Q. But the medical profession is like any other profession it has men that stand prominently at the top in St. Louis?

A. Yes sir.

Q. Then comes the next strain of doctors?

A. Yes sir.

Q. And then the lower strain, that is where the greatest number are found, is it not?

A. Yes sir.

Q. Now, in 1900 a circular letter was sent out by the health department to all the physicians?

12649 A. Yes sir.

Q. At the time that that circular was sent out, do you remember of the public press of the city discussing the question of the opening of the drainage canal and its effect upon the public health of the citizens of St. Louis?

A. No sir, I can not remember the dates. I know there was such a discussion, but I can not recall whether it was at that particular time or not.

Q. About the time of the opening of the canal?

A. Yes sir.

Q. The canal was opened on January 17, 1900?

A. Yes sir.

Q. Now, while that letter had no effect upon you, are you prepared to state that it had no effect upon any of the doctors that practiced in the city of St. Louis?

A. No sir.

Q. If you would compare the typhoid condition for four years before the opening of the drainage canal with the typho-

malaria condition with the four years since the opening of the
canal with the typhoid, malaria condition, which I will
12650 read to you, as the figures taken from the board of
health reports and sworn to as follows:

	Typhoid fever.	Typho malaria.
1896	106	177
1897	175	172
1898	95	134
1899	131	148
1900	168	112
1901	198	80
1902	222	102
1903	288	91

After considering the typho-malaria column for four years previous to 1900 and the typho-malaria column for the four years subsequent to 1900, the typhoid death column for the four years previous and the four years subsequent, can you account for the decrease in the typho-malaria column and the increase in the typhoid fever column in any way except that the fevers which had heretofore been diagnosed as intermittent, remittent, typho-malaria, congestive and simple continued fevers have been
diagnosed as typhoid fever and placed in the typhoid
12651 fever column, when heretofore they were placed in the
typho-malaria column prior to 1900?

A. No sir.

Q. Would you say, interpreting this statistical deaths from the St. Louis health reports, that if a letter had been sent out by Dr. Teichmann, who was connected with the city health department to all the doctors in the city, asking for a report on typhoid fever cases and mortality, under penalty, that the effect of such a letter is not manifest in the statistics that are published by the city of St. Louis health department?

MR. JEFFRIES: Object to the question for the reason it is for the court to determine whether it is manifest and not for this witness.

A. Yes sir, I think if there was a penalty, the doctors would make a report accurately.

MR. TODD: Q. And does that report manifest itself in your opinion in the statistics?

MR. JEFFRIES: Objected to for the same reason.

A. Was there to your knowledge, if I may ask you a question before replying, any penalty attached in that circular letter? I do not recall such a one as that.

12652 MR. TODD: Q. According to the testimony of Dr. Teichmann, such a letter was sent out calling attention to the provision of the ordinance that contained the penalty.

A. If that was sent at the time, I do not believe, as stated before, that that letter made any particular impression on the physicians at all, and from what I know of it personally. and the physicians, I can not see how that would influence the physicians at the present time.

Q. Then how do you account, Doctor, for the large number of cases of reported deaths for four years previous under the typho-malaria, intermittent, remittent, congestive and simple continued fever columns and the small number since 1900?

MR. JEFFRIES: I object to the question for the reason that there is no evidence showing that any such number of cases was ever reported to the board of health, certainly not on the part of the complainant.

MR. TODD: In reply will state that Professor Jordan testified to the figures which I am using as coming from the official reports of the board of health of the city of St. Louis and by an agreement between counsel for complainant and counsel for defendant the board of health reports were not questioned as to their admissibility, and that they were not 12653 required to be verified by counsel, and the record in this case will show it, and the statement by counsel that objects that he offered no objection as to the fact that they were the official health reports of the city of St. Louis.

MR. JEFFRIES: In reply to the statement of counsel I will say that as to the number of deaths from typhoid fever reported in the published health reports, and which was referred to by complainant, no question was made as to the authenticity or correctness thereof, and that as to the introduction of the records showing the number of cases of remittent, intermittent, simple continued fever, no objection was made to the introduction of the published health report as such, but no agreement was ever entered into or made by counsel for complainant

that what is shown in such report represented true conditions in the office of the board of health of the city of St. Louis, and in the mortuary office thereof, and counsel at the time that Professor Jordan and other witnesses for defendant were
12654 testifying specifically asked each of these witnesses if they did not obtain that information with reference to the remittent, intermittent, simple continued and congestive fevers from the published health report and that they had not at that time or at any other time examined the original books in the office of the board of health of the city of St. Louis and particularly the mortuary office thereof.

MR. TODD: For the information of counsel, and to call the attention of the court to the fact when Dr. Teichmann was on the stand, I had him identify the official records of the health department of the city of St. Louis and offered them in evidence as an exhibit for identification and it was then and there agreed by counsel for both sides, as the record will disclose what agreement was entered into in regard to the health reports. When counsel for complainant made use of the health report it was objected to, and if the objection urged by counsel for complainant against the defendant in this case is valid then the defendants' objection is equally good or valid against complainant, and all these matters appear in the record in this case.

12655 MR. JEFFRIES: I will state that the offer was made and no objection was made to the formality of the introduction of the health reports so far as it related at that time to typhoid fever, by counsel for the defendant. No offer was made at that time to make any showing as to the number of deaths that had occurred from any other disease or any disease other than from typhoid fever and while in truth and in fact the original books in the mortuary office of the board of health disclose conditions that, if anything, are against complainant so far as is displayed in the published health report, yet we are willing to concede and do concede that point to the defendant so far as typhoid fever is concerned, as made by the counsel, that no agreement has ever been made upon the part of the complainant with respondent to the correctness of the figures set out in the published report of the board of health upon the total number of deaths reported or carried for the various years for remittent, intermittent, congestive and simple continued fevers, or any other disease than typhoid fever.

MR. TODD: Why complainant did not offer in his case the number of deaths under intermittent, remittent, typho-malaria, and congestive fevers is patent to the court and 12656 needs no remark from me. As far as I understand that the board of health reports published by authority of the city health department would be permitted on the part of defendant to use those reports without the necessity of verification, I contend that such an agreement was made, and the record in this case will disclose it, and if it was not put into the record I still assert that such an agreement was made, whether it is repudiated or not, is another question, but I am satisfied that the records will show at the time that these books were used, such an admission by counsel and the purpose and objects conceded by him as to the use that defendants could make of these reports.

MR. JEFFRIES: In response to what counsel has said, I will say that at the time that the published health reports of the city of St. Louis were introduced for the purpose of showing the total number of deaths occurring in that city during the various years, from typhoid fever, that the original mortuary records had been compared with their health reports by the State of Missouri for the purpose of determining whether or not the facts set forth in that report, so far as typhoid fever is concerned, was correct, and finding that it was correct in 12657 that report, the published report, because it was more convenient to do so. Then as to the question of remittent, intermittent, typho-malaria, congestive and simple continued fevers and other diseases, they were injected into this case by respondent, were not referred to by the complainant and there would have been and was no objection at the time of the introduction of the typhoid statistics and making that examination or comparison for the purpose of determining the accuracy of the published health report, and that the admissions that have been made in this case so far as the published board of health reports are concerned, bearing in mind that they were admitted at the time as evidence as to typhoid conditions were being considered, that the agreement went only to typhoid conditions, and the complainant having no idea at the time that any other disease would be brought into consideration defendants not having raised the point that they are now raising, did not, as heretofore stated, make a comparison of the original record with the published record, and during the course of the examination of the defendants' witnesses specifically called their attention to the fact that they were testifying from the 12658 published reports, and asked them each that question, and they each answered that they had never seen and never examined the original records with reference to these nondescript diseases in the mortuary office of the city health department of the city of St. Louis, and I make this statement in order to show to the court and to counsel that I am not undertaking to take advantage of him, as he seems to contend in his statement.

MR. TODD: In reply will state that aside from any agreement of the kind or character, I contend that the published official reports of the board of health of the city of St. Louis is competent evidence, and as such have been employed by the defendants in this case.

MR. JEFFRIES: I will state that while under circumstances they might be competent, yet they are never conclusive evidence of anything stated therein, nor are they under any circumstances the best evidence.

MR. TODD: Counsel for defendant submits it is a matter for the court to pass upon.

Q. Question read.

A. Mistaken diagnosis.

12659 MR. TODD: Q. In what way was the mistake in diagnosis in your opinion?

A. Classifying those diseases under typho-malaria that were probably typhoid.

MR. JEFFRIES: Q. Doctor, are not those diseases known and recorded as intermittent, remittent, typho-malaria, congestive and simple continued fevers confounded with other diseases than typhoid?

A. Yes sir, they could be.

Q. And more particularly is that not true with reference to these inexperienced and young physicians which Mr. Todd has referred to?

A. Yes sir.

Q. But, Doctor, a young physician is not able to diagnose a true case of typhoid fever as typhoid; is he not just as liable because of his inexperience to attribute the cause of death to a various number of diseases as to one particular disease?

A. Certainly.

Q. Then if a young and inexperienced physician with the well known fact which is taught in all of the medical books and journals and profession that typhoid disease is such a 12660 disease that when death occurs its symptoms are generally well known and are well to be observed within the last two or three days prior to death then any young and inexperienced physician would be more liable to report that death as true typhoid than he would as intermittent, remittent, congestive or simple continued fever?

A. I believe that would be true of the more recent graduates from the medical colleges, since they have raised the standard of education and extended the course from two to four years, I think they are better fitted to diagnose disease than the graduates prior to that time who had only a two year course.

Q. Is it not a fact, Doctor, that the disease known as typhoid fever, when it becomes fatal, as a general proposition, has such symptoms that an honest, intelligent, progressive physician can without much difficulty determine the cause?

A. Yes, I should think he could, if it were so pronounced as that.

Q. As a general proposition does it not become very pronounced in case of death?

A. Yes sir.

Q. Is it not generally true that when there is a confounding of cases in the diagnosis, and when physicians are unable to determine with precision the character of the disease, 12661 that such inability and such confounding generally occur in cases of typhoid rather than in deaths from typhoid?

A. Yes.

Q. As a general proposition, Doctor, is it not true that when families in St. Louis, of the intelligent class, and the general run of people in St. Louis, when they have a member of the family afflicted with the disease that takes them so low unto death as typhoid fever that they secure the advice of competent physicians?

A. That is generally supposed to be so, yes sir.

Q. Doctor, in the case of Senator Hanna, there is no question but what he died of typhoid fever, is there, in the mind of the general public?

A. I think not. I believe that is the generally accepted opinion.

Q. For the last three days prior to his death there was no question as to the diagnosis of the disease?

A. I believe not according to the statements.

Q. And that is equally true in all cases of death from typhoid?

A. As pronounced as that, yes sir.

12662 Q. If Senator Hanna had been afflicted with a light attack of typhoid fever, it then would have been possible, might it not, for him to have recovered, without the physicians ever having known the true disease, that he was afflicted with?

A. Yes sir, that is a possible case.

MR. TODD: Q. Doctor, if a doctor treats a patient in St. Louis for a disease which he calls congestive fever, and that patient dies, would he issue a certificate as typhoid fever or a certificate of congestive fever?

A. I do not think I can answer that. I do not know what a man would do under those circumstances.

Q. If he treated a patient for a disease which he called intermittent, remittent, typho-malaria, congestive or simple continued fevers, any one of these, and the patient should die, would he not issue the death certificate for the disease he thought the man had?

A. I should think so.

Q. And is not that true, evidenced by the fact that doctors do do that because of the number of deaths reported in the board

of health reports of the city of St. Louis, as occurring
12663 under those different heads?

A. Yes sir.

C. H. GOODMAN, M. D.

12664 DR. HERBERT E. SMITH

a witness called on behalf of the complainant, being duly sworn by the Commissioner, was examined in chief by Mr. Jeffries, and testified as follows:

Q. What is your name, Doctor?

A. Herbert E. Smith.

Q. Your residence and profession?

A. New Haven, Connecticut; Dean of the Yale Medical School.

Q. Yale Medical School?

A. Yes sir.

Q. Is that the Medical School of Yale University?

A. It is the Medical Department of the Yale University.

Q. Doctor, where did you receive your educational training, aside from your professional training?

A. After the usual college preparatory course in the Hartford High School, I entered the Sheffield Scientific School of the Yale University, in the chemical and biological course which is designed as a preparation for the study of medicine; then in the Medical Department of the Yale University where I was laboratory assistant to Professor Benjamin Sillmann. Then I went to the University of Pennsylvania, in Philadelphia and re-
12665 ceived the degree of Doctor of Medicine, there in 1882. Then I went to the Yale Medical School as a laboratory assistant to Dr. Benjamin Sillmann. At the end of that year I was appointed Lecturer in Chemistry in that department, and retained that position for three years, meanwhile doing, besides my teaching there, a certain amount of research work in Chemistry in the Sheffield School and also worked at Heidelberg, Germany, where I did some special chemical work at the University there. After the death of Professor Sillmann I was appointed Professor of Chemistry in the Medical Faculty of Yale, which position I still hold. This was in 1885. Shortly

after that I was appointed Dean of the Medical Faculty, which position I still hold.

Along in the latter part of the 80's I was appointed by the Governor, one of the State Chemists for Connecticut, and became interested in water works and water analytical work, being connected with the Connecticut State Board of Health in the work which they were pursuing on Rivers Pollution in the State of Connecticut, and the examination of water supplies.

After being associated with the Board for some time I was appointed Chemist of the Board and now, for a matter of about fourteen years, I have had immediate charge of all the 12666 chemical work and bacteriological work which the board has done on the matter of Rivers Pollution and examination of sewage and sewage effluent and drinking water.

Q. Did you receive a degree of any kind from Sheffield University?

A. I graduated there with the degree of Bachelor of Philosophy.

Q. That was Sheffield Scientific School?

A. Yes sir, of Yale University.

Q. Have you studied bacteriology?

A. Yes sir. I first became interested in bacteriology when I first began to look after the executive work of the Medical School and in 1887 I imported a set of Koch's apparatus and established a laboratory there and followed the work in that laboratory for a number of years. Later, when bacteriology began to assume a considerable importance in water works, I began to do personal work and have for a number of years done bacteriological work as it relates to the practical work of water examination.

12667 Q. State, Doctor, whether or not you were one of the first to import and use bacteriological apparatus and methods in this country?

A. Yes sir. I believe that set that was imported at that time was among the earliest apparatus of Koch's that were imported in this country.

Q. State whether or not you have anything to do with bacteriology in your connection with the State Board of Health?

A. Yes sir, I make a number of bacteriological examinations of samples of water that are submitted for that purpose by the County officials principally.

Q. State whether or not you are a chemist and bacteriologist and familiar in a general way with the method and results of chemistry and bacteriology as applied to water and sewage?

A. I am.

Q. State, Doctor, whether or not you are familiar in a general way with the subject of rivers pollution?

A. Yes sir.

Q. And waters pollution as well?

A. Yes sir, I have had this brought to my attention partic-
ularly in the earlier part of my work, through the practi-
12668 cal work which was inaugurated by the State Board of
Health in Connecticut on the Rivers Pollution, and that
has continued up to the present time.

Q. State whether or not you are familiar with the various investigations that have been made, scientifically, bacteriologically and chemically speaking on the subject of Rivers Pollution?

A. In a general way, I am.

Q. Please state, Doctor, whether or not you have investigated epidemics of any kind?

A. Yes sir, I have been called upon through appointment in each case by the State Board of Health to investigate the number of epidemics which have occurred.

Q. Please state, Doctor, in a general way the various epidemics that you have investigated both for the State Board of Health of Connecticut and elsewhere?

A. An epidemic of typhoid fever in Waterbury, Conn.,

An epidemic of typhoid fever in Hartford,

An epidemic of typhoid fever in North Manchester,

An epidemic of typhoid fever in Stanford,

An epidemic of typhoid fever at Money Island Hotel in
12669 Branford, Conn.

One of typhoid fever in New Haven.

One of typhoid fever at the New Haven County Jail, in New Haven,

One of typhoid fever at Bristol.

One of typhoid fever at Forestville,
One of scarlet fever at Norwalk.
One of typhoid fever at Danbury.

Those are mentioned especially because they are epidemics on which I have made reports which have been published in each case.

Q. State, Doctor, whether or not you have been called in consultation with reference to other epidemics than those mentioned?

A. I have been quite frequently consulted in the way of small outbreaks, but the epidemics which have occurred in Connecticut, I have been sent to examine, for the most part. There was one in New Haven which was a milk epidemic in which I was in consultation, but which was investigated by the local authorities of the state, but I had nothing to do with it.

Q. What was the character of the epidemic at Hartford?

A. That was a typhoid fever epidemic which was traced 12570 to the pollution of the drinking water then being taken from the Connecticut River.

Q. What was the character of the epidemic at New Haven?

A. That was an epidemic of typhoid fever which was traced to the pollution of one of the supplies of drinking water of New Haven.

Q. What was the character of the epidemic at Forestville?

A. That was a typhoid epidemic which was traced to the pollution of the water supply which supplied that village through the taking into the pipes of water from a sewage polluted stream owing to a break in the main crossing the stream.

Q. State, Doctor, whether or not you have made these investigations as the Epidemiologist to the State Board of Health?

A. It has been the custom of the board to refer that sort of work to me, but they have never conferred that title upon me. I have made all the reports recently for the board in that line of work.

Q. Doctor, state whether or not you are acquainted with and have kept yourself informed of the various publications and literature upon typhoid epidemics throughout the 12671 United States?

A. I have read the reports of many such epidemics and meant to gather a general run of the character of them.

Q. Are you acquainted with the literature on the more important epidemics such as the one at Butler, Pa., Ithaca, N. Y., and Plymouth, Pennsylvania?

A. I am familiar with those outbreaks, the character of them.

ADJOURNED until 1:45 P. M. same day.

1:45 P. M., Tuesday, May 24, 1904.

12672 Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

DR. HERBERT E. SMITH

resumed the stand for further direct examination by Mr. Jeffries, and testified as follows:

Q. Doctor, in addition to what was stated in your qualifications this morning, I will ask you whether or not you have recently been appointed to any position other than those which you mentioned this morning, in some institution?

A. About three years ago, I think it was, I was appointed as Lecturer on the Interpretation of Water Aanalysis in the Sheffield Scientific School of Yale University, and have continued to hold that position and to give instruction to the class in Sanitary Engineering in that branch.

Q. Doctor, I show you tables of mean results presented and read in evidence in this case by Professor L. P. Kinnicutt, and
ask you to examine that and state whether in your opin-
12673 ion a sanitarian and epidemiologist can from these tables
determine the condition of the Chicago Canal for sanitary purposes, which tables are known as tables A, B, C, D and E, table A consisting of analyses showing the changes which took place during the passage of the sewage of Chicago through the drainage canal, from Professor Jordan's analysis, from Ap 30th to June 25th, 1900, the same being the compilation of tables 119 to 123, contained in Streams Examination, which are the results of experiments made by Professor Jordan; table B representing the analyses showing the changes which took place during the passage of the sewage of Chicago through the drain-

age canal, based upon Professor Long's analyses, from June 5th to September 4th, 1900, compiled from tables 43 and 44 of the Illinois State Board of Health report of 1901; table C purporting to consist of analyses showing the changes which took place during the passage of the sewage of Chicago through the sanitary canal, according to Professor Palmer's analysis, from July 9 to October 5, 1900, taken from Palmer's tables 39 to 45 of Streams Examination; table D consisting of the mean of Long, Jordan and Palmer's analyses, compiled from tables 1, 2 and 3,
purporting to show the changes, parts removed and the
12674 per cent. of purification that took place during the passage
of the sewage of Chicago through the sanitary canal; table E representing the action of the septic tank on the removal of substances contained in sewage; all the tables contained in the book known as Streams Examination, Sanitary District of Chicago, having been introduced in evidence by the defendants and the report of the State Board of Health referred to by these tables having been submitted for identification.

Mr. Todd: I object to the question for the reason it is not competent for this witness to pass judgment upon whether Professor Kinnicutt could pass an opinion such as is asked in the question or not, but it is for the court to determine whether such an opinion carries weight with the court, and for the further reason that it is incompetent, irrelevant and immaterial, and is not rebuttal.

Also for the further reason that Professor Kinnicutt did not testify as an epidemiologist but strictly as a chemist and an expert on septic tanks.

A. I would state that the figures represented in these
12675 tables do not furnish sufficient data to permit me to form
a positive opinion as to the value, as a sanitary apparatus for the purification of the sewage of the drainage canal. The figures do show that there is a considerable solution of the suspended matter; that there is a considerable decomposition of the organic matter; that there is the development of a considerable amount of free ammonia.

These changes are such as are found taking place in sewage which is stored, by the agencies of the bacteria.

The tables also show that there is a considerable reduction

taking place in various ingredients in the sewage in passing through this canal. In so far there is a removal of the polluting material from the sewage, but in an important element in the discussion these tables are incompetent to form an opinion as to the destruction of the pathogenic organisms, particularly the typhoid fever, and there is no data with which I am acquainted which will give a true value to the extent to which bacteria may be destroyed or are destroyed in such an apparatus. The experiments which have been made tend to show that there is a reduction of the typhoid bacteria under such conditions, but
12676 how efficient such an apparatus is it, is impossible to state.

Mr. Todd: I move to strike out the answer for the reason that if the question is competent, the answer is not responsive, as this witness was not asked his opinion upon the tables, but was asked if any competent expert could express an opinion from the tables, and I move to strike it out for the same reasons in addition that are assigned as objections to the question.

Mr. Jeffries: Assuming, Doctor, that at all times during the analyses upon which these tables are based, there was nothing contained in the drainage canal except the concentrated sewage, state whether or not in your opinion these mean averages, as made up by Professor Kinnicutt, would not have shown a much greater reduction than they do show, owing to the fact that there is and was, at that time, 250,000 cubic feet of water per minute, from Lake Michigan, passing through the canal?

Mr. Todd: Object to the question for the reason it is not rebuttal and is therefore incompetent, irrelevant and im-
12677 material, and for the further reason that complainant introduced evidence upon the same subject in putting in their case in chief.

Mr. Jeffries: I suggest that this question is based upon the tables introduced by the respondents.

A. In my opinion the introduction of the large quantity of water discharged would tend to reduce the purification which would take place in an apparatus of this sort.

Mr. Jeffries: Q. What do you mean by the use of the word "apparatus" as used by you?

A. I mean the drainage canal.

Q. Now, Doctor, I show you tables 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, introduced and read in evidence by Professor Kinnicutt, these tables showing the mean of Professor Jordan's and Palmer's result, May to December, 1899, in the Illinois River, Joliet, North of Jackson Street; Ottawa, La Salle, Henry, Averyville, Pekin, Havana, Beardstown, Kampsville and Grafton. I will ask you to state what conclusions you draw from these tables, and what these tables of mean results show with reference to the condition of the stream at these points, as to its average pollution, at all times of the year?

12678 Mr. Todd: Object to the question upon the ground it is not rebuttal and is not impeachment, and has no foundation laid for the impeachment of Professor Kinnicutt in the cross-examination conducted by the complainant and therefore not being rebuttal or impeachment it is immaterial, incompetent and irrelevant, as all the questions arising out of the purification or impurification of the Illinois River from the mouth of the Chicago River to Grafton is a matter that has been introduced in evidence in chief by complainants in their original case, and the evidence would be purely accumulative and is therefore incompetent, irrelevant and immaterial.

Mr. Jeffries: There is no effort made to impeach Professor Kinnicutt, but this question is directed to the competency of the tables, for the reason it fails to show true conditions at all times of the year.

Personally, will say that failure to cross examine Professor Kinnicutt is not brought about by any such derilection of duty on my part, I being detained in the trial of a case at that time, not being desirious of interfering with the progress of this hearing, and to not discommode or inconvenience respondents'

12679 counsel who had treated us so fairly and agreeably that I permitted Professor Kinnicutt to leave the stand without cross examination.

Mr. Todd: Accepting what counsel has said in the matter does not change the rules of evidence in this case and make an exception to a well established rule such as I believe I have enunciated in my objection.

Mr. Jeffries: I know of no rule of law which prohibits opposing counsel to attack the incredibility of a table or the competency of a table simply because the person who drafts the table was not cross-examined in reference to it.

Mr. Todd: Counsel for defendants make no such contention that there is such a rule, but contends that where complainant has gone into the whole question in chief he can not on re-direct examination go into the question as being proper rebuttal.

Q. Question read.

A. These results show the average composition of the samples of water at the times and places at which they were collected. The several samples show that in the upper portion
12680 of the water way there was a very high chemical and bacterial pollution; that there was a gradual diminution in the amounts of the various chemical constituents in the progress down the river and that there were certain places where there was an increase in these constituents; the figures for the samples taken at Grafton show that there was in those samples a very considerable evidence of sewage contamination still remaining. There was some variation in this diagram, also in bacteria, the number at the Grafton station being somewhat higher than at the Kampsville station, for instance.

The tables fail to show the true conditions of the river at these several stations at all times because a sample taken from a running stream, from time to time, can not of course show the composition of the river at that place at other times, and further, there is no evidence in these tables that the samples taken at the time they were taken were proportional to the flow in the river, and obviously they would represent a different proportion of the constitutents in the river at times of flood from what they would at the time of low water, the samples being of the same size.

12681 MR. TODD: I move to strike out the answer for the reason given in the objection to the question, and for the additional reason that no witness has testified that the samples taken, as evidenced by the tables, express true conditions for the entire year, but only for conditions for the time covered, the period covered during the taking of the samples, and for the additional reasons given in my objection to the question itself.

MR. JEFFRIES:. Q. I show you tables 57 to 64, inclusive, Doctor, introduced in evidence by Professor Kinnicutt, and based upon the mean of Jordan and Palmer's results, from January to June, 1900, and the following points in the Illinois River: Table 53, Joliet; table 54, Morris; table 55, Ottawa; table 56, La Salle; table 57, Henry; table 58, Averyville; table 59, Wesley City; table 60, Pekin; table 61, Havana; table 62, Beardstown; table 63, Kampsville, and table 64 at Grafton, and ask you to examine these tables and state whether or not from the mean results shown by them positive conclusions can be drawn as to the sanitary condition of the water in the river at those points at all times in the year?

MR. TODD: Object to the question for the same reasons
12682 given in my objection to the previous question.

A. In my opinion these tables do not show the condition of the water in the river at the several points at all times of the year for the reason that the samples were taken occasionally and not continuously; that they did not as far the tables show, take into consideration the flow at the time the samples were taken and that in general an average of this sort can not show the condition of the stream at other times than those at which the samples were taken.

MR. TODD: I move to strike out the answer for the same reasons given in my motion to strike out the previous answer.

MR. JEFFRIES: Q. Doctor, I will show you tables 1 to 12, inclusive, introduced in evidence by Professor Kinnicutt, as giving the mean of Doctors Long and Palmer's results for May, June, July and August, 1899, and 13 to 24, inclusive, the mean of Doctors Long and Palmer's results for May, June, July and August, 1900, and will ask you to state what, in your opinion, is the value of these tables as to their showing the sanitary condition of the water in the Illinois River at all times
12683 of the year?

MR. TODD: Object to the question for the same reasons heretofore stated in my objection to the previous question.

A. In my opinion these tables fail to show the condition of the water in the river at all times and seasons for similar reasons stated in my answer to your last question.

MR. TODD: I move to strike out the answer for the same reasons advanced in my previous motion.

MR. JEFFRIES: Q. Doctor, have you examined the individual results upon which these averages were based?

A. I have.

Q. State whether or not you have noticed any individual samples, the determination of which deviate markedly from the average in the evidence of sewage pollution?

MR. TODD: Object to the question for the same reasons heretofore stated.

A. In my examination of the individual results upon which these tables of averages are based, I have noted many results which deviate widely from the average.

As an illustration, on table 101 in the Streams Examination, which relates to the analysis of the Illinois River at Grafton during 1899, I find that on November 8th, the samples
12684 showed a chlorine of 4 parts per million; on May 31st
of 3.7 parts per million, while the average given in Professor Kinnicutt's table of the results obtained at this point is 18.4 parts per million.

I would say that on that particular table there were 17 samples, more than half, therefore, that were above the average in chlorine, and there were 16 that were below the average.

With regard to the free ammonia, I find that on December 6th there was present 1.12 parts per million, and on June 21st, .04 parts per million, while the average of all the determinations at that point gave 0.23. There were 12 samples above the average and 21 samples below the average.

In the same tables, the figures for suspended matter, or suspended residue referred to in another place as suspended solids, was, on May 31st, 873.8 parts per million, and on October 11th was 1 part per million, while the average of all the determinations is given as 82.4.

These indicate some of the ranges which I have noted, and similar discrepancies are found in the other tables.

12685 MR. TODD: I move to strike out the answer for the same reasons heretofore given.

MR. JEFFRIES: Q. Doctor, state whether or not and in what way, if any, true conditions fail to be displayed from the tables of averages such as these about which we have been testifying?

MR. TODD: Object to the question for the same reasons.

A. The general average does not show a true condition because the general average can only relate to the conditions at the times and places when and where the samples were taken.

In a stream of running water, which varies in volume, it is very important that the samples should be taken in such volume as will indicate the relative flow at the time the samples are taken.

For another reason a sewage contaminated stream varies greatly from time to time in its content of impurity, depending largely upon the irregularities in the discharge of the sewage, at one time the sewage being of a certain character and at another time differing widely from it, either because of the sort of discharge of materials from factories or manufacturing establishments or something of that sort, or from the varia-
12686 tions which are found in the flow of sewage in the matter from houses at or during different hours of the day.

Moreover, there is a very marked difference in the flow of streams, due to the variable rainfall at different seasons and times. This has the effect not only of increasing the volume of the flow, diluting it at one time, the constituents over the conditions which prevail at another time, but the larger flow tends to bring down the stream accumulated materials and form movable deposits, both upon the watershed and in the stream itself. For these various reasons an average result can not show the condition of the stream at all times.

Mr. Todd: I move to strike out the answer for the same reasons heretofore stated.

Mr. Jeffries: Q. Doctor, in the present developed state of sanitary science, state whether or not a table of averages, such as were introduced by Professor Kinnicutt, are considered by the scientists as sufficient to enable one to make a competent determination of the sanitary condition of water in a running stream?

12687 Mr. Todd: I object to the question for it is not competent for this witness to answer a question comprehending the entire learning on sanitary science, to pass judgment upon the ability of others to express an opinion in regard to sanitary problems, and for the further reason that the question is not rebuttal to any testimony introduced in this case, and the question of averages, of chemical as well as bacterial examinations have been introduced and sustained by the witnesses who testified in this case for the complainant, and it is not competent to contradict complainant's own witnesses upon a proposition plainly embodied in the question, and it is therefore incompetent, irrelevant and immaterial.

Mr. Jeffries: Counsel is mistaken in the purpose of the question. It is only to show the weight of credibility that must be attached to the particular tables here referred to and introduced in evidence by Professor Kinnicutt.

Mr. Todd: In reply, counsel is aware of its purpose, but he objects to its effect.

A. In my opinion the tables of averages which are re-
12688 ferred to as having been introduced by Professor Kinni-
cutt do not form a competent basis in the present condition of sanitary science to permit a definite opinion as to the sanitary condition of the stream to which they relate.

Mr. Todd: I move to strike out the answer for the reasons stated in my objection.

Mr. Jeffries: Q. Upon what do you base your last answer?

Mr. Todd: Object to the question as incompetent, irrelevant and immaterial.

A. I base my answer first upon the reasons already assigned why a general average can not be taken as representing the general character of the stream to which they relate at all times.

And further, I base my opinion upon my belief that chemical analyses do not and can not show all the evidences of dangerous pollution which may exist in a stream. The chemical analysis is addressed to the deduction and determination of certain
elements which are useful in determining the presence or
12689 not of sewage in a stream, but in the present state of the
science it is impossible to decide whether certain results are or are not evidence of sewage contamination and further, that there are certain ingredients which may be present in a stream coming from sewage and which are of material importance which are not revealed at all by the chemical analysis. In

my opinion, therefore, the chemical analysis alone is not a sufficient basis to decide whether a sewage polluted stream contains the dangerous elements of sewage.

Further, I base my opinion upon my belief that in the present state of sanitary science the bacteriological analysis does not reveal in all cases the presence of those constituents of sewage which are dangerous.

And, further, I would state that in the present condition of sanitary science, neither the chemical nor the bacteriological analysis alone, nor both together, can be absolutely relied upon to show the presence in a stream of those substances which may come from sewage and do come from sewage and which are dangerous.

Mr. Todd: I move to strike out the answer for the reason 12690 that it is not rebuttal of any testimony introduced in evidence by the defendants, but is a contradiction of the testimony introduced in evidence by the complainants, to wit: the testimony of Doctor Ravold and especially Dr. Teichmann and Professor Keiser, and is therefore incompetent, irrelevant and immaterial and is not proper at this stage of the case.

Mr. Jeffries: Q. Doctor, you have examined the book known as Streams Examination, all the tables from which were introduced in evidence in this case, have you?

A. I have.

Q. In giving your answer to the last questions have you considered the tables contained in this book known as Streams Examination, and what you have learned from it?

Mr. Todd: I object to the question for the same reason.

A. In answering your questions relating to the analysis I have taken into consideration the information which I obtained by consideration of the tables in the book known as Streams Examination.

Mr. Jeffries: Q. From your examination of all the tables contained in this book known as Streams Examination, 12691 and which said tables have been introduced in evidence, and from the tables introduced in evidence by Professor Kinnicutt state whether or not you are able to say that all the harmful elements and disease producing bacteria discharged into the canal at Chicago have become eliminated from the Illinois River by the time that it reaches Grafton?

Mr. Todd: Object to the question for the same reasons heretofore stated.

A. From my examination of the results given in the tables in the book, Streams Examination, and of the tables of averages based thereon, I would say that I am unable to state that they show that all injurious ingredients have been eliminated from the sewage.

Mr. Todd: I move to strike out the answer for the same reasons.

Mr. Jeffries: Q. Are you acquainted with the extent of the population residing upon the watershed of the Illinois River the rural and the urban population?

A. I have seen the figures, yes sir.

12692 Q. Have you acquainted yourself, Doctor, with the relative amount of sewage that is immediately discharged into the Illinois River for the various periods mentioned, upon the Desplaines and upon the banks of its tributaries, exclusive of the Sanitary District of Chicago?

Mr. Todd: Objected to as incompetent, irrelevant and immaterial.

A. I have examined the figures showing the amount of sewage discharged into the Illinois River at various points upon its course.

Mr. Jeffries: Q. Doctor, have you made yourself acquainted with the velocity flow of the Illinois River from Chicago to the Mississippi?

A. I have examined figures showing the flow of the Illinois River at the points mentioned.

Q. The figures that you examined in reference to that were those determined by Professor Van Ornum and Isham Randolph are they not?

A. I understood that they were the figures introduced by 12693 the gentlemen named.

Q. Taking into consideration, Doctor, the extent of the urban population residing upon the water shed of the Illinois River, exclusive of the city of Chicago, and taking into consideration the usual volume of water passing down that river, together with the added volume of 250,000 cubic feet per minute, from Chicago, state whether or not in your opinion the chemical and bacterial results shown upon the tables contained in Streams Examination and the results upon the tables introduced in evidence by Professor Kinnicutt show the sanitary chemical and bacterial condition of the water in the Illinois River to be higher or lower from a sanitary standpoint than ordinarily exists in rivers of this kind having similar population and flowing similar volumes of water?

Mr. Todd: Object to the question for the reason it is not rebuttal and for the additional reason that this whole question was gone into in chief by the complainant, and it is therefore incompetent, irrelevant and immaterial.

Mr. Jeffries: I suggest it goes to the competency of the 12694 tables introduced and the conclusions drawn therefrom.

A. Taking into consideration the urban population upon the several water sheds tributary to the Illinois River, exclusive of that of the Chicago Sanitary District, I will state it is my opinion that the results shown in the tables in the examination of streams and in the tables of averages based upon them, show that at the times when these samples were taken there was more evidence of sewage than I should expect in a river of this size and population.

Mr. Todd: I move to strike out the answer for the same reasons.

Mr. Jeffries: State whether or not in your opinion, Doctor, the chemical and bacterial data found in the tables contained in Streams Examination, and the tables introduced in evidence by Professor Kinnicutt, show more or less any such bacterial and chemical constituents which are usually considered as evidence of sewage than which you would expect in event the sewage from the sanitary district of Chicago was not discharged into that river, the same volume of water flowing down the river in 12695 each event?

Mr. Todd: Object to the question for the same reasons stated in my previous objection.

A. In my opinion the tables referred to do show that there was at the times when the samples were taken more evidence of sewage contamination than I should expect to find from the urban population on the watersheds tributary to the Illinois River, exclusive of the Chicago Sanitary District.

Mr. Jefferies: Q. Assume, Professor, that a larger portion of the sewage of Chicago passed through the old Illinois and Michigan Canal in a more concentrated condition than it does through the drainage canal; assuming further that during the greater part of the year, under such conditions the water in the Illinois River, practically from Grafton to Henry, was covered with a green scum as though in a quiescent condition, and as described by some of the fishermen on the river, who testified for respondent, stood in a stagnant condition with no perceivable current, such that when a skiff would be rowed across it, it would separate the green scum and leave the line of separation
distinct and visible for a great distance behind; that if a
12696 chunk should be thrown in the river it was as liable to float
up stream as down stream, depending altogether upon the direction of the wind; that the five dams practically retarded the progress of the water down the stream; that in order to protect navigation it was necessary for them to erect banks on top of the dam so as to increase the height of the water above the dam; assuming further that since the opening of the canal that there has been a continuous current at all times of the year, both above, below and over the respective dams. State whether or not upon these assumptions the facilities for removal of the pathogenic bacteria and harmful ingredients of the water coming from the sewage of Chicago were not better prior to the opening of the drainage canal than subsequent to that time, and also is it not a fact that such facilities for removal are not and can not be displayed by the table of averages and by the tables themselves contained in Streams Examinations and introduced by Professor Kinnicutt and which you have examined,
the volume of water that passed through the Illinois and
12697 Michigan canal prior to the opening of the drainage canal
ranging from 19,000 to 49,000 cubic feet per minute, and the volume of water passing through the drainage canal since its opening ranging from 200,000 to 250,000 cubic feet per minute?

Mr. Todd: Object to the question for the reason that the whole substance of the question has been gone into as part of complainant's original case as well as the second question contained in the preceding question, and it is therefore not rebuttal testimony and consequently is incompetent, irrelevant and immaterial.

Mr. Jeffries: I suggest in response to what Counsel has said that the question is perfectly competent, and is based solely upon evidence introduced by the respondents, both as to the tables and as to the condition of the water of the Illinois River both prior and subsequent to the opening of the canal, as testified to by the fishermen and others living upon that stream.

Mr. Todd: In reply Counsel will state that on a careful reading of complainant's case by the court, it will be evident that this question is not rebuttal. 12698

A. In answering your question I have taken into consideration the assumptions and statements made and would state it as my opinion that the conditions assumed and stated to be present in the river prior to the opening of the drainage canal were such as would afford greater facilities for the removal of pathogenic organisms than those conditions which exist since the opening of that canal.

And, further, I would state as my opinion that the data furnished by the tables in the book of Streams Examintion, and the tables based thereon, do not furnish data for determining the extent to which these pathogenic organisms have been removed.

Mr. Todd: I move to strike out the answer as it is evident from the answer itself that it is not rebuttal but the original case of complainants and therefore incompetent, irrelevant and immaterial and not proper evidence.

Mr. Jeffries: Q. Doctor, have you examined the typhoid mortality statistics introduced in evidence in this case, showing the number of deaths from typhoid that have occurred in the principal towns and cities upon the water shed of the Illinois and Mississippi and the Missouri within the last six or seven years? 12699

A. I have.

Q. Are you acquainted with the typhoid statistics of the city of Chicago?

A. I am.

Q. Are you acquainted with the extent of the population of the drainage district of Chicago?

A. I am.

Q. Have you informed yourself with reference to the physical character and condition of the Illinois River?

A. In a general way, by description.

Q. State whether or not you are acquainted with the character of the river bed of the Illinois River?

A. I am.

Q. Speaking as a sanitary chemist, familiar with the pollution of rivers, and chemical analysis as a means of determining the character, and after examination of the tables introduced in evidence by Professor Kinnicutt, please state whether or not it is in your opinion possible to determine from such chemical and bacteriological data whether the sewage of Chicago
12700 has or has not at all times and at all seasons of the year become purified before reaching Grafton?

Mr. Todd: I object to the questions for the reasons heretofore stated.

A. In my opinion the data furnished in the tables show that there has been considerable removal of the polluting material introduced into the river from the sewage of Chicago, but that they are not sufficient to determine that the purification from the dangerous elements in the sewage has been complete at all times and all seasons.

Mr. Todd: I move to strike out the answer for the reasons heretofore given.

Mr. Jeffries: Q. Speaking as an expert in the interpretation of sanitary water analysis, bacterial analysis and all other means of determining the sanitary condition of a running stream I will ask you to state your opinion concerning the purification of the sewage of Chicago at the time it passes out of the drainage canal.

Mr. Todd: Object to the question for the reasons heretofore stated, namely that it is not rebuttal.

12701 A. Basing my opinion upon the results of the chemical and bacteriological analysis which have been furnished, and the tables referred to, and upon other data within my knowledge bearing upon the subject I would state it as my opinion that the sewage is not purified from the harmful agents at the time it is discharged from the drainage canal.

Mr. Todd: I move to strike out the answer for the reason that it is not rebuttal and it not contradictory of any testimony given in this case by any witness that has heretofore testified.

Mr. Jeffries: Q. Assuming that the water passes from the city of Chicago through the canal into the Des Plaines River, and down the Illinois to the Mississippi, past the chain of rocks at St. Louis, within from ten to twenty days, state your opinion as an expert on water supply for cities and towns as to whether or not the waters of the Mississippi River at the chain of rocks are less available for drinking purposes and more liable to contain water borne diseases such as typhoid now than it did before the sewage of the Sanitary District from Chicago was borne into the drainage canal and through it to the Illinois River?

12702 Mr. Todd: Object to the question for the reason that the identical question was asked of Professor Sedgwick, Professor Fuller and all the other epidemiologists, witnesses, who testified in this case in chief on the part of the complainant, and it is therefore plainly not rebuttal but a part of complainant's original case and is therefore incompetent, irrelevant and immaterial.

A. I will state it as my opinion, based upon the facts which you have stated that the water at the chain of rocks is less available for sanitary use than it was before the opening of the sanitary canal, and that there is a very much greater liability of the infection with typhoid bacilli of persons drawing water from that point in the river.

Mr. Todd: I move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Doctor, Professor Kinnicutt in his direct examination by counsel for respondents was asked this question,
and I desire to ask it of you: If an increased volume of
12703 water in the Illinois River, by the addition of the water
of the drainage canal at the rate of 250,000 cubic feet per minute would make an increased speed in the current of the Illinois River, would that increase in said current have any effect in increasing or diminishing the liability to typhoid and other water borne diseases on the part of the inhabitants of the State

of Missouri using the water of the Mississippi River for drinking purposes below the mouth of the Illinois?

Mr. Todd: Object to the question for the reason that the question asked was a question put to Professor Sedgwick by counsel for complainant and that the question put to Professor Kinnicutt was put by way of rebuttal, and it is not competent to ask this witness a question which was gone into in chief by complainant under the assumption that the question originated in the direct examination of Professor Kinnicutt, when as a matter of fact the question was framed and asked by the counsel who is now asking it, and it is therefore incompetent, irrelevant and immaterial and not proper rebuttal.

Q. Question read.

A. In my opinion an increase in the flow of the Illinois River as assumed would very largely increase the liability 12704 of the infection of persons drawing a water supply consisting in whole or part of water from the Illinois River.

Mr. Todd: Move to strike out the answer for the reason given in my objection to the question.

Mr. Jeffries: Q. Doctor, in his testimony Professor Kinnicutt was asked this question by counsel for respondent: "Based upon your knowledge as a chemist, bacteriologist and sanitarian, is there anything that you know of that would lead you to believe that the water coming from the Illinois River was infected by the sewage from Chicago, and assuming that the water of the Illinois River, mixed with the waters of the Mississippi at Grafton, and of the waters of the Missouri above the intake and the waters of the Illinois and Missouri Rivers thus comingling with the waters of the Mississippi, state whether or not you then consider the waters of the Mississippi River a menace to the inhabitants of the State of Missouri living on its banks below the mouth of the Illinois River?"

Mr. Todd: Object to the question for the same reasons 12705 advanced in my objection to the last question and for the additional reason that because a question was asked of defendant's witness, that simple fact does not make it competent to ask in rebuttal, in view of the fact that the subject matter of the question as well as the question itself is part of the original case of complanants and is not rebuttal of anything offered in evidence by the defendants and is therefore incompetent, irrelevant and immaterial.

A. Replying to your question, I will state that there are factors in my knowledge which would lead me to believe that the Illinois River was infected by the sewage of Chicago, and that the mingling of this water with that of the Mississippi River and Missouri River is a serious menace to the health of persons living below the mouth of the Illinois River.

Mr. Todd: I move to strike out the answer for the reasons given in the objection.

12706 Mr. Jeffries: Q. Doctor, taking into consideration all of the chemical and bacterial data found in the tables contained in Streams Examination, which tables have been introduced in evidence by the respondents, and the tables introduced in evidence by Professor Kinnicutt, and assuming that there is no typhoid fever pollution of the waters upon the water shed of the Mississippi River and its tributaries above the intake of the St. Louis water water works other than that derived from the sanitary district of Chicago, do you or do you not believe that typhoid fever germs from said district of Chicago are liable to find their way into the water supply of the city of St. Louis through the intake of the waterworks of the city of St. Louis at the chain of rocks?

Mr. Todd: Object to the question on the ground it is not rebuttal; that this whole question was gone into in chief by complainant and it is not proper to reopen the case after complainant has rested, and it is therefore not rebuttal and is incompetent, irrelevant and immaterial.

12707 A. Replying to your question, and taking into consideration the statements made in it, I will state it as my opinion that I do believe that typhoid bacilli from the sewage of Chicago are liable to find their way into the water supply of the city of St. Louis through the intake at the chain of rocks.

Mr. Todd: I move to strike out the answer for the reason given in the objection to the question.

Mr. Jeffries: Q. Doctor, based upon the chemical and bacterial data contained in the tables found in Streams Examination, which have been introduced in evidence, and the tables introduced in evidence by Professor Kinnicutt, and taking into consideration all the knowledge which you possess upon the subject of sanitary science, do you or do you not consider that the Illinois River water containing mixed sewage and canal water from the Chicago Drainage Canal has rendered less safe and wholesome than before the opening of the canal, the waters of the Mississippi River for drinking purposes on the part of the inhabitants of the State of Missouri below St. Louis and

12708 below Grafton, and the inhabitants of the city of St. Louis?

Mr. Todd: I object to the question because it is not proper rebuttal and for the other reasons stated in my previous objection, and it is incompetent, irrelevant and immaterial.

A. Taking into consideration the statements made in your questions, I will state it as my opinion that I would believe that the introduction of the sewage from the City of Chicago has rendered the water of the Mississippi River less wholesome as supply of drinking water.

Mr. Todd: I move to strike out the answer for the same reasons as contained in my objection to the question.

Mr. Jeffries: Q. Doctor, please state in a general way as a sanitarian and epidemiologist what is necessary in order to enable one to pass intelligent judgment upon the sanitary character of water?

Mr. Todd: Object to the question as not rebuttal.

12709 A. To form a competent opinion as to the sanitary condition of a water and its suitability for use and as a supply of drinking water, one should avail himself of all knowledge obtainable on the subject. A chemical examination may give such results as would indicate that the water is sewage polluted. The discovery of such evidence must always make such a water to be regarded with suspicion. To decide the importance of the suspicion one must determine the condition and the extent as far as possible from other means as to the extent and nature of the pollution.

There are cases, however, which the chemical analysis will fail to give positive data as to the presence of sewage even when it is undoubtedly present as shown by other data.

Regarding the bacteriological analysis, I would say that

it is frequently possible to obtain results which also indicate the presence of sewage contamination and that such evidence must always render that water suspicious, and that the import-
ance of the suspicion must be determined by a thorough
12710 examination as to the source and nature of the source of
the pollution, but there are cases in which the results of the bacteriological analysis will not disclose the presence of the ingredients of sewage when it is known by other tests that they are present.

Indeed, the bacteriological tests have frequently failed to show the evidence of sewage contamination positive in streams which were known to have received sewage contamination. When one must depend upon such data for the determination of the suitability of a proposed water supply, one must use not only the evidence of the chemical and bacteriological examinations but all data relating to the surroundings of the source from which the water comes.

In determining, however, whether a water in use has been a subject of sewage pollution, unquestionably the most positive way of obtaining evidence is a careful study of the effects which have been produced by the water upon the persons who have used it. Where a large community uses a water which has been
sewage polluted and the injurious ingredients of the sew-
12711 age still exist in the water it is inevitably shown in its
results upon the health of the people. This is so much the case that the statistics of typhoid fever in a community is on the whole the best evidence which pertains to the fact of sewage pollution.

I would state, therefore, that in my opinion the best test which can be applied to decide whether a given water supply has been infected by sewage is to study the typhoid statistics of the community using the water.

Mr. Todd: I move to strike out the answer for the reasons given in my objection to the question.

Mr. Jeffries: Q. As sanitary expert, availing yourself of all the chemical and bacterial knowledge which is available to you, what is your opinion as to whether typhoid bacilli living in the sediment of a polluted stream for the period of sixty days would be able to produce typhoid fever if taken into the human system?

Mr. Todd: I object to the question for the reason the same question was asked of Professor Sedgwick on re-direct 12712 examination as well as the other witnesses for the complainant and it is a part of complainant's original case and is therefore not rebuttal of anything that has been introduced in evidence on the part of the defendants in this case, and is therefore incompetent, irrelevant and immaterial.

A. I would state it very positively as my opinion that typhoid bacilli living in the sediment of a polluted stream for the period of sixty days would be able to produce typhoid fever if taken into the human system.

Mr. Todd: I move to strike out the answer for the reasons given in my objection to the question as not rebuttal and part of complaintant's original case.

Mr. Jeffries: Q. What is your opinion as a sanitary expert as to whether pollution and typhoid fever bacilli coming from the sewers of Chicago, through the drainage canal, deposited in the bottom of the Des Plaines and Illinois Rivers can remain there for the period of from thirty to sixty days and yet retain their dangerous qualities as well as pathogenicity?

12713 Mr. Todd: Object to the question for the same reason as given to the last question.

A. I will state it as my opinion that I believe when typhoid bacilli are deposited on the bottom of the Des Plaines or Illinois River, between Chicago and Peoria for a period of thirty or forty days they might retain their dangerous qualities as well as their pathogenicity, for I know of nothing which would make it certain that such an organism would meet with any material which would be certainly destructive to it under such conditions.

Mr. Todd: I move to strike out the answer for the same reason as made in my objection to the question.

Mr. Jeffries: Q. From your knowledge of the Illinois River and your knowledge as a sanitary expert, together with the chemical and bacterial knowledge derived from the tables contained in the book known as Streams Examination and which have been introduced in evidence by the respondent, what your opinion as to whether the sewage from the city of Chicago,

passing through the drainage canal into the Illinois River
12714 at different seasons of the year and at different stages of
the water in this river would be a danger and a menace to
the inhabitants of Missouri and St. Louis using the water of the
Mississippi at the intake tower at the chain of rocks for drinking purposes?

Mr. Todd: Object to the question for the same reasons heretofore stated in my objection to previous questions of the same character and kind.

A. I would state it as my opinion that sewage from the city of Chicago, passing through the course described in the question would be a menace and a danger to the inhabitants of Missouri and St. Louis using the water of the Mississippi River at the intake at the chain of rocks, for I know of nothing with which the infection contained in such sewage would meet which would be certainly destructive of it, and from my knowledge of conditions at Chicago such sewage must be very largely at times infected with typhoid bacilli.

Mr. Todd: Move to strike out the answer for the same reasons given in my objection to the question.

12715 Mr. Jeffries: Q. Based upon the chemical and bacterial
data contained in the tables in Streams Examination and introduced in evidence by respondents, and based upon all the knowledge which you possess as a sanitarian, chemist and bacteriologist, I will ask you to state whether or not in your opinion harmful elements of the sewage of the Chicago River reach the intake tower of the St. Louis water works at the chain of rocks?

Mr. Todd: Object to the question for the reason it is not rebuttal and the whole question was gone into in chief by complaintant, and it does not make it rebuttal by asking the witness's opinion, based upon the tables introduced, together with all other knowledge which he has upon the subject, and therefore it is incompetent, irrelevant and immaterial.

Mr. Jeffries: I suggest that at the time the evidence on the part of the complainant was introduced we had no knowledge of the tables contained in Streams Examination and we certainly have the right to introduce the opinion of witnesses as to the
effect of and the results contained in those tables so in-
12716 troduced by the defendants.

Mr. Todd: Counsel's suggestion does not remedy the effect of the question.

Mr. Jeffries: And have the right to controvert the opinions of respondent's witnesses based upon those tables.

Mr. Todd: Counsel's statement does not remedy the objection as the question is plainly not rebuttal but a part of complainant's original case.

A. Taking into consideration all the knowledge which I have bearing upon your question, I will state it as my opinion that harmful elements of the sewage of Chicago have reached the intake of the St. Louis water works at the chain of rocks and have been the cause of typhoid fever among the persons using that water.

Mr. Todd: I move to strike out the answer for the reasons assigned in my objections.

Mr. Jeffries: Q. Taking into consideration, Doctor, the contents of the tables contained in Streams Examination, which have been introduced in evidence, and the contents of the 12717 tables introduced in evidence by Professor Kinnicutt, and taking into consideration all the knowledge that you possess in regard to the chemical, bacterial and physical condition of the water in the Illinois River, and the different towns sewering into the Illinois River and its tributaries, and the population upon the Illinois River water shed, both rural and urban, the stages of the river in all conditions during all the seasons of the year, what is your opinicn as a sanitarian as to the effect of the flow of the sewage of Chicago through the drainage canal into the Des Plaines and Illinois Rivers, upon the inhabitants of the State of Missouri and the citizens of the city of St. Louis using the water of the Mississippi River for domestic purposes?

Mr. Todd: I object to the question for the same reasons heretofore stated.

A. Taking into consideration all the data which you have enumerated in your question, I would state it as my opinion that the flow of the sewage of Chicago from the sanitary 12718 or drainage canal, through the Illinois River, has had a deleterious effect upon the health of the persons living in St. Louis and using the water drawn from the intake at the chain of rocks.

Mr. Todd: I move to strike out the answer for the reasons given in my objection to the question.

Mr. Jeffries: Q. From the studies that you have made upon the question of self purification of running streams, I will ask you to state what is your opinion as to the ability of a running stream to purify itself so as to be free from all pathogenic bacteria that may be discharged therein at a given point so that the zone of purification may be determined to exist at a certain point, and that this given point may apply under all conditions, local and otherwise, at all velocities and volumes of water, all temperatures of weather and seasons of the year?

Mr. Todd: I object to the question on the ground and for the reason that the same question was gone into in complainant's original case and is not rebuttal and is therefore incompetent, irrelevant and immaterial.

A. The conditions affecting the purification of streams
12719 from the materials introduced by sewage are so complex
that in my opinion it would be impossible by the ordinary methods to determine at what point in the river the purification was always effected, the only way which I can suggest as being entirely satisfactory for the solution of such a problem is the study of the results of the use of such a water by a considerable community. If these fail to show any evidence of a deleterious effect produced by the water, and especially if they fail to show any evidence of typhoid fever, that typhoid fever has been produced by the use of the water, I should think we might reasonably conclude that that point was without the zone of danger during the time of the experiment, but owing to the fact that the chief deleterious constituents of sewage are living organisms, that they may be protected at certain times and in certain numbers by being enveloped in solid materials which would protect them from the influences ordinarily working against them in
streams, it would be impossible to predict with certainty
12720 that at some other time than the time of the experiment
the water would be perfectly safe at that point.

It is important to recognize in the question of sewage pollution that the chief injurious ingredients are living organisms and the question of dilution does not come into the discussion to anything like the extent that would be the case if the injurious ingredients were inert chemical substances.

If this were the case it is perfectly certain that we could reach a point where the most harmful chemical substances could be diluted to such a point that the dose in any given amount of water in the stream would be without effect upon the living persons, but with regard to a living organism we have to recognize the point that the dilution does not effect the individual organism but only its dissemination through the water, and that therefore it is possible to find in one portion of the water something that would be deleterious while in other adjacent units of the same size there might not be any.

Mr. Todd: I move to strike out the answer for the reasons given in my objection to the question.

12721 Mr. Jeffries: Q. Doctor, Professor E. G. Smith in his testimony on behalf of defendant was asked this question, "What do you say as to the assumption that typhoid germs could pass from the sewers of Chicago by way of the drainage canal to Lake Peoria and be deposited in the bed of Lake Peoria for the period of a month, as to whether or not the typhoid germs coming from the drainage canal under conditions as they exist, could live for the period of a month and not be destroyed at the end of that period?" said "In regard to the assumption that typhoid germs could pass from the sewers of Chicago by way of the drainage canal to Lake Peoria and be deposited there in the bed of Lake Peoria for a period of a month, it is my opinion from my study in regard to the purification of the stream embracing any knowledge upon the analytical data submitted as evidence in this case, which data indicates the removel of sewagic bacteria before Lake Peoria is reached, it would follow that the typhoid germs from the city of Chicago and the drainage canal did not reach as far down as Peoria, and in further support of this view we have a great deal of evidence secured by the results of experiments upon the duration of life of the typhoid fever
12722 germ showing that in the water of the Illinois River it does not live for a period of more than three or four days." I will ask you to state whether or not in your opinion typhoid fever germs deposited in the waters of the drainage canal at Chicago and carried thence into the Illinois River by

way of the Des Plaines River do or do not live for a period longer than from three to four days?

MR. TODD: I object to the question on the ground it is not rebuttal as the longevity of the typhoid bacillus was gone into in chief by the witnesses for the complainant and the question which is asked of Professor Smith was one of the questions asked by the counsel for the state of Missouri of George W. Fuller when he was a witness on the stand in this case, and it is therefore, incompetent, irrelevant and immaterial.

A. Replying to the question I would say that I know of no experiments which are entirely satisfactory as proving typhoid bacilli are not able to survive the immersing in sewage for a period of three or four days; that there is nothing in the way of experimental knowledge to show that the typhoid bacilli 12723 may not survive in sewage for longer periods, and that taking these facts into consideration, and the further fact that typhoid bacilli might be deposited in the bottom of a stream at any point between the emptying of the drainage canal and the mouth of the Illinois River under conditions which would protect it from such deleterious influences as the sewage exerted upon the bacteria in the experiments which are referred to, especially in the question which you asked, it would be my opinion that typhoid bacilli might survive a very much longer period than three or four days and even be likely to do so if they were deposited upon the bottom of the Illinois River.

Mr. Todd: Move to strike out the answer for the reason given in my objection to the question.

ADJOURNED until 8:00 p. m.

12724 Room 282 Southern Hotel, St. Louis, Mo. 8:00 p. m., Tuesday, May 24, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

DR. HERBERT E. SMITH

resumed the stand for further direct examination by Mr. Jeffries, and testified as follows:

Q. Doctor, state whether or not you have examined the evidence introduced by Doctors Zeit, Jordan and Russell with reference to certain experiments conducted by the use of parchment sacs for the purpose of determining the longevity of typhoid bacilli in the waters of the canal and the Illinois River so as to exemplify true conditions in that water?

A. I have.

Q. Have you familiarized yourself with that testimony in this connection?

A. In a general way I have.

12725 Q. State, Doctor, whether or not in your opinion these experiments so conducted by Doctors Zeit, Jordan and Russell exemplify actual conditions existing in the running waters of the canal and the Illinois River with reference to the longevity of the typhoid bacilli?

A. In my opinion these experiments do not exemplify the true conditions, the conditions which exist in the water of the drainage canal with relation to the life of the typhoid bacilli discharged into that as a part of the sewage.

Q. Upon what do you base this opinion?

A. The opinion is based on several points: First, the introduction of typhoid bacilli in an artificial culture in such a quantity of sewage enclosed in a parchment sac and protect it. This does not simulate the condition which would exist in the case of typhoid bacilli discharged into sewage and coming from a patient suffering from typhoid fever in which case the organisms might readily be and frequently are enclosed in fecal masses.

Further, the condition of the bacilli in this sac is quite different from that which they would be under if they were free in the stream where they would be free to settle, deposited in the sediment they might then become protected from the influence of the sewage upon them. 12726

Q. State whether or not in your opinion the fact that the bacterial and the chemical condition of the running water in the canal and river remain the same from one end of the day to the other, at the point where these parchment sacs may have been suspended in the water?

A. In my opinion the condition of the water would frequently change at any one spot owing, as I have said previously in my testimony, to the changeable condition of the discharge which we find coming from the sewers in Chicago.

Q. Would the fact that there is a different volume or quantity of sewage passing down at night than at day have any effect upon the chemical and bacterial changes of the water?

A. Yes, the difference in the flow between day and night would make a difference in the composition of the sewage water at any one place, and further, the flow at night is very different in composition from the flow during the day.

Q. Might not the fact, Doctor, that these bacteria were detained at one point in the parchment sac be harmful to them while if not so retained in the parchment sac they would 12727 pass further down the river, in a more favorable media and their longevity be preserved?

A. Yes sir. If the destructive action which was found in these cases to be exerted upon the bacilli was due in any way to the concentration of the sewage, the further the bacilli moved down the stream the less they would be subjected to this because of the increased dilution in the lower stretches of the river.

Q. Doctor, state whether or not in your opinion you know of any bacteriologists, epidemiologists or sanitarians who have limited the longevity of the life of the typhoid germ either in sewage or sewage polluted water to less than six days?

A. I know of no previous experiments which were of such a character as to warrant the experimenters for making such an assertion.

Q. Do you know of any expert as having written any article or expressed an opinion that the longevity of the ty- 12728 phoid fever germ in sewage or polluted water is within the limit of six days?

A. I do not recall any such limitations placed by any one.

Q. I will ask you to state whether or not, Doctor, from your researches in sanitary science and epidemiological work the opinions based upon the experiments of Doctors Zeit, Jordan and Russell wherein the longevity of the typhoid germ is limited to within six days do not stand by themselves and alone from all opinions that have been expressed and all determinations and observations that have been made by reputable sanitarians?

A. As far as I know this period of time is shorter than given by other authorities. Most experiments of this sort have demonstrated that sewage is in concentrated form detrimental to the life of the typhoid bacteria but the length of time which bacteria have lived in sewage of the different experiments have been so various that I do not recall a limitation expressed by any standard authorities on this subject.

Q. Doctor, I will ask you if you know of any instance
12729 where typhoid fever germs are known to have lived in sewage longer than six days?

A. Yes, there are published records of experiments showing the longer period than six days. To refresh my memory a moment the one set of experiments that I have in mind are those of Dr. Horrock's who showed that typhoid bacilli survived in unsterilized sewage a period of fourteen days and there have been other experiments made by different experimenters on this point.

As I state, I do not know of any one who has felt justified, as the result of these experiments, of limiting the period which typhoid bacilli might survive in sewage when they were introduced in what we might speak of as natural media and under natural conditions.

Q. You mean by unsterilized sewage ordinary sewage?

A. Yes sir, as contrasted with that in which other forms of bacteria have been destroyed before the other experiments have begun.

12730 Q. Doctor, Professor E. G. Smith who testified in this case for defendants was asked by defendants' counsel this question: "What do you say as to the assumption that typhoid germs could pass from the sewers of Chicago by way of the drainage canal to Lake Peoria and be deposited in the bed of Lake Peoria for the period of a month, as to whether or not the typhoid germs coming from the drainage canal under the conditions as they exist would live for the period of a month and not be destroyed at the end of that period," answered, and in his answer referred to the experiments conducted by Doctors Zeit, Jordan and Russell as follows: "In regard to the assump-

tion that typhoid germs could pass from the sewers of Chicago by way of the drainage canal to Lake Peoria and be deposited there in the bed of Lake Peoria for a period of a month, it is my opinion from my studies in regard to the purification of the stream embracing that knoweldge upon the analytical data submitted as evidence in this case, which data indicated the removal of sewagic bacteria before Lake Peoria is reached,
12731 it would follow that the typhoid germs from the sewage
of Chicago and the drainage canal do not reach as far as Peoria, and in further support of this view we have a deal of evidence secured by the results of the experiment upon the duration of the life of the typhoid fever germ showing that in the water of the river it does not live for a period of more than three or four days." I will ask you upon all the information that you have obtained from the study of the data introduced in evidence by respondent and found in the tables contained in Streams Examination, the report of the State Board of Health of the State of Illinois as contained in the testimony of Professor Long, the tables introduced in evidence by Professor Kinnicutt and the experiments of 1901 introduced in evidence by Professor Jordan, whether or not in your opinion you are able to say, taking into consideration also all that you have been able to observe upon the science of bacteriology and epidemiology, the period that the typhoid can be safely limited in the waters of the canal and the Illinois River at from three to four days?

12732 A. Taking into consideration the data to which you have called my attention and considering also the other facts which have come to my attention concerning the probable life of the typhoid bacilli after it has left the body of the patient, I would express it as my opinion that we would not be justified in concluding that the life of the typhoid bacilli would be limited to the period of three or four days under the conditions which are found to prevail in the drainage canal and in the Illinois River.

This conclusion would have to be based in my opinion, upon the evidence as shown in the chemical results that organic matter was so far decomposed as to admit no nutriment to these bacilli and that I can not see any justification for in the results.

As far as the bacteriological results go the deduction would have to be made from the experiments indicating the presence of small quantities of colon bacillus and the experiments in the sacs relating to the life of the typhoid bacilli under those conditions.

12733 In my opinion the experiments in those sacs deviate too far from the conditions which exist naturally and they are so much at variance with the ordinary experience which persons have had who have had to deal with the tracing of epidemics of typhoid fever, that they seem to me to afford facts altogether too incomplete to risk an opinion of such wide and far reaching importance as the decision that would follow in a case of this sort. The decision is too grave to be based upon any such experiment in my opinion.

Q. Doctor, in his testimony under date of March 1st, last, Professor E. G. Smith was asked by counsel for defendant the following question: "Assuming that the only pollution of the waters of the Mississippi River above the intake of the St. Louis waterworks derived from the sanitary district of Chicago, and having in mind a large amount of typhoid fever in Chicago, do you or do you not believe that infectious and dangerous pollution might, under existing conditions, find its way into the water supply of the city of St. Louis," answered as follows: "The evidence is already introduced in this case, both chemical

12734 and bacteriological, showing, in my opinion, some conclusions that the agency of self-purification above in this stream have practically transformed the sewagic matters from the city of Chicago before they reach Grafton, reducing the river at that point practically to the conditions of the streams, and the positive results secured in the experiments of Doctors Zeit, Jordan and Russell upon the viability of the typhoid fever germ in the polluted water of this stream, I do not believe that infected and dangerous pollution might, under existing conditions, find its way into the water supply of the city of St. Louis." I desire to ask you this same question, and ask you to take into consideration all of the matters contained in the tables found in Streams Examination introduced in evidence, the tables introduced by Professor Kinnicutt, the tables introduced by

Professor Jordan, outside of such tables as are prepared by him and found in Streams Examination, and also to take into consideration what bearing, if any, the experiments of Doctors Zeit, Jordan and Russell have upon actual conditions,
12735 and state whether or not in your opinion, under existing conditions, the infected and dangerous matter coming from the sewage of Chicago would find its way into the water supply of the city of St. Louis?

Mr. Todd: Object to the question upon the ground that the question asked, if it be the same question asked of Professor Smith, was a question prepared by counsel for the complainant and asked of Professor Sedgwick in his original examination when complainant was putting in their case in chief, and was asked of Professor Smith by the defendants by way of rebuttal to Professor Sedgwick's evidence, and now to ask this witness the same question which was gone into in chief by counsel for the complainant is not rebuttal evidence and is therefore incompetent, irrelevant and immaterial, and for the further reason it is an improper way to secure the opinions of this witness upon the original case of complainant by subjoining to the questions asked of Professor Sedgwick the testimony introduced in evidence by the defendants.

12736 A. Taking into consideration the various data to which you have called my attention, I would state that I have been able to find no evidence which to my mind is conclusive that the agencies at work in the stream are adequate to destroy the typhoid bacilli which undoubtedly are introduced into the sewage of Chicago and through it into the Illinois River, and therefore I believe that dangerous and infected pollution might reach the intake of the St. Louis waterworks.

Mr. Todd: I move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Under the same assumptions, Doctor, as stated in the last question, do you or do you not believe that such infection and dangerous polluting matters coming from the sewers of Chicago do, under existing conditions, find their way into the water supply of the city of St. Louis?

Mr. Todd: Object to the question for the reason that this is not the time and place in the giving of testimony for com-

plainant to make out their case as this question was propounded to all the witnesses that complainant put on the stand in their
original case, and this is not proper rebuttal of any-
12737 thing that has been introduced in evidence and is there-
fore incompetent, irrelevant and immaterial.

A. In answer to your question I would state that considering all the data which I have been able to consider as bearing upon this problem, I believe that typhoid bacilli from the sewage of Chicago have reached the intake of the St. Louis waterworks.

Mr. Todd: I move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Doctor, Professor Smith in his testimony under date of March 1st, was asked by counsel for defendants the following question: "Considering your personal knowledge as a sanitary expert of the typhoid conditions in the drainage district, the existing conditions in said city as to sewers and outfalls there and the amount of sewage and all existing conditions of the Desplaines, Illinois and Mississippi and Missouri Rivers, and all the conditions existing upon the watersheds of these streams and the tributaries thereof, and all conditions as to the water supply of the city of St. Louis, would you or would you
not, beyond a reasonable doubt, attribute the principal
12738 portion of the increase of typhoid fever of St. Louis to
the infected sewage of the sanitary district of Chicago, assuming that there has been an increase of typhoid in St. Louis since the opening of the drainage canal." Now, I will ask you to state, considering your knowledge as a sanitary expert of the typhoid conditions in the sanitary district of Chicago, your knowledge of the pollution and the amount of sewage deposited into the canal, and thence into the Illinois River from the sanitary district, under all existing conditions on the watershed of the streams of the Mississippi River and its tributaries above the chain of rocks, and all existing conditions as to the water supply of the city of St. Louis and the general sanitary conditions existing in St. Louis, do you or do you not, beyond a reasonable doubt, attribute the principal portion of the increase in typhoid fever in St. Louis to the infected sewage of the sanitary district of Chicago, also taking into consideration the re-

sults from the various analyses made by analysts who have testified in this case, as shown by the tables contained in the book known as Streams Examination, the report of the
12739 State Board of Health of the State of Illinois, and the tables introduced by Professor Kinnicutt and the tables introduced by Professor Jordan and the special experiments carried on by Professors Zeit, Jordan and Russell with reference to the longevity of the typhoid germ as contained in parchment sacs?

Mr. Todd: Object to the question for the reason that the question quoted as having been asked of Professor Smith was a question prepared by counsel for complainant and asked of Professor Sedgwick and George W. Fuller upon their examinations in chief by counsel for complainant and the second question following the question quoted is in substance the same questions propounded by counsel for complainant to all of complainant's witnesses in putting in complainant's case in chief, and is not rebuttal testimony of anything that is proper to be rebutted and is therefore introducing evidence of this witness upon the original case under the guise of rebuttal testimony which is incompetent, irrelevant and immaterial and not proper examination.

12740 A. I consider the problems involved in your question and would state that in my opinion the data available, especially those relating to the typhoid fever conditions upon the watershed of the Mississippi and Missouri Rivers above the intake of the St. Louis waterworks, and the data concerning the occurrence of typhoid fever in the Chicago sanitary district, are sufficient to demonstrate that the increase in typhoid fever has been due in considerable part at least to infection from the Chicago sewage.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: I will ask you to state, Doctor, whether or not you have examined the evidence introduced in this case upon the part of the complainant and the defendants as to the typhoid mortality in the city of St. Louis for the last six or eight years.

A. I have.

12741 Q. I will ask you to state, Doctor, bearing in mind the fact that in 1895 the intake of the waterworks of the city of St. Louis was changed from Bissell Point to the chain of rocks above the pollution of the Mississippi river by the city of St. Louis, to state whether in your opinion you consider it competent to compare the typhoid fever mortality of St. Louis previous to 1896 with that subsequent to that time in order to determine accurately and correctly whether or not an increase of typhoid deaths has taken place in the city of St. Louis since the opening of the drainage canal?

Mr. Todd: Object to the question on the ground that the whole question was gone into by complainants in their case in chief and it is not rebuttal, but merely accumulative and is therefore incompetent, irrelevant and immaterial.

Mr. Jeffries: In answer to counsel's objection I will say that defendants' witnesses in their testimony have insisted upon going back for a period prior to the change in actual conditions brought about by reason of the removal of the intake from Bissell's Point to the chain of rocks, being a well recognized fact that prior to the change the water of St. Louis was 12742 being polluted by the sewage of the city of St. Louis.

Mr. Todd: In reply counsel denies that the witnesses for defendants did anything of the kind; that the comparisons made by defendants' witnesses were limited to a period of four years before the opening of the drainage canal with the four years subsequent, and I would like to have the counsel specify the witnesses to whom he refers as having made such a comparison.

Mr. Jeffries: I will state that the record is plain and can be observed by the Court. Both Messrs. Jordan, Palmer and Barker, and even in counsel's cross-examination of complainant's rebuttal witnesses, taken at this session, he referred to conditions existing prior to the change of the St. Louis intake.

Mr. Todd: What counsel for defendant has done is not evidence in this case and he has not posed as a witness.

A. In reply I would state that it is my belief that a comparison of the typhoid fever death rates in St. Louis 12743 during the two periods, 1896 to 1899, inclusive, and 1900 to 1903, inclusive, is a competent method of deciding whether there has been an increase of typhoid fever in St. Louis.

And, further, I will state that in my belief this is the best method of testing the question as to whether there has been a change in the quality of the drinking water supplied to St. Louis with reference to its infection with typhoid fever.

Mr. Todd: I move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. You mean by your answer that the manner suggested by you in the answer is the best method?

Mr. Todd: Object to the question for the same reasons as well as its form.

A. I mean that the comparison of the typhoid death rate in St. Louis for the two periods is the best method of ascertaining the conditions of the drinking water of St. Louis with reference to this period, of course using in connection with that the data concerning the upper watershed.

Mr. Todd: I move to strike out the answer for the same
12744 reason stated in the objection.

Mr. Jeffries: Q. I will ask you to state, Doctor, whether in your opinion and judgment there has been an increase in the mortality from typhoid fever in St. Louis since the opening of the drainage canal as compared to mortality for the same number of years immediately prior to the opening, such increase being based upon the typhoid mortality per 100,000 or based upon the percentage typhoid mortality.

Mr. Todd: Object to the question for the reason that this question has been put to nearly every witness offered in this case by complainant and is the very basis upon which complainant predicates its case and is not rebuttal, but a part of the original case and therefore is incompetent, irrelevant and immaterial, and is an improper question.

A. In my opinion there has been an increase in the typhoid death rate in St. Louis, based upon the mortality per 100,000 population or upon the percentage of typhoid deaths to the total mortality.

Mr. Todd: I move to strike out the answer for the reasons stated in my objection to the question.

12745 Mr. Jeffries: Q. Upon what facts in evidence do you base this opinion?

A. I base this opinion upon the study of the facts presented from compilations as to the death rates made from the records of the mortuary office and a comparison of the rates for the two periods.

Mr. Todd: I move to strike out the answer for the reasons given in my objection to the question, and for the further reason it is not competent for the witness to testify from any records that have not been proven in evidence.

Mr. Jeffries: I will state, for the benefit of counsel, that such testimony as referred to by the witness will, under the rule that has been adopted by counsel for the respondents for the introduction of their testimony, be shown in evidence later on.

Mr. Todd: Assuming the comity existing between counsel, the answer is not competent for the reason given in my objection.

12746 Mr. Jeffries: Q. State, Doctor, whether or not you have examined the testimony introduced in evidence here by respondents showing from the published reports of the Health Commissioner of St. Louis, the total number of deaths reported from remittent, intermittent, typho-malaria, congestive and simple continued fevers, and state whether or not you have examined the compilations taken from the original record in the office of the mortuary officer of the city board of health and made a comparison as to the total number of deaths so reported by respondent's testimony upon these various and respective diseases now designated as nondescript, and state whether or not upon your examination of these records there has been, in your judgment or opinion, an increase in the typhoid in the city of St. Louis since the opening of the drainage canal?

Mr. Todd: Object to the question for the reason that it is not rebuttal; for the additional reason it is incompetent, irrelevant and immaterial and that the records are the best evidence.

12747 A. I have examined the data given in the Health Commissioner's report and also those given in the compilation from the mortuary office referred to and have compared the data, and would state that it is my opinion, based upon these examinations and comparisons that there has been an increase in the typhoid death rate in St. Louis during the period covered by the four years, 1900 to 1903, inclusive.

Mr. Todd: I move to strike out the answer for the reasons assigned in my objection to the question.

Mr. Jeffries: Q. This compilation from the records of the mortuary office of which you speak is the one represented to you as being prepared by Mr. Lochridge, is it not?

A. That is the compilation which I referred to.

Q. And Professor Sedgwick—Mr. Lochredge and Professor Sedgwick?

A. Yes sir, I understood the compilation was effected by both, and shown me by Mr. Lochredge in particular.

Q. State, Doctor, whether or not the increase in typhoid fever deaths in the city of St. Louis since the opening of the drainage canal as compared to the same number of years immediately prior thereto has been a decided increase?,

12748 Mr. Todd: Object to the question for the reason that it is not rebuttal as the same subject has been gone into in chief by complainant's witnesses and is therefore incompetent, irrelevant and immaterial.

A. I would state that the comparisons which I have made indicate that the increase has been a very considerable one.

Mr. Todd: I move to strike out the answer for the reasons indicated in my objection.

Mr. Jeffries: Q. State whether or not an increase in typhoid fever in St. Louis since the opening of the canal is shown to any considerable extent during the winter months?

Mr. Todd: Object to the question for the same reasons as heretofore stated.

A. I would state that the increase has been more noticeable during the winter and spring months than it has during the summer and autumn months.

Mr. Todd: I move to strike out the answer for the reasons stated in my objection.

Mr. Jeffries: Q. Doctor, are you acquainted with what 12749 is known as the Widal test?

A. I am.

Q. Please state the purpose for which this test is used?

A. It is used as one of the aids in the diagnosis of typhoid fever.

Q. Will you state as a physician and sanitary expert what effect if any the use of the Widal test may have upon the reports of typhoid fever deaths by physicians?

A. I think that the use of the Widal test has probably not affected very materially the reports of deaths of typhoid fever. Its influence has been more marked in the matter of correct diagnosis of the milder cases of typhoid fever.

Q. Doctor, I will ask you to state whether or not it is usual in all large communities and cities for health authorities to issue circulars urging physicians to report cases of deaths of typhoid fever to them?

Mr. Todd: Object to the question as it is incompetent, irrelevant and immaterial and not proper rebuttal evidence.

A. Boards of health in large cities usually have regula-
12750 tions relating to the reporting of lists of certain diseases
and among these typhoid fever is always included, and it is common for the boards of health to issue circulars to physicians calling to their attention the regulations pertaining to the report of such cases.

Mr. Todd: I move to strike out the last answer for the reasons stated in my objection to the question, for the same reason as the other objection.

Mr. Jeffries: Q. What in your opinion is the effect of the issuance of such circulars upon the typhoid fever death statistics of these communities and large cities to which you referred in your last answer?

Mr. Todd: I object to the question for the same reason as stated in my former objection.

A. As the circulars relate to the reporting of cases and not at all to the reporting of deaths, and as deaths are usually reported to some regular office, and in many instances separate from the board of health, I see no reason why there should be
any special effects shown in the reporting of deaths from
12751 typhoid fever from such circulars, and I have in my ex-
perience not seen any occurrence which would lead me to suppose that there was any such general effect.

Mr. Todd: I move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Doctor, at what ages do the most of the deaths from typhoid fever occur?

A. The ages of most susceptibility to the typhoid fever are from fifteen to thirty, though there are many cases between ten and forty, the cases under ten and over forty being less common than in the other decade.

Q. Is not the disease rare in infants or persons over sixty years of age?

A. Yes sir, the disease is comparatively rare at these ages.

Q. Doctor, I will ask you if in your professional work you have become associated with the cost, manner of operation and cost of operation of filtration plants?

A. I have had occasion to consider the cost of operating filtration plants, especially as related to the expert over-
12752 sight of their operation, this having come to my attention through my connection with several water companies.

Q. Doctor, taking into consideration all the analytical data introduced in evidence by defendants and found in Streams Examination or otherwise, and taking into consideration the fact that Chicago sewage is discharged into the Illinois River by means of the drainage canal, and that the sanitary district of Chicago has a population of more than 1,700,000, which is constantly and rapidly increasing, and taking into consideration the bacterial and chemical results shown from the analysis introduced in evidences, taking into consideration the physical surroundings and conditions existing upon the Illinois River and the Mississippi River watershed above the chain of rocks at all times and all seasons of the year, I will ask you to state whether or not if a filtration plant should be established at St. Louis, the cost of its operation would be increased on account of the opening of the drainage canal and the passage of the sewage from the city of Chicago and the sanitary district of Chicago through the canal into the Illinois River, and taking into
12753 consideration the fact of this large amount of sewage continuously being discharged from the city of Chicago, state whether or not the operation of such a plant would require less cost if the deleterious and dangerous and infectious substances contained in the waters discharged from the canal into the river were eliminated from that river?

Mr. Todd: I object to the question for the reason that complainant went into the subject of the cost of filtration in their original case with the witnesses Professor Sedgwick and Professor Fuller, and it is not competent to introduce evidence upon the subject in rebuttal, and it is therefore incompetent, irrelevant and immaterial.

A. Taking into consideration the facts which you have called to my attention, I would state it as my opinion that the installation and operation of a filter plant at St. Louis would be more expensive by reason of the discharge of the sewage from Chicago into the Illinois River and that if the deleterious agents in this sewage were removed that the cost of the installation and the maintenance of a filter plant at St. Louis would be
12754 lessened.

ADJOURNED until 10:00 a. m., Wednesday, May 25, 1904.

12755 10:00 a. m., Wednesday, May 25, 1904. Room 282 Southern Hotel, St. Louis, Mo. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

DR. HERBERT E. SMITH

resumed the stand for cross-examination by Mr. Todd, and testified as follows:

Q. Doctor, have you ever made a chemical and bacteriological survey of a river as long as the Illinois River and of equal flow?

A. I have never made an examination of the whole course of a river as long as the Illinois River, but I have made frequent analyses, covering several years, of the Connecticut River in that part which goes through the state of Connecticut.

Q. In making a chemical and bacteriological survey of a river, what method would you adopt in order to show the true condition of that river at all times and throughout all seasons of the year?

A. By chemical and bacteriological survey I understand you to mean analyses. I would reply to that that it is not possible by any kind of analysis, chemical and bacteriological, to arrive at a positive conclusion as to the condition of a river at all times and all seasons.

The reason that I answer that way is that there are
12756 two problems involved. The problem of sampling—it is
possible to sample a river in such a way as to represent the water pretty closely which passes through that river, but that means taking continuous samples, and samples in quantities proportional to the flow and that is impracticable in a large stream, but the other reason why it is impossible to come to such a conclusion is embodied in my answer to a question yesterday, that chemical and bacteriological analysis alone can not show the true sanitary condition at all times and seasons, of the river.

Q. What do you mean by taking samples proportional to the volume of the river?

A. I mean this, that if a stream is flowing, to assume 1,000 gallons a minute at one point in a small stream, and you take a gallon sample of that stream flowing 2,000 gallons, you ought to take two gallons.

Q. How would you be able to analyze a gallon sample, chemically and bacterially?

A. You have to take a sample of the water of the gallon
12757 for definite determinations and that sample has to be
taken by a thorough mixing of the sample. It is still, however, only a sample of the whole. As far as the chemical features are concerned, that can be diffused equally through the volume, so that a sample of say a half liter will represent the chemical composition of the whole.

As far as bacteriological samples are concerned, it is exceedingly difficult.

Q. Would not the samples bear the same relation to the two gallons as the samples taken out of the river in small quantities would be to the river at the same time and place?

A. Precisely the same proportion, but the results have to be considered in making an average. That is, you would have to give twice the value in making your average on the sample collected when the flow was 2,000 cc. per minute than you would when the flow was 1,000.

Q. How often would you take these samples?

A. I have stated if you want to get a result from a thorough sampling, you have to take them continuously.

12758 Q. How often continuously—every five minutes?

A. There is only one way to take a continuous sample, and that is to have some sort of a weir arrangement which will give you a continuous flow, one portion coming into your sample bottle and the other portion going on down the river. There is no way of taking a sample every five minutes or every hour or every week which will fully represent the sample.

Of course you will approximate to it the more frequently you take it.

Q. In the examination which you made of the Connecticut River did you pursue there that method?

A. Not by any means. There was no attempt to make a thorough determination of the sanitary condition of that river at all times.

Q. Do you know of any analysist of waters who has pursued such a course in Europe or in this country, according to the methods which you prescribe?

A. No sir, I do not and I should say that no one would be likely to recommend such a thing because the results obtained by those methods would not be comparable to the experi-

12759 ence of course—in other words the method is required to solve problems.

Q. In other words you are giving the ideal method regardless of experience?

A. The ideal method would be that which you have asked for, which, in my opinion, is an ideal method and which can not be solved by the limitations of the bacteriologists and chemical analysists which you have asked me to consider.

Q. Such a method would be true as to one point in a river would it not, but would not be true as to all points in a river one hundred miles long?

A. If you wish to sample a stream at any point and get a set of figures which will represent accurately the condition of that stream at different points, you would have to at every point.

Q. Would you not also have to take samples at different depths?

A. Yes sir.

Q. So that in a stream one hundred miles long your stations would have to be located nearer than five miles apart in order to get a perfect accurate determination?

12760 A. Assume that you could get an accurate determination, I should say that the nearer the stations were together the more closely you would approximate to that result, but the location of the stations and the distance between them would depend upon the surroundings as to whether there was water flowing in from other tributaries and so on.

Q. In your investigations of the Connecticut River, how often did you take the samples?

A. These samples were taken only once a month.

Q. And was that often enough to enable you to give an opinion as to the quality of the water of the Connecticut River?

A. No sir, and I did not attempt such an opinion, based upon those analyses.

Q. What purpose did you have in taking the samples once a month if it was not for the purpose of forming an opinion as to the condition of the river?

A. It was with a view of obtaining the data showing the general character of the water flowing in the river, but it was not an attempt to ascertain the character of the flow at all times and all seasons. There was no reason for it.

12761 Q. Did you make a bacteriological examination of that river?

A. I have of water from that river.

Q. Did you make a bacteriological examination of the waters of that river covering the periods that you made the examination?

A. No sir.

Q. What other rivers, Doctor, have you made any chemical or bacteriological survey of, in this country?

A. Assuming again that you mean analysis by the word survey, I have made chemical analysis of samples of water from the Nantucket River, the Still River, the Thames and the various tributaries flowing into it, the Hockanum, and numbers of other samples were sent to me from outside of the state which I do not recall the situation of.

Q. What I mean by chemical survey, Doctor, is not the analysis of a few samples, but the analysis of a number of samples of the river throughout its entire length in order to ascertain the general character of the waters of the river. Have you made any such chemical or bacteriological survey of any river?

Mr. Jeffries: Object to the question for the reason the 12762 witness has already stated that the character of the water can not be accurately obtained from the chemical survey it matters not how frequently samples may be obtained and analyzed.

A. Those that I have enumerated, I have made frequent determinations, some running over periods of three years, monthly samples, and for the purpose of showing the general chemical character of the water, but not for the purpose of showing all the details of the sanitary condition of the river. There have been analyses in connection with the rivers pollution of the State of Connecticut and have been for the most part with reference to the manufacturing wastes.

Q. At how many points in the Connecticut River were samples taken?

A. They were taken at four stations.

Q. How long is the Connecticut River?

A. In Connecticut it is about seventy-five miles.

Q. Did you make any other surveys, using the word in the sense that I have explained it, of any other river then the Connecticut River?

A. The analysis made of the Nantucket River extended 12763 over a period of four years, I think.

The Still River was made at periods covering perhaps three years, and the others that I have named of the sewage polluted streams in Connecticut, mostly cover periods of a year.

I would say in this connection, that I may not be misunderstood, that none of these streams are used for drinking supplies and the problem was not as to the suitability of the water for drinking.

The Connecticut is the only one of these that has been used, and that is not now in use for that purpose.

Q. Have you made any experiments upon sewage disposal?

A. You mean experiments or analysis?

Q. Experiments and analysis?

A. I have made analysis of sewage and analysis of the effluent of sewage beds for a number of different sewage purification works, but I have never entered into series of experiments for determining methods of purification.

Q. Have you had any experience in the operation and management of what is known as sèptic tanks?

12764 A. No sir.

Q. Have you studied the septic operation of these tanks, personally?

A. Not in the way of making analysis, no sir.

Q. Have you visited any septic tanks for the purpose of studying their operation?

A. Not any large tanks which were taking the sewage of any considerable community as they are, but of those located in the East. There are one or two small places that I have examined. We have one near New Haven which, as it is run, it is practically a septic tank, or comes pretty near it in its operation of being a cess pool.

Q. Do you regard yourself as an expert on septic tanks?

A. I consider that by my study of the subject I understand pretty well the chemical and bacterial theory of a septic tank but I should not undertake to agree to discuss the engineering features of the construction of a septic tank. That is not in the scope of my work at all.

12765 Q. In giving your opinion upon the tables referred to in your testimony, as introduced in evidence by Professor Kinnicutt, in regard to conditions that obtained in the drainage canal, I understood you to say that those tables were not sufficient to enable you to pass a satisfactory opinion upon the elimination of the pathogenic bacteria in the waters of the drainage canal, and in expressing that opinion you confined it purely to yourself and not to what others may be able to do from those tables, do you not, Doctor?

Mr. Jeffries: Object to the question for the reason it is duplex and misleading.

A. In making the reply I referred to what I could do with these data, basing it upon the evidence which I have found in the literature which goes to show that the knowledge of what destructive action takes place in septic tanks is not yet complete, and in this point I agree thoroughly with the statement made in the testimony of Professor Kinnicutt, when he states that the experiments on this point are not very numerous.

Q. In your testimony in regard to the tables of Professor Kinnicutt, in connection with the drainage canal, your 12766 opinion was based upon the efficiency of the drainage canal as an apparatus for the purification of sewage was it not?

A. My opinion was based upon the data shown in the tables introduced in that connection, and what I know about the operation of septic tanks as to the efficiency of that particular apparatus as a sanitary appliance.

Q. Would you say from the tables that sewage is not reduced considerably from the time it enters the drainage canal• until it leaves the canal at Lockport?

A. From the evidence given in the tables I should say that there was a very considerable reduction in the constituents of the sewage between the two points named and so testified.

Q. Is there any septic action taking place in the drainage canal?

A. According to the tables, especially the table E, which is a comparison of the loss in certain ingredients in that tank as compared with the loss in certain other specified septic 12767 tanks, there is a loss which is to be accounted for by the bacteriological action which takes place and is responsible for the beneficial action of septic tanks.

Q. Is that what is commonly known as septic action?

A. It is.

Q. In looking over Professor Kinnicutt's tables, did you take into consideration his personal knowledge and personal observation of the drainage canal as testified to by him in his testimony in interpreting his tables?

A. In the answer to the question which you have referred to, I think I was confined to a consideration of the tables, but in the answer which I gave you a few minutes ago, when I said I agreed with Professor Kinnicutt as to a statement which he made about the experimental knowledge of the action of septic tanks, I, of course, took that into consideration in stating as I did a few minutes ago that the action shown of the tanks was of a septic character.

12768 Q. Are you acquainted with the physical conditions of the Illinois River from Joliet to Grafton?

A. In a general way, as testified, yes sir, I am.

Q. What is the effect of an increased speed in the character of the Illinois River?

A. The effect of an increased speed in the current of the Illinois River would be to hasten the passage of the water from the upper reaches to the discharge, and also to lower the point where the most active oxidation effects take place, and also to carry down any matter which was suspended and which otherwise would tend to sink.

Q. What is the fall of the Illinois River from La Salle to Grafton?

A. I do not know the exact fall, but it is, according to my recollection, about thirty feet.

Q. Are you acquainted with the banks of the Illinois River?

A. In a general way, by description.

12769 Q. Are you acquainted with the condition of the Illinois River prior to the opening of the drainage canal?

A. In a general way, by description, especially by description, and according to my knowledge that condition was in a general way described in a question at length, which I had yesterday.

Q. Will you give me your ideas of the Illinois River prior to the opening of the canal, throughout the year, as to the different stages of the water?

A. I understand that there was a very considerable difference in the flow ni the Illinois River due to different stages from the various tributaries at different times of the year, but that there were certain periods when the flow was very slight, and I base this opinion upon the sort of information which I have received and which was practically embodied in the question referred to in my answer to your last question.

12770 Q. Did you understand that that condition obtained for any considerable period of the year?

A. My understanding was that the stagnant condition was practically a warm weather condition.

Q. Are you acquainted with the flow conditions of the Illinois River prior to the opening of the drainage canal?

A. In a general way I am, and this was indicated in my answer that I understand there is considerable variation from the discharge of the other rivers and also upon my study of the tables which were presented in the book of Streams Examination which tables show a very great variation in the height of the water and also in the amount of sediment which is carried and both of these, of course, are conditions indicating large water flow.

Q. Have you read the guage readings that have been offered in evidence by both sides in this case?

A. I have not, unless you refer to the column marked height in the table in streams data. I note a number of them.

12771 Q. Professor, are you aware that the flood conditions prior to the opening of the canal were as great as they have been since the opening of the canal at times?

A. Yes sir, I understood that the flood conditions prior to the opening of the canal had been at times greater than the maximum at times since the opening of the canal, and this variance is the result of rainfall and would vary from year to year surely.

Q. What effect do flood conditions in the Illinois River have upon the surrounding country?

A. There are two effects of a flood in the Illinois River and other rivers of the same general physical condition.

One is that the low country is flooded by reason of the incapacity of the water course to take off the flood water and it therefore backs up, and the other is that owing to the rush of waters there is a larger amount than usual of sediment which is swept down the stream. Those are the two essential
12772 things.

Q. What other river in the country that you are acquainted with other than the Illinois River?

A. In making use of that term I referred to the conditions of low banks and the conditions of a variable fall upon the water shed and most of the smaller streams with which I am familiar are subject to that sort of flood.

Q. Do you know of any river in this country that for a distance equal to that from La Salle to Grafton, as large as the Illinois River, that has a fall of only 30 or 40 feet?

A. I can not answer your question with regard to feet because I have, of course, given no attention to the general hydraulic conditions. In a general way I should say that there were a number of rivers on the western plains, the Arkansas for instance, where there would be a very small fall, and I think it would be as small as that, but I can not give the exact figures.

Q. Do you know how many acres of land is inundated along the Illinois River when the stream rises above its bank at flood times?

12773 A. I think I have seen some statement which gave the impression that it was a large number of acres, but I can not quote the number.

Q. By large number, what do you mean, Doctor?

A. Well, I am unable to state in acreage, and if you desire that figure, I shall have to be allowed to present it.

Q. Will it run up into the hundreds of thousands of acres? That is, I mean the land on the Illinois River subject to over flow?

A. If you will permit, I shall desire not to express an opinion, when I can present the figures.

Q. It has been testified here there are about 300,000 acres of land subject to overflow along the Illinois River. At the time of such overflow, when the rate of time for passage from Chicago to St. Louis is at its minimum, what effect do these over flowed lands have on the question of sedimentation?

Mr. Jeffries: Object to the question unless it includes sedimentation in the bed of the stream, the effect of sedimentation upon the bed of the stream as well as upon the overflowed

12774 lands.

A. There are two effects of the over flooding of a stream by a large amount of water. One is that the sediment of the stream is in part distributed throughout the bulk of the territory which is covered and the water being less turbid in those particular parts there is an accumulation of the sediment upon those parts or areas.

The other effect is that owing to the increased height of the water there is a more rapid flow in the channel of the river so that under those conditions there is a tendency to scour out the sediment, part of which is distributed and another portion carried down through the channel.

Q. Professor, in studying the analytical data of the Illinois River, did you see the tables of analysis introduced in evidence by Professor Palmer, that were not published in Streams Examination?

A. I have examined, in addition to those given in Streams Examination, the tables given in the Illinois State Board of Health report and in the publication by the University of 12775 Illinois.

Q. Did you take the analysis of Professor Palmer into consideration in giving your testimony in chief?

A. In giving my testimony as to the sanitary condition of the stream as judged from the tables and what other tables of chemical analysis and what other information I had concerning them.

Q. Did you examine the analytical data of Professor Teichmann the chemist for the State of Missouri?

Mr. Jeffries: I object to the question for the reason that that was not gone into in chief, and for the reason it would have been incompetent had he examined it.

A. I do not recall that I have seen that.

Q. Of Professors Ravold and Keiser?

A. No sir.

Q. So then in answer to the question, where the clause "Other information that you had" the analytical data of Teichmann, Keiser and Ravold were not considered by you under that clause?

A. No sir.

12776 Q. You are acquainted with the water shed of the Mississippi River prior to and since the opening of the drainage canal are you not?

A. In a general way, I have a number of times crossed it and in a general way I know the conditions.

Q. Prior to January, 1900, would you consider the Missouri as a safe water, for domestic and drinking purposes in its raw state?

Mr. Jeffries: Objected to as immaterial.

A. In its raw state I would not recommend the stream referred to for drinking water to any community.

Q. Would you recommend the Missouri River water as treated by the settling basins in St. Louis as a safe drinking water, for drinking and domestic purposes, before the opening of the drainage canal?

Mr. Jeffries: Objected to as immaterial, and in contention
of my objection to the question asking this witness
12777 whether or not he would recommend the waters of the
Illinois River prior to the opening of the canal, suitable for domestic purposes, I move for judgment on the grounds that under the evidence of respondent which shows that the addition of the lake water has preserved the longevity of the typhoid germ over conditions which existed in the Chicago River prior to the discharge of the 250,000 cubic feet of water per minute in that canal, and for the further reason that the testimony of respondent taken down the Illinois River shows that the saprophytic and other conditions for the destruction of pathogenic bacteria and substances was far greater and far better than under the conditions existing today, since the opening of the drainage canal, and that under conditions now existing the life of the germ coming from Chicago and at other points on the Des Plaines and elsewhere is prolonged, and that the testimony of respondent is to the effect that by reason of the longer preservation and prolongation of the life of pathogenic bacteria, there is more danger and more impending harm hanging over the
inhabitants of the State of Missouri and the City of St.
12778 Louis using and drinking the waters of the Mississippi
River by reason of the discharge of the waters of the Illinois River into it than existed prior thereto.

Also object to the question as immaterial.

Mr. Todd: I move to strike out all that counsel has said as having no bearing upon the subject.

Q. Question read.

A. In answering that question, I must assume that the water treated in the sedimentation tanks for the water supply of St. Louis is the Missouri River water. Under this understanding I would say that my recommendation would have to include two

considerations. If it were feasible to recommend an ideal water supply, under all considerations, I should recommend that the water of the Missouri River be treated more efficiently than by the sedimentation tanks, but I should also have to consider that the statistics of the typhoid fever rate which, in my opinion, is on the whole the best test of the sanitary condition of the drink-
ing water during the four years, 1896 to 1899, inclusive,
12779 would indicate that the water at that time was in a pretty
satisfactory sanitary condition, and if it was not possible
to have the ideal condition, I would be willing to recommend under those conditions the continued careful use of the present sedimentation system.

Q. Are you acquainted with the sedimentation basins in the city of St. Louis and how long the water remains in those settling basins before it is distributed to the consumers?

A. I am acquainted by having seen them some time ago, but have not made a careful investigation of their action, nor do I know their rate of flow.

In expressing the opinion which I did in reply to your last question, I have considered the results of the action of their treatment as indicated by the test which I referred to in the examination of the typhoid death rate.

Q. Would you recommend that river water for drinking and domestic purposes that has the population upon the water
shed such as the Missouri River has, which is only treated
12780 with settling basins, when the water does not remain in a
quiescent state to exceed three days for drinking and domestic purposes?

Mr. Jeffries: Objected to as immaterial.

A. In reply to your quesction I should have to refer you to my answer to your previous question as to the recommendation of the Missouri River water, and would state again that if it were feasible to obtain an ideal water supply, I should recommend the installation of much more efficient purifying apparatus, but in view of the typhoid statistics I might recommend the continuance of the present system under careful oversight.

Mr. Todd: Q. Do you know how far Kansas City is located from the intake tower of the St. Louis water works in point of time?

A. I have had the data before me.

Q. Well, assuming, Doctor, that the distance of Kansas City is from four to six days from the intake tower of the city of St. Louis, and the city of St. Charles is about forty miles above the intake tower, where it has an open system of sewage, and has typhoid death rate there some years up to twenty 12781 deaths within the last five years, and assume that the total number of deaths on the water shed of the Missouri River within a distance of fifteen days for the years '97 was 97 deaths, 1898 was 118 deaths, 1899 was 158 deaths, which were traceable in the cities of Lincoln, Omaha, Council Bluffs, St. Joseph and Kansas City, and that the water of the Missouri River was treated as it is now treated by the settling basins in St. Louis during that period, would you recommend the water of the Missouri River thus treated as a safe drinking water for drinking and domestic purposes taking into consideration all that you know about other typhoid conditions on the water shed of the Missouri River, as well as the physical and hydraulic conditions of the river, both rural and urban?

Mr. Jeffries: Objected to as immaterial.

A. Replying to your question I would again refer you to my answer on the original question as to recommending the water of the Missouri River, and would state again that the consideration and the data which you have presented to my attention would certainly lead me to the opinion that the water 12782 is not an ideal water for a public drinking supply, but I would again state that the typhoid fever statistics during this period compare so favorably with those of other cities having reasonably good water supplies that I might recommend the continued use of the water even in view of the facts which you have presented to me.

I would again emphasize that part of the answer which refers to the necessity of operating such a plant with caution.

Mr. Todd: Q. My question, Doctor, eliminates the Mississippi and the Illinois River waters and simply deals with the Missouri River water in the condition that it existed at that time and does not ask for an ideal water supply, but simply asked you whether you would recommend that water, knowing the conditions that obtain upon the water shed, and knowing the treatment that such a water would receive from the settling basins of the city of St. Louis, as a safe drinking water for 12783 drinking and domestic purposes, as it comes from the hydrant.

A. Replying to your question I would say that I took into consideration by the original assumption that the water was the Missouri River water, and I took into consideration the question that such a water is not absolutely safe and therefore not ideal, but that under conditions as they exist, the actual operation of the plant during the period which you refer to as shown by the typhoid statistics indicates that the water was a reasonably safe water supply at that time and my opinion which I have given throughout here is based upon the effect of the water after the purification which the treatment seems to have been adequate and complete as indicated by that test.

Q. Would you recommend such a water so treated as a safe drinking water for domestic and drinking purposes?

Mr. Jeffries: Object to the question for the reason it has been answered.

Mr. Todd: I contend it has not.

A. Replying to your question I would say that I do not consider such a water an absolutely safe water and that there are very few absolutely safe waters, even waters which have 12784 had a certain amount of contamination and are filtered are not absolutely safe. Such things are not accomplished readily. One has to decide as to the reasonable safety of all conditions and this, I consider, has been shown during the years in question by the statistics which have been quoted.

Q. As sanitarian would you recommend that water for drinking and domestic purposes of the Missouri River, treated in the settling basins in St. Louis?

A. As stated in my original answer that must depend somewhat upon the conditions. If it is not feasible to acquire an ideal purification plant, then in view of the knowledge which I have as to the efficiency which has been shown by the purification plant, I would recommend it as one which might be used under the same conditions with reasonable safety.

Q. Would you drink the water and have your family drink it, coming from the Missouri River, passing through settling basins and delivered out of the hydrant?

12785 Mr. Jeffries: Object to the question for the reason that the question is confined personally to the witness's own personal use while we are dealing with a question looking towards the betterment of conditions generally, taking into consideration the character of the people and the extent of the population of the city using a water for domestic purposes and that the question involved is one of practicability, construed in the light of sanitary science as it exists today throughout the United States and that the sanitary condition of a water to be used as a public supply can not by reason of all the physical circumstances surrounding the various rivers throughout the United States, be compared or placed upon a level with the individual opinions and personal preference of any one particular user of that water, but must be construed in the light of the science as it exists today and as it is applied to the subject of water supply.

Q. Question read.

A. In reply I would refer you to my statement that I would recommend the water as a reasonably safe water that personally knowing the dangers of typhoid infection and having in 12786 my family young persons of the age which is particularly susceptible to the infection of typhoid fever, I should hesitate myself to use it or have my family use it, and would not do so under ordinary conditions, but I should have to recognize and did recognize, in giving the opinion that I could recommend the water as a reasonably safe water, that the average community in the United States do not as yet accept as high a standard for their requirement of a drinking water as I should with my own knowledge for my own individual use.

Mr. Todd: Q. That being the case, Doctor, assuming that the community of St. Louis should entrust the securing of a water supply for their people to you, and you were selected as a sanitary expert, knowing the conditions that obtain upon the Missouri River and in the city of St. Louis would you recommend to the people and put yourself on record as a sanitary expert recommending the waters of the Missouri River as a safe drinking water, treated as it is in settling basins?

Mr. Jeffries: Object to the question for the reason that the witness has already answered the question and stated his 12787 reasons for the answer, and for the further reason that sanitary experts as a rule are required, because of public necessity, to make such recommendations looking towards the health of the community in question as they may see fit and that it is afterwards the right of the community to determine whether or not the recommendations shall be carried out or which set of recommendations will be carried out and observed by them.

Mr. Todd: Q. Divorcing your answer to my question from all recommendations whether it be carried out or not, but simply giving your answer as a sanitarian, assuming the conditions in the question, would you recommend the waters of the Missouri River to the people of St. Louis, treated in the settling basins as it is today, as a safe water for drinking and domestic purposes?

A. Replying to your question I would again refer you to my repeated statements that I could recommend the water of the Missouri River, under my original assumption, as it existed during the years 1896 to 1899, as a reasonably safe water. That I do not consider it an ideal water.

12788 Assuming that I was forced to express an opinion as to whether the water were absolutely safe, and that I was not permitted and not desired to recommend anything except an absolutely safe water, I would not recommend this water as an absolutely safe water.

Q. Do you regard the Mississippi River water above Grafton if treated in the same manner with the apparatus of the settling basins as a safe drinking water for drinking and domestic purposes, to be used by the citizens of the city of St. Louis?

A. In answer to your question I would state that according to my understanding of the situation existing at St. Louis, the water supply of the city of St. Louis during the period of four years which we have been discussing, and that subsequently the questions of its sanitary condition as affected by the processes of purification as carried on at St. Louis is to be judged by the same test as applied to the Missouri River.

Q. Assuming, Doctor, that the drainage canal should be closed and none of the sewage from Chicago should come

12789 by way of the drainage canal or the Illinois and Michigan Canal, would you recommend the water of the Mississippi River today, being a mixture of the Missouri, Mississippi and Illinois River water after it passed through the settling basins of the city of St. Louis as of today as a safe drinking water for drinking and domestic purposes?

Mr. Jeffries: Object to the question for the same reasons.

A. Replying to your question I would say that according to my understanding the areas referred to, discharged from the Illinois River into the Mississippi River and that from land tributary to the water supply of St. Louis during the period 1896 to 1899, and that therefore my conclusions with regard to the Missouri River water as affected by the process of purification in vogue at St. Louis during that period would also have to include this area.

Mr. Todd: Q. My question is, Doctor, would you recommend the water with the entire population of Chicago excluded, after it passed through the settling basins, knowing as

12790 you do the typhoid conditions that exist upon the three water sheds, knowing as you do the distances in time from Minneapolis and St. Paul, from Peoria to St. Louis, from Lincoln, Nebraska, to St. Louis, as a safe drinking water for drinking and domestic purposes?

Mr. Jeffries: Object to the question for the reason that it is immaterial and for the further reason that the witness has already answered the question and stated that so far as this question is concerned he made the same answer as to the question referring to the Missouri River alone.

Mr. Todd: I submit that the witness has not stated whether he would recommend the water as a safe drinking water for drinking and domestic purposes, and that it is the question that I have asked repeatedly, and it is the question that I ask now, and I have a right to have a definite answer to my question as he is an expert on sanitary science.

Mr. Jeffries: I will suggest to counsel that witness has answered the question time and again, but I object to counsel

12791 insisting upon witness answering the question as he desires or having counsel to put the answer in witness's mouth.

Q. Question read.

A. Replying to your question I would state that I understand that the conditions enumerated in your question indicating the discharge of sewage throughout the water shed above the chain of rocks at the point where the St. Louis water supply is taken was, during the period 1896 to 1899, excepting that during that period there was a certain amount of discharge of the sewage of Chicago into this area, and under this understanding I would again refer you to my previous answers as to my opinion concerning the recommendation of the Missouri River water and the discussion following as in my opinion answering your question.

Mr. Todd: Q. Doctor, do you mean that you would recommend the water of the Mississippi River as it passes through the settling basins to the city of St. Louis as a safe drinking water for drinking and domestic purposes, assuming that the entire sewage of Chicago should be eliminated?

A. Replying to your question I would state that I have 12792 already answered that the water supply which was used in St. Louis during the period in question gave such results according to the test of the typhoid fever death rate that in my opinion, as I have stated, it was during that time a reasonably safe water and I understand that during that period a part of the Chiego sewage was discharged into the river. The removal of that would of course not, affect my opinion as already expressed, so that I would state explicity that I would not recommend, as already stated, the water in use at that time as an absolutely safe water but the results of the tests are, in my opinion, sufficient to justify one in recommending it as a reasonably safe water.

Q. Would you recommend it now as a safe, not reasonably safe, as a safe drinking water for drinking and domestic purposes if the entire sewage of the sanitary district of Chicago was eliminated, treated as it is today in the settling basins?

A. In my answer to your question as has already been practically stated in my statement that I would not recommend it as an absolutely safe water.

12793 Q. I am not asking, Doctor, for absolute safety.

Mr. Jeffries: Object to the question for the reason that the questions themselves put to the witness by counsel when the term safe is used it means and can mean nothing else except absolutely safe, unless counsel will put those questions so as to refer to particular conditions rather than absolutely safe conditions.

Mr. Todd: In reply will state that counsel for defendants believes that in the employment of the English language in expressing his questions that he needs no assistance on that point from my opponents.

Mr. Todd: Q. Doctor, would you recommend any river water in this country as a safe drinking water for drinking and domestic purposes, without filtering?

A. Replying to your question and assuming that by safe you mean absolutely safe, I shall have to say that I suppose that there is no river which flows over the surface which might 12794 not at some time become infected and that therefore under that assumption I could not recommend them in this country. There are many mountain streams which have been used for long periods with no ill effects to the persons using them as far as typhoid fever is concerned.

Q. Doctor, do you regard water that has gone through filters as absolutely safe?

A. I have already answered that question in the statement that there is no water flowing over the surface that might not receive some contamination.

Q. If you were called upon to recomend a water supply of a city, could you guarantee the water supply as being absolutely safe or can you conceive of a water supply as being absolutely safe, in the sense that you use absolutely?

A. I can conceive of a water being absolutely safe, but it is so difficult to find a large quantity of water that is absolutely safe that I should not expect to be able to recommend any supply of water in a large community that would be absolutely safe.

12795 Q. Would you recommend the water of any large river that receives the sewage of cities and the drainage from rural populations to any given community without filtration?

A. Oh, I might recommend under certain conditions other methods of purification than filtration.

Q. But eliminating the other methods, in its raw state, I mean would you recommend the water of any river east of the Alleghanies and within the Mississippi River valley as a safe drinking water, without filtration?

A. Yes sir.

Q. What rivers have you in mind?

A. I can not mention especial rivers because I have not examined any group of rivers with reference to that point, but I can conceive there are in the mountainous districts and in the region you have mentioned small rivers which are so remote from liability to sewage infection that they might be used.

Q. Would you recommend any river in this country that
received the sewage of any cities above it as well as the
12796 sewage from the rural and urban population as a safe
water supply for a city without filtration?

A. Under certain conditions there might be other methods of purification which could be substituted for filtration, I would say that I could not recommend a water such as you have described without some other process of filtration.

Q. What other process would you recommend?

A. Under certain conditions the process of purification by subsidence might accomplish satisfactory results.

Q. How long a period of subsidence would you recommend before the water would be reasonably safe?

A. That would depend upon the character of the water.

Q. Have you in mind any river in the Mississippi River Valley that you would recommend subsidence for a period of from three to five days as sufficient to make the water safe?

A. In reply to that question I shall have to refer again
12797 to our original discussion as to the Missouri River water.

Q. Have you ever been called upon to pass judgment upon the quality of a river water for drinking and domestic purposes when you recommended subsidence?

A. No sir.

Q. Have you ever been called upon to pass judgment upon the quality of a river water in its raw state for any municipalities in this country?

A. I have had occasion to give advice on such matters.

Q. Have you ever recommended for municipalities the use of river water without filtering?

A. No sir.

Q. Have you ever installed a filtration plant?

A. No sir, that does not come within the line of chemistry or bacteriology.

Q. Have you ever operated a filtration plant?

A. I have never operated one in the sense of having charge of the works. I have, of course, made analysis showing the character of the work.

12798 Q. Have you had anything to do with the engineering features of a filtration plant?

A. No sir.

Q. Have you ever accepted bids for the installation of a filtration plant or passed upon the reasonableness of the bills?

A. I have never been called upon to pass upon such matters when they are engineering matters.

Q. Have you ever employed men to operate a filtration plant and passed upon the reasonableness of their compensation?

A. I have never been called upon to make such decisions, no sir.

Q. Are you acquainted with what it cost to operate a filtration plant filtering 200,000,000 of gallons of water per day?

A. In a general way I know the cost of filtering water but it differs under different conditions, and as I give little or no attention to the engineering side, I have not paid special attention to that. 12799

Q. Have you had any experience in filtration plants in the Mississippi River Valley?

A. No sir.

Q. Are you acquainted with the number of men necessary to operate a filtration plant?

A. Why, in a general way I am.

Q. Is that information based upon actual experience in the employment of men figuring out the cost of the filtration plant?

A. No, sir, that has to do with the administration and engineering features of which I have had no experience.

Q. If you have had no experience in the engineering and administration whatever of a filtration plant, wherein does the element of cost come in, in operating a filtration plant when infection is present in the water, together with matters in suspension that are to be removed?

A. The chief sanitary object of filtering water is to remove the infection. The questions relating to the rapidity of 12800 filtration, the character of the filtration, the scientific oversight of the operation of the filter all depends upon the relative contamination of the water which has to be filtered.

In other words a water which has a certain or given contamination would be satisfactorily filtered at a certain rate. If the water had a greater amount of contamination then the rate, in order to accomplish the removal of the obnoxious parts, with the same degree of thoroughness, must be as a bacteriological factor slower and it will take a larger plant to filter the same amount of highly contaminated water than it would of a less contaminated water.

Then, further, as filters are liable to fail in their operations at times, a filter which is filtering water highly contaminated must have more careful scientific oversight in the way of the testings of the water to get at the general character of the water.

Q. Is it not a fact that the chief cost in the establishment and operation of a filter depends upon the matter in suspension and the question of infection is a matter of secondary 12801 consideration?

A. Not from a sanitary standpoint, no sir.

Q. What city in this country is operating the largest filter plant?

A. The plant which is operated in part in Philadelphia is one of the largest plants in the country, I believe.

Q. Do you know whether the waters of the Schuylkill and the Delaware rivers are any less infected than the waters of the Mississippi as they pass St. Louis?

A. The typhoid death rates of the two cities are both pretty high. The typhoid death rate at Philadelphia is higher than the typhoid death rate at present in St. Louis and from that standpoint I should judge that the water which is used in the raw state supplied in Philadelphia is a more contaminated water than that which has been supplied to St. Louis.

This opinion, however, is modified somewhat by the fact that part of the water in St. Louis is purified to a certain extent by the assistance of subsidence and part of the water
12802 supplied to Philadelphia is treated by filtration, so I cannot answer your question absolutely as to the relative contamination of the two streams. It is a question which I have not given special attention to.

Q. Are you aware, Doctor, that in the construction of filters in the city of Philadelphia, which is under the direction of John W. Hill, a bacteriologist and chemist and sanitary expert, that the question of infection is not an element of cost either in the building or in the operation of that filter plant, and that the chief cost is in the removing of the matters in suspension?

A. I am not aware of the figures in the case, no sir.

Q. Have you ever given the question consideration as to the difference in cost between a water that is sewage polluted greatly charged with matters in suspension and a water of equal pollution that has infection present as to difference in cost of operation and maintenance of a filtration?

A. As stated those are matters which pertain to the engineering side of the problem, and I have not given the details of such matter attention.

12803 Q. Then, Doctor, how were you able, in your examination, to pass an opinion as to the relative cost of filtration here in St. Louis with the waters of the drainage canal turned in over conditions that obtain if the sewage of Chicago was eliminated?

A. The opinion which I expressed regarding that was a general one in regard to the relation and not a specific one which would require the knowledge of an engineer and was based upon the considerations which I enumerated a short time ago relating to the question of rapidity of flow through the filters as affecting their size and the oversight as affecting the character of the effect from a sanitary standpoint, and I did not mean to express it on any other facts.

Q. The opinion then was very general?

A. It was general that it would cost more on these accounts.

Q. Have you any specific knowledge that justifies you in expressing such general opinion based upon your experience in matters of filtration and filter plants?

A. I know that it is customary in connection with the filter plants of the various cities in Europe to operate them ac-
12804 cording to the results of the bacteriological examinations. If the tests show a larger proportion of bacteria on a given day that is taken as evidence that the filter is passing the water too rapidly for a satisfactory purification, and then the rate is modified accordingly and this varies with the number of organisms in the raw water to be filtered.

Q. Doctor, have you made any experiments yourself upon the longevity of the typhoid bacilli?

A. No sir, not laboratory experiments.

Q. Have you made any experiments under natural conditions of the typhoid bacilli to ascertain its longevity?

A. Those would be what I would call laboratory experiments. I have not. I do not mean to say that it is in connection with laboratory methods.

Q. You stated that you were not acquainted with any experiments that limited the longevity of the typhoid to less than six days, outside of Jordan, Russell and Zeit. Do you mean to have it understood that there are no bacteriologists of a
12805 reputable standing that hold to the view that typhoid fever germs will not live to exceed six days in a sewage polluted water, or that you do not know of them?

A. What I meant to say was that I do not know of any one who would express an opinion to that effect as to the longevity of typhoid bacteria under natural conditions of sewage pollution of streams.

Q. Are you acquainted with the series of experiments conducted by John W. Hill in the laboratory at Philadelphia in sewage water for the purpose of ascertaining the longevity of the typhoid bacillus as affected by the chlorine in the water?

A. In a general way I know something of his work.

Q. Do you know what the results of those experiments were?

A. I know that the period was a short one, but I can not state the exact length of it. I do not know the exact date nor do I understand that as a result of those experiments the experimentors would be willing to apply those figures to 12806 sewage under natural conditions.

Q. Do you know that the result of those experiments did not extend the longevity of the typhoid bacillus six days?

A. I do not know that those experiments lead to the general conclusions which I have stated, that typhoid bacteria under natural conditions, as they exist in the sewage, do not have a longer longevity than six days.

Q. Are you aware of the fact that John W. Hill, who supervised those experiments testified in this case and gave his opinion that the typhoid germ would not live to exceed six days in diluted sewage?

Mr. Jeffries: Object to the question for the reason that the evidence of John W. Hill in this respect and to this effect based upon analyses as made by him and the analyses themselves were too limited to enable a sanitarian, to express an opinion as to the longevity of typhoid fever germs in sewage or in sewage polluted water.

Mr. Todd: In reply would state that notwithstanding counsel's objection John W. Hill did so express an opin- 12807 ion based upon the results of his examination.

A. That fact was called to my attention and was included in my answer when it was originally stated, outside of those who testified in this case—that was in the original question.

Mr. Todd: Q. Have you made any laboratory experiments upon the longevity of the typhoid bacilli in sewage, yourself?

A. As already stated, I have not.

Q. Then your opinion, as far as it is influenced by laboratory experiments, is influenced by the experiments made by others and not by yourself?

A. Assuming that my opinion was influenced by laboratory experiments or methods that would be so.

Q. Was your opinion influenced by laboratory methods?

A. The opinion that I expressed was that the laboratory experiments were so different from the conditions naturally occurring in sewage polluted streams, that in my opinion they were not adequate therefore I do not credit them as being sufficient to form a judgment on that matter and did not express an opinion. 12808

Q. You mean by that all the laboratory experiments of which you have knowledge?

A. Surely.

Q. Do you know of any experiments that have been made by any bacteriologist in this country or in Europe that simulates natural conditions as nearly as the experiments made by Professors Jordan, Zeit and Russell, to which you referred, and which were as extensive in their scope as that experiment upon the longevity of the typhoid bacilli?

A. No sir, I do not.

Q. Can you suggest any experiment that is possible to be made by a bacteriologist that would stimulate natural conditions more closely than the experiments made by Professors Jordan, Russell and Zeit on the longevity of the typhoid?

A. Yes sir; unquestionably the technique of such experiments could be rendered somewhat more approaching the natural conditions, but the problem is so difficult, the variations in the conditions are so extreme, the conditions that the typhoid bacillus exists in in the sewage is so different, that I can not conceive how laboratory conditions or methods can afford a perfectly satisfactory solution as to the matter of how long typhoid bacilli may exist in a stream, and in my opinion such data can not be expected to yield a definite, positive answer to that question under any given set of conditions. 12809

Q. Do you know how many distinct and separate experiments were made by these three experimentors on parchment sacs?

A. I looked over the list and I remember there were a considerable number.

Q. Do you know that they used in addition to the cultures bacteria the feces or urine of a typhoid fever patient?

A. Yes, I know that there was some variation in the details as to the source of the material.

Q. Will you state to what technique you refer that could supplement the technique that was employed in the making of these experiments? 12810

A. It would have obviated one difficulty if the sacs had been allowed to float down the stream, properly protected so that they would not have been subjected in succession to a series of different character of water as they must have been when they were put stationary at one point. That is one thing that would suggest itself to me.

Q. Any other?

A. These experiments might have been tried in sacs of such size as to admit the accumulation of considerable quantities of sediment with a view of ascertaining whether they would have influenced the result. That would have more nearly simulated the conditions in the stream.

Q. What criticisms have you of the celloidon sac method that was employed by Professor Zeit?

A. There is no particular criticism that occurs to my mind as comparing the use of the celloidon and the parchment. Of course there was a difference in the fact that one permits dialysis, while the celloidon does not. The experiments
12811 were very carefully worked out and unquestionably they
were very well done, but the difficulty of simulating natural conditions are what appear to me to be of importance.

Q. You have examined the typhoid fever statistics of the city of St. Louis have you not?

A. Yes sir.

Q. From what source did you gain your information as to the typhoid fever conditions in the city of St. Louis?

A. There were two sets of data brought to my attention. Those which have been referred to as the ones published in the reports of the Commissioner of Health and those which were referred to in my testimony of yesterday as having been furnished by Professor Sedgwick and Mr. Lochridge from the records in the mortuary office.

Q. Professor, do you regard intermittent, remittent, typho malaria, congestive and simple continued fevers as distinct types of disease?

12812 A. Under the names which you have described, there are different diseases included. The terms remittent fevers and intermittent fevers are names applied to a malarial infection and are in use in statistical work as representing the different manifestations of the malarial disease.

The term typho malaria is a term regarding which there is some variation in the usage in the medical profession. The best usage is that it should be confined to the condition which exists when there is in one person a combined infection of the typhoid and malarial organisms, but it has been used and is used by some practitioners as applied to malarial conditions which exhibit what is known as the typhoid state which refers rather to the symptomology than the cause, but it is not a typhoid infection, but it is the symptomatic condition which is best realized in the typhoid infection.

12813 The term congestive fever, by the best usage is undoubtedly restricted to a severe form of malarial infection which is manifested by the congestive chill.

The term simple continued fever is a term which is no longer correctly used and can not be used as representing any specific disorder but grouped under that have been unquestionably many low conditions which were characteristic or characterized by a continued fever. Many of these were simply bacterial infections but not associated necessarily with the typhoid organisms nor with the malarial organism.

Q. Are you acquainted with the mortality from malaria?

A. The mortality from malaria differs very greatly in different localities. In the temperate zones there is usually not much mortality to malarial diseases except among the feeble. This is of course seen more particularly among the feeble young and among the old, though of course adults of intermediate ages may succumb to malarial conditions if they are feeble.

12814 Then there are certain types of malarial disease such as typified by what I said concerning congestive fevers, which affect adults of all ages, but they are not very common in temperate zones. They are the malarial disease of the tropics.

Q. Do doctors confound typhoid fevers with other diseases?

A. Yes sir.

Q. And report deaths that should properly be typhoid under some other head?

A. Such confounding of diagnosis of course may happen. It is probably much more frequent among cases that do not die than among fatal cases because when a person dies from typhoid fever the condition is likely to display itself in such a character that the diagnosis is likely to be corrected at or before the time of death, if there was a mistake. There are some fatal cases that are misdiagnosed.

Q. In the number of deaths reported in the board of health
reports in the city of St. Louis under the heads intermittent, re-
mittent, typho-malaria, congestive and simple continued
12815 fevers, how many of those deaths would you charge to
malaria?

A. That is a question which I could not answer by any general average. The only way to answer such a question as that is to enquire into the habit of the office when these results are compiled and to state what the original diagnoses were.

Q. In your inquiry and investigation of the compilation of the mortuary office here, did you find a discrepancy between the figures in that office and those that are published in the official reports of the Commissioner of Health under remittent, intermittent, typho-malaria and congestive fevers?

A. There is a marked discrepancy between the list given in the report of the Commissioner and the data which were compiled by Professor Sedgwick and Mr. Lochridge from the records of the mortuary office.

Q. Did you make a comparison of the typhoid death rate as published with those that are in the same office, the number of typhoid deaths?

12816 A. The number of typhoids, yes. The two sets of records
substantially agree in this respect.

Q. Under the heading of intermittent, remittent, typho-malaria, congestive and simple continued fevers, what is your opinion as to whether any of those fevers should be properly classified as typhoid fever?

A. It is not uncommon to find differences in diagnosing in the early stages of typhoid fever and in mild cases between the malarial condition and the typhoid condition so that I think that errors of this sort are more or less common in the diagnosis of cases, but in the matter of deaths I can see no reason why there should be very much confusion, for the reason which I have already stated, that by the time a typhoid case reaches that condition where it proves fatal the disease has generally so directed itself so as to admit of the application of the diagnosis if there was an error.

There are, however, doubtless some cases which are never correctly diagnosed.

12817 Q. When a doctor, through his inability to diagnose a typhoid fever case as typhoid, treats it for something else and the patient dies, do you know of any case where he has subsequently changed his diagnosis and issued a death certificate after death?

A. Yes sir; the formal diagnosis is the diagnosis named on the death certificate, and the early diagnosis is very frequently a temporary one made in the family, and in many cases there is no statement made what the diagnosis is.

Q. But among the general practitioner when he treats a case for some other disease than that of typhoid fever and the patient dies, is there anything in the death of the patient that will inform that doctor that it is typhoid if he did not find it out before the death without a post mortem?

A. Not at the time of death because it is a condition which exists within a reasonable time prior to the death which reveals the true nature of the disease.

Q. Is it your opinion that the doctors in the general practice in a city like St. Louis are all qualified to diagnose ty-
12818 phoid fever, in all of its varieties?

A. I have no doubt that there are incompetent physicians in the city of St. Louis as there are incompetent persons in other professions or callings.

Q. Are you acquainted with the number of medical students turned out in the number of our western medical colleges in all schools of medicine in the Mississippi Valley each year?

A. I know that there are large numbers of medical students graduated in the western colleges and most of the colleges of this part of the country are now in what is known as the American Medical College Association, and they at present and for the past few years are having a very much stricter course than formerly, but that is true all over the country.

Q. In the certificates of death they are made up by doctors of all standing, high and low degree, are they not, that reach the health department?

A. Any registered physician may sign a death certificate, yes sir.

12819 Q. From your examination of the board of health in the city of St. Louis, did you find the accuracy in the comparing of statistics such as should obtain in a branch of government of such importance?

A. I have made no examination of the health office. The only matters that have come to my attention are the records of the Commissioner of Health and the data derived from the mortuary office. I know nothing about the details of the reports of the Commissioner of Health.

Q. In figuring out the typhoid condition in the city of St. Louis, did you allow any cases of typhoid fever under the column of remittent, intermittent, typho maiaria, congestive and simple continued fevers as being typhoid?

A. I have considered the typhoid deaths as reported, I have considered the data concerning each of the diseases which you have enumerated as well as those from malarial fever, and I have considered the statistics combining the typhoid
12820 deaths with those which are shown by those certificates
to be included in the miscellaneous class which you have enumerated.

Q. Did you allow any of the deaths reported under this miscellaneous class as typhoid in arriving at your conclusions as to the typhoid condition in St. Louis?

A. I have considered, as stated, that possibly, and I have seen, including them all in the typhoid deaths, there is still an increase of typhoid fever between the two periods, but I have further considered compilations of the deaths under each of the miscellaneous class, especially with the view of attempting to form an opinion as to whether any considerable portion of them might have been typhoid deaths. I can not state, of course, that none of them were, and I cannot state personally how many of them were, but considering them from the standpoint of the age of the persons and from the distribution of the cases of deaths by months, it will be seen that there would be comparatively few of those which are classified under 12821 this group which should be included in the typhoid class.

Q. Doctor, what effect would the coming in of a great number of people during the last three years, while the Exposition was being constructed here, and the number of people naturally attracted to St. Louis from people unacclimated, have upon the typhoid rate in the city of St. Louis?

A. The introduction into the city of a considerable number of persons from other sections might have some effect as raising the number of cases of typhoid fever.

Q. Was that fact taken into consideration by you in your testimony?

A. Yes sir.

Q. What proportion of typhoid deaths in the city of St. Louis would you attribute to local causes such as wells and the failure to remove garbage?

A. The number of cases which come from local infection such as wells is indicated to probably not have much 12822 more existed during the period since the opening of the canal than they obtained before the opening of the canal. There is, of course, no way in which I can estimate absolutely the proportion of the deaths which occurred during the years 1896 to 1899, inclusive, there is no way in which I could tell the proportion or portion from any such local cause and those which may be due to some other cause, but the rate which prevailed here during that time was about the same rate which we find in some of the better class of cities in this country.

RE-DIRECT EXAMINATION

By Mr. Jeffries:

Q. Doctor Smith, in reference to your testimony on cross-examination upon the longevity of the typhoid fever bacilli in a running stream, I will get you to state whether or not in your opinion the present state of bacteriology is such as to enable a sanitary expert to fix with accuracy the longevity of a typhoid fever bacillus in a running stream, under all conditions and at all possible times, and to state with even approximate 12823 accuracy the comparative resistance of a colon bacillus and the typhoid bacillus in a running stream under all possible conditions and at all possible times or to deduce from any experiments heretofore made and introduced as evidence in this case such true and trustworthy information as would enable you to conclude that a sewage polluted river might be used for drinking and other domestic purposes with absolute safety at all times and in all seasons?

Mr. Todd: I object to the question on the ground that I did not cross examine this witness upon the longevity of a typhoid bacillus in a running stream, and for the further reason that it is not re-direct examination of anything brought out in the cross, and for the additional reason not having been gone into on the cross it is not rebuttal evidence of anything offered in the case by the defendants, but it is a part of the original case of complainant and is therefore not rebuttal and consequently is incompetent, irrelevant and immaterial.

A. My reply to your question is a repetition of points which I have previously taken up, and I would therefore 12824 reply briefly that in my opinion the present state of bacteriology is not such as will permit an expert to fix with accuracy the longevity of the typhoid bacillus in a running stream under all conditions and at all possible times.

Further that it is not possible to state with accuracy the comparative resistance of the colon and typhoid bacilli in a running stream under all possible conditions and at all possible times, and further that it is my opinion the present state of bacteriology is such that it is not possible to conclude from bacteriological analysis that a sewage polluted stream might be so purified as to be used for drinking and other domestic purposes with absolute safety at all times and all seasons.

Mr. Todd: I move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Doctor, what is the full length of the Connecticut River?

A. Why, it is about three hundred miles.

Q. What effect has a flood upon the water shed of the 12825 Des Plaines River and the upper Illinois River upon the sewage of Chicago coming through the canal during the time of such flood?

A. The effect of a flood at this point would be first to dilute the sewage and to hasten the period of passage of it through the river.

Q. State, Doctor, whether or not, under such flood conditions as mentioned in the last question, it would prolong the life of the typhoid bacilli and other pathgenic organisms?

Mr. Todd: I object to the question for the reason that it is not re-direct of any subject gone into in my cross examination, as I did not touch the question of the typhoid germ in the Illinois River for the reason that I have objected to its introduction into this case by this witness as being not rebuttal, and therefore on the theory that it is not re-direct of what I have gone into on the cross it is incompetent, and for the addition reason it is part of the original case of the complainant and should have been introduced in chief, and this is not the proper place to bring it in under the guise of rebuttal, and it is therefore incompetent, irrelevant and immaterial.

12826 A. The trend, as already stated, of bacteriology researches is to show that concentrated sewage has some deleterious effect upon the life of the typhoid bacilli, consequently the effect of diluting the sewage by floods in the upper Illinois river would be to introduce a condition which would tend to increase the longevity of the typhoid bacilli in the water, first by the dilution of the sewage itself and second by carrying the organisms quicker into the lower stretches of the river where there is more dilution from natural causes.

Mr. Todd: I move to strike out the answer for the reasons given in my objection to the question.

Mr. Jeffries: Q. Doctor, assuming that the total area of the Illinois River water shed is 32,081 square miles; that the total area of the Mississippi River water shed above St. Louis, Missouri, exclusive of the Illinois, is 1,396,170 square miles; assuming that the total drainage area of the Missouri River is 320,086 square miles; assuming that the total urban population, including the sanitary district of Chicago, upon the Illi-
12827 nois River is 1,843,800; that the total population upon the Missouri River is 552,000 from the mouth of said river to and including the city of Omaha; that the total population upon the Mississippi from Minneapolis is 697,200. Please state your opinion as to which of these rivers would be the more

unsafe and the more liable to contain dangerous disease producing organisms, basing your opinion upon your knowledge as a sanitarian and epidemiologist, and upon all of the chemical and bacteriological data that have been introduced in evidence in this case, and which you have observed, including the tables in Streams Examination, the health reports of the Board of Health of the State of Illinois, and the report of the University of the State of Illinois, and the tables and the experiments in reference to the colon and bacterial counts introduced in evidence by Professor Jordan, aside from those contained in the books just mentioned, including also the tables of results introduced in evidence as to the longevity of the typhoid germ in the parchment and celloidin sacs and the experiment of Doctors Zeit, Jordan and Russell?

12828 Mr. Todd: Object to the question for the reason that it is not re-direct of anything brought out in my cross-examination, and for the additional reason it is not rebuttal evidence of anything that is introduced in evidence by the defendants, but part of the original case of complainants and therefore incompetent, irrelevant and immaterial.

Mr. Jeffries: I suggest that this question is based upon the cross-examination given this witness by the counsel for the defendants.

A. I would state I have considered the data summarized in your question and would state it as my opinion that the water of the Illinois River would be most likely to contain the largest relative number of disease organisms such as are transmitted by sewage.

Mr. Todd: I move to strike out the answer for the same reason stated in my objection to the question.

Mr. Jeffries: Q. Based upon the same assumptions state whether or not it is your opinion that the Illinois River does or does not contain more disease producing organisms than
12829 either of the other two?

Mr. Todd: Object to the question for the same reasons stated in my objection to the previous question.

A. In my opinion the waters of the Illinois River do contain relatively more disease germs such as are transmitted by sewage than the waters of the other rivers mentioned.

Mr. Todd: I move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. State whether or not that opinion applies to the condition of the water in the Illinois River at its mouth, the Mississippi River at a point immediately above Grafton, and the Missouri River at its mouth?

Mr. Todd: Object to the question for the reasons stated in my two previous objections.

A. In my opinion this does apply to the water at the mouth of the Illinois River as contrasted to the water at the mouth of the Missouri, in the Mississippi, in the immediate neighborhood at the points referred to.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

12830 Mr. Jeffries: Q. While it may be true that all river water should be filtered yet is it not essential to preserve the physical condition of the rivers in their natural state as near as may be?

A. It is my very positive opinion that it is desirable to preserve the rivers of our country as free from pollution by sewagic matter as possible, and especially as related to their use for drinking waters, and considering the question also of subsequent filtration.

Q. Is it not a fact, Doctor, that when filtration is undertaken that it is advisable to obtain that water for filtration, if obtainable, which has been the least subjected to sewagic discharges?

A. I will state it as my opinion positively that of two waters originally alike in other respects that one which has the least sewage pollution should be chosen for the process of filtration for a public drinking water supply.

Mr. Todd: Q. While it is desirable to preserve the rivers in their natural condition in your opinion does the State 12831 of Missouri, with the cities of Kansas City, Jefferson City, St. Charles and Cape Girardeau emptying their sewage into the Missouri and Mississippi Rivers present an exception in your opinion to the rule enunciated by you in answer to the former questions of Mr. Jeffries?

Mr. Jeffries: Object to the question for the first reason that we do not claim that any exception is necessary or made, and I object to the question for the further reason that there is no evidence showing that Missouri or any city, municipality or township that has ever taken sewage through a natural water shed and discharged that sewage into and upon a water shed other than that prepared by nature for it.

I object to the question for the further reason that the suggestions therein contained do not under any circumstances justify Chicago in the construction of the drainage canal and the discharge of the sewage from 2,000,000 of people into and upon the people residing in the Mississippi River Valley below the mouth of the Illinois River and compelling them to
12832 suffer the responsibilities of guarding against the destructive elements contained in such sewage when comingled by the action of the sanitary district of Chicago with the water used for domestic and drinking purposes in the Mississippi Valley and particularly in the State of Missouri and the City of St. Louis.

Mr. Todd: I move to strike out so much of counsel's address as is not included in the legal objection to the question.

Q. Question read.

A. Replying to your question I would say that we have to expect a certain contamination of the streams of a certain territory in which the population is growing, and while it is desirable to avoid that, we have got to endure the results of our own progress. I expect you would hardly think me qualified to express an opinion on a legal question as to whether water from another water shed could properly be brought into this water shed thereby increasing the pollution.

HERBERT E. SMITH.

ADJOURNED until 2:45 P. M., same day.

12833 2:45 p. m., Wednesday, May 25, 1904.
Room 282 Southern Hotel, St. Louis, Mo.

Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

JOHN W. ALVORD,

a witness called on behalf of the complainant, being duly sworn by the Commissioner, was examined in chief by Mr. Jeffries, and testified as follows:

Q. Please state your full name and address?

A. John W. Alvord.

Q. Also your occupation?

A. Sanitary and Hydraulic Engineer, Chicago, Illinois.

Q. How long have you been engaged in the practice of your profession as a hydraulic and sanitary engineer?

A. About twenty-four years.

Q. Where?

A. With Chicago as a center, in and about Chicago and the middle west.

Q. Mr. Alvord, give an outline in a general way of your educational training?

A. I was ready for entrance to the Sheffield Scientific
12834 School of Yale College in 1877, but was unable to take
the course owing to poor health. My engineering education has therefore been confined to study and travel, coupled with practical experience. The first engineering work in which I was engaged was in 1879 in Chicago in connection with the construction of the Hyde Park Pumping Station of the Chicago water works and the Inlet tunnel to such station under Lake Michigan.

Later, I was in charge of the operation of the Lake View Station of the Chicago water works, and was for four years City Engineer of Lake View, then a separate municipality from the city of Chicago, since annexed.

After the annexation of Lake View I engaged in general practice in sanitary work in the suburbs of Chicago and adjacent cities.

I visited Europe in 1888 and 1894 and examined the question of water purification and sewage disposal particularly. From 1890 to 1893 I had charge of a department in the construction of the World's Columbian Exposition at Chi-
12835 cago and in 1894 resumed private practice, since which
time I have been engaged in various capacities with

about thirty-five different city water works plants and about forty-five municipal sewer systems, including the purification of water supplies and the disposal of sewage. I was engaged in 1898 in making a report to the city of Columbus, Ohio, on the extension of its sewer system and the disposal of its sewage, which report was published.

From 1898 to 1902 I was consulting engineer to the Illinois State Canal Commission, advising as to the works of the sanitary district channel in and through Joliet and in the litigation as to the removal of dams and locks at Joliet.

I have been engaged recently in the development of water power at Petosky, Michigan, and Big River, Missouri, and Des Moines, Iowa. I have been engaged in the design of some twelve water works plants which have been constructed and in which the question of river pollution bore an active part.

I have had some limited experience in typhoid epidemics, having studied them at Hurley, Wisconsin; Iron Wood,
12836 Michigan, and Culver Academy, Indiana in 1894, and the
typhoid epidemic of Chicago in 1892 and 1893, the Duluth epidemic of 1896, the typhoid epidemic at Grand Forks, North Dakota, in 1894, and was engaged to investigate the causes of the epidemic at Wequetansing, Michigan, and Petosky, Michigan, in 1903.

Q. State whether or not the epidemics that you have referred to were caused by water in any case?

A. So far as I have studied them they were all caused by polluted water supplies.

Q. Are you familiar with the Chicago river, the drainage canal, the Desplaines and the Illinois river?

A. I am. In 1888 I was engaged in conducting the litigation in behalf of the State of Illinois with the Sanitary District, in the course of which the hydraulics of the upper portion of the Desplaines river were thoroughly reviewed. I have studied in general the progress of the construction of the drainage channel and the related questions, and I was engaged in working for the special commission which reported upon its com-
12837 pletion.

I have observed the Illinois river at Morris, Ill., where I designed the system of sewers; at Ottawa, where I was engaged in water power litigation; at Marseilles, where I advised as to the enlargement of the water power, and have also observed the general characteristics of the river at Seneca, La Salle, Peru, Hennepin, Peoria, Pekin and Havana, at which latter two places I have designed sewerage systems.

I am also familiar with the Mississippi river from St. Louis to Alton, to some extent.

Q. State whether or not you are familiar with the ordinary minimum flow of the Illinois river before and since the opening of the drainage canal?

A. I have had occasion to observe at different times before the opening of the drainage channel the flow of the Illinois and the lower Desplaines river, and have also observed it since the opening of the drainage channel.

Q. Mr. Alvord, state whether or not you have given the subject of bacteriology any attention in connection with your
12838 profession?

A. I have to a limited extent. I have tried to keep myself posted upon bacteriology in a general way ever since it has come into use among engineers.

Q. Now state whether or not you have familiarized yourself with the subject of chemistry as applied to your profession?

A. Also to a limited extent. I took a partial course in chemistry at the University of Chicago in 1894. In 1900 I studied bacterial quantitative analysis under the advice of Professor Novy of Ann Arbor, Michigan. I have endeavored to keep informed on the subject in everything which would be of interest to my work as a sanitary engineer.

Q. State whether or not you were ever engaged with the water investigations of the city of St. Louis?

A. I was employed in 1902 by the special commission that investigated the extension of the water supply of the city of St. Louis, and my part of the work was to study the financial history of the present works, their physical cost and the cost of their operation. In the course of this work I became familiar
12839 with the characteristics of these works and have visited
the Chain of Rocks stations and sedimentation basins, also the old station at Bissel's Point, and have studied the physical features of the sedimentation plant.

Q. State whether or not you have made any special study of the typhoid condition on the water shed of the river above St. Louis?

A. To some extent.

Q. Where did you obtain the data which you have in regard to the typhoid deaths and the population of these water sheds?

A. From the records in this case.

Q. From evidence introduced by the respondents?

A. Yes sir.

Q. And complainants?

A. Yes sir.

Q. State whether or not you have prepared a diagram showing the relations of typhoid fever deaths in St. Louis with typhoid deaths on the water sheds?

A. I have.

Q. Will you submit this diagram?

A. I will.

12840 MR. TODD: Objected to for the reason it is not rebuttal as part of the complainant's case, complainant's original case and gone into in chief, and is therefore incompetent, irrelevant and immaterial.

MR. JEFFRIES: I will state in answer to the objection that this diagram is based not only upon the evidence introduced by complainant as to the number of deaths upon the respective water sheds, but is also based upon the additional evidence in relation thereto by respondents.

MR. TODD: In reply would state that while complainants attempted to introduce the typhoid statistics of the cities on the three water sheds in their original case and did not introduce them all, that defendants supplemented that evidence by the additional cities not introduced by complainant, but that does not make this competent evidence on rebuttal as it is admitted by counsel in his statement that complainant went into the question of the typhoid fever statistics on the water sheds of the three rivers when putting on his case in chief, and is therefore incompetent, irrelevant and immaterial, and not rebuttal.

12841 MR. JEFFRIES: Q. I will ask you, Mr. Alvord, whether or not this diagram is based upon the typhoid fever deaths upon the water sheds of the Mississippi, the Illinois and the Missouri rivers respectfully, as shown by a tabulated sheet of the evidence upon that subject, introduced in this case?

MR. TODD: Object to the question for the same reasons stated in my previous objection.

A. It is.

MR. JEFFRIES: I now, Mr. Commissioner, offer this diagram in evidence.

MR. TODD: Objected to for the same reasons heretofore stated.

The diagram is as follows:

12842 Complainant's Rebuttal Chart No. 1.

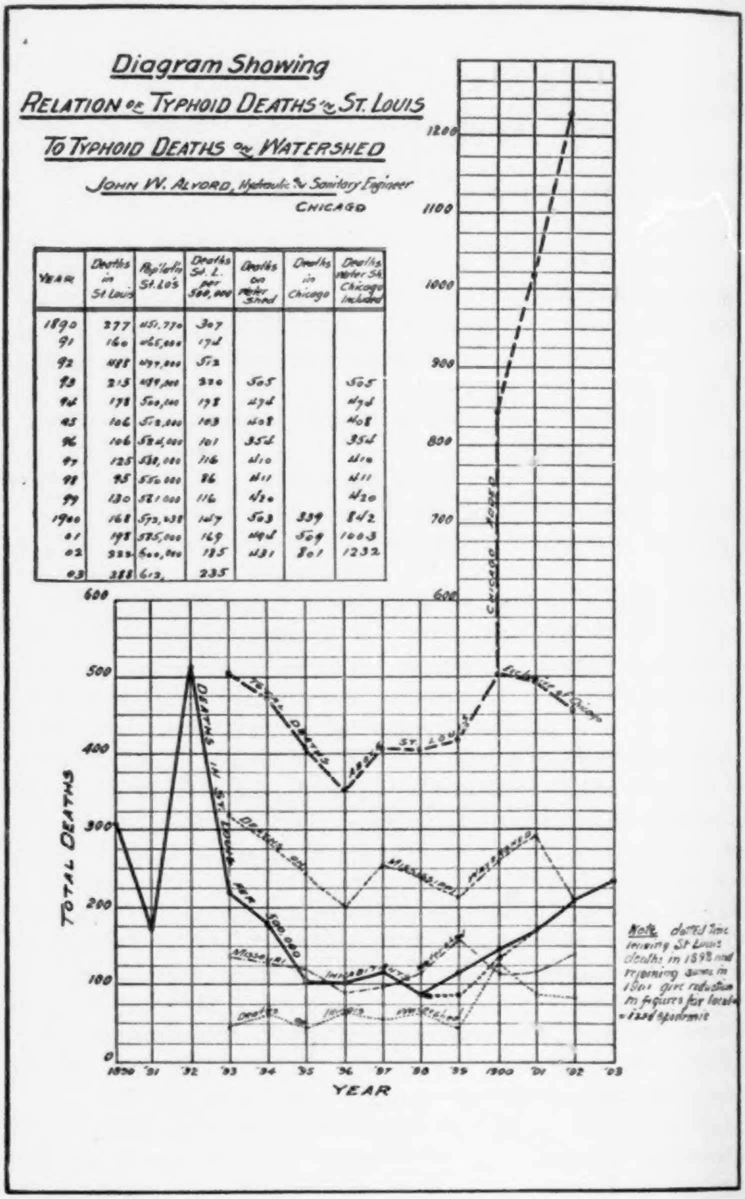


Diagram Showing
RELATION OF TYPHOID DEATHS IN ST. LOUIS
TO TYPHOID DEATHS ON WATERSHED

JOHN W. ALVORD, Hydraulic & Sanitary Engineer
CHICAGO

YEAR	Deaths in St Louis	Pop'lat'n St. Lo's	Deaths St. L. per 500,000	Deaths on Water Shed	Deaths in Chicago	Deaths Water Sh. Chicago Included
1890	277	451,770	307			
91	160	465,000	174			
92	488	477,000	512			
93	215	489,000	220	505		505
94	178	500,000	178	474		474
95	106	512,000	103	408		408
96	106	524,000	101	354		354
97	125	538,000	116	410		410
98	95	550,000	86	411		411
99	130	581,000	116	420		420
1900	168	573,238	147	503	339	842
01	198	575,000	169	494	509	1003
02	222	600,000	185	431	801	1232
03	288	612,	235			

Note. dotted line removing St Louis deaths in 1898 and returning same in 1901 give reduction in figures for localized epidemic

TOTAL DEATHS
YEAR
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1890
'91
'92
'93
'94
'95
'96
'97
'98
'99
1900
'01
'02
'03
DEATHS IN ST. LOUIS PER 500,000 INHABITANTS
TOTAL DEATHS ABOVE ST. LOUIS
Exclusive of Chicago
CHICAGO ADDED
DEATHS ON MISSISSIPPI WATERSHED
MISSOURI
DEATHS ILLINOIS WATERSHED

12843 MR. TODD: I move to strike out the diagram for the same reasons stated in my objections heretofore made.

THE COMMISSIONER: This diagram is known in evidence as complainant's rebuttal chart number 1.

MR. TODD: I object to the word rebuttal and object to it being characterized as such.

MR. JEFFRIES: Q. Please explain this chart or diagram?

MR. TODD: Objected to for the reasons heretofore stated.

A. The data from which the diagram is plotted are shown in a table of seven columns, in the upper left hand corner. The first column which gives the year in which the deaths occurred, the second column showing the total typhoid deaths in St. Louis for each given year, the third column showing the population of St. Louis for each given year, taken from the Federal Census for the years 1890 and 1900, and the Federal estimated census for the years 1901 and 1902, and estimated complete for the remaining years, such estimate being made at the proportional rate of increase to the figures of the Federal census and the Federal estimates.

12844 The fourth column gives the typhoid death rate in St. Louis per 500,000 population, being reduced to that standard population for the years as given.

The fifth column gives the typhoid deaths on all of the water sheds above St. Louis, taken from the records in this case above referred to and excluding the sanitary district of Chicago.

The sixth column gives the typhoid death rate in the city of Chicago for the years 1900, 1901 and 1902, as taken from the record in this case above referred to, and the seventh column gives the death from typhoid for all of the water sheds above St. Louis, including the Sanitary District of Chicago, as taken from the records in this case above referred to.

The diagram is plotted so that the ordinates represent the total typhoid deaths, the abscissa the years from 1890 to 1902, inclusive, in which such deaths occurred. The lower dotted line of the diagram marked deaths on the Illinois water shed shows the deaths on the Illinois water shed, excluding the drainage district for the years 1893 to 1900, inclusive. Above this line will

be found a light dash and dotted line marked Missouri
12845 water shed, which gives the total typhoid deaths on the
Missouri water shed for the years 1895 to 1902, inclusive.

Above this line again will be found a light dash line marked deaths on the Mississippi water shed which gives the typhoid deaths on the Mississippi river above St. Louis for the years 1893 to 1902, inclusive.

Above this line again will be found a heavy dash line marked total deaths above St. Louis, exclusive of Chicago, which gives the total typhoid deaths on the three combined rivers above St. Louis for the years 1893 to 1902, inclusive, excluding the Sanitary District of Chicago.

In January, 1900, the drainage channel was opened, adding the discharge of the sanitary district of Chicago to the last described line. This is shown on the diagram by a line extending vertically upward from the last described line to the year 1900 and plotted of such a length so that it shows the total deaths from typhoid in that year in the sanitary district of Chicago which is added to the total typhoid deaths on all the water sheds.

This heavy dashed line, marked on the diagram "Chicago
12846 added," extends diagonally upward from the year 1900
through the years 1901 and 1902, being in each case plotted
so that the total typhoid deaths in the sanitary district of Chicago are added to the total deaths on the line marked total deaths above St. Louis, exclusive of Chicago, and shows the total deaths on all water sheds including the sanitary district of Chicago. The heavy line on the diagram marked "Deaths in St. Louis per 500,000 inhabitants," shows the typhoid deaths in St. Louis taken from the records in this case above referred to for the years 1890 to 1903, inclusive, the dotted line leaving this heavy black line in the year 1898 and rejoining it again in the year 1901 shows a correction made by deducting certain deaths due to a localized milk epidemic described by Professor Sedgwick and Mr. Lochridge.

MR. TODD: I move to strike out the answer for the reasons given in my objection to the question.

MR. JEFFRIES: Q. Mr. Alvord, state what conclusions you draw from this diagram?

MR. TODD: Objected to for the reasons heretofore
12847 stated.

A. It has been the endeavor in this diagram to disclose the causes for the increase in typhoid deaths in St. Louis during the last few years. In order to intelligently determine such causes, the typhoid deaths along the different rivers have been separated from each other and platted separately so as to determine the source of the most marked pollution. It will be seen that the deaths from typhoid on the Illinois water shed, exclusive of the sanitary district of Chicago, are fairly uniform up to the year 1899, but show a rise in the year 1900, the year in which the drainage canal was opened. Otherwise they seem to be fairly uniform for the years preceding and following the commencement in the rise in the number of typhoid deaths in St. Louis.

The deaths on the Missouri river water shed appear also to be reasonably uniform for the period under consideration, and the typhoid deaths on the Mississippi river water shed, while fluctuating somewhat more than the first two described, are nevertheless generally uniform before and near the rise in the typhoid deaths in St. Louis.

In summing up the total typhoid deaths on the water shed
above St. Louis, as given in the record, it would appear
12848 that while there is some fluctuations and a low period
about the year 1896 that at no time since the rise in
tphoid deaths in St. Louis they have materially exceeded a fair
average rate and have in fact fallen off since the year 1900.

It will be observed, however, that the addition of the deaths from the sanitary district almost doubles the total typhoid deaths, influencing the pollution of the St. Louis water supply and that such addition is materially increased during the years 1901 and 1902, so that in 1902 the total typhoid deaths are nearly two and one-half times the deaths on the water shed above St. Louis, exclusive of the sanitary district of Chicago.

A local epidemic in St. Louis typhoid deaths in 1892 is clearly shown by the diagram and is attributable to the contamination of the water supply at the old station at Bissell, by Ginras Creek, and neighboring sewers.

Upon the removal of the source of supply from Bissell's Point to the chain of rocks in the years 1894 to 1895 there is shown a marked improvement in the total number of deaths from typhoid for the latter year.

12849 MR. TODD: I move to strike out the answer for the reasons given in my objection to the question.

MR. JEFFRIES: Q. What cities were considered by you on the three water sheds in the plotting of this diagram?

A. Only those referred to in the records of this case.

Q. I will ask you to state briefly, if you know, what changes have taken place in the conditions of the water in the Mississippi river at St. Louis since the removal of the intake from Bissell's Point to the chain of rocks in 1895?

MR. TODD: Object to the question for the same reasons heretofore stated.

A. The sanitary district of Chicago opened their channel on or about the 17th of January, 1900, introducing into the water shed above St. Louis a large additional amount of water and sewage.

MR. TODD: I move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. State whether or not you are acquainted with the physical conditions, drainage area and the population upon the water sheds of the Illinois, the Mississippi above Grafton and the Missouri river. 12850

A. In a general way I am.

Q. Taking into consideration the evidence introduced in this case upon the typhoid death statistics upon the water sheds of these rivers, and all evidence in connection therewith, I will ask you to state to what do you attribute the increase in typhoid in the city of St. Louis, during the years 1900 to 1903, inclusive?

MR. TODD: Object to the question for the reason it is not rebuttal and part of complainant's original case and it is not proper to go into the original case under the pretext of rebuttal and is therefore incompetent, irrelevant and immaterial.

Q. Question read.

A. I should consider, after a study of the data that in all human probability the rise in typhoid deaths in the city of St. Louis in the last few years has been caused by the added typhoid contamination from the sanitary district of Chicago.

12851 MR. TODD: I move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. In what way, Mr. Alvord, is the longevity and vitality of typhoid organisms of special interest to you in your profession as a sanitary engineer?

MR. TODD: I object to the question as immaterial.

A. In advising municipalities as to the purity and safety of their sources of water supply.

Q. State whether or not you are familiar with and have acquainted yourself with the literature upon this subject?

A. I have endeavored to do so for the past fifteen or eighteen years.

Q. What was your object in doing so?

A. In order that my advice to municipalities might be conservative.

Q. What do you consider in your practice and in the recommendations which you make in your profession as a fair statement of the longevity of typhoid organisms which would lead you to give what you consider conservative advice upon this subject?

MR. TODD: Object to the question as not rebuttal and 12852 therefore improper, incompetent, irrelevant and immaterial.

A. I have for some years past considered the life of the typhoid bacilli would be from sixty to ninety days under favorable environments, and while large masses of such bacilli might be removed from any given source of supply in a comparatively short time under unfavorable environments, it would not be safe to assume that a water once thus polluted would be safe to recommend for public use under the time given, unless the contamination were eliminated by a carefully designed and properly operated system of purification.

MR. TODD: Move to strike out the answer for the reason given in my objection to the question.

MR. JEFFRIES: Q. Are you familiar with the results of the experiments found in the reports of the Massachusetts Board of Health in which Hiram T. Mills presents data on the longevity of typhoid bacilli in the waters of the Merrimack river which results were obtained by him upon analysis and experiments conducted by him?

A. I am.

12853 Q. Where, if any, do you find other similar experiments or determinations?

MR. TODD: Object to any other experiments being introduced for the reason it is not proper rebuttal and not referred to by defendants in putting in their evidence, and it is therefore incompetent, irrelevant and immaterial and not proper evidence.

A There will be found in the proceedings of the Sanitary Institute of 1899, some experiments made by Dr. Horrocks which appear to be similar to those carried out by Mr. Mills. These experiments are also quoted in Mr. Samuel Rideal's book on sewage, on page 70.

MR. TODD: I move to strike out the answer for the reasons given in my objection to the question.

MR. TODD: Q. Are the experiments that you are quoting the experiments of Mills?

A. No sir, Horrocks.

MR. JEFFRIES: Q. Are you familiar with the sewerage system of Chicago?

A. I am. A portion of it has been constructed under
12854 my design and supervision.

Q. Under what conditions in your opinion are typhoid bacilli carried away from Chicago so as to approximate conditions which Mr. Hiram F. Mills and Dr. Horrocks used in their experimental work?

MR. TODD: Object to the question as not proper rebuttal.

A. The sewerage system of Chicago has very flat gradients and requires frequent artificial flushing. It has been the history of heavy rainfalls in that city that the entire content of the sewers are at such times disgorded into the river bringing into it a mass of pollution which has been accumulating for months together. Before the opening of the drainage channel such periods were extremely dangerous to the water supply of the city, as was shown in the increase in typhoid deaths following the period of such contamination. Such heavy flushings of rainfall occur
ordinarily in the early spring or after the breaking up of
12855 the winter and at times when the temperature is most
favorable to the longevity of the typhoid germ and greatly increases for the time being the rate of pollution in the drainage canal and Desplaines and Illinois rivers.

In my opinion the action of such a flushing of the Chicago sewer system into the Chicago river with its present large proportion of pure water and low temperature furnishes conditions which parallel or indeed form more favorable conditions to the longevity of pathogenic bacteria than those under which the experimental work above noted were taken. The discharge of this various amount of pollution at times of flood waters appears also to furnish the necessary velocity for rapid conveyance through the drainage canal down the Desplaines and Illinois rivers to the intake of the St. Louis water supply; the increment of tributary streams also increases the dilution and decreases the chance for toxic destruction of the total number of typhoid germs present. Such conditions are prevalent in greater or less degree during many times of each spring.

MR. TODD: I move to strike out the answer for the
12856 reasons given in the objection to the question.

MR. JEFFRIES: Q. In what you have said of the spring flood, do you have reference to the ordinary spring floods or to the exceptional floods which sometimes occur in this region?

MR. TODD: Object to the question for the same reasons heretofore given.

A. My answer refers entirely to ordinary conditions such as occur perhaps eight or ten times or more in the spring of each year and often at other times in the year, rather than to exceptional floods since as that of 1888 or 1892 and one or two other heavy floods in which extreme high water marks were reached. Such floods would naturally produce the danger from typhoid pollution to greater distances from the source or origin.

MR. TODD: I move to strike out the answer for the reasons given in the objection to the question.

MR. JEFFRIES: Q. Are there any other evidences from the testimony introduced in this case and which you have observed which would increase the flow above that men-
12857 tioned by you?

A. Yes sir, in the case of heavy rainfall on the water shed of the Chicago river, it is often necessary in order to prevent outflow into Lake Michigan through the main river, to lower the Bear Trap Dam at Lockport so as to produce greater velocity at all stations down the channel at such times. This undoubtedly aids in the rapidity with which pollution is conveyed away from Chicago down the channel of the Desplaines and Illinois rivers.

Q. What are the conditions of stream flow in the Desplaines river?

MR. TODD: I object to the question for the reason that the whole question of streams flow and the Desplaines river was gone into in chief by Professer Teichmann and consequently is not rebuttal testimony and therefore incompetent, irrelevant and immaterial.

A. Below the outlet of the drainage canal at Lockport, the Desplaines river flows very rapidly to a pool formed by what is known as dam number one at Joliet. This descent over ordinary and normal flow produces rapid velocity and
12858 a slight rise, but rainfall will develop velocity in the channel of from 40 to 60 miles per day.

MR. TODD: Move to strike out the answer for the reasons given in the objection.

MR. JEFFRIES: Q. What are the conditions of flow in the Desplaines and Illinois river as far down as the Marseilles dam?

A. Below dam number one and at Joliet the flow again becomes very rapid at times of moderate rises. This flow is slightly checked through Lake Joliet, but there is a further rapidity incurred on its outlet all the way down to the mouth of the Kankakee river. Below this point the Marseilles dam slightly checks the current.

Q. What are the conditions of flow in the Illinois river immediately below the Marseilles dam, below Marseilles at Peru?

A. Another rapid flow takes place below the Marseilles dam as far down as to Peru, where the influence of the Henry dam is felt.

Q. State whether or not that is especially true in time of
12859 spring floods or rises?

A. In the time of spring rises the velocity in these reaches is very materially increased, running, as I have said, up to as high as forty to sixty miles a day.

Q. Are you familiar with the testimony of Mr. Randolph in this case?

A. I have read Mr. Randolph's testimony.

Q. Taking into consideration the testimony of Mr. Randolph and the testimony of all other witnesses affecting the subject of hydraulics and sanitary engineering, I will ask you to state, Mr. Alvord, what effect, if any, has the discharge of 250,000 cubic feet of water per minute through the Chicago Drainage Canal upon the dangerous and deleterious substances contained in the sewage discharged into the Chicago river and the drainage canal?

MR. TODD: Object to the question for the reason it is not rebuttal of anything offered by the defendants, but is a matter that was gone into by complainant in his original case
12860 and it is therefore incompetent, irrelevant and immaterial.

A. The effect is to materially increase the current of the Desplaines and Illinois river and to carry dangerous pollution to greater distances and with more rapidity.

MR. TODD: I move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. Are you familiar with the flow measurements of the Chicago river, the main drainage canal, the Desplaines river and the Illinois river as described by Mr. Randolph in his testimony?

A. I have studied them.

Q. Do you know the discharge of the river at the time these observations were made under Mr. Randolph's directions?

A. I am unable to find anything in Mr. Randolph's testimony which gives any clue to the amount of discharge in the Desplaines and Illinois river either at Joliet or Peoria and therefore am unable to determine what stage the river was in at the time of his float measurements. The times of these experiments were in July, 1903, as appears by the record and such time is not covered by the table of discharge given in his testimony at Lockport, nor are any guage readings given at
12861 Peoria where the testimony includes a rating table. I only find the statement that the floats passed over this distance in fifteen days, which is raised to eighteen and one-half days by dividing by eight-tenths.

Q. What distance do you refer to in your last answer?

A. The distance from the Chicago river to the chain of rocks in the Mississippi above St. Louis.

Q. As a hydraulic engineer state whether or not the time limit as ascertained by the floats should be raised in the manner indicated by Mr. Randolph in his testimony, by dividing by .8?

A. I fail to see the pertinency of his conclusion that a correction should be made, tending to reduce the maximum surface velocity to the mean velocity of flow. The use of the .8 correction, in the manner described in Mr. Randolph's testimony is a very rough approximation, used by hydraulic engineers when surface floats are run in the most rapid part of the channel of a river to determine the average flow for the whole cross section of the channel in order to get at the
12862 quantity passing a given point per second. In the case under consideration, we are not endeavoring to determine the quantity of water passing any given cross section per second, but the problem presented is what length of time will any given pollution, flowing in mid channel, pass over the necessary distance from the Chicago river to the chain of rocks. This only requires, in my opinion, a determination of the mean velocity of the bore or central section of the stream.

Q. Do you as a hydraulic engineer consider the floats described by Mr. Randolph and Mr. Crane as surface floats?

A. I should not consider them so. As described in the testimony they appear to be partially submerged and I believe they give the mean velocity of the central portion of the stream with a fair degree of accuracy.

Q. Assuming, Mr. Alvord, that these determinations as made by Mr. Randolph give the mean velocity of the central portion of the stream, state whether or not in your opinion corrections of the character named and described by Mr.
12863 Randolph are necessary?

A. I believe that they are not necessary.

Q. What, then, would you consider the length of time that it would take pollution to pass over the described distance as the results of these experiments so conducted by Mr. Randolph at the time such experiments were made?

A. I should judge that fifteen days actual time would fairly represent the ability of the water of the Illinois and Desplaines rivers to carry pollution to the Chain of Rocks at the stage when the experiments were made.

Q. State whether or not in your opinion the mean flow of the stream should be considered as the time element in the passage of sewage and pollution from a given point to a point below on that stream?

A. I think it should not. Pollution is carried much faster on a given stream than would be indicated by a mean average flow. It may not be carried as fast as the very fastest thread of the stream, but it is certainly carried as fast as the average velocity of the central or fastest part.

12864 Q. Have you examined the evidence of the experiments conducted by Professor Van Ornum, described in the records of this case?

A. I have.

Q. Taking into consideration the testimony of Mr. Randolph in the experiment which he conducted with the floats in obtaining the velocity of the water in the Illinois river, in July, 1903, I will ask you to state what conclusions you draw from a comparison of the respective velocities obtained by Mr. Randolph and Professor Van Ornum, and taking into consideration the evidence as to the guage readings that existed for a period prior to these experiments and subsequent thereto, as introduced in evidence by Mr. Randolph and Crane, in what way do these experiments represent the minimum or maximum velocity of the water in the Illinois river?

MR. TODD: I object to the question for the reason it is not competent for this witness to draw conclusions based upon the testimony of Randolph or Van Ornum as it is a matter for the court, and for the further reason that the question of velocity in the Illinois river is a matter that was gone into in chief by complainant in his original case with Professor Van
12865 Ornum and is not proper rebuttal and therefore is incompetent, irrelevant and immaterial.

A. I should judge, in answer to the first part of your question, that the float experiments of Mr. Randolph in July 1903, were undertaken at a very much lower stage of the river than were those of Professor Van Ornum in March, 1903, as Professor Van Ornum finds materially greater velocity than does Mr. Randolph.

I also observe that Professor Van Ornum commenced his float experiments in a low stage point, between two March rises, in the river. There were flowing over the Bear Trap dam at the time he commenced his operations, as taken from the figures in the tables in the evidence, 289,000 cubic feet per minute, which gives a rather low velocity in the drainage channel. About 394,000 cubic feet per minute was passing over dam number one at Joliet at the same time.

Eight days prior to this, and on the 8th and 9th of March, 707,000 and 718,000 cubic feet per minute, respectively, passed over the dam at Joliet.

12866 Five days after Professor Van Ornum commenced his experiments, or on the 21st and 22nd of March, 764,000 and 711,000 cubic feet per minute passed over dam number one, or nearly double the amount of flow, both earlier and later, was in existence than occurred when his experiments were commenced.

It would seem, therefore, that Professor Van Ornum's experiments were undertaken at a very comparatively high stage but not by any means the highest stage so far as the drainage channel and the upper portion of the Desplaines river are concerned.

In passing Peoria, Professor Van Ornum observes the stage of water upon the gauge, which I find, by referring to the table of flow submitted by Mr. Jacob A. Harmon, in this case, gives a flow of about 50,000 cubic feet per second. This flow would correspond to a stage of the river which is somewhat overflowing the banks in the lower courses.

As Professor Ornum used submerged floats, I feel that the actual time traveled by the velocity floats represents fairly the mean velocity of the pollution vehicle, and I take the total time as represented by these floats as representing the total
12867 time which it requires to travel the total distance under consideration, with the exception that I believe that there are times when the velocity in the drainage channel in that portion of the river immediately below the Bear Trap Dam is greater than those which he found.

In 1898 I was engaged as consulting engineer for the State Board of Canal Commissioners in litigation with the sanitary district of Chicago over certain water powers and these channels below the Bear Trap Dam, and had occasion to very carefully study the velocities and stages and various stages in this vicinity. I have, therefore, verified Professor Van Ornum's float experiments in this vicinity, recognizing them to correspond with what I know to be the facts in the spring rises in the upper portion of the course under consideration. Below Lake Joliet I have accepted Professor Van Ornum's experiments to the chain of rocks as being properly indicative of what might happen in ordinary spring floods.

From Bridgeport to the chain of rocks I find that 9.8 days is consumed, using mean velocity to Joliet, and Professor Van Ornum's float experiments from there to the chain of
12868 rocks. I do not consider that this is the shortest time in which polution would travel this distance, but believe that the maximum flood such as occurred in 1892 would reduce this time to at least eight days and possibly slightly less. The 9.8 days represents to my mind a stage which could be counted upon as occurring a number of times in each year.

MR. TODD: I move to strike out the answer for the reasons given in my objection to the quetsion.

MR. JEFFRIES: Q. State whether or not you have had occasion to examine and study the velocity and stages of the rivers in question, in the course of your professional career?

A. I have.

Q. From what you have said of your observations of the testimony introduced in this case and of the testimony of Mr. Randolph, from his float experiments, state whether or not in your opinion the float experiments of Mr. Randolph represent a minumum velocity of the water in the Illinois river from Chicago to St. Louis at all times of the year?

MR. TODD: Object to the question for the reasons it is not competent for this witness to pass judgment upon the
12869 testimony of another witness and on the additional ground that it is not rebuttal as the question of the float experiments was entered into in complainant's case in chief and this testimony is not rebuttal and is therefore incompetent, irrelevant and immaterial.

A. Not having been able to ascertain the specific stage at the time of Mr. Randolph's experiments, I should be unable to state positively that his experiment was made at the minimum stage of the river, but speaking generally it is my impression that it was and represents the average of the minimum velocity in the ordinary dry seasons of the year between the Chicago river and the chain of rocks.

MR. TODD: I move to strike out the answer for the reasons given in my objection to the question.

MR. JEFFRIES: Q. I will ask you if you have examined the chart referred to by Mr. Rudolph Hering, 12870 who testified for respondents in this case, in which it is referred to by Mr. Hering in his evidence as follows, the chart with the caption "Sanitary District of Chicago, schematic representation of the self-purification of the waters of the Missouri, Mississippi and Illinois rivers between the points indicated based upon the longevity of the life of the typhoid bacillus as fixed by the experiments made under the direction of Hiram F. Mills, the results of which are given in the paper entitled 'Typhoid fever in its relation to water supply?' "

A. I have.

Q. State what to you, then, it represents, as observed by you as a hydraulic sanitary engineer?

A. It represents an attempt to derive the possible amount of contamination in the water at the chain of rocks from the sanitary district of Chicago, by assuming that the original pollution is proportional to the population, and that the longevity of a typhoid bacillus is, as found by the experiments of Hiram F. Mills in the paper referred to. The chart also makes the same deductions for the Mississippi and Missouri rivers and gives the rate of fall of the three watersheds. In the case of the Illinois river the length of time of flow from the Chi- 12871 cago river to the chain of rocks is taken at 18½ days, as stated by Mr. Randolph from his experiments, after adding to the original experiments an additional time for the correction to the mean velocity. It would seem to me in the first place that Mr. Hering has not given due weight to the relative effectiveness of different populations in the production of typhoid pollution. The sanitary district of Chicago has been afflicted for years with an abnormal number of typhoid deaths. Other cities on the Illinois watershed, deriving their water supply from artesian wells, have extremely low death rates from the same cause. It would appear, therefore, to me, that to make the diagram more exact some method should be introduced by which the disparity in typhoid data could be allowed for in its effect upon the St. Louis water supply.

Again, I should judge that the diagram as compiled under Mr. Hering's direction gives the time of travel of the pollution vehicle at low stages of the river and therefore does not 12872 fairly indicate the greater danger of pollution to the St. Louis supply at medium or high stages of the river. It would seem that the diagram should be so constructed that these modifications might be clearly apparent.

Q. Have you prepared a diagram which, according to the methods suggested by Mr. Hering, based upon the experiments of Mr. Hiram F. Mills, which would also include the two modifications just described by you?

A. I have.

Q. Will you submit this diagram?

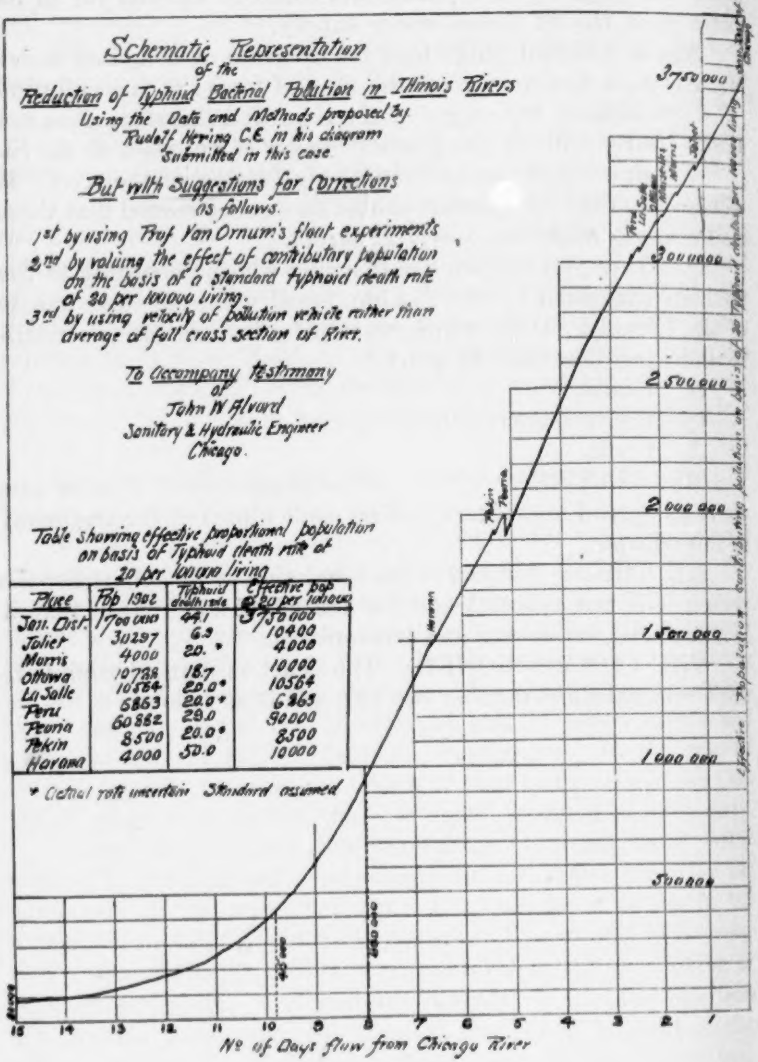
A. I will.

MR. JEFFRIES: Now, Mr. Commissioner, I offer this chart to be read in evidence and be made a part of the testimony of this witness.

MR. TODD: I object to the admission of this chart for the reason it is not rebuttal and for the additional reason that it is immaterial, irrelevant and incompetent.

THE COMMISSIONER: The chart is marked complainant's rebuttal chart number two (2), and is as follows:

12873 Complaints Rebuttal Chart No. 2.



Schematic Representation of the Reduction of Typhoid Bacterial Pollution in Illinois Rivers

Using the Data and Methods proposed by Rudolf Hering C.E. in his diagram submitted in this case

But with Suggestions for Corrections as follows.

1st by using Prof Van Ornum's float experiments

2nd by valuing the effect of contributary population on the basis of a standard typhoid death rate of 20 per 100000 living.

3rd by using velocity of pollution vehicle rather than average of full cross section of River.

To accompany testimony of John W Alvord
Sanitary & Hydraulic Engineer
Chicago.

Table showing effective proportional population on basis of Typhoid death rate of 20 per 100000 living

Place	Pop 1902	Typhoid death rate	Effective pop @ 20 per 100000
San. Dist.	1700000	44.1	3750000
Joliet	30297	6.3	10400
Morris	4000	20. *	4000
Ottawa	10728	18.7	10000
La Salle	10564	20.0*	10564
Peru	6863	20.0*	6863
Peoria	60882	29.0	90000
Pekin	8500	20.0*	8500
Havana	4000	50.0	10000

* actual rate uncertain Standard assumed

3750000
3000000
2500000
2000000
1500000
1000000
500000
Peru La Salle Ottawa
Marseilles Morris
Joliet
Pekin Peoria
Havana
250000
40000
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
No of Days flow from Chicago River
Effective Population contributing pollution on basis of 20 Typhoid deaths per 100000 living

12874 MR. JEFFRIES: Q. Will you please explain this diagram or chart?

MR. TODD: Objected to for the reasons stated in my objection to its admissibility.

A. The diagram which I have submitted covers only the reduction of the typhoid bacterial pollution in the Illinois river as being the object under consideration, and is prepared as nearly as possible in the manner described by Mr. Crane in his testimony, using the experiments of Mr. Hiram F. Mills as to the longevity of the typhoid germ. The ordinates in the diagram represent the tributary population calculated in its relative typhoid death production. As a basis for this I have assumed a standard of 20 deaths per 100,000 living as being the death rate of an ordinary well regulated city in the situation of Chicago, having due regard to the protection of its water supply.

Upon this basis I have determined for the year 1902 the typhoid death rate of Chicago and the cities along the
12875 Illinois river which are given in the table in the lower left hand corner of the diagram.

This diagram shows in the first column the place under consideration; in the second column the population of the place from the estimated Federal census of 1902, when possible. The third column shows the typhoid death rate in 1902 per 100,000 living, and the last column shows the tributary population contributing typhoid contamination on the basis of 20 deaths per 100,000 living, per annum, as calculated from the actual population and the actual typhoid death rate. The population of the sanitary district is taken from Mr. Hering's chart and not from the Federal census. The abscisse of the diagram give the number of days consumed in the flowing of the pollution from the sewers of Chicago to the 15th day, based upon the float experiments of Professor Van Ornum, from Lake Joliet to the chain of rocks, and from my estimates of the velocity in the drainage canal, and Desplaines river down to Lake Peoria.

12876 With this data I have plotted a curve in a similar manner to that plotted upon the diagram prepared under the direction of Mr. Hering, giving due consideration to the percentage of reduction in the typhoid contamination from the population center through the proper increments of time to agree with the experiments of Hiram F. Mills.

MR. TODD: I move to strike out the answer for the reasons given in my objection to the question.

MR. JEFFRIES: Q. State what the curve in this chart indicates?

MR. TODD: Object to the question for the same reasons heretofore stated.

A. The curve plotted upon the diagram indicates the relative typhoid bacterial pollution, so far as the same can be predicated upon the population, by using the bacterial reduction found in the experiments of Hiram F. Mills and substantiated by Dr. Horrocks.

MR. TODD: I move to strike out the answer for the reasons heretofore stated.

12877 MR. JEFFRIES: Q. State whether or not as a general proposition the number of deaths from typhoid fever in any community represent the total amount of pollution from typhoid bacteria?

MR. TODD: Object to the question for the same reasons heretofore stated.

A. They do not; if they are confined to deaths only they do not represent the whole number of cases.

MR. JEFFRIES: Q. What else should be taken into consideration?

MR. TODD: Object to the question for the reasons heretofore stated.

A. There are always a very large number of cases of typhoid fever which recover and which nevertheless are active producers of typhoid infection in addition to the infection produced by cases when deaths have occurred.

Adjourned until May 26, 1904, 10:00 a. m.

12878 Room 282, Southern Hotel, St. Louis, Mo. 10:00 a. m., Thursday, May 26, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

JOHN W. ALVORD

resumed the stand for further direct examination, by Mr. Jeffries, and testified as follows:

Q. State whether or not this diagram, as constructed, represents pollution from fatal cases alone or from all cases which actually existed in the communities under consideration, special reference being here made to complainant's rebuttal chart number two (2).

MR. TODD: Object to the question for the reasons heretofore stated, as not rebuttal.

A. It represents the comparative pollution contributed by the fatal cases alone. Furthermore it should be remembered that fatal cass cease to contribute infection to the stream 12879 on and after the date of the death, while unfatal cases do and may continue to contribute infecting material to the stream for days, weeks and even months.

The diagram as constructed fails to take account of this extra and added pollution and is therefore conservative.

MR. TODD: I move to strike out the answer for the reasons heretofore stated, and that part of the answer wherein the witness attempts to describe the conservativeness of the diagram as the diagram speaks for itself and it is a matter for the Court to de [illegible] tness to characterize.

MR. JEFFRIES: Q. How do the corrections which you have applied to Mr. Hering's chart affect the final results and especially the estimate of the typhoid contributing pollution at the chain of rocks?

A. Assuming active typhoid contamination is proportional to the population, and assuming diminution in the number of typhoid germs day by day to be as shown in the experiments of Mr. Hiram F. Mills, the modifications which I have introduced in the diagram would considerably increase the 12880 amount of typhoid pollution entering the intake at St. Louis.

I find that whereas Mr. Hering's diagram shows that the typhoid pollution entering the intake at the chain of rocks is equivalent at the end of a low river flow of 18½ days to an infection from a tributary population immediately above the intake of a city of 13,000 people, the conclusions of the diagram would seem to indicate that the normal flow of fifteen days would be equivalent to an infection from a tributary population with a death rate of 20 per 100,000 living of a city located immediately above the intake, with a population of about 90,000 people, while on the basis of ordinary spring floods, such as were gauged by Professor Van Ornum the infection arising at the chain of rocks would be equivalent to the population of a city of 415,000 population, situated immediately above the intake tower, and with a typhoid death rate of 20 per 100,000.

With a maximum flood such as occurs only once in every
several years, it would appear that the comparative
12881 pollution reaching the intake of the St. Louis water-
works would be equivalent to a population of 960,000
with a typhoid fever death rate of 20 per 100,000 living, this latter assumption being based upon the movement of the pollution vehicle from the Chicago river to the chain of rocks in eight days.

MR. TODD: I move to strike out the answer for the reason it is not rebuttal, in this that it takes into consideration elements which are based upon the assumption of the witness himself and not upon any facts that are proven in evidence as based upon a typical typhoid basis which the witness himself presumes to assert as a maxim which is not proven in evidence by any other witness and which was not considered in Rudolph Hering's chart, and is therefore new matter and not proper rebuttal and consequently is incompetent, irrelevant and immaterial, and for the further reason that the charts and conclusions drawn therefrom do not make any comparison between conditions of the Mississippi and Missouri river as the chart which Hering introduced in evidence did and is therefore not rebuttal in any way.

12882 MR. JEFFRIES: Q. Why do you employ 20 deaths
from typhoid fever per 100,000 population in your last
answer?

MR. TODD: Object to the question for the reasons heretofore stated that it is not rebuttal.

A. Because there are a very considerable number of cities which have so exercised care and discretion in the protection of their water supplies that they have reduced the typhoid death rate to a point below this rate. Some of the smaller cities upon the Illinois river have typhoid death rates as low as 6.9 per 100,000 living. It would therefore seem to be a fairly reasonable standard to assume that all cities having reasonable regard to the purity of their water supplies should be able in the light of present science to reduce their typhoid death rate at least to the basis assumed, if not materially lower.

MR. JEFFRIES: Q. In the chart which you have introduced in evidence in comparison with the chart or diagram introduced in evidence by Mr. Hering, based upon the experiment of Hiram F. Mills, what weight do you attach to these
12883 experiments?

A. I believe they are what might be termed incomplete investigations, that is to say, they are valuable, but neither sufficiently comprehensive nor numerous. The results show that typhoid germs do live under the conditions of the experiments the length of time given, but they do not show that typhoid germs may not live much longer. The difficulty of isolating typhoid bacteria from waters of known pollution would seem to substantiate this view of

MR. TODD: I move to strike out the answer for the reason that this witness by his qualifications has not shown sufficient bacteriological knowledge to be an authority upon criticising the extent to which he refers of Hiram F. Mills and for the additional reason that it is not rebuttal of any testimony put in the case by the defendants as the experiment of Hiram F. Mills was introduced in evidence by complainant on his own original case and quoted in support of that theory of the case, and it is incompetent for complainant to rebut the testimony of his own witnesses.

12884 MR. JEFFRIES: Q. Are you familiar with the testimony of Professor Kinnicutt in this case?

A. I have read it over.

Q. State whether or not you are familiar with the principles of practice of modern sewage purification?

A. I am.

Q. State whether or not you have given attention to the development of processes of sewage purification by means of septic tanks?

A. I have given particular attention to the development of septic tanks and have designed some ten or fifteen plants for muincipalities in which a septic tank has been employed on my recommendations. Of these plants eight septic tanks have been constructed under my immediate supervision for different municipalities and have been in operation for periods ranging from one to four years. Two of these plants have been under my immediate supervision ever since construction and I have watched the operation of others.

Q. What is septic action and how long should sewage remain in a septic tank in order to obtain practical results from a sanitary standpoint?

12885 MR. TODD: Object to the question for the reason it is not rebuttal as the question of septic tanks was gone into in chief in the testimony of Dr. Ravold and made a part of complainant's original case.

A. Septic action is the process of breaking down the organic matters in sewage by micro-organisms or their products in the absence of oxygen. This process is continuously brought about by allowing the sewage to come nearly or quite to a state of rest in deep tanks and allowing it to remain so until the dissolved oxygen present, if any, is exhausted and until the solid particles of the sewage have been attacked and broken up more or less in soluble compounds. It is desirable in order to provide favorable conditions for this process that the temperature remain as constant as possible and very high, and it is preferable that light and air should be excluded, although this is not absolutely essential. The proper period of rest necessary to get the best results will vary with the composition of the sewage, its temperature and character. It has been found desirable to adjust the rest period so that the temperature and 12886 other variables can be controlled and the period of rest adapted to the concentration of the sewage and its relative flow proportioned to the tank in which it is confined.

MR. TODD: I move to strike out the answer for the reasons given in the objection to the quetsion.

MR. JEFFRIES: Q. State whether or not flowing sewage ordinarily undergoes the process of septic action?

A. It does not ordinarily.

Q. State whether or not diluted sewage flowing in open channels simulate septic tank conditions?

A. It would not. The flow of liquids through open channels tend to bring all portions of the liquid from time to time to the surface where it may receive oxidizing influences tending to retard septic action.

Q. Are you acquainted with the present physical condition of the Chicago Drainage Canal?

A. I am.

Q. Please compare the conditions existing in the Chicago Drainage Canal with those of a true septic tank?

12887 A. In the Chicago Drainage Canal we have a large volume of diluted sewage flowing at the rate of one to three feet per second, giving ample opportunity for renewing its dissolved oxygen. And we have this action further increased by the opportunity of the wind to stir the surface of the stream and still further oxygenate it.

We have also an opportunity for exposure to low temperatures, light, etc., which are detrimental to the septic action.

Q. State whether or not septic action to any considerable extent takes place in the sewage of Chicago during its passage through the drainage canal?

A. It does not.

Q. Are you acquainted with the chemical data that has been introduced in evidence by the defendants?

A. I am to some extent.

Q. State whether or not in your opinion the chemical data introduced by the defendants with reference to the character of the contents of the Chicago drainage canal, indicate any septic action has taken place?

12888 A. My opinion is that they do not. The amount of improvement in the sewage in its travel of the drainage canal found by Professor Kinnicutt in his testimony in this case would seem to me to be largely due to aerobic action. Possibly there is anaerobic action to a very limited extent, but not enough in my opinion to influence the results perceptibly.

Q. State whether or not the extensive dilution of the sewage of the city of Chicago by the richly oxygenated water of Lake Michigan is a useful preliminary to septic action?

A. It is not. On the contrary it is distinctly opposed to the inception of septic action. In good practice, in the designing of septic tanks it is the endeavor always to bring the sewage into the tank as quietly as possible, undiluted with surface or underground waters containing undissolved oxygen.

Q. State whether or not you were familiar with the South branch of the Chicago river prior to the opening of the drainage canal?

A. I am.

Q. What was the condition of that part of the river at that time?

A. It presented all the characteristics of septic action to a marked degree.

12889 Q. What were those characteristics?

Mr. Todd: Object to the question for the reason that the characteristics of the South branch of the Chicago River were gone into in chief by Professor Ravold and this is not rebuttal evidence of anything that has been put in by the defense and is not contradictory of any testimony, and a part of complainant's original case and therefore incompetent, irrelevant and immaterial.

A. The absence of marked current, and the presence in certain places of more foul products and considerable surface scum, the absence of undissolved oxygen as shown by chemical examinations and the visible production of gases bubbling up from the depths below such as characterize the septic tank when in active reduction of its organic matter.

MR. TODD: I move to strike out the answer for the reason stated in my objection to the question.

MR. JEFFRIES: Q. State whether or not in your opinion typhoid germs are now more able to survive longer under the present condition of sewage dilution in the drainage 12890 canal than they could formerly have survived in the South Branch of the Chicago River or in the Illinois and Michigan Canal?

Mr. Todd: Object to the question for the reason that this matter was gone into in chief by the complainant in the testimony of nearly every witness who testified to any knowledge of the South Branch of the Chicago River, and it is not rebuttal testimony and therefore incompetent, irrelevant and immaterial.

A. I believe that typhoid germs could survive materially longer under the present conditions than was the case formerly in the Illinois and Michigan Canal and the South Branch of the Chicago River.

Mr. Jeffries: Q. Taking into consideration your knowledge of septic operation, and all that you know upon the subject of sanitary science and sanitary hydraulic engineering and taking into consideration the physical condition of the Illinois River the drainage canal and the Desplaines River, and the chart or diagram introduced in evidence by Mr. Hering, and the diagram introduced in evidence by you in connection therewith, state whether or not in your opinion the presence
12891 of sewage from the sanitary district of Chicago in the waters of the Mississippi River at the chain of rocks makes it more costly to provide suitable water for domestic purposes for the citizens of St. Louis?

Mr. Todd: Object to the question for the reason that it is part of complainant's original case, and the subject matter of the question was gone into in detail by every witness who took the stand for complainant and is therefore not proper rebuttal and consequently is incompetent, irrelevant and immaterial.

A. In my opinion it does make it more costly.

Mr. Todd: I move to strike out the answer for the reasons given in my answer to the question.

Mr. Jeffries: Q. In what respects is the water supply of St. Louis made more costly or difficult by virtue of the opening of the drainage canal?

Mr. Todd: Object to the question for the reasons stated in my objection to the previous question.

A. The design and construction of a purification plant dealing with a seriously polluted water, especially of one of known high typhoid pollution should be more complete and delicately adjusted to its work than when dealing only with water
12892 of rare infection and presenting less dangerous difficulties such as turbidity and color.

Mr. Todd: I move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. What form should this added protection take?

Mr. Todd: Object to the question for the reasons heretofore stated in my previous objections.

A. It should take the form either of double filtration or have complete sedimentation in more than one stage followed by most careful filtration.

Mr. Todd: I move to strike out the answer for the reasons stated.

Mr. Jeffries: Q. State whether or not you know of any case where double filtration is being used or resorted to?

Mr. Todd: Object to the question as the matter of double filtration has been gone into in complainant's case in chief by Mr. George W. Fuller and is therefore not rebuttal of anything offered by the defendants.

12893 A. It has been resorted to in several places in Germany and has been recommended at Springfield, Massachusetts, by Messrs. George W. Fuller and Samuel M. Gray, and is now being introduced into the new filtration plant of Philadelphia by Mr. John W. Hill, in which case they are proposing to pass water of known typhoid pollution through what are called preliminary filters as a first stage and then through slow sand filters as a second stage.

Mr. Todd: I move to strike out the answer for the reasons stated.

Mr. Jeffries: Q. Would such methods be more expensive than single filtration?

Mr. Todd: Object to the question for the reasons heretofore given.

A. They would. It is my opinion that they would very greatly increase the cost of filtration, both in its first construction and in operation.

Mr. Todd: I move to strike out the answer for the reasons stated.

Mr. Jeffries: Q. State whether or not single sand filtration as practiced in the United States is always a protection from the danger of typhoid infection?

12894 Mr. Todd: Object to the question for the reasons heretofore stated, that it is not rebuttal.

A. It is not.

Mr. Todd: **I move to strike out the answer for the same** reasons.

Mr. Jeffries: **Q. Why is it not?**

Mr. Todd: **Objected to for the reasons heretofore stated.**

A. **Sand filtration of either type is practically able to remove** pathogenic **bacteria from domestic water supply, but we** find that in **practice filtration works are a most delicate mechanism,** which **have to be very carefully operated in order to produce** at all **times and under all conditions the results antici**pated by their **designers. In cases where the danger of infec**tion hovers **over the filtration plant year in and year out it is** obvious that **the slightest relaxation may result in the most** serious **consequences.**

Mr. Todd: **I move to strike out the answer for the reasons** stated in **the objection to the question.**

Mr. Jeffries: **Q. State whether or not you know from your** own observations **and study of the cases in which single sand** filtration **or filter plants of either type have failed to**
12895 protect **the water supplies from typhoid infection?**

Mr. Todd: **Object to the question for the reasons here**tofore stated.

A. I do. **There have come under my observation, typhoid** epidemics in **water supplies protected by filtration in the follow**ing places:

Rock **Island, Illinois,**
Ashland, **Wisconsin,**
Berlin, **Germany,**
Lawrence, **Massachusetts,**
Lake **Forest, Illinois,**
Butler, **Pennsylvania,**
Waterloo, **Iowa,**
Beaver **Falls, Pennsylvania, and**
Augusta, **Maine.**

MR. TODD: **I move to strike out the answer for the rea**sons stated **in the objection to the quetsion.**

MR. JEFFRIES **Q. Mr. Alvord, are you a member of any** engineering **societies or associations?**

A. Yes, **sir; I am a member of the American Associa-**

12896 tion of Civil Engineers since 1893. I am a member and trustee of the Western Society of Civil Engineers. I am president of the Illinois Society of Civil Engineers and Surveyors. I am a member of the American Waterworks Association and of the New England Waterworks Association. I am also a member of the American Public Health Association, and am serving this year upon its committee of water and sewage purification. I am a member of the American Association of Municipal Improvements of the American Academy of Social and Political Science, and of the Engineers' Club of Chicago.

Q. Mr. Hering, who testified for the defendants on March 10th last, was asked by counsel for the defendants the following question "From what you know of the question of disposal of sewage and from the knowledge which you have in regard to the drainage canal, the manner in which it is operated, and taking into consideration the experience you have had since you made your preliminary report, what changes would you recommend for the sewage disposal of the city of Chicago if the same problem was submitted to you now which was submitted to you in 1886, as a sanitary and hydraulic engineer?" Answering this question Mr. Hering said that in considering the several ways of disposing of the sewage of Chicago, from personal knowledge and experience, my recomendation would be that the sewage of Chicago should be disposed of by dilution through the channel substantially as that which has been constructed with the subsequent discharge into the Desplaines and Illinois rivers." Thereupon the following further question was asked him: "In the study of this problem have you discovered anything that would change the view expressed by you in your preliminary report at that time?" In answer to which question Mr. Hering said: "I have not." I will ask you, Mr. Alvord, to state whether or not there are in your opinion any practical modifications of the existing system of sewage disposal of the city of Chicago by which the drainage canal could still be employed for keeping the Chicago river in an inoffensive condition and yet avoid the pouring of unpurified sewage into and through the canal over the Bear Trap Dam at Lockport and into the Desplaines and Illinois rivers? 12897

MR. TODD: Object to the question for the reason that it
is incompetent, irrelevant and immaterial and for the
12898 further reason that it is not for the complainants to de-
vise means for the disposal of Chicago sewage unless
the only complaint that complainant may have is whether the flowing of the sewage is a danger and a menace to the public health of the citizens of Missouri using the water for drinking and domestic purposes, and is therefore incompetent, irrelevant and immaterial.

A. I am of the opinion that it is entirely practicable to retain the drainage channel so that it can be still employed for keeping the Chicago River in condition and yet avoid pouring unpurified sewage into and through the canal and into the Desplaines and Illinois Rivers, and I would suggest as the proper remedy the construction of suitable intercepting sewers along the Chicago River and its branches, by means of which the sewage flow of the city may be kept out of the Chicago River and lead along its banks to the upper end of the drainage channel beyond Bridgeport and then raised by a suitable pumping station preferably operated with water power derived from the drainage canal to and into a suitable purification plant con-
structed in accordance with the latest bacteriological
12899 principles and effectually remove from such sewage all
or practically all of its organic wastes and pathogenic
bacteria and emptying the effluent from such sewage plant into the drainage channel near Bridgeport to be conveyed through the same and through the Desplaines and the Illinois Rivers in a harmless and purified state.

Mr. Todd: I move to strike out the answers for the reasons given in the objections to the question.

Mr. Jeffries: Q. State whether or not you have considered the relative expense of such a plant as you have described in your last answer?

Mr. Todd: Object to the question as immaterial and not proper rebuttal.

A. I have considered the expense in a general way and am of the opinion that such intercepting sewers and purification plant could be constructed at an expense no greater than that necessary to widen the South Branch of the Chicago River in order to increase its flow of dilution water to the requirements of dilution.

And I am further of the opinion that the operating ex-
12900 pense of such a plant would be no greater than the operating expense of the present system of pumping sewage and the necessary dilution water through the same for the northerly and southerly portions of the sanitary district and the dilution water for the proposed additions to such sanitary district.

Mr. Todd: I move to strike out the answer for the reasons stated in my objection to the question.

CROSS-EXAMINATION, by Mr. Todd:

Q. In figuring out such a purification plant as you have referred to in your last answer and the building of intercepting sewers and the operation of pumps and the installation of pumping machinery, what estimate in dollars and cents do you place that such a plant would cost, according to your estimates?

A. Between twelve and fifteen millions of dollars.

Q. Does that contemplate the purification of the entire sewage of the sanitary district?

A. It does.

Q. From Calumet on the south and Lake View on the
12901 north and the building of intercepting sewers on each side of the Chicago River and on each side of the north branch which receives the sewage from its adjacent neighborhoods as well as the sewage from Twelfth Street south and the west side?

A. I should not think it necessary to build intercepting sewers on each side of the river. One main sewer connecting across the river by tunnels would probably result in economy of expenditure over a double intercepting sewer along each bank.

Q. How would you intercept the sewers that empty into the Chicago River from its left bank?

A. I should carry an intercepting sewer along either one or the other banks of the river, along the most economical location, connecting it with the mouths of the sewers on each side of the river, either by short branch tunnels, grouping several sewers together on the opposite side or in the case of the large sewers by direct tunnel connections in each case.

Q. What would be the cost that you would figure for the pumps necessary to pump the entire sewage of Chicage from its sewers and the intercepting sewers to this purification plant?

A. I would not be able to give you those detail figures at this time as I do not have them by me. The estimates were made some years ago.

12902 Q. How many acres of land would be necessary for the plant located in the neighborhood of Bridgeport, sufficient to dispose of the entire sewage of the city of Chicago and the sanitary district?

A. That would depend entirely upon which of several available systems of bacterial purification might be adopted.

Q. Taking the one that you had in mind when you gave your testimony?

A. I do not think I had any particular one in mind.

Q. How were you able to make an estimate if you did not have a particular system in mind upon which to base an estimate?

A. By estimating the cost of the one which would in all probability be the least and the most expensive.

Q. Taking the one that would probably be the most expensive, how many acres of land in the neighborhood of Bridgeport would it require to establish such a purification plant?

A. Possibly 1,000 acres.

Q. Do you know what the value of real estate in the neighborhood of Bridgeport is?

12903 A. I have general ideas.

Q. What are your ideas on the value of 1,000 acres of land in the neighborhood of Bridgeport where you contemplated the establishment of such a plant, per acre?

A. Possibly a half a million of dollars. It would be desirable perhaps to place the plant at the point where the maximum of land could be obtained at the minimum price, not confining ourselves to any exact location in the vicinity or below Bridgeport.

Q. Have you any spot in mind where such an amount of land could be had near Bridgeport at $500.00 per acre?

A. The sanitary district of Chicago has a large amount of land in that vicinity and without having given the subject particular attention I should judge that it might be possible that they had land enough without having to purchase any additional.

Q. Do you assert that as a fact or as a surmise that the sanitary district owns 1,000 acres of land within a distance of three or four miles of Bridgeport, available for such use?

A. I would not limit myself to three or four miles. It is not necessary in the location of such a plant to limit
12904 yourself. The plant could be eight or ten miles away.

Q. If the sanitary district of Chicago owns 400 feet on each side of the channel from its mouth at Robey Street to Summit, with the exception of a few places where it goes back as far as 700 or 800 feet, would you consider the plant such as you have contemplated could be utilized on a long stretch of that kind?

A. It might be done or some other mode of purification which occupied less land than that, which I have estimated might be put in. There are several different kinds of bacteriological purification which demand different and varying amounts of land. We find at times we are limited in land and we recommend often that kind of purification which can be placed upon the minimum of land. If we find that land of a suitable character exists in abundance it varies our ideas as to what form of purification we would recommend.

Q. In bringing the sewage from the different sections of the city what estimate did you place upon the cost of the construction of additional sewers in order to bring the sewage to the plant?

12905 A. About five million dollars.

Q. Where would those sewers be located?

A. Following as closely as possible the north and south branches of the Chicago river and endeavoring to strike with the shortest possible length the greatest number of present sewer outlets emptying into the river.

Q. Have you figured out the cost of such a system as you have in mind in making your estimate?

A. I have figured it far enough to see that it is practicable and reasonably economical.

Q. Will you give in detail briefly the plan which you have in mind for the disposal of Chicago sewage?

A. Well, I have quite a number of plans in mind. I have not limited myself to any one plan.

Q. Well, give me the plan as it pertains to the delivery of sewage to the plant which you had in mind?

A. Well, in order to utilize as far as possible construction already commenced, I would begin by saying that the intercepting sewers now under way would form possibly a basis for conducting the sewage of the outlying portions of the city
12906 from the north end and from the south districts so far
as they go. These I should supplement with additional intercepting sewers conveying their conduits and the outflow of the sewers now emptying into the different branches of the river to the vicinity of the drainage channel beyond Bridgeport, necessarily finding that in doing so I had consumed some gradient or fall which must be recovered by pumping not only to raise the sewage to the level of the drainage channel, but to raise it an additional height necessary to pass it through that system of purification that might be selected. Different systems of purification also vary in that they require different amounts of head necessary to properly purify the sewage which passes through them.

Q. How would you bring the sewage from the north branch of the city to Bridgeport?

A. The north side of the city has already under construction a system of intercepting sewers along the lake shore now completed, and a branch across at Lawrence Avenue to the north branch of the Chicago river where it is proposed to erect a pumping station to elevate that sewage into the north branch. This collects all of the sewage of the north portion of the city,
which formerly emptied into the lake. I would, there-
12907 fore begin at the point where this sewage is to be lifted
into the north branch and continue a new intercepting sewer from that point along the north branch of the Chicago

River on the side which might be found by detailed study to be the most convenient, thence to the junction of the north branch with the south branch of the Chicago River and along the south branch of the Chicago River to Bridgeport, in such location that it would receive the discharge of all of the sewers on the north side of the city not connected with the intercepting sewer system now under construction, it would be further necessary in order to collect the sewage of the north side of the city to extend a short branch of the intercepting sewer easterly from the junction of the north and south branches of the Chicago River to intercept those sewers emptying into the main river from the north side.

Q. How would you bring the Calumet District to Bridgeport?

A. The Calumet district within the limits of the sanitary district is now proposed to be brought to the east fork of the south branch by a system of intercepting sewers now nearly completed. This intercepting system contemplates a pumping station in the vicinity of Seventy-third Street, I think,
12908 proposals for which have just recently been advertised.
This pumping station will lift the sewage of the extreme southern portion of the district into the intercepting sewer already finished or nearly so which runs northerly along Stoney Island Avenue and the right of way of the Illinois Central Railroad to Thirty-ninth Street, where a very large pumping station is now being erected to pump dilution water into a conduit which will take such dilution water and sewage from the intercepting sewer and carry it westerly to what is known as the Stock Yards Slip at Halstead Street.

Q. How would you take the sewage from South Chicago by the method you have described as the method adopted for the Calumet District?

A. The sewage of South Chicago is proposed by the present plans of the sanitary district of Chicago to be carried to the main channel by way of Blue Island and the Sag Valley. I would say that in making my estimate of $5,000,000.00 for intercepting sewers I covered the territory of the original sanitary district and not the district as enlarged by the act of the Legislature in 1903. Such outlying territories as have since

been added could be brought to Bridgeport in any event by methods and at an expense which would be equal in
12909 either case with the methods and within the costs now proposed by the sanitary trustees, but the preference, if any, in favor of the system which I have outlined is that no dilution water would have to be pumped in addition to the sewage.

Q. What estimate do you place for the widening and deepening of the Chicago River to a width of 200 feet and to a depth of 26 feet, as is contemplated to be done at present?

A. The best of my knowledge and belief the estimates for widening of the Chicago River to the uniform width of 200 feet so far as I have seen them published range from eleven to fourteen million of dollars. I believe it would be fair to say that the cost can not be accurately estimated in advance as large portions of valuable land will have to be acquired by condemnation.

Q. Are you aware of the amount of land that has already been acquired by condemnation?

A. I am aware that condemnation is constantly going on.

Q. Are you aware that over seven-tenths of the land has already been acquired?

A. I have no information other than that that I have stated.

Q. And this is in detail the method of the sewage disposal systems that you have proposed to construct, the amount of land that it would be necessary to acquire under this
12910 estimate is in the neighborhood of twelve million dollars?

A. The total cost of the whole project would be twelve to fourteen millions of dollars.

Q. At the time that Mr. Hering made the preliminary report when the question of sewage disposal for Chicago was under consideration was the question of bacteriology then recognized as a science?

A. Not generally.

Q. Was the question of the purification of sewage in the manner that you have described it then known?

A. The purification of sewage was then known and extensively practiced, but the systems which I now have in mind were not developed, and speaking generally the systems then in use while efficient, were expensive.

Q. What experiments have you conducted upon the longevity of the typhoid germ as a bacteriologist?

A. None whatever.

Q. Have you ever separated the typhoid germ in the laboratory from the excreta of typhoid patients?

A. I have not.

12911 Q. Are you sufficient of a bacteriologist to do so?

A. I am not.

Q. Have you ever made any experiments of your own upon the longevity of the typhoid germ in sewage?

A. I have not.

Q. Have you made any experiments of your own upon the longevity of the typhoid fever germs in sterilized water in lake water, in the water of the drainage canal or the waters of the Illinois River?

A. I have not.

Q. Have you examined and read the experiments introduced in evidence in this case and made by Professors Jordan, Zeit and Russell?

A. I have.

Q. Have you read the entire testimony in regard to those experiments or has it been told to you?

A. I can not say that I have read it all. My time has been too limited to read all that has been introduced on the subject. I have read portions of it and am familiar with parts of it.

12912 Q. Have you read the experiments of Professors Jordan, Zeit and Russell as carefully as you read the experiments of Hiram F. Mills?

A. Yes sir.

Q. In reading the experiment of Hiram F. Mills, have you read the technique of the manner in which the experiment was conducted and the method employed in the detection of the typhoid germ?

A. Yes sir.

Q. How do the methods employed by Hiram F. Mills compare with the methods employed by Jordan, Zeit and Russell in the detection of the typhoid germ?

A. I should not consider myself competent to criticize the technique of either Mr. Hiram F. Mills or Messrs. Jordan, Zeit and Russell.

Q. Have you read the experiments made and introduced in evidence in this case in the testimony of John W. Hill of Philadelphia, who is in charge of the filtration bureau?

12913 A. I have read as much of it as was possible in the time at my disposal.

Q. I mean the testimony on the experiment of the typhoid germ in the water of the Schuylkill River?

A. I do not think I have read that. I do not remember to have seen that.

Q. In the chart which you have introduced in evidence, in which you testified that since the opening of the drainage canal the typhoid rate in the cities on the watershed of the Illinois River has gone up since 1899 to 1900, exclusive of Chicago, I believe you called special attention to that feature of the chart in your direct testimony did you not?

A. It seemed to me a variation in the general result worth noticing.

Q. How do you account for that rise as evidenced on that chart from 1899 to 1900?

12914 A. I have not attempted to account for it particularly. I think I observed that the line was fairly uniform and that the only marked departure from the uniformity was that rise which I considered not of large amount.

Q. For the years 1900, 1901 to 1902 there is a fall in the typhoid along the Illinois River, exclusive of Chicago, is there not, as evidenced by this chart?

A. There is a slight fall.

Q. How do you account for that?

A. I have not attempted to account for it.

Q. Upon the Mississippi River from 1899 to 1901 there is a rise in the typhoid rate as evidenced by the chart. How do you account for that?

A. I have not attempted to account for that, or for any of the minor fluctuations except on the theory that there are always fluctuations in any such death rate, and that in order to be of interest they should be somewhat marked.

Q. There was a rise in St. Louis from 1898 to 1899 to 1900—was that not evidenced by this chart?

A. That was on the face of the returns from the typhoid deaths.

12915 Q. From the face of the returns in each instance is it not?

A. In each instance with the exception noted in the lower right hand corner of the chart which refers to a dotted line leaving the deaths in St. Louis at the year 1898 and rejoining that again in the year 1901. In this case the face of the returns are plotted in the usual line in which all of the St. Louis deaths are situated, and the possible deduction due to localized epidemics is shown by this dotted line above referred to. With that exception the diagram is constructed wholly from the deaths agreed upon in this case.

Q. Is there anything on this chart that shows that the rise of typhoid fever in the city of St. Louis is due to the typhoid condition in the city of Chicago?

A. I think there is.

Q. Will you point out on this chart where such a fact appears?

A. The diagram shows that the deaths on each of the three water sheds contributing to St. Louis are fairly and reasonably uniform, barring the minor fluctuations which always occur in such death rates from various slight causes, but the diagram further shows that at and from the year 1900 a very large number of deaths were added to the normal deaths upon the combined water shed by the opening of the drainage canal. In two years after the opening of the drainage canal the total number of deaths attributable to the water supply of St. Louis had been more than doubled, in marked contrast to the fairly uniform conditions which prevailed on each water shed, excluding the sanitary district of Chicago. 12916

Q. And is that evidenced by the chart which you have referred to?

A. I think it is.

Q. Have you seen the charts prepared by Professor Mason, comparing the typhoid conditions in Chicago with the typhoid fever conditions in St. Louis by the month?

A. I have not. They do not seem to me to be among the records which I have examined in this case.

Mr. Jeffries: I want to state in this connection that the
charts offered in evidence by Professor Mason and about which
this evidence concerns were placed in the hands of the
12917 Commissioner at once and the complainant since that
time has not been in condition to examine them or have
witnesses examine them.

Mr. Todd: Q. Have you compared the typhoid condition in the city of Chicago by the months with the typhoid condition in the city of St. Louis by the months?

A. I have not.

Q. Would such a comparison, allowing thirty days interval between Chicago and St. Louis to intervene, shed any light upon the question as to whether Chicago has any effect upon the typhoid conditions in St. Louis in your opinion?

A. I should be afraid that it would induce too many fluctuations and variables of the greatest value, I should prefer to take the averages for the year, showing in a more marked manner any main distinguishing characteristics.

Q. Might not an increase in the typhoid fever in the city of St. Charles be expressed in the typhoid conditions in the city of St. Louis?

A. Possibly.

Q. Might not an increase of typhoid fever in Kansas City
be expressed in the increase in typhoid fever in the city of
12918 St. Louis, taking into consideration that sixty-seven per
cent. of the water consumed in St. Louis is Missouri River
water?

A. It might possibly but so far as I have been able to observe it does not.

Q. Can you tell whether the infection that afflicted St. Louis comes from St. Paul, Minneapolis and the cities on the Mississippi River, the cities on the Missouri river or the cities on the Illinois River?

A. I think when conditions are marked and data fairly adequate that it is possible to tell.

Q. Do you consider that any of the typhoid fevers cases in the city of St. Louis is due to Missouri River water?

A. There is always that possibility.

Q. What is your opinion as to whether any of the typhoid fever in St. Louis is due to Missouri River water?

A. My opinion would be that a percentage of the normal typhoid deaths in St. Louis prior to 1900 would very probably be due to the contamination from waters of the Missouri River.

Q. What cities on the Missouri River would you attribute the infection to?

12919 A. I should want to make a more detailed study of the case before venturing an opinion. My endeavor has been to study the problem by water sheds rather than cities, except in the case where I have added the sanitary district of Chicago.

Q. Would you regard the conditions at St. Charles as contributing as much typhoid as the city of Kansas City, to the city of St. Louis?

A. It is probable that it may have an equal effect upon the normal typhoid deaths in St. Louis.

Q. How far would you consider the city of St. Charles by water in point of time from the St. Louis intake?

A. I am not exactly informed as to that.

Q. The distance has been estimated by the river at approximately forty miles. Are you acquainted with the hydraulic conditions of the Missouri River?

A. To some extent.

Q. If one typhoid fever patient could create the epidemic at Plymouth, Massachusetts, what effect in your opinion would the number of cases of typhoid deaths in the city of St. Charles as evidenced by the statistics which you have studied, have upon the water supply of St. Louis?

A. There are always possibilities of contamination from 12920 unexpected sources.

Q. Would you say that beyond all reasonable doubt the typhoid fever as you know it te exist in the city of St. Charles is not responsible for the great proportion of the typhoid fever in the city of St. Louis, bearing in mind what you know about the epidemic at Plymouth, Pennsylvania, and of other epidemics that you have studied and introduced in this case?

A. I should be inclined to think from my diagram that the typhoid deaths in St. Charles might have influenced the normal typhoid deaths in St. Louis prior to 1900 to some unknown percentage.

Q. Since 1900?

A. I should be disinclined to think that since 1900 the typhoid in St. Charles could have been responsible for so marked a change in the number of deaths in St. Louis from typhoid.

Q. Does the number of people afflicted with typhoid fever in a given city depend upon the number of people that have typhoid fever above on the water shed?

A. It does to some extent when you are considering averages over long periods.

12921 Q. How do you account for the Plymouth epidemic that was due to one typhoid fever case?

A. There are always exceptional occurrences of that kind.

Q. Might not such an exceptional occurrence happen between St. Charles and the city of St. Louis?

A. It is within the range of possibility.

Q. Being in the range of possibility, can you assert that the greater proportion of typhoid fever in the city of St. Louis can not be attributed to such a possibility beyond all reasonable doubts and to a moral certainity?

A. In the absence of direct proof that the typhoid deaths in St. Charles have been responsible for the rise in deaths in St. Louis, we are obliged to proceed on the theory of probability, and the theory of probability would indicate that the preponderating number of deaths, wherever they may be found, are the responsible cause, therefore I would be disinclined to attribute (in the absence of direct proof) the rise in the typhoid deaths in St. Louis to the typhoid deaths in St. Charles.

Q. Do you employ the theory of probabilities in drawing your conclusions that the typhoid increase in St. Louis
12922 is due to Chicago?

A. Whenever we deal with a problem of the magnitude of this problem and its complications, we are obliged as one of the contributing data to proceed on such theory.

Q. And that theory has been employed by you in giving your opinions on the effect of the opening of the canal upon the typhoid condition in St. Louis?

A. As one the data from which I draw my conclusions.

Q. What importance do you attach to the typhoid conditions on the water shed of the Missouri River?

A. The importance that is shown by the plotting of their deaths upon this diagram in its relation to the deaths from other sources.

Q. Anybody could plot those deaths on a diagram could they not?

A. Well, they might not always be able to accomplish that in such a way that they would bring clearly out the facts.

Q. But my question is, what importance do you attach regardless of the diagram to the number of cases of typhoid fever on the water shed of the Missouri River as affecting the
12923 sanitary quality of that river?

A. I should attach this importance, that I observe that the typhoid deaths on the Missouri water shed, all things considered, have been fairly uniform for the whole period shown, and therefore whatever percentage of contributory infection the Missouri water shed may have produced prior to 1900, I should be inclined to attribute in equal degree to the period since 1900.

Q. Do you regard the water of the Missouri River in its raw state as a safe drinking water for drinking and domestic purposes?

A. I do not.

Q. As treated by the settling basins of St. Louis, do you regard it as a safe drinking water for drinking and domestic purposes?

A. I should say that it has in all probability been greatly improved in its general character.

Q. Is it not a fact that the water of the Missouri River has been deteriorating as a safe drinking water for the last twenty-five years, and each year more so?

A. I think that may be safely assumed and the same is probably true perhaps of all our western rivers.

12924 Q. Do you regard the Mississippi River above Grafton as a safe drinking water?

A. I do not.

Q. Do you regard the water of the Illinois, Mississippi and Missouri Rivers, assuming that the sanitary district of Chicago was eliminated, and treated as it is treated in the settling basins at St. Louis, as a safe drinking water to be used by a city of 800,000 inhabitants, such as St. Louis is, as it is at present used?

A. I do not regard it entirely so.

Q. If you were selected as a sanitary egineer or a hydraulic engineer to pass upon the quality of the water of the Mississippi River, a mixture of Missouri, Mississippi and Illinois River water, excluding the sanitary district of Chicago, treated as it is now treated, would you recommend it as a safe drinking water, free from typhoid infection?

A. I should not like to so recommend it.

Q. What were the discharges of the Illinois River at the time that Randolph made his float experiments?

A. I was not able to discover. I believe Mr. Randolph 12925 gave some gaugings at Peru and gauge readings at La Salle, but as I have no data for this cross sections, I am unable to determine what the stage was in terms of the discharge.

Q. Was it at high, low, average, mean or below mean flow of the Illinois River?

A. If I were obliged to determine from such evidence as I am able to derive from his testimony, knowing that the time when the floats were run, was in the month of July, and knowing that the total time of transit in comparison with Professor Van Ornum was as 10 is to 15, I should be inclined to judge that the stage at which Mr. Randolph's experiments were taken were the average low waters of mid summer.

Q. If you do not know the stages of the river and its flow, how are you able to give that opinion?

A. I do not think that that opinion is as valuable as it would be if I did know the exact stages of the flow.

Q. It is more in the nature of a guess than an opinion based upon scientific knowledge?

A. It is an intelligent guess.

Q. Did you ever measure the current from the Bear Trap
12926 dam to Lake Joliet with floats yourself?

A. I believe not personally.

Q. Do you know what the fall is from the Bear Trap dam to Lake Joliet?

A. Yes sir.

Q. Knowing the fall and the volume of water, can you figure the velocity of flow?

A. Yes sir.

Q. Can that be accurately ascertained by that method?

A. Not as accurately as it could by the floats.

Q. Did you have it done?

A. No sir.

Q. With floats?

A. No sir.

Q. When you corrected Professor Van Ornum's time, what method did you employ in doing it?

A. I calculated the mean velocity by the cross-section and fall and deducted the surface velocity by dividing by .8.

Q. Is there a better method than floats such as Professor Van Ornum used?

A. There would not be if the same stages were considered,
12927 but it is impossible to predicate the surface velocity at
another stage from the float experiments of Professor Van Ornum, with any very great exactness. I might say however that I used the speeds found by Professor Van Ornum for the lower stage as a check upon the calculations which I made for the slightly higher stage which I got.

Q. In figuring out the average time between Chicago and St. Louis, what conclusions did you come to?

A. That at most stages of the river uninfluenced by flood of any kind, the time of passage of the pollution vehicle would be in the neighborhood of the float experiments, as determined by Mr. Randolph or thereabouts, but not reduced to mean velocity, and that in times of slight or medium rises, the time of passage of the pollution vehicle would be aparently in accordance with the experiment of Professor Van Ornum, and that in time of very great floods, such as occurred in 1902, and I believe in 1888, and at one or two other times in my recollection, the time of passage might be reduced to eight days or less.

Q. In the times of flood there would be greater dilution would there not?

12928 A. Yes sir.

Q. And dilution minimizes danger from infection, does it not?

A. Not altogether; it increases the longevity of the typhoid germ.

Q. But is disseminates them in a greater body of water thereby diminishing on the theory of probability, the danger from infection does it not?

A. I should think that would be a fair statement, yes sir.

Q. In figuring on Mr. Hering's chart that is introduced in evidence, did that chart show a population of 13,000 people above the intake tower?

A. I have not seen the original chart that Mr. Hering produced but a zinc etching which has been reduced in size, so that it is difficult to determine what the actual figures might be from the scale. I have, however, relied upon the statement of Mr. Crane, who prepared the chart, with reference to those figures.

Q. By the method that you employed on the Illinois end of this chart, applying that same method to the Missouri and Mississippi Rivers, will you state what the results show?

12929 A. I have not undertaken to reduce the Missouri and Mississippi Rivers to terms of typhoid pollution at St. Louis in the manner shown by Mr. Hering.

Q. Why?

A. Because I did not deem them pertinent to this inquiry.

Q. The chart which Mr. Hering introduced in evidence showed a comparison between the conditions that obtained on the Illinois, Mississippi and Missouri Rivers, based upon Mill's experiment, did it not?

Mr. Jeffries: Object to the question for the reason that this inquiry is not to determine the extent of the pollution and the infection of the Mississippi River above Grafton and the Missouri River, but that the inquiry is directed solely to the effect that the sewage discharged from the city of Chicago has upon the waters of the Illinois River and consequently upon the waters of the Mississippi River below Grafton.

A. Yes sir.

Mr. Todd: Q. If you had carried out the comparison contemplated in the chart introduced by Mr. Hering, would the pollution from the Illinois River be as great as the pollution
12930 from the Mississippi and the Missouri Rivers, figured in
the same manner that you have figured the chart which you introduced?

A. I am not able to say, not having worked out the data.

Q. In order to make a comparison between your method of calculation and the method employed by Mr. Hering, do you not think it would have been more accurate to have carried out your charts for the three rivers instead of one?

Mr. Jeffries: I object to the question for the reason that it is not competent evidence in this case to make comparison between the relative pollutions of the three rivers, the question involved in this case being as to the effect of the sewage discharges from the city of Chicago upon the Illinois River and Mississippi River below Grafton, and for the further reason that the chart introduced in evidence by this witness based upon the chart of Mr. Hering, which was prepared by Mr. Crane, was not introduced for the purpose of showing a comparison between the pollutions of the three rivers, but for the purpose of showing the effects of the sewage of Chicago upon the waters of the Mississippi River below Grafton.

Mr. Todd: In reply will state that the chart speaks for itself and shows the opposite of what the counsel con-
12931 tends.

Q. Question read.

A. I do not see how it could.

Mr. Todd: Q. In the chart which you introduced, computed upon the method which you adopted, I believe you stated that at a maximum flow in the Illinois River, the pollution at the intake tower of the chain of rocks was equal to an infection from a population of 960,000 people. Is that correct?

A. I think I stated that the method of Mr. Hering, worked out with the corrections which I have suggested, would indicate that.

Q. Did you not understand Mr. Hering's chart to be for the purpose of showing the relative pollutions of the three rivers with a ratio of 13 to 97 and 106, whether expressed in people or otherwise?

A. I understood that that was one of the facts which he endeavored to bring out, but I also understood from the study of his chart that he was endeavoring to bring out as well the probable amount of pollution which would reach the intake at the chain of rocks from the sanitary district of Chicago, based upon the experiments of Hiram F. Mills and the float experiments of Mr. Isham Randolph.

12932 Q. You did not understand his testimony and the chart to mean that there was a city of 13,000 people dumping sewage into the Mississippi River at the intake?

A. I took it that that was the practical effect of his reasoning.

Q. And under your interpretation of the chart, supplemented by your method of calculation, there would be, at maximum time, a population of 96,000 people?

A. There would be.

Q. In the testimony that you have given when filter plants have been in operation, and the cities using such filter plants have been the victims of a typhoid fever epidemic through the mismanagement or other cause of the plants, are any of those plants to which you refer owned and operated by the municipality itself or by private water companies?

A. They are about equally divided between the two.

Q. How many of these epidemics were due to shutting down of the filters and turning in the raw water to the water supply of the people?

A. I think two.

Q. Which ones?

12933 A. Butler, Pa., and Beaver Falls, Pa.

Q. That was not the cause then of the filter plant as much as the carelessness of the water company?

A. Well, it was the fault of the filter plant to adequately protect the water supply through the carelessness of the employe connected with it.

Q. In the matter of the Butler Company do you know whether it was a question of the employes or the question of the management that took that filter plant out of operation and turned the raw water in?

A. I think it was, in that case, the question of the management.

Q. Are you familiar with the causes that led to the epidemic at Butler?

A. Somewhat.

Q. In the case at Beaver Falls the same thing is true is it not?

A. I should say that it was.

Q. What is the cause of greatest expense in constucting a filter, matters in suspension or infection?

A. That will depend very much upon the kind of water and its amount of pollution that is to be dealth with.
12934 In a turbid water free from typhoid pollution, the turbidity will undobutedly be the cause of the greatest expense, but in a water comparatively clear, or clear most of the time, but subjected to typhoid infection, the infection will undoubtedly be the greatest cause of expense.

Q. Which would it cost the most to filter, the Missouri, Mississippi or the Illinois River water?

A. Based on turbidity the Missouri River water. Based on typhoid infection the Illinois River below the sanitary district of Chicago.

Q. I mean at Grafton?

A. I should say at Grafton the typhoid infection would be at least equal in cost to the turbidity.

Q. The Mississippi?

A. For the Mississippi River I should think the cost would be about equal for both turbidity and typhoid infection.

Q. Would the cost of the Mississippi be greater or less than that of the Illinois?

A. It would be greater for turbidity and less for typhoid infection.

Q. In the general cost of filtering the two rivers taking
12935 everything into consideration for an equal sized plant,
would it cost any more to filter the Illinois River at Grafton than it would the Mississippi at Grafton?

Mr. Jeffries: I object to the question for the reason that the question assumes that the turbidity of the two rivers is the same and that while increased turbidity might to some extent increase the cost of the construction as well as the operation, but inasmuch as the cost of the construction and operation of a given plant for a given river is determined upon the question of turbidity and the well known and probable existence of infectous material, that by reason of the introduction of the additional infectous material from the Illinois River, the cost might or might not be greater, and therein lies the impropriety of the question, and for that reason the question is misleading and does not contain sufficient facts upon which to base an intelligent and reasonable answer.

Q. Question read.

A. I should say that it would for the reason that in filtering the Illinois River at Grafton we are obliged at first to provide for the cost of removing the turbidity which, while
12936 it is less than the turbidity of the Mississippi is nevertheless very great at certain seasons of the year, and in addition to this question of alluding to provide for the cost of protection against typhoid pollution which in my opinion would be greater than in the case of the Mississippi River.

Mr. Todd: Q. You would recommend filtration for the water supply of the city of St. Louis would you not?

A. In any event.

Q. If the sanitary district of Chicago should be eliminated, you would still recommend a filtration system for the water of the city of St. Louis would you not?

A. I would.

Q. When in the employment of men to supervise and attend a filter plant of that kind you would get the highest skill, would you not?

A. Yes sir, reasonably so.

Q. If the sanitary district of Chicago should turn its sewage in, you would still recommend the filtration system would you not?

12937 A. Yes sir, but I should recommend at least a double filtration system, preceded by successive stages of sedimentation or some additional form of protection to that which

I would suggest for waters from the water shed, excluding the sanitary district of Chicago.

Q. Would you employ any less competent men to operate the filter plant with the sewage of Chicago eliminated, than you would with it present?

A. I am inclined to think I should want a very high grade of intelligence at the head of such a plant, if it were going to provide against typhoid contamination as against perhaps less expensive treating if it were going to deal with turbid waters or waters of very rare pollution.

Q. Where would you get the men from to operate such a plant that had experience in a filter system the size that would be needed in the city of St. Louis?

A. Albany, Berlin, London, or men in this country who had given those large filters close study and attention.

Q. Would you put men in charge of a filter plant with less capability and experience if the sewage of Chicago was
12938 eliminated than you would if it were present?

A. Not to any very marked degree. I should think I would be a little more cautious and would recommend a little greater expense, but I do not think that the difference in the cost of filtration would be very much affected by that particular item.

Q. In the construction of the filtration plant at Philadelphia —which is the largest in the United States is it not?

A. Yes sir.

Q. Do you know whether there is any element of cost entered into in that plant in order to guard against infection?

A. Yes, I think the preliminary filters can be properly so considered.

Q. If John W. Hill who was constructing that plant should testify that infection was no element of cost in the operation and installation of that plant, would his opinion have any weight with you?

A. I think I should be disinclined to agree with him.

Q. Have you constructed any filter plant wherein you have made additional cost to guard against infection?

12939 A. I do not think I have personally, with this exception that I have provided for the filtration of sewage as well as the purification of water in a plant deriving its water supply from the same source into which it emptied the sewage.

Q. Have you designed any filter plant where the question of infection was eliminated, in the purification of water?

A. I think I have not designed any plant where it was wholly eliminated. In some of the places it was a very minor consideration?

Q. Has that consideration of infection added to the cost of any plant which you have been connected with?

A. Yes at the plant where I considered sewage purification.

Q. What was the size of the plant to which you refer and where located?

A. The plant was situated at Lake Forest, Illinois, a suburb north of Chicago, which derives its water supply by pumping from Lake Michigan and empties its sewage into Lake Michigan. They filter the water, and filter the sewage.

Q. What was the cost of that plant and its capacity?

A. The plant for the filtration of the water cost from
$7,000.00 to $8,000.00. The plant for the purification of
12940 the sewage cost $7,500.00, and might be taken as the
measure of the added cost due to known pollution.

Q. What is the population of Lake Forrest?

A. About 2,000 people.

Q. Are you acquainted with the recommendations made in the report of Mr. Hazen upon the filtration of the water at St. Louis when he served as a special commissioner?

A. I have read his report.

Q. Have you designed a filter plant for any city in the country larger than Lake Forest?

A. Yes sir, I have designed a plant last summer for Ottumwa, Iowa.

Q. Was it installed?

A. Not as yet.

Q. Have the designs which you have made for Ottumwa been accepted by the city of Ottumwa?

A. They were not made for the city of Ottumwa. They were made for a private company applying for the franchises at Ottumwa.

12941 Q. Have the plans which you have made for Ottumwa been accepted?

A. Not as yet.

Q. Do you know whether they will be accepted or not?

A. Well, the chances are against it.

Q. Then the only personal practical experience that you have had in connection with the building of filtration plants is limited to Lake Forest?

A. No sir, I have been engaged upon a plant at Terre Haute, Indiana, quite a large plant.

Q. A filtration plant?

A. Yes sir. I was in co-partnership with the responsible engineer in charge and superintended it.

Q. When was this plant at Terre Haute built?

A. In 1889.

Q. What was its cost?

A. My recollection is that it cost between forty and fifty thousand dollars at that time. It was added to later on.

Q. Did you design that filtration plant?

A. No sir, I had the experience of being connected with
12942 its construction. It was a mechanical filter plant, however, and mechanical filter plants are really largely designed by the mechanical filter companies.

Q. It was a patent filter?

A. A patent filter, yes sir.

Q. Then in your experience in the installation of this patent filter and building the filter at Lake Forest, does that include all your personal connection with the construction of filters?

A. My personal connection with the design and construction of filter plants has been rather more limited than my experience in the design and construction of sewage plants. At the same time I have designed a number of important plants for the purification of water supplies and constructed others, and had to do with the operation of still others, perhaps to the total number of eight or ten all together.

Q. But in the active construction and building of filter
12943 plants, where you have figured on cost, and were responsible for the filters, are these the only two plants that you have been connected with in that way?

A. I believe they are.

RE-DIRECT EXAMINATION.

Mr. Jeffries: Q. You mean by your last answer that that is all you have had supervision of the construction of the plant?

A. Yes sir.

Q. As far as the experience in the construction is concerned?

A. Yes sir.

Q. State whether or not you have been called in consultation in reference to the repairing of filtration plants and the cost of the repairs and the cost of maintenance and such suggested improvements as might take place from time to time?

A. I have been so engaged in quite a number of places. I would not be able to say them all off hand, I should say at least a dozen places where I have advised as to the construction of filters or modifications of them or the designing of them. I am now working on some very large designs and recom- 12944 mendations for filter plants, and I am familiar through personal inspection and the collection of data with a very large number of such plants which I have visited abroad.

Outside of the patent mechanical filters, there have not been as yet a very great many filters built in the United States from special designs.

Q. Mr. Alvord, Mr. Hering, in his testimony, was asked this question: "In the construction of a filtration plant, is it not a fact that sanitary engineers take into consideration the extent of the infecting material discharged into a stream above in determining the character of the plant to be recommended," and in answer thereto said, "We do take that fact into consideration." The further question was asked, "In considering the construction of a filtration plant for the filtering of a water supply for a city which is taken from a running stream, sanitary scientists would recommend the use of a larger quantity of sand, if it be that character of a plant, per 100,000 population than if such water be subjected to the sewerage of a city of 1,000 population would they not," and in answer thereto, Mr. 12945 Hering said: "The population would cut no figure in my mind. We would under peculiar conditions possibly recommend one system of filtration for a highly polluted water, while we would be satisfied with another system of filtration in a very slightly polluted water." I will ask you if in the construction and operation of a filtration plant, sanitary engineers do not take into consideration the fact that when water is highly polluted with infected material that more complex construction must be obtained and that complex construction or plant more perfectly marked and that by reason of such superior construction and cautious maintenance a municipality would be required to employ more efficient men and be more cautious and observant as to the operation of the plant, and that this fact is well recognized by sanitary engineers and by the officers of the municipalities where filtration plants are being constructed.

Mr. Todd: Object to the question as not re-direct examination, and as leading. It is not rebuttal and therefore incompetent, irrelevant and immaterial.

A. I think this is a fact well recognized.

12946 Mr. Jeffries: Q. Is it not a fact that as the infection material is increased in a running stream that is being filtered that it is recognized by all sanitary engineers that the construction must be more perfect, of a higher grade, and that the equipment, the maintenance and the character of the employes more efficient?

Mr. Todd: Object to the question as to the previous question.

A. I think that it is.

Mr. Todd: Move to strike out the answer for the reasons heretofore given.

Mr. Jeffries: Q. In the filtration of a given water when the filtration plant has been constructed, assume that subsequent to the construction of this filtration plant the sewage disposal of a large and populous city be so disposed as to find its way, or the deleterious substances that are found therein, into the waters of that river above the filtration plant, state whether or not in your opinion more precaution and greater care should afterwards be maintained in the operation of that

12947 plant?

Mr. Todd: Object to the question for the same reason as heretofore stated.

A. In my opinion they should.

Mr. Todd: Q. If you were going to construct a filtration plant for the city of St. Louis would you construct it less stable and durable and with infected material to filter in order to filter the water of the Mississippi River with the sewage of the drainage canal eliminated than you would if that sewage was in it?

A. I do not think that the stability or permanency would enter into the question. I think it would be simply a question of the number of stages into which the purification would be divided, and the resulting complexity of the plant as a whole.

Q. But in answer to one of Mr. Jeffries' questions you stated that it would not require the same high skill in the putting up of the plant under the one condition as the other. As a matter of fact building a filter plant to filter the amount of water necessary for the city of St. Louis, you would employ the very best material and the highest skill obtainable in
12948 such a plant under either condition would you not?

A. So far as the actual construction was concerned, yes. But in so far as the complex arrangement of the plant is concerned, no.

Q. In the employment of the men to handle the filter that would be a matter that would be left to the municipality would it not?

A. I presume it would.

JOHN W. ALVORD.

ADJOURNED until 2:30 P. M., May 26, 1904.

12949 Room 282, Southern Hotel, St. Louis, Mo. 2:30 p. m., Thursday, May 26, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

E. E. LOCHRIDGE,

a witness called on behalf of the complainant, being duly sworn by the Commissioner, was examined in chief by Mr. Jeffries, and testified as follows:

Q. State your name?

A. E. E. Lochridge.

Q. What is your address?

A. Boston, Massachusetts.

Q. Where were you educated?

A. After graduating from the high school at Elkhorn, Wisconsin, I entered Beloit College in which I pursued courses in sciences, giving particular attention to the study of chemistry, and from this college I graduated with the degree of Bachelor of Science, in 1898. During my senior year I acted as private assistant to Professor E. G. Smith, and under his
12950 direction studied questions of water supply with special reference to the water supply of cities and towns.

Immediately after graduating from Beloit College I served as instructor in Chemistry for two terms at Drury College, Springfield, Missouri. I then returned to Beloit, having been appointed a regular instructor in Chemistry in Beloit College, but again served a large part of my time as private assistant to Professor E. G. Smith in further work on water supplies, mainly from the chemical point of view.

In 1900 I took the regular and some special courses in bacteriology at the University of Chicago, in the department of E. O. Jordan. I then resumed my duties as private assistant to Professor Smith. In the course of my work with him I have had occasion to visit many public and private water supplies and to examine such supplies and to study and investigate several epidemics of typhoid fever among which I may mention the epidemic at Rock Island, Illinois, Baraboo, Wisconsin, and Ashland, Wisconsin.

I also studied the operation of filters for municipalities
12951 in a practical way at Davenpart, Iowa, Cedar Rapids, Iowa, Rock Island, Illinois, Ashland, Wisconsin, Warren, Ohio, Kankakee, Illinois, Binghampton, New York, and two filter plants connected with the water supply of the Borough of Brooklyn, New York.

During the years 1902 and 1903 I attended the Massachusetts Institute of Technology, in Boston, as a graduate student, taking the regular courses in sanitary engineering.

Q. State whether or not at this school you also pursued advanced courses in bacteriology?

A. Yes, sir.

Q. And sanitary science?

A. Yes, sir, and sanitary science.

In June, 1903, on the recommendation of Messrs. Samuel M. Gray and George W. Fuller, consulting engineers for the special commission on water supply of the city of Springfield, Massachusetts, I was appointed by that commission to make special studies on the question of purification of the water supply of that city. This work involved experimental in-
12952 vestigation of the various methods of double filtration of water and as resident engineer in charge of this work I had in my employ a number of trained assistants. A report of this investigation has recently been published.

During my residence in Springfield an epidemic of typhoid fever broke out in one section of the city, which epidemic I investigated partly on my own account and partly in co-operation with the secretary of the local board of health.

Q. Mr. Lochridge, I will ask you to state whether or not you have examined the tables of typhoid fever statistics for St. Louis, introduced by witnesses and now formally a part of the record of the defendants in this case, and especially introduced by Dr. Barker on October 24, 1903?

A. I have.

Q. I will get you to state whether or not the number of typhoid fever deaths given upon that table for the years 1896 to 1902, inclusive, is approximately correct?

A. It differs only slightly from the results obtained by compiling the deaths attributable to typhoid fever in the record books of the mortuary office.

Q. I will get you to state whether nor not you have made a special study of the tables from typhoid fever and
12953 other fevers in the mortuary office of the board of health of the city of St. Louis?

A. I have.

Q. Will you state whether or not in your opinion any comparison of the typhoid fever deaths previous to 1896 with those subsequent to 1896 would yield or would be practicable as a means of determining whether or not typhoid fever had or had not increased in St. Louis after the opening of the Chicago drainage canal on January 17, 1900?

MR. TODD: Object to the question for the reason it is not rebuttal as the entire typhoid fever conditions in St. Louis for ten years prior to the opening of the drainage canal were introduced in evidence by Dr. Ravold and supplemented by charts of various kinds as to the typhoid conditions of St. Louis, and is therefore incompetent, irrelevant and immaterial.

A. I do not believe that any such comparison is either practicable or feasible for the reason that while previous to 1896 the intake of the water works of the city of St. Louis was so located as to expose the water supply to infection from sewers coming from the city, and during 1894 and 1895 the 12954 intake was removed to a point further up the Mississippi river at the chain of rocks, above any such contamination.

In order to show that the great change in the typhoid fever mortality of the city of St. Louis, at the time the intake was moved, I have prepared a diagram which serves to illustrate this point, as well as certain other points to which I have occasion to refer hereafter.

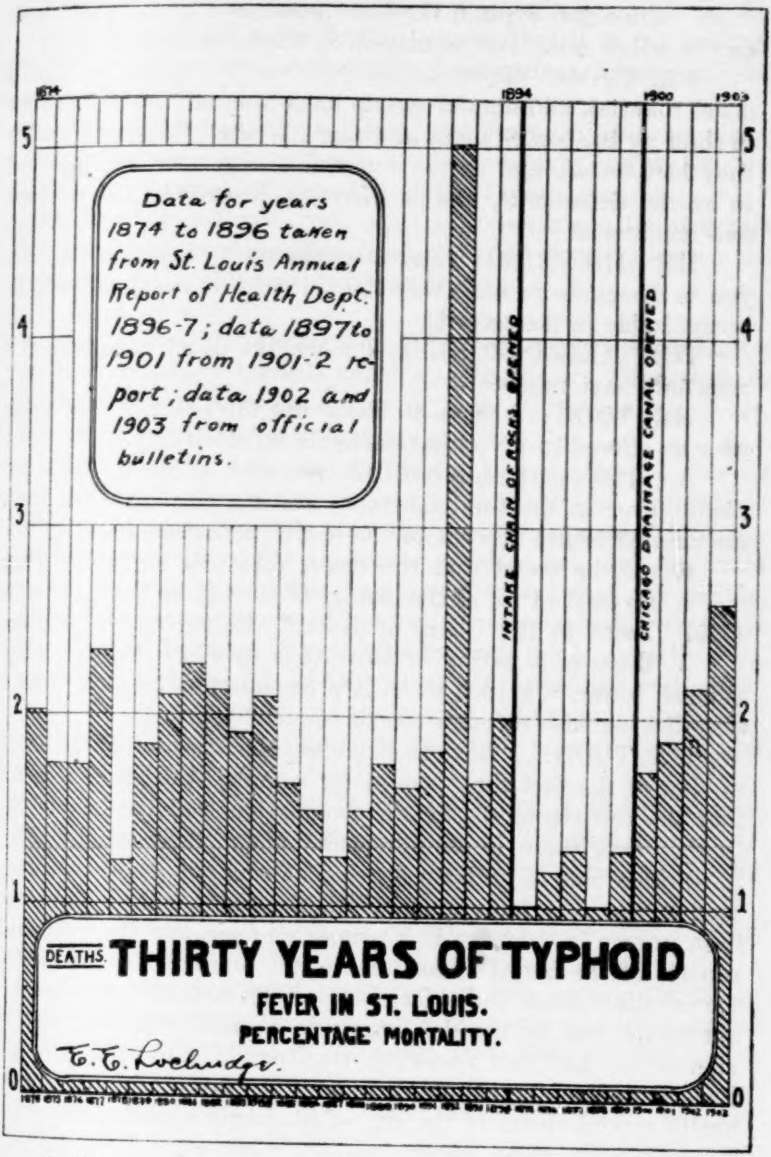
MR. TODD: I move to strike out the answer for the reason it is not rebuttal as the whole matter was gone into by complainant in chief by nearly every witness who testified in this case on the part of the complainant, and it is therefore incompetent, irrelevant and immaterial, and is not rebuttal evidence.

MR. JEFFRIES: Q. Will you produce in evidence this diagram to which you have referred in your last answer?

MR. TODD: Objected to for the reasons heretofore stated.

A. I will. It is as follows:

12955 **Complainant's Rebuttal Chart No. 3.**



E. E. Lochridge.

12956 MR. JEFFRIES: Q. Will you read in evidence this table and explain the facts presented by it in the manner in which such representation is made by the chart.

MR. TODD: Object to the question for the reason that it is not rebuttal, and similar charts have been offered in evidence in chief by the complainant as going into the original case after they had rested, and as not rebuttal of any new evidence put in by the defendants, and is therefore incompetent, irrelevant and immaterial.

MR. JEFFRIES: Mr. Commissioner, I would like for you to designate in some way the title of this chart so as to be recognizable in the record.

THE COMMISSIONER: I mark the chart complainant's rebuttal chart number 3.

MR. TODD: I move to strike out the chart for the same reasons offered in my objection to its admissibility.

A.- This chart represents the per cent. of deaths from typhoid fever to the total mortality for the city as taken from the printed health records of the health department.

It will be noted that the death rate was uniformly high up to the time of the change of the intake from Bissell's

12957 Point to the Chain of Rocks. Following this change there is a period of five years in which the mortality is much lower. In 1900 there is a considerable increase and a step like increase through the subsequent years.

MR. TODD: I move to strike out the answer and the chart in view of the fact that counsel for complainant has contended that the reports of the health commissioner of the city of St. Louis,—that there is no agreement about their admissibility in evidence and if such an agreement was not made, as I contend it was, the facts upon which the chart is built have not been proven in evidence in a proper manner, and the published reports of the board of health are not competent evidence for the complainant, if the objection made by counsel for complainant to the use by the defendants is a valid objection, and in view of the fact that these reports from 1874 to 1903 have not been proven as the official report of the health department or health commissioner of the city of St. Louis, and that the chart is based upon those public reports, I move to strike out the answer and the charts as it is not competent evidence and is not based upon any facts that have been proven in this 12958 case, and for the further reason that it is not rebuttal evidence and is therefore incompetent, irrelevant and immaterial.

MR. JEFFRIES: Q. Have you examined the records of the deaths from other fevers in the mortuary office of the health department of the city of St. Louis; remittent, intermittent, typho malaria, congestive and simple continued fevers for the four years preceding and the four years following the opening of the Chicago drainage canal?

A. I have.

Q. Please state what you found upon your examination of these mortuary records respecting the deaths from typhoid fever, remittent fever, intermittent fever, typho-malaria fever, congestive fever, and simple continued fever?

MR. TODD: Objected to for the reason that the records are the best evidence, and in view of the fact that counsel for the complainant contends that there is no agreement existing between the counsel for the State of Missouri, and the State of Illinois and the Sanitary District that the official 12959 published reports of the health commission of St. Louis shall be used in evidence by both sides, then it is incompetent to have the witness testify to what the records in the mortuary department of the city of St. Louis may show in regard to other things, and it is therefore incompetent, irrelevant and immaterial.

MR. JEFFRIES: As to this objection I refer to and stand upon the statement made by me on the first day of the resumption of testimony at this place and at this time, to-wit, on the 23rd day of May, 1904.

MR. TODD: In reply to counsel will state that I stand upon my objection.

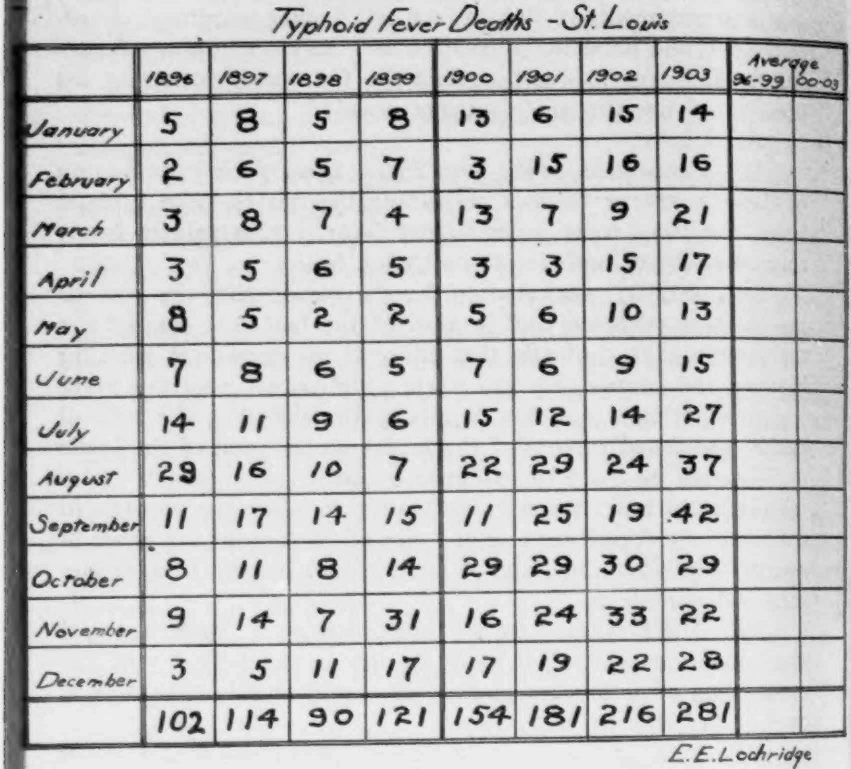
A. I have examined these records and have made tables showing the number of deaths from the causes mentioned in the question in each month of the years from 1896 to 1903, inclusive, which tables are as follows:

MR. JEFFRIES: Mr. Commissioner, I would like for you in some way to identify the tables which have just been offered in evidence.

THE COMMISSIONER: They are designated as complainant's rebuttal charts numbers 4 to 9, both inclusive. 12960

Which said charts are as follows:

12961 Complainant's Rebuttal Chart No. 4.



Typhoid Fever Deaths - St. Louis

	1896	1897	1898	1899	1900	1901	1902	1903	Average 96-99	Average 00-03
January	5	8	5	8	13	6	15	14		
February	2	6	5	7	3	15	16	16		
March	3	8	7	4	13	7	9	21		
April	3	5	6	5	3	3	15	17		
May	8	5	2	2	5	6	10	13		
June	7	8	6	5	7	6	9	15		
July	14	11	9	6	15	12	14	27		
August	29	16	10	7	22	29	24	37		
September	11	17	14	15	11	25	19	42		
October	8	11	8	14	29	29	30	29		
November	9	14	7	31	16	24	33	22		
December	3	5	11	17	17	19	22	28		
	102	114	90	121	154	181	216	281		

E.E.Lochridge

12962 Chart No. 5.

Remittent Fever Deaths - St. Louis

	1896	1897	1898	1899	1900	1901	1902	1903	Average	
									96-99	00-0
January	3	2	1	1		2	1			
February	3	1	1	1						
March	1	2	4				1			
April	3	4		1		2	1	2		
May	2	3	3	3	2	1	1	2		
June	2	4	3	2	2	4	1			
July	3	1	4	1	1	5	2	3		
August	12	6	2		2	2	1	4		
September	5	2	4	5	4	2	3	1		
October	3	2	2	1		2	4	2		
November	2	1	1		3	1		2		
December	1	1	1		1	2	2	1		
	40	29	26	15	15	23	17	17		

E.E. Lochridge

12963

Chart No. 6.

Intermittent Fever Deaths – St. Louis.

	1896	1897	1898	1899	1900	1901	1902	1903	Average	
									96-99	00-03
January			2	1	2		2			
February	1		1	4						
March	1		1			2				
April		1	1	1		1				
May	3	2	1		1	2	1			
June		4		2	1	1		1		
July	1	3	2	4	2	1	2	2		
August	3	1	1	6		1		3		
September	2		1	2	1	3	1	2		
October	1	1	1	2	2	1	2	1		
November			2	2	1		1			
December			3	1				2		
	12	12	16	25	10	12	9	11		

E.E. Lochridge

12964

Chart No. 7.

Typho-Malarial Fever Deaths - St. Louis.

	1896	1897	1898	1899	1900	1901	1902	1903	Average	
									96-99	00-0
January	4	2		2	3	2	2	2		
February	2	1	2		1		2	1		
March	1	3	1	2	4		4	5		
April	4	3	3	3	3	3	2	2		
May	1	3	1	4	3	2	4	6		
June	2	2	5	2	3	3	1	6		
July	9	4	3	1	3	2	6	3		
August	7	4	1	5	4	1	1	1		
September	8	7	4	2	6	4	2	6		
October	6	5		5	1	4	4	4		
November	6	5	3	3	2	2	3			
December		3	7	2	3		3			
	50	42	30	31	36	23	34	36		

E. E. Lochridge.

12965

Chart No. 8.

Congestive Fever Deaths - St. Louis.

	1896	1897	1898	1899	1900	1901	1902	1903	Average	
									96-99	00-03
January	2	1					2	3		
February	2			3				1		
March		2	1	1	2		1			
April	2	1	2							
May	2		1				1			
June	1		1		1	1				
July	3	5		2	1	2	1	2		
August	7	7	3	4	6		1			
September	2	3	2	4	2	1	4			
October	1	2	2		2		2	1		
November	3	1	1	1			3			
December	1				1					
	26	22	13	15	15	4	15	7		

E.E. Lochridge

12966

Chart No. 9.

Contiued Fever Deaths - St. Louis

	1896	1897	1898	1898	1900	1801	1802	1903	Average	
									96-99	00-03
January										
February										
March							1			
April								1		
May										
June		1			1					
July										
August	1									
September										
October								1		
November										
December										
	1	1	0	0	1	0	1	2		

E. E. Lochridge

12967 A. In the tables headed "Typhoid Fever Deaths, St. Louis," it will be noted that a double line is placed between the years 1899 and 1900, and in the case of almost every month it will be seen that there is a distinct rise from that point, in the number of deaths for that month in the four following years.

In the tables headed "Remittent Fever Deaths, St. Louis," the total number of remittent fever deaths will be seen to be in the year 1896, 40; in the year 1897, 29; and in the following years 26, 15, 15, 23, 17, 17, respectively, showing in a general way from the year 1898 no change in the mortality from this cause.

In the tables headed "Intermittent Fever Deaths, St. Louis," it will be noted that the deaths from this cause are about the same in number each year, that is 12, 12, 16, 25, 10, 12, 9 and 11, and that with the exception of the year 1899, in which the number was about double that of any of the other years, there has been no change in the number.

In the table headed "Typho-malarial Fever Deaths, St. Louis," the number of deaths from this cause in the year 1896 was 50, in 1897 it was 42, and from that time to 1903 about 30 each year, no marked variation being noted.

In the table headed "Congestive Fever Deaths, St. Louis," it will be noted that there are in 1896 and 1897, re-
12968 spectively, 26 and 22 deaths from this cause, and from 1898 to 1903, respectively, there are 13, 15, 15, 4, 15 and 7 only, and that with the exceptions of the years 1901 and 1903, when the number was perceptibly lower, the number remained precisely the same.

In the chart headed "Continued Fever Deaths, St. Louis," it will be noted that there were but two deaths from continued fever in the four years prior to the opening of the canal and four in the four years subsequent.

MR. TODD: I move to strike out the answer for the reasons given in my objection to the question, and for the additional reasons that the typhoid fever deaths per month was gone into in chief by complainants in Dr. Ravold's testimony and in detail by the months as well as by charts, and is therefore not rebuttal, consequently incompetent, irrelevant and immaterial.

MR. JEFFRIES: Q. State whether or not, in your examination of the mortuary records in the office of the board of health of the city of St. Louis you discovered, during your examination, any tables designated as deaths due to simple continued fever during those years?

12969 MR. TODD: Object to the question for the same reasons heretofore advanced, and the additional reason it is incompetent, irrelevant and immaterial.

A. I find six deaths marked continued or continuing fever, but none marked simple continued fever in the years 1896 to 1903, inclusive.

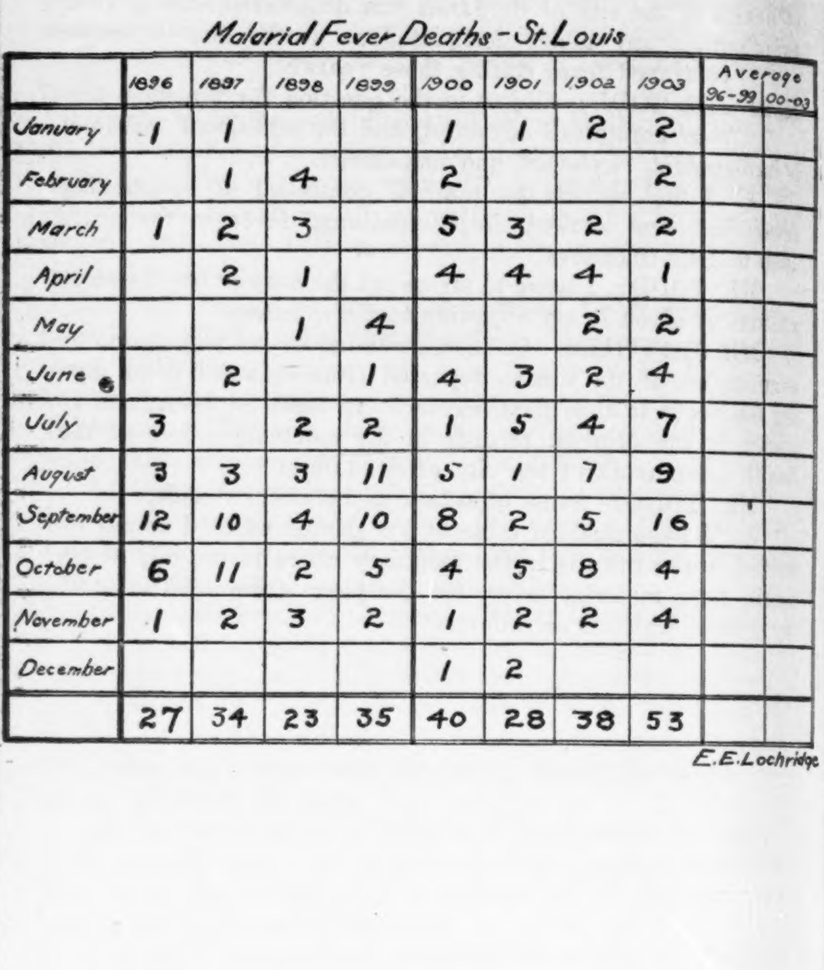
MR. TODD: I move to strike out the answer for the same reasons as given in my objection to the question.

MR. JEFFRIES: Q. State whether or not you made any examination of the deaths reported from malarial fever during the years 1896 to 1903, inclusive, as malarial fever, and as shown in the original records in the mortuary office of the health department of the city of St. Louis?

MR. TODD: Same objection as heretofore made.

A. I have made a table of the deaths which I found recorded in the records in the mortuary office in the city of St. Louis, from malarial fever, for the years from 1896 to 1903, by months, which is as follows:

12970 Chart No. 10.



Malarial Fever Deaths - St. Louis

	1896	1897	1898	1899	1900	1901	1902	1903	Average 96-99	Average 00-03
January	1	1			1	1	2	2		
February		1	4		2			2		
March	1	2	3		5	3	2	2		
April		2	1		4	4	4	1		
May			1	4			2	2		
June		2		1	4	3	2	4		
July	3		2	2	1	5	4	7		
August	3	3	3	11	5	1	7	9		
September	12	10	4	10	8	2	5	16		
October	6	11	2	5	4	5	8	4		
November	1	2	3	2	1	2	2	4		
December					1	2				
	27	34	23	35	40	28	38	53		

E.E.Lochridge

12971 A. The number of deaths from malaria and malarial fever were in the years from 1896 to 1903, 27, 34, 23 and 35, respectively, before the opening of the canal, and 40, 28, 38 and 53, respectively, for the four years since the opening of the canal.

MR. TODD: I move to strike out the answer for the reason heretofore stated in my objection.

MR. JEFFRIES: Q. State whether or not you have read the testimony introduced in evidence by Dr. Barker and Dr. Jordan in this case?

A. I have.

Q. Did you examine the tables of typhoid statistics for St. Louis prepared and introduced by him, and which now forms a part of the evidence of defendant in this case?

A. I have.

Q. I will ask you to state whether or not any of the deaths from the fevers known as intermittent, remittent, congestive and typho malaria and continued fevers for the years 1896 to 1903, inclusive, or all of them taken together, correspond in number with the numbers given by Professor Barker and Professor Jordan, the tables of typhoid statistics
12972 from St. Louis introduced by them in evidence?

MR. TODD: Object to the question for the same reasons heretofore given.

A. Adding together the deaths which I found in the study of the records at the mortuary office from remittent, intermittent, typho-malaria, congestive and continued fevers, I find that for the years 1896 to 1899, inclusive, there were respectively 129, 106, 85 and 86 deaths, and that if the number of deaths which I found in the records in the mortuary office from malaria are added to these, there are in these years respectively 156, 140, 108 and 121 deaths, while Professor Jordan gave for the corresponding years 177, 172, 134 and 148, or the number of deaths which I find recorded on the books in the mortuary office from these causes is a little lower in each year than the list taken by Professor Jordan from the printed health report.

In the four years from 1900 to 1903, inclusive, adding together the deaths which I found in the books in the mortuary office in the city of St. Louis from intermittent, remittent,

typho malaria, congestive and continued fevers, I find
12973 for these years 77, 62, 76 and 73 deaths. Adding to these the deaths which I find of malarial fever for these years, there were 137, 90, 114 and 126 deaths, or a little higher in each year than those given by Professor Jordan.

MR. TODD: I move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. State whether or not there is considerable difference between the data compiled by Professor Jordan and adopted by Dr. Barker and that ascertained by you from your examination of the mortuary records in the health department of St. Louis, and state wherein the difference lies?

MR. TODD: Object to the question for the reasons heretofore stated.

A. Considering the fact that the malarial fevers were in all probability recorded in this list as they do not occur under any other caption, so far as could be discovered in the printed health reports, I find that Professor Jordan has in his list 21 more deaths in 1896, 32 more in 1897, 26 more in 1898, and 27 more in 1899, 25 less in 1900, 10 less in 1901, 12 less in 1902, and 35 less in 1903, than I found in my study of the records in the mortuary office in St. Louis.

12974 MR. TODD: I move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. State whether or not you made any examination of the mortuary records of the city of St. Louis for the years 1896 to 1903, inclusive, for the purpose of determining the number of deaths attributable by the attending physician to bilious fever, enteric fever and deaths in which typhoid was assigned as the cause, but not the principal cause of deaths, and typhoid-pneumonia deaths?

MR. TODD: Object to the question for the same reasons set out at length in my previous objection.

A. I have.

MR. JEFFRIES: Q. Please state what you found in reference to deaths being caused by these diseases and the number of deaths from them?

MR. TODD: Objected to for the same reasons heretofore stated.

A. I have tabulated the deaths by the causes mentioned
in four tables. In the table which is headed "Bilious Fever
Deaths, St. Louis," the deaths occurring in these eight
12975 years are tabulated by month and year, the total number
of that year being given at the foot of the column.
I have merely tabulated the deaths caused by enteric fever in St. Louis with the total deaths from this cause per year at the foot of the respective columns and deaths in which typhoid fever was assigned as a cause of death, and which I have not included in any of the other tables I have tabulated in a similar way. The deaths from typho-pneumonia were variously recorded as "typho-pneumonia" or "pneumonia and typhoid." All of these deaths I have recorded in a similar table headed "Typho-pneumonia Deaths, St. Louis."

MR. TODD: I move to [illegible] swer for the same reasons assigned in my objection to the question.

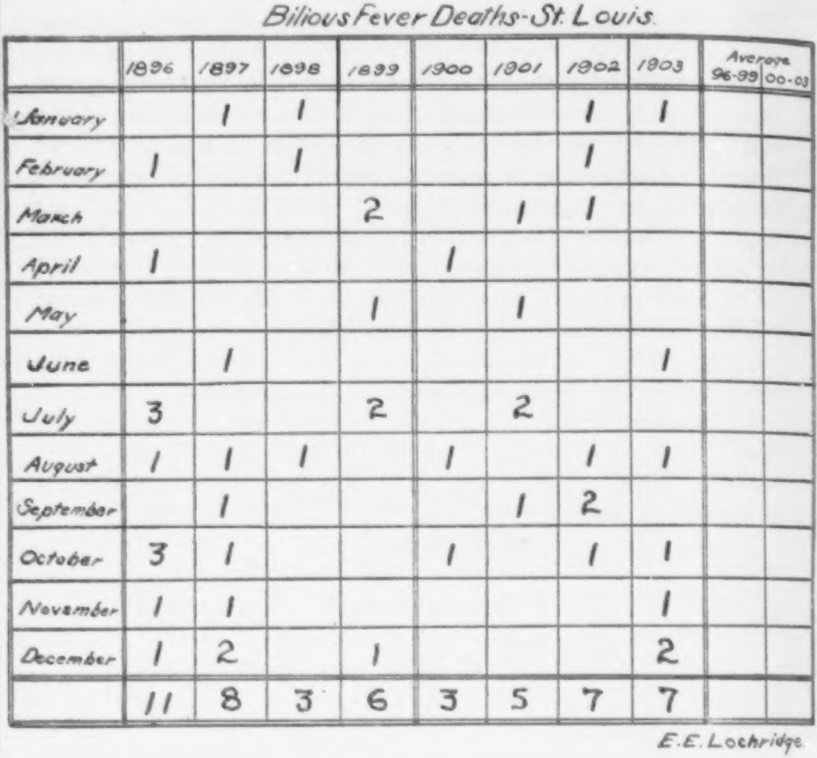
MR. JEFFRIES [illegible] d these tables in evidence?

MR. TODD: Object to the tables for the same reasons as heretofore given.

A. They are as follows:

12976

Chart No. 11.



Bilious Fever Deaths-St. Louis.

	1896	1897	1898	1899	1900	1901	1902	1903	Average	
									96-99	00-03
January		1	1				1	1		
February	1		1				1			
March				2		1	1			
April	1				1					
May				1		1				
June		1						1		
July	3			2		2				
August	1	1	1		1		1	1		
September		1				1	2			
October	3	1			1		1	1		
November	1	1						1		
December	1	2		1				2		
	11	8	3	6	3	5	7	7		

E.E. Lochridge

12977

Chart No. 12.

Enteric Fever Deaths - St. Louis

	1896	1897	1898	1899	1900	1901	1902	1903	Average	
									96-99	00-03
January										
February										
March										
April										
May										
June			1							
July				1						
August							1			
September										
October		1			1	1				
November			1			1	1			
December			1	1	1					
	0	1	3	2	2	2	2.	0		

E.E.Lochridge

Chart No. 13.

Deaths in which Typhoid was a cause—not included under other tables.

	1896	1897	1898	1889	1900	1901	1902	1903	Averages 96-99	Averages 00-03
January				1		1		1		
February										
March								1		
April										
May										
June										
July								4		
August		1						1		
September			1			1				
October							1			
November							2			
December								1		
	0	1	1	1	0	2	3	8		

E. E. Lochridge

12979

Chart No. 14.

Typho-Pneumonia Deaths – St. Louis

	1896	1897	1898	1899	1900	1901	1902	1903	Average	
									96-99	00-03
January	1		2	4	3		1			
February		1	2			1	1	5		
March	2		5	1	2	2	3	1		
April	4	3	3	1	1	2		1		
May		3	1	1			3	1		
June	2	2		1		2		2		
July			1	1		2		2		
August	1	1	1		1	2	2	2		
September		3				1	2	1		
October	2	2	1			1		2		
November	1	1		4		3		2		
December		2	1	1	2	2	3	7		
	13	18	17	14	9	18	15	26		

E. E. Lochridge.

12980 MR. TODD: I move to strike out the tables for the same reasons as heretofore given.

MR. JEFFRIES: Q. Mr. Lochridge, state whether or not in your examination of the mortuary records and in obtaining the deaths reported from the various diseases heretofore referred to, you tabulated those deaths according to the results of the disease in the seven respective sanitary districts of St. Louis for the years 1896 to 1903, inclusive?

MR. TODD: I object to the question for the reasons heretofore stated.

A. I have tabulated the typhoid fever deaths in the city of St. Louis according to the residence address in which the patient died for the years mentioned.

MR. TODD: I move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. Will you present those charts and explain them and read them in evidence?

MR. TODD: Object to the question on the ground stated in my objection to the above question.

A. They are as follows:

12981

Chart No. 15.

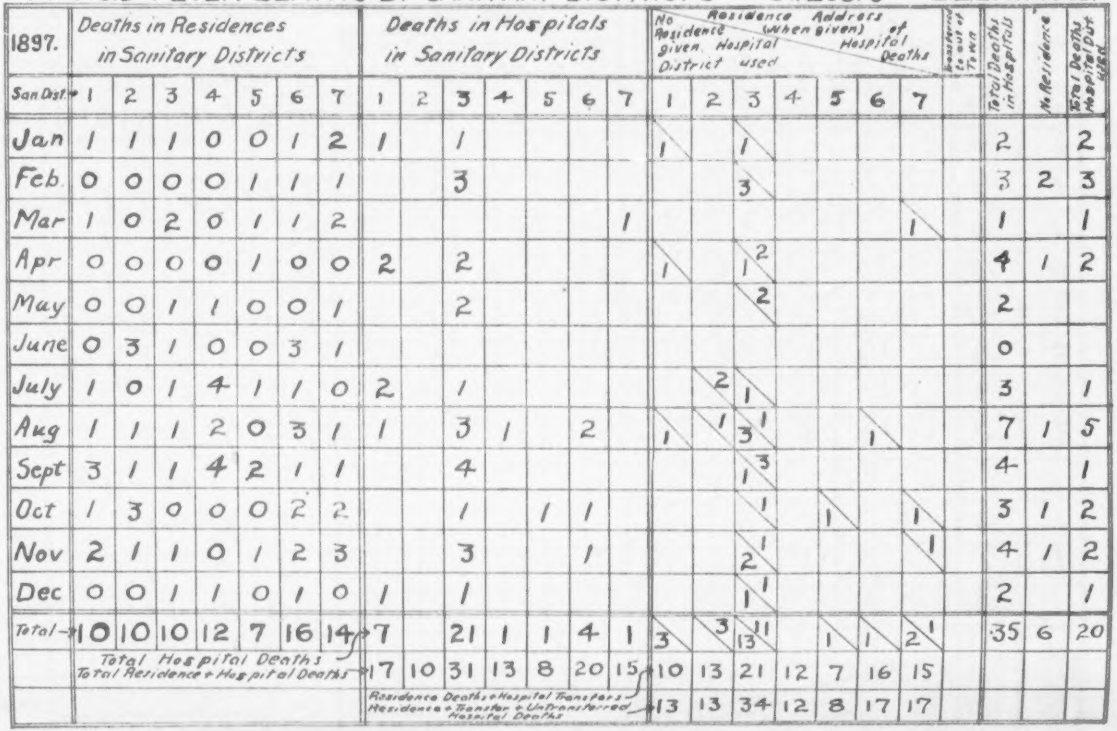
1696	Deaths in Residences in Sanitary Districts							Deaths in Hospitals in Sanitary Districts							No Residence given: Hospital District used / Residence Address (when given) of Hospital Deaths														Transf's to out of Town	Total Deaths in Hospitals	No Residence	Total Deaths Hospital Dist. Used
San Dist	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1		2		3		4		5		6		7					
Jan			1		1	2				1												1								4		
Feb			1									1											1							1		1
Mar			1		1					1										1										1		
Apr		1		1			1																									
May			1	1	1	2	1					1		1									1				1			2	1	2
June				1		1	1	1		2				1	1				1	1							1			4		3
July	2	1	1	4						5				1					2	1						2	1			6		3
Aug	3	1	2	2	3	2	4	1		11					1	1			3	1		1			1	2		2		12	1	5
Sept	1	1		2		1	1			4				1					3	1							1			5	1	4
Oct		1					3	1		1		1		1		1				2					1					4		1
Nov	2	1	1		1	1	1			2									1									1		2		1
Dec			1							2									1							1				2	1	1
Total →	8	6	9	11	7	9	12	3		29		3		5	2	2			11	7		2	2		2	5	4	3		40	4	21
	Total Hospital Deaths Total Residence + Hospital Deaths →							11	6	38	11	10	9	17	10		6		16		13		7		14		15					
								Residence Deaths + Hospital Transfers Residence + Transfer + Untransf'd Hospital Deaths →							12		6		27		13		9		16		19					

E.E. LOCHRIDGE

12982

Chart No. 16.

TYPHOID FEVER DEATHS BY SANITARY DISTRICTS — ST. LOUIS — E. E. LOCHRIDGE.



1897.	Deaths in Residences in Sanitary Districts							Deaths in Hospitals in Sanitary Districts							No Residence given. Hospital District used \ Residence Address (when given) of Hospital Deaths							Transferred to out of Town	Total Deaths in Hospitals	No Residence	Total Deaths Hospital Dist used
San. Dist.→	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7				
Jan	1	1	1	0	0	1	2	1		1					1 \		1 \						2		2
Feb	0	0	0	0	1	1	1			3							3 \						3	2	3
Mar	1	0	2	0	1	1	2							1							1 \		1		1
Apr	0	0	0	0	1	0	0	2		2					1 \		1 \ 2						4	1	2
May	0	0	1	1	0	0	1			2							\ 2						2		
June	0	3	1	0	0	3	1																0		
July	1	0	1	4	1	1	0	2		1						\ 2	1 \						3		1
Aug	1	1	1	2	0	3	1	1		3	1		2		1 \	\ 1	3 \ 1			1 \			7	1	5
Sept	3	1	1	4	2	1	1			4							1 \ 3						4		1
Oct	1	3	0	0	0	2	2			1		1	1				\ 1		1 \		1 \		3	1	2
Nov	2	1	1	0	1	2	3			3			1				2 \ 1				\ 1		4	1	2
Dec	0	0	1	1	0	1	0	1		1							1 \ 1						2		1
Total→	10	10	10	12	7	16	14→	7		21	1	1	4	1	3 \	\ 3	13 \ 11		1 \	1 \	2 \ 1		35	6	20
	Total Hospital Deaths Total Residence + Hospital Deaths→							17	10	31	13	8	20	15	10	13	21	12	7	16	15				
								Residence Deaths + Hospital Transfers Residence + Transfer + Untransferred Hospital Deaths							13	13	34	12	8	17	17				

12983

Chart No. 17.

TYPHOID FEVER DEATHS BY SANITARY DISTRICTS — ST. LOUIS — E. E. LOCHRIDGE.

1898	Deaths in Residences in Sanitary Districts							Deaths in Hospitals in Sanitary Districts							No Residence given. Hospital Districts used \ Residence Address (when given) of Hospital Deaths							Transferred to out of Town	Total Deaths in Hospitals	"No Residence	Total Deaths Hospital Dist used
San Dist	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7				
Jan.						2				2			1							1 \ 1	\ 1		3		1
Feb.	1					2				2							2 \						2		2
Mar	1	1	1	1	1	1	1																		
Apr		3					3																		
May					1					1							1 \						1		1
June		1	1			3								1							1 \		1		1
July	1		1			2	1	2		1			1		1 \		1 \		\ 1	\ 1			4	1	2
Aug	1	1			1	1	3			2				1			2 \				1 \		3	1	3
Sept		3		1	2	2				4			1	1	\ 1		3 \			1 \	\ 1		6	1	4
Oct	1	1	1		1	3	1																		
Nov		1			1	1	3							1						\ 1			1		
Dec			1	1		3	1			3	1		1				2 \ 2	\ 1					5	1	2
Total →	5	11	5	3	7	20	13 →	2		15	1		4	4	1 \ 1		11 \ 2	\ 1	\ 1	2 \ 3	2 \ 2		26	4	16
	Total Hospital Deaths Total Residence + Hospital Deaths →							7	11	20	4	7	24	17 →	6	11	7	4	8	23	15				
								Residence Deaths + Hospital Transfers Residence + Transfer + Untransferred Hospital Deaths →							7	11	18	4	8	25	17				

12983a

Chart No. 18.

TYPHOID FEVER DEATHS BY SANITARY DISTRICTS — ST. LOUIS — E. E. LOCHRIDGE

1899	Deaths in Residences in Sanitary Districts							Deaths in Hospitals in Sanitary Districts							No Residence given Hospital District used \ Residence Address (when given) of Hospital Deaths							Transferred to out of Town	Total Deaths in Hospitals	"No Residence"	Total Deaths Hospital Dist used
San. Dist. →	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7				
Jan.				1	1	3		1		1		1			1 \		1 \		1 \				3	1	3
Feb.		1		3		1	1				1							1 \					1		1
Mar	1		1		1		1																		
Apr	2		1	1	1																				
May		1				1																			
June		2						1		2							1 \ 2						3		1
July	1	3					1	1								\ 1							1		
Aug	2	0	1	2	1		1																		
Sept	1	2		2	3	1	2			1	2	1						1 \	1 \		\ 2		4		2
Oct	1	3		1	4	2	2			1									\ 1				1		
Nov	5	1	3	6	3	6	2	2		1		1	1				\ 1	\ 1	1 \	1 \		1	5		2
Dec	2	2	1		1	2	6			2	1						1 \	1 \ 1					3		2
Total →	15	15	7	16	15	16	16 →	5		8	4	3	1		1 \	\ 1	3 \ 3	3 \ 2	3 \ 1	1 \	\ 2	1	21	1	11
	Total Hospital Deaths —— Total Residence + Hospital Deaths —— →							20	15	15	20	18	17	16 →	15	16	10	18	16	16	18				
								Residence Deaths + Hospital Transfers Residence + Transfer + Untransferred Hospital Deaths →							16	16	13	21	19	17	18				

12983b

Chart No. 19.

TYPHOID FEVER DEATHS BY SANITARY DISTRICTS — ST. LOUIS — E. E. LOCHRIDGE

1900	Deaths in Residences in Sanitary Districts							Deaths in Hospitals in Sanitary Districts							No Residence given. Hospital Districts used / Residence Address (when given) of Hospital Deaths							Transferred to out of Town	Total Deaths in Hospitals	"No Residence"	Total Deaths Hospital Dist used
San Dist →	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7				
Jan				2	2	3				1						1							1		
Feb					2					1										1			1		
Mar			1		4	6	1				1							1					1		
Apr				2	1																				
May	2		1				1			1											1		1		
June	1	2					1		1	1		1*				1	1					1	2*		
July	2	2		2		2	1	2		2				2		1		1	1	1	 1	1	6		1
Aug	5		1	1	2	2	4	3				1	2	1	2	1	1		1	2			7		
Sept	1			1	2	3	2			2							 1					1	2		1
Oct		3	2	3		6	6	3		5		1			2	1	2 1		2	1			9	1	1
Nov	2	2	1	2	1	4	2			1				1			1			1			2		
Dec			2	3	1	2	5	1		1		1		1	1			1	1 1				4		1
Total →	13	9	13	16	15	28	23 →	9	1	15	1	4	2	5	5	5	5 2	3	5 1	6	1 1	3	36	1	4
	Total Hospital Deaths Total Residence + Hospital Deaths →							22	10	28	17	19	30	28	18	14	18	19	20	34	24				
								Residence Deaths + Hospital Transfers Residence + Transfer + Untransferred Hospital Deaths							18	14	20	19	21	34	25				

12983c

Chart No. 20.

TYPHOID FEVER DEATHS BY SANITARY DISTRICTS — ST LOUIS — E E LOCHRIDGE

1901	Deaths in Residences in Sanitary Districts							Deaths in Hospitals in Sanitary Districts							No Residence given Hospital District used / Residence Address (when given) of Hospital Deaths							Transferred to out of Town.	Total Deaths in Hospitals	No Residence	Total Deaths Hospital Dist. used
San Dist →	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7				
Jan		1		1		1	2							1							1		1		1
Feb	1	4		1	1	2		1		4		1			1		3			1	1		6		
Mar	1			2		3					1							1					1		
Apr	1	1			1																				
May		1	1	2	2																				
June		1		1			2			2							1		1				2		
July	1	2		2	1					4				1			1	2		1		1	5		
Aug	2	4	1	2	3	6	5	2		2			1	1				1	1		1	3	6		
Sept	1	2	2	2		1	8	2		5			2		1	1	1 1		1	3	1		9	1	2
Oct	1	1		5		4	7	1		4		1	2	3		2	3			1	3	2*	11		3
Nov	4	5			5		1	2		4			2	1	1	1	1	1		3	1	1	9		1
Dec.	3		2		1	6	2			4			1				1	1	1	1			5		
Total →	15	22	6	18	14	23	27 →	8		29	1	2	8	7	1 2	4	11 1	6	4	10	4 4	8	55	1	7
Total Hospital Deaths Total Residence + Hospital Deaths →								23	22	35	19	16	31	34 →	16	26	17	24	18	33	31				
Residence Deaths + Hospital Transfers Residence + Transfer + Untransferred Hospital Deaths →															18	26	18	24	18	33	35				

12983d

Chart No. 21.

TYPHOID FEVER DEATHS BY SANITARY DISTRICTS — ST. LOUIS — E. E. LOCHRIDGE.

1902	Deaths in Residences in Sanitary Districts							Deaths in Hospitals in Sanitary Districts																						Transferred to out of Town	Total Deaths in Hospitals	No Residence	Total Deaths Hospital Dist. used
San Dist →	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1		2		3		4		5		6		7					
															No Residence given Hospital District used	Residence Address (when given) of Hospital Deaths	No Residence given Hospital District used	Residence Address (when given) of Hospital Deaths	No Residence given Hospital District used	Residence Address (when given) of Hospital Deaths	No Residence given Hospital District used	Residence Address (when given) of Hospital Deaths	No Residence given Hospital District used	Residence Address (when given) of Hospital Deaths	No Residence given Hospital District used	Residence Address (when given) of Hospital Deaths	No Residence given Hospital District used	Residence Address (when given) of Hospital Deaths				
Jan		2	2	1		2	2			3		1	2			1		1	1	1		1				1				6		1
Feb	2			4		4	4			2										1						1				2		
Mar	2	1		1	1	1	1			1			1					1		1										2		
Apr	3		1	1	1	4	2					1	2											1		2				3		
May	2			1		2	2	1		2						1		1								1				3		
June			2	3	3					1										1										1		
July		2			2	2	3	2		2			1		1				1	2				1						4	1	1
Aug	1	1	2	3	2	3	3	1		6			2			1		2		3						1			2	9		
Sept	2	2	1	2	1	2	2	1		4		1	1						1			3		1		1			1	7	1	1
Oct	2	1		1	2	8		1		11		2		2					2	2		3		1		1		4	3	16		2
Nov	5	4		3	3	6	3	1		4		3	1			1				1		1				1		2	3	9		
Dec	1	3	3	2	2	3	3			3		1	1						1	2		1				1				5	1	1
Total →	20	16	11	22	17	36	25	7		39		9	11	2	1	4		5	6	14		9		4		10		6	9	67	3	6
	Total Hospital Deaths Total Residence + Hospital Deaths							27	16	50	22	26	48	27	24		21		25		31		21		46		31					
								Residence Deaths + Hospital Transfers Residence + Transfer + Untransferred Hospital Deaths							25		21		31		31		21		46		31					

12983e

Chart No. 22.

TYPHOID FEVER DEATHS BY SANITARY DISTRICTS — STLOUIS — E.E. LOCHRIDGE.

1903	Deaths in Residences in Sanitary Districts							Deaths in Hospitals in Sanitary Districts							No Residence given. Hospital District used / Residence Address (when given) of Hospital Deaths							Transferred to out of Town	Total Deaths in Hospitals	"No Residence"	Total Deaths Hospital Dist. used
San. Dist →	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7				
Jan	3	1	2	1	3	1	2			1						1							1		
Feb	1		1	4	3	2	2	1		2					1					1		1	3		
Mar		1		2		3	2	3		6		1	3			1	3		2	3	2		13		
Apr	2	3			1	4	3			3			1				2	1		1			4		
May		1		2	4		2			2			2				1			1	2		4		
June	1	2	1	2	2	3	1	1		2						1		1		1			3		
July	3	1	4	6	1	4	3	1		1		2	1		1	1				1		2	5		
Aug	3	2	2	7	1	4	7	2		6			3			2	1	3	1	1	2	1	11		
Sept	4	4		9	2	5	6	3		3		2	2	2	1	2	1 1	2		2		3	12		1
Oct	6	4		5		2	6	3		1		2			1		2			1		2	.6		1
Nov	2	1	3		2	4	4			4		1	1				1		1	1		2	6		1
Dec	4	5			2	6	4			5			1	1		1	3	1			2		7		
Total →	29	25	13	38	21	38	42 →	14		36		8	14	3	3 1	9	14 1	8	3 1	13	8	11	75		3
	Total Hospital Deaths Total Residence + Hospital Deaths →							43	25	49	38	29	52	45 →	32	34	27	46	24	51	50				
								Residence Deaths + Hospital Transfers Residence + Transfer + Untransferred Hospital Deaths →							33	34	28	46	25	51	50				

12984 MR. TODD: I move to strike them out for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. Please exlpain these charts?

MR. TODD: Objected to for the reasons stated in my previous objection.

A. The residence at the time of death of each decedent is recorded in the first seven columns following the column giving the month when the death occurred in a residence. The total deaths thus occurring in the residence in each of the seven sanitary districts are given at the foot of each column. Following this are seven more columns in which the deaths occurring in hospitals are recorded. It will be seen that a large number of the hospitals being in the third district, that number is rather higher than any of the others. At the foot of these columns will be found the total number of deaths occurring in the respective district.

A second addition is made in the line below this in which the deaths in residences in the seven sanitary districts are added to the deaths in hospitals. This tabulation gives the actual number dieing in each of the seven sanitary districts from typhoid fever. 12985

Following these are eight more columns, the first seven representing the seven sanitary districts, and the eighth a column in which the cases from out of the city are recorded. Each square in these columns is divided by a diagonal line, and in these columns are recorded above the line the residence addresses of the patients who died in the hospitals, when such residence address is given on the mortuary records. Below this diagonal line in the same square are given the number of deaths in hospitals in that district where no residence address is given, and it was found necessary to use the district in which the hospital is located.

The first footing of these columns, the total number occurring in that district, transferred to that district from the hospital, is given above the diagonal line, while the total number of those where no residence address could be obtained and the sanitary district in which the hospital was situated was used, is recorded below the diagonal line.

In the second footing I have added to those deaths which

could be transferred to their proper residence, the total deaths in residences in the seven sanitary districts, so that the
12986 total number of typhoid fever deaths where the place of residence is known are here recorded.

In the third or last footing to these columns of the tables have been added those deaths which are recorded under the hospital district where death occurred, and which could not be transferred to a residence address.

In the three columns following, the last three on the sheet, are given first, the total deaths in the hospitals by months, with a footing at the bottom to indicate the total hospital deaths in the year. In the second column the number of these in which the record bore the note "no residence" or "no home," and in the third the total number of these hospital deaths where the residence was not given.

MR. TODD: Move to strike out the answer for the same reason heretofore given.

MR. JEFFRIES: Q. Now each of these charts which you have just described refer to each one of the various years referred to, commencing with 1896 down to 1903, inclusive?

MR. TODD: Objected to for the same reasons heretofore stated.

12987 A. Yes, sir.

MR. TODD: Move to strike out the answer for the same reasons stated in my objection to the question.

MR. JEFFRIES: Q. Mr. Lochridge, state in a general way what these tables which you have just read in evidence show?

MR. TODD: Object to the question for the reasons heretofore stated.

A. These charts show, first, that there were forty typhoid deaths in the hospitals of St. Louis during 1896, of which it was not possible to transfer the deaths to the proper residence district of the deceased in 21 cases. In 1897, 20 of the 35 hospital deaths from typhoid fever could not be referred. In 1898, 16 of the 26 could not be referred to their proper residence. In 1899, 11 of the 21 could not be thus referred, while in 1900 but 4 of the 36; 7 of the 55 in 1901; 6 of the 67 in 1902 and 3 of the 75 in 1903 could not be referred back to their residence districts.

These charts show, second, the distribution of the typhoid fever deaths in the city. If a local epidemic of typhoid 12988 fever should break out, in one part of the city, it could be noted in the months of the year of its occurrence.

Since the year 1900 the distribution throughout the seven sanitary districts has been very uniform when we consider the deaths occurring in hospitals, but referred back to their residence district. There is no district in which there was an unusual number of deaths when compared with other districts since 1900.

These charts also show the increase in the number of deaths in the hospitals and the increase in each district in each year.

MR. TODD: I move to strike out the answer for the reasons stated in my objection to the question, and also that the whole matter of districts was gone into by Professor Sedgwick in his examination in chief.

MR. JEFFRIES: Q. What do these tables that you have prepared show with reference to the distribution of typhoid deaths in St. Louis in the various districts since and including the year 1900 throughout the city?

MR. TODD: Same objection as to previous question.

A. The distribution of the typhoid deaths in the va- 12989 rious districts has been quite uniform since that time, such as might be expected if the cause for the typhoid were one which would be equally applicable to all of the citizens of the city in the way that pollution by water is applicable.

MR. TODD: Move to strike out the answer for the reasons heretofore stated.

MR. JEFFRIES: Q. Have you prepared similar charts showing the deaths from malarial fevers in St. Louis, by districts?

A. I have.

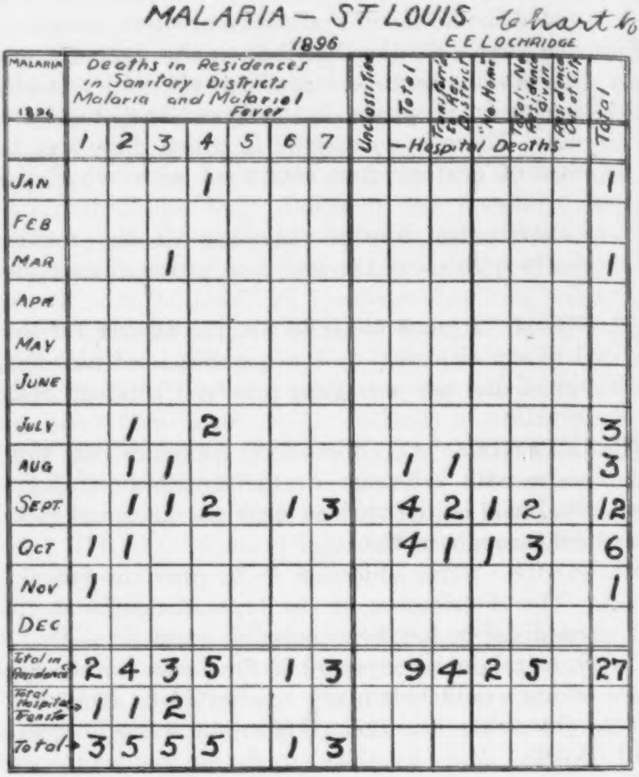
MR. TODD: I make the same objection as to previous question, and move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. Will you produce those charts and read them into the record?

MR. TODD: Same objection as to previous question.

A. I will; they are as follows:

12990 Chart No. 23.



MALARIA — ST LOUIS Chart No.

1896 E E LOCHRIDGE

MALARIA 1896	Deaths in Residences in Sanitary Districts Malaria and Malarial Fever							Unclassified	Total	Transferred to Res. District	"No Home"	Total: No Residence Given	Residence Out of City	Total
	1	2	3	4	5	6	7		— Hospital Deaths —					
JAN				1										1
FEB														
MAR			1											1
APR														
MAY														
JUNE														
JULY		1		2										3
AUG		1	1						1	1				3
SEPT		1	1	2		1	3		4	2	1	2		12
OCT	1	1							4	1	1	3		6
NOV	1													1
DEC														
Total in Residences →	2	4	3	5		1	3		9	4	2	5		27
Total Hospital Transfer →	1	1	2											
Total →	3	5	5	5		1	3							

12991

Chart No. 24.

MALARIA — ST. LOUIS.

1897. E. E. LOCHRIDGE.

MALARIA 1897	Deaths in Residences in Sanitary Districts Malaria and Malarial Fever							Unclassified	Deaths in Hospitals	Total Transferred to Districts	"No Home"	Total - No Residence Given	Total out of City	TOTAL
	1	2	3	4	5	6	7		Hospital Deaths					TOTAL
JAN.			1											1
FEB									1	1				1
MAR						1	1							2
APR							2							2
MAY														
JUNE				1			1							2
JULY														
AUG			1						2	2				3
SEPT			1	2					7	5	1	2		10
OCT	2		2	4					3	2		1		11
NOV						2								2
DEC														
Total in Residences	2		5	7		3	4		13	10	1	3		34
Total Hospital Transfers	2		3	2	1	1	1							
Total	4		8	9	1	4	5							

12992

Chart No. 25.

MALARIA — ST. LOUIS

1898. E. E. LOCHRIDGE.

MALARI 1898	Deaths in Residences in Sanitary Districts Malaria and Malarial Fever							Unclassified	Deaths in Hospitals	Total Transferred to Residence	"No Home"	Total—No Residence Given	Transferred Out of City	TOTAL
	1	2	3	4	5	6	7			— Hospital Deaths —				
JAN														
FEB			1			2			1	1				4
MAR	1			2										3
APR						1								1
MAY				1										1
JUNE														
JULY					1		1							2
AUG			2						1	1				3
SEPT		1		1					2	1		1		4
OCT		1							1	1				2
NOV	2			1										3
DEC														
Total in Residences	3	2	3	5	1	3	1		5	4		1		23
Total Hospital Transfer			2	1			1							
Total —	3	2	5	6	1	3	2							

12993

2993

Chart No. 26.

MALARIA — ST. LOUIS.

1898, E. E. LOCHRIDGE.

MALARIA 1899	Deaths in Residences in Sanitary Districts Malaria and Malarial Fever							Unclassified	Total	Total Transferred to Districts	"No home"	Total: No Residence Given	To Out of City	TOTAL
	1	2	3	4	5	6	7		—Hospital Deaths—					
JAN														
FEB														
MAR														
APR														
MAY	1	1		1	1									4
JUNE					1									1
JULY				1		1								2
AUG		1	1			1			8	6	1	2		11
SEPT	1	1		1		1	1		5	4		1		10
OCT					1		2		2	1		1		5
NOV	1		1											2
DEC														
Total in Residence	3	3	2	3	3	3	3		15	11	1	4		35
Total Hospital Transfer		2	5	1			3							
Total -	3	5	7	4	3	3	6							

12994

Chart No. 27.

MALARIA – ST. LOUIS.

1900. E. E. LOCHRIDGE.

MALARIA 1900	Deaths in Residences in Sanitary Districts Malaria and Malarial Fever							Unclassified	Total	Transferr'd to Residence District	No home	Total- No Residence Given	Residence Out of City	TOTAL
	1	2	3	4	5	6	7		–Hospital Deaths–					
JAN							1							1
FEB		1							1	1				2
MAR	2					1			2	2				5
APR	1	1	1						1		1	1		4
MAY	1						3							4
JUNE		1	1				2							4
JULY							1							1
AUG		1		1	1	1	1							5
SEPT	1	1			1	1		1	3	1		1	1	8
OCT			1				1		2	2				4
NOV		1												1
DEC		1												1
Total in Residence	5	7	3	1	2	3	9	1	9	6	1	2	1	40
Total Hospital Transfer	2	1	3											
Total –	7	8	6	1	2	3	9							

12995

Chart No. 28.

MALARIA — ST. LOUIS.

1801

E. E. LOCHRIDGE.

MALARIA 1901	Deaths in Residences in Sanitary Districts Malaria and Malarial Fever							Unclassified	Total	Transferred to Res. District	No home	Total - No Residence Given	Residence Out of City	TOTAL
	1	2	3	4	5	6	7		—Hospital Deaths—					
JAN									1				1	1
FEB														
MAR							1	1	1	1				3
APR	2					1			1				1	4
MAY														
JUNE		1		1					1				1	3
JULY				2		2			1				1	5
AUG									1	1				1
SEPT							1		1				1	2
OCT				2	1		1		1				1	5
NOV		2												2
DEC									2				2	2
Total in Residences →	2	3		5	1	3	3	1	10	2			8	28
Total Hospital Transfer →		2												
Total →	2	5		5	1	3	3							

12996

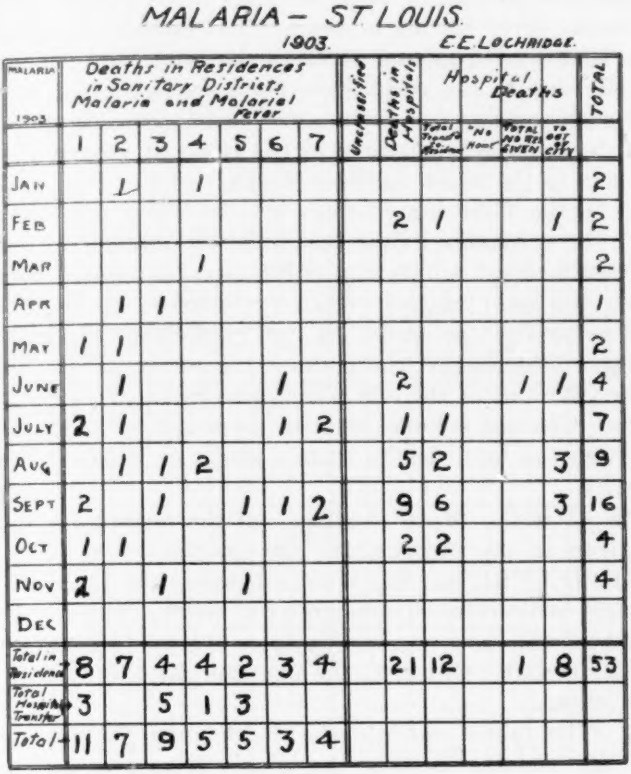
Chart No. 29.

MALARIA – ST LOUIS

1902. E.E. LOCHRIDGE.

MALARIA 1902	Deaths in Residences in Sanitary Districts Malaria and Malarial Fever							Unclassified	Total	Transf'd to Residence District	"No Home"	Total no Residence Given	Residence out of City	TOTAL
	1	2	3	4	5	6	7		–Hospital Deaths–					
JAN	1				1									2
FEB														
MAR		1							1				1	2
APR		2		1		1								4
MAY	1				1									2
JUNE			1						1				1	2
JULY					1				3	1		1	1	4
AUG			2			1	1		3	2			1	7
SEPT		1	1	1					2			1	1	5
OCT		1	1	1					5	3			2	8
NOV		1							1	1				2
DEC														
Total in Residences →	2	6	5	3	3	2	1		16	7		2	7	38
Total Hospital Transfers →			4	1	1	1								
Total →	2	6	9	4	4	3	1							

12997 Chart No. 30.



MALARIA — ST LOUIS

1903. E.E. LOCHRIDGE.

MALARIA 1903	Deaths in Residences in Sanitary Districts Malaria and Malarial Fever							Unclassified	Deaths in Hospitals	Hospital Deaths				TOTAL
	1	2	3	4	5	6	7			Total Transfd to Residence	"No Home"	TOTAL NO RES GIVEN	TO OUT OF CITY	
JAN		1		1										2
FEB									2	1			1	2
MAR				1										2
APR		1	1											1
MAY	1	1												2
JUNE		1				1			2			1	1	4
JULY	2	1				1	2		1	1				7
AUG		1	1	2					5	2			3	9
SEPT	2		1		1	1	2		9	6			3	16
OCT	1	1							2	2				4
NOV	2		1		1									4
DEC														
Total in Residence →	8	7	4	4	2	3	4		21	12		1	8	53
Total Hospital Transfer →	3		5	1	3									
Total →	11	7	9	5	5	3	4							

12989 MR. TODD: I move to strike them out for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. Please explain these charts or tables that you have just read into evidence?

MR. TODD: Object to the question for the reasons heretofore stated.

A. The tables headed "Malaria, St. Louis," one table for each of the years from 1896 to 1903, inclusive, have in the first column the month of the year, in the next seven columns the deaths occurring in residences in the seven sanitary districts of the city caused by malaria or malarial fever as found by me in the records in the mortuary office.

The first footing to these columns gives the total number of malarial fever deaths in the residences in the city by districts. The second footing contains the total number of deaths referred back to the residences, from the deaths in hospitals where such residence is given. The third gives the total number of deaths which can be referred back, or occurring in the residences in the seven sanitary districts of the city.

12999 In the following columns will be found the total number of deaths in the hospitals, the number of these in each month which can be referred back to the residence district, the total number which are marked on the hospital record as having "no home" or "no residence," the total number of hospital deaths where the residence is given, and the number from out of the city which occurred in the hospitals in the city. The last column contains the totals by months and at the bottom the total deaths from malaria or malarial fever by the year.

MR. TODD: Move to strike out the answer for the reasons given in my objection to the question.

MR. JEFFRIES: Q. What conclusions do you draw from the tables with reference to malarial deaths which you have just described?

MR. TODD: Object to the question for the reasons heretofore stated.

A. The tables indicate the distribution during the year in the city and the increase in malaria from year to year between the years 1896 and 1903, which show that the distribution in these districts is not as uniform in the city as is the case of deaths from typhoid fever.

MR. TODD: Move to strike out the answer for the reasons stated in my objection to the question.

13000 MR. JEFFRIES: Q. State whether you have in like manner prepared tables showing the deaths from typho-malaria fever in St. Louis during the past same years?

MR. TODD: Object to the question for the reasons heretofore stated.

A. I have.

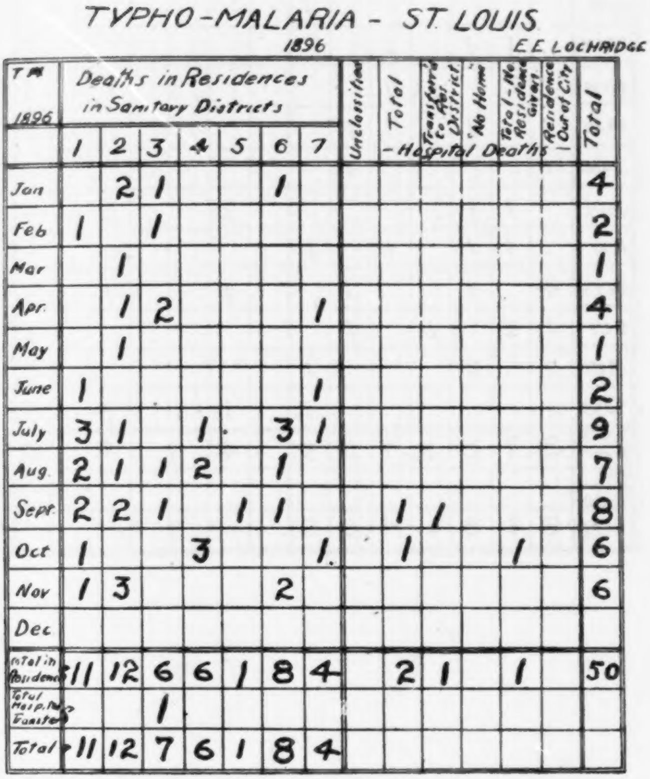
MR. TODD: Move to strike out the answer for the reasons heretofore stated.

MR. JEFFRIES: Q. Will you please present them and read them in evidence?

MR. TODD: Objected to for the reasons heretofore stated.

A. I will; they are as follows:

13001 Chart No. 31.



TYPHO-MALARIA - ST. LOUIS

1896

E.E. LOCHRIDGE

T M 1896	Deaths in Residences in Sanitary Districts							Unclassified	Total	Transferr'd to Per District	"No Home"	Total - No Residence Given	Residence Out of City	Total
	1	2	3	4	5	6	7		- Hospital Deaths					
Jan		2	1			1								4
Feb	1		1											2
Mar		1												1
Apr.		1	2				1							4
May		1												1
June	1						1							2
July	3	1		1		3	1							9
Aug.	2	1	1	2		1								7
Sept.	2	2	1		1	1			1	1				8
Oct	1			3			1.		1			1		6
Nov	1	3				2								6
Dec														
Total in Residence	11	12	6	6	1	8	4		2	1		1		50
Total Hosp. Transfers			1											
Total	11	12	7	6	1	8	4							

13002

Chart No. 32.

TYPHO-MALARIA – ST. LOUIS

1897

E. E. LOCHRIDGE.

T. M 1897	Deaths in Residences in Sanitary Districts							Unclassified	Total Deaths in Hospitals	Hospital Deaths Traced to Res.	"No home"	No Res. given Hospital [illegible]	Hospital Deaths Referred to Out of City	TOTAL
	1	2	3	4	5	6	7							
JAN			1			1								2
FEB							1							1
MAR		1	1		1									3
APR		2			1									3
MAY			1		1	1								3
JUNE	1					1								2
JULY		1	1						2			2		4
AUG		1	1		1		1							4
SEPT	4		1			1			1			1		7
OCT	1	2		1		1								5
NOV	2		2				1							5
DEC							2		1			1		3
Total in Residences	8	7	8	1	4	5	5		4			4		42
Total Hospital Transfers														
Total	8	7	8	1	4	5	5							

13003

Chart No. 33.

TYPHO-MALARIA – ST. LOUIS.

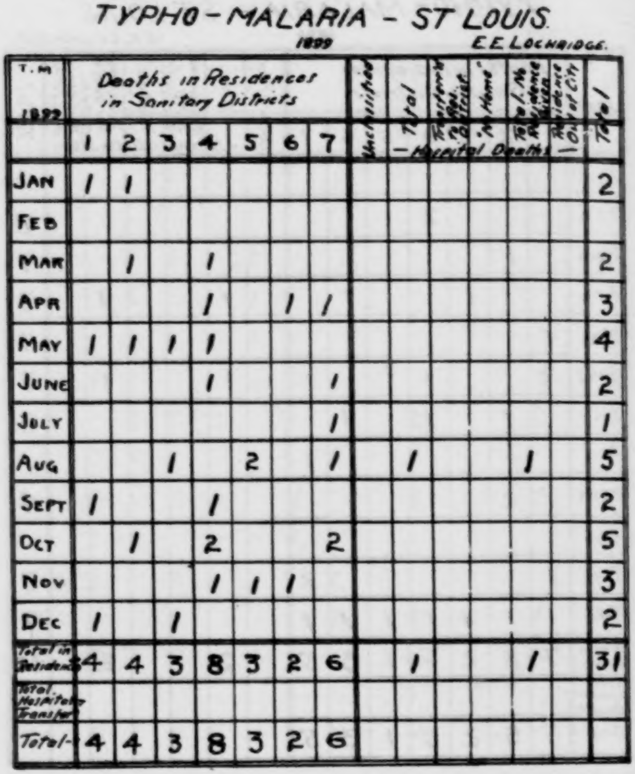
1898

E. E. LOCHRIDGE.

1898	Deaths in Residences in Sanitary Districts							Unclassified	Total	Transferred to Res. Districts	"No Home"	Total No Residence Given	Residence Out of City	Total
	1	2	3	4	5	6	7		– Hospitals Deaths –					
JAN														
FEB				2										2
MAR		1												1
APR			1			1			1			1		3
MAY	1													1
JUNE	2			1			1		1			1		5
JULY		1		1		1								3
AUG							1							1
SEPT	2	2												4
OCT														
NOV	1						2							3
DEC	1	1	1	1	1	1	1							7
Total in Residence →	7	5	2	5	1	3	5		2			2		30
Total Hospital & Transfer														
Total →	7	5	2	5	1	3	5							

13004

Chart No. 34.



TYPHO - MALARIA - ST LOUIS.

1899

E.E. LOCHRIDGE.

T. M. 1899	Deaths in Residences in Sanitary Districts							Unclassified	Total —	Transferred to Hospital	"At Home"	Total I. M. Residence Within	Residence Out of City	Total
	1	2	3	4	5	6	7		— Hospital Deaths —					
JAN	1	1												2
FEB														
MAR		1		1										2
APR				1		1	1							3
MAY	1	1	1	1										4
JUNE				1			1							2
JULY							1							1
AUG			1		2		1		1			1		5
SEPT	1			1										2
OCT		1		2			2							5
NOV				1	1	1								3
DEC	1		1											2
Total in Residences	4	4	3	8	3	2	6		1			1		31
Total Hospital Transfer														
Total-	4	4	3	8	3	2	6							

13005

Chart No. 35.

TYPHO-MALARIA – ST. LOUIS.

1900

E. E. LOCHRIDGE.

T M 1900	Deaths in Residences in Sanitary Districts.							Unclassified	Total	Transferred to Res. District	"No Home"	Total, No Residence Given	Residence Out of City	Total
	1	2	3	4	5	6	7		— Hospital		Deaths		—	
JAN	1					2								3
FEB							1							1
MAR	1			1			2							4
APR		1		1			1							3
MAY				1		1	1							3
JUNE	1				2									3
JULY	1	1				1								3
AUG	1	1	1	1										4
SEPT			1	1	1		1		2	1		1		6
OCT									1	1				1
NOV	1				1									2
DEC					1		1		1	1				3
Total in Residences →	6	3	2	5	5	4	7		4	3		1		36
Total Hospital Transfer →	1				1		1							
Total →	7	3	2	5	6	4	8							

13006

Chart No. 36.

TYPHO-MALARIA - ST. LOUIS.

1901

E. E. LOCHRIDGE.

T M 1901	Deaths in Residences in Sanitary Districts.							Unclassified	Total	Transferred to Res. District	"No Home"	Total. No Residence Given	Residence Out of City	Total
	1	2	3	4	5	6	7		-Hospital Deaths-					
JAN	1					1								2
FEB														
MAR														
APR		1		1			1							3
MAY				1	1									2
JUNE	1								2	2				3
JULY		1		1										2
AUG				1										1
SEPT			1			2			1	1				4
OCT		1		1		1			1	1				4
NOV		1	1											2
DEC														
Total in Residences →	2	4	2	5	1	4	1		4	4				23
Total Hospital Transfer →	1	2		1										
Total →	3	6	2	6	1	4	1							

13007

Chart No. 37.

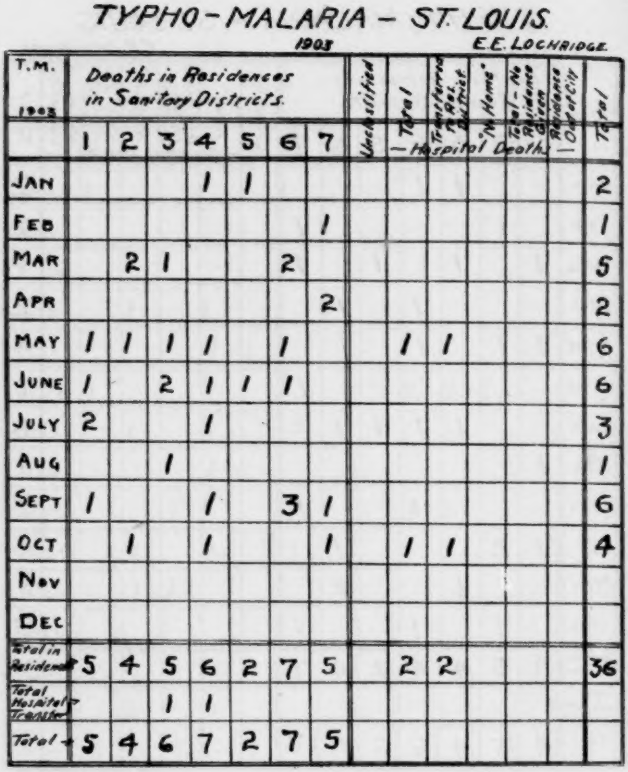
TYPHO-MALARIA – ST. LOUIS.

1902

E. E. LOCHRIDGE.

T M 1902	Deaths in Residences in Sanitary Districts							Unclassified	Total	Transferred to Hos. District	"No Home"	Total. No Residence Given	Residence Out of City	Total
	1	2	3	4	5	6	7		—Hospital Deaths—					
JAN			1	1										2
FEB		1					1							2
MAR	1		1		1		1							4
APR				1		1								2
MAY	1	1		1		1								4
JUNE							1							1
JULY			1	1	1	1	2							6
AUG	1													1
SEPT				1			1							2
OCT	1	2				1								4
NOV			1			2								3
DEC		1		1			1							3
Total in Residence	4	5	4	6	2	6	7							34
Total Hospital Transfers														
Total	4	5	4	6	2	6	7							

13008 Chart No. 38.



TYPHO-MALARIA – ST. LOUIS.

1903

E.E. LOCHRIDGE.

T.M. 1903	Deaths in Residences in Sanitary Districts.							Unclassified	— Hospital Deaths —					Total
	1	2	3	4	5	6	7		Total	Transferred to Res. District	"No Home"	Total – No Residence Given	Residence Out of City	
JAN				1	1									2
FEB							1							1
MAR		2	1			2								5
APR							2							2
MAY	1	1	1	1		1			1	1				6
JUNE	1		2	1	1	1								6
JULY	2			1										3
AUG			1											1
SEPT	1			1		3	1							6
OCT		1		1			1		1	1				4
NOV														
DEC														
Total in Residences →	5	4	5	6	2	7	5		2	2				36
Total Hospital Transfer →			1	1										
Total →	5	4	6	7	2	7	5							

13009 MR. TODD: Move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. Please describe them?

MR. TODD: Objected to for the reasons heretofore stated.

A. The construction of the chart is exactly similar to that just described for the charts headed "Malaria, St. Louis."

MR. TODD: Move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. State what these tables show, if anything?

MR. TODD: Object to the question for the reasons heretofore stated.

A. These tables show the total number of typho-malaria deaths in each of the seven sanitary districts for each month for the eight years mentioned, each year being on a separate chart. The distribution is here, as in the case of the malaria, less uniform than the distribution of the typhoid fever deaths.

MR. TODD: Move to strike out the answer for the reasons heretofore stated in my objection to the question.

13010 MR. JEFFRIES: Q. State whether or not you have prepared charts of the deaths from typhoid fever in the city of St. Louis for the years 1896 to 1903, inclusive, in which the deaths from this cause are tabulated according to age at the time of death and by the month of the year?

MR. TODD: Object to the question for the reasons stated in my objection to the former question.

A. I have.

MR. TODD: Move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. Will you please present these charts, read them in evidence and explain them?

MR. TODD: Objected to for the reasons stated in my objection to the previous question.

A. They are as follows:

Chart No. 39.

TYPHOID FEVER DEATHS — ST. LOUIS.

1896

E.E. LOCHRIDGE

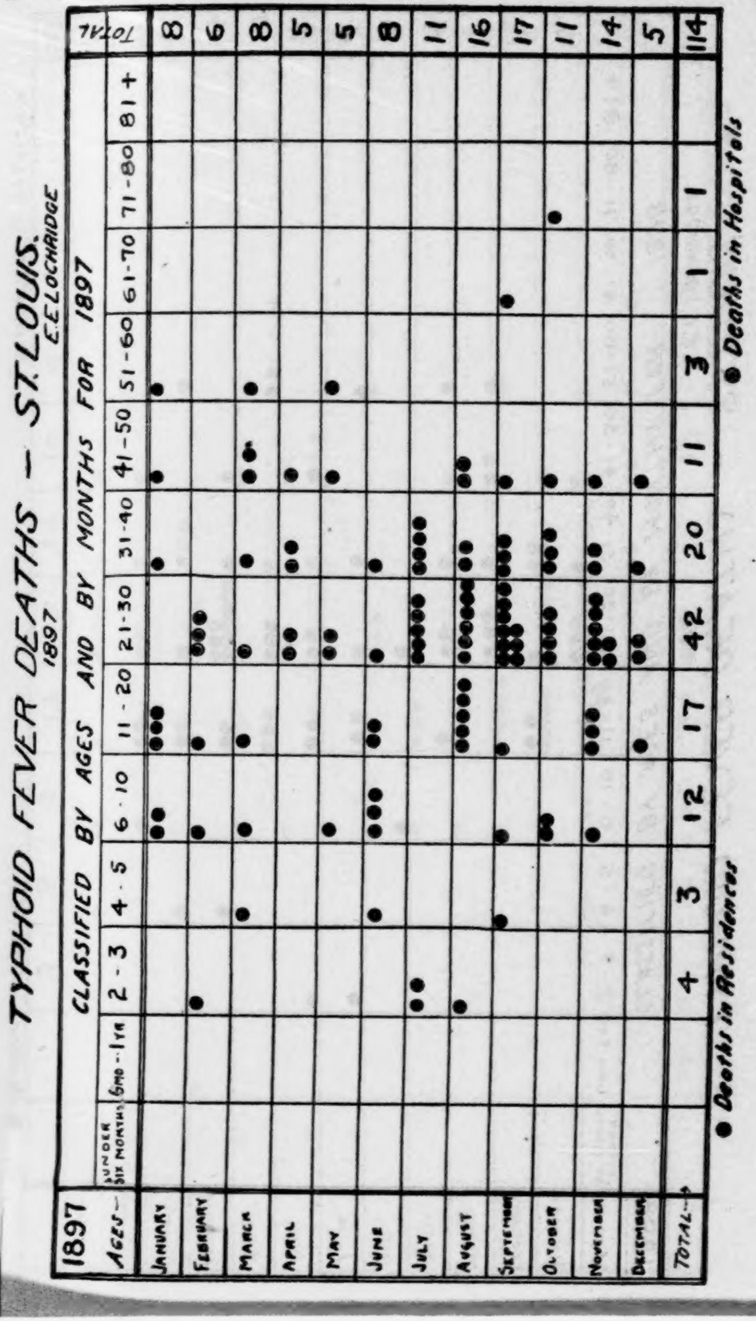
1896	CLASSIFIED BY AGES AND BY MONTHS FOR 1896													TOTAL
AGES–	Under Six Months	6Mo-1Yr	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	80+	
Jan.						●	●◎		●	●				5
Feb.					●	◎								2
Mar.				●		◎			●					3
April			●							●●				3
May		●			●	●	●	●	●	●●				8
June						●●	●●◎				●		●	7
July				●	●	●●●●●	●●●●●	◎	●					14
Aug.					●●●●●	●●	●●●●●●●●	●●●●●●	●●●	●●●●				28
Sept.					●	●	●●●●●	●●	●			●		11
Oct.					●	●●●	●●●	●						8
Nov.						●●	●●●●	●●		●				9
Dec.							●●			●				3
Total –		1	1	2	10	19	33	13	8	11	1	1	1	101

● Deaths in Residences

◎ Deaths in Hospitals.

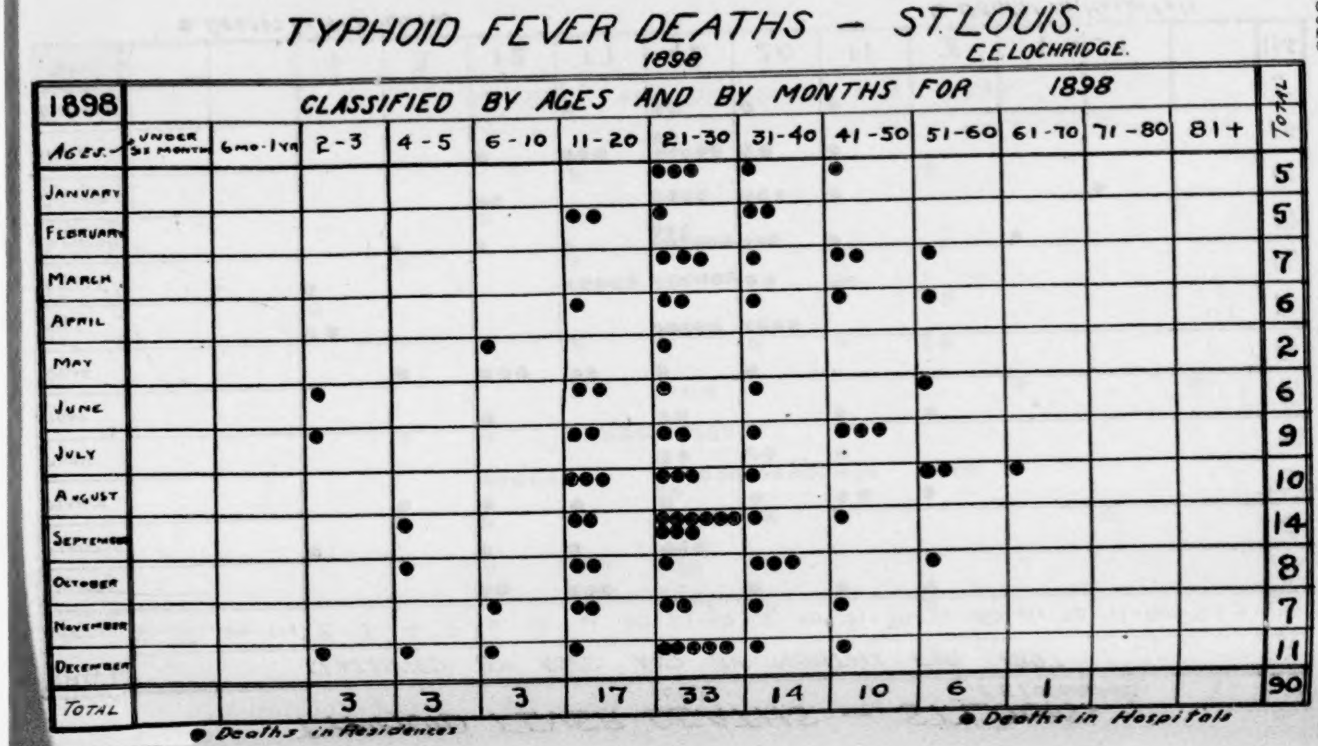
13012

Chart No. 40.



13013

Chart No. 41.



TYPHOID FEVER DEATHS — ST. LOUIS.
1898

E. E. LOCHRIDGE.

CLASSIFIED BY AGES AND BY MONTHS FOR 1898

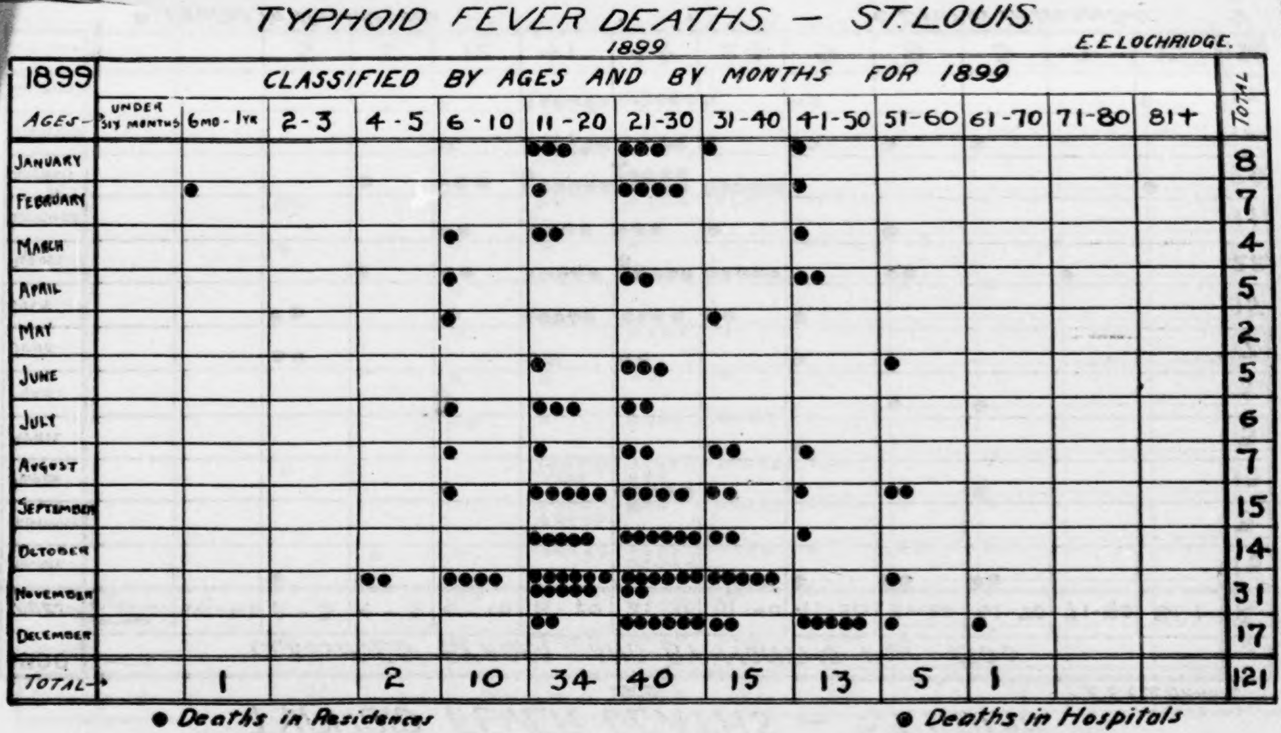
1898 AGES	UNDER 6 MONTHS	6 MO.-1 YR.	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	TOTAL
JANUARY							●●●	●	●					5
FEBRUARY						●●	●	●●						5
MARCH							●●●	●	●●	●				7
APRIL						●	●●	●	●	●				6
MAY					●		●							2
JUNE			●			●●	●	●		●				6
JULY			●			●●	●●	●	●●●					9
AUGUST						●●●	●●●	●		●●	●			10
SEPTEMBER				●		●●	●●●●●●●●●	●	●					14
OCTOBER				●		●●	●	●●●		●				8
NOVEMBER					●	●●	●●	●	●					7
DECEMBER			●	●	●	●	●●●●●	●	●					11
TOTAL			3	3	3	17	33	14	10	6	1			90

● Deaths in Residences

● Deaths in Hospitals

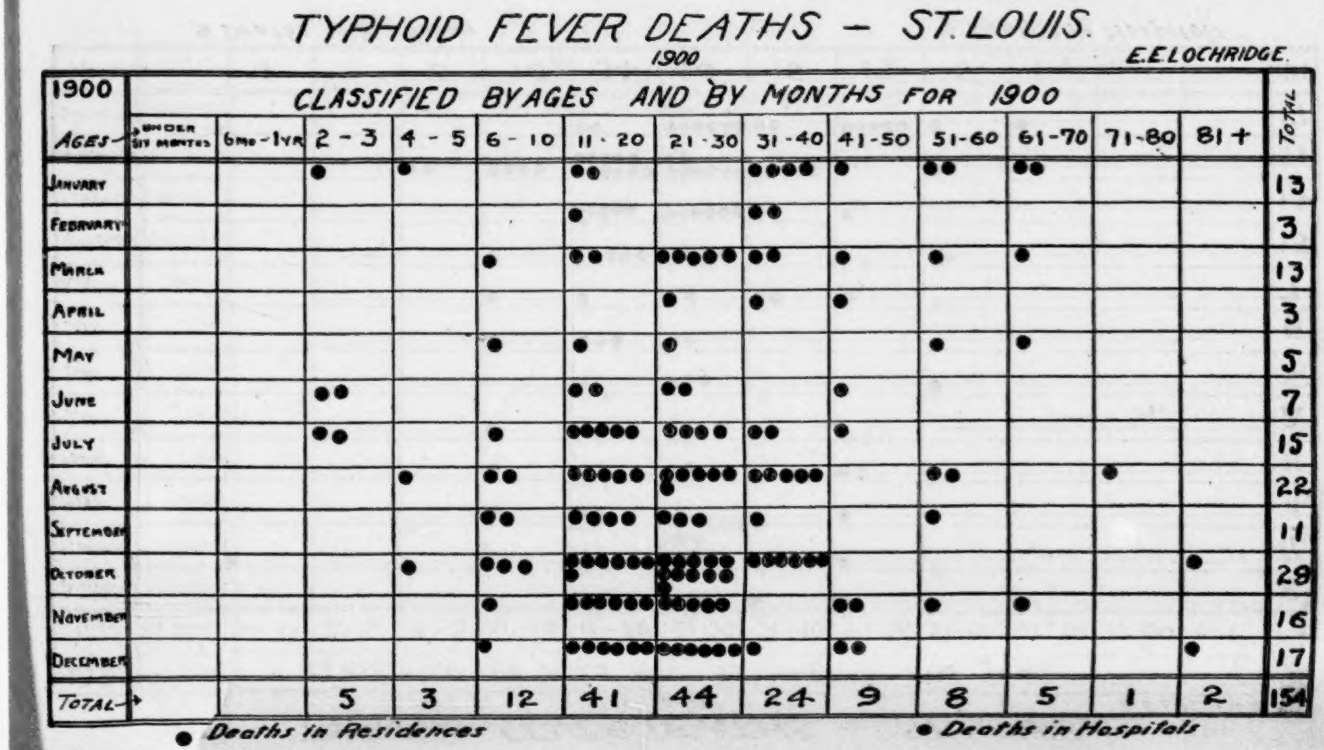
13014

Chart No. 42.



13015

Chart No. 43.



TYPHOID FEVER DEATHS – ST. LOUIS.
1900
E. E. LOCHRIDGE.

1900	CLASSIFIED BY AGES AND BY MONTHS FOR 1900												TOTAL
AGES →	UNDER SIX MONTHS	6mo-1YR	2 - 3	4 - 5	6 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80	81 +	
JANUARY			●	●		●●		●●●●	●	●●	●●			13
FEBRUARY						●		●●						3
MARCH					●	●●	●●●●●	●●	●	●	●			13
APRIL							●	●	●					3
MAY					●	●	●			●	●			5
JUNE			●●			●●	●●		●					7
JULY			●●		●	●●●●●	●●●●	●●	●					15
AUGUST				●	●●	●●●●●	●●●●●●	●●●●●		●●		●		22
SEPTEMBER					●●	●●●●	●●●	●		●				11
OCTOBER				●	●●●	●●●●●●●	●●●●●●●●●●●	●●●●●●					●	29
NOVEMBER					●	●●●●●●	●●●●●		●●	●	●			16
DECEMBER					●	●●●●●●	●●●●●●	●	●●				●	17
TOTAL →			5	3	12	41	44	24	9	8	5	1	2	154

● Deaths in Residences

● Deaths in Hospitals

13016

Chart No. 44.

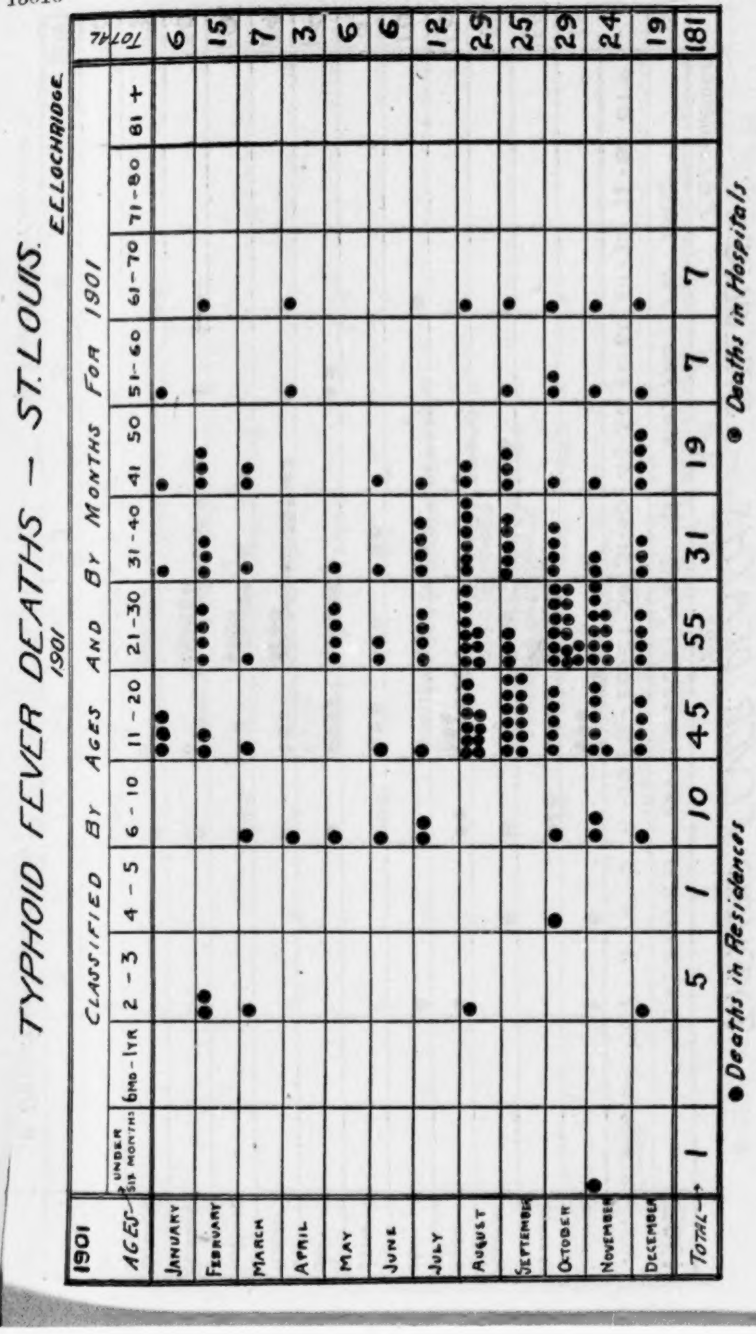
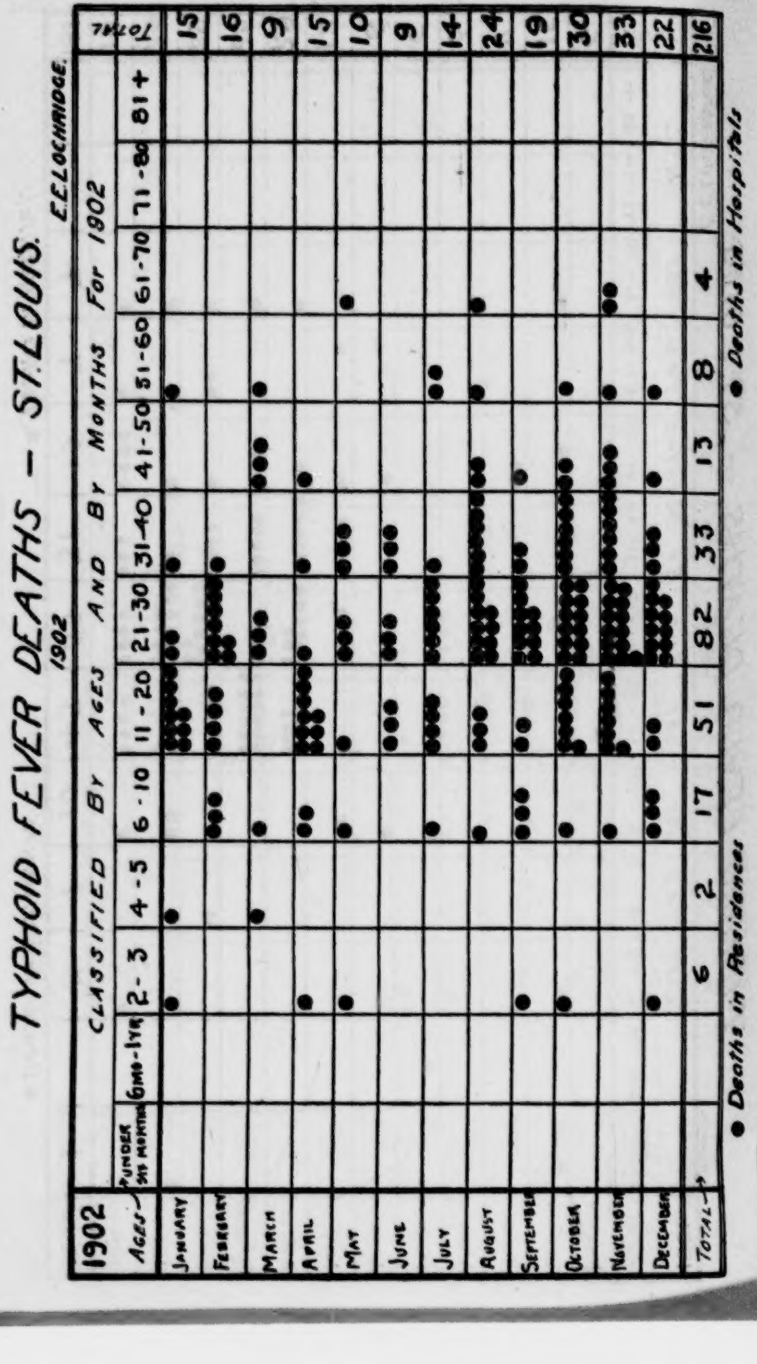
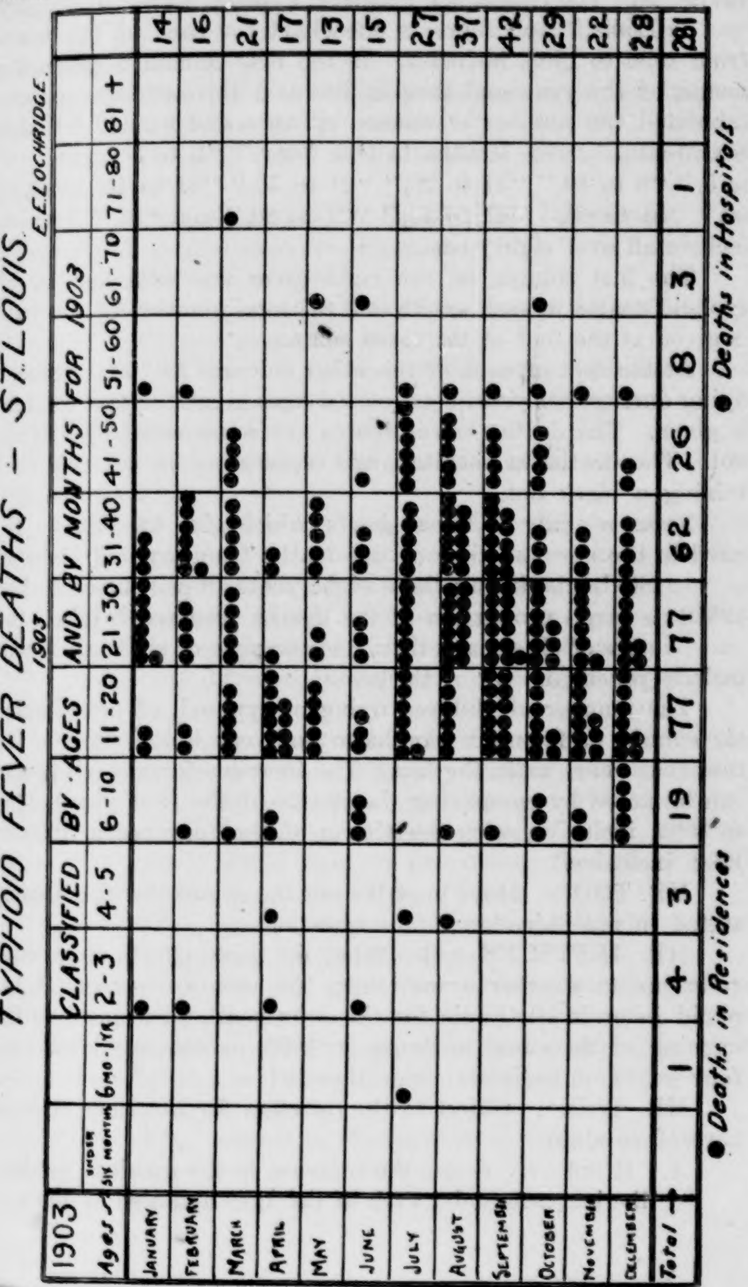


Chart No. 45.


TYPHOID FEVER DEATHS - ST. LOUIS.
1902
E.E. LOCHRIDGE.
CLASSIFIED BY AGES AND BY MONTHS For 1902
1902
AGES
UNDER 6th MONTH
6MO-1YR
2-3
4-5
6-10
11-20
21-30
31-40
41-50
51-60
61-70
71-80
81+
TOTAL
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
TOTAL →
15
16
9
15
10
9
14
24
19
30
33
22
216
6
2
17
51
82
33
13
8
4
● Deaths in Residences
● Deaths in Hospitals

13018

Chart No. 46.



13019 A. The charts are headed "Typhoid Fever Deaths, St. Louis," and there is one chart for each of the years from 1896 to 1903, inclusive. In the first column is given the month of the year and then in the next thirteen columns are tabulated the number of deaths by ages and headed "Under Six Month." "Six Months to One Year," "2 to 3 years," "4 to 5," "6 to 10," "11 to 20," "21 to 30," "31 to 40," "41 to 50," "51 to 60," "61 to 70," "71 to 80," and "81 +" which include all over eighty-one.

The last column on the right gives the total number of typhoid deaths in each month and the total number for the year is given at the foot of the same column.

At the foot of each of the other columns the total number dying during that year, between the ages given for that column, is given. The deaths in residences are represented by a black dot. The deaths in hospitals are represented by a circle containing a black dot.

From a study of these charts, which give the data in regard to the age and time of the deaths from typhoid fever in St. Louis during these eight years, it will be seen that 13020 a large proportion of the deaths occurred between the ages of eleven and fifty, and the ages of six to sixty will include practically all of them.

The number of children dying of typhoid, of those under six months or from six months to one year is the same in the first four years as in the last. The increase for any given age can be noted by comparing the charts of the four years, 1896 to 1899, inclusive, with the charts of the four years, 1900 to 1903, inclusive.

MR. TODD: Move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. What do these charts show with reference to whether or not there has been an increase in typhoid fever in St. Louis for the four years subsequent to the opening of the canal in January, 1900, as compared with the four years immediately prior thereto?

MR. TODD: Object to the question for the same reasons heretofore stated.

A. It not only shows the increase in the number, but also the increase under each of the ages and also by the sea-

13021 son of the year. This may be noted by a comparison of the number of dots for any given month and for any given age.

MR. TODD: Move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. State whether or not an increase is shown?

MR. TODD: Object to the question for the reasons heretofore stated in my previous objections.

A. An increase is shown.

MR. TODD: Move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. State whether or not the particular seasons of the year in which this increase is shown can be observed from the chart?

MR. TODD: Object to the question for the reasons heretofore stated.

A. The increase in any season can readily be seen from this chart, comparing, for example, any of the years since the opening of the canal with any of the years prior to the opening
of the canal. It will be noted that there is a consider-
13022 able increase during the winter months as well as a some-
what less increase, though very marked, in the summer months.

During the early years represented by these charts the number during the months of January to May, and the month of December is quite low, while since the year 1900 there has been a very marked increase of the number of deaths for this six-month period, much more in proportion than during the other six months.

MR. TODD: Move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. Have you prepared similar charts of the deaths in St. Louis from remittent fever during or for the years 1896 to 1903, inclusive, in which the deaths from this cause are tabulated according to ages at the time of death and by the months of the year?

MR. TODD: Object to the question for the reasons heretofore stated.

A. I have.

MR, JEFFRIES: Q. Will you produce such charts, read them in evidence and explain them?

13023 MR. TODD: Objected to for the reasons heretofore stated in my previous objections.

A. The charts are as follows:

13024 Chart No. 47.

REMITTENT FEVER DEATHS.-ST.LOUIS.
1896

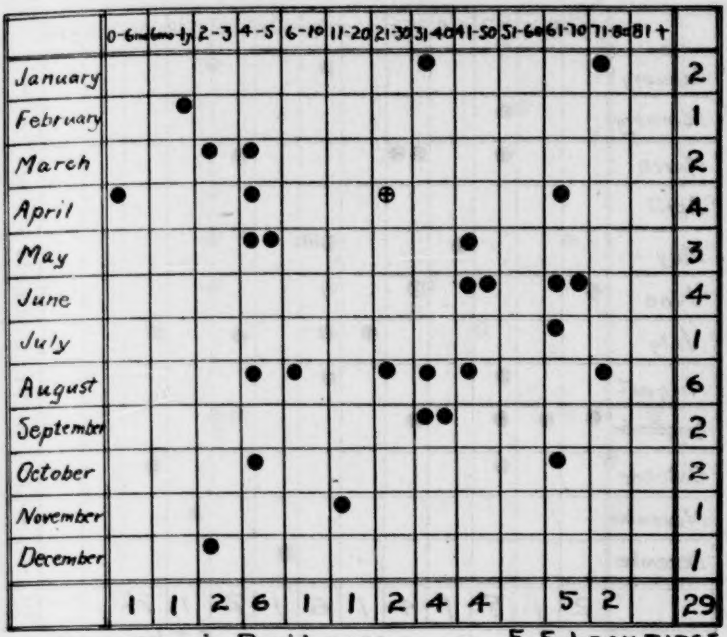
	0-6mo	6mo-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January		●	●			●								3
February									●		●●			3
March								●						1
April	●●		●											3
May	●										●			2
June				●	●									2
July	●							●		●				3
August	●		●	●	●	●●	●●	●		●	●	●		12
September	●	●								●●	●			5
October			●		●							●		3
November								●●						2
December		●												1
Total	6	3	4	2	3	3	2	5	1	4	5	2		40

E.E. LOCHRIDGE.

13025

Chart No. 48.

Remittent Fever Deaths. St. Louis. 1897.



	0-6mo	6mo-1y	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January								●				●		2
February		●												1
March			●	●										2
April	●			●			⊕				●			4
May				●●					●					3
June									●●		●●			4
July											●			1
August				●	●		●	●	●			●		6
September								●●						2
October				●							●			2
November						●								1
December			●											1
	1	1	2	6	1	1	2	4	4		5	2		29

● Deaths in Residences.
◉ " " Hospitals.
⊕ " " M.P. Hospital.

E. E. LOCKRIDGE

13026 Chart No. 49.

Remittent Fever Deaths. St. Louis 1898.

	0-6mo	6mo-1yr	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January							●							1
February			●											1
March			●		●●				●					4
April														
May				●			⊕⊕							3
June	●				◉		◉							3
July						●	●		●		●			4
August			●				●							2
September	●	●	●		●									4
October			●								●			2
November										●				1
December								●						1
	2	1	5	1	4	1	6	1	2	1	2			26

E. E. LOCHRIDGE.

● Deaths in Residences.
● " " Hospitals.
● " " M. P. Hospital.

13027 Chart No. 50.

Remittent Fever Deaths. St. Louis 1899.

	0-6m	6m-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January			●											1
February										⊕				1
March														
April			●											1
May			●		●						●			3
June			●					●						2
July									●					1
August														
September			●● ●								●		●	5
October												●		1
November														
December.														
			7		1			1	1	1	2	1	1	15

● Deaths in Residences
◉ „ „ Hospitals
⊕ „ „ M.P. Hospital.

E.E. LOCHRIDGE.

13028

Chart No. 51.

Remittent Fever Deaths. St Louis 1900.

	0-6m	6m-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January														
February														
March														
April														
May	●	●												2
June							◉				●			2
July	●													1
August							◉				●			2
September		●					●				●	●		4
October														
November			●							●		●		3
December				●										1
	2	2	1	1			3			1	3	2		15

E.E. LOCHRIDGE.

● Deaths in Residences
● " " Hospitals
● " " M.P. Hospital.

13029

Chart No. 52.

Remittent Fever Deaths. St Louis 1901

	6m-	6m-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January			●			●								2
February														
March														
April			●		●									2
May											●			1
June		●		●	●					●				4
July	●	●		●					●		●			5
August							●					●		2
September	●				●									2
October	●							●						2
November			●											1
December					●	●								2
	3	2	3	2	4	2	1	1	1	1	2	1		23

● Deaths in Residences.
● " " Hospitals.
● " " M.P. Hospital.

E.E. LOCHRIDGE.

13030

Chart No. 53.

Remittent Fever Deaths. St. Louis. 1902.

	0-6m	1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January						●								1
February														
March												●		1
April			●											1
May							●							1
June									●					1
July									●●					2
August					●									1
September				●			●		●					3
October			●				●		●		●			4
November														
December							●		●					2
			2	1	1	1	4		6		1	1		17

● Deaths in Residences

● " " Hospitals

● " " M.P. Hospital

E. E. LOCHRIDGE.

13031

Chart No. 54.

Remittent Fever Deaths. St. Louis 1903.

	0-6m	6m-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January														
February														
March.														
April			●	●										2
May	●		●											2
June														
July	●		●				●							3
August			●				●	●				●		4
September												●		1
October					●		●							2
November							●	●						2
December							●							1
	2		4	1	1		5	2				2		17

● Deaths in Residences.
◉ " " Hospitals.
⊕ " " M.P. Hospital.

E. E. LOCHRIDGE

13032 A. These charts were made in the manner described for the charts headed typhoid fever deaths, St. Louis, classified by ages and by months.

It will be noted on several of these charts recording deaths from the various causes that the same black dot is used to represent a death from the cause given under the head of that chart that the dot in the circle represents a hospital death, while on some charts there is also a cross in the circle which represents a death occurring in the Missouri Pacific Hospital. This was marked in this manner for the reason that the Missouri Pacific Hopital has, during the last few years, contained during these years the record of a number of deaths of railroad men brought in from out of the city, or from their yards, and that the terms remittent, intermittent and congestive are used in their records up to about the year 1899 or 1900, and that no malarial deaths are recorded by them prior to this time, while several are recorded from malaria since that time, and the number of remittent and intermittent fever deaths has similarly declined from that hospital.

It will be noted by looking at the chart headed "Remittent Fever Deaths, St. Louis, 1896," that there are six un-
13033 der the first column who were under six months of age;
3 recorded as one year of age or under; 4 more of two or three years of age, or 9 under one year of age, or 13 under three years of age out of a total of 40 deaths occurring in that year.

There are also between the ages of 61 and 70, 5 deaths during this year, and between the ages of 71 and 80, 2 more deaths, or 7 deaths occurring of people above the age of 61 years, 20 of the 40 which do not occur between the ages of 4 and 60.

In the year following there is but one death in the first column of six months or under, and one in the column of one year of age, and but two in the third column of children of two or three years of age, or a decrease in the number of deaths of those one year of age, and under from 9 to 2, and no such corresponding increase occurs in this year in the typhoid tables already submitted.

In all of these tables the variations in the number of deaths from this cause will thus be seen to be in the column of children under three or people above 61 years of age, the numbers during the ages ordinarily considered as typhoid ages and indicated on
the typhoid charts, both before the opening and since
13034 the opening of the canal, as typhoid ages remains about
constant.

These charts also show the seasonal distribution of the remittent fever deaths.

MR. TODD: Move to strike out the answer for the reasons given in my objection to the question.

Adjourned until 8 p. m., Thursday, May 26, 1904.

13035 Room 282 Southern Hotel, St. Louis, Mo.
8:00 p. m., Thursday, May 27, 1904.

Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

E. E. LOCHRIDGE

resumed the stand for further direct examination and testified as follows:

MR. JEFFRIES: Q. Mr. Lochridge, have you prepared charts from the deaths from intermittent fever in the city of St. Louis from 1896 to 1903, inclusive, in which the deaths from this cause are tabulated according to the age at the time of death, and by the month of the year?

MR. TODD: Object to the question for the reasons heretofore stated.

A. I have.

MR. TODD: Move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. Will you please present the charts, read them in evidence and state what they show?

13036 MR. TODD: Object to the question for the reasons heretofore stated.

The charts are as follows:

13037 Chart No. 55.

INTERMITTENT FEVER DEATHS—ST. LOUIS.
1896

	0-6m.	6m-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January														
February									●					1
March								●						1
April														
May				●	●			●						3
June														
July							●							1
August	●										●●			3
September				●						●				2
October							●							1
November														
December														
Total	1			2	1		2	2	1	1	2			12

E. E. LOCHRIDGE.

13038

Chart No. 56.

Intermittent Fever Deaths. St. Louis. 1897.

	0-6m	6m-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January														
February														
March														
April											●			1
May	●		●											2
June	●	●							●		●			4
July	●	●										●		3
August											●			1
September														
October									●					1
November														
December														
	3	2	1						2		3	1		12

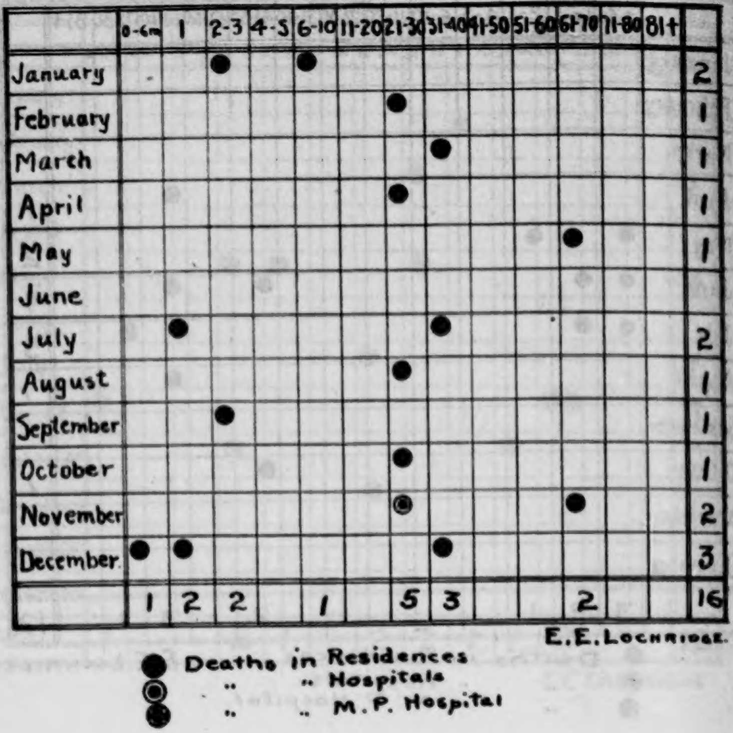
● Deaths in Residences.
◉ " " Hospitals
◍ " " M. P. Hospital.

E. E. Lochridge

13039

Chart No. 57.

Intermittent Fever Deaths. St. Louis. 1898.



	0-6m	1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January			●		●									2
February							●							1
March								●						1
April							●							1
May											●			1
June														
July		●						●						2
August							●							1
September			●											1
October							●							1
November							◉				●			2
December	●	●						●						3
	1	2	2		1		5	3			2			16

E. E. Lochridge.

● Deaths in Residences
◉ " " Hospitals
⊛ " " M. P. Hospital

13040

Chart No. 58.

Intermittent Fever Deaths. St. Louis. 1899.

	0-6m	6m-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January		●												1
February	●		●					⊕				●		4
March														
April					●									1
May														
June					●							●		2
July		●	●					●			●			4
August	●	●	●●		●			●						6
September	●								●					2
October	●	●												2
November	●								⊕					2
December		●												1
	5	5	4		3			3	2		1	2		25

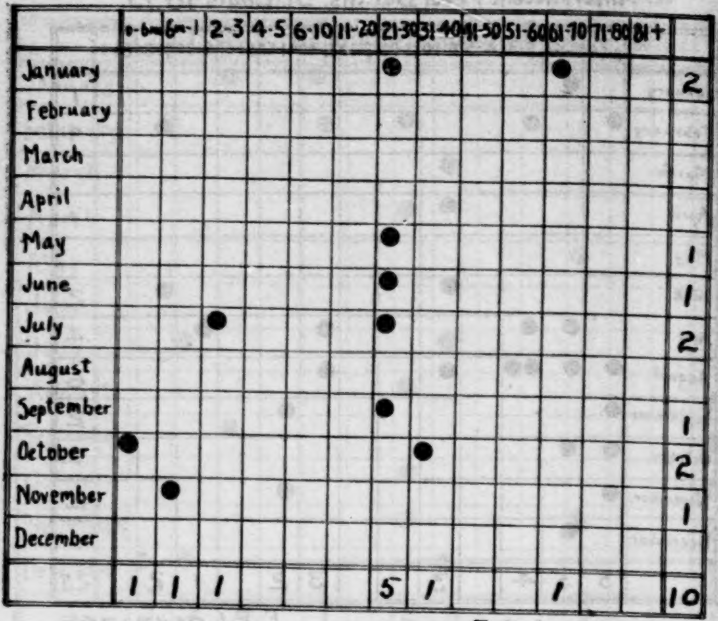
E. E. LOCHRIDGE

● Deaths in Residences.
● " " Hospitals.
● " " M. P. Hospitals.

13041

Chart No. 59.

Intermittent Fever Deaths. St. Louis. 1900.



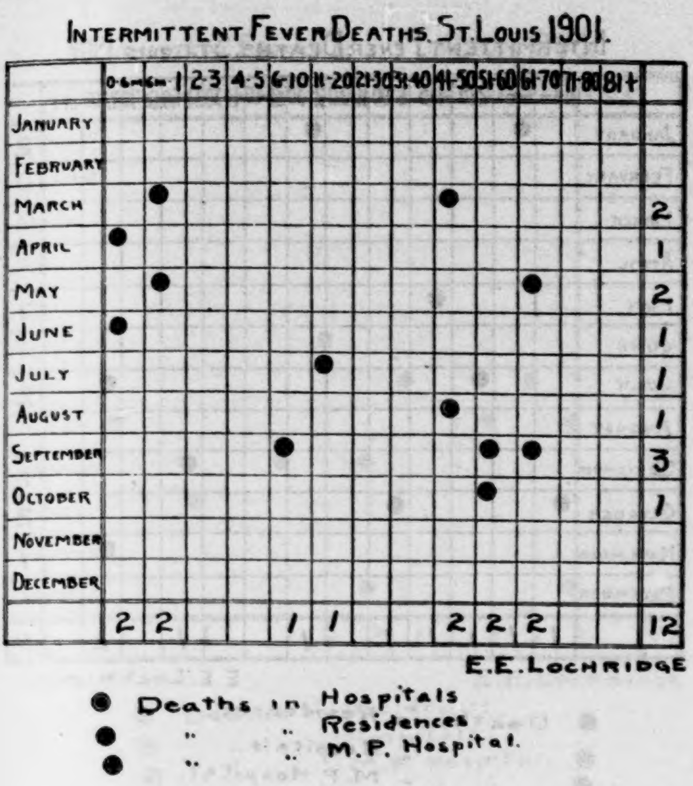
	0-6m	6m-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January							⊕				●			2
February														
March														
April														
May							●							1
June							●							1
July			●				●							2
August														
September							●							1
October	●							●						2
November		●												1
December														
	1	1	1				5	1			1			10

E.E. LOCHRIDGE

● Deaths in Residences.
◉ " " Hospitals.
⊕ " " M.P. Hospital.

13042

Chart No. 60.



INTERMITTENT FEVER DEATHS. ST. LOUIS 1901.

	0-6m	6m-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
JANUARY														
FEBRUARY														
MARCH		●							●					2
APRIL	●													1
MAY		●									●			2
JUNE	●													1
JULY						●								1
AUGUST									●					1
SEPTEMBER					●					●	●			3
OCTOBER										●				1
NOVEMBER														
DECEMBER														
	2	2			1	1			2	2	2			12

E.E. LOCHRIDGE

● Deaths in Hospitals
● " " Residences
● " " M.P. Hospital.

13043

Chart No. 61.

INTERMITTENT FEVER DEATHS. ST. LOUIS. 1902.

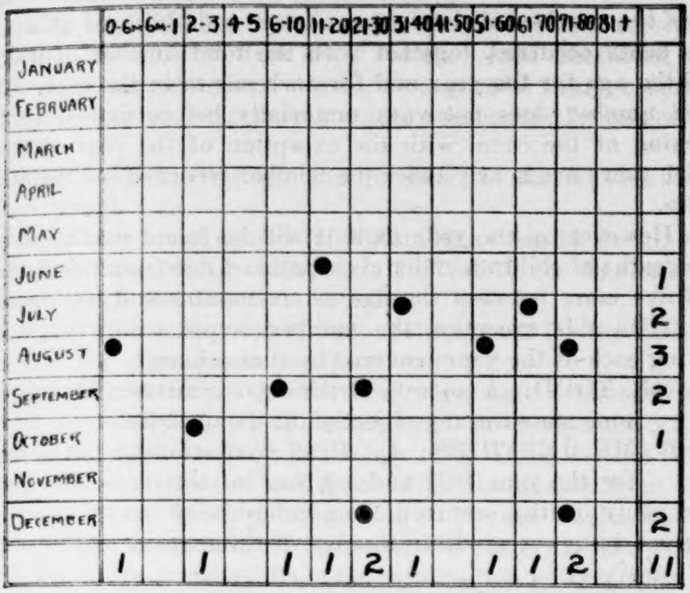
	0-6m	6m-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
JANUARY		●					●							2
FEBRUARY														
MARCH														
APRIL														
MAY				●										1
JUNE														
JULY			●									●		2
AUGUST														
SEPTEMBER										●				1
OCTOBER	●				●									2
NOVEMBER												●		1
DECEMBER														
	1	1	1	1	1		1			1		2		9

E. E. LOCHRIDGE

● Deaths in Residences.
● " " Hospitals.
● " " M. P. Hospital.

13044 Chart No. 62.

INTERMITTENT FEVER DEATHS ST. LOUIS 1903.



	0-6m	6m-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
JANUARY														
FEBRUARY														
MARCH														
APRIL														
MAY														
JUNE						●								1
JULY								●			●			2
AUGUST	●									●		●		3
SEPTEMBER					●		●							2
OCTOBER			●											1
NOVEMBER														
DECEMBER							●					●		2
	1		1		1	1	2	1		1	1	2		11

E.E. LOCHRIDGE

● Deaths in Residences.
● " " Hospitals.
● " " M.P. Hospital.

13045 A. These charts are headed "Intermittent Fever Deaths, St. Louis," and there is one for each year from 1896 to 1903, inclusive. They are prepared in the same way as the charts headed "Typhoid Fever Deaths, St. Louis," and show the number of deaths per month and the ages at which this death occurred, together with the total number of deaths and the age for the year and for each month in the year. The total number does not vary materially before and since the opening of the canal with the exception of the year 1899, in which there are nearly twice the number recorded for the other years.

However, in the year 1899, it will be found that there are five deaths of children under six months of age from this disease and five more between the age of six months and one year.

With this exception the number is practically the same during each of the years covered by these charts.

MR. TODD: I move to strike out the answer for the reasons stated in my objection to the question.

13046 MR. JEFFRIES: Q. I call your attention to the chart for the year 1899 and ask you to state from that chart how many deaths occurred from intermittent fever when the persons dying were within the age of three years and over the age of sixty?

MR. TODD: Objected to for the reasons heretofore stated in my objection to the previous question.

A. There were 17 deaths from intermittent fever in St. Louis in the year 1899, as shown by this chart, of persons either of or below the age of three years and of or above the age of 61. This number subtracted from the total of 25 leaves 8 of the ages when typhoid fever is most prevalent.

MR. TODD: Move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. I will ask you to state from that chart how many deaths occurred from intermittent fever with patients between the ages of 11 and 30 years, at the ages when typhoid is most susceptible?

MR. TODD: Object to the question for the reasons heretofore stated.

A. There was not a single death from intermittent

13047 fever during the year 1899 of a patient between the ages of 11 and 30 years.

MR. TODD: Move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. Examine the tables with reference to deaths from intermittent fever for the years mentioned and state whether or not those deaths, as a general thing, occurred during the winter season or summer season of the respective years?

MR. TODD: Object to the question for the reasons heretofore stated.

A. There are a considerable number of deaths during the summer months, as for example, in 1897 all of the deaths were between April and October, inclusive.

MR. TODD: Move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. Mr. Lochridge, state whether or not you have prepared charts of a similar character upon the deaths from typho-malaria in the city of St. Louis for the years 13048 1896 to 1903, inclusive, in which the deaths from this cause are tabulated according to the age at the time of death and by the months of the year, and state whether or not these charts are prepared from the information gathered by you from the mortuary office of the health department of the city of St. Louis?

MR. TODD: Object to the question for the reasons heretofore stated.

A. I have prepared eight charts, one for each year, for the years 1896 to 1903, inclusive, with the heading "Typho-malarial Deaths, St. Louis," which have been prepared in the same way as the charts headed "Typhoid Fever Deaths, St. Louis."

All of the data for these charts was obtained from the records in the mortuary clerk's office of the department of the board of health in the city of St. Louis.

MR. TODD: Move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. Will you please read these charts in evidence?

MR. TODD: Object to the question for the reasons
13049 heretofore stated.

A. They are as follows:

13050 **Chart No. 63.**

Age and Month of Death

TYPHO MALARIA DEATHS ST. LOUIS 1896

	0-6m	6m-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January					●				●	●	●			4
February				●		●								2
March							●							1
April					●			●●	●					4
May			●											1
June				●									●	2
July				●		●	●	●	●●		●●	●		9
August					●	●	●●●		●		●			7
September	●						●●●	●●		●		●		8
October			●		●				●	●●	●			6
November					●	●●	●		●	●				6
December														
Total	1		2	3	5	5	9	5	7	5	5	2	1	50

● ◉ ⊕ Deaths from Typho-Malarial Fever
◉ Deaths in a Hospital
⊕ " " Missouri Pacific Hospital
● " " Residences

E. E. LOCHRIDGE

13051

Chart No. 64.

TYPHO-MALARIAL DEATHS St. Louis 1897

	0-6mo	6mo-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81 +	
January								●	●					2
February							●							1
March							●	●			●			3
April		●	●					●						3
May				●				●●						3
June						●					●			2
July						●	●●		●					4
August			●				●	●	●					4
September			●			●●	●●●		●					7
October			●	●		●		●	●					5
November							●	●	●●	●				5
December							●	●			●			3
		1	4	2		5	10	9	7	1	3			42

● ◎ ⊕ Deaths from Typho-Malarial Fever

● Deaths in Residences

◎ " " a Hospital

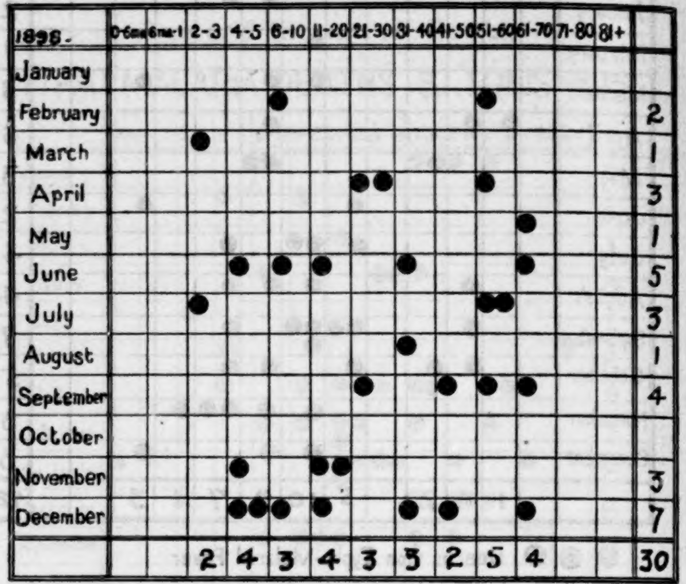
⊕ " " the Missouri Pacific Hospital

E.E. LOCHRIDGE

13052 Chart No. 65.

Age and Month of Death

TYPHO MALARIA DEATHS ST. LOUIS 1898.



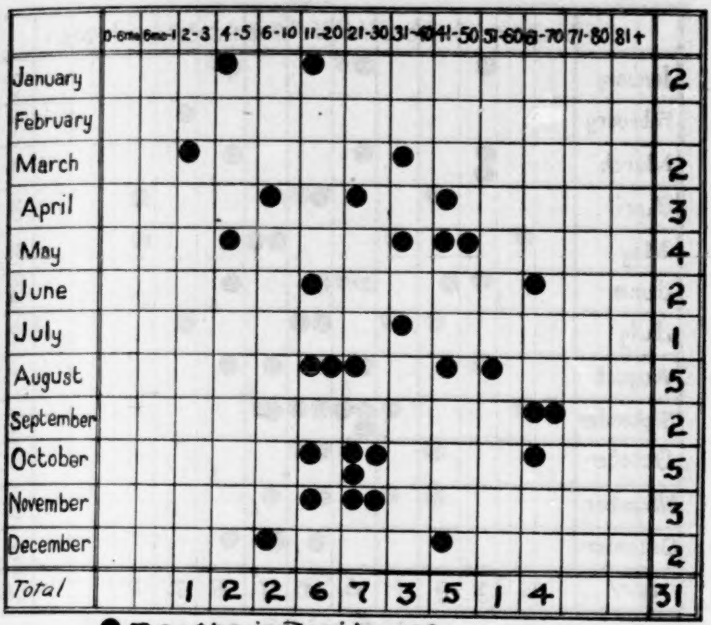
1898.	0-6mo	6mo-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January														
February					●					●				2
March			●											1
April							●●			●				3
May											●			1
June				●	●	●		●			●			5
July			●							●●				3
August								●						1
September							●		●	●	●			4
October														
November				●		●●								3
December				●●	●	●		●	●		●			7
			2	4	3	4	3	3	2	5	4			30

● Deaths in Residences.
● " " Hospitals.

E. E. LOCHRIDGE

13053

Chart No. 66.



Age and Month of Death

TYPHO-MALARIA ST. LOUIS - 1899.

	0-6mo	6mo-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January				●		●								2
February														
March			●					●						2
April					●		●		●					3
May				●				●	●●					4
June						●					●			2
July								●						1
August						●●	●		●	●				5
September											●●			2
October						●	●●●				●			5
November						●	●●							3
December					●				●					2
Total			1	2	2	6	7	3	5	1	4			31

● Deaths in Residences.

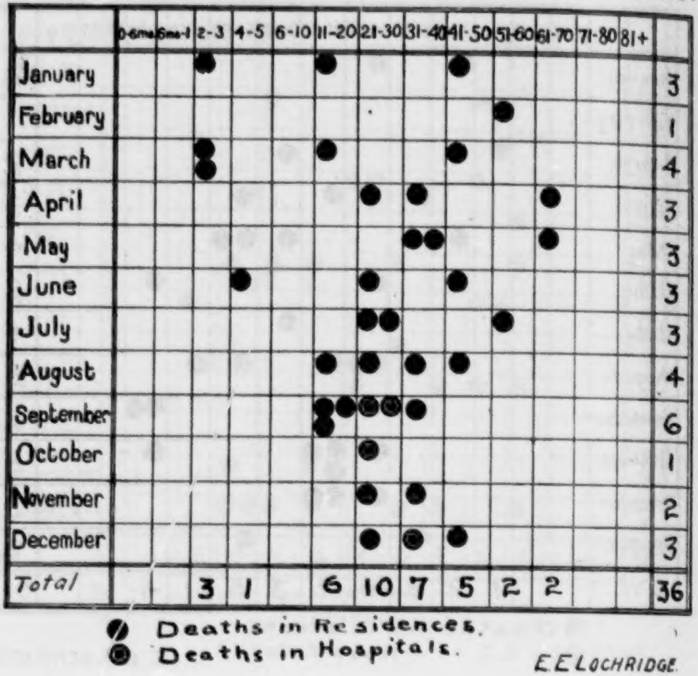
● " " Hospitals.

E. E. LOCHRIDGE.

13054 Chart No. 67.

Age and Month of Death

TYPHO-MALARIA – ST. LOUIS – 1900



	0-6mo	6mo-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January			●			●			●					3
February										●				1
March			●●			●			●					4
April							●	●			●			3
May								●●			●			3
June				●			●		●					3
July							●●			●				3
August						●	●	●	●					4
September						●●●	◉◉	●						6
October							◉							1
November							●	●						2
December							●	◉	●					3
Total			3	1		6	10	7	5	2	2			36

● Deaths in Residences.
◉ Deaths in Hospitals.

E. E. LOCHRIDGE.

13055

Chart No. 68.

Age and Month of Death

TYPHO-MALARIA—ST. LOUIS—1901.

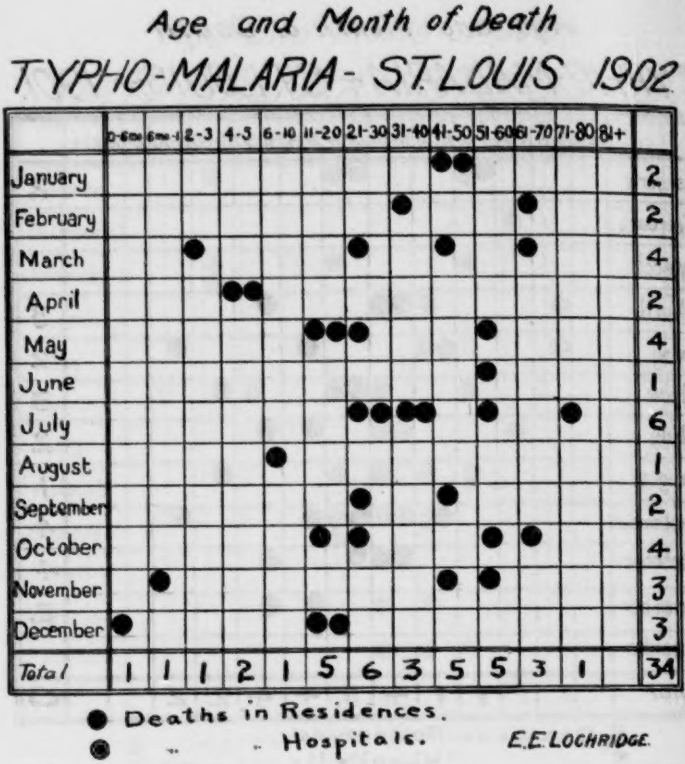
	0-6mo	6mo-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January				●			◉							2
February														
March														
April						●●			●					3
May								●			●			2
June							◉◉			●				3
July								●	●					2
August										●				1
September					●		●	●			◉			4
October						●●	●		◉					4
November								●	●					2
December														
Total				1	1	4	5	4	4	2	2			23

● Deaths in Residences.
◉ " " Hospitals.

E. E. LOCHRIDGE.

13056

Chart No. 69.



Age and Month of Death

TYPHO-MALARIA- ST. LOUIS 1902

	0-6mo	6mo-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January									● ●					2
February								●			●			2
March			●				●		●		●			4
April				● ●										2
May						● ●	●			●				4
June										●				1
July							● ●	● ●		●		●		6
August					●									1
September							●		●					2
October						●	●			●	●			4
November		●							●	●				3
December	●					● ●								3
Total	1	1	1	2	1	5	6	3	5	5	3	1		34

● Deaths in Residences.

◉ " " Hospitals.

E. E. LOCHRIDGE.

13057 Chart No. 70.

Age and Month of Death

TYPHO-MALARIA – ST. LOUIS. – 1903

	0-6mo.	6mo-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
January							●	●						2
February						●								1
March						●●	●	●	●					5
April				●		●								2
May				●			●●●	●●						6
June		●		●	●	●	●				●			6
July								●		●	●			3
August							●							1
September						●	●	●	●	●	●			6
October						●●	●◉							4
November														
December														
Total		1		3	1	8	10	6	2	2	3			36

● Deaths in Residences

◉ " " Hospitals.

E. E. LOCHRIDGE.

Mr. Todd: Move to strike out the answer for the reason
13058 heretofore stated in my objection to the question.

Mr. Jeffries: Q. State whether or not you have prepared similar charts from the evidence so obtained by you from the mortuary office of the city health department of the City of St. Louis, from malarial fevers, for the years 1896 to 1903, inclusive, in which the deaths from this cause are tabulated, according to age at the time of death, and by the months of the year?

Mr. Todd: Objected to for the reasons heretofore stated in my objection to previous questions.

A. I have.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Will you present them and read them in evidence?

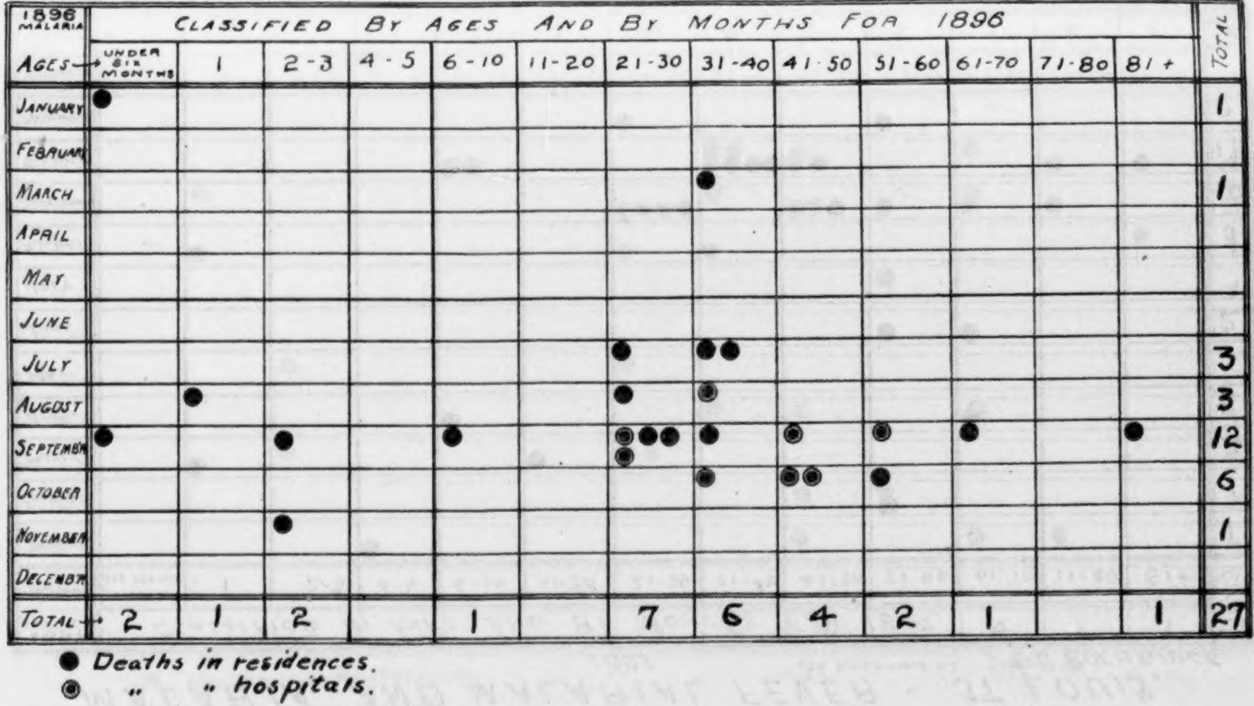
Mr. Todd: Objected to for the reasons heretofore stated in my objections to previous questions.

13059 A. I will; they are as follows:

13060

Chart No. 71.

MALARIA AND MALARIAL FEVER - ST. LOUIS.
1896
E. E. LOCHRIDGE.

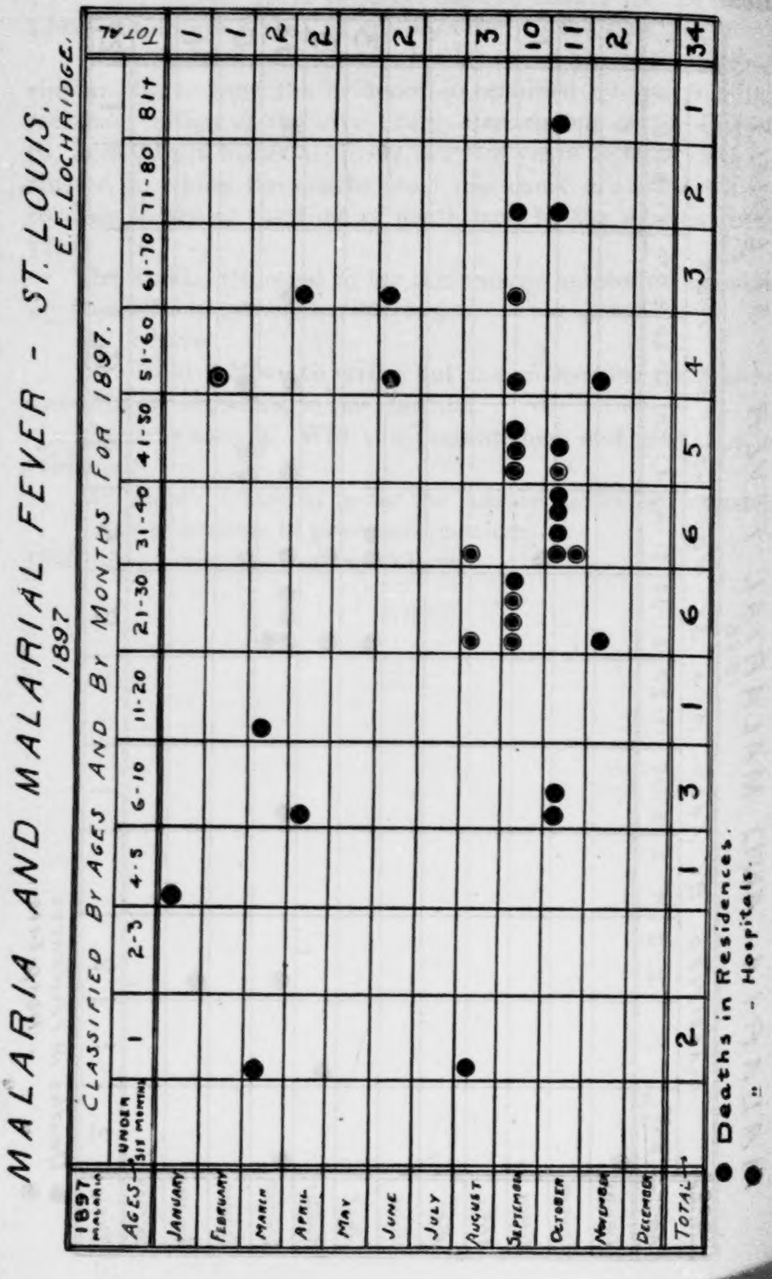


1896 MALARIA	CLASSIFIED BY AGES AND BY MONTHS FOR 1896													TOTAL
AGES →	UNDER SIX MONTHS	1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
JANUARY	●													1
FEBRUARY														
MARCH								●						1
APRIL														
MAY														
JUNE														
JULY							●	●●						3
AUGUST		●					●	◉						3
SEPTEMBER	●		●		●		◉●● ◉	●	◉	◉	●		●	12
OCTOBER								●	◉◉	●				6
NOVEMBER			●											1
DECEMBER														
TOTAL →	2	1	2		1		7	6	4	2	1		1	27

● Deaths in residences.
◉ " " hospitals.

13061

Chart No. 72.



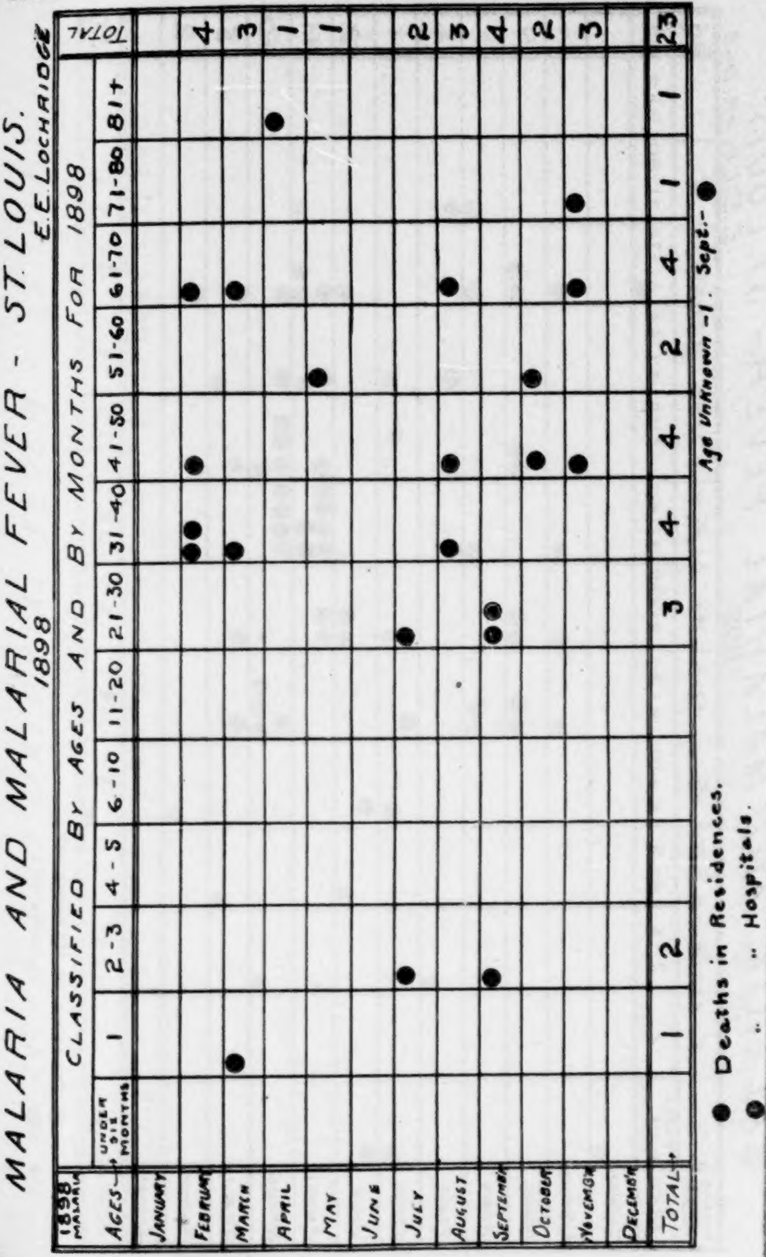
MALARIA AND MALARIAL FEVER - ST. LOUIS.
1897
CLASSIFIED BY AGES AND BY MONTHS FOR 1897.
E.E. LOCHRIDGE.

1897 MALARIA AGES →	UNDER SIX MONTHS	1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	TOTAL
JANUARY				●										1
FEBRUARY										●				1
MARCH		●				●								2
APRIL					●						●			2
MAY														
JUNE										●	●			2
JULY														
AUGUST		●					●	●						3
SEPTEMBER							●●●●		●●●	●	●	●		10
OCTOBER					●●			●●●●●	●●			●	●	11
NOVEMBER							●			●				2
DECEMBER														
TOTAL →		2		1	3	1	6	6	5	4	3	2	1	34

● Deaths in Residences.
● " Hospitals.

13062

Chart No. 73.



MALARIA AND MALARIAL FEVER - ST. LOUIS.
1898
CLASSIFIED BY AGES AND BY MONTHS FOR 1898
E.E. LOCHRIDGE

1898 MALARIA AGES →	UNDER SIX MONTHS	1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	TOTAL
JANUARY														
FEBRUARY								● ●	●		●			4
MARCH		●						●			●			3
APRIL													●	1
MAY										●				1
JUNE														
JULY			●				●							2
AUGUST								●	●		●			3
SEPTEMBER			●				◉ ◉							4
OCTOBER									●	●				2
NOVEMBER									●		●	●		3
DECEMBER														
TOTAL →		1	2				3	4	4	2	4	1	1	23

Age Unknown -1. Sept.- ●

● Deaths in Residences.
◉ " " Hospitals.

3063

Chart No. 74.

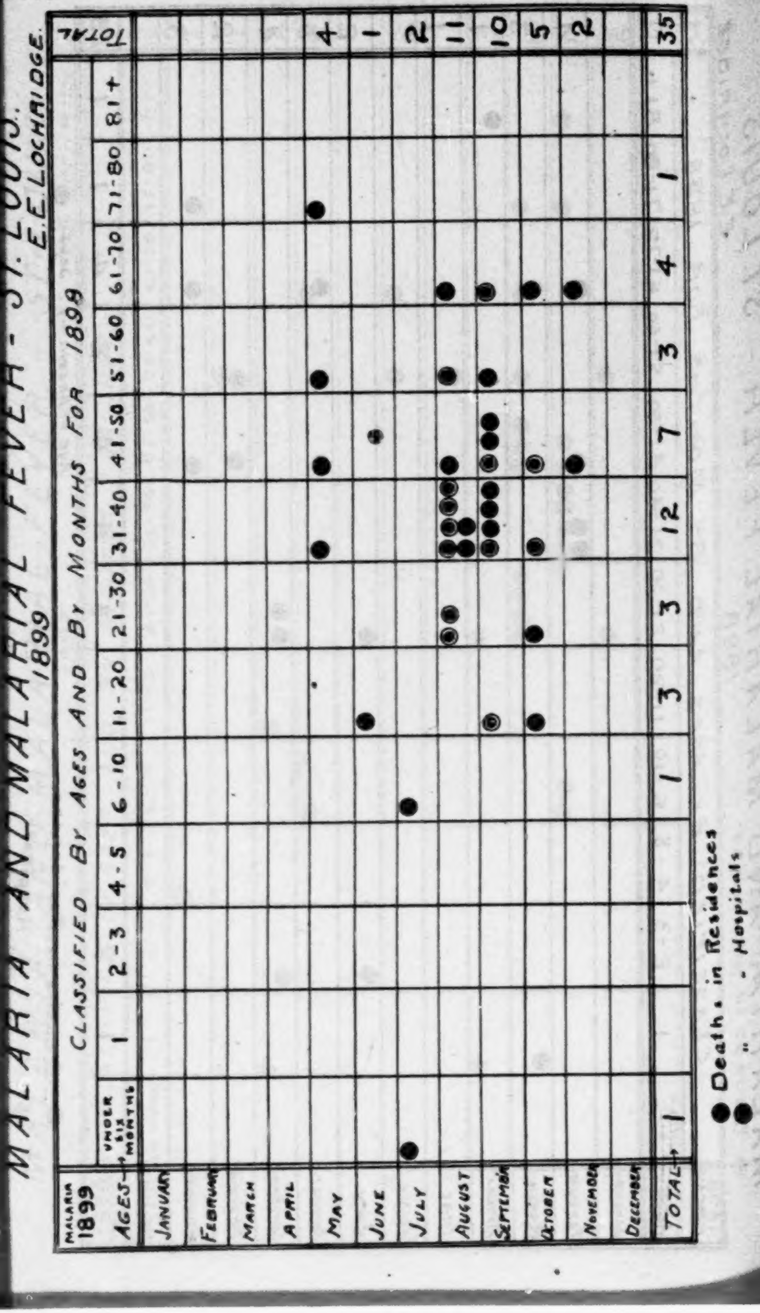


Chart No. 75.

MALARIA AND MALARIAL FEVER - ST. LOUIS.

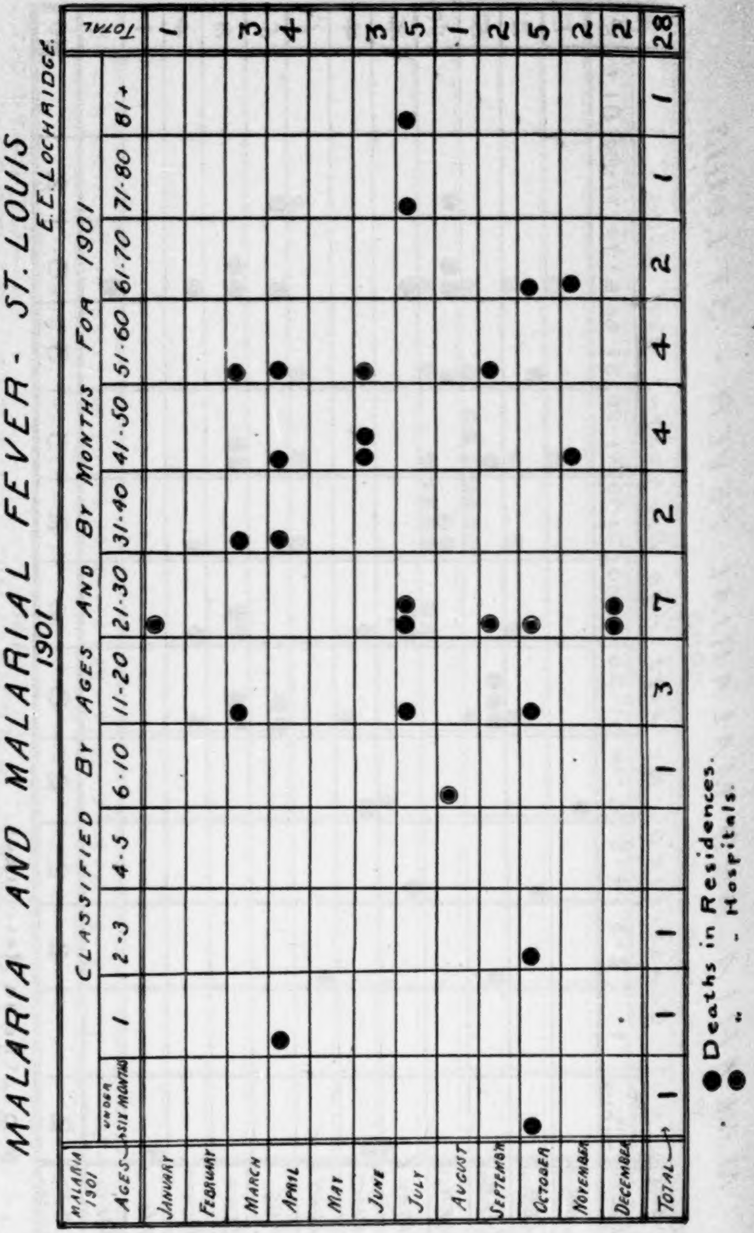
1900

E. E. LOCHRIDGE.

MALARIA 1900	CLASSIFIED BY AGES AND BY MONTHS FOR 1900													TOTAL
AGES→	UNDER SIX MONTHS	1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
JAN.					●									1
FEB				●						●				2
MAR			●			●◉●			●					5
APR										◉	●●	●		4
MAY				●			●●				●			4
JUNE	●				●		●			●				4
JULY			●											1
AUG.						●◉		●			●	●		5
SEPT						●●	●●		◉●		◉●			8
OCT						●	●	●			◉			4
NOV	●													1
DEC											●			1
TOTAL→	2		2	2	2	8	6	2	3	3	8	2		40

● Deaths in Residences
◉ " Hospitals.

Chart No. 76.



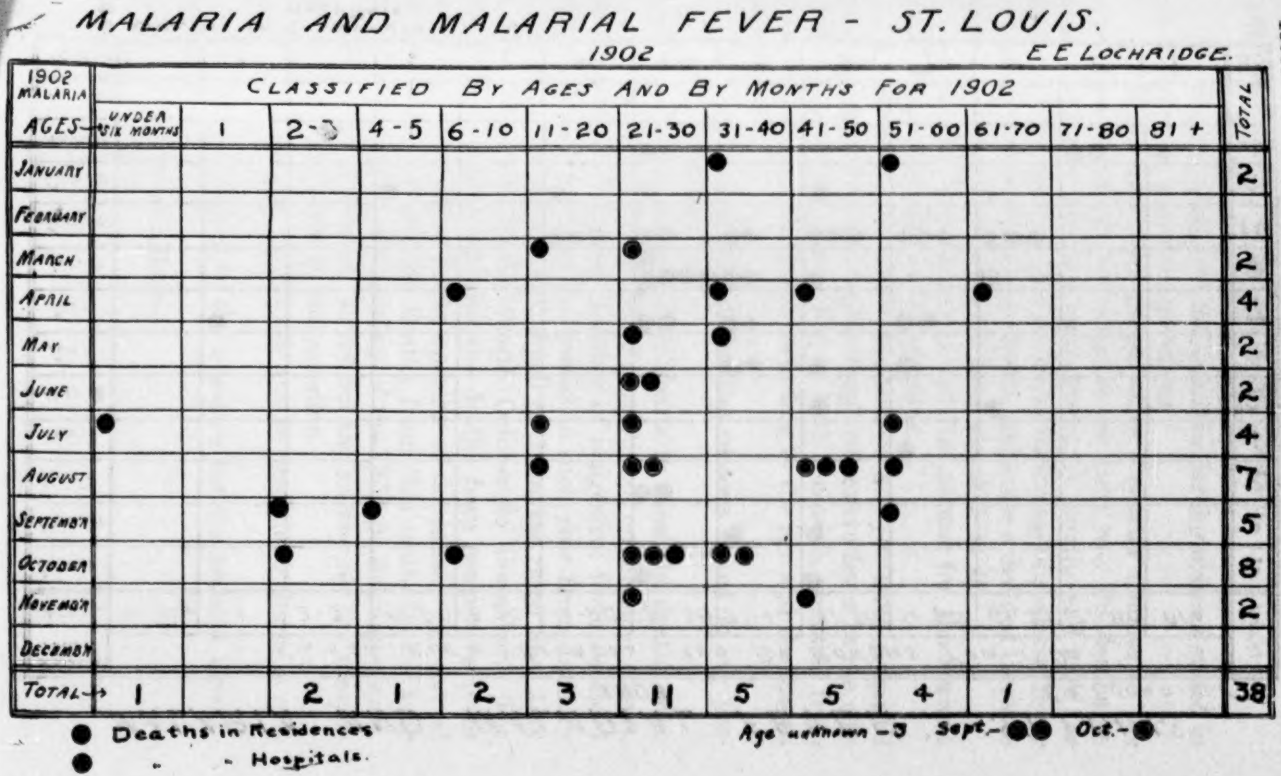
MALARIA AND MALARIAL FEVER - ST. LOUIS
1901
CLASSIFIED BY AGES AND BY MONTHS FOR 1901
E.E. LOCHRIDGE.

MALARIA 1901 AGES→	UNDER SIX MONTHS	1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	TOTAL
JANUARY							◉							1
FEBRUARY														
MARCH						●		●		●				3
APRIL		●						●	●	●				4
MAY														
JUNE									●●	●				3
JULY						●	●●					●	●	5
AUGUST					◉									1
SEPTEMBER							●			●				2
OCTOBER	●		●			●	◉				●			5
NOVEMBER									●		●			2
DECEMBER							●●							2
TOTAL→	1	1	1		1	3	7	2	4	4	2	1	1	28

● Deaths in Residences.
◉ " " Hospitals.

13066

Chart No. 77.



MALARIA AND MALARIAL FEVER - ST. LOUIS.

1902

E E LOCHRIDGE.

1902 MALARIA	CLASSIFIED BY AGES AND BY MONTHS FOR 1902													TOTAL
AGES→	UNDER SIX MONTHS	1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
JANUARY								●		●				2
FEBRUARY														
MARCH						●	●							2
APRIL					●			●	●		●			4
MAY							●	●						2
JUNE							●●							2
JULY	●					●	●			●				4
AUGUST						●	●●		●●●	●				7
SEPTEMBER			●	●						●				5
OCTOBER			●		●		●●●	●●						8
NOVEMBER							●		●					2
DECEMBER														
TOTAL→	1		2	1	2	3	11	5	5	4	1			38

● Deaths in Residences
● " - Hospitals.

Age unknown -3 Sept.-●● Oct.-●

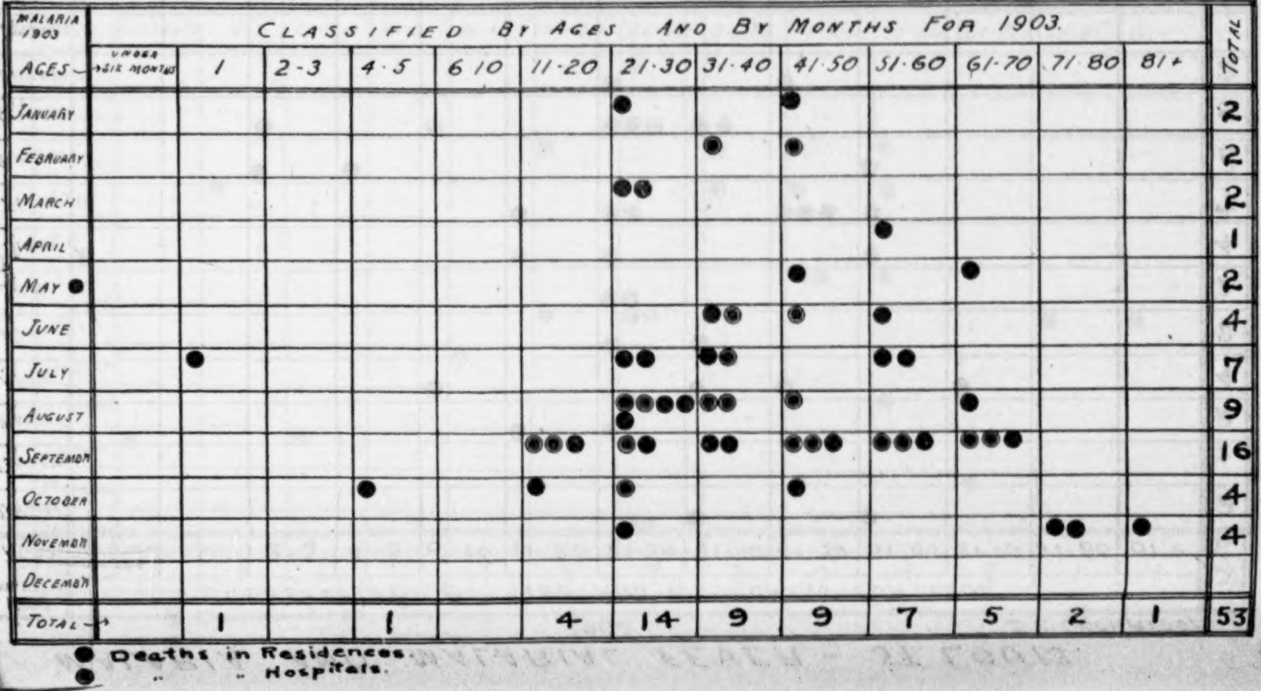
13067

Chart No. 78.

MALARIA AND MALARIAL FEVER - ST. LOUIS.

1903

E. E. LOCHRIDGE



MALARIA 1903	CLASSIFIED BY AGES AND BY MONTHS FOR 1903.													TOTAL
AGES →	UNDER SIX MONTHS	1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
JANUARY							●		●					2
FEBRUARY								●	●					2
MARCH							●●							2
APRIL										●				1
MAY ●									●		●			2
JUNE								●●	●	●				4
JULY		●					●●	●●		●●				7
AUGUST							●●●●●	●●	●		●			9
SEPTEMBER						●●●	●●	●●	●●●	●●●	●●●			16
OCTOBER				●		●	●		●					4
NOVEMBER							●					●●	●	4
DECEMBER														
TOTAL →		1		1		4	14	9	9	7	5	2	1	53

● Deaths in Residences.
● " " Hospitals.

Mr. Todd: Move to strike out the charts for the reasons
13068 stated in my objection to the question.

Mr. Jeffries: Q. What do they show?

Mr. Todd: Object to the question for the reasons stated in my objection to previous questions.

A. They have been prepared in a similar manner to the charts just described, and show in the same way the deaths by months and ages and the total deaths by months and ages for the year of the charts. The period of incidence of malarial fever or malaria is shown by these charts, and quite a decided increase since the year 1900 in the ages from about 20 to 40.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. State whether or not you have prepared similar charts from the deaths from congestive fever in the city of St. Louis for the years 1896 to 1903, inclusive, obtained from the same data and tabulated according to the age and the season of the death?

Mr. Todd: Objected to for the reasons stated in my previous objection.

13069 A. I have prepared two charts to show the deaths from congestive fever at the ages mentioned on the other charts, but on account of the low number of congestive fever deaths I have plotted in one line the deaths in each year from January to March in the second line, April to June, the third line, July to September, and in the fourth October to December. The first of these charts contains the deaths from congestive fever in the four years prior to the opening of the canal. The second of these charts shows the deaths from this cause in the four years subsequent to the opening of the Chicago drainage canal.

Mr. Todd: I move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. I will ask you to read these charts in evidence.

Mr. Todd: Object to the question for the reasons heretofore stated.

A. They are as follows:

13070 Chart No. 79.

E.E. LOCHRIDGE

CONGESTIVE FEVER-ST. LOUIS.

	UNDER SIX MONTHS	1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
JAN-MAR	●●			●					⊕					4
APR-JUN		●●	●								●	●		5
JUL-SEP	●●	●●●			●		●●	●	●	●		●		12
OCT-DEC	●		●			●		●	●					5
TOTAL 1896	5	5	2	1	1	1	2	2	3	1	1	2		26
JAN-MAR	●	●				●								3
APR-JUN					●									1
JUL-SEP	●●●		●			●	●●●●●⊕			●●●	●			15
OCT-DEC	●						●			●				3
TOTAL 1897	5	1	1		1	2	7			4	1			22
JAN-MAR							●							1
APR-JUN						●	●	●		●				4
JUL-SEP	●		●					●		●●				5
OCT-DEC							●	●			●			3
TOTAL 1898	1		1			1	3	3		3	1			13
JAN-MAR			●	●		●		●						4
APR-JUN														
JUL-SEP	●	●		●	●●		●●		●	●●				10
OCT-DEC							●							1
TOTAL 1899	1	1	1	2	2	1	3	1	1	2				15

13071 Chart No. 80.

CONGESTIVE FEVER–St. Louis.

1900 — 1903

E. E. LOCHRIDGE

	UNDER SIX MONTHS	1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
JAN-MAR	●											●		2
APR-JUN	●													1
JULY-SEP	●	●●	●●	●●			●	●						9
OCT-DEC	●							●	●					3
TOTAL 1900	4	2	2	2			1	2	1			1		15
JAN-MAR														
APR-JUN						●								1
JUL-SEP	●					●						●		3
OCT-DEC														
TOTAL 1901	1					2						1		4
JAN-MAR							●		●	●				3
APR-JUN		●												1
JULY-SEP	●●						●	●	●●					6
OCT-DEC	●		●			●●			●					5
TOTAL 1902	3	1	1			2	2	1	4	1				15
JAN-MAR	●						●		●		●			4
APR-JUN														
JUL-SEPT		●	●											2
OCT-DEC	●													1
TOTAL 1903	2	1	1				1		1		1			7

13072 Mr. Todd: I move to strike out the charts for the reasons stated in my objection to the question.

Mr. Jeffries: Q. State whether or not you have prepared similar sharts showing the deaths from bilious fever in the city of St. Louis for the years 1896 to 1903, inclusive, upon the information obtained from the same source, said charts being tabulated according to age at time of death and the seasons of the year?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. I have prepared two charts of the bilious fever deaths in the city of St. Louis, one covering the period from 1896 to 1899, inclusive, the four years prior to the opening of the canal and the other for the four years subsequent, the years 1900 to 1903, inclusive.

These represent the deaths in the city of St. Louis by ages and seasons, from bilious fever, bilious remittent, bilious intermittent and bilious colic or occasionally called also a fever. These are designated on the charts so that one can be told from another. These charts show the total number dying at 13073 each age and in the four seasons of the year described.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Will you please read these charts in evidence?

Mr. Todd: Objected to for the reasons heretofore stated in my objection to previous questions.

A. I will; they are as follows:

13074

Chart No. 81.

1896-1899
ST. LOUIS
BILIOUS FEVER DEATHS.

E. E. LOCHRIDGE

	UNDER 6 MONTHS	1	2-3	4 5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
JAN-MAR						B								1
APR-JUN											B			1
JUL-SEP	C		B		R			B						4
OCT DEC	C C						B		C	B				5
TOTAL FOR 1896	3		1		1	1	1	1	1	1	1			11
JAN-MAR		R												1
APR-JUN												B		1
JUL-SEP	B											B		2
OCT DEC						B	C		B		B			4
TOTAL FOR 1897	1	1				1	1		1		1	2		8
JAN-MAR						R	B							2
APR-JUN														
JUL-SEP								B						1
OCT-DEC														
TOTAL FOR 1898						1	1	1						3
JAN-MAR		B				B								2
A														1

○ Deaths in Residences.

● :: Hospitals.

R - Bilious Remittent

I - " Intermitten

C - " Colic

B - " Fever

13072 Mr. Todd: I move to strike out the charts for the reasons stated in my objection to the question.

Mr. Jeffries: Q. State whether or not you have prepared similar sharts showing the deaths from bilious fever in the city of St. Louis for the years 1896 to 1903, inclusive, upon the information obtained from the same source, said charts being tabulated according to age at time of death and the seasons of the year?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. I have prepared two charts of the bilious fever deaths in the city of St. Louis, one covering the period from 1896 to 1899, inclusive, the four years prior to the opening of the canal and the other for the four years subsequent, the years 1900 to 1903, inclusive.

These represent the deaths in the city of St. Louis by ages and seasons, from bilious fever, bilious remittent, bilious intermittent and bilious colic or occasionally called also a fever. These are designated on the charts so that one can be told from another. These charts show the total number dying at
13073 each age and in the four seasons of the year described.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Will you please read these charts in evidence?

Mr. Todd: Objected to for the reasons heretofore stated in my objection to previous questions.

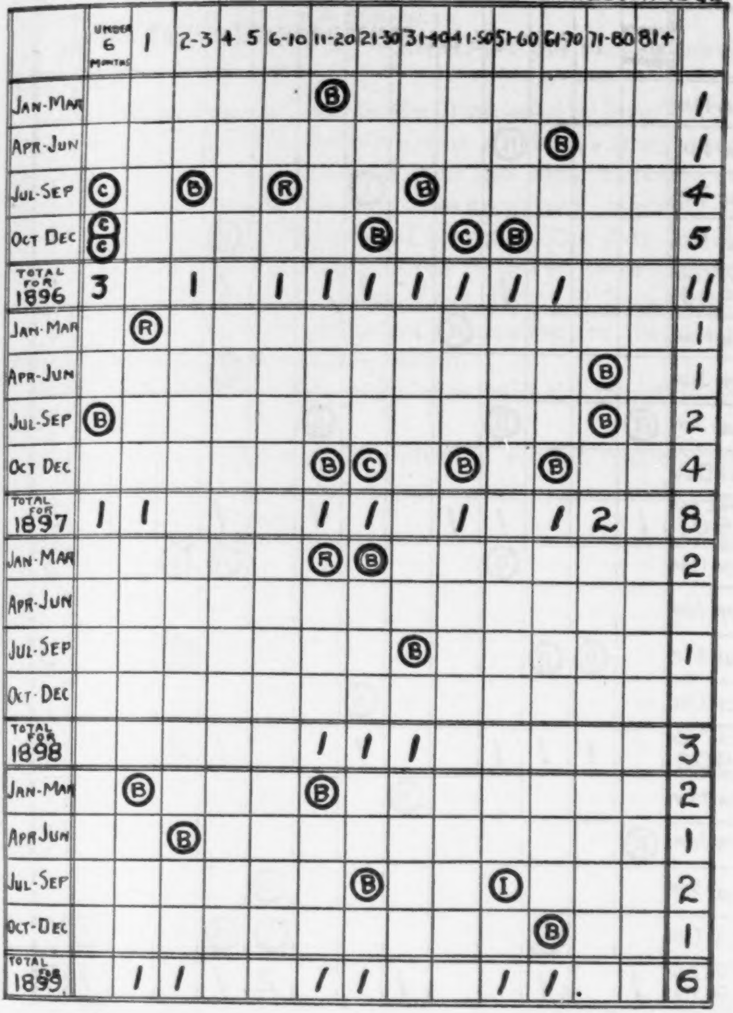
A. I will; they are as follows:

13074

Chart No. 81.

1896-1899
ST. LOUIS
BILIOUS FEVER DEATHS.

E.E. LOCHRIDGE



	UNDER 6 MONTHS	1	2-3	4 5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
JAN-MAR						Ⓑ								1
APR-JUN											Ⓑ			1
JUL-SEP	Ⓒ		Ⓑ		Ⓡ			Ⓑ						4
OCT DEC	Ⓒ Ⓒ						Ⓑ		Ⓒ	Ⓑ				5
TOTAL FOR 1896	3		1		1	1	1	1	1	1	1			11
JAN-MAR		Ⓡ												1
APR-JUN												Ⓑ		1
JUL-SEP	Ⓑ											Ⓑ		2
OCT DEC						Ⓑ	Ⓒ		Ⓑ		Ⓑ			4
TOTAL FOR 1897	1	1				1	1		1		1	2		8
JAN-MAR						Ⓡ	Ⓑ							2
APR-JUN														
JUL-SEP								Ⓑ						1
OCT-DEC														
TOTAL FOR 1898						1	1	1						3
JAN-MAR		Ⓑ				Ⓑ								2
APR JUN			Ⓑ											1
JUL-SEP							Ⓑ			Ⓘ				2
OCT-DEC											Ⓑ			1
TOTAL FOR 1899		1	1			1	1			1	1			6

○ Deaths in Residences.
◯ - - Hospitals.

R - Bilious Remittent
I - " Intermittent
C - " Colic
B - " Fever

Chart No. 82.

1900 -1903
ST. LOUIS
BILIOUS FEVER DEATHS

E.E. LOCHRIDGE.

	UNDER SIX MONTHS	1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+	
JAN-MAR														
APR-JUN				Ⓑ										1
JUL-SEP							Ⓘ							1
OCT-DEC										Ⓡ				1
TOTAL FOR 1900				1			1			1				3
JAN-MAR					Ⓡ									1
APR-JUN										Ⓑ				1
JUL-SEP	Ⓑ			Ⓑ				**Ⓑ**						3
OCT-DEC														
TOTAL FOR 1901	1			1	1			1		1				5
JAN-MAR				Ⓑ						Ⓑ	Ⓑ			3
APR-JUN														
JUL-SEP		Ⓑ	Ⓑ								Ⓑ			3
OCT DEC							Ⓑ							1
TOTAL FOR 1902		1	1	1			1			1	2			7
JAN-MAR						Ⓑ								1
APR-JUN	Ⓑ													1
JUL-SEP									Ⓑ					1
OCT-DEC			**Ⓑ**						Ⓑ	Ⓑ			Ⓑ	4
TOTAL FOR 1903	1		1			1			2	1			1	7

○ Death in Residences.
● " " Hospitals.

R - Bilious Remittent
I - " Intermittent
C - " Colic
B - " Fever

13076 Mr. Todd: I move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. State whether or not you have prepared a similar chart showing the deaths from enteric fever in the city of St. Louis by the ages and seasons of the year for the years 1896 to 1903, inclusive, the information for which you have obtained from the same source.

Mr. Todd: Object to the question for the reasons heretofore stated.

A. There were but six deaths from enteric fever in four years, 1896 to 1899, inclusive, and six deaths from enteric fever for the four years between 1900 and 1903, inclusive and therefore I have given but one line to a year, marking the month of death on the right hand margin. The data for this chart were obtained from the records in the office of the mortuary clerk of the board of health of the city of St. Louis.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Will you please read this chart in evidence?

13077 Mr. Todd: Object to the question for the reasons heretofore stated.

A. It is as follows:

Chart No. 83.

ST. LOUIS.
ENTERIC FEVER DEATHS.

	0-6m	6m-1	2-3	4-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+		MONTH OF DEATH.
1896														0	
1897							●							1	OCTOBER
1898							●●	●						3	NOVEMBER DECEMBER JUNE
1899				●			●							2	DECEMBER JULY
				1			4	1						6	
1900			●	●										2	DECEMBER OCTOBER
1901					●				●					2	OCTOBER NOVEMBER
1902						●	●							2	NOVEMBER AUGUST
1903														0	
			1	1	1	1	1		1					6	

E. E. LOCHRIDGE.

13079 Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. State whether or not in your examination of the mortuary records of the board of health of the city of St. Louis, you found any facts bearing upon the prevalence of continued fever in the city of St. Louis during the years 1896 to 1903, inclusive?

A. During the eight years between 1896 and 1903, inclusive, there were six deaths marked continued or continuing fever, two of these occurring in the four years prior to the opening of the canal and four occurring in the four years subsequent to its opening.

There were so few of these that I did not plot them, but I will give the record of the six cases.

In 1896, 1 death, August 16th, age six months, continued fever.

In 1897, 1 death, June 2nd, age 11 years, continued fever.

In 1900, 1 death, June 8th, age three months, continued
13080 fever.

In 1902, 1 death, age three years, March 19th.

In 1903, 1 death, April 9th, age 30, marked continued fever, with a note under it, "not typhoid." Another death October 5th, 1903, age 74, marked nephrites. fever, continuing, four months.

These six are the only cases of deaths occurring, as far as I could discover from continued or continuing fever. There were no deaths marked simple continued fevers.

Mr. Todd: Object to the question for the reasons heretofore stated, and move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Mr. Lochridge, taking into consideration the deaths from typhoid fever as shown by your tables, what do these tables show with reference to the usual age at which death from this disease most usually occurs?

Mr. Todd: Object to the question for the reasons heretofore stated.

13081 A. The largest number of deaths occur between the ages of 11 and 50, and on either side of these ages that is, under 6, or over 50, there are few deaths from this cause.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. As to the season of the year, what do these tables show in a general way upon the question as to what time of the year are more deaths reported from this disease to the health department of the city of St. Louis?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. In the earlier years, notably the first four years, 1896 to 1899, inclusive, the much larger proportion of deaths occurred between the months of July and November inclusive. During the years 1901, 1902 and 1903 it will be seen that there are much larger numbers than the proportional increase in the months just referred to, during the months from January to June, and in the month of December, so that during the latter years the typhoid fever deaths are scattered pretty generally through the year, there being a few more during the summer months
13082 than during the winter months.

Mr. Todd: Move to strike out the answer for the reasons heretofore stated, in my objection to the question.

Mr. Jeffries: Q. State whether or not you have prepared any charts showing these facts?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. I have.

Mr. Jeffries: Q. Will you produce them?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. I have prepared the chart with the caption "Winter Typhoid, St. Louis," on the lower half of which are recorded the number of deaths in the months of January, February, March, April, May and December, for the years 1896 to 1903, inclusive. In the line above this tabulation is given the estimate of population found in the testimony of Messrs. Barker and Jordan.

Confirmatory of this it might be well to call attention to the fact that the United States Census estimate gives for the year 1903, 612,000, instead of 618,500, as the population for the city, but this variation would make but slight difference.

13083 In the line above the population are given the deaths per 100,000 per annum based upon the winter typhoid death rate exclusively. Above each year of actual deaths per month is plotted the deaths per 100,000 living based on the figures given below and the population given on the chart.

This death rate per 100,000 is represented by a heavy black line, and covers the years mentioned. It will be noted that in the year 1898 a dotted line leaves the heavy black line, rejoining it again in 1901. This correction was made because it was found that a local epidemic of typhoid was prevalent in the city of St. Louis at that time.

The number of deaths during this short epidemic in each of the sanitary districts was not in the proportion usually maintaining, and all of the evidence which I could obtain indicated that typhoid deaths for these months, or as far as this chart is concerned, for the months of December, 1899, and January, 1900, were in part due to this localized epidemic. For this reason the average number of deaths for the three years prior were taken and the differences between this averaged number and the recorded number was deducted and the deaths per 100,000 living, recalculated and plotted, thus showing that not consider-
13084 ing in these winter months the added deaths due to this localized epidemic, there was no increase in the winter typhoid death rate in the year 1899, and that the rise was marked in 1900 even after deducting in the same way the deaths probably due to this localized epidemic in January, 1900.

On this diagram a heavy vertical line is drawn between the spaces for the years 1899 and 1900, showing the time of the opening of the drainage canal, and the line in the space to the left of the line representing the year indicates the increase for that year. These deaths are considered per 100,000 population per annum.

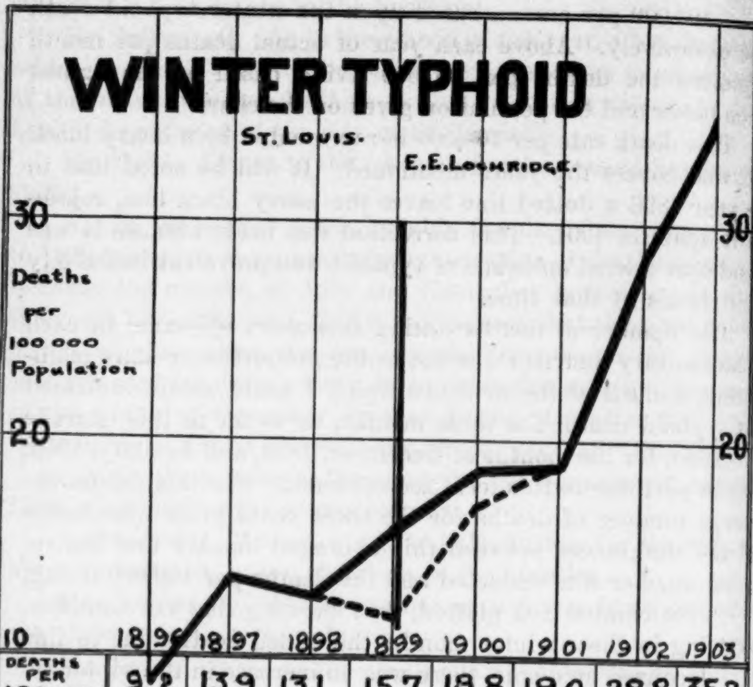
Mr. Todd: I move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Will you read this chart in evidence?

Mr. Todd: Objected to for the reasons heretofore stated in my objections.

A. I will; it is as follows:

13085 Chart No. 84.



	1896	1897	1898	1899	1900	1901	1902	1903
DEATHS PER 100 000	9.2	13.9	13.1	15.7	18.8	19.0	28.8	35.2
POPULATION (Bertier)	522 225	533 762	548 590	561 510	575 238	589 315	603 736	618 516
JANUARY	5	8	5	8	13	6	15	14
FEBRUARY	2	6	5	7	3	15	16	16
MARCH	3	8	7	4	13	7	9	21
APRIL	3	5	6	5	3	3	15	17
MAY	8	5	2	2	5	6	10	13
DECEMBER	3	5	11	17	17	19	22	28
TOTAL DEATHS SIX MONTHS	24	37	36	43	54	56	87	109

13086 Mr. Todd: I move to strike out the chart for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Have you prepared a like chart based upon summer conditions?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. I have.

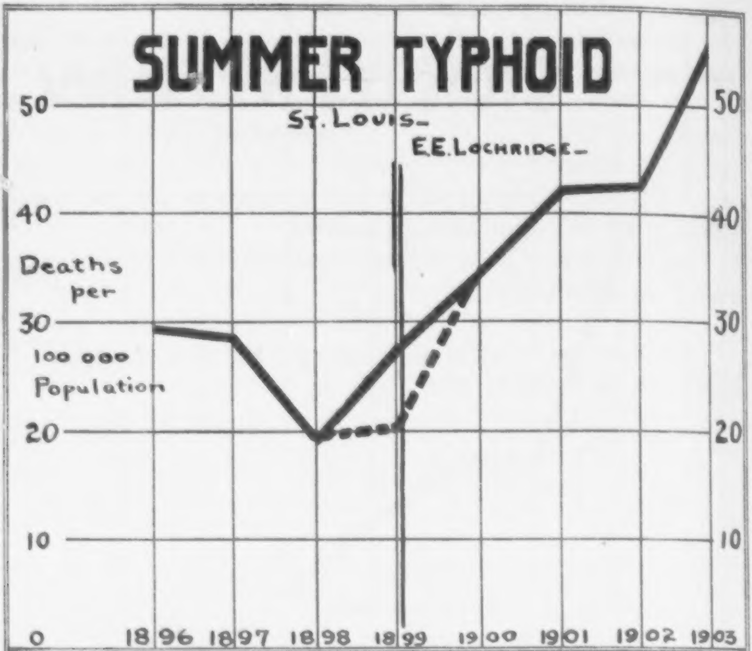
Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Will you please produce it, explain it and read it in evidence?

Mr. Todd: Objected to for the reasons heretofore stated.

A. The chart, with the heading "Summer Typhoid,—St. Louis," is as follows:

Chart No. 85.



	1896	1897	1898	1899	1900	1901	1902	1903
DEATHS PER 100 000	29.5	28.8	19.7	27.8	34.8	42.4	42.8	55.6
POPULATION –Jordon– –Barker–	522 225	533 762	548 590	561 510	575 238	589 315	603 736	618 516
JUNE	7	8	6	5	7	6	9	15
JULY	14	11	9	6	15	12	14	27
AUGUST	28	16	10	7	22	29	24	37
SEPTEMBER	11	17	14	15	11	25	19	42
OCTOBER	8	11	8	14	29	29	30	29
NOVEMBER	9	14	7	31	16	24	33	22
TOTAL TYPHOID DEATHS SIX MONTHS	77	77	54	78	100	125	129	172

13088 A. This chart is prepared in a similar manner to the one just described; the months considered are, June, July, August, September, October and November, or the six not considered on the other chart. The years 1896 to 1903, inclusive are plotted. The heavy black lines here represents the typhoid deaths per 100,000 population per annum, as shown in the table on the lower part of the diagram, a black vertical line between the lines representing 1899 and 1900 indicated the time of the opening of the drainage canal. The localized epidemic already referred to in connection with the winter typhoid chart began in the month of November, 1899, and I have therefore in the same manner as in the chart showing winter conditions taken the average of the total typhoid deaths for the three years prior and have deducted the difference between this number and the number recorded for the month of November, 1899, which are shown by means of a heavy dotted line thus indicating this correction for the localized epidemic on the chart. This dotted line leaves the black line indicating the total typhoid death rate of this period in 1898 and rejoins it in 1900. It will be seen that eliminating the effect of this one localized epidemic in the
13089 one month, that the typhoid death rate per 100,000 was
not materially different in 1898 and 1899, but that a sharp rise is indicated for the year 1900.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: State whether or not you have prepared a chart showing the comparisons of typhoid deaths in St. Louis for the winter and summer months prior to and since the opening of the drainage canal?

Mr. Todd: Object to the question for the reasons heretofore stated.

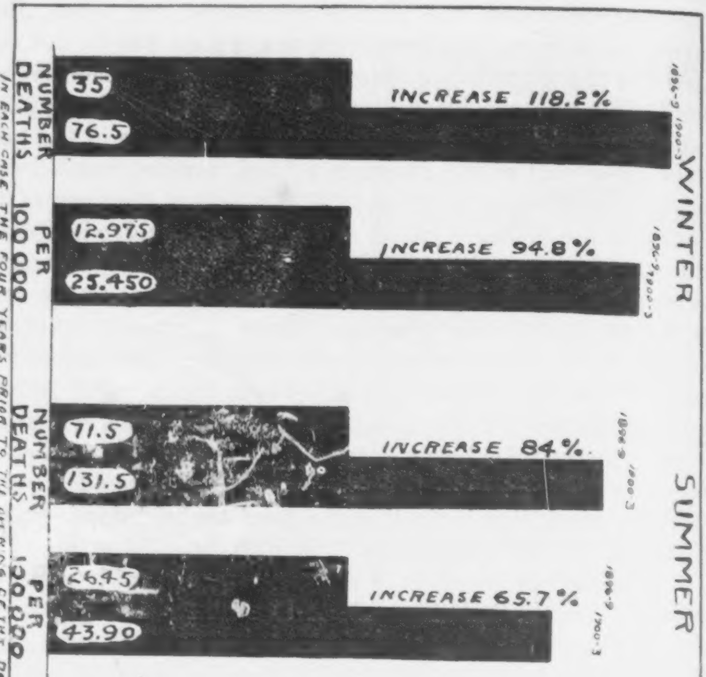
A. I have prepared such a chart.

Mr. Jeffries: Q. Will you produce, read the chart in evidence and explain it?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. The chart entitled "Comparisons of Typhoid Deaths,—St. Louis." is as follows:

13090 Chart No. 86.



13091 A. This chart shows the relative increase of the typhoid deaths and the typhoid death rate in the two seasons mentioned. The data from which these charts are prepared is all given on the last two charts just submitted. The first black staff or column on the left shows graphically, first, the average number of deaths from typhoid fever occurring during the months from January to May and in December for the years 1896 to 1899, inclusive, and also the average number of deaths occurring from typhoid fever in the city of St. Louis during these same months for the years 1900 to 1903, inclusive.

The average number for the first four years referred to was 35; for the second four years referred to was 76.5, indicating an increase in the total deaths from typhoid during the winter months referred to of 118.2 per cent.

The second staff or column indicates graphically the typhoid death rate per 100,000 per annum during the winter months referred to for the years 1896 to 1899, inclusive, and compared with the same months for the years 1900 to 1903, inclusive, the death rate per 100,000 in the first four years referred to was 12.975, and for the second period of four years 25.45 or
13092 an increase in the typhoid death rate during the winter months referred to of 94.8 per cent.

The third staff or column represents a comparison of the actual number of deaths occurring in the city of St. Louis from typhoid fever for the four years, considering the months of June to November, inclusive, prior and subsequent to the opening of the Chicago Drainage Canal, the average number of deaths occurring during these months during the years 1896 to 1899, inclusive, was 71.5 per annum. The average number of typhoid deaths occurring in the city of St. Louis for the years 1900 to 1903, inclusive, during the same summer months was 131.5, or an increase in the number of deaths during these months of 84 per cent.

The fourth staff or column from the left represents diagramatically the average death rate from typhoid fever in the city of St. Louis per 100,00 population, for these same summer months during the years of 1896 to 1899, inclusive, as compared with the average of the years 1900 to 1903, inclusive.

This average typhoid death rate during the first four years mentioned was 26.45. During the second four years it was 43.9 for the months mentioned or an increase of 65.7 per cent.

13093 The fifth staff or column from the left gives a comparison of the averages of the total number of typhoid deaths occurring in the city of St. Louis for the entire year and considering the periods of 1896 to 1899, inclusive, and the years 1900 to 1903, inclusive. The average number of deaths per annum was, prior to the opening of the canal, 106.5 per annum and 208.0 in the four years following.

The sixth and last staff or column represents a comparison of the deaths from typhoid fever per 100,000 in the years 1896 to 1899, inclusive with the years 1900 to 1903, inclusive. This average rate per 100,000 was in the first four years mentioned 19.6 and in the second four years mentioned 34.7 per 100,000, or an increase of 77.7 per cent.

In these diagrams the number or the mortality for the four years *prior*, as in the case plotted, are the same height, and the increase represented diagramatically with this as a standard so that the *relative* increase in the seasons represented may be clearly show diagramatically.

Mr. Todd: Move to strike out the answer for the reasons
13094 stated in the objection to the question.

Mr. Jeffries: Q. From what source did you get the data upon which the last three charts are based, and which you have read in evidence?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. This data was obtained by me from the records in the office of the Clerk of the Mortuary Office or Mortuary Department in the city of St. Louis. I have already read it in evidence.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Where did you get the estimates of the population of the city employed by you in preparing these charts?

Mr. Todd: Objected to for the reasons heretofore stated.

A. I have used the same estimates that were used and submitted in evidence by Dr. Barker and Professor Jordan.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Mr. Lochridge, state the character, in a general way of the examination that you made of the records in the mortuary office of the Health Department of the 13095 city of St. Louis in securing these data and the mortuary death records of the various diseases mentioned?

Mr. Todd: Object to the question for the reasons heretofore stated in my former objections.

A. I copied the date of death, the name, the age, the residence in the city, and if a death occurred in a hospital the name of the hospital and the residence address from which the case had been transferred to that hospital, the ward and sanitary district given in this record; the contributing cause of death named by the physician of every case of typhoid, typho-malaria, remittent, intermittent, congestive, continued, enteric, bilious, typho-pneumonia, or any other deaths referred to by me. In doing this I examined the cause of death of every person dying in the city of St. Louis during the eight years from 1896 to 1903, inclusive.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. From what book or books in the office of the mortuary clerk did you obtain the data? Also state how the books from which this data was obtained are made?

13096 Mr. Todd: I object to the question for the reasons already stated, and for the additional reason that this witness has not shown any familiarity with the workings of the office to which he refers and that he knows anything about how these books were made up unless he was present and saw that done himself.

A. In order that a burial certificate may be issued, the attending physician or the Coroner must bring to the mortuary office a certificate of death showing the age and cause of death in each case. These certificates contain the age at death, also quite frequently the duration of the illness, the contributing cause and any remarks of the physicians and the residence and place of death of the deceased.

The data from these certificates is then copied into large books which are so ruled that each part of the data referred to is recorded in a separate column, this record being made by an assistant. Every death is then checked by the mortuary clerk. These books are then regarded by them as the official records of these deaths and any certified copies of death made to insurance companies or others are made from these books.

13097 These books are all kept with great care, in a large vault.

Mr. Todd: I move to strike out the answer for the reasons assigned in the objection to the question and for the additional reason that this witness is not competent to pass upon whether a book is a public record, and the method of certifying said records for different uses, and for the further reason that he is not competent to pass upon whether the books kept in this office are public records and entitled to the force of such.

Mr. Jeffries: Q. These books about which you have spoken in your last answer are the only mortality records in the mortuary office of the board of health in the city of St. Louis are they not, from which the data which you obtained can be secured?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. I believe they are. I was so informed.

Mr. Todd: Move to strike out the answer for the same reasons contained in my objection to the question.

13098 Mr. Jeffries: Q. State whether or not the officer in charge of these books permits them to be taken from the office?

Mr. Todd: Object to the question for the reason that a subpoena from this court will produce any public record in the city of St. Louis, and it is not competent for this witness to pass judgment upon questions of that character.

A. He will not.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. State whether or not those records, as observed by you, while you were working upon them, were not in daily use?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. Those records were in daily use.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. State whether or not you made inquiry as to whether and how these books may be taken out of the mortuary office, if at all?

Mr. Todd: Object to the question for the reasons already 13099 stated in my previous objection, and for the additional reason that what any one told to him is hearsay and not competent evidence.

A. I made such inquiry and was informed by the Clerk of the mortuary office that such records might not be taken by any one from the office, and that if it was necessary to use them at any time outside, permission must be secured from the Commissioner and subpoena issued and a regular member of the staff must always accompany them.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: I will state for the benefit of the Court I would be very glad, indeed, to introduce this book in evidence, but on account of its public importance I am unable to do so, on account of it being absolutely necessary that it remain in the archives of the mortuary office.

I will also state to the counsel for the defendants that if he desires I will have this book produced before him, subject to his inspection, if it is possible to do so.

13100 Mr. Todd: In reply will state that counsel for the defendant desires nothing as complainant has the burden of making out their own case according to legal evidence.

Mr. Jeffries: Q. How many of those books are there, as well as you remember?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. I should think 11 or 12.

Mr. Todd: I move to strike out the answer for the reasons heretofore stated in my objection to the question.

Mr. Jeffries: Q. How large are they, about how many pages?

Mr. Todd: Objected to for the reasons heretofore stated in my objections to former question.

A. Why several hundred pages. They are perhaps four inches thick and the height of the page over two feet.

Mr. Todd: Move to strike out the answer for the reason stated in my objection to the question.

Mr. Jeffries: Q. Have you your original transcript from 13101 the record, showing the data which you have introduced in evidence, together with the name of the decedent?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. I have.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Will you present those?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. I will.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: I desire to offer those as complainant's rebuttal exhibit for identification, which said exhibits are produced and marked by the commissioner, complainant's rebuttal exhibit 1 for identification.

Mr. Jeffries: Q. Mr. Lochridge, will you compare the deaths from remittent fever in the city of St. Louis with those of typhoid fever during the periods referred to by you in your testimony and upon which your tables and charts are 13102 based?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. Deaths from typhoid fever in the year 1896 will be seen to lie quite well between the ages of 6 and 60, while 22, or considerably over fifty per cent. of the remittent fever deaths for this same year are either younger or older than the ages mentioned, or in other words, are either infants or old people.

In the year 1897 there were 11 less deaths from remittent fever than there were from this same cause in 1896, but that loss might be considered as entirely among the very young children, and it can be seen by referring to the typhoid deaths for 1897 that not one of these has been added to the death rate from typhoid fever, or in other words there could have been no transfer to typhoid fever due to better diagnosis. If the change in the annual number of remittent fever deaths be due to such better diagnosis, these deaths have been referred to some other disease than typhoid fever. A study of the tables through all the following years from remittent fever will show this same variation, the variation being in the number dying under the age of six years, the number of deaths remaining practically the same during the ages in which the mass of the typhoid fever deaths occur.

Mr. Todd: Move to strike out the answer for the rea-
13103 sons stated in my objection to the question.

Mr. Jeffries: Q. Will you compare the deaths from intermittent fever in the city of St. Louis with those of typhoid as shown upon the charts and plats as compiled by you?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. In the year 1896 there were 12 deaths from intermittent fever and in the year 1897 there were 12, but these may be seen to have been in entirely different ages, the same variation in the number of deaths in children under the age of 1, particularly, and in some cases under the age of 6, being quite apparent. This is noticed quite effectively in the increase in 1899 of the number of deaths from intermittent fever to 25, the increase being entirely in these younger ages.

The next year, or the year 1900, there were but three deaths from intermittent fever of people 20 years of age or younger, while if we consider the deaths from typhoid fever there is no marked increase in this age and there were no deaths from typhoid fever in that year recorded in the first two columns, those of six months of age and under and those of one year, so that
the decrease in the number of intermittent fever deaths
13104 for the year 1899, when there were 25, and the year 1900,
when there were 10, has not been brought about by transfer of these deaths to the typhoid group. In the other ages the intermittent and typhoid deaths are practically the same respectively, in each of the seven years.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Will you compare the deaths from typho-malaria fever in the city of St. Louis with those of typhoid?

Mr. Todd: Objected to for the reasons stated in my previous objection.

A. The deaths from typho-malaria follow more nearly the age periods of the typhoid fever than do those of either the intermittent or the remittent fevers. The number of deaths from typho-malaria per year is practically the same during the four years prior to the opening of the canal and the four years subsequent. A greater variation in the age at the time of death occurs in the typho-malaria group than in the typhoid group, the numbers remaining proportionately the same for the respective years.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

13105 Mr. Jeffries: Q. Will you compare the deaths from malaria fever in the city of St. Louis with those of typhoid for the respective years, as shown on your charts?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. The deaths from malaria and malarial fever will be seen to be distributed about the same proportionately over the various ages in the different years plotted. There has been a marked increase in malaria and malarial fevers during the past few years. It will be noted that there are about the same number of deaths in the younger ages from malaria or malarial fever during these years and the number of older people is proportionately considerably higher than the mortality in these ages from typhoid fever.

Mr. Todd: Move to strike out the answer for the reasons stated in my objections heretofore.

Mr. Jeffries: Q. Please compare the deaths from congestive fever in the city of St. Louis with those of typhoid during the respective years as shown upon your tables?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. Here again we find the large variation occurring 13106 among those under the ages of six months, one year and two and three, the variation being about the same as in the case of remittent and intermittent fevers. The year 1896 was much higher than any of the other years, although 1897 was also high. It will be noted however, looking at the list in 1896 that 13 of the cases of the congestive fever deaths were under the age of five years, ten of those under one year, and as pointed out before there has been no increase in these ages in the latter period, in the typhoid fever list. With the exception of two years when the congestive fever list was low, the variation was due to the deaths under these younger ages or of quite old people.

Mr. Todd: I move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. Will you compare the deaths from bilious fever in the city of St. Louis with those of typhoid as shown by your charts?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. The number of deaths from bilious fever is in all cases without any variation in the number, being either 13107 in the younger ages or in the older ages, and as mentioned before there has been no increase in the typhoid fever deaths in these ages to correspond with the decline in the bilious fever deaths of those ages. The bilious fever has been considered because no record of it was found in the printed report, and it was thought that possibly it might have been included in the group of "fevers" referred to in this case.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Based upon the increased death rate from typhoid fever in St. Louis since January, 1900, as compared with the typhoid mortality prior to January, 1900, in the city of St. Louis, state whether or not you have made any estimates as to what would be the probable influx of people coming to St. Louis on account of the construction of the World's Fair in the last few years, assuming that any considerable portion of such increase in typhoid in St. Louis was brought about by reason of the influx?

A. Yes sir, I have made such a calculation.

Q. What is it?

13108 A. The highest mortality from typhoid fever per 100,000 in any of the four years prior to January 1, 1900, was 21.6 in the year 1899. This is the total typhoid mortality per 100,000 for that year, including the localized epidemic of that year, or 21.6 was the typhoid death rate for 1899, that being the highest of any time of any year during the four prior years.

On the basis that such influx of those connected with the construction of the Fair or attendance at the Fair would increase the typhoid death rate of the city, I have calculated the population that would be required in order that 21.6 should be the death rate per 100,000 for each of the six years since that time.

In 1900 there were 154 deaths according to my figures from typhoid fever in the city of St. Louis. This would indicate a population of 714,000, or an influx of 139,000 being the difference between 714,000 and 575,000, the population of that year. In 1901 there were 181 deaths from typhoid fever in the city which, considering a death rate of 21.6 per 100,000, would indicate a population of 840,000 or an addition of 251,000 people.

Considering the same death rate from typhoid fever, the 13109 total of 216 deaths from this cause in 1902 would indicate a population of 1,000,000 people or an increase of 395,000. With 281 deaths from typhoid fever in 1903, in order to make the death rate of 21.6 per 100,000 would require a population of 1,300,000, which would require an increase in the population above the population of St. Louis estimated by Professor Jordan of 681,500 people, or an increase of more than the entire present population of the city.

Q. State what conclusions you draw from that estimate, basing the population for 1903 upon Professor Jordan's figures as to whether the population in the city of St. Louis has increased proportionately with the increase of deaths from typhoid fever?

A. On the basis of Professor Jordan's estimates of the population in the city in the year 1903 of 618,500 which is but something less than 60,000 increase in population over 1899, it will be seen that the increase in typhoid has been much more rapid and that it can not be ascribed to any considerable extent to the addition of these or others who may have been in the city during this time.

ADJOURNED until 10:00 a. m., Friday, May 28, 1904.

13110 Room 282 Southern Hotel, St. Louis, Mo. 10:00 a. m., Friday, May 28, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

E. E. LOCHRIDGE

resumed the stand for further direct examination by Mr. Jeffries, and testified as follows:

Q. Can this comparison be shown in any other way?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. It can. Considering the figures given by Professor Jordan for the population of St. Louis, and supposing that the typhoid death rate per 100,000 had remained at 21.6, this population at this rate would have indicated about 130 deaths from typhoid for the year 1903. The actual number of deaths was 281. It can thus be seen that the increase in the typhoid death rate is more than double in 1903 what it was in 1899, while the population has increased but little over ten per cent.

Mr. Todd: Move to strike out the answer for the reasons stated in the objection to the question.

13111 Mr. Jeffries: Q. Mr. Lochridge, have you read the testimony of Professor Jordan and Dr. Zeit and Professor Russell in this case?

A. I have.

Mr. Todd: Move to strike out the answer for the reasons given in my objection to the question.

Mr. Jeffries: Q. Are you familiar with their experiments which are known in the record in this case as their parchment sac experiments upon the longevity of the typhoid bacillus in the waters of the canal and the Illinois Rivers?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. I am.

Mr. Todd: Move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. State whether or not in your opinion the results of these experiments represent or simulate natural conditions?

A. I do not think they do.

Q. Why?

13112 Mr. Todd: Object to the question for the reasons heretofore stated.

A. In the first place any sac lodged at one place will receive the influence, if the osmotic conditions are as perfect as is supposed, of sewage which is fresher continually than would be in contact with similar germs passing down the stream. The actual influence, if there is any, of the sac itself is not known. The results vary to some extent from earlier results obtained by various bacteriologists on this same point. There were but three of the series of Professor Jordan's experiments in the drainage canal at either Robey Street or at Lockport in which the typhoid organisms were found at all *after* 10 minutes had elapsed, with the exception of one case where it was found ten minutes after inoculation. Of these three cases one is a recorded instance of its occurence on the 10th day. This has been attributed, by Professor Jordan, to the fact that bacteria, and especially the typhoid bacteria may be dried against the neck or some part of the sac, and thus be subjected to conditions of greater longevity. This is a possible explanation for this, but there seemed to me to be other explanations. It is a fact, recognized in general, I believe, by bacteriologists that of several forms 13113 of micro-organisms in the water that one of these forms will apparently mask others, as in the case of experiments with colon and streptococci.

In the earlier periods the colon masks the streptococci so that but few or none are seen. While later the streptococci develop much more abundantly and to an extent over growing the coli. Later, however, the coli may again appear. Considering this principle it may have been impossible on any of the earlier determinations to have detected the typhoid, although there is no conclusive proof that they were of necessity absent up to the time of this appearance on the tenth day, and the three typhoid colonies found may be ascribed to the fact that their presence was masked before that date. In regard to the other determinations of Professor Jordan, showing that the typhoid were certainly alive in two cases after the second day, indicates that this germ will live at least this long, but I do not believe that it necessarily shows that they do not live longer.

Mr. Todd: I move to strike out the answer for the reasons stated in my objection to the question.

Mr. Jeffries: Q. State whether or not in the parchment sacs in which the fecal matter and the urine of typhoid patients was deposited by Professor Jordan, that the typhoid germs might not have been encased in particles of fecal matter and thus preserved? 13114

A. It seems to me quite probable that they may have been thus encased and in this way have lived for a considerable period of time.

Q. State whether or not these experiments maintained natural conditions in the waters of the canal and the Illinois River at all times of the year, and all seasons of the year?

A. I do not believe that they do. The experiments were attempted at one season of the year, I believe during the fall, and for this reason I do not believe that they simulate all conditions of flow and the conditions prevalent in all seasons of the year.

Q. State whether or not you have read the evidence of Professor Jordan and Professor Burrill upon the colon tests and experiments made by them and introduced in evidence?

A. I have.

Q. State whether or not these tests disclose an elimination of the coli from the waters of the Illinois River? Also your reasons for the answer?

A. They do not show by any means the total elimination. Of course there is a reduction, but there is no point reached where there is an elimination of the colon as is shown directly from the tables. These coli determinations are always subject

to a good many conditions, especially the presence of
13115 streptococci or perhaps even other bacteria present in
the water. These very frequently mask the coli so that any reaction of the coli is not given. In a river water it quite frequently happens that two samples of equal volume, from the same source, will one give the positive, the other the negative reaction for coli, for this reason; so that I do not believe that a negative reaction by any means is indicative of the absence of the coli, especially when it is frequently found in other samples from this same source.

Q. Mr. Lochridge, in your work upon water sanitation, state whether or not you have been engaged in the work of testing the presence of coli and typhoid bacilli?

A. I have made a great many such determinations.

Q. State whether or not you are acquainted with what is known as the Widal test?

A. I am.

Q. Have you had any experience with this test or in making this test?

A. I have frequently made the test in the laboratory and in the class, and have since that time, on several occasions made this test in the office of a city board of health.

Q. State what in your opinion the effect of the use of
13116 this test, the Widal test, has upon the typhoid mortality
records of a city?

A. I do not see any indication that it does materially change them at all. There are some reasons for believing that it has reduced the number of typhoid fever deaths, for the reason that it throws out many deaths of fevers with somewhat similar symptoms which might have been in the earlier stages originally diagnosed as typhoid.

Q. Upon your examination of the records of the mortuary office of the city of St. Louis, prior to and subsequent to the use of the Widal test, what is your opinion as to the effect of this test upon the typhoid mortality at St. Louis?

Mr. Todd: Object to the question for the reason it is incompetent, irrelevant and immaterial and not based upon any facts legally established in evidence.

A. The use of the Widal reaction was begun in the city of St. Louis in the early part of 1897. I do not see that any considerable numbers have been either transferred to or taken from the typhoid list for the city of St. Louis on account of the adoption of the Widal test.

Mr. Todd: I move to strike out the answer for the reasons stated in my objection to the question.

13117 Mr. Jeffries: Q. State whether or not, Mr. Lochridge, from the tables which you have introduced and the charts which you have prepared and read in evidence, and from your examination of the records of the mortuary office in the Board of Health of the city of St. Louis there has been any considerable number of deaths transferred from remittent, intermittent, typho-malaria, malaria, congestive and continued fevers to those designated as deaths from typhoid fever since the opening of the canal in January, 1900, as compared to the four years preceding?

Mr. Todd: Object to the question for the reasons heretofore stated.

A. I do not believe that any considerable number of deaths have been classed as typhoid since the opening of the drainage canal, which without the use of the Widal reaction would have been placed in the column entitled remittent, intermittent, typho-malaria, congestive and continued fevers. The variation in the number of the people dying from the fevers I have diagrammed has been of people of ages when there are the least number of deaths from fevers and there are more deaths of those at the age of typhoid susceptibility, in the years since 1900 than at any other time during the eight years examined.

Mr. Todd: I move to strike out the answer for the reasons in addition to the ones already assigned that this witness has not qualified as an expert upon the technical diag-
13118 nosis of fevers and is not competent to pass an opinion upon the subject.

CROSS-EXAMINATION, by Mr. Todd:

Q. In preparing the tables which you have introduced in evidence, were you assisted in going through the entire records by any official of the office of the health department of the city of St. Louis, checking up the deaths with you, or did you do it alone?

Mr. Jeffries: Objected to as immaterial.

A. All the work was done in the office of Mr. M. Smyth, the clerk of the Mortuary office. He looked over all that I had copied, and I asked him to check certain places which he did, finding the number the same.

Mr. Todd: I move to strike out the answer as not responsive.

Q. Question read.

Mr. Jeffries: I suggest that the answer is responsive to the question.

13119 A. I did every bit of the work myself and was assisted only in the way mentioned.

Mr. Todd: I move to strike out all of the evidence of this witness in regard to the records of the mortuary office of the board of health of the city of St. Louis, the tables, charts, deductions and conclusions drawn therefrom, for the following reasons:

That the public records of the mortuary office if admissable at all are the best evidence. That it is not the proper way to prove a public record. That the testimony of this witness is not proper and competent evidence to impeach the official published reports of the health commissioner of the St. Louis Board of Health, published by authority of said board, for the reason that the published records of the mortuary office if competent to impeach the authorized published reports of the health department or health commissioner of St. Louis can not be proven in the manner as testified to by this witness, but that the public records themselves are the best evidence and can not be proven in this manner. That it is improper at this time for plaintiff to attempt to impeach the official reports of the 13120 health commissioner of the city of St. Louis, which report was relied upon and testified from in the evidence in chief by the complainant's witnesses and made a part of the evidence in chief in this case and is therefore not proper rebuttal and is incompetent and improper evidence. That it is not proper rebuttal after being considered and gone into in chief as the defendants had the right to rely upon the official reports of

the Health Commissioner of the city of St. Louis, published by the authority of the board of health of St. Louis and introduced in evidence by complainant, and if said reports were incorrect, inaccurate and unreliable it was the duty of complainant to make such proof in chief and not wait until defendants had rested their case to introduce such improper and incompetent evidence for the purpose of impeaching the official reports of the health commissioner of the city of St. Louis or of proving the public records of the St. Louis health department in the manner attempted to be done by the testimony of this witness. The entire testimony of this witness in regard to the public records of the board of health of St. Louis being incompetent, all conclusions, charts, deductions and opinions are therefore incompetent, and not proper rebuttal for the reason that the alleged facts and alleged records which are the basis of such tables, charts, deductions and opinions not being legally proven
13121 and legally established vitiate any charts, tables, deductions and conclusions of this witness and not being proper rebuttal evidence is incompetent, irrelevant and immaterial.

Mr. Jeffries: In answer to the objection. I will state to the Court that counsel for defendants, together with the witnesses Dr. Barker, Professor Jordan and Dr. Thayer have themselves impeached the validity and accuracy and correctness of the published report of the city board of health.

I desire to say further that at the time complainant introduced its evidence as stated a few days ago, no attempt upon the part of complainant was made to use the mortality record upon any disease other than typhoid fever, complainant believing at that time that deaths from no other disease would be brought into this controversy or had any part in it. Having previously verified the record with the published report upon the question as to the number of deaths from typhoid during the various years, and that after complainants had closed their testimony, the defense saw proper to inject deaths from remittent, intermittent, typho-malaria, congestive, and con-
13122 tinued fever in evidence with a view of showing a greater number of deaths from those diseases in St. Louis than had actually occurred, it was but natural for counsel to

have the original record as made up by the mortuary officers from the death certificates of the physicians upon the nondescript and other diseases so referred to and that after defendants had closed the taking of its testimony these compilations were employed by this witness in due form with a view that the court, in passing judgment upon this controversy, may have all the information obtainable and have it accurate and correct.

Now, as to the introduction of the original records, I desire to state, as I stated last evening, that it is impossible to introduce them in evidence, and that if they were introduced and placed before the court, it would be necessary for the court perhaps to spend months in making the determinations themselves because of the fact that all deaths from any character and from all diseases are recorded in these books, and we have therefore secured this data in the most practical and best manner possible.

13123 Mr. Todd: In regard to counsel's statement, the argument of convenience does not obviate the legal objections made by defendants to the admissibility of the testimony, and defendants have a right to demand that evidence in order to be competent must be legal.

Mr. Jeffries: Mr. Commissioner, will you issue a subpoena duces tecum for Mr. M. Smyth, mortuary clerk, for the mortuary records containing the deaths from typhoid, typho-malaria, intermittent, remittent, congestive, simple continued and bilious fevers and malarial fevers, for the years 1896 to 1903, inclusive.

Mr. Todd: Q. When did you complete your studies in bacteriology, Mr. Lochridge?

A. I do not know that such studies are ever completed. I have taken work under Professor Smith of Beloit, dating back as far as 1897. I completed the work in the Chicago University in 1900 under Dr. H. E. Daviess who was at that time Dr. Jordan's principal assistant.

Q. Have you ever made any experiments on your own account with the parchment, celloidin and agar blocks?

A. I have not.

13124 Q. Have you ever conducted independently and on your own account any experiments upon the longevity of the typhoid fever bacilli under natural conditions?

A. No sir.

Q. Have you made a study of the diagnosis of fevers?

A. No sir.

Q. Have you ever made the Widal test for the purpose of diagnosing fevers?

A. I have.

Q. Are you acquainted with the number of doctors in the city of St. Louis who employ the Widal test?

A. I do not know the number that employ that test.

Q. Have you any means of knowing anything about the number of doctors in St. Louis that employ that test?

A. I do not know where the records could be obtained in that line.

Q. You are not acquainted in St. Louis among the medical fraternity, except those who have testified in this case, are you?

A. No sir.

ELBERT E. LOCHRIDGE.

13125 PROF. WILLIAM T. SEDGWICK,

recalled as a witness in rebuttal by complainant, having been duly sworn by the Commissioner in his examination in chief, was examined by Mr. Jeffries, and testified as follows:

Q. Professor Sedgwick, you have testified in this case before, have you not, for complainant?

A. I have.

Q. Professor, I will ask you to explain why you have used in your testimony in this case the percentage mortality basis in determining the increase or decrease of typhoid fever death rate in the city of St. Louis?

Mr. Todd: Object to the question for the reason it is not rebuttal, as the Professor was the first witness in this case who introduced the mortality percentage method, and at the time of its introduction he went fully in his explanation into why he used it, and it is merely repetition and not rebuttal and therefore incompetent, irrelevant and immaterial.

A. I think I stated briefly when testifying in chief my reasons for using the percentage mortality basis, but inasmuch as witnesses for the defendants have criticized this method, I de-

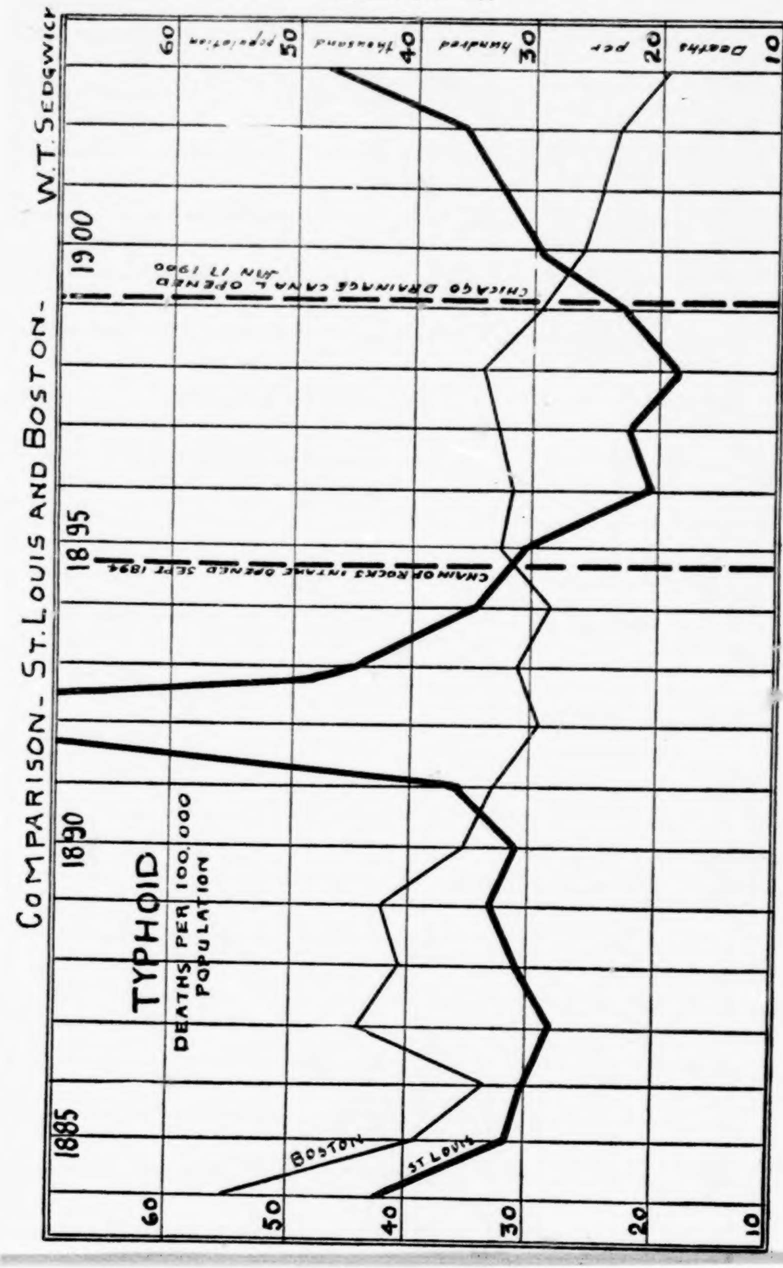
sire to state further my reasons and to show by two sim-
13126 ple charts that in the case of two cities of closely sim-
ilar population, St. Louis and Boston, this method yields results similar to those which would be obtained by the deaths per 100,000 basis, that is, the basis of deaths to population. Both methods are in common use and it is to a considerable extent a matter of choice or taste whether one shall employ one method or the other. In favor of the percentage mortality method is the fact that it eliminates from the problem altogether the question of population, and inasmuch as population in many communities, especially between census years, is a most uncertain matter, I personally make frequent use of the percentage mortality method.

On the other hand there is no doubt that under certain circumstances the other method furnishes more instructive and sometimes more accurate results. This is particularly true when the population is accurately known.

In order, however, to show that in the present case the method of percentage mortality, that is to say the proportion of the typhoid deaths to the total number of deaths is neither inaccurate nor misleading, I have prepared the charts above referred to. One of these, entitled "Typhoid percentage to total
mortality" is constructed upon the basis which I em-
13127 ployed in my testimony in chief and upon this chart I
have indicated not only the typhoid fever death rate computed in this way for the city of St. Louis, but also for that of Boston, a city of almost exactly the same size.

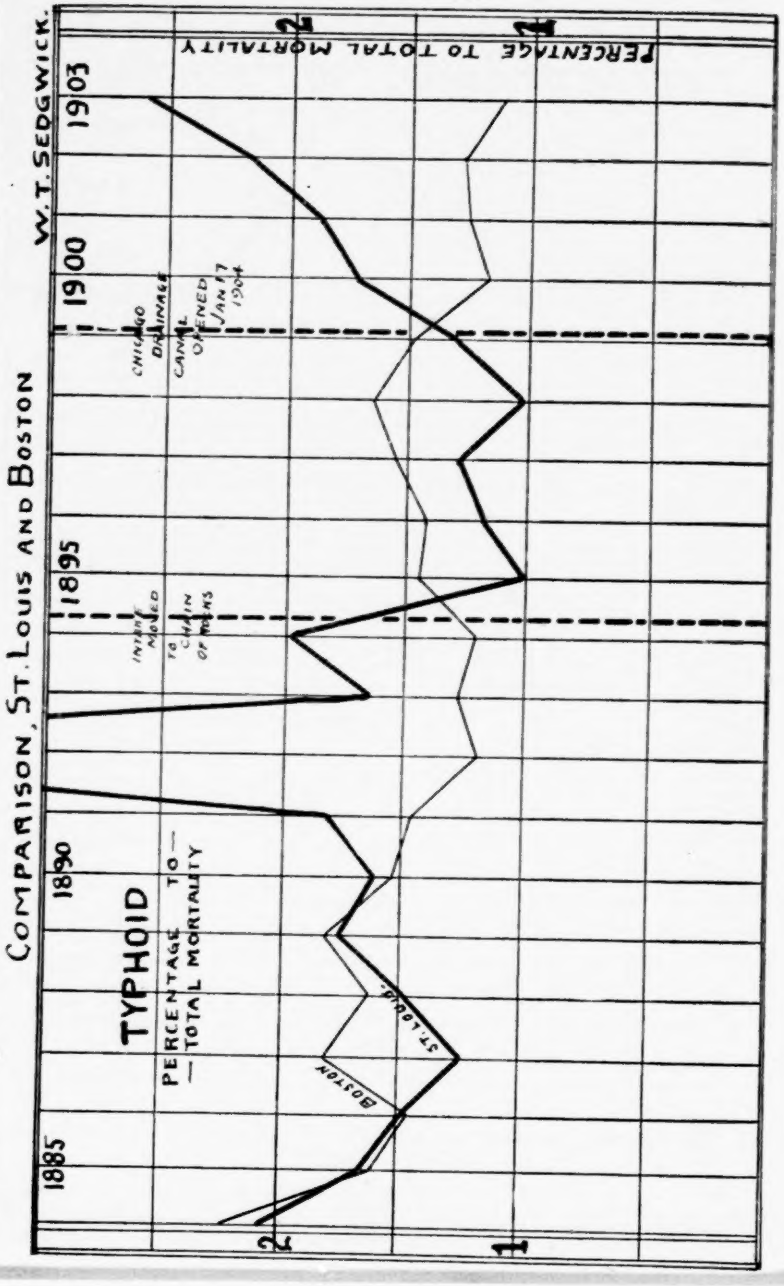
The second chart, entitled "Typhoid Death per 100,000 Population ." is constructed upon the other plan and represents the deaths from typhoid fever in St. Louis and in Boston for the same years covered by the first diagram, namely the ten years, 1884 to 1894. These charts show, I think, clearly the fact that no misleading conclusion could have been drawn from my original testimony, for both demonstrate clearly and to the same effect the essential facts as testified to at that time. These charts are as follows:

13128 Chart No. 87.



13129

Chart No. 88.



13130 MR. TODD: I move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. In the testimony of defendants, taken on February 3rd, 1904, Professor Jordan was asked the following question: "Professor Sedgwick stated * * * * the River Commissioners of Great Britain, in a report published by them in 1874, stated that there is no river in England long enough to purify itself from any sewage admitted to it even at its source. That stands as one of the axioms of sanitary science today, that those River Commissioners, in 1874 I think it was, made the statement that there is no river in the United Kingdom, I think they said, long enough to purify itself of any sewage introduced into it, introduced at its source and of course some of the rivers of the United Kingdom are very long." Professor Jordan stated that he was not able to find this quotation, saying that the closest that he could find to it was the following: "It will be safe to infer that from the above results there is no river in the United Kingdom long enough to effect the destruction of sewage by oxidation." Professor Jordan was further asked "What 13131 is the difference between the expression 'to effect the destruction of sewage by oxidation' and the expression 'to purify itself of any sewage introduced into it at its source.' "

Now, Professor Sedgwick, I will ask you to state whether or not the quotation as you gave it from memory or the version suggested by Professor Jordan is the nearer the true quotation and was essentially correct?

A. I think that the quotation which I made from memory was nearer the original, which I will now read from the report referred to by myself, and I presume by Professor Jordan, namely the Sixth Report of the Rivers Pollution Commission appointed in 1868, which inquired into the best means of preventing the pollution of rivers. This report was published in London in 1874 as one of the British Blue Books, and on page 427 occurs the statement to which I referred, as follows:

"There is no river in the United Kingdom long enough to secure the oxidation and destruction of any sewage which may be discharged into it, even at its source."

I may say that I am not surprised that Professor Jor-

13132 dan had difficulty in discovering this precise quotation, inasmuch as the book is a large one and is not at all well arranged. I may say further that the popular version of the statement made by the Commissioners is simply that "there is no river in England long enough to purify itself." It is easy to see how this shorter version has arisen, and if it were simply made to run "There is no river in the United Kingdom long enough to purify itself" I believe that it would substantially represent the true doctrine of sanitary science today.

Q. Professor Sedgwick, have you examined the testimony of Professor Jordan, Dr. Zeit and Professor Russell concerning their experiments upon the longevity of the typhoid germs in parchment and celloidin sacs and agar blocks suspended in Lake Michigan, the Chicago river, the drainage canal and the Illinois river, and all other similar experiments made by these gentlemen and introduced in evidence?

A. I have.

Q. State whether or not you are able from the determinations made by them in the above connection to formulate an opinion as to the longevity of typhoid organisms con-
13133 tained in these waters?

A. No, I should not be able either to form or to formulate a comprehensive opinion from these experiments alone. It is clear of course that, as shown in these experiments, the germs survive for certain lengths of time, but I should be unable to conclude from the experiments that under different conditions typhoid fever germs might not survive for longer times. The experiments appear to me to have been very ingenious and interesting, but not by any means conclusive upon the whole subject of the longevity of typhoid fever germs in moving bodies of sewage or water.

Q. State whether or not in your opinion these experiments just referred to simulate natural conditions in the water?

A. Undoubtedly they were devised as far as possible to do this, but in a great deal of experimental work the result of the experimenter falls short of his endeavors. I do not see how it is possible in the present state of bacteriology to devise any series of experiments which shall accurately and completely imitate the infinitely various conditions of running streams, and particularly streams such as the Chicago river, the Chicago

drainage canal and the Illinois river, subject as these are, to
an endless variety of alterations, in their physical,
13134 chemical and bacteriological conditions.

For example, these experiments were carried on in cold weather I believe, but even if they had been carried on for an entire year, under all actual variations and conditions, they would still in my judgment have been incomplete for the reason that in other years under other conditions organisms as sensitive as typhoid fever microbes are, might have encountered environments which would have materially altered the results. Besides, it seems to me that the conclusions arrived at by these able investigators indicate a shortness of life of the typhoid fever germs which is not in harmony with the longevity naturally deducible from the experience of mankind with epidemics due to typhoid infected waters, and while evidence of this kind is hard to reduce to a strictly scientific basis it has, I believe, nevertheless great value, for the reason that it is the outcome of the experience of the race.

Furthermore, the results of these experiments, broadly speaking, indicate a considerably shorter period of life for the typhoid fever germs in sewage and water than has been found by the majority of previous investigators. My own opinion is that a greater number of experiments, conducted for a longer
time, and under different conditions, would not fail to
13135 show that typhoid fever germs may, and do, live in
sewage and running streams a very much longer time
than was found in these particular experiments.

Q. In what particular way did these experiments fail to represent true natural conditions?

A. I should not say that these experiments failed to represent natural conditions, any further than many experiments must necessarily fail to imitate natural conditions. I mean by that, that these experiments were undoubtedly well planned and well conducted, but it is easy to suggest a great number of points in which they do nevertheless fail, the principal failure being to duplicate all the various conditions of the running stream. Some other matters have already been mentioned by witnesses for complainant in rebuttal, such, for example, as the fact that the germs in the several experiments were anchored, so to speak, at fixed points, instead of being allowed to float

down the stream with a particular body of water. Anyone can readily see that this is an unnatural condition, especially in the case of the Drainage Canal, and the Chicago and Illinois rivers, for the reason that the chemical composition of these bodies of sewage and water is subject to frequent changes. If, for example, the waste from a large industrial establishment
13136 shoudl be turned into the Chicago river at any particular moment the water which received it would vary materially in chemical composition from the water just preceding and just following it. For this reason sacks or blocks at anchor are probably exposed to a greater variety of changes than they would be exposed to if they were to float down the stream with one particular body of water.

The sewage discharged from a city at night is a very different body, chemically, from that discharged by day. The sewage discharged during a heavy storm is very different from that discharged in dry weather. Again, the seasonal conditions must be taken into account, and in the case of the Illinois river physical conditions, such as floods in the tributaries, or the overflow of lakes upon these tributaries, bringing in new materials and a strange bacterial flora. These and many other things which I need not, and could not, mention undoubtedly play a highly important part. The trouble is that in trying to fix the longevity of typhoid fever or any other microbes we are dealing with extremely sensitive and almost infinitesimal organisms which we have only within the last few years learned to recognize at all, and have not yet by any means learned to know thoroughly. I believe, therefore, that while the experiments of the experts for the defense are interesting, in-
13137 genious and important in the science of bacteriology, they should not be allowed to have too much weight in determining the issues in this case.

MR. TODD: I move to strike out the last sentence in the witness's answer for the reason that it is not testimony, but argument.

MR. JEFFRIES: Q. Assuming, Professor, that the longevity of a typhoid fever germ in an open sewer, such as the drainage canal, as characterized by different witnesses, and as limited by the experiments of Doctors Zeit, Jordan and Russell to from two to four days, in what respect is the credibility of these experiments reflected upon by the ordinary, usual and general practice of sanitarians in the construction and recommendations for the construction of plants for the treatment of water for domestic purposes, which has been subjected to sewage pollution?

MR. TODD: Object to the question on the ground of its ambiguity, and it may be proper rebuttal and it may not.

A. As I understand the question, it is my opinion that their results are so far out of harmony with the results of previous investigators and so contrary to the prevailing opinion upon this subject which forms the basis of the practice
13138 of sanitarians and engineers in forming their opinions
concerning the availability of polluted streams for drinking and other domestic purposes, as to throw grave doubt upon the results, and therefore upon the conclusions to which these naturally lead.

MR. TODD: Move to strike out the answer for the reason it is argumentative and is not testimony.

Adjourned until 2:00 p. m., Friday, May 27, 1904.

13139 2:00 p. m., Friday, May 28, 1904.

Room 282 Southern Hotel, St. Louis, Mo.

Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

PROF. WILLIAM T. SEDGWICK

resumed the stand for further examination by Mr. Jeffries, and testified as follows:

Q. Professor, have you examined the testimony of Professor Mason with reference to the effect that increased typhoid fever in the city of Chicago would have upon typhoid conditions in the city of St. Louis, assuming that the germs of this disease pass from Chicago to St. Louis?

A. I have.

Q. State whether or not, based upon the chemical and bacterial analyses that have been introduced in evidence in this case on the part of the respondent, and upon the physical conditions and surroundings of the Illinois river, including the sanitary district of Chicago, what effect would you reasonably expect an increase in typhoid in Chicago to have upon typhoid conditions in St. Louis?

13140 MR. TODD: Object to the question for the reason that it is not proper rebuttal and was gone into in chief by this witness on his direct examination.

A. Taking into consideration the distance between the two cities and the time required for the passage of typhoid fever germs from Chicago to St. Louis down the drainage canal, the Desplaines, Illinois and Mississippi rivers, and taking into consideration also the character of the drainage canal and of the Illinois river, and considering also the fact that the water drawn from the intake at the chain of rocks by the city of St. Louis for its public supply is now, and long has been, subjected to extensive sedimentation, I should not expect to find any close correspondence between the details of the typhoid fever curves of the cities of Chicago and St. Louis over such periods.

We must also take into consideration the fact referred to by Professor Zeit in his testimony, that typhoid germs arriving at the city of St. Louis might act through the formation of local foci of infection, the time required for which must always be of uncertain duration.

I should therefore expect to find a correspondence between the prevalence of the diseases in the two cities, in general and broadly speaking, only when considerable periods were 13141 dealt with. It is of course probable that a very severe epidemic of typhoid fever in Chicago would make itself felt in St. Louis in such a way that cause and effect could be clearly connected, but here again much would depend upon the season of the year, the rate of flow in the Illinois and Mississippi rivers, the local conditions of the sewage, and the efficiency of sedimentation in the sedimentation basins of the water works of St. Louis. I am therefore not surprised to find that the curves of Professor Mason do not indicate any conspicuous and constant relation between waves of typhoid fever in Chicago and similar waves in St. Louis. I do believe, however, that by taking long periods and averages we ought to see and do see a definite connection, as for example when comparing typhoid fever in the years following 1900 with those preceding that date.

MR. JEFFRIES: Q. State whether or not you have examined the evidence of Professor Jordan and Professor Burrill upon the colon tests made by them and their evidence in connecion therewith?

A. I have.

Q. State, Professor, from the consideration of these colon tests and tables so introduced by Professors Jordan and Burrill, together with the other testimony upon the chemical and bacterial data, your conclusions as to the appearance of pathogenic bacteria in the waters of the Illinois river at its mouth, originating at Chicago? 13142

A. The tests applied by Professor Jordan and Professor Burrill to the waters of the Illinois river, while they show a very great decline in the numbers of these organisms present in the lower reaches of the river at the times when the specimens examined were taken, in those particular specimens, do not, in my opinion, enable any one to form an accurate opinion as to the presence or absence of typhoid fever germs in the waters of that river at those points.

The reasons for my opinion are, first, that only a comparatively small number of specimens was examined, and from the nature of the case such specimens only imperfectly represent the true and complete character of the stream at all times and all seasons, and, second, that while the colon test is a valuable aid in sanitary water analysis, it is by no means a sure and perfect measure of the presence or absence either of the bacillus coli itself or of the typhoid fever bacillus. It is not a sure and perfect test for the colon bacillus at all times because experiments have shown that this organism sometimes fails to make its appearance in the tests applied, even where it is proven to be present by a further study of the same specimen. 13143 And it is by no means a sure test of the presence or absence of the typhoid fever germ, not only for that reason, but also because it is not yet established beyond all reasonable doubt that the life of the typhoid fever germ so closely resembles that of the colon bacillus as to be fairly represented by it under all conditions at all times and all seasons.

I am therefore of the opinion that while the experiments of Professors Jordan and Burill throw great light upon the process of bacterial purification going on in the Illinois river, they do not by any means establish the fact that typhoid fever is completely or effectually removed from the waters of that river before it empties into the Mississippi at Grafton.

Q. State whether or not you have examined the tables and charts introduced in evidence by Mr. Lochridge, based upon the mortality record of typhoid, typho-malarial, intermittent, remittent, congestive and continued fevers and enteric and bilious fevers?

A. I have, and I am thoroughly familiar with them for the reason that Mr. Lochridge has frequently consulted me with reference to them, and their preparation, which was begun and carried out by him at my request and with my constant advice and supervision.

13144 Q. Will you examine those charts and tables and state what they show with reference to an increase or decrease in typhoid fever since January, 1900, to December, 1903, inclusive, as compared to a corresponding period immediately preceding, and taking into consideration in this connection the deaths reported from malaria, intermittent, remittent, typho-malarial, congestive and continued fevers?

MR. TODD: Object to the question for the same reasons advanced by me in my motion to exclude the testimony given by Mr. Lochridge in regard to these tables and for the additional reason that it is not rebuttal and is therefore incompetent, irrelevant and immaterial.

A. The typhoid fever deaths taken by themselves and alone, show a marked annual increase during the last four years, that is to say since the opening of the Chicago drainage canal. This increase, moreover, is not only considerable from year to year during this period but is much more marked than it was during the preceding period. In fact, during the four years, 1896 to 1899, inclusive, typhoid fever in the city of St. Louis may be said to have been stationary or very nearly so, and not at all excessive, the annual death rate from typhoid fever measured either by percentage mortality or by comparison with
13145 the total population having been such as, broadly speaking, prevails only in cities having good water supplies. But during the last four years of the period under consideration, typhoid fever in St. Louis has risen far above this level, until

it stands at the end of the period higher than at any time during the whole period under consideration.

The testimony introduced by the defendants having tended to show a possibility of the transfer of deaths from other diseases, especially remittent, intermittent, typho-malaria, congestive and simple continued fevers into the typhoid group, especially in the latter years under consideration, I have examined with special interest Mr. Lochridge's analysis of these several nondescript fevers, or rather of the deaths attributed to them, and tabulated by him upon his charts; for it was a possibility that some such transfer might in fact have been made. The unquestioned improvement in medical education which has been going on for the last twenty years, especially after the introduction of the Widal test, might conceivably have had some influence in causing such transfer, the effect of which would have been to increase the number of deaths attributed to typhoid fever in the latter years of the period under consideraton. Any such change must, however, of necessity, have been gradual, while in point of fact the increase of typhoid fever in the
13146 city of St. Louis was sudden, sharp and has thus far been continuous. In the second place the Widal test, having been introduced by the Board of Health of the city of St. Louis early in the year 1897 should have made its influence felt, if it had any in the direction indicated, previous to the year 1900, but no such influence is visible in the figures compiled by Mr. Lochridge or upon his charts. It is not, however, by any means clear that the Widal test woud always tend to increase the total deaths from typhoid fever for, while it unquestionably clears up the diagnosis, and in some cases perhaps leads to the recording of deaths as due to typhoid fever which without its use might have been referred to some other disease, the Widal test works also in the opposite direction, giving negative results in many suspected cases and removing from the typhoid group deaths which without its use might have appeared there. It is important to note that only from five to ten per cent. of the specimens sent in by physicians for the Widal test ordinarily prove positive and it is particularly important to note that in the city of St. Louis a large number of cases diagnosed as remittent fever, malaria and typho-malaria fever, the blood from

which was subjected to the Widal test, failed to give any typhoid reaction.

Again, Mr. Lochridge's compilations and charts throw 13147 great light upon the whole matter by enabling us to consider the ages of the decedents from the various diseases referred to, as well as the seasons in which they died; and a careful comparison of the incidence of death at the different ages and months, enables one to show beyond doubt that, even if a considerable proportion of the deaths from remittent, congestive and intermittent fevers which occurred previous to the year 1900 were by better diagnosis removed from those groups in the remaining years, these were not in point of fact transferred to the typhoid group.

As to the matter of season it is important to observe in the first place that Mr. Lochridge's charts indicate a considerable increase in typhoid fever in the city since January 1, 1900, at all seasons, but especially that this increase has been greater in the winter and the spring, than it has in the summer. This is one of the most important facts which I deduce from the charts, for it shows in the first place that the increased number of deaths found in the typhoid group is almost certainly, as proved by this test alone, not due to a transfer of malarial death to the typhoid column since malaria is not prevalent in the winter.

In the second place, this winter increase is extremely 13148 important for the reason that during the winter months the Missouri river is a less important factor in the water supply of St. Louis than it is during the summer months; so that this winter increase must have had its origin elsewhere than in the Missouri river. I do not think it necessary for me to dwell longer upon these charts which Mr. Lochridge has already explained in detail, and I believe that I have stated some of the principal conclusions to be drawn from them. I will, however, say before leaving them that they appear to me to prove beyond all reasonable doubt that the typhoid fever increase in the city of St. Louis since January 1, 1900, has not been due to any transfer of deaths from remittent, intermittent, congestive, typho-malaria, or simple continued fevers into the typhoid fever group.

One thing more I ought to mention. Mr. Lochridge has made a correction indicated by dotted lines upon some of the charts for the localized epidemic of typhoid fever which occurred

in November and December, 1899, and the deaths from which continued, apparently, into 1900. This epidemic, as I have taken pains to inform myself by inquiry of physicians in different parts of the city and otherwise, was localized in the west central portion of the city, was such that in
13149 my judgment could not have been due to a general pollution of the public water supply. I believe that it was due to milk, but I am unable to state this positively.

MR. TODD: I move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. In answer to your last question the last question of mine, did you take into consideration also the age of the patients dying?

MR. TODD: Object to the question for the reasons heretofore stated.

A. I believe that I briefly referred to that matter which is of special importance as establishing some of the facts and conclusions which I mentioned, in the deaths recorded as due to some of the fevers not typhoid. A comparison of the ages of decedents from these diseases and of those from typhoid fever makes it perfectly clear that if, as sometimes happens, the number of deaths from a disease in the first group has declined, this cannot be because deaths from this particular disease have been transferred to the typhoid fever group, for the reason that no deaths of corresponding ages can be found in that group.

MR. TODD: Move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES: Q. State whether or not, Professor, from these charts and tables introduced in evidence by
13150 Mr. Lochridge, which are based upon the typhoid fever deaths and deaths from the nondescript fevers show in any way an increase of any character since the opening of the drainage canal which may be due to the influx of people on account of the construction of the Louisiana Purchase Exposition?

MR. TODD: Object to the question for the reasons heretofore stated.

A. Replying to this question I may say that I have given

in the past some attention to the influence which expositions of this kind have upon typhoid fever death rates, for the reason that in the year 1892 I studied the typhoid epidemic in Chicago, as I have already testified in this case. That date was just before the opening of the World's Columbian Exposition, and it was frequently alleged that the excess of typhoid fever in Chicago at that time was due to the influx of workmen and others preparing for that exposition. In studying this question I also examined the typhoid fever mortality of Philadelphia before, during and after the Centennial Exposition of 1876, and found that while typhoid fever was excessive in Philadelphia during the year of the exposition it was not much, if any, higher than usual during the years immediately preceding it. Further investigation led me to conclude that the excess of ty-
13151 phoid fever in Chicago just before the opening of that
exposition was not due to any influx of outsiders, but to a grossly contaminated water supply, and this latter opinion has come to be generally accepted as true. In fact, during the Exposition itself the typhoid fever in the city of Chicago was decidedly lower than it had been in the preceding year, owing to the energetic measures taken by the exposition and city authorities for improving the public water supply. In view of these facts I am of the opinion that no important portion of the increase in typhoid fever in the city of St. Louis since January 1, 1900, can reasonably be attributed to the influx of workmen or others connected with the World's Fair.

MR. TODD: Move to strike out the answer for the reasons stated in my objection to the question.

MR. JEFFRIES. Q. From the examination which you have made of the charts introduced by Mr. Lochridge, and from your general information upon the subject, epidemiologically and otherwise, state what effect in your opinion circular letters sent out by the health department from year to year has had upon the mortality records of the city of St. Louis and especially with reference to typhoid conditions?

MR. TODD: Object to the question for the reasons
13152 heretofore stated.

A. I have had much experience with boards of health and their workings, and in many cities I have had occasion to observe that circulars of this kind, issued by boards of health are generally ignored altogether. I am of the opinion that no circulars issued by any board of health and urging the reporting of *cases* of typhoid fever could have any influence upon the reporting of *deaths* from that disease, for the reason that physicians are legally bound to report deaths anyhow, before a burial permit can be obtained from the board of health or other municipal authority. Such circulars in fact sometimes tend to diminish the number of deaths reported from typhoid fever rather than to increase them. I have, indeed, known of a few instances in which a physician had reported a death really due to typhoid fever as due to some other disease because, having failed to report it while living as a case of infectious disease, as required, he feared to incur the displeasure of the authorities if he should report it as a death from that disease and thus possibly subject himself to a summons, a fine, or other penalty.

MR. TODD: Move to strike out the answer for the reasons stated in my objection to the question.

13153 MR. JEFFRIES: Q. Professor, Dr. Zeit in his testimony along with other witnesses for the defendant attributed extensive destructive effects upon typhoid fever germs in sewage and sewage polluted water to the toxic products of the saprophytes in sewage. State whether or not bacteriologists and epidemiologists agree with him as to these facts?

MR. TODD: Objected to for the reason that the evidence in this case, if read by the Court, will show that bacteriologists and epidemiologists do not agree upon that one point and this witness is already on record as opposed to the theory of Professor Zeit, and Professors Jordan and Russell and the other witnesses who have testified on that subject.

A. Unquestionably some would agree with him. Others, like, myself, do not accept this view and against Dr. Zeit's theory I may quote the following experiment made by myself and one of my students, Mr. D. D. Jackson, as long ago as 1893. In this experiment we undertook to test the very point under consideration. A portion of sewage was carefully freed, by filtration, from all microbes present, whether saprophytic or parasitic. The filtrate was proved to be free from such germs, but was otherwise ordinary sewage, that is to say it contained the toxic products, if any, of the saprophytes which it con-

13154 tained in abundance and which had been removed by filtration. A portion of this filtered sewage was then seeded with typhoid fever microbes, to the number of 329 per cc. Now if the toxic products of saprophytes had been capable of destroying typhoid fever germs these should have gradually declined in number. The facts were, however, that one hour later the number present was 333 per cc.; 24 hours later, 63,198, and two days later the typhoid fever germs present were innumerable. This specimen was kept at blood heat. The germs were carefully examined to make certain that they were true typhoid fever bacilli and were found to be such. The culture was next placed in the ice chest and six days later the number of typhoid fever germs present had fallen to 888,000 per cc.; 12 days after seeding the number present was 832,100 per cc.; 20 days after seeding the number present was 375,000 and 36 days afterwards 56,500. This experiment satisfied me that whether or not typhoid fever germs ultimately disappear in sewage they are not readily destroyed by the toxic products of saprophytes, but rather multiply and live long in their presence.

More recently a similar experiment has been made by Dr. W. H. Horrocks, a well known English bacteriologist in which Dr. Horrocks found abundant typhoid fever germs in sewage, filtered in the same way, after 42 days.

MR. JEFFRIES: Q. Professor, you have examined the 13155 tables introduced in evidence in this case, contained in the book known as Streams Examination?

A. I have.

Q. You have examined the tables and charts contained in the Illinois State Board of Health Report introduced in evidence by Professor Long?

A. I have.

Q. State whether or not you have examined the tables introduced in evidence by Professor Palmer aside from those made up by him and contained in Streams Examination?

A. Yes, sir, I have.

Q. Have you examined the tables and bacterial and chemical data of Professors Jordan and Zeit upon the various chemical and bacterial determinations of the water in the Illinois river and the sanitary canal not contained in Streams examination?

A. I have; yes, sir.

Q. Taking into consideration, Professor, all of the chemical and bacterial data introduced in evidence by the respondents, state whether or not the data so introduced leads you in any way to change your former opinion expressed in this case?

A. I have obtained from these tables and other data a 13156 much better knowledge of the process of chemical and bacterial purification going on at certain times and seasons in the Illinois river, but I have failed to discover any reason for changing the opinion which I expressed on my examination in chief a year ago, namely, that the principal part of the increase of typhoid fever in the city of St. Louis since the first of January, 1900, has been due to the presence of deleterious elements contained in the public water supply, and derived from the unpurified sewage of the city of Chicago. The additional information which I have gained on the history of typhoid fever and other fevers in St. Louis, especially during the last year, has only served to strengthen that opinion.

CROSS-EXAMINATION, by Mr. Todd.

Q. Professor, in the experiment which you made and introduced in evidence upon the longevity of the typhoid in the effluent of filtered sewage, what was the character of the sewage employed in the making of that experiment?

A. Owing to the fact that this experiment was made more than ten years ago, I am unable to state the precise source from which the sewage was derived, but I have reason to think that it was from the sewers of the city of Lawrence, inasmuch 13157 as at that time I was frequently visiting Lawrence and officially connected with the Sewage Experiment Station of the State Board of Health of Massachusetts located there.

Q. Have you done any work in bacteriology yourself in recent years?

A. If you mean personal work in the laboratory with the bacteria themselves, I shall have to answer, not much, although I am constantly in touch with the subject, partly by teaching some portions of it, and partly through my several assistants, and graduate and special students, all of whom are actively engaged in personal work on the subject.

Q. In your line of work does it have to do with original research in bacteriology?

A. Yes, sir, my professional work brings me constantly in touch with original work in bacteriology. For example, I am at this moment director of a new Sanitary Research Laboratory and Sewerage Experiment Station recently established by the Massachusetts Institute of Technology. In my official capacity as director I have there constantly to consider problems of original work in bacteriology and sanitary chemistry, and I have also constantly, either immediately under my own supervision, or in my laboratory under my frequent observation, young
13158 men and young women working at original problems in bacteriology, sanitary science and public health.

WILLIAM T. SEDGWICK.

MR. JEFFRIES: I REST.

THE COMMISSIONER: Complainant's case in rebuttal is here closed.

MR. TODD: I offer in evidence, on behalf of the respondents, in sur rebuttal, the annual reports of the Health Commissioner of the city of St. Louis, published by the Board of Health of the city of St. Louis for the years from 1890 to 1903, inclusive, and ask to have them marked respondents' sur-rebuttal exhibit "A." (See Note next page.)

Mr. Jeffries: Objected to for the reason stated at the time of the introduction of the evidence of the witness E. E. Lochridge, on the part of the complainant, in rebuttal, wherein the evidence upon the facts contained in the original health records in the mortuary office of the health department of the city of St. Louis was introduced with reference to the inter-
13159 mittent, remittent, malaria and malarial fevers, typho-malaria, congestive, continued fevers, bowel and enteric fevers and typhoid fevers, and for the further reason that said reports are not shown to contain accurate calculations or tabulations of the number of deaths occurring for the respective years, and for the further reason that said report does not contain the full information required by competent witnesses for respondent, wherein those reports are criticized.

And I object to the introduction of the reports for the further reason that their correctness and accuracy and credibility have been attacked and shown to exist in part by the statements of witnesses for the respondents and I object to their introduction for the further reason that expert witnesses for the defendants stated while upon the witness stand that epidemiologists were unable as a rule to obtain accurate and correct data with reference to the number of deaths occurring in the great municipalities of this country because of the inaccurate manner in which the tabulations in public health reports are made up and published.

I object to the introduction of the reports in question for 13160 the reason that they are incompetent, irrelevant and immaterial and not competent proof.

Mr. Todd: In reply will state that in view of the misunderstanding existing between counsel for complainant and the defendants in regard to an agreement wherein these reports were to be placed in evidence, which agreement was made when Dr. Teichmann was on the stand, as the evidence of Dr. Teichmann, wherein he identified certain board of health reports that were offered, I have offered the entire reports covering the period of these investigations, and submit that these are admissible in evidence as being the official reports of the health department of the city of St. Louis.

Which said reports are considered offered in evidence.

Mr. Todd: In behalf of the State of Illinois and the Sanitary District of Chicago, defendants in this case, I rest the case in behalf of the defendants.

The Commissioner: Gentlemen, my commission for taking the testimony in this case is now closed and further hearing is adjourned without day.

Note.—Defendants have furnished the Commissioner only the following annual reports of the Health Commissioner of St. Louis (being each for the year ending March 31), 1892, 1894, 1895, 1896, 1897, 1901, 1902; and in lieu of the annual reports the monthly bulletins of the Health Commissioner of St. Louis for 1897-8 and 1902-3, all of which have been marked by the Commissioner "Respondent's Sur-Rebuttal Exhibits 'A.'"

Complainant assents.

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IN THE

Supreme Court

OF THE UNITED STATES

October Term, A. D. 1905

THE STATE OF MISSOURI,
vs.
THE STATE OF ILLINOIS
AND SANITARY DISTRICT
OF CHICAGO.

Abstract of Record for Defendants

W. H. STEAD,
Attorney General of Illinois,
H. J. HAMLIN,
of Counsel.

JAMES TODD,
Attorney Sanitary District of Chicago.
JOHN G. DRENNAN,
of Counsel.

IN THE

Supreme Court of the United States.

October Term, A. D. 1905.

THE STATE OF MISSOURI
vs.
THE STATE OF ILLINOIS AND THE SANITARY DISTRICT OF CHICAGO.

Abstract of Record.

Before
FRANK S. BRIGHT,
Commissioner of the Supreme Court of the United States.

1 Testimony begun at City Hall, St. Louis, Mo., Feb. 17, 1903, at 10 A. M., pursuant to order heretofore entered in said cause.

Present:

The Commissioner;

Attorney General Edward C. Crow, Charles W. Bates, and S. B. Jeffries,
On behalf of Missouri.

Attorney General H. J. Hamlin,
On behalf of Illinois.

William M. Springer, and
J. G. Drennan,
On behalf of Sanitary District of Chicago.

2 THE COMMISSIONER: My commission is now open and I am ready to hear testimony pursuant to rule heretofore entered by the Supreme Court and notice of Complainant's Solicitors.

Adjournment.

Met pursuant to adjournment at same place at 2 P. M., same day.

Present, same parties and Alexander Nicholson, also representing complainant.

AMAND NICHOLAS RAVOLD, called in behalf of complainant, after being duly sworn by the Commissioner, on direct examination by Attorney General Crow, testified as follows:

Reside at 2806 Morgan st,. St. Louis, Mo. Am a physician and have been practicing since 1881. Since 1885 have been a professional bacteriologist. Was first connected with Shaw School of Botany in 1886—was assistant to Prof. William Trelease at Washington University. In 1887 became lecturer on bacteriology in medical department of Washington University. Then known as St. Louis Medical College. Later was professor of Bacteriology in medical department of Washington University and continued so until last year when I resigned to go abroad.

3 The Washington University Medical College stands now with reference to other schools as one of the great schools of the country.

6 A non-pathogenic organism is one that does no harm to an animal, while a pathogenic organism is one that lives in his tissue and does him harm.

In 1894 I was employed by the St. Louis health department—the city government—to aid in the bacteriological work of the health department. My title was consulting bacteriologist. I then made bacterial culture experiments and did any work of that kind that came in; I carried out experiments for the department working on tuberculosis, diphtheria, typhoid, blood and various things that came up at that time, and made diphtheria anti-toxin.

7 Bacteriology in the medical world means the study of bacteria. Bacteria are the lowest forms of vegetable life. They are closely allied to the algae. They belong to the group thallophyta, and come in the division known as schizomycetes or fission fungi. They are found everywhere on earth, on the surface of the earth, more or less on the surface or in the earth in the waters of the earth and in the air close to it, even extending up to some height, as high as they can go, as high as the currents of the air will carry them above the earth's surface.

(Gives a history of the origin and development of the science of bacteriology.)

10 Pure culture means that a micro-organism, say anthrax bacilli, are separated out and made to grow alone in the medium or upon the medium. It is free of every other micro-organism, it is a pure culture and if it is not free of every other micro-organism, it is impure culture.

11 Prior to along about 1849 or 1850 there had been no demonstration in the scientific world that showed that bacilli had any particular relation to diseases of the human body.

17 Explains the manufacture of anti-toxin for diphtheria.

22 Some bacteria are water born and others are not. Most of the bacteria can be water born for a short distance, but many of them die—very many—in water. The water born diseases as we know them are typhoid fever, the cholera and dysentery. Most of the other bacteria are in the soil or in the air.

There would be no life on earth without bacteria, consequently they are the undertakers of the organic world. By this I mean that when an animal dies or a tree falls, in a short while, as we know, that material begins to break down. After it lies awhile we see that it gradually disappears, breaks apart and finally disappears, and so with an animal dead upon the field. It swells up and stinks for a while and then disappears, leaving

nothing but bones. Now the cause of the disappearance of a tree or the meat of a dog or dead animal are the result of a destructive action of the bacteria upon the chemical compounds that compose the heterogeneous structure of that animal. They reduce, in other words, the highly complex nitrogeneous compounds and carbon compounds to the lower forms of carbon,
hydrogen, oxygen and nitrogen.
23 These are the four basic forms of animal and vegetable
life. These heterogeneous molecules are broken up so that in the end we have ammonia and carbon dioxide as a result. The carbon dioxide passes off in the air. Ultimately these complex heterogeneous structures are reduced to the elements from which they came. These simple compounds form the food for plants again, and the plants take up this broken material, and grow. Plants are food for animals, hence animals upon earth; so that without bacteria there would be no life upon
earth. They are also the destroyers of the organic world.
24 Bacteria destroy sewage, for instance. That is, sewage
in a tank is destroyed by them.

Q. Now what is it the septic tank produces?

A. It consists in running crude sewage into tanks hermetically sealed, and the bacteria there being of two kinds, aerobic and anaerobic, break up the organic compounds of the sewage. I am using crude sewage in the technical sense. It doesn't make any difference whether it is diluted or concentrated sewage. It is run into these practically hermetically sealed tanks. The aerobic micro-organisms act upon the sewage, first working in the presence of the oxygen of the air in the sewage; so soon as the available oxygen is used up, the aerobic bacteria cease their destructive action on the sewage which gives the anaerobic bacteria which flourish best in the absence of oxygen a chance to attack the organic compounds of the sewage. The result of the destructive action of these two kinds of bacteria on the sewage is to quickly liquify the solid organic ma-
terials and to reduce them to lower and lower nitrogen-
25 eous and carbonaceous compounds. Ultimately am-

monia, carbon dioxide, hydrogen and marsh gas are produced, which are gases and lower forms of nitrogen and carbon compounds which are food for plants.

I have one of these tanks in my cottage in the north. It works during the whole summer, and it works in the way I spoke of it.

Those bacteria are present in all sewage mostly.

An enormous number of bacteria in the world are beneficial, and a great many of them are harmless. There is only an occasional one that is harmful.

The bacteria that has been looked upon as the index of fecal pollution and is found in water fed by sewage, and in the stomach of animals, including man—or rather in the intestinal canal is called bacillus coli communis.

26 By fecal pollution I mean that whenever there is sewage from man or animals the bacillus coli communis is generally found present.

They are also found in discharges from man or animals on the soil or anywhere else. In some of our work we found that it does not exist in the intestinal canal of fish in the ordinary streams, but in the fish of the Illinois river it exists in very large numbers in the intestinal canal—in about 70 per cent of the fish. In the fish in ordinary streams it does not exist, but in the highly polluted water of the Illinois river we found the bacillus coli communis in the intestinal contents of the fish taken from that river.

29 Koch discovered the cholera bacteria in the intestinal contents of people sick or dead of the disease, and he found it in the water of one of the tanks in India, from which the cholera had come, from which an epidemic of cholera had spread. He put it in steriled water and also studied it in living water, and he found that it would live a definite number of days in various kinds of water. It is subject to changes of temperature—water hot and cold. It takes a temperature of boiling water to kill it. Boiling water is 100 degrees centigrade. It takes five or ten minutes. It will stand indefinite freezing—

that is steady cold; but alternate heat and freezing will destroy great numbers of the bacteria very rapidly. It is highly active —it is motile, a swimmer.

30 It increases very rapidly. Increases most rapidly in the human system. I think no experiments have shown that it multiples in the water. It will grow on all media easily? It is a water born disease. There is a possibility of taking it through the air.

31 All bacteria arrest their own destructiveness—both the injurious and non-injurious. Bacteria growing on or in a medium produce toxins and after a time when they accumulate in sufficient quantities, stop the growth of the bacteria. They do not destroy exactly, but there is not enough nutritive media left for them to grow upon, besides the toxin produced inhibit the growth of the micro-organism. A man might have diphtheria or typhoid fever, and not be free of poison, and still recover.

32 The body itself produces anti-toxin to the specific bacteria.

Q. Well, does the poison that is thrown off with this bacteria, so that a man gets well without the pure anti-toxin, does that have the effect of curing him of his disease?

A. Yes, sir. A spore is known as the resting stage of the micro-organism.

(Describes spores and bacteria and method of propagation.)

33 A spore is the most high vitalized thing on earth. Some of the pathogenic organisms form spores, the anthrax bacillus for instance. That is a highly resisting spore. Tetanus (lock jaw) has a highly resisting spore that is especially obnoxious.

Typhoid fever, cholera or diphtheria have no spores. Tetanus and anthrax are the principal bacteria having spores.

(Explains method of sand filteration in which bacteria form part of the system.)

36 These filters have proved efficient and perfect. Typhoid

bacilli will occasionally go through this. That is demonstrated by typhoid fever breaking out in a community where these filters exist.

37 A good filter, kept in proper shape at all times will stop typhoid. It will work if the individual who is using it is a skilled man and will take care of himself, but if it is left to the ordinary servant it will be in bad condition at all times.

38 Bacteria are classed into the pathogenic or non-pathogenic; those that produce disease and those that do not produce disease. The non-pathogenic are the most prevalent. A general classification shows the non-pathogenic exists in vastly great numbers.

39 The aerobic bacteria is the most active agency in the destruction of sewage in the open stream. The effect of that upon the sewage in the running water would be its gradual reduction from the higher compounds to the lower compounds.

Q. Now would that reduction affect the vitality or existence of the disease bearing bacteria in that running water?

A. Not the mere destruction of the bacteria in the water, no, but the action of the toxins of the individual bacteria upon one another is a vital problem. By that I mean this: You take bacteria confined in a space all growing vigorously and active, and each producing its kinds, and giving forth its products, these products are not only poisonous to themselves, but poisonous to other bacteria around them, and some bacteria produce poisons that are very deleterious to others. That is true of the bacteria in running water.

Q. Is it known that the injurious agencies are running and operating in the running water, and whether in that way they tend to destroy the cholera or typhoid or dysentery bacteria?

A. Now if the waters available were merely polluted, the action would be much less where the water was confined than where it was running.

Q. In this form of water there would be less liability of the destruction of these bacteria than there would be if they were confined and the water was still?

A. Yes, they would die much quicker in stagnant water than in running water.

Q. In other words, the toxin would be much freer to have its effect?

A. Yes, sir.

41 This process (septic tank) tends to destroy typhoid and cholera germs. Also dysentery germs.

A septic tank properly constructed and maintained in a proper way would be an absolutely sure day of destroying any germ bearing bacteria in the sewage of a city, if the sewage of a city was confined exclusively in septic tanks.

There are several cities in England that have these tanks. They are experimenting with septic tanks in Massachusetts. I do not know just now of any place where they have got beyond the experimental stage.

43 Inspected the sewage system of Berlin. They have the sewage farm system. The sewage is collected in large reservoirs in the town and from these reservoirs it is pumped out on to what used to be a sandy waste. The water is pumped up into the tanks upon those places, and then distributed for irrigation all over those farms, and it lies upon the surface for a time, percolates down through the sand, and a good deal of it passes into large ditches at the side of the field and out into the water courses. The bacteria are eliminated on the fields—the sand fields, by the filtration. At top of the soil they are held and destroyed. It is a fine way to conduct a city sewage system.

44 The pollution of sewage in running water must be very great in order to cause experts to say that the water is no longer healthful to use for domestic purposes. The volume of water does not destroy the bacteria.

45 My experience would be, and I believe the fact to be that the disease bearing germs that flow away from a city in

the sewage of that city would be borne mostly from the homes of the city where the disease existed.

46 Epidemics of typhoid and cholera and dysentery are usually caused, or believed at least to be caused, by the water born micro-organisms, which means a tainted water supply. That is true in this country at this date. The most common disease bearing bacteria that is born in the water of this country is typhoid. The reason for this is because crude sewage is discharged into the water closets, and water closets discharge into sources of water supply. Crude sewage is sewage that is not treated—disinfected.

47 Cholera germs live in the Mississippi river here, in the sunlight and dark, from 12 to 25 days.

If the Mississippi river had cholera germs in it and it should freeze over, it would not hurt them. It would not hurt typhoid fever germs.

In 1892 an epidemic of cholera was caused at Hamburg, Germany, from the dejecta of Jews suffering with the disease which was thrown in the River Elbe, that river being used as a source of water supply for Hamburg.

49 My experiments lead me to believe that typhoid bacteria will live in Mississippi river water here at St. Louis in the sunlight as high as eight days and in the dark as high as 21. That is living water.

50 The scientists of the Massachusetts state board of health found that they (typhoid bacteria) would live 25 days in the water of the Merrimac, in experiments at Lawrence and Lowell.

Q. Is there any other place where they have ever experimented?

A. Yes, throughout the literature, quite a number.

Q. What would be the average time?

A. About that time—from a few days to as high as 25 and 30 days, and always longer in steriled water, of course.

The effect of the sand filters at the places where I observed them, in London and other places, was to diminish the amount of typhoid and other diseases from the water-born bacteria.

Have had no experience with any typhoid epidemic in this country other than in the city of St. Louis. That was in 1892 prior to the time that the present intake was placed at its present existing spot. The intake was then at Bissell's Point. The present intake I suppose is six or eight miles above that on the river. Both on the Mississippi river. I do not know the width of the river at the present place of the intake. It is fourteen miles above the city, I think. Six or eight miles below the confluence of the Missouri and the Mississippi rivers. The division of the waters at the confluence of the two streams is quite perceptible. At the intake if the Missouri river is very high it can be very distinctly seen at the intake. Its great volume of
53 yellow water runs down clinging to the Missouri shore,
and can be seen. If the Mississippi is high and the Missouri not high, the effect of its waters can be seen at the intake.

Q. Well, if the Mississippi is very high and the Illinois is very high and the Missouri is not, what effect has that on the volume or character of the volume of water that comes over to the intake and into the waterworks?

A. Well, as a rule under those conditions the Missouri predominates.

Q. Where the Mississippi is high?

A. Not where the Mississippi is high.

Q. I mean where the Mississippi is high and the other two are low, in ordinary stages?

A. Then the waters exist in about equal quantities, or the Mississippi water may predominate. It appears that way to the naked eye.

Q. Now you stated that the bacteria in the water at the intake tower, when you cross sectioned the river there, would indicate the presence of more than one stream?

A. Yes, sir.

Q. What is there in the indication of that bacteria that indicates that to a scientific investigator?

A. Well, we know the numbers of bacteria in the Missouri river before it enters the Mississippi; we know the numbers of bacteria in the Mississippi above the junction with the Missouri river, and that these two streams flow down together, the Missouri clinging to the Missouri shore, the Illinois and Mississippi rivers combined, clinging to the Illinois shore, now the cross section of the stream will show whether the greater number of bacteria are on the Missouri side or on the Illinois side; then we can finally reach the point where we can see the two streams are about to touch one another, or commingle.

Q. Now you use the term "bacteria" without regard to whether they are injurious or non-injurious?

A. They are non-injurious.

Q. That is, they are simply indigenous to running water?

A. Water born. They are found everywhere in the
54 water of these two streams. They are the same bacteria.

Q. Is there anything to indicate after the Illinois enters the Mississippi below the mouth, the presence of the Illinois river, in the Mississippi river water?

A. No, sir. The bacteria of the Illinois are very similar in numbers and character to those in the Mississippi, and it is only by putting different kind of bacteria in the Illinois river and watching them as they flow, that we can trace the Illinois river water, species of bacteria that are not indigenous to either stream.

As to the waters, a visual inspection will show that samples from the Illinois and Mississippi are of a less muddy color, and contain less sediment than the samples from the Missouri in the greater part of the year.

55 My impression was that the Mississippi above the Illinois is more rapid than the Missouri above the Illinois. That is in equal stages of water. The more rapid the stream the further the bacteria carry. I think the Missouri would sediment its bacteria much quicker, because the sediment in the stream is very much larger. All inorganic particles are larger

and would carry down the bacteria in the water very much more rapidly than the Mississippi river will.

Q. What would be the result of that on the number of bacteria the non-injurious bacteria, that are just useful water-born bacteria, in the two streams, in the same volume of water? Both running at about equal speed?

A. For some reason or other the Missouri has the larger number.

Q. Now they are non-pathogenic, are they?

A. Yes, sir, a great majority of them.

56 The sand in the soil above the mouth of the Missouri river, contains large numbers of bacteria. I am speaking of the Missouri. They were alive.

Q. Now, are they non-pathogenic?

A. A great majority of them.

Q. Harmless?

A. Yes, sir.

Have examined at the confluence of the two rivers, the soil and the sand in the bottom of the Mississippi. Found a large number of bacteria, a very large number.

Q. What was the character of these bacteria?

A. Mostly harmless.

Q. Now do you know anything about the proportion of the bacteria in the two rivers and the sand and soil on the bottom of the two rivers at the point I mention, the confluence, as to which has the greater number of bacteria?

A. Practically about the same.

Q. Could you distinguish between the pathogenic and non-pathogenic bacteria?

A. What do you mean?

Q. Why in counting these bacteria that you discovered in your examination, in your estimate of the two rivers, or in the waters of the two rivers?

A. Not without separating out each individual bacterium to get it as a pure culture.

Q. Have you done that?

A. I have separated out different varieties or different species found in the rivers, the Missouri, the Mississippi, and the Illinois, at Peoria and Grafton.

Q. Well, by this method of separation then, the numbers of pathogenic and non-pathogenic bacteria could absolutely be determined?

A. Yes, sir, but not absolutely. It would be a slow process, a gigantic task.

Adjourned.

Met pursuant to adjournment at Southern Hotel, at 10:00 A. M., February 18, 1903.

Present, the Commissioner and same counsel.

I am familiar with what is known as the Chicago Drainage Canal.

59 I know that Lockport and Joliet and Peoria—most of the towns along the (Illinois) river that have a sewage supply whatever, discharge the sewage into the river.

65 I am familiar with the St. Louis intake—that is the place where the water supply for St. Louis is taken.

66 In the Mississippi river, on the Missouri side of the Mississippi river, 1500 feet from the shore is built a large tower of stone. Connecting with that tower there is a tunnel in the bed of the river to the shore. It runs alongside of what is known as the Chain of Rocks, which were put out there to deflect the flow of the river away from the Missouri shore. The water passes down through openings in this tower into the tunnel; from the tunnel it runs into what is known as the uptake and reservoir and from there to the pumps or to the reservoirs, six in number. After settling in these reservoirs the water is allowed to rest in these reservoirs from 24 to 48 hours, generally 36 hours. It passes out into a conduit and is carried to St. Louis. On the way it meets the pumps at Baden. The high service pumps there pump the water into what is known as the high surface tower which is located on Grand and La Fayette avenues. From there it is distributed throughout the west-

ern part of the city, and the high portions of the central portions of the city. The remaining part of the water passes on to Bissel Point, and there passes into reservoirs, and rests for a time in the reservoirs, to pass from the reservoirs into a series of low service pumps which supply all this part of the city, the low part of the city, the central part of the city.

67 I think it is six miles from the settling basins to Baden and eight miles to the low service pumps or low service reservoir at Bissell Point. From Baden to the high service reservoir I suppose it is 3 or 4 miles. The distance from Baden to where the low service basins are located is two miles. The tunnel that runs from the tower in the river to the shore I think is an eight foot tunnel. That tunnel is walled with stone and brick.

68 The settling basins are very large. The tower in the river is in the main channel of the Mississippi river. I do not know exactly the width of the river at that point. In the ordinary stages of the river I would say it was a mile across.

It is eight miles from the water tower in the river to the point of conjunction of the Mississippi and the Missouri rivers. It is 25 miles to the conjunction of the Illinois and the Mississippi.

At the intake of the St. Louis Water Works there are no filtration plants or processes anywhere that the water passes through or over between the time that it enters the tower in the river up to the time that it goes out in the service pipes. The subsidence that occurs while the water is resting in the reservoirs at the Chain of Rocks is the only treatment whatever that the water receives.

All fecal matter of a man or animal contains what is known as bacillus coli communis.

Fecal matter is the intestinal contents discharged from man, from the bowels of man and animal.

This bacillus coli communis is found in animals and also in fish.

I have been unable to find any reference whatever that shows that it has been found in fish prior to my investigation.

We found the bacillus coli communis in the waters of the drainage canal, the Des Plaines river, the Illinois and Mississippi.

69 The finding of bacilli coli communis is looked upon by bacteriologists as the index to fecal pollution, for the reason that whenever these micro-organisms have been found in water, the conclusion is reached that the water must contain sewage, either from the intestinal contents of man or animals. It is an indication of sewage in water.

There are several other bacilli that are found in running streams that are an indication also of sewage in water. But there really is no good index. There are micro-organisms that are found in sewage steadily wherever sewage is present, but a true index to fecal pollution, I don't know a single one.

Q. Now do you mean to include in that statement the bacilli that we have been talking about?

A. Yes, sir, that is, previous to our work upon the intestinal contents of fishes, these micro-organisms were really looked upon, and I believe it is still by Prof. Jordan, looked upon as an index to fecal pollution, but our own experi-
70 ence robbed it of that dignity.

The reason for this is that if it is found in a stream steadily, and we know that fish in the stream at the same time, not only have had in their intestinal contents and have it in there, and are discharging it from their intestines, then the bacilli coli communis found in that particular water may be either from sewage, from man, or from animals, or fish.

We have found it in fish in the Illinois river. Also in carp in the Mississippi. Am not sure whether I found it in the fish of the Missouri river—I think not.

Whatever fish we found in the canal, the drainage canal, were dead. We didn't go into their intestinal contents at all. They were killed by the fact that the aerobic micro-organisms which are present in water polluted by sewage, consumed

71 the oxygen that was in the air in the water. That leaves the water without air for the fish to breathe, and having no air to breathe, they die.

The cause of the presence of large numbers of these aerobic micro-organisms was due to the fact of sewage in the water.

Don't know whether there are any fish in the Des Plaines river. Saw men fishing there. Examined 68 fish in the course of several months in 1900—1899 and 1900.

Was consulting bacteriologist for St. Louis in July, 1899. Health Commissioner was ordered by a motion made in the city council, to have investigations made, and I was assigned to the work.

72 Suit was begun 22d of January, 1900. Had made investigation of the waters of the Mississippi and Illinois between that date and July, 1899, and the drainage canal. *Began work August 10, 1899.* Consisted in taking samples from the water at various points, in four ounce bottles.

73 The examination made was of a bacteriological nature. The water was taken with a special apparatus designed by me, in sterile vessels, from about 3 feet below the sur-

74 face of the river.

Sterilizing may be done by three methods. (Methods explained.)

75 Constructed special apparatus for taking samples.

76 There are particular rules or methods adopted generally by bacteriologists in this country, in the examination of water and other things for the discovery of bacteria.

The American Public Health Association—the bacteriological committee, have published a report in 1898 and is called "Procedures recommended for the study of bacteria, with special reference to a greater uniformity in the description and differentiation of species. Being a report of a committee of the American Bacteriologists to the committee on pollution of water supplies of the American Public Health Association, submitted at the meeting of the Association in Philadelphia, September, 1897, published by the Rumford Press. 1898."

This report made part of the record that outlines the method that is approved by bacteriologists generally.

At a meeting in 1901, a few minutes were made in some of the details or media.

77 We collected samples at the intake of the St. Louis water works. We immediately plated them.

We followed the method laid down in that volume for the preparation of media throughout, by plating I mean we mixed a definite quantity of the water from the sample with the media in a tube and poured it out in a petri dish. This was put in the ice chest, kept at a temperature of 20 centigrade about 60 Fahrenheit, and the bacteria allowed to grow for two or three days, and the colonies of bacteria which have formed are counted. Each colony is considered one bacterium. The number is then recorded. Now for each sample of water we made from two to three plates. The result of these investigations simply gives the unclassified number of bacteria.

Besides that we carried out some work identifying the number of bacilli coli communis in sterilized water collected at these points.

These collections were made at the Mississippi river just above the intake of the St. Louis water works, August 10,
79 and Aug. 30, 1899. Two plates were used of each sample.

The results shown are the mean number of bacilli on the two plates at each point, per cubic centimeter of all kinds.

80 Mississippi river just above the intake,

August 10, 275 bacteria,
August 30, 275 bacteria,
September 12, 650 bacteria,
September 13, 1500 bacteria,
September 15, 2300 bacteria,
September 16, 1700 bacteria,
September 20, 1200 bacteria,
September 25, 3600 bacteria,

Illinois side of the intake, toward the Illinois shore directly in line with the intake, on August 23d, the number of bacteria was 240.

In the intake, as the water flowed into the intake,
August 10, 500 bacteria,
August 21, 375 bacteria,
August 22, 950 bacteria,
August 23, 550 bacteria.

After this water had flown from the river and discharged into the uptake, a sample of water was taken from the uptake. From the tower to the shore is a tunnel, and when it flowed out of the end of the tunnel, 1500 feet from the river, a sample was taken there. As I say, we found no difference in the numbers in the intake and the uptake, as you see:

(Following is all uptake)
August 10, 600,
August 11, 650,
August 12, 650,
August 14, 650,
August 15, 1500,
81 August 17, 750,
August 18, 650,
August 19, 400,
August 21, 325,
August 22, 150,
August 23, 1300,
August 24, 475,
August 25, 400,
August 26, 275,
August 28, 275,
August 29, 170,
August 30, 300,
September 4, 300,
September 5, 270,
September 11, 300,

Made six boat trips up the river between August and January 23d. Up the Mississippi to the mouth of the Missouri.

In the Illinois as far as the brick house club, 5 or 6 miles up the river and 2 or 3 or 4 miles up the Mississippi above the conjunction with the Illinois river, and samples were collected at different points between those.

82 We took 32 samples. Colon basillus in the presence of sugar produces fermentation, it breaks up the sugar, producing gases. Now if we can put sugar broth into a U tube known as a fermentation tube, and have the glass arm filled with broth and the open arm so that we can throw water into it, if the bacillus coli communis is there, it will break up that sugar and form gases in the glass tube. The gases form at the top and force the water down. It produces as a rule about 60% of gas in the tube, so when we put a small quantity of water in the fermentation tube and collect about 40 to 60% gas, sometimes 75%, we know there is gas-producing bacillus there, and then we merely search for this gas producer by plating and studying the colony characteristics of the micro-organism that we think produce this gas. The micro-organism is picked off and showed on a variety of media, its microscopic form and motility studied.

Motility means whether it swims in fluid or not.

This is not the character of coli work that was carried on on these boat trips, altogether. Samples were returned to my laboratory in the city chemist's office, and there these experiments were carried out.

Result of examinations, number of unclassified bacteria, is as follows:

83 September 6, Illinois river, Wheeler's ferry, 3 miles above the mouth, 130 bacteria.

Illinois river, five miles above the mouth, at Grafton, what is known as Brick House club, 170 bacteria.

Illinois river, 7 miles above Grafton, 6 mile Island, 160 bacteria.

Following is Mississippi river:
September 6—all on same day.
Opposite Grafton, 190 bacteria;
4 miles above Grafton, 550 bacteria;
6 miles above Grafton, 276 bacteria.
Above plated on harbor boat after collection.
September 9th:
Mississippi river as follows:
Chain of Rocks, 160 bacteria;
Madison Landing, above mouth of Missouri, 210 bacteria;
1½ miles below Alton, in the channel, 190 bacteria;
1 mile above Alton, 240 bacteria;
1 mile below Grafton, 160 bacteria;
Opposite Grafton, 150 bacteria;
Missouri river, near mouth, 180 bacteria;
Illinois river, just above Grafton, 90 bacteria.

Bacteriologists mark a bacillus coli communis positive or negative. They mark it with a cross if the bacillus coli is present, and if it is not present, it is marked "minus." Zero means sample not examined for coli. By the word "present" I mean that it was a positive reaction; that it showed the coli communis were present in the sample. I found bacillus coli communis in it. (The letter B indicates the word "Bacteria.")

September 16:
Mississippi river, Chain of Rocks, 1700B;
84 Mississippi river, Madison Landing, 800;
Missouri river, near the mouth, 2600;
Mississippi river, 2 miles above mouth of Missouri, 700B;
Mississippi river, 1½ miles below Alton, 800B;
Mississippi river, 1 mile above Alton, 700 B.
September 21:
Illinois river, 1½ miles above Grafton, 450B;
Illinois river, 3 miles above Grafton, 400B;
Illinois river, 5 miles above Grafton, 425B;
Mississippi river, 1 mile above Grafton, 500B;

Mississippi river, 4½ miles above Grafton, 500B;
September 25:
Mississippi, Chain of Rocks, 3600B;
Mississippi, Madison Landing, 750B;
Missouri river, just above mouth, 5600B;
Mississippi river, half way between Alton and mouth of Missouri, 750B;
85 Missouri river, opposite Clifton, 750B;
Mississippi river, half mile below Portage, 600B;

Between September, 1899 and January 23, 1900, no bacteriological investigations were carried on by me to determine the presence of bacillus coli communis in the Mississippi or Illinois, other than above mentioned.

Above testimony is in regard to work done from August, 1899 to January 23, 1900, under my personal supervision, I doing the coli work personally, media made in my office, plating done at the Chain of Rocks.

Drainage Canal was opened six days prior to January 23, 1900.

Bear trap Dam was lowered January 17, 1900.

89 Beginning January 23, 1900, pursued bacteriological investigation in the waters of the Canal, Lake Michigan, the Illinois, Des Plaines and the Mississippi rivers.

90 Took samples of water from various points, studied it for its bacteriological points, that is the number of bacteria per cubic centimeter, for the detection of bacillus coli communis, and the study of the bacteriological flora of the water—that is the different species found in it.

Following are distances from St. Louis intake to points named:

Lake Michigan, 357 miles;
Lockport, 327 miles;
Joliet, 320 miles;
Peoria, 196 miles;
Grafton, 39 miles;

Alton, 23 miles;
Hartford, 12 miles;
All above towns are in Illinois.
Bellefontaine on the Missouri river, 14 miles.

92 Lowering of the dam at Lockport and the working of the pumps at Bridgeport changed the flow of the Chicago river—reversed it.

I collected samples of water daily at Lake Michigan, Lockport, Joliet, Peoria and Grafton, beginning 23d of January, 1900.

93 Our instructions were to take it from the channel where the water flowed the most rapidly and deepest, three feet below the surface with the apparatus designed by us.

Water was taken in Chicago at the four mile crib, Carter Harrison crib, ten miles from the Chicago shore, Lakeview, three mile crib, four mile crib, 68th street, four mile crib. The cribs are intakes for Chicago water supply:

Following is the time taken, place, number of bacteria, etc.
July 23d, 4 mile crib, 11:45 A. M., 1,600B.

94 Carter Harrison crib, July 30th, 11:30 A. M., 1900, 12,300B, ten feet below surface.

Ten miles from shore, ten feet below the surface, Aug. 9, 4 P. M., 16,300B.

95 Carter Harrison crib, 31st of August, 10:30 A. M., 21,400B.

Lake View crib, Sept. 7, 11:30 A. M., 5,200B.
Two mile crib, Sept. 15, 10:30 A M., 909,700B.
Three mile crib, Sept. 15, 11:45 A. M., 111,500B.
Two mile crib, Sept. 22d, 2 P. M., 61,000B.
68th St., Sept. 22d, 11:15 A. M., 44,000B.
Two mile crib, Sept. 28, 10:45 A. M., 11,300B.
Lake View crib, Sept. 28, 12:15 P. M., 3,100B.
Two mile crib, Oct. 11, 12:15 P. M., 1,100B.
Three mile crib, Oct. 11, 11:30 A. M., 1,000B.
Two mile crib, Oct. 19, 11 A. M., 4,400B.

Two mile crib, Oct. 19 11 A. M., 4,400B.

Three mile crib, Oct. 19, 10:30 A. M., 1,100B.

96 Four mile crib, Oct. 26, 11:45 A. M., 90,000B.

68th st. crib, Oct. 26, 12:30 P. M., 157,500B.

68th st. crib, Nov. 9, 11:30 A. M., 3,300B.

Four mile crib, Nov. 9, 11 A. M., 2,900 B.

Sample taken Oct. 11, at the two mile crib and contained organisms of bacillus coli communis—bacillus delicatulus, bacillus fluorescens incognitus; bacillus helvolus; bacillus proteus mirabilis; bacillus pyocyaneus; bacillus stellatus bacillus superficilis; bacillus viridis.

All these bacteria are harmless except the bacillus coli communis—except when injected beneath the skin. It is harmless in the individual except when it goes down into the appendix and causes appendicitis. Mucous membrane of the appendix is very delicate.

97 All these bacteria other than the bacillus coli communis are inhabitants of fresh water, both lake and river. Their presence other than the coli does not indicate the absence or presence of sewage.

Next examination was made on the Drainage Canal at Bear Trap Dam, March 3, and continued daily until October 9, 1900. And from September 26 to November 25, 1901.

There was a very great bacteriological variation or fluctuation in the examinations at this point. It ran from millions of bacteria per cubic centimeter down to a few thousand. This depended on the amount of sewage from Chicago discharged in the canal. 98

During the first period of time above stated, this examination disclosed the presence of coli bacillus. This bacteria was found in 87 per cent of the samples collected.

In March, 1900, it was found in 72% of the samples. May, June and July, 87%. Aug., Sept., and October, up to the 10th, 100%.

From Oct. 5, to 27, 1901, 81.2%.

Made a microscopical examination of the waters of the canal at this point. Samples were submitted to Mr. Johnson and to Mr. George C. Whipple, of New York.

We separated out a number of micro-organisms at these different periods. Inasmuch as bacteria belongs to the vegetable kingdom, we speak of the bacteria found in water as
99 the basterial flora of that water. It means the class of schizomycetes, order thelophyta.

Four sets of ten organisms each and 80 at another time, were found at Bear Trap Dam. Sets of samples were collected Sept. 16, May 31, June 14, and July 9, 1900. Eighty organisms were isolated from the water during the months of October and November, 1901.

Second investigation was from March 3, to Oct. 11, 1901.

Following is water taken from the Chicago Drainage Canal before the water passed over the Bear Trap Dam at Lockport, Illinois. (See table.)

"Not found," and "absent" means the same thing; it
107 means that in examining a quantity of water that we did not detect the presence of the bacilli. It does not mean that it was not there, but it means that they were unable to find it.

An examination of a biological character, of the water in the Des Plaines river at McDonough street bridge, Joliet, which is in the body of the city. Some of the sewage from the penitentiary and from the iron works comes in above this point. This was made from March 3d, until October 24, 1900.

The bacillus coli communis was found in 73% of the
108 samples collected daily at McDonough street bridge in the five months, March to July, inclusive. This organism was found in 64% of the examinations made. In August 78%; Sept. 1st to October 9th, inclusive, 99% of the time.

The third period, or the Ruby street bridge, 83.3% of the time, and at Brandon's bridge, also in Joliet, 79.2% of the time. That was in the third period.

The third period extended to Oct. and Nov., 1901.

109 The results March 3, at Des Plaines river, McDonough street, Joliet. (See table.)

114 On the 17th of Oct., determination made, 16,000 coli present; Oct. 24, 146,000 coli present.

115 Made examination as to the bacteria flora and located 17 distinct species—isolated, as follows:

Albus; aquatillis, sulcatus No. 1; aquatillis sulcatus No. 5; cloacae; coli communis; delicatulus; fleuresens tenuis; helvolus; iridescens; lacti viscosus; liquefaciens; ocracous; proteus mirabilis; proteus zenkeri; stellatus; superficialis sarcina lutea.

These were found during the investigation of 1900. Next point material was collected was at Peoria, above Peoria, 120 miles from Joliet.

116 Peoria is on the Illinois river, which is formed by the joining of the Des Plaines and Kankakee rivers at a point 23 miles below Joliet. At La Salle, 102 miles below Chicago, the Vermilion river comes in and the Illinois and Michigan canal. Investigation was made at Averyville, below Peoria.

118 There was a great variation as to the number of bacilli at Peoria. They seemed to fluctuate somewhat during the seasons, to very high numbers at the Bear Trap Dam. There seems to be a perceptible rise in the number of micro organisms at Peoria at this period. Coli bacillus was found in 75% of the daily tests made. Samples were taken in the stream where the current was running fastest. This was the second period

119 beginning January 23, 1900, to October 9, 1900. (See Table.)

126 Examination made at Grafton, Illinois, 163 miles below

127 Peoria. From January 23, to October 9, 1900, two miles above Grafton. (See table.)

134 Bacterial flora of the Illinois river just above Grafton, Illinois—species: (See Rec. 134.)

Quantitative examination of Mississippi river, 3 miles above Grafton. (For result see table and Rec. 135.)

143 Bacterial flora of the Mississippi river just above Grafton, Ill.

144 Samples taken from Mississippi river, one mile above Alton, below the mouth of the Illinois river.

Coli bacillus was found in 52% of the tests made for it in this period.

Result of quantitative examination of waters of Mississippi river at above point. (See table and Rec. 145.)

Bacterial flora found in the Mississippi river one mile above Alton.

Hartford is in Illinois, 7 miles below Alton and one mile
153 above Missouri river where it empties into Mississippi.

Bacteriological examination made at Hartford, Illinois. A boat was sent out in the middle of the stream and samples collected. Coli bacillus was found in 61% of the daily samples collected. This is a slight increase over the average in which this organism was found at Alton—52% at Alton and 61% here.

The results of the quantitative determination of bacteria in the Mississippi river opposite Hartford, Illinois, together with the results of tests for the bacillus coli communis, was as follows: (See table. Also Rec. 153.)

Bacterial flora of the Mississippi, opposite Hartford, Illinois, 1900.

161 Bellefontaine is situated on the Missouri river, six miles above the mouth, on the Missouri shore—the south shore. Result of examination made there is as follows: (See table and Rec. 161.)

168 Bacterial flora of the Missouri river opposite Bellefontaine, Missouri, covering the period from January 24, to October 25, 1900, as follows:

Three separate examinations were made at the Chain of Rocks, known as the Missouri shore, the intake, and the Illinois shore. Missouri shore was taken about 300 yards from the shore in the channel on the Missouri side of the stream.
169 The intake sample was taken from a boat out in front

of the intake, just above it. The third sample was taken in a line with it over toward the Illinois shore.

Bacilli coli communis was found in 58% of the daily samples collected at the Missouri shore.

Following is result of the quantitative determination of the bacteria in the Mississippi river water near the Chain of Rocks near the Missouri shore, together with results for the tests of the bacillus coli communis—bacteria per cubic centimeter: (See table and Rec. 170.)

175 Bacteriological character of the Mississippi river water at the Chain of Rocks near the Illinois shore, about 300 yards from the shore, in the channel. The coli bacillus was found in 68% of the samples collected at this point during this period. (See table and Rec. 178.)

186 Coli bacillus was found in 62% of the daily samples taken at the intake at the Chain of Rocks.

Bacteriological examination of the water is as follows:

194 Bacteriological flora of the Mississippi river at the intake tower:

195 Samples of water were collected for analysis from basin No. 3, the water having rested 70 hours. This basin has a capacity of 29,000,000. Quantitative determination of sample from reservoir, Chain of Rocks, varies somewhat. Each reservoir has a capacity of 29,000,000. There are six of these basins.

Average number of bacteria in samples collected during the second period was 56% of the number found in samples collected at the intake tower. 44% of the bacteria in the water taken into the reservoir, therefore, were removed by this

196 70 hours subsidence—by this sedimentation. We don't care to say anything about the third period at all.

When the water goes into these reservoirs it is not absolutely quiescent, but it is the water flowing from one end of the large reservoir to the other in 70 hours. The only movement of the water is that caused by it flowing into and on through the reservoirs. The time it is in transit across the reservoir would be about 70 hours.

When I refer to the intake tower, I refer to samples taken just above the intake tower. At that point the coli bacil-
197 lus was found in 65% of the daily samples collected. That is inside the tank in the reservoir, after 70 hours sedimentation. Results of quantitative determination of bacteria in samples of water collected from the reservoir at Chain of Rocks, as follows: (See table and Rec. 197.)

204 Water was collected at the old city hall, from a tap. The city hall is on 11th street, between Market and Chestnut streets. It gets its supply from these reservoirs.

Water from the Mississippi river at the Chain of Rocks passes through the settling basins, then through an 11 foot conduit to the high service pumps at Baden, which is situated 4½ miles from the Chain of Rocks. Then it is pumped into
205 the stand pipe located at Compton Hill reservoir, and distributed to the western part of the city, while the remainder flows through a 9 foot conduit and empties into four reservoirs at Bissell's Point. Each reservoir has a capacity of 15,000,000 gallons, and while the actual periods of subsidence of the water in these reservoirs can not be ascertained definitely, it is stated to be three or four days on the average. No samples were collected from these basins. We did that in the later period. From these reservoirs the water passes into the distributing system of the city. The water is turned into the stand pipes at the foot of Grand Avenue, and distributed to the eastern part of the city in which the old city hall is located. That is the low service pumps.

It is 3 miles from the city hall, as the crow flies, to Bissell's Point, and from there it is here recorded, the distance, I just gave you, 4½ miles from Baden, and so many miles from Chain of Rocks. This is northwest of the city.

During this period the average percentage removal of bacteria, found on comparing the results obtained from samples collected at the intake of the St. Louis water works, Chain of Rocks and the tap in the bacteriological department of the old city hall, respectively was 90 per cent.

206 That is 90 per cent of removal from the intake between those points.

The bacillus coli communis was found in 71 per cent of the samples collected during the period from May 1st to October 31st, 1900.

Results of quantitative determination of bacteria and results of tests for bacillus coli communis from samples taken at the old city hall, 11th and Market streets, beginning May 11, when we moved into this laboratory, together with the results of tests for bacillus coli communis per cubic centimeter:

(See table and Rec. 206.)

211 Bacterial flora of water taken from the tap of the bacteriological laboratory, old city hall, St. Louis, Missouri, May to October, 1900.

In July, 1901, a motion was adopted by the Municipal Assembly ordering a third investigation of the city water
212 supply to be taken. This period of investigation embraced the work done between August 26 and December 1, 1901.

Temporary bacteriological laboratories were established and equipped with the necessary apparatus at the following points:

First, at Joliet, Illinois, 306 N. Joliet st., under Dr. W. C. C. Kirchner.

330 Second, Y. M. C. A. bldg., Peoria, Illinois, Dr. Wm. H.
386 Rush in charge.

Third, at Grafton, Illinois, in the Dempsey House. Mr. Leon G. Tedesche, in charge.

1141 Market st., St. Louis, with 5 assistant bacteriologists, under charge of witness.

Samples were collected from the following points:

Des Plaines river, above Lockport, from October 5, to November 25, 1901. That sample was collected about two miles up the river, above its junction with the drainage canal so there would be no backwater in it.

213 Drainage canal, Bear Trap Dam, above dam, September 25, to November 25, 1901.

I. & M. Canal, 9th St. Bridge, Lockport, Illinois, September 25 to October 30, 1901.

Drainage canal, 9th St. Bridge, Lockport, Illinois, October 2 to November 26, 1901.

Drainage canal below Rubey St., Joliet, September 25 to November 26, 1901.

Drainage canal, Brandon's Bridge, Joliet, September 25 to November 26, 1901.

Illinois river, what is known as Shady Beach, about 3 miles above Peoria, Illinois, October 1 to November 27, 1901.

Illinois river, above railroad bridge, Pekin, Ill., October 1 to November 27. This station is five miles below the lowest Peoria sewer.

Illinois river, Kingston, 3 miles below Pekin, Ill., October 4 to November 27, 1901.

Illinois river, 3 miles above Grafton, Illinois, October 4 to November 27, 1901.

Mississippi river, two miles above Grafton, Ill., October 4 to November 30, 1901.

Mississippi river, one mile above Alton, Illinois, October 5, to November 30, 1901.

Mississippi river, opposite Hartford, Illinois, October 5, to November 30, 1901.

214 Missouri river, opposite Ft. Bellefontaine, October 4, to November 30, 1901.

Mississippi river, Chain of Rocks, near Illinois shore, September 14 to November 30, 1901.

Mississippi river, Chain of Rocks, near the Missouri shore, September 14 to November 30, 1901.

Mississippi river, intake tower, September 14 to November 30, 1901.

Reservoir at Chain of Rocks, September 15 to November 30.

Reservoir, Bissell's Point, September 16 to November 30.

Tap laboratory, 1141 Market st., St. Louis, September 17 to November 30, 1901.

Tap, residence, 5946 Garfield avenue, Oct. 2 to November 30, 1901.

Seven samples were collected at La Salle, Ill., from the Illinois, and 24 at Beardstown, Ill. Both samples were sent to Peoria, packed in ice for analysis.

Mr. Randolph, chief engineer of the Sanitary District, constantly spoke to me of the Des Plaines river between Lockport and Joliet as being the canal—the drainage canal.

215 Des Plaines river at Lockport, 2 miles above its junction with the drainage canal water, there were forty samples taken.

Drainage canal, Lockport, above Bear Trap, 52 samples were collected.

216 Illinois & Michigan Canal, Lockport, 9th st. bridge, 34 samples.

Drainage canal, 9th st. bridge, Lockport, 41 samples.

Drainage canal, below Rubey st., Joliet, 6 or 7 miles from 9th st. bridge, 51 samples.

Drainage canal, Brandon's bridge, 49 samples.

Brandon's bridge is 40 miles below this Rubey street sample, so that would be about 12 miles from the drainage canal.

Illinois river, Shady Beach, above Peoria, 54 samples. That is 120 miles down the river. About 3 miles above Peoria.

Illinois river, above railroad bridge, Pekin, Ill., 57 samples. It is ten miles from the center of Peoria to the center of Pekin. It is five miles below here—below the last sewage discharge from Peoria into the Illinois river.

217 Kingston, 3 miles below Pekin, 55 samples.

Illinois river, three miles above Grafton, 56 samples.

Mississippi river, 2 miles above Grafton, 56 samples.

Mississippi river, 1 mile above Alton, 52 samples.

Mississippi river, opposite Hartford, 51 samples.

Missouri river, opposite Ft. Bellefontaine, 55 samples.

Mississippi river, Chain of Rocks, Illinois shore, 74 samples.

Mississippi river, Missouri shore, 72 samples.

Mississippi river, intake tower, 70 samples.

Reservoir, outlet screen chambers it is called, Chain of Rocks, 75 samples.

Outlet screen chamber is located about the middle of the end of the reservoir, facing south, and the water discharges out of this hole in the wall through a screen, and consequently they call it the outlet screen chamber. About 300 or 400 feet
from the Mississippi river.

218 Bissell's Point, 72 samples.

Tap laboratory, 1141 Market st., 69 samples.

Tap, 5946 Garfield avenue, 59 samples.

Illinois river, La Salle, 7 samples.

Illinois river, Beardstown, Illinois, 24 samples, making a total of 1,215.

The work during this period was done under my supervision.

Samples collected from the canal at Lockport and the river at Peoria were taken at once to the laboratory, placed on ice and plated without delay. This is true of all of these samples that were collected at points where laboratories were established. In St. Louis a room was secured from the water commissioner at the Chain of Rocks pumping house, and there the samples were collected in the river for the Chicago experts—a Chicago and a St. Louis bacteriologist, at the same time and place, brought ashore and both bacteriologists plated in this same room, so they were plated immediately there when they came ashore. Facilities were furnished by the city at time of taking these samples. I believe Chicago paid for some of the
heat.

218 The samples were just brought to the laboratories of both
parties, brought to 1141 Market st., by Mr. Damon, who did this plating at the laboratory of the Chicago expert, some-

where on Locust street, both going in and out together.
219 These samples were collected by both parties at the
same place—they went out together. They were collected with an apparatus designed by myself in wide mouthed, sterile flasks, at 3 feet below the surface. Same manner and same apparatus were used as were used in second period. The temperature of the water and air were taken at the same time with a thermometer that was a part of the apparatus; 2,325 samples were collected at the various points noted above, and analysis for quantitative determination of bacteria and tests made for bacillus coli communis.

We also investigated the bacterial flora of the water. Besides that a systematic study of the flora was made by an expert microscopist, Mr. George C. Whipple, of Brooklyn, N. Y.

We separated out eight sets of ten organisms each—separated out in pure culture, and 80 organisms in each station.

The sample collected once or twice a weak, was plated according to the method described in the first period, and then ten organisms were selected from that plate, always trying to select an organism that was new to the bacteriologist. He selected the first ten that were familiar to him and the next time he went over that plate he tried not to select any of that same
form, the idea being to try to find all the different species
220 of micro-organisms in that particular water. When a
colony was seen to be different from the others, it was picked out and picked up and thrown on agar agar. If the culture proved to be a pure one, then it was shown in a variety of media to detect it, to ascertain its cultural characteristics.

The results were recorded on a chart that was original with our laboratory. Then those charts, 300 of them, some 30 different varieties of media, were used.

Experiments in this period were carried on in the same manner and according to the same rules laid down for the first
period.
222 Result of examination above Bear Trap Dam drainage

canal, Lockport, Illinois, beginning September 26, as follows: (See table and Rec. 222.)

224 Illinois & Michigan canal, 9th street bridge, Lockport, Illinois. I took some samples from this canal to see what were the numbers in that also, because the Chicago sewage is being dumped into that from the south fork of the Chicago river. This is not the Chicago Drainage canal.

Results are as follows: (See table and Rec. 224.)

225 Quantitative determination of bacteria per cubic centimeter and the detection of the bacillus coli communis in the Drainage canal, just below Rubey street, Joliet—it is really the Des Plaines river. (See table and Rec. 225.)

227 Des Plaines river, Brandon's bridge, below Joliet, beginning September 26, as follows: (See table and Rec. 227.)

228 Des Plaines river two miles above the conjunction, with the effluence of the Chicago Drainage Canal. (See table and Rec. 229.)

230 Drainage canal and Des Plaines river at 9th street bridge, Lockport. (See table and Rec. 230.)

230 Drainage canal, 9th street bridge, Lockport. (See table and Rec. 230.)

231 Coli communis was found in 73 per cent of the samples collected daily at McDonough street, Joliet. That was in the second period we have just mentioned. That was given day before yesterday.

At Rubey street, 83% of the samples. That is the Des Plaines river at Joliet and at Brandon's bridge in 79% of the samples examined.

232 The next examination made, the laboratory was established at Peoria in the Y. M. C. A. building, and a few samples were collected at La Salle, in the Illinois river, and samples taken daily from the river at Peoria. These examinations were made immediately and they came to the laboratory immediately and were plated. That was at Peoria, below Peoria, at Pekin, and at Kingston, and further down, Beardstown,

samples were collected and sent back to the Peoria laboratory encased in ice.

At Grafton they were plated and examined right there.
233 The coli bacillus was found in October, 1901, in 87.1 and in November 79.1 per cent above Peoria at Shady Beach.

Quite a number of rivers enter into the Illinois river between Joliet and Peoria. The distance between Joliet and Peoria on the Illinois river is 120 miles. We have the Du Page, forming with or joining the Des Plaines river to form and join the Kankakee. The Fox comes in from the north, and the Vermilion from the south. I have viewed all these rivers but the DuPage. From Mr. Harmon and Mr. Cooley's figures I
234 find during the low water stages of October, 1889, the Des Plaines flowed per cubic feet per second, 13.21; the DuPage 32.77; the Kankakee, 509.24; the Fox, 329.95. He has the Vermilion marked here, 4, which is wrong because the Vermilion is a very much larger river than the Des Plaines.

At this particular time last year when this examination was going on, the water was particularly stagnant and very little water flowing out of it. That is out of the canal, the I. & M. canal, into the Illinois river.

235 The samples collected at La Salle were packed in ice, after being collected with the apparatus which is described, by a man employed there, collected above the point of discharge of the I. & M. canal into the Illinois river, so as not to have the effluence of the I. & M. canal mixed with this water. They were at once shipped to Peoria by express and examined there as soon as it arrived.

Water from Shady Beach, three miles above Peoria, was immediately carried to the laboratory in the Y. M. C. A. building at Peoria. Pekin sample was carried directly to the laboratory at Peoria.

Result of examination made at La Salle is as follows:
236 October 28, 1901, 7,500 coli present.
October 29, 16,500, absent.

November 15, 9,000.

Coli tests not made in the November samples at this point.

November 16, 38,000.

November 17, 19,500.

November 18, 13,500.

November 21, 68,500.

Three miles above Peoria, the results of the examination were as follows: (See table and Rec. 236.)

238 Pekin bridge, Pekin, Illinois. These samples were taken to Peoria on the same day. There is a street car that runs from Pekin to Peoria.

This is five miles below the Peoria sewage. It is above Pekin. It is above the railroad bridge, in the channel at Pekin, Illinois. (See table and Rec. 238-239.)

240 At Kingston, in the channel, three miles below Pekin. The sample was obtained and the test made at Peoria, traveling by train, a few minutes after being taken it was plated.

These samples were taken well below Kingston. The river was low during this time and a man drove down in a buggy as far as he could drive and collected his sample.

Results were as follows: (See table and Rec. 241.)

242 At Beardstown the sample was taken in the river above the town, right out in front of it. The samples were packed in ice and shipped to Peoria where they were examined in the bacterial laboratory by Dr. Rush. It would take but a short time to get the samples to Peoria, Beardstown being a couple of hours by train. Most always made the same day. I didn't superintend that part of it. But I saw it was working right. I had general charge of it traveling up and down from those points.

243 Result of that examination was as follows: (See table and Rec. 243.)

244 Next examination was made at Grafton. A laboratory was established in the Dempsey House, under the charge

of Mr. Leon G. Tedesche. Grafton is about 160 miles below Peoria.

245 In October, 1901, the percentage of coli bacillus found in the samples was 53.6—for both November and October, 53.6.

For October, 1901, the coli was found in 53.6% of the cases, and for November, 29.17% making an average of 45%.

These samples were taken and examined the same day. The laboratory was three miles from the place of taking on the Illinois.

They were taken in the middle of the stream, in the current, three feet below the surface, with this same apparatus I have testified about, and the same precautions were used and the same instruments were used.

246 The results were as follows: (See table and Rec. 246.)

247 Next was an examination of the waters of the Mississippi river two miles above Grafton, in the channel of the river, selected the same as the water selected in the Illinois above Grafton, with same apparatus and precautions.

The results of the examination were as follows: (See table and Rec. 248.)

249 In October, the percentage of instances in which the coli was found in the Mississippi river above Grafton was 33.33; for November, 62.50; total per cent 47, for two months. Those two rivers run very uniformly.

Samples were taken at Mississippi river, at Alton, one mile above Alton; Mississippi river at Hartford, Illinois; Missouri river, Ft. Bellefontaine; intake tower, Chain of Rocks; Illinois shore, Chain of Rocks; Missouri shore, Chain of Rocks; outlet screen chamber reservoir, Chain of Rocks; outlet
250 stream chamber; basin, Bissell's Point; tap in city chemist's office, 1141 Market st., tap at 5946 Garfield avenue.

First samples of water during this investigation were taken at the intake tower, beginning at St. Louis, September 14 and from that on until November 30. The samples from the Missouri river at Ft. Bellefontaine, Mississippi river at Hartford, and Mississippi river at Alton, began October 4, October 5, October 6, rather, for Hartford, Illinois; and October 5, for Alton.

One mile above Alton, began on October 5, 1901, taken in the channel of the river, from a boat, taken ashore and brought back to St. Louis, carried there by the collector, the same day they were collected. Collected at ten o'clock and arrived at the laboratory about two, packed in ice, and plated at once.

The results were as follows: (See table and Rec. 251.)

252 Mississippi river at Hartford, Illinois, which is six or seven miles below Alton and one mile above the mouth of the Missouri river where it empties into the Mississippi. Hartford is 6 or 7 miles below Alton. These samples were sent to St. Louis. They reached the laboratory about 2 o'clock and plated immediately.

The result of the investigation was as follows: (See table and Rec. 253.)

255 Missouri river at Ft. Bellefontaine, six miles above the mouth of the Missouri where it empties in the Mississippi. Commenced taking samples October 4. Collector got the sample about 10 o'clock in the morning, reached the laboratory about two o'clock—between noon and two o'clock.

Results were as follows: (See table and Rec. 255.)

257 At the intake, Chain of Rocks, a cross session was taken by drawing a line across the river from shore to shore through the intake. The intake sample was taken in front of the intake tower anywhere from 100 to 300 feet in front of it, as the man rowed across the river. The first sample was taken 300 yards from the Missouri shore, and the third sample from the Illinois shore, 300 yards from the shore in the channel. The samples were taken ashore and plated immediately, and
when the plates were hard were carried to the bacteri-
258 ological laboratory at 1141 Market st., and there incu-
bated, and counted when ripe.

We will begin with the Missouri shore sample, 300 yards from the Missouri shore, just above a line drawn through the intake. You see it is impossible to get a sample below there because it is rocky—a chain of rocks has been thrown out into the river to deflect the water away from the shore, so it would be shallow water below the chain of rocks; consequently the samples were taken above the Chain of Rocks, where the water was deep.

The results were as follows: (See table and Rec. 258.)

259 Missouri shore, Chain of Rocks, result was as follows: (See table and Rec. 259.)

260 Illinois shore, Chain of Rocks, the result was as follows: (See table and Rec. 261.)

263 At the intake the samples were taken at the intake tower from 100 to 300 feet above the tower in the river where the river was running fast. This was not taken from the intake tower itself. The intake tower is 1,500 feet from the shore, and the samples were taken in the channel in front of it. It is difficult to take a sample in a tower, because the water is pouring into it from all sides, and it is very difficult for a man to get down there.

The results were as follows: (See table and Rec. 263.)

265 Outlet screen chamber, Chain of Rocks is in the reservoir, after 70 hours rest in the reservoir. It compares about the same with a year ago, or a little bit better during that time. I think there wasn't so much bacteria in the water.

Samples were taken from the same place as in period number two. They were taken as soon as collected, to the house or pumping station here and plated immediately. The plates were put into a special apparatus designed by Mr. Damon and carried to the city chemist's office, 1141 Market st., and there incubated and counted afterwards.

Results were as follows: (See table and Rec. 266.)

268 Next samples were taken from the water in the settling basin at Bissell's Point—out of the settling outlet where the water was flowing out into the deep well that they have there. The results were as follows: (See table and Rec. 268.)

270 At the tap in the city chemist's office, 1141 Market st., the water was allowed to run five minutes before the sample was taken in a steriled flask and plated immediately. The results were as follows: (See table and Rec. 271.)

273 At the tap at 5946 Garfield ave., which was the residence of one of our bacteriologists, Mr. Snodgrass, the water was supplied from the Compton Hill reservoir stand pipe or from the high water service at Baden. It is about four miles directly across there, but you see it first come to the stand pipe and goes back to him, so it must have traveled six miles to the stand pipe and received its pressure there, and then was carried out to this district.

274 It traveled six miles to the stand pipe and about four miles from the stand pipe to his residence. That would be about ten miles.

The samples were brought immediately from the tap to the laboratory where it was plated. The results of that examiation were: (See table and Rec 274.)

275 The percentage of coli at each one of these places was, 1 mile above Alton, Ill., coli for October, 1901, 100%; November, 1901, 77%, making an average of 88.6 of samples collected.

276 Hartford, for October, 1901, 86.4%; November, 56%; average 70%. Hartford is seven miles below Alton.

Bellefontaine, October, 1901, 92.6; November, 1901, 80%; avreage of 86.2.

Missouri shore, Chain of Rocks, September, 76.9; October, 97%; November, 84.6; average for this period is 88.4.

Chain of Rocks, Illinois shore, percentage of coli for September, 1901, 76.9; October, 97%; November, 77%; average is 81.7.

Intake tower, Chain of Rocks, September, 1901, 76.9% October, 90%; November, 77%; average 80%.

Reservoir, Chain of Rocks, after sedimentation, September, 1901, 83.5%—there is something wrong in this typewritten copy here and I will have to go over the results. I will go over those calculations tonight.

277 Outlet settling basins, Bissell's Point, September, 86.4; October, 94.04%; November, 93.8%; average 91.41%.

Tap at 1141 Market st., September, 85.7%; October, 97%; November, 80%; average 87.5%.

Average of bacteria at the Chain of Rocks intake for September, 14 days, is 2,686. This has no reference to the bacilli coli communis. That was at the outside of the intake in the river.

Outlet screen chamber settling basins, Chain of Rocks, after passing through the reservoir, 1,375 is the average, 14 days, after settling 70 hours, or the percentage removal of bacteria is 48.43%. The average for 14 days at Bissell's Point, outlet of the basins, the number of bacteria is 363, or the per centage of bacterial removal after passing through both reservoirs, is 86.05%. That means the loss of bacteria in the one reservoir and before they go out of another; that means 86.05 per cent have been removed to the outlet chamber of the second reservoir, from the intake. Now then, the removal to the
278 tap, 300—the number of bacteria removed per cubic centimeter, average 14 days, is 300. Percentage of removal is 88.83.

October average number of bacteria for the month is 20,500, at the intake in the river. The average number for October in the outlet screen chamber in the settling basin at the Chain of Rocks is 2,975. Percentage removal for this month is 85.6.

Bissell's Point, outlet of the basins, the number of bacteria averaged for the month, 1,137. Percentage removal, 90%.

Average number of bacteria for October at tap 1141 Market st., 843. Percentage removal 95.9%.

Average for month at 5946 Garfield ave., the tap, 412; per centage removal, 98.

November, total number of bacteria found at the intake, average 39,518.

Outlet screen chamber, Chain of Rocks settling basins, November, 7,600. Percentage removal, 81.5.

Bissell's Point, outlet settling basins, average number of bacteria per month, 2,545; percentage removal, 93.5.

Tap, 1141 Market st., average is 2,560; percentage removal 93.2.

5946 Garfield ave. tap, average number for month 2,880. This is more than the other place and I don't know how to account for it except that they were stirring things up in the pipes.

Percentage removal is 92.7, or I can give total percentage lost for those three months, which is 14 days in September all of October and all of November, at the outlet of the seven settling basins, and the outlet screen chamber, Chain of Rocks, 71.84 per cent.

279 Bissell's Point, outlet settling basins, 90%.

Tap, 1141 Market st., 92.64%.

Tap, Garfield ave., 95.3%.

Mississippi river, above Grafton, average number of bacteria per cubic centimeter for October, 1901, 717.

For November, 2,290:

Illinois river above Grafton, for October, 1,780; for November, 3,050.

MR. JEFFRIES: Now give us the result of the cultural and bacterial features of the bacteria found in the Illinois river, the Mississippi river, the Missouri river, Lake Michigan 280 and the Canal—that is the Chicago Drainage Canal during the second period from January to October, 1900.

A. Now this is a chart original with this laboratory, presenting the morphological, cultural and biochemical features of the micro-organisms found in the waters of Lake Michigan, the Chicago drainage canal, the Illinois river and the Mississippi river at the intake.

The bacteria here are classified into types according to the colors which they produce upon the media, or certain other characteristics by which they can be confined to groups, distinctive groups, and the morphological, cultural and biochemical features which carry it through a variety of media.

We have on the fluorescens type first, the bacillus fluorescens incognitis. The first investigator was Wright—he first discovered it or found it in the water. It is a bacillus, motile, does not form spores. Under cultural feature now: in nutrient broth it produces a scum and the nutrient broth is made
281 turbid by it. In an agar tube it shows a wrinkled membrane.

Gelatine plate colony characteristic, not distinct.

Potato, a luxuriant and visible growth.

Fermentation tube does not produce gas.

Grows best at body temperature.

In gelatine it does not liquefy.

In milk it does not coagulate.

It does not liquefy blood serum.

It does not ferment.

It produces no gas.

Does not reduce nitrates.

Does not produce indol.

Again it does not coagulate milk.

Is chromo-genic on nutrient agar, and it produces fluorescens of the media.

Body temperature is a negative temperature, 98 3-5 or 36½ centigrade.

By developing I mean it grows best on our nutrient media, more vigorous in a definite period of time.

282 We have two words in bacteriology, aerobic and anaerobic. Aerobic bacteria grow best in the presence of oxygen. The an-aerobic bacteria grow best in its absence. Now there are classes of micro-organisms that grow under both conditions. They grow nearly as well under an-aerobic conditions as they do under aerobic conditions. Since they have this faculty of doing this thing they are called facultative an-aerobic

of facultative aerobic, depending upon which condition they grow best.

Indol is one of the products, one of the putrefied products of the result of destructive composition or the destructive action of bacteria upon organic matter.

307 Under the head of morphology we have here the question of the form of the micro-organisms—bacillus meaning a rod, and it is marked here either positive or negative. If it is bacillus positive, it is marked with a cross—positive; if in any other form than bacillus, it is marked negative, with a minus sign.

The next under morphology comes the diameter greater than 1M. "M" is for the Greek word Micron and micron is one 1-1000 of a millimeter, or 1-25,000 of an inch, so that a
308 micro-organism here recorded will be larger or smaller than 1-25,000 of an inch, according to this chart.

Then comes motility. A micro-organism may be motile, that is, swim about, or it does not do so.

Under morphology comes the word spore which means that these micro-organisms contain within themselves bodies for the preservation of the species, so that the chart is marked positive and negative whether it be present or absent.

Under cultural features are the growth characteristics, with the certain nutritive media which will be named as we approach them.

Nutritive broth, that is nutritive broth as will be described, in test tubes, and into that the micro-organism is sown. Now it grows in that medium or it does not grow, and it grows in a certain way. If it grows in the medium making a cloudy condition in the medium that is recognized as turbidity. Then if the micro-organism grows out on the surface of the medium, forming a pellicle or membrane on it, it is called a scum and here so recorded. And if it is either one of these it is marked positive and if neither one, negative.

Under cultural features also comes nutrient agar-agar, of a definite percent in nutrient broth. This material is a solid medium and is slanted in the tube, and on the surface of that medium is sown the micro-organism in pure culture. Now the micro-organism grows and whether it grows with a dull growth, it is practically not transparent or translucent, and if the growth be wrinkled, it is so recorded here. If it does neither one, it is marked negative. If it grows dull or wrinkled, it is so marked.

The third feature is growth in gelatin plate. The micro-organism in pure culture is plated as described, generally in a petri dish, and this allowed to grow at 20 centigrade or about 60 degrees Fahrenheit. The growth that occurs here is called a colony which is a growing out of the micro-organisms into
numbers sufficiently large to be seen either with the un-
309 aided eye or with the microscope. The colony has cer-
tain characteristics. These are marked as its appearance
is characteristic or as it is not characteristic.

309 On potato, that is a potato cut into cylinders and then
crosswise, so as to slant, it making a surface upon which growth can be easily made. Upon the steriled potato then is sown this micro-organism and the micro-organism grows either with visible growth or with invisible growth, and the growth is luxuriant or not so.

Under cultural features we have fermentation tubes. Now the question is whether a micro-organism in this fermentation tube, which is a "U" tube, grows in the closed arm or not. The heating of media in these fermentation tubes dries the air out of it, so that the medium in this closed arm is practically free from air, consequently a strictly aerobic or so called obligatory aerobic will not grow in that arm, while one that is facultative, or has the faculty of growing in the absence of any oxygen will grow.

Then we come to the biochemical features we have here recorded, growth at body temperature. Now the micro-organism is sown upon agar-agar as a rule, and kept at the incubated temperature of the body, that is 98 3-5 degrees Fahrenheit, or 36½ degrees centigrade, or it is kept at 20 degrees entigrade, which is the ordinary temperature of about 60 degrees Fahrenheit.

Now, at which of these temperatures it grows best is here recorded, so that if it grows at body temperature—if it grows at that temperature best, it is marked positive. If marked negative, it does not grow that way best, while at that temperature. It does not mean that it does not grow at all, but that it does not grow so well as it does at the temperature below.

310 Affected by range of reaction, that was omitted in my testimony this morning, that means whether it grows in the presence of alkali, neutral or in the absence of an alkali or acid. We have first a medium alkaline to phenol phtalein 1.5%. Now in making up these tables I did not record that fact and that was omitted in my testimony this morning.

A second medium neutral to phenol phthalein, and a third acid, 1.5 per cent to phenol phthalein. Upon these three media the micro-organism is sown and the luxuriancy with which it grows indicates the reaction at which it best grows, alkaline, acid or neutral.

Under biochemical we have liquefaction, and we have first liquefaction of gelatin. Some micro-organisms have the faculty of digesting gelatin and liquefying it, and this is so recorded. It either liquefies or it does not liquefy. That is quite a cultural characteristic of these organisms, of most of these organisms.

The next feature is casein. The word "casein" is next used, which is the cheese of milk. Some micro-organisms have the faculty of growing in milk, precipitating the casein and reducing it to a liquid, others have not, so that is recorded.

The micro-organism is sown upon blood serum collected and sterilized in test tubes with the slanting surface, and kept at room temperature for 12 days, and if the micro-organism liquefies that blood serum, it turns it to a fluid, it is so recorded. If it does not do that, it is so recorded, positive or negative.

Dextrose broth—that means a nutrient broth prepared as we will show, with one per cent of dextrose, sugar, added to it. Now that is put in a fermentation tube and the micro-organisms inoculated into it. If these micro-organisms break up the sugar so as to form a gas in the closed arm of the tube, we speak of that as gas production, and it is marked positive. If it does not produce gas it is marked negative.

In the reduction of nitrates, a nitrate broth is made up
311 and in it the micro-organism is sown, nitrate broth I
should say, and if it reduces the nitrates to nitrites why that is so recorded, positive and negative.

Under the biochemical feature next is indol production. It is the result of destructive action of micro-organisms on organic matter. It produces a peculiar odor, a fetid odor, and whether it produces it or not, it is so recorded.

In milk sterilized in tubes, the micro-organism is sown. Now whether it coagulates the milk or not, it is so recorded, if it makes cheese. Then upon the nutrient agar-agar slanted in a tube, the micro-organism is grown, and whether it produces a color upon the medium or not, that is whether the bacterium itself has a color within its cell walls, that is spoken of as chromo-genesis, or pigment production. Fleurescent means that the toxines or whatever it may be which is produced by the micro-organism, colors the medium. The color does not remain within the micro-organism as impigment production, but it gives off a material which colors the medium itself. Then we have fleurescent coloration.

This chart is reproduced as Abstract Table No. 2 and will be found at end of this volume.

What I have testified to in reference to the bacterial qualities of this water in the forenoon and this afternoon is the result of practical experiments with the water under my supervision. Samples were collected from January 23 to October

11, 1900. Every micro-organism was separated out upon a gelatin plate which seemed to be different from the other micro-organism, and was first, after the agar-agar culture was obtained, sown in broth and its form and motility recorded from that. You see the bacterium undergoes three different transfers from the genatin plate to agar-agar, to get a good
312 growth of it, and then into broth so as to get as nearly as possibly constancy of form under these new conditions, and then here are recorded motility, size and form, and whether it contains spore or not and from this culture, if pure, all other cultural media was inoculated and recorded after a definite period of time. We were looking for constance of form and optimum reaction, and then recorded the results in books and then charted out as here shown.

In the sanitary examination of water there are several procedures, first the physical aspect of the water, that is, testing its temperature, its color, its turbidity, its sediment, its odor, hot and cold, that is the physical appearance. Then we have the chemical examination for the organic and inorganic constituents in the solution, and then the microscopical examination for the lower and higher forms of animal and vegetable life. Under the microscopical examination we have two kinds of examinations that will here be presented, first, the larger forms, what is known as the floating matter in the water, the animal and vegetable life, and known as plankton from planktos, the Greek meaning wandering. Then we have the so called bacteriological examination of the water which is an examination of the lower forms of vegetable life.

The history and method of microscopical examination of water is as follows: (Rec. 312.)

315 The samples of water for microscopical examination for Lake Michigan were collected first, July 23, from the four mile crib; next July 30, from the Carter Harrison crib, this is 1900. The third sample was collected August 9, ten miles out fro mthe Chicago shore. The fourth sample was

316 collected September 7th from the Lake View crib, and the fifth sample September 15th, from the two mile crib.

From the four mile crib the result is as follows: (Rec. 316.)

Carter Harrison crib July 30. (Rec. 517.)

Samples collected ten miles from shore, August 9, the result was as follows: (Rec. 318.)

Sample September 7, from Lake View crib, was as follows: (Rec. 319.)

From two mile crib, September 15th, as follows: (Rec. 320.)

Result of microscopical examination of the discharge of the Chicago Drainage Canal before it passes over the Bear Trap Dam at Lockport, Illinois, on dates named: (Rec. 321.)

Des Plaines river at Joliet on dates named. (Rec. 331.)

These samples were all collected at the same place as the bacteriological samples for this 1900 period.

Microscopical examination of the Illinois river two miles above Peoria, Illinois, taken out in the channel three feet from the surface. (Rec. 334.)

Microscopic examination of the Illinois just above Grafton, Illinois. Three miles above Grafton, as follows: (Rec 339.)

Mississippi river two miles above Grafton, as follows: (Rec. 342.)

Mississippi river one mile above Alton. (Rec. 344.)

Hartford, Illinois. (Rec. 346.)

Intake tower, St. Louis water works. (Rec. 349.)

353 This chart is a graphic representation of the number of micro-organisms found in the Illinois river at Grafton. It is a weekly estimation taken from the daily numbers in samples obtained of numbers of bacteria in samples obtained at this point, beginning January 23, in the year 1900 to October 9th. (Rec. 353.)

Mississippi river at Grafton, two miles above Grafton. (Rec. 355.)

Mississippi river at Alton, Illinois. (Rec. 356.)

Mississippi river at Hartford, Illinois: (Rec. 358.)

Mississippi river at Ft. Bellefontaine: (Rec. 359.)

Missouri shore, Chain of Rocks: (Rec. 360.)

Missouri—Illinois shore, Chain of Rocks: (Rec. 361.)

Intake tower, Chain of Rocks. In the river about one hundred feet in front of the tower, up the river: (Rec. 362.)

Outlet chamber, reservoir, at Chain of Rocks: (Rec. 363.)

Tap, laboratory at old city hall, 11th and Chestnut sts: (Rec. 364.)

Map received in evidence and marked complainant's exhibit No. 1: (Rec. 364.)

365 (Referring to complainant's Exhibit 1.)

This chart shows the bacteria per cubic centimeter. The numbers recorded perpendicularly along the profile lines. The weekly averages have been obtained by adding the bacterial contents, obtained from samples collected daily, dividing by seven, which gives the weekly averages. These weekly averages are recorded, beginning January 23d, and ending October 9th, 1900. They are recorded for the Illinois river at Grafton, Illinois; the Mississippi river at Grafton, Illinois; the Mississippi river at Alton, one mile above the town; the Mississippi river at Hartford, seven miles below Alton; the Missouri river at Ft. Bellefontaine; the Missouri shore, Chain of Rocks; the 366 Illinois shore, Chain of Rocks; the tap, bacteriological laboratory old city hall, beginning May 8th, ending October 9th, 1900.

We make a comparative estimate beginning with the weekly averages at Grafton from January 23d to 30th, and compare it with each one of these elevations upon this chart for the individual stations where the samples were collected. The result is as follows: (See table "Abstract" and Rec. 366.)

376 This map indicates that the water of the Illinois comes into the Mississippi, so far as can be ascertained from the bacterial contents of the stream taken in the center of the river, we show a mixture both at Alton and at Hartford.

This is also a comparative estimate of the waters, of the cross section of the stream, Missouri shore, intake, Illinois shore, as you see here, show that quite often there is an intimate mixture at the intake of the waters of the three rivers, that is bacteriologically as is indicated on the two sides of the intake.

The waters of the Mississippi river and the Missouri river commingle at the intake, at times they do markedly, that is estimating the number of bacteria.

377 From memory I remember that the Illinois river was high from February 12, to 20, 1900. I know that the Mississippi river was covered with ice at the time and it was low, comparatively speaking. I know that the Missouri river was covered with ice at the time, and was comparatively low. In fact I know the period of the thaw in the whole Illinois river valley, the river was swept out, in February, 1900.

Beginning in the middle of February and running for a couple of months, all the rivers were high. They had the spring freshets then. That is when the bacteria flows in such enormous numbers, in all rivers.

378 The flushing of streams by the rains and floods increases the number of bacteria in the channels of the rivers.

In the Missouri river there are generally two periods of rise, there is the spring rise, which occurs as soon as the thaws and rains of spring begin, which may be in February or it may not begin until the latter part of March, depending on the weather. Then there is the flooding of the river with the thawing of the ice on the mountains, which generally is in June. The flood tides of the Mississippi are highest in spring. If there should be heavy rains in June there would also be a rise then.

I know that when the Mississippi and Missouri are high, the Mississippi river above the mouth of the intake is high, the flood volume, I don't know at this time from memory.

It shows on this chart, (chart not identified) for the Illinois river, for the week beginning February 13, there
379 was a very high rise in the Illinois river which extends to
the week beginning March 27.

During that period of time that bacteriological examination discloses to me as a bacteriologist that the water from the Illinois and Mississippi rivers was coming into the intake tower.

Here is the period of time at which the Illinois river was flushed. I call attention especially to the dates beginning in the week of February 13, and say extending to the week beginning February 20, during which time the numbers of bacteria in the Illinois river at Grafton were 257,600 and 221,800 respectively, for those two weeks.

The Mississippi river at that time was covered with ice, and the river fairly high. For the week beginning February 6, the number of bacteria in the Mississippi river at Grafton was 46,000, and the week ending February 13, the number of bacteria was 161,000. For the week February 20, at Grafton, Mississippi river, it was 105,500.

For comparison of weekly averages which witness claims shows an increase of bacteria in the Illinois as compared with the Mississippi and the commingling of those waters, see
Rec. 379.

380 I am giving the bacteria per cubic centimeter for weekly
averages, taking a definite period of time, and I show you by the river stages that the Illinois river was high at this particular time and contained enormous numbers of bacteria; that these other rivers were covered with ice, and were low in bacteria.

This chart shows that a mixture of the Illinois and Mississippi river at Hartford, and the mixture of the Mississippi river and the Illinois river and the Missouri river at the intake

That is on the quantitative determination of the numbers of bacteria.

381 This chart, (Exhibit No. 2) is marked "Results showing mixture of the waters of the Mississippi and Missouri rivers at the Intake of the St. Louis water works, bacteria per cubic centimeter for the weekly estimations.

The bacteria per cubic centimeter on the Illinois shore is marked in black; the intake tower is marked red and the Missouri shore is marked blue. The figures on the left hand column indicate the bacteria per cubic centimeter.

The weekly estimates are here marked in black, upon the dates named, in the lower margin of the chart giving January 23, 1900, and extending through until October 2.

(The determination of whether the waters commingle at the Intake and what waters predominate is effected by taking the number of bacteria at the Missouri shore, the number at the Illinois shore and noting how the number at the Intake compare therewith.)

382 Complainant's Exhibit 3 is a chart of the weekly average of the result of quantitative determination of the number of bacteria in samples of water collected daily from the Mississippi river at Grafton, two miles above the town, together with the stages of the river at Missouri shore.

The red indicates the bacteria per cubic centimeter, and the blue represent the stages of the river.

On the left hand side we have the number of bacteria
383 per cubic centimeter, in five thousands, running from
zero up to 250,000. Next to that we have a column bearing the stages of the river in feet running from zero to 25 feet.

My assistant, Mr. Johnson, made this chart, at my direction. This is also true of the chart marked complainant's Exhibit 2.

384 This shows that as a rule, running through here when the river is falling, the number of bacteria decreases

markedly; when the river is rising the number of bacteria run up to great heights.

This table shows that when a river steadies itself and is not washing the surface soil a great many bacteria disappear, not by settling but they are washed into the stream, it simply holds itself steadily, which shows here right straight along.

385 (Complainant's Exhibit 4.) This chart shows a weekly average of the results of quantitative determination of the number of bacteria in samples of water collected daily from the Mississippi river one mile above Alton, Illinois, together with the height of the Mississippi river at Alton, Illinois.

The chart was made from the data collected during the period January 23 to October 9, 1900, under my supervision. The determinations were made in the bacteriological laboratory at the old city hall, and medical department of the Washington University. These figures of stages of the river were obtained from the government meteorological survey. The bacteria per cubic centimeter is arranged perpendicularly, on the left hand margin of the page, beginning at zero and running to 250,000. The figures in relation to the bacteria per cubic centimeter are perpedicular and marked in red. Next to that, in blue, are the stages of the river running from zero to 25 feet.

386 When the river is high the number of bacteria is high. The greatest height of the river is reached on March 13, when it was 16 feet and about 4-10, and the number of bacteria recorded for that week is 312,000 per cubic centimeter.

388 (Complainant's Exhibit 5.) Chart same as above for Mississippi river at Hartford, Illinois.

389 Q. Now what, if anything does the bacteriological examination as disclosed by that chart, show with reference to the rise of the waters of the river and the fall of the waters, and the increase or the decrease in the number of bacteria per cubic centimeter, in the water bacteriologically examined?

A. With the rise of the river we find an increased number of bacteria in the water, and with the fall of the river, as a rule we find a decrease in the number of bacteria; so rising and falling then, as the river rises, beginning at its lowest period, it rises steadily until February 20, when the height of 7.9 feet is recorded; the number of bacteria at that time being 266,700. The river then drops to 5.6 feet in the week beginning February 27, when the number of bacteria dropped to 193,000 or 194,000, and then the river rises rapidly, in great volume, until the week of March 13, when 320,500 bacteria are recorded, as the weekly average; then with the fall of the river the bacteria drop very rapidly. The river falls in the week beginning April 27, to 2.2 feet about. The bacteria in that week fall to 60,000. The river seems to hold itself steadily here, falling until July 10, then there is a slight rise, the bacteria holding themselves steadily in the meanwhile, fluctuating between 7000 and about 2000.

390 (Complainant's Exhibit 6.) Same as above showing same condition at Ft. Bellefontaine, on the Missouri river.

393 (Complainant's Exhibit 7.) Chart showing same conditions at Chain of Rocks, Missouri shore.

395 The rise of rivers is caused by either thawage of snow and ice, upon the drainage area of the river, or rainfall upon it. This means water rushing towards the lowest part of the drainage area, sweeping the surface of the soil of its bacteria and carrying them with the water and debris into the river, and when the river falls and no longer has the bacteria swept into it from the surface washings, the river depends upon springs and sewers for water. That is, these particular rivers. Spring water is a good water and contains very few bacteria, consequently the numbers of bacteria during the falling or low stages of the river, are small.

397 (Complainant's Exhibit 8.) Chart representing same conditions at Illinois shore, Chain of Rocks.

400 (Complainant's Exhibit 9.) Same, Intake Tower, Chain of Rocks.

404 (Complainant's Exhibit 10.) Same chart for Illinois river three miles above Grafton, Illinois, without the height of the river recorded, the height of the water to be filled in later.

406 Prior to 1895 the Intake Tower of the St. Louis water works was located 3½ miles from Market st., measuring by the river, up the Mississippi, at a place called Bissell's Point.

It was not near so well built as the present intake. It was built a short distance from the shore connecting with a bridge. It is an iron tower into which the water flower and was carried by low service pumps to reservoirs that were located at this point. When the river was very low they had a movable intake that ran down a tramway, carrying a flexible tube to follow the river out. The water was pumped directly from the river instead of running into the intake. There was a creek about 1,000 feet above the intake at Bissell's Point, known as Harlem Creek which discharged itself into the Mississippi river. This has a drainage area upon which there resided at that time probably 10,000 people. The sewage from these 10,000 people discharged upon this drainage area and into this creek, also the offal from a number of dairy stables that were built out and projected over this creek. All of this material during freshets was washed into the Mississippi river and at times flowed directly into this Intake at Bissel's Point.

407 This Intake was there 25 years ago. The city stopped pumping from the river at that point and began taking water from the Intake tower at Chain of Rocks in 1895.

408 I know that in 1892 the sewage ran into the Mississippi river about 100 feet above the intake at Bissell's Point, because I saw it doing it.

I know in '92 the attention of the Health Commissioner was called to this thing of the typhoid epidemic having resulted from this Harlem Creek discharging the sewage into the intake and a dam was thrown across Harlem Creek and pumps used so that the water that came into Harlem Creek was stopped and pumped across, and discharged below the intake of the water workes, into the Mississippi river.

The typhoid epidemic following the discharge of this sewage occurred the latter part of August, 1892, and extended until February, 1893.

I made a personal investigation and found that standing on the bridge out on the Intake tower at Bissell's Point, the black dirty water from Harlem Creek could be seen running along in the yellow water of the Mississippi anl entering the Intake tower of the St. Louis water works. My atten-
410 tion was called to this in October, 1892. Dr. Francis, the Health Commissioner, and the St. Louis Medical Society made an examination. The facts were reported back to the Health Commissioner and he attempted to turn the course of Harlem Creek, over 500 yards back from the river. Pumps were established and the water pumped from this Harlem Creek to a point below the intake of the water works. That was practically the end of the typhoid fever there.

From the chief sanitary report of the Health Department for the fiscal year ending April 1, 1893, 3,624 cases of typhoid were reported to the health authorities by the officers of the city, with a total of 514 deaths.

The figures for the preceding year I obtain from the annual report of the Health Department of St. Louis. They are monthly and will be found on page 624 and 625. A great majority of the cases, 3,385 with 442 deaths, occurred during the months of September, October, November and December, 1892, and January, 1893.

412 I examined the Mississippi tap waters from the tap in the bacteriological laboratory and succeeded in separating out a micro-organism that resembled a stock culture very closely stock culture of bacillus typhoid. I thought it was the typhoid bacillus at the time and I still think so.

This was taken from the tap during this epidemic of typhoid, on November 8th. I did not make any bacteriological examination of the waters of the creek as it was crude sewage and the numbers would be up into the hundreds of thousands, so I did not plate it.

413 I examined the conditions along the banks of the creek. All along from probably 400 yards from the mouth up to quite a distance along the crek are a number of dairies with their cow sheds projecting over this creek, and the manure is pitched out through the holes in the floor into this creek, great masses of it, lying there fermenting, and it is there still. I was over there the other day and saw it. A part of this drainage district extends into Bellefontaine cemetery and the other part is a rolling upland, and is inhabited and the sewage from all the people on this drainage area, probably 10,000, discharge into this creek, so that in dry weather the flow of this small creek has black fetid water flowing in it.

Prior to the breaking out of the epidemic there was typhoid on that drainage, of which there is a record in the health department.

414 In 1892 there was no other source of supply except that from Bissell's Point, with the exception of 7,000 wells scattered throughout the city. A mass of the wells were inspected and it was found that the typhoid fevers were uniformly distributed throughout the city and not around any particular well or wells—distributed independently of any well water.

In my investigation of the matter at that time I did not discover any cases among the families that used well water. The water was pumped directly from the river into the settling basins there, but the demand for water was so great in the city at that time that it rested but a short time; it was practically water delivered from the river to the consumer.

415 Describes method of examination of water at that time. Sound bacteria. It responded to all the tests and was declared by me to be typhoid bacilli.

417 This particular micro-organism lived in sterilized tap water, in an ice chest, right up against the ice, from 30

to 60 days. In non-steriled tap water in the sunlight they lived from 12 to 15 days, and in the gloom or dark of that ice chest, 24 to 30 days.

The chart here shown shows the number of cases of typhoid fever and the number of deaths in St. Louis from 1890 to 1900, graphically. I made that map. Besides that it graphically represents in groups the weekly averages of the river stages at St. Louis, the Mississippi river. The map goes further and shows another period which we will describe later. It was made from the official statistics of the St. Louis Health Department.

418 From 1890 to the year 1895 the water supply was taken from the Mississippi river at Bissell's Point. At the present time it is taken from the Intake tower, Chair of Rocks.

On the left hand margin of this map are written figures beginning with zero and running up to 200, written in black ink and they represent the cases and deaths, from typhoid fever. In the second column, or third from the left hand margin, the stages of the river, in feet, taken from the government figures and represent the stage of the river at the foot of Market

419 st., in St. Louis. The curved line in blue indicates the stage of the river. It begins in January, 1900, and the stage of the river was 6.1.

The black lines indicate the number of cases of typhoid fever reported to the Health Department and the red lines indicate the deaths from typhoid fever.

Witness reads from chart, beginning on page 49.

432 We find, in consultation with this map, that as a rule when the river is low the typhoid fevers were high, the number of cases and deaths. I mean the water low in the river.

On this chart is a separate chart running to December, 1900, upon which is shown the curves showing the weekly average of the stage of the Mississippi river at St. Louis; percentage of Mississippi water taken in; total solids flowing into the Intake, and number of typhoid fever cases for the year 1900.

I mean by total solids the residue remaining after evaporation. I made this map—it was under my direction. The data of the typhoid cases taken from the Health Department;
433 the total solids were taken from the figures of Dr. Wm. C. Teichmann, city chemist. The river stages were taken from the government reports.

434 Witness reads percentages shown on small map.

439 This map shows that typhoid was most prevalent in 1892. Prior to 1900 typhoid was most prevalent in the fall and winter months.

After a person receives the typhoid bacillus into his stomach the disease will develop itself from five to six days to three or four weeks.

440 Q. Now is there any relationship as shown by this map between the rise in the number of cases of typhoid fever and the rise in the percentage at the times you mention of the water in the Mississippi river at the Intake tower?

A. Yes, sir.

Q. Just explain what that is.

A. As I showed you already, on the 18th, 100% of the Mississippi river water, as it came into the Intake tower of the St. Louis water works—

Q. What do you mean when you say 100 per cent?

A. 100% of Mississippi river water. In other words the Mississippi river water only—not mixed with the Missouri river water, went into the Intake tower and on March 3d, there was an increase in the typhoid cases. That is February 8th and March 3d and 23 days later a rise in the typhoid death rate was noted and that increased until March 17th, gradually decreasing with the falling out of the Mississippi water here. The Mississippi water reached 12 per cent on the 17th of February,
441 and the typhoid fever cases on April 21st were recorded only 4. So that there was an increase of the typhoid cases from March 3d up to March 17th, then a gradual decrease to March 24 and from March 31st to April 7th, and as I say, reached the low number of four on the 21st.

From January 27 to February 10, the Mississippi river was falling, in 1900, and the Missouri river also at those dates was falling. I know that from February 6th, I think it is, to February 20th, the Illinois river was high.

The Mississippi and Missouri were frozen over from February 3d to February 20th. I think about the 20th they broke up.

Q. What effect on the oxidation by bacteria or organic matter, and animal and inorganic matter, in the water, does the freezing over of the river have?

A. The bacteria do not multiply very rapidly in cold water; they remain dormant.

Q. Well, the oxygen is shut out of the water by the freezing of the ice?

A. Yes, but there is enough oxygen in the water for the bacteria, if they could multiply in the temperature, but not so much as when the river is open. The organic matter in the water is not decomposed in so great a quantity.

Q. If there was organic animal matter in the water of the Mississippi river and in the Missouri at this time, its decomposition would be the result, if it was open and not frozen?

A. Yes, and the temperature higher, and the temperature not near freezing point.

442 Witness reads stages of Illinois river at Peoria from January 17 on.

444 These figures show that from the 23d day of January or from the 17th of January there was a steady rise in the Illinois river until the 29th of January, when eight feet were recorded, then there was a fall to 7.9 feet, and 7.8 feet on February 1st. It rose through February, March and April. 19.9 feet was reached on the 17th of March, and that is the highest.

Q. Do you know the date the Illinois river broke up?

A. Well, from what I understand, there was a thaw along the Illinois river beginning the 7th of February and it extended to April 12th. The river I see here begins to rise on the 8th, and rises steadily from the 8th of February, and from the bacteriological record, and from personal recollection of samples collected at Peoria, at Joliet and Grafton, I know the condition of that water.

445 Trace the relationship there between the percentage of of the Mississippi river water as shown by this map and the increase or decrease of the typhoid fever rate.

A. We have traced that increase from March. That is for February, and the increase of typhoid fever that occurred in March in St. Louis, and no such thing has ever been known before in the history of this town; the Illinois river high, and the other two rivers covered with ice, and the Mississippi water coming into the intake in 100 per cent. Now as the rains began and the spring thaw began on the drainage area of all these rivers in the latter part of February and in March, there was high water for all these rivers, so the flood flowing into the Mississippi river was very great. From the 17th of February on, we find the highest stage of the Mississippi reached at this point was on March 17, 1900, and the highest stage also recorded for the Missouri at this period. This stage for the Mississippi was 22.4 feet and for the Missouri river 16.2 feet. Then the rivers fell until March 31, when again there was a rise. Then a gradual fall until the fall rise, which began on September 29th. Now at this time, according to the total solids, that is, beginning on March 3d, and reaching its acme on March 24th, we find that on March 24, 25, 26, 27 and 28th there was 100 per cent of the Mississippi river water going into the intake at St. Louis water works, Chain of Rocks. Then there was a fall to 62 per cent on the 29th of March; again a rise on the 31st to 100% ; then a fall to 87% on the 1st of April and on the 2d of April to 50%. Then a rise on the 3rd of April to 62%, and a fall to 56% on the 5th. And on the 6th to 32%, and then, on April 7th to 1 % ; then again it rapidly rose.

446 Q. Now what was the number of typhoid cases?

A. At flood volume of the river. It was very high at this time and the number of typhoid cases rapidly diminished. All the rivers were very high, and the quantity of the pollution was very great. And the percentage of the Mississippi river water at the intake was high at one period, at the very high period.

Q. It wasn't high when all the rivers were at flood tide?

A. Yes, it was high once. That is the period I have just referred to from March 24th to 31st. It was 100%. I named the dates. It reached 100% twice in the spring and fall of 1900. So the quantity rises and falls; that is, the percentage of the Mississippi river water at the intake rises and falls until May 28th, when it is at its lowest; then it remained low, that is, rising and falling to a slight degree until July 29th, when it again rose, and the amount of Mississippi river water going into the intake reached 39 per cent. I can read farther on if you care to have me.

Q. Well, just trace the relationship there is in it between the typhoid rate and the percentage of the Mississippi river water.

A. The waters during this stage now, are—the Mississippi at the intake is falling when its percentage reaches 39; then the percentage fluctuates between the dates July 29th to August 7th, when it reaches 6 per cent. On August 31st the percentage again reaches 50 per cent. It falls on August 2nd to 2 per cent; then rises again to 28 per cent until the 5th of September. On the 7th of September it falls to 4 per cent, then it rapidly rises to the 12th, when it reaches 40 per cent.

447 The number of typhoid cases at that time was increasing, with the increase of the Mississippi river water at the intake at this low stage of the river.

The number at that particular point was forty cases. The percentage now fluctuates between 26 per cent on the 15th of September to 46 per cent on September 22nd; then there is a fall again, September 25th, to 34 per cent; then a steady rise until the percentage of 64 per cent is reached on October 4th.

Then it falls on October 6th to 27 per cent. rises on the 7th, October 7th, to 42 per cent· falls on October 9th to 24 per cent; on October 10th to 26 per cent, and the record ends there. When the flood volume of the river is very great the percentage of typhoid is very low.

Q. What water?

A. The percentage of the Mississippi river water at the intake, when the river is high, the typhoid is low. The typhoid fever rate increases with the increased percentage of Mississippi river water going into the intake.

Q. Take all this period here, the latter part or half of 1900, just give us the periods of time—just the dates, that is all, at which the typhoid was the greatest in the city of St. Louis—I just simply want the dates as shown by your map.

A. For the March term, for March 3rd, to March 31, extending into April 7th—March 3rd to April 7th, was one period, and from August 1st to December 15th.

448 I have made a calculation to determine what percentage of increase there was in March, 1900, of the typhoid rate in this city, or with that of the month preceding, February, 1900. It was greater for the period of March. For the period of February there is very little difference. For March there is an increase over March of the previous year. The number of cases of deaths from typhoid reported is as follows:

March, 1900, 40 cases.
March, 1899, 3 cases.
449 March, 1897, 3 cases.
March, 1896, 6 cases.
March, 1895, 6 cases.
March, 1894, 15 cases.
March, 1893, 14 cases.
March, 1892, 5 cases.
March, 1891, 6 cases.
March, 1890, 7 cases.

Above map offered in evidence as complainant's Exhibit No. 10.

When the flood volume of the river is very great the percentage of typhoid is very low—the percentage of the Mississippi river water at the intake and when the river is high, the typhoid is low. The typhoid fever rate increases with the increased percentage of the Mississippi river water going into the intake.

There is an increase of typhoid fever patients for March, 1900, over March 1899. It is greatly increased in March over February. The highest number of typhoid cases was recorded on the 17th of March, 1900, forty cases.

Above map offered in evidence as complainant's Exhibit No. 10.

449 This other map is for the third period, 1901, for the
months of October and November. It shows the results
of the daily determination of the number of bacteria in sam-
ples of water collected from Drainage Canal at Bear Trap
Dam, Lockport, below Ruby street, Joliet, and Bran-
450 don's Bridge, Joliet. The bacteria per cubic centimeter
are ranged along the left hand margin of the map be-
ginning with 200,000 and extending up to 5,000,000 bacteria
per cubic centimeter. The bacteria at Bear Trap Dam, Lock-
port, are marked in black ink; at Ruby street, Joliet, in red;
Brandon's Bridge, Joliet, in green. On the 4th space at the
top of the map are the dates, beginning Sept. 26 and ending
Nov. 29, the number of bacteria are recorded every third day—
not every day.

The greatest number recorded at Bear Trap Dam recorded on this map is 7,200,000 on Nov. 23.

452 Now the water tumbles over the Bear Trap Dam and mixes it with the Des Plaines river and pollutes it somewhat, so that we see the pollution in this graphic representation.

Witness then reads from chart.

453 Now then we have the green line for Brandon's bridge. It shows a mixture of every stream and everything else that comes into the Des Plaines river—a mixture of the Drainage Canal with the Des Plaines river; the I. & M. canal with the Des Plaines river and the sewage of Joliet. The figures are as follows: (See Rec. 453.)

455 This map shows that the number of bacteria was the highest beginning the 17th of November—there was a lapse between the 10th and 17th—beginning on the 17th and up until the 23rd, when they reached the highest, but they are still high on the 25th, at all of these points.

The highest point was the Bear Trap dam.

Map offered in evidence as Complainant's Exhibit 11.

This chart you now show me is the result of daily quantitative determinations of the number of bacteria in samples of water collected at Peoria, Illinois, at Shady Beach, above the city; covering a period of time from Oct. 1st to Nov. 27th.

The lines and figures on this map, beginning on the left hand margin, show the number of bacteria per cubic centimeter, ranging from zero to 10,000, in black. The river stages in feet are printed in red and range from zero to 10 feet. At the top margin of the map are the dates from Oct. 1st to Nov. 30. The figures are as follows: (Rec. 456.)

457 This map shows there was a decided and rapid rise from November 13th to November 17th; then it dropped until Nov. 21, and then a rapid rise on Nov. 23 to 9,000, and then a drop for the 26th to 500. It seems to correspond with the rise and fall of bacteria at Bear Trap dam, Ruby street and Brandon's bridge at Joliet.

458 During this period the stage of the river remained remarkably even throughout, and when the bacteria was so high for the two periods in November, the water was a little bit lower than it had been for previous weeks. (Witness then reads the figures showing stage of the river for period referred to.)

459 You see the river fluctuated an inch or two only. The river remained stationary practically during this period from October 1st to November 29. In any ordinary river the bacteria would have remained practically stationary, but in the dates as given before you find a remarkable rise without any rise in the river.

This indicates that large numbers of bacteria put in above apparently came through to Peoria.

460 Q. Now above the Bear Trap dam, in the Des Plaines river, have you any analyses of that water?

A. Yes, that has already been sumbitted.

Q. Now you have investigated those analyses, have you?

A. Yes.

Q. What does it show—a larger or smaller number of bacteria above the Bear Trap dam than it does below?

A. Oh, a very small number, comparatively.

There is no other place than the Chicago canal at the Bear Trap dam from whence this large number could come into this river at this stage of the water.

I have the rain precipitation in that tributary of that river for that period. There was no precipitation practically in that area at that time.

Map introduced in evidence and marked Complainant's Exhibit 12.

Q. What is this map I show you?

A. This map is made up from results of the daily quantitative determination of the number of bacteria in samples of water collected from the Illinois river at Grafton, Illinois, from Oct. 1st to Nov. 27th, 1901. The distance from

461 Peoria to Grafton is 63 miles, and the mean fall of the river is thirteen feet.

Description of chart is same as previous exhibit.

Greatest number of bacteria per cubic centimeter were found 17th of Nov., 1901. There was slight rise of the stage of the river at that date, but it was not as high as it had been at a previous period.

462 The river was five-tenths of a foot lower when the greatest number of bacteria was found.

Map offered in evidence as Complainant's Exhibit 13.

I was at Lausen, Switzerland, about 15 miles from Basle, as a sanitary and hygienic expert, in 1897. The town 463 is in the mountains—in the valley. Experiments were made by Dr. Haegler, after the typhoid epidemic of 464 1872, to discover the cause thereof. I have asked him what he knows of the history of this epidemic at this place, for the purpose of showing the manner in which it has been demonstrated that the typhoid bacillus will travel. 465 It went through the mountain, about a mile, and affected the spring at its base, and this mountain acted as a filter sufficiently good to keep out the starchy particles of flour thrown in a mile above, but allowed salt and typhoid bacilli to go through. This spring is enclosed; the spring is in an enclosed space, not open at all.

Never been to Plymouth, Pa., but am acquainted with the literature on the subject and the report made by the Pennsylvania State Board of Health, as to the typhoid fever epidemic that occurred there in 1885, due to the discharges of a 466 typhoid fever patient thrown upon the bank of the reservord that was the source of the water supply of this town. The town had a population of 8,000 and there were 1,104 cases.

Am acquainted with the investigations made—that is the reports of the State Board of Health of Massachusetts and of Dr. Sedgwick's writings of his investigation at Lowell, Lawrence and Newburyport on the Merrimac river, Mass., in 1891-2-3.

Objection by Attorney General Hamlin.

467 The epidemic at these places was due, at least ascribed ot the dejecta from typhoid fever patients getting into

the water supply and being taken and being drank by these people. The town got its water from the Merrimac river.

I think Dr. Sedgwick carried out some experiments to determine the question as to whether or not it was in the Merrimac river, (the bacilli), but I am not sure about that.

Typhoid fever is more prevalent in the fall and early winter, as a rule. The faster water flows the further it will carry bacteria. In waters that flow very slowly, or are stagnant, or still, the bacteria are precipitated into the silt or slush at the bottom of the river. The speed of the river or the volume of the water does not destroy typhoid bacilli.

468 There is a difference in the conditions surrounding the typhoid bacillus in sterilized water in a bottle and the ordinary tap water in the city. Water that has been sterilized by heat contains the inorganic matter of the water, but the bacteria have been destroyed in it. It still has food for bacteria and it has no other bacteria. Now the typhoid bacilli put into that water have no other form organic leife to contend with and the bacteria will live a great deal longer in sterilized water of a district than they do in the living water of that district, in a bottle. They live sixty days.

469 Witness reads from table showing longevity of bacteria at various points along the various rivers, in sterilized waters. Witness then explains manner of collecting and preparing water in which to determine the length of life of typhoid bacillus, and reads on page 722 the weather conditions on each day.

473 Explains the manufacture of the media in which the typhoid cultures were made.

474 The typhoid cultures used in these experiments were: 1, from Dr. Westbrook, of the University of Minnesota, said to have been found by him in the waters of the Mississippi
475 at Minneapolis; No. 2, from a spleen sent in by Dr. W. C. G. Kirschner, from a patient dead of typhoid fever at the city hospital, and plated.

Water was taken from various points set out in the table and innoculated with the typhoid bacillus and they lived under conditions and for the length of time specified in the table, from which witness quoted on page 475.

479 The chances for life of a typhoid bacilli in running river water would be greater than if confined in a flask.

I don't see that the food supply cuts any figure in these experiments. I find that in sterilized, distilled water, micro organisms live for a long time. There is no assertion here made that the typhus bacillus lives and multiplies in the water. It simply lies dormant until its life history is over, unless in the meanwhile it reaches a favorable condition.

The death of the typhoid bacillus in water in a bottle is due to toxins produced by bacteriological conditions that exist there. In running water it lives out its period and dies after a time. Its period of longevity is not definitely known
480 in running water. The distance they would be carried, according to what men know of the longevity now, would depend entirely on the rapidity of the flow of the stream.

In the floodtide of the Illinois and Mississippi rivers, if typhoid bacilli came down from the Chicago river and emptied it in the Illinois river, they would come into the intake tower much more rapidly than they would if the waters were low.

I do not know from my own knewledge anything about how long it takes water to come from the dam at Lockport or from the canal there in Chicago, the Chicago river, down to the city of St. Louis.

481 BENEZETTE WILLIAMS, a witness called in behalf of the complainant, on direct examination by Attorney General Crow, testified as follows:

My occupation is civil engineer and consulting engineer, and I reside in Chicago. Have lived there 30 years. Have been following my profession for 32 years.

I am very familiar with the geography and location of the city of Chicago.

Chicago lies very low. With minor exceptions, elevations of the ground within the city is over the lake level to a height of 25 feet, and a very large portion of the city lying but a few feet above the lake level, both the old and central portion of the city and other portions, so that the process has been in the settled parts of the city, to raise the grades in order to get the depth to cover their sewers, and to get sufficiently out of the mire, you might say.

In other portions of the city they are overcoming that difficulty now by building sewer districts; building the sewers in districts and pumping the sewerage. They build sewers below the lake level and pump a flow to the lake level or to a point of discharge.

482 The soil on which the city is built is reasonably firm.

The greater portion of the city of Chicago is clay soil, overlaid, of course, with prairie soil originally, which is a soft loamy soil, free of stone and gravel. You find stone in the underlying clay. It has a glacial portion. Clay has what we term a glacial portion, and it is more or less filled with stone; that is sometimes cobble stone size and a gravel material to a greater or less extent. In some places you will find this clay quite pure with very little of that with it. In other places you will find almost a complete mass of boulders cemented together with clay; then another portion of the city lying directly along the lake at a certain depth consists of this same clay, but it is overlaid with a sand ridge formed by the flowing up of the lake and the washing and blowing of the same into the ridges. That is close to the lake, however.

But a small proportion of the surface of the city limits is on the lake level, but there are a great many square miles that are so low that you have to pump in order to get drainage. The land is flat, apparently, in its natural condition. It would seem like a dead level with the few exceptions of these sand ridges.

483 The greater portion of it would be about 12 and 14 feet above the low water of the lake, what you call Chicago datum.

The Chicago river and in fact all of the rivers that empty into the lake along the southern and western portions of Lake Michigan, you may say, have been formed as the lake shore—as the water receded, and the lake shore was built up so that they have been formed, so that they run parallel with the lake. They have been shut out from the lake as the waters receded by ridges of sand or drift, or something that has come in and left them running parallel with the lake. That is a peculiarity of that portion of Lake Michigan.

The Chicago river is short, originally not over a mile long from the lake back to the confluence of the two forks; one leading from the south and one from the north; the southern fork called the south branch and the northern fork called the north branch. The northern branch really drains the most territory and from a district of higher elevation somewhat as its source, which is in the State of Wisconsin. The south branch at a distance of about 5 miles from the lake, as it originally existed, has two branches, one known as the west fork, and the other as the south fork. The south fork draining a very limited territory, wasn't much, you could hardly call it a stream except in floods. The west fork only drained a small territory also, except as the flood waters of the Des Plaines river at a distance of about 9 or 10 miles from the lake would break over and come down
484 the west fork of the river; then that would become a large stream.

The Des Plaines river is another stream running parallel with the lake, but it is more remote from the lake.

The upper Des Plaines river heads in Wisconsin and flows southward until it comes to South Chicago, and about ten miles distant from the lake, when it turns southwest and joins the Kankakee, below Joliet, forming the Illinois river.

There is a divide between the Des Plaines and the south branch of the Chicago river. That is the Des Plaines never flows into the Chicago river except at one point where it turns southwest to the Illinois river. It has always within recent geological times, at high stages, flowed both ways. It would divide, one portion going to the southwest, the other portion going to the east and through the Chicago river to the lake.

The distance to the extremity of the west fork of the Chicago river, of the south branch of the Chicago river, was only a very few miles, and really, within thirty years you may say it has been practically connected with the Des Plaines river. They built out there a ditch—the land owners did, and absolutely tapped the Des Plaines river and drew it to Chicago, even at low water, until the city went and built a dam and shut that off and restored the natural condition.

485 That is outside of the city limits and the distance from the present city limits is about 3 1-2 miles.

The north branch takes its origin at a distance of about 20 or 25 miles.

In the ordinary stage it is not a large river and in extremely dry weather it disappears practically. We have had floods there that discharged about 210 feet a minute—cubic feet in the north branch.

The mouth is a harbor now—it has been dredged and docked. The stream has been widened and deepened, by dredging.

486 Where it has been dredged it varies from a rapid current in high stages to no perceptible current at all. In ordinary times it is modified by some artificial work that has been done by the city, pumping works connected with it. The pumping works are at Fullerton avenue. There is a conduit extending from the lake to the north branch on Fullerton avenue, twelve feet in diameter, and a pumping works connected therewith. The works are at the river, but the conduit is below the lake so that it acts the same as if it was at the lake. It merely takes the water from the conduit and throws it into the river.

487 The capacity of the pumps when at its usual working capacity, is 15,000 cubic feet a minute. That was built about 1879. The conduit strikes the lake on the shore through Lincoln Park—it strikes the north shore of the city. It is adjacent to a densely populated portion of the city and extends directly west from the lake to the river 12,000 feet.

That conduit is in operation with the pumping works now at intervals, sometimes it is not working. The effect of that is to flush the river out to a greater or less extent, depending upon the amount of water put in. When flushed out it emptied at the confluence of the south and west branch of the river and from thence into Lake Michigan except as it went down the south branch due to a change of the regimen of the river.

488 For thirty years, there has been a flow through the south branch, southwest to the Illinois and Michigan canal.

The north branch carries the most water in its natural stage, except as I say in the Des Plaines river flood. As far as the size goes, in the rivers, as they stand today, perhaps there isn't much difference; they have been docked and dredged to the same depth and width.

From the confluence of the south branch and the north branch of the river to the exit in Lake Michigan, as it exists today, with the piers that have been extended out into the lake and caused a channel, is, I think about 7,400 feet. It is exactly 7,113 feet.

489 I can not say exactly how far the present opening has been extended out into the lake by artificial means. Nearly half of that distance is an extension from the original. There has been a filling in of the lake front at the mouth of the Chicago river with soil, debris, etc.

The mouth of the Chicago river was at one time, nearly half a mile south of where it is now. It turned south. It didn't change the river where it was naturally, you may say, from Rush street to the confluence of the forks, and at that point it turned south and entered the lake nearly half a mile south of where it is now. There was a bar existing there at what is now the outlet. They cut through that and have filled that old channel of the river—south of the river, what was the old channel of the river, and they have been filling continuously more or less, and are today, out into the lake. I think the north branch is dredged and docked about four miles from the conjunction of the main river, but it is being dredged up as far as Lawrence avenue, about six miles above the confluence of the two branches of the Chicago river.

As far as it is dredged and docked at the present time it is opened for shipping and used for that purpose. The
490 depth is very near fifteen feet. Sixteen feet has been about teh deepest they have dredged up to within a few years.

The City of Chicago has been building a conduit at Lawrence avenue for several years, but there has been difficulty with the contractor and it is now tied up. It is 16 feet circular inside and will connect with the lake and extend across to the north branch of the river similar to the manner of the Fullerton avenue conduit and is in the northern portion of the city of Chicago.

That conduit is to take away by means of a system of intercepting sewers the sewage that now discharges into the lake along the north shore over to the north branch of the Chicago river, and it is also to take the supply of water from the lake to the north branch, with the view of emptying that sewage into it by means of the pumping station into the north branch of
491 the Chicago river which now goes into Lake Michigan.

The west fork of the south branch of the river has its origin very near to Ashland avenue and 31st street—or Ashland avenue and 26th street, in the limits of Chicago. It flows only one way; to the east, slightly to the north and flows in that direction now.

The volume of water is less in that than in the north branch, for ordinary times, but more at other times. That is there have been especially in the past before there were any changes in the conditions of the river, flood waters of the Des Plaines which have overflowed into that river, and swelled that river to a greater volume than the north branch.

Aside from any artificial interference the west fork carries more water than the north fork at high floods of the Des Plaines. Where the Des Plaines overflows, breaks over and connects with it. That happens now but to a somewhat reduced extent. A flood must now be higher than in the past in order to furnish the supply to the north branch, but in very high floods it still furnishes a large amount of water there.

492 There is very little, almost no speed in the current—an almost imperceptible flow. It is dredged and docked for a considerable distance about the confluence of the south branch of the west fork, I should say two miles more or less. From the confluence of the two large branches of the south fork of the Chicago river to what was formerly the mouth of the Chicago river at Lake Michigan is about five miles.

The origin proper of the south fork of the south branch of the Chicago river is three miles south of its confluence with the south branch, and it was, you might say, merely gullies leading into a larger channel—it ran out into the prairies—it was practically no river at all, connected with what is known as the west fork. The drainage area of it was originally prairie with a flat surface and in the ordinary stage there was no water
493 in it—it was only a storm water drain.

At this time the south fork of the south branch is dredged and docked to the stock yards and that is one and one-half miles from the point of confluence of the west and south forks of the south branch of the Chicago river. It is dredged and docked for shipping. It is about 14 feet deep; lake vessels can pass in it there to the stock yards—they did do it. By the stock yards I mean the principal stock yards of the city of Chicago and the slaughter houses and packing plants.

All the live stock that goes to Chicago, except perhaps some that goes to Hammond, Indiana, goes in there.

There has been a conduit built from that we call the east arm of the south fork; that arm is merely a slip dredged
494 out for docks, for ships; the conduit leads to the lake and is 20 feet in diameter. It is to be used to carry sewage from the district, from Lake Michiagn on the south shore,

and south side, to the stock yards slip, and to take the sewage in from the lake to the stock yards. It is to be taken in for the purpose of supplying water to the river and flushing that south fork, that is, purifying it, putting in better and making it better in a sanitary way, and of furnishing water to the drainage canal. Pumps are being built there for a capacity of 120,000 cubic feet a minute. The main conduit is finished, they are cleaning it out now. The pumps have not been built. No one knows exactly when it is proposed to open that; probably in the course of a year.

495 The length of the conduit is 12,000 feet. There has been dredging going on in the channel of the south fork of the south branch of the river recently, especially up to te hmouth of this conduit, or the outlet of this conduit that is to be. Within the past year. They are certainly deepening it. They must have deepened it in the neighborhood of twenty feet. They are deepening at least at the outlet of this conduit, to the bottom of the conduit, which would be over twenty feet.

There is no flow in the south fork of the south branch except as comes from the sewage discharged into it and from the various sewers that connect with it.

496 The area of the sanitary district of Chicago is 185 square miles. After the legislation establishing the Sanitary District Board, I was chief engineer of the work from January, 1892 to some time in 1893, about a year and a half.

That area remains the same now as when established.

497 The sanitary district of Chicago is bounded on the north by Devon street, partly in and partly on the borders of the city limits. (Describes the boundaries of the district.)

498 Out of 186 square miles of area in the district, 141.8 square miles is within the city limits of the City of Chicago and 43.2 lies outside.

The Indiana state line runs north and south at right angles to the southern boundary of the sanitary district.

The eastern limit of the southern part of the City of Chicago joins the State of Indiana; the western boundary of the State of Indiana.

500 Was city engineer of Chicago in 1878 or 1879.

501 Now what would you say as to whether or not the City of Chicago from its topographical and geographical location, is naturally adapted to the easy disposition of its sewage.

Objected to.

The building of the sewers was not a complicated problem in its original inception except in the matter of grades to give to the sewers. Finally a system of grades was established and used that was what might be called unprecedently low, that is the inclination was very slight—that wasn't the difficult thing only it was somewhat of a doubtful thing, that's all. That was caused by the level surface of the ground on which Chicago was built and the long distance you had to traverse with the sewers. In its natural condition water would flood it and stay flooded a good while, but you could and did adapt or fix the sewers to a natural slope to a certain extent. The surface was practically prairie soil and is not a good drainage, of course not for
502 a long distance run. You had frequent connections with the sewers to take off the surface water promptly. The precipitation of rain could not be drained fast enough by natural conditions.

In consequence of that frequent connections had to be made with the sewer to take care of the rain precipitation.

There is a difference in a city with reference to the amount of sewage matter produced according to the population and generally depending upon the manufacturing conditions. And also as to the general custom of connection of the sewers. An iron foundry and a machine shop or a planing mill wouldn't greatly affect the system of sewage, of the quality of sewage, but slaughter houses and stock yards and cattle pens are very liable to affect it materially and do.

In some cities that have a system of sewers the people will not all connect unless they are forced by some board of health. In the City of Chicago, I suppose, practically all connect with the sewer as soon as one is built in the street. It is not a good place for cess-pools because of the impervious clay—that there would not be much percolation from a cess-pool. The sewage would accumulate and overflow. For that reason the sewer connection in the city of Chicago is very large and general. You might say practically that the only population in the city of Chicago that has not sewage connections in their houses, are districts that have not got main sewers built, and those are of minor importance.

504 As compared with my knowledge of the sewage systems of other cities, I think the proportion of organic matter flowing out through the sewers is greater in Chicago in proportion to the population than is usual, and only very extraordinary cases would have a greater amount than Chicago.

All the sewage that is laid below the level of Lake Michigan is in the southern district, about 60th street and east of State street. Compared to the whole city it is small, although it is large in itself. Some portions of it are quite densely populated and other portions even that are not sewered are densely populated. There are districts there where they haven't got any sewers at all, with 19,000 people in a district, in these flat, low districts.

In the territory where the sewer is laid below the level of the lake, that has to be pumped up to the water level to dispose of it.

Am familiar with the Illinois and Michigan canal. It 505 runs into the Chicago river and at 26th street at the place where the canal joins the south fork there is a pumping works. I think that canal was built in the '40's.

These pumps were built by Chicago for the purpose of creating a greater flow through the canal for the sanitary benefit of the Chicago river and were maintained by the city and operated until 1900 I think, when they were turned over to the sanitary district board. The sanitary district board has since turned them over to the Illinois and Michigan canal commissioners. They are now maintained for the purpose of keeping up the level in that canal for navigation purposes.

506 The building of the sanitary canal was for the purpose of keeping the sewage in the city of Chicago out of the lake and polluting its water supply and for the purpose of improving the condition of the river and branches.

The outflow—the outflow of the sewers is mostly in the Chicago river and branches, although a portion goes into Lake Michigan and some into the Calumet river. The Calumet is in the southern part of the city, entering the lake about 92d street. It has its origin in Indiana. There are two branches and they both head in Indiana around the end of the lake and they flow
generally westward, turning for a time, one of the
507 branches turning almost eastward, and a little south of
eastward and joining the other branch, and then flowing
northward and slightly eastward.

After striking the city of Chicago it has been dredged and docked, I think, to a width of 200 feet and eighteen or twenty feet in depth—I don't mean all the way—only its mouth. It is a pretty good sized stream. It has been dredged continuously for three miles at least and then it has been done in places so that the river has been navigable for boats of lighter draft clear up to Hammond, Indiana, a distance of nearly 20 miles from its mouth, following the windings.

507 The south branch of the Chicago river varies in width from 150 to 200 feet. At the bridges there is less than 100 feet up to the point of confluence of the west fork and the south fork. The sanitary district has been dredging and docking it and are preparing to widen and dock it so as to increase the flow and they have made it possible to increase the flow in places. But it don't necessarily mean that the flow has been increased though.

508 They are working to get a standard width or a minimum width of 200 feet and a depth of 26 feet to the central portion of the stream and 16 feet at the docks.

Based on the census made by the board of education of Chicago in 1900, there is a population of 70,636 that drains into or is tributary to the Calumet river.

509 I have made a distribution of the population of the city of Chicago according to the points of watercourses to which it is tributary for the whole city, and I have represented that distribution and division of the city into districts on the accompanying map. The boundary of the city, except the lake shore is shown in blue, etc. (See Rec. 509.)

511 The board of education census is over 300,000 more than the Federal census, for the whole city.

512 I have confined my sewer districts within the city of Chicago—within the limits of Chicago. District No. 4 is outside of the sanitary district of Chicago and there is a small part of districts Nos. 11 and 10 that is outside of the sanitary district.

513 Now, outside of the city of Chicago, within the sanitary district is the town of Cicero, lying west, and having a population by the Federal census of 16,310. Also the villages of Lyons, Summit, part of Riverside, and a certain rural territory estimated in all, including Cicero, 18,145 in population in the sanitary district outside of Chicago. This makes the total population of the sanitary district based on the Federal census, 1,639,456. The Federal census of Chicago is 1,698,575.

515 ATTORNEY GENERAL HAMLIN: Now, at this point as you are proceeding along another branch, I move to exclude from the consideration of the Court, all the testimony introduced with relation to the Calumet district or district No. 4 as marked on this map, as that territory is not involved in this suit; this being an action against the Sanitary district and that territory lies outside of the district. I make that objection in behalf of the State of Illinois.

JUDGE SPRINGER: I make that objection in behalf of the Sanitary district.

ATTORNEY GENERAL CROW: I will offer this map in evidence.

ATTORNEY GENERAL HAMLIN: I object to it on the ground that it is not based, as far as the population is concerned, upon a proper basis; that it is based upon the school census and not on the Federal census.

516 Q. Now give me the population there, according to the school census, then according to your reduction to that corresponding with the same area as the Federal census in the sewer districts as you have divided them.

A. The population of Chicago by the school census of 1900 was 2,000,695. That has been distributed through the several sewer districts which I have mentioned, numbered 1 to 11 inclusive, and the population marked on the map, and they are as follows: consolidating certain districts in accordance with the source of water, or rather this point to which they drain. (Witness enumerates population of each district.) I find the population tributary to the main river and the south branch which is carried directly into the drainage canal by the flow from the lake, and is included in districts 1, 8 and 12, about
517 791,677. The population tributary to the lake on the south shore, and which will ultimately be discharged into the south fork through the 31st street conduit in district 2, 175,182. The population that is tributary to the south fork in district No. 5 is 282,655. That tributary to the west fork within the city limits in district 7, is 74,899. In addition to that I would add that a considerable portion of the town of Cicero has been sewered which lies within the sanitary district and that also drains into the west fork. The population tributary to the north branch of the Chicago river and that is included in districts 9 and 10, is 555,789. The population that is tributary to the lake on the north shore, district No. 11, is 28,878.

Now aside from those districts as described there is a district shown on the map there as No. 3 in the south part of the sanitary district with a population of 18,827; that has not yet a system of sewers otherwise, and while there is considerable population there, they have no sewage outlet. There is also district No. 6 with a population of 9,152, which has no considerable amount of sewers—practically no drain at all.

District 4, which is the Calumet district lying in the city of Chicago south of the sanitary district, has a population of 70,636.

ATTORNEY GENERAL HAMLIN: That is objected to and I move to exclude it on the ground that it is not in the Sanitary district, and not relative to the issues in this case.

Summarizing a little further, I would say that there drains into the main river the south branch and the various forks which are tributary to those rivers, a total of 1,705,020 by the school census, and that there drains into the lake on the north shore and the south shore that are ultimately to go to the
518 Lawrence avenue conduit and the 39th street conduit
now in the course of construction, 204,060. After these conduits are put into operation and the sewage intercepted and turned into the river that would have been distributed on the face of this population directly into the main river, the south branch and the drainage canal, 800,829:

Into the south fork, 476,664;

Into the west fork, 74,892;

Into the north branch, 584,664.

And the same quantity into the Calumet river before mentioned, making up the total population of the city in its manner of drainage.

Now to reduce them to the United States census, all those districts except No. 4, I would apply 16 per cent reduction. District 4 comprises wards or parts of wards that were found not to differ materially from the United States census.

Q. Now do you know approximately the amount of population of the Sanitary district that drains into the north branch of the Chicago river in say about up to the first of January, 1900?

A. Five per cent reduction would more than cover it and this would apply to the other branches of the river.

519 By the Federal census about 170,000 people—the sewage represented by 170,000 would drain into Lake Michigan.

520 The establishing of the pumping works at 26th street set the current of the river the other way and reversed the flow of the Chicago river.

520 The various branches of the Chicago river in the Sanitary district and city of Chicago were very badly polluted prior to January, 1900, with sewage and drainage from manufacturing establishments. The pumps at 26th street were inadequate to meet the purpose for which they were erected. I know that from a survey and examination of the whole question officially in 1886 and 1887. The water supply at that time was polluted by this sewage.

521 The city of Chicago from 1886 on up to January, 1900, was taking their water from the lake at various points of intake according to the dates and times. They took it from in front of the city from two to four miles out. I think none less than two miles. There are now five intakes and there were the same number in January, 1900. The most remote one is four miles out in the lake. They are as follows: (Rec. 52.) They are all connected. Of course the supply depends on the pumping works. There is a great number of pumping works in the city and of course from every pumping works it has a certain district that the supply from those works predominates. Some of them are located at the lake front and some of them many miles in the interior. There are no settling basins. The force is entirely supplied by pumps and there is no natural pressure or water tower. There is no system of filtration.

Describes the beginning and location of the drainage canal. (Rec. 524.) The bottom of the channel of the canal at Robey street is minus 24.46 feet, which means that it is below the datum to which all the levels are referred in the city of Chicago, which was low water mark of 1847 of the lake.

Taking a series of years, the lake fluctuates over a range of four or five feet, and over a range of several years taking the series of years up to a few years ago I found that the datum was 1.9 feet lower than the mean level of the lake.

525 Now there comes the maximum rise of the lake which would go three or four feet above datum; and then there come times when it is a foot below datum. In every year there is a period of minimum level and a period of maximum level, the minimum coming almost invariably about January; the maximum some time in the summer, probably August. Then there are daily and hourly fluctuations due to the variations of the wind. Then there are seasonal fluctuations; there are a term of years often over ten years at a time that the lake will be continuously rising, these seasonal fluctuations, that is from August to January, still going on just the same, but the general trend is a rise—then there is the reverse. These are due, doubtless or probably ascribed to the rainfall.

525 Witness describes the canal. (Rec 525.)

529 Witness gives weekly averages of the flow of water in the canal after January 17, 1900. (Rec. 529.)

531 The pumps at the end of the Illinois and Michigan canal are on the south fork about a quarter of a mile south of the south branch of the Chicago river, which is the channel leading to the main drainage channel, and it takes its water from the south fork. The south fork is a very foul, black and malodorous stream and as fast as this water works out of the south fork towards the south branch it is taken in by the pumps going into the Illinois and Michigan canal, hence the preponderance of at least all that comes up to the capacity of the works from the south fork, goes into the Illinois and Michigan canal when they are in operation. That condition exists now. There is a current in the south fork of the south branch of the river but it is not perceptible to the eye. There is a flow due to the sewage and storm water that reaches that branch which flows northward towards the south branch.

532 The drainage from the stockyards all goes into the south fork or the slips of the south fork at the head of the south fork. Generally the pumps of the Illinois and Michigan canal are in operation. They operate those pumps now purely for the

purpose of navigation of the canal, to keep the level of it, astensibly at least that is what it is done for.

With the present flow of water through the Chicago river and the drainage canal the south fork of the Chicago river is yet stagnant water. At this time it is black, absolutely black. The lake water enters the river at its mouth.

533 The current in the north branch of the Chicago river is perceptible at times and at other times it is not. It is affected by storms and by the operation of the Fullerton avenue conduit—it is rather irregular—intermittent.

When the pumps at Fullerton avenue are at work they pump in 15,000 cubic feet a minute which would make a slow velocity in the canal. When they are not at work and when there is no storm water flowing, then it is stagnant.

The Illinois and Michigan canal, the only time I have seen it since the main drainage canal was open, it was apparently like it used to be before that channel was put in operation, very black and odorous and with a flow in the channel. There
534 was a flow prior to January, 1900.

When they are operating the pumps to their rated capacity there is a flow of about a foot in a second. That would be about two-thirds of a mile an hour. The Lawrence avenue system of intercepting sewers consists of an intercepting sewer beginning at the upper end of the sewer at the north line of Lincoln Park, and running northwardly to Lawrence avenue; and another one beginning at the city limits or near the city limits on the extreme north and running southward to Lawrence avenue, and making connection with Lawrence avenue, and on the line of Lawrence avenue to the river and the north branch of the river, those intercepting sewer systems, I would say are built; that is the sewers I have described are built and the Lawrence avenue conduit is built within a few hundred feet of Clark street. The remaining portion of it is not built.

That is to collect the sewage from all the sewers that enter into the lake on the north shore within the city limits, and conduct it through the north branch of the Chicago river by way of

Lawrence avenue—the sewage from the north end of Lincoln Park upward to the Lawrence avenue conduit and another one from the north line of the city to the Lawrence avenue
535 conduit. These sewers don't go clear through the north branch of the Chicago river, except the Lawrence avenue conduit. That sewage is to be pumped in the Chicago river. The Lawrence avenue conduit is built below the lake level.

The 39th street conduit is laid out in the same way. There is an intercepting sewer starting on the south at 73d street running north on Stony Island avenue and along the lake shore to 39th street and another one from 35th street south to 39th street. These two sewers will collect all the sewage now flowing into the lake on the south shore of the city, and deliver the sewage at 39th street. This system has been built from 39th street south to 60th street and is in process of construction. The conduit on 39th street is finished with the exception of cleaning up, and the water from the lake and the sewage from that district is to be put through the 39th street conduit with pumps. The 39th street sewer is all below the level of the lake and pumps located at the lake have been provided for lifting the sewage into the south fork of the river. The population that would contribute to the intercepting sewer on the north that is connected with the Lawrence avenue conduit would amount to 28,878 by the school census. There is no intercepting sewer connected with the Fullerton avenue conduit. From the school census the population of the area that is connected with the 39th street conduit is 178,182. By the Federal census would make 16 per cent reduction, or about 150,000.

In January, 1900, and at the present time, all the sewage from the district covered by this 39th street intercepting sewer system, ran into the lake.

537 If all the intercepting sewers now in process of completion, were finished, there would be none of the population of Chicago that would have the outflow of their sewage into Lake Michigan direct from the outlet of Chicago. Some of Chi-

cago goes into the Calumet, and goes indirectly into the lake, but nothing direct into the lake.

CROSS-EXAMINATION, By Attorney General Hamlin:

The Illinois and Michigan canal was constructed some time in the forties.

These pump works were established about 1879 or 1880. They have been in operation ever since at intervals most of the time. There have been intervals when they did not operate. They were in operation pretty much all the time from the time they commenced operation up to the time the drainage canal was put in operation. They were not shut down much.
538 After being put in operation they were under control of the city of Chicago. The Illinois and Michigan canal connects with the river that way.

From 1879 to January, 1900, the north branch of the Chicago river carried sewage, to the confluence with the main river, and with the south branch. That went sometimes to one place, sometimes another, sometimes in the lake and sometimes down the south branch. When the pumps were in operation it went the same, depending on the quantity of flood water reaching the river. The south fork of the south branch reached the stock yards district. The stock yards from 1879 to 1900 were about the same size, perhaps increasing some in the actual number of animals killed there.

The per centage of sewage discharged into the canal by the pumps was variable. In dry time when there was very little or no flood water reaching the Chicago river or its branches, and the pumps in operation to their capacity, which was then not far from 45,000 cubic feet a minute, there would be none of the sewage that went into the river reached the lake, only such sewers as had their direct outlet into the lake. It would ultimately go into the canal through the pumping works.

That condition existed about twenty years. The fall from Robey street to Lockport in the drainage canal—or as far
540 as Willow Springs, was at the rate of one in forty thousand, and from Willow Springs to the controlling works,

one in twenty thousand. The fall in feet from Robey street to the controlling works, I put it, I think at 5.55, that is the bottom of the canal.

The sewers that are to finally connect at Lawrence avenue and the other points I have mentioned are partly constructed but they are not in operation and the sewage that they will carry is now going directly into the lake. I think in 1900, February and March, they had the contracts let for the construction of these sewers. Based on the Federal census the population that drains in the lake would be not far from 150,000.

RE-DIRECT-EXAMINATION, By Attorney General Crow:

The controlling works consist of seven sluice gates that
541 move in slides and are operated by certain mechanical
appliance. Each of those gates has an opening of thirty feet, clear opening. These gates were not all in use; they have not needed them; but they are there as a reserve when the flow becomes so great that they may need them. Then the early appliances relied upon for the main control now, is what is known as the Bear Trap dam, which is 160 feet long in its horizontal
section and it has an oscillation vertically of seventeen
542 feet. The dam is made out of steel—a steel caisson, and
the upper edge of it that points up-stream can be lowered or raised by the water. By letting the water in underneath the dam, it will be raised. By letting that water out into the tail race it will be lowered so that that dam can be oscillated just by operating valves, over a range of seevnteen feet.

I mean that if you put the dam down to the lowest point, it will be seventeen feet below what it would be if it was at its highest. It might not lower the water materially in front of it, it would be just pouring out as a mass over that dam, you know, a good many feet deep.

The town of Lockport is located off to the southeast of these works. The Illinois and Michigan canal lies partially between the drainage canal and the town. At this point the drainage canal is off from the Illinois and Michigan canal a considerable distance. To go to the town you would have to cross the Illinois and Michigan canal.

543 These controlling works at the Bear Trap dam were constructed for the purpose of controlling the amount of water that passed out of the canal into the Des Plaines river, and the volume of water that can be discharged through these sluice gates will more than equal the amount of water taken in at the intake of the river at Chicago.

The necessity for these controlling works arises from the fact that sometimes they would want to shut it off entirely, possibly, and sometimse when you must limit the flow through the river, and as a matter of fact that is what they have been compelled to do all the time by the United States government. They have had to cut down the flow through the Chicago river in accordance with the standard set by the Secretary of War, and it is only by means of this controlling works, that they could do that. Without these controlling works it would simply run wild. That is it would simply flow all that the hydraulic conditions would allow until it would flow all the water that could go through the river and canal under the conditions of cross section and head and fall, and all of that. In other words it would do like a river itself; it would take its uniform flow and you would have no control over it. This was a measure of precaution for the purpose of controlling the outflow of water at all seasons.

544 DR. WALTER C. G. KIRCHNER, called on behalf of complainant, examined in chief by Attorney General Crow, testified as follows:

Am a physician and have been for two years. Am senior physician at the City Hospital. 28 years old. Assisted Dr. Amand Ravold in investigating Chicago river, Des Plaines river, the Drainage canal itself; the Illinois and Michigan canal; Illinois river, Missouri river and Mississippi river. Worked and assisted mainly in quantitative analyses of the water.

545 Began working with Dr. Amand Ravold about August 10, 1899. (This witness states the manner of taking samples of water, plating, etc.

555 EDWARD JAMES RAVOLD, called on behalf of complainant, examined in chief by Attorney General Crow and testified as follows:

Am brother of Dr. Ravold. (This witness testifies as to taking samples of water, the method, etc.)

568 DR. WALTER C. G. KIRCHNER, recalled, on further direct examination by Attorney General Crowe, testified as follows:

570 (This witness identifies the detail made of the bacteriological examination at various points, testified to by Dr. Ravold, and states them to be in accordance with the original figures made by him at the time of the examination.

582 (States method of taking samples and of conveying to laboratories.)

588 DR. AMAND NICHOLAS RAVOLD, resumed the stand for further direct examination by Attorney General Crow and testified as follows:

I heard and saw the comparisons made from the data Dr. Kirchener had and those you presented to him, and will say they are the same details for the corresponding period that I have heretofore read into the record in this case.

589 JAMES J. MOORE, on behalf of complainant; examined by Mr. Jeffries:

Worked under Dr. Teichman and Dr. Ravold, for the Health Department of St. Louis, in collecting samples of water. Describes method pursued.

593 FRANK J. BROW.., in behalf of complainant, examined by Mr. Jeffries:

Resides in St. Louis. Collected samples of water for Dr. Teichmann. Describes method pursued.

598 EUGENE BRUNK, in behalf of complainant; examined by Mr. Jeffries:

Live in St. Louis. Gathered samples for the Health Department under direction of Dr. Teichmann. States method pursued.

605 JAMES GOLDEN, in behalf of complainant; examination by Mr. Jeffries:

Live in St. Louis. Am inspector in Sanitary Division of Health Department. Between months of May and July, 1900; worked under Dr. Teichmann, getting samples of water. States method pursued.

610 BENJAMIN FRANKLIN HART, in behalf of complainant; examined by Mr. Jeffries:

611 Live in St. Louis. Am water inspector for Water Department of St. Louis. From April to August, 1900, took samples of water for Dr. Teichmann. States method pursued.

616 C. V. MERSEREAU, in behalf of complainant; examination by Mr. Jeffries:

Live in St. Louis. Am civil engineer. Am assistant engineer in the Water Department of St. Louis.

617 From Jan. 22, 1900, to May of that year, I was working with men who were taking samples of water for the city chemist. States instructions given to the various collectors.

621 Explains method, apparatus, etc.

628 HENRY R. TAYLOR, in behalf of complainant; examination by Mr. Jeffries:

Live in St. Louis. Was janitor of the office of city chemist of St. Louis. (Explains method of preparing and sterilizing bottles used to collect samples of water.) I prepared all the bottles and shipped them.

633 FRANK J. BROWN, recalled in behalf of complainant; examined by Mr. Jeffries:

Identifies tags used on bottles shipped to city chemist's office from various points where the water was collected.

635 JACOB APEL, in behalf of complainant; examined by Mr. Jeffries:

Was collector of samples of water. Describes method pursued and places where water was taken.

DR. WILLIAM C. TEICHMANN, called on behalf of complainant, upon examination by Attorney General Crow, testified as follows:

640 My name is William C. Teichmann, and am forty-three years old. I reside at 3624 Shaw avenue, St. Louis. I am city chemist and have been since April, 1893.

641 I had charge of the chemical investigation of the waters of the Mississippi and the Missouri rivers and the Chicago Drainage canal and the Illinois and Des Plaines rivers which was begun along in 1899 and continued through 1899, 1900, 1901 and 1902.

The first period of investigation began on August 23, 1899, and continued until January 22, 1900.

642 I was ordered by the health commissioner of St. Louis, who is the superior official of my department, to take these samples.

Total number of samples collected during the first period was 142.

The points were as follows:

Mississippi river, Chain of Rocks, near Intake tower, 26 samples.

Mississippi river, Chain of Rocks, Missouri shore, 3 samples.

Mississippi river, Chain of Rocks, Illinois shore, 3 samples.

St. Louis water works, the uptake, 28 samples.

643 Mississippi river, Madison Landing, between Chain of Rocks and the mouth of the Missouri river, near the Missouri shore, 3 samples.

Mississippi river, Madison Landing, between Chain of Rocks and the mouth of the Missouri river, near the Illinois shore, 7 samples.

Mouth of Missouri river, 10 samples.

Mississippi river points, between Alton and the mouth of the Missouri river, 13 samples.

Mississippi river, near Clifton Terrace, between Alton and Portage, 6 samples.

Mississippi river at Elsah, near Piasa Bluffs, between Portage and Grafton, 5 samples.

Illinois river at points located, one, two, three and five miles above Grafton, 19 samples.

Mississippi river at points 1, 2, 3 and 5 miles above the mouth of the Illinois river, 19 samples, total 142 samples.

644 These samples were taken to the city chemist's office, St. Louis, and they were there analyzed by myself and my assistant, Mr. Thomas A. Buckland. From Aug. 23, 1899, for two months these samples were taken in demijohns, by holding in the hand under water.

Exhibit 16 is the character of bottle that was used in collecting the samples after two months.

647 Originally educated at Washington University, academic department. My education is chemical. I left the academic department of the Washington University and entered in the fall of 1875 the Polytechnic College of Brunswich, Germany. I studied chemistry at that college from 1875 to 1879. In the fall of 1879 I proceeded to Berlin and entered the University of Berlin, Germany. I studied there chemistry and a number of other corresponding branches, like history and literature, for general educational purposes from 1879 to 1881. In Berlin I studied principally under Prof. Ferdinand Tiemann, who is considered one of the leading authorities on water analysis, and the author of a well known standard work on water analysis. In 1881, in the summer, I left the University of Berlin and studied a half year's course in the University at Leipsic—I studied history. I then proceeded to the University of Munich in Germany and studied history from 1882 to 1885, and I graduated as a doctor of philosophy in chemistry and history in the year 1885, from the University of Munich, Germany

648 Under Prof. Tiemann, at the University of Berlin, I made a specialty of the study of the analysis of water. In 1885 I returned to this country and was principally occupied in literary pursuits until 1890. I then became private assistant to Prof. Charles O. Curtman, professor of chemistry in the Missouri Medical College at St. Louis. In 1891 I became assistant instructor of chemistry, as assistant to Prof. Curtman, in Missouri Medical College, which position I retained until 1895. In that position I assisted in quite a number of analyses of water. In 1893 was appointed city chemist of St. Louis, and have occupied that office since that time. Among the duties of the office, which are manifold, there is first of all, analytical work for the Health Department, which includes constant analysis of samples of well water and of cistern water. Some branches of it is continuous work.

644 Since this examination began, I have analyzed the water from the Chain of Rocks, not only for this litigation, but also for the water department, in order to give them a correct daily record of the water supplied to the city.

Prior to August, 1899, the analyses were made of a sporadic character. That is, they were not regular in intervals—it was only at times when the board of health just wanted to know how the city water supply was. I took samples then from the tapl and on one occasion, in 1893, in October, I took a number of samples from the mouth of the Illinois, and from various poins, about twenty-two samples, from various points

650 between the mouth of the Illinois and the Chain of Rocks, but that was only one collection made, and I consider that analytical survey of a sporadic character, and I don't consider myself justified in drawing definite conclusions of the character of the water at that time from this sporadic series of collections.

The next period begins January 23d, and ends for the largest part of the collection of the samples on October 11th, 1900. During that period 3,492 samples were collected.

Witness then states points at which samples were collected. Entire number of samples analyzed from Aug. 23, 1899, until Jan. 1, 1900, amounted to 4,000.

657 During the time above indicated, the samples were taken daily. From Oct. 12, this daily collection of samples outside of St. Louis ceased and we only collected weekly or semi-weekly after that period until November 30, 1900.

658 These bottles were tagged and the tags are here; there are about 8,400 of them.

659 The books containing the official register of the city chemist's office, of all samples of water beginning with
660 sample 148, until the present date, are stipulated to be in evidence but not to be printed. The record corresponds with the memorandum on the tags, and the register also states in every case that duplicate chemical sample was turned over to Prof. Keiser, and that the bacteriological sample collected at the same time by that collector had been turned over to the Bacteriologist.

There are five periods of investigation altogether.
661 This is the third investigation. The date particularly as far as the collection of samples at the Chain of Rocks is concerned, was from October 12, 1900, to September 30, 1901. During this period of collection analysis of samples was confined to such as were taken from the Mississippi river at the Chain of Rocks, daily, from the following points:

Illinois shore.

Missouri shore.

Intake tower.

Near Intake tower; one opposite Intake tower, from Illinois shore, and one from Missouri shore, Intake tower.

Also a sample was taken from the outlet chamber of the St. Louis water works, every day.

662 And from the top of the city chemist's office.

These samples were taken daily from Oct. 12, 1900, to September 30, 1901.

664 The next period was from Oct. 1, 1901, to Nov. 30, 1901. This was the most extensive period, or the period of the

most extensive investigation connected with this litigation. It was principally a daily collection of samples with the exception that at some points, cross-sections were taken and
665 for special scientific reasons connected with the investigation, samples at random had to be taken, but not consecutively every day, from day to day, but there was from a large number of points during this two months, daily samples collected.

665 The samples were taken from various points beginning with Bridgeport down to the intake. (See 1063-4-5.)

Tri-weekly samples were collected from Lake Michigan during this period.

666 Semi-weekly samples were taken from the south branch of the Chicago river at a point near the Chicago & Alton bridge; also at Wesley, Illinois, left, right and center section of the Illinois river. Wesley is three miles south of Peoria.

Four samples during this period at Omaha, above and below the city of Omaha.

Four samples from above and below the following cities, on the Missouri river:

Kansas City, Jefferson City, Herman, St. Charles.

Two samples were also collected from the following points:

Missouri river at St. Joseph, Mo.; Kaw river near Argentine, Kan.; from the Missouri at Wathena, Kan.

During this period occasional cross-sections of samples were taken at various points enumerated on page 666.

668 Next period extended properly from December 1, 1901, to July 1, 1902, and represents a daily collection of samples from the Mississippi river at the Intake tower and from the Missouri and Illinois shores; and also from the outlet chamber of the St. Louis waterworks and from the tap in the city chemist's office.

CROSS EXAMINATION

By Judge Springer.

671 The samples at Chain of Rocks, Missouri shore, were taken—supposed to be anywhere from 25, 50 or 75 yards. It is impossible to designate a particular point there on account of the current, but the general instruction was that the collector was to get a sample from the Missouri river current, which is generally supposed to hug the Missouri shore very closely, to get a sample of that current.

Q. Now what were your instructions with regard to the point on the opposite shore or the Illinois shore?

A. Exactly the same, only applied to the general supposition of a certain current hugging the Illinois shore there.

Q. How far was that point from the land, from the shore of the Illinois side?

A. Well, now, that varies very much according to the point taken at the shore, and it has to be left to the judgment of the collector largely.

672 My instructions in regard to that particular point was that they were to get water that was close to the Illinois shore, a certain current there with which the collector would very soon become familiar after entering upon his duties.

Q. Was there any distinction at that point between water which it was supposed by you or your collectors to come from the Mississippi river proper, or from the Illinois river in part—in other words, had the Illinois and Mississippi waters commingled at that point so that they could not be designated or separated from each other by the eye?

A. Well, we could only determine by the chemical analysis, that is, the results of the chemical analysis would demonstrate that.

675 CHARLES F. WERNER, called on behalf of plaintiff, examined by Attorney General Crow.

Collected water samples and testifies as to method pursued, etc.

684 DR. W. C. G. KIRCHENER, recalled. Upon examina-

tion by Attorney General Crow testified as to receiving samples at laboratory, etc.

686 **LOUIS SAUER**, examined by Mr. Jeffries. Collected samples of water. States method, etc.

689 **DR. W. C. G. KIRCHENER**, recalled, identifies tags on bottles.

691 **ALBERT WINSCHELL**, examined by Mr. Jeffries. Is a barber, collected samples of water. States places at which samples were collected, method of packing, etc.

697 **FRED DIESELHORST**, examined by Mr. Jeffries. Was collector of water samples. States how samples were collected, etc.

701 **THOMAS A. BUCKLAND**, examined by Mr. Jeffries. Am assistant city chemist. Identifies tags used on water samples. States the condition of the bottles when they came in; assisted in making examination of water under Dr. Teichmann.

706 **EDWIN A. SLUDER**, examined by Mr. Jeffries Collected water samples at various places and states method used and places where samples were taken.

718 Stipulation and order of court of March 3, 1903, in regard to taking of testimony.

719 **THEODORE G. RUFF**, examined by Mr. Woerner. Collected samples of water. States method.

722 **ED. BOCHERT**, examined by Mr. Jeffries. Drove the wagon that conveyed samples from Chain of Rocks to city hall, etc.

726 **ANTON KREH**, examined by Mr. Jeffries. Collected samples of water. States places at which collections were made and method.

732 **FRED B. WENZEL**, examined by Mr. Jeffries. Collected water samples. States places at which collections were made and method pursued.

736 **WILLIAM TOOHEY**, examined by Mr. Jeffries. Collected samples of water. States places at which collections were made and method pursued.

DR. AMAND NICHOLAS RAVOLD, recalled and examined by Attorney General Crow:

740 I am acquainted with L. H. Taylor's report to the city board of health of Plymouth, Pa. I never was in Plymouth. Following as to information received from report, objected to by Attorney General Hamlin. It seems from the report the typhoid fever epidemic of 1885 in that town, was caused by a person being sick with typhoid fever in January and his dejecture, urine and feces were thrown out upon the side of the mountain, with the water reservoirs down below. Here in the ice and sun of this cold region, it remained frozen until early in March when it thawed and this water containing the feces ran down, into the reservoir, and when the superintendent of the reservoir found the lower reservoir low enough to permit him to pump, or rather to turn this water into the water supply of the town, then the pumping was stopped from the Susquehanna river and this water supplied, and within an incubation period of from two to three weeks, April 9th the first case of typhoid fever appearing, this epidemic occurred.

741 Water amounting to 5,000,000 gollans in reservoir was infected by the discharges of one person.

Have been to Hamburg, Germany. They have a water filter there for their city water supply. The water is pumped from the river Elbe, the Norder Elbe. First it is carried into

742 two very large sedimentation tanks. Here the water is allowed to settle from 24 to 36 hours and it is then carried across to a series of sand filters. They have forty to fifty inches of filtering surface. The water is admitted slowly from below until the sand in this whole mass of rock, etc., is saturated with water. The water is allowed to cover the surface of it. Then the filtered water is allowed to run in so as not to disturb the filter bed too much and anywhere from 30 to 50 inches of water are allowed to stand on top of the sand. The water that first passes through the filter is bacteriologically practically the same as that which runs into it—contains the same number of bacteria.

After a time the filter begins to filter. The bacteria has this little gelatinous capsule on its cell wall which permits it to adhere to a grain of sand or to one another and in this way a glue like mass was in the sand layer of the filtering tank, or as the Germans call it, a Smutzdecke is formed. This bacterial layer now catches all bacteria and solid particles that are in
743 the water as it passes through the filter and holds them tenaciously.

The water passes from these reservoirs into what is called a clear well at Hamburg. The clear well is covered. Every few hours a sample of this water is taken. This well is walled, with masonry. The water taken from this clear well, according to the German law, must not contain more than 100 bacteria per cubic centimeter. If it does the filter is not working properly and is put out of use. There are what is known as open filters, not covered as they are in Berlin. The filter basin is open. That number of bacteria is harmless.

744 I have here chart showing the course of the typhoid fever in Hamburg before and after the filtration of the municipal water supply. On the left hand side of this chart of figures ranging from 0 to 100. This represents deaths per 100,000 of population. Along the lower margin are written in figures in ink, the years from 1880 to 1898. Then I have columns here in black and the deaths per 100,000 can be read from the left hand side of the map and also from the figures written on top of the column.

From 1880 to 1893 in May, the average death rate was 39.7 per 100,000. From 1893 to 1898 the average death rate after this filtration is 9 per 100,000.

745 Said map marked Exhibit 21.

I received information through Dr. Seibert of New York, of the New York Medical Journal, that in 1901 the typhoid death rate in Hamburg was one death to 60,000 of population. So if marked on that map it would be a very small column showing the efficiency of filtration against water born diseases.

Have seen the water supply of London. They have the oldest filters in the world, started to put them in in 1829 and are much similar to the Hamburg filter. I saw those at Lambeth and Hampstead.

746 The water is pumped from the Thames. There was a great decrease in typhoid death rate in London following the introduction of the filter system.

The water supply of Vienna is taken from the Springs in the Schneeberg mountains. They come 67 miles. When I was there they were intending to put in filters of the Wormse of Plague type.

748 The death rate from typhoid in Vienna is very low. In 1890 it was 9 deaths per 100,000 population.

Have been in Berlin and investigated their water supply from a sanitary standpoint. They have a filter water supply.

749 From 1843 to 1853 the typhoid death rate was 1 to every 900 inhabitants of the town. The first filter was put in in 1856. Now 1883 to 1893, before the bacteriologists had really taken hold of this subject of filtration, before we understood it, the typhoid death rate was 1 to 900. In the meanwhile Berlin had some shallow wells in which some of the water supply of the town was taken, but from 1892 on when the new works were put in with all water filtered, we find that in 1900 it is reported there was one typhoid case to over 50,000 in-
750 inhabitants. That is a remarkable reduction.

Have investigated the water supply of Paris, France. They have some filtered water there and water brought a long distance from springs in the mountains as high as 100 miles.

They also pump directly from the Seine. In some houses you will see two faucets. One faucet has a sign on it, "This is dangerous. Do not drink it." The other is the good water that has been filtered or that has been brought in from the mountains.

They have sand filters pretty much the same as the Hamburg and Vienna and Berlin filters.

751 I am familiar with the report of the man who made the investigations, Dr. Thorne, of the epidemic of Catterham

and Red Hill, England, in 1879. The water supply of Catterham and Red Hill was supplied by a water company which pumped their water from deep wells. Two of the wells were somewhat near together and it was decided to connect them with a tunnel or an adit, and they were working on a small tunnel for the purpose of connecting these two wells together.

One of the workmen worked from January 5th to 20th. He had diarrhoea all this time and on the 20th was so sick that he was taken to his bed and remained there. While he was at work his discharges were carried up in a bucket that carried up rock, and discharged on the surface of the soil. It was a liquid discharge and the leakage from these buckets affected the water supply. On January 19th the first case of typhoid occurred. All of the typhoid occurred in places where the water supply was had from this company. The inmates of the Insane asylum and the military forces stationed there, who received their water from an independent well, were not affected.

752 I am familiar with what is called the London Bond Street Pump Epidemic. The pump was sunk into the ground on Bond street and the water was taken by a number of people living in that neighborhood. It was said to be a good well and the water was sparkling and tasted very nicely. When this cholera epidemic was investigated by the authorities they found that close to it was a cess pool and also a sewer that carried the sewage from one or two houses near by it.

There was found to one side or near it, when this cistern or well was broken, a drain which was practically pervious, allowing the sewage to come through and also the cess pool which allowed the discharge to enter almost directly into this well. The case of cholera existed in the house that used this cess pool and the feces were carried directly from the cess pool into this water.

Witness reads from Hill's work on public water supplies, the deaths per 100,000 in foreign cities.

Witness then reads deaths per 100,000 in cities of the United States. The foreign cities have filtered water supply while the United States has not and the difference in deaths is in favor of the European cities.

756 ARTHUR C. LOOLEY, examined by Mr. Woerner. My business is grocery clerk. Was employed to collect samples of water for Dr. Teichmann. Explains method pursued, etc.

759 DR. AMAND NICHOLAS RAVOLD, resumed the stand for further direct examination by Attorney General Crow. This is a chart prepared by me. It reads as follows: Chart showing cases and deaths from typhoid fever in St. Louis, Missouri, when water supply was taken from the Mississippi river at Bissell's Point, from January, 1890, to September 28, 1894, to December, 1902, when the water was taken from the river at the Chain of Rocks. Below that is written water from Bissell's Point, January, 1890, to September 28th, 1894, five years. Cases of typhoid fever 1,268. Below that is writ-
760 ten: Water from Chain of Rocks, 1895 to 1900, five years. Typhoid fever cases, 2,490; deaths from typhoid fever, 562.

Back of that is written, with an index pointing to the percentage decrease in typhoid fever death rate 125 per cent.

That is the difference between these two points. The reason for this decrease is that when the water was taken from Bissell's Point, Harlem Creek, which drained an area containing 10,000 inhabitants, discharged its contents into the intake of the St. Louis water supply.

761 Next is water at Chain of Rocks since the opening of the drainage canal, January 17, 1900, 3 years, 3,426 cases and 588 deaths.

Water at Chain of Rocks three years before opening of the drainage canal, for 1897, 1898 and 1899, 1,807 cases; 350 deaths.

Back of that is shown increase in typhoid death rate since opening of the canal, three years, 68 per cent.

From the statistics of the Board of Health of St. Louis this chart has been made to graphically illustrate these matters.

The Harlem creek epidemic occurred in 1892.

In 1890, there were 547 cases; deaths 277;

In 1891, cases 447; deaths 160;

1892, 3,624 cases; 488 deaths;

762 1893, cases 788; deaths 215;

1894, cases 816; deaths 178.

During 1893 and 1894 the Harlem creek still affected the conditions somewhat because in high water the pumps were not heavy enough to take all of the water that is discharged on that watershed, so it ran over the dam.

1897, 433 cases; 125 deaths;

1898, 426 cases; 95 deaths;

1899, 948 cases; 130 deaths.

764 In 1899 we have a remarkable number of cases. In November, 488 cases reported and 31 deaths; and in December, 116 cases and 20 deaths, which makes this great increase here.

The river was so low in 1899 that it was feared that the lowest gates in the intake tower would not be low enough to admit enough water for the pumps, so a coffer dam was built about the intake and men put at work breaking a hole through this tower and they got down pretty low and stirred up the mud in the bottom of the river.

The result would be, of course, part of it, to stir up any bacteria, any typhoid or pathogenic bacteria in the water there.

I have no data to assist me in drawing a conclusion that

765 that was really the cause, although the cause for that particular flare in November has been ascribed to the work that was going on in October, in that tower.

I know that at that time there were dredges at work in the Illinois river below Kampsville.

766 In 1900 there were 1,213 cases, and 168 deaths;

1901, 1,101 cases, 198 deaths;

1902, 1,112 cases, 222 deaths.

Map offered in evidence as Exhibit No. 22.

767 Chicago has a population of 1,650,000 according to the United States census.

The proportion of population in the vicinity of Chicago, which also discharges its sewage into the drainage canal above Lockport, is roughly estimated at 350,000 people.

That makes approximately 2,000,000 people whose waste products are emptied in the drainage canal above Lockport.

768 There are about three ounces of solid excrementatious matter and 40 ounces of urine per capita per day. That is a low average. If each of those 2,000,000 people discharged three ounces a day the total results would be above 187 to 190 tons of solid matter, human offal.

769 Forty ounces a day would give 670,000 gallons of urine per 24 hours.

When I say sewage I mean the urine and feces and liquid matter flowing in a sewer.

The consumption of water by Chicago is 150 gallons per day per inhabitant, which would make the consumption reach 360,000,000 for the 2,000,000.

770 The dilution of sewage by waters flowing in drainage canal assuming that 300,000 cubic feet are discharged per minute is as one is to nine. The diluted sewage at Lockport does not approach in the slightest degree to the resemblance of a sanitary water.

767 The population of Chicago is given by the last U. S. Census as 1,650,000. Sewage from 350,000 people is also discharged in the canal above Lockport. This is outside of the Sanitary District. The waste products of these
768 2,000,000 people are emptied into the Drainage Canal above Lockport, 27 miles approximately from Chicago.

There are about 3 ounces of solid excrementatious matter and 40 ounces of urine discharged per capita per day. 2,000,000 people discharging 3 ounces per day would be about 187 to 190 tons of solid matter, and 40 ounces of urine a day would give 670,000 gallons of urine. That is per 24 hours.

769 The water consumption of Chicago is 150 gallons per

inhabitant per day, making something like 360,000,000 gallons per day for the whole population.

770 Based upon the assumption that the Drainage Canal was discharging 300,000 cubic feet of water per minute, we find the sewage of Chicago would be diluted as 1 to 9—that is one of sewage to nine of water.

It is readily seen by a perusal of the bacteriological resykts which have been submitted here, obtained from an analysis of samples collected daily at Lockport, that the diluted sewage at this point does not approach in the slightest degree to the resemblance of a sanitary water. The effect on fish of this water at the Bear Trap Dam was to kill them. In November 1900, 500 fish were observed passing over the dam in the space of ten minutes.

772 1900 census gives Peoria a population of 56,100.

Before canal was opened the minimum flow of the Illinois river at Peoria, according to Mr. Harmon's figures from his report to the Illinois State Board of Health, is 1,221 cubic feet. We figured it 1,200 cubic feet per second.

Q. Now assuming that the people in Peoria had an outfall of sewage equivalent to the same number of people in the city of Chicago, how many gallons per day per capita at Peoria would go into the water of the Illinois river?

ATTORNEY GENERAL HAMLIN—That is objected to on the ground that there is no allegation in the bill charging the discharge of sewage at Peoria, or any claim made growing out of any such discharge.

A. Assuming the same we would have 150 gallons per minute. Basing it on a flow of 1,200 cubic feet per minute and taking 56,100 people with a discharge of 150 gallons per head per day, that would give a dilution of 1 to 92 at the low river stage. That is the Peoria sewage. The distance from Peoria to Grafton is 160 miles.

773 With the 300,000 cubic feet per minute added by the

Drainage Canal, if that were added to the low river stage of the river, at Peoria, the dilution would be 1 to 413.

Q. If the Chicago canal water were free from sewage contamination and was emptying this Lake Michigan water in the pure state into the Illinois River at Peoria, at low stage of the Illinois river, would the pollution from Peoria, if the pollution in the sewage is in the proportion that you have stated heretofore, render unpotable the water of the Illinois river at its confluence with the Mississippi at Grafton, 160 miles below, from a bacteriological standpoint?

I mean fit for domestic purposes, drinking and cooking.

A. Well, it would reduce the danger to a minimum, that is just dilution alone, at Grafton.

JUDGE SPRINGER—I want to enter an objection to that question and answer from the fact that it does not illustrate any issue in this case, and from the further fact that there is a great deal more pollution from Peoria comes into the stream from Peoria, and the Illinois river.

774 One sixth of the sewage of persons in towns not sewered, rural districts, in proximity to rivers or the feeders there-

of, brooks and streams, eventually gets into the stream. I have a report of L. E. Cooley. (Said report is as follows):

	Flow per cubic feet per second	Urban population, census 1890	Rural population	Total population
Des Plaines River	13.21	20,354	45,247	75,601
Du Page River	32.77	5,344	10,890	16,234
Kankakee River	509.24	26,697	140,441	170,138
Fox River	329.95	72,763	89,889	162,652
Vermilion River	4	17,543	43,257	60,800
Mackinaw River	......	5,247	30,106	35,353
Spoon River	87.76	19,619	56,428	76,047
Sangamon River	372.30	103,720	177,638	281,358
Crooked Creek	......	12,739	44,289	57,028
Macoupin Creek	......	9,155	32,296	41,453
McKee's Creek	......	......	8,823	8,823
Illinois River, direct	......	135,139	184,877	320,016
Sanitary District of Chicago	......	1,800,000	....	1,800,000
Totals	....	2,241,320	864,183	3,105,503

776 Alton has a population of 15,000. It discharges its sewage into the Mississippi river. They have five main outlets, three of which empty into the Mississippi river, behind dikes, which quite effectually check that portion of the sewage from becoming mixed at once with the waters of the main channel of the river.

Hartford is on the Illinois shore, five or six miles below Alton, about one mile above the point where the Missouri river enters into the Mississippi river.

777 I have the average number of bacteria found in the waters of this river at these two points, Alton and Hartford.

MONTHLY AVERAGE RESULTS OF QUANTITATIVE ANALYSES OF MISSISSIPPI RIVER WATER ONE MILE ABOVE ALTON AND OPPOSITE HARTFORD RESPECTIVELY, TOGETHER WITH THE AVERAGE RESULTS OF THE TESTS FOR THE BACILLUS COLI COMMUNIS.

	January, 1900.	February, 1900.	March, 1900.	April, 1900.	May, 1900.	June, 1900.	July, 1900.	August, 1900.	September, 1900.	October, 1900.	October, 1901.	November, 1901.
Alton Bacteria	118,800	192,500	192,300	29,400	10,300	8,200	7,700	2,400	2,600	2,100	1,137	1,566
Percentage Bacillus Coli Communis	.14	.17	.51	.39	.54	.60	.52	.88	.90	100	100	.77
Hartford Bacteria	90,600	190,600	208,300	29,700	12,800	5,800	61,000	2,100	2,800	2,400	2,141	3,000
Percentage Bacillus Coli Communis	.17	.50	.52	.41	.86	.61	.55	.89	.93	100	86.4	.56

778 The sewage at Alton hangs behind those dikes and is only flushed out at times when the river is flooded. Assuming that the whole of the sewage of Alton becomes mixed with the Mississippi river water and is carried directly towards Hartford with a minimum flow of 25,000 cubic feet per second, in the Mississippi, it will be seen that the sewage of this city of 15,000 people is diluted in a minimum of over one to 70,000.

779 From these figures it will be concluded from the biological results, that the sewage of the city of Alton has no effect on the sanitary conditions of the Mississippi river water at Hartford.

Explains the nature of bacillus prodigiosus.

780 Never found this bacteria in the waters of Lake Michigan, Drainage Canal, Illinois river, or Mississippi river.

On August 31,1900, we prepared in a forty-gallon whiskey barrel, forty gallons of broth culture of this bacillus prodigiosus and grew it for several days in that barrel. On August 31, 1900, this broth, containing over one thousand million

781 bacteria per cubic centimeter, was emptied into the Mississippi river just below the mouth of the Illinois river.

On the way down on the boat samples were taken right straight along, of the Mississippi river water, the samples were collected hourly and studied. Sept. 3rd, four days later, this organism was found in a sample collected in the channel of the river at Alton, but at no other place.

Sept. 20 this experiment was repeated. A barrel containing 40 gallons of bacillus prodigiosus broth was emptied at the same point, and on Sept. 23 this organism was found in a sample collected near the Illinois shore at the Chain of Rocks. On Oct. 18 this bacterium was found in a sample from the laboratory tap in the old city hall, and on October 24 in a sample collected near the Illinois shore, Chain of Rocks.

782 One hundred and seven barrels of prodigiosus broth each containing 40 gallons, were prepared at the old pumping tation at the St. Louis water works, by Mr. E. J. Ravold, my rother, and shipped to Lemont, Illinois, and emptied in the hicago Drainage Canal on the evening of November 6th, 1901.

There were one thousand million bacteria per cubic centi-

783 meter of the contents of the 107 barrels.

All the laboratories were notified and samples were colected every hour of the day and night at the Controlling Vorks, Drainage Canal, and at Joliet, Peoria, Grafton, on the Illinois river, and the intake of the water works, Chain of Rocks.

784 Bacillus Prodigiosus was found in samples collected at Intake Tower, Chain of Rocks, December 4th, at 8:45 A. M. Another sample collected at 9 A. M. on Dec. 5, contained the prodigiosus. Found at Grafton, Illinois, Illinois river, December 6th, at 8 A. M. Found again at same place December 7, at midnight.

785 A series of experiments were made with the bacillus prodigiosus to ascertain its longevity in samples of water collected from Chicago river, Drainage Canal, Illinois river at Pekin, and laboratory tap, St. Louis. A summary of the results is as follows: (See record 85.)

787 With these micro-organisms side by side, comparative estimation of the longevity of the bacillus typhosus, and the bacillus prodigiosus, in separate samples of water collected at the same time and place, and kept under the same conditions as to sunlight, temperature and darkness, the bacillus prodigiosus in sunlight, in living waters, that is, non-sterilized waters, lived from two to ten days. The bacillus typhosus in sunlight, and in living waters, non-sterilized, lived from 24 hours to ten days.

In the dark, in non-sterilized, living waters, the bacillus prodigiosus lived from 31 to 53 days and bacillus typhosus from 24 hours to 21 days.

There is a resemblance between these bacterium. They are both bacilli, non-spore forming, and from the above table it is seen that the bacillus prodigiosus is an organism which closely resembles the bacillus typhosus in its power to resist unfavorable surroundings.

788 Q. Now doctor, I will ask you in your judgement, if typhoid bacillus coming from the out-falls of the Chicago sewers into the Chicago river and carried into the Canal, could come into the Intake tower of the St. Louis water works, still retaining its vitality?

A. That will depend upon the time it takes the waters to come from Chicago to St. Louis. But basing my conclusions upon the experiments that I have carried out, and showing that the Mississippi and Illinois river water comes into the intake of the St. Louis waterworks, I am inclined to believe it is highly probable that a typhoid bacillus can live and be carried by water carriage from the Chicago sewers into the Intake of the St. Louis water works, especially in high water conditions in the Illinois river.

ATTORNEY GENERAL HAMLIN—I will enter a motion to exclude that answer as not responsive to the question.

WITNESS—The rapidity of the current does not tend to destroy the typhoid bacteria.

Q. Well, does the volume of water into which a typhoid bacillus may be put affect in any manner its vitality?

A. No sir, it does not kill it.

ATTORNEY GENERAL HAMLIN—I move that that question and answer be excluded as not responsive.

791 In our laboratory experiments, we find that when we take water for instance from the Drainage Canal, that it contains on an average of three or four hundred thousand bacilli to the cubic centimeter. We sow typhoid bacilli in this water and for the first two, three or four days the water bacteria, not the typhoid bacilli, increased enormously, and used up the nutritive material in the flask for food. The results of this destructive action on the organic matter both solid and liquid in the water, results in the production of poisons. True toxin and enzymes and these products seem to act not only deleteriously upon one another but upon the pathogenic micro-organisms that the bacteria in the living waters die much quicker than they do in sterile distilled waters, or than in river waters sterilized.

Q. But in the water in the running streams of course there is no means of judging the results of that?

A. No, the conditions are these: That the toxine or products produced by water bacteria that are deleterious to the typhoid bacillus would be greatly diluted by the flowing water. Besides typhoid bacillus is a mover, and it can swim and get out of the way of anything that would be deleterious to it in a river.

792 Results of experiments as to the longevity of the typhoid bacilli. (See rec. 792.)

799 Q. Now from your knowledge as a bacteriologist and from the knowledge you have of the Chicago Drainage Canal, the DesPlaines river, the Illinois river, the Mississippi river, and the distances, and the speed of the streams, can you state whether or not when the water is running through the Chicago Canal with the sewage running into it, bacteria could come from the Drainage Canal into the Mississippi river?

800 A. Yes, sir. I think the bacteriological experiments indicate that bacteria discharged by the Drainage Canal, especially in high river stages, are carried into the Mississippi river by way of the Illinois river.

Q. Well, do you say that as a fact?

A. Yes, sir.

Q. Now from the same state of facts, above mentioned, as to the rivers and the relative geographical location of the Illinois river, the Mississippi river and the Chicago Canal, etc., do you say, or can you say whether or not the bacteria coming out of the Illinois river, being discharged into the Mississippi river may or do enter the Intake of the St. Louis water works?

A. I think they not only may, but they do, and I base this statement upon the bacteriological investigation that has been conducted by me from 1899 to the present time, from special experiments that were carried out which led me to assert that they do from the mixture of the waters that takes place at the Intake.

From my bacteriological examination the average number of bacteria found in the Intake of the St. Louis water works for the 1900 period— this is Mississippi river water—that is the samples contain on an average of 72,600 bacteria per cubic centimeter, and bacillus coli communis 62 per cent of the time. That is the average for the whole of that period beginning January 23, 1900, and extending to October.

801 Bacillus coli communis is a pathogenic bacteria. I don't know that it ever does destroy the potability of water. I cannot say that it contaminates water at all; it is an index of pollution. It is never dangerous to the human being except when injected beneath the skin, or when it gets out into the blood stream or lymphatic stream from the intestinal canal. It is one of the most active causes of appendicitis.

802 It (the bacillus coli communis) is not classed as pathogenic bacteria by water bacteriologists, but by the pathologists on account of the pathologic conditions which they produce, which I have already explained, (rec. 801) They are classed as pathologic when they get into the tissues. Pathogenic would be the better word. You can say pathologic too.

Q. Can you state from your examination bacteriologically of the waters in the Mississippi river at St. Louis water works, whether or not that water supply is pure or impure, and if it is impure whether it is a menace to the health of this city?

A. Bacteriologically it is an impure water; it is not a potable water, and it is unfit for human consumption. That is, it flows in the river.

803 Typhoid bacteria is considered one of the highly vitalized and hardy bacteria.

Witness relates the results of experiments made to determine the longevity of typhoid bacilli in various waters under various conditions. (See rec. 803.)

(These experiments tend to show that the typhoid bacteria lives a shorter period of time in ordinary water taken from a stream than in sterilized water.)

807 Drawing conclusions from the laboratory experiments we find that the bacteria (typhoid) live from four days to as high as 21 days in the laboratory flask, in living, non-

sterilized waters. Basing conclusions on them I would be inclined to believe that the bacilli would live much longer in a running stream, living water, than that period.

Q. How much longer?

A. Anywhere from fifteen to thirty days, and that would be a very small limitation.

808 Objection to question by Attorney General Hamlin.

Taking 20 days as the period of time of travel from Chicago to the tap in St. Louis, I think it highly probable from my experiments that typhoid bacilli discharged by the sewage system of Chicago, in the Drainage Canal, could live and retain its vitality the whole, enter the Intake of the St. Louis water works and be distributed to a user of the water sufficiently vitalized to cause disease in a susceptible individual.

ATTORNEY GENERAL HAMLIN—I move to exclude the answer on the ground stated in the objection to the question.

Witness explains various theories explaining the disappearance of bacteria in running water, such as aeration, dilution, sunlight, sedimentation.

813 (Explains method pursued and where typhoid cultures were gotten that were used in experiments to determine longevity of typhus bacillus in various waters.)

817 (Explains apparatus used and method employed in examinations and tests made for the bacillus in the waters of the various rivers during the various periods of examination.)

830 Cause of typhoid fever is typhus bacillus. Cannot be contracted except by taking the bacteria in the mouth or nose and down into the stomach and intestinal canal.

832 The usual method by which this disease is conveyed is infection by water polluted with the dejecta of typhoid fever patients containing the typhoid fever bacillus.

837 From February 8th until the 20th, 1900, the water on the Illinois shore (at the Chain of Rocks) was dark, black. The water on the Missouri shore was fairly clear. The sample

at the Intake showed about an equable mixture of these two waters, and this is demonstrated in the bacteriological examination.

Q. What relation did those dates have to the epidemic of typhoid that ensued in the spring of 1900, that you have heretofore testified about?

A. Within an incubation period the typhoid death rate ran up rapidly in this town in March. Samples were collected in February, and in March 117 cases and sixteen deaths by typhoid occurred in St. Louis, a phenomena that never had occurred previously, and I believe has not since. No such a flare of typhoid in March has ever been recorded in the history of St. Louis, as followed this mixture of this dirty water at the Intake.

I do not consider this water potable and safe for drinking purposes that comes from the Intake tower of the St. Louis water works now, without filtration or without boiling.

837 CROSS EXAMINATION

By Judge Springer.

838 While the river was high the samples from the Illinois river previous to that date, the 10th, were fairly clear, running back a definite time, but this remarkable difference in the water followed a thaw in the Illinois valley and a precipitation of a good deal of water—this whole sweeping out of the Illinois river, came. The Mississippi still remained covered with ice and the Missouri river was covered with ice, this thaw not having reached round to the entire region, and until this thaw did reach the Mississippi river above, towards St. Paul, and finally sweep down onto the Missouri and the waters of all these rivers raised then this difference could be noticed. So at a particular time the Illinois river was high this flood

839 volume was very great and the Missouri and Mississippi rivers were low and the difference in the aspects of the water were recorded.

The first marked condition of discoloration which appeared at Grafton and on the Illinois shore I think was about the 10th of February, 1900. There was a high stage of water then in the Illinois river. It was a thaw, you see, that was in February. January and February are winter months.

Our work upon the rivers indicated, and we are pretty confident about that, that the first discharge of the Chicago river through the Drainage Canal, at the opening of which occurred on the 16th or 17th of January, reached here by the 29th or 30th of January, and passed, at which time fortunately the Missouri river was very high.

I reached a conclusion as to the cause of this discoloration or polluted condition at Grafton and on the Illinois shore. It was this: This mass of filth that was in the Chicago river
and in the Drainage Canal while it was retained there,
840 after the waters of the Drainage Caanal were allowed to
stand, or the waters of the Chicago river were allowed to stand in the Drainage Canal for a time without being discharged. The opening of the canal discharged the water over the dam and came rushing down the Illinois valley and traces of it could be seen with the unaided eye for a great distance as the water traveled along. The greater part of the sediment was carried down by a sedimentation, making a black, nasty mud in the stream. It was winter and the anaerobic bacteria were not at work. Consequently they had not destroyed the organic sediment. And then I also ascribed it partially to
taking mud that was in behind the dams along the Illinois
840 river and also the muck and slime and sludge that was
put into the river by the opening of the Chicago river.

CROSS EXAMINATION.

By Attorney General Hamlin.

847 Would you, as a bacteriologist, be willing to give an opinion as to the condition of the waters in the Illinois river above Grafton in 1899, for that year?

A. For these particular samples at these particular times?

Q. No, for the year 1899.

A. Knowing the stages of the river, I could.

Q. Your opinion is simply for the dates that you took the samples?

A. Just upon the date that I took the samples?

Q. Yes, for no other time?

A. I couldn't give an opinion upon that of which I have not.

Q. From the samples that you took in the Illinois river in 1899, are you prepared to state what was the condition of these waters during that year, or any considerable portion of the year?

A. On none other than the time I took the samples.

Q. Would you, as a bacteriologist, state in your judgement as such, that that would be a fair test of the conditions of the water in the Illinois river above Grafton for the year 1899?

A. I would not.

Q. Do you know how much sewage was carried into the Illinois river from Chicago in the year 1899?

A. I do not.

Q. Do you know whether or not there was practically the same kind of sewage carried into the waters of the Illinois river from Chicago in 1899 as there is now?

A. I do not. I have no information on that subject.

848 The primary cause for the disappearance or elimination of the bacteria known as typhoid bacillus, is due to dilution and sedimentation. The other causes that have been assigned by various observers of water as the cause for the disappearance of bacteria are aeration and agitation, sunlight, oxidation and exhaustion of food supply and planckton.

Q. Do you recognize these causes also, the same as other bacteriologists?

A. I recognize planckton as probably having nothing to do with it. I have no personal experience with it; hence can not make any definite statements. Turbidity of the water has something to with the disappearance of bacteria by sunlight.

851 The effect of the sunlight as an element of the disappearance of the typhoid bacillus would be less on the Missouri river than it would be on the Mississippi or Illinois river, on account of its turbidity.

Our experiments show that the typhus bacullus has a little longer period of life in highly turbid waters than in very clear waters the difference being a few days, five or six I believe.

853 Before the Canal gets to Joliet it widens out into a lake. The water spreads out there for quite a distance, I suppose 300 yards. Part of it is run through turbines, for power and the other part runs over a little dam. There must be a dam there because there is a water fall. There is some sedimentation in that lake or basin. There must be.

855 Assuming that there was a lake at LaSalle as large or larger than the one at Joliet, and that the water moves slowly the current at this point, and through this lake or basin, I would say that there would be a sedimentation. We took samples of water at La Salle in 1901, in October and November. I know that the water spreads out in quite a little lake above Peoria. I understand there is a dam at Henry, Illinois.

856 Assuming that there is a pond or lake at Henry, there would be more sedimentation there.

In any stream of water where there are places that we speak of (lakes or basins) there will be sedimentation. At Peoria there is another lake—the water spreads out over quite an area there. The sewage of Peoria is discharged below this lake. In 1901 when I saw this lake at Peoria the current was slow, very slow. There would be considerable sedimentation there. There are three dams across the river now below Peoria. The first is Copperas Creek Dam. I have been up and down it a number of times in a launch, the Copperas Creek Dam, the dam backs the water or the water is backed up a great many miles and it makes quite a stream, navigable for large boats. In the low water season of 1901 I was in it. We had a launch drawing three and one half feet of water and occasionally it would hit the bottom and the water was running slowly at that time, and the current in the river was slow. The water was running over the dam in a good volume.

857 There would be considerable sedimentation there. The next dam is at LaGrange, below Beardstown. The water backs behind this dam for quite a number of miles back. The river at the stage I saw it several times was anywhere from 500 yards to a mile wide and the water was deep enough to have the boats run smoothly along up to Beardstown where the water was shallow. There would be considerable sedimentation there. The next dam is at Campsville. Here the water is again dammed and backs up, the current is retarded and a great deal of sedimentation will go on here in this flowing water.

858 As to dilution, calculating upon a 300,000 cubic foot flow a minute and taking all of the sewage of the two million people that discharge into it, we said there would be a dilution of one to nine, but that if four-fifths of the sewage is now discharged into the canal, as it is now claimed, the dilution would be one to eleven.

Q. Do you know as a matter of fact that a certain amount of sewage now is discharged into the canal, that was at that time discharged into the Illinois and Michigan Canal at Bridgeport?

859 A. No.

Q. Well, there is a dilution. Assuming, as I understand, that the sewage of the entire population is carried in at the rate of 1 to 9?

A. Yes.

Q. But assuming that three-fourths—of course the proportions would change correspondingly?

A. Yes, sir.

Q. And if it was only the same that had been discharged for several years, in the Illinois and Michigan Canal, why it would be whatever the proportion of its sewage discharge was to the number of cubic feet from the lake which was poured into the canal?

A. Yes, sir.

Q. There would be a greater dilution?

A. Yes, sir. There is a large volume of water dis-
860 charged into the Illinois river from its tributaries, from
861 Lockport to Grafton. Never found the typhoid bacillus
in any of the waters I examined.
862 In the epidemic of typhoid fever in 1892 in St. Louis the
source of the disease was three or four miles from the
water works. St. Louis discharges all of its sewage into the
Mississippi river, and has done so ever since the city was large
enough to have sewers. It seems to me it was 1849 that the
first sewers were built, but I am merely trusting to memory for
that. The present population is 600,000. I have been
863 told by Dr. Morgner, of St. Charles, which is located 20
miles above St. Louis, on the Missouri river, that that city
discharges its sewage into the river. I believe they had once a
typhoid epidemic there following the discharge of dejecta from
a typhoid fever patient in a hospital, which was carried into
the water supply.

865 A typhoid bacillus, if in the water of the Chicago river,
would have to travel down the Drainage Canal, pass
through all these sedimentations, lakes and ponds that have
been mentioned, be diluted with the waters from Lake Michigan and the tributaries of the Illinois and join the waters of
the Mississippi at Grafton, then join the waters of the Missouri
and pass by St. Louis.

866 Assuming that typhoid bacillus could come from Chicago, if one was found at St. Louis, I couldn't tell whether it come from the sewage of Chicago or came from some tributary of the Illinois—not even if I found it in the water. The chances are that the bacillus traveling from Chicago would lose its virulency sooner than one that had traveled only a few miles.

Q. You spoke of having examined the report made of the typhoid epidemic in Massachusetts. Where was that?

A. Well, that was a report which Dr. Sedgwick made. In that report he makes the statement that the evidence shows that there is no stream long enough to purify itself from sewage even put in at its source.

867 Q. Is it not a fact that as a result of that report, the legislature of Massachusetts passed a law providing that there should be no sewage discharged into the streams in that state less than 20 miles above the intake of water supplies?

A. I think a law of that kind did come into force, following that.

Q. Do you say as a bacteriologist that in your judgment that limitation is a reasonably safe one?

A. It is an absolutely absurd one, it is not based on bacteriological evidence at all.

868 A very small percentage of typhoid fever epidemics show the source of typhoid fever from water pollution to be exceeding fifty miles. I have one in mind. That was the dredging of the St. Clair river, and the typhoid fever epidemic following in Detroit; that has been reported by Dr. Williams. That occurred when the river was being dredged. I don't know what the distance from the original typhoid case was to the waterworks at Detroit, but I think it is more than 50 miles.

869 I have Mr. Williams' report. I understand it was something over 60 miles.

Q. Isn't that the most extreme case on record?

A. My memory serves me with no other case at the present time. I would say that 95 per cent of the reported cases of typhoid fever epidemics or a large increase of typhoid fever from water pollution, has been shown to be less than 50 miles. The sewage of Kansas City is discharged into the Missouri River after resting in so-called cess-pools for a time. I have been told that the sewage of St. Joseph, Mo., is carried into the Missouri River. The sewage of Leavenworth and the hospitals there is carried into the Missouri River.

870 There is only one safe way of purification of waters and that is by filtration.

Q. How much filtration in addition to what you have here in St. Louis, would have to be installed in your waterworks system to make it a successful system of filtration?

ATTORNEY GENERAL CROW: Objected to as irrelevant.

A. That is not known by anybody. A body of engineers and expert filter men have been at work on that problem and they have made recommendations without having carried out an adequate series of experiments on the water to ascertain the facts connected with it and nobody knows how to filter this water supply. I do not mean to say that a system of filtration could not be installed here, but it is not known how best to filter this water and what it will cost. I do not know how best to filter this water.

871 In the reservoir system we have here there is some seventy per cent of the bacteria removed from the water, to the consumer; at a definite period of 1901, we found as high, I believe as 90 to 95 per cent to the consumer, of bacteria removed.

872 I have seen the sewage discharging from Quincy, Keokuk, Rock Island, Burlington and Davenport, into the Mississippi River. I think all of them do. St. Paul and Minneapolis also discharge their sewage into the Mississippi River. I know that there are several rivers discharging in the Mississippi. Of the towns that discharge their sewage in the Missouri River, I know of Kansas City. I don't know of St. Joe by personal knowledge, but I know they discharge their sewage into the Missouri and I know Kansas City, Leavenworth, St. Charles, and Jefferson City do.

873 It is a fact that the Mississippi, Missouri and Illinois rivers are used by the inhabitants of the various towns along those respective rivers, for the purpose of depositing their sewage in each of the rivers.

St. Louis discharges its sewage into the same common drainage that the inhabitants of the other rivers do. The first sewer was constructed in 1849.

874 Population of St. Louis, within the corporate limits that discharges sewage in the Mississippi river is 600,000.

875 The water consumption is about 130 gallons per inhabitant, making 78,000,000 gallons every 24 hours.

Basing St. Charles' population at 10,000, water consumption at 100 gallons per day, they would discharge 1,000,000 gallons of sewage per day from St. Charles.

Kansas City has a population of 200,000, basing a calculation of pumping 130 gallons—or make it 100 gallons per inhabitant, would make 20,000,000 gallons of sewage per day.

876 Explains cause of typhoid fever and how that disease may be communicated. One of the means of communication is milk.

877 St. Louis gets a large part of its milk supply from the rural districts of Illinois and Missouri. In my work as sanitarian I have visited the companies furnishing milk supply. In nearly all of these places they steam sterilized the cans before sending them away or they drive them into boiling hot water with streaming steam in it before sending the cans away from the city. I never visited the Union Dairy Company and do not know whether they have any system of sterilization. They handle a large quantity of milk. If the cans are not sterilized I would say that it was a gross act of negligence, owing to the fact that there is a possibility of typhoid bacillus being conveyed that way.

878 I know that there are accounts in the literature of typhoid epidemics caused by the milk supply.

I know in the books where a man washed the milk bucket with this diseased water and not entirely drained and the typhoid bacilli got into the milk.

881 Isn't it a fact that you know that the Illinois river only contributes about one-tenth of the volume of water that is contributed by the Mississippi above Grafton and the Missouri at its mouth?

A. In these low river stages this would seem to be the case because I find that just below Grafton in the Mississippi the minimum flow of 24,858 cubic feet per second was noted on January 11th of this same year. So that would give the Illinois there 2,360 cubic feet per second. That would be about one tenth.

882 Witness is asked to verify tables showing per centage of death rate from typhoid, per cent of cases to population and of deaths to cases for the years 1897-8-9-1900-01-02.

883 The watershed of the Missouri river embraces 530,000 square miles.

884 The drainage area of the Illinois river is 27,914 square miles. The drainage area of Illinois as compared with the drainage area of the Mississippi and Missouri is very small.

CROSS EXAMINATION

By Mr. Drennan.

885 The principal water-born pathogenic bacteria are typhoid, cholera and dysentery and I found none of these in the Illinois river.

Q. Is'nt it recognized as a scientific proposition that these pathogenic germs do not thrive in sewage?

A. No, it is not entirely that way. It depends upon the character of the sewage. Some observations by different men show that the typhoid bacillus has lived as high as five months in sewage, while others but a few days. So you see it depends upon the character of the sewage at the particular time.

I made no investigations as to the sewage there in Chicago, and I cannot answer as to that.

886 The septic tank system is still in its experimental stage. For certain classes of sewage it does not seem to be entirely practical. It is very efficient in some localities and not at all so in some others.

CROSS EXAMINATION

By Judge Springer.

(Witness is asked about 32 pathogenic bacilli mentioned in the works of Abbott and Frankland.)

889 Of the list mentioned, I found in the waters of the Illinois river, the bacilli coli communis, proteus vulgaris, proteus mirabillis, proteus zenkari and I think we once found bacillus pyocaneus. I don't remember whether I found these in the Missiuri river water also. I found the proteus zenkari one time in the Missouri river water oposite Bellefontaine. I found none of the others except the bacillis coli communis. They produce no disease in man; they are non-pathogenic to man.

Q. Are they regarded as injurious to drinking water?

890 A. They are related somewhat to sewage producing, when associated with others. But not of themselves.

Q. Then your conclusion, as to the dangerous quality of bacteria in the Illinois river, was not based upon the poison, the actual germs that produced disease there, but other germs which were kindred, or sometimes found with them?

A. Yes, sir.

The same is true of the Missouri river about the mouth of that stream and of the Mississippi river above the mouth of the Illinois. I found substantially the same conditions existing in all these three rivers, only more of this sewage bacteria in the drainage canal and Illinois river than we found in these others. We found them a greater number of times.

Q. Is there any means now known of obtaining absolute proof of the hygenic quality of water supply?

A. Well, bacteriology will indicate the presence or absence of bacteria.

Q. Is that sufficient to determine the potability of the water supply itself?

A. Yes, it was used by the German government. All these

samples that I have taken and have examined must be
891 considered in the light of the stage of the river and rainfall at the time.

Q. In order to obtain a perfect, or approximately perfect knowledge of the bacteriological conditions of running water, would it not be necessary to take samples every day in the year and under precisely similar conditions for those days in order to make your calculations reliable?

A. Yes, sir, that is what we did.

Q. Every day in the year?

A. Every day in 1900 from January 23d to October 11th, I think. For 1901 during the months of September, October and November. They covered only one sixth of the year.
892 During that period of investigation in 1901, from September to November there was practically no rainfall in the Illinois river basin, and the same obtained on the Missouri and Mississippi river basins. It was a time of drouth when all the rivers were depending on the springs that were discharging into them, and they remained practically level, as I showed on the charts. The Chicago sewage has shown less after running a definite number of miles, there is less trace of it in the Illinois river than there is at higher periods. It showed fewer bacteria than were originally carried by the drainage canal after running to Peoria and then to Grafton than it did in the season either following a freshet or when the river was high but steady.

Q. Did the drainage from the farm region and from the pasturage of the country districts generally, if that was coming into the stream, wouldn't it be more peculiarly a condition created by the ordinary flow of water from Lake Michigan and the Chicago canal?

A. Yes, sir.

Q. So that would be a better time for determining the influence of the Chicago water on the Illinois water?

A. This particular time was an extraordinary time, the 1901 period was an extraordinary condition, there was very little water in the river other than that discharged into it by the drainage canal.

893 It is true that water in stream is, by all recognized standards of potability, at one time and another, the subject of contamination. Bacteriologically, absolutely pure water there is none except that of boiling springs. All water from whatever sources, save from hot boiling springs, contains more or less bacteria, from very few numbers up to large numbers. The presence of bacteria in water is not of itself an evidence of fecal pollution, but simply evidence of food supply for bacteria to grow upon. I have found bacteria in fresh fallen snow, in hail and in rain water.

894 There is no such thing as running water, such as is found in rivers and streams of any country, being free from bacteria.

895 It is true that the conditions bacteriologically considered, of the Illinois, the Mississippi and Missouri rivers at the places where I have taken samples of water, are very similar to the conditions found in rivers of similar size in this country and Europe. This is true of all the periods of which I have referred as the 1st, 2d and 3d period of investigations here. I would have been terribly surprised had I not found bacteria in these waters. The rivers generally in this country and in Europe are in such a condition as to render them unfit for water supply for cities without some kind of sedimentation or filtration. That applies to all the rivers to which I have referred in my examination here.

Q. As a bacteriologist, then, you would not recommend supplying cities with water taken from the running streams of this country without some system of sedimentation or filtration being adopted for the purpose of removing the bacteria?

896 It is possible from my observation of conditions, to prevent sewage from getting into running streams. They do that effectually at Berlin with their irrigation farms; in Glas-

gow, Scotland, I drank the sewage that had been chemically treated before it was discharged into the river Clyde; at Paris the same thing is done after it is treated, and there are well known methods of purifying sewage before discharging it into a stream.

There is a greater number of bacteria per cubic centimeter in river water during flood time for the reason that all surface soil contains millions of bacteria growing upon nutritive matter that there exists—vegetable matter—as a rule these bacteria are washed into the running streams by the rainfall, so the bacteria at these particular times are soil bacteria in preponderance as a rule.

897 This contamination is not sufficient to condemn all our running water for potable purposes because they are non-pathogenic germs. If there was any town in the vicinity of this city that had a typhoid fever epidemic and the flood came and washed these typhoid germs into the river, that would contaminate the stream. If this was thrown out on the soil or from privy vaults it would sweep out into the stream in the mass of volume of water that washed all that surface and be carried along the Lord knows how far.

898 If a mass of feces should be thrown out on the sides of a reservoir, that at any time would be a dangerous thing. That may occur at any time in all the rural districts contiguous to the rivers. At Plymouth to which I have testified, there was a reservoir but it is such a very minute thing where there is a vast volume of water.

It moves the bacteria farther apart, that is all, they are still alive and they are still dangerous.

As a chain is not stronger than its weakest link the water supply is not better than its weakest place. You ought to have a water supply that would be good at all seasons, at all times, and under all conditions.

Q. Can you have that if you take your water supply from the rivers without filtration?

A. There is danger from a river that may contain, or does contain the sewage of any community ,it is unsafe to drink and no matter how far above the sewage is thrown into the river it is unsafe to drink that water unless it receives some treatment for the purpose of removing bacteria. The danger would be greatly minimized if you eliminate the city sewage, but still the danger would be there.

899 The epidemic at Lausen, Switzerland, was caused by contamination which existed only a mile and a half away from the place of the epidemic. The same conditions existed at Chatterham, England, to which I referred. The contamination was direct in the water supply, in the well itself. At Plymouth, Pa., the contamination was direct into the water supply. The epidemic at Zurich, Switzerland, was caused by contamination of a lake in the immediate vicinity. At Springwater, N. Y., the cause of pollution was in the immediate vicinity. Lowell, Mass., epidemic was caused by contamination of the Merrimac river, close to the city. Same at Sault Ste. Marie. Epidemic of typhoid at Elmira, N. Y., in 1896, the contamination came from the Chemung river and there were some places above, the highest above being 50 miles and the nearest 16 miles, and Prof. Hill says it must have come from some of these localities. Epidemic in Paris, France, in 1895, occurred from pollution in the immediate vicinity of a camp of soldiers.

902 Same as to epidemics of San Francisco, Calif., Denver, Colo., and Middletown, Conn. Stanford, Conn. epidemic of 1895 was caused by the use of milk.

903 From the recorded instances, which are the most classes, if I may use that word in this connection, as to typhoid epidemics in this country and Europe, all of them were caused by conditions which existed in the immediate vicinity of the place where the epidemic occurred.

904 The epidemic at Detroit caused by dredging of the St. Clair river, 67 miles to Port Huron, the course of the epidemic, is the only authenticated case on record where the place of pollution and place of infection were as far apart as

67 miles. I know of no ascertained case where the infection was brought further than the case I have just mentioned.

908 November 6, 1901, 107 barrels of prodigiosus broth containing more than one thousand million bacteria per cubic centimeter were emptied in the Drainage canal at Lemont.

909 The record shows one side of a cube representing a cubic centimeter.

919 The first prodigiosus bacteria was found at the intake tower, Chain of Rocks, December 4, at 8:45 A. M. I found only one. That is, I found one colony, I believe. I don't think I found more than one in a cubic centimeter. I found another on December 5th.

920 The water was cold and the chances are that there was very little growth, if any, of bacterium as it floated down the river, it simply depending upon its inherited vitality to keep alive, so I will state emphatically that I think there was no growth of the bacteria at that time in the water. The individual bacterium put into the canal at Lemont undoubtedly floated all the way and lived.

921 Found it again on December 8 in the intake tower. Found it at Grafton, Illinois, in the Illinois river on December 6, at 8 A. M. Next sample was found by Collector Homer at Grafton, Illinois, Illinois river, at midnight, December 7th. That was all the times that I found it. I never found it again —I continued searching the tap water in the laboratory until March 1, 1902. I therefore found it twice at Grafton and three times at the Chain of Rocks, which would be five times out of 1,100 samples taken for the purpose. This bacterium has never been found in the waters of the United States.

934 Bacteria known as saprophites are useful in the arts. In the production of alcohol. In tobacco culture. In beer. In the production of butter and cheese.

938 All unsterilized milk as it is furnished in the milk cans in the market, would hvae more or less bacteria.

939 The typhoid fever germs, if found in milk, would be from

extraneous introduction as milk before it comes from the cow is practically sterilized.

942 It has never been proved satisfactorily that disease bearing germs increase in number in the water—in running water.

944 If you had one hundred men with typhoid fever discharging sewage into the river at the mouth of the Illinois river, at Grafton, the danger to St. Louis would be much greater than if one hundred men were discharging their typhoid fever discharges into the Illinois river at Lockport from the Drainage canal.

Q. Suppose that there should have been 20 persons who died of typhoid fever within the year 1900 or 1901 or 1902, and that there was a corresponding number of persons in the same vicinity in the village who, recovered from the disease and the dejecta of all persons, those who died and those who lived, was deposited in the Illinios river at Grafton, what would you say as to the probability of such a deposit producing typhoid fever in St. Louis?

A. There is a possibility of such bacteria being carried into the St. Louis intake and producing disease in St. Louis.

945 Q. Now, suppose that four persons were afflicted at the same time and the urine and dejecta were deposited in the Missouri river within 30 miles of this city would not that be a sufficient number to create and probably cause at least disease germs to appear in the St. Louis intake.

A. The small number that would reach the consumer would be extremely small from these four people, from the daily discharge of four people into the Mississippi river, which we saw in a low river stage discharges something like 24,000 cubic feet a second so the separation of the bacteria which would be discharged by 4 patients into that volume of water would be very wide apart and it is possible that some of them might be carried into the intake tower and through it into the distribution system of the city to susceptible individuals, but the danger would not be very great.

Q. Take the city of Alton, 25 miles from St. Louis. Take the same conditions, what would you say would be the danger to St. Louis from the near proximity of cases of that kind?

A. We saw that the dejecta of each one of the inhabitants of Alton when discharged and mixed with the waters of the Mississippi river passing that point would be one to 70,000 and that we trace very little evidence of the sewage of Alton at Hartford, seven miles below, bacteriologically, and consequently it would be again a very remote possibility of having bacteria coming from those patients into the intake.

946 If you were afflicted with a typhoid epidemic in St. Louis where as many as 200 persons were dying in a year during the recent years and you could not trace the cause to any other source than one which you have imagined might be in existence at Alton, would not that sufficiently account for any trouble?

A. No, I think not, sir. Two hundred deaths would mean three thousand cases at least of typhoid fever in the city and that is a great many sick at the same time out of a population of 675,000 to 700,000 with 90 per cent of the bacteria removed by the reservoirs to those who consumed the water. It would take a much larger infection than four people could produce even if above the intake. It is worthy of consideration and is a factor to be considered in this connection in trying to trace the source of a typhoid epidemic every fact must be brought to light.

From St. Charles to the intake is about 50 miles. If 20 people who died in St. Charles a year and a corresponding number of patients who survived discharged their dejecta both liquid and solid, in the Mississippi river, owing to the dilution there would be the remote possibility of the bacteria reaching the intake.

948 If a lively colony got into the intake you might get several millions into the waterworks from that source?

A. And 90 per cent taken out by the reservoirs before they got to the consumer, so it would leave a few to be distributed throughout the city.

949 RE-DIRECT EXAMINATION

By Attorney General Crow.

Dilution does not in any way destroy pathogenic germs.

Considering my knowledge of the water supply of St. Louis before and opening the Drainage canal I think the water supply at the intake tower of this city has been rendered less wholesome and safe for domestic and primary use than before the opening of the canal. I can prove it chemically and bacteriologically. Formerly the sewage remained in the Chicago river in a stagnant state, long enough to become purified, and to kill the pathogenic germs. Now the current there is three miles an hour and the chances of pathogenic bacteria vitalized and strong as they come from the bowels of an individual being carried down to St. Louis water supply is infinitely greater than when the pumps were at work at Bridgeport.

951 Bacillus carried a great distance would be less virulent, but would cause typhoid fever in a susceptible patient the same as those carried a short distance. The difference being that the disease produced by a sea of typhoid bacillus would be of more severe type than that produced by bacilli carried some distance.

953 Sand or any other filtration is only a relative preventative of typhoid fever. The effect is to greatly minimize the danger.

954 Basing conclusions on dredging such as that at Detroit, it would seem that typhoid bacilli will retain their vitality a great number of days in the sludge that exists in the bottom of a river or mouth of a river.

Where sewage is found in a stream it is presumed that pathogenic bacteria may be there also because sewage polluted water contains the discharges of human beings and if there by typhoid or other diseases among them like diseases will follow in those drinking the water. Aside from the repulsiveness of drinking sewage that comes from aesthetic reasons the real danger in sewage comes from the germs. The ordinary scientific tests as to whether contains sewage pollution are microscopic, chemical and bacteriological examinations. It takes the three to determine the potability of a water supply.

955 Authentically the typhoid bacilli has been found in running waters probably a hundred times in all the history of the world.

956 Q. As a bacteriologist and hygienist I will ask you if you consider it safe for the citizens of any city to sewer into running streams the waters of which are used for primary and domestic purposes by those below.

A. I think it is a dangerous thing to do to use that water. As I remember the conclusions of the English River Pollution Commission, which worked eight years, they were something like this—that the evidence is overwhelming that sewage polluted waters are dangerous to drink and that no river in England is long enough to purify itself of sewage, consequently of pathogenic bacteria even if put in at its source.

Q. Did you find in the waters of the Illinois, DesPlaines and Mississippi rivers coli communis in greater numbers in a flood stage than in ordinary seasons?

A. In flood stages the percentage was less than in low waters. The typhoid death rate in Chicago compared with other cities of a similar size in this and other countries, is very high. The population of Chicago according to the census of 1890 was 1,148,710. The deaths in Chicago, from typhoid fever for the years indicated, are as follows: 1891, 1,997; 1892, 1,489; 1893, 670; 1894, 491; 1895, 518; 1896, 751; 1897, 437; 1898, 636; 1899, 442; 1900, 337; 1902, 509; 1902, 597—first ten months of the year only given.

In 1893 the water was taken from the four mile crib. Prior to that it was taken from small cribs not very far out. There has been a steady increase in deaths since the opening of the canal.

961 RE-CROSS EXAMINATION

By Mr. Springer.

965 CHARLES LEWIS STEVENSON examined by Mr. Woerner. Am a traveling man. Collected water samples under direction of St. Louis Water Department. Describes method pursued and where samples were taken.

968 EDWARD H. KISER, direct examination by Mr. Crow. Am professor of chemistry in Washington University, St. Louis. Have been occupying that position since the fall of 1899. Came here from Bryn Mawr College, near Philadelphia, Pa., where I had been 14 years. Was professor of chemistry there. Prior to that time was instructor in chemistry in Johns Hopkins University at Baltimore for about 18 months. I was Fellow in Chemistry previous to that in Johns Hopkins University for two years. I was graduated from Swarthmore College, Pa., in 1880, taking degree of Bachelor of Science and took degree of Master of Science in 1881 from same institution. In 1884 took the degree of Doctor of Philosophy in Johns Hopkins University, and studied in Germany in the summer of 1884, at Freiburg, in Saxony, and in 1887 Gottingen University, and in 1894 at Heidelberg, in Germany. In Germany I studied chemistry.

969 I was called upon in January, 1900, by the Water Commissioner of St. Louis and the City Chemist, to make an examination of the waters of the Mississippi river at the intake tower of the St. Louis water works, of the Missouri river, and of the Mississippi river about the mouth of the Missouri, the Illinois river, the DesPlaines river and the Chicago Drainage canal.

970 (Witness states his experience in examination of various waters.)

972 (States how waters under consideration were examined and methods pursued.)

974 I made eight determinations in the analysis of water. First, of the total solid matter in the water; second, the

amount of free ammonia; third, the amount of albuminoid ammonia; fourth, the total ammonia; fifth, the oxygen consuming properties of the water; sixth, the nitrogen present as nitrates; seventh, the nitrogen present as nitrites and eighth, the chlorine. For the first five determinations we used the water in an unfiltered state. For the last three we used filtered water.

980 We began the analyses of these waters on January 24,
982 1900. I analysed these waters to determine the presence of nitrites, nitrates, albumoid ammonia, free ammonia and chlorine and the amount of oxygen consumed. The presence of nitrites and free ammonia I regard as of chief importance for the reason that the presence of measureable quantity of nitrites in drinking water is often regarded as a sure sign of contamination, and a chemist finding a measurable quantity of nitrites in water would condemn that water as unsafe for drinking purposes. And so free ammonia, likewise, is of great importance in judging of the sanitary conditions of the water for the reason that the first product produced by bacteria in decomposing sewage is free ammonia. We always find a quantity of free ammonia in sewage, so the chemist lays special stress on these two constituents, namely, nitrites and free ammonia. Free ammonia is ammonium carbonate, or ammonium chloride existing in the water, that has been formed by the action of bacteria upon nitrogenous organic matter. Free ammonia is absent from pure water.

983 The presence of these nitrites indicates there is decaying vegetable or animal matter in the water—and the same with free ammonia. That is the reason these two chemical substances are indication or warning to the chemist that the water should be looked upon with suspicion.

I have a record of the fluctuation of the nitrites in the reservoir of this city (St. Louis) from January 14, 1900 to October 11, 1900. We made daily analyses and from them made daily averages, and from the daily averages we made weekly averages. I have those weekly averages of the parts of nitrogen present in one million parts of water in the form of nitrites.

984 Table No. 1 is read, showing result of examination of reservoir at St. Louis water works from January 24, 1900 to October 11, 1900, and giving nitrites, parts per million.

986 The average amount of nitrites during the period from January 24, 1900 to January 31, which was the time prior to receiving the water fom the drainage canal, was .0044 parts per million.

Following is the average for the months indicated, at the same place: February, .0133; March, .0107; April, .0180; May, .0055; June, .0032; July, .0017; August, .0021; September, .0013; October, .0021.

The following is the maximum: February, week of 21st to 28th, .0240; March, week of 21st to 31st, .0130; April, week of 14th to 21st, .0260; May, week of 1st to 7th, .0097; June, week of 1st to 7th, .0040; July, week of 14th to 21st, .0021; August, week of 14th to 21st, .0035; September, week of 14th to 21st, .0016; October, week of 1st to 10th, .0021.

987 Plate No. 1, presented. Curve shows the changes of nitrites in the reservoir water of St. Louis from October 1st, 1901 to November 30th, 1901.

988 Chart is marked Complainant's Exhibit No. 23. This table and this chart show that early in February the quantity of nitrites in the reservoir water began to increase very materially, and the water of the reservoir was in a highly polluted condition. This pollution continued during March and during April. About the end of April and beginning of May the quantity of nitrites materially diminished; and then during the summer months it was low, and in October they began to increase again, in 1900. Then in 1901 we continued the analyses, and found that they were again higher.

989 The abnormal increase in February in nitrites in the reservoir water we attributed to the coming down in the Mississippi river of large quantities of sewage. As shown by analyses made at other points on the Mississippi, at Alton and Grafton on the Mississippi, and on the Illinois, it was shown that they came down the Illinois river. Our analyses point to

the Drainage canal as the source of them. The decline in May, June and July from the pollution or the falling off in the quantity of nitrites in the reservoir water in the spring months was coincident with the heavy rains and the high stages of the river. This caused a greater dilution of the large volumes of rain water flowing into the rivers—the quantity of nitrites was materially diminished in the early part of May and during June, and in the summer months the high stages continued.

990 Table No. 2 shows the weekly averages of the nitrites of the water at the intake tower in October and November, 1901. (See rec. 990.)

The maximum amount in October was in the week of October 28 to November 4, and the amount was .0084. The maximum amount in November was in the week November 11 to 19, and the amount of nitrites was .0143.

991 In 1901 there was an increase over what had been found in 1900.

When the amount of free ammonia in river water arises above .045 per million, the water is regarded with suspicion, and it is generally recognized that such water is polluted. That is not a hard and fast rule, however, that is applied under all circumstances. That will vary with the local history of the water and the local surroundings. For instance, a water might contain more free ammonia than that and it might be from a source that was absolutely harmless. To illustrate, the sale might be placed in such juxtaposition to a well or reservoir that it would cause a much higher per centage of free ammonia and be absolutely harmless from a sanitary standpoint.

992 I have made weekly and monthly averages of free ammonia in reservoir of St. Louis waterworks between January 24, 1900 and October 11, 1900, which is table No. 3. (See rec. 992.)

993 These weekly averages and also monthly averages show great increase in the free ammonia immediately after the last week in January, and this high ammonia continued throughout the months of February, March and April. After the 21st

of April there was an improvement in the water, which continued until the middle of June, and after June, there was a slight increase in July and August, and again in October. So that throughout the summer the water was much better than it had been in February and March.

996 Chart No. 2 offered in evidence.

This is a chart on which there is plotted a curve, showing the changes in the amount of free ammonia in the reservoir water, St. Louis, from January 24, to October 10, 1900. This table and chart shows a very great increase of free ammonia immediately after the first week in February. The quantities of free ammonia increased very considerably in the reservoir water in February, 1900. It extended into March and April and began to diminish then just as previously the nitrites were diluted by the spring rains, so we find that the ammonia was diluted and the quantity found in the reservoir water was very much less during the spring and summer months than it had been immediately after the opening of the Drainage canal. This increase was caused by pollution which we traced to Peoria and farther beyond Peoria up to Joliet and Lockport.

997 I made averages of the free ammonia found in the intake of the St. Louis waterworks during the months of October and November, 1901. (See rec. 998.)

999 For table No. 5 see rec. 999.

This table shows that there was a decided increase in February in the number of nitrates, and also in March. Then a gradual decrease in April and that decrease became more pronounced in May. There was a slight increase in June, and a decrease in August and September. In October we find the value very near the same as at the beginning. The increase began about the time when the water of the Drainage canal reached St. Louis. Then again as in other cases, when the spring floods came, there was a diminution in the quantity of nitrates found in the reservoir water.

1001 Table No. 6 is a record of the nitrates found at the intake from October 1 to November 30, 1901. Plate No. 3 contains a curve showing the changes in the amount of nitrates found in the reservoir water. There was less nitrates in 1901 that in 1900. This would indicate that the water was more impure because the organic matter had not been completely oxidized. There were more nitrites but less nitrates in the water examined in 1901 than there was in 1900.

Exhibit 25 offered in evidence.

1003 The fourth form in which nitrogen is found in water is as albuminoid ammonia. That is not found in water in its natural state free from pollution. It is the product of decomposing nitrogenous organic matter. That albuminoid ammonia would be derived from both vegetable and animal matter in water. The reservoir water of the city of St. Louis is turbid at nearly all times of the year. That means that it contains washings of the surface of the earth, vegetable matter that has been carried in by rain fall.

1004 I made an investigation of the reservoir water to determine the quantity of albuminoid ammonia contained in it from January 24, to October 11, 1900.

Table 7 shows the average results.

1005 Maximum results for same period.

1007 Table 8 shows the results of examination at same place for months of October and November, 1901.

Plate No. 4 contains a curve showing the changes in the amount of albuminoid ammonia in the reservoir water.

According to these figures the maximum pollution occurred in March and April, 1900.

1008 The minimum was about the middle of June, 1900. There was an increase after that again in July and in August, and it remained pretty high in September and in October.

Taking all of the result of the chemical analyses made by me in the period from January 24 to October 10, 1900, the conclusion is that the water became suddenly badly polluted about the first week in February, as is shown. That is shown by a very large increase in the quantities of free ammonia and nitrates in the reservoir water and this pollution continued during the months of February and March and began to diminish in April. This was coincident with the increase in the volume of the rivers. In the succeeding year the analyses show that the water was certainly in no better condition and as far as nitrites and free ammonia are concerned, the water was more polluted in 1901 than in 1900.

Complainant's Exhibit 26 offered in evidence.

1009 This water would not be classed as a safe drinking water owing to the large amount of decomposing organic matter in it. The warm weather of the summer assists in oxidization in water. All chemical changes proceed more rapidly at higher temperatures than lower temperatures and the bacterial action is greater in the warm seasons of the year.

1011 When we find free ammonia and nitrites present in considerable quantities we regard the pollution as of animal origin and caused by sewage. Albuminoid ammonia on the other hand is not in itself so characteristic of polluted waters because albuminoid ammonia may be there of vegetable origin. Nitrogenous organic matter is the starting point from which the albuminoid ammonia as ammonia is gotten out of the organic matter in water by treating it with an alkali and by potassium permanganate, and in that way we distill off ammonia from the organic matter which is not there as ammonia in the water. We decompose what organic matter is left in the water by chemical agents and measure the ammonia that distills over. For that reason albuminoid ammonia is not an index of any particular pollution in water.

1012 There is a lower form of pollution of water that contains nitrates and nitrites. The nitrites are a final product. When we find very little ammonia and no nitrites, and a good deal of nitrates, we know the water has been polluted at one time, and it has gone through the process of oxidation so the pollution has been rendered comparatively harmless. The oxidization is brought about by bacteria, we look upon it as a process of the transference of oxygen from the air to the organic matter in the water so that the complex organic substances are resolved into simple inorganic material. I look upon the original form of polluted matter in water as a complex combination of carbon, hydrogen, oxygen and nitrogen. That would represent, for instance, albuminoids, albuminous substances that are in water, compounds of that kind are in sewage, and the bacteria break up those substances and we get ammonia, a part of the nitrogen is evolved as ammonia and then afterwards the bacteria transfer the oxygen from the air to the nitrogen that is there, forming nitrites and then transforming the nitrites into nitrates, by adding still more oxygen. The analysis of the water that I made at the intake of the reservoir was for determining the presence of these four bodies, nitrites, free ammonia, albuminoid ammonia and nitrates.

1013 I also examined for the purpose of determining whether there was chlorine in the water. I have the record of chlorine at different points. I made a comparison of the water on the Missouri and Illinois shores opposite the Chain of Rocks for the purpose of determining whether the river at the intake was of homogeneous character, whether the water was of the same character on both sides of the river. I found a marked difference in the character of the water, chemically, water taken at the Missouri shore opposite the Chain of Rocks and water taken at the Illinois shore opposite the Chain of Rocks. I found that there was a difference in the nitrites.

Table No. 9 shows the parts of nitrites per million from January 24 to October 11, 1900, at the Missouri shore and at the Illinois shore opposite the intake.

For comparison of the water on Illinois and Missouri shores, see rec. 1014.

1017 Table No. 10 shows result of examination for nitrites at same places for October and November, 1901.

1018 Plate No. 6 shows a curve giving the variations in the amount of nitrites at the Illinois shore opposite the Chain of Rocks. Plate No. 5 shows the variations on the Missouri shore. These two plates were made to illustrate the examinations as disclosed in table No. 9.

Plates offered in evidence as Complainant's Exhibits 27 and 28.

1019 It will be seen that the nitrites in January are nearly twice as great on the Illinois side of the river as on the Missouri side. They begin to approach one another in February. They are about equal in March, but in April the quantity on the Illinois shore is twice that on the opposite side and this increase was maintained throughout the summer and it became six times as great in September and October, 1901. In February, 1900, there was a rise in the Illinois river coincident, I think, with the coming down of the water of the Drainage canal. From my recollection the Missouri was low and the Mississippi river was low. During the period that we made the analyses there at the eastern shore of the river, the water was from four to five times more polluted than the water on the Missouri shore as shown by these nitrites—by the quantity of nitrites.

1020 From the fact that the amount of nitrites in the reservoir was greater than that in the Missouri river on the Missouri shore and less, somewhat, than that on the Illinois shore, we naturally conclude that it was a mixture of the two waters—in fact not only the nitrites but all of our determinations showed that the water taken in at the intake is a mixture of those two waters. The chemical analyses indicate that the water on the eastern shore at the intake tower is Mississippi river water and the water on the western shore is Missouri river water.

Now on the Illinois shore in January, 1900, the average amount of nitrites was .013 and in February it went up to .0187 and it came down somewhat in March but it went up very high in April, .308 and gradually came down during the summer but throughout the entire summer it was from four to five times as great as on the Missouri shore. The average value of the nitrites was .0068 in 1900; in September, 1901, it was .0125, nearly twice as much. Comparing the analyses made at Bellefontaine with the analysis at the point opposite the intake on the Missouri shore it discloses the fact that the water running along at the point on the Missouri shore of the intake is Missouri river water.

1021 I made an analysis at Hartford. The anaylsis showed that was Mississippi river water. I have a table showing the average of free ammonia on each side of the river at the Chain of Rocks. It is table No. 11. (See rec. 1021-2.)

1024 Plate No. 7 shows a curve giving the variations in the amounts of free ammonia at the Missouri shore at the Chain of Rocks. Offered in evidence as Complainant's Exhibit 29.

1025 This plate No. 8 shows the same thing for the Illinois shore at the Chain of Rocks. Offered in evidence as Complainant's Exhibit 30.

Table No. 12 shows the average amount of free ammonia found on each side of the river opposite the intake tower of the St. Louis waterworks in October and November, 1901. (See rec. 1025.)

1026 These tables show that much larger quantities of free ammonia are found on the Illinois side of the river during the months of January, February, March and April. During the remaining months both sides are practically alike as regards this form of nitrogen.

The analyses made in 1901 shows the quantity of free ammonia was greater on the Illinois Shore than on the Missouri shore.

Table No. 13 shows the amount of nitrites found opposite the intake, first on the Missouri shore and second on the Illinois shore. (See rec. 1026.)

1030 Nitrates found at same place in October and November, 1901. Plates 9 and 10 contain curves giving changes in amount of nitrates at Missouri shore and Illinois shore, Chain of Rocks. Marked Exhibits 31 and 32 for Complainant.

1031 There were more nitrates as a rule on the Illinois shore than on the Missouri shore.

Considering all the facts heretofore set out, with reference to my chemical work, the water is most polluted from a chemical standpoint on the Illinois side.

In regard to the sanitary character of the water, the Missouri shore is the better water.

The chemical analyses showed that the water on the Illinois shore is Mississippi river water; and the water on the Missouri shore is Missouri river water.

The chemical analyses showed that the water in the reservoir was a mixture of these two waters.

1032 From a sanitary standpoint the water of the reservoir is better than the water from the Illinois shore at the intake. The water in the reservoir is worse than that of the Missouri shore.

1033 (Witness explains mathematical method of determining the proportion of each of the waters that constitute the reservoir water daily.) By applying that method I can determine the proportion of each of the waters, that constitute the reservoir water daily. They vary from day to day.

1034 As far as analyses enables me to judge there would always be Mississippi river water in the reservoir because it stands in the settling basins for several days and there is a constant mixture there of the two waters.

My analyses show that as we go up the Mississippi river we find the water is badly polluted until we get above the mouth of the Illinois. Above the mouth of the Illinois the Missisisppi is in a very much better condition.

1035 The water of the Mississippi river above the mouth of the Illinois and the water of the Missouri at Bellefontaine they are both fairly good streams from a sanitary standpoint. The nitrites in the Mississippi river above Grafton were lower than the nitrites in the Illinois river above Grafton, and also the nitrites at any subsequent place in the Mississippi river below Grafton, namely, at Alton, and at Hartford, and at the Illinois shore, Chain of Rocks. The nitrites are quite low at the Missouri shore, Chain of Rocks. In the Mississippi river the nitrites are lower above the mouth of the Illinois and are considerably higher just below the mouth of the Illinois. The nitrites are less in the upper Mississippi river than they are at the intake.

1036 Table No. 14 shows the analyses of the waters on the Illinois shore, at Alton above the sewage of the city and above Hartford above the sewage of the city, for nitrites. (See rec. 1036.)

(For October and November, 1901, same places, see rec. 1040.) These averages show that with very few exceptions the nitrites were higher at Hartford than they were at the Illinois shore, Chain of Rocks, and they were higher at Alton than they were at Hartford. The Mississippi river is more impure above Alton than it is at Hartford, below Alton.

1041 The sewage of Alton apparently has no effect upon the condition of the river at Hartford. Its dilution is so great that it produces very little effect upon the character of the river as a whole. Our analyses shows more nitrites in 1901 than in 1900.

1042 My analyses shows that the nitrites increase as we go up the Illinois river. They are higher in the Illinois river above Grafton than they are in the Mississippi river above Grafton. The Mississippi river above Grafton is in a better condition than it is at the Chain of Rocks. The chemical analyses show that the pollution of the Mississippi comes from the Illinois river.

If it were not for that pollution by the Illinois river, the water of the Mississippi river opposite the intake would be very similar in character to the water on the Missouri side of the Mississippi opposite the intake as to the free ammonias and nitrites. The waters would be almost the same and there would be a higher chlorine found on the Missouri shore than on the Illinois shore for the reason that the Missouri river always contains a larger quantity of chlorine—chlorides, than the Mississippi, but from a sanitary standpoint, the water from the Mississippi river above the mouth of the Illinois, is very similar to the water of the Missouri river, and were it not for the inflow of the waters of the Illinois river, the Mississippi on both sides of the river at the Chain of Rocks, would be of equal sanitary character. It would be a good drinking water on both sides. As it is now the Illinois comes in and carries with it the nitrogenous organic matter which we find in the river at Grafton and at Alton and at Hartford, and on the Illinois shore at the Chain of Rocks.

1043 The Missouri and Mississippi rivers run through practically the same kind and class of agricultural region and the land in the drainage area of those two rivers for the first 1,000 miles of each stream is practically used for the same purpose by a similar class of people.

Plat No. 12 is intended to show the variation in the quantity of nitrites found in the Illinois river at a point above Grafton, and also at another point above Peoria.

1044 The lower curve gives the average amount of nitrites at a point above Grafton in the Illinois river.

The upper curve gives the amount of nitrites in the Illinois iver at a point above Peoria, throughout the time of the anlyses extending from January 24 to October 11, 1900.

Offered in evidence as Complainant's Exhibit 33. I made n analysis of the waters of the Illinois river above Grafton.

Comparing the values found for nitrites and also free amnonia, the value found for these substances at Grafton with the ame values found at a point above Alton, we find higher values, niformly above Grafton, than we do at Alton, showing that as e ascend the Illinois river the impurities constantly increase.

We have tabulated the daily analyses of the waters taken at eoria. We find that at Peoria the amount of pollution was ery great and as we go up still further to Joliet and Lockport he analyses showed that the water is simply sewage, and the nalyses there for free ammonia and nitrites are such as one btains by analyzing sewage. Began analyses at Peoria and

Grafton on January 24, 1900. At first we found less nitrites at Peoria than we did at Grafton, in January.

1045 After the opening of the Drainage canal the nitrites at Peoria increased, and were greater in number than those found at Grafton.

I conclude from these analyses that before the opening of the Drainage canal there was sewage matter in the waters of the Illinois river, but there was greater oxidation in the region above Peoria and immediately below Peoria—all along the river there was greater oxidation. That was shown by diminution. That was because it moved more slowly. The rapidity of the current retards oxidation. Before the opening of the canal, the movement was slower and while the water was impure above Peoria, we found a smaller quantity of nitrites there, showing that the oxidation had proceeded further, and then after the opening of the Drainage canal the quantity of nitrites at Peoria increased enormously, and they kept on increasing throughout the time that we made these analyses, and from that I conclude that the effect of the opening of the Drainage canal was to wash these oxidized materials further down the river. The region of bacterial action, and the conversion of nitrogenous organic matter into nitrites was moved much further down the Illinois river and into the Mississippi river below the mouth of the Illinois.

1046 The analyses made in 1901 showed that the same state of affairs existed. The quantities of nitrites found above Peoria were still very considerably greater than the nitrites found in the Illinois river above Grafton.

My analyses showed that the Illinois river above Grafton was more impure in 1901 than in 1900 for the corresponding months.

1048 Comparing the amount of decomposed sewage in the Illinois river at a point above Peoria in January, 1900, with that supposed to be there in the early part of September and October, 1900, I would say it was eight of nine times as

ich in September and October as compared with January,
00. That is shown by the red curve on the chart, which con-
ntly rises throughout that period. The impurities are some-
at diminished as they come down the Illinois river. So far as
analyses go, there has been a decided increase since the
ening of the canal in the amount of impurities that come down
Illinois river. In my opinion these impurities are not suf-
iently oxidized to be converted into harmless products by the
time they reach the Mississippi and the intake tower.

49 As a chemist and from my chemical examination of these
waters, it is my judgment that this pollution and the con-
mination from the Chicago river continues down through the
ain of Rocks, a portion of it finding its way into the intake
er of the waterworks and thence into the reservoir. In my
nion and from the analyses of these waters, the water supply
St. Louis is contaminated by the Chicago Drainage canal and
sewage emptied into it by the city of Chicago. The volume
water going down the Illinois river is greater since the open-
of the canal. The effect of this in disposing of the sewage
ses it to be pushed further down the Illinois river and into
Mississippi river in greater quantities than before the open-
of the canal. It acts to prevent sedimentation.

The sedimentation would be less now than before the waters
he canal were turned into the Illinois river because there is
ore rapid current which carries the suspended matters fur-
r down in the stream and gives less opportunity for sedi-
mentation.

9 The water at the intake is a mixture of Mississippi river
and Missouri river water. My chemical analysis discloses
the Missouri river water is far superior to the Mississippi
r water opposite the intake. The Missouri river water con-
s a larger proportion of common salt than the Mississippi
r water. I think that affects the flavor of the Missouri river
er. It has been found that one of the tributaries of the Mis-
i river that runs in from Kansas flows over salt beds and
gives it a large proportion of common salt, and that water

mixing with the Missouri gives it a high proportion of
1051 salt. There was a decided increase in the impurities of the water in the reservoir after the opening of the Drainage canal. There was a coincident increase in the impurities of the water of the Mississippi at that time, as shown by all these curves, or nitrites and free ammonia that have been exhibited. In the month of May, 1900, there was a marked improvement in the reservoir water, this improvement being coexistent with an improvement in the Mississippi river water.

I attribute the great improvement of the waters of running streams in spring and summer first to the greater oxidation which takes place in warm weather; secondly, in these waters, to the much greater volume of the streams. Throughout the time of this examination analytical results show that the water on the Illinois shore at the Chain of Rocks was in an unsanitary condition. It was water that would be condemned by water specialists. The figures for nitrites and free ammonia are beyond those that are allowable in a potable water.

1052 In potable water the average or maximum amount of free ammonia allowed is .05—when it goes above that the water is to be regarded with suspicion. If the albuminoid ammonia goes above .2 parts per million, then there is so much organic matter in the water that the conditions are favorable for the growth and development of disease germs. Then, if there are measurable quantities of nitrites, if you can measure the nitrites, that is express the result in numbers, we are usually inclined to condemn such water. If we can at all measure the amonuts of nitrites we condemn the water, as good drinking water has no nitrites in it, and whenever the chlorine goes above the normal amount, that is indicative of sewage pollution.

1055 Witness gives maximum amount of nitrites in water at Joliet in March, 1900, and extending until Oct. 11, 1900.

1056 Witness states the amount of free ammonias at same place and same dates.

1057 Same date for Lockport.

Tables No. 15, 16, 17 and 18 show results above indicated.

1059 Witness states maximum amount of nitrites found at Peoria. Also free ammonia.

1060 Above are read from tables 19 and 20.

Witness gives results of examination for nitrites at Drainage canal, off Pauline street.

1062 Result for chlorines at same place and dates.

1063 Free ammonias, same place and time.

1064 From these analytical results we see that the water of the Illinois river was more highly contaminated with nitrogenous organic matter at Joliet than it was at Peoria and likewise at Lockport there was a greater contamination than at Peoria. Now our results show higher values for free ammonia nitrites at Joliet than they do at Lockport. This I account for by the fact that the samples at Joliet were taken immediately under the Illinois and Michigan canal that passes over the river at that point. The results for Joliet show, or rather the analyses show, that it is sewage. It cannot be called water. The samples we have were really to be called sewage instead of water and at Lockport while the proportions were less than at Joliet, nevertheless we must still call it a somewhat diluted sewage.

1065 Now I notice further that sevaral months after our analyses began along in the spring months, the quantities of nitrites and free ammonia diminished both at Lockport and at Joliet. This is accounted for by the outflow of the water of the Drainage canal. At Lockport the free ammonias diminish from 2.437 down to 1.411 in June. We find that they again increased and in the subsequent year, 1901, they did not diminish below 1.239, showing a partial improvement. In other words, after the opening of the Drainage canal, this concentrated sewage at Lockport and Joliet was diluted. That in portion is the result of the analyses. That before the canal was opened there was concentrated sewage there and that after the canal was opened ther was diluted sewage there and the the results obtained at Peoria and points further down the river show that this sewage from Lockport and Joliet had been washed further down the river. My analyses show that this river was contaminated before the investigation. The river was polluted with sewage long before the opening of the Drainage canal but after the opening of the canal the sewage was diluted with water and carried farther down. We found at Grafton much higher nitrates and free ammonias after the opening of the canal than before and that in my mind, is evidence of the flushing down of the sewage matter which had accumulated at Lockport and Joliet and in the upper regions of the river, by the opening of the canal.

1066 Plat No. 11 was made by me. It contains curves of the quantities of nitrites in the Mississippi river above Grafton, at the Illinois shore, Chain of Rocks, at Hartford and at Alton and also in the Illinois river above Grafton. Those are the quantities of nitrites that have been read off in the table that have been platted on this chart.

Offered in evidence as Complainant's Exhibit 34. These examinations disclosed that in the Illinois and Mississippi river the water had a decided odor of sewage as here recorded.

Witness describes the various odors of waters in the Illinois river.

1069 The water of the Illinois river above Grafton has a musty smell or a smell of sewage, and that from the Mississippi above Grafton has the odor of earth, earthy or clay like smell.

1072 The chlorines in the Illinois river above Grafton steadily increased. I have here a table giving the average values of chlorine in the Illinois river above Grafton, above Peoria and at Joliet and at Lockport. We see a steady increase of chlorine as we ascend the river to Joliet. The Lockport samples show less chlorine than at Joliet. The explanation I give for that is that the sample at Joliet was taken immediately under the canal, under the Illinois & Michigan canal and probably contained water from that canal.

The nitrites are decidedly higher at a point above Peoria than they are at Grafton. They are lower in the Drainage canal, showing there has been less oxidation, and I think they are a little lower at Lockport than they are at Joliet. That

1073 shows that there is more crude sewage in the canal than
there is at points further down. The nitrites being
formed gradually, free ammonia is first formed by the decompos-
ng sewage then the oxidation processes set in and gradually
orm nitrites, so we find more nitrites at Peoria than we do at
some of those higher points, at Joliet or Lockport. There hasn't
een oxidation sufficient to produce large quantities, but there
re larger quantities of free ammonia at the higher points than
t the lower points.

This map shows the Illinois river connecting the Drain-
ge canal with the Mississippi river at Grafton; then it shows
he Mississippi river below Grafton, at Alton and at Hartford;
t shows the flowing in of the Missouri river at Hartford; then it
races the Mississippi river down to St. Louis. The map is an en-
argement of the map of the State of Illinois, taking only the Il-
nois river and the Mississippi river and these rivers. On the
ide of this map are given the averages of the condition of the
ater, first before the opening of the canal, viz: in Jan., 1900, at
he reservoir. First the table shows the condition of the water
at the reservoir in St. Louis in black letters, the amounts
074 of free ammonia, nitrites and albuminoid in January,
1900, and then below the values obtained for the same
ubstances, in February, 1900, after the opening of the Drain-
ge canal. These are averages taken from the tables we have
resented. For instance the free ammonia before the opening
f the canal averaged 0.111; after the opening, 0.210. The
itrites averaged before the opening 0.004 and after the open-
g 0.013. Albuminoid ammonia before the opening was 0.214
nd after the opening 0.271. It shows a doubling of the free
mmonias and trebling of the nitrites and some increase in
e albuminoid ammonias in the waters of the reservoir in Feb-
ary over what there was in January. That was in the reser-
oir of the St. Louis waterworks. The same table is shown
here for the various points on these rivers.
78 The frequent or sudden changes of nitrites and free am-

monia and chlorine in streams is looked upon as indication of pollution. The sudden changing in the nature of water is always to be regarded as suspicious, because it shows that there is sewage pollution. Sewage brings about changes in the composition of waters much more readily. These fluctuations vary more in samples taken at the same point in a stream charged with sewage pollution than you find in a stream containing vegetable or organic matter. Vegetable organic matter is much more stable than animal matter; that is very much less stable and we are apt to find greater changes and sudden fluctuations in the free ammonias and in the nitrites in sewage polluted waters than water containing vegetable organic
1079 mats. The waters of the Mississippi river above Grafton
and the Missouri above the confluence of the Mississippi are much more stable than the water of the Illinois river or of the Mississippi river below the mouth of the Illinois.

Map offered as Complainant's Exhibit No. 35.

1080 CROSS EXAMINATION by Mr. Johns:

Arrived in St. Louis and took up my duties as a chemist September 20 1899.

Before I commenced these analyses I had not traveled up the Missouri river any to examine the character of the soil
1081 and the locality from which the Missouri waters came.
Nor up the Mississippi, nor up the Illinois. I have since traveled up the Mississippi with a view of examining the soil and the water and the sources of the water. Have not traveled up the Illinois, never was at Joliet or Lockport. I have no personal knowledge of the physical situation of the waters and the origin and derivation of the waters of which I have been testifying.

Q. Isn't that knowledge regarded as important in making up a judgment as to the water?

A. Only in so far as the water is of different origin from that which we have examined in this case. A spring with water or a well water it is especially necessary to know the surroundings, the country, the soil and the character of the buildings, and so on, with that kind of water but the topography of the country in general through which the Illinois river runs has been described so frequently in reports by various scientific bodies and I have read those descriptions so that I have been able to form a very clear opinion on that point. But I have no personal observation of it whatever.

1083 Describes laboratory in which analyses were made and method pursued.

1087 Unless water is liable to a chemical change if kept any length of time at a different temperature than that at which it was collected.

1088 If kept at a lower temperature than that at which collected would slowly convert nitrites into nitrates and free ammonia into nitrites, but this change would be very much less than if the water had been kept at the original temperature.

The Mississippi river water has considerable matter in suspension. That would settle if allowed to stand. It would vary according to the length of time it is allowed to stand in the reservoir. A glass tube full of water from the intake two feet high, being allowed to stand for four hours, 75 per cent of the solid matter would settle. That would be at least 50 per cent of the original weight of the water.

1090 Have never allowed the water to settle with a view of determining the weight of the matters in suspension. Then there are solids in solution.

1095 There is not a very definite standard of potable water.

1096 The standard of potability for river water is given in our text books something like this: Free ammonia not above .06 parts per million; albuminoid ammonia, if it goes above .18 that shows that the nitrogenous organic matter in that water has approached the danger limit. Nitrites, .001 or .002 parts per million condemns the water because it has gone beyond the limit—measurable quantities of nitrites condemn the water.

1097 If the chlorine runs higher than the average for that section of the country then we suspect sewage contamination. The averages are from 15 to 16 parts of chlorine in the Missouri.

Q. Now then at 23 the waters of the Mississippi become unpotable?

A. No. If it runs very much higher than that we would say it was.

Q. Say it was 50?

A. Yes, we would suspect then sewage contamination.

Q. Now, when you read the figures, I think you read that there were .1112 parts per million of chlorines in the Missouri river off the intake tower at the Chain of Rocks on the Missouri shore.

A. That must be a mistake. There is no such state as that occurring in the Missouri shore. It runs from 10 to 23 parts per million.

1101 In regard to your algebraic formula for determining the relative amounts of two sources of water in a given place at a given time. (Certain algebraic equations are presented to witness.)

Q. Well, if the fact was independent of the algebra that the Illinois river at Grafton at that time was less than one tenth of the Mississippi in volume, your mathematics are not of much account?

A. Well, it shows that as far as the nitrites are concerned, one-fifth of the nitrites were furnished by the Illinois river and four-fifths by the other.

Q. That is precisely to the point I want to bring it. Your algebraic formula does not represent the amounts of water at all?

A. They represent the amounts of water that are necessary to furnish that constituent to the Illinois.

1102 It means that that proportion of the whole, that much of the other water, is required to furnish that much nitrites.

Q. So that it is a calculation of the comparison of pollution as to a certain element and not a determination of the actual volume of water?

A. It is not an actual determination of the volume of water.

Q. What you meant to attempt to do with that and what you do as far as the mathematical formula is concerned, or algebraic formula, is to determine that if at a given point there are .0120 of free ammonia and at some other point a certain other number of parts and a certain other point a certain other number of parts, these two confluent sources furnish a certain ascertained amount of free ammonia at the given point?

A. Yes, sir. And that is theory and not actual water.

Q. Now, with the waters of the Mississippi and Illinois mixed bearing nitrites into the intake tower and therefore into the reservoir at St. Louis of four parts of nitrites for the Mississippi and one for the Illinois, and supposing at the same time that of the total water going into the intake tower the Missouri furnished three-fourths and the Illinois and Mississippi combined one-fourth, which is your algebraic equation here, that was the conclusion at which you arrived. A. Yes, sir.

CROSS EXAMINATION by Judge Springer:

1103 Q. Now, what proportion of the Illinois nitrites under those proportions got into the intake tower, what amount?

A. Well, if the Illinois furnished one part to the four parts of the Mississippi, which it never does, the Illinois always furnishes more than the Mississippi, but making this assumption one-fourth of the nitrites furnished by the Mississippi would come from the Illinois, and since one-fourth of the nitrites would come from the reservoir, come from that, one-fourth of one-fourth is one-sixteenth, therefore, one-sixteenth of the nitrites in the reservoir would come from the Illinois.

Q. Why do you say that the Illinois never does furnish one part of nitrites to three or four parts of the Mississippi?

A. My analyses show and all the analyses that I have seen of the water at the mouth of the Illinois and Mississippi, show invariably higher nitrites, especially in the winter time. The Illinois having greater nitrites than the Mississippi.

Q. Certainly, but when one-tenth of the volume comes out of the Illinois of the volume out of the Mississippi to make a total at the Chain of Rocks then the proportion of the nitrites to the whole body is much less for the Illinois than for the Mississippi?

A. Yes, the proportion that came from that, certainly.

GENERAL CROW: Let me understand. You and the witness don't understand each other. You mean the proportion of nitrites in the whole body of water, the combined waters at the intake, that is what you mean? A. Yes, sir.

1104 Result of examination of water of Missouri river at Bellefontaine, for chlorine for the year 1900.

1105 Average same months for nitrites.
Average same months for nitrates.
Average same months for free ammonia.

1106 Average same months for albuminoid ammonia.
Above are monthly averages.

1107 The total solids run very high. The Missouri often is very muddy and taking it unfiltered and simply shaking it up we got an enormous weight of total solids.

I have been informed by the city chemist of the city of St. Louis, Dr. Teichmann, here, that one of the tributaries of the Missouri coming in at Kansas City has gone across salt beds in Kansas, and that it is very highly charged with chlorine, and that is the reason for chlorine in the Missouri river. I never made any analysis of this Kansas river.

Q. Now, if it should appear by analysis that the river from Kansas coming in from Kansas City, which I believe is called the Kaw?

A. Yes, I think that's it.

Q. That if it did not run any higher in chlorine than the waters of the Missouri river above that point, then the theory as to chlorine constituents coming from Kansas would not obtain?

A. That is so, I agree to that.

1108 In making the analyses to which I have testified here as to the condition of the water at Grafton above the mouth of the Mississippi river, I did not take into account any supposed pollution that might have been brought to the Illinois river by the entering of its tributaries.

If the waters coming into the Illinois river from the Kankakee river above the mouth of that river should contain free ammonia and albuminoid ammonia and nitrites and nitrates in pronounced quantities, they would tend to pollute the Illinois river. And so with the Fox river coming in and the Big Vermilion and other streams known to empty into the Illinois river.

1109 Q. If it should appear upon investigation and reliable data that more than half of the waters constituting the Illinois river at Grafton were contributed by streams entering that river other than the Drainage canal, and that the averages for chlorine, free ammonia, albuminoid ammonia, nitrites and nitrates, were larger or equally as large in the tributaries as in the main river, what would you say or what would be your opinion as to the amount of pollution if any contributed by the stream itself and by its tributaries?

A. In that case the proportion of these impurities which came from the tributaries would form a fraction of the impurity of the Illinois river and the magnitude of that fraction would depend upon the relative volumes of the Illinois and its tributaries and it would vary as the volumes of those tributaries vary.

In my conclusions as to the amount of pollution that is contributed to the Mississippi river at Grafton for the Illinois river, I take no account whatever of what might have come from the tributaries of the stream. I simply analyze the water as it is taken out of the mouth of the Illinois river.

Q. Then so far as your analysis is concerned, you charged up all the impurities that you found at Grafton to the Drainage canal?

A. Well, in this way, as we ascended the river we found the impurities increasing steadily and I reasoned that if the impurities came slightly from the tributaries of the river the quantities of free ammonia and albuminoid ammonia and nitrites would be pretty constant all the way up the river and up through the tributaries if the waters were homogeneous, they would show that on analysis, but we found as we ascended the Illinois river that there is a very great increase all the way up to Joliet where the analyses showed the water to be diluted sewage.

1110 The water increased in free ammonias and nitrites and in chlorine and in albuminoid ammonia. We determined the chlorine at all points. It wasn't stated in my conclusions. We didn't make a tabulated table of that but on the record or daily analysis the chlorines are given. Chlorine in potable water comes from the salt that is dissolved in the water and there is always a certain quantity present in natural water. Now if we find that a given water has a proportion of chlorine higher than this so-called normal chlorine, we at once suspect sewage contamination, for the reason that common salt is used so extensively in articles of foods and it would thus find its way with the sewage into the water.

In making my various analyses of water to which I have testified the standard of purity for drinking and domestic purposes of river water which I carried in my mind, as to chlorine was as follows: Since my analyses disclose that the Mississippi river averaged in chlorine from 4 to 5 parts per million above Grafton and since below Grafton the chlorine suddenly jumps to 15 and 16 parts per million, I conclude that that may be taken as evidence of contamination as regards chlorine, by the

Illinois river. The safe standard for the Mississippi
1111 should be four or five parts. The Missouri river, however, runs from 15 to 16 parts normally and we cannot use that standard very well with the Missouri. If the chlorine goes higher than 15 or 16 parts then it indicates contamination, but owing to the fact that the Missouri is charged with salt, from the salt beds, we are deprived from using this standard in judging of the purity of the Missouri river. We then fall back upon the nitrites and free ammonias and albuminoid ammonias.

The chlorine at the Illinois shore, Chain of Rocks, runs higher and the averages are higher than the averages for chlorine for the Mississippi river above Grafton. We find, however, that the averages for chlorine in the Illinois shore, Chain of Rocks, are very nearly identical with the averages for chlorine at Hartford, which is above the mouth of the Missouri.

Q. So it depends entirely on where the water comes from as to the potability of the water in reference to chlorine?

A. Yes, in order to use the chlorine standard we have to have the so-called normal chlorine, an idea of what the average of chlorine would be in water in an uncontaminated state. When I gave my opinion as to the potability of water coming from the Missouri at Bellefontaine and the waters coming from the Chain of Rocks, the Illinois shore, I had different standards in mind, as regards the chlorine, but not as regards the free ammonia, nitrites and albuminoid ammonia.

1112 As to nitrites, if you have nitrites that you can measure and readily represent in parts per million, it shows contamination of the water. It is the opinion of a good many writers upon the subject. There are variations, of course. And our own water is not always free from nitrites. We have measurable quantities present most of the time. The work of Prof. Mallet of the Wilmington Board of Health was done a number of years ago and he allows .0135 parts per million, although he states the average for nineteen waters that cause disease was .0403 and Leeds standard for American waters was

.003, that is the allowable amount of nitrites, the maximum amount.

1113 As to nitrates the standard which I use in making my comparisons in regard to the analyses I have made myself and to which I have testified here is five-tenths parts per million. When water comes above that it is to be regarded as suspicious. The standard for free ammonia is that when it gets above .06 it is to be regarded as non drinkable, or rather polluted, that is .06 parts per million. If it contains much higher quantities it may be used as drinking water, but it is dangerous. As to albuminoid ammonia, whenever it gets above three-tenths it is suspicious water and is unsafe.

1114 In regard to solids, I had no fixed amount in my mind as to what was regarded as safe because our solids varied so very much in the Missouri river. In high water it is so heavily charged with mud that the total solids cannot be used in judging of the purity of the water.

Q. Prof. Keiser, Saturday in your testimony you had occasion to refer to a report by Prof. J. H. Long, with reference to analyses made from water taken from the Illinois river in the year 1899, do you remember that? (See rec. 1076.)

Q. You were asked this question, "Give me the result of that, professor?"

"A. The values before the opening of the canal of free ammonia were 0.895 and after opening of the canal 3.060 according to Prof. Long, and according to my analysis 1.950."

That was above Peoria. Now I want to call attention to
1116 the fact that that is the river below Peoria and not above
Peoria at the Narrows as you compared it with.

A. Yes, I see that is Wesley. (Wesley is between Peoria and Pekin and after the sewage of the city of Peoria has been received into the Illinois river.) There is no analysis given there above Peoria, that is as near as we could come to it.

Q. Now if you will look at page 64 (of Prof. Long's report) you will see another table, that is the averages for the summer of 1900 by Prof. Long. Cast your eye along from the Peoria Narrows until you get the free ammonia—what do you find?

A. The free ammonia there in the summer is .21. And at Wesley, 1.62.

Q. You stated the value before the opening of the canal of free ammonia was .0895 and after the opening of the canal 3.060 according to Prof. Long and according to your analysis .0950. You put the comparison after the opening of the canal at 3.060. Now couldn't you have put it Peoria at the Narrows free ammonia 0.21?

A. Well, for the reason that is a further period of time.
1117 The canal was opened in January and we have our analyses that run up to November of the previous year. These first analyses come up to the end of November 1899, and then the next analyses, the nearest analyses that are published, after the opening of the canal at the point nearest Peoria, give the value I have stated in my report. The first analyses by Prof. Long were for 1899 on page 24 I think of this report. That began in July and ran until November 23. It was for the year 1899. Now, beginning with the other table for 1900, it began with June 7th and ran until October 9th. This is the one upon which .021 is based.

Q. That was based upon the analyses of water taken between June 7th and October 9th, 1900, practically the same periods in the two years.

A. Well, one is July and runs until the end of November and the other one begins in June and ends in October. There is considerable difference.

1118 What I want to call your attention to is the fact that in this statement you compare the water at Peoria before the opening of the canal, of the samples taken above the Narrows and after the opening of the canal with the samples taken below the Narrows after the Peoria sewage was in and on that basis you show a large increase in free ammonias. Isn't that right?

A. There is shown a large increase there, but the analyses come as nearly together as they have been published.

Q. Well, what I want to get into your mind if I can, is the fact that this statement here as to the difference between the conditions before the water was turned in and afterwards, was based upon two very different conditions.

A. Samples were taken at different places, I understand, but they were taken not so far apart in point of time.

Q. Well, there is a great deal of difference between the Illinois river below Peoria and above Peoria.

1121 Q. Your comparisons for this period of the conditions of the waters at the Illinois river at Peoria before the opening and after the opening of the canal, were based before the opening upon the waters above Peoria and after the opening upon the waters at Wesley, below Peoria, isn't that true?

A. I have followed the report as given here so far as Wesley is concerned.

Q. You took it at Wesley then for comparison after the canal was opened?

A. I tried to compare the points as close together as I could get them.

(Same explanation with reference to the nitrites.)

1122 (Same as to albuminoid ammonia.)

1123 Now, having called your attention to the fact that you are basing your estimate upon waters taken at different places, viz: in the first period above Peoria and in the second below Peoria, if it appears from these books that you took your second period at a place below then your conclusions wouldn't be borne out by the fact as it appears here?

A. My conclusion is borne out by the fact that I made the analyses myself of water taken above Peoria and upon those analyses showing an increase of impurities I based the conclusion that there was increased pollution after the opening of the drainage canal.

1124 Peoria Narrows is three miles above Peoria, before the sewage of the city has been received in the Illinois river. This place was called Shady Beach by Dr. Ravold.

Q. I call your attention to your testimony of Saturday in which it is stated, "Albuminoid ammonia before the opening of the canal was 0.572 by Prof. Long; after the opening of the canal, 2.210, by Prof. Long, and according to my analyses, 0.627." Now you have Prof. Long's report before you, please point out in it the page upon which you found the first figure, 0.572. That was in the year 1899.

A. This is on page 36. I took it from the line marked Peoria Narrows, 0.572. The statement from which I took the comparison of the condition after the opening of the canal I found on page 44 where the averages are given for the spring work of 1900. That was 0.221. That was as nearly after the opening as these analyses are given. That was taken from under the head of Wesley, Illinois river. And they my own determinations upon which I base the conclusions gave .627 also an increase over the original for the same period of time.

Q. Now turn to page 64 of Prof.Long's report and on 1125 the left hand column you will find Peoria Narrows, and run along until you come to albuminoid ammonia. What do you find?

A. Well, we find there .34, but I maintain that that is not a fair comparison.

Q. If you took Prof. Long's data for comparison it would show a decrease in free ammonia after the opening of the canal as compared with the period before the opening, taken from Prof. Long's statement?

A. Well, the figures that Prof. Long gives us for the summer months are lower than the figures which he gives us for 1899 for the fall months.

1126 Q. Well, is not that period covered for 1900, between

June 4th and October 1st, according to page. It is the period June 7th to October 7th, Peoria analyses?

A. Yes, sir, that is June 7th to October 9th.

Q. That is the period upon which he bases his comparison for the period after the opening? A. Yes, sir.

Q. Now the same fact will appear in reference to the findings for nitrates, free ammonia and nitrates, would it not, as far as Prof. Long's tables are concerned?

A. Yes, I have used his tables for free ammonia, nitrites and albuminoid ammonia.

Q. Then according to those two tables to which I have called your attention, Prof. Long's tables show a decrease in these items after the opening as compared with before the opening?

A. A very long time after the opening, in the summer months. I didn't know that Wesley was located below Peoria and I didn't know whether the sewage of Peoria got into the river at Wesley, I thought it was considerably below, if anything. I didn't think it was right in the town of Peoria.

1129 Well, what I desire to have you correct, if you desire to do so, is the impression which you left here, that Prof. Long's tables sustain your conclusions as to the increase of these conditions at Peoria, that is nitrites, nitrates and free ammonia and albuminoid ammonia at Peoria before and after the opening of the canal. (No answer.)

1130 Q. Having Prof. Long's tables as appear in his report, to which reference has been made, of analyses of water taken from the Narrows, above Peoria, before the opening of the canal and after the opening of the canal, don't his figures show that there was at that point a decrease in free ammonia, albuminoid ammonia, nitrates and nitrites, in the year 1900 after the opening of the canal, as compared with 1899, before the opening of the canal?

(Witness refuses to answer yes or no.)

1131 Q. In order to direct the witness' mind to the question

that I desire him to answer, I will call his attention to page 36 of Prof. Long's report. Now that contains the averages at Peoria from July 5th to November 23, 1899, is that right.
A. Yes, sir.

Q. Well, now, taking the average found for free ammonia, albuminoid ammonia and nitrites and nitrates at the Narrows, above Peoria, from samples of water taken during that period, namely, from July 5th, 1899, to November 23d, 1899, compare those averages with the averages on page 64 for the summer of 1900, taken at the same place, namely, at the Narrows at Peoria above that city, during the period from June 7th to October 9th, 1900, do they not show that for free ammonia, albuminoid ammonia, nitrites and nitrates, there was a material reduction in the latter period as compared with the former period? 1132

A. Yes, sir. We are now comparing analyses of waters made at different seasons of the year. We are comparing analyses made in the fall of the year, from July down to the end of November, when the results are apt to be low, with the analyses made in the early summer when the rivers are apt to be swollen with the rainfall, and therefore it is not a good comparison.

In my direct examination I stated that the waters of the Missouri river at Bellefontaine and the Mississippi river above the mouth of the Illinois river are both fairly good streams from a sanitary standpoint.

1133 Q. Are we to understand from that that you regard the waters of the Missouri river as suitable for the water supply of a city?

A. Yes, sir. It is not as good as it might be, but still it can be used. I stated in my direct examination that if there was an ascertainable amount of nitrites in the river water that it was to be regarded with suspicion for potable purposes.

Q. Now in your testimony Saturday you stated Bellefontaine was on the Missouri river 14 miles from the intake of the

St. Louis water works, by river, but it is above the mouth of the Missouri river. You also stated, "In order to get the idea of the condition of the water in the Missouri river during the same period, immediately before and after the opening of the Drainage canal, I have taken the average of the analyses of the Missouri river water from January, 1900, and I find that before the opening of the canal that free ammonia was 0.135, and after the opening the average for February was 0.148. The nitrites before the opening were 0.008, and after the opening 0.014. The albuminoid ammonia before the opening was 0.063, and after the opening 0.395." Now do not these conditions in the Missouri at Fort Bellefontaine show, according to the standard which you laid down this morning, that the waters at that point are not suitable for drinking purposes?

1134 A. During that period of time for which these analyses were made the nitrites ran high and the water was to be looked upon with suspicion, during the summer, however, the nitrites are very low, and sometimes you can measure them, and with that amount I say that the river is a fair stream. It is not as good as we would like to have it, but still, and during the winter months, I admit that it is to be looked upon with suspicion according to the standards that I have given. It ought to be rejected as polluted in its unfiltered state, according to the standards I gave. These conditions prevail usually during the cold season of the year, in November, December, January, February and March, along when the spring rains come the nitrites fall, and in June, July and August, they are low, sometimes we get merely a trace.

Q. Well, what would you say then of a source of water supply for a great city, that four months of the year the water was unfit for use, and they were compelled to take it always from the same place?

A. Well, I should say it ought to be filtered. Boiled anyhow, you can filter it or boil and filter too, and stop sewers from running into it.

1135 The water at the Missouri shore, Chain of Rocks, is very similar with the water at Fort Bellefontaine on the Missouri river. Of course there are variations from day to day, but taking it altogether the water at the Chain of Rocks is substantially Missouri river water.

The intake tower is about 1,500 feet from the Missouri shore.

Q. How far would that tower have to be moved inward in order to put it at a point where it would take Missouri river water only?

A. I asked that same question of the water commissioner, and at the same time asked him why he didn't take the Missouri river water, and he informed me that it was necessary to have the tower out as far as this because in dry weather the river is so low that it is impossible to get enough water for the city without having the tower out at its present position; that at low water, when the rivers got low, there is not enough water any further to the Missouri shore than the present position of the tower.

1136 Q. Then in low water, wouldn't the Missouri river be further from the shore proper?

A. At low water the water falls and the volume in the Missouri is very low, and we get much more Mississippi river water, so that it is necessary to have the tower out at least as far as it is now.

1136 RE-DIRECT EXAMINATION by Attorney General Crow:

1139 The results shown by Prof. Long of analyses made at Peoria are from weekly samples. My samples were daily samples. The daily samples enable you to get a very much better weekly average than simply taking one result. They approach very nearly the continuous condition of the stream. The daily samples are therefore to be regarded as the better for the test as to the purity of the water.

Q. Now, Judge Springer asked you a hypothetical question to the effect that if the rivers that run into the Illinois river were highly polluted, if it would not have an effect upon the pollution of that stream, and you said yes. I show you here a book called, "The Illinois State Board of Health." Turn to page 64, examine that and see if it is Prof. Long's report.

A. Yes, sir, it is Prof. Long's report as to the condition

1140 of the Illinois and some of its tributaries. That report is from June to October, 1900. The analyses show that the Illinois river is very much more polluted than any of its tributaries, and at low stages of course, less water would flow in.

1141 I have here a preliminary report to the State Board of Health by Prof. Rauch, M. D., Secretary. There are two appendices, one, chemical investigation of water supply of the Illinois, by Prof. J. H. Long and the other Illinois Basin and its relation to sanitary engineering, by L. E. Cooley, civil engineer. Turning to page 15, I find that Prof. Long, in a note paged to table 7 states:

"From table 7, it will be seen that the amount of organic matter in this water as indicated by albuminoid ammonia and oxygen consumption, is quite large, and as both are undoubtedly chiefly of vegetable origin, its effect should not be lost sight of." This refers to the table giving the physical conditions and constituents of the Kankakee river. I will ask you to examine that table and see if it bears out the statement that Prof. Long makes.

MR. JOHNS: Objected to as not re-examination.

A. Compared with the values for the Illinois river, there is very much smaller free ammonia and albuminoid ammonias. For instance they only run up to .1—free ammonia .1, and the Illinois river running much higher.

Q. I show you here a report of the Illinois State Board of Health: Advance notes of the Sanitary Investigation of the Illinios river and its tributaries, Springfield, Illinois, 1900, with special reference to the effect of sewage of Chicago on the

DesPlaines and Illinois river prior to and after the opening of the Chicago Drainage canal. On page 34 we find a table of averages of chemical constituents of the waters of the canal at Bridgeport, Lockport, Joliet, Wilmington and then Illinois river at Ottawa, Peoria and the different streams that
1142 come into the Illinois. I will ask you to take that, examine it and say if you can determine from that table whether or not the tributaries there are less polluted as shown by the nitrites, free ammonia and nitrates they carry, than that of the Illinois river.

MR. JOHNS: Objected to for same reason.

A. The nitrites run very much lower. The free ammonias are also very much lower than of the Illinois river. This holds for Wilmington, and for Ottawa, on the Fox river, and for Havana on the Spoon river, and for Brownings. The free ammonias and the nitrites, and the chlorines are all very much lower in these tributaries than they are in the Illinois.

If most of the drainage from the tributaries of the Illinois, into the Illinois, were what we would call the rural character that would be different in its effects on the water than if there came into those streams and tributaries sewage flowing through sewers from larger cities and towns. We would find high chlorine, for instance. Now we do find low chlorines in these tributaries that flow into the Illinois, and we also find low ammonia—free ammonia, whereas in the Illinois itself there
1143 is a higher free ammonia, and similarly with the nitrites in the tributaries—they are low. This indicates that the organic matter is of vegetable source when we have low chlorines and low nitrates, whereas when the chlorines are high, and the free ammonia is high and the nitrites high, those three things together indicate animal sewage.

Q. Now, Professor, Mr. Johns asked you the question as to whether or not your analysis made to determine the quantity of Mississippi and Missouri river water that came into the intake of the St. Louis waterworks was an actual measurement, scientifically made, of the amount of water of the two respective streams, the Missouri and the Mississippi, that came into the intake of the waterworks at that point, and I will get you to state now, whether or not it was such a scientific measurement.

A. It was a scientific measurement, calculated from the measured quantities of nitrites in the water. It is the usual and ordinary method that water chemists use for the purpose of determining the relative amounts of two streams, whose waters have commingled at a given point. That analysis made by me determined chemically the amount of those waters. It was made for the purpose of tracing these impurities that I found in our reservoir water, to their origin. A chemical analysis of water does not constitute the measurement of the volume of the flow of the water, or body.

1144 The analyses made by me determined the quantity of pollution as contributed by the two streams. The chemist is able to determine that from this method of water analysis.

Q. Suppose where the Missouri and the Mississippi come together the water of the Missouri was about 1-3 greater than that of the Mississippi—but the Mississippi was polluted twice as great as the Missouri at the point of confluence. Then would the amount of pollution found by water analyses below the junction of the streams correspond necessarily with the relative volumes of the two streams at the point of confluence?

A. No, sir. It would show rather than the volume of the streams it would show us the proportion of impurity which came from each of the streams. That is the value of the analytical determination of the commingling waters of the two

1145 streams. I do not consider the water commingling of the Missouri and Mississippi, as it comes into the intake of the St. Louis waterworks, since the opening of the canal, is a safe, sanitary water for the use of cities of this size. The water that I drink at my house is all boiled and filtered.

1147 **RE-CROSS EXAMINATION** by Judge Springer:

I sometimes drink water when it has been run through a

Pasteur filter. A Pasteur filter would remove the larger proportion of the bacteria from the river water, without boiling, I believe.

Q. Are there any waters in the navigable rivers of the United States that you would recommend people to use without being filtered and boiled, for drinking purposes?

1148 A. Well, I imagine there are some rivers. The upper Missouri is probably in a very good state, and it is navigable I believe for many thousand miles. I believe the Missouri above Kansas City and St. Joseph is a very fair stream and that it could be used as a potable water. I think all of our river waste waters ought to be filtered. There is danger of contamination from any of them unless they are filtered.

WILLIAM C. TEICHMANN, resumed the stand for further direct examination by Attorney General Crow and testified as follows:

States his professional training, and methods pursued in the chemical analyses of the waters under consideration in this hearing.

1154 I suggested to the city authorities that Prof. Keiser be engaged for duplicate work. The work he did corresponded with the work I did, in quantity. I did duplicate work the same as he did. I superintended the analyses of duplicate samples with the samples that Prof. Keiser received in my laboratory.

1163 In order to get the proper weight of the sources of pollution which affect the sanitary character of the Illinois river we will have to consider some figures from responsible authorities on the effect of dilution from the Illinois & Michigan canal and the tributaries.

Since it is of the greatest importance to find out the stages of the river during the periods of drouth, we will look for the low water stages of the Illinois river water shed. Perhaps the lowest on record is that discussed from the U. S. Government data by Lyman E. Cooley in a report published in 1890, entitled

"Lakes and Gulf Waterways as relating to the Chicago Sanitary Problem."

Witness quotes from this work, and adds.

1164 MR. JOHNS: I object to reading from books. If the evidence is competent the books themselves are the best evidence.

From Lyman Cooley's remark we may assume for the purposes of calculation, that the natural low water volume independent of Chicago sewage, above Havana is 300 cubic feet per second and below this point is 8 cubic feet per second. Now this is the condition prior to the opening of the Drainage canal.

1165 From those figures I have calculated the following ratio of dilution of Chicago sewage in the Illinois river prior to the opening of the Drainage canal.

Upper Illinois volume of flow 600 cubic feet per second, as established by Cooley and Harman.

Sewage of Chicago, 400 cubic feet per second, ratio of dilution, 1.05.

Lower Illinois: volume of flow, 1,200 cubic feet per second, that is the upper district runs to Utica and the lower district from Utica to the mouth. That is, the lower Illinois had a volume of flow of 1,200 cubic feet per second and the sewage of Chicago 400 cubic feet per second, making the ratio of dilution one to two. I deducted the sewage from the water.

1166 Now for instance, 600 cubic feet of water I have there and I have 400 cubic feet of sewage, that leaves 20 per cent. 200 to 400 equals 0.5 as the ratio of dilution. In the same way we would refer to the 1,200 cubic feet of volume per second in the lower Illinois and sewage 400. Deduct that 400 from 1,200 and it leaves 800 and 400 is to 800 as is one to two.

Amount of sewage from Chicago was obtained by taking it equal to the water supply of 42,000.00 cubic feet per day. We have thus deducted 400 cubic feet per second as the amount of sewage discharged there prior to the opening of the Drainage canal.

Of course these dilutions are given only to show just what proportion of the Illinois river is made up as the diluted sewage of Chicago and the purification of this sewage must be taken seriously into account before arriving at definite conclusions.

1174 I have no data for my own analytical work of the condition of the Illinois river in 1899, but have consulted the following reports.

Water Supplies of Illinois, published by Rauch.

Long's Chemical Investigations of the Water Supplies of Illinois.

Palmer's Chemical Survey of the Water Supplies of Illinois, etc.

I have here some tables quoted from these reports in their comparison lead to the following deductions, first:

That the Illinois river prior to the opening of the Drainage canal was being constantly polluted by the I. & M. Canal and to such an extent as to give the entire water course the character of a carrier of diluted sewage, showing that the dilution of sewage for the lower Illinois river between Utica and the mouth at times of draught was one to two.

1175 It is true that dilution, sedimentation and oxidation gradually lessen the quantity of characteristic ingredients of sewage present, but not sufficiently by the time the Illinois reaches its mouth to have completed the process of self purification. All the tributaries entering the Illinois river are comparatively much purer than the Illinois itself. That is a conclusion that I draw from these reports.

These are all conditions previous to the opening of the Drainage canal.

The second conclusion that I draw is that there was a remarkable increase in the sewage pollution as evidenced by the higher nitrites, chlorine and free ammonia in the river since Long has examined it in 1888, and again since Palmer's investigation.

This pollution cannot be ascribed to accessions from the tributaries or from the Peoria and Pekin pollution for the reason that during the same period those tributaries show no increase in pollution.

1176 It is only necessary to consider the corresponding increase of water in the Illinois & Michigan canal during this period of 1888, 1896 and 1900 and to remember the enormous growth of population and industries in Chicago to find the right explanation of the gradual conversion of the Illinois river at that time into a condition of very bad pollution.

Prof. Palmer states that "the I. & M. canal and Illinois river were during the fall of 1895 and year of 1896 much more fully charged with sewage than they were in 1888 and 1889," the time of the investigations made by Long under the Board of Health.

As to examinations made prior to opening of canal, from August 23 to January 22, at mouth of Illinois above Grafton and from the Mississippi above Grafton, I have presented a table of maximum, minimum and average results.

(Table No. 1, Teichmann's testimony.)

1178 From the original date it will be seen the nitrites, free ammonia and chlorines of the Illinois river were found to exceed those of the Mississippi.

On September 30, for instance, a sample from the Illinois river contained 31 parts of chlorine per million; 44 parts of ammonia per million, and .015 parts of nitrogen in the form of nitrites.

Whereas in the Mississippi we find, 5 parts of chlorine per million; .134 parts per million of nitrogen in the form of free ammonia; and .002 parts per million of nitrogen in the form of nitrites.

It is true that the highest albuminoid ammonia in the Mississippi river was on the same day found to be higher in the former than in the Illinois river, but it was not accompanied by correspondingly higher nitrites and chlorines. Therefore the conclusion is justified that the sanitary character of the Mississippi river at that time was better than the Illinois river.

1179 We next come to the chemical character of the Mississippi river water between Grafton and the intake of the St. Louis water works in 1899.

There was no doubt of the polluting effect of the Illinois river on the Mississippi.

1180 Analyses of the water of the intake, in 1889. From August 23 to September 16, 1899, four samples were collected near the intake of the water works, but beginning with October 16 and ending January 22, 1900, semi-weekly analyses were made at the intake. The averages of the most important chemical constituents were as follows:

Table of averages, parts per million: Nitrogen as free ammonia, maximum, .138; minimum, .008; average, .0063.

That is the whole of the period at the intake. I will give the number of samples, 26 samples.

Nitrogen as nitrites, maximum, .01; minimum, .0; average, .002.

Nitrogen as nitrates, maximum, .8; minimum, .2; average, .4.

1181 Nitrogen as chlorine, maximum, .27; minimum, .9; average, .17.

The maximum stamps the water as polluted, whereas the minimum characterizes it as good potable drinking water.

These great fluctuations can only be ascribed to the daily varying mixtures of Mississippi and Missouri river waters at the intake which is located on the edge of the channel 1,500 feet from the Missouri shore.

The Missouri river showed much lower nitrites and free ammonias than the Mississippi above the mouth of the Missouri at that time. When the Missouri would go into the intake the impurities in the water at the intake would be low. When the Mississippi river prevailed, the impurities in the intake would go up.

1182 Now as to the final conclusions on the work of 1899, the Illinois river at its mouth was badly polluted during the entire period. The Mississippi river above the mouth of the Illinois, was much better in sanitary quality than the Illinois throughout the investigation.

The Mississippi river between Grafton and the St. Louis intake showed very much the effects of pollution from the Illinois river and on such days when the Mississippi river water entered the intake, the result would be an increased pollution of our water supply.

The Missouri river was generally purer than the Illinois above Grafton and purer than the Mississippi after its junction with the Illinois river.

The next period of the investigation covers the time from January 23d until October 11, 1900.

Witness states that 3,492 samples were taken and enumerates the various points and the number of samples at each point.

1183 After October 12, weekly samples were collected from the following points until November 30th. (Naming them.)

The sources of pollution in the Illinois river are the sewage of Chicago, the sewage from the towns along the banks of the DesPlaines and Illinois river and from the tributaries. Particularly a large percentage as I have already said, according to the statement of E. O. Jordan, a large percentage of the sewage from Chicago came by way of the I. & M. canal. I wish to emphasize that this is the opinion of Prof. Jordan. Much of the Chicago sewage to-day passes through the main branch of the canal.

1185 The sewage passing or mixing with the lake water in the Chicago river, south branch and entering the Drainage canal, that sewage represents the drainage of a population less than 800,000. That is the sewage that enters the main branch of the canal.

The sewage entering the I. & M. canal, according to my observations and the testimony of Mr. Benezette Williams, comes from the south fork of the south branch.

The sewage that enters the south branch is of a different

character than the sewage in the south fork of the south
1186 branch of the Chicago river. There being no current in the south fork it is kept there for a sufficient time to enable it to undergo preliminary purification. This is not the case with the sewage entering the south branch directly that is draining from the population of 791,677. The south fork may be compared to a septic tank.

Now it has been proven that water when it stagnates facilitates to a great extent, purification much more so than that of running streams. In septic tanks the most effective are always
the obligatory anaerobic bacteria. The Chicago Drain-
1188 age canal contains dissolved oxygen. The lake water provides it. There is also dissolved oxygen in the south branch today. The north branch ordinarily is also a septic tank. This is an advantage to the water as it leaves the Drainage canal and enters the Des Plaines and Illinois rivers.
1190 The conduits testified to by Mr. Williams will change this condition and push the sewage right out into the south branch and will prevent its purification while in a stagnant condition in the north branch and south fork of the south branch.

In a measure it is already being done by the so-called Fullerton avenue conduit, whenever that is in operation, but it will be done still more by the Lawrence avenue conduit and the 39th street conduit now in course of construction. This will then carry all the remaining sewage of the city of Chicago through those conduits directly from the Chicago river into the Drainage canal, excepting that part of the sewage, of course, still being dumped into the Illinois and Michigan canal whenever in operation. There will still remain the sewage of the district of Calumet and the district of Evanston, representing in toto a population of about 100,000. They will still drain into Lake Michigan. The remaining sewage will all be discharged into the Drainage canal at the rate of flow fixed by the United States War Department at 250,000 cubic feet per minute.
1193 In all problems dealing with the sewage disposal by

method of discharge of crude sewage in streams, there are two important problems to be considered:

First, the oxidation or mineralization of the organic matter in sewage with subsequent absorption of final products by plant life.

Second, the destruction of pathogenic or disease producing bacteria.

The prime factor which affects the capacity of the streams to accomplish the results as outlined above, are the volume of sewage discharged into it, the degree of dilution of the same, the volume and velocity of the stream, the length of the stream, and finally the character of its water—the chemical and bacteriological character of its water.

1192 The flow of water in the canal is about 1.92 miles per hour in the rock section, and 1.26 miles per hour in the earth.

1193 Taking Prof. Jordan's figures, the ratio of dilution of Chicago sewage in the Drainage canal is one to nine.

These figures should be modified. Less than 800,000 population of the city of Chicago drain directly into the Chicago river, and the south branch and mixes directly with the 250,000 cubic feet of lake water running through the Drainage canal, per minute. Now this sewage, as I said this morning, is running to the Drainage canal, and mixes with the water and is really the only sewage from Chicago, from which a normal calculation should be based as to the ratio of dilution. This ratio of pollution based upon the population of say 800,000 would make a ratio of dilution from one to about twenty-one.

The rest of the sewage from the other 900,000 population drains partly into the north branch of the Chicago river and partly into the south fork of the south branch of the river, and partly, according to the estimates of Engineer Williams, into the lake, the latter representing the drainage of 300,000 into the waters of the lake.

1194 Q. Don't the waters of the north branch of the Chicago river run into the south branch? A. Yes, sir.

Q. And thence into the canal?

A. Whenever storm water and heavy rains flush out the north branch and the south fork much of this sewage which has largely undergone an advanced stage of preliminary purification, is rushed with recent accessions of fresh sewage into the Drainage canal. Eventually it all goes in, but I drew the distinction this morning between the sewage previously decomposed and in the preliminary stage of purification by the anaerobic bacteria and fresh sewages.

I will demonstrate from my data, whenever an increased amount of sewage was run into the Drainage canal during my investigation, the impurities at Lockport would increase. In fact there is shown an increase all along the line up to the mouth of the Illinois.

So that in time of rain, when these streams are high, it all goes in the Drainage canal except the sewage from about 300,000.

1196 ATTORNEY GENERAL HAMLIN: I object to testimony collected from reports and hearsay.

1197 Chemical examination of the water from Lake Michigan in the harbor of Chicago. 32 samples were collected during this period of July 23d to November 17th, 1900, from Lake Michigan, at various distances of from two to ten miles from Chicago.

Since the opening of the Drainage canal the condition of the lake water has improved materially. This is shown by average results of our analyses as compared with those performed by other investigators in previous years.

We found an average of the 32 samples of water collected
1198 from July to November, 1900, of free ammonia, .045 parts per million; nitrogen as nitrites, .15; chlorines, .6.

These averages would probably be still lower were it not for the fact that during September on certain days the Chicago river again flowed into the lake because of the temporary closing of the gates at Lockport, and this resulted in a re-pollution of the water on the lake front, and the sample taken near Lake

View crib, December 7th, contained .086 parts per million nitrogen as free ammonia; .014 parts per million, nitrogen as nitrites; .2 parts per million of nitrogen as nitrates; six parts per million of chlorine.

1200 During the last ten years the discharge from the pumps at Bridgeport in the I. & M. canal was practically crude sewage, after having partly been disintegrated by anaerobic action in the Chicago river and in the south fork and north branch.

The analyses of samples of the contents of the canal showed an entire absence of absorption of oxygen, without which practically no oxidation can take place. In other words you have here in the I. & M. canal a septic tank.

1201 These conclusions are largely confirmed by Prof. Long's analyses of 1899, by whom 27 weekly samples were taken between July 1 and November 27, 1899, with the following results:

At Bridgeport nitrites were absent, or present only in immeasurably small quantities or amounts, for all but three of these weeks. Twice they were as high as 01. and once reached .64 parts per millions.

At Lockport almost identically the same conditions were found. The nitrates at Bridgeport were uniform—absent with but one exception. That was before the opening of the Drainage canal.

1203 Results of examination at Joliet, in Des Plaines river: free ammonia, maximum 8.284; minimum 1. 246; average, 2.759.

Rudolph Herring says that when free ammonia is greater than 1.2 per millions, the conditions are probably objec-
1204 tionable. This represents chart 1, describing in curves the comparison between weekly averages of results of analyses of daily samples collected at Lockport, from the Drainage canal, collected at Joliet after mixture of the Drainage canal, and the Des Plaines river, and also respecting the mixture of the Illinois & Michigan canal. The samples were taken

at McDonough street in Joliet and three miles above Peoria. That is the curves will show fluctuations at Lockport and Joliet and that they produce similar fluctuations at Peoria to show that there is little change and practically no material improvement in the Chicago sewage in traveling from the lake front to Lockport.

1205 You see here (indicating on map) a rise in the Drainage canal in free ammonia is followed by a rise of free ammonia in the river at Joliet and is followed by a rise of free ammonia at Peoria, and you will find here the amounts of free ammonia all figured out. Of course the crossing of the DesPlaines river at Joliet by the I. & M. canal—the canal causes a large acquisition of the sewage there from the Illinois & Michigan canal, and that must be taken into account in reviewing this chart. That is what brings those high free ammonias, as I said before, at Joliet, and also brings the high chlorine up there at Joliet, running as high as 32 parts per million of free ammonia; here as high as 54 per million, but you will notice the fluctuations correspond pretty much.

1206 I have a table of average results of daily analyses for the period from January 23 to October 11, 1900, and I have also a table containing the maximum, minimum and average results of analyses from January 23, to October 11, for the same year, 1900.

1207 This would show for the Bear Trap dam free ammonia on September 18, the highest amount of free ammonia was reached at Bear Trap dam, at Lockport, 4.8 parts per million.

Minimum May 18th, .706 parts per millions, making average of 1.585 which is represented on this map here.

Nitrites, maximum also at Bear Trap dam, .2 parts per million; minimum, zero; average, .026.

This is chart No. 2. The red line shows Illinois river; three miles above Grafton. The blue line represents the Illinois river three miles above Peoria.

The curves represent the graphical condition of the Illinois river at Grafton, and Peoria during January and February, 1900, prior to and immediately after the opening of the Drainage canal, January 17.

These results clearly show the enormous pollution caused by the flushing out of the Chicago river and the Drainage canal, and that owing to the excessive quantities of organic matter present, self-purification was practically impossible. The amounts of free ammonia, chlorine and nitrates represented the effects produced, and although the incomplete purification is also demonstrated by the other results of the organic matter the principal object of this chart is to make a comparison of the results at Peoria and at Grafton during the months of January and February, 1900. It will be noticed that in January, immediately after the opening of the canal, the chlorine go up from 21 parts per million to 28 at Peoria. This is follow-
1208 ed by an increase at Grafton from 15 to 23 parts per mil-
lions. It will be seen that the chlorines go pretty much together in the fluctuations at Peoria, as well as Grafton.

As regards free ammonia, we notice the same conditions Illinois river three miles above Grafton as we do three miles above Peoria. The fluctuations correspond between Peoria and Grafton, making allowance for the flow of the water.

This is chart number 3. We find here the results at Grafton and Peoria again campared by covering a period from January until October, 1900.

1209 The top line indicates free ammonias. We again see the corresponding fluctuations in the free ammonias at Grafton and Peoria, particularly during the early parts of the year.

As regards the nitrites, we notice a significant correspondence of the fluctuations in nitrites results for the two points during the first two months, but during the summer months, the warmer weather facilitating the action of the aerobic bacteria in the Illinois river, we find much of those nitrites oxidized eventually because the fluctuations are not so high any more during those summer months for Grafton as they are at Peoria.

Chart number 4 shows the results of the waters analyzed from the mouth of the Illinois several miles above the mouth of the Illinois in the Illinois and several miles above the mouth of the Illinois in the Mississippi. They show above all, the peculiar unstability of the Illinois at Grafton as compared with the Mississippi, a much more stable river as far as its pollution is concerned, and as far as fermentative action itself takes
1210 place.

I have also here the river stages for the two rivers.

1211 My conclusion is that the Illinois river was very much more impure than the Mississippi above the mouth of the Illinois during the year 1900, and was evidently in a badly polluted condition.

1212 I have already stated that the Chicago sewage is only partly purified by the time it reaches Peoria, as was shown on the chart by the high free ammonia, high nitrites and the high chlorines coming together, we must certainly admit a large amount of nitrification and oxidation between Lockport and Peoria, but it is in no sense sufficient to render the Illinois river potable by the time it reaches Peoria.

The water above Peoria, as determined by analytical examinations shows that it is polluted.

I have already quoted Prof. Drown as having stated that high free ammonia, with high nitrites and high chlorines together, establish water as sewage polluted.

Now regarding Peoria sewage. Population of Peoria is 56,000. We figure on 150 gallons of sewage per inhabitant. On this basis we take 8,415,000 or 1, 222,000 cubic feet
1213 of sewage per 24 hours running into the Illinois river from the city of Peoria. That is, if we take the total population. But from recent data I have learned that the sewage draining from the city of Peoria into the Illinois river would represent only 47 per cent of the population. The rest of it goes into privy vaults and is lost in the ground.

Minimum flow of the Illinois river at Peoria prior to opening of Drainage canal, according to Cooley, was 72,000 cubic feet per minute. If we add to this the discharge from the canal of 250,000 cubic feet per minute, we have a minimum flow of the Illinois at Peoria of 322,000 cubic feet per minute. Now we take the above value of 1,122,000 cubic feet per 24 hours or 779 cubic feet per minute, and we will find that the dilution of the Peoria sewage at a low river stage as was recorded by Government data and presented in Cooley's report, and taking in the whole population, which as I say I have recently discovered is not the case, we find a ratio of dilution of the Peoria sewage in the Illinois river of 1 to 413, at the lowest stage of the river.

In other words, if we take the sewage of Peoria and run it into water at such a ratio of dilution, the sewage would, in my opinion, after a run of from 25 to 50 miles, be sufficiently purified with so much water added to the sewage, so as to remove the effect, the polluting effect of the Peoria sewage on that river.

1214 The sewage of Peoria adds to the pollution of the Illinois river, but only to an extent that if the Illinois river were pure, that would be what I call a comparatively pure water, because absolutely pure water is only distilled water which you find in the laboratory, but I mean to say an ordinary good river water, potable—I will say that if it were a potable water before it came to Peoria, that the sewage entering the Illinois from Peoria would, after running from 25 to 50 miles, purify itself so as to remove the polluting effect of the Peoria sewage on the Illinois river.

Q. You mean by that chemically or bacteriologically?

ATTORNEY GENERAL HAMLIN: Objected to as not being proper; the answer doesn't require any explanation.

A. Chemically, yes.

Q. Do you mean that that would also be bacteriologically purified?

A. Well, that would involve a consideration of the bacterial action of facultative anaerobic bacteria and aerobic bacteria. 1215

Q. Well, go ahead.

A. That is, would certainly have finished the purifying process after having run the distance that I have mentioned.

In conclusion I wish to say that the Illinois river as a whole, furnishes a good example of the inability of an excessively polluted stream, excessively polluted at the point where the Des Plaines river enters it, shows the inability of an excessively polluted stream to recover itself.

It is seen that the ability of such a stream to purify itself is dependent on the amount of sewage added, and the volume of water coming down the river, and the results at Grafton plainly show that the Illinois river is at times overloaded with sewage, and literally fails in this capacity of recovering itself or of purifying itself.

Chart number 5 shows:

Sanitary condition of the Mississippi river between Grafton, Illinois and St. Louis.

Red line represents the Illinois river three miles above Grafton.

1216 Blue line represents the Mississippi river one mile above Grafton and yellow line represents the Mississippi river at Hartford and brown line represents the Mississippi river at Alton.

This represents 1900 from January 23d until October 12th.

It will be seen that during the months of January and February there was a marked pollution of the Illinois river water at Grafton.

1217 It is again demonstrated by the results as shown here for nitrites during 1900, that high nitrites at Grafton in the Illinois river were always followed by an increase in nitrites at Alton and Hartford.

That indicates that the Illinois river effectually pollutes the Mississippi after joining it at Grafton.

I have here chart No. 6 showing a comparison of the Missouri river water taken from Bellefontaine, Missouri, and the water taken from the Missouri shore at Chain of Rocks from January 23, to October 12, 1900.

1218 It shows clearly that the water coming down the Mississippi river along the Missouri shore as it passes St. Louis, is principally consisting of Missouri river water. You have here the red line representing the Missouri river at Bellefontaine and the dark line representing the Missouri shore at Chain of Rocks. It will be seen how the chlorines run together, very close together and it will be seen from the total solids that they are almost identical, almost alike.

Whenever the Missouri river is high and is flushed out or storm water comes down the river, there is a marked stirring up of the river and the increased sedimentation produces very high total solids or residue on evaporation. This can be seen if you look at the chart for February and March and April where the amount of solids estimated in parts per million, rose from 800 on February 27 to 3,750 parts per million of total residue was found then in both waters, the waters of the Missouri at Bellefontaine as well as the Missouri river at the Chain of Rocks, and the subsequent remarkable drop back again to about 1,200 in the latter part of March, again shows how closely those waters resemble each other, the waters of the Missouri river at Bellefontaine and the water on the Missouri shore.

Chart No. 8 represents a cross-section of the Chain of Rocks, St. Louis where the intake of the St. Louis water works is located.

1219 This covers from January 23 to October 12, 1900.

It shows there are more solids in the water after evaporation, from the Illinois shore than the Missouri shore.

1220 I have a table which I shall present. It shows that the intake tower invariably has higher total solids than the Illinois shore except on the occasion here shown on the map in March when they come very close together, and the Missouri shore has, of course, always higher total solids except on the occasion there where the mixtures result in slightly higher total solids at the intake.

The conclusion is this, that since the results at the intake and the Missouri shore differ as a rule, although they come close together some times as is shown in August, 1900, that there must be a mixture of the water running along the Illinois shore and of the water running along the Missouri shore, at the intake tower.

1223 In discussing the results of the analyses of samples taken in 1900 from January 23 until October 11, from the Mississippi river between Grafton and the intake, I wish to call attention to the excessive pollution of the Mississippi river during the months of February and March as resulting from the excessive pollution of the Illinois river.

I will just take a week beginning January 30, 1900, and take the averages of the results for this week. The average free ammonia in the Illinois river at Grafton for the week bginning January 30, 1900, the nitrogen in the form of free ammonia found in the Illinois a few miles above Grafton amounted to 1.675 parts per million, while in the Mississippi river, a few miles above the mouth of the Illinois, the corresponding average amounted to .175. That is only one-tenth of the free ammonia was found in the Mississippi above the mouth of the Illinois than was found in the Illinois at Grafton.

At Alton and Hartford we find 1.055 and .865 parts per million respectively, so that we see here from the figures a remarkable increase in free ammonia at Hartford and Alton after the two rivers had mixed.

1224 The Missouri river is noted for its great variations in amount of suspended matter it carries, which variations are most noticeable at the times of freshets, when it may contain as much as 4,000 parts per million of suspended clay and silt.

Another characteristic feature of this water is its high chlorine contents. This is due to the drainage of the Kaw river through large districts in Kansas of salt deposits. The Kaw is a tributary of the Missouri.

A very important point as regards the Missouri is the condition of the banks which owing to enormous corroding action of the current steadily washing many portions of the soil, particularly the case when it approaches its mouth.

1225 The soil that is washed by the freshets into the Missouri river carries an abundance of organic matter contained in this soil, of vegetable origin principally. If the high albumonis ammonias that are found in the Missouri river were due to sewage contamination they would be accompanied by high nitrites and high chlorines. NOW I HAVE DEMONSTRATED THAT HIGH CHLORINES IN THE MISSOURI BETWEEN KANSAS CITY AND ST. LOUIS ARE NOT OF SEWAGE ORIGN, ARE OF SALT DRAINAGE ORIGIN IN KANSAS, BECAUSE THE MISSOURI RIVER ABOVE KANSAS CITY SHOWS COMPARATIVELY LOW CHLORINES.

The nitrites in the Missouri throughout the year are low. They are frequently absent. The fact that they are low and absent and that the variations between the highest nitrites found and at times when they are absent, the variations being very small, show that there is a very little fermentative action going on in the Missouri river, particularly as it approaches its mouth. We are justified in stating that the general character of the Missouri river as it approaches the mouth is one of great stability.

These tables that I refer to show that all the times during this investigation, the second period from January 23 until October 12, 1900, the Missouri river water was better in its sanitary quality than the Mississippi river water at the mouth of the Missouri river. While the averages may show free ammonias quite high in the Missouri river, the averages for the nitrites show much lower results for the Missouri than for the Mississippi at the mouth of the Missouri. That would stamp the Mississippi as being a more polluted stream than the Missouri. And since the chlorines, nitrites and free ammonia in the Mississippi at Hartford and Alton, Hartford being situated one mile above the mouth of the Missouri I say since those results from those points of collection at Alton and Hartford show correspondingly high nitrites, free ammonias and chlorines, that the pollution of the Mississippi at these points must be principally of sewage origin.

I have here a table of percentage calculations of which I spoke in discussing the charts of the Missouri and Mississippi river water at the intake, a mixture as represented by the analytical results, of total solid determination.

The tables offered are 1, 2, 3, 4 and 5 of Dr. Teichmann's testimony of March 18, 1903. (See rec. 1227.)

1240 Chart number 9 represents a comparison of the percentage of the Mississippi river water pumped at the intake as represented by the determination of total solids or residue on evaporation, from January 23 until October 10, partly and October 30, for the typhoid fever cases.

1241 The percentage of Mississippi river water pumped at the intake during this period as compared with the number of typhoid fever cases for the years representing 1895 until 1899 inclusive.

It will be seen from this chart that during February from February 15 to 25, a marked increase of Mississippi river water in distinction from the percentage of Missouri river water was pumped into the intake. There then followed, taking into account a period of incubation of two to three weeks, a remarkable increase in number of typhoid fever cases reported to the health department of St. Louis.

I also show here in blue the normal number of cases, reported to the health department for 1895, 1896, 1897, 1898 and 1899. They show a very low number of cases during that period and the increase in the number of typhoid fever cases reported in March, 1900, over the period found for the five preceding years amounts to 1,300 percent.

1242 We notice during the latter part of the summer again an increase of percentage of Missouri river water entering the intake and we see subsequently a large increase in the number of typhoid fever cases reported to the health department over the average of the five preceding years. In September, 1900, the increase in the number of typhoid fever cases reported over the period of the five preceding years amounted to nearly 70 per cent.

Chart number ten represents a comparison of the water at the intake, the water after it has been in the reservoir for two days and just before it leaves the reservoir.

Between the reservoir and the tap in the city chemist's office and the intake.

The blue line represents the intake, the yellow line the reservoir and the red line the tap and the top line represents the stage of the Mississippi river at St. Louis and the number of feet are marked up here in lead pencil. They simply show the enormous removal of suspended matter in the subsiding reservoir; the average percentage of removal of suspended matter in the reservoirs for the period of 1900 from January 23 until October 12 represents 85 per cent. That is 85 per cent of the sediment of the water passing through the reservoirs remains in the reservoirs.

Increased pollution of the water entering the intake is always followed by increased pollution of the water in the reservoir. As a rule there is no marked purification as far as the free ammonia is concerned in the reservoir. Whenever the intake water is bad the water leaving the reservoir and the water from the hydrants in St. Louis must be correspondingly affected.

The same applies to nitrites.

Now I wish to call attention to a marked increase in pollution of the water at the intake during the early part of 1900. You will see that there is a tremendous rise in the free ammonia and you will see a tremendous rise in nitrites. The ammonia lines and the nitrite lines indicate this on the map.

1244 There are analyses on record for the last twenty years. None of these ever showed such a remarkable quantity of free ammonia and corresponding with it a large increase in nitrites at the intake tower or the reservoir or the water of the hydrants of St. Louis. At that time (early in 1900) there was a wave of pollution coming down the Des Plaines river, the

Illinois river entering the Mississippi at Grafton running along the Illinois shore opposite the St. Louis waterworks at Chain of Rocks, and as shown by the percentage mixture, entering the intake of the waterworks. We find during that period the percertage of Mississippi river water entering the intake varying from 19 to 100 per cent during this early period of 1900. After the opening of the canal.

1245 Generally comparing the results of the analyses of waters collected between Grafton, Illinois river and the Mississippi river and the St. Louis intake, and also from the Misrousi river and the St. Louis intake, and also from the Missouri river for the periods of 1899 and 1900, we notice from the averages an increase in the nitrites and free ammonia in 1900 as compared with 1899, for the route between Grafton and the St. Louis intake. Our analytical results show that the water entering the intake in 1900 was more polluted than the water entering the intake in 1899, and that the increased pollution, since there was no correspondingly increased pollution in the Mississippi river above the mouth of the Illinois, nor was there increased pollution in the Missouri river above its mouth, it shows that the increased pollution of the water going into the intake tower must be ascribed to the increased pollution of the Illinois river in 1900, and since I have shown that the increased pollution of the Illinois river at Grafton was due to the increased pollution of the DesPlaines river following the opening of the Drainage canal, I feel justified in declaring that the opening of the Drainage canal resulted in increased pollution of our water supply.

1246 After the investigation closed in October, 1900, a number of samples were still collected between October 12 and November 30, from points in the Illinois river, and these samples were promptly analyzed at the city chemist's office. These samples were not collected daily as before.

For the samples taken outside St. Louis they covered the period from October 12 to November 30.

But from October 12 to November 30, 1901, the third period of investigation, covered in addition to those sporadic samples outside of St. Louis, they covered the analyses of samples collected daily at the Chain of Rocks.

1247 Sample was daily taken during this period at the Chain of Rocks from the Mississippi river close to the Illinois shore. Then a sample close to the Missouri shore. Also from the water right at the entrance of the intake tower, and on from the outlet chamber. And one from the tap in the city chemist's office.

The analytical data thus collected have all been noted down in the report which can be presented if required. They demonstrate the continued polluted character of the St. Louis water supply during this period. Furthermore, that the water along the Illinois shore during this period was at all times more polluted than the water running along the Missouri shore and that during such periods when a mixture of the waters from those two rivers entered the intake, the impurities found in the samples from the intake were higher than those found in the samples from the Missouri shore.

The next or fourth period of investigation, covers the time from October 1, 1901, to November 30, 1901. It was the most comprehensive investigation conducted since the beginning of the analytical survey of these waters in August 1899.

1248 Samples were collected at Bridgeport, Lockport, Bear Trap dam, etc.

1250 First period of investigation was from August 23, 1899, to January 22d, 1900;

Second period, from January 23d until October 12, 1900; and a number of samples were still taken between October 12, until November 30, 1900;

1251 Third period from October 12, 1900, until September 30, 1901;

Fourth period, October 1st came the large investigation and continued until December 1, 1901.

The resumption of the collection and analyses of samples along the water route from Chicago to St. Louis in October and

November, 1901, was undertaken for the chief purpose of ascertaining whether the continued operation of the Chicago Drainage canal during the interval between the cessation of the investigation in October, 1900, and the resumption of the investigation for samples outside of St. Louis, in October, 1900, had produced any improvement of the sanitary conditions of the water as established by the former investigation along this route in 1900. I will now present a number of charts briefly explaining these conditions as we found them.

1255 This is chart number 11 for the investigation of 1901, October and November. This chart represents a comparison of results obtained from the analyses of water in the months of October and November, 1901, from the Illinois and Michigan Canal at Lockport; Des Plaines river at Brandon's bridge, Joliet; Drainage canal, Bear Trap dam, Lockport, and from the Des Plaines river above Bear Trap dam at Lockport.

The red line represents I. & M. canal; blue line the Des Plaines river at Brandon's bridge, Joliet; green line the Drainage canal, Bear Trap dam, Lockport, and yellow line the Des Plaines river above the Drainage canal—that is before they meet.

It will be seen from this chart that during that period the I. & M. canal was highly charged with free ammonia. It reached the figure of 22.4 parts per million of nitrogen in the form of free ammonia. During the last week a considerable fluctuation can be noted and at the time the collection and analyses was started the amount represented the figure of 18.8 parts
1256 per million of nitrogen as free ammonia. The same is true as to the chlorines found in the Illinois & Michigan canal at that time. We see variations there in the chlorine representing parts per million from 106 up to 150.8; then going down again within one week to 120.6, etc.

If we look at the nitrites we find fluctuations in the nitrites but notice that the nitrites do not fluctuate as much as the free ammonia and the chlorines. They are either absent or run up to a maximum of .15. Now that would indicate that the Illinois

& Michigan canal at that time was in a great state of fermentation. The action of the facultative anaerobic bacteria in this canal resulted in a considerable advance in the initial process of purification usually performed by these bacteria.

The variations in chlorine show that the amount of sewage coming into the Illinois & Michigan canal during this time, together with the varying amounts of free ammonia and nitrites, that the amount of sewage pumped into that canal must have been of great variable quantity. The water condition at that time may have been influenced by the action of the anaerobic bacteria somewhat and as it is an established fact that during the colder season of the year the purification process in the rivers is retarded considerably, the results would in a measure explain themselves. We see considerably less free ammonia in the main Drainage canal than we find in the Illinois and Michigan canal. The very high nitrites in the Des Plaines river after the two canal mix with the Des Plaines river at Joliet, show that the process of purification was in an intermediate stage as yet.

1259 Chart number 12 represents or gives a comparison of analytical results obtained from the daily collection of samples of water taken from the Des Plaines river above Bear Trap dam, Des Plaines river at the 9th street bridge, Lockport, and at Brandon's bridge, Joliet. It shows the result of the mixture of the water from the Drainage canal and the Des Plaines river and the result of the mixture of the Des Plaines river, the Drainage canal and the Joliet sewage in the Illinois & Michigan canal. Green line represents Brandon's
1260 bridge, at Joliet; red line Des Plaines river at 9th street bridge, Lockport, the dark line represents the Des Plaines river above Bear Trap dam.

1261 Chart number 13. The curves represent the comparison of the chemical character of the two canals at Bridgeport and at Lockport. Bridgeport is in Chicago on the south fork of the south branch of the Chicago river. Lockport is 29 miles from Bridgeport.

1262 The green color, or this top represents the I. & M. canal at Lockport. The red color or red line represents the I. & M. canal at Bridgeport. What I wanted to show by these curves is the remarkable fluctuations in the amount of free ammonia in that canal, showing its fermentative character. That is in the I. & M. canal as compared with the Drainage canal, the yellow line representing the Drainage canal at Bridgeport and the dark line representing the Drainage canal at Lockport. The ammonias in the Illinois and Michigan canal are very much higher, showing that the anaerobic bacteria have performed their work in the old I. & M. canal much more effectively than in the Drainage canal. The sewage in the Drainage canal as it reaches Lockport does not show very much improvement during its route from Bridgeport to Lockport. It demonstrates that the facultative anaerobic bacteria do not work so effectively in the main Drainage canal as they do in the I. & M. canal. The sewage from the Drainage canal is in a much more retarded state of purification. It is in a much cruder state and it is very much less purified in its initial state of purification at Lockport than the I. & M. canal sewage when it reaches Lockport.

Chart number 14 represents comparison of results of analyses of samples of water collected during the months of October and November, 1901, at Joliet and Peoria, Ill.

1263 The green line represents Des Plaines river at Joliet; the yellow line represents Illinois river at La Salle. The dark line represents the Illinios river three miles above Peoria. The very high results of free ammonia found in the water at Joliet are reduced somewhat by the time the water reaches Peoria. In other words, the initial process of purification has been materially facilitated during the transit of the water in the Illinois river from Joliet to La Salle and Peoria. This map will also show that the nitrites found in the Des Plaines river at Joliet at that time during those two months, were lower than the nitrites found at Peoria and at La Salle. While this would indicate that the process of purification had advanced somewhat for the sewage running down the Illinois river between those points, the very high nitrites found at La Salle and Peoria—at La Salle representing a maximum of .164 parts per millions and at Peoria a maximum of .154, I say they demonstrate that the process of purification of that sewage in the river coming from the main Drainage canal principally, and from the Illinois and Michigan canal, and from Joliet, that the process of purification has by no means been completed when the water reaches Peoria. The Illinois river, in other words, is found to be highly sewage polluted by the time it reaches Peoria. It is 124 miles between Joliet and Peoria. I wanted to say while the ammonias are much lower at those points of LaSalle and Peoria, they are still quite high and going with comparatively high chlorines and going with very high nitrites, that stamp the water of the Illinois river as it reaches Peoria as badly polluted water, during the entire investigation.

1264 Chart number 15 represents a comparison of results of the chemical analyses of samples collected during this period from October 1, to November 30, 1901, from Illinois river at the points of Beardstown, Peoria, Kingston, Pekin and Grafton. If we take free ammonias here we will notice that with the approach of colder weather the process of purification is retarded in the Illinois river as well as every other river in such climates. This demonstrates that if a wave of polluted water proceeds down the Illinois river, it increases the pollution of the Illinois river correspondingly during its entire course.

1266 Chart number 16 represents a comparison of the results obtained from the analyses of samples taken during the months of October and November, daily from a point in the Mississippi river several miles above the mouth of the Illinois and from the Illinois river several miles from its mouth. The blue line represents Illinois river at Grafton; the red line represents the Mississippi river at Grafton.

You will see that the free ammonias and the chlorines and the nitrites during these two months are always higher in the Illinois river than they are in the Mississippi river at Alton. Until the week beginning the 15th of November there was not much difference between the free ammonias of the two rivers although the free ammonias in the Illinois were always higher, but when the cold weather set in during the latter part of November, the free ammonia in the Illinois river went steadily up, so that finally on the 18th of December it showed one part per million of nitrogen in the form of free ammonia.

1267 Now, there is no corresponding rise to that extent shown in the Mississippi river, while there is an increase there in free ammonias and you can see the effect of the colder weather, yet the Mississippi river must not have been sewage laden to any extent whereas the Illinois river being a river of great instability because as we see, from the nitrites, the intermediate state of purification as represented by the nitrites, is varying continuously. In other words, if the Illinois river were not a heavily sewage laden river, the sewage would have been oxidized much more readily and better, but being in large quantities the effect of the colder weather proportionately retarded the process of purification so much the more and there being evidently considerably less pollution in the Mississippi river the effect of the cold weather there was not so material because of the absence of pollution to any material extent.

1270 Chart number 17 represents the results of the chemical analyses of the samples of water taken daily during the months of October and November, 1901, from a point several miles above the mouth of the Illinois river, represented by red line; the blue line representing a point in the Mississippi river one mile above Alton, the yellow line representing a point in the Mississippi river above Hartford, Illinois, and the green line representing the Mississippi river at Grafton, several miles above the mouth of the Illinois.

The free ammonia for the larger part of this period was lowest in the Mississippi river above the mouth of the Illinois.

It was the highest in the Illinois river several miles
1271 above the mouth of the Illinois and that for most of the
time the free ammonia at Alton and Hartford were higher than in the Mississippi river above Grafton, showing that the mixture must have taken place of the Mississippi and Illinois river after their junction resulting in an increase in the free ammonias at Alton and Hartford. That is for the larger part of the period. During one week the free ammonias were a little lower at Alton than they were in the Mississippi river above Grafton. They were also a little lower during the first week in October but only to a very small extent. For the remaining six weeks the free ammonia was higher at Alton than it was in the Mississippi river at Grafton. The highest free ammonia found during this period in the Illinois river was .17; the lowest .06. The highest found in the Mississippi river at Alton was .08 and the lowest is .04. The figures obtained for Hartford were almost like those found at Alton. The variation was slight. The maximum variation amounting to .015 so that I need not quote those figures. I will say the maximum variation showing that the free ammonias at Alton and at Hartford did not vary to any extent.

The chlorines we find lowest for this period in the Mississippi river at Grafton and we find it highest in the Illinois river at Grafton running as high as 26 parts per million. At all times during this period the figures for chlorine at Alton and Hartford were higher than those of the Mississippi river at Grafton and lower than the Illinois river at Grafton, demonstrating that the mixture of the two rivers had taken place in the channel from which the Alton and Hartford samples were collected, and demonstrating further with the increase in free ammonias and chlorines and also a corresponding increase in nitrites, an increased pollution of the Mississippi river from the higher polluted water of the Illinois river.

The nitrites in the Mississippi river above the mouth of the Illinois for this period were very low, as I have already stated for several weeks practically absent. The nitrites in the Illinois river during this period were comparatively high. The nitrites obtained from the Illinois of the samples at Alton and Hartford during this period, always showed an intermediate figure between the always lower figure from the Mississippi river and always higher figure from the Illinois river, clearly demonstrating the mixture of those two rivers and as a result, an increased pollution of the Mississippi river coming from the Illinois river.

1272 Chart number 18 represents results of chemical analyses of samples of water collected in October and November, daily in 1901 from Mississippi river at Hartford and at intake of St. Louis waterworks, Chain of Rocks, and from Missouri river at Fort Bellefontaine. The blue line represents the Mississippi river at Hartford; the green line the intake and the red line the Missouri river. The highest chlorines were found in the Missouri river. The lowest in the Mississippi river at Hartford and the chlorines at the intake represented during the entire period, an intermediate figure. This demonstrates that during this period a mixture of the waters of the Mississippi and Missouri was taking place in the Mississippi river after the junction of the two and its effect could be shown in the lower chlorines at the intake.

Hartford is one mile above the mouth of the Missouri river.

1273 It shows that the free ammonias during the months of October and November at these three points were not differing much. If at this time the nitrites of the Missouri river would be as high as those found in the Mississippi river at Hartford, or higher as was shown by the free ammonia, we could ascribe the higher free ammonia in the Missouri river to sewage pollution, but the nitrites are lower and since the high chlorines in the Missouri river are not attributable to sewage pollution of the towns and cities on the upper Missouri but are proven to be due to the drainage of the Kaw river through districts of Kansas containing vast areas of salt beds, it is to be concluded that the sanitary character of the Missouri river was better during this period than that of the Mississippi after it was joined by the Illinois river and increasingly polluted by the Illinois river. The figures for the nitrites at the intake tower during this period are almost similar to those of the Missouri river.

1274 Chart number 19 shows the correspondence between the curves representing the chemical examination of the samples of water collected during the months of October and November, daily, in the year 1901, from the Mississippi river at the intake tower at the St. Louis waterworks from the outlet of the St. Louis waterworks for the water as it passes through the reservoir. Now I want to demonstrate by this chart that there is a partial purification taking place in the reservoir. The average amount of sediment that remains in the reservoir is 85 per cent. Now, while the sediment remains in the reservoir to such a large extent the quantities of impurities are not reduced so much—they are reduced some, but it is very small. So small that practically we can say that the amounts of free ammonias and chlorines found in the water at the intakes and the amounts found in the outlet of the reservoir do not differ materially. As regards the nitrites, there is some oxidation taking place in the reservoir at times, but we will see that the nitrites for the month of October do not vary much in the reservoir.

This shows that whenever the impurities rise in quantities in the water from the Mississippi river at the intake, a rise in quantity of these impurities follows in the reservoir and follows in the water taken from the tap of the city water supply. What I said for free ammonia applies also to nitrites as you can see from these curves and it applies to the chlorines and in a measure to the nitrates.

1276 In November and December, 1901, samples were collected from points in the Missouri river about the mouth of the Missouri, at following places. (Witness in each instance gives result of analyses.)

Missouri river, above Omaha, near Nebraska shore.

1277 Ten miles below Omaha at Belle View, Neb.

1278 These results show that the Missouri river, as it approached Omaha, Neb., on November 13 and November 24, was polluted as shown by the presence of free ammonia, nitrites and chlorine. However, the nitrites found on both days being very low, showing only .004 parts per million on November 13 and .001 parts per million on November 24, together with comparatively low free ammonia and chlorine, and demonstrating that the pollution cannot be designated as sewage pollution.

1279 Sample was collected from pump house of city of St. Joseph on the Missouri river on November 14, 1901.

Sample collected 12 miles below St. Joseph.

November 26, sample collected from Missouri river at St. Joseph near waterworks and November 25 at Wathena, Kansas, 12 miles below St. Joseph.

1281 Sample collected on Missouri river, November 17, ten miles below Kansas City.

From Kaw river at Argentine, Kansas.

November 28, sample collected from Missouri river at Kansas City at the point where the waterworks of Kansas City are located.

1282 Ten miles below Kansas City.

Kaw river, at Argentine, Kansas, November 29.

One mile above Jefferson City, November 19, 1901.

1283 November 19, five miles below Jefferson City.

December 1, 1901, above Jefferson City.

December 1, 1901, five miles below Jefferson City.

1284 November 20, 1901, Missouri river one mile above Hermann. Hermann is between Jefferson City and St.

Louis, 125 miles from the mouth of the Missouri.

November 20, three miles below Hermann.

1285 December 1, one mile above Hermann, Mo.

December 1, 1901, three miles below Hermann, Mo.

November 22, half a mile above St. Charles.

November 22, one and one-half miles below St. Charles.

1286 December 3, one-half mile above St. Charles.

December 3, one and one-half miles below St. Charles.

1287 These examinations show with reference to chlorine in the Missouri river that there is an accession of chlorines in the Missouri river at Kansas City from the Kaw, also called the Kansas river, a river which has a length of about 300 miles and drains through a number of counties in which large salt deposits have been located, as it is reported by the U. S. Geological Survey.

The chemical analyses show that the Missouri river as analyzed from Omaha down to St. Louis, has a character of considerable stability. The results are pretty much uniform along the route, with the exception that the high chlorines coming from the Kaw river increase somewhat the amount of chlorine in the Missouri river between Kansas City and St.
1289 Louis. The data on these sheets represents the analytical results obtained from a chemical examination of samples of water collected from various points indicated upon the table which samples were collected and the analyses of the same performed daily during the months of October and November, 1901.

Q. That is enough. The table can be inserted here.

(Table not subsequently furnished F. S. B., Com'r.)

The fifth period of investigation began on December 1, 1901, and continued to July 1, 1902. As already stated yesterday, during this period samples of water were collected above Chain of Rocks from two points only during this period, that is from the Illinois river several miles above the mouth of the Illinois river at Grafton. Daily samples were collected until

December 18, 1901, and daily samples were collected from the Mississippi river a few miles above the mouth of the Illinois river from December 1, to December 14, 1901. With the exception of these samples taken at Grafton from the two
1290 rivers, there were no samples collected from any point during this investigation above the Chain of Rocks, St. Louis, in the Mississippi river.

Five samples were collected daily during this investigation. Three from the Mississippi river at Chain of Rocks opposite St. Louis waterworks—one from Illinois shore, one from entrance to intake tower, one from the Missouri shore, one from outlet chamber of waterworks and fifth sample from tap in city chemist's office, St. Louis.

I have shown in the curves on chart number 16 presented yesterday, the results of the analyses of the samples of water taken from the Illinois and Mississippi river at Grafton from December 1, until December 18.

1293 The investigation, as far as reported to the authorities, terminated on July 1, in the laboratory of the city chemist's office because of the removal of that office to new quarters in the old city hall. After the equipment of the new laboratory in the new city hall, the investigation was resumed on October 1st and continued until January 1, 1903, as follows:

Three samples were collected form Mississippi river at Chain of Rocks, one close to Illinois shore, the other close to Missouri shore and the third one at the intake. Daily samples were also taken during this period from the outlet chamber of the waterworks and from the tap in the new quarters of the city chemist's office.

The results of these analyses do not show any improvement in the sanitary quality of the water supply of St. Louis as compared with the results obtained from the various investigations conducted in the city chemist's office since August 23, 1899.

I consider the Lake Michigan water as it enters the Chicago river, polluted. It is not a pure water. From my examination of the streams, it is my opinion that the waters of the Drainage canal pollute the Des Plaines river.

1294 The Illinois river is polluted by the Drainage canal indirectly through the Des Plaines river. I can state from my examination of these waters that the water coming into the intake of the St. Louis waterworks is now less wholesome or less pure and less fit for sanitary use and domestic use than it was before the opening of the Drainage canal..

In analyzing water the most accurate results analytically are obtained from samples collected daily.

The English River Pollution Commission was created in 1866 by the British Government for the purpose of investigating the question of the pollution by sewage from cities of the rivers in Great Britain. The investigations cover a period of eight years. During this period six reports were published. It was perhaps the most comprehensive investigation of the kind ever attempted until then and while a variety of opinions have been expressed as to the conclusions to be drawn from these reports, the predominating opinion after the publication

1295 of the reports—

ATTORNEY GENERAL HAMLIN: I object to any opinion given by the English Commission or any statement as to what those reports contain on the ground, first, that the reports would be the best evidence; second, that the evidence is not relative to the issues here.

MR. TODD: The Sanitary District joins in the same objection with the State.

A. The predominating opinion among sanitarians has been that the pollution of streams by sewage from cities and towns located on the banks of these rivers should be prevented by legislation, because the investigations conducted by the commission resulted in establishing the fact that pollution of streams by sewage of towns and cities in England was being carried on to an extent rendering the streams unfit for drinking purposes.

ATTORNEY GENERAL HAMLIN: I move to exclude all of the answer to the last question for the same reasons that are given in the previous objection.

MR. TODD: The Sanitary District joins in the same motion.

In Kansas City, the development of the sewer system did not keep pace with the growth of the population and as a result today only 60 per cent of the sewage of Kansas City goes into the Missouri river. There are as many as 4,000 cess pools in Kansas City into which the sewage of the city is placed and kept there for some time, until the tanks are filled up and the sewage is then disposed of in various ways, used for manuring purposes—some burn it up, and about one-fifteenth of this sewage eventually reaches indirectly the Missouri river, but when it reaches the Missouri river it is sewage far advanced in its purification or rather in its oxidation and has an en-
1296 tirely different character than the fresh sewage run into
the river from the sewers. The water of the Missouri river is better for use for domestic purposes and is a more sanitary drinking water than that of the Mississippi river at the confluence of the two streams. The Mississippi river above the mouth of the Illinois river is better for drinking purposes than the Mississippi river above the mouth of the Illinois.

The water coming into the intake tower in January, 1900, and from that time on, as a rule has not been potable. I am familiar with the theories of Tidy and Letherby and other English scientists with reference to the effect of sewage upon running streams. The theory of Tidy and Letherby originally attracted much attention. It practically amounts to this, that sewage diluted in pure water at the ratio of one part of sewage to fifteen parts of water would purify itself after running a distance of about 10 or 12 miles. It was this very theory
1297 that in its application in England proved to be falla-
cious in many instances, that led to the creation of the

Rivers Pollution Commission in England to which you referred in a previous question. The result of this investigation was that a new theory practically supplanted the theory of Tidy and Letherby in England, and that is that there is no river in England long enough to purify itself. I consider Tidy and Letherby's theory from the facts ascertained by a careful study of the question of river pollution, as antiquated and overthrown by the experiences of many communities in England as well as in other counties. This theory of Tidy and Letherby was tested, so to speak, by investigations carried on in England on the rivers Irwell and Mersey, by Frankland, a prominent chemist and sanitarian of England in the seventies. The conclusions drawn by Frankland from these investigations were that sewage discharged into a river at the ratio of a dilution of 1 to 15, instead of purifying itself after a run of from 10 to 12 miles, only two-thirds of the sewage would purify itself after running a distance of 168 miles.

The Illinois river, after the opening of the Drainage canal, showed its highest stage at Grafton on January 21st, when it showed 5.9 feet. It then began to fall steadily until February 3, when it showed only one foot at Grafton. Then there began a rise steadily from day to day and within a week the stage was 7.3 feet.

1298 It remained close to that figure for the following week.

In the third week in February the river took a sudden rise on the 21st. On the 20th the stage was 6.9 and the following day it was 8.3 and it remained at 8 feet and went up to 8.5 and in the following week began to fall again down to 7.4, 6.1 and at the end of the week was 5 feet.

It rose from the 5th to the 6th of March from 5.1 to 7 feet. From day to day it rose averaging a foot until March 13 it reached 14.8 feet. March 14, 16.1; March 16, 17.3. That was the highest in March and then it fell steadily. For the next month it remained pretty steady around 12 feet.

1299 The Mississippi river at Louisiana, Mo., showed during the month of January, 1900, throughout, a very low stage varying between 1 and 3. There was a period of very cold weather prevailing at that time and in the beginning of the month in the first week the river was frozen over and again at the end of the month, so that would have to be taken into account in calculating the measurements. Hence, there are such low figures as .7 which means seven tenths of a foot. The stage of three feet was only reached once during that month, on January 19th, for the major part of the month the height of the river varied between one and two and one-half feet. These estimates are based upon the regular gauge of the river as taken for the U. S. Weather Bureau.

1300 In February it was about the same the first week. In the next week it went up to 3.8 and in the following week it showed some slight variation only from 3.4 to 4 feet the highest reached during the month and at the end of the month it fell to 1.5 feet. It remained low again for about a week in March when it rose again to 12 feet on the 15th of March after which it fell steadily until the last week of March when it was 5.1 feet.

1301 The fall in the rivers, the Illinois and Mississippi at those points continued until the 3d day of April when there was a corresponding rise again in both rivers to 8.7 in the Mississippi river and 13.6 in the Illinois river at Grafton, which was the maximum gauge for both rivers during that time. They began to fall down to 5.9 for the Mississippi and 11 feet in the Illinois river during the next week and during the last week of April both rivers rose about one foot reaching a maximum height during that week of 8.4 feet for the Mississippi river and 12.7 for the Illinois river. In other words during this month the heights, the rises and falls in the two rivers were corresponding for the month of April.

Am not acquainted with the waters of the Drainage canal or the Chicago river and its different branches prior to the opening of the Drainage canal in 1900. I had seen these waters

when I was in Chicago. Prior to the opening of the canal, most
of the times when I was in Chicago the Chicago river
1302 had the appearance of a dark colored sewer water
emitting offensive odors and gas bubbles. The water in
the I. & M. canal had the appearance of sewage and it was also
of a dark color and emitting offensive odors and gas bubbles.

The Pettenkofer theory of the effect of pollution of waters upon running streams was that sewage discharged into a river and diluted at the rate of one part of sewage to fifteen parts of water would purify itself after a run of fifteen miles, provided that the velocity of the river into which the sewage was being discharged, was at least about the velocity of the sewage and that this velocity was at all times three-fifths of one metre which is equal to about two feet and one inch per second; that would
be the least velocity per second.

1303 That theory was advanced first sometime in the seventies.
That theory does not maintain today among sanitary scientists in water supplies. One of the greatest difficulties in the country is that running streams in themselves are not pure. The ratio of dilution is based upon a mixture with pure water and whenever the ratio is applied, of a mixture of sewage with polluted waters, it proves to be fallacious. It is true that a number of scientists have declared in various instances and quoted in scientific publications that the theory proved to be successful, but other investigators have shown that those investigations upon which these scientists based their conclusions were carried on in an inaccurate manner. For instance, it was proven that the velocity of the current differs—that is the velocity of the water running along the shore and the velocity of the water running in the channel differ. The velocity on the surface differs from that in the middle depth of the river. The velocity of a channel is greatest in the middle of the depth of the river. Now, in taking samples a great many of these investigators who agree with Pettenkofer evidently have made the mistake of taking samples from

the surface. The character of the water on the surface is different than the character of the water at the middle of
1304 the depth—that is, oxidation processes are somewhat facilitated by light, and the top water in the channel would present a different chemical character accordingly than the water running at a certain depth, as I said before. Therefore Classen, who is a chemist of much distinction in Germany, and water specialist, and others, challenged the correctness and reliability of the analytical results upon which many of the followers of the Pettenkofer theory base their conclusions that Pettenkofer theory was correct. They proved contradictory data showing that this so-called self purification was in reality impossible, etc. These investigations have been published in one of the greatest works that has been written on the pollution of waters, by an investigator of great eminence in Germany.

That is Julius Koenig and the title of the work is "Die
1305 Verunreinigung Der Gewasser," published in 1899.

According to the researches as described in this work a conclusion is justified that the oxidation of sewage discharged in the rivers depends so much upon various conditions and circumstances constantly varying and differing so materially as applied to various streams, that a hard and fast rule as to ratio of dilution cannot be considered reliable any more.

I have a table showing the average daily and weekly rate of flow in cubic feet per minute of the water in the Drainage canal, the I. & M. canal, the Chicago river at Chicago, the Des Plaines river at Riverside, the Des Plaines river at Joliet for the years 1900 and 1901, secured from Mr. Todd, and compiled by L. E. Cooley, assistant engineer of the Sanitary district. In September, 1900, the Drainage canal was closed during the day time for several weeks excepting Sundays. The volume of water running over the dam at night is estimated and represented in the table there. There was some water coming in but in comparison to the regular flow it was a small flow.
1306 The daily closing of the Drainage canal at that time in September, 1900, resulted in the reversion of the flow

of the Chicago river back into the lake and as I have already testified evidently resulted in an increase of the pollution of the water taken from the lake front, and as I also testified, I believe that the Chicago river at that time in the reversion of the flow back to the lake again assumed this character which it had shown prior to the opening of the Drainage canal, that is its color was darkened again and offensive odors and gas bubbles were noticeable along the route of the Chicago river during that period. After the re-opening of the canal with the average regular flow, after that time of temporary closing in September, 1900, the accumulated accretions of Chicago sewage in the Drainage canal being discharged into the Des Plaines river and subsequently into the Illinois river, resulted in increased pollution of these rivers as traced along the route down to the mouth of the Illinois by the analyses of samples collected at points between Chicago and St. Louis at that time.

1307 After having made these examinations I can say that the sewage in the outfalls of the sewers in Chicago goes into the Drainage canal, the Illinois river and into the intake of the St. Louis waterworks.

From these examinations I am able to state that the water of St. Louis is more polluted now by reason of the opening of the Chicago canal and the inflow of the sewage from Chicago than it was prior thereto.

THOMAS A. BUCKLAND, examined by Attorney General Crow:

Am Assistant City Chemist of St. Louis. Have occupied that position for about ten years.

1308 Took part in the examination of the waters under consideration. Worked in the office or laboratory of the city chemist in the city hall. States methods used, etc.

1313 HENRY DETTMER, examined by Attorney General Crow: Am a chemist. Was educated in Germany. In

1314 1900 I was engaged by Dr. Teichmann in this case especially for the purpose of determining the total solids, and at the present time I am first assistant chemist in our milk examination department in the city chemist's office.

States methods pursued in doing the chemical work and analyzing the samples of water heretofore testified to.

1325 SHERMAN LEAVITT, examined by Attorney General Crow: Am a chemist. States previous experience. Was connected with Dr. Keiser as his assistant for about a year and I worked on this work in the city chemist's office under Dr. Dettmer. I worked on the total solids for Dr. Dettmer.
1326 I was under him. States methods employed and course pursued, etc.

1331 CROSS EXAMINATION by Mr. Johns: Generally the analysis was made the same day samples arrived. We couldn't keep up if extra samples were sent in as they were very often. We would get three or four days behind.

1343 WILLIAM H. GOETZ, examined by Attorney General Crow:

1344 Am civil engineer. Have studied chemistry. I had two years at college and then my experience since. Worked on samples collected for Dr. Teichmann. I performed
1345 the analytical work, and working up the results afterwards, getting them tabulated and averaged in the form of charts. Did all my work in the city chemist's office. States methods pursued.

1364 ALEXANDER N. MILLER, examined by Attorney General Crow: Am a graduate civil engineer, that is I am a graduate in civil engineering. Studied chemistry in connection with my course in civil engineering at the University of Cincinnati from which I graduated in 1897. Have been employed on this investigation by Dr. Teichmann, as analy-
1365 tical chemist. States methods used in the laboratory and also method employed in making sheets showing results of analyses. (Former witnesses also testify to latter fact.)

1372 JOSEPH F. SONDAG, examined by Attorney General
1373 Crow: Am a druggist by trade but since October 1,

1901, I have been employed in the city chemist's office as a clerk. I was assistant at the distillation table and took part in the analyses of the waters brought in from the Mississippi river. I worked under the direction of Dr. Teichmann.

States methods pursued, etc.

1377 THOMAS A. BUCKLAND, resumed the stand and was examined by Attorney General Crow.

States what part he took in the analytical work.

1378 I know from my own recollection that I found the ammonias quite high in December, 1901, in the Illinois river at Grafton. The maximum amount I found was somewhere in the neighborhood of one part per million. According to my recollection the ammonias run rather high for the samples taken at the intake during the subsequent months.

CROSS EXAMINATION by Mr. Johns.

1379 I am not prepared to state what caused the ammonia to run high in the Illinois river at that time. I presume it was from pollution in the Illinois river farther up. According to my recollection the state of the ammonias in the Mississippi at that time, was lower—the free ammonia was lower. I do not remember the state of the Mississippi as to ammonia on that same day. Nor of the Missouri. I am not able to state whether the Mississippi was at that time as to ammonia, higher or lower than a fair average. Nor the Missouri.

1380 DR. WILLIAM C. TEICHMANN, resumed the stand for cross examination by Mr. Johns.

Q. What is your idea or reason for calculating the volume of the Illinois river and its flow per minute or cubic feet, or per second of cubic feet, to place it at the extremest low water that you could find data for?

A. The low water stages are the most important in my opinion in calculating the effect of the sewage on the Illinois river, because of the lower volume of water producing a lower ratio of dilution. The idea was to calculate the smallest

1381 amount possible of dilution for the purposes of calculation of the dilution of the river.

A low water stage might continue for a day or a week or ten minutes.

Q. And the very lowest stage is extremely rare and a very unusual thing, is it not?

A. Well, that depends upon the weather conditions very much. But the very lowest stage of the river is the thing which occurs less frequently than an average or a mean stage of the river. I got my figures for the low stage of the Illinois from a report published by Lyman E. Cooley, formerly chief engineer of the Chicago Drainage canal made in the year 1890. I have data as to the stage of the Illinois river from 1890 to 1899. I got those records from reports published by the Illinois State Board of Health up to 1899, in which the stage of the Illinois river was given at various times by Civil Engineer Harman. I did not take some time nearer to the opening of the canal than 1890 as the basis of my data because I thought
1382 that the lowest stage on record would be exactly the stage to take because it might possibly recur again, this lowest stage, and the lower the stage of the river of course the smaller will be the amount of water for dilution of the sewage in the river, and worse than the amounts of pollution shown on the charts.

In your testimony of March 17th, you have the lowest stage at Wilmington, on the Kankakee, 25,200 feet per minute, on the Des Plaines 256 feet and at another time you have for the Des Plaines 339 cubic feet—in the Fox river, 31,339 feet per minute; the Mason river 15,000 cubic feet and the canal at La Salle 37,900—that would make 110,034 cubic feet or 18,339 cubic feet per second. The rivers named are above Utica.

Q. Then where do you get your basis of 600 cubic feet of water, upon which you calculate the basis of dilution and pollution?

1383 Well, Mr. Johns, the question is whether my testimony on that day conveyed that idea. Of course I am not sure about that just now, but certainly the figures that I presented there would lead to the conclusion that the flow was considerably less than 18,339.

Q. Well, now, how do you happen to assume the sewage of Chicago at 400 cubic feet per second?

A. Well, figuring on the amount of sewage coming from the I. & M. canal, it is simply that the flow per minute is converted into seconds; they would have to take sixty times that; that would give you a certain figure per minute, and that would be the flow from that sewage.

Q. If you have any data or know any way in which you can figure that the sewage of Chicago is 400 cubic feet per second, state now what it is and how you arrive at that conclusion.

A. Well, that was at that time from the Illinois & Michigan canal based on the theory that there is 60 times—figuring on 36,000 per minute of flow.

Q. Assuming that the discharge from the Illinois and Michigan canal was 36,000 per minute, and that 60 per cent of that flow was Lake Michigan water, 40 per cent of it then you say would be sewage?

A. Yes, from Chicago. 40 per cent of 36,000 would be two-fifths—40 per cent would be 14,400. That would be 240 feet per second.

1384 Q. Then where did you get your figures of 400?

A. Well, you must take the total volume of the sewage mixed with the water as it leaves the canal.

Q. That is precisely what I am doing, and assuming that 60 per cent of the flow of 36,000 feet is Lake Michigan water, dilution, and 40 per cent is sewage as you say, then your statement of 400 feet per second for Chicago sewage is incorrect, is it not?

A. No, I don't think so because the sewage as it leaves the canal is supposed to be the sewage mixed with the lake water there. It is diluted sewage; you can't base the calculation on the sewage there, because it is mixed with the water and leaves the canal together; that is what is understood by the sewage leaving the I. & M. canal. It is of course the sewage mixed with the water there.

Q. Well, you say at the ratio of 40 per cent sewage to 60 per cent Lake Michigan water, so that your assumption of 400 feet was incorrect by 140 feet, was it not?

A. No, sir, not the way I construe it, and the way Mr. Cooley and Mr. Harman construe it in their reports. They calculated on the total volume leaving the canal and entering the Des Plaines river, or rather at La Salle and call it all sewage.

Q. If the flow from the Illinois and Michigan canal is 36,000 feet per minute, and if 40 per cent of that is Chicago sewage; then assuming that state of facts, without any argument with reference to it, your assumption of 400 cubic feet per minute of Chicago sewage is a mistake, it is not?

A. No, I can't admit that, because the mixture there is still sewage.

1385 Assuming that the volume per second of the Illinois river above Utica is over 18,000 feet and that the sewage of Chicago is 400 feet per second, your rate of dilution of 1 to 5 is also incorrect, is it not?

A. Well, based upon your premise.

Q. Assuming that the volume of the Illinois river above Utica before the opening of the Drainage canal was in round numbers 18,000 feet, and that the sewage of Chicago was 400 cubic feet per second, what is the ratio of dilution?

A. One to forty-five. That is a very considerable dilution.

Q. Do you know that in this calculation that you have made here of the stage of the Illinois river above Utica, you have left out a number of rivers?

A. Well, those rivers were left out because in the opinion of Mr. Cooley, their stages were such that they were practically
dry during that season of drouth, so that Cooley omitted
1386 them from his calculations. My entire argument upon
the question of the dilution of sewage is based upon an

opinion of Mr. Cooley, given in 1890 and also upon an opinion in figuring out those stages and averages, presented by Mr. Harman, published in 1901.

Sewage is the discharge of matter from cities through tubes into some place of exit, including various kinds of discharges. The discharge of sewage in Chicago in 1899, in December would have to be calculated with the water supply. I
would make it for Chicago, 42,000,000 cubic feet per day.
1387 I figure that the amount of sewage amounts to the water
supply of the city without any kind of deduction. That
is an approximation, of course. The figure may not be absolutely correct, but it is an approximation that is accepted by all engineers and practically all text-books on engineering. That's a scientific argument, though that is the basis upon which investigators carry on their investigations, engineers.

Q. By whom, for instance?

A. Well, now, I cannot quote any particular one just now,
but it is usually recorded in various text books.
1388 If the water is converted into steam it doesn't return into the sewers, or if it is consumed by animal or man, or if
is destroyed in the purposes of some manufactory and its identity lost, it does not again return to the sewer as water.
1389 Assuming that it is 42,000,000 cubic feet per day, that
would be 291,666 cubic feet per minute.

Q. Now where did you get your estimation of 400 cubic feet per minute, for the sewage of Chicago.

A. That is the I. & M. canal at that time. The total amount of the sewage of Chicago was not pumped into the canal at that time. Only a part of it. I calculated on 36,000 cubic feet per minute. That was the water pumped at the Bridgeport pumping works.

Adding chlorine to absolutely pure water would be adding
impurity to it.
1390 Q. What amount of chlorine in water would make it
unpotable to a resident of Missouri?

A. Well, I claim that there may be as much as 500 parts chlorine in that water and yet it may be potable.

Q. If there is any standard, state it, for chlorine in potable water.

A. No standard would be recognized that would condemn water solely on its contents of chlorine. In itself, considered alone, as a constituent in the water, it is the same when you find it whether it comes from dissolving salt or from a dissolving manure heap, chemically, if you leave out of consideration everything else and simply look to the chlorine. It is identified the same way and it is present. Solely as such it is not an element of pollution in water without reference to its source. However, that depends upon what you define as pollution. If entering pure water, it may add impurity to the water, but is generally considered as pollution, I cannot class it with that.

1392 The general definition of pollution in water, is understood to be pollution principally by organic matter and I do not call salts and minerals organic matter, of course. When I find chlorine in water, I cannot tell, considered by itself and separate from all other things, whether it comes from organic matter or mineral matter. Albuminoid ammonia having a number of organic compounds is an element of pollution in water. It is an evidence that in that water there must have been some organic substance. These organic substances may be fecal discharges or the result of dissolution of plants or it may be both. If albuminoid ammonia was to be attributed to the decomposition of fecal matter, it would be the highest in the Mississippi river, in June, July and August. That would apply very well to all rivers and to all waters.

1393 It would be higher in the waters of the Illinois if attributable to vegetable substances, in September, October and November, as a result of the decomposition having taken place during the summer months, of vegetable matter.

Q. When you find albuminoid in water in the Illinois river at Grafton, can you tell whether it comes from decomposition of animal organic matter or vegetable organic matter?

A. In a measure I will be able to distinguish approximately
whether this albuminoid may be more of animal origin
or vegetable origin, by comparing the results for oxygen
1394 consumed, etc. We take all these things in general together
and that enables us in a measure to say approximately
and form an opinion as to whether the albuminoid ammonia
there may be of animal origin, principally, or of vegetable
origin. It is an approximation, but in general we can
draw some conclusions from these comparisons.

I found nitrites in the Illinois river at Grafton. I cannot tell whether they are from the decomposition of vegetable or animal organic matter, taken by themselves.

My theory is that the I. & M. canal was in a way a septic
tank, and that therefore the waters discharged from it into the
Illinois river at Joliet were in a better condition chemically
than the waters discharged into it by the drainage canal. I
never made any chemical analyses of the waters of the Illinois
river at Joliet before the opening of the Drainage canal; I did
not have anybody do that. So as to what was the condition of
the Illinois river at Joliet consequent upon the discharge of the
Chicago river through the I. & M. canal prior to the opening of
the Drainage canal I do not pretend to know from my own personal
analytical examination.
1395 So that I have no personal knowledge in any way of the
conditions chemically either above or below the place
where the Drainage canal flows into the DesPlaines river, prior
to the opening of the canal as I made no examination of it.
If a septic tank is good at one place it ought to be good at another
place in the course of decomposition. Water is only purified
to a certain extent in a septic tank—so it would not be benefited
by passing through a second septic tank.
1396 It has been established that in these septic tanks the
aerobic bacteria are present to a limited degree and these
aerobic bacteria by being present in subsequent tanks may to a
small degree continue these processes of purification and produce
a purified product, that is, as far as they are able to do so

in that tank. In the I. & M. canal there was some current of water. The current is exceedingly slow and it depends very much upon the amount of sewage pumped into the canal and how long it is permitted to be in the canal. It varies greatly. If 36,000 cubic feet per minute were pumped in and 36,000 cubic feet per minute discharged there was a current in the I. & M. canal at that time. If that was the average state and condition, it must have had somewhat of a current.

If below where the I. & M. canal discharged into the Illinois river there was a stretch of river of say three miles, in which the current was very slow, scarcely perceptible, that would operate as a septic tank.

1397 If there was another stretch of 23 miles that would also operate as a septic tank. In any investigation of the Illinois river that I have made, a long and continued series of septic tanks would have been very beneficial to the purification, in a measure. I know that upon the Illinois river there are a large number of bayous and lakes, adjoining the banks of the Illinois river, which are spring fed and which in low water discharge their water into the Illinois river and which in high water are completely overflowed. They could operate as septic tanks. From my own personal study I don't know whether they do or not.

In the course of the investigation we took cross sections of the Illinois river. We took some at Joliet and then at points below Peoria and Pekin. We took one at Kingston, Illinois, which is eight miles below Pekin.

1398 The cross sections taken at Pekin and Peoria represented three sections across the river—we took the center of the river and then the right and left shore. I have not as yet presented the result of the analyses of these cross-sections. The average stages of the Missouri, Mississippi and Illinois

1399 rivers from August, 1899 to January 22, 1900, were comparatively low. (Table No. 1.) This is the table of the data for 1899, compared with the Illinois and Mississippi rivers at Grafton.

1399 MR. JOHNS: We would like to have the table presented showing the results of the analyses of each sample at that place at this time. We don't understand that table has ever been given.

1400 I don't recollect just now how many samples we took from September 6, 1899 to January 17, 1900. There were 18 samples taken.

1402 I got the information that only 47 per cent of the population of Peoria discharged its sewage into the Illinois river from a report published by Mr. Harman, civil engineer, in the Illinois State Board of Health report of 1900.

1403 I don't know that by any personal examination. I know that at Peoria there are a number of large distilleries and very large glucose works and that there are a great many other manufactories in the city of Peoria. I know that in these distilleries a very large number of cattle are fed and that the sewage from this city of Peoria, in proportion to its population is enormously large. I won't admit that it is very much disproportioned to the amount of the water supply as discharged from its sewers into the river. I know that quite an amount of sewage and refuse matter is dumped into the Illinois river at Peoria, between Peoria and Pekin. I do not admit it is disproportionate to its population.

1404 Q. Did you ever see floating down the Illinois river islands of discharged animal matter, combined with straw, and find them sixteen and eighteen miles below Pekin, 25 or 30 miles below Peoria?

A. I haven't seen such, but I have heard of so-called floating islands coming down the river there and being recognized by parties in the towns below Peoria, between Peoria and Beardstown.

Q. Now, that is a very unusual state of affairs, isn't it?

A. I have seen some of these so called little islands myself. I remember now, in the trips I made down that river on such occasions.

1405 Q. If the sewage of Peoria will purify itself, if the dilution which it receives from the Illinois river, in a run of from 25 to 50 miles down the river, why will not the sewage of Chicago discharged at Lockport, purify itself in a run from Lockport to Peoria?

A. First of all, the sewage of Peoria cannot purify itself by such a run of from 25 to 30 miles under the conditions prevailing in the Illinois river. That is, the water of the Illinois river as it reaches Peoria not being sufficiently pure. The water in the Illinois river as it reaches Peoria and passes down is confined to the current in the Illinois river. There is water outside of the current, but it is the current of the Illinois river that carries the water of the Illinois river down that river. There is a different speed of the river in the channel from the speed along the shore.

1406 The sewage as it enters the Illinois river from the sewers does not reach the channel right away. It remains along the shore and since it has been established that the velocity of the river along the shore is always slower and different from the channel itself and there being quite a number of impediments there, the river makes certain curves between Peoria and Pekin, there is a considerable slackening of the speed of the river along the shore and this sewage from Peoria has a considerable time to perform certain initial purification processes along its route whereas in the channel the current is faster and this sewage from Peoria when it reaches the channel finally has remained for some time along the shore and has undergone certain processes of initial purification. The chemical analyses of cross-sections show that. In a measure we can call that a septic tank.

Q. Now, if the waters of the Illinois river were potable when the sewage of Peoria was deposited in them, and if the waters of the Illinois river were of the same volume as they are now with the drainage canal open, would the sewage of Peoria purify itself in 25 or 30 or 50 miles?

1407 A. If that water, the Illinois river water, as it reached Peoria, would be pure, from the analytical data obtained, from the examination of samples of water collected between Peoria and Grafton, the conditions as described by me prevailing in the Illinois river, between Peoria and Kingston, and through the lower towns there, these analytical data would demonstrate that chemically the effect of the pollution of the Illinois river by the Peoria sewage would not be noticeable. I previously said it would take from 25 to 50 miles for that sewage to disappear in the channel of the river, not to be noticeable in the channel of the river, the effect of it.

MR. JOHNS: You are to assume that the waters of the Illinois river at Peoria are potable, and of the same volume as when the Drainage canal waters flowed at that point, and at that point they receive the sewage of Peoria, would not those waters purify themselves so as to be again potable in a run of 25 or 50 miles, and I would like you to answer yes or no.

A. Whether that sewage would be purified or not, absolutely purified or not, that is a question I cannot answer, because, as I said, the water in the channel shows a different character from the water along the shore, and samples taken from the channel from 25 to 50 miles below Peoria do not show any more, chemically, the effect of the discharge of sewage of Peoria into the river. That don't preclude that the Peoria sewage may still be, partly, in a partly decomposed state along the shore, not in the channel, and may still necessitate further purification before it could have disappeared, from the anayltical results. 1408

(Question repeated.) A. As I have stated before, a chemical analysis of the water taken from the channel 25 to 50 miles below, would not show any more the presence of the sewage from the city of Peoria, but that would not preclude the sewage from the city of Peoria still being in the river along the shore, undergoing its natural processes of gradual purification.

1409 Assuming that the waters of the Illinois river when they reach Peoria, are potable, and of the same volume as when the Illinois Drainage canal is discharged into them, and that at that point they receive the sewage of Peoria, would these waters become potable again in a run of from 25 to 50 miles?

A. I don't think they would; that is, potable in general.

Q. Would they become potable in a run of 75 miles under the same circumstances supposed in the previous question?

A. That would depend very much upon the character of the sewage of the city of Peoria.

Q. You made a statement on March 17th, that the sewage entering the Illinois river from the city of Peoria, after running from 25 to 50 miles, would purify itself so as to remove the polluting effect of Peoria sewage on the Illinois river? (See rec. 1214.)

A. I said chemically, yes. I didn't say at that time, but it was understood, and if I had been asked the question I would have said so at that time, that a chemical examination of the samples of water taken at a point below Peoria, and taking into consideration the general conditions of the river, I would say
that that sewage disappears from the channel, that is,
1410 the chemical result would not show its presence in the
channel.

Q. 25 to 50 miles below Peoria, do you think it would show its presence along the sides of the channel?

A. The cross-sections that we have taken from the Illinois river below Peoria show chemically a difference between the water running along the shore and running in the channel.

Q. Does it show in the Illinois river on the sides, or would it show, and not in the channel, 25 to 50 miles below Peoria?

A. That I couldn't tell because I haven't made any examination of samples from that point. I have not produced any analyses of the cross-sections which show any such results here.

The samples of water which I took from the Illinois river were all taken within the channel. The orders issued to the collectors were that they should always take them from the channel. When I took samples at the Chain of Rocks, on the Missouri shore the sample was taken as close to the Missouri shore as was necessary to get a characteristic sample of the Missouri river water as it hugged the Missouri shore.

That part of the river which runs close to the Missouri shore is composed principally of Missouri river water.

Q. Run a line two miles up the current of the Missouri river and a line in the current of the Mississippi river at the junction of the two, and what would the angle be?

1412 A. That would produce an angle.

Q. Produce pretty close to a right angle, wouldn't it?

A. Yes, sir.

Q. Well, when there are equal stages of water, and in an average condition, your theory is that the current of the Mississippi overcomes the current of the Missouri and turns it down the Missouri shore towards St. Louis.

A. No, not exactly; it don't turn it over to the shore so that the Mississippi river would prevail. The two currents will run alongside of each other, each river hugging one shore —the Missouri hugging the Missouri shore, and the Mississippi river hugging the Illinois shore. Now, it will depend entirely upon the volume of water in each of those currents which will prevail in the channel—of the channel water.

Q. When the stages of the river are equal, the fact is that the current of the Mississippi overcomes the current of the Missouri and turns it down at right angles, and runs it along the Missouri shore?

A. Yes, that can happen. It does hapen.

Q. But at the same time there is more or less a mixture of each of the rivers on the Missouri shore at St. Louis, at the Chain of Rocks?

A. Sometimes this mixture which may be found in the channel may crowd over toward the Missouri shore somewhat, but still our analytical data show that samples taken close to the Missouri shore will always be prevailing Missouri river water, if close to the Missouri shore.

1413 Before the Mississippi and Illinois meet there is a long narrow strip of land that divides them, and when they meet they run almost parallel; that is, they come together slowly. The Illinois river water keeps close to the Illinois shore. It is entirely a different situation than that at the mouth of the Missouri. The place where the samples were taken at the Chain of Rocks was left very much to the judgment of the collector.

Q. There was then, as to the Missouri shore, no fixed and certain place at which the samples was taken?

A. No, sir, it depended upon the current entirely and it was left to the judgment of the man who took the sample as to where he should take it.

1414 Q. So that a sample one day might have been taken 300 feet from the Missouri bank, and the next day 1,000 feet from the Missouri bank?

A. Yes, sir, if the current would run that way; he was instructed to get samples accordingly. The current of the Missouri at the Chain of Rocks on the Missouri shore is constant and regular. It varies somewhat in volume and in the width of the current at that place, but there is always
1415 some Missouri river current water running close to the Missouri shore. Our analytical data shows that. I could not tell from the analytical data alone whether a sample was taken within three hundred feet of the Missouri shore line or whether it was taken from about nine hundred feet from the Missouri shore line.

1417 Q. Do you suppose that any of the water which you took at the place which is designated as the Illinois shore ever got into the intake?

A. Yes, it got into the intake quite frequently.

Q. Well, how did it do it?

A. Well, when the Missouri river was low, and the larger volume of the Mississippi river water coming down the Illinois shore would push the Missouri river toward the Missouri shore and beyond the intake, which is 1,500 feet distant from the

Missouri shore line, and on such days the Mississippi and Illinois mixture water would get into the intake.

Q. Now let us see if we can understand each other. The point on the Illinois shore opposite the Chain of Rocks, and the point at the intake tower and the point which you designate as the Missouri shore, constituted a cross-section of the Mississippi river?

A. They were to constitute a cross-section as near as possible.

1419 Q. The water at the Illinois shore at the point at the Chain of Rocks, and at the point from which you took it, never did get into the intake, did it?

A. It could not on such days because the point of collection was to be far enough away from the intake so that it should not be water that was going into the intake, but should be water that was passing along the Illinois shore.

1421 Q. Take your chart 8, for instance, and tell me whether or not you base your calculation as to the percent of chlorine at the intake tower upon the 23d day of January upon the data which that table or chart shows?

A. Yes, based upon the chlorines there I made an approximate estimate there, and an approximate average of the per centages as found at the Missouri shore, Illinois shore and the intake tower, at the Chain of Rocks.

1422 The waters at the point called the Illinois shore do not turn a right angle and make a straight shoot for the intake tower.

Q. What point up the Mississippi river do you think that it would be fair to select in order to get a sample of Mississippi river water which actually intermingled with the Missouri and went into the intake tower?

A. I consider one mile above the mouth of the Missouri river in the Mississippi as a proper point.

Q. Well, then your calculations as to the pollution of the waters of St. Louis having been based entirely on the samples taken at the Illinois shore, are upon a false basis, are they not?

1423 A. I cannot say that they are on a false basis because they have not been compared in such a way.

Q. Where did you obtain data upon which you base the calculation made as to the percentage of Mississippi river water and Missouri river water entering the intake tower?

A. One sample was taken from the Missouri river at Ft. Bellefontaine; another sample from the Mississippi river one mile above the mouth of the Missouri designated as Hartford in the analytical records; the third sample was taken from the collection point at the intake tower. The samples from these three points were compared. The residue on evaporation was selected as affording the widest range in figures, and therefore the closest approximate estimate of percentages of mixtures at the intake.

Q. What percent of what proportion of the water taken at Hartford of the entire water, was Illinois river water at that point you don't pretend to know?

1424 A. Well, by inspection alone I could not ascertain that chemically that water was a mixture, it required the chemical analysis subsequently made to determine that Illinois river water was contained in the mixture running in the channel.

1428 If I find by analysis that the water going into the intake tower has a higher per cent of pollution than the water of the Missouri river at Bellefontaine, my chemical conclusion is that the water going into the intake tower is very largely Mississippi river water. My conclusion is based not upon any ability to observe by the currents, which river it is, but solely and entirely from the chemical analysis.

1429 Q. Why, in order to determine the respective quantities of Missouri and Mississippi river water pumped, did you take a sample from the Illinois shore when you knew it was a physical impossibility for that water to be pumped at all?

A. Well, that is to show the character of the current running down the Mississippi river at the Chain of Rocks.

1431 Q. Was chart 8 made for the purpose of showing that the water at the intake tower was intermediate in its quality, as between the Missouri river and the water on the Illinois shore?

A. In so far that the study of the analytical data proved that, yes.

As to chart 9, my data as to typhoid wer obtained from the Health Commissioner's office of St. Louis. My instructions were to take them from the official reports.

1433 Can you explain why the typhoid fever in St. Louis did not visibly increase from March 20 to August 14, 1900?

A. In February, the upper Mississippi above the mouth of the Illinois was low. The water then represented in the mixture at the intake—I want to say that evidently there was a larger percentage of Illinois river water, of that mixture going into the intake in February and being represented by a high percentage, one day as high as 100 per cent, going down again and then going up again, in February, up to 90 per cent; there was more Illinois river in that mixture; that was followed by a rise in typhoid for the month of March.

Q. Now, why did the typhoid fall and the percentage of cases fall when the Mississippi river was at 100 per cent on the 27th or in the middle of April?

1434 A. Because then at that time the Mississippi river water had a different character than the Mississippi river water coming down in February, and it had a larger per centage of upper Mississippi river water and a smaller per centage of Illinois river water.

Q. So that the chart doesn't contain anything about the Illinois river, but simply assumes that when the typhoid fever is bad, the Illinois river water prevails.

1435 I have ascertained that a large majority of the cases of typhoid fever in St. Louis reported during one year after the opening of the canal, that these cases all correspond with the fact that the patient had been drinking city water during that period. I got this from the official reports of the physicians when they reported their cases to the health department.

1436 These reports show that in some instances they have been drinking milk. There are about 3,500 or 4,000 wells in St. Louis. There are quite a number of cisterns in addition to that, so that we usually say there are 7,000 cisterns and wells in the city of St. Louis. It was ascertained in this special investigation that of the 1,160 or 1,180 cases reported in 1900, of typhoid, three-fourths of these patients did not drink any well water or cistern water, but only drank water from the city supply.

CROSS-EXAMINATION by Mr. Todd: These 1,180 cases were cases reported by the physicians of St. Louis to the Health Department—not deaths. The number of deaths in 1900 was over 100.

1438 There has been typhoid fever in the city all along every year—the statistics will show some typhoid.

1439 Have been connected with the Board of Health of St. Louis for ten years. There was a letter sent out to the physicians in the city asking them to report typhoid cases coming under their immediate care in the fall of 1900 and another one issued in the fall of 1901.

Q. Previous to the one issued in the fall of 1900, do you know of any letter having been sent out to the physicians in St. Louis during your term in connection with the Health Department of the city of St. Louis?

A. There wasn't exactly a letter sent out, but I remember as long as I have been connected with the health department that the Health Commissioner has frequently requested physicians through the press and in official reports, to report the number of typhoid more promptly.

1440 Q. Well, that letter stimulated the doctors in reporting cases of typhoid, didn't it?

A. Well, it called their attention to the violation of that law in not reporting cases.

1442 There were more cases of typhoid in 1899 than 500; that is during the entire year. Typhoid was very low, but during one month they went up some.

That increase in typhoid was in November, 1899.

1443 Q. The Drainage canal had not been opened then?

A. That I couldn't tell.

1445 I do not consider myself a medical expert on typhoid.

Q. Can you as an expert in chemistry attribute any part of the 1,180 cases in 1900, to the opening of the Drainage canal?

A. Indirectly, yes; in connection with my statements. I consider it in a measure as very striking that with the increase in the pollution of our water supply, and the increased pollution of the DesPlaines river from the Drainage canal, and the Illinois river and the Mississippi down to the intake in the year 1900, I consider it very striking that there was corresponding with that increase in pollution in the month of March, 1900, an increase in typhoid of 1,300 per cent over the average of the five preceding years for the number of cases in St. Louis.

1446 A person not a chemist nor an expert on typhoid could draw the same conclusions if he would give the matter as careful study as I have tried to do. During the five years previous to 1900, the water supply of St. Louis as found in the hydrants, was not good, potable water. It required boiling, and filtration.

Q. Now, do you compare potable water or drinking water as being bad or worse?

A. I do compare the analytical results in 1899, prior to the opening of the canal. I compare those results with those of 1900, 1901 and 1902, after the opening of the canal, and the water has become worse in its chemical character since the opening of the Drainage canal.

1447 Q. But before that it wasn't drinkable, was it?

A. Frequent warnings were issued by the Health Department and myself to boil the water or filter it well before drinking. Those instructions were given because the water was not found to be potable. The water as it existed today, if filtered or boiled would be as good as the water that existed prior to 1900 if boiled or filtered. The Health Department of St. Louis has advised the citizens not to drink the water of St. Louis since 1893.

The water as proved to be prior to the opening of the Drainage canal, was polluted. The analytical results showed pollution in a measure from sewage and in a measure of vegetable origin.

Q. Where did the sewage come from that got into the water of St. Louis?

A. In my opinion, as a result of my investigation in 1899, I found that the Missouri river and the Mississippi river above the mouth of the Illinois were of much better sanitary quality than the Illinois river at the mouth of the Illinois, and I found at that time that the Illinois river polluted the Mississippi river after meeting the Mississippi river and that this pollution extended along the line or along the route of the Mississippi river as it came down and passed the intake, or at times when the Missouri river was low, it would go into the intake. At that time the Missouri river water was potable.

1448 Missouri river water is now potable water. In this case I testified as a chemical expert who is supposed to make himself familiar with all the bacteriological features connected with the chemistry of water. Chemically, I am prepared to say the waters of the Missouri are potable. But bacteriologically, I am not prepared to answer the question. The water

1449 of the Mississippi river above the mouth of the Missouri was not potable prior to the opening of the drainage canal.

1450 I am prepared to say that (prior to the opening of the canal) 75 per cent of the daily quantity of water going into the intake would be Missouri river water, and about 25 per cent would be Mississippi river water.

Q. Would the amount of Mississippi water entering the intake be sufficient to keep the water supply of St. Louis in a polluted condition?

1451 A. As I stated in my testimony in direct examination, prior to January, 1900, the water supply of St. Louis as coming from the water going into the intake, was potable at times. I said in my conclusions there were great variations, and at some times the water would be a good drinkable water, the water would be potable, and at other times it would be very bad, polluted, as I said. (Witness states on page 1447 that the water was not potable.)

1452 Above Grafton, the water of the Mississippi river prior to 1900 was potable.

1453 The Illinois is prevailingly a slow river, sluggish current. Its current is supposed to be slower than the Missouri and Mississippi and the results of examinations as published demonstrate that. The volume of water coming down the Illinois varies greatly. Sometimes may amount to 1,200 cubic feet per second and then it may be 112,000 cubic feet per second. The volume of the Mississippi never goes down to 1,200 cubic feet per second from what I have studied about it.

1454 The Illinois river water, as it runs along the Illinois shore, is stopped by dikes, and it is kept in the corners of the dikes, and only a part of that water is gradually, when the upper rivers rise, swept out, and gets into that narrow channel, so that the identity of the Illinois river, as such, would, in my opinion, be lost before it reaches the intake.

1457 Took samples from DesPlaines river in October and November, 1901. From the analyses made of those samples I considered that water potable water.

1458 I mean by that good drinking water. I know that some towns drain their sewers into that river. I do not know that the waters of the DesPlaines river have been condemned by the Board of Health of the city of Chicago as being contaminated and that ice men are prohibited from selling the ice from that river.

1459 Q. Then if the sewage of these different places that I have indicated, (Riverside, La Grange and Maywood,) (Riverside being ten miles away), does empty into the Des Plaines river, and did empty at the time that you made your examination, purification of that sewage had been completed at the point that you made the examination. Is that correct?

A. Yes, sir; if the facts are such; provided, however, that the volume of water was sufficient, and the DesPlaines river at times can discharge as much as 600,000 cubic feet of water per minute.

Q. And assuming also that the sewage from these points above there was emptied into that river, before that sewage got to the point that you took your samples, it had been purified, and the water had been rendered potable, according to your anaylses, is that correct?

A. Yes, my analyses established the fact that during those two months the water taken from the DesPlaines river was potable before it reached the Drainage canal.

1460 Q. The principles of purification will apply to the Des Plaines river the same as to any other river, would they not?

A. Well, if the conditions were alike, of course.

1463 There is no general theoretical principal that sewage contaminated water from cities above, receiving an additional discharge of sewage from cities below, that the water of the river so contaminated at the time of the additional discharge will retard the purification of the stream. It all depends upon the practical results.

1464 Q. Is there any principle established by chemical science that holds the river would not purify itself of sewage that it has received?

1465 A. I don't know of any as applied to those conditions prevailing in the Mississippi river above the mouth of the Illinois.

At certain times during the year the water of the Mississippi river above the mouth of the Illinois, from three to five miles above the mouth of the Illinois, that water is potable; at other times it is not potable. It varies according to the amount of impurities. During the warmer period of the year the water from that river is always better than it is during the winter months.

1466 June, July, August and very often we have summer weather prevailing through the month of September.

1467 The potability increases in the spring slightly with the warm weather.

Q. Does the rain-fall in July affect the potability of the water in the Mississippi river above Grafton?

A. Assuming the weather is warm, certainly warm temperature will assist materially in purifying—it assists in making it potable.

1468 Q. Doctor, if the waters at Grafton were chemically decided to be potable, is not the conclusion irresistible that the sewage, however magnified or increased in the upper Mississippi has been purified by the time it got to Grafton?

A. It would demonstrate that the pollution of the Mississippi river above Grafton is of such a character that it does not affect the potability of the water of the Mississippi at the mouth of the Illinois.

Q. And how is that question of potability arrived at aside from the theory that running water purifies itself in a certain distance if the analysis of the water demonstrate beyond question that the waters at Grafton are potable? (Taking into consideration the fact that St. Paul, Minneapolis, etc., discharge their sewage into the Mississippi.)

1469 It is possible that such purification may take place, but it is necessary for various conditions all to co-operate to being favorable to such a result being obtained.

1473 Q. Now, if the water of the Mississippi river at Grafton is potable, doesn't it convey to your mind, as a chemist, that sewage discharged into that water at Minneapolis and St.

Paul and all the cities nursing the banks of the Mississippi river, has become purified to the degree of potability by the time it gets to Grafton, the point where you made your examination?

A. Stating as I have done, that I am not familiar with the conditions, whatever pollution there might have taken
1474 place in that Mississippi river above the mouth of the Illinois river, whatever pollution has taken place, it has been rendered sufficiently harmless by the time that water reaches the mouth of the Illinois as to render that water potable during certain times of the year, as I have stated. My opinion is that practically throughout the year the water of the Mississippi river above Grafton is permissible as good drinking water.

Assuming Grafton was a large city and I was placed in charge of the water supply of that city as a scientific man, I would consider that water from the Mississippi river potable and would advise the citizens of Grafton to use the waters of the Mississippi river above the entrance of the Illinois river for drinking purposes during those eight months without boiling and without filtering.

1477 The bacteriologists who hold that sewage polluted streams are not potable water, the views of those learned men, meet with the approval of my judgment.

1479 Q. Now if a condition of that character presented itself to you where a stream was chemically potable and bacteriologically contaminated, what would be your opinion as to the potability of the water?

A. If such a condition should exist—I don't know of any—if it should exist, that water would certainly from a general hygienic standpoint, not be considered potable because the bacteriological pollution would certainly stamp it as unpotable, as not potable.

1481 I adopt the rule that all sewage contaminated streams are not potable, but I do not accept it as a hard and fast rule for every possible care, disregarding entirely the various conditions that should come into consideration. It is possible that the rule may be applicable to the Mississippi river above Grafton, providing that the conditions prevail that will justify its application. I do not know whether those conditions prevail or not. I don't make the Mississippi river an exception to that rule. I can not tell whether it comes within that rule unless I make an examination of the conditions necessary to form an opinion.

1483 I have examined both conditions chemically and bacteriologically and thereupon formed a conclusion that the water of the Mississippi is potable three and five miles above the mouth of the Illinois. I did not make a personal analytical examination at the points above indicated, neither did I make a bacteriological examination. I do not know from my personal knowledge whether the waters at that point were bacteriologically pure, or not.

1484 The information I have has been reported by bacteriologists who made examinations at that point.

Excluding the opinions of everybody and basing my opinion upon my personal knowledge I cannot say that the waters of the Mississippi river three miles above Grafton are potable bacteriologically and chemically, that is, based upon personal analytical investigation of my own, so that when I testify as to the potability of these waters, my answer is based upon my personal research as a chemist. If the bacteriological information that I base the final conclusion on, is erroneous, I would certainly modify my views accordingly.

1485 I have no opinion of any bacteriologist who holds that the waters of the Mississippi above Grafton are potable. I form my own opinion from the study of analytical data.

1490 If Dr. Ravold drew the conclusion that the waters of the Mississippi river were not potable at Grafton, I differ with him in his conclusions, that is, viewed from a general hygienic standpoint.

1492 I consider the waters of the Missouri river potable at Ft. Bellefontaine, the station in the Missouri river where we collected samples of water. Bellefontaine is five miles above the mouth of the Missouri. The water is more or less potable all the year around. It varies according to the seasons.

1493 I would consider the water found at Ft. Bellefontaine station potable throughout the year to a varying degree. *Sioux City* empties its sewage into the Missouri river. So does Omaha. Omaha has large packing industries and large distilling interests. Across the river from Omaha is Council Bluffs, which is quite a manufacturing town.

1494 They discharge their sewage into the Missouri river. So does St. Joe, Leavenworth, Atchison and Kansas City. Kansas City has great industries in the packing and slaughtering business. It has distilleries, too.

MR. JEFFRIES: I object to all the questions and move that they and the answers be stricken out.

1495 The sewage of Jefferson City empties into the Missouri river. So does Herman, Missouri and St. Charles, Missouri. The reason the Missouri river at Bellefontaine is potable, when all these cities and towns that have been mentioned here empty their sewage into the Missouri river, depends very much upon the amount of sewage which these cities discharge into the Missouri river. It depends furthermore upon the volume of water in the Missouri river. It depends also upon the velocity of the flow, the general conditions of the course of the Missouri river, what accessions of soil in the form of clay and silt the Missouri river takes along its winding course and what effect sedimentation of this enormous quantity of soil will have on the sanitary character of the water. There are various conditions that obtain in the Missouri river that do not obtain in the Illinois river.

1496 The water in the Missouri river is generally larger. The courses that the Missouri river takes is one of a great many bends and curves, much more so than the Illinois river. There are, as I have said, enormous accessions of soil swept along the course of the river from the shores of the river into the Missouri river. This is not the case in the Illinois river. Heavy sediment of clay will produce at such points along the river where the velocity is slow, particularly if there are many bends and curves, considerable sedimentation along the banks. The Missouri river overflows and this overflow will cover vast areas of land sometimes. This helps the purification because sedimentation, according to the accepted axiom of modern science, will assist materially in purification. These conditions prevail from my own observations along the Missouri river between Kansas City and St. Louis.

1497 Between Kansas City and St. Louis I might have seen ten square miles that were overflowed, but I could not say positively that it was that much. Since these conditions prevail along the route between Kansas City and St. Louis from information that I have I should think it would have a considerable effect in the purification of the Missouri river.

1498 Q. Is there anything else more beneficial for the purification of that stream than that?

A. It has a character of great stability which I would distinguish as a chemical characteristic. Stability in contradistinction from instability would be that the processes of purification have reached the stage where the final product of the nitrifying cycle, that is, the oxidation of the free ammonia to nitrites and nitrates has reached a stage so that it is largely completed as is always evidenced in the Missouri river between those points that I have mentioned, by low nitrites, and uniformly low nitrites between Kansas City and St. Louis and comparatively high nitrates. I do not know how far below Omaha and Council Bluffs the water becomes purified and potable after the sewage has been emptied into it. As regards the point of purification, the question could not be answered.

1499 Because the conditions are such in the river that while the water in the channel below Omaha might show chemical improvements after the sewage of Omaha has been discharged into the river, the water running along the shore line would not show that to that extent. Because it is a well known fact that the sewage from cities is discharged on the shore. It flows along the shore where there is supposed to be a current of less velocity than the current in the channel. The sewage may appear in this shore water whereas the channel current is entirely different water. It does not get into the channel until at high stages of the river when flood water comes down. The serpentine course of the Missouri river would not necessarily serve to get the sewage in the channel. It would be impossible for me to say that the sewage would be purified 20 miles down from Omaha.

1500 If the sewage should be placed in the channel sometimes it would take longer to purify it than it would along the shore on the banks, because it would depend somewhat upon the character of the water, the velocity of the stream and the character of the water the velocity of the stream and the character of the sewage being flushed from the shore into the channel.

1501 It would take longer for the sewage in the channel to purify than it would if it remained in a quiescent stage in the overflowed banks along the shore. The conditions in the channel of the Missouri river are such that usually when the sewage of the cities is flushed into the channel that it has previously undergone a certain stage of preliminary purification along the shores in the sediment of the banks which are overflowed at those points in this poorly regulated river.

1502 I know that it is a fact—I have obtained it from analytical data from those points. I have never seen the sewage of Omaha and Council Bluffs when it entered the Missouri.

1503 At that point I could state it is a theory. At Kansas City I investigated the conditions there but I have not seen the sewers myself. It is a theory justifiable from analytical data obtained. As to Kansas City I have no personal knowledge based upon observation as to how the sewage enters the Missouri river, nor as to Leavenworth and St. Joseph. I have not seen the sewer outlets of any of these places with my own eyes. If you define it as personally known to me (as to how long the sewage remains along the banks instead of entering the channel) I say it is a theory.

1505 I have no opinion based upon scientific data as to how long it would take the sewage from Omaha, Council Bluffs, Kansas City, St. Joseph or Leavenworth to purify itself. I have no opinion in regard to any of the cities located upon the Missouri river as to how long before the sewage from such cities would purify itself, if emptied into the channel.

I have a reason why the water at the point of Bellefontaine
is potable, based upon investigations I made of the Missouri
river. Those are the great length of the river, its many
1506 curves and bends, its many sedimentation beds along its
course and the long time water takes to flow all this distance
from Kansas City. The distance from St. Louis to
Omaha by the water line of the Missouri river is 676 miles; to
Kansas City it is 403 miles; from Omaha to Kansas City is 273
miles. The character of the sewage entering the Missouri river
at Kansas City is a sewage very high in percentage of refuse
matter from slaughtering houses and rendering establishments
and it contains 60 per cent of the sewage of Kansas City as discharged
into the river. This sewage, of course, includes the
fecal matter, it includes all the dirt in the streets as
1507 swept into the sewers from rainfall or from street
sprinkling. There is considerable sewage entering the
river from slaughter houses and other manufacturing establishments.

Q. Does that sewage from Kansas City purify itself in the Missouri in going 400 miles?

Objection by Mr. Jeffries.

A. Whenever sewage pollution has taken place from the sewage of Kansas City, that sewage pollution has to such an extent disappeared when the water reaches Fort Bellefontaine, after a run of 403 miles, that water is potable at Fort Bellefontaine.

1508 In a normal stage I am of the opinion that the Missouri river is slightly swifter than the Illinois. When the Missouri river is low and the Illinois river is low, the velocity of these two streams would be about alike. The average velocity of the Missouri river would be from three to three and one half miles.

1509 I have been at times on the Illinois river when the current was one mile and then again, when it was declared to be two miles, but not from my own investigations. At times, at high water, I have known that it was three miles an hour. The current can go up, at high water, in the Missouri, to four miles an hour.

1510 It is very likely that I have analyzed waters taken from the river at Bellefontaine when the current of the river was four miles an hour.

Q. How can you state that the waters of the Missouri river all the time are potable, in view of the fact that when the current of the river is four miles an hour and it is only 403 miles from Kansas City to St. Louis, which at that rate would be four days for the sewage to get from Kansas City to St. Louis, that the water is potable?

A. I can only form the conclusion that the water is potable, from the chemical analyses performed upon the water taken from the Missouri river at Fort Bellefontaine and the water was potable.

1511 Q. If your analytical data is correct, would not it justify the conclusion that when the current of the river is four miles an hour that it will purify itself in running a distance of 403 miles?

A. I can not draw the conclusion that sewage will purify itself in four days' running, because it can not be ascertained whether it came down in four days.

1518 In my examination at Fort Bellefontaine I found albuminoid ammonia in the waters of the Missorui river.

1519 The albuminoid ammonia in comparison with the free ammonia was considerably high. That indicates contamination of organic matter. If albuminoid ammonia is found in suspension more than in solution it will indicate organic matter due to contamination of vegetable origin.

Q. Why not animal origin, Doctor?

A. Because the organic contamination of animal origin is more represented in the albuminoid ammonia in solution. Because the organic matter of animal origin that is found in solution in the albuminoid ammonia will represent to a large extent the pollution of animal origin in soluble forms. If the albuminoid ammonia is in solution instead of suspension to a high degree that will enable the conclusion that the origin of the organic matter may be more from animal sources.

Q. In what condition would you find the albuminoid ammonia from the sewage of slaughter houses—in suspension or solution?

A. Well, in both, very likely. In suspension would prevail the more largely. I found considerable high albuminoid ammonia in the Missouri river at Bellefontaine. It was partly in suspension and partly in solution.

1520 At times the albuminoid ammonia in suspension would be larger than the albuminoid ammonia in solution and at other times the reverse would show.

Q. If that is true, how would you distinguish between the albuminoid ammonia of vegetable and animal origin?

A. The distinction could be made from that point of view that the organic matter in suspension is very largely composed of such matter as is of vegetable origin.

The albuminoid ammonia found at Bellefontaine, Missouri, for a larger part of the time appears to be in suspension and the smaller part in solution.

1521 Organic matter is the origin or albuminoid ammonia, that organic matter may be from animal and it may be from vegetable origin.

Q. Is albuminoid ammonia derived from vegetable, the same ammonia that is derived from animal?

A. Well, as a product of distillation it is the same. There are no identifying characteristics of albuminoid ammonia when it is found, that will enable the chemist to say whether that ammonia came from vegetable or animal origin, if he bases his opinion solely upon the product of distillation.

1522 There is nothing in the albuminoid ammonia itself that will enable the chemist to ascertain whether it came from animal or vegetable origin, that is, not in the analytical product itself. In the Missouri river I found albuminoid ammonia in solution and in suspension in different degrees.

Q. When albuminoid ammonia is found in suspension does that indicate whether it is of animal or vegetable origin?

A. Well, that could not be determined from the analytical product itself.

Q. If albuminoid ammonia was in solution would that indicate whether it was from vegetable or animal origin?

A. Not if determined as found from the analytical product itself.

1523 When this albumen which we denominate albuminoid ammonia becomes disintegrated by bacteria or oxidation it gives what is known as carbonate or chloried of ammonia. Then when the free ammonia by similar processes of oxidation or bacteria is broken up, it results in what is known as nitrites and the nitrites by similar process change into nitrates, the final product in the cycle of nitrification.

Q. So that in the beginning is what is known as albuminoid ammonia or albumen in the process of fermentation or purification?

A. Yes, probably carbonate of ammonia and chloride of ammonia, but including of course these almubinous compounds.

1524 Albuminoid ammonia is present in the sewage from slaughter houses and fecal discharges from man and animal. It is also found in the decomposition of vegetable matter.

Q. Doctor, as a chemist, do you enunciate as a principle of chemistry which you yourself by your analytical investigations have established, that albuminoid ammonias in suspension indicate vegetable origin, and albuminoid ammonias in solution indicate animal origin?

A. I said that they may be present in both; not altogether in one.

I can differentiate between albuminoid ammonia of vegetable origin and that which is of animal origin by taking into consideration the oxygen consumed results, which enable, in a measure, an opinion as to the vegetable or animal origin.

1528 Q. Can you tell from the presence of nitrites whether the nitrites come from vegetable or animal origin?

A. I could only take the general results of the entire analyses and certain local conditions as they are prevailing at the point where the sample is taken.

Q. That is, if you knew, independent of chemistry, that the water was sewage contaminated from the sewage of man or animal, then the nitrites appearing there, you would draw the conclusion that they came from animal rather than vegetable origin? Is that correct? A. Yes, sir.

Q. If you did not know the origin but only had the nitrites to go upon, could you tell whether it was of vegetable or animal origin?

A. No, sir, not if I took the nitrite results by themselves, I could not do it.

1529 I can not tell by the presence of free ammonia in itself whether it is of animal or vegetable origin, nor of nitrites,, nor of nitrates. Nitrates come from nitrites and nitrites from free ammonia; free ammonia comes from albuminoid ammonia.

1530 High chlorines in a river may indicate sewage pollution and they may indicate the passing of the river through a deposit of salt in the geological structure. It is uncertain what it indicates for chlorines alone.

1531 The sewage from all the cities upon the Missouri river entering into the Missouri river carries with it sodium chloride and in addition to that, I have testified about the Kaw river. As a chemist I can not distinguish the sodium chloride which comes from sewage and that which comes from the beds of the Kaw river, as I have testified.

In a measure, I took into consideration, in drawing my conclusions as to the conditions of the Missouri river as to its potability, the sodium chloride which entered that river from the sewage of all the cities along it. There is a certain amount of chlorine found in the Missouri river above the mouth of the Kaw river. The analyses show that and also a certain amount of chlorine is found in the Missouri river after the Kaw river empties into the Missouri river. When it got to Bellefontaine, I was not able to state what percentage of the chlorine I there found came from the sewage, and what percentage came from the Kaw river, whether the percentage from the sewage was larger than the percentage that came from the Kaw river, I am not able to ascertain chemically.

1532 The conclusion is justified that since the average chlorines are uniformly higher between Kansas City and Bellefontaine, that since as much as 100 parts per million, or five and six times as much chlorine is found in the Kaw river, that the Kaw river certainly is responsible for the high chlorine prevailing between Kansas City and Bellefontaine, as compared with the chlorines between Omaha and Kansas City.

The Kaw river enters the Missouri above Kansas City.

1533 The Kaw river chlorines show 100 parts per million.

The Missouri river after the Kaw river discharges into it may not show more than 24 parts per million of chlorine and above the Kaw, it might be 16, that would show an increase in the chlorines of the Missouri river resulting evidently from the mixture of the two rivers. The samples I took in the Missouri river were taken below Kansas City, that point had received the sewage of Kansas City, in addition to the volume of water from the Kaw river.

1535 The sample that was taken above Kansas City was taken above the mouth of the Kaw river.

1536 Took three samples all together below Kansas City, Missouri. The sample that I took above the Kaw river in the Missouri river showed on the day of collection, 16 parts per million of chlorine. The sample taken in the Kaw river showed on one day 100 parts per million of chlorine.

1537 The Missouri river sample below Kansas City showed 24 parts per million of chlorine. Above Kansas City showed 16 parts per million, which shows an increase of one-third in the chlorine. Since that day the Kaw river showed very high chlorine—80 to 100 parts per million—the conclusion could be drawn that so much chlorine coming from the Kaw river into the Missouri river would affect the quantity of chlorine found in the Missouri river below Kansas Ctiy.

1538 Q. Doctor, in the absence of the known volume of the Missouri and of the Kaw, do you take into consideration the sewage contamination from Kansas City, Missouri and Kansas City, Kansas, as to the chlorines?

A. Well, I didn't in this case. I admit that a definite conclusion could have been drawn if the quantity of chlorine coming from the sewage into the river could have been ascertained, but that is an impossibility and, on the other hand, the Kaw river showing such tremendously high chlorines, I considered it a natural conclusion that there must be some effect of the high chlorines in the Kaw on the increase in the Missouri river.

1539 I eliminated from my opinion or conclusion, the volume of water in the Kaw, the volume of water in the Missouri and the sewage of Kansas City.

1540 The volume of water in the Missouri above Kansas City varies considerably. It may be 100,000 cubic feet and it may be 600,000 cubic feet per minute. I have no accurate data as to the Kaw, nor as to the volume of sewage that enters the Missouri river from Kansas City, Missouri and Kansas City, Kansas, except that I have ascertained from the city engineer of Kansas City, Missouri, that only 60 per cent of the population drain sewage into the river directly. In order to draw a conclusion as to whether the chlorine below Kansas City comes from the sewage of Kansas City, Missouri and Kansas City, Kansas, or from the Kaw river, it is important to know the volume of the Kaw and the amount discharged into the Missouri from those cities. Such knowledge would enable an absolutely accurate estimation.

1541 Q. Your conclusion then is not accurate, is it?

A. Well, I consider it an approximation. If the Kaw river was only a river of two or three hundred cubic feet per second, emptying into the Missouri with the volume I have indicated, that would dilute the chlorines in the Kaw flowing into the Missouri enormously. Those very analyses I presented show that they are reduced from 100 in the Kaw to 24 parts per million in the Missouri, which is an enormous dilution. I cannot say what proportion of the increase of chlorine below Kansas City is due to the Kaw river and what to the Kansas

City sewage. I don't know whether 90 per cent of it is due to the sewage or not.

1543 Q. Doctor, why didn't you take into consideration the sewage from Kansas City in your conclusions in regard to chlorine?

A. I had no available data. I could not obtain them. It would have necessitated an investigation which I could not undertake at that time.

1544 In none of my investigations have I taken into consideration the sewage discharge of Kansas City, in calculating the chlorines for the Missouri river. It was because I could not obtain the data that eliminated the sewage of Kansas City entirely from my consideration. I relied upon the condition of the Kaw river as found, to justify the approximate conclusion.

1545 Q. Then you don't know what proportions of the chlorines below Kansas City came from Kansas City and what came from the Kaw river, do you?

A. Not from any investigation of the Kansas City sewage.

1546 Q. Now the chlorines that you found at Bellefontaine, you are unable to say what proportion of those comes from Kansas City sewage and what porportion comes from the Kaw river?

A. I feel justified, when the Missouri river is low and I find high chlorines at Ft. Bellefontaine that those chlorines can come from the Kaw river chlorines largely, if not altogether.

Q. Assuming that 90 per cent of the chlorines found at Bellefontaine comes from the Kansas City sewage, would that have any effect upon the potability of the waters of the Missouri river?

A. Not unless corresponding high nitrites and correspondingly high free ammonias would be shown.

Q. If correspondingly high nitrites and correspondingly high free ammonias were shown and the albuminoid ammonias you were not able to ascertain whether they were from animal or vegetable origin, could you tell?

A. And how much chlorine would be in that calculation?

Q. The amount which you found by your analyses. Would you denominate that water potable?

A. If the nitrites, chlorines and ammonias were high and I was personally convinced that the chlorines were due to sewage and not from the Kaw river, I would say, according to the axiom of sanitary science, that the water was not potable.

1548 Q. If the albuminoid ammonia should be of animal origin and accompanied by high nitrites and nitrates and free ammonia and high chlorines, the water would not be potable, would it?

A. It would not, if accompanied by those other high ingredients you mention.

1549 You could have high ammonia in solution and in susnever found high nitrites in the Missouri river. The nitrates are high.

1552 Q. Now, if you have got high albuminoid ammonia, free ammonia, low nitrites, high chlorines and you do not know what the source of that chlorine is, would you say the water was potable, or not?

A. I would base my judgment upon the conditions prevailing and the source of that high chlorine.

1553 I would refuse to give an opinion without that information. The waters of the Missouri river at Fort Bellefontaine are what is known as stable waters. The term "stable" is applied to a river where the fermentative changes and the nitrification changes which the impurities in the river undergo are more of a uniform character and are going on in the manner that they do not change rapidly and where analy-
1554 tical results show by uniformly low nitrites that the cycle of purification has reached a stage where a large portion of the impurities have been converted into nitrates, the final product of the cycle of nitrification.

1554 I found the albuminoid ammonia in the waters of the Missouri at Bellefontaine quite high. I found the free ammonia as a rule, which I consider low, but at times I found a slight increase in the free ammonia, where I would say that the free ammonia was there in a considerably quantity. The nitrites I found uniformly very low for a river. The nitrates I found at times quite high. The chlorines I found high, sometimes as high as 46 parts per million. The Missouri river was a polluted stream at Fort Bellefontaine based upon my chemical analyses.

1555 Its pollution is variable, you could not define it. That is, you could call it a polluted stream. I would not call it a very polluted stream. I attribute the pollution to organic matter of vegetable and animal origin, the degree of each varying. I am approximately able to state from my analyses the extent of pollution attributable to vegetable origin and to animal origin. Applying the same principle in determining the vegetable origin of the organic matter, I would say that whenever the albuminoid ammonia in solution runs very high with the organic matter—as estimated by the oxygen consumed process—high and the nitrites, although uniformly low, would still show their presence by a figure showing that there was still fermentative changes going on at that time—at such times I would say that the pollution could be of animal origin. At such times the water was not potable.

1556 The conditions I have just described would obtain during the winter months. Absolutely considered as winter months, I would consider from three to four months. During those four months this condition of pollution that I have described as being attributable to animal origin obtains in the Missouri river.

1557 During that time the waters of the Missouri are not potable.

Q. Then when you stated in your testimony yesterday that the Missouri river was potable throughout the year, you eliminated from your consideration the four winter months, during which animal contamination existed in the Missouri river?

A. I am very glad that you brought that matter up, because if I said "throughout" I did not mean to say that. What I meant to say was, "prevailed during the year," in taking the larger part of the year when I think the water is potable but for those four months I do not consider it potable. As to the other eight or nine months of the year when I claim the water is potable, that condition was ascertained by chemical analyses. I have supplemented my chemical analyses by bacterial investigation. The waters of the Missouri river are not bacterially pure. The bacilli coli communis I consider are found in smaller quantities in the Missouri river during those summer months than in the winter months.

1558 The presence of bacilli coli communis may indicate either sewage pollution, if corroborated by chemical analyses or may indicate fecal discharges of fish. There are many fish in the Missouri river. Since investigations have determined that fish have in their fecal discharges the colon bacillus, and if the chemical analysis does not demonstrate sewage pollution of the waters, the conclusion may be reached that sewage not being identified as present by the chemical analyses, the presence of the bacilli coli communis may be ascribed to the fecal discharges of fish. It is some time ago since I have studied data and reports on such investigations and at this moment I cannot remember whether it has been proven that bacilli is present in fish in streams other than sewage contaminated.

1560 Outside of the data secured from Dr. Ravold I have not made any independent investigations on the line of bacteria in the Missouri river. From the data compiled by Dr. Ravold, I consider the Missouri river potable during these eight or nine months that I have specified as representing the warm season of the year—potable at Fort Bellefontaine.

1562 The Missouri river at various points is sewage polluted wherever the sewage enters the river from cities along the line.

Q. Do you know of any scientific man who has investigated the waters of the Missouri, who holds to the doctrine that it is potable, aside from yourself?

A. Well, if I understand the testimony of Prof. Keiser correctly, he testified to that effect. From a bacteriological standpoint alone, a running river should not be judged as to its potability. The chemical condition should be taken into consideration. I do not know of any other authority on bacteriology who holds that the Missouri river is potable.

1564 Q. Assuming that the conditions existed at Bellefontaine as you found them, by your analyses, and that the high chlorines that you found there were attributable to the sewage discharge of Kansas City, what would be your conclusions as to the stability of the Missouri river at Fort Bellefontaine?

A. Even if those high chlorines you mention there were due to the sewage from Kansas City, after a run of 403 miles, even then it would be very difficult to ascribe such character to the water as you hypothetically present to me as due to sewage pollution from Kansas City, for various reasons—first of all, the distance from Kansas City to St. Louis would be 403 miles by water. Only 60 per cent of the Kansas City sewage would go into the Missouri river. The Missouri river during its winding course, with many curves, there being no dams or anything, the river overflowing frequently during its course, carrying a great deal of sewage over vast places adjoining the river, and at a low stage of the river, as the river falls, much of this sewage never coming down the river, being left there in a condition of fermentation, on that soil, previously overflowed. It would be impossible to claim that any Kansas City sewage reached St. Louis or reached Bellefontaine.

Q. Then the conclusion is irresistible that the sewage of Kansas City has become purified before it reaches Bellefontaine, in going a distance of 403 miles?

A. At certain times, when all of such conditions would prevail as I describe, I would say yes.

1565 The distance that the stream would purify itself from Kansas City would depend upon the velocity of the current and the condition of the river itself, that is, in enabling the overflow over large banks. It is a uniform rule that the waters in the Missouri, with the higher stage of water, have a swifter current in the channel.

1566 The lower stage of water, the slower the current.

1567 I cannot tell how far above Bellefontaine the water purifies itself of the sewage of Kansas City.

1568 I know from the official statement of the city engineer of Kansas City that 60 per cent of the sewage of the population of Kansas City, Missouri drains directly into the Missouri river. I have no information about whether the sewage from the cattle and stock yards is included in the 60 per cent population.

1570 The time it takes nitrites, by the process of oxidation to become nitrates would depend upon the number of aerobic bacteria in the water.

1571 If the waters contain large quantities of bacteria the time would be lessened. In laboratory experiments we find that the nitrites found present in the respective samples of water on the first day disappear after a number of days and the nitrates increase showing that nitrites have been converted into nitrates.

Q. Supposing that there would be a great number of aerobic bacteria present in the water and the nitrites were not in a large quantity, how long would it take?

A. This process would be a very rapid one. It might take 24 hours and it might take 48 hours for a small amount of nitrites to disappear. If the aerobic bacteria were present in the running water in great numbers that would have a tendency to decrease the nitrites even in the water.

1574 The presence of clay and silt in water is evidence of a greater number of these bacteria that possess the nitrifying effect upon the nitrites. The conclusion is justifiable that they are there in great numbers. There are more nitrifying or so-called oxidizing aerobic bacteria in the Missouri river water than in the water of the Mississippi and that, of course, would accelerate the oxidizing action in that water.

1575 The laboratory experiments show in the analytical results of water of one sample collected day after day from the same original sample that the changing of the ammonia into nitrites is slow, that is, the reduction per day of ammonia in quantity as estimated by analyses was very small, whereas the reduction of nitrites was large and small amounts of nitrites would, as I said, disappear in a period of from 24 to 48 hours. The samples taken at Fort Bellefontaine arrived at the laboratory three or four hours after they were taken. The nitrites were determined immediately upon arrival of samples.

1577 Q. Can you state, Doctor, as a positive fact that the low nitrites which you found in the waters of the Missouri at Ft. Bellefontaine are not attributable directly to the action of these bacteria from the time of the taking of the sample up to the time of the analysis?

A. If such a reduction of nitrites to nitrates, or rather oxidation—to be absolutely scientific—if oxidation of nitrites to nitrates took place in those samples while they were in transit from the station at Fort Bellefontaine to the laboratory, it would be so inappreciable that it could be disregarded because of the fact that the samples were packed in ice and kept at a very low temperature from the time they were collected until the time the chemist would take the sample, open the bottle and make his nitrite test.

Q. How do you know that, Doctor, as a scientific fact, is applicable to the waters of the Missouri?

A. From comparative tests that I made on a boat analyzing samples for nitrites probably ten minutes after they were taken from the place of collection and analyzed on the boat, and comparing the result with samples packed in ice and taken to St. Louis and analyzed. From these tests I have come to the conclusion that the oxidation of nitrites is inappreciable for six hours at times and other times, at eight hours, if the samples were properly packed in ice.

1578 These were Mississippi river samples; they were not Missouri river samples. There were no bacteriological approximations made on the number of aerobic bacteria from these samples.

1580 I made no investigation in any of my analyses for the presence of aerobic bacteria in the waters of the Mississippi. The oxidation of nitrites depends upon the presence of these bacteria. If this bacterium is present in large quantities oxidation will be facilitated provided there is also a large quantity of dissolved oxygen present in the water. There may at times be more dissolved oxygen found in one river than there is in the other.

1582 I have never made an examination of the waters of the Missouri river at Fort Bellefontaine at the time they were taken out of the river.

1584 In making my analyses I looked for causes so far as the water is concerned, on the route between Chicago and St. Louis. As regards Fort Bellefontaine samples, I only looked for the condition of the water at Bellefontaine and did not look for the causes.

1585 I don't admit sewage pollution at Fort Bellefontaine from Kansas City or the stock yards.

1586 I looked for causes partly during that period when the investigation showed pollution at Fort Bellefontaine. I considered it my duty to ascertain what this pollution might be ascribed to.

Q. Then your answer to my previous question that you were looking for effect and did not take into consideration the causes, you wish to modify, do you?

A. That is to be applied to that period when I found that water good and potable, then it was unnecessary to look for any cause but during that period of the investigation when I would find the Missouri river water polluted, I made an effort to ascertain the causes of that pollution.

1587 When I found the water pure or good at Fort Bellefontaine I did not look for the causes which created that good condition of the waters. I was mindful all the time in my investigations that the sewage of Kansas City, Missouri and Kansas City, Kansas, and the other towns located upon the Missouri river was emptying into the Missouri river. As long as I found the water good, I did not look for the causes that purified the water from the sewage contaminations of the cities above.

Q. Are you able to state what made the waters good, with the knowledge that there was sewage pollution at Kansas City and at other points?

pension in the Missouri river from vegetable origin. I

A. Nobody could state that. That is impossible.

Q. Then that is a matter outside of the realm of scientific research?

A. No, sir. I can not name anybody who could tell. Scientific men give an explanation from stating the general conditions in the Missouri river between Kansas City and Bellefontaine.

1588 It is problematical.

Q. But it is not problematical what becomes of the sewage of Chicago, is it doctor?

A. The Chicago sewage is entirely different.

Q. Has the light of scientific truth shone more clearly upon the chemical and bacteriological mind in regard to the Chicago sewage than that of the Kansas City sewage?

A. The conditions of the two rivers are so materially different, the quantity of sewage coming from Kansas City being discharged into the river is so materially different from the sewage being discharged from Chicago into the Des Plaines river, the conditions of the Des Plaines river and the Illinois river vary so much from the conditions prevailing in the Missouri river. The distance between Chicago and St. Louis for

the sewage to run is 357 miles and the distance from Kansas City to St. Louis is 403 miles, making 46 miles difference.
1591 I have estimated in volume the sewage discharged from
Kansas City, Missouri and Kansas City, Kansas, by usual or customary calculation.

Q. After you find that out, what use did you make of it?

A. Well, I studied the conditions of the Missouri river and I utilized the data in the customary way such conditions are studied.

1592 Q. Why didn't you take into consideration in ascer-
taining the source that chlorine came from the sewage of Kansas City, Kansas, and Kansas City, Missouri, when you made the test below Kansas City?

A. Because it is difficult to estimate from the volume of sewage discharged into that river the quantity of chlorine.

Q. How much of the chlorine that you discovered in your analyses below Kansas City was attributable to the sewage of Kansas City, Kansas, and Kansas City, Missouri?

A. That is a question which I yesterday answered that I could not tell, because I had not made investigations as to the quantity of chlorine to be found in the sewage discharged from various outfalls into the Missouri river because of the extreme difficulty in ascertaining the amount of chlorine there. The amount attributable to the Kaw river would vary much. It depends upon the volume of water in the Missouri.

1593 Q. Is there anything in connection with the chlorine
itself that will enable you to tell whether it is mineral pollution, as evidenced by the discharge of the Kaw, or sewage pollution as evidenced by the sewage of Kansas City, Kansas, and Kansas City, Missouri?

A. Yes, sir. As I explained yesterday, the fact that the analytical results of the water at Fort Bellefontaine do not show correspondingly high free ammonia and chlorines and nitrites together, and that the nitrites are uniformly low
1594 is no justification to ascribe the high chlorines to sew-
age pollution.

Q. The question is, is there anything in the chlorine itself?

A. No, sir.

Q. Then the only reason that you attribute the presence of chlorine at Fort Bellefontaine to the Kaw river and not to sewage is based upon consideration aside from the chlorine itself?

A. No, sir, in determining that question it is necessary to take into consideration the general analytical results as found from the analyses of the samples at Fort Bellefontaine. If the chlorine is due to sewage pollution there should be high nitrites, high free ammonias and high organic matter would show in the results. If the nitrites are low and the free ammonias low as it usually is in the Missouri river this high chlorine cannot be attributed to sewage pollution. It must come from mineral matter, it must come from salt. The determination of the sources of chlorine must be had from outside considerations, aside from the chlorine itself and that determination is based
largely on low nitrites, high free ammonias and high
1595 chlorines. I believe I stated that albuminoid ammonia
would come into consideration as organic matter either
high or low. If the free ammonia were low that is the most essential point involved there. The free ammonia for the major part of the year is very low in the Missouri river. The nitrites are either very low or absent entirely.

Q. Assuming that the general analytical results show albuminoid ammonia, free ammonia, low nitrites, chlorines in the amount that you found it, but that the chlorines were attributable to sewage pollution and that there was no river
Kaw?

1596 A. Well, if it would be an established fact that the
chlorine was due to sewage pollution, why that water in itself would be unpotable because of its sewage origin. If the chlorines were identified as coming from sewage pollution, the presence of the other ingredients going with it would of themselves form a part of that conclusion, because the fact is then established as such that the chlorine is due to sewage pollu-

tion. In making the nitrite test, alum was added to the
1597 water to clarify it. After the addition of alum, the water was filtered. I have known that the waters were
1598 potable since 1899. I have always been an advocate of using Missouri river water for consumption in the city. I have agitated the use of the Missouri river water in preference to that of the Mississippi at the present intake. I first entertained those views in regard to the Missouri water being the best water to be used in the city of St. Louis in 1899. I first became connected with the city as chemist in 1893. At that time I knew of the contemplated building of the Drainage canal.

1599 Q. From 1889 on to 1893 or 1894, was anything said about the canal and its construction in the papers of St Louis that you know of?

A. Yes, sir. The matter was discussed in the year 1893 to some extent. It was a matter of general knowledge in St. Louis that this improvement was being made in Chicago. It came up before the Board of Health in the form of a discussion of a resolution introduced in the year 1893. I believe the Health Commissioner of St. Louis at that time—Dr. George Homan—introduced the resolution. One resolution in 1893 was that in view of the construction of the Drainage canal at that time going on in Chicago, a National Board of Experts should investigate the question as far as it would affect the water supply of St. Louis and questions in general pertaining to sewage pollution. The Board of Health recommended in the resolution either that Representative Barthold of St. Louis, in Congress, should introduce a measure asking for such an investigation, or that such a measure had already been introduced by Mr. Barthold and was supported by this resolution. The other resolution was calling upon the city chemist to perform some analyses of water. He was to collect them from the mouth of the Illinois down to the city of St. Louis at that time, from the Mississippi river and the Illinois river.

1600 I don't recollect whether the recommendations of the Board of Health made to the Mayor of St. Louis for an injunction suit in the Federal Courts against the construction of the Drainage canal whether that was the result of the analyses that I made of the water or whether it preceded this investigation. I cannot recollect at this time because it is nearly ten years ago.

Objection by Mr. Jeffries.

I made a cross-section of the waters in the Mississippi river above Grafton. I did not make a cross-section of the waters of the Illinois river before the same entered into the Mississippi river at Grafton. I made a cross-section of the Mississippi river below Grafton, at Alton and at Hartford.

1601 Five samples were taken at Alton in that cross-section. That is, whenever a cross-section was taken, five points were selected in a line across the river and the samples taken at that point. The number of days when these cross-sections were taken cover about a month—every day. The samples taken at Alton were practically taken during the same months and days that the samples were taken at Hartford. There were a few samples taken at one point I believe which the record will show. They cover the same period of time in both places. It was the month of November, 1901. I also made a cross-section at the Chain of Rocks, St. Louis waterworks. 12 samples were taken across the river on five different days from November 25 to November 30. There were some cross-sections taken from the Illinois river at points betwen Peoria and Pekin and at Pekin. No samples were taken at the mouth of the Illinois river for cross-sections.

1603 At Fort Bellefontaine on the Missouri two cross-sections were taken. Eight samples were taken across the river November 29, then again on the following day on November 30, another cross-section was taken at Fort Bellefontaine. There was no other place in the Missouri river that samples were taken in cross-sections. Alton is 16 miles below Grafton. Hart-

ford is 14 miles below Alton, and nine miles above the
1604 Chain of Rocks. The distance between Pekin and Grafton is about 140 miles. Cross-sections were taken at Pekin bridge on November 12, 16, 19, 23 and 26, 1901, two samples on each day.

1605 Q. Now in order to ascertain between the 25th and 30th of November, at the Chain of Rocks, the component constituents of the waters of the Mississippi as to whether the water there was Missouri, Mississippi or Illinois water, you would be confined to the data from the period between November 29th and 30th, would you not, as those are the only two days that the cross-sections were made in the Missouri river?

A. Well, if the conclusions to be derived from the analytical data would depend upon the cross-section—

Q. Well, doesn't the conclusion which you arrive at depend upon the cross-sections?

A. That depends upon conclusions in what respect, because I—

Q. As to the character of the waters at the Chain of Rocks in the Mississippi river?

A. Not altogether.

Q. Then what was the purpose of taking 12 samples of water across the Mississippi river at the Chain of Rocks, between the period of November 25th and November 30th daily?

A. I said that it was not dependent altogether upon those cross-sections, but the cross-sections of course gave me certain information that I wanted to obtain from the cross-sections in order to obtain facts that the cross-sections would reveal to me.

Q. Well, when the cross-sections failed to reveal the facts that you were looking for, would you go anywhere else for those facts? A. Yes, sir.

Q. Where would you go?

A. Well, I would take all the analytical data that I could obtain on that qusetion and consider them from a general standpoint as every chemist would.

1606 And what were you trying to prove by cross-sections,—these waters mixed and went into the intake?

A. Yes, sir.

Q. And if these cross-sections did not reveal that fact, then you went elsewhere to find that fact to prove that they mixed and went into the intake, did you?

A. Well, I said in connection with the general analytical result, I would take the result of the cross-sections and consider them.

Q. But you would not consider them by themselves, would you?

A. Not in determining that question entirely. I would take into consideration the total solids, which total solids were not estimated in these cross-sections that I looked for.

Q. If this cross-section made at the Chain of Rocks, at Hartford, Alton, Bellefontaine and at Pekin did not prove conclusively to your mind that the waters of the Illinois river entered the intake of the city of St. Louis, did you go any where else for any facts in order to establish that fact?

A. Well, in reviewing the analytical results from these cross-sections my views were strengthened as to the currents coming down the Mississippi at the Chain of Rocks.

Q. Then before you made these cross-sections you had views that the waters of the Illinois entered the intake tower of the city of St. Louis, did you not?

1607 Yes, sir. These cross-sections were made to confirm that view as far as nitrites and chlorines could confirm that view, because I only took cross-sections for that purpose. These conclusions that I drew were to my mind sufficiently definite to dispense with a further investigation of that problem. Those cross-sections did not establish independently the fact that the Illinois river went into the St. Louis intake. I had formed an opinion on that question prior to the taking of the cross-sections.

1608 In the Missouri river I only took two cross-sections on November 29th and 30th.

Q. Wouldn't it be fair to limit your investigations in the cross-sections at the Chain of Rocks in ascertaining the St. Louis water, to November 29th and 30th?

A. No, sir, that wasn't necessary because I had practically formed on opinion as to that question prior to the taking of those cross-sections.

1613 On the 29th of November the Missouri river itself would press the waters of the Mississippi toward the Illinois shore by the time it got to the Chain of Rocks. It will always push the water somewhat toward the Illinois shore because of the manner in which it comes down the Missouri river and during a larger part of the year this volume being quite large, it would press the Mississippi river somewhat toward the Illinois shore, it follows that if the pressure is very great and the volume of the Missouri river very large and the volume of the Mississippi river not so large, that the pressure of the volume of water would push the Mississippi so close to the Illinois shore that on such days nothing but Missouri river water would enter the intake at the edge of the channel in the Mississippi.

1614 At other times, the condition might be the reverse and then the intake being located 1,500 feet from the Missouri shore, would receive at that time nothing but Mississippi river as it comes down the river. There has been a sand-bar formed in the Mississippi river just above the intake. It can happen that the water would sweep around that sand-bar and I have seen considerable of an angle, and be pushed over toward the Missouri shore.

Q. And keep the Missouri river towards the Missouri shore?

A. Yes, push it a little more toward the Missouri shore because this water at an angle, it would come around that sandbar with considerable pressure and would press the Missouri closer toward the Missouri shore. At such times, the water in the intake would be from the Mississippi.

1615 The analytical results of samples taken at Hartford and Alton in the Mississippi river as compared with the results of samples taken at the Illinois shore opposite the intake always show by comparison somewhat less in impurities in the sample of the Illinois shore at the Chain of Rocks. That would show some mixing effect of the Mississippi and Illinois rivers at the point on the Illinois shore if the sample was taken opposite the intake.

Q. Have you made any calculations of the percentages of decrease in nitrites of the waters of the Illinois from Grafton down to Alton, in going that distance?

A. No, but there is invariably a decrease noticeable in the analytical results of the nitrites found at Alton as compared with the samples taken from the Illinois river at Grafton.

1616 Q. Do you attribute that to the mixing of the Mississippi or to the natural fermentative changes that take place in the water?

A. I think that it may be due to either cause. It is difficult to determine to which cause in all those instances it would be due. It may be due to either and the same is true for the sample found at the Illinois shore at the Chain of Rocks. I have not made an analysis of the waters of the Illinois river for a distance of 39 miles immediately above its mouth to Grafton. I do not know how much the varying changes would be for the samples taken 39 miles above Grafton on the Illinois river.

Q. Do you know whether it would be any greater than is evidenced by your analysis from Grafton to the Chain of Rocks along the Illinois shore?

A. I don't think the change would be so great in the Illinois river from the point 39 miles as you state.

1617 On what do you base that, doctor? Have you made any experiments of it?

A. Because of the fact that the Mississippi river connects with the Illinois river at Grafton and that the Missouri river connects with the Mississippi river at the mouth of the Missouri. That would change the conditions materially and bring about a different situation than exists in the Illinois river between the point 39 miles above Grafton and Grafton. I do not know what perçentage of Mississippi water and Illinois river water is in the channel of the Mississippi river at Alton. There would be a way of ascertaining it. By comparing the general analytical data I formed the opinion that there is some mixture taking place in the channel.

1618 I thought approximations would suffice for the purposes of my investigation. The same condition obtained at Hartford. I made no investigation to ascertain the amount of Illinois and Mississippi river water at Hartford. When I got to the Chain of Rocks I could, by approximations, form a conclusion as to the relative mixtures there prevailing at the Chain of Rocks.

Q. Could you take a gallon of that water in the channel of the Mississippi river at the Chain of Rocks and tell how much of that water was Missouri river water, how much Illinois river water and how much Mississippi river water?

A. No, sir, not that way.

Q. Could you anyway?

1619 A. I could by careful study of the analytical data obtained from anaylses of samples taken in the Illinois river a few miles above Grafton, above its mouth, samples analyzed as collected from points in the Mississippi river at Alton and Grafton, from the analytical data obtained from samples in the Missouri river. I have done that.

Q. Well, will you tell me what are the parts of those three rivers making up the channel of the Mississippi river at the Chain of Rocks?

A. It is impossible to make these approximations without carefully studying for every case.

Q. You have done it, then?

A. I carefully studied these analytical data. I have done so, yes, sir.

Q. Can you give me the result of your investigation?

A. No, sir. I have not those data at hand. I have done it though, taking the analytical figures.

1620 This is an approximation as applied to the different waters in the channel of the Mississippi river at the Chain of Rocks.

1622 Q. Can you mention any of the substances in the sewage that is discharged into the Drainage canal at Robey street, which are in themselves harmful to health, whether in large or small quantities?

A. Well, the analyses of the samples taken from the Drainage canal at Robey street show certain chemical conditions—the chemical analysis I am referring to now—showed certain chemical conditions of that sewage if confined to the chemical conclusions would not justify me in saying if anybody would drink that water in the Drainage canal at Robey street, after that sewage would have entered it, that it would be injurious to his health, as far as the chemical constituents are concerned, but that leaves out of the question all the bacteriological character of that sewage. There is a question of the potability of that water. It may not show any chemical ingredients that would injure anybody who drinks that water. You can drink sewage—what you call pure sewage, although impure, and there may be no pathogenic bacteria in that sewage and it may not do you any harm.

1623 The chemical analyses alone would not reveal that there are any substances in the sewage discharged into the Drainage canal at Robey street that are dangerous to health.

1624 From the tables that have been prepared on bacteria and introduced in evidence I would draw the conclusion that they disclose pathogenic bacteria as being present in the sewage at Robey street in the Drainage canal. This pathogenic bacteria is coli communis. I consider it in a measure a pathogenic bacteria. Some intestinal diseases are ascribed to the presence of soli communis.

1625 There is abundant evidence that they are found in the intestinal tracts of many individuals.

Q. Is it not a fact, doctor, and recognized by bacteriologists everywhere that the bacilli coli communis is non-pathogenic?

A. There are some authorities who will call it non-pathogenic because in many individuals it is harmless and then again, there are others who call it pathogenic because it is harmful to others.

Q. Is it not a fact, doctor, that the only way coli communis becomes harmful is when it is inoculated into the blood or into a cut and not harmful when it is taken into the alimentary canal?

A. Well, some authorities assume that standpoint. I am not an expert bacteriologist.

1630 I have not made an accurate scientific estimate of the extent of organic pollution from the Peoria distilleries and glucose works. In my investigations I took into consideration the sewage conditions of Peoria. I gave this pollution which is mentioned some consideration.

1631 The composition of the sewage from the distilleries of Peoria is a certain swill of organic matter that is cast off as refuse.

1632 This material will, in the course of time, undergo some certain chemical changes and will disappear in the run of the river into which it is discharged. I could not tell whether it will oxidize more slowly or more rapidly than household sewage.

Q. If it disappears rapidly, does it disappear more rapidly that household sewage?

A. That I could not tell.

1633 At places where the discharge is in such large quantities as in the Illinois river at Peoria and Pekin, my own eyes have shown me this swill and refuse from the distilleries. I have seen it anumber of miles down the Illinois river.

1634 Seventeenth annual report of the Health Commissioner of the city of St. Louis introduced. In 1893 by authority of the St. Louis Board of Health, I made analyses of the Illinois river. I started with the collection of three samples on October 11, 1893, at points one, three and five miles above the mouth of the Illinois.

1635 These samples were taken on one occasion only. I did not take any other samples until September, 1899.

Q. Now in the examinations that you made of the waters taken in 1893, what was the condition of the waters of the Illinois river?

A. The results showed the presence of organic matter as evidenced by free and albuminoid ammonia; the presence of nitrites to some extent and the presence of high chlorines, proved contamination of the Illinois river at the mouth.

Q. By sewage pollution?

A. Well, since only one set of samples was taken on that day and I thought that a longer series of collections should be made, I did not pass any definite conclusion at that time on the character of that pollution. In 1899 when I made examinations of the waters of the Illinois river I did draw the conclusion from the large number of samples collected that there was considerable pollution of the Illinois river at Grafton. I stated at that time that the pollution found in 1899 was of a character indicating sewage pollution of the Illinois river. One of the conclusions was that the Illinois river at its mouth was badly polluted during the entire period of investigation, from September, 1899, until the middle of January, 1900, before the opening of the canal.

1637 Q. And in that investigation, did it demonstrate conclusively the character of the pollution as to whether it was sewage or vegetable?

A. My opinion was that it was sewage pollution.

Q. Sewage pollution? A. Yes, sir.

1638 In my investigation in 1893, I found high albuminoid ammonia. I did not determine at that time the albuminoid ammonia in suspension or solution. Free ammonia was comparatively low and the nitrites were quite high in the Illinois at that time. I would not say high, but quite high, the intermediate between low and high. The chlorines were very high. In my examination of 1899, I found the albuminoid ammonia, the free ammonia, the nitrites and the chlorines to be quite high and at times again, low. Albuminoid ammonia I found comparatively high in solution. In suspension I did not find it as high throughout as I did in solution.

1639 I found the albuminoid ammonia in suspension, as compared with the albuminoid ammonia in solution lower that the albuminoid ammonia in solution, but the albuminoid amomnia in suspension was high also aside from being compared with that in solution. Sometimes it would be high but for most of the time the albuminoid ammonia in solution would be higher.

1640 During 1899 I found sometimes the free ammonia low and then again I would find it high. The nitrites the same way. The chlorines I found pretty high. From that analysis I concluded that the Illinois river as it enters the Mississippi was a sewage contaminated stream and the waters were not potable taking into consideration the reports of Prof. Long and Prof. Palmer as to the condition of the entire Illinois river valley. Taking into consideration all the information that I had at hand, I concluded in 1899 that the Illinois river was a sewage polluted stream and was not potable water. I am not acquainted with what is known as Lake Joliet, south of Joliet along the line of the Des Plaines river.

1641 Q. If Lake Joliet was two or three miles in length and from one-half to a mile in width, with a kind of peat bottom bogs, and the waters passing through would disseminate themselves throughout the lake and would only leave a slow current through the lake, would not that act as a sediment basin for the waters of the Des Plaines river?

A. It would somewhat, and the slower that current would be, the more sedimentation would take place. The faster the current would be, the less the sedimentation would be. A great proportion of the sewage going through a lake of that character would have a tendency to be deposited on the bottom of such lake or morass as it were and fermentative changes would operate in a lake of that character.

1642 Q. If it should appear, doctor, that before getting to Lake Joliet there were quite a number of acres of land over which the waters of the Des Plaines flowed, sedimentation would take place under those conditions the same as it would in the lake, would it not?

A. Yes, if the current were very slow and these low lands would retain any of the sewage that had been during the overflow deposited on the banks. If such conditions would prevail, these fermentative changes would be facilitated somewhat.

Q. While the waters were over the land would sedimentation be the only method of purification?

A. Well, since sedimentation would be one of the material forces of nature, that would bring about various stages of what we call purification. It would operate as a septic tank, for the ordinary conditions that are requisite for a septic tank would prevail there. As I said, slow flow and an abundance of anaerobic bacteria to perform the initial process of purification. I would consider a slow current a current that would have perhaps one-eighth or one-eighth of a mile flow per hour. If the current should be as high as half a mile per hour that would have some effect in facilitating sedimentation.

Q. After the waters left Lake Joliet on their way down the Illinois river, if it should appear that thousands of acres of land were inundated, low-lands, over which the water in its course traversed, what effect would that have upon the prification of the sewage laden waters of the Des Plaines river?

A. It would have some effect in distributing the sewage over vast fields there, during the overflow, and if the sewage would have some time there to remain in a quiescent state some fermentative changes would take place in the ordinary process of purification.

1643 If after traversing over these many acres of land that were inundated, it finally empties into the Illinois river, where it continuously overflows the banks of the stream in high water, that condition of purification would be facilitated whenever conditions of inundation of large areas of land would prevail.

Q. Do you know what the conditions are through which the Des Plaines river runs, from Joliet to La Salle, on the Illinois?

A. I am familiar with the conditions somewhat. I have no data or idea of the number of acres of low land between those points that the sewage laden waters of the Drainage canal run over in arriving at La Salle.

Q. Have you any idea or any information of any kind in regard to those conditions?

A. I have nothing definite in that direction.

Q. Don't you think that in order to properly consider this question intelligently, data of that character is essential? A. No, sir.

Q. Isn't it as essential to know in the Illinois river as in the Missouri?

A. It is a matter of analytical investigation as far as the character of that water is concerned, in considering the question of sewage pollution of those rivers, and if the analytical results show high figures at various points along the route that the river is traversing, it would be the most important information, and if found consecutively along the entire route, it would justify general conclusions as to the character of that water chemically.

Q. Wouldn'e it be essential, doctor—as essential in ascertaining the origin of contamination as to whether from vegetable or animal, to know these conditions obtaining in the Illinois river betwen La Salle and Lockport?

A. It is not necessary when the analytical data from the samples taken along the route demonstrate high pollution because the object of the analytical investigation is only to ascertain the character of that water as it flows along that route.

Q. Have you not repeatedly stated in your examination, doctor, that the anlaytical data, in the absence of knowledge as to the source from whence pollution came, was not sufficient to enable you to determine whether it was sewage or animal pollution? 1644

A. The source, yes, of the pollution as estimated in the analyses of the samples.

Q. And have you not stated that large areas of overflowed land eliminated sewage contamination from waters?

A. I said that it may do so under certain conditions.

Q. And is it not necessary to ascertain whether those conditions exist or not, before drawing a conslusion as to whether the elimination or the presence of the chemical constituents of the water are attributable to animal or vegetable origin?

A. If the analytical results uniformly show high impurities along the route of a river, there are various questions that come into consideration, such as the original source of that pollution, the relative proportion of pollution that might come from tributaries, the relative proportion of pollution that might come from large cities that discharge their sewage into that river. Those questions of primary importance would be considered and in explanation of the origin of the pollution if the chemical analyses enable an approximate distinction between vegetable and animal origin of the organic matter, it would be sufficient to form final conclusions on the character of that water as it traverses the route of the river.

Q. Did you ascertain all those conditions that you have enumerated?

A. In application to what investigation do you mean?

Q. Illinois river?

A. Illinois river, you mean after the opening of the Drainage canal? Q. Yes? A. Yes, sir.

Q. What tributaries of the Illinois river did you investigate for sewage pollution?

1645 I investigated practically all the tributaries that may come into consideration in determining that question. I did not make any analytical investigations of my own because I found such data published by responsible authorities, by Professor Long and Professor Palmer, that could be taken as a fair criterion for the character of those rivers and also a report published by Lyman E. Cooley in 1890.

1646 I understand that there is a large stagnant pool in excess of a mile right under the hill at La Salle. If the Illinois river there would stop its flow completely and enable sedimentation by the stagnant condition of the river there, fermentative changes producing initial purification would certainly be facilitated. I have no idea how many thousands of acres of land in the form of marshes are along the course of the Illinois river. I understand that inundations take place at times of overflow by the Illinois and Des Plaines rivers before the waters get to Peoria. Purification and sedimentation would take place on these overflowed lands the same as would take place along the shore of the Missouri river if conditions were alike in both rivers. Those conditions are, first of all, the chemical character of that water, carrying the sewage. The quantity of the sewage in that water in proportion to the quantity of water with which it is mixed, the weather conditions and several other conditions as I have explained them before, which would facilitate the fermentative initial purification process.

1647 That part of the sewage, however, that would remain in the channel would not be similarly affected. That part of the water that would overflow those areas of land would be

come impregnated with vegetable matter. What it would lose
in sewage pollution it would gain from vegetable pollution to
a certain amount. If that land had vegetation it would neces-
sarily receive accessions from that source. Vegetable pollu-
tion would manifest itself in the presence of albuminoid am-
monia and also in the color of the water and sometimes as found
in the odor of the water. Lake Peoria is located above Peoria.
When the waters pass into Lake Peoria after coming from Chi-
cago over vast swamps and marshes, through different lakes
and stagnant pools, Lake Peoria would continue the fermenta-
tive changes and oxidations of that sewage water more or less
dependent upon the size of that lake and dependent upon the
question whether there is a flow in that lake, any current carry-
ing the water through the lake rapidly and so forth. I made
no investigation to ascertain the dimensions of Lake
1648 Peoria. I don't know how large Lake Peoria is nor how
swift the current is. I don't know the source of the
Kankakee river. I know of the Kankakee marshes of Illinois,
from literature published on the subject. If it should appear
that those marshes drain into the Kankakee river, the Kanka-
kee river would carry into the Illinois large quantities of pollu-
tion due to vegetable origin at times of very high water in the
Kankakee. I deem it a matter of considerable importance to
know the number of acres of land in the form of marshes that
the waters of the Illinois commingle with and overflow before
arriving at Peoria.

1649 I tried to obtain all the information from available data
published. I did not get any specific information in re-
gard to the number of acres of land along the Illinois river that
was overflowing marshes or farm lands, except that there are
general conditions which I familiarized myself with from the
literature published on the subject. The dam at Henry is locat-
ed above Peoria. At times the flow of the Illinois river is very
much retarded at that dam as well as at the other four principal
dams which are located in the Illinois river. The retarding of

the flow of water at these places serves to elevate the water and back it up stream and overflow the banks of the river and on each side of the river at those places the land is low and thousands of acres of land are inundated by virtue of those dams. Those conditions, in a measure, act as a septic tank for the waters of the Illinois when it is backed up there and held by those dams. I didn't in my examinations endeavor to ascertain in what measure and to what extent purification would take place at those points.

1650 I think I was able to judge from analytical results from the samples taken along the route what effect the dams would have in the ordinary purification processes of the sewage in the water. I think that at times during the year some effect is due to those dams in purifying these waters of the Illinois river to some extent. That effect would be prevalent during the low water stages of the year, after the overflow had taken place, carrying the sewage laden water over those fields. That is, at the low water stage that part of the sewage that would remain on those fields would not be swept back into the river and of course the low water stages then would facilitate the purification processes.

1652 Q. During high water, there is increased dilution with a correspondingly increased current, with a correspondingly greater area of territory inundated, is that true?

A. Yes, sir. These elements may be of value but not essential in drawing a conclusion as to the sanitary character of that water as it flows in the river.

1653 I have not taken into consideration all those conditions.

Q. Would you be able to draw a definite conclusion from the analyses in the absence of any knowledge upon those conditions—a conclusion as to the condition of the water and the source of its contamination, whether vegetable or animal?

A. Yes, as far as that is concerned.

Q. Take the chlorines—could you tell to what the high chlorines would be attributed in the Illinois river if you didn't know the source from which it was derived, except by the analyses that were made of the waters?

A. These high chlorines and the high ammonias and the high organic matter in general found there, if accompanied by high nitrites would suffice to enable the conclusion that the chlorine there was due to sewage pollution. The conditions of the Illinois are different from the conditions of the Missouri.

Q. Can you tell by the chlorines whether in the Illinois river they come from vegetable or animal origin?

1654 A. Well, that would be impossible for anybody to determine as to the chlorine itself. As chlorine, I cannot tell whether it comes from mineral, vegetable or animal origin. It is not likely that you can have free ammonia, high albuminoid ammonia and high nitrites from vegetable origin. It may be possible. I think it does in exceptional cases, but not as a rule. Those conditions can not obtain in water from animal origin unless accompanied by correspondingly high chlor-
1655 ines. You could have high free ammonia, high albuminoid ammonia and high nitrites with the chlorines attributable to salt beds. You could have that condition as being derived from vegetable origin.

1656 That may be possible in some instances but it would be an exception to the rule.

1661 Q. At what times would these rivers (tributaries of the Illinois) pollute the waters of the Illinois so as to make the waters of the Illinois unpotable.

A. Well, they could do so when the stages of the river, by its tributaries, would be high, because that would sweep out whatever accretions of pollution there might have been on the banks, that would increase the ammonias. It would sweep out the deposited sludge in those rivers and that would enter the rivers. Now this would depend very much upon the character of that pollution, whether of vegetable or animal origin. I speak of pollution in general—not specifying sewage pollution. The general analytical results from those rivers demonstrate that the pollution from those tributaries disappear during the run of the Illinois river. I think that the Joliet sewage before it would reach the mouth of the Illinois would be purified to the extent that the effect of the original pollution would be of a character that while the water at the mouth of the Illinois would be pure, yet it would it would be in a much better condition than the water at the mouth is, because of the sewage of the drainage canal entering the Des Plaines river.

Q. I am eliminating the drainage canal, doctor. I am taking conditions that are based upon the elimination of the sewage of Chicago? A. Yes, sir.

1662 That would be true of La Salle and the towns located along the river there. If the water of the Illinois river when it reached the city of Peoria would be pure, it would be true that the sewage of the city of Peoria would chemically have undergone changes by the time it reached Grafton to the effect that it would not be noticed in the analytical results found in the water at Grafton, chemically speaking.

Q. Now, doctor, if your statements are properly based upon investigation and if you properly state the conditions of the Illinois river and its tributaries, as to pollution, will you explain to me how it was in 1899, before the opening of the Drainage canal, you reported to the Board of Health of the city of St. Louis, that the waters of the Illinois river at Grafton were contaminated, and not in a potable condition as evidenced here, by the report on file?

A. Because I found the water of the Illinois river above Peoria badly polluted.

1663 My chemical analyses of the samples taken in the Illinois river a few miles above Grafton demonstrated the polluted character of the river at that point and my investigation of analytical data furnished by Prof. Long and Prof. Palmer showed that the Illinois river was badly polluted a few miles above Peoria.

Q. Then if your conclusions are correct that the Illinois river was a badly polluted stream in 1899 throughout, why is it then that you conclude that the sewage of the cities along the banks and its tributaries do not contaminate the waters of that river at Grafton?

A. Because the Illinois river was badly polluted before it reached Peoria it passes those towns and simply assumes its bed character again. The Illinois river could be badly polluted and yet any pollution from the tributaries and the towns along the Illinois river could be so inappreciable that it would not materially affect the character of that river. The river in its entire course was polluted in 1899.

Q. The sewage of Chicago previous to the opening of the Drainage canal did not enter the Illinois river, did it, or the Des Plaines river?

1664 A. Yes, sir, it did.

Q. Havn't you testified that when the sewage from the Illinois and Michigan canal was pumped into the Des Plaines river that it had been operated upon by conditions such as a septic tank would give and that the sewage had almost disappeared?

A. Yes, I consider that the preliminary stage of purification had been greatly facilitated by the conditions prevailing in the Chicago river and in the Illinois and Michigan canal but I never claimed that it was not sewage any more when it was discharged from the Illinois and Michigan canal into the Des Plaines river and the Illinois river at La Salle. Why, that is still sewage as long as it is not purified in its entirety and has reached the final stage of nitrates. It is my conclusion that the Illinois river was polluted by the sewage from the Illinois and Michigan canal to some extent in 1899 certainly, and the analytical data show that. It manifested itself at Grafton by the bad condition that the water was found to be in at that point.

1665 Previous to the opening of the Drainage canal the amount of sewage entering the Des Plaines river through the Illinois and Michigan canal could not very well be estimated but the chemical analyses can show the presence of characteristic ingredients of sewage pollution that would enable an estimate of the degree of pollution of the water in the Illinois and Michigan canal with the sewage. An accurate count has been kept and published of the number of gallons pumped from the south fork of the Chicago river into the Illinois and Michigan canal at Bridgeport. The amount that is pumped each day indicates the amount of sewage that enters the Illinois and Michigan canal. It varies considerably, sometimes it may be 10,000 or 12,000 cubic feet per minute and other times, it may be 20,000 and 30,000 and as much as 40,000 cubic feet per minute.

1666 I could not tell how that compares with the amount of sewage from Kansas City, Missouri, at that time.

1667 My opinion, based upon my knowledge of the conditions prevailing in the Illinois river prior to the opening of the Drainage canal is that the sewage from the Illinois and Michigan canal does not disappear by the time it gets to Grafton. I never took any samples of Illinois river water at Peoria before the opening of the Drainage canal.

1668 The reason I am able to express an opinion on the matter is because there are data of responsible investigators at hand showing the chemical character of the Illinois river at Peoria that enable conclusions.

Q. Why is it that the sewage from Chicago prior to the opening of the Drainage canal would purify itself in running 350 odd miles when the sewage from Peoria does in going less than 150 miles?

A. First of all, I don't concede that the sewage from Peoria purifies itself from a general hygienic standpoint during that distance. I only assert that the effects of the pollution of the Illinois river from the sewage of Peoria are not discernable in the chemical analyses as far as chemistry is concerned, from the samples collected at Grafton several miles above the mouth of the Illinois—as far as chemistry is concerned.

Q. If that is true, doctor, what you have just stated, can you determine whether the sewage which you found at Grafton is Chicago sewage or sewage from Peoria?

A. It can only be ascertained what the effect of discharge of Peoria sewage into the Illinois river is on the sanitary character of the Illinois river, that is the only thing that can be ascertained.

The conclusion is justified that since the chemical analysis of samples of water taken at a point a few miles above
1669 Peoria, the chemical character shows certain conditions of the Illinois river at that point, that after the introduction of the Peoria sewage into the Illinois river, before the Illinois river reaches Grafton, the chemical character of the water at Grafton is of a certain character, comparing that character with the character found in the water above Peoria, the conclusion is justified that the effect of the Peoria sewage on the Illinois river has disappeared, and the general pollution of the Illinois river as established above Peoria continues in a measure to the mouth.

Q. Can you determine by your analysis at Grafton, if what you stated before is true—Chicago as distinct from Peoria sewage?

A. That could not be done. Nobody could do that.

Q. That includes yourself, does it?

A. Yes, sir. Hypothetically I would say that since the Illinois river showed such high pollution during its route from La Salle to Peoria, and this high pollution being found throughout all our investigations, that while the absence of sewage from Peoria might reduce that figure, it is my opinion now—hypothetically—that the pollution of the Illinois river, without the addition of the pollution from Peoria, would prevail to a sufficient extent to still render that water as found a few miles above the mouth of the Illinois, unpotable.

Q. Would it be to such an extent to the same degree under those conditions as it would if supplemented by the sewage of Peoria?

A. Well, I have already answered that question; that I said that while there might be less of pollution noticeable at the mouth of the Illinois river in the absence of pollution from Peoria, that still the pollution of the upper Illinois, before it reaches Peoria being uniformly high, as found throughout all our investigations, this pollution would still prevail to a certain extent at the mouth of the Illinois, rendering the water of the Illinois river at its mouth unpotable. As I have

1671 already testified, if the Illinois river water before it reached Peoria would be pure chemically the effect of the pollution of Peoria sewage in the Illinois river would not be discernible at Grafton. From the examinations and the sources of information I had at hand I concluded that the Illinois river was a polluted stream prior to the opening of the drainage canal. I atrtibuted that pollution to sewage pollution from the Illinois and Michigan canal. I did not investigate whether the tributaries of the Illinois contribute any pollution for 1899. I had no data to that effect.

1672 As I have testified before, when the stages of the tributaries are low, the pollution from these tributaries is inappreciable. When they are high, it may be possible that at times—when they are very high, and they sweep out considerable pollution that has accumulated in the course of the tributaries—that that pollution may have some influence in increasing the pollution found at Grafton. I do not know, off-hand, whether the sewage unconverted that emptied into the Des Plaines river from the Illinois and Michigan canal exceeded in volume and quantity all the other sewage from the tributaries and from the cities along the banks of the Illinois river between Lockport and Grafton.

1673 I think that the sewage coming from the Illinois and Michigan canal would be larger than from the tributaries and from those small cities along the route.

1680 The addition of water does not increase or decrease the quantity of polluting substance in that water.

1682 At times of low stage of the Ilinois river the sewage that entered the Des Plaines river from Chicago prior to the opening of the Illinois and Michigan canal was greater than the sewage from all of the tributaries of the Illinois river and the cities that were built upon its banks from Lockport to Grafton. I could not state how much greater, because I would have to consult the original data.

1683 I have made such calculations several years ago in preparing my report on the investigations in question here. I do not recollect how much sewage I gave to Peoria. The sewage from the city of Chicago at that time I figured hypothetically from publications by authorities who had expressed opinions on the quantity of sewage from Chicago.

Q. I asked you if any sewage from Chicago entered the Illinois and Michigan canal except at the pumping works at Bridgeport?

A. To my knowledge at this moment, only at Bridgeport.

1684 It is a fact that not a drop of the sewage from the Chicago river enters the Illinois and Michigan canal except what is pumped in there. At times of low river stages I say that exceeds the sewage polluted water that comes from all the cities lying on the tributaries of the Ilinois river which empty into the Illinois river.

1685 I have not made an estimate of the cause of the effect of the sewage of Springfield, Illinois, on the Sangamon river. It wasn't necessary. I based my estimate as to the amount of sewage draining into the Illinois river from Joliet, on the water supply of the city of Joliet. My estimate of Pekin I made upon chemical analyses of samples of the water taken above and below Pekin. The quantity of sewage from Peoria I based upon the water supply; that was to include all
1686 the sewage from the city of Peoria. I do not know directly how many tons of sewage or refuse is drained into the Illinois river every day by the distilleries of
1687 Peoria. Prior to the opening of the drainage canal the Illinois river was a polluted stream. In 1899 there was

somewhat of an epidemic of typhoid fever in St. Louis. There were 482 cases reported in November, 1899.

1688 The only other month of any year in which the number of typhoid fever cases exceeded that of November, 1899, was in 1892. I have not got the data at hand now, but it is my impression that it was October or November, 1892.

1689 No reason has been found for explaining the presence of typhoid in 1899 in St. Louis, to my knowledge. That was before the opening of the drainage canal. Since the opening of the drainage canal we have not had as many as 482 cases of typhoid in St. Louis in any one month.

Q. Then the conditions in the public health of the city of St. Louis since the opening of the drainage canal has never reached the point in typhoid that occurred for any one month in 1899. Is that correct?

A. If based upon the estimate of one month you are right. The data I get my information from, that the Kaw river runs through a salt country is "Mineral resources of the United States. Calendar year 1887. United States Geological Survey." A tabular presentation of salt deposits in the United States, published in this government publication, page 732, in the column, "Mineralogical Name."

1690 Several tributaries of the Kaw river, as well as the Kaw river itself—the Kaw river being 300 miles long—drain through several of these counties which are mentioned here as having salt deposits. I have no other sources of information on that subject from literature.

1691 (Wtiness states what potable water consists of.)

1693 (What is potable water, or not, depends upon public health statistics.) If the public health statistics show that the water does not have any injurious effect upon the public health, such water can be considered permissible.

1694 DR. WILLIAM C. TEICHMANN, re-direct examination by Mr. Jeffries: Information I have, aside from literature and geological reports, that leads me to believe that the Kaw river runs through salt laden territory consists of the results of chemical analyses made of samples of water collected from the Kaw river. Assuming that the waters of the Illinois river have been condemned as unpotable; that the immediate tributaries of the river have likewise been condemned as unpotable and assuming the fact that the effect of the waters of the Illinois river on the Mississippi at their junction, or at any point below their junction did not render the Mississippi unpotable prior

1695 to the opening of the canal, the effect of the opening of the canal carrying the Chicago sewage into the Illinois river, upon the Mississippi river water, from my chemical analyses, was a polluting effect and rendered it unpotable.

RE-CROSS EXAMINATION by Mr. Todd:

If water is unpotable the addition of additional sewage will render it more unpotable. The increased pollution caused by the entrance of the Drainage canal into the Illinois river would, of course, have an increased effect on the public health of such community as would use that water for a water supply.

1696 Q. If the people thought that they wanted to use that water and did use it, it would be potable for all practical purposes, would it not?

A. You mean after the increased pollution? Yes, sir.

RE-DIRECT EXAMINATION by Mr. Woerner:

I meant, in answer to the last question asked by Mr. Todd that the potability of the water could only be judged by its effect on the public health. I determine the potability by chemical analyses and a general consideration of the analyses from a chemical and bacteriological standpoint. That is a theoretical way. The practical way would be to judge its effect on the public health.

Q. Has the people's judgment anything to do with the potability of water?

A. Well, the experience of the people in drinking the water may enable them to form an opinion.

1697 A chemist without knowledge of local conditions from analyses can not pass upon the potability of water in streams.

PROF. EDWARD H. KEISER, resumed the stand for further direct-examination by Mr. Jeffries:

1698 I have made an examination from data furnished me by the Board of Health of St. Louis of the condition of the water supply of St. Louis subsequent and prior to the opening of the Drainage canal. In the first place I tabulated all the analyses that were made of the waters of St. Louis prior to the opening of the Drainage canal and I find that the records go back to the year 1894.

1699 (Gives results of analyses made prior to the opening of canal.) Comparing these averages obtained in different years, we see that there are but very slight changes in the character of the water supply at St. Louis. The free ammonia ranged between .019 and .063 parts per million. The nitrites varied from .002 to .005; the albuminoid ammonia from .310 to 1.033, and the nitrates were practically constant. The maximum value for free ammonia before the water of the Drainage canal reached St. Louis was .138 on January 21, 1900, and for nitrites the maximum value was .01 on the same day. These analyses that are recorded prior to the opening of the canal show that the water was comparatively stable, and that it was not an unwholesome water compared with its present condition.

1700 (Witness gives results after opening of canal.)

1701 A portion of this great increase in free ammonia and nitrites noticed in February and March, 1900, may have been due to the fact that in the winter months, impurities are usually found to run higher than in spring and summer. (Witness reads table showing results for free ammonia, nitrites, albuminoid ammonia, nitrates and chlorine for various months in 1900 and 1901.)

1702 Comparing the average results for this table with the average results before the opening of the canal, we see that there has been a very decided increase in each of these forms of nitrogen and that the chemical analyses show a permanent pollution of the water.

MR. JOHNS: I move to exclude the entire answer of the witness to the last interrogatory as argumentative.

In looking over the statistics of the Health Department of the city of St. Louis I found 11 analyses of water of the Missouri river at a point above the mouth of the stream, are on record.

MR. JOHNS: I object to the announcing of results of those analyses and the average of them, on the ground that it is all of record, as testified to by the witness.

1703 Witness gives table of average results of analyses of Missouri river water made by city chemist until October 10, 1900, and also during period October 1, 1901 to November 30, 1901.

MR. JOHNS: Same objection.

Comparing these averages now, with the averages of analyses before February 1, 1900, we see that there is but a
1704 slight difference in the average condition of the Missouri river during these two periods. In other words, the Missouri river during the period of September 2, 1899 to November, 1901, has undergone no permanent change in its sanitary character. We see from these that while St. Louis water had undergone a marked deterioration, the Missouri river water had remained unchanged. (A reference to these tables will show that the Missouri river did change, and that there was not much of a change in the Mississippi water at the intake.) It is true that in the winter months the impurities in this river (the Missouri) are higher than in the summer. This is true of all streams, but we see that in the fall of 1901 the water had again returned to its former condition. These results show then, that the increase of impurities in the St. Louis water did not come from the Missouri river.

MR. JOHNS: I move to strike out the entire answer as an argument.

1705 Witness reads average of analyses made of Mississippi river water by health department, of 17 samples collected at Hartford, one mile above mouth of Missouri river. Samples were collected between August 3, 1899 and December 4, 1899. Also averages for same point from daily analyses of samples taken from January 23, 1900 to October 10, 1900, and from October 1 to November 30, 1901. (Witness averages both series after the opening of the canal. A reference to the results on pag 1705 will show that the average for 1901, after the canal had been opened a year, are much lower than right after opening of canal.)

Comparing these results with the average condition of the Mississippi river at the same point before the opening of the canal we see that there has been a permanent increase of the pollution of the water.

1706 The water of the Mississippi, like that of the St. Louis intake, has been very materially inferior in sanitary quality since February, 1900, and further, these analyses show that since the St. Louis water is a mixture of the water of the Missouri and Mississippi, the increased impurities of the St. Louis water must have come from the Mississippi river and not from the Missouri river.

MR. JOHNS: I move to strike out the latter part of the answer as an argument.

Between September 6, 1899 and January 17, 1900, 18 samples were collected from the Mississippi river at a point above the mouth of the Illinois river. Daily analyses were made from January 23, 1900 to October 10, 1900, and from October 1, 1901 to November 30, 1901. (Witness gives results of these examinations.)

Comparing these with the results as given, we see that
1707 the Mississippi river above the mouth of the Illinois, while higher in impurities in the winter months, returned in the fall of 1901 to a condition very similar to that which it was in 1899. Plainly, then, the upper Mississippi river is not the source of the impurities that pollute St. Louis water.

19 samples of water of the Illinois river from a point 3 miles above Grafton we re-collected and analyzed by the city chemist at intervals between September 6, 1899 and January 17, 1900. (Witness gives average values.)

THESE RESULTS SHOW THAT AT THIS TIME THE WATER WAS BADLY POLLUTED AND NOT FIT FOR DRINKING ACCORDING TO ACCEPTED STANDARDS. (This was before opening of canal.) From January 23 to October 10, 1900, averages were as follows (see 1707). For October and November, 1901, the averages were as follows (see 1707.)

1708 (Witness then takes averages for both series taken after opening of canal and compares with one series taken before opening.) We see from these that for the ten months since the opening of the Drainage canal there was an increase in free ammonia of nearly 27 per cent and of nitrites 167 per cent. We can only conclude from these figures that after the canal was opened there was a much larger quantity of sewage undergoing putrefactive changes than before 1901. The analyses have shown that both the Missouri river and the Mississippi river above the Illinois have undergone no permanent change but the Illinois river has been rendered more impure as a result of the opening of the Drainage canal. (A proper comparison would be the results obtained prior to opening of canal with the period of October and November, 1901. During the year 1900 the accumulation of sewage was being carried through the canal—this sewage having accumulated before the canal was opened. Such a comparison would be as follows:

From September 6, 1899 to January 17, 1900: Free ammonia, .215; nitrites, .012; albuminoid ammonia, .553; nitrates, .8; chlorine, 25.0.

For October and November, 1901: Free ammonia, .110; nitrites, .043; albuminoid ammonia, .373; nitrates, 1.71; chlorine, 21.0.

This comparison shows less free ammonia, more nitrites, less albuminoid ammonia, more nitrates and less chlorines in the samples prior to opening of canal than after opening of same. Increased nitrates means an advanced state of purification. Therefore the water is much better after the opening of the canal than it was before with the exception of higher nitrites.)

There were no analyses of the water of the Illinois river at points above Grafton made by the city chemist before the opening of the canal. But from January 23, 1900 to October 10 of the same year, daily samples were taken at a point three miles above Peoria and occasional samples at Joliet and at Lockport. These
analyses show that as we ascend the river from Grafton
1709 to Chicago, the water becomes steadily more and more
impure. (See average results of analyses at Grafton, Peoria, Joliet, I. & M. canal, Drainage canal, Lockport, Bear Trap dam and Lake Michigan.

1710 Q. Now, what conclusions do thes results show, or lead you to?

MR. JOHNS: I object to the question, as the conclusions have already been testified to and are not, at any rate, competent evidence.

A. We see that the entire Illinois river is in a highly polluted condition. Going down to Grafton, we find that the free ammonia has fallen, but still is far from being in a condition fit for drinking. We see that the oxidation and self-purification processes become very slow as the concentration of the sewage is diminished, and for the same reason we find these impurities in the water of the Mississippi and the water of the St. Louis water works.

MR. JOHNS: I move to exclude the answer as an argument.

(Comparisons shold be made of the average results shown as testified to by this witness from page 1697 to page 1710.)

CROSS-EXAMINATION by Mr. Johns:

1711 As to these samples taken in 1903 and 1904, I have no
knowledge as to how they were taken or analyzed except as stated in the report of the Water Commissioner of St. Louis for 1894, page 418. The samples of water referred to in Ap-

pendix I, annual report of the Water Commissioner for year
ending 1894 were taken at St. Louis intake, but I don't know
what time elapsed after the taking until they were analyzed.
I do not regard the St. Louis intake the same thing as the dis-
tributing well, but the water is very much the same. The
samples upon this paper (appendix) which I enclose in pencil
mark, are from the distributing well and from the clear
1712 wells. As to any of these samples in the paper described
in Group D and Group C, I cannot tell at what time they
were taken either from the distributing well or from the clear
wells, or how long a time elapsed until they were analyzed after
they were taken. I do not know anything personally in refer-
ence to the manner in which those samples were kept or the plan
by whcih they were analyzed, except what I have read in that
report. In reading of these results I do not state the amount
of oxygen consumed, simply to make the report concise and
not to overburden the report with the table of figures. There
was a statement of total solids as to those samples of May 2,
1893, to January 24, 1894, in group D, and from April 14, 1893,
to January 24, 1894, in group C. I did not state the solids,
simply because it would throw very little light on the sanitary
condition of the water. I regard the question of solids
1713 in solution as having very little to do with the potability
of the water. There were no statements in the report of
chlorines. I would be able to give an opinion as to the sanitary
condition of the water without a knowledge of the chlorine.
In order to determine the potability of water there should be
taken into consideration the chlorines; the oxygen consumed
is not always taken into consideration; it assists in form-
1715 ing an opinion. I have no personal knowledge of the
samples taken in 1892 to 1904, nor of those taken from
September 9, 1899, to January 22, 1900. I have taken the figures
from the tables furnished by the city chemist. I do not
1719 know anything personally as to the eleven analysis of
water taken from the Missouri river above its mouth from
September 2, 1899, to December 4, 1899. I did not give the

oxygen consumed nor the chlorines because it would have
lengthened this statement very much. The chlorine is not of
any importance in the Misouri river, because the Mis-
1720 souri river is highly charged with chlorides which is of
mineral origin. I have no knowledge of that, only in so far as
the analyses show this water comes from the Kaw river. I
have no personal knowledge as to the Kaw river. The results
as to that water enable me to form an opinion that it is a fair
drinking water—not above suspicion, but still it is drinka-
ble. I come to that conclusion without reference to the solids
in solution or suspension or chlorine or oxygen con-
1721 sumed.

Q. Referring to the sanitary condition of the Mississippi river between August 3, 1899, and December 4, 1899, having free ammonia, .107; nitrites, .004; albuminoid ammonia,, .622; nitrates, .5, is that water potable?

A. I should say that was unsanitary water and water that had reached the limit. It shows so much impurity in that water that it ought not to be used for drinking purposes.

Q. Would you consider water having the following parts, namely: Free ammonia, .107; nitrites, .004; albuminoid ammonia, 622, and nitrates, .5, a potable water? A. No, sir.

Q. Now, that was the average condition of the Mississippi river as given in your tables, before the opening of the canal?

A. Yes, at a point above where it mixes with the Mis-
souri. As a chemist and without reference to this ques-
1722 tion, if I had been called upon to analyze a sample of
Missouri river water, not knowing that it was Missouri
river water, considering the high chlorine in that sample, I
would have been inclined to condemn that water as unpotable.

RE-DIRECT EXAMINATION by Mr. Jeffries:

1725 These (indicating paper) are the printed analyses of
the water taken from the distributing well and the
settling basin of the St. Louis waterworks in 1893.
1726 This paper is from the annual report of the Water Com-

missioner for the year ending April, 1894. The system used in making this examination is stated on the next page in the report. I have read the methods described in this report, and they are the usual standard methods used in analyzing water.

(Page offered as complainant's Exhibit 36.)

MR. JOHNS: I object to the paper with the proposed addition, as it is not a public record and not such a publication in any event as becomes competent evidence.

The first one of these two papers (indicating) give the result of twenty-one analyses of samples of St. Louis water, made from December 15, 1892, to April 20, 1894, in the chemical laboratory of Washington University. That was tap water. (Offered in evidence as complainant's exhibit 37.)

MR. JOHNS: Same objection as made to exhibit 36.

1728 This sheet contains results of daily analyses of water from the Missouri river at Fort Bellefontaine from January 23, 1900, to February 1, 1900. They were made under my direction in the chemical library of Washington University. (Offered in evidence as complainant's Exhibit 38.) 1729

MR. JOHNS: Same objection as made to Exhibit 36. These twenty-eight sheets of paper (indicating) contained the records of analyses made by the city chemist of St. Louis of samples of water taken in the Misouri river at a point above its mouth in 1899, 1900 and 1901, and at the intake tower, Mississippi river, at Hartford, Mississippi river at a point above Grafton; Illinois river at a point above Grafton, all the above for the years 1899, 1900 and 1901, and for the Illinois river at a point three miles above Peoria, at Lockport and Joliet, in the years 1900 and 1901, and of the water of the drainage canal in 1900, and of the Illinois and Michigan canal in 1900, and of Lake Michigan in 1901. Some are the daily analyses and the weeklies have been added on the bottom, and some are the 1730 weekly averages. Mr. Miller and Mr. Getz, together with the city chemist, prepared them. (Offered in evidence as com-

plainant's Exhibit 39.) The evidence which I gave this morning was based on complainant's exhibits from 36 to 39, inclusive. The averages to which I testified this morning were cal-
culated from the data contained in those tables. The
1731 water analyzed within the days mentioned in Exhibit 37
came from a place known as Bissell's Point, before the
1732 removal of the intake to the present location at the Chain
of Rocks. I think this water which was analyzed had passed through the settling basins. I am not certain, because I was not a resident of St. Louis at that time. As to the derivation or character of the samples of water out of which the results in Exhibit 37 are tabulated, I know nothing.

J. L. VAN ORNUM, examination by Mr. Jeffries:

1733 Live in St. Louis; am professor of civil engineering at
Washington University at present. Graduated in 1888
at University of Wisconsin. In March, 1903, I made in-
1734 vestigations to determine the time it will take for water
to flow from Chicago through the drainage canal, the Des Plaines river and the Illinois river and the Mississippi to the water works intake at St. Louis. Investigation was intended to be divided into three sections, one from Chicago to Peoria, another from Peoria to Grafton, and a short and third section from Grafton to the water works intake. The character of the weather and the conditions of the rivers concerning driftwood made it impossible to follow the floats except during the daytime. The floats were taken out of the water during the night, and their progress was followed and watched from the point where they were taken out the day before continuously during the day until they were taken out again.

1735 The floats used were what is technically known as submerged floats—that is to say, a lower portion consisting of curved vanes so that in whatever position the vanes turned there shall be a considerable area exposed to the force of the current. This is connected by as light a chain as is practicable, to a portion floating on the surface of the water, which offers buoyancy enough to cause the whole affair to float.

1736 The submerge dportion below the surface was one foot, two feet and three feet and those used on the Mississippi this distance were regulated to be about two, four and six feet respectively. The work was first begun on Saturday, March 14, 1903.

1737 I had personal knowledge as to the results I am about to testify to—as to a part of them. I followed some of these floats myself. Others were reported to me by the parties who did follow them.

MR. TODD: Now I want to interpose an objection to the testimony of this witness in regard to all the other floats that were followed by other parties than the witness himself as being incompetent. I learned from the field notes submitted to me and verbal reports given by the observers that on March 15, the party starting in the Drainage canal placed the floats in that canal at Western street bridge following them on that day to the C. & C. T. bridge during a time of 7 hours and 59 minutes. The floats were left in the water during the night and it was the intention to overtake them in the morning but before they were overtaken it was found that these floats had been removed from the canal. It was, therefore, necessary to resume the observations over that same distance of the canal which had been covered by the floats during the night.

1738 The time consumed was a total of 33 hours and 46 minutes from Western street bridge to the Bear Trap dam at Lockport. These floats were not started at Robey street. This omitted distance is about 2,800 feet and we should add about 40 minutes to the total time above given, which would probably make the time from the south branch of the Chicago river to the Bear Trap dam as about 34 hours and 26 minutes. The gauge at the Bear Trap dam when this point was reached read minus 2.3 feet, and the depth of water flowing over the dam was 4.4 feet. This is said to correspond to the discharge of 295,000 cubic feet per minute, or about a normal flow.

1739 The time from the Bear Trap dam from Joliet was observed to be 2 hours and 15 minutes. On the 17th, the observations were carried from Joliet to a point marked by a flag on the bank, two miles above a certain place where they stopped over night. The time here was 3 hours and 36 minutes. On March 18, the floats were followed from this same point to another marked point, one mile above the DuPage river, the time being 3 hours and 6 minutes. At about this point practically all the floats which were made and which were of the character I have described, were lost. To provide against the necessity of giving up the observations entirely, temporary floats were devised which were used in connection with those remaining floats of the character with which they were provided, and were run continuously and alongside of them. Fortunately these submerged floats remaining were not lost and it was only from Chillicothe to Peoria that the temporarily devised floats were used entirely. On the 19th the floats were observed from this point one mile below the DuPage river to Morris, during the time of 7 hours and 54 minutes. On the 20th, the time from Morris to Seneca was 5 hours and 2 minutes, and from Seneca to Marseilles, without any interruption at Seneca, 2 hours and 15 minutes. On the 21st, the floats were observed from Marseilles to Utica, the time from Marseilles to Ottawa being 2 hours and 7 minutes. From Ottawa to Utica 3 hours and 36 minutes.

1740 On the 22d, from Utica to a point at Depue, the time from Utica to LaSalle being 2 hours and 28 minutes; from La Salle to Peru 58 minutes; from Peru to Marquette 5 hours and 6 minutes; from Marquette to the point at Depue 1 hour and 1 minute. A total from the Bear Trap dam at Lockport to Peoria of 102 hours and 26 minutes. From Peoria to Pekin, 4 hours and 30 minutes. For clearness, I will say that my personal observation of the floats of this party was only the starting of them.

1741 From Pekin to Kingston, 3 hours and 17 minutes, the total time from Peoria to Grafton, 102 hours and 27 minutes.

1742 I, in person, observed floats in the Mississippi river from the point at Grafton where the observations were discontinued as described, through the Mississippi river to a point opposite the St. Louis waterworks intake. The time from Grafton to Alton was 6 hours and 36 minutes and from Alton to the intake tower, at the Chain of Rocks, 4 hours and 34 minutes. The total time from Grafton to the waterworks intake was 11 hours and 10 minutes. This makes a total time as observed from Lockport opposite the Bear Trap dam to opposite the waterworks intake, at the Chain of Rocks, St. Louis, of 9 full days and 3 minutes and as I have said before, including the 40 minutes calculation, about 34 hours and 26 minutes through the Drainage canal, or a time noticeably less than ten and a half days from the south branch of the Chicago river to opposite the waterworks intake at the Chain of Rocks. These floats of the submerged character that I have described are those ordinarily used by civil engineers to determine the velocity at a certain depth.

1744 The Mississippi was at about half stage, that is the gauge readings at that time indicated the heighth of the river about one-half its extreme flood stage. The reading at Grafton on the morning of the day when these observations were taken, was 16 feet. The reading of the St. Louis gauge on that day was 24.3 feet. The wind on that day was in general up stream, never having a component down stream; sometimes the wind coming partially from one side and sometimes from another—the windings of the stream making the wind vary from one side to the other.

1745 The velocity of the wind varied probably from about 5 to 12 miles an hour. The floats were placed in the lower end of the Illinois in such a way that they spread across the river, one in the center, one about half way from this one to the right bank and one about half way from the center one to the left bank.

1746 That was in the mouth of the Illinois river. As they flowed into the Mississippi they moved closer and closer to the Illinois shore of the Mississippi and in a general way, from the Illinois river to below the mouth of the Missouri, they were more or less close to the Illinois shore, sometimes in the extreme going to the middle of the Mississippi, but most of the time being within three or four hundred feet of the Illinois shore. At about two miles above the waterworks intake, for instance, the floats were quite close to the Illinois shore, probably about 50 feet from it, but from this point on down to the waterworks intake, the floats rapidly left the Illinois reaching the middle of the Mississippi and finally passing the waterworks intake, between the intake and the Missouri shore—all of them and somewhat closer to the Missouri shore than to the intake. The distance from the Missouri shore to the waterworks intake is about 1,500 feet and from that I judged that the floats passed the intake about 700 feet from the Missouri shore.

CROSS-EXAMINATION by Mr. Johns:

The stage of water in the Des Plaines river is very fluctu-
1747 ating. The guages were read by these engineers as they
passed them wherever they saw them, but beyond that I know nothing about it. I have been unable to get such readings. I have no exact knowledge of the stage of the Des Plaines river as to the time that these floats were in the river. The river was high. At the time the floats were placed in it the Illinois river was high—it was very high. The bottom lands and the overflowed land along the Illinois river was very ex-
1748 tensive.

It may be that the river was sometimes four or five miles wide, in very high water, from waterline to waterline. The ordinary banks of the river at all places were overflowed, the water extending out into the bottoms. In the Des Plaines river five floats were put in at one time. They were put in at the same places and at the same time. We had floating down the Des Plaines river, under observation at the same time, five different floats—that is, through a portion of it, but from time to time the floats were lost, so that before reaching the mouth of the Des Plaines river I believe that one or two more had been lost. The plan was to distribute them across the channel por-

tion of the river. By channel I mean that part which is the swiftest moving water, as near as could be judged. I had in the Des Plaines river floats of different lengths, one to three feet. I continued that also in the Illinois river. As a
1749 rule the longer floats were placed in deeper water, in the center of the channel. When these floats were placed in the water on a cross-section of the river I understand that the tendency was towards separation, although there was nothing very marked to be observed in that direction. The stage of river throughout our observations in the Des Plaines and Illinois being in a condition of overflow caused them to rather seek the banks. Quite often it was found that they were aground; then they were released and taken back.

Q. Did those floats in the Des Plaines river keep abreast of each other if they were floating rapidly?

A. That would depend largely upon the wind, sir, whether they would keep abreast of each other or not. In general they would keep abreast of each other.

1750 As to which one would advance more rapidly, that would depend whether the wind was more up stream or more down stream. In general the wind was more than otherwise up stream, or had a component up stream, which would affect the shorter float more and hold it back. I could not say whether the direction of the wind would have a considerable effect upon the direction in which the floats went down the river. The effect would be small compared with the effect of the current, of course, but it would have a certain effect. Of course it was generally noticed that during a half day's or a day's run that the floats would work toward the leeward side of the
1752 river.

It is a fact, as a general observation, that the float nearest the center of the channel traveled most rapidly. The floats nearer the shore were much slower.

1753 Whenever I have mentioned a time here that the float was taken out it was the time of the arrival of the most advanced float at that point. The total time of nine days and three minutes is the fastest time that these floats made down the Illinois river. I have no knowledge of how rapidly the current flowed at the side or the banks of the Ilinois river, except for one portion between Peoria and Pekin, when I simply observed a very slow current at the side of the banks of the stream. I haven't any doubt it was less than a foot a second and very much less.

Q. So that all your observations have determined is the quickest time of the most swiftly flowing water from Lockport to Grafton?

A. Under conditions existing at the time the observations were made, yes, sir.

Q. Isn't it true that the current of the Illinois river at the time of these observations was very much swifter in its channel than at the ordinary stage of the river?

A. I suppose it is.

Q. Is it not true that it was very much swifter than at the low stage of the river?

A. Undoubtedly.

1754 The Mississippi was at about half its flood stage.

1755 The lowest water known at St. Louis was 2.5 feet below the zero of the St. Louis guage. In a straight piece of river the center of the channel is that part of the river in which the flow is swiftest. If it is curved it is swifter toward the concave bank and sometimes very close to the concave bank.

In general the water on the surface flows slower than that
1756 two feet below.

The longest chain I used on a float in the Illinois river was three feet and the shortest was one foot.

1757 In the mississippi river these floats hugged the Illinois shore below the entrance of the Missouri river to two miles above the waterworks intake, then above the intake they started across the river. Ther were only two then. We started with three, but the chain parted and one was lost below Alton. I think from Alton down there were only two. About two miles above the intake both floats were about fifty feet from the Illinois shore. One of the chains to these floats was six feet long and the other four feet.

1758 I am wrong in what I just said. The floats were about fifty feet from the Illinois shore at a point where the Missouri river enters the Mississippi. A mile below this point both floats were three or four hundred feet from the Illinois shore. Two miles below this point the red, No. 5, which is the six-foot float, was 200 feet from the Illinois shore and the four-foot float was 400 feet or thereabouts from the Illinois shore. In passing the upper end of Chouteau's slough, still nearer the water works intake, the four-foot float was 600 feet or thereabouts from the Ilinois shore, and the six-foot float was about 100 feet in the rear and about 100 feet from the Illinois shore, and just below that the six-foot float kept moving still further toward the left, and was about to pass at what is called by river men the chutes —that is a passage to the eastward of the island opposite the intake, and was pulled out of the water and put in again opposite the four-foot float, which had not been disturbed, and about sixty feet to the left of it. That is, sixty feet toward the Illinois shore from the four-foot float. That is below the Madison Point light; and still the six-foot float kept working off toward the left and moving toward those chutes, as they are called, behind the islands, to the east of them, and was pulled out again and put in abreast of the four-foot float about sixty feet toward the Missouri shore—at this time, from it. From that time on they both kept on very closely together, the six-foot float, however, lagging behind, but with reference to the shore they seemed to keep or work toward each other, and crossed opposite the intake at about the same distance from the shore. That is to say, the red was disturbed twice; the six-foot float was disturbed twice between Alton and the water works intake. The four-foot float was not touched.

1759 When I say that the floats were close to the shore at a point where the Missouri river enters the Mississippi I mean that the floats passed the mouth of the Missouri river at Missouri River Point, as it is called on the river, at about fifty feet from the Illinois shore of the Mississippi river—that is, the left bank of the Mississippi.

1760 The Mississippi at that time was at about a half stage, and so was the Missouri. At the lowest guage I could get on the Missouri on this date the reading was 15 and one-half. This is at Hermann. The high water is 35.6, indicating very much the same thing as the stage of the Mississippi. The Missouri river where it enters the Mississippi was very wide at this stage. The floats kept along very steadily. They were aparently so close to the Ilinois shore that they were not affected at all directly by the inflow of the Missouri river.

1761 I don't know of any dikes in the river along the Ilinois shore oposite the mouth of the Missouri river and below that down toward St. Louis. If there were such dikes they would, to an extent, affect the direction or velocity of the current for such a stage as I have described. The floats passed the intake itself on the west side and between that and the shore.

1762 I took them out immediately below as soon as I could get them after timing them as they passed. Both the floats went over there, one of them, as I have stated, however, being removed and put in again, which destroys any significance that may be attached to it.

I should think it is 5 or 6 miles from the mouth of the Missouri to the Chain of Rocks.

1763 In another mile or two the four foot float was somewhat farther from the Illinois shore—perhaps 600 feet and the six foot float was still closer to the Illinois shore, or about 100 feet from it perhaps. This was at Chouteau's slough, that is about three miles below the mouth of the Missouri river. The Mississippi at that point between its normal banks I think is about three-fourths of a mile wide.

1764 It is practically four miles from Chouteau's slough to the intake, by the course followed by the float. Now below the point where the six foot float was about to go into Chouteau's slough, there is a sand-bar or island. In low or medium stage it is quite a large island and the general current of the river goes around to the left of the island, as you go down the river. It certainly must be the general current of the river at low water when there is practically no flow here and the course of these floats indicated it to be the case at medium stage.

1765 If the red float had not been interrupted, it would have gone through Chouteau's chute, as the river men call it. I was afraid of it. If it had done so, it might have gone below and to the left as you go down the river, of three other islands or two other islands, between that and the Chain of Rocks. That float might have gone to the left of three islands between Chouteau's slough and the intake, if it had not been interrupted at that time. There was a decided current that way and in order to prevent it going that way, I took it out of the water and placed it in the same channel of the Mississippi.

1766 The general direction of the Mississippi river from Chouteau's slough to the Chain of Rocks is very crooked in that vicinity. Its flow at Chouteau's slough, as I recollect it, is about southwest and from that direction there is a gradual curve until at the Chain of Rocks I believe the Mississippi river flows nearly south.

CROSS EXAMINATION by Mr. Todd:

1767 I did not make any investigation as to the volume of water coming down the Illinois river at the time this ex-
1768 periment was made. At the time these experiments were made, the river was much higher than the average condition of the river. In fact, it was overflowing the low lands. The necessary accompaniment of that fact is that the current was swifter.

1769 Q. If the water was six to ten feet above the crest of the dams at Henry, Copperas Creek, LaGrange and Campsville, at the time you made the experiment that would indicate that there were flood waters in the Illinois river.

A. It is a fact that at the time the experiment was made
there was a great amount of flood water in the Illinois
1770 river. My experiments were based upon conditions when
the river had fallen. It had passed its crest, the highest
water had occurred shortly before the observations were taken.
So as a general principle I can say that the length of time occupied and recorded here is probably greater than it would have
been if the observations could have been made when the river
was at the same stage but still rising. I do not know what
1771 the proportion of water in the channel was to the water
in the Illinois river outside of the channel. As far as I
1772 saw the water in the basins beyond the banks of the river,
or rather the water in the basins of the overflowed lands
had a barely perceptible current. As far as I saw it it was
practically in a stagnant slow condition.
1773 From my observations in this experiment I am not able
to tell what the velocity of the current would be if the
Illinois river was contained within its banks. The condition
that I found in the Illinois river does not obtain the year around.
I don't suppose it will obtain for a period of six weeks during
the year. I have no idea whether it would obtain for three
weeks. I presume the experiments I made would apply to the
Illinois river for a period not to exceed six weeks throughout the
year. The reading on the gauge at Peoria was 19.1 feet. The
way to interpret that reading would probably be by stating that
the low water reading for Peoria is 2.6 on the same gauge and
that the highest water previously on record is 21.9 feet.
1775 My experiment only serves to prove the velocity of the
current at a time and under the conditions that existed in the
Illinois river at the time that the experiment was made.
1776 The water of the Mississippi from Grafton to the intake
at the time of the experiment was what is known as high
1777 water. As to the sand-bar in the Mississippi heretofore
testified to, I understand that at low water stages, very
little, if any, Mississippi water passes to the left of the same.
There is a channel to the left of the sand-bar that were are talk-

ing about in the Mississippi river. The three islands south of the sand-bar were submerged when my observations were taken.

1778 After I left Joliet, some of the floats were lost again, mostly from floating into the woods from the side channels which are full at high water. That indicated that the waters of the river separated wherever there was an opportunity to do so and the current is more or less dissipated and the water went over and submerged the lands.

1779 RE-DIRECT EXAMINATION by Mr. Jeffries:

This chart is a tracing I had made to show the point at, or figures of time of the flow from really the Chicago river to the St. Louis waterworks intake, embodying graphically what was given in the figures this morning. It was prepared by me. The figures, for instance, were taken from tables furnished me by different United States engineering officers. (Said map marked complainant's Exhibit 40.)

1780 MR. TODD: I object to the map being introduced.

1782 RE-DIRECT EXAMINATION, by Mr. Jeffries:

That is a graphic representation of the gauge reading of the Mississippi river at Keokuk, Grafton and at St. Louis during the month of March, 1903, and at Hermann, Missouri, for the Missouri river for the same time. I prepared that from figures furnished to me by the weather bureau and in the case of Keokuk, by the figures furnished directly by the gauge reader.

1783 (Chart offered as complainant's Exhibit 41.)

This is a chart prepared by me showing the gauge readings in the Illinois river during the month of March, 1903, at Peoria, Beardstown and Grafton, Illinois. This was prepared by a table furnished by the weather bureau also. (Offered in evidence as complainant's Exhibit 42.)

MR. TODD: I object to both charts being offered as not competent and not prepared from any data which has been verified and known to be correct.

1784 The wind as it existed during these observations in its effect upon the float was not sufficient to drive it or carry it to the westward of the intake, supposing, of course, that without wind it would have gone to the eastward of the intake. I say it is very evidently the case in the first place, and it must be said that the wind does have an effect on the float, because it reaches the unexposed portion of the float, and the amount of that effect is a matter of computation, depending upon the circumstances existing. (Witness gives details of computation on which he bases his answer.)

1786 If there had been no wind, according to my conclusions, this four-foot float would probably have passed 450 feet to the westward of the intake instead of 800, as it did.

1787 Foat, white, No. 5, on which I wrote my name at the time it was used in the Mississippi river, is the one that passed, as I stated, about 800 feet west of the intake before it was taken out. (Offered in evidence as complainant's Exhibit 43.)

RE-CROSS-EXAMINATION by Mr. Todd:

At the time this experiment was made the water was wavy. I calculated the velocity of the wind simply from being obliged for a great many years to arrive at that from observation only. I did not have an instrument.

1790 The velocity of the wind that I give is an estimate.

RE-CROSS-EXAMINATION by Judge Springer:

1792 When I made these observations I was in a steam launch in the vicinity of the floats all the time. I got the measurements as to the relative distances from the shore of these lines by estimation, by eye and by experience in that class of work a great many years. I had no actual location or measurement. I made only one experiment between Alton and the intake as to the velocity of this float.

1793 The wind was blowing in a general direction from the southeast, that would make the waves move across the current of the river in a northwesterly direction. The force of the waves, whatever it might have been, would be to crowd the float northwesterly and therefore toward the Missouri shore.

C. V. MERSEREAU: I made observations of the
1794 velocity of the water in the Chicago drainage canal and
the Des Plaines river under the direction of Prof. Van Ornum. These observations were begun on Mach 15 and ended on March 26, 1903. For part of the work we used floats similar to the one exhibited here. Part of the time we used a float that was made of a white pine picket, about one and one-eighth of an inch square, on the bottom of which were nailed two pieces of tin, bent at right angles so as to resemble those floats.
1795 About 9 o'clock on March 16 the water guage of the Bear
Trap dam at Lockport was 4.4 feet.

CROSS-EXAMINATION by Judge Johns.

1805. The float was in the middle of the current a part of the time. I would put a float in the river and try to put it where I thought the point of maximum flow was. Whenever that float appeared to be working too much to one side I would go out and drop another float oposite to the first one and then let them both run from there and see which was running the fastest, and take up the one which was lagging behind, the object being to keep the float traveling as fast as I could discover current to make them travel. I was taking the fastest float, and if the float began to get slow I put in another one opposite and
1807 ran it.

In the drainage canal I read two guages, one at the Bear Trap dam and the other in the corner of the basin. I think the next guage I got was at Morris. The guage at Morris was 91.25, The next one I read was on the same day at the Seneca Railroad bridge. The guage was 95.0.

1809 I had the reading of the guage about a quarter of a mile above the dam at Marseilles. It was 98 feet even. At the Ottawa bridge the "10" figure was indistinct; it was either 80.6 or 90.6. At the La Salle bridge the reading was 81 feet. The guage on the Peru highway bridge was 14.75. At Henry the guage reader gave me the 1810 guage at 11.8 at seven in the morning. He gave me the high water of the Thursday or Friday before that at 13.4 feet.

1811 The actual time from Chillicothe to Peoria was 29 hours and 59 minutes. The progress of the floats, even in this high water, through Peoria lake, was very slow. No one float floated along uninterruptedly from Mossville to Peoria.

1813 CROSS-EXAMINATION by Judge Springer:

Q. I desire to learn the velocity of the float in Peoria lake, if you have a note of that, so as to indicte the velocity at that place?

A. I will have to work it out for you definitely; that is, the time here is not continual on account of putting in and taking out the floats. I would have to add the different times in order to give it to you. There was a very decided diffierence in the velocity of the floats in going through the narrows or through the lake.

CROSS-EXAMINATION by Mr. Todd:

1815 The floats were taken out of the water once on an average of every five minutes; that is, one float, that is where I was running five. As a rule the cause was that the float was not following the channel of the river. The country was overflowed and there was a tendency of the floats to leave the river and go out across the point, so that you had to be continually taking up a float that was on the inside and putting it on the other end of the line.

CROSS-EXAMINATION by Judge Springer.

1818 The total time of the float in going from the upper bridge at Peoria to the bridge at the central part of the town, which is approximately three miles, was 5 hours and 49 minutes, which would make one mile in about 1 hour and 56 minutes. It was practically one mile every two hours.

1819 The width of the lake oposite the city of Peoria was wider than when the river is at an ordinary stage. In other words, the river was out of its banks. All the way down from Joliet to Peoria the character of the water was a little turbid.

1820 I think that the water in the river was more turbid than
the water in the canal. I think the water that was coming in from the Fox river was rilier than the water in the Illinois—more turbid.

FRANK J. BROWN, examined by Mr. Jeffries:

1821 Employed by the waterworks of St. Louis. Worked on
the Illinois river last March to ascertain the velocity of
the current of the Illinois river. I started at Peoria and came
down as far as Naples.

1822 The total time was 71 hours and 40 minutes from Peoria
to Naples.

CROSS EXAMINATION by Judge Johns:

I started the floats about 50 feet apart, at Peoria, on
1823 March 14th. In going from Peoria to Pekin I had to take
them out of the water, some of them, because they
grounded, partly on the right bank of the river and partly on the
left. I think it was on the right bank the most, if I remember.
The river from Peoria to Pekin is quite tortuous. I think that
the one-foot submerged floats made a little the best time. The
three-foot was the slowest, except in case of high winds up
stream, and if anything they would fall behind, but in an ordinary current or wind, the red floats made the best time. If the
wind was high and blowing up stream, the three-foot floats
would travel the most rapidly.

1824 The gauge at Peoria, at the starting place was 19. At
the highway bridge at Pekin, on the 15th of March, it
was 13.6. At the State locks, the same day, 17.5—that is, the
Copperas Creek dam. At Havana, March 17th, at the highway
bridge, it was 16.9; on March 19th at Beardstown, it was 16.1.
At Meredosia, March 21, the gauge was 17 feet, nine and one-half; just below the boat landing at La Grange, 24.50, at the
upper end of the locks, and 24.25 at the lower end.

1825 CROSS EXAMINATION by Mr. Todd:

I said that with a very high wind blowing up stream the
free-foot submerged float made a little the best time. I think
at one time the wind was fully as high as 25 mile an hour.

1826 That is all a pure guess as I had nothing to measure it by.

1827 A ten-mile an hour breeze across stream would not affect the six-foot float at all. I noticed that the white float would make better time when the wind was blowing upstream. When the wind blew up stream the two floats did not go down the stream with uniform regularity.

1828 When the wind was blowing a gale, ten or fifteen miles an hour, I did not take the floats out of the water at any time. When they would get out of the channel or get too near the shore or get aground I would take them out. From Peoria down to Havana I had some trouble with them but it didn't seem to bother me so much after that. I do not know what was the cause of it, unless it would be the wind blowing from the bank driving them over that way. I noticed which way the wind was blowing, the floats always go that way. The floats would always go with the wind across the stream. The wind had a perceptible influence on the floats in going across.

1829 When the wind would come up at a ten-mile an hour gale it would some times be a couple of hours before they would strike the shore. I think that if they were out in the current, ordinarily they would go two or three hours without running ashore.

JOSEPH GIBSON, examined by Mr. Woerner:

1830 Am employed in the Water and Construction Departments. Made observations last March in order to ascertain the rapidity of the current of the Illinois river. I started from Naples, Illinois and went down to Grafton. I was 30 hours and 37 minutes from Naples to Grafton. Started from Naples on March 18th.

CROSS EXAMINATION by Judge Johns:

1832 At Naples the gauge reading equals 18 feet two and one-half inches. March 19, Chicago & Alton's draw-bridge, gauge reading 16 feet and 6 inches. Government gauge at Campsville, March 19th reading equals 24.7, that is above the dam. Saturday, March 21st, at Grafton the gauge reading was 17.0.

1833 Sometimes the floats would run into the drifts or drift out on the edge of the bank. When they did so, we would take them out and put them in the current opposite where we took them out as closely as we could.

1834 The wind was mostly upstream. The first day the wind was upstream, mostly from the right bank. The second day it was partly from the right bank. The third day we had a higher wind.

Q. Did they seem to dritf off toward the bank in the direction in which the wind was blowing?

A. Well, I think it had a kind of tendency to draw them over, at times. The river was very high—out all over the bottoms. When there was considerable wind there were waves in the current of the Illinois river, sometimes quite rough.

1835 Q. When the waves struck these floats, it seemed to knock them over in the direction which the waves ran, didn't it, a little?

A. Yes, that had a tendency to work that way somewhat. There was a visible effect of that character. When the wind blows upstream and the floats are floating down-stream, I don't think the wind would have very much effect on them—not the wind I encountered.

THOMAS F. REED: Live in St. Louis. Am rod man in the water department. Took part in observations, the object of which was to determine the velocity of the flow of the Illinois river last March.

1836 I covered from Lockport to Morris and from seven miles above Henry to Chillicothe. Those two portions were assigned to me. I started two floats at the Bear Trap dam on the 16th of March. From Lockport to Joliet, it took me

1837 two hours and 15 minutes. It took me 3 hours 35 and one-half minutes to go two miles and a half, about, above Millsdale. It took me 18 hours and 20 minutes to go from Lockport to Morris.

CROSS EXAMINATION by Judge Johns:

1841 At Ninth street bridge at Lockport, the gauge on the bridge read 16.7. On the 18th of March, at the mouth of Jackson creek, I read the gauge 81.55. Three miles below Millsdale 81.1. On the 19th of the month on the E., J. & E. railroad bridge 87.7. The Lacon wagon bridge was 18.7 feet.

1842 The river was very high. The wind caused the floats to move out of the channel. The wind would drive them right into the shore right along. The wind was generally across-stream and up-stream part of the way. The wind would blow the floats towards the shore in the direction the wind was blowing.

1843 On the second section that I was working, the river was very wide and the dams were all submerged with water. The wind had a free sweep. The water was quite rough all the time. The waves ran a foot high and more. When I had to take the floats out they had drifted in the direction in which the waves were running.

1844 L. B. ENGLISH, examined by Mr. Jeffries:

Live in St. Louis, am a law clerk in the city counselor's office of St. Louis.

Q. I will ask you if you have done anything with reference to the collection of typhoid death rates in various cities along the Mississippi to the north of St. Louis, in the last two or three months?

A. Yes, sir. I examined Minneapolis, St. Paul, Dubuque, Des Moines, Keokuk, Burlington, Hannibal, Quincy and Fort Madison. This was done commencing on the 6th of April and extending over a period up to and including April 15th this year. I went to Minneapolis first.

1845 I examined the records to determine the deaths per month and year from typhoid fever and the total number of deaths.

MR. TODD: I object on the ground that the records are the best evidence and on the additional ground that anything that he might say is here hearsay and is not competent.

I examined the records in the office of the Health Commissioner of Minneapolis to ascertain the deaths from typhoid fever and the total number of deaths from all causes. I have got those by the month beginning with January 1, 1893, up to and including December, 1902.

MR. TODD: I object to the question on the ground that the records are the best evidence and it is incompetent for this witness to testify to what the records disclose. In order to save time, will it be understood that this objection goes to all of this?

GENERAL CROW: Yes, sir, that will be understood to apply to all this class of testimony.

1846 (Witness gives number of deaths from typhoid in Minneapolis for years 1893 to 1902 inclusive.)

1850 On the following day I made a record of the deaths from St. Paul. (Witness gives same statement as to St. Paul.)

1854 I went to Prairie du Chein, but the records were incomplete, and they had only been taking them since the State law was passed requiring the clerk of the city to make them, and he had only been making them a short time. That place has a population of 3,500. Went to Dubuque, Iowa. (Witness gives number of deaths from typhoid in Dubuque by months from 1893 to 1902, inclusive.)

1858 Next is Des Moines, Iowa. (Same testimony.)

1862 From there I went to Burlington, Iowa. (Same testimony.)

1865 From there I went to Fort Madison. The records had
only been kept a very short time, and they commenced
with the year 1900. In 1900 they had four deaths, in
1866 1901 no deaths from typhoid reported. The law in Iowa
is that all deaths must be reported to the city clerk, and
he keeps a record of them. It was from this record I got this.
From January 1 to March 31, 1903, they had no deaths from
typhoid. From there I went to Keokuk, Iowa. (Witness gives
number of deaths from typhoid fever by months from 1893 to
1902, inclusive. I collected these figures from the rec-
1870 ords themselves. The next place I went was Quincy. I

made the same character of examination at Quincy as I did at the other points. (Witness gives number of deaths from typhoid fever by months from 1893 to 1902, in-
1874 clusive.) The next point was Hannibal. (Same testimony.)

1878 CROSS-EXAMINATION by Judge Johns:

These records themselves were kept in tabulated form in all the cities with the exception of Fort Madison. They gave the cause of death and age, birthplace and deathplace and burial place, and all those sort of things. In each one of those towns when I found those records they had persons and clerks as custodians of those records. In some cities that I took in—two or three places—the records were kept by the city clerk. In larger places they were kept by the health commissioner, but in all these places except Fort Madison they were in the custody of some officer appointed for the purpose of keeping the records.

1879 CROSS-EXAMINATION by Judge Springer:

I did not examine the records at Davenport, Iowa, or at Rock Island, Illinois. Rock Island is a large city. I did not examine the records at Galena. In each instance I took account of the population at the time I took the records—that is, the census of 1900. I found upon some of these records a statement as to the number of cases of typhoid that were treated—that was in one or two places—but they told me it was not accurate, as it depended upon the physicians to report them, and as a rule they were not sufficiently accurate to make any complete record from.

CROSS-EXAMINATION by Mr. Todd:

1880 All I have testified to I have simply got from the inspection of the records, copying from the records at the different places I have indicated.

1881 CROSS-EXAMINATION by Judge Springer:

In the cities of Des Moines, Burlington, Minneapolis and Dubuque I have the certificate of the clerk as to the correctness of those figures.

J. L. VAN ORNUM recalled, examination by Mr. Woerner.

1882 I have taken samples of the waters of the Mississippi
and Missouri rivers recently for the purpose of examination. On the 10th and 12th of April samples of water were
taken at sections noted on this sheet (referring to map), one
section being just above the confluence of the Missouri
and Mississippi rivers in the Mississippi river, another above
the same confluence in the Missouri river, another section in
the Mississippi river below the confluence of these two rivers,
and a fourth one about a thousand feet above the water works
intake. These samples were taken for the purpose of sending
to Mr. George C. Whipple, at Brooklyn, for turbidity examination. Duplicates of each sample were retained in St. Louis.
For distinguishing the samples at the time of taking, a tag was
tied about the neck of each bottle, on that tag being a capital
letter to distinguish the section as noted here (referring to
map), section I being close to the intake and section C
1883 also in the Mississippi river below the confluence of the
Mississippi and Missouri, section M in the Mississipi
above the mouth of the Missouri, and section B in the Missouri
river above the confluence. These were all cross sections, locations being kept on each cross-section from 1 to the highest
number, No. 1 always being towards the right bank of the river
—toward the Missouri shore. The number of samples taken
from each cross-section are indicated on this same sheet. There
were three points on section B in the Missouri river, and there
was one sample taken at a ten-foot depth at each of these three
points.

1884 This map that I have in my hands is a correct indication of the number of points at which samples were taken
at each location. It shows the current or the direction of the
river, of the flow of the respective rivers in so far as it may
be indicated on the map. That red line, as near as may
1855 be, indicates what may be called the channel line, or the
deepest water throughout the length of the Mississippi,

as shown on the sheet. (Map offered in evidence as complainant's Exhibit 44.)

MR. TODD: I object to the introduction of the map, in regard to what the map itself indicates, on the ground that it is not a correct condition that exists in the Mississippi river to-day, as the map was made in 1880, and has been stated by the witness in the other examination as not being correct as of to-day. I object on the further ground that the red line indicating the channel is placed upon the amp by the witness, and there is not sufficient evidence in the record to justify that that
is the channel to-day as indicated by the red line. My
1866 ascertainment of the channel is based upon soundings
marked upon this map at the time it was made by the
government officials.

JUDGE SPRINGER: We object to it as not showing the channel at the present time.

MR. TODD: I want to make a further objection. I object to the note that is placed on this map at the northwest corner, and signed J. L. Van Ornum, as being no part of the map.

CROSS-EXAMINATION by Judge Johns:

These samples were taken under my direction. (Witness
states how samples were taken.)
1887 Part of the samples were taken on the 10th of April
and part on the 12th. Section I, for instance, the distance between the various stations numbered from 1 to 12 is 400 feet. Section 1 is 300 feet from the Missouri shore. That distance was ascertained by sextant angle taken between transit placed on shore and the intake tower. We took three samples at station 1, section I, at six inches, ten feet, and I am
not positive whether the lowest was 30 feet now.
1890 Chouteau's slough is this (indicating on map).

Q. Was it at one of those places, where the word "sand" is, that you took out one of the floats and placed it back in the river, to which you testified the other day?

A. Somewhere along there. It was, I think, about a half a mile to the northeast, as I recollect it.

Q. If the float had gone down that chute it would probably never have gone anywhere near the intake?

A. Probably not.

CROSS EXAMINATION by Mr. Todd:

1891 This map, according to the notes placed upon the sheet by the Mississippi River Commission, was made when the stage of water was comparatively low. The stage of the Mississippi at the time I collected these samples was higher. The map was made at stages varying evidently from four feet above to ten feet above the low water stage. My impression is that the stage of water when we took the samples was 15 and 20 feet above the low water stage. The channel at high water is very often more or less different from the location of the channel at low water. The currents of a river are generally increased by high water. They do not run the same in certain places, as far as direction is concerned. High water has a tendency to change the currents in a river, especially where the channel passes from one side of the river to the other.

1893 Q. Is there anything on this map which indicates the direction of the currents at the stage of water that you found at the time you made your experiments?

A. Only in a general way.

1894 The rate of current at these points where samples were taken would be necessary to know, in order to figure the volume of water passing a given point. That I did not escertain. The current flows most rapidly at the top.

1895 It is a fact that in the Mississippi river channel of today might not be the channel of six months hence. I do not know whether the channel indicated here, by the red line on this map, is the true channel of the Mississippi river today. I have no scientific knowledge on the subject of what is the true channel today in the river.

1903 GEORGE CHANDLER WHIPPLE, examined by Mr. Woerner:

I reside in Brooklyn, New York.

1904 My official title is that of biologist and director of Mount Prospect Laboratory of the department of water supply, gas and electricity of the city of New York. I have been in that position since 1897, except that when I began at that time, I was employed by the city of Brooklyn and since then, there has been a consolidation with New York City. (States his 1909 professional training and experience.) I have had occasion to make microscopic examinations of samples of the waters of the Illinois, Mississippi and Missouri river. In October and November, 1901, I made microscopic examinations from, I think it was 136 samples, some from Lake Michigan, Drainage canal, Illinois river, tributaries of the Illinois, Mississippi river above Grafton, Mississippi river at Alton, Missouri river at Bellefontaine, Mississippi river at the Chain of Rocks and at the Illinois shore opposite the Chain of Rocks and settling basins of the St. Louis waterworks. These samples were sent to me at Mount Prospect laboratory in Brooklyn by express. They were marked so as to identify their source. They seemed to be in good condition for the purpose of microscopic examination.

1910 I examined all of them microscopically and in some of them I determined the turbidity and color. I examined them microscopically in order to determine the number and character of the microscopic organisms present. Strictly speaking, all very minute organisms may be called microscopic organisms but all water analysis have come to understand by the term "microscopic organisms" those minute forms of life which are too small to be readily identified without the use of a microscope, but which are large enough so that they do not need to be studied by artificial cultures as we study bacteria. For example, the microscopic organisms belong, some of them, to the plant kingdom and some of them, to the animal kingdom, although these low forms of life it is somewhat difficult to draw the distinction between animals and plants. In the water that I received, some of the organisms found might die out during the period of transit ,others of them might possibly develop during transit while others still would probably remain unchanged.

1911 They would not increase in number neither would they disintegrate to such an extent as to be unrecognizable. I have tabulated the results of the observations and the microscopic examinations which I made and I have with me these tables which contain the results. I have here a table which I have marked table zero, which gives the results of the microscopic examinations made from samples of water said to be collected from Lake Michigan, five of these samples being labeled as coming from the Lake View crib, three as coming from the Carter Harrison crib, and two as coming from the Four Mile crib. At the top of the table is a line giving the number of the sample, and I may explain that the samples as they were received, were given a serial number, and that these numbers in this line refer to those serial numbers. Beneath the line giving the number of the sample, is a line giving the locality from which the sample was collected, and beneath that a line giving the depth in feet at which the samples were collected, and beneath that a line giving the date of collection. Then in vertical columns I have placed at the left the name of the group of organisms found in the sample. In the second vertical column are the names of the genera found, and in the succeeding columns are the numbers of those genera which were found expressed in terms of standard units of organisms per cubic centimeter. Near the bottom there are two lines, one giving the total microscopic organisms, which numbers are the summation of the numbers given in the vertical columns, and then the last line giving the amount of amorphous matter which represents the amount of matter without form, simply, you might say, dirt, almost. Matter which is not recognizable as an organism; also expressed in terms of standard units per cubic centimeter. And I may say that this term "standard unit per cubic centimeter" is designed to show the relative bulk of these organisms present. In some cases, one standard unit corresponds with one organism. A standard unit as it is used is a unit of superficial area equal to 400 square microns, one micron being equal to 1-1000 of a millimeter. The advantage of using this unit of a standard unit instead of numbers is that the organisms differ in size and it is our intention in these analyses to express, as far as possible, the relative bulk of the different organisms present, in order that one may be compared with another.

1912 What I have just said applies to all of the tables, as I used the same standard and measure.

(Witness gives descriptions of various micro-organisms found in Lake Michigan, as indicated on table zero.)

1913 The total number of microscopic organisms expressed in the usual forms of standard units per cubic centimeter varied fom 576 to 1,656.

1914 The sheet that I now present is known as plate No. 1, and it contains the results of examinations of samples said to be collected from the drainage canal. The first four were marked Paulina Street and the last six were marked Bear Trap Dam, Lockport. The general arrangement of the sheet is similar to that of sheet No. zero. (Witness describes micro-organisms found in these samples.) The total numbers or organisms varied from 644 to 2,750.

1915 Plate No. 2 contains results of six samples from the Des Plaines river at Lockport above the entrance of the drainage canal. It wil be seen by this sheet that the organisms in general were much less numerous than in Lake Michigan or the Chicago drainage canal. The total number of organisms varied from 24 to 126, excepting on November 26, when there were 2,316. Plate No. 3 contains results of examinations from the various tributaries of the Illinois river. It will be seen that these tributaries vary considerably in the number of microscopic organisms found. For instance, the total numbers varied from 20 to 11,296. It will be noticed that the synedra and tabellaria which were so commonly present in the Lake Michigan water and in the water from the Chicago drainage canal are here only sparingly found.

1916 Plate No. 4, samples received from the Illinois river, three miles above Peoria. This sheet represents the results of six examinations. Plate No. 5 is Illinois river at Beardstown.

1917 Plate No. 6 represents results of samples collected from the Illinois river at Grafton, there being seven such analyses reported. Plate No. 7 represents results of seven examinations from samples from the Mississippi river above Grafton. Plate No. 8 shows results of six samples collected from the Mississippi at Alton.

1918 Plate No. 9, five examinations of samples collected from the Missouri river at Fort Bellefontaine. It will be seen that the organisms in the Missouri river were far less numerous than in the Mississippi river. Asterionella and tabellaria, which were observed in Lake Michigan and in the samples from the Illinois river and the Mississippi river at Alton, were not found at this point. Synedra were found.

1919 Table No. 10 represents the results of examinations of seven samples collected from the Mississippi at a point near the Illinois shore opposite the intake. The total number of organisms varied from 1,588 to 8,344. Plate No. 11 represents the results of seven examinations of samples collected at the intake. Synedra were present in three out of the seven samples, and the total number of microscopic organisms varied from 310 to 1,880.

1920 Table No. 12 represents the results of two examinations from samples collected at the settling basins of the St. Louis water works. Plate No. 13 represents results of examinations of twelve samples collected from the Mississippi river at a cross-section just above Alton on November 12, 1901.

1921 Plate No. 14 gives results of microscopic examinations of samples collected from the Mississippi river at a cross-section just above the Chain of Rocks. The arrangement of these samples in the cross-section from 1 to 11 being from the Missouri shore toward the Illinois shore.

1922 (Charts offered in evidence as complainant's Exhibit No. 46, with sub-numbers 1 to 15, inclusive.

A diatome is a unicellular plant, and perhaps its most important difference from other unicellular plants is the fact that its cell wall is so impregnated with silica that it is practically an indestructible thing. That is, a diatome might be described as a little plant cell made of glass. The living matter lies within this silicious cell, and after the death of the cell the walls of the cell remain just as they appear during life. In fact, they may be considered as fossil remains of a plant, and there are in existence to-day geological deposits which are composed almost entirely of diatomacious cells.

Q. Are they considered more hardy and more likely to survive the voyage from Lake Michigan down the various water courses to the intake at St. Louis than the other microscopic organisms, or not?

A. Yes, sir. These cells being indestructible, or practically so, could be identified after a long passage through the river, and this cell wall being a strong protection to the cell, offers more favorable resistance than many of the microscopic plants, such, for example, as the blue-green algae or the green algae, even.

Q. Where are those diatomes most likely to be found?

A. Diatomes are likely to be found in almost any kind of fresh water, but there are thousands of species of diatomes, and the particular diatomes with which we are concerned in those examinations, namely, asterionella, synedra, melosira, cyclotella, stephanodiscus and the others mentioned, are more commonly found in ponds and lakes and such bodies of water than they are elsewhere. These organisms just enumerated, or these diatomes just enumerated, are not as likely to be found in the waters of running streams, unless these streams are fed from lakes or ponds or similar bodies of water.

1923 Experience has shown that these organisms would not be likely to be found in streams tributary to the Illinois river excepting so far as these streams are fed by lakes or ponds.

MR. TODD: I move to strike out the answer.

It is my opinion that the diatomes in the Illinois river above the point where it enters the Mississippi river at Grafton came partly from Lake Michigan and partly from the tributaries of the Illinois river; that the waters of the Mississippi river from the various points below Grafton came partly from the upper Mississippi, from Lake Michigan and from the tributaries of the Illinois river, my answer being understood as to refer to the diatomes as a class and without reference to particular genera or species.

1924 There was an organism which I will describe as synedra pulchella variety sub-prolongata, which was found at the intake of the waterworks at the Chain of Rocks, and which was found also in the water of Lake Michigan, but was not found in the water of the Missouri river or the water of the upper Mississippi river, or in any of the tributaries of the Ilinois river, unless we consider the Chicago drainage canal as being a tributary.

1925 (Witness reads table representing averages of all examinations made at each point enumerated for the entire period covered by the observations.)

It contains the average results of the number of most important diatomes present at the various places between Lake Michigan and the settling basin of the St. Louis water works, where samples were collected. It gives the names of the diatomes and the average number of each for each place. I notice from this table that certain diatomes are especially characteristic of certain waters. Take the first on the table, synedra; the conclusion I draw from the results shown there is that the sixteen synedra which were found in the intake of the St. Louis water works came not from the Missouri river nor from the Mississippi river at a point above Grafton, but rather from the Illinois river at Grafton, and if we consider that there

1927 were 577 synedra in Lake Michigan, with only an average of 17 per cubic centimeter in all the tributaries of the Illinois river, I should conclude that the chances were that the sixteen synedra found at the intake, or most of them, came from Lake Michigan. As to the next one, the tabellaria, the conclusion I would draw from the table is that in all probability the tabellaria found in the settling basin of the St. Louis water works and at a point in the Mississippi river near the Illinois shore came not from the Missouri river or from the Mississippi river at a point above Grafton, but from Lake Michigan by means of the Illinois river, and not from any of the tributaries of the Illinois. Let us consider the melosira.

1928 The conclusion from the figures shown on the table is that for the most part the melosira found at the intake of the St. Louis water works and at the Mississippi river near the Illinois shore were derived not from the Illinois river or from Lake Michigan or from any of the tributaries of the Illinois, but rather from the Mississippi river above Grafton. Now consider the cyclotella, the conclusion being that these cyclotella found at the intake of the St. Louis waterworks at the Chain of Rocks came for the most part, not from the Missouri river, but from the Mississippi river and the Illinois river, and only to a slight extent from Lake Michigan. The cyclotella found in the Illinois river at Grafton being derived not from Lake Michigan, but from one or more of the tributaries. Now consider the astrionella, the conclusion being that for the

1929 most part the asterionella found at the intake of the St. Louis waterworks and at the Missouri shore, or at the Illinois shore opposite the Chain of Rocks, were derived not at all from the Missouri river, but chiefly from the Mississippi river above Grafton, but in part from the Illinois river and its tributaries and Lake Michigan. Now the stephanodiscus, from the table I conclude that of the stephanodiscus, or that the majority of the stephanodiscus found at the intake of the St. Louis waterworks and at the Illinois shore oposite the Chain of

Rocks were derived not so much from the Missouri river or the Illinois river as from the Mississippi river above Grafton.

The synedra found in Lake Michigan belong to the species pulchella and variety sub prolongata, while the synedra found in the tributaries of the Illinois river were either the synedra lonslotta or the synedra pulchella variety curta. The synedra pulchella are very easily distinguishable from the synedra lonslotta, because of the different shape, while the synedra pulchella, variety sub prolongata differ from the synedra pulchella variety curta in their size; the sub prolongata being in round numbers, twice as large as the variety curta. All three of these forms of synedra are very easily distinguishable under the
powers of the microscope used in the examination.
1930 This would enable me to distinguish which came from
Lake Michigan and which came from other sources when they were taken from the waters at the intake. I found the synedra pulchella variety sub prolongata at the intake of the St. Louis waterworks I think on November 12, if I recollect the date correctly. So far as all of my examinations show I should say that they came from Lake Michigan. I made a chart of the comparative number of these different diatomes in various sections —that is, those which were most prominent. This chart depicts graphically the results of my investigations. I present first, diagram No. 1, which gives the results of the determinations of synedra pulchella, per cubic centimeter, at the various places
between Lake Michigan and the intake of the St. Louis
1931 waterworks. The next diagram is No. 2 and is drawn by
the same plan as the preceding and shows the number of tabellaria fanistrata at the points enumerated on the diffenent sections.

1932 The next diagram being No. 3, shows the number of stand-
ard units of microscopic organisms actually discharged with the pollution by the various towns between Lake Michigan and noted at the bottom of the diagram, and states the organisms included in the above.

1933 This diagram shows that the organisms were very few in Lake Michigan, and that they were quite numerous in the Chicago Drainage canal and the Illinois river above Grafton, and from the Missouri river at Bellefontaine and that they were found in the Illinois river or rather in the Mississippi river at the Illinois shore opposite the Chain of Rocks and at the intake of the St. Louis waterworks.

The next diagram shows the number of melosira granulata in the Illinois river at Grafton did not exceed 24 per cubic centimeter standard units, and in the Missouri river at Bellefontaine, they did not exceed 60 per cubic centimeter, the quantity being so low they would scarcely appear on this sheet. The results indicate that during the period covered by the investigation there was a gradual decrease in the number in the Mississippi river at Grafton and that this decrease was also noted at Alton in the Mississippi river and at the Illinois shore opposite the Chain of Rocks, and also at the intake of the waterworks at the Chain of Rocks.

Diagram No. 5 shows the number of cyclotella operculata at various points in the Mississippi river and at the Illinois river at Grafton. The note states that during this period the cyclotella operculata did not exceed 60 per cubic centimeter in the Missouri river at Bellefontaine, but the results indicate that during the latter part of November there was an enormous increase in the cyclotella operculata in the Illinois river at Grafton, the numbers being so great it could not be shown upon the scale of this diagram; and that this increase was also noted at Alton at the Illinois shore, Chain of Rocks, and at the intake of the St. Louis waterworks.

Diagram No. 6 shows results of examinations made of samples collected at 12 points in the cross-section across the Mississippi river above Alton. It shows the results of microscopic organisms and it also shows the results of certain turbidity and color observations which I have not yet put in the testimony. The upper line shows the turbidity of the water at the different stations expressed in terms of the silica standard.

1935 The second section shows the color of the water at the different stations expressed in terms of the platinum coblat standard.

The next section shows the number of microscopic organisms characteristic of the Mississippi river, indicated by lines of different character, the full line referring to the total organisms; the melosirt being expressed by the dash line, the cyclotella by the dotted line and the stephanodiscus by the dot-dash line.

The last section on the sheet shows the microscopic organisms characteristic of Lake Michigan. The synedra expressed by the full line and the tabellaria expressed by the dash-line. The results show that the turbidity was fairly constant across the stream, but that it was lower on the eastern shore than on the western.

The turbidity of the water means its opacity to light, or its opacity or opposition to the passage of the rays of light and is a measure of the suspended matter present. Observations of turbidity are frequently made instead of determinations of suspended matter because of the much greater convenience of the method. The diagram shows that there was in general a gradual decrease of color from the Missouri shore toward the Illinois shore and that the color was particularly low near the Illinois shore. The diagram also shows that the melosira, which, as has previously been offered in testimony, were especially characteristic of the waters of the Mississippi river above Grafton, decrease generally from the Missouri shore towards the Illinois shore, while the cyclotella, which were found in both the Illinois river and the Mississippi river, but were more abundant in the Mississippi river at the time when the cross-section was made, were fairly constant across the river excepting near the Illinois shore, while the stephanodiscus were nearly uniform across the stream, but showed a slight tendency to decrease toward the Illinois shore.

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The syndera which were characteristic of Lake Michigan were not present in samples 1 to 5 and were most abundant in sample 7; while tabellaria, which also was especially characteris of Lake Michigan, were not found in samples 1 to 4, or in samples 7 and 8, but were found in the other samples.

This last diagram is No. 7, and it shows the results of the observations of the samples taken in the cross-section of the Mississippi river about one mile above the Chain of Rocks, and it shows the turbidity of the water at each station, the color at each station, and there is a line showing the comparative abundance of melosira, cyclotella and stephanodiscus organisms which at that time were especially characteristic of the Mississippi river above Grafton, and a line showing the synedra and tabellaria organisms which at that time were especially characteristic of Lake Michigan. These samples were collected on November 10, 1901. These are the turbidity observations shown on this diagram, and indicate a progressive decrease from the Missouri shore towards the Illinois shore, while the color progressively increases from the Missouri shore towards the Illinois shore. The lines at the bottom of the diagram show the progressive increase in the melosira, cyclotella and stephanodiscus, speaking in a general way, from the Missouri shore towards the Illinois shore, while the same is practically true of the synedra, an organism especially characteristic of Lake Michigan. The tabellaria, which was characteristic of Lake Michigan, was not found west of station 7. It will be noticed, however, that all of these organisms which were characteristic of the Mississippi river water were found at
1937 station 1, and that the synedra, which was characteristic of the water of Lake Michigan, was also found at stations 1, 2, 3 and 4. (Diagrams offered in evidence as complainant's Exhibit 47, sub-numbers 1 to 7, inclusive.) I made calculations as to the relative amount of water coming from the Mississippi and Missouri rivers into the intake. I assume, for the purpose of this calculation, that the samples which were collected at the Missouri river at Bellefontaine represented the

character of the water in the Mississippi river, and that the samples which were collected in the Mississippi river at Alton represented the character of the Mississippi river just above the point, or above the point where the Missouri river enters the Mississippi river just above the point or above the point where the Missouri river enters the Mississippi, and I compared the average results of similar organisms found in the water at the intake of St. Louis waterworks. I concluded that on an average 32 per cent of the water which entered the intake of the St. Louis waterworks was considered as Mississippi river water and that 68 per cent of the water was Missouri river water.

1939 I made turbidity observations and observations of color in the samples taken from the two cross-sections, one just above Alton and the other one mile above the Chain of Rocks, to find the relative turbidity of the water across the stream at the different points and the relative color across the stream at the different points. (Witness gives results of turbidity and color of twelve samples in cross-section taken in the Mississippi river above Alton November 12.) When I say that the turbidity of a sample is 18 it means that that sample is just as turbid as it would be if it contained 18 parts per million of what we call silica standard, or 18 parts per million of finely divided silica, which is prepared according to a definite formula.

1940 The relative opaqueness would be arrived at by the turbidity, and the higher the number the greater turbidity, or the greater opaqueness. The color is measured by comparing the sample of water after removing the suspended matter, with arbitrary standards which are varied in color by the addition of different amounts of platinic chloride, and when I say that the color of the water is 34 it means that the color is as dark as an artificial solution which contains 34 parts per million of this platinum salt.

1941 (Witness gives results of examination of eleven samples in cross-section from the Missouri shore to the Illinois shore, one mile above the Chain of Rocks.

1942 I received some samples from Prof. Van Ornum during the month of April, 1903. They were received at my laboratory in Brooklyn on April 14 and April 16. I received 68 samples. These samples were tagged. I received a letter from Prof. Van Ornum, in which he stated that the capital letter M referred to a cross-section about one-quarter of a mile above the mouth of the Missouri river, across the Mississippi river, and that the serial numbers from 1 to 8 represented stations in that cross-section, beginning with the Missouri shore and running across to the Illinois shore, and stating further that the samples were spaced 200 feet apart, and also that the letter "b" meant that the sample was collected at a depth of ten feet below the surface. Upon each tag there were also figures indicating the temperature of the water in degrees Fahrenheit.

1943 I also received some samples marked "I," thirty-three bottles, with serial numbers from 1 to 12, that referred to a cross-section of the Mississippi above the intake at the Chain of Rocks. The serial numbers from 1 to 12 represented the stations across the river from the Missouri shore towards the Illinois shore, samples being taken 400 feet apart. The small letter "a" meant that the sample was taken at or near the surface. The small letter "b" indicated that the sample was collected at a depth of ten feet, and the small letter "c" that the sample was collected at or near the bottom of the stream.

1944 On April 16 I received three samples marked with a capital "B," with serial numbers from 1 to 3, followed by the small letter "b" in each case. These represented a cross-section of the Missouri river just above its mouth, No. 1 being near the south shore, No. 2 in midstream, and No. 3 near the north shore, also twenty-four samples marked with capital "C," with serial numbers from 1 to 8, and small letters either "a," "b" or "c." These I collected across the Mississippi river below the point where the Missouri river enters into it. Serial numbers ran from 1 near the Missouri shore to 8 near the Illinois shore, stations being 200 feet apart.

1945 I examined all the samples for turbidity.

1946 (Gives results of examination of samples "M," "B" and "C.")

1947 (Gives result of sample "I.")

1949 (Witness exhibits 12 bottles of water from complainant's exhibit 45, marked with capital letter "I" and explains method of ascertaining the turbidity of water.)

1950 Sample No. 1 is very much more turbid than sample No. 12 (referring to bottles Nos. 1 to 12 above referred to.)

1951 Comparing these samples as they stand before me, it is evident that there is a rather sudden decrease in the turbidity of the water from the Missouri shore toward the Illinois shore in the first four or five bottles and that from there on toward the Illinois shore, the difference in turbidity is comparatively small. My recollection is that the first sample was taken about 150 feet from the Missouri shore and that succeeding samples were taken at intervals of 400 feet in this cross-section.

1952 I prepared diagrams to show graphically these cross-sections of the rivers according to the samples that were taken by Prof. Van Ornum, that is, for three out of four—sections "I," "M" and "C." This diagram which I hold in my hand represents graphically the results of the turbidity observations made at section "I" already put in evidence, taken from the samples of water furnished me by Prof. Van Ornum in April, 1903, that is, about one-quarter of a mile above the Chain of Rocks. There are three lines upon this diagram, the line represented by the dots and dashes refers to the sample taken just below the surface of the stream, that would be the samples marked with a small letter "a," the full line refers to those samples collected at a depth of 10 feet, marked with small letter "b," the dash line represents samples collected at the bottom, which were marked with a small letter "c." In the last three samples, the solid line and the dash line were the same, that is, the bottom sample was at a depth of 10 feet.

1953 I should say that the intake tower would lie approximately between stations 4 and 5 shown on this diagram. (Chart offered in evidence as complainant's exhibit 48.)

1954 The next diagram shows the observations made at section C, being a cross-section of the Mississippi river about one mile below the mouth of the Missouri. The diagram is drawn in similar manner to the preceding. (Offered in evidence as complainant's exhibit 49.) The diagram which I hold in my hand graphically represents the results of observations made at section M, being a cross-section of the Mississippi river, at a point about a quarter of a mile above the mouth of the Missouri. (Offered in evidence as complainant's exhibit 50.)

1955 (Charts of water analyses referred to by witnesses Teichmann, Miller, Getz and others, containing 117 pages, offered for identification, to be known as complainant's exhibit 1 for identification.)

CARL UNGAR, examined in chief by Mr. Woerner:

Attorney at law. Resides in St. Louis. Has made investigation as to typhoid statistics of towns in Illinois river valley.

1956 Left St. Louis by instruction of City Law Department on or about April 7th. Visited Springfield and found the records there in poor shape. Only got three years—1900, 1901 and 1903. (Gives number of deaths per year in Springfield.) Next went to Bloomington. (Gives results of examination of records, showing deaths in Bloomington from 1893 to 1902.)

1958 (Statement as to Peoria and Ottawa.)

1959 (Decatur.)

1960 (Joliet.)

1961 (Pekin.) I found the reports very incomplete.

1962 (Elgin and Aurora.) They hadn't any records worth speaking of.

1963 (Havana.) I took what I could get by the year.

1966 **WILLIAM H. GETZ, re-called for direct examination by Mr. Jeffries:**

This is a table of percentages of the Missouri and Mississippi river water at the intake of the St. Louis waterworks. These calculations are based upon the daily estimation of total solids in samples collected at Bellefontaine, the intake and at Hartford, covering a period from January 23d to October 11, 1900. (Witness examined in regard to complainant's exhibit 1 for identification, stating how they were prepared and what they represented, in order that they may be introduced in evidence.)

1969 CROSS-EXAMINATION by Judge Johns:

On the charts that were made, the gauges were put, but there were no numerical figures put on the sheets that these were taken from. There was no need of the stages of the river for the purpose of assisting in this conclusion. (This exhibit being offered for the purpose of showing the mixture of the water at the intake.) There is nothing on this table of percentages which shows that on the 7th of February when the percentage of Mississippi river water in the intake was 100 and the percentage of the Missouri river water was zero, as to the state of the gauges at that time. Such figures were put on the charts that have been exhibited covering the weekly averages but not in the tables.

1971 These calculations do not depend, in any way, on the stage of the river. Stages of the river may affect the result, but there was no use made of them in the calculations.

1972 GENERAL HAMLIN: I object to the introduction of the table unless complainant offers to follow it up with proof of rain-fall, and so forth, on the lower Illinois river and the Mississippi and Missouri at the time these calculations were made.

GENERAL CROW: At the proper time, we will offer such statistics on the question of rain-fall and water gauges in the Missouri, Mississippi and Illinois rivers as we think proper to offer.

CROSS-EXAMINATION by Mr. Todd:

The date from which these percentages were figured was taken from the original note-books first and collected on to these charts, or on the tables and then it was taken from there for this special purpose. These figures were taken from the tables marked here as complainant's exhibit 1 for identification.

CROSS-EXAMINATION by Judge Johns:

1973 When I made these figures as to solids, I took them from the Missouri river at Bellefontaine and for the Mississippi at Hartford. I made the calculation for total solids. Well, there is always considerable variation in the total solids as found in the Missouri river at Bellefontaine, and those found in the Mississippi river at Hartford, and the total solids at the intake of the St. Louis waterworks was found to lie between those two, or approximately the same as either one of them, and by taking the difference in the total solids in the two rivers at those places, and interpolating the value of the total solids found at the intake, we find the percentage of the two rivers, which is represented by the mixture.

1974 CROSS-EXAMINATION by Judge Springer:

Now, for the month of January, 1900, I have presented here 25.75 as the average for all the samples we had during that month and that figure represents the average amount of Mississippi river water entering the intake during that period —about seven or eight days. This average amount of water from the Mississippi that entered the intake during those days in January which are here noted simply means an average which I have reached by estimating the total solids which I found in the waters of the two rivers, one at Bellefontaine and the other at Hartford.

1977 Q. The fact that at one time, during one month for instance, the average would be 25.75 and the next month would be 40.67, and for another month 60.29, and so on—they are variations which can only be explained from different stages of the river and the different conditions of the weather along the line of the rivers above the place where the samples were taken? A. Yes, sir.

RE-DIRECT EXAMINATION by Mr. Jeffries:

Q. Now, Mr. Getz, along the line of the questions propounded to you by Judge Springer, state what effect the fact of a flood in the Missouri river and a comparatively low water stage in the Mississippi river would have with reference to the correctness of arriving at the proportionate amounts or relative amounts of the two waters going into the intake?

A. It would have absolutely no effect.

GEORGE C. WHIPPLE, re-called for further direct examination by Mr. Jeffries:

1978 Have visited the Chain of Rocks and made myself personally familiar with that portion of the waterworks' plant of St. Louis which is located at that point. The approximate distance from the Missouri shore to the intake tower of the waterworks is about 1,500 feet. The intake tower is located a few hundred feet to the west of the channel of the Mississippi river at that point. I mean the center of the channel of the river—that is, the central thread of the main channel of the stream. It is about six miles from the intake tower to the mouth of the Missouri river. The Mississippi river, before it reaches the intake tower curves to the westward.

1979 (Witness explains the general features of the Mississippi river with regard to curves and directions of flow between the mouth of the Missouri and the intake tower, at the Chain of Rocks, as indicated on complainant's exhibit No. 44.)

1980 From my general knowledge of the subject of rivers and the effect of curves upon the currents of those rivers, it is my opinion that this curve which I have described, in the Mississippi river between the mouth of the Missouri river and the intake of the St. Louis waterworks would tend to allow, or would increase, or would be favorable to the mixture of the waters which come down the Mississippi river and the Missouri river.

1981 Judged from samples I have examined from section B and section M, I should say that the water in the Missouri river is much more muddy than the water in the Mississippi river and that it contains very much larger amounts of suspended matter. I also found that the water of the Mississippi river at Alton was more highly colored than the water of the Missouri river at Bellefontaine.

1982 In using this term I refer not to any substance in suspension but rather to substances in solution. I have observed that the amount of chlorine in the Missouri river was generally higher than that in the Mississippi river above the mouth of the Missouri. From the same sheets—complainant's exhibit 1 for identification, I also observe that ordinarily the amount of alkalinity in the Missouri river at Bellefontaine was higher than that in the waters of the Mississippi above the mouth of the Missouri.

If I should find certain forms of vegetable life which can be distinctly identified by well defined characteristics in the water of the Mississippi river above the mouth of the Missouri, and if at the same time, these organisms were absent from the water of the Missouri river itself, and if at the same time I should find them in the water of the intake tower of the St. Louis waterworks at the Chain of Rocks; it is my judgment that these organisms found at the intake tower of the St. Louis waterworks came from the water of the Mississippi river above the mouth of the Missouri river and that they were borne thither by the water of the Mississippi river above the mouth of the Missouri.

Q. Assuming that at times the water of the Mississippi river above the Missouri contains very little mud, and that the water of the Missouri river at the same time is highly charged with mud and further assuming that the water taken through

the intake tower at the Chain of Rocks, contains an amount of
mud intermediate in quantity between those of the two
1983 rivers before they unite?

A. It would be my opinion that the water found at the intake tower of the St. Louis waterworks, at the Chain of Rocks, was not entirely water derived from the Missouri river nor water entirely derived from the Mississippi river above the mouth of the Missouri, but was a mixture of the two waters.

Q. I hand you a table containing a transcript of the quantities of the total solid matter in the Missouri river at Bellefontaine, and the Mississippi river at Hartford and the water at the intake, which is a table read in evidence by witness Getz and ask you to explain the table and state whether or not the results as to the quantity of water of the respective rivers entering the intake at the Chain of Rocks, are determined by that table?

A. In looking over this table, I find that in general the total solids found in the samples at the intake were intermediate in amount between those found in the Mississippi river at Hartford and in the Missouri river at Bellefontaine and it is my opinion that it is possible from the figures given to calculate approximately the relative amounts of the water of the Missouri river and of the Mississippi river above the mouth of the Missouri present in the water at the intake of the St. Louis waterworks. I understand that the percentages obtained in the last two columns were obtained from the information given in the previous columns. Does that sufficiently answer your question, Mr. Jeffries? Q. Yes.

GENERAL HAMLIN: I move to exclude the answer for the reason that the witness did not make the table itself, or the table from which it was made, nor does he undertake to say that he has examined the samples or made analyses of the waters mentioned. His answer is simply to bolster up a table
made by some one else and not by him.
1985 It is my opinion that if the figures given in this table
represent the total solids in the water of the Mississippi

river at Hartford and the water of the Missouri river at Bellefontaine, and the water of the intake of the St. Louis waterworks, at the Chain of Rocks, if these figures are accurate representations of the total solids in the samples collected, and if the samples collected fairly represent the waters of the streams at the points named, then the calculations made by using these figures in obtaining the percentage of water of the Missouri river and of the Mississippi river above the mouth of the Missouri, in the water of the intake of the St. Louis waterworks, are reliable.

1987 My calculations showed from the samples that I examined that the percentage of Mississippi river water which was present at point 4 in section I was about 90 per cen that the percentage of Mississippi river water at point 5 in the same section was about 97 per cent. (Witness states metho of ascertaining these averages, on pages 1986 and 1987.)

1988 Assuming that when the waters of the Mississippi and Missouri unite at that junction, that there is no minglin of the waters with each other as they flow down stream, I should expect to find that in crossing the river from the Missouri shor to the Illinois shore at a point referred to by section "I" o complainant's exhibit 44, that there would be a sharp line o demarcation separating the waters of the Missouri on the wes shore from the water of the Mississippi on the east shore. N examinations which I have made have shown that such a shar line of demarcation existed and that can be illustrated by referring to samples of water collected at 12 points on sectio "I," numbered 1 to 12, beginning on the Missouri shor

1989 It is my opinion that the relative percentage of th waters of the Mississippi river and the Missouri river a the intake can be most readily determined from the total solid

Q. When considering cities having a population of 25,0 or more according to the census of 1890, what percentage increase to the population naturally resident upon the wate shed of the Mississippi, at the Chain of Rocks, is caused by t Sanitary District of Chicago diverting its sewage into t

Illinois river and becoming thereby tributary to the Mississippi?

GENERAL HAMLIN: That is objected to on the ground that it is not a proper basis of estimation upon which to base a proper conclusion as to this subject matter by an expert, and the further objection that the testimony is not relevant to the issue in hearing, made by the bill and answer.

Speaking generally the population is about double.

1990 If you consider the population of cities which have more than 4,000 population situated upon the watersheds of the Missouri, Mississippi and Illinois rivers, above the Chain of Rocks, but not including the population of Chicago, and if we add to this population, the population of Chicago, we should increase the populations as mentioned, by about 63 per cent.

(Objected to by Mr. Hamlin.)

1991 There is this custom among sanitarians, that when it is desired to determine the amount of sewage pollution which exists in a stream at any certain point, to consider the population dwelling upon the watershed above that point in cities which have 4,000 or more inhabitants and for this general reason we take it the country over. It has been found that in general, communities which have more than 4,000 inhabitants are ordinarily supplied with such public improvements as public water supplies and sewerage systems, while, in general, those communities which have less than 4,000 people are not ordinarily so supplied. In making those calculations, I have adopted the same means. It is about 23 miles by river from the mouth of the Missouri to the mouth of the Illinois.

I believe it is possible by analytical means to determine the percentage of the Illinois river water which is present in the Mississippi river at Hartford, for example. I also made such a calculation in order to determine the percentage of Illinois river water at Alton, as well as at Hartford. I made these calculations from the analyses shown upon the sheets which I hold in my hand and which form a part of complainant's exhibit 1 for identification. (Witness states method pursued in making such calculations.)

GENERAL HAMLIN: I move to exclude the answer as to the results obtained, as they are not expert's statements, but are statements of a fact determined from tables not made by the witness.

From these average figures, I have calculated the percentage of the Illinois river at the five points in the cross-section of the Mississippi river at Alton and at Hartford.

1994 (Witness states results of calculations at Hartford and Alton.)

This is a diagram which shows graphically the results, the average amounts of nitrites and chlorines at the cross-sections at Alton and Hartford, across the Mississippi river, for the period from October 30th to November 4th, from the period of October 30th to November 29th, in the case of the Alton cross-section and from November 4th to November 30th, in the case of the Hartford cross-section. It also gives in the lower portion of the diagram, a graphical illustration of the percent of the Illinois river at the two cross-sections.

1995 (Diagram offered in evidence as complainant's exhibit 51.)

Q. Mr. Whipple, assuming that at a certain time Lake Michigan water contained an organism called cynedra pulchella sub prolongata variety, and that this plant is not contained at corresponding times in any of the branches tributary to the Illinois river, nor in the upper Mississippi water at Grafton, nor in the Missouri river water, and further assuming that this plant was found at a corresponding time in the water at the intake tower at St. Louis, what in your opinion does that show?

MR. TODD: I object to the question on the ground that the assumptions have not been established in the evidence, especially as to the Missouri river.

It would show that this synedra pulchella variety sub prolongata was not derived from the water of the Missouri river or from the water of the Mississippi river above Grafton, or

from the tributaries of the Illinois river, but that it
1996 came from Lake Michigan and was borne thither by the
water from Lake Michigan.

1996 (Same question answered as to tabellaria.)

When the germs of typhoid fever are put into natural waters they will continue to live for several months, though in gradually decreasing numbers.

1997 From what I know about the life of the typhoid fever bacillus in the water, and from my knowledge of the conditions which exist between the Chicago Drainage canal and the intake of the waterworks of St. Louis, at the Chain of Rocks, it is my opinion that if typhoid fever germs exist in the sewage of Chicago, they will survive the passage down the Chicago Drainage canal and to the intake tower of the St. Louis waterworks at the Chain of Rocks under existing conditions. (The question to which this answer was given, assumes the water to reach St. Louis in ten and one-half days.)

1998 From personal observations to which I have testified (an inspection of the Chicago river, canal, and so forth) and assuming that the sewage and lake water passing through the Chicago river into the Drainage canal reaches the Mississippi at the Chain of Rocks, in ten and one-half days, it is my belief that typhoid fever germs coming from the sewers in Chicago, survive the passage through the Chicago Drainage canal, the Des Plaines river and the Illinois river to St. Louis. (Objected to by Mr. Hamlin and Mr. Todd.)

Under the conditions assumed (flood times) it is my judgment that a greater proportion of typhoid fever germs would reach the intake of the St. Louis waterworks from the Chicago Drainage canal when the time of transit was 8 days than when the time of transit was 10 1-2 days.

GENERAL HAMLIN: I move to exclude the answer on the same ground as previously stated.

1999 I believe from my general knowledge of typhoid fever epidemics that there are cases on record where such epidemics have occurred where the evidence shows that typhoid fever germs considered to have caused the epidemic, remained in natural water for at least 10 01-2 days prior to the entrance of the water into the service pipes of the community where the epidemic prevailed. The cases on record of this character are those which occurred at Detroit, Michigan and at Lawrence, Massachusetts.

MR. TODD: I move to strike out the answer as not being competent evidence.

2000 From my knowledge of existing conditions of the Drainage canal and the several connecting water courses between that canal and the intake tower of the St. Louis waterworks, it is my opinion that there does not exist any efficient work of artificial construction which continually insures the prevention of typhoid fever germs, which may enter the Chicago Drainage canal, from reaching the intake. (Objected to by Mr. Hamlin and Mr. Todd.)

Q. Assuming that between Jan. 17, 1900, and Dec. 31, 1902, as compared with the period from 1885 to 1899 inclusive, there had been no increase on an average in the number of deaths from typhoid fever in those cities situated upon the Missouri river, upon the Mississippi river above Grafton and upon the Illinois river and its branches, exclusive of the Chicago Drainage canal, and further assuming that the typhoid fever death rate in the city of St. Louis had increased about 54 per cent on an average during this period, over the previous period mentioned, and further assuming that there was no substantial change in the manner of treatment of the water supply of St. Louis and assuming further that since January 17, 1900, a large part of the sewage of Chicago has been passed through the Drainage canal and thence into the Des Plaines river, 2001 the Illinois river, the Mississipi river, and into the intake, and assuming further that some of the water of the Mississippi river would contain a certain amount of Illinois river water at the intake of the waterworks at the Chain of Rocks,—state what, if anything, in your opinion the Chicago sewage from the Drainage canal had to do with the increased typhoid death rate in St. Louis.

(Various objections by Mr. Hamlin and Mr. Todd.)

A. Under the assumption which you have mentioned, and if the conditions named are those which obtained, it is my judgment that the sewage of Chicago was the most probable cause of the increase of typhoid fever in the City of St. Louis which you mentioned.

1902 From my knowledge of existing conditions in the Drainage canal and the several connecting courses between that canal and the St. Louis waterworks, it is my opinion that no reliable and efficient natural agencies exist which can continuously insure the prevention of typhoid fever germs which may enter into the Drainage canal, from reaching the intake at St. Louis.

Q. Assuming that 106 barrels containing 40 gallons each of the culture of bacillus prodigiousus, etc., were emptied into the Drainage canal at La Monte, that at the time of this experiment this germ was absent in the waters under consideration in this case, and assuming that soon afterwards some colonies of bacillus prodigiousus on several occasions were found in samples of water taken from the intake tower at the Chain of Rocks, what, in your opinion, does this show? (Several objections by Mr. Todd and Mr. Johns.)

2003 It is my opinion that the origin of the bacilli found was the culture which was introduced into the Chicago Drainage canal. To judge from experiments which I have made and what I know generally on the subject, it is my judgment that the longevity of the typhoid fever and prodigiousus germs in natural waters is not greatly different. From my general sanitary knowledge, it is my judgment that the dejecta of typhoid fever patients would enter the sewage of Chicago—

GENERAL HAMLIN: That would, or does, did you say?

A. That do, I say, enter the sewers of Chicago, and that under the assumption mentioned, that the sewage of Chicago enters the Chicago Drainage canal, or has entered the Chicago

Drainage canal since its opening, since January 17, 1900, it is my judgment that the dejecta from the typhoid fever patients of Chicago enters via the sewers of Chicago, the Chicago Drainage canal, or the Chicago river, and the Chicago Drainage canal.

2006 GEORGE C. WHIPPLE: In my testimony yesterday I did not have at hand the average amount of chlorine in the water of the Illinois river above Grafton for the period between October 30, and November 29, 1901, which I used in calculating the percentage of Illinois river at various points in a cross-section of the Mississippi river at Alton. Upon consulting my notes I find that the average figure which I used was 20.3—this figure being an average of the results of daily chlorine determinations given upon one of the sheets in complainant's Exhibit No. 1 for identification. Neither did I have the figure for the average chlorine in the water of the Mississippi river above Grafton for the same period, and upon consulting my notes I find that the figure which I used was 3.9 parts per million of chlorines. This figure being an average of daily determination of chlorines given upon one of the sheets in complainant's Exhibit No. 1 for identification.

2007 I understand that those sheets are the results of examinations made by Teichmann and Keiser—under the direction of Mr. Teichmann.

2008 GENERAL HAMLIN: I move to exclude this statement or answer on the ground that it is a mere calculation testified to by this witness based upon tables that were not prepared by him and are not the subject of expert testimony.

Assuming that since January 17, 1900, a larger amount of the sewage of Chicago has entered the Des Plaines and Illinois rivers via the Drainage canal, than was previously the case, and assuming that water of the Illinois river containing such sewage, enters the Mississippi river and passes to the intake of the St. Louis waterworks, it is my judgment that since January 17, 1900, the water at the intake of the St. Louis waterworks has been relatively less safe for drinking purposes than prior to that time.

GENERAL HAMLIN: I move to exclude that answer for the reason the facts assumed in the question are not the facts as testified by complainant's witnesses and the records, so far.

It is my judgment that the most dangerous kinds of pollution of water supplies derived from rivers, lakes, ponds, or reservoirs, with reference to the safety of these waters for drinking purposes, are the dejecta and urine of human beings, such as are commonly found in the sewerage systems of cities and towns.

2009 CROSS-EXAMINATION by General Hamlin:

Made seven anaylses of the waters of the Mississippi river above Grafton, between the dates of October 16 and November 26, 1901. I received those samples at my laboratory in Brooklyn, New York. A number of years ago I made certain physical tests of the water of the Mississippi at Minneapolis. I ordinarily include under the general head of water analyses,
2010 such physical tests as that of the determination of color and turbidity. Such physical tests I made at Minneapolis some three or four years ago. I made no test for sediment ammonia, chlorines or organic matter, at that time excepting as the organic matter may be included in the color of the water. Nor for nitrates or nitrites or total solids.

2011 I received seven samples from the Illinois river at Grafton between the dates of October 16 and November 26, 1901, from one or more collectors working under the direction of Dr. Ravold. The samples were received in glass bottles which had cork stoppers and these bottles were sealed when received. I do not make any chemical analysis of those waters. Nor bacteriological examination.

2012 Those were all of the samples immediately above Grafton that I ever personally examined. And the ones that I have testified that I received above Grafton on the Mississippi, are the only ones that I have personally examined. I received some samples further up the Illinois river at Beardstown in the month of November, 1901, sent to me by one or more collectors who worked under the direction of Dr. Ravold.

Q. Didn't you expect at that time to be a witness in this case?

A. I didn't consider the matter at that time.

2013 I don't remember just when I knew that I would be called as a witness

I received five samples between October 16 and Novem- 21, 1901, from sample collectors who worked under the direction of Dr. Ravold, and who collected the samples at Fort Bellefontaine. I did not make any chemical analysis of those samples, nor bacteriological examination. I regard myself and am regarded in my judgment, as an authority on the chemical analysis of waters and the bacteriological examination of waters. The next samples I received from the Missouri river were those which were collected by Prof. Van Ornum on April 12, 1903, the present year. I received three samples.

2014 They were all taken at a depth of ten feet. I did not make any chemical or bacteriological examination of these samples. I received the samples already mentioned (from the Mississippi river above the mouth of the Missouri) and in addition 8 samples collected in a cross-section known as section M and which were collected by Prof. Van Ornum on Apr. 10, 1903. Prof. Van Ornum is professor of civil engineering in the Washington University of this city. I did not make any chemical or bacteriological examination of these waters. That covers all the samples that I have ever received from that point. I received six samples of water from the Mississippi river at Alton, Illinois, which were collected between October 16 and November 21, 1901, and also 12 samples of the water of

2015 the Mississippi river above Alton, collected on November 12, 1901. I did not make any chemical analyses or bacteriological examination of those samples. I received seven samples of Mississippi river water at the Illinois shore, opposite the Chain of Rocks, which were collected between October 15 and November 29, 1901. Also 11 samples from Mississippi river just above the Chain of Rocks, collected on November 10, 1901; also 7 samples from Mississippi river at intake, collected between October 15 and November 29, 1901. Also 24 samples from Mississippi river at cross-section which has been described as series C, just below the mouth of the Missouri river, which samples were collected by Prof. Van Ornum, on April 12, 1903. Also 33 samples from cross-section of the Mississippi river which has been described as series I, just above the intake, collected by Prof. Van Ornum on April 10, 1903. Those are all the samples. Cross-section I, I think, is about a quarter of a mile above the intake.

2016 Now these samples that I have mentioned, I did not make any chemical analysis or bacteriological examination of these samples. That is all the samples I received from the Mississippi or Missouri river, but I received other samples from the Illinois river. I received 6 samples from the Illinois river at a point 3 miles above Peoria, which were collected between October 16 and November 21, 1901, and which were sent to me by collectors who worked under the direction of Dr. Ravold. I did not make any chemical analysis or bacteriological examination of these samples. I received no other samples in any of the three rivers named, the Illinois, Missouri and Mississippi.

2017 I made no chemical analysis or bacteriological examination of the samples which I received from the tributaries of the Illinois river. I received 6 samples from the Chicago Drainage canal at the Bear Trap dam at Lockport, which were collected between October 17 and November 26, 1901. I did not make any chemical analysis or bacteriological examination of those samples. I received 4 samples which were marked Paulina street and which are included in this sheet marked Chicago Drainage canal, but I understood that these were collected from the Chicago river just before it enters the Chicago Drainage canal. These 4 samples were collected between November 8 and November 30, 1901. I received 5 samples from the Lake View crib between November 4 and November 22, 1901;

2018 3 from Carter Harrison crib between November 6 and November 15, 1901, and 2 from the 4 mile crib on November 20 and November 27, respectively, 1901. I did not make chemical analyses or bacteriological examinations of any of the samples mentioned. I made microscopical examinations of all of the samples mentioned, except those samples which were collected by Prof. Van Ornum. It does not include the 3 samples collected in the Missouri river on April 12, 1903. I didn't make chemical examinations of these samples or bacteriological examinations because I wasn't asked to do so. I could have made these examinations very easily. In my direct examination I stated that there were two microscopic organisms, vege-

2019 table plants, if you choose, synedra and tabellaria, which were especially characteristic of Lake Michigan water, but not of the waters of the Missouri or the Mississippi river above Grafton, or the tributaries of the Illinois river. I do not mean that these two do not exist in the waters of the Mississippi above Grafton. They might be found, as far as I know, in the Mississippi river above the mouth of the Illinois. I do not mean to say that they cannot be found or do not exist in the waters of the Missouri river. I do not mean to be understood as saying that they do not exist nor cannot be found, in the tributaries of the Illinois. These micro-organisms are usually found in the waters of lakes, ponds or reservoirs. I have no personal knowledge of how many lakes are situated on the Illinois river between Lockport and Grafton or whether or not there are any lakes or ponds that connect with the Mississippi river above Grafton.

Q. If there were lakes on the Illinois river between

2020 Lockport and Grafton that connect with the Illinois river, you would expect to find those micro-organisms, wouldn't you?

A. They might be found there.

Q. Well, wouldn't it be reasonable to suppose that they would be found there?

A. At times, yes, sir. And the same is true of the Missouri river and of the Mississippi river, under the same conditions. I never made any examinations of the waters of the Mississippi river below St. Louis. Never examined it at New Orleans to my recollection. I have seen the waterworks plant at Chain of Rocks, I have seen the pumping station at Baden; I have ridden along the conduit connecting the two. I have seen from the train the settling basins at Bissell's point.

2021 There are four settling basins at Bissell's point and six at the Chain of Rocks. That would make 10 all together counting each particular tank as a basin. Settling basins are used to get rid of the mud and to get rid of the suspended matter in the water also. It makes the water clearer and freer from suspended matter. It purifies the water to some extent by the removal of matter in suspension.

I consider the principal elements in the purification of water the removal of those substances which would render water impure.

Q. Has dilution anything to do with it?

A. If the water is diluted with another water which is purer than it is, it makes that first water purer. Sedimentation ordinarily makes the water purer. Dilution and sedimentation are regarded by scientists and sanitarians as two important elements in the purification of water.

2022 I wouldn't say they are regarded as the principal elements. In certain cases they are regarded as important elements. Settling basins are used in cities in cases where the original water contains large amounts of suspended matter which would settle out during the process of sedimentation. Natural water is any water found in nature. When I was asked some questions yesterday regarding sewage being discharged into natural water I meant natural water in that sense. That is the esnse in which I intended. That is the sense in which I have used the term during my entire examination by the complainant.

2023 I didn't prepare all the expert questions which were asked me yesterday. In some of them I assisted. I don't think I repeated any of them myself absolutely, or any one entire question. In my testimony yesterday in regard to chlorine, I used an average figure taken from the sheets of complainant's exhibit 1 for identification, which gave the chlorine in parts per million. I took the average, found in the Mississippi river above Grafton; in the Illinois river above Grafton and at five points in the cross-section of the Mississippi river at Alton and Hartford.

2024 I used that for the purpose of showing the mixture of the waters of the Illinois and the Mississippi. I didn't adopt the same plan of using the solids instead of the chlorines because there were no determinations of the total solids on those sheets at the five points in the two cross-sections at Alton and Hartford.

2025 Q. You stated yesterday, I think, to Mr. Jeffries, that the best test, that is the most reliable test, is the test made with solids?

A. I consider it to be such for the particular case which is being discussed, I wouldn't lay that down as a universal proposition.

2026 I believe that a mixing of the Illinois river with the waters of the Mississippi was evident at Alton.

The banks of the river from there to Grafton, from my recollection of the charts, I believe to be very nearly parallel with each other and very nearly in a straight line, barring slight
irregularities. My recollection is that there are no im-
2027 portant curves. I think that the Illinois river water
mixes with the water of the Mississippi by the time it reaches Alton, to some extent. That I understand to be about 15 miles away from where the rivers unite. I think it is about 6 miles from the mouth of the Missouri river to the St. Louis intake.

Q. In your examination you stated: "From my general knowledge of the subject of rivers and the effect of curves on the currents of these rivers, it is my opinion that this curve which I have described (referring to a curve on the map or chart which you had in front of you) in the Mississippi river, between the mouth of the Missouri river and the intake of the St. Louis waterworks, would tend to allow or would increase or would be favorable to the mixture of the waters which come down the Mississippi river and the Missouri river." Now which one of those statements do you wish to adopt, "Would tend to allow, or would increase, or would be favorable?"

A. I don't think they mean the same, but I think they are all applicable. I wish to stand by all of them. I should say the mixture I speak of would take place most rapidly in that part of the curve where the central thread of the main channel crosses from the position near the left bank to a position near the right bank.

2028 That position or place is 2½ miles below the southern point of the mouth of the Missouri river.

2029 In the statements of the population made by me in my examination in chief, I did not state the total population of the watershed of the Illinois river.

2030 It is not true that all authors use the amount of urban population and the amount of rural population instead of the population of cities which have more than 4,000 inhabitants, as the population upon which they base their research. I think that where the pollution of a stream is involved, that the rural population is an element to be considered on the question of the discharge of sewage into that stream. I do not know what the rural population of the Illinois watershed is from my recollection. I find from the report of Jacob A. Harman, included in a report of the Illinois State Board of Health, on Sanitary Investigations of the Illinois river, 1901, on page 119, that in the year 1900, it was 893,723. That does not include Chicago but only the natural drainage of the Illinois river, and what he has called the rural population.

2031 I find in the same report and on the same page that the urban population for the same region for 1900 was 617,664.

Q. I will ask you if exclusive of the Chicago river and the I. & M. canal and the Drainage canal, if there are not about fifty creeks, rivers and tributaries to the Illinois river having their watershed drain into the Illinois river, making about 25,000 miles of creek, river and tributary draining portions of Indiana, Wisconsin, and a large part of Illinois, into the Illinois, which empties into the Mississippi river near Grafton?

A. I think that statement is approximately correct. But I find on page 120 of Mr. Harman's report that the sum of the areas of the watershed of the Illinois equals 27,814 square miles; and a memorandum from the 11th U. S. Census which states it to be 29,013 square miles and another from the Chief of the Weather Bureau from 1896 to 1897 which states it to be 29,150 square miles.

2032 I have no knowledge of the lineal number of miles of river or creeks draining into the Illinois river. All I know about the rural population upon the watershed of the Illinois river is what I get from this report of Mr. Harman's, he giving it at 893,723. The report of Mr. Harman I refer to does not undertake to give the urban and rural population of all the tributaries of the Illinois river, outside of the Chicago river, Illinois & Michigan canal and Drainage canal.

2035 It is impossible for me to say how much sewage is discharged into the Illinois river and its tributaries outside of the I. & M. canal, the Drainage canal and the Chicago

2036 river. I have no means of telling with any degree of certainty the amount of sewage discharged into the Illinois river exclusive of the Chicago river, the I. & M. canal and the Drainage district.

2038 In so far as the question of distance alone, is concerned, a typhoid fever bacillus would reach the intake of the St. Louis waterworks from St. Charles, Mo., or from Alton, Ill., more easily than a typhoid bacillus of equal vitality introduced

at a distance of 350 miles from the intake. But whether a typhoid bacillus discharged at St. Charles or at Alton would actually reach the intake of the St. Louis waterworks more easily than a typhoid bacillus of similar vitality, discharged at a distance of 350 miles from the intake, would depend among other things, upon the degree of mixing of the waters into which the bacilli were discharged, before they reached the intake, and
to some extent, perhaps, upon the character of the water
2039 into which the bacillus which was introduced at a distance of 350 miles from the intake, was introduced. And it would depend still further upon the velocities of the streams
into which the bacilli were discharged at the three points
2040 mentioned. If it depended on velocity, the one nearest
the intake would reach the intake first provided the velocities of the streams were such that the one which was nearest the intake got the shortest time of transit. Alton is nearer the intake than a point 350 miles away, in so far as that flow is concerned, as I understand it.

Q. Do you want to be understood that a typhoid bacillus with equal vitality at Alton and starting on his journey to the intake, with one of equal vitality 350 miles away, that one would be as liable to reach the intake as the other, and still maintain their vitality?

2041 If by vitality you mean the ability to resist external conditions, that would depend upon the relative character of the water into which the bacillus was introduced at Alton, and the water into which the bacillus was introduced at a distance of 350 miles, and the time required for the bacillus to travel from Alton to the intake, as compared with the time required for the bacillus to travel from a point 350 miles away to the intake of the waterworks.

From memorandum that I have read, according to the 11th Census of the U. S., the drainage area of the Missouri river was about 527,000 square miles and according to report of Chief of Weather Bureau for 1896 and 1897, was about 527,150 square miles; the drainage area of the Mississippi river above Grafton according to 11th U. S. Census was about 143,512 square miles and according to report of Chief of Weather Bureau it was 126,750 square miles, while the drainage area of the Illinois river I have already given. Making a total for the three watersheds of the three rivers mentioned, and excluding the I. & M. canal and Drainage canal, of 699,525 square miles according to the U. S. Census and 693,050 according to the Chief of Weather Bureau.

2042 If, by urban population we include the population only of those towns and villages and cities which contain more than 4,000 inhabitants, I find on page 27 of the report on the water supply of St. Louis by the Commission of Hydraulic Engineers, dated 1902, that the aggregate urban population on the three watersheds mentioned in the last question was, according to the U. S. Census of 1900, 2,694,738. I do not know what the rural population is.

Q. I will get you to state if it is not a fact that in this area of these three rivers, that you have mentioned, that is within these drainage basins, exclusive of the Chicago river, the I. & M. canal and the Drainage district, if the population according to the United States Census was over 12,000,000?

A. I don't know as I haven't made any estimate of such a population.

2045 If we assume there are 12,000,000 inhabitants living upon the watershed of the Missouri river and the Mississippi river above Grafton, and the Illinois above Grafton, exclusive of the population living within the Chicago Sanitary District, and if we assume that there are living within the Chicago Sanitary District 1,639,456 inhabitants, and if we assume that the amount of sewage from each individual is the same as the amount of sewage from every other individual upon the three watershds mentioned and within the sanitary district, and if we assume further that all the sewage from all these individuals mentioned as living upon the three watersheds, and within the Sanitary District empties into the streams mentioned, the amount of sewage contributed by the inhabitants of the sanitary district of Chicago would be about 13.6 per cent of the amount of sewage contributed by the 12,000,000 population dwelling upon the three watersheds mentioned, exclusive of the Sanitary District.

2047 According to the authenticated cases of the contamination of water that has produced typhoid fever, to the best of my recollection and in the absence of my notes, it is my opinion that the distance from the point or place where typhoid fever was contracted from the point of contamination, has been *as great at times as 50 or 60 miles.*

I should say that the majority of the well recognized epidemics caused by water borne typhoid fever bacillus were due to infection less than 30 miles distant.

2051 The best way to determine the presence of sewage in water is to actually find out whether or not sewage enters the water.

Q. In the absence of that information can water be taken from a river and by any process known to science, can it be determined whether that water is sewage polluted or not?

A. Some water can be and some water cannot be. If water is much polluted with sewage that fact can be ascertained by scientific methods; if it is but very slightly polluted with sewage, it cannot always be determined by scientific methods. I have not a definite idea as to what degree of pollution I denominate much polluted.

2055 Q. Then, in order to ascertain the presence of sewage in water of the character that we have been talking about,, with these elements eliminated, is it necessary to make a chemical analysis of the sewage before it enters that water, in order to ascertain the proportion of the sewage to the water into which it enters, in order to ascertain its presence?

A. In order to ascertain the proportion of the particular sewage mentioned, it would be necessary to make some sort of an analysis. In the absence of any analysis having been made of the sewage before it enters the water it might be possible to ascertain its presence in the water into which it empties but not its exact proportion.

2056 Q. Do you know the character of the waters of Lake Michigan when freed from any sewage pollution from Chicago?

A. Only from analyses of such portions of Lake Michigan as are used for the water supply of Chicago. I couldn't state definitely whether that is free from sewage contamination or not. I am not able to state from my knowledge of the
2057 sewage of Chicago before it commingles with the waters of Lake Michigan at what proportion of water to sewage I would be able to ascertain the presence of sewage in that water.

Q. Your experience as a scientist has not enabled you to make that kind of a determination, has it?

A. It has not enabled me to determine that point exactly. I do not know of any scientist of established standing or admitted standing that has been really able to solve it.

Q. Then the line between much polluted water and slightly polluted water has never been scientifically defined as to the ratio of sewage to water, or dilution, has it?

A. It is my opinion that it has not been truly defined, and that it cannot be truly defined.

If a scientist did not know that the sewage entered the water, and if he didn't know the character of the water before the sewage entered it, the question of whether he could determine the probable presence of sewage in that water, would depend in part, upon the original character of the water and the character of the results shown by his analysis.

Q. If he didn't know the character of the water into which the sewage entered, or the character of the sewage that entered the water, in fact didn't know that any sewage entered the water at all, what would have to be the results of the analyses in order to demonstrate the presence of sewage in the water?

A. I should be unable to state in definite terms.

Q. Do you know?

A. Not in definite terms, no, sir.

2058 If I didn't know the character of the water originally or the character of the sewage; if I obtained from my analysis results which approached those in character which would ordinarily be obtained by the analysis of sewage, I should be able to form a fairly reliable opinion as to the presence of sewage in the water. I should compare the qualities which have been already enumerated, namely, the amount of organic matter as shown by albuminoid ammonia, the character of the organic matter as indicated by the free ammonia, the nitrites and nitrates; the amount of total solid matter, the matter in suspension, the chlorine, the hardness, the prevalence of certain particular species of bacteria, such for example, as the bacillus coli; the number of bacteria, the color, the presence of certain microscopic organisms, etc.

2059 There is no one element to which I should attach special prominence. Suppose some of these elements were absent, I might be able to conclude the presence of sewage pollution, but my judgment would be to that extent, or to the existence of the pollution, less reliable. Albuminoid ammonia in water serves as a measure of the amount of undecomposed organic matter present, but taken by itself, it cannot be used to determine the amount of sewage pollution present.

2060 There is no such substance as albuminoid ammonia. It is simply a form of expression for describing the amount of organic matter present. It is a form of expression for the substance and is not the name of the substance itself.

Q. Chemistry is an exact science, isn't it?

A. Fairly so.

2061 If the water is said to contain free ammonia, we meant that the water contains ammonium compounds which are such as upon boiling the water the ammonia will be driven off in such a way that its amount can be determined. Nitrites are both a name for a substance and a substance. Nitrates are also a substance which may exist in water.

2062 You can get the nitrogen of free ammonia as the term is used in water analysis, from the nitrites and nitrates. The substance for which the term albuminoid ammonia stands, may be derived either from animal or vegetable matter. In fact, it may be animal or vegetable matter. When I find the presence of albuminoid ammonia in water the science of chemistry does not enable me to ascertain whether that albuminoid ammonia comes from animal or vegetable origin.

2063 From any methods of chemical analysis with which I am familiar, it is impossible to tell whether the substance represented by the term albuminoid ammonia, is derived from animal or vegetable matter. The origin of the free ammonia which may be present, whether from vegetable or animal matter, cannot be definitely determined, although if the amount of free ammonia is high compared to the amount of albuminoid ammonia found, there is, to some extent, more reason to expect that it comes from animal matter, using the terms free ammonia as standing for the substances. I should say that that fact rises to the dignity of a scientific demonstration.

2064 Now that which is true of free ammonia is true of nitrites and nitrates, is it not, as to the origin, whether animal or vegetable?

A. Not in the same sense, because nitrates may come from substances of mineral character. It is a fact that the substances which you describe as free ammonia, that the nitrogen of that substance may become changed to nitrites, and afterwards to nitrates under the influence of certain bacteria.

2065 If you found nitrates in the water analysis, these nitrates may come not only from animal and vegetable, but also from mineral origin. When they come from mineral origin it does not come from sewage unless the sewage contains minerals from which they came. Sewage contains mineral matter besides chlorine. If these nitrates come from mineral, I couldn't say definitely that they came from mineral sewage or without knowing whether any of the sewage entered the water, or whether the water in any way came into contact with minerals which would give up nitrates. Speaking popularly, minerals do not come from vegetables, but in so far as nitrates represent mineral matter, these might be derived under the action of bacteria, from vegetable matter.

2066 If nitrates are found in the chemical analyses of water, their presence there does not indicate from what source they have their origin—whether vegetable, animal or mineral, simply because they are found there. The hardness of water is an attribute which is derived chiefly from mineral origin. It might be derived from sewage pollution to some extent when the sewage is from the fecal and urinal discharge of man.

Q. To what extent would you consider it?

A. I could not express that in definite terms, but I might say that would be a smaller fact to be considered than most of the other elements which I have mentioned. Of itself it would not decide sewage pollution.

2068 Q. Now, from the table and analyses that you have before you, (Complainant's exhibit 1 for identification) are you able to tell whether that sample of water was sewage polluted or not, or whether those elements are derived from animal or vegetable origin?

A. I am not able to tell either of those things from these figures as I find them right here, considering nothing else, than these figures.

2069 What other element would you consider in connection with those analyses in order to determine whether the chlorine, albuminoid ammonia, free ammonia, nitrites and nitrates were derived from animal or vegetable origin, as indicated in those tables marked Complainant's Exhibit 1 for identification?

A. I should want to have more information—more practical information in regard to the source of this sample and the place from which it was derived. That table indicates that sample was taken at Fort Bellefontaine, in the Missouri river.

That gives the locality of the sample, as to place and the river from whence it was taken. I should like also to know the character of the watershed from which this sample of water was derived, with reference to the existing pollutions. I think the analysis is of such a character that it would be difficult to tell from the analysis itself, whether or not this water were sewage polluted without knowing the character of the watershed. Assuming that the sewage of Kansas City, Kansas, and the sewage of Kansas City, Missouri, and the sewage from slaughter houses and cattle sheds located at those two places, emptied into the Missouri river about 400 miles above this point, those facts would indicate that this water might perhaps be sewage polluted, except in so far as the effects of the pollution may not have been interferred with by processes of sedimentation, etc., between the point of pollution and the
2070 point where this sample was collected. I should have to balance a number of different conditions in order to arrive at such a result.

2071 Q. Do you consider the water of the Missouri river above Kansas City a sewage polluted water?

A. In so far as the sewage of the cities dwelling upon the watershed of the river above that point enters the river, I should consider it as a sewage polluted river. Whether suitable for drinking purposes I am unable to state from the facts which I have at hand.

2072 I stated that whether the sewage of Kansas City reached Fort Bellefontaine in quantities sufficient to be detected, or have any effect upon the water when used for drinking purposes, depended upon dilution, sedimentation, the action of bacteria—I would say the possible action of bacteria and microscopic organisms or other such natural agencies and I understand you are barring out any artificial actions which might be introduced. The amount of dilution necessary to meet the requirements of my answer would depend upon the character and the amount of the sewage and also perhaps upon the relative effect of some of the other agencies mentioned, including for example, the time of transit of the water from the one place to the other. I don't know the exact amounts of dilution because I don't know the volume of the sewage and I don't know the volume of the stream at that point.

2075 The presence of the bacilli coli communis I could not state definite that it indicates sewage origin. It is believed by many scientists today that this organism may be found in waters where pollution may be remote. I hold that if this organism is constantly present, or is very often present in a water, and if this organism is present in such numbers that we can readily determine its presence by analyzing one cubic centimeter or less of the water, it is probable that this is an indication of contamination by fecal matter. I do not believe that the test is an absolute test, but I consider it is a valuable one to be interpreted in connection with the rest of the analysis.

2076 The bacilli coli communis is found most commonly in the intestines of man and certain animals, for example, the cow, horse, pig and I think birds and speaking generally, in warm blooded animals.

It has been my experience that the intestines of fish do not ordinarily contain bacillus, and that if this bacillus is found there, it is a case where the bacillus has been derived from the water, and I base my judgment upon considerable personal work which I have done in that direction. I would disregard its presence in the intestines of fish in the Missouri river so far as any interpretation were made from the presence of the coli communis in the water.

2078 Q. What organisms—what micro organisms found in water demonstrate sewage pollution from the fecal discharge of man?

A. I don't know of any that absolutely demonstrate its presence, but there are certain microscopic organisms or microorganisms which are so often associated with sewage that in a very general way they do serve as an index of the presence of sewage, but I wish to be understood as saying that they indicate it only in a general way. I could not assert that a stream was sewage polluted because these organisms were found in the water, barring all other considerations. There are none of the elements which you have mentioned taken singly, that would demonstrate their origin to come from the fecal discharge or the urine discharge of man, if found in waters. And even when taken collectively, they are not able to demonstrate their origin as coming from the urine or feces of man, but taken collectively and making comparisons with what we know of their character and amount of sewage, we are sometimes able to judge as to whether or not a water may be polluted with sewage which presumably contains the dejecta and urine of man. I wouldn't call that a straight scientific demonstration, but I would consider it what you may call a reasonably correct judgment That judgment is liable to be mistaken like all human judgments.

2081 I don't know definitely how long the bacillus of typhoid will live in sewage contaminated water. I don't know of any scientist who actually knows. I know the bacillus of typhoid will live in sewage polluted water, but scientists have made laboratory experiments to determine that fact and they have arrived at certain conclusions. I do not consider conditions in the laboratory where experiments have been made, similar to conditions that exist in a running stream, sewage polluted.

2082 I know of people who have claimed to have discovered the germ of typhoid in running waters, but I am unable to state whether they actually did discover that germ in running waters or not.

2083 I don't see how it is possible in the present state of bacteriology for reliable experiments to be made as to the rate typhoid bacillus dies out in running waters.

2085 I believe that the best scientific information which we have leaves us to suppose that after leaving the human system, typhoid bacilli do not ordinarily multiply in the water.

Q. Would the presence of lakes in the river act as settling basins for the purification of the sewage discharged from the Drainage canal at Lockport?

A. If such lakes were present on the Illinois river, and if in such lakes the water therein should become more quiescent than in that of other portions of the stream, the suspended matter of the sewage—the suspended portions of the sewage might tend to settle more rapidly than in the swifter portions of the stream. Purification of the water which contained the sewage would depend in part upon what happened to the suspended matter after it had settled, and whether or not the suspended matter was afterwards carried into the stream again, to Grafton.

From what I have learned from reading various reports which describe the conditions of the Illinois river between Lockport and Grafton, it is my opinion that at times such sedimentation may take place. That is at times when the
2086 velocity of the water in the stream was low. Flood conditions would add to the dilution. They would increase the dilution of the sewage.

2087 There are four dams in the Illinois river.

They are there for the purpose of assisting navigation by raising the water and backing it up stream. Now when the water in the Illinois river is at normal and is backed up by these dams, would not the backing of the water up above the dams act as settling basins?

A. If in this water above the dams the velocities were reduced to such a degree that sedimentation of suspended matter could take place.

2088 Q. What is your individual judgment upon the subject as to the speed of a current that would be necessary in order to permit sedimentation?

A. My judgment is that if the velocity is reduced say from a quarter to one-third, or perhaps to a half a foot per second, sedimentation of suspended matter of a certain character might occur. If the suspended matter were coarser, it would settle with greater velocities. I can imagine suspended matter so fine that it would not settle even at those velocities.

Q. Suppose that the current was a mile in two hours, would sedimentation take place?

A. I think it would, sedimentation of substances of a certain character.

2089 Those four dams in the Illinois river, I think they would allow sedimentation to take place under more favorable conditions than if they were not there to just the extent to which they reduced the velocity of the stream. Of course we understand that the laws governing sedimentation of suspended matter would apply to the Illinois river the same as they would apply to other streams, and I know from reports that sedimentation actually is said to take place in the Illinois river at certain places. I think that a velocity of one mile in two hours would allow sedimentation of a certain size or kind of suspended matter to take place. Under the conditions which exist, it is my judgment that the proportions of the sewage, of all parts of the sewage of the city of Chicago, would not be eliminated by the time that it reached Peoria. I am unable to state definitely what part would be.

2090 I said parts of the sewage, and when I said parts I did not mean a half, or a quarter or an eighth or sixteenth. I mean parts of the sewage, understanding that sewage is not a single substance, but is composed of various ingredients. If we take chlorine, for instance, which is a constituent of sewage, that chlorine would not be affected by sedimentation, for instance, but practically by dilution, and to that extent the sewage of Chicago would not be eliminated by the time it reached Peoria, but simply reduced in amount by the dilution it might receive. From what I know of the existing conditions on the watershed of the Missouri river and from the fact that there are certain salt deposits, and from analysis which I have seen showing the indication of such salt deposits, of the effect of such salt deposits on the water of the Kaw river, it is my opinion that the chlorine in the Missouri river, in its low reaches, cannot be used as an index of pollution, although part of it may be derived from sewage pollution, because the effect of the chlorine from the salt deposits, would simply mask any chlorine from sewage pollution, and in that particular case the chlorine could not be used to determine whether or not the water was sewage polluted.

2091 Q. Is it your opinion, and I believe you stated that the increase in typhoid in the city of St. Louis, is due to the sewage from the Drainage canal, from 1900, 1901 and 1902?

A. I think that I stated that under certain conditions which were assumed, the most probable cause of the increased typhoid in the city of St. Louis during that period was due to the sewage of Chicago, meaning by that that was the easiest explanation of the increase under the conditions which were assumed.

Q. Does an easy explanation always explain, Mr. Whipple?

A. It doesn't always explain.

2095 You cannot state as an established fact that the opening of the canal at Lockport is the cause of the increase in typhoid in St. Louis, can you?

A. I cannot state it as an established fact absolutely, and conclusively proved.

2096 I don't know that the sewage of Peoria purifies itself in 25 or 50 miles. If you mean by purification, the fact that the water into which the sewage of Peoria is discharged because free from all the constitnents of that sewage, if you put the time within 25 or 50 miles, or if you mean by purification the fact that the water into which the sewage of Peoria is discharged, becomes free from all the constituents of that sewage, I should say that it did not.

Q. Would it purify itself by the time it got to the St. Louis intake?

A. If you mean by purification of the sewage the fact that all of the elements of the sewage were absolutely removed from the water I should say that it did not, but in connection

with both of these answers, I wish it to be understood that the
factors of dilution, etc., must be taken into consideration.
Chlorine in water is not injurious to health unless you get an
excessive quantity of it and it would probably be impossible
to get enough to injure one as I understand your question. In
order to make water dangerous to the public health, it must
contain something which would affect the human system, and
that something would ordinarily be a pathogenic germ, rather
than any form of poison, or anything of that sort. If
2097 you wanted to know the character of the microscopic
organisms in the water for the entire year and the
changes which might take place in the number of microscopic
organisms present at different seasons, the samples should be
taken at different seasons of the year, and the more frequently
these samples were taken the better would be our knowledge in
regard to the general character of the water with respect to
microscopic organisms. Take one set of samples in a cross-section
of the Illinois river and examine them microscopically,
and we would learn the condition of the water at the point
where the samples were collected at that time.
2098 That determination might not apply to the conditions of
the river a month previous or a month subsequent. One
set of samples taken at a selected time would give reliable information
as to the character of the water of that stream at
that time at the point where the sample was taken.

Q. And at no other time, or at no other point?

A. No, sir, so far as those samples alone were concerned,
and in the absence of any one from which we know that those
waters remained constant in character through a period of
time.
2100 In making up an opinion as to the conditions of these
rivers, I have assumed that the results which I have seen
as tabulated or published, were correct.
2101 I do not consider that there is a well defined standard
regarding what I may term the safety of water with respect
to its use for drinking purposes, excepting that of the

absence of substances which might render the water unsafe. It is my opinion that it is practically unknown subject as to whether or not the presence of microscopic organisms would render a water which once unsafe, safer for use than if they were not present. So that the presence of a greater or less quantity of any kind of micro-organisms such as I have named, is not indicative that the water is undergoing a process of purification.

2102 Any one of these groups, (diatomaceae, chlorophyceae and protozoa) might encounter conditions which might exterminate them so far as their life were concerned, but I have already testified that the cell walls of the diatomes are practically indestructible in water. Diatomes are found in all surface waters, to a more or less extent.

2103 The synedra pulchella variety sub prolongata is more commonly found in ponds—in the waters of ponds and lakes than in the waters of streams, except in so far as those streams might be fed by lakes which contain them. I mean the natural habitat of the organism is in ponds and lakes. That is also true of some species of tabellaria. If the variety of synedra which I have mentioned, and the tabellaria could be required to pass through twenty miles of what has been called pure sewage, I think it might survive the journey.

2104 Assuming that the Illinois river has upon both banks from Joliet to Grafton, or from La Salle to Grafton, large numbers of ponds and lakes, many of which are fed by springs, over-flowing in time of high water, and acting as feeders to the Illinois river in time of low water, having their low water outlet into the Illinois river, the synedra and the tabellaria of which I speak exist there.

2105 If we have a certain volume of water contributed by the tributaries of the Illinois river, and the assumed lakes which are assumed to contain a certain number of these organisms, and if we have a greater volume of water from the Chicago Drainage canal which contains per cubic centimeter an equal

number of these organisms; then if we assume a thorough mixing
of the waters, it would be my judgment that the organisms
found in the resulting water would be more likely to come from
Lake Michigan than from the other sources named—it would be
my judgment that these organisms would come from both
sources, but that more of them would come from the water which
was greatest in volume, provided that the two waters contained
an equal number per cubic centimeter. All other considerations
2106 being equal. I don't think the fact that the supposed
organisms traveled through 22 or 24 miles of sewage,
of any consequence, for the reason that in the examinations
that I have made I have not attempted to differentiate
between a live synedra and a synedra not capable of developing.
2109 I do not know that one thousand million
bacillus prodigiosus could be concentrated in one cubic
centimeter and exist for two days alive. A bacillus may be
carried by water from one point to another provided nothing
happens to it on the passage. I suppose it might be taken from
the river by pump and through along the decks of a steamer
traveling up the river, in the process of washing decks, and go
out into the river again, five or ten miles above where it was
taken from. If conditions were favorable, a bacillus might be
taken in a portion of water and put in a boat and carried up
stream and then put down in the water again.

2110 I think that the bacillus—speaking in general—might,
under certain conditions, become attached to a duck, for
example, the duck might travel up stream and the bacillus
might get away from the duck and go into the water. I think
it might be taken up by a duck or through a pump and be used
for the purpose of washing the decks of a boat and returned to
the water again alive, three or four miles or ten miles from
where it was taken out. So far my knowledge goes, that principle
would apply as well to prodigiosus as to any other bacillus.
The fact that the bacillus prodigiosus—one colony of them
—was found three miles up-stream from the place at which it

was put into the river, would simply show that the water at that point, at that time contained this bacillus.

2111 It is my opinion that if the bacillus were taken out from the place where it was put in and carried up by boat three miles and put into the water—it would be there. I think it would bear the transportation probably, under the circumstances which you have mentioned.

Q. Suppose bacilli, naturally inhabitants of running waters which are turbid to some extent, should be removed from their natural place of abode, developed by special culture, put in bottles of sterilized water, and hung out in the sun, would that be a fair means of determining how long they live in their natural waters?

A. I don't think it would enable us to tell how long they would live in their natural waters, no, sir.

2112 An experiment of that kind does not enable us to give a definite opinion as to the life of any particular bacillus in its natural situation.

2113 Q. Taking into consideration all that you know of the physical conditions surrounding the Drainage canal, Illinois river, the Mississippi river and the intake, and the character of the prodigiosus bacillus, and assuming that some bacillus were put in near the mouth of the Illinois river in August, 1900, and in November, 1901, 107 barrels of them were put in near Lockport, and that they were afterwards found at the intake and in taps of the city waterworks here, could you tell, with any kind of certainty, to which dose of the bacillus put in those waters, those found were to be attributed?

A. It is my judgment that if those came from either the one dose or the other, that they came from the second dose rather than the first.

2115 If you consider the question of percentage mixture, I would say that the percentage of mixture of the two waters would not be the same at all times, of Mississippi and Missouri water.

2116 As a rule, if we consider a certain point below the point of mixture, the percentage of the waters would not be the same at all times, on account of natural variations in the flows of the two streams, and questions concerning their currents, etc., so that when it is determined that upon a certain day the percentage of the Mississippi water and the percentage of Missouri river water bear certain relative proportions to each other, that determination would not necessarily apply to any time. It would simply apply to that one time. When I testified here to percentages of volume of water of the Missouri river and the Mississippi river at the intake, based upon total solids and also upon the chlorine as to the Illinois and the Mississippi, I meant to say that the percentage of water carried a certain percentage of the solids in solution and represent relatively the volumes of the water as far as the solids represented the samples.

2117 I think if the determinations for the chlorine represent fairly the waters from which the samples are taken, that the calculations will give us the limits of accuracy governed by the sample and the determinations of the percentages of the two waters.

2119 (See pages 2118 and 2119 for method employed in determining percentage of Illinois and Mississippi river at various points.)

2120 CROSS-EXAMINATION by Judge Springer:

2121 The larger the number of samples and the more complete the examination made, the better judgment we could make of the sanitary condition of the water or the sample analyzed. Microscopic examinations of water cannot be depended upon to determine the pathogenic qualities of drinking water. So far as I know the common microscopic organisms found in water are not the cause of disease. Their presence does not definitely indicate pollution but as I have already testified, there are certain forms of microscopic organisms which are so commonly found in waters known to be polluted that to some extent their presence in water is indicative of pollution—to a ical examination does not definitely determine the nature of the organic matter in the water. Some microscopic organisms are very susceptible to changed conditions of temperature and light.

2122 In order to obtain the most accurate result, the bacteriological examination of a sample of water should be begun immediately after the time when the sample is collected, but the character of the water would, to a considerable extent, influence this fact. Water which came from the Illinois river during the months of October and November should be examined immediately after the sample was collected or within a few hours of the time of its collection.

2124 As to the samples I examined microscopically and which were examined three or four days after being taken, I would say the results would have been the same if I had examined them immediately upon being taken from the water, so far as diatomes are concerned, but perhaps not so far as some of the more delicate forms are concerned.

2125 I stated in my examination that there were two organisms which I called synedra pulchella variety sub prolongata, and tabellaria which were especially characteristic of Lake Michigan waters, but I think I stated that only with regard to the synedra pulchella variety sub prolongata, that that organism was not found anywhere else than in the water of Lake Michigan, or the waters with which Lake Michigan might have been afterwards mixed. The microscopic organisms which I found in Lake Michigan are found in all parts of the world and in great variety of climatic conditions, speaking generally. These organisms have received a great deal of attention.

Q. Are the laws governing their distribution in determining the places at which they may be found, understood at this time by scientists?

A. They are certainly not fully understood. I think we are beginning to understand something concerning these laws.

Q. May not a certain genus of the varieties to which you have referred, grow vigorously in one pond or place, and be absent from a neighboring pond where the conditions are equally as favorable for its existence?

A. Yes, so far as we know those conditions, I can recall such cases.

Q. Does it not often happen that a certain genus of the species to which you have referred may suddenly appear in a pond, lake or water in which it has never been before seen?

A. They certainly do suddenly appear in waters where apparently they have not before been seen, but just how far back observation has extended in regard to the previous history of that water, or just how far observations of a scientific character have been made concerning that water, would have to be taken into account in comparing their presence to-day with their presence on former days.

2126 An examination of a sample of the water in the Missouri river, or in the Mississippi river above Grafton taken today might show the presence of the two genera which I failed to find in the samples found in Lake Michigan.

2128 The samples of water that I examined microscopically were taken in October and November. If additional samples of water had been taken during that year in other months, at Fort Bellefontaine and in the Mississippi river above Grafton, it might be that I would have found the two genera of micro-organisms which I failed to find in the samples submitted to me from those points.

In the typhoid epidemic of Lawrence, which I mentioned, it was supposed that the bacilli travelled somewhere near 21 miles.

2129 The other case, which was that of Detroit, the distance travelled was from 50 to 60 miles. I think I have heard of greater distances, but I am unable to recall at the present moment. I mentioned the distance of 50 or 60 miles the other day, because I felt quite sure it had been carried at least that. The distance travelled is only an important factor in so far as

it affects the time required for the bacilli to travel through
water. I don't think it is any question of linear distance so
much as it is time transit. There are a great many other ele-
ments to be considered, for example, the so-called vitality of the
organisms; the rate at which they die out in water, the rapidity
of the current in which they flow; with reference to possible
sedimentation; the possible phenomena that they might settle
to the bottom of the stream and again be taken from the bottom
of the stream and carried down; the question of the tem-
2130 perature of the water might influence their vitality and
the character of the water might, to some extent. I
think it is the concensus of the opinion of scientists that such
a pathogenic germ as typhoid fever for example does not develop
in water, but on the contrary dies out.

2131 Their presence is best accounted for by considering the probable presence of the dejecta and urine of human beings which contain such bacilli so that when any of these pathogenic germs are destroyed in transitu they reduce of course the possibility of transmission of disease in proportion to the number destroyed in transitu. Scientists or authors have not ascertained by any experiments today the probable duration of pathogenic germs such as typhoid fever, in running water except by means of laboratory experiments which naturally cannot be made under the same conditions as actually exist in running waters. It is my opinion, speaking generally, that the laboratory experiment would be less favorable to their longevity than the natural conditions. (Witness is shown "Micro-organisms in Water," by Percy and G. C. Frankland, showing experiments made as to the longevity of typhoid bacillus.)

2133 From those figures I should question whether the results that he actually obtained would stand the test of the bacteriology of the present day.

2134 I considered the question of sedimentation in those expansions of the Illinois river to which references have been made and it is my opinion that under certain conditions, sedimentation of bacteria might certainly occur in those places.

2136 The greater the amount of dilution of a polluted water, the less danger there would be from drinking this water, so far as dilution alone is concerned.

2137 It is quite conceivable that the conditions in the Illinois river between the Chicago Drainage canal and Peoria (taking into consideration the Narrows) are such that the total numbers of bacteria in the Illinois river at that point, might be as low or even lower than the numbers of bacteria in the waters of Lake Michigan before it received the sewage of Chicago, but I would add to that, that when we speak of a bacteriological condition, we must consider not only the number present but also the character of those bacteria. The probability is that pathogenic germs would decrease, but whether or not they would decrease exactly in proportion to the water bacteria, is a thing which I cannot state.

2138 It is my general impression from experiments that have been made, that at most temperatures water bacteria would live longer in water than the typhoid bacilli. If we neglect all other conditions, such as sedimentation, etc., etc., and consider only the fact that typhoid bacilli do not multiply in water, while water bacteria do multiply under the conditions assumed, why then it is probable that the typhoid bacilli would not linger in water as long as the bacilli which multiplied there, but as a natural practice it would not do to neglect all such other considerations in studying a problem of that character.

2139 Q. This work by Percy and G. C. Frankland, on pages 100, 101 and 102, refers to experiments made by one of the authors, by bacteriological examination of the waters of the River Dee in Scotland, the results shown here are that near the mouth of the river the waters exhibited about the same number of micro-organisms as it did 40 miles up the river and that there were as many as four different sources of pollution entering the river and that after each one, the river reached its normal condition and came out at the end comparatively bacterially pure. In view of these facts, is it not highly probable that the waters of the Illinois river, in passing from Joliet to the Narrows, above Peoria—a distance of over 100 miles—were rendered comparatively bacterially pure, by reason of the sedimentation, oxidation and other causes tending to the purification of rivers?

(Objection by Mr. Jeffries.)

A. It is my opinion that the conditions which exist in the River Dee have not been described with sufficient completeness as to the amount of dilution, course of the stream, sedimentation, etc., to enable a fair comparison between the River Dee and the Illinois river.

2141 Assuming that there was a typhoid epidemic in 1890 in cities on the Missouri and Mississippi and that the sewage of the respective cities was emptied into the Missouri and Mississippi rivers, speaking very generally, the danger of contracting typhoid fever by drinking the water of those streams would decrease down the stream.

2142 Q. Then the danger of contamination of the lower river would be lessened in proportion as the pathogenic germs were eliminated by the sedimentation and other causes to which you have referred?

A. The danger from drinking the water in the stream further down the river is certainly lessened in proportion as typhoid fever germs are actually eliminated from the water.

(Question propounded in which the number of deaths from typhoid and population of various cities which drain their sewage in the Mississippi and Missouri rivers, is given, the number of deaths from typhoid being in each instance from 4.5 per 10,000 to 21.7, ending with New Orleans with 1.9 per 10,000.)

Q. How do you account for the fact that the death rate of New Orleans, which was 1.9 per 10,000 persons was less than it was in any of the up-stream cities to which I have referred?

A. The problem is too big a one to be solved without knowing many more conditions than anything that I have at hand at this moment, aside from these figures.

2144 I have no doubt that starting with Denver and the Missouri river and St. Paul on the Mississippi river, and continuing down the two streams, both before and after their junction, that in so far as the bacilli—typhoid fever bacilli in the sewage of those cities are concerned, there was an increasing dilution; there may have been sedimentation; there was no doubt a dying out of the typhoid fever bacilli. On the other hand, some of the bacilli which settled may have been again carried into suspension and borne a distance, possibly to be again settled; possibly to be again carried on, and I should judge from these figures, that the water which was being used by the people of New Orleans, for example, was less dangerous from the standpoint of typhoid fever, than the water which was being used by the city of Memphis, for example, assuming that there were no local conditions or no other conditions to account for the difference in the typhoid fever rate. In short, the death rate from the typhoid fever in the two cities for a certain period offers a fair index for the comparison of the danger of the two water supplies for the period, irrespective of other causes which might account for some of the cases aside from the water.

2146 I do not think it is universally recognized as a fact that the greatest pollution in streams of water is at times when the flood is greatest or the flow of water is the greatest. At times of flood or spring rains, there might be a greater amount of polluting matter washed into the streams but, on the other hand at such times the volume of water is usually large and dilution greater, so that the result might not be different from what would occur under normal conditions by the constant pollution of the stream by a sewer, for instance. I do not believe there is any practical method by which pathogenic germs can be determined in water, either chemically or bacteriologically.

2148 I believe it to be a fair statement to say that in ordinary natural running waters, there is no practical method by which the presence of the typhoid fever bacillus can be determined. I do not think it is absolutely impossible to do so, but there is no practical every-day method for doing it.

The germ might be there and you might fail to find it and it might not be there when you failed to find it.

RE-DIRECT EXAMINATION by General Crow:

I certainly believe that the liquid leaving the Chicago Drainage canal at Lockport is polluted.

2149 If we consider the liquid which leaves the Chicago Drainage canal at Lockport to be polluted sewage, and to be flowing at the rate of 300,000 cubic feet per minute, and if to that is added 40,000 cubic feet per minute of diluting water, the sum of these two amounts would be 340,000 cubic feet per minute, and of this sum about 88 per cent would be the diluted sewage. (Witness does not take into consideration the Lake Michigan water entering into the sewage.)

2150 I believe that at times the contamination of the water supply of Chicago, at the intake cribs of said city is appreciable. (Objected to by Mr. Todd and Mr. Johns.) Assuming that an epidemic of Asiatic cholera should occur in the city of Chicago, under existing conditions it is possible that the germs of that disease might find their way into the intake tower of the St. Louis waterworks, because I do not believe there are any existing artificial or natural agencies which would, at all times, insure the prevention of these germs reaching the intake.

2151 I believe I have stated that the banks of the Mississippi river from Grafton to the mouth of the Missouri are straight, barring certain sinuousities—I forget just the expression which I used. I know that the channel does change from side to side a number of times during that reach of the river, as I recall it, some five or six times, passing from a position near the right bank to a position near the left bank. As to the effect which this changing channel would have on the mixing of the water, I believe that it would tend to assist the mixing of the Illinois river water with the water of the Mississippi river, and that a greater mixture would naturally occur than if the channel formed a perfectly straight line during that reach. I stated that the Mississippi river had two sharp bends in it between the mouth of the Missouri river and the Chain of Rocks intake tower and I believe that just as these bends would tend to increase the mixing or commingling of the waters of the Mississippi river with the water of the Missouri, so it would tend also to mix the waters of the Illinois river with the waters of the Mississippi and with those of the Missouri river. Speaking as an expert, I do not think it is possible for the Illinois river water at all times to flow from Grafton to the Chain of Rocks, and by the Chain of Rocks without some of it reaching the intake tower of the St. Louis waterworks.

2152 Assuming the minimum stream flowof the Mississippi river at the Chain of Rocks is at times as low as 40,000 cubic feet per second and assuming that the flow of the Chicago Drainage canal is increased in the future from 5,000 cubic feet per second to 10,000 cubic feet per second, it is my opinion that under the increased conditions of flow there would be a material increase in the liability of infectious material to reach the intake tower of the St. Louis waterworks from the Drainage canal.

MR. TODD: I object on the ground that the facts assumed have not been proven and that this is not re-direct examination.

I should say that the conditions assumed in the last answer would tend to increase the proportion of Illinois river water which would become mixed with the water of the Mississippi. (Same objection.) (Question asked giving results of analyses of three different samples of water.) If these three samples are supposed to represent different mixtures of pure water and sewage, I should think that so far as dilution alone is concerned, sample No. 1 contained the least sewage, sample No. 2 contained more than sample No. 1 and less than No. 3 and that sample No. 3 contained the most, speaking solely with respect to dilution.

2154 On the basis of the chlorines, I would say that the relative dilution of sewage in the three samples is as to the amount of chlorine in each, which were 6 in the first sample, 16 in the second and 26 in the third, that would not be an exact ratio, but for practical purposes it would give us the desired result. If informed that the first sample represents Chicago water from the tap at 2421 Dearborn street, and that the second and third samples represent water taken from points on the Illinois river, since I was interpreting the results simply from the standpoint of a water analyst and under the assumption named in the previous question, it would make no difference where the samples came from. If water of the character of sample No. 1 has been the cause of typhoid fever, and if this sample be compared with samples Nos. 2 and 3, which, according to the analyses and the previous assumptions indicate a less degree of dilution with the sewage, it would be my opinion that there would be more chances of samples 2 and 3 causing typhoid fever than sample No. 1 so far as dilution is concerned.

2156 It is my judgment that the water of the Mississippi river below the mouth of the Illinois and above the St. Louis waterworks intake is less valuable for drinking purposes now that before the opening of the Drainage canal January 17, 1900. (Objected to for the reason that the value of the water prior to the opening of the Canal has not been proven nor witness has not shown his knowledge thereof.)

RE-CROSS EXAMINATION by Judge Johns:

Supposing that the current of a stream in its deepest part runs close to a precipitous curved bank of a river at the rate of three miles an hour when it comes to a point where the river is again straightened—or, in other words, assume a condition where there is a curve, followed by a straight stretch and where the current at the curve is near a precipitous bank, it might follow along the straight reach and on the other hand it might be deflected to some extent across the stream again. It is possible it might be either of those things—there would without doubt be a slight deflection, that would be the natural condition.

2157 I do not believe that it would keep exactly to a straight line along a straight stretch under the assumed conditions of a uniform cross-section. I have not been on the Mississippi river between the Chain of Rocks and Grafton. I derive my knowledge of the banks and curves and reaches of the Mississippi between the Chain of Rocks and Grafton from several maps, among them the Government charts and charts of the Mississippi river commission.

2158 I don't recollect the date of these maps. They were the same charts which I examined with reference to the cross-section for turbidity for my examination in chief. I don't think any of these charts were within the last ten years. I think they were made along in the 80's. I do not know whether these charts represent exactly the condition of the banks and curves of the Mississippi river in January, 1900. I understand that the banks of the Mississippi do change from time to time, sometimes rather suddenly, due to the variations in the flow of the stream—due, perhaps, to the cutting away of some of the banks, the cutting away of the bank might be caused by a change in the direction of the current or in the amount of flow.

2159 My knowledge of the probability of the waters of the Illinois reaching the intake is not derived from a personal inspection of the river, but from various maps and charts which were made from 1870 to 1880. Assuming that the volume of the Illinois river at Peoria before the opening of the canal given me, namely 40,000 cubic feet per minute, is the lowest known stage of water of the river at any time within the last 25 years, that assumption would be fair upon which to make a calculation of the percentage of dilution with reference to that particular time. I could form simply an opinion of the dilution at the time the figures were given.

2160 I know of no exact requirements of scientists as to the dilution of sewage with good water so that the water might be used with safety. I prefer the word "safety" to "potable" because the word "potable" in testimony does not convey to my mind a definite meaning. Water polluted with sewage can be diluted to such an extent that the chance of contracting disease by drinking the water is very remote.

2161 The greater the dilution the less the chance of harm, so far as the dilution goes.

Q. Assuming that the city of Chicago had for fifteen years prior to 1900, discharged into the Illinois and Michigan canal substantially the same amount of sewage that has been discharged by the Drainage canal into the Illinois river since 1900, with a dilution of only 40,000 feet per minute, would you think that that sewage had, during that fifteen years, reached the intake at St. Louis? Objection by Mr. Jeffries.)

Q. I just want to know whether if it goes into 40,000 feet of dilution in the Illinois river, it is just as likely to reach the intake as with 300,000 feet of dilution?

A. I understand that you made no comparison; I understood you to ask if it did? Q. Yes, sir.

A. And I believe that so far as dilution goes, it might.

Q. Well, if the waters of the Illinois river, to which are added 300,000 feet of water from Lake Michigan, certainly reach, in your opinion, the intake at St. Louis, why wouldn't the waters of the Illinois to which were added 40,000 feet, as certainly reach the intake at St. Louis?

A. I think that so far as dilution alone is concerned, they might as certainly reach, so far as dilution is concerned.

Q. But if for 15 years prior to 1900, substantially the same amount of sewage discharged into the Illinois river from Chicago, diluted with 40,000 feet of water as is discharged since 1900, diluted with 300,000 cubic feet of water, then the danger of disease in St. Louis from the sewage of Chicago, diluted with 40,000 feet of water, would be more than seven times as great as if diluted by 300,000 feet of water, would it not?

MR. JEFFRIES: I object to that question for the same reasons stated in my objection to the previous question.

A. In so far as dilution itself is concerned, that would practically be the case, so far as dilution itself is concerned;

dilution is a good thing. I do not know whether there ever was
any Asiatic cholera in Chicago.
2163 As to whether Chicago might have an epidemic of Asia-
tic cholera would depend wholly upon circumstances.
If our health officials in most of our cities, particularly the sea-
coast cities of this country did their duty, this country ought
not to be visited by cholera, but I cannot say and no one can say
when cholera might not occur in this country. When I say that
the pollutions in the Illinois river are sometimes appreciable
at the intake, I mean that if the Illinois river is polluted that
that pollution may reach the intake, at the Chain of
2164 Rocks, but I cannot state the extent to which it would
reach the Chain of Rocks, or when it would. I cannot
say whether it would at all times. As a general rule, typhoid
fever comes in the early fall in this hemisphere. I could not
say definitely whether the pollution in the Illinois river was ap-
preciable at the intake, in the fall of 1902. By appreciable,
I mean that it may have an effect upon the health of the people
who drink the water. I cannot say that it does, as a matter of
fact, have an effect upon the health of the people, but I believe
there is a possibility that it might.
2165 I do not know that the waters of the Missouri river have
an appreciable effect upon the character of the water at
the intake, but I believe that they may. I attribute the extra-
ordinary amount of matter in suspension in the waters of the
intake to come largely from the Missouri river. If there were
typhoid fever germs reaching the intake on a certain date from
the Missouri river, and if there were others reached the intake
from the Mississippi river and others reached it at the same time
from the Illinois river, and if these germs caused typhoid fever
in the city of St. Louis, I couldn't say exactly which one of the
three or whether all of them caused the typhoid fever, and I
couldn't tell the relative number of cases which each one caused
without knowing more about the number of germs that came
from each one. If, under the conditions supposed in a former
answer, the typhoid germs from the Missouri river traveled

forty miles, those from the Mississippi 100 miles and those from the Illinois 350 miles and supposing that the time of transmission to St. Louis was proportionate to the distance named, so far as that fact alone—disregarding everything else and disregarding the numbers and those other factors, and considering the question of time, why, those nearest might be con-
2166 sidered as having the greatest effect, but in making a true comparison, you would have to compare all factors.

2169 In regard to the questions asked me in relation to sample Nos. 1, 2, and 3, supposing sample No. 2 was taken above Peoria and represented fairly the quality of the water at that point at a given time, by the time that water reached Grafton, I should suppose that it would be changed, under existing conditions. The process of nitrification would practically have changed it to some extent. It would have changed it for the better. If sample No. 3 was taken below Peoria, the same conditions would apply to that. If after the arrival of these two conditions of water thus improved, they were added at Grafton to the Mississippi river in the proportion of 1 to 7, at the time they reach the intake, they would be changed, as far as nitrification is concerned probably.

2170 I suppose that process might keep on, in the Mississippi river to some extent. They would be changed by dilution. After the mixture of the water of the Mississippi river, the resulting water would no doubt be quite different from that in the Illinois river. I could not say from these anaylses whether either one of these samples are positively bad and unsafe for drinking purposes. I could not say whether they would produce typhoid fever or other disease.

2171 RE-CROSS EXAMINATION by Mr. Todd:

I could not say exactly what proportion of the 300,000 cubic feet of water that is passing over the Bear Trap dam at present, is sewage and what proportion is Lake Michigan water.

2173 When I stated that 88 per cent of the flow at Peoria was made up of Chicago Drainage canal water, I figured on 300,000 cubic feet from the Drainage canal and 40,000 cubic feet from the Illinois river, but I cannot tell you the exact proportions of Lake Michigan sewage in the water. In the samples known as Nos. 1, 2 and 3, I could not tell whether those samples indicate sewage pollution without regard to anything else. I should want to know the character of the water, the character of the so-called pure water with which the sewage was supposed to be mixed. I should desire to know something about the bacteria present, the abundance of bacillus coli, and the color and odor of the water may be of some assistance.

2174 I was able to make a comparison between those samples in regard to the diluted sewage contained in each, because they were assumed to be a mixture of pure water and sewage and I was simply asked to compare one with the other.

2175 Q. If three samples of water, such as you have testified to, should be presented to you and your analyses should disclose ingredients such as have been assumed to exist in these three separate samples, and your opinion was asked as to whether those samples were sewage polluted or not, what answer would you make?

A. I could not be able to tell definitely from these. I could give some idea possibly as to the relative probability, but I could not give what I would consider a definite answer from these analyses.

Q. Could you give any scientific opinion based upon these analyses alone?

A. Based upon any one of these analyses alone, without considering anything else than the figures here shown; and without knowing the source from which they came, I couldn't state definitely that these were samples of sewage pollution if I knew absolutely nothing about them aside from these figures. There is nothing in either one of those samples which would indicate that if a person took into his system water chemically similar to either one of those samples that he would contract typhoid fever. There is nothing connected with the analyses of these three samples that would indicate typhoid fever.

2176 The germ of small pox is not transmitted by water. The same is true of scarlet fever. When the assumption was made that sample No. 1 referred to would cause typhoid fever in Chicago, there was nothing in the sample indicated that such a condition would obtain. Without any assumption that these three samples were all mixtures of pure water and sewage I could not say, from samples Nos. 2 and 3 that they contained sewage. Assuming that the water at Grafton, in 1899 prior to the opening of the canal, was condemned by the St. Louis Health Department as being not potable, the entrance of the Drainage canal into that water would render that water less valuable for drinking purposes. It is a case of relative conditions.

2178 If water had been declared absolutely unfit for drinking purposes, I should consider that, from a sanitary standpoint, it had a very low value. If I could not get any other kind of water I would give some value to that water. Assuming that the city of St. Louis is so situated that it could get other water, and that the water of Grafton in the Illinois river by the analyses of the city chemist in 1899 was condemned and pronounced dangerous to the public health of the city of St. Louis, what value would you give to that water?

A. If it were really dangerous to health, I should give it a low value.

2180 As I understand it, there is a greater possibility today of the water supply of the city of St. Louis at the intake being polluted than there was before January 17, 1900, by reason of the discharge of the sewage of Chicago through the Chicago Drainage canal.

That probability has been demonstrated within the bounds of scientific judgment; it has not been chemically demonstrated. I have no information that leads me to believe that it has been chemically demonstrated excepting that I understand that certain results of the analyses in general show slight increases in the organic matter, etc., indicating of itself, but not proved. I do not consider that these indications rise to the dignity of proof. I don't believe it has been chemically or scientifically proved that the waters that enters the intake tower today are more injurious to public health than they were prior to 1900. I don't believe it has been chemically or scientifically proved, but I believe that scientific judgment leads us to believe that such is the case.

Q. When scientific demonstration fails to establish a fact then the so-called scientific judgment does not differ from the judgment of a man who is not scientifically advised, drawing his inference from the same conclusion?

A. Where an absolute scientific demonstration is impossible, the next best thing to my mind is a scientific judgment.

Q. Well, can a judgment be scientific when the facts upon which that judgment is predicated, are incapable of scientific demonstration? A. No, sir.

2182 If it could be proven to me that Asiatic cholera germs would not live longer than five or ten days in natural waters under conditions existing, my conclusion that they could reach the intake from Chicago would be changed, but I am not sure at all that the conditions existing in a laboratory experiment would be comparable to those which would exist in running streams.

2184 WILLIAM THOMPSON SEDGWICK, examined in chief by General Crow:

Am not a physician, have studied in a medical school but have no medical degree. Taught physiological chemistry at Yale for one year, etc.

2185 Am a biologist. Scientifically that term implies work upon living things which may be anything from man to microbes. It is a very general term and of course I do not pretend to be an expert in all its departments. Am now Professor of Biology in the Boston Institute. I am an epidemiologist. That term implies an expert knowledge of epidemics, their origin, their characteristics, their scope and everything else relating to them. I have made that branch of sanitary science as related to American cities and towns and the American public, a study.

2186 Am a bacteriologist. Have taught and have had practical experience in that line. In the preparation of the paper I have mentioned on typhoid fever, in Chicago, in 1892, in a general way I had occasion to investigate the physical and sanitary conditions of Chicago with reference to water supply, sewerage and sewer out-falls at that time.

2187 I came to the conclusion mainly from a study of the typhoid fever statistics and the general arrangements of sewerage and water supply that the city was then suffering from one of the worst epidemics of typhoid that ever afflicted any American city and that this pollution was derived from typhoid cases in the city which contributed their sewage to the sewers of the city which emptied either into the Chicago river or into the Lake and in that way, gave occasion for the germs of the diseases to get into the cribs or the intakes of the water supply. I made no very thorough investigation of the Chicago river and its branches. I simply walked along the river at various points and noticed its condition—which was obvious to the eyes and nose. It was grossly polluted.

2188 Chicago sewers are built on the combined plan. This means that street washings and storm water find their way into the sewers and greatly accelerate the flow in the sewers, at the same time, diluting the sewage somewhat. This accelerates the flow and shortens the time spent in the sewers.

2189 I should say several hundred tons of sewage matter are discharged daily into Chicago sewers. The sewage from a quarter of a million of inhabitants goes into Lake Michigan. The remainder is discharged into the Chicago river and from that, into the Drainage canal.

2190 The effect of the sewage now going into the Lake is to pollute the waters in the vicinity of the intake cribs.

I recognize a difference between mere pollution and infection—or what I might call infectious pollution—somewhat as follows: I understand by pollution alone, a condition in which water contains organic matters, or even filth, free from the germs of specific diseases; and I understand by infected water or an infectious pollution of water, or an infectious contamination of water, a condition in which, either with the same or more, or less pollution, the germs of specific diseases are present; so that a water may be polluted, from my point of view, but not infected, or it may be infected and yet to the ordinary eye not polluted. Water contaminated by infectious pollution is dangerous.

2191 Mere dilution will not destroy or eliminate infectious pollution or matter in water. On the basis of dilution alone, I do not consider that the sewage from the Chicago Sanitary district as it reaches the Illinois river above Peoria is at all times rendered pure and safe for domestic use. (Witness expresses himself at length on the question of self-purification of waters.)

2192 There is, at all times, in certain streams, especially, a large measure of self-purification. The subject is a complex and difficult one and the growth of opinion has been to increase our distrust in the efficacy of self-purification of waters or sewage.

2193 (Witness reads from his work on "Principles of Sanitary Science and Public Health.") (Motion to exclude by Judge Johns and Mr. Todd.) Sewage flowing directly from the out-falls of the city sewer will affect the value for drinking purposes of a running stream of water.

Q. State whether or not the sewage from a district as large as the Sanitary District of Chicago would affect the value for drinking purposes of a steam as large as the Drainage canal and as large as the Drainage canal and the Des Plaines river and Illinois river combined, and if so, in what manner?

A. Yes, sir, the mere introduction of sewage into a stream at once creates suspicion as to the—at once throws suspicion

upon the character of that stream, and unless it can be shown that that sewage has been effectually removed by puri-
2194 fication, the value of that stream is distinctly lowered. The water of the Mississippi west of the main channel of said river, below the mouth of the Illinois, is decidedly less valuable for drinking purposes now than it was before the sewage from the Sanitary District of Chicago was run into the Drainage canal and through it into the Illinois river.

The addition of such a volume of liquid as passes through the Drainage canal must materially—must often materially, quicken the flow of the Illinois river; it must therefore hinder effective sedimentation, and thus by shortening the time required for infectious germs to pass through the river, and by interfering with their detention, aggravate the danger of their arrival at the mouth of the river. I should like to say right here, that the time allowed in all these matters is very important, so that any quickening of the flow is a grave consideration. It is not so much distance as time which is the basis of self-purification of streams.

2196 By increasing the flow, sewage or infectious pollution from Peoria and the lower points on the Illinois, might arrive more quickly at the mouth of the Illinois and mingle with the waters of the Mississippi. The clearer the water—other things being equal, the slower the rate of sedimentation of bacteria. I believe that increasing the speed of the current of the Illinois, by the addition of the water of the Drainage canal, would have an effect in increasing the typhoid and liability to typhoid and other water-borne diseases, on the part of the inhabitants of Missouri using the waters of the Mississippi for drinking purposes, below the mouth of the Illinois. Speaking generally, the sewage from cities and towns renders unfit for drinking purposes the waters of a running stream for the purposes of domestic use.

2197 Settling basins alone—not considering anything else, are not recognized as an efficient and adequate means for the purification of sewage to be discharged in a drinking water stream. As to the longevity of the germs of typhoid fever, as a general proposition, in connection with sewage polluted water, our ideas have undergone some change of late years. My ideas have undergone some change. The tendency has been to come to the belief, or has been to show or to indicate a greater and greater longevity. Laboratory experiments have sometimes indicated a short and sometimes a longer longevity. Practical experience has tended to make us believe in a greater longevity than that formerly entertained and having reference to the conditions in the stream, my belief is that in a sewage polluted stream, the typhoid fever germs might live, in gradually diminishing numbers, for weeks or months or even years.

2198 Assuming that the bacillus coli communis is not found in greater numbers in the Illinois river now, than before the opening of the canal, I do not consider that the water is at all times no more dangerous for drinking purposes than formerly. Bacteriological examinations cannot be made at every moment and are at best not absolute guides as to the sanitary condition of the water. Assuming that germs of typhoid fever coming from the sewers of Chicago, might be in large numbers deposited in the bed of Lake Peoria, for the period of a month, I do not consider that typhoid germs would be entirely destroyed at the end of that time. Assuming that typhoid germs coming from Chicago are deposited in large numbers in the lakes and slack water portions of the Illinois river above Peoria, I think at times that flood conditions such as would scour the deposits from the bed of the stream would cause the water leaving Lake Peoria to contain at times more infectious and dangerous pollution than is at present in the diluted sewage entering the Des Plaines river at the Bear Trap dam.

2199 The removal of deposits of sewage matter from the beds of streams has resulted in causing typhoid epidemics. (Refers to the old case of St. Clair river.) I do not consider that the water of the Illinois river, since the opening of the Drainage canal and now, as it enters the Mississippi river, is one which may be used with safety for drinking purposes.

Q. Now, Professor, assuming that the only pollution of the Illinois river was that contributed to it by the Chicago Sanitary District, and having in mind the large amount of typhoid fever in said district, do you, or do you not consider the effects of the time interval, dilution and sedimentation occurring between Chicago and Grafton, would be such as to render the waters as it enters the Mississippi at all times free from liability of producing water-borne diseases in those who drink it?

A. Emphatically not, for the reason that such processes of self-purification, including sedimentation and dilution, as would take place in the Illinois river and above, to Chicago, would be, in my judgment, inadequate to insure at all times and seasons a complete removal of infectious material.

2200 (Refers to the Lowell, Mass., epidemic. Says it was caused by Stony Brook stream running into the Merrimac at right-angles.) Stony Brook stream was much smaller in proportion to the Merrimac than the Illinois is to the Mississippi.

2201 This infection came a very short distance up Stony Brook. It entered the Lowell waterworks and produced an epidemic three and one-half miles below but there was also reason to believe that it reached Lawrence, nine miles further on. I believe that infected water coming from the Illinois river and entering the Mississippi would become mixed with the water so as to menace the health of the inhabitants of the Missouri shore using Mississippi water. I consider it probable that infectious pollution would, at times, enter the intake of the St. Louis waterworks.

2202 During a period of fifteen years prior to January 1, 1900, typhoid fever death rate in St. Louis has not in general been above that of some cities provided with water supplies considered pure and of good repute. Beginning with January 1, 1900, there has been a marked annual increase in the typhoid fever death rate of St. Louis so that it has, during that period, not only been higher than during the previous period of five years, but also higher than at any time in its own history since 1885 and very much higher than the death rate in Boston, with which it previously compared very favorably.

2203 Assuming that the only pollution on the water-shed of the Mississippi and its tributaries, above the intake of the St. Louis waterworks, was that derived from the Sanitary District of Chicago and having in mind the large amount of typhoid fever in Chicago, I believe that infection and dangerous pollution might find its way into the water supply of the city of St. Louis.

2204 Under the same assumptions I believe that typhoid fever germs from that district are liable to find their way into the water supply of St. Louis. (Witness states that experiment made with 107 barrels of bacillus prodigiosus shows that typhoid fever germs can be carried down the canal, the Illinois river and to the intake.) Assuming that an epidemic of Asiatic cholera took place in Chicago, it is possible that the germs of the disease might find their way into the intake of the St. Louis waterworks.

2205 (Recounts details of Plymouth, Penn., epidemic in 1885.)

2206 (Same as to the Lowell, Mass., epidemic. Gives details of Newburyport epidemic. Newburyport is at the mouth of the Merrimac river.)

2207 The cause of this epidemic was the drinking of water from the Merrimac, which had been infected at Lowell, 25 miles away. The Rivers Pollution Commissioners of Great Britain in the report published by them in 1874 state that there is no river in the United Kingdom long enough to purify itself from any sewage admitted to it, even at its source. That stands as one of the axioms of sanitary science today.

2208 The epidemic at Windsor, Vermont, was caused by one case of typhoid fever on the water-shed above, not very far above, a mile perhaps. In 1898 I made a special study of typhoid fever in Pittsburg. They drew their water supply from the Allegheny which is a swift stream with only remote pollutions. A study of conditions there resulted in recommending the filtration plant for the city of Pittsburg, for the reason that in my judgment, infectious materials might be brought to cities which had no filtration plant, from points as distant as Oil City or even more remote—113 miles or more.

2209 The epidemic at New Haven, Conn., occurred about 3 years ago. It was caused by feces washed from a house on the water-shed where there had been a few cases of typhoid fever. The epidemic at Ithaca, New York, we have every reason to believe that the conditions were quite similar to those at Plymouth, and New Haven.

2210 (Refers to epidemic at Hamburg, Germany, in 1892, and the breaking down of the Berlin, Germany, filters, which caused a small epidemic of typhoid fever.) It is a matter universally admitted among sanitarians that running water uncared for and unprotected by special processes of filtration or prolonged and very thorough storage, is liable, if from an infected watershed, to convey the germs of disease. I found in Buffalo, rather to my surprise, a feeling prevailing among medical men that the time was at hand when Buffalo had got to purify her water because of the pollutions put into the lake at Cleveland and higher points.

2211 I think it is a great question whether the people who are using the big lakes have not got to give up the use of them after while. A while ago, Professor Jordan reported practically to that effect for Chicago, and Detroit certainly stands in great danger from pollutions at Port Huron and possibly other points. Cleveland I have been told, although I am not sure of this, is seriously thinking of giving up its tunnels and going into filtration because the water that comes down from above is polluted. It was one of the commonest things that chemists and sanitarians believed and they had reason to believe at that time—that running water, at even modern distances, would so purify itself as to be safe. But Pittsburg, Lowell and Lawrence, and so far as I know, nearly all of the cities that have trusted to that, have been typhoid ridden and today, as I reported at Pittsburg, the distance of 100 miles, or even more remote points may produce typhoid fever. It is not today so much a question of distance. It is the question of giving time for the germs to settle out and die out and it is dilution and time of quiesence, particularly quiesence.

2212 Q. Professor, would the amount of infectious pollution affect the question of time needed, or the degree of danger?

A. It affects the degree of danger. It would not affect the time; that is the time for each individual microbe; of course that is its own individual problem. One microbe coming down from Chicago and resting quietly in the slack water of the Illinois, if it lay there long enough would probably die out—I would say, must certainly die out if it lay there long enough. Of course, someone might not agree with me on that, but I think so; but of course, if a million came down, the chances that some might be carried on by a little freshet or something of that kind before they had died out—for they don't all die at the same time—would be greatly enhanced, and other things being equal, the larger the infection, the more serious the danger.

2214 After a careful consideration of the subject I can say that in my opinion, beyond a reasonable doubt, the principal portion of the increase of typhoid fever in St. Louis, since January 1, 1900, of the principal annual increase, since January 1, 1900, has been due to the pollution of the water supply of St. Louis by the sewage of the Sanitary District of Chicago.

2215 I stated this morning that from 1895 to 1899 the typhoid rate in St. Louis was substantially normal, comparing favorably with similar cities of like situations and of similar size. I should like to add that the word "normal" must be taken in a general rather than in an advanced sanitary sense, for I believe that both Boston and St. Louis are capable of further improvement in this direction, and both are higher than New York and London. From 1895 to 1899 the death rate from typhoid in St. Louis compares favorably with that in Lowell after the introduction of the ground filter water supply. I have no experience that would cause me to believe any running stream can be relied upon, at all times, to remove disease-bearing germs, such as the typhoid bacillus, if the pollution was at all serious or extensive.

2216 The opening of the canal has resulted in the addition of an amount of lake water which will yield 5,000 cubic feet a second at Lockport, passing out of the canal, and this, on the face of it, adds a purer water than that sewage. The sewage is unquestionably diluted, as is shown by the improved condition of the Chicago river, but this water is drawn from the

mouth of the Chicago river and vicinity and that water has long been known to be infected more or less. The problem then resolves itself into this—does the dilution of a presumably often infected sewage, by a presumably often infected water contribute to the purity of the Illinois river? But that is not all. The Chicago river was formerly a sluggish stream. Today it is much less so, and those infectious materials that were formerly put into the Chicago river are today carried with comparative swiftness down the Drainage canal and into the Des Plaines and Illinois rivers. We have further, then, to consider whether sewage, as described above, carried quickly, and in considerable volume, into the Illinois river, does or does not render that river safer than before. My only belief based upon those considerations which I have already outlined in regard to time as a purifying factor is that it is at least very doubtful whether the pouring of the sewage of Chicago, diluted as described, into the Illinois river does at any time improve that river. Looking at it still more closely and considering the larger amount of sewage now delivered, the opportunities for sedimentation, the susceptibility of the Illinois river to
2217 freshets, large and small and in view of the changed conditions brought about by the introduction of this fresher sewage with a larger volume of water, I am inclined to believe that—and further, in view of the frequent extensive pollution of the sewage of Chicago by the germs of typhoid fever.

Q. You mean infection, don't you?

A. Infection of typhoid fever, I should say—I am inclined to believe that the pouring of the sewage diluted as described, into the Illinois river, has not at any time improved it from a sanitary point of view—from the point of view of the health of the people who may use that water on the Missouri shore. I may say that undoubtedly at times it may have improved its appearance, and may seem to have improved its quality; but taking it through the year at all times, at all seasons, I am inclined to doubt exceedingly such improvement—any such improvement at any time. I believe that the danger is contsant, immediate and continuous on the part of the inhabitants of Missouri using the Mississippi river water, by reason of the sewage from the Chicago Drainage canal infecting the water of the Illinois river. (Witness states reasons.)

2218 Dams undoubtedly, so far as they produce slack water or quiesence, favor purification and the disappearance of disease germs for the time being, but if the sediment or sludge is allowed to remain in the stream and is not removed artificially, the chances are good and experience shows that in freshets, it may be returned to the stream and again become a part of it, travel with it and produce trouble below.

2219 The only safeguard is to keep the germs quiet in the sediment at the bottom so long that they shall have entirely died out. We hardly ever know when that is. It is a very weak reed to lean upon. At Lawrence there is a big waterpower supplying immense amounts of machinery with power to run. At times the water reaches back almost to the Lowell sewers—nearly nine miles, and the dam above Lowell, which furnishes the power to Lowell reaches back almost to Nashua, New Hampshire—sixteen miles. The Merrimac in the summer, is a series of mill-ponds, slack water like that, the water used for mill power.

2220 In time of freshets we get our epidemics—when the freshets come down the river and scour it out. We do not have a high typhoid rate in summer when the dams are effective and sedimentation is going on. We get it in the spring, when the pollution is great and the scouring is also great. We also get epidemics in the autumn or after the autumn rains. Lawrence immediately set to work and put in an intermittent sand filter and Lowell put in driven wells. Both are now among the cities having entirely reasonable death rates from typhoid fever. My opinion is that the rate of growth in the Chicago Sanitary District is likely much to exceed, and the total growth is likely greatly to surpass that upon the water-sheds of the Des Plaines, Illinois, Mississippi and Missouri and their tributaries.

2221 I should expect it to be at least ten times as great. I will add to this answer, basing an opinion upon pages 119 and 121 of the Illinois State Board of Health report for 1901, sanitary investigation of the Illinois river and tributaries, I should even be willing to make this figure very much larger, as the increase in rural population given there is less than one per cent; that in urban population outside the Sanitary District of Chicago is 28.2 per cent, and that of the city of Chicago is 54.4 per cent. The urban population as compared to the rural population in this country is increasing very much faster. Now it is one of the most striking facts with which sanitarians have to deal, that villages are growing into towns; towns into cities; water supplies and sewerage systems are being introduced and in consequence of this growth, problems of water supply and sewage disposal are almost everywhere becoming common and pressing. This condition of things is bound to increase. In the older cities, it has already led to serious investigation and litigation, with long and varied attempts at remedial legislation, and I cannot help feeling that with the impending growth of cities and towns in the Mississippi valley, it is a question of the gravest sanitary consequence what becomes of the sewage of the cities and towns in that valley—in or near that valley—and also how their water courses may be kept from pollution and the dangers of infection. (For answer of witness as to effect of increase in population in Chicago to 5,000,000 people, with conditions as they are now, see record, pp. 2221, 2222 and 2223.)

2224 I consider that the Illinois water polluted and infected by the sewage from the Sanitary District has rendered less safe the water supply of St. Louis as drawn at the intake, for the reason that I believe the germs of typhoid fever may and do find their way through the intake into the water supply of St. Louis. Assuming that the population of Chicago Sanitary District covers 3,000,000 people and that the flow through the canal reaches 600,000 cubic feet per minute, I believe that the water of the Illinois river would be less pure and less wholesome as compared with that water at its mouth as found during the past three years. The danger of infection would be increased. If the population of the Sanitary District was increased to 5,000,000 people and the flow of the canal reached 1,000,000 cubic feet per minute, I believe that the water of the Illinois river at its mouth would be less pure, less wholesome and more infectious and less suitable for drinking purposes as compared with the water at that point as found during the last three years.

2225 I believe that a mixture of the Illinois and upper Mississippi river water during their flow from Grafton to the Chain of Rocks takes place at times, such that the water of the Illinois river may find its way to the intake of the St. Louis waterworks. Assuming that sewage from 1,500,000 people living in the Sanitary District should be discharged into the Drainage canal, thence into the Des Plaines and Illinois rivers, Chicago being situated 358 miles from the St. Louis intake, and assuming that a typhoid fever epidemic of extraordinary proportions should become prevalent among the residents of the Sanitary District of Chicago at a time when the sewage from said district is being so discharged into the canal, I believe that such an epidemic would be likely to produce an epidemic of large proportions among those people living on the Missouri side of the Mississippi river below Grafton who use the waters of the Mississippi for drinking purposes. The citizens of St. Louis and the Missouri shore would have a right to regard themselves as in a critically dangerous condition as far as their water supplies were concerned.

2226 The same would apply to an epidemic of cholera. (Witness states that there will come a time when the rivers will get so sewage polluted that mere filtration will not suffice. It will be increasingly difficult to secure good water and to get rid of the sewage, etc.)

2227 Stream flows, in general, will not increase, but rather decrease as time goes on.

2228 (Offers in evidence, certificate showing number of deaths from typhoid fever in St. Charles, Missouri, from July 1, 1899 to January 1, 1903.)

2229 (Same as to city of Davenport, Iowa, from 1893 to 1902, inclusive. Same for Rock Island by months from 1893 to 1902. Same as to Moline, Illinois, from 1893 to 1903. Galena from 1893 to 1903. Warsaw for year 1902.)

2230 (Same for Kansas City from 1893 to 1902; St. Joseph, Missouri, Council Bluffs, Iowa; Omaha and Lincoln, Nebraska, and Chicago.) In regard to my testimony taken yesterday, I will state that the quickening of a stream by the addition of a volume of other water, especially under conditions such as prevail on the Illinois, is a very serious menace to the people of the regions below who use that water. It is my opinion that in spite of the addition of the so-called "pure lake water;" in spite of the greater dilution resulting from that, the water of the Mississippi river is constantly and beyond all reasonable doubt rendered more dangerous to the public health and to the citizens who use it, because of that addition, and under all the circumstances which exist on the Illinois and Mississippi rivers.

2231 The Lowell epidemic of 1890 was caused by the dejecta of one person infected with typhoid fever, contaminating Stony Brook about three and one-half miles above the intake of the Lowell waterworks.

2232 The New Haven epidemic was caused by the dejecta of two or three cases of typhoid in a family living upon the watershed. Their dejecta were thrown out on the ground near by and in the thaw which I described yesterday, were washed into the stream. I think they were quite a little distance from the stream, perhaps 50 feet or something like that. It went only two or three miles down the stream, something like that, and from the stream into the reservoir where it underwent probably a very slight sedimentation. In the Windsor, Vermont, case the infection came from about a mile, from a storage reservoir and were supposed to have been washed into a very small stream—a mere thread of a stream.

2233 In the Newburyport epidemic the pollution was derived from the regular typhoid fever in the city of Lowell. The germs were carried down past Lawrence to Newburyport.

2234 At Zurich, Switzerland, the typhoid fever in 1885 was attributed to disturbance of sediment near an intake pipe and a defective filter.

2235 As a general proposition the urban population is very much more dangerous, very much more efficient in the pollution of the waters than a rural population. It would probably be fair to say that the urban is at least ten times as dangerous. The reason for this is that urban populations are more often sewered and when not sewered, are more often upon streams. The opening of the canal, which has been brought about by cutting through the natural divide between the watershed of Lake Michigan and the Illinois river, has added to the drainage area tributary to the watershed of the Mississippi river as it flows to the intake tower, 63 per cent of the entire urban population; 63 per cent has been added to the amount above the St. Louis intake.

2236 Exclusive of the Sanitary District of Chicago, of the population of the watershed of Lake Michigan, I find the amount of urban population on the watershed of the Mississippi and its tributaries, the Illinois, Missouri and Des Plaines and their tributaries above the intake of the St. Louis waterworks, on the basis of cities and towns by 4,000 inhabitants and more, to be, 2,695,782. According to the 1900 census the population on the watersheds mentioned would be as follows: Missouri river, 1,090,832; Mississippi river above mouth of the Missouri, exclusive of the Illinois, 1,219,645; Illinois river, 385,305. All those added together make the sum I gave you a moment ago.

2237 The mouth of the Lowell sewers is about 9 miles above the intake of the Lawrence waterworks. From that point the water was pumped to the reservoir of the city of Lawrence where it was kept for a period varying from one to a little more than two weeks. If we add to this the time spent in flowing the nine miles we may say that the period of time required for water containing typhoid germs to pass from the Lowell sewers to the Lawrence water consumers was sometimes probably as long as 14 days or more.

2238 Settling basins holding suspected water for longer periods than this one at Lawrence have failed to protect the people using such water from typhoid fever. At Covington, Kentucky the water of the Ohio river more or less polluted on the stream above is kept at times as long as 32 days and yet Covington suffers severely from typhoid fever apparently due to infected water. At New Albany, Indiana, the same conditions exist. The typhoid at Niagara Falls is attributed by every one who is familiar with the facts, to the sewage of Buffalo, although that sewage has passed down a stream one of the most favorable in the world perhaps, for dilution, aeration, oxidation, self-purification and similar processes. I consider the case of Niagara Falls as it is today, one of the most instructive we have. The sewage is well diluted, well aerated, and that for a considerable distance. The distance as I recall it between the sewers of Buffalo and the intake at Niagara Falls is about, I should suppose, 18 miles. It may be only fifteen. (Hypothetical question assuming certain numbers of cities to be situated on the watershed of the Missouri river, giving population, number of deaths from typhoid fever per year, number of miles from St. Louis, and stating that the sewers of all such cities discharge their sewage into the Missouri river, also assuming the same as to the Mississippi and Illinois rivers, and ending with, "State what, in your opinion the sewage from 1,500,000 people of Chicago had to do with the increased death rate from typhoid fever in St. Louis as above stated?")

2249 (Objected to by Judge Johns and Mr. Todd.)

2250 After having carefully considered the question and the assumptions which it contains, I believe that beyond all reasonable doubt the principal factor of the annual increase of typhoid fever mortality of the city of St. Louis since January 1, 1900, has been due to the pollution of the water supply of the city of St. Louis by the unpurified sewage of the Sanitary District of Chicago. In fixing this increase in typhoid in St. Louis I used the method known as that of "mortality percentages" in which the typhoid fever mortality is compared with the total mortality of any given district. Measured upon this basis, the typhoid fever mortality during the years 1901, 1902 and 1903 as compared with that during the years 1895, 1896, 1897, 1898 and 1899 was 73 per cent in St. Louis.

2251 Assuming the same state of facts as embraced in the last hypothetical question and considering in addition thereto the rural population of the watersheds of the rivers mentioned therein, my answer would not be materially modified for the reason that as I stated this morning the wastes of rural life are, speaking broadly, usually disposed of satisfactorily from a sanitary point of view upon the areas within which they arise. Occasionally, of course, a rural contamination may produce an epidemic of typhoid fever, but such cases are infrequent and exceptional.

2252 The conveyance of water from the Lake Front of Chicago and from a population which I have already testified has been estimated at more than a quarter of a million people, now draining directly into Lake Michigan at the rate of 300,000 cubic feet a minute through an elongated conduit reaching from Chicago to the mouth of the Illinois river would, in my judgment, be a source of danger to persons using the water for drinking purposes on the Missouri shore and at St. Louis.

2253 I do not believe it is within the bounds of human possibility for any competent expert to say that in a period of low water in the Missouri river such as is likely to occur next Christmas time, a thaw on the Illinois watershed might not endanger the lives of people using the waters of the Mississippi below the mouth of the Illinois on the Missouri shore at the city of St. Louis by sending to them in that water, the unpurified sewage of the Sanitary District of Chicago. No competent expert either can or will say that any means exist at present by which such unpurified sewage can be warded off from the people on the Missouri shore and the citizens of St. Louis under those conditions.

2254 CROSS EXAMINATION by General Hamlin.

Am familiar with waterworks. Have given that matter some study. The system of purification I would recommend, where the water supply is taken from running streams would be filtration, in some cases, and storage in others.

2255 Storage is the accumulation of waters in great reservoirs so that it may be kept for some time before it is used without any treatment of it. The larger size the better. Filtration would be my judgment as the system for a city like St. Louis. I am of the opinion that there is more or less pollution in all running streams as distinct from infection and where sewage is carried into running streams then there is usually infection. That in my judgment exists in the streams to which I have testified in this case, such for instance as the Mississippi, Illinois and Missouri.

2256 If the cities or towns below St. Louis on the Mississippi should take their water supply from the Mississippi river they would be affected by the sewage of St. Louis, if they took it unpurified. Unless the dilution was so great that the sewage of St. Louis was lost in the volume, I suppose that they would be affected. I attach much importance to dilution alone. It is a large amount of sewage that is discharged into the Missouri river and into the Mississippi above the mouth of the Illinois. If I were to eliminate all the sewage from Chicago and take the Illinois, with the Sanitary District out and its tributaries, and the Mississippi and its tributaries, and combine those waters as they are combined above St. Louis, I should say unhesitatingly that the water is and would be, under such circumstances, a polluted water, and that the chances are that it would be dangerous to the people of the city of St. Louis and the towns below.

2258 At the present time my judgment is that the best process of making this water a potable water would be by filtration.

Q. Well, then, so far as the purification of the water of St. Louis is concerned at present, and rendering it fit for domestic use here, for drinking purposes, the expense of doing that would be the same, whether the sewage of the sanitary district was in it or not, wouldn't it?

A. The probable cost of doing it at present, owing to the conditions on the various rivers and at Chicago would, I should suppose not be materially affected by the addition of the sewage of Chicago to the Mississippi river as those rivers are and as that sewage is today.

CROSS-EXAMINATION by Judge Johns:

I am not a chemist, but I regard myself as a bacteriologist. I consider the chemical examination of water of importance in determining its condition for drinking, under some, but not under all circumstances.

2259 A chemical analysis of the waters of the Missouri river at times might determine whether such waters are polluted and at times it might not. The same answer would apply to the the Mississippi river.

2260 Sometimes I can determine from a bacteriological examination of running water whether it is polluted and sometimes I cannot. I could determine from my examination of the evidence as to the bacteriological examination of the waters of the Missouri whether the Missouri is a polluted stream but I very much prefer to do it in other ways. I could at times, I say, but when common sense comes in, I like to use that. I would make the same answer as to the Mississippi river and the same answer as to a joint consideration of chemical and bacteriological examination. A chemical analysis and bacteriological examination of the waters of the Missouri and Mississippi rivers I should not consider as competent at all times to determine the qualities of the waters for drinking purposes.

2261 I believe that waters of running streams, sewage polluted, purify themselves by the flowing of the streams to a large extent under favorable circumstances. The rapidity of the flow would have something to do with the degree of purification. It is the time factor which comes in and that would be profoundly modified by the rapidity of the flow. Numerous reaches where the flow of the water was extremely sluggish and occasional dams checking the water would contribute to the purification of it. Such reaches and dams would contribute to the purification by other means than sedimentation, by detaining the germs present and thus favoring their dying out if they lay there long enough to die out. Mere detention apart from sedimentation would be a factor in this time factor I have spoken of.

2262 If near a given river there were numbers of small lakes or ponds which filled up during the overflow or high water of the river and which contributed to the flowing stream of the river, when the water subsided, they would contribute to the purification of the stream in the proportion in which the supposed lakes and ponds afterwards contributed to the current of the stream. In times of flood, it would certainly contribute to the purification of that part of the water which was over lakes. If there was a flod in the Illinois river in which the waters overflowed the banks and spread out in the bottoms which continued for four weeks and in the bottoms there is no perceptible current of the river those portions which stood upon the bottoms would certainly be purified somewhat. They would be purified so far as the sewage is concerned very considerably. I am familiar with the general physical characteristics of the Illinois river from studying maps and talking with men who have been up there.

2263 I understand that the bottom lands or the overflowed lands of the Illinois river are very considerable. The fact that the Illinois is a sluggish stream in its overflowed stages, that there are several dams and at times much so-called slack water, that in reaches of the river which are not affected by the back waters of the dams, there is in ordinary stages, in many places, and for long distances, a very slight fall, would aid in the purification of the waters of the Illinois river under ordinary conditions. The amount of dilution that would make sewage polluted water safe for drinking purposes is a pretty hard proposition. I do not think that I can answer that except to say that a very large dilution is required to make it reasonably safe. One gallon of sewage from Chicago to 100 gallons of good water would not make that water reasonably safe for drinking purposes. One gallon of sewage to 200 gallons of water I should not consider safe. I hardly know what to call reasonably safe.

2264 One gallon of sewage at Alton might pollute the waters of the Mississippi at the intake tower so as to make them unsafe for drinking if it was typhoid fever infected. (Same as to one gallon of sewage at St. Charles, Missouri.) Knowing that one gallon of sewage from St. Charles infected with typhoid germs had been put into the Missouri river, I should consider the water at the intake unsafe, as a general proposition, provided, of course that I did not know when that gallon was coming along.

2265 Assuming that I knew a gallon of sewage infected with typhoid germs was put into the Missouri river at St. Charles at a certain time and that I knew when that water would reach the intake tower, as a general proposition I would consider the water at the intake tower at the time of the arrival of this water from the Missouri as unsafe for drinking purposes. As to the same amount of infected sewage from Kansas City, which is between 400 and 500 miles away, I should not want to drink the water at that time when it was expected at St. Louis but I should not be willing to say, as a sanitarian, that that was unsafe for drinking.

Q. Then you are a little more particular as to yourself than as to the community in general?

A. No, but others are not as particular as I am.

Q. Well, having an equal regard for others, as for yourself, you would say that the gallon of sewage put into the waters of the Missouri at Kansas City, was unsafe, would you not, at the intake of St. Louis?

A. Assuming that the water was to be taken at the intake at the time that the arrival of that polluted water might be expected, yes, sir.

Q. If a gallon of sewage were put into the Missouri river at Omaha, Nebraska, and you knew when that water would arrive at the intake tower at St. Louis, would you consider that water unsafe for drinking purposes if the sewage were typhoid infected?

A. I don't know how far that is. It is farther away—it is six or seven hundred miles.

2266 A good deal would depend upon the flow of the Missouri at that time. If it were in flood, I should probably not consider that unsafe. If the Missouri was at its ordinary stage, I do not know whether I should consider it dangerous or not. I should have to think that over. I should want chemical and bacterial analyses of the waters and I should want to know conditions more than I do now, the conditions of purification en route, etc. Taking my knowledge of the Missouri river and assuming that a gallon of sewage was put in that river at Omaha when the river was at its ordinary stage and that the sewage was typhoid infected sewage, when the water arrived at the St. Louis intake, I would consider that water unsafe for drinking purposes.

Q. If, in the year 1901 there were 13 deaths from typhoid fever at Lincoln, Nebraska, 58 in Kansas City, 6 in Omaha, 12 in St. Joseph, and 5 in St. Charles, and the typhoid bacilli in each of these cases, went by some means into the waters of the Missouri river, and some of them arrived at the intake in St. Louis, to which one of the six towns would you prefer to ascribe the bacilli arriving at the intake?

A. In answering this question I should have to say in the first place that I should not have any preference in the matter, except such as came from study of the facts laid down, and a weighing of the probabilities as to the origin of each of these— as to the part played by each of these. Other things equal, the nearer the infection, the greater the probability of derivation from that source. The question, however, is a very complicated one, inasmuch as it assumes a large number of cases in the upper regions of the river, and a small number at St. Charles, 47 miles away, as I believe. I should expect, as a result of the consideration of all the circumstances, that I should be entirely unable to assert any preference in the matter or to determine from which of these places the bacilli had come. If found, they would be more likely to have come from Kansas City, because that would mean 580 cases in Kansas City and 50 cases in St. Charles, in round numbers, assuming a mortality of 10 per cent and the likelihood of one getting into the intake at the Chain of Rocks would I believe be greater, all things considered, from 580 cases at that distance than from 50 cases at the other distance. It is a matter, however, almost entirely of guess work.

2269 Considering that Kansas City is 403 miles from St. Louis, I could not say positively that any of the typhoid bacilli would arrive at all. I could not say positively that none would arrive. I don't know whether they would or not. I have an opinion and that is, that they would. The greatest distance that I now recall that typhoid bacilli have been transported by running waters and caused infection in some water supply is that of the Detroit epidemic in which it was apparently well established that the infection was conveyed for about 57 miles. The assumed and supposed distances, however, are very much more than that. For example at Pittsburg, I myself supposed and assumed that typhoid fever germs might have come as I said in my report, from Oil City, which was 113 miles, or even, as I remarked, from points much more remote. That is, there are cases on record where the sewage of towns above, apparently influences the typhoid death rate of towns below, and where no epidemic has ever happened or been traced, conclusively fastening the one upon the other.

In the present state of the subject I should not be willing to set any limit as to the distance typhoid bacilli might travel and at the end of their journey be of sufficient strength and vitality to communicate typhoid fever to people who drank the water.

2271 The real problem would be not so much the distance as the time. The Alleghany river is a swift stream—those 113 miles were covered quickly. It was a babbling stream most of the way, scouring the stones and while I was willing to believe that the typhoid fever in that case came as far as 113 miles, in another case with a slow stream I would not be willing to suppose that they had come fifty miles. I based my opinion that the typhoid bacilli came from Oil City on the rate of flow of the river largely and on my knowledge of the life history of the typhoid bacillus. There is such a thing as accurate and certain knowledge as to the life history of the typhoid bacillus in running water. I know, for example, that they may live to pass from Lowell to Lawrence—nine miles.

2272 In the Lowell and Lawrence case, the waters were polluted, all told, by about eight or ten cases.

Q. Well, your examination of the cases at Lowell and Lawrence excluded every other possible consideration of source of contamination than that which you discovered?

A. I tried to, and I believe I did.

Q. You didn't consider that it was possible that typhoid infected urine or dejecta might have been put in the reservoir or waterworks of either one of the places? A. No, sir.

2273 Assuming that some malicious person had injected typhoid bacilli into the reservoir at Lawrence or Lowell, which it is possible they might have done, those cases do not afford an accurate knowledge of the life history of bacilli.

2274 I wish to make it clear, however, that a malicious infection of the Lowell reservoir would not have invalidated my conclusion in regard to the Lawrence epidemic. From Lowell to Lawrence is 9 miles along the Merrimac river. The community living on the river is more densely populated than rural districts of Missouri. It is within the limits of possibilities that persons living near the Merrimac, between Lowell and Lawrence, might have had typhoid fever and that their dejecta might either be thrown into the river or washed in.

2276 (Witness is cross-examined as to the cause of the Lowell epidemic.)

2282 Q. In reporting upon the condition of affairs at Pittsburg and the remedy to be applied, did you exclude all considerations except the existence of the Alleghany river, and the flourishing towns above Pittsburg? A. I did.

Q. And without knowing whether there was typhoid fever in any one of those towns, or an excessive rate of typhoid fever in any one of those towns, you ascribed the typhoid fever in Pittsburg to the infection of the Alleghany river from towns above it?

A. I do not remember whether there was any or not; whether I based my conclusion upon that partly or not; but in any case even supposing there had been an excess up there, I should have come to the same conclusion, because they were pouring regularly a certain amount of sewage into the stream. All that is necessary to make the waters of a running stream

unsafe as to typhoid fever, is the fact that the sewage of populous places above is poured into the river, broadly speaking, without regard to the fact as to whether there is or has been typhoid fever in any of the populous places above where the sewage is poured into the river. In the epidemic at Detroit my knowledge is taken from books and publications and conversations. The St. Clair river is a passage way for the water of the three great lakes on their way to Lake Erie. I do not know that on each side of it there is a very flat country, full of marshes, that in these marshes and dwelling about them there is a large population of fishermen, that the St. Clair flats are dotted with club-houses, the resort of all classes of people during certain seasons of the year. It seems to me that something of that kind was referred to in the paper which described the epidemic. I understand that the papers which described the epidemic and the persons to whom I talked, exclude all these considerations from the determination as to the cause of typhoid fever at Detroit. I presume they took the most easily ascertained and most prominent possible cause and ascribed to it and to it alone the entire increase in sickness, that would be good sense. I was perhaps a week in Chicago investigating the cause of typhoid fever. I made very little investigation except to study the general situation, but I secured the reports of the board of health and compared the typhoid fever death rate in Chicago with that in other cities. I also inquired into the water and milk supply and other possible factors and then bringing the results all together, arrived at my conclusion jointly with Mr. Hazen. I attributed the abnormally high death rate from typhoid in Chicago
2285 after excluding, as well as I could, other considerations,
to the infection of the water supply by the sewage of the city. I discovered that typhoid fever had nearly always been very high in Chicago, that it never had what might be called an average rate of typhoid. At times, when it was lower than the general average of a series of years I ascribed the typhoid fever to occasional limited pollutions of milk supply, food supply, of the air and of the water and to some minor factors. When the

average rate of sickness in Chicago was less than the usual rate I did not attribute that solely and entirely to the infection of the water supply.

2286 When it rose above the average and far exceeded it, I attributed it to the water supply as a general proposition. The curve or line of typhoid fever in Chicago has been very irregular, always high as compared with cities having a very low, or as compared with most cities having purer water supplies, but occasionally rising rapidly to much higher points. I was led to believe that these rapid and unusual rises were due to the washing out of sediment from Chicago river into the Lake and an unusual contamination of the water supplies by such dislodged sediment or other fecal materials conveyed to the intakes.

Q. Did you compare the statistics, or examine the statistics as to the rain-fall in Chicago and find that such rain-fall was coincident with—or that the increase of typhoid fever actually followed a violent rain-fall, and a sudden rise in the Chicago river?

A. As I remember it, it did so in some cases, and enough to confirm us in the general belief.

If, by pathogenic germs you mean those of well defined infectious diseases, I never discovered such germs in running water.

2288 Water-borne diseases are such as are capable of being transmitted by water or which are capable of being conveyed from one person to another and from one community to another, by means of water as a vehicle. Typhoid fever and Asiatic cholera may be conveyed in this way. It is probable that some others may be conveyed in this way, but the evidence is far less clear than it is in regard to these two diseases. Asiatic cholera is an infectious disease, and it is believed may be
2289 communicated by the air or any of the other means by which typhoid fever may be communicated.

Asiatic cholera in Chicago is of very rare occurrence today, formerly, however, it prevailed very seriously in Chicago. I don't recall that it was ever serious or existed at all except in

1848 or 1847. Inasmuch as Asiatic cholera is by no means an exterminated disease, it might turn up in a population like that of Chicago at almost any time and the danger to the citizens of St. Louis under the existing conditions would be grave. The danger to St. Louis would not depend wholly upon the existence of Asiatic cholera in some one of the streams from which St. Louis derives its water supply. There would be danger of conveyance by train and in articles of merchandise but I should think that the most omnipresent—the most serious danger, would be from the water supply.

2290 The danger by train and by handling of merchandise must be added to the possible cause of typhoid fever anywhere. It is a possibility that a person in San Francisco whose hands were infected by typhoid fever germs, might arrive in St. Louis and spread the disease, or if he carried such germs in his clothes, or if some person packing goods in San Francisco should have typhoid infection on his hands, it might be communicated to people in St. Louis, New York, London, St. Petersburg, Moscow, Karthoum, by way of Moscow, and Nijni Novgorod. It might be conveyed as far as that, if he did not wash his hands en route. I see no reason, if he did not free himself from infection, why he might not convey it around the world. In a trip around the world, say in sixty days, I believe that they might convey it around the world and out of their habitat and away from anything in which they are known to essentially support themselves and that these germs would live.

2291 I should be unwilling to say that Asiatic cholera might not also be conveyed around the world under certain conditions, in other things than in water. Say, in clothes of persons traveling, or in merchandise that went around the world, and a great deal would depend, of course, upon the time and conditions to which the germs were subjected, but in the present state of our knowledge, I see no reason why they might not be transmitted even as far as that in those ways under favorable conditions, of course. A person traveling with ordinary speed around the world I should expect would leave some of the bacteria en route. I don't know that he would arrive with some of them. The chances are that he would not. If he was a respectable person and traveling around the world, he would probably take a bath and change his clothes.

The bacilli coli communis are common in the sewage polluted waters of Massachusetts, or some of them.

2292 There is no geographical limitation to the existence of bacilli coli communis in polluted waters, so far as I am aware. Whenever there is sewage polluted water, there either may be now or may have been the colon bacillus. It is not pathogenic in the sense in which I define pathogenic, although it is put down in some of the books as capable of producing disease.

It is not the cause of a well-defined specific disease, nor
2293 is it, to my knowledge, the cause of ill-defined and general
diseases. I do not regard the bacilli coli communis a standing or floating menace or any other kind of a menace to the city of St. Louis, in themselves, inasmuch as every citizen of St. Louis has millions of them in his alimentary canal. I do not intend to be understood as testifying that the bacilli coli communis in themselves were dangerous to the health of the city when found in the waters supplied to the inhabitants of the city for drinking purposes. In order to become of themselves a menace, they would have to be capable of producing disease. For practical purposes we may acquit the coli communis of being a pathogenic germ and I would acquit them in the Illinois river, of being pathogenic for practical purposes.

Q. Do you mean to say that the typhoid deaths of the city of St. Louis since the year 1900, considered annually are about 73 per cent increased over the deaths from the same disease before?

A. Not exactly that. What I did say was this: that the increase in the average percentage mortality from typhoid fever in St. Louis, reckoned annually since January 1, 1900, was about 73 per cent above the average percentage mortality during the previous five years.

2294 (Explains method employed in computing percentage of mortality from typhoid fever in St. Louis.)

2296 (Upon being examined as to the limit of 4,000 as a basis fore the estimate of urban population, witness stated as follows:) I have no doubt that on the Illinois, Mississippi and Missouri rivers there is a considerable number of people residing actually upon the banks and the water, engaged in fishing largely and sometimes in agricultural pursuits, and all of whose sewage goes directly and without any intermediation whatever, into the rivers. I have no doubt that among such people there is a considerable amount of typhoid fever.

2297 The percentage of typhoid fever deaths in the assumed river population would be somewhat larger than the same per cent of the assumed urban population having the same water supply. In my testimony I did not calculate any percentages on the urban population. What I did say was that the addition of Chicago to the urban population upon the river above St. Louis was an addition of about 63 per cent.

2298 In making these figures, I took the census as I found it. I do not know whether in the census they counted this river population that is floating about.

2299 The rural population, so-called, contributes very largely to the pollution of streams in whose watersheds they reside, using that word as distinct from infection.

2300 As to the method of disposing of sewage in communities having a population of less than 4,000, spoken of by me in my direct examination, I do not know whether that process prevails in the villages and towns along the Illinois, Mississippi and Missouri rivers, having a population of less than 4,000 inhabitants. It is a fact in sanitary science that the pollution of rivers by what we term the rural population is a very large factor in the consideration of the amount, and degree and kind of pollution, but scientifically, considering infections I do not take it so much into account, because in a rural population infection, to begin with, is less common. In the second place, owing to the time factor which is apt to come in, in the partial purification of pollutions, the infectious materials may be destroyed. I have no knowledge as to whether the mortality percentage along the Illinois river is greatest in the urban or in the rural population. Take a common rural population—meaning by that a population not in a village or city of 4,000 inhabitants or more, such a population enters very largely into the consideration of all sanitary questions in regard to the pollution of rivers and into the consideration of the infection of rivers. I think I have the means of determining what per cent the rural population of the Illinois river watershed adds to the population of the watershed of the Mississippi river. I don't know that I can lay my hands on it at this moment but I think the data for such a comparison exists.

2302 I have not in my mind approximately what that per cent is. I have very definite ideas of the time in which the typhoid bacilli do actually live in the waters of running streams. I think I have traced the typhoid bacillus by its effects from the place and time of its origin until it ceased to exist in any given case. I might refer to the Newburyport case.

Q. What was your evidence in the Newburyport case?

A. My evidence was of this character, I traced a small epidemic in Newburyport to a larger epidemic in Lowell, and I knew by the history of the disease in Lowell and in Newburyport, when I had a right to assume that the germs in the flowing water had gone by. Still, I must confess, I do not know how long they remained in the sediment of the river, if any were deposited.

2303 There was reason to believe that it was constantly more or less infected from the sewage of Lowell. The distance is about 30 miles from Lowell to Newburyport. The Merrimac in places is a rapid stream. There is one dam between Lowell and Lawrence and the stream is a tidal stream at Newburyport but not at Lowell.

2304 I should not say that it took the typhoid bacilli injected into the river from the sewers of Lowell more than two or three days to reach the intake at Newburyport. I should say not less than three probably and should not suppose it would be more than five or six but I really do not know. In my direct examination, I stated that at Lawrence, the germs came down nine miles and were pumped presumably into the service reservoir of Lawrence and by comparing the time elapsing between the corresponding periods of the two epidemics in Lowell and Lawrence, and knowing the custom of the water department of holding the water in the reservoir, I have estimated that the bacilli may have lived in the water for between one and three weeks, covering a distance of perhaps ten miles.

2307 If any one maliciously threw typhoid fever germs into the stream with the expectation that they would kill people below, and if they did kill people below, I should convict him of murder.

Q. That is, if the particular typhoid fever germ which he threw into the river were shown by the evidence beyond a reasonable doubt to have produced it?

A. If the evidence was conclusive, that is the act had produced the death of innocent persons, if the act was knowing and intelligent, and if he knew that his act was of such a character as would be likely to produce the deaths of such persons, and if he were sane, I should. In this particular case, I should not expect to detect the germs. Theoretically, I know that the bacilli that killed this suppositious man, he might have received from any other of a dozen different sources.

2308 I hold in a case of this kind, it is not necessary to discover the bacillus. It is sufficient to get the facts of epidemic and connect them as is done constantly in sanitary science, and I think might be applied legally in a case of this kind. My first step would be to exclude every reasonable possibility from my mind as to the derivation of the death-dealing bacillus from some other source. I should also consider that there was no isolated case, any infection from washing infected hands in the river and any other of a thousand ways in which the bacilli might be put in the river.

2309 I want to give you the exact dates in the Newburyport case. The supposed causative cases appeared in Lowell in December, 1902, and reached Lawrence and Newburyport in January, 1903. From my own personal experience, I do not know of a case of typhoid fever which was certainly traceable to typhoid bacilli which had existed for any length of time in the sediment of a running stream. My opinion as to whether typhoid bacilli do exist in the sediment of running streams is derived partly from my reading and partly from my general biological and bacteriological acquaintance with the typhoid bacillus and with bacteria in general.

2310 I do not think it is stated in the reports whether in the Zurich instance, the bacillus of typhoid fever was actually discovered in the sediment which was disturbed at Zurich. I think I have read of some cases in which it was believed that the typhoid bacillus had been discovered in sediments of a running stream. I do not remember now, in what book, and I am not even sure that such was the case. Other bacilli have been discovered in great numbers in the sediments of running streams very frequently and with great ease.

Q. And because other bacilli do live, you reason that the typhoid bacilli may live, or do live in the sediments of running streams?

A. I reason partly by analogy; partly from the general behavior of bacteria in organic materials, and partly from the epidemiological evidence that I have referred to. We have a great deal of evidence outside of the Zurich and Detroit cases. The fact that the beginnings of freshets are very apt to cause epidemics of typhoid fever in communities using the water derived from such freshets, indicates very clearly that heaps of material at the mouths of rivers or in running streams when stirred up may and do cause epidemics of typhoid fever. It is a well known fact that washing in of materials from banks of streams has, as I understand, produced some of our worst epidemics. I should attribute epidemics in an uncertain proportion to both surface washings and sediment washing in case of freshets.

2312 I do not recall any cases in which the bacteria of typhoid fever has been discovered and identified in the sediment of running streams. First experiments in laboratories showed a short longevity for typhoid bacillus but as time has gone on the opinion has I think grown among the bacteriologists—it certainly has in my mind—that those earlier experiments upon the germs were based upon unnatural conditions and that under perhaps slightly different conditions, in mud or manure, the typhoid germ must live very much longer than we had at first believed.

2313 Bacteriologists differ among themselves, like other men. They are at war among themselves as much as doctors, more or less. I don't know that I ever heard any bacteriologist say that the typhoid bacillus would live in a journey of 400 miles in running water, nor 300 miles, because such assertions would be fool assertions.

2314 He doesn't know whether they would live in such a journey or not unless he knows more about the conditions. I have said over and over again that it is not so much the distance, it is the time that comes in and bacteriologists don't go around making assertions of that sort—at least, the good ones don't. I am ready to assert my positive conviction that typhoid bacillus may and do live to make the journey from the Drainage canal through the Illinois river down the Mississippi, to the intake tower at St. Louis.

Q. Based on what evidence?

A. Based on the whole chain of evidence which I have in my possession regarding the sanitary history of Chicago, the character of the water used to dilute the sewage of the city of Chicago, the character of the Illinois river, especially as to being subject to floods, and the character of the Mississippi river into which the Illinois empties, and with which in my opinion, the Illinois freely mixes, so that such germs may be carried alive and virulent, from the people of Chicago to the intake tower of the St. Louis waterworks, and further, upon the vital statistics of the city of St. Louis, as I have studied and compared them with the vital statistics of other communities.

2315 I think I may say it is an extension of the theories as to the existence and time of existence of typhoid germs in running streams but I am not ready to say that it is a very large or remarkable extension, all things taken into consideration. I should say the same thing if an identified body of sewage or water, took five weeks to make the journey or five months. If the time required were one year, I should want to know a good deal about the sediment and the particular conditions that prevailed during that year. I can conceive of conditions which might destroy the germ en route during that time or even before that time, but I can as readily conceive of other conditions which might prolong its life—for example, the pouring of a large quantity of acid from manufacturing wastes down the canal during that year might conceivably destroy the typhoid germs in the water and in the sediment. On the other hand, the pouring down of an unusual amount of organic matters from the stock yards, or from some other place, might so enrich the water as to sustain the life of the germs, perhaps even leading to a greater duration of life than that that you have stated. The fact is that the conditions which have got to be considered in a case of this kind are so many that it is impossible to make categorical answers which will have any real value, unless all of the conditions can be assumed, and that is impossible.

2316 If the journey took one year I think the chances are good that for the greater part, the germs have died out, but I should be afraid that some might still be alive, if they came in Chicago sewage, in conditions existing in the Illinois river—I should expect that some might still be alive—a small percentage. I should say that in regard to the periods beyond a few weeks or months that in general the mortality among the typhoid bacteria would be heavy but that I should never feel certain personally, even after one or two years, or possibly longer, that some of those were not still alive there. I, as a biologist and sanitarian, can see no reason why these little fellows may not, under some circumstances, have their lives very extensively prolonged, and at the present state of our knowledge—indefinitely prolonged. Of course. I mean in diminishing numbers and with a small percentage left.

2317 I think we may fairly assume that there is a diminishing virulence, but there again we are very much in the dark, as we are in a good many of the finer points in bacteriology and medicine. The best place for the typhoid bacilli to thrive and multiply is in the human body. They thrive also in our laboratories under favorable conditions for that purpose. Nothing is known as to their multiplying in nature outside of laboratories. The general acceptation of the most modern bacteriologists is that they do not multiply in running streams. It is commonly supposed that Asiatic cholera lives in the polluted water butts of Calcutta the year around and I think the same thing was found, or believed to be found in Egypt.

2318 Am fairly familiar with the bacillus prodigiosus. There are what some bacteriologists believe to be varieties, and others hold them to be distinct species. On the whole, I believe it is a very well defined species, with no troublesome varieties turning up.

2319 Do not know whether it exists in the waters of the St. Lawrence river, Lake Erie, Columbia river, Lake Michigan or Missouri river. In other words, I may say I do not know whether it exists, but that in my experience, it is not found ordinarily, so that while I don't know whether it exists in those places or not, I should be very much surprised to find that it did exist there, unless exceptionally and rarely. (Same answer applies to the Mississippi and Illinois rivers.) I have never found it in natural waters of the United States.

2323 If numbers of bacillus prodigiosus—large numbers—were injected in a stream and the numbers were large enough to stock the stream pretty well, it would not be very surprising if they were taken up the stream by boats, for instance in the process of washing the decks of the boats, by pumping water from the river. If they were in any water that was conveyed up the river, I should expect them to come with it.

2324 My opinion is that if the waters and sewage coming from the Drainage canal should be wholly diverted into another channel so that none of such waters could enter into the Mississippi river or into the intake of the St. Louis waterworks, and that the only waters that could enter such intake would come from the Missouri, Mississippi and Illinois rivers—excluding the water and sewage from said Drainage canal, that such waters would not be suitable and safe for drinking purposes, in their natural state, or as they enter the intake tower of the St. Louis waterworks.

2325 In my judgment it is entirely possible and practicable to so treat the waters which now enter the intake of the St. Louis waterworks that they shall be suitable and safe for drinking purposes on the part of the citizens of St. Louis. I have taken pains to satisfy myself that the present system of supplying water to St. Louis is now substantially the same as it was prior to January 17, 1900. In my judgment it is now and was, prior to January 1, 1900, insufficient for adequate purification.

CROSS-EXAMINATION by Mr. Todd:

The death rate of typhoid fever is taken as a basis of calculation in preference to taking the number of typhoid cases, as a matter of taste largely.

2326 Investigations have been made and results obtained by various observers and the general result is that the number of microbes discharged in a day from a normal human being is very large—enormous—and that in cases of typhoid fever, the probable discharge is also very large.

2327 By a normal typhoid death rate I mean a death rate which places a city or town having it, in the ranks of cities and towns having good water supplies and good general sanitary arrangements and conditions. This is the sense in which I used the expression that the rate of mortality in the city of St. Louis was normal. If there were 215 deaths and 788 cases in 1893 that would not be a normal number of cases, it would be too small. That means that the physicians did not report the cases.

2327 If it should appear that in 1899 there were 130 deaths and 908 cases of typhoid, that would come near being normal, but here again the number of cases is rather small for the number of deaths. The normal death rate from a sanitary standpoint for typhoid in a city with the population of St. Louis, would be about that which St. Louis had in 1895 to 1899 inclusive, although it might be lower than that under the most favorable circumstances. I attribute the presence of typhoid in St. Louis from 1895 to 1900 to a variety of causes. For example I have no doubt that the water may have contributed something to the net result. Milk, oysters, secondary infection,

2328 dirty hands and that sort of things, from person to person, and also infected foods other than milk and oysters, such as watercress, celery and unwashed fruits, flies and animals and other factors.

2329 I cannot give you the name of any French or English bacteriologist who has discovered the germ of typhoid in an oyster.

2333 I must frankly say that I believe a part of the rise in typhoid cases in 1900 was due to the same cause which operated at the end of 1899. The amount of typhoid fever in St. Louis at the end of 1899, in a city of this size and considering the season of the year, is entitled to be called an epidemic, but it was somewhat above the ordinary.

2334 I should consider an increase such as I have actually found in typhoid in St. Louis for the period since the Drainage canal was opened, 73 per cent, a large increase. (See record 2335.)

Q. If the number of deaths in 1890 was 277, to what would you attribute this high death rate?

A. I don't believe I should be able to answer that question. I would have to give it up.

2341 Typhoid fever may be conveyed by small particles of sputum from the patient, flying off in the air and by kissing. There are at least two or three thousand wells in St. Louis. I have no doubt that some of them are located in the neighborhood of out-houses. I exclude altogether the 2342 wells of St. Louis as producing any important part of the increase of typhoid fever since January 1, 1900. (For reasons, see record 2342 and 2344.)

2343 Q. How many wells in the city of St. Louis have you investigated personally, that privies drain into? A. None.

Q. How many privies in the neighborhood of those wells, within these three years, have received the excreta of typhoid patients?

A. I don't know..

Q. How many people living in the houses where these wells are located and drinking the well water, have contracted typhoid fever from them, if you know?

A. I have no means of knowing.

Q. And in the absence of knowledge upon those three propositions, do you claim as an expert sanitarian, that your conclusions in answer to my former question were established beyond a reasonable doubt? A. I do.

2344 MR. TODD: If conditions existed in any of the wells of St. Louis where fissures appeared, permitting the conamination of privies to enter the wells, such as you have inlicated in part of your answer, have you investigated to ascertain whether that condition obtains or not?

2345 A. I have not. If that condition should obtain, then in my opinion, it would be a serious menace to the health of the people drinking that water. I do not know whether in the three thousand wells in St. Louis, that condition obtains in one or more wells.

2346 I do admit that conditions may exist whereby the water of a well may be contaminated as well as infected.

2351 Q. Assuming that in the different sanitary districts in the city of St. Louis, where the typhoid was high in omparison with the other districts, that there existed a number of infected wells, would not that condition account for the typhoid in St. Louis for 1900, 1901 and 1902?

A. It might, if one were justified in making such an assumption and excluding from the same assumption the possibility of the occurrence of infected wells in other districts. (See pages 2350 and 51 for the number of wells and number of deaths from typhoid in 1900, '01, '02, in the seven sanitary districts composing the city of St. Louis.

2357 (Witness is asked question giving the number of deaths for 1900, '01, '02, in Lincoln, Kansas City, Quincy, Des Moines and Indianapolis from typhoid fever, and stating that those deaths indicate a gradual rise from 1900 to 1902, and asking the witness as to the cause of this apparent increase.)

2358 Objection by Mr. Jeffries and General Crow.

A. Having made no investigations of the sanitary conditions and causes of the typhoid fever in any of the cities mentioned, I am unable to give any reasons for the facts stated. In the case of Kansas City, it is apparently not very large and may be due simply to the rapid increase in population.

2359 MR. TODD: Professor, in the hypothetical question put to you by Mr. Jeffries, and the tabulation of typhoids from each of the cities located on the water-shed of the Missouri, Mississippi and Illinois river, exclusive of the sanitary district of Chicago, would you regard the excreta of the typhoids that appeared in each one of those several cities, if emptied into the rivers, upon which those cities are located, alone sufficient to make unsafe the water supply of St. Louis? By that I mean any one city, as distinct from all the cities?

A. I should certainly regard the rapid and practically continuous pouring of typhoid excreta from such a number of cases as appears to have occurred in any of these cities, as contributing to make the water supply of the city of St. Louis unsafe, but inasmuch as this is purely a theoretical question, and as a matter of fact, such a condition does not, and in the nature of the case, cannot exist, and furthermore, keeping in mind the partial purification of the water supply of St. Louis after it has been taken from the river at the Chain of Rocks, I cannot say whether I should or should not under real conditions, so regard the water.

2360 I have no doubt that the number of typhoid fever deaths and cases existing during the three years mentioned, 1897, '98, '99, upon the watershed above the intake of the St. Louis waterworks, which numbers would indicate perhaps between three and four thousand cases, annually, would render the water supply of the city of St. Louis, if taken at the Chain of Rocks and delivered to the citizens unpurified, somewhat unsafe and somewhat dangerous, but it must be borne in mind that many of these deaths occurred at very remote points. It must be remembered furthermore that at no one time was there anything like any such number of cases as three or four thousand, and that for some periods, the number of cases and deaths upon this immense watershed must have been comparatively very small, so that there may have easily been times during those years, or any one of them, when the water was neither unsafe nor dangerous. Putting all the facts together, then I should say that inasmuch as at no time was there any very large number of cases or deaths upon the said watershed, exclusive of the sanitary district of Chicago, so far as I am aware, and inasmuch further, as the water taken from the intake tower at the Chain of Rocks was considerably purified by sedimentation before its delivery to the people of the city, the danger at any one time could not have been very great. In point of fact, the statistics show that during those years typhoid fever in St. Louis was, for St. Louis, remarkably low, and the water probably better than for many years previous, excepting the years 1895 and 1896, when the conditions of the intake were similar to those which prevailed during the three years under consideration.

2361 I do hold that the pouring in of raw sewage materials into a drinking water stream is likely to render the water below unsafe for drinking purposes.

2363 There may be, however, times when such water could be used with safety owing to the so-called self-purification en route, by dilution, sedimentation and the time factor. Assuming the conditions to be as we have considered them, during the years 1897, '98, '99, I should not, as a sanitary engineer, be able to state the times when it would or would not be safe for the citizens of St. Louis to use the water that comes from the intake. I should probably not have recommended it for drinking purposes or as a safe drinking water at any time during that period, without treatment and purification, inasmuch as one would never know—assuming that typhoid bacilli once found access to the river above in these large numbers—with any precision or certainty, that these would have been effectually removed. I do not know whether the health department of St. Louis has ever examined any of the wells located in the city, but even if they had, I should not feel certain as to the results of such examination, because in the present state of the art, as I stated this morning, it is often impossible to tell by ordinary methods of examination whether a well is or is not safe for drinking purposes.

2364 If the excreta of typhoid fever should be placed in a privy vault, no man knows how long it would have to remain there before it would lose its infection. I believe it might be days, weeks or years.

2365 Ordinarily a privy vault does not closely resemble a septic tank, because it is a mass of tolerably solid material, while a septic tank is essentially standing or stagnant sewage. That is to say, something very much more dilute. At the same time, some privy vaults are undoubtedly septic tanks, but as to septic tanks, while I believe that pathogenic germs are relatively quickly destroyed, we are not yet in possession of sufficient evidence to enable us to speak with entire precision on that head. I do believe that under some circumstances the typhoid excreta in a septic privy vault might be disinfected and under slightly different conditions, might not; but the ordinary privy vault is not in my judgment, a good septic tank. If the contents of such a vault should be placed where the same could get into a stream, it would contaminate the stream, both by way of pollution and infection.

2368 We attributed the cause of typhoid fever in Chicago in 1892, from the investigation I made, to the water supply.

2369 (Witness reads from his report of 1892.)

2370 The newspapers differed with us as to what was the cause of the polluted water supply at that time.

2371 If I remember right, they further quoted some of the city officials who made statements that the water supply of Chicago was pure and unadulterated. My paper was read before the American Statistical Association on January 22, 1892.

Q. Assuming that the water supply of Chicago was contaminated by the sewage emptying into the lake and this sewage was what caused the prevalence of typhoid fever in Chicago, would the elimination of all that sewage from Lake Michigan cause, in your judgment, a reduction of typhoid in the city of Chicago?

A. I should certainly expect it to do so. If the sewage of Chicago did not enter the lake, I should certainly not consider the lake water seriously contaminated water.

2372 In view of the fact that steamers are constantly passing in and out of the mouth of the Chicago river and that the lake apparently is used by numerous fishermen and pleasure seekers and that in times of extraordinary rain-fall the Chicago river may even today have its current reversed for a time, I cannot say that I should consider the water of Lake Michigan within four miles of the shore on the lake front of Chicago as a perfectly wholesome and suitable material for drinking purposes under the conditions assumed. I do not know of any large city in the country whose water supply rises to the perfect standard fixed by sanitarians.

Q. Do you know of any city in the country that will have a better water supply than the city of Chicago when the sewage of the Sanitary District is completely eliminated from Lake Michigan?

A. Yes, I think so. I think that the water supply of New York is better than that of Chicago would be under those circumstances, or would be likely to be later on. I think that the water supply of Boston is another example.

2373 If the sewage system of Chicago when completed will be a complete elimination of the sewage of Chicago from Lake Michigan into the Drainage canal, that ought to be followed by material reduction in the typhoid fever death rate. I should expect that it would be. As the reduction of typhoid takes place, the danger from the sewage of Chicago going into the lake will be thereby decreased. The elimination by that process will tend gradually to purify and improve the water conditions of Chicago so far as that element is concerned. That in turn will eliminate to a large extent, the infection of the Illinois river but if the rate fell off one-half and the total number of cases continued the same, owing to the growth of the city, or by any other means, then the quantity of typhoid material put in the sewage would remain the same.

2374 I assume that Chicago is going to be one of the greatest cities in the world, but I assume also that under the conditions mentioned, the typhoid fever death rate will fall off very largely. Yet, the total amount of typhoid material thrown into the Drainage canal may even get bigger than it is at present. As I recall the river when I examined it, I should say that some parts of the Chicago river at times were undoubtedly in such a condition as to be likely to abbreviate the life of pathogenic germs.

2377 Typhoid germs are found in various parts of the human body, especially in the spleen and alimentary canal. I believe that there are so-called cases of typhoid fever in the lower animals, but these are, to say the least, uncertain and I cannot say that the existence of such well-defined germs has ever been made out. We therefore look to the human subject as the source of pollutions of water, sewage and the like, rather than to any of the lower animals. The sewage that enters the Illinois river at Peoria will purify itself within 25 or 50 miles, to a certain extent, but not to such an extent that I should consider the stream into which it is poured, fit for drinking purposes.

2378 In my direct examination I stated that if the water of Lake Michigan, considering the fact that the sewage from about a quarter of a million of people is discharged into the lake, was conducted through a conduit directly to Grafton, and that no other sewage from Chicago was conducted to Grafton, that such Lake Michigan water would be dangerous and unsafe to the citizens of St. Louis. I should say that the dilution would be enormous from Chicago; it would be enormous in Lake Michigan and would be still further increased in mixing with the Mississippi at Grafton.

2379 I am still of the opinion it would render the water supply of St. Louis dangerous and unsafe under the present conditions at the intake. As to whether it would be more dangerous than the water supply of St. Louis prior to the opening of the canal I cannot say. I have testified that I did not regard the Mississippi water, previous to the opening of the canal, as it arrived at the Chain of Rocks, as suitable for a modern city.

RE-DIRECT EXAMINATION by General Crow:

2381 During the years 1897, '08, '09, 1,001 deaths were reported on the watershed tributary to the intake tower of St. Louis. In Chicago during the same years, the total deaths reported were 1,115. The number of deaths reported on the watersheds tributary to the Missouri river for 1901 and 1902 were 1,144; for the same years in Chicago, 1,647.

2382 I do think there would be a material increase of cost in the proper management of filters at St. Louis by reason of the added pollution and infection from Chicago. This I state upon reflection, after having considered my testimony on cross-examination.

2383 The fact that Chicago had an epidemic in 1902 of typhoid fever and that such a thing is likely again to arise, the operation of filters in the hands of any competent person would require extraordinary and constant attention and skill at St. Louis and such things are costly. The increase in population in Chicago to three or four million people might necessitate double filtration at St. Louis. (Witness refers to future consequences that might arise by virtue of the increased population in Chicago.) When we consider that during each of the three-year periods referred to heretofore, I have been able to learn of only about 11,000 cases of typhoid in the cities on the watershed on which the intake is located and that I find there must have been about 16,000 cases in Chicago during the period of three years since the opening of the canal, it appears that the opening of the canal has more than doubled the probable number of typhoid fever cases in the urban communities on the watershed above the intake. Although Chicago is 358 miles distant from St. Louis, some of the cities on the Missouri and Mississippi watersheds are even farther away. When I consider all these facts, I cannot escape the conclusion that the opening of the Drainage canal was a very grave addition to the sanitary and financial burdens of the people of Missouri using the water of the Mississippi below Grafton.

MR. TODD: I move to strike out the answer as not responsive and is not proper on re-direct examination.

In my cross-examination, reference has been made to the dams in the Illinois river; the general effect of dams is to hold back the water and produce slack water basins and any checking of the flow and slowing down of the stream—other things being equal, favors sedimentation and the disappearance from the supernatant waters of infectious material. The carrying down of the germs and the detention of them in the sediment removed them from the moving water in the first place, and in the second place, by detaining them, gives them an opportunity to die out more or less. On the other hand, streams are subject to scouring more or less frequently, and the disappearance of infectious materials is not necessarily their destruction. A considerable increase in the flow of such a stream as the Illinois river must tend to favor the return to the supernatant stream or lake or pond of some of the materials which it had previously deposited.

2387 While there is undoubtedly a high value in sedimentation and storage of infectious materials and a tendency toward their permanent removal either mechanically or by death, I do not feel that the processes referred to are trustworthy means of sewage purification under such conditions as existed in the Illinois river.

2388 Although typhoid bacilli are very rarely found in running streams there are other bacilli that are transported by water and convey water-borne diseases and they are, for example, the cholera germ and the supposed germs of diarrhoea and dysentery. As to animals, while I do not know whether glanders has been found in water, still glanders is supposed to be conveyed from one horse to another by water. Anthrax has been supposed to be conveyed by water. There is every reason to suppose it might be so conveyed, because it is one of the hardest germs to kill, of all that we have. I dare say there is a record of anthrax being found in the Illinois by the State Board of Health, but I don't know.

2389 As it is so difficult to discover the typhoid bacilli in water, one must judge of their presence by the effects which the water produces on those who use it.

2391 As to the typhoid fever at Pittsburg, I did not mean to state in my cross-examination that it was caused by the typhoid fever epidemic at Oil City or at Johnstown. The condition in Pittsburg was rather like that in St. Louis today—a large amount of typhoid fever, rather than what I should call an epidemic. It was not due to any special epidemic in Oil City or Johnstown or in any any other community upon the watershed, because I could not find in any of these, such unusual occurrence of typhoid fever, but rather that the regular and steady occurrence of typhoid fever in many places on the watershed had each contributed its proportional share to the making up of the total in Pittsburg.

2392 (Witness reads from his report in regard to Pittsburg.) JUDGE JOHNS: I move to strike out the extract so read as irrelevant and incompetent.

2393 As I have already said, broadly speaking, people living on farms on a watershed, and away from the banks, generally take care of their wastes on their own farms.

2394 The fact that there were 19 deaths from typhoid fever in January, 1900, in St. Louis, which was a larger number than had happened in January for several years at least, in February, the number was 5, which was smaller than in 1897, 1898 or 1899, shows that the little outbreak at the end of 1899 (prior to opening of canal)—whatever it might have been due to, had spent itself, while the occurrence of 16 deaths in March, 1900, has been, I believe properly attributed by Dr. Ravold, to the opening of the Drainage canal on January 17, 1900. At least a part of that increase may have come and probably did come from that source. On the other hand, the deaths in the next month fell off again to four, which was lower than during the two previous years, so that it is not easy to be absolutely sure that the number 16 did really come to any great extent from the first arrival of the material held in the Drainage canal. I may add that it is only by taking these things in a large way and for considerable periods that any safe conclusion can, in my judgment, be drawn. Boardly speaking, I do not think that after sewage which is infected with bacilli of water-borne diseases, is placed in running water, there is any absolute safety in using that water for drinking purposes within a month's time.

2395 I have been looking over what I said this morning, or parts of it, and I find that in answering the next question to the last, I contradicted myself and I desire to put myself right on the matter. (This question and answer related to the cause of typhoid fever in St. Louis in 1900.)

2396 What I intended to say was this, that there is evidence that the outbreak at the end of 1899 reached over into 1900, as is seen in the fact that there were 19 deaths in January in St. Louis, from typhoid fever, a larger number than had occurred in that month for several years previous. It is very clear that the outbreak referred to had spent itself in February, for the deaths in that month were lower than in any of the three years preceding. In March the number rises again to 16, being larger than for several years before in that month. It might be that some epidemiologists—in fact, I should myself have suspected, if I had no other explanation of the fact, that these 16 deaths meant a recrudesence of the previous outbreak. Fortunately, however, we have a simpler explanation in the fact that the Chicago Drainage canal was opened on January 17, 1900, and it is in evidence, I believe that not long after a mass of black and dirty water arrived at the intake of the St. Louis waterworks, which was believed to have come directly from the Chicago Drainage canal. In view of this evidence, I regard the excess in March, or at any rate, the larger part of it, as due not to a recrudesence of the outbreak at the end of 1899, but to the pollution of the St. Louis water supply by material arriving from Chicago. This conclusion was reached, I believe, or a similar conclusion by Dr. Ravold, who, as it seems to me, very properly attributed the greater part of the excess in this month to the cause described.

2397 (Objected to by Mr. Todd.)

In April on the other hand, the number was again low, which goes to show that the cause which operated, or the cause of the deaths in March, was apparently absent, or at least very slight. In matters of this kind, we must take the statistics in a broad way and cover considerable periods of time, if we wish to be absolutely sure. Mr. Johns in cross-examining me, stated as an assumed fact that the population along the banks of the Illinois river produced a larger number of typhoid cases than populations not upon the river.

2398 The increased flow from the Drainage canal would obviously move forward the typhoid dejecta from this pop-

ulation more rapidly and quicken somewhat its delivery into the Mississippi river and the time of its arrival at the intake. Judging chiefly by the typhoid fever death rate in St. Louis during the years 1895, '96, '97, '98, '99, the sanitary condition of the water supply as actually delivered to the citizens during those years, was good. Based on the typhoid death rate since January 1, 1900, and assuming that there has been no change in the treatment of the water supply of St. Louis, the death rate has been such as to place the said water supply under the gravest suspicion of contamination, to tend to remove it from the class of cities having good water supplies and to place it in or
2399 near the class having polluted water supplies.

RE-CROSS EXAMINATION by Judge Johns:

Since giving my answer to Mr. Hamlin stating that the expense of filtration of the waters of the St. Louis supply would probably be the same whether the waters of the Illinois River were added or not, I have been giving that question considerable thought. What I meant to convey was that in view of the infection that I believe comes from the Illinois iver, we should have to have here a more careful and expensive system than we would have had to have without it.

2400 Broadly speaking, I should say that for the last ten years the water supply of St. Louis ought to have been filtered. If they ought to have a filter, it ought to be managed with great care and by good men, in any event.

2401 Assuming that the waters of the Illinois River which entered the intake would be as one is to sixteen, I would not know what the additional expense would be in arder to filter this Illinois water.

2403 I don't think any one ever made a filter for non-pathogenic germs and I should not think it was necessary, broadly speaking, to make a differently constructed filter with reference to non-pathogenic than for pathogenic germs. If the Missouri River has twice as many germs in number as the Illinois River and the Mississippi River combined, at the intake, it would be necessary in filtering against the entrance of these rms, to have very great care taken of the waters from the Missouri River.

05 You have got to construct filters with reference to conditions.

Q. Well, the conditions being assumed that the Missouri ver as to all kinds of bacteria combined and all kinds of solids suspension and solids in solution, is much worse than the aters of the Mississippi and the Illinois arriving at the intake the waters leading to the filter, it would be necessary in the eparation of that filter, to recognize the condition of the Misuri River, wouldn't it, and arrange to filter the waters of the issouri, combined with the other two?

A. Certainly, if that were the fact and if that were the hole fact, but I don't understand that it is.

Q. I am assuming the questions and am responsible for em. If that were the fact then in constructing the filter you ould construct it with reference to the very large predominice of the Missouri water requiring filtration, wouldn't you?

A. Certainly, if that were the fact and it was so all the time.

06 Q. Suppose that a filter was constructed which would at all times and under all circumstances, filter successlly the waters of the Missouri river, wouldn't that filter at all nes and under all circumstances filter with equal success, the aters of the Illinois?

A. I don't know. I should have to know more about the emical composition of the waters of the two rivers, at differt seasons and times. Not being sufficiently familiar with e general character of the waters to form an opinion, I should be unable to answer that question.

09 I do not know whether or not the total increase in population of Chicago upon the basis of the census of 1890 d the census of 1900 is equal to, or greater than the total inease in population of all the other cities in the watershed of e three rivers combined, the Mississippi, Missouri and Illiis. I took into consideration, in stating the future pollution

of the Mississippi river, not only the increased population in Chicago, but the increased population in the watershed. I intended to include in my remarks the idea that if the population along the banks of the Mississippi should increase, as I anticipate, and excluding the population of Chicago and its consequent sewage, there might in the future come a time at very low water, when the Mississippi would be almost a river of dilute sewage.

2410 (The same applies to the Missouri river.)

Q. In which case, it would be necessary for St. Louis to get its water from the Merrimac, or resort to double filtration?

A. No man can say, but something would have to be done —something serious.

Q. Do you not anticipate that at some time in the future all these things will be changed, and these communities will destroy their sewage at their point of origin?

A. I have often wondered about that and tried to imagine what was likely to happen. As I think I intimated in some part of my testimony, that has been the general line of human progress in the most civilized communities. In England, for example, they are paying more and more attention to the purification of the sewage before they put it into streams, and similar processes are going on today in the older communities of this country. I was told that when the canal was opened in 1900 that the waters of the Illinois were very high and that there was an appearance of black water at the intake of the St. Louis waterworks.

2411 I understood that at that time the Missouri was low or at any rate, that the conditions were such that the mixed Illinois and Mississippi found ready access to the intake. I know that the pumps at Bridgeport undoubtedly at times did lift considerable sewage into the Illinois and Michigan canal, but I have always regarded the Bridgeport pumps as an uncertain element in the matter. I have understood the purpose of putting the pumps at Bridgeport was to pump the sewage of

Chicago into the Illinois and Michigan canal from substantially the same area as is now drained by the Sanitary canal. I have made no special study of the point, but I should judge there would be a difference of a day or two in the flow of the Illinois before 1900, in January, and after that time, with reference to the arrival of the waters at its mouth at Grafton.

2412 I should not expect that, assuming the quantities of sewage to be the same, that those two days more of time in arriving at the mouth of the river at Grafton would so immensely purify the water that it would be innocuous. Assuming that the dangerous qualities were equal in the two, I should not expect it to be so immensely purified in that lapse of two days as to remove 30 per cent of its dangerous qualities. I should not assume that it would remove 10 per cent of the danger, because any such assumption would be contrary to the facts. I don't think that a difference of two days would make any very great difference in the degree of purification under the conditions assumed, or existing, because the two days would be so small a portion of the whole period that if, for instance, the sewage came down in ten days, two days more would not make any difference—certainly would not make very much difference—in the life of the germs.

2413 Q. Which one of two individuals, one on the lake front in Chicago, and one on the Illinois river below Joliet, immediately casting dejecta, one into the waters of Lake Michigan and the other into the waters of the Illinois, would be most dangerous to the health of the city of St. Louis, if both were typhoid infected persons?

A. I think other things being equal, the one at Joliet.

2414 I am not prepared to say that the household sewage of the river population of the Illinois river is not as dangerous to the waters of the intake tower at St. Louis as the dejecta of the supposed 3,000 fisherman on the lake front in Chicago is to Chicago. I have never denied or failed to believe that there must be a lot of people along the shores of the Illinois river who throw things into the river.

2415 I should say that the three years after the opening of the
canal show the greatest death rate from typhoid fever
for the following reasons: (1) Assuming that the same amount
of sewage from the same population was pumped in, in the old
way, through the old Illinois and Michigan canal; it was really
a very different sort of sewage. The conditions then existing
on the Chicago river were totally different to those that exist
today. At that time the Chicago river was a kind of sedimentation
basin, and it not infrequently ran in the opposite direction
to that which it now takes. It was for the most part a putrescent
stream, resembling more or less what we sometimes call
a septic tank. And also (2) because in certain places, owing
to these facts, there were opportunities for the dying out of
typhoid germs in that river or its branches, but thirdly, and
perhaps chiefly, because the sediment deposited, as I have indicated,
was from time to time belched out into the lake, as I
have said, so that the Chicago water supply was often worse
infected than it is today, indicating that the typhoid germs
which now very likely come down to St. Louis, at that
2416 time, if alive, went on into the lake much more freely and
more readily polluted the water supply of the city of
Chicago. To sum up, because the conditions in the Chicago
river were so different from those which exist there today, that
it is not, in my judgement, difficult to explain the facts. I have,
of course, thought a great deal about this question, and have
endeavored to give it the fairest possible consideration. It is
a perfectly natural question which you have asked me, and one
that occurred to me long ago, and I have met it to my own
satisfaction, studying all the conditions and remembering all
the circumstances, and I may say that I believe that the period
since the opening of the Drainage canal would be far more likely
to be the one showing high typhoid fever in St. Louis largely
because the typhoid germs formerly held back in the Chicago
river, where they either died or were washed out into the lake
by heavy rains from time to time, have since January 17, 1900,
for the most part, been sent down the Illinois river, and al-

though many of them no doubt have disappeared en route, at least for the time being, they have in greater or smaller numbers, nevertheless, survived at other times, and even at some times have reached the intake tower of the St. Louis waterworks and caused typhoid in St. Louis.

2417 I don't know what the average rate of flow per mile of the waters in the Illinois and Michigan canal was for 15 years prior to 1900. I don't know what the average rate of flow of the waters of the Drainage canal has been since its opening.

GARDNER STEWART WILLIAMS examined in chief by Attorney General Crow:

2418 Am Consulting Water Supply and Hydraulic Engineer and Professor of Experimental Hydraulics in Cornell University. The results of some of my investigations which were presented to the American Society of Civil Engineers during the past two years recently received the Normal Medal, awarded by that Society. (States his experience.)

2420 Generally speaking, we have a practically equipped channel and streams of water at Cornell, with which hydraulic experiments are made. We are able to produce on the actual scale on which they exist, a very large number of the structures which are met with in the ordinary streams of the United States. The apparatus and streams which we have there are used both in connection with construction and in the line of original investigation.

2421 The water supply of Chicago, viewed from a sanitary
standpoint is certainly the worst of any supply furnished
to a large city on the great lakes; in fact I doubt if there is a
supply of any of the smaller towns that has such a con-
2422 tinuous reputation for infection. The amount of human
feces daily delivered into the sewers of Chicago is in the
neighborhood of 4,400 cubic feet. That is, the solid human feces
aside from any liquid mixture—that would amount to about 150
tons every 24 hours. It amounts to something more than 50 per
ent of the suspended matter of Lockport, as appears from
analyses there.

2423 The water used to dilute the sewage of Chicago as it is
drawn through the Drainage canal is taken from Lake
Michigan near the mouth of the Chicago river, and therefore,
from immediately over those large beds of sewage deposits which
have been found by investigators to be from one to four feet
deep in some cases. Assuming then as I have stated, that the
water supplied through the intake of the Chicago water-
2424 works is the principal cause, or one of the principal
causes of the high typhoid death rate in Chicago, the
water used to dilute the sewage of Chicago and sent into the
canal would certainly be likely to carry typhoid infection into
the Illinois river. Speaking generally, I should consider that
the discharge of such an infected water as that which would
flow into the conduits from Lake Michigan, near the mouth of
the Chicago river, or along the lake front of Chicago into the
Mississippi river would be likely to carry disease and infection
into the Mississippi river at Grafton and would therefore be a
menace to the health of people using the water of the Mississippi
river below that point, for drinking purposes. Most emphatically, I do not consider the mixture of water and sewage discharged into the Des Plaines river at Lockport of such a character as to be safe for use for drinking purposes.

Q. How is the character of this liquid discharged into the Des Plaines river at Lockport, changed by the time it reaches Grafton on the Missisippi river?

A. It is changed by the dilution with the waters reaching the Des Plaines and the Illinois rivers from other sources, by the effects of sedimentation along the line of the stream and by the action of the vegetation along the same. There is no question that under the conditions which exist in those localities on the Illinois river near Joliet and Peoria, where slack water is found and where the current is slow, there would be a very extensive deposit of the suspended material in the water upon the bottom of the stream, at such times as the flow through these portions is low and of a uniform character. As the pressure of the water varies from top to bottom, a particle in order to settle to the bottom must be of sufficient weight to overcome the differences of pressure from layer to layer in the water.

2427 Consequently, the lighter particles in the water will be the last to be deposited and bacteria, which are of very nearly the same specific gravity as the water itself, will only be borne to the bottom when entangled with the heavier suspended matter which is finding its way to the bed of the stream. In other words, the mud will be deposited first and the lighter particles—the vegetable and animal particles later, if at all. Any condition which tended to change what is called the regimen of flow—that is, which causes a change in the velocities from the bottom to the top of the stream, will cause changes in the amount of deposition, and will also frequently lead to what is known as scouring. It is particularly likely to stir up the suspended matter in the layer of water next to the bottom which is in a very dry unstable condition, and to distribute that material which in the quiet portions of the stream would be largely made up of the vegetable and animal life in the water, back into the stream.

2429 It is not necessary to have a condition of flood waters to take up the suspended matter and move it down from behind a dam. A very small change in the stage of the river at low water time would make a very decided difference in the transportation of sedimentary matter.

2430 The passage of boats would have a very decided effect in stirring up the deposits along the bed of a stream. This was evidenced by our investigations in the St. Mary's river. The observations were made by means of current meters after a boat had passed.

2431 In times of flood, the particles of sedimentary deposits which would be first picked up would be those in the layers of water overlying the bed of the stream, or in other words, those that were last laid down.

2432 The lighter particles of the suspended matter in the water and the lighter particles of the matter lying actually on the bed of the stream. Winds are very likely to cause similar disturbances. It has been observed on the great lakes, particularly Lake Erie, that after heavy winds, the waters of the lake are charged with greatly increased numbers of bacteria. At times of flood or of the disturbance of waters, I should say that the bacteria would be much more likely to be re-suspended, and when re-suspended would be carried much farther than would the particles of mineral matter. The bacteria thus stirred up would be carried on down stream. They might be in part re-deposited somewhere in the course of the flow, but some of them would undoubtedly be carried for very long distances in the water and in the case of the Illinois river would be discharged into the Mississippi. Whether the germs of typhoid coming from sewers of Chicago and passing by way of the Drainage canal into the Des Plaines and Illinois rivers that might be deposited in the bed of these streams and remain there for considerable periods, would be entirely destroyed or not, would depend upon the length of time which the bacteria might remain deposited in the bed of the stream, but under such conditions as existed upon the Des Plaines and Illinois rivers, receiving the sewage of the city of Chicago, I see no reason to believe that germs deposited in the bottom of the stream would be destroyed under existing circumstances.

2434 I have made an estimate of the length of time required for the passage of water, under existing conditions, from Bear Trap dam at Lockport, to the mouth of the Illinois river, and it appears that we may expect the water to travel this distance under the different conditions existing in the stream, in from one to three weeks, speaking generally. I estimate that in 1900, during something over 300 days, water would have flowed from the Bear Trap dam to the mouth of the Illinois river in less than 15 days. The discharge into the Missisippi river at Grafton, of the Illinois river, after the latter has received the mixture of Chicago sewage and water at Lockport, tends to increase the pollution and infection of the water of the Mississippi river and render it less safe for use for drinking and general household purposes below the mouth of the Illinois. When the Mississippi is in flood and the flow of the Illinois not above normal, I consider it possible for the waters to become so mixed as to effect the quality of the water upon the Missouri shore of the Mississippi river.

2435 That brings us back to the question again of the distribution of velocities and the distribution of pressure * * * * we may perhaps place this in more popular language by saying that the swifter moving stream exerts a suction upon the water of the slower moving stream, which leads to the dissemination and mixing of the latter throughout the volume of the former. The mixture would occur to a more considerable extent when the Illinois river was in flood and the Mississippi low, by reason of the velocity of the Illinois river, the momentum of the particles delivered into the Mississippi would be such as to carry them well out into the stream. In fact, it is observed that when the Illinois river is in flood the waters do pass well out into the main stream of the Mississippi river. The backing up of the Mississippi water into the Illinois river would have the effect of producing a quite thorough mixture of the waters of the Illinois and so much of the Mississippi as backed up into the stream, and as the flow or effect of this water which had been stored in the Illinois, considering it as an estuary, as it came out of the Illinois, would have the same effect as a flood rising in the Illinois itself, and producing an effect of additional scour on the bottom of the stream, and carrying the water into the Mississippi, which then being flowing rapidly, would have the mixed water more generally disseminated throughout the main current than would be the case with the rising river. I am prepared to state positively that at times the waters of the Illinois river reach the intake of the St. Louis waterworks.

2437 Even supposing that all the disease germs and infectious matter in the diluted sewage of Chicago as it passes Lockport should be rendered inocuous, under such circumstances, I should consider that the discharge into the Illinois river of the quantity of water now delivered through the Drainage canal would be a menace to the health of the people of Missouri using the water for drinking purposes for the reason that this quantity of water added to the stream during the low water periods, tends to materially decrease the time required for the flow of the water from various points along the Illinois river where pollution and infection may be and are added to the stream and thereby increase the liability of such pollution and infection reaching the Mississippi river in condition to do injury and harm to the citizens of Missouri who may be using the water.

2438 Each year the water of the Chicago Drainage canal would probably arrive in the Mississippi river at the Chain of Rocks within ten days of the time that it passed over or through the Bear Trap dam.

In making this estimate I used the proper methods that are used by hydraulic engineers in estimating the flow of streams to the best of my ability. Considering the suspended matters in the diluted sewage at Lockport, the quantity of water flowing in the Drainage canal and in the Des Plaines, Illinois and Mississippi rivers, I find that during about seven months in the year, the dilution of the suspended matters in the diluted Chicago sewage delivered into the Des Plaines river at the Bear Trap dam, when the said sewage and water reach the Mississippi river at the Chain of Rocks, would be from one-half to one part per million and that in the case of very low water in the Mississippi, the dilution might be reduced so that the suspended matter would represent a dilution of only one and three-fourths parts per million.

2439 I mean that the ratio of the amount of suspended matter delivered into the Des Plaines river from the Chicago Drainage canal at Lockport, and the quantity of water flowing in the Mississippi river is as from five tenths to one part of the suspended matter, to one million parts of the water of the Mississippi river, and that in time of low water, this ratio may be one and three-fourths parts of the suspended matter to one million parts of the water of the Mississippi river. This is based upon the solids which are in suspension in the sewage at the Bear Trap dam, and has no bearing upon any substances which may be in solution and therefore not appearing as solids in suspension, in the analyses of the water. At Detroit in 1892 a similarly diluted mixture of suspended solids from sewage matter produced typhoid fever. (Gives a description of the Detroit epidemic. See pages 2442-3 in regard to conditions existing on St. Clair river and Lake St. Clair, as to depth of water, rate of flow, etc.)

2443 I think that ten days is a fair estimate of the time required for the water to travel from the place where this material was dumped to the intake of the Detroit waterworks.

JUDGE JOHNS: I move to exclude that answer and to exclude all testimony descriptive of Lake St. Clair and its waters.

2444 The period of incubation for typhoid fever may be as short as seven days, or it may require in the neighborhood of four weeks, but probably about 75 per cent of the cases will incubate in from 10 to 15 days of the time infection is taken. I have concluded that 12 days is a reasonable and proper period of incubation to be allowed in the study of typhoid epidemics.

2445 I found that making allowances for the time required for infection to come from the point at Port Huron where this material was discharged into the St. Clair river and allowing the average period of incubation and the ordinary time to elapse between the taking down of the patient and the occurrence of death, that the sum of such times agreed within 24 hours with the time which had elapsed from the deposit of the dredged material from Black river into the St. Clair river.

MR. TODD: I move to strike out the answer because the witness has not shown that he is in possession of facts of personal knowledge sufficient to make the answer that he has made.

JUDGE JOHNS: I move to strike out all the witness' testimony as irrelevant and incompetent.

2445-6 (Witness makes comparison of Detroit waters with those of the Illinois river.)

2447 The presence of infectious matter in the water of the Detroit river was indicated by a largely increased prevalence of typhoid fever in all the towns along the St. Clair and Detroit rivers which had public water supplies taken from the Detroit and St. Clair rivers.

2448 I have figured the dilution of the matter taken from the Black river and find that it ranged from a ratio of 55 of a part of dredged material to 1,000,000 parts of water, to 1.1 of dredged material to 1,000,000 parts of water. The materials dredged were composed of deposits of silt and sediment apparently coming from the sewers of Port Huron. In ordinary stages, I would state the range of dilution of the sewage matter of Chicago, from the Sanitary District of Chicago, in the waters of the Mississippi river flowing past the Chain of Rocks to be from .5 of a part of suspended matter to 1. part of suspended matter in one million parts of water.

2450 Port Huron had sewers in 1892 and they discharged into the Black river. There had been typhoid fever in Port Huron during September and October, 1891. (Objection by Mr. Todd.)

2451 This dredging and dumping was done in the Black and St. Clair rivers in 1892. It began April 16, and the work continued on through the year, but the dredging of the particularly infectious matter ended in a comparatively short time—it was a matter of a few weeks.

2452 JUDGE JOHNS: I object on the part of the State of Illinois to all the testimony with reference to the history of the epidemic at Detroit, as irrelevant and incompetent.

2453 The quantity of the dredged material dumped daily into the St. Clair river at Port Huron in 1892 varies in amount from two to five times the amount of human fecal matter that is delivered by the sewers of Chicago into the Chicago river and thence into the Drainage canal each day. (Objection by Mr. Todd and Judge Johns.)

2454 Made a thorough investigation of conditions in Detroit and failed to find any local cause for this epidemic or any cause other than this dredging of Black river at Port Huron.

MR. TODD: I move to strike out the answer for the reasons heretofore stated. There has been considerable dredging in the Detroit, Black and St. Clair rivers and in Lake St. Clair since 1892. This has always been accompanied by increased typhoid fever in Detroit.

JUDGE JOHNS: In order to save the necessity of objections to each question and answer as propounded, the State of Illinois now objects to all testimony to be elicited from this witness with regard to investigations either by himself or other persons, of the cause of typhoid fever, and in any other place than in St. Louis, arising from infection of the waters at the intake at St. Louis, caused by the inflow of drainage from the Drainage canal in Chicago, and insists that such testimony is neither competent nor relevant and desires that this objection shall stand to all such testimony from this witness.

Another instance where the disturbance and discharge of sediment from sewers into a running stream has caused typhoid fever among the users of the water of such a stream is that of Grand Forks, North Dakota. The main sewer of Crookston, Minnesota, became damaged so that it failed to discharge the material delivered into it. Temporary repairs were made and a small connection was made around the break which carried off a portion of the liquid matter of the sewage and discharged it into the Red Lake river, which was the stream into which the sewage of Crookston was regularly discharged. In the fall of 1893 the sewer was repaired and on November 17, the sewerage system of Crookston was flushed of the accumulations which had gathered during the several months preceding. Sixty cases of typhoid had existed in Crookston in October and November, 1893. At the time of the flushing of these sewers into Red Lake river the river was frozen over. Grand Forks, North Dakota, is about 60 miles by river below Crookston. In November, 1893, there were reported in Grand Forks two cases of typhoid fever and no deaths. In December following the flushing of the sewers at Crookston on November 17, there were reported 230 cases of typhoid and 4 deaths; in January 712 cases and 52 deaths; February, 231 cases and 27 deaths; March, 46 cases and 11 deaths; April, 26 cases and 2 deaths; May, 1 case and no death.

2457 MR. TODD: I move to strike out the answer for the reason that witness has not shown that he had personal knowledge of the facts concerning which he has testified. (Witness again compares condition in St. Clair river with that in the Mississippi and Illinois as to flow and mixing.)

2458 Lake St. Clair might be and has been regarded as an ideal settling basin. When the Detroit waterworks was located, a commission of engineers, members of the United States engineer corps pointed out that in Lake St. Clair, Detroit was provided with a vast sedimentation basin which would add materially to the purity of the water drawn from the river at the point where it was proposed to take it. That report was made about 1860 or 1870.

2459 I am entirely satisfied that some of the infection in the sewage matter dredged in the spring of 1892 from Port Huron had remained or lived in that material for three or four months at least. I think it entirely probable that much of it had lived a very much longer time. The typhoid germs delivered into the St. Clair river at Port Huron must have lived a sufficient length of time to have traveled to Detroit, to have passed through the distribution system of the city, and to have been delivered to the consumers, and such time could not, in my opinion, have been less than eight or nine days, and in a great many cases, must have been as much as 12 or 15 days, or more.

2460 Typhoid infection usually comes into the water of streams through the sewage discharged into those streams. As a general proposition I most emphatically do not consider it safe to permit the discharge of human sewage in the streams of water which may thereafter be used as a source of water supply.

2461 It is my opinion that taking the conditions which I have found along the Drainage canal and streams which unite the sewers of Chicago to the intake, that typhoid infection or typhoid germs have at times come from Chicago to the intake of the St. Louis waterworks, that they may and will continue at times to do so under conditions which exist and which may be expected to exist in the streams aforesaid. The best criterion of the sanitary quality of a water supply that is being used by a community for domestic purposes, is the presence or absence among the users of such supply, of water-borne diseases, of which in this country, typhoid fever is at present the most important. The number of cases and deaths from typhoid fever in a community, I should consider the most important evidence to be adduced as bearing upon the sanitary quality of the water supply.

2462 The evidence afforded by the typhoid fever statistics of St. Louis for the period from 1895 to 1899 inclusive, indicates that while the water supply of St. Louis at this time was not ideal, it nevertheless would compare favorably with that of a very large number of our American cities. Considering the typhoid statistics since the beginning of 1900, it appears that up to near the end of January the water supply of St. Louis during the year 1900 must have been about as good as formerly, but that about that time there appears to have been considerable infection of the supply which has continued to increase from time to time since, with the result that the typhoid statistics show the probable infection of the supply during the year 1902 to have been nearly twice as great as existed on the average from 1895 to 1899 inclusive, and that the rank of the water supply of St. Louis has materially dropped, judged by the standard of sanitay purity. I have not found anything in the typhoid statistics for the cities on the Mississippi, Illinois and Missouri rivers outside of the sanitary district of Chicago that would account for this.

2463 Basing my opinion upon the facts brought to light in an extended examination of the conditions which seem to me likely to bear upon the question involved, it is my judgment that to the discharge of sewage by the sanitary district of Chicago into the Mississippi river, by means of the Chicago Drainage canal, the Des Plaines and the Illinois rivers, is attributable the major part of the increase in typhoid fever, revealed by the typhoid statistics of the city of St. Louis since the beginning of 1900, as compared with the period from 1895 to 1899 inclusive. The fact that the chemical analysis fails to show the presence of disease producing infection, is no evidence to an expert that such infection may not exist in the water in question.

2464 A chemical analysis is a valuable aid in that it may show the presence of substances which would be inimical to the health of persons using the water. If it fails to show anything of a deleterious character, it is not to be accepted as evidence of purity. If it does show the presence of substances which are recognized as connected with infectious material, then it is to be regarded as a valuable indication of the possibility of contamination.

2465 Chemical analysis made of the water of the River Dee in Scotland, were entirely unable to detect the presence of microbes, while in the bacterial analysis simultaneously made, the bacterial content of the water was shown to contain thousands of organisms in a cubic centimeter. Analyses of the water of the Detroit river were made by competent and experienced chemists in 1892, who were accustomed to making analyses of that water and they expressed themselves as entirely unable to detect in that water any indication of pol-

2466 lution. The water at Detroit at that time was clear.

2467 I consider that whenever chemical, microscopical or bacterial analyses of the water indicates the presence therein of substances which are known to be related to infectious matter, then it is proper to give to the evidence of those analyses, great weight in estimating the quality of that water and the expert should not recommend such water for use, speaking generally, until he is satisfied that the source of such organisms or such constituents or impurities, is such as to be unlikely to affect the sanitary quality of the water. On the other hand, it is not necessary for the expert to depend, or to require either a chemical or microscopical or bacteriological analysis of water to determine its pollution, if it is possible for him to see polluting matter flowing into it. Assuming that the numbers of bacilli coli communis in the waters of the Illinois river at Grafton are at intervals no greater than the numbers contained in it before the opening of the canal, I most certainly do not consider for that reason that said water is at all times no more dangerous for drinking purposes than before the opening of the Drainage canal.

2468 The germs of diphtheria, tetanus and anthrax have considerable length of existence in water. There have already occurred in St. Louis, cases of anthrax, one of which has been traced apparently to the water supply and the germ of anthrax is reported to have been found in the waters of the Illinois river. Should anthrax be present among cattle which are daily slaughtered in the Chicago stock yards and from them be transmitted by the discharges from the nostrils, mouths or bowels of those cattle, into the sewers of Chicago, there would be no question that the germs of anthrax might easily find a lodging in the people of Missouri with extremely fatal results.

2469 Should the sewage of Chicago become infected with anthrax there would be great danger of the occurrence of an epidemic of anthrax not only among the human inhabitants of Missouri, but also among the lower animals using the water.

Glanders is also transmitted through water and the same would apply to that disease.

2470 MR. TODD: I want to object to the question as to form and to strike it out as being based upon information and hearsay evidence.

Hog cholera is the nearest prototype of typhoid fever that is known among the lower animals. The bacilli of hog cholera are conveyed by water in the same manner as the bacilli of typhoid fever and coli communis, the three germs being very closely related. There is no doubt in my mind but what the cholera bacilli of hogs might be transmitted through the canal and the water-ways connecting the Mississippi river below the mouth of the Illinois.

2471 There is no doubt in my mind but what mud, silt and sewage matter under existing conditions may be removed from the bed of the Illinois river, the Drainage canal and the Des Plaines river into the Mississippi river and there deposited to remain for a greater or less time upon the bed and sides of such river. The volume of water added to the Des Plaines and Illinois river by the opening of the Drainage canal would unquestionably increase the quantity of such material so delivered because it has greatly increased the velocity of flow and has therefore prevented to a considerable extent the deposit of material which otherwise would have found its place upon the bottom of the stream.

2472 In the event of an epidemic of Asiatic cholera in Chicago under the conditions now existing in the waters between Chicago and the Chain of Rocks, through which the sewage of Chicago now flows, there is not only a possibility but probability and almost a certainty that the germs of the disease would be communicated or transmitted to the water supply of the city of St. Louis and the consumers thereof.

2473 If, with the knowledge of the existence of the conditions at Chicago and along the Drainage canal and the Des Plaines river and the Mississippi river, that are now known to me to exist, an expert should state that it is impossible for infec-

tious matter discharged by the sewers of Chicago to reach the Missouri shore of the Mississippi river, and the intake of the St. Louis waterworks at the Chain of Rocks, and to be a source of danger to the citizens of Missouri, residing on the Missouri shore of the Mississippi river and using the water therefrom for drinking purposes below the mouth of the Illinois river, and the citizens of St. Louis using the water supply drawn through the intake at the Chain of Rocks, I should say that he had thereby shown such lack of knowledge of the history of water-borne diseases, and the life and phenomena connected with their transmission and infection, as well as of the laws of flow of water in open channels, as to totally disqualify him as
2474 an expert upon the sanitary value or quality of a public water supply.

MR. TODD: I move to strike out the answer.

Considering the existing conditions in Chicago and the Sanitary District, the Drainage canal, the Illinois, Mississippi and Missouri rivers, I would, as an expert on water supplies, beyond reasonable doubt attribute the principal portion of the increase of typhoid in St. Louis since Jan. 17, 1900, to the infected sewage of the Sanitary District of Chicago. The most common method of sewage becoming infected with typhoid bacilli is by the discharge into sewers of the dejecta of typhoid fever patients. The most dangerous source of danger-producing infection in public water supplies of towns and cities in this country is the sewage of large communities.

2475 I have not any experience which would cause me to believe that any stream can be absolutely relied upon at all times to remove disease bearing germs such as typhoid bacilli, which may have been placed therein. (Witness testifies as to the effect on future generations of the discharge of Chicago sewage into the Illinois river and states that the menace to the health of St. Louis arising therefrom, will be much more tremendous and impending than exists at the present time, grave though the present condition be.)

2478 Based upon my past experience and knowledge, I would say the city of Chicago is today contributing considerably more than half of the entire sewage pollution which reaches the streams upon the water-sheds tributary to the Mississippi river above the Chain of Rocks. Upon examination of the population of cities of 4,000 inhabitants or more, resident upon the water-shed of the Mississippi river and its tributaries above the Chain of Rocks, exclusive of those residing in the Sanitary District of Chicago, and a comparison with the population of the said Sanitary District, contributing its sewage of the Chicago Drainage canal, I find that when the said Chicago Drainage canal was opened in January, 1900, there was added to the population previously existing in cities of 4,000 inhabitants or more, upon the water-shed of the Mississippi river, above the Chain of Rocks, a number of urban inhabitants amounting to over sixty per cent of those already there, and a number of sewage contributing inhabitants sufficient to more than double the number previously existing.

2479 I stated in my examination yesterday that the flow of water in low water stages in the Missouri would lessen as the years increase. This I attribute to the increase of population and the denudation of the forest areas.

2480 The amount of sedimentary matter carried by the Missouri itself will be reduced by reason of the reduction in flow in its upper tributaries and consequently its effect in producing precipitation of the bacteria in the mixed water will be deceased in even greater proportion than the decrease of percentage of Missouri river water at the intake.

2481 There has been an epidemic of typhoid at Ithaca, New York. The population is between eleven and twelve thousand with probably three thousand students. About half the deaths occurred among students. The water supply is taken from four sources. Cornell university takes its supply from Fall Creek. The public supply is furnished by a corporation known as the Ithaca Waterworks Company and obtained from two streams—Buttermilk creek and Six-mile creek.

2482 The epidemic broke out practically all over the town excepting upon the campus and in those portions where well water was used exclusively. An investigation revealed the fact that the epidemic was beyond question, primarily due to an infection of the water supply of either Buttermilk or Six-mile creek, or both. An examination of the specific cause of the outbreak showed that it was possible it might have come from several sources, but the most probable source of the bulk of the infection lay in the fecal discharges of a gang of workmen who were employed by one of the railroads in the construction of some culverts across one of the tributaries of Six-mile creek, some five or six miles above the intake of the waterworks.

2483 It is quite interesting in connection with this epidemic to see that there were continued re-infections of the water supply following successive freshets. I have investigated the water supply of Charlevoix, Michigan.

2485 During the warm season of 1897 the U. S. Revenue Cutter Rush, came into the harbor into Round Lake and anchored several hundred feet away from the intake of the waterworks, having on board a case of typhoid fever; the dejecta from the patient was discharged into the waters of Round Lake. Typhoid fever made its appearance in epidemic form in Charlevoix within two weeks of the appearance of the cutter.

2486 JUDGE JOHNS: I move to exclude the answer of the witness as to the disease in Ithaca and Charlevoix.

CROSS-EXAMINATION by Judge Johns:

2487 At the time of the epidemic of typhoid fever in 1892, I made no kind of investigation of it. I was not then practicing that branch of civil engineering which pertains to the erection of water supply systems. I began investigating it some time in the fall of 1895.

2489 In my investigation of the cause of that epidemic, I embraced territory for 100 miles up the Detroit river, Lake St. Clair, the St. Clair river and Lake Huron. I did not go

further because I regarded it as quite improbable that typhoid fever infection contributed by any of the communities tributary to the shores of Lake Huron above the mouth of the St.
2490 Clair river—those communities being in general small and very few and they not discharging sewage into the lake anyway—could possibly contribute a sufficient amount of contamination to mix itself with the water of such a body as Lake Huron and thereby produce any such serious infection as evidently had existed in the Detroit water supply at the time I had under consideration. When I commenced this investigation in 1895, so far as I recall, I had no knowledge of a case where the infection was attributed to a travel of more than thirty miles in a water supply.

2491 When I commenced the investigation in 1895 as to the cause of typhoid fever in Detroit in 1892, I think it may be considered that it was a new branch of water engineering and supplies, to me.

2492 The first I knew that the harbor of Port Huron had been dredged was at a meeting of the Detroit Engineering Society, held at the Hotel St. Clair in Detroit, sometime in 1896 or possibly 1897. I will correct my answer. It occurs to me that information did come to me in a letter from the city engineer of Port Huron a matter of a few weeks before the meeting of the Engineering Society. I am unable to state positively, but I think it was late in the fall, possibly in December, 1896. I ascertained the number of deaths from the mortuary records of the Detroit Board of Health. They were recorded consecutively as certificates were issued.

2493 All that I know positively as to the number of deaths in Detroit is from an inspection of the records and from the public reports of the local board of health and of the Michigan State Board of Health. I did not go to Port Huron in 1896 to investigate the dredging done there in 1891 and 1892. The records of deaths in Port Huron were obtained from the Michigan State Board of Health. They obtained them from the health officer of Port Huron. I did not know whether the report was correct or not.

2494 I do not know from the records, of the existence of typhoid fever in Port Huron prior to November, 1891, with the exception of two cases, which I recollect. The two cases I remember, my impression is they were cases and not deaths. Port Huron in 1891 had a population of nine or ten thousand.

2495 The population of St. Clair County in which Port Huron is situated in 1890 was 51,000. My impression was that there was no other town except Port Huron in that county, having a population of 4,000 or over. The towns with a population over 4,000, above Port Huron on the eastern side of the southern peninsula of Michigan, on the borders of the lake, are Bay City, West Bay City and Alpena. Alpena is pretty well up.

2496 Bay City and West Bay City together would have a population of 40,000. These towns are situated about three miles above the mouth of the Saginaw, which drains into Saginaw Bay, which is an arm of Lake Huron. St. Clair is between Port Huron and Detroit, on the shores of Lake St. Clair, with a population of 2,500 or 2,800. Marine City is also situated there, with a population not quite so large and Algonac which is nothing more than a village.

2498 There are flats or marshes in St. Clair Lake on both sides of the lake. There is considerable fishing in the delta at the upper end of the lake. The flats of Lake St. Clair are the delta of the St. Clair river and there are a number of summer resorts and club houses there.

2499 There is a considerable number of people visiting there, hunting and fishing so that there is a considerable number of constantly changing population on the lake during the summer season and the dejecta of these people goes directly into the water.

2500 You would be in Lake St. Clair in going a mile above the Detroit waterworks. In fact, I think in going half a mile. You would travel across Lake St. Clair about 24 miles to get to the St. Clair river and 30 miles by the St. Clair river to Port Huron. The St. Clair river is the outlet of Lake Huron, Lake Michigan, Lake Superior and all their bays and estuaries, on the travel of the water of these three lakes to the sea. At Port Huron the river is 1800 or perhaps 2000 feet wide in places. The St. Clair river is not subject to very great variations upon the six feet.

2501 I believe such variations as six feet have been recorded. These are not sudden and violent but very gradual. I am familiar with the data or measurements of discharge and velocity by which the cubic feet per second of the flow of the St. Clair river is ascertained. I obtained this data in conversations with men who were carrying on the work, who have been intimate acquaintances of mine for years, and an examination of the data of the discharges and the reading of their reports in their offices. The discharge varies from 180,000 to 200,000 cubic feet.

2502 If the discharge was 180,000 cubic feet per second, it would be over 15,000 million cubic feet for 24 hours. The discharge of the Mississippi river at St. Louis is between 180,000 to 200,000 cubic feet per second during the greater portion of the year. I obtained that from the reports of the Mississippi River Commission and of the United States Corps of Engineers.

2503 I found reports which indicated very much less amount at times and a very much greater amount at times. On August 5, 1881, the gauging of the Mississippi river at St. Louis shows 179,000 cubic feet per second.

2504 I do not find any for 1900. If there were any published I investigated them. I am not sure there were any as late as that. The same answer would apply to 1901. I am quite sure that I did not investigate any for 1902. I wish to correct my testimony and say that Port Huron had a population of about 18,000.

2505 I do not think I have sufficient familiarity with the city of Port Huron in 1890, 1891 or 1892, to make a guess as to the number of people whose sewage was discharged into the sewers of Port Huron. As to the volume or amount of such discharge, I have no kind of an idea, excepting that there were such discharges. It would be fair to estimate that 5,000 people discharged their household sewage into the sewers of Port Huron in 1890 and 1891, that would be between six and seven thousand cubic feet a year of solid matter.

2506 That would be about 230 to 250 cubic yards, or less than one-half the amount that was usually dredged in a day during the dredging of the Black river in 1892—substantially in round numbers, 40 cubic yards in two months. In the month of April, 1892, there was about 5,300 cubic yards dredged out of the Black river. That would be substantially 10,600 yards in April and May. This memorandum from which I read these figures was made by me from figures of some United States officer.

2507 I made this memorandum may be as early as 1897. I should assume 15,000 cubic yards would be a correct statement of the case and that 40 cubic yards might possibly be a fair estimate of the amount of solids in the household sewage coming from the bodies of persons using the sewers of Port Huron. I estimate the fecal and urine discharges of the people of Chicago who use the sewers of Chicago, which flow
2508 into the Drainage canal for one year, to be about 60,000
cubic yards, that would be 10,000 cubic yards for two months.

Q. Well, then, such solid discharges into the sewers of Chicago from the bodies of the inhabitants, which sewers enter into the canal are not five times as much as the entire amount dredged at Port Huron?

A. No, sir; they are not.

2509 The cubic feet of flow in the St. Clair and Mississippi rivers, assuming 180,000 cubic feet per second, would be 15,552 millions per day; for sixty days, being April and May, 1892, would be 933,120,000,000. In order to regularly, systematically and scientifically pollute a body of water flowing past Port Huron in the St. Clair river for one day of 24 hours, there would have to be 15,552 cubic feet of polluted matter to make one part in a million of pollution.

2510 If 15,000 cubic yards were regularly and systematically in a constant and regular flow put into the waters of the St. Clair river at Port Huron, such discharge would not pollute the water of the St. Clair river for more than 27 days, that is, at the rate of one part per million.

Q. What per cent of pollution of 933,120,000,000 cubic feet of water is 40 cubic yards of solid material, stated in parts per million?

A. About 108-10,000.

Q. 108-10,000 of one per cent?

A. 108-10,000 of one part per million.

Q. Do you want to be understood as saying on the basis of these figures, that if there was the dejecta of two typhoid patients put in some time about the first of April, 1892, in 40 cubic yards of solid sewage, from the bodies of people, in 933,122,000,000 cubic feet of water which would travel 57 miles, that that dejecta would pollute the entire body of water during any considerable portion of that time, or any portion of it?

2511 A. Considering the fact that the number of bacteria found in the excrement of typhoid patients has been on the average about 200,000 million per day, and that if these patients were sick with typhoid fever and recovered, they would each have been discharging that excrement so charged with infection, for a period of sixty days, and considering that there were assumed to be two patients, we find that there would have been probably discharged into the sewers of Port Huron, and from there possibly into Black river, and the material dredged therefrom, 24 million million bacteria, which would have been sufficient to have put about 27 bacteria into every cubic foot of water discharged under the conditions assumed, and it therefore seems to me possible that the infection might have been so distributed. During March, April and May in 1892, figuring on seven and a half gallons to a cubic foot, there were on an average 4,500,000 cubic feet of water pumped into the Detroit waterworks daily; assuming that the water in the St. Clair river passing Port Huron in a day was 15,552 millions, the per cent of it pumped into the Detroit waterworks would be three-hundredths of one per cent I think. 27 typhoid bacilli to a cubic foot of water would be about 4 individual, separated bacteria roughly speaking, to a gallon.

2512 I see no reason why some of these four bacteria in a gallon of water traveling 57 miles might not live and be virulent. In a laboratory experiment in 1888 it was shown that in ordinary potable waters the germs had been found alive after two weeks and it would not take them two weeks to go from Port Huron to Detroit under the circumstances assumed.

2513 I do not know whether these two people died of typhoid fever in Port Huron. I do not know whether these two cases recovered, nor whether the discharges from their bodies were cast into the sewers of Port Huron nor whether such discharges were destroyed or disinfected.

2514 Q. Without stating what you may have in your mind, do you wish to be understood as a sanitary expert, epidemiologist and sanitary engineer, that under the facts and figures elicited by your cross-examination, you are still of the opinion that typhoid fever resulted from the dredging of the harbor of Port Huron, and the mouth of the Black river in 1892?

A. I wish to be understood as saying that it is my belief that the typhoid fever in 1892 was very largely caused by the dredging of Black river in Port Huron during the same year.

2515 Assuming that 5,000 cubic feet of human discharges are put in the Drainage canal in Chicago in one month, there diluted with 300,000 cubic feet of water per minute, as it continuously flows into the Sanitary canal and then travels 357 miles down the Illinois and Mississippi rivers to the intake, and by the time it arrived at the intake was thoroughly mixed with the Mississippi river water, arriving continuously during the month and being diluted so that during the month it was contained in 933,120,000,000 cubic feet of water during the same month, understanding the word "pollute" to mean the addition to water of filth or infectious matter, or both, whether in large or small degree—I think that that sewage would pollute the intake waters at St. Louis.

2516 Considering the same facts and assuming that in this sewage there was dejecta from 75 persons who died of typhoid fever during that month, I wish to be understood that to whatever extent they might arrive at the intake, those bacilli in that dejecta would have a poisonous or deleterious effect on the waters of the intake, and I want to be understood as saying that they might arrive. I base that conclusion upon my knowledge of the life of the typhoid germ in water as determined experimentally; upon my knowledge of its transmission in the epidemic of Detroit, and epidemics other than Detroit; upon my knowledge of the conditions affecting the water supply of St. Louis previous to the opening of the Chicago Drainage canal; upon my knowledge of the conditions existing in and about St. Louis since the opening of the said Drainage canal, and the conditions existing in and about Chicago since the opening of the said Drainage canal, whence it appears clearly to my mind that there has as yet been found no other explanation sufficient to account for the increase now amounting to about 100 per cent in

2517 the number of annual typhoid deaths in the city of St. Louis, as compared with the annual number recorded during the five years previous to the opening of the Drainage canal, other than that the said infection has been received from Chicago throughout the Drainage canal, the Illinois river and the Mississippi river, and that therefore if much may come, it must necessarily follow that little may also come. I got my information about Crookston, Minnesota in the Engineering News and I believe it is also referred to in one of the health reports of Dakota.

2518 The report of this epidemic came to my attention along somewhere about 1897 or 1898. It was published in the Engineering News in 1893 or 1894. The author of the publication in the Engineering News was the city engineer of Grand Forks.

2519 There had been typhoid fever in Crookston. The supposition is that is where the typhoid epidemic of which we are talking, originated. I do not know how many cases occurred in one month, nor how many deaths there were from those sixty cases. I don't recollect whether I have seen a statement of the population of Crookston at the time the sewer became broken or clogged. I don't know what proportion of the people of Crookston have their household sewage emptied in the sewers nor whether any one of the supposed sixty cases had their dejecta thrown into the river. It was stated in the report that the city had sewers. Red Lake river at low water stage, its discharge has been shown to be 988 cubic feet per second. Grand Forks is 60 miles from Crookston. I do not know whether there were any cases of typhoid in Crookston prior to 1893 or 1892. I do not know whether there were any cases of typhoid fever there in January, February, March, April, May, June, July or August. I have no idea where the contagion came from that caused the
supposed cases at Crookston or whether that was a water-
2521 borne infection or not. I should not wish to make the
assumption that the infection which caused the disease
in Crookston was water-borne, without further knowledge of the
conditions existing there.

2526 I know that typhoid fever had been practically unknown in Charlevoix up to the time the United States Revenue Cutter came into the harbor. As to whether there had been or not, as a matter of fact I am not able to state positively. That boat remained in the harbor two or three days.

2527 The boat was in Round Lake and there was only a single case of typhoid on the boat. I have never heard whether or not the excretions of this typhoid patient were destroyed on board the boat or disinfected.

2528 Not knowing the usage on board U. S. boats in regard to the dejecta of people having contagious or infectious diseases, I presumed for the purpose of the investigation, that the United States officer allowed that stuff to be cast into the water.

2531 If 15,552,000,000 cubic feet each 24 hours passes into Lake St. Clair, as much water must go out through the Detroit river in order to maintain the stage of the water. It goes through with a velocity that I don't know that you would be warranted in saying that it was what would be dignified as a current.

2533 It would take a few hours for a body of water to flow from the head of the river at Detroit to the Detroit waterworks intake.

2534 I have not been up the Illinois river at a time of ordinary stage of water, nor at any stage of the water. I believe there are five dams in the river, but I never saw those dams in any stage of the river.

2535 Basins are created by those dams to a considerable extent. If a given dam on the Illinois river had a perpendicular heighth of eight feet above the pool below, in extreme low water it would back the water up the river a considerable distance. I am not certain that I have any information as to the fall of the Illinois river from Ottawa to Lacon. From Morris to Peoria the fall is 50 or 60 feet. From Peoria to Copperas creek dam, between 2 and 4 feet. The distance is about 30 miles. That is a very low grade. At certain stages that entire reach of river would be almost a sedimentation tank.

2536 I should say that at a stage of the river when the distance from the crest of Copperas creek dam to the surface of the pool below is six feet, the effect of Copperas creek dam would be to retard the flow of water above Peoria.

2537 When a dam ceases to be a submerged weir and is actually an effectual instrument in retarding the flow of the water above it, it does not necessarily aid in sedimentation and very frequently does not. The disturbance set up by the obstruction by the dam when the water runs over the dam, in causing change of direction in the flow of the current, stirs up particles on the bottom and tends to carry them over the dam.

2538 If the dam was 7 feet high, I would be willing to say it might extend back 50 feet. The passage of a stern-wheel steamer up the Illinois and the consequent agitation of the water would not contribute to the purification of that stream. Bacterial examinations for instance of the Niagara river above and below the falls have shown no change in the bacterial contents of the water at all and I doubt if any stirring up by boats would accomplish anywhere near the result that the flow over the falls and the stirring up afterwards would produce. I am unable to say if the waters of the Illinois river were continuously agitated for thirteen days that it would add to the purification of the water. My opinion of the value of aeration is that it has been greatly over-estimated. I have no definite idea as to the length that the typhoid bacillus might live in the sedimentation of the Illinois river.

2539 I am quite sure it would live more than 15 days. I am unable to cite a case of specific experiment and at the present moment do not recall one as to the length of time that any given lot of bacilli lived in sedimentation. (Witness states on what he bases his conclusion that the flow of water from Bear Trap dam to Grafton occurs in 15 days, for 300 days of the year.)

2543 At an average stage it would take the water a little less than twice as long; sometimes less than twice as long, to travel over the distance as it would in the case of flood, so that if floats were run over the Bear Trap dam to Grafton in the Illinois river at a stage of high water in 10½ days, I should say it would take possibly, 16, 17 or 18 days in traveling the same distance. I think an addition of 6 or 7 days in the flow of a stream like the Illinois would be a considerable time factor in its purification.

2544 There are cases on record where a bacteriological examination has determined whether the water was infected or

not. There are some reported on page 93, paragraph 18 of the report of the sanitary investigation of the Illinois river and its tributaries, prior to and after the opening of the Drainage canal, by Professors Zeit and Futterer. The statement is on record in a report of the Massachusetts State Board of Health that typhoid bacilli were found in the tap water as supplied from the running water at Lawrence, Mass. A bacteriological examination as a rule does not absolutely determine whether the water is infected, in fact, generally not. The ordinary assumption among sanitary engineers and experts is that if there are populous communities having their sewage and drainage thrown into running streams, that the streams are infected. I anticipate a very marked increase in population in the Missouri river
2545 valley and its tributaries as well as the valley of the Mississippi and Illinois rivers, and I might add that there is a probability of greater growth on the Mississippi and Missouri than there is in the valley of the Illinois, exclusive of Chicago, so that I think the amount of sewage pollution in each of these rivers—the Mississippi and the Missouri—is likely to increase much in the future.

Q. In their natural state, considering the future, the untreated waters of the Missouri river will be necessarily a menace to the inhabitants of St. Louis as the waters came into the intake, would they not?

A. I shouldn't think that the waters of the Missouri river in their natural state, either in the present, past or
2546 future, would be a menace, but if you mean with the growth of population upon the Missouri watershed, it would contribute additional infection to the Missouri river and cause it to become less healthful and less safe as a water supply, I am perfectly frank to answer, yes. That answer would also apply to the waters of the Mississippi. I can hardly conceive that in the distant future in a stage of very low water, that the Missouri river would become substantially a stream of liquid

sewage. I could conceive that as to the Mississippi a little more readily. This would not depend entirely upon the supposed and anticipated increase of sewage, but upon other considerations—the decrease of the flow of the streams themselves, for one. From the decrease of the flow and the increase in the population, the waters of both of these rivers would be dangerous for ordinary domestic purposes to the inhabitants of the state of Missouri on her banks.

Q. Are there other persons, sanitary engineers, expert in water supplies in this country, who are as familiar with the subject as yourself?

A. I think there are not very many.

Q. About how many?

MR. JEFFRIES: I object to the question as being incompetent, irrelevant and immaterial.

A. At the present moment, I do not think of any whose judgment I would take in preference to my own, or whose judgment I would advise a client to take in preference to my own.

2547 Assuming a certain number of cases of typhoid fever at St. Charles, Missouri and an equal number of cases at Kansas City, Missouri, and consequent typhoid fever in St. Louis, I would attribute the typhoid fever in St. Louis to both St. Charles and Kansas City. Of course I assume that the typhoid occurred in St. Louis at a proper time after the appearance of the other to permit of the connection. Assuming typhoid fever in St. Charles and Omaha and in St. Louis. I would attribute the St. Louis typhoid to both cities. Assuming typhoid at St. Charles and an equal number of cases at Helena, Mont., I would attribute the typhoid in St. Louis to both places.

2548 Assuming 50 cases of typhoid fever at Helena, Mont., and no other possible source in the Missouri river of infection of its waters from typhoid at that time, and that the waters from Helena, Mont., arrived at the intake and that in a proper time after that, there occurred in St. Louis an increase in typhoid fever, on the hypothesis stated, I should not want to attribute a very large part or more than a very small part of the increase of typhoid fever in St. Louis to the typhoid fever cases at Helena. The life of the typhoid bacilli in streams, is rather a question of time and distance, and as a general proposition I would say that it is my present opinion that there is no stream of water on the surface of the earth flowing in natural channels, that is long enough to warrant the absolute assurance that a typhoid germ might not live from one end of it to the other.

2549 If there were typhoid germs cast into the waters of the Mississippi at St. Paul, I think it is possible to a certain degree that these typhoid germs might arrive at New Orleans and infect the water supply of New Orleans. That is, I think it is possible that some of them might arrive. I would not want to be understood as saying that they would all arrive. One instance in which scientists in water supply have determined to their own satisfaction that the typhoid bacillus has lived in running streams for a distance of over 150 miles is the instance of the pollution of the St. Louis supply by the drainage of the city of Chicago. The pollution of some of the cities on the Merrimac river I believe are traced to distances as great as that. The pollution of the Connecticut river similarly and of the Hudson river.

2550 I am not prepared to make a specific statement that the infection of water in the Hudson river at a given point was caused by similar infection of the Hudson river 150 miles above, but a statement was made to me not very long ago that such was the case, by a gentleman who had made some investigation along those lines. I know of no other instance where the pollution of one water supply or infection was caused by the infection of a water 300 miles above, outside of the case of Chicago and St. Louis that we are considering.

2551 I do not recall of having heard or knowing of an instance in which the infection of a water supply was attributed to an infection 250 miles above the place where the infection was found to exist. Cincinnati and Pittsburg is an instance where the distance would be about 200 miles or considerably farther apart than that,—somewhere around 300 miles I believe. I think I have seen a statement on what would be considered the authority of some kind of a scientific man that waters of Pittsburg infected the waters at the intake at Cincinnati. My impression is that it was the Board of Sanitary Engineers who were considering the water supply of Cincinnati. I think so, but as I am speaking from memory on that, I won't be positive about it.

CROSS EXAMINATION by Mr. Todd.

2553 In my direct examination I figured the period of time in regard to the Detroit epidemic from the deposit of infectious material in Lake St. Clair to the four deaths occurring in Detroit and stated that the time corresponded within 24 hours for the transmission, incubation and death. A man may contract typhoid fever and not die before two months or perhaps six months.

2554 There are no cases on record that I know of or that have come to my attention where they have died before the end of three or four days after contracting it. I figured the time that these four patients were sick or had been down with typhoid fever before they died, by my study of statistics, regardless of knowing whether those patients had been sick for two or three months prior to death or not.

2555 In my study as a sanitary engineer and epidemiologist I don't think I have enunciated and demonstrated any new principles. I should hardly want to claim that I had been the pioneer in any new departure of investigation in these sciences. I rather think this science of epidemiology and sanitary engineering as to water supply, has not been exhausted. I think there are persons in this country or elsewhere that have made more extensive investigations than myself. If such a person should draw different conclusions than those which I have drawn, unless they were possessed of other facts which are not known to me, I would certainly consider that they had made a mistake. I consider that in my investigations of the conditions existing between Chicago and St. Louis on the watershed of the Mississippi above the intake that I am in possession of all the facts possible and necessary in this investigation and sufficient to establish the certainty of my conclusions.

2556 If one who has made greater investigation and had broader experience in these sciences than I have and should be acquainted with all the facts with which I have been acquainted, should draw different conclusions, unless he had different information to that which I had, I would consider these conclusions were unwarranted and unworthy of acceptation. I cannot conceive of any different information that could be obtained that would change my conclusions. I do not consider my conclusions in this case as infallible.

2557 If during the years 1896, 1897, 1898 and 1899 there existed upon the watersheds of the Mississippi, Illinois and Missouri rivers typhoid fever that resulted in the death of from 300 to 375 people annually, the presence of such cases would undoubtedly render the water supply of St. Louis unsafe and dangerous for domestic use. For even though the water was treated by what we know to be, and what analysis has shown was an inefficient method of treatment, the typhoid fever death rate and number of cases of death in St. Louis apparently traced to water infection is greater than should exist attributable to a good water supply. Had I been sanitary engineer of the water supply of St. Louis during those years, I should certainly not have recommended this water as a safe water. I should not have advised the people to drink it without further treatment by boiling, filtration or some treatment that would be sure of certainly reducing the possibility of infection from it. Boiling would add very much to the safety of the water. If the water were boiled now, I would consider it would be a safe water.

2558 Q. Is there any way known to sanitary science or epidemiology which can tell or demonstrate that the increased typhoid in St. Louis in 1900, 1901 and 1902, did not come from any one of the cities whose sewage emptied into the Mississippi river above the intake on the Mississippi?

A. There is no method that I am aware of that would enable one to demonstrate that no part of the infection came from any one of the cities in question.

2559 If there were a certain number of deaths from typhoid in Minneapolis and Kansas City each year during the years 1896-7-8-9, there is no means by which it would be possible to determine how much typhoid came to St. Louis from either one or that it did not come from both.

2560 It is not possible to establish the fact that it came from either one of the sources, that is, assuming that there was no existent history that would exclude either one or the other of these places as being the cause of typhoid in St. Louis. If conditions existing between Minneapolis and St. Louis and Kansas City and St. Louis were such as to be the cause of typhoid in St. Louis, there is no way known to my knowledge which can demonstrate whether the cause of the typhoid fever in St. Louis came from Kansas City and not Minneapolis, or from Minneapolis and not from Kansas City.

2561 I should not think it possible that notwithstanding the fact that conditions of that kind might exist as to those two places, that the contagion could come exclusively from Kansas City or Minneapolis. I think it would be impossible to make absolute proof either in the affifmative or negative. Now if we add to those conditions, all the conditions which actually exist along the watershed of the Mississippi river above the intake, I do not think it is possible then to say which one of these cities contributed the largest amount of typhoid existing in St. Louis for the years 1900-1-2. It seems to me that the proportionate share in the increase in typhoid fever in St. Louis from any of the upper cities can be demonstrated without an assumption. I could not say what proportion Minneapolis contributed.

I doubt that I can say what proportion any of the cities contributed outside of Chicago.

2562 Q. Can you show what Chicago contributed without assuming anything?

A. Not the absolute quantity.

Q. Any more than you could for Minneapolis?

A. I think so.

Q. Any more than you could for Kansas City?

A. Any more than for Kansas City, I think so.

Q. Any more than you can for any one of the number of cities, the typhoid statistics of which have been introduced in evidence here?

A. I think so.

Q. Is there a different rule applied by epidemiologists and sanitarians to the city of Chicago than would be applied to all or any of the other cities lying tributary to the water supply of St. Louis?

A. There is not, but different facts are in our possession in regard to the city of Chicago from those which exist in regard to the other cities on the watershed. We haven't got the facts as elaborately in regard to all the other cities as we have in regard to Chicago, but we have them sufficiently for all practical purposes, I think.

2563 The facts that I have about Chicago that I haven't about Peoria are that at a certain time, its sewage was added to the waters which supply St. Louis with its water supply. At that time the sewage at Peoria was being added to the water supply of St. Louis. I am not prepared at the present moment to give figures as to what was the difference as to the volume of sewage from Chicago entering the Des Plaines river previous to the opening of the Drainage canal and that which empties into the Des Plaines river now since its opening. The 4400 cubic feet that I have testified about of fecal discharges represented the solids in the fecal matter discharged into the sewers of Chicago which are tributary to the Chicago river and the

Drainage canal. Some of it undoubtedly enters the Drainage canal, but I do not know what proportion of it does.

2564 I could not say at the present moment positively whether the same territory that empties into the Chicago river the 1400 cubic feet of fecal mater is any different today from what that same territory was prior to the opening of the Drainage canal. I don't know how much or what proportion of that 1400 cubic feet was pumped into the Illinois & Michigan canal prior to Jan. 17, 1900. I am sure all of it was not pumped into the Illinois and Michigan canal prior to the opening of the Drainage canal. I don't know how much of it was. I don't know that I have any judgment at the present time based upon any accurate knowledge as to how much it was.

2565 I don't see how that influences the case any more than knowing the actual amount of infection that may have come from any other source that was continuous before the opening of the canal. I do not know the amount of infection that came from any other one source before the opening of the canal. I couldn't say how much sediment there was on the bottom of the Chicago river at present. I did not consider the sediment on the bottom of the Chicago river as a continually important factor at the opening of the canal. Today it has its importance, but it is not paramount.

2566 I examined the lake front in Chicago in 1892. I know that it is quite materially different in some respects at the present time. The conditions have been considerably improved.

2567 If it should appear that the Chicago river from the entrance to Robey street was of a depth of 26 feet in the channel, with the exception of the tunnels, and the condition has been created within the last three years, I do not think it would have any effect upon my conclusions in regard to the effect of sedimentation in the Chicago river. I don't know what effect the sewage pumped into the Illinois and Michigan canal prior to the opening of the Drainage canal had upon the water supply of St. Louis, nor how much typhoid in St. Louis could be attributed to it. I think it is safe to state now that the major part of the increase in typhoid fever in St. Louis is due to the sewage discharged through the Drainage canal. By major part, I mean considerably more than half.

2568 I should say that in St. Louis the cases probably increase to about the same extent or the same proportion as the deaths. The increase in deaths would be the most scientific way to consider the question of typhoid. If I have both the deaths and the cases, I say that the deaths are the better criterion because a man never dies but once and under the law, a record of his death is bound to be made somewhere, whereas a man may be sick of typhoid and no record appear, so that records of cases are always deficient. A man frequently has been acused of dying of typhoid, when as a matter of fact he did not have it, but there have been other cases where he died of other causes and they thought he had typhoid.

2569 To a moderate extent, it leaves the whole situation in doubt, but considering these things from a broad practical standpoint they will balance up in a period of years.

Q. If a man has typhoid fever and does not know it, why should the epidemiologist assume the fact that he has it when there is no evidence?

A. The epidemiologist does not assume the fact that he has it.

2570 Q. Assume that 160 deaths occurred in 1900 as against 198 in 1901, would that be evidence that typhoid had increased in St. Louis when the facts are that the number of cases decreased?

A. I should never base concluusions in a typhoid epidemic on the number of cases which are reported, for reasons already stated, and there is no question that an increase from 160 deaths to 198 deaths shows an increase of typhoid in the city. There is no question that the mortality in typhoid is affected by the skill of the physician, the care of the nursing and attendants, and so on; the asumption is that we are able to handle it better than before and I should say that the probability was that less people would have died of typhoid fever out of the same number of cases, in 1901 than would have died of it in 1900.

Q. Now if we assume that the number of cases, as is illustrated upon the chart that is already in evidence, is true, and that those cases started in 1896 with 291; 1897, 433; 1898, 426; 1899, 908; 1900, 1213; 1901, 1101; 1902, 1112, would you say, as an expert sanitarian, that the typhoid conditions existing in St. Louis for 1900 and 1901 and 1902 were attributed to the Drainage canal of Chicago and not to the same causes which created the uniform increase in typhoid fever from 1896 up to 1899?

2571 Assuming that the figures given are correct, I consider that the records of cases in the city of St. Louis in regard to typhoid prove nothing except that all of the cases were not reported in the earlier years and are not reported now. Assuming that the number of cases which you have stated in your question from 1896 to 1902 were deaths, I would attribute the gradual increase of typhoid fever in St. Louis during that period to gradually increased infection from somewhere. Where from I do not know. I would have to investigate the matter to see. Inasmuch as the condition assumed is contrary to the fact, I have not taken the trouble to investigate it. Supposing that in this number of cases none of them died, that by the best scientific knowledge of today, these cases were ascertained to be typhoid fever, and included all the typhoid in St. Louis, I could not say to what I would attribute the gradual increase of the number of cases from 1896 to 1902 without making a study of the conditions with such facts in view.

2573 In my consideration of this question, I took into consideration the sewage from Peoria. I don't know what the amount of sewage is that enters the Illinois river from Peoria. I do not know how many cattle are fed at Peoria. I could only make a guess. I know that Peoria is a place where cattle are very extensively fed. I have not particularly investigated the character of the sewage that comes into the river at Peoria. There is some difference in the sewage from distilleries and slaughter houses and the sewage from glucose factories. There would likely be acids discharged into the river from a large glucose factory. I do not know in what quantities. It would be likely that acids would be discharged into a river from distilleries.

2574 The effect of the discharge of acids in a stream the size of the Illinois from large distilleries and glucose factories at Peoria upon the life of the typhoid bacillus would depend very much upon the alkalinity of the water in the first place. Under some conditions it might tend to prolong it; under other conditions it might tend to decrease the life of the bacillus. I have not personally made any experiments under those assumed conditions. I am not aware of any one, at the present moment, who has made experiments with the typhoid bacillus in water impregnated with the sewage discharged from a distillery or glucose factory. I am not able to say positively whether that discharge would tend to increase or decrease the life of the typhoid bacillus. It might do either.

Q. Then if you are not able to say whether it would or it would not, can you say whether or not a typhoid bacillus on his journey from Chicago to St. Louis coming in contact with the sewage laden water at Peoria from the distilleries and glucose factories, would be able to live the journey?

A. I cannot say whether a specific typhoid bacillus would or would not be able to live under the circumstances assumed.

Q. Can you say whether a whole tourist excursion of those bacilli would live or not?

2575 A. I think it is entirely probable that some of them might squeeze through. I base my doctrine of probability, in the absence of any specific knowledge as to whether the individual bacillus would live in a medium of that character, upon the fact, which is very evident to my mind, that certain typhoid bacilli started from Chicago have lived, passed through the Illinois river and infected the water supply of

St. Louis and produced typhoid fever in those who have used it. I think we have pretty nearly proved in this case that the typhoid bacillus that left Chicago arrived in St. Louis. I don't know that I want to say that by my own individual self I have proved it, but I think it has been proven. I don't think that anybody knows very much more about this subject than I do. The typhoid bacillus that leaves Chicago, in order to get into the intake tower of St. Louis, must pass by Peoria. I do not know how many distilleries empty their filth and sewage into the Illinois river at Peoria. I do not see that it is of any importance whether there is one, one hundred or one thousand in that case.

2576 Moderately, I have some knowledge of the character of the sewage that comes from a distillery. I should not expect a typhoid bacillus to live in that kind of sewage a great while. I have a moderate idea of the character of sewage that comes from a glucose factory. I could not say whether a typhoid bacillus will live in that medium any length of time.

Q. Have you ever been able to identify any bacillus of typhoid found in the Mississippi river above the intake as being indigenous to Chicago and not coming from the other towns located upon the watershed of the Mississippi river, above its intake, the Missouri and Illinois?

A. Certainly not, and it would be absolutely impossible to do so any more than it would be possible to determine from what source a potato came that you might find floating in the river.

Q. Would the fact that you found a potato floating in the river prove that it came from Chicago?

A. Certainly not.

2577 Have never known of anybody catching lockjaw from drinking the germs of tetanus. I believe it is not contended that people get it by taking it in through the alimentary canal.

2578 As to whether it would have any effect on the health of the man who drank it, would depend upon the condition of his intestines. It would affect him if he had a raw place in his throat due to a cold or something of that sort. Assuming that there should be typhoid fever in New Orleans and two months before, one case of typhoid fever appeared on a steamer in Lake Itasca—the source of the Mississippi—and there were no other cases of typhoid fever between that point and New Orleans, and no other source of infection, I am afraid I would have to attribute the cases in New Orleans to the case in Lake Itasca. These things do not originate of themselves.

2579 I don't think I ever heard of a case of anthrax in Chicago.

I am free to say that I have not heard of a case coming from Chicago. I regard the sewage of Chicago as a greater menace to the inhabitants of Missouri than the sewage discharged by St. Louis into the Mississippi river would be to those living south of St. Louis. Assuming that Chicago sewage should be cut off, the water of the Mississippi river on the Missouri side, after it had received the sewage discharge of St. Louis would be unfit water to drink. I do not know that there is any more liability of anthrax or hog cholera occurring in Chicago than in St. Louis. It is entirely possible that if they did get hog cholera along the southern border of Missouri, south of St. Louis along the Mississippi, that it would come from St. Louis more likely than Chicago. I should look in St. Louis for the source of infection before I looked in Chicago. I believe that Chicago is more likely to get Asiatic cholera than St. Louis in event of its coming to this country at all.

2581 In regard to the case of anthrax I spoke of, appearing in St. Louis, I think it was due to the water of the Mississippi. It was attributed to the water by the man who had the case,—a physician here in town by the name of A. Ravold. Dr. Ravold attributed it to the water as being the most probable source. The case referred to was that of a woman who was scrubbing a sink and got a piece of slate in her hand. It was proved to be a case of anthrax. Inquiries were made to ascertain the source, and it was impossible to ascertain that there had been anything in the neighborhood of the sink that might have communicated the germ; at least it was not ascertained that there had been, other than the water, and knowing that bacillus had already been found in 2582 the waters of the Illinois river, it is at least a moderately justifiable assumption to say that it may have come from the water, and in fact, very probably did. I would not say for a minute, from the history of the case as I got it, that the water is the only explanation. I could not say whether it was attributed to the water of the Illinois river. When I look into the future I should not be surprised to see an anthrax epidemic in Missouri, understanding that there has been an epidemic of it in Missouri in the last few years. I could not say whether that was before or since the opening of the canal.

2583 I have personally investigated four or five epidemics. There is no school in this country that I am aware of which graduates a student with the degree of epidemiology.

RE-DIRECT EXAMINATION by General Crow.

I stated in answer to Judge Johns' question that I only found recorded in the official records two cases of typhoid fever in the year 1891 in Port Huron. They made no regular reports in Port Huron prior to 1893 I think. The two cases in 1891 seem to have been accidentally reported by somebody to the State Board of Health.

2584 There is no doubt that there were other cases in 1891 and prior to 1891 for several years, of typhoid fever in Port Huron. (Witness refers to report of State Board of Health, wherein reference is made to cases attributed to infection from Port Huron, in various years.)

2585 I estimate the least time, under conditions as they ordinarily exist, that water would flow from the point where the material dredged from the Black river in front of Port Huron, was dumped into St. Clair river, down to the intake of the waterworks of Detroit in 1892, would be somewhere in the neighborhood of 8 days. I think it is entirely possible that the water passing through the Illinois and Michigan canal in 1899 may have contributed somewhat to the typhoid in St. Louis. It very evidently did not contribute very largely because the typhoid in St. Louis was not excessive during those years. Moreover that amount of water passing into the Illinois and Michigan canal at Bridgeport was not sufficient to take care of anywhere nearly the sewage of Chicago.

2586 My impression is that some of the sewage of the Sanitary District still goes into the Illinois and Michigan canal. The elevation of the crest of the Copperas Creek Dam is given as 149 below the dam, and the Marseilles dam is given as 101, speaking of the river level of course.

2587 I should certainly consider, in determining whether or not Chicago sewage infected with typhoid germs would be likely to infect the water coming into the intake tower of the St. Louis waterworks, the time factor, that is, the time in which it would take water bearing infected sewage to flow. I should consider the time factor as one of the most important ones, in fact, next to the fact that infection was put in, I think I should consider the time it took to get somewhere else. When I stated to Mr. Todd that there are no facts that could be educed or come to my knowledge as to the prevalence of typhoid fever in the cities from which the complainant has introduced reports from the watershed tributary to the intake of the St. Louis waterworks, which would affect my judgment materially, I meant to convey by my answer that it did not seem to me possible that any facts could be educed which had not already been considered that would have a sufficient importance bearing upon the question, to change my opinion on a general proposition. I did not mean of course that my opinions were not subject to modification as additional facts might be brought out.

2588 I found from the statistics that the increase in typhoid fever in St. Louis has been regular and continuous since the 17th of January, 1900 and that up to the very last date of which we have a record, it shows it is continuously increasing. Any one in studying the conditions of nature is compelled to look for a cause for every effect, and if it were found that certain diseases were increasing the natural inference and proper assumption would be that there was a continuing and increasing cause for the existence of that disease, and if it should prove upon investigation that at a certain time this increase began, we should look at that time for the beginning of the cause which was leading to the increase.

RE-CROSS EXAMINATION by Mr. Todd.

In my investigations in regard to increase, I take into account the number of deaths. If the number of deaths should show an increase and the number of cases a decrease, or normal condition for 1901 and 1902, I would say, as I have stated alread, that I consider the death record decidedly more reliable than the record of cases. It is not a question of diagnosis; it is a question of report and a question of ascertaining the cases. If it should appear that the cases reported were the correct number of cases existing and the cases reported were correct diagnostications of the cases, I should consider that in all human probability the death standard would be the safer one to rely upon. If it were absolutely proved that the other were the case, that is that the number of cases represented all the cases, and that the probability of a correct diagnosis was the same as in the case of death, I should then give the record of cases an equal weight with the record of deaths.

2589 (Complainant offers a certified copy of typhoid fever death rates for the various years previously stated, at Kansas City, Missouri; St. Charles, Missouri; Council Bluffs, Iowa; St. Joseph, Missouri; Lincoln, Nebraska; Omaha, Nebraska; Chicago, Illinois; Davenport, Iowa; Moline, Illinois; Rock Island, Illinois; Galena, Illinois, and Warsaw, Illinois.)

(Complainant's exhibit 22 is withdrawn for correction, defendant's counsl consnting thereto.)

2602 GEORGE W. FULLER examined in chief by Attorney General Crow.

2603 Am sanitary expert. Professionally educated at Massachusetts Institute of Technology in Boston and University of Berlin, Germany. Have received an education as Bacteriologist, although that is not the particular branch of sanitary work which I gave the most attention to while at the Institute of Technology. That was the principal topic which I studied in Berlin. It was from the department of chemistry that I graduated at the Institute of Technology in Boston. In regard to the necessity and advisability of treating water supplies by artificial processes, I would say that I have given that matter special attention and with regard also to plans and specifications. (Witness states his further education, knowledge and experience.)

2606 Am familiar with the general features regarding the source and method of treatment of the water supply at St. Louis.

2608 As a general proposition, it is my judgment that the best index to the sanitary character of a public water supply is the mortality record from water-borne diseases in the community using the water supply in question, and especially the mortality statistics of typhoid fever. It is my experience that the typhoid fever mortality statistics are preferable to those of other water-borne diseases for a number of reasons, of which the principal ones, are the wide-spread nature and distribution of typhoid fever, its abundance in those communities having supplied to them sewage polluted waters; the well defined character of the disease, taking everything into consideration, and also the substantially large percentage of deaths to those who have the cases, that is, the percentage of deaths to cases is larger than in some other instances. From twenty-five to thirty thousand deaths result annually in the United States from typhoid fever. The number of cases occurring in this country annually I would place at more than a quarter of a million. It is my judgment that the water supplied to the citizens of St. Louis by the municipal water department during the years 1895

1899 inclusive, was what might be called a good sanitary water.

2609 I base that judgment on the fact that during the period mentioned the typhoid fever mortality statistics showed as low a rate, approximately speaking, as in the case of quite a number of other American cities having a pure or very nearly a pure water supply. The treatment of the water during that period consisted of settling the water in the basins at the Chain of Rocks. The result of this settling was to improve the water to a considerable degree as regards the elimination both of mud and bacteria, including those of a pathogenic nature, when such were present in the raw river water. There was substantially no change in the period for sedimentation during the years in question. Pathogenic bacteria, as used by me, include water-borne bacteria that might convey infectious diseases such as cholera and typhoid. In my judgment the raw Mississippi river water as it entered the intake during this period was a much less safe water from a sanitary standpoint than was the water after it had been treated in the settling basins. This was due, of course, to the elimination of bacteria of an injurious nature by the processes of sedimentation, and in which process the
2610 injurious bacteria subside—falling to the bottom of the
basin and from time to time are removed and thus prevented from passing on to the water delivered to consumers. These deposits are removed by artificial means once or more each year, by emptying the basins and flushing the mud into channels which conduct it to a sewer leading from the end of the basins to the river and down below, a considerable distance below the intake tower. I will classify this raw river water as it entered the Chain of Rocks intake tower during the years 1895 to 1899 inclusive as a suspicious water, meaning by that, not distinctly a good water, but one in which there is a liability of danger from time to time to those who drink it in its raw condition.

2611 The average annual deaths from typhoid fever from 1895 to 1899 inclusive is 112. During the three years, beginning with Jan., 1900, it is 196, showing an increase in the number of deaths of about 80%. Taking into consideration the differences in population, that is, the increasing population during that period, and expressing the typhoid fever deaths with reference to the number per 100,000 of population living there has been an increase during the past three years on an average, of about 60 per cent over the annual typhoid fever death rate per 100,000 population living, for the five years, 1895 to 1899 inclusive. Comparing the number of deaths from typhoid fever during these eight years, with reference to the total number of deaths from all causes, occurring in the city of St. Louis, and obtaining the percentage mortality from typhoid fever, the percentage increase for the last three years on an average as compared with the average percentage of mortality from typhoid fever during the five preceding years, is 73 per cent. I will further state that the average number of deaths from typhoid fever in St. Louis during the first five years under consideration was about 20.4 per 100,000 population living, and that this rate during the past three years, on an average, was about 32.3 on the same basis; that is, the average number of deaths per annum per 100,000 population living. In my judgment, the three methods of investigating and comparing typhoid fever statistics when considered together afford a proper and reasonable basis upon which to base conclusions with reference to typhoid fever statistics of the city for the reason that each throws light on the matter, but the data regarding the two last methods of comparison taken together are the fairest and best way.

2612 I should say in round nunmbers there has been an increase during the second period under consideration of about sixty to seventy per cent above the average rate in the earlier period mentioned. The number of deaths by months for

1903 up to and including Ma, clearly indicate an increase in typhoid fever in this city.

2613 The record of number of deaths from typhoid fever in St. Louis by months shows a continuance of these comparatively high figures to an unusual degree, showing that for this season of the year, there is an unusual prevalence of this disease in this city. I ascribe the increased mortality from typhoid fever in St. Louis since Jan., 1900, to an increased amount of infection in the water supply, and predicate this opinion on the practically uniform distribution of the homes or residences in which the typhoid deaths have occurred in St. Louis and the further fact that a careful examination of the other several possible sources of typhoid fever, show that no substantial portion of this increase may be explained in that way. I consider that the sanitary character of the public water supply delivered to the consumers in St. Louis has been less safe since Jan., 1900, than it was formerly. It is my judgment that this water as delivered to the consumers since Jan., 1900, cannot be classed as a good water. The treatment of the water since 1900 has been essentially the same as it was before. I consider that the sanitary character of the raw Mississippi water entering the intake tower of the St. Louis waterworks since Jan., 1900, has been distinctly and decidedly less safe than during the five preceding years.

2614 The principal source of dangerous impurities in public water supplies in raw condition is sewage pollution. I am familiar with the typhoid fever statistics in the larger center of population on the Mississippi watershed above the Chain of Rocks, excluding the Sanitary District of Chicago, since Jan., 1900. Taking the statistics upon this watershed area based upon the average number of deaths from typhoid fever per year, it is my judgment that there has not occurred on such area, any increase in the number of deaths sufficient to explain to a material degree the less safe condition of the Mississippi water at the intake tower during the last period as compared with the period from 1895 to 1899. In my judgment it is the Chicago Drainage canal discharging sewage and drainage containing filth and infection from Chicago which makes the water in its raw condition at the intake tower less safe than it was preceding Jan., 1900.

2615 There have been about 1647 deaths from typhoid fever in Chicago since Jan., 1900, and the infectious discharges from the persons sick and dying of typhoid fever, have to a very large degree been disposed of by their passage through the sewers to the Chicago river and the Chicago Drainage canal.

2616 In round numbers, I place the figure for those people who sewer directly into the Mississippi, its branches and tributaries above the St. Louis waterworks, exclusive of the Sanitary District, at about 2,700,000. This figure is based upon a separation, on an average of the sewage contributing population from the rural population by taking towns of 4,000 and over as representing those who have sewage systems and contribute sewage directly to the water courses. I include in this number the Missouri river and the Illinois river, exclusive of the Chicago Sanitary District, as well as the upper Mississippi. (Witness states reason for drawing the line at cities having population of 4,000.) In round numbers I estimate an increase of 60 per cent in population sewering into the Mississippi valley above St. Louis, due to the Chicago Drainage canal bringing sewage of Chicago into the Mississippi watershed. I place the figure as to the time required for the Chicago sewage to flow from Lockport to Grafton—291 miles—at from 10 to 25 days. The average time required, in my opinion, is about 15 to 18 days.

2618 I consider that the typhoid fever germs may and do continue to live for weeks and months in sewage polluted waters. Generally speaking, it is my opinion that there is not any very great difference in the life history of the germs of Asiatic cholera and typhoid fever. At times the flow of the drainage canal exceeds the flow of the Illinois river and there consequently results at times, a dilution of the Chicago sewage by the Illinois river, and at times, a dilution of the Illinois river by the contents of the drainage canal. Dilution at best does not destroy disease germs or infectious matters. Its effect is to minimize the danger to those who may drink of the water so diluted. One effect of the dilution existing in the Illinois river at low stages is to bring to Grafton more quickly than would otherwise be the case, injurious matter entering the Illinois river at points along the route of its flow and also entering the Illinois river from cities and towns located upon the tributaries of that river.

2619 The most significant feature of the ponds, dams and slack water stretches which are found in the Illinois river, is the low velocity of flow of the water, at times of low stages of the Illinois river. There are a good many days in the course of a year when these velocities at the places above referred to are so low that deposition takes place to a considerable degree, of the bacteria and other matters suspended in the water, and which to a large degree are derived from the contents of the Chicago drainage canal. The deposition of these bacteria including those of infectious diseases like typhoid fever, does not mean their permanent elimination and removal from the flowing water. The reason of this is that as they reach the bottom and lie upon the bed of the stream they are disturbed from time to time, due to changes in velocity of stream flow, such as caused by moderate rains, or by the passage of boats or the action of the wind and the like. The resulting disturbances cause the bacteria to leave the bed of the stream in which they may rest for some time, bringing about a return of those bacteria to the flowing water. In this way the germs of disease may pass from the Chicago drainage canal at Lockport to the mouth of the Illinois river at Grafton. I believe that typhoid fever germs disappearing from the flowing stream and becoming deposited in the bed of the river are able to live there for weeks or months. In my judgment, it is not only possible but probable that the water of the Illinois river, as it flows into the Mississippi may sometimes be richer in typhoid fever germs derived from the Sanitary District of Chicago and coming through the drainage canal, than was that portion of the water drawn from the drainage canal when it flowed over the Bear Trap dam. Such a condition of affairs made and at times probably does arise through the disturbance of the sediment lying upon the bed of the stream in places, which sediment may and undoubtedly does at times contain relatively large numbers of typhoid fever germs.

2620 As these typhoid fever germs are returned to the flowing stream from their position in the bed of the river, there is effected an accumulated result whereby at times at least the waters of the Illinois river flowing to Grafton may discharge the concentrated essence of the infection of the Chicago sewage by taking in the manner above described, portions of the infection coming from many days' flow of the drainage canal into the Illinois river. I know of no instance connected with public water supplies in which sedimentation is employed for the purification of sewage polluted water without any provision being made for the removal of the sedimented materials so that they will not re-enter the water as it leaves those basins. Without such means of removal, the object and purpose of the settling basins entirely fail. I do not believe that the conditions from Lockport to Grafton are sufficient at all times to prevent infected materials coming through the Chicago drainage canal and entering the Mississippi valley at Lockport, from reaching the Mississippi river at Grafton. It takes a fraction of one day in the ordinary stage of water for the Mississippi river to flow from Grafton to the Chain of Rocks—a distance of 29 miles.

2621 I do not believe that it is possible for the Illinois river water to flow by the Chain of Rocks without some of it ordinarily entering the Chain of Rocks intake tower.

Q. Mr. Fuller, in view of all the facts and conditions as you know them, do you or do you not consider that the sewage of the Chicago Sanitary District pollutes and infects the water of the Mississippi river along the Missouri shore, and especially at the Chain of Rocks intake tower of the St. Louis waterworks, to such an extent that it makes the Mississippi river water less safe for drinking and domestic purposes than it was before the opening of the Drainage canal?

JUDGE JOHNS: I object to the question as requiring the witness to determine what is to be ascertained by the United States Supreme Court on the trial.

A. It is my judgment that it does.

2622 Assuming that for the years 1900-1-2 there was no increase in the number of typhoid deaths on the watershed of the Mississippi river above the intake, exclusive of the Sanitary district of Chicago and that there were 1647 typhoid deaths for these three years in the city of Chicago, it is my judgment the typhoid infection coming from Chicago and passing through the Drainage canal by way of the Des Plaines and Illinois rivers to the intake tower had an influence on the typhoid fever death rate in St. Louis and that it is the cause of the principal portion of the increase during the past three years. Assuming that the population of the Chicago Sanitary District grows larger and that the amount of Lake Michigan water and sewage, etc., is correspondingly increased, I am of the opinion that the water at the intake tower would be rendered less safe than at the present time, due to the increased amount of infection entering the Mississippi watershed from Chicago, and to the

2623 shorter interval of time required for the passage of that sewage from Chicago to the intake tower. Such increased sewage caused by the increased population of Chicago would make the Illinois river and the Mississippi river at low water stages a much less safe water, generally speaking, than at the present time. It is quite possible that looking far enough into the future, this amount of pollution would become sufficient to exceed the oxygen and to make it in many ways resemble an open sewer—that is to say, it would be a stagnant pool resembling sewage rather than a live active water containing atmospheric oxygen. In my judgment the increased amount of infection coming into the Mississippi river from the city of Chicago's sewage at the present time makes an added responsibility as regards the treatment of that water, to make it perfectly safe and wholesome as supplied to the citizens of St. Louis. Such treatment of the water would involve, I think at the present time, more responsibility, and in a financial way, it would be shown by the greater expense of supervision of a filtration plant, and the added cost of supplies used in connection with the operation of filtration works, especially at times of low water.

2624 Looking into the future, there will be a time when single filtration will not be sufficient to produce a satisfactory quality of water at the Chain of Rocks excluding the water from the Sanitary District of Chicago. It is certain that the added infection from the Chicago sewage will hasten the day when single filtration at St. Louis will prove unsatisfactory and when it will be necessary to give attention either to double filtration or to other methods involving increased expense and increased responsibility.

CROSS EXAMINATION by Judge Johns:

My opinions are based on the assumption that the waters of the Illinois river are so polluted with the waters of the Drainage canal that they cannot purify themselves by the time they reach the intake at St. Louis, if they ever do, but with the idea that that degree of purification can take place at certain times—not at all times. There may be and may not be times in the Illinois river in the flow of the water from Bear Trap Dam to the intake tower at St. Louis when that water would free itself of infection, if any infection existed—I don't know.

2625 I doubt if there is any season of the year, any rate of flow or any stage in which it might happen. At times I certainly believe that infectious matter flowing from the sewers of Chicago into the Drainage canal will certainly arrive at the St. Louis intake. In order to provide against that contingency, some means of filtration or purification of the water should be adopted at St. Louis in order to get those particular germs out. It would be desirable to filter the water supply of St. Louis if it was received only from the Missouri, but it is not necessary in order to get a reasonably good water, as has been shown by the typhoid statistics and experience during 1895 to 1899. In order to get a thoroughly satisfactory water without liability of pollution from time to time, the waters at the intake, if consisting only of Missouri water, ought always to have been treated by other means than sedimentation, but it is also true that before 1900 they got a reasonably good water without filtration, but with the sedimentation.

2626 The typhoid fever in St. Louis prior to 1900 was due to a variety of causes. There is a residual number of typhoid deaths in American cities which are not ordinarily eliminated even with a pure water supply and they are still found in cities which are now provided with good water supplies. If the Illinois river and the city of Chicago did not exist, and the problem before the people of St. Louis now was what to do with their water, I think it ought to be treated in order to get a thoroughly satisfactory water, but as I have said, sedimentation from 1895 to 1899 gave them a reasonably good hygienic water. Sedimentation from 1895 to 1899 I would hardly say gave them a reasonably good water at all times. Judging from a sanitary standpoint, I should be inclined somewhat to doubt that sedimentation from 1870 to 1885 gave St. Louis a reasonably good water.

2627 The germ theory of disease became generally recognized in the United States among sanitary engineers in the late eighties. They have been learning all the while and are still learning. There is a possibility that in the future, the practice of filtration would have to be abandoned and sewage destroyed at its origin. Looking into the future, it is possible in low water that the Missouri river might become a stream of liquid sewage but that would be a long way off; it would be very highly sewage polluted no doubt. The same is true of the Mississippi.

2628 It is possible that the Illinois river might become a stench to the nostrils of the people, in which case there is a possibility of quadruple filtration being necessary if St. Louis persisted in taking its water from these rivers, but as I have stated it is also possible that other types of purification might be required in connection with filtration. I believe that typhoid bacilli entering the Drainage canal at Chicago not only may be, but are transmitted to the intake at St. Louis. It is a question of time interval and not distance which is the controlling factor in this proposition. Given a sufficient distance and a sufficient time in running water, and taking the proposition independent of dilution, there would be a very large reduction ultimately of typhoid bacilli, but whether those germs would be wiped off the face of the earth that way, it seems to me is very doubtful.

2629 If a stream of water of 300,000 cubic feet per minute, into which was poured the sewage of Chicago, was started in a tortuous course of a small river at Bear Trap Dam and received no dilution on the way, I do not believe it would be absolutely freed of infection by the time it reached New Orleans. There would be a greater reduction though, in the number of typhoid germs present. If the sewage of Chicago was poured into the Mississippi river at St. Paul, it would purify itself to a large degree by the time it got to St. Louis, but I don't think it would be absolutely purified. It would be dangerous to the people taking water at St. Louis, in the sense that the liability of trouble would always exist to my thought. Absolutely speaking I think that such a thing as the purification of a stream of running water into which infection is poured by sewage is a very doubtful proposition. In order to be absolutely safe, I think the water ought to be filtered.

2630 If there were typhoid bacilli in the Missouri river and the water supply of St. Louis was taken from the Missouri river only, I should advise filtration or some treatment of that water. If there were typhoid bacilli in the waters of the Mississippi and Missouri and the water supply of St. Louis were taken from those two streams without the intermixture of the

Illinois river water, in my judgment it still ought to be filtered. I do not have any idea of the average proportion of Illinois river water passing the intake. I don't think that I would express any figure off-hand. I should think it would be very likely in the vicinity of one-twentieth of the entire body of water that passes the intake.

2631 If I were providing a filter against Missouri river water only I would not make it larger and more elaborate because of its present condition of infection. The same with reference to the Mississippi river water and with reference to the Mississippi and Missouri river water combined, without the Illinois river water.

Q. Would you make it larger and more expensive in its construction if the Illinois river were so included, at the intake at St. Louis?

A. The way that would probably come about in practice is that there would be no very marked difference in the size of the first installation; but the reserve portion of the first installation would serve for a shorter period of years, due to the presence of the Illinois river water and its pollution, than would be the case without that water.

2632 As a general proposition if you are going to manage a filter you ought to have pretty good men to do it and you ought to do it the best you know how, having regard to the health of the people who are to drink the water, but ordinarily a water that can be easily handled by filtration and where the possibility of a slight deterioration in the quality is not a serious matter, it is very seldom in practice that the expense of the organization would be so great. The proper filtration of southern and western waters depends very much upon the skill with which the coagulant is adjusted. The adding of a coagulant is necessary for the water supply of this city at the St. Louis intake, or the Missouri river. There is required some skill and judgment in the man who manipulates the coagulant.

2633 It would require much more skill and judgment to add the coagulant to the filtration of the combined waters of the Mississippi and Missouri and would require still more skill to filter the waters of the three rivers combined. The additional expense would be for the payment of the increased amount to the men who had sense enough to do it and to the members of the staff who would take the responsibility in detail during the 24 hours of each day and each day of the week and each week of the year. I endorsed a project for St. Louis involving mechanical filters following sedimentation of the river water and then coagulation and supplementary subsidence and that this mechanical filtration should be by gravity.

CROSS-EXAMINATION by Mr. Todd:

2634 There should be more experienced and more able men operating the filters here in St. Louis, should the Illinois river containing its infection, become a factor. If twenty men were required to handle the filters I suppose somewhere from four to six would require extra skill. I hardly think that the man at the head of the plant would have to be as skillful and intelligent to operate that plant for the filtration of the waters of the Mississippi and Missouri, as he would have to be if the Illinois river water was added.

2635 The cost of securing a man to operate such a plant would be between the limits of $2,500 and $5,000 a year. I do not know of any man who operates a filter such as would be operated here, in filtering the waters of the Illinois, Mississippi and Missouri, nor of any conditions that would be exactly parallel.

2637 It would cost several thousand dollars a year additional in the management of the plant, if the waters of the Illinois were to be filtered in connection with the waters of the Mississippi and Missouri. The entire additional expense of operating the plant if the waters of the Illinois were filtered would be from twenty to twenty-five thousand dollars. I could not tell you accurately what per cent of the waters passing the intake consist of Illinois water.

2638 I think there may be some days in the course of a year when the waters of the Mississippi and Missouri are more infectious than the waters from the Illinois.

2639 I think there is some Illinois river water at the intake at all times. I think that the general average for the year would show a smaller percentage of Illinois river water than the Missouri and the Mississippi river water combined in the St. Louis intake.

2640 I can conceive of times when the sewage discharges of Kansas City would be a great menace to the public health of St. Louis. If there should be an epidemic in Kansas City, to a certain degree it would be a menace to the water supply of St. Louis. Under average conditions it would take in the neighborhood of a week for the sewage to come from Kansas City to St. Louis. Assuming that in Kansas City there should be an epidemic of typhoid fever and the filter system such as I would construct for the filtration of the Missouri and Mississippi waters, was operated by a less skillful crew than would be established there when the combined waters of the Illinois and Mississippi waters would be filtered, I should hope the filters would be a protection to the public health of St. Louis; under those conditions so operated, I think they would.

Q. Then if the crew that you have mentioned would be able to compete with the epidemic at Kansas City within seven days' journey from the waterworks of St. Louis, why couldn't that same crew protect the city water supply when filtering the waters of the Illinois?

2641 A. It is possible that they might, but there would be the added danger from the Illinois river water in that is intermittently flushing out large accumulations of sediment making the water here much more dangerous than it would in connection with the Kansas City epidemic. When I look into the future I have no pessimistic views about the growth of Kansas City. With its near proximity to St. Louis in point of time and the possibilities of it getting a typhoid contagion, as a general proposition Kansas City is a danger and menace, present and impending to the water supply of St. Louis. I do not consider that the water in the Missouri river at the present time is a fairly safe water.

2642 With the treatment that it receives from the water system existing in St. Louis I should not pronounce it as a safe and usable water in absolute terms, but practically speaking, and based on the experience from 1895 to 1899 I would say that it would be reasonably safe. Practically speaking I consider a filter plant such as we have talked about, absolutely safe, but there is no such thing as an absolute germ-proof filter on a large scale.

2643 The waters of the Missouri, with the typhoid conditions existing from 1893 to 1899 along the watershed of that river, would not be absolutely safe water, after having been treated in the Chain of Rocks settling basins, but I think it would be a reasonably good water. I would consider the waters of the Missouri, after that period so treated, as reasonably safe. Assuming that I was sanitary engineer of St. Louis and they were about to adopt a plant like the one at present in operation and conditions existed along the Missouri river such as I am acquainted with, and the water supply was to be taken from the Missouri river, I should probably recommend that they adopt filtration in connection with it. Assuming the same conditions with the water being taken from the Missouri and Mississippi, excluding the Illinois, prior to 1899, I should still think it would be a reasonably safe water.

2644 Assuming that the water supply came from the Missouri, Mississippi and Illinois rivers, excluding the Chicago sewage, I should still think the water would be safe and usable with the sedimentation which takes place. I think that the sewage poured into the Illinois & Michigan canal prior to 1899 contained infection in a considerable proportion but a large proportion of the infection remained undelivered in the Chicago river. The contents of the Chicago river pumped into the Illinois and Michigan canal were in such a state of advanced decomposition that the proportion of typhoid fever germs originally present in that liquid was comparatively small. The sewage pumped into the Illinois and Michigan canal and then into the Des Plaines river was not absolutely free from infectious germs dangerous to St. Louis, but measured by the infection from 1895 to 1899 at the Chain of Rocks and taking it in connection with the infection coming from the Missouri, Mississippi and Illinois, all these together resulted in a polluted water at the intake tower, but which degree of pollution was not such but that the sedimentation protected the citizens of St. Louis from any serious trouble from typhoid.

2645 If in the watershed of the Illinois, Mississippi and Missouri rivers for 1897, exclusive of Chicago, there were 374 deaths from typhoid fever and as high as 148 in Minneapolis, in its raw condition the water supply of St. Louis was menaced to a certain degree. It was not absolutely free from infection and the liability of infection, but that degree of infection was not such but that the sedimentation which the city waterworks provided could protect reasonably the water consumers of St. Louis. Assuming that the typhoid bacilli discharged from 3740 cases during an average period of fourteen

2646 days was dumped into the watershed of the Mississippi river above its intake, it would pollute the waters of the Mississippi somewhat no doubt; it would be bound to. As to how long it would take that water thus polluted, placed in a sediment basin, to become pure, safe and usable, I don't think any one can answer specifically but it would be a very much longer period than almost any one would be inclined to think, for sedimentation basins holding thirty days' supply are not able uniformly to protect water consumers in such instances where the waters entering such basins are sewage polluted and infected.

2647 The water remains in the settling basins of St. Louis between two and three days. During that time the water is never in a perfectly quiescent state. If all the typhoid germs we are talking about up the several rivers, continue to live and reach the intake tower, the time they would remain in the settling basins would not be sufficient to eliminate them.

2649 A typhoid germ that got into the sedimentation of the settling basin would live there a good long while in all probability. If the water is slightly typhoid infected it would be liable to accumulate a great many of these germs during the course of six months in the sediment.

2650 With such a wind phenomena as we have had during the last two or three weeks passing over these basins, it would have a tendency to stir at the bottom. Provided the churning action of the wind were to get the sediment in there, the water containing these typhoid organisms would be liable to be carried into the outlet and distributed to the people of the city.

2651 A fair general average of the time the water has to settle in these basins would be a day and a half. A day and a half will do very well as far as sedimentation alone is concerned, and it undoubtedly does eliminate a very large number of typhoid germs. The lakes upon the Illinois river and the back water of the different dams in the river would affect the same result, provided all the conditions were the same. Nature would work the same in the two instances. There is a great deal of elimination from the flowing stream of typhoid germs and other bacteria as the water of the Illinois river passes through those basins, but at the Chain of Rocks the sediment is removed by draining the basins and washing them out.

2652 On the Illinois river, the typhoid germs and other bacteria which leave the flowing water and go to the bottom are subsequently flushed out by conditions which naturally occur on that bed, and are returned to the flowing water and many of them doubtless reach the mouth of the stream. I know that it is so from common sense. When these germs sink to the bottom of the lake and the sewage pollution sinks down with them, I presume there is quite a little chemical action going on at the bottom where these microbes are. The anaerobic bacteria have an effect upon the destruction of the typhoid bacilli under conditions such as would obtain in a septic tank or in the Illinois and Michigan canal, but in the bed of the Illinois river where such septic action does not ordinarily, if ever, obtain, I do not think that they would affect the life very materially of the typhoid fever germ. This back water caused by the dam, if my memory serves me right, raises the water some forty or fifty miles back. When the water is not at flood tide in the Illinois river, the current through these back-water basins gets down to less than half a mile an hour.

2653 During those times, sedimentation can and does take place to a considerable degree and the bacteria of typhoid would go to the bed of the river, if they settled—a great many of them would settle. When these settling basins extend over surrounding country where vegetation and grass are plenty, some of these organisms would get out among the grass and when they got out there, it is possible that a freshet would drive them back into the center of the stream, but I think more of them would not go back than would.

2654 The percentage removal of bacteria on an average in the settling basins of St. Louis would be in the neighborhood of 75 per cent. The water used in summer in St. Louis is somewhat in excess of that used during any other period of the year. During those months, the time of sedimentation in the settling basins would be less. I am acquainted with the conditions that obtain in what is known as Lake Joliet.

2655 The current through Lake Joliet goes down to a fraction of a mile, at times. It gets quite rapid at times—very rapid. I presume several miles per hour. I should think that a current of several miles per hour would remove a considerable portion of the bacteria.

2656 When the sewage of Chicago passing through Lake Joliet when the current was only a mile and a quarter or a mile and a half, there would probably be some considerable removal of those germs rrom the flowing stream. It is possible that part of the germs that entered would be scattered and disseminated over that part of the lake which is not adjacent to the current. After it passes Lake Joliet, the first dam it would reach, the principal of which extends for several miles or more, would aid in the removal of germs at times, when the velocity of flow was small, and such velocities at times do occur in my judgment. I suppose those times would aggregate upwards of half a year. When these back-water pools spread out over the country, overflowing the land, the germs that settle along the shores and on the over-flowed land would be less likely to be disturbed by freshets than those just deposited in the bed of the stream, but I think there are undoubtedly conditions which obtain in these overflowed portions which would enable some of those germs lying in the sediment of the overflowed banks to be returned to the stream.

2657 Those conditions would obtain in regard to all the dams along the Illinois river. There would be at times a sedimentation of removal from the flowing stream. They would become deposited upon the bed and following would come the scouring velocities and pick up and move them on. During those times there would be a dying out among the germs. I should not expect that the current at Lake Peoria would exceed two miles an hour under ordinary high stage conditions. Assuming that the current at Lake Peoria was six-tenths of a mile per hour, that velocity would not make a complete removal. There would be disturbances probably, boats and wind actions and such things, which would make a considerable removal of sediment, but not complete. I do not imagine that there are a great many boats that run up the Illinois river from Peoria. On an average when this water gets to Peoria, after passing the dams above Peoria and the lakes above Peoria, considerable elimination of its pollution and infection is accomplished. I presume ordinarily that this is true, but there are times when I think it is not so.

2660 I have not analyzed the sewage that comes from the glucose factory at Peoria. I know that the volume of sewage that is emptied into the Missouri river from the factories and distilleries at Peoria cannot be a very material one, for in examining the analytical evidence I have been unable to detect that that is a controlling—or I might say, a general or dominating factor, taking this entire proposition of the disposal of the Chicago sewage as it comes down through the Illinois river. I should say that the amount of sewage pollution in the Mississippi river at the Chain of Rocks, considering that water in its raw condition, is such that it would not be thoroughly safe. I would ascertain that fact with reference to the amount of pollution entering the streams above. I think it is very essential for any sanitary engineer or expert to ascertain the amount of pollution entering the streams above and it would be a very reckless proposition for any one to make a definite statement in the absence of such information. A sanitary engineer can ascertain from the water itself whether it is safe and usable or dangerous water, through the assistance of tests made for the presence of intestinal bacteria, which is colon bacillus.

2662 There are observers in Switzerland who made examinations of running streams with positive result showing the presence of typhoid germs in the sediment of Lake Geneva and I think also Lake Zurich.

2663 I consider that it is a very clean-cut demonstrated fact that typhoid germs may, do, and have continued to live in the sediment of running waters. I should say for a month or more, possibly in cases for years. I think that the conditions existing in the moist soil in many rural places in this country where typhoid fever prevails from time to time, are proof that typhoid fever germs in the presence of moisture can live for such a term. If that were not so, then there would be an elimination absolutely, of typhoid fever through the rural districts of this and all other countries. My common knowledge of existing conditions in many country towns satisfies me, beyond all doubt, that those germs have lived for at least a year. In a great many instances, my common knowledge is superior to scientific demonstration.

2665 I think those germs live several years. I will not go into details beyond that. I think unquestionably they live several years. I think I am safe in stating that Prof. Sedgewick holds that a typhoid germ will live three years. I do not recall any one who has exploited that longevity for a typhoid bacillus in any work. I think that a prodigiosus bacillus was found in the Ohio river at Cincinnati on one occasion in the course of over a year's investigation, involving practically daily examinations of the waters of that river.

2666 Some typhoid germs, out of a large number put in water, I have no doubt, will live a year.

Q. If a typhoid germ should be deposited in Lake Itasca, from the excreta of an Indian up in that neighborhood, and that the typhoid germ floating down the Mississippi should enter the intake at New Orleans, and get into the system of a creole, would that creole be likely to take typhoid fever?

A. I think there is a decided possibility in that direction, and if there were enough of those individual instances, of one germ coming down from Lake Itasca to the New Orleans intake, there would surely trouble result to the person drinking that water in its raw condition, and in which were present germs coming from Lake Itasca. ?

RE-DIRECT EXAMINATION by General Crow.

Considerable typhoid fever prevails in the city of Louisville. The water supply for that city is drawn from the river and passes through settling basins holding five or six days' supply and in which sedimentation takes place.

2667 The sewage coming into the Ohio river is almost entirely confined to points at and above Cincinnati, which is distant about 150 miles by river. At times of low flow it would take those germs to pass from Cincinnati to the taps of the citizens of Louisville more than one month. I consider that is a very reliable demonstration that typhoid fever germs are not absolutely removed from sewage polluted waters in which that pollution takes place, one month before the water is used. At Covington, Ky., the source of the water supply is the Ohio. There are provided sedimentation basins holding approximately thirty days' supply. It has been found that year after year the citizens of Covington using the Ohio river water coming from those basins are not protected from typhoid fever. I consider that there is no room for doubt but that a portion of the pollution existing in the Ohio river at Cincinnati is due to the sewage coming from cities and towns located in Allegheny County, Pa., between 450 and 500 miles away. I will further say that in my judgment were all sewage pollution of the Ohio river and its tributaries between Pittsburg and Cincinnati eliminated, I consider that the Pittsburg sewage would unquestionably make its influence felt in the hygienic character of the river water at Cincinnati (a distance of between 450 and 500 miles.)

2668 (Witness reads from report of the Chief of Engineers of the United States army in regard to the Illinois river, as follows):

"Channels dredged twenty years ago are but little deteriorated, and it is surprising to find that there has been no deterioration in depth in the pools created by the Henry and Copperas creek dams after from fifteen to twenty-eight years' use."

"The dams (meaning in the Illinois river) have no appreciable effect above mid-stage of the river when currents are the strongest, so that all lighter sediment is swept away as well now as before constructing the dams. That there has been no appreciable change felt in the pools of the Illinois river is a fact that has been so often remarked upon by steamboat men and persons interested in the use of the river since the construction of the first dam at Henry, thirty years ago."

JUDGE JOHNS: I move to strike out portions of the answer which are read from reports.

In my judgment, no great amount of sediment accumulates and remains upon the bed of the stream of the Illinois river for any great length of time.

2669 RE-CROSS EXAMINATION by Judge Johns:

(Witness is examined as to the towns on the Ohio river near Louisville and Cincinnati, and the tributaries of that river entering said river between those points.)

2671 If there was constant accumulation and no scouring out of material that might be deposited on the bed of the Illinois or any other river, the result would be that there would not be any bed there.

WILLIAM H. GETZ, recalled and examined in chief by General Crow:

The table I have here is the same one I presented before, showing the percentage of mixtures of the Mississippi and Missouri rivers at the intake of the St. Louis waterworks. I have re-checked all the calculations and think there is no reason to doubt that that table is correct now as made from examinations and analyses of the water. The difference of amounts of total solids in the Mississippi river and in the Missouri river, at the points where these samples are taken, is found, and also the difference between the total solids at the intake and those at Hartford on the Mississippi river. In this manner the per cent of Mississippi river water is obtained.

The percentage of Missouri river water for instance would be the total difference divided into the difference between the intake and Hartford. (Witness states method of making the calculation of percentages from the table.)

(Table introduced in evidence.)

2679 (Section 2 of table shows calculations based upon daily estimation of total solids.)

2688 HIRAM R. MILLS, examined in chief by Attorney General Crow:

Am physician and reside at Soldiers' Home, Grand Rapids, Mich. Have been practicing medicine 35 years. Resided nearly all the time at Port Huron, Michigan. Left Port Huron on the 25th of April, 1903. Was practicing physician in Port Huron in 1889, '90, '91, '92. Port Huron is on the St. Clair river and the Black river divides Port Huron into two parts and empties into the St. Clair river. There is not a great deal of difference as to the size of the town on either side of the St. Clair river.

2689 The present population of Port Huron is about 21,000. In 1890, '91, '92 it was probably 15,000 or 16,000. A large portion of Port Huron was sewered in 1890, '91, '92 on both sides of the river. The natural drainage for the greater part of the town is into Black river. There has been typhoid fever there off and on every year since I have been there, more or less. I have been there 33 years in December next. In 1891 there were four cases I looked up.

2690 They were under my personal knowledge. There were 4 in 1890 and 4 in 1891. The sewers of Port Huron empty into the Black river almost entirely. They have been emptying in there for a long time.

2691 The river was dredged from the mouth of Black river to the Fiber works in 1891, '92.

CROSS-EXAMINATION by Judge Johns:

There was a board of health in 1891 and '92 but it was not in very active running order. They did not have any statistics of deaths and causes of deaths at that time. The deaths and births were collected by the supervisors twice a year. A record was kept, but I do not know what became of them. As a matter of fact I suppose they were kept—I know that was the law. They had blanks furnished by the State and there was some disposition made of those blanks. There ought to be a copy in the County Clerk's office.

2692 The first case in 1890 was that of Otis Scott, corner Broad and Ontario streets. I attended him personally and he lived. I understood that the house at the time was connected with the sewers but I could not say positively that it was. I told the nurse what to do with the dejecta. She was to use disinfectants and put it into the closet. I think their closet was connected with the sewer. I ordered that before it was put into the sewer it should be disinfected. I told them to use carbolic acid or copperas and sometimes to put in boiling hot water.

2693 The second one was Mrs. Bunce, on Lepear avenue, near 9th st. That was in October, 1890. There was a sewer on Lepear avenue, but I do not know whether their house was connected or not. I always give instructions for the disinfecting of the dejecta. I could not say positively whether the dejecta went into the sewer or not. The next in 1890 was Fred Gooding, Ontario street, near Pine Grove ave. I think that house was connected with the sewer. I am not sure about that either.

2694 I always gave orders to have the dejecta disinfected. I do not know whether it was or not in that case. I could not say positively whether the dejecta from that patient—whether disinfected or not—went into the river.

The next in '90 was Massmore on Lepear ave. That was connected with the sewer. I gave the usual orders to have the dejecta disinfected. I suppose it was done but I don't know. I don't know whether the dejecta—whether disinfected or not—went into the river, but I suppose it did. In 1891 was Mrs. John Folkers, 1209 Miller st. There was no sewer on that street for that house.

2694 The dejecta was thrown into the closet and the closet drained into a little stream there—Indian creek, or the stream that ran down into Indian creek through the
2695 clay. It was one of those surface vaults that might be washed out by flood or something of that kind. At any time there was a heavy rain, there would be a certain amount of sewage from this vault which would go into Indian creek and that went into Black river. I gave the usual orders to have the sewage disinfected but do not think it was done because it was that class of people that would not be apt to do it if you did tell them, while I have no positive knowledge in regard to it.

2696 I have no knowledge positively as to whether the dejecta of that patient—disinfected or not—went into the vault or outhouse; that is a surmise.

In October '91 is another of the same family, living right on the bank of the Black river. This house was not connected with the sewer. The outhouse was practically on the dock over the edge of the river. I gave orders to have the dejecta disinfected but do not know whether it was done. Another in 1891 was John McFadden, Court street. I think it was connected with the sewer in 1891, but I don't know as I never traced
2697 it. Gave the usual orders to have the dejecta disinfected but do not know whether it was done. There was a waterworks in Port Huron in 1890 and 1891. The water supply was taken from the St. Clair river above the mouth of Black river. I think all of these cases in 1890 received their water supply in the houses from the public waterworks of Port Huron. The water of Port Huron was not filtered. It came direct from the St. Clair river.

2698 It is counted one of the best water supplies of the world, but there was contamination there—that is where we got our fever from. The upper part of the city extended quite a distance above the intake pipe and contaminated water was constantly going down from the upper part of the city into the St. Clair river from the cases that occurred along the eastern slope of the city. This man Scott drank the water from the public water supply without filtering it. I am positive of that. I attribute this case of typhoid fever to the contamination of the water supply of Port Huron.

2699 Fred Gooding also received the water from the waterworks. He was the only one in the family having typhoid. I know he drank water from the public supply. I know the Bunce family did not have any well—their water came from the public supply. It is a mere theory that these cases in 1890 and 1891 were attributable to the water supply. It could not be demonstrated. In 1891 the people sick with typhoid who re-

ceived their water from the public water supply were the
Folkers on Miller street.

2700 The Fiber Works are about three-quarters of a mile from
the mouth of Black river. No sewers of the city empty
into the Black river above the Fiber Works. Dredging was
done in the Black river up to the Fiber Works in 1891 and 1892.
These cases were about equally divided on the north and south
side of the city. The waterworks system extended on both sides
of the city.

2701 99 per cent of the people in Port Huron or at least 90
per cent, use the public water supply. The dredging was
started in 1891 in May, June or July, and there was some dredg-
ing done in 1892, probably the first part of the summer.

2702 This dredged material was taken and dumped over the
shallow places, over the tunnel, or in the deep places,
where the tunnel came near breaking through and that would
be probably two-thirds of the way across from the American
side, along the line of the tunnel under the St. Clair river.

2703 It would look as if the major part of this dredging matter
was deposited over in Canadian water about 30 miles
above Lake St. Clair. It may be about 35 or 40 miles by river.
St. Clair river is a wide, rapidly flowing stream and St. Clair
lake is, in places, very shallow. In fact, it is a shallow lake.
The current is along the channel in the lake and there is some-
thing of a current there. It broadens out so that the current is
very much reduced after it leaves the canal—it goes through
the ship canal, you know. The ship canal connects the St. Clair
river with the lake up at Star Island. On the south of
2704 the lake, after you go down the St. Clair river to Lake St.
Clair, then through Lake St. Clair, is the Detroit river.
St. Clair lake was dredged to make a channel but not the entire
length. While the current is not so swift as in the St. Clair
river, there is considerable current in Lake St. Clair. The
Detroit river current is also swift. There is an enormous quan-
tity of water that flows down the St. Clair river.

2705 The river is not subject to great floods. It only varies in depth with the wind. It is a straight between Lake Huron and Lake Erie. It is about 65 miles from Port Huron to Detroit by river. The speed of the current in St. Clair river varies. At the foot of the lake, it is about six miles an hour and as you get down, it is probably about 3 miles an hour in the lake.

2706 The speed of the current of the Detroit river is not as strong and rapid as that of the St. Clair river. There is a considerable agricultural population on both sides of the St. Clair river, having its natural drainage into that river. There are a number of summer resorts and club houses on Lake St. Clair.

2707 It is a great resort—fishing, duck hunting, boating and clubs. Large numbers of people resort there during the fishing and hunting season. The number of resorters at Lake St. Clair and the St. Clair river in the summer would be in the thousands every day. These people might as well have had typhoid fever as anybody else.

2709 CROSS EXAMINATION by Mr. Todd.

2710 Among those 8 people having typhoid fever, two resulted fatally, Mrs. Bunce and Mr. McFadden.

2711 Most of the nurses were just their own people. For instance, Mrs. Bunce was attended by her daughter. I left directions with the nurses in all these cases for the disinfecting of the dejecta and how to attend the patient, and I found that in matters which came directly under my observation, these nurses carried out my instructions and there is no reason to believe they did not. The only thing is, I know that sometimes they get careless about those things, but that is outside of my knowledge. As I said a minute ago, we had our water contaminated from sources above the intake pipe. Exclusive of the sewage of Port Huron, there was what is called McNeil creek which drained quite a territory in that part of the city.

2712 There was nothing outside the city draining into the river.. The theory our medical society has had there always, has been that we had contaminated water or contaminated milk. As to what brought the typhoid fever in this particular locality was not discovered in this particular instance.

2713 It might have come into Port Huron by rail, but there are no cities above Port Huron and it must have come just from the town itself—contamination of the water there.

RE-DIRECT-EXAMINATION by General Crow.

Am not an expert on stream flows. What I said about the rapidity of the current of Lake St. Clair and St. Clair river is guess-work. Typhoid fever has existed in Port Huron for 33 years to my knowledge, that being the time I was there. The disinfectants that are applied to stools of typhoid patients do not always destroy all the typhoid bacilli entirely. If the disinfectants were used in the manner in which I prescribed them to be used, it did kill them—it ought to destroy the germs. I do not know that it was used in that method. My experience as a physician leads me to believe that they did it with a great deal of carelessness.

2715 CHARLES B. STOCKWELL, examined in chief by General Crow.

Am physician and surgeon. Reside at Port Huron, Michigan, have lived there 51 years and practiced medicine 23 years. Was practicing in Port Huron in 1892. There was typhoid fever cases in Port Huron that year. From personal knowledge I have record of three, in February, March and April—one case extended into May. In one case I know there was direct connection with the river by private sewer and in another there was connection through one of the sewers which emptied near the waterworks. In another case, the house was located on the border of Indian creek which emptied into the Black river—whether there was a sewer there or not, I cannot tell.

CROSS EXAMINATION by Judge Johns.

2716 This case in which the sewage went directly into the Black river by private sewer was attended by me personally. The sewage was not disinfected that I remember. I did not give instructions to have it disinfected. That was my practice or custom. The case having indirectly a connection by

ABSTRACT TABLE NO. 1.

The following table shows the results of the bacteriological investigation made by Dr. Ravold for what is termed the "First Period." This is before the canal was opened. In his testimony it is referred to as the period from Aug. 10, 1899, to Jan. 23, 1900. Dr. Ravold testifies, however, on Record 85, that between September, 1899, and Jan. 23, 1900, there were no bacteriological investigations carried on by him to determine the presence of coli communis in the water. Reference is made at the head of the table to the page of record where the testimony will be found. If the testimony extends to some other page of the record, such page is indicated directly above the number of bacteria. A plus sign indicates the presence of bacilli coli communis; a minus sign denotes the fact that , that bacteria was not found. Where there is no sign after the number of bacteria, the witness has not testified that the same was examined for coli.

1899		Mississippi River, just above the intake. (80)	Intake, as water flowed in. (80)	Uptake. (80)	Illinois River, Wheeler's Ferry, 3 miles above mouth. (83)	Illinois River, 5 miles above mouth. (Brick House Club.) (83)	Illinois River, 7 miles above Grafton—6-mile Island. (83)	Mississippi River, opposite Grafton. (83)	Mississippi River, 4 miles above Grafton. (83)	Mississippi River, 6 miles above Grafton. (83)	Mississippi River, Chain of Rocks (83)	Mississippi River, Madison Landing (above mouth of Missouri River.) (83)	Missouri River, just above the mouth. (83)	Mississippi River, 1½ miles below Alton. (83)	Mississippi River, 1 mile above Alton.	Mississippi River, 1 mile below Grafton	Mississippi River, opposite Grafton	Illinois River, just above Grafton. (83)	Mississippi River, 2 miles above mouth of Missouri. (84)	Illinois River, 1½ miles above Grafton. (Rec. 84)	Mississippi River, 1 mile above Grafton. (Rec. 84)	Missouri River, opposite Clifton. (Rec. 85)	Mississippi River, ½ mile below Portage (Rec. 85)	Intake, Illinois shore, toward Illinois shore. (80)
August	10	275	500	600																				
	11			650																				
	12			650																				
	14			650																				
	15			1,500																				
	17			730																				
	18			650																				
	19			400																				
	21		375	325																				
	22		950	150																				
	23		550	1,300																				
	24			475																				
	25			400																				
	26			275																				
	28			275																				
	29			170																				
	30	275		300																				
September	4			300																				
	5			270																				
	6				130	170	160	190	550	276														
	9										160	210	180	190	240	160	150	90						
	11			300																				
	12	650																						
	13	1,500																						
	15	2,300																						
	16	1,700									1.700	800	2,600	Rec. 84 800	Rec. 84 700				700					
	20	1,200																		450+	500—			
	21				Rec. 84 400+	Rec. 84 425+			500+															
	25	3,600									Rec. 84 3,600+	750—	Rec. 84 5,600+	750+								750+	600—	

ABSTRACT TABLE NO. 1A.

Table showing result of bacteriological examination of Lake Michi-n water, taken from places indicated, which are intakes for the ter supply of Chicago. Based on testimony of Dr. Ravold, pp. 95-6 Record.

This is second period of investigation made by Dr. Ravold, running om Jan. 23, 1900, to Oct. 10, 1900.

1900		Four-mile Crib. Rec. 96.	Carter Harrison Crib. Rec. 94	Ten miles from shore. Rec. 94	Lake View Crib. Rec. 95.	Two-mile Crib. Rec. 95.	Three-mile Crib. Rec. 95-96	Sixty-eighth Street Crib, Rec. 95-96	Four-mile Crib. Rec. 96.
y	23	1,600+							
	30		12,300+						
gust	9			16,300+					
	31		Rec. 95 21,400+						
tember	7				5,200–				
	15					909,700+	111,300+		
	22					61,000–		44,000–	
	29				3,100+	11,300–			
ober	11					1,000–			
	19					4,400+	1,100–		
	26							157,500–	90,000–
ember	9							3,300–	2,900–

See Rec. p. 96 for species of bacteria found, all of which are harmless except bacillus coli munis, and that only when injected beneath the skin.]

ABSTRACT TABLE NO. 1B—Continued.

		Bear Trap Dam, Drainage Canal, Lockport. Rec. 100.	Desplaines River, Joliet, Ill., at McDonough St. bridge. Rec. 109	Illinois River, 3 miles above Peoria. Rec. 119	Illinois River, 3 miles above Grafton. Rec. 127	Mississippi River, 3 miles above Grafton. Rec. 135	Mississippi River, 17 miles below mouth of Illinois, 1 mile above Alton. Rec. 144	Mississippi River, opposite Hartford, Ill. Rec. 153	Missouri River, at Bellefontaine. Rec. 161	Mississippi River, Chain of Rocks, between Intake and Missouri shore. Rec. 170	Mississippi River, Chain of Rocks, near Illinois shore. Rec. 178	Intake proper. Rec. 187	Reservoir, Chain of Rocks. Rec. 197	Tap, City Hall, 11th and Market, St. Louis. Rec. 206
April 1900	1	11,092,000+	9,872,000+	183,000+	56,500−	129,500+	112,000−	64,000−	42,000+	82,500−	72,500−	104,000−	94,000+	....
	2	2,715,000−	3,054,500+	213,000+	54,000+	104,000+	80,000+	63,000−	155,000−	84,000+	2,600+	93,000+	25,000+	....
	3	3,410,000+	14,960,000−	253,500+	53,000+	175,500−	64,500+	45,500+	162,500−	68,500+	88,500−	107,000+	46,300+	....
	4	4,425,000+	5,460,000+	200,800−	37,500+	142,300−	46,000−	58,500−	111,000−	111,000+	87,500−	80,000+	47,800−	....
	5	1,900,000+	3,850,000+	278,500+	17,800−	161,000−	38,000−	66,000+	135,500−	91,000−	28,500−	20,700−	37,000+	....
	6	3,075,000+	8,450,000+	283,000−	38,500−	175,000−	57,000+	51,000−	114,500−	39,000+	34,500−	127,500−	25,000−	....
	7	670,000+	645,000+	587,500+	24,800+	76,000−	57,000−	75,000−	277,500+	62,500−	68,000−	160,000−	65,000−	....
	8	2,350,000+	2,400,000+	274,000−	78,500+	134,000−	70,500−	56,000+	77,500−	60,500−	59,000−	208,000−	49,500+	....
	9	1,600,000+	3,450,000+	182,500+	17,800+	182,500−	82,000−	52,300−	101,500+	75,400+	71,000+	149,500+	116,500−	....
	10	1,675,000+	4,700,000+	81,500+	24,500+	101,000+	36,500+	43,500+	63,900−	92,000+	70,500+	197,500+	28,800+	....
	11	1,225,000+	3,275,000−	98,000−	18,500+	124,500+	31,800+	38,000+	66,000−	39,500+	22,500+	88,000−	66,500−	....
	12	1,950,000−	7,720,000−	37,000−	15,400−	75,000−	13,000−	50,500−	31,500+	50,500+	29,800−	71,500+	36,500+	....
	13	5,390,000+	5,075,000+	50,000−	24,200−	58,000+	17,300+	26,500−	65,000+	52,000+	27,500−	84,500+	34,500−	....
	14	1,080,000	1,900,000−	58,500	10,400+	21,000+	23,200−	21,000	58,500−	55,500	21,000	57,000−	22,000−	....
	15	4,425,000+	9,450,000+	65,100	62,000	63,000−	24,300	32,500−	87,000+	57,500	39,500	70,500+	34,000	....
	16	990,000+	580,000+	65,100−	18,500−	44,000−	16,300	27,000−	87,500	89,500+	49,500	59,500	26,000	....
	17	340,000+	2,380,000+	36,500+	10,500−	30,000+	15,000−	13,500+	168,500−	44,000+	29,300+	58,000+	21,500+	....
	18	230,000+	490,000+	95,500−	6,200+	16,800+	13,500+	24,800+	64,500+	29,000+	6,800−	24,500−	9,500+	....
	19	90,000−	1,500,000+	11,000−	13,000+	6,500+	4,200−	13,300+	59,500+	18,500+	14,500+	27,500+	8,000+	....
	20	155,000+	190,000+	65,100+	6,000+	5,100+	3,900+	6,400+	58,300+	12,000−	4,400+	9,700+	3,000+	....
	21	2,843,000+	1,320,000−	51,500−	65,000+	34,300−	20,600+	10,400+	38,000−	16,800+	8,400−	30,800−	10,000−	....
	22	440,000+	245,000−	118,400−	21,800−	22,000−	5,700−	10,000−	21,500−	7,000−	9,300−	56,300−	2,900+	....
	23	247,000−	415,000+	78,000+	1,500+	12,600−	5,700−	23,900−	18,900−	19,900−	27,500+	28,500+	3,800−	....
	24	245,000+	186,000+	19,900−	4,800−	19,700−	17,900−	15,900+	....	29,000+	27,600−	11,800+	48,000+	....
	25	105,000−	270,000−	67,000−	2,900−	6,400+	4,500+	4,700−	15,400+	16,400+	54,000−	14,600+	4,100−	....
	26	325,000−	200,000+	19,900−	250−	8,300+	7,700+	6,800+	32,000−	6,800−	6,900−	18,500−	5,300−	....
	27	97,000−	129,000+	20,800−	1,250−	22,500+	7,200−	8,700−	10,800+	7,000+	2,400−	19,600+	10,500−	....
	28	....	390,000+	10,100−	1,200−	5,200+	3,850−	6,900−	16,800−	10,300−	2,700−	11,800−	3,450+	....
	29	185,000+	110,000−	900−	4,800−	3,200+	3,450−	3,900−	7,650+	13,500−	....	5,600+	1,900−	....
	30	....	365,000−	500−	600−	1,100−	700−	1,650−	1,400−	1,600−	750+	850−	300+	....
May	1	24,500	12,500	750	600	1,100	900	600	3,800	1,300	500	1,400	400	....
	2	612,500+	345,000+	500+	1,700+	600+	1,600	1,200	1,800	1,300+	600+	1,700−	750	....
	3	350,000+	430,000+	950−	750−	1,000−	700−	1,500+	4,200+	2,000−	950+	3,300+	1,000−	....
	4	18,800+	18,300−	275+	150−	950+	2,000−	500+	4,200+	2,500+	450+	1,900+	1,500+	....
	5	900,000+	412,500+	....	600−	1,200+	700−	4,900+	4,100+	2,400+	1,400+	1,750+	1,200+	....
	6	1,294,000+	92,600+	14,700+	9,100	11,500+	37,800+	49,200+	88,000+	27,000−	12,500+	181,000+	82,500+	....
	7	2,254,000+	164,800+	14,800+	3,500	3,000−	13,400−	20,100	40,200	37,300	6,300	21,200	12,400	....
	8	114,500+	420,000+	10,500+	10,600+	7,900+	17,600+	21,800−	33,100−	27,600+	16,600+	23,500+	15,200+	....
	9	149,500+	1,516,000+	5,500+	9,700+	7,300+	13,400−	15,700+	33,100−	41,400+	4,700+	15,500+	7,600−	....
	10	188,000+	592,000−	4,600+	6,820+	6,400+	14,300+	13,000+	33,100+	112,200−	17,500+	97,400+	16,400+	....
	11	663,000+	7,500+	68,800+	5,200	11,300−	12,100+	15,800+	33,100+	79,600+	41,900+	63,700+	34,100+	8,400
	12	795,000−	366,000−	98,000+	15,400−	8,300−	13,000+	13,500+	33,100−	48,500−	12,700−	30,600+	21,000−	12,900
	13	255,000+	584,000+	249,000−	6,400−	7,000+	13,400−	15,700+	33,100−	106,000−	41,000−	51,500+	58,500−	13,700
	14	128,000+	....	112,000+	32,100+	8,400+	10,000+	13,800+	33,100+	33,100−	16,400−	38,500+	14,800−	5,100
	15	78,000−	710,500−	615,500−	7,600+	13,000+	11,100+	14,600	67,400+	20,800+	14,500−	36,300+	14,400−	7,100−
	16	376,500+	164,000−	1,585,000−	7,100−	5,100+	16,100−	22,600+	27,600+	26,000+	17,900−	26,100−	15,200+	5,600−
	17	96,000+	593,000−	152,500−	2,600−	3,700+	5,200−	8,800−	51,500−	16,200+	14,300+	23,200−	4,000−	1,900−
	18	85,000+	129,000−	531,400−	2,400+	6,200−	7,400+	11,700+	53,500−	77,000−	10,700+	12,300−	5,900−	1,900−
	19	28,000−	319,000−	155,000+	6,300−	3,000−	3,100−	5,400−	27,500−	42,800+	13,600+	23,200−	4,400+	2,100−
	20	40,000+	472,000+	149,000+	8,500−	11,200+	52,400+	43,700−	45,400−	....	23,800−	27,400−	14,500−	3,000−
	21	273,000+	89,000+	47,000−	5,900+	5,400−	18,000−	19,800+	45,400	77,000−	7,200−	42,200−	43,200	1,900−
	22	2,725,000+	2,810,000+	62,300+	6,400+	4,800	2,700+	3,800+	36,000	29,400−	4,900−	14,800+	3,300	1,000−
	23	1,306,000+	1,500,000+	40,000−	7,200+	11,500+	18,200−	11,000	38,000+	39,300+	13,000	22,200+	4,500+	3,800−
	24	394,500+	92,000+	85,800+	8,600−	8,800+	6,300+	7,200+	50,500−	61,100+	14,000+	60,500+	5,000+	3,700−
	25	1,311,000+	157,000+	23,500+	....	....	....	+	83,800−	29,400+	....	....	....	7,800−
	26	....	....	....	3,300+	3,200+	3,800+	2,100+	20,000	5,200+	74,000	5,200+	3,300+	3,000+
	27	332,000+	111,000−	62,300+	....	+	....	+	....	....	....	....	....	....
	28	736,000+	28,000+	100,000+	3,900+	3,600+	8,900+	6,200+	15,600+	11,900+	6,500+	9,800+	4,100+	2,500+
	29	15,000+	20,000+	522,000−	3,200+	2,300−	4,000+	18,600+	23,500+	96,000−	13,200+	17,000+	1,400+	1,600+
	30	2,510,000−	84,000+	179,000+	3,500+	3,200−	8,200+	5,000+	50,000+	10,200+	23,300+	6,300+	10,400+	1,600+
	31	....	158,000−	279,000−	1,900+	8,300−	2,700−	2,800+	31,000+	8,800+	36,500+	5,000+	....	2,100+

ABSTRACT TABLE NO. 1B.

This table shows the results of the bacteriological examination for the points indicated and on the days indicated. This is what is known in the testimony as the "second period" of investigation and extends from Jan. 23, 1900, to Oct. 31, 1900. See Abstract Table No. 1 for explanation.

		Bear Trap Dam, Drainage Canal, Lockport. Rec. 100.	Desplaines River, Joliet, Ill., at McDonough St. bridge. Rec. 109........	Illinois River, 3 miles above Peoria. Rec. 119	Illinois River, 3 miles above Grafton. Rec. 127........	Mississippi River, 3 miles above Grafton. Rec. 135 ...	Mississippi River, 17 miles below mouth of Illinois, 1 mile above Alton. Rec. 144	Mississippi River, opposite Hartford, Ill. Rec. 153......	Missouri River, at Bellefontaine. Rec. 161...........	Mississippi River, Chain of Rocks, between Intake and Missouri shore. Rec. 170...	Mississippi River, Chain of Rocks, near Illinois shore Rec. 178...........	Intake proper. Rec. 187......	Reservoir, Chain of Rocks. Rec. 197...........	Tap, City Hall, 11th and Market, St. Louis. Rec. 206 ....
1900 January	23	......	......	22,900+	241,000-	17,000+	......	......	......	......	14,900-	16,000-	5.400-	......
	24	......	......	284,900+	......	30,500-	96,400+	43,500+	158,300	......	......	......	......	......
	25	......	......	211,600+	170,200+	38,300+	190,600+	159,100-	245,200+	262,100-	181,600+	123,400-	87,500+	......
	26	......	......	85,100+	25,100-	54,300+	119,400-	4,000	236,300-	329,700-	155,400+	81,400+	7,400+	......
	27	......	......	49,200+	37,000-	29,100-	119,800-	32,800-	560,000-	121,400-	308,500-	344,400+	......	......
	28	......	......	363,400+	2[illegible]6,700+	70,000+	119,400-	38,300-	195,600+	222,700+	155,400+	170,700+	50,400	......
	29	......	......	173,800+	81,300	48,000-	111,000	100,500	196,200	264,000	117,300-	174,300	97,500	......
	30	......	......	336,900+	174,400-	66,200-	115,100-	53,100-	278,800-	263,400-	......	299,000-	105,100-	......
	31	......	......	365,400+	165,100+	48,700-	118,500-	137,300-	235,700-	102,800-	......	126,200-	124,700-	......
February	1	......	......	268,800+	125,400-	86,400	166,900-	178,400	178,200-	125,500-	102,300-	......	94,900-	......
	2	......	......	392,900-	332,400+	39,700-	149,500-	163,600-	98,700-	122,500-	116,000+	78,700-	118,800+	......
	3	......	......	824,300+	252,300-	42,800+	48,900	153,900+	76,000-	113,900-	62,400+	130,300-	110,600-	......
	4	......	......	548,100-	76,700-	13,700	92,500	196,000	69,000-	205,100-	......	68,100-	87,300-	......
	5	......	......	294,000+	195,700-	27,000-	114,300-	137,500+	52,500-	82,900-	36,200+	107,500-	127,500-	......
	6	......	......	239,500-	142,400-	28,400-	151,300-	95,700	49,100-	82,900-	38,300-	70,200-	41,700-	......
	7	......	......	167,300+	63,000-	39,600-	47,400-	30,100-	150,100-	......	99,500-	88,900-	2,700-	......
	8	......	......	64,900-	97,100-	21,200-	80,900-	90,500-	42,200-	63,000-	79,600-	103,600-	15,500	......
	9	......	......	25,400+	62,700+	57,800+	91,900-	119,900-	53,800	58,200-	72,700-	339,700-	18,300-	......
	10	......	......	21,200+	203,200+	58,500-	113,900-	125,900-	36,300-	27,300-	161,500-	64,400-	73,400-	......
	11	......	......	48,700+	......	20,600-	118,200-	106,900-	61,000-	64,000-	136,800-	78,700-	38,000-	......
	12	......	......	72,800-	84,300-	74,400+	100,600-	170,100-	40,700-	51,500	154,900-	80,600-	58,600-	......
	13	......	......	126,800	134,800	98,300	166,600	134,900	22,600-	34,200-	98,100-	75,300	47,500	......
	14	......	......	761,600-	360,200+	214,800-	203,400+	......	124,300-	100,000-	330,100+	145,900+	90,200-	......
	15	......	......	653,800+	294,400+	158,100-	277,800-	276,300	68,600-	191,400+	271,000-	181,500+	104,000-	......
	16	......	......	696,400+	361,300+	158,300-	429,400-	311,800-	53,200-	71,800+	188,500-	132,300+	119,000-	......
	17	......	......	745,100-	174,700+	170,800-	119,600-	272,800-	35,000-	60,500-	......	......	90,800-	......
	18	......	......	800,800+	281,600-	150,800+	236,400+	185,300+	31,900-	139,200-	......		108,200-	......
	19	......	......	571,700+	145,000+	174,400-	459,300-	217,700-	33,500-	97,200-	......	......	86,000-	......
	20	......	......	771,300+	182,400+	172,000-	191,500-	276,900+	39,000-	76,000-	176,700+	107,000-	176,700-	......
	21	......	......	540,000+	140,400+	139,900-	396,400+	319,700+	55,600-	107,100-	......	......	86,000-	......
	22	......	......	377,300+	113,800-	121,500+	287,400-	173,300+	54,500	84,400+	209,000+	154,300+	131,300	......
	23	......	......	......	157,500-	70,500+	130,100-	......	63,100-	44,800+	184,200+	74,000+	81,200+	......
	24	......	......	99,400-	247,500+	68,500-	265,100-	224,600+	120,000-	......	......	......	104,000+	......
	25	......	......	215,100+	233,300+	......	271,800-	275,700-	68,200-	......	......	......	79,700-	......
	26	......	......	262,000-	378,000+	61,500-	204,900+	261,900+	85,800-	......	......	......	85,500-	......
	27	......	......	......	......	......	......	......	......	......	......	......	......	......
	28	......	......	484,500+	588,400+	78,600+	......	......	......	......	......	......	......	......
March	1	......	......	347,600-	180,400+	76,800+	169,400+	464,300-	63,500+	50,500+	......	......	73,400+	......
	2	......	......	471,100+	198,700+	38,200+	145,500-	113,900+	68,900+	93,900+	......	51,300+	58,100+	......
	3	541,000-	494,200+	379,000+	321,800+	59,100+	105,200+	134,800-	40,600+	27,500-	52,700+	481-	29,800-	......
	4	304,000-	714,100-	199,000+	145,600+	58,700+	205,900+	172,000+	85,600+	40,100+	107,800+	......	30,700+	......
	5	1,014,000+	536,300+	362,100-	127,600-	33,600-	156,300-	76,400-	50,000-	39,200-	71,400+	63,000-	54,200-	......
	6	1,602,100+	1,114,600+	175,600+	227,100-	69,000-	233,900+	186,700-	105,300+	107,000-	147,900+	135,700+	48,300-	......
	7	873,900-	476,000+	356,600-	260,500-	84,000+	164,600-	159,300-	173,700+	......	......	......	82,100-	......
	8	408,600+	839,000-	188,900-	328,000+	125,900+	232,700+	296,500-	154,500-	......	......	236,700-	72,400-	......
	9	552,400+	4,605,000-	186,100+	315,900+	109,000+	213,800-	250,200+	136,000-	164,200+	......	106,200-	60,800-	......
	10	......	4,633,500+	158,800+	234,000+	171,000+	288,100-	201,800+	255,900-	230,900+	216,300+	216,500-	75,800-	......
	11	......	3,899,400+	156,800-	232,800-	121,700+	203,000+	208,100-	227,100+	191,800-	204,100+	197,800-	96,100+	......
	12	1,614,000+	3,974,800+	244,300-	257,300-	193,500-	178,000-	179,700-	183,200-	190,[illegible]0+	130,600+	186,100+	83,200+	......
	13	1,836,000+	2,858,800+	270,600-	196,900+	172,800+	204,600+	139,100+	229,200+	237,000+	178,600-	241,300-	......	......
	14	4,082,000+	4,612,500+	138,440+	209,300+	355,400+	248,500+	212,600+	246,900-	277,200-	114,600+	227,500-	104,100+	......
	15	5,644,000+	5,691,000-	617,200+	216,800+	513,000+	454,100+	283,000-	485,900+	324,300-	1,566,300+	420,900+	157,700+	......
	16	3,182,000	807,400-	544,500+	245,600+	437,000+	242,500-	297,500+	401,500+	377,900+	411,700+	......	149,500-	......
	17	12,130,000+	7,640,000+	943,600+	279,800+	669,600+	115,500-	486,500+	821,500+	841,100+	586,500+	887,000-	408,300+	......
	18	11,200,000+	33,640,000+	968,000+	291,000-	713,000-	242,300-	345,600+	398,800+	440,800-	351,600+	575,700+	370,600+	......
	19	34,300,000-	......	579,500+	239,800+	576,900+	229,500+	379,000+	596,600-	695,100+	567,000+	559,300+	327,000+	......
	20	27,800,000-	16,300,000+	777,500	184,000+	465,700	206,500+	309,000+	354,000+	474,500+	539,500+	538,500+	431,300+	......
	21	21,450,000+	14,705,000+	601,300+	444,600-	681,800+	198,100+	282,000+	290,000-	345,800-	243,000-	469,500-	252,000+	......
	22	22,600,000+	14,550,000+	535,500+	193,400+	358,700+	133,000+	213,500-	217,000+	368,000+	141,500-	493,000+	346,300+	......
	23	15,000,000-	17,400,000+	508,500+	199,000-	662,000+	147,000+	194,000+	271,500+	315,500+	263,500+	599,000+	404,500+	......
	24	12,450,000+	14,900,000+	510,000-	196,000+	313,000-	174,000-	115,000+	302,200-	175,000-	219,000+	672,000-	298,000-	......
	25	10,880,000+	8,000,000+	546,000+	210,800-	309,500+	117,500-	262,000-	283,000-	288,500+	200,000-	451,000+	499,000-	......
	26	3,450,000-	7,300,000-	270,000+	65,000+	245,300-	132,000-	178,000+	233,000-	236,500-	176,000-	379,000+	215,500+	......
	27	3,480,000+	4,700,000+	287,500-	49,500-	158,000	59,000+	58,000-	147,000	53,300-	59,000+	166,500-	106,000-	......
	28	6,250,000-	2,830,000+	153,500	88,700+	221,500	87,750-	72,500-	251,500-	88,000+	118,500+	131,300-	129,000-	......
	29	275,000+	1,190,000-	486,300-	29,500-	139,000-	80,800-	43,300-	113,000+	47,500-	52,800+	89,000-	58,300-	......
	30	8,100,000+	9,875,000+	328,500+	48,800+	158,700-	119,000-	60,400-	91,300-	44,300-	113,800+	117,300-	63,300-	......
	31	2,033,000+	2,940,000-	275,600-	41,560-	200,000-	89,800+	57,000+	172,500+	81,000-	38,000+	128,500+	61,500-	......

ABSTRACT TABLE NO. 1B—Continued.

		Bear Trap Dam, Drainage Canal, Lockport. Rec. 100.	Desplaines River, Joliet, Ill., at McDonough St. bridge. Rec. 109	Illinois River, 3 miles above Peoria. Rec. 119	Illinois River, 3 miles above Grafton. Rec. 127	Mississippi River, 3 miles above Grafton. Rec. 135	Mississippi River, 17 miles below mouth of Illinois, 1 mile above Alton. Rec. 144	Mississippi River, opposite Hartford, Ill. Rec. 153	Missouri River, at Bellefontaine. Rec. 161	Mississippi River, Chain of Rocks, between intake and Missouri shore. Rec. 170	Mississippi River, Chain of Rocks, near Illinois shore. Rec. 178	Intake proper. Rec. 187	Reservoir, Chain of Rocks. Rec. 197	Tap, City Hall, 11th and Market, St. Louis. Rec. 206
June 1900	1	485,000+	308,000+	118,000+	34,400+	5,800–	9,100–	9,800+	78,000+	37,700+	31,800+	12,500+	10,000+	4,600+
	2	282,000+	590,000+	670,000+	16,400+	7,000+	300–	12,500–	44,000+	24,900+	11,800–	29,400+	12,200+	2,100+
	3	149,000+	19,500+	58,500+	7,500–	4,800–	5,500–	5,500–	34,500+	48,600+	16,200+	22,500–	4,900+	1,600+
	4	415,000+	288,000+	69,600+	9,300+	11,800+	3,100–	3,300+	28,000+	19,100+	22,800+	25,300+	14,300+	1,000+
	5	296,000+	117,000+	85,000+	13,900+	4,900+	....	3,800–	19,000+	49,400+	5,000+	9,200+	3,500+	1,800+
	6	95,000+	189,000+	320,000+	6,000+	4,600+	12,500–	15,200+	41,000+	11,000–	15,500+	15,000+	11,000+	2,700+
	7	196,000+	70,000+	106,500–	6,000+	8,900+	8,100+	7,500+	41,500–	11,300–	4,400+	21,100–	3,400+	1,100–
	8	188,000+	214,000+	77,000–	7,000+	3,700–	12,900+	8,600–	71,000+	15,300+	62,200+	16,700+	37,000+	2,700–
	9	1,770,000+	360,000+	216,000–	6,600+	6,900+	7,900+	4,300–	51,000–	32,300+	30,600+	32,400–	4,000+	1,500+
	10	1,565,000+	109,000+	154,000+	8,700+	2,000	27,000+	7,300+	85,000–	19,200+	41,100+	31,800+	4,700+	2,400+
	11	2,520,000+	136,000–	358,000+	4,000–	17,600–	5,300+	1,600–	57,000+	18,200–	33,600+	39,800+	2,900+	2,800–
	12	805,000+	316,000+	161,000+	357,000+	3,300+	14,300–	2,200+	27,500–	88,300–	12,100+	17,100+	9,600–	2,100+
	13	281,000+	1,275,000–	196,000+	26,600–	23,100+	23,400+	10,200–	47,000+	40,200+	23,300–	48,000+	11,700+	2,700–
	14	378,000+	568,000+	172,000+	16,900+	11,400–	5,000–	2,700+	71,000–	40,500–	29,000+	37,400–	7,100–	1,400–
	15	2,200,000+	400,000–	668,000+	15,800+	48,300+	5,000+	1,600+	64,000–	21,600+	33,200+	12,100+	12,900+	1,300+
	16	4,050,000+	17,800	343,700	15,200+	20,300+	4,400–	3,500+	31,000+	38,000+	12,600+	12,200+	6,200+	1,500–
	17	4,860,000–	135,000+	460,000+	15,800–	24,000+	7,300+	3,100+	87,000+	32,200–	12,400+	21,000–	31,400+	1,400–
	18	380,000–	370,000	405,000+	4,000	10,900	3,800+	3,300+	62,500+	48,500–	29,300+	36,200–	7,100+	1,000+
	19	66,000	83,500–	320,000+	2,300+	12,000+	2,400	3,600	47,500	34,000–	19,700–	25,000	6,000	1,200+
	20	22,000+	58,000–	460,000+	36,500+	12,000–	1,600+	2,100+	25,500+	27,400–	11,500+	17,600–	6,400+	800+
	21	3,700,000+	93,000–	818,000–	5,800–	12,000+	3,600+	11,500–	80,000–	38,700–	9,900+	26,000–	4,600–	1,100+
	22	1,412,000+	87,500–	840,000–	57,400+	2,100+	2,500+	2,300–	78,000–	42,000–	45,600–	29,400–	9,900–	1,000–
	23	1,480,000–	172,000–	2,315,000+	13,800+	27,900+	2,500–	1,600–	43,500+	27,300–	17,100+	27,600+	10,800+	900+
	24	8,250,000+	83,000+	3,780,000+	23,200+	4,700–	9,600+	8,100+	68,500+	41,100+	26,600+	32,300+	18,200+	2,100–
	25	5,480,000+	251,000–	3,830,000–	79,000–	13,200–	15,400+	6,800+	76,000+	60,500+	14,700+	25,600+	8,800+	1,700+
	26	365,000+	90,500+	270,000+	3,600+	9,600+	9,500–	9,600–	158,000+	30,300+	19,000+	42,300–	9,100–	1,800+
	27	665,000+	36,500–	207,000+	7,400–	15,300+	7,200+	....	118,500+	31,100+	13,100+	22,300+	6,600+	650+
	28	92,000+	330,000+	....	5,800–	9,500+	6,500+	4,100+	112,300–	11,900–	9,800+	11,000+	3,600+	500+
	29	4,500+	177,000+	59,500+	8,700–	14,600+	4,600–	4,800+	165,000+	10,500+	9,200+	13,500–	6,400–	400+
	30	....	124,000+	168,500+	15,500–	11,800+	3,100–	3,600+	112,300+	12,300–	4,500+	8,200–	2,800–	600+
July	1	214,000+	60,000–	570,000–	5,100+	7,800+	7,900+	2,200+	60,000–	18,300–	8,000+	18,200+	21,500–	1,500+
	2	1,006,000+	178,000+	550,000–	6,600+	33,900–	4,000–	2,200+	65,000–	13,900+	8,600+	9,100+	3,800+	1,100+
	3	370,000+	180,000+	400,000+	18,400+	12,600+	2,200–	1,000–	93,000+	1,200+	8,100+	14,000–	8,100+	750+
	4	60,000+	44,000+	30,000+	20,600+	....	6,100+	3,600+	18,900+	1,100+	3,900+	10,000	4,800+	650+
	5	4,640,000+	214,000+	754,000+	1,700+	12,000+	2,700+	2,100–	240,000+	2,200+	....	....	5,400+	[illegible]
	6	450,000+	36,000+	960,000+	26,000+	25,500+	....	3,300–	37,500+	1,900+	21,000+	15,700+	6,700+	....
	7	662,000+	36,000+	606,000+	13,100+	18,900+	1,800+	3,000+	67,000+	1,100+	6,800+	8,300+	1,600+	600+
	8	240,000+	110,000+	1,250,000+	17,000+	5,500+	5,900+	6,600–	43,000–	2,300+	6,100+	14,300+	4,700+	2,200+
	9	2,150,000+	226,000+	1,435,000	7,100	19,100–	3,600+	3,500+	47,500+	2,200–	18,000+	14,400+	4,000+	1,400+
	10	133,000+	109,000+	9,460,000+	8,600+	2,100–	3,800–	10,600+	21,000+	3,300+	12,900+	21,500+	8,700+	700
	11	109,000+	149,000+	801,000–	4,000+	16,900–	2,400–	17,300+	18,500+	1,100+	5,100–	8,900–	2,600+	700+
	12	94,000–	105,000–	65,000+	27,900–	5,300–	3,600+	66,800+	28,500	13,200+	7,800+	9,200+	4,200+	1,300–
	13	94,000+	107,000+	376,000+	34,600+	7,700+	10,600–	1,400+	15,500+	18,800+	7,000+	7,900+	6,100+	1,650+
	14	302,000+	79,000+	404,000+	14,800–	16,700–	8,600+	3,800+	62,000+	13,000+	8,300+	28,300+	5,100+	600+
	15	148,500+	27,000+	243,000+	14,600+	30 400+	3,000–	5,700+	52,000+	26,000+	4,800–	9,300+	5,400+	700–
	16	388,000–	55,000–	498,000–	4,000+	72,300+	2,000–	1,800+	28,500+	15,800+	8,900–	4,100–	6,000–	400–
	17	82,000+	102,000+	1,362,300+	41,000–	15,800–	32,000–	....	18,500+	29,600–	12,900+	29,400+	9,400+	400+
	18	405,000+	70,000–	500,000+	11,400–	6,200+	7,400+	3,800–	26,000–	31,300–	11,500–	11,200–	1,000+	600+
	19	444,000+	82,000+	998,000+	11,400+	16,200+	10,000–	3,100+	46,500+	34,500+	8,500+	16,000–	2,800+	850+
	20	84,000+	144,000+	286,000+	11,400+	9,200+	38,800–	9,500–	34,400+	11,700–	2,900+	7,800–	3,900–	600–
	21	146,000+	122,000–	14,500+	3,200–	2,300+	2,800+	3,500–	11,800+	23,500+	10,500–	13,400	2,900+	650–
	22	130,000+	90,000+	50,000+	3,800+	6,300–	31,800+	1,400–	11,900	6,500	4,900+	8,100–	2,000+	800+
	23	99,000+	48,000–	128,000+	8,600+	8,100–	8,200+	3,200–	34,400+	7,600–	2,600+	48,400+	2,400–	350
	24	26,310,000–	70,000–	87,000+	6,300+	5,200+	6,700+	3,100	37,400+	11,200+	1,000+	12,900+	850+	900+
	25	137,000+	95,000–	750,000+	4,400+	2,900+	5,100+	2,000+	10,200–	27,800–	5,600–	13,000–	3,100+	730+
	26	184,000+	71,000–	43,000+	9,000+	11,800+	5,600+	2,800–	22,900–	31,200–	6,600+	15,800+	2,600	750+
	27	644,000–	763,000–	326,000–	1,800+	6,700+	2,000–	2,300–	18,300+	15,600+	5,200+	6,600+	2,000+	750+
	28	870,000+	110,000+	174,000+	38,000+	11,800+	4,700–	2,700+	19,000+	15,000+	4,000–	....	2,700+	1,500+
	29	650,000+	22,000+	42,500+	32,000+	11,800+	4,600+	3,200–	29,500+	6,600+	4,400+	18,300+	5,400+	1,800+
	30	380,000+	35,500+	2,200,000+	18,200+	32,000–	7,200–	3,600+	8,700–	15,800+	3,000–	9,500+	2,500+	1,400–
	31	....	82,000+	620,000+	8,800+	28,900+	2,600	3,100	....	37,000+	4,000+	8,700+	5,500+	1,100+

ABSTRACT TABLE NO. 1B—Continued.

1900		Bear Trap Dam, Drainage Canal, Lockport. Rec. 100.	Desplaines River, Joliet, Ill., at McDonough St. bridge. Rec. 109..........	Illinois River, 3 miles above Peoria. Rec. 119	Illinois River, 3 miles above Grafton. Rec. 127..........	Mississippi River, 3 miles above Grafton. Rec. 135 ...	Mississippi River, 17 miles below mouth of Illinois, 1 mile above Alton. Rec. 144.	Mississippi River, opposite Hartford, Ill. Rec. 153......	Missouri River, at Bellefontaine. Rec. 161..........	Mississippi River, Chain of Rocks, between Intake and Missouri shore. Rec. 170...	Mississippi River, Chain of Rocks, near Illinois shore. Rec. 178..........	Intake proper. Rec. 187......	Reservoir, Chain of Rocks. Rec. 197..........	Tap, City Hall, 11th and Market, St. Louis. Rec. 206....
August	1	700,000+	198,000+	1,185,000+	8,800+	28,500+	1,800+	1,400+	14,900+	8,300+	7,100+	11,600+	5,000+	1,600+
	2	388,000+	50,500+	460,000+	8,800+	48,800+	....	....	18,200+	10,100+	5,700+	5,400+	6,400+	350+
	3	261,000+	2,600,000+	313,000+	9,100+	4,600+	2,400+	1,700+	5,800+	5,800+	7,400+	5,800+	2,300+	1,500+
	4	204,000+	132,000+	139,000+	4,800+	7,300+	1,300+	1,500+	4,500+	8,100+	1,800+	5,700+	1,300+	1,100+
	5	294,000+	29,000+	212,000+	12,400+	7,400+	2,100+	1,200+	11,700+	7,200+	3,200+	3,300+	600+	1,000+
	6	330,000+	51,000+	488,500+	8,800+	19,700+	800+	1,100+	4,100+	5,100+	3,800+	10,500+	4,300+	900+
	7	172,000+	67,000+	47,000+	25,600+	20,600+	1,100+	2,300+	4,100+	7,300+	2,700+	....	1,400+	900+
	8	130,000+	55,000+	158,000+	13,800+	16,200+	900+	850+	13,000+	4,000+	9,100+	6,900+	1,100+	1,300+
	9	325,000+	42,000+	295,000+	13,800+	12,500+	400+	400+	11,400+	7,900+	4,500+	5,100+	1,200+	900+
	10	240,000+	160,000+	68,000+	6,400+	9,200+	600+	1,700+	16,100+	6,300+	3,000+	4,200+	1,900+	700+
	11	279,000+	58,500+	7,700,000+	4,000+	1,500+	1,000+	1,400+	22,300+	8,500+	4,400+	10,100+	2,100+	1,000+
	12	129,500+	57,000+	770,000+	13,800+	7,500+	1,400+	1,900+	7,300+	5,900+	2,400+	2,800+	1,000+	450+
	13	184,000+	351,000+	940,000+	19,300+	20,100+	2,000+	1,400+	5,600+	4,800+	650+	4,300+	2,600+	650+
	14	45,500+	78,000+	570,000+	3,700+	12.200+	1,400+	2,800+	11,500+	41,400+	25,500+	24,800+	4,400+	1,700+
	15	40,500+	114,000+	680,000+	33,000+	17,800+	3,200+	700+	5,300+	2,700+	2,800+	14,100+	4.700+	450+
	16	161,000+	218,000+	290,000+	42,600+	17,800+	1,400+	1,400+	12,400+	3,400+	1,900+	1,600+	3,300+	900+
	17	236,000+	98,500+	1,350,000+	5,300+	35,600+	2,000+	1,700+	1,400+	5,600+	1,600+	2,700+	5,800+	550+
	18	197,000+	30,500+	1,175,000+	1,300+	29,000+	2,200+	1,500+	6,300+	4,200+	2,200+	5,900+	800+	1,600+
	19	126,000+	28,000+	25,500+	2,500+	7,500+	3,600+	3,600+	6,100+	2,100+	1,000+	3,100+	3,000+	200+
	20	1,400,000+	66,000+	6,700,000+	2,800+	4,900+	1,700+	1,200+	6,700+	8,300+	3,000+	4,400+	500+	275+
	21	338,000+	108,000+	298,000+	8,000+	27,100+	3,100+	1,300+	6,900+	5,600+	3,100+	8,900+	1,500+	350+
	22	117,500+	468,000+	388,000+	15,400+	67,500+	3,200+	9,800+	3,900+	3,100+	3,000+	4,400+	1,100+	700+
	23	3,850,000+	99,000+	66,000+	15,400+	5,600+	3,900+	3,800+	3,400+	16,800+	2,600+	9,200+	2,600+	900+
	24	3,300,000+	318,000+	101,000+	2,200+	37,200+	5,200+	4,100+	7,400+	19,900+	5,300+	7,600+	2,300+	1,700+
	25	1,300,000+	120,000+	340,000+	35,800+	20,600+	2,200+	3,000+	6,500+	7,700+	3,400+	3,300+	2,400+	1,000+
	26	244,000+	10,500+	188,500+	15,400+	48,800+	1,400+	2,600+	5,900+	10,100+	1,700+	5,300+	2,400+	700+
	27	2,460,000+	322,000+	1,250,000+	15,400+	53,800+	2,800+	1,700+	....	8,100+	3,900+	6,200+	2,500+	850+
	28	160,000+	204,000+	950,000+	15,400+	134,000+	1,700+	2,400+	7,800+	11,100+	4,800+	11,200+	1,200+	700+
	29	152,000+	83,000+	175,000+	1,700+	10,100+	3,600+	1,800+	9,800+	15,100+	3,000+	8,700+	2,500+	700+
	30	412,000+	55,000+	340,000+	5,100+	16,000+	6,700+	3,300+	8,300+	6,900+	2,300+	....	3,800+	1,000+
	31	....	69,000+	229,000+	26,400+	12,300+	26,500+	1,200+	6,300+	6,900+	1,500+	6,800+	3,300+	500+
September	1	470,000+	33,500+	1,175,000+	10,300+	9,200+	3,500+	2,200+	10,900+	15,600+	21,700+	45,000+	3,300+	9,000+
	2	130,000+	42,500+	4,230,000+	26,400+	32,200+	3,800+	10,100+	46,100+	7,900+	18,500+	7,300+	5,700+	950+
	3	209,000+	82,000+	192,000+	17,300+	11,300+	4,300+	....	9,700+	9,500+	7,000+	5,100+	4,200+	650+
	4	71,000+	57,000+	845,000+	29,600+	17,000+	1,500+	2,600+	6,500+	7,500+	2,000+	6,000+	2,100+	1,000+
	5	240,000+	1,540,000+	2,350,000+	41,500+	9,800+	3,200+	2,800+	10,800+	9,600+	2,100+	6,000+	1,700+	1,100+
	6	186,000+	608,000+	272,000+	15,400+	17,000+	2,200+	7,800+	16,700+	10,900+	1,800+	7,100+	4,100+	1,100+
	7	118,500+	97,000+	890,000+	22,000+	33,900+	1,500+	1,300+	15,200+	16,400+	2,400+	9,900+	2.700+	....
	8	222,000+	2,100,000+	1,000,000+	29,600+	25,600+	1,300+	1,100+	12,000+	11,600+	....	8,400+	3,600+	850+
	9	251,000+	48,000+	508,000+	53,000+	45,600+	1,000+	1,200+	6,300+	22,700+	1,100+	8,600+	2,800+	900+
	10	740,000+	106,000+	455,000+	16,400+	4,400+	1,300+	2,100+	9,100+	5,400+	2,900+	67,000+	....	1,000+
	11	836,000+	134,000+	721,000+	30,400+	4,700+	15,300+	1,500+	6,100+	6,000+	850+	5,400+	1,000+	800+
	12	1,330,000+	210,000+	142,000+	4,900+	3,600+	750+	1,000+	7,700+	4,300+	1,400+	4,400+	1,100+	500+
	13	3,100,000+	218,000+	142,000+	2,000+	5,100+	1,500+	650+	5,800+	5,800+	1,900+	4,100+	1,100+	750+
	14	2,225,000+	2,075,000+	178,000+	3,200+	7,300+	950+	1,000+	4,300+	4,900+	1,200+	3,900+	2,800+	500+
	15	1,040,000+	....	181.000+	7,300+	8,000+	1,400+	1,500+	4,100+	3,800+	1,300+	3,600+	16,000+	700+
	16	2,960,000+	3,230,000+	28,000+	1,900+	16,000+	900+	800+	4,400+	4,300+	800+	4,200+	650+	550+
	17	134,000+	540.000+	115,000+	1,600+	12,300+	1,000+	1,300+	18,200+	7,800+	1,700+	6,200+	2,600+	950+
	18	106,000+	32,000+	117,000+	2,400+	5,800+	1,500+	1,500+	9,100+	7,600+	2,000+	5,300+	4,400+	1,000+
	19	....	....	....	....	....	1,300+	1,100+	12,400+	7,100+	2,400+	9,000+	2,600+	800+
	20	98,000+	114,000+	84,000+	22,000+	6,500+	....	....	....	....	....	....	....	....
	21	322,000+	108,000+	350,000+	1,500+	5,200+	1,800+	2,500+	64,000+	68,000+	87,500+	91,000+	....	1,200+
	22	55,000+	430,000+	326,000+	2,900+	20,800+	1,400+	1,400+	40,000+	21,900+	5,300+	45,900+	5,200+	1,000+
	23	24,500+	1,300,000+	28,000+	7,800+	4,200+	1,900+	6,900+	105,500+	57,000+	22,100+	58,100+	2,800+	1,300+
	24	86,000+	975,000+	218,000+	3,000+	77,500+	4,000+	....	69,300+	....	8,900+	53,800+	....	....
	25	3,390,000+	2,900,000+	1,040,000+	39,200+	12,500+	4,400+	3,200+	64,200+	43,600+	7,000+	38,000+	5,900+	1,200+
	26	740.000+	112,000+	200,000+	56,200+	95,000+	2,200+	3,700+	34,900+	18,000+	8,800+	48,400+	4,000+	1,900+
	27	1,215,000+	434,000+	346,000+	1,300+	3,700+	5,400+	4,700+	48,000+	42,500+	34,000+	34,500+	7,200+	2,000+
	28	174,000+	87,000+	184,000+	1,100+	31,200+	3,400+	2,300+	4,700+	11,600+	4,700+	9,900+	1,800+	1,400+
	29	69,000+	134,000+	81,000+	4,200+	12,800+	7,800+	5,700+	27,000+	18,800+	22,600+	13,800+	26,000+	1,300+
	30	316,000+	77,000+	24,000+	5,200+	9,200+	3,100+	4,200+	28,200+	20,000+	8,800+	21,400+	31,000+	2,600+

ABSTRACT TABLE NO. 1B—Concluded.

	Bear Trap Dam, Drainage Canal, Lockport. Rec. 100.	Desplaines River, Joliet, Ill., at McDonough St. bridge. Rec. 109..................	Illinois River, 3 miles above Peoria. Rec. 119	Illinois River, 3 miles above Grafton. Rec. 127...........	Mississippi River, 3 miles above Grafton. Rec. 135 ...	Mississippi River, 17 miles below mouth of Illinois, 1 mile above Alton. Rec. 144	Mississippi River, opposite Hartford, Ill. Rec. 153......	Missouri River, at Bellefontaine. Rec. 161..............	Mississippi River, Chain of Rocks, between Intake and Missouri shore. Rec. 170...	Mississippi River, Chain of Rocks, near Illinois shore. Rec. 178.....................	Intake proper. Rec. 187......	Reservoir, Chain of Rocks. Rec. 197........................	Tap, City Hall, 11th and Market, St. Louis. Rec. 206 ....
1	1,825,000+	1,125,000+	138,000+	7,100+	26,400+	1,700+	3,500+	16,600+	29,000+	4,000+	19,200+	2,700+	1,700+
2	137,000+	98,500+	266,000+	10,000+	46,600+	3,200+	2,300+	22,600+	24,400+	56,000+	17,000+	2,000+	1,100+
3	186,000+	100,000+	755,000+	13,000+	12,200+	3,600+	3,400+	24,800+	37,600+	9,000+	16,000+	2,300+	1,200+
4	180,000+	140,000+	274,000+	22,400+	11,600+	1,400+	1,000+	30,000+	29,600+	7,000+	21,400+	3,100+	1,800+
5	254,000+	220,000+	790,000+	60,600+	44,000+	1,600+	3,600+	21,000+	15,400+	7,400+	26,000+	5,100+	1,700+
6	204,000+	114,000+	49,000+	1,400+	19,000+	3,200+	3,700+	29,600+	30,800+	2,800+	17,800+	2,300+	2,000+
7	166,000+	68,000+	2,500+	1,400+	2,200+	1,400+	1,600+	22,400+	17,600+	4,000+	10,200+	3,900+	2,100+
8	156,000+	133,000+	5,000+	8,400+	9,400+	1,100+	1,600+	16,800+	10,600+	4,000+	8,800+	3,200+	1,300+
9	58,000+	34,000+	4,500+	400+	4,400+	2,400+	2,600+	26,000+	19,200+	2,600+	13,400+	4,400+	1,700+
10	....	....	....	850+	6,300+	2,600+	1,700+	36,400+	12,600+	2,300+	10,700+	4,100+	1,200+
11	....	....	....	....	....	....	....	....	....	....	7,700+	....	1,600+
12	....	....	....	....	....	10,500+	....	....	....	....	17,600+	....	1,500+
13	....	....	....	....	....	....	2,600	....	....	....	5,600+	....	1,400—
14	....	....	....	....	9,100+	....	....	....	....	....	16,400+	....	2,900+
15	....	....	....	....	2,200—	....	....	....	....	....	6,800+	....	1,400+
16	....	....	....	....	....	....	....	....	....	....	4,600+	....	1,900—
17	....	16,000+	....	....	....	1,300+	....	....	5,400+	2,100+	5,400+	....	750+
18	....	....	....	....	....	....	....	....	4,100+	750+	2,800+	....	1,100+
19	....	....	....	....	....	....	1,700	9,000+	6,400+	2,500	5,300+	....	650+
20	....	....	....	....	....	....	....	....	5,000+	1,300+	4,300+	....	750+
21	....	....	....	....	....	....	....	....	7,300+	1,100	5,800	....	950+
22	....	....	....	....	....	1,300+	....	....	5,300+	6,600+	6,900+	....	750+
23	....	....	....	....	1,800+	....	....	....	7,000+	1,200+	5,300+	....	750+
24	....	146,000+	....	....	....	....	1,600	....	9,000+	1,500+	7,400+	....	1,300+
25	....	....	....	....	....	....	....	29,500+	11,800+	1,200+	4,700+	....	800+
26	....	....	....	....	....	....	....	....	11,600+	1,700+	5,400+	....	900+
27	....	....	....	....	....	....	....	....	24,600+	850+	9,600+	....	1,400+
28	....	....	....	....	....	....	....	....	9,200+	1,000+	7,500+	....	1,300+
29	....	....	....	....	4,400+	....	....	....	14,000+	750+	8,800+	....	1,400+
30	....	....	....	....	....	700+	....	....	23,200+	6,200+	5,400+	....	1,100+
31	....	....	....	....	....	....	3,000+	....	13,900+	2,750+	9,600+	....	1,700+

FOLD-OUT IS TOO LARGE TO BE FILMED

sewerage with the St. Clair river was at the southern border of the park, within 200 feet of the St. Clair river. There was a public sewer leading from that house to the St. Clair river below the intake. The mouth of the sewer in the St. Clair river would be half a mile above the mouth of the Black river. The current of the St. Clair river would carry that sewage, if deposited in the sewer, past the mouth of the Black river. There were experiments carried on to find out whether any of that sewage could get into the water supply. The other case was on Court street, but that was my father's case—he is now dead. I do not know where the discharges from that patient were deposited or whether they were disinfected or not. Another case was 200 ft. from Black river, just above the 7th street bridge, that is below the Fiber Works. It is connected by private sewer to the Black river.

2718 I do not think the discharges of that patient were disinfected. That would be Feb. 6, 1892.

CROSS EXAMINATION By Mr. Todd.

2719 Those were the only cases I had in February, March and April, 1892. I think there were other cases I have had but those were all I was asked to look up. Typhoid fever was prevalent at Port Huron at this time.

2720 OLIVER STEWART. Examined in chief by General Crow.

Am physician. Reside at Port Huron, Michigan. Have lived there 16 years. Practiced medicine there in 1889, 1890 and 1891. In 1889 I had five typhoid cases—in August, 3 cases; September, one case, and one that ran between October and November. In 1890 I had five cases, four in one house in September, and I had one case on 9th street in September. In 1891 I had four cases—one in September that ran into October and in October I had three other cases, one of them being a tramp at the hospital.

2721 I am not sure but I believe one of the houses in which these patients were located had sewer connection. It was

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over at the end of Pleasant street, in 1891. I believe the hospital was connected with a sewer at that time. There were about 20 physicians practicing in Port Huron during that period.

2722 I know as a matter of fact that there were other cases of typhoid in Port Huron besides those I attended.

CROSS EXAMINATION By Judge Johns.

In 1899, one case was that of a colored woman, very poor. I don't know whether they had sewer connection with that house. The house of Gilbert Rogers—another case—I am pretty sure was not connected with a sewer. It was a standing thing for me to leave material to disinfect the discharges.

2724 Those four cases that I had in one family were three boys and one girl. I think the instructions as to disinfecting the dejecta were carried out in those cases. In 1891, in the case of the boy on Miller street, I think the instructions were carried out.

2725 I don't believe the sewage discharges were disinfected at the hospital.

CROSS EXAMINATION By Mr. Todd.

2728 Among those cases that I have given an account of, I believe there are only two from which the excreta emptied into the sewers.

2729 FRANK F. ROGERS Examined in chief by General Crow.

Am a civil engineer. Live at Port Huron, Michigan. Have lived there since June, 1890. Been civil engineer for twenty years.

2730 Black river is a very sluggish stream in most seasons of the year, having no perceptible current, excepting during the Spring freshets and excessive rainfall. (Explains the topographical situation with reference to the location of Port Huron on the Black river and St. Clair river.) The bottom of Black river—the native soil—is sand and clay, having a little gravel and a good deal of soil is washed into it from above. The intake of the waterworks of Port Huron in 1890, 1891 and

1892 was on the west side of St. Clair river a little over a mile north of the mouth of Black river.

2731 The river flows in a southerly direction. The intake is located near the shore. There were no city sewers up the river above the intake excepting what we call the Grant Locomotive Shops, which discharge sewage of a considerable population at times. The city was always given to understand that it was not used as a regular sewer for feces, but I know it was used for urine. It was perhaps half a mile above the waterworks. There would only be a little portion of the territory north of the intake that would naturally drain by washings of rain into the river. The banks are quite high, without any decided slope to the St. Clair river from the waterworks north, until we get up to where a creek known as McNeil creek, used to enter St. Clair river and then the natural flow is along that creek-bed into the river.

2732 In 1890, 1891 and 1892 there were deposits of sewage from Port Huron into the Black river in front of and adjacent to the wharves and docks there. That was removed by dredging in 1892 partly. I think there was a little dredging done in the fall of 1891. The principal dredging was done in 1892. The object was to secure shipping facilities along the stream and also on account of making a winter harbor for vessels. The channel was deepened at that time from the neighborhood of 12 to 16 feet and to the width of 100 feet in the central portion of the river. The material was dumped into St. Clair river. In 1891 there were about 10 miles of sewers in Port Huron and about two miles were added in 1892. All these sewers emptied into Black river.

2733 CROSS-EXAMINATION by Judge Johns:

The Fiber works or Iron Bridge, is approximately a mile and three-quarters from the mouth of Black river. The Government dredged to Washington avenue, which is the north boundary of the Fiber works property, and the channel was 100 feet wide to Suffern street and 50 feet wide from there above. That took it through the built up portion of the city.

At that time all of the sewers emptied into Black river at and below Suffern street. There were six large sewers, not counting some private sewers that I haven't any record of. In 1890 less than one-fourth of the total inhabitants were accomodated with sewers.

2734 The larger part of that was from the better residence portion and the business portion of town. In 1892 the dredging commenced in the Black river in April and continued through the summer season. The dredged material was loaded on to scows and taken out into the river and dumped from the bottom of the scows.

2735 The ordinary lake boats of today or of 1890 could not go very far up the Black river, without this dredging. It is a very sluggish stream. The Fiber works is the principal manufactory on the banks of the river. It deposited the water that came from their process of manufacturing paper cloth into the river. It is dirty and discharged in quite large quantities. There are such fish as German carp and cat fish in the Black river. The ordinary lake fish do not live in it. They do not seem to like the waters.

2736 (Witness explains the drainage areas and the sewage system of Port Huron in 1890 and 1891.)

2739 I saw the material that was dredged when it was passing through the bridges. It was earthy material and such refuse as had accumulated in the river above it.

2740 Like any other river working under a good current, I suppose that the Black river scours the same as any other stream, so that the ordinary sewage deposits in the Black river in times of flood would be washed out to some extent.

CROSS-EXAMINATION by Mr. Todd:

I never made any soundings of the river to ascertain how much of the deposit above its natural bed was created by the sewage discharged into the Black river. I have no definite idea or opinion upon the subject.

2742 The water of the Black river is a dark colored water. The source of the Black river is in mucky swamps.

There is a town of a thousand or two thousand above Port Huron on the Black river about 25 miles up.

2743 The last sewer above the mouth of the river was at Suffern street, a little over a mile from the mouth.

2744 MR. TODD: I move to exclude the evidence of Charles B. Stockwell, Hiram R. Mills, Oliver Stewart and Frank F. Rogers, for the reason that the evidence is incompetent, irrelevant and immaterial.

2745 E. J. HAYNES, examined in chief by General Crow:

Live at Detroit. Am United States Inspector at United States Engineer's office, Detroit. I have been in this same line for 14 years, first as laborer and since 1891 as Inspector. According to civil service rules, an inspector is a man who takes charge of dredging rivers or lakes. He keeps track of the amount of material dug, the positions it is dug in, and makes a weekly or monthly report to the United States Engineers' office in charge of the work. There was dredging done in the fall of '91 and the spring of '92 in the Black river and in front of Port Huron, Michigan.

2746 I was connected with that work. We began that work about the 27th of November. The character of the work we did there at that time was deepening the river somewhere between the mouth and 10th street and the material dredged was taken down to the St. Clair river and dumped, as near as possible over the St. Clair tunnel. There was work done in the spring of 1892 at Port Huron in the Black river.

2747 I could not say just how long it lasted. I went there about the middle of April. I was there for something like two or three months. I had charge of the work as inspector during May of 1892. The material was dredged out of the Black river between Military and 10th streets in Port Huron, and taken to the same place in the St. Clair river. 5,300 cubic yards were taken out in April, 1892. It was done by contract under the supervision of the Government employes.

CROSS-EXAMINATION by Judge Johns:

I first drew my pay as inspector in the spring of 1891. I was not the sole inspector of the work in 1891.

2749 There was dredging done in the spring of 1892 above Military street. In May, 1892, the river was dredged in front of what is called Haynes' Lumber Dock about two blocks above 10th st. The cutting in some places, would be 4 feet, not over that, and the average for the entire

2750 distance up to 10th street, was about 2 feet. This dredged material consisted of some sediment and very little sand and blue clay. Not over one-third would be blue clay. The rest of the dredging would be mixed entirely with a black muck, it is a wash from the marshes above, and I shouldn't think—probably one-sixth of the entire remaining material would be sand. The sediment which is in the bottom of the Black river is partly the wash from the swamps and marshes in which that river has its origin.

2751 There was another contract for the deepening of what they called the Middle Grounds, gravel washed from the rapids of the St. Clair river. These Middle Grounds were directly below the mouth of the Black river on the American side.

2752 There were 5,300 yards taken out of the Black river in 1892. I obtained those figures from the U. S. Engineer's office in Detroit, last Tuesday. I investigated this record at the request of Mr. Gardner S. Williams.

2753 He communicated with me from Ithaca, New York, about the 16th of June. The St. Clair river is about three-quarters of a mile wide at Port Huron. The current is quite swift towards the Canadian shore and towards the American shore there is an eddy that causes gravel to settle on the American side. The dumping was done on the Canadian side. The dumping was done by scow loads and not in one body. The same is true of work done in 1892.

2754 These 5,300 yards were obtained in 1892 from the Black river between 10th and Military streets. 10th street is something over half a mile from the mouth of Black river.

There are ten streets. This dredged material was de-
2755 posited along the line of this tunnel for a distance of
about a quarter of a mile.

CROSS-EXAMINATIONS by Mr. Todd:

I don't know in what months the dredging was done in
1891. I know there was some done in November.
2756 I do not know whether there was any done in December
or January, I believe the season was closed in November,
1891. If that statement is true there was no dredging done in December, 1891, and January, February and March up to the middle of April, 1892. The material that was dredged gave off rather an offensive odor at all times. There was a sediment from all the causes I suppose that ordinarily occur in such a creek, where the sewage and such things were dumped into the river. During the summer months there was no current. In the spring there was a freshet which took the ice and everything out. The character of the soil, excavated between 6th street and the river was the same as that found above 6th street, as I remember. I did not observe any difference in the character of the dredging.

2757 The same characteristics prevailed from the mouth of the river up above the point where we ceased to dredge. This dredging was done immediately in front of the city of Port Huron.

WILLIAM C. TEICHMANN, recalled for further direct examination by Attorney General Crow:

These are 19 charts which were prepared under my direction and supervision by Mr. Alexander Miller and Mr. William H. Getz. They are the ones referred to in my testimony as charts No. 1, 2 and 3, and so on, up to 19. They are made from the analyses made under my direction in this case. They are made entirely from analytical data which I collected from the analyses of samples of water made in the City Chemist's office during the years 1900 and 1901.

2758 (Said charts received in evidence, marked Complainant's exhibits No. 52 to 70 inclusive.)

WILLIAM T. SEDGWICK recalled and examined in chief by General Crow.

When on the stand before, I testified as to the pollution of certain streams which I then named, which had come under my personal observation, which pollution was caused by sewage being discharged thereinto. I have investigated other streams and found the waters polluted. I refer to the pollution of the Potomac river and the effects of this pollution on the typhoid fever conditions in Washington, D. C.

(Witness refers to examination of typhoid records and correspondence had with physicians since the time he testified in this case in regard to the epidemic of Cumberland, Md.)

2759 JUDGE JOHNS: I object to any recitation of facts learned by witness from other source than his own personal observation, etc., and move to strike out the testimony.

MR. TODD: The Sanitary District joins in the same objection.

I ascertained that there was an epidemic of typhoid in 1889 and 1890 in the city of Cumberland, Md. There appeared to have been in January, 1890, 18 deaths; in February, 27; March, 39; April, 8; and May, 5. There was also one death in December, but it was that of an imported case. That was December, 1889.

2760 There was, all told, in the epidemic in Cumberland, 98 deaths from typhoid and although it has been repeatedly stated in the sanitary discussions and pamphlets that there were 485 reported cases of typhoid fever in Cumberland, the number of deaths indicates that there must have been actually nearly double that number. An effect of this epidemic appears to have become marked in Washington in 1890 and to have extended as follows: March, 19 deaths; April, 11; May, 13; June, 33; July, 36; August, 28, and after August, no effect of the epidemic can be traced in the deaths from typhoid fever in Washington. I regard it as a most instructive example of the transmission of typhoid germs in a polluted stream over a long distance, because Cumberland is about 175 miles from Washington by river, and because the river is of such character as to offer a good example of a stream neither very swift nor very slow, but having occasional areas of what might be called slack water; these succeeded by steeper portions, and therefore affording good opportunities for a certain amount of so-called self-purification en route.

2761 (Offers a copy of Dr. Kober's plate showing the unsanitary conditions at Cumberland.) Between October 4, 1889 and March 18, 1890, the sedimentation basin in Washington was out of service, so that the water was delivered to the citizens of Washington without purification of any kind, a fact which no doubt added to the severity of the outbreak in Washington.

MR. TODD: I move to strike out the answer for the same reasons that are stated in the last objection made.

JUDGE JOHNS: The State of Illinois joins in the same motion.

In Senate Document No. 94, 55th Congress, Second Session, Capt. Gaillard of U. S. Engineers, gives the rate of flow from Cumberland to Washington, of the Potomac river to be 4 to 7 days and one of the officials of the U. S. Geological Survey gives it as 2 to 4 days.

2763 (Motion to strike out answer and all recitations and conclusions cited by witness in regard to other experts.)

The population of Cumberland at that time is said to have been 12,000. It is nearly 20,000 today. The epidemic in Cumberland is supposed to have been caused, and in my judgment, was caused by an infection of their own water supply by a case of typhoid fever just above the intake of their waterworks. The source of their water supply is the same stream as that of the city of Washington—the Potomac river.

2764 The number of deaths in Washington during this epidemic was 140, that would indicate 1,400 cases. The population of Washington at that time was 250,000. The problem of the water supply of Washington has been a matter of very grave concern to the citizens of that city. It has long been high in typhoid fever. It has been attributed, in my judgment, and with reason, in large part to the use of the polluted water of the Potomac river. It was recognized that the Potomac is a polluted stream, although there are very few sewered towns upon it, but there are these overhanging privies and the like, and it is anything but a good supply. Steps, however, are being taken at the present time to adequately purify it. They are going to use partly the slow sand filters and when the water is very turbid and clayey, the rapid mechanical filters.

2765 That is the Alton method, so they will have a combination of the two methods of filtration. The Thames in the United Kingdom is 209 miles long, and this epidemic seems to confirm in a very remarkable way that statement of the Rivers Pollution Commission of Great Britain, to which I have referred in my previous testimony, where they said that there was no river in the world that was long enough to purify itself of any sewage introduced into it, even at its source. From my knowledge of the situation and of the conditions that prevailed in 1889 and 1890 in Cumberland and Washington on the Potomac river, this excess in typhoid deaths in Washington is directly traceable to the epidemic occurring shortly before and during a portion of the same period in Cumberland.

2767 CROSS EXAMINATION by Judge Johns.

I made examination of the excess of typhoid fever in Washington immediately after I left St. Louis on my last visit and about the first of June and after I had finished my testimony here in May. I was then in the employ of the State of Missouri and was instructed by the Attorney General to make this investigation. I am still in the employ of the State of Missouri as an expert in this case and expect to be until further notice. I understand that I am acting for and in behalf of the State of Missouri, in an advisory capacity in this lawsuit as as expert.

2768 Washington City receives its water supply at a point called Great Falls, 14 miles above Washington. That information I derived from a report from which I am now refreshing my memory. I understand the tide is felt above Washington, but salt water does not run up above Washington.

2769 At the time of this epidemic I suppose the water was pumped virtually from the Potomac river into the mains of the city of Washington. That is stated in a letter of Capt. Gaillard, U. S. Engineer, dated February 24, 1898, addressed to Dr. Kober the well known sanitary expert who first studied the Cumberland epidemic and who first pointed out its probable connection with Washington. So far as I know, no one has studied it thoroughly except Dr. Kober, and if I may be permitted to say so—myself.

It was Dr. Kinyoun who had grave apprehensions as to Asiatic cholera when it was discovered that there was a case in Cumberland.

2770 He is the only one I know who had such anxiety. I did not talk with Dr. Kinyoun myself. My information as to his grave anxiety arises from reading something that he got into print.

2771 Whether any committee of Congress actually investigated the typhoid epidemic in Cumberland I am not prepared to state. There were 485 cases reported in Cumberland.

2772 That rests upon the authority of Dr. W. W. Wiley of Cumberland. I believe there were 485 reported cases but I also believe that there must have been upwards of about one thousand cases, judging by the deaths.

2773 The drainage area above the intake figures 11,043 square miles. Col. Miller gives the population as 44½ to the

2774 square mile. There is a considerable number of towns above Washington and below Cumberland. There are towns upon the branches of the Potomac river above Cumberland. The valley of the Potomac river is a very rich and fertile country and is thickly populated and has upon it a large amount of domestic animals.

2775 In '89 there was no typhoid fever in any of these towns, save Cumberland, so far as I have been able to learn. I was in Cumberland half a day, arrived at noon and left at night. Talked with Dr. Wiley, Dr. Johnston and Dr. Speers.

2776 There were no health records in the office for any period prior to 1900.

2777 Having learned from the reports of conferences that there was considerable typhoid fever at Cumberland at one time and subsequently a remarkable increase of typhoid fever in Washington, and not knowing as to typhoid fever any place else, I conclude that the typhoid fever in Washington is attributable to Cumberland. I cannot tell why the cases in January in Cumberland did not show any effect in Washington, in February.

2778 In June '89 there was a freshet in the Potomac river, according to the statement of Capt. Gaillard. I do not know whether there was any flood in 1890. I believe that the typhoid fever which occurred in Cumberland in January, '90, contributed to the typhoid fever in Washington in March of the same year.

2779 We have good reason to believe that germs of that disease were deposited in the Potomac water at Cumberland and we know that this water travels down the river and is in part at least, used for drinking purposes by the people of Washington. We find an otherwise inexplicable excess in Washington at a time following, when such increase would reasonably be unexpected.

Q. All the water in the Potomac river at Cumberland had flowed past the city of Washington in the Potomac long before this epidemic or increase of typhoid fever in Washington, that is to say, the water infected, if it was infected, by typhoid fever in January at Cumberland, had flowed past the city of Washington a very considerable time before allowing for the period of incubation, had it not?

A. I should suppose that it must have in a large part. Perhaps entirely.

Q. Then, if the typhoid fever in Cumberland in January contributed to the typhoid fever in Washington in March, the germs must have been deposited somewhere in the meantime?

A. That seemed to me a very decidedly suggestive fact, but I think we should bear in mind that in January it is possible that the stream was tightly frozen and that sedimentation took place to an unusual extent for a time, the so-called self-purification going on. I have no personal knowledge of the Potomac river being frozen between Cumberland and Washington. There is no way of determining as an actual fact, whether any typhoid fever germs were deposited in any of the sluggish places of the Potomac river.

2780 Nor whether they were washed out so as to contribute to the typhoid fever in Washington in March. We can only infer from the end result what may have happened and the belief that typhoid fever in Cumberland was the cause of typhoid fever in Washington is based on the theory that typhoid fever germs will live in water and are transported by water and retain their virulence and that theory in this case must be applied to a distance of 160 to 165 miles.

CROSS EXAMINATION By Mr. Todd.

There was no regular system of sewers in Cumberland in '90, but there were short, private sewers and according to the best information I can obtain, privies overhanging streams then as they do now and draining into the runs which contribute to the river.

2781 I should suppose that one-third to one-half of the population reside immediately upon the banks of the Potomac river and the two little runs.

2782 I have no information as to the number of typhoid deaths that occurred in houses where the privies overhang the stream, or that occurred in houses that used private vaults.

2783 I have no information as to how often the privy vaults of Cumberland were cleaned or renovated.

2786 If there should have been 15 or 20 cases of typhoid fever at Harper's Ferry, as to whether that could be attributed to account for the increase in Washington, would depend upon whether Harper's Ferry had had a similar outbreak before, and if so, what the effect of that had been on the typhoid rate in Washington.

2787 I made no inquiries of anybody except the health authorities of Washington and Cumberland.

2788 I made no investigation to ascertain the number of typhoids between Cumberland and Washington.

2789 ALLEN HAZEN Examined in chief by General Crow. I reside in New York city. Am a civil engineer.

2790 Have studied chemistry, particularly the chemistry of water supplies. (Witness states his qualifications as an expert.)

2792 Am engaged at Ithica now building a filter plant. There was a typhoid epidemic in the winter due to the use of the Six-mile Creek water. I built a filter plant at the State Lunatic Asylum, at Harrisburg, Penna., at West Superior, Wisconsin, at Watertown, N. Y. and at Yonkers. I advised the city government of Pittsburg, Penna. as to the character of their water supply. The water supply of Pittsburg was unsatisfactory because it was sewage polluted and caused typhoid fever among the users.

2793 Have advised in regard to filter plant at Providence, Rhode Island. The Pawtucket river above the intake is polluted by sewage and waste from mills and was unwholesome because of that. The desire for the purification of the water at Washington and the making of plans for filters in Washington, was because of the sewage pollution which that water received. I advised the city of Chester, Penna., in an action which it brought to compel the water company to furnish pure water. Principally the sewage of Philadelphia occasioned the impurity of the water at Chester.

2794 I have advised Trenton, New Jersey with reference to the quality of its water supply. The source of supply for that city is from the Delaware river. The principal reason for wishing to make other arrangements was the pollution by the city of Easton and other cities above. Was member of the Commission to investigate the waterworks of Toledo, Ohio. Those waters are polluted by the sewage of numerous cities and towns up the river. The Maumee river is the source of supply. Had engagement to examine waterworks and report on means for improving them at Grand Rapids, Michigan, Lancaster, Penna., and Millbury, Mass. I advised the town of Millbury in a suit which it brought against the city of Worcester, to compel it to purify its sewage so that it would not pollute the Blackstone river.

2795 Worcester had established a sewage purification plant as it had been required to do as a result of the action which Millbury brought against it. Prior to that time its purification plant was only partial. Since that time the court has compelled a greatly extended and improved character of the plant, so that the stream has been much more satisfactory than it had been prior to that time.

GENERAL HAMLIN: I move to strike out everything in that answer regarding the suits and complaints and results of suits at Millbury.

Was consulting engineer for the Ohio State Board of Health for a few years. I think in 1898 and 1899. Visited Chicago in 1891. I was very much interested in the water question and I met several officers and others interested in the matter and saw something of the waterworks and sewage disposal at that time. In a general way I became familiar with the conditions that then obtained. I did some work with Professor Sedgwick on the question of typhoid in Chicago.

2796 After that visit I secured additional data and worked them up with Prof. Sedgwick and wrote a paper jointly with him upon the typhoid fever in Chicago, which was published. That was with reference to the water supply, and was

in 1892. Later I made a report on the drinking water used in Jackson Park during the World's Fair period. I also wrote a paper jointly with Prof. Reynolds, who was then and I understand, is now Health Commissioner of Chicago, upon the water supply of Chicago. I have made maps showing the location of sewer outlets and water intakes for different periods. These maps were also arranged to show the typhoid death rates.
2797 Have observed the Chicago river and the canal at Joliet. I was at LaSalle in 1893 and examined the waterworks at that time. Saw the Illinois river and the canal. I made analyses of the Illinois and Michigan canal water at that time. I think my last visit to Chicago was January, 1902. I have looked at plans for various parts of the sewerage work in the city of Chicago. I went through part of the large sewer being built on 39th street. Have noticed the condition of the Chicago river before and since the opening of the canal. First visited the St. Louis waterworks in 1896. Was a member of the Commission to report on improvement of the water supply of St. Louis. Appointed in 1901 and reported early in 1902.
2798 Examined the waterworks system, pumping station, etc., etc. Went up as far as Grafton at the mouth of the Illinois river. Investigated sources of pollution above the intake tower upon the two rivers. Made tables of the populations of towns on the banks of the various tributaries and of their distances, from the best data I could get. In making these diagrams and tables we used the data of the Census office, and for the maps and distances, the Census report of 1880 on water power, was very useful. I used whatever Federal Government records were accessible to me. I got the record of typhoid deaths in St. Louis as reported at the Health office. I made no detailed investigation of the methods of securing and recording that data. At that time I studied the relation of Chicago sewage to St. Louis water supply. Since 1901 I have been familiar
2799 in a general way with the conditions in St. Louis. I have paid some attention to the record of typhoid fever

deaths in St. Louis since that date. (Objection and motion to strike out.)

Q. Mr. Hazen, I will ask you what has been the effect, if any, in your opinion, of the discharge of the waters of the Chicago drainage canal, carrying the sewage of the Chicago sanitary district, into the Des Plaines river under conditions existing since January 19, 1900, upon the water of the Mississippi river along the Missouri shore, and particularly as drawn from the intake tower of the waterworks at the Chain of Rocks, with reference to its use for drinking and domestic purposes?

A. I believe that the quality of the water is seriously damaged by this discharge.

2801 I am only familiar with the conditions that existed as to the St. Louis water supply prior to 1901 by records and by a visit in 1896.

Q. Now this opinion that you have given as to the effect of the Chicago drainage canal upon the waters of the Mississippi river at the intake—what was that based upon?

A. It was based upon the facts that the sewage entering the water courses above the intake, was nearly doubled by this discharge; that the distance from Chicago to St. Louis is very considerably less than the average distance of the other points of pollution, from the St. Louis intake; that the mixing of the waters in the channel of the Mississippi is such that the amount of sewage received at the intake is a large part of what it would be if the mixing were complete, and that the times of passage from the point of pollution to the intake were not sufficient to allow the complete destruction of the injurious and polluting matters discharged. The waters of the Mississippi and the Missouri and the Illinois rivers, of my own knowledge, commingle at the intake of the St. Louis waterworks. I know of my own knowledge that the waters of the Illinois river or some portion thereof, pass into the intake of the St. Louis water works.

2802 Q. What has been the effect, if any, in your opinion, of the discharge of the waters in the Chicago Drainage canal carrying the sewage of the Chicago Sanitary District, into the Des Plaines river under the conditions existing since January 19, 1900, upon the water of the Mississippi river along the Missouri shore, and particularly as drawn from the intake tower of the St. Louis waterworks at the Chain of Rocks, with reference to its use for drinking and domestic purposes?

(Objected to.)

A. It seriously injures the quality of the water.

CROSS-EXAMINATION by General Hamlin.

Have been engaged as civil engineer in establishing filtration plants for eight years. During that time have personally, and under my direction, installed sixty or seventy plants.

2803 I have made designs for others which I have not myself built. I was in St. Louis as a member of the Commission, composed of Mr. Williams, Mr. Wisner and myself, for the purpose of making investigations to determine the question how best to supply St. Louis with clear and wholesome water. The discussing and determining the question of filtration was part of the main question. The report we made was divided, Messrs. Williams and Wisner reported for a gravity supply from the Merrimac river and I recommended the continuance of the Mississippi river water with filtration. At that time the intake was established at the Chain of Rocks, where it is now.

2804 I made an estimate of the cost of filtration. I could give you an approximate idea of it,—about $2,000,000 for filtration plant proper, and $700,000 or $800,000 for auxiliary works,—something like $3,000,000 for the whole project required by the present requirement of the city. In a large part my business has mainly been the making of designs and construction of filtration plants. That is the department of my work upon which I am able to speak advisedly. I have not made a chemical analysis or bacteriological examination of the waters at St. Louis. That is not a department of my work. I have made, in years gone by, chemical analyses.

2805 I do not remember how many times I have been employed to advise in suits that were brought by a city against a water company. In all cases that I have mentioned, where I have advised the installing of filtration plants, I have not taken the opinion of others as to the pollution. I usually make a personal examination in each case. In my reports I have depended principally upon my own investigations. As to the pollution of St. Louis I made no chemical analysis of the water because it was not necessary.

2806 Based upon either bacteriology or chemistry I have no knowledge at all other than what I got from some other source. I had analyses from other sources but the deductions to be drawn from those were entirely my own. Take the Ohio case. I had a report of the State Board of Health showing the conditions as they found them and I drew deductions from those reports and the other facts in the case. In many cases my main business was to install filtration plants; I drew the designs, made the plans and estimated the cost and I have superintended the work. In most of the cases I mention I have superintended the work unless I mention otherwise. I have a practical as well as a professional knowledge of the actual construction of this kind of work. It is a large part of my business. I am of the opinion that there should be filtration in St. Louis.

2808 It would cost more to establish a filtration plant, if one was necessary, if the Mississippi did not receive the waters of either the Missouri or the Illinois, because the character of the water off the upper Mississippi is different physically from the water of the Missouri. I have not studied the kind of plant which would be necessary for the Mississippi water above the Missouri but I think it would be very different from the plant required for the Missouri river water. Whether it would cost more or less I don't know at this time. Suppose you eliminate the Illinois river and put in the Missouri and Mississippi river, it would make no substantial difference.

CROSS-EXAMINATION by Mr. Todd.

2809 I first investigated the water supply of St. Louis in 1896. Next was in July, 1901, upon my appointment upon a commission for that purpose.

2810 In 1896 I did not examine it in a way to enable me to have an opinion upon its quality. (States examination in detail that was made in 1901, which is similar to that testified on direct examination.) In examining the waters of the Missouri, I examined the plants of the waterworks at Kansas City, Kansas, Kansas City, Missouri, St. Joseph and Omaha, to find out the character of the Missouri water and the methods which were necessary to treat it and the results which could be secured by those methods.

2811 In my examination of the Omaha waterworks I assumed that the sewage from Omaha and Council Bluffs entered the Missouri. I assumed that the sewage from Kansas City, Kansas, and Kansas City, Missouri, emptied into the river. I assumed that all the cities on the watershed sewered into the water courses. I assumed that this sewage injured the quality of the Missouri river. I did not consider it a safe and potable water and I do not consider it so now. If the Illinois river should be dammed at its mouth and a channel cut whereby it should empty below the intake tower of St. Louis, I would not consider the water of the Missouri and Mississippi which entered the intake tower at St. Louis a safe and potable drinking water. Assuming that a channel cut from the Illinois river should empty into the Ohio at Cairo, thus eliminating entirely the Illinois river water from the Mississippi between Cairo and Grafton, I would not consider the water of the Mississippi at Cairo a safe potable drinking water.

2812 I think that the discharge of the sewage into the Mississippi river by St. Louis and cities in Missouri emptying their sewage into the Mississippi river, as well as the cities on the Missouri emptying their sewage into the Missouri river renders the waters of the Mississippi above Cairo less wholesome and less potable. I cannot say that it renders it unwholesome and unpotable because it may be that it would be unwholesome and unpotable without them. By the comparative term "less wholesome" and "less safe" I mean that it would produce or might produce more sickness and more deaths among those who use the water.

2813 Assuming that the waters of the Mississippi above its confluence with the Missouri and the Missouri above Kansas City were non-polluted streams and assuming that the sewage was discharged into those rivers by the cities in Missouri, I should not off-hand consider the waters of the Mississippi river above Cairo a safe and potable water.

2814 I would not consider the water of the Mississippi river above Cairo under the conditions existing in the last statement, but with the additional information as to the rate of current and time of flow in the Missouri river and the Mississippi river, a reasonably safe drinking water after it had received the addition of the sewage from these different cities in Missouri. A water classed as good 20 years ago is classed as bad now and a water that satisfies us today probably will not satisfy the most exacting people a generation hence. Assuming that in the southeast corner of Missouri a company was about to establish a large city and conditions existing along the Mississippi above that point were such as are contained in the last hypothetical statement made, and I should be selected as sanitary engineer to look out for its water supply, knowing the conditions such as I have assumed them, and before I could ascertain whether this water was going to kill anybody or not, I do not think the waters of the Mississippi, under those conditions would be a safe drinking water for the future inhabitants of this supposed city without being artificially treated. (Objected to by General Crow.)

2815 I would not consider that water a safe drinking water. Assuming that the Illinois river was entirely eliminated from the waters of the intake, I would not consider the St. Louis water a safe drinking water with the water system as it now exists. The cities bordering upon the Illinois river and the conditions that obtained prior to January 17, 1900 would not make the water supply of St. Louis a safe and usable water supply under existing conditions, in my judgment.

2816 The conclusion that I reached in my investigation of typhoid conditions in Chicago in 1892 was that the typhoid resulted from the sewage that entered Lake Michigan and got into the water supply. I presume some one else arrived at that conclusion before Prof. Sedgwick and I did. I was aware that the Sanitary District Act had been passed in '99. The purpose of the intercepting sewer system in Chicago is to keep the sewage of Chicago from entering the lake and diverting it to the drainage canal.

2817 Have investigated the waters of Lake Michigan. If the Chicago sewage was excluded the water of Lake Michigan would be safe and potable. If the Calumet district on the south and Evanston on the north should be added to the sanitary district of Chicago and all that sewage should be diverted into the drainage canal, it would improve the water supply of Chicago. When the entire sewage from the population of Evanston on the north to the Indiana line on the south is diverted from Lake Michigan, the waters of Lake Michigan will become safe and potable, if you go out far enough.

2818 I could not tell you the distance out that you would have to go—not offhand. I would not necessarily consider the location of the present intakes as being a safe distance from shore, owing to possible overflows and the sewage from shipping. I think the completion of the intercepting sewers of Chicago will reduce the typhoid death rate. (Objected to by General Crow.)

2820 So far as the typhoid infection is concerned, the infected sewage of Chicago will be greatly lessened when those conditions obtain.

2821 I have given the subject of the drainage canal and the sewage conditions in Chicago considerable thought and study. The Chicago river enters the drainage canal at Lockport. I do not remember the name of the place where the Chicago river and the drainage canal meet. I do not know the length, the width, the depth nor the capacity of the drainage canal. Dilution of sewage polluted matter, if the water which is used for the dilution is aerated, furnishes more oxygen in proportion to the matters requiring oxygen and so changes more or less radically, according to the character of the changes which take place in the oxidation and fermentation of the sewage.

2822 From my observation of the water flowing out of the Chicago river, as I have seen it in the last few years, it looked to me as if there was dilution sufficient to give an excess of oxygen and I do not doubt that that is the case.

2824 An increased dilution of water to the sewage of Chicago would not lessen and mitigate its dangers to St. Louis. The matters which would cause damage in the sewage which we know most about are bacteria. The typhoid bacteria are the best known and best studied but there is every reason to believe that there are also other kinds which are harmful. I have given their life history, their relations to water supply and disease, study. I have never studied them in a laboratory with a microscope. The explanation I have for the fact that the typhoid bacillus has never been found in the Des Plaines, Illinois and Mississippi rivers is that it is a difficult matter to find it. The amount of water that can be examined effectively for them is extremely small and the infinitesimal proportion of the water flowing and failure to find in the small samples which can be examined is not evidence that it is not present.

2825 The failure to find it is not evidence that it is present.

Sedimentation would remove some of the objectionable matters from sewage and put them upon the bottom of the stream. Aeration tends to purify sewage polluted waters. In my investigation I did not ascertain what facilities existed between Chicago and St. Louis for the aeration of the sewage in the waters, any more than a general knowledge of the conditions and I assume, as I believe to be the fact, that oxygen is in excess throughout. I do not know how far it is from the Chicago river to the end of the canal. I should think that the conditions which obtain at Bear Trap Dam are such that they might tend to greatly increase the aeration and oxidation of the waters. I don't know certainly. I have never seen the conditions which obtain when the waters pass over the Bear Trap Dam.

2826 I don't know what the effect of that waterfall is upon the waters of the canal. After the waters leave the controlling works at Lockport I do not know how far they flow before they enter the Illinois river. I do not know whether there are many lakes along the Des Plaines river. If there are lakes, where the current is very slow, such places would require much more time for the passage of the water and so would afford facilities for purification; it would tend to increase sedimentation and the sedimentation that did settle would be eliminated from the water as it passed off, for the time being. I have never investigated the conditions that obtain in Lake Joliet and do not know whether there is such a thing as scouring which takes place in the lake,—I only observed it as I passed on the train.

2827 From La Salle down, did not observe conditions of the river. Have seen records of how many dams are located in the Illinois river. The effect of those dams is to retard the flow somewhat. Could not say how far from the dams is the effect of those dams experienced by the waters of the Illinois river up-stream. If it should run up from 25 to 50 miles, that would increase the sedimentation when it operated that far. I do not know how long this sewage would have to lie upon the bed of the river in order to be made non-injurious. In the Millbury case, we were confronted by the proposition, backed up by very eminent experts, that the trouble that our people were experiencing, was due to sewage mud which had been deposited prior to a time some years before and that was the cause and the sole cause of the trouble. To some extent the conditions in that river were similar to those in the Illinois river. I believe the Illinois river is a river which is scoured by freshets or high water.

2828 I should rather have the judgment of one who understood the subject and who studied the floods in ascertaining whether the Illinois is affected by scouring. That would be by asking the inhabitants along the river. I would rather have one who understood the subject and who watched the flow of the river in floods. I think that would be more conclusive than the judgment of those who live along the banks.

2829 Supposing there are floods along the Illinois river, the best means of ascertaining whether the bottom of the river where sedimentation has taken place, has been disturbed by these floods, would be by seeing if the current was such that it would stir up and carry away such deposits. By inspection I have no opinion as to what amount of deposit has been made in the Illinois river above the dams. If there was a foot or six feet of sediment on the bottom of the stream above the dams, it could be established by soundings. As to whether deposits are disturbed by the freshets so-called from the Illinois river, I have only my knowledge as to what happens generally in rivers. I do not understand what period of the year the Illinois river flows between its banks nor how many acres of land are overflowed throughout the year by the Illinois river. If it should appear that there was an excess of 500,000 acres of land inundated outside of its banks, the sedimentation would undoubtedly be much greater in that portion of the stream outside of its banks, where the water was shallow and the current was slow. The scour might or might not be less but that I don't know.

2830 I did not examine any waters of the Illinois river prior to 1900 excepting some samples from La Salle. Am not acquainted with the size and dimensions of Lake Peoria, nor the condition of the water before or since the opening of the canal above Peoria, nor whether the water of the Illinois river above Peoria is less polluted today than it was prior to the opening of the canal. I assume that the sewage of Peoria pollutes the Illinois river.

2831 I do not know how many distilleries or factories are located at Peoria. I have no idea of the number of cattle

that are fed along the banks of the Illinois river by the distilleries. I should say that the ratio of sewage of Peoria and Chicago was in proportion to their respective populations. I have no knowledge as to how much of the Chicago sewage has been eliminated from the waters of the Illinois by the time it gets to Peoria. The amount of sewage at Peoria would not be as great as the amount that passes over the Bear Trap Dam.
2832 I do not think that any part of the sewage has been eliminated by the time it reaches Peoria but some of the constituents have been eliminated. I don't know if the pollution of the waters at the Bear Trap Dam would be as great as the waters of the Illinois. I presume that the water that passes over the Bear Trap Dam is more polluted than the water is by the time it reaches Peoria. The lessening of the pollution of the
2833 waters at Peoria is due to dilution, sedimentation, destruction of a number of organic matters by oxidation in the water, and the death of a portion of the bacteria. The water of the Illinois below Peoria would be more polluted than the water above Peoria. The wastes from Peoria probably contain enormous quantities of organic matter which make a perfectly tremendous show upon your chemical analyses, but which from a sanitary standpoint are of no significance whatever. I should suppose that the amount of infected matter brought from Chicago would be very largely in excess of the amount added by Peoria. That opinion is based upon my experience with streams in general, under conditions as I understand and assume
2834 them to be, but not upon any personal knowledge in regard to the conditions that obtain at Peoria itself. The waters of the Illinois river at Grafton, I regard as quite certain—beyond a reasonable doubt—are infected. I don't prove that proposition. I would like to prove it if I could. The proof would necessarily be somewhat indirect and circumstantial. It has perhaps never been absolutely demonstrated. The increased death rate in St. Louis since the opening of the canal is a very strong indication of it. If we eliminate St. Louis for the time being, I don't know about the possibility of demonstrat-

ing it at Grafton. I believe the waters of the Illinois river at Grafton have been proved to be infectious and polluted.
2835 The best available proof is the increased death rate among those who use it. I don't know of anyone who uses the waters of the Illinois river at Grafton, or immediately above it. If it should appear to me that a great number of people fishing on the Illinois river, living in flat boats along the Illinois river—a floating population of several thousand, was using this water for drinking purposes and that typhoid was a thing almost unknown among those people, it would be an interesting consideration and I should consider it.

Q. If you saw these people drinking and knew that these people drank that water and you knew that these people did not have typhoid fever as a consequence of drinking that water, would you not draw the conclusion from that fact, that the water was not infected?

A. If there were a sufficient number of people; if the evidence was clear and conclusive on the point that they drank the water and that they drank it straight, and that they did not have typhoid fever, it would be a very important piece of evidence. If the evidence showed that in the cities along the Illinois river where great numbers of people were engaged in the fishing industry, and that these people should contend that the water of the Illinois river is better today than it was prior to the opening of the canal, and that they drank the water and experienced no deleterious effect from it, it would not be strong evidence to my mind, as a sanitary engineer that that was not infected water. That is an entirely different proposition. The men who use the water as you say, would measure its character by its appearance and the addition of the clear, colorless lake Michigan water.
2836 The fact that a number of people would testify that they drank it and did not have typhoid would be valueless in the absence of the complete record about which you speak, because even with the most polluted waters, a large majority of people drinking such water escape while only a small minority

contract disease and suffer. In order to make the evidence of value, it is necessary to have a definite population and to get the statistics of sickness and death for that population—to show that a large number of people use the water and do not suffer from it, is entirely inadequate.

Q. Then, assuming that you eliminate St. Louis and disregard the evidence of the people who use the water along this river, how can you determine whether or not the water of the Illinois at Grafton is an infected or non-infected water? (Objection by General Crow.)

2837 A. If we eliminated the evidence in this particular case, there might be no proof. We could still form an opinion and back it up on very good grounds, that the water would be injurious, because of the large proportion of sewage which it contains, and the fact that the time required for the sewage to reach that point is insufficient to allow complete destruction of the deleterious matters contained in it. The chemical analyses can never show infection of the water. They can only show pollution and infection can be sometimes inferred from the pollution.

Q. Then the way you ascertain a conclusion that a water is infected is by its use and effect upon the inhabitants, on the people who use it?

A. If that evidence is available it is about the best, usually. If it is not available, we have to resort to indirect methods, methods which have been established by experience in other cases, and which when reasonably applied are reliable. I have been told by people who have studied the matter that it takes the sewage of Chicago two weeks to go to the intake at St. Louis.

2838 I don't recollect how far it is from Kansas City to St. Louis. If it is 400 miles away and the time required for the water to flow from Kansas City to the intake of St. Louis is four or five days, and if you should have in Kansas City 490 cases of typhoid in a year, I think both Chicago and Kansas City would be contributors to the death rate in St. Louis. As to which would be the more generous contributor, Kansas City would be nearer in point of time. In point of population Chicago would be much greater. I should think probably the extra population of Chicago would more than offset the extra time, but that is a matter which from the nature of the case, could not be determined with precision. The nearer the water supply, measured by time, is to the source of contagion, the greater the danger.

2839 If it should be shown that there was a general increase in typhoid over the Mississippi valley co-incident with the increase in St. Louis, it would tend to show that the pollution from the cities up the valley contributed more to the increase in St. Louis, and the addition of the Chicago sewage less, than I should suppose under opposite conditions. I have not given the question of the increase of typhoid fever for 1900 and 1901 in other cities outside of St. Louis any consideration. I understood that in some parts of the country cases of typhoid were brought into this country by soldiers of the Spanish-American war. I do not know what position St. Louis occupied during those years, 1900 to 1902 inclusive, as to being a central point for returning soldiers from this war, to separate and go to their homes.

2840 An increase of 30 deaths in St. Louis in a year is a substantial increase. If the total number of deaths in St. Louis was 168 for a year, as to whether it was an epidemic or not, I would leave to the doctors. The fact of the increase has significance to me as a sanitary engineer but whether it is called an epidemic or not is something which I would not attempt to say. Under our system of registration, the record of deaths is much more reliable than the record of cases. If it should appear that in the city of St. Louis in 1900, 1901 and 1902 the death rate was a gradual increase and the number of cases was a gradual decrease, I should think there was a new kind of germ—a more active kind, that was getting into the water.

I should give the record of deaths much greater weight than the record of cases, because while the percentage of deaths not reported is comparatively small, a large number of cases, even under the most stringent laws in this country are never reported.

2841 Q. It is not an easy matter for an ordinary practitioner to diagnosticate a case of typhoid fever, is it, Mr. Hazen?

A. I understand there is doubt sometimes. Assuming that in St. Louis for these three years particular effort was made by the Health department in sending out letters to all practicing physicians, to report cases of typhoid fever and deaths, and these tables that I have given were the results obtained (See record 2840) I could not accept that record as true, because the ratio of cases to deaths is such that it would indicate a clumsiness on the part of St. Louis doctors.

2842 I recognize the fact that different doctors of different degree of talent have greater or less success in the treatment of typhoid cases. I presume there is a difference of skill.

2843 Assuming that in 1900 in St. Louis there were 1213 cases and 168 deaths from typhoid and in 1901 there were 1101 cases and 198 people died, I should say that the typhoid for those two years in St. Louis was on the increase.

Q. In other words, the more people that die and the less number of cases, would be indicative of an increase in typhoid fever, and if few people died, and more cases prevailed, it would be on the decrease?

A. That would in general be my conclusion, but I think a full accurate statement of that would include data upon both points. I would consider the waters at St. Louis prior to the opening of the drainage canal as dangerous for drinking purposes. There may be additional cost for a filter for filtering bacteria, in the construction of filters, aside from the filtering of mud. In the case of St. Louis, there would not be a material additional expense.

2844 I expect as the water of Chicago becomes less contaminated from sewage by the city, by diverting sewage into the Des Plaines river and the public health of the city becomes improved, the infectious material entering into that river will gradually become diminished. In proportion to its diminishing, in just such proportion does the danger of that water in the Illinois river decrease to those using it so far as typhoid fever is concerned, but as I said this morning, from the best data I can get, where there is one death from typhoid fever, there are several deaths from other diseases shown by the general death rate which come from the preponderance of the diseases there. I would put it this way,—when a city has a bad water supply and does away with it and gets a good one, the general death rate falls. The subject is speculative, to some extent. The question of the effect of Chicago sewage upon St. Louis is speculative to some extent. I saw the mixing of the waters of the Mississippi and Illinois. That is a thing susceptible of demonstration by the naked eye.

2845 The mixing begins at the mouth of the Illinois and is not absolutely complete by the time it gets to the mouth of the Missouri; it is approximately so, and more so at low water than at high water. The Missouri river water entering the Mississippi commingles and mixes before it reaches the St. Louis intake. The proportion of Illinois river water at the intake is variable. It can be substantially demonstrated, but not precisely.

2846 About 30 per cent Mississippi water and 70 per cent Missouri river water enter the intake. I could not say how much of that 30 per cent I would call Illinois water. I could not tell if it averaged 5 per cent. I think it averages something because it mixes with the Mississippi and the Mississippi mixes with the Missouri. It completely mixes on the west side of the Mississippi. I did not follow it down because I regarded it so obvious that it was not necessary to do so. I assumed that to be the fact. I did not demonstrate it. I can see it. I regard ocular evidence as all sufficient for that purpose.

2847 I expect that the Mississippi river water runs up to 70 or 80 degrees in the early spring and down to 10 or 15 degrees in the July rise in the Missouri. It probably varies from year to year—constantly varies. The dike at the intake would have the effect of throwing the water of the Missouri river out towards the intake.

CROSS EXAMINATION By Judge Springer.

I found the water of the Potomac to be somewhat polluted and objectionable.

2848 I recommended filtration—a combined system consisting of the use of coagulants at times of flood only, settling, and after settling, filtering. That system has been adopted as to the filters. The provision for applying the coagulant has never been officially adopted. Where the deleterious properties of water are the result of ordinary sewage pollution from the sewage of cities and towns in the river districts and that only, my system of purification is to filter the water through sand, as is done in Europe, where the conditions are favorable for that.

2849 The pollution that comes from the natural rise of rivers, where rural districts are washed out, and farm and breeding lands and small villages are washed out is an important element. There are saving features, if it comes at a time when the flood is greatest; if that amount of pollution were put in the rivers at low water flow, it would be most disastrous. When I passed upon the question of a water supply for St. Louis I considered particularly the removal of the mud which comes largely from the Missouri, the color which comes largely from the upper Mississippi and the sewage pollution which comes from all of them. It was a system of settling the water first, to remove the grosser matters; then coagulate it; then settle it again and then taking it to mechanical filters and then to clear water reservoirs; then to the pumping stations in the city. I consider that the water after passing through this process would be a satisfactory supply. So far as the large

rivers are concerned, it is true that where I have been consulted in regard to water supplies for cities, I have recommended some kind of artificial treatment before the use of the water, but it is not true with reference to smaller streams and lakes. When I took into consideration the various conditions to be overcome at St. Louis, I was aware that the drainage canal had been opened and that the sewage of Chicago was emptied into the Des Plaines river. Having that in mind and the large amount of water in suspension in the Missouri river and the turbidity of the upper Mississippi, I reached the conclusion that
2851 a wholesome, safe water supply could be obtained for that city by the use of the system which I have described. The cost of construction, including the auxiliaries was something under $3,000,000. I have not the exact figures. Of course, the operating cost would be in addition to that. The cost would not be materially reduced if you could eliminate the water that comes into the Des Plaines river from the drainage canal.
2852 I could distinguish the waters of the three rivers because where they come together, the Illinois river water has a low color and the Mississippi water is yellow. For a little way below you could see nearly colorless water on the Illinois side but it only went down a short distance and went across so that no difference was perceptible. There is not so much difference in clearness but the Illinois river was nearly white and the Mississippi was quite yellow. The cause of that difference in color was the peaty matter in the Mississippi river water.
2853 The Illinois river water was a nicer looking water. I should think that as it tended to increase the pollution of the river it would tend to be objectionable for farming purposes along the line of the river below St. Louis. I presume that it would not be large in its influence below St. Louis, especially for watering stock and cattle.

RE-DIRECT EXAMINATION By General Crow.

No amount of dilution will remove typhoid bacilli from water. It simply reduces the proportion and minimizes the danger of receiving it. Besides putting in filter plants, I have been engaged in purely chemical work also.

2854 That was at Lawrence, before I went to Chicago. My title was chemist in charge of the Lawrence Experiment Station. For five years I had charge of very important chemical work at that station in Massachusetts. I had charge of chemical work frequently in Chicago but I always got some one else to do it for me in Chicago and I have not attended to it personally. I have been consulted and have advised different towns and cities as to the disposal of sewage without reference to the supply of water.

2855 Aeration does not destroy typhoid germs. At the time of the investigation of 1901 in St. Louis, I was familiar with the chemical and bacterial data that was under the control of and accessible to the city authorities at that time and these were taken into consideration by me in my report and in the opinion I have expressed today.

2856 I had the figures as to the width, depth, relative flow of the water and speed thereof, so far as the Drainage canal is concerned and have studied them at various times, but in my cross-examination I did not have them accurately in my mind and could not state them off-hand. The operation of filtration does not absolutely eliminate the objectionable matters in the water. It reduces them very largely, but as the removal is not complete, if the amount of pollution of the raw water is increased, it does increase in some manner, the danger from the use of the filtered water.

2857 I have had records which show that the Illinois river carries suspended matter at times. That would indicate that it scoured. The proposition of putting in filter plants is only one of the different lines of mechanics that go to make up my profession and it is an important one.

DR. W. W. WILEY examined in chief by General Crow.

2858 Am a physician and reside in Cumberland, Maryland. Have lived there 30 years and practiced medicine about that length of time. Am still engaged in regular practice there. Cumberland has a population of about 20,500 and is located in Allegheny county on the north branch of the Potomac river. By rail, it is 153 miles from this city (Washington. D. C,) to Cumberland; by river, it is about 204 miles; by Chesapeake & Ohio canal, it is 184 miles. There is a sewer system at this time in Cumberland.

2859 The typhoid epidemic commenced in Cumberland about the 10th of December, 1889. It first struck my attention when called to see a young man sick with typhoid fever. It continued until June, 1890, and increased in severity. In the early part of January they cropped up and in February more than in January, and more in March and then it dropped off in April and May. After that we had a few cases. There was no health record kept by the city government. There were at least 485 cases reported by the physicians' society. (Motion to strike out by Mr. Todd as incompetent.) There were a great many cases of my own personal knowledge besides those reported.

2860 To be within the limits I would say that I had personal knowledge of 270 cases,—those that I attended and consulted with. The fever was pretty well scattered over the town. Indirectly there was sewerage connection with the Potomac river. There were private sewers running into small streams and they emptied into the Potomac. The town is pretty evenly divided in half by Wills creek, which runs into the Potomac. There is a stream known as Sulphur Run which comes down Fayette street on the west side and joins with the one coming down Green street and they together empty into the Potomac. At that time it was above the waterworks, about 175 ft. above the intake. In December, January, February, March and April there was water in all of these streams.

2861 I know of my own personal knowlede that some of the houses in which people were ill of typhoid fever in 1889 and 1890 had direct sewer connection with either Willis creek or Sulphur Run. At that time the physicians generally ordered the disinfection of the dejecta of patients. They did all that was in their power. Of course in private practice you cannot carry it out rigidly. Where it is attempted to be done it does not result in the destruction of all the germs anyway.

CROSS-EXAMINATION by Mr. Todd.

2862 At that time we had no general sewerage system. Individual sewers were running into this run or into Wills Creek or into a place called Millrix, or directly into the canal. Not over 20 per cent of the population had their closets in their houses. The other 80 per cent used what is known as privy vaults. Many of these were built right over the edge of the streams and it was carried directly into the river. The population at that time was about 12,000 of which there were about 3,600 people adjacent to the streams. I do not know how many people had typhoid fever that occupied houses whose privies overlooked these different streams.

2863 In that part of the city away from the banks of the river, the epidemic was most prevalent. Decatur street, which is pretty far removed from any one of these streams had more of it I think than any street in town. Most of the sewers in that street were private and the household sewage was deposited in privy vaults. Those people on Decatur street almost nearly all used river water at that time.

2864 I don't know what caused the epidemic, only that the people who drank this water seemed to get typhoid fever and when the river was abandoned for drinking water, the typhoid gradually died out.

2865 The nearest town on that river is Keyser, 29 miles above. There were said to be two or three cases there at that time. I made no investigation of it. Cumberland has the Holly water system—the water being pumped direct from the Potomac and forced to the city. Of the 270 cases that I treated or had personal knowledge of, I should say that the fecal discharges of about 70 per cent, if not beyond, would go directly from the house into the sewer.

2866 Hancock, which is 60 miles below Cumberland, soon after we had our epidemic, began to have cases and they accused us of communicating it to them. Exclusive of those cases that occurred in houses where the privies overhung the river, with the water running that way, it would take sewage a very few hours to get from the houses into the river.

2867 The sewage of a part of Cumberland itself entered the water above the intake and the water that got into the intake was contaminated and polluted by the sewage discharged from Cumberland itself. About one-third of the population drain into the river above the intake. At Cumberland the river is 300 yards wide.

2868 The deepest place is about 29 feet.

2869 WILLIAM B. STOCKMAN Examined in chief by General Crow.

Am District Forecaster United States Weather Bureau; residence, Washington, D. C. Have been in the service 25 years. Am in charge of the division of meteorological records. It has a record of the rain precipitation throughout the country. These two charts marked "United States Department of Agriculture, Weather Bureau," show the rain precipitation. They represent the mean annual rainfall of the various places mentioned or indicated. They are copies of the official record.

MR. TODD: I do not object to the form of the testimony but I object to its materiality. (Witness explains meaning of figures, etc., on chart.)

2873 (The figures show the mean annual rainfall at the places indicated for various years to the year 1895. Witness agrees to mail Commissioner Bright the same data for the years 1895 to 1903 for these stations.)

2874 Charts marked Complainant's Exhibits Nos. 71 and 72. Additional chart marked Complainant's Exhibit No. 73.

CROSS EXAMINATION By Mr. Todd.

2875 In getting these averages for the periods that I have indicated, we take the total for the months, and for the annual, we take the annual data. These figures, for instance, Chicago, 34.76, mean the mean annual precipitation at Chicago in inches. That is true throughout.

WILLIAM C. WOODWARD, Examined in chief by General Crow.

Reside in Washington. Am health officer of the District of Columbia. Have lived here (Washington) my entire life, since 1867.

2876 Have been health officer of Washington since 1894. Have practiced medicine since about 1892.

2877 This statement showing the number of deaths from typhoid fever, typhoid malarial fever, malarial fever and diarrhoeal diseases, occurring in the District of Columbia each month from January, 1885, to December, 1895, inclusive, is a correct copy from records in my office. That is my signature attached to the certificate and the official seal of the District of Columbia. (Document offered in evidence and marked Complainant's Exhibit No. 74.)

2878 I have records of deaths from typhoid fever by months from 1895 to 1902 inclusive. (See record pages 2878, 2879 and 2880.)

2881 As a health officer of Washington, I have had occasion to make personal inquiries into the water supply of this city, but I have never investigated the watershed nor personally made bacteriological nor chemical analyses, though I am familiar with the work that has been done along both lines.

2882 My opinion after a careful consideration of the entire subject, is that the chief cause of our typhoid fever is our Potomac river water. Steps have been taken to remedy that. The Federal Government has in course of construction a filter plant to filter the entire public water supply of the District of Columbia by means of slow sand filtration. That was done by Act of Congress. The kind of pollution that renders bad the Potomac river at this point is human excreta, I think, and sewage pollution.

CROSS EXAMINATION By Mr. Todd.

I don't hold myself out as an expert on typhoid fever nor on
causes of epidemics. I don't hold myself out as an expert on
anything. I have carefully studied the subject of typhoid fever
in the District of Columbia since 1894 and I have especially
closely studied the subject of water supply here and elsewhere
and as a result of that study, covering a period of nearly nine
years, I have expressed that opinion. I have expressed
2883 the opinion and I stated my experience. I will leave it
to the court to determine whether I am an expert or not.
The Potomac river water is not absolutely the only cause of
typhoid fever in Washington. We have direct infection of one
patient to another, infection from milk, oysters and vegetables
eaten raw, persons visiting here from other cities, or persons
who are returning from summer resorts who develop the disease
and then we have the class of persons who develop it either from
drinking well water or Potomac river water.
2884 Of course the persons who contract it here and develop
it elsewhere will probably even it up. I have no statistics showing
the number of persons who contract it here and develop it
elsewhere. From 60 per cent to 70 per cent of the total typhoids
in Washington I attribute to the waters of the Potomac and the
other 30 per cent or 40 per cent I attribute to the causes I have
previously named.
2887 In table marked Exhibit No. 73 I have what is known as
typho-malaria and typhoid fever. I regard a case of typho-malarial
fever as a case of typhoid fever in which the physician
has made a mistake in the beginning and called it malarial
fever and he seeks the best way out of the hole. The typhoid
death rate in Washington is high according to the U. S. Census
figures, which I have recently gone over for a purpose other
than this. There were about two large cities that excelled it in
typhoid fever death rate, one was Pittsburg and the other
Atlanta.

2888 I should say that the death rate should run down certainly not above one in 10,000 inhabitants, from typhoid fever.

2889 RE-DIRECT EXAMINATION by General Crow.

There are nine towns on the watershed above our intake.

(Witness gives names of towns, populations and the distance in miles from the intake.)

2891 TESTIMONY OF THE DEFENDANTS.

On board the steamer "Illinois" at the foot of Vine street, St. Louis, Missouri.

AUGUST JOHNSON, Direct examination by Mr. Todd.

I live in Burnesville, Missouri. Took samples of water for the Sanitary District of Chicago opposite Jefferson Barracks in the Mississippi river in 1889 and 1900.

MR. JEFFRIES: I move to strike out the testimony in regard to Jefferson Barracks for the reason that it is irrelevant and does not tend to prove any issue in the case.

(States instructions received and the method of taking samples.) Sent the samples to the University of Illinois, University of Chicago and the health department at Chicago.

2894 CROSS EXAMINATION, By Mr. Jeffries.

Don't know whether the bottles had been sterilized when I received them.

2896 In 1900 collected samples once a week and sometimes three times a week.

HENRY ATKINS, examined in chief by Mr. Todd. (At Mitchell's Point on Mississippi river).

Live at Mitchell Postoffice, Illinois. Live about 150 yards
2897 from the Mississippi river. Was employed by the Sanitary District of Chicago to take samples of water from the Mississippi at the Chain of Rocks in 1899 and 1900. The instructions on the card, sample 2528, are those which I followed in taking the water. Took the water over to Mitchell's and shipped it to Chicago and Urbana. (Witness states method pursued and the places at which samples were taken.)

2900 CROSS-EXAMINATION by Mr. Jeffries.

2901 It would be about four hours before I would get over to Mitchell's with them. Two times is all I can recollect that we missed the train on special collections and had to hold the samples over until the next day.

2904 Collected once a week up to July, 1900. After July, 1900, collected three samples three times each week.

F. M. CALHOUN examined in chief by Judge Johns, (At Alton, Illinois.)

Am a fisherman and reside at Alton, Illinois. Have been employed by the State Board of Health in taking samples out of the Illinois river at its mouth and the Mississippi also. The Illinois river about two miles above Grafton and the Mississippi river about half a mile above the town, across on the other side of the channel of the Mississippi. The samples taken in the Mississippi river were taken above the mouth of the Illinois, that is, from where the Illinois water could not possibly reach the Mississippi water at that place.

2905 (Witness states method pursued in collecting samples and the points from which samples were taken.)

2908 (Cards and envelopes used in connection with the shipping of samples, marked Exhibit No. 1 for the State of Illinois, for identification. Same as to two more bundles of cards and envelopes, marked exhibits No. 2 and 3 for the State of Illinois for identification.)

2909 I lived ten years in Grafton. During that time my business was fishing with nets. Prior to 1900 assisted in putting up ice, every year that the ice was fit to put up during that time. Fished every year for eight years prior to opening of canal and for two years after the opening of the canal.

2910 Prior to the opening of the canal, take this time of the year, in low water, the Illinois river was very stagnant. Not a very good current in it and therefore it was in bad shape. After the canal was opened, it never got so stagnant as it did before. We could fish it different before you turned the canal in than we could afterwards because the current interfered in part of our way of fishing. Of course we all considered it was better by having a good current. Before the canal was turned in, there would be a green scum form over it and you couldn't tell whether it was very clear or not. We had but very little of that afterwards. Used the water for drinking purposes part of the time. The fishermen living on the river in my vicinity use the water of the Illinois river for drinking purposes. (Objected to by Mr. Johns.)

2911 It was better in cold weather for drinking purposes. It was not so good before the canal was turned in, when that green scum was on it. We drank it before and afterwards just the same. Couldn't tell any difference in the ice before
2912 or after the opening of the canal.

CROSS EXAMINATION By Mr. Jeffries.

2914 There is no scum on the water now. The current keeps it carried off. That is about the only difference in the water so far as appearance is concerned. The real difference is that there is a running current now, when before, at times, there was no current. If the back water from the Mississippi stood in the Illinois long enough a green scum would form very likely in hot weather.

2915 That green scum didn't form on the waters of the Illinois when there was no back water from the Mississippi river in there before nor after the opening of the canal. My idea of drinking water is good, clear, pure water; water that is clear and cool I would pronounce good drinking water if it had no stench to it. That is my idea of the Illinois river water. I think it is about as good as any—about as good as well water.

2916 I drink it at any and all times of the year regardless of its appearance. There is considerable more current now than there was before the opening of the canal. The volume of the water coming down the Illinois river now at all times of the year is far in excess of what is was prior to the opening of the canal. There is no back water in the mouth of the Illinois except when the Mississippi river is high. At ordinary stages it runs out regularly down to the Mississippi, with a distinct, rapid current—a fair current.

2917 GUST BAILEY, Examined in chief by Judge Johns.

Am a fisherman, except when I was collecting water. Reside at East Alton. Have been engaged in taking samples of water for the State of Illinois.

2918 (Witness states method of taking samples and the places where samples were taken.) Cards marked Exhibit 4 for the State of Illinois for identification are in my hand writing.

2922 GEORGE BROOKS, Examined in chief by Mr. Todd.

Live in Alton. Collected water for the sanitary district of Chicago. (Witness states methods pursued and places where samples were taken.)

2927 Sample tag No. 2222 marked "Sanitary District of Chicago's Exhibit No. 3 for identification."

2928 JAMES MATTHEWS, Examined in chief by Mr. Todd:

I live on Little's Island just above the bridge in the Missouri river. Took samples for the Sanitary district, the State University of Illinois and the University of Chicago, in 1899 and 1900. (Witness states method pursued and places at which samples were taken..) Card No. 9746 is in my handwriting.

2934 V. J. SCHUMACHER, Examined in chief by Mr. Todd, (at Grafton, Illinois.)

Live at Grafton. Am pilot on the Illinois and Mississippi rivers. Have been pilot for six years.

2935 Prior to that was steamboat engineer or mate, either one, for 14 years on the Mississippi and Ilinois rivers—mostly on the Illinois. Have been acquainted with the waters of the Illinois river for 32 years from St. Louis to LaSalle, Illinois. Prior to the opening of the canal the water of the Illinois river was green. The water from—well, we will say from Beardstown up—it stunk. We could not drink the water, it would foam the boilers, but now we can go along and drink the water. We pump the water and use it on excursion boats—before we could not.

2936 Before the canal was opened it had a green scum on it. It smelled bad. It was not fit to drink. We would have to get water from the shore, but since the drainage canal has been opened we don't have to do that. Before the opening of the canal we would find dead fish floating in the river—tons of them—floating in the river above these dams. Since the opening of the canal we have had better water and better fish.

MR. JEFFRIES: I move to strike out the testimony of the witness that water is purer since the canal was opened than prior thereto, for the reason that witness is not qualified as an expert.

Those dead fish were found at Copperas creek dam and also at the dam below Beardstown, also at Kampsville. We found them up there every time we would go through. We found the green scum plumb up to LaSalle. It would generally go down about to Alton before it would begin to vanish.

2937 I don't know that there would be much difference in the water at Grafton as compared with that at Beardstown and at Pekin. Of course, further down the river the water would naturally become more pure on account of the current in the river. Those distilleries at Peoria would have great piles of stuff in the river. It would lay there and a steamboat would come up and throw great mounds of it up into the river and the water would stink. We don't see that any more. The water was always better above Peoria than below. It was some better than it was below because it was stiller up there, because the sewage business could not go up the river and consequently it didn't have this bad green smell and look to it that it had below Peoria always. We find we have a good deal better water in the channel now than we had before. Before the opening of the canal we never drank the water at all. We would dig holes along the banks or the shore, or sink pumps down and get the water that way.

2938 In my opinion as a layman and a man who has observed the conditions along the river, the water has been better since the opening of the drainage canal. It has been better to drink and better to use in every way. The green scum has not entirely disappeared but more so than it ever was before. The odor of the water has disappeared and the water has become clearer than heretofore.

2939 I believe the water at Grafton is better now than it was before. There is a good deal of difference between the water at Grafton and at Pekin. It is like a man taking a drink of river and taking a drink of spring water, like where there has been rotten fish or somebody had been laying in it. I would not want to drink the water there. Here, we drink the water all the time when we are out in a skiff. I do not know how many people live along the Illinois river from LaSalle to Grafton in fish or flat boats, engaged in the fishing industry, who live upon the river and drink the water of the river—there is too many of them. There is more than I could tell you. There is so many that live upon the river in cabin boats that I couldn't tell you and tell the exact number that is there.

Q. Does it run up in the thousands?

A. Well, it gets pretty close to it I believe, yes sir.

2940 CROSS EXAMINATION, By Mr. Jeffries.

I have known this river 25 years. A green scum formed on the Illinois river prior to the opening of the canal during the summer season or late in the fall until the ice would drive it out. It extended from bank to bank all up and down the river.

2941 We have a current now and we have a little scum now. There has been no scum to any great extent. There are no additional waters coming into the river today other than those from the drainage canal. The water from Lake Michigan coming through the canal is the cause of the additional volume of water in the Illinois and the current that now exists in the river.

2942 The current purifies the water. Where there is no current there must be stagnated water. I am not attempting to give the reasons why the water since the opening of the canal is better than it was before. I am simply stating what in my opinion is a fact.

2943 The main reason I say the water is better is because the water is better and I know it is better from using it and the hundreds and hundreds of people that we carried on the steamboats using the water and not kicking against the water.

B. F. ROBINSON, Examined in chief by Mr. Todd.

Live at Grafton. Took samples of water for the Sanitary district of Chicago, Chicago Health Department, University of Chicago and University at Urbana. (Witness states method pursued and places where samples were taken.)

2948 JAMES M. ALLEN, Examined in chief by Judge Johns: Reside at Grafton. Am retired miller and President of the town council. We were formerly located on the Mississippi river but since the Government has built dikes between Calhoun county and the island opposite, we are now located on the Illinois river. Formerly the mouth of the Illinois river was two miles or more above Grafton. Have lived here 56 years.

2949 Prior to opening of the drainage canal the water in the Illinois river at times was almost stagnant. At times there was an odor. The water was not used for drinking purposes, when we could help it. Frequently it was covered with a green scum. At the times I have seen it since the opening of the drainage canal it has been better but whether it has always been better I couldn't say.

MR. JEFFRIES: We object to any testimony from this witness upon the character of the water for domestic or drinking purposes, for the reason that he has not qualified as being possessed of sufficient scientific knowledge to express an opinion or belief as to the sanitary condition of water; for the further reason that experience shows that various people will insist upon drinking certain water known to be diseased and infected, with no other excuse than that the water is clear water, and for that reason the testimony of this witness as a layman is immaterial, irrelevant and incompetent.

It is agreed that the above and foregoing objection shall apply to all testimony of all witnesses whose testimony is taken upon the Ililnois river, who are not experts, and that this objection shall be treated and considered as applying to all such testimony, without its being further stated. (F. S. B. Com'r). It was purer and looked better. Grafton's supply is from wells and springs. I do not think any portion of the population obtain water for domestic purposes from the river.

2950 As a usual thing it is Illinois river water that is next the shore on the Mississippi river at Grafton. There are times though, when the Mississippi river predominates, that is, where there is a rise in the river and the Mississippi is higher, the current comes through to this shore and we get Mississippi water, frequently backing up the Illinois river for some miles. There is a population in and about Grafton engaged in the business of fishing. I suppose to a certain extent they drink the water of the Illinois river since the opening of the canal. Since the opening of the canal there has been stagnant water having a green scum upon it in the river near this point. That was in 1901 I think, along in the summer months; it was unusually dry.

CROSS EXAMINATION, By Mr. Jeffries.

I say the water is better for the reason that there has been a larger body of water and the current has been stronger.

2951 It is perhaps a mile and a half. I always have believed that water will purify itself in a running stream. The water has a better appearance and is not sluggish and there is not as much of that scum on the surface as it formerly had. When I speak of the water of the Illinois river being better now than prior to the opening of the canal, I speak simply from my observation of the water rather than from its use by me.

Grafton has a population of 988.

2952 WESLEY PARK, Examined in chief by Mr. Todd.

Have lived in Grafton 14 years. Am practicing physician and surgeon and have been for 43 years. Am acquainted with the Illinois river between Grafton and Hardin, but not much above Hardin. Hardin is about thirty miles from here

by river. I did not notice any difference in the water at Grafton and Hardin prior to the opening of the canal.
2953 Since the opening of the canal the water at Grafton is better, purer, cleaner and has greater current. Before the opening of the canal the water at Grafton was sluggish, had more or less grenn scum and moss, the current was not as swift and the water was more of an impure character. There are two doctors in Grafton. I cannot call to mind any case of typhoid fever among the fishermen in the last three or four years. I don't know of any cases that I have attended during the last three years that I could attribute to zymotic causes—that is, of typhoid character that could have been caused
2954 by drinking Illinois river water. Between here and Hardin I certainly know of fifty fishermen engaged in the fishing business. From a knowledge based upon appearance and a use of the water, I would say that the waters are much better than they were before the canal was opened and I mean by that, its appearance. It has a purer appearance.

CROSS EXAMINATION, By Mr. Jeffries.

2955 I have not noticed any green scum on the river now. It does not form now because the current is swifter. It is said now that the current is about six miles an hour. I do not think it used to be six feet an hour thirty years ago. At that time I used to cross over to Hardin and go back and forth in the same track where the canoe had parted the scum hours before. The year prior to the opening of the canal the condition was the same.
2956 The increase in the volume of water and this increased flow of the current is caused by throwing the water from Lake Michigan into the canal. The people at Grafton get their water from wells and springs.

RE-DIRECT EXAMINATION, By Mr. Todd.

Mr. Meysenburg has a pump with which he lifts the river water into a tank and I piped from his tank to my residence. I have used that water for five or six years for stock. I never have used it for washing purposes. I do not use it as a beverage or for cooking. That water has no injurious effect upon stock. A family living close to me use it for domestic purposes.

RE-CROSS EXAMINATION, By Mr. Jeffries.

I suppose that tank holds ten or twelve hundred gallons. The water is pumped into the tank and allowed to settle; during hot weather we run one or two tanks full a day.

2957 That tank was in operation prior to the opening of the canal and the water in that tank is put to the same use now as it was when it was built, and no other use.

E. MEYSENBURG, Examined in chief by Mr. Todd.

Have lived in Grafton since 1867. Am sole proprietor of the Grafton bank and am in the merchandising business. I have always been fond of the river. I keep a boat of my own and have always spent considerable time fishing, hunting, etc., on the river. I live on the bank of the river. I am familiar with the river up from Grafton I should say 14 miles.

2958 Since the opening of the canal the water is not stagnant as it was previous to the opening of the canal. To my mind it looks much better. My well and cistern were flooded during this high water and I used water out of the elevated tank for domestic purposes during that time, which was since the opening of the canal. That water came from a well that was fed by the river. It was June 11th when the water flooded my well. I have used it up to the present time (July 14) but had my well cleaned out today. My family has used it to a certain extent.

2959 There has been nobody sick at my house. Prior to the opening of the canal the Illinois river frequently looked like a stagnant pool. There was a scum on it such as would form on a pond that had no current in it. There is now a decided current in the river. As to the fishing industry here, I have known as high as 12 tons to be shipped from here in one night. Fishing is queer business. The fish sometimes run for a week or two and then again the catch is very small, but the fishing industry is quite an item here. The Illinois river is quite a prolific fishing ground.

CROSS EXAMINATION, By Mr. Jeffries.

The well that I said was fed from the river was fed through some source under the ground.

2960 The water that came from this well I am convinced is river water filtered through the soil. I did not go out into the river and dip the water up and use that water. When I say that the water in the Illinois river is better since the opening of the canal than prior to the opening, I base my opinion partly upon the fact that the water is clearer and free from scum and partly from the fact that I believe running water is better water than stagnated water. My opinion is that swift running water polluted 200 miles above where it is to be used, is good water to use.

2962 JOSEPH SPANLE, Examined in chief by Judge Johns.

Have been a fisherman since 1851. Live at Grafton at the present time. Have fished in the Illinois river since 1857 but I couldn't say much about the water in the Illinois river before the canal opened, either way. Sometimes the water got too low. It didn't smell much but it did get kind of still. There was no current in those days. It had a green scum on it in the summer, lots of it, sometimes. It was no good to drink at that time, that is in the part of the year when it was low.

2963 It was a natural color. I couldn't see no difference in the color much. Before the opening of the canal moss and slime got on our nets, some little moss yet comes once in a while but the current washes it off more. I have not drunk the water since the canal was opened. In the winter time when it was cold enough to drink, I have. The water looks more clear now than it was.

Q. You are a German and do not speak English very well?

A. Well, I used to come from France. They used to call me a Frenchman. The State used to belong to France where I came from, but now the Germans took it away from France.

CROSS EXAMINATION, By Mr. Jeffries.

There is a good deal more current now than there was before the opening of the canal. I live here in Grafton. I have a well at my residence.

2964 I don't use the water from the river at all when I am home, but when I am out I do use it sometimes.

DANIEL HEATH, Examined in chief by Judge Johns.

Reside at Grafton. Am a fisherman. Have been a fisherman for twenty odd years. Have fished in the Illinois river during this entire time. Before the opening of the drainage canal after the spring freshets in the summer time there was no current. The river was dead. It used to have a green scum on it just like a pond in the summer time. We used to

2964 drink it in the cool weather in the summer and fall. Before the opening of the canal there used to be a green scum gather on our nets. It would hang down in tassels. In the summer time when it was stagnated it would smell. Since the opening of the canal we have always had a current in there and the water always seemed to be purer because the current was in there. It kept the banks washed off—the current you know. I drink the water now in the spring and fall and winter —in the hot weather we don't drink it.

2965 Am acquainted with a good many of the fishermen on the river up as far as Kampsville. Since the opening of the canal there has been but very little moss on our nets. The slime that hung down in tassels is not so bad any more. I do not remember of the fishermen having typhoid fever since the opening of the canal. I cut ice nearly every winter for a week or so here at the mouth.

2966 The ice that I cut would be of Illinois river water. It seems to be about the same now as it was before the opening of the canal.

CROSS EXAMINATION By Mr. Jeffries.

My opinion is based altogether on the appearance of the water. There always is a great deal more current now than there was formerly. We always have a high current only when the Mississippi is the highest and backs it up.

2967 I have a cistern at my house. We get the water out of a well but I haven't any myself. Only use the river water when I am on the river working.

GEORGE SEIK, Examined in chief by Judge Johns.

Live at Grafton. Am a fisherman. Have been a fisherman since 1892. Have fished in the Illinois river every spring. Before the opening of the canal the water in the summer time was a good deal like a pond. The current would leave it and a green scum would come over it. When we had a heavy raise, there would be a good deal of current in the river. The water would smell like stagnated water in the summer time.

2968 The water never smelt in the spring of the year but when it had this green scum on it it smelt like a stagnated pond. The water had a kind of milky color as near as I can tell. Before the canal was opened we drank it right along in the spring and fall. In the summer time we wasn't in the Illinois very much in the hot weather. If we should happen to be there and had no water we would drink it then. In the fall of the year there would be moss on the nets. Since the opening of the canal there has been more current, therefore I think the water is purer than it was before. I do not know that it is any better to drink. The water tastes cool and it must undoubtedly be better to drink because there is more current in the water. It is a purer water.

2969 When the river raises it muddies up and when it falls, it clears some, but whether that is the fault of the canal or not I do not know. There are 20 or 30 fishermen from my own place. I don't know of any typhoid fever among the fishermen in the last three years.

CROSS EXAMINATION, By Mr. Jeffries.

I don't know what typhoid fever is. I am not posted on the disease whatever. As I said I do not know of any one having it. By pure water I mean a clear running stream, I think is pure water.

2970 We use cistern water at our house most of the time. I do not use the river water all the time, only when I am on the river; I use it in the spring and fall. There is more current in the river now. The current lasts longer.

ALBERT FREIMANN, Examined in chief by Judge Johns.

2971 Live at Grafton. Have been a fisherman 19 years. Fished in the Illinois river during that time. Before the opening of the canal the Illinois river would be kind of stagnant during the summer season. When it got down low it was a kind of a dark black. In that condition it smelled like a pond or an inland lake. The moss and stuff would get on to our nets. We drank it in cool weather. Since the opening of the canal the water seems to be much purer than it was—more current I suppose, is the reason. I drink it since the opening of the canal during the cool weather. It seems like it is a kind of milky light color. In cold weather all the fishermen that I know of, drink it.

2972 No one that I know of has typhoid fever. I have cut ice here every winter that they cut it for over 20 years. I don't know as I notice any difference in the ice now to what it was before the opening of the canal. Moss hasn't as yet gathered on our nets since the opening of the canal. I have fished up the Illinois river 15 miles.

CROSS EXAMINATION, By Mr. Jeffries.

The water isn't exactly the same color as it was. I never paid much attention to the ice. Before the opening of the canal the water was of a rather dark color and since the opening it has a kind of a milky-like color. It looked like you might take a drop or two of milk and drop it in a glass of clear water—just changed about that much from clear water.

2973 Am a married man. Use well water. Don't use water from the river at my house, only use the river water when I am out fishing. By pure water, I mean water fit to drink—healthy—I suppose would be pure water. It seems that since the current has been there it was more pure than it was before.

It seems that there was more chills and fevers around town before than there has been since. It was kind of an ague fever I guess, it wasn't typhoid fever as I know of.

2974 I judge the drinking qualities of the water from its appearance.

WILLIAM WRIGHT CRANDELL, Examined in chief by Judge Johns.

Am a fisherman. Reside in Grafton. Have been fishing since 1896 in the Illinois river above Grafton. Before the opening of the canal, water in the Illinois river was stagnated, unless we had a head raise. It was dark in color. It didn't have a pleasant smell by no means. It affected the nets pretty badly. It covered them all over. It was mostly slime first. It would come on the net and hang down in pieces that long (indicating) as thick as your finger and then the moss would come and cover the nets so heavy you scarcely could lift them.

2975 It wasn't so good to drink then. I have fished there now since the opening of the canal, within the last two years, in April and up to that time the water was pure and reasonably clear, with the exception of the leads that would run into it, you know, and in heavy rains. There hasn't been any odor to the water since. The fishermen on the Illinois river who drink its waters have not had typhoid fever.

CROSS EXAMINATION, By Mr. Jeffries.

The water wasn't as good prior to the opening of the canal as it is now, because if you take a spring or a pool, if it hasn't an outlet and a stream to flow to, it is impure, and before the drainage canal we had no current in the Illinois river at this time of the year. We now have the last few years, all the year around, a right good current.

2976 Before the opening of the canal it was dark in color and now it is a kind of clear, milky color. Am a man of family. We use well water. Don't use river water at my house. My family doesn't use it.

CHARLEY JONES, Examined in chief by Judge Johns.

Live in Grafton. Have been a fisherman for about ten years. Fished on the Illinois river more or less every year. Before the opening of the canal the Illinois river was generally dead water. Since the opening of the canal there is generally a good current and it throws off all that green scum and things of that kind.

2977 Before the opening of the canal there was no current and in taking up a net there was a kind of slime and sediment all over it. Since that, there hasn't been so much of it. Have helped to put up ice. Where there is a curent there is bound to be purer water and bound to make better ice. Before the drainage canal was opened the water had a smell. Since then it has none that I have noticed. The fishermen on the Illinois do not have typhoid fever that I know of.

CROSS EXAMINATION, By Mr. Jeffries.

We use well water at home.

2978 We don't use river water. Prior to the opening of the canal the color of the river was kind of milky. Since the opening of the canal I should judge the water would be better to drink. It would be purer. There is a current to drive that stagnated water off, that slime, etc.

THOMAS COCKSCHOTT, Examined in chief by Judge Johns.

Live at Grafton. Am a fisherman. Fished in the llinois river every season for 20 years.

2979 Before the opening of the drainage canal, the Illinois river after the spring rise was dead. Now there is a good deal of current in it and has been for the last three years. Whenever it comes a raise it is a dirty color, it is muddy and dirty. It is clearer now than it was before the opening of the canal. There is more the color of lake water in it when there is no raise. I drank it before the opening of the canal. In hot weather, when it was warm, it was pretty tough to drink. It is better to drink now than before the opening of the canal. It is clearer. The moss on our nets before the opening of the canal was worse than it is now. I have engaged in put-

2980 ting up ice. I believe it is clearer now than it was before the opening of the canal. Fishermen on the Illinois river haven't had typhoid fever either before or since the opening of the canal that I know of.

CROSS EXAMINATION, By Mr. Jeffries.

At home we don't use the river water. We use a cistern.

2981 MARTIN GILMORE, Examined in chief by Judge Johns.

Live in Grafton and am a fisherman.

2982 I have fished in the Illinois river every year for 12 years.

Before the opening of the canal the Illinois river at certain seasons the water was dead. There was no current. It had a scum on it. Since the opening of the canal there is a pretty fair current in there all the time. We never see no scum up there now. When the water is down pretty low it is clearer than it used to be, but when there is a rise in it it looks just the same as ever. Before the canal was opened there was times that slime and scum smelled very bad, when the water was dead and had no current. We seined up there one year when there was no current and we couldn't seine over three or four hours. If we would catch any fish we would have to come down here and ice them. They would spoil right away, but since the opening of the canal it seems like the fish live better. I have drunk the water both before and since the opening of the canal. The water seems to be more clearer now than it used to be and it is clearer.

2983 I never heard of fishermen in the Illinois river having typhoid fever. I have never known of but one fisherman to die around here that I can remember and he was an awful old man. Have engaged in putting up ice and it seems to me the ice is clearer than it used to be. There aint the dirt in it and there aint as much drug in it as there used to be.

CROSS EXAMINATION, By Mr. Jeffries.

There is a good current in the river now. Before the opening of the canal there was times there was no current unless there was a raise out of it. There is always some current now.

When I say the water is better now than it was before I say it is clearer looking, it aint stagnant, it is running water.

2984 WALTER RICHEY, Examined in chief by Mr. Todd.

Am a fisherman. Live at Grafton. Have lived here 23 years. Have been engaged in fishing 14 years. Am acquainted with the Illinois river from here to 12-Mile Island, which is 12 miles from here. Before the opening of the canal there was a slight current in the Illinois river and it was stagnant, like a pond most of the time in the summer and fall. There was a green scum in low water when the current was slack and where the water would flow away from the mud, it smelled bad. If we put fish in a float box then, they didn't seem to live as well. There was no current and it seemed like they were softer. They didn't live as well in the nets.

2985 I think the water is purer now; clearer, more pure than it was. It is a different color. I don't think it gets green now in low water time. I haven't seen it that way in the last couple of years. The opening of the drainage canal and the turning of the waters of Lake Michigan into the river has put the river in better shape and I think the water is in better shape. It is more purer than it was. I always drink the water in the cooler season of the year. We always carry water with us in warm weather. When we carry water we don't carry ice. About 30 or 35 fishermen fish upon the Illinois river from Grafton. I don't know of any fishermen having typhoid fever from drinking the waters of the Illinois river since the opening of the canal. I don't know of any fishermen having had typhoid fever during the last three years. I don't know that the water of the Illinois river which I drank had any effect upon my health.

CROSS EXAMINATION, By Mr. Jeffries.

2986 Am a married man. Use well water at my house. My family uses well water at my home but they use river water when we are on the river. I live on the river part of the time. The water is a little muddy now. It is more muddy when it is raised than it was before the opening of the canal. It has a milky color. It used to have a kind of green moss on it.

2987 Pure water is running water, water that looks purer, I think it is more pure than water with a green scum or that looks kind of green. That is my reason for saying it is better water.

R. A. SAWYER, Examined in chief by Mr. Todd.

Live in Grafton. Have been a fisherman for ten years. Fish in the Illinois river every spring. I think the water is in better condition now than it was before the drainage canal was turned in.

2988 Before the drainage canal was turned in, it was like a lake or a pond. Green scum on the water and moss all over the shores. The water was really a dark green and today the water is clearer and purer looking than it was before. I prefer drinking it now better than then, as far as I am concerned. I drink the water in the spring of the year. Haven't experienced any ill effects from the water since the opening of the canal. The fish live better today when we take them out of the net than they did before. It don't form a scum on the nets like it used to. I never knew but one fisherman to die since I have been in Grafton and he died with the heart disease. He was about 65 or 70 years of age.

2989 CROSS EXAMINATION, By Mr. Jeffries.

Am a married man. Use well water at my house. I say the water is purer now than it was before the opening of the canal because it looks purer and clearer when you look at it. I have drunk the water both before and after when it was cold. That is the only way I can tell it is better now than before. There is a current now. Before the opening there was a current when we would have a rise, but the majority of the time there was no current in the Illinois.

ALBERT LEE, Examined in chief by Mr. Todd.

Live at Grafton, am a fisherman.

2990 Have fished about 15 years. Most of the time I was fishing on the Illinois and part of the time in the Mississippi. Before the canal was opened, the Illinois river water, when the water would get low, it would get very stagnated and would get a kind of green scum, and would smell very bad. When we were seining up there in the fall of the year, it would be nearly impossible to keep our fish alive. Since the opening we have always had a pretty fair current in the river and the water has been more clear except when there would be a rise in the river, and it was better water and more pure. When I am out fishing, I drink the water but when the weather gets so warm we quit drinking it. We generally take a jug of water with us and then when we get up to the club house we fill the jug there. I do not know but one fisherman that has died in the last 12 years and he died of heart disease. The fish live better now than they did before.

2991 CROSS EXAMINATION, By Mr. Jeffries.

There is a current in the river now. Not so very much. It seems to be slackening off a little. There is no green scum on the water. Before the opening of the canal the river was like a lake, sometimes there wasn't any current at all. I say the water is better now because there is a current in the river and there is no scum on the water and it doesn't smell and it is better to drink than it was; then, you couldn't drink it at all and the fish wouldn't live in the water either. Am a married man. Don't use river water for drinking purposes at home now, but up to a year ago we did.

2992 When I said the fish didn't live in the water I meant that it seemed like the water was so foul that when you would take them out, and in handling them and putting them in the box or float net, just that little time out of the water would kill them.

(AT HARDIN, ILL.)

2994 CHARLES FLAMM, Examined in chief by Mr. Todd.

Am an insurance agent. Before last fall was county clerk of Calhoun County. Live in Hardin. Have been acquainted with the Illinois river at this point (Hardin) for the last ten years. Hardin is about 41 miles above the mouth of the Illinois. Population is about 500.

2995 In my opinion the water in the river prior to the opening of the drainage canal wasn't as pure as it is now. Prior to opening of canal the low water on the river on the east side was covered with vegetation and it looked to me as if the water was very impure. There was a scum on the water. It was a greenish scum and when you passed through it with a boat it left a trail. You could notice it for some time afterwards; that is when the river was rather low; low water; during the summer months. Since the opening of canal it has a better current and this scum no longer appears. I have drank the water since the opening of the drainage canal. I did not drink it before. About 12 or 15 fishermen are engaged in fishing at this point in the river.

2996 I do not know of any one who had typhoid fever or who died from typhoid fever in the last two years at this point. In my opinion from the appearances, the water has improved since the opening of the drainage canal in January, 1900.

CROSS EXAMINATION, By Mr. Jeffries:

My opinion is based entirely on the appearance of the water. I say that the water is better since the opening of the canal than it was prior thereto for the reason that the green scum that formed on the river prior to the opening does not form since the opening, and because of the creation of the current caused by the opening. Am not a physician. Don't make it a business of looking after the health of my people. We use cistern water at home. Hardin has no water system—only wells and cisterns.

2997 EDWARD ATHY, Examined by Mr. Todd.

Live in Hardin, Calhoun County, Illinois. Lived here about 20 years. Work at carpenter work. Have been acquainted with the Illinois river since I have lived in Hardin. By the appearance of the Illinois river it has improved since the opening of the canal. Before that time the water was inclined to be milky looking and muddy, and a scum over the river that was noticeable by every one. I cannot say there was any odor to the water. During the time this scum was over the river, row boats left a clean furrow over the river. I have crossed the river many a time and could see clear across, or half across. Since the opening of the canal I have observed a more lively current, a better movement of the water and I have observed less of this scummy looking filth on the top of it than before.

2998 My judgment is only from appearances and the water appearing clearer and cleaner, I should say it was purer. Have not noticed any odor in the water since the opening of the canal.

CROSS EXAMINATION By Mr. Jeffries.

I am not on the water a great deal. I am not qualified to judge only by appearance. I think a better movement of the river carries the scum away. It did not give it an opportunity to form. I don't know whether the sewage matter from Chicago gets down this far. My opinion is the waters have been improved by the increased flow. I have not observed here anything in the Illinois river that would lead me to believe that the sewage from Chicago was present in the waters of the Illinois at this point.

2999 NATHANIEL BULL, Examined in chief by Mr. Todd.

I live in Hardin. Have lived here six years. Have lived in the county since 1860. Am a farmer. I have been slightly acquainted with the river for the last 10 or 15 years. Not traveling around on the water but living along the river.

3000 Prior to opening of canal river was like a pond—there was a scum over it—you could see if anything had passed through it. There was an odor to it. Since opening of the canal I have seen none of that to amount to anything on it. It appears to have a current. Haven't noticed any odor at all since the opening of the canal. With a good current in the river since the opening of the canal, it certainly has improved—taking that away and making the water pure.

MR. JEFFRIES: Move to strike out question and answer for reason witness has not qualified himself to testify on that subject. (Same objection is made to all these witnesses.)

CROSS EXAMINATION, By Mr. Jeffries.

There is no scum on the water now because there is a better current, I guess. Never had the water examined. Just by appearances as I passed along it.

3001 There is a big difference in the current. It is a better current now than before, it was a pond—you could throw a chunk in and it was pretty near as apt to float up stream as it was down. I drink well water. Two years ago we used Illinois river water—the dry season. I hauled water from the river; when I couldn't get any other water—we don't use river water when we can get well water.

M. E. FISHER, Examined in chief by Mr. Todd.

Am merchant, reside in Hardin. Have lived here 35 years—all my life. Am acquainted with the Illinois river. Got acquainted by being on it all my life. I fish with a hand line. Before opening of canal so long as river was down low and green grass growing in it and scum all over it, it made a smell.

3002 When a skiff went through it left a track through the grass and scum. Since the opening of canal the river is up higher and clearer and a swifter current; better water. Drank waters of the river before and after opening of canal. Think the water is in good condition here now. It is better since the opening of the canal. The river is clearer and swifter current. About 10 or 12 people are engaged in fishing business at this point.

3003 Don't know of any deaths from typhoid fever in this locality. Am acquainted with all the people in this town. Every body knows each other here and each other's business.

CROSS EXAMINATION, By Mr. Jeffries.

Have a well or cistern at our house. Use cistern water at home. No water system in town. Made no examination of the water in the Illinois river prior or since the opening of the canal. All I know about the water is what I get from appearance. Opening of canal has increased current very much more. Don't know whether the water contains deleterious substances now or not.

3004 **ABNER POOR, Examined in chief by Judge Johns.**

Live in Hardin and fish for a living. Have been a fisherman about 28 years. Fished here prior to 1885. At that time the river along in summer and fall, I don't know what you would call it, but I would call it poison; more poison than water. There was a green scum on it; no current in it nor nothing. You could put a net in the water and raise it up you know and it would just be hanging in tags.

MR. JEFFRIES: Motion to strike out answer.

Was not aware that in 1885 the city of Chicago pumped its sewage into the I. and M. canal and continued that until 1900.

3005 The water is more pure and better now than it was in 1885 at this time of the year, it has been in the last two years. I know the water is better now than it was then. Before 1900, for 15 years, the water in the Illinois river was substantially always in the same condition. It was low, no current, and most awful dirty and nasty. This dirt and nastiness come from the stagnated water, as far as I know—it couldn't come from anything else but the stagnated water, that I know of; it was just like one of these ponds. In the water if you cut a hole in the ice a kind of nasty green scum would come up in that hole and you would pull a net up and it would just be tags hanging all over it. Those tags were filth from the dead water. Lots of fish died under the ice. I have drank the water ever since I have been fishing. I never pretend to take spring water or well water with me at all.

3006 When I would be seining and pulling the sein where it was shallow and this grass growing in it all rotten, it smelled pretty bad there. Since the opening of the canal the water has been more pure and it tastes better too. We don't have any more moss and filth in the river since that. We don't smell it any more, the current takes off the filth and smell.

3007 My fishing operations have extended from 12-Mile Island to Kampsville. That is about 16 miles by river. I never knowed a fisherman along the Illinois river to have typhoid fever. As a general thing the fisherman is the hardiest thing there is along the river. The fishermen, the majority of them, generally drink the river water. That is I can say that much for the fishermen around here; none of us carries water with us no matter how far we go.

CROSS EXAMINATION, By Mr. Jeffries.

My fishing trips have made me acquainted with the Illinois river for a distance of about 18 or 19 miles. I am 61 years old and have been fishing right here for 28 years.

3008 We had no current at all before the canal was opened. When a skiff got loose it was as apt to go up stream as down stream. Just like this spring when the Mississippi was backing the river up. I say the water is better now than it was before the opening of the canal for the simple reason it tastes better now. Better fishing now than there was then. Water is deeper and there is more of it. Before canal was opened you could take a tin cup full of water and let it set and there would be a thousand little worms in it, just like you get in one of these ponds, and dip it up, like wiggle-tails. That is not the condition now.

3009 RE-DIRECT EXAMINATION, By Judge Johns.

Before the opening of the canal fish lived 24 hours in live boxes. Now you can keep them for four or five days—I kept them that long last summer. Fish are livelier and appear better—they have got more life about them than they had before and there is more of them too.

DR. P. C. BERRY, Examined in chief by Judge Johns.

Am a retired practicing physician. Practiced medicine in Hardin and vicinity for over 30 years. Retired from active practice about 4 or 5 years but am still doing office practice. When in active practice I covered sometimes 30 miles south of Hardin and 15 miles north.

3010 Prior to opening of canal there seemed to be a scum on the river in summer time and no current and even in best season of year you could smell it; there was a sort of stench on it and water did not appear to be clear. I attributed the stench more to decayed vegetable matter in the river and washings from these creeks along the river. Since opening of canal it seems to be better—clearer and purer. I consider the water now purer and better for consumption by the people.

3011 I consider the well water all river water seeped into wells. To my knowledge we have had no case of typhoid fever here; we have had cases of typhoid-malarial fever. Fishermen do not have typhoid fever that I know of. Have practiced medicine among them as well as among other people. When in active practice I generally had the largest practice of any physician in Hardin in those days.

CROSS EXAMINATION, By Mr. Jeffries. (Similar to preceding witnesses.)

CHARLES H. LAMAR, Examined in chief by Judge Johns. Editor and publisher of Calhoun Herald.

3013 Have lived in Hardin 8 years and in vicinity of Illinois river all my life time, 40 years. Lived 3 miles north of Hardin, about 1 mile west of river, before coming to Hardin. From boyhood I don't think there has been a year passed but what I have had occasion to fish and swim and hunt around the Illinois river. Prior to opening of canal water was less; not so rapid current and at times stagnant; in low water much so; considerable vegetation found in river; had an odor in summer. Attribute odor to grass growing in river and to green scum found upon water. Used the water for drinking and domestic purposes when on the farm.

3014 Water is now clearer and fresher. Don't know of a case of typhoid fever from using the water before or after opening the canal.

CROSS EXAMINATION, By Mr. Jeffries.

Never examined the water, only in a casual way in rowing on it or bathing in it. What I say in reference to it is obtained simply from my observation. People in town drink well or cistern water; use it in their homes, and I do. River water is not used for domestic and drinking purposes by people in town.

3015 G. A. WILLIAMS, Examined in chief by Judge Johns.

Live at Hardin. Practicing physician. Practiced 22 years at Hardin. Been engaged in the general practice among the people. Prior to opening of canal water was at times stagnant; during summer had an odor arising from no current and stagnant condition; odor arose from decaying vegetation and perhaps sewage too. Since opening of canal it is much better—much improved.

3016 I suppose people living along river use water for domestic purposes and drinking to some extent. Prior to opening of canal there seemed to be a good deal of typhoid fever among people living along the river. Since opening of canal we haven't any cases, at least I haven't had any. Ice taken from river is clearer and better ice since opening of canal than it was previous.

CROSS EXAMINATION, By Mr. Jeffries.

There were as many typhoid cases as a dozen, in 15 or 20 years. Since opening of canal I haven't had any cases;
3017 other physicians may have had. Some of the cases prior to opening of canal were genuine typhoid and others of typho-malaria. Never made a chemical or bacteriological examination of the river. Know nothing of its qualities except from observation.

CHARLES E. COOKE, Examined in chief by Judge Johns.

Am implement dealer and agent for Eagle Packet Company. Lived in Hardin about 19 years. Been agent for Eagle Packet Company about 14 years. That company is running a line of boats on the Illinois river. There is great deal more
3018 water now in river than prior to opening of canal; much more current and no odor at all now. Prior to opening of canal there was odor and it was very bad when the wind was from the east, very offensive, that is, in low water.

There is not much ice put up at Hardin since dam was put in at Kampsville. When we could get good ice, the ice has been much clearer. I don't know of any people using river water being sick, complaining any, only rheumatism, which is always the case on a river.

3019 M. J. PARKER, Examined in chief by Mr. Todd.

Live in Hardin. Lived here since 1873 with exception of five years I was on my farm in Jersey county. I run on Illinois river for 4 years, steamboating, from St. Louis to Montezuma and part of the time as far as Naples. It is 32 miles to Montezuma and we call it 50 miles to Naples. Am in orchard business at present.

3020 Quit steamboating in 1899 but have been on river hunting and fishing every season. Before opening of canal it was a very sluggish stream and it looked like there was an accumulation of moss and grass and the stench was pretty bad at times, especially in warm weather and low water; the water had a kind of a greenish appearance and very little current. There was considerable of a scum on the water at times, especially when we had a continued drought, and low water; it would be a good deal more than it would be in the wet season;
when the water was coming in from the draw, that is
3021 after heavy rains, it would clear it up considerable.

Since the opening of canal I consider there is quite an improvement in the appearance of the water; it looks clearer and purer and we have got a decidedly better current, and it tastes better; it is not so sickly and such a flat, filthy taste. I have drank the water since the opening of the canal. Early in the year the water is just splendid, but during this season of the year the water is too warm; take the ice along it makes it very nice. When I go fishing I take ice with me and drink Illinois river water. I don't think I ever experienced any deleterious effects from the use of the water.

It is 100 per cent better now than before the opening of canal. I base my conclusion on the condition of the water and the appearance of it, and the life and the current we have and the tasting of it. Of course, I don't want it understood that I am an expert on this, but then it was in a fearful condition prior to the opening of the canal, especially in hot weather and at low stage.

3022 CROSS EXAMINATION, By Mr. Jeffries.

When I say that the water is better now than it was prior to the opening of the canal I just judge from its appearance and the current and the stage. I am not scientific enough to explain whether there is any deleterious substance in the water now or not. The scum and green matter and substances that produced the smell, before the opening of the canal has disappeared to a great degree. I attributed the disappearance to the current and to the stage of water and flow which we have now compared to the river here prior to the opening. Don't use Illinois river water for domestic and drinking purposes. We have fine wells in Hardin, and cisterns; we don"t use any river water at all, without it flows in our wells here—it might seep in, you know.

3024 G. B. CHILDS, Examined by Judge Johns.

Live in Hardin—have lived here all my life with exception of my school days and about 5 years in St. Louis. Have become familiar with the Illinois river by living on it; rowing on it, hunting on it, and living near it, right on the river bank here. Prior to opening of canal I have seen it in the summer during extreme low water when the weeds were growing thickly in it on either side of the channel; it was a greenish cast and full of greenish sediment and I have seen it so low that we have had no boats at all on it. It had an odor. The odor
3025 was offensive. Attributed the odor to the grass and moss on it. Since opening of canal so far as my observations have gone, it is clearer and the water seems to be better and more volume. I have seen no grass and sediment since the opening of the canal. Opening canal has raised the river about five feet. Some people drink river water since opening of canal. Health has been better since opening of canal.

3026 CROSS EXAMINATION, By Mr. Jeffries.

Use cistern or well water at home. In my statement that the water is better I judge from appearances and I have drank it, being out fishing and taking ice with us. We have a more rapid current. Last spring there was no current. The river was higher. I mean it was high on account of the backwater of the Mississippi. Aside from the time when the backwater from the Mississippi came up, there has been no time that there was not a current since the opening of the canal.

3027 Have never had the water examined chemically or bacteriologically. I don't know what its ingredients are. Don't know whether it contains Chicago sewage or not.

DR. S. FLATT, Examined in chief by Judge Johns.

Am physician and reside in Hardin. Have been practicing physician at Hardin five years. Prior to opening of canal Illinois river was muddier in color, less in quantity; current slower; odor more disagreeable. The odor was due to what is generally termed stagnant water.

3028 There was vegetation in the river prior to opening of canal. There are quite a number more fish in the canal now and the fish all seem to be in good condition. The fishermen on the Illinois river drink the water of the river. There has been but little typhoid since I came here. I had 3 cases I think prior to and 2 since opening of canal; though one of them was not on this river; one was across towards the Mississippi river. Since opening of the canal the health of the community has been good—exceptionally good.

MR. JEFFRIES: Move to strike out question and answer for reason there is no evidence showing that the people use the water of the Illinois river for drinking purposes and domestic purposes.

CROSS EXAMINATION, By Mr. Jeffries.

I never examined the water in the Illinois river. When I say it is better now than it was prior to opening of canal I simply judge from its appearance; from its color; it was not so thick and greenish looking; it is clear and a better smell to

it. The people here in Hardin generally use wells and
3029 cisterns; two years ago they used water from the river on account of drought. The people throughout the country generally used river water two years ago. The current of the river is better; it is three times what it was prior to opening of canal.

GEORGE L. ADERTON, Examined in chief by Judge Johns.

Am county clerk of Calhoun county, Illinois. Reside in Hardin. Lived here since 1894. Have fished great deal on
3030 river with rod and line. I noticed prior to the opening of the drainage canal the water was sluggish and not so clear as it is at the present time, or after the opening of the canal. There seems to be more current and the water has generally a better and clearer appearance since the opening of the canal. Never to my knowledge have I noticed that it had any odor. I have a pretty tolerably extended acquaintance around here throughout the county, bordering on the Illinois river. We have used river water before and since open-
3031 ing of canal, but not for cooking or anything like that; we have had it for laundering and such as that. I have drank the water while out fishing and I have known others with me, but to make a general statement of it, I couldn't say as to that. I think the general health of the people is about as good now as it was prior to opening of canal.

CROSS EXAMINATION, By Mr. Jeffries.

We use cisterns and wells for domestic and drinking water. I couldn't say that my neighbors do; sometimes their cisterns go dry and they have got a good many public wells in town. Perhaps they use more well water than river water, because our town is well supplied with wells, and as to saying positively whether they do or not, I couldn't do it.

3032 Prior to opening of canal we had no current scarcely. We have got a good current now at all seasons of the year except when the water of the Mississippi backs up. I don't think the river water is used for cooking to any great extent or drinking except by the fishermen that are out in the river. Still, there is a good many people that use it ocasionally. I am one of them myself. They do not make a practice of it though.

3033 Never had the water in the river examined either chemically or bacteriologically before or after opening of canal.

T. J. SELBY, Examined in chief by Judge Johns.

Lived in Hardin since September 16, 1884. Was member of 57th Congress. Commenced practicing law in Hardin in 1875; I lived then at Jerseyville. From Hardin to Grafton by river is 30 miles.

3034 Prior to opening of canal, in high water time we would have a good current. In summer season when the water was lowest there was very little current in the river at this point anyway; it resembled very much a large pond; I have seen it filled with grass, particularly on the eastern side of the river at this point. The color of the water I am not positive about that, It was not absolutely clear nor yet really muddy so far as my recollection goes. As to odor, sometimes that would be pretty bad in the fall season, perhaps in September, owing to this decaying vegetation being in the river. That was not always the case, however; when the river was high why the conditions would be different. The water then would be muddy and the current stronger and it would sweep away this accumulation of stuff in the river. Our low water period is I would say from the first of July on into the fall. Since opening of canal grass and vegetable growth is now totally absent. 1901 was a very dry year and we had very fair water. The water may be clearer now, but I would not be positive about that. From the general appearance of the river itself it looks probably clearer, but I have not inspected it for the purpose of ascertaining. The health of the community since opening of the canal has been good. I don't know of any time when it has been particularly bad, however.

3035 CROSS EXAMINATION by Mr. Jeffries.

I only state from general appearances. I have been on the river frequently, crossed it and fished in it and noticed it; drank out of it, before and since opening of the canal. My idea is if there is any difference I would say it is clearer now than it was at low water times before. That is simply an ocular observation; all I know about it is from observation; I have had no examination made either chemically or bacteriologically. I am no bacteriologist; I don't know of any ill effects from the use of the water or haven't heard of any. I can't say whether or not it does now or did prior to opening of canal contain deleterious substances so far as I personally know. If it does there don't any of us know.

3036 People in Hardin use both well and cistern water. People living in shanty boats get it from the river. I have seen them dip it up in buckets. Since opening of canal we have a better, stronger current—a great deal stronger. I don't know what the per cent would be, but I would say considerable.

ELMER E. WILLIAMS, Examined in chief by Mr. Todd: Cashier of Bank of Calhoun County. Lived in Hardin since February, 1899.

3037 From February, 1899, to January, 1900, we had a swimming club and would go swimming down at Rocky Bar about a mile below. The water got so foul along in July and August, about August I guess, that we couldn't go in swimming any more. There would be a green scum on the water and a very foul odor; very turbid. And it was very low, too. We could observe the odor from where we lived; we lived about two blocks from the river and the street runs right down to the river with no buildings south of it; it was very offensive. Since opening of canal there was no green scum formed and no perceptible odor like there was the previous year, and that condition has been, I think, improving for the better as to the sanitary condition and clearness of the water and less foul. The sanitary canal waters have purified the Illinois river at this point; the drainage canal has purified the water.

3038 CROSS EXAMINATION by Mr. Jeffries:

Am not an expert on the sanitary condition of water. It is just my general observation, that's all. Never had this water examined either before or after opening of canal.

Don't use water of Ilinois river for drinking and domestic purposes but we use cistern or well water. I have drank the Illinois river water, though, when I was out fishing. My neighbors have cisterns or wells, but then for drinking purposes they most all use water from the town pumps here.

3039 I don't know whether or not the deleterious matter contained in Chicago sewage comes down this far.

Q. It may or may not so far as you know?

A. No, I do not konw.

WILLIAM McNABB, Examined in chief by Mr. Todd:

Am druggist. Been living in Hardin about six years. Have been on Illinois river a good deal boating and have been fishing. The water in 1899 was very low, the stage of the water here, scarcely any current and the condition of the water was not as good as it is now by any means; there was a scum over the river during that year, a green scum. There was an odor to the water. Since the opening of canal we have had
3040 a better stage of water, a good current, and we have no scum over the water and there is scarcely any perceptible odor now. The water is a good deal better than it was before the opening of the canal. My observation leads me to that conclusion. I am the only druggist in town. I disremember of a case of typhoid fever in town since opening of the canal. There has not been as much malaria in this community since as existed before opening of canal. I know the chill tonics and preparations for that complaint; we haven't sold since the opening of the canal one-third or perhaps one fifth as many as we did before.

CROSS EXAMINATION, By Mr. Jeffries.

3041 I board and don't use water from Illinois river. I never made an examination of the water for sanitary purposes. I don't know whether the deleterious matter contained in the sewage that comes from Chicago is contained in the water here at Hardin or not. Not from a bacteriological standpoint. I never examined the water in that way. Only of course from seeing it that I know, and the changes. I don't know anything about the ingredients of the water. It may contain deleterious matter and it may not so far as I know.

3042 (See re-cross examination of this witness.)

3043 L. M. DAVIS, Examined in chief by Judge Johns.

General merchant. Lived on Illinois river since 1855 except five years I was in army. Prior to 1900 Illinois river was less current and to my judgment a great deal more odor and so far as the use of that water for domestic purposes—I know but little about that; I don't know who uses it.

3044 I attribute the odor to stagnation; lack of current would be my idea about it. Since the opening of canal I can't say as I see a great deal of difference in the color of the water. There has been no scum on it and I haven't noticed any odor. Am pretty well satisfied that the health of the community has been equally as good as it was prior to opening of canal. Prior to opening of canal have seen the water very low. 12 or 13 years ago the waters got so low they got men at a point 20 or 25 miles north of here to go in with plows and scrappers to make a channel for a boat to go through. In 1901 we had no rain from June to November. If in that time the waters of the drainage canal had not flowed through the Illinois river, it would not have been navigable with anything larger than a skiff.

3045 CROSS EXAMINATION, By Mr. Jeffries.

In my statement that the water is better since the opening of the canal I am speaking from observation only. I use well or cistern water. I do not know whether the river water contains deleterious matters or not from experience. It is a stronger, swifter current now. The people in this locality use well or cistern water to a great extent. Almost exclusively outside of the fishermen.

WILLIAM U. MORTLAND, Examined in chief by Judge Johns.

Postmaster. Have lived in Hardin approximately 37 years. Was born and raised here. Have always lived within 500 yards of the river. Know nothing about chemistry but
3046 what I know about the Illinois river is from general observation. Have fished more or less with hook and line and have been in bathing frequently. Prior to opening of canal condition of river varied with the years. It was something in the nature of stagnant pool; water was covered in summer with yellow scum; apparently little current and very strong odor. varied in different months. When weather got warmer it was stronger; August was especially bad. Great deal of vegetation; what we call commonly buffalo grass. Grass was everywhere here. I should judge odor was from vegetation. Since opening of canal from general appearances the current is stronger and water clearer and comparatively little if any odor from the water and absence of this buffalo grass. A few years ago there was more malaria than there is today. Whether it can be attributed to the difference in condition of water or not I can't say.

CROSS EXAMINATION, By Mr. Jeffries.

Don't know whether water contains deleterious matters or not. Don't use the water. Current is much swifter now than it was before. I only judge from boating I have done and swimming occasionally. I presume water flows now with a regular current at all seasons of the year except when the back water from the Mississippi interferes. It had a current prior to opening of canal—very little of a current before; considerable of a current since. Don't know whether deleterious matter from the sewage of Chicago reaches this point or not.

3048 JEFFERSON WELCH, Examined in chief by Judge Johns.

Am a fisherman. Have been in that business 21 years. Fished in Illinois river mighty nigh all the time. Of course I get over in the Mississippi sometimes in June or July, but then I fish kind of steady here. Fish with nets all the time.

Fish about 18 miles north and about that far down the river. Prior to opening of canal Illinois river was low in summer, full of moss and no current. Moss covered the nets; green moss. Would have to take it off with my hands; sometimes let it dry and knocked it off. Don't think the fish were as good as they are now. Haven't in the last few years seen dead fish along the banks like I used to see. Since opening of canal, water has been more pure, more current and there was not near as much sickness; wasn't near as much fever and ague along the banks
or low-lands as there was before.
3049 Condition of the fish is better. They live longer in
live boxes if you keep the live boxes in the current. As a fisherman I drink the waters of the Illinois river. The drinking qualities of the water now are better than it was; more cooler, the water drinks better. Fishermen along the Illinois river generally drink its waters while they are fishing. Don't know of any typhoid fever among the people drinking the Illinois river water since the opening of the drainage canal. Have been engaged somewhat in assisting in putting up ice. It seems like to me the ice is more clearer than it was before, more solider and more bluer than it was before.

CROSS EXAMINATION, By Mr. Jeffries.

We have more current now than prior to the opening of canal. Before opening of canal we had a very slack current in the summer time and of course if we had a head raise, then there
3050 was a current. We have a pretty fair current now all the
time. I live in a house a mile and a half north of here. I have a well and cistern and use well water for domestic purposes.

WILLIAM MORTLAND, Examined in chief by Mr. Todd.

Farmer and fruit grower. Live in the corporation here of Hardin. I was county judge and member of legislature in 1881
and 1882. Have wood-boated on the Illinois river. I
3051 came here in 1848 and been here since. Prior to opening
of canal I have seen this grass growing all the way except about 100 feet of the channel that wasn't covered with grass;

I have seen cattle and hogs grazing on it, and I have seen it here when we couldn't get a boat; when we couldn't get our freight loaded and I have seen it with a green scum all over it; it was unhealthy. It is a good deal healthier here since the canal was opened and I think the water is much better than it used to be.

CROSS EXAMINATION, By Mr. Jeffries.

I say the water is better than it used to be because there is not so much sickness here as it used to be and I am satisfied it is healthier than it used to be. That's my opinion. I have wells and cisterns on my farm and use them for domestic and drinking purposes. Some of my neighbors are supplied with wells and cisterns, and those who do not use the town water.

3052 The reason I have for believing the water is better since the opening of the canal is there is more current than there used to be and there is no green scum on the water like there used to be and there is not so much malaria as there used to be. Don't know whether the water contains any deleterious matter. Don't know anything about the ingredients of the water.

(Kampsville, Ill., July 16, 1903.)

C. B. BRAKEVILLE, examined in chief by Judge Johns:

Live at Kampsville. Am a fisherman. Have been fisherman all my life. I fished at Copperas Creek Locks, Havana, Meredosia, Pearl and Kampsville.

3053 At times wastn't as much water in the Illinois river prior to opening of canal than there is now. River sometimes became stagnant, it would be all green on top. To a certain extent there was an odor in the water, came from the vegetation. There used to be a good deal of moss and slime on our nets. Since opening of canal have never seen it smell. There isn't any more grass and weeds than there ever was. To best of my knowledge the water is clearer than it ever was; it clears up a little quicker. The fishermen as a rule drink the

water of the river. I guess there hasn't been a day in ten years
but what I have drank some of the water; every day that I
have been on the water. Am pretty well acquainted with the
fishermen along the river.
3054 The fishermen do not get typhoid fever very bad; you
hardly ever see a fisherman sick. Never heard of typhoid
fever among the fishermen since the opening of the canal.

CROSS EXAMINATION by Mr. Jeffries:

I live in a boat all the time. We have a good deal stronger
current than before the opening of the canal. The water is not
clearer at all times of the year now; when it rains it muddies up
but it clears up much quicker than it used to I think. Whenever a fair sized flood comes, the water gets just as cloudy and
muddy now as it did prior to the opening of the canal, for a
short while.
3055 I don't know what has become of the grass and moss
growing in the river. There is a pretty fair current here
now which continues over the dam.

There is a good current from Beardstown to this point.
There is a pretty fair current from here to Grafton. There has
been a good current in the river ever since the opening of
3056 the canal. Prior to opening of canal there was no current above this dam at all. I don't know whether the
water contains certain substances that are injurious to health
if used for domestic purposes. My only reason for believing
that the water is better is because there is some increase in volume and a stronger flow. Am out on the river every day and a
part of the night.
3057 I never paid much attention to the sickness in this town
and around the country.

EDWARD HEATON, examined in chief by Judge Johns:

Live at Kampsville Locks, and am fisherman. Have been
fisherman for 42 years. Commenced fishing at Chillicothe;
fished at Peoria, Beardstown, Meredosia, Montezuma, Bedford
and Kampsville. From the time the government locks were

put in the river until we opened the canal, our low water got very stagnant, dead and bad. In winter time when we were setting nets the smell that would come out from the ice we couldn't stand at all; a sort of a gas. First observed that at Bedford and Montezuma; the two towns are right close together.

3058 It was either in 1893, '94, or '95 it killed all our catfish. In summer it had an odor or smell; here at the dam anybody could notice it all summer long. We would have moss and slime on our nets in low water just the same as we have it now-days. You couldn't notice any difference in the fish. In live boxes the fish didn't live at all before in low water; we didn't have current enough to give them fresh water. They live middlin' fair in live boxes now. Have assisted in taking ice from the river. We get the ice a good deal clearer in some places, but we have got so much current it gorges together and we don't get as good ice now as we did before when we could catch dead water. I drink the water. There is very little typhoid fever that I have ever seen during all the time that I have been on the river. The fishermen generally drink the waters of the Illinois river and you don't find as many sickly fishermen as merchants.

3059 CROSS EXAMINATION, By Mr. Jeffries.

Live in a house. Get water for domestic purposes from public well. Am familiar with the river for 160 or 170 miles up. The water was stagnant and still and void of current from this to Henry Lock, about 189 miles up, prior to opening of canal. Since opening of canal I have only been acquainted with river for 10 miles up, and 8 or 10 miles down.

3060 The difference in the current or flow of the river is about one-half. There is a good current now. Opposite Kampsville it is about 2 miles per hour. This point is one mile and a half above Kampsville dam. That rate of current continues from this point to the dam. The rate per mile per hour above Kampsville is about the same until you get above the back-water of this dam and it gradually increases as you go up.

3061 There is not very much green scum or moss in the river now. German carp seem to prosper best in the river at this place. German carp feed on all the scavenger stuff they can get; horse manure or any kind of manure or anything of that kind; filth and animal matter. I do not know that they feed on fish or minnows. This ain't such a big community but what you can tell when a case of sickness comes up. I only know what I hear and come in contact with. My opinion on the water is based from what I know and what everybody teaches me, that the swifter the current the better and purer the water.

3062 If polluted, that you say is far enough away in rushing over gravel and sand it is bound to purify it more than if it would lay stagnated. I know it from drinking out of streams. I do not know that the water does not contain deleterious substances. I don't know whether it contains more or less since the opening of the canal; I ain't analyzed it any.

JAMES MORAIN, Examined in chief by Judge Johns.

Live at Columbiana, Green county, Illinois. Have been a fisherman for 15 years.

3063 Before opening of canal this river was like a pond here; filthy stuff and a green scum. Smelled some; especially about nine o'clock of a morning when there was no draught that the breeze raises. The moss and slime was bad; plenty of it, all covered; it took two men to get them out sometimes. Since opening of canal we have had a much better current; the water has been much better in my opinion since the opening of the canal; that is, it don't smell. In warm weather we take ice and put it in the river water and use it. The water of the Illinois river when you drink it, does not produce disease. I have lived right here 14 years and I have never had a chill. Neither

3064 I nor any of my family have had typhoid fever. The fishermen who drink the water do not have typhoid fever as I know of. I don't know of anyone here that has had typhoid fever at this place. Have assisted in putting up ice. Since opening of canal the ice is very nice if we have a head-raise on it; that is it is clear ice. Of course, if we have a head raise you know, there is more muddy water settles in it.

CROSS EXAMINATION, By Mr. Jeffries.

There is a good, strong current from Columbiana and Kampsville to the government dam at Kampsville, one-half a mile below. There is a good, strong current up the river from Columbiana and Kampsville. It gets much stronger as it goes up. It was so dead that the nets would not stand up
3065 before this drainage came in, in low water. The carp thrive best in the Illinois river at this point. They live on such as they can gather; the substance in the water, I reckon, and that they gather floating in it; most anything that they can find floating, bugs and worms and such as that. They don't live on minnows to amount to anything at all. The 3rd year before the opening of the canal, our healthiest fish died. I don't think that there is any healthier fish in the world than the cuigan. That year they died. That was when the river was frozen over with ice. Since the drainage came in it has never killed no fish. Since the opening of the canal they have had a good current from here to Meredosia, which is about forty miles. Before the opening of canal it was like rowing in a pond. We would begin to strike some current then at Graysville I think; that is the first current we would strike between here and Meredosia.
3066 The reason for saying the water is better is because we have a current now. It don't seem to contain substances that are poisonous and injurious to the human system; I use it right smart during this last high water when I used ice in it; I have got a family of six of us, and my doctor bill is very little.

3067 IRA DAVIDSON, Examined in chief by Mr. Todd.

Kampsville is my postoffice. Am a fisherman and have been for year and a half. Came here from St. Louis. Lived in St. Louis two years and prior to that time lived in Green county,

Illinois. I lived 8 or 10 miles from the river but I crossed the
river twice a week every week for about 3 or 4 years. Before
1900 the Illinois river was low and no current practically.

3068 The water was dark and had green scum on it. Since
opening of canal water has been clearer and we haven't
had any scum or grass. There has been no odor. Have been on
the river 18 months out of the last two years. Drank the water
as often as half a dozen times a day. Never taken a dose of
medicine since I have been here. About 40 fishermen are engaged
in fishing at this point. They are in the habit of drinking
the water of the Illinois river when out fishing.

3069 There has been no typhoid fever or sickness in this community
during the last 18 months, that I know of. Opening
of drainage canal has made the water better.

CROSS EXAMINATION, By Mr. Jeffries.

Use water from a well where we live.

3070 There is a good current in the river now, at Kampsville.
That current continues from here to the government
dam about one-half a mile below. The farther from the dam
you get the stronger the current. The depth of the water flowing
over this dam is 3 or more feet. The water never injured
my health.

3071 Carp thrive best in the Illinois river. I have never seen
anything they wouldn't eat. Cat, buffalo, bass and
perch also thrive here besides the carp.

W. L. FLATT, Examined in chief by Mr. Todd.

Live in Columbiana. I fish and have been a fisherman for
about 10 years. Been acquainted with the Illinois river for
40 years. Before opening of canal there was more or
3072 less of a scum on the river; in low water and hot weather.
It had a smell to it. There was dead fish in the water
at that time. Since opening of canal water is more clear; hasn't
been so muddy. There has been no green scum on the water.
It has a clear color more or less only when it rains. It has im-

proved the water I think. I have drank the water. It has never made me sick since the canal has been put through.

3073 CROSS EXAMINATION, By Mr. Jeffries.

I had the ague before the opening of the canal; I don't know whether the water did it or not. Am 53 years old. Have a well at my residence. I don't know whether the water contains deleterious matter or not.

ISAAC STABLER, Examined in chief by Mr. Todd.

I live in Columbiana, Green county, across the river from Kampsville. Have lived here since 8th of last October. Before that lived in Montezuma on the banks of the Illi-

3074 nois river, for 7 years. Am fisherman and been engaged in that business about 28 years. Prior to opening of canal as near as I can recollect, the water was pretty badly stagnated; about that time there was a heavy green scum on the water and since that time I haven't noticed it; since this drainage has been turned in I haven't noticed that scum. Before opening of canal color of water was dingy green. Water had bad smell and didn't have a good color. Opening of the canal has given river a good current and I think it carried off the filth and it don't have the green scum that raises on the water. I think it made the water more pure than it was before. If we have a freshet it doesn't take it near as long to

3075 clear up as it did before. The color is much better than before and no odor whatever. Drink the water occasionally. It tastes a great deal better than it did before; it is more clear and pure. The drinking of the water has had no deleterious effect whatever upon me. The fishermen generally drink the water. Assist every year with taking ice from river. I think our ice is more pure. It is more clear; we don't get no moss in the ice since that and we always did before; it was impossible to get it without moss, or a green substance of some kind. Before canal was turned in our nets would all

3076 turn green and form a scum all through the meshes so you couldn't hardly hold the nets. We can place the nets most anywhere we choose now and the scum don't pull them any more. Opening of canal gives river more current, it gives it more power which leads off and carries away faster; I did think at one time that it was a discharge, but I don't now, but that was only the rising of the water in the Spring, but I see the current now carries the water away a great deal faster than it did before it was turned in. I think it purified the water simply because we have got a better body of water than we had before and a stronger current, and the water can't help but be better than it was before because we have more of it.

3077 CROSS EXAMINATION by Mr. Jeffries.

Am acquainted with the river up as far as Peoria, which is maybe 110 miles and I am acquainted down the river to its mouth. Since opening of the canal the current from Peoria to Grafton is more stronger; it has a stronger current and carries water away faster. The water before opening of the canal was still. We have a right smart current now; more than we
3078 had before. There is a very strong current now; there is a strong current here in the Illinois river which is one-half mile above the Kampsville dam. The stage of the water is about the same or little higher than the month the canal was opened. There will always be a good current here at Kampsville. As you go up the river from Kampsville the cur-
3079 rent gets stronger. I live in a cabin boat on the bank of the river. Carp thrive best in the water here. They feed on anything most; anything in the shape of something to eat. They feed on minnows. Not as well as they do on other matters. They feed principally on grass and moss and go in the mud after mussels. I don't think the water contains delerious substances. I have been around it a good deal and I never found anything like that. Never examined it chemically.

JOHN M. HIPPLE, examined in chief by Mr. Johns.

3080 Live in Kampsville for the last three years. Am pilot on the river in the employ of the government. Am pilot in season and in winter, day watchman on the fleet of three dredges, three steamboats and quarter boats and scows. Have been in employ of government three years last May. Prior to that I lived on the river all my life and ferried and fished and steam-boated. I am 38 years old and have been on the river 30 years. Most of the dredging operations has been below here. In dredging below here we find mostly sand and mussel shells and in some places we strike mud; some places thin and other places stiffer, and gumbo, but the most of it was sand and mussel shells.

3081 Worked one season with the dredges prior to opening of canal between the locks here and the Six Mile Island which is at the mouth of the river. I couldn't say whether there was much difference in the material dredged before the opening of the canal. I saw the material but the mud was different in so many places. Prior to opening of the canal there was sediment in places, but not in the channel, but out at one side and behind the island, and where there was slack water, and the river had filled in, there was, but it hadn't filled in the channel; around the creeks and where the creeks empty it fills in some and changes. Before opening of the canal the water of the river at low water got very filthy and green. Filth was caused by lack of current to drive it away. Filth was from both decayed vegetation and from sewage but mostly from sewage. From Peoria to LaSalle in low water it was filthy and dirty. It seemed to be more filthy about the Henry lock.

3082 When we got over the Henry dam it got better, when we got down to Peoria or down near to Peoria. The stretch from Peoria to Copperas Creek dam was very bad, very bad. It was a good deal worse down below Peoria than it was above. I think it was on account of sewage from Peoria—no current to drive it away. Since the opening of the canal the water below Peoria and the Copperas Creek dam is much improved. I was over it yesterday and it looks as well as the river down here. It is 30 miles from Peoria to Copperas Creek and from Copperas Creek to La Grange dam it is 82 miles according to steamboat men. From La Grange dam to Kampsville dam is 60 miles.

3083 Prior to opening of drainage canal the water between Copperas Creek and La Grange was a good deal better than it was above; after it went over the dam it didn't get bad again until it got down to Beardstown, or near the other lock—down to La Grange lock. Since the opening of the canal that stretch of water seems to be a great deal improved. Before opening of canal the stretch of water between La Grange and Kampsville wasn't near as bad as it was up above Copperas Creek, but it is better now than it was then. The river is in better condition now than it was then.

Prior to the opening of the Drainage canal the water of the Illinois river improves as it travels from LaSalle to Peoria Lake. Since the opening of the canal the water from LaSalle to Peoria Lake improves as it travels. Prior to opening
3084 of canal the water immediately below Peoria was in worse condition than at LaSalle. The water below Peoria was the worst; the water above Peoria was the best.

Q. Did the water as it traveled from Peoria to Copperas Creek dam improve in appearance?

A. No, it seemed like it got worse until after it came over the dam and then it seemed to improve. It had to come to Pekin you know and there it got mixed with a lot more. Between Peoria and Copperas Creek dam there was a large amount of sewage and offal added to the water in the river at Pekin. Before the opening of the canal the water in the Illinois river appeared to improve between La Grange and Kampsville; and between Kampsville and Grafton. Since the opening of the drainage canal the waters of the Illinois river appear to improve between LaSalle and Peoria. The waters in that stretch of the Illinois river are better since the opening of the drainage canal than before.

3085 Since the opening of the drainage canal the waters of the Illinois river between Copperas Creek dam and Peoria are better as compared with their condition before the opening of the Drainage canal. The water looks better. Since the opening of the Drainage canal the waters of the Illinois river between Copperas Creek dam and La Grange dam are better and purer and not so much vegetation and green stuff. The further down this way the better the water is. Between La Grange and Kampsville the waters of the river are better since the opening of the canal. Since the opening of the canal the waters below Kampsville dam to Grafton are improved some; the waters are better, but you can't notice it here like you can on the upper end.

Q. Since the opening of the drainage canal, you may state whether the waters of the Illinois river gradually and steadily improved from LaSalle to Peoria Lake.

Objected to as leading, and misleading.

A. Navigation improved, yes sir; wonderfully. It looks clearer. From LaSalle to Peoria the water looks clearer.

Q. Since the opening of the canal do the waters of the Illinois river improve between Peoria and Copperas Creek dam, and if not, state why?

Objected to as leading and suggestive.

3086 A. Yes, sir; they improve.

The amount of offal and sewage these waters receive at Pekin is considerable.

Since the opening of the canal the waters of the Illinois river improve in condition between Copperas Creek and La Grange; between La Grange and Kampsville and between Kampsville and Grafton. Couldn't see any difference in the ice as a general rule taken before opening of canal or afterwards as to whether it was clearer or not. Have been drinking waters of the Illinois since I was 8 years old. Fishermen on river drink the water as a rule. Men in the employ of the government on the dredging fleets drink the waters of the Illinois. If any of
them ever had typhoid I never heard of it. The use of
3087 the dams in the Illinois river is to back up the water over
the bars. These dams retard or stop the flow of the river up to their aprons. Kampsville dam backs up the water as far up as LaGrange, 50 miles. LaGrange dam backs the water up 50 or 60 miles. Copperas Creek dam backs up the water 40 or 50 miles. Henry dam backs up the water for about 40 miles.

High water in the Illinois river causes the channel to fill up. The flood in the Illinois river does not wash out the channel and remove whatever sediment there is in it.

3088 High water in the tributaries of the Illinois is the cause of deposits filling and bars forming in the Illinois. Dredging is done to deepen the channel so steamboats can run. Dredging is done where bars are formed. These bars form in the Illinois river generally below the entrance of the tributaries. In my experience in dredging on the Illinois river I find that the channel below the entrance of tributaries quite often fills up after high water or flood below the entrance of tributaries. It don't fill up every time a creek comes out.

3089 In times of flood the Illinois river does not always wash out all the sediments deposited between its banks and carry it away. The deposits in the river outside of the running channel was increased by this year's flood, but as a general thing it is diminished. That depends somewhat upon the character of the flood.

3090 CROSS EXAMINATION, By Mr. Jeffries.

3091 Commenced service for the government in May, 1899.

3092 Government had been dredging in Illinois river prior to that time. In some places they went over it and had to re-dig it out; it might have been a deposit; most of the places where the dredging was done it was a natural bed, but in some places it was a deposit.

3093 All these places pretty near all fill up and they have to
re-dig them. (Witness states various places where dredging was done.) We are dragging the mud out of the locks here
at Kampsville. The mud that comes out of those locks is very
thin and awful dark. The mud we are digging now varies in
depth—some places 5 or 6 feet deep. At LaGrange dam the
mud was 4 or 5 feet or more. We take out the mud out
3095 of the channel and dump it—just move it out of the
channel. Along here at Kampsville there was no current in the river prior to the opening of the canal. The water

was all green out here; just plumb green like a pond. Since the canal was opened there has been a fair current when the water was low; it was not a good current, exactly. I don't know that the water is better from a scientific standpoint; I know it's better navigating and it is better to drink and it looks better.

3096 C. V. BRAINARD, Examined in chief by Mr. Todd.

Am a civil engineer. Had charge of the taking of water above Kampsville lock for the sanitary district of Chicago and University of Illinois and University of Chicago. Water was taken in parts of 1900 and 1899. (States method pursued in taking samples, marking them, etc.)

3098 Card used for sample No. 1242 offered as "Sanitary District Exhibit 6 for identification."

Been connected with the government improvement on the Illinois river since February, 1891. At low water the waters of the Illinois river got very bad before opening of canal. There would always be a greasy sort of a scum on the top of it; it would frequently be green the whole depth of the river. There was always more or less of an odor to it. It hasn't been as bad since the opening of the canal. There has been more current and there hasn't been that bad look to it; it has always looked clearer and better than it did before. The color has been better. Before the drainage water was turned in we frequently had grass growing in the river up to the side of the channel where the steamboats kept it worn away; since the water of the drainage canal has been turned in I have seen none of that.

3099 I don't think the water of the canal has injured the waters of the Illinois at all; there has been improvement for the time it has been in, over what it was for certain years before. There was one case of typhoid in Kampsville since the opening of canal. That was the doctor. He had been attending typhoid patients back from the river and we suppose he got it from that. There are ten or a dozen fishermen in this vicinity engaged in fishing. The number of people living along the llinois river in flat boats is very large; probably several thousand. They live with their wives and children and form a floating population.

3100 CROSS EXAMINATION, By Mr. Jeffries.

The water in the current has increased both above and below the dam. Sometimes we use water from the town wells and we use it from the river at times. When I say the water is better now than before I simply judge from its appearance. I know nothing about its sanitary or unsanitary condition because have made no analysis of it.

3101 RE-CROSS EXAMINATION, By Mr. Todd.

We have used the water where we live at the lock for domestic purposes ever since we have been there. I don't know whether the water caused it or not, we have all had chills and fever. My family consists of myself, my wife and three children.

FRANK TOZIER, Examined in chief by Judge Johns.

Residence is at Kampsville. Am a steamboat engineer. Have been such for 15 or 20 years all told. All the steamboating I ever did was on the Illinois river. Am now in employ of government as engineer; blacksmith.

3102 The only dredging being done now is at the mouth of the locks. We have done no dredging last year nor the forepart of this year. I dredged over 8 years as a steady work. dredged from the upper end of the river from Devil's Elbow, which is eight miles this side of Havana, and every bar to the mouth of the river. The purpose of dredging is to make a channel. When we dredge we get clay, sand, clam shells and soft mud. Dredged many places more than once. The creeks cause the channels we have dredged to fill up. When the creeks are in flood they carry out dirt which fills up the channels. The bars in the river are below the creeks.

3103 I think very nearly the whole cause of the formation of bars in the Illinois river is the sediment that comes out of the creeks. After each high water there will be a sediment of an inch or two inches; sometimes maybe three all over the banks, on the flats will be an inch to three and four inches of a sediment, after a long high water. This year there was about 3 inches. When there is high water in the Illinois river I think it causes more sediment to settle; there isn't current enough in this river to wash out anything.

Objected to for the reason has not qualified.

I have dredged out a place upon the Illinois river where afterwards I was not able to find the channel again. That was at Otter Creek bar; we dredged it out and then moved up on the other bar and then in two or three weeks we had to go and dredge it again. A storm came up right after we had dredged it and when we went back after two or three weeks we couldn't find where we had dredged. It filled up on account of a flood in Otter creek. The bars form again after being dredged be-
cause there has been a flood in the creeks; I have dredged
3104 bars where it was quicksand and came right back. We
drink the water of the Illinois when we are out dredging. We use the water with ice. Don't use ice water when water is cool. The water does not give us any disease. The government fleet now on the llinois river consists of 3 barges, 3 steamers, 8 dump scows, 4 flats, 2 quarter boats and an officer's boat. 40 or 50 men are employed on this fleet. These men generally drink the water of the Illinois river. It doesn't seem to have
any bad effect upon them. Most of them are in good
3105 health the whole thing through. Once in a while there
will be one that will have a chill. Prior to opening of canal you could find this whole river here as far as you could see covered with a green slime all over it. We don't have that and haven't had it for the last two years. May be one of the hot days you may see a little streak of that green right where the channel comes, but very little of it. The water now with ice in it, I believe would be perfectly healthy right at the present time. I believe it will be fit to drink the year around. After

the weather begins to get cold in the fall we drink it right out of the river.

3106 The purpose of putting dams in the Illinois river is to raise the river so boats could run. The dam at Kampsvills backs up the water so that it will make at Meredosia about six inches of water. A raise of seven feet here will make it about six inches at Meredosia. It is about 42 miles from Kampsville to Meredosia. LaGrange dam is about 7 miles from Meredosia. The LaGrange dam was calculated to back the water clear to Copperas creek lock, but it don't do it. It is 7 feet high. The Copperas creek dam backs the water up between Henry and Lacob. It is about 70 miles from Copperas creek dam to Henry dam. The Henry dam used to back the water plumb to La Salle.

3107 It is about 40 miles from Henry dam to LaSalle. The dams on the Illinois river are 7 feet high from dead low water.

CROSS EXAMINATION, By Mr. Jeffries.

The last piece of dredging was done about three years ago. What we are doing now we do not call dredging—it is cleaning up around locks and the like of that.

3108 There has been no dredging since 1900. Prior to 1900 we dredged for 7 years right straight. Am a married man and live at Kampsville. Have a well at home, but don't use that for drinking and domestic purposes at the present time. I would rather take it out of the river than out of the well.

3109 Am using out of a neighbor's well now, though. This is the only dredging outfit on this river now. There is another outfit that belongs to the State.

3110 VALENTINE TOTZELL, Examined in chief by Mr. Todd.

Am a fisherman. Have been a fisherman since 1874 on the Illinois river. Live at Kampsville. Prior to the opening of the canal the river was stagnated water—green. I have seen it here one season when the water was green fully six inches deep. If you dipped up a bucket of water it would be perfectly green. There were times that there was a kind of a bad smell, coming in kind of puffs like. Since the opening of the canal we have had better water, that is, say six or eight weeks after the canal was let in, we had pretty bad water, the water was colored. At the same time it was cold weather; it was kind of a coffee-colored brown, but then six or seven weeks after that it cleared out and we have had good water since. We have got a better current now than we generally have.

3111 There is no smell that I could catch. I drink the water now regularly. Before the ditch was in, we couldn't drink it at all. Drinking the water has had no effect on my health that I can see. I have always been hardy since I have been on the river. If turning in the drainage canal had any effect at all, it would give us better water—I mean purer water and more of it. Before the opening of the canal there was several times when the river was very low that we had no current at all and it was dead water above the locks here. Three times I have raised, all the fish in my nets were dead. There was a kind of slime formed on the nets.

3112 Since the opening of the canal the fish keep better in live boxes and you can leave them longer in nets without raising them and they won't bruise themselves or die with disease as they would before.

CROSS EXAMINATION, By Mr. Jeffries.

Use water from a well for domestic purposes. I can drink the water now when I couldn't before, the year around. I could drink it before but there were times in the year when I couldn't. The most fish that we have is German carp at the present day. They feed on everything that I have tried yet—potatoes, meal, flour or anything else. They feed on animal matter.

3113 We have a fair current now which we did no thave before the ditch came in. The people here in town have wells and cisterns that they use water out of.

O. C. BARTHOLOMEW, Examined in chief by Mr. Todd.

Am fisherman. Employ from three to five men in my business, which is a half-mile north of Kampsville. Fish with about 80 nets. Have lived in Kampsville ten years.

3114 Before the opening of the canal here at times, during the summer season, the river would have scum on it and I have seen nothing of that kind since. Before the canal was opened, in the winter after a heavy freeze, there was a smell connected with the water. Since the opening of the canal we have had a right smart current and no scum on the water. We have no scum any more and there seems to be a pretty fair current. The water appears better, it doesn't seem to be as stagnant. I drink the water and have done so since the opening of the canal only through the winter season.

3115 The fishermen also possibly do that when out in the water in the winter season.

CROSS EXAMINATION, By Mr. Jeffries.

All the people around here have wells or cisterns and use the water from those wells for domestic purposes. I do not know whether the water contains deleterious matters or not. Before the opening of the canal, there was no current, the stuff went which ever way the wind was. Now, we have a fair current all the time, both in high and low water. There is a current here opposite this place.

3116 The farther up you get the stiffer current you get until you reach the other lock. Two years ago the Illinois river was lower than it is today—that was in 1901 during the drought.

WILLIAM MAPPIN, Examined in chief by Mr. Todd.

Am fisherman. Live at Kampsville. Have lived here 7 years. The water in the river was pretty bad before opening of the canal. At times would get down pretty low and there was a right smart scum on it. It had an odor. I drank it then once in a while when we were seining. The water now is purer and better. There is not the sediment. We don't have any scum. Of course, it doesn't get down now like it did then. I suppose that is the reason. I don't drink the water now. I think the water is better. I don't see why it wouldn't be. We have got a good current in the river. We have what we call low water for a couple of months.

3118 We have high water for the rest of the year.

CROSS EXAMINATION, By Mr. Jeffries.

By high water I mean that the water is above low water mark. In July and August as a general thing the water gets down about the lowest. When I say the water is better I mean simply from my observation and my belief is based altogether upon the fact that there is no more stagnant water and that we have a continuous current through the year. I live on a boat right up on the bank of the river. Prior to the opening of the canal there was little or no current here at all. Whichever way the wind blew that was the way the current went.

3119 It is a pretty good current now. There is no stagnant water. The current gets stronger as you go up above.

DR. T. O. HARDESTY, Examined in chief by Judge Johns.

Have been practicing medicine since 1896, in Kampsville. 3120 I cover a territory ten miles on the north, 9 miles on the south and 8 miles on the west. A very small proportion of the population in this territory use Illinois river water for domestic purposes. In my opinion the fishermen use it when engaged in their business. I have had no typical cases of typhoid fever. We have every summer a number of cases. We call them typho-malaria. These cases no doubt are a modified form of typhoid fever. The cases that I have had to do with have been practically altogether situated in the hills, back three or four miles from the river.

3121 My observation has been that within the last three years there has been less sickness in this community than there has been in the time that I have been practicing here.

CROSS EXAMINATION, By Mr. Jeffries.

The census gives this town a population of 320. As far as my information goes, the people here use well and cistern water for domestic purposes. The farmers use mostly spring or living wells.

3122 **EDWARD DAUGHERTY, Examined in chief by Judge Johns.**

Am a carpenter. Live at Kampsville. Have been on or near the Illinois river 30 years. Have been employed by the government on the Illinois river since the spring of 1882 as carpenter and cranesman on the dredges. Have been connected with the business of dredging the Illinois river for 21 years.

3123 Have been dredging from Devil's Elbow, 4 miles below Havana to Six-Mile Island, about six miles above Grafton. The dredging operations are carried on in the Illinois river in the fall. The object is to deepen the channels and dredge out bars which have formed in the river, as a general rule below creeks. These bars are formed by creeks overflowing and throwing out their sediment into the river.

3124 We have dredged several places three or four times. These dredgings generally have been below the mouths of tributaries of the Illinois river. I have not noticed any serious results from the sediment during the times of floods in the Illinois river. The river does not scour in times of flood or high water. There is more sediment every time there is a flood.

3125 In the course of my business in dredging I always drank the Illinois river water in its unfiltered state. Forty-five men are in the employ of the government on the river while dredging operations are conducted. They drink Illinois river water. I do not know of one case of typhoid fever among our dredgmen. I had typhoid fever once in Cass county, 7½ miles east of the Illinois river. I was only about 15 years old when I had it.

3126 I know it left me bald-headed. The skin came off my body, hands and feet. I was not able to be up for about three months after I was taken. I did not fairly get over it for fifteen years. Have not seen among the men engaged in the employ of the government any such disease as that. Prior to the opening of the canal the color of the water from Devil's Elbow to Six-Mile Island was green—stagnated. Stirring the water with an oar you would find it to be ropey, with a green fiber in it for about two feet down and very little current, unless we had a big head raise a little up the river. The odor here one winter when it froze up was terribly bad, after it got broken up in the spring and the ice got broken so it could get out. That was the only time I noticed any bad odor.

3127 Since the opening of the canal the river has been a good deal healthier. We have had a better current and it is bound to be better drinking water. It seems to be more pure. The character of the material dredged varies. In dredging out a second or third time, it is a soft, mushy mud, as nearly as I can tell you. The first dredgings are mussel shells and mud and dirt and a lot of sand. There aint any clay in the Illinois river except at two places that I have dredged. The clay is blue at LaGrange and down here below, it is yellow. I don't believe I ever noticed any gumbo in the bottom of the Illinois river.

CROSS EXAMINATION, By Mr. Jeffries.

3128 The last dredging we did was in 1900, all the way along up.

3129 After those shallow places had been dredged out the matter that was deposited there was mostly mud. That was generally true of all the places as to the second dredging and the third. It would be thin, sloppy mud. In places right close to those creeks it would be almost level; that is the cut would be filled level with the original bottom of the river.

Q. What do you mean by being filled level with the original bottom of the river?

A. When we would dig down, say three feet through this bar, then the creek would come down and fill that three-foot cut up again with the original bottom of the river; that would be the original bottom again, that cut. When I say the water is better, I take my judgement from the look of the water and the current and condition of the water before and now.

3130 Before the ojening of the canal there was no current. Since the opening we have always had a good current. Opposite Kampsville we have got about a mile or a mile and a half an hour. The current continues from here to the dam and on over the dam. I don't think it changes much as you go up. It is about as swift at one place as another. When this mud and filth is taken up out of the bottom of the river in these places where we have dredged, it is generally taken out and put in behind islands, when it is possible to get behind an island. If not, then right up on the bank as near as we can get it.

3131 There would be a little current 15 feet from the bank, certainly. The people in town use well water for domestic and drinking purposes. Am a man of family. I use well water.

DR. T. O. HARDESTY, Recalled. Examined by Judge Johns.

I was taken sick September 26, 1902, and confined to my bed for eight weeks. The diagnosis was typhoid fever. Prior to getting sick I had treated two cases in August—the latter part of July and August for what we diagnose in this country as typho-malarial fever. The weather was very warm and my opinion was that in drinking the water that I would find at these houses when I would go there, that I contracted the disease from these two patients. Those two cases were five miles south of Kampsville and two and a half miles west of the river.

3132 The people who had the cases did not use Illinois river water for drinking purposes. The urinary and fecal discharges from my own person at that time were just thrown outside on the ground, and not disinfected.

RE-CROSS EXAMINATION, By Mr. Jeffries.

One of the patients was a male and the other was a female. The gentleman had opportunities to drink water away from home. He was running a threshing machine. The lady did not. The sickness of one ran into the other, one was sick and the other was taken sick a couple of weeks later. The gentleman was a man of family. The lady was a young girl about sixteen. The man had done some threshing along the bluffs. My opinion was that I contracted the disease from one or the other of those two patients. I was just as likely to have taken a drink at some other place as at these two houses, but these two cases were the only cases I had last summer of typhoid fever.

3133 DR. FREDERICK W. RUNDE, Examined in chief by Judge Johns.

Have been practicing medicine since 1898.

3134 Practiced in Denver, Colo. a year and a half and the balance of the time at this place. Have been in Kampsville four years on the 26th of November. I have had two cases of typhoid fever in this vicinity. One was that of Dr. Hardesty, the other was three miles south of Kampsville, a mile and a quarter from the Illinois river. The person having the fever did not drink the waters of the Illinois river, to my knowledge. The condition of the health of the people of this community since the opening of the canal has been fairly good.

3135 As far as my knowledge is concerned, very few people drink the river water except those who probably live along the river and can't get anything else. There is just as much malarial disease out in the hills as along the river. I also conduct a pharmacy. Since the opening of the canal the sales of patent medicines are a great deal less and especially antimalarial medicines.

CROSS EXAMINATION, By Mr. Jeffries.

Am a married man. Use well water at home. Use well water in the preparation of my prescriptions.

3136 ALBERT R. ZIMMERMAN, Examined in chief by Judge Johns.

Live at Kampsville. Am a ship carpenter and calker by trade. Am 44 years old and have been on this river 43 years.

Am familiar with the river from 12-Mile Island to Havana. Before 1900 during low water the river was very low and there was a great deal of green stuff and such as that floating on the river. The water would get pretty green, all over the top of the river. Pulling a skiff over the river you could see the mark of the boat right through the green stuff. I noticed a
3137 few years ago that the odor was so bad you could scarcely stand it at all up there at LaGrange locks. We used to use it for washing purposes and for drinking purposes, but it got so bad we couldn't even stand the smell of the water in the house, boiling on the stove. We had to quit using it entirely for washing purposes. We used to drink it very nearly altogether when we were out with the fleet dredging. I have never heard of a genuine case of typhoid fever right on the river bank in my life, since I have been on it. All the typhoid fever that ever I heard of I know has been back of the river. Since the opening of the canal we have had a higher stage of water, more current, and as far as speaking about the condition of the water in general, whether it has been a benefit or detriment to the water, I could not say. I don't see so much of that green stuff in the river. We have drank the water since, and as far as drinking it, we can't tell any difference in the taste of it and we don't find any more sediment in the water than we did before. I presume, taking the water in general, of the Illinois river, it is today, I believe, really better than before the canal went in.

3138 CROSS EXAMINATION, By Mr. Jeffries.

I never analyzed the water. I can't tell whether it contains deleterious matter or not. Am a man of family. Use well water at home for drinking and domestic purposes. Before the opening of the canal there was not very much of a current in the river.

3139 There is a fairly good current in the river for the last two or three years.

C. V. BRAINARD, Examined in chief by Judge Johns.

In my employment by the government I have been in charge of all the dredging operations that have been done in the Illinois river in the last 12 years and a half, from Copperas Creek lock to the mouth. I accompanied the dredge boats at times. The material that is dredged from the Illinois river is some sand, some clay and some mud. Most of the dredging has been done between Kampsville and the mouth of the river, also between Kampsville and Copperas Creek locks. The purpose of the dredging is to deepen the channel and is done largely where bars have formed, in order to cut a channel through them. The majority of the dredging that has been done is to cut
3140 these bars that have been formed for years and have been an obstruction to navigation for probably 20 years and they exist in all points of the river, but the new bars forming are generally below the mouths of the creeks. After high waters, we frequently find some of our channels filled up. That is usually in parts of the river that are affected by back water from the Mississippi. This may be caused by two reasons, either that the water that is entering the river from the Mississippi is full of sediment which is deposited when the current is slack, or it may be that the water coming from above in the Illinois river, deposits the sediment into the slack water that is formed from above in the Illinois river, by emptying into the back water of the Mississippi; the deposits may be made in either of the two ways.

3141 Before the opening of the drainage canal in 1900 I never knew of the Illinois river scouring and cleaning itself in times of high water. Since the opening of the canal it does not scour and clean itself any more than it did before. Before and since the opening of the canal if sedimentary matter is deposited in the Illinois river, the only way it is removed is by dredging it, or some mechanical process. The river does not clean itself at all that I have ever been able to find out. During the high water of the past spring I was told by Mr. Worman of the government survey, that he had obtained data that indicated that the current flowed up-stream above what is known as the Griggsville Bridge, about 60 miles from the mouth of the river. (Motion to strike out, by Mr. Jeffries, as hearsay.) The excessive rise in the Mississippi river occasioned this reversal of the current of the Illinois river.

CROSS EXAMINATION, By Mr. Jeffries.

(Motion to strike out all the evidence of this witness taken today.)

3142 Coperas Creek dam is 106 miles from Kampsville. Records are kept of all this work and in those records are daily statements of the amount of deposits removed, the character of the deposit and the disposition made of it. I have a copy of that record here in my office and there is a copy in Chicago, in the office of the district engineer. Those records cannot be removed from my office, but a copy of them could probably be obtained. Where we have been dredging in these various places the mud might be from a few inches to three or four feet. We finished dredging below the mouth of what is known as Otter Creek below here, one night and moved up half or three-quarters of a mile and began dredging again, and there was a big storm up Otter Creek that night and the next morning we found that there had been a deposit of over a foot in our dredged channel from that storm. Another instance was at French Bar; we dredged from that for about a mile in 1894, and in 1899 we went back to widen the channel; we found that during the high water of 1899 that in parts of that old channel there had been from three to four feet of a deposit, and this was caused by backwater from the Mississippi. It has been two years this summer since there has been any dredging done on the river.

JAMES R. FULLER, Examined in chief by Judge Johns.

Live at Kampsville. Am in government's employ as overseer of Illinois river crew.

3144 Have been in employ of the government 13 years altogether as clerk and overseer. I have charge of repairs and construction work and dredging operations under the supervision of the assistant engineer, when he is there. When he isn't there I have the same duties that he has. W. M. Charles was assistant engineer when I first came on board and C. V. Brainard since. As far as I am concerned myself I have not done any dredging above Meredosia, between Meredosia and Six-Mile Island. The dredging is done to improve navigation. The dredging is done through bars that have principally been in the river and always were in the river, through bars only. As a general rule the channels have been cut 200 feet wide. The dredged material as far as possible is dumped along the shore opposite the dredged channel. The material dredged is sand, mud and mussel shells.

3145 The bars are formed generally below the mouths of the tributaries of the Illinois and are caused by the flood washing it down from these tributaries. The deposits are washed down by the floods. The channels cut in these dams fill up. This is caused by freshets out of these tributaries. We have re-dredged the channels formerly dredged out.

Just now I can only think of two instances, one at French Dam and one at Six-Mile Island—there are four, one at Herriken Island and one at Otter Creek. Floods in the Illinois river will make some deposits along the banks. At the lower end, if we have back water from the Mississippi it is likely to make deposits in the main channel. I have never seen any effects of lifting up and removing sedimentary matter previously deposited, either in the channel or along the banks of the river by floods. If sedimentary deposits are made or occur, dredging as a rule in some form or other is the only means of removing them. The Illinois river before the opening of the canal never scoured or cleaned itself in times of flood that I ever saw.

3146 Since the opening of the canal, the Illinois river does not scour or clean itself in either times of flood or other stages of water. Since the opening of the canal if sedimentary matter occurs, the only means of removing it is by dredging. I should think Copperas Creek dam is seven or eight hundred feet long. Prior to 1900 the current of the river, especially in low water was sluggish and the river was always muddy. In low water it smelled pretty strong a good deal of the time. I think the water has been clearer since the opening than it ever was before and there is a good deal more current. The men under me that worked in the dredging operations drank the Illinois river water before and after the opening of the drainage canal, part of the time. Occasionally there would be a spring near where we were working and they would drink that water, otherwise they drank the river water.

3147 There has been no typhoid among those men to my knowledge.

CROSS EXAMINATION, By Mr. Jeffries.

I mean to say that in times of high water the river does not cut through these bars and deposits and at places form new channels. The river don't cut out channels, don't change a channel from itself. It won't cut a channel through these bars. In my experience the channel never changes from the river itself. I never saw this river change a channel from the effects of the water. I have studied civil engineering but not hydraulic engineering.

3148 I never analyzed the water. I don't know anything about it in that respect.

(AT GRAVEL POINT, ILL.)

JOHN WEIMER, Examined in chief by Mr. Todd.

Live at Gravel Point, that is about 40 miles from the mouth of the Illinois and have lived there about three months. Prior to coming here I was employed by the government as dredging engineer in the neighborhood of about 16 years all told on the Mississippi and Illinois rivers. I am acquainted as far up the river as LaSalle and down to the mouth. I have dredged along the river from three miles above Hennepin down to the

3149 mouth. I am familiar with the character of the Mississippi river from Winona to about 20 miles below St. Louis. The Mississippi and Illinois rivers do not compare at all as to their channels. The Mississippi river moves in its channel and the Illinois stays stationary. The Mississippi river scours and the Illinois river doesn't.

3150 When sedimentary substances are deposited on the bed of the Illinois river I don't see that high water has any effect upon the beds of the stream and the deposits made upon the bed of the stream. High water in the Illinois river will not scour out the bed of the river. I have had experience with the Illinois river that justifies me in making that statement. I have sounded the gauge of the water when we dredged and have sounded it a year or two after we dredged and found about the same water. Freshets in the tributaries of the Illinois have quite an effect on the Illinois river in washing the soil off the hills and carrying it into the river. This soil is deposited at the mouth where it strikes a big body of water where it loses the swiftness of the current. That deposit so made by freshets might subsequently be removed by high water in some cases, but most of the cases it don't on the river.

3151 It might in a case where the river is very close and a creek comes out into the river, while if there is a big stage —a big, flat bed, it won't. It might remove it of its own accord where it is very shallow but in the 12 years I was here we had no such experience, but yet such might be the case. Such bars are removed by dredging. There have been instances where we have dredged out a channel and that channel subsequently filled up. We were down here dredging at 12-Mile Island, right below Macoupin, and we were just about through and we were going to move up the river with the fleet and a rain came that night up the Macoupin and it come down the Macoupin creek an awful strong current, and it regular flooded; it filled up the channel about a foot. I know when the Kampsville and La Grange dams were built.

3152 I don't believe that the river has filled up above those dams by sediment outside of the channel. It might reach above the locks. I don't think that it does but it might be.

When the matter is deposited on the bed of the Illinois river
don't know of any way by which it can be removed except b
dredging. High water or current doesn't change the channel i
the Illinois river. Current and volume of water in the Missis
sippi change the channel. That is common on that river.
have found that condition to exist upon the Illinois.

3153 Before the opening of the canal the Illinois river wate
in low water was stagnated fearful, it was greenish. Sinc
the opening I consider that it has been lots better. I conside
it purer now than it was before. It hasn't the odor. Six o
seven families are engaged in fishing at this point. I do no
know of any typhoid fever among those people. I have dran
the water of the river nearly altogether for 12 years both i
summer and winter. It is lots better now for drinking pu
poses than it was before.

CROSS EXAMINATION, By Mr. Jeffries.

3154 Lived at Kampsville before I came here. I have a we
here and use the water of the well for domestic and drin
ing purposes. We quit dredging about 2½ years ago bu
3135 we have been continually on the river since. I did m
dredging on the Illinois river from Hennepin down t
the mouth. Our dredging was sometimes two feet, three fee
or four feet. The material we dredged was very heavy loam an
in places in those creeks we would get heavy gravel and mu
sel shells and necessarily heavy mud in it.

3156 I ain't positive whether the last place I dredged wa
Hennepin or Kampsville. The material we took out ther
was principally mud. I made a report of all this dredging an
kept a record of the amount of filth and mud that I took from th
bottom of the river. The government has it on file. My r
port is kept at Kampsville.

3157 When I say the water is better I mean I made my obse
vations by using it for drinking purposes. I find it i
better now than it was before.

THOMAS J. NELSON, Examined in chief by Mr. Todd.

3158 Am a fisherman. Have been for about six years. In the fall of the year, the Illinois river had a bad current before the opening of the canal. There was a smell to it. It was no current, and green moss and grass grew in it. There hasn't been any since. I don't know whether there was an odor to it. I didn't use any of it. It was impure was all you could call it. The effect of the opening of the canal has been to give it a current and the water has become purer. There is more current in it is all I can say.

CROSS EXAMINATION, By Mr. Jeffries.

I have been farming on the river for the last fifty years.

3159 I live in the first house below here. I have a well. I use the water from that for drinking or domestic purposes. I have no information as to whether or not the Illinois river water contains more deleterious matter than it did before. I could not say whether the sewage from Chicago gets down here this far or not.

3160 THOMAS CARTER, Examined in chief by Mr. Todd.

Live at Gravel Point. Have been a fisherman for 45 years. The Illinois river prior to opening of the canal was stagnated, had a low current, a green scum on it, and a smell in the hot part of the season. The opening of the canal has put some current in it and keeps that green scum off so far that I think the water is purer than it was. Have drank the water since the opening of the canal. I never drank it much in the summer time. There are about five men engaged in the fishing business at this point. I never heard of any typhoid fever among them.

CROSS EXAMINATION, By Mr. Jeffries.

Have been living here about 25 or 30 years and fishing all the time. I live in a house and have a well and use water out of that for household and domestic purposes. When I say the water is better now than it was before, I mean it has a better current and a larger volume of water. I couldn't say whether the water contains more deleterious matter than it did before. It isn't used very much for drinking purposes, only when you get out on the river and want a drink and haven't got anything else.

3162 RE-DIRECT EXAMINATION, By Mr. Todd.

I don't know as there is any difference in the color of the water. The water before the opening was as clear as it is now, except the scum. I don't know as I said the water was any better. I said there was a better current than there was. I drank the water before and after the opening of the canal. I don't know that I can tell any difference in the taste of it.

3163 GEORGE NELSON, Examined in chief by Mr. Todd.

Am a fisherman. Have been fishing for about seven years. I haven't seen any difference in the condition of the water only in the fall of the year, since the opening of the canal. We have a current now the last three years and the water doesn't get so green and isn't so filthy. I have drank it both before and since the canal was opened. It has a better color and is purer water. I don't see any green scum upon it now.

3164 CROSS EXAMINATION, By Mr. Jeffries.

We use well water at home for drinking and household use. When I am around home I always drink out of the well but lots of times I am caught out when I have to drink river water. There is a good deal of difference in the water; before this water came in, it was a regular lake, the water was green, now there is a reasonable fair current here. That is the main difference. I don't know whether Chicago sewage gets down this far or not.

3165 RE-DIRECT EXAMINATION, By Mr. Todd.

The water is more clearer. It is not so stagnant. More pure. Of course the current was pure water since the opening of the canal and before that it was stagnant.

S. D. THURSTON, Examined in chief by Mr. Todd.

Am a fisherman and have been such for three years steady. Before that time I farmed. I have lived along the river most of my life.

3166 Before the canal was opened the river was stagnant in low water; there was a green scum on it and an odor in hot weather. Since the opening there is a better current and a clearer water in the winter season anyway. I would say better, in fact. There is no scum on it now this low down. I saw it over at Peoria. I drink the water out fishing when it is cold. There has been no sickness among the fishermen in this locality that I know of, nor any cases of typhoid fever.

CROSS EXAMINATION, By Mr. Jeffries.

3167 I live in a dwelling house and have a well. Use the water from the well for household and drinking purposes. Don't know whether the sewage comes here from Chicago or not. There is more current in the river. Don't drink the water unless I get caught out and have to drink it.

(AT PEARL, ILL.)

MARION HESS, Examined in chief by Judge Johns.

Live in Pearl. I fish and farm some along the river. Have fished off and on for ten or twelve years, 15 miles each way up and down the river. Before the opening of the canal the river was pretty filthy and bad.

3168 During July and August it was pretty filthy, green-looking water. It would form a scum and slime all over the nets. During this time when there was slime and scum upon the waters we drank it, along in the spring of the year. Since January, 1900, the water seems purer and all right. There is a good current. Now whenever I want a drink of water I take the cup and get me a drink most any time. When I can get no other water it does pretty well. I don't know exactly as I know of any typhoid fever among the fishermen since the opening of the canal. I couldn't mention any around here.

3169 CROSS EXAMINATION, By Mr. Jeffries.

Have a well at my home. Use the water from the well for domestic and drinking purposes. When we can't get any other water we use the river water. There was a time in July and August you couldn't drink the water on acocunt of scum over it. Now we take the bailing cup and dip it down and don't get no scum. It seems to do for thirst. We have a current now all the time. In July and August before the opening of the canal we had no current at all.

3170 E. H. CHANDLER, Examined in chief by Judge Johns.

Am agent of the C. & A. Ry. Co. and U. S. Express Co. Live at Pearl. Took samples of water in 1899 and 1900. Had Joseph Lindsey take the samples personally.

3171 He was about 21 years old and is in the Philippine Islands now as a soldier. (Witness states the times and places at which samples were taken.)

CROSS EXAMINATION, By Mr. Jeffries.

I didn't see Lindsey personally take any of the samples nor see any of the samples taken at any time.

3175 J. RADER, Examined in chief by Judge Johns.

Am a barber and live at Pearl. Know Joseph Lindsey; took samples of water in his stead at various times. He was sick with the measles and I took them while he was sick. (States method of taking samples and places at which they were taken.)

3178 WESLEY FRISE, Examined in chief by Judge Johns.

Live at Pearl. Am a fisherman. Fished on the Illinois river about 12 years, as far up as Hennepin and down to here. Before opening of canal the river water was pretty bad. Stagnated and scum. In summer time when the water got down low, it would smell. In the winter time when you cut a hole in the ice there would be regular gas come from the water and I have cut holes in the water where dead fish would come right up through the holes, from gas and stagnated water, I guess. I remember two winters its being that way—one was at Hennepin and the other was at Lacon, but that has been 18 years
3179 ago. Couldn't drink the water prior to January, 1900.

Fished at Beardstown and Frederick in 1897, 1898 and 1899. We had some pretty bad water there at that time. While at Beardstown and Frederick, if we cut holes in the ice, the water would smell and gas would come out. Didn't drink the water at that time, but had to when caught out. Since the opening of the canal I claim the water has been pretty fair, good water.

3180 I never smell anything now. We do drink it now sometimes. I used it a good deal this week when I have been out up the river I drink it right along. It is a good deal better for drinking. I don't see no scum on it now and it is cooler and clearer. I do not know of any cases of typhoid fever among the fishermen since the opening of the canal.

CROSS EXAMINATION, By Mr. Jeffries.

I live on a boat. Have lived on a boat about eight years. There is a good deal more current now than there was before, at all times of the year. I do not know whether the water contains any deleterious substances or not.

3181 Carp thrive best in this river. They feed on pretty nearly everything. With a trout line they will feed on mussells, crawfish and dough-balls. I have catched them on roasting-ears and grains. I don't believe they feed on flesh or dead meat. I never caught any with any. I tried it with beef and never caught any. I believe this current goes up as far as Peoria. I know the water is better. I know it because you don't see the scum along here and this stagnated water and you don't smell this gassy smell any more like you used to. I used to live at Hamburg on the Mississippi. I have seen the Mississippi frozen over several times—for a short time though. I have seen it frozen over at Quincy.

3183 JOHN WINDT, Examined in chief by Judge Johns.

Am a buyer and shipper of fish and live at Pearl. Have been in that business 18 or 19 years. Have been a fisherman myself on the Illinois river. Before the opening of the canal we had a very slow river—no current and no flow and the water would get very stagnant. Had a very bad smell, gas like. In buying and shipping fish used ice in packing them. The ice was from the Illinois river generally. In 1896 and 1897 I put up ice at Gravel Point, and also at this place and I noticed when cutting ice at that time there was a gassy smell where you would open the ice. The water looked as though there was a dark scum on it. Since the opening of the canal there has been more current and the river clears up faster after a rain or after a flood. I think the water is more clear now. I drank some of it the other night. I never drink it unless I have to.

CROSS EXAMINATION, By Mr. Jeffries.

The people here in Pearl have wells or cisterns. They don't use the Illinois river water without they have to. It is not considered good water by them in the summer season.

3186 There was very little current at times before the canal was opened. There has always been a good current since. It shows that it is better. It is cleaner. We don't have much scum. I don't know whether it contains deleterious matter or not.

JOSEPH HALL, Examined in cheif by Mr. Todd.

Am a fisherman. Have lived at Pearl three years. Before coming here lived at Frederick on the Illinois river four miles above Beardstown. Have been fishing on the river since 1881.

3187 Before the opening of the canal, in the summer time when the water was low, it was pretty bad. Green scum on it. Since the opening of the canal we don't see that any more and the water is more pure. We use the water more or less all the time. The water was better last year than I ever saw it on the Illinois river. I have cut holes in the ice up there at Beardstown, seven years ago this winter and the fish died right in the net and the water smelled so you couldn't hardly stand it. It is better now than I have seen it for a good many years. It is purer, we don't have that gas and no green scum and it has more current. I cut ice every winter. When we cut the ice there is a big difference. The water is pure and clear and you can see the bottom in five or six feet of water and the water tastes better—no gas and no dead fish.

3188 I drink the water. Have heard of no cases of typhoid fever of people drinking the water. We use the water all the time in the winter time right in the family.

CROSS EXAMINATION, By Mr. Jeffries.

I live in a house boat and have done so about 11 years. There is a larger current now and the water keeps purer. The water is purer. A man can tell it when he drinks it. German carp thrive best in this water. I don't know what they feed on. They bite well on crawfish. There is a good current in the river now and I do not know whether the water contains deleterious matter or not.

3189 I never had it analyzed.

GEORGE HOPPLER, Examined in chief by Mr. Todd.

Live in Pearl and have been a fisherman sixteen years. Before the opening of the canal the Illinois river water in July and August was not very good. It had a green scum on it and in the winter, the water would get so stagnated the fish would die. It smelled awful bad and it would get red. I fished here one winter when we would go and cut our nets out of the hole and there would be fish come up in the hole dead.

3190 There was a substance looked like coal-oil in the water. Since the opening of the canal when the river is froze over it is better. No green scum nor coal-oil substance. The water is a good deal better and purer and there is no odor. I have not drank any water lately but the water looks a great deal better than it did before the canal came in. I have not noticed any deleterious substances in the water.

CROSS EXAMINATION, By Mr. Jeffries.

By the word deleterious I should think it would mean stagnated.

3191 The water isn't stagnated now and it was before the opening of the canal. There is a good current now at all times. I have lived on a boat about ten years. Always used the water from the river. It gets warm in the summer time and we have to put ice in it. Don't know whether the sewage from Chicago gets down here or not.

3192 (AT NAPLES, ILLINOIS.)

W. H. WATERS, Examined in chief by Judge Johns.

Am a fish dealer and have lived at Naples 24 years. I have also engaged in catching fish by nets as employer and actual worker. I have put up ice in the river on and off for about eight years. Naples is about 38 miles from Kampsville dam, 26 miles from Pearl and 25 miles from Beardstown.

3193 Before the canal was opened we had a very low stage of water at times and in the summer time a little green scum would come on which would last probably for two or three weeks. At that time the fishermen did not drink the water in warm weather, but in the early spring and late fall they did. At that time there wasn't very much sickness here. There was but very few cases of typhoid fever to my knowledge. Since the opening of the canal I don't notice very much difference in this vicinity. I haven't heard of any typhoid here since the opening of the canal. Before the opening of the canal, I noticed no scent particular, but I noticed a green scum.

3194 The condition of the ice varied even before the canal went in. Since the opening of the canal the water has been clearer and purer up to this spring. I haven't analyzed it. There has been no scum on the river. The ice we got was thin and would only freeze about six inches but what we got was good, clear, pure ice.

3195 Before the opening of the canal the people complained about the taste of the fish more than they did the smell. They claimed that they tasted like coal-tar. That was about seven or eight years ago.

CROSS EXAMINATION, By Mr. Jeffries.

Naples has a population of 400. The people have wells mostly—sand pumps. The current has been very sluggish here this year on account of high water in the Mississippi, the current, as a general thing, since the canal was turned in, is a little swifter. The water from the Mississippi backed up within about seven or eight miles of here last spring. That lasted about two weeks. We didn't have back water here but we had very little current.

3196 Outside of this back water from the Mississippi we have had a good current since the opening of the canal. The water has been all right. We haven't any fish but that thrive well. Carp is more abundant than any other fish. They feed on vegetation in the bottom and some feeds on green grass, green hay, wheat or anything where it would be overflowed. The water is normal now, that is, speaking of it since the opening of the canal. I presume there has been two or three cases of typhoid here in the last several years.

WALLACE HART, Examined in chief by Mr. Todd.

3197 Have lived in Naples 30 years. Am notary public and town clerk. Am 69 years old. Have been familiar with the Illinois river all my life. Have been on and off the river most of the time. Before the opening of the canal the river was low and almost stagnant. There was a green scum on it and a bad smell in the evening. My house is probably half a block from the river and I noticed that smell. Saw lots of dead fish floating in the river. Since the opening of the canal there has been more water in the river and it looks clear and pure to me and I haven't seen any dead fish, scarcely any, since, nor any odor. It is a great deal clearer than it was before.

3198 There are 10 or 12 people engaged in fishing here. Hardly ever hear of a case of typhoid fever for the last two or three years. Naples is about 40 miles from Grafton.

CROSS EXAMINATION, By Mr. Jeffries.

There is much better current now than before the canal was opened. I have a sand pump at home. Get water for household and drinking purposes out of this pump. Those people that live any ways back from the river don't use the water, but those that lives right on the river probably do.

3199 The water doesn't become stagnant like it did and it don't have that smell to it like it did before. I don't know what the water contains in the way of deleterious substances nor whether or not it contains more than it did before the opening of the canal.

WALTER SURRATT, Examined in chief by Mr. Todd.

Am a fisherman and have lived in Naples 20 years.

3200 Before the opening of the canal the river seemed foul and stagnant. Fish wouldn't live in it and water was low and wasn't pure at all. There was a scum on the water during the summer season and at places there was odor where there was a kind of eddy or anything like that. A kind of substance would form on the net and it was something like grease. In fishing under the ice some of the fish would live and part of them would die. The fish did not seem to be healthy and lively as they have been—we would lose some fish. Since the opening of the canal we have got current, none of the green scum and the fish seem to live better. We have more fish in the river to my judgment. It fills up the lakes and I believe it really helps the lakes in purifying, because we don't have near the moss in the lakes we had, as well as the river. The water is more pure than it was.

3201 The ice is clear, before it would be dark. In places you would get moss in the water at low water. In winter we do not have this oily substance in the water that we had before. I haven't discovered any odor under the ice since the opening of the canal. Fish live better in live boxes now. I haven't had any fish die on me this year.

CROSS EXAMINATION, By Mr. Jeffries.

3202 Before the canal was opened, we fished right along. I sold the fish to the markets here. I don't know whether the fish in the Illinois river before the canal was opened; were condemned by the state board of health as unhealthy. I sold my fish on the market before the canal was opened.

3203 At different periods we have got better current in here and we don't have the stagnated water we had before. We have had a good current for the last two years. I use the town pump. I don't drink the water of the Illinois unless when I am out fishing. I suppose the current has taken that green scum off. I don't know as the water here contains any deleterious matters or not. I have used right smart of the river water and I have been healthy. When I would be out fishing I have drank it. That is the only way I have of judging it. I drank it before the opening.

3204 JAMES WATERS, Examined in chief by Judge Johns.

Have been a fisherman ever since I was big enough to fish. I have fished as far up as Browning, which is 36 miles, and about 10 miles below. Before the canal was opened, the river was kind of stagnated. Slime and scum on the water. It smelled like tar to me. Six or 7 years ago my brother and I were fishing together for some years before the canal was opened; we was raising nets and in the nets would be big catfish and white perch and they would be dead on the ice.

3205 There used to be slime on our nets. It was kind of greenish slime. The nets would not last as long as they do now. Since the opening of the canal the water has been more purified than it was before. There is no smell to it. I know I drank some of it here about a month ago. There is no moss on it that I can see. Before the opening of the canal the fishermen in this community did not drink the water much, to my knowledge. Since the opening of the canal, they do drink it. Among the people who drank the river water before the opening of the canal, there was typhoid fever and a good deal of chills. Since the opening, I don't know of any typhoid fever or chills in town. The ice used to look more slimy and dirty than what it is now. We put up some as fine ice last winter as we ever have.

3206 CROSS EXAMINATION, By Mr. Jeffries.

That ice was cut out of Smith Lake, a mile and a half or two miles long. It is deeper this year than it generally is.

I live in a house back from the river one block. We have a pump at home.

3207 Used the water from this pump for household and drinking purposes. Never drink the water from the river unless I am out upon it and can't get any other. Before the canal was opened, we sold the fish in the same market that we sell now. There were no objections at that time that they were bad fish that I can remember. I have never seen them die and become as bad as they were those two particular winters, but it was not a continuous thing every winter before the canal was opened. I haven't seen any fish dead in the winter time since the canal was opened. German carp thrive best in this river. I don't know whether they feed on manure. They feed on most anything I guess.

3208 I don't think this water contains anything that would be harmful to the health, because I have used it in the winter time when I was out fishing and I have drank it when I was not working and it has never hurt me. I know of other fishermen being out the same way. There is more current in the river now. There is no time of the year in which there is no current, except from back water.

BENJAMIN FRANKLIN ECKLES, Examined in chief by Judge Johns.

My occupation has been that of farming.

3209 Have lived upon the Illinois river about 15 years. For four years I have lived within eight feet of the bank and that is where I live now. I have lived in this vicinity since 1846. Prior to the opening of the canal when we had a little rain the river was muddy and whenever we had a long dry spell it was clear. There was considerable moss and even grass, but that was years ago. There was a smell to the water in warm weather. Since the opening of the canal I pronounce the water clearer, purer, brighter and better and use it stronger for all uses than I did before. The last four years, I have lived on the river and I have used that river water a good deal for all purposes. In right warm weather I don't use it for drinking but in cool weather I do. In cool weather I use it for drinking, cooking and everything.

3210 The people have splendid pumps here. I haven't suffered from any disease caused by drinking the water, that I know of. I enjoy very good health for a man of my age.

CROSS EXAMINATION, By Mr. Jeffries.

I am 65 years old. Have a better current now than we did before the canal was opened.

3211 (AT MEREDOSIA, ILL.)

JOHN CHRISMAN WORKMAN, Examined in chief by Mr. Todd.

Live in Meredosia. Am a fisherman. Have been working at the business for about 20 years. Prior to the opening of the canal the river was stagnant. Sometimes it was muddy; sometimes it was clear. At times of the year, there was a green scum upon it. At certain times of the year it would smell
3212 bad along the river, the same as it does now. It does that along here now sometimes. It is bound to do that whenever the water gets low, more or less. Two years ago the water here was so low that it dried up in those little lakes up here. Whenever the water gets low and the water gets down off the banks, it is bound to smell. Since that low water that I speak of we haven't had any low water. There is a smell along the river here now, pretty bad too, on account of these mussels.

3213 I don't think I have observed any smell since the canal was opened. The opening of the canal I think, has a tendency to make the water purer. That is, you understand when the water is low; at this time of the year, when the water is high, of course, it don't do it, because it is bound to be muddy when the water is high, but that is because it comes from the rains. As far as the canal is concerned, I think it has a tendency to purify the water at this point. That has always been my argument anyway.

CROSS EXAMINATION, By Mr. Jeffries.

It is a pretty hard question, to tell the difference between the water now and what it was before the canal was opened. It is pretty hard to remember back so far. At a certain time of the year, the water is clear and at other times, it is muddy and that was true before the canal was opened.

3214 I did not say that the water smells now. I say it would whether the water contains deleterious matter or not. We don't whether the water contains deleterious matter or not. I don't drink the water only when necessary.

JULIAN L. GRAHAM, Examined in chief by Mr. Todd.

Am a fisherman. Live at Meredosia. In 1900 the water of the Illinois river was very foul, very low and navigation was almost impossible at times. There was an odor connected with the water.

3215 It has been so low and so foul that it was almost impossible to go bathing. There was a scum on it to such an extent that a person could hardly pull through it at times with a boat. Since the opening of the canal we haven't had any low water. The effect of the opening of the canal has been the best in the world for navigation, sanitary considerations and everything else in that line. There has been no smell since and no scum. I believe it has purified the water itself to a great extent during both winter and summer. Before the opening of the canal there would be a scum on the nets. I don't know as I see much difference now, only it has been an improvement. I don't think I see as much slime and stuff accumulate on the web.

3216 I suppose there would be about 80 or 90 fishermen engaged in the fishing business at this place. Since the opening of the canal, I don't know of any typhoid fever among the fishermen.

CROSS EXAMINATION, By Mr. Jeffries.

Fish about six miles up the river and six down. I think there is a better current in the river now than there was before the canal was opened. We don't see a particle of green scum. We see the green but we don't see the scum. The scum is decayed vegetable matter but the other is the buds of buck-brush floating down. If there is a current, it passes it through.

3217 Carp thrive best in this water. They feed upon willow flies and of course the parasites in the water and the grasses on the bank, the scum and such stuff as that. They also feed on any kind and all kinds of manure.

RE-DIRECT EXAMINATION, By Mr. Todd.

There are other fish that thrive here. The carp, of course, is the principal fish that thrives. Buffalo thrive, but they can't very well do it. The carp is the only fish that flourishes and the only fish from a financial standpoint for the fishermen. The others don't amount to a continental from a financial standpoint. The carp is the billy-goat of the water.

GEORGE S. LEWIS, Examined in chief by Mr. Todd.

Am a hotel man and live in Meredosia.

3218 Have lived here six years last March. Have spent a good deal of my time on the river. Before the canal was opened the water was low and the current was dead. Next to the bank there was a scum and it seemed kind of stagnant. The opening of the canal has made the water clearer and cooler. I notice it more in my fish that I use here. My fish are better than they were before. I use a good many at the hotel. They are of a good deal better quality than before this water was turned in. I judge the water is purer now than it was before this water was turned in. If it wasn't it wouldn't be so much cooler than it was. I haven't heard of any typhoid fever here since the opening of the canal. I don't pay no attention to things of that kind.

3219 I haven't noticed any smell to the water since the opening of the canal.

CROSS EXAMINATION, By Mr. Jeffries.

We have a drove well at the hotel and use the water from it. We never use the water of the Illinois river here. Our waters here are all filtered through the sand. Our wells run all the way from 24 to 36 feet. I don't know whether the water contains any deleterious substances or not. The fish that we caught here before the canal was opened were sold on the open market. There is more current in the river now—considerably more.

3220 Prior to the opening of the canal there was a scum on the water on account of the water being low and stagnant. I don't know that the water was clear underneath. I never paid much attention to that. It seems purer now than then.

WILLIAM HAUSER, Examined in chief by Mr. Todd.

Live at Meredosia. Have run this cable ferry 16 or 17 years.

3221 Before the canal was opened, in the fall of the year we had right smart of stagnant water, but since the canal has come in here, our water has been more pure than it was before. In the fall of the year, lots of times, we drink the water when it gets colder and I find that since the canal is in, it is better to drink than it was before. I call it a kind of a grit that makes it taste better than it did before. Before the canal was opened, there was a green scum on it, especially in the fall of the year. That has disapepared. I don't know of any typhoid fever since the opening of the canal. About three years before this canal was opened, I took a scythe and mowed the weeds across the river so I could get through with my ferry boat. Since the canal has been here, I haven't had any trouble with them.

CROSS EXAMINATION, By Mr. Jeffries.

When I spoke of mowing the weeds, it was in the fall of the year when the water would be down. I have seen it here year after year right along. I haven't mowed much in the last five or six years.

3222 We have a whole lot more current now than we had before.

REV. R. G. LINKER, Examined in chief by Mr. Todd.

Am minister of the Gospel. Have preached in Meredosia
six years. Before the opening of the canal when the water of
the river was low it didn't seem to be as good as now.
3223 I have observed an offensive smell but would not be positive
that it came from the river. The effect of the opening
of the canal upon the water, in my judgment, is that the water
has been better. There has been no typhoid fever among the
members of my congregation in the last three years that I know
of and no member of the congregation has died from that disease
in that time.

CROSS EXAMINATION, By Mr. Jeffries.

We drink the water from what we call drive wells. The people don't use the water of the Illinois river for domestic purposes. When I say the water is better now, I make this statement from my observation and from the appearance of it. I don't know whether the sewage from Chicago affects the water here or not.

A. J. LESLIE, Examined in chief by Mr. Todd.

Am a dealer in grain. Live in Meredosia. Have lived here
nearly thirty years, within 100 yards of the river. Before the
opening of the canal, in low water, there was a green scum all
over the river and sluggish current. There was an odor.
3225 Since the opening of the canal I have never noticed no
more of that green scum. The water appears to be clearer
and purer and a better current. I haven't noticed any odor
particularly for two or three years. I haven't known of any
typhoid fever in Meredosia since the opening of the canal.

CROSS EXAMINATION, By Mr. Jeffries.

Before the opening of the canal if the scum was removed, it wasn't so very clear underneath, on account, I suppose, it was more stagnant and not as much current. Naturally the water is not as clear. Am a man of family, have a pump at my home and do not use the water from the river for domestic and drinking purposes.

3226 They cut the ice that they get in the winter time sometimes from Meredosia lake and sometimes from the river —mostly from the river. I don't know anything about the sewage from Chicago coming down here. I don't drink the water from the river and the people around here don't drink it.

F. A. NEVILLE, Examined in chief by Mr. Todd.

Have been a practicing physician for over 16 years. Before the opening of the canal, in the fall the river water would become rather stagnant and green and there would be a good deal of organic material in the water and floating. There was very little current in the water, to speak of.

3227 I believe the opening of the canal has improved the character of the water. The water is more clear and there is less organic material in it. At least I would judge so from the appearance. My practice extends among the fishermen as well as other people. I think there are between 50 and 100 fishermen here. Have had no typhoid fever cases during the last three years from the fishermen, and have not had to exceed one-half dozen cases during that time in Meredosia. None of those cases were attributed to the waters of the Illinois river. In those cases that I had the excreta was disinfected and some of it dumped into sink basins and others dug holes; at least that was what I ordered done. Meredosia has a population of about 800.

CROSS EXAMINATION, By Mr. Jeffries.

I do not use the river water for domestic and drinking purposes.

3228 The people in town do not use it. So far as I know, it was not used for that purpose among any of those patients who were afflicted with typhoid fever that I treated. When I say the water is clearer I say it simply from appearance. I know nothing about the water other than from appearance, and the fact that there is a stronger current and a larger volume of water than there was prior to the opening of the canal.

S. D. ALLEN, Examined in chief by Mr. Todd.

Live in Meredosia and have lived here about 25 years. My business is pumping water out of the Illinois river into a tank for the Wabash Railway Company. I began pumping water in 1896, I think.

3229 Prior to that time I was working here on the bridge about four years. Before the opening of the canal, at low water, the Illinois river was pretty filthy in my estimation. There was green scum on the river and grass growed all up in the water here, and a sediment in the river. The water went down and left all the filth on the ground outside. It was a pretty bad stench here as soon as the water went down and left it. The water acted bad on the boilers before the opening of the canal. It foamed in the boilers. The opening of the canal has been a benefit to the water. The water has been purer. We have used it for drinking purposes on the bridge right along when it was cold enough to use it. There is no odor that I could discern. I haven't seen any of that scum on it. It has been better for steam making purposes. It has not foamed and has not lined the boilers as bad. We drink the water there on the bridge all the time when it is cool enough. Drinking of the water hasn't made any of us sick that I know of. The water now is better. It hasn't got that gas or stench to it that it had before. It is more clear and it is purer I think.

CROSS EXAMINATION, By Mr. Jeffries.

Am a man of family. Have a pump at my home.

3231 Use the water from the pump for domestic and drinking purposes. There is quite a stronk current now. On account of the increased volume of water and better current I think the water is better. The water never foams in my boilers now.

RE-DIRECT EXAMINATION, By Mr. Todd.

I think it is because there is a better channel and a better current and because the water of Lake Michigan is purer than in this river.

RE-CROSS EXAMINATION, By Mr. Jeffries.

3232 I an't no analyzer or anything of that kind. I don't know anything about the effect that Chicago sewage has on the water. I do know one thing, that is I believe—well, I know it, that the water is better here than it was before.

J. P. BAUR, Examined in chief by Mr. Todd.

Am a fish culturist in the employ of the U. S. Fish Commission. Am at present in charge of the station at this point of the U. S. Fish Commission at Meredosia. I have been employed in that position about 14 years. I look after the collection and loading of the U. S. Fish Commission cars. Seven men compose the crew, not including myself.

3233 My duties give me an opportunity to become acquainted with the Illinois river. Up to five or six years ago, I had charge of the Steamer "Lotus" in making collection of fish for distribution by the U. S. Fish Commission. I became acquainted with the river from LaSalle to Grafton. The fish we handle for the U. S. Government are black bass, croppie, channel catfish and bream. There are lots of other fish that we handle as a collection, put up in formalin and send to Washington. Before the opening of the canal, the river between La Salle and Grafton, during the summer months, the water would get very low and the water was in what I would call bad condition. So much so that you couldn't drink it, even by the use of ice in the water. From Copperas Dam for about five miles above it, I have gone up that stream in the steamer "Lotus" and turned up sediment and dead fish and on several occasions there was a terrible stench and a man could hardly stand the smell, which I suppose was from the distilleries, or I believe it was the filth of the distilleries at Pekin and Peoria. (Motion by Mr. Jeffries to strike out.) I know that there were distilleries at Peoria and Pekin, but I didn't know there was a glucose factory at Pekin or Peoria. At low stages the water in the Illinois river would not affect fish so far as I know, in ponds I don't know that it affected the fish below these dams any at all, only during the winter season when the ice was over the water after the ice was broken up, we would find quite a number of dead fish. Those ponds I speak of are fed by the Illinois river when the water is high enough to go back into them. I have seen thousands of dead fish in these ponds. They were eaten by the different kind of water fowls that we have around this country.

3335 During the winter time I have noticed similar conditions as existed from Copperas Creek to Peoria, at La Grange locks. I don't know of any complaint ever having been made about any stench around LaGrange locks. At this point, before the opening of the canal there was nearly all the time a green scum on the water. We always had a current in the river. The channel would perhaps not be over 75 yards wide and vegetation would grow for about 100 yards from the channel bank to the east, to Meredosia. There would be a smell but I don't know whether you would lay it to the water or the fish. This is a great point along here for fishermen to throw off the offal of fish and it might have been that. That offal is thrown into the river at this point. The effect of turning the water of Lake Michigan into the Illinois river has been to make the water clearer and we have a three-foot high stage of water from low water mark. I could drink the water now in the Illinois river today if it had ice in it. I wouldn't have done so previous to the entering of the Chicago river, unless it was absolutely necessary to do so. I have noticed a green pod that floats on the water since the canal has been opened, but it isn't a scum. It might be taken for scum in looking at it from a distance. It seems to come from some tree or perhaps grows right in the water, I don't know. In my opinion the Illinois river has been greatly benefited by the opening of the canal.

3236 CROSS EXAMINATION, By Mr. Jeffries.

3237 During the hottest part of the summer, these dead fish are found in the lakes and ponds. The ice in the river didn't kill the fish every winter, only during a very low stage and when the ice was very heavy. It seems to be behind the dams.

Am a man of family. Have a pump or well at my house and use water for domestic and drinking purposes from the well. The carp is the most bountiful fish in the Illinois river.

3238 When I say the water is clear now, I give that as my opinion from the water being nearly perfectly clear nearly all the time during a fair stage of water. I do not know whether it contains deleterious matter or not, nor whether the sewage from Chicago gets here.

(AT LA GRANGE LOCK, ILL.)

JOHN D. KERR, Examined in chief by Judge Johns.

Am superintendent of LaGrange Lock. Versailles, Ill. is our postoffice. Have been superintendent for 21 years.

3239 LaGrange is called fifty miles from Kampsville lock. It is called six miles from Meredosia. These are not actual measurements. LaGrange Lock is 12 miles from Beardstown and it is 12 miles from Beardstown to Browning. The width of LaGrange dam between the abutments is about 835 feet. Since the opening of the drainage canal, the water of LaGrange dam has been raised, to the best of my judgment, I would say, four feet. That is shown by the gauges at the lock. There is one gauge above and one below the dam.

3240 At the present time there is a difference of 2.8 in the reading of the gauges. Prior to 1900 we used the water for drinking purposes and around the house. There was not as big a current as there is in some rivers. It wasn't as fresh as in other rivers at other times. There was a green scum—what we called water clover, on the river. It growed there. In low water it would be 20 feet wide some times. In times of low water, it was reasonably clear. You could see, I should say, a foot or a foot and a half at the dam. Since the opening of the canal the current has been a little over half faster.

3241 I haven't seen this clover groth on the river since. We have wells or cisterns at LaGrange. I don't drink the water of the river since we have had the wells and cisterns. The water is pretty near as clear as it was before. It has never been really as clear since I have seen it. I haven't observed any odor unless it was caused by the drift accumulating. Since the opening of the canal I have noticed an odor anywhere around the locks. When the water was first turned in, it was very disagreeable here for eight or ten days. In damp weather now you can smell it very distinctly; the wind blowing it just right blows over to my house and I cansmell it.

3242 I think the most of it is caused where the water flows over the dam, stirs it and the wind blows it. I think that is where most of it comes from. When the water stands in the locks and the locks are consequently not flushing for some time, an odor arises, to a certain extent; it forms a kind of oily substance on top and when you open the valve and the water runs out and stirs it up, you can notice it very distinctly. It is different in that respect now, as to the time before the opening of the canal. I don't think there is any difference in the appearance of the ice.

3243 CROSS EXAMINATION, By Mr. Jeffries.

The water was clearer before the opening of the canal. That is my judgment, in fact I know it is. The stage of the water is about four feet higher than it was then. The depth of water that is flowing over the dam now is two foot three and the dam is 835 feet wide. At low water stages I had to keep one foot of water on the dam and used flash boards for that purpose.

3244 There has always been a good current since the canal was opened except when we had the high water in the Mississippi. It kind of slacked up. Before the opening of the canal the water didn't smell. Since the opening there has been considerable odor, at times worse than others. It is the same in the summer time. We don't get as much of it. One reason I think is because we are using the lock all the time and the water don't stand. It keeps going all the time, but whenever the water stays in the lock all the time then we can smell it very readily and it has a scum and oily substance. It is a scum like formerly was on the river. I have shown the gentlemen some of it down there that was formed since this boat came through. I stated a moment ago that when the wind was in the right direction, this smell came over the dam but that is only at times when there is mucky water.

3245 I have a well and cistern at home but I use cistern water altogether. I dont use the Illinois river water because I don't think it is healthy. At least I imagine it ain't. A physician was down here a week or ten days ago, it was when I had found that bad cake of ice in the ice house and he advised me not to drink that water and told me to put the ice around the water in the receptacle and cool the water that way.

RE-DIRECT EXAMINATION, By Judge Johns.

The physician was Dr. Bley, Jr., of Beardstown. When I spoke of the water being clearer before the opening of the canal, I mean at all times except when a freshet.

3246 It doesn't clear up more rapidly since the opening of the drainage canal than before. It doesn't clear up as clear as it did before. It never gets clear. It hasn't been clear since the drainage has been in. It is about four miles from here to the Sangamon. The Sangamon comes in right above Browning and has three or four outlets above Beardstown Bay. It is about six miles from here to the mouth of Crooked Creek.

3247 When the Sangamon river rises, it makes the river here black and when Crooked Creek rises it makes the water yellow.

BENJAMIN COE, Examined in chief by Mr. Todd.

Live at LaGrange Locks. I commenced work at the locks here in 1882.

3248 We had a very slow current in this river before the canal was turned in and when the water would get low, of course it would get stagnant. LaGrange Lock was built with the calculation to back the water 50 miles. The dam raises the water seven feet four. In times of low stage of water, the lower the current gets the less water we would have and of course above the dam, it would get stagnant. I have seen it get so low that I could walk across the river on top of the dam and the river would naturally have a green scum on it. There would be very little current. My judgment is that since the opening of the canal we have almost twice the current above the dam that we had before. I never notice any odor in the water here in the locks. Of course when it ain't disturbed there used to be a green scum came in the locks just the same, that is, it would be just the same as it would be above the dam, you know.

3249 Since the opening of the canal I have never noticed any odor in the water in the locks. It is the water that runs over the dam that I noticed the odor in. It was soon after the canal water was turned in. At the present time we never notice anything of that kind only when the water froze over close to the dam below and close above. I have gone under the water in diving apparatus.

3250 The water now would compare very favorably to what it was before in clearness. I think it is fully as clear now as it was before the canal was turned in and at times clearer. I have seen the water here since the canal was turned in the clearest I have ever seen it. I would think the water was lots cooler now than it was before. I have seen it when it wasn't fit for a man to go bathing but now it is most too cool. Since the opening of the canal I haven't noticed any typhoid fever any closer than say two and a half miles and that is along the bluffs and not along the river. I haven't noticed anybody having ague here for several years.

CROSS EXAMINATION, By Mr. Jeffries.

The water never freezes up against, above and below the dam and when the water would be frozen up and there would be an opening above and below the dam, I have noticed an odor since the opening of the canal.

3251 The government outfit here drinks cistern and well water. We don't have occassion to drink river water. We have well water which is colder. I don't notice any oily scum on the water here. The water gets foul around the locks if it ain't disturbed. At this season of the year there is lots of fish and more or less dead fish in the water. People throw in many fish that they don't take and it makes the water rather foul around the locks when it ain't disturbed. I never noticed any odor before the canal was opened. I should judge the current is now double what it was before.

(AT BEARDSTOWN, ILL., July 20, 1903.)

G. W. BARNEYCASTLE, Examined in chief by Mr. Todd.

3252 Live at Beardstown. Took samples of Illinois river water at this point for sanitary district of Chicago to be sent to University of Chicago and to the board of health of Chicago in 1899 and 1900. (Witness explains method pursued and times and places where samples were taken.)

3255 DR. GEORGE BLEY, Examined in chief by Judge Johns.

3256 Have been practicing physician 22 years; have practiced in Beardstown 21 years. Have had a general practice among the people of this vicinity during that time. Beardstown has a population of 15,000. The water supply is obtained from a six or eight inch well driven ninety feet into the sand, about 10 or 11 blocks from the river in the back part of town. Before the opening of the canal the Illinois river had less current than it has now. A scum formed on the river and I have noticed odors at times. I rather think I have noticed that odor since the opening of the canal, but I wouldn't be sure.

3257 I would consider the water at this point as better than it was. There has been typhoid fever in this vicinity, among all classes of people. Typhoid fever has been increasing here probably for the last ten or fifteen years. During the last three years I have had ten, twenty or may be 30 cases. I think though at least thirty under my observation. I have had cases from among people who drink from the public water supply and from the Illinois river. In my practice the dejecta is disinfected and buried.

3258 I could not say what the practice of the other physicians here is in that respect but it is my impression that they do likewise. Since the opening of the canal there hasn't been this stagnation which I previously observed. We have had higher water since.

CROSS EXAMINATION, By Mr. Jeffries.

The current has increased, I should say. The number of cases of typhoid fever has increased to some extent since the opening of the canal, and before. It has been increasing for a good many years. I don't think they have increased any faster since the canal was opened than they did for the last ten or fifteen years.

3259 There has been a gradual increase. I think the people in this town pretty generally use the water from this public supply. There is a portion that have wells, perhaps half of them. I don't think the people use the water from the river to any extent for domestic and drinking purposes, possibly these people living along the river in the cabin boats do, but otherwise I don't think it is used at all. When I say the water is better I say so from appearances mostly. It is clearer under the same conditions than it was before. Before and since the opening of the canal I have noticed at times a greasy and oily appearance to the water.

3260 L. W. GOODELL, Examined in chief by Judge Johns.

Live in Beardstown. Am in wholesale and retail ice and fish business. Have been in the ice business since 1887 and in fish business about seven years. We buy fish from fishermen and run a seine also. My partner, George Swan, engages in the seining.

3261 Prior to the opening of the canal, the water would get pretty low at times. The current was quite sluggish and the water somewhat riley—dirty looking, not very clear looking. I have noticed a green growth—a sort of small vegetable with two or three leaves, a little short root that would form in large masses over the surface of the water. I don't recall whether there was any odor to it in the summer time. I have noticed it in the winter time when there were holes cut in the ice. There have been times when a great many fish died in the winter time, when there was ice on the water. I don't know exactly what I attributed this smell to, except the sewage from Peoria and Pekin. I think it was that partly. It is 80 miles to Pekin and 90 miles to Peoria and 50 or 60 miles to Copperas Creek dam. Before the opening of the canal we cut the ice from the waters of Muscoopin Bay, from the arms that project off the river above the C. B. & Q. bridge. That water is derived both from the Illinois river and from surface water that drains into the bay at the north end of it.

3262 As I recollect it, it was at least two winters that the fishermen complained largely of the fish dying and several times we have noticed an odor coming from the water under the ice, prior to the opening of the canal. Since the opening, I haven't noticed this green growth in the water. I have cut ice and put it up since the opening. I didn't detect any odor from the water during the last three years and the fish did not die under the ice in the last three years to my knowledge. I haven't noticed any difference in the ice cut in the last three years. The water looks clearer now than it did before.

CROSS EXAMINATION, By Mr. Jeffries.

3263 I don't drink the water from the Illinois river. The town here is supplied with water from drive wells. In the winter time we drink water from the river when we are cutting ice. The deepest point in this bay, when the ice was being cut, was about 16 feet.

3264 Before the opening of the canal I have noticed an odor on the water. I noticed an odor when we cut a hole through the ice. I have not detected the odor since. Since the opening of the canal I have noticed an oily substance along close to the shore. I can't say that I have detected any out in the bay or out in the body of the river.

H. EHRHARDT, Examined in chief by Mr. Todd.

Live in Beardstown. Am a physician. Have been practicing 36 years. Am health officer.

3265 Am acquainted with the Illinois river within a radius of ten or 15 miles above and below Beardstown. Before the opening of the canal, the river during low stage was often covered with a vegetable growth, a sort of fungus, grass and also a scum. The current during low stage of water was very sluggish. Since the opening of the canal so far as external appearances go, the water has had a better appearance, is clearer and it has been devoid of that vegetation which was observed before. I have observed no cases of typhoid fever before or since the opening of the canal. I do not know of any people having died of typhoid fever in the last four or five years in Beardstown. I don't know of any typhoid fever existing in this territory now, or within the last two or three years.

3266 The health of the people along the river is better than that of those living in the foothills or the high lands. I have noticed no difference as to malaria. I have had cases of typho-malarial fever, so designated. I consider typho-malarial fever a malarial fever that, owing to intestinal irritations assumes a typhoid character.

CROSS EXAMINATION, By Mr. Jeffries.

I know nothing of the water's internal conditions. The water is not used here generally for domestic and drinking purposes, excepting after it is filtered. We know that the water that is obtained from these public drive wells is river water because the water rises to a level in these wells to the same height as the stage of water in the river.

3267 These wells are all over the town. Without filtration I don't consider this water in the Illinois river suitable for domestic purposes. I consider that by our driven wells the water is perfectly filtered. I think the current is more rapid since the opening of the canal. I haven't noticed since the opening of the canal a greasy, oily appearance to the surface of the water.

3268 ED F. HARRIS, Examined in chief by Judge Johns.

Reside in Beardstown. Am in the fish business. Cover a terirtory of pretty near all the river from Peoria down below Kampsville. Before the opening of the canal the water was not as clear as it is at the present time. We always had through the month of July and August a green scum on the river and in the winter time we could cut open holes in the ice and there would be a gas smell from it. The mud and moss on the river would gather on our nets. I drank the water at that time.

3269 Since the opening, the water has been very clear and I think it has been in better shape except winter before last. It clears up a good deal quicker. There has been this green scum on the water in the summer but not so much before. Since the opening, we find a slime on our nets. It is a white substance as near as I could give it, like where you boil pigs' feet together—gelatine. It is very hard to get off; it is very near a whitish color. It forms in strings and hangs down from the nets. I use considerable ice and the ice has been good. I don't think it could be any better than what we have got here. It is as clear as crystal.

3270 It is taken from the bay above here and forms from the river water. The fishermen when on the river drink more or less of the water. I don't know of any typhoid fever in the last three years among fishermen. As a general thing they have got good health.

CROSS EXAMINATION, By Mr. Jeffries.

There has been some scum on the river nearly every summer during the months of July and August. It is hardly an oily, green scum now, not as much as it used to be. I don't know whether there is deleterious matter in the water or not.

3271 Unless the river overflows its banks there is no current in this bay.

MARTIN McDONOUGH, Examined in chief by Judge Johns.

Live at Beardstown and run the Park Hotel. Have lived here all my life. During the fishing season fish with line and rod on the river several times a week. Before opening of the canal there were 15 or 18 inches less of water. I noticed in the fall we had a scum on our water that we don't have now. I don't know very much about that. I don't see any difference in the ice. The ice that we use comes off the bay and that water is usually always clear. 3272

CROSS EXAMINATION, By Mr. Jeffries.

This ice is cut from the bay up here where the water is still and deep. During low water there is very little water from the river gets in. It is really part of the river, only the current doesn't get over there and it leaves the water dormant. I don't know whether the water contains deleterious matter or not. I don't use it in any way.

THOMAS K. CONDIT, Examined in chief by Judge Johns.

3273 Have lived in Beardstown since 1874. Am cashier of the First National Bank. Before the opening of the canal during low water stage we had what we regard as a very bad condition here—very stagnant water during August, September and October. In fact, a greater portion of the time there was a green scum in front of the city here all the time. Since the opening of the canal my opinion is that we have a much better condition of the river than before. There is no smell to the river and no green scum on the water. Before the opening of the canal it had an odor, smelled more like rotten fish than anything else. I don't notice that now.

3274 So far as my knowledge goes, there has been very little typhoid fever either before or after the opening. Occasionally we hear of a case, but very seldom.

CROSS EXAMINATION, By Mr. Jeffries.

I haven't noticed any of this odor since the opening of the canal. Don't use the water for domestic or drinking purposes. We have a great many drive wells in town. When I say the water is better now than it was before the canal was opened, I am basing my statement on the general conditions, that is as it appears to me.

3275 Of course there is a stronger current and we have had higher water all the time consequently there has been a greater volume of water passing down the river.

G. P. HOLLINGSWORTH, Examined in chief by Judge Johns.

Reside in Beardstown. Am fireman on the C. B. & Q. out of here. Formerly lived at Browning. Had a fruit farm there. Was engaged to take samples of water from the Illinois river. Made arrangements with J. A. Harman and Dr. J. H. Long in 1899 and 1900. (Witness states places where samples were taken and method pursued.)

(AT HAVANA, ILL.)

HAROLD G. HEBERLING, Examined in chief by Mr. Todd.

Now live in Easton, about 13 miles east of here. Formerly lived in Havana. Took samples of water from the Illinois river for the sanitary district of Chicago in years 1899 and 1900. (Witness states places where samples were taken and method pursued.)

3286 O. H. HARPHAM, Examined in chief by Judge Johns. Am postmaster at Havana. Have lived here 58 years. Have been acquainted with the river all my life.

3287 Before the opening of the canal in low water the river was very foul. At times, extremely so. I have in mind noticing that large islands of floating manure came down. Prior to the time I was appointed postmaster there was a large island of floating manure and offal, which I thought was from the Peoria distilleries, lodged against the pier of the wagon bridge. My attention was called to it from the fact that at that time I was one of the directors of the Illinois Bridge Company. We were fearful that it would injure the bridge and in attempting to remove it, we used common blasting powder. We were unsuccessful in that and finally removed it by prying and nicking off pieces until the current swung it around and took it through, but it was so large that it was impossible for it to go through the draw of the bridge. (Objected to by Mr. Jeffries.)

At low water there was a certain scum on the river and it was so much in evidence that you could see the wake or track of a boat. That wasnt always so but it was occassionally so.

3288 At times there was a smell. At low stage and in warm weather it was very offensive. I have noticed it at my place of business and at my house four or five blocks from the river. Since the opening of the canal I haven't noticed anything of that kind. I don't think there has been what you would call a scum. In my opinion the water is in better condition now than it was before, that is ,at the same stage. I have not heard of a single case of typhoid fever since the opening of the canal among people using river water. I am pretty generally acquainted with the people of this community. We have no delivery system, the people come to the postoffice for their mail. We have a drive well system of waterworks.

3289 We have only a partial sewage system, the sewer empties into the river. The sewer only reaches up into the business part of the town a little ways, not very extensive. One-third to one-half of the people use the water from the public water supply. The other people obtain their water from drive wells and pumps. There are very few open wells. The population is 3,400 or 3,500. Havana is 18 miles from Copperas Creek Locks. LaGrange is I should think 40 or 50 miles from here. It is 41 miles from Peoria by rail.

CROSS-EXAMINATION, by Mr. Jeffries.

3290 These sand wells that belong to the town are located seven or eight blocks from the river. The soil through which they go, from the surface down, is as follows: A few feet on the surface is what we call soil, from there to the bottom, as far as we have gone, is sand and gravel with occasional streaks of clay here and there. Those streaks of clay are small, sometimes only an inch or two, or a foot or two through. The people of Havana don't use the river water for domestic and drinking purposes. I don't consider this water good for domestic and drinking purposes. I don't consider any open river water, river or pond or anything of that kind, proper water for domestic purposes.

3291 The current is considerably greater now than it was before.

GEORGE W. BUNKER, examined in chief by Judge Johns:

Am an upholsterer and reside in Havana. Have lived here twenty years. Have lived on a boat on the river quite a while. Used to be employed on the steamboats. Before the opening of the canal the condition of the water was very bad indeed in very low water. The water was so impure that they talked a great deal then about blowing out the dam, thought they would get better water by cutting a waterway out and letting the water pass off quicker. There was an odor in the water and there was a green scum sometimes in places where the wind did not blow it away. I have made the remark several times that if it was not for the steamboats running up and down the river, the people could not live on it. Steamboats agitating the water, naturally purify it a little.

3292 Through the ice it wouldn't do to drink the water at all. I have tried it and know something about it. When the water was covered with ice and a hole was cut, as a general thing there was an odor from the water, you could smell it. There was a good many fish died but we laid it to the Pekin and Peoria slop, or something coming down the river that killed them. Since the opening of the canal the water has been far superior to any water we have had since I have known the river. It has been better, purer and sweeter. We don't get none of that bad smell now we used to have so much. I don't use the water now myself. It is a little too muddy of late. There is a lake and the Spoon river right across here sends out a good deal of mud and muddies the water here. Spoon river comes in here perhaps a quarter of a mile up the river. I don't know of any typhoid fever since the opening of the canal. I don't think there is any at all. There is a good many people living right on the river and I know that there is no typhoid fever. Before the opening of the canal there was times we had a good deal of fever, ague and chills, but that seemed to disappear. We don't see that now.

3293 CROSS-EXAMINATION, by Mr. Jeffries:

People in town use hydrant water mostly.

3294 They don't use the water from the river for drinking purposes as a general thing. I say the water is better now because it smells better. It hasn't got that bad offensive smeell like it used to have. You would naturally suppose of course that it was the flow of water that remedies that. I don't know whether filth is in there now or not. I know the water is a little better now, that is all I know. I don't know what it contains. The current is much stronger now than it was before the canal was opened.

3295 C. M. MORRILL, examined in chief by Mr. Todd.

Have lived at Havana ten years next January. Am a physician and surgeon. Before the opening of the canal we had very low water. It was a filthy bank all along, scum and filth all along the banks, a good deal of odor to it so you could smell it clear up town sometimes. There used to be cakes of
3296 filth that came down from Peoria. There was one at the bridge that they had to dynamie out. There was a large island came here one time and lodged at the bridge and they tried to blow it out. There was a green scum here every summer. The opening of the canal has made more current. The water has not been so low during the summer. The water looks purer and cleaner and the banks have been much better and there is no stench as there was before. In times of sudden freshet, before the opening of the canal, the river would be cleared out and there was less malaria in those seasons when we had high water and less typhoid-malaria. We have had very little here since there has been high water here. Since the opening of the canal I haven'tt seen any real typhoid here.

3297 CROSS-EXAMINATION, by Mr. Jeffries:

There was some typhoid before the canal was opened. I haven't seen any cases here since. The water of the river is only

used for drinking purposes by the fishermen I guess. They tell me they use it. I have seen them drink it. I don't consider any river water good for domestic purposes where cities drain in it. I wouldn't drink any river water, I have, though. I wouldn't unless I had to. I wouldn't recommend it for drinking purposes. I have drank it on these excursion boats when they had ice in it. I wouldn't be particularly afraid of it but I would
rather have better water.

3298 L. A. EVERIST, examined in chief by Mr. Todd.

Have lived in Havana 30 years. Have been a fisherman all my life. Before the opening of the canal the water got very low during this season of the year (July) and got very filthy. During the cold season the water seemed to be more filthy. During the season when it would be froze up, it would smell bad. In
the summer there was scum on it, a green scum. It would
3299 kill the fish in the winter time. After the river would
be frozen up for some time the fish would have to go into the spring water or they would die. They would get weak, they would swim along the edge of the river and people would pull them out with gigs or forks or something. I have seen them condemned in the St. Louis and New York markets. If you cut a hole in the ice there would be an awful smell and the water would be very filthy. There were what is known as Peoria islands floating down the river. They were composed of manure. I have seen them all the way from this place to Peoria, they would vary in size all the way from two or three feet to
50 feet.
3300 I have seen them here at Havana. I saw a large one
lodged against the bridge here that I know was blasted loose. Since the opening of the canal the nets last longer. The water is more cool. This slime or stuff that collects on the nets comes from the stills at Pekin and the glucose factory I suppose. It is a slimy substance and will stick to anything it touches. It flows in small pieces but will collect in large quantities on anything it touches. We call it slur-gut among the fishermen. We had it before the opening of the canal. The nets are cleaned

from the effects of this slur-gut by shaking them and taking
them to the bank and whipping with sticks. It is a kind of
white color. I fish between here and Kingston.
3301 I find that substance on my nets up that far. There is
not much difference as to the quantity we find now as com-
pared with the quantity found before the opening of the
canal. The opening of the canal has made the water higher
and the water has been cooler and purer and not much smell
to it. In the fall of the year as the water begins to get cooler,
it is stronger and there is more filth near Peoria than
there is near this point. The slur-gut can scarcely be noticed in
summer. It don't have a tendency to float in the warm weather.

CROSS-EXAMINATION, by Mr. Jeffries:

3302 Have an open well at home. These Peoria islands come
down the river during the spring season. At times they
are frozen. They come since the opening of the canal and travel
a little faster. I drink the water of the river when I am fishing
in the spring. I don't drink it when I can get anything else to
drink, though.
3303 We have more current in low water than we did before.

I notice very slightly the oil scum on the river now. It
has a mossy appearance. I do not know positively that these
Peoria islands come from Peoria. I always heard so. The fish
are all thriving well. The carp does the most well. They will
feed on almost anything.

SAMUEL F. KYLE, examined in chief by Judge Johns:

Reside in Havana. Am in the ice business.
3304 Have been in that business for nine or ten years. Took
samples of water at this point for J. H. Long and for the
State. (Witness states places where samples were taken and
method of shipping, etc.) The ice we have taken here
3307 has been the same before and since the opening of the
canal because we have taken it out of the bay here. As
3308 far as I know the water is better now than it was before.
There is more current and less stagnation about it.

CROSS-EXAMINATION, by Mr. Jeffries:

Am a married man. We use hydrant or well water at home. Haven't to my knowledge, since the opening of the canal, noticed the oily greasy substance of coloring on the water. The current is quite a good deal swifter now. We have a good current at all seasons of the year. The lake from which ice is cut is called Cook Harbor.

3309 It is fed by springs and by the flow of water that comes down from Quiver Creek. Year before last we cut from Seid's Lake, about 200 yards from the river. Seid's Lake is fed from Thompson's lake I think and from the Illinois river. Thompson's lake is fed from Thompson's river and from the Illinois.

3310 JOHN McGARVEY, examined in chief by Mr. Todd:

Live at Havana. Have fished for 26 years on the Illinois river. Before the opening of the canal, the condition of the river was pretty poor. I don't think if the Drainage canal hadn't been turned in here we would have had half the fishing we have got now. The water was dead, kind of rotten and smelled at low water.

3311 There was an odor at low water mark. That odor extended from here to Peoria. There wasn't any scum without the water was right low. As you went from Havana towards Peoria the water got worse. The distilleries at Peoria and Pekin were the cause of it. After you passed Peoria it got better. That condition prevails as far as I ever was along it, and that was as far as La Salle and Peru. Since the opening of the canal the water has been better.

3312 The water is purer than it was before. There is a current through it and it is purer. If you cut a hole through the ice in the winter time there is a smell to it but not as bad as it was before. I have run across slur-gut. We thought it come from those distilleries at Peoria. There ain't none of it above Peoria. We have that stuff yet but I don't think it is quite so bad since we got the current in the river. I never see that substance above Peoria. I have seen Peoria islands floating down

the river, some pretty good sized ones, too. Some 30 or
3313 40 yards large. They are composed of hay and manure.
They all say they come from the still houses at Peoria
and Pekin. I never saw any above Peoria.

CROSS-EXAMINATION, by Mr. Jeffries:

I never saw one of those Peoria islands in the summer time.
When I say the water is purer I mean it ain't dead. There is a
good current through here and it keeps all trash and everything
out. That trash all goes down the river or else back, I don't
know where it goes. If you cut a hole in the ice in the
3314 winter, you can still smell the water a little. The current
is much stronger than it used to be. All fish thrive well
here. Carp is the most plentiful. They feed on flags and roots
and things. They feed on most anything. I don't use water
from the river at home. We use water from the hydrant. When
it is cold in the fall and spring and winter, we use river water
for domestic purposes.

3315 ERNEST O. SPINK, examined in chief by Mr. Todd:

Live in Chandlerville. Took samples of water for the Sanitary District. (States method and places where samples were taken.)

3317 RICHARD L. ENGLAND, examined in chief by Judge Johns:

3318 Reside in Havana. Have been a fisherman over 30 years.
Have lived in Havana over 50 years. Have fished say 20
miles above and 20 miles below here. I employ men and fish on
a large scale. Prior to the opening of the canal, in our early fishing here, we used to fish altogether with bait nets and seines
and the sediment or settling was so bad we had to quit that kind
of fishing. There were substances floating here. The main body
of it was corn. It would fill the nets full and we had to crab it
out with a widlass. When the water got cold it would form on
there like cotton, it would collect on the nets and the meshes

were all full like a blanket. There was more smell when it was froze up than any other time. We would cut holes in the ice and could hardly stand it over the holes in winter; we would raise the nets and the fish in the nets would be dead.

3319 Since the opening of the canal the water has been a good deal better. We went back to the same kind of fishing that we did then but we had to quit. We don't get near so much of that floating stuff as we did before. More current makes the water purer. The floating slime on the water came from Pekin and Peoria. The sugar refineries and the distileries I think is what caused it. It wasn't at that time above Peoria. I was acquainted with all the fishermen there and they claimed they were not bothered with it above there. I can't hardly mention a fisherman that ever had typhoid fever. We have fish now for a week in the live boxes and before, in hot wetather, they would die in one night.

CROSS-EXAMINATION, by Mr. Jeffries:

The current is much stronger now than it was before the canal was opened.

3321 We have a nick-name for that substance, and call it slurgut. We get the substance now since the canal is opened, but it is only just a short time. We get rid of it quickly; if there is any in the river, just a little of it will come down. We don't use the water of the Illinois river for domestic purposes at home. In winter time when we are fishing and the water is cold enough, we don't use any other than the river water.

GEORGE E. McHOSE, examined in chief by Judge Johns:

Live at Havana.

3321 Have lived here permanently since 1872. I run a boat livery and am mayor of the city. I think this is my seventh term. Before the opening of the canal the river was dirty and stagnant and everything else and had a bad odor. Since the opening, the water is in a great deal better condition. Before the opening there was a kind of slime in the water and now there is not much of it. There is some. I don't know of any typhoid fever in this vicinity since the opening of the canal.

CROSS-EXAMINATION, by Mr. Jeffries:

3322 Don't use the river water for domestic purposes except for washing. We have a cistern. The current is swifter and we have more water now than before the canal was opened. I don't know whether it contains deleterious matter or not. All I know about it is from observation. The fish and turtles and stuff used to die before the opening.

PHILIP L. DIEFFENBACHER, examined in chief by Mr. Todd:

Am a physician and surgeon. Have been practicing in Havana for about 48 years. Before the opening of the canal the river got very low and since the dams were put in, there is a good deal of deposits along the shore. There was a scum on the water at low tide and an odor. The opening of the canal has improved the condition of the river. Before the opening of the canal the river I think caused malaria. Since the opening of the canal there has been no typical cases of typhoid in Havana.

3324 CROSS-EXAMINATION, by Mr. Jeffries:

We have a splendid water system here. We get the water from drive wells. The people in Havana don't use river water for domestic purposes. Never analyzed the water. I don't recommend the river water for drinking and domestic purposes. It never has been fit to use. The current in the river is much more rapid now than it was before the canal was opened. It don't seem to me that there has been much odor lately. I don't think I have noticed it this summer at all.

3325 (AT PEKIN, ILL.)

C. G. HERGET, examined in chief by Judge Johns:

Live at Pekin. Am manager of the Globe Distillery. We are engaged in distilling alcohol spirits and whiskey made from grain, corn about 90 per cent, rye and malt about 10 per cent. The distillery was in operation in the years 1900, 1901, 1902 and thus far in 1903. In connection with the distilling, cattle were fed from the refuse.

3326 With reference to the city of Pekin, the cattle are fed a little below. We are below the city. After the operation of distillation is completed, the residue is called slop. In a bushel of grain there are so many gallons of water; Uncle Sam takes 56 pounds to the bushel on all grains—wait a minute; now there are 45 gallons of water to the bushel mashed, so each thousand bushels of grain represents 45,000 gallons. This product after the distillation of the spirits, constitutes what we call slop, so that for each thousand bushels of grain, in distilling there are substantially 45,000 gallons of beer. This beer is then distilled, after which there remains about 40,000 gallons of slop.

3327 It is stored in tubs and from the tubs it is fed to cattle through a trough three times a day and divided equally about three pecks to a steer per day, which would be about 11 gallons to the feed. The barns are located about one-half mile from the river. The construction is entirely wood, with proper ventillation and sewage connection. Each steer has slop three times per day and roughness twice per day, salt twice a day and the barns are thoroughly cleaned with cold water twice a day. We feed 440 head of cattle under one roof. What we call roughness is hay or straw or cotton seed hulls.

Q. When the sheds are washed up, what becomes of the washings?

MR. JEFFRIES: The question is objected to for the reason that it is incompetent, irrelevant and immaterial, not proving any issue involved in the case, it being immaterial so far as the issues of this case are concerned, what the volume or extent of sewage matter or offal from cattle pens at Pekin, into the Illinois river, are, and that such deposits are not and cannot be under any circumstances a legal or equitable defense or a justification of the right or privilege to Chicago or the Sanitary District of Chicago to make such deposits or deposits of any character, whether sewage or otherwise, into the Chicago Drainage canal and thence into the Illinois river. And for the further reason that Pekin is situated upon the natural watershed of the Illinois river, and the fact of discharging decomposing matter from distilleries or other sources from cities and places upon the natural watershed of the Illinois river does not and will not either in law or equity, entitle the city of Chicago and the Sanitary District thereof to deposit its sewage, filth and other deposits into a stream carrying said deposits into the Illinois river by means of artificial canal or waterway, when said deposit naturally belong to and flow into, the basin of a watershed other than that of the Illinois and Mississippi rivers, and for the further reason that there is no evidence showing that the deposits into the Illinois river from the distilleries and cattle sheds of Pekin contain deleterious matter or matter injurious to the public health or to the health of those consuming the water and there is no evidence showing that such substance contains disease germs, or the bacilli of water-borne diseases.

It is herby stipulated and agreed between counsel that the foregoing objection shall be considered as having been made to all testimony as to deposits in the Illinois river below the Bear Trap Dam and may be raised at any time in the argument of the case without renewing the objection at the time any witness may testify.

F. S. Bright, Com'r.

A. They go into the Illinois river. When the sheds are washed, the urine and manure from the cattle are washed out and flow into the Illinois river.

3329 The cattle are fed through troughs which are also washed out. The roughness is fed in hay alleys which are cleaned twice per day by scraper. These matters go into the sewer and are carried into the Illinois river. This refuse from the cattle sheds forms an island, in the Illinois river, composed principally of manure, hay, straw, and refuse. The cattle are fed salt twice a day, about a quarter of a pound to a steer per day. If any remains, it would be washed into the sewer.

3330 Q. You mean that there is about eight or ten gallons of urinary discharge per steer per day, and that the local discharge would be about half that amount, about four to five gallons?

A. Yes sir. There would be about 160,000 gallons of water per day used in washing out the stables. These islands that are formed in the river are cast adrift and allowed to take their course. This is done about once a year. Before it goes away, it is covered or left exposed to the air. We were feeding cattle continuously during the year 1900.

3331 We fed during that year about 5,000 head, from Oct. 1st to June 1st; that year we fed 4200 head per day and from June 1st to Oct. 1st about 2300 head per day. In 1901 the variaations would not be over 400 or 500 head. We feed every year about the same we fed in 1900. It may vary from 150 to 200 head. There are other refuse products of distilleries than those described. They are hot and cold water used for cooking, in the boilers, and for cooling purposes. I don't think these waters contain any foreign substance nor any organic matter. The water used in the distillers is obtained from drive wells and open wells of about 80 ft. depth. We feed about 8 lbs. of roughness per day per steer. In 1900, 1901, 1902 and thus far in 1903 we have had two distilleries in operation in Pekin.

CROSS-EXAMINATION, by Mr. Jeffries:

We don't use the water from the river for any purpose. The Globe Distillery has been in operation here since 1893 and operated until 1898 by that name, then was sold to the Standard Distilling and Distributing Company, with home offices at No. 27 Williams St., New York. The plant was operated from 1893 to 1898 with 4,000 bushels eigth months in the year and 2,000 bushels the remaining four months, per day. The cattle industry during that period was the same as I stated a little while ago.

3334 The capacity of the plant and the output both as to distilled product and cattle has been about the same from the day the plant was built in 1893 to the present day, subject only to slight variations. There is no offal or products not used in the distillery that is thrown into the Illinois river, aside from what is fed to the cattle, to my knowledge. The offal and the unused roughness is scraped and then washed into the sewer and then flows into the Illinois river, forming an island. The mouth of the sewer is above the surface all the time. It is an open sewer. This material forms in a heap at the mouth of the sewer. It doesn't act like other manure, it is entirely different. We don't feed anything except perfectly sound and healthy cattle and we keep them in that condition

3335 They are about three or four years old. The steers will average about four years. We don't use any chemicals of any kind in our distilleries. Pekin has a water system. It gets its supply from driven wells and doesn't use water from the Illinois river.

3336 C. G. MUEHLMANN, examined in chief by Mr. Todd: Have lived in Pekin since 1900. Am a physician and surgeon and health commissioner of Pekin. The source of the water supply of Pekin is drive wells. They are pipes driven into the ground about 150 feet and from there piped over the city and the water is piped into a tank, that is where we get the pressure.

3337 The main sewer of the city is four blocks long, and they have some sewers in four blocks of alleys that connect with the main sewer that empties into the Illinois river. I was born and raised in Pekin and went to Chicago in 1886. Studied medicine from 1897 to 1900 and during that time was in Pekin at intervals. Before the opening of the canal the water was more sluggish, there was more green scum and filth on the surface of the water. The current wasn't as swift as it is now, and I think the opening of the canal, or the water coming in from Lake Michigan has deepened the channel. The water is clearer now than it was at that time.

3338 The deaths from typhoid fever for 1900 were 2; for 1901, 1; for 1902, 2 and for 1903, up to July 1st, 1. Those are the statistics I furnished to Mr. Unger, the representative of St. Louis, who called here. I don't know the history of the cases, but they occurred in the city.

CROSS-EXAMINATION, by Mr. Jeffries.

I gave Mr. Unger the deaths for 1897, 1898 and 1899. I think we ran back ten years, but the books were in very poor condition. I don't know whether I gave him a statement that could be relied upon as authentic prior to 1900.

3339 There are a number of private driven wells in town. Most every one has a cistern of their own. The population is between nine and ten thousand. The people in Pekin don't use the water from the Illinois river for drinking and domestic purposes. I don't believe they ever used it. I have not made a scientific investigation of the water. The water is somewhat clearer than it was before. All the clear water is not necessarily free from harmful effects. All cloudy water, or of muddy appearance, is not necessarily disease laden. I believe the current is much swifter since the opening of the canal than it was before. I would not recommend the water of the river for drinking purposes. I would recommend it for domes-
3340 tic purposes. I don't believe any river water ought to be used for drinking purposes without cooking.

D. H. JANSEN, examined in chief by Mr. Todd:

Live in Pekin. Am city enginner also in the brick and tile business. Collected water for the Sanitary District of Chicago in 1899 and 1900. (States method employed and places where samples were taken.)

3344 H. G. HERGET, examined in chief by Judge Johns:

Am a manufacturer and reside in Pekin. Was connected with an establishment for the manufacture of beet sugar, commenced in this town in 1900 and 1901. Continued two years, and about two months each year. Manufactured several million pounds of beet sugar during those two periods. The refuse material was beet pulp, some of it was run through sewers into Dead Lake and some of it was fed to cattle. Dead Lake is in the southwestern limits of Pekin, about 1,500 feet east of the
3345 Illinois river and has an outlet into the river. When the river is high the water backs into the lake. When the river is low, the waters from the lake flow into the Illinois river. In the manufacture of beet sugar we use an infinitesimal percentage of muriatic acid. Deducting the water which would

evaporate we deposited six thousand pounds of beet pulp in Dead Lake in those two seasons. The form of beet pulp as it comes from the diffusion batteries is similar to macaroni. When it is dried, it is like hay, it is fibrous. When it is deposited in Dead Lake it is more of gelatinous nature. It is that part of the beet from which the sugar and solids have been extracted. When floods come into the Illinois river some of this material was washed out into the Illinois river.

3346 In the manufacture of sugar we deposited water in Dead Lake which contained lime and other solids in infinitesimal quantities. We used and passed through our sugar refinery possibly one million gallons of water per day, which was discharged into Dead Lake, and which passed into the Illinois river, if not evaporated by the sun. This was deposited through a sewer, so that mixed with the solid matter during two months of each year there was also one million gallons of water a day. During the time the sugar was manufactured there was a sluggish stream flowing from Dead Lake into the Illinois river.

3347 I hardly think the solid matter was carried out into the river excepting what little pulp was carried. Some of the pulp remained in the lake and some got into the river. After the close of the factories as a beet sugar concern, it was converted into a glucose factory, in June 1901. I am a director of the Corn Products Company. In the modern manufacture of glucose as now produced in Pekin, there is no refuse. All solids in the corn are recovered and all that runs into the lake is water, possibly two or three million gallons each 24 hours.

3348 It contains a nominal per cent of sulphuric acid, a moderate fraction of one per cent per thousand gallons of water. The water from the Glucose factory runs into the Illinois river from Dead Lake. The manufacture of glucose is still continuing. At times there is a discharge from a glucose factory of a whitish or yellowish color, when filter cloths burst or tear. It is apt to consist of a very small per cent of gluten. This rarely occurs at Pekin.

3349 In the event it does occur only such a small amount goes through as would pass through a small rip in a filter cloth and on many occasions, repairs are immediately made.

CROSS-EXAMINATION, by Mr. Jeffries:

There are no other glucose factories in Pekin.
3350 There is one other at Peoria. I don't know of any other on the Illinois river. They manufacture glucose, grape sugar, corn oil, feed, oil cake and starch at our glucose factory. In the manufacture of these products from corn, there is no substance or material or solids from the corn wasted. We use sulphur and acid in the manufacture. The sulphur that is in the water escapes. It is a very small percentage as compared with the amount of water.
3351 The amount is enough to be a good disinfectant, I know. None of the acid escapes. The solids lost in steeping were carried into Dead Lake until some few months ago, since which time they are being evaporated. We get the water that we use from the Illinois river for the boilers and pump it from the ground for manufacturing.

E. W. WILSON, examined in chief by Judge Johns:

Am president of the American Distilling Company and of the German National Bank at Pekin. The name of the distillery we manage here is the American Distilling Company.
3352 It is about a mile and a half below the centrol portion of the city and on the bank of the Illinois river. We manufacture spirits and alcohol generally. We have a mash made of corn principally and some malted barley and rye. Before we commence to distill we have a product called beer. After the distillation of this beer and the alcohol is extracted, the remainder is called slop, the quantity of which we estimate by the bushel. About forty gallons of beer or mash is equivalent to a bushel of grain. After the alcohol is extracted, we feed the slop to cattle, which are located on the same premises, on the bank of the river, in sheds on the distillery premises.
3353 When the distillery is running at full capacity we feed 4,000 cattle from the refuse. The cattle are tied in sheds

to a trough in which the slop is run. We feed the cattle three times a day, about a third of a bushel, or about 12 to 15 gallons each time. If there is any slop left, it is run out on to the bank of the river. We also feed the cattle some hay and cotton seed hulls, which is fed to them dry. If there is any remainder from that food, it is carted away in wagons, generally. They use it for bedding the cars. We keep the sheds clean by men going in behind the cattle and scraping the excrement into a sewer and it is washed out by the water, which goes out on the bank. I suppose the water gets into the river, but most of the excrement would remain in the low land on the banks of the river. We clean the streets twice a day.

3354 I haven't any idea how much water we use in cleaning, probably 50,000 gallons each time, or 100,000 gallons per day. It might be double that amount, I don't know that I could estimate it. The refuse below the distillery on the bank of the Illinois river forms a mass of hay and manure. In times of high water a large portion of it floats away down the river. It washes away itself, under the influence of the current. During 1900, 1901, 1902 and thus far in 1903, the distillery has been running all the time and all that time we have been feeding cattle with slop and hay and throwing the washings of the cattle sheds and manure on the bank of the Illinois river.

3355 There is from 12 to 15 gallons of urine from each animal and from 40 to 50 pounds of excrement. We feed these animals about a barrel of salt a day. I don't think we feed them as much as a quarter of a pound each per day. About 6,000 head of cattle have been thus fed at the American Distillery in each of the years 1900, 1901, 1902 and thus far in 1903. We feed about 4,000 at one time. There is no other refuse material from the distillery than slop. 500,000 or 600,000 gallons of water are used for cooling purposes in the distillery which afterwards gets into the river.

3356 There is about 200,000 pounds of excrement per day. Dead Lake is east of our distillery. It is a lake which empties its waters into the Illinois river. The Illinois Sugar

Refining Company discharges its refuse into Dead Lake. In times of low water the color of the water in Dead Lake is very black and an odor arises from it at times. I think this is caused by the steep waters and the action of the acids that they use on the water, but that is my opinion, I don't know.

3357 CROSS-EXAMINATION, by Mr. Jeffries:

The American Distilling Company was organized in 1892. Prior to that time it was the Hamburg Distilling Company. The capacity of the Hamburg Company during 20 years was about 2,000 bushels per day. It fed, I should judge, 3,000 cattle per annum.

3358 The home office of the American Distilling Company is here in Pekin. It is an Illinois corporation. The offal and manure and drainage from that company was deposited in the same manner but hardly in the same place as that of the present company. We don't use any chemicals of any kind. The water that we use in the boilers we pump from the river and the wtaer for cooling purposes is pumped from wells drilled along the bank of the river.

3359 We feed no cattle that are not healthy and sound and give them nothing but the products of the distillery and hay, and at times some cotton seed meal. This offal from the cattle goes into the river by means of a wooden sewer. The mouth of the sewer is above the surface of the water. This offal from the cattle doesn't empty direct into the Illinois river, but empties on a piece of low ground, I should judge 100 feet from the water's edge. The sun strikes it before it gts to the water and it becomes very dry. That is true at all seasons of the year, extept during high water. We have gradually been filling up and moving this sewer further out each year. I presume that the sewer has been lengthened out a couple of hundred feet in the last ten years so that the mouth of the sewer is now about 100 feet from the river.

FRANK MILLER, examined in chief by Mr. Todd:

3361 Live in Pekin. Collected samples of water. (States method employed and places where taken, etc.)

3363 **WILLIAM J. CONZELMAN**, examined in chief by Judge Johns:

Am Mayor of Pekin and one of the managers of the Globe Distillery. The water supply of Pekin is obtained by means of drive wells; pumped into a tank or water tower and afterwards distributed about town. I think there are about 17 miles of pipe. About 80 per cent of the inhabitants take water from the public supply. There is a main sewer extending up First street and numerous latterals connecting therewith, constituting a sewer system of about two miles.

3364 About five per cent of the population connect with the sewers. The population is between nine and ten thousand. The remainder of the household sewage in Pekin is disposed of by means of cess-pools. The water supply of Pekin is considered very good. The rate of typhoid fever during the last three years has been normal, about the general average. About 4,500 cattle are fed yearly in the distillery of which I am manager. I would say that there would be daily about 8 gallons of urine and 4 gallons of manure from each head of cattle. The animals are fed with slop and rough feed such as hay and cotton seed hulls and about a quarter of a pound of salt to each steer. The offal from the cattle is disposed of by means of a slough or sewer into the river.

3365 It is washed out with water. The cattle are not bedded down. They are kept in sheds about eight months before they are ready for market. There are occasionally a few that become sore and are turned out into the yard. They would number about 40 or 50. Their offall accumulates in the yard and is subsequently carried off to the river bank. After this stuff is carried from the cattle shed and yard to the river, it forms an accumulation or mass which we often term an island. Usually with high water in the spring it is taken away and if not, we assist by running a boat into it or something to loosen the matter. When loosened it floats on the current of the river. A season's accumulation would aggregate a space of about 100 feet square and three or four feet deep. This condition has been continuous at the Globe Distillery during the last three years.

3366 I have been connected with the business here since 1892 and fed about the same number of cattle from 1892 to 1900 and from 1900 to the present day, and consumed about the same amount of corn and manufactured about the same amount of whiskey. The offall from these cattle and the washings from the distillery now are emptied into the same place as they have been since January, 1900. The sewer through which this stuff flows is an open sewer with its mouth above the surface of the water at its ordinary stages. It empties directly into the river and accumulates there until there is sufficient current to carry it away. We feed nothing but healthy cows.

3367 We don't use any chemical in the manufacture of whiskey from corn. We get the water we use from drive wells.

HARRY TAYLOR, examined in chief by Judge Johns:

Reside at Pekin, am a fisherman and have been since 1895. I have fished from Lake Depew, 12 miles above Hennepin, to LaGrange dam. I have fished all the way from here to Peoria. The water is more pure and clear now above Peoria than it was before the opening of the canal.

3368 Before the opening of the canal the water above Peoria was good water. Since the opening of the canal it is good water yet, but it is better. The water in the river below Peoria before the opening of the canal was rotten. It was slimy and the slime got on our nets. At Pekin it was just the same as it was below Peoria. There was a slime to the water. Since the opening of the canal it has been more pure below Peoria. At Pekin the sliem still forms but not so bad as it was before. Since the opening of the canal the slime decreases as it goes down the river from here.

CROSS EXAMINATION by Mr. Jeffries:

3369 The current is more stronger now than it was before it was opened. I don't believe there is a mile. There is some better current throughout the year. The water is clearer now than it was before the canal was opened, above and below Peoria. Above Peoria it is blue, like the water of Lake Michigan. It contains deleterious matter below Peoria, caused by those sugar houses and one thing and another dumps their offall into it. I don't know whether the sewage of Chicago gets in the river above Peoria.

3370 I have never seen any effect of the Chicago sewage in the water. Because I have never seen it, I don't think it hurts the water.

J. C. LOSCH, examined in chief by Mr. Todd:

I run a little boat of my own here; have done so for 12 or 15 years, the Steamer Olive A. Before the opening of the canal in summer time the river was in bad condition, the water being foul. The foulness manifested itself by smelling and in killing the fish.

3371 I have seen them between here and the locks that my steamboat wouldn't have carried them, laying on the shore, killed probably the night before, that would be about 10 or 15 tons. That was about 1889 or 1891 before I bought my big boat. The water has always been better above Peoria than it has been below. Since the opening of the canal, its effect on the waters has been to make them beteer. They seem to be purer. There don't seem to be as much smell nor look as bad. I haven't seen any dead fish to the extent I have saw before. There is some smell. It isn't so bad as that which existed before the opening of the canal. Years ago, every time we went from here to Peoria, every two or three trips, we had to blow out our boilers. We don't have to do that now. The boiler would foam and raise up with the filth and gas, between here and Peoria.

3372 As you go away from Peoria towards Grafton the water gets better. I have seen islands of manure in the Illinois river. I have struck them big enough that if I had hit them fair, they would take me down the river, with the little baot.

Those that I have reference to come from Peoria. Right here at Pekin I had clearing out the distilleries here; the manure would be five or six feet deep and covered probably an acre that I tore out for them, they paid me $25.00 for tearing it out. That is the only place I have had to clean it out. The Peoria distilleries paid me for taking it out of the canal above Spring Lake canal, and the still house here and the Peoria parties paid me for taking it out of the canal. This manure floated down from Peoria and got into the canal and stopped it up.

CROSS EXAMINATION by Mr. Jeffries:

We see very few dead fish on the river now.

3373 The current is a little stronger. The higher the river is the stronger the current is. It is not so very much here at low water, as near as I can judge, less than half a mile or a third of a mile an hour and in high water, three or four miles an hour. I don't believe it would be much more than half a mile an hour now. The current is much swifter now here opposite Pekin than it was before. When I say the water is purer now than it was before, I judge from the appearance of it. That is the only way I have of testing the water. There is not so much smell since the opening of the canal as there there was before.

3374 (AT CHILLICOTHE, ILL.)

JERRY FOLSOM, examined in chief by Judge Johns:

Am a fisherman. Have fished off and on for about 47 or 48 years. I have fished from here clear up to Spring Valley. Before the opening of the canal the conditions of the water was poor. In the winter season when we cut holes in the ice, it would smell so bad you couldn't hardly stay around the hole and the fish would die in the nets in two or three hours' time after they were caught or confined, and they tasted of gas or tar until they wasn't fit to market.

3375 You could smell it when you was dressing them. It smelled like gas or tar. When the water got very hot there was a good deal of stuff growed in the water and it smelled bad. Since the canal was opened I haven't seen any of that growth. A little green strip comes once in a while but the growth hasn't come here since and I haven't had any dead fish since that time and no gassy fish. The smell hasn't been nothing like it was—nothing like the gas that I have seen. The fishing is good and the fish appear to be healthy. I haven't seen any dead fish along the shores like there used to be. Before the opening of the canal there was filth of some kind settled in our nets. I couldn't tell what it was but it was filth anyway and nasty. We would find a great deal of it. We haven't had any of that since—not like that.

3376 It is 18 miles I think from here to Peoria by river. I never head of slur-gut. I never heard of such a name up here.

CROSS EXAMINATION by Mr. Jeffries:

3377 Chillicothe gets its water supply from wells and what they call the waterworks. The people here don't use the water from the Illinois river for domestic or drinking purposes. There is more current now than there used to be and the river stays higher. I have noticed the scum on the river since the opening of the canal. There is, once in a while, the green scum, but no growth over it. It looks green and at times it looks kind of greasy, but it has always done that since I have known it, at times.

3378 The dirt and filth gets on the nets to some extent, but it isn't the kind of stuff that used to gather on them before. The difference between the deposit that gathered on the nets before the canal was opened, and since, is that it was a good deal more nastier then than it is now—more slimy and more smell to it.

BRADLEY B. HAWLEY, examined in chief by Mr. Todd: My business is steamboating and boating.

3379 Am captain of the "City of Henry." I have been steamboating and working on the Illinois river about 43 years. Before the opening of the canal the quality of the water in the

Illinois river was always better above Peoria than it was below Peoria, but in low water, it was a pretty sluggish current and the water was pretty bad—very bad water between Peoria and La Salle before the opening of the canal. In the spring we didn't notice much difference but in the hot weather or low water, and dry times, the water was what we called pretty bad, that is, it moved slowly in the river. There would be an odor at times, especially in the morning. There was a good deal of green stuff floating on top of the water. Below Peoria the opening of the canal, it was pretty bad, caused by the sewage from Peoria.

3380 The water above Peoria was a good deal better than it was below Peoria at the same time. Of course we think the sewage and polluting matter comes out of the cattle pens, but we never went up to see about it. The most we noticed is between the T., P. & O. bridge where spouts lead into the river and where sugar and still houses are located. The gas works put out a lot of bad water there. The manure that we saw in the river was in front of those spouts that run out that are supposed to be from still houses. Last summer they hired us to go in there and kick it out in the river and get the stuff away from the end of the spout.

3381 It was in the summer after the water went down. It was in June or July. There would be as much as half an acre of it. After you get down below the bridge at Peoria, say a mile below the bridge, the water begins to get thick and full of something. It is a kind of thick, dirty water.

3382 Since the opening of the canal, there is more of a current going and the water is what I should call more pure that it was before. It looks more pure and clearer to me. Below Peoria it is the same as it was before, only it isn't so bad. It doesn't look so bad to me. The water in Lake Peoria, immediately above Peoria, looks more pure to me than it was when this green scum settled on it. The water above Peoria never was very muddy, that is, after it got below this scum that used to float on it in low water. The Peoria lake water was what you might call bad water, except when this scum was floating over the top. In my opinion, the water of Lake Peoria is better and clearer now than it was before the opening of the canal. Oftentimes we noticed a substance that looked like this stuff that passes out of the cattle pens below Peoria. It raises up in a great large piece that comes up with bubbles. It seems to come from the bottom of the river.

3383 Before the opening of the canal if you cut a hole in the ice, the water smelled bad.

CROSS EXAMINATION by Mr. Jeffries:

I live aboard the boat, but we are more at Peoria than at other points. The current in the Illinois river from Henry to Pekin is swifter than it was before the canal was opened.

3384 There never was much current in Peoria lake. It runs very slow and always did, that is excepting in high water.

3385 Peoria lake would be about 17 miles long. At one place place, Spring Bay Narrows, it is only a few feet wide. After you get below the Narrows it seems to me it is three-quarters of a mile wide.

3387 It seems to me about three-quarters of a mile wide from the Narrows to its head, that is before the opening of the canal. It would be a little wider than three-quarters of a mile all along its length excepting at the Narrows. It would be about eight or nine feet deep in the channel. Outside of the channel I wouldn't suppose there would be over four or five feet of water. It varies according to the stages of the water in the river.

3388 Q. You don't know whether the sewage gets down here or not?

A. Why, I know just the same as other folks do, that it does; that it comes here and affects the river, because there is more water than there used to be; the supposition is that it gets here.

RE-DIRECT EXAMINATION by Mr. Todd:

Our boiler used to foam below Pekin from what was supposed to come out of the stillhouses and sugarhouses. Before the opening, the boilers seemed to act all right with that water above Peoria.

3389 Since the opening of the canal the water in the boilers that you take for steam seems to work better with our boat than it used to all the way along as far as we have been. The water is better now than it has been and clearer. It doesn't foam above Peoria. We haven't had any trouble between Peoria and Pekin so far as foaming in the boilers is concerned.

3390 O. F. THOMAS, examined in chief by Mr. Todd:

Have been physician and surgeon for 25 years and live at Chillicothe. For the last three years there has been no typhoid fever here except two cases two years ago. They were four blocks west of the river. The cause of those cases was not attributed to the river. The dejecta of those cases was treated with bi-chloride of mercury and run into water closets. We have no sewage system in this city, but privy vaults. We consider this a very healthy town and community. The city water supply comes from wells that are sunk along the side of the river up here at the power house.

CROSS-EXAMINATION, by Mr. Jeffries:

3391 I have been here about 48 years. These wells, in my judgment, are deeper than thirty feet. They are driven in gravel and sand. If the water comes from the river to these wells, it is filtered through the sand and gravel.

3392 The people of Chillicothe and North Chillicothe do not use the water from the river for domestic purposes. I don't consider the water from the Illinois river good and wholesome for domestic purposes. Those two cases of typhoid fever that I spoke of, I know the cause of. I had an examination of the milk supply made and it was attributed to the milk. I found typhoid germs in the milk. I had the examination made in Chicago. The milkman got the water that he used in a dairy four miles northeast of town; it was four miles from the river.

The two patients lived here in town and were in the same family and had the typhoid fever at the same time.

3393 No one else using the milk had the fever that I know of. The dairyman supplied milk to many other families in Chillicothe.

RE-DIRECT-EXAMINATION, by Mr. Todd:

The letter that the chemist sent to us said that his opinion was that the milk was the cause of the trouble.

3394 WILLIAM COLWELL, examined in chief by Mr. Todd:

I came to Chillicothe in 1847. Have been in the contracting business for the last fifteen years most of the time, bridge building, etc. Helped to build the Santa Fe bridge at Chillicothe and did trestle work east of the river; then I went to Peoria the next season afterwards and built the Santa Fe road; I helped to build the upper free bridge at Peoria.

3395 Am acquainted with the Illinois river from Peoria to Beardstown. When I first went on the river in the early days back 50 years ago, the Illinois river was a very nice stream of good water, but after the towns began to grow and they pumped the Chicago river into the Michigan canal at Bridgeport, the river began to get foul and it kept on getting more so until when we built the Santa Fe bridge the river was very nearly entirely scummed over with a green coating which looked like fine vegetation. This vegetation was so thick that when we were building the bridge up here and towing stone barges, it made quite a hindrance to the towing of the barges. When the wind blew from certain directions you could smell the river pretty plain. At the upper bridge at Peoria the river was just about the same as it is here. The upper bridge was just at the foot of the Narrows.

3396 Of late years the river between Peoria and Pekin was pretty foul sometimes from the sewage and filth. At Beardstown it was pretty clear. I never could discern any filth any more in the river at Beardstown than we could up here. Since the opening of the canal I think the water is purer than it was then and less odor to it and I have never seen the river scummed over with green vegetation since the opening of the canal. The condition of the water at Chillicothe since the opening of the canal is better than it was before I think.

3397 When I would clean out the engine and put in fresh water, before the opening of the canal, every time I would go around the engine I could smell the odor from this water and the odor was quite offensive, but since the lake water has been turned down here, I have never noticed that odor from my engine like I did before. My best judgment is that it has been 25 or 30 years back since the Illinois river was as pure here and clear as it is today; am 71 years of age.

CROSS-EXAMINATION, by Mr. Jeffries:

The city gets its water supply from drive wells, about 100 feet from the bank of the river.

3398 These wells are about 40 feet below the surface of the river I think. I think there are six 6-inch pipes. The ground or earth through which these wells are driven is sand and gravel. There are other wells used by private individuals called living wells.

3399 The people here do not use river water for domestic and drinking purposes that I know of. The farmers in the rural communities use well water. The Illinois river water has gradually grown worse for several years back and particularly so after the opening of the Illinois and Michigan canal. I couldn't tell the amount of sewage from Chicago that comes down here but the water now appears to be better than it was before the opening of the canal. I judge from using it in my engine boiler, by the difference in the smell of it, etc.

3400 I haven't noticed any odor from the river for the last year or so. The current is much stronger now than it was before the canal was opened.

J. E. DALRYMPLE, examined in chief by Judge Johns:

Live in Chillicothe and am a fisherman. Have fished for 16 years from Hennepin to Copperas Creek locks below Peoria. Four years ago there was moss or slime in the river. It was a white colored slime. At places it was very bad and got into our nets.

3401 In our fishing above Peoria we found that some kind of slime but not so bad. I haven't been bothered with it any the last two or three years above Peoria and at htis point. Before the opening of the canal at this point we had a plant of moss growing that we called shamrock. I have seen it pretty bad. In the winter time there would be a pretty bad smell. You could smell it above the town when the river was frozen. I have seen fish die in good numbers here.

3402 There wouldn't anybody buy the mfrom me around town. You couldn't eat them yourselves. I ate one of the fish and it tasted to me just like tar. This shamrock, if you would pile it up, it would heat and then a smell would come from it. Since the opening of the Drainage canal we have had good water and lots of it. It is purer than before. I haven't noticed any odor in the last couple of years. The slime don't bother us any more. Before the opening of the canal fish wouldn't keep over night in live boxes; now our fish live very good.

3403 I am acquainted with some of the fishermen all the way from Copperas Creek dam to Hennepin. I don't know of any typhoid among them since the opening of the canal.

CROSS-EXAMINATION, by Mr. Jeffries:

I live one block from the river. We get our water supply for domestic purposes from the city. We don't carry water when we are fishing in the winter season or fall. We carry water now.

3404 When I say the water is better now, I mean it is better in every way. It is clearer, purer, and better to drink. No slime on the nets to bother the fishermen. There doesn't any slime form, particularly lately, on the nets. We used to have stuff that formed on the nets here. We ain't been bothered with it lately. Too much current for the fishing business. I haven't noticed any greasy, oily substance formed on the water for two or three years. The State Board of Health of Illinois hasn't condemned the fish in the Illinois river to my knowledge.

SAMUEL HOSSELTON, examined in chief by Judge Johns:

3405 My residence is Chillicothe and I am a fisherman. Have lived on the Illinois river in this vicinity since 1864. Before the opening of the canal the Illinois river in low water was in very bad condition. There was very little current and the water was very foul. There was a vegetation growed on the river, and being no current it would be impossible almost to get through it at places. In low water, there was an odor. There was an odor in the water under the ice in the winter. It killed nearly all the fish in this vicinity that were under the ice. Since the opening of the canal, in my opinion, the water has been purer. I see nothing more of vegetation only in pools and backwater.

3406 There is no odor in the water now that I could discover. Before the opening of the canal, the water was in pretty bad shape, very filthy, and the water wasn't fit to drink and the fish died in it. One summer here the clams all died. The river was floating full of them. Some turtles died. About the next year after the Henry dam was put in, that is when it commenced to get bad.

3409 There was a scum formed on the river and we had to skim it off. The smell in the water was fearful. The stuff would float down East river. It would be that thick you couldn't row a skiff through it and it would stink terribly. In the winter it would freeze hard and the fish would die and they were gassy and you couldn't eat them at all—just like you had fried them in tar. It got so it would be impossible for you to stand near a hole for the smell. It was just as bad as the Chicago river smelled, right under that ice, only it was kind of more gassy and I wouldn't warrant a fellow to live five minutes if he tok a drink out of it.

3410 Since the opening of the canal the water has been pretty fair. The first year the Drainage canal was opened we could seine and we never had fish to die in the live boxes. The water is a great deal cooler. It would be so hot it would scald your feet, very near. I don't know of any typhoid fever among the fishermen since the opening of the canal.

3411 CROSS-EXAMINATION, by Mr. Jeffries:

There was no current here until after the Copperas Creek dam was put in. There is an awful current in the river now. There is some green scum on the river now in the summer time, but not like it was before.

3412 I live on a cabin boat on this side of the river.

A. C. WILKEY, examined in chief by Judge Johns:

I run a boat-yard and reside in Chillicothe. I fished on the Illinois river for about ten years from Hennepin to Beardstown. I fished below Peoria in 1897 and 1898. At that time the water was very bad. It covered our nets with slime.

3413 Before the canal was opened when the water in this vicinity was very low it was pretty bad and in the winter when it was froze up it was very bad. In the summer there was what we called shamrock and this long grass that grew on the bottom. When the river froze over before the opening of the canal the water was gassy adn the fish were so gassy that you couldn't eat them. They died under the ice.

3414 I was here the summer the clams died. It was either 1895 or 1896. They came up and floated on the top of the river. Since the opening of the canal the water has been better than it was before, as to smell. I never noticed any of that slime above Peoria, either before or after the opening. Since the opening, the shamrock plant in the water here isn't as bad as it was before. It comes out of the sloughs. I know every fisherman in this stretch of river. I have never known one of them to be sick.

3415 CROSS-EXAMINATION, by Mr. Jeffries:

I live a block from the river, have a well and cistern. I use the hydrant water entirely for drinking. There was only one time that the clams died. The fish died every winter when the river froze very solid and when it was low. The current now is considerably more than it was.

3416 Before the canal was opened there was very little current here at ordinary stages. Now there is very much more current. I see some of the scum on the river now but not very much smell.

MARTIN TRUITT, examined in chief by Judge Johns:

Live in Chillicothe. Have been a fisherman on the Illinois river for the last 25 years. Have fished between Chillicothe and Peoria and Chillicothe and Lacon. Before the opening of the canal the water of the river was pretty bad and there used to be green stuff here that you could hardly row a skiff through and in winter time if you chopped a hole in the ice you would have to get away from it on account of the rotten gas coming out. The fish would die. Since the canal has been opened it hasn't been that way. I never saw it purer in my life. The fish live better in live boxes, too, since that. The fishermen, since the opening of the canal have not had typhoid fever.

CROSS-EXAMINATION, by Mr. Jeffries:

I live in a cabin-boat. There is more curent in the river now since the canal was opened.

3418 Before the canal was opened there wasn't enough current to float the green stuff off the river. There ain't so much greasy, oily substance on the water since the opening of the canal.

CHARLES F. SCHMIDT, examined in chief by Judge Johns:

I reside in Chillicothe. Have been a fisherman for the last twelve years. I have fished from Copperas Creek lock as far as Hennepin. The water in the Illinois river below Peoria before the opening of the canal was floating about. The slime would gather on the nets so you couldn't hardly raise one into the boat.

3419 Since the opening of the canal the water below Peoria has been better. In this vicinity before the opening of the canal you couldn't keep fish alive in the live boxes very long. It wasn't as bad there as it was below Peoria. There was moss on the water.

3420 In the winter time the smell was bad. Sometimes you couldn't hardly stand it through the ice. It killed the fish every winter very near. Since the canal has been opened the water has been better in this vicinity to my knowledge, and has never killed any fish that I know of. Before the drainage was turned in the fish got so here that we couldn't eat them but since then I haven't heard anything of it. I haven't seen any green substance to speak of. I haven't heard of any fishermen having typhoid since the canal was opened.

CROSS-EXAMINATION, by Mr. Jeffries:

There is a green scum now but it grows in the backwater, unless the wind happens to blow it out.

3421 Since the opening of the canal there has been more current and more water. Before the opening of the canal the current wasn't strong only in high water. Since the opening of the canal the current has been a good deal swifter. The current used to get swifter in high water times than it gets now in high water times.

E. N. NELSON, examined in chief by Judge Johns:

Live at Chillicothe.

3422 Have been fisherman off and on for 20 years. Have fished between Lacon and Peoria. Before the opening of the canal the water in the Illinois river got very foul in low stage. In July and August the water would look green. It smelled foul and bad, especially when it was stirred up by a boat or anything. In winter when it froze up it would get a kind of gassy, tarry smell. If you cut a hole in the ice you could hardly stand over it. The fish were unmarketable at that time of the year when the river was frozen over. You could hardly stay in the house where they were cooking them and you couldn't eat them at all. They would die in the live boxes in a very short time. Since the opening of the canal the water has been very good in my estimation. I haven't noticed any smell and last winter I kept fish in live boxes for two months and a half.

3423 I haven't known of a fisherman having typhoid. I haven't known of but one case in Chillicothe in years and that wasn't a fisherman or riverman.

CROSS-EXAMINATION, by Mr. Jeffries:

3422 The river passing Chillicothe flows through Lake Peoria and on past Peoria. Lake Peoria is nothing more than a wide space in the river. There used to be a good deal of scum on the river. I haven't seen any on the river since the canal opened, only in the backwater at times.

I haven't seen any greasy, oily substance on the surface of the water. Before the canal was opened the water was very sluggish and had hardly any current at all. Since the canal is opened, the current is a good deal swifter.

3425 When I say the water is better I say that from my experience of the water, it is colder and better looking and a person can drink it in a pinch now, and they couldn't at this time of the year before. I have drank it this season and last season both, when I would be on the river.

JESSE HORN, examined in chief by Judge Johns:

Am a fisherman. Have fished off and on for 13 years between Hennepin and Peoria. Before the opening of the canal the river was stagnated water and in cold weather when it was froze up we had plenty of gas under the ice. You couldn't hardly stand it if you cut a hole in the ice and there used to be a good deal of malarial fever. I have had malarial fever pretty nearly every year. I have missed it this year so far. I don't know whether that is on account of that. The water killed lots of fish both winter and summer.

3426 There was a green substance in the water. Some called it clover and some called it shamrock. Since the opening of the canal the water has been purer and colder. We haven't had no dead fish floating around on the water. There hasn't been any smell to it and I don't know of any typhoid fever among the fishermen since the opening of the canal. I know of some, years before that.

CROSS-EXAMINATION, by Mr. Jeffries:

Every year before that as long as I have been around here there was typhoid fever. I couldn't mention just exactly how many cases. I believe there was five every year. I mean the ague or malarial fever. I don't that typhoid fever is caused from being on the river. I never knew of any fishermen having the typhoid fever in my life and I have known a good many. There has been typhoid fever in town. The scum or moss that formed on the river before the opening of the canal was some sort of vegetation.

3428 It branches out in leaves like clover. Since the opening of the canal I have seen green scum on the sloughs, not in the river. The current is now greater than it was. I have a well at home.

T. H. HARRIS, examined in chief by Judge Johns:

Am a fisherman. Have fished on the Illinois 10 years between Peoria and Lacon.

3429 Before the opening of the canal the water in the Illinois river was very bad at times. In July and August it would get kind of stagnated and of a green color. It was pretty bad on fish in winter. I have seen the fish rush up in the spring holes as if struggling for life. The mouth of most any creek would be alive with fish, that is where fresh water was coming in. There was a smell to the water in winter. Lots of fish died under the ice. Since the opening of the canal, in my opinion, the water is better than it used to be. I have never seen the fish die in the water since the canal has been turned in. I haven't seen any of this growth on the river only in the fall, and that was through the bottoms here and through

3430 Goose Pond. I haven't seen any of this growth between the banks of the river. I haven't heard of a case of typhoid among the fishermen since the opening of the canal.

CROSS-EXAMINATION, by Mr. Jeffries:

There might have been some of it but I never heard of any. Use cistern water for household purposes.

3431 Before the canal was opened there wasn't much current in the river. Since the opening of the canal there has been considerable of an increase in the current. I don't see dead fish floating in the river now. There is some difference in the channel of the water since the opening of the canal.

L. S. McCULLEY, examined in chief by Judge Johns:

Am an engineer and reside at Chillicothe. Have been an engineer on boats running on the Illinois river.

3432 Have been engineer at this Turner-Hudnett Company elevator for four years. When running boats on the Illinois river I used Illinois river water in the boilers. I have run from Copperas Creek to Henry and above. I was an engineer between those points upon boats both before and after the opening of the canal. Below Peoria, before the opening of the canal, the water foamed slightly and at times strong in the boilers. Closer to Peoria it foamed stronger than it did below. Pollution causes water in a boiler to foam. Below Peoria there was a smell to the steam that escaped from the boiler. It was a real strong odor of decayed mater. Since the opening of the canal below Peoria the water has been quite clear; it hasn't foamed any. Before the opening of the canal above Peoria the water in the boilers foamed and there was odor to the steam.

3433 Since the opening the action of the water in the boilers here has been better; no foaming and no odor excepting that that comes from natural clear water. Since the opening, the water from above Peoria is the best a little, for steaming purposes. Before the opening of the canal the water above Peoria was the better water for steaming purposes. Before the opening of the canal the water for steaming purposes taken at this point foamed in the boilers and there was an odor to the steam. The odor was stronger in summer. Since the opening the water has been better, not as much lime or scale.

3434 There was a great deal of lime and scale in the water used below Peoria. Since the opening of the canal not as much.

CROSS-EXAMINATION, by Mr. Jeffries:

There is more or less odor to all steam. It depends upon the water. At times the water in my boiler here at the elevator foamed very badly prior to the opening of the canal. The foam comes from decayed matter. The substance in the water which caused the foam was not altogether decayed vegetable matter.

3435 The cause of the foaming was the pollution in the water and the water at that time was stagnant both above and below Peoria.

(AT LACON, ILL.)

WILLIAM MANGLE, examined in chief by Judge Johns:

Am fisherman. Have been a fisherman on the Illinois about 18 or 20 years. Fish between Henry and Chillicothe all the time.

3436 Before the opening of the canal the river at this point was pretty low. It had a kind of moss or green stuff floating in it in low water. It would be probably a foot deep along the shore. No smell in summer to amount to anything. The water was pretty bad under the ice at low stage. It was gassy. When you cut a hole in the ice a kind of gas or tar smell came out. The fish would taste just like it smelled. A good many died under the ice. Fish didn't live long in hot weather in live boxes. Since the opening of the canal there hasn't been much of the green plant in the water. No smell under the ice and the water is better a good deal, and the fish live better. We drink the water in cold weather. Fishermen in this vicinity haven't had typhoid fever that I know of since the opening of the canal.

CORSS-EXAMINATION, by Mr. Jeffries:

The population of Lacon is 1200. They get their water from wells.

3438 These wells are not over 40 feet deep, driven through gravel and sand. There are a lot of living wells in town.

People don't use water from the river for domestic and drinking purposes. There is a scum on the water at present. It is a kind of thin scum instead of them seeds, a kind of an oily substance. Before the canal was opened there was a very little current in the river. The current is now much stronger. There is quite a good current all the time. There is a good current in the river now from Henry to Chillicothe. If a steamboat stirs the water up now I believe you can smell a kind of smell to it, a kind of a dead smell.

3440 JOHN BAUMISTER, examined in chief by Judge Johns:

Have been fisherman on the Illinois river since 1867. Fished from above Hennepin down the river as far as Pearl. We have a little tug of our own. Before they turned that canal in, the water used to foam and we had to blow her out every two days and last year we never had to blow her out once, so the water must be purer. What they called duck seed growed awful thick some places. You couldn't hardly seine through it. There has been very little of that lately. When it was frozen over a short time the water became gassy and smelled and the fish tasted tarry so we couldn't eat them. Since the opening of the canal I never noticed any odor under the ice. I don't know of any fishermen having typhoid fever since the opening of the canal.

CROSS-EXAMINATION, by Mr. Jeffries:

I live in the first house up here on the bank of the river.

3442 Have a living well. The green scum that formed on the river before the opening of the canal was duck seed. The scum that forms now would be about the same, but not near as much of it.

3443 Before the canal was opened there was a very little current in the river. No current to speak of at all. Now there is a good current at all times of the year from Hennepin to Peoria.

WILL REED, examined in chief by Judge Johns:

Am fisherman. Have also fired on steamboats. Have been occupied as a fireman on the Illinois river pretty much every summer more or less. I have traveled from Peoria to La Salle and from Peoria to St. Louis on the Cherokee. I made a trip or two on the Bald Eagle. I noticed a difference in the quality of the water for steam purposes above and below Peoria.

3444 Q. What was the difference before the opening of the Drainage canal?

A. Well, sir, from the time you leave Peoria; of course after you get past them still houses down there it is all right. For a ways after you hit them still houses it is bad; that is, it would foam and it was foam up here; it was a kind of a scum raised up in your boiler and made it foam. We would notice that foaming in the boiler until we got down pretty near to Copperas Creek. From Copperas Creek down to the mouth of the river the water was certainly better for steaming purposes. We was bothered more was sand in the boilers. The water was mud run; more sandy the water was. At times there was foaming in the boiler below Copperas Creek dam.

Q. How was the water below LaGrange dam as compared with the water above Copperas Creek dam?

A. I think it was better above; that is, the quality of the water.

Q. How was the water below Kampsville dam as compared with the water above Copperas Creek?

A. Well, I think it was better; couldn't see much difference in it. From Kampsville dam down the river the water foamed in the boilers more or less; after we got down about Alton there and got down below there; after we got into the Mississippi. In the Illinois river below Kampsville and down to Grafton the water foamed more or less; there wasn't no big amount of foaming or anything of the kind. Above Peoria before the opening of canal the water foamed in the boilers.

3445 The better water for steaming purposes as compared to the water in Peoria Lake, was the water here at Lacon.

Before the opening of the canal the water at this point (Lacon) I have seen it pretty bad at times. It had scum and one thing and another. There was a smell in the water. The water under the ice in winter was pretty foul. It killed lots of fish along the river between here and Henry. The fish were not fit to be cooked. Above Peoria, since opening of canal the water has been first rate for steam purposes. I haven't had no foaming; every time I was firing I have seen none of it.

3446 Since the opening of the canal I didn't find any odor or smell when the river was frozen over. I haven't seen any dead fish in the water. Before the opening of the canal the fish did not live very good in live boxes; now I could hold them four and five days. There hasn't been any considerable amount of this green plant in the river. The fishermen upon the Illinois river in this vicinity do not have typhoid fever that I know of.

CROSS-EXAMINATION, by Mr. Jeffries:

Before the canal was opened there was very little current in the river here at Lacon. Since the canal was opened
3447 we have a good fair current. I haven't noticed any green, oily or greasy scum on the river since the canal was opened.

Q. You know that the oily green scum does form on the river since the opening of the canal, right here where this boat stands?

A. There is some there, yes, sir. It is a kind of a scum, it isn't very bad at that. I use cistern water at home.

3448 FRED MAWBEY, examined in chief by Judge Johns:

Reside at Lacon. Have fished upon Illinois river 25 years or more. I fished from LaSalle as far as below Naples. I fished at Havana before opening of canal. The conditions were bad; there was a white slime in the water that collected on the nets. The nets would fill up so that two men could hardly lift them. The condition of the Illinois river in this neighborhood (Lacon) before the opening of the canal was bad. Through the summer season it would be green in fact from top to bottom and in the winter season, take it above Henry dam, it would take it about

8 or 10 days to kill every fish in it. There was a smell in the water in the summer and in the winter the smell was so bad you would have to cover your face when you went across the bridge at Henry dam.

3449 The fish tasted gassy; you couldn't eat them at all, nor you couldn't stay in the house where they were cooked. Since the opening of the canal the condition of the river in this vicinity has been good. There has been no smell or odor in the river here in the winter or summer that I know of. The fishermen on the Illinois river in this vicinity since the opening of the canal, do not have typhoid fever that I know of.

CROSS-EXAMINATION, by Mr. Jeffries:

I couldn't say whether they had typhoid fever before the canal was opened. There was lots of ague though. I never seen anybody have any typhoid fever along the river neither before nor after the opening of the canal. I have seen them have it in town—in Lacon. Not very much of it. There was a man died with it here day before yesterday. That is the only case I know of since the opening of the canal. I don't remember of any before the canal was opened.

3450 I live in a house boat up on the bank of the river. Before the opening of the canal in low water there wasn't any current to speak of. The current now is good at all times. This green scum that I spoke of on the river prior to the opening of the canal was in the river; the river was just about the same as dead water; there was no current. If it was not for the steamboats running in it, I don't believe you could live on it; they stirred the water up. I have seen the water you could take a 16 foot oar and stir it up, put it down and it would come up green. Of course seeds would form on it at times; I have seen them at times from Henry to Lacon 2 feet deep. Since the opening of the canal there is not very much vegetation. There is not much scum unless you go into the slough. When I say the water is better since the opening of the canal than it was before I judge from its appearance and the clearness of it—from its looks.

3451 HENRY STOEHRS, examined in chief by Judge Johns:

Reside at Lacon. Am engineer at the woolen mills. Have held that position for 20 years. For 12 years have obtained water from the Illinois river for my boilers. Before opening of canal water used to be very slimy, scummy, muddy. It didn't act very good in the boilers. It foamed the boilers and we would have to blow them off pretty often. There was a smell to the steam when we blew them off.

3452 The stuff that came out when we blew them off was a kind of a muddy scum, with an awful smell to it. Since the opening of the canal it is better. I don't find that scum in them at all and haven't. The water foams very little in the boilers. There is no odor to the steam now. The water that comes off when I blow off the boilers now is in very good order; there is very little mud and very little scale.

CROSS-EXAMINATION, by Mr. Jeffries:

The people living in Lacon don't use the water from the Illinois river for domestic and drinking purposes. Before

3453 the opening of the canal the water in the river was awful. No current. Since the canal was opened it is better. Seems to be a good current. The water foamed in the boilers in summer and winter before the canal was opened. Boiler house is 1200 feet from the river. There was no occasion for driving a well to get water for the boilers. I don't think the water was so bad that I couldn't use it for that purpose. The green scum that formed on the river before the canal was opened was of a vegetable character. I don't drink river water as long as we have got well water.

3454 I have heard and read that the water in the Illinois river was pretty good for drinking and domestic purposes during the last two years. I have heard it condemned also. I don't know of anybody that uses it.

JOHN FAY, examined in chief by Judge Johns:

Reside at Lacon. Have been fisherman on and off on Illinois river for 15 years. Fished at Chillicothe and Peoria and down as far as LaGrange. It has been about 10 years I guess when I fished below Peoria. Before opening of canal the water at this point (Lacon) was pretty bad, take it in the winter time. It kind of smelled after you cut open the ice; kind of a gassy, tarry smell. It killed a good many fish in the river; when it didn't kill them they tasted tarry, kind of tarry.

3455 They wouldn't smell but they tasted tarry. Since the opening of the canal the condition of the river has been better. The fish have not died here in the water since. It hasn't had any smell. There hasn't been much, if any, of that green growth in the water. There was a good many duck seed on the river before the drainage was opened. Since the opening of the canal the fishermen in this vicinity had not had typhoid fever.

CROSS-EXAMINATION, by Mr. Jeffries:

I don't know as any fishermen had typhoid before the canal was opened. There is a good deal of difference in the current of the river now—more current now than there was then. It was pretty dead water then. There is a good current here now. There is a little scum yet. There is more oil to it now. There is a good current in the river over the whole distance I have been fishing lately.

WILLIAM V. McKINLEY, examined in chief by Judge Johns:

Reside at Havana. Have been an engineer upon boats on the Illinois river. Have been licensed engineer since 3457 1884. Ran engines on the river before that for five or six years. Have been in the employment of the Illinois State Fish Commission since 1894; not continually; I was off two years, last year and the year before. During my employment by the fish commission I have traveled the whole length of the Illinois river as far as navigable with our boats and have been on the bayous, tributaries and lakes tributary to the Illinois river.

3458 I know the general condition of the river at different times of the year and all along the river. The Illinois river does not scour or clean itself in any of its stretches or reaches, to any extent—not to amount to anything. (Objected to by Mr. Jeffries for reason that witness has not qualified himself.) The river does not change its channels in any of its stretches. (Witness temporarily withdrawn.)

J. W. POTTS, examined in chief by Judge Johns:

Reside at Lacon. Have been a physician in Lacon and vicinity for 11 years or more. My practice has extended south to Crow Creek; that's about six miles, and north probably 3 or 4 miles.

3459 Lacon receives its water supply from wells probably 1000 feet from the river. I was on city council when they lowered the well. My recollection is that the bottom of the well from the top is about 39 feet. It is open for 20 odd feet and then driven from there down; pipes. Three-fourths of the population get their supply of water from this public supply. There is no sewerage system in Lacon. The domestic sewage is dumped in cess-pools, top drainage, of course. Most of them are just allowed to drain. The modern cess-pools of course are cleaned out, but they are not numerous. This drainage is absorbed mostly, I should judge.

3460 I do not know of any typhoid fever in this community within the last three years, neither among the people along the river nor back from the river.

CROSS-EXAMINATION, by Mr. Jeffries:

Three-fourths of the people use the water from the public water supply. The remaining people procure their water from some public wells here, and then there are cisterns. This water that is used from these wells, is filtered through the sand and gravel. That is the theory on which they were built. None of the people of Lacon and vicinity use the water of the Illinois river for domestic purposes to my knowledge. I wouldn't recommend the water of the Illinois river for drinking purposes since the opening of the cnal nor at any other time.

3461 S. S. EVERETT, examined in chief by Judge Johns:

Have lived in Lacon seven years and a half. Am physician and surgeon. Am a graduate of the regular school. Have practiced in this vicinity for ten years and a half. Practiced

the remaining years in Sparland, across the river, a community
of 450. They have no public water supply—they have largely
well water over there. We have a public supply here (Lacon.)
The water is taken from the deep wells down on the bank of the
river. We have no sewerage system. Natural drainage is ideal
—the lay of the land, and the sub-soil is sand and gravel and
there is perfect drainage almost to the river. There is no strata
of sub-soil to hold the water and prevent it going down towards
and draining back toward the river. The natural subterranean
drainage is towards the river. Household sewage is dis-
3462 posed of by cess-pools and privy vaults. I have had only
4 cases of typhoid fever in the last three years. They
were in town and I think imported cases. Dejecta of patients
was disinfected and buried as a rule. We have a little malaria
along the river all the way here; it is not severe; the types of
malaria here are not severe; they are easily treated; it is getting
less and less as my judgment serves me.

3463 CROSS-EXAMINATION, by Mr. Jeffries:

There was a little typhoid fever before opening of canal. About the same as now. I don't notice any difference about that. The malarial fever has been growing less and of a milder form particularly the last two or three years. And from what the older physicians have told me it is of a much milder form now than formerly. None of the people of Lacon or Sparland use river water for domestic purposes. Would not recommend river water for domestic purposes since opening of canal—never would. These wells here in Lacon obtain their supply by filtration through sand and gravel.

(AT HENRY, ILL., JULY 24, 1903.)

J. A. McCUNE, examined in chief by Mr. Todd:

3464 Live at Henry. Took water for Sanitary District and University of Illinois in 1899 and 1900 at the dam at the north end of the lock. (States method of taking samples, etc.)

3466 CLYDE BAUTER, examined in chief by Judge Johns:

Live here in Henry. Have been fishing here for last nine

years. I fished about three miles below Copperas Creek and clear to Spring Valley. Below Copperas Creek before opening of canal the water was low; it was in the fall of the
3467 year when my brother and I were down there. The water seemed to be all right then. I couldn't see nothing wrong with it then; it was a little scummy along the banks. There was slime in the nets in the fall and winter time. They don't slime to amount to anything now. At this place before the opening of the canal the nets took the slime up a great deal and the water used to be green and scummy like. I don't think it was as pure as it is now by no means. In the winter time in low water when the river froze the water would get gassy, tarry and make the fish taste so people couldn't eat then. There was no market for them; fish couldn't stay in the back water lakes in low water before the drainage was in. Since the drainage canal was opened the first year the water wasn't as good as it
3468 is now; now the fish lives good and everything; we wouldn't ask for any better water at all, and the boilers on the boats don't foam or nothing. Four years ago we couldn't keep steam in the boiler for foaming water; she would foam over. I have run a boat operated by steam on the Illinois river five years this July 1st. The water foamed in the boilers
3469 prior to opening of canal below Peoria, in the summer time. First year after canal was opened she foamed a little bit, but she don't foam any more. Since the opening of the canal the water from Peoria to Spring Valley is all right for the boilers; no complaint at all; for the last two years there ain't been no foaming done in the boilers at all. I am acquainted with nearly all of the fishermen between here and Copperas Creek. I don't think there is anybody that I know of amongst the fishermen that had the typhoid fever in the last three years. I know, by golly, I ain't had the chills for a long while.

CROSS EXAMINATION by Mr. Jeffries:

3470 I get my water for domestic purposes out of two cisterns. The people of Henry got their water supply out of wells and cisterns until they got their water system here last fall. Before opening of canal people did not use Illinois river water for domestic purposes.

3471 The water in the Illinois river below Peoria the first year after the opening of the canal didn't look as good as it does now nor as good as it did before the canal was opened. The current from below Peoria to the Henry dam before the canal was opened was pretty swift. Since the canal was opened it carries a pretty good stream, about four miles an hour. The green scum that formed on the water before the opening of the canal was of a vegetable character as near as a fellow could get at it. There is some scum yet on the
3472 banks, but not in the middle of the river. In the winter time and in the fall slime forms on the nets yet, but it ain't the same stuff. It is a kind of rotten stuff; it don't hang on like the other did; the other stuff was a kind of a glue.

B. F. FORREST, examined in chief by Judge Johns:

Reside in Henry. Have been a physician for 20 years and practiced in Henry and vicinity about 13 years. My practice extends in a general way as far north as Hennepin and as far south as Lacon. I was mayor of the city from 1892 to 1894 and 1898 to 1900. We have no system of public sewers. As
3473 a rule the household sewage is thrown out. Some people haul it away in barrels but the most of it is thrown on the top of the ground in back yards and alleys, a large portion of it, and privies. There are no cess-pools here. The population is about 1,700. There are two cases of typhoid here at present. One of the patients has been away from home, visiting in Indiana and was taken down with this malady at once after returning, and has had it for three weeks. I don't
3474 know what to attribute the other case to. I enquired particularly as to any cause of infection and learned that they have been using cistern water only. Since the opening of the canal there has been no deaths from typhoid. The dejecta of the two patients is disinfected with carbolic acid and lime and emptied into the vault. I have fished a good deal on

the river with pole and line and also backed a seining outfit knowing what they were doing. At this point before the opening of the canal in times of high water the Illinois river was in good condition—that is the condition of the water was fairly good. In conditions of low water the water was very bad, polluted. After the river would become frozen over, there was a break in the column of ice at the dam; at times the gases that would arise from that break in the dam where it didn't freeze over would become very bad; at times so much so that it was offensive. The effect was to kill the fish. The fish were tainted and unfit for food.

3475 Since the opening of the canal the water apparently has been better; there has been an absence of this stench and I haven't noticed it as much, not near as much. As to the fish I have heard no complaint. I have known the fishermen have taken them all this season and used them for food. It is 30 miles from here to LaSalle and 33 to Peoria.

CROSS EXAMINATION by Mr. Jeffries:

The water system has only been in operation three months. Before that the water was taken from cisterns and wells. The water from the river was not used except in ice. The ice is cut from the river or the little ponds supplied from the river. There were cases of typhoid here before the canal was opened. There never has been an epidemic. There hasn't been 20 cases of typhoid fever since I have been here. I wouldn't recommend the water of the Illinois river for domestic purposes.

3476 There is more current in the river now; at times before the drainage canal was put in there was no current or almost none. When the water was low it was ordinarily worse; very low, it became stagnant.

WILL SIEWERS, examined in chief by Judge Johns:

Live at Henry; am grocery clerk. (Took samples of water. States method employed, etc.)

3478 ELMER MELICK, examined in chief by Judge Johns:

Am lock tender at the Henry lock. Held that position since October 1, 1900. Before that I was three seasons with

Capt. York on the steamer Peoria; 5 or 6 years I was with a grocery store at Henry and I was east about 1 year. The steamer ran from Henry to Peoria and return. The distance from Henry lock to Copperas Creek dam I think is 65 miles. Henry is a State dam. Since I have been attending the locks the water of the Illinois river has been lots better than it was before. Before it used to be a bad odor arise from it and since I went to work over there I haven't noticed this odor. The river at this point tday is higher than the average. The lower guage is 8.9; the upper guage that gives the water on the dam is 2.4. The upper gauge shows that there are two feet and four-tenths of water going over the dam. The flash boards were taken off this dam before I came here.

3480 Since I have been here the extreme low water mark on the lower guage to the best of my recollection was I think about six feet.

CROSS-EXAMINATION, by Mr. Jeffries:

The dam across the river is 540 feet long, I think. The water is now 2.4 deep on top of the dam. In years gone by we ought to have about 1.2 on the dam. That is before the canal was opened. The current now is prettty swift. The fishermen are all kicking about it, is all I know. They say they can't seine. Occasionally see a green, oily substance forming in the lock now; very little though.

3481 WILLIAM McKINLEY, direct examination continued by Judge Johns:

Before opening of canal, the water in the Illinois river in dead low water, from Kampsville to the mouth, was very bad. It was stagnant; weeds grew in it. Since the opening of canal there is more water and running water, and there isn't any moss or any vegetation of that kind. It has been all right for steaming purposes. Before opening of the canal the water between Kampsville and La Grange dams was about the same as it was below; there wasn't so much vegetation on account of the dam held the water up; made the water deeper here. I heard them say at Meredosia that the Kampsville dam raised the water four

inches at the lock. Before opening of canal the river between La Grange and Copperas Creek dams was a kind of a pond like; not much current; stagnant. We would have to clean the boilers every 8 days, we calculated on. After the opening of the
3482 canal the river between La Grange and Kampsville dam was improved to what it was before. For steaming purposes it was about the same as river water; you couldn't notice much difference; we had to clean the boilers every so often any way. The water was cleaner than it was before; at least we don't get as much out of the boilers. The water between La Grange and Kampsville dam since the opening of the canal is about the same as the water below Kampsville dam. It is 83 miles from La Grange. I don't know how far the influence of La Grange dam is felt. But it is felt at Havana, about six inches there.

3483 Before opening of canal the water between Copperas Creek and La Grange was low and there wasn't much current; it was stagnant the same as it was below. After the opening of the canal it was improved the same as it was below. When we cleaned out the boilers we had more real mud than we did before the opening of the canal; as to lime and scale I don't think it made any difference. After the opening of the canal the water between Copperas Creek and La Grange was all right for steaming purposes. The farther up the river you got I think the water was worse until you get to Peoria. From Pekin to Copperas creek dam before opening of canal the water was pretty rank, pretty bad. From Pekin to Peoria it kept getting worse that is in low water. There was more sediment in the
3484 water and it was more difficult to get an injector to work between Pekin and Peoria than it was below there. After opening of canal water was improved between Copperas creek dam and Pekin. There was more water. It was all right for steaming purposes. If you let the boilers get dirty or run them over, they would prime, it didn't make any difference where it was. After opening of canal water between Pekin and Peoria was and is still bad—it has improved some. We haven't had any

dead water. The water from Pekin to Copperas creek dam is not as good as from Copperas creek dam to La Grange. Prior to opening of canal water from Peoria to Chillicothe was all right, good. It is still good. You couldn't tell much difference in it as compared to its condition before opening of canal. Before opening of canal the water between Chillicothe and Henry dam was all right, but there wasn't much current; it was kind of a stagnant place; every now and then there would be a green scum on it in low water or warm weather.

3485 Before opening of canal water from Henry to Chillicothe was about the same as the water from Chillicothe to Peoria. After the opening it was about the same. I couldn't notice any difference for steaming purposes. Before opening of canal the water from Henry to La Salle was kind of stagnant, slow current, same as it was between here and Peoria. Since opening of canal it has improved, there is more water.

3486 In cleaning boilers at Peoria after coming up the river there would be no smell in the water to speak of.

CROSS-EXAMINATION, by Mr. Jeffries:

Since opening of the canal the current has increased and there is more water. At times before canal was opened there was scarcely no current at all. In places not any; in wide water there was scarcely any. The odor I spoke of as coming
3487 from the water before the canal was opened was mostly from decayed vegetation. There is more or less odor to all steam, after the boilers begin to get dirty. I haven't seen any green scum since the canal was opened. If you run the boilers too long the water will foam; you can notice it when the whistle blows. When the waters foams it is because the boilers get very dirty. As far as for boiler purposes is concerned
3488 you can't notice much difference since the canal was opened. the water looks better and has a better appearance all the time so far as that is concerned. I don't know what is in it. I don't drink the water because I can get better water. I have drank it and do yet in the spring and when I am out hunting and can't get any better.

A. G. HUMPHREY, examined in chief by Judge Johns:

Live at Henry and am in the grain business. Prior to
3489 opening of canal water in Illinois river at this point was very bad. It had a greasy scum on the surface of it and it smelled like coal tar, and in low water that was very bad. In low water in summer time I have seen it covered with a vegetable growth. In winter after the river had been frozen over for a while we could notice a very strong odor of gas, or tarry; the wind would blow it towards town. Since the opening of the canal I have not noticed anything of the kind; the water seems to be a good deal purer; and not that green stuff on the surface. I haven't noticed any odor in the winter.

CROSS-EXAMINATION, by Mr. Jeffries:

There is more current in low water now than there was before. I think there is a great deal more in low water.

3490 There were two kinds of scum on the river; one was a vegetable matter we called duck seed: the other was a greasy substance that would be on the surface of the water when it was calm. I never noticed any of that greasy substance on the water since canal was opened. I don't drink the river water. It wouldn't be considered good water for domestic purposes.

W. T. LAW, examined in chief by Judge Johns:

Live at Henry and am a banker. Have resided in Henry 44 years. Before opening of canal, water in Illinois river I did not consider was in as good condition as it is today; the water wasn't very good; there was a smell about it in the summer time in the evening and I don't notice that much now. There was usually a green scum on the water here in the summer before the opening of the canal. From its general appearance today I conclude that the water is better than before the opening of the canal.

CROSS-EXAMINATION, by Mr. Jeffries:

The people in Henry just put in a water system this season. Prior to that water plant they used water from driven wells and open wells and cisterns. They don't use water from the river to any extent. There is more current in the river and the water seems to be clearer. I have made no examination of it.

3492 FRED BAUTER, examined in chief by Judge Johns:

Live at Henry. Have been fisherman on the Illinois river between 9 and 10 years. Run a steam tug or boat in my fishing on the river. Before opening of canal below Peoria to Copperas Creek take it along in the winter time and when the water began to get cold, it was so dirty and slimy that you couldn't set the nets. The slime stuck on the nets in big chunks; it was a white slimy stuff, sticky. Fish would not live in the live nets. Water foamed in boilers in hot weather. Put coal oil in boilers to keep foam down. Above Peoria the water was not so bad. You could fish any time of the year up here and never get any slime. Above Peoria we never had any trouble with the boilers at all. Before opening of canal the water above Peoria was awful green; especially along at Peoria, and a green matter would collect; there was no current to let it pass. At Henry the condition was about the same as it was below. Above Peoria and up to this point in the winter time when it used to freeze over the water would get bad and kill the fish off, and the water and fish both would smell tarry and taste tarry. Since the opening of the canal the
3494 conditions above Peoria and up to Henry has been good;
the water is more pure; keeps cooler, fish keep a good deal better and there is no time in the water that you can't drink it. I never notice any smell. Am pretty well acquainted with the fishermen. Since opening of the canal I have not known of any typhoid fever among them.

CROSS-EXAMINATION, by Mr. Jeffries:

Before opening of canal there was scarcely any current in the river. Now I judge it was about two miles and a half an hour. I think this scum that used to form was filth; that is how it looked to me; there was a green scum from the duck seed but this wasn't. I have not noticed any of that filth now; may be once in a while you will see a little piece. I don't know where it has gone to. I think it is all stopped up. It must still be in the water.

3495 **H. HALL, examined in chief by Judge Johns:**

Reside at Henry and am an iceman. Put up ice at this point 9 seasons. Before opening of canal ice had a good many sediments in it; after we cut the ice out of the lake there would be a scum over the water where we would take it out. There would be a smell to the water after it was froze up a while. It would kill the fish. Fish would freeze up in the ice and had to cut them out in summer. After canal was opened in January, 1900, we took a chunk of ice out of the lake and one that we took out a year before that and boiled them and found that the ice that we took out of the lake was better ice than the ice that we had in the house. This ice is taken out of the river; you might call it the river. Since the canal was opened we haven't

3496 noticed much sediment. Noticed no odor last winter where we took the ice out but there was some odor at the dam but not quite as bad as it was the year before. Haven't found any fish in the ice since the opening of the canal.

CROSS-EXAMINATION, by Mr. Jeffries:

The current is much swifter now than it was before the canal was opened; you can't do any fishing here with a seine at all.

The smell at the dam last winter was not near as bad as it was before. We have a pretty good stage of water.

3497 I don't know what has become of the green scum unless the current carries it away.

MR. JEFFRIES: I move to strike out all the testimony of all the witnesses taken on the Illinois river dating from Monday, July 13th to Friday, July 24th, who have testified as to the character of the water before and since the opening of the canal for the reason that the said witnesses did not properly qualify themselves as being competent to express an opinion or give their judgment on the subject; and for the further reason that water may be apparently clear and at the same time be filled with germs of disease, and that testimony of the character in question is incompetent and immaterial and irrelevant. Move to strike out all testimony of witnesses and physicians as to the typhoid fever cases up the river for the reason that the evidence shows that the Illinois river water has not been used for drinking or domestic purposes to any extent and therefore could not be the source or cause of the increased typhoid death rate in St. Louis; and move to strike all the evidence of witnesses testifying to the water foaming in the boilers for the reason that such fact does not prove or disprove that the water is in a better condition from a sanitary standpoint since the opening of the canal than it was prior thereto, and for the further reason that it is incompetent and irrelevant; and I move to strike out the testimony of all witnesses to the deposit of material in the Illinois river at Peoria and Pekin and other places for the reason that such fact is no justification for the right of the Sanitary District and the city of Chicago to discharge the sewage of Chicago into the drainage canal and thence into the Illinois river and for the reason that all the testimony so taken between said dates and places is incompetent, irrelevant and immaterial.

(NATIONAL HOTEL, PEORIA, ILL., AUG. 14, 1903.)

H. E. BEASLEY, examined in chief by Judge Johns:

3499 Am city engineer of Peoria. Have been since Oct. 15, 1900. Water supply of Peoria is owned by a private corporation, the Peoria Water Company. Until about 1888 the waterworks system was owned by the City of Peoria. Water is obtained from a water bearing strata of gravel, located about 3 miles northeast of the court house, or the central portion of the city and about 300 yards from the Illinois river at ordinary stage of water. The water is taken from a well fifty feet deep. I cannot say positively but in my opinion this water comes from the opposite direction to that of the Illinois river. There is an auxiliary well located some 330 feet east of the plant and connected with the main pumping plant by a vitrified pipe some 30 inches in diameter. This auxiliary well is not more than

3500 25 feet from the Illinois river at ordinary stage. These wells are located in what might be called the bottom lands and in the vicinity of the well are not subject to overflow and periods of high water in the Illinois river. The bottom of these wells extends below the ordinary level of the bottom of the Illinois river. All distilleries, glucose works, in fact all large corporations located along the river have their own private water supply. In all cases these wells are sunk to this water-bearing gravel, and are located within 100 to 300 yards of the water of the Illinois river at ordinary stage. The water company does not furnish the city with information regarding the number of gallons of water pumped der diem but I would judge it to be in the neighborhood of 5 or 6 million gallons every 24 hours. The census of 1900 gives the population of Peoria as 58,600. There has been an increase since and a conservative estimate of the present population would be about 70,000 to 73,000.

3501 After being used for domestic and manufacturing purposes the water from the public water supply in a large majority of cases is turned into the public sewers of the city. We have official records in the office of 2,500 connections with the public sewer. This record is not complete and I would judge that there would be in the neighborhood of 3,000. These connections are from all buildings, residences, hotels, or any other public building. There are three hospitals in Peoria and they are connected with the public water supply and discharge their sewage into the public sewers. Where corporations and manufacturers have their private water supply their sewage is discharged into their private drains leading into the Illinois river. Peoria is located on the west bank of the Illinois

3502 river and extends about 5 miles along the bank of the river. Kickapoo creek is below Peoria and empties into the Illinois river very close to the south-western corporate limits of the city. The creek is about 18 miles in length and of an average width in low water not more than ten to fifteen feet in places. In high water it overflows and extends over the lowlands to a width of 300 feet.

3503 Averyville is a village north of Peoria lying along the

banks of the Illinois river. The city of Peoria is located on the bank of the Illinois river, the ground rising from the river bed to the bluffs and extending back from the brow of the bluff a distance of approximately a mile and a half. This bluff is about 200 feet above the river bed in some portions and from three quarters to about a mile and a half from what might be termed the foot of the bluff. The surface drainage of the streets, alleys and public areaways of Peoria flow into the public sewers, wherever they are located. In places where there are not sewers it empties into the Illinois river, through conduits or ditches. The street sweepings are dumped into what is known as the levee on the river front, the larger portion, however, being distributed on lots which are lying low, throughout the city. About 40 per cent of the city of Peoria is
3504 sewered. About one-fourth or one-third of the population discharge their sewage into the city sewers. The remaining 66 per cent is discharged into vaults. Paper marked "City of Peoria; Sewer Map, January, 1898" represents the sewers of Peoria; the entire system of the city of Peoria at that date to which I have added the Persimmon street and Chestnut street sewer systems which have been constructed within the past year. This represents Peoria before annexation of what were formerly known as North Peoria and South Peoria.

3505 The brick sewers of Peoria are about 21 miles in length; the pipe sewers about 58 miles in length. Map marked Defendant's Exhibit No. 1. Objected to by Mr. Jeffries.

3506 (It is agreed that every possible objection pertinent to any question to any witness may be considered as having been made by complainant to defendant's testimony, with respect to the character of the deposits or discharges into the Illinois river from its mouth to Lockport dam, and this objection shall go either as to the form of the question or substance of the question. F. S. B., Commissioner.)

CROSS EXAMINATION by Mr. Jeffries:

3507 The people of Peoria do not use the water of the Illinois river unless it be those that live in shacks or houseboats on the banks of the river. The mains of the waterworks do not extend all over Peoria. Where the mains do not extend the people have wells or cisterns.

3508 The water from the well of the water company is taken from the lower side of an impervious strata of clay or shale. The private wells throughout the city are from above this point.

3509 PETER CASEY, examined in chief by Mr. Todd:

Live at Peoria. From August, 1895, to June, 1901, I was manager of the Whiskey Trust. Since that time have been manager of the Corning Distilling Company. At the time I had the management of the Whiskey Trust there were four active distilleries located in Peoria, the management of which I had. From 1895 to 1900, we fed from 12,000 to 20,000 cattle. The most we ever had was in 1896 when we fed 20,000. In 1897 we fed 15,000; in 1898, 12,000 or 14,000; in 1899, 12,000; in 1900, 8,000 or 10,000; in 1901, 10,000; in 1902, 8,000.

3510 During the years the distilleries were known as Trust Distilleries, we ran a capacity of between 17,000 and 18,000 barrels a day. The corn is first ground into meal and put into large cookers; the heat is drawn out by a vacuum and malt is added to convert the starch into sugar. It is then fermented and separated over a beer still, which separates the whiskey from the slop and the slop is then pumped to the cattle and fed to them. This slop is principally composed of protein and fat. It has a certain amount of moisture and with other minerals in there, such as ashes, etc. The average protein is 33 per cent and the fat about 11 per cent and the other 66 per cent is composed of the other minerals that I spoke of. The cattle are kept in sheds built in sections. The slop is supplied to them and the offall is pushed out not less than twice a day into a sewer which is directly behind each steer.

3511 This is pushed out into the main sewer that runs through the middle of the cattle barns and water is used to flush that into the river. Hay, cotton seed meal and cotton seed hulls are also fed. The rule is to feed a bushel of slop to every steer but that has been modified to about three-quarters of a bushel. There are about 31 gallons of slop to a bushel. From 7 to 10, and as high as 15 pounds of hay is fed to a steer daily and from a pound and a half to two pounds of hulls. Salt is given to them frequently.

3512 I suppose some of it goes through and is wasted. 10 or 15 barrels are used every week in the feeding of 10,000 head of cattle. The urine and manure from the cattle go into the river. Some of these sheds are directly on the bank of the river and I think the farthest is about 700 feet. Sometimes the manure accumulates on the bank of the river.

3513 These accumulations have been pretty extensive. This last high water took them all away again. In the absence of high water they just lay there and disintegrate. They have been dislodged by steamboats and floated down the river in large islands. These islands of manure were so large that they could not pass between the piers of the Pekin bridge. The condition of the river before the opening of the drainage canal below Peoria was very bad. It smelled so bad sometimes that we could hardly stand it along there. The water seemed to be perfectly stagnant and there was no life to it. I have noticed a foam on it. I think it was the offal from the cattle barns that caused that condition in my opinion. The water above where it received the offal of the cattle barns was a great deal better but nothing like it is now. Since the opening of the canal the water both above and below this point has been much improved in every way, especially for mechanical purposes.

3514 I haven't noticed any stench since the opening of the canal to amount to anything. There is a great improvement in the river. In my opinion it is purer than it was before. I know those facts in a mechanical way. We don't have foaming in the boilers now nor slimy formation on the coolers or condensers that we formerly had. When I was with the American Spirits Mfg. Co. we operated four distilleries at one time.

3515 The Great Western distillery was located above any of the cattle barns and we had less trouble there than most anywhere else, both with slime in the boilers and in the coolers. The Manhattan distillery was located below the Great Western cattle barns on the river and we had considerable trouble there from water foaming in the boilers and the slime in the condensers and coolers. The Manhattan distillery was located below all the cattle barns except the Manhattan cattle barns and we had a great deal of trouble there. We had our river pipes out farther than any other pipes and we were constantly pulling it up to get out the accumulation of slime and manure and so forth. We have at times pumped nothing but which looked like excrement from the cattle barns up through that pipe. The water is very much better now; in fact I have not heard of any trouble at all lately.

3516 Since the opening of the canal I have had experience only with one distillery, that is the Corning Distilling Company. It is below all the houses that I have named and we have not had any trouble at all.

3517 The length of time a steer is kept for fattening purposes before he is ready for market varies considerably. We formerly kept them nine months, now we endeavor to get them out in six or seven months.

LEWIS A. McFADDEN, examined in chief by Judge Johns:

Have lived in Peoria since July, 1887. Have practiced the profession of physician and surgeon during that time continuously. I was county physician of Peoria county for five years. I was one of the United States pension examiners under President Cleveland's administration; was alderman from the First ward for four years, and also commissioner of health from October, 1901, until June, 1903.

3518 I think when I was County Physician there must have been as many as 500 people living in cabin boats on the river and along the river. A great many people living on the cabin boats got their water from the springs along the river bank. I found a great deal of sickness among those people prior to January, 1900, more than in any other part of the city. They suffered from malarial diseases, dysentery and typhoid fever. I attributed those diseases at that time to their mode of living and to the use of river water.

3519 The health of those people is certainly as good now as it was before. There may have been some cases of typhoid fever since 1900 but none to my knowledge. Prior to the opening of the canal the water never was good in front or below Peoria, on account of the Peoria sewage which in various ways found its way into the river, and the slops from the distilleries that flowed into it. Since the opening of the canal so far as I could observe, the water above Peoria is about the same as it was before only there is more current. This green scum forms on it now. Some of it is duck weed and some of it is like moss, such as you find in stagnant water in some localities when the weather is warm.

3520 I have examined the statistics of the Health Department since 1895. In August and September, 1895, there were 45 cases of typhoid fever reported to the Health Department. This is a greater number than has ever been reported during the same length of time since. 1896 I haven't got. In 1897, there were 15 deaths; in 1898, there were 18 deaths; in 1899, there were ten deaths; in 1900, there were 17 deaths; in 1901, there were 12 deaths, and in 1902, there were 18 deaths and so far during the present year (1903) there have been 3 deaths. While I was Commissioner of Health, in the families where typhoid fever existed, they were instructed by an officer to disinfect the stools and destroy them by boiling or burying.

3521 There are a great many cess-pools in Peoria. I think one-third of the population of Peoria discharges its sewage into the public sewer system. The contents of the vaults and cess-pools are deposited in the current of Kickapoo creek near where it empties into the Illinois river. These materials then pass naturally into the Illinois river. About 750 permits are issued in a year for the cleaning of such vaults and cess-pools.

3522 CROSS EXAMINATION by Mr. Jeffries:

3524 The water in the Illinois river is not used by the people of Peoria to any great extent for domestic and drinking purposes.

3525 I don't think the water from the river is any more suitable now than it ever was for domestic or drinking purposes and I would not recommend it. There is a scum in the bogs in the lowlands where the water remains stagnant. The water is not stagnant in the river proper at this time.

3526 The green scum and stagnated condition is removed to a greater extent than formerly by reason of the current in the channel. The appearance of the water has nothing to do with the impurities that it contains.

RE-DIRECT EXAMINATION, by Judge Springer:

Our water is perhaps is not as pure as we imagine.

3527 While we don't use the river water to any extent for drinking or domestic purposes, yet nearly all our ice is harvested from the Illinois river; that is used in and around the city. This ice is used by hundreds of families for drinking purposes, by putting the ice right into the water, and we don't find any bad results arising from that source.

RE-CROSS-EXAMINATION, by Mr. Jeffries:

3528 The ice used here is cut from Peoria Lake, which is a widening of the Illinois river at this point.

3529 W. A. McMILLAN, examined in chief by Judge Springer:

I have resided in Peoria 20 years. Have been sanitary officer of Health Inspector two years under a former administration. I was off two years and I have been at work about a month this last time. The sewage of the town goes through the sewers where they are connected and the garbage is hauled away. The sewage from private vaults and garbage is deposited on

3530 Kickapoo Creek. It is dumped into the deep water of the creek there and finally reaches the river I suppose. In 1899 there were 639 privy vaults cleaned and dumped into the Kickapoo Creek; in 1900, 725; in 1901, 700; in 1902, 735; and so far this year (August 11, 1903) there have been 500 cleaned.

3531 CROSS-EXAMINATION, by Mr. Jeffries:

These figures represent the number of vaults cleaned. There is but one ice plant here in Peoria where ice is manufactured.

3532 EDWARD N. WOODRUFF, examined in chief by Mr. Todd:

Am mayor of Peoria and dealer in natural ice. We have a capacity of 26,000 tons, divided into three locations along the river.

3533 We get our ice from Peoria lake—a widening of the Illinois river immediately above Peoria. I have been in the ice business about 22 years. The water of the Illinois river as compared to its condition prior to the opening of the canal is better than it was. The water is clearer and in better condition in every way. Before the opening of the canal we were hunting for other locations for ice cutting purposes.

3534 This was due to the natural prejudice of the people to begin with. In winter when the river was covered with heavy ice there was always more or less odor to the water. We have had times when there have been a lot of dead fish along the rivers. Since the opening of the canal I haven't observed that odor under the ice.

3535 In my opinion, as an ice man, the water is better beyond question since the opening of the canal. The only objection that we have had to the ice is from the soot that grows on the top and in soft weather gets into the ise and freezes there.

3536 The water today is much better in my opinion than it was prior to the opening of the canal.

CROSS-EXAMINATION, by Mr. Jeffries:

There are two other dealers in town here, one being an artificial plant, with fifty tons a day.

3537 When I say the water is better now than before the canal was opened, I judge from the appearance of the water. I could not tell by looking at the water whether the impurities that were in the water before the canal was opened are in there now. The water is clearer now.

3538 I believe that freezing destroys germs. I pronounce it better ice than it was before the opening of the canal, because the water is clearer and from the fact that I believe that freezing destroys germs.

RE-DIRECT EXAMINATION, by Mr. Todd:

I have never made any experiments in bacteriology.

3539 The other two firms that are cutting ice here I understand are shipping the ice to St. Louis.

3540 PETER CASEY, re-called for cross-examination by Mr. Jeffries:

3541 At the time I was superintendent of the four distilleries in Peoria, the Atlas Distillery and Stark Bros. & Co. were also in existence here. They have for the last six or eight years fed cattle. They fed 2500 head this year. I think they fed the same number last year. They had a contract for five years. There have not been as many cattle fed since 1896 as there were fed in that year. The number of cattle fed has been decreasing right along every year.

3542 I think there has been a slight decrease recently in the corn and grain consumed by the distilleries here. The slop that is not fed to the cattle is dried. It demands a very good price for export.

3543 When we are not feeding cattle, the substance that goes into the sewers and thence into the Illinois river is a water that it is hardly perceptible there is anything in it at all. The cattle we feed are a good quality of cattle and are not diseased if we know it.

3544 The foaming of the water in the boilers before the canal was opened was caused by the decaying of both vegetable and animal matter. I don't know from any examination that those same impurities are not in the water now, but the action is entirely different, is all we go by. I don't think the water in the river is as much polluted now as it was before the canal was opened. In fact I know it is not. I know only from observation and for mechanical purposes. The rapidity of the current now carries away these impurities that were in the stagnant places and it did not carry it away before in low water.

3545 ROBERT R. MARTIN, examined in chief by Mr. Todd:

Am chief engineer of the Peoria waterworks. E. J. Cain and myself took samples of water for the Sanitary District. The water was taken from the Illinois river in the channel at Averyville, above Peoria, adjoining Shady Beach. (Witness states method pursued, places where samples were taken, how marked and shipped, etc.)

3550 E. J. CAIN, examined in chief by Mr. Todd:

(This is the person referred to in the examination by Mr. Martin.)

3551 ROBERT R. MARTIN, recalled for further examination by Mr. Todd:

Have been acquainted with the Illinois river for the last 15 or 16 years. I have worked along side of it. I have pumped it into the city mains and have been quite a fisherman.

3552 Prior to the opening of the canal in the winter time when the river would be frozen over here, the fish caught above Peoria would have a tarry, gassy taste—so much so that they were not fit to eat in the winter after the ice was frozen over for a short time. This winter we have had fish once or twice a week at our house and they have not that taste now. We relish the fish as much in winter now as we do in summer. The water is clear now; before the opening of the canal it had an odor to it. Its condition is a great deal better now. I haven't observed any odor. I think the effect of the Drainage canal has been to give us a better river—better water. I don't know whether it has any effect on the mosquitoes. In the last few years we have had less mosquitoes up here.

CROSS-EXAMINATION, by Mr. Jeffries:

3553 The fish used to be all right in the summer time when
they had plenty of air. When I say the water is better I
say so from drinking it. I am around the river all the time. I
have charge of about 4500 feet of river frontage.

3554 I am chief engineer at the Water Supply Pumping Works.

3555 We pump an average of four to six million gallons a day, for the last two years.

3556 CHARLES F. HIXSON, examined in chief by Judge Johns:

Reside at Peoria. Run a summer resort at Shady Beach.
Shady Beach is about three miles and a half above Main street.
We are right at the Narrows. The condition of river above the
Narrows before the opening of the canal in the summer
3557 time when the water was very low, the water became
very foul and had a very bad odor to it, and there would
come a very heavy green scum through the months of July and
August particularly; a man get up in the morning there at 4
o'clock or daylight, the odor that come from the river was something fearful. In winter time when river was froze over fish were not fit to eat; tasted tarry and gassy. Lots of them would die. When ice broke up in spring you would see thousands and millions of dead fish floating in the river. Since the canal was opened it has been very much better; we have a higher stage of water. The water has been purer to the naked eye, and clearer; and we haven't that odor coming from the river that we had prior. We have had no trouble in regard to the fish since. I was engaged by Jacob Harman to take samples of water at the Narrows. (States method pursued and manner of shipping samples, etc.)

3560 CROSS EXAMINATION by Mr. Jeffries:

Before the canal was opened the water in the river at this point was stagnant at this time of the year, very low. It is much better now; there is a good current and there isn't the odor that there was before.

3561 WILLIAM BAKER, examined in chief by Judge Johns:

Reside at Peoria. Am Inspector for the State Board of Live Stock Commissioners. I have general supervision of the stock on foot that passes through the yards. I can't say that I officially inspect the stock that is fed here by the distilleries. That stock does not go through the stock yards as a rule. The Peoria Stock Yards are located at the foot of South street and the river. The entire stock yards would be about two blocks wide and 4 blocks long. The yards have their divisions for cattle and others for hogs and sheep, laid out for convenience. I would say 6,000 hogs are received a week and from 300 to 600 cattle and probably 100 sheep. The manure and urine from these animals goes into a catch basin and into the sewers and from there into the Illinois river. That part of the material which is hauled away from the pens is hauled below or near around the river bank. To a certain extent some of it is washed off into the Illinois river by the high water. The balance fills in a low portion of the ground that is located there. Some material is dumped on one side of the C., R. I. & P. railroad track and a part of it is dumped in the river and a part on the
river bank. The seepage of that would naturally have
3363 to pass into the Illinois river. By seepage I mean the
seepage from the general dumping of the offals which are hauled from the pens. There is one team hauling this offal all the time.

3564 The live stock that goes through the yards is mostly cow stuff and a great deal of through cattle that are unloaded here for resting and watering purposes. The yards are located below the city.

3565 PERCY M. SWAIN, examined in chief by Mr. Todd:

Am captain of the steamer Fred Swain, plying between here and La Salle. Prior to opening of canal in 1900 there
was very little current and there was a green scum
3566 formed on the river and the water was not clear; more

of a sewage color; and in places it had a greenness and also this white stuff; and considerable odor came from the water. In winter time when river was frozen over there was more or less dead fish and more or less odor. The river is altogether different now than it was prior to the turning in of the drainage. It is clearer and this green scum doesn't form any more, only in places like for instance, Lake Depew, or for instance the Illinois river where there is no current; that would be in eddies, you know. Heretofore it was necessary to clean boilers once a week; but of late once in two weeks is sufficient. We fill buckets on the boat for fire purposes. It evaporates as much now, but there isn't so much of this greasy appearance around the edge of the buckets as there was heretofore.

3567 The water is clear. Lots of times you can see right down to the bottom. Prior to the drainage canal you couldn't see the bottom of the river at any place at all. Since the opening of the canal the condition of the water is better. There is more or less current and this green slime doesn't form any more on the river; it is a good deal clearer and better in every way. I was down to the stock yards yesterday. Above the bridge the water is considerably different from the water below the bridge. Below the bridge where it gets the sewage from the stock yards and packing houses, it is a thick, heavy, mushy appearance. Two or three hundred feet from land you can see this stuff bubble up. It has a black appearance; an awful appearance. We always stop the pumps before getting in there, to keep from pumping this stuff into the boiler and causing a stoppage of the pipes. And it has a kind of rotten smell coming off of it.

3568 I suppose that is caused by the turning in of those distilleries and cattle pens and packing houses; that stuff accumulates there, that thick refuse. At times you can see this sewage coming out of those runs. At this time the river

3569 above the bridge is clearer. Below those stock yards and still houses, it is very sluggish and as I said before, it has this odor coming from it; it is filled up.

CROSS-EXAMINATION, by Mr. Jeffries:

The volume of water and the current of the Illinois river is much greater now than it was prior to the opening of the canal. From Peoria to La Salle there was very little current before the canal was opened. There is considerably more current now. Where the water is dead there is some scum, and in the eddies and up in the sloughs. This scum, I suppose forms only where there was no current or where there was very little current. The water is considerably clearer and that odor doesn't come from the water as it did before, and we don't get this slime. I
3570 don't know what particular ingredients are in the water. The water has been more or less purer than it was heretofore.

3572 ALEXANDER RICHARDSON, examined in chief by Judge Johns:

Reside at Peoria. Have been in jewelry business. Have fished on Illinois river for 30 years, annually and hunted and fished for 15 to 20 years. The condition of the water be-
3573 fore opening of canal was very bad, extremely bad, in my opinion. Water was very low at certain seasons of year; at some points covered with green scum clear across; at some places near the city, up above the city, you could smell it here, a very bad odor. Before opening of canal unless we caught fish around the springs we couldn't eat them at all. Before opening of canal there is no doubt but that the water was always very bad below Peoria, that is below the stills at Peoria, for a number of miles. It was bad above Peoria and a good deal worse below. There was an odor to the water and scum formed on it below the city. Since opening of canal the water in the Illinois
3574 river above Peoria is virtually a new stream. There has been so much larger volume of water, and so much greater current, that we find the water is purer, colder and better in every way. The green scum does not form and I haven't detected any odor. The condition below Peoria is like it was above; it is wonderfully improved. I might add that it is not what it ought to be on account of the refuse from the distilleries. On

real hot days I have noticed an odor. The fish in the river are now harder and firmer and of a better flavor and we catch larger fish, such as bass and pike which we didn't catch before.

CROSS-EXAMINATION, by Mr. Jeffries:

3575 I don't know anything about the sanitary condition of the river from analyzing it, but I know from its appearance and its smell.

3576 MICHAEL D. HURLEY, examined in chief by Mr. Todd: Live in Peoria. Am doing special work for the fish commissioners. Before that I was captain of police in Peoria and before that wholesale fish dealer. Prior to the opening

3577 of the canal, below Peoria the Illinois river at low stage was muddy, mixed with manure and what we used to call slop. It was pretty strong smelling. Above Peoria in Peoria Lake and the lakes above here, it was covered with green scum during the warm season. The water itself looked green. It smelled badly with a different smell than below. There were times both winter and summer that fish used to die in numbers; in the winter more particularly above Peoria; in the summer, just from the distilleries on down. Since the opening of

3578 the canal there has been an absence of the scum, and the smell has disappeared almost altogether, except a little below the city proper here. The water was clearer apparently, and better. There are two bridges below Peoria. Below the first one the water is now quite good and a little below that it is bad. It is riley and muddy and discolored somewhat. That condition is noticeable pretty well all the way down the river to the Havana territory. Opposite the distilleries the condition of the river is bad. It is filthy; lots of bubbles; plenty of those little patches of bubbles floating down all over. That condition continues pretty well down to Pekin; then it clears up somewhat, and then it begins again and extends below Pekin for six or seven miles. The water above Peoria seems clearer and better in every way than that below Peoria. Knowing the river as well as I, my opinion is that the opening of the canal has had the effect of purifying it. I think it is true to a considerable extent below Peoria as well as above.

3579 CROSS-EXAMINATION, by Mr. Jeffries:

In the spring time, in flood tide the volume of the water is about the same now as it was before opening of the canal. At low water season, the water is somewhat higher. There is more current. I base my knowldege of the purity of the water from experience. It made several people sick before and I have not known any to be sick since.

3582 I only know of the ill effects before and of none since.

3583 CHARLES F. BARTSON, examined in chief by Judge Johns:

Live at Peoria. Am in the saloon business. Was formerly in wholesale fish business. Before opening of canal the water in the Illinois river below Peoria and down the river from Copperas creek dam was a great deal lower than it is now; the conditions that exist down there now are as they did then in regard to fishing. There was a sort of slime accumulated on the 3584 nets. Below Peoria the water was green and there was an odor to it. Whenever we got a bad winter it killed a great many fish. When there was ice on the river they got so bad we couldn't use them. It was a common thing to have fish die in summer. Above Peoria the water was low and had a green scum on top. Did not have an odor. Couldn't keep fish long in live boxes.

3585 Since opening of canal the water below Peoria has been a great deal higher and I have never seen any of the green scum on the river like it was heretofore. The slime is still there. Above Peoria there is more water and I have never seen it green or with a scum on it since the canal was opened. In the winter the water is good under the ice. No fish have died under the ice that I know of. The fish live longer in live boxes. The 3586 fish are stronger and healthier since opening of canal.

Before opening of canal I drank the river water and it caused me a spell of sickness. Since the opening of the canal the water is better for drinking purposes. The condition of health of people living on the river has been better. I haven't known of any typhoid fever among the fishermen. Before the opening I knew of one case sure and a few others that they said was typhoid. The health of fishermen is better as compared with that of people following other pursuits.

3587 CROSS-EXAMINATION, by Mr. Jeffries:

There has been a very large increase in the volume of water since the canal was opened and a very great increase in the flow of the current.

3588 I. N. FEGER, examined in chief by Judge Johns:

Reside in Peoria; am in electric business. Have fished
3589 upon Illinois river all my life—from Havana to Henry.

Prior to opening of canal the water in the Illinois river above Peoria I considered bad. It was scummy and green and sluggish and had an odor. The fish above Peoria were bad; they were soft and I have known them to bury lots of them. At Pekin the city had to hire people to go and bury them. I considered the water below Peoria bad too. It was a yellow scum; bad odor. Since opening of canal the condition of the river below Peoria has been much better. Fish are better too. The fish above Peoria and the water has been good. The water above Peoria is and has been better than the water below
3590 Peoria.

CROSS-EXAMINATION, by Mr. Jeffries:

When I say the water is better now I say so from the fact that there is a better current, a larger volume of water and the water is clearer. I know nothing of the chemical or bacteriological properties of the water. Don't know whether the filth from Chicago has polluted the water with disease germs or not.

R. R. BOURLAND, examined in chief by Judge Springer:

Reside at Peoria. Am in real estate and loan business. Am Secretary of Illinois River Valley Association. The object of the association is to look after the interests of the residents in

the Illinois Valley in relation to the use of the river itself. Have been connected with the association since 1897. Lived in Peoria all my life. Before opening of canal Illinois river
3591 was an ordinary, sluggish stream that was disagreeable in low water. The river above Peoria was as I said an ordinary prairie stream; below Peoria it was very much affected by the drainage of Peoria, and was a much more disagreeable stream below. There was certainly an odor from below Peoria; I am not so positive as to the fact of the odor coming from above. Since 1900 the water above Peoria is certainly a great deal better than it was prior to that time. The water is clearer in color and does not get so low at low water, and therefore does not have disagreeable features of the former low stage of water. Below Peoria since 1900 the waters still show the effect of the offal from the factories, but not to the same extent as before, because of the greater volume of water, and I
3592 find the odor not nearly so apparent as it formerly was.

Before 1900 the use of the river for pleasure craft was almost entirely given up during low stage of water. Since that time there is continual use of the river by a great many people for pleasure purposes—using house boats for summer residences. A great many people also row for pleasure.

CROSS-EXAMINATION, by Mr. Jeffries:

3594 I think the opening of the canal has raised the water in the river about two and one-half feet in low water and in high water it is absolutely impossible to estimate it. The current in the narrow part of the river has materially increased.

3595 When I say the water is better I simply judge from its appearance and also make that statement that it is better for the purposes to which the river might be employed.

JOHN D. McCLURE, examined in chief by Mr. Todd:

Am in real estate and loan business. Have lived in Peoria 53 years. For 53 years I have been on the river every year. Before opening of canal the Illinois river was at times very offensive; a green scum would form on it and a sticky, gassy smell to it, especially in low water and when ice was on the river. Since the opening it has been very much improved; the water has been better; at least there is not so much of a smell and not so much scum forms as there did before. The water appears purer.

CROSS-EXAMINATION, by Mr. Jeffries:

There has been a better current and increase of volume.

3597 JUDGE JOHNS: I now hand the Commissioner envelope containing 26 tickets, which it is admitted were made by witness Charles F. Hixson, and which would have been identified by him in his testimony today if the tickets had been present.

Envelope marked State of Illinois Exhibit No. 11 for identification.

NAT H. COHEN, examined in chief by Judge Johns:

Am President Illinois Fish Commission, reside at Urbana, Ill. Been commissioner since 1897. Prior to that time was familiar with Illinois river. The wardens make reports
3598 to me. The steamboat Illinois is employed by the Illinois Fish Commission to patrol the river for the enforcement of the law and to collect fish for distribution from the
3599 overflows of the ponds and lakes adjacent. Fish are collected by a crew, with a seine. These fish are afterwards distributed to various waters of the State. From Grafton to La Salle is as far as the Illinois boat can navigate. Before opening of canal above Peoria the Illinois river in the spring during the freshet I couldn't tell much difference in the water, but as the summer came on and water receded from the banks, the water became stagnant, little or no current, covered with a green scum and with a bad odor. The lakes adjacent were low, in a very high temperature, destroying fish from decayed aquatic matter; destroying what we term plantain. Plaintain is the vegetable and animal life in the water that the fry, the small fish, live on. The temperature becomes so high that they are all destroyed. I have found thousands of dead fish in lakes adjacent to the river from this cause. Since that time the temperature in those same lakes is much lower; the water much

clearer and we find an absence of dead fish. Above Peoria before opening of canal a scum formed on the water. Duckweed also formed. There was also a scum that is usually on stagnant water. The water had an odor. The fish didn't have the tenacity of life they have now and as a general thing the coloration was much lighter. Since the opening of the canal the
3601 water above Peoria seems to be clearer, the temperature lower, and a stronger current. The fish are much better, those that I have seen. The temperature of the water in the sloughs and ponds which are filled up by the overflow is lower now because they have an inlet from the river. Before opening of canal the condition of the Illinois river from Peoria to Pekin was very foul. Had bad odor, green scum and frequently
3602 we find dead fish floating. From Pekin to Copperas creek it was bad too. We would find floating islands, being refuse from the distilleries of Peoria, as far down as Copperas creek. The water from Copperas creek to La Grange was better than from Peoria to Pekin. The water improved as it went down. There was some odor in the river and some scum on it almost as far down as Grafton.

3603 Before the opening of the canal the fish between Peoria and Copperas creek were of a light color and not as healthy as they seem at present. When the temperature goes up from 90 to 110, it is hard for fish to exist and the temperature was sometimes as high as 90 to 110 degrees Fahrenheit. Since the opening of the canal the water between Peoria and Copperas creek is much improved. There is a large amount of stuff cast into the river at Pekin from distilleries and city sewage. Since the opening of the canal the water between Copperas creek and La Grange is much better than that above Copperas creek. Since the opening of the canal the fish are much better, of finer color, have more tenacity of life and I regard them as healthier and better than ever before. The water between La Grange and Kampsville is better than that between Peoria and Copperas creek. The water improves as it goes down.

3605 In my observation of the Illinois river the waters as they travel from sources of impurity tend to purify themselves. We occasionally find a herring from Lake Michigan but the conditions of the Illinois river are not suitable for the fish of Lake Michigan.

3606 There is a great deal of land overflowed all along the river from La Salle to Grafton.

3607 There are from five to ten thousand people employed on the river from La Salle to Grafton, and bringing into the State probably $500,000 and shipping out from twelve to fifteen million pounds of fish per annum. The people who follow this business usually live along the river in cabin boats and in villages, the larger number living in cabin boats. From the information I get along the river, they say there is less malaria and scarcely any typhoid fever among the fishermen in the last three years. They tell me they drink the water now and they could not drink it then.

3608 CROSS-EXAMINATION, by Mr. Jeffries:

There is a much swifter current now than there was before. You could hardly tell which way the current went in the summer months. There has been quite an increase since the opening of the canal. When I say that the river is better since the opening of the canal I say that from the fact that the current is better, the temperature of the water is better, and from its appearance, and the fish are better.

3609 As to whether or not the sewage from Chicago contaminates the water, I do not know anything about it. Game fish will not live in anything but pure water and they will not get the color they have got unless the water is pure. Bass will thrive only in pure water and if the water should be foul and there is a spring close by, you will always find the bass in the pure water.

3610 DR. FRANK C. BOURSCHEIDT, examined in chief by Judge Springer:

Am a physician and surgeon. Have resided in Peoria since 1874. Was Health Commissioner from 1898 to 1901. Have made a special study of chemistry and bacteriology. I don't think there is much difference, if any, in the death rate at Peoria before and after the opening of the canal from enteric diseases. The period to which I refer relates to the time since the present waterworks system was established. At the present time, the supply of water is obtained from wells which intercept the spring water, which comes from this high plateau north of the city. Our water supply has nothing to do with conditions in the Illinois river.

CROSS-EXAMINATION, by Mr. Jeffries:

I was not Health Commissioner 12 years ago, or at the time the present system of waterworks was established.

RE-DIRECT EXAMINATION, by Judge Springer:

I have not known of a case of typhoid fever among those persons who reside on the banks of the river or in house boats. Deaths from typhoid fever were recorded officially to the Board of Health. While I was in office there was not a body buried without a permit and the cause of death.

RE-CROSS EXAMINATION, by Mr. Jeffries:

3612 There has not been any increase in typhoid fever since the opening of the drainage canal since I was health officer. I stated I did not know of a single case on the river bank where they use the river water.

HENRY B. OCKER, examined in chief by Judge Johns:

Reside at Peoria and my occupation is that of land agent. Was engaged to take samples of water in the Illinois river by Dr. Long of Chicago. (States where samples were taken and method of taking and transporting same.)

3618 S. P. BARTLETT, examined in chief by Judge Johns:

Reside at Quincy and am Field Supt. of United States Fish Commission, which position I have occupied for about 31 years. I am also a member of the Board of State Fish Commissioners and have served consecutively for 24 years.

3619 We have no hatcheries in Illinois, but we have retaining ponds at Meredosia. As a member of the State Fish Commission, my duties are the collection and distribution of indigenous fish and the management of the Commission's boats. Prior to July, 1903, the fish wardens along the Illinois river, under the supervision of the Fish Commissioners would average one to each county, and perhaps two or three that had entire jurisdiction of the river.

3620 In the employ of the Fish Commission, in the summer, there are about 150 people. I have been intimately associated with the Illinois river for over thirty years. Prior to the opening of the canal in the early spring, the current at times would reach a mile or a mile and a half an hour. Later in the season when the water was lower, it has been frequently impossible to tell which way the current was going. It was very sluggish and very slow. There are four dams in the Illinois river.

3621 The Henry and Copperas creek dams were built by the State of Illinois; those at Kampsville and La Grange were built by the United States. In low water the effect of those dams would be to make the current of the river very slow. At high water, there would be no perceptible effect. The effect would also be to make slack water at a very low stage of water. Prior to the opening of the canal, the river between La Salle and Henry dam was about on the average of river water. There was an odor more or less, as I remember it at low water times.

3622 It came from decaying vegetation and refuse matter dumped into it. I have seen the stage of river so low in the Illinois river during the winter season that the fish would perish under the ice. The condition of the fish between La Salle and Henry would vary with the different seasons. I have known fish to die there previous to the opening of the canal. Fish are very susceptible to the condition of the water in which they live. It is nothing uncommon to find fish taking on a coloration from the character of the water they are in. The temperature and condition of the water have a material effect on the coloration of the fish.

3623 The strong fish always have a dark bright color. Judging from personal observation, and going over it frequently, my judgment would be that the water of the Illinois river above Henry dam shows a decided improvement in every way since the opening of the canal.

3624 Since the opening of the canal my observation has been that the water is frequently better and clearer between Henry and Peoria Narrows. The fish seem to be in good merchantable condition. At Peoria there are foreign substances deposited in the river from all sources. The sewage is very large. The refuse from the gas houses and distilleries and glucose factories is immense.

3625 I have noticed this foreign matter in large quantities below Peoria. I met this condition of pollution frequently as far down as Havana in limited quantities, of course. I am talking of this floating substance on the water—those islands. I have seen a very heavy scum on the water below Peoria and at Peoria, which I believe to be the sewage and refuse from those places at Peoria. That did not go down very far.

3626 I have met with it at Pekin and below perhaps. It was a kind of broth. It looks like grease on top of the water. Since the opening of the canal the condition of the water below Peoria, as far as Pekin, has been improved. I have seen some floating stuff in the river but nothing as bad as it was prior to the opening of the canal. This particular refuse from the gas works, distilleries and glucose works is run off in spouts at the edge of the water and allowed to accumulate there and when the very low water comes, it breaks off and floats off with the current. That would be an impossibility if the stage of the water was of sufficient height to keep the shores clean. I attribute the absence of it now to the better condition of the water and the swifter current. To the best of my recollection I have seen the substance cast into the river at Peoria floating just above Havana, but it was not in great quantities nor in large pieces.

3627 There are a number of lakes below Peoria and above Copperas creek dam which have natural connection with the river. Spring Lake is the one containing the greatest area.

Prior to the opening of the canal this lake was affected very materially by the cast off matter from Peoria and Pekin. If the water was rising, this stuff would break off from the shores very easily and was taken in great quantities into this lake. In fact I have seen it in sufficient bulk, in the canal leading into the lake, to prevent our going in with boats. We had to break it up before we could get by. It floats off into the lake and with other impurities makes the lake very foul at times. (Witness states bad condition of Spring Lake a number of years ago when an investigation was made thereof.)

3628 The artificial canal leading into Spring Lake is about four miles above Copperas creek dam.

3629 Since the opening of the canal I have made inquiries into the condition of Spring Lake, both above and below the revetment where this pollution entered the same.

3630 About ten years ago, some of the black bass I took from this river, upon post-mortem examination disclosed that all of the digestive organs of the fish had been absolutely dissolved. The men sickened in making a haul of fish at that place. Since the opening of the canal I do not believe there has been a season when any dead fish have been found in the lake. The water is very much clearer and an examination of the bottom, while it shows quite a deposit, is very slight as compared to the season of which I spoke. Before the opening of the canal, between Copperas creek and La Grange there would be a great deal of vegetable growth in the water and in a good many places fish would die from the high temperature and the decaying vegetable matter.

3631 Since the opening of the canal there has been a much greater volume of water and the water has been much better and there has been a great decrease of various kinds of vegetation. The best evidence that we have of the increased betterment of the water at points below Copperas creek is the fact that there are more black bass in the river this year than I have ever known. Before the opening of the canal the water between La Grange and Kampsville, except in very low water, was classed as fairly good. Before the opening of the canal the lakes and bayous between La Grange and Kampsville varied according to the seasons. Some seasons the water became very bad from decaying vegetation and very foul and very destructive to fish life. Since the opening of the canal the condition has been in my opinion good.

3632 The fish between La Grange and Kampsville, since the opening of the canal, have been in fine condition. As I stated a moment ago, there are more black bass, which are inhabitants as a matter of choice of only clear water. The ponds and bayous have been higher and the fish propagate better. Between La Salle and Peoria, since the opening of the canal the character of the water is improved, until we get to Peoria Lake we get a practically good water. Between Peoria and Copperas creek the water improves as you get close to Copperas creek. The water below Peoria from Peoria to Copperas creek dam is very considerably worse than that in Lake Peoria. Except under extraordinary conditions, there is very rarely a better body of water found anywhere than in Peoria Lake. The water gets better all the time as you go farther down the river. A man does not have to be an expert to notice that.

3633 (Witness states condition of the Illinois river in 1877.)

3634 In 1885 the city of Chicago commenced to pump water from the Chicago river into the Illinois and Michigan canal, which emptied into the Illinois river. The drainage canal has increased the volume of the Illinois river very materially and has accelerated the current. I have a very large acquaintance with fishermen from La Salle to Grafton. There are from 2,500 to 3,500 people directly interested in fishing themselves, which does not include the helpers. All told there would be 5,000 people—this would be a fair estimate. Before the opening of the canal we had a great deal of sickness among our men. Not much typhoid but a great deal of low grade fever. I was going to say as a physician—but from what knowledge I have, this was owing to the very bad stage of the water during low water. I have never practiced medicine. I was educated and graduated as a physician.

3636 Since the opening of the canal my observation has been that there has been a very great decrease in typhoid and intestinal diseases among the people engaged in the fishing industry on the Illinois river.

My work carries me to almost every town along the Illinois river and in my talk over semi-professional matters with physicians, every one of them has commented on the decrease of typhoid and malarial fevers during the last two or three years.

3637 The health of my own men has been very vastly improved. From all sources of information I should say that the health of the fishermen generally has been a great deal better. In my opinion there are more than 5,000 people in tents and flat boats or in house boats on the sloughs and bayous, bays and lakes connected with the Illinois river. In my opinion the health of that class of the population has improved since the opening of the canal. The towns along the Illinois river are much sought after as resorts for pleasure fishing.

3638 The interest in fishing and sport on the Illinois river has been great and almose every available lake on the river of any size, has been taken for a pleasure resort. They build either club houses on the bank or house boats. The Illinois river is very peculiar in its formation, in that it has flat shores on both sides of the river. These bottoms extending from three to fifteen miles in width and filled almost in every case, with lakes and sloughs, aside from the river itself. As the fall is only a half inch to the mile, the overflows are very frequent and the lakes fill up and evaporate again several times during a season, during the dry seasons. The course of the river is inclined to be free from bars and of a very even depth. The land on both sides of course, on account of frequent overflows, is very much as nature left it. The river in extreme high water will sometimes be 12 to 15 miles wide.

3639 The country adjoining the Illinois river is devoted to agriculture. Domestic animals, adjoining the river are accustomed to drink these waters. The lowlands in some places are used for pastures during low water.

3640 Cattle are brought from a distance in the seasons of low water for the purpose of being pastured on the lowlands of the Illinois bottoms. I have never heard of anthrax among cattle along the Illinois river, nor have I ever heard of any diseases among cattle drinking the Illinois river water, which were attributed to the drinking of the water of the river. The increase in fish in the Illinois river has been very great in the last three years. In 1901 the report of the Fishermen's Association —an organization of about 1,000 men on the Illinois river, gives a total of eighteen million pounds of coarse fish caught, with quite a per cent of fine fish, as well.

3641 (Witness withdrawn.)

WILLIAM H. BINNIAN, Examined in chief by Mr. Todd.

I am connected with two companies manufacturing agricultural implements and straw board. I am President of the Acme Harvesting Company, which employs about 700 men and also President of the Peoria Straw Board Company. Have lived in Peoria 46 years.

3642 Before the opening of the canal we considered the Illinois river a pretty foul stream—quite sluggish. The river was very much more filthy below the city than it was above, on account of the refuse thrown in by the manufacturing plants on the river bank. To all appearances the opening of the canal has cleared up the water in the Illinois river very materially and practically we have found it has been a very great benefit, particularly through the straw board mill. Before the canal was opened I took my family on the river once in a while under protest from them. Since the canal was opened, I don't hear any objections. Prior to the opening of the canal it used to cost us from 50 cents to 60 cents per ton of board for felts and our average cost now is 27 cents per ton for felts.

3643 The life of a felt now is about five to six weeks when formerly it was but three to four. The water formerly rotted them more quickly than it does now, on account of the impurities of the water. In regard to the machinery, our bills for repairs are much lighter than they used to be. The present water does not have so evil an effect on the valves and pipes as the old water had. They do not rot out as quickly and do not wear out as quickly.

3644 The water used in the harvesting plant for condensing and steam making purposes is secured from the Kickapoo Creek. This creek receives its supply of water from the back water of the Illinois river and from surface drainage up in the country. I am firmly convinced that the quality of the Illinois river water at present is far superior to what it was prior to opening of the drainage canal, by practical experience and scientific tests that have been made at both plants at times.

3645 I don't think the water can be excelled for manufacturing purposes and for steaming purposes. We use about two millions and a half gallons of water per day at the straw board plant. The refuse from the straw board factory is thrown back into the river. This refuse is impregnated with lime and the washings from the cooked straw which takes off the silica and other refuse matter of the straw. The Acme Harvesting Company is a mile and a half from the lower city limits and the straw board factory is in Averyville, a quarter of a mile above the city limits.

CROSS EXAMINATION, By Mr. Jeffries.

3646 I don't know the character of the impurities in the water before the opening of the canal. I simply testify to the facts on the mechanical side of it. Before the opening of the canal there was very little current in the river. The current now is much swifter.

3647 S. P. BARTLETT, resumed the stand for further cross examination by Mr. Jeffries.

3649 Nearly all the bottoms of the Illinois river are used for pasturing cattle and hogs. The current in the Illinois river has increased since the opening of the canal. A large amount of the damage above Peoria, before the canal was opened, was due to the decomposition of vegetable matter. Below Peoria, that is the worst, the greatest amount of damage is done in my opinion from the offal and refuse and whatever escapes from the sewers of these manufacturing institutions.

3650 My own personal opinion is that outside of the manure and slop and offal from the cattle pens, some of the most destructive elements come directly from the sewers of Peoria and from the gas houses.

3652 W. F. YORK, Examined in chief by Judge Johns.

Live in Peoria; am a licensed captain and pilot on the Illinois river. Have been afloat on the river since 1850. I have traveled the entire length of the river. Before the opening of the canal the water was pretty sluggish and dirty. No current in it, and a green scum on it. It smelled badly above Peoria. Did not stir at all. It just lays around rotten and full of all kinds of insects.

3653 The water above Peoria was not as good then for steaming purposes as it is now. We had to clean the boilers every week. Since the opening of the canal above Peoria, the water has been better for steaming purposes. We get lake water instead of river water and slough water. The lake water is purer water. Before the opening of the canal below Peoria as far as Copperas Creek it was just about a sewer. It was full of offal and manure and hay and everything that comes out of cattle and hog pens. Bad, dirty and very bad smell. There were islands of this stuff in the river. It was bad for steaming purposes. The boilers would foam. Since the opening of the canal below Peoria, it has been considerably better than it used to be, purer and not so much dirt in it. We have never had any trouble since the canal was put in. There is three feet more water and about a mile more current. The boilers do not foam now.

3654 Between Copperas Creek and La Grange, before the opening of the canal the water was pretty dirty. It was better than it was above Copperas Creek. If you got a 7 or 8 foot rise out of the Missouri you would have some more foam after you went below Madison. When there is a raise in the Missouri or Mississippi river the water from those rivers backs up the Illinois for 30 or 40 miles.

3655 CROSS EXAMINATION, By Mr. Jeffries.

The boilers would not foam in the spring of the year when the water was high.

3656 You would find this green stuff on the water when the water was low and there was no current to carry it off.

3657 ISAAC TAYLOR, examined in chief by Mr. Todd:

I reside in Peoria. Have been in the real estate and loan business 33 years. Have been canal commissioner and also on special commission to inspect the Chicago Drainage canal. I have been familiar with the Illinois river from 1850 to the present time. Am chairman of the Illinois Valley Association. I was one of the committee appointed by Governor Tanner to inspect the drainage canal and report to him as provided by law under which the Drainage canal was constructed. Our duties were to inspect the Drainage canal and ascertain if the Sanitary District had complied with the law in the construction of the canal. We employed an engineer in chief and made complete surveys and a full investigation following the requirements of the law, and found that the law had been complied with.

3659 As a member of the Valley Association, I made an inspection of the Illinois river during the summer and fall of 1901 and have made frequent inspections of the river since that time. This was for the purpose of ascertaining the character of the water as compared with the water before the Chicago Drainage canal was opened, and also to make some estimate of the amount of the flow. I will add to that the effect of the flow upon the Illinois river. Before the opening of the canal the water in the Illinois river was low, bad looking and bad smelling. It was more noticeable from La Salle to Henry and it was also noticeable from Henry to Peoria. From Peoria down it was in bad condition.

3660 When the water was low from Peoria down to Copperas creek, the water was of a bad character with considerable sediment in it. That condition obtained to a certain extent all the way down to Copperas creek. The turning in of the waters of Lake Michigan through the Drainage canal has made the water very much clearer and very much better. The water above Peoria in Lake Peoria at the present time is in very bad condition. There is no odor discernible. As to the condition below Peoria, I could not testify so definitely in regard to that, only that the water has a dark appearance; it is darker than above Peoria. The condition below Peoria is much better today than it was before the opening of the canal. The river has a larger flow of water. I estimate it from two and a half to three feet deeper, the water is clearer and better in every way for navigation and sanitary purposes.

CROSS-EXAMINATION, by Mr. Jeffries:

(Witness states manner in which the commission made investigation as to whether the Sanitary District had complied with the provisions of the law in relation to the construction of the canal.)

3664 E. M. WYATT, examined in chief by Judge Johns:

Reside in Peoria and am on the Health Department at present. Was an inspector at the stock yards from 1897 to 1901. The stock yards I should judge are about a block and a half each way, perhaps two acres and a half in the yard.
3665 There are two packing houses and one slaughter house near there. My duties were to look after the diseased animals that were shipped in. I have heard of anthrax but I never knew of it here. The cattle that were brought here when diseased were affected with lumpy jaw, sore eyes and lung trouble. The number of cattle brought here for home consumption would average from 500 to 700 a month. In addition to that would be through cattle stopping here in transit. I should judge that 15,000 to 25,000 hogs a month pass through these stockyards and very few sheep. There were some cases of hog cholera.

3666 The animals infected with that disease were generally killed and sold for people to eat; the scalpers would buy them. The packing houses never bought them and packed them. There were catch basins to take the water out of the yards and out of the pens. The drainage flowed finally into the river. The dirt and cobs on the floor were hauled out and thrown on the river bank.

Goden & Sons kill anywhere from three to five hundred hogs a day and the other firm about the same. Perhaps those two firms kill 300 cattle a week. The sewage from these three institutions is emptied into the river.

3667 Some of the privy vaults are connected with the sewer system and some are hauled and dumped.

CROSS-EXAMINATION, by Mr. Jeffries:

At the public slaughter house I speak of, they kill stock for anybody that brings it around. A great many of the hogs that the farmers kill for winter use are brought here to be slaughtered. The butchers that do their own butchering go there and have it done.

3668 There are no diseased cattle killed there that I know of, only what are caught by the inspector and taken there to be killed, then they are postmortemed by the Assistant State Veterinarian. Those that have sore eyes and lungs are generally condemned; they are steamed and pressed and sold for fertilizer.

3669 R. D. CLARK, examined in chief by Mr. Todd:

Am General Manager of Clark Bros. Company's distillery. Have been in the distilling business since 1892.

3670 I am also President of the Thomas & Clark Cracker Manufactory and President of the Peoria Board of Trade. We feed one steer about 275 (?) gallons of slop and 8 pounds of hay per day. This slop contains about 12 to 13 pounds of solids. During the last five years the cattle fed in Peoria would average about 10,000, perhaps a little more. In the fattening of 10,000 head of cattle, we use about five carloads of salt a year. About 140 barrels to the carload.

3671 Most of the excreta from the cattle runs over the bottom land back of the distillery. That disposition has been made of it for two years. We feed 600 head of cattle at one time. When we fed in the old distillery the offal ran into the river. The excreta of the cattle fed in the other distilleries in Peoria runs into the river. We have no connection with the river whatever in the mashing of grain for distillation purposes.

3672 All the distilleries use Illinois river water for boilers except myself. Have used river water in the rectifying house for four years. The water since the opening of the canal has been better for boiler purposes. The boilers do not foam as they used to. In my opinion I think it must have been the organic matters in the water that caused the boilers to foam. On investigating this subject, I find that there are three principal things that make boilers foam; one is sodium carbonate, one is organic matter and one is an alkali. I don't think we have enough sodium carbonates or alkalies in the water to make it foam and therefore I judge it must be the organic matter. Our principal scale forming substances are carbonate of lime and magnesia, and sulphate of lime and magnesia. Since the opening of the canal the scale forming in the boilers and machinery seem to have a little different color to it. I do not hear of any complaint about foaming now. My opinion is that the Illinois river water now is very much improved for steam purposes. Before the opening of the canal the water between Peoria and Henry during high water was good, but a trifle muddy. During the low water stage there appeared a sort of green scum which would foam and bubble after the boat which I have not noticed of late. There was considerable odor to the water at times. I have seen thousands of dead fish along the river but do not remember seeing them above Peoria bridge.

3675 The water between Peoria and Pekin was considerably more dirty. It smelled a little different. The cause of that condition was the offal from the cattle and the sewage from the city. I always considered the river at Copperas creek dam

in the same condition that it was above Peoria. Between Peoria
and Henry since the opening of the canal the water seems
to be very much improved.
3676 The water in the river opposite the distilleries and glucose
factory in front of Peoria is much dirtier than it is
above town. That condition disappears before it reaches Kickapoo
creek less than two miles. To Pekin it gets better. Below
Pekin for a mile or two it is bad and by the time you reach Copperas
creek the water is in good condition. The general condition
of the water in the Illinois river appears to me to be very
much better today than it was before the canal opened.
3677 I have drank the water and know of others who have
drank it and do not know of any one getting typhoid
fever from drinking it since the opening of the canal. As to the
general sanitary condition of the water at present, I take it for
granted it is better than it used to be from the absence of smell
and color. There are not as many mosquitoes now. The water
in the river today could be used in the distillery for the mashing
process.
3678 CROSS-EXAMINATION, by Mr. Jeffries:
I will eat anything but the hay my cattle get. There is
not now fed more than one-fifth of the cattle per annum that
were fed at Peoria several years ago. We consume about
3679 a million bushels of corn at my distillery in a year. The
quantity of salt fed to the cattle has not decreased exactly
in proportion as the number of cattle has decreased because
it takes more salt for cattle eating cotton-seed hulls than it does
when they are fed hay. It takes quarter more salt. It appears
to me that the water in the river has become void of the impurities
discharged into it at Peoria much before the time it reaches
Copperas creek dam. That is simply my observation. That was
also true prior to the opening of the canal. I don't think there
is anything to my knowledge discharged from still houses in
Peoria into the Illinois river that is injurious to health.
3680 LOUIS P. BAUER, examined in chief by Judge Johns:
Am Superintendent of the Glucose Sugar Refining Co.,

of Peoria, Illinois. Been superintendent since June, 1898. Works are situated within 500 feet of the shore of the Illinois river in the city of Peoria. On an average 31,000 bushels of corn are used in the manufacture of glucose, per day. (Explains manufacture of glucose.) When the material gets

3682 into the form of starch we use water to wash it. This water then goes into the sewer. The water is almost colorless, a little whitish. It contains a very small percentage of organic matters and traces of sulphuric acid. We use water in the rooms where the starch is separated from the water, for the purpose of washing the floors. This water then goes into the sewer. It has a whitish color. There is no other refuse from our establishment than this water that runs into the sewer.

3683 Use about 6,000,000 gallons of water per day. 1,000,000 from the river and the balance from wells. Before opening of canal we were sometimes embarrassed by a short supply of water from these wells. Since the opening of canal have had no such trouble. I believe the amount of water in these wells varies with the height of the river. Use river water for

3684 steaming purposes. We filter the water before using it for our boilers. Before opening of canal we sometimes used river water without filtering when the filters were out of commission. The unfiltered water caused the boilers to foam. When the boilers were cleaned out a large amount of soft mud was found in the boilers. Have used unfiltered water since opening of canal and there was nothing noticed; no foaming of the boilers. The better water for manufacturing purposes from the Illinois river is that after the opening of the canal.

3685 Of the 6,000,000 gallons of water which we use each day, about the same amount is returned to the river through the sewers. Formerly there was more solid matter discharged into the river through the sewers. The substance was gluten of the corn, more or less starch and slop. The Pekin glucose works does not concentrate its steep water; that is they do now, but they haven't done so until recently. Before concentra-

3686 tion this steep water contains the soluble part of the corn which consists of sugar, gluten and starch. Our factory commenced the concentration of the steep water about 8 years ago. Prior to that time the steep water was discharged into the river. At that time the corn consumption was 12,000 to 15,000 bushels per day.

CROSS-EXAMINATION, by Mr. Jeffries:

3688 Only 10 per cent of the water that goes out of the works has traces of acid in it and that consists of about .001 part of a per cent. You could only notice it by taste—you couldn't see it in the water. The color of the water or matter that runs into the sewers is not clearer than the river water now.

3689 The refuse and other material carried into the river by our factory pollutes the water to a very small extent.

ADOLPH WOOLNER, JR., examined in chief by Mr. Todd:

3690 Am manager of the Woolner Distillery in Peoria. The capacity of the distillery is 7,500 bushels in 24 hours. There has been as high as 40,000 head of cattle fed here in Peoria at one time but I think that is more than seven years ago. They feed in the neighborhood of 10,000 head now. Between 5,000 and 8,000 head are fed in Pekin now. The
3691 cattle are fed about 40 gallons of slop—it weighs in the neighborhood of 10 pounds to a gallon making 400 pounds of slop fed to a steer in 24 hours. They receive besides the slop 10 or 11 pounds of hay and a small amount of salt. Sixty odd ton of urine and feces are discharged from each head of cattle every year. 40,000 times that amount would be 2,400,000 tons. 1,080,000 tons of excreta would come from 18,000 cattle and 600,000 tons from 10,000 cattle. The urine and fecal
3692 discharges from the cattle is run into the Illinois river. That has always been the custom here. The amount of pollution from the cattle-sheds of Peoria from 1887 to the present, has varied from 2,400,000 tons when 40,000 head of cattle were fed to 600,000 tons when 10,000 head of cattle were fed.

I think the water is some better since the opening of the canal, for steam purposes. We had some trouble with foaming before and have had very little since. I do not think that 3693 we had as much current in the river before the canal was opened and the water was sluggish and stagnant and had a bad appearance and considerable color. That section of the river that received the discharge from the distilleries and cattle-sheds before the opening of the canal at low water was in pretty bad shape. There was some smell. The river today I don't think is any worse, if anything some better. I think it is some little clearer than it was before.

CROSS-EXAMINATION, by Mr. Jeffries:

I don't think there were over 10,000 head of cattle fed in Peoria last year. The Atlas has fed 2,500 head for the past nine years—about that. In the future we intend to dry 3694 the slop and export it and use it for domestic purposes. The water is better because the amount of water that is being sent down from the canal gives the river a stronger current which naturally clears the river better than when the river is sluggish; and there is less cattle being fed and will be fed and there is less refuse going into the river.

D. S. BROWN, examined in chief by Judge Johns:

Reside in Peoria. Am in real estate and piano business. Was engaged in distillery business from 1876 to 1886. There were probably ten or twelve distilleries in operation in Peoria during that time. The slops were fed to cattle. 3695 I think there were more cattle fed then than now. During that period the offal from the cattle was run in the river. Those distilleries at that time were located on the river. Prior to opening of canal the Illinois river above Peoria was very bad, very offensive; also at and below Peoria. 3696 It showed the effects of stagnant water and emitted bad odors, and had a bad color. I attributed the condition of the water at that time at and below Peoria to the Chicago sewage. Before opening of the canal below Peoria the water showed the effects of the distillery slop and refuse from the

cattle in addition to the other. It was offensive to the smell. The water below Peoria showed the effects of sewage and had a bad odor. It was a dark brown color. Since opening of canal the water above Peoria has been very good as compared with what it was before, and as I think with other rivers. It is clearer, freer from sewage and has a better color and comparatively little odor. Below Peoria the water is far
3697 better than it was above Peoria before the opening of the canal. I attribute this improvement to the emptying of the clear water from the lake. The opening of the canal has increased the value of lands adjoining and in the vicinity of the Illinois river. It is surer of a cleaner river, a steadier current, better transportation and a healthier river to live by. I considered the Illinois river immediately below Peoria and lands in the immediate vicinity of it, unhealthy before the opening of the canal. I consider the same surroundings healthier since the opening of the canal.

CROSS-EXAMINATION, by Mr. Jeffries:

(Witness is cross examined as to his knowledge of the Chicago river; reasons for constructing the canal and whether all of Chicago sewage has been sent through canal.)

3704 SOLOMON YORK, examined in chief by Judge Johns:

Reside in Peoria. My occupation is steamboating. Have been licensed pilot and captain for the last 34 years. In 1852 I came on the Illinois river when four years old. Prior to opening of canal Illinois river above Peoria was bad; no current and stagnant. At times the growth on it would take the wheels off the boat that was running over 25 or 30 revolutions a minute till a kind of whiskers would grow on it. Hair 4 or 5 inches long would grow on the buckets and hull of the boat. The water never foamed above Peoria. Below Peoria the
3705 water was very bad on account of the sewage here; from here to Havana, down as far as Beardstown, you could see the offal from the distilleries here. We worked in front of the distilleries 3 or 4 years digging that out and starting it down the river; it would pile up there 8 or 10 feet deep. Be-

low La Grange the water was very bad. It still had traces of Peoria sewage in it below La Grange. Since opening of canal water above Peoria has been better; great deal better current. It is cleaner, purer water; I know it is. Below Peoria it is better; we have 18 to 20 inches more water which makes a current in the river. When you get down to La Grange dam it gets purer. The further you get away from the source of pollution the clearer the water gets and the purer.

CROSS-EXAMINATION, by Mr. Jeffries:

I don't know anything above the sanitary condition of water. What I have said is simply my observation of the river by being upon it.

3706 J. F. VINCENT, examined in chief by Judge Johns:

Live in Peoria. Manager of Peoria Union Stock Yards. Stock yards company owns 22 acres altogether; part is taken up for packing houses, etc. Part that I operate as stock yards is I think seven acres. We drain into the city sewers. An average of 50 cattle a week pass and have passed through these
3707 stock yards since 1897. These yards are used also for
the unloading and feeding of stock in transit. That would average two or three loads a week. We run all the way from 300 to 2,000 hogs a day—an average of 800 hogs a day. Very few sheep. There are two slaughter houses in the
3708 vicinity. One house will kill on an average of 500 a
week and the other 600 a week. The sewage from one of these slaughtering houses enters the city sewer and the other one has a private sewer from their place to the river.

CROSS-EXAMINATION, by Mr. Jeffries:

Handle about 100 horses a month. No diseased animals are taken in the yards. If found diseased they are slaughtered and tanked—rendered out for grease purposes.

3710 FREDERICK KINSINGER, examined in chief by Mr. Todd:

Manager of the American Spirits Manufacturing Co. In Peoria three distilleries are connected with that company, the Monarch, the Great Western and the Atlas. Combined capacity of

3 houses is 25,500 bushels a day. We feed cattle only in one of these distilleries and that averages about 4,000 head. One distillery in Pekin is operated by this company and feeds about 3,000 head of cattle at present. These cattle are fed slops from the distillery. The excreta runs into the river.

3711 CROSS-EXAMINATION, by Mr. Jeffries:

I don't know that my company intends to discontinue the feeding of cattle altogether in the still houses here at Peoria.

3713 FRANK C. WHITE, examined in chief by Judge Johns:

Reside in Peoria. Am dealer in live stock. I feed cattle at the distilleries in Peoria. We are feeding at the Atlas Distillery. At present we are getting the slops from the Corning Distillery, but our contract is with the Atlas; when they closed down the last two months we got the slop from Cornings. Have been engaged in live stock business 30 years and cattle feeding
business 20 years. For the last two or three years I
3714 have been feeding from 2,500 to 3,000 cattle at one time.

The cattle are fed slop and twice a day the men take a scraper and scrape the urine and manure in the sewer; there is running water in the sewer all the time while they are scraping and probably 3 parts of water to 1 part of sewage. From each head of cattle the chances are there are from 10 to 15 gallons of urine and I don't see how it could be to exceed 6 or 7 pounds of solids. This offal is all washed from the barns into the
sewers. We also feed about 8 pounds of hay or cotton
3715 seed hulls per day. Prior to opening of canal this distillery discharge accumulated and was washed off by the high waters into the Illinois river. Some springs it wouldn't have sufficient raise or sufficient water to wash it off and it would remain there during the whole season. There was times when it was a good deal of stagnant slop and manure that accumulated and remained there. We haven't been troubled that way for the last two or three years. Formerly this matter settled in the bottom of the Illinois river and it was dislodged by sending steam boats in to stir it up. It is my im-

pression now that they are forced to do that every year. Salt is also fed. There has been no anthrax in Peoria. I had some experience with cattle in Omaha that veterinarians claimed had anthrax. I didn't agree with the veterinarians. I 3717 thought it was caused by sewer gas. There was a large smelter just above there and in my opinion the poisonous gases got into the sewers and up into the barn and cattle. They were losing 25 to 35 cattle per day. I had the cattle removed. After the cattle were removed we lost none. Later on they cemented the floor of the barn and they haven't had the same trouble with the barn since. That same season after the ground was froze up we put cattle in there without any cement and took them out in the spring before the ground was thoroughly thawed up and we lost no cattle. This was in Omaha on the Missouri river. The sewage from these barns in which these alleged diseased anthrax cattle were, entered the Missouri river.

3718 CROSS-EXAMINATION, by Mr. Jeffries:

There was I think last year about 11,000 cattle fed against 27,000 to 30,000 fed here ten years ago.

LA SALLE, ILLINOIS, AUGUST 17, 1903.

3719 ROMAN J. RIMMELE, examined in chief by Mr. Todd:

Live at La Salle, Ill. Am a tinner. Reside in La Salle. Have been acquainted with Illinois river 46 years. I run a launch on the river two or three times a week. Run excursion parties up and down the river. Before opening of canal the water used to be very low; dirty looking color; floating grass and weeds all the time; hardly any current at all except in high water; a little odor. Opening of canal in my judg- 3720 ment has improved the water; water looks better; better channel and better water in every way; clearer water. No odor in the water now as I notice. Have about double the current; there was hardly any current before; almost dead water.

CROSS-EXAMINATION, by Mr. Jeffries:

I follow tinner's trade and boat business at the same

3721 time. There is an odor here in the basin all the time but
that comes from the sewers here, from the town, in my
opinion. The current now is little over double what it used to
be. The water is between 2 and 3 feet higher than it used
to be.

3722 WALTER A. PANNECK, examined in chief by Mr.
Todd:

Am an attorney. Am mayor of La Salle. City has complete
sewerage system which empties into the Illinois and Michigan
canal. The I. & M. canal empties into the Illinois river
about 2,000 feet west of the western limits of the city of La
Salle. Population of La Salle is about 14,000; nothing but an
imaginary line between La Salle and Peru which has a population
of between eight and nine thousand. Peru has about same
system of sewerage we have except they empty in Illinois
3723 river below the bluffs. About two-thirds of population
of La Salle is connected with the sewers. Excreta from
population that does not enter Illinois river through the sewers
is hauled by employes of city to bottom lands lying about quarter
of a mile south of La Salle. In flood times that land becomes
overflowed. The excreta so deposited would get into
Illinois river at flood times if it was there. Condition of
3724 public health for last three years has been very good.
No typhoid fever at present time. Our water supply
comes from Smith's Springs, and Spring Dell Springs and
water that comes from I. & M. canal that is driven through
gravel and sand to what is known as the intake, three and one-quarter
miles east of La Salle and from there it comes by natural
gravity into the pumping station and is from there sent
out to the city. The connection between this intake and the
I. & M. canal is a kind of a small canal with a sand and
3725 gravel bottom to it, and the water coming from the
canal just simply flows over the sand and gravel into
the lake. It does not flow through it; it travels over it. The
water used in the city is made up of a mixture of the spring

waters and the water of the I. & M. canal. This water is used
for domestic purposes. The people drink the water. From
that water there has not been a case of typhoid fever
3726 since I went into office. Before opening of canal during
dry season the Illinois river was very low and stagnant;
generally a green scum; practically no flow and the odor was
very strong. Since opening of canal it has improved considerably.
There is no nauseous smell emanating from the river
and there is considerable current to it now. It doesn't get as
low as it frequently did and the water is clearer. The
3727 Little Vermilion river enters the Illinois river at this
point.

CROSS-EXAMINATION, by Mr. Jeffries:

3729 At the present time we must be using, I would judge,
about 500,000 gallons of water per 24 hours out of the
I. & M. canal. We are using considerable of that water at the
present time. The water comes out of the I. & M. canal through
a 12 inch pipe and flows on the surface of the ground immediately
south of the embankment, upon the south of the
canal. There it travels a distance of probably quarter of a
mile through gravel, weeds, shrubbery and such things until it
comes to a small lake. The bed of the lake is sand, and below
the level of the water is a valve, and a pipe connecting the lake
with the intake, and whenever the valve is opened at the lake
the water is let in and comes down to the intake by gravity
from this lake. The lake is small. I don't know as it
3730 would cover a half an acre. I think we pump in the
neighborhood of a million and a half gallons of water
per 24 hours in this city. The valve that empties the water
from the I. & M. canal into our lake is probably about 97 miles
from Chicago. We are 100 miles from Chicago. We
3731 have never spent a dollar upon graveling or filtering that
water. It spreads itself or comes all over the surface
but must travel a distance of three or four hundred feet around
until it gets into this little lake. Since opening of canal the

water in the Illinois river is considerably deeper. The river is deeper and there is considerable more current now than there was.

3732 The water is clearer now than it was. The water that comes into the lake through the valve from the I. & M. canal while it is in the canal at this point appeared muddy, dark. The water from the I. & M. canal mixed with spring water is all right. It is common, ordinary canal water. The people in general say that by itself it is unfit for domestic use, for domestic purposes.

3734 CHARLES H. NICOLET, examined in chief by Judge Johns:

Have lived in La Salle since 1893. Am a civil engineer. Was city engineer of La Salle from 1893 for about four years. La Salle is 60 miles from Joliet by rail.

3735 Water supply for La Salle is drawn from three sources —artesian wells, springs and seepage from I. & M. canal.

La Salle has a system of public waterworks and these three sources of water are received at the same intake. The water is pumped 400 feet from the I. & M. canal until it reaches the intake. I think the so-called springs have their source from the canal and that they are really seepage. The public sewers of La Salle empty into the canal and canal basin and the canal empties into the Illinois river three-eighths of a mile below La Salle. Took samples of water for the State of Illinois in 1899 and 1900 under the direction of Prof. Long. States where samples were taken, method of shipment, etc.

3739 (36 tickets enclosed in an envelope and marked "State of Illinois Exhibit No. 13 for identification, Witness, C. H. Nicolet." 10 tickets marked Exhibit No. 14.)

There are two plants for the manufacture of zinc at La
3740 Salle. I am the civil engineer of the plant. The company which I represent obtains its water from the Little Vermilion river. There is a trace of sulphuric acid in the water that leaves these works and goes into the Vermilion river and

thence into the Illinois above La Salle. This plant uses perhaps a quarter of a milion gallons a day.

3741 CROSS-EXAMINATION, by Mr. Jeffries:

The people do not use the water of the Illinois river for domestic purposes, but it gets into the waterworks system when the water is high from overflows.

3742 The bottoms of the pipes are unsound and the pressure is reversed and the water from the river gets into the pipes and it is drawn into the pumps and circulated. That condition has prevailed this year for about four or five months. The entire city is supplied with that water.

3744 The water that comes from the river during these high stages is not recognized by the people as potable water and all means in the city's power at the present time and heretofore have been used to avoid anything of that kind.

JOHN GRUBB, examined in chief by Mr. Todd:

Am a fisherman.

3745 Before the opening of the canal the Illinois river was kind of stagnated along the shores and slimy stuff would be running along the shores and it would stink. People could not live along there. They would get malarial ague and one thing and another that way and the fish would not be any good along the shore. The only effect I see of the opening of the canal is that fishing has been a little bit better and the fish will live longer in the water and furthermore when I go over there in the spring or fall, I generally take a drink of it. I have not heard of any fishermen who drank the water being made sick on it. There is more fresh water now. Fish live in live boxes and before the opening of the canal they would not live until the next day hardly.

3746 They live now for a week. Before the opening of the canal the fish we used to catch under the ice would taste tarry and gassy. You couldn't eat them. Now the fish have been tasting pretty good. I have drank the water in the river since the opening of the canal eight or ten times a day in the spring or in the fall. It has had no effect on me. It made me feel like drinking more. Since the opening of the canal I think the river is better for my part and for all the fishermen. They are all catching lots of good fish up there. They catch cat fish, lake perch, a few white fish and all kinds of game fish. There were more pickerel and black bass around this spring than there have been for a good many years.

3747 I never caught lake perch and white fish before the opening of the canal.

CROSS-EXAMINATION, by Mr. Jeffries:

There is a swifter current now and the water is clear. I note that when it rains the water is muddy and that is all. When it is settled, it is as clear as crystal and especially in the fall, last year and the year before.

3748 They claim that the perch came from Lake Michigan through the drainage canal. They never caught them around here before that size. I have caught two or three white fish.

CHARLES RIMMELE, examined in chief by Mr. Todd:

3749 Am in the boating business. Run a small pleasure launch. My father and I run it together. Before the opening of the canal the water had a strong smell to it, full of moss. The water was low, pretty near dead water. Since the opening of the canal the water has been a great deal clearer, no moss, better fishing and no smell. There are more fish than we ever had, and more water. We have got a good deal better current.

3751 W. E. STAFFORD, examined in chief by Mr. Todd:

Have lived at La Salle seven years. Am manager of the Postal Telegraph, also run a boat with Mr. Masterman—the Steamer Creve Cœur. Before the opening of the canal the river did not have the clear appearance that it has had since. It had more grass, gas and stuff of that kind. Sometimes there was an odor. Since the opening of the canal we don't discover it so much. The water has more of a blue cast now. It looks clearer, a great deal. The opening of the canal has raised the water some. The color is clearer than it used to be and the current has increased. We all drink the water on the boat. It never made me sick.

3752 Have not had typhoid fever.

CROSS-EXAMINATION, by Mr. Jeffries:

City water is not supposed to come from the river. It is supposed to come from springs. I suppose it probably does come from the Illinois and Michigan canal when it overflows from there.

3753 F. L. MASTERMAN, examined in chief by Mr. Todd:

Have lived in La Salle off and on for thirty years. Am agent for the Adams Express Co. Have been on the river a great deal running steam boats. Run the Creve Cœur
3754 with Mr. Stafford. Since the opening of the canal the water is 18 to 24 inches higher. The quality of water in the upper river, where we do the most of our boating is a great deal better—nice clear running water, where it used to be stagnant. There was a natural swamp odor to it. There is no chance for odor on the water now. There is probably in the upper river from four to five mile current. Never experienced any deleterious effects from drinking the water.

3755 C. L. DIESTERWEG, examined in chief by Judge Johns:

Have lived in La Salle forty years. Am a shoe merchant and well acquainted with the Illinois river.

3756 Before the opening of the canal the river was a very dirty foul-odored stream. The opening of the canal has increased the depth of the river from 12 to 18 inches. Since the opening of the canal from observation the water looks to be much better and cleaner. It is a good deal better color. There is a better current and no grass or green scum. There is nothing in the appearance of the water that leads me to believe that Chicago sewage is in the water at this time.

3757 DR. FLOYD CLENDENNIN, examined in chief by Mr. Todd:

Have been practicing medicine in La Salle about thirty
years. I think the public health in the city of La Salle since
the opening of the canal has been improved. There is very little
typhoid fever in the city now.
3758 The condition of the Illinois river before the opening
of the canal was bad. It is now decidedly better. The
water is purer. The drinking water used here is based on the
water from the Illinois river, the I. & M. canal and from some
springs and some artesian water. It is a mixture. That water
is largely drank by the people. There is very little typhoid
fever among the people. I am surprised that there is not
more of it, some of the water comes out of the canal and
swamps. I had less typhoid to treat last year than I ever had
before.

CROSS-EXAMINATION, by Mr. Jeffries:

There are 12 to 14 physicians in La Salle and about five
3759 in Peru. I know of my own knowledge that some of the
water comes from the Illinois river. The city has not
been using every precaution to improve the conditions. They
have simply done nothing as I look at it.
3760 The physicians generally advise against the use of the
water I think.

3761 AT OTTAWA, ILLINOIS, AUGUST 17, 1903.

W. A. PIKE, examined in chief by Judge Johns:

Have been practicing medicine in Ottawa for seven years.
Took samples of water for the State in the Illinois and Fox
rivers here, under the direction of Dr. Long. (States where
samples were taken, method of shipment, etc.)
3764 Identifies tickets which are marked "State of Illinois,
Exhibit No. 15 for identification, Witness, W. A. Pike.)"
3765 The Fox river is a very small stream and enters the
Illinois at Ottawa above the main part of the sewage.
The samples in the Fox river were taken above the sewage of
Ottawa so that neither the samples of the Illinois river water
nor of the Fox river water were affected by the sewage of
3766 Ottawa. Before the opening of the canal the Illinois

river was a good stream, except in the summer time. It got pretty low and then there was a great deal of scum and weeds and such things as that floating down the stream or stagnant in it. In low water it had an odor. Since the opening of the canal the current has been greater and the average depth has been greater. There has been a great deal less scum on the surface and the general condition of the river has been much improved.

3767 Ottawa has a source of water supply from artesian wells. The population is nearly 11,000. Sewage is emptied into both the Illinois and Fox rivers.

3768 Since the opening of the canal there has been very little typhoid with the exception of one year which I think was 1901. We had about 20 or 25 cases. Physicians were instructed to have the dejecta of patients disinfected.

3769 CROSS-EXAMINATION, by Mr. Jeffries:

The comparison that I speak of in my direct examination, and prior thereto, is based altogether on my observation of the water.

3774 HENRY MAYO, examined in chief by Judge Johns:

Have lived in Ottawa since 1854. Am an attorney and postmaster. In 1887 was at the head of the Executive and Judiciary Committee for the Illinois Valley Association, which was an organization of people looking into the question of turning the sewage of Chicago into the valley of the Illinois river. I was associate counsel for the special commission appointed by the Governor until the water was turned into the channel of the Des Plaines river.

3776 For five years prior to January, 1900, the upper level of the Illinois and Michigan canal itself supplied the water from the pumping works at Bridgeport. The water lifted by the pumping works into the canal was very largely sewage from the south branch of the Chicago river. It was almost thick. The average amount of water lifted by the pumps at Bridgeport, I think was about 45,000 cubic feet per minute; sometimes more and sometimes perhaps a little less, but the average amount would be about 45,000 cubic feet of water per minute, about 12,000 cubic feet of water per minute of that amount was required for the purposes of navigation in the Illinois and Michigan canal. The balance, the excess drawn by the pumping works at Bridgeport was spilled into the Des Plaines river where the canal came to the river, and came down through the Des Plaines river from the upper basin of the canal and thence into the Illinois river. The condition of the Des Plaines river at Joliet and down to the Illinois river, while this matter was discharged into it was very offensive. There was a very strong odor from the dams at Joliet, the water was very dark in color and very thoroughly impregnated with sewage. The Des Plaines river entered the Illinois river just above Wilmington and forms the Illinois, by its junction with the Kankakee river.

3777 The Illinois river where it is formed by the junction of these two rivers, prior to the opening of the drainage canal was very much impregnated with the sewage that was taken out of the south branch of the Chicago river by the pumping works at Bridgeport, so much so that the water had a very strong smell—very offensive and was in a bad unhealthy condition. In the vicinity of Ottawa there was a vegetable growth on the water in warm weather and a scum formed upon it. It had a very strong odor, but not so much in the summer as in the winter when the river was frozen over. I live on the south side of the river and cross it two or three times a day and know what I am talking about. I have seen times when it disturbed my meals very much to cross the river before the water was turned in, when the ice was breaking around the piers. The odor was generally most offensive in the winter.

3778 Since the opening of the canal the Des Plaines river at Joliet and down to Wilmington, and the Illinois river from Wilmington to Ottawa, have been, in my judgment, very much improved. The condition of the water both winter and summer has been very much better than it was before. It has not an odor in winter that I have perceived. It has very much improved in appearance as well. At the Illinois bridge, which is just below the mouth of the Illinois river, there passed 150,000 cubic feet of water per minute and the water in extreme low stage was very offensive, because perhaps one part in six was sewage that came through the pumping works at Bridgeport. That condition has improved vastly since the opening of the canal.

CROSS-EXAMINATION, by Mr. Jeffries:

3780 The people in Ottawa do not use the water from the Illinois river for drinking and domestic purposes that I am aware of. The river is now raised about two feet and the current is a little more rapid than it was before.

3782 CHAS. E. HOOK, examined in chief by Mr. Todd:

Am cashier of the First National Bank and have been mayor of Ottawa for four months.

3783 Have been on the Illinois river more or less all my life, boating and swimming. Prior to the opening of the canal, the condition of the river was bad. It was in such a condition that in the evenings you could not go out in a boat and stand it. It was foul and had a scum on it, but it is much clearer now. The opening of the canal has produced more of a flow and the river appears to be much cleaner and freer from foul odors. The condition of the public health in Ottawa is good. The sewage of Ottawa empties into the Fox river and into the Illinois river.

CROSS-EXAMINATION, by Mr. Jeffries:

3784 I do not know of any one using the water from the Illinois river for drinking or other domestic purposes. As to the condition of the water, I am governed by my personal observation. It is 84 miles from Ottawa to Chicago by the Rock Island road.

M. T. MALONEY, examined in chief by Mr. Todd:

Have practiced law for a living most of my life. I control and own the gas plant in this city, a hotel, an office building and considerable other property. Have been City Attorney, State's Attorney, Attorney General and Mayor of Ottawa for the last four years. Am acquainted with the Illinois river. Before the opening of the canal from about the middle of June to the end of September, the water was low, foul and filthy. Scum, a greenish plant, permeated all of it right along from one end of it to another. There was little or no current. There was a stench arose from it.

3786 Since the opening of the canal there has been a very vast improvement—that is God's truth—a vast improvement.

3787 Since the opening of the canal my observation is that the water has been free from all of those noxious odors and the accumulation of that stuff on the surface of the water, which of course would indicate a breeding of malaria ordinarily if it continued to exist. I think we are very much benefited. I would say by reason of the accumulation of water that has been coming down here. I think that is the concensus of opinion of all us people throughout this entire valley.

CROSS-EXAMINATION, by Mr. Jeffries:

There is a marked difference in the current of the river.

3788 I think the current carries this decayed matter away. Of course, I don't know just exactly whether it prevents the odor from arising. It certainly prevents that scum that used to form during the summer. The odor is not detected in winter time, as it formerly was.

3790 J. O. LESLIE, examined in chief by Judge Johns:

I reside in Ottawa. Am principal of the High school. Have lived in Ottawa 15 years. Before the opening of the canal the water in the Illinois river was pretty bad, especially in the summer time. You could notice an accumulation of slimy mud and then the water would go off the places where it was not very deep and leave mud on the banks, a dirty stinking mud. That was a regular condition here after a flood and when the waters retired.

3792 The odor was offensive. The current was very sluggish; the water was dirty and full of chunks of stuff. Since the opening of the canal it has been very much improved. The water stands 20 inches higher and the old muddy banks we used to notice are not exposed any more. You see the white sand and clean gravel that you never used to see before the ditch was turned in.

3793 I cannot see a very great deal of difference in the condition of the health of the children in the schools.

CROSS-EXAMINATION, by Mr. Jeffries:

When I speak of the condition of the water being improved I do so simply from what I have observed. I have never used it for drinking or domestic purposes. I should judge that the current is now at least twice as great as it used to be.

3794 JAMES F. FARRELL, examined in chief by Judge Johns:

Reside at Ottawa. Am a newspaper man and city clerk. There is in the office of the city clerk a record of the deaths from all causes, which has been kept for about 35 years. I am custodian of that record and have the record with me. In 1897 there were five deaths from typhoid fever. In 1898, none. In 1899, two deaths. In 1900, two deaths, in 1901, four deaths. In 1902, one death and none up to the present time in 1903.

CROSS-EXAMINATION, by Mr. Jeffries:

I do not think there is any distinction made between typhoid malaria and typhoid fever. It all comes under the head of typhoid. I have not included deaths caused by pneumonia, where it is stated as typhoid pneumonia.

3795 LESTER J. HORAN, examined in chief by Mr. Todd:

Live at Ottawa, Illinois. Took samples of water for the Sanitary District of Chicago. (States where samples were taken, method employed and method of shipping, etc.)

3801 ALBERT HAHN, examined in chief by Mr. Todd:

Live at Ottawa, Illinois. Took samples of water for the University of Illinois. (States where samples were taken, method employed, manner of shipment, etc.)

3805 DANIEL C. WOODS, examined in chief by Mr. Todd:

Am at present clerk in the Clifton Hotel at Ottawa. I have done a little work for the Government in the way of reading the gauge on the river for the U. S. Geological Survey. Have been acquainted with the Illinois river forty years. The condition of the Illinois river prior to 1900 in the early days away back, was not so bad. Afterwards it became fouler and fouler until it was very foul. I was engineer on the Chicago & R. I. railroad and that road abandoned their tanks in the station at Joliet and built a coal chute and tanks out about a mile and a half from the station. They also put in filters, but even using the filter the water was so foul that when it was running from the train into the tank, if the wind happened to blow towards the engine it was sickening to the engineer and steam escaping from the gauge cocks or boiler head would sicken you with the foul smell. At Ottawa the smell could be noticed three miles before you reached the town, governed by the direction of the wind.

3807 The water improved as it diffused itself in traveling in the river. Since the opening of the canal there is all the difference in the world. It is now what you would say a clear stream. I see the river every day twice a day at the C. B. & Q. bridge where I go to get my gauges. There is not a particle of slime now any more than any stream you would find in the country that was a clear nice river. The effect of the opening of the canal has been to change the river from a vile stream—a stream that you would know at one glance was vile—that you wouldn't eat a fish out of the river—to a nice clear stream that you would class with any other stream. In fact they are catching lake fish right here at Ottawa.

CROSS-EXAMINATION, by Mr. Jeffries:

There are a great many men and boys fishing at the bridge and I see them catching the same lake perch that I have caught in Chicago myself. I don't drink the Illinois river water.

3810 The current in the river is much more now than it was before the canal was opened. It is forty-five and one-half miles from here to Joliet, which is as far as the river goes.

3811 **GUSTAVE KNEUSSL, examined in chief by Judge Johns:**

I am a druggist and live within ten yards of the Illinois river. In times of high water part of my premises are overflowed. Prior to the opening of the canal the Illinois river has been covered in summer with mosses and high grass, making it impossible for rowboats to go through. It had a stagnant odor and when the waters receded, there would be a deposit of mud running from one-half an inch to three inches and full of debris. Since the opening of the canal there has been a clear channel. Haven't noticed any moss nor weeds on the shore at all. The current has been greater, much greater. There hasn't been any odor since the opening of the canal. The general condition has been much better since the opening of the canal.

3815 AT MARSEILLES, ILL., AUGUST 18, 1903.

T. W. THIRY, examined in chief by Mr. Todd:

Am a cigar manufacturer. Have lived in Marseilles about eight years. Have visited the river on an average of twice or three times a week during the last eight years. Prior to the opening of the canal the Illinois river was not near as high; had a sort of greenish hue and during the summer would smell bad. The opening of the canal seems to have changed it to a sort of blue, has taken off the scum, made a better flow and it seems to be better and larger. Before the drainage came in, the fish seemed to have a kind of tarry taste, gassy. This year we do not taste it at all. We have now several varieties that we did not have before. We get cisco, lake perch, and pickerel has been plentiful this year.

3817 **CROSS-EXAMINATION, by Mr. Jeffries:**

The people at Marseilles get their water supply mostly from artesian wells. They do not use water from the Illinois river. The population of Marseilles is about 2,500.

G. W. SMITH, examined in chief by Judge Johns: Reside at Marseilles. Am in furniture business and am an undertaker. Have lived here thirty years.

3818 Prior to the opening of the canal the water in the Illinois river was very bad. Had a bad odor, smelled like dead animals and had a stinking rotten smell.

3819 It was more disagreeable in winter than in summer. We had flumes here used for running wheels to furnish water power for mills and factories. When the water was frozen over it would pretty nearly make one sick to go into the mill. The gas was so strong it was hard for the men to work in there at times. Since the opening of the canal I consider the water far better than it ever was before. It is clearer and has less color to it—no noticeable odor. It used to have a tendency to foam in the boilers unless the boilers were frequently cleaned.

3820 We have no sewerage system here. The sewage finally goes into the river.

CROSS-EXAMINATION, by Mr. Jeffries:

The people here don't use river water for domestic and drinking purposes.

3821 DONALD A. NICHOLSON, examined in chief by Judge Johns:

Am police magistrate and have resided in Marseilles upwards of 40 years.

3822 Prior to opening of canal the river water was in very bad condition. It had a kind of soapy, gassy appearance on its surface, a dark color, and a green scum would form on top of the water. At one time I had charge of the water power company here. Their works were up on the river above the head gates where the water was kind of still. I have seen green scum form there six or eight inches thick. Since the opening of the canal the water is very much better, clearer and that offensive odor is not there. There is a dam here called the Marseilles dam. The dam when originally built was eight and one-half feet high I think. It is perhaps a little bit higher now—not very much. The Power Company put flash boards on the dam occasionally in low water before the opening of the canal, but not since. These flash boards were 12 inches above the crest of the dam. We have three paper mills, one agricultural works and two box factories and all the manufacturing that is done here is done by water power. The paper mills run from six to thirty tons each, per day. The liquid from the paper mills would be dark colored, especially where it had been used in cooking straw.

3824 That goes into the river.

3827 JAMES BRUCE, examined in chief by Mr. Todd:

Have lived in Marseilles eight years and am a grain merchant. Have been acquainted with the Illinois river all my life. Prior to the opening of the canal during the summer months, the river was very low. It showed the effect of the drainage of Chicago and the gases from the river were very strong. There were places in the river where it showed stagnant water covered with green slime. Today I think that has all disappeared with the extra head of water and very little gas is found. There has been a general improvement. The river is fairly clean so far as I can see—no stagnant water, and the water has a good flow. At Joliet, my old home, especially between Lockport and Joliet, the operation of the gas showed its effect on the houses there. If you painted a house, inside of a year, it would turn black like my father's place there. Since the canal was opened, we have no such trouble. The game fish are returning up here.

CROSS-EXAMINATION, by Mr. Jeffries:

There is more of a current now than before the opening of the canal. I don't drink the river water.

3829 If there is any gas in the river it ought to show more at the dam and the rapids, than at any other point, because the water is churned up thoroughly there.

3830 W. H. SPENCER, examined in chief by Judge Johns:

I am a grocer and have lived in Marseilles since I was three years old. Before the opening of the canal the Illinois river, when the water would get very low, would have a green scum over it. It would smell very bad and in the winter time when it froze up, the water would churn up in going over the dam and if there happened to be a south wind the stench was almost unbearable at times. That stench was like an outhouse that the city scavenger would condemn to be cleaned out. Since the opening of the canal I haven't noticed any of those conditions mentioned. The water is much clearer and I have never noticed the smell since. I live about a quarter of a mile from the river. I haven't noticed any odor since the drainage canal was turned in. I noticed it before, any time I would go down to the river when there was a south wind blowing towards town.

CROSS-EXAMINATION, by Mr. Jeffries:

I think the stench was worse when there was no current.

3832 It smelled all times of the year except after a hard rain when there would be lots of fresh water all over the country, which would dilute the water so you wouldn't notice the smell so much. The lower the water got, the worse the smell was. We don't use the water for domestic or drinking purposes.

3833 A. S. GUM, examined in chief by Judge Johns:

I have lived in Marseilles over 60 years. My business is that of teaming. Since the opening of the canal we don't get such a stench from the Illinois river as we used to. The worst we used to get was in the winter when it was frozen over and then dropped over the dam. That was when we would notice it the most. The odor was not as bad in summer as in winter. It was a kind of dark water. A scum formed on it.

3834 Since the opening of the canal I haven't noticed this odor.

CROSS-EXAMINATION, by Mr. Jeffries:

The current is much more rapid now than it was before the canal was opened. The water is pure and more clear than it was before the canal was opened.

3835 H. R. ADAMS, examined in chief by Mr. Todd:

Am Vice President of the Marseilles Mfg. Co. We manufacture agricultural machinery. Have lived here 36 years. We employ from 150 to 250 men. Prior to the opening of the canal, the Illinois river water was very impure, the water of the stream rising from swamps largely. The water was in a very impure condition and before the sewage of Chicago was turned into the I. & M. canal, we didn't dare to bathe in it for fear of getting mud itch. It was quite a dark, dense color and there was a good deal at times of a kind of formation would come down and the water was not pure enough so that you could see any depth in it.

3836 When the sewage of Chicago was turned into the I. & M. canal there was a bad odor to the Illinois river. If the water was not high, you would see a kind of oily substance on the surface. Just before the opening of the drainage canal, the condition was bad. It had a bad smell and was so intensely filthy that the water from the wheels would saturate the men's clothes and even their systems so that when they would go away from the shops sometimes for days if you went near them you would smell what we called the shop smell of the water. It got very strong. Since the opening of the canal the water has improved very much. During the past year since they have let in some water. I don't know that there has hardly been a time we have had any of that smell. In our head raises, where it used to be so dense you couldn't see any depth, there are often times when you can see two or three feet down clearly. The opening of the drainage canal has effected a very decided improvement on the Illinois river in every way, in health and everything, I think. Prior to the opening of the canal in some parts of the town we used to have quite a little malarial fever, ague and such things as that. Of late, I have not heard anything of that.

3837 CROSS-EXAMINATION, by Mr. Jeffries:

The flow of the current is very much greater now than it was before. It is not very strong at the present time. I haven't noticed any odor in nearly two years, when I have gone through the shop where the water wheels are.

3838 H. B. McKAHIN, examined in chief by Judge Johns:

Am assistant secretary of the Marseilles Mfg. Co. Have resided in Marseilles since 1871. Prior to the opening of the drainage canal during low water stage in the summer time, the Illinois river was very foul, so foul that I had to quit going on

the river much after sundown on account of the malaria. There was a very perceptible odor after the sun left it. In the winter time when the water came through our water wheel at the plant the odor was very foul, very similar to rotten cabbage out
3839 of an old cellar. The odor was so strong that you could smell it on the clothes of the men when they came from the wood shop. Since the opening of the canal I haven't noticed anything of the kind. We don't notice that odor in the winter time nor in the race nor flume of the water power. Before the opening of the canal, a scum formed on the river above the dam and there was considerable growth in the river of vegetable and animal life.

3840 CROSS-EXAMINATION, by Mr. Jeffries:

There is a large volume of water now and a swifter current. So far as I have noticed there is water going over the dam at all times of the year. There is still a slight odor there.

U. T. SMITH, examined in chief by Judge Johns:

I have not any particular business now. I ran a livery stable here for about twenty years and I farmed. I have been here 24 years this fall. Prior to the opening of the canal the river was very offensive and smelled very bad, especially when frozen over. You could hardly endure it. In the summer time, the water would not run over the dam and there would be a green scum and a bad smell. I have never smelled anything since the drainage water has been turned in. The water looks clear and very nice. I haven't noticed this green scum on the water since and I have never seen that dam dry.

CROSS-EXAMINATION, by Mr. Jeffries:

There is more current. The water runs over the dam all the time I think now. I don't drink the water. When I say there is improvement, that is just from my observation.

3842 G. H. SWADER, examined in chief by Mr. Todd:

I live at Marseilles. Am foreman of the Marseilles Mfg. Co. Illinois river water before the canal was opened was pretty bad. There was a kind of a slaughter house smell to it in the summer time, this grass seed and stuff would run down the river and stop us sometimes at the mill. It would almost hold you up to walk upon it. It had a dirty color to it. The odor made some of the employes sick.

3843 Since the opening of the canal we have more water and it is purer, clearer and better. The water is not drank now. We don't notice that odor. The general condition of the river is better. There is a lot more water running and of course the current is a lot swifter than it was.

CROSS-EXAMINATION, by Mr. Jeffries:

I don't drink the water from the river. I have drank it more or less. I have had to. I don't know anything about what substances are contained in the water.

3844 LEANDER G. DOUGLAS, examined in chief by Mr. Todd:

Am retired farmer and live in Marseilles.

3845 The water in the Illinois river has been decidedly better than it was before the opening of the drainage canal. Before the opening it had a stench, except in extreme flood. At times, it was filthy like. The cattle on my farm up to 1880 had to drink out of the river or out of the canal. In wet times we had what we called sloughs that we watered from.

3846 In my judgment the water is decidedly better in the river than it was before the opening of the canal.

CROSS-EXAMINATION, by Mr. Jeffries:

I don't drink the water from the river. Never use it for domestic purposes.

GILBERT HOWLAND, examined in chief by Judge Johns:

Have lived in Marseilles fifteen years or more. Have lived in the vicinity of the Illinois river for sixty years. Before January, 1900, the Illinois river I considered very bad. It smelled very bad and it seemed down here almost what you might call floating islands. It is a plant or something that grows on the water. I have seen it 18 inches to two feet thick, decaying in the water. There was a terrible odor in the summer. I have not seen a thing of it since the opening of the canal. I have not seen this scum at all and no odor to amount to anything.

Since the opening of the canal I have caught lake fish here, ciscos and lake perch that I never saw in the river before. I caught any amount of them last season here. It is quite common here to catch lake perch and ciscos here in the river.

CROSS-EXAMINATION, by Mr. Jeffries:

I am on the river pretty much every day. I don't use the water from the river for drinking purposes. There is very little odor now, a larger volume of water and a stronger current.

3849 H. W. COLLIER, examined in chief by Judge Johns:

Have lived in Marseilles and vicinity around here since the spring of 1870. Am now and have been engaged for the last nine years in sprinkling the streets. With the exception of this year we have been getting the water from the canal. Before the opening of the canal the Illinois river at this point was very rotten. You could smell it—seemingly from refuse.

3850 A scum formed on the water like and floating with it. It seemed to be a kind of a slimy gathering. The smell seemed to be worse in the winter. Before the opening of the canal there was objection to using the water because they claimed it was so stinking and it was not fit to be thrown on the streets. Since the opening of the canal, I haven't had any trouble. I never have had any one refuse the water. It certainly has been clearer. There hasn't been one-hundredth part of the odor that there was before.

3851 J. W. VAN LOON, examined in chief by Judge Johns:

Am a painter. Have been in Marseilles 11 years. Have been upon the Illinois river fishing.

3852 Before the opening of the canal the Illinois river was a good deal worse than it is now. In warm weather there was quite a stench to the water. There was a mass of stuff floating in the water. It looked like a kind of jelly that gathered along the shore. The water was very dark oily, greasy and muddy. Since the opening of the canal we don't see so much odor. The water seems purer. It has the same color as lake water—blue. Don't see any floating stuff and no scum on the surface.

3853 CROSS-EXAMINATION, by Mr. Jeffries:

There is a larger volume of water and a stronger current now.

3855 AT MORRIS, ILLINOIS, AUGUST 18, 1903.

HENRY COOPER, examined in chief by Judge Johns:

I came to Morris in 1866. Am in the harness business. Am acquainted with the condition of the Illinois river during that time.

3856 Prior to 1885, before the sewage was pumped into the I. & M. canal, I did not see anything wrong with the Illinois river, but afterwards it finally got so bad we couldn't catch fish at all. It smelled so bad and they told me it was the sewage that was pumped into the Chicago river. We saw lots of dead fish. There was so much sewage, slime and stuff that came in and it created an odor in the summer.

3857 That condition of affairs continued up to 1900 when the drainage canal was opened. After the canal was opened it began to get better. We have a public water supply here, the water being obtained from artesian wells. We also have one large sewer that runs down the main street and some little branches from it, but that is recent. The sewage empties into the Illinois river.

3858 Since the opening of the canal the water is about five hundred or a thousand per cent better than it used to be. It looks good to me, and it was not fit to be seen before.

CROSS-EXAMINATION, by Mr. Jeffries:

People in town do not use it for domestic and drinking purposes.

3859 There was always some current in the river, and some places where it ran quite fast. It was shallow in some places and the current was so sluggish that it deposited this stuff along the banks but I never see anything of the kind now. I think there are five thousand people in town.

3860 H. M. FERGUSON, examined in chief by Judge Johns: Am a physician and reside in Morris, Illinois.

3861 I was health officer both before and after the opening of the drainage canal in 1900.

3862 Mortality statistics are reported to the city clerk, but only during the last year. Our mortality here is a little less than 14 per thousand. Formerly typhoid was very prevalent here. Now there is practically none, except imported cases. Since the opening of the canal we have had no typhoid fever except what is imported. I have noticed that and discussed it with the other physicians only last night. We have a paper mill, a foundry, a tannery, a large machine shop, an oatmeal mill and the usual small shops.

3863 The tannery is quite a large one. The refuse from it empties below the bridge into the river.

We have just inaugurated a sewerage system. Before the opening of the canal the Illinois river here was bad. It was murky, ill-smelling, dead and rotten. We could smell it here in town, about a quarter of a mile away. There was a scum on the river and plant life.

3864 This plant was like a clover leaf.

3865 The water in the winter time was very bad. Since the opening of the canal the condition has been better. The water is clearer, less odor and less solids in suspension, and you can see the bottom more. There is a better current. I consider the water since the opening of the canal decidedly better than before. Took samples of water for the State Board of Health, in 1899 and 1900, under the instructions of Dr. Long and Mr. Harman. (States where samples were taken, method pursued and how samples were shipped.)

3869 CROSS-EXAMINATION, by Mr. Jeffries:

The river was very sluggish before the canal was opened.

3871 There is no longer any shore wash. The current is much stronger.

3872 My recollection is that the typhoid fever we had dropped off about the time the city waterworks was instituted, six or seven years ago.

3873 DEWITT C. HOUSTON, examined in chief by Judge Johns:

Am in the grocery business and have lived in Morris continually since 1874. Am acquainted with the Illinois river. Prior to the opening of the canal the water was very bad.

3874 It smelled bad, looked bad and dirty and nasty. It was covered over with green scum in summer along the edges. I have seen places where it was clear across the river. The ice supply here is obtained from the canal. They used to get it from the Mazon creek that comes into the river here opposite the city. Since the opening of the canal the water is a great deal better.

3875 It don't have that bad odor and it don't scum over like it used to. About 1885 was when the fishing quit here. Since the opening of the canal I understand they are catching quite a few fish in the river. We have no professional fishermen here.

CROSS-EXAMINATION, by Mr. Jeffries:

In low water, before opening of the canal, the current in the river was sluggish.

3876 Since the opening of the canal there is a great deal stronger current. I don't drink the water from the Illinois river when I can help it. When I say the water is better I say so simply from my observation. The water looks clearer a good deal.

L. D. RAY, examined in chief by Judge Johns:

I have lived in Morris, Illinois, since 1855. Have been a member of the legislature, in both houses, and Lieutenant-Governor four years. Mazon creek drains the northern part of Livingston and the southern part of Grundy counties.

3878 The DuPage river is quite extensive, with its source up in Wisconsin. In dry seasons before the opening of the canal the condition of the Illinois river was not good. There have been times when you could be in town and get an odor here which I suppose is from the river. In winter when we were driving on the river, when we came to an air hole, it would be vile.

3879 Since the opening of the canal the condition of the water has been improved. The Illinois river at this point is a considerable body of water at flood season. Nettle creek runs up through the northwestern part of our county. It empties into the river just below the town here.

3880 CHAS. D. FERGUSON, examined in chief by Mr. Todd: Am a blacksmith. Have lived in Morris nearly all the time since 1854. Before the opening of the canal the Illinois river was bad.

3881 I was sheriff six years and have been from the mouth of the river to Ottawa in a boat. Before the opening of the canal the water was inky. It smelled like sewage. Since the opening of the canal the water is not so dark and has not smelled so strong. It smells very little. It is a good deal lighter in color and clearer. I should say that the drainage canal betters the Illinois river.

CROSS-EXAMINATION, by Mr. Jeffries:

I judge from the appearance and nothing else.

3882 G. W. ELERDING, examined in chief by Mr. Todd: Am a photographer and have lived in Morris about 26 years. Have hunted and fished on the Illinois river all my life.

3883 Before the opening of the canal the water in the Illinois river here at Morris was very dark. It was pretty nearly black, kind of an oily appearance, just like grease and it smelled very bad. The farther you went up the river the better it got on the other side. The Illinois river is formed by the junction of the Des Plaines and Kankakee. The water would be better on the Kankakee side. The Des Plaines river would show black on one side and the Kankakee river, white on the other side. That separation of the waters, if there was a considerable amount of water coming from the Kankakee would extend sometimes farther east than Morris. The general condition of the water at Morris before the opening was bad. It had a bad odor and there weren't any fish to speak of.

3885 The opening of the canal has improved the water. It is clearer, doesn't smell so bad and there are more fish. At times you can detect the presence of sewage from Chicago in the water at this point; it looks a little bit like a sediment of starch floating in the water.

CROSS-EXAMINATION, by Mr. Jeffries:

The current is much more rapid now than it was before the opening of the canal. When I say the water is better, I am judging from its appearance. Two years ago we were camping and we used it to cook with. We drank it in coffee.

HENRY STOCKER, examined in chief by Mr. Todd:

Live in Marseilles. Have been in the boot and shoe business for the last thirty years. Have fished on the river twice a week in the fishing and hunting season for the last ten years. Prior to the opening of the canal the water was pretty rotten and filthy.

3888 It couldn't have been much worse. It had a most disagreeable smell. Since the opening of the canal the water is much clearer. It has lost that odor. The water is much brighter, it isn't so dark and greasy looking. The opening of the drainage canal, in my opinion has been a great benefit to the Illinois river.

CROSS-EXAMINATION, by Mr. Jeffries:

I judge altogether from the appearance of the water. I have drank it since the opening of the canal. There is a good current now.

RE-DIRECT EXAMINATION, by Mr. Todd:

I don't suppose the fish could have lived in that water here. I never heard of anybody catching any. Now they live here. I have seen them.

3890 J. O. LERETTE, examined in chief by Mr. Todd:

Am in the saloon business. Live in Morris. Have been acquainted with the Illinois river through boating, etc. Prior to the opening of the canal the condition of the Illinois river was very bad. Cattle and horses wouldn't hardly drink it. It looked black and smelled a little loud. The opening of the canal has made it a great deal better. It looks better and I do not know that I have noticed any odor since.

CROSS-EXAMINATION, by Mr. Jeffries:

When I say it is better, I say so simply from observation. I have smelled no odor. There is a pretty good volume of water in the river now to what it used to be. There didn't use to be any current in it hardly.

3892 J. C. HARRIE, examined in chief by Mr. Todd:

Am a jeweler and well acquainted with the Illinois river. Cross it every day. Have lived alongside of it for a lifetime. Before the opening of the canal to all appearances the river was bad. We smelled it up town early in the evening. The opening of the canal has had a good effect on the Illinois river. I haven't noticed any smell in the Illinois river since. It is a good deal clearer than it was before and more current.

CROSS-EXAMINATION, by Mr. Jeffries:

I know nothing of the chemical ingredients of the water.

3893 The current is much more rapid than it was before. The people don't use the water from the river. It has a bad reputation among them. Compared with what it was before, the sewage has disappeared altogether from the water in my estimation.

3894 FRED SLACK, examined in chief by Mr. Todd:

3895 Am deputy sheriff in Grundy county. Have fished and hunted on the Illinois river a great deal. Prior to the opening of the canal it was a sluggish stream. The water was stagnant and had a bad color. It was so black at times I could hardly row a boat through it. The opening of the canal has been a benefit to the river at this point. There is much more water flowing through here and the water is clear. I don't observe the odor. There are fish in the river at the present time. I have caught them out of there. Before the opening of the canal they didn't catch any fish for a long while.

3896 CROSS-EXAMINATION, by Mr. Jeffries:

My opinion as to the condition of the water is based upon observation. They say there is Chicago sewage in the water but I have never seen it. I have an idea there is but I have never been able to find it. Just to look at it you wouldn't think there is any in it. I don't drink the water.

3898 AT ROOM 869, ROOKERY BUILDING, CHICAGO, ILLINOIS, SEPTEMBER 21, 1903.

R. P. ELLIOTT, examined in chief by Mr. Todd:

Am express agent at Wilmington, Illinois. Have been agent since 1866. Took samples of water for the Sanitary District of Chicago. (States where samples were taken, method pursued and manner of shipment.)

3910 JAMES MACK, examined in chief by Mr. Todd:

Collected samples of water for the Sanitary District of Chicago. (States where samples were collected, method pursued and manner of shipment.)

3921 JOSEPH WEIS, examined in chief by Mr. Todd:

Am milk inspector of the city of Chicago. Collected samples of water for the Sanitary District of Chicago, upon the order of Commissioner Reynolds. (States where samples were collected, method pursued and manner of shipment.)

3932 HARRY HUDSON, examined in chief by Mr. Todd:

Took samples of water for Sanitary District. (States where samples were taken, method employed and manner of shipment.)

3938 ARLIE TAYLOR, examined in chief by Mr. Todd:

Am city electrician of Lockport, Illinois. Took samples of water for the University of Illinois, for Prof. Palmer. (States where samples were taken, method pursued and manner of shipment.)

3945 WILLIAM E. O'BRIEN, examined in chief by Mr. Todd:

Am a drayman. Live at Lockport. Took samples of water for the Sanitary District. (States where samples were taken, method employed and manner of shipment.)

3956 T. J. KELLY, examined in chief by Mr. Todd:

Am a dairy inspector. Took samples of water for Sanitary District when Mr. Jos. Weis was taken sick. Took them at the Western Avenue Viaduct. (States method pursued and manner of shipment.)

3962 DR. WM. H. FRASER, examined in chief by Mr. Todd:

Am physician and surgeon. Live at La Salle, Illinois. Have lived there thirty years. Collected samples of water. (States where samples were collected, method pursued and manner of shipment.)

3970 The city of La Salle has a population of probably 12,000. Some of the people have private wells. Most of the people get their water from a spring, or you might call it a series of springs about three miles to the eastward. The water comes those three miles in a vitrified pipe and comes by gravity to the pumping station, and then is pumped of course through the city through mains. When we had dry weather—one
3971 year we had pretty dry weather; I think it was about three or four years ago that we had it very dry and our water supply was short, and it was late in the autumn, the water had been let out of the canal and this stream that runs into the canal about two or three hundred yards to the eastward of this spring, and a pipe was laid from that river called Crozier's creek, and a pipe was laid from that creek through below the canal and it discharged this water into this bed of gravel and that made our supply sufficient for the time. This water of course came from the river, or Crozier's creek, but the pipe got blocked up more or less from debris getting into it, the pipe leading from the river got blocked up so that it would not discharge the water sufficiently and some of the officials went up and punched holes in the bottom of the pipe as it crossed into the bottom of the canal and let canal water in, and so it discharged canal water instead of water from the river.

3972 Q. What proportion of water from the Illinois and Michigan canal entered the water supply of La Salle?

A. Well, there is a pool along the canal on the south side for quite a little distance, besides this pipe that runs out of the canal and the water collects in a large pond or pool, and from that pool there is a pipe laid to the water supply, and it is, I think a six-inch pipe. About one-fourth of the water from La Salle comes from this source. There is no artificial treatment of the water in the Illinois and Michigan canal that enters the supply of La Salle, excepting that which is seeping through the bank of the canal and coming through the pipe that I mentioned, and then it runs into this swampy place and it runs into this pond and then from the pond between the pond and the entrance to the pipe leading to the water supply there is a little bank of gravel which is very coarse and the water rushes right through in quite large streams. You can see it coming through quite distinctly.

3973 I know of only four cases of typhoid fever in the hospital of La Salle and another on Canal street and two in the eastern part of the city. Two of these cases seem to have originated in the city and two came from the outside.

CROSS-EXAMINATION, by Mr. Jeffries:

The water system of La Salle has been in its present condition not more than a year and a half. Of course there was a certain amount of seepage before. This breaking was done by the authorities of the city.

3974 I would not recommend the water for domestic or household purposes.

3977 J. W. MILLER, examined in chief by Mr. Todd:

3978 I live in Joliet and am a guard at the State's prison. Collected samples of water for the Sanitary District of Chicago. (States where samples were collected, method employed and manner of shipment, etc.)

3984 PROF. JOHN H. LONG, examined in chief by Mr. Todd:

Am teacher of chemistry at Northwestern University, Chicago. Have been connected with that institution 22 years.

For one year prior to that I taught in the Wesleyan University at Middletown, Conn. Seven years prior to that I was engaged in the study of chemistry. For four years, from 1873 to 1877, in the University of Kansas, and from 1877 to 1880 in the German Universities of Teubingen, Wuerzburg and Breslau. (States societies to which he belongs, names of several books on analytical chemistry, which he has written and states that his work has been mainly in the line of sanitary and medical or physiological chemistry.) Between 1885 and 1890 was chemist of the Board of Health of Chicago. Since 1885 have been chemist of the Illinois State Board of Health and the work which I have done for that Board has been almost wholly in the line of water examination. I have made a special study of water analysis even as a student and in the summer of 1882 I made the first practical examinations.

3986 The first examinations of water that I made in Illinois were in connection with the study of Lake Michigan beginning in 1882. I made numerous tests of the water from the various pumping stations, beginning with Evanston on the north, and Chicago avenue particularly, and later from the Hyde Park station. These first investigations were not official, but were taken up through my general interest in the question of the lake supply. I gave a portion of my time as instructor in the College of Liberal Arts of our institution at Evanston and there became acquainted with the varying conditions of Lake Michigan water, and was led to take up these investigations because of the very general complaints of the character of the water of that place, the supply being drawn from a point pretty near the shore. So, I began at that time rather an extended series of tests, carried on in the laboratory, of my own motion. Later, some tests were made of the water taken at the city inlets I mention, particularly Chicago avenue and Hyde Park. This work was all preliminary to the work taken up by the City Board of Health in 1885. At that time the character of the water had become so altered here that an extended series of investigations was decided on and these were begun and continued for some years.

3987 My acquaintance with the Illinois and Michigan canal began as far back as 1883 or 1884—I cannot give that date exactly, but a year or two before the beginning of these regular analyses. The difficulty with the lake water was recognized of course, as depending largely upon the water flowing out from the Chicago river, which in turn depended on the efficiency and flow in the canal; so I gave very early attention to the canal and to the sources of the water going into the canal.

The Illinois and Michigan canal begins in a part of Chicago which is commonly described as Bridgeport. It begins at the pumping station which is very near the corner of Ashland avenue and 31st street, a little north of 31st street and a little east I believe, of Ashland avenue. It runs in a southwesterly direction connecting above Joliet with the Des Plaines river; being led off again it follows down the north bank of the Illinois river to a point below La Salle, where it connects with the river finally. This canal in a general way has been in operation since about 1850 or a little before, and was fed intermittently by pumps from the Chicago river, and to some extent by an old feeder known as the Sag feeder, the water being taken from the Calumet near Blue Island. This canal was so supplied for a good many years, until about 1866, the flow being small. Then it was decided to deepen it, enlarge it, and this was done about 1871, the work was completed about that time, the intention being to produce a gravity flow to carry over 30,000 cubic feet a minute—30,000 to 35,000 cubic feet. This gravity flow began in 1871 and continued until after my examinations began here, so I am familiar with those conditions, and continued until 1883 or 1884. By that time it became so filled with sediment that the flow was extremely uncertain. It very often did
3988 not exceed 10,000 cubic feet a minute, and with variations in the direction of the wind it was probably at times less than that, so that as a matter of fact the Chicago river was practically stagnant in those days. In 1884 as a consequence

of the very general discussion and complaint of the people here, the present system of pumps was established at Bridgeport and these were intended to maintain a flow of fifty or sixty thousand cubic feet a minute. As a matter of fact the flow probably never reached 50,000 during the period in which they were operated. It is altogether likely that the flow did not average above 35,000 or 36,000. I speak of this because I several times went with committees of engineers and city officials to investigate the thing and we never could determine that the flow reached the volume which was claimed for it, so it is safe to say on the average it was much below 40,000 cubic feet all the time.

The Bridgeport Pumping works pumped the water from the south fork of the Chicago river into the canal. The present pumping system was begun in 1884.

3989 A large sewer which is known now as the Brennock sewer was constructed to drain from practically all of the packing houses and to divert and carry the water from those packing houses to the so-called stock yards slip. The amount of filth carried down in that sewer increased enormously for a number of years. Some years after 1871 a contract was given to Mr. John Brennock to take charge of that sewer and see that it was not allowed to clog up. The material was thrown out into the slip, and found its way, a good deal of it, into the river. Mr. Brennock carried that work on for some time as he was directed to do, but later put in a series of settling basins and wiers in the sewer unknown to the stockyards authorities. This is a matter of a great deal of importance as bearing on the amount of stuff which got into the river, so that I ought to explain the facts, as I am familiar with them personally. Mr. Brennock put in these series of settling basins and wiers, which he operated at night. He had a number of men who were employed by him privately, to take out an immense amount of grease and paunch waste, and practically everything which came out of the yards. To begin with, at the start nearly the whole of the stock yards sewage was discharged directly into the slip, but when

his private system was brought into practical operation it took out the greater part of the solid waste. Later, when that fact was discovered, the packers themselves undertook to retain this stuff in or near their works by putting in similar systems. This of course would have a very considerable bearing on the amount of stuff that got away from the yards. In the early days very nearly the whole of that got into the slip and occasionally caused greater pollution than we have ever had since from the yards. From the days of Brennock to the present time there has been a gradual modification of the methods followed by the packers in discharging the filth into the river, so there has been a gradual decrease as shown by the various analyses which have been made at different times. By these wiers and settling basins it was possible, however, to retain only more or less insoluble and solid substances. Anything which passed into the sewers in a dissolved condition, extracted from the beef—beef extract, escaped and finally got into the river. The amount of
3990 stuff which now escapes is largely of that character
owing to the conditions improving from the days of Brennock to the present time. Practically the whole of the solid substances are removed, but when these pumping works were established that condition was not perfected and the river was foul very largely from the filth coming down in that way. Then another item of importance tending to foul the river and the lake is this: west of the city of Chicago is a small stream, small in dry weather, known as the Des Plaines river. It drains a very large area and at times of wet season, at times of high water, the volume that comes down that river is very large. Ordinarily the stream flows southwest and enters finally the Illinois river, but in times of high water instead of taking that course a very large portion of it always overflows, or always did overflow, a low watershed west of the city and drained down into the Chicago river at a point near the Bridgeport Pumping works. Within my own recollection I have seen hundreds of acres in the western part of the city flooded from that stream. Attempts were made on the part of the city to pre-

vent that flow of water, and on the part of the land owners west, to increase the facilities in order to drain their land. As a matter of fact, on a great many occasions the dam at the head of the Ogden ditch, a name which is familar to all of our old citizens of Chicago, was cut by the land owners permitting this flood of waters to go down and flow into the Chicago river and practically wash everything out into the lake. That was the case before 1884 and even after the establishment of the pumps it was frequently the case. When the Des Plaines river overflowed its banks, or the dam was cut, there was a big flood of water coming down and entering there, sweeping everything into the lake. The pumps working at a maximum capacity in those days of 35,000 cubic feet per minute or 50,000 as was claimed, were quite inadequate to direct that flow of water, which, at times, flowed out into Lake Michigan unchecked, causing greater contamination. Those conditions were commonly known and recognized and discussed for several years.

3991 The putting in of the pumping works and the stock yards sewer as far as the amount of filth discharged was of course most important. Further, two large sewers drained the same section of the city, the southern section. One is known as the Halsted street sewer, which empties into the stock yards slip, which is north of the stock yards, approximately at the corner of 39th street and Halsted street, and another is known as the Western avenue sewer, which in those days, however, drained a limited area, but which has since become a very important sewer. At that time another very important sewer was the 39th street sewer which emptied also into the river. All of the west side was drained into the river in those days, and as at the present time, a large part of the south side and a large part of the north side also. Then, as now, in other sections of the north and south side most of the drainage was towards the lake. The sewer at 31st street and the big sewer at 22d street discharged a very large volume of water into the lake.

Practically all of the sewers are gravity sewers. They were in the early days and are yet. Omitting a number of sewers which are pumped—and they are few—practically the whole of the sewage is discharged by gravity and because of the general level condition of the city the flow is very slow and the sewage remains a long time in the sewers. The water pumped into this canal was essentially the sewage of the city. The pumping works were practically adequate to counter-balance the tendency of the river to flow into the lake. In other words, there was practically no current into the lake, so that the water pumped at Bridgeport corresponded to the sewage of the city.

3992 I am acquainted with the history of the public agitation in regard to the contaminated water of Lake Michigan. That acquaintance extends as far back as 1881. Dr. Rauch was for many years secretary of the State Board of Health, and a large part of his interest and activity was given to the subject of drainage of Chicago. He was one of the first of our Illinois men to take up the question of the disposal of the sewage in Chicago in some way and suggestions which he made even before 1880, in the circulars and bulletins of the State Board of Health, were among the first and most important which led finally to a solution of the problem. His recommendations were practically followed in much of the subsequent engineering work. The question of the sanitary condition of Chicago was the subject of very frequent discussion.

Frequently in the meetings of the Chicago Academy of Science, for example, which I always attended, and took part in those discussions. They began even before 1885. This question was also discussed at the time of the first water-way convention, the large water-way convention, which was held in Peoria in 1887. While most of the formal addresses were given on the question of a deep water-way, the discussions in committees and the smaller bodies were very largely on the point of the disposal of the sewage of Chicago. I was a delegate to that convention and I was taken there at the instigation of Dr. Rauch, to be able to help to discuss that fact.

Dr. Rauch died seven or eight years ago. This general question of the disposal of the sewage of Chicago was discussed also at a very large meeting at Springfield in the following year—1888. A meeting which was attended by health officers and sanitarians and public officials all over the State. The meetings were held at the capitol building.

3993 At that time there was in Chicago a voluntary organization known as the Citizens' Association, which was very active in stirring up discussion on these matters. I was at one time, as early as 1884, employed by this association to make some examinations of the sewage coming from the stockyards and other points near the Bridgeport pumps. This association was perhaps a most important factor in crystalizing sentiment in favor of the commission which was later established, known as the Hering Commission. There was a meeting called at Peoria in 1887 by the people interested in the question of a deep waterway from Chicago to the Mississippi river. That convention was made up of delegates from all parts of the State of Illinois and adjacent states and cities. There were delegates at that convention from the State of Missouri and the City of St. Louis. Personally, I remember the name of Mr. McMath.

3994 I met at that time delegates from a number of cities who were particularly interested in the question of sewage rather than the question of waterways, as I said a little while ago, that question was, among many of these men, a prominent feature of the discussion. It was recognized that the construction of a waterway canal involved the disposition of the sewage of Chicago, so that that feature of the question received the greatest publicity in the discussion.

There were four or five other delegates from Missouri. Mr. McMath is an engineer of the city of St. Louis, who has had a great deal to do with water and sewerage systems of that place and of considerable reputation, and his name has been known in connection with this work for years. The proceedings of that convention were given publicity in the public press. The matter was discussed in the St. Louis papers at that time. The Hering Commission was established as a result of this agitation for the improvement of the water supply of Chicago and the diversion of the sewage; agitation kept up for a number of years. It was established in 1886 or appointed at that time. It began work and continued through 1887 I believe.

3995 The lake water at that time, at periods of dry weather, was in general, fairly good. At the time of rain, however, when the discharge from the sewers into the lake was considerable and when the flow through the river was out instead of in, the water became, at the various pumping stations, more or less contaminated, noticeably contaminated. The river for that period was practically always bad and foul.

Q. Did you make any series of investigations of the water of the Illinois river, its tributaries, the Illinois and Michigan canal, Lake Michigan, and the Chicago river, prior to the opening of the drainage canal in 1900?

A. Yes, I made made several series of those investigations. The first investigations were on the lake water to determine the fact of its increasing pollution, the water being taken from the Chicago avenue tunnel and from the Evanston and Lakeview tunnels, and from the Hyde Park tunnel, the two longer tunnels not having been built at that time. The waters were taken from faucets connected with the city mains, and were also taken by myself from the lake direct, at various times, to determine the general condition of the water at various distances from the shore, the object of all these investigations being to learn the facts of the condition of the lake with reference to increasing pollution. This work was done prior to any work which I took up on the Illinois river and canal.

The first investigation included the examination of a great many samples of water from these stations that I have mentioned, weekly examinations carried on through a period of several months at each one of the stations.

3996 The next examinations were concerned with the river and canal water, beginning at Bridgeport. That first series of investigations was started in 1886. That comprised a study of the water samples taken weekly at a number of points beginning at Bridgeport and continuing down the river to Peoria. It comprised examinations from Bridgeport, Lockport, Joliet, Ottawa and La Salle, to Peoria. The average number of samples analyzed at each of those points as I now recall it was about 12. They were not quite all the same number in 1886, between the beginning of the investigation and the early summer and fall. I have all the dates but I don't recall them. I didn't think they were essential. I have in memoranda and reports the results of those analyses. They were published in the reports of the Illinois State Board of Health. Following this first series in the summer and fall of 1886 I began a second series of experiments in the winter of 1886 and 1887, taking the colder months, beginning about the first of January, the end of December, 1886, to the first of January, 1887, and this

3997 series was continued through two or three months into March. These investigations were carried out at the same points between Bridgeport and Peoria. A smaller number of samples of water were analyzed than through the summer, as the period of investigation was shorter. The result of these investigations were published in the same reports of the Illinois State Board of Health. I am the John H. Long referred to in the testimony of different witnesses for the State of Missouri, having made the reports referred to by these witnesses. The next investigations were made two years later beginning in 1888. I will give the exact dates on that. The summer of 1888, beginning with May 1st and continuing into the fall and ending about the middle of November, I made along the river 650 chemical examinations, beginning with Bridgeport and including the same places included in the previous examination, but continuing below Peoria to the mouth of the river at Grafton.

3998 In 1888, during the period mentioned, May to the middle of November, samples were taken from Bridgeport, and Lockport, Joliet, Morris, Ottawa, La Salle, Henry, Peoria and Pekin, near the mouth of Copperas creek in the Illinois river, Havana, Beardstown, near Pearl at the crossing of the Chicago & Alton railway, the Alton bridge as we call it, and Grafton. In that same investigation waters were taken from a number of the tributaries of the Illinois; from Du Page river which enters from the north from below Joliet; from the Kankakee river which enters from the south still farther down; from the Fox river which enters just above Ottawa; from the Big Vermilion river which enters from the south near La Salle, or a little above La Salle; from the Little Vermilion river which enters from the north near La Salle and from the Sangamon river which enters across from the town of Browning; enters from the opposite side of the river from Browning. Those were tributaries of the Illinois.

The results of this investigation were published in the preliminary report of the State Board of Health printed in 1889.

This preliminary report was brought out by the Secretary of the State Board of Health for the use of some committee of the Springfield legislature in a very great hurry. The work of printing the report was begun but a few days after the completion of the last analyses, so that the work must be regarded only as of a preliminary character, and while the details were complete, the text and explanatory matter was comparatively meagre. The full report which was put in the hands of the secretary, in some way was lost and was never printed. The details are substantially completed here, but the report itself is not. That explanation is due the secretary of the State Board of Health, Dr. Rauch, and myself, to account for the peculiar character of this work. It was brought out in two or three days very hastily.

3999 The detailed analyses published in that report are essentially correct as far as I could read the proof and correct the figures in two or three days. The averages are practically all correct. This investigation I have described was made in the late spring and summer and fall of 1888 and that was followed in the winter of 1888 and 1889 by another investigation, and the waters were collected at essentially the same points to determine the winter conditions of the river. I should have included them as one series. 96 samples of water were analyzed in this investigation and the results published in the same report of the Illinois State Board of Health printed in 1889. The details and averages as published in that report are essentially correct.

4000 (Witness states how the samples through the series of 1886, 1887, 1888, 1889, 1890 and 1891 were collected and shipped.) The next investigation was made in Chicago of the water in the neighborhood of Bridgeport pumps, in the winter of 1890 and 1891.

The object of that investigation was to show the relative amounts of pollution coming from the stock yards and from the rest of the city. Therefore, samples were taken at points which would best show that. They were taken from the large sewers leading from the stock yards, and from the so-called Brennock sewer which I spoke of a little while ago, which enters the stock yards slip, very near Center street, practically at Center street; from the Ashland avenue sewer which enters the south branch of this south fork some distance west of the stock yards slip, and from the Halsted street sewer which enters the slip at Halsted street just mentioned. Water was also taken from the 39th street sewer, and from a point north of where the water is diverted from the main river, going to the Bridgeport pumps. Samples were marked "Main street;" I cannot describe it more closely, but these samples included the bulk of the sewage, or represented the bulk of the sewage outside of the stock yards sewage.

4001 The purpose of these analyses was to show the effect of the discharge of the sewage from Chicago on the Illinois river. The analysis made of those waters was a so-called sanitary analysis, which embraced the determination of certain factors, which are considered as important in showing the sanitary character of water. This included the determination of total solids, suspended matter, nitrates or nitrogen in nitrates and chlorine.

4003 (Describes the difference between the old and new method of determining chlorine.) I have used in preference to the old method the Volhard method.

4004 I also determined the so-called hardness of the water, free ammonia, albuminoid ammonia also oxygen consumed. (Witness states method by which these determinations were made. Witness states how these results obtained by chemical analyses are interpreted by the chemist and their significance with reference to water.)

4012 JOHN E. THOME, examined in chief by Mr. Todd:

Am mechanical engineer, at Washington Heights Pumping Station. Collected samples of water for Sanitary District, at the discharge of the Canal Pumping Station, about 300 feet west of the canal station probably. One sample to go to Chicago University, one to laboratory at city hall and one to Champaign. (States method pursued, etc.)

4018 PATRICK O'BRIEN, examined in chief by Mr. Todd:

Live at Lockport, Ill. Collected water for Sanitary District of Chicago and State of Illinois in 1899, 1900 and 1901, from I. and M. Canal and Des Plaines river. (States method pursued and places where water is taken.)

4026 PROF. JOHN H. LONG, resumed stand for further direct examination by Mr. Todd:

If chlorine is found in water in large amounts, above the amount found in waters of a region known to be uncontaminated, it is taken as an indication of a possible addition to the water of sewage in some form at some time. If chlorine is found in water and these other nitrogenous compounds of which I spoke are absent it is simply a suggestion that possibly the water has received sewage of some kind. Not necessarily sew-

age because the water may have received drainage from a salt mine or well—so I say it is a suggestion of the possible addition. I have in this report of the proceedings of the Illinois State Board of Health, the quarterly meeting at Chicago, October 28 and 29, 1886, a table of results of examinations made at that time. I have a table of averages drawn from those results. In this table of averages that I have here, there were but three determinations made in that year, 1886, free ammonia, albuminoid ammonia and the oxygen consumption. This table I have in two different forms. In the first report the average of all the analyses was given. In the second, published along with
4028 this preliminary report as it is called, there is a table
calculated from the individual experiments, leaving out certain ones, however, in order to include the sample taken in the same day. For instance, in the first table there are ten analyses at Bridgeport and only 7 at Peoria. In calculating this table the averages are based on the same number of samples throughout. Therefore the fairer table to use would be this.

MR. JEFFRIES: I object to the reading of the averages for the reason no evidence shows samples were properly taken, etc.

Results given are in parts per million.

(Witness reads results for Bridgeport, Lockport and
4029 Joliet, Ottawa and Peoria.)

That is taken from page XXVII of preliminary report of Illinois State Board of Health, published in 1889, by the authority of the State Board of Health. These analyses show beyond any question a very marked destruction of organic matter in the flow between Bridgeport and Peoria, showing the effect of what is called bacterial oxidation in an extremely marked degree, the water at Peoria in that particular season being practically potable and actually used by a large number of people. I was at Peoria during the season and observed that fact myself. That was in the summer of 1886. This effect is partly of course due to the oxidation and also to the dilution from tributaries, but the largest part of the effect is unquestionably due to actual destruction by bacterial oxidation.

4030 The summary for the winter of 1886 and 1887 is for four places, Bridgeport, Joliet, Ottawa and Peoria and is taken from page XXIX of the same report. (Objected to by Mr. Jeffries.) Summaries read.

4031 The conclusion I draw from these averages is that in the winter of 1886-7 as in the summer of 1886, there is a very considerable destruction of organic matter in this stretch between Bridgeport and Peoria, but the destruction or oxidation is much less marked and characteristic than in the summer, as is always the case in these observations.

The summary for 1888 will be found in same report, page 30. I made that table of the analytical details which I made at the time of the analyses.

(Witness gives pages of report from which summary is made for various towns.)

4032 MR. TODD: I offer the tables appearing on those pages as State of Illinois, Exhibit A for Identification.

(Objected to by Mr. Jeffries.)

4033 I have the summary made by me from those tables of analyses which are known as State of Illinois Exhibit A for identification.

(Witness reads into record table entitled, "Means of Analyses, May to October, inclusive, 1888." Results are expressed in parts per million. Also table entitled, "Means of Analyses during 1889." These tables follow each other as follows: Bridgeport, Lockport. (4033.)

4034 Joliet, Morris, LaSalle, Henry.

4035 Peoria, Pekin, Havana.

4036 Beardstown, Grafton, Alton. Table No. 2, Bridgeport,

4037 Lockport, Joliet, Joliet, (Dam 2) Morris.

4038 La Salle, Henry, Peoria, (Upper Bridge), Pekin.

4039 Havana, Beardstown, Grafton and Alton, (4040.)

These results show a purification of the river between the source of the water at Bridgeport and the outlet of the

Illinois river at Grafton. The purification measured by the destruction of organic matter, showed a very great or a very marked diminution of the organic matter. This diminution of the organic matter is due to two principal factors—the dilution of the stream by the water from various tributaries, and to the destruction of the organic matters by the oxidation, using that term in a general sense, or broad sense. The disappearance of organic matter is very much more marked than is the dilution, as indicated by the change in chlorines, the condition being finally reached in which the organic matters are not larger or greater in amount than in the tributary streams.

(Objected to by Mr. Jeffries.)

And are not larger in amount than in the streams commonly found in that part of the country.

4041 I made in connection with this investigation an analysis of the waters of the tributaries of the Illinois river; the DuPage, Kankakee, Fox, Big Vermilion, Little Vermilion and Sangamon rivers. That is all bearing on that.

4042 (States where samples for this purpose were collected and the manner, etc.) I have the table of analyses made by me from these samples for the DuPage river. That table is found on page 14 of this preliminary report of John H. Rauch.

4043 Table read as Table No. 3, showing results at Channahan, Du Page river, for period from May 4 to September 21.

4049 I have table of analyses made of the Kankakee river and it will be found on page 15 of this same report, (Arabic notation.) (Objected to.)

4050 Table read in record as Table No. 4, Wilmington, Kankakee river, for same period.

4056 Table for Fox river will be found on page 17 of said report; for Big Vermilion on page 18; Little Vermilion on page 18 and for Sangamon river on page 26.

Table No. 5, being Ottawa on Fox river, read in record.

4063 Table No. 7, being LaSalle on Little Vermilion.

4065 Table No. 6, being La Salle, Big Vermilion.

4068 Table No. 8, being Chandlerville, Sangamon river. (Objection by Mr. Jeffries to reading tables and to making conclusions therefrom.)

4072 The consideration of these tables which have been referred to and given by me, and the comparison of the results of the analyses of the Illinois river at its mouth, with the results of the analyses of the tributaries of the Illinois, indicate that a condition of organic purification of the Illinois at its mouth has been reached, which is comparable with or similar to that found in the tributaries mentioned. As indicated by the various tests which have been described, the organic matters in the Illinois river have been reduced to a point where they are not larger in general than the organic matters found in the several tributaries. They have been reduced to a point beyond which the destruction of organic matter in the river by natural means can not practically be exceeded or surpassed. Apparently the limit of oxidation of the organic matters has been reached. We have here a condition in which the organic matters have been broken down and destroyed largely, and the residues that are left, not destroyed, are of a stable type, very resistent to all oxidizing influences. A condition characteristic of organic matter of vegetable rather than animal origin, from which I conclude that in general these organic matters must be attributed to the leechings of the soil, that is to products of vegetable origin rather than to the products of animal origin. This condition obtains in all the rivers to some extent and in the Illinois river at its mouth and its tributaries.

Objection by Mr. Jeffries.

4073 The organic matter in the Illinois river at points far above its mouth, is in general larger than the organic matter in most of its tributaries, but by the time the mouth of the river has been reached, the organic matter has become so far reduced that it compares in general very closely with that found in the tributaries, and does not exceed that in the tributaries in general. In most of the examinations the condition of the water

at Upper Peoria or Averyville, as it is sometimes called, is very analagous to that of tributaries. There is a purification of the organic matter there so that the water corresponds closely to the water of the tributaries. These answers are all directed to the period of these examinations. The water of the Illinois river at Grafton in this season, in the summer of 1888, has reached a degree of organic purity fully equal to the mean condition of the waters in the tributaries mentioned, the DuPage, the Kankakee, the Fox, the Big and Little Vermilion and the Sangamon. In drawing these conclusions I have taken into consideration essentially these three factors, the amount of free ammonia, the amount of albuminoid ammonia and the figure repre-
4074 senting the oxygen consumption. I have also considered the condition of oxidation as shown by the amount of nitrates, nitrogen in nitrates. There are four elements in reality going to make up this conclusion and by comparison of these four elements, it has been shown that the Illinois river has reached a condition of organic purity comparable with the tributaries. (Witness gives a comparison of averages of chemical elements from which he has formulated his opinion, for the tributaries of the Illinois and at the mouth of the Illinois river.)

4075 The average of all of these results from all of the rivers will show a condition of organic impurity as great as that of the Illinois at its mouth. (Witness explains reasons for his belief.) Am acquainted with the Illinois river and its tributaries from personal knowledge by actual observation at various times. Have personal knowledge of the sources of sewage contamination entering the Illinois river and its tributaries from an examination of many points along said river and its tributaries.

4078 I have the table of analyses made by me in the winter of 1888 and 1889. I made examinations in the winter of 1888 and 1889 of 8 or 9 samples from Bridgeport, Lockport,

Joliet, Morris, LaSalle, Henry, Peoria, Pekin, Havana, Beardstown, Grafton and Alton. The table of analyses appears in the State of Illinois Exhibit A for identification. The summary made by me from these tables of analyses is in this preliminary
report, page 30 with Roman notation. That is the table
4079 that was read into the record yesterday by me, immedi-
ately following the table on same page of report from May to October, inclusive, 1888.

Objection by Mr. Jeffries to witness giving conclusions for reasons stated in objection.

This table giving the summary of the analyses made during the winter of 1888 and 1889, shows a considerable reduction of organic contamination of the water between Bridgeport and Grafton, but a very much less marked degree of reduction than was observed in the summer of 1888. This difference is particularly noticeable in the factor for the oxygen consumption, and for the albuminoid ammonia, and it is also shown by the factor expressing the amount of the free or saline ammonia present. One of the most important points in this table is found in the figures showing the amount of free ammonia, albuminoid ammonia, and the extent of oxygen consumption at Pekin during the winter. While in the summer work the amount of organic matter in the river at Pekin as disclosed by the analyses does not appear to be excessive, at any rate no very great increase is detected there, during the winter of 1888-9, these factors show, especially as regards the undecomposed nitrogenous substances indicated by the albuminoid ammonia, a very large residuant. The condition indicated by the figures for oxygen consumption is also one of increased organic contamination. The explana-
tion of this is not difficult and should be given here.

4080 During the summer season in the stretch between Peo-
ria and Pekin, which is a nearly level stretch of eight or ten miles in extent, an enormous decomposition of organic matter occurs, as is observable in passing through the stream. This decomposition is a bacterial or fermentative decomposition, as

disclosed by the rapid evolution of gases in this part of the stream, so that roughly, this stretch may be compared to a great septic tank in which hundreds of tons of organic matter are undergoing decomposition all the time. The rate of decomposition of organic matter varies as is well known, by temperature. In the winter season therefore, we have this rate very much slower, so that at Pekin, below the distilleries and cattle sheds of Peoria, the enormous pollution as indicated by the residual albuminoid ammonia factor and the factor for oxygen consumption indicates fresh and recent additions. The consideration of these figures shows beyond question whatever, that the addition of filth at Peoria is a very important factor in accounting for the organic matter in the river below. I am confining my answer to the period of 1888 and 1889, and not to a date subsequent to that time.

4081 Another feature which must be referred to here is the high free and albuminoid ammonia as disclosed at Grafton, and the high oxygen consumption also. This summary is made from the average of results given on page 28 Arabic notation, of the body of the report, and the individual examinations there show very great and considerable variations.

In the last of the examinations made in March of 1889, for some reason which I cannot explain now, the factors for free ammonia, albuminoid ammonia and oxygen consumption, were unusually high. The addition of these in making up the general average, as given on page 30, Roman notation, accounts for the relatively high figures given opposite Grafton—figures relatively higher than those given for the next town above, Beardstown. It is evident from a consideration the figures on page 28, Arabic notation, of the report, that at that time the river must have received at that point a very greatly increased contamination, possibly from the breaking up of ice and the washing down of accumulated filth. I have no data to show at the present moment how that could be accounted for. So, in resume, in consideration of this table, while in general a reduction of organic matter appears during the colder season, it is markedly less than during the warmer summer weather before.

4082 I had personal knowledge as to the condition of the sewage of Peoria during this period from trips down the river at that time. I made several trips to Peoria during the period of these examinations, and between Peoria and Pekin. I have read the testimony given by witnesses in this case at Peoria, in regard to sewage. I have read the testimony given by Dr. Keiser and Dr. Teichman in their analyses.

I have not with me the table of analyses for winter of 1890 and 1891. Those analyses were of the sewer waters discharged near Bridgeport, and were not published. I have a resume of these summaries in report form. It is found in the report of the Illinois State Board of Health published in 1901, p. 67.

4083 JAMES M. QUINLAN, examined in chief by Mr. Todd: Am clerk in Law Department of Sanitary District of Chicago. Took samples of water from Kaw and Missouri rivers. (States where samples were taken, etc.)

4087 I investigated the sewage out-falls of Kansas City, Mo. The sewers all emptied into the Missouri river above the place where we took this water. That is, there are two or three —but we took the samples about a mile above where they entered and then below where they all entered. There are four large sewers empty into the Missouri from Kansas City. I saw them.

CROSS-EXAMINATION, by Mr. Jeffries:

4088 I know that there are four sewers. There may be smaller ones, but I know of my own personal knowledge that there are four. There may be more.

4089 I know what proportion of the sewage empties into cesspools. I can say that five-sixths of the sewage empties into the Missouri.

4091 FRANK C. BURKE, examined in chief by Mr. Todd: Am in teaming business at present time. Went to Kansas City with Mr. Quinlan.

4092 Took samples of water from the Kaw and Missouri rivers. We investigated the different sewers that emptied into the Missouri river as far as we could do so.

4094 We found four large sewers emptying into the Missouri.

4095 PROF. JOHN H. LONG, resumed stand for further direct examination by Mr. Todd:

I made on several occasions, examinations of the sewers in the neighborhood of Bridgeport and south of Bridgeport, first in 1888 and later in 1890 and 1891. The winter of 1890 and 1891, I made more extended investigations to determine, if possible, the proportions of organic matter discharged from the sewers of the city and from the stock yards, and the amount of this which passed the pumps at Bridgeport. The 1886 investigation was made for Citizen's Association and was concerned mainly with what I spoke of yesterday, as the large Brennock sewer, carrying the bulk of the stock yards sewage at that time. The amount determined then was equivalent to about 112 tons daily of dry, organic matter. I made altogether about 130 examinations in 1890-1891.

4096 The figures I quote from were made when I had those averages in my possession some years ago. They have been mislaid since. These figures are important as showing as accurately as I could determine at that time, the amounts of organic matter. The facts which I am about to detail I know of my own personal knowledge to be correct. These facts were obtained by me in the analyses of samples of sewer water collected in the winter of 1890-01. The original analyses I still have, but the memoranda which I have not are memoranda of flow in the sewers, which would be necessary to calculate the amount for 24 hours, but before these memoranda were mislaid, the statement I have here was made and I vouch for the correctness of that statement. The statement was made by me.

4097 I found at that time that the organic matter which was discharged from the city and stock yards sewers in the neighborhood of the Bridgeport pumps amounted to approxi-

mately 240 tons daily. (States method of arriving at this conclusion.) The figure that I have given here of 240 tons is the amount discharged from the sewers. The next important
4098 question was what portion of this actually passed the pumps into the canal. It was found that about five-sixths of the water in one series of investigations, the one which I have given, passed the pumps at Bridgeport. The decomposition of the remainder of the organic matter was in the city. In the warmer months a very much larger proportion of the organic matter is decomposed in the city than in the colder months. The last examinations I have testified to were not made a matter of publicity. The first ones made in 1886 were. The last ones were not published except in this book. The only publications made were in the resume which I have quoted from, pp. 67 and 68 of report of State Board of Health, printed in 1901.

4099 The comparison of the results obtained in the Illinois river in 1886, with those obtained two years later, 1888-1889, indicate increased pollution of the Illinois river at Peoria. From personal observation of the Illinois river at Peoria in 1886, I know that the water was potable, and formed a large part of the water supply of Peoria. From personal observation I know that later this water supply was abandoned because of the increasing pollution of the river, which was shown also by the analyses. For 1886 the point farthest down the
4100 river for which I have analyses is Peoria.

Am acquainted with the facts that led to the appointment of the Hering Commission. As chemist of Health Department of Chicago and chemist of State Board of Health, I was familiar with the discussion regarding the water supply of Chicago and the increasing pollution of the same. A commission consisting of Rudolph Hering, an engineer, as chairman, and Benzette Williams, and the city engineer, Mr. Actingstall were appointed in 1886. This commission after considering various plans (enumerated in the testimony) decided in constructing the so-called drainage canal, following essentially the recommendations which had been made by Dr. Rauch of the State Board of Health, and others, years before.

4102 The recommendations of Dr. Rauch were frequently published in various bulletins from the State Board of Health and the proceedings of sanitary conventions and elsewhere. The recommendations of Dr. Rauch were made in 1879 and published in the preliminary report of the Illinois State Board of Health of the water supplies of Illinois and the pollution of its streams, printed in 1889 by the Illinois State Board of Health by Dr. Rauch. This report was published in 1889 for the purpose of giving the results of examinations of the water in the lake and Illinois river made by myself for the Illinois State Board of Health. At that time the legislature was in session.

4103 This report was gotten out in answer to questions brought up in Springfield regarding the character of the water of the Illinois river and the changes in the water by flow from the sewage from Chicago through the canal, the Des Plaines river and the Illinois to Peoria and the towns below. These questions emanated in the legislature at Springfield. It was called a preliminary report because it had to be got out in a hurry. As an actual fact the full report was made by me later, but it was not published.

I made a series of analyses in the year 1899.

4104 In the summer of 1899 I was authorized by the State Board of Health to begin a chemical examination of the waters of the Illinois river and its tributaries and the canal leading from Chicago into the Illinois river. Before beginning those analyses I made a trip of inspection from Bridgeport through the canal and down the Illinois river to the mouth of the river at Grafton. This trip was made in company with Mr. Jacob A. Harman, an engineer employed by the State Board of Health, and was for the purpose of familiarizing us with the locations and general conditions along the river and for the further purpose of selecting water takers to obtain samples of water for the various points and ship them to me

at Chicago for examination. The points selected were Bridgeport
at the source of the Illinois and Michigan canal near Ashland
avenue and 31st street, Chicago; Illinois and Michigan
canal at Lockport; Des Plaines river at Lockport; Joliet,
4105 being the water of the canal and Des Plaines mixed;
4106 Morris; Ottawa; La Salle; Henry; immediately above
Peoria at the part of the river described as the Narrows
and sometimes called Averyville; below Peoria, the point
being described as Lower Peoria, or sometimes as Wesley;
Pekin, below the outlet from the cattle sheds of the distilleries,
being about two miles below Pekin bridge; and Havana, above
the mouth of the Spoon river; at Pearl, and at Grafton.
4107 A number of samples were also taken from the tributaries
of the river. The first is Kankakee river below
the town of Wilmington; from the Fox river above the Rock
Island bridge; from the Big Vermilion river at a point about
two miles above La Salle; from Spoon river several hundred
feet above its junction with the Illinois; the Sangamon river
near its mouth, at a place called Browning; the Missis-
4108 sissippi at Grafton, being above the mouth of the Illinois.
Also some head water samples from the Kankakee river
near South Bend, Ind.; the upper Des Plaines near Libertyville;
the upper Du Page near Wheaton; the upper waters of
the Big Vermilion at Pontiac; from the Mackinaw at the town
of Kappa; the upper Sangamon at Mahomet; the upper Spoon
at Dahinda. Those are all the places from which samples of
water were taken for investigation in 1899. (Witness also
gives names of collectors taking the above samples.)

In 1900 samples were collected at the same points as during
1899, with the exception that samples were taken in 1900
from the now opened drainage canal at the Western avenue
bridge and also from the basin of the canal at Lockport.
4109 In 1901 samples were collected at the mouth of the

Illinois river at Grafton; the Mississippi at Grafton; from the mouth of the Missouri at a point about 200 yards above its junction with the Mississippi. Those were the only places where samples were collected in 1901.

4110 The collectors who took these samples were selected by myself mostly. (States directions that were given to collectors. States how samples were received at the
4114 laboratory.) When these samples were brought to the laboratory the analyses were undertaken at the earliest possible moment and always the same day. The samples from each particular point had a serial number and were labeled with a card in an envelope.

4116 These cards are marked "Defendant's Exhibit No. 4."

4119 In the first investigation of 1899 the samples of water were collected for most of these places weekly, the dates of collection being given in the Illinois State Board of Health report published in 1901. The samples were collected in 1900 from the same places also weekly. In 1901 samples were collected weekly or in some cases more frequently. These samples that were received at the laboratory—each card represents one chemical and one bacteriological sample. After the arrival of the bacteriological sample at the laboratory certain tests of a chemical nature, sometimes spoken of as bacteriological, were made by me. The remainder of this sample was then turned over to Dr. Robert Zeit for examination. Prof. Zeit's laboratory being in the same building and on the same floor. (States the difference in method employed in the later analyses as compared to the method used in 1886 down to 1890 and 1891 inclusive.)

4121 In these analyses for the periods of 1899, 1900 and 1901 examinations were made for essentially the same determinations as were made in the previous analyses from 1886 to 1890 as heretofore testified to by me, with the addition of the test for nitrites which has just been described. (States number of samples examined from each place in 1899.)

4122 (Motion by Mr. Jeffries to strike out statement in reference to samples analyzed from water in rivers tributary to the Illinois.)

4123 (Witness produces large and small bottle used in taking samples.) I believe these bottles are essentially similar to the ones used by the St. Louis experts for the collection of water.

4124 I have the results of these analyses in printed form, as they appeared in my reports to the Illinois State Board of Health published by authority of the Secretary of that Board, covering 1899 and 1900. The proofs for that report were sent to me for comparison with the original manuscript and notes. This comparison was made, and to the best of my belief the figures given in this report are correct.

4125 In addition to the ordinary generally recognized chemical tests, I made a certain number of tests which have been described as bacterial, but which are really of a nature of chemical tests or reactions intended to show the presence of organic matter in the living or organized forms. These tests included an estimation of the amount approximately of this organized organic matter described usually as a count of the colonies. That embraced also a test of the water with reference to the organic forms in it which are able to produce a certain kind of fermentation in the liberation of gases. It embraced also a determination of the behavior of water with reference to its power of liberating or forming acids from certain sugars, recognized by the coagulation of milk, and finally, it embraced a test for those living forms in water which are able to decompose or break down protein matters with the production of a substance known as indol. These tests being in a measure quantitative, as well as qualitative, that is, they give an indication of the kind of organized organic matter present, and also to some extent, of the amount of this organic matter present. These tests were made by the methods usually employed by bacteriologists or chemists in the examination of waters.

4126 (States method employed in making these tests.)

4127 The results of these tests are incorporated in the tables of analyses made by me at my laboratory from the water taken from the points heretofore testified to.

4128 The tables prepared by me for the 1899 series are in printed form as they appeared in the report of the State Board of Health. These tables are cut from two volumes of this report and pasted on sheets of paper. These tables are true and correct copies of my original sheets. They are numbered from Table No. II up, beginning at Bridgeport. The first I have here is numbered II, in Roman. They were prepared by me in my official capacity as chemist to the State Board of Health. Table No. II appears on pages 12 and 13 of the State Board of Health report, published in 1901.

4130-1 Table No. II showing result of analyses of water at Bridgeport pumping station in 1899.

4132-3 Tables Nos. III and IV giving results of analyses of Des Plaines river water taken in 1899 at Lockport. No. III being canal water and No. IV Des Plaines river water.

4134-5 Table No. V giving results of analyses of canal water taken at Joliet in 1899 and Table No. VI giving result of analyses of Kankakee river water at Wilmington in 1899.

4136-7 Table No. VII giving results of analyses of Illinois river water taken at Morris in 1899 and Table No. VIII giving results of analyses of Illinois river water taken at Ottawa in 1899.

4138-9 Table No. IX giving results of analyses of Fox river water taken at Ottawa in 1899 and Table No. X giving results of analyses of Illinois river water taken at La Salle in 1899.

4140-1 Table No. XI giving results of analyses of the Vermilion river water taken at La Salle in 1899 and Table No. XII giving results of analyses of Illinois river water taken at Henry in 1899.

4142-3 Table No. XIII giving result of analyses of Illinois river water taken above Peoria at the point described as the Narrows, in 1899. This point also being known as Averyville, and Table No. XIV giving results of analyses of Illinois river water taken below Peoria opposite a point known as Wesley and sometimes described as Lower Peoria.

4144-5 Table No. XV containing results of analyses of Illinois river water collected at Peoria in 1899 and Table No. XVI giving results of analyses of Illinois river water collected at Havana in 1899.

4146-7 Table No. XVII giving results of analyses of Spoon river water collected near Havana in 1899. Table No. XVIII giving results of analyses of Sangamon river water collected near Browning in 1899.

4148-9 Table No. XIX giving results of analyses of Illinois river water collected at Pearl in 1899.

4150-1 Table No. XX giving results of analyses of Illinois river water collected at Grafton in 1899. Table No. XXI giving results of analyses of Mississippi river water collected above Grafton in 1899.

4152-3 Table No. XXII giving result of analyses of water from Kankakee river at South Bend in 1899. Table No. XXIII giving results of analyses of Fox river water at McHenry in 1899. Table No. XXIV giving results of analyses of Des Plaines river water collected at Libertyville in 1899 and in January, 1900.

4154-5 Table No. XXV giving results of analyses of Sangamon river water collected at Mahomet in 1899. Table No. XXVI giving results of analyses of Mackinaw river water collected at Kappa in 1899. Table No. XXVII giving results of analyses of Spoon river water collected at Dahinda in 1899.

4156-7 Table No. XXVIII giving results of analyses of Big Vermilion river water collected at Pontiac in 1899. Table No. XXIX giving results of analyses of West DuPage river water collected at Winfield, sometimes described as Wheaton in 1899.

4158 I have a table of averages prepared from the preceding tables of analyses which I have read into evidence. That table was prepared by me and is a true and correct table of averages based upon the preceding tables of analyses. (Objection by Mr. Jeffries to the reading of table of averages and there was also objection to the reading of all the foregoing tables.)

4159 Table No. XXX giving result of analyses made in 1899 of the waters indicated in the preceding tables. From a consideration of the tables presented and from the tables of averages drawn from these individual tables, these general conclusions may be reached:

4160 First: That the first and most general examination of this table shows a very great diminution in the organic pollution of the Illinois river and its tributaries, and the source between Bridgeport and Upper Peoria or Averyville, a diminution of the organic matter which cannot be accounted for by the dilution from the tributary waters as shown approximately by the decrease in the chlorine contents. This decrease in organic matter is explained by a consideration of several factors. We find in considering data given for oxygen absorption or oxygen consumption in the filtered water as well as in the unfiltered water, that between Bridgeport and Peoria there is a very marked decrease, a point being reached finally where the organic matter as disclosed by the oxygen consumption test does not appreciably differ from that found in the tributaries of the Illinois as shown by the same test. I find also a very marked decrease in the amount of the product indicated by the albuminoid ammonia, a decrease from over 3 parts per million to .57 parts per million. This last amount being not a great deal different from that found in several of the tributaries of the Illinois. I find also in considering this table a very marked change in the decrease in the amount of the so-called free ammonia, the decrease here being very nearly from 20 parts per million to less than one part per million, this decrease being in a measure, an index of the extent of bacterial oxidation or purification which has taken place in this part of the stream. We observe also in the figures showing the amount of nitrogen present in the form of nitrates, that a very great oxidation has taken place in the Illinois river, the nitrates resulting from the bacterial oxidation of the nitrogen which has previously existed in some other form, and which has gone through the stage of free ammonia. We observe also the appearance of nitrites in considerable amounts in the lower stretch of this part of the river. The nitrites indicating also the advance of oxidation. A very noticeable feature of these tables is that after Upper Peoria or Averyville, or the Peoria Narrows is passed, the condition of the river as disclosed by the analyses shows a very marked organic pollution again. We find that below Peoria the amount of organic pollution as measured by the albuminoid ammonia is very nearly as great as that observed in the canal at Bridgeport. We find also in passing Peoria that the free ammonia has increased from less than one part per million to over four parts per million. We find also that the figures measuring the oxygen consumption in passing Poria have increased in the case of the unfiltered water from over six parts per million to over 17 parts per million, and the figure indicating the oxygen consumption in the filtered water has increased approximately from five and one-half parts per million to nearly thirteen parts per million. This remarkable increase in the numbers given shows that at this point a very great amount of organic matter has been added to the Illinois river. From the investigations which I have myself made at different times, an explanation of this increase is given. It is a matter of personal investigation and also of common knowledge that in the city of Peoria there are great industries which discharge waste of a highly organic nature into the Illinois river and the samples of water collected at Wesley were taken from a point below the discharge of these industries. These industrial wastes are mainly from distilleries and from cattle sheds in which cattle feeding on the slops of these distilleries are kept, and from glucose factories. Coming down the river from Peoria we observe again, as we did in coming down from Bridgeport to Peoria, a very marked gradual decrease in organic contamination. This decrease is observed in a gradual fall in the figures indicating the oxygen consumption in the filtered and unfiltered water and in the free ammonia and in the albuminoid ammonia so that a change takes place in the Illinois river below Peoria, and is due to the same general causes, as indicated by the amount and character of the products given here, as takes place in the river above Peoria, so that finally, at the mouth of the river at Grafton, we have reached a condition in which the factors for organic pollution are not greatly different, or essentially different from those observed in the tributaries of the Illinois river. Taken as a whole, then, these tables disclose two main sources of contamination of the Illinois river, first, the sewage from the city of Chicago which decreases very greatly before Peoria is reached, and secondly, the industrial wastes from the city of Peoria, which decrease greatly before the mouth of the river at Grafton is reached. A consideration of these figures shows beyond any question whatever that the main factor in the contamination of the Illinois river at its mouth is not the waste or sewage contributed from Chicago, but the industrial waste contributed from the various industries of the city of Peoria.

4164 (Objection by Mr. Jeffries and motion to strike out.)

In comparing the results of the analyses made for the canal and the Des Plaines river at Joliet, and the obtained analyses of the Illinois river water at Wesley, we see that the number for the albuminoid ammonia is greater at Wesley than it is at Joliet, indicating a larger amount of protein products, decomposable in the albuminoid ammonia distillations at Wesley, than is found in the Des Plaines river and canal at Joliet. We have also the albuminoid ammonia at Joliet, being measured by 2.88 per million, while that at Wesley is measured by 3.2 per million. This average being drawn from individual experiments which are comparable in time and number. It is seen from comparing Joliet with Wesley, that we have at Wesley, as indicated by the oxygen consumption, an amount of organic matter almost as great as at Joliet, in the filtered water. In the filtered water of Joliet, the oxygen consumption being 15.1 parts per million, while at Wesley it is 12.84 parts per million. In the water not filtered the oxygen consumption number is 25.9 parts per million at Joliet, and 17.44 parts per million at Peoria. As the waste of Peoria is known to be largely of a nitrogenous character, this difference in the numbers is simply and easily accounted for, the oxygen consumption number being relatively greater at Joliet, and the albuminoid ammonia numbers being relatively greater at Peoria; the albuminoid ammonia numbers measure most fairly the protein condition of contamination. (Motion to strike out by Mr. Jeffries.)

The comparison of the water at Joliet with that at the Peoria Narrows is very instructive, the condition of the water at Joliet in every way being much worse than that at the Narrows. In my analyses the numbers given for oxygen consumption and for free ammonia and albuminoid ammonia, indicate at Joliet a very highly polluted condition, such as we find in the waters of marked sewage contamination, while at the Peoria Narrows the numbers given for oxygen consumption and free ammonia and albuminoid ammonia are not greatly different or essentially different from those which are found in the waters of the ordinary streams of the State of Illinois, not unreasonably contaminated, or not contaminated with anything more than is taken up by the passage of these waters through a soil rich in ordinary organic matters.

4165 The water of the Fox river at Ottawa contains as indicated by the oxygen consumption test, practically as much organic matter as that contained in the Illinois river water at the Narrows, the average result showing a greater oxygen consumption for the filtered water of the Illinois at the Narrows. While the oxygen consumption results for the unfiltered water at Ottawa are slightly greater than for the unfiltered water at the Narrows, the free ammonia figure of the Fox river water at Ottawa is very much less than the free ammonia figure for the Illinois river water at Peoria, the free ammonia at this place, the Narrows, not yet having undergone complete oxidation. In the case of the albuminoid ammonia figures, the amount in the Fox river at Ottawa is almost as great as that of the Illinois river or canal, both figures being in the proportion that we find in the ordinary streams of the State of Illinois, flowing through soil containing a large amount of organic matter. By a consideration of the figures given for the analyses of the Illinois at La Salle and at Pekin, these relations are observed: The organic matter as indicated by the albuminoid ammonia at Pekin is very much greater than the organic matter indicated by the albuminoid ammonia at La Salle; the amount of free ammonia at La Salle on the contrary is greater than the free ammonia found at Pekin.

4166 That indicates that the oxidation of the free ammonia at La Salle has not gone as far as the oxidation of the ammonia at Pekin. In the case of the contamination as measured by the oxygen absorption, the condition at Pekin is very similar to that at La Salle, the numbers being nearly the same. In comparing the waters of the Illinois river at Peoria and the Peoria Narrows, and Grafton, we find as measured by the oxygen consumption figures and by the free and albuminoid ammonia figures somewhat more organic matter indicated at Peoria than at Grafton, but not a great deal more. As indicated by the oxygen consumption test, the Mississippi river water at Grafton contains more organic matter than the Illinois river water at Peoria Narrows. As indicated by the figures for free ammonia, oxidation has gone very much further in the Mississippi river at Grafton than at the Narrows at Peoria. As indicated by the albuminoid ammonia test, the organic matter in the Mississippi river at Grafton is about eighty per cent of that in the Illinois river at the Peoria Narrows. As measured by the oxygen consumption test, the Mississippi river water at Grafton contains more organic matter than the Illinois river water at Grafton. As measured by the albuminoid ammonia, the Illinois river at Grafton resembles very closely the Mississippi river water at Grafton.

4167 The other determination shows that in the Illinois river water at Grafton we have evidence of a large amount of nitrogenous matter which has undergone oxidation. Nitrites for example, at Grafton, or the Illinois river at Grafton, being nearly twenty times as great as the nitrites in the Mississippi river water at Grafton. We have also in comparing the Mississippi with the Illinois river at Grafton this fact, that of the unoxidized ammonia we have in the Illinois river about three times as much as in the Mississippi river water. From a consideration of all these tables and averages, the conclusion is a necessary one, that the organic matter discharged at Bridgeport into the canal and subsequently into the Illinois river, has undergone practically complete oxidation before the mouth of the Illinois river is reached at Grafton, because at this point we find no more organic matter than can be accounted for readily by that discharged from the tributaries and from the contamination at Peoria. I have made analyses of the Des Plaines river above Lockport and am acquainted with that river above that point.

4168 I am familiar with the towns on the river and the character of the drainage entering the river. The Des Plaines river is a sluggish stream which drains a number of suburban towns around Chicago. One of these is the town of Riverside, which is not far above the controlling works at Summit, north of Summit. The Town of La Grange is also in part drained into the Des Plaines, the sewage of La Grange flowing into a small stream, a small creek which in turn enters the Des Plaines near Riverside. Above Riverside there are several towns located on the Des Plaines, the drainage of which is taken up by that stream. Maywood is one and Norwood Park is another. The Des Plaines furnishes the only outlet for drainage for these various towns, and when it becomes mixed with the canal water, it is not a potable stream and has not been in a great many years, not in twenty years.

I have made analyses at the point where the Bear Trap dam is located, which is at Lockport. I should not consider from these analyses that the water of the Des Plaines river at that point is safe and potable water. From my analyses and from my present knowledge of the Des Plaines river above Lockport and of the towns that empty their sewage into the river, I should not consider that a safe and potable river.

4169 The Des Plaines river is extremely variable. At times of high water it carries a flood but in dry season it is almost dry. It contains little more than the sewage from the towns draining into it. I have testified as to the chemical results of the 1899 investigation. The bacterio-chemical results agree in a general way with the chemical results, in showing the condition of extreme organic contamination at Bridgeport, Lockport and Joliet, which show gradual improvement as we go down the river until Peoria is reached—Upper Peoria or the Narrows, or Averyville, as it is called, where the individual results obtained by the various methods which I referred to this morning do not differ essentially from similar results obtained from the tributaries of the Illinois. But leaving Peoria Narrows and going down to Wesley, we find as indicated by these bacterio-chemical results, great marked increases of contamination again. The number of forms of organic matter in the organized condition, or living condition at Lower Peoria or Wesley

4170 as disclosed by what is called the colony count, is certainly as great as that found at Bridgeport, while the factors indicating the fermentation of carbo-hydrates by the bacteria present and indicating the presence of those bacteria which convert carbo-hydrates into acids and coagulate milk, are likewise as great at Wesley as at Bridgeport, so these bacterial results then in general agree with the chemical results in showing an enormous increase in pollution, as Peoria is passed, and these chemical bacterial results show as we leave Peoria and go down the river, a gradual diminution in the organized forms until the mouth of the river is reached at Grafton, where the number of bacteria present, and the behavior of the bacteria with the reagents mentioned, show a condition similar to that found in many of the tributaries of the Illinois. I have the table of analyses compiled by me for the samples of water taken in 1900. These tables correctly state the results of my analyses as made in the manner heretofore stated in my testimony.

4171 I have in 1900, two sets of tables, one embracing examinations made shortly after the drainage canal was opened in the spring of 1900 and the other taking up a later period in the same year.

4172-3 Table No. XXXII gives result of one examination of water from Bridgeport Pumping Station and I. & M. canal, made March 6, 1900. Table No. XXXIII giving results of analyses of water from the main drainage canal, water being taken at Western Avenue bridge between March 13 and April 25, 1900.

4174-5 Table No. XXXIV giving results of analyses of Illinois river water taken at Morris, in the spring of 1900. Table No. XXXV giving results of analyses of Illinois river water taken below Peoria, opposite Wesley, in March and April, 1900. Table No. XXXVI giving results of analyses of Illinois river water collected at Havana in March and April, 1900.

4176-7 Table No. XXXVII giving results of analyses of Spoon river water taken near Havana in March and April, 1900.

4178-9 Table No. XXXVIII giving results of analyses of Illinois river water taken at Pearl in March and April, 1900. Table No. XXXIX giving results of analyses of Illinois river water taken at Grafton in February, March and April, 1900.

4180 Table No. XL giving averages of the results of analyses made in the spring of 1900 of samples of water taken at the places indicated in the previous tables.

4181 From these various tables I note that the amount of organic matter at Bridgeport in the old canal and the drainage canal at Western Avenue is less than disclosed by the previous analyses given in 1899. An exact comparison is however difficult because of the fact that in this period, in the spring of 1900, the water flowed through both canals, through the Illinois and Michigan canal and through the drainage canal, but not at a constant rate, so that an exact comparison of these figures is difficult. However, as we proceed down the river to Morris, where there is a complete mixing of the waters, we find for the numbers representing the free and albuminoid ammonia a lower amount than disclosed in the analyses made in 1899. When Lower Peoria or Wesley is reached, there is here a very great increase in the figures for all constituents. In the factor representing the oxygen absorption, the free ammonia and the albuminoid ammonia the increase is very marked. Following below Peoria, we observe a decrease in these factors, representing or pointing to the amount of organic matter present. We find at Pearl that the factors for oxygen consumption and for albuminoid ammonia are as low as in the 1899 examinations in general, and as low as disclosed in the waters of many of the tributaries of the Illinois. We find at Grafton, however, below Pearl, for some reason which cannot be given, a slightly larger amount of organic matter in the mean, than at Pearl, but the point of greatest importance in this table is the very marked increase of the organic matter at Peoria and at Wesley, the point below Peoria, as compared with the amount found at points above during this same examination.

4182 A comparison between the waters at these points is a fair one because they were collected through the same months and shows this: that at Wesley, below Peoria, the organic matter as measured by the oxygen absorption and by the albuminoid ammonia and as indicated also by the results of the bacterio-chemical examinations, is greater than that found at Morris through the same period. Any increased dilution below Morris would tend to decrease rather than increase the contamination at Peoria, making it appear even more strongly. The organic matter is larger than at Morris. At Grafton, the various factors given in the table show a lower condition of contamination than at Morris, in practically all cases. At

Morris in 1900, after the opening of the drainage canal the amount of albuminoid ammonia is very much less than the amount found in 1899, before the opening of the drainage canal. The factor for oxygen consumption in 1899, is, in the filtered water somewhat greater than for the filtered water in 1900, but for the unfiltered water, slightly less.

4183 That indicates simply as stated, that the amount of organic matter is less one year than the other, to make that direct comparison. At Wesley, in 1899, in the mean, as indicated by the albuminoid ammonia, there was more organic matter present than in 1900, as indicated by the oxygen consumption; also somewhat more in 1899 than in 1900. The free ammonia at Wesley in 1899 is greater than that at Wesley in 1900. It contains less pollution in 1900 than it showed in 1899. At Havana, in 1899 the amount of organic matter as measured in parts per million by the free and albuminoid ammonia was greater than in 1900, and the oxygen consumed shows a somewhat similar condition. The oxygen consumed is a little greater in the spring of 1900 than in 1899. As measured by the albuminoid ammonia, in a given volume of the water, the analyses showed that there is a greater pollution in 1899 than in 1900. While, as measured by the oxygen consumption the result for 1900 appears to be slightly greater than the result for 1899.

4184 At Pearl, as measured by the oxygen consumption, the organic matter in parts per million is greater in 1900 than it is in 1899, but as measured by the albuminoid ammonia present, the contamination in 1899 is greater than that in 1900. Comparing the river through the summer of 1899 at Grafton, with that at Grafton through the spring of 1900, we find that the condition at Grafton shows more organic matter from a given volume in 1900 than it does in 1899. This comparison, however, is made between the river at the time of high floods in the second year and through the summer conditions in the first year. From the fact that these analyses which I last gave, made in 1900, were carried out in the spring of that year, 4185 when the waters in general were high, any comparison between the river at this time—the lower stretches of the river at this time, with the lower stretches of the river in 1899, is impossible—any fair comparison is impossible. The Illinois river in the spring of 1900 in its lower stretches shows the condition of the ordinary western rivers at the same time, irrespective of the source of their contamination. We have here the large amounts of free and albuminoid ammonia, and high figures for oxygen consumption, which are found in the ordinary tributaries of the river. A comparison in this table is important mainly as it shows the increased contamination at Peoria or Wesley. (Witness states number of samples taken at the various points indicated during the spring of 1900.)

4186-7 Table XLII giving results of analyses of water of the Illinois and Michigan canal at Bridgeport, collected in July, August and September, 1900.

4188-9 Table No. XLIII giving results of analyses of water from main drainage canal at Western Avenue bridge in June, July, August and September, 1900. Table No. XLIV giving results of analyses of water from the drainage canal at Lockport in June, July, August and September, 1900.

4190-1 Table XLV giving result of analyses of water at Joliet, being a mixture of water from both canals and the Des Plaines river, collected in June, July, August, September and October, 1900. Table No. XLVI giving results of analyses of water of the Illinois river at Morris in June, July, August, September and October, 1900.

4192-3 Table XLVII giving result of analyses of water of the Illinois river at Ottawa in June, July, August, September and October, 1900. Table No. XLVIII giving results of analyses of water of Fox river in June, July and August, 1900.

4194-5 Table No. XLIX giving results of analyses of water of Illinois river at La Salle in June, July, August and September and October, 1900. Table No. L giving results of analyses of waters of Vermilion river at La Salle in August and September, 1900.

4196-7 Table LI giving results of analyses of water of Illinois river at Henry in June, July, August, September and October, 1900.

4198-9 Table No. LII giving results of analyses of water of Illinois river at Upper Peoria, or the Narrows, or Averyville, in June, July, August and October, 1900. Table No. LIII giving results of analyses of waters of Illinois river collected at Wesley or Lower Peoria in May, June, July, August, September and October.

4200-1 Table No. LIV giving results of analyses of waters of the Illinois river at Pekin, in May, June, July, August and September, 1900. Table No. LV giving results of analyses of waters of the Illinois river at Havana collected in June, July, August, September and October, 1900. Table No. LVI giving results of analyses of waters of the Spoon river collected at Havana in July and August, 1900.

4202-3 Table No. LVII giving results of analyses of waters of the Illinois river at Pearl, collected in June, July, August and October, 1900. Table No. LVIII giving results of analyses of Illinois river at Grafton in June, July, August and September, 1900.

4204-5 Table No. LIX giving results of analyses of Mississippi river at Grafton in July, August and September, 1900. Table No. LX giving results of analyses of waters of the Sangamon river opposite Browning, collected in August and September, 1900. Table No. LXI giving results of analyses of waters of the Kankakee river near Wilmington, collected in August and September, 1900.

4206 (Motion by Mr. Jeffries to strike out tables referring to the tributaries of the Illinois river.)

4207 Table No. LXII giving averages of results of analyses of water at the points referred to in preceding tables. (Witness states numbers of samples and places at which same were taken in summer and autumn of 1900.)

4208 These tables considered in comparison with each other, and a consideration of the averages of the tables for the
4209 work of the summer of 1900, show in general, to begin with, a lower initial contamination of the water at Bridgeport than was the case in the examinations of the waters made in the previous year, 1899. The tables show further, as we proceed down the river and canal from Bridgeport to Lockport and Joliet, and down the Illinois river proper a gradual and continuous diminution in the factors indicating the organic contamination, and to an extent which is very much greater than can be accounted for in any way by the amount of dilution coming in from the tributaries. An examination of these tables shows first, in general, a marked reduction of organic matter as compared with the amounts present at the source of contamination—Bridgeport, in the main drainage canal. At the Narrows above Peoria, the factors indicating the extent of organic pollution as drawn from the results of the oxygen consumption test, and the free and albuminoid ammonia tests are not greater than those found from an examination of the ordinary tributaries—from the ordinary tributary waters of the Illinois in this State. We find also on further consideration of the table that after Peoria Narrows is passed and the next point is reached, a remarkable increase in the organic pollution again, as measured by the important factors already referred to, the oxygen consumption and free and albuminoid ammonia, this increase being in the free and albuminoid ammonia several hundred per cent. The figures for oxygen consumption increase are likewise very large. The increase, from the known nature of the contaminating material entering the river at Wesley is largely nitrogenous, and hence the much greater increase apparent in the figures for free and albuminoid ammonia than that apparent in the figures for oxygen consumption. Below Peoria as we proceed down the river we observe a decrease

again in these figures—a decrease in the oxygen consumption by the water, a decrease or disappearance of the free ammonia, and a very marked decrease in the albuminoid ammonia at Pekin. At the points below Pekin there is but little further decrease in the albuminoid ammonia for the reason that we have reached here a condition in the amount of albuminoid ammonia which is comparable with that found in the ordinary rivers of the State, beyond which the reduction does not commonly proceed to a great degree, for the reason that we have reached here the comparatively stable types of organic substances which are not much subject to reduction by the bacterial oxidizing agents. In the case of the free ammonia, however, as this substance does undergo change, we find a progressive improvement or disappearance by oxidation to the mouth of the river, the figure for free ammonia at Grafton being .07 parts per million. In considering the indications given by the figures for the oxygen consumption we have a similar condition. Below Pekin there is a general gradual decrease until Grafton is reached, where the figures for the oxygen consumption again have sunk to a point corresponding to those given by the waters of the tributaries entering the Illinois, and by waters of this type in general, which flow through soil containing a large amount of organic matter. These figures for oxygen consumption have reached a point which is not passed in the waters of this region when exposed to the contamination of ordinary organic substances of vegetable origin. In drawing full comparisons in this table, it is necessary to make, to begin with, a calculation of the combined flow through the main drainage canal and the Illinois and Michigan canal. Inasmuch as the water reaches the Des Plaines river at Joliet through two canals, carrying unequal portions and drawing different kinds of water, it is necessary to make a calculation of this kind in order to have a starting point for the comparison. The calculation which I refer to is to determine what the constituents present would amount to on the supposition that all the water was carried through one channel instead of two, because in considering the points further down the stream, we are dealing with only one channel. In order to make a computation of this kind, I have taken from the published tables of the chief engineer of the Sanitary District the flows through the two canals at the periods in question, and have combined them in such a way as to obtain the total flow. Knowing the total flow in each canal it is a matter of arithmetical calculation to find what the content would be on the supposition that all of the water passed through one channel. During the period in question, as deduced from the tables of the chief engineer of the Sanitary District, about sixteen per cent of the flow was through the old, or Illinois and Michigan canal, and about eighty-four per cent of the flow through the main drainage canal, and these figures were used in a calculation which I will next present, which, however, has not been carried out for all constituents but only for the most important ones. Assuming that all of the water passed through one channel, the volume being equivalent to the volume flowing through the two channels, the constituents in that one channel would be this: Chlorine 23.5 parts per million. Free ammonia—

JUDGE SPRINGER: At what place is this?

A. This is the assumed entrance of the one channel at Bridgeport, supposing the water all went through one, instead of through two.

Chlorine	23.5	parts per million
Free ammonia	3.9	"
Albuminoid ammonia	1.13	"
Oxygen consumption in unfiltered water	7.46	"

These numbers may be taken as representing then the composition of the total flow through the combined channels. It will be seen by comparing these numbers which I have just given, with those given for the water at Joliet, that there is a discrepancy in some of the figures. That discrepancy depends on this fact, that, at Joliet in the basin there is not, or was not at all times, a perfect mixture of the Des Plaines and main drainage canal water, and the old canal water, so that the results are somewhat dependent on the point there at which the samples were taken, and at the times there at which the samples were taken. Because of that discrepancy the Joliet collection is not considered in the comparison that I wish to make. With this calculated composition of the canal on the assumption that the water all flows through the one channel, I have made some graphic charts which illustrate the variations in the amount of substances present, expressed in parts per million in the whole flow between Bridgeport and Grafton at the mouth of the river, these charts illustrating somewhat more clearly and plainly the variation than do the figures as read from the tables. The first chart shows a decrease in the chlorine, which is a measure approximately, of dilution by tributary waters.

4212 (Objection by Mr. Jeffries.)

4214 Chart representing the decrease in chlorine present expressed in parts per million, between Bridgeport and Grafton as determined by the examinations of the Illinois river water, made during the summer of 1900.

4215 (Witness explains significance of figures on the chart.) In this chart we have a decrease of the chlorine from Bridgeport to La Salle; an increase at Henry corresponding to the chlorine coming into the river at or below La Salle from the industries there present, largely. A further decrease to Upper Peoria; a slight increase at Wesley; a decrease at Pekin; about the same amount at Havana, and a gradual decrease to the mouth of the river.

4217 Chart representing change in the amount of free ammonia present in the water between Bridgeport and Grafton for the period of the summer of 1900. That chart being drawn from the average of results of chemical analyses made through that period. The chart indicates a very great decrease in ammonia from the starting point, until Upper Peoria is reached, and then a remarkable increase—followed by a decrease to Pekin.

4218 I have also a chart for albuminoid ammonia prepared from the results of analyses made in the summer of 1900 from Bridgeport to Grafton. We have, beginning at Bridgeport, the amount of albuminoid ammonia, calculated for the assumed flow of water through one channel in place of two, 1.13 parts of albuminoid ammonia per million. This amount decreases rapidly to Morris and then to Ottawa, where the amount found is below .4 of a part per million. A further decrease takes place at La Salle; then a slight increase to Henry, where the amount present is almost exactly .41 of a part per million. We have then a further slight decrease until Upper Peoria or Averyville is reached, where the amount reached is .34 of a part per million. From this point a very marked increase takes place at Wesley, at which point the amount of albuminoid ammonia present is .34 parts per million. This amount decreases again rapidly. At Pekin the amount found is below .5 of a part per million; it sinks to Havana where the amount of .41 of a part per million is reached.

4219 A slight increase is observed from here to Pearl where the amount present is found to be .43 of a part per million, and a further decrease to Grafton follows, where the amount is given as .36 of a part per million. The characteristic point in this table is the sudden and great increase of the albuminoid ammonia at Pekin, due to the introduction of fresh organic matter, essentially of protein character, and the rapid decrease as observed at Pekin is due to the remarkable condition of decomposition taking place in the stretch between Peoria and Pekin which has been observable at periods before and after the opening of the main drainage canal.

4220 Chart referred to.

4221 I have also a chart called oxygen consumption curve, which was made from the analyses of the summer of 1900.

4222 This chart illustrates the variation in the oxygen consumption as expressed in the figures of Table LXII heretofore read. This oxygen consumption being given for the points between Bridgeport and Grafton. The abscissa lines have the same significance as already explained, and the ordinate lines represent parts per million of oxygen consumed.

These represent the unfiltered water. We have at Bridgeport an amount of oxygen consumption found to be 7.46 parts per million, which amount decreases gradually to La Salle, and increases slightly to Henry, from which point a decrease follows to Upper Peoria or Averyville, where the amount present is found to be 5.5 parts per million. We have then a very marked increase to Wesley, below Peoria, where the amount present is 9.91 parts per million. From this point a decrease follows again to Pekin, and to Havana, and from Havana there is a slight increase to Pearl, and finally a decrease in the amount to Grafton where the results show 5.85 per million.

(Chart referred to.)

4223 (Motion by Mr. Jeffries to strike out all the charts offered.)

JOSEPH WEIS, examined in chief by Mr. Todd:

4224 I know John E. Thome of the Bridgeport Pumping works. I got the samples that were collected by him at the Bridgeport Pumping works and took them to the city hall and to the University of Illinois and to the University of Chicago.

4225 PROF. JOHN H. LONG, resumed the stand for further direct examination by Mr. Todd:

4226 A consideration of all the tables presented and of the charts drawn from them leads to this important and necessary conclusion: That in the flow of the sewage water from the pumps at Bridgeport through the drainage canal and subsequently into and through the river there is a very remarkable reduction or destruction of organic matter to Peoria; a great increase again between Peoria and Pekin, beyond which the reduction follows which continues to the mouth of the river, and at the mouth of the Illinois river as far as the organic content is concerned, the Illinois river is not more contaminated than are the ordinary tributaries and rivers of this region flowing through a soil which contains large organic matter, and finally, and the most important conclusion to be drawn from these tables and charts is, that the main factor in contamination of the Illinois river is the addition of sewage, stockyards and distillery waste of the city of Peoria. (Objected to by Mr. Jeffries and motion to strike out.)

4227 I made some chemical examinations in 1901 and the spring of 1902. The points selected in 1901 were: in the Illinois river above Grafton; in the Mississippi river above Grafton, and in the Missouri river above the mouth of that river, or the point where it flows into the Mississippi. This investigation was made the last part of 1901 between the last of September and the middle of December. The next investigation was made in the spring of 1902 in part of February and March, at the same points. Samples for these tests were taken in the manner that I have heretofore testified.

4228 I have tables that were made as the other tables were, from the results of these examinations. They are in the form in which they were printed by the authority of the Illinois State Board of Health, in one of the bulletins or reports of that Board, printed in 1902.

4230 Table No. I giving results of analyses of water of the Illinois river taken above Grafton between September 23, 1901 and December 12, 1901.

4232-3 Table No. II giving results of analyses of Mississippi river water above Grafton between September 23, 1901, and December 12, 1901.

4234-5 Table No. III giving results of analyses of water of Missouri river taken some 600 feet above the mouth of that river between September 17, and December 12, 1901.

4236-7 Table No. IV giving result of analyses of water of the Illinois river above Grafton between February 24, 1902, and March 18, 1902. Table No. V giving results of analyses of water of the Mississippi river above Grafton between February 24, 1902 and March 17, 1902. Table No. VI giving results of analyses of waters of the Missouri river about 600 feet above the mouth of the Missouri in March, 1902.

4238 I have a table of averages prepared by me from these tables of analytical data.

4239 Table read in evidence.

From a consideration of these several tables, I draw the following general conclusions: That the organic condition of the Illinois river above Grafton is very much better than the organic condition of the Missouri river above its mouth. This is shown by several factors. By the factor measuring the oxygen absorption, which for the Illinois river is for the unfiltered water, 4.31 parts per million, and for the filtered water, 3.21 parts per million. For the Missouri river, for the unfiltered water, 10.28 parts per million, and for the filtered 3.17 parts per million. By the factor for the albuminoid ammonia, as measuring the substances of comparatively complex composition to be yet decomposed, 0.413 parts per million in the Illinois, as against .6 parts per million in the Missouri. By the factor measuring the organic ammonia, as determined by the Kjeldahl process, which is .81 parts per million for the Illinois, as compared with 1.61 parts per million for the Missouri. As measured by the oxygen absorption, the Illinois river contains less organic matter above its mouth than does the Mississippi river.

4240 As measured by the albuminoid ammonia, the Illinois river contains very nearly the amount of organic matter that is contained in the Mississippi river. As measured by the organic ammonia determined by the Kjeldahl process, the amount in the Illinois river is not greatly different from that in the Mississippi river. Considering the chemical reactions due to the living organic matter in the Illinois and the Missouri rivers, it is evident that the condition of the Illinois is very greatly superior to that of the Missouri, throughout the whole period. This is especially shown by the chemical determinations made to indicate the presence of those living organisms which decompose protein matters, with the production of indol. The reaction for indol is found at the mouth of the Illinois river above Grafton very rarely, while in the Missouri river 600 feet above its mouth, this reaction is extremely common, showing a very much greater number of the living organisms capable of bringing about this peculiar chemical decomposition in the Missouri river than are found in the Illinois river. From the information obtained from the tests for the presence of those organisms, which have the power of breaking down carbo-hydrates, with the liberation of acid, which subsequently coagulates milk, it is likewise evident that the contamination in the Missouri river is very much greater than the contamination in the Illinois river through the same period. The number of acid forming organisms as disclosed by the results of the tests being greater in the Missouri than in the Illinois. It also appears by a comparison of the tables in which a determination of the number of living organisms was made by the so-called colony count process, that the Missouri river shows a greater contamination than does the Illinois, through this same period. In its organic condition as indicated by these chemical tests which I have described as sometimes called bacterial, although they involve true chemical reactions, the Illinois river is as pure as the Mississippi at the point of junction of the Illinois with the Mississippi, and the Illinois river is very much purer than the Missouri at the point where the Missouri flows into the Mississippi.

4241 When we turn to these results just given as applied to a comparison of the results for the fall of 1901, and when we turn to the results obtained in the spring of 1902, the same general conclusions follow. The indol reaction is more common in the Missouri river than it is in the Illinois. The purely chemical tests indicate the presence of a larger amount of organic matter in the Missouri river than is indicated in the Illinois. It is, beyond question, true, that at the period of this investigation the Illinois river at its mouth, was a much less contaminated stream than the Missouri river at its mouth. As disclosed by the experiments described, the Missouri river is far more contaminated organically than the Mississippi at the points at which the samples analyzed were taken. I also examined the waters of the Kaw and the Missouri rivers. I am familiar with the Kaw from its mouth for a distance of 100 miles or more west. I lived for a number of years on the Kaw and have been on it at numerous points.

4242 This investigation was made in the Kaw at a point above its entrance into the Missouri; in the Missouri above Kansas City, and above also the confluence of the Kaw; in the Missouri below the entrance of the Kaw and finally in the Missouri below Kansas City. I suggested and directed the locations for taking the samples, to Mr. Quinlan and Mr. Burke, the employes of the Sanitary District of Chicago. I instructed these men to go to Kansas City and collect samples at each point I have mentioned, in May, 1903. They were to be taken on three days, three samples on each day, a sample from the middle of each stream and from near the right and left banks, making a cross-section of three points.

4243 These samples were received by me and I used these waters for the determination of the amount of chlorine present. I made no other special determinations. I secured from the engineer of the United States Geographical Survey at Washington the volumes of the Kaw and Missouri rivers. For the Kaw, at the town of Lecompton, Kansas and for the

4244 Missouri, at a point a short distance above the city where the gauge is read. Lecompton is in Kansas on the Kaw, about forty miles above its mouth. The volumes of these rivers is given in cubic feet per second as follows:

For the Kaw:

May 24, 1903, 51,000
May 25, 1903, 49,600
May 26, 1903, 39,100
May 27, 1903, 63,500
May 28, 1903, 72,200

4245

For the Missouri:

May 22, 1903, 125,000
May 23, 1903, 145,000
May 24, 1903, 184,000
May 25, 1903, 198,000

May 26, 1903, 226,000
May 27, 1903, 242,000
May 28, 1903, 310,000

I have a table of analyses for chlorine. This table shows the results of the examinations of the Missouri and Kaw rivers. (Table read in evidence.) The general averages shown by this table are as follows, being the parts of chlorine per million:

Kaw river, one and one-half miles above Kansas City, general average, 9.71;

Missouri river above Kansas City, general average, 10.67;

Missouri river below mouth of the Kaw, general average, 10.97;

Missouri river below Kansas City, general average, 12.31.

4246 (Motion to strike out by Mr. Jeffries.)

4247 The averages drawn from these tables show a considerably larger figure for chlorine below Kansas City, than in the Kaw or in the Missouri above Kansas City. The excess of chlorine below Kansas City being more than can be accounted for by any addition from the Kaw, and showing the fact that a certain proportion must come from the stock yards industries, and the sewers of Kansas City. The volume
4248 of the Missouri river is very considerably greater than the volume of the Kaw throughout this period, and the amount of chlorine in the Kaw, taking its volume into consideration, cannot act to increase the amount of chlorine in the Missouri above the figure given for the Missouri above Kansas City. My analyses of the waters of the Missouri river in 1902 disclose relatively high chlorines in that river. The chlorine in the Missouri river is always much higher than the chlorine in the Mississippi river. The chlorine at the mouth of the Missouri river can be attributed only in part to the chlorine of the Kaw river, the tables showing that the additions from Kansas City is an important factor. The analyses show considerably less chlorine above Kansas City than below Kansas City, at the time the examinations were made.

4249 The chlorine below Kansas City is considerably greater than the chlorine in the Kaw. It is my opinion that I have sufficient data to draw a fair conclusion in this case. That was my opinion before I ordered the samples taken.

Q. How did the chlorine below Kansas City compare with the chlorine in the Missouri river at its mouth, in the examinations as made by you in 1902?

MR. JEFFRIES: We object to the question for the reason that the conditions under which the samples were taken are not shown to have been the same or shown to have been taken under conditions which would be comparable with each other and we object to the question for the further reason that the evidence showing pollution of the Missouri river is not justification for the Sanitary District of Chicago polluting the waters of the Illinois river by the discharge of the sewage from Chicago into it.

A. It is not possible or profitable to make comparison here because the samples were not collected at the same time or under identical conditions.

4250 From all the examinations I made of the Illinois river and its tributaries, it is my opinion that no part of the original organic matter leaving Chicago through the sanitary canal and finding its way into the Illinois river, can reach the mouth of the Illinois river, and much less the intake tower of the St. Louis waterworks. It is my belief that the sanitary condition of the water supply of St. Louis is not and cannot be injured by any pollution passing through the drainage canal from Chicago to the Illinois river and down. As the sewage is disposed of in two general ways, practically by dilution and by oxidation, or chemical destruction through bacterial means—inasmuch as the volume of water is greatly increased, the diminution of the sewage for a given volume, per cubic centimeter, for example, or per liter, is necessarily less, and inasmuch as at the same time with this new dilution there is no decrease enforced in the bacterial activity throughout the channel, so there can be no decrease in the purification from those causes. We have remaining, the diminution of organic matter by dilution, making the final effect better rather than a worse condition of the river.

The volume of water going down the Illinois river is now greater than it was before the opening of the drainage canal.

4251 I am acquainted with the Illinois river in flood time.

The effect of very high water in the Illinois river is a complicated one. The floods carry into the river an immense amount of organic matter from all the tributaries and numerous living organisms or bacteria which are practically always associated with this organic matter. The floods in general, from the gathering up of this large amount of organic matter, have the effect of increasing the organic contamination irrespective of any original contamination which may have been present. A further effect of these floods, inasmuch as the banks of the Illinois river are very low, is to spread an enormous volume of water over an area of many hundreds of thousands of acres, providing for the sedimentation and oxidation to a marked degree, of the matters carried by the waters at these periods. The conditions in the Illinois river because of the peculiar character of the banks, are unique in this respect. The overflow disposes in this manner of a vast amount of organic matter, which in a stream with high banks would have to be carried forward. The great overflow area provides numerous settling and purification basins in the Illinois river. Inasmuch as by far the largest volume of the water at flood time, leaves the natural channel of the Illinois river, and is distributed through a vast area of land, as a matter of necessity, any original sewage from Chicago or remnants of sewage carried by this water must be in a like manner, so distributed and delivered into a condition for purification by sedimentation or oxidation.

4252 I am acquainted with the various lakes along the course of the Illinois river between Chicago and Grafton. Lake Joliet has the general effect of offering a large basin for oxidation and has the effect of holding up the water to some extent for that purpose. It is true for most of these lakes, in a far greater degree than Lake Joliet, which is in a measure hemmed in and limited in extent. These lakes, extensions and widenings of the Illinois river below Henry and particularly below Peoria and the region around Havana, north and south of Havana, and not in fact for the whole region practically between Havana and Beardstown, these widenings or lakes in the river provide very important agencies in the disposition of organic matter at flood time, and also to some extent at the time of low water. There are a good many dams along the Des Plaines and Illinois rivers from Lockport to Grafton. There is the dam at the end of the main drainage channel, known as the Bear Trap dam, also I believe two dams in Joliet, one at Henry, another at a point below Pekin some distance, called Copperas creek, and further down at La Grange and Kampsville, also one at Marseilles. These dams in the Illinois river are extremely important factors in holding up the water, retarding its rate of flow, distributing it over a wider area, and therefore of importance in hastening general purification.

4253 They are important because of the effect which I have mentioned, that they serve to distribute the water over a greater superficial area and retard its rate of flow. It is my belief that the Mississippi river at the Illinois shore opposite the Chain of Rocks is not at that point a potable stream and fit for drinking purposes. The Mississippi river was not, at any period prior to the opening of the drainage canal a suitable river for household use. I made numerous analyses of the Mississippi river in years back, prior to the opening of the drainage canal. (Motion to strike out by Mr. Jeffries.)

4254 Because of the addition of a large volume of Lake Michigan water to the canal water flowing down the Illinois, and because further, the increase in the amount of pure water, is very much in excess of the increase in the amount of sewage carried at the same time, the resultant effect is produced that the mouth of the Illinois river today, is in a far better sanitary condition than obtained before the drainage canal opened.

MR. JEFFRIES: I object to the answer and move to strike it out, on the ground that it is based upon analytical data prepared by the witness from samples of water taken from the Illinois river and that such samples were taken at various times without reference to local conditions, the volume of water, and taken in such a manner as not to be competent, and that in the analyses made by this witness, the volume of water was not considered a source of pollution and the extent of pollution was not considered as an element of the analyses.

4255 Taking into consideration all the conditions which have been supposed and especially the condition of the increased pollution I am still of the opinion that the sanitary condition of the water of the Illinois river at its mouth has been improved instead of injured by the increased flow through the drainage canal. Since the opening of the canal, beyond all possible question the sanitary condition of the Illinois river at its mouth is far superior to the Missouri river at its mouth and not greatly different from the condition of the Mississippi river at a point where the Illinois and Mississippi rivers unite.

(Objection by Mr. Jeffries.)

4256 As I have stated in my previous testimony, I believe the effect of the Chicago sewage is completely lost before the mouth of the Illinois river is reached, and therefore cannot be a factor in determining any pollution in the Mississippi or Missouri rivers. Assuming that the waters of the Illinois river in 1902 were emptied directly into the Missouri river at its mouth before the Missouri enters the Mississippi, the water of the Missouri would contaminate the water of the Illinois, the water of the Illinois being in a purer and better sanitary condition at that time than the water of the Mississippi. (Witness is asked hypothetical question in regard to the depositing of the 107 barrels of bacillus prodigiosus in the drainage canal, etc. This question includes the number of samples of water that were taken at the time the experiment was made and the number of bacillus prodigiosus that were found.

4258 Considering the longevity of the typhoid bacillus as measured by the longevity of the bacillus prodigiosus, which consideration in no way involves a knowledge of bacteriology but simply a knowledge of arithmetic as set forth in this question, I would say that the suppositions advanced in this question indicate that the longevity of the bacillus prodigiousus and the the typhoid bacillus as compared with it, is so extremely slight as to make the probability of a germ of this character being able to survive a passage from the drainage canal to Grafton, so remote as to be entirely unworthy of consideration. This conclusion depends on certain calculations which I have made and which I will present. (Witness shows mathematical calculation from which he deduces the folowing conclusions):

4259 We should find 10,000 bacilli prodigiosus per cubic centimeter at some corresponding time in some part of the river below, but admitting the fact that the change by dilution occurred and that these bacteria were all found in samples collected in a period of four days, I have calculated this original volume of water as diluted with the volume of water which flows at the mouth of the river in a period of four days. On that assumption, a number of at least 200 should be found per cubic centimeter, for each cubic centimeter examined, on the assumption that no death or less of these bacteria takes place anywhere in the course.

4260 As a matter of fact, not 200 were found in one cubic centimeter, but a very large number of examinations had to be made to find a cubic centimeter in which there was one contained. It is evident that an enormous destruction of these organisms must take place between the point at which the bacteria were thrown in, and the mouth of the river where the examinations were made. The actual finding is not over one ten-thousandth of what should be expected from 107 barrels on the assumption that these organisms did not die out; that is, we find less than one ten-thousandth of the expected amount. If we consider a number less than 107 barrels as added, one barrel for example, the probability of any organism of this character reaching the mouth of the Illinois river is less than one chance in 1,000,000. If we consider one barrel, or one one-hundredth of a barrel as added, the chance of one of these organisms reaching the mouth of the river and being found in a cubic centimeter becomes correspondingly reduced. Therefore, without involving any question of bacteriology, but simply a question of calculation, it is evident that the probabilities of any number of bacteria in a given small volume, reaching the mouth of the Illinois river is extremely remote and not one which can be practically or seriously considered.

(Objection by Mr. Jeffries.)

4261 Q. Professor, assuming all the facts to be true in the foregoing hypothetical question, which was first presented to you, and assume that the longevity of a typhoid bacillus is measured by the longevity of a bacillus prodigiosus, what is your opinion as to the probality of a typhoid bacillus entering the drainage canal at Chicago, from the sewers of Chicago, surviving the journey down the Illinois river and Mississippi river to the intake tower at the Chain of Rocks at St. Louis, based upon all the facts contained in the foregoing hypothetical question?

A. Measuring the longevity of the typhoid bacillus by that of the bacillus prodigiosus, from the fact as stated in the question that in the large number of examinations made at Lockport and Joliet and Peoria, no prodigiosus bacteria were found at all, and from the further fact that at the mouth of the river and at the intake tower at the Chain of Rocks, and in the water supply of St. Louis, the small number mentioned were obtained, and none at all in a period before the fourth of December and none at all after the 8th of December, the possibility is extremely remote, and it is practically improbable, that a typhoid bacillus with longevity and virility as measured by that of the bacillus prodigiosus could ever survive the passage down the drainage canal and the Illinois river and enter the water supply of St. Louis.

4262 CROSS-EXAMINATION, by Mr. Jeffries:

I am a chemist by profession and have made a specialty, among other things, of sanitary chemistry, in the last twenty years or more. I was connected in the early 80's with investigations made of the character of the different waters by the National Board of Health. The investigations which I made were on the question of impurities in the atmosphere and the measurement or organic matter in the air.

4263 The greater part of the work I have done in the way of sanitary chemistry has been done in connection with the State Board of Health of Illinois and with the Health Department of Chicago. Part of my duty is the teaching of physiological chemistry to the classes of the medical school at Northwestern University. I have given such instructions over 20 years. I made certain bacterial tests in connection with my study of the Illinois river, which I have distinguished from the bacterial tests proper. In my examination of water, I have made no attempt whatever to go into the question of the identification of bacteria. That is a field calling for the work of a specialist in bacteriology, but inasmuch as certain changes or reactions of a purely chemical nature are brought about by bacteria, I have given some attention to the conditions of such reactions. Those are properly of a chemical rather than a bacterial nature. Certain bacteria have the power of producing certain decompositions, which can also be produced by chemical means. For example, the decomposition of protein matters by bacteria are analagous in many cases to those by chemical reagents, and in such examinations as I have made, I have confined by attention to these reactions in using what are sometimes called methods in water analysis.

4264 In all recent examinations I include these bacterio-chemical tests with the others. These experiments are those in which the action of bacteria are concerned, but I consider them as chemical experiments and not as bacterial. I consider both the chemical and bacterial tests of importance in such work, but it would be impossible to state which has the greater value. I think both lines of investigation should be considered.

4265 In some cases that I now recall, the evidence of the bacterial examinations that I made is sufficiently definite to lead to a definite conclusion without appeal to the result of the chemical analyses. For example, in comparison of the Missouri with the Illinois river in 1901 where the bacterial evidence is very strong that the Missouri is a more contaminated stream than the Illinois, I mean the bacterio-chemical evidence as it appears from the purely chemical reactions, brought about by the micro-organisms, the production of indol and the liberation of acid and the coagulation of milk. I cannot determine from a chemical bacterial examination whether or not the pollution spoken of is sewage pollution or from other sources. I cannot tell from my examinations whether or not the bacteria which I discovered are harmless or not. I am not a bacteriologist and can answer no questions involving expert bacteriological knowledge. I do not consider any river water receiving organic matter or drainage of farms or towns as at all suitable for drinking purposes directly. I have not stated that from my chemical bacterial analyses of the water that the pollution is such as to make the water unhealthful.

4266 Q. So your testimony in chief upon the sanitary condition of the water was not altogether based upon the chemical and chemical-bacterial tests that you made of that water, but also in connection with your general opinion upon the sanitary condition of river water?

A. In general, yes.

Q. What is the source, Professor, of the most objectionable contamination of river water?

A. Well, that is a complex question, very difficult to answer in brief terms. The answer to that question would involve a theory as to the origin of diseases. I am not attempting to testify at all as to the origin of infectious diseases, and therefore cannot attempt to tell what is the most objectionable contamination in water. It calls for a kind of knowledge outside of my special province.

4267 I am familiar with what is generally stated by sanitarians as the most objectionable addition to be made to river water. I concur in their opinion in a general way, that is, that certain products of human or animal excretion are the most objectionable substances in water for consumption. I think some scientists agree on the origin of diseases, and on such points in which they agree, I should concur naturally with the belief held in general.

4268 The most harmful source of pollution is that coming from animal excreta. It is measured by the character of the refuse or matter thrown off in this excreta and by the large number of micro-organisms which may be detected by chemical-bacterial tests which I have described and by the relatively large amounts of certain nitrogenous constituents recognized in the chemical tests. There is no way of always determining sharply the origin of all bacteria but where enormously great numbers are found in sewage, from the known facts regarding the production of these substances, the conclusion is, in general warranted, as to where they come from. The general fore-knowledge has to be taken into consideration in reaching a conclusion. In the case of water flowing from a swamp and containing the sewage of some city, it would not be possible to determine the origin of the pollution in most cases. It can be determined only sharply in the case of very strong fresh solutions of either the sewage or vegetable products found and from the decayed or vegetable matter. It is shown by both the chemical and bacterial tests to some extent.

4269 (States how the distinction is made.)

4270 (States the sources of information used in chemical-bacterial tests to assist in determining the source of pollution.)

4271 It is always desirable of course in drawing a conclusion from such examinations, chemically and bacteriologically, to have as much knowledge as possible of all the conditions that obtain in any stream in question—all possible factors should be taken into consideration in reaching a conclusion.

Q. Now, what are the most important conditions of that stream?

A. Well, the character of the watershed—what is called the watershed, the tributaries in the watershed, the character of the water in these tributaries, the abundance of salt deposits for example, as contributing to the main stream or the tributaries, and many factors of this kind which it is always desirable to have in reaching a final and fair conclusion.

Q. Now, can a fair conclusion be reached without that information?

A. I think it would be unsafe in most cases to draw very sharp conclusions without more or less of this information. (See pages 4263 to 4274 inclusive, for information as to what are the essentials in determining the polluted condition of water.)

4274 I have been familiar with the sewerage system of Chicago since 1886. (States the leading features of that system during the period since 1886.)

4276 The Calumet district empties into the lake. Recent legislation will bring it into the Sanitary District. If the whole territory, including this Calumet region were brought into the district it would add above 250,000 to the present population draining into the canal.

4277 It is expected to include sooner or later the district north of Chicago, so-called Evanston, or the North Shore district. At the present time about one-fourth or perhaps a little less than one-fourth of the population of Chicago drains into the lake and the rest into the river. The population of the district now is not far from 2,000,000, somewhere in the neighborhood of 1,600,000 people drain into the river. Because of the flat character of the city of Chicago, the time consumed in the flow of sewage through the sewers is comparatively large, as compared with the time in most of our American cities; the sewage remains a comparatively long time in these sewers.

4278 In general the condition of the Chicago river in this period from 1886 to 1891 has been bad. It has been foul, and there have been perhaps two general kinds of changes taking place here. There has been an increasing amount in general of sewage going into the river, and an increasing amount from the population, and an increasing amount probably from the stockyards. In my testimony, I explained that while there has been at the same time an increasing effort made to retain this filth in the stock yards because of its commercial value, so that it is impossible to say whether much more or much less has found its way into the river. But this, in general, may be stated as now true, that whereas in the former conditions, rather large amounts of insoluble substances, or floating substances found their way into the river, at the present time practically only that escapes which cannot be precipitated or separated by pressure, or by retarding the flow by means of weirs or dams in the sewers. In general, those extractive matters only which are not easily retained are now allowed to escape from the stock yards. Practically all of the fats and insoluble proteids are retained because of their commercial value for fertilizers or other purposes. It would be difficult to say at the present time whether there is more or less actual matter coming from the stock yards than was the case some years ago. The flow of the Chicago river was somewhat uncertain. Still, in general, it was to the west and south. That is this was maintained by means of the pumps at Bridgeport. In flood time, at the time of heavy rains, the flow was very often reversed, and went toward the lake. Sometimes the condition appeared practically stationary, no current could be observed. At other times it was perceptibly more to the south, and at still other times, to the lake. That occurred at intervals of heavy rains. Of course in the main the flow was through the canal. It was south and west. At times of heavy storm for a day or so perhaps, 24 to 48 hours at a time, the current might be in the opposite direction.

4279 Subsequent to 1900 the flow has been to the west and south and not into the lake. From 1891 to 1900 at several periods of short duration each, the flow was out toward the lake, in the rainy season of 1892, for example, there were a number of days when the flow was toward the lake. During the times of these reversals, I made analyses of waters in the lake. These samples were taken about a mile from the mouth of the river and up and down the shore.

4280 From 1886 down to January, 1900, the Chicago river would be considered a very foul water. At the present time the south fork of the south branch is rather foul. The north fork is in general in very much better condition than the south fork of the south branch. The longest series of examinations that I made of the water of Lake Michigan was beginning with 1885, but I made occasional examinations down to about 1900. Since then I have made some more. By far the greatest number of these examinations, at least the recent ones, were published in the reports of the Illinois State Board of Health already considered here.

4281 From my examinations I concluded that in time of flood water some of the pollution of the lake came from the Chicago river. These evidences of pollution existed in the waters taken at Lake View tunnel, Chicago Avenue tunnel, the Four Mile tunnel and from the Hyde Park tunnel, that is, from the four main supplies of the city, have shown a slight increase in these factors. At times there has been apparently a very considerable increase in these factors, and false conclusions have been drawn from observations made at those times. It is now well known that there have been several periods when the water was assumed to come through the tunnels when it was pumped from very near the shore. For example, in 1892, when very erroneous and widespread conclusions were published regarding the source of typhoid fever in Chicago, when it was assumed that the waters were all drawn from the long tunnels, it is now well known that a large part of the water
4282
used on the North Side was pumped from a so-called emergency tunnel, extending out four or five hundred feet in the

lake and ending within the break-water. The engineers, anxious to make a record of economy in use of coal, drew from the short tunnel, delivering a very contaminated supply, and the epidemiologists, seeing the results of this contamination, concluded that the supply from several miles out was badly polluted. At a much later period, which has likewise been very generally discussed, it is known that water has been drawn from sewers in Chicago at frequent intervals. In the matter of discussion why the mortality for certain diseases should be apparently greater in a part of the city which is furnished with the best water supply, this increased mortality having been apparent through a great many years, certain pronounced conclusions were drawn from observations to the detriment of the reputation of the water supplied from the long tunnels. It has since been discovered that owing to very faulty construction in the pumping station, drawing water for one of our supplies, that at frequent intervals in the last thirteen or fourteen years water has been drawn not from the tunnel as supposed, but from the overflow of a sewer into a well in the waterworks, the sewer discharging as much as a volume of ten inches or twice ten inches into the pumping well for hours at a time. I mention this fact because it is to illustrate that it is not always best to draw a definite conclusion from the result of analyses of the Chicago water which came through the taps. The location of the pumping station which I refer to, was on the West Side, drawing water from the so-called Four Mile tunnel—the Harrison street station.

4283 I made some analyses in 1890 of collections made in the lake two and four miles out, at about the location of the tunnel. At that time the water was very good at the tunnels themselves and there was no appreciable difference between the water taken there and the water taken six or eight miles out. The water at these points (the tunnels) is subject to some changes on account of high winds particularly, when there is always more or less sediment washed into the water and stirred up even as far out as the intake of the two four-mile tunnels.

4284 At times of high water the lake water appears somewhat turbid. This turbidity is caused by the deposit of a large amount of substance—a large amount of clay from the construction of a tunnel under the city having been dumped into the lake, also in building one of the parks a large amount of street sweepings has been dumped into the lake at a point largely enclosed by a breakwater. The tests which I mention indicate the presence of this clay substance which I think is mainly responsible for the opalescent condition which is very frequently observed now.

4285 This was not observed in former years. In my earlier examinations of the water of Lake Michigan the water was very clear most of the year. The water at the intakes at the entrances of the tunnels I consider in the main, generally potable. It would hardly be fair to say that it should be considered absolutely safe for drinking purposes at all times. In reaching this conclusion I consider my own analyses. I depend to some extent also on the opinions of those who are making investigations in other lines, bacterial tests proper. They have some weight in influencing me.

4286 Q. Now, do you take into consideration in passing judgment upon that water, its effect upon the people who use it?

A. I will have to answer that question in this way. Inasmuch as it is practically impossible to determine the effect of the real Lake Michigan water on the people who are using it, or supposed to be using it, I am inclined to depend very little on the stated effect. So little dependence do I place on the statements of the epidemiologists and etiologists that I use and have used, without boiling, Lake Michigan water for twenty years.

Q. Did you ever have typhoid fever?

A. Never, sir, and don't expect to.

4287 Q. Then you discredit the reliability of the effect of the water upon people who use it as being any indication whatever of the sanitary condition of the water?

A. No, that is not what I said. I discredit the assumed effect of the Michigan lake water on the people of Chicago, since it has been determined that many of the conclusions have been drawn from, not lake water, but from the sewer water, water pumped almost directly from a sewer. The most weighty and unsound conclusions ever drawn were drawn from water collected in that way. A difference is made between a polluted and an infected water, but not chemically.

4288 A polluted water is one which may contain foreign substances while infected water is one which contains or is assumed to contain the elements of disease. The sources of pollution in water are the adding to the water of trade wastes, household wastes, sewage and practically everything which does not belong in a normal water. The sources of infection I can speak of only in a general way, as I am not an etiologist, a bacteriologist nor an epidemiologist. Infections come from so-called pathogenic bacteria, about which I am not testifying. As a chemist really, in a limited sense, infected water has no meaning to me. As a sanitarian, of course, I should object to the use of infected water.

Q. And you haven't considered that anywhere in your analyses?

A. I have been very careful not to go into a province which is outside of my line of inquiry.

4289 The fact that my chemical analyses did not disclose infected matter in the water does not necessarily mean that no infection is contained in the water that I have analyzed. From the analyses that I have made I cannot determine whether there is infection in the water or not.

Q. Professor, are all pollutions equally dangerous?

A. No, in general, it would be safe to say not.

Q. Of what benefit then is the chemical analyses of the water which you have examined, and which is represented by the tables which you have introduced in evidence here, in deriving knowledge as to the sanitary condition, or information as to the sanitary condition of the water?

A. Well, this chemical knowledge, combined with the knowledge of the origin and sources of the waters in question, permits a comparison to be made between the different waters as to the amount of their pollution. The work is of comparative value.

Q. Then as a chemist, any conclusions as to the sanitary condition of the water from the chemical analyses that were introduced by the tables here, would be unreliable, would it not, so far as infection is concerned?

A. That does not follow, because we must call upon our practical knowledge and practical experience regarding the sources of water, as we know that infection in the general sense of the term cannot and does not take place in water except by the addition of something else, which the chemist can recognize and does recognize. These tables then have some value in measuring the relative danger or the relative safety of water.

4292 I will admit that sanitarians regard certain diseases as water-borne and in some cases where the weight of evidence seems to be very great, I am inclined to accept the opinion of sanitarians without advancing an original opinion of my own on the subject. In determining the condition of the water in the Illinois river, I depended almost solely on the information afforded by my own experience—my own examination of a chemical nature, and what I spoke of as bacterial chemical experiments. I did not take into consideration infection as I have said repeatedly this morning, and I did not take infection into consideration as to the Missouri or Mississippi rivers.

4293 In forming my conclusions I have left out of consideration the question of infection, because it does not come within my province of discussion. I cannot agree with the assumption of counsel in the question that that is the only point of importance to be considered here. I differ from that very decidedly and strongly. For the purpose of the examination that I have made it is not the most important at all. The object of all my investigations has been to determine the extent and rate of destruction of organic pollution in the waters in question and to compare these several waters with each other.

4294 I have declared that in my opinion, none of these waters under consideration are safe to drink, because they receive a large amount of filth of all kinds from innumerable places and whether there is any infection or not, I object to the drinking of such waters; that would include Lake Michigan in case it received an amount of filth at all comparable with the waters in question, which it does not. I still prefer Lake Michigan to Illinois river water as drinking water, even since the canal has been opened. It is not possible to assign a hard and fast rule as to what amount of polluted matter in any water would be necessary in order to make it undrinkable and I should not be drawn in any such discussion as that.

4295 If I should find five parts of albuminoid ammonia per million, in Lake Michigan, I should certainly be afraid to drink it. I have never found one part per million. If all organic pollution consisted of dead and not living matter, the water containing any of it would not at all times be specifically injurious but under many circumstances it would be. A great many kinds of dead organic matter are of such a nature that when taken into the human stomach they would interfere with the natural and necessary and normal processes which go on. There are some of them acting as toxins or poisons, and thereby interfering with normal processes; others because of a sense of disgust which they may arouse, so influencing the normal functions that they will not take place in their usual manner. Dead organic matters of these kinds, and products from dead
4296 organic matter may be in themselves then harmful and injurious from the reasons which I have just given. In sufficient amount they would undoubtedly kill people. The chemical analyses would not enable me to differentiate between dead and living materials, or dead or living organic matter in

the water, but the bacterial chemical tests which I have made indicate the presence of the living organic matter as I have explained on several occasions. Most waters contain both vegetable and animal matter.

Q. But you cannot detect it from the chemical analysis?

A. Chemical analysis would not; that is chemical analysis as ordinarily made would not. I would not like to give a perfectly sharp answer to that, because off-hand I do not want to attempt to limit the power of organic chemistry in detecting certain things.

4297 In presenting my opinion, I make practically no use of the assumed experience of epidemiologists.

Q. Professor, as a chemist, are you able to differentiate between organic matter that comes from human excreta and
that which comes from street washings, barnyards, cat-
4298 tle pens and other places of like character,

A. No, as a chemist, I should not attempt to make any such differentation in the course of water analysis. In forming my conclusion, or in stating my conclusions, I will say that I have not attached much importance to the opinions of epidemiologists, but have in the reports which have been published, referred to the work of others who have made parallel investigations and who will testify when the time comes, whose investigations were made parallel with my own and on the same waters in most instances.

Q. You have never investigated the relations of health and water here at Chicago, or anywhere else, have you, Professor?

A. Not in a very extended way, but far enough to show that the assumptions made by certain epidemiologists who claim that they have made studies of the water supply of Chicago at several periods in the history of Chicago, but not founded on sufficient knowledge of the facts to merit the attention which the publications really attracted.

Q. Now, Professor, will you state the reason why you have thus concluded?

A. I stated yesterday in some detail, one of the main reasons for my lack of faith in the opinions advanced by these infant industry scientists called epidemiologists. It is well known that in drawing their conclusions these people have been so often ignorant of the most important facts in the case, that the conclusions are finally of no value. From my own studies and investigations and from my knowledge of things as a citizen of Chicago, things which I have paid close attention to for over twenty years, I am able to state positively that in several of the most noted of these cases where epidemiologists from abroad have passed on the condition of affairs in Chicago, they were certainly mistaken in their conclusions. For instance during the World's Fair, when a good deal was said about the infection of Lake Michigan water, a good part of the supply in
4300 one section of the city was drawn not as was supposed—
from the Chicago Avenue tunnel, extending out about two miles, but from a short, or emergency inlet—a short tunnel extending out to a distance of about 500 feet, to be used in case of emergencies, in case of a large fire for example. At that time the pumps which were at work in the pumping station at Chicago Avenue, were generally in pretty poor condition. There was frequent complaints of the amount of water which they could pump. There was very frequent complaint of lack of sufficient head to carry the water above the first or second stories of the buildings. At that time in order to lesson these complaints it has been established by investigations, as will be explained, that water was drawn by the engineer in a large quantity and through a very considerable period from the short inlet. This water was very dirty. It was drawn from a point where there was considerable contamination from dumpings and washings and sewers and so on. Therefore I say that the conclusion that the water from the two-mile tunnel was the source of the disease which the epidemiologists described at that time, is not a fair conclusion. At a later period, last year, through the spring and summer of last year, there was a remarkable epidemic of typhoid fever in Chicago. It was a very singular fact—puz-

zling in fact—that the greatest prevalence of this appeared to be in a part of the city which received what was supposedly the purest water drawn from the longer tunnel, and a great deal was written and expressed in public addresses, in regard to the infection of the water at that great distance, shown from the appearance of the fever in this part of the city. It was later discovered, some time in June, I believe, that through some accident or oversight which occurred many years ago—how many we cannot say definitely, perhaps over ten or fourteen years, certainly at a period beyond the recollection of the men employed in the pumping station—a connection was left between a well in the pumping station and a sewer, so that at the time of high water, at the time of heavy rains, it was possible for one of the large sewers in that part of the city to flush over and throw a great volume of foul water through a ten-inch pipe, into this well, so that it could be drawn into the supply. That fact is known to many people in the city and in the engineer's office.

4301 I state that here then as a further explanation of why I am not willing to accept the determinations of the etiologists and epidemiologists. I am referring principally to people in Chicago who made these complaints of last year, that the source of the infection must be referred to Lake Michigan. It is evident that that was not the source of the pollution in the mains in that part of the city. Those are two and, I think, sufficient illustrations for all practical purposes. I recognize that the relation between the water and the water-borne diseases is a proper subject of study and that certain people are engaged in this very study and have been for some years

4302 back. I have not tried, from a chemical standpoint, to make it a study because in the employ of the State Board of Health there is a competent bacteriologist and etiologist, to whom these questions are always referred.

4303 The amount of sewage coming from the stock yards has been greatly reduced in late years since the commercial value of the substances going to make up the sewage has been recognized. Everything is separated in the packing houses

themselves and also to some extent in the big sewer outside,
which is the one main which drains most of the packing houses.
The amount of substance which actually passes through this
Brennock sewer I think I stated was about 90 tons a day of or-
ganic matter, through the period of 1899. In 1886, it was about
112 tons daily. The amount of nitrogen corresponded
1304 very closely to the amount of organic matter. On the
basis of 250,000 cubic feet of water per minute for 24
hours, this 90 tons of organic matter would make, expressed in
parts per million, 90 parts per million of organic matter. For
nitrogen it would be about 14, but I would not to put this in as
as an absolute calculation until I look it over.

4306 I have stated that in 1890 and 1891 I estimated that five-sixths of the sewage in the stock yards refuse entered the Chicago river and passed into the Illinois and Michigan Canal.

4307 That estimate was made by comparing as well as possible the amount of matter contained in the water west of Bridgeport, that is, the pumping station, with the amount discharged as near as I could estimate it, from the stock yards and other sewers. The investigations were made largely, as I now recall them, in the fall and winter of 1890 and 1891. 130 examinations were made. The larger part were concerned with the stock yards sewage itself. (Witness states how stock yards' examinations were made.)

4309 When a freshet happened, it did not flush out all the sewage that had been deposited in the Chicago river. This freshet from the Des Plaines would carry out practically only that part of the sewage which was in the south branch between the main river and the pumping station. This Des Plaines freshet would not affect the north branch or the part of the south branch south of Bridgeport. Freshets have very little effect on the north branch. I have seen the Bridgeport pumps many times during a period of ten years. There was no subject in Chicago more frequently discussed and on which more varied opinions were given than on the capacity of the Bridgeport pumps and it would be foolish for me to attempt any accurate definition of what they did. The remaining one-sixth of the polluted matter that entered the Chicago river in 1890 and 1891 but which did not enter the Illinois and Michigan canal was destroyed by decomposition and through bacterial agency.

4310 At times a portion of the sediment must have found its way into the lake. From 1886 to 1900 I am not able to make any definite statement as to the condition throughout all of the river, but in extreme south part of the river there was always a very considerable collection of sediment and in certain parts of the north branch. There were changes going on all the time in the river as in all streams with large amounts of organic matter in them. There was constantly arising foul and putrid gases from it during that time. I always believed that gas refuse had something to do with the odor of gas in the river.

4311 Prior to the opening of the drainage canal, some of the conditions for decomposition in a part of the Chicago river, were doubtless somewhat better than after the opening of the canal. They were better in this particular, that since the opening of the canal, in a certain stretch of the river, less time is given for the oxidation or for the completion of these changes than before. I have not made any examinations of the water since the opening of the canal.

4313 The source of pollution entering the Illinois and Michigan canal since July, 1900, is, as before, the combined house and general industrial and stock yards sewages.

4314 It is very difficult to give a sharp and definite answer as to the flow in the old Illinois and Michigan canal. In 1900 the flow was assumed to be about 50,000 cubic feet per minute. It is generally believed and I have used this acceptation in my experiments, that the flow was nearly 35,000 cubic

feet per minute. In the main drainage canal the flow is approximately 250,000 cubic feet per minute. As to the conditions for the purification of the water in the Illinois and Michigan canal in 1886, my recollection is that the experiments showed
4315 a nearly complete destruction of the organic matter or the breaking down of the nitrogenous products. The loss of organic matter was very marked between Bridgeport and Lockport. This reduction being shown particularly in the change in the free ammonia to the albuminoid ammonia and also in the oxygen consumption, the amount being reduced, the amount as indicated by these determinations being reduced to one-half of what we had at Bridgeport. In 1899 at the same place, and for some reason which I am not able to assign in detail, practically no change in the free ammonia, the albuminoid ammonia or the oxygen consumption was observed between these same points—Bridgeport and Lockport. I know of no conditions positively, nor have I any definite knowledge which would account for the difference in the purification observed in the Illinois and Michigan canal from the analyses of 1886 and those of 1899. I should regard the sewage matter from Chicago in its original condition as detrimental to the quality of any water supply with which it was mixed.

4317 When I stated that in my judgment the sewage matter from Chicago was not injurious to the water supply of St. Louis, I was relying upon the purification which takes place enroute, and assuming that that purification is of the kind and extent such as has been shown by my analyses. These analyses cover all of the conditions which I considered necessary to reach the conclusion expressed. They cover some periods of high water, probably not the maximum or excessive floods. To some extent they cover cold weather periods also. In the recent analyses I don't recall that the river was frozen over when samples were collected, since the canal was opened. I don't know that it freezes over.

4318 No investigations were conducted by me personally throughout the whole year.

Q. Professor, if a very marked purification was obtained in the Illinois and Michigan canal in 1886, and practically no purification in 1899, the conditions remaining the same, is it not possible that the conditions of purification as you have observed them since the opening of the drainage canal—since the drainage canal has been in operation, have been at times changed in some way, unknown to you, so that the water has passed down the Illinois river with a lack of purification corresponding to that which you observed in the Illinois and Michigan canal in 1899?

A. No, I would not be willing to admit that in general, because in leaving the Illinois and Michigan canal, the disturbing factors which interfered with the oxidation in 1899, have evidently largely disappeared, because of the observed fact that the oxidation has gone on further down. The pouring in of this canal water, in which the oxidation in that later of second period, was very much retarded, into the river below apparently restored the conditions of oxidation, so we find a better effect below than would be pre-supposed from what we observed from the canal itself. Hence I would not like to conclude, or would not conclude that there might possibly be conditions interfering with the oxidation in the whole river below.

4319 I make positive statements only about the periods which I have covered in my investigations and where I speak of other times at all I only speak from analogy with those that were in existence at the time I made the examination. I have not made examination as a sanitary chemist of the condition of water in any river when it was completely frozen over with ice.

4320 In general I would consider the question of temperature and all questions of the exclusion of air by ice, as having some bearing on this question. It is in general true that the changes which we describe in broad terms as oxidation are more characteristic in the summer season than in the winter season.

The investigations made in the early part of 1900 I think came nearest to the observation in flood period.

4321 The high water did not continue through the entire series of examinations that I made at any one particular period. The samples were not taken during any of those periods for the purpose of determining the conditions that existed all along the river during that flood period, following the flood from its source to the mouth of the river.

4322 I did not and have not said at any time that the water of the Illinois river at its mouth at Grafton could be considered as a good suitable water. As to the second part of your question, whether this water is less pure in the colder season than in the warmer season, as measured by these several factors, I would say yes. They indicate a much less degree of oxidation in the colder weather than in the warmer times, but at no time would I consider them good, wholesome, safe waters. The degree of purification in February and March of 1902 as compared to the results shown from the examinations made in the summer of 1901 as measured by the oxidation of ammonia is decidedly less, but free ammonia when it appears is one of the last stages in the oxidation of organic matter. The main stages have been long past.

4323 That condition is reached largely by one portion of the substance in sewers before it reaches the outlet of those sewers. One of the common products in sewers in urea, which represents a very large fraction of the excretion of human urine. Urea is a body which undergoes hydrolysis very rapidly, and it breaks down, yielding ammonia, and therefore ammonia does appear early in the sewers. I do not know absolutely what time the ice breaks up on the lower Illinois river.

4324 From my recollection of 1899 and the summer of 1900, the seasons were pretty dry and the water relatively low, but as to whether there was extreme low water or not I cannot say.

4325 Q. Is there any way to determine from the standpoint of a chemist whether the pollution in the Illinois river at its mouth is sewage pollution or pollution of some other character?

A. I should not attempt to make any such characterizations there. In general I should object more to the water from a sewered region than the water from an uninhabited region.

4326 The Missouri is usually a very much greater volume than the Illinois, both receiving large amounts of organic filth. I should consider from general knowledge of the situation a part of the organic matter discharged at Omaha, Council Bluffs, Kansas City and other points as very objectionable. As compared with the pollution of the Illinois river by Chicago, and most especially by Peoria, I consider the pollution from the household waste and stockyards industries of Omaha and Kansas City as small, comparatively, or relatively smaller than the amount of pollution from these places, but it is still large. From these sources it is considerably smaller than the original discharge at Chicago. As a sanitary chemist I should feel that the discharge of the sewage of Omaha into the Missouri river and coming down very rapidly in a swiftly flowing stream, would be a factor to be considered as affecting the sanitary condition of the water of the Mississippi river at St. Louis.

4327 As I just stated for the Missouri river, the discharge of the sewage of Chicago into the Illinois river would be an extremely important factor to be considered in forming any opinion regarding the purity of the water at the mouth of the Illinois river.

Q. And for the same reason it would be an important factor for St. Louis?

A. It would be a factor to be considered in any case.

Q. Now what is your opinion as to the strength of that as a factor.

A. From the tables which I have presented, and from the curves which I drew, illustrating some of these tables, I made the statement that I believed the pollution from Chicago is the least important, and a comparatively unimportant factor in any residual pollution left at the mouth of the Illinois river.

4328 All these things are factors to be considered of course, but I stated further that the determinations made through these investigations, show a larger amount of organic matter as measured in the usual way at the mouth of the Illinois river, than can be well accounted for by the contribution of the tributaries and the contribution of Peoria, so that the Chicago contribution is completely covered up and lost sight of and minimized as compared with the other. I would say decidedly that there is not more known harmless organic matter in the Missouri river than there is in the Illinois river. We have no proof that the products of organic decomposition left in the Missouri river are any less harmful than the decomposition left in the Illinois.

4329 Well, there is a great deal of nitrate in the Illinois river, more than in the Missouri river, which simply indicates this, that there is a larger amount of nitrites in that form which has yet to be oxidized, whether that nitrogen came originally in ammonical form, or from the nitrate form, we are absolutely unable to determine. In drawing a conclusion from the observation of organic matter I should want to know—as I explained yesterday, that a chemist should know, in all cases—something about the original conditions along the river giving rise to this organic matter. I know about the source of the organic matter in the Missouri and Illinois rivers. I should consider the comparison a perfectly fair one. The organic matter left in the river is in itself harmless. That must be admitted. The organic matter as such is harmless in its advanced stage of decomposition. The comparison therefore is a fair one. It is harmless as far as chemical tests show and undoubtedly as far as any test can show, that this residual organic matter must be harmless in either river; that is as far as its capability of

producing disease is concerned. It should be condemned for drinking purposes because I have stated in general that I should condemn water containing any large amount of substance other than water for the reason that along with this organic matter other things may enter which are not harmless. This organic matter of course supports a certain amount of organic life which I object to. I object to that from the opinions of the class of sanitarians referred to who have worked modern theory of diseases, (I cannot give an original opinion) that some of these living forms of organic matter are the important agencies in the production of disease; that is, I borrow from the knowledge of others in coming to a conclusion regarding the harmfulness of the living organic matter. I take that into account as a factor in comparing the waters of the Illinois river at its mouth with those of the Missouri at its mouth. I referred distinctly in my statement yesterday to the fact that the determinations measuring what is called the bacterial contamination in the mouth of the Missouri are more pronounced than those in the mouth of the Illinois. By bacterial contaminations I mean the presence of those organisms which are able to decompose complex nitrogenous matter, break down complex nitrogenous matters and yield the aromatic compound or substance known as indol, that very long experience has shown to be a reaction produced in waters by certain kinds of bac-
4331 teria, a reaction which, however, can be brought about in laboratories by other agencies. In addition to this, we include in this pollution all those substances or bodies which are able to decompose carbo-hydrates, with the liberation of acid, which is recognized in turn by its power of coagulating milk. If, therefore, we expose milk to the action of water under proper conditions, the speedy coagulation of that milk points to the presence of a relatively large number of these micro-organisms which decompose the sugar in the milk and liberate the acid, which precipitates the casein of the milk, and further, in addition to that, we detect the presence of these microorganisms by the activity of the liberation of certain gases,

when the water is mixed with a solution containing a constituent which the bacteria will decompose with the liberation of gases. Certain carbo-hydrate substances are decomposed by the bacteria yielding several gases, particularly carbonaceous gases, carbondioxide gas, some of them cause even the liberation of methane. These factors are pronounced in the Missouri river, more pronounced there than in the Illinois river. These things simply point to the presence of a certain kind of pollution, the presence of certain micro-organisms which may or may not be pathogenic. I pronounce no opinion on that. Ammonia and albuminoid ammonia indicate an original pollution with, at some time, nitrogenous matter of some kind. What, I will not attempt to say. The oxygen consumption reaction indicates also the presence of organic matter in the water, because we know from long experience that the mineral substances in the water are not able to bring about the production of permanganate in this way.

4332 I will say in general that I cannot draw any very sharp conclusions from the above as to the character of the pollution contained in the water.

4333 I don't know that any micro-organisms ever get to Grafton from Chicago. I should judge from these reactions that there are micro-organisms there but whether they are Chicago micro-organisms I don't know. There is no way of making such determinations from the standpoint of the science of chemistry and bacteriological chemistry. In general it is true that there is a greater degree of reduction of micro-organisms and pollution in the summer time than in the cool seasons of the year, but the bacterial chemical tests at the mouth of the Illinois river at Grafton in the cool or colder seasons (February and March, 1902) do not show a markedly greater or appreciably greater contamination than during the warmer sea-
4334 son. The presence of some of these bacteria is suggestive of the presence of substances which are widely decomposed, or greatly decomposed. We have nothing present which can yield indol, and the bacteria which thrive on these matters so

decomposed, therefore, tend to disappear. Now, the fact of the absence in general of these bacteria at the mouth of the Illinois river, is a very strong suggestion of the breaking down of the original protein matters beyond that stage where such bacteria thrive, certain bacteria thriving, as we know from chemical experience, on original protein matter, or protein-like matter not far removed from the original protein matter, either on original protein molecule or the albuminoid molecule or the peptone molecule derived from it, but as we continue disintegration, or breaking down of these molecules, we reach gradually bodies which will not support certain kinds of bacterial life, that is, where the original proteins can support certain kinds of bacteria, the more advanced products of the decomposition of this protein cannot. The absence of these bacteria then, through the investigation made at the mouth of the Illinois river, is a very strong suggestion of the practical absence of that kind of matter.

4335 So far as I know these indol producing bacteria are not what bacteriologists call pathogenic or disease bearing.

4336 (Witness is told to refer to Table No. IV giving result of analyses of water at Grafton in February and March, 1902, and reads the rapidity of the coagulation of milk from certain samples.) I will state that I do not know from what source these bacteria which coagulate milk, come; but since the matter has been referred to, I will state that the Illinois as compared with the Missouri river shows a very much less marked indol reaction in the Illinois than in the Missouri. We have production of indol twice in thirteen cases in the Illinois, while
we had six times out of eight for the Missouri. The ab-
4337 solutely exact significance of any one constituent contained in the water would be extremely hard to give—practically impossible, but as to whether there is any particular case or instance throughout my whole examination of the water in the Illinois river where any two of these properties enable me to determine the character of the pollution so far as the wholesomeness of the water was concerned, that is fairly easily

answered. I find a certain very large amount of albuminoid ammonia, for example, at Peoria. I can say that the pollution occasioning that is highly nitrogenous. I can say that without hesitation it is more than comes from any ordinary source and I should condemn the water immediately on that determination alone. There is no gradual scale by which ammonia in the water may be reduced until it becomes permissible which will obtain for all waters. We have to judge the waters very largely by what we know of their sources.

4338 I will state as I have said before that I cannot attempt to state exactly the character of the residual pollution at Grafton, whether from two or from all of the chemical determinations I have made. Nitrites in water are not necessarily characteristic of animal or organic matter. The fact that they may come from the oxidation of ammonia or from the reduction of nitrates shows that they cannot be taken as characteristic. They are not necessarily more characteristic of sewage pollution than of pollution of some other character. It would depend very largely upon the drainage area in which the water is found.

4339 Take two rivers with cities situated on their respective watersheds, which discharge their sewage into those rivers and the samples of one water show an average of .034 parts of nitrogen as nitrites, and the other show .0006 nitrogen as nitrites, it would not be possible to draw any very sharp conclusions from such a consideration. The large amount of nitrites in one place you have mentioned, may come from imperfect oxidation of ammonia, but it may come from a reduction of the nitrate already formed, if this nitrate happens to be present with a considerable amount of fresh organic matter, for instance, such as would be left in the stream by the death and decomposition of water plants. We have there a condition similar to that which has been observed frequently by agricultural chemists; there the reduction of nitrates may follow. So far that fact it is very difficult and practically an impossible matter to draw any conclusions from the case you state. If you eliminate everything from the water of those rivers save the sewage discharges of the cities, my answer would be the same, because the products of decomposition of sewage in some stage may bring about a large growth of water plants which dying off in the presence of nitrates—products of oxidation, would lead to a reduction of these nitrates and a reduction of nitrites. That is the case any way you look at it.

4340 We do not know whether the condition is one of advanced oxidation or a retrograde change of reduction. If the nitrites were accompanied by very high free ammonia, it might still just as well follow that we have a reduction of nitrates to nitrites in the presence of organic matter. The presence of free ammonia would not interfere with that fact at all. The fact that on the banks of the river is located a large and populous city of 1,500,000 people would have some effect on those results in the way of discharging sewage from such a large population.

Q. Isn't it reasonable to expect from a scientific standpoint that as the population increased, as the sewage discharge from the city increases, that these particular properties will increase and be shown in the chemical analyses?

A. It would necessarily follow that there must be an increase in the products of carbon dioxide in the various amido and aromatic compounds, in the ammonia produced and in the nitrates produced, but of the subsequent reactions between these things themselves, it would be very difficult to say very much from the present state of our knowledge of just how those changes were all brought about.

4341 It is natural for scientists to expect large results in these different properties and forms of nitrites or nitrogen coming from the sewage of a large and populous city. From a large protein discharge we would naturally expect correspondingly large amounts of nitrates, whether it be from the city or the distillery or a cattle shed. Such as, for example, are in the city of Peoria, in the State of Illinois. I believe as a rule, nitrites and free ammonia run higher in the Illinois river at its mouth than they do in the Missouri river, but it doesn't follow that the Illinois is more polluted than the other streams because the pollution is measured by many factors in addition to these. Free ammonia is considered as a measure of sewage pollution, but nitrites absolutely not, as it has been shown so conclusively by the investigations of agriculturalists that nitrites can come just as well from the reduction of nitrates, as from any other source.

Q. Now, Professor, speaking of free ammonia and assuming that it is indicative of organic matter of animal origin, give me the average amount of free ammonia disclosed by your analyses at Grafton of the Illinois river for the year 1900?

A. For the summer of 1900 we have left at Grafton in the Illinois river an amount of free ammonia measured by .07. In 1901, through the late season, the summer, fall and early winter season, we have .238. During the spring of 1902 we have left free ammonia at Grafton, an amount measured by 1.344.

4342 If, as assumed by the question, the only indication of organic pollution is that of free ammonia, then I should answer affirmatively, that the Illinois river in 1902 in the winter appears to be more contaminated than in the summer of 1900, but as we have other measures of organic pollution besides free ammonia, it would be necessary to consider them before drawing a final conclusion for the whole case. The nitrites increased in 1901 over those of 1900 but there is not much difference, there is a trifle. I could not tell what was the cause of this rise in free ammonia in 1901 over 1900. The large amount of free ammonia in the spring of 1902 indicates a lower degree of oxidation, that we would naturally expect from the colder season. Whether this is due to the great increase of material at Peoria I have no means of knowing, as I made no determination of Peoria at a corresponding time. Assuming that the deposits from the cattle sheds and distilleries of Peoria decreased during the years 1901 and 1902 I would say in general that the oxidation of this factor is not as far advanced

as in the other seasons, that the breaking down of the pro-
4343 teid from the more complex stage, or the breaking down
of the nitrogenous matter from the complex proteid stage
has apparently gone practically as far, but the oxidation of
the ammonia as one of the products of this decomposition has,
for some reason been delayed. It does not follow that no correct
analyses could be made upon which a credible opinion could
be based, unless the analyses be taken for one end of the year
to the other. I insist that the opinion I have given can be be-
lieved as much for these analyses as for any other. I believe
the analyses which I have presented represent correctly the
conditions of the river at Grafton at all times of the year.

4344 Assuming that Chicago would grow to sufficient size and
proportion from the standpoint of population that its
sewage discharged into the canal and thence into the Illinois
river would produce the same ratio of increase in free ammonia
at Grafton, I would say that it was a very bad water to show
such an increase in the amount of ammonia. I believe that in a
general way the period of beginning oxidation has been some-
what retarded in the Illinois river by the opening of the
canal.

4345 I made an examination of the Mississippi river water
above Grafton in the late fall and early winter of 1901
and the spring of 1902, probably 25 to 30 examinations in the
fall and 10 or 12 in the spring.

Q. Now, Professor, suppose that you had made a series of analyses of water on both sides of the Mississippi river at St. Louis, for a long period of time, and that you had found that organic nitrogen in its different forms invariably ran so much higher on the Illinois shore than on the Missouri shore, and suppose further that you had also made analyses of the water of the Mississippi at a point above Alton, and of the water of the Missouri river above its mouth, for a long period of time and had found that organic nitrogen always ran higher in the Mississippi than in the Missouri and suppose that you had also made analyses of the Illinois at Grafton, and of the

Mississippi above Grafton, and had found that as a rule organic nitrogen in its various forms was higher in Illinois than in the Mississippi, what would you say as to the effect of the Illinois river upon the water of the Mississippi at St. Louis?

(Objected to by Mr. Todd on the ground that the facts predicated in the question were not based on the evidence.)

A. If I had ever made such analyses and had obtained such results, I should of course be obliged to attribute the high nitrogen in the Mississippi to the Illinois, but I do not believe that such results are found or ever have been found in any such examination in any given period of time.

4346 Eliminating all other sources of pollution of the Illinois river save that caused by the sewage of Chicago, if I found that the water at the mouth of the river disclosed large quantities of organic nitrogen, in excess of that found in the tributaries of the Illinois, flowing through farm lands, tributaries not contaminated to any large extent by household drainage or sewage; then I should say that the organic nitrogen starting from Chicago had not been completely decomposed, but as a matter of fact at the mouth of the Illinois we do not find any such condition, even with everything which is added. At the mouth of the Illinois the condition reached, considering all circumstances, is so close to that found in the tributaries, that the supposition made is impossible. I mean to say that at the mouth of the Illinois river during flood times; times of high water, because of the spread of this water over enormously great area, the fraction of contamination starting from Chicago has been so far reduced by this dilution that any effect which it might have in retarding oxidation is fully counterbalanced by the enormously greater dilution and that condition of the Illinois river so far as the original sewage is concerned I believe is no worse then than at any other time.

4347 Assuming that the land over which there is an overflow in high water was levied, then conditions would be changed and we would find a difficult result.

4348 In determining the aggregate amount of pollution flowing into the Mississippi river from the Illinois at Grafton, I would not consider the total weight in the whole river. That is the least important factor to be considered. If we consider the whole weight of common salt, for example, in Lake Michigan, we would have enough there to poison an army. In the Illinois river we do not care, nor should anybody care what the total amount of pollution is. We are practically concerned there, and in every other case, only with that part which is contained in a given volume.

4349 The increased volume of flow in the river is a very important element. The increased flow in the Illinois river will put 20 times the volume of water at St. Louis than that which was discharged through the original Illinois and Michigan canal; with a dilution of 20 times and no possible increase of contamination beyond perhaps 50 per cent, it is perfectly preposterous to think that there should be a larger amount of organic matter from Chicago in a given volume reaching the mouth of the Illinois under such conditions. In that answer I have taken into consideration the condition of the Illinois river as it existed prior to the opening of the canal and the condition of that river as it has existed since the opening of the canal. I have been familiar with the Illinois for 18 years. I have compared the volume of flow in the Illinois river before the canal was opened, with the volume after the canal was opened, the amount of sewage going into the canal, in the old Illinois and Michigan canal, with the maximum amount which can go into the canal when the proper sewage connections are made in Chicago.

4350 Frequently in the Illinois river, before the opening of the canal, it is a fact that the water was low. At times it was very low; but in those times, however, the Illinois river water received from a source outside of Chicago a very much greater portion of—or a somewhat greater portion of contamination than it does at the present time. The increase of water in the Illinois river has not carried any corresponding increase of contamination from Chicago at all. This increase of water has not been sufficient to impede in any material way, the rate of destruction of organic matter. As a matter of fact we find today at the mouth of the Illinois river in general a better organic condition than was found before the opening of the canal.

4351 I will say, as determined by my investigations, that the condition of the Illinois river at its mouth after the opening of the canal is very much better than it was before the opening of the canal. It is evident from this fact that the conditions for the destruction, elimination, and reduction of organic matter must therefore be better now than they were in 1899.

Q. Now, Professor, with a slow current, with practically no current at times, with the life period of all bacteria limited, with the period of the breaking up of the solid parts in water limited, I will ask you if it is not more reasonable to believe and if it is not according to the experience of scientists, upon the subject, that the solid matters and the decomposing matter that came from the source of the river prior to the opening of the canal, was more readily removed before it reached Grafton than it has been since?

A. In answer to that question I will say that I base my conclusions simply on the record. I cannot go behind that, the record shows the reverse of what you assume in your question.

4352 Assuming that it will require 20 days for the water in the Illinois river to run from its source to its mouth prior to the opening of the canal and that it requires ten days since the opening of the canal, this time limit can have no possible bearing on the question of the determination of the fact whether decomposition has taken place more rapidly or not, because chemical analysis is made irrespective of the rapidity with which the water comes down there.

4353 Dilution does not necessarily destroy but it renders less probable an effect in proportion to the extent of the dilution. The effect diminishes as dilution increases.

4354 I have not compared the gross pollution of the Missouri with the Mississippi, or the gross pollution of the Illinois with the Mississippi. I say that for all practical purposes, for the purposes of household use, such a comparison is absolutely valueless and absurd.

Q. But, Professor, you gave an opinion as to the sanitary condition of the water of the Missouri river. Now I want to know whether or not you considered the question of dilution in passing upon the condition of that water. Yes, or no?

A. The question is unfair because as I have stated myself several times, the only practical problem we are concerned with in considering waters, is not the gross pollution in any large amount, as a lake, sea or the ocean, but the pollution appearing in a given volume. It makes no difference what the volume of the Mississippi river is, or the volume of the Missouri, or the volume of the Illinois, or the volume of Lake Michigan. The chemist is concerned therefore only with that amount which one is liable to come practically in contact with in his daily usage as drinking water or for household purposes, and parts per million or grains per gallon or any other unit per given volume is the only thing which a practical man has to take into consideration at all.

4355 I haven't attempted to determine in all cases from chemical analyses alone the sanitary condition. I believe no chemist would make as broad a claim as that. I do not know what the sewage discharges of Kansas City, Council Bluffs, etc., in fact the whole drainage of the great Missouri valley, with its tributaries entering the river, amounts to, but it is unquestionably large.

4356 As I made no such examinations in giving my opinion as to the pollution of the Missouri river in parts per million, of course I have never considered the amount of sewage flowing in. It would not be necessary to consider it; I know it is there. In expressing results in parts per million, dilution is a factor that goes in—volume as compared with the amount of stuff present. The dilution factor enters right into that opinion every time it is given. My opinion regarding the Illinois river as to dilution is based on my experience as an analyst. It is based further on my experience as a pretty close observer extending back through a period of 18 or 20 years.

4358 In my opinion, the sanitary condition of water can be determined by chemical analyses of that water, regardless of the source of pollution or drainage territory of that river in numerous cases. As an exampie, if I should be sent a jug of water taken from the river at Joliet and analyzed it, I could determine in one-twenty-fifth of a second that that was pretty poor stuff to use. I would not recommend it for household use. If I were to be sent a sample from the Mississippi or the Missouri without knowing anything further, I should not be inclined to give a very definite opinion on the results of one examination, and should not. If I were sent a sample of water with the statement that that water flowed through no natural salt beds, the soil of which was not of a saline character and that the sample so analyzed would disclose from 12 to 15 parts per million of chlorine, I would say that it contained so much salt, that is all I could say. I could not express an absolutely definite opinion as to the source of that salt, but I should be inclined to think that it had been exposed to some organic contamination somewhere, if all the assumptions in the question were correct. The presence of the chlorine however, does not necessarily imply the absence of deleterious matter. I suppose most of the water that passes through the canal and enters the Illinois river at its source, reaches the Mississippi river at the Chain of Rocks, subject of course to evaporation and absorption. When that water reaches there it is necessarily diluted. The only constituents of the sewage of Chicago which would remain with that water in its journey down the Illinois river would be the mineral or organic. They are the only ones of which we can say with certainty that they must remain largely, or in the main.

4360 The organic bodies are those on which the bacterial destructive processes are carried on. These are the substances which are changed and altered and in many cases absolutely destroyed. These processes change the form and change profoundly the character of the organic matter. I think beyond all question there must be some organic substances of stable type which remain for long periods unchanged in natural waters. What these are it would be very difficult to say.

4361 We cannot determine whether they are living or dead organic matter but the so-called bacterial-chemical test would give us an indication of the presence of living substances.

4362 Q. Then if I understand you correctly it is possible that some of the residue and bacteria from Chicago deposited in the Illinois river, remain with that water until it reaches the Chain of Rocks?

A. You have involved two assumptions in your question which do not at all go together. While it is possible that the ring structure residues may remain, which bodies are of a remarkable stable character, it would not follow that bacteria leaving Chicago would exist one one-hundredth of the time or distance.

4363 It would be perfectly absurd to assume that because various stable bodies can pass down the river that the very unstable substances should likewise be able to pass down the river.

4364 Inasmuch as in spite of all the investigations which have been made no one as yet has found a disease germ passing from Chicago to St. Louis, I do not believe that a disease germ would pass.

4365 As a chemist pure and simple I do not know that these diseases producing materials or substances of a living character do not pass from Chicago to St. Louis, but I am not aware that any one has ever discovered their passage. Inasmuch as through these investigations they have not been discovered, I am justified in taking the position that they are not there. Not being an etiologist or bacteriologist, I cannot speak from that standpoint but from the standpoint of an educated layman I should think the probability of death and destruction following in St. Louis, the detection of one typhoid fever bacillus, is so absurd as not to be worthy of consideration. 10,000 samples taken in two years, the examination of only one cubic centimeter being made at each time, would be 10,000 cubic centimeters of water. Reduced to gallons this would be something like two and one-half gallons and would be an infinitisimal part, of course, of the water flowing in the Illinois river during those two years. My statement of opinion that there were no typhoid germs in the water, was based on the experiments of others and from the standpoint of an intelligent layman and not of a bacteriologist. After these thousands of examinations have been made and none found, there was no evidence apparently that they were there.

4369 It is my individual opinion as a layman that because out of these thousands of investigations no disease germs have been found, it strikes me as highly improbable that there is any reason for assuming that they are there.

4370 Going back to these live organic substances, following the various specific organic matter found in the waters of the Illinois river and the residue of the organic matter, I would say in general that it does not follow that these small particles of injurious substances that may follow will more readily reach the Mississippi river during high stages of the river than during low stages, for the reason already explained that because of the character of the pollution in spreading out in the waters over the land, the probability of any single thing reaching the mouth of the Illinois river from the drainage canal is correspondingly diminished. While great dilution increases the stream flow it at the same time increases the stream expanse covering an enormous area for sedimentation and settling and loss of organic matter. I have said that a very large part of the discharge from the canal is spread out over a broad area of land upon the river. That part of it is not spread out which remains in the channel of the river, but at the time of flood this part is but a fraction and even a very small fraction of the whole. The dilution does not necessarily mean the absence of the germ. Whatever matter is there is distributed through a larger volume. Inasmuch as bacterial activity is less

4371 in winter than in summer time, it is altogether probable that the amount of material passing down the river in the colder season, is greater than the amount passing down the river in the warmer season, how much greater I don't know. The characteristics of a septic tank, exclusive of air, is the presence of certain bacteria. The exclusion of air is a vital consideration in certain kinds of septic tanks I believe. I have not testified as a sanitary engineer and do not care to go into any description.

4373 I have some little knowledge about septic operation of the water in sewage in the Chicago river prior to the opening of the main drainage canal. For the purpose of the comparison I have described the conditions in the Illinois river as comparable with those conditions which obtain perhaps more or less perfectly in the operations of a septic tank; I have observed the conditions in the old canal and in the river before the canal was built, and also in Peoria above Pekin, at Wesley, and these conditions seemed to be analogous to those which would obtain in a septic tank. The operations which I have noted at those places are largely the disturbances due to the liberation of gasses and in some cases I have observed also a coating or scum over the water which is described by the people who were in charge of the operation of these septic tanks as a peculiar thing very frequently noticed in them. I do not recall ever noticing anything in the main canal of that character before Joliet was reached, but I have observed after the opening of the canal, the same thing above Pekin.

4374 I observed the important fact of a large amount of filth added at Peoria half way down the Illinois river and it doesn't concern me at all and does not enter into the problem as important whether there is dissolved oxygen there or not. I would not be prepared to admit that in an investigation of any kind the presence or absence of dissolved oxygen at Peoria, Wesley and the mouth of the river, cuts any figure at all.

4375 I am not prepared to state the amount of dissolved oxygen because as I said several times, I did not determine it, but I am glad it has been determined. In the lower part of the river I have no doubt that the testimony will show it was abundantly present.

I did not take cross sections of samples in the Illinois river at Peoria or at Wesley, but in my examination of the water at Wesley, in company with the engineer of the State Board of Health, Mr. Jacob A. Harman, I spent considerable time in looking at the river and determining the point at which the mixture of the cattle sheds and distillery wastes or discharge, with the river water was practically complete and uniform. We decided finally on a place far enough out to secure what I considered a very fair representative sample, neither exaggerating or diminishing the average condition of purity there.

4376 At that time in 1899 there appeared to be considerable of this operation which I have described as septic, that is the liberation of more or less gas in places, from the river. As I recall now this action was pretty general at a point below Wesley. When I state that I had a fair sample of the water in the river at that point I say so from my observation of the water at that time.

4377 I made no cross-section there. These samples were taken probably a quarter of a mile below Wesley. If the water in the river was in such condition as to be undergoing process of septic operation the current would be relatively smaller than it has been at other times, but the current is still quite perceptible and the amount of these great masses of filth is perceptible. This observation I am speaking of was in 1899. The masses which are locally described as floating islands here.

Q. Do you not maintain, Professor, that while these discharges from the distilleries were lying upon the shore of the Illinois river at Peoria, fresh sewage being continually added to it, so as to keep it in a moist condition, in a condition suitable for decomposition, that objectionable features of that material would not disappear in part while it remained there on the banks of the river and that the same deposits if carried at once into the river and passing down the river would carry more objectionable qualities with it than it would if it remained on the banks of the river a certain time?

A. If all the assumptions made in the question were true, it would necessarily follow as a matter of course, that this objectionable matter would be further carried down the river, but the assumption does not correspond to the practical case. Going back to my record, on which I must depend, my record of analyses, I find that the reverse of what has been assumed in the question is the actual situation.

4380 I have seen, since the opening of the canal, the same floating islands. It is possibly true that the effect of the opening of the canal has been to hasten them in their passage down the Illinois river. These islands do not flow as such any very great distance down the river. They appear to break to pieces and sink and come up again and eddy about.

4381 I do not recall that I ever saw them any very considerable distance below that location in the river. If I should find that a fair cross-section set of samples was taken

4382 and showed results at the same points different from that of my sample, I should be in duty bound to think that perhaps there was some mistake made in the collection of my sample, assuming all the conditions. But if I have no such evidence that a cross-section was made at the proper point, then I would have no reason to modify in any respect the opinion which I give, based on the evidence of the analysis of the sample at the point where my directions were given to collect the sample. In my analysis I am not concerned with the population of Peoria or the extent of the cattle industry at that place.

4383 In forming my opinion I have taken in consideration the fact that there is a large amount—or there are a large number of cattle fed there, and that there is a very large amount of grain mashed at Peoria, mashed before fermentation, and that this offal or slop from this in various years has been sufficient to amount to a contamination equal or in excess of that proceeding from Chicago. As the first products of the disintegration of the discharges from the distilleries, etc., at Peoria require a relatively large time for the final disposition, it is my opinion that the discharges from Peoria are probably more important in the contamination of the lower Illinois river than the discharges from Chicago. The discharges from Peoria, consisting as they do largely of material in which the progress of oxidation is very slightly advanced, require a longer time for their final decomposition than would the discharges which would have gone through the human organism and in which the decomposition has been practically completed.

4384 In the fresh mash there is certainly nothing harmful, but I know of no fouler contamination or worse smelling or worse acting putrefying substance than this slop material when it begins to undergo bacterial decomposition. That substance deposited into the Illinois river, consists pre-eminently and characteristically of undecomposed protein substances, and must be considered as far more objectionable than the ordinary agricultural farm washings. I am using that word "objectionable" in the sense of applying to the character of the products as produced from this material in its early stages of putrifaction.

4385 The sewage of a large city consisting in the main of the products of animal disintegration, contain substances which have been largely broken down. (Witness states constituents of such sewage and method of disintegration.)

4386 In the distillery refuse, because we have a very large complex substance there not yet broken down and because they must undergo the first as well as the final stages of decomposition, a very much longer time is required for that decomposition.

4387 If as assumed in this question, in 1900 there was a large amount of water from tributaries and from rainfalls, in addition to the large amount of water from the drainage canal, and then assume that in some subsequent year we have a very much smaller amount of water from the tributaries of the Illinois, and the same amount of water flowing through the drainage canal, or no increase of water from Lake Michigan through the canal, with the same amount of sewage discharged, it would follow as a matter of course, that in the succeeding years the dilution at the mouth of the Illinois river, as compared with the 1900 period, would be less, making all those assumptions.

4388 If the dilution at the mouth of the Illinois river were allowed to depend mainly on the water of the tribuaries, then there would be of necessity a variation in pollution there, and possibly some variation in the sanitary condition, but if the water from the tributaries becomes gradually a small factor, compared with the great and to be greater flow in the drainage canal, then these variations become of less and less moment in the succeeding years. It is possible that an increase of water might, by hastening the flow, push farther down the point at which oxidation is completed.

4389 If we grant that assumption that the amount of organic matter in the Illinois river is greater now than it was before 1900, then it would necessarily follow, taking in the stream flow also, that the aggregate amount of matter in the Mississippi river must be increased but not necessarily the important factor, which is parts per given volume.

Q. Professor, assuming that the Illinois river exists in its primal condition, with no pollution there either as to human being or as to domestic animals, and that the Illinois river itself exists as at the present time and that the Chicago sewage enters as it now does, into the Des Plaines river and thence into the Illinois river, are you able to state that all objectionable and injurious qualities of the Chicago sewage would be eliminated by the time it reaches Grafton?

A. From the study of all the results of the chemical analyses which I have made of the water from Chicago to Peoria,

and through Peoria and to the mouth of the river, I see nothing in the condition at the mouth of the river which suggests at all that the condition today organically is any worse than that in the ordinary streams of the State, and any worse than that which might have existed in the upper Illinois river. In comparing the Illinois river at its mouth, with the waters of the various tributaries through the season of 1899 and 1900, when such comparisons were made, I notice and have noticed, and have referred to the fact that the peculiar relation of the factors of albuminoid ammonia to oxygen consumption,—in other words the ratio which the factors expressing the albuminoid ammonia, bear to the factors expressing the oxygen consumption, are very similar, practically identical at the mouth of the Illinois river with what we observe in the examination of the tributaries. It is a peculiar and very interesting fact that for the tributaries the relation of the oxygen consumption is nearly a constant value which would be expressed, taking the average of all streams, by .07 about; we find by observing the same relation as I have before mentioned, several times practically the same figure at the mouth of the Illinois
4390 river, while the characteristic figures of waters with known animal pollution or containing essentially animal pollution, show a factor in mean about double this; so from these observations I am inclined to say that as far as the organic pollution is concerned the Illinois river today as disclosed by the analyses I have made—and these are the only things on which I am at the present basing my opinion—is very similar, practically identical with the waters flowing through our State, and taking up a large amount of organic matter from the soil and decaying vegetation. Assuming the conditions mentioned in the last preceding question, I do not undertake to make any positve assertion that any part of the objectionable pollution from Chicago reached the intake at St. Louis but from all the evidence with which I am acquainted I see no reason to believe that any of the original elements of the Chicago sewage have reached the intake of the St. Louis waterworks.

4391 Assuming that all possible sources of pollution are removed from the entire drainage area of the Mississippi river above the Chain of Rocks and that said watershed and drainage area were in their primal condition, the water at the Chain of Rocks would have to be considered suitable for household use. Assuming the same conditions as in the previous question and also assuming that the sewage discharges from 1,600,000 people in Chicago were discharged into the Illinois river by means of the canal as it now exists and the waters of the Illinois river entering the Mississippi above the Chain of Rocks, with such assumption, and the evidence that I have of the rate and conditions of purification in the Illinois river, and with no other discharges into the Illinois river in its course of 300 miles and over, I see no reason to condemn the Mississippi river at the Chain of Rocks, because of the entrance of the sewage of Chicago plus no other contamination, over 300 miles above. From all the evidence in my possession, I believe that none of the contaminating qualities or properties of Chicago would reach that far. I have nothing to show that they do.

4393 I insist emphatically that there is nothing to show that original contamnation from the city of Chicago does reach the mouth of the Illinois river or the Chain of Rocks.

4394 If the assumption be granted, which it is not, that original organic contamination reaches Grafton from Chicago, then I would not be prepared to state that it might not reach the Chain of Rocks.

RE-DIRECT-EXAMINTION, by Mr. Todd:

Under the assumption that the Illinois river was a virgin stream, receiving no pollution or contamination from Lockport to Grafton, except that which enters through the Drainage canal, I do not wish to be understood as saying that any of the original pollution could pass as far in the channel as Grafton.

4395 CROSS-EXAMINATION, by Mr. Jeffries:

4396 My first answer to Mr. Todd, on re-direct-examination I did not mean that the residual organic matter could not be found at Grafton. As I have explained, that residual organic matter was so comparatively stable that it may pass very long distances in a stream.

F. ROBERT ZEIT, examined in chief by Judge Springer: I live at No. 4016 Vincennes avenue, Chicago.

4397 Am teacher at Northwesern University Medical school and Post Graduate Medical school of Pathology and Bacteriology. My early education was received in Switzerland and Germany. My medical degree is from the Western Reserve University of Cleveland, Ohio. I was afterwards with Professor Klebs and when he opened his laboratory in Chicago I was his instructor for three years. He is one of the noted bacteriologists. For twenty-five years he was a teacher of pathology and bacteriology, at German, Swiss and Austrian universities, and was induced to come to this country and was here five years in all. He was called to Rush Medical College as professor of pathology. After one year, I was made professor of bacteriology at Northwestern University Medical school and one year or more ago, I was given the whole department of Pathology and Bacteriology. I obtained my M. D. degree at Cleveland, Ohio, in 1887.

4398 I have practiced medicine and surgery about 10 years, partly in Wisconsin and partly in Chicago. I have made special study of the causes of diseases of human beings. I made bacteriological examinations of waters of the Chicago river and Illinois river between February 6 and October 1, 1900. I obtained samples of water from Prof. Long.

MR. JEFFRIES: We object to the answer for the reason that there is no evidence showing that the samples obtained by this witness or any of the samples that were taken out of the Illinois river or the Drainage canal, and no evidence showing that the samples were taken under his direction, or the manner in which the samples were taken.

4399 MR. JEFFRIES: Now I move to strike out all that the witness has said with reference to the bottles received from Prof. Long, for the reason that bottles so received by this witness, as shown by the testimony in evidence, was a limited number, and not such a number as would justify any conclusions as to the sanitary condition of the water in the

Illinois river, and for the further reason that sanitarians are unable to derive any value from the results of a limted number of analyses of any water, and especially water flowing in a running stream, and for the further reason that the evidence shows that the samples so collected were not so taken as to cover storm periods, cold weather periods and all the variations of the river, and the water therein, and for the further reason that the evidence does not show that the samples were so taken as to obtain a correct bacteriological examination of the water in the Illinois river at flood times, commencing at the source of the flood, or the entrance of the flood into the Illinois river and following it to its mouth, so that any analyses made by this witness of the water of the Illinois river would be incompetent,, irrelevant and immaterial and of no probative force.

4400 The tables printed on page 46 and the succeeding pages down to page 62 of the book entitled "Illinois State Board of Health, Sanitary Investigations of the Illinois River and Tributaries, 1901," contain the chemical analyses of similar samples examined by me bacteriologically during that period.

MR. JEFFRIES: I object to these tables for the reason that the original tables upon which the results of the analyses were recorded is the best evidence and for the reason that I cannot cross-examine the witness on the original table.

4401 MR. JEFFRIES: If it be true that the bacteriological tables of this witness were introduced in evidence by Professor Long and so sworn to by him, I move to strike them out for the reasons stated in our previous objection, that we have not been given an opportunity, on account of the failure to produce the original tables, to cross-examine this witness as to the correctness of the entrance made thereon.

The specimens of water which I received from Prof. Long were plated by us. The object of our examination was principally to determine the presence or absence of pathogenic bacteria in the specimen of water submitted. That was our function in the investigation—no other.

4403 We further made a number of animal experiments, with all the samples obtained, or which were given to us by Professor Long. The experiments included intraperitoneal injections of guina pigs with four cubic centimeters of the water of every station. Another set of experiments with the same waters included the inoculation, also intrapitoneally, with culturs made by adding one cubic centimeter of the suspected water to five cubic centimeters of nutritient bullion and keeping the mixture in the incubator at a temperature of 37 degrees centigrade for 24 hours. Of these cultures, one cubic centimeter was injected intraperitoneally into guinea pigs. The object of the latter experiment was to favor the growth of pathogenic bacteria and keep back the growth of non-pathogenic saprophites and water bacteria. In other words, to enrich the water in disease producing bacteria by adding favorable culture medium and exposing them to a favorable temperature. Disease producing bacteria are favored and multiply rapidly at 37 degrees centigrade, whereas water bacteria would be somewhat held back by such a temperature. The culture thus enriched in pathogenic bacteria was injected intraperitoneally and when the animal died, cultures were taken from he blood, the heart blood, the spleen and lymph glands. Also smears were made at that time, and a diagnosis as to the disease and the organisms causing the death was attempted and made in most of the cases.

Q. Please state, Professor, in detail now, the results obtained by the various bacterial examinations which you made, the number of examinations made of the waters of each place, indicating the number of bacteria, pathogenic and non-pathogenic, found, and what tests were made, if any, to determine the number of pathogenic bacteria that may have been in the samples?

MR. JEFFRIES: Objected to for the following reasons. Witness has not produced original table from which these results were recorded and therefore counsel for defendant have been denied the privilege of cross-examining witness on the correctness of said tables. That witness is reading from report of State Board of Health. That that part of report
4404 which he is reading from shows that no sufficient num-

ber of samples was analyzed by him and his assistants to determine the correct character and state of the water in the Illinois river at the various places where the samples were taken, nor do these samples display the correct bacterial character of the Illinois river at flood times, at winter times, at low stages, at high stages, nor are any floods followed from source to mouth. That samples were so sparsely taken and so few examinations made that no expert would consider them of any importance in passing upon the sanitary condition of the water flowing down the Illinois river and the bacterial changes resulting therein.

A. From Lake Michigan tap water found colon baccillus three times. Guinea pigs injected with different specimens of water all recovered. Three guinea pigs injected with specimens containing pathogenic bacteria, only one died of sepsis and the blood of the animal contained bacilli coli com-
4405 munis. Subcutaneous injection caused only a local abscess and the animal recovered. Some of these specimens of water contained a moderate variety of bacteria commonly found in sewage but only one of the samples contained virulen coli bacilli. (Witness gives names of non-pathogenic bacteria found in these waters and the number of times each genius or specimen was found. Examined 13 specimens from Western Avenue, in the new Drainage canal. Gives list of pathogenic and non-pathogenic bacteria identified.)

4406 (Gives list of pathogenic and non-pathogenic bacteria found at Bridgeport.)

4407 The intraperitoneal injection of four cubic centimeters of several samples of water into a guinea pig did not produce death, whereas, one cubic centimeter of a mixture of one part of water to five parts of bullion, kept in the incubator over night at 37 degrees centigrade, proved invariably fatal to guinea pigs in a short time. Even subcutaneous injections of one guinea pig produced a fatal septicemia.

4408 (Gives list of pathogenic and non-pathogenic bacteria found at Lockport.) Injection of four cubic centimeters into guinea pigs produced no effect. A 24 hour mixture was uncertain in its effect, some animals recovering after two cubic centimeters by intraperitoneal injection; one died promptly of sepsis. All those recovering had an elevated temperature and lost rapidly in weight for several days.

4409 (Gives list of pathogenic and non-pathogenic bacteria found at Joliet.) Injection of four cubic centimeters into guinea pigs produced no effect. Of four guinea pigs inoculated with one cubic centimeter of 24 hour culture, one died of sepsis and the others recovered.

4410 Examined two specimens from the Kankakee river at Wilmington. Found no pathogenic bacteria. (Gives names of non-pathogenic bacteria found.) Injection of water and bouillon culture proved non-pathogenic. (Objected to by Mr. Jeffries for the reason that there is no evidence showing that such samples were ever taken, and that they were properly taken, or by whom taken.) (Gives names of pathogenic and non-pathogenic bacteria found in the Illinois river at Morris.)

4411 Injection of one specimen of this water caused death of guinea pig in 11 days. No post-mortem findings or bacteria were found in the blood or organs of his animal. Other samples of water from the same place did not cause death by direct injection. Experiments with mixed cultures gave uncertain results. The animal sometimes dying and other times not. (Gives names of pathogenic and non-pathogenic bacteria found in the Illinois river at Ottawa.) Both the water and the mixed cultures proved non-virulent after intraperitoneal injections into guinea pigs in the same manner. In samples of water from the Fox river at Ottawa, found bacilli coli communis and non-pathogenic bacteria named.

4412 Neither the water nor mixed cultures proved pathogenic to animals. (Gives names of pathogenic and non-pathogenic bacteria found in Illinois river at La Salle.)

4413 One guinea pig receiving injection of four cubic centimeters of this water died of sepsis, the others recovered, but the bouillon mixture proved very virulent to guinea pigs. (Gives names of pathogenic and non-pathogenic bacteria found in Illinois river at Henry.) Direct injection of water did not cause death. Mixed bouillon cultures were virulent.

Found bacilli coli communis and non-pathogenic bacteria named at Averyville or Upper Peoria.

4414 Direct injection of water as well as mixed bouillon cultures proved entirly non-virulent, even large doses of 24 hour cultures could be given without causing death.

4415 I have taught classes in bacteriology for years how to find pathogenic bacteria in various mixtures and waters. My problem in this investigation was to determine the presence or the absence of pathogenic, that is, disease-producing bacteria in the specimens of water presented to me. As to experience, I have that of a teacher in bacteriology. I have taught bacteriology for five years, and while I have not an extended experience in sanitary investigations, I certainly have done enough work in the separation and identification of pathogenic bacteria, I think, to feel that I am entitled to an opinion as to whether they disappear or not, and that is what I have done in this case.

MR. JEFFRIES: I object for the reason that the tables in evidence are incompetent, that there was not a sufficient number of samples examined; the character and changes of water with reference to flood times and winter seasons were not so followed as to enable any scientist to express an opinion; that the witness has not shown that he is acquainted with bacterial organisms and changes of river waters and has not had sufficient experince with reference to the bacterial examination of running streams.

A. I think I have distinctly stated in the beginning that my part of this investigation was the finding and identification of pathogenic organisms, and such other sewage and water bacteria as could be identified, and I have, I think, qualified sufficiently in that direction. I found that there was a gradual decrease in the number as well as in the kind of pathogenic or disease producing bacteria in the water specimens submitted as we got further away from Chicago. Further, I found that bacteria that are generally known as sewage bacteria or saprophytic organisms gradually decrease as we aproach Upper Peoria. The number as well as the kind of disease-producing bacteria, as well as the sewage bacteria, is continually decreasing to this point, and the absence of pathogenic effect in animals, I think is also a sufficient proof that the zone of bacterial self-purification, which every river has, which has become polluted, must be located somewhere above or near Upper Peoria.

4417 (Gives names of pathogenic and non-pathogenic bacteria found in Illinois river at Lower Peoria.)

4418 Direct injections of the sample caused death of a guinea pig in eleven days. Another animal died of sepsis within 24 hours after inoculation. The pathogenic and saprophytic bacteria have again markedly increased. (Gives names of pathogenic nad non-pathogenic bacteria found in the Illinois river at Havana.)

4419 Several of the specimens of this water proved highly pathogenic to guinea pigs and white mice, when intraperitoneal injections were given, and numerous animal experiments were necessary to prove beyond any doubt that anthrax spores must have been in two samples of this water. We injected finally pure cultures of all lanthrax-like organisms obtained from these water specimens. A number of the animals died within 40 to 48 hours of anthrax bacteremia, the blood of all the organs containing enormous numbers of anthrax bacilli. The colon bacillus and the staphylococcus areus found a few times in these samples proved non-virulent, when pure cultures were injected into animals, whereas the proteus forms were very virulent.

(Gives names of pathogenic and non-pathogenic bacteria found in Spoon river, near Havana.) Injection of four cubic centimeters of the water into guinea pigs in two cases did not prove fatal. Bouillon cultures were non-virulent in doses of one cubic centimeter by intraperitoneal injection.

4420 (Gives names of pathogenic and non-pathogenic bacteria found in the Illinois river at Pearl.) Neither water nor culture was pathogenic by intraperitoneal injection. (Gives names of pathogenic and non-pathogenic bacteria found in Illinois river at Grafton.)

4421 Neither waters nor mixed cultures proved fatal. Ordinary water bacteria multiply in river water and pathogenic bacteria do not. The conditions of the water bacteria are the same everywhere, that is, they will be able to grow and multiply even when there is very little organic matter present and even at low temperature. The condition of growth of the saprophytic bacteria depends more or less on the presence or absence of dead organic material; the more organic material, the greater the number of saprophytic bacteria, and they usually require a somewhat higher temperature for rapid multiplication than do the water bacteria. In other words, the greatest multiplication of saprophytes will take place in the presence of the greatest quantity of organic material, and a temperature slightly above that of the lake or river water. The existence or disappearance of disease producing bacteria, typhoid bacilli, the cholera vibrio, and various pus micro-organisms depends upon dilution, light, the tempetature and the presence or absence of large numbers of saprophytes. Conditions exactly as shown by experiments are these: In the presence of many saprophytic bacteria, that is, at a temperature at which saprophytes grow best, at room temperature, typhoid bacilli, staphylococci, anthrax bacilli, and similar pathogenic bacteria are rapidly overgrown by the saprophytes and disappear from the mixture. Even in the absence of organic material where there are only water bacteria present, the water bacteria multiply also at a tremendous rate, and we find that the typhoid bacilli disappear in eight or ten days. In the first case, where many saprophytes are present, there is a great multiplication of saprophytes at room temperature, and the typhoid bacilli are overgrown and disappear very much sooner, in five or six days. When there are only water bacteria and no colon bacilli, no sewage contamination, but simply the common water bacteria, as found at times in pure Lake Michigan water, or non-polluted river water, the typhoid bacillus lives somewhat longer. If typhoid bacilli are put into a sterile water they can live still longer than in either one of the other cases. The typhoid bacillus in sterile water can live for weeks, even in the absence of food. These statements are all based on personal experiments and I have repeatedly

observed that in the presence of such organic material the greater the number of saprophytic bacteria, the sooner the cholera vibrio, staphylococci, anthrax and streptococci and typhoid bacilli will disappear. Another point which I ought to add here is, the higher the temperature of course, the more favorable it is for the growth of the disease producing bacteria, and that in the low temperature of a river or lake water the typhoid bacillus can not multiply. These lower temperatures are favorable to the growth and multiplication of water bacteria and many saprophytic bacteria. The typhoid bacillus in the absence of many water bacteria and saprophytes might live for some time. The smaller the number of saprophytic bacteria which are present, the longer, of course, the typhoid bacilli may exist, and the less they will be overgrown by the rapidly multiplying saprophytes or sewage bacteria or water bacteria. Every lake and every river has a normal bacteriological flora. By water bacteria, I mean bacteria which do not cause putrefaction, which do not produce gas, which do not produce indol, which can live even where there is little or no organic material present.
4423 They are organisms that are found in every water. By
saprophytic bacteria or sewage bacteria, I mean those which produce gas, cause putrefaction, coagulate milk, produce acids and so on, and require for their rapid multiplication organic material in a larger quantity, and a higher temperature than the water bacteria. The water bacteria grow and multiply best at the temperature of the water; the sewage bacteria or saprophytic bacteria grow best at room temperature. The pathogenic bacteria are disease-producing bacteria and grow best at blood temperature, so that when the three are mixed, it is mainly a question of temperature as to which kind will multiply most. If you mix pathogenic germs and saprophytic bacteria and keep the mixture at blood temperature, the pathogenic germs will multiply more rapidly than the saprophytes; but if you keep them at the tempertaure of air, the saprophytic bacteria, in the presence of much organic material, will increase at a tremendous rate, whereas the disease producing organisms cannot multiply

because the temperature will not allow them, and they are overgrown by the saprophytes. For instance, the typhoid bacilli doesn't multiply at all at the temperature of water. The typhoid bacillus grows best at blood temperature, 37 degrees, but can grow at as low a temperature as 24 degrees Centigrade. There must be organic material for food. With other rapidly growing bacteria at this temperature, the typhoid bacillus will be overgrown and will disappear, even when the temperature is in the neighborhood of 24 degrees to 30 degrees due to the rapid growth of the ohter bacteria present.

4424 Some five years ago Prof. Klebs suggested that I test the question of the longevity of typhoid and other pathogenic germs. At that time, we made a number of experiments with common tap water. We found that the typhoid bacilli in all flasks, in all temperatures, disappeared at different times. If we kept the flask at room temperature, we found that the water cocci increased at a tremendous rate even in a few days, and that the typhoid bacilli we had inoculated it with in all cases and in all flasks had died after three weeks.

4425 At blood temperature in diffuse daylight and another set in the dark room, we obtained colonies for a little over two weeks. At room temperature in the dark, we obtained colonies for ten days, but at room temperature in the light, we obtained colonies for about eight days. We found that the typhoid bacilli disappeared very soon when sewage was added, in fact much sooner; after five or six days we were unable to find typhoid bacilli in any water to which we had been adding sewage. We became thoroughly convinced from our work at the time that typhoid bacilli in the presence of much organic material and the overgrowth of saprophytic bacteria disappeared entirely from the water inside of a week; that if only water bacteria were present and no sewage contamination, typhoid bacilli could live a somewhat longer time, but that no multiplication took place at the temperature of lake and river water and they
4426 finally were annihilated. Whenever saprophytes were numerous, the typhoid bacillus disappeared rapidly, that

is, in five or six days. Briefly stated, in the presence of water bacteria only, the typhoid bacillus can live a longer time than in the presence of such organic material and saprophytes, but in all cases it rapidly disappears from any water to which sewage is added. In determining the purity or impurity of a stream or body of water, the number of bacteria has not as much importance as the kind of bacteria. The number may be great and not have much significance, whereas if they are sewage bacteria and pathogenic bacteria, the number may be very small and the water might be called perfect chemically and yet it might not be called perfect bacteriologically. If the water contains only 50 germs and those happen to be disease producing germs, that water should be condemned. The number is only significant in so far as after the normal number of bacteria in a stream, lake or river has been once determined in the summer and winter, at all times and in all conditions, a sudden great increase in the number found above that which is normally found under like conditions would mean pollution. In the numerous bacterial examinations which I have made of the water of the Drainage canal and the Illinois river, I have not found the typhoid bacillus. Nor is that strange. We cannot find the typhoid bacillus usually because even if sewage, contaminated with typhoid bacilli, should get into the lake for instance, the dilution would be so tremendous that it would be very difficult to find them again. The typhoid bacillus does not multiply at the low temperature of such water, and in case of sewage contamination of lake and river water, the sewage and water bacteria overgrow it and other elements such as tremendous dilution, and the effect of light, cause its disappearance. Even where we know that pollution of a water supply with sewage containing typhoid bacilli has taken place, bacteriologists cannot find typhoid bacilli. First the unfavorable temperature of water prevents multiplication of pathogenic germs. Secondly, sewage bacteria or saprophytes undergo rapid multiplication and overgrow the parasitic bacteria. Third, extensive dilution takes place and separates the bacilli so far that the bacteriologist is unable to find them any more. Another factor to be considered is that in most of the epidemics where bacteriologists have searched for typhoid bacilli and were unable to find them, the time of infection or of contamination has no doubt been passed by several weeks, and typhoid bacilli, which might have been found earlier, have been entirely annihilated during the period.

4428 I think with our present means of differentiating the typhoid bacillus, if the typhoid bacillus was present in the water, we would in examining one cubic centimeter be able to determine that fact.

4429 If there was only one germ of any pathogenic kind, in four cubic centimeters of water, when intraperitoneally injected, it would not produce any effect. Even much greater quantities than that might not produce any virulent effect. A few germs do not produce an infection, even if they are virulent or pathogenic germs. That is true in all cases. The number is just as essential as the presence of the germ itself.

4430 It is true that in all infectious diseases the number of the germs is very essential in producing an infection. We find that of persons who die of other diseases, 90 per cent have evidences of an infection by tubercle bacilli somewhere in their bodies. I mean healed tubercular foci. The same also holds true of typhoid. The number of typhoid bacilli essential to produce infection are not found in the amount of water usually used by an individual for drinking purposes, be it lake or river water. I do not believe personally that direct infection can take place in such a manner. I think that if all the sewage of Chicago containing the typhoid bacilli from every case of typhoid fever in the city should get into Lake Michigan, that no one could be infected by the water of Lake Michigan directly, because the dilution of the bacilli and of such sewage, would be so great that one would have to swallow thousands of quarts of water to supply the necessary numbers of typhoid bacilli to produce typhoid fever, and that yphoid infections, in view of the fact that typhoid bacilli do not multiply at the low temperature of water, must take place in an indirect manner. To illustrate, the infected water containing we will say, one typhoid bacillus to so many thousands of gallons, would reach some favorable culture medium, like various food

products, and in a favorable temperature, like that of a hot summer day, or in the house, in milk, or in oysters or in vegetables, or in various other foods, the few typhoid bacilli present begin to multiply and produce a pure culture in, on or upon these foods, a person taking of such food, will swallow the necessary number of typhoid bacilli, to bring about an infection, and have typhoid fever, because he has swallowed
4431 a culture of many millions of typhoid bacilli, whereas, the other idea of the direct infection by drinking the water is illogical, when we consider the biology of the typhoid bacillus, and the tremendous dilution that takes place when turning sewage or other pollution into a large body of water, and the fact that the typhoid bacillus does not multiply at the low temperature of lake or river waters. If the sewage gradually disappeared and with it the sewage bacteria, I would judge that by the overgrowth of saprophytes in the presence of organic material and a temperature favorable to rapid multiplication of saprophytes, pathogenic bacteria that might have been present in this mixture, have been wiped out entirely. In other words, by the rapid multiplication of sewage bacteria, the disease-producing bacteria which grow best at the temperature of the body will be overgrown and perish, so that by the time the sewage bacteria and organic material has disappeared, the purification of the river or lake, of pathogenic bacteria, must be most complete.

4432 I have gone all over the territory of the waters of the Chicago Drainage canal and the Illinois river from Chicago to St. Louis and have seen the water and formed some opinions in regard to it. I have recently, about two weeks ago, something like that, gone over this whole region and observed the conditions that prevail in these streams.

4433 I think that in the Drainage canal the growth and multiplication of immense numbers of saprophytes, due to the presence of a large quantity of organic material, is unfavorable to the life, the multiplication, or even the existence of disease-producing bacteria. I believe that in the Drainage canal the conditions must be such that they are gradually wiped out, whereas, in the Illinois river, the saprophytes are less numerous, and any disease-producing bacteria that would enter the Illinois river, would be tremendously diluted, but they could probably exist no longer in the Illinois river than they could in the Drainage canal. Any disease-producing bacteria that would get into the Illinois river could, on account of the absence of the decrease in the number of saprophytic bacteria, live no longer. The question could be answered by saying that in the Drainage canal the existence or multiplication of pathogenic, disease-producing bacteria would be made impossible, and that they would disappear in such a sewage tank would depend also upon the resistance of the organism, but during the overgrowth of saprophytes. The time, of course, under the conditions of my laboratory experiments, I would judge that a week ought to be sufficient to wipe out all the cholera vibrio, staphlococci and typhoid bacillus.

4434 The tables found beginning on page 21 and ending on page 23 of pamphlet entitled "Illinois State Board of Health Advance Sheets of Report of Sanitary Investigation of the Illinois, Mississipi and Missouri rivers, 1902," were prepared by me from samples of water furnished to me by Professor Long, at the time stated in those tables.

4435 They were made between October 3, 1901, and March 11, 1902,at my laboratory, Northwestern University Medical school.

4436 We used all the water in these samples and made cultures from it, and afterwards injected guinea pigs with one cubic centimeter of this water after the mixture, it having remained 24 hours in the incubator. We examined 38 specimens of water from the Illinois river at Grafton and 37 samples from the Mississippi river some distance up, before the Illinois river joined it.

4437 MR. JEFFRIES: We move to strike out what witness says with reference to point samples are supposed to have been taken from in the Mississippi river and because there is no evidence showing these particular samples which he examined were the identical samples which were collected from these various rivers and sent to Professor Long and for the reason that the samples that he examined had not been properly identified in evidence.

4438 I took down the numbers which I found on those bottles and which you will find in this report as to bacteriological findings. The dates and the numbers were always given to me by Prof. Long with the bottles. I received 36 water specimens from the Missouri river, which were marked with the date and number given in this report.

At the time I made the examination, the samples were numbered and it was frequently the case that we did not know whether it was Illinois, Mississippi or Missouri water. When we were through with our investigations we had to assort all these numbers according to Prof. Long's record to tabulate them under these headings: Illinois river, Mississippi river, Missouri river. The tables found on pages 21, 22 and 23 of the pamphlet, called advance sheets, are those prepared by me at that time.

4440 prepared these tables from the originals in my office that I made myself. I have the original tables from which these were printed, in my possession.

4442 Table No. 1 of the investigation of 1901-2 shows the bacteria and other micro-organisms found in 38 water specimens from the Illinois river.

4443 (Objection by Mr. Jeffries, because witness has not properly shown the particular place where these samples were taken.)

4444 The table which has just been put in evidence is the result of examination of water taken from the Illinois river at its mouth or at Grafton above its mouth.

4445 The cross in the table means that the particular organism was found in the specimen of water whose number appears in the second column. The date given here represents the date we received the specimen. Where there is a blank the organism was not found in that specimen of water. The division marked "Other Micro-organisms" were organisms which were but rarely found and which received no special column therefore.

4446 Table No. 2 shows results of examinations of 37 specimens of Mississippi river water from Oct. 8, 1901, to March 11, 1902. This represents the examination made in the Mississippi above the mouth of the Illinois.

4447 Table No. 3 shows result of examination of water specimens from the Missouri river.

4448 In my testimony today in reference to the examination of waters of the Illinois river, I stated that the self-purification of the Illinois river began at Morris and was practically completed between Henry and Upper Peoria.

4449 After a consideration of the results of the examinations to which I have just testified, I do not see any reason for changing the opinion expressed, that bacterial purification has taken place in the Illinois river long before the water reaches Grafton. For the purpose of the identification of pathogenic bacteria and for determining the virulence of such bacteria.

4450 I have plated out the suspected water and obtained pure colonies of the various organisms found, passed them through the usual cultures in order to identify them, and immediately after platin gout, I have added to the suspected water enough nutritive bouillon to the four ounce bottle of the specimen of the water to favor the growth of the bacteria therein, and incubated the whole bottle for 24 hours at 37 degrees centgrade. After the time I injected one cubic centimeter of the water, enriched in pathogenic or disease-producing bacteria intraperitoneally, into guinea pigs. When the animal died, a complete bacteriological examination was held and the cause of death determined. Cultures were made from all the organs of the animal, particularly the blood, the spleen and the lymph glands and the contents of the abdominal cavity. We also made a number of side experiments in order to arrive at a more certain diagnosis of the pathogenic bacteria found there. We also tried more modern means of precipitating typhoid bacilli by agglutination, if there should be

4451 any, and then enriching the water, using the serum of an immunized rabbit to agglutinate the typhoid bacilli, but these efforts to detect typhoid bacilli proved entirely unsuccessful and we dropped that again. In fact we never produced any precipitation, so we gave it up. If there had been one typhoid bacillus in one of these bottles, there would have been millions of typhoid bacilli in 24 hours in this water in the incubator. In fact we have done that. We have taken other water specimens not from these sources and we have added minute quantities of typhoid bacilli to the water in the regular laboratory cases and after incubating them for 24 hours had them plated out and the colonies and cultures that looked like typhoid colonies we ran through and tested as to whether they were typhod bacilli. So, according to this method, it seemed to me we were able to find typhoid bacilli even if there was one cubic centimeter of bouillon culture to a million liters of water.

4452 If there had been one bacillus of typhoid fever in any one of these bottles, I would by this process have increased the number to such an extent that they could easily be found. I inoculated the water with a known quantity—a very small quantity and yet was able to find them afterwards by this enriching process. I am of the opinion, that by this enriching process I should have succeeded in finding colonies of typhoid bacilli if one bacillus had been present in the water, although I, of course, repeat again that difficulties may arise in some specimens containing great numbers of colon bacilli. I did not in any of these investigations find the presence of the bacillus typhosus. I found a number of other pathogenic bacteria. (Witness gives names of pathogenic bacteria and the number of times they were found in the Illinois, Mississippi and Missouri rivers.)

4454 During the spring of 1902 we found great numbers of moulds, numerous spores of moulds, such as mucor, aspergillus and odium types in great numbers. I think they were mainly found in such great numbers on account of the entrance of surface waters into the river during the early spring.

4455 The specimens we received were ice-packed. There could have been no multiplication of the pathogenic bacteria present. The typhoid bacillus can grow at 75 Fahrenheit. It grows best at 98 2-5 Fahrenheit. It will not multiply below 20 centigrade or 68 Fahrenheit. It will not die by freezing and it will die at a temperature of 60 in ten minutes, 60 centigrade being equal to 140 Fahrenheit.

4456 Under the conditions in which I received these samples of water there would not have been any increase of typhoid bacilli between the time of the packing of the sample and the making of the examination, if there had been any present in the water. Assuming that the dejecta of typhoid fever patients in Chicago were deposited in the sewers of the city and carried into the drainage canal and that the canal contained immense numbers of saprophytes and ordinary water bacteria to the number of 70,000 and frequently as many as 4,000,000 per cubic centimeter and assuming that it required at least 24 hours and as much as 48 hours for the water to pass from Chicago sewers into the Chicago river and canal and Bear Trap Dam, and assuming that the flow in the Des Plaines and Illinois river is equal to 40 miles in 24 hours, in my opinion such
4458 typhoid bacilli would not survive for the reason that the saprophytic bacteria increase at such a tremendous rate in the drainage canal as to actually overgrow and annihilate any pathogenic or disease producing bacteria. Knowing the conditions that exist in the waters of the Chicago river, the drainage canal, the Illinois, Mississippi and Missouri rivers at their confluence, and taking into consideration the enormous dilution which the sewage passing through the drainage canal receives from Lake Michigan and from other sources on its way to the Chain of Rocks, in my opinion it is not possible for typhoid bacilli deposited in a sewer in Chicago which empties into the Chicago river to reach the intake of the St. Louis waterworks. My opinion is based on the fact that whenever conditions are favorable for the rapid multiplication of saprophytic bacteria, pathogenic bacteria disappear. It is my opinion further that the reason why reputable bacteriologists have been unable to find the typhoid bacillus in the polluted supply of streams or localities where a typhoid epidemic existed, was due to the same cause. (Objection by Mr. Jeffries.)

4459 In regard to the bacteriological flora of the three rivers during the examination of 1901-2 from the investigations made as a bacteriologist I would judge that the Missouri was more polluted than either the Mississippi or the Illinois during the periods of these examinations and that the Mississippi was more polluted than the Illinois at the same time. (Motion to strike out by Mr. Jeffries.) This investigation is entirely independent of any other data.

4460 It is simply to determine if the water of these three rivers specimens of which were examined, is to be condemned bacteriologically, and which of the three is more dangerous than the other two, and I think bacteriologically and qualitatively that can be determined a great deal better in this way than by a great many of the methods that are employed sometimes as the more dependable methods by sanitarians. A physically pure water that contains a great number of pathogenic bacteria is certainly to be condemned. A water may be physically bad and contain a thousand times the number of bacteria that the other water contained and yet it may not contain any pathogenic bacteria. In spite of its apparent bad character physically it need not be condemned. I would be perfectly willing to swallow water, in which I was capable of producing a culture, like I have done here and keep it 24 hours in the incubator and inject it intraperitoneally into the abdominal cavity of a guinea pig, without any effect. After all, the question of determining the safety of drinking water from a river or a lake does not depend upon its physical character and the number of bacteria that may be present, but depends upon the number and kind of pathogenic bacteria present in the water. I testified as a medical bacteriologist, and I believe my opinion in this matter has some cause and some Justice. In my examination yesterday I gave bacterial results of certain examinations of lake water taken from the tap at my laboratory, for the purpose of ascertaining if possible the longevity of the typhoid bacillus.

4461 If there is to be any comparison as to which of these experiments conformed most nearly, if at all, with the condition of the waters of the drainage canal, the only comparison that could be made would be to say that the one nearest to conforming to conditions in the canal is, of course, the one with the lowest temperature. The conditions for the disappearance of typhoid bacilli from the waters here were if anything more unfavorable than they would be in a water like the drainage canal which is teeming with saprophytic bacteria. If I had used water from the drainage canal instead of Lake Michigan, I should judge that they would disappear sooner yet. In Lake Michigan water, the shortest time in which these bacteria lived was six days. If drainage canal water had been used the time would have been at least as short.

4462 I believe modern sanitation owes its advance mainly to the advance of bacteriology. Modern pathology and sanitary science have been entirely changed as we have learned to know the etiology of infectious diseases and their spread, so the modern sanitarian makes a specialty of applying what we have learned from chemistry, bacteriology and associated branches in the study of infectious diseases, as well as their prevention.

(Witness states what advantages modern investigations by bacteriologists have afforded sanitation.)

4463 I graduated at a medical college in 1887. Since that time we have learned to know the causes of many infectious diseases and we have learned how to cure and prevent such diseases by the employment of substances which either destroy the germ itself or will destroy its poisonous products, as for instance diptheria anti-toxins and tetanus anti-toxins, etc. We think the longevity of the bacillus prodigiosus and the typhus bacillus is quite similar.

4464 Assuming that they were in the waters of the Illinois river and the Illinois and Michigan canal, the longevity of the prodigiosus should be longer than that of the typhoid bacillus because the optimum temperature for the prodigiosus is 25 degrees centigrade or 77, Fahrenheit. The optimum temperature of the typhoid bacillus is 98 Fahrenheit. (Witness states method of ascertaining presence of prodigiosus in water.)

4465 If while making an examination for the presence of the prodigiosus I should reach that point in the investigation where the red color appeared, and were to stop there, we could not be certain by the color alone whether we had prodigiosus or some other red organism. I have never, in my bacteriological examinations of the waters of Lake Michigan, Chicago river, Illinois river or the drainage canal, discovered the presence of the bacillus prodigiosus. In Lake Michigan I discovered the presence of a bacillus which disclosed the red color to which I have referred. In 1900 in the early part of our work we occasionally obtained a few red colonies which appeared to have all the characteristics of the prodigiosus. This organism was different, however, from the prodigiosus in the fact that it grew very well on sterilized banana slices and the organism itself was larger than the prodigiosus commonly is, and it occasionally produced some gas. If I had rested my experiments on discovering the red appearance to which I refer, I would have called it a prodigiosus. In fact, I did at first.

4466 I stated yesterday that the zone of bacterial purification of the waters of the Illinois as disclosed by my examinations of that river had been reached at Averyville, just above Peoria. The zone of bacterial purification is that part of a sewage polluted river, where saprophytic organisms and pathogenic bacteria have disappeared and where the normal bacteriological flora of the river, before it received such pollution, is again established. In other words, where practically the same bacteria are found or exist that are found in the same river before it receives such pollution. The zone of bacterial purification varies in the different localities and in the different cities that empty their sewage into rivers, in its distance between very short distances, as short as nine miles, and longer distances, to the extent usually of forty miles. As an example of other rivers where the zone of purification has been ascertained by bacteriologists, I might refer to the Seine, in Paris—a distance of 43 miles. The river Oder at Breslau, at 33 kilometers below the city. At Zurich, Switzerland, we have the lake sending out a river, the Limmat. The lake water contains only a few bacteria, and is considered very pure. The river receives all the sewage and the effluent of Zurich and has again 14 kilometers below the city, practiçally the same bacteriological flora that it had before receiving the sewage.

4467 33 kilometers is the purifications zone of the Isar in Munich. 33 kilometers is about 20 miles. 100 kilometers is about 62 miles. The Isar at Munich purifies itself in a distance of 20 miles.

4468 These data were compiled in 1900 and 1901. They are in the German language and appear in the Zeitschrift fur Hygiene, page 56, volume 190, in which is contained the investigation made by Schlatter, of the Limmat, in Zurich. The river Seine you will find in Rubner—Hygiene, Berlin. The Oder is given in Frankland and the Isar is given in Prausnitz—Hygiene. The Spree, in Berlin, also receives sewage which then allows the bacteria to raise up to 1,000,000 per cubic millimeter. Then it goes into the small lake of Havel and at the exit of the lake, or Sacrow, the bacteriological flora is again the same as it was in the river Spree before it entered the city of Berlin. This is also given in the Zeitschrift fur Hygiene, page 355, volume 3. I should ujdge the whole distance travelled in that lake is about nine miles.

4469 As to the Illinois river, I think the zone of purification here ought to be even nearer to the city of Chicago than what I have allowed, in fact I think that the zone of purification is above Upper Peoria. I spoke of it simply there as being bacteriologically complete. I believe that the real zone of bacterial purification is complete very soon after leaving the drainage canal.

4470 DIRECT EXAMINATION, By Mr. Todd.

The samples of water which I examined or analyzed in both of these investigations I received directly from Prof. Long. They were numbered. My analyses were based on these samples and my tables correctly indicate what the numbers signify. They did not always state as to the places from whence they were taken. When the place was not on the sample, I sent to Prof. Long, and with the number, secured from him the location. In my opinion, those examples which I have related in my answer to the question put by Judge Springer, as to the zone of purification of running streams are examples recognized by the scientists of Europe as established scientific facts. My opinion is that typhoid bacilli lying in the bed of streams for a period in excess of sixty days would be dead after remaining in such sediment for that length of time.

4472 My opinion would be that pathogenic bacteria from the Chicago river would have died in the drainage canal before reaching the Illinois river, due to the great increase of saprophytic bacteria and the overgrowing of the pathogenic germs both in the sewers and the drainage canal. As to pathogenic bacteria it is my opinion there will be no source of danger to St. Louis or the inhabitants of Missouri from sewage deposited by the drainage canal from Chicago into the Illinois river at different seasons of the year and at different stages of water in the Illinois river, that is, if they use this water for drinking purposes. From 38 specimens of the Illinois river and 37 from the Mississippi river and 36 from the Missouri river made during the months of October, November and December, 1901, and February and March, 1902, I concluded that bacteriologically the Illinois river was less polluted than either the Mississippi or Missouri. During the period of these examinations, the effect of emptying the Illinois river into waters in which the Missouri river was a part would have only tended to make the Missouri less infectious, because the Illinois river was less infected than either the Mississippi or the Missouri was during those times. I would say that there would have been no source of danger to add the Illinois to the already severely polluted Mississippi or Missouri.

4474 I do not believe that the drainage canal or the sewage entering the drainage canal can be of any danger due to pathogenic bacteria remaining in it, to St. Louis or Missouri,

for the reasons already stated. My opinion being based mainly on the behavior of pathogenic bacteria in the presence of saprophytes and my opinion also being based on the general
4475 knowledge the world over of the existence of a bacterial zone of purification in any river, and a continuous and permanent purification as the river flows along. As it flows along new pollution occurs and new bacterial purification zones form, which is my reason for feeling certain that no pathogenic bacteria entering the sewers of Chicago, or the drainage canal, will pass beyond Averyville, where bacterial purification was complete. This distance is much greater than that which is generally found the world over, in every river. I would have liked of course very much to have more material, make more examinations and to determine more positively the exact place of the bacterial purification, which I am quite certain is far above Peoria. I wanted to feel safe in saying that the absolute disposal of all pathogenic bacteria had been completed for the reason that even the saprophytic bacteria and the sewage bacteria have disappeared, and for the reason that here, practically no bacterial pollution whatever of the river existed. Practically the same condition would apply to the germs of Asiatic cholera that apply in the case of typhoid bacillus. As to the question whether the germ of typhoid fever could lie in the sediment of the drainage canal or the Illinois or Mississippi river for a period of one to five years and still retain its virulence, I will say that I am thoroughly convinced that typhoid bacilli even under the most favorable conditions would not live one year, much less five years. (Witness is asked hypothetical question involving the dumping of 107 barrels of prodigiosus at Lamonte, the taking of samples night and day for the purpose of discovering that bacteria as it went down the river, and the finding of one bacillus at the Chain of Rocks, and two at Grafton, and was then asked his opinion as to the value of these experiments.)

A. In the first place, there would be considerable doubt whether the red colonies were really prodigiosus colonies. In the second place, the great numbers that were poured into the canal and the practical absence of them afterwards would only indicate what the self-purification of rivers means, because this germ grows best in room temperature. It would perhaps not die as easily in water as the typhoid bacillus because it would probably exist better than the typhoid bacillus under those conditions. I think it would prove that if it is true that the prodigiosus disappears under such conditions that it would be much more true of the typhoid bacillus.

4479 In order to establish the identity of the germs denominated bacillus prodigiosus that were found at the places indicated in the last hypothetical question, it would be necessary to pass the germs through different culture media, and it would be necessary that this germ conform to the description as given in the literature in order to name it a bacillus prodigiosus. It cannot be distinguished by the color alone.

CROSS-EXAMINATION, By Mr. Jeffries.

4482 I have inoculated liter flasks with known quantities of the typhoid bacillus in lake water, into the Missouri river water, into the Mississippi river water, into the Illinois river water. Some of these experiments were made at a temperature of 12 degrees centigrade. Those of the Illinois river water at Grafton and the Mississippi and Missouri river water were made at a temperature varying from 10 to 12 degrees centigrade in the refrigerator. I did not describe those experiments yesterday because I was not asked to do so. At that temperature I was not able to find a typhoid bacillus in five days and in six days.

4483 (States how experiments were made.) The water in which these experiments mere made came from the Illinois river at Grafton, the Missouri above its mouth, and the Mississippi before the Illinois enters it.

4485 Out of 38 samples of Illinois river water from which boullion mixtures were made after 24 hours incubation we tested six samples on animals with the result that the animals usually died of proteus infection, but not always. As to the typhoid experiments, the temperature was 50 to 53 degrees Fahrenheit. The cause of the earlier death here is the overgrowth of saprophytic bacteria that grow best at a low temperature.

4486 These experiments in the investigation of the life of typhoid bacillus in river water involved about ten tests and were made in a refrigerator. Sometimes after four days we were unable to find any colonies of typhoid bacilli. If the samples can be prevented from changing by ice, I think it is true that when river water is at the temperature of ice as it is at the coldest part of the year, that it would be correspondingly protected from changes in composition.

4487 The amount of organic matter coming from the bouillon containing the culture of bacteria was very little. No analyses were made to determine the amount of organic matter contained in the water in which my experiments on the life of typhoid germs was made and the aggregate amount of organic matter coming from the bouillon contained in the culture of the bacteria. In making these experiments I first make a bouillon culture of typhoid bacilli. That is grown for
4490 24 hours in the incubator and then I take one loopful and add it to five cubic centimeters of river water. After that has been added this is immediately plated out on agar. In the following experiments we do not plate out until the typhoid bacilli have been in the water for one day, two days, three days, four days and so on, until we do not find any more typhoid bacilli in the plates. This loopful of bouillon culture contains an inappreciable amount of organic matter which produces this saprophytic growth. This saprophytic growth brings about the death and destruction of typhoid bacilli, but the organic material which I have added by one platinum loopful of bouillon culture is inappreciable compared to the amount of organic material which must already be present in that water.

4491 I do not see what difference there exists whether I add
typhoid bouillon to the river water or whether the
typhoid bacillus enters that water in the form of fresh sewage
conatining typhoid bacilli. I believe in fact that in my case I
am introducing less organic material with the typhoid bacillus
than under natural conditions where sewage containing typhoid
bacilli enters the water. My experiments only show the longevity
of the typhoid bacillus in that water under conditions
4492 as they exist in the laboratory. Those conditions
are different from what they are in the river, although
I have made them as closely similar to those of the river as I
could. I believe that the conditions in a seriously sewage
polluted water, are more unfavorable for the life of the typhoid
bacillus than they would be in the laboratory experiments, on
account of the greater amount of organic material that would
be present there. My experiments were all done with water
that was not seriously polluted. I mean that the water specimens
I experimented with did not contain abnormal amounts
of saprophytes, like, for instance, the water in the drainage
4494 canal. In my direct examination I spoke of the purification
of the sewage from European cities, Munich,
Zurich, Paris, Berlin and Breslau. The effluent of the sewage
from those cities passes into the rivers mentioned and is absorbed
by the waters of these rivers and reduced to harmless
substances within the distances which I have mentioned, and
without injury to those residing on the rivers below the points
of the purification zones I have mentioned.
4495 I speak of the general proposition that any river ought
to be polluted as little as possible where it is necessary
that towns near by use that water for drinking purposes. That
is not from a bacteriological standpoint but from a general
hygienic standpoint supported by the science of bacteriology
and by the science of hygiene. Bacteriology has something to
do with the science of hygiene in so far as hygiene originally
taught us that there was no river long enough that it could
purify itself of any pollution that it received, and as bacteri-

ology has proven that that dogma is not correct and that there is in every river a purification zone.

4496 English authorities on hygiene taught twenty years ago that no river was long enough that it could purify itself of any pollution that it received. As soon as bacteriology was employed an entirely different condition was found. It was found that there is a zone of bacterial purification in every river and that sewage bacteria turned into it really disappeared within a certain distance. I, as a bacteriologist, have of course accepted that view and based upon my own findings in the matter have expressed it also as my opinion that there is a bacterial purification zone in every river.

4498 It has been known particularly that there is a zone of purification from a bacteriological standpoint in every river since these questions were investigated at Zurich, Berlin, Munich and Breslau. I am not able to state whether that was prior to the construction of these sewage purification plants at these various places.

4499 I do not know that since these sewage purification plants were established in Europe, various cities throughout Europe and the United States are today expending large sums of money to purify their sewage and remove from it the objectionable material before it goes into the rivers.

4503 There is no question in a general way, that the discharge of the sewage such as ordinarily is discharged from sewers of large and populous cities of this country, without treatment of some kind, into a river renders the water in that river in a less sanitary condition than without the sewage. I do not know whether or not the city of Peoria abandoned the Illinois river as its water supply some years ago. I do not know the condition of the Illinois river prior to the opening of the canal, as far as Peoria.

4504 Bacteriologically considered I would not think it necessary for Peoria to abandon the Illinois river as a water supply. I do not speak as a sanitarian. A water may be chemically and physically pure and yet contain pathogenic bacteria and bacteriologists would condemn that, whereas the chemist and sanitarian does not make those examinations and would consider that a pretty fair supply. If I found pathogenic bacteria anywhere I would consider that substance whether it be food or water, as dangerous and to be prohibited from using it. It is not a question of the number of bacteria of all kinds and classes that are found in a water that condemns it. It is the presence of pathogenic bacteria or bacteria commonly found in sewage.

4505 In passing my judgment and opinion on the sanitary condition of the water of the Illinois river at or above Peoria I only expressed an opinion in regard to the bacteriological purification at that place and the absence of pathogenic bacteria.

4506 My opinion is based solely and alone on my bacteriological tests with regard to the bacteriological flora at that place and from that bacteriological flora I express a judgment and draw certain conclusions only in regard to the bacterial purification, but not with regard to any other purification. My examination refers purely to the bacteriological side. You do not determine the sanitary condition of any water purely by bacteriology. You only determine the bacterial pollution of a river or lake water by bacteriology and not any other element. Bacteriology has nothing to do with the final judgment. We leave that to the sanitarian to decide upon all the factors which he has collected from all different sciences. A water may be bacteriologically pure and may be chemically impure and vice versa.

Q. Now then, Professor, confining yourself to bacteriology and confining your opinion and judgment and your con-
4507 clusions as to the sanitary condition of the water in the Illinois river at Peoria and at other points, I want to ask you if it would not be necessary before you could express a reliable and adequate conclusion as to the condition of that water for you to first have a bacteriological analysis of that water from one end of the year to the other end of the year to

the other, taking into consideration the various changes in temperature, cold weather, hot weather, warm weather, flood times, low water seasons and local conditions from one end of the river to the other, and if it is not necessary to have all this information. What is there in the analysis which you have made, which leads you to believe and which furnishes you sufficient information to pass judgment upon that water?

A. I did not pass judgment on that water. I examined a number of specimens between February and October from each place and mainly for the presence of pathogenic bacteria. I was not to pass judgment on the potability of the water, but I was to determine during this period what pathogenic or disease producing bacteria could be found in the specimens submitted to me for examination. As to the rest of the question, I am willing to say that the more numerous the examinations the better the final conclusions are. There is no doubt that 10,000 examinations are better than ten. The necessity of having the water examined bacteriologically at all seasons of the year is another point that is desirable.

4508 When I stated on direct examination that the sewage of Chicago has no influence whatever on the sanitary condition of the water in the Mississippi river at the Chain of Rocks, my opinion as to the bacteriological purification of the river was based on the findings in this report to the State Board of Health.

Q. I will ask you this question, professor, if you did not state a few moments ago that in determining the sanitary condition of the water from a bacteriological standpoint that it was necessary for you to take into consideration the temperature of the water at all seasons of the year, the stage of the water, the flood seasons, winter season, summer season, the extent of the polluting material entering that river, and that you stated you had not taken such facts into consideration in forming these conclusions?

A. Yes, I have not. I did not determine the sanitary condition of the water. I determined the bacterial purification.

(Witness is asked hypothetical question involving conditions alleged to have existed prior to opening of canal, in Chicago river and the Illinois and Michigan canal.)

4509 A. I will simply say that in a long canal, 30 miles long, sewage entering and remaining more or less stagnant, will allow the same multiplication of saprophytes that we find here in the drainage canal and the same destruction of pathogenic bacteria. If there was greater concentration of polluted matter in the Chicago river prior to the opening of the canal than there is now in the main drainage canal, as to whether such conditions would be more or less favorable as to the vitality of pathogenic germs, I can answer that in a general way. If you take a gallon of water and dilute it with a pint of sewage the conditions for the disappearance of pathogenic germs would be more favorable in that composition than it would to take a barrel of water and dilute it with a pint of sewage. Assuming that the same amount of sewage is discharged into two streams, one with a flow of 35,000 cubic feet per minute, and the other with a flow of 250,000 cubic feet per minute, I will say that the greater the dilution the farther separated, of course, will be the pathogenic germs and the less will be the bad effect upon the rapidly multiplying saprophites and their products and therefore as a general proposition a pathogenic germ ought to live longer the purer the water, but in the larger stream the dilution would be so much greater. The greater the dilution the farther apart will be the individual bacteria and the less effect the growth of the saphophytic bacteria exert on pathogenic germs.

(Witness temporarily withdrawn.)

4511 W. E. LAUTZ, examined in chief by Judge Springer:

4512 Was employed to take samples of Illinois river water for drainage canal commission at Pekin, Illinois. (States places where samples were taken and method employed.)

4515 The sewage of Pekin entered the river above the point where these samples were taken. There was a complete mixing of the Peoria sewage in the water. I know that the

Pekin sewage was not mixed with the water. It was in the fall of the year that I took these samples and the sewage was of a higher temperature than the temperature of the river water. You could see the steam arising from the sewage in the water along the Tazewell county shore of the river and hugging that shore all the way down.

4516 Tazewell is on the east side of the river opposite from where I took the samples.

4520 PROF. F. ROBERT ZEIT, resumed the stand for further cross-examination by Mr. Jeffries:

(Witness states extent of his study of pathology and causation of diseases, etc.)

4522 I have also studied the behavior of pathogenic or disease producing bacteria in water. I found that when pathogenic bacteria are put into water containing much organic material, and polluted with sewage bacteria, or containing many water bacteria, and the mixture is kept at a low temperature, as low as ten or twleve degrees centigrade, the water bacteria multiply rapidly and the other saprophytic bacteria multiply and overgrow the pathogenic bacteria which then die out quickly. If the temperature is somewhat higher, say the temperature of the room, the other conditions being the same, the saprophytes grow—multiply most and overgrow the pathogenic bacteria to such an extent that they disappear also within several days. When the pathogenic bacteria are put into pure water—I mean sterilized water, containing no bacteria of any kind, they will live for weeks.

Q. Four weeks, you say, or for weeks?

A. For weeks—three or four weeks even, even if there is no organic material present. If there is a slight amount of organic material present, and the temperature is favorable, they will even increase and they will live in there for weeks. If we take pathogenic bacteria and put them in a so-called pure potable water, a water containing no saprophytic bacteria, but only water bacteria, such as are commonly found in water, innocent water bacteria, and keep the temperature at that of the

water or even at that of the room, there is a great multiplication of water bacteria only. I am speaking now of a water which is almost free of organic material. Water bacteria seem to be able to grow more rapidly even in the absence of any organic material, whereas saprophytes will grow better and increase more when organic material is present, so that even in a pure water where there are no saprophytic bacteria present, a rapid multiplication of the common water bacteria takes place and the pathogenic bacteria are overgrown and disappear. The experiments that I have made were mostly with Lake Michigan water and also with sterilized water, and finally they were made with the waters of the Illinois river above Grafton, with the Mississippi river just before the Illinois enters it, and
4523 of the Missouri above the mouth of the Missouri. Those three waters contained great numbers of saprophytic bacteria and the pathogenic bacteria died out quicker than they did in Lake Michigan water.

JUDGE SPRINGER: Can you state within how much time?

A. In five to six days. I might add here, that I also know this to be a common experience. For instance, in the water of the river Ganges and the river Yumma, which is very rich in organic material, the vibro of Asiatic cholera will die in two to four hours, according to the experiments of Hankin. I have in none of my experiments found any such conditions. The shortest periods of life I have observed were five days in the waters that I have examined. (Witness states where and how the typhoid bacillus cultures were obtained that were used in these experiments.) The typhoid bacilli used in the experiments were the fifteenth to the thirtieth generation, possibly more in some instances.

4524 In passing so many generations they no doubt lost some of their virulence, but they were still alive. They might grow even better in the later generations, although they lost their virulence entirely. They may be alive and show all the characteristic bacteriological factors by which we recognize the typhoid bacilli even if their virulence was lost. The problem was not as to whether it would lose or increase its virulence in that water. We cannot keep the typhoid bacilli alive in the laboratory for a number of years. (States manner in which they may be kept alive for a short time.)

4525 A typhoid bacillus is a parasitic organism. It lives only too well on the broth that we use. It will multiply at such a tremendous rate, if the temperature is that of human blood that it will kill itself by producing substances that are poisonous to itself. As grown in the laboratory it is a saprophyte. As applied to the system of man it is a parasite. It is a parasite at no other time.

4526 A typhoid bacillus coming from the patient is not more hardy than one cultivated in the laboratory. We frequently find that a parasitic germ will grow much better after it is grown a few times as a facultative saprophyte. We find sometimes that we do not get as hardy a form from our cultures as we do from new cultures. I stated that pathogenic bacteria died in five or six days in the presence of large numbers of saprophytes at a temperature of between 10 and 12 degrees centigrade. If these conditions are changed and the saprophytes are absent, or the temperature is changed, they will live longer.

4527 Increase of organic material in saprophytes decreases the life of the typhoid bacilli. I stated last Saturday that in my experiments I made the conditions identical with those in the river, except in one point—that in the laboratory experiments the products of the saprophytes have remained in the culture or in the water with the typhoid bacilli, whereas in river water they would be diffused.

4528 The bottles were stopped with cotton, which allowed the oxygen of the air to be present upon the water. I cannot state any definite figures as to the amount of oxygen in the river and in the bottles. There may be some difference and there may not.

4533 Colon bacillus would probably not produce disease if it was swallowed, but would do so if it entered the tissues in large numbers from the intestines. As to the swallowing of colon bacilli, this is in my opinion, not pathogenic. In fact, it has been advocated recently for the cure of chronic constipation to drink pure cultures of colon bacilli. Those who believe in that sort of treatment might go to the drainage canal. The colon bacillus is not pathogenic unless it is virulent. It is always considered more or less pathogenic when found anywhere in the body except in the intestines. It is a facultative saprophyte.

4534 We find that some organisms appear to be purely parasitic organisms, and do not grow at all on dead organic material, so that is an obligate parasite, whereas, we find that a number of the disease producing bacteria can be made to grow on dead organic material, so those can be accustomed to live as saprophytes, that is on dead organic material. I think we ought to draw the line between the two and we ought to say that there are some bacteria that grow only on living organic material (obligate parasites) and then there are some that live only on dead organic material and are destroyed immediately they are injected into the tissue of man or animal (obligate saprophytes) and then there are some that stand between those extremes, favoring the living organic material but capable of existing on dead organic material (facultative saprophytes.) The typhoid bacillus is a facultative saprophyte and has the faculty of growing on dead organic material. The cholera vibrio the same. Neither one of them, however, occurs in nature, and whenever found, it must have come from the intestinal canal of a case which had the disease. Both of these germs require for their multiplication organic material. They may live in the absence of all organic material for a short time. The proper kind of organic materials will produce a better growth.

4535 I have examined other waters bacterially for the presence of pathogenic germs than those that I have testified about. I have examined numerous well waters from different parts of the State, suspected of producing disease.

4536 In making these examinations, we look for all pathogenic bacteria. The injection of typhoid bacilli into a guinea pig will produce death under all conditions, provided the germ is alive, of course and virulent. There is a difference as to the colon bacillus; I do not think the two can be compared.

4537 Injectiong a bouillon culture of typhoid bacilli produced no infection of the animal. The animal dies of the poisons of the typhoid bacilli, so it is a toxic effect. All animals are immune to typhoid fever. If you inject colon bacillus in bouillon culture in large quantities, you can also kill the animal by the poisons of the colon bacilli but usually a virulent colon bacillus will cause an infection and the animal lives for about five or ten days then dies with septic peritonitis. It is possible that a water might be perfectly harmless for drinking purposes and yet contain properties that would kill a guinea pig if injected into it. That is the reason why we attach so little importance to the cases where the animal dies promptly. The value of that test is mainly this, that is the animal can live after such a test that it is pretty certain that that water will not be injurious to the person who drinks it. If such a severe test does not have any effect on a guinea pig, then I think it would be perfectly safe to drink such water from a bacteriological standpoint.

4538 We also made plates and determined pathogenic bacteria from the plates and consequently if there are no pathogenic bacteria present, an animal might die anyway of the disease produced by saprophytes. Waters which are teeming with saprophytes usually are found by the chemical test to be very bad, that is the reason they are condemned. We must judge the potability of water by three tests: First, the physical characteristics of the water may be bad; if they are not bad, then the chemical characteristics may be bad, and if both of these are good, the bacteriological character of the water may be such as to condemn it. If the bacteriological character is good and the others bad, of course I would condemn it on other grounds than purely bacteriological grounds.

4541 I have examined the water in wells that have been charged with being infected with typhoid bacillus. In my examination of that water I never discovered any typhoid bacilli. I have not in my investigations of any typhoid infected water ever been able to discover the typhoid bacillus except in laboratory experiments when I infected water with typhoid bacilli. I had an excellent opportunity at one time. It was in Wisconsin where about sixty cases of typhoid occurred in a small hamlet, which all seemed to be traced to drinking the water of a certain well after the arrival in this little hamlet of one person who had been injected with typhoid fever several hundred miles away. In that particular instance it was almost certain that a certain well had been polluted with discharges of this case and was a source of infection in all the cases but at no time was I able to find any typhoid bacillus in this well water. I think we were reasonably certain that the water in that well was typhoid infected, because people who drank from other wells in the neighborhood were not infected. I reasoned that the time of incubation had been sufficent to allow the typhoid bacilli to disappear from the well water. What became of the typhoid bacilli in this well water? Why weren't they there any more? If we figure that it takes two weeks to infect, it almost seems as if those weeks had been enough to wipe out the typhoid bacteria that must have been in there, to judge from the whole history of this epidemic. I believe the cause why we did not find the typhoid bacillus is, aside from the difficulty of finding it in small quantities of water, that we never examined that water until the epidemic had already existed for several weeks and after that the typhoid bacilli seemed to have disappeared. Most of the investigators who examined water in districts where the typhoid infection seems to have been postively traced to the water supply were unable to find them any more. I examined the water several weeks after the epidemic had broken out. We

condemned the water on suspicion before I examined it. After
I examined it, I told them not to use the water but they did
use it. It was finally proven that our warnings were not
4543 heeded. This epidemic ceased just as quickly as it had
come, after 60 or 80 cases I think had all run their
course. It was clearly brought there by one case that came
home ill and everything started from that well. The name of
this place is Little Black, Wisconsin. It was ten or twelve
years ago.

4544 It is pretty hopeless to examine water for typhoid bacilli.
The bacteriological examination for disease-producing
bacteria is a better test than the experience of the people who
use the water for domestic purposes.

4546 If I were told that the water in a well is typhoid infected,
because the people who drink it were made sick of typhoid fever, I would condemn the water on the experience you mention just the same as I would condemn any river water that was not filtered, for the use of any city, even if it had not received sewage.

Q. I want to know whether or not you would put more reliance upon your bacterial analysis of the water than you would upon the effect of the water upon the people who drank it, if its effects were known?

A. I think that if I was able to make such a test, an animal test as I have described, with that water, without producing any effects upon the animal, whatever, I think that I would be willing to drink that water.

4547 That is not excluding even the presence of small numbers
of typhoid bacilli in the water. If it had been the supposed experience, even the suspicion that the water was the cause of an epidemic I would prohibit the use of that water on suspicion. The experience is no test. It is only a safeguard against suspected danger.

4549 The Chicago sewage would not be drank. I judge if there
was so much organic matter in the water there would also be large quantities of saprophytic organisms which could

produce substances and bring about intestinal diseases, aside from any pathogenic bacteria.

4552 If pathogenic bacteria are in the water and have not died there yet, they will be distributed and separated more or less by dilution according to different conditions existing for dilution, and then require mostly, for their pathogenic effect, of first meeting with a favorable temperature, and favorable culture media, before they produce an infection. If a very pure water and a very potable water is infected with pathogenic bacteria, a water tolerably free from organic material, they would live longer than in a badly polluted water with much organic material. Now, even under the latter conditions, there would be a large separation by dilution, which is probably the reason why we do not find them, so they would be separated so far apart from each other that in order to produce an infection it would be necessary that they should first meet conditions favorable for multiplication. Take the case of the typhoid bacillus, one germ might be in a barrel of water and if that one germ happened to get into a milk can, during a hot summer day, for 24 hours perhaps, this bacillus would find in the milk a favorable culture medium, and the persons drinking that milk would drink a culture of typhoid bacilli; whereas, one would have to drink all that water to get one bacillus, and further one germ alone would not produce infection. Numbers are very
4553 essential to produce an infection. In order to produce typhoid fever the germ must be swallowed, it must be virulent; it must be swallowed in great enough numbers and even then the resistent forces of the organism must be decreased. We see occasionally, where the infection has been traced to milk, that some people partaking of it develop typhoid fever and others do not. Assuming a discharge of 250,000 cubic feet of water per minute through the Drainage canal since its opening and that prior thereto the sewage of Chicago passed through the canal at the rate of 35,000 cubic feet per minute, I should judge that the less the dilution the more rapid will be the mul-

tiplication of saprophytes and the destruction of the organic matter. In other words, if you have much organic material, you favor the growth of great quantities of saprophytes, and they dispose of the organic material more rapidly than if you spread them over large areas and allow the saprophytes to attack it there.

Q. State, professor, what difference there would be in the longevity of pathogenic germs, or disease-producing germs in those two streams of water which I have just mentioned?

A. I will say what I have said several times, that the more organic material there is, the more rapid the destruction of the pathogenic bacteria, so the dilution of the organic material does not increase the rapidity of destruction of pathogenic bacteria. In fact, it would rather tend to decrease it. If we place pathogenic bacteria in sterilized water, where no other bacteria are present, they live longer than if we put them into the worst sewage contaminated water. The purer the water the longer the life of the pathogenic germ. By purer I mean less organic matter, therefore less saprophytes.

4554 Two streams flowing side by side, carrying sewage from Chicago, the one existing in a diluted condition with a flow limited to 250,000 cubic feet of water per minute, the other limited to a flow of 35,000 cubic feet per minute,—the disease-producing germs would disappear much more rapidly in the smaller stream than in the larger.

(Witness temporarily withdrawn.)

WILLIAM S. SAYER, examined in chief by Judge Springer:

I live in Chicago and am employed by the Kennicott Water Softener Company. I am a graduate of Beloit College and also attended the University of Chicago, where I studied chemistry and bacteriology.

4555 In 1901 I was instructed by Dr. Jordan, under the direction of Mr. Irons to go to Grafton and establish a laboratory. From Oct. first until about the 25th of December, we made daily bacteriological analyses of the water of the Mississippi and of the Illinois rivers. Samples from the Illinois river were taken about three miles from the mouth of the river.

4556 The Mississippi river samples were for the most part taken near the Government dock, near the mouth of the Illinois. (States how samples were taken.)

4557 The principal determination was a count and enumeration of the bacteria developed on gelatine plates. The results of the examinations were indicated on blanks which were provided for that purpose.

4558 The blanks that are handed to me are the ones which I used for that purpose. I did the writing myself. These tables are correct determinations of the results which I obtained from the examinations which I made during that period.

4559 It requires all of these sheets to correctly set forth all the bacteriological examinations that I made. There was also as what is known as fermentation tests made. When these sheets shall be presented by Dr. Jordan with my signature, as it is here, they will contain the fermentation tests that Imade at that time. (Sheets marked "Defendant's Exhibit F," for identification, sheets No. 1 to 18 and agreed that the witness may hereafter draw conclusions from these records as if they were set out in extenso.)

4563 PROF. F. ROBT. ZEIT, resumed the stand for further cross-examination by Mr. Jeffries:

Q. Assuming, professor, that all the sewage of the city of Chicago was discharged into the Illinois river in a diluted condition, or in a diluted state of sewage and water amounting to a flow of 35,000 cubic feet per minute, what effect would the addition of 250,000 cubic feet of water per minute have upon the life and longevity of disease-producing bacteria contained in the sewage of Chicago?

A. The greater the dilution the longer the life of pathogenic bacteria, but as to the possibility of infections, the greater the dilution the less the possibility for direct investion on ac-

count of the greater dilution. If you turn a thousand
4564 typhoid bacilli from a case of typhoid fever into a badly polluted stream with very much sewage, then they will die sooner than if you pour a thousand bacilli into a stream that does not have sewage otherwise, except from the discharge of the typhoid fever patient. The more water, the greater the dilution; the further will be separated the individual bacilli, and therefore, also the less the danger of direct infection by the typhoid bacilli, on account of the smaller number. A typhoid bacillus will live longer in water not seriously polluted by sewage than in another water that is seriously polluted by sewage.

4565 Q. Now, professor, would not the addition then of 215,000 cubic feet per minute, have some effect upon the zone of purification in the river?

A. You are asking me again questions on sanitation, not purely bacteriological questions. A river water of sufficient quanitity to dilute the sewage water fifteen times with a flow of at least six-tenths meter per second permits sedimentation banks of sewage to be formed. No putrefaction or stench forms, which, however, is the cause in the Drainage canal, no algae or fishes are destroyed, which is the case in the Drainage canal. The chemical impurities become insignificant as the dilution becomes greater than the ratio given and the bacterial impurities, of course, remain longer, but also disappear in what I have been terming here, the purification zone.

4566 Q. Then, professor, as you add the volume of water you increase the rapidity of the flow, you increase the abilities of life of the typhoid and other pathogenic germs. Now, as you increase the ability of life, and as you increase the ability to flow, do you not at the same time change this zone of purification that you spoke about a few days ago?

A. Yes sir, you change the zone of purification if you do that.

4567 From my own investigation of the matter, I look upon the Drainage canal as one big sewage tank, even as it is now, with an increased amount of water, and I hardly believe that very much will get out of the Drainage canal in the way of pathogenic bacteria alive, because the conditions are certainly such as to show no lack there of organic material and no lack of saprophytic life.

4568 I consider the Drainage canal as it is at present an open sewer. I made guinea pig experiments with that water.

4569 Some of it was from Lockport, in the Drainage canal. The animals died mainly of proteus infections. The specimen from the upper part of the drainage canal produced a condition of sepsis, and the animals promptly died from saprophytic poisons. Inoculations of specimens of the Drainage canal at Lockport, did not always cause death. The animals which died had proteus vulgaris infections. The proteus injected into the peritoneum of the animal set up a peritonitis usually of a purulent type. The animal had an enlarged spleen and bacilli in the heart blood. One animal died of sepsis, the same as at Bridgeport. There were evidently bacteria present pathogenic to animals in Lockport, not only toxic substances produced by saprophytes. According to that they are not killed out by the water flowing through the canal and they do enter the Des Plaines river. My report showed the presence of this germ, but the proteus usually is not considered as a pathogenic organism to human beings under common conditions when swallowed.

4570 When I say the typhoid germ has disappeared from the sewage of Chicago before it gets out of the Drainage canal I do not say so upon the experiments which I have made with the life of that germ in the water of the canal, but only by analogy of the laboratory experiments and the conditions existing in the canal. I made no typhoid bacillus experiments with Drainage canal water, only of Lake Michigan, Illinois, Mississippi and Missouri river water.

4571 Q. I am assuming now, professor, that in the samples of water that you examined, typhoid germs existed. Was your examination so accurate as to enable you to have detected it if it was there?

A. No bacteriologist is able to do that. We examined 38 samples of water from the Illinois river at Grafton with a view to detecting the presence of typhoid germs. We made

4572 10 to 16 plates for each sample. The water that was actually examined would amount to about 130 cubic centimeters in all.

4573 It is possible to miss the typhoid bacilli on account of dilution. If I had found one typhoid fever germ in each cubic centimeter that I had examined it would have disclosed a greater polluted stream than I have ever come in contact with. If I found typhoid bacilli in the water I should consider that very serious.

4574 My examinations in the Illinois river were made from February to Oct., 1900, and from Oct. 3 to March 11, 1901 and 1902. As to the findings summed up at Grafton, I find the colon bacillus and proteus types and there is no appreciable difference in the kind of pathogenic bacteria found during the two periods. I never made any counts and therefore no comparison can be drawn from these tables as to numbers. The kinds were the same. There is no difference. There will be more of these kinds in spring and summer when more pollution results, due to rains and other pollution. In winter there is no doubt less general pollution than in summer and spring. In other words, there is less saprophytic life in the winter than in the summer. They multiply less in winter than in summer.

4575 The term "purification zone" and "zone of bacterial purification" is not used peculiarly by myself. It is a term which you will find in every modern text-book on hygiene. (Witness refers to European rivers and cities and gives the distance of the purification zone as heretofore testified to by him.)

4577 In fixing the zone of bacterial purification, they have been determined mainly to find out what effect sewage had on the water, whether it was possible for a river to free itself again of any bacterial pollution which it had received.

Q. Does the science of bacteriology enable you to determine the place in a running stream where it has been freed from disase-producing bacteria caused by the discharge of sewage into that stream?

A. Under the conditions which I have stated here, yes. We are able to state, as bacteriologists, without the aid of chemistry, the exact place where purification is taking place from pathogenic germs. The bacteriologist claims that with the disappearance of the saprophytes the pathogenic bacteria have disappeared, because the pathogenic bacteria will disappear very much sooner in water than saprophytes.

4580 I define the zone of purification by the great reduction of bacteria of all characters.

Q. I will ask you professor, if that zone is not continually changing from day to day?

A. Yes, sir, that zone is continually changing. I would like to give here an illustration of continuously increased pollution and continuous purification. You spoke of the river Dee. This river Dee above Braemar, shows 84 colonies per cubic centimeter, below the old Mar castle; after receiving the sewage of Braemer, 2,829 colonies per cubic centimeter were found. Below at the bridge of Ballater, 1,139 colonies were found. Below Ballater, after the sewage effluent of Ballater has entered the river, 3,780 colonies per cubic centimeter were found, whereas the effluent of Ballater contained from 235,000 to 26,000,000,000 per cubic centimeter. At Kincardine, O'Neil, 938 colonies only were found in the cubic centimeter. After the junction of the river Neil-burne, again 860 colonies were found in one cubic centimeter. The Neil-burne, 12 yards before the sewage outfall of the river contained 1,200,000 colonies per cubic centimeter. In Invercarnine, only 950 colonies per cubic centimeter were found, so we have here a reduction in the total of 40,000,000, a rapid pollution and a rapid bacterial purification, and in spite of all these pollutions of sewage containing 26,000,000 germs per cubic centimeter and in the other case 1,200,000 per cubic centimeter, you have finally again only 950 per cubic centimeter.

Q. Where do the bacteria disappear in these instances?

A. At Invercarnine.

4581 Q. What became of it?

A. The organic material which entered the river, with rapid multiplication of the saprophytes, accounts for the increase of bacteria, and as the organic material became less, was consumed, was eaten up by the bacteria. The conditions for life and multiplication of saprophytic bacteria became unfavorable and they died out.

Q. Do you know this for a fact or is this your theory?

A. This is a fact which hold true in all cases, of rivers, that the rapid multiplication of saprophytes corresponds to the great quantity of organic matter present, and that if these great numbers of saprophytes disappear, the organic matter has been consumed.

4582 Q. Professor, do you know of any cases in Great Britain or in the United States, in which the instance of the bacterial zone of purification has been so well established, that the water below it is considered by competent authorities, safe for drinking purposes?

4583 A. The epidemiologist who neglects entirely the bacterial questions and their significance, of course condemns all waters which are polluted, but the bacteriologist speaks of a zone of bacterial purification, due to those conditions which I have mentioned many times.

Q. Professor, assuming that the sewage of the city of Cumberland is discharged into the Potomac river, and that the city of Washington is situated on that river 160 miles below

Cumberland, and assuming that from a bacteriological standpoint the zone of purification had taken place in that river ordinarily 40 miles below Cumberland, and assuming further that there was a typhoid fever epidemic in the city of Washington, and assuming that that typhoid epidemic was the result of a previous typhoid epidemic at the city of Cumberland, which discharged its sewage into the Potomac river—

A. That is a theory.

Q. Just wait. This is an assumption. There is no theory about it. I would like to ask you what effect and what bearing the ascertainment of the zone of bacterial purification at a point ordinarily forty miles below the city of Cumberland would have upon establishing the sanitary condition of the water of that river, after it had received the sewage of Cumberland and passed down as far as the city of Washington?

A. If it was proven bacteriologically that at forty miles the bacterial purification and the disappearance of saprophytes, and the consent decrease of the organic matter which it must have contained, according to your assumption, had taken place, then I would judge that with the disappearance of the saprophytes at forty miles in the zone of bacterial purification, not only the saprophytes would have died by that time but that all the other pathogenic bacteria would have died before that time, and that therefore an epidemic of typhoid fever 160 miles away from the source of such pollution, according to bacteriological judgment would have been due to other causes, and that the water, if condemned was condemend on suspicion only, because there has been a typhoid epidemic higher up on the
4584 river. I think that in a case like that it is much more probable that the typhoid bacilli have been brought by a patient, directly and not by way of the water to the city of Washington, 160 miles below.

4585 If we assume that the typhoid dejecta of the patients at Cumberland flowed from Cumberland down to Washington and produced the typhoid epidemic at that place and that the zone of bacterial purification has ordinarily been found at a point about 40 miles below Cumberland, notwithstanding the determination of that zone of bacterial purification, we would prohibit the use of the water and the ascertainment of the zone of bacterial purification would be valueless, but that is a pure hypothesis and I only answer it as such and under the assumption that all that you state was proven.

4587 I do not believe that the zone of bacterial purification will vary within such large distances as 40 to 160 miles, because the disappearance of saprophytes takes place with the disappearance of organic material, and taking the average for the exminations of a whole year, the variations will not be 120 miles. I have never known of a pathogenic germ multiplying in a running stream or in an open sewer.

4589 Taking the water in the stream or the sewage in the Chicago drainage canal, the pathogenic germs will die out more rapidly in cold water than they will in warm water, but that depends upon other bacteria present in the water. I can say nothing definite with regard to that question. In cold water it would depend on other bacteria present how long they would live. In warm water they might even multiply. Many of them will live longer in cold water than in warm water

4590 if the water is sterile. The zone of purification in a river may move up and down, according to the elements of rapidity of flow, the temperature and the amount of water. The zone of purification from the source of pollution should be much less than 100 miles.

4591 In my opinion it may not be more remote than 160 miles. I stated that the conclusion of the British River Pollution Commission was that there is no river in Great Britain long enough to purify itself from sewage introduced into it, even at its source. That conclusion is not accepted by bacteriologists. According to the experiments I mentioned today of the Bacteriologist Frankland, with regard to the river Dee in July, 1892, that ought to be withdrawn. That conclusion has been denied absolutely in Germany. Some English authorities still continue that prejudice in spite of the work of the bacteriologists. The Germans have made more thorough investigations on this subject than the English people. The statement that no river purifies itself was given up by a good many as soon as bacteriological research proved its incorrectness.

4596 This bacterial zone of purification depends largely upon the amount of sewage in the stream. The more sewage the more rapid the disposal of the disease producing bacteria on account of the overgrowth of saprophytes. The more sewage and the more favorable the temperature for the growth of saprophytic bacteria in that sewage tank, the sooner the disposal of the organic material, and the earlier will be the purification zone. The more sewage with additional increased flow means a change in the position of the bacterial zone of purification.

4597 If there were deposited into the drainage canal the sewage of 3,200,000 people into 500,000 cubic feet of water per minute, instead of the sewage from 1,600,000 people in 250,000 cubic feet of water per minute, the dilution would be the same. The increased volume of water from the lake and the increased sewage polluted water coming through the canal would create a more rapid growth and therefore remove the zone of bacterial purification further down the river. It is not an easy matter to detect typhoid bacilli in sewage. It is a difficult matter to distinguish between typhoid bacilli and coli in sewage. These experiments as to the longevity of typhoid bacilli were made in water at a temperature of 50 to 53 degrees Fahrenheit.

4600 If the experiments had been made with water at 32 degrees Fahrenheit the water would have been frozen and there would not have been an increase.

4601 Slight variations in the temperature of the water have very little to do with the life of pathogenic germs but greater variations, if you take blood temperature, 98, that increases the growth of the typhoid bacilli. As you recede from 98 1-2 Fahrenheit the typhoid fever germ lives longer as a general proposition in colder temperature when no other bacteria are present. Typhoid bacteria can live a long time in ice. I must modify that. The typhoid bacillus lives best in a high temperature; it multiplies rapidly then, but when it multiplies produces poisons to itself.

4604 As you increase the dilution in a running stream and remove the whole material farther down, you increase the ability of the pathogenic germ to live. If the pathogenic germs should get out into the stream and get free from any saprophytes or saprophytic influence or effect, they would live much longer than they would if they ran their chances in a septic tank. It is a fact so far as I know, that to the water of Lake Michigan has been attributed repeatedly the typhoid fever from which Chicago has long suffered. I wish to say that I do not wish to deny the presence of the typhoid bacillus in Lake Michigan, when there are many cases of typhoid fever in the city of Chicago and when the sewage of such patients is emptied into the lake, but the tremendous dilution taking place in the lake with billions and billions of gallons of water before such sewage can enter the inlets will produce such a tremendous dilution and spread of typhoid bacilli that the one who drinks this polluted water is not liable to be infected directly because only very few typhoid bacilli could be swallowed in this way. The dilution in the lake would be much greater than in the canal and much greater than in the Illinois river.

4605 It is my opinion that water is not the direct cause of typhoid fever. Many physicians are under the impression that one germ is all that is necessary to produce typhoid fever, but bacteriologists are trying to instruct their students, as well as physicians in general that it is not true and that a large number of virulent germs must be swallowed before infection results and further that not only a great number of virulent germs is necessary to produce an infection but that the resisting forces of the organism must be reduced. Disease producing germs disappear more rapidly in room temperature.

4606 The temperature of the water in the drainage canal is very similar to that in the lake. I should judge that the temperature in the Illinois river is lower than that in the lake. The addition of 250,000 cubic feet per minute from the lake would have a tendency to lower the temperature of the water in the drainage canal. The temperature in the drainage canal is such as to allow the rapid multiplication of saprophytes as indicated by the gas production which can be seen in the drainage canal, the large bubbles of gas that arise, and as seen also by the great increase of saprophytic life. Those gas bubbles still rise since the canal has been opened. If the temperature was higher there would be still more of a growth of saprophytes and a correspondingly more rapid reduction of organic material and pathogenic germs. Disease producing germs may live in ice.

4607 From my experiments I would judge that typhoid bacilli could live in ice for thirty days. If ice made the journey from the river to the intake tower at the Chain of Rocks in thirty days, it would carry the typhoid germs with it, if they were still alive. Assuming that during the cold snap late in the winter some of the water of the drainage canal containing typhoid germs is frozen into a block and gradually enters the Mississippi river and passes on in it and then melts and mingles with the waters of that river, arriving by the time it is completely melted, on the Missouri shore at the Chain of Rocks, there would be a possibility of the typhoid bacillus, which has not died in this ice, entering the intake, with great dilution of course, but in the first place, the typhoid bacillus ar-
4608 riving in the drainage canal would have had to pass through the sewers of Chicago and in the temperature of those sewers there would have been such rapid multiplication of the saprophytic bacteria due to the great quantities of the organic material, that in my opinion the typhoid bacillus never reaches the drainage canal; at least the lower part of the drainage canal and probably not even the upper part of the
4609 drainage canal. In my opinion they are dead when they arrive in the canal, because the sewage in our sewer

system is in a much more favorable condition for the growth of saprophytes than the drainage canal. This depends, of course, upon the length of time the sewage remains in the sewers.

4612 It may be true that if typhoid bacilli lived five, six or seven days in samples of laboratory water taken from the canal that they would live ten or twelve days in the canal proper but the very opposite may be true. It might be similar to conditions existing in the river Ganges. Cholera vibrio live longer in laboratory experiments than they do in this river.

4614 Assuming that there were typhoid germs in the canal and the river flowed at the rate of forty miles in 24 hours, they would get to St. Louis in ten days. If typhoid germs were there and were alive after ten days, they, of course, could get into the intake.

4615 (Witness temporarily withdrawn.)

FRANK WRIGHT, examined in chief by Judge Springer:

Live in Chicago. Am medical student. Took samples of water from the Illinois and Michigan canal from Bridgeport, from the Drainage canal at Western Avenue and from the Illinois and Michigan canal at Western Avenue, in 1899 and 1900. (States were samples were taken and method pursued, etc.)

4621 PROF. F. ROBT. ZEIT, resumed the stand for further cross-examination by Mr. Jeffries:

Typhoid fever bacillus does not form spores. If it did, its longevity in water would be igreater. The spores of anthrax may get into a river, as does the tetanus bacillus. I testified that I found anthrax germs and tetanus germs as well as one of the pus formers, in the Illinois river water, also the bacillus enteritidis.

4622 The spores of anthrax or tetanus bacillus might be washed into the river and exist for many months. Tetanus spores are found in nearly all garden earth and street dirt and could therefore be washed into a river during any heavy precipitation. Anthrax spores are not commonly found in nature. The spores of tetanus can live for months. Tetanus spores are found usually in all rivers so that it would not be surprising to find them in rivers.

4623 Garden earth and street dirt are more likely to contain those spores. The addition of the street washings of a city containing two million people to a stream such as the Illinois river would be insignificant compared with the large area the river travels and with the large amount of washings that that river would receive from heavy precipitations all along the river. The addition of the street washings of a city containing 1,600,000 people might be the source of the tetanus spore which may be found or which may exist in the water of that stream at any given point below the city. If a tetanus germ be detected in the water supply of St. Louis it could not be determined by examination of the sample of water from which the germ was extracted that its original source was the city of Chicago or some other point along the river.

4624 The contents of the intestines of animals as to tetanus bacilli must be mainly due to the foods that have been eaten and that were soiled with earth, or dirt containing those spores and in that way the tetanus bacilli may be found in the intestines of those animals. My opinion is that it is simply the germ in the soiled food that has entered the intestine in that manner, foods soiled by street dirt or garden earth. If there was a great increase or multiplication in the intestinal canal of the animal, the animal would die of the toxins produced by the bacillus.

4626 Assuming that fifteen to twenty thousand cattle are slaughtered in Chicago daily and that in the intestines of these cattle there is a large number of tetanus germs which find their way by washings from the slaughter houses into the

Drainage canal, it may be true that they will find their way into the water supply of St. Louis, but tetanus is not produced by swallowing the germ. It is produced by inoculation subcutaneously in the form of a wound.

4629 Assuming that a steer with anthrax bacilli or spores in its hair was slaughtered in Chicago and that the washings of the hair and the animal got from the pens of the slaughter house into the sewers carrying with it the germs of anthrax, those germs if they were spores, when they reached the Missouri shore of the Mississippi river at the end of thirty days would be alive and active. They would, if numerous enough, produce anthrax in susceptible animals. The fact, however, remains that such animals could not pass inspection here in Chicago and be slaughtered.

4631 Anthrax bacilli have been found in water occasionally or anthrax spores, and have been supposed to be the cause of infections among cattle through water. That was the supposition because it was known in these cases that infected material had been poured a short distance above, into the river. Both the anthrax and the tetanus in order to produce infections in man are usually inoculated subcutaneously and do not produce infection by swallowing although cases of intestinal anthrax have occurred. In case the spores came from Chicago and were found on the shore of the Mississippi below the entrance of the Illinois, if the cattle there drank large enough quantities of virulent anthrax spores, it would be possible that the animals would develop intestinal anthrax.

4633 My position is that one anthrax germ will not produce disease if taken into the intestines of an animal.

4634 Probably pathogenic bacteria would live a little bit longer in soil and earth than they would in water that was rich in organic material. (As to the bacteria that cause dysentery, etc., and the relative vitality and longevity of other disease-producing germs than those of cholera and typhoid fever, see testimony of witnesses on pages 4634-5-6-7-8.)

4639 (As to how many germs are necessary to cause an infection, their virulence, etc., see pages 4639-40-1-2.)

4647 I stated in my direct examination that I discovered the bacillus enteritidis in the Illinois river. This bacillus produces no spores. It is not the bacillus enteritidis sporogenes of Klein; it is the bacillus enteritidis of Gaertner. Others have found the bacillus enteritidis sporogenes in sewage and have described it as Klein's and claim they have found it in great numbers with spores.

4648 That bacillus may produce disease. It is not commonly described by bacteriologists as a pathogenic germ. I would class it in its pathogenic effect with the colon group.

4649 It would live in the spore form for months and is very resistent. If in the water, they could travel from Chicago to the Chain of Rocks and be still alive. (Witness however states on page 4637 that it was not the bacillus enteritidis sporogenes of Klein but the bacillus enteritidis of Gaertner which produces no spores, that was found by him in the Illinois river.)

4650 If I should find this particular spore or organism in the water that I was examining along with large numbers of colon bacteria, it would have some effect upon my conclusions as to the condition of the water examined. If there were large numbers of different bacteria belonging to the colon class, I would consider that as sewage polluted water.

4651 It is true that pathogenic bacteria in the form of spores can exist in the water for a long time and may be either virulent or non-virulent. Spores may pass down the Illinois river to the Mississippi on the Missouri shore and the intake of the St. Louis waterworks. I think that the majority of bacteriologists are pretty well agreed that typhoid bacteria can live but a short time in water, as well as sewage, and shorter in sewage of course than in water and that they live the longer in water the purer the water and the more free the water is from saprophytic bacteria and water bacteria.

4652 Some men have found that with water bacteria only, they live for 20 days; or that typhoid bacilli live in water 20 days, 30 days, providing the water is not badly polluted by saprophytes. Others have found them to die very much earlier. I believe that all competent bacteriologists are agreed that typhoid bacilli in the presence of large numbers of water bacteria and saprophytes at low temperatures, have no opportunity of existing there more than for a number of days.

4653 These experiments were all made in the laboratory. I will admit that it would probably live longer in running water if those saprophytic products were not present but were capable of being removed. As to the time, I think it has never been determined by any one what the difference would be between the laboratory experiment and the actual experiment in the river water. I stated that they would live for a number of days in the laboratory experiments. In my experiments the shortest time was five days when I was unable to find them. In Lake Michigan water the shortest time was in one case where there were many colon bacteria—six days, and in the others where there were many water bacteria, ten days, and the longest that I found them in very pure Lake Michigan water at room temperature, eighteen days.

4655 The same may be true as to the cholera vibrio. Their longevity depend upon the organic material and the other bacteria present and the temperature. In sterile water it is a fact that competent observers have found cholera germs alive for a period of seven to fifteen and twenty days, and even for three months.

4657 Assuming that the germs of cholera live in sewage and river water as long as 13 days and that cholera should appear in Chicago and that the germs were discharged into the Chicago Drainage canal they might arrive at the Chain of Rocks if they were not killed before.

4658 Even if they did arrive there we would again have to consider the same conditions which I have mentioned so many times. That is the germs would have to be swallowed in sufficient number, they must not have lost their virulence, and the resistant forces of the body must be reduced because Professor Pottenkofer swallowed fresh bouillon cultures of the cholera vibrio, the Asiatic cholera vibrio, repeatedly, to bring the experimental proof that if the resistant forces were normal, you could not produce Asiatic cholera. In my opinion there cannot be conditions existing within the human system that would produce the culture and growth of cholera germs from one germ, and that growth continue until the patient finally becomes sick of the disease. In my opinion, it is necessary to decrease the resistant force of the human organism. It is also necessary that the germs be virulent and that a sufficient number of them be introduced to produce the disease. If one or more of these factors is absent the disease is not produced.

4660 When Pottenkofer drank the bouillon culture of Asiatic cholera, he did not develop Asiatic cholera, but he had vibrios in the stools, but it is shown thereby that even a great number of the virulent germs is not sufficient to produce the disease when the factor or reduced resistant force is absent. All the factors have to be present to produce infection. Pottenkofer was in excellent health at the time. He did not diet and prepare himself for the test. The only proof at that time that the germ alone was not everything, that the other factors which are recognized today in bacteriology, all played an important part, first, the germ; second, the number must be great; third, the resistant force of the organism must be reduced, and fourth, the germ must be virulent, and only when all factors are right an infection takes place. Typhoid and other pathogenic germs, survive longer in purer water than in the more polluted water. If the dilution of the Chicago sewage should, at any time, become greater, more water of Lake Michigan being mingled in any way with it, it is also true that the pathogenic bacteria will tend to survive longer. It is true that the greater the dilution the longer will be the life of the typhoid bacillus, but at the same time also the greater will be the dilution or separation of typhoid bacilli which entered that water, so that a given quantity of water will also contain a smaller number of typhoid bacilli.

4662 Typhoid bacilli can grow upon food or vegetables at the ordinary temperature of a room but they do not multiply as rapidly as they do at body temperature. It multiplies rapidly and readily on vegetables on a hot summer day but they would not multiply in the winter or spring.

4663 Q. Then, professor, on your theory of no direct infection from drinking water, at what season of the year should typhoid fever be the most abundant when derived from drinking water?

A. The season has nothing to do with it. If water that contains very few typhoid bacilli should get into the milk and the milk into the household, and the common temperature of a room in the household, even in winter for that matter, should be favorable, the typhoid bacilli can multiply. There will be a culture of typhoid bacilli in that milk, and persons drinking that milk will drink a culture of typhoid bacilli. I realize that the seasons for typhoid fever are the spring and fall and not very much in the summer. I have seen typhoid fever all through the summer.

Q. But on your theory, professor, assuming that typhoid fever is always present in the same quantity in the water that is being used, wouldn't it be natural to believe that there would be more typhoid fever in the summer than at any other time of the year?

A. I have also an explanation for that. The reason why there are less cases of typhoid fever in the summer than in the spring and fall is because in the summer the temperature of the water is more favorable to the life and growth of saprophytes, and if any typhoid bacilli do get into the water, they are rapidly overgrown by saprophytes, more rapidly than in the fall and winter when the temperature is low. I realize that my theory is perhaps not quite accepted by some epidemiologists, but I have reasons for it, which are entirely based upon the biology of the germ, and its behavior when it gets into competition with other bacteria, such as water bacteria and saprophytes, as observed in the laboratory experiments stated. There can be no such great and essential differences between laboratory experience and the behavior of typhoid bacilli in nature.

4664 I do not believe that many of the leading pathologists, epidemiologists, bacteriologists and sanitarians are opposed to my theory of indirect infection. I believe that most epidemiologists admit the great role and importance that this indirect infection plays in the epidemics of typhoid fever. The one point in which I think I differ from many epidemiologists is that I do not believe there is such a thing as direct infection from drinking water. In view of what I know of the biology of the typhoid bacillus, I cannot see that a direct infection can occur, except perhaps under the following conditions: If the excrement of typhoid fever patients containing millions of typhoid bacilli should get into a well, where there is little water, and other persons drinking that water should develop typhoid fever, then it would seem evident that in that case, due to the great number of bacteria swallowed in that way, there was a direct infection from water. I certainly admit that, but I am speaking here in regard to conditions that exist in Chicago, where a large body of water, Lake Michigan, receives sewage polluted material containing typhoid bacilli, or in the Illinois river water, after the sewage of Chicago enters the drainage canal. Even if no saprophytic life whatever should occur and typhoid bacilli should be able to exist until they reached St. Louis, there would be such a tremendous dilution with billions and billions of barrels of water, and the distribution of the individual bacilli to such extent, that they could not, if they did arrive there, produce a direct infection because their number would be too small and only by finding in milk or food supply and favorable temperature conditions a possibility for multiplication sufficient to produce infection.

4666 The history of the last Chicago epidemic illustrates better than anything else I know, that my opinion is the correct one, because the district that had the greatest number of typhoid fever cases was the district receiving the purest water from Lake Michigan; in other words was the district that received the water from the Four Mile crib, whereas the district receiving the water from the Two Mile crib, much nearer to the shore, had no typhoid fever at all. The district which had most of the cases of typhoid fever here in the city evidently may have used the water which contained typhoid bacilli in a greatly diluted condition. Now if the dilution of the typhoid bacilli had been equal all over the lake, why is it that the people that were drinking the water from the Two Mile crib should not have had typhoid fever, if it was direct infection, why should they not have had more typhoid bacilli and more cases than the district receiving the water from the Four Mile crib? The fact was that Hyde Park had very few or no cases of typhoid and the poorer district, supplied with the purest water of Lake Michigan, had all the cases of typhoid fever. In that poorer district, the water reached decomposing vegetables, and did get into the milk supply of that locality—these people were too poor to buy ice and keep their various food products in the best condition.

Q. And too poor to boil the water also?

A. And too poor to boil the water also, and the result was that if there was one typhoid bacillus in one barrel of water one could have drank the whole barrel without becoming infected, but if that one bacillus happened to reach the milk supply or food materials and was exposed to a favorable temperature it multiplied and these people then simply swallowed cultures containing millions of typhoid bacilli. Now, if it were direct infection by drinking water, why did not the people who used water from much nearer the shore, where there was supposedly much more sewage, why did they not have typhoid fever? Because they were people living under the best of sanitary conditions, using only the best of foods, preventing any multiplication or growth of typhoid bacilli reaching their milk supply or food material by way of lake water, which may have contained them in small numbers, by refrigerators and so on. Assuming that one bacteria would be capable of passing through the drainage canal without being destroyed—which in my opinion is impossible—if it got into St. Louis and should find itself in a barrel of water and then find itself on some vegetable at room temperature, or in some media, it would multiply and if virulent it would affect those with decreased resistant force.

4674 If the drainage canal today is a septic tank, the effect of the discharge of 250,000 cubic feet of water per minute from Lake Michigan through that canal, as much as I can see, is only that of dilution, and removing some of the objectionable features with regard to stench, it removes some of the septic operations but the septic operations and the disposal of pathogenic bacteria by rapid multiplication of saprophytes need not be carried to such an extent as to produce a nuisance by producing stench. There is no doubt a point between extreme dilution and stench where the same process will go on, the destruction of organic material, by saprophytes, and with it also the disposal of disease producing bacteria and where at the same time, by dilution by lake water, the other objectionable features, such as stench can be removed. The septic operation might remain complete in the drainage canal even without destruction of the fauna and flora of the Illinois river, and the animal life, I will say, of the river. The addition of the 250,000 cubic feet of Lake Michigan water per minute in the canal has, by dilution, reduced the septic operation but not stopped it. The introduction of this 250,000 cubic feet of water per minute reduces the multiplication of the saprophytes and reduces the time limit for ultimate destruction of all organic material that is contained in the sewage of Chicago and discharged into the canal but at the same time it is not of such an effect as to allow pathogenic bacteria to remain, because there are no fish and no algae capable of living in the drainage canal. Therefore the action of saprophytic bacteria upon sewage and organic material in the drainage canal in spite of the great dilution that you speak of, has not been affected, so that I would say that the operation in the drainage canal, even with this large body of water that is turned in, is perfect as far as the multiplication of the saprophytes is concerned and its septic tank action.

4677 Assuming that the typhoid germs prior to the opening of the canal remained in the Chicago river for weeks and were then flushed into Lake Michigan and caused typhoid fever in Chicago, as to whether the facilities for such germs getting into the Illinois river are better today than the facilities for their discharge into Lake Michigan prior to the opening of the canal, I will say that according to my view it is impossible that the typhoid bacilli can remain for weeks in the sewage polluted Chicago river, but granted that they were still alive, they would have even then a shorter way to travel into Lake Michigan, than they would have through the drainage canal and therefore there would be more certainty that they had been alive and remained alive after they once entered Lake Michigan, than they would when they entered the Chicago river, or entered the Illinois river.

4678 Q. But, Professor, were not the facilities for destruction of the pathogenic germs remaining in the Chicago river with scarcely no current, for days and weeks, more readily produced than in the drainage canal today?

A. Yes, I think that is true.

4679 Q. That is exactly what I want to get at.

A. In other words, the sewage was present for a longer time without any current whatever, and therefore had a longer time to destroy other pathogenic bacteria.

Q. Then to that extent their ability to get into Lake Michigan would not be so great as their ability to get into the Illinois river, by means of the canal, because of having remained in the stagnant sewage of Chicago, in the Chicago river, for days and weeks?

A. They would have disappeared in both cases, according to my view. Assuming that they got to Lake Michigan in the

one case and into the Illinois river in the other case, the condition as to their reaching the Illinois river would be the more favorable because the saprophytic bacteria would not be as numerous in the Drainage canal, that is answering still on the assumption made first. Assuming that the sewage of Chicago would remain in the Chicago river for days and weeks before it was discharged into the lake or into any stream, and assuming also that the sewage is now discharged into the Drainage canal with the present flow from Lake Michigan and that it
4680 requires only 24 hours for the water to run from the mouth of the Chicago river at Lake Michigan to Bear Trap dam, for that distance and that flow the best place for the disappearance of the pathogenic bacteria would be in the Chicago river prior to the opening of the canal.

4682 As a general proposition, I believe it is true that the greater the flow of the river the less the opportunities for sedimentation of bacteria. There is more sedimentation in the lake than in the river with the rapid flow.

4684 It is possible that all the pathogenic bacteria would be destroyed in the Drainage canal excepting perhaps the spores.

4686 Even if living typhoid bacilli should pass the Bear Trap dam and even if they should get much farther down, they will be constantly exposed again to overgrowth by the saprophytic bacteria and will be constantly exposed to the destructive effects of such overgrowth. Further, the temperature of the water is too low to allow multiplication. The effect of the discharge of 250,000 cubic feet of water per minute in the Illinois river by means of the Drainage canal would effect an increase of dilution. It would have the effect of hastening the journey of pathogenic germs on into the Mississippi river but it would also have the effect of greater dilution and greater separation of the individual germs.

4688 Q. Professor, assuming that all sorts of pollution from the sewage of cities situated upon the Illinois river watershed, and pollution from domestic animals were eliminated, so that the Illinois river and the watershed of that river would be in its primal condition; state whether or not, in your opinion, the germs of typhoid fever and other pathogenic germs would not pass from the sewers of Chicago into the Drainage canal, the Des Plaines river, down the Illinois to the Mississippi; assuming that they do not perish in the sewers or in the Drainage canal within two days, within the two days that they are confined therein, if so confined, and assuming further that it requires less than fifteen days for the water to flow from Lake Michigan to St. Louis by means of the Drainage canal, the Des Plaines river and the Illinois river?

A. If all those impossible assumptions were true, the typhoid bacillus would no doubt arrive there.

4689 With nothing else to effect it, except the low temperature, during the fifteen days, if it had been virulent before, it probably would preserve its virulence.

4690 The possibility of millions of typhoid bacilli coming from Chicago to the Chain of Rocks would be absolutely impossible; even if all the typhoid bacilli of all the typhoid cases in Chicago would reach without destruction the Chain of Rocks, the dilution would be such a tremendous one that but very few of them could enter the inlet.

Q. Professor, if that be true, why is it that occasional discharges, and carrying out of the sewage from the Chicago river into Lake iMchigan at the mouth of the Four Wile crib produce typhoid fever in Chicago?

A. Because the one bacillus that might have been in a million barrels of water happened to get into the milk supply of a number of families and produce by multiplication in a favorable temperature millions of bacilli and these people were drinking cultures of them. Such a multiplication does not take place in water.

4691 All the typhoid bacilli that are produced by all the typhoid cases in Chicago, if they were all turned into the river and if they were not exposed to any conditions whatever of destruction and if they all arrived in the Mississippi at that locality, they would be so far distributed and so diluted through the immense amount of water, that the number of them would be inappreciable, and that it would be a great question whether any of them, even one would enter the inlet at the Chain of Rocks.

4694 I do not like to answer questions which are put on such purely theoretical assumptions and then afterwards be accused of having expressed opinions that are not in harmony with Mr. Jeffries' conviction. I do not wish to go on record as saying that if all the germs or bacteria of all the typhoid fever patients entering the river, if there was absolutely no destruction whatever by any saprophytic bacteria or products, could reach the Chain of Rocks, that none of those that should get there, got into the intake. I stated and want to be understood that the dilution would be such a tremendous one that there would be very few only and that those few would not produce infections by drinking that water containing them. This was the idea which I have expressed right along, of not believing in direct infections with water that contained greatly diluted typhoid discharges, so if you say that I have denied the possibility of any typhoid bacilli entering the inlet under the assumption stated, I have either expressed myself wrongly, or you have misunderstood me.

4698 Q. Then, professor, your position is that infection can be more readily brought about by smaller quantities of bacteria in the water when used in the household for domestic purposes than in the case of large quantities taken into the human system directly by way of drinking the water?

A. Yes, because small numbers of typhoid bacilli contained in the river or lake water could, on favorable culture media, when kept at favorable temperatures, multiply rapidly and produce millions of bacilli. Such infected food would contain millions more of bacilli to the cubic centimeter than well water which had received the discharges of a typhoid patient. Assuming that pathogenic germs are discharged into the Illinois river from the Des Plaines river and that the Illinois river is frozen over with ice from the mouth to the source and the Mississippi river is frozen over from Grafton to a point at the Chain of Rocks.

4699 The destruction of organic material by multiplication of saprophytes would be slower and the typhoid bacilli, or some other pathogenic bacteria might live longer. Some disease germs would be destroyed by low temperature; for instance, the cholera vibrio dies in ice in a few days.

Q. How about the typhoid germ?

A. The typhoid germ would live longer. Some disease producing bacteria are more susceptible to low temperatures than others. The typhoid bacillus lives much longer at low temperatures than the cholera vibrio. Assuming that typhoid fever germs pass from the canal into the Illinois river and that as they reach the Illinois river they meet a flood.

4700 The flood would mean greater dilution; it would separate them further apart. It would mean more water; it would mean more rapid flow, so they would pass a further distance down the river than if the flow was slower as in low water. The saprophytic life and destructive effect of organic matter would be less. Greater numbers of typhoid bacilli could pass further down the river before they were destroyed.

Q. And if they live from ten to thirteen days, and the water of that flood reached St. Louis within the thirteen days, they might flow on right through, might they not?

A. If they could live thirteen days, which is improbable, because floods carry immense quantities of organic material into the river and immense numbers of other bacteria, which would again take up this competitive struggle. The more the flood the more impurities would reach the river and the more saprophytic bacteria would be present, and therefore, the struggle would be the same. The only difference that I can see is the greater dilution of pathogenic germs and the more rapid flow, so that less time is given for these competitive struggles to take place.

4701 Pathogenic bacteria die in sunlight in a few hours. In my experiments I excluded the effects of sunlight entirely. I think my experiments were rather more favorable to the life of the typhoid bacillus, than natural conditions in the river.

4703 If typhoid bacilli from whatever source they come, entered the intake of St. Louis, they are capable to produce the same conditions in St. Louis that they would if typhoid bacilli reached the city of Chicago from the Four Mile crib. I mean by this that typhoid bacilli, from any source, entering the intake at the Chain of Rocks, will not produce a direct infection by the drinking of the water, because too small in number, but they are capable of getting upon favorable culture media, such as milk and foods, multiplying at room temperature and producing infections.

4704 Q. Now then, Professor, I will state the question in another way. Assuming that typhoid fever germs will live in the Chicago sewers, the drainage canal and the Illinois river for thirteen days or longer, and assuming that prior to the opening of the Chicago drainage canal, typhoid germs lived in the Chicago river and Lake Michigan for thirteen days or longer, and that they sometimes found their way to the Four Mile crib and after reaching the crib, caused typhoid fever in Chicago among the users of the water from that crib; assuming further that the typhoid germs discharged into the drainage canal since the opening of the canal, enter the water supply of St. Louis within thirteen days, assuming further that the dilution of said germs in the water of the Mississippi at the Chain of Rocks is not greater than that of the typhoid germs in the water of Lake Michigan at the mouth of the Four Mile crib, prior to the opening of the drainage canal, would not the use of water from the Mississippi river at the Chain of Rocks by the people of St. Louis produce as much typhoid fever as would be produced among the people of Chicago using the water of Lake Michigan drawn from the Four Mile crib?

A. That is true, but the whole proposition has been proven to be impossible.

(Witness temporarily withdrawn.)

4705 FRANCES C. BLANCHARD, examined in chief by Judge Springer:

I reside at Wheaton, Illinois. Am a physician. Was employed by Professor Long to take samples of water from the head waters of the Du Page river.

MR. JEFFRIES: I object to any evidence as to samples of water being taken from the head waters of the Du Page or any of the tributaries of the Illinois river for the reason that any analyses that may have been made of such waters, as applicable to the condition of the water in the Illinois river, is incompetent, irrelevant and immaterial, and for the reason that such evidence will throw no light upon the question as to whether or not the disease producing germs that flow from the sewage of Chicago by means of the drainage canal reach the waters of the Mississippi along the shore of the State of Missouri.

(States where samples were taken, method of collecting, etc.)

4709 PROF. F. ROBERT ZEIT, resumed the stand for redirect examination by Judge Springer:

Mr. Jeffries in one of the questions asked me, assumed that English authors or bacteriologists were more thoroughly informed on questions of sanitation and hygiene and bacteria than the scientists of other countries. The Franklands, authors of a book called "Micro-organisms in Water," a work which Dr. Ravold, in his testimony stated was of the highest 4710 authority, state that the river Dee affords a most perfect example of the repeated pollution and the repeated restoration of a stream to a state of comparative purity. (Objection by Mr. Jeffries to witness reading from book.)

4711 The Franklands state in their book:

"It will be seen from a careful study of the numerous investigations which have been made on the behavior of pathogenic organisms in water, what enormous differences exist in their capacity for living in this medium, that whereas, some varieties are destroyed in a few hours, some will live and flourish for many months. Moreover, it is obvious how greatly in some cases, the character of the water influences the vitality of the micro-organisms, a point which is especially brought out in Trenkmann's experiments with cholera bacillus, and it is of particular interest to note how in the case of unsterilized waters the ordinary water bacteria are able to overwhelm and suppress those foreign pathogenic forms which have been introduced. Krause's experiments are particularly instructive in this respect, for they exhibit the multiplication which takes place in the ordinary water bacteria, and the simultaneous disappearance which ensues of the pathogenic organisms introduced."

4712 The title of the book is "Micro-organisms in Water," by Percy Frankland and Mrs. Percy Frankland, pages 94, 101 and 331. German scientists and bacteriologists have taken the same position that I have stated in my testimony. Other German authors whose works I am familiar with, that I could cite upon that subject are Rubner, Prausnitz and Flugge. Prof. Rubner is considered one of the foremost sanitarians of Europe. (Objection by Mr. Jeffries to witness testifying as to whether or not he stands with others, or alone on the question of longevity of disease producing germs, for the reason that there is no opportunity to cross-examine the persons who are the authors of the books it is proposed to read from, etc.)

First with regard to my position that the indirect infection is the common way of infection of typhoid, and not the direct infection by drinking of the water itself. There are many other ways of carrying the infection from the diseased person to the well, than that by drinking of polluted water. Rubner states:

"It is peculiar that even now days, after we know the biology of the typhoid bacillus so well, people cannot separate themselves from the theory that direct infections take place by drinking of polluted water, although it is well known that the typhoid bacillus can be carried and is carried in so many other ways, which would explain the epidemics that arise."

In the same connection, he states that:

"In water, particularly in cold dwater, the longevity of the typhoid bacillus is longer than that of the cholera vibrio (that is the vibrio of Asiatic cholera) but the typhoid bacillus cannot multiply and dies in about six days."

4714 This is page 931 and 930 of the edition of 1900.

The title of the book is "Text-Book of Hygiene, by Max Rubner, Professor of Hygiene at the University of Berlin, and Director of the Hygienic Institute of Berlin." On page 325 he states that, "at the present state of our knowledge it has a certain value to determine, in an experimental way, the relations which pathogenic bacteria have to water. Experiments in which the artificial inoculation of cholera, typhoid, anthrax and pus germs into water was practiced, show that not one of these organisms persists; all of them die in a shorter or longer time. The rapidity of their destruction depends upon (a) the richness or the poverty in organic material. In slightly polluted waters, the quantity of organic material is too small to cause the growth of pathogenic germs. (b) Upon the temperature. In
4715 ice, cholera vibrio died in a few days. The other bacteria
named are more resistant. Anthrax spores live a long time. (c) The third condition—the competition with our water bacteria. In sterilized water, which of course, never occurs in nature, all pathogenic bacteria live better. Anthrax spores, cholera vibrio, and typhoid bacilli die in non-sterilized tap-water in a few days, at the temperature of 10.5 centigrade. (d) The fourth condition. The influence of light destroys bacteria. Furthermore, according to the practical conditions, or stimulating practical conditions, Kalinski infected wells with anthrax spores and typhoid bacilli, as well as with the excrements of typhoid fever patients and could not find these germs after one

week. According to these results, it is certain that the bacteria mentioned have no ability of multiplying in drinking water, but may remain alive a few days. The germs have lost a great deal of their danger because they cannot multiply."

Q. Professor, if there were not zones of purification in rivers, and if pathogenic germs were not short-lived, as you have testified, what would be the condition of the rivers in the world in inhabited regions?

A. I think I stated once before that if there was no purification of rivers, such natural purifications of rivers of the polluted material that constantly enters these, the human race would long ago have died out by the overgrowth of pathogenic bacteria. Tetanus is a bacillus found in earth. It is not a water bacteria. It is most commonly found in nearly all earth, practically everywhere where there is garden earth. They may reach St. Louis from Kansas City and other points along the Missouri river in the State of Missouri.

4716 Q. What, Professor, takes place in the human system when typhoid bacilli are taken into the system in drinking water?

A. If the number of typhoid bacilli is small, in my opinion, as I have already stated, no infection takes place. If the number of bacilli is large and they are virulent, and the resistant forces of the organisms are reduced, then infection takes place. If any of the factors are lacking, no infection takes place. Even when large numbers of virulent bacilli are swallowed the resistant forces might be so great as to overcome the infection. In fact, if any of those factors would be lacking, no infection would take place.

4717 I have not made any bacterial examinations of ice for the purpose of ascertaining the longevity of pathogenic bacilli which have been frozen in such ice. According to what I know of the literature on the subject of the experiments of others, the cholera vibrio died in a few days, according to experimental work done by Winslow, under Professor Sedgwick's direction; typhoid bacilli also are destroyed within three weeks in ice. Although not entirely destroyed numerically, a great destruction of them takes place, and only very few remain after three weeks. The experiments of Hill of the Boston City Board of Health established the fact that typhoid bacilli died very rapidly in ice. Assuming that ice should form in the Chicago drainage canal and the Des Plaines and the Illinois rivers should be frozen over as far down the stream as Peoria and should continue frozen from six to eight weeks and the ice should be broken up and float down the river, being obstructed as is usually the case, in its flow by ice gorges and dams in the river, and assuming that typhoid bacilli should have been frozen in the ice formed in the drainage canal and that they should be carried in that ice as far as the mouth of the Missouri river and that the ice should melt before reaching the intake at the Chain of Rocks, as to whether such bacilli would reach the intake alive and be a menace to the people who might use such waters for drinking or domestic purposes, I will say that there are two factors which would allow me to express the opinion that no living typhoid bacilli would enter the Chain of Rocks. The first one, the experiments stated with regard to the destruction of the typhoid bacillus at freezing temperatures, if the typhoid bacillus should really be in the ice. The second one, the fact that if typhoid bacilli should really get into the drainage canal by way of the sewage from typhoid fever cases, that they might, by reason of their own motility seek the warmer strata of the water and not rise to the surface where the colder strata of water could be frozen.

4719 They would not reach there alive in either case. In the warmer strata, saprophytic products would destroy them. Assuming that the same conditions exist except that the bacteria contained in the ice were cholera, streptococcus and staphylococcus, I would say that the cholera vibrio would die in a few days in ice. The others would probably disappear, if we can reason by analogy, at least as rapidly as the typhoid bacillus, although I do not recollect from the literature, any experiments with ice as to the streptococcus and staphylococcus. I can only reason by analogy here, but as regards a cholera vibrio, that is different, that has been determined. Cholera vibrio die in ice in a few days.

4720 Assuming the same conditions with anthrax spores, I can answer that in a general way. Anthrax spores remain alive under the most unfavorable conditions, therefore with anthrax spores, we would simply have the question of dilution and separation in the water, and there would still be spores present. Now as to the infectious nature of anthrax spores we can only again take the actual experience of anthrax infections in general, and the fact that whenever an epidemic of anthrax amongst cattle or sheep has broken out, that it was confined to the immediate neighborhood of such source of infection, and that even where we know that the infectious material containing anthrax spores did get into the river, the cattle and sheep some distance down the river did not develop the disease, only those in the immediate vicinity of the original source of pollution being infected. Anthrax spores can live a long time in water, and we must, therefore, conclude that either the factor of great numbers of infecting bacteria is absent further down the river, due to great dilution, or to the factor of lost virulence of the germ. Where intestinal anthrax amongst animals
4721 could be traced to direct pollution of rivers, the disease was only prevalent near the original source of pollution and not further down the river. Man is not very susceptible to anthrax. We have had infections, but they have been very rare and could not be traced to the drinking of infected water. (Witness refers to the anthrax infection at Black river, in Wisconsin, and states the conditions and circumstances surrounding such infection.)

4722 Assuming that the anthrax spores might pass through the drainage canal and reach the Mississippi river and that cattle should drink the water of that river below the mouth of the Illinois, according to what I know of the literature and of anthrax infections and the case I have just mentioned, I would say that there would be no danger of a direct anthrax infection by the drinking of that water at St. Louis. From what I know with regard to this question, I think the Government inspection is a very thorough one at the stock yards at Chicago.

4723 Assuming that tetanus spores should be deposited or get into the drainage canal and should be carried by ice or otherwise to the Mississippi river, I will say that tetanus spores may remain alive in the sewers and drainage canal and

4724 river, but that the amount of tetanus spores entering the drainage canal and arriving at the intake channel at the Chain of Rocks in St. Louis, would be insignificant as compared with the amount of tetanus spores that would enter the river from all other sources along the river, the Illinois as well as the Mississippi and Missouri; further that the number of tetanus spores from Chicago sewage that would really be capable of entering the inlet at St. Louis, would be absolutely insignificant as compared with the number already present in the streets of the city of St. Louis as well as in any other city, or as well as in any other town all along the river. The tetanus bacillus produces lockjaw and tetanus. In order to produce infection the germ must enter the tissues subcutaneously and at some depth and the wound much be closed hermetically, otherwise the germs cannot grow.

4725 As soon as the germs grow they produce a toxin which when absorbed into the body produces first conclusive movements of the muscles, of the lower jaw, then of the upper extremities, then of the lower extremities and finally death. I have never heard of any case of lock-jaw being produced by drinking water.

4726 If tetanus and anthrax are present in water in their non-spore bearing form, all I have stated with reference to the behavior of pathogenic bacteria in water applies here. As soon as those organisms form spores then of course the spores are not subject to that general rule to which I have testified in the earlier examination.

4727 Tetanus bacilli as well as anthrax will die at least as soon, if not sooner than the typhoid bacilli in their non-spore bearing form under similar conditions. The cholera vibrio dies sooner the lower the temperature. The stapylococcus and streptococcus die sooner than typhoid bacilli. The pathogenic germs that are spore bearing are the anthrax bacillus, the tetanus bacillus, malignant oedema, the bacillus aerogenes capsulatus. Of the important disease producing bacteria, these are the ones.

Q. Now, Professor, assuming there is a remote possibility that a tetanus spore might be carried from Chicago through the drainage canal down the Des Plaines, and Illinois rivers and a possibility that such a spore might enter the St. Louis intake and the hydrants of the St. Louis waterworks, and the possibility that a St. Louis urchin might moisten his finger with water and then shoot a wad into his finger, thus moistened as aforesaid, as stated by Mr. Jeffries in one of his hypothetical questions, and that such moisture may contain a Chicago tetanus spore, as assumed in one of the other questions by Mr. Jeffries, and that such tetanus spore thus subcutaneously injected into the finger of said urchin may have entered the anatomy of said urchin at a time when his system was susceptible to tetanus infection, and the possibility that said St. Louis urchin might then and there contract the disease of lock-jaw—are such remote possibilities as I have mentioned, in your opinion as a bacteriologist, of such a grave and serious character as to constitute a menace or danger to the inhabitants of St. Louis or of the State of Missouri?

4728 A. I will have to answer that question with No. Tetanus infection takes place when street dirt or garden earth containing numerous virulent germs, enters the deeper tissues and not by water as stated.

RE-CROSS EXAMINATION, by Mr. Jeffries:

I stated to Judge Springer that bacteria would not freeze in the ice as long as they possibly could avoid it by swimming away from where the ice was forming into the warmer water. It is no doubt true that they will swim away from the light as far as they can and from the saprophytic bacteria and from all other materials and conditions that will not be conducive to their welfare and longevity. They will not move large distances. The motility is not as great as that. As they swim away from the point where the water is frozen they are carried down the river according to the current that happens to exist. If that ice is formed over the whole bed of the river and remains there from six to eight weeks and if the conditions of the water are such as will permit the typhoid bacilli to live from ten to twenty days or thirty days in that cold water underneath the ice, and it only requires either ten or twelve days for the water to go from Chicago to St. Louis, it is reasonable to believe that these germs will find their way during their life time down the entire course of the Illinois river, if the bacilli would live at these lower temperatures without dying and would be alive in St. Louis, of course.

Q. That is, if they would live that long?

A. That is your assumption.

4731 As to how long typhoid bacilli live in ice, has not been definitely determined, if we take all of the evidence from all sides. Some find they die in a short time; others say they only die in great numbers, but some of them remain alive for a longer time. Large quantities will not remain at the end of thirty days. The majority of them will die even according to the experimenters that say that some remain alive. The percentage that will remain alive is an insignificant one according to their findings.

4732 The spore of anthrax can no doubt live for years. I realize fully that it takes a very minute quantity of anthrax material to produce an infection, but in cases of epidemics we hear of no anthrax infections a few miles down the river. Knowing that the spores can live for years and also knowing that such spores certainly must be in the water and upon the overflowed shores of this river for longer distances, although only the animals near the original source of pollution die of anthrax infection, I conclude that the factor here, that was lacking, was the necessary number to infect.

Q. May it not, Professor, depend upon the fact that no animal whose system was in a proper condition, swallowed one of those spores?

A. Then they shouldn't have all died nearer the source of infection there, whereas no deaths occurred further down the river.

4733 This anthrax epidemic originated near a tannery in Medford, Wisconsin. Some of the hides used came from Brazil and from China; by the experiments, I believe of Professor Russel, these hides were found to contain anthrax spores. A number of animals just below the tannery had suddenly died and practically all at the same time on the meadows immediately below this tannery. The Black river received the sewage of the tannery and had shortly before overflowed the meadows on both shores of this river. In fact the whole epidemic came suddenly amongst the cattle on the banks of the river, and there was much apprehension among the farmers farther down the river because it had also flooded its banks there. I have a farm a few miles below this tannery on this river, and my neighbors were of course also very much alarmed. Their cattle

4734 were usually on my land, which is simply wild woods, the river crossing it, on both banks of the river there are openings, where the cattle of the whole neighborhood graze, because this wooded land is not fenced in, consisting of virgin forests, whereas all the surrounding land is cleared up. All the herds of the neighbors around there have been grazing on the banks of the river on my lands which are frequently overflowed. This is only a few miles below the tannery, but none of these animals died whereas horses, cattle and sheep died just below that tannery. Horses of farmers living within a distance of half a mile or a mile died. Lawsuits followed by many of the people living below the tannery. This matter was investigated by Professor Russell of Madison, Wisconsin, as the State Bacteriologist. He found anthrax spores in the water of this Black river below the tannery and he has yet water specimens in his laboratory which when injected into animals produce anthrax showing that there are still virulent spores present. This is now a number of years ago. During all these years there has been no death of any animal, I think I may safely say, one mile below this tannery or farther down the river. This is such a striking case where water can be shown to contain virulent spores and retain them for many years, and yet farther down the river not an animal dies, in spite of the fact that there must have been tremendous pollution with anthrax material of that river.

4736 Under favorable conditions an infection of anthrax may take place in an indirect manner although we know of no such infection. It is possible that the germs of anthrax may be carried into the stock yards and slaughtering houses in the hair and wool of the cattle and sheep and discharged into the drainage canal and thence into the Illinois river, but that condition exists all along the Illinois river.

4740 Assuming that germs of anthrax are deposited in the Illinois river by means of the Chicago drainage canal and that they flow down the Illinois river into the Mississippi and in flood times are carried by the waters of that river into the lowlands, into the various river counties of the State of Missouri below the mouth of the Illinois river and deposited upon the earth, weeds, grass and growing substances and that after the water has receded, these anthrax spores are carried into the food preparation which is brought to a temperature favorable to the multiplication of the anthrax spore, the remote possibility exists that the cattle, horses and sheep of said counties, feeding upon such food might become infected with the disease of anthrax, although all the history with regard to epidemics of anthrax and their spread would be opposed to the spread of anthrax in that way. Such spores, if carried on to the lowlands of Missouri, we would never hear of. They would never produce anything even if they had been spread in large numbers. I reason again by analogy according to the history of epidemics of anthrax where we know that large quantities have been spread over large districts and you never hear of them again. They must have lost their virulence or the number of spores is not sufficient. The individual germ will not produce infection.

4742 It is possible that one of the spores that is carried from the tanneries of Chicago to the proper food media in one of the southeastern counties of Missouri might produce a culture of anthrax germs and produce disease.

4743 It is possible that if it was transplanted to the food and that the food was a proper media at the proper temperature to bring about a multiplication of the germs that it will produce disease but it is not probable and it is not reasonable to believe. It is possible, if I take a spore from a tannery in Chicago, carry it to southeast Missouri to a food preparation and reduce that food preparation to the proper temperature, that I would bring about a multiplication of the germs and if that spore was alive and active and produced a large number of spores upon that media, that it would produce an infection of the disease.

4744 That is possible under the usual conditions of infection but not as probable as in the case of the typhoid bacillus.

Q. You say it is possible. I want to know if as a bacteriologist you do not consider it reasonable on the theory of indirect infection?

A. It is even reasonable under the conditions which usually govern direct infection, that is, first, that the germ is present; second, that it be virulent; third, it is necessary that it finds the proper temperature for its rapid multiplication, and fourth, that the animal infected shall have the necessary reduced resistant forces, and fifth, it is necessary that the animal receive a sufficient number of these germs to produce infection.

ADOLPH GEHRMANN, examined in chief by Judge Springer:

I reside in Chicago and am a physician and bacteriologist. From 1893 I was connected with the Chicago Department of

Health in the capacity of bacteriologist and microscopist for the Milk Department during 1893 and from January, 1894, until June, 1902, as director of the laboratory and bacteriologist of the department. Have taught bacteriology and hygiene in the College of Physicians and Surgeons, which is the medical department of the University of Illinois in Chicago. My connection there began in the spring of 1892 and continues up to the present time. I am now Professor of Hygiene in the Dearborn Medical College at Chicago and am Professor of Bacteriology in the Harvey Medical College in Chicago.

4746 I have all of these connections now. I have been teaching bacteriology for eleven years and hygiene for about eight years. Part of my daily work has been giving special attention to the causes of disease in the human race. In connection with the Health Department of Chicago my employment was the conduct of the laboratory for chemical and bacterial examinations particularly as a bacteriologist.

JUDGE SPRINGER: Q. Where were the samples of water obtained, of which you made bacterial examinations?

A. The laboratory received samples from a number of different places, that is—we were continuously making examinations of water samples from the city water supply. The samples of water were from places where ice was obtained, connected with farms from which milk was supplied from time to time, and for a period, samples of water from the Illinois and Michigan canal, the Illinois and Des Plaines rivers, and tributaries and the Mississippi and Missouri rivers.

4747 During the year 1893, a weekly examination of the water was made from Lake Michigan, from the four tunnels in use and the water supply as delivered in the laboratory, making five samples per week in 1893. These samples were taken at the shore end of the tunnels except the one which was taken in the laboratory which was taken from the tap of the laboratory. From the beginning of 1894 on as long as I was connected with the work the samples were taken daily for every working day. Later some samples were taken from added territory.

(Witness gives names of persons who made chemical analyses of these samples while he was director of the Chicago laboratory.)

4748 The examinations daily were recorded in series and arranged by months. The work each month was tabulated together, averages were drawn, and with the reports that were published from the department a large number of the records for the months were published in detail. They were not all published up to date. These monthly records were published in a number of the reports but they have not all been published up to date, there are one or two years left out. The object of such work was to learn as to the conditions that could be ascertained from bacterial and chemical examinations of the water, as to its quality. These records which were published are in the reports published by the Board of Health of the City of Chicago.

4749 I left the service of the Health Department in June of 1902. I do not hold any official position at this time with the city, state or national government. In the early months of 1899, I was instructed by the Commissioner of Health of the City of Chicago to arrange for the examination of samples from the Illinois and Michigan canal, the Des Plaines river, the Illinois river and its tributaries, and the Mississippi and Missouri rivers, and attended a number of conferences with Professors Palmer and Burrill of the University of Illinois and Professor Jordan of the University of Chicago. The object of these conferences was for the purpose of laying out a plan for the collection of samples and the chemical and bacterial examination of the same at points as before stated, and to arrange for the details of such an investigation. These conferences were to settle first, the localities in which the samples would be collected; second, all matters relating to the exact points in the rivers from which samples would be taken, and the selection of the collectors to be left to the mutual agreement of Professors Jordan and Palmer.

4750 The arrangements for the transportation of the samples and the equipment of the collectors with outfits to be conducted by the Health Department laboratory. It was decided as to the outfits to be used by the collectors.

Q. What did that embrace?

A. That embraced the cases in which the bottles would be shipped, the bottles themselves, the necessary labels, tags and matters of that kind. It was also agreed as to a summary of procedures as to the methods to be used in making the examinations. Three laboratories were engaged in the investigation, the laboratory of the University of Illinois, the laboratory of the University of Chicago and the Health Department of the city of Chicago. At the Chicago laboratory under my charge a chemical and bacteriological examination was made of the samples.

4751 The chemical examination was conducted by D. B. Bisbee and the bacteriological examinations were conducted by myself. It was understood at that time that similar analyses and examinations were to be made at the other two places that I mentioned.

4752 During April and the early part of May, 1899, I purchased the required number of outfits and prepared them for the collectors to use in making their collections. I sent a letter to each collector, copy of which will be found on 4752 of record.

4753 On May 31, 1899, letter was sent to each of the collectors in regard to packing the small bottles in cans, etc. Professors Palmer and Jordan selected the exact point in these various waters at which samples were to be taken and employed the persons who were to take the samples.

4754 I saw several of these collectors engaged in their work along the river. I was at Bridgeport a number of times and at Lockport and Joliet. (Witness states points at which samples were taken in the canal, Kankakee river, Illinois river, Fox river, Big Vermilion, Little Vermilion, Sangamon river, Mississippi river, Missouri river, etc. Witness gives names of collectors at the different points at which samples were taken.)

4757 The outfits furnished these collectors with which to collect samples were accompanied by a slip on which was recorded the number of sample, the date and time of collection, place of collection, temperature, etc. On the back of this slip were printed specific instructions for the collection of samples. (See page 4758.) Samples were all received in good condition in Chicago.

4759 Mr. Bisbee took his large bottles for chemical analyses and delivered the small bottles for bacteriological examination to me and I proceeded with my examination of the samples. Mr. Bisbee made entries on the cards as to the heighth of the water and the temperature, etc., as to all the samples. I made an examination for the numbers of bacteria of all kinds present in the samples by making Petre plate cultures on agar culture medium and counting the number of colonies developed, estimating then the number of bacteria present per cubic centimeter of water. Beyond this, an examination for bacteria of the colon-typhoid group was made. Preliminary cultivation of the water sample in glucose broth and separation of the bacteria therein present, with isolation of the colonies, and studied the specific characteristics presented by the cultures obtained from these colonies. I recorded the results of the examinations on record sheets.

4760 In the tables prepared by me I designated the presence of the bacilli coli communis by a plus sign. Where there is no designation at all, for some reason or other the examination was not completed or fully carried out. Where they are not found the record was made by indicating the minus sign.

Q. Professor, I hand you certain tables numbered from 159 to 196 inclusive, entitled, "Streams Examinations, Sanitary District of Chicago, Sanitary Water Analyses, Parts per Million; Source of Water," indicating at each place in that table where the source was, and designated as a report of Adolph Gehrmann and D. B. Bisbee, Municipal Laboratory, Chicago, Illinois. Will you please examine these tables and state whether or not these are the tables that were prepared by you

and Mr. Bisbee, as chemist in the city laboratory of Chi-
4761 cago, at the times indicated on each of these tables, as
the results of chemical analyses and bacteriological examinations of the samples of water taken at various places during the time indicated, in the waters indicated by you in your examination up to this time?

A. These tables that I present are the tables that are prepared in connection with Mr. Bisbee—the record of work on the samples that we received from the collectors at the points as stated before. Mr. Bisbee and myself worked together on these tables. (Witness explains meaning of marks and forms on tables.) (Witness is asked to read each of the tables to which his attention has been called, beginning with No. 159 and ending with No. 196, to which objection was made by Mr. Jeffries. For objection and argument made thereon by Mr. Todd and Judge Springer, see pages 4764-5-6-7-8.) Tables read in evidence beginning with page 4769 and ending on page 4807, said tables showing results of bacteriological and chemical examination of samples of water at the following named points, the page on which each table will be found, being placed after the point indicated:

Table	Source of Water.	Point where Sample was taken.	Record Page.
Table 159	Ill. & Mich. canal	Bridgeport	4770
160	Ill. & Mich. canal	Lockport	4771
161	Des Plaines river	Lockport	4772
162	Des Plaines river	Joliet, north of Jackson st	4773
163	Des Plaines river	Joliet, south of town	4774
164	Kankakee river	Wilmington	4775
165	Illinois river	Morris	4776
166	Fox river	Ottawa	4777
167	Illinois river	Ottawa	4778
168	Big Vermilion river	La Salle	4779
169	Ill. & Mich. canal	La Salle	4780
170	Illinois river	La Salle	4781
171	Illinois river	Henry	4782
172	Illinois river	Averyville	4783

Source of Water.	Point where Sample was taken.	Record Page.
173 Illinois river	Wesley City	4784
174 Illinois river	Pekin	4785
175 Illinois river	Havana	4786
176 Sangamon river	Chandlerville	4787
177 Illinois river	Beardstown	4788
178 Illinois river	Kampsville	4789
179 Illinois river	Grafton	4790
180 Mississippi river	Grafton	4791
181 Mississippi river	Alton, 100 ft, from Illinois shore	4792
182 Mississippi river	Alton, ¼ distance from Illinois shore	4793
183 Mississippi river	Alton, midstream	4794
184 Mississippi river	Alton, ¼ distance from Missouri shore	4795
185 Mississippi river	Alton, 100 ft. from Missouri shore	4796
186 Mississippi river	400 yds. from Ill. shore at Chain of Rocks, Pumping Station, St. Louis Waterworks	4797
187 Mississippi river	Midstream at Chain of Rocks, Pumping Station, St. Louis Waterworks	4798
188 Mississippi river	Chain of Rocks, Inlet Tower, St. Louis Waterworks	4799
189 Mississippi river	400 ft. from Mo. shore, at Chain of Rocks	4800
190 Missouri river	Ft. Bellefontaine, West Alton, Missouri	4801
191 Mississippi river	100 yds. from Ill shore, Jefferson Barracks, Mo.	4802
192 Mississippi river	Jefferson Barracks, East of midstream	4803

Source of Water.	Point where Sample was taken.	Record Page.
193 Mississippi river	Jefferson Barracks, midstream	4804
194 Mississippi river	Jefferson Barracks, West of midstream	4805
195 Mississippi river	Jefferson Barracks, 100 yds. from Mo. shore	4806
196 Tap water	St. Louis, Mo.	4807

4808 **PROF. ADOLPH GEHRMANN**, resumed the stand for further direct examination by Judge Springer:

The tables read in evidence, beginning with No. 159 and concluding with 196 contain a correct statement of the results of its findings.

4810 In Table No. 159, which shows result of examination of samples from Illinois and Michigan canal at Bridgeport, in the column headed "Number of Bacteria per Cubic Centimeter," the lowest number of bacteria per cubic centimeter was 81,350, on July 17, 1899. The largest count was made from sample collected November 27, 1899, and numbered 8,425,000. I have not made up the averages but believe that it would be somewhere in the hundred thousands column. The corresponding column for Averyville, in Table No. 172, shows the lowest number of bacteria found as 7,350,000 per cubic centimeter and the largest number 50,000 per cubic centimeter.

4811 From an examination of these two tables, and the figures contained therein, I should conclude that in the first place there was a difference of from ten to twenty per cent in the number of bacteria present, it being less for the samples at Averyville than for those at Bridgeport, and in some instances a difference of 100 per cent in favor of the samples at Averyville. I should further conclude that the samples collected at Averyville showed a much greater bacterial purity than those collected at Bridgeport. From an examination of the samples collected from the Illinois and Michigan canal at Lockport and those collected from the Illinois river at Averyville, I should conclude in the first place that there were from ten to twenty

per cent less numbers of bacteria in the Illinois river waters at
Averyville and in some instances a difference of 100 per cent in
favor of the samples from the Illinois river at Averyville,
4812 and should conclude that the water in the Illinois river at
Averyville shows a much greater bacterial purity than
the waters of the Illinois and Michigan canal at Lockport. Comparing the results of my examinations of the waters of the
Illinois and Michigan canal at Bridgeport, the waters of the
Illinois river at Morris and the waters of the Illinois river at
Averyville, I should conclude in the first place that the numbers of bacteria present are not materially different in the
waters of the Illinois and Michigan canal at Bridgeport, and the
Illinois river at Morris, and that the waters of the Illinois
river at Averyville contain from ten to twenty per cent of the
number found at the other two points and in some instances one
per cent of the numbers found at the other two points, more
particularly at Bridgeport, and that the bacterial condition of
the water represented by these tables, shows that the water
of the Illinois river at Averyville is of greater bacterial purity
than the water of the Illinois river at Morris, or the waters of
the Illinois and Michigan canal at Bridgeport. A comparison
of the result of the examination of the samples of the water
in the Illinois river at Morris, Illinois, the Illinois river at
Henry, Illinois, and the Illinois river at Averyville, shows from
the numbers of bacteria present, that there is not a material
difference between samples collected at Henry and Averyville,
except in two instances—August 8th and September 30th, when
they were much higher in the Illinois river at Henry. The
bacterial counts at these two points are ten to twenty per
4813 cent of those as found at Morris, and show that the water
at Henry and at Averyville is of greater bacterial purity
than the water of the Illinois river at Morris. The bacterial
counts of the waters of the Kankakee river at Wilmington,
Illinois and of the Illinois river at Averyville show only slight
differences. In some instances they are in favor of the Illinois
river and other instances they are in favor of the Kankakee

river. The samples are taken about the same time or near the same time. From a bacterial examination or standpoint I should conclude that there was no material difference in these two waters as to their bacterial purity.

JUDGE SPRINGER: Q. Assuming, Professor, that the Kankakee river above the mouth of the Des Plaines river is merely an upper portion of the Illinois river, differing only in name, from the lower reaches, and assuming that the condition of the water contained in the Kankakee river before its confluence with the Des Plaines river to be as stated in your testimony heretofore, what is your opinion as a bacteriologist, from an examination of the two tables to which your attention has been called, as to whether or not the Illinois river at Averyville has reached a condition bacterially substantially the same as that which it had before the waters of the Des Plaines river and the Chicago drainage canal and the Illinois and Michigan canal were emptied into it?

4814 A. From an examination of the bacterial counts as made of the samples of water from the Kankakee river at Wilmington, and from the Illinois river at Averyville, I should conclude that the examination showed very much the same conditions as regards bacterial purity, the numbers in the majority of instances being not very different.

Q. Then if we assume that there is such a thing in the Illinois river as a zone of bacterial purification where in your opinion, as a bacteriologist, is this zone to be found in the Illinois river?

4815 In reply to this question I can say that from the examination of the samples and the number of bacteria found, that there is a point at about Averyville where the condition as to the number of bacteria exists about equal to that of the tributaries of the river, and that the waters here show the least numbers of bacteria in the course of the river to the point at which they increase next below. I should therefore say that a degree of purification had taken place at about the location of Averyville in the river. My opinion would be from the bacterial count that there was no particular difference in the bacterial purity of the waters in the Kankakee river and at Averyville and nothing that would indicate to us to what amount pollution had been applied between these points or near those points. The results of the examinations of the Illinois river water at Wesley City, and at Pekin showed very much the same condition. There is a wide variation between the counts made at different times, some being as high as two or three million, and others as low as 10,000.

4816 In comparison, the examination of the waters of the Illinois river at Averyville shows in general a much smaller number of bacteria present, not in any instance having been over tens of thousands, and would indicate to me that the water of the Illinois river at Averyville is of greater bacterial purity than the water of the Illinois river at Wesley City or at Pekin. From the difference in these results which is apparent, I attribute the increased bacterial count at Wesley City and Pekin, as compared with that at Averyville, to increased pollution of the river. I have seen that increased pollution coming from the city of Peoria and in that neighborhood. The results of the examination of the Illinois river water at Wesley City and Pekin as compared with those at Grafton, in the Illinois river, show that at Grafton there are from ten to twenty per cent of the bacteria present as shown in the samples from Wesley City and Pekin, and in some instances, one per cent of the bacteria that are present at Pekin and Wesley City. I should conclude from this that the waters of the Illinois river
4817 at Grafton show a much greater bacterial purity than those at Wesley City and at Pekin.

Q. If you compared the waters of the Illinois river as disclosed by table 179 at Grafton, with the waters of the Illinois river at Averyville, as disclosed in table 172, what conclusion do you draw so far as these counts are concerned, as to the relative bacterial purity or impurity of the water?

A. I should conclude that the bacterial purity of the water or its condition was about the same. I should conclude from the bacterial count made on samples of the water of the Illinois river at Wesley City, and Pekin and Grafton, that as far as the bacterial purity is concerned, the river had changed to the condition that we find it in from examination of the samples taken at Averyville, above the City of Peoria.

4818 The results of the bacterial counts of samples taken from the waters of the Illinois river at Grafton and the Mississippi river at Grafton, as shown by tables 179 and 180, show no material difference and I should conclude from this that the bacterial condition of the two rivers is approximately the same from the numbers of bacteria present. The results of the bacterial counts made on the Illinois river at Grafton, and the Missouri river water from Fort Bellefontaine, show that there is no great difference as to the numbers of bacteria from these two points. I should therefore conclude that the bacterial purity or impurity of the two streams is about the same.

4819 Bacterial counts made of the samples of water taken from the Mississippi above the station at the Chain of Rocks, the pumping station of the St. Louis waterworks, all show practically the same bacterial counts, and I should conclude that the bacterial purity or impurity of the water at this point is about the same. There is no material difference in the bacterial counts from samples taken from the Mississippi river 400 yards from the Illinois shore at the Chain of Rocks as shown by table 186 and samples taken at the same place 400 feet from the Missouri shore as shown by table 189. Examination of the result of samples of Mississippi river water taken at the Chain of Rocks, as shown in table 188, compared with the examination of samples of the Mississippi river water taken at Jefferson Barracks, 100 yards from the Missouri shore, shown in table 195, show no material differences as to the number of bacteria present, and I should conclude that the waters at these particular points show approximately the same bacterial purity or impurity.

4820 In the examinations which I made of the waters of the Illinois and Michigan canal and the Illinois river I made

an examination for the colon bacillus and the typhoid bacillus. I did not make any examinations to determine the presence of any other pathogenic germs. The results of my examinations for the coli communis are correctly stated in the tables which I have read in evidence. I did not discover any typhoid bacilli in any of these examinations. I cannot say that I found bacillus prodigiosus in waters. I can say, however, that I have found it during the examination of waters. My opinion is that it was an accidental entrance upon the culture plate, caused in some way through the making of the plates, the preparation of the plates, that it arrived on the plates as a contamination approximately. I cannot say positively that such ascertainment or discovery indicated that there were in any of these waters in the
vicinity of Chicago, the bacillus prodigiosus. My tests in-
4821 dicated to me that the bacillus prodigiosus is usually
present in this vicinity and can be found by exposing material suitable for it to grow, in various places. If there had been large numbers of any particular kind of pathogenic germ I would have found them. Examinations for bacterial counts will give organisms that will grow under the conditions in which the colonies are made, and some bacteria of course will not be developed. We will have to admit that they are lost in the examination. If certain other varieties are present in large enough numbers, they will appear in the examination as a definite part of the examination so that in reply to this question I cannot say that we would have positively isolated the other bacteria present.

4823 In the hospitals with which I am acquainted in Chicago, efforts are made to prevent the spread of infectious diseases in some cases by special rules and special rooms being set apart. In regard to typhoid cases the discharges are disinfected. I can only state positively as to the method of disinfecting where I had something to do with it. It was to place a quantity of one to one thousand of bichloride solution in the vessels in which the discharges were passed, and they were allowed to stand several hours before they were emptied into the drains and carried into the sewers. That would kill any pathogenic germs that might have been discharged from the patients.

4824 The Health Department issued a circular regarding the care and disinfection of typhoid. (Witness reads instructions in regard to the destruction of the discharges of typhoid fever patients.) In the hospitals where I visited and in my own practice as a physician, as far as I know, these rules were enforced, although I do not believe that this particular disinfectant was used in all cases—its equivalent or something else was used.

4825 R. J. BEDFORD, examined in chief by Mr. Todd:

I live in Dahinda, Knox County, Illinois. Was employed by Prof. Long of the Northwestern University to collect water from the Upper Spoon river. (States where samples were taken, method pursued, etc.)

4827 COMTE MAX Le COUPPEY De La FORREST, examined in chief by Judge Springer:

(See record 4827 for reasons why witness was not asked concerning conditions in the United States.)

4828 My official residence is Paris, France. My title, Secretary of the Commission d'Etudes des Eaux, Paris, France, that is, Secretary of the Commission of studies of water—the study of the sewer waters and water supply for the city of Paris and the metropolitan district of Paris, what we call the Department of the Seine, in France. I am also Secretary of the Society of Hygiene of France, but that is private business—not official business. During the great Exposition in 1900 I was one of the Secretaries of the International Congress of Hygiene in Paris. I am also a sanitary engineer. The city of Paris began the construction of what is known as the irrigation system in 1868. Experiments were made before—from 1866 to 1868 in Clichy, near Paris, for the purification of sewers and

4829 irrigation, and after these experiments it showed that the sewage could readily be purified with irrigation so the city of Paris began, after these experiments were closed, in

1868, to irrigate the fields. In the beginning it was a very small area, it was only fifteen acres that was in operation in 1869, in the place known as Gennevillier, but the areas were not increased immediately, because we had a great war between Germany and France and it was not possible at this time to work, but in 1872, we began to increase this area and every year it would be increased, and now, in 1889 the area of Gennevillier was 1900 acres instead of fifteen acres as in the beginning. The system is very good. The rent of the land before the irrigation was about 45 francs or $9 per acre and after the irrigation the land—the same land, would rent for 200 francs instead of 45, or $40 instead of $9 in the beginning. Soon there was no more room in Gennevillier for further irrigation, so we had to go farther away to a place where the soil was good for irrigation. We went afterwards to Acheres. In the field of Acheres in 1879 we put in operation a superficial area of 2,600 acres. The population of Paris increased, and before that we had very many private cess-pools and we built great sewers and obliged all the houses to be connected with the sewers, and so we must always increase the area of the irrigation field. After Acheres, we built an irrigation field at Mery, of 3,000 acres. This was put in operation in 1898 and after that we built the field at Triel, of 1,800 acres, so the amount now of our irrigation fields is 9,300 acres.

Q. At this time?

A. Yes, sir, now. Our houses are connected with the sewer system in Paris. There are in Paris 80,000 houses, or there were on the 1st of April, 1903. 35,000 of these houses were connected directly with the sewer system. About 25,000 houses have filter cess-pools. The urine and liquids of these filter cess-pools go directly into the sewers, and the solids are afterwards emptied into the Seine, in many places near Paris. So we have in Paris perhaps 60,000 houses which were connected directly or indirectly with the sewer system. The population of Paris is now 2,750,000 inhabitants. Of this the residences of six-eights were connected with the sewer system, so it is about 2,100,000 of the inhabitants that are directly or indirectly connected with the

sewer system. The method of irrigation is not everywhere the same. In Gennevillier, there are little garden farmers who have only a little garden in which to grow vegetables or fruit, and these people can take as much sewage water as they will and
when they will. A comparison since twenty years has
4830 shown that these people take always an average of the
same amount of water every year.

Q. Sewage water?

A. Yes, sewage water; always the same average every year. They average over 40,000 cubic meters every year per hectare. I will reduce that to gallons. That is 6,500,000 gallons per acre per year, but for the other fields, for Acheres, Mery and Triel all the land, all the country is the property of the city of Paris, and this land is rented to the great farmers, who give some money to the city of Paris for it, and the people are obliged to take every year the same amount of sewage as before. It is a law, which allowed the building of this irrigation field near Paris; the farmers are obliged to take this amount of sewage and to be sure that the people do that, we have many employes of the city of Paris who every day open the gate to the sewer to give the required amount of sewage to the farmers, and we have foremen and engineers to oversee the employes. I think upon the irrigation question that is all that I can say now.

Q. How is the water that was brought onto the land through the irrigation pipes taken away from the land again and returned to the river?

A. It is not the same everywhere. The field of Gennevillier, the field of Archeres and of Triel are near the Seine river, and the field of Mery is near one affluent of the Seine river, near the river Oise, which empties afterwards into the Seine river. We have drained a great portion of the irrigation field with tile drain and this title drain empties into little creeks that afterwards empty into the river Seine or the river Oise. All the effluent of the sewage will be discharged into the river Seine after purification through the soil, and this purification is good. In Acheres, Mery and Triel, where the land is the property of the

city, the city of Paris has built little gardens, because cities desire always that her works are pretty for the visitors and in these gardens are lakes. These lakes are supplied only with
4831 the effluent water from the irrigation field, and in these
lakes live many fish, and at the point where the main drain comes into or empties into the lakes there are springs, but the springs are all of the effluent water. And all of the workmen who live on these different farms—there are perhaps 200 or 400 hundred of these workmen living in this country, they drink only the water of the effluents, and we have a medical survey of these men. All the physicians of the country are connected with the city of Paris and must give weekly reports upon the sanitary conditions of all these men, of all these workmen, and since these different irrigation fields are in operation we have had no typhoid fever or cholera or dysentery, or the diseases which come from water. Those who use the water from the irrigation fields, or the effluents, have not had any of these diseases. I have drank the water myself very often and many times, foreign people who come to see our irrigation field, whom I, as engineer of the city of Paris, would take to the irrigation field, would drink and I drank always the water. There are three reasons which caused the government of paris to adopt this irrigation system. The first reason you might say is only a pleasure reason, the other was a sanitary reason and the third, industrial. Above Paris are little cities and residence towns, to which came in the summer time many people of Paris. There are perhaps three or four hundred thousand people who come from Paris during the summer to live, near Paris, 20 or 30 miles below Paris, that is below the city. All of these residences are built on the banks of the river Seine are very pretty, many trees and little hills; it is very pretty and very agreeable, but when the city of Paris began to discharge its sewage into the Seine, there was a great smell, the water was very dirty; it was no more possible to bathe in the water and every year the condition got worse and worse and that began in 1860 and from 1860 to 1870 that was always worse and worse. That is the pleasure reason

if I can say so. And the second reason is the sanitary reason, and that is that in summer when the river Seine is low the people who live near the Seine had in time a little fever, not typhoid but malaria or something like that. Not quite malaria, but a little fever, intermittent fever at the point where the river Seine was low and where the river had many branches. And the third reason is an industrial reason if you can say so. There are a great deal of people who live below Paris between Paris and perhaps sixty miles below engaged in the fishing industry and all of the fish died because there was too much sewage in the water and every year the condition of the fish became worse and worse because the amount of the sewage that was discharged into the river was in summer diluted in a very small amount of water. The dilution of the sewage in the Seine was only at this time one-fifteenth or one-eighteenth. That means one part of sewage was diluted in fifteen times that many parts of Seine water or eighteen parts of Seine water.

Q. How far down the river did this pollution extend at that time during that period?

A. Perhaps 35 miles below Paris in the summer time. I have here the different chemical analyses of the river Seine, above Paris, in Paris, below Paris, and at many points below Paris from 5 miles to 100 miles below Paris. That was before the irrigation was begun. One of the analyses is for 1847 and the other 1869, when we were ready to begin the irrigation in the field of Gennevillier and I also have here the organic matter and the total nitrogen in the water. You can see that where the main sewer emptied at this time into the river Seine, it was 25 parts of total nitrogen in the water per 100,000 parts of the river Seine and 42 miles below, near the city of Maneese, it was only 1.4 instead of 25 parts.

4833 I have also the figure for the organic nitrogen at the same point where the main sewer emptied into the river Seine. It was 7.2 parts of organic nitrogen per 100,000 parts of the river Seine and near the city of Meulan 40 miles below Paris, it was only .4 of a part of organic nitrogen per 100,000 parts of water of the river Seine. So we can see that at this time the river Seine had a self-purification after 45 miles, at this time in 1869. At that time perhaps only 800,000 people deposited their sewage into that river. At this time the city of Paris has 2,750,000 inhabitants. The people of Paris do not now discharge the sewage into the sewers and into the river Seine. They discharge it into the irrigation fields, that is, six-eighths of the inhabitants do and the other two-eighths sell their sewage to a company who make fertilizer of it. The suburbs below and above Paris also discharge their sewage directly into the Seine and that was a population of about 1,100,000 in 1899. The two-eighths of the sewage of the city of Paris that is not carried off into the irrigation fields, those people fix cess pools in their houses and a company will empty these cess pools once or twice a year and will make fertilizer with all the matter that was in the cess pools.

4834 These people must pay something to the company for the removal. They pay per cubic meter. I think in some parts of France it is two francs per cubic meter. I do not know the general price. This irrigation plant has cost the city of Paris, up to the present time, as follows:

Gennevillier cost, 5,200,000 francs.

Acheres cost, 10,500,000 francs.

Mery cost, 10,800,000 francs.

Triel cost, 15,000,000 francs.

Buildings for housing of machinery and general expenses 5,000,000 francs. I am sorry but I have not here the cost of maintenance. I have only the cost of the elevation of the sewage, to put the sewage into the irrigation field, and this cost is something high, because we must elevate the sewage very much. The pumping of the sewage comes very high. This cost in 1901 was 2,967,500 francs, or $593,000. That is the cost for the pumping. I haven't the other figures here. The other cost is very high because at Acheres, Mery and Triel we have a great many employes who must open every day the gates of the sewers. We have perhaps 200 of these men and I do not know how much these people cost.

4835 The employes are what we name in French skilled workmen. They are well informed and do not work alone. There are all the time foremen and many superintendents and three sanitary engineers above the superintendents. For the purpose of ascertaining the character and condition of the water above and below the city we make chemical and bacteriological experiments of the water in the Seine and continually we make analyses and examinations of the drainage of the different irrigation fields. Below Paris we take two samples every week, five miles below Paris, ten miles and fifteen miles below Paris, two times every week, and the effluents of the different drains in the different irrigation fields are also examined for bacteria and for chemical compositions, every week, one or two times or three times, not always the same. The river Seine at all times is polluted by many cities above Paris so that the water is not drinkable in Paris, but below Paris after it has emptied into the river Seine the sewage perhaps of 1,000,000 or 1,200,000 inhabitants, the condition of the river Seine is very much worse than above Paris.

4836 In summer immediately above Paris especially, fish cannot live in the water of the river Seine. In the summer time the volume of the water in the Seine below Paris is 126,000 cubic feet per minute in the lowest stages. In the ordinary months, it is 190,000 cubic feet per minute. I have said that in 1869 when 800,000 people discharged their sewage in the river Seine, the purification of the Seine was perhaps—the zone of purification was perhaps 45 miles below Paris, but now we have perhaps 1,200,000 people who discharge their sewage into the river Seine, and the zone is, I think—I am not quite sure— it is perhaps 55 miles below Paris. I have no figures here but I think that it is so, 55 miles. I have the figures in Paris but I have not them here. I am almost sure that it is 55 miles from Paris and I must say that the sewage is diluted now in the proportion of 1 to 20. One part of sewage to 20 parts of the river Seine. We have in Paris a double water supply and two kinds of pipes. We have drinking water and cleaning water.

4837 We use the river Seine water for everything except drinking purposes and cooking purposes. The drinking water comes from springs which are far away from Paris and is brought there over aqueducts. The shortest is 60 miles long and the greatest is 110 miles and now we are bringing to Paris new springs and the aqueduct will be 200 miles long. We furnish each day 24 gallons of drinking water and 45 gallons of cleaning water per capita. The river Vanne furnishes one-third of the amount of drinking water. Vanne is not a river—there are springs which are in the valley of the river. It is really a spring.

4838 CROSS-EXAMINATION By Mr. Jeffries.

Paris is not quite sure whether it will further extend its sewer fields or whether it will be a sewage field or septic tanks or the aerobic system, because these septic tanks, or the aerobic system do not cost us so much as the irrigation field. Two years ago the chief engineer of the sewers of Paris was sent to England to study the septic tanks and this year I was sent to America to see what the American people are doing for sewage disposal because we must increase our system of sewage in Paris. There are 60,000 houses connected directly or indirectly with the sewerage system and we must build a sewage plant for the 20,000 houses that are not connected. This must be a field irrigation or a septic tank or something else. The object of the authorities of Paris in treating this sewage is to purify the Seine between Paris and 55 miles below Paris where the self-purification of the river is not great enough. It is 250 miles perhaps from Paris to the sea by the river Seine. The city of Paris has two sources of revenue for the sewage. First, each house that connects with the sewage system must pay a tax, and second the irrigation fields are rented to farmers who give a great sum of money, but I think that in all it costs something to the city of Paris, because we must elevate the sewage very much and so we must increase often the tax for the connection from the houses to the sewer to do that. It cost nothing to the city. On these irrigation fields it is not allowed the farmers to produce all kinds of crops. They won't allow them to grow the crops which people eat raw without cooking, such as raw fruit and salad, and it is no more allowed to make the crops of wheat that will grow very near from the soil, because we have seen that people who will eat the crops that grow very near to the soil, which is covered with the sewage and which has in it the bad bacteria, and the people who eat that, afterwards can be sick. The board of health of Paris first, and afterwards several boards of health of France, prohibited the use of the soil for fruits and crops which grow very near to the soil, that can be eaten without cooking, and since the board of health, two or three years ago, made this prohibition, or regulation, the condition for the farmer is not so good as before, because before that they had very good strawberries and slaw and salad, which they cannot any more have now. I just say that I and my family before the board of health said that, for the last fifteen years, we have never eaten any Paris raw salad because the greatest quantity of salad in Paris came from the irrigation fields, and I say it is very dangerous to eat the salad. Not so now, because now the salad comes no more from the irrigation field but comes from other gardens or fields and does not come any more from the irrigation fields, but before that it was very dangerous to eat the salad from Paris. They can grow potatoes, because you eat cooked potatoes and you will not eat the shell of the potato, it would be dangerous to eat the shell of the raw potato, but nobody ever does that. Before that order the sewage fields were a good revenue. I do not know how much revenue per acre they derived from these sewage fields but the field at Gennevillier does not belong to the city. It belongs to private people. There they have crops like strawberries and salad and asparagus. This kind of crops will give very much more money than other crops, perhaps ten times more. I know that for Gennevillier the rent of the soil is 300 francs per acre and that is six times as much as they get for good soil in France. An effort is now being made to purify the sewage of 1,200,000 people which is directly emptied into the river Seine and the sewage of perhaps 500,000 people who live near Paris. They are going to do away with the sale of the sewage to private companies and are going to treat it in some way that has not yet been determined upon. After that has been treated it will comprise practically all the population of Paris and its suburbs. The idea in making this investigation being to obtain the most approved and scientific method of treatment, with a view to removing all of the harmful substances from the sewage. This sewage is immediately taken in charge by the farmers night and day. An employe of the city of Paris will open the gates of the sewer, just as the man will say to this man, one day in one part of the field and the other day in the other part, and none of the sewers will remain without being used. They are used immediately. It goes through the sewer and is immediately discharged upon the field.

4842 J. J. STITES, examined in chief by Judge Springer:

Am a physician and live at Pontiac on the Big Vermilion river. Took some samples of water from the river for Dr. Long of the Northwestern University, in November and December, 1899.

4843 (States places where samples were taken and method employed, etc. Testimony of this witness objected to because samples of water were taken from the tributaries of the Illinois river.)

4846 B. F. LONG, examined in chief by Judge Springer:

Am a stationary engineer and reside at Joliet. Took samples of water from the Des Plaines river at Joliet at the instance of Dr. Long, in the summer of 1899 and the summer of 1900. (States where samples were taken, method used and where they were shipped.)

4852 PROF. ADOLPH GEHRMANN, resumed the stand for cross-examination by Mr. Jeffries:

The determination of the number of bacteria present in water is a small part of the examination of water for purity. It indicates a degree rather than an absolute fact. The kinds of bacteria are more important than numbers and so far as pathogenic bacteria are concerned, the kinds may depend to a degree upon the source of pollution. A cubic centimeter is about one-quarter of a drachm. I do not know how it would compare with an ordinary thimble. I have no experience as to thimbles.

4853 These examinations were made in water known as dilutions. It became necessary, owing to the large number of bacteria present to dilute the water 100 times or a thousand times and then take a portion of this dilution for the plate cultivation, so that in none of the instances was a cubic centimeter taken.

4854 Q. Now, doctor, was this small quantity of water examined sufficient to determine with accuracy the bacterial condition of the whole canal or river from which it came?

A. I might confess that an examination of this kind shows a degree of accuracy that gives results that can be comparable with other results made about the same time or in the same line of work. Such an examination is scientific but it is not like mathematics. I believe each particular sample would be a representative of all the water in the river at the point where taken, for the time and moment that it was collected.

4855 I do not think that the bacterial count in itself will decide as to the sanitary condition of water. The bacterial count is not a statement of quality, it is distinctly a statement of quantity. When I testified that the bacterial purity of water examined by me from the Illinois and Mississippi rivers at Grafton was about the same, I was speaking at the time about the numbers of bacteria present, and the results indicate that as far as the numbers of bacteria and the activity of the bacteria present in the water in these two localities, is approximately the same.

4856 Bacterial purity is not recognized as its sanitary condition, except as far as the general activity of decomposition that is taking place, is concerned, which has a slight bearing on the question as to purity or impurity.

4858 I examined the water from the Two Mile tunnel and the Four Mile tunnel at the time there was typhoid existing in the 19th ward of Chicago and also before that time and did not discover any typhoid bacilli in such water. I don't believe the typhoid bacilli were there. I am quite certain that that epidemic did not come from the water.

4859 The epidemics that I have any definite knowledge of in Chicago, outside of the one of the past year, 1902, were due to the water. I would say that about one-half of the cases of typhoid fever in Chicago since 1894 under all circumstances come from the water supply, owing to two or three causes. There has been continuously a certain amount of flow of sewage into the lake, especially along the south side, from 35th street, south, so that infectious matter could be carried out to the cribs, and there has been dumping of dredges along shore almost continuously during these years.

4860 I have noted some slight difference in the bacterial count of Lake Michigan water during the time typhoid fever was prevalent in Chicago. In one small increase in typhoid that occurred in 1897 the bacteria were more numerous and the water was worse at that time and there was an increase in typhoid two or three weeks later. That is the only one that I can recall that is very definite. The water of Lake Michigan during all of the years that analyses have been made by me and in my laboratory taken from the various cribs, in respect to bacterial count and bacterial purity are better than the averages which I have obtained from Grafton. I am very certain that upon many occasions the bacteria found in the water of Lake Michigan came from the dredgings that were deposited in the lake, because I had occasion to follow the dredge or follow the water for as much as an entire afternoon, as to its movement in the lake. The dredging referred to is not one of stirring up but it is the emptying of dredgings from the scows into the water and my view is that a portion of the typhoid comes from these dredgings but not any material proportion of the typhoid. The typhoid that we have, that is, that portion of it that we can attribute to the water, comes from the direct transfer of infectious matter from the sewers to the cribs. I think the dredging is a party to it, but to a less extent.

4861 When I said the counts were better in comparing the bacterial counts in Lake Michigan with those of the Illinois at Grafton I meant that they were lower in the waters of Lake Michigan. The bacterial counts I made were made upon agar plates. We kept them at 18 to 20 centigrade. It was the intention to keep it exact but it ranged from 18 to 20. That would be what is known as moderate room temperature. I have found bacillus prodigiosus in examinations of different kinds. When I really tried to get a culture of bacillus prodigiosus, I took plates where there was decomposed vegetable matter in considerable quantity. For instance in a garden, cabbage field or something of that sort, and I found it there. I believe that it lives wild in the United States.

4862 It is not common in nature. Sometimes it appears in considerable numbers at a given point. As a general thing thing it does not. It is not as prevalent as many other organisms.

4863 The examinations that I have made as to the extent of bacterial contamination in Lake Michigan from the lake front at Chicago show that the degree to which the sewage and shore contamination would extend into the lake varies a great deal, varies rapidly at times, depending upon wind movement and the amount of rainfall as to the flushing of sewers. Some of the recorded examinations show that there is no evidence of any pollution any further out than two miles and again we have evidence of pollution by the presence of excessive numbers of bacteria and colon bacillus ten miles out. The sewage entering Lake Michigan is highly diluted before it enters the intakes of the city waterworks. I have used in my water examinations the so-called guinea pig tests for the purpose of determining the presence of pathogenic germs. This test will not necessarily show the presence of typhoid bacilli. It might under some circumstances but not as a routine method. I do not believe it would positively in all cases show the absence of it.

4864 I consider that an important test in water examinations. It was not used in my examinations of the water of the Illinois river because the examinations that were made were made in the way they were made on account of a mutual agreement between a number of parties to which I was a part, and the concensus of opinion was to conduct them in that way. That is all I know about it. The difficulties of animal experiments may have a possible bearing on a question of that kind. A pathogenic micro-organism is one that under conditions is able to alter physiological conditions. The alteration of any physiological function has in it at the bottom the disease or pathological condition.

Q. But it may not be an infectious disease germ?

A. Infectious? No, it might be a toxic disease. The saprophytic bacteria is one that is capable of living on dead organic matter. Pathogenic germs may be capable of living on dead material in laboratories and may be what we call facultative, that is, may live either on dead material or as parasites on living material. In the analyses of the water from the Illinois river in 1899, I recorded simply the presence of the colon bacillus and not the numbers.

4866 These examinations by the Chicago Health Department were made under my immediate supervision. I made a great many of the counts and the direct examinations personally. I have supervised the work personally throughout. I had as assistants, Kierueff and Dr. Kilburn.

RE-DIRECT EXAMINATION, by Judge Springer:

As to the effect of taking the 12th and 22d street sewers from the lake and turning them into the Chicago river, on the typhoid death rate in Chicago, I will say that these two sewers were relaid in 1898 and 1899. The work was completed in the fall and winter of 1899 and the drainage of all of the district as far south as 31st street in this city was changed from discharge into the lake to discharge into the river, that is westward. The records of the following year show that 1900 is the best year that the city has had as regards typhoid fever. It is due in part to the removal of this amount of drainage from the lake, because these sewers were in such a position that their discharge would pass more nearly opposite the important intakes. The removal of the intakes further into the lake has reduced the amount of typhoid fever in Chicago because of the greater dilution and greater time required for the sewage matter to reach the intakes. The increase in typhoid in 1902 was mainly a local epidemic in the Nineteenth ward and was due to the overflow of the portion of the basement and a pump well of the Harrison street pumping station during the early summer and also to the presence of open vaults in this ward, as shown by the investigations of the members of Hull House and published in the report of the City Homes Association. In the overflow of this pump well as stated, it was found that a sewer connection had overflowed and was the direct cause of the flooding by sewage from the street sewers. Out of 402 deaths recorded in 1902, 180 were in this immediate neighborhood, that is something over 35 per cent. When I say immediate vicinity, I mean the 19th ward, which has a population probably of 30,000 or 40,000 people. If sewage should pass into the lake at this time or if sewage is now passing into the lake, there is not more typhoid fever in Chicago because the intakes are at such distance from the shore that the dilution of the sewage is so great and the time for the passage to the intakes and back to the population is sufficient to give opportunity for destruction in a considerable portion of the infectious matter.

Q. From your studies of the water supply of Chicago and from your knowledge of what has been done in reference to this supply, will you state what improvements, if any, have been made in the system from time to time?

4869 A. Up to the years 1890 and 1891, the intakes for the obtaining of water were not over two miles from shore, the furthest being two miles. Other intakes were less than a mile from shore, and up to that time there had been a continuous excess of typhoid fever in the city. In the epidemic of 1890 and 1891, and a portion of 1892, which was due to the special taking of water from the shore intake, the extension of the intakes was completed, and from that time a marked decrease in typhoid was noticeable. In 1899 the work of relaying the sewers at 12th and 22d streets was completed and a further decrease in typhoid resulted. By infectious matter, I mean portions of the structures or tissues or excretions of the individual containing the micro-organisms that will lead to infection.

RE-CROSS EXAMINATION, by Mr. Jeffries:

Undoubtedly if all the sewage of Chicago was turned into Lake Michigan today it would increase the number of typhoid cases in Chicago.

4870 The dilution of typhoid bacteria in the water of Lake Michigan when the average typhoid conditions at Chicago existed must be extremely great because I cannot find the typhoid bacillus in the water and I have made many examinations of the water of Lake Michigan for that purpose.

4871 When I find colon bacilli present in water that I am examining, which water I know has produced typhoid fever among the people using it, I conclude that the presence of the colon is in part significant of the presence of other organisms, but the effect that the water has upon the peo-
4872 ple using it is better index than the simple finding of the colon bacillus. Dilution pure and simple would not remove pathogenic micro-organisms from a lake or running stream. It would aid in their destruction because it would bring about a more rapid dissemination and breaking up of the particles derived from individuals that are sick with the various diseases and in that way would liberate the micro-organisms from the protection of particles, so the destructive effects might be more easily operative in bringing about their ultimate death.

4873 Assuming that a typhoid bacillus was deposited in an ordinary well I would not recommend the use of that water knowing that the bacillus had been deposited there. I do not believe that there is very much danger from even a few single free typhoid bacilli. I must draw a distinction between infectious matter and free single typhoid bacilli and in a case where I knew positively that one typhoid bacillus had been placed in a certain quantity of water, without knowing anything of the conditions under which that water was to be placed, the amount of organic matter in it, the possibility of the rejuvenation and growth of them—of this single typhoid bacillus, of course I should say that the water was not potable. But under conditions where I knew that there would probably be no multiplication of that typhoid bacillus in the water—no incarnation as it were, of the amount of infection present, I should not myself have any hesitancy in drinking the water, because I do not believe, even though I should swallow that one germ—that it would affect me. I believe that in highly contaminated water, where decomposition and the action of saprophytes is very active, the pathogenic organisms, or disease producing organisms are more quickly destroyed.

4875 D. B. BISBEE, examined in chief by Judge Springer: Live at La Grange, Illinois. Am a chemist. Graduated from the Agricultural College of Iowa and took a post-graduate course afterwards. Made chemistry my specialty right straight through.

4876 For four years, beginning in February, 1896, I was Assistant City Chemist of Chicago and was engaged all that time in water analyses. I am now Chief Chemist of the City of Chicago. I should say that I made analyses, on an average, of seven samples a day six days in the week, for the four years referred to. I also made chemical analyses of a number of ices, milks and other liquids.

4877 I heard parts of Dr. Gehrmann's testimony. The tables to which you call my attention, beginning with 159 and ending with 196, to which Dr. Gehrmann referred, are the tables that were drawn up from my notes—that of Streams Examination work, which I did jointly with Dr. Gehrmann.

4878 I made all the parts of those tables with the exception of the notes under the headings, "Heighth of Water," "Temperature of Water," "Temperature of Air," "Presence or Absence of Coli," and the number of bacteria per cubic centimeter." (Witness states how samples were received and the method employed in determining the qualities enumerated in the tables, of turbidity, sediment, color and odor, residue on evaporation, chlorine, oxygen consumption, total dissolved and suspended matter, etc.)

4889 CROSS-EXAMINATION, by Mr. Jeffries:

There was no test for sediment. It was just simply the relative amounts that I judged present. It appears on the bottom of the tables.

4890 It was by ocular observation, that is all. If the sediment had been as transparent as the water I would not have been able to detect it. If there had been living organisms existing in the water capable of motility I would not have been able to detect them with the naked eye. As to the turbidity, I judged that; it was simply an estimation; it was my judgment. The question of turbidity does not in itself determine the presence or absence of living organisms that do or do not produce disease.

4891 It has nothing to do with the question of the presence or absence of micro-organisms. Samples of water may contain large quantities of various chemical substances which would be considered by chemists as rendering the water unpotable and at the same time would not contain a single disease producing organism.

4892 It would not be a living mass of organisms of any kind unless there was at least a certain amount of organic matter for them to live upon and you could detect that. The organic matter may be present with the disease producing germs absent. Unless the organic matter was there the disease producing germs could be present but they could not live.

Q. So then, the idea is, the more organic matter, of whatsoever character, contained in any water, the more dangerous it is for domestic purposes, is that it?

A. The more apt we are to mark it suspicious, or call it unpotable water.

4894 In November the amount of suspended matter found at Grafton in 1899 was five or six times higher than what was found in July. The sample examined on the 7th of July and the 13th of July was 7 parts per million of suspended matter and on the 20th of July was 16 parts per million; July 27th, 18 parts per million; November 3, 94 parts per million; November 10th, 27 parts per million; November 16th, 48 parts

4895 per million; November 23, 85 parts per million, so that there was a greater amount of suspended matter during the month of November than there was during the month of July. (States how the determinations of residue on evaporation were made. As to the effect of delay in shipment of samples prior to their examination by witness, see pages 4899, 4900, 4901.)

4903 ARTHUR W. PALMER, examined in chief by Judge Springer:

I reside at Champaign, Illinois. Am Professor of Chemistry in the University of Illinois. Have held that position fourteen years. Was educated in the public schools of Illinois; at the University of Illinois; at Harvard; at Berlin and Goettingen in Germany. (States qualifications.) Have been engaged in making chemical analyses about 22 years as a student and investigator. I had conferences with Prof. Jordan of the University of Chicago with reference to making certain examinations and analyses of the Illinois and Michigan canal, Sanitary canal, Des Plaines, Illinois and other rivers, in March, 1899.

4905 The conference in March, 1899, included a number of other individuals besides Professor Jordan and myself and at that conference it was decided that samples of water should be taken at various points along the Illinois river, the Mississippi river, the Missouri river at one point, and from the Illinois and Michigan canal. Also from some of the tributary streams of the Illinois, and that samples should be taken from each point selected, once a week; that the number of samples taken at each point simultaneously should be sufficient to send one set of said samples to Prof. Jordan at the University of Chicago; one set to Dr. Gehrman, at the municipal laboratory, Chicago, and one set to me at the University of Illinois. Professor Jordan and I jointly selected the persons who were to take the samples of water and the places at which they were to be taken. We went to different points along the different streams mentioned just before—visited them, noted local conditions, pointed out the spot where a sample which should be most representative of the conditions in the river in that vicinity, could be obtained. We selected men to make the collections by reason of their availability and their apparent fitness for doing the work. (Witness states points at which samples were taken and the reasons why such points were selected, also names of the persons who took the samples at the points indicated.)

4918 The relative flow of the Illinois and Mississippi rivers at Grafton in the year 1899, taking the mean for the year through was about five times, or a little more than five times as much in the Mississippi as in the Illinois. Measurements were made by U. S. engineers about the year 1882 at the mouth of the Illinois and at Hanibal in the Mississippi river.

4919 Measurements of the flow in the Illinois river have been made at Kampsville where the flow as measured constitutes ordinarily practically all the flow of the Illinois river at Grafton, and so indicates the volume of water discharged into the Mississippi at the mouth at Grafton. For 1900 the flowofthe Illinois amounted to about 22.6 parts as compared with 77.4 for the upper Mississippi. These determinations being made from the determinations of the proportions of chlorine contained in the Illinois river water, and a comparison with the proportions of chlorine contained in the upper Mississippi river water and in the water of the Mississippi river below the mouth of the Illinois, where partially mixing of the two streams occurred. (It is important to read testimony of this witness as to reasons samples were taken at the points selected. Witness states what instructions collectors were given and method pursued in collecting samples and shipping them to laboratories. After their receipt the analyses were begun immediately, particularly the determination of such constituents as are susceptible to change readily. Witness states method of determining the color, odor, total solids, loss on ignition, presence of chlorine, oxygen consumed, nitrogen as free or solid ammonia, etc.)

4928 Nesslerization is the determination of free ammonia in solution by means of the so-called Nessler re-agent. (States method by which this was done.)

4936 The results of these analyses about which I have been testifying were set forth in certain tables which were numbered from 1 to 80. I identify the tables which you have just placed in my hands, as the ones to which I but a moment ago referred as incorporating the results of the various analyses of the samples of river waters which are the subject of the present investigation. These tables contain a correct statement of the determinations which are indicated in the tables respectively.

MR. JEFFRIES: I object to the reading of the tables because no proper foundation has been laid for their introduction.

4937 Complainant further objects for the reason that according to the explanation given by this witness and all other witnesses who have been produced by defendants, they are unable to give any connection between the analyses of the samples of water taken from the Illinois river, the drainage canal and the Chicago river, and the sanitary condition of the water in the river. Complainant objects for the further reason that this witness has not qualified as a sanitarian or a pathologist, and for the further reason that there is nothing in the tables which shows the presence or absence of disease-producing organisms, and for the further reason that defendants have proved that this is beyond the power of the science of chemistry to determine, the sanitary condition of water for domestic and drinking purposes. Complainant objects for the further reason that the samples of water were not taken with reference to all conditions of the river so far as temperature and the seasons of the year are concerned, and the manner of taking was not such that the results of the analyses based thereon are comparable with each other, or that the results are in any way comparable with the conditions actually existing in the river at any time and at all times.

(Motion by Judge Springer to strike out objection.)

4938 These tables were read in evidence and are numbered from 1 to 80. They will be found on pages 4939 to 5026 inclusive, The source from which the sample of water was taken is indicated and the page on which the table will be found, follows such indication. The samples were taken from May 23, to Dec. 27, 1899.

Table.	Source of Water.	Place of taking sample.	Record Page.
1	Ill. & Mich. canal	Bridgeport	4939
2	Ill. & Mich. canal	Lockport	4940
3	Des Plaines river	Lockport	4941
4	Des Plaines river	Joliet, nor. of Jackson st.	4942
5	Des Plaines river	Joliet, south of town	4943
6	Kankakee river	Wilmington	4944
7	Illinois river	Morris	4945
8	Fox river	Ottawa	4946
9	Illinois river	Ottawa	4947
10	Big Vermillion river	La Salle	4948
11	Ill. & Mich. canal	La Salle	4949
12	Illinois river	La Salle	4950
13	Illinois river	Henry	4951
14	Illinois river	Averyville	4952
15	Illinois river	Wesley City	4953
16	Illinois river	Pekin	4954
17	Illinois river	Havana	4955
18	Sangamon river	Chandlerville	4956
19	Illinois river	Beardstown	4957
20	Illinois river	Kampsville	4958
21	Illinois river	Grafton	4959

Table.	Source of Water.	Place of taking sample.	Record Page.
22	Mississippi river	Grafton	4960
23	Mississippi river	Alton	4961
24	Mississippi river	Alton, ¼ distance from Ill. shore	4962
25	Mississippi river	Alton, midstream	4963
26	Mississippi river	Alton, ¼ distance from Mo. shore	4964
27	Mississippi river	Alton, 100 ft, from Mo. shore	4965
28	Mississippi river	Chain of Rocks Pumping Station, 400 ft, from Ill. shr, St. L. waterworks.	4966
29	Mississippi river	Chain of Rocks, midstream, pumping sta. St. L. waterworks	4967
30	Mississippi river	Chain of Rocks, Inlet Tower, St. L. waterworks.	4968
31	Mississippi river	400 ft. from Mo. shore, at Chain of Rocks, Pumping Sta. St. L. W. w'ks.	4969
32	Missouri river	W. Alton, Mo.—Ft. Bellefontaine	4970
33	Mississippi river	Jefferson Barracks, Mo., 100 yds from Ill. shore.	4971
34	Mississippi river	Jefferson Barracks, Mo., east of midstream	4972
35	Mississippi river	Jefferson Barracks, Mo., midstream	4973
36	Mississippi river	Jefferson Barracks, Mo., west of midstream	4974
37	Mississippi river	Jefferson Barracks, Mo., 100 yds. from Mo. shore.	4975
38	Tap water	St. Louis	4976
39	Sanitary Canal	Kedzie Avenue	4977
40	Ill. & Mich. canal	Bridgeport	4978
41	Ill. & Mich. canal	Lockport	4979

Table.	Source of Water.	Place of taking sample.	Record Page.
42	Des Plaines river	Lockport	4980
43	Drainage Canal	Lockport--Bear Trap dam.	4981
44	Des Plaines river	Joliet—North of Jackson street	4982
45	Kankakee river	Wilmington	4983
46	Illinois river	Morris	4984
47	Fox river	Ottawa	4985
48	Illinois river	Ottawa	4986
49	Big Vermillion river	La Salle	4987
50	Illinois river	La Salle	4988
51	Ill. & Mich. canal	La Salle	4989
52	Illinois river	Henry	4990
53	Illinois river	Averyville	4991
54	Illinois river	Wesley City	4992
55	Illinois river	Pekin	4993
56	Illinois river	Havana	4994
57	Sangamon river	Chandlerville	4995
58	Illinois river	Beardstown	4996
59	Illinois river	Kampsville	4997
60	Illinois river	Grafton	4998-9, 5000-1
61	Mississippi river	Grafton	5002-3-4
62	Illinois river	Grafton	5005
63	Mississippi river	Grafton	5006
64	Mississippi river	Grafton	5007
65	Mississippi river	Alton, ¼ distance from Ill. shore	5008
66	Mississippi river	Alton—midstream	5009
67	Mississippi river	Alton, ¼ distance from Mo. shore	5010
68	Mississippi river	Alton, 100 ft. from Mo. shore	5011
69	Mississippi river	400 ft. from Ill. shore at Chain of Rocks, St. L. waterworks pumping station	5012-13

Table.	Source of Water.	Place of taking sample.	Record Page.
70	Mississippi river	Midstream, at Chain of Rocks, pumping station, St. Louis waterw'ks.	5014-15
71	Mississippi river	Chain of Rocks, Inlet Tower, St. Louis waterworks	5016-17
72	Mississippi river	400 ft. from Mo. shore, at Chain of Rocks, pumping sta. St. Louis waterworks	5018-19
73	Missouri river	Ft. Bellefontaine, W. Alton, Mo	5020
74	Mississippi river	Jefferson Barracks, Mo., 100 yds. from Ill. shore.	5021
75	Mississippi river	Jefferson Barracks, east of midstream	5022
76	Mississippi river	Jefferson Barracks, midstream	5023
77	Mississippi river	Jefferson Barracks, west of midstream	5024
78	Mississippi river	Jefferson Barracks, 100 yds. from Mo. shore	5025
79-80	Tap water	St. Louis, Mo	5026

5027 I prepared these tables myself. They are the original tables. My original was in pen and ink and this is a printed sheet. I read the proof sheets after they were set up by the printer and compared them with the papers I had prepared in the first instance and made the necessary corrections, if any were required. I and my helpers received these samples of water at the laboratory. When the sample was received the date and hour of reception at the laboratory and the serial number was placed on the certificate which accompanied the sample and the same number was placed on the bottle containing the sample.

5028 These serial numbers appear at the left hand of the various tables. Under the head of turbidity, the star indicates a decided turbidity; the section mark, a very decided turbidity; the dagger, a distinct turbidity; the double dagger, a very slight turbidity; the vertical parallel, a slight turbidity.

5029 (States manner in which the presence of sediment and color were determined. See pages 5028 to 5034 for explanation of these tables.)

5035 (Motion by Mr. Jeffries to strike out the testimony of witness in explanation of samples and answer thereto by Mr. Todd and Judge Springer.)

5037 The tables which I have read in evidence, beginning with No. 1 and ending with No. 38 contain analyses of water samples taken during the year 1899. I have made averages of all results of my analyses of the samples collected from each of the points under consideration during the year 1899. Table "A" entitled "Streams Examination, Sanitary District of Chicago, Sanitary Water Analyses, Parts per Million, Averages of Results for year 1899," is the one I prepared and represents the general averages for the year 1899 of the figures appearing in tables No. 1 to 38 inclusive.

5040 Table read in evidence.

5042 Table "B" "Streams Examination, Sanitary District of Chicago, shows averages of Results for year 1900," report of Arthur W. Palmer, University of Illinois.

5046 The averages for the tables numbered 1 to 80 are given in tables "C" and "D" respectively. Table "C" contains verages of results for the period of June, July, August and eptember, 1899, and is made from the detailed analyses apearing in tables No. 1 to 32 inclusive and was prepared in the same manner as Tables "A" and "B."

048 Table "C" read in evidence.

050 Table "D" shows averages of results for June, July, August and September, 1900.

052 Table "G" is a table made by bringing together some of

the averages of tables C and D covering the two four-month periods namely June, July, August and September, 1899, and June, July, August and September, 1900, also showing the highest and lowest figures of various determinations made during the periods in question.

5054 Table H comprises a comparison of the general average of all the work during the years 1899 and 1900 which appear in the tables numbered 1 to 80 inclusive. It was made for the purpose of comparing the condition of the water as between the two years as covered by the examinations made which appear in tables numbered 1 to 80 inclusive.

5055 Tables 95-A, B, C, D, E, F and G contain results of various determinations of dissolved oxygen in samples of water from the various points in the Illinois river and some of its tributaries and the Mississippi river. These determinations ranged from the latter part of April, 1899, until about the middle of October, 1900. These determinations were made from a separate set of samples taken at the same time. In some cases they were collected simultaneously with the large samples that were used for chemical analyses and in all other cases all shipped samples were collected at the same time as the bacterial and chemical samples.

5056 Most of the samples, determinations upon which are recorded in these tables 95a to 95g inclusive, I collected myself and analyzed myself. Samples which were not collected by me—and they include only a portion of the samples collected at Grafton—were collected for me by a collector who had been specially instructed.

5057 In the series of three columns, for which the heading is "Milligrams per liter," represented by the ordinary abbreviation, capitals "M. G." for milligrams, there appear the results of determinations upon duplicate samples in the first two columns, and the average of these two determinations in the third column, save where in a few cases, from lack of time, duplicate determinations were not made. In the next column is given the temperature of the water, which determination was made by the one who took the sample. In the next column, under the general heading "Per Cent of Saturation," are figures which represent that portion of the possible quantity of dissolved oxygen which was actually contained in the water. That is, it is well understood that under the conditions of exposure to the atmospheric there will be modified somewhat by atmospheric pressure, modified very largely by the temperature of the water. The proportion of oxygen which the water may hold in solution varies, and the maximum which can be held in equilibrium in solution at any given temperature is called the saturation figure, and when the water is fully saturated it is regarded as holding 100 per cent of dissolved oxygen, which means all that the water can normally, under the given conditions, retain in solution.

5058 The succeeding determinations down through all the tables, including 95g were made in the same way as that I have just explained, excepting that a few of the analyses or determinations of dissolved oxygen included in these tables were made by the well known Winkler method. (Witness explains process of making examinations by said method.) In the column headed "Remarks," in some instances is the statement, "Test of Keeping Qualities."

5059 The explanation of this is that in some cases even where the work was done on the spot, and for the reason of getting some information as to what changes take place during transportation from the point of collection to the laboratory, samples collected simultaneously with those in which the determination was made as the water came from the stream, were set aside and kept sometimes ten or twelve hours, sometimes until the next day, sometimes two days. The test of keeping qualities applies to this, for the reason that it is found that waters containing notable quantities of organic matters frequently suffer a loss of dissolved oxygen when the samples are allowed to stand out of their natural environment, that is,
5060 taken out from the stream in which they normally are found, or from which they have been collected. If there

is a great diminution of the quantity of dissolved oxygen, then the keeping qualities are regarded as being inferior to what they are in case there is less diminution on standing. (Witness explains how samples were collected and shipped.) With reference to my statements concerning saturation of the water with dissolved oxygen, a reference to the column in which the data under this head is given, shows at once that the figures there are in many cases considerably above 100. For instance, under the Illinois river water at Henry above the dam for 1899, under date of August 17th, the first in that series, the percentage shown in the last column under saturation is 220.88. This shows that the water is highly supersaturated, the supersaturation takes place by reason of the fact that the chlrophyl containing organisms with which the river water at such seasons especially abounds, under the influence of sunlight, give off streams of oxygen, which may be seen coming up through the water and under these conditions, the water naturally
5061 dissolves much more oxygen than it could under these
conditions dissolve from the atmosphere, and this oxygen for a time remains in the water, although on long standing it undoubtedly would be given off in part into the atmosphere, down to the saturation figure of 100 per cent, and also might in part be utilized by the organic matters in the water, and so the proportion be reduced. (These tables will be found on pages 5062-3-4-5-6-7 and 8.)

Objection by Judge Springer to the reading of the tables in question.

When these samples were analyzed in these tables just put in evidence, I was acting as collector, analyst and investigator of the conditions of the water in the Illinois river and tributaries and the Mississippi. I began this work at my own instance, but such portion of it as is included in the tables here under consideration, tables 1 to 80 inclusive, and the tables of averages, were begun as a result of the conference held March 15, 1899, at the city hall, which conference has been described in part by myself and more fully by Dr. Gehrmann in his testimony. I undertook the work on dissolved oxygen myself for the purpose of getting information concerning that particular constituent or condition of these waters as a part of the general investigation, in progress, of these various waters.

5070 The results of our determinations of dissolved oxygen in some 400 samples of water from the Illinois river have shown that the waters of the Illinois river at all times contained a considerable percentage of the quantity of oxygen which was required for saturation, and that at times it contains much more than the saturation figure; indeed, occasionally at certain points it contains even more than double the saturation quantity. The supersaturation of the water with oxygen, if we may so term it, is due to the liberation of oxygen by the chlrophyl containing micro-organisms, and other minute plants which are very abundant in the waters of the Illinois at certain seasons of the year. In fact, oxygen evolving organisms seem to be always present and almost always active in these waters.

5071 Many of the determinations have been made upon the spot, but inasmuch as circumstances rendered it impracticable for us to make very extensive series of determinations in this way, the samples of water were, throughout a considerable portion of the time, shipped to the laboratory and the determinations of dissolved oxygen made there ordinarily in about 20 hours after the time of collection, but sometimes not until 40 or 48 hours had elapsed from the time of collection. These shipped samples gave results which are always less than the saturation figure, except on a few occasions, when the original water was highly supersaturated with oxygen. The exceptions noted from the general diminution of dissolved oxygen during transit, were occasioned by the treatment of some of the samples with mercuric chloride, in which cases there appeared no diminution in the proportion of dissolved oxygen, as the mecuric chloride prevented such changes in the water, as under other circumstances brought about such a decrease of the oxygen contained in solution. Comparison of the results of determinations made upon the spot with those made upon duplicate

samples which were either shipped to the laboratory or kept under similar conditions to those involved in shipping, show that there was in all cases a notable diminution of dissolved oxygen during the time which elapsed between the time of collection, and the time of making the examinations. Consequently, it is certain that the actual content of dissolved oxygen in all these waters was in reality greater than the results here recorded. There was but one case in which a greater percentage of dissolved oxygen was found in the sample which had been kept. This determination is recorded in the bottom line upon table 95a, where a sample of the Illinois river water was taken at Averyville, Aug. 17, 1899, at 6:30 p. m. and examined Aug. 18, 1899 at 7:05 p. m. approximately 24 hours after the time of collection. This abnormal condition will be considered more in detail farther along, when we discuss the conditions at Averyville. Dissolved oxygen in the water of the Illinois river, at its mouth at Grafton: The series of determination dissolved oxygen which appear in the tables 95a to 95g, show that during the
period January 4th to June 27th, 1900, the percentage
5072 of saturation in the Illinois river water ranged from 43.1
to 95.7 the average being 76.47 per cent for the entire
series of 141 shipped samples. As is seen in the date columns, the determinations were made upon samples shipped to the laboratory in usually about 24 hours after collection. The minimum 43.1 per cent was found in the case of four samples collected May 16th, and examined May 18th. In no other case was less than 52.7 per cent found, and indeed, in but five other samples was less than 61 per cent dissolved oxygen found. Dissolved oxygen in the waters of the Mississippi river at Grafton: A parallel series of determinations of dissolved oxygen in the waters of the Mississippi just above the mouth of the Illinois was made upon samples collected at the same time, that is, within a few minutes and shipped and examined under similar conditions. The details appear upon tables 95e and 95f, inclusive. The degree of saturation in these samples ranged from 55.78 per cent to 108.84 per cent, the average for the entire

series of 127 samples being 82 per cent. Comparison of the data obtained from these two series of shipped samples, shows that the waters of the Illinois contain 93.2 per cent of the quantity of dissolved oxygen found in the waters of the Mississippi. I mean by that, that in these shipped samples there was little more dissolved oxygen in those which came from the Mississippi river than was found in those which came from the Illinois river, the relation being as 92.2 in the Illinois to 100 in the Mississippi. This was the year 1900. Analyses made upon the spot (see tables 95c, 95d and 95e) show that both the Illinois river water at Grafton and the Mississippi river water at Grafton frequently contain a greater proportion of dissolved oxygen than is required for saturation, but each of them also frequently contains less dissolved oxygen than the saturation figure required. In general it is true, that the waters of the Illinois do not retain their dissolved oxygen so long as do the waters of the Mississippi, that is, the dissolved oxygen diminishes more quickly and to a greater extent in the water of the Illinois than it does in the water of the Mississippi although the difference between the two river waters in this respect is not very great as may be seen by a study of the data of the tables.

5073 The upper Illinois: In the Illinois river at La Salle, just above the town upon August 16, 1899, we found the water eighteen inches below the surface just saturated with dissolved oxygen, the actual figures being 100.12 per cent to 100.36 per cent in samples taken at different points across the stream. Sample of the water taken at the same time, but examined 24 hours later contained but 75.7 per cent of dissolved oxygen, while still another sample collected at the same time as the three above mentioned, but kept 41 hours, contained but 58 per cent of the amount required for saturation. The evidence would seem to show that during sunshine, oxygen was being evolved by the vegetable life in the water with sufficient rapidity to keep the water saturated, yet when the conditions were changed by placing the sample in the dark such action ceased,

and the oxygen began rapidly to disappear. Similar conditions were found with respect to the water of the Illinois and Michigan canal at La Salle. The water at the upper basin at La Salle was, before the opening of the sanitary canal, in a better condition ordinarily, than was the water of the Illinois river at this point, for the reason that the canal above La Salle was fed from the Fox river and other streams. The records with respect to the water in this place, as given in table 95a show that the water in its original condition contained 102.42 per cent while after standing 24 hours, it was reduced to 62.26 per cent. Upon August 17th, somewhat striking conditions were found at Henry. The samples were taken above the dam at 1:15 p. m. upon a bright day. The temperature of the water, 32 degrees C. being very nearly as high as that of the air, which in the shade was 34 degrees. A sample of the water taken one inch below the surface was found to contain considerably
5074 more than twice the amount of oxygen required for saturation, presuming of course, the saturation figure should be that for an equilibrium between the oxygen of the atmosphere and that dissolved in the water. The water was full of minute vegetable organisms, and it had a very distinct yellowish green tint. The temperature of the top inch of water was 32 degrees C. or 89.6 Fahrenheit. The quantities of dissolved oxygen found by the Levy method in this water were 220.9 per cent and 211.4 per cent respectively. Samples taken at the same time and place, but at eighteen inches below the surface had a temperature of 28 degrees Centigrade, and were found by the Levy method to contain dissolved oxygen corresponging to 200 per cent of saturation and 208.3 per cent of saturation respectively. While the determinations made upon the same samples by the Winkler method showed 208.35 per cent. A sample collected at the same time and kept until the next day, the analysis being made 24 hours after the time of collection, during which time the sample was kept in the dark, was found to contain 110.1 per cent of the saturation figure. At the same time and place a collection was also made at two feet

from the bottom or ten feet below the surface. At this depth also the water was found to be supersaturated but far less so than the water at the surface above the dam and it is probable that the water at two feet from the bottom was comparatively sluggish in motion, and the conditions of temperature and of illumination by sunlight were not the same as those prevailing in the strata of water nearer to the surface. The dissolved oxygen in the water very near the bottom disappeared much more rapidly and was reduced far more proportionately than that in the water taken near the surface. The percentage remaining at the end of 24 hours being about 47.42 per cent. This difference as to retention of dissolved oxygen was undoubtedly due to a difference in either the Plankton or the other organic matters contained in the water in these two different strata.

Averyville: Several visits were made to Averyville, just above Peoria, for the purpose of making determinations upon the spot, and some of these developed quite interesting results
as upon July 21, 1899, the water 18 inches below the
5075 surface was found late in the afternoon, to contain 171
per cent of the saturation figure of dissolved oxygen and the water was still supersaturated with oxygen when samples which were kept in the dark were again examined 18 hours and 24 hours later, after the lapse of this time, the figure being 115 to 117 per cent respectively. The quantity of dissolved oxygen in the samples collected at the same spot the following morning were found to be only 87.8 per cent, but during the morning it increased slightly to 95.6 per cent at 10:10, reaching 111.7 per cent at 12:20 p. m., and 114.3 per cent at 1:10 p. m., at which time the examinations were stopped by the necessity for catching a train. Samples collected at the same time were kept over for two days, and it was found that the quantity of dissolved oxygen had diminished in 48 hours from 114 per cent to from 38 to 40 per cent. (See in Illinois river, Averyville, July 2, 1899, at bottom of table 95a.) On August 17th, late in the afternoon the quantity of dissolved oxygen found in the water at the depth of 18 inches at Averyville was 80.5 per cent, while

the water coming from about two feet above the bottom in fourteen feet of water contained 74 per cent of the saturation figure. A sample of the water taken eighteen inches below the surface at 6:30 p. m. which was kept until the next day was found to contain a considerably higher quantity of dissolved oxygen than the sample which was examined at the time of collection. The determination on the spot gave 80.49 per cent, and that made 24 hours later gave 97.53 per cent. It may be that this is an error, but it is possible that in this case some more hardy oxygen evolving organisms than usual were contained in the water, and that during the following day, which was excessively hot, light was not entirely excluded from the sample; or the original content of oxygen may possibly have been quite different, for as is evident from the records for the 19th, when this point was again visited, the water earlier in the afternoon was supersaturated. Upon August the 19th at 12:30 p. m. a sample taken 18 inches below the surface contained 184 per cent; another taken at the same time but three
hours later contained slightly more than 200 per cent,
5076 and a sample collected at four o'clock contained 215 per
cent. Another collected at 4:25 contained 215.7 per
cent, while the samples of water collected one and one-half hours later at the same point and under the same conditions were found to contain 95.6 per cent dissolved oxygen. During the time that these examinations were made, the surface of the water was marked here, there and everywhere, with patches of blue-green scum the size of a man's hand, apparently consisting of masses of filamentous algae. The current was quite rapid and these patches were about two or three feet apart in various directions. The samples were taken under such conditions as to exclude these floating matters from the sample of water upon which the test was made. The sun was shining very brightly and the temperature was very high. These examinations were made at the Averyville bridge where the river is very narrow and the current rapid. Between this point and Henry, about 38 miles above, the river spreads out to a considerable width,

forming a series of so-called pools, lakes or lagoons, in which the current is very sluggish. In these broad stretches the conditions of depth, spread of surface, temperature and rate of movement are in the summer season especially, favorable for the development of plant life and the water consequently so teems with green and green-blue organisms that oxygen is evolved in great abundance, in fact may frequently be seen coming from the floating plants in streams of minute bubbles. During the middle of the day when the chemical activity of the sun's rays is at the maximum, the evolution of oxygen naturally will be at the maximum and the water then becomes supersaturated, but as the sun sinks towards the West, the action slackens and the excess of oxygen begins to disappear; partly perhaps by diffusion into the atmosphere, but undoubtedly in the main through absorption by the organic matter either living or dead, contained in the water, and in part by the cessation of the evolution of oxygen through the agents just referred to. The water which was found to be supersaturated at Averyville doubtless received its oxygen mainly at some distance above, and the rather sudden drop from 215 per cent to 95.6 per cent was in all probability due to the fact that a new body of water which in
the late hours of the afternoon had not been exposed to
5077 such vigorous action as prevailed earlier in the day began to reach the point of collection. This change may have also been due to the fact that as evening approached the sun was in part obscured from the particular point at which these examinations were made, by dropping below the high wooded bluffs which line the west bank of the river in this vicinity. Later in the year, that is upon October 16, 1899, another series of examinations were made in Averyville, but at this time the conditions were entirely different. The quantity of dissolved oxygen reached but 74.5 per cent to 77.5 per cent. Examinations which were made during January, 1900, gave similar results to those mentioned for October, 1899. Examinations made in June, 1900, showed figures which were consider-

ably below those obtained in July and August of the preceding year.

It is unfortunate that we did not have an opportunity to make determinations in 1900 upon the same dates as in 1899, for in June the season is not sufficiently advanced to bring about the conditions which are commonly encountered in the latter part of July and the middle of August. The results obtained in October, 1900, were practically identical with those obtained in October, 1899, which would seem to imply that the opening of the drainage channel has not materially changed the conditions with respect to dissolved oxygen at this point and for this season of the year. Dissolved oxygen just below Peoria: A few examinations made at Wesley City have always shown that the water of the river at this point contains far less than the saturation quantity of dissolved oxygen, a result due of course to the fact that so much sewage is discharged into the river about two or three miles above. Somewhat similar conditions were found with respect to the water at Pekin. The effect of a bright sunlight is strikingly shown by comparison of the figures obtained upon August 18th, in the middle of the morning with those obtained August 19th late in the afternoon, the figures for the morning being 24 per cent; those for the afternoon averaging about 82 per cent. Examinations of water collected early in the morning of August 19th at Havana, 30 miles below Pekin showed about one-third as much dissolved oxygen as would correspond to the saturation figure,
5078 while later in the day determinations by both the Levy
and the Winkler method made at Copperas Creek dam and at Lancaster Landing—points between Havana and Pekin —showed considerable excess of dissolved oxygen. The weather was hot, 100 degrees to 108 degrees Fahrenheit in the shade, and there was considerable plankton in the water, much of it appearing to consist of filamentous and other algae. Dissolved oxygen in the water of the Drainage Canal: Several determinations were made of the dissolved oxygen of the waters of the Sanitary canal itself. Upon August 13, 1900, an examination was made

of the water in the upper end of the Sanitary canal at Kedzie Avenue. At 5:15 in the afternoon, a sample taken 18 inches below the surface was found to contain 29 per cent, and a little further down the canal, that is, at the Belt Line bridge at 5:40 o'clock it was found to contain 28.2 per cent. Upon June 29, 1900, at 5:00 o'clock in the afternoon, this water just above the Bear Trap Dam at Lockport was found to contain 10.9 per cent of dissolved oxygen, while at 200 yards below the dam, after the water had been agitated with air in its escapes from the higher level of the drainage canal to the bed of the Des Plaines river below, the aeration had been sufficient to bring the proportion of dissolved oxygen up to 55.5 per cent of the saturation figure. Upon August 14, 1900, similar determinations showed that the water above the dam contained 5.9, and that below the dam 70 per cent of dissolved oxygen. At Joliet, examinations made upon June 30, 1900, showed 27.8 per cent of dissolved oxygen just above dam No. 1 while just below the dam where the water has fallen 12 or 13 feet, the percentage of dissolved oxygen was found to be 81.28. In making these determinations, due care was exercised to prevent any minute bubbles of air being retained by the water which was made the subject of the examination. The entire pipette was filled with the water and was allowed to stand for a few minutes until such bubbles as were contained in the samples collected in the upper part of the pipette, and were allowed to escape. The results obtained at Lockport and at Joliet show strikingly the effect of agitation of the water with air in falling over the dam.

5079 A single determination made upon the water of the Fox river at Ottawa, August 20, 1899, showed the water of this tributary to be quite supersaturated. It contained 128.35 per cent of dissolved oxygen. The water of the Illinois and Michigan canal just above Channahan was examined upon August 21st and was found to contain three per cent of the saturation figure of dissolved oxygen. At this time there was practically no water flowing in the bed of the upper Des Plaines below Joliet, as at Joliet all of the flow both from the Des

Plaines river above and from the Illinois and Michigan canal was carried down the north bank of the river in the canal itself.

5080 Plate No. 1 was prepared by me and is a representative of certain of the averages which appear in table A, which averages have been made from the detailed data of tables No. 1 to 38 inclusive. (Objection by Mr. Jeffries.) Plate will be found on page 4082.

5084 I identify Plate No. 1 as a chart which I prepared to show graphically some of the results which are given in detail in tables No. 1 to 80 inclusive, and the averages which are shown on table A heretofore read in evidence. This particular plate No. 1 shows graphically the proportions of chlorine, oxygen consumed, nitrites, free ammonia, albuminoid ammonia, and total organic nitrogen as determined by my analyses, set forth in detail in tables 1 to 80 inclusive, and particularly as shown in the form of averages in table A. In order that the significance of the figures of table A, as shown graphically by means of the curves and columns of plate 1, may be fairly understood, I will as I proceed, state briefly the general significance which pertains to each constituent there represented, as we proceed with the discussion of the plate. First, the chlorine. This substance is contained in water in combination with various basic elements, but chiefly in the form of sodium chloride or common salt. Chlorides occur in very small quantities in all soils, and hence are present in small proportions in the waters of streams, ponds, lakes and so on, in their natural condition, and in a greater quantity are found also in wells, particularly in many artesian wells, and in salt springs. Most animal matters, and especially various animal secretions contain more or less chlorides, and chlorides are constant in considerable constituents of sewage. In the sewage they are derived not only from the various animal secretions and particularly the urine contributed to sewage, but also are introduced in various manufacturing wastes, as the wastes from soap factories, packing houses and so on. They are also contained in kitchen wastes,

being derived from the liquids which have been in contact with food during the preparation of foods for the table. The only natural causes of change in the proportions of chlorine aside from such concentration as may result from long continued hot weather during the season of minimum flow, would be its decrease by dilution with waters which contain less, or its increase by mixing with waters and other liquids as sewage, and so on, which contain more. The chlorine introduced into streams in the form of chlorides remains unchanged (if it were at any time introduced in other forms, it might change, but it is not ordinarily so introduced.) That is, is not in any way removed, absorbed or destroyed, but finds its way finally into the sea into
which the stream or streams finally discharge. The de-
5085 termination of the proportion of chlorine consequently
is an index to the total quantities of chlorides introduced into the stream from whatsoever source, above the point at which the determination in question is made. Referring now to the curve for chlorine upon the plate, we note that a very large proportion, namely 124.2 parts per million, was contained in the water of the Illinois and Michigan canal at Bridgeport, on the average for the period, May to December inclusive, 1899. This period it should be understood is referred to throughout in the discussion of Plate No. 1. The proportions of chlorine at Lockport and Joliet, respectively, 29 and 33 miles below Bridgeport, respectively, are smaller than the proportion at Bridgeport. The reduction in proportion at Lockport being due to slight dilution along the course of the Illinois and Michigan canal; that at Joliet being due to the dilution effected by mixing of the waters of the Des Plaines river with the discharges from the Illinois and Michigan canal, just above the point at which the Joliet samples were taken. From this point on down to Peoria there is shown continuous and considerable decrease in the proportions of chlorine. The decrease between Joliet and Morris, 25 miles below, due to the introduction of the discharges of various small streams into the Des Plaines, but mainly due to the introduction of the waters of the Kankakee

river, which latter was found for this period to contain on the average, 3.9 parts of chlorine per million. Below Morris there are small streams discharging water into the Illinois, which brings about a reduction in the proportion on the way to Ottawa. At Ottawa the discharge of the Fox river brings about a very considerable reduction in the proportions of the chlorine, so that at La Salle the proportion is 47.3 as against 59.4, the proportion contained at Ottawa. The Fox river at Ottawa during this period containing on the average 5.8 parts of chlorine per million. There is but slight dilution, as indicated by reduction of chlorine, between La Salle and Henry, but
5086 beyond Henry again, a notable decrease in the proportion
of chlorine occurs, to Averyville, where the proportion is 41.1 parts per million. The decrease resulting from the dilution effected by the discharges of various small streams, and in part by the underground flow of land water into the river. This underground flow is known to be considerable along the entire stretch of the Illinois river between La Salle and Beardstown and is particularly considerable between Peoria and Havana, and in times of low water may have quite an appreciable effect in diluting the waters in the stream, an effect which of course was more considerable before the flow and the initial dilution were increased by the inflow of lake water secured by the opening of the Chicago main drainage canal in January, 1900. The increase of chlorine between Averyville and Wesley City resulted from the contribution of Peoria's sewage to the river and in small part probably was due to the inflow of the water of certain saline artesian wells and springs. From this point, that is Wesley City just below Peoria, there was a continuous and considerable diminution in the proportions of chlorine at all points down to the mouth of the river at Grafton, and the final discharge into the Mississippi river contained chlorine in the proportion of 18.5 parts per million. The next curve which we may consider represents the oxygen consumed. Oxygen consumed is the quantity of oxygen required for the burning of the organic matters contained in the water, or rather the quantity

of oxygen required for combination with and oxidation of those organic matters contained in the water which are readily affected by the process used in these determinations, for it is well known that not all of the organic matters are affected, or at least are not completely oxidized by the chemical processes employed. It is evident from the curves which merely represent the figures in the table of averages in table A that the organic matters which at Lockport required a great deal of oxygen for their consumption, namely 37.7 parts per million, were so affected by dilution and natural oxidation as to appear in much smaller proportions at Morris and at Ottawa. A notable increase occurs between Ottawa and La Salle, but the organic matters then below La Salle diminish in proportion until we reach Averyville, where the proportion was 11.1 parts per million. Below Averyville there occurs an increase until we pass Pekin, and from
5087 there on down to the mouth of the river at Grafton, occurs
a gradual but definite diminution, the quantity of oxygen consumed by the waters as they pass from the Illinois into the Mississippi being 9.9 parts per million. Free ammonia, or saline ammonia as it is variously designated, is naturally present in small proportions in surface waters, being introduced into them by the washings of the air by the rain and from surface soils, by the rain water, which in times of storm flow in part over the surface to the streams. It is contained in comparatively great quantity in fresh sewage or sewage which is in the first stages of putrefaction. In the sewage it has come in part from the sanitary wastes of the household, including the discharges from human beings, but comes also from other household wastes, and from the discharges of other animals. It comes in part from discharges of manufacturing wastes and industrial wastes of various sorts, including stock yards wastes, refuse from gas works, and the decomposition products of the same and so on, and is produced by the putrefactive changes to which organic matters from all these sources are naturally susceptible. The

large proportions of nitrogen as free ammonia contained in the waters of the canal at Bridgeport and Lockport respectively are represented at the left hand of the table and by the figures 17.16 and 15.58 which appear in table A of averages. The diminution in proportion between Lockport and Joliet is due to dilution by the waters of the Des Plaines, and between Joliet and Morris, to the dilution referred to above under the discussion of chlorine and oxygen consumed, namely, dilution effected mainly by the introduction of the waters of the Kankakee, and is in part effected by the natural decomposition or changes to which this substance is subject in streams and other surface waters. Between Ottawa and La Salle there is a very great diminution, namely from five parts per million to 2.65 parts per million. This diminution being effected in part by dilution with the waters of the Fox river and other but minor tributary streams, and in part due to nitrification which takes place vigorously in the stretch of stream between Ottawa and La Salle, and it may in part be due also to assimilation by the plant life,
which is abundant in this part of the river, and in part
5088 due to its conversion to free nitrogen which escapes in
part into the air. On the other hand, there may at times be a tendency toward an increase of the proportions of free ammonia as a result of the de-oxidation of nitrates and nitrites, which takes place when these substances in water are in contact with various organic matters. Between La Salle and Henry there is further diminution in the proportions of free ammonia notwithstanding the fact that just below La Salle the sewage of La Salle is, by the final discharge of the Illinois and Michigan canal, introduced into the Illinois river, and that the sewage and wastes of Peru also are introduced at this point. Between Henry and Averyville, there takes place a more considerable diminution in the proportions of free ammonia, this being undoubtedly due to the natural destruction of ammonia or its oxidation into nitrates and nitrites or its assimilation by the plant life of the river, or to all of these causes together. Now I notice a mistake in the figures given upon this plate. The figure

in the table of averages is correct and the curve is drawn to proportion all right, but the figures there above Henry in the plate is put 2.56 and it should be 2.156—perhaps a minor correction but one it is well to have made. Beyond Averyville there is an increase in the free ammonia to Wesley City, a slight further increase to Pekin, and from there on down to the mouth of the river, continuous decrease—slight it is true—until we reach Havana, but beyond Havana more considerable in proportion until we reach Kampsville, where the proportion is only slightly greater than that contained in the water as it is discharged into the Mississippi at Grafton, 31 miles below, where the proportion is .221 parts per million. Nitrites: Nitrites as contained in surface waters may be derived from the washings of the air by the rain; the leachings from the surface soils with which the fallen rain has been in contact on its way to the surface streams, which discharge it into ponds or rivers, and is also produced by the oxidation of nitrogenous organic matters derived from these or other sources and contained in the surface water, be it that of ponds or streams.

5089 The nitrites constitute a stage or represent a stage in the series of decomposition which convert organic matters finally into the comparatively unobjectionable mineral matters which are chiefly carbonic acid and nitrates. The comparatively small proportions of nitrites in the upper river down to the neighborhood of Morris shows that this second stage of natural purification is to this point but beginning, but the great increase below Morris witnesses to the fact that from here on this highly important feature of nature's purification processes is efficiently active. The gradual diminution of the nitrites on the way down the river from Ottawa to Averyville would indicate a gradual progressive exhaustion of the food supply for the organisms which are responsible for this oxidation and thus serves as evidence that the purification is proceeding. The proportions of nitrites contained in the water may at times also be increased by the reduction of nitrates which reduction at times proceeds beyond this stage, and brings about the liberation of nitrogen in the form of nitrogen gass, the element, or may proceed further to the stage of ammonia, and so increase the proportion of the latter. The nitrites decrease in proportions from Pekin on down to Grafton, and this indicates considerable improvement in the sanitary condition of the water during its passage from Pekin to the point of discharge into the Mississippi river at Grafton. Total organic nitrogen: This determination, made by the Kjeldahl process, represents the total proportions of nitrogen contained in the water in combination in organic matters. The nitrogenous organic matters are contained in all soils in some quantity, but they are the most significant and constant constituents of sewage and include all sorts of animal refuse, tissues, fecal matters, constituents of the urine, household wastes and manufacturing wastes of various sorts, particularly those of animal origin, but also those of vegetable origin. Nitrogenous organic maters too, are essential constituents of all living things, great or microscopic, both vegetable and animal. It is 5090 substances of this class in part which serve as the nutrients upon which bacteria thrive and multiply. The proportions of nitrogen as total organic nitrogen, that is the total nitrogen contained in organic matters, are shown by the figures of table A, and represented by the line upon plate 1 as being very considerable in the waters of the Illinois and Michigan canal, both at Bridgeport and at Lockport, the quantity diminishing between Lockport and Joliet, diminishing again very considerably between Joliet and Morris, and again diminishing on the way to Ottawa, but beyond Ottawa increasing in proportion on the way to La Salle and Henry, below which there is again a decrease to Averyville. The decrease between Joliet and Ottawa is partly due to dilution by the introduction of the waters of various tributaries, but in very large part is due to the natural destruction of these organic matters, and their conversion into more innocous forms, partly into mineral matters, partly into the organic matters of the vegetation of the river. The increase on the way to La Salle and Henry is due to the introduction of sewage by means of the Big Vermillion river, and the sewage of La Salle

and of Peru. The increase below Averyville on the way to Wesley City is due to the introduction of Peoria's sewage and refuse. Below this point, there occurs at first slight, but then a more considerable decrease in the quantities of total organic nitrogen on the way down to Beardstown, below which point there is a very slight decrease down to the mouth, where the proportion contained in the water as it is discharged into the Mississippi was during this period 1.037 parts per million. Albuminoid ammonia: The albuminoid ammonia varies somewhat in conformity with the variations of the total organic nitrogen, although the quantity is but from 40 to 50 per cent that of the latter. Its significance is similar to that of the total organic nitrogen, but the total organic nitrogen represents all of the nitrogen that is contained in the organic matters that is as constituting part of the tissues, living or dead, as well as various products of vital activities of living organisms, while the albuminoid ammonia represents only the nitrogen. Of such part, about one-half of these substances, as is comparatively easily affected by the chemicals and processes used in the albuminoid ammonia determination. Comparison of the waters of the Illinois with those of its tributaries and those of the Mississippi and the Missouri are made in groups 2 and 3 of plate 1. The various columns show the comparative proportions of total organic nitrogen, albuminoid ammonia and free ammonia contained in, and the oxygen consumed by the waters of the more
important tributaries of the Illinois river, the waters of
5091 the Mississippi river above the mouth of the Illinois and
the waters of the Missouri river just above its mouth.
The columns in all cases representing the figures given in table A. It appears that during this period the waters of the Illinois at its mouth at Grafton, contained more free ammonia than those of the Mississippi and the Missouri and considerably more than those of its tributaries, except the Big Vermillion, the Illinois and Michigan canal not being considered. On the other hand, the columns show that the waters of the Mississippi and the Missouri contain considerably more total organic nitrogen

and albuminoid matters than did the waters of the Illinois, while the oxygen consumed by the waters of these two streams was nearly twice as great as that consumed by the water of the Illinois. In these respects, too, the columns show that the water of the Illinois river at its mouth compares favorably with the waters of its several tributaries. The Mississippi at Alton: The curves of group 4, plate 1, referring to the cross-section of the Mississippi river at Alton represent the averages of analyses of samples of water taken at the five points across the Mississippi at Alton, about sixteen miles below the mouth of the Illinois. It is evident from the consideration of the data, tables 23 to 27 inclusive, and the averages of table A, and as graphically shown by the curves of plate 1, that the waters of the Illinois do not mix thoroughly with the waters of the Mississippi, but chiefly pass down along the Illinois shore, and that the proportions of organic matters contained in the Mississippi river water are greater than the proportions of the same substances contained in the Illinois river water. The chlorine and ammonia, on the other hand, being higher in the Illinois river water at Grafton than in the waters of the Mississippi river at Alton or Grafton. The Mississippi at Chain of Rocks, or Mitchell: The waters of the Missouri river during the period here considered, did
5092 not average so high in chlorine as did the waters of the
Illinois, but they contain an enormous amount of suspended matters, and notably greater quantities of various objectionable organic matters. From the data of tables 28 to 31 and the averages of table A, exhibited in group 5, plate 1, it would seem that at the Chain of Rocks the waters passing down the west bank and beside the intake tower consist mainly of Missouri river water and contain much larger proportions of organic maters than do the waters of the Illinois. Further comparisons: A consideration of the analyses of the individual samples given in tables 28 to 31 shows that the proportions of the nitrogenous organic matters never during the given period were so great in the Illinois river water as they were in the Missouri, and that the minimum proportion of these matters in

the Mississippi and in the Missouri river water never reached quite the low point that they did in the water of the Illinois river at Grafton. The general conclusion from the consideration of these data, which, however, it must be remembered cover simply the period from the beginning of May, 1899, to December 31, 1899, is that the water discharged from the Illinois river is in these respects in purer condition than the water of the Mississippi river just above Grafton, or the water of the Missouri river at Fort Bellefontaine, or West Alton, and that it is in most respects quite similar to the waters of the larger tributaries of the Illinois. Table G gives the specific data. I prepared plates II and III and they are based on some of the averages which appear in table B heretofore read in evidence and which shows the results of analyses of water taken at the points indicated between January 1st and October 1st, 1900, the details of which appear in tables No. 39 to 80 inclusive.

5093 (Objection by Mr. Jeffries to the introduction of the plates which are reproduced on pages 5094 and 5095.)

5096 Plate II is similar to Plate I in that it shows the proportions of various significant constituents contained in the waters of the Illinois and its tributaries, and the Mississippi at Grafton, Alton and the Chain of Rocks and the Missouri at Fort Bellefontaine, for the period January 1st to October 1st, 1900. That is, the nine months immediately subsequent to the opening of the Chicago main drainage channel. The effect of the dilution of the Chicago sewage with the lake water before discharging it into the Des Plaines and the Illinois river is shown by the analyses made during the year 1900. The data of these analyses appear in tables 39 to 80 inclusive, and the averages are brought together in table B. The features of Plate II are similar to those of Plate I but differ in that the proportions of the various constituents are not the same. These conditions being caused in the main so far as the samples from the Illinois river are concerned by the dilution effected by the opening of the Chicago main drainage channel. Discussion of this plate in detail is hardly necessary or especially profitable for

the reason that the period covered is not the same as that covered by the figures and lines of Plate I and for the further reason that a consideration of all such data as are included in the representations of Plate II, which are strictly comparable with the figures and lines of Plate I, are discussed and are represented by columns and curves in plates which are shortly to be considered. It is a well known fact that the waters of streams vary greatly at different seasons, both as to the volume of water and the content and nature of substances carried by the water. These seasonable variations are particularly important in the cases of some of the streams of the Mississippi valley and especially so for the Illinois, the Missouri and the Mississippi. Although the entire series of analyses for the year 1900 does not correspond as to the time and season with the entire series of analyses for the year 1899. These two seasons overlap during the summer months, namely the four months, June, July, August and September, during which period the most important physical features are the comparatively small volume of flow and the comparatively high temperature, not only the atmosphere but of the water itself, features which are especially important with reference to the Illinois river. In consequence of this overlapping, the data during this period for the two different years, namely, June, July, August and September, 1899, and June, July, August and September, 1900, are fairly and reasonably comparable with each other. For
5097 the purpose of making this comparison, I have prepared
averages of the data of the Illinois made during June, July, August and September, 1899, that is before the opening of the main drainage channel and similar averages from data obtained from analyses made during the same four months in 1900 or immediately after the opening of the main drainage channel. The data appear in detail in tables 1 to 80 inclusive, and the particular averages in question appear in tables C and D respectively. Plate IV was made by me. The data represented upon it appears in the form of averages in tables C and D which were heretofore read in evidence and the details from

which the averages were made appear in tables 1 to 80 inclusive. (The introduction of said plate was objected to by Mr. Jeffries, and is copied in evidence at page 5099.)

5100 Plate IV is one of a set running from IV to XV inclusive, which have been prepared for the purpose of representing graphically the average proportions of some of the more significant constituents of the waters of the Illinois river, its tributaries, the Mississippi and the Missouri, as they appear in the tables of averages C and D, representing the detailed analyses of tables 1 to 80 inclusive, covering the period June, July, August and September, 1899, the year prior to the opening of the Chicago main drainage channel, and the same period, that is, June, July, August and September, 1900, the year subsequent to the opening of the Chicago main drainage channel. In order that the situation and the full significance of the data which are represented by the plates be realized, reference should be made to the statement of the reasons for selecting the various points at which the collections of samples were made and to the map which shows the relative situations of these points of collection. In each plate of this set, IV to XV inclusive, there are two sets of curves or two sets of columns, one set representing the data for the summer of 1899 and the other representing the data for the summer of 1900. By following the various lines of the curve, and the proportions of the various constituents which they represent, it is made evident that the conditions in the river have changed considerably since the opening of the main drainage channel. The portions of the curves and sets of columns at the left hand of each plate representing the conditions prevailing between Chicago and Lockport are of course modified more greatly than the other parts of the curves for the reason that until January, 1900, it was the old or Illinois and Michigan canal only which carried the discharge of Chicago sewage into the Des Plaines river valley, while since the opening of the drainage channel, the sanitary canal itself
5101 carries not merely undiluted sewage and stock yards drainage, but a very large proportion of diluting lake

water. Inasmuch as the Illinois and Michigan canal is still mainly fed from a fork of the south branch, which is not yet flushed with lake water, we find that the proportions of the various constituents are still excessive in the waters of the old or Illinois and Michigan canal, both at Bridgeport and at Lockport. It is to be remembered that the discharge through the Illinois and Michigan canal is now much less than it was formerly, for since the opening of the drainage channel, the old canal is used chiefly for transportation and not particularly as a sewer and the pumps at Bridgeport are supposed to raise only such fluid as is required to maintain a serviceable depth for commerce. The average flow in the Illinois and Michigan canal prior to 1900 was from 35,000 to 36,000 cubic feet per minute. In 1900 it varied during the year, but the average was 26,700 cubic feet a minute. In 1901, the pumps were in operation only during seven months, beginning the latter part of April and reaching to the latter part of November. During this period of seven months, the average rate at which liquids were raised from the south fork of the Illinois and Michigan canal was 23,000 cubic feet per minute; the average for the entire year, which is not a true average for the time of operation, however, being 13,800 cubic feet per minute. The figures of tables Nos. 40 and 41 in which the data of analyses of samples from the Illinois and Michigan canal at Bridgeport and Lockport for the year 1900, are set forth, reveal occasional variations of considerable magnitude. These variations are chiefly due to the fact that the pumps at Bridgeport which feed the Illinois and Michigan canal are situated but a few rods within the mouth of the south fork and that the diluted sewage which, on its way through the south branch to the drainage channel, passes the mouth of the south fork, sometimes enters a short distance within the mouth and is thence pumped into the old canal. The short duration of such occasional conditions during which comparatively dilute sewage
is pumped into the Illinois and Michigan canal, ac-
5102 counts for the fact that the variations are less frequent

and less considerable at Lockport, 29 miles below, for the reason that on the way the mixing of the more concentrated sewage ordinarily raised, and the more dilute sewage occasionally introduced by the pumps, is more or less perfected. At Joliet where the discharges through the two canals and that from the upper Des Plaines river have come together, there is frequent and considerable variation in the proportions of organic matter and other impurities contained in the waters of the Des Plaines river, partly in consequence of variations in the flow of water from the Illinois and Michigan canal through the use of locks, partly from occasional closing of the gates at the Bear Trap dam, thus shutting off or reducing the flow of the more dilute sewage from the drainage channel. The accumulation of sewage in the Chicago river, which follows a stoppage or reduction of the flow through the drainage channel is another cause of variation, for when the gates are again opened the sewage discharged is for a time necessarily less dilute than it would otherwise have been. The variations at Joliet result in large part also from incomplete commingling of the waters, for the discharge from the old canal entering by the south or east bank at Lockport and at Joliet generally passes down beside that bank for some considerable distance, but at times when the flow from the drainage channel is reduced, it often extends further out into the stream or possibly may entirely cross the river bed. The variations which appear in table 44 are largely due to the facts just above considered. Upon Plate IV there is shown, first, general curves representing the proportions of chlorine and of nitrogen as albuminoid ammonia in the waters of the Des Plaines and the Illinois rivers at different points between Chicago and the mouth of the river at Grafton. For the purposes of this study the Illinois and Michigan canal and the sanitary canal are both regarded as being part of the one system which includes these canals, the Des Plaines river and the Illinois river stretching from Chicago to the Mississippi at Grafton. Comparison of the two curves representing the chlorine shows a much more considerable diminution of the

proportions of chlorine contained in the water flowing through the bed of the Des Plaines river at Joliet, in 1900 than
5103 in 1899. This is obviously due to the dilution of Chicago sewage with lake water which passes through the drainage channel. The continuous diminution in content of chlorine between Bridgeport (in both years, following the Illinois and Michigan canal as far as Joliet) and the mouth of the river at Grafton, is of course due merely to dilution. The average quantity of chlorine contained in the natural surface waters of the regions in question has ranged from two to three parts as in the water of Lake Michigan, to as much as five or six parts as frequently found in the waters of such streams as the Fox, the Kankakee and the Sangamon. The waters which pass through the drainage canal contain a considerably smaller portion of chlorine than is contained in the waters passing through the Des Plaines and Illinois river valley, for the reason already noted that the sewage carried by the Illinois and Michigan canal, and discharged by it into the Des Plaines river at Lockport, and just above Joliet, is still very concentrated. Moreover, in and about Lockport and Joliet there are various saline artesian wells. There are sewers and manufacturing establishments which discharge into the old canal or the river between the collecting point at Lockport and that at Joliet. From Joliet down, the river there is a slight fall in chlorine for 1900 as we reach Morris, and the subsequent apparent increase in the content of chlorine at Ottawa, notwithstanding the inflow of the waters of the Kankakee above Morris, are in some measure misleading, and untrustworthy, for the mixing of the two streams is at these points still incomplete as subsequent work has shown, and to the incomplete mixing of the main body of water from the drainage channel with the waters of the various tributaries is due many of the variations in both directions which appear in the results for 1900 for the several points between and including Joliet and Ottawa. Various cross-section determinations made at La Salle, Averyville and Grafton have shown that at these several points the mix-

ing is complete. Particularly at Averyville and Grafton, which we may regard as critical points, determinations of
chlorine in samples taken at a number of points across
5104 the river have invariably shown that in these localities
there is no difference in the chlorine content of the water anywhere between the two banks. At the mouth where the Illinois discharges into the Mississippi river, this water contains less chlorine than is found in it anywhere between that point and Chicago, except in the sanitary canal itself. The proportion contained in the water at the mouth of the river in 1900 was very slightly greater than that contained during the corresponding time in 1899. The curves representing the nitrogen as albuminoid ammonia show for 1899 a very rapid diminution in quantity as we pass from Bridgeport down the stream to Ottawa. Beyond Ottawa there is a notable increase, reaching the maximum at Henry, but beyond that point there occurs a considerable diminution to Averyville or Peoria. Below Averyville, that is at Wesley City and Pekin, the quantities of nitrogen as albuminoid ammonia were greatly increased as a result of the discharge of sewage and wastes from distilleries, cattle sheds, glucose works and such plants at Peoria and Pekin. Below Pekin again there is a slight but constant diminution until we reach the mouth of the river at Grafton. The curve for 1900 shows that there were much smaller quantities of albuminoid matters contained in the waters of the sanitary canal and in the waters of the Des Plaines river at Joliet, and as we proceed down the stream from Joliet there is a decrease which reaches the limit at Ottawa. Beyond Ottawa, the albuminoid nitrogen increases until Henry is reached beyond which point it diminished to Averyville. A slight increase occurred as we passed from Averyville to Wesley and Pekin and so on to Havana. Beyond Havana there is a gradual but continuous diminution until at the mouth of the river at Grafton the proportion of albuminoid nitrogen contained in the water discharged from the Illinois into the Mississippi was notably less in 1900 than it was in the year 1899. Comparison

of the Illinois with the Mississippi and Missouri, group 2, on Plate IV, represents first, comparison of the chlorine contained in the waters of the Illinois as it discharges into the Mississippi at Grafton, for the summer months of 1899 and for the summer
months of 1900. The proportions are stated in tables
5105 C and D, and represented in Plate IV by two columns
at the lower right hand corner. Mere inspection of these columns is sufficient to show the relation of these proportions and to make manifest the slight difference as to chlorine content in the waters of the Illinois at its mouth between these two years. Second, a comparison of the chlorine contained in the Mississippi above the mouth of the Illinois for like periods in 1899 and 1900. This is shown by the two columns next to the left of those referring to the Illinois river water. Inspection of the figures in the tables make manifest—and the two columns in the plate show graphically the differences as to chlorine content in the Mississippi river water between these two years, and show that the proportion of chlorine in the Mississippi river water during this period of 1900 was considerably greater than during the similar period of 1899. This difference as to chlorine content between the two years was due doubtless to the fact that the water in the upper Mississippi river was at a lower stage during the summer of 1900 than it was during the
summer of 1899. Upon Plate XVII which will be here-
5106 after introduced in evidence, the stages of water in the
Mississippi river for the years 1899 and 1900 are represented. Third, a comparison of the chlorine contained in the waters of the Missouri river near the mouth for the same periods. The figures in tables C and D show that the waters of the Missouri river contained a much higher proportion of chlorine during the summer of 1900 than during the corresponding season of 1899, but it must be noted that the period covered in 1899 is somewhat shorter than that for 1900, as in the earlier year the collections from the Missouri began July 10. The facts as represented in the tables of averages are shown in the plate by the columns labeled "Missouri" and serve to repre-

sent the considerable difference between the proportions for these two periods. Fourth: Comparison of the content of albuminoid nitrogen in the Illinois river for 1899 and 1900, referred to in the general statement above, is shown graphically in this group, and these differences appear to the eye at once upon inspection of the columns. Fifth: Comparison of the content of nitrogen as albuminoid ammonia in the water of the Mississippi river above the mouth of the Illinois. The second set of columns under the title, "Nitrogen as Albuminoid Ammonia," shows a slightly smaller proportion contained in the water of the Mississippi for 1900 than was contained during the same period of 1899, and shows further that there was considerably more albuminoid nitrogen in the waters of the Mississippi river during each of these periods—that is both 1899 and 1900, than was contained in the waters of the Illinois river in either of the seasons in questions. Sixth: Comparison of the content of nitrogen as albuminoid ammonia in the waters of the Missouri. The figures which appear in tables C and D, show that during the summer of 1900 the proportion was greater than during the summer of 1899 and shows further that more than twice as much albuminoid ammonia or albuminous substances was contained in the water of the Missouri river in each of these years as was contained in the water of the Illinois river at
Grafton and very considerably more than was contained
5107 in the waters of the Mississippi river. These facts as
they appear in the tables of the averages C and D, being represented graphically by the two columns at the left hand of the group 2, in Plate IV. Cross-section of the Mississippi at Alton and at Mitchell, or Chain of Rocks, group 3, on Plate IV, represents the content of chlorine and of nitrogen as albuminoid ammonia in the waters of the Mississippi river at four points across the stream at the Chain of Rocks, opposite the intake tower of the St. Louis waterworks. From consideration of the curves which represent the averages appearing in tables C and D, it is made evident that the content of chlorine and of albuminoid nitrogen was considerably greater upon the Missouri

side of the river than it was upon the Illinois side, and shows further that there was a greater difference between the two sides of the stream at the St. Louis pumping station during the season of 1900 than there was during the same period of the preceding year, that is, the year 1899. These differences between the proportions of chlorine at the different cross section points at the Chain of Rocks and also the seasonal variations of the chlorine at these points are exhibited in Plate XIV which is to be hereafter introduced, and we will give a short description of that hereafter. Plate V was made by me from the same data that was the basis of the lines and columns upon Plate IV. The description is the same but there was something more. We show upon Plate V, cross-section proportions at Alton, as well as cross-section proportions at the Chain of Rocks and the columns upon Plate V represent the chlorine only for those various points and not also the nitrogen as albuminoid ammonia, which said Plate V is copied in evidence on page 5109.

5110 Plate VI was made by me and represents graphically some of the averages which appear in tables C and D, which averages are based on the detail analyses, shown on tables 1 to 80 inclusive, or such part of these latter tables as cover the period June, July, August and September of 1899 and 1900. (Objection to said plate by Mr. Jeffries.) Said Plate VI is copied in evidence on page 5114.

5115 Plate VI was made by me for the purpose of facilitating a realization of the significance of certain averages which appear in tables C and D, and in this respect is supplementary or rather complementary to that portion of Plate IV which represents the proportions of nitrogen as albuminoid ammonia. It has the different lengths of the column to show the differences between the two years. The columns in this plate show in addition to the total albuminoid nitrogen, also that portion of nitrogen as albuminoid ammonia which is derived from albuminous substances contained in solution, and the difference between the black portion and the total heighth of each column

represents the proportion of nitrogen as albuminoid ammonia derived from that portion of the albuminous substances which are in suspension in the waters. As all of the Plates IV to XV inclusive, this plate covers the periods June, July, August and September, 1899 and 1900. The successive shortenings of the columns as we proceed from near to the left hand side of the plate to the right hand, shows the successive steps of decrease of nitrogen as albuminoid ammonia as we proceed down these streams from the neighborhood of Chicago, that is Bridgeport and Lockport to the mouth of the Illinois river at Grafton, and shows moreover, the notable increase in the proportions of these substances contained in the waters of the Illinois river just below Peoria. Moreover, the differences between the two seasons, that is the period June, July, August and September of 1899, and the same months of 1900, readily appear on comparison of the right hand column with the left hand column in each set of two across the bottom of the plate. The very considerable difference between these columns showing the very considerable decrease in proportions of albuminoid nitrogen effected for the season 1900 by the dilution consequent upon the opening of the Chicago main drainage channel, and the discharge of lake water through it into the Des Plaines valley. That this has not during the period in question brought any notable increase in the proportions of ni-
5116 trogen as albuminoid ammonia in that portion of the waters of the Mississippi which passes down from the vicinity of Grafton to the Chain of Rocks near St. Louis toward the Missouri bank, is evident from an inspection of the columns of group 4 and group 2. Plates VII and VIII were made by me and represent certain data which appear in the tables of averages in tables C and D, the detailed analyses of which appear in tables 1 to 80 inclusive. These two plates represent in general similar features to those already referred to in the description of Plates IV and VI, but the particular substances

represented on Plates VII and VIII are the total organic nitrogen, that derived from substances which are in solution, that derived from substances which are in suspension and the sum of the two for the real total. Plates VII and VIII are reproduced on pages 5117 and 5118 respectively.

5119 The periods covered by Plate VII are the four summer months, June, July, August and September, 1899, and the same months of the year 1900. They are intended to illustrate, by a representation of the figures of the tables of averages C and D, the changes which take place along the course of the Illinois river and the Des Plaines river and the Illinois and Michigan canal and the Sanitary canal from Chicago to the mouth of the Illinois at Grafton, in the proportions of the total organic nitrogen, and also to show the relative quantities of total organic nitrogen in the water of the three streams, namely, the Illinois river, Missouri river, and the Mississippi river near the point at which these two streams come together, and to show the variations across the stream of the Mississippi river at Alton, and opposite the intake of the St. Louis waterworks at the Chain of Rocks, and to represent the difference between these two years for the period indicated. With reference to the effect of the opening of the Chicago main drainage channel upon the waters of the Illinois and such portion of the Mississippi river as extends from the mouth of the Illinois to the intake tower of the St. Louis waterworks: The considerable differences between the right hand and left hand column in each pair in Plate VIII show how much less was the content of nitrogenous organic matters as represented by the total organic nitrogen in the summer period referred to above, of the year 1900 as compared with the same period of the year 1899, the latter being the period before the opening of the Chicago main drainage channel and the former the period subsequent thereto.

5120 Inspection of the two columns at the lower right hand corner of Plate VIII shows graphically the relation between the figures which appear in tables C and D, representing the average proportions of total organic nitrogen, and that contained in substances in solution in the waters of the Illinois in 1899 and in 1900. Inspection of the columns represented in group 3 serves to show that the proportions of total organic nitrogen contained in the waters of the Illinois river at its mouth at Grafton, in 1900 was very considerably less, in fact, but little more than half as much in 1900 as in 1899. Same comparison of the next two columns which represent the proportions in the Mississippi river shows that in it also the proportions for the summer period of 1900 were considerably less than during the same period in 1899, although the difference is not proportionately so great as in the case of the waters of the Illinois. The third set of columns in this group represent the conditions with respect to the total organic nitrogen in the waters of the Missouri river. These columns serve to represent figures which appear in tables C and D, and express the fact that in the waters of the Missouri river in 1900 there was a greater proportion of total organic nitrogen than in the preceding year, that is the same period for the year 1899, but to those there must be noted the fact that the period for the Missouri river in 1899 was not so long as the period for the year 1900, for the reason again that the collections in the Missouri river did not begin in 1899 until July 10th.

Cross-sections of the Mississippi at Alton shown in group 4, show that the proportions clear across the stream in 1900, were considerably less than the proportions of total organic nitrogen contained in the waters of the Mississippi river at this point during the preceding year, the year 1899. Consideration of the columns of group 2 show that the relative proportions at the different points across the stream at the Chain of Rocks were not much different in the year 1900 from what they had been in the year 1899, although the total proportions at each of the four points across the stream were less in 1900 than in 1899.

5121 Plate VII represents similar data by means of lines and curves instead of the columns, and will probably need

no further explanation than that just given in respect to Plate VIII. The total organic nitrogen referred to in these tables and in these plates and in the tables in which the figures represented upon the plates appear, is contained as a constituent of organic matters, particularly such organic matters as are contained in animal substances, and which are essential constituents of all living things, including micro-organisms, as well as all other and irrespective of size, of the animal or vegetable character, except that in general a greater proportion of nitrogen is contained in animal substances than is contained in most vegetable organisms or the substances in vegetable organisms which in particular contain the nitrogen in organic combination. It includes that just referred to above and in the earlier plates as nitrogen as albuminoid ammonia, and in general it is from two to three times as much as the latter. The dissolved organic nitrogen is of course derived from these nitrogenous organic matters which are commonly in solution in the water, while the total includes not only this, but also that which is contained in matters which are suspended in the water. These comparisons further give expression to the fact that the nitrogenous organic matters in solution which are here represented by the term "organic nitrogen in solution" are contained in the Illinois river water in greater proportion than in the waters of the Mississippi or in the waters of the Missouri, but it is noticeable that the difference between these streams has been considerably less during the summer of 1900 than it was during the summer of 1899. In the waters of the Missouri river there was somewhat more in 1900 than 1899, but the difference is slight. For the Mississippi and the Illinois, however, there are as represented, considerable differences indicating a better condition of their waters in this respect during the summer of 1900 than during the summer of 1899. The striking differences between these three streams with respect to the
proportions of the nitrogenous organic matters becomes
5122 clearly manifest upon inspection of the unshaded portions of the columns of Plate VIII. I made Plates IX,

X and XI and they were made as representations of the figures appearing in the tables of averages covering the four summer months, June, July, August and September, 1899, and the same months in 1900, which averages appear in tables A and D, and represent the detailed data which appear for these two four-months periods, in tables 1 to 80 inclusive. Plates IX, X and XI reproduced on pages 5123-4-5 respectively.

5126 Plates IX, X and XI represent the proportions of nitrogen as free or saline ammonia and of nitrogen as nitrites contained in the waters of the Illinois and Michigan canal, the Sanitary canal, the Des Plaines river and the Illinois river at various points between Chicago and the mouth of the river at Grafton, except that the data which are given generally upon the single Plate IX are separated for presentation in the form of columns and appear, nitrogen as free ammonia upon Plate X and nitrogen as nitrites on Plate XI. After what has been said concerning similar plates representing other important constituents but little explanation is needed in order to understand the meaning and significance of the curves of Plate IX, or the columns of Plates X and XI with reference to the purification of the stream. The total organic nitrogen and the albuminoid nitrogen referred to in the descriptions of Plates IV, VI, VII and VIII represent largely waste organic matters which may be derived from either vegetable or animal sources or both. All vegetable and animal organisms contain as essential constituents substances which in their original condition and also in certain various stages of decomposition are classed as nitrogenous organic matters. Such matters are included in feces and urine, in waste from the household, in wastes from all industries which utilize plant and animal substances and products as well as in the vegetable substances contained in soils and which accumulate in swamps and in forests. Those substances which make sewage and animal waste in general offensive to the senses and dangerous to the health are, as a rule, nitrogenous organic substances, either living organisms or the products or wastes of living things. The natural processes of

purification of sewage and similar organic wastes involve the oxidation of these nitrogenous matters. The first stage in the purification process includes such a decomposition of these substances and the breaking down of the molecules of the complex proteid bodies, as results in the liberation of a portion of the nitrogen, together with the hydrogen in the form
5127 of ammonia. This may remain merely dissolved in the
water, or it may unite with acids, particularly with the carbonic which in these decompositions of the organic matters may be formed simultaneously with ammonia, and thus appear as a salt of ammonia, or carbonate of ammonia. Ammonia is not in general contained in the surface waters in considerable proportions except it be derived from the sources above mentioned, or it be formed by the reduction of nitrates and nitrites when these substances under some conditions are in contact with decomposing organic matters. The proportions of free ammonia contained in the water of the stream or in sewage, indicates on the one hand the relative quantity of refuse matters contained, and shows the stage of decomposition or on the other hand, it may represent the relative proportions of reduction of nitrites and nitrates. In this reduction process a considerable portion of the nitrogen which was at one time present in the water in the form of nitrates or nitrites, may be wholly lost, so far as the possibility of analytical determinations are concerned, by conversion into the element nitrogen, which as a gas may in part remain dissolved in the water, or it may be discharged from the water into the air in a gaseous state. Referring to Plates IX and X, we may observe that in 1899 a considerable proportion of nitrogen as free ammonia was contained in the water of the Illinois and Michigan canal and that although the proportion contained in the Des Plaines river at Joliet was considerably diminished through mixing with the waters of the upper Des Plaines river, yet considerable proportions of free ammonia were found in the river as far down as La Salle, but that the diminution still proceeded as we passed down the river until we find the minimum at Averyville. Be-

low Averyville the free ammonia increased in proportion again, reaching the maximum at Pekin, diminishing then more rapidly and continuously until the mouth of the river at Grafton is reached. The curve for 1900 shows of course the effect of dilution with lake water in the sanitary canal, that is the proportions of nitrogen as free ammonia never were so great in the water flowing into the upper end of the canal and past the points between that and Grafton as they were in the preceding year in the Illinois and Michigan canal and the Des Plaines river and the Illinois river. Otherwise the curves show similar features, that is the very rapid diminution of free
5128 ammonia until we reach Averyville shows that the natural
decomposition of the organic matters is taking place very vigorously in the upper reaches of the stream, but this action diminishes as we proceed down stream. The indication being that the diminution of the bacterial action is caused mainly by the exhaustion of the nutrients, that is, the supply of substances which are being converted by bacteria through ammonia into other innocuous forms of matter and which may be regarded as the food supply of the bacteria, is more rapidly diminishing. It is notable that the proportion of free ammonia increases again below Averyville, but afterwards diminishes until we find at the mouth of the river considerably less than elsewhere along the course of the stream and less during the summer of 1900 than during the summer of 1899. Upon Plate IX there are two curves and upon Plate X various columns representing the proportion of nitrogen as nitrites. Nitrites are oxidation products derived from the nitrogenous organic matters above referred to. In the conversion of objectionable and harmful nitrogenous organic matters into innocuous substances, the nitrites mark a stage following that which is indicated by the presence of the free ammonia. The curve for 1899 shows the maximum content of nitrites at Ottawa. From thereon considerable diminution occurs until we reach Averyville and Wesley but beyond that there is again an increase. We find the maximum at Pekin, beyond which there is a gradual

decrease until we reach the minimum at the mouth of the river at Grafton. The two maxima indicate the two zones in the river at which the second stage of the natural purifying processes is most vigorously under way. Referring now to the curve for 1900, it becomes evident that the increase in the proportion of nitrites becomes marked very much nearer the source of the sewage, that is, since most of the sewage has been diluted before it is discharged into the Des Plaines river valley, those natural decompositions and oxidations of the organic matters which result in the formation of nitrites and subsequently nitrates, have begun vigorously at a point much nearer
5129 Chicago. The point at which the maximum quantity of nitrites is found during the summer of 1900 is again at Ottawa as during 1899. From there the curve varies in general in the same direction, but it is notable that the minimum is less than during the earlier season, and that the maximum never reaches the high proportion found in 1899. Consideration of the curves and columns shows that the zones at which the purifying action takes place with the greatest vigor are in the vicinity of Ottawa, and the stretch of river between Pekin and Havana, under both sets of conditions, that is, those conditions prevailing during the summer of 1899 and those prevailing during the summer of 1900 or both before and after the opening of the drainage canal. It is evident then that so far as the significance of nitrites is concerned, those purifying processes which effectively destroy the nitrogenous organic matters introduced into the waters of the stream either in sewage or in other ways, enter upon the decomposition earlier in their course of transit between Chicago and the mouth of the river, and the activities which bring about these changes reach their maximum at points no further down the stream since the opening of the Chicago main drainage channel than they did prior thereto. (Motion by Mr. Jeffries to strike out testimony of witness.)

5130 As to Plates IX, X and XI, a study of the various figures of the tables and the curves and columns of the plates reveals the fact that in each of the summers in question, there was less nitrogenous organic matter contained in the water of the Illinois river at Ottawa just above the mouth of the Fox, than was in the Illinois river water at points farther down its course, except at Averyville, and at Grafton. This may in part result from incomplete mixing in the upper stretches of the river, but is undoubtedly due in part to the fact that organic matters of animal origin such as constitute the chief organic matters of sewage, are more easily susceptible to the putrefaction and oxidizing influences which bring about the purification of water, while vegetable matters, which constitute the greater part of the organic matters found in the natural waters of swamps and streams such as are contributed in larger proportion to the Illinois by its tributaries and by the run-off from its own slopes, are less easily decomposed and persist in the water of the lower river in greater proportion. Moreover, vegetation, particularly of the minute and floating forms, that is the plankton, is more abundant in the waters of the lower stretches of the river from La Salle down. The nitrites and nitrates produced abundantly in the waters of the upper part of the river through the decomposition of the nitrogenous organic matters of sewage are in turn utilized by the vegetation and in part their nitrogen is built up into more stable and less objectionable nitrogenous organic matters which remain floating or dissolved in the water and appear in the analytical results but must be regarded with much less disfavor and objection than would be accorded a like proportion of nitrogenous matters of animal origin.

5131 I identify Plates XII and XIII as plates which I made, to represent graphically certain averages which appear in tables C and D, which averages were made from those portions of tables 1 to 80 inclusive, which represent analyses of August and September, 1899, and the same months of the year 1900. Plates XII and XIII reproduced on pages 5132 and 5133.

5134 Upon Plates XII and XIII are shown curves and columns representing the proportions of oxygen consumed by water in the Illinois river at various points, as indicated on the other charts or plates, and a comparison of the waters of the Missouri river near its mouth, the Illinois at its mouth, and the Mississippi just above the mouth of the Illinois, and cross-section determinations at Mitchell or the Chain of Rocks, on Plate XII and at the same points and also the cross-section at Alton, in Plate XIII. It is obvious from inspection of the curves and columns which represent the figures recorded in tables C and D, heretofore read in evidence, that the water in the upper stretches of the river contains a great deal more of such organic matters as are easily susceptible to oxidizing agencies, than does the water in the lower stretches of the river. The diminution in 1899 was very rapid until we reached Ottawa and Averyville, below Averyville the quantity of oxygen consumed increased owing to the discharge of sewage and wastes into the river at Peoria and Pekin. Below Pekin there is a continuous diminution in these matters until the mouth of the river is reached. Similar features appear when we consider the total oxygen consumed by matters in solution in the water, that is in the filtered water. The curve for 1900 shows variations at different points along the river and makes manifest the fact that the proportion of easily effected organic matters in the water is considerably less than during the corresponding season of 1899, though there is not such a great relative diminution along the course of the river, for the reason that the initial dilution through the operation of the sanitary canal at once decreases the proportions of oxidizable matters in or near to Chicago and there is consequently less opportunity for diminution on the way down the river because the proportions at the upper end are already less than they were in former times, that is times prior to the opening of the drainage canal.

5135 Group 2, Plate XII, represents a comparison of the relative quantities of oxygen consumed by the waters of the Illinois river, those of the Mississippi river and those of the Missouri river. It is evident that the waters of the Illinois river contain considerably less readily oxidizable matter in the

summer of 1900 than in the summer of 1899. In the case of the Mississippi river water it is evident that the proportion of oxidizable matters far exceeds that contained in the Illinois river water at the mouth, and that the proportion is practically the same for the two seasons, namely 1899 and 1900. In the case of the Missouri river water the proportion of oxidizable matters is essentially the same in 1900 as it was in 1899, but in both years it is very much greater than the proportion contained in the water of the Illinois river. On the other hand, comparison of the proportionate quantities of oxygen required by dissolved organic matters shows that there is less required by the waters of the Missouri river than by the waters of the Mississippi river or those of the Illinois river, this appearing from the columns which appear in Plate XIII. In 1899 as appears from this same group 3 of table XIII, the quantity of oxygen consumed by the waters of the Illinois river was considerably greater than in 1900, also by the Mississippi river water, more was required during the summer of 1899 than during the summer of 1900, but in each year the quantity required by the Mississippi river water was greater than the quantity required by the Illinois river water. In answer to the question of counsel,
I would say that the smaller proportions of oxygen re-
5136 quired by dissolved substances in the Missouri river
water, notwithstanding the fact that the total oxygen consumed by the Missouri river water was greater than that required by either the Mississippi or the Illinois river water, was due to the fact that the substances in suspension in the Missouri river water were more considerable in quantity, required more oxygen for their oxidation than did the suspended matters in the waters of the Mississippi river or the waters of the Illinois river. Now group 3 of Plate XII and group 4 of Plate XIII show the relative quantities of oxygen consumed by water samples collected at the four points across the stream of the Mississippi river at the Chain of Rocks or Mtichell. It is evident that the water along the Missouri shore and in the vicinity of the intake tower contains much greater quantities

of organic matters than does the water which passes down near the Illinois shore. On the other hand, in this latter group it is apparent that the dissolved readily oxidizable matters contained in the water near the intake tower are less in proportion that those contained in the water near the Illinois shore. Group 2, of Plate XIII, representing the cross-section at Alton, shows that the proportions of oxidizable matters at various points across the stream were greater during the year 1899 than they were during the same period of 1900, both for the totals and for that in solution, and shows further that the proportions of total oxygen consumed and that consumed by matters in suspension, were greater as we pass from the Illinois shore down which the Illinois river water flows, toward the Missouri shore, where the water in greater proportion is that from the upper Mississippi river. Considering the evidence represented by the columns in group 1, and that of the curves in groups 2 and 3, Plate XII, and the columns of group 1 and those of groups 3 and 4 of Plate XIII, it appears that the water passing down near the Missouri shore and passing the intake tower of the St. Louis waterworks is much more nearly like the water of the Missouri river than it is like that of the Mississippi river in its upper stretches or the Illinois river in its lower stretches.

5137 I made Plate XIV and the data which are represented here by means of curves are contained in tables No. 1 to 80 inclusive, referring to the points named in the plate, which tables have been heretofore put in evidence. Plate XIV reproduced on page 5139.

5140 Plate XIV is supplementary to or complementary with Plates IV and V, which were heretofore put in evidence. It exhibits the differences between the proportions of chlorine at the different cross-section points at the Chain of Rocks, and also shows the seasonal variations of chlorine at these points during such periods, as the tables corresponding refer to, as indicated by the years marked upon the plate and the months and days appearing in the scale at the bottom thereof. The small circles along the lines place the dates and show also the proportions of chlorine by their relation to the vertical scale at the side of the plate. There appears in these curves seasonal variations in the proportions of chlorine, and differences between the proportions of chlorine contained in the water of the Mississippi river at the four different cross-section points, opposite the intake tower of the St. Louis waterworks. It also institutes a comparison between the proportions just mentioned, and the proportions contained in the water of the Missouri river at West Alton, and serves further to illustrate the point previously discussed, that the water near the intake tower and near the Missouri shore at the Chain of Rocks is more like the water of the Missouri river than is the water passing down at mid-channel, or that passing down toward the Illinois shore in this locality, that is opposite the Chain of Rocks.

5141 Considering the various lines for 1900 which appear upon Plate XIV, it is evident that the proportion of chlorine contained in the water of the Missouri river at West Alton was greater at the dates indicated in January, 1900, than in February and that in March the proportion is considerably less than in either February or January. Proceeding on through such portion of the year as this curve represents, we find slight increases and slight decreases from time to time, but that in August there was a more considerable increase in chlorine than during several months preceding, and that after a decrease again in the latter part of August and in the early part of September, the proportion of chlorine increases considerably, to be followed by a decrease near the middle of September which was again followed by a very considerable increase near the end of September, the latter increase being followed by a more considerable decrease to a date early in October, which is stated in the table from which these data have come, but at which date the collection of samples from this river was discontinued. The dates at the bottom of the plate represent the dates at which the collections were made, but in order to avoid crowding at certain points in the scale at the

bottom of the plate some dates are merely indicated by lines, and not by figures. The figures all appear in table 73, which has heretofore been read in evidence. The line marked 1899 represents the data of the analyses for the same river, and the same point given in table 32, and covers the period July 10 to December 29, 1899. It shows similar seasonal variations, the content of chlorine in this case being lowest in the summer months and increasing during the fall and winter. Consideration of the other lines of Plate XIV shows that the waters pass-
ing down near the inlet tower of the St. Louis water-
5142 works and near the Missouri shore opposite, are subject
to the same seasonal variations, as regards content of chlorine, as those just described, with respect to the water of the Missouri river at Fort Bellefontaine or West Alton, and show further that the water at these two points is more greatly like that of the Missouri river itself than is the water passing down at mid-channel, or that passing down toward the Illinois shore opposite the intake. I made Plate XV. It is based upon the figures given in tables C and D, which refer to the averages for the four summer months of June, July, August and September, 1899 and 1900, which averages were made from the detailed figures found in tables 1 to 80, inclusive, heretofore offered in evidence, and the columns of this table represent by their proportions the figures of the tables of averages referred to, namely tables C and D. The particular set of figures of tables C and D represented upon this plate are those which pertain to the waters of the Kankakee river, the Fox river, the Big Vermilion river, the Sangamon river, the Illinois river at Averyville, and the Illinois river at Grafton for the two periods in question, and have been brought together in this plate for the purpose of rendering easy a comparison of the relative proportions of the different constituents named upon the plate as contained in the waters of the tributary streams, and the waters of the Illinois river at Averyville and Grafton. (Mr. Jeffries objected to the introduction of all these plates.)

Said Plate XV reproduced on page 5144.

5145 Plate XV is intended to represent by means of columns the averages which appear in tables C and D, referring to the proportions of chlorine, of oxygen consumed, of nitrogen, as free and as albuminoid ammonia, and as nitrites, and the total organic nitrogen in the waters of several different tributaries of the Illinois, and to facilitate a comparison of the proportions represented by these figures of tables C and D, with the proportions contained in the waters of the Illinois at Averyville and Grafton. The comparison of these columns which merely represent the figures in the table of averages, renders evident at a glance the fact that the proportions of organic matters as represented by oxygen consumed, by albuminoid ammonia and total organic nitrogen, are even more considerable in the waters of the larger tributaries of the Illinois than they are in the waters of the Illinois at Grafton. Free ammonia and nitrites, however, are more abundant in the waters of the Illinois river at Averyville than in the waters of the tributary streams, but the waters of the Illinois river at its mouth at Grafton, contain less nitrogen as nitrites than is contained in the water of the Sangamon river, the proportion contained during this period of four summer months, June, July, August and September, 1900, being less than half as much as was contained in the corresponding period of 1899, and about three-fourths as much as was contained in the waters of the Sangamon river during the same period in 1900 and in 1899, and less than was contained in the waters of the Big Vermilion river during the corresponding period of 1899. The waters of the Illinois river at Grafton contain considerably less nitrogen as free ammonia during these four months in 1900 than was contained during the same period of 1899 and the proportions in both years were less than the proportions contained in the waters of the Big Vermilion river in either year, although the Big Vermilion river water contained less in 1900 than it did in 1899.

5146 Moreover, the proportions of free ammonia in the water of the Illinois at Grafton during this period in 1900 are slightly less than the proportions contained in the water of the Sangamon for the same period and year and still more considerably less than was contained in the water of the Big Vermillion river, the Fox river, and the Kankakee river, during this same period. The proportions of nitrogen as nitrites and as free ammonia in the waters of the Illinois river at Averyville were very considerably greater than the proportions of nitrogen as nitrites or that as free ammonia in the waters of the Illinois river at Grafton in both years, and very considerably greater than the proportions of these substances contained in the waters of the Kankakee river during these periods and years. Consideration of the columns of group 4 representing the proportions of oxygen consumed, show that the waters of the Kankakee river and the Fox river required more oxygen than did the waters of the Illinois river at Grafton in both of these years, and that the waters of the Sangamon river required more oxygen in the year 1900 than did the waters of the Illinois river at Grafton in the same year. Comparison of the figures of group 5 shows similar facts with respect to the proportions of albuminoid ammonia, namely, that there was a greater proportion in the waters of the Fox river and in the Sangamon river in 1900 than in the waters of the Illinois river at its mouth at Grafton, and that in the year 1899 the proportions of nitrogen as albuminoid ammonia in the waters of the Kankakee and Fox were considerably greater than the proportions of these substances in the water of the Illinois river at the mouth. Similar facts appear from consideration of the columns of group 6, referring to the total organic nitrogen. In both years it appears that the water in the Illinois river at its mouth at Grafton contained less total organic nitrogen than did the waters of the Kankakee or Fox river, and that in the year 1900 the water of the Illinois at Grafton contained less total organic nitrogen than was contained in any of the tributary streams here referred to, namely, the Kankakee, the Fox, the Big Vermilion and the Sangamon.

5147 I made plate XVI. It represents the discharge of water of the Des Plaines river at Joliet of the Chicago main drainage channel or sanitary canal at Lockport and of the Illinois river over the dam at Kampsville, 31 miles from the mouth of the river. The data relating to the flow of the Des Plaines river at Joliet, and the discharge of the sanitary canal at Lockport, were furnished me by the engineer of the Sanitary District, Mr. Isham Randolph, I believe is the name. The data concerning the discharge over the dam in the Illinois river at Kampsville were furnished me by the United States engineer in charge of the Kampsville dam and the improvement of the lower Illinois river, Mr. C. V. Brainard. (Objection by Mr. Jeffries.) Plate XVI reproduced on page 5149.

5150 The data which are represented by the curves of plate XVI, and which will be introduced in evidence, show the seasonal variations in the flow of the three bodies of water to which the plate refers, the curves being based upon the total measurements of the height of water, and computation of the flow corresponding to those heights. The points being the Bear Trap dam at the lower end of the Chicago main drainage channel at Lockport, Illinois, and the Des Plaines river at dam No. 1, Joliet, Illinois, and the Illinois river at the dam at Kampsville, 31 miles within the mouth of the Illinois river. Thus, in the early part of January, 1900, the flow in the Des Plaines river at Joliet is exceedingly small; the discharge from the sanitary canal which began on the 17th of January is represented by the lowest curve in the plate, by the underneath curve in the plate, and it is evident that the opening of the canal by the manipulation of the Bear Trap dam resulted in increasing the flow in the Des Plaines river at Joliet, and that throughout a very considerable portion of the year, that is, for much the larger part of the year, the flow at Joliet was but slightly greater than the dis-

charge of the drainage channel at the Bear Trap dam. The figures at the left hand side of the plate and those which appear at the right hand side also, indicate the volumes of water discharged per second, these figures applying to each one of the horizontal lines which is just beneath it. The line representing, where it touches the curve, the flow for the day so indicated. Thus, the line indicated by the figure 10,000 at the left hand corner of the plate crosses the line representing the discharge of
water in the Illinois river over the Kampsville dam at
5151 about January 16th, the precise date being given in the
tables of figures hereafter to be offered in evidence and shows that at or upon this date the discharge of the Illinois river at this point was 10,000 cubic feet per second. That there had been a somewhat sudden increase of the discharge upon a day or two preceding and an increased discharge for a day or two following this date. Continuing along the line of the curve, the variations, that is, the increases and decreases are at any point and every point indicated by the position of the curve, with respect to the horizontal lines of the plates, while the dates are indicated by the relative position of the curve with respect to the figures at the bottom of the plate, and certain vertical lines which have been drawn to facilitate the comparison. The flow is greatest at Kampsville in the latter part of March, that is, for this year 1900. This plate relates to 1900 altogether, the flow at that time being about 50,000 cubic feet per second. The figures represent the quantity of water going over the dam at Kampsville. I made plate XVII and it represents the figures supplied to me by readers of the gauge at the C. B. & Q. bridge
at Alton, Illinois. Plate XVII reproduced on page 5153.
5154 On plate XVII there are represented the stages of water
in the Mississippi river at Alton during the years 1899 and 1900, the chart being made from figures representing the heighth of water in the stream at this point each 24 hours during the year, the mean daily heights during each of the years indicated, namely 1899 and 1900, for the purpose of showing the seasonal variations in the height of the water, which figures bear a

direct relation to the volume of water flowing, and for the purpose of comparing the heights at various seasons during one year, with the heights during the same season during the other year. The figures on the left hand and right hand side of the plate represent the height of the surface of the water in feet with reference to the height of the sea at Biloxi, on the Gulf of Mexico, and indicates the relative stages of water in the Mississippi river at this point, namely, Alton, by reference to the lines indicating low water, and extreme low water respectively, as they appear near the bottom of the plate. The lighter line refers to the year 1900, and the heavier line refers to the stages of water during the year 1899. That this record as extreme low stage of water at Alton is a point 183.3 feet above the mean sea level on the Gulf of Mexico or the lake, whichever it is at Biloxi. The increase above this point then would represent the increased height of the water at the time stated at Alton.

5155 I have made other chemical analyses of the waters of the rivers of Illinois, and especially of the waters which have been under investigation since I took the stand as a witness in this case, than those about which I have already testified. As professor of chemistry in the university, it fell to me to examine many waters in connection with the instruction work of students, and also for the information of citizens, and also in connection with the work of the biological station of the university, which just at the time I began this work systematically, was located at Havana on the Illinois river. My first work upon the Illinois river with the exception of some few examinations made many years ago when I was a student, began in the summer of 1894, the result of which examinations,—comparatively few samples being examined, were reported by me to the president of the university in 1897. In the following year provision was made for a somewhat extensive series of investigations of the water supplies of the State, including not merely river waters and other surface waters, but also the ground waters, and the investigations at that time commenced, included an attempt at a systematic study of the waters of the Illinois river.

5156 The State of Illinois made provision for more extended examinations of these waters. The legislative assembly of Illinois in the spring of 1897 passed an act establishing a survey of the waters of the State and by this act directed the trustees of the university to establish such survey and made appropriation for the work in this survey. The act is as follows: "An Act to establish a chemical survey of the waters of the State of Illinois, approved June 7, 1897, in force July 1, 1897."

Section 1. *Be it enacted by the people of the State of Illinois represented in the General Assembly,* that the trustees of the University of Illinois are hereby authorized and directed to establish a chemical and biological survey of the waters of the State in connection with said university.

Section 2. It shall be the duty of the university to collect facts and data concerning the water supplies of the State; to collect samples of water from wells, streams and other sources of supply, to subject these samples to such chemical and biological examination and analyses as shall serve to demonstrate their sanitary condition, and to determine standards of purity of drinking waters for the various sections of the State; to publish the results of these investigations in a series of reports to be issued annually, or oftener, to the end that the condition of the potable waters of the State may be better known, and that the welfare of the people of the various communities of the State may thereby be conserved."

5157 This is read from the laws of Illinois. I was directed by the Board of Trustees of the University of Illinois to proceed to carry out the directions in this act of the legislature. I proceeded to make the investigations indicated in section 2 of the act, that is, to obtain data and information concerning the waters of the State; to obtain samples of water from the various different sources, and subject these to examination and to prepare the results thus obtained in the form of reports to the president of the university and the trustees. The investigations which I at that time began, included the examination of samples of water drawn from Lake Michigan, delivered at tap in the city of Chicago; samples of water from the Illinois and Michigan

canal at Lockport; samples of water from the Kankakee river at Wilmington; from the Illinois river at Morris; from
5158 the Fox river at Ottawa; from the Illinois river at La Salle; from the Big Vermilion river, near La Salle; from the Illinois river at Averyville, or North Peoria; from the Illinois river at Havana; from the Spoon river at Havana; from the Illinois river at Kampsville; and later from the Illinois river at Grafton; from the Mississippi river at Alton and at Grafton and at Quincy. I selected the persons to take the samples of water and gave them the instructions.

5161 (Witness gives names of collectors at various points, tells how samples were collected and shipped, etc.)

5163 The samples were treated and analyzed in precisely the manner set forth in my testimony of the last three days, respecting the samples examined by me on behalf of the Sanitary District of Chicago. I made an entry of the ascertainments of those analyses on records made by me and will produce such record. (Witness produced certain tables entitled "Department of Chemistry, University of Illinois, Sanitary Water Analyses, parts per million," which constitutes a part of the report of the State Water Survey as made by the department of chemistry of the University of Illinois, approved June 7, 1897, and in force July 1, 1897, heretofore this day read in evidence, which tables were made by witness Arthur W. Palmer, Professor of Chemistry, University of Illinois, and which tables shall be hereafter known in this evidence as "Department of Chemistry, University of Illinois, A. W. P., table 1 to table 80 inclusive.")

MR. JEFFRIES: I object to the reading of the tables referred to in evidence. (Mr. Jeffries states reasons.)

These tables show the serial number, date of collection, date of examination, appearance, residue of evaporation, chlorine, oxygen consumed, nitrogen as ammonia, organic nitrogen and nitrogen as nitrites and nitrates, the examination running from January 4, 1897, to December 26, 1900, samples being collected about once per week. Places at which samples were taken, and the page of record on which table is reproduced, showing result of such examination are as follows:

Table.				
No.	Year.	Source of Water.	Point from which sample taken.	Record page.
1	1897	Lake Michigan	Chicago	5166
2	1898	Lake Michigan	Chicago	5168
3	1899	Lake Michigan	Chicago	5170
4	1900	Lake Michigan	Chicago	5172
5	1897	I. & M. Canal	Lockport	5174
6	1898	I. & M. Canal	Lockport	5176
7	1899	I. & M. Canal	Lockport	5178
8	1900	I. & M. Canal	Lockport	5180
9	1901	I. & M. Canal	Lockport	5182
10	1900	Sanitary Canal	Lockport	5184
11	1901	Sanitary Canal	Lockport	5186
12	1897	Des Plaines river	Lockport	5188
13	1898	Des Plaines river	Lockport	5190
14	1899	Des Plaines river	Lockport	5192
15	1901	Des Plaines river	Joliet	5194
16	1901	Des Plaines river	Joliet—west side	5196
17	1897	Illinois river	Morris	5198
18	1898	Illinois river	Morris	5200
19	1898	Illinois river	Morris	5201
20	1899-00	Illinois river	Morris	5202-3
21	1899	Illinois river	Ottawa	5205
22	1900	Illinois river	Ottawa	5206
23	1901	Illinois river	Ottawa	5208
24	1897	Illinois river	La Salle	5209
25	1898	Illinois river	La Salle	5211
26	1899	Illinois river	La Salle	5212
27	1900	Illinois river	La Salle	5214
28	1897	Illinois river	Averyville	5216
29	1898	Illinois river	Averyville	5217
30	1899	Illinois river	Averyville	5219
31	1900	Illinois river	Averyville	5221
32	1901	Illinois river	Averyville	5223
33	1897	Illinois river	Havana	5224
34	1898	Illinois river	Havana	5226

Table.			Point from	Record
No.	Year.	Source of Water.	which sample taken.	page.
35	1899	Illinois river	Havana	5228
36	1900	Illinois river	Havana	5230
37	1897	Illinois river	Kampsville	5232
38	1898	Illinois river	Kampsville	5234
39	1899	Illinois river	Kampsville	5236
40	1900	Illinois river	Kampsville	5238
41	1901	Illinois river	Kampsville	5240
42	1902	Illinois river	Kampsville	5242
43	1899	Illinois river	Grafton	5244
44	1900	Illinois river	Grafton	5246
45	1901	Illinois river	Grafton	5248
46	1902	Illinois river	Grafton	5249
47	1899	Mississippi river	Grafton	5250
48	1900	Mississippi river	Grafton	5252
49	1901	Mississippi river	Grafton	5254
50	——	Table missing		
51	1897	Mississippi river	Alton	5256
52	1898	Mississippi river	Alton	5258
53	1899	Mississippi river	Alton, 100 ft. off Ill. shr.	5260
54	1900	Mississippi river	Alton, 100 ft. off Ill. shr.	5262
55	1899	Mississippi river	Alton, 1/4 dis. from Ill. shr	5264
56	1900	Mississippi river	Alton, 1/4 dis. from Ill. shr	5266
57	1899	Mississippi river	Alton, midstream	5268
58	1900	Mississippi river	Alton, midstream	5270
59	1899	Mississippi river	Alton, 1/4 dis. from Mo. shr	5272
60	1900	Mississippi river	Alton, 1/4 dis. from Mo. shr	5274
61	1899	Mississippi river	Alton, 100 ft. from Mo. shr	5276
62	1900	Mississippi river	Alton, 100 ft. from Mo. shr	5278
63	1897	Mississippi river	Quincy	5280
64	1898	Mississippi river	Quincy	5282
65	1899	Mississippi river	Quincy	5284
66	1900	Mississippi river	Quincy	5285
67	——	Table missing		
68	1901	Mississippi river	Quincy	5286
69	1902	Mississippi river	Quincy	5287
70	1903	Mississippi river	Quincy	5288

Table. No.	Year.	Source of Water.	Point from which sample taken.	Record page.
71	1897	Kankakee river	Wilmington	5289
72	1899	Kankakee river	Wilmington	5290
73	1900	Kankakee river	Wilmington	5292
74	1898	Fox river	Quincy	5294
75	1899	Fox river	Ottawa	5296
76	1900	Fox river	Ottawa	5298
77	1901	Fox river	Ottawa	5300
78	1897	Spoon river	Havana	5301
79	1898	Spoon river	Havana	5303
80	1899	Spoon river	Havana	5305

5306 I made investigations as to the waters of the State of Illinois before the passage of the act of the legislature to which reference has been made. I began investigations in 1889 but did not begin systematic investigations of the Illinois river until the summer of 1894 when samples were collected at Havana and in 1895, under the provisions of an appropriation made by the legislature and assigned by the trustees of the University to the purpose, I made preliminary report which was published by the University in 1897 and covered all the work done under the provisions heretofore mentioned up to the end of the year 1896. (Said report offered as defendant State of Illinois Exhibit 23 for identification.) I made tables of averages made from the tables of detailed data just introduced in evidence as Department of Chemistry, University of Illinois, A. W. P. Table 1 to 80 inclusive, and State of Illinois Exhibit No. 23 for identification. Charts which are to be known in this investigation as "Department of Chemistry, University of Illinois, A. W. P. Plates V to XLII inclusive," illustrate in a graphic form the data contained in the tables which I have read in evidence and also in defendant State of Illinois Exhibit 23 for identification. Plates
5308 V to XVII are reproduced on pages 5309 to 5321 inclusive.

5322 Mr. C. V. Millar assisted me in making tables of analyses that I have read in evidence, up to the summer of

1900 and R. W. Stark right through the entire series.

5323 (Witness temporarily withdrawn from the stand.)

R. W. STARK, Examined in chief by Judge Springer.

Reside in Champaign, Illinois. Am a chemist employed in the State Water Survey. (Gives educational qualifications.)

5324 Assisted Professor Palmer in making chemical analyses which he prepared together with Mr. Millar and myself during the years 1897 to 1902.

5325 Table No. 1 down to and including table No. 21 put in evidence by Prof. Palmer were tables I assisted in making, and so far as the entries are made by me, are correct ascertainments of the analyses made by me at that time. The same applies to tables made by Prof. Palmer as a part of the sanitary survey of Illinois, covering periods from 1897 to the end of 1902, known as Department of Chemisty, University of Illinois, A. W. P. 1 to 80.

5326 PROF. ARTHUR W. PALMER, Resumed the stand for further direct examination by Judge Springer:

The data in table marked "Department of Chemistry, University of Illinois, A. W. P. 1," include the analyses of samples collected from the year 1897 until the year 1902. (Witness explains what is included in each column of the table, whch is shown by the table itself.)

5331 The dissolved oxygen determination covered a portion of the year 1897, the entire years 1898 and 1899 and a portion of the year 1900. The plates illustrating the dissolved oxygen to which I have referred have already been put in evidence. Plate V on page 5309 being a graphic illustration of the dissolved oxygen in the water of Lake Michigan drawn from a tap supplied from the four-mile crib opposite 14th street. The data represented in the curves of the plates already put in evidence is marked "defendant State of Illinois Exhibit No. 24 for Identification." These tables are known as "Department of Chemistry, University of Illinois, Plates V to XLV inclusive." (The tables marked 1 to 80 inclusive and heretofore read in evidence, on pages 5166 to 5305 inclusive, contain certain determinations indicated on the said tables, except the dissolved oxygen determination, which is supplied by Plate V above referred to. Witness refers to tables and reads the determinations as indicated thereon, stating the places at which the samples referred to in the table were taken.)

5337 As to the analyses shown in tables 15 and 16, the witness states the object of taking the samples of the water of the Des Plaines river at Joliet just above dam No. 1 in the town of Joliet to be for the reason that observations of the waters at this point flowing through the bed of the Des Plaines river and variations in the analyses of samples collected at mid-channel at this point in the previous year, led witness to take these two sets of samples, one toward one bank and the other toward the other bank of the stream at Joliet, in order to secure the data respecting the different compositions of the water of the two sides of the stream, and with reference to a study of the mixing of the waters of the upper Des Plaines river, of the Sanitary canal and of the Illinois and Michigan canal after they had come together at Lockport, four miles above, and at the point a few hundred yards above that of collection at Joliet. This point was above that at which the sewers of Joliet discharge into the stream, although a portion of the Joliet sewage and manufacturing wastes mixes with these various bodies of water.

5338 There is a very considerable difference between the averages obtained from the analyses of samples collected at one side of the stream at this point, and the averages obtained from the analyses of the samples collected at the other side, these differences being due to the incomplete mixing of the several bodies of water which are passing down the valley of the Des Plaines at this point, or perhaps I had better say the bed of the Des Plaines river at this point. The variations being caused at this time by variations in the discharge at the Bear Trap dam, by variations in the quantities of sewage pumped from the south fork of the Chicago river into the

Illinois and Michigan canal and variations in the flow of the upper Des Plaines river.

5339 C. V. MILLAR, Examined in chief by Judge Springer: I reside in Joplin, Missouri. My occupation is that of assayer or chemist. (States educational qualifications.)

5340 Between 1895 and 1900 I made chemical analyses of the water at the University of Illinois in connection with Prof. Palmer.

5341 (States how samples were received, etc.)

5345 PROF. ARTHUR W. PALMER, Resumed the stand for further direct examination by Judge Springer:

The samples of water, the result of the analyses of which is shown on tables 21, 22 and 23, were taken at one point in the river at Ottawa where occurred a mixing of the waters of the Kankakee with the waters of the Des Plaines, which latter included the discharges from the Illinois and Michigan canal, the Sanitary canal and the waters from the upper Des Plaines. But the mixing not being complete this accounts for certain variations in the analytical data. This point was about 18 miles above the outlet of the old Illinois and Michigan canal. (From pages 5333 to 5356 the witness gives the location of the samples, number of times same were taken, etc., which data is all included in the table immediately preceding this testimony and found beginning with page 5166 of this record.)

5356 Stipulation that the samples of water taken at Joliet from the Des Plaines river, the Illinois river, and the Missouri river at West Alton and Chain of Rocks in the Mississippi river were taken in the manner stated and required, as shown by Sanitary District's Exhibit No. 11 for identification.

No. 869, The Rookery Building, Chicago, Ill., Nov. 16, 1903.

PROF. ARTHUR W. PALMER resumed the stand for further direct examination by Judge Springer:

5357 JUDGE SPRINGER: Defendant's Exhibit A, entitled "University of Illinois Chemical Survey of the Water

Supplies of Illinois, Preliminary Report, by Arthur William Palmer, S. C. D., Professor of Chemistry, published by the University, 1897," offered for identification. This may be used by either party hereafter as evidence in the case, or it may be referred to by witnesses or counsel, without being printed as part of the record.

This is my official report to the President of the University of Illinois.

5358 The data of the analyses show the general chemical character of the waters of Lake Michigan, and a comparison of the data for the different years with each other, and the averages for the different years with each other, show that the water of the lake is subject to no great variation as to the proportions of the various substances which are determined in the sanitary chemical analysis. They show that the water contains but a moderate proportion of mineral matters, that the organic matters are small in quantity as compared with many surface waters, and especially the proportions of nitrogen as free ammonia, as albuminoid ammonia, the total organic nitrogen, nitrites and also nitrates are present in a small quantity. The variations during the four years covered by the tables which have been read in evidence, namely, tables 1, 2, 3 and 4, of this series were in general, comparatively slight, and apparently were mainly caused by conditions which brought about variable discharges from the Chicago river, and from those sewers which empty directly into the lake and pass further out into the lake than they commonly do. They are also in part due to storms which stir up the sediment near the shore of the lake and near the cribs at which the intakes are located. The sediments being in the main such are natural to any considerable body of surface water, but including also a certain amount of refuse from the city and of dredgings from the Chicago river. The variations in no case vary considerably, and on the whole the water of the lake is to be considered as superior in quality to the water of all of the larger streams of Illinois and the vicinity.

5359 The determinations of dissolved oxygen in the water of Lake Michigan, upon samples drawn at the same time and place as those which were subjected to the sanitary chemical analyses showed that the waters of the lake were at all times fairly well charged, that is, generally saturated with dissolved oxygen.

The data of the dissolved oxygen determinations are included in Defendant's Exhibit No. 24 for identification and are represented by the curves on plate marked "A. W. P. No. V" which has heretofore been placed in evidence.

The averages of these tables are to be found at the bottom of each table. The tables of analyses No. 5 to 9 inclusive, include the results of examinations of samples of water taken from the Illinois and Michigan canal at Lockport just before it discharges into the Des Plaines river. The periods covered in these tables are the years 1897 to 1901 inclusive. In addition to the data in these five tables, I have made use of the averages for the year 1896 which are recorded in the Preliminary Report of the Chemical Survey of the waters of Illinois, which has heretofore been presented for identification, as Defendant's Exhibit A.

5360 The data reveals notable variations generally in April and March, the usual season of freshets, but for most of the year they show a somewhat remarkable uniformity in the proportions of organic matter.

5361 I have prepared some tables of averages of the analytical results at various points and they will be referred to hereafter as "Defendant's Tables of Averages, A. W. P. No. 1 to 15, inclusive." Table No. 1 shows the averages for the years 1896-7-8-9 of the waters of the Illinois and Michigan canal at Lockport, before the opening of the drainage canal and is reproduced on 5362 of record.

5362 Inspection of the yearly averages which appear in table No. 1 of this series shows that up to the time of the opening of the Chicago main drainage channel there were in most respects but slight variations from year to year, such changes as did occur being in the direction of a small but constant increase of the nitrogenous organic matter.

Examination of the data of the analyses for the year 1900, which appear in table 8, and for the year 1901, which appear in table No. 9 reveal much greater and more frequent variations than occurred before the opening of the Chicago main drainage channel. The averages of the analyses of the waters of the Illinois and Michigan canal at Lockport for the years 1900 and 1901 appear in tables of averages No. 2, A. W. P., and will be found on page 5363 of record.

Comparison of the averages for the two periods shows that the relative proportions of organic matters were considerably reduced as a result of the diversion of a part of the sewage, and the new drainage channel, although the proportions of nitrogen
as free ammonia became greater than before, a result
5363 which may be due to the effect of the greater dilution in
facilitating the more speedy oxidation of the organic
matter. The variations are mainly due to the fact that at times when the lake is high, or the discharge from the drainage canal at the controlling works is reduced comparatively pure lake water backs up into the south fork of the Chicago river in such volume that a more dilute sewage than usual is raised by the pumps at Bridgeport into the Illinois and Michigan canal, while ordinarily inasmuch as the south fork is not yet flushed out, the liquid pumped into the old canal, that is, the Illinois and Michigan canal, still consists mainly of the comparatively concentrated sewage from the stock yards district.

As compared with the analyses of the waters of Lake Michigan as given in tables 1 to 4, the waters of the Illinois and Michigan canal of course show evidence of the enormous quantities of refuse matters which are discharged into the Chicago river, and which thence pass into the Illinois and Michigan canal, this being revealed by the very much greater proportions of organic matters contained in the canal water as compared with those contained in the lake water.

The Defendant's Table of Averages No. 3, A. W. P. will be found on page 5364 of record and contains the averages of results for the years 1900 and 1901 from an examination of the waters of the drainage canal at Lockport, and consists of the averages of the determinations made as indicated by tables No. 10 and 11, found on pages 5184 to 5187 inclusive.

5365 The variations which appear in these analytical data are due in the main to variations in the volume of flow in the drainage channel, caused partly by differences in the lake level, partly by the partial closing of the gates or the raising of the Bear Trap dam at Lockport and also at certain times by the overflow of water from the Des Plaines river at the spillway into the main drainage channel itself. Further, they are caused in part by variations in the pumping at Bridgeport for when the Bridgeport pumps are not in operation a portion of the contents of the south fork enters the south branch of the Chicago river, and passes thence into the main drainage channel while when the pumps at Bridgeport are kept in operation practically all of the sewage of the south fork is discharged into the Illinois and Michigan canal, and enters the Des Plaines river below the point of discharge from the main drainage channel. Comparison of the figures in table of averages No. 3, with the figures appearing in tables of averages Nos. 1 and 2, show that the waters discharged through the sanitary canal are far more dilute than the waters discharged through the Illinois and Michigan canal, that is, the proportions of the various significant constituents notably those of the nitrogenous constituents, are very much less in the waters of the sanitary canal or main drainage channel, than they were and than they are in the waters of the Illinois and Michigan canal.

5366 Plate VI reproduced on page 5310 gives the flow for the year 1900 in the Illinois and Michigan canal at Bridgeport, the Des Plaines river at Riverside, the Drainage canal at Lockport and the Des Plaines river at Joliet. Plate VII reproduced on page 5311 gives a comparison of the relative vol-

ume of water discharged by these various streams or agencies at
the same points for the year 1901.

5369 Table of Averages No. 4, A. W. P. gives results of analy-
ses of samples of water referred to in Tables No. 15 and
16 on pages 5194 to 5197 inclusive, of record, and is reproduced
on page 5370.

5371 (Witness explains cause of variations in the results ob-
tained.) Table of Averages No. 5 is reproduced on page
5374 and gives the results of averages for tables No. 17, 18, 19
and 20 heretofore offered in evidence.

5375 Morris is the first station upon the Illinois river proper.
At this point the waters of the stream consist of an incomplete mixture of the sewage laden waters of the Des Plaines river with the waters of the Kankakee. Prior to the opening of the drainage channel the Chicago sewage discharged into the Des Plaines river experienced no considerable dilution before getting the waters of the Kankakee, except when the Des Plaines itself was in flood. This, however, was rarely the case at times other than those of the usually short spring freshets. When the Kankakee was in flood, the dilution at this point was of course correspondingly great, as much as 50 to 1; the average dilution for the year being about ten to one, but ordinarily in the summer and autumn the dilution would probably rarely exceed two or three to one, and often fall far short of this. Since the opening of the drainage canal the flow in the lower Des Plaines is far more uniform and the average is just about equal to the average flow of the Kankakee, which is about 300,000 cubic feet per minute.

5377 Nitrogen as nitrates was present in greater proportion
in the year 1900 than in the year 1899, or the average for the four years preceding the opening of the Chicago drainage canal was greater than the proportion contained during the year 1900.

5378 The nitrites in the waters of the Des Plaines river at
Joliet have been considerably greater in proportion since

the opening of the Chicago main drainage channel than they were prior to that opening, and the same is true at Morris.

It is evident then, that such agencies as bring about the oxidation of the organic matters through ammonia to nitrites, and finally to nitrates, are fully as effective since the sewage has been more extensively diluted at and near Chicago. The fact that the nitrites are now found in greater quantity at Joliet and at Morris indicate that the nitrifying action going on in the river is more active at a point nearer to Chicago; that is, that the oxidizing influences at work upon the organic matters in the waters of these streams are more efficient now nearer to Chicago, this undoubtedly being one of the results of the greater dilution of the sewage with comparatively pure and oxygen saturated Lake Michigan water.

5379 Table of Averages No. 6 corresponds to tables 21, 22 and 23 heretofore placed in evidence, and is reproduced on page 5379 and represents the averages for the Fox river.

5380 The analyses show the changes which take place during the flow of 24 miles from Morris to Ottawa, without further dilution and without notable addition to impurities, but the mixing of the discharges from the Des Plaines and the Kankakee is not yet complete at this point, and some of the variations of the individual analyses are due to this cause. It is to be noted that at this point the nitrites are found in the waters of the Illinois river in greater proportions than at any other point along its course, which fact taken into consideration with the other indications of the analyses, shows that it is in this stretch of the river that the final oxidation processes which convert the organic matters of the sewage into innocuous mineral substances, the free ammonia, the nitrites and the nitrates and so on, are most active and effective.

5381 Defendant's Table of Averages No. 7 for the waters of the Illinois river at La Salle shows averages of results of

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tables No. 24, 25, 26 and 27 heretofore introduced in evidence.

5382 Between Ottawa and La Salle the conditions in the river are such as favor the abundant growth of vegetation and the waters at this point consequently become charged with organic matters to a greater extent than at Ottawa. The nitrates also are found at this point in greater proportion than they are found at Ottawa, and they have not been very notably reduced in proportion by the dilution resulting from the discharge through the Chicago main drainage channel, a fact which is noted from comparison of the averages for the four years preceding, and those for the year following the opening of the drainage channel.

From Lockport to Ottawa the mixing of the waters seems to be at no point complete, and variations in the analyses due to this imperfect mixing are frequent, but a study of the conditions at La Salle including analyses of cross-section samples has shown that at this point the waters have ordinarily mingled completely. Just below the town of La Salle there occurs the final discharge from the Illinois and Michigan canal which carries most of the sewage of La Salle and the discharges of sewage and manufactering wastes from the town of Peru. It should be noted at several points between Joliet and La Salle there are minor discharges from the Illinois and Michigan canal into the Des Plaines river and the Illinois river, and that prior to the opening of the drainage channel the old canal, that is, the Illinois and Michigan canal, at times carried practically undiluted Chicago sewage throughout much of the sixty-six miles of its lower course. Indeed, in period of low water, the channel often carried the entire body of Chicago sewage past Joliet and discharged it at various points many miles below that at which it is now delivered into the river, thus carrying the pollution much farther down stream than the points at which it is now found.

5383 Since the opening of the main drainage channel the diluted sewage which enters the stream between Lockport and Joliet is mainly carried by the Des Plaines and Illinois rivers, and the volume discharged from the canal at points below Joliet constitutes a much smaller proportion of the volume of the river. Moreover, the water of the channel is now in far better condition because of its great initial dilution at Joliet and the more thorough-going natural purification thereby occasioned.

5384 It is evident from the comparison of these averages that the proportions of organic matters contained in the waters of the Illinois river at La Salle have been very considerably reduced as a result of the greater dilution produced by the opening of the Chicago main drainage channel, that the proportions of nitrogen as nitrites is now less than one-half what it was before the opening of the drainage channel, while the proportions of nitrogen as nitrates are but slightly less than they were before that opening.

Table of Averages No. 8 shows average of results as indicated on tables No. 28 to 32 inclusive, heretofore introduced in evidence, as to the examination of the Illinois river at Averyville.

5385 Q. Now what significance do you attach to these tables and to the table of averages which you have just put in evidence?

A. The tables Nos. 28 to 32 inclusive contain the data of analyses of samples of water taken from the Illinois river at North Peoria or Averyville. That is beside the bridge at the Narrows, three miles above the Peoria Court House, a point where none of the sewage of Peoria finds its way into the waters of the stream.

The analyses were made upon samples which were collected regularly each week throughout the period in question beginning April 26, 1897, and ceasing December 26, 1901, except that during the first half of the year 1901 the collections were made but once a month, the averages however, for such years as are not covered by regular weekly samples have been made first for each month in the year, and the year's average made up from the monthly average. In other cases the averages have been made straight from the various weekly samples.

Between La Salle and Averyville there is no considerable additional dilution of the waters of the stream and no great amount of impurities introduced except that discharged from the Illinois and Michigan canal just below La Salle, which discharge contains most of the sewage of La Salle, and in addition the discharge of the sewage and manufacturing wastes of Peru, which is just below La Salle.

5386 The study of the data of the analyses and particularly comparison with those for the other points along the river between Averyville and Lockport show unmistakably that a very great purification of the waters of the stream takes place as they flow along the 125 miles of its course between these two points. The seasonal variations in the water of the river at Averyville as may be seen by study of the detail analyses contained in tables 28 to 32 inclusive, are quite considerable, but the limits of variations are in most respects considerably less since the opening of the Chicago main drainage canal than they were formerly. The variations of the chlorine are shown diagramatically upon Plate VIII.

It is quite natural under the existing circumstances, that the proportions of chlorine should be smaller during the high water period, that is, in February, March and April, and that in
5386 the later season of the year, the warmer summer months
when the flow is very much reduced, the contents of chlorine should be much greater than at other periods, and this plate too, shows in general the difference between the first six months and the second six months of the year, for formerly, that is particularly before the opening of the Chicago main drainage channel there was a much more considerable difference between high water conditions and low water conditions in the Illinois river with respect to the chlorine contained, as also with respect to the organic matters than is the case since the opening of the main drainage channel.

Plates IX and X show graphically the seasonal variations in content of free ammonia. Plate IX having upon it the data for the weekly analyses represented by curves for the years 1897, 1898, 1899 and 1900, while upon Plate X the monthly averages, showing the proportions of nitrogen as free ammonia for the years 1897 to 1901 inclusive are represented.

The curves of both of these plates show the general variations in the content of nitrogen as free ammonia, as it varies with the seasons, the proportion being very great in the cold weather season, that is in January and February, and in general too, in November and December, while the proportions during the warmer seasons, that is the late spring, the summer and the early autumn seasons, are very much less than at other times during the year.

It is very noticeable that both before and since the opening of the Chicago main drainage channel the proportions of free ammonia are much greater in cold weather than at other seasons, and it is evident too, that the proportions of free ammonia content in the water of the Illinois river at Averyville are much less since the opening of the Chicago main drainage channel than they were before that time.

Plate XI of this series gives by means of curves the proportions of nitrogen as nitrites contained in the water of the Illinois river at Averyville, these being represented as monthly averages.

The curves of this plate show at a glance that the period when nitrites are most abundant in the Illinois river water at Averyville, is in general the summer time, or early autumn when
the flow is at the minimum and the temperature at the
5387 maximum. The conditions with respect to nitrates being
just the opposite to those referred to above, with respect to the nitrogen as free ammonia. It is evident from the figures in tables of analyses, and it is shown graphically upon the plate, that the proportions of nitrites since the opening of the drainage channel are in general less throughout the year than they were before the opening of the main drainage channel.

Comparison of the figures of table of averages No. 8, show that as a result of the dilution effected by the opening of the Chicago main drainage channel, or at least subsequent to that opening, the proportions of the various significant constituents of the water of the Illinois river at Averyville are very greatly reduced.

The data throughout show this. The chlorine has been reduced from 20.2 the average for the three years prior to the opening of the drainage channel, to 17.5, the average for the two years subsequent to the opening. Similar reductions in the proportions of oxygen consumed both the total and that consumed by dissolved and by suspended matters, are evident. That the
nitrogenous organic matters are very much reduced in
5388 proportion is evidenced at once by comparison of the
relative quantities of nitrogen as albuminoid ammonia, and the total organic nitrogen for the two periods, the total organic nitrogen being on the average for the two years of 1900 and 1901 .742, while the average for the three years 1897 to 1899, is .98.

The total organic nitrogen in dissolved matters being .555 for the two years 1900 and 1901 as against .72 for the three years prior thereto. The nitrogen in suspended matters for the two years 1900 and 1901 being .187 as against .262 the average for the three preceding years.

The nitrogen as albuminoid ammonia, the total, was for the years 1900 and 1901 .286, while for the three years preceding the average was .466.

The albuminoid ammonia derived from dissolved substances being for the years 1900 and 1901 .212, while for the three years preceding, it was .336.

The albuminoid ammonia derived from suspended matters was on the average for the years 1900 and 1901 .076, and for the
three preceding years the average was .13.
5388 The proportion of nitrogen as free ammonia for the years
1900 and 1901 was .643, while for the four preceding years the proportion was .909, and for the year 1899 the proportion was 1.025.

The proportion of nitrogen as free ammonia thus was less than two-thirds as much in the waters of the Illinois river at this point after the opening of the Chicago main drainage channel than it was prior thereto.

Comparison of the proportions of nitrites shows a very great decrease at this point since the opening of the drainage channel, the quantity being less one-half that formerly contained. Thus the proportions of nitrogen as nitrites on the average for the years 1900 was .079, for the year 1901, .081, and the average for the two years being .08.

The average proportion of nitrogen as nitrites for the year 1897 was .254; for the year 1898 .124; for the year 1899, .204; the average for the three years being .194, considerably more than twice the proportion found in the water at this point since the opening of the drainage canal.

That the reduction of these constituents is not wholly due to mere dilution, but that in part at least it is due to the greater proportional destruction of the organic matters discharged into the stream at Lockport and Joliet would seem to be evident from the fact that the nitrates are found in greater proportions in the water at this point now than they were before the opening of the drainage channel; the average proportion for the three years prior to the opening of the Chicago main drainage channel being 1.351 while the average for the two years subsequent to the opening of the channel was 1.46.

Comparison of the figures of table 8 for Averyville, with those of table 7 for LaSalle, show that there has been a very great decrease in the organic matters during the flow of 60 miles between these two points. The diminution is very considerable in each case, even including the nitrates, but the most significance attaches to the marked diminution in the proportions of nitrites and free ammonia and albuminoid ammonia, and total organic nitrogen. The proportions of nitrites have been reduced about fifty per cent., which would appear to indicate that the nitrification processes are approaching completion; this in

turn indicating that those organic substances which are
5389 easily susceptible to bacterial action have in great part
already been consumed. In fact, it is highly probable that the refuse animal matters introduced in the sewage of Chicago have been completely destroyed, and that the organic matters which are contained in the river water at this point are derived from vegetable and not from animal sources.

In fact, vegetation of various forms, the plankton, and so on, is exceedingly abundant in the river between LaSalle and Averyville. The water of the river between these points and especially near Averyville may often be seen covered with floating masses of vegetation consisting largely of filamentis and other algae.

Comparison of the averages for Averyville with those for the tributary streams serves to show that the waters of the Illinois river at this point contain considerably less organic matters than are contained in the waters of its chief tributaries, which latter have never been in contact with Chicago sewage, although of course they receive some sewage from comparatively small towns. It is very evident of course that free ammonia and nitrites are still present in the waters of the Illinois river at this point in greater quantities than are contained in most of the tributary streams but the considerations detailed above and all available data show unmistakably that the character of the water in the streams at Averyville is now far better than it was before the Chicago sewage received its initial dilution at Chicago, and not at the junction of the Des Plaines and Kankakee rivers, sixty miles nearer to the point now under consideration.

5390 It is my opinion that the animal matters discharged by the two canals, the Chicago main drainage channel and the Illinois and Michigan canal, into the Des Plaines river in the vicinity of Lockport and Joliet, and discharged by the Des Plaines into the Illinois river about ten miles above Morris, have been entirely destroyed before the waters of the Illinois river reach Averyville, and the substances of said animal matters have been in part converted into mineral substances, and in part built up into the substance of living vegetation, this opinion being based upon my study of the waters of the streams in question, at the various points enumerated in my testimony in this case, and upon the evidence of the chemical analyses which have been introduced as part of my testimony.

Defendant's table of averages No. 9 conforms to tables No. 33, 34, 35 and 36, showing results of examinations of waters from the Illinois river at Havana and is reproduced on page 5391.

5391 The collections for Havana were made at a point about a mile and a half above the town, above the mouth of the Spoon river and the mouth of Quiver Lake, between Averyville and Havana. The sewage and manufacturing wastes are introduced into the river at Peoria and Pekin in quantities second only to those introduced through the Chicago main drainage channel and the Illinois and Michigan canal. These, however, consist very largely of refuse from stockyards, from cattle sheds; from some 40,000 to 50,000 cattle which are fed upon distillery slops.

5392 Prior to the opening of the Chicago drainage canal the condition of the river along this stretch of 45 miles was at many places during the summer time practically that of an immense septic tank. The offensive condition of which was striking throughout much of this stretch, but was greatest in the near vicinity of Peoria and Pekin.

The data of the detailed analyses which appear in the tables 33 to 36, inclusive, show the seasonable variations similar to those which were found at Averyville in comparison of the yearly averages which are brought together in table of averages No. 9, A. W. P., with those for Averyville which appear in table of averages No. 8, A. W. P., show that notwithstanding the introduction of an enormous amount of filth between Averyville and Havana, the putrefactive and other purifying processes going on in the waters of the stream have sufficiently reduced them to proportions of the various constituents so much that they were but slightly different at Havana from what they were at Averyville, although an analysis of samples taken at Wesley just below Peoria and also at Pekin, show a notable increase in the content of organic matters at these two points, above the quantities found at Averyville and above those found at Havana, thirty miles below Pekin.

Comparison of the figures for the year 1900 with those of the years 1896 to 1899, inclusive, all of which appear in table of averages No. 9, shows the effect of the opening of the Chicago main drainage channel in reducing the proportions of the various constituents here considered. With the exception of the nitrates, the reduction of the various constituents is very considerable. The fact that the nitrates are not propor-
5393 tionally lowered seems to indicate that oxidation at this point is more complete since the opening of the sanitary canal than it was previously.

Numerous determinations of dissolved oxygen in the waters of the Illinois river at Havana covering several years show that although at times the water is saturated in general, the content of dissolved oxygen is at this point considerably less than is required for saturation and at all times the dissolved oxygen diminished rapidly upon allowing samples to stand, as will be shown hereafter when a table upon that subject will be presented.

Table of averages No. 10 conforms to tables No. 37, 38, 39, 40, 41, 42 and 43, showing results of examination of Illinois river water at Kampsville and is reproduced on page 5393.
5194 The comparison of the data of the two three-year periods affords an excellent opportunity of judging of the effects of dilution occasioned by the opening of the Chicago main drainage channel upon the character of the waters of the Illinois river as they are about to flow into the Mississippi river at Grafton thirty miles below Kampsville.

Plates Nos. XII and XIII show that in the usual high water period, that is, the first half of the year, chlorine is contained in the water of the Illinois river at this point in just as considerable proportions as before the opening of the Chicago main drainage channel but that in the latter part of the year which was formerly a period of extremely low water, the content of chlorine is now found to be considerably less than formerly, the seasoned variations as revealed by regular weekly analyses being represented upon plate XII by lines for the years 1897 to 1900, inclusive, and upon plate XIII, the averages for each month being represented for the years 1897 to 1901, inclusive.

Plate No. XIV represents variations in the proportions of nitrogen as free ammonia, and shows the great difference in respect to proportional content of free ammonia between cold weather and warm weather conditions.

Plate XV represents the seasonal variations in the proportions of nitrogen as nitrites and shows that the nitrites are not contained in the river at this point in so great quantity as they were previous to the opening of the Chicago main drainage channel, but that they follow the same general course of seasonal variations as formerly; that is, they are least in cold weather and greatest in hot weather.

5395 Plate XVI shows by means of monthly averages, the proportions of total organic nitrogen both dissolved and total and the seasonal variations which took place with respect to the content of nitrogenous organic matters.

Comparison of the averages for the three years 1897, 1898 and 1899 with each other shows no very great variation in the organic matters, though the oxygen consumed, the free ammonia and the total organic nitrogen increase somewhat from year to year, while the nitrites and the nitrates decrease.

Comparison of the averages for 1900 with those for 1899 show that immediately after the opening of the Chicago drainage channel there was a notable decrease in the proportions of the various constituents with the single exception of nitrates. The decided increase of which, taken into consideration with the 25 per cent. decrease in the proportion of nitrogen as albuminoid ammonia indicates that under the new conditions the oxidation of the organic matters is more complete as the waters of the

Illinois flow along its course from the point of initial pollution by Chicago sewage to Kampsville where they are about to discharge into the Mississippi river, that is, within 30 miles of the point at which that discharge into the Mississippi occurs.

The averages for 1901 correspond fairly well with those for 1900 except that the total organic nitrogen appears decidedly higher, but this is due to the fact that the data for this constituent cover but the first nine months of the year as a press of overwork made it necessary to discontinue the determination of total organic nitrogen at this time. The higher free ammonia in 1902 over the proportions contained in 1901 and 1900 is chiefly due to the fact that in January and February, when the cold weather conditions are usually accompanied by high free ammonia in the Illinois river, the stage of water in the Illinois was remarkably low and the concentration correspondingly great.

Comparison of the averages for the two 3-year periods makes evident the great diminution in the proportions of
5396 the various constituents except free ammonia which is .393 parts per million in the latter period as against .371 parts per million in the earlier period and the nitrates, which have very considerably increased.

Plate XVII exhibits graphically by means of columns some of the facts shown in table of averages No. 10 and facilitates the comparisons between the averages for the separate years.

Stipulation that samples of water taken at various places have been taken in the manner described by Prof. Long.
5397 "Department of Chemistry, University of Illinois, Defendant's Exhibit B for identification, A. W. P." offered in evidence, being a table representing the dissolved oxygen in the Illinois river at Havana.

JUDGE SPRINGER: Professor, will you proceed with your explanation of the chemical examinations of water at Kampsville, and table of averages based thereon?

A. With respect to the higher proportion of free ammonia in the water during the second period of three years, that is the period subsequent to the opening of the Chicago drainage channel, it is evident that this is mainly due to the unusually high proportion of free ammonia contained in the water of the stream at this point during the year 1902. The proportions of free ammonia during the months of January and February, 1902

5398 were particularly excessive, the weather being at this time very cold and the volume of water in the stream being unusually small, even for this season of the year, and the proportion, that is the average proportion for the year is at a higher point for the reason that the year 1902 was on the whole, an unusually high water year. The water was higher particularly during the ten months following February than it had been at any time during the six years here under consideration. Plates XVIII and XIX representing the discharge curves of the Illinois river from Kampsville dam, reproduced on pages 5399 and 5400.

5403 Tables No. 1 to 7, A. W. P entitled, "Tables of Discharges of water over the Kampsville dam for years 1896 to 1902 inclusive," offered in evidence and reproduced on pages 5404 to 5424 inclusive.

5425 These tables were the basis upon which the charts or tables were made.

5426 Table of Averages No. 11 shows the averages of results shown in tables No. 43, 44, 45 and 46 heretofore introduced in evidence, being an examination of the waters of the Illinois river and the Mississippi river at Grafton.

5427 Comparison of the data of the analyses show seasonal variations of considerable magnitude in the waters of the Illinois river at Grafton, the most important of which are the albuminoid ammonia and the total organic nitrogen are shown in Plates XX and XXI, which are reproduced on pages 5428 and 5429.

5431 It is obvious from inspection of the curves of Plate XX and is shown definitely by the figures of the tables to which the curves give expression, that during the times when the albuminoid nitrogen and the total organic nitrogen are particularly excessive in quantity, in the water of the Illinois river at this point, it is mainly in suspended matters and not in the substances which are in solution, while during the periods of less flow, the organic nitrogen and the albuminoid nitrogen are general chiefly in substances which are in solution in the water, and not in the matters which are merely suspended.

Upon Plate XXI, there are shown similar lines for the year 1900. The lines follow much the same general course throughout the year. They represent the various analyses, the details of which are given in table No. 44 of this series.

5432 Study of the figures of the table and inspection of the curves of the plate show that during the year 1900 the variations in the proportions of nitrogen as albuminoid ammonia and of total organic nitrogen follow much the same curves as during the preceding year 1899, thus there was during the early part of January a decrease in the proportions which was followed in the latter part of January by an increase, to be again followed by a decrease to the 31st of January, which decrease in the case of the total organic nitrogen continued to the 7th of February, after which there was an enormous increase to the 14th of February, which again was followed by a considerable decrease to the 21st of February, which however was followed by another though less considerable increase to the 28th of February, and on to the 7th of March, after which again a decrease occurred, followed by an increase to the 14th, after which the decrease which occurred again was more considerable, and from that time on to the end of the year the proportions never rose to such considerable amounts as during February and March, and the variations were much less considerable from week to week.

Again with respect to the curves of this plate it may be stated that during the time when the proportions of total organic nitrogen and of total albuminoid nitrogen are at the maximum, or at the higher points, it is mainly due to the excessive proportion of the nitrogen contained in suspended matters, that is the greater proportion of the total organic nitrogen, as also of the nitrogen as albuminoid ammonia is at such times contained in matters which are in suspension in the water and not in the substances which are in solution.

Comparison of the averages for the different years which appear in the table of averages No. 11, above referred to shows that subsequent to the opening of the Chicago main drainage channel, the proportions of the various significant constituents of the water of the Illinois river at Grafton, were in most cases considerably reduced.

5434 The samples of water from the Mississippi river at Grafton were taken at mid-stream, at a point about two miles above Grafton, and above that at which any discharge from the Illinois river enters the Mississippi. The detail analyses which appear in tables 47 to 50 inclusive, show that seasonal variations in the constituents of the waters of the Mississippi river are in many respects more frequent and more considerable than the seasonal variations in the waters of the Illinois. This is especially true of the albuminoid ammonia and the total organic nitrogen as is evident upon consideration of the features of Plates XXII and XXIII, which are reproduced on pages 5435-6.

5440 Upon Plate XXIV, reproduced on page 5439, there appears lines which represent the proportions of chlorine contained in the waters of the Illinois river near the mouth at Grafton, and similar lines representing proportions of chlorine contained in the waters of the Mississippi at a point just above Grafton, the curves in this plate representing the monthly averages for the chlorine and covering the years 1899, 1900 and 1901. With respect to the lines representing the chlorine in the waters of the Illinois river, it is evident that during most of the year the proportions are far in excess of the proportions of chlorine contained in the Mississippi river, but that there is a great variation or difference between the conditions in this, with respect to the proportion of chlorine in the high water period, which is generally March and April, and the low water period which generally is the latter part of the year, but which frequently includes also the first two months of the year, that is, January and February.

Comparison of these data of table of averages No. 11, which represent the averages for the Mississippi river water just above the mouth of the Illinois for the years 1899 to 1902 inclusive, shows somewhat notable variations from year to year, but a comparison of the averages for the Mississippi with those for the Illinois shows that organic matters as represented by the oxygen consumed were, in each of the four years contained in the waters of the Mississippi in considerably greater proportions than in the waters of the Illinois in 1899, and were nearly 50 per cent greater than the average for the three years after the opening of the Chicago main drainage channel. Thus, the oxygen consumed by the waters of the Mississippi river at Grafton for the year 1899, was 15.2; for the year 1900, 16.4; for the year 1901, 14.1; for the year 1902, 14.7; the average for the four years being 15.1 as against the average for the Illinois river in 1899 of 12.6. The average for the three years, 1900, 1901 and 1902, being 10.

The proportions of oxygen consumed by matters contained in solution in the water of the Mississippi river at this point were for 1899, 9.8; 1900, 10.6; 1901, 10.6; 1902, 9.3; the average for the four years being 10 parts per million as against 8.3 for the Illinois in 1899, and an average of 7.4 for the three years subsequent to the opening of the Chicago main drainage channel.

5441 The oxygen consumed by suspended matters in the waters of the Mississippi were in 1899, 5.4; in 1900, 5.8; in 1901, 3.5; in 1902, 4.5; the average for the four years being 4.8; the proportion in excess of that required by suspended matters in the water of the Illinois river during 1899, which was 4.3, and also considerably greater than the average for the Illinois river for the three years, 1900, 1901 and 1902, the figures for that year being 3.3.

The free ammonia contained in the waters of the Mississippi river at Grafton, reached the proportion of .077 for the year 1899, the average for the year 1900 being .133; for the year 1901, .182; for the year 1902, .095; the average for the four years being .116, as against the average for the Illinois river in 1899 of .313, and the average for the three years, 1900 to 1902, being .332.

The albuminoid ammonia in the waters of the Mississippi river for the year 1899 were on the average .508, the average for 1900 being .448; for 1901, .403; for 1902, 464, the average for the four years being .455, a quantity slightly less than that contained in the Illinois river water in 1899, which latter was .479, but considerably in excess of the proportions found on the average in the Illinois river water for the three years, 1900, 1901 and 1902, which average was .37.

Albuminoid ammonia derived from dissolved substances in the Mississippi river at Grafton for 1899 was .217; 1900, .222; 1901, .202; 1902, .189; the average for the four years was .207; the average for the water of the Illinois river for 1899, was .247, and for the three years subsequent thereto, that is, 1900, 1901 and 1902, it was .22; the proportions in the Illinois river being slightly greater than the proportions in the Mississippi.

5442 The albuminoid ammonia derived from suspended matters was for the Mississippi river in 1899, .291; 1900, .226; 1901, .201; 1902, .275; the average for the four years being .248, as against .232 in the Illinois river in 1899, and .149 the average for the Illinois river for the three years 1900 to 1902 inclusive.

Total organic nitrogen in the waters of the Mississippi at Grafton were for 1899, 1.168; for 1900, 1.03; and .969 for such portion of 1901 as is covered by the data in table 49 of this series. The average for these three years or such portion thereof as the data pertains to being 1.0155 as against the average for the Illinois river in 1899 of 1.148, an average for two years, 1900 and 1901, of .957.

Organic nitrogen derived from dissolved substances in the Mississippi river at Grafton for 1899, .485; 1900, 4.76; 1901-.431;

the average of these being .464, as against .596 for the Illinois river in 1899, and .512, the average for the Illinois river for the years 1900 and 1901.

Total organic nitrogen derived from suspended matters for the Mississippi river water at Grafton for 1899 is .683; for 1900 .555; 1901, .538; the average being .592, as against .552 in the Illinois river water for 1899, an average of .444 for the Illinois river water for 1900 and 1901.

Nitrogen as nitrites in the water of the Mississippi at Grafton were .012, for 1899; and .007 in 1900; and .006 in 1901, and .01 for 1902, the average for the four years being .009, as against .045 in the Illinois river water in 1899, an average of .03 for the three years, 1900, 1901 and 1902.

Nitrogen as nitrates in the Mississippi river water at Grafton was on the average .34 parts per million for the year 1899; for the year 1900 the average was .471; 1901 the average was .314; 1902 the average was .469; the general average for the four years being .405 as against the average of 1.063 in the Illinois river water in 1899, and 1.237, the average in the Illinois river water for the three years, 1900, 1901 and 1902. The data of the tables show in general that the proportions of nitrogenous organic matters as represented by albuminoid ammonia and total organic nitrogen were notably higher in the Mississippi river than in the Illinois river, although in the year 1901 they were slightly higher in the latter stream. On the other hand the oxidation products of nitrogenous organic matters represented by free ammonia, the nitrites and the nitrates, were present in the waters of the Illinois in proportions which are two to three times those contained in the waters of the Mississippi, and the total nitrogen, that is, the sum of the total organic nitrogen, the nitrogen as free ammonia and the nitrogen as nitrites and nitrates was 2.546 parts per million in the waters of the Illinois
as against 1.585 in the waters of the Mississippi. The
5443 preponderance of nitrogen in the waters of the Illinois
over the proportions contained in the waters of the Mississippi is doubtless due to the fact that the watershed of the

former is more extensively and more intensively cultivated than that of the latter, and that the industrial wastes which are discharged into the Illinois are more highly nitrogenous in character than are many of those which find their way into the Mississippi. For example, the refuse matters discharged into the Illinois river at Peoria and Pekin consist largely of the highly nitrogenous wastes from glucose factories and those resulting from the feeding of cattle upon distillery slops, while the organic matters contained in the waters of the upper Mississippi are derived largely from the wastes of the lumber industries and these are not nearly so highly nitrogenous in character. Both streams of course, receive in the aggregate enormous quantities of sewage.

Determinations of dissolved oxygen in the waters of the Illinois and Mississippi rivers at Grafton, show that in general of the waters of the Illinois contain practically the same proportions of oxygen in solution as the Mississippi although the stability of the organic matters as measured by the partial disappearance of the dissolved oxygen when the samples are allowed to stand in the dark for 24 hours, is somewhat greater for the Mississippi than for the Illinois.

The data of these various determinations of dissolved oxygen have been heretofore introduced as evidence and need not be brought in here in detail, but in order to explain graphically the proportions of dissolved oxygen in these waters I refer now to Plate No. XXV, A. W. P., which has already been offered in evidence and is reproduced on page 5444.

5445 I have prepared no tables of averages with respect to tables No. 51 to 62 inclusive, except the averages which appear at the bottom of each of the tables.

With respect to the data included in the tables 51 to 62 inclusive, I may say that for several years samples of water were collected from the Illinois river at the intake of the old Alton city waterworks, and also a few samples were collected at mid-stream, but that in the fall of 1898, arrangements were made for the collection of a series of samples at a point opposite the new waterworks nearly a mile above the town. At this place five samples were collected at five different points across the stream for the purpose of determining the differences in composition due to the incomplete mingling of the waters of the Illinois river with those of the Mississippi river. The point at which these samples were taken was 16 to 17 miles below the mouth of the Illinois river at Grafton and six or seven miles above the mouth of the Missouri river or fifteen or sixteen miles above the intake of the St. Louis waterworks at the Chain of Rocks.

Consideration of the data of the twelve tables shows how incomplete is the mixing of the waters of the Illinois with the waters of the Mississippi, the facts being brought out especially by comparison of the proportions of chlorine contained in the waters of the Illinois river and the Mississippi river above Grafton with those found at different points in the cross-section of the stream at Alton. In explanation I will refer
5446 to Plate No. XXVI which has heretofore been offered in
evidence. This Plate No. XXVI gives comparative curves representing the results of chlorine determinations in the regular weekly samples collected throughout the years 1899 and 1900, the data appearing in detail in the tables 53 and 62 inclusive. Several times in January and February when because of stationary ice or floating ice it was impracticable for the collector to reach the proper points, collections were made at the ferry crossing opposite the town, nearly a mile below the point at which collections were at other times made, so that the data for portions of these two months for both years, show the proportions of chlorine, which are not truly representative for the Missouri side of the stream, because the collector who started from the Illinois side couldn't get far enough out toward the Missouri shore.

Plate No. XXVI is reproduced on page 5447.

In the latter part of the year 1900, as it was found necessary to contract the amount of work being done upon these waters

the collection at one-fourth distance from the Missouri
5448 shore and at one-fourth distance from the Illinois shore, were discontinued and only three taken at the cross-section points, namely: one near to the Illinois shore; one near to the Missouri shore, and one at a point midway between the two banks.

Comparison of the lines representing the proportions of chlorine contained in the water of the Mississippi at Grafton and with the lines representing the proportions of the chlorine contained in the water of the Illinois at Grafton and with those representing the proportions of chlorine found in the incomplete mixture of Illinois river and Mississippi river waters at the different points at Alton, show that the water toward the Illinois shore was much more like the water of the Illinois river than it was like that of the Mississippi river above Grafton, with respect to the content of chlorine, and that the water of the Mississippi at Alton towards the Missouri shore was very much like that of the Mississippi above Grafton and very much more like that of the Mississippi above Grafton than like that of the Illinois.

5449 Plate XXVII represents a cross-section of the Mississippi river at Alton and shows seasonal and other variations of chlorine at five different points across the stream in 1899 and is reproduced on page 5449.

5450 Plate XXVIII represents the same conditions for the same place for the year 1900 and is reproduced on page 5450.

5453 Plate XXIX reproduced on page 5452 represents the proportions of Illinois river water and Mississippi river water which constitute the mixture at different points across the stream at Alton, that is opposite the pumping station of the Alton city water works.

The quantities of water, that is the proportional quantities of Illinois river water and Mississippi river water have been calculated from the average content of chlorine for the year for each one of the five points in the cross section. They show that comparatively little of the water of the Illinois river reaches the Missouri side of the Mississippi at this point. For the year 1899 2.4 per cent of the water near the Missouri shore came from the Illinois river; the other 97.6 per cent consisting of water from the upper Mississippi at the point one-fourth the distance from the Missouri shore, the Illinois river water amounted to 4.8 per cent., while the Mississippi river water was 95.2 per cent of the mixture; at the mid-stream, that is a point midway between the two banks the proportion of Illinois river water was 11.3 per cent; that of the Mississippi, that is the upper Mississippi river water was 88.7 per cent. At a point one-fourth distance from the Illinois shore, the Illinois river water amounted to 23.5 per cent., while the Mississippi river water amounted to 76.5 per cent. Near the Illinois shore the Illinois river water preponderated, amounting to 30 per cent. of the water passing down at that point; the Mississippi water constituting 62 per cent of the mixture.

For the year 1900, similar facts appear, except that there was a little more of the Illinois river water towards the Missouri shore, the percentage being 4 per cent Illinois river water near the Missouri shore; 96 per cent Upper Mississippi river water.

At one-fourth distance from the Missouri shore the Illinois river water constituted 10 per cent of the mixture, while the Mississippi river water constituted 90 per cent. At mid-stream there was 13 per cent of water from the Illinois river and 87 per cent of water from the upper Mississippi.

At one-fourth distance from the Illinois shore the mixture consisted of 40 per cent. Illinois river water and 60 per cent. water from the upper Mississippi; while close to the Illinois shore, the mixture contained 46 per cent of Illinois river water and 54 per cent of water from the upper Mississippi.

It is evident from the data of the tables 51 to 62 inclusive, and is expressed graphically by the figures and the lines of this plate, that the Illinois river water does not mix perfectly with

the Mississippi river water, but passes down mainly to-
5454 ward the Illinois shore or along side the Illinois shore
on its way down stream in the bed of the Mississippi
river.

From certain analyses of samples of water taken in the Mississippi river about half a mile above the mouth of the Missouri river, it is my opinion that the mixing of the water of the Illinois with the water of the Mississippi is by no means complete by the time these bodies of water reach the mouth of the Missouri.

In my opinion there is no thoroughly satisfactory basis for a calculation of the relative proportions of Illinois river water, Mississippi river water and of Missouri river water, in the mixture which passes the intake tower of the St. Louis waterworks, but for such calculations the chlorine content would in all cases be the most satisfactory basis because the chlorine is not a variable constituent, or rather does not vary from causes which bring about variations of all other constituents which it is customary to determine in sanitary water analysis.

Q. Would it be practicable to calculate the mixing of the waters of the three rivers at the chain of rocks from the proportions of free ammonia?

5455 A. It would not, because free ammonia changes, sometimes rapidly, sometimes slowly, but does change as a result of decomposition of organic matters contained in the water, in a way totally different from chlorine and it could not be assumed with good reason that a quantity of free ammonia found at one point or at one time would not change from processes going on within the water. On the other hand, chlorine does not change from any processes going on within the water itself, but only through the addition of more chlorine by the introduction of liquids or substances foreign to the water itself, or by concentration due to evaporation of the water containing the chlorine.

Q. Would it be practicable to calculate the mixing of the waters of these three rivers from the proportions of nitrites?

A. It would not for reasons similar to those just stated with reference to the ammonia. The variability of the proportions of nitrites standing in the way of the nitrites constituting a reasonably safe basis for calculation of the quantities of the water, and the mixing of waters containing originally different proportions of nitrites.

Q. Would it be practicable then to calculate the mixing of the waters of these three rivers from the proportions of total solids?

A. It might be; in case the proportions of total solids were sufficiently different in the three streams which were coming together, but even then there would be very great difficulties in the way of making a reasonable approximate calculation or a reasonable approximation of the true proportions, for the reason that the total solids include matters which are in suspension, and which by reason of variations in velocity of the stream, variations in the character of the material lying in the bottom of the stream and constituting the banks of the stream, which cause variations in the proportions of suspended matters even within short distances.

Q. What reliability could be placed upon a calculation as to the mixing of the waters of these three rivers from the proportions of suspended matters?

A. That would be unsatisfactory for the reason just stated in referring to the possibility of calculating the mixing
5456 from the total solids, which total solids of course include the suspended matters. The different velocities at different times in the year and at different points even within short distances of each other, and the different character of the material with which the water is in contact, bring about in many cases a deposition of much of the suspended matters, forming as is well known, sand-bars and other deposits in the stream, and on the other hand, where the character of the banks or of deposits in the bed of the stream are such that they can be easily removed by water, oftentimes the water picks up and

holds in suspension considerable quantities of foreign matters which it may derive not from tributaries at some distance, but from localities and deposits quite near to the point at which determinations are made. That is to say, there is no certainty and in this particular case there would be no certainty that the quantities of suspended matters found in the waters of the Illinois at Grafton would proceed down in the Mississippi river to the St. Louis water works. There is no certainty that the quantities of suspended matters contained in the waters of the Mississippi above the mouth of the Illinois would remain in those waters until such time as this body of water reaches the intake of the St. Louis waterworks, and there is no certainty that such suspended matters as are contained in the waters of the Missouri river above its junction with the Mississippi remain in that water until such time as it reaches the intake tower of the St. Louis water works; for these reasons: Calculations based upon the suspended solids and upon the total solids which include suspended solids, have no sound basis in fact, and on the other hand, at times the body of water passing down the bed of the Mississippi above the mouth of the Missouri may between the mouth of the Illinois and the mouth of the Missouri pick up and hold in suspension matters which would then be in excess of the quantities found in the waters of the Illinois and of the Mississippi at and above Grafton, and likewise the mixture of the three bodies of water between the mouth of the Missouri river and the intake tower of the St. Louis waterworks, may in this stretch of six or seven miles,—perhaps eight or nine miles, pick up from the sand-bars and the banks of the river, suspended matters which were not contained at this time,
5457 at least, in the waters of either the Missouri or the Illinois or the Mississippi.

Hence, in my opinion, it is totally impracticable to calculate the relative proportions of water from these sources contained in the mixture passing down the Mississippi river beside the intake tower of the St. Louis waterworks, though by general study of all these constituents of the water, it is practicable to get a general idea as to the relative quantities constituting the mixture at this point, that is to say, a rough general approximation may at times be arrived at by consideration of all these constituents, as the basis for a calculation, but only a rough general approximation, can in my opinion be arrived at from these considerations.

5458 The seasonal variations of free ammonia and also the cross section variations of free ammonia at Alton are shown in part upon plate XXX, which is reproduced on page 5459.

It is to be noted that during much of the year there is little difference between the proportions of free ammonia found at the different points, and also between the proportions found in the Illinois, and those in the Mississippi, and that at times more free ammonia is found in the waters of the Mississippi river than in the waters of the Illinois river.

Before leaving the discussion of the Mississippi river water at Alton I refer to plate No. XXXI, which has heretofore been offered in evidence and which gives by curves the stages of water in the river at this point for the years 1899 and 1900; and is reproduced on page 5461.

5462 I have prepared averages which appear at the bottom of each of the tables numbered 63, 64, 65 and 66, but none other.

With respect to these, I have to say that I have not got in print all of the set, but the numbers which are mentioned by counsel are here in print, but in addition to these there are three other tables which were offered in manuscript when the entire series of plates was introduced, and which are refered to at this point, together with the three mentioned by counsel.

A. I have those manuscript tables with me and they have already been put into the record, and are numbered 68, 69 and 70.

No. 67 appears in the original description of these tables, but I find that through my mistake that number was given to table 66, thus making two numbers for one and the same table, so that we may, to straighten the matter out, designate this particular table as 66 and 67.

The samples of water, analyses of which appear in these tables, were collected from the Mississippi river at Quincy at a point near the end of the intake conduit of the Quincy waterworks, which is at a point above that at which any discharge of sewage from Quincy enters the river.

Before referring to the data of the analyses I will refer to plate No. XXXII, heretofore introduced in evidence, and upon which there appear curves representing the stages of water in the Mississippi river at Quincy during the years 1899 and 1900, which plate XXXII is reproduced on page 5463.

5464 A study of the data of analyses shows that the seasonal variations in the proportions of the different constituents of the water of the Upper Mississippi river are quite as frequent and fully as considerable as are the variations of these constituents in the waters of the Illinois river.

A portion of the data of table 63, namely all the data of that table which represent the proportions of chlorine the proportions of nitrogen as nitrites, the proportions of nitrogen as free ammonia, and the proportions of nitrogen as albuminoid ammonia, both the total and that derived from dissolved substances, and also the stages of water in the Mississippi at this point for the year 1897, are represented by curves upon plate XXXIII, which has heretofore been introduced in evidence, and which is reproduced on page 5465.

5466 Consideration of the lines representing the chemical constituents, and a comparison with the line representing the stages of water in the river, show that when there is a rise in the stage of water there is usually also a rise in the proportions of nitrogen as albuminoid ammonia; in the proportions of nitrogen as free ammonia and in the proportions of nitrogen as nitrites, and it is apparent from the lines in this plate which merely represent the figures of the actual analyses a record which is made in table 63 of this series, that the proportions of these significant constituents contained in the water during the early spring, that is in March and in April, are very much greater than later in the year.

With respect to the data of table No. 64, in which there is given the results of analyses of samples of water taken from the Mississippi river at Quincy during the year 1898, regular weekly collections throughout the year, I refer to Plate XXXIV which is reproduced on page 5467.

5468 With regard to Plate No. XXXIV. It may be noted that in January and February of this year the proportions of nitrogen as free ammonia and of nitrogen as nitrites was much more considerable that at any other time during the year, while the proportions of nitrogen as albuminoid ammonia were greatest during the latter part of the month of March and at a time at about the middle of May. It will be noticed from both of these plates that the variations in the proportions of chlorine are never so considerate in the waters of the Mississippi as they are in the waters of the Illinois.

Comparison of the data for the Mississippi river at Quincy with those for the same stream at Grafton show substantially a similarity of the water at these two points, more than 100 miles apart, both as to the proportions of the different constituents and the variations of the same.

5469 In the table of averages No. 12, I have the averages of the data which appear in tables 71, 72 and 73 and also averages of analyses of waters of the Kankakee river collected at Wilmington during the year 1896, the data for which appear in my preliminary report which has been heretofore presented as defendants' Exhibit A for identification.

With respect to the data of these analyses I would say that the samples of water were collected at Wilmington a point ten or twelve miles from the mouth of the Kankakee river, and that the data of the analyses may be regarded as fairly representing the condition of the water of the Kankakee river as it is about to unite with the water of the Des Plaines river. Until the

Chicago main drainage channel was opened, the sewage 5470 discharged through the Illinois and Michigan canal met with its first notable dilution, usually only upon mixing with the waters of the Kankakee for although at times the flood flow in the Des Plaines would for a few days equal or even exceed the main flow in the Kankakee, that is, would amount to 300,000 to 400,000 cubic feet per minute, and at times even amount to twice this quantity, and would dilute the waters discharged from the Illinois and Michigan canal eight to ten and even sixteen to twenty times, yet the mean flow of the Des Plaines for the year is but one-fifteenth to one-tenth that of the latter stream, and the ordinary low water flow is proportionally even less.

Inspection of the figures of the detailed analyses show that there are notable variations in the composition of the waters of the Kankakee during the year. In general the variations are greatest in the spring of the year when freshets bring down much suspended matters, both mineral and chemical, but it will be noticed that there is a considerable diminution in the proportions of nitrates during the warm summer months; this diminution being in part the result of the growth of vegetation in the flowing waters of the stream; in part the result of the simulation of nitrates by the vegetation of the head waters in the Kankakee marshes, which during this portion of the year constitute the chief source of supply. The higher nitrates during the high water season are in part due also to the leeching of nitrates from the soil by the run-off, and the discharges from tile drains, both of which occur chiefly during the seasons of lower temperature and greater precipitation, which are consequently of course the seasons of high water.

With respect to these variations in the waters of the Kankakee I refer to Plate No. XXXV heretofore offered in evidence, but which has not been made up into a plate and printed, and I have but this one plate. The plate will be made and copies will be introduced. This plate is as follows:

(Copy not subsequently furnished, F. S. B., Com'r.)

5472 Table of averages No. 6 which also contains similar averages for the waters of the Illinois river at Ottawa, contains the averages for the Fox river at Ottawa, indicated on tables 74, 75, 76 and 77.

The Fox river is the largest tributary of the upper Illinois proper and next to that of the Kankakee its discharge is the most important diluting factor of the upper Illinois. Its discharge is more uniform in volume than that of the Des Plaines river and is greater in proportion to its water-shed area. The samples for analyses were collected above the town of Ottawa, and above the aqueduct which carries the water of the Illinois and Michigan canal across the stream, the season being that this aqueduct leaks and discharges water from the Illinois and Michigan canal into the Fox river at a point a short distance within its mouth.

The waters of the Fox are rather highly charged with organic mtaters which are mainly derived from the vegetation which is abundant in this stream, particularly in the marshes and shallow lakes which constitute the chief source of its head water supply. The stream receives the sewage and manufacturing wastes of a number of towns, of which Elgin, with a population of 22,433, and Aurora, with a population of 24,147, are the largest. Between these two towns is the town of Geneva, where there is a large glucose works, and in which 40,000 carloads of corn are used annually, the wastes from which—probably at least 150 tons of highly nitrogenous organic refuse daily, are discharged into the river. Below Aurora, comparatively little sewage and wastes enter the stream and there is considerable opportunity in the flow of 50 miles, between Aurora and the mouth, for the natural purifying processes to exert their influence in bettering the condition of the water. The averages which appear in table 6, contain the data of tables 74, 75, 76 and
5473 77 in the form of general averages, and also an average for the entire three years represented, that is the years 1898, 1899 and 1900.

I was informed by an individual connected with the management of the concern in question referred to, who first told me personally that about 40,000 car-loads of corn were used annually there, and that the refuse was discharged into the river, and he subsequently confirmed his information in Geneva and wrote me to the same effect. I have further been informed by the president of the Fish Commission of the State of Illinois that such quantities of corn are used in the works at Geneva, and that the refuse is discharged into the Fox river and that it kills the fish in the Fox river.

5475 There are averages at the bottom of the tables numbered 78, 79 and 80, the latter of which appears only in manuscript and covers a portion of the year 1899, extending from January 3d to May 30th, this latter, that is table 80, has not been incorporated in the tables of averages No. 14, but there appear in that table in addition to the averages for the Spoon river for the years 1897 and 1898, also the average for the year 1896, the detail data of which appear in my preliminary report heretofore offered for identification as Defendants' Exhibit A.

Collections were made in the Spoon river at a point within about a half a mile of the mouth. Spoon river drains a watershed area of about 1870 square miles, but as there are no very considerable towns situated upon the stream of its watershed, it receives but little sewage and may be regarded as one of the least polluted of the natural streams of the State.

Q. Did you make any chemical examinations of the waters taken from the Big Vermilion river, which is one of the tributaries of the Illinois river?

A. I did. Most of these examinations however, have already been reported in my testimony with reference to the streams examination report. The table of averages No. 13 A. W. P. contain the averages for the years 1899 and 1900, details of which are given in the set of tables 1 to 80 inclusive referred to above as being testified to as part of the streams examination report, and in addition, there is a set of averages for the year 1896, which have been taken from the preliminary report heretofore offered for identification and referred to as defendants' exhibit A.

5476 Table of Averages No. 13 of waters taken from the Big Vermilion water at La Salle, and table No. 14 of waters from the Spoon river at Havana, reproduced on page 5476. The Big Vermilion is a most important tributary beteen Ottawa and Peoria; the discharge varies between wide limits, but it is an important factor as a diluting agent, only during the freshet season. In the drier season its flow is practically nothing but sewage, derived mainly from the towns of Pontiac and Streator, and from the drainage of factories and mines upon its banks; the stream is used as a source of water supply for the towns of Pontiac and Streator, and during much of the year the

5477 entire flow of the stream above these towns is used for water supply, and then is discharged again into the stream as sewage below the respective towns. The samples for analyses were collected about a half a mile within the mouth of the stream, the mouth being about three miles above the wagon bridge.

A. Comparison of the detailed data of the analyses of the water of the Illinois at Averyville and at Grafton, with the data of the analyses of the waters of the tributary streams, shows that the latter are subject to seasonal variations which in most respects are as great as are those of the Illinois. Comparison of the yearly averages which are given in defendants' tables of averages No. 15, A. W. P., shows that the proportions of organic matters as represented by oxygen consumed, albuminoid ammonia and total organic nitrogen are even more considerable in the waters of the larger tributaries than in the waters of the Illinois at Grafton, and the general averages for the six tributaries examined are substantially equal to the averages for the Illinois for 1900, 1901 and 1902.

5478 I should have explained before, that in the tables of averages, there is also given averages of analyses of samples collected from the Sangamon river at Chandlersville, details of which have been given in the set of tables 1 to 6 inclusive, offered in the report of Streams Examinations for the Sanitary District.

In the table of averages it appears that the free ammonia and nitrites however, are in general more abundant in the waters of the Illinois river than they are in the tributary streams although three of the latter carry practically as much or more in nitrates as does the Illinois, thus, the proportions of nitrites contained in the water of the Illinois at Grafton during the years 1900 to 1902 being .03 parts per million; the average for the water of the Big Vermilion during the years 1896, 1899 and 1900 was .025, but little less and during the years 1896, 1897 and 1898, the waters of the Spoon river contain nitrogen as nitrites in the proportion of .041 parts per million, while the waters of the Sangamon contained on the average for the years 1890 and 1900, nitrogen as nitrites in the proportion of .032.

A portion of the data included in this table of averages No. 15 A. W. P., have been used in the preparation of Plate No. XXXVI, which is the duplicate of the one introduced in an earlier report, and which itself has been introduced in my testimony. The plate represents by means of columns the
5479 proportions, or the various constituents as chlorine, oxygen consumed, nitrogen as free ammonia, and nitrogen as nitrates. In the Illinois river at Averyville and at Grafton, in the Kankakee river at Wilmington, the Fox river at Ottawa, the Big Vermilion near La Salle; the Sangamon river at Chandlersville for the four months period, June, July, August and September, 1899 and 1900, and as this has been discussed elsewhere, it is not necessary to do more than to refer to it at this point.

Table No. 15 is reproduced on page 5479.

Q. Professor, can you institute any comparison based upon the tables of analyses of the waters of the Illinois river with the different points on that river?

A. Yes, I have studied the proportions of various constituents as contained in the waters of the Illinois river at various points along its course.

Q. Will you submit those, please?

A. And in consideration of this matter, I will refer to plate No. XXXVII, which has heretofore been offered in evidence and is reproduced on page 5483. It represents seasonal variations in the proportion of chlorine in the waters of the Illinois river at Morris, La Salle, Averyville, Havana and Kampsville for the years 1896 to 1900 inclusive. Upon an inspection of these curves, which are representations of all the analyses made in the respective years for the points considered, the great differences in the content of chlorine, as between the first half and the second half of the year is manifest, these figures being due to the greater volume of water flowing during the first half of the year and the consequent greater dilution of the sewage, while in the second half of the year the dilution was in general very small and the proportion of chlorine naturally greater. Comparison of the line for the year 1900 with those for the preceding year shows that after the opening of the Chicago main drainage channel the proportions of chlorine were very much more uniform throughout the year, the reason being that the dilution in the latter half of the year more nearly corresponded to what it was formerly, or to the natural dilution in the earlier part of the year, that is the flow throughout the year was much more uniform in volume, and consequently the concentration of chlorine in the liquid flowing in the Illinois river never rose to such a height as it in general did during the second half of the year in times prior to the opening of the Chicago main drainage channel.

5485 On Plate XXXVIII, reproduced on page 5484, there are shown lines which represent proportions of the various constituents contained in the waters of the Illinois river at several different points from Lockport to Grafton inclusive. For a number of these points the lines represent averages for four years analyses preceding the opening of the Chicago drainage channel. Some of the analyses do not cover so long a period, but in every case they cover two years or more. There are also shown in a number of cases the average proportions of the constituents at these same points during the year 1900; that is, the year just after the opening of the drainage channel. The figures which are represented by these curves, have been taken from the defendants' tables of averages 1 to 15 inclusive, which have been heretofore offered in evidence.

Q. Professor, at the time of adjournment on yesterday you were considering the data in Plate XXXVIII and were explaining the curves on that plate. Will you proceed with this explanation?

A. The proportion of chlorine in the canal water at Lockport is shown by the figures in the table of averages and represented by the line upon the plate, and is a little more than 120 parts per million. The considerable drop in the curve between Lockport and the next point, which is Morris, is due in small parts of course, to dilution with the waters of the Des Plaines river, but is mainly due to dilution with the waters of the Kankakee between Morris and La Salle, the next point. There come in the discharges from several minor tributaries, but the most important diluting factor between these points is
5486 the Fox river. From La Salle to Averyville there is
practically no change in the content of chlorine, for although between these points various smaller tributaries discharge into the river, the stream also receives some sewage and waste waters which are quite highly charged with chlorides, and which consequently, notwithstanding the increase in volume which occurs, keep up the proportion of chlorine.

Between Averyville and Havana there is a notable diminution in the content of chlorine, and from there on to Kampsville and down to the mouth, at Grafton, a somewhat continuous decrease is apparent. The proportion at Grafton being 15 parts per million.

The curve for 1900 begins at about the same point, but is intended to show the content of chlorine in the mixture at Joliet, since it is at this point that the different discharges of Chicago sewage come together. The proportion is about one-fourth that of the canal at Lockport, for the earlier period, the difference representing approximately the effect of the dilution produced by the use of the drainage channel. From this point down there is a notable diminution in the proportions of chlorine contained in the water, which in a measure keeps step with the diminution which formerly occurred, but is less considerable from point to point, and finally at the point of discharge into the Mississippi the proportion of chlorine is slightly more than 13 parts per million, which shows the effect of the dilution by the use of the drainage channel as it affected the chlorine content in the discharge from the Illinois river into the Mississippi river during the year 1900.

Oxygen consumed: The lines representing the oxygen consumed both the total and that consumed by the filtered water, show marked diminution between Lockport and Morris, a considerable and somewhat continuous diminution from Morris to Havana, beyond which point the total oxygen consumed increases slightly, so that the proportions required by the water discharged from the Illinois into the Mississippi at Grafton, are greater than they were at either Averyville or Havana, this being in part due to the luxuriant growth of vegetation in the lower stretches of the river, and in part due to the presence of other suspended matters, silt and so on, which during a portion
of the year are more abundant in the lower stretches of
5487 the river than they are farther up.

Nitrites: Comparisons of the proportions of nitrogen as nitrites show that before the opening of the drainage channel there were but extremely small proportions contained in the water at Lockport, but notable greater proportions at Morris, the maximum being reached at La Salle. This argues for the greater activity of the oxidizing processes near this point than at points far above or far below La Salle, for while the proportions of nitrites below this point are always considerable, there is continuous diminution all the way down to the mouth of the river at Grafton.

The curve for 1900, shows similar relations between the different points, but a very notably smaller proportion of the nitrites at points below Morris. It is evident from the curves however, and these curves represent merely the figures of the tables of averages above repeatedly referred to—it is evident from these curves, however, that the zone in which the greatest activity of the nitrifying processes is reached has not been changed in position by the opening of the drainage channel. That is, it appears unmistakably from the data of our analyses and is shown clearly in these curves, that the point where the oxidation is most active, and thorough going, is still in the vicinity of Morris and La Salle. The data of table of averages No. 6 A. W. P., show that the point is somewhere between Morris and La Salle, probably near Ottawa.

That is to say the point of greatest activity is at or near Ottawa.

Nitrates. The lines representing the proportions of nitrates show a remarkable increase in the proportions contained as we proceed from Lockport and Joliet to Morris, and so on to La Salle. The increase of nitrates between Joliet and Morris is due in part to the fact that the waters of the Kankakee river which unite with those of the Des Plaines between these two points, are in certain seasons very highly charged with nitrates but much of it undoubtedly is due to the activity of the nitrifying organisms which in this stretch of the river appear to find the conditions of food supply and dilution most
5488 propitious. The great increase of nitrates between Morris and La Salle must be regarded as practically entirely due to the nitrifying processes which in this stretch of the river complete the destruction, that is the oxidation of the organic matters discharged into the river in the Chicago sewage at

Lockport and Joliet. From La Salle to Averyville there occurs a very considerable decrease in the proportions of nitrates. This is due not to dilution, for no considerable dilution occurs between these points—but to the utilization of nitrates by the vegetation which is extremely abundant in the broad lake-like stretches of the river between these points.

From Averyville down to the mouth of the river there is considerable further diminution in the proportions of the nitrates, and this also is due to the cause referred to above, namely the luxuriant vegetation—both that of the river banks and bed and the floating forms.

The curve representing the proportions of nitrates for 1900 shows similar sets of conditions, although the proportions of nitrates is not so great at Morris as it was formerly, a fact which is undoubtedly due to the greater dilution. At La Salle the proportions more nearly approximate those formerly contained, and below this point, although there takes place a notable diminution in the quantity of nitrates on the way to Averyville and Havana, beyond Havana they again increase. Below La Salle there is no point along the river at which the nitrates are not now present in considerably greater proportions than were found in the river water before the opening of the drainage channel. With respect to these differences in the proportions of nitrates between the two periods in question, it seems evident that the conclusion to be drawn must be that nitrification now takes place at least as completely and it would seem far more completely than before the opening of the drainage channel.

The fact that the proportions of nitrates are less at Havana than at Kampsville and Grafton is undoubtedly due to the fact that the great masses of filth which are discharged into the stream in the vicinity of Peoria and Pekin owe their destruction in part to the utilization of oxygen from nitrates which are brought down in abundance by the waters passing Averyville.

Free ammonia. The line representing the proportions of nitrogen as free ammonia for the period prior to the opening of the drainage channel shows excessive proportions of this constituent at Lockport, the diminution on the way to Morris being chiefly due to the dilution, but that between Morris and La Salle being mainly due to the oxidation of the free ammonia to nitrites and nitrates; to its assimilation by the vegetation of the river and in part undoubtedly to its elimination as free nitrogen gas. Between La Salle and lower points upon the river the diminution proceeds continuously although free ammonia is contained in notable quantities in the water finally discharged into the Mississippi at Grafton.

The line for 1900 shows a much lower content of ammonia at the point of initial discharge of Chicago sewage, but it also shows considerable diminution on the way down the river, although as is apparent from the plate and also from table of averages No. 10, A. W. P., the proportions contained in the water as it passes Kampsville, and is discharged at Grafton, were slightly greater in 1900 than the average for the preceding years.

Albuminoid ammonia.

The line representing the nitrogen as albuminoid ammonia constitutes for the upper part of the river a curve quite similar to that just discussed for the free ammonia, but below Averyville there is a slight increase on the way to Havana, due to the discharge of the refuse at Peoria and Pekin. Below this point the quantity does not further diminish, but on the other hand very slightly increases. Comparison of the line for total albuminoid ammonia with that for the albuminoid ammonia derived from substances in solution shows that while the latter diminishes markedly between Havana and Grafton, the total very slightly increases, owing to the presence of greater proportions of nitrogenous suspended matters in the waters at this end of the river.

Total organic nitrogen.

The line representing the total organic nitrogen shows much the same features as those just referred to, although the proportions of total organic nitrogen are more than twice as much as those of the albuminoid ammonia.

Comparison of the curves for the period 1897 to 1899,
5490 with the curves for 1900 shows how great an effect the
dilution produced by the opening of the drainage channel has had, and shows that this effect extends to the mouth of the Illinois river. The fact that the total organic nitrogen and the nitrogen as albuminoid ammonia, do not decrease below Havana, is undoubtedly due to the presence of the enormous masses of vegetation in the waters of the lower river. That the free ammonia does not decrease below the proportions shown for Grafton is doubtless due to its continuous production through the decomposition of the various organisms constituting the plankton, which from time to time complete their life cycles and leave their substances then to enter upon that universal series of transformations to which all organic matters are subject.

These ten sheets contain various tables of monthly averages which have been prepared from the detailed analyses given in tables 1 to 80 of this series, Department of Chemistry, University of Illinois, A. W. P., 1 to 80.

Upon sheet 1, there are the monthly averages for the analyses of the waters of the sanitary canal at Joliet, the west side, for 1901; for the samples taken from the Illinois river at Averyville in 1901; for those collected from the Illinois river at Pekin during the three months, October, November and December, 1901.

On the second sheet, there appear similar monthly averages for the year 1901; samples of water taken from the Illinois river at Kampsville, and at Grafton, and from the Mississippi river at Grafton.

On sheet No. 3 there are data for the year 1902. Monthly averages made from analyses of samples of water taken from the Illinois river at Kampsville.

On sheet No. 4 there are monthly averages for the waters
5491 of the Illinois river at Grafton, for the year 1899, and for the year 1900, and also for the Mississippi river water at Grafton for the same years, that is, 1899 and 1900.

Upon sheet No. 5 there are given the monthly averages of analyses of samples of water taken from the Illinois river at Kampsville during the years 1897, 1898, 1899 and 1900.

Upon sheet No. 6, similar data for the Illinois river at Kampsville during the year 1901.

On sheet No. 7, monthly averages of analyses of samples of water taken from the Illinois river at Averyville during the years 1897, 1898, 1899 and 1900.

Upon sheet No. 8, monthly averages of analyses of samples of water taken from the Illinois and Michigan canal at Lockport during the year 1901; from the drainage canal at the Bear Trap dam at Lockport during 1901; from the drainage canal at Joliet east side, during the year 1901.

On sheet No. 9 there are given the monthly averages of analyses of samples of water collected from the Illinois and Michigan canal at Lockport during the years 1897, 1898, 1899 and 1900.

Upon sheet No. 10 there are given the monthly averages of analyses of samples of water collected from the Des Plaines river at Joliet during the years 1899 and 1900.

JUDGE SPRINGER: Let these be designated as Defendants' Exhibit C for identification, sheets 1 to 10 inclusive, A. W. P. They are not to be printed in the record, but may be at the request of counsel of either side, incorporated in the testimony hereafter, and are to be held by the Commissioner for reference by counsel on either side if they so desire.

5493 Q. Professor, have you any data which show the conditions of the water in the Illinois river just prior to the opening of the sanitary canal as to stages of water, temperature, proportions of constituents, etc.

A. I have.

Q. Will you submit that data at this time?

A. The numerical data, that is, the figures resulting from the analytical determinations, have all been introduced in the detailed tables 1 to 80 which have been referred to above, but some of these data, and the data with respect to stages of water and the temperature of the water, I have represented upon Plates Nos. XXXIX and XL, heretofore introduced in evidence and to which I now refer in response to the question of counsel,
the plates being reproduced on pages 5494 and 5495.
5496 Upon Plate XXXIX there are shown three sets of curves
the upper set representing the proportions of nitrogen as nitrites contained in the waters of the Illinois river at Kampsville during the last six months, that is July to December, inclusive, of the year 1899, and the first six months, January to June, inclusive, of the year 1900. Also the last six months in 1898 and the first six months in 1899, and the last six months in 1897, and the first six months in 1898.

These curves have been prepared with the purpose of bringing together the data which show the conditions as we proceed from the warm summer months to the winter, when the temperature is much lower and on again from the winter to the following summer, where the temperature rises.

With respect to the proportions of nitrogen as nitrites contained in the water of the Illinois river at Kampsville in the fall of 1897, the light continuous line in the upper portion of the plate shows the notable variations of this constituent, in the various seasons of the year, the greatest proportion being found in the latter part of July and August. In the latter part of August, the proportions had decreased to about one-third that which is contained in the water at the end of July and the beginning of August. After this there was a slight increase followed by a notable diminution in the early part of September,

which in turn was followed by an increase to double the proportions found earlier in this same month. During the latter part of September and October the proportions were quite notable, but at the beginning of November and after a considerable reduction at the end of October, they rise again to
5497 considerable proportions, which were practically maintained
to the end of the year; that is, until the beginning of January of the following year, namely, 1898. In January they rose very considerably, being more than doubled in proportion in the early part of the month, after which there was considerable diminution, and the minimum point was reached at the beginning of March, from which time on there were notable variations, but mainly in the direction of increases in the proportions of nitrogen as nitrites, to near the end of the year.

Following the curve for 1898, that is the last six months of 1898, and the first six months of 1899, which curve is shown as a broken line, we find some analagous variations in the early part of the year, although in the end of July and the beginning of August the minimum proportion of nitrites was reached, with the maximum for this period appearing at the end of August; this followed by a very considerable diminution, the line for the next two months, that is, September and October, following almost the same course as for the preceding year, but with the beginning of November, dropping below the line for the other year, that is, the proportions were very considerably less during November, December, January and February, the line again following much the same course as that for the previous year in the latter part of the period, that is the second quarter of the year 1899.

The third line in this group—that represented as a heavy continuous line, represents the proportions of nitrogen as nitrites during the last six months of the year 1899, and the first six months of the year 1900, beginning with notable proportions namely .1 part per million in the early part of July.

There was a drop to about .05 part per million later in the

month, which was followed by an increase to .09 of a part per million in the latter part of July of this year. This followed by a very considerable decrease until the early part of August. In August several increases and decreases followed each other, but none very considerable until the beginning of September, when the proportions diminished to about one-half of what they had been in the latter part of August. Later in September, there was a notable increase, followed by decreases until we get a minimum figure .02 of one part per million of nitrogen as nitrites in the middle of October. In the latter part of
5498 October an increase again, reaching the maximum early
in November, reaching .12 of one part of nitrogen as nitrites per million; this followed by decreases until the minimum was found in the latter part of December, after which an increase took place to the first of January following, namely January, 1900, and in the beginning of the year 1900, there was considerable diminution in the proportion of nitrites continuously until the early part of February after which there was a very slight increase in the proportions from .018 of one part per million upon February 7th, to .023 of one part per million on February 14th, to .022 of one part per million on February 21st, this being followed by diminutions throughout the month of March. The next increase in proportion of nitrites coming in the early part of April, following after which there were the ordinary increases and decreases in the proportions of nitrites similar in character to those which I have referred to above, as taking place in the previous years here considered.

It is evident from these lines, which merely represent the figures in tables 37 to 41 inclusive, that the proportions of nitrites contained in the waters of the Illinois river as they were about to discharge into the Mississippi river, were not during the early months of the year 1900, that is particularly January, February and March, 1900, abnormal. In fact the proportions were very much less than were found in the waters of the Illinois at this same point during the same months of the year 1898, and while somewhat greater in the first part of January than the proportions found at this point in the year 1899, during the latter part of January and during the month of February the figures were almost identical and beginning with March the proportions were almost uniformly less during the year 1900, until the month of June in the early part of which and in the latter part of May, the proportions rose somewhat beyond those which had existed in the water of the Illinois at this point for this time in the year 1899, but were still less than the proportions which had been found in the water at this point in the preceding year at this time, namely, the year 1898.

The second group, that is the group at the middle of plate XXXIX represents the proportions of nitrogen as free ammonia contained in the water of the Illinois river at
5499 Kampsville, for the same periods referred to above in
discussion of the nitrites.

The light continuous line represents the proportions of nitrogen as free ammonia contained in the water of the Illinois river at Kampsville during the last six months of 1897, and the first six months that is, January to June inclusive of the year 1898. It is very notable from the curves which merely represent the figures which are given in detail in tables 37 to 41 inclusive above referred to, that the proportions of free ammonia are less in the summer time, the months of July and August, that they begin to increase in September, reaching a considerable proportion about the middle of September, after which they diminish somewhat, but remain of notable proportions without much change either up or down, during the months of October and November, until at the beginning of December there is a very remarkable increase in the proportion of nitrogen as free ammonia, as the colder weather of the winter season approaches or arrives.

From the early part of December, when the proportion found was 1.6 parts per million, there is again notable increase in the proportions of the nitrogen as free ammonia, to the early part of January when the proportions were somewhat more than two parts per million, after which there is a slight decrease to nearly the middle of January followed by a more considerable decrease to 1.44 parts per million upon the 18th of January, and increase to 1.5 parts per million upon the first day of February, followed by a decrease to 1.24 parts per million on the 8th, and a further decrease to .72 parts per million on the 15th of February, a still further decrease to .956 parts per million upon the 22d of February, and further decrease to .52 parts per million upon the first of March, after which there was more continuous and more considerable successive diminutions until the minimum was reached in April, and from that time to the end of June the proportions never rose to as much as .01 of a part of nitrogen as free ammonia per million.

Following the broken line of this set, which represents the proportions of the nitrogen as free ammonia for the late months that is the last six months of 1898, and for the first six months of the year 1899, we note that in the latter part of the year there were similar variations to those referred to above, but that the proportions did not increase so early in the year, that is, the proportions found in the water during Sep-
5500 tember were practically similar to those found in the
same water in July and August, but that with the beginning of October considerable increase of the nitrogen as free ammonia took place, the maximum being reached early in November, which was followed by a decrease to the middle of November; this in turn followed by an increase to the latter part of November, the minimum for November being reached at .28 of one part per million upon the 29th. After this there were considerable increases until the maximum proportion of nitrogen as free ammonia for the period now in question was reached, upon January 3, 1899, the proportion being 1.28 parts per million. After this there were diminutions in the proportions of nitrogen as free ammonia until at the end of January, namely, January 31, 1899, there were but .6 parts per million,

which was followed, however, by increases to a maximum of .96 parts per million of nitrogen as free ammonia, upon February 21st. After this there were successive decreases and increases, but on the whole diminutions until the warm weather of the summer period was reached, when the proportions were as usual for this season of the year, less than .1 part per million. Following the heavy continuous line which represents the proportions of nitrogen as free ammonia in the waters of the Illinois river at Kampsville during the last six months of 1899 and the first six months of the year 1900, we find nothing particularly unusual in the proportions of the curve. During the first part of the year the lines follow the course above described for the lines of the same months of 1897 and 1898. In the months of September and October it more nearly corresponds to the curve for the year 1897, showing greater proportions than were found during the year 1898, and proportions somewhat less than the considerable proportions found during these months in the year 1897. About the middle of October there was a decrease of nearly 50 per cent in the proportion of nitrogen as free ammonia, followed by an increase more considerable until the proportions .552 parts per million, upon the first day of November, followed by a slight decrease to the next week, and that in turn by an increase to .688 parts per million on the 22d, and 1.44 parts per million on the 29th of November, 1899. Following this there was a decrease to 1.184 parts per million upon the 6th of December. A further diminu-
5501 tion to .368 upon the 13th of December, and from that
time an increase to .672 parts per million upon the 20th of December. Following this increase in the latter part of December there was further increase to the maximum of 2.24 parts of nitrogen as free ammonia per million upon the 3d day of January, 1900; from the 3d of January, 1900, to the 17th of January the same month, there was a decrease in the proportions of nitrogen as free ammonia contained in the waters of the Illinois river at Kampsville, to 1.28 parts per million, and

a further decrease between the 17th of January and the 25th of January. The proportion upon the latter date being 1.04 parts per million. From this date to the 31st of January there is a notable increase in the proportions of nitrogen as free ammonia, the maximum of 1.6 parts per million being reached upon January 31st, the same proportion being found a week later, that is, for February 7th. From which time there was a considerable decrease in the proportions of nitrogen as free ammonia, to .736 parts per million, upon the 14th of February; to .672 parts per million upon the 21st day of February; to .656 parts per million upon the 7th of March; again to .32 upon the 14th of March, an increase to .368 parts per million, upon the 21st of March, and again to .432 parts per million upon the 28th of March. From this time on there were variations in both directions, but the general direction of the curve was in the way to represent the diminutions which are shown in the detailed tables of analyses, as occurring during the warmer summer months.

Comparison of this line representing the conditions with respect to the proportions of nitrogen as free ammonia in the waters of the Illinois river at Kampsville during the last six months of the year 1899 and the first six months of the year 1900, show in general great similarity between the conditions during this period of twelve months and the period of twelve months referred to above, that is, the period July, 1897, to June, 1898, inclusive.

The third group of lines upon this plate gives a representation of the proportions of nitrogen as free ammonia contained in the water of the Illinois river at Grafton thirty miles below the point we have been considering, and within two miles of the point where the discharge of the water from the Illinois into the Mississippi occurs. The heavy continuous line represents the proportions of nitrogen as free ammonia. The broken line represents the temperature of the water as 5502 taken at the time the samples for analyses were collected. The upper curve represents the height of water as read at Government gauges at Kampsville. The stages are given for Kampsville because at this point there is ordinarily no disturbances due to variations in height of the water in the Mississippi river.

At times back water from the Mississippi river causes higher water above the dam at Kampsville, but this is only in times of extreme high water in the Mississippi, while ordinarily at Grafton the stages in the Illinois river follow uniformly the variations in the stages of the Mississippi river.

MR. JEFFRIES: You mean extremely high water in the Mississippi?

A. Yes, sir. The line representing the proportions of nitrogen as free ammonia in this group have been compared from the figures which appear in tables Nos. 21 and 60 of the series 1 to 80 heretofore read in evidence. The data for the latter part of 1899 and for the first part of the month of January, 1900, being thus derived from analyses of collections made once a week, but beginning with the 24th of January the collections were made more frequently and from the 28th of January, 1900, on, the collections were made each day, that is, until the end of April, and the data from these daily collections are represented in the curve for this section of the period in question.

The stages of water represented by the upper curve of this group are the daily readings, or, rather, the mean of tri-daily readings, as in the other case the stages of water and volume of discharge referred to above in my testimony in discussing the conditions at Kampsville.

In the early part of July, 1899, the nitrogen as free ammonia contained in the waters of the Illinois river at Grafton increased from .06 parts per million on the 5th, to .176 parts per million on the 12th, following which there was a decrease to

.03 parts per million upon the 19th, after which the proportions were at the minimum until they began to increase in the early part of September, reaching the proportions .24 parts per million upon the 13th, decreasing to .18, and increasing again to .396 upon the 27th of September, these increases being followed by a decrease to .192 parts per million upon October 4th, to .172 parts per million October 11th, to .084 parts per million on October 25th. The decreases to this point being followed by a considerable increase to .404 upon the first day of November, to .48 upon the 8th of November, these increases being followed by a considerable drop to .12 parts per million upon the 15th. An increase then occurred to .16 parts per million upon the 22d, to .88 parts per million upon the 29th, to the maximum of 1.12 upon the 6th of December, the increase being followed by a great decrease to .176 parts per million upon the 13th, which is in turn followed by an increase to .432 parts per million on the 20th, to .88 parts per million of nitrogen as free ammonia upon the 27th of December, 1899. The increase in proportions of free ammonia continued. The proportion upon January 4, 1900, being the maximum for the entire period under consideration, namely, 2.24 parts per million nitrogen as free ammonia.

Slight diminution from the 4th to the 10th occurring, the proportion on the latter date being 2.16 parts per million; after this there was a considerable diminution to .704 parts per million upon the 17th day of January, 1900. After this an increase to .8 parts per million upon the 24th of January to 1.6 parts per million upon the 28th, upon the 29th, upon the 30th and upon the 31st of January; then a decrease to 1.24 parts per million upon the first day of February, 1900, the same proportion being found upon the 2d of February; upon the 3d day of February the proportion being 1.36; upon the 4th day of February a slight increase again to 1.44 parts per million, an increase again upon the 5th to 1.504, and again upon the 6th an increase to 1.52 parts per million; after this upon the 7th a

diminution to 1.36; upon the 8th to 1.28; upon the 9th to .96; upon the 10th to .72; upon the 11th to .576, followed by an increase upon the 12th to .608, and a decrease upon the 13th to .512. Again upon the 14th a slight increase to .544, followed by a greater increase to .8 parts per million upon the 15th. Upon the 16th the proportion being the same, that is, .8. After this, an increase upon the 16th and 17th to .896 and a decrease to the 18th to .768. From this point on there were various minor increases and decreases, the general direction or
5504 variation, however, being a diminution toward the minimum, which was reached in the warmer months of the year represented in this period, namely, May and June, for the year 1900. The relation of temperature to the proportion of nitrogen as free ammonia is in part illustrated by the curves in this group, for it is notable that as the temperature diminishes in the autumn months, that is, in September, the nitrogen as free ammonia increases in proportion. In this particular year there was an increase in the temperature of the water in the latter part of October, and in conformity with this there appears, or at least in unison with this there appears a decrease in the proportion of nitrogen as free ammonia; then a considerable fall in temperature of the water in the early part of November was accompanied by an increase in the proportion of free ammonia while the increase in temperature of water later in the month was accompanied by a decrease in the proportion of nitrogen as free ammonia. A very considerable further decrease in temperature during the latter part of November and the early part of December was followed in the early part of December by a considerable rise in the proportion of free ammonia. Toward the middle of December there was again a very considerable diminution in the proportions of the nitrogen as free ammonia, although at this time the temperature of the water remained constant, or but a very slight increase. No other very general relation between the temperature condition and the proportion of free ammonia for this time appear. A

further decrease in the temperature of the water to the freezing point, that is, zero degree centigrade, in the latter part of December was accompanied by a very great increase in the proportions of free ammonia contained in these waters. In the latter part of December and the early part of January, a notable rise in temperature of the water from the freezing point, that is, zero centigrade, to four degrees centigrade, just about the middle of January, which rise in temperature was mainly caused by weather conditions, including the precipitation of rain at this time; these were accompanied by a very considerable diminution in the proportions of nitrogen as free ammonia.

Following this there was again a drop in the temperature of the water to the freezing point, that is, zero degrees centigrade, which was accompanied by another very con-
5505 siderable rise in the proportions of nitrogen as free ammonia and later, although the temperature remained practically the same, that is, zero centigrade, there was a considerable dimunition in proportions of free ammonia in the waters of the Illinois at this point which was coincident with a very considerable rise in the stage of water in the river and the volume of flow at this time, which increased very considerably as shown in the various plates upon which the discharges of the Illinois river over Kampsville dam, have been represented.

From the early part of March on, the temperature of the water was gradually rising until the maximum was reached. Of course in the warm summer months, and step by step with this rise in temperature, there were notable diminutions in the proportions of free ammonia, but the very great diminution in the proportions of free ammonia in February and through March, 1900, corresponded throughout with the diminutions and other variations referred to above in our discussion, and the variations of nitrogen as free ammonia in the waters of the Illinois at Kampsville, and were in part occasioned by the high water naturally produced by precipitation as rain during the latter part of February and March and the early part of April during the year 1900.

5506 As I have represented upon plate XL referred to above, the stages of water in the Missouri river, the Missisipi river and the Illinois river were in the latter part of the year 1899 comparatively low, but in the Missouri river at Fort Bellefontaine and in the Mississippi river at Quincy and at Alton the water was remarkably low just at the end of the year 1899, that is, after having been in general low throughout the later months of the year, that is, throughout the months of October, November and December, there was a very considerable fall in the stage of water in these streams just at the end of December, and in some cases, continuing into the early part of January following, that is, January of the year 1900. After this there was a very considerable increase in the height of the water in the Mississippi river both at Quincy and at Alton and in the Missouri river both at Fort Bellefontaine and at Hermann; Hermann being some considerable distance higher up the Misouri river where but little effect of the height of the water in the Mississippi river would ordinarily be felt, and Quincy being more than 100 miles further up the Mississippi river than is Alton and where no effect upon the height of the water in the Mississippi caused by higher stages or low stages in the water of the Missouri river would ordinarily be felt.

I have put in this curve for Quincy and the section of a curve for Hermann in order to show that the conditions at Alton for the Mississippi river and at Fort Bellefontaine for the Missouri river were not caused in the one river by the conditions in the other particularly, but that they existed also at points considerably farther up each of these streams respectively.

In January, the latter part, it is notable that the Missouri went from a little less—it is notable that the Missouri at Fort Bellefontaine rose from a little less than two feet upon the gauge, to seven feet, a rise of five feet between the early part of the month and the latter part, while the Mississippi river at Quincy also rose from the end of December, being less than one foot upon the gauge—it rose to a little more than three

feet upon the gauge at Quincy in the early part of January, to be followed by a decrease to two feet a little later, and in the latter part of January rising to 3.6 feet. This followed by a
decrease to a little less than two feet in the early part of
5507 February, an increase from less than two feet to more
than five feet, and a rise of over three feet in the stage of water in the river at this point. Later in this month, that is, February, during the middle, the rise came, the stage of water reached six feet, to be followed by a decrease, that is, a fall in the water to about three feet in the end of the month, but in the early part of March there was a sudden and great increase in the height of the water at Quincy, to approximately 13 feet.

The stages of water in the Mississippi at Alton follow the same general course as indicated by the curve, but were more considerable both in the rise and in the fall. In the end of December, 1899, the water in the Mississippi river at Alton reached the extreme low water stage. From there it rose to three feet in the early part of January following to February but rising again in the latter part of January to more than nine feet upon the gauge. From this date to the early part of February there was a very considerable fall in the stages of the water at this point. It went below the extreme low water point but was almost immediately followed by a rise of more than six feet. From this time on there were minor variations in height, the maximum being reached in the latter part of February, followed by a decrease in the early part of March which in turn was followed by a very considerable rise in the stage of the water a little later in March from which time there was a more or less continuous diminution to the end of the period, covered by this plate.

The lines representing the stages of water in the Mississippi river at Alton follow much the same general direction and in general are much similar in proportion to those representing the stages at Quincy, but the rises at this point are more considerable, and the falls in stage of water also more considerable, that is, the variations up and down are more notable at Alton than at Quincy and conform more nearly to the variations both up and down as shown for the Missouri river at Fort Bellefontaine and at Hermann, than they do with the upper Mississippi at Quincy.

5508 The low set of curves upon this plate No. XL, reperesent the stages of water above and below the dam at Kampsville, the crest of the dam being at 14.8 feet upon the government gauge, from which the readings are taken at this point.

A curve representing the stages of water below the dam shows the variations which are in part occasioned by the relative stages of water in the Mississippi, in the vicinity of the mouth of the Illinois, while the curves representing the stages of water above the dam vary somewhat in conformity with these. They are not so much and ordinarily in fact are not at all particularly affected by the stages of water in the Mississippi.

On the upper part of this section of the curve a cross line drawn at the horizontal line marked 22 in the scale at the side, indicates a point at which the water in the Illinois river at Kampsville above the dam begins to go over the banks. It is between stage 22 and 23 feet. The fact that the length of time in the year when such conditions as send the water over the banks and in part around the dam prevail, is short, is apparent by comparison of that section of the curve represented by the line 22 feet, with the date scale at the bottom of the set of curves.

Adjourned until 2:00 p. m., same day, Wednesday, November 18th, 1903.

Q. Professor, at the time of the noon recess you had just completed your statement in regard to the stages of water in the Illinois, the Mississippi and Missouri rivers late in the years 1899 and early in 1900. What effect did these conditions and changes have upon the condition of the waters of each of these streams?

A. The conditions of the water of the Illinois river at Kampsville and at Grafton at this time, and the relation of these conditions to the stage of water in the Illinois river have been discussed somewhat in detail in my testimony of this morning and also incidentally in my testimony with respect to

the water at Kampsville and at Grafton given yester-
5509 day, and illustrated or rather represented graphically
by plates Nos. XII, XIII, XIV, XV, XVI, XVII, XVIII, XIX, XX, XXI, and XXXIX. The data of the tables series A. W. P., 1 to 80, inclusive, which have been used in preparation of the plates above referred to show that the waters of the Illinois during the first three months of the year 1900, that is, January, February and March, 1900, were in practically the same condition as they ordinarily are in this season of the year as shown by comparison of the data of analyses of the waters collected during these three months of the year 1900, with the data of analyses of samples of water collected at the same points in the Illinois river during the same months of the years 1897, 1898 and 1899.

With respect to the waters of the Mississippi river at this time I would refer to my testimony and discussion of the data of analyses of samples of water drawn from the Mississippi river at Quincy and at Grafton above the mouth of the Illinois river during this period, namely, the months of January, February and March, 1900, and given in the respective tables of series A. W. P., 1 to 80, inclusive, and represented for purposes of illustration and ready comprehension in part in charts XXII, XXIII, XXIV, XXV, XXXIII and XXXIV, respectively. Consideration of the data of the tables referred to shows that early in January of the year 1900, nitrogen as albuminoid ammonia and the total organic nitrogen were present in the waters of the Mississippi at this point, Grafton, in about the same proportions as in the waters of the Illinois, and that in the middle of February, there was a very considerable increase in the proportions of total organic nitrogen as of nitrogen as albuminoid ammonia in the waters of the Mississippi river above the mouth of the Illinois, which increase in these substances was fully as great in the waters of the Mississippi as in the waters of the Illinois river, and was doubtless occasioned by causes similar to those which at this time brought about these increases in the waters of the Illinois, namely, a rise of notable proportions in the height of water in the stream following upon an unusual fall in the stage of water which in turn had followed a somewhat lengthy period of comparatively low water.

The conditions in the Missouri river as stated in my testimony regarding the stages of water in that stream at the same time that I discussed the stages in the Illinois and Mis-
5510 sissippi were with respect to variations in height of water in the stream similar in character and in extent to those in the Mississippi and similar in character but greater in proportion than those in the Illinois river.

The determinations of the total organic nitrogen and nitrogen as albuminoid ammonia in the samples of water collected from the Missouri river at Fort Bellefontaine show that the variations in height of water in that stream were accompanied by similar variations in the proportions of these constituents of the waters, that is, there was a very considerable increase in the proportions of nitrogenous organic matters contained in the waters of the Missouri just at this time, the latter part of January and the early part of February, of the year 1900.

While my data with respect to the composition of the waters of the Missouri river at this time are not as numerous as those which I have described concerning the composition and the constituents contained in the waters of the Mississippi and the Illinois, the results of those analyses show similar fluctuations and by reference to the data submitted in this case on behalf of the complainant in the case, that is, the tables of results of chemical analyses of waters of the Missouri river made by Professor Teichmann, we find that his results fully corroborate my own with respect to these conditions in the Missouri river water, and being more numerous than my own, having been taken daily in the Missouri river, afford a series of determinations which compared from day to day with those which I obtained for the Illinois and the Mississippi rivers, and show even more conclusively than do my own more meagre data, for this period, a more considerable conformity between the conditions of the water of the Missouri river and the Mississippi river at this time, that is, the complainant's data

for this period show a worse condition in this respect in the waters of the Missouri river at Fort Bellefontaine than do my own less numerous data for the reason that they cover the period more fully and they show complete conformity with the conditions I have stated with respect to the Mississippi river; the data with respect to the free ammonia in the waters of these streams my own for the three rivers, and as corroborative of my data for the Missouri river, and refers to the data already referred to, presented by the complainant, these
5511 show similar conditions, that is, similar fluctuations and increase in the proportion of free ammonia contained in the water of each one of these three streams at the time I have mentioned, that is, coincident with the rises in the height of water in these three streams and particularly in the Missouri and in the Mississippi above the mouth of the Illinois during the early part of February and March, 1900.

These conditions involving as they do an increase in the proportions of the various nitrogenous organic maters in the waters of the upper Mississippi and in the waters of the Missouri river, and the increased proportions of these substances and matters which accompany them in the mixture of waters passing down the Mississippi river below the mouth of the Missouri increase them in that mixture, which is drawn into the St. Louis waterworks system at the intake tower at the Chain of Rocks.

The waters in the lower reaches of the Illinois river have not been more greatly charged with organic matters since the opening of the Chicago drainage canal than they were prior to the openng of the canal.

The data to which I have testified and the various plates representing different portions of the data particularly those referring to the condition of the water in the Illinois
5512 river at Kampsville and at Grafton and testified to somewhat in detail heretofore by me, show that the water in the lower reaches of the Illinois river is now, since the opening of the Chicago main drainage channel, less charged with organic matters than it was previous to that opening.

I present four sheets. On sheet No. 1 there are special cross sections taken in the Illinois river at Averyville, upon July 21, 1899, and upon November 26, 1901, cross sections at Wesley City taken July 22, 1899; cross section at Peoria at the foot of terminal bridge, taken November 26, 1901, and cross sections one and one-half miles below Pekin taken November 26, 1901. These do not involve complete analyses in any one case. In the first case menteniod, namely, Averyville, determinations of the chlorine, of the oxyegn consumed by dissolved substances; of the free ammonia and the total albuminoid ammonia and the nitrites and the nitrates were made.

Those taken at Averyville in November, 1901, were subjected to determinations of chlorine merely.

Those taken at Wesley City July 21, 1899, were submitted to determinations for chlorine, free ammonia, total albuminoid ammonia, nitrites and nitrates.

The samples collected by the terminal bridge at Peoria and below Pekin were submitted to determinations of chlorine merely.

These cross section were taken for the purpose of noting what if any variations there were in the proportions of constituents contained in the waters at these several points in the Illinois river at different distances across the stream. Sheet No. 2 represents the results of analyses of special cross section samples collected in the Mississippi river at Grafton just above the mouth of the Illinois. Samples collected January 5th,
1897, January 18th, 19, February 15, 1899, May 24, 1899,
5513 and July 28, 1899, and also cross-section samples collect-
ed in the Illinois river at Grafton January 5, 1899, and July 28, 1899. Most of these samples were subjected to complete sanitary chemical analyses, such as I have testified to heretofore, with respect to the bulk of the work of this investigation. In a few of these samples a fewer number of determinations were made, as is represented upon the sheet here submitted.

Sheet No. 3 has upon it the results of analyses of samples collected at certan cross sections of the Mississippi river at

Hartford, within a half a mile of the mouth of the Missouri river, a portion of these samples were subjected to complete sanitary chemical analyses. In another portion of them only the chlorine was determined, and in yet another the chlorine and the nitrogen as nitrites were determined. At the bottom of this sheet No. 3 there are several analyses of samples of water collected below the mouth of the Missouri river at different points across the Mississippi within two miles of the mouth of the Missouri, and one sample collected a quarter of a mile within the mouth of the Missouri river.

Sheet No. 4 of this series contains the results of analyses of special cross-section samples collected in the Mississippi river at Alton and at points below Alton, namely, at Hartford, and at the Chain of Rocks opposite the intake tower of the St. Louis waterworks.

5514 JUDGE SPRINGER: The tables are to be known as Defendants' Special Cross Sections Numbered 1 to 4, A. W. P., inclusive, and reproduced on pp. 5515-5522.

5522 The data of the special cross sections made at Averyville show that the waters of the Illinois river are of substantially the same composition, that is, contain substantially the same proportions of chlorine and of other constituents at various points across the stream; that the entire body of water passing this point, in the Illinois river is substantially homogeneous as regards these substances, generally determined in the sanitary chemical analyses of waters.

The chlorine determinations alone is sufficient to show the substantial uniformity of composition of the water at the different points in the cross section, hence the different points across the stream.

The purpose of making such cross-section determinations lies in the fact that when different bodies of water are brought together into one stream, it takes some considerable time for them to mingle completely, and our data show what has repeatedly been referred to in giving my testimony, that at different points in the various streams considered in this investigation the waters from different sources do not mingle completely, so that analyses of samples taken at one point in the stream at such a place would not fairly represent the composition of the entire body of water passing down that stream opposite said point.

The data with respect to the cross-section samples at Averyville show that by the time the waters of the Illinois containing the discharges from the Illinois and Michigan canal from the Chicago main drainage channel; from the upper Des Plaines river, the Kankakee river, the Fox river and numerous other minor tributary streams and containing sewage discharges from various towns situated upon its banks, have by the time they reach Averyville completely commingled so that the waters passing this point at the Narrows at Averyville, is of uniform homogeneous character, with respect to the constituents referred to.

The cross section at Wesley City, made in July, 1899, involving a determination of chlorine, of free ammonia, of total albuminoid ammonia, of nitrites and nitrates, show that the water at this point is not uniform in character all the way across
the stream so far as various significant chemical con-
5523 stituents are concerned. The differences in proportions
of chlorine at different points here are not great, but the differences in the proportions of nitrogen as free ammonia are very considerable between the two sides of the stream.

The free ammonia at the east shore at this point was but .256 parts per million, while at the west shore within five feet of the west shore the proportion was 2.24 parts per million of nitrogen as free ammonia. At the other points in the cross-section, namely, one-third distance and two-thirds distance across the stream the proportions of nitrogen as free ammonia were greater than near the east shore, but nowhere near so great as the proportions found close to the west shore of the river at this point. This excess of free ammonia near the west shore of the stream at Wesley City is derived from or was at that time, derived from the discharges of Peoria sewage, including industrial wastes and house sewage, distillery slop, cattle shed slop, refuse and so on, passing down mainly along the west bank of the river at this point, so that the condition of the water at the west bank at Wesley City is in these respects far inferior to its condition near the east bank, that is, for the time specified,—July, 1899.

The determinations made near the terminal bridge at Peoria and below Pekin, which determinations involve merely the chlorine, show somewhat notable though not considerable variations in the proportions of chlorine at the cross-section points; the greater proportion of chlorine being found near the west shore; the smaller proportion being found near the east shore.

On sheet No. 2, defendants' special cross-sections, No. 2, the cross-section samples collected from the Mississippi river just above the mouth of the Illinois at Grafton, were taken for the purpose of determining whether the waters of the Mississippi at this point were substantially of uniform composition across the stream, and it was found that they were, that there were no very notable differences in the composition at the different points in the cross-section,—the cross-section samples being taken at various intervals, ranging from January, 1899, to July 28th, 1899.

Cross-sections taken in the Illinois river at Grafton
5524 January 5th, 1899, and July 28th, 1899, show substantial
uniformity of the composition of the waters of the Illinois at different points across the stream.

Defendants' Special Cross-section Sheet No. 3, containing data of the analyses of cross-section samples collected in the Mississippi river at Hartford half a mile above the mouth of the Missouri river, which samples were collected December 6th, 1899, and July 7th, 1900, and August 17th, 1900, show that the waters of the Mississippi river have not commingled perfectly with the waters of the Illinois river by the time these two bodies of water have reached this point where they are about to come in contact with the waters of the Missouri river, and show that even down to this point the waters of the Illinois river pass down mainly along the Illinois shore, while the water passing down near to the Missouri shore is mainly the water of the upper Mississippi river.

The cross-section of the Mississippi river taken two miles below the mouth of the Missouri river merely affords evidence of the incomplete commingling of the three bodies of water at this point, and is corroborative of the more extensive series of cross-section analyses which have heretofore been testified to.

Defendants' Special Cross-section Analyses Sheet No. 4 contains the results of analyses of samples of water collected in special cross-sections at Alton, Hartford and at the Chain of Rocks. These samples having been collected at the same cross-section points referred to above, but in addition to the ordinary collection, collections were made at different depths below the surface, for the purpose of determining whether the composition at a given point was the same at different depths below the surface of the water in the river.

They show in general that there was at times considerable difference between the proportions of constituents found in the water at eighteen inches below the surface and at depth from six to ten and up to 30 feet below the surface at points where the water reached such depths.

I have made a few other special collections of waters.
5525 I have not got all the data for them here. I made one series of cross-section collections for determinations of chlorine at LaSalle during the summer of 1899, which showed that at this point at that particular time, the water at different points across the Illinois river beside the wagon bridge at La Salle, was of substantially uniform composition all the way across the stream.

I made also special collections of water from the Illinois river at Grafton for the purpose of noting whether the composition varied at different times in the day, that is, during the 24 hours, and I have that data here on sheet No. 5, Special Collections.

This sheet contains the results of analyses of samples of water collected during 24 hours from the Illinois river at

Havana on June 23d, and 24th, 1899. Again similar collections made November 1st and 2d, 1899, and similar 24 hour collections of water from the Illinois river at Havana, November 1st and 2d, 1897, and August 5th and 6th, 1898.

JUDGE SPRINGER: I now offer this sheet in evidence, to be known as Defendants' Special 24 hour collections No. 1, A. W. P. Reproduced on pages 5526-7.

5528 For the purpose of noting whether the composition of the water in the Illinois river varied greatly during the 24 hours on November 1st and 2d, 1897, samples of water were collected from the Illinois river at Havana, at a point a short distance above the mouth of the Spoon river and Quiver lake, during both the day and the night. Samples taken from the river every two hours during this time were mixed together, thus yielding a composite sample representing the character of the water during the 24 hours covered by these collections, and the data secured by the analysis of said sample given in this table No. 2, Defendants' Special 24 Hour Collection, A. W. P., show that the composition of the water collected in this manner is substantially the same as that of samples collected upon previous days, for the same period and upon days shortly following those, indicating that the ordinary collection of a single sample yields results which are substantially correct for the composition of the water passing during at least the 24 hours in which the period of collection ordinarily falls.

Upon August 5th and 6th, 1898, another similar collection was made at the same point, at Havana, and gave 5529 results which were simply corroborative of those referred to above regarding the sample collected at this point November 1st and 2d, 1897.

On June 23d and 24th, 1899, some similar 24 hour collections were made in the Illinois river at Grafton. The collection at this time and place, however, was made under somewhat different circumstances by means of a specially constructed galvanized iron boat or tank; the samples were collected continuously during the 24 hours, that is, every hour, every minute and every second of the 24 hours. By means of siphon tube connections the water was kept continuously flowing throughout the 24 hours into the sample bottle into which it was taken for shipment to the laboratory and subsequent analysis. At this time but two samples were taken at the same point simultaneously, one eighteen inches below the surface of the stream and the other eighteen feet below the surface of the stream, or about two feet above the bottom, the water at this point at this time in the Illinois river being about twenty feet in depth. These two analyses compared with other analyses of samples collected at about the same time at this point show substantial uniformity therewith, and comparison of the two 24 hour 5530 collections made simultaneously here shows substantial uniformity of the composition of the water at this point throughout the depth of the stream. The chlorines were identical in proportion; the oxygen consumed was somewhat greater in the sample collected near the surface, than it was in the sample collected near the bottom of the river. The free ammonia was precisely the same in both samples, as was also the total albuminoid ammonia, though the dissolved albuminoid ammonia, that is, albuminoid ammonia derived from dissolved substances, was somewhat greater in the water collected at the depth of eighteen feet than it was in the sample collected at the depth of eighteen inches, the suspended matters being greater in the water near the surface at this time.

Total organic nitrogen was found to be slightly more considerable in proportions in the water taken near the surface than in the water taken near the bottom.

The dissolved total organic nitrogen being somewhat greater at the greater depth, and less near the surface; the suspended matters conversely being greatest near the surface and least near the bottom.

Nitrites were .017 parts per million in the sample taken at eighteen inches below the surface, and were .032 parts per million in the sample taken at 18 feet beneath the surface, while the nitrates were the same,—1.12 in each case.

In 1901 a series of examinations of water at points in the Illinois river, the Mississippi river and the Missouri river were made by me on behalf of the Sanitary District of Chicago.

These sheets contain analyses of samples of water collected from the Illinois river at Averyville during October, November and December, 1901. Analyses of samples of water collected from the Illinois river at Pekin for the same months, 1901; collected in the Illinois river at Grafton, October, November and December, 1901. The Mississippi river at Grafton, October, November and December, 1901; the Missouri river at Fort Bellefontaine, October, November and December, 1901; the Mississippi river at the Chain of Rocks, the Illinois shore, at the mid-channel.

5531 JUDGE SPRINGER: I offer these tables in evidence to be known as Sanitary District series 1901, A. W. P. Sheets numbers 1 to 21 inclusive. Reproduced on pages 5532-5558 inclusive.

5560 I have prepared plates graphically illustrating the detailed examinations contained in these tables.

Plate No. 101, series 1901, A. W. P., represents the averages for the period of three months, October, November and December, 1901, and those for the same three months in 1899 in parallel columns.

The comparison of the three rivers, the Missouri, the Mississippi and the Illinois, exhibits a very great difference between the Illinois and the Missouri on one hand and the Mississippi on the other, during the periods in question.

This plate represents the average proportions of chlorine in the waters of the Illinois river at Grafton, the Mississippi river at Grafton above the mouth of the Illinois, the Missouri river at Fort Bellefontaine and at four points in a cross-section at the Chain of Rocks, for the months of October, November and December, 1899 and the same months in 1901.

The comparison of the three rivers, that is the Illinois just above its mouth at Grafton, the Mississippi just above the mouth of the Illinois at Grafton and the Missouri river at Fort Bellefontaine, exhibit a very great difference between the Illinois and the Missouri on the one hand and the Mississippi on the other, during the periods in question.

The content of chlorine in the Mississippi is practically the same as in the earlier year, the same in 1901 as in the earlier years.

The content of chlorine in the Mississippi river water was about the same as in the Illinois river. The greater dilution in 1901 has of course manifested itself in somewhat lower chlorine than in the year 1899.

5561 The significance of these features is determined upon the fact that we have demonstrated elsewhere that the water of the Illinois river does not mix perfectly with the water of the Mississippi on its way from Grafton down to the Chain of Rocks, and that the Illinois river water flows mainly close to the Illinois shore, while the water near the Missouri shore consists mainly of Mississippi river water, mixed only slightly with Illinois river water, though at mid-channel there is more or less considerable mixing of the waters of the two streams. That these conditions prevail down to the mouth of the Missouri river, the Missouri river water as it enters the Mississippi deflects the Mississippi river water forcing it toward the Illinois shore, and it passes down chiefly toward the Missouri shore. It mixes of course to some extent with the fluid coming down from the upper Mississippi at this point, but it is substantially but slightly mixed Mississippi river water, which is toward the Missouri shore; that is the main body of water from the Illinois river is toward the Illinois shore and it is water of the Mississippi river mixed with but small proportions of the water from the Illinois, which comes into immediate contact with the discharge from the Missouri river when the Missouri river water enters the bed of the Mississippi and it is quite unlikely that any considerable proportion of Illinois river water mixes at first with the Missouri river water, but rather it is mainly Mississippi river water containing but a small proportion of the water of the Illinois river. 5562

What we have then, briefly stated is, first, a body of Missouri river water passes down the west or Missouri bank; second, the mixture of Mississippi river water with Missouri river water, containing but a very slight proportion of Illinois river water; third, Mississippi river water containing more Illinois river water in the middle; fourth, Mississippi river water mixed with a more considerable proportion of the water of the Illinois river; fifth near the Illinois shore the larger proportion of Illinois river water mixes of course with the Mississippi river water and to some extent also with the water of the Missouri river.

To be sure, there is no fixed line of demarkation between any of these mixtures, but the mixing takes place gradually, and we certainly have combinations such as I have indicated at the different points across stream. Water for samples taken at the Chain of Rocks shows that the water at the Illinois shore contains far less chlorine than does the Illinois river water pure and simple, but far more than does the Mississippi river water above Grafton. There has occurred a somewhat extensive mixing at mid-stream. We find water having almost the same content of chlorine as at the Illinois shore, while at the intake there is less chlorine than in the Missouri river water at Fort Bellefontaine and considerably less than at the Missouri shore. It is to be noted, however, that the collections at Fort Bellefontaine are not quite so numerous as those at the Chain of Rocks. They did not begin for some ten days or so after the time when those taken at the Chain of Rocks began.

The data of the analyses show, and it is evident from the relative heights of these columns that although the Missouri river water did not extend so far across the stream beyond the intake tower in 1901 as it did in 1899, yet, there was no more Mississippi river water and there was no more Illinois river water in the mixture at the intake tower in 1901, that is, after the opening of the Chicago main drainage channel, than there was in 1899.

Upon chart 102 of this series there are represented the proportions of oxygen consumed or required by the waters of the Illinois river at Grafton, the Mississippi river at Grafton just above the mouth of the Illinois; the Missouri river at Bellefontaine just above its mouth and the Mississippi river at four different points across the stream opposite the St. Louis waterworks intake at the chain of rocks.

The columns representing general averages of analyses of samples collected during three months, October, November and December 1901 and the same three months for the year 1899.

A comparison of the three rivers shows at once that the total oxygen required was much greater in the Mississippi river water than in the Illinois and was still greater in the Missouri river water than in the Mississippi.

5563 It shows further that the oxygen required by matters in solution in the water, was much greater in the Mississippi water than in the water of the Illinois, and less in the Missouri river water than either the water of the Illinois or the Mississippi. In this respect the Mississippi river water was inferior to both the Illinois river water and the Missouri river water. A cross-section at the Chain of Rocks shows that in 1901 there was a greater difference between the two sides of the river and particularly between the waters passing down the side of the intake tower and that passing down along the Illinois shore than in 1899.

Comparison of the three rivers shows too a considerable improvement in the Illinois river in 1901 as compared with its condition in 1899, and an improvement too, in the Mississippi river in 1901 as compared with its condition during the same period of 1899.

While the conditions in the Missouri river were worse during this period in 1901 than they were in the same period in 1899.

5564 Chart No. 103 of this series represents the average proportions of nitrogen as albuminoid ammonia contained in the waters of the Illinois river at Grafton, the Mississippi river at Grafton just above the mouth of the Illinois, the Missouri river at Fort Bellefontaine, just above its mouth, and at four different points across the stream of the Mississippi river at the St. Louis waterworks intake at Chain of Rocks. Data from which these averages represented upon the charts are made, which averages are upon sheet 21 of the series, covering the three months, October, November and December, 1899 and 1901.

The conditions with respect to the proportions of albuminoid nitrogen as revealed by this chart is somewhat similar to those exhibited by chart 102, representing the proportions of oxygen required; that is, the total albuminoid oxygen was greater in proportion in the Missouri river water in 1901 than in either the Mississippi or the Illinois, while the albuminoid nitrogen in solution was less in the Missouri than in the others.

In 1889 the conditions in these respects were much worse than in 1901, although in the Illinois river, and in the Mississippi river, and the cross-section at the Chain of Rocks, there is shown much less mixing of the water of the Mississippi river with that of the Missouri at the intake tower during the autumn of 1901, than existed in the corresponding season of 1899.

Chart No. 104 of this series represents the total solids, both mineral and organic matters in the waters of the Illinois river at Grafton, the Mississippi at Grafton just above the mouth of the Illinois; the Missouri river at Fort Bellefontaine, and so on, the same points as referred to in the three preceding charts of this series, and is based upon similar averages covering the two periods of three months each, namely October, November and December, 1899 and October, November and December, 1901.

Comparison of the three rivers shows that the total solids in the Illinois river water were notably less in proportion in 1901 than in 1899, and the same is true concerning the water of

the Mississippi river. On the other hand the water of the Missouri contained considerably more total solids in 1901, than it did in 1899, the mineral matters in solution too, are very much greater in quantity in the Missouri river water than in the Mississippi river water, and are notably greater than in the Illinois river water, but the greatest difference between the
5565 Missouri river water on one hand, and the Mississippi and Illinois on the other, is in the proportions of suspended matters, the suspended matters in the Missouri river water during this period in 1899 amounted to about 448 parts per million, while during the season of 1901 they amounted to 906 parts per million. During the same periods the proportions of suspended matters in the Illinois river averaged about 42 parts per million for both years.

In the Mississippi river water in 1899 there were about 55 parts of suspended matters per million. In 1901 about 32 parts per million. It would seem that during these periods the averages representing the quantities of matters in suspension constitute the best basis for calculation of the relative proportions of water from the three streams contained in the mixture at the points where the three have more or less come together.

A comparison of the data at the Chain of Rocks where we note the relative quantities of the suspended matters at the four different points across the stream, shows at once that there is far less mixing of the Illinois river water with that of the Mississippi and that of the Mississippi with the Missouri in 1901, that is after the opening of the Chicago main drainage channel than there was in 1899, the season just preceding the opening of the drainage channel. The relative proportions of suspended matters contained in these waters at the several different points across the stream at the Chain of Rocks and also in the three different rivers are shown more in detail upon chart 105, that is upon this chart, instead of having the averages for the entire period represented by columns, there are lines, that is, curves, which represent the proportions contained in the water on the day of each collection. The very notable increase in suspended matters in the Illinois river, December 16, 1901 appears to be due to the fact that the Mississippi and Missouri rivers fell greatly and suddenly at this time, and created a rapid current in the lower Illinois, that is, particularly between the Kampsville dam and Grafton, thus causing a scouring out of the Illinois river along this stretch. The conditions which prevailed during the same season in 1899 are exhibited upon chart No. 106.

Comparison of the two charts shows how much greater 5566 were the differences between the Missouri river water on the one hand and the Illinois and Mississippi river water on the other and how much less complete was the mixing of these waters at the Chain of Rocks in 1901 than it was in the corresponding season of 1899.

The total solids in suspension are shown in detail upon chart No. 107 of this series, and this again exhibits the great difference between the water at the intake tower and that passing down near the Illinois shore, and also shows that there is comparatively little mixing even so far across the stream as the mid-channel of the Mississippi river; that is a point somewhat to the east of the intake tower.

The fact that the water at the Missouri shore itself frequently contains less suspended matters than that at the intake tower is undoubtedly due to the fact that in times of low water the main current is further out from the shore and beside the intake tower, while the water nearer to the Missouri shore flowing with less velocity does not retain so much matter in suspension as does that farther out, which is moving more swiftly.

The solid matters in solution both at the different points at the Chain of Rocks and in the three separate rivers, are shown upon chart No. 108. The features exhibited with this chart show again that between the mixture of the Illinois river water and the Mississippi river water, which is passing along the Illinois shore, and the Mississippi river water which hugs the Missouri shore, is a body of water consisting chiefly of upper

Mississippi river water which intervenes between that coming down the Illinois shore and the body of water passing down beside the intake tower, and the Missouri shore, and substantially prevents the Illinois river water from reaching the body of water which enters the intake of the St. Louis waterworks.

The relative quantities of total solid matters that is both the matters in solution and those in suspension, contained in the waters of the different streams are shown on chart No. 109, which simply corroborates what has been stated above respecting the significance of the lines of charts 107 and 108, and the others of this series.

JUDGE SPRINGER: I now offer these charts in evidence as Defendants' Exhibits 5, 6, 7, 8, 9, 10, 11, 12 and 13.

(Charts not reproduced in print.)

5567 The proportions of organic matters in the Illinois river near the mouth have been less since January, 1900. I have data bearing upon that in form different from that in which it has already been presented. It has gone in the detailed tables No. 1 to 80 inclusive, which we have been discussing and it was incidentally contained in the tables of monthly averages which were introduced yesterday.

I now have in hand certain tables which bring together the averages of the different constituents for the different years in order to facilitate a ready comparison, a comparison which may indeed be made by study of the detailed tables or by study of the tables of monthly averages, but which being here brought together are more easily considered, and their significance more easily grasped.

I have it in the form of tables here, typewriten tables much of it; some of it I have only in my original personal note book.

The tables are designated Combined monthly and yearly averages of proportions of certain chemical constituents of the waters of the Illinois river at Kampsville, and are numbered from 1 to 7.

A. Table No. 1 of this series gives the proportions of total organic nitrogen as determined by the Kjel Dahl process in the water of the Illinois river at Kampsville during the years 1897, 1898, 1899, 1900, 1901 and 1902, both for the monthly averages and the yearly averages. These represent the monthly averages of analyses for each year during the period, and the yearly average has been made from all of the detailed analyses made during the year.

5568 The averages for the entire years 1897, 1898 and 1899 have been combined into an average for the three year period, and also the yearly averages for 1900, 1901 and 1902, have been combined into an average for that three year period. The three years average prior to 1900 is 1.0866 parts per million of total organic nitrogen, and for the three years subsequent to the opening of the Chicago main drainage channel, that is, for the three years 1900, 1901 and 1902; the composite average is .8966. Calculating the percentage difference between these two averages, it appears that there has been a decrease in the proportions of total organic nitrogen in the waters of the Illinois river since the opening of the Chicago drainage channel, amounting to 17.48 per cent. Direct determinations of the total organic nitrogen were discontinued after September, 1901, and from that time on to the end of 1902, the data which appear in these tables have been calculated from the relation between the proportions of nitrogen as total organic nitrogen and nitrogen as albuminoid ammonia, on the basis of the nitrogen as albuminoid ammonia, constituting forty per cent of the total organic nitrogen.

The tables here referred to are reproduced on the pages of the record on which reference is made to them.

5569 Upon table No. 2 of this series there is shown similar averages both monthly and yearly, for the disolved organic nitrogen, that is, the total organic nitrogen held in solution or contained in substances which are in solution in the water. The general averages for the three year periods are given at the bottom; they are .636 for the period 1897 to 1899 inclusive, and .522 for the period 1900 to 1902 inclusive. The percentage difference between these is 17.92 which shows a decrease in the proportions of the organic nitrogen derived from dissolved substances, since the opening of the Chicago main drainage channel, of 17.92 per cent.

5570 Table No. 3 of this series gives in similar way the monthly averages and yearly averages of proportions of nitrogen as albuminoid ammonia, for the years 1897 to 1902 inclusive, and at the bottom of the sheet there are given also the averages for the first six months and the averages for the second six months. In addition, at the bottom there is given the general average for the three years period, 1897 to 1899 inclusive, and the three year period, 1900 to 1902, inclusive, that is for the three years immediately preceding the opening of the Chicago main drainage channel and the three years immediately following the opening. The general average for the earlier period is .4665 parts per million; for the period immediately following the opening is .3495. The difference between these two amounts to 25 per cent, showing that the decrease in the proportions of nitrogen as albuminoid ammonia, immediately following and for the three years period subsequent to the opening of the Chicago main drainage channel, is 25 per cent.

5571 Table No. 4 of this series represents similar facts. The data with respect to the nitrogen as free ammonia in the waters of the Illinois river at Kampsville, that is, the average monthly proportions and the yearly averages for the years 1897 to 1902 inclusive, and contains also the general averages for each of these three year periods, the average for the three years prior to the opening of the Chicago main drainage channel, was .3717; for the three years period subsequent to the opening of the Chicago main drainage channel, the average was .3957, the relation of these to each other being such as to show an increase in the proportions of nitrogen as free ammonia of six per cent.

5572 Table No. 5 of this series gives similar data with respect to the nitrogen as nitrites contained in the waters of the Illinois river at Kampsville, for the years 1897 to 1902 inclusive, both the monthly averages, the yearly averages and the general averages for the three years period prior to and the three years period subsequent to the opening of the Chicago main drainage channel.

The average for the former period is .0672, and for the latter period is .0405, manifesting thus, the fact that there was a decrease of 40 per cent in the proportions of nitrogen as nitrites contained in the waters of the Illinois river at Kampsville on the average of three years period subsequent to the opening of the Chicago main drainage channel from the proportions contained on the average during the three years period prior to that opening.

Table No. 6 represents by means of monthly averages and yearly averages as in the other tables of this series, the proportions of nitrogen as nitrates, contained in the water of
5573 the Illinois river at Kampsville during the years 1897
to 1902 inclusive. There are given also the general averages for the three year period prior to the opening of the Chicago main drainage channel, and for the three year period subsequent thereto. The relation of these general averages is such as to show an increase in the proportions of nitrogen as nitrates subsequent to the opening of the Chicago main drainage channel of 15 two-thirds per cent.

Table No. 7 represents the monthly averages of proportions of suspended albuminoid ammonia, that is albuminoid ammonia derived from suspended matters contained in the waters of the Illinois river at Kampsville for the years 1897,
1898 and 1899, and for the years 1900, 1901 and 1902.
5574 The general averages for the three year period before
the opening of the main drainage channel is .2794, and for three year period subsequent thereto, was .2265, showing a decrease in the proportions of nitrogen as albuminoid ammonia derived from suspended matters, of 19 per cent.

The quantities of organic matters in the Chicago sewage
5575 discharged into the Des Plaines river are greater since
the opening of the Chicago main drainage canal than they were prior to that opening.

My data touching this question bears reference chiefly
5575 to the quantities of nitrogen in the form of free ammonia
and nitrogen held in organic combination, and determined by the Kjel Dahl process, in the waters of the Illinois and Michigan canal at Lockport, for the years 1896 to 1902 inclusive, and for the waters of the Chicago main drainage channel for the years 1900 and 1901.

The analytical data of defendants' table of averages No. 1, heretofore introduced in evidence, show that the average proportion of nitrogen as free ammonia in the waters of the Illinois and Michigan canal at Lockport for the four years 1896 to 1899 inclusive, was 13.5 parts per million, and the total organic nitrogen determined by the Kjel Dahl process was 5.3 parts per million.

The average volume pumped into the canal, which was 36,000 cubic feet per minute during these four years, amounts to 1,623,000 tons of water or sewage every 24 hours, which gives us the factor 1.623 for calculating the total weight of nitrogen carried in the canal.

Q. Which canal was this?

A. The Illinois and Michigan canal at Lockport.

5576 We thus find that the discharge of nitrogen as ammonia,
that is 13.5 times 1.623 was 21.9 tons per day, that is per 24 hours, and the total organic nitrogen, 5.3 times 1.623, equal to 8.6 tons of total organic nitrogen per day, the sum being 30.5 tons of total nitrogen, that is nitrogen in the form of free ammonia, and nitrogen in organic combination as determined by the Kjel Dahl process.

I have left out of account the very minute quantities of nitrogen as nitrates for the reason that these are forms of nitrogen in combination with oxygen and hence not regarded as so nearly allied to organic substances as is the nitrogen as free or saline ammonia. The 8.6 tons of total organic nitrogen represents 53.75 tons of protein or nitrogenous organic matters, and the 21.9 tons of nitrogen as free ammonia if presumed to have been originally in the form of protein or albuminoid matters, would represent 136.9 tons of nitrogenous organic matters. Upon this basis the total quantities of nitrogenous organic matters discharged through the Illinois and Michigan canal, before the opening of the Chicago main drainage channel would amount to 190.7 tons per 24 hours.

It is probable that the population contributing to the sewage which flows into the Chicago river, and was transferred from the Chicago river to the Illinois and Michigan canal during the period in question, excreted 34 tons of urea per 24 hours, corresponding to 15.7 tons of nitrogen, and that the major part of the 21.9 tons of nitrogen as free ammonia contained in the water of the Illinois and Michigan canal was derived from this source, and not from the more complex nitrogenous organic matters or proteid bodies. The quantities of organic matters contained in the waters of the canal however, were undoubtedly far less than the total quantities of these matters discharged into the river by the proportion of the population considered, the difference being in very large measure due to the putrefactive changes which begin in the sewers and proceed actively in the river. The changes which
formerly occurred in the waters of the Chicago river
5577 were similar in most respects to those which take place
in the so-called septic tanks, and which serve to destroy
much of the organic matter, some of it being converted into comparatively inoffensive sludge, and another portion into gaseous substances which partly escape into the air, some of them characterized by disagreeable odors, but others, as free ammonia, carbon dioxide, nitrogen, hydrogen, and so on, being comparatively inoffensive. The fact that ordinarily there was but very slight difference between the quantities of these matters contained in the water of the canal at Lockport, and the quantities contained at Bridgeport, which has been shown by the comparative analyses of samples collected at these two different points, one at the beginning of the Illinois and Michigan canal at Bridgeport in Chicago; the other at Lockport, the point now under consideration, would appear to indicate that

the putrefactive or septic changes which went on in the river proceeded approximately as far as under these conditions it was possible that they should go, and that the matters remaining in the waters of the canal were in a proper condition for the speedy reception of those changes which mark the next step in the oxidation of the nitrogenous organic matters and their transformation into inocuous products, that is to say, putrefactive changes appear to have approached completion and the conditions become such that no further changes took place, revealed within the canal itself; but the next succeeding step in oxidation and putrefication was facilitated by dilution, of the sewage, and also by introduction of bacterial forms of a different character, derived from or contained in the diluting waters of streams tributary to the Des Plaines and the Illinois, or in the waters of the upper Des Plaines when these waters were sufficient in volume to have marked diluting effect upon the concentrated, but ripened sewage discharged from the canal into the Des Plaines river at Lockport in the main, but in particular at Joliet, three to four miles below.

Since the opening of the sanitary canal of Chicago,—or the main drainage channel, the larger part of Chicago sewage experiences its initial dilution in the Chicago river and passes through the main drainage channel in which the mean daily flow for 1900 was 188,340; for 1901, was 241,323, and for 1902 was 257,006 cubic feet per minute.

5578 The volume of sewage pumped into the Illinois and Michigan canal which is now intended to subserve purposes of navigation only, or for purposes of navigation and to supply hydraulic power to the Norton mills at Lockport, was reduced from the former average of 36,000 cubic feet per minute to 26,700 cubic feet per minute in the year 1900, and to about 23,000 cubic feet per minute during the seven months, May to November, inclusive, in the year 1901; the pumps at Bridgeport standing inoperative during the other months of the year 1901,—the daily and weekly variations in flow of the Illinois and Michigan canal and of the Chicago main drainage channel, as also the daily flow of the upper Des Plaines river, measured at Riverside, are shown in plates which have been introduced in evidence.

Throughout 1900 and during such part of 1901 as the pumps were in operation, the Illinois and Michigan canal discharged from 40 to 45 per cent of the nitrogen contained in that part of Chicago's sewage which is conveyed into the Des Plaines river, and thence into the Illinois river; the other 55 to 60 per cent during this period passing through the main drainage channel.

That the disposition, that is, the destruction of the organic matters of the sewage by the natural processes which are in operation in the waters of the sanitary canal, the Des Plaines river and the Illinois river, are facilitated by the increased dilution affected by the operation of the Chicago main drainage channel, has been demonstrated by the investigation of the waters of the Illinois river at Averyville and Kampsville as heretofore testified to by me.

The data in the following tables have been calculated from the average daily flows for each month, in each canal, and the monthly averages of the analytical data.

These tables are known as Quantities of nitrogen as free ammonia, and total organic nitrogen, in the Chicago
5579 sewage discharged into the Des Plaines river, being numbered 1, 2 and 3, and I will put them in as we reach them.

5580 Concerning the flow in the Illinois and Michigan canal during the four years prior to the opening of the Chicago main drainage channel there is no detailed evidence, but the engineers of the Chicago Sanitary District and the engineer to the State Board of Health and others who have studied the question, have given as the mean daily flow, during these years, the volume of 36,000 cubic feet per minute. For the year 1900 the flow has been computed by the engineers of the Sanitary District of Chicago, and are printed in the report of streams examinations, which has been discussed in the conduct of the case now being tried.

From the data contained in that publication which has been furnished to me in duplicate by the engineers of the Board, I have computed the monthly average or the mean daily
5580 flow for each month in the year 1900, and these are as follows:

January,	35,156	cubic feet per minute,
February,	38,104	do.
March,	37,326	do.
April,	31,921	do.
May,	28,740	do.
June,	23,188	do.
July,	25,616	do.
August,	23,730	do.
September,	25,977	do.
October,	24,060	do.
November,	22,521	do.
December,	13,778	do.

The mean for the year being 26,768 cubic feet per minute.

From these I have calculated the flow in tons, and give data in units of one million tons per 24 hours. These data are as follows:

January, 1.582, which signifies that there were 1,582,000 tons of sewage, or water pumped into the Illinois and Michigan canal at Bridgeport, on the average for each 24 hours during the month of January, 1900.

February,	1.71468
March,	1.68
April,	1.4364
May,	1.2933
June,	1.0345
July,	1.1527
August,	1.06785
September,	1.168

October,	1.0827
November,	1.013445
December,	.62

From these data as to the flow in weight of water, the unit is 1,000,000 tons of water or sewage or mixture per 24 hours.

5581 There was no flow in the Illinois and Michigan canal, that is the pumps at Bridgeport were not in operation until the end of April in the year 1901, and the amount pumped during the months of May, June, July, August, September, October and November are as follows:

May,	23,000	cubic feet per minute,
June,	23,000	do.
July,	23,000	do.
August,	23,300	do.
September,	24,000	do.
October,	24,500	do.
November,	20,100	do.

December there was no pumping done; there was nothing discharged.

Calculated into tons per 24 hours and units of one million tons, these are, for

May,	1.035
June,	1.035
July,	1.035
August,	1.0485
September,	1.05
October,	1.1
November,	.9045

The average for the period of seven months being 1.034.

The flow in the drainage canal, that is the discharge at the Bear Trap dam during the year 1901, the mean per 24 hours for each of the twelve months, was as follows:

5582 Cubic feet Tons per 24 hours in units

Month.	per minute.	of one million.
January,	285,000	13.27
February,	304,800	13.7
March,	317,700	14.3
April,	275,000	12.37
May,	190,000	8.55
June,	175,000	7.87
July,	180,000	8.1
August,	236,000	10.6
September,	234,000	10.53
October,	230,000	10.35
November,	234,000	10.53
December,	246,000	11.07
Mean for the year,	242,000	10.89

The flow in the Chicago main drainage channel for the year 1900, that is, the mean flow per 24 hours for each month and the tons of discharge in units per million, are as follows:

January,	179,682	8.08
February,	138,834	6.36
March,	125,935	5.66
April,	106,644	7.36
May,	161,400	7.46
June,	193,542	8.71
July,	203,447	9.155
August,	224,256	10.19
September,	138,417	6.21
October,	171,490	7.717
November,	228,775	10.3
December,	254,900	11.47

I haven't got the year's average stated here, but I have it somewhere else. I can easily supply that. We will not wait for it now.

Q. Professor, you will now proceed with the explanation of table 1 heretofore referred to and put in evidence?

A. Table No. 1 shows the discharge of nitrogen as free

ammonia from the Illinois and Michigan canal and the
5583 Chicago main drainage channel, or sanitary canal in tons per 24 hours, during each of the months of the year 1900, and the year 1901, the figures in the column opposite each month representing the mean discharge of nitrogen as free ammonia for each 24 hours throughout the month represented. There is shown also the mean discharge in tons per 24 hours for the year both from the Illinois and Michigan canal and from the sanitary canal or drainage channel, and the sum of these, which represents the total amount of nitrogen in the form of free ammonia contained in the sewage discharged by means of these two canals from Chicago or by Chicago into the Des Plaines, and thence into the Illinois river, the mean flow in cubic feet per minute for the Illinois and Michigan canal for the year 1900 is stated at the bottom of the column designated "I. & M." The mean daily flow or discharge from the sanitary canal for the year is stated at the bottom of the column designated "Sanitary" for 1900, and is 188,340 cubic feet per minute.

The fourth column in this table contains the sum of the nitrogen as free ammonia discharged by the Illinois and Michigan canal and that discharged by the main drainage channel or sanitary canal.

The fifth column in this table contains the figures showing the quantities of nitrogen as free ammonia discharged by the Illinois and Michigan canal during the year 1900.

It will be noted that during the first four months nothing appears in this column for the reason that there was no discharge, the pumps at Bridgeport being left inactive during this time, and again during the month of December, the blank is present for the reason that there was no pumping and no discharge from this canal during the month of December, 1901.

The figures for the sixth column represent the quantities in tons per 24 hours of nitrogen as free ammonia discharged by the sanitary canal and in the 7th column there appears the sum of the nitrogen as free ammonia discharged by the Illi-

nois and Michigan canal and by the sanitary canal for each month during the year 1901. The figures in this column representing the total discharge per 24 hours of nitrogen in the form of free or saline ammonia in the Chicago sewage sent through these two canals into the Des Plaines and thence
5584 into the Illinois river; the mean flow for the seven months of 1901 during which there was a discharge from the Illinois and Michigan canal, was 23,000 cubic feet per minute; the mean daily discharge from the sanitary canal during this year being 242,323 cubic feet per minute.

The aevrage flow of the Illinois and Michigan canal during the years 1896 to 1899 is given as 36,000 cubic feet per minute. Upon this basis calculations from the figures representing the average content of nitrogen as free ammonia in the waters of the Illinois and Michigan canal at Lockport during the years 1896 to 1899 inclusive, which appear in defendants' table of Averages No. 1, A. W. P., show that the average discharge of nitrogen as free ammonia in the Chicago sewage sent into the Des Plaines river during the years 1896 to 1899 inclusive, was 21.9 tons per 24 hours and that during the year 1899 the year immediately preceding the opening of the Chicago drainage channel the quantity of nitrogen as saline or free ammonia thus discharged into the Des Plaines river in Chicago sewage was 22.5 tons per 24 hours.

The nitrogen as free ammonia represented in the table, that is, for the discharge by the sanitary canal, .2 of one ton per 24 hours, was contained in the diluting lake water drawn through the Chicago river, and not in the sewage discharged into the Chicago river.

Table No. 1 is reproduced on page 5585.

5587 Table No. 2, A. W. P., showing quantities of nitrogen discharged into the Illinois river in Chicago sewage; total organic nitrogen discharged into the waters of the Illinois and Michigan canal and sanitary canal, tons per 24 hours.

5589 Table No. 3 shows quantities of nitrogen discharged into the Illinois river in Chicago sewage; total nitrogen, i. e., sum of the nitrogen as free ammonia, and the total organic nitrogen discharged by the two canals. Tons per 24 hours.

5592 These tables numbered 4, 5, 6, 7, 8 and 9 of this series give the mean daily discharge of nitrogen in the form of free or saline ammonia, in the form of albuminoid ammonia, the total organic nitrogen and nitrogen as nitrites, and the nitrogen as nitrates, in the waters of the Illinois river discharged over the Kampsville dam for the years 1897 to 1902 inclusive, and also show the average discharge per 24 hours for the first six months and the second six months in each year referred to, and the average discharge for the entire year. Also the average discharge for the period of three years prior to 1900, and the average daily discharge for the three year period 1900, 1901 and 1902, inclusive, thus covering the three year period immediately preceding the opening of the Chicago main
5593 drainage channel and the three year period immediately subsequent thereto.

The computations of these quantities have been made in similar manner to the computations of the quantities of nitrogen discharged by the Illinois and Michigan canal and by the sanitary canal into the Des Plaines river; that is the computations have been made from the mean daily flow of water over Kampsville dam, and the average content of the constituents for the month in question, the mean daily flow for the first six months, that for the second six months and that for the year, and the average content of the respective constituents for the first six months, and the second six months and the entire year.

The calculations respecting the quantities of nitrogen in different forms of combination in these waters have been made in several different ways, those which appear in Plate 41 represent the total organic nitrogen that has been in tons discharged per 24 hours calculated on the basis of the discharge of water for the day upon which the sample for analyses was collected, and the proportion of the total organic nitrogen found in the sample collected that day.

Plate 41 is reproduced on page 5594.

5594 The lines of this plate show how considerable were the seasonable variations in the weights of organic nitrogen discharged over the dam at this point during the years 1896 to 1900 inclusive, only the last five months in 1896 being considered because our examinations of the water of the Illinois river at Kampsville began in the latter part of July of that year.

5595 Comparison of these curves with each other shows that during the year 1900, that is, the first year after the opening of the Chicago main drainage channel, the weights of organic nitrogen carried by the water of the Illinois river over the dam at Kampsville, just as they are about to discharge into the Mississippi at Grafton, thirty miles below, were generally less than they were during the preceding years, during both the high water period and the low water period, except that in 1899, during the period ranging from the middle of August to the middle of November, when the flow in the river was extremely low, the quantities of organic nitrogen carried were less than 1900.

Calculations based upon monthly averages both for the data of the analyses and for the flow of the river show similar but of course less irregular variations throughout the years.

Table No. 4, A. W. P. of the series under consideration, is total organic nitrogen; quantities of nitrogen in the Illinois river at Kampsville. Tons discharged per 24 hours and is reproduced on page 5595.

5596 The figures of this table representing the mean daily discharge of total organic nitrogen for the year 1900 have been represented upon plate No. 42, of this series, together with similar lines refering to the quantities carried by the waters of these streams at certain other points during the same period. Plate No. 42 is reproduced on page 5597.

5598 Comparison of the lines upon this plate, with each other, which merely represent the data which has been introduced, shows that at times there is six times as much total organic nitrogen discharged in the waters of the Illinois river over the dam at Kampsville as is contained in the water of the Des Plaines river at Joliet, which latter comprizes the mixture of the flow from the upper Des Plaines, that from the Chicago main drainage channel and that from the Illinois and Michigan canal.

The difference between the lines for Averyville and Kampsville, indicates the quantities of organic matters brought into the lower Illinois by tributaries and the sewage of Peoria and Pekin and so on which escape oxidation or complete destruction by the time the waters reach Kampsville, or the organic substances of the living vegetation which is present in the lower reaches of the Illinois river.

5599 Plate No. 43 shows seasonal varieties in the relative quantities of nitrogen as albuminoid ammonia, discharged by the sanitary canal at Lockport, the Des Plaines river at Joliet, and the Illinois river at Averyville (North Peoria) and Kampsville. Tons per 24 hours calculated from monthly averages.

5601 Plate No. 44 shows seasonal variations in the relative quantities of nitrogen as free ammonia and as nitrates discharged by the sanitary canal at Lockport, the Des Plaines river at Joliet, and the Illionis river at Averyville (North Peoria) and Kampsville. Tons per 24 hours, calculated from monthly averages.

5602 This plate represents by means of curves, seasonal variations in the relative quantities of nitrogen as free ammonia and as nitrates discharged by the sanitary canal at Lockport, the Des Plaines river at Joliet, the Ilinois river at Averyville, and at Kankakee. The figures representing the discharge in tons per 24 hours, that is the mean daily discharge in tons for each month in the year 1900. So far as the curves represented upon the plate cover the various months of the year.

The lower portion of this plate representing the nitrogen as free ammonia, shows that the quantities of nitrogen as free ammonia contained in the waters of the Illinois river at Kampsville are very much greater during cold weather and high water, that is in January, February and March, than at any other time during the year, and the quantities contained here at Kampsville are at this part of the year several times greater than the quantities discharged with the Chicago sewage into the Des Plaines river at Joliet and Lockport, but later in the year, from May to November, the conditions are just reversed. The quantities of nitrogen as free ammonia contained in the stream at Kampsville and also at Ayersville, being very much less than the quantities found in the waters of the sanitary canal or in the waters of the Des Plaines river at Joliet. The very large quantities of free amonia in January and February are coincident with comparatively low water. See plates 18 and 19 already introduced in evidence. And with the excessively high proportion of free ammonia, see plates 10, 14 and 39 of this series, which is characteristic of the Illinois for the extreme cold weather season. The much greater quantities of free ammonia contained in the waters of the Illinois at Kampsville and other points in March, are derived in a large part from the rain and the surface wash.

Upon plate No. 44, there are also shown lines representing quantities of nitrogen in the form of nitrates. The enormous quantities of nitrates found in the water at Averyville and Kampsvile during March and April, the freshet season, are in the main, derived from the leechings or surface soils by the run-offs and the discharges of tile drains. The decrease at the coming of warm weather and lower water in May and June, results in a partial cessation from this leeching,
5603 from the partial oxidation of the supply of nitrates in the soil and from the assimilation of nitrates by the vegetation, especially that of the plankton, which at this season of the year increases in abundance with very great rapidity during the cold weather season.

5604 Plate No. 45 shows Illinois river at Kampsville, discharge curves, also showing concentration of chlorine and discharge of chlorine.

5605 Table No. 5 of this series being quantities of nitrogen in the water of the Illinois river, tons discharged per 24 hours at Kampsville, Illinois, reproduced on page 5605.

5606 This table gives the discharge of nitrogen as albuminoid ammonia in the waters of the Illinois river passing over the Kampsville dam in tons per 24 hours, for each month of the year 1897 to 1903, inclusive, and gives also the average daily discharge during the first six months and during the second six months, and for the period, the three year period; also the average, that is, the period prior to the opening of the Chicago main drainage channel and the average for the three years subsequent to that opening, these averages being 20.08 tons per 24 hours, and 14.07 tons per 24 hours, respectively, showing a decrease in the weight or quantity of nitrogen as albuminoid ammonia discharged by the waters of the Illinois river at Kampsville in the second period of three years, that is, the period following the opening of the Chicago main drainage channel as compared with the three years prior thereto, which decrease amounts to 30 per cent in weight.

5607 Table No. 6 being tons of free ammonia. This table gives similar data respecting the discharge of nitrogen as free ammonia or saline ammonia in the waters of the Illinois river passing over the Kampsville dam during the years 1897 to 1902 inclusive. For the three years prior to the opening of the Chicago main drainage channel 10.78 tons of nitrogen as free ammonia every 24 hours, and for the three year period, 1900 to 1902, subsequent to the opening of the Chicago main drainage channel, 11.1 tons of nitrogen as free ammonia every 24 hours, thus showing an increase in the quantity of nitrogen as free ammonia discharged by the waters of the Illinois
5608 at this point in the second period over the quantity
discharged during the first period, amounting to practically three per cent, the figure on this plate being 2.968 tons per 24 hours.

5608 Table No. 7 represents the quantities of nitrogen as nitrites discharged into the waters of the Illinois river

over the Kampsville dam for the period 1897 to 1902, inclusive. The discharges appearing as the average daily amount carried by these waters for each month of the year indicated
5609 respectively, the average daily amount in tons during the first six months, the average daily amount during the second six months and the average daily amount during the whole year, and also the averages for the three year period prior to the opening of the Chicago main drainage channel and the average for the three years subsequent thereto, the figures for these two periods being as follows:

For the first, 2.23 tons per 24 hours; for the second, 1.282 tons per 24 hours; showing that subsequent to the opening of the Chicago main drainage channel the proportions of nitrogen as nitrites discharged by the waters of the Illinois river at Kampsville were 42½ per cent less than they were during the three year period immediately prior thereto.

Inspection of the figures representing the data for the year 1902 in this plate, shows the shifting during this year of the high nitrites period, consequent upon the shifting of the high water period as shown upon the plates 19 and 18 heretofore introduced in evidence, which plates show the discharges of water by the Illnois river at Kampsville for the years 1896 to 1902, inclusive, and show the fact that is given in detail in the tables of discharge which have been heretofore introduced in evidence, that while usually the high water period in the lower Illinois river comes in March and April, in the year 1902 the highest water of the year came in July and August, and for the last nine months of the year the water was
5610 throughout, unusually high, in fact, the discharge for the year 1902 was considerably higher than any other year of this period, that is, of the years 1896 to 1902, inclusive.

Table 8 represents the discharge in tons per 24 hours of nitrogen as nitrates, contained in the waters of the Illinois river passing over the dam at Kampsville during the years 1897 to 1902, inclusive, and includes also the average daily discharge for the first six months, and the second six months, and the year.

The data of this table touching the year 1900, has been used in making the curve for this point shown upon plate No. 44 heretofore introduced in evidence.

5611 Comparison of the data for the various years shows that during the year 1897 the quantities of nitrates discharged into the waters of the Illinois river at Kampsville, were very much greater throughout the year, that is, throughout the high water season, and also in general throughout the low water season, than they were in the years 1898 and 1899.

The proportions discharged during the years 1898 and 1899, were on the average considerably less than during the years 1900 and 1901, and still more considerably less than during the year 1902, though in no one of the years subsequent to the opening of the Chicago main drainage channel were the quantities of nitrates in the water of the Illinois at Kampsville so great as they were during the year 1898.

It is notable that for the year 1902 the quantities of nitrates carried in the waters of the Illinois river at Kampsville were much greater during the latter part of the year than during the first two months, and that during what is ordinarily the low water season in the Illinois, that is, the last six months in the year, the nitrates at this point were present in very considerably greater quantities than during the similar periods of the five preceding years, which fact is in the main due to the high water which existed during this portion of the year 1902, an unusual condition as referred to in my testimony above.

The comparison of the monthly averages of the discharges of nitrogen as nitrates per 24 hours for the two points, Kampsville and Averyville, shown in the upper part of Plate No. 44 heretofore introduced in evidence, shows that during the
5612 high water season the discharge of nitrates at Kampsville was less than the discharge at Averyville, while in the latter part of the year, especially during the months of July, August, September and October, the quantities are approximately equal at the two points, in the latter part, that is, in the

months of November and December, there being a somewhat greater quantity of nitrates discharged by the waters of the Illinois at Kampsville and at Averyville.

Table No. 9 shows the discharge of nitrogen as nitrites, nitrates, free ammonia, the total organic and the total nitrogen; also the albuminoid nitrogen and the oxygen consumed by the waters of the Illinois river discharged over the Kampsville dam in tons per 24 hours, during the years 1897 to 1900, inclusive.

5613 The figures representing the average daily discharge of the various constituents mentioned during each of the years referred to and being calculated from the mean yearly flow and the yearly average of the given constituent.

The total nitrogen referred to, the figures representing the quantities of which appear in column 6, consists of the sum of the nitrogen as nitrites, the nitrogen as nitrates, the nitrogen as free ammonia and the total organic nitrogen, and consequently represent all of the nitrogen contained in the waters in combination with different substances. I explained that to distinguish from nitrogen gas, which may be dissolved in the water and which may be formed by the decomposition of any of these substances, or be dissolved from the air.

5614 Table No. 10 has similar data but computed for the first six months of the respective years and calculated from the mean daily flow during the first six months, and the average proportions of the constituents during the first six months of the respective years.

Table No. 11 contains similar averages to those just referred to, but for the second six months in each of the respective years.

5615 Table No. 12 gives the quantities of nitrogen in the waters of the Illinois river at Kampsville in tons per 24 hours discharged; yearly averages calculated from the discharges in tons per 24 hours for each month, which appears in the tables which have just been referred to.

5616 Table 13 shows the quantities of nitrogen in the waters of the Illinois river at Kampsville in tons discharged per

24 hours, calculated from yearly averages of flows and yearly averages of the various constituents, the nitrogen as nitrites and as nitrates, as free ammonia, the total organic as determined by the Kjel Dahl process, the total nitrogen, that is, the sum of that as nitrates, that as nitrites, that as free ammonia and the organic nitrogen, and in addition to these similar data regarding the nitrogen as labuminoid ammonia and also the quantities of oxygen consumed by the waters. The averages for the three years preceding the opening of the Chicago main drainage channel and the averages for the three years immediately sub-
5617 sequent thereto, together with general averages for each of these two or three year periods.

The organic nitrogen ordinarily as determined by the Kjel Dahl process is for the year 1902, in this table computed from the nitrogen as albuminoid ammonia on the basis of the latter constituting 40 per cent of the total organic, the Kejl Dahl determination of organic nitrogen. At the bottom of the table there are also given the mean yearly flows or discharges of water over the Kampsville dam corrected for submergence of the wier for the years 1897 to 1902 inclusive.

(Witness gives data showing flow over the Kampsville dam, by months from 1896 to 1902 inclusive.)

5621 Table 14 represents the quantities of nitrogen discharged in the waters of the Illinois river over Kampsville dam in tons per 24 hours, and is calculated for the first three year period, that is the years 1897 to 1899, inclusive, immediately preceding the opening of the Chicago main drainage channel and for the three year period 1900 to 1902, inclusive, immediately following that opening.

During the first period the average flow was 13,900 cubic feet per second, or 37,530,000 tons of water per 24 hours.

During the second period the flow was 13,614 or 36,750,000 tons of water per 24 hours.

In the table there are given the average proportions of the different constituents and also the average daily discharge in tons of the constituents in question.

The nitrogen as nitrites amounted to 2.52 tons per 24 hours during the first period, and 1.49 tons per 24 hours during the second period, which shows a decrease in the quantities 5622 of this constituent discharged by the water of the Illinois river at Kampsville during the second period, as against the first, of 40.8 per cent.

The nitrates are shown by the table to have increased during the second period, the increase amounting to 13.3 per cent.

The free ammonia discharged was found to be greater in quantity during the second period than during the first to the extent of 3.7 per cent.

The organic nitrogen as determined by the Kjel Dahl process was contained in smaller quantity during the second period than during the first, and as represented upon the table the decrease in weight was 18 per cent.

At the bottom of the table similar data show that the quantities of nitrogen as albuminoid ammonia decreased, the decrease as stated being 30.6 per cent.

The oxygen consumed during the first period amounted to 438 tons per 24 hours, and during the second period 393 tons per 24 hours, showing thus a decrease of 10.2 per cent subsequent to the opening of the Chicago main drainage channel.

The evidence shows conclusively that since the opening of the Chicago main drainage channel there has taken place not only a considerable diminution in the proportions of the organic matters contained in the waters of the lower Illinois river, and as they are about to discharge from that stream into the Mississippi, but that a substantial decrease of the actual quantities of the organic matters contained in these waters has occurred, and this notwithstanding the fact which I have testified to, already, that the quantities of organic matters conveyed in Chicago sewage into the Des Plaines and thence into the upper Illinois are considerably greater now than they were before the opening of the Chicago main drainage channel.

As it has been shown in my testimony that the organic matters contained in the Chicago sewage discharged into the upper Illinois are practically destroyed or converted into vegetable matters by the time the waters reach Peoria, that is Averyville, while another great influx of sewage and other organic wastes occurs, it will be of importance to compare the condition of the water at Averyville, just above Peoria with its condition at Kampsville, 140 miles below, with respect to the quan-
5623 tities of organic matters carried by the stream at these two points.

The data involved in this comparison have been brought together upon table 15 of this series, which is reproduced on page 5623.

Table 15 represents the quantities of nitrogen in the waters of the Illinois river at Averyville, above Peoria, tons discharged per 24 hours; that is, the average for the years 1897 to 1901 inclusive, and with the general averages first for the three
5624 year period before the opening of the Chicago main drainage channel and second, for the two year period immediately following, and also there are introduced here once more, for purposes of comparison, similar data with respect to Kampsville.

Comparing the averages for the three year period before the opening of the Chicago main drainage channel with the averages for the two year period subsequent thereto, and I may say here that no analyses of the waters of the Illinois river at Kampsville were made by me for the year 1902, the work at that point was discontinued—comparison of the general averages for these two periods shows that subsequent to the year 1899 there was a decrease in the weight of nitrogen as nitrites discharged by the waters of the Illinois river at Averyville, from 5.24 tons per 24 hours to 2.34 tons per 24 hours, a decrease of 55 per cent.

The nitrates on the other hand were increased, the increase amounting to 16.85 per cent.

The nitrogen as free ammonia showed a very considerable decrease, amounting to 22.9 per cent, the total organic nitrogen, Kjel Dahl, show a decrease amounting to 17.86 per cent.

The total nitrogen, that is, the sum of those before referred to, show a decrease of 6.26 per cent.

The nitrogen as albuminoid ammonia decreased in quantity 32.78 per cent.

The oxygen consumed by the waters of the Illinois at this point showed a decrease amounting to 25.55 per cent.

Comparing the data for Averyville with those for Kampsville for the years 1897 to 1899, inclusive, the data for Kampsville having been taken from the tables heretofore introduced by me in evidence, shows that between Averyville and Kampsville there is a very considerable decrease in the quantities of nitrites carried by the waters of the Illinois river, this amounting to 48.47 per cent.

That the nitrogen as nitrates during this period increased 14.5 per cent. The nitrogen as free ammonia decreased 43.56 per cent. The total organic nitrogen as determined by the Kjel Dahl process increased 62.15 per cent, this increase being due to the organic matters brought in by the various tributaries of the
Illinois, the discharges of organic matters at Peoria and
5625 Pekin and the wash from the immediate water-shed of
the river, and including the vegetation of the river which has subsisted upon refuse organic matters, introduced at points above and from the conversion of mineral matters contained in the water, including nitrates, nitrites free ammonia, carbon and so on, into the substances of the vegetation which is so luxuriant in the lower reaches of the Illinois, the total nitrogen is found to increase 7.47 per cent during this period between Averyville and Kampsville.

The albuminoid nitrogen increased between these two points to the extent of 44.39 per cent, considerably less in proportion than did the total organic nitrogen.

The oxygen consumed by the waters increased in quantity between these two points to the extent of 45 per cent.

Comparing the periods after the opening of the Chicago main drainage channel and for the purpose of putting this comparison upon a more reasonable basis I have calculated an average for the content, that is the quantity of these constituents contained in the waters of the Illinois at Kampsville for the two year period following the opening of the Chicago main drainage channel since we have data for Averyville only for this period, we find generally as follows:

A decrease in the quantities of nitrogen as nitrates from 2.34 tons per 24 hours at Averyville, to 1.22 tons per 24 hours at Kampsville, a decrease of 47.85 per cent, which is almost as considerable in percentage as the decrease between these two points in the earlier years, while the actual quantities themselves are about one-half the quantities contained in the water at these two points during the previous period, that is the three years prior to the opening of the Chicago main drainage channel. The nitrates show a change between Averyville and Kampsville, that is, a decrease, amounting to 5.49 per cent, while in the former period between these two points there occurred an increase in the weights of nitrogen as nitrates. The nitrogen as free ammonia were for Averyville during this period 18.88 tons per 24 hours; the quantities for Kampsville being 11.24 tons per 24 hours, showing a decrease of 40.46 per cent between the two points, which is practically the same as the decrease which took place between these two points during the
previous period, which was 43.56 per cent, while the
5626 actual quantities contained at both points in the second
period were considerably less than they were in the
earlier period.

The organic nitrogen as determined by the Kjel Dahl process increased between these two points in this period from 20.88 tons per 24 hours to 27.43 tons per 24 hours, showing an increase of 31.37 per cent, which is but little more than one-half as much as the increase which took place between these two points in the period of three years prior to the opening of the Chicago main drainage channel. The figure for that period being an increase of 62.15 per cent.

The total nitrogen contained in the waters shows a decrease of 5.16 per cent in this period as against an increase of 7.47 per cent during the earlier period.

The albuminoid ammonia shows an increase of 25.03 per cent as against an increase of 44.39 per cent during the earlier period, the oxygen consumed showing an increase of 27.68 per cent as against the increase of 45 per cent during the earlier period.

The data of this table No. 15 of this series show that the condition of the water of the Illinois river just above Peoria is very much better since the opening of the Chicago main drainage channel.

The data of this table No. 15 of this series corresponds completely with the data of the various tables I have introduced in evidence, in showing that the condition of the water of the Illinois river just above Peoria is very much better since the opening of the Chicago main drainage channel, and that the natural destruction of the organic matters discharged into the river in the sewage is by the time the water reaches Averyville, is far more complete than it was at this point prior to the year 1900.

A comparison of the data for Kampsville with those at Averyville shows that at the like periods which have been referred to (and no examinations of the water at Averyville were made in 1902)—the actual weights of nitrites and of free ammonia carried by the water of the Illinois, decreased more than 40 per cent during the flow from Averyville to Kampsville; inasmuch as the waters of the tributaries of the Illinois contained organic material in proportions equal to those of the Illinois it-

self, and since enormous quantities of nitrogenous or-
5627 ganic matters are discharged into the Illinois at Peoria
and Pekin, a few miles below Averyville, a considerable
increase in the quantities of nitrogenous organic matters in the waters of the lower Illinois might well be expected, but it is to be remembered that the organic matters in the waters of the Illinois below Havana, 45 miles below Peoria and 88 miles above Kampsville, consist of vegetable matters chiefly those of the plankton, as is shown both by observation and by the results of the general investigations which have been introduced in evidence.

I previously made a statement that the number of cattle fed at the distilleries and in the stock yards at Peoria and Pekin were 40,000 annually. While this was true of previous times, for previous years, the number have in late years been reduced, and I understand that there are now being fed in the distillery sheds at Peoria and Pekin but 18,000 head of cattle annually.

One other correction I wish to make, with respect to the amount of corn used in the glucose works at Geneva, from which discharges of organic matters are made into the Fox river. I stated that 40,000 car-loads of corn per annum were used in these works, while the correct amount, according to my information is 30,000 car-loads of corn per annum, averaging 40,000 pounds of corn per car.

Beginning on page 5627, witness gives a definition of the terms used in rendering his testimony.

By the term "Organic matters" I mean such matters con-
taining carbon in combination as constitute the tissues of
5628 living things or organisms, and as are contained in the
various secretions or liquids contained in living things of
all sorts, great and small, and some of the products elaborated by living organisms, excreted by them, or built up into their tissues, excluding the carbon di-oxide, which is excreted by certain living organisms, and absorbed and utilized by other living or-

ganisms, but which is commonly regarded as mineral or inorganic substance.

Q. What is the meaning of the words "nitrogenous organic matters in water?"

A. By the term "Nitrogenous organic matter" we mean to designate those organic matters which contain the element nitrogen as an essential constituent. Not all organic matters contain this element, but the tissues of living things all contain or in part consist of, organic matters of which nitrogen is an essential element. Such matters as the substance or flesh, the proteate bodies, stirred up in the seeds of plants known as gluten and so on, and other substances contained in the juices and secretions of living organisms, which are organic in character, and which contain nitrogen as an essential constituent. There are certain nitrogenous organic matters secreted by plants and animals of which the best example perhaps is, the urea excreted by animals in the urine, which contribute in partial proportion to the nitrogenous organic matters contained in sewage.

Q. What is meant by the term "oxidation" used in the consideration of the organic matters in water?

A. By the term "oxidation" I mean the combining or uniting of oxygen with the various organic matters contained in the water, and in a general way also, the union of the elements of water possibly, with these organic matters which latter is frequently called hydrlosis. The effect of this oxidation being in general to convert the organic matters into substances which are regarded as inorganic or mineral in character.

Q. What agencies produce oxidation in water?

A. The chief agencies in bringing about oxidation of organic matters in sewage are the living organisms present in the water, particularly those of the minuter forms, and which are commonly referred to as bacteria.

5629 A. By the term "nitrification" as I have used it in my testimony I understand such oxidation of the nitrogenous organic matters contained in the water as results in the conversion of the nitrogen of these matters into nitrite and nitrates; that is, essentially finally into saltpetre and nitre. Complete conversion of the nitrogenous organic matters that have undergone nitrification into mineral substances which comparatively are innocuous.

A. The turbidity of water is due to or consists in a certain appearance of cloudiness and partial opacity, which result from the water containing matters in suspension. The color of the water is distinguished from turbidity in that it results from the presence of colored matters in solution. A water may be quite clear and transparent, but have a decided color, and it may on the other hand be both turbid and colored. One is not necessarily associated with the other. Suspended matters which make a water turbid, may impart also a color to the water, but such color is removed by such filtration as takes out these suspended matters.

By total solids we mean all solid matters which are contained in solution and in suspension in the water, which matters are generally determined together as total solids, by evaporating a measured portion of the water to dryness, so that the water itself is expelled. The residue thus obtained is designated as the residue on evaporation or the total solids. By loss on ignition we mean the loss in weight which takes place when the total solids or residue on evaporation is gently ignited, that is, heated to dull redness, the loss resulting from this ignition is due to the partial burning away of organic matters, and to the
loss of certain inorganic substances, and to the volatiliz-
5630 ation of certain inorganic substances or constituents of
the residue. No very great significance attaches to the loss on ignition today for the reason that it is not practicable to distinguish accurately between such loss, as due to the destruction and removal of organic matters from the loss of inorganic constituents as water, carbon-di-oxide, oxygen from nitrates, salts of ammonia and so on. The significance attaching to the determination of total solids or residue on evaporation, lies in

the fact that too great a quantity of such matters contained in water render it unsuitable for domestic use or for manufacturing or steam making purposes.

Q. What does the presence of chlorine in water indicate?

A. Chlorine is contained in the soils in some proportion, but it is a considerable constituent of sewage and of manufacturing wastes. As contained in the water, it may be derived from one or all of these sources. The quantity contained in spring waters, is generally far less than the quantity contained in the waters of deep or artesian wells. The significance which attaches to the proportion of chlorine in the water, depends upon the source of the chlorine, the chlorine itself in such porportions as are found in ordinary waters is not objectionable. The proportion in sea water is so great as to render such water unfit for domestic use. The proportions of chlorine contained in the water of many deep wells is so great as to render the water saline in taste, and to render such water unfit for use for drinking or industrial purposes. It is to be understood in my statements covering chlorine, that it is chlorine in combination with basic matters and not the free substances or element that is referred to, as existing in these waters, that is, in general, it is in the form of sodium chloride, otherwise known as common salt.

Q. Does the presence of chlorine indicate at times the presence of sewage, or might it not indicate the fact that sewage has previously existed, but has now departed?

A. The presence of chlorides in the water is frequently an index to the quantity of sewage that the water does or has contained, but no inference concerning the quantity of sewage contained in the water can be had from a determination of the quantity of chlorine, the chlorides contained, unless other information regarding the water in question previous and
5631 subsequent to the introduction of the sewage, is in hand.

A. By the term "oxygen consumed" we mean the quantity of oxygen that the subtsances contained in the water absorb or unite with in the chemical process used in making this determination. The quantity of oxygen consumed is an index to the quantity of organic matters contained in the water, and affords information concerning the character or, I might say, in some measure affords information concerning the character of the organic matters contained, that is, some organic matters required more, or combined with more oxygen under conditions of the determination that do others. If a considerable quantity of oxygen is required or consumed by the substances contained in a given water, the reasonable inference is that a considerable quantity of organic matters is contained. If on the other hand a small quantity of oxygen is required or consumed by the substances in a given water, the reasonable inference is that the quantity of organic matters contained in that water is correspondingly small.

In my testimony I have already stated what is meant by the term "nitrogenous organic matter." The term "total organic nitrogen" designates the nitrogen contained in combination in the nitrogenous organic matters. It is determined by the Kjel Dahl process, described in my testimony with reference to methods of analysis, and is to be distinguished from the nitrogen contained in the form of free ammonia, that contained in the form of nitrites, and that contained in the form of nitrates which are regarded as nitrogenous substances, and is also to be distinguished from that designated as nitrogen as albuminoid ammonia, although it includes the nitrogen of the latter. It is usually from two to three times greater than the nitrogen
5632 as albuminoid ammonia so-called. The nitrogen as albuminoid ammonia is derived from the substances which are designated as nitrogenous organic matter, but the nitrogen which, in the process of chemical examination, is determined under the name of nitrogen as albuminoid ammonia is only part of the nitrogen contained in the organic matters.

Nitrogen as free or saline ammonia as recorded in the results of the sanitary chemical water analyses, is the quantity of nitrogen contained in the water in the salts of ammonia or possibly as free ammonia, and as contained in water, is derived from various sources. The rain in falling through the air washes from it small quantities of nitrogen in the form of ammonia, or ammonia salts, and at times the proportion of ammonia and ammonia salts so introduced into water, may be considerable.

It is also derived from the soil or earth with which water comes in contact on its way to the streams, and is derived also from waste organic matters either of vegetable or of animal origin which may be upon or in the soil and earth with which the waters on their way to the streams in times of fall of rain or the melting of snows, come in contact.

It is also derived from the decomposition of various nitrogenous organic matters which I have described above, both those which are contained in the vegetation, that is, the leaves and stems of grasses, and other plants; of trees, waste vegetable products and waste animal matters of various descriptions,
5633 and also from the nitrogenous organic matters contained in sewage and in manufacturing wastes of various descriptions.

It is also produced at times by the reduction of nitrites when these are in contact with decomposing organic matters, when these all are wet or contained in water. The significance which attaches to the presence of free ammonia in a water depends upon the source from which it has been derived. The ammonia in itself in the proportions in which it is contained in waters is not objectionable, but inasmuch as the free or saline ammonia is a considerable constituent of sewage, the conditions under which it is introduced into or produced in or continues to exist in a given water, must be fully understood and considered in determining its significance in the particular case.

Nitrogen as nitrites as recorded in the results of the sanitary chemical water analyses refer to the nitrogen contained in combination with oxygen and other substances and constituting salts, which are called nitrites. They are derived in part from the air, being washed from the air usually in the form of nitrites of ammonia by falling rain. They are also derived from the leechings of soils and earth strata with which the fallen rain on its way to the streams comes in contact. They are formed, moreover, in the oxidation of the various nitrogenous organic matters which have been referred to above in my testimony, both those lying upon the surface of the ground or contained in surface soils, in the streets, in barn-yards, in the fields, and from similar changes taking place in the nitrogenous organic matters contained in the water of streams and lakes and ponds; both those derived from or contained in nitrogenous vegetable matters of all descriptions and nitrogenous animal matters, such as are contained in the wastes of habitation, including sewage, barnyard wastes and various manufacturing wastes.

They are also formed by the oxidation of the free or saline ammonia above referred to, as well as by the reduction of nitrates.

The significance of the proportion of nitrites contained in
a water depends upon the origin and the amount of the
5634 nitrites and the conditions prevailing at the place and
time and in the body of water in which they are found.

Nitrogen as nitrates, as recorded in the results of the sanitary chemical analyses of water, represents the quantity of nitrogen that is in combination with basic matters and oxygen, the latter in greater proportion than is contained in the nitrites above referred to. The nitrates, like free ammonia, and nitrites are at times derived in part from the air, being washed from the air by rain and so carried to the earth. They are derived also from the earth strata with which the rain comes in contact and over which or through which it flows on its way to the streams or into the great body of ground water.

The nitrates are derived from the oxidation of the nitrogenous organic mtaters repeatedly referred to in my testimony above, to the oxidation of free ammonia and to the oxidation of nitrites, both in soil strata and in the water itself. The nitrates constitute the chief final nitrogen containing product of the oxidation of nitrogenous matters of various descriptions, including the nitrogenous organic matters.

A portion of the nitrogen contained in all these various nitrogenous matters, organic and inorganic, is often separated in the form of free nitrogen gas, which may remain in solution in the water or escape from the water and mingle with the air, but generally the major part of the nitrogen of the various nitrogenous matters above referred to is oxidized finally to nitrates.

Nitrates are genarally found in notable quantity in the waters of wells, of considerable depth, the so-called shallow wells, and is frequently found in the water of deep wells. It is commonly found in the waters of springs, and is rarely, if at all, absent from surface waters.

It is formed in the oxidation of all sorts of nitrogenous organic matters, both those which are derived from natural vegetation and animal matters, as also from the wastes of habitation, including barnyard refuse, street washings, sewage, and so on.

The significance of the nitrates contained in water depends upon the source and quantity of the nitrates and the conditions under which it has been introduced into or produced in and continues to exist in, the given water.

5635 It is to be noted that the nitrogen passes through a series of conditions, or a cycle of transformations the starting point in which may be regarded as any one of the stages or any one of the conditions or combinations described above, in which it exists in waters. If we consider the nitrogenous organic matters as the first condition or combination in which the nitrogen exists, we may consider the nitrogen in the form of free ammonia as marking the next step or stage in the cycle, this free ammonia being produced in the decomposition or the breaking down of the nitrogenous organic matters, the result of this decomposition being to bring the nitrogen into a sort of combination, namely, the free or saline ammonia, which in the proportions found in water, is not in itself injurious or objectionable.

Following upon the transformation of the nitrogenous organic matters, and the conversion of the nitrogen from organic combination to the inorganic form of free or saline ammonia, the next step in the stage or cycle may be regarded as the partial oxidation of the free ammonia into nitrites which thus constitute the second stage in the series of transformations. The nitrites in turn by further oxidation are converted into nitrates, a comparatively stable form of combination usually regarded as the final stage of oxidation of nitrogenous matters, but the nitrates are utilized by living organisms, that is, plant life, as a food stuff, and the nitrogen of the nitrates built up into the substance of the plant, that is, converted again into the tissues, and so on, thus being converted into the nitrogenous organic substances of the plant, which nitrogenous organic substances either directly or after digestion and assimilation by animals and conversion into the tissues and secretions of animals may, when in contact with or contained in waters, enter again upon the same series of transformation we have just briefly discussed.

Q. Professor, is it possible to form a reasonably accurate judgment of the condition of a given water from consideration of any one constituent determined in the sanitary chemical analysis?

A. No reasonably fair judgment regarding the sanitary condition or the potability of a water can ordinarily be drawn from the consideration of any one single constituent determined in the sanitary chemical analysis of a water, but all must be considered together, and with full knowledge of the source of the water, and of the substances contained in it, and the conditions of time and place and environment, season, and so on.

5637 The fact as set forth in my testimony of this morning, relating to the mean monthly flow of water in the Illinois river at Kampsville during the years 1897 to 1902, inclusive, which showed that at times during the later period, that is, the

three years after the opening of the sanitary canal, or Chicago main drainage channel, a smaller volume of water was discharged than was discharged at times during the earlier period, and that the mean or average daily flow during the three
5638 years subsequent to the opening of the sanitary canal was slightly less than the mean daily flow during the three years period prior thereto, was due to the fact that in the years 1897 and 1898, the rainfall was considerably greater than it was during the years 1900 and 1901.

The year 1899 was a year of drought and the rainfall during that year was deficient, that is, below the normal, and the flow in the river at Kampsville was very considerably less than it had been during the years 1898 and 1897. In the following year, the year 1900, the drought continued, but there was increased flow in the Illinois river at Kampsville due to the increased discharge of liquid, that is, water and sewage, from Chicago through the Illinois and Michigan canal and the main drainage channel.

The year 1901 was a year of severe drought, deficient rain fall, high temperature and dry winds, and the flow in the river during this year was practically the same as the flow during the year 1899, the year immediately prior to the opening of the main drainage channel. On the other hand, the year 1902 was a year of exceptionally great flow, that is, the greatest flow during the six years here in question was that for the year 1902.

The average for the three year period, because of these variations in the rainfall for the various years was, on the whole a little less than the average for the three years prior to the opening of the main drainage channel.

Touching the questions at issue in this case, the real value of the evidence which I have introduced in this case in the way of analytical data lies in the comparison which it institutes between the period prior to the opening of the Chicago main drainage channel and the period subsequent to that opening. For the reason that the various determinations so far as they them-

selves were concerned, and including the collections of the samples, were made under precisely the same conditions throughout both periods, and that they afford data which are strictly comparable, and which show the conditions prevailing in the waters of the streams in question before and after
5639 the great change which was coincident with and produced by the opening of the Chicago main drainage channel.

The conditions which prevail at the mouth of the Illinois river at Grafton are such that at times water from the Mississippi backs up into the Illinois, and fluctuations in the height of the water in the Mississippi, and indeed, in the Missouri, produce fluctuations in the Illinois below Grafton. For these reasons, and because it was practicable to secure the services of most intelligent collectors, namely, the Assistant United States Engineers who were in charge of the improvements on the lower Illinois, and in residence at the Kampsville dam, Kampsville is the best place on the lower Illinois, near the mouth, to obtain, samples which should truly represent the character of the water of the Illinois river as it is about to discharge into the Mississippi.

5640 I have lived upon the watershed of the Illinois river for about 36 years. During a portion of that time living on the banks of the Fox river, one of the chief tributaries of the upper Illinois, and I have been fairly familiar with the conditions prevailing upon the watershed of the Illinois river and with the conditions along the stream itself during the last ten years, and am familiar with the conditions prevailing along that stream and upon much of its watershed today.

Taking into consideration my knowledge and information concerning the Illinois river, its tributaries, its watershed, and the conditions prevailing upon and along the same, and taking into consideration the chemical examinations that I have made of the waters of the stream and its various tributaries, both before and after the opening of the Chicago main drainage channel, it is my opinion that the effect of the greater dis-

charge of water resulting from the operation of the Chicago main drainage channel, has greatly improved the condition of the water of the Illinois river all along its course, rendering its waters less offensive to the senses in the immediate neighborhood of the point of discharge of Chicago's sewage into the Des Plaines and thence into the Illinois, and reducing the proportions of the organic matters contained in the waters of
5641 this stream at Averyville and at other points along its
course, and reducing the proportions of nitrogen as free ammonia and as nitrates, and reducing also the quantities of nitrogen as ammonia and as nitrites contained in these waters, and in reducing not simply the proportions, but reducing also the actual quantities of the nitrogenous organic matters contained in the waters of this stream at various points, and particularly at Averyville, to all of which I have testified heretofore, in the evidence I have presented in this case; and with respect to Kampsville I may refer to my testimony given above in this case, and state it as my opinion here, based upon the considerations enumerated above, that the condition of the water at Kampsville has been greatly improved co-incident with and as a consequence of the operation of the Chicago main drainage channel, in that my evidence shows a great reduction in both the proportions and the actual quantities of the most significant constituents of these waters as determined by the sanitary chemical analyses. And I base this opinion further upon the fact that since the opening of the Chicago main drainage channel, or sanitary canal, although the quantities of organic matters in the sewage now discharged into the Des Plaines and thence into the Illinois river, are 30 per cent greater than before that opening, the proportions of organic matters contained in the waters discharged by the Illinois river into the Mississippi are considerably smaller than they were prior to 1900; and that this decrease of the proportions is not a mere dilution is shown by the fact testified to by me, that the actual quantities of organic matters discharged are now less than they were formerly. I have visited

the mouth of the Illinois river, the mouth of the Missouri river and the Chain of Rocks in the Mississippi river repeatedly and am somewhat familiar with the state of affairs there.

5642 From a consideration of my knowledge and information concerning these bodies of water, and a consideration of the results of investigations I have made of these waters, and the study of investigations made by others of these same waters, it is my opinion that neither the water of the Illinois river at its mouth, nor that of the Mississippi river just above the mouth of the Illinois river, nor that of the Missouri river just above its mouth, is suitable for domestic use; that is, particularly for drinking purposes without filtering, or without such treatment as shall render it sterile as by boiling or other means.

5643 From the knowledge and information which I possess concerning the waters of the Illinois river and the watershed of that river, the drainage canal and the Des Plaines river, and the conditions existing in and about them, and the results of the investigations which I have made of these waters before and after the opening of the Chicago main drainage channel and the knowledge I have of investigations of these same waters made by others before and after the opening of the Chicago main drainage channel, it is my opinion that the effect of the increased flow secured by the opening of the Chicago main drainage channel has been at times to increase the flow of water in the Mississippi river along the western borders of the State of Illinois and the eastern borders of the State of Missouri, and further it is my opinion that the increased flow secured by the opening of the Chicago main drainage channel containing as it does, increased quantities of organic matters derived from Chicago sewage, does not injuriously affect the waters of the Mississippi along the eastern borders of the State of Missouri so far as the use of such waters for domestic, agricultural and manufacturing purposes is concerned, for the reason that the effect of the increased flow secured by the opening of the Chicago main drainage channel, has been co-incident with or the cause of more complete destruction of the organic matters introduced into the upper Illinois river to such an extent that the waters discharged by the Illinois at its mouth contain less organic matters than they did prior to the opening of the Chicago main drainage channel, and further for the reason that it is my opinion that the organic matters contained in the Chicago sewage conveyed into the Illinois river by the Illinois and Michigan canal and the Chicago main drainage channel, so far as the sanitary chemical analysis can determine, are destroyed completely or converted into mineral matters and vegetable matter, which as contained in such water are practically innocuous.

5644 CROSS-EXAMINATION, by Mr. Jeffries:

5645 It is my opinion that the analyses which I have made of the waters of the streams of Illinois and to which I have testified in this case throw much light upon the sanitary condition of the waters in these streams but do not directly determine the question as to the presence or absence of disease producing organisms in said waters. My sanitary chemical analyses of the waters of the Illinois and Michigan canal, and of the Chicago main drainage canal were not such as might be expected to determine directly the presence or absence of disease producing organisms, but inasmuch as they were of such a character as to show the presence or absence of sewage, they do indicate the possible presence or absence of substances characteristic of sewage and hence, in some measure, disclose the presence or absence of deleterious substances, substances 5646 which as a class are objectionable in drinking waters, for the reason that they themselves, or substances which accompany them in sewage, are deleterious to health when introduced into the system through drink. It is my opinion that the basis for the detection of the presence and the kind and characteristics of the disease producing organisms and subatsnces which in sewage and waters at times accompany the chemical constituents

found in these fluids, rests mainly upon the various chemical reactions
and decompositions which said organisms and substances
produce and the chemical substances which result from
their action. The sanitary chemical analyses which I have made
of these waters do not directly indicate the presence or
5647 absence of disease producing substances, and I have not
determined directly the presence or absence of said disease
producing substances in these waters.

5648 As a chemist and individual, it is my opinion that there
can be no doubt but that disease producing organisms
and substances are contained in sewage, and in sewage are frequently
introduced into running streams.

5649 A chemist who concerns himself with the study of
running waters, their pollution and purification, the seasonal
variations to which they are subject, as to content and
character of various substances does recognize the fact that disease
producing organisms and substances are introduced into
running waters in sewage and recognizes as a fact that the
quantities of such disease producing substances and organisms
may be greater or less at different points and at different times,
although he, as a chemist simply, does not ordinarily determine
the quantities of such disease producing organisms or substances.
As a chemist pure and simple, one cannot determine
the quantities nor their presence. There is nothing in the sanitary
chemical analyses of water, as ordinarily conducted which
discloses the kinds and character of the disease producing substances
and organisms contained in polluted water.

5650 It is my opinion as a chemist and an individual, that the
substances, the presence and proportions of which are
shown by the sanitary chemical analyses of waters as ordinarily
conducted, include those substances which serve as the food
supply of micro-organisms, and include the substance itself of
micro-organisms, both the harmless sort and the disease producing
sort. (Witness is interrogated as to what a sanitary

chemical analysis of water may and may not determine.

5654 The nitrogenous organic matters in the water would most likely contain the disease producing organisms, if such a determination could be made. I have on several occasions found greater proportions of organic nitrogen in samples of water taken other than from Lake Michigan at the places heretofore testified to by me, then I have found in numerous samples of water taken from the Illinois river at Kampsville.

5655 In general the waters of Lake Michigan analyzed by me contained considerably less total organic nitrogen than I found in the waters of the Illinois river at Kampsville. Whether the organic nitrogen contained in the water of Lake Michigan analyzed by me, did or did not contain the micro-organisms which produce typhoid fever, I do not know, but assuming it to have been present therein, it is my opinion that there is nothing in my sanitary chemical analysis of the waters of the Illinois river at Kampsville which has determined whether or not a bacillus of typhoid fever was contained in that water.

5659 It is my opinion that my analyses give as complete evidence concerning the composition of all the waters passing the points at which samples of said water were collected, so far as it is possible by a sanitary chemical analysis to do so, for the reason that it is not practicable to analyze at any time much less at all times, all the water flowing past a given point in a stream, of such a stream as the Illinois and other streams referred to in my testimony introduced in this case; and

5660 Iwill add further that while it is always desirable to have as many analyses as is possible, and even more than the number which I made for, say the point on the Illinois river at Kampsville, practical reasons, that is, those involved in the time, labor and expense, have prevented my making more analyses of the waters at the given points during the periods covered in my testimony, and it is my opinion that the evidence which I have submitted covers the case reasonably well, and as well as similar cases have been covered at other places and by other people in the examination of the waters of running streams.

It is my opinion that the water of the Illinois river at Kampsville has not been at other times during the period in question materially different from the condition revealed by the analyses which I have submitted in evidence, and it is further my opinion that the data which I have submitted reveal substantially the true composition of the water of the Illinois river at this point, namely, Kampsville, during the entire period covered by the analyses, namely, the years 1897 to 1902 inclusive.

5663 (Witness explains the variations between results shown by tables introduced by himself and those introduced by Prof. Bisbee.

5665 In my opinion, these variations in the results of the
5666 analyses do not indicate similarly considerable variations in the actual content of the total organic nitrogen in the water samples collected at the same date and hour, nor do they show rapid variations in these substances contained in the water, but in my opinion the variations in the determinations as recorded in the tables you have quoted, are very largely the result of differences in the details of the method employed in making these determinations to which I have referred in my answer to the preceding question.

These variations between the analyses made by Prof. Bisbee and myself, doubtless are in part due to differences in accuracies and differences in inaccuracies, but in my opinion, in the main, they are due to variations in the details of the processes employed in making the determinations. I have been told by mathematicians and physicists at times, that chemistry is not an exact science. Undoubtedly it is not in my opinion,

capable of such exactness as are the various processes of mathematics. It is my opinion that the averages based upon a
5667 given series of chemical determinations afford as accurate a basis for comparison and for determination of certain facts, as do the averages computed concerning the height of man, in the determination of the heights of man, or as the averages of the length of life of individual man, and of individuals of a certain class of men computed by the actuaries of insurance companies, which afford a substantially accurate basis for the determination of the length of life of individual man and classes of men, and thus afford a reasonably accurate basis for conducting the business of life insurance.

If we were to assume that there were no inaccuracies in
5669 the details of the methods employed in making the determination of the total organic nitrogen in these two samples collected at the same point, at the same time and analyzed, the one by Mr. Bisbee, the other by myself, then the results of said analyses would indicate a difference in content of total organic nitrogen as between the two original samples, but as I have stated in my answers to the three or four preceeding questions, in my opinion, the variations in the details of the methods employed in making the determination of total organic nitrogen in these two cases is mainly accountable for the differences which appear in the record.

Q. Then what you have stated with reference to the variation between the analyses with reference to total organic nitrogen as determined by yourself on the 6th day of September, 1899, from the sample of water collected at Kampsville, as compared to a companion sample collected at the same time by the same collector, and analyzed by Professor Bisbee, which shows a variation of 40 per cent, the same answer is applicable to the sample collected on the 13th day of September which shows a variation of 23.8 per cent, is it not?

A. In my opinion it is.

The same is also true as to the other samples in which there is a variation between results obtained by me and those obtained by Professor Bisbee.

5671 (Witness states the variations in accuracy in the determination of the various analyses made in his laboratory.)

5678 I would further add that in my opinion the comparison of the data of individual analyses from the various series of analyses introduced by me as evidence in my testimony does not constitute a very important part of said testimony, but that the comparison which I have instituted between the averages for the individual years, and for the three year period prior to January, 1900, and the three year period subsequent to the first of January, 1900, rests upon a reasonably accurate basis in fact, and that these averages made up as they are from the data of analyses of samples collected at regular stated periods, namely once a week, throughout the six year period mentioned, afford a sound basis for a comparison of the condition of the waters in the Illinois river at Kampsville during the two periods in question.

5680 It is my opinion that high chlorides together with high nitrates result in a loss of a portion of the nitrogen contained originally in the water in combination with organic substances when organic nitrogen results are effected by the Kjeldahl process. (Witness is interrogated as to changes which may take place as to organic nitrogen, etc. in the samples during transportation from place of collection to the laboratory.)

5683 (Witness explains difference in method employed by Prof. Bisbee and himself in the determination of the various analyses made by them.)

5685 I made but three or four determinations of dissolved oxygen in the waters of the sanitary canal, but such as I have made did not reveal the absence of dissolved oxygen therefrom, and I have at no time found the waters of the Illinois river in its lower stretches wholly devoid of dissolved oxygen. However, in the water of the sanitary canal at the Bear Trap dam on August 14, 1900, I found but 5.88 per cent saturation with dissolved oxygen and on June the 29th, at the same point, but 10.88 per cent saturation with dissolved oxygen.

Q. Is it possible for a septic operation to be going on in a water where analysis shows nitrogen in the form of nitrates?

A. With respect to that the only information which I have personally upon the subject is the result of examination of sewage entering, and the effluents proceeding from septic tanks which showed the presence at times of nitrates in the effluent of the septic tank, from which it may be inferred that a septic action going on within the tank, went on with the presence of nitrates.

It is in my opinion true, that a septic tank affords one of
5686 the best and quickest means of resolving the constituents of sewage into simpler and less noxious forms, but the action of the septic tank never completely resolves these matters into the simplest forms, and following upon the series of decompositions which it produces, there must, in order to bring about the oxidation of these products and their conversion into other sets of simpler forms, be a new or other series of agencies set in operation.

5692 In answer to a hypothetical question assuming that immediately after the opening of the canal the water in the Illinois river at Grafton, and the Mississippi river below Grafton and at the Chain of Rocks, assumed a black, sewage muddied condition at times, and asking what, if anything, the sanitary analytical examinations of the waters of those rivers and of the canal show, in reference to the presence of such polluting substances therein contained, witness stated that so far as the assumption of a black sewage muddied condition of the Illinois river water throughout its length, or at various points along it, and the same condition including Grafton and the Mississippi river between Grafton and the chain of rocks, is concerned, I would state as my opinion that such assumption is altogether beyond the fact, that no such condition was to my knowledge, observed along the course of the Illinois river, nor at Grafton, nor in the Mississippi river between Grafton and the chain of rocks, but that on the other hand, the results of my analyses, particularly those having to do with the appearance and the odor of the water, indicate that no such condition maintained or held except that in the upper stretch of the Des Plaines river in the vicinity of Joliet, the odor of the water as recorded in table 44 of the series of analyses I have submitted, as gassy, from January 2d to March 26th, 1900, and that the water in the Illinois river at Morris, collected upon January 26, 1900, had an odor which is indicated as gassy. There is nothing else in the series of analyses included in my tables which indicates directly a more than usually large proportion of sewage contained in these waters. On the other hand the variations in color and in the proportions of suspended matters and in the color of the suspended matters contained in the water during this period, were not different from those observed in other years in like seasons.

I would further add that I obtained from the various collectors of water samples along the river, information concerning the appearance of the water at this time and in no case did they note an unusually dark or black sewage colored mud contained in the water. They failed to note anything particularly different from the usual appearance during the season of high water in the Illinois river, in the spring.

5694 Q. Professor, assuming that there is discharged into the
Illinois river by means of the drainage canal, the sewage
from the city of Chicago which contains certain organisms
which produce typhoid fever; assuming that those organisms
are of a living character and that they live in the sewage
5695 of Chicago the drainage canal and the waters of the Illi-
nois river from five to thirty days or more, disappearing
by death gradually at from five to thirty days or more until at
the end of thirty days or more, all have become innocuous;
assuming further that they flow down the canal to the Illinois
river with the water and with the same velocity as the water
in the canal and the river. Assume that the mean velocity from

Chicago to St. Louis is eighteen days; assume that the average life of these organisms has expired at some point between Averyville and Grafton, but assume also that as heretofore stated, the extreme life limits will carry them in thirty days or more to a point far below St. Louis. State whether or not a table of averages upon the life limit of these organisms, which shows that such average took place at some point in the river between Averyvilie and Grafton, can be used by a sanitarian, or by a sanitary chemist, as proof from a practical sanitary standpoint that no such disease producing organisms pass a given point between Averyville and Grafton and do not reach the St. Louis intake at the chain of rocks and pass beyond the city of St. Louis.

5697 A. It, in my opinion cannot, but the conditions prevailing in the Mississippi river between Grafton and the chain of rocks as to the mixing of the waters in the Illinois with the waters of the Mississippi and the waters of the Missouri, render it, in my opinion, highly improbable that any considerable proportion of such pathogenic germs as may be contained in the waters of the Illinois at Grafton,—that is, if we grant the assumptions of the question, passes down the Mississippi to the point below, St. Louis, and is taken into the intake of the St. Louis waterworks.

PROF. ARTHUR W. PALMER, resumed the stand for re-direct examination by Judge Springer:

In my opinion there is evidence given by my analyses that septic action takes place in the waters of the drainage canal. My reasons for that are that the comparisons of the averages which appear in table D heretofore introduced in my testimony representing the analyses of the waters taken from the sanitary canal at Kedzie avenue at its Chicago end, and taken at Lockport at the Bear Trap dam, for the four summer months, June, July, August and September, 1900, show a series of changes of the organic matters which are of the same nature as the changes which take place during the passage of sewage through a septic

tank. (**Objection by Mr. Jeffries, which objection is argued on pages 5698-9.**)

5700 Thus the average proportion of the total oxygen consumed by the water collected from the sanitary canal at Kedzie avenue, was, *for the four months* in question, namely, June, July, August and September, 1900 8.9 parts per million, while the proportion contained in the waters collected at the Bear Trap dam during the same period was upon the average, 8.8 parts per million, showing a reduction of 1.1 per cent in the proportions of total oxygen consumed. The proportions of oxygen consumed by the dissolved substances in the water at Kedzie avenue, were 4.6 parts per million, while the proportion required by the water at the Bear Trap dam was 7 parts per million, showing an increase in the proportion of oxygen consumed by dissolved matters as between the samples collected at these two points on the drainage canal, of 52 per cent.

The proportion of oxygen required for suspended matters was, for the samples collected at Kedzie avenue 4.3 parts per million, while the proportion required by the waters collected at the Bear Trap dam were 1.8 parts per million, showing a reduction of 6 per cent.

The average proportions of free ammonia found in the waters at Kedzie avenue, were 1.174 parts per million, while the proportion found at the Bear Trap dam was 1.235 parts per million, showing an increase in the proportion of nitrogen as free ammonia of 5.2 per cent.

The nitrogen as albuminoid ammonia, that is the total for Kedzie avenue, was .45 parts per million, while the proportion found at the Bear Trap dam was .426 parts per million, a reduction of 5.3 per cent.

5701 The proportion of nitrogen as albuminoid ammonia derived from dissolved substances was for the Kedzie avenue sample, .158 parts per million, and for the sample collected at the Bear Trap dam it was .218—showing an increase between these two points in the dissolved albuminous matters in the proportion as against the nitrogen contained, of 38 per cent.

The nitrogen as albuminoid ammonia derived from suspended matters was, in the Kedzie avenue sample, .292 and for the samples at the Bear Trap dam, .208—showing a reduction between these two points of 28.7 per cent.

The total organic nitrogen for the Kedzie avenue samples was 1.047, and for the samples taken at the Bear Trap dam, it was .902, a reduction of 12.9 per cent.

The total organic nitrogen derived from dissolved matters was at Kedzie avenue, .365, and at the Bear Trap dam .435, an increase of 19 per cent.

The total organic nitrogen in suspended matters was, for the samples taken at Kedzie avenue, .682 parts per million, while the proportions found in the samples collected at the Bear Trap dam were .467 parts per million, showing a reduction of 31.5 per cent.

These changes, which occurred during the time of the passage of the water from the upper opening of, or the entrance to the Chicago main drainage channel, and the out-flow of these waters at the Bear Trap dam are similar to the changes that occur during the passage of sewage through a septic tank in this particular, that the proportion of free ammonia is increased, and that nitrogenous organic matters and other organic matters which were in suspension, have been taken into solution and thus brought into a condition which prepares it for the next process of purification, namely the oxidation which occurs as these waters mix with the waters of the Des Plaines and the Illinois, and flow on down the course of the Illinois river; that is particularly the oxidation of the organic matters and the nitrification of the same; these two sets of processes resulting in the destruction of much of the organic matter, part of it being converted into gases, the oxidation process producing mainly carbon di-oxide and water, and from the nitrogen producing nitrites and nitrates.

5702 (Witness states to what he ascribes the fact mentioned in his testimony that no unusual appearance of black sewage muddied condition occurred in the waters of the Illinois river just after the opening of the drainage canal.)

5704 In reference to the limits of accuracy in the determination of the various substances disclosed by my analyses of the water in question, it is my opinion that the data of the analyses which I have read in evidence, and to which I have testified in this case substantially represent the sanitary chemical condition of the waters in the Illinois river at Kampsville during the entire periods covered by the series of examinations, and that in particular the comparison of the averages for the various years and for the two three year periods rest upon a substantial and sound basis.

RE-CROSS EXAMINATION, by Mr. Jeffries:

5705 In the absence of direct knowledge of the conditions prevailing in the bottom, near and in the mouth of the Chicago river, I can make no definite statement, but in a general way would state it is my opinion that in all probability, at times there is still septic action going on in the sediments in the bottom of the lake, in the vicinity of the mouth of the Chicago river.

5709 I have no doubt that at times the water before it leaves Lake Michigan and passes into the river is in an unsanitary condition.

5711 THOS. J. BURRILL, Examined in chief by Judge Springer:

Am a member of the faculty of the University of Illinois. I hold now the Professorship of Botany. Was educated at the Illinois State Normal University. I pursued a course largely for teachers and specialized as much as possible in biology. I quit that institution in 1863. (Witness states his educational qualifications.)

5716 Beginning with May, 1899, I made a series of examinations from selected points in the course of the Illinois river and its tributaries, and these were conducted until October, 1900, and then in 1901, a series was made extending from October to December inclusive.

These were for the most part weekly collections, from the stations arranged for by Professors Palmer and Jordan.. There were two samples in each collection, and in the whole for the two years first named, there were 2800 of these samples; the number of entire cultures made from these samples amounted to about 7,000.

These examinations were upon samples taken under the direction of Prof. Palmer and Prof. Jordan and were procured at the times and places mentioned in the detailed reports of Streams Examinations by Prof. Palmer. The tables No. 1 to 80 inclusive, put in evidence by Prof. Palmer and published in the book known as "Streams Examinations, Sanitary District of Chicago," were made by Prof. Palmer and myself. (These tables are reproduced on pages 4939 to 5026 inclusive of this record.)

5717 The last two columns in each of the tables were made by me. The "+" sign, or an upright cross, is used to indicate the positive presence of the bacillus coli communis as determined by me. The horizontal line "—" commonly called the minus sign, is used to indicate, according to our tests, the absence of this organism and the interrogation point, "?" is used when the test could not be relied upon to indicate its presence, but did give some evidence of its being there. The small dots indicate that for some reason no examination was made of the samples collected under those particular dates.

5718 Witness gives errata as to bacterial counts in tables No. 1 to 80.

5722 Table F, Streams Examination, Sanitary District of Chicago, Sanitary Water Analyses, Monthly Average of Colony Counts, Report of T. J. Burrill, contains the monthly averages of colony counts based upon tables 1 to 80, to which I have referred, subject to one difference. This table of averages was based on the regular weekly collections from the streams. When there were any extra collections, as there were at Grafton and at the Chain of Rocks and other places sometimes, those extra collections were not included in these averages. Said table offered in evidence and reproduced on pages 5724 and 5725.

5726 (Witness states method of plating for these colony counts.)

5728 (Witness explains method of determining presence or absence of the bacillus coli communis and refers to two photographs giving conditions for one week's tests, which photographs were marked Defendant's Exhibits D and E for identification to be incorporated in the testimony hereafter if counsel on either side so desires.)

A. The difference in colony counts for different portions of the stream is very marked, and while there is considerable variation for each point, there is for all of our tests very striking agreement in the greater number existing in the course of the stream near its head at Bridgeport, amounting to several millions a cubic centimeter, and then a more or less gradual decrease to Peoria, and from Ottawa to Peoria, this decreased number is exceedingly marked.

Q. Please point out the differences which are indicated between the colony counts at Bridgeport and Averyville, for the period in question?

A. The colony counts from the tests made from samples taken at Bridgeport on November 7, 1899, were 4,790,000;

November 15th, 1,960,000; November 21st, 3,920,000; November 29th, 315,000, with the average for the four tests of 2,497,000.

At Averville for the same time, the counts were respectively, 550, 1,100; 1,200; 2,800; an average for the four tests, 1,640.

Q. For the year 1900 what do those counts show for these two places?

A. And for the year 1900 in April at Bridgeport, on the 3rd of that month, 5,300,000; on the 10th, 3,725,000; on the 17th, 11,200,000; on the 25th, 3,925,000, with an average for the four tests of 6,037,500.

While at Averyville for the same times, the counts were 28,000; 17,000; 5,500; 1,850; and with an average for the four of 13,087.

The colony counts showed a great increase in number of bacteria after the pollutions were received by the river from Peoria and Pekin. As an illustration of this I will say that in 1899 on November 1st, there were found at Pekin, 2,780,000 bacteria per cubic centimeter; on November the 9th, 170,000; on November 16th, 145,000; on November 24th, 95,000; with an average for the four tests of 797,500.

5730 For the same times at Beardstown, which is 56 miles further down stream, the colony counts were respectively 6,500; 21,500; 7,150; 35,200, with an average for the four tests of 17,590 for the year 1900. For July 6, 1900, there were at Pekin 38,500; for July 12th, 555,000; July 19, 370,000; July 26th, 220,000; with an average of 295,875. While at Beardstown for the same times there were respectively 3,500; 4,000; 3,000; 3,600, with an average of 3,700. I should say that in order to make this tabular statement, the dates given sometimes vary by one day, for one or the other of the numbers given, because the collection was not always made on the same day.

The averages in the last figures show respectively, 45 and 71 times as many bacteria in the water at Pekin as at Beardstown, though the distance is 56 miles and the time required for the flow of water 24 hours. I prepared graphic plates based on the data contained in monthly averages exhibited in table F of the data contained in tables No. 1 to 80 of the series in question. These plates are known as plates XXI to XXVIII of the Bacteriological Laboratory of the University of Illinois.

Plate XXI is reproduced on insertion facing page 5730.

5731 The earlier tests (those from samples taken above Ottawa) were not indicated on this plate because the numbers are so great that they could not be shown on this scale. It will be noticed that at Ottawa the number was 20,000; at La Salle it was about 18,000; at Henry it was about 64,000; at Averyville it was about 9,000; at Wesley City the number was so great that it could not be shown on the plate. The lines were stopped near the upper part of the plate and the number inserted, 1,476,480. And at Pekin for the same reason the line does not show the number, but the figure is put in 1,500,000. Now the number drops quickly to Havana, where it is shown to be about 8,000; at Beardstown about 5,000; and at Kampsville about 6,000; and at Grafton about 5,000 again. At Alton about 6,000; and at Mitchell as named on this plate, about 17,000.

It ought to be said that the term "Mitchell" is used here as the nearest railroad station to the place otherwise called the Chain of Rocks. Now for June in the year 1900, at Ottawa, the number is about 14,000; something a little less at LaSalle, and 3,000 at Henry, and 1,500 at Averyville, all of which is below that of 1899, and then at Wesley City, six miles below Averyville and below the reception of the Peoria sewage, 59,000 and at Pekin, 150,625; and at Havana, about 15,000. At Beardstown, 8,000; at Kampsville, 2,000; at Grafton, Illinois river about 7,000; and at Alton, 8,000; and at Mitchell, 21,000.

I wish to say that the showing is for 1900, less than for 1899 in the first part of the stream as here indicated, and more for some distance after Havana, less at Kampsville and more again at Grafton, Alton and Mitchell.

5732 There is further shown on this plate the colony counts for the Mississippi river at Grafton, by a little separate circle, showing about 5,000 for 1899, and 3,000 for 1900; that is, the showing for the Mississippi during this comparison is a little lower in each case than for the Illinois river. Plate XXII shows the same thing as plate XXI but represented in a different way and has in addition the showing for the Illinois and Michigan canal at Lockport; for the Des Plaines river at Joliet, and for the Illinois river at Morris. In Plate XXI the presentation is shown by oblique lines; in plate XXII, the exhibit is made by perpendicular lines. Plate XXII is reproduced on page 5734.

5735 Plate 23 shows the average number of bacteria per cubic centimeter as determined by the tests during July, in 1899, and also for the same months in 1900. The solid black line, exhibits the number for 1899, and the broken line for 1900 of this month.

It will be seen that for the year 1899 we started Ottawa with about 9,000 bacteria. At LaSalle the number sinks to about 7,000, at Henry it rises again to about 22,000; at Averyville it is a little over 9,000; and at Wesley City the line, if drawn would extend beyond the plate, and the figures are given to indicate 3,925,000, and at Pekin, 737,625. At Havana the number rapidly decreases to about 6,000 and at Beardstown to about 1,000. Again at Kampsville it rises somewhat, to about 3,000; slightly sinks again at Grafton, to about 2,500, for the Illinois river, and at Alton to something less than 2,000, while at Mitchell it rises to about 6,000.

For July, 1900, we have commencing at Ottawa, from 2,000 to 3,000; at LaSalle, 3,000 to 4,000; at Henry, 40,000; at Averyville about 4,000; at Wesley City, about 96,000; at Pekin 313,375; and at Havana 23,000; at Beardstown about 4,500; at

Kampsville 2,000; at Grafton about 4,000; at Alton about 6,000 and at Mitchell 26,000.

5736 Plat XXIII is reproduced facing page 5736.

Plate XXIV is another way of showing what was con-
5737 tained in plate 23, and with the addition of the exhibit for the Illinois and Michigan canal at Lockport, for the sanitary canal at Lockport, for the Des Plaines river at Joliet; and for the Illinois river at Morris. In this plate the indication is made by vertical lines, with the black solid lines for 1899 and the open light lines for 1900.

The line for July, 1899 at Lockport, Illinois and Michigan canal, shows about 5,320,000 and for the same month in 1900, 740,000; for the Des Plaines river at Joliet, for 1899, 2,850,000; for 1900, 170,000; Morris for 1899, 930,000; for 1900, a little less than 45,000. At Averyville, the exhibit shows very few numbers for both years, about 10,000 for 1899 and rather less than 5,000 for 1900. For Wesley City, for 1899, 3,925,000; for 1900, a little less than 100,000; at Pekin, for 1899, 740,000; for 1900, 315,000.

5738 From Havana on through the course of the stream, the indications show very clearly that the number of bacteria were, compared with those already mentioned, exceedingly small. Plate XXIV is reproduced on page 5739.

5740 Plate XXV shows the average number of bacteria per cubic centimeter of the water tested during August, 1899, and for the same month, 1900, from Ottawa to Mitchell.

Plate XXVI gives the same exhibit as that for plate XXV, but in plate XXVI the indications are by vertical lines, the solid black line for 1899, and the open or lighter line for 1900, and with the addition of the exhibit for the Illinois and Michigan canal at Lockport; sanitary canal at Lockport; Des Plaines river at Joliet, and the Illinois river at Morris.

Here again the line for 1899 for the Illinois and Michigan canal at Lockport show that the number of bacteria were very much greater for the same waters than for the same place in

1900; that for 1899, indicating about 3,240,000; and for 1900, 790,000.

5741 Q. The counts which are indicated thereafter beginning with Havana, and ending with Mitchell, show what condition?

A. Here again it is indicated that the comparative number of bacteria found is very much less than at Wesley City and at Pekin, but upon the whole, very similar to those found from Ottawa to Averyville. The largest number represented in this section of the plate, that is, from Havana to Mitchell inclusive, was, in the Missouri river at West Alton, in 1899. The showing is not far different in this part of the plate, otherwise than as mentioned, between the two years.

Plates XXV and XXVI are reproduced on pages 5443-5.

5744 Q. I call your attention now to plates XXVII and XXVIII of this series. What are represented by these plates?

A. Plate XXVII shows in a graphical way the average number of bacteria found at the collections taken from Ottawa to Mitchell in September, 1899 and 1900; and plate No. XXVIII is an exhibit of the same in vertical lines, with the addition of the showing for the Illinois and Michigan canal at Lockport, the sanitary canal at Lockport, the Des Plaines river at Joliet, and the Illinois river at Morris. Reproduced on page 5746.

These tables present in a graphical way the very great 5748 difference in the number of colonies of bacteria found on our test plates made from water taken at these different places. It will be seen that without exception these numbers are very large, from the waters taken from the Illinois and Michigan canal at Lockport, from the sanitary canal at Lockport; from the Des Plaines river at Joliet, throughout the time that the examination was made. At Morris also the plates show that the number was very large, yet a considerable decrease from those at the places just mentioned, in most cases, though in the showing for August, 1899, the number is nearly as large as we find it to be at any of the places. This indicates to me that the waters through this course of the stream, have in them great quantities of decomposable organic matter suitable for food for these organisms, and that the other conditions are such that the latter multiply enormously in these waters; but between Morris and Ottawa the indications are from these plates, that a great change takes place; that the numbers of bacteria are greatly increased. The decrease is out of all proportion to the increase of water received by the stream during this time, or in other words, the amount of dilution that the stream has after passing Morris. This decrease in the number is maintained with some irregularity to Averyville, where the number found on an average, equals that of ordinary river water, not especially subject to contamination. This seems to be true in every case, as shown by these plates for the condition of things in the Illinois river at Averyville.

This showing seems to prove that the pollution of the water at Bridgeport, and subsequently near the head waters, has practically disappeared at Averyville.

5749 The plates taken together show very conclusively great pollution of the stream below Averyville, but that the organic matter is largely absent in the course of the stream after it reaches Havana, and especially so at the mouth of the Illinois at Grafton.

There is practically no difference so far as shown by these plates, in the waters of the Illinois river before they enter the Mississippi river at Grafton, and of the Mississippi river above the mouth of the Illinois river at this place. There is, however, a continuous exhibit of a greater number of bacteria in the waters of the Missouri river at West Alton than there are in either the Illinois river or the Mississippi river at Grafton.

Q. What conclusion do you draw from this difference?

A. I can only infer that the waters of the Missouri river at West Alton have in them greater contamination than have the waters of the Illinois river and the Mississippi river at Grafton. I do not think I have enough information of the special reasons for the conditions as shown for the waters of the

Missouri river at West Alton to be able to say why the pollution is greater there than in the Illinois and Mississippi at Grafton. I will say, however, that the records of temperature in these waters show that those of the Missouri are for the most part somewhat lower than are those for the Illinois and the Mississippi. This lower temperature probably has something to do with the lessened rate of decrease in these colder waters, than in the warmer ones, for it must be understood that the waters which have a temperature favorable to the growth and multiplication of bacteria, clear up sooner than those not so favorably conditioned.

I would like to express my opinion, that the greater part of this clearing up from the pollution of the water is directly due to the agency of the bacteria themselves, and this will explain why I say that the more favorable the condition for the growth and multiplication of the bacteria the quicker the pollution disappears.

5750 The bacteria have in general, as a source of food, dead organic matter. They in this respect have the same influence upon this organic matter as do animals, reducing the compounds from their higher or complicated states to less and less complex conditions, until finally the hydro-carbons are so reduced to water and carbon dioxide and the proteid matters, to ammonia or still further, to nitrites and nitrates ultimately; in other words, the principal role of bacteria in this regard is exactly opposite to that of green vegetation,—the latter are concerned in building up organic compounds from the simpler states, and the bacteria are reversing the process and ultimately the result is that the operations of the green vegetation are exactly destroyed; and we start over again with the condition of the substances in which we had them at first.

Sewage is richer food for bacteria than any other that
5752 commonly escapes into our river water courses from the
land, or from the surface of the earth otherwise. There is rarely found such very large numbers of organisms in river

waters except from sewage contamination, and I mean by this when the numbers run into the millions per cubic centimeter.

When, in the examination of water at different points in a river, I discover a material reduction in the number of micro-organisms I think I am entitled to infer that the matter suitable for food for these bacteria has disappeared, and since, as has just been said, sewage is the richest food commonly in such water, I may further infer that the sewage has disappeared. Plate XXIX and XXX being identifications of bacillus coli communis in the Illinois and Mississippi rivers and tributary streams, are reproduced on page 5754.

5755 Witness reads from these plates and states that this indicates that the organism is most often present in the
5756 waters of the Missouri river; next in those of the Illinois at the mouth and somewhat less frequently in those of the Mississippi, if we take into consideration the whole time of the investigation.

By reference to the graphical showing in this connection it will be seen that the less number of positive results through the whole course of the stream from Bridgeport to Mitchell was at Averyville, there being a slightly greater per centage of positive results at Grafton than at this last place. The greater number shown for the waters collected near Mitchell, seem to be due to the larger proportion or greater number in the waters of the Missouri river.

5759 In my opinion the very decided reduction of the number of the bacteria found in the course of the stream up to the time the waters reached Averyville, causing the waters at this place to assume the character of a normal river water, indicates that the contaminations from the sewage introduced into the stream from Chicago have disappeared at this point, and I cannot otherwise than conclude that the evidence now presented shows that the water at the mouth of the Illinois river at Grafton is practically free from any such contaminations introduced at Chicago.

I find also that the contamination as indicated in the water at the inlet tower at the Chain of Rocks, has a larger portion of its contamination from the water of the Missouri river rather than from the combined waters of the Illinois and the Mississippi at this point. I can say that the opening of the drainage canal has had no effect upon the waters of the Mississippi river one way or the other.

I made bacterial examinations of the waters of the Illinois river, the Mississippi river and the Missouri river in the months of October, November and December, 1901.

5760 These examinations were conducted for an extension of
the examinations made in the years 1899 and 1900 and for the same purposes so far as relates to the condition of the waters in the stream. I prepared tables which are intended to indicate the number of bacteria in a cubic centimeter, and the identifications of the bacillus coli communis in the weekly samples taken from the Illinois river at Averyville, at Pekin, at Grafton, and from the Mississippi river above the mouth of the Illinois at Grafton, and from the Chain of Rocks in the Mississippi river, and from the Missouri river at Fort Bellefontaine. The samples were collected under the direction of Prof. Palmer in the same way that they were made for the years 1899 and 1900 and were obtained from the express company at his laboratory, from which they were immediately removed to my labora-
tory on arrival. The said tables are reproduced on pages
5770 5761 to 5769 inclusive. I computed averages from the
total tests made of the water collected at each place and also the percentage of positive results from all tests made for the bacillus coli communis in each case. Plate No. XXX 1-2 showing averages graphically indicated, based upon tables heretofore introduced in evidence, showing colony counts and the presence of the bacillus coli communis as found in samples of

water taken from the Illinois, Mississippi and Missouri rivers in 1901.

5772 This series of investigations shows very closely just what was presented in the series for 1899 and 1900, already presented, and gives clear evidence that the water from the stream of Averyville is comparatively pure, or at least
5773 free from great numbers of micro-organisms, and also quite commonly free from the bacillus coli communis. The percentages of total tests which were positive in this examination proved to be 6.2.

Q. That 6.2 per cent refers to the percentage of times that you found the bacillus coli communis?

A. Yes sir. If we compare this with the water taken from the Pekin station, we find a very great difference, and it shows local contamination, since there are an average of 299,000 bacteria to the cubic centimeter, and 7.6 per cent of positive tests for the bacillus coli communis.

This pollution at Pekin seems to have disappeared at the mouth of the Illinois river at Grafton, since the average number of colonies is 8,441, and the percentage of positive tests for bacillus coli communis is 10.7.

If we compare the results from the waters of the Illinois river near its mouth, with that of the Mississippi river above the mouth of the Illinois, we find the result in regard to the number of colony counts slightly in favor of the Mississippi river as was found in the previous case, the average here being 5,407. This difference between 5,407 and 8,441, may or may not show a constant condition of things, as the difference is too small for this purpose, but the tests in regard to these two waters made for the determination of bacillus coli communis, favor somewhat the Illinois river water as against the Mississippi river water, since the percentage in the former is 10.7 and in the latter 11.5.

At the Chain of Rocks, where four samples were each time taken across the stream, the indications are that the pollution increases from the Illinois shore to the Missouri shore, as this series of counts show, namely, for the Illinois shore 52,177, for the midstream, 43,185; for the intake tower 127,862 and for the Missouri shore 32,845. This last is the only count which does not support the statement just made.

For the determination of bacillus coli communis in the same water we find beginning with the sample taken near the Illinois shore, 21.7 per cent; from midstream 50 per cent; from the intake tower 36.3 per cent; and from the Missouri shore 57 per cent.

5774 Comparing now these last result with those obtained from the waters of the Missouri river at Bellefontaine, or as it is sometimes called, West Alton, the indications are that this latter stream is considerably more contaminated, since the average number of bacteria per cubic centimeter is 127,353, and the percentage of positive tests for bacillus coli communis is 57.1.

This means, so far as this evidence can be taken to mean anything, that the waters at the intake tower are largely derived from those of the Missouri river, and to present this a little more clearly, the results of the examinations of the water from the Missouri at Bellefontaine and of those at the intake tower may be placed together. From the former, that is the Missouri, the average number of bacteria per cubic centimeter is 127,353; at the intake tower the average is 127,862. The percentage of positive tests for bacillus coli communis from the Missouri river is 57.1 per cent, and the intake tower 36.3 per cent.

The whole examination seems to indicate that the water which is comparatively pure at Averyville, becomes very greatly contaminated at Pekin, clears up again at Grafton, and at this point compares favorably with the waters of the Mississippi river above the mouth of the Illinois, and very favorably with those of the Missouri at Bellefontaine.

Q. What significance do you attach in running river water to the presence of bacillus coli communis?

A. The presence of this organism means to me more than anything else, that the water is contaminated with sewage, and that this shows its bad quality for drinking purposes.

I will say that since bacillus coli communis, and bacillus typhosus is mainly derived so far as they are found at all in water, from the same source, that the very common presence of the former may be held to give some indication, though by no means a positive proof, of the presence of the latter.

Q. Did you have any difficulty in determining the presence of the bacillus coli communis in your examinations of the water?

A. I cannot say that we did.

Q. Professor, on day before yesterday, in your testimony in this case, you gave it as your opinion that the sewage from the City of Chicago had not produced any effect either
5775 one way or the other, in the waters of the Mississippi river, covering the months of October, November and December, 1901. Please state whether you still entertain that opinion after taking into consideration the tables which you have given in evidence this morning?

A. I don't think there is anything shown by these later examinations to warrant any change in that opinion.

CROSS-EXAMINATION, by Mr. Jeffries:

I have been studying bacteriology practically ever since there was anything known of that science. Before I commenced the study of bacteriology, my line of work was cryptogamic botany. I had studied biology prior to that time.

5781 I think the preponderance of opinion would be that pathogenic bacteria in the open running streams have less advantage than they commonly have in a bacteriological laboratory test.

5786 It is certainly true that the interpretation to be made from the bacteriological examinations must be influenced by the knowledge of the physical conditions and all other matter pertaining to the sources of pollution. In answer to the question propounded by Mr. Todd, the witness stated:

5792 This bacillus is well known to all bacteriologists, and is made common use of in bacteriological laboratories for various purposes. In my own work, it has been frequently used in connection with other organisms in various kinds of water contaminated and otherwise, and the general result has been that this organism soon dies out in any kind of water.

I happen to have the exact results of an experiment made this last summer, and found that when the bacillus prodigiosus was placed in water entirely sterilized and free from other organisms and kept at about room temperature, though the room temperature at that time varied between 20 and 25 degrees Centigrade, the organism did not last over four days in a living condition. When put in with various other organisms some of which could live continuously in water, it was found that in several instances the bacillus died after a period of three days. In one instance a few of the organisms were found after a period of five days, but in no other case were there any found living up to that length of time.

I think I am entitled to the opinion that under any ordinary circumstance, bacillus prodigiosus will not live in ordinary tap water or in common river water or in sewage polluted water more than five days.

5793 From my bacterial analyses of the water of the Illinois river, I should not consider it proper water to drink. An examination of the data reveals the fact that there were on an average from seven to ten times as many bacteria per cubic centimeter in the water taken from the station at Averyville and also from the mouth of the Illinois river at Grafton as were found in Lake Michigan.

5794 The colon bacilli were found much more frequently, as a common thing, in the water at Averyville and at Grafton, than in the water of Lake Michigan as examined. That organism was very frequently found in the waters of the lake according to my remembrance. I do not think we could call that water bacteriologically pure. I should not consider it to be very desirable for domestic and drinking purposes according to these tests in many instances.

5795 I will say that a comparison of the tables will generally show that a larg number of colonies of bacteria is accompanied by positive determination of the bacillus coli communis, but there are frequent variations from this, and the particular circumstances cited by you as shown by the tests of the Illinois river at Averyville, seem to belong to this unexplainable variation in the results. I should have anticipated, after finding 102,000 bacteria from the water taken on December 9th, that there would be a positive determination of bacillus coli communis. Our results based upon the particular samples examined, seemed to show that in these samples it was not present. I should by no means take this to mean that it was absolutely absent in the water from that point at that time commonly. I am not at all surprised to find it present on December 23d, when the number of colonies as made out was 5,900. The greater variation from the ordinary results is in the first instance. But during the fermentive processes continued for some time there is among the organisms present a survival of the fittest and the special water bacteria are likely to be these which ultimately prevail, while bacillus coli communis dies out. This may be one of these instances.

I may say if I may speak generally of this series of investigations at Averyville, for the time from October to December, 1901, that the number of negative results in the tests for bacillus coli communis, is upon the whole, to me quite surprising taken into account with the total number of colonies that were found at that time.

5796 The number of bacteria at Averyville is very considerably greater than that found in the waters of Lake Michigan and the variation is greater. The number found at Jefferson Barracks is very considerably more than the number at the Chain of Rocks, as reported in tables 69 to 72 inclusive, for the Chain of Rocks, and tables 74 to 78 inclusive, for the Jefferson

Barracks. I have not figured out these averages, but as I now glance at the tables, the number is from ten to twenty times the number in the latter instance, that is the number for Jefferson Barracks.

5800 So far as typhoid fever is concerned, I have beed led to the belief and understanding that the detection of bacillus coli communis was the best practical test that we had of the possible presence of the organism causing this disease of typhoid fever. Of course there are other organisms sometimes carried in the water which can be readily identified by proper examination, and when they can be identified, that is the best evidence as to whether this water is proper for potable purposes in respect to those particular diseases.

5801 FREDERICK WILLIAM SCHULE, examined in chief by Mr. Todd:

Am a student at Ann Arbor, Michigan. In the fall of 1901, in October, November and December, I had charge of the laboratory at Peoria and did work under the supervision of Prof. Jordan.

5802 (States where samples were collected and how they were received at the laboratory, etc.)

5803 CROSS-EXAMINATION, by Mr. Jeffries:

(Witness states class of work he was engaged in, etc.)

5804 MR. TODD: I want to offer for the inspection of counsel, all the tags which have been testified to by the water takers at the various points along the river, also the cards which have been offered in evidence as Defendants' Exhibit 3, and the envelope, Defendants' Exhibit 4. I also offer in evidence Sanitary District of Chicago's Exhibit No. 11 for identification, as a sample of all the cards which I have offered for the inspection of counsel and which are in my possession and ask that same be marked Defendants' Exhibit No. 14.

5805 PROF EDWIN OAKES JORDAN, examined in chief by Mr. Todd:

Am instructor at the University of Chicago. Have been connected with the Chicago University since its opening—that is eleven years I think. I am associate professor of bacteriology.

(Witness states educational qualifications.)

5807 I have made analyses of the water of the Illinois and Michigan canal; of the Chicago drainage canal; of the Illinois river; of the Des Plaines river; of the Kankakee river; Fox river; Big Vermilion river; Sangamon river; Mississippi and Missouri rivers, and of Lake Michigan for the Sanitary District of Chicago.

There are really three periods of time, one extending from April or May, 1899, to the end of the year; the second period extending from the first of January, 1900 to the end of June, 1900, and the third period from October, 1901, to about the first of January, 1902.

5808 (Witness states where samples were taken and the places where taken are indicated on the tables which are to be hereafter introduced in evidence.)

5809 This series as I understand it was taken by agreement with the authorities of the State of Missouri at certain designated points. Those points were at Peoria from a short distance above and below the city; at Grafton at the mouth of the Illinois river, samples being taken from both the Illinois and the Mississippi at this point, and at the Chain of Rocks, the source of the water supply of St. Louis, where samples were taken across the stream as in the preceding examinations. Examinations were also made from the Missouri river at Fort Bellefontaine.

The analyses were made in laboratories which were established under my direction at Peoria, at Grafton and at St. Louis. I think the gentlemen in charge of those laboratories, with the exception of Mr. Irons, have already testified in this case. The laboratory at Peoria was in charge of Mr. F. W. Schule, a 5810 graduate of the University of Wisconsin, who came to me with recommendations as to his ability and experience in bacteriology from Professor H. L. Russell.

The laboratory at Grafton was in charge of Mr. W. S. Sayer, one of my own graduate students, trained in my laboratory and previously associated with me in other work.

The laboratory at St. Louis was in charge of Mr. E. E. Irons, and Mr. W. G. Sackett.

Mr. Irons also had general supervision of these three laboratories, and although he spent most of his time at the St. Louis laboratory, he visited the laboratories at Peoria and at Grafton at frequent intervals and made reports upon the work to me.

The men in charge of these laboratories sent in written reports of their work to me at weekly intervals and a duplicate copy of this report was also kept on file in the separate laboratories, and was turned in to me at the expiration of the work.

At a conference between Professor Palmer, Dr. Gehrmann, Dr. Reynolds, Mr. Randolph, Dr. Reiley, and myself, in the office of the Health Commissioner of Chicago, the field was gone over in some detail and certain points indicated as being favorable points for collection, in the opinion of the gentlemen attending this conference. In consequence of this conference, Professor Palmer and I were appointed to visit the places indicated, and to determine whether in our opinion these were the most suitable points for the collection of water samples and whether if, that being so, it was possible to make satisfactory arrangements with reliable persons for the collection of such samples at stated intervals.

5811 In March, 1899, we visited most of the points that I have mentioned as being the places from which samples of water were actually collected. In each case we made a special effort to obtain the services of some person whom we supposed to be trustworthy, for the purposes of collecting water samples. These persons were provisionally engaged by us through a personal interview for this purpose.

5813 These samples of water were examined physically, chemically and bacterially.

5814 In the routine work for the bacterial analyses, the number of bacteria capable of forming colonies upon a nutrient agar plate, was the principal determination. Examinations were also made to determine the relative abundance of colon bacillus. (Witness describes the methods employed in collecting, sending, and making bacterial analyses of samples for the years 1899 and 1900.)

5815 In the chemical analyses of these waters the analyses were made for residue on evaporation, chlorine, oxygen consumed, nitrogen as free ammonia, as albuminoid ammonia, nitrogen as nitrites and nitrates. (Witness states methods employed in determining the above constituents.)

5816 As to the physical character of the water, the turbidity and sediment were roughly determined in the laboratory by simple ocular inspection. The color of the water was determined by comparison with Nessler standards. The odor of the water was usually tested, but no attempt was made to classify the odors minutely.

5817 The tables on which the results of the examinations made by this witness have been indicated will be known as Jordan's Tables No. 81 to 158 inclusive.

5818 Table No. 1 reproduced in evidence.

5819 That shows the results of analytical determinations upon the water of the Illinois and Michigan canal at Bridgeport, collected in the manner stated on the days specified in the left hand column. During this period the water from the Chicago river was pumped into the Illinois and Michigan canal. The large amount of chlorine, the large amount of free ammonia and albuminoid ammonia in this water, together with the amount of oxygen consumed by dissolved and suspended matter, and the immense numbers of bacteria show that the water of the Illinois and Michigan canal was on these days simply sewage of varying degrees of concentration and staleness.

5821 Table 82 reproduced on page 5820 embodies analyses made from the water obtained from the Illinois and Michigan canal at Lockport, a distance of some 29 miles from Bridgeport during the period covered from May 5th to December 26th, 1899. The contents of the canal are but slightly diluted during this journey. The significant constituents of the water, the chlorine, ammonia and the number of bacteria show that but little change has taken place in the constitution of this sewage during this flow, except that it is further advanced in decomposition.

5823 Table 83, reproduced on page 5822, contains the detailed analyses of samples of water from the Des Plaines river at Lockport, Illinois, obtained on different days from May 5th to December 26, 1899. The amount of the several significant constituents of this water indicates a water more or less polluted. The Des Plaines river in fact receives sewage from several of the suburbs of Chicago. The point from which samples were taken was above the mouth of the present drainage canal. From the analyses of this water, as well as from the known facts regarding the entrance of sewage into the Des Plaines river, I should not regard this water as being potable at this point. At the time these analyses were made in table 83, the Des Plaines river received sewage only from the suburbs of Chicago, Riverside and other places that directly empty into it. The Des Plaines river at this point had not received any of the sewage of Chicago, entering the Chicago river.

5825 The samples of water the analyses of which appear in table 84, reproduced on page 5824, were obtained from the Des Plaines river north of Jackson street at Joliet, Illinois on the various dates between May 4th and December 26th, 1899. The Des Plaines river between the point on the Des Plaines river at which the samples appearing in table 83 were taken and Joliet, received the contents of the Illinois and Michigan canal. From the chemical and bacterial constituents of this water, it is evident that the mingling of the waters of the Des Plaines with the waters of the Illinois and Michigan canal have resulted in little alteration of the composition of the canal water. In other words, the canal water was but slightly diluted. The Des

Plaines river at this point must be regarded as a stream charged with sewage.

5827 Table 85 is reproduced on page 5826 and embodies the analyses of samples of water taken from the Des Plaines river just below the town of Joliet. The analyses were made on the various dates between May 4th, 1899, and September 18th, 1899. At this latter date the analyses were terminated owing to the interference of construction work with the taking of samples at this point. The sewage of Joliet enters the stream in this vicinity.

5828 Table 86 shows result of examination of the Chicago river at Wilmington, Illinois.

5829 Table 87, reproduced on page 5830, contains analyses of samples of water taken from the Illinois river at Morris, Illinois, between May 29th and December 26th, 1899. About nine miles above Morris the waters of the Kankakee mingle with the waters of the Des Plaines river, forming by their junction the Illinois river proper. The water of the Illinois river at Morris therefore shows the influence of dilution of the highly polluted Des Plaines river with the purer waters of the Kankakee, although the commingling is not complete at this point.

Some change in the composition of the water appears also to have taken place during its passage from Bridgeport to Morris.

Q. What is the nature of that?

A. A diminished amount of albuminoid ammonia and increased amount of free ammonia. The number of bacteria is however, still high.

5833 Table No. 88, reproduced on page 5832, includes the analyses of water from the Fox river near its mouth at Ottawa, Illinois, the samples being taken from between May 29th and December 28th, inclusive, 1899.

Sewage from several towns enters the Fox river, the principal towns being Elgin, with a population of about 22,000, and Aurora with a population of about 26,000. Aurora is about 40 miles about the mouth of the Fox, and Elgin about 55 miles.

The composition of the water is what might be expected from its origin.

It is a river water receiving some sewage.

5835 Table No. 89, reproduced on page 5834, contains the results of analyses of water from the Illinois river at Ottawa, Illinois, samples being taken from June 19th, to Decemreb 28th, 1899. In the flow from Morris to Ottawa a very considerable change takes place in the composition of the water. This is partly due to more thorough mixing, but in a large part due to changes in the constituents of the water. The albuminoid ammonia and free ammonia, the oxygen consumed the number of bacteria are all lower than at Morris, indicating that a really considerable purification of the water has taken place during its passage from Morris to Ottawa.

5837 Table 90, reproduced on page 5836, includes the analyses of water from a tributary of the Illinois river, the Big Vermilion river, entering the Illinois above La Salle. Samples of water being taken a short distance above the mouth of the Big Vermilion, between May 24th, and December 26th, 1899. The sewage of Streator and Pontiac enter the Big Vermilion. The determinations for chlorine and residue on evaporation were influenced by the operations of a cement factory a short distance above the point of collection. This affords an explanation for the large amount of residue on evaporation and for the high chlorine in September, October and November of this year.

5839 Table No. 91, reproduced on page 5838, contains the analyses of samples of water from the Illinois and Michigan canal at La Salle. The samples were taken between May 24th, and December 26th, 1899. The samples were taken just before the canal discharges into the Illinois river. Some of the sewage from La Salle enters the canal.

The large amount of free ammonia and albuminoid ammonia and the large number of bacteria show considerable pollution is present at this point.

5841 Table 92, reproduced on page 5839 contains the analyses of samples from the Illinois river at La Salle. The samples were taken above the town and were taken between May 24th, and December 26th, 1899.

The various determinations show that considerable purification has taken place in the Illinois river during the flow from Ottawa to this point, a distance of 22 miles.

5843 Table 93, reproduced on page 5842, contains the analyses of water from the Illinois river at Henry, Illinois. The samples were taken between May 30th and December 27th, 1899. The samples at Henry were taken above the dam. At La Salle the sewage and drainage of La Salle and Peru, with a combined population of about 17,000 enters the Illinois and Michigan canal, which discharges into the river, and into the river itself. Little additional impurity enters the river between La Salle and Henry, and little dilution enters.

5845 Table 94, reproduced on page 5844, contains the analyses of samples of water from the Illinois river at Averyville, Illinois, the samples being taken on various dates between May 30th and December 26th, 1899.

Between Henry and Averyville there is practically no addition of impurity and little dilution, so that the changes occurring in this flow of 36 miles are due to oxidation and other processes. The point where the samples were taken is at the place known as the Narrows, near the Peoria waterworks above the city of Peoria, and before any pollution from the city enters the river.

The large amount of nitrogen in the form of nitrates at this point shows that a very considerable amount of oxidation of the organic matter has taken place. The small number of bacteria shows that the stream which was originally laden with the bacteria of the Chicago sewage derived from the Illinois and

Michigan canal has practically freed itself from these bacteria in this flow of about 160 miles.

5847 Table 95, reproduced on page 5846, contains analyses of samples of water taken from the Illinois river a short distance below Peoria near the place know as Wesley City. The samples of water were taken on different dates from May 29th, to December 28th, 1899. A large part of the sewage of Peoria, a city with a population of about 60,000, enters the Illinois river between Averyville and Wesley City. In addition to the house sewage the discharges from extensive stock yards, the slop from distilleries and other refuse enter the river above this point of collection. The large number of bacteria in the water indicates the organic character of a large part of this pollution and shows the extent as well as the nature of the defilement.

5849 Table 96, reproduced on page 5848, contains analyses of samples of water taken from the Illinois river at Pekin between May 24th, and December 28th, 1899. The mixing of the Peoria sewage and refuse with the river water has become more nearly complete by the time this point is reached, and in addition to the sewage of Pekin, a city with a population I believe of about 8,000, has entered the river, together with considerable distillery refuse. The sample was taken far enough below Pekin to get the effect of all this pollution, and so far as practicable to show the mixing of the pollution, although here, as at Wesley City, the amount of pollution shown by the water in the middle of the stream was not the same at all times.

5851 Table 97, reproduced on page 5850, contains analyses of samples of water from the Illinois river at Havana, Illinois, the samples being taken between May 30th, and December 20th, 1899. A considerable degree of purification takes place between Pekin and Havana, as shown by the different determinations in this table.

5853 Table 98, reproduced on page 5852, contains analyses of samples of water taken from the Sangamon river at Chandlerville, Illinois, between May 31st, and December 20th, 1899. The samples from this river were taken from Chandlerville because it is the last easily accessible point above the mouth of the Sangamon. Chandlerville is about 20 miles above the mouth. A very considerable amount of sewage enters the Sangamon river and its tributaries, from Springfield, with a population of about 35,000; from Bloomington, with a population of about 24,000; and from Decatur with a population of about 20,000. This very considerable amount of pollution is not particularly manifest in any of the determinations in this particular table, but it comes out with considerable clearness in the determinations that were made for the relative abundance of the colon bacillus, as will be shown in tables that will be presented later.

5855 Table 99, reproduced on page 5854, contains analyses of water from the Illinois river at Beardstown, Illinois, taken between May 24th, and December 28th, 1899. Between Havana and Beardstown the Sangamon river enters, but otherwise little additional impurity is added to the river.

5857 Table 100 contains analyses of samples of water taken from the Illinois river at Kampsville, Illinois, between May 31st and December 20th, 1899. Between Beardstown and Kampsville only a very small amount of polluting material enters the Illinois river. In fact, from Beardstown to the mouth of the river at Grafton, the polluting matters entering the river are relatively insignificant. Some dilution, however, occurs from small tributary streams. The small number of bacteria found on many occasions in the water of the Illinois river at Kampsville, together with the amount of nitrates in the water, shows that the river at this point has practically regained the condition that it possessed at Averyville, above Peoria.

5859 Table 101, reproduced on page 5858, contains the analyses of samples of water taken from the Illinois river at its mouth at Grafton, the samples being taken between May 10th and December 27th, 1899. These samples were taken at a point in the Illinois river where no mixing with Mississippi river water was possible. The condition of the Illinois river at this point compares very favorably chemically and bacterially with the water of the Illinois river at Averyville and with the tributary streams entering the Illinois.

5861 Table 102, reproduced on page 5860, contains the analyses of samples of water taken from the Mississippi river at Grafton, Illinois, the samples being taken between May 10th and December 27th, 1899. The collections were made at a point in the Mississippi river where no mixing of water with the Illinois river was possible.

From a sanitary standpoint, the water of the Mississippi river above Grafton, does not differ materially so far as can be determined by chemical and bacterial examinations, from the water of the Illinois river at its mouth.

5867 Tables 103, 104, 105, 106 and 107 are reproduced on pages 5862 to 5866 inclusive, and contain results of analyses of samples of water taken from the Mississippi river above Alton, about twenty miles below the mouth of the Illinois river. The samples were taken at approximately equi-distant points across the river, with a view to determining so far as practicable, the extent of mingling of the waters of the Illinois and the Mississippi rivers at this point.

Table 103 contains the analyses of samples taken 100 feet from the Illinois shore.

Table No. 104 contains the analyses of samples taken one-fourth of the distance from the Illinois shore to the Missouri shore.

Table 105 contains the analyses of samples taken from mid-stream.

Table 106 contains the analyses of samples taken one-third of the way from mid-stream to the Missouri shore.

Table 107 contains the analyses of samples taken from the Mississippi river 100 feet from the Missouri shore.

The degree of the commingling of the waters of the Illinois and Mississippi at this point is approximately shown by the chlorine determinations. The higher chlorine on the east bank shows that a portion of the Illinois river water still hugs the

Illinois shore, and that the water west of mid-stream to the right bank was largely if not altogether Mississippi river water.

5869 Table 112, reproduced on page 5868, contains the analyses of samples of water taken from the Missouri river at Fort Bellefontaine, West Alton, Missouri, between July 27th and December 28th, 1899.

Owing to difficulties in making arrangements for collection of samples, the analyses of water from this source were begun later than in the other cases, so that the average of these determinations is not strictly comparable with averages of other determinations covering a different period.

5874 Tables 108, 109, 110 and 111 are reproduced on pages 5870 to 5873 inclusive. These tables contain analyses of samples of water taken in cross-section from the Mississippi river at the Chain of Rocks opposite the pumping station of the St. Louis waterworks.

Table 108 contains the analyses of samples taken about 400 feet from the Illinois shore.

Table 109 containing the analyses of samples taken in midstream.

Table 110 contains the analyses of samples taken at the inlet tower of the St. Louis waterworks.

Table 111 containing the analyses of samples taken from the Mississippi river 400 feet from the Missouri shore.

Between Alton and the Chain of Rocks, the Missouri river enters the Mississippi river some six miles above the point of collection.

The Missouri river like the Illinois river, has a high chlorine content, and contains as a rule, more bacteria per cubic centimeter than the waters of either the Mississippi or the Illinois.

5880 Tables 113, 114, 115, 116 and 117, contain analyses of a series of samples taken from the Mississippi river at Jefferson Barracks, Missouri, about nine miles south of Eads bridge.

Table 113 containing the analyses of samples from the east bank, 100 yards from the Illinois shore.

Table 114 containing the analyses of samples taken between this point and mid-stream.

Table 115 the analyses of samples taken from mid-stream.

Table 116 containing the analyses of samples taken from a point one-third of the way from mid-stream, to the Missouri shore.

Table 117 containing analyses of samples taken about 100 yards from the Missouri shore.

I might state that the sewage of St. Louis enters the Mississippi river above Jefferson Barracks.

These tables are reproduced on pages 5875 to 5879, inclusive.

5882 Table 118, reproduced on page 5881, contains the analyses of samples of water drawn from the tap in the city of St. Louis, Missouri. The diminished amount of suspended matter and the smaller number of bacteria in the tap water bear witness to some of the changes effected in the passage of the Mississippi river water through the settling basins. These tables that have been read in evidence, numbered 81 to 188, inclusive, are for periods prior to the opening of the canal. The printed tables numbered from 119 to 158 inclusive, cover the period from the 1st of January to June, 1900, after the canal was opened.

5884 Table 119, reproduced on page 5883, contains the analyses of water taken from the Chicago drainage canal at Kedzie avenue, nine samples of water being taken between April 30th, and June 25th, 1900. As compared with the character of the water in the Chicago river pumped into the Illinois and Michigan canal at Bridgeport during the period covered by the analytical work of 1899, these analyses indicate a water proportionately much less impure and much less heavily loaded with organic matter.

5886 Table 120, reproduced on page 5885, contains analyses of samples of water taken from the Illinois and Michigan canal at Bridgeport, from January 2d, to April 23d, 1900. Some effect of the dilution of the contents of the Chicago river is shown by the various determinations being during this period less highly charged with putrescible organic matter than was the case before the opening of the drainage canal with the consequent influx of purer water from Lake Michigan. At the same time the proximity of the pumping station at Bridgeport to the south Branch of the Chicago river, which is a practically dead end, allowed at times much organic matter and many bacteria to enter the canal.

5888 Table 121 contains the analyses of water taken from the Illinois and Michigan canal at Lockport from January 2d to June 25th, 1900.

The change in flowing from Bridgeport to Lockport during this period is as in the 1899 series, not a marked one.

5890 Table 122 reproduced on page 5889 contains analyses of samples of water taken from the Des Plaines river at Lockport between January 2d and June 25th, 1900. During this period more water was flowing down the Des Plaines valley than in the 1899 period, and this led to a change in the composition of the water that is shown among other things by the increased number of bacteria.

5892 Table 123, reproduced on page 5891, contains analyses of samples of water taken from the Chicago drainage canal at the Bear Trap Dam at Lockport, between April 16th and June 25th, 1900.

5894 Table 124, reproduced on page 5893, contains analyses of samples of water taken from the Des Plaines river north of Jackson street at Joliet, between January 2nd, and June 25th, 1900. Owing to the work in progress on the levees in the neighborhood of Joliet during the latter part of 1899 and 1900, the samples from this station were not always taken at exactly the same point, and some of the divergencies shown by the analytical data can properly be attributed to this fact.

5896 Table 125, reproduced on page 5895, contains analyses of samples of water taken from the Des Plaines river at Jefferson street, Joliet, between March 5th and June 25th, 1900. The statements made in regard to the collection of samples at Jackson street, Joliet, (table 124) apply here also.

5898 Table 126, reproduced on page 5897, contains analyses of samples of water taken from the Kankakee river at Wilmington from January 2nd to June 23rd, 1900.

I should like to make a correction in the column of figures under "Height of water." The first two figures in the column refer to feet. The following figures to height of water in inches, which by an oversight were not reduced to feet as they should have been to be strictly comparable with the 1899 table. One of the chief differences between the analyses of the Kankakee river for 1899 and 1900, appears in the number of bacteria per cubic centimeter, the number being higher through the winter and early spring months of 1899.

5900 Table 127, reproduced on page 5899, contains the analyses of samples of water taken from the Illinois river at Morris between January 5th and June 26th, 1900. During the month of January the conditions were not dissimilar to those prevailing during 1899, but the analyses for subsequent days show in several ways the effect of the dilution of the Chicago sewage in the Chicago drainage canal.

The smaller amount of chlorine particularly is evidence of this increased dilution and on several occasions notably in the month of May, the number of bacteria in the Illinois river at this point was lower to a striking degree, than at any time in the preceding period.

Q. How is the great number of bacteria in the month of January and the small number of bacteria in comparison in the months of April, May and June, explained in this table 127?

A. The difference may be in part at least explained by the fact that during the early part of January, 1900, the water from the drainage canal was not flowing into the Des Plaines river, but the water from the Illinois and Michigan canal was entering the Des Plaines river during that period.

5902 Table 128, reproduced on page 5901, contains analyses of samples of water from the Fox river at Ottawa between January 4th and June 25th, 1900.

During the early part of this period the number of bacteria was much higher than in the period of 1899 and much higher than for the latter part of April and for May and June, 1900. This is a phenomenon of common occurrence in river waters and so far as I am aware no adequate explanation of this occurrence has been adduced.

5904 Table 129, reproduced on page 5903, contains analyses of samples of water from the Illinois river at Ottawa between January 4th and June 25th, 1900. The various determinations chemical and bacterial, especially those showing the amount of albuminoid ammonia, free ammonia and nitrates and the number of bacteria per cubic centimeter, indicate that a considerable change in the direction of purification has taken place between Morris and Ottawa as in 1899.

5906 Table 130, reproduced on page 5905, contains analyses of samples of water from the Big Vermilion at La Salle, the samples being taken between January 2nd and June 26th, 1900. The number of bacteria during this period is on the whole higher than in the period for 1899. The amount of free ammonia during the first part of this period is much higher than in the latter part of the period.

5908 Table 131, reproduced on page 5907, contains analyses of samples of water from the Illinois river at La Salle between January 2nd and June 26th, 1900. During the months of January, February and March, the number of bacteria in the river is, as in the other river waters that have been considered, much higher than during 1899. The amount of free ammonia is likewise much higher during the first part of this period than during the latter portion.

5910 Table 132, reproduced on page 5909, contains analyses of samples of water from the Illinois and Michigan canal at La Salle from January 2nd to June 26th, 1900. I should like to strike out in table 131 the height of water in the Illinois river at La Salle for February 6th, as being obviously a clerical error.

5912 Table 133, reproduced on page 5911, contains analyses of samples of water from the Illinois river at Henry between January 3rd and June 25th, 1900. Here again is shown the increase in the number of bacteria in the river water during the late winter and early spring. This has already been shown to be a common phenomenon in river water and occurs in the tributaries of the Illinois as well as in the Illinois itself. The diminished chlorine in the latter part of this period shows the effect of the dilution due to the opening of the Chicago drainage canal.

5914 Table 134, reproduced on page 5913, contains analyses of samples of water in the Illinois river at Averyville from January 2nd to June 26th, 1900. Both the effects of purification and dilution are shown in this table, especially during the latter part of the period when the effect of the condition of early spring had disappeared.

5916 Table 135, reproduced on page 5915, contains analyses of samples of water in the Illinois river at Wesley City. The smaller number of bacteria during this period as compared with the 1899 period shows that the pollution entering the Illinois river at Peoria, has been crowded in part towards the western bank and does not make its presence so evident in mid-stream as was the case during 1899.

5918 Table 136, reproduced on page 5917, contains analyses of samples of water taken from the Illinois river at Pekin from January 11th, 1900, to June 27th, 1900.

The effect of pollution here in mid-stream sample is more manifest than in the samples from Wesley City owing possibly to a more thorough mixing at this point.

5920 Table 137, reproduced on page 5919, contains analyses of samples of water taken from the Illinois river at Havana, between January 11th and June 27th, 1900. The purification in the river as shown by the amount of nitrates and the number of bacteria is manifest here as well as in the 1899 period.

5922 Table 138, reproduced on page 5921, contains the analyses of samples of water from the Sangamon river at Chandlerville, from January 3rd and June 27, 1900. The usual spring increase in the number of bacteria is manifest at this point as in the other tributaries of the Illinois and in the Illinois river itself.

5924 Table 139, reproduced on page 5923, contains analyses of samples of water from the Illinois river at Beardstown from January 4th to June 28th, 1900. Taking into consideration the greater dilution of the water at this point, the analytical data are not materially different from those covering the 1899 period.

5926 Table 140, reproduced on page 5925, contains analyses of samples of water taken from the Illinois river at Kampsville from January 3rd to June 27th, 1900. The usual spring rise in the number of bacteria, the amount of free ammonia and albuminoid ammonia and so on, is manifest here as elsewhere, but during the latter part of the period the condition of the water both chemically and bacterially compares very favorably with that in the 1899 period.

The number of bacteria averages less at Kampsville than at Averyville. The amount of free ammonia is on the whole lower. The albuminoid is very similar.

The nitrates are on the whole lower at Kampsville than at Averyville during this period.

The nitrates are also lower, and the oxygen consumed on the whole does not differ materially.

5928 Table 141 reproduced on page 5927 contains analyses of samples of water from the Illinois river at Grafton, taken between January 4th, and June 29th, 1900.

A very considerable degree of purification is shown chemically, and in the latter part of the period bacterially also, as compared with the collecting stations in the upper stretches of the river. The increased volume of water in the Illinois river, especially in the months of March and April, is reflected in the lower chlorine content during this period.

5930 Table 142 reproduced on page 5929 contains analyses of samples of water taken from the Mississippi river at Grafton, Illinois, the samples being collected between January 4th and June 29th, 1900.

The amount of albuminoid ammonia in the water of the Mississippi during this period is on the whole somewhat higher than the amount in the Illinois river in samples taken on similar dates.

5936 Tables 143 to 147 reproduced on pages 5931 to 5935, inclusive, show the analyses of a series of five samples taken approximately equi-distant points, across the Mississippi above Alton, Illinois.

The points of collection were the same as during the 1899 period.

The analyses show that in the 1899 period, there is a lack of complete commingling of the waters of the Illinois and Mississippi river at this point, the water derived from the Illinois river clinging as before, to the left bank of the Illinois shore, as is shown particularly by the chlorine and nitrate determinations.

5938 Table 152 reproduced on page 5937 contains the analyses of samples of water taken from the Missouri river at Fort Bellefontaine, West Alton, Missouri, between January 4th and June 27th, 1900.

The large amount of suspended matter carried by the Missouri river in high water periods is shown by these determinations, especially by the suspended residue on evaporation, by the amount of oxygen consumed by suspended matter, and by the amount of nitrogen present in the form of albuminoid ammonia in suspended matter. Throughout the greater part of this period also the number of bacteria in the Missouri river water was high.

5943 Tables 148, 149, 150 and 151 reproduced on pages 5939 to 5942, inclusive, contain analyses of samples of water taken from the Mississippi river opposite the pumping station of the St. Louis waterworks at the Chain of Rocks between January 5th and June 28th, 1900, the samples being collected from the same points as were specifically designated for the 1899 period.

The considerable amount of suspended matter, as is shown by the residue on evaporation, which was present in the water of the Mississippi river at the inlet tower and in midstream at this point, when compared with the smaller amount of suspended matter in the Mississippi river above the entrance of the Missouri, indicates that the major part of the water entering the St. Louis water intake during the period covered by these analyses was derived from the Missouri river than from the Illinois.

5949 Tables 153, 154, 155, 156 and 157 reproduced on pages 5944 to 5948, inclusive, include samples of water taken from the Mississippi river at Jefferson Barracks, Missouri, below the city of St. Louis, between January 4th and April 26th, 1900, the points at which the samples were collected being the same as those specified more particularly for the 1899 period. Aside from the changes attributable to the differences already noted in the composition of the Illinois, Mississippi and Missouri river waters, the analyses at this point contained nothing of special significance.

5951 Table 158, reproduced on page 5850, contains analyses of samples of water drawn from the tap at St. Louis, Missouri, the samples being collected between January 4th and June 28th, 1900. The large amount of suspended mater in the water of the Missouri river during the latter part of this period is reflected in the increased residue on evaporation in suspended matter in the tap water, although the reduction in pasage

through settling basins is very great. (Motion by Mr. Jeffries to strike out tables No. 81 to 158.) The physical characters of the water have been roughly determined with reference to the amount of turbidity, amount of sediment, the color and odor. Little or no sanitary importance can be attached to the turbidity, sediment and color in the cases under consideration. As regards the odor of the water, it is found that, in general, waters containing a large amount of organic matter in
5952 the early stages of decomposition, possess an offensive
odor readily perceived by the senses, while less impure water or waters further advanced in the procession of oxidation possess little odor, or, it may be, none at all. It sometimes happens, however, that waters containing a large number of microscopic forms of life, chiefly algae and infusoria, yield odors that are more or less offensive, and that simulate the odors of decomposition. The death and disintegration of these microscopic forms may likewise be the cause of disagreeable smells. Offensive odors, then, may or may not be accompanied by dangerous sanitary qualities.

Turning next to the various chemical determinations, we may first consider the residue on evaporation. This determination gives information as to the amount of solid substance remaining after the water in which it was dissolved or suspended has been completely evaporated. During the process of thorough drying, certain substances, organic and mineral, are decomposed and driven off.

In general polluted waters contain a rather high residue on evaporation, but in certain cases the residue on evaporation may have reference simply to harmless mineral matters in suspension. In all cases a distinction was made between the dissolved residue on evaporation and the suspended residue on evaporation, the determinations being made both upon filtered and unfiltered samples, the difference between the two being taken as the weight of the residue in suspension.

The determinations of chlorine may next be considered. Chlorine is present in practically all natural waters in combination with sodium in the form of sodium chloride or common salt. Owing to the large amount of salt in urine and in various forms of household waste, it has been found that sewage contains an amount of chlorine in marked excess of that present in most natural and unpolluted ground and surface waters.

When the amount of chlorine normally present in the unpolluted wells and springs of a given district is accurately known, it becomes possible to determine with a considerable degree of precision the amount of pollution existing in the various ground and surface waters of that region which have received a larger or smaller amount of drainage.

The content of a water in sodium chloride is therefore under some conditions a fairly satisfactory gauge of the
5953 sanitary condition of that water. Owing to the permanence of the salt, however, the amount of chlorine in a polluted water does not afford conclusive indications as to whether the pollution is recent or remote. In following the passage of salt down stream in a polluted river, the permanency of this substance renders it a valuable indication of the degree of dilution and mixing, but on the other hand, does not afford a clue to the rapidity and extent with which processes of oxidation and bacterial purification are taking place.

The determinations known as oxygen consumed concerns especially the carbonaceous matter in the water.

The significance of this determination lies in its comparative rather than its absolute value, since the amount of oxygen consumed as determined by the quantity of permanganate solution consumed during heating, is affected materially by the period of heating, and by other factors. Exact uniformity of the analytical process involved is therefore of great importance, and in order that the results in one and the same laboratory shall be strictly comparable throughout it is necessary to maintain perfect uniformity of procedure. The changes necessary to maintain perfect uniformity of procedure. The changes taking place in carbonaceous matter in a water cannot be followed step by step as is the case with nitrogenous compounds, since the carbon di-oxide formed in decomposition processes either goes off, or enters into combination with mineral elements.

The most significant organic compounds in a polluted water are those of nitrogenous character. These nitrogenous compounds are usually determined in four different states, as albuminoid ammonia or organic nitrogen, as free ammonia, as nitrites and as nitrates.

If we follow the history briefly of the waste nitrogenous compounds discharged from the animal body it is as follows:

These compounds are at first relatively complex and are chemically highly organized bodies. When subjected to bacterial action free ammonia is liberated from these substances, and enters into loose combination with certain of the elements present in the water or sewage. When a water into which such matters have been received a short time before is heated, the ammonia is driven off in the steam and can be collected and measured with a considerable degree of accuracy.

This is the so-called free ammonia in the analytical tables.

The nitrogen in the more chemically complex substances 5954 on the other hand, is for the most part not driven off by this process. This is the so-called albuminoid ammonia, the amount of which, however, can be determined by heating in an alkaline solution in the presence of permanganate, destruction of the albumen or nitrogenous molecule taking place under these conditions. This process results in the liberation of ammonical compounds which can then be distilled over, collected and measured by the same method as used for the determination of the free ammonia.

In general it may be said that a fresh sewage contains a relatively large proportion of nitrogen in the form of albuminoid ammonia, while a stale sewage contains a smaller proportion of nitrogen in the form of albuminoid ammonia, bacterial activity having converted the albuminoid ammonia into free ammonia.

These early stages in the decomposition of organic matter are followed by oxidation processes which result in the conversion of the free ammonia of the water into nitrites, nitrites being less highly energized compounds than the ammonical compounds from which they have been derived. The reason for this oxidation process resides in the need of bacteria for food. Food being matter containing available potential energy, many kinds of bacteria are able to obtain this energy from the ammonium compounds.

Under favorable conditions the process of oxidation does not stop here, as certain bacteria are able to obtain the energy necessary for their development even from compounds containing so little available potential energy as nitrites, and are able to carry on their vital processes with the aid of the energy derived from the oxidation of the nitrites, which by virtue of this bacterial activity are converted into mineral nitrates, the nitrogen then passing successively through the various stages of albuminoid ammonia, free ammonia, nitrites and nitrates. The oxidation of the free ammonia into nitrites and of the nitrites into nitrates is what is termed the process of nitrification. The importance of these facts from the sanitary side is due to the connection of these oxidation processes with processes of purification.

5955 In general, large amounts of albuminoid and free ammonia indicate the existence of products of decomposition, while the presence of a large amount of nitrate, together with little free and albuminoid ammonia and little nitrite, characterizes a water which may perhaps in the past have received a considerable quantity of polluting matter, but which after the lapse of time, and through bacterial activity has become relatively stable. It has been found empirically that waters in which these oxidation processes have taken place, less commonly give rise to disease, or are a source of danger, than waters that have received recent pollution, as indicated by the relatively high amounts of free and albuminoid ammonia.

The number of bacteria in a water is usually determined by mixing an accurately measured quantity of the water with nutrient beef jelly and then pouring the mixture out into a sterilized glass dish. The theory underlying this procedure is that each germ originally present in the water, finding itself in a favorable nutrient medium, grows, multiplies and in a few hours or days has formed about itself a growth or colony large enough to be plainly visible to the naked eye.

Different kinds of bacteria form colonies that can be distinguished, one from the other, by various physical characters. The kinds of bacteria in a water vary greatly in their sanitary significance, most being perfectly harmless saphrophytic forms, which do not so far as is known, have any injurious effect upon the human system, even when taken into the alimentary tract in large quantities. Others, the poisonous or so-called pathogenic germs, are able when taken into the animal body, under suitable conditions, to produce poisonous substances which damage the organism.

The number of bacteria per cubic centimeter as enumerated in the analytical tables 81 to 158 includes the colonies of all kinds developing upon the bacterial plates, no distinction being made between the harmless and injurious kinds.

By enumerating the number of colonies occurring on one of these plates of beef jelly or nutrient gelatin, some approximation can be arrived at regarding the number of germs originally present in the water, although the absolute number of bacteria
in water is not always convincing evidence of the sanitary
5956 quality of water, since under certain laboratory conditions, bacteria may be made to multiply in a pure water.
At the same time experience has shown that in waters collected under natural conditions from springs, rivers, lakes and reservoirs, the purer waters contain fewer bacteria, while those waters that are polluted with sewage or large quantities of organic matter, contain numbers of bacteria much in excess of those found in purer waters. Under natural conditions, it is in general true, that as the food supply of bacteria diminishes, the

number of germs becomes fewer, while an influx of food material favors the longevity of certain bacteria and their further multiplication. Surface waters contain as a rule, larger numbers of bacteria than ground waters, which have been freed of a portion of their bacterial content by filtration through layers of sand or soil. It has been observed that the water of a sewage polluted river may contain large numbers of bacteria just below the source of the pollution, but that these numbers diminish with the passage of the water down stream.

I have made a table of comparative averages of the different chemical and bacterial analyses from tables No. 81 to 158 both inclusive for the years 1899 and 1900.

5957 This table of averages is designated as Table E and Table E continued, and is contained on two sheets and reproduced on pages 5958 and 5959.

5960 From an examination and consideration of the tables of separate analyses and the tables of averages for this period, the period of 1899, it appears that the water in the Illinois and Michigan canal at Bridgeport and Lockport, as well as the water of the Des Plaines river at Joliet and of the Illinois river at Morris, contained throughout this period a large amount of nitrogenous organic matter in the early stages of decomposition. It appears also from the large amount of chlorine present in these waters that the initial pollution of the Illinois river reached a considerable height during this period. The large number of bacteria present in these waters shows that the substances capable of serving as food for these organisms were present in great abundance.

5961 The tables and averages also show that by the time the Illinois river reaches Ottawa, being somewhat diluted in its course by the purer waters of the Kankakee, mingling with which is incomplete at Morris, a very great change has taken place in the composition of the river water, a change which is manifested especially by the diminution in the amount of albuminoid ammonia by the increase in the amount of nitrites and nitrates, and particularly by an enormous and significant diminution in the bacterial content.

The oxidation of the organic matter continues with the passage of the water down stream and by the time the flow reaches Averyville the amount of free ammonia is greatly diminished as compared with the amount at Ottawa. The amount of albuminoid ammonia is diminished. The amount of nitrates has greatly increased, while the bacteria which were present in such enormous numbers in the waters of the upper Illinois have now sunk to a point where they can be compared with the number present in ordinary surface waters in the United States and with the number present in the tributaries of the Illinois during this period.

Below Averyville the Illinois river receives a large influx of polluting material from Peoria with its stock yards and distilleries, which is evidenced by the increase in some of the significant constituents in the river water, notably in the free ammonia and the albuminoid ammonia and in the number of bacteria.

At Pekin some additional sewage is received and the mingling of the Peoria sewage with the Illinois river water has become more perfect. From Pekin to the mouth of the river, the purification follows a generally progressive course, until by the time the mouth of the river is reached at Grafton, the amount of free and albuminoid ammonia, the oxygen consumed by the carbonaceous matter and the number of bacteria are again low, while the relatively large amount of nitrates bears witness to the practically complete oxidation of the enormous amount of organic matter with which the sewage was laden at Peoria, as well as that with which it originally set forth at Lockport.

5963 The conditions in the Illinois river during the larger part of the period covered by these investigations are shown by analyses of samples collected at the same points and under the same conditions as in 1899, the whole series of analyses from May, 1899, to the end of June, 1900, forming one continuous period.

From April to June, 1900, analyses were made of the water from the Chicago drainage canal at Kedzie street and at Lockport. These analyses show that as compared with the condition of the water in the Chicago river considerable dilution has taken place as witnessed particularly by the chlorine determination, as well as by similar changes in the other constituents of the sewage.

A mingiling of the waters coming from the Chicago drainage canal at Lockport and from the Illinois and Michigan canal at Lockport, with the waters of the Des Ploines river which is subsequently joined by the Kankakee, took place during this period. The first admixture of the waters of the drainage canal took place on the 17th of January, 1900, after the canal had been filled and the gates finally opened.

Examination of the separate analyses of the samples of water from the Illinois river at Morris and also of the averages of these analyses, shows that the water of the river at this point was charged with organic matter; that it contained a large amount of nitrogen in the form of albuminoid and of free ammonia; that the amount of oxygen consumed was high, and that the number of bacteria was still large.

5964 The samples of water taken from the Illinois river at Ottawa during this same period showed that considerable purification took place between Morris and Ottawa, the amount of free ammonia and of albuminoid ammonia and of oxygen consumed, being diminished, and the number of bacteria being little more than one-fourth the number in the Illinois river at Morris during this period.

By the time Averyville is reached the process of purification had proceeded still farther, both free and albuminoid ammonia being notably lower than at Ottawa.

At this station also the amount of nitrate was high, showing that considerable nitrification had taken place in the flow from the drainage canal to this point. The number of bacteria was not half as great as in the Illinois river at Ottawa during the same period.

A further addition of polluting water took place at Peoria and Pekin, with the result that in the lower half of the river the process of purification had again to be completed. How complete this purification was may be seen from the determinations at Grafton for this period, the amount of free and albuminoid ammonia in the water and the amount of nitrates indicating that this purification followed a parallel course to the purification in the upper half of the river.

The second period, the conditions in which have been just described, has been arbitrarily separated from the first period, namely, that for the months May to December 1899, but the analyses show plainly that the essential course of events in the water of the Illinois river is the same, whether a period of two months, or five months or fourteen months, be considered.

In all cases the same phenomenon is noticed. The water at the outset, highly charged with putrescible organic matter and laden with sewage material, regains in the course of about 130 miles flow the condition usually existing in surface waters in this country.

5965 Witness gives reasons for the following statement: From
5966 a comparison of the analytical data therefore, at this point, it is evident that the separation of the two periods on the basis of calendar years, is from the point of view of sanitary water analysis, an arbitrary one, and does not bear any definite relation to any meteorological or biological conditions. So far as the chemical and bacterial determinations show, the condition of the Illinois river at Averyville, Kampsville and Grafton differs in but slight and insignificant particulars from the waters of the tributary streams. Witness then makes comparisons between the tributaries of the Illinois and the waters of the Illinois at various points.

5967 The number of bacteria in the Illinois river at Grafton being lower than the number in the Sangamon river at Chandlerville, and almost exactly the same as the number in the Fox river at Ottawa, and the Big Vermilion river at La Salle for this period; so that considered from the point of view of a comparison of the chemical and bacterial analyses, the condition of the Illinois river at Averyville, Kampsville and Grafton, compares favorably with the important tributaries of the Illinois.

5968 Throughout the period covered by this investigation, namely, from May, 1899 to the end of June, 1900, the water of the Illinois river at Pekin was usually in a more highly polluted condition chemically and bacterially, than the water of the Illinois river at Averyville. The large amount of sewage and refuse that enters the Illinois river at Peoria and at Pekin offers a sufficient explanation in my opinion for the increased pollution of the Illinois river at this point as compared with the condition of the river above Peoria, at Averyville, before this pollution enters. It is a somewhat difficult question to answer as to how far down the river from Peoria the pollution which the Illinois river takes on at Peoria, disappears, because the conditions undoubtedly vary at different times of the year and with different rates of flow. The water of the Illinois river at Havana is on the whole, considered in the light of the chemical and bacterial examinations given in these tables in a less satisfactory condition than the water of the Illinois river at Averyville. The same might possibly be said on some occasions, of the water of the Illinois river at Beardstown; at Kampsville and at Grafton. However, the water of the Illinois river at Grafton, is usually in a condition very similar to that obtaining at Averyville. Peoria is about 124 miles from Kampsville and Averyville is about 130 miles from Lockport. During this entire period my chemical and bacterial examinations do not disclose the presence at Kampsville of the sewage from Chicago whether from the Illinois and Michigan canal for the first part of this period or from the Chicago main drainage canal for the second, so far as the number of bacteria in the water is concerned,
5969 nor do they, so far as the various chemical determinations of albuminoid ammonia, oxygen consumed, nitrites and nitrates are concerned. The large amount of chlorine that enters the Des Plaines river along with the Chicago sewage, is,

however, permanent, and not being liable to destruction by various influences, as is the case with the nitrogenous organic matter and the bacteria, that are added in the Chicago sewage, the chlorine manifests itself at Kampsville and Grafton, and even beyond, into the Mississippi river.

Q. Does the presence of chlorine in the water of a river in the absence of the other chemical ingredients or constituents of sewage indicate of itself the presence of sewage pollution?

A. In my opinion the presence of chlorine under those conditions would be absolutely devoid of sanitary significance. It would be possible for a stream in the condition that the Illinois river was in at Kampsville, to be passed around the world several times in a closed conduit, consuming years or decades in the process, without altering materially the amount of chlorine in the water, although it is my judgment that, supposing the water were at the outset injurious to health, in the course of such a passage and in such a time, it would become entirely free from any injurious qualities it might have originally possessed.

I prepared five charts based upon the analytical tables for this period, concerning which I have testified. The first one is designated, "Chlorine, parts per million, in the Illinois river, Edwin O. Jordan," and is reproduced on page 5971.

5972 This chart is a diagramatic representation of the averages of the chlorine determination for May and June, 1899 and for May and June, 1900, the amount of chlorine being plotted in numbers per million and the miles along the course of the Illinois river being indicated at the foot of the chart.

The solid line representing 1899 period.

The broken line representing the 1900 period.

The diagram shows that the large amount of chlorine present at Lockport during May and June, 1899, and May and June, 1900, is diminished by dilution with the water of the tributaries which are less highly laden with chlorine during the progress of the river from Lockport to Gafton.

The curves for the two periods follow substantially the same course. The greater dilution of the water in the upper stretches of the river during May and June, 1900, being shown by the smaller amount of chlorine at Morris and Ottawa for example. In the lower part of the river such dilution as occurred during these periods is apparently about balanced by the additional amount of chlorine in the river.

5974 The chart, reproduced on page 5973, designated by the heading "Albuminoid ammonia, parts per million, Illinois river, Edwin O. Jordan," is a graphic representation of the amounts of albuminoid ammonia in the water of the Illinois river at different points for May and June, 1899, and for May and June, 1900.

Unlike the chlorine, the albuminoid ammonia is not permanent, but undergoes certain changes in its passage down the stream. The curves for May and June, 1899, and May and June, 1900, follow like the curves for chlorine, a substantially parallel course, but the May and June determinations for 1900, are somewhat lower throughout the whole stretches of the river than for May and June, 1899.

Reference to the chlorine chart already offered in evidence, will show that this is not so with the chlorine, so that so far as these determinations go, there has apparently been a greater purification based on the decomposition of albuminoid ammonia in May and June, 1900, than in May and June, 1899.

5976 The chart, reproduced on page 5975, designated as "Free ammonia, parts per million in the Illinois river, Edwin O. Jordan," is a graphic representation of the averages of the free ammonia determinations for May and June, 1899 and for May and June, 1900.

The effect of increased dilution in the upper stretches of the river is evident here as in the case of the albuminoid ammonia and chlorine. In the lower half of the river the amount of free ammonia was somewhat greater in May and June, 1899, than in May and June, 1900. This condition coincides more closely with the condition shown in the chart of albuminoid ammonia than in the chart of chlorine.

5978 The chart, reproduced on page 5977, designated "Number of bacteria per cubic centimeter at Grafton," is a graphic representation of the number of bacteria as determined by weekly determinations in May, 1899 to the end of June, 1900. The full line representing the number of bacteria in the Mississippi river at Grafton, and the broken line representing the number of bacteria in the Illinois river at Grafton.

Throughout May and June, 1899, and to a lesser extent in July and August of this year, both rivers had a high bacterial content. This condition was followed by relatively small numbers of bacteria in both rivers through September, October and November, a condition that was followed in December, by a sudden and notable increase in the number of bacteria, and then by a period of irregular step-like ascent in both cases, amounting in March, 1900, to an exceedingly high point. This was followed by a rather abrupt decline in the numbers of bacteria until in May and June, 1900, the numbers were very similar to those in July and August of 1899.

5980 The diagram, reproduced on page 5979, designated, "Number of bacteria per cubic centimeter in the Illinois river, Edwin O. Jordan," is a graphic representation of the average numbers of bacteria for May and June, of 1899, and May and June, 1900, starting at Lockport with high initial numbers in both cases.

The number of bacteria drops to a relatively low point in the neighborhood of Ottawa, continuing low to Averyville, below that point, showing a very notable increase, especially during the first period, apparently due to the pollution of Peoria. As with the initial pollution the numbers of bacteria introduced at Peoria diminish, and for the last stretch of 120 miles the numbers of bacteria are very similar to those found at Henry and Averyville above Peoria.

The increase in numbers of bacteria at Wesley City below Peoria is apparently much less in May and June, 1900, than in

May and June, 1899. This however is probably apparent rather than real and is due to the fact that the sample which was collected in mid-stream at Wesley City, did not give as definite indication of the addition of Peoria sewage as was the case in the 1899 period, since the greater body of water in the Illinois river at this time probably crowded the pollution towards the western bank.

5981 Witness gives distances from Bridgeport in miles as follows:

5982	Lockport,	29	miles.
	Joliet,	33	do.
	Morris,	57	do.
	Ottawa,	81	do.
	La Salle,	95	do.
	Henry,	123	do.
	Averyville,	159	do.
	Wesley City,	165	do.
	Pekin,	175	do.
	Havana,	199	do.
	Beardstown,	231	do.
	Kampsville,	288	do.
	Grafton,	318	do.

5983 An attempt is made to indicate the less complex condition of these nitrogenous bodies by smaller and less intricate spirals. The oxidation of the free ammonia to nitrites being in turn oxidized to the completely mineralized nitrates, which with carbon dioxide, water and other substances devoid of available potential energy, occupy the region of complete mineralization at the bottom of the circle.

Various forms of plant life are able with the aid of sunlight to utilize hte nitrogen of the nitrates as food; and through stages of ever increasing complexity, the exact nature of which is unknown, the nitrates are built up again, into the living bodies of plants and animals, and become again organic nitrogen, from which point the nitrogen eventually starts anew on its cycle.

Owing to the effect that the occurrence of nitrogen in the form of organic nitrogen and as free ammonia is associated with the decomposition of substances discharged from the bodies of animals, the presence of nitrogen in these forms indicates relatively recent contamination with organic matters, while owing to the time that must elapse for the process of nitrification to be completed, the occurrence of nitrates in inconsiderable abundance in surface water is taken as indicating that a relatively long period has elapsed since original contamination took place.

In such a water as the Illinois river, the nitrogenous matter introduced in the Chicago sewage may pass through this complete cycle several times on its way to the mouth of the river. The oxidation of the organic nitrogenous compounds introduced into the river at Lockport may take place under certain circumstances in the upper stretches of the river. The nitrates thus formed may be utilized by microscopic algae for building up their life substances, and thus again pass into the state known as organic nitrogen or albuminoid ammonia. From the advent of cold weather, or from other unfavorable circumstances these organisms may die, and the nitrogen composing their bodies being again decomposed, may reach
5984 the mineralized form of nitrate and perhaps again begin
the upward part of the cycle.

Under certain circumstances, any river into which an excessive amount of nitrogenous matter is emptied, will contain throughout a large part of its course, an amount of nitrogen in one form or another, in excess of that existing in a stream not so laden at the start. Under such conditions the appearance and reappearance of nitrogen as free ammonia, albuminoid ammonia, or one or another of these compounds, cannot be held to possess the same sanitary significance as under some other conditions.

Free ammonia at the mouth of the Illinois river for example, may be derived from a decomposition of algae, while free ammonia at Lockport or Bridgeport may be derived from decomposition of waste substances leaving the human or animal body, or discharged into the water in the course of various manufacturing operations.

This diagram I think, serves to illustrate some of these points and to show the complexity of the phenomena attending the decomposition of organic compounds containing nitrogen, and the re-composition of this nitrogen in the bodies of other living forms.

I made hourly bacterial surveys of the water of the Illinois below Morris, between Morris and Ottawa, at Wesley City, and at Grafton.

Taking first the determinations made on the Illinois river at Morris. Several series of observations were carried out at this point. The first of these was on October 7th, 1899. The day was bright and sunny, the temperature of the air being 7 degrees centigrade at six o'clock in the morning, and reaching 20.5 by mid-day. A slight breeze ruffled the surface of the water in the middle of the day, but was at no time strong. The river was very low, the gauge reading for that day being five feet, and the current exceedingly sluggish.

5985 With a view to determining the distribution of bacteria indifferent portions of the Illinois river at this point, a cross section was taken across the river from the right to the left bank; three samples being taken at approximately equi-distant intervals from one another and from the shores. The upper cross sections were taken at a point just above the Mazon river, the lower about three-quarters of a mile below the mouth of the Waupecan Creek. This was at a dry period, and little if any water passed into the Illionis from these tributaries at this date. This stretch of river is almost exactly three miles in length. The rate of flow between the two points was determined by weighted floats and by the use of fluorescein solution, and was found to be very close to half a mile per hour.

Four series of cross sections at hourly intervals were taken at the upper station, which may be designated as Station A, and these were followed by similar series at the lower station,

Station B, beginning six hours later. These samples were plated immediately after the collection, the plating being completed within the hour in each case.

At Station A the river was about 150 yards wide, and at Station B about 125.

The figures given for the number of colonies in the tables that follow are the averages of counts of two separate platings.

These tables reproduced on page 5986 *et seq.*

5986 Attention may be directed to the fact that between these collecting stations, a distance of three miles traveled by the stream on this date in about six hours, a great bacterial diminution occurs. The chlorine determinations show that the mixing of the Kankakee water and the Des Plaines water is very incomplete both at the upper station which is about nine and one-half miles below the junction of the rivers, and at the lower station as well. This is entirely confirmed by the bacterial count and turbidity cross sections at the two points.

It should be noted that the decline in the numbers of bacteria occurs in almost equal degree throughout the whole breadth of the stream, being as great along the highly polluted right bank of the river as along the comparatively incontaminated left bank.

A second series of observations was carried out on November 9th, 10th and 11th, 1899, in similar fashion, upon a longer stretch of river. The distance between the regular collect-
5987 ing station at Morris and the regular collecting station
at Ottawa is about 24 miles, and the rate of flow between these points averaged one-half a mile per hour at the time our observations were made. A point midway between Morris and Ottawa was selected, near Seneca, and a three days series of operations was planned. The sun was wholly obscured by clouds during these three days, but no rain fell. The results are given as before in tabular form.

Figures are given for the upper station at Morris, the middle station at Seneca and the lower station at Ottawa, the averages being reproduced on page 5988.

5988 The averages are as follows:

	Distance from Morris.	No. Colonies per c. c.			No. of Hourly Analyses.
		Right Bank.	Center.	Left Bank.	
Upper Station (Morris)...........	......	261,000	204,000	29,000	3
Middle Station (Seneca).......	12 miles. 24 hours.	100,000	49,000	35,000	2
Lower Station (Ottawa)	24 miles. 48 hours.	11,500	10,700	13,500	2

During this flow of 24 miles therefore, the Illinois river became nearly free from the great mass of sewage bacteria with which it was originally laden. In fact the bacterial content of the Illinois at Ottawa on this date was not greatly in excess of that of the local tributary streams.

In connection with this series of bacterial determinations may be given the averages of the regular chemical determinations made at the laboratory in Chicago during the period between October 23d and November 20, 1899. These determinations, which follow, show that a considerable degree of nitrification takes place in the river between these two points, as witnessed by the increase in the amount of nitrites and nitrates, the diminution in free and especially in the albuminoid ammonia.

Station.	No. Determinations.	Residue on Evaporation.			Oxygen Consumed.		
		Total.	Dissolved.	Suspended.	Total.	By Dissolved Matter.	By Suspended Matter.
Morris	5	398	380	18.	10.7	8.4	2.3
Ottwa.......	5	356	353.5	2.5	7.5	7.3	.2

Free Ammonia.	Nitrogen as Albuminoid Ammonia.			Nitrites.	Nitrates
	Total.	Dissolved.	Suspended.		
7.98	.860	.478	.382	.028	.340
6.6	.364	.315	.049	.382	.648

A third series of similar observations was made between these same points on May 24th, 25th and 26th, 1900. The sun was partially obscured on May 25th, but shone brightly on May

24th and 26th. No precipitation occurred during the period.

5989 The results are shown on pages 5988 and 5990 in tabular form.

5990 This last series of determinations shows that on May 24th, 25th and 26th, 1900, the mixing of the Kankakee and Des Plaines rivers at Morris was more complete than on November 9th, 10th and 11th, 1899. They also show a smaller number of bacteria per cubic centimeter of the water at this time. A diminution in the numbers of bacteria, however, similar to that noted in the earlier series takes place during the cubic centimeter as shown by the colony count at Ottawa during this period in 1900, than in November, 1899.

5991 I see no escape from the conclusion that in this flow of approximately 24 miles, the Illinois river which at Morris contained a large number of bacteria in all probability derived more or less directly from the sewers of Chicago freed itself from these bacteria to a remarkable and impressive degree in a short distance and, in a relatively short space of time. The probable reason for the high mortality among bacteria in this particular stretch of the river will be discussed in another connection.

I should like to state that these three series of observations upon the water of the Illinois river between Morris and Ottawa are not the only series that I have made between May, 1899 and June, 1900.

I have made several other series of observations between Morris and Ottawa of the same character as those just described. The samples were collected in the same way, the experiments in each case being conducted by my chief assistant, Mr. Irons, and myself.

Between July, 1899 and June, 1900.

Between Morris and Ottawa.

One of these was on September 2, 1899. I have memoranda of the others with my papers at the University.

5992 One of these, of which I have a record here, was made on June 13th, 1900. It gave the following result:

	Free ammonia.	Albuminoid ammonia.	No. of colonies per c. c.
Right bank,	.504	.864	4,340,000
Center,	.144	.248	40,000
Left bank,	.168	.240	2,400

This cross-section was not made by me personally, but by Mr. Irons, in pursuance of my directions.

The large amount of pollution entering the river at Peoria on the right bank of the river is clearly shown in this sample. The free ammonia, the albuminoid ammonia, and the number of bacteria per cubic centimeter being immensely greater than on the left bank of the stream. Slight changes in the position of sand-bars and in the height of water deflect the main mass of pollution now to one side, of the the stream, now to the other, and so lead to the sudden and marked fluctuations in the analyses which the detailed tables show to be so characteristic of the samples obtained from this point.

Yes, on a number of occasions both in 1899 and in 1900, cross-sections were taken of the Illinois river at Grafton. These cross-sections at Grafton dealt simply with the number of bacteria per cubic centimeter. In general it may be said that the results obtained from samples taken midway between the banks of the streams and the center were not materially different from those taken from the center of the stream, mixing of the bacteria, so far as these determinations go, being complete at this
point. Slight variations were however, sometimes no-
5993 ticed, the number being sometimes higher in the center
than on the sides; sometimes higher on the sides than in
the center.

These observations upon the bacterial content of the Illinois river between Morris and Ottawa indicate in my judgment that a very large proportion of the bacteria entering the Des

Plaines river from the Illinois and Michigan canal and from the Chicago drainage canal do not survive to reach Ottawa. From a sanitary point of view this observation would seem to be of importance in that it renders less probable the passage of disease germs down the river, as far as this point. Since these sewage bacteria disappear in such numbers, it is my opinion, fair to assume that the various non-spore forming pathogenic bacteria entering the Chicago sewage, die out at least in the same proportion.

5994 In giving the last opinion I am of course obliged to take
into consideration all the knowledge that I possess on the life of pathogenic germs and their relation to sewage bacteria. I regard however, these observations upon the bacterial content of one and the same body of water as reinforcing in a remarkable manner all that I have been able to learn in other ways regarding the life of bacteria introduced into water with sewage. I made determinations for the bacillus coli communis. There were several series, the first covering a period between May, 1899, and June, 1900. (Witness states points at which these determinations were made, ranging from Lockport to the
5995 tap water at St. Louis.). I have a list of tables prepared
showing bacilli coli communis determinations. (Witness gives characteristics of that bacillus, also states relationship of bacillus coli communis to the bacillus typhosus and some of the main points of differentiation between those two germs.

These are some of the fundamental distinctions between
5996 these two germs. The colon bacillus is in every respect
more hardy than its near relation the bacillus typhosus.

In comparative tests that have been made on the relative viability of the bacillus coli and the bacillus typhosus under certain conditions, the following facts have been demonstrated:

1. As regards sand filtration with the water to which both species have been added, 99.9 per cent of all the bacillus coli and 100 per cent of the bacillus typhosus were removed by an intermittant filter, and 99.8 per cent of bacillus coli and 99.9 per cent of bacillus typhosus by a continuous filter.

2. As regards the persistence of the two organisms in a filter after infection of the applied water has ceased, bacillus coli was found to continue in the effluent from the intermittent filter for 24 to 36 hours, and the bacillus typhosus only for two to three hours. With the continuous filter the bacillus coli continued for 46 days, and the bacillus typhosus for 2 days.

5997 3. The effect of cold without freezing. In a water subjected to a temperature of 38 degree Fahrenheit, about 90 to 95 per cent of both species were destroyed within 24 hours. A few organisms of each, however, may live for a considerable number of days.

4. Elimination by freezing and viability in ice. About 50 per cent of the bacillus coli and 75 per cent of the bacillus typhosus, were destroyed by fifteen minutes freezing, after one hour, 95 per cent of the bacillus coli and 98 per cent of the bacillus typhosus were killed, and at the end of 24 hours over 99 per cent of all the organisms had disappeared.

5. Resistance to heat. Both species resisted temperatures up to 45 degrees for five minutes. And between 45 and 55 degrees centigrade, all but a few individuals of each are destroyed. These few individuals however, resisting temperature up to 85 degrees centigrade, at which temperature all organisms of both species were destroyed.

As bearing further on the question of the relative resistance of these two organisms I may state that some experiments were made by me some years ago a report of which is printed in the Medical News on September 28th, 1895, in which it was found that the typhoid bacillus when introduced into sterilized Lake Michigan water, does not multiply, but may under certain conditions, maintain its vitality for upwards of 93 days. The colon bacillus on the contrary, under the same conditions, undergoes rapid multiplication and may remain alive for upward of 263 days.

6000 From the facts just enumerated, it is clear that while the colon bacillus resembles in many important particulars the typhoid bacillus, it is under all conditions in which the viability of these two organisms has been compared a more hardy and more resistant organism. Its longevity under adverse conditions is greater than that of the typhoid bacillus. This fact, and the ease with which it is isolated and identified, combine to render it a particularly significant organism from a sanitary point of view.

6001 Witness gives illustration through experiment made by Dr. Bissell of Buffalo, New York, and states that this illustration suffices to show that it is possible by means of the delicate test for colon bacilli to detect a degree of pollution which might be altogether missed by the use of less delicate and less precise methods.

So far as I have been able to discover, it is at the present time, the prevailing opinion among those bacteriologists who deal with sanitary water analysis that the test for the colon bacillus properly applied and interrupted, furnishes one of the most satisfactory clews to the sanitary condition of a water.

In this connection it should be emphasized that it is not so much the presence or absence of bacillus coli communis in a large quantity of water that is significant as it is the relative abundance of this micro-organism.

Witness then refers to various scientific authorities on the subject of the importance of the bacillus coli communis test as a determination of the pollution of water. The witness also quotes from various works on this subject.

6005 Witness states method employed by him in determinations made for the bacilli coli communis.

6007 In support of my opinion as to the value and importance of the presumptive test for the presence of the bacillus coli in water, I may cite some conclusions in a paper by Mr. George C. Whipple, of Brooklyn, who I understand has already testified as a witness in this case. The paper is entitled "On the Practical Value of Presumptive tests for Bacillus Coli in Water." It was printed in the "Technology Quarterly, published at the Massachusetts Institute of Technology," volume 16, No. 1, March, 1903.

"The methods necessary for the certain identification of bacillus coli in water involved technique so complicated and so time consuming that they are not practical as working tests in connection with the supervision of water supplies.

2. The fermentation of Dextrose broth as first suggested by Dr. Theobald Smith, furnishes the most rapid and most practical test for the presence of bacillus coli in water.

3. The extension of this test to cover different quantities of water in the same samples, thus making the test quantitative, within limits as well as qualitative, greatly enhances its value.

4. But whether or not bacillus coli is simply an intestinal germ, the fermentative test described above is a useful test to determine the sanitary quality of water and is one which gives results that agree well with chemical and biological analyses."

At another point in this same paper, page 22, Mr. Whipple says:

"Speaking broadly the typical reactions offer satisfactory presumptive evidence of the presence of this species (B. coli-communis) or species very closely allied to it. In a subsequent paper I hope to give the data to support this assertion, but at this time will offer as corroborative testimony, the statement of Mr. Irons, who in his paper on some observations of methods for the detection of the bacillus coli communis in water, states:

"When the Dextrose tube yields approximately 33 per cent of carbon dioxide, bacillus coli communis is almost invariably present."

6008 From all my experience upon the value of presumptive tests for B. coli, I am obliged to believe that this test is of high value in sanitary water analysis, and enables conclusions to be drawn as to the presence or absence of the colon bacillus which are in the main thoroughly satisfactory and decisive. The table of chlorine determinations which I have prepared cover a period of time between May, 1899, and the end of June, 1900. These determinations were made from the bacteriological samples collected by the same water takers and at the same time as heretofore specified in my testimony. (Witness then states places at which samples of water were taken, and determinations made.)

6009 Table No. I, Illinois and Michigan canal at Lockport, read in evidence.

6010 The table shows that in this highly polluted water, the bacillus coli was occasionally present in so small an amount of water as .0001 of a cubic centimeter, and that it was usually present in so small an amount of water as .0001 of a cubic centimeter. Table No. I-B, Drainage canal at Kedzie avenue.

6011 The greater dilution of the sewage in the drainage canal during this period as compared with the condition of the Illinois and Michigan canal shown in Table I, is manifested by the comparatively rare occurrence of the colon bacillus in .0001 of a cubic centimeter of water, and its occasional absence, even when .001 of a cubic centimeter of the water was examined.

Table No. I-C, Drainage canal at Lockport. The dilution shown in the drainage canal, at Kedzie avenue, is shown also in the drainage canal at Lockport, the colon bacillus being present in all the samples of .1 of a cubic centimeter that were examined and in many of those of .01 of a cubic centimeter, but being almost invariably absent where .001 of a cubic centimeter
6012 was examined. Table No. II contains the results of colon determinations made upon the water of the Des Plaines river between August 1st and November 28, 1899.

Q. On page 150 of his testimony, Dr. Ravold testified that the colon bacillus was found in 72 per cent of the samples taken from the Bear Trap dam at Lockport in the month of March, 1900, and at page 320 of his testimony, he testified that the bacillus coli communis was found in 71 per cent of the samples
6013 collected from the St. Louis settling basins during the period from May 1st to October 31, 1900. Would you infer from those statements that colon bacillus was present in the water of these settling basins in St. Louis in anything like the same proportion that it was in the water of the drainage canal at Lockport?

A. I certainly should not. (Witness gives reasons for his answer and on page 6014 states:) I am compelled to assume that the statements to which you refer are based on defective analytical methods, and do not indicate that the actual number of colon bacilli in the water of the drainage canal and in the St. Louis settling basins are at all comparable. Table No. III, Kankakee river at Wilmington. This table shows that between August 7th and November 20th, 1899, the colon bacillus was frequently present in .1 of a cubic centimeter, and usually present in one cubic centimeter.

6015 Table IV, Illinois river at Morris. This table contains
6016 the results of colon determinations made upon samples
of water taken from the Illinois river at Morris between October 31, 1899, and June 27, 1900. They show that during the early part of this period the colon bacillus was generally present in .001 of a cubic centimeter of the water, while in the latter part of this period, namely from January 30, 1900, to April 23, 1900, it was rarely present in this dilution. In fact in May and June, 1900, the colon bacillus was even absent in quantities of .01 of a cubic centimeter, and occasionally absent in quantities of .01 of a cubic centimeter, and occasionally absent in .1 of a cubic centimeter sample.

6017 Table V, Fox river at Ottawa, contains the results of
colon determinations made upon samples of water taken from the Fox river at Ottawa between August 1st, 1899, and June 26, 1900. They show that in this water, the colon bacillus was rarely present in .1 of a cubic centimeter; was often present in one cubic centimeter and usually present in five cubic centimeters of water.

6018 Table VI, Illinois river at Ottawa shows that during the
6019 greater part of this period, colon bacillus was occasion-
ally present in .01 of a cubic centimeter, and that it was frequently present in .1 of a cubic centimeter.

Table VII, the Big Vermilion at La Salle. The colon bacillus was commonly absent in .1 of a cubic centimeter of water and found only about half of the time in one cubic centimeter samples.

6020 Table VIII, Illinois river at La Salle. The number of colon bacteria found here corresponds very closely with the number found in the Big Vermilion river, it being noted that the samples were taken at these two points on the same dates.

Table IX, Illinois river at Henry, contains results of
6021 colon determinations made upon samples of water taken between June 7, 1899 and January 17th, 1900.

Table X, Illinois river at Averyville.

6022 The relatively large number of colon bacteria present in the Illinois river at Morris as shown by Table IV has been greatly diminished between Morris and Averyville, so that while at Morris the colon bacillus was found almost invariably in .1 of a cubic centimeter of water, at Averyville it was but rarely present in this amount of water, and occasionally absent even in one cubic centimeter of water. This group of organisms appears to have suffered a great mortality in the water between Morris and Averyville.

6023 Table XI, Illinois river at Wesley City.

6024 The increased pollution of the river at this point is shown by the swollen number of colon bacilli, which were found quite often in .1 of a cubic centimeter of water. Table XII, Illinois river at Havana. The colon bacillus was commonly present in one cubic centimeter of water.

6025 Table XIII, Sangamon river at Chandlerville.

6026 As before stated, the Sangamon river receives above Chandlerville, the sewage of a very considerable urban population, and this condition is reflected in the relatively high number of colon bacilli, which during the period covered by these determinations, range much higher than the number found in the water of the Illinois river at Averyville, as evidenced especially by the determinations made of .1 of a cubic centimeter samples. The colon bacillus was even found occasionally in .01 of a cubic centimeter of water taken from the Sangamon river at this point.

6027 Table XIV, Illinois river at Grafton.

6028 The colon bacillus was present in .1 of a cubic centimeter samples in about the same proportion as at Averyville, and was present in the majority of one cubic centimeter samples, as is usually found to be the case with unprotected surface waters receiving at more or less frequent intervals the drainage of urban and rural communities.

6029 Table XV, Mississippi river at Grafton.

6030 The colon bacillus was found during this period not infrequently in .1 of a cubic centimeter samples, and in the majority of one cubic centimeter samples, being in this respect like the Illinois river, a typical unprotected surface water.

6031 Table XVI, Mississippi river cross-section at Alton.

6033 Table XVII, Missouri river, West Alton.

6034 During this period the colon bacillus was found quite commonly in .1 of a cubic centimeter of water, especially in the months of May and June, 1900, and was commonly present in the one cubic centimeter of water samples. Table XVIII, Mississippi river, intake tower, St. Louis waterworks,

6035 Mitchell. The results show a general similarity with those obtained from the water of the Missouri river at West Alton. Table XIX, St. Louis tap water. The smaller number of colon bacteris in .1 of a cubic centimeter samples, as compared with the number found in the Mississippi river, at the water intake, indicates a considerable diminution in the number of colon bacteria during the passage through the settling basins and water pipes. I have a table of summaries of results for the principal stations in the Illinois river. This table is reproduced on page 6036, and it summarizes the results obtained from the colon determinations made upon the waters colected at the principal stations along the Illinois river. It shows that in the water of the Illinois and Michigan canal at Lockport the bacillus coli was present in .001 of a cubic centimeter of water on

28 days out of 32 days on which examinations were made. It shows further that in the water of the Illinois river at Morris the colon bacillus was present in .01 of a cubic centimeter of
water on 20 days out of 30 days on which examinations
6037 were made, while at Ottawa it was present in the same
quantity of water on only 6 days out of 22 days on which examinations were made.

At Ottawa the colon bacillus was found in .1 of a cubic centimeter of water on 19 days out of 34 days on which examinations were made, while at Averyville it was found in the same quantity of water on only 5 days out of 27 days which examinations were made.

The increased pollution of the water at Wesley City is shown by a larger number of colon bacilli as indicated by the fact that the colon bacillus was found in .1 c.c. of water from this point on 13 days out of 26 days, on which examinations were made, or more than three times as frequently as in the Illinois river at Averyville above Peoria.

At Grafton at the mouth of the river the colon bacillus was found in .1 of a cubic centimeter on 13 days out of 35 days on which examinations were made.

These summaries show that the colon determinations coincide with the results of the routine chemical and bacterial examinations already referred to.

The processes of oxidation of the organic matter, the death of the mass of sewage bacteria and the mortality among the specially significant group of colon organisms appear to run a closely parallel course, and the inference as to the purification of the stream drawn from the chemical analyses and from the count of bacterial colonies, is further emphasized by the mortality shown to occur in this significant class of sewage bacilli.

6038 Table reproduced on this page, which contains a summary of the results of the colon determinations made upon the Illinois river at Averyville and Grafton, compared with the tributaries of the Illinois and with the Mississippi and Missouri rivers.

On comparing the number of days on which bacillus coli was found in one cubic centimeter, samples of water taken from the Illinois river at Averyville, with those taken from the Illinois river at Grafton, from the Mississippi river at Grafton, from the Des Plaines river, from the Kankakee river; from the Fox river, from the Big Vermilion river; from the Sangaman river, and from the Missouri river, it appears that so far as the colon content enables one to pass an opinion as to the sanitary quality of these waters the Sangamon river at Chandlerville, is one of the more highly polluted streams.

The Illinois river at Grafton, the Mississippi river at Grafton and the Missouri river at West Alton appeared to be
6039 on substantially the same footing with one another in respect to their colon content, while the Fox river contained a smaller proportion of colon bacilli than any of the streams under consideration.

The Illinois river at Averyville compares in respect to its colon content very favorably with the Illinois, Mississippi and Missouri rivers and is perceptibly less highly contaminated than the water of the Sangamon river at Chandlerville.

Summing up these facts in the second division of this table it is seen that samples of water taken on 69 different days from the Illinois river at Averyville and at Grafton contained bacillus coli communis on 39 days, while the various tributaries of the Illinois river, samples from which were taken on 69 days, contained colon bacillus on 36 days. Samples taken from the waters of the Missouri on 66 days contained colon bacillus on 44 days.

It appears therefore from these tables, that if the opinion that I have expressed regarding the sanitary significance of the colon bacillus in water is correct, the water of the Illinois river at Averyville and Grafton was not materially different from what it would have been if the tributaries of the Illinois, exclusive of the Des Plaines river and its sewage content, had alone fed the basins of this stream. The colon content of such a stream at Averyville and at Grafton would have been substantially what it is at present.

As stated in my testimony of yesterday, my experience leads me to adopt the view that the relative abundance of the colon bacillus in water affords the most satisfactory single analytical indication that sanitary science at present possesses as to the sanitary quality of a natural water.

Basing my opinion upon this I may say that I regard the relative abundance of colon bacilli in the water of the Illinois river at various points, and in the various tributary streams as furnishing a highly important clew to the freshness of the pollution entering, and the amount of real purification undergone by each stream. Considered from this standpoint the water 6040 of the Illinois river at Averyville and at Grafton, is no more impure than the water in the principal tributaries of the Illinois, and certainly no more impure or dangerous than the water of the Mississippi river at Grafton, or the Missouri river at West Alton. The successive and striking diminution in the number of colon bacilli at various points along the Illinois river from Lockport to Averyville, is proof in my judgment of the occurrence of a process of genuine self-purification.

I regard these determinations as forming a connected and correlated whole, mutually sustaining one another, and all pointing in my judgment, to but one interpretation. The oxidation of the organic matter that was introduced in enormous quantities at Lockport, the more or less complete destruction of sewage bacteria also introduced at this point, and especially the high mortality among the colon bacteria occurring in the upper stretches of the river, all appear to me to indicate that infectious matters that might have been introduced into the sewage of Chicago and found their way into the drainage canal during this period from May, 1899 to the end of June, 1900, did not make their way down river so far as Averyville. So far as my interpretation of the results of the chemical analyses, the bacterial counts and the colon determinations is concerned, I have no hesitation in expressing as my opinion that the water of the Illinois river at its mouth is no more liable to convey disease or to produce injurious consequences of any kind than the waters of the Mississippi river at this point, or the water of the Missouri river at West Alton. In expressing this opinion I am taking into consideration all the knowledge that I have acquired by personal experience and all the information that I have obtained regarding the chemical and bacterial content of these waters during the period under consideration.

6041 I made a survey of the waters of the Illinois, the Mississippi and the Missouri rivers in 1901. So far as I understand these circumstances, an agreement was reached between the authorities of the State of Missouri and the State of Illinois, for conducting a joint investigation of the water of the rivers named, at certain points. The aim of this joint examination was, as I understand it, to secure that the samples should be taken at specified places, at specified times, and under uniform conditions. Witness states in whose charge the various laboratories were, the nature of the work carried on, the points where samples of water were collected for examination in these three different laboratories, the instructions given for the plating of these samples relative to the time of collection, and states
6043 on page 6043 that the work done during this period was wholly bacteriological in character and may be grouped conveniently under three heads:

(a) The determination of the number of bacteria in the river water as shown by the ordinary colony counts.

(b) The number of germs of the colon group in the river water as shown by the Dextrose fermentation tube test.

(c) Study of the species of bacteria isolated from the river water.

The first two determinations were carried out in the respective branch laboratories, and it is certain that a decided gain in the accuracy of the results was attained by conducting this work at or near the points of collection, upon freshly collected samples, instead of allowing as in the previous work, a considerable interval to elapse while samples were being transported to a distant point. The detailed study of the bacterial species was carried out under more advantageous conditions offered for this kind of work by the University laboratories.

Witness states the method employed in making all these determinations.

6044 I have the tables prepared at the different stations where these determinations which I have just described were made.

6045 MR. TODD: I offer the original analytical report from the laboratory at St. Louis made by W. G. Sackett, that at Grafton made by W. S. Sayer, and that at Peoria made by F. W. Schule, to Professor E. O. Jordan of the Chicago University, under whose direction and supervision these analyses were made. Also the coli determinations made by the same parties at the three different laboratories for this period and reported to Professor Jordan in the same manner as above indicated. These reports are offered for the inspection of counsel and will be made a part of the evidence if objection is made to their non-introduction.

Two sets of tables were made of the determinations at Peoria, one covering the samples of water collected at Averyville; the other covering those collected at Pekin. Table for the determination made at Averyville, in the Peoria laboratory, read in evidence on pages 6046-7-8-9.

This table contains the results of daily bacterial determinations made upon samples of water from the Illinois river at Averyville between October 9th and December 30th, 1901. On this table are specified the date of collection, the hour of collection and the hour of plating, the temperature in degrees centigrade of the water and air; the height of water; the dilution in which the sample was plated, the number of colonies

per cubic centimeter (two samples in most cases) and the average of these daily determinations. Throughout October
6050 and November the numbers of bacteria in the water as shown by the colony count were low; the counts showing often only a few hundred colonies per cubic centimeter. In December the numbers increased somewhat and in the latter part of December, the numbers are on several occasions in the tens of thousands.

So far as the bacterial count is concerned, these examinations show that the water of the Illinois river at this point was in a condition which considered as a river water, was fully up to the average of river waters in this country.

On pages 6051-2-3 is reproduced table showing determination made at Peoria laboratory for the point at Pekin.
6054 This table shows the result of colony counts made from samples of water collected from the Illinois river at Pekin between October 16th and December 13th, 1901, the same data being given as in the table for Peoria.

Throughout this period this water is characterized by a much higher bacterial content than the water of the Illinois river at Averyville. On October 26th, for example, the average number of four determinations at Pekin was 341,000, per cubic centimeter, while at Averyville on the same date there were only 890 colonies per cubic centimeter.

Table read in evidence showing determination made of
6059 the Illinois river at Grafton. This table contains the results of bacterial counts made from samples of water taken from the Illinois river at Grafton between October 1st and December 24, 1901. The data specified as given in the Peoria tables are given also in this table. The numbers of bacteria per cubic centimeter found in the water of the Illinois river at Grafton are very similar to those found in the water of the Illinois river at Averyville.

Table read in evidence showing determination made of the Mississippi river at Grafton.

6064 This table contains the tabulations of colony counts made from samples of water obtained from the Mississippi river at Grafton between October 1, 1901, and December 24, 1901, other data specified in the Peoria tables being also included in this table. Throughout most of the period covered the results correspond rather closely with those obtained upon the Illinois river at its mouth. Tables for the cross section of the Mississippi river at the Chain of Rocks read in evidence. These tables contain tabulations of colony counts made from samples of water taken from the Mississippi river at the Chain of Rocks between October 7, 1901, and December 14, 1901, at four points across stream, namely, those specified in the records of the cross section at this point for 1899 and 1900. These tables show that throughout the period covered the number of bacteria contained in the water taken from the Mississippi river at the intake tower, and from the Missouri shore contained a noticeably larger number of bacteria than the water on the Illinois shore.

6077 Tables read in evidence showing colony determinations from the Missouri shore at Fort Bellefontaine.

6080 This table contains tabulations of colony counts made from samples of water collected from the Missouri river at Fort Bellefontaine between October 9th and December 16th, 1901; other data being included as hereinbefore specified. It shows that throughout this period the number of bacteria in the water of the Missouri river at this point was noticeably higher than in the water of either the Illinois river at its mouth, or the Mississippi river above Grafton.

6081 Tables of averages from the table just read, read in evidence.

This table contains the averages of the colony counts made from the waters of the Illinois river at Averyville, at Pekin and at Grafton; from the Mississipi river at Grafton, and in cross section at the Chain of Rocks, and from the Missouri river at Fort Bellefontaine. The number of bacteria found at Averyville and at Grafton was not dissimilar. These averages were higher than the average for this period in the Mississippi river. The usual winter increase which occurs in river waters took place this year in the Illinois river before making its appearance in the Mississippi. Up to the middle of December, 1901, the two waters were very similar as regards their bacterial content. Throughout the whole of the period studied, the average number of bacteria as shown by the colony count in the water of the Missouri river at West Alton was several times as great as the water in either the Illinois river at its mouth or the Mississippi river above Grafton. The number of bacteria in the Illinois river at Pekin as shown by these averages was greatly in excess of that found at any other of the collecting stations, as in my opinion naturally follows from the entrance of the sewage and refuse of Peoria, into the river above this point.

6082 Table of averages for cross section of the Mississippi at the Chain of Rocks.

6084 This table contains the results of the bacterial counts made upon samples of water taken from the Mississippi river at the Chain of Rocks. The averages are arranged in their proper relation, namely, the Illinois shore, mid-stream, intake tower and Missouri shore, the count for the Missouri river being contained in the right hand column. These figures show that during the period covered by this investigation the number of bacteria in the water of the Mississippi river at this point was much lower on the Illinois shore than on the Missouri shore. It shows, moreover, that the water of the intake tower during this period partook of the character bacterially of the water of the Missouri river and of the Mississippi river on the Missouri shore. In other words, during these three months of 1901, judging from the bacterial content of the Missouri river and of the Mississippi river at this point, little, if any, water from the Illionis river entered the intake tower of the St. Louis waterworks. It is evident also from the bacterial count, that if any water from the Illinois shore did pass into the water intake, it improved the condition of this water so far as reducing the number of bacteria per cubic centimeter was concerned.

I have photographs illustrating the different cross sections of the Mississippi river at this point, which are reproduced as plate No. 1, facing page 6084.

6085 Witness gives the following explanation of the photograph introduced in evidence:

To this card has been affixed five photographs of agar plates showing the number of colonies in .01 cubic centimeter, developing in different water samples collected from the Mississippi river in cross section at the Chain of Rocks, and also from the Missouri river at Fort Bellefontaine on October 28, 1901.

This is designated plate 1. These photographs show that the number of colonies appearing in the Mississippi river at the Chain of Rocks was at this date very much lower than the number in the Mississippi river at the intake tower and the Missouri shore, and also in the Missouri river.

These photographs are thoroughly representative of the results obtained at the Chain of Rocks throughout this period, October, November and December, 1901, and show clearly that the mingling of the water from the Illinois shore of the Mississippi river with the water of the Missouri river would tend to diminish the number of bacteria per cubic centimeter in the latter water.

It is also evident from these photographs that the water entering the intake tower at the Chain of Rocks, was much more largely composed of Missouri river water than of Illinois river water.

I also have photographs of other samples taken at the cross section of the Mississippi, marked No. 2, and reproduced facing page 6086.

6087 The photographs on plate 2 are the photographs of agar plates made from samples of water collected on November 20, 1901. They show the number of colonies in .01 of a cubic centimeter, developing in different water samples taken at cross section of Chain of Rocks in the Mississippi river and also from the Missouri river at Fort Bellefontaine. They show a substantially similar condition to that obtained on October 28, 1901, as shown in plate 1. The water from the Illinois river is much freer from colonies than the water from the Missouri river, from the Mississippi river at the intake tower and from the Missouri shore.

Plate 2 shows again the close similarity between the water from the Missouri river and that taken from the Mississippi river at the intake tower and shows that in the mixing of the water from the Mississippi river along the Illinois shore, that the water from the Missouri river would diminish the number of bacteria per cubic centimeter.

Photograph or plate No. 3 reproduced facing page 6088.

6089 Plate 3 shows five photographs of agar plates made from samples of water collected from the Mississippi river at Chain of Rocks on November 13, 1901. They show the number of colonies in .01 cubic centimeter of water, developing in different samples taken in cross section at the Chain of Rocks, and also from the Missouri river at Bellefontaine.

A similar condition to that shown in plates 1 and 2 is also apparent in these photographs, namely, that the water in the Mississippi river on the Illinois shore contains fewer bacteria per cubic centimeter than the water in the Missouri river or the water at the intake tower, Missouri shore. The general similarity of the photographs of samples of water from the intake tower, the Missouri river, from the Missouri shore, the Missouri river and from the Missouri river itself shows that the water entering the intake tower at this date was in a great part, if not wholly, derived from the Missouri river. These photographs show also that in case any water from the Illinois shore of the Mississippi river intermingled with the water of the Missouri river at this date it would decrease the number of colonies developing per cubic centimeter as shown in the table of averages for this cross section at the Chain of Rocks during the period of 1901, which has just been introduced in evidence. These photographs are thoroughly representative of the conditions obtaining in the Mississippi river during this period. The agar plates showing this condition have been selected for reproduction because of this representative character.

(Motion by Mr. Jeffries to strike out photographic plates just introduced in evidence.)

6093 I made some determinations for colon bacillus in 1901. These determinations were made from samples taken in 1901.

In 1901 from the Illinois river at Averyville and Pekin; from the Illinois river above Grafton, and the Mississippi river above Grafton, from the Missouri river at Bellefontaine and from a cross section in the Mississippi river at the Chain of Rocks. At four places, the Illinois shore, mid stream, intake tower an Missouri shore.

Q. What purpose did you have in view to be subserved in making determinations for the bacillus coli communis?

A. The relative abundance of the colon bacillus in water I consider as affording the most satisfactory indication of the sanitary quality of such water. In my opinion this is the judgment of most sanitary experts at the present time. In a paper entitled "The Significance of Bacteriological methods in Sanitary Water Analyses," published from the Biological Laboratories of the aMssachusetts Institute of Technology by C. E. A. Winslow and C. P. Nibecker, and printed in the Technology Quarterly, Volume 16, number 3, September, 1903, appears the following statement:

6094 "Colon bacilli are either wanting in good waters or are so rare as not to be found in the examination of samples of one cubic centimeter; they are found in a majority of one cubic centimeters of water so polluted as to be dangerous for drinking; between these two extremes their numbers vary with the amount of pollution. Klein and Houston in England, Jordan and Winslow and Hunnewell in America, and very recently Petruschky and Pusch in Germany have exhaustively studied the distribution of the colon bacillus with uniform results, and that the absence of this organism demonstrates the harmlessness of a water as far as bacteriology can prove it, no one would probably hesitate to acknowledge; and that when present its numbers form a trustworthy measure of its sanitary condition, the observers above quoted have proved beyond reasonable cavil."

This statement represents my own judgment in the matter as well as what is the prevailing opinion among sanitary experts generally and it is for this reason that in my studies into bacteriological conditions existing in the waters above mentioned, I have paid particular attention to the presence and relative abundance of the colon bacillus.

I employed a method known as the Dextrose Fermentation Tube Method. Exhaustive comparative tests were made with the dextrose fermentation tube method, with the neutral red method, with the carbol broth method and other methods sometimes used in making this test with the result that the dextrose fermentation tube method proved the most reliable.

The method consistent in inoculating measured quantities of the water to be tested in fermentation tubes containing ordinary nutrient broth with an addition of one per cent dextrose.

The interpretations adopted for the changes so produced were as follows:

States method employed in the determination of the colon bacillus in this examination made in 1901.

6095 Positive reactions, that is those indicating presence of B. coli were regarded as those tubes showing the gas production of over twenty per cent of the tube length; the tubes yielding on absorption with sodium hydroxide a gaseous residue appreciably in excess of the carbon dioxide observed. Negative reactions were those showing.

(a) No gas production or

(b) Gas production less than ten per cent of the tube length.

The doubtful class were made to include:

(a) Those tubes yielding only ten to twenty per cent of gas, and

(b) Those yielding more than twenty per cent before that appreciable excess of carbon dioxide.

A series of fermentation tubes was examined in detail to determine the limits of accuracy of this method, with the result that out of sixty-three tubes examined in thirty-nine cases where the interpretation was positive typical bacillus coli communis was isolated from the tube and identified in all its biological characteristics.

In seven cases where the presumptive test yielded a positive result the bacillus coli was not isolated. This may have been and in my opinion was because the colon bacillus after producing its characteristic fermentation changes was subsequently overgrown by other forms such as the sewage streptococcus.

In nine cases where the interpretation was doubtful the colon bacillus was not isolated.

In four cases where the interpretation was doubtful typical bacillus coli was isolated.

In four cases where the interpretation was negative the bacillus coli was not isolated.

It may be added that these last named cases were those showing less than ten per cent of gas in which gas forming organisms not B. coli were isolated. In addition some twenty tubes were examined which showed growth in the closed arm but yielded no gas producing organisms of any kind.

These results, in my opinion, show conclusively that where a large number of water samples are treated the error due to relying on the presumptive test alone is not unduly large.

The specific application of this method to the problem of self purification of streams depend upon ascertaining in each case the dilution at which the tests give uniformly positive and that at which it gives uniformly negative results. This method which rests upon the determination of the relative abundance of the colon bacillus is an extremely delicate test for recent sewage pollution.

6096 Winslow and Nibecker in the paper just referred to, on the significance of bacteriological methods in sanitary water analyses state, on page 237, "In the second place the bacteriological methods are far more delicate than in the others. Klein showed experiment with dilutions of sewage that the colon test was from ten to one hundred times as successful as the methods of chemical analyses."

"Studies of self-purification of streams have confirmed these conclusions on a practical scale. Thus, "in the Sudbury river it was found that while the chemical evidence of pollution persisted for six miles beyond the point of entrance the bacteria introduced could be detected for four miles further."

This latter statement refers to the study of self purification in the Sudbury river in Massachusetts carried out by A. G. Woodman, C. E. A. Winslow and P. Hansen, and published in the Technology Quarterly, Volume 15, 1902, page 105.

I prepared tables of the results of the analyses which I made in regard to the colon bacillus. Table designated "Illinois river, Averyville, presence of bacteria of the colon group," includes a record of determinations made on daily samples collected between October 19th and December 30th, 1901, reproduced on page 6097.

6099 The table shows that during this period the colon bacillus was never found in .001 cc. That it was but rarely found in .01 cc. (4 positive out of 72 determinations.) That it was found 49 times out of 114 determinations in .1 cc. and 39 times out of 54 determinations in .1 cc. Table headed "Illinois River —Pekin, Presence of bacteria of the colon group," reproduced on page 6099, includes the colon determinations made daily between October 19 and December 30, 1901. Shows that out of 25 determinations made with .001 cc. of river water taken from the Illinois river at Pekin, the colon bacillus was found in 28 per cent of the samples examined. In .001 cc. in 21 per cent; in

.1 cc. 78 per cent and in all 100 per cent of the 1. cc. samples.

6101 The table number 3, entitled "Illinois river, Grafton, Presence of bacteria of the colon group," includes a record of colon determinations made daily between October 10th and December 24th, 1901, and is reported on page 6101.

6104 This table shows that the colon bacillus was present in 7 per cent of the .001 cc. samples.

In 5 per cent of the .01 cc. samples.

In 13 per cent of the .1 cc. samples, and

in 30 per cent of the 1. cc. samples.

Table number 4, headed "Mississippi River, Grafton, presence of Bacteria of the Colon Group," includes a record of colon determinations made daily from the water of the Mississippi river above Grafton between October 10 and December 24, 1901, and is reproduced on page 6104.

6106 This shows that the colon bacillus was present in five per cent of the .001 cc. samples; in 24 per cent .1 cc. samples; in 38 per cent of the 1. cc. samples. Table number 5, headed "Missouri River, Bellefontaine, Presence of Bacteria of the Colon Group," contains the result of daily determinations made upon samples of Missouri river water between October 23 and December 17, 1901, and is reproduced on page 6106.

6108 This shows that the colon bacillus was present; in 19 per cent of the .001 cc. samples, in 50 per cent of the .01 cc. samples, in 79 per cent of the 1. cc. samples. Tables No. 6, 7, 8 and 9 contain records of the daily colon determinations made upon the water of the Mississippi river at the Chain of Rocks, in cross sections, as previously described in my testimony, viz: At a point near the Missouri shore, at the intake tower, in mid-stream, and at a point midway between the Illinois shore and mid-stream, made between October 22 and December 14, 1901, and reproduced on page 6109.

6117 These tables show that on the Missouri shore the colon bacillus was present in 13 per cent of the .01 cc. sample.

In 41 per cent of the .1 cc. sample, and

88 per cent of the 1. cc. sample.

At the intake tower the colon bacillus was present in 20 per cent of the .01 cc. sample, and in

57 per cent of the .1 cc. sample, and

84 per cent of the 1. cc. sample.

In the samples taken from mid-stream the colon bacillus was present in 6 per cent of the .01 cc. sample,

In 22 per cent of the .1 cc. sample,

81 per cent of the 1. cc. sample.

In the water of the Mississippi river at the Illinois shore the colon bacillus was present in

5 per cent of the .01 cc. samples,

10 per cent of the .1 cc. samples,

60 per cent of the 1. cc. samples.

Q. Did you prepare a table of summaries based upon the coli tables which you have already introduced in evidence?

A. Yes, sir, I have them here.

6118 Table A of summaries read in evidence.

6119 This table shows the presence of bacteria of the colon group in the water collected from the stations just set forth. This table shows the total number of days on which water was examined during this period and the total number of days on which bacilluscoli was found.

6120 Table B read in evidence.

6121 Table B shows that the total number of determinations made from samples of water collected from the already specified points in the Illinois, Missouri and Mississippi rivers, together with the number of positive results and the percentage of positive results.

In my opinion the fate of the colon bacillus in running water furnishes a very satisfactory indication as to the degree and rate of self-purification in such water.

The fact that the colon bacillus is present in but 43 per cent of the .1 cc. examinations from the Illinois river at Averyville while it is present in 100 per cent of the .1 cc. samples taken from the Illinois river at Pekin and in only 13 per cent of the

.1 cc. sample taken from the Illinois river at Grafton shows not only the extreme delicacy of this test for sewage pollution but shows a very considerable improvement in the sanitary quality of the water occurs between Pekin and Grafton, notwithstanding the large amount of pollution at Pekin. Comparing the condition of the water in the Mississippi river above Grafton with that in the Illinois river above Grafton as evidenced by the colon content of these two waters, it appears that the colon bacillus was present in 5 per cent of the determinations made of .01 cc. of water from these two places.

It may be mentioned that 117 determinations were made of the Illinois river water above Grafton and 115 of the Mississippi river water above Grafton during this period, so that the substantial agreement in percentage shown in the sanitary character of these waters during this period has a satisfactory statistical basis.

Comparing the examinations made of .1 cc. of water during the same period it is shown that 24 per cent of the samples from the Mississippi river yielded positive results while 13 per cent of those from the Illinois river above Grafton yielded positive results.

In 1. cc. of water from those two stations 38 per cent of the samples from the Mississippi river and 30 per cent of those from the Illinois river gave positive results.

6122 In other words, so far as any conclusion as to the sanitary character of these waters can be drawn from the colon determinations—and I have already indicated that in my opinion and in that of sanitary experts generally, the colon test is the most delicate and satisfactory clue that we have to the sanitary condition of the water—the water of the Mississippi river above Grafton during this period was, if anything, of a less wholesome character than the water of the Illinois river above Grafton.

Comparing further the colon content of the Missouri river water above Bellefontaine during this period it is shown that 19 per cent of the .01 cc. samples were positive as compared with

5 per cent in the Illinois river at Grafton, and that 50 per cent of the .1 cc. samples were positive as compared with 13 per cent in the Illinois river at Grafton and that 79 per cent of the 1. cc. samples were positive as compared with 30 per cent in the Illinois river above Grafton.

Comparing the per centages of positive results obtained in the examination of 1. cc. of water in cross section at Chain of Rocks it appears that there was a smaller percentage of colon bacteria in the Mississippi river on the Illinois shore and in mid stream than at the intake tower and on the Missouri shore. This confirms the difference already noted between the colon content of the Illinois river and the Mississippi river at Grafton and that of the Missouri river at Bellefontaine. The higher colon content of the Missouri river betrayed itself in the larger number of colon bacilli found in the Mississippi river at the intake tower and near the Missouri shore at the Chain of Rocks.

The sanitary significance which I attach to these findings is based on what I have been able to learn by my own observation and experiments regarding the significance and relative abundance of the colon bacillus in waters of various kinds as well as that derived from an examination of the available literature on the subject and the opinions of various sanitary experts already referred to in my testimony. It may be summed up by the statement that the water from the Missouri river during this period was distinctly more dangerous and unwholesome than the water of either the Illinois or the Mississippi river at Grafton, and further that the difference between the Illinois river above its mouth and the Mississippi river above 6123 Grafton while not great shows that on the whole the Illinois river was in a less highly polluted condition than the Mississippi.

Those examinations were made in pursuance of an agreement mutually entered into between the representatives of the complainant and the defendant. Plate IV is a photograph of fermentation tubes, showing differences in amount of gas production in said tubes, in samples of water taken from the Mississippi river at the Chain of Rocks, and Missouri river at Fort Bellefontaine. Reproduced facing page 6126.

6127 Witness explains what is shown by the photographs.

6128 These four photographs illustrate entirely typical conditions in the water of the Mississippi river at the Chain of Rocks and show that as a rule the water from the Missouri river and from the Missouri shore and intake tower of the Mississippi river and the Chain of Rocks contains the colon bacillus in larger numbers than the water of the Mississippi river along the Illinois shore. Plate V reproduced on page 6130.

6131 Plate 5 shows photographs of a series of 30 fermentation tubes prepared from samples of water collected from the Mississippi river on November 23, 1901, in cross section at the Chain of Rocks and from the Missouri river at Bellefontaine. On the left of the photograph are the samples taken from the Mississippi river, Illinois shore; only one of these, viz: that in which 1. cc. of water was inoculated shows gas production. The same is true of samples of water taken from the Mississippi river in the channel, although more gas was produced in this case.

The sample of water taken from the intake tower shows gas production, not only in the 1. cc. tube but in the .1 cc. tube, and in one of the .01 cc. tubes.

An entirely exact correspondence is shown by sample No. 200 taken from the Mississippi river at the Missiuri shore. 4 tubes showed gas production in this case also.

The Missouri river, No. 201, shows a very similar condition, except that no gas was produced in either of the .01 cc. tubes.

This close correspondence between the colon content of the Missouri river and that of the Mississippi river along the Missouri shore and at the intake tower points in my opinion unmistakably to the conclusions that the sanitary character of these waters was very similar, and the water flowing past the intake tower at the time at which these samples were collected was derived in a large part from the Missouri river rather than from the Mississippi or Illinois.

The close agreement between the samplees from the Illinois shore and the channel shows the essential uniformity of the body of water from those two sources and shows, furthermore, that from the sanitary point of view the water in this part of the river was less unwholesome, less highly charged with objectionable bacteria than the water from the Missouri river or than the water in the Mississippi river at the intake tower.

Q. What do the photographs show, professor, as to the mixing of the waters at this point of the three rivers?

A. They show that as far as the bacterial content is concerned the water flowing along the Missouri shore and by the intake tower was derived in large part if not wholly from the Missouri river while the water derived from the Illinois river clings to the Illinois shore and mixes little, if any, with the water of the Missouri.

6132 The character of these waters during this period as shown by the colon examinations and as set forth in the tables and illustrated by the photographs is quite different. The colon content of the Missouri river is markedly higher than that of either the Illinois or the Mississippi river at Grafton, and from this I infer that during this period the Missouri river was more highly charged with dangerous bacteria and was distinctly less safe than the waters of the Illinois river.

Under these conditions the effect of any mixture of the Illinois river water with the Missouri river water at the intake tower of the St. Louis waterworks would therefore tend to diminish the colon content of the water at that point, thereby rendering it less dangerous for the human use. Such mixing of the Illinois and Missouri waters as took place would hence improve the conditions existing during this period in the Mississippi river at the intake tower.

Throughout this period, in the later part of 1901, the water was low in the three rivers, the Illinois, the Mississippi and the Missouri.

MR. TODD: Professor, Mr. Allen Hazen, on page 4530 of the record, was asked this question " when the mixing begins at the mouth of the Illinois river, by the time it gets to the mouth of the Missouri river, is that mixing complete" and he answered "I do not think it is absolutely complete. It is approximately so; more so at low water than at high water." What do your bacterial analyses show as to whether there is more mixing of these waters at low water than at high water.

6133 I may state in reply that in my opinion the total number of bacteria in the water at the intake tower and near the Missouri shore at the Chain of Rocks as well as the number of colon bacteria in the water at these points shows conclusively that during this period of low water, the water collected at these two stations was almost wholly if not altogether Missouri river water and was mixed a little, if any, with the water from the Illinois. If it be true, therefore, that mixing is more complete at low water than at high water it will certainly follow that the amount of Illinois river water present in the Mississippi at these two points at high water stages must be exceedingly small.

I made an extended examination of species of bacteria taken from the river water at the three stations already described. That inclueds six points. I made a table of results, which said table is marked table No. 2 and is reproduced on page 6134.

6135 This detailed study of species shows that on the whole those forms regarded by bacteriologists as characteristic of sewage pollution are found more abundantly in the water of the Illinois river at Pekin than elsewhere. The Streptococcus forms which are believed by some to be specially characteristic of recent sewage pollution were found in four cases only, viz: two in the Illinois river at Pekin and two in the Mississippi river near the Missouri shore. The results as a whole confirm the deductions drawn from the study of the colon tables.

(Referring to the question of the practice in this country as to the number and time of determinations of river water, in order to determine the sanitary quality of same, witness refers to works of investigators in this country wherein examinations were made daily and weekly for a certain period of the year.

Witness then states:)

6136 In European countries, so far as I know, no extended examinations of river water, based on daily and weekly analyses, have been made, which cover so long a period of time as those that have been made in this case.

It is, therefore, my opinion that the usual practice of those experts having to do with the examination of river waters in this country is based on the belief that an adequate opinion as to the character of the water can be formed by examinations made at intervals as frequent and during periods as long as those indicated in the instances just cited.

6137 The examinations which I have made in behalf of the Sanitary District of Chicago cover two periods, the first, one of weekly examinations extending from about the first of May, 1899, to the first of July, 1900. During this period the regular weekly examinations were supplemented by daily and in some instances hourly examinations of the river waters at several points. The second period includes daily examinations made between about the first of November, 1901, to about the first of January, 1902. In all, the examinations that I have made cover a period of one year and five months. It is decidedly my opinion that it is possible to pass a competent judgment upon the waters of the Illinois, Mississippi and Missopri rivers on the basis of the analyses I have submitted in my testimony. The analytical data, chemical and bacterial, that I have secured by these weekly, daily and hourly determinations, extend over a sufficient interval of time and include sufficiently varying conditions to permit of a satisfactory judgment being rendered as to the general character of the waters dealt with. The separate analyses number many thousands and the results embody the experience gleaned from a study of high water and low water conditions, of summer and winter temperature, and of varying climatic and meteoroligical factors. It is my judgment that taking into consideration the analyses made concurrently by Professors Palmer, Long, Zeit, Gehrmann and Burrill, no such extensive and exhaustive study of river water, in connection with the problem of self purification of streams, has ever been made anywhere in the world as that carried out during this period. From my survey of the Missouri and Illinois rivers, as evidenced by the various analyses heretofore testified to in this case, prior to the 17th of January, 1900, the condition of the Missouri river as compared with that of the Illinois above Grafton was less satisfactory from a sanitary point of view and was distinctly inferior to the Illinois river at Averyville.

6138 The relative character of the two rivers was not materially different from the 17th of January, 1900, to the first of July, 1900. That is to say, the Missouri river water was more objectionable from a sanitary standpoint than the water of the Illinois river at its mouth or at Averyville.

During the period October-December, 1901, when daily examinations were made and a large number of results obtained, the sanitary quality of the Missouri river water was, in my opinion, distinctly inferior to the Illinois river water at its mouth and at Averyville, as shown especially by the colon determinations.

Taking into consideration all the analytical data that I have obtained throughout the seventeen months covered by the investigations, I conclude that one of the most remarkable facts, if not the most remarkable, is the entire concurrence of the results derived from the chemical and the various bacterial determinations. The amount and rate of nitrification in the water of the Illinois river at various points along its course, as shown by the tables of chemical analyses, are in line with what the experience of water analysts has shown to accompany a real purification. The large amount of organic matter present in the upper stretches of the Illinois river is oxidized during its passage down stream, and before Averyville is reached the nitrification of this organic matter has progressed practically to completion.

On the bacterial side, the evidence is wholly confirmatory

of this improvement in the quality of the Illinois river water. The enormous number of bacteria poured into the Illinois river
in its upper stretches, as shown by the number of bacteria
6139 present in the Illinois river at Lockport and Joliet, is
greatly diminished in a flow of less than one hundred
miles. Under certain conditions even, and at certain periods of the year, the Illinois river becomes nearly free from the great mass of sewage bacteria with which it was originally laden in as short a distance as 24 miles, as evidenced by the observations between Morris and Ottawa, already introduced. Both at Averyville and above Grafton the bacterial composition of the Illinois river water is about the same as that of tributary streams and as that of the Mississippi river just above Grafton. The colon contents of the Illinois river is in my opinion, especially significant from a sanitary point of view, and affords evidence in entire harmony with the conclusions derived from the chemical examinations and from the number of bacteria of all kinds shown to be present in these waters. The colon bacteria which are found in great abundance in the waters of the drainage canal and in the upper stretches of the river practically disappear before Averyville is reached.

It is clear from the data that I have presented that the water of the Illinois river undergoes a real and very considerable purification. The colon bacteria which are shown to be present in large numbers in Chicago sewage disappear almost completely in less than 150 miles flow. At the mouth of the Illinois river, despite the enormous initial pollution and the very large secondary pollution at Peoria, the number of colon bacteria is certainly no greater than the number in the Mississippi river at this point, and not as large as the number in the Missouri river at Bellefontaine. Since all investigators are agreed that the colon bacillus is more hardy than its relative, the typhoid bacillus, and can live in water for a longer time there is every reason for supposing that the latter microbe dies out with at least the same rapidity. If it be true, as I firmly believe to be the case, that the fate of the colon bacillus in running water furnishes the most satisfactory indication we can secure at present of the continuance of vitality of the typhoid bacillus, there can be no hasitation as to the conclusion to be drawn from this investigation. Since this biological relative of the typhoid bacillus perishes speedily and in large numbers in the course of the Illinois river, it is my opinion that the typhoid bacillus itself cannot long survive exposure to the same conditions.

The study of bacteria has been my main occupation for some 15 years. (Witness states what bacteria are, how they are classified and distinguished, how they are distributed, the characteristics of bacteria peculiar to waters and distinguishes between the so-called saphrophytes and parasites and between non-pathogenic and pathogenic bacteria.

6143 States the characteristics and life history of the bacillus prodigiosus.) The bacillus prodigiosus has been found in the waters of rivers and in other bodies of water in various parts of the world. On November 6, 1899, I isolated from the water of the Illinois river collected at Morris an organism which in all the characters I have described resembles exactly the bacillus prodigiosus. I have here a sheet of species description in which the biological characteristics of three cultures of bacillus prodigiosus obtained respectively from the University of Michigan Bacteriological Laboratory, from

6144 Yale University, and from the Ontario Board of Health, are tabulated. This shows that the characteristics of these three organisms, were similar. The organism isolated from the water of the Illinois river just above Morris on November 6, 1899, possesses all the characteristics manifested by these three specimens of bacillus prodigiosus and it is in my opinion a member of that group.

In addition to this form that I have identified as becillus prodigiosus I found on several occasions organisms which resembled the bacillus prodigiosus very closely, and might on superficial examination be mistaken for it.

(Witness states in what respects these organisms differ from the true bacillus prodigiosus type. Witness made a diagram showing species description of the prodigiosus from the University of Michigan, Yale University, Ontario Board of Health and the one which he separated from the Illinois river at Morris on November 6, 1899, also that found in the Mississippi river near the Missouri shore near the Chain of Rocks, November 16, 1901, which chart or diagram discloses the fact that the supposed bacillus prodigiosus found in the Mississippi river differs in three very important respects from the true bacillus prodigiosus type.

6148 On several occasions we have isolated from the water of the Illinois and Mississippi rivers organisms which in many particulars, especially in regard to pigment production, resemble very closely the typical bacillus prodigiosus. These organisms differ oftentimes in very slight degree from the true prodigiosus type. The differences consist, for the most part, in variations in their actions upon milk, gelatin, casein and blood serum and in their action upon the different sugars. Any examination of these organisms, other than a searching and detailed one, might lead to their being mistaken for the true prodigiosus type.

I read the testimony of Dr. Ravold wherein he detailed the result of what is known as his prodigiosus experiment. That experiment seems to me to constitute a demonstration of the power of self purification in streams, from the fact that along the upper collecting stations in the Illinois river this organism was not recovered, although frequent examinations were

6149 made of the water at these points and although, according to the testimony, prodigiosus numbers of this organism were introduced into the water of the drainage canal.

As regards the finding of a few individuals in the water of the Mississippi river, assumed to be of the same variety as that introduced, I can only say that the identification does not appear from the records to be altogether complete. And, furthermore, assuming that the organisms recovered from the Mississippi river were actually those introduced in the drainage canal, the appearance of so small a number would not in itself be significant. This is true especially since organisms belonging to this prodigiosus group, as has been shown, are sometimes found in the water of these rivers and are saprophytic forms which are evidently rather easily habituated to acquatic life.

(Witness is asked a hypothetical question assuming the deposit of 107 barrels of bacillus prodigiosus culture into the canal, the subsequent examination of the waters for its discovery and the finding of one bacillus at certain points at a later period, as heretofore testified.)

6150 In my opinion this experiment sheds a certain amount of light on the probable longevity of a typhoid bacillus under the conditions as stated. This is true for the reason that the relatively insignificant findings of bacillus prodigiosus, assuming identification to be correct, indicate that this organism, while in a fairly hardy saprophytic form, does not live long in the river water, and that the typhoid bacillus, which is beyond doubt a more highly specialized parasitic form than bacillus prodigiosus, would not survive as long as the latter. The
6151 experiment, in my judgment, affords strong confirmation of the evidence already derived from a study of the death rate among colon bacilli in the water of the Illinois river. Since bacillus prodigiosus dies off so speedily and in such large numbers, the typhoid bacillus would be less likely to survive exposure to these same conditions.

(Witness gives characteristics and pathological significance of cholera germ and tetanus germ.) I know of no instance where a case of tetanus has been traced to water borne infection. The germ is common in street dust, finding its way there probably from the droppings of horses in which it is usually present in considerable abundance. (Gives characteristics and pathological significance of anthrax germ.)

6153 There are a few cases on record where the refuse from tanneries has been washed into stream and deposited on fields; and cattle grazing on these fields have been known to became infected. There are also a few cases where the water of a well has become infected in this way and has caused disease among cattle. So far as man is concerned, anthrax is not, properly speaking, a water borne disease, since infection from this source, if it has ever occurred, is extremely rare. (Gives characteristics and pathological significance of the bacillus enteritidis sporogenes.) When this germ enters the human system through drinking water it will not produce disease so far as known. The evidence indicates quite the reverse. (Witness gives characteristics and pathological significance of dysentery bacillus and typhoid germ.)

6155 The typhoid germ is related to the colon bacillus in being a member of this large colon typhoid group. It differs from the colon in being less vigorous. I have already shown that as regards longevity in water, resistance to freezing, to drying and other adverse conditions of life, the colon bacillus is a more hardy organism than the typhoid bacillus.

6156 There are cases on record where even years after an attack of typhoid fever, the typhoid bacillus has been found in the bone marrow and other situations in the body of human beings. Outside of the human body, on the other hand, the life of the typhoid bacillus is comparatively brief. There is no evidence that it can remain alive in the water for more than a few days. It may remain alive in accumulations of dejecta in outhouses and privies for a much longer time and in the soil also it may retain its vitality for a considerable period. Although the evidence which connects polluted water supplies with outbreaks of typhoid fever is entirely convincing both in character and mass, there have been relatively few instances in
6157 which bacteriologists have succeeded in isolating a specific typhoid bacillus from suspected waters. (Witness then gives names of investigators who claim to have found typhoid bacillus in water.)

6158 There are therefore perhaps six cases where undoubtedly typhoid bacilli have been isolated from ordinary drinking water.

The meagreness of the findings despite the thousands of examinations that have been made by skilled bacteriologists in every part of the world is in my opinion explained chiefly by the relative short duration of the life of the typhoid bacillus in water. The period elapsing between the moment of infection and the initiation of bacterial investigation is usually at least two or three weeks, owing chiefly to the time occupied in incubation and in the insidious development and perhaps tardy recognition of the disease. Sometime is also consumed by the preliminaries necessary for the setting on foot of competent investigation. It is apparently only under exceptional conditions, such for instance as obtained in the case reported by Kubler and Neufeld, that the life of the bacillus can be extend throughout any considerable period. The history of most outbreaks of typhoid fever shows that the bacilli have disappeared from the water by the time search is inaugurated and it is for this reason that a negative finding is the usual result of bacterial examination.

6159 (Witness gives results of experiments made upon the life of the typhoid bacillus in sterilized waters kept in glass bottles in a laboratory.) In sterilized Lake Michigan water the bacillus does not multiply but may, under certain conditions, maintain its vitality for upwards of 93 days. The colon bacillus, under similar conditions under goes rapid multiplication and may remain alive for upwards of 262 days. I know of no evidence that the typhoid bacillus multiplies and increases in nature. On the contrary, from an examination of literature, the evidence appears to me overwhelming that typhoid bacilli as soon as discharged from the human body undergo a constant diminution in number. In my opinion the conditions of laboratory experiments are decidedly more favorable to the longevity of the typhoid bacillus than the conditions which obtain in nature. (Witness gives his reasons.)

6160 From what I know of the chemical composition and bacterial content of the waters of the Illinois river at various points along its source, it is my opinion that the life of the typhoid bacillus introduced into the Illinois river at the upper end of the drainage canal would not be more than three or four days. I think the germ will live longer in pure water than in polluted water. It is well known from the experiments of many observers that it lives longer in sterilized water than in unsterilized. I attribute this to the saphophytic microbes which inhabit polluted and unsterilized waters. (Witness gives reasons for above statement.)

6161 Am acquainted with the Chicago river, the drainage canal, the Des Plaines river, the Illinois river and the Mississippi river from Grafton to St. Louis and the Missouri river as it empties into the Mississippi. Witness states opportunities for becoming acquainted with the above named rivers and the tributaries of the Illinois, consisting of personal visits and inspection of the same between the years 1899 and 1903.

6163 (Witness describes the physical conditions of the Illinois river and its tributaries.)

From the point where the drainage canal empties into the Des Plaines river at Lockport, the fall is quite rapid to a point somewhere below Morris. The lower portion of the Illinois river, especially that part of the river from La Salle to the mouth of the Illinois at Grafton is very sluggish and consists of a series of pools in which the current is very slow and in which opportunities for sedimentation abound. In the lower reaches of the river the current is so slight as to be hardly noticeable. At intervals in the course of the river, dams are located; one at Marseilles, between Morris and Ottawa, one at Henry: between La Salle and Averyville, one at Copperas creek, some 58 miles below Peoria and two others between this point and Grafton at La Grange and Kampsville. These dams accentuate the tendency of the river to form pools and back waters. At Joliet and above Peoria there are wide expansions of the river known respectively as Lake Joliet and Lake Peoria. In these expanded reaches the current is very slight and the body of water as a whole is almost entirely quiescent. At many points along the course of the river, especially below La Salle, the banks of the river are low and an increase in the height of water in the river causes an overflow of the surrounding country flooding the meadows and low lands adjacent to the river bank. In the lower 225 miles of the Illinois river there is a fall of only about 30 feet and the extremely sluggish current thus produced affords nearly ideal conditions for sedimentation. During the flood stages the valley of the Illinois river becomes virtually a great lake into which flood waters from the upper portion of the valley and tributaries are precipitated, and from the lower end of which they pass out in diminished and equalized volume.

If it were true that any of the infecting and polluting matters from Chicago reached as far down even as Lake Peoria, the conditions existing there and farther down the Illinois
6164 river would be such as to bring about a further diminution in the amount of the substances. Under the circumstances of semi-stagnation already enumerated, the settling out of food particles, the entanglement of the bacteria in these, and possibly the slow sinking of the bacteria themselves would all have full effect and would work to diminish the number of suspended bacteria.

6165 I regard the conditions of semi-stagnation prevailing in the Illinois river at most points along its course as an important factor in influencing the fate of polluting and infectious matters added to the water of this stream and to the various tributaries. The exceedingly low gradient in the river which has been already referred to and which is further accentuated by dams at various points, retards the progress of suspended matters down stream and affords highly favorable conditions for purification. This is most marked during period of low water but at high water the flooding of the low lands and the meadows along the banks of the river also affords opportunity for sedimentation and the retarding influences are still active. It is my opinion that the conditions prevailing in the Illinois river during summer and winter, during low water and high water, are much more favorable to the self purification of the stream than conditions that exist in a stream flowing over a bed with a steep gradient where any infectious elements introduced might be hurried down without opportunities for sedimentation or for loss of vitality. The considerable time that must be consumed by a given mass of water flowing along the Illinois river affords opportunity for the death and destruction of such infectious and polluting matters as may be introduced into this river, either directly or from the tributaries.

6166 Sedimentation of bacteria occurs more quickly in water containing a considerable amount of suspended mater than it does in water which is relatively clear. As to the effect of the dilution of the sewage of Chicago with Lake Michigan water, there is at times a considerable amount of suspended matter in the water of Lake Michigan near the mouth of the Chicago river, but on the whole, the water of Lake Michigan is not a turbid water. In that portion of the Illinois river, however, where most sedimentation occurs, the amount of suspended mater introduced into the water from the tributaries and entering the river directly, is, in my judgment, sufficient to affect the same degree of sedimentation that would occur if the present amount of dilution with Lake Michigan water at the extreme upper end of the river was absent. In my judgment if the sewage of Chicago is turned into the drainage canal, diluted by one million cubic feet of Lake Michigan water per minute, such a dilution as that indicated would affect the degree of sedimentation in the Des Plaines river and probably in the upper part of the Illinois near the union of the Des Plaines and the Kankakee, but in the lower part of the Illinois river, especially in that stretch from La Salle to Grafton, where sedimentation is most active, it is my opinion that such dilution as that described would not materially affect the degree of sedimentation of bacteria. From what I know of the physical conditions of the Illinois river, and

of the character of the various tributary streams, it is my opinion that there would be sufficient suspended matter in
6167 the water to bring about a mechanical dragging down of bacteria,, and, moreover, that such an increase in the body of water as might result from this dilution would result in the spreading out of water of the Illinois river over the low lands, thus affording peculiarly favorable conditions for the sedimentation of bacteria.

When polluting or infectious matters are added to a water it naturally follows that the greater the dilution of such matters the less dangerous is a given quantity of such water, such for instance as a quart or a liter. In this sense dilution with a purer water may be said to increase the purity of the stream. So far as the actual destruction of infectious elements is concerned, dilution to such an extent as usually occurs, probably has but little influence.

Danger of infection is diminished by dilution for the reason that the infected matter is spread over a large area. Considering the conditions at the mouth of the Illinois river above Grafton, I should say that the dilution of Chicago sewage with the pure water of Lake Michigan has little if any effect upon the infectious quality of such water, since whether the sewage be diluted or not, death of any typhoid bacillus originally present therein would occur, in my opinion, long before the mouth of the Illinois river was reached.

6169 Assuming that the water of Lake Michigan under the conditions stated to Prof. Sedgwick on page 3542 of the record, passes through a conduit from the Lake front of Chicago to the Mississippi river at Grafton, I would say that I do not consider that it would be a menace or danger to the inhabitants of the State of Missouri and especially to the citizens of St. Louis drinking the Mississippi river water in its raw condition. I make this answer because in my opinion the typhoid bacillus would not survive exposure to the conditions in such a closed conduit any more than in my opinion it does survive exposure to the conditions existing in the Illinois river. And furthermore, assuming that no greater mixing of such water with the waters of the Mississippi river and Missouri river occurs than is the case at present it is my judgment that a very small portion of such water would reach the intake tower of the St. Louis waterworks, pass through the settling basins and be delivered to the inhabitants of the city of St. Louis.

Assuming the conditions in the Missouri and Mississippi river to be as they are at present, it is my judgment that the water issuing from such a conduit, and experiencing the same degree of purification which now takes place in the Illinois river, would tend rather to improvement and purification of such water so far as it might mingle with it.

The physical conditions of the Illinois river are better suited for the purpose of purification than are those of the Mississippi and Missouri rivers. (Reasons stated on page 5170.)

6172 (Witness is referred to answer of Prof. Sedgwick on page 369 of his testimony wherein he states that the river pollution commissioners of Great Britain in a report published by them in 1874 state there is no river in England long enough to purify itself from any sewage admitted to it, even at its source. That stands as one of the axioms of sanitary science today. Same statement was also made on page 4398.)

6173 The River Pollution Commission's report for 1874 states: "It will be safe to infer, however, from the above results, that there is no river in the United Kingdom long enough to effect the destruction of sewage by oxidation." At the time this report was published in 1874, the knowledge of sanitarians regarding the quality of water, was based on chemical data, this being before the rise of the science of bacteriology. Practically nothing was known at that time regarding the elements in sewage that imparted to its dangerous character. It does not, by any means, follow that because complete destruction by oxidation of the organic maters contained in a sewage polluted water does not occur within a specified distance, that the real purification of the sewage, that is to say, its freedom from dangerous bacteria may not be accomplished within that distance.

6175 I have examined the report of the Rivers Pollution Commission of 1874 with some care and have failed to discover in it any statement that no river in the United Kingdom is long enough to purify itself of any sewage introduced into it at its source. As to the effect of the sewage of Chicago discharged into the drainage canal, upon the waters of the Mississippi river as the same passes along the shore of the State of Missouri, I would say that a large amount of harmless inorganic

6176 chlorine in the water of the Illinois river at its mouth is derived chiefly from the sewage of Chicago and Peoria. So far as the water of the Illinois mingles with that of the Mississippi along the Missouri shore, so far is the chlorine content of the water heightened. In respect to the other constituents of the Illinois river water, the sewage introduced at Chicago influences the total amount of nitrogen compounds in said water. This is especially true of the nitrates, which are usuelly high at Grafton. In respect to the bacterial content of the water, the mixing of the Illinois with the Mississippi does not in my opinion introduce into the mixture any significant number of bacteria derived from the sewers of Chicago. It is my opinion that practically all the bacteria introduced into the drainage canal from the Chicago sewers perish long before the mouth of the Illinois is reached.

6177 I conclude that the sewage from Chicago, introduced into the drainage canal, has no injurious effect upon the waters of the Mississippi as the same passes along the shore of the State of Missouri.

I am unable to differentiate clearly between infectious matter and pollution dangerous to public health in this connection, since polluting matters dangerous to the public health are, so far as I am aware, those able to communicate infection. I, accordingly, would answer this question in the same way as I have answered the preceding, namely, that in my opinion no infectious matter coming from the sewers of Chicago by way of the drainage canal reaches as far down the Illinois river as the city of Grafton.

It is my opinion that no pollution dangerous to public health entering the drainage canal from the sewers of Chicago, reaches as far down the Illinois river as Grafton. I know of no evidence bacterial or chemical that would justify the conclusion that polluted and infected matter coming from the sewers of Chicago would reach as far down the Illinois river as Grafton. On the contrary, the evidence of which I am cognizant points to a precisely opposite conclusion. In my
6178 judgment the Illinois river at its mouth does not contain infectious matter of a dangerous character, derived from the sewers of Chicago, and so could not be a factor in carrying infectious and polluting matters from the sewers of Chicago to the city of St. Louis.

6179 From my knowledge of the conditions that obtain in Chicago and the drainage canal, it is my judgment that the sewage of Chicago has no injurious or deleterious effect upon the water supply of the city of St. Louis or upon the water of the Mississippi as it passes along the shore of the State of Missouri.

6180 I base my opinion that the typhoid bacillus will not live more than three or four days under conditions as they obtain in the drainage canal, the Des Plaines river and the Illinois river, chiefly on an elaborate experiment that I have recently carried out on the life of the typhoid bacillus under natural conditions in the water of the drainage canal at Robey street and at Lockport.

This experiment was conducted under the supervision of Prof. Russell of the University of Wisconsin, Prof. Zeit of the Northwestern Medical School and myself. (Wtiness states method of conducting the experiment referred to. It is important that the testimony as to this experiment, which is reproduced on the above page, *et seq*, be read.)

6198 Table I shows results obtained by the experiment performed at Lockport. This table shows that from one to nine days plates were taken, on none of which typhoid colonies were found.

6199 Table II shows result of experiment at Lockport in waters of the Drainage canal. This table shows that no typhoid colonies were found in from one to nine days.

6201 Table III, drainage canal at Lockport. This table shows that colonies were picked off every day for seven days and no typhoid bacilli were found among this number.

6202 Table IV, drainage canal at Lockport. Colonies were picked off every day from one to ten days inclusive, without discovering any typhoid bacilli.

6203 Table V, drainage canal at Lockport.

6204 This table shows that colonies were picked off for five days, none of which proved to be typhoid.

These early experiments gave negative results throughout largely because of the number of typhoid bacilli added in these cases; but especially because in these early experiments the time allowed to elapse after inoculation before a very large number of colonies were examined was in most cases too great, as is shown by the later experiments in which a shorter interval was allowed to elapse between inoculation and examination of the material in these sacs. The experiments, for example, recorded in table IV where no examinations were made of the water of the sac until after 3 days had elapsed is a case in point.

The outcome of these early experiments convinced us that if typhoid bacilli were to be found at all in the waters of the drainage canal under these conditions it must be by examinations made within a short time after the infection of sacs had been effected.

Table VI, drainage canal at Lockport.

6206 The table shows that after two days up to ten days no typhoid colonies were found.

Ten minutes after the typhoid bacilli had been introduced varying amounts of the mixture of the sewage and typhoid bacilli were plated in three different media. In one of these cases .001 of a c.c. was plated and there were 45 colonies in all on the plate. Fourteen of these colonies were picked out as looking suspiciously like typhoid colonies and on applying appropriate tests, as already described, 13 of these proved to be genuine typhoid bacilli. From this same sample of water .001 of a c.c. of water was plated and 160 colonies in all developed on the plate. Eighteen of these were picked off as looking like typhoid colonies and 17 of them proved to be genuine typhoid bacilli. Of this same sample .001 of a c.c. was plated in Hiss' medium, 230 colonies developed on the plate, 36 of these were picked off as resembling typhoid colonies and 33 of these proved to be genuine typhoid colonies.

The fact that on these three different media 63 out of 68 colonies that appeared to be like typhoid colonies turned out to be genuine typhoid organisms, demonstrates the great aid that these special media were in differentiating the typhoid bacillus in the presence of a multitude of sewage forms.

I consider this as one of the most remarkable of all experiments that were made. On the 10th day after inoculation 1 c.c. of the contents of the sac was plated in Hiss medium and 85 colonies in all developed on this medium, which is not only very favorable to the growth of the typhoid bacillus but to all

6207 other sewage forms, its inhibitive effect being less than that of other media. Eighty-five colonies in all developed in 1 c.c. of this sewage, and the whole number of 85 colonies was picked off the plate and examined and not one of these proved to be typhoid although 10 days previously when the sac was inoculated, each c.c. in the sac contained 360,000 typhoid bacilli.

This experiment plainly shows an enormous mortality among typhoid bacilli under these natural conditions in the water of the drainage canal. Examination of one whole c.c. of the water after 10 days shows that of the 360,000 that it originally contained not one was left alive.

6208 Table VII, drainage canal at Robey street. This table shows that colonies were plated from four to fourteen days and no typhoid bacillus found.

6209 Table VIII, drainage canal at Robey street. Colonies were plated from two to seven days inclusive and no typhoid bacillus found.

6210 Table IX, drainage canal at Robey street. Colonies were plated from four to fourteen days inclusive and no typhoid bacillus found.

6212 Table X, drainage canal at Robey street. Colonies were plated from two to six days and no typhoid found.

6213 Table XI, drainage canal at Robey street. Colonies were plated from two to five days and no typhoid found.

6214 Table XII, drainage canal at Robey street. Colonies were plated from two to five days and no typhoid found.

6216 Table XIII, drainage canal at Robey street. Colonies were plated from one hour to eight days. After one hour, after 20 hours, after 28 hours, after 2 days, typhoid found. From three to eight days, no typhoid found.

6218 Table XIIIa, drainage canal at Robey street. Colonies were plated from three to ten days. No typhoid found until the tenth day when three colonies were discovered.

6219 Table XIV, drainage canal at Robey street. Colonies were plated from 20 hours to 9 days. Typhoid found after 20 hours, 28 hours and two days. From two days to nine days, no typhoid found.

6222 Table XV, drainage canal at Robey street. Colonies were plated from four days to ten days and no typhoid found.

6223 By using the control sacs, we discovered that there was no such multiplication of bacteria under natural condition as has long been known to occur in glass bottles in the laboratory.

6224 This is one of the reasons for assuming that the conditions in these glass bottles are more favorable for the life of bacteria generally than in nature, and I have already indicated that one possible reason for this favorable effect is to be found in the nature of the substances dissolved by the water.

Tables A. B. C and D, reproduced on pages 6224 to 6227 inclusive, show results of experiments for the determination of river bacteria. Table A contains records of observations in canal water at Lockport. The initial number of sewage bacteria per c.c. was 470,000. In 3 days this number had sunk to 2,000. The initial number of colon bacillus in one c.c. was from 4,000 to 6,000. In 9 days the number of colon bacteria had diminished to 5; the number of streptococcus in one c.c. was, at the beginning 1,000; at 9 days no streptococcus was found when 10 c.c. of this water was examined.

Table B also shows observations at Lockport, showing a decrease in the number of sewage bacteria, colon bacilli and streptococcus. Table C contains records of observations in the drainage canal at Robey street and shows a decrease in sewage bacteria, colon bacilli and streptococcus. Table D shows observations at Robey street with the same results.

6227 I regard this experiment as being especially interesting in that it shows a slight initial increase similar to what is observed sometimes in the waters of the drainage canal flowing between Robey street and Lockport. This very slight initial increase is, however, followed by a rapid decline, and I would call particular attention to the fact that the initial increase does not amount to anything like what is observed in samples of this sewage standing in glass bottles in the laboratory.

6228 I regard the evidence presented by these control sacs as confirming altogether the inferences which I have already drawn concerning the naturalness of the conditions in these parchment sacs. The course of events, so far as the death of sewage bacteria and colon bacilli are concerned is precisely the same as what I have been led to consider happens in the river when these sewage bacteria are added to it in Chicago sewage. In both cases there is the same marked diminution in the number of sewage bacteria and in the number of colon bacilli.

6230 Table showing summary of averages for the drainage canal at Lockport, based on the tables already offered in evidence.

6232-3 Summary of averages for drainage canal at North Robey street.

6235 Also made experiments comparing the parchment sacs with celloidin sacs. (Witness describes experiments and results thereof.)

6237 I compared the behavior of sewage placed in parchment and celloidin sacs and kept under the same conditions. Fresh sewage obtained from the 56th street sewer in Chicago was placed in parchment and celloidin sacs, suspended in running lake water in the laboratory. The results showed that a multiplication of the sewage bacteria occur the first day followed in the next 24 hours by a marked decline. The number of colon bacteria and streptococci remain about the same for the first three days and then diminish very greatly.

I sent cultured medium to Prof. Russell at Peoria, which was used by him in his work.

6238 It was found by actual experiment under conditions which I believe to simulate closely those in nature that the typhoid bacillus, introduced into unsterilized Lake Michigan water was recovered four days after inoculation and was not found in subsequent examinations made up to the end of the fifteenth day. It is probable that specially resistant individual cells might survive longer than appeared to be the case in the experiment described in my testimony, but in my opinion even such highly resistant individuals, if they did exist, would not live more than about twice as long as the time recorded in these experiments. So that I conclude that 8 to 10 days would be a maximum period of longevity for the typhoid bacillus in the water of Lake Michigan, under natural conditions.

These experiments, of which a large number were made with varying numbers of typhoid bacilli introduced directly into the water of the drainage canal, gave generally uniform results. It was not difficult to discover typhoid bacilli during the first two days. Later than that they were never found either at Lockport or at Robey street, with one exception. In this anomolous case, 3 typhoid bacilli were isolated on the 10th day from a single plate in a single sac.

Taking into consideration all of the experiments made in the waters of the drainage canal, and assuming, as before, that specially resistant individual cells might exist, which would live twice as long as those found it is my opinion that typhoid bacilli introduced into the waters of the drainage canal, under
natural conditions, would not and do not live in that
6239 situation longer than four days.

Remembering that the upper stretches of the Illinois river are highly polluted with sewage and that considerable additions of sewage are made to the Illinois river at points along its course, I do not believe that bacilli introduced into the Des Plaines or upper portion of the Illinois river would live under natural conditions more than five or six days.

It is my opinion that a typhoid bacillus, discharged from the body of a typhoid patient in Chicago and assuming that such discharges were not disinfected so that the bacillus could pass into the sewers of Chicago and thence into the Chicago river and drainage canal, might live as long as 3 or 4 days after leaving the body of the patient.

From what I know of the rate of flow in the drainage canal and in the Des Plaines and upper Illinois rivers, in my judgment such a typhoid bacillus would perish long before Averyville was reached, even at a period of low temperature and high water.

6240 (Witness explains probable reason for the discovery of typhoid bacilli in one sac after ten days had elapsed.)

6241 I found no reason for believing that bacilli live any longer in the sediment of such sacs than freely suspended in the fluid. In my opinion the colon bacillus can live much longer in soil than in water but there is evidence that a certain destruction of colon bacilli takes place also in the soil although not so rapidly as in the water. Dr. Wm. G. Savage, who wrote a paper on self-purification of made soil, finds that the colon bacillus lives for some time in the soil but disappears as time goes on, the ordinary soil organisms invading the material and taking the place of colon bacillus. He concludes "that the gradual diminution and disappearance of the B. coli in this refuse is of interest from the point of view of specific contamination. This organism, apparently, rapidly dies out in such material. It is a more resistant organism than the typhoid bacillus. It is a fair assumption from this that the typhoid bacillus, if present in such soils, would also rapidly die out and that the danger of *specific* typhoid contamination from building on such made soil can be neglected."

6242 (Witness states that the experiment shows that colon bacillus and streptococcus, disappear in running water.) In my opinion, typhoid bacillus will not live as long in polluted water as in pure water because the products of the microbes are present in more concentrated form in the polluted waters than they are in the purer waters. The action of these toxic products in their concentrated form is naturally more intense than where these products are in a diluted condition. In my opinion there would be little material difference as to the longevity of typhoid bacillus in the sediment of a polluted stream as compared with that in the water of the same

6243 stream. (Witness gives reasons for above statement.)

(Witness differentiates between conditions which exist in moist soil and the sediment of a running stream with reference to the longevity of typhoid bacillus.)

6244 Under such circumstances as prevail where the contents of privy vaults are spread upon the surface of fields or vegetable gardens, typhoid bacilli may in my opinion live for many months. Under these conditions there is sufficient moisture present for them to retain their vitality, and at the same time, owing to the lack of continuous layer of fluid, any toxic products of other microbes can not diffuse through the mass and injure the typhoid bacilli. The fact that typhoid bacilli live several months in moist soil does not justify the assumption that they would live for the same length of time in the sediment of a river for the reason that there is slight opportunity in moist soil for the action of the soluble toxic products of saprophytic bacteria upon the typhoid bacilli and as I have stated, there is reason to believe that it is the effect of these soluble products upon the typhoid bacillus in water that causes the death of the latter. The poisons of these bacteria could not influence so profoundly the longevity of the typhoid bacillus in soil. The experiments by Dr. Savage that I have already cited, on the disappearance of the colon bacillus from soil indicate, however, that the typhoid bacillus will probably die out in soil, like its more hardy relative the colon bacillus, although less speedily than in the sediment of a river or in polluted water.

I don't know of any bacteriologist, since the beginning of bacteriology who has demonstrated by any experiment that typhoid germs do live in the sediment of lakes or rivers for a long period of time.

6245 (Referring to the statement made by Prof. Fuller, in his testimony on page 4218 of the transcript of the record, that "there were observers over in Switzerland who made such examinations with positive results showing the presence of typhoid germs in the sediment of Lake Geneva, I think also Lake Zurich," witness states:) No statements are made as to the methods of identification of these microbes. This was before the Widal tests were used for the identification of the typhoid bacillus, and in view of the fact that no statements are made by this authority regarding his other methods of identificatoin, the mere report of finding these organisms was not a satisfactory one.

6246 Loeffler, in his treatise on water micro-organisms, one of the leading German authorities on questions of this sort, in mentioning Lortet's report of the finding of the typhoid bacillus in the slime of Lake Geneva, puts an interrogation mark after the name "typhoid bacillus," indicating his skepticism as to the correct identification of this microbe. Personally I share this skepticism and am unable to assume, in view of the facts given by Lortet in his report, that this identification was correctly and satisfactorily accomplished.

6247 (Referring to Prof. Fuller's testimony on pages 4218 and 4219, with reference to the longevity of typhoid bacillus, the witness states on 6248 of record:) I do not know of any experiments or observations that demonstrate that typhoid fever can live in the sediment of running streams for a period up to a year. In my opinion, the conditions obtaining in moist soil are very different from those obtaining in the sediment of running streams, and I see no reason whatever for believing that the typhoid bacillus will live in the sediment of running streams for a similar period. I do not know of any published report of an experiment entering into the question of the life of the typhoid bacillus in natural waters as extensive as the experiments which Prof. Zeit, Prof. Russell and myself have made, which has been introduced in evidence.

6249 I have already indicated it as my opinion and to this I firmly hold, that the conditions under which this experiment were conducted imitate natural conditions as closely as it is possible to imitate them in the present state of bacteriology. **(Witness states reasons why conditions in the experiments made closely simulate natural conditions.)**

6251 It is my opinion that typhoid bacilli could not survive the journey from Chicago to St. Louis under the conditions just mentioned, and I do not believe that such typhoid bacilli would arrive in the Mississippi river in a condition that they could be called a menace to the inhabitants of St. Louis. Infectious matters which the settling basins at St. Louis eliminate, come, in my opinion, from places nearer to St. Louis than Chicago, places situated on the Missouri, Mississippi and Illinois river, within five or six days flow from the intake tower. I don't believe that any dangerous elements entering the sewers of Chicago reach as far as the Mississippi river, and if that is the case, I don't see how the settling basins of St. Louis protect against the sewage of Chicago.

6252 It doesn't seem to me that because a reservoir or settling basin holds thirty days' supply that all typhoid bacilli introduced into the reservoir remain there for 30 days.

6253 (Witness quotes from paper by Dr. Hoeber on experiments of the longevity of cholera and anthrax bacilli in an aquarium. I have investigated several epidemics of typhoid fever in this country, one being at Ithaca, New York, and another at Butler, Penna. I have also as already stated investigated in considerable detail the circumstances of several of the most important outbreaks of typhoid fever that have occurred in the Unietd States. (Witness gives history of the Ithaca epidemic on page 6254.)

They were such sources of infection as one sees frequently in the country districts of this country; overhanging privies and water closets close to the banks of streams. There seemed to be no supervision of the water shed in the way of guarding against contamination by bands of laborers. I should call the sources of infection in this case distinctively and peculiarly rural.

6255 Witness describes the Butler epidemic.

6256 The Butler epidemic was attributed to rural population.

These houses on the Connoquenessing water shed in which the cases of typhoid fever occurred were typical small American farm houses and shanties provided with loosely constructed privies. Discharges from the bodies of patients were thrown, with little attempt at disinfection, either into these outhouses or directly upon the steep rocky hill sides where they remained until washed down into the creek by heavy rains. The class and character of the infection were such as pertain distinctively to rural conditions. I was at Lowell for a short time with Prof. Sedgwick when he investigated the outbreak of typhoid fever in that city, to which reference has been made in his testimony. I visited Stamford, Conn., during the progress of a considerable epidemic of typhoid fever in that town, due to infected milk supply. I have also known something about the conditions in the city of Chicago, leading to excessive prevalence of typhoid fever in this city. In regard to the Plymouth epidemic this was also a case of rural infection. The outbreak was traced to an infection of the water supply with the dejecta from a single typhoid patient which had been thrown out on the hillside and allowed to accumulate near one of the feeders of the reservoirs supply the town with water. There the most of infectious material remained until washed down into the stream by spring floods and melting snows. The Lowell outbreak was also a case of rural infection.

6260 In the interpretation of vital statistics the racial characteristics must be taken into consideration.

6261 It is well known that certain races of mankind manifest inborn powers of weakness or of resistance to the onslaughts of various forms of disease. For example, persons of Irish parentage are much more liable to consumption and pneumonia than Russian and Polish Jews. Any city or any section of a city, therefore, having a large proportion of its population of Irish parentage, will have a higher death rate from consumption and pneumonia than a district containing few Irish and a larger proportion of Russian and Polish Jews. By the expression, "mortality percentage method," is meant the method of representing the prevalence or fatality of a disease by reckoning the ratio of deaths from that disease to the total deaths occurring in that population during the period under consideration. It is my opinion that the mortality percentage method may and often does fail to give correct information as to the prevalence of a given disease in a community during any specified period.

6262 This mortality percentage method is distinctly not in favor among sanitarians and epidemiologists here and in Europe. In support of this statement witness reads from Newsholme's Vital Statistics, page 186.

6263 (Witness also gives as an illustration of the fallacious character of the mortality percentage method as not furnishing the correct rule for the interpretation of vital statistics, the records of the city of New York, also of the city of Boston.

6265 (Referring to the testimony of Prof. Sedgwick on page 3540 of the transcript, wherein he states that he used the mortality percentages in fixing the increase in typhoid in St. Louis, witness states:) I have already indicated my reasons for believing that the mortality percentage method is not a valid method. Uncertain as the population factor may sometimes be, the estimation of the death rate on the basis of population does not involve any such fundamental fallacy as that contained in the mortality percentage method, when owing to the fluctuation in the number of total deaths from year to year, it is dealing with two variables and the ratio of deaths from one specific cause to the total number of deaths can not give a true indication of the prevalence of mortality from a specified cause. It is, therefore, my opinion that the mortality percentage method is not a valid one to use in estimating the typhoid conditions in the city of St. Louis.

6266 In my opinion the statistics in the health records should be carefully examined and scrutinized as there are considerable differences in the practice of various health boards and organizations in the matter of reporting deaths under various and varying designations.

The ratios of deaths from a specified cause to the population, or what is known among vital statisticians as the death rate, usually considered on the basis of 1,000, 10,000 or 100,000 population, will then give, with a reasonably accurate estimate of the population, a fairly correct conception of the mortality from year to year and from decade to decade.

6267 In my opinion chemistry and bacteriology often afford very great assistance in arriving at a judgment of the character of a river water. It is sometimes true that chemical and bacteriological data are the only data that one can obtain in regard to the character of a given water and while the inferences from the bacteriological or chemical data alone are perhaps rarely final, such data are frequently the only available material upon which a judgment can be founded.

In any case an experienced epidemiologist would attempt to secure chemical and bacteriological data regarding the character of a river water as constituting an important element in enabling him to form a judgment of the water.

Here, in particular, analyses offer a material aid in determining the rate and extent of the process of self-purification. Analyses of a river water, polluted at its source, which are made at various points along its course, make it possible to trace the successive changes that take place in the amount and condition of the organic matter in the water, and in the number and kinds of bacteria.

It is my opinion that correct inferences may be drawn regarding the process of self-purification by the study of such analytical data.

I will reiterate what I have already stated that all sources of information of any kind, tending to shed light on questions in issue, are valuable to sanitarians and epidemiologists and should be investigated and considered.

(Wtiness states method of ascertaining presence of infectious diseases in various communities, also the ordinary mode of causation of infectious diseases and the chief sources of infection in typhoid fever.

6269 It is not a legitimate inference that because typhoid fever increases in a city, that such increase is due to an increase in the infection of the water supply, unless other sources of infection are eliminated. An increase of typhoid fever in a city may be due of course to an increased infection of the public water supply, but it may also be due to the infection of the milk supply, or an infection of private wells, to special opportunities for the transmission of the disease by insects or to a change in the character of the population, such as the immigration of a large number of persons of susceptible ages, who had not previously lived in the city, and acquired a certain degree of immunity.

6270 Assuming that the reports of the St. Louis Board of Health show an apparent increase in typhoid fever during the years 1900, 1901, 1902 and 1903, as compared with previous years, it is not in my opinion a justifiable conclusion that said apparent increase of typhoid fever in St. Louis is due to any infectious matter passing into the sewers of Chicago and thence into the Illinois and Mississippi rivers, by way of the drainage canal. An increase in the infection of the Mississippi river water from points near at hand would seem to me to afford a more satisfactory and scientific explanation of an increase of typhoid fever in St. Louis than the passage of any typhoid bacilli into the intake of the St. Louis waterworks from a point so far removed as Chicago.

6271 The specially severe incidence of disease in one district or in one section of a city might be regarded as a special intensity of infection. If there are 1,000 cases of typhoid fever in one ward in the city as compared with 50 in a neigh-
6272 boring ward, with the same population, the infection might be said to be more intense in one case than in the other.

The word intensity might be used, too, I suppose, to indicate severity of individual cases of disease. If among 1,000 cases of typhoid fever in one ward 200 died while in a neighboring ward with the same number of cases only 50 died, the intensity of infection might be said to be greater in the former case than in the latter.

It has been observed that where a community is served by an infected water supply there are often fewer cases of typhoid fever in the periphery of the town at a distance from the central source, than they are close to the point where the water is pumped into the mains. In other words, the greater the distance from the source of infection the less the intensity of the disease. The nearer the source of infection the more severe the incidence.

The observations that I have just alluded to are observations of this character and indicate that the more remote the source of infection the less severe is the incidence of disease.

(Witness states that typhoid bacilli decline in virulence through a prolonged sojourn in water and quotes from authorities presenting the same opinion after investigations which they made, and who also state that typhoid bacilli were found by them in waters that were not giving rise to typhoid fever.)

6273 By decrease in virulence of a typhoid fever germ, I mean a diminution in its power to invade the human body and bring about pathological conditions.

6274 Typhoid fever is a rural, rather than an urban disease.

6275 It is my opinion that the danger from a rural population can by no means be ignored by any sanitarian or epidemiologist who wishes to take into account all data bearing upon questions of the spread and transmission of infection. (Witness gives figures and instances in support of the above statement.)

6276 (Witness refers to epidemic caused by infection from a rural population.)

6277 (Gives reasons why infection from rural population is to be specially feared.) I have a table of deaths reported from typhoid fever in St. Louis, by months, from January, 1890, to December, 1903, inclusive, and I have a similar table for Chicago for exactly the same period. (These tables are reproduced on pages 6279 and 6280.)

6281 From these tables, I am unable to discover any relation between the monthly deaths from typhoid fever in Chicago and those in St. Louis. An increase in the death rate from typhoid fever in St. Louis is not preceded by a corresponding increase in the death rate in Chicago. A decrease in number in Chicago is not followed by a decrease in number in St. Louis.

6282 If typhoid fever in St. Louis during that period was caused by infection coming from Chicago, I should certainly expect to find some relation obtaining between the prevalence of this disease in Chicago and that in St. Louis.

I should anticipate that in general if the typhoid fever conditions in St. Louis were dependent upon those in Chicago that a large number of deaths from typhoid fever in the latter city would be followed within three or four months by an increase in the number of typhoid deaths in St. Louis.

No such relation appears in the monthly records of typhoid fever of these two cities as tabulated.

It is therefore my judgment that typhoid fever conditions in St. Louis are unaffected by a large amount or small amount of typhoid fever in Chicago.

(Witness refers to water gauge readings at Kampsville, Illinois, of which tables have been made.)

6283 From an examination of the tables just referred to, I am unable to discover any connection between the stage of low water as disclosed in the gauge readings at Kampsville, and a large amount or small amount of typhoid fever in St. Louis. In the four years for which record is at hand, absolutely no relation exists between low water in the Illinois river as shown by the gauge readings at Kampsville and an increase or decrease in the typhoid mortality in the city of St. Louis.

6284 From an examination of the monthly deaths reported from typhoid fever in Chicago and St. Louis between 1890 and 1903 inclusive, I am unable to discover any dependence of the mortality in St. Louis upon that in Chicago, as respects extent of mortality, season of year or stages of water in the Illinois river.

6285 Have made a study of the so-called germ diseases in connection with my work in bacteriology.

6286 (States what typhoid fever and malarial fever are and their clinical diagnosis.) (Witness refers also to other types of fevers and states:)

6288 It is generally considered that these designations relate in almost every instance to cases of typhoid fever and that they should be so regarded. It is the general opinion among statisticians that the deaths so classed should be transferred bodily to the column of deaths from typhoid fever since they are practically in all cases deaths from typhoid fever and not deaths from malaria. Malaria in fact, as it occurs in temperate countries is rarely fatal.

(Witness quotes from various authorities tending to show that typhoid malaria and typhoid fever are the same disease.) The number of deaths reported, as occurring from typhoid fever in St. Louis according to the reports of the St. Louis Health Department, in my opinion, certainly do not represent the total number of typhoid deaths actually occurring in that city from the period 1890 to 1903 inclusive.

6291 I find in the records of the Health Department of the City of St. Louis a very considerable number of deaths under the heading "Remittent, Intermittent, Typho-malarial, Congestive and Simple Continued Fevers." I have already given what seems to me adequate reasons for believing that the majority of these, if not indeed all of them, were deaths from genuine typhoid fever and properly should be so classed. Since there is no reason to suppose that these figures do not correctly represent the reports received from the physicians of St. Louis, I see no escape from the conclusion that the value of these statistics to properly disclose the number of typhoid fever deaths occurring in St. Louis was due to an improper diagnosis. The terms "Remittent, Intermittent, Typho-malarial, Congestive and Simple Continued" fevers have a weight of traditional use behind them. Furthermore it is only in relatively recent years that the sure distinction and differentiation of typhoid and malarial fevers has become possible, through the application of laboratory methods. Many of the physicians who received their medical education before these laboratory methods were in vogue do not habitually employ such methods in their practice, and without these modern methods, on the basis of clinical symptoms alone, it is often difficult and indeed well nigh impossible

6292 to differentiate obscure and indefinite types of fever. In my opinion no city in the United States has as large a death rate from genuine malaria as would be indicated by the official records of St. Louis, assuming that all deaths reported under this head of remittent, intermittent fever, etc., were deaths from malaria. (Table read in evidence of page 6293 showing typhoid deaths by each month from 1895 to 1903 inclusive, with table for same period with the fevers indicated in heading as "Remittent, Intermittent, Typho-malarial, Congestive and Simple Continued fevers." The table shows a close parallel between the number of deaths reported from these two causes—that is, typhoid fever and the other fevers enumerated.

6294 An interesting change is noted in the latter part of this table. For the first five years of the table the number of deaths under the heading B (remittent fever, etc.), was greater than the number of deaths under the heading A (typhoid fever). Beginning with 1901 the reverse is true. The number of deaths reported under the heading typhoid fever becomes greater than the number reported under the heading remittent fever. To take for example the month of September.

6295 Inspection of these figures shows that in the last four years there has been a transfer from the column B, that of remittent fever, etc., to the column A, that of typhoid fever, the effect being to diminish the number of deaths reported as remittent fever, etc., and increase those reported as typhoid fever.

Witness reads table in evidence showing same results as previous table but by years instead of months. This table shows a similar condition to that evidenced in the monthly tables just produced. They show that a much larger proportion of deaths is reported under the heading "Remittent fever, etc., before the year 1900 than since that year.

6296 They also show that whereas the number of deaths reported from typhoid fever was generally less during the first 10 years of this period than the number of deaths reported from remittent fever, etc., during the last four years, the case has been just reversed. It is evident that there has been some cause or that there have been some causes at work tending to produce a more accurate diagnosis on the part of the physicians and that a larger number of cases of true typhoid fever have been recognized as such during the latter period than during the earlier one.

6297 (Witness refers to circular letters issued by the St. Louis Health Department in the fall of 1900, calling upon physicians to make reports of typhoid fever deaths, etc.) It is certainly in my opinion a significant fact that since 1900 there has been this decided change in the mode of reporting deaths.

6299 There is every reason to suppose that during the first five years covered by these tables a larger proportion of the deaths recorded under the heading "intermittent fever, etc.," were genuine typhoid fever than in the latter period owing chiefly to the progress that has been made in the methods of diagnosis.

(Witness refers to tables and figures by which he attempts to show that the typhoid fever returns made to the city of St. Louis prior to the year 1900 were not complete and that many of the reports of death from intermittent and other fevers, should have been classed under the head of typhoid fever. It is quite important that the testimony of the witness on these matters should be carefully reviewed from the record itself.)

6308 In consideration of all the facts regarding the mortality of typhoid fever in the city of St. Louis during the period indicated that can be obtained from the official records as published it is my opinion that the average annual death rate from typhoid fever in that city has been lower for the four years 1900 to 1903 than for the preceding decade, excluding the epidemic year of 1892.

From the facts already cited which embody all the information that I have been able to obtain, and from a critical analyses of the figures presented in the reports of the health department of the city of St. Louis I conclude that there has been no increase in the annual death rate from typhoid fever in the city of St. Louis since January 17, 1900, as compared with the average annual death rate for the four years preceding 1900. As shown in my answer to a previous question the death rate for these two periods computed on the assumption that the typhoid fever deaths and the typho-malarial deaths should be considered as a whole, is almost exactly the same.

6309 It is my best judgment based upon all the information of which I have become possessed that no portion of the typhoid fever mortality occurring in St. Louis since January, 1900, can be attributed directly or indirectly to the opening of the Chicago drainage canal.

6310 Running water, like still water, will rid itself of pathogenic bacteria after a sufficient time. The factor of time rather than distance influences the disappearance of pathogenic microbes. There is satisfactory evidence that a flowing stream becomes freed from large numbers of sewage bacteria that are introduced into it, and since many of these sewage bacteria are much more resistant than most pathogenic microbes it follows that the rate of disappearance of the latter is probably more rapid than that of the harmless sewage bacteria. A remarkable instance of the disappearance of sewage bacteria in running water is furnished by the condition of the Mississippi river at New Orleans. Although the sewage of the whole interior of the North American continent enters the Mississippi river and its tributaries, the number of colon bacilli, the most characteristic bacteria of sewage at New Orleans is so small that from this standpoint the water compares favorably with many filtered waters and indeed many pure spring waters. The evidence on the whole is overwhelming that running water, like standing water, can and does purify itself.

It is my opinion that the waters of the Mississippi west of the center of the main channel of the river below the mouth of the Illinois river and down to the intake tower of the St. Louis waterworks at the Chain of Rocks are no less valuable for
6311 drinking purposes nor more liable to carry water borne diseases than they were before the sewage of the sanitary district of Chicago passed through the drainage canal and through it into the Illinois river.

I have seen no reason to think that the added volume of water from the drainage canal would materially affect the

amount of sedimentation occurring at most seasons in the Illi-
nois river, since the speed of the current in the river appears to
be but slightly affected by the increased discharge from the drain-
age canal. The increased volume leads rather to the spreading
out of the river into the low-lying banks and subjacent
6312 meadows thus affording additional opportunities for sed-
imentation rather than leading to a scouring of the
channel.

The analyses and examinations that have been made of the water in the Illinois river at its mouth do not in my opinion show that the opening of the drainage canal has caused the sewage from Joliet, Peoria and other towns of the Illinois river to be hurried into the waters of the Mississippi river any more rapidly than was the case before the added volume of water from the drainage canal was poured into the waters of the Illinois.

6313 I do not think that such increased speed as might reasonably be assumed to result from the opening of the drainage canal would increase in any degree the liability to typhoid and other water borne diseases of the inhabitants of the State of Missouri for the reason that such shortening of the time involved as might legitimately be assumed to occur would not come within the range of longevity of a typhoid bacillus under these conditions.

6314 I know of no evidence that indicates that in a sewage polluted stream typhoid bacilli might live for years, months or even weeks. On the contrary all the evidence that I am familiar with regarding the life of typhoid germs in water, even under the very favorable conditions present in sterilized water, in glass flasks in a laboratory shows that this organism is not only able to multiply under thesse conditions. but that it diminishes rapidly and steadily.

6315 In my opinion, and I believe in that of bacteriologists generally, the presence of colon bacilli in water affords a satisfactory clue to the amount and freshness of sewage pollution.

Since it is true that the number of colon bacilli now found in the water of the Illinois river at Grafton is no greater than the number found in the water at this same place before the opening of the drainage canal, I am certainly compelled to conclude that the character of the water and its liability to contain typhoid germs has not been materially changed and that the water is no more dangerous than formerly.

From all that I have been able to learn concerning the life history of the typhoid germ in water, it is my opinion that it is most improbable that typhoid germs would live long enough in the Illinois river to pass from Lockport to Lake Peoria. In case of such an extremely unlikely occurrence any such typhoid germs deposited on the bed of Lake Peoria would in my judgment be in an extremely weakened condition and would
6316 not be likely to live for more than a few hours. It is my opinion that there certainly would be no accumulation of bacilli under these conditions.

Water leaving Lake Peoria cannot at any time contain more living typhoid bacilli than exist in the diluted sewage floating from the Bear Trap Dam.

6317 It is my opinion that typhoid fever germs coming from Chicago sewage rarely, if ever, live long enough to reach Averyville, and it is consequently my judgment that such germs cannot be deposited in large numbers in the lakes and slack water portions of the Illinois river above Peoria. It is emphatically my opinion that the number of typhoid germs in the water of the Illinois river and Lake Peoria is never as great as the number in the drainage canal near the Bar Trap dam at Lockport, and furthermore that the assumption that they are is not, so far as I am cognizant of the facts, borne out by any data, chemical, bacteriological or epidemiological.

6318 I have studied the facts and read the testimony regarding the dredging of the Black river at Port Huron and I do not consider the cause of the epidemic at Detroit has been established as coming from the Black river.

6320 From all the knowledge that I have, I have formed the opinion that the water of the Illinois river at Grafton does not contain infectious elements derived from the sewage of Chicago, and that consequently such water reaching the Mississippi river and becoming mixed with that water is not a menace to the health of the inhabitants of the State of Missouri, on the Missouri shore of the Mississippi river or to the citizens of St. Louis.

I know of no evidence that indicates directly or indirectly that the waters of the Illinois river at Grafton are infected from the sewers of Chicago, and in view of the large amount of pollution of the Illinois river that takes place at points less remote from its mouth than Chicago, it is my opinion that convincing evidence of such infection coming from Chicago would be very difficult if not impossible to secure.

6323 Assuming that there had actually been a marked increase in typhoid fever in St. Louis since the opening of the drainage canal, which appears to me to be contrary to the fact, it would, in my opinion, be more reasonable and significant to attribute such an increase in typhoid fever to other causes, such, for example, as an infection of the water supply nearer the water intake, to infection of the milk supply or to some other factor rather than to infected sewage coming from the sanitary district of Chicago.

6324 It is my opinion and judgment that the chemical, bacteriological and epidemiological evidence is altogether convincing that the water of the Illinois river at its mouth is no more unsafe and unwholesome now than it was before the opening of the canal, and that consequently the water of the Illinois river since the opening of the canal has not rendered less safe and wholesome the waters of the Mississippi river below the mouth of the Illinois river.

(The witness in this examination was asked a great many questions that were asked Prof. Sedgwick.)

6329 From all the tables and analyses submitted by me in evidence in this case, assuming that by practical purification is meant the death of typhoid bacilli, in my opinion this purification has occurred before the flow of the Illinois river reaches Averyville. The exact point must vary somewhat with the rate of flow, temperature, number of bacilli introduced, concentration of sewage, etc. The question of self-purification of running streams has been given great attention in Europe and in parts of this country. I have read the statements on this matter by the leading authorities on water supply and river water, published in English, French and German.

6330 (Witness quotes from Dr. Thresh's work on "Water and Water Supplies," which witness states is one of the best known and most authoritative treatises in the English language on water supply.) In order to qualify as a sanitary expert, I should consider that some knowledge of chemistry and bacteriology was absolutely necessary.

6331 It is my opinion that a typhoid bacillus that had remained alive for sixty days in the sediment of a stream or a lake,—a supposition in itself extremely improbable,—would not be virulent and capable of causing disease in man. I base this opinion upon the observations on virulence of typhoid bacilli after a long sojourn in water. Meager as these observations are, they indicate that a decline in virulence does occur. I should like to add that from all the information that I have been able to gather it seems to me highly unlikely that a typhoid bacillus could remain alive and virulent in sediment for a period as long as that designated.

6332 Comparing the Missouri river near its mouth with the Illinois river above Grafton, and the Mississippi river above Grafton, I have no hesitation in saying that I regard the waters of the Mississippi and Illinois, at the point indicated, less dangerous and less unwholesome than the waters of the Missouri river. Between the Illinois and the Mississippi rivers, at the point indicated, there is, in my opinion, not much to choose from a sanitary point of view.

6333 Such an admixture as occurred of the Illinois river water with the Missouri river water would tend to improve the quality of the water since the number of colon bacilli in the waters of the Missouri river are distinctly greater than those in the waters of the Illinois, and this condition, in my opinion, indicates that the Missouri river water, which is more highly charged with these objectionable bacteria, is more likely to be the vehicle of typhoid fever bacilli than the water of the Illinois which does not contain so many bacteria of this type.

All the analytical data that I have obtained myself and all that I have seen which has been obtained by other investigators indicate both from the chemical changes that take place and from the diminution in the number of ordinary sewage bacteria, and especially in the diminution of the number of bacillus coli communis that under existing conditions, infectious materials introduced into the sewers of Chicago can not and do not pass down the Illinois river as far as Grafton.

The mixing of the Illinois with the Mississippi and Missouri rivers does not create any added danger to the already polluted and contaminated waters of the Missouri and Mississippi rivers below Grafton.

6334 (Witness makes a comparison of the increase in typhoid fever in Washington, D. C., due to an epidemic in Cumberland, Md., with the conditions existing on the Illinois river and the city of St. Louis, and states that in the later instance the conditions are radically different.)

6335 It is my opinion that the typhoid bacillus could not live nearly as long as from one to three years in the sediment of the river or drainage canal.

6336 The pollution that has occurred in Chicago is manifest at the mouth of the Illinois river chiefly in the increased amount of chlorine present in the water of the Illinois river at that point. The introduction of a large amount of nitrogenous organic matter is also betrayed by the large amounts of various compounds containing nitrogen present in the water of the Illinois river at its mouth, but so far as the original polluting matters and pathogenic bacteria introduced into the Chicago drainage canal are concerned, I can find no grounds for adopting the opinion that these substances and these bacteria persist in their original condition as far down as Grafton.

6338 The dams of slack water basins or lakes in the Illinois river, in my opinion, materially facilitate the process of sedimentation and also serve to retard the current in a not inconciderable degree.

6339 So far as the purification of the sewage of Chicago is concerned, the assumption of the removal of the dams at the places stated would in my opinion not materially affect such purification, since the elimination of typhoid bacilli takes place, in my judgment, in the upper stretches of the Illinois river. It is possible that a removal of said dams might have some effect in retarding the purification of the sewage and the elimination of dangerous bacteria discharged by various communities in the lower half of the river.

The water supply of St. Louis and the water supply of the citizens from the Mississippi river would not be endangered or infected by the sewage of Chicago entering the drainage canal if the four dams before mentiond, in the Illinois river should be removed. In my opinion, those dams have little, if any share in effecting or accelerating the effect of the Chicago sewage.

6340 In my opinion the Mississippi river water at the intake tower at St. Louis was unfit and unsafe for drinking purooses prior to January, 1900. The Missouri river water at Bellefontaine prior to 1900—assuming that the period of storage of such water in settling basins was not greater than three or four days—in my opinion was not fit or safe for drinking and domestic purposes. The Illinois river in my opinion was not a safe water for drinking and domestic purposes prior to the opening of the drainage canal at Grafton.

In my best judgment the sanitary quality has not been materially affected either in the direction of improvement or in deterioration.

So far as I can judge from all the analytical data that have come under my observation the Illinois river water at this time was no worse than the water of the Mississippi river, while the water of the Missouri river was distinctly inferior in its sanitary qualities to both the water of the Mississippi and the Illinois.

6341 Beyond increasing the amount of chlorine and perhaps of some other constituents of no sanitary significance it is my opinion that the sewage of Chicago has had no material effect upon the water of the Mississippi river.

6342 It is my opinion, assigning due consideration to all the facts mentioned, that the discharge of the sewage of Chicago into the drainage canal has had no injurious or detrimental effect upon the health of the inhabitants of St. Louis or the State of Missouri.

6343 Summing up all the experience that I have gained in my studies of the Illinois and Mississippi and Missouri rivers and their tributaries and all the information that I have gained from all sources it is my firm opinion that no relation near or remote, has been traced between the typhoid conditions in St. Louis since January 17, 1900, and the opening of the drainage canal on that date; and it is further my opinion that no such relation exists, and that the opening of the drainage canal was an event entirely unconnected and unrelated with any typhoidal conditions prevailing in St. Louis at that time and has remained up to the present time, unrelated and unconnected with the typhoid fever mortality in the city of St. Louis.

CROSS-EXAMINATION, by Mr. Jeffries:

6345 The best evidence as to water being typhoid infected is the result which it produces upon a community using it for domestic or drinking purposes. (Witness states that typhoid bacilli are never found in suposedly infected water for the reason that the examination of such water is made after the disease is prevalent and the period of incubation has elapsed and during that time the typhoid bacteria in the water that may have caused the typhoid fever have disappeared.)

6350 In the event that there would be one typhoid fever germ for every pint of water I should not consider that as a highly infected water supply. Nothing is known as to the number of typhoid fever bacilli necessary to produce a case of typhoid fever in man. A laboratory worker attempted suicide through swallowing several tubes of broth cultures of typhoid bacilli but only a mild case of typhoid fever resulted, in spite of the hundreds of millions of bacilli that were taken in this highly infected broth.

6351 This instance of experimental suicide would not have the same effect if undergone by all persons promiscuously. We do not know how widely the susceptibility of different individuals to infection with typhoid fever bacillus varies or upon which such susceptibility depends.

6352 All the experience gained in bacteriological laboratories from inoculation of hundreds and thousands of animals with many kinds of pathogenic bacteria under varying conditions has shown that rarely if ever can one, two or three germs, even when belonging to highly virulent varieties produce infection. It is my opinion that swallowing one or two or a half dozen typhoid germs would not produce a case of typhoid fever in man, basing this opinion on the analogies drawn from laboratory experience.

6361 (Witness is asked hypothetical question based upon table 134, introduced by witness, upon which averages of results of examination of water at Averyville are shown and then asked if, in his opinion, the water at that point has become free from the effect of the sewage of Chicago, as shown by the results of the analyses referred to.)

6362 The large amount of chlorine present in the Chicago sewage as in all sewage makes itself evident in the waters of the Illinois river at Averyville, as shown by the analysis cited. So too does in my opinion the large amount of nitrogen introduced in the sewage of Chicago. It is difficult to see how this could be otherwise. The chlorine is in the form of a stable, mineralized compound, common salt, and suffers little if any diminution in the total amount in its passage down the river. The nitrogenous compounds of various kinds are altered more or less in their passage down stream, and the amount of nitrogen appearing under different heads varies from point to point, and some of that originally introduced into the stream disappears. There is, however, a large amount of nitrogen in the form of its various compounds, free ammonia, albuminoid ammonia, nitrates and nitrites, in the waters of the Illinois at Averyville which has in my opinion come in a more or less changed condition from Chicago.

6363 In the light of all the experience that I have had in the chemical examination of water, and all the information that I have derived from a study of the work, of other investigators, the amount and rate of nitrification in the waters of the Illinois river, from Lockport to Grafton, are such as have been found in the experience of water analysts to accompany the disappearance of disease producing elements.

Answering your question directly I will say that I do not believe it is possible to affirm absolutely from the results of the chemical examinations alone that the water of the Illinois river at any point where I have taken samples and made analysis is free from disease producing elements.

Furthermore, assuming that such disease elements are present in the water of the Illinois river at Grafton, I do not see how it is possible to affirm, on the basis of chemical analyses alone, whether these disease producing elements were derived from Peoria, from Havana, or from some farm house situated two or three miles above the points where the samples were taken. The whole question of chemical water analyses, as I have reiterated, is simply one of deduction made on the basis of past experience. A chemical examination does not disclose the existence or presence of the different disease producing elements in the water.

It simply affords a certain kind of evidence that must be weighed in forming a judgment as to the sanitary quality of the water.

What is true with reference to the chemical condition of the Illinois river is shown by table 134, just referred to, so far as the respective chemical substances are concerned, is also true with reference to all other tables introduced by me, containing the chemical analyses of the water of the Illinois river, that is, that same effect exists, due to the introduction of the Chicago sewage. (Witness testifies relative to the differences that might exist in the determinations made by him and by Prof. Palmer in the various samples of water taken, owing to greater length of time required in transporting samples to Prof. Palmer, difference of methods employed, etc.)

6371 I do not believe that it has been demonstrated that competent analysis and observers have found the cholera germ able to live in sewage as long as from seven to 13 days. It seems possible that some of the experiments to which you refer were conducted not with the genuine cholera germ but with some of these sewage bacteria which there is every reason to anticipate would have a greater longevity than the cholera germ itself. Furthermore, the isolation of a spirillum from a polluted water into which cholera spirilla had been introduced would have little or no significance unless the agglutionation was applied.

6374 As to the effect of the added volume of water from Lake Michigan upon the typhoid germs discharged from the sewers of Chicago, as it passes through the Chicago river and the drainage canal, I have made no experiments upon the life of the typhoid bacilus in sewage taken directly from the sewers of Chicago, as compared with the life of the same bacillus in such sewage diluted twenty times with Lake Michigan water. I have made such an experiment with colon bacilli and I don't believe that such influences would extend the life of the bacillus more than a few hours. Assuming that the sewage of Chicago was discharged into the drainage canal as now and that the water

and sewage passes down the canal for a period of six days, at which time it is discharged into a reservoir from which a
6375 community obtains its water supply, I should not hesitate to consider the water as being free from typhoid bacilli.

6379 I know of absolutely no ground for assuming or supposing that the products of one micro-organism are more injurious to itself than the products of every other micro-organism are to that particular one. Witness is cross-examined as to the experiment made for the determination of the longevity of typhoid bacillus by means of suspended sacs.

6397 I have made a number of examinations of Lake Michigan water during the prevalence of typhoid fever in Chicago prior to the opening of the canal and have several times found more bacteria drawn from the laboratory tap than were found at Averyville and at Grafton.

6399 RE-DIRECT-EXAMINATION, by Mr. Todd.

Investigations have been published on the speed of the typhoid bacillus and other bacteria. These experiments show that from one to five inches per hour would represent the speed with which a typhoid bacillus could move.

6400 In a river flowing at the rate of half a mile an hour the velocity of the current then would be about 5,000 times as great as that of the typhoid bacillus, so that this organism would be helplessly borne along and brought into contact with various toxic substances without being able to remove itself from their neighborhood.

In regard to the nature of these so-called toxic products in water very little is known, as I have already stated in my testimony. They are, however, doubtless in solution and not in the form of concrete solid particles.

RE-CROSS-EXAMINATION, by Mr. Jeffries:

6401 Taking into consideration the enormous number of bacteria and the large number of species discharged into the drainage canal at Chicago and the relatively small number of bacteria found in the water of the Illinois river at Averyville, and taking into consideration also the continuous discharge of

bacteria into the Des Plaines and Illinois rivers between Lockport and Averyville, from the sewers of Joliet, La Salle and from the drains of many smaller streams or places, it seems evident that by far the larger number of germs introduced by the Chicago sewage must have perished long before Averyville is reached. Whether every individual bacterial cell entering the drainage canal perishes before reaching Averyville is a matter difficult to determine. There is this indirect evidence,
6402 however, gathered from the composition of the various streams tributary to the Illinois. These streams, such for example as the Fox, the Sangamon and others, have not received the drainage from Chicago and yet their bacterial content, so far as numbers is concerned, is almost identical with that of the Illinois river at Averyville.

6403 N. MAC L. HARRIS, examined in chief by Mr. Todd:

Am assistant in the Chicago University, associate in bacteriology, under Prof. Jordan. (States educational qualifications.) Prepared media used for the concentration of organisms in connection with the experiment made in the drainage canal under the direction of Prof. Jordan. My duties were also the identification of the organisms isolated by Miss Lincoln, who was an assistant.

6405 ERNST E. IRONS, examined in chief by Mr. Todd:

Am assistant in the University of Chicago in bacteriology. Have been connected with the University under Prof. Jordan in bacteriology from January, 1897. I did some work in connection with Streams Examination, in the years 1899 and 1900. This work was done in connection with the examination of the Illinois, Missouri and Mississippi rivers. I made bacteriological examinations. (Witness states nature of his work, how samples were received, etc., also states his connection with the experiment as to the longevity of bacilli in parchment sacs and manner of conducting the experiment.)

6412 I made examinations in the fall of 1902 and until February, 1903, of the Mississippi river at Quincy, for the purpose of determining the presence of bacilli colon communis.

6413 Table introduced in evidence showing results of such examination. Judging from the determinations that I made during the course of my work for the Steel Company, the colon bacillus was much more numerous in the Mississippi river at Quincy than it is in the Mississippi river at Grafton, or of the Illinois at Grafton.

6419 MARY C. LINCOLN, examined in chief by Mr. Todd: Am a bacteriologist.

6420 Did work under Prof. Jordan of the Chicago University in connection with experiment made by him on the waters of the drainage canal.

6421 F. ROBT. ZEIT, recalled for further direct examination by Mr. Todd:

Since I gave my testimony in this case last October, I have made experiments upon the longevity of the typhoid bacillus in conjunction with Prof. Jordan and Prof. Russell. (Witness states the general plan and outline of the experiment.)

6431 In all the experiments made at Ashland avenue, with a surprising similarity we found that during the first 24 hours the total number of bacteria would greatly increase and typhoid bacilli could be found even with the increasing numbers of all bacteria present in the sac. That typhoid bacilli were found for the next day, during which the total number of bacteria greatly decreased and from now on the total number of bacteria continued to decrease except the typhoid bacteria which were found for three days at the most in Chicago river water. It was impossible, after three days in any of our sacs to find typhoid bacilli. There was no difference in the results of the experiments between the parchment sac and the celloidin sac. In both there was great increase of all bacteria for 24 hours, then the number dropped from day to day and no typhoid bacilli could be found after the third day. In some of the experiments, after two days we found no typhoid bacilli.

The longest we ever found them was three days.

6435 In Lake Michigan water the longest that we found typhoid bacilli was eight days.

6437 As result of the experiments I am of the opinion that typhoid bacilli cannot live in the drainage canal or in the Chicago river or in the Illinois river for more than three days.

What is your opinion, based upon all the knowledge which you possess in regard to this experiment, and other experiments made by you, as to whether the typhoid bacilli coming from the sewers of Chicago and entering the drainage canal and from thence into the Illinois river could survive the journey from Chicago to St. Louis, a distance of 357 miles, and be a danger and a menace to the inhabitants of St. Louis using the waters of the Mississippi river at the St. Louis intake, or the residents of Missouri using the waters of the Mississippi river, as it passes along the eastern shore of the State of Missouri, for domestic and drinking purposes?

It is my opinion that it offers absolutely no danger to the citizens of St. Louis and that no typhoid bacillus coming from the sewers of Chicago will live to reach there.

6438 DR. EDWIN C. ROSENOW, examined in chief by Mr. Todd:

Am graduate of Rush Medical College and am an intern at the Presbyterian Hospital at Chicago. I gave Prof. Jordan three strains of bacillus typhosus sometime last October. I got them from three cases of typhoid fever in the Cook County Hospital. (Witness states that the clinical history and diagnoses of these cases, as given by Prof. Jordan, is correct, etc.)

6439 PROF. F. ROBT. ZEIT, recalled for further re-direct examination by Mr. Todd:

(Gives size of sacs employed in experiment heretofore referred to.) In my opinion a typhoid bacillus lying in the sediment of a polluted stream such as the Illinois river, for a period in excess of sixty days would disappear. There would be no typhoid bacillus present.

6440 The conditions existing in material on the bottom of rivers and lakes by sedimentation must contain organic material and saprophytic bacteria which again would produce substances that would destroy the typhoid bacillus if it was present in just as quick a manner as they do in the river or lake water. In fact I should think that being so much closer in contact with the saprophytic bacteria in the presence of organic material that the quantity of these poisonous substances produced by saprophytes would be even greater and cause typhoid bacilli to die at least as quick if not quicker under these conditions than in flowing water.

From experiments that we have made it would be impossible for bacilli coming from the sewers of Chicago through the drainage canal to remain deposited on the bottom of the Des Plaines and Illinois rivers for a period of thirty to sixty days. Typhoid bacilli die, under those conditions, in three days.

6441 It is my opinion that typhoid bacilli from the sewers of Chicago would never reach the intake at St. Louis alive. My opinion as a bacteriologist, based upon my examinations, is that the Illinois river, bacterially speaking, was less polluted during my investigations than either the Missouri or Mississippi.

During all of my investigations in the past, that has been the case. As the Illinois river is bacterially purer than the

Mississippi river, it could only improve conditions by dilution.

6442 I do not consider that the sewage of Chicago emptying into the drainage canal and the Illinois river, which in turn empties into the Mississippi river, is a menace and a danger to the inhabitants of Missouri, for the reasons stated in my former examinations, that the Illinois river at Averyville was purer, bacterially, than any part of its course from Chicago to Grafton, and that I considered that absolute purification from saprophytic as well as pathogenic bacteria had taken place above Averyville.

The contamination produced by the sewage of Chicago would be all practically removed before it reaches Averyville, according to my investigations and answers in this case, in which I have expressed these convictions at some length. I am speaking now, of course, of bacterial purification and not of chemical substances, but I should judge that also chemical purification has taken place so as to convert dangerous organic compounds into non-dangerous ones, as soon as saprophytic life has again decreased and thereby shows that the end products of organic material have been produced by saprophytic multiplication, and I therefore can not consider this a danger or a menace to the citizens of St. Louis or the citizens of Missouri using the water for drinking and domestic purposes.

6443 CROSS-EXAMINATION, by Mr. Corum:

6447 In the lake water the longset time we found the typhoid germ was eight days. In filtered river water the germs lived two days only—that is filtered through a Pasteur filter. We have done that numerous times now, some of the experiments in fact were finished yesterday nad we know that the filtered river water as it exists now will kill typhoid bacilli in two days—river water containing no bacteria whatever. Having proven that filtered river water, free of all germs, kills typhoid bacilli within two days, and also knowing that the boiling of such river water allows the same bacilli to live a longer time, I conclude that by boiling you destroy certain poisonous saprophytic products present in the water and that, therefore, in boiled river water the typhoid bacilli will live somewhat longer than they would in filtered river water. Under the same conditions in lake water typhoid bacilli will live eight days in the filtered lake water and have lived fifteen to eighteen days in the boiled lake water.

6448 There is no other way of removing these saprophytic products other than by boiling. I don't think they are eliminated by the running of the stream—they are simply diluted by the volume of water.

If the other streams are polluted with the same material the same saprophytic products are produced which are again harmful to disease producing bacteria. The reason of the saprophytes multiplying more in water than the disease producing bacteria is because the temperature of the water is more favorable to the multiplication of saprophytes than it is to the multiplication of parasites, therefore pathogenic or disease producing bacteria can not multiply in lake or river water. They are not destroyed, if the lake or river water was pure and free of all polluting organic material and therefore free or practically free of saprophytic life. As soon, however, as there is any pollution whatever with organic material you have an increase of saprophytes and an increase of saprophytic products and then the few disease producing bacteria that are present, and that were unable to multiply, are now destroyed by the saprophytic products. I originally thought that this effect of the disappearance of the typhoid bacteria was really due more to the over growth of saprophytes, making the conditions of life for typhoid bacilli unfavorable, than to the saprophytic products which are diffused through the water, but I have convinced myself now by these filtering experiments, that there is in the river water sufficient of these saprophytic products present to destroy disease producing bacteria.

6449 In making our experiments we found that the typhoid germ lived in boiled water in Lake Michigan as long as 15 to 18 days. Such is not the case in the river. In the river, while they also lived longer in boiled than in filtered water, they disappear sooner so that there must be present in the river water certain substances that are injurious, to the typhoid bacillus which are not destroyed by boiling, although river water is not as deadly to the typhoid bacillus when boiled as when it is only filtered.

6450 Bacteria living, but not multiplying in water do not produce any product.

6452 I have stated the longest time for which we were able to find the typhoid bacillus with the most exhaustive work in detecting them. I think I want to strictly confine myself to the actual findings that I have given here and say that they live that long and that I know by experiment on the filtered water of the river that they die in two days or less and in non-filtered river water in three days or less.

6455 These tests were made in October, November, December and January.

6456 I am quite certain that if these tests had been made in the hot summer months that we would have found them to die sooner yet than what we state here, because the saprophytic multiplication in the summer must be a great deal more pronounced than it was during the time of our experiment.

6457 DR. VICTOR H. BASSETT, examined in chief by Mr. Todd:

(Gives educational qualifications.) The first two years after the spring of 1896 was assistant in chemistry under Dr. Daniels at the University of Wisconsin and the following year I became assistant to Dr. Russell and remained with him one year. After leaving the University of Wisconsin, went to the Johns Hopkins Medical School and was there four years.

6458 Afterwards became assistant to Prof. Zeit in the Medical College of the Northwestern University and assisted Prof. Zeit in the experiment which he made upon the waters of the Chicago river and Lake Michigan, testing the longevity of the typhoid bacillus. (Explains method of conducting the experiment referred to. On cross-examination, witness testified to the length of time in which he found the typhoid organisms in these sacs, which testimony is similar to that of Prof. Jordan, heretofore introduced.)

6467 PROF. H. L. RUSSELL, examined in chief by Mr. Todd:

Am in charge of the Department of Bacteriology in the University of Wisconsin. (States educational qualifications and experience in sanitary work.) Am bacteriologist for the Wisconsin State Board of Health, have made a special study of water analysis, bacteriology, etc.

6469 MR. TODD: Mr. Commissioner, have you compared all the tables and charts introduced in evidence with all the tables and charts contained in the book known as reports of Streams Examinations published by the Sanitary District of Chicago? I ask this question for the purpose of simplifying my examinations as I will refer to Stream Examinations instead of to the individual tables that have been introduced in evidence.

THE COMMISSIONER: I have made this comparison and have found that all the tables and plates printed in the publication referred to have been copied into the testimony in this case by the witnesses who have hitherto testified.

Counsel for complainant makes no objection to this interrogatory or answer.

6470 Have examined and studied the bacterial and chemical analyses of the waters of Lake Michigan, the drainage
6471 canal, the Des Plaines river, the Illinois river, the Mississippi river, and the Missouri river as made by Professors Jordan, Gehrmann, Palmer and Burrill, the same being published in what is known as "Reports of Streams Examinations," published by the Sanitary District of Chicago.

In September, 1903, I made a trip, in conjunction with a number of other individuals, from Chicago to St. Louis, by way of the drainage canal, Des Plaines river, Illinois river, Mississippi river and had given me special opportunities for the physical examination of those streams.

This trip was made by boat from Chicago to Lockport; we then went by rail from Lockport to Joliet, and from Joliet to Peoria on the Rock Island, and then took the Fish Commissioner's Steamer, Illinois, at Peru, and made the continuous passage from there to St. Louis, stopping en route during the night so as to give an opportunity for the physical examination of the stream throughout its entire course by day light. We went up the Mississippi at its junction with the Illinois to Grafton, for the distance of a few miles, so as to observe the physical conditions of this stream before and at its confluence with the Illinois.

6473 In several instances I have found the organism known as bacillus prodigiosus under external conditions. Several of these cases have been in samples of milk which were examined, but in other cases I have found it in water supplies which were reasonably certain to be entirely free from any polluted material. Am acquainted with the experiment made with the bacillus prodigiosus by Dr. Ravold. (Witness is asked hypothetical question that has been heretofore asked witness, assuming conditions said to have existed at the time of the experiment referred to, to which question, witness answers as follows:)

6474 Taking into consideration the assumptions as indicated in the question and also considering the question in the light of all the knowledge which I possess with reference to the distribution of the organism known as bacillus prodigiosus under natural and normal conditions, my opinion is that this experiment does not in any way throw any light on the matter of the probable longevity of the typhoid bacillus as measured by the longevity of the bacillus prodigiosus,
6475 and the assumptions mentioned in the question propounded, leads me to believe it is highly improbable that the organisms reported to have been found on the fourth, fifth and eighth of December at the intake tower, Chain of Rocks, on the sixth and seventh of December were the same or derived from the organisms which were placed in the waters of the

Chicago Drainage canal at Lemont on the sixth day of November.

This conclusion is based upon the fact that a series of examinations made on the samples taken from the water of the Illinois river at Lockport, Joliet, Peoria and Grafton between the 7th of November and December 15th, amounting in all to 1752, and also samples taken from the intake tower at the Chain of Rocks, at the laboratory tap in the city of St. Louis, between November 20th and March 1st, amounting in all to 3120 failed to reveal the presence of the bacillus prodigiosus until 28 days had elapsed from the time the cultures were placed in the river at Lemont.

If the organisms which were reported to have been isolated from the waters of the Illinois river at Grafton and the Mississippi at the Chain of Rocks had been the same or the progeny of the same as those which were deposited in the Chicago drainage canal at Lemont, it would have been natural to expect that in the numerous preceding analyses which had been made, organisms of this species would have been found, as there is reason to believe that the flow of water from Lemont through the Illinois river to the city of St. Louis would not have consumed a period of 28 days.

Assuming that the organisms reported as bacillus prodigiosus, which were found on December 4, 5 and 8th, at the intake tower, Chain of Rocks, and December 6 and 7 at Grafton, were organisms derived from other sources than those due to the depositing of 107 barrels of cultures of the bacillus deposited on November 6th in the river, and assuming that hourly and daily samples were made at these stations along the course of the Illinois river from Lockport to Grafton, and from the waters of the Mississippi river at St. Louis, said analyses amounting in all to 5304, and assuming that in no case were any organisms

belonging to the bacillus prodigiosus found in any of these stations, with the exception of three germs found at the
6476 intake tower, Chain of Rocks, December 4-8, and two organisms found in the Illinois river at Grafton on December 6th and 7th, after a period of 28 days after those 107 barrels of culture had been placed in the Illinois river at Lemont, and assuming the well known fact that the bacillus prodigiosus is a saprophytic organism, capable of living in the water under natural conditions a longer period of time than active, vigorous non-spore bearing parasitic bacteria, such as the bacteria of typhoid fever, it is my opinion that the results of the above experiment show that it is highly probable that the saprophytic bacillus prodigiosus had been destroyed in the waters of the Illinois river during the course of its flow from Lemont to Grafton and the city of St. Louis, and, therefore, assuming that such was the case it would be much more probable that the more delicate and easily affected organism of typhoid fever, entering the waters of the drainage canal of Chicago, from the sewers of Chicago, would not have survived a journey down the Illinois river and Mississippi river to the intake tower, Chain of Rocks, at St. Louis.

As to throwing light upon the question at issue as to the longevity of the typhoid organisms, I do not consider the experiment detailed in the foregoing case, where bacillus prodigiosus were placed in the waters of the Illinois river, would be of any direct value, as the selection of this organism would not give conditions which would permit of a proper interpretation of the results obtained.

It is not uncommon to find in water, organisms possessing the characteristics which simulate those belonging to the prodigiosus. (Witness gives characteristics and pathogenic significance of cholera, tetanus, anthrax, enteriditis sporogenes and dysentery bacillus and also the typhoid germ.)

6480 The typhoid fever organisms is capable of retaining its vitality in soil for a varying period of time, depending upon the influences to which it is subjected and its environment. When deposited in the soil by burial, the organism rapidly loses its vitality so that at the expiration of a short period, measured by a few days, it can no longer be detected in the upper layers of the soil. When the soil is moist and the organism is deposited in typhoid dejecta, the germ is capable of retaining its vitality for a longer period of time, a period of time which may be measured by months. Some experiments indicate a retention of vitality for five or six months.

The longevity of the typhoid bacillus in water is materially shorter than it is under soil conditions, and here again depends largely upon the conditions of exposure. Where the organism is brought in contact with an aqueous medium with normal saprophytic bacteria, such as would naturally be found where the organism was exposed in sewage or polluted
6481 waters, the vitality of the typhoid germ is greatly impaired, and its longevity is thereby lessened, so that it is my opinion that under such conditions in waters of this character, the longevity of the organism would not normally be more than three or four days or so, but that in waters of a greater degree of purity where saprophytic bacterial life is not so abundant and therefore the vital concurrence between these native bacteria and the typhoid organisms would not be so great, the longevity of the typhoid organisms, under these conditions, would be increased so that it might be found in waters which would ordinarily be deemed as pure waters, even at the expiration of a longer period, possibly one or two weeks.

I have carried out an extensive series of experiments in connection with this matter of the longevity of the typhoid organism. These experiments indicate that when the organism is exposed in water which is ordinarily pronounced as pure and which has first been sterilized by heat and thus deprived of its germ life and possibly of metabolic products of bacterial activity, this process changes the conditions of the water so that in these waters the germs of typhoid fever are capable of retaining their vitality for a period of time, measured by months.

I have also conducted experiments where such water was deprived of its bacterial life by filtration rather than by heat, and under conditions where the soluble products of bacterial growth in the water would be brought in contact with the typhoid organism.

6482 The conditions under which laboratory experiments have been performed on the longevity of the typhoid fever organisms, are, as a rule, more favorable for the prolongation of vitality of this organism, than would exist where the organism was exposed under natural conditions. It has been recognized by practically all investigators on this subject that the organism of typhoid fever lives longer in the sterilized water than it does under raw conditions and if such waters are polluted, if normal raw waters are polluted, it is my belief that the longevity of the germ would be much less in the case of purer sterilized water.

6483 From my knowledge of the conditions which obtain in the water of the Chicago drainage canal and the Illinois river my opinion is that the longevity of the typhoid organism would not be beyond the average more than a few days, at the most, say three or four days.) I have made a large number of experiments on the vital concurrence or competition which would exist when the typhoid organism was exposed under artificial conditions to the influence of various saprophytic bacteria. These experiments have covered a period of four or five years. (Witness details experiments made with celloidin sacs.) These experiments were also made and investigated by a number of my advanced students working under my direction and the results have been confirmatory in a general way. The dams in the Illinois river at low water, where the flow is small, must produce slack water and to a certain extent, cause sedimentation.

6487 The specific gravity of bacteria is only a trifle above that of water. Hence the sedimentation of bacterial cells themselves cannot well occur in pure water freed from all insoluble sediment except in a state of absolute quiescence.

In this connection I have made a large number of experiments on the vertical distribution of bacteria in lakes such as Lake Mendota, at Madison. In the winter when the lake is covered with ice, and therefore there is no disturbing currents due to wind action and temperature changes, the results of these experiments show that the upper layers of the water, although entirely free from the sediment contain a relatively larger 6488 amount of bacterial life and in fact I am unable to ascertain that there is any material settling out of germ life by mere gravitation in waters which are pure, even in a quiescent condition, and much less so that of a running stream.

The reason why bacteria settle to the bottom of a flowing stream depends not on the sedimentation of these organisms, but on account of the subsidence of suspended matter in the stream. The small soil particles, which constitute the mud and silt found in running streams, carry down with them as they fall to the bottom of the stream, a large part of the bacteria which may be found in such waters. In this way the germ content of the muddy water may be very greatly reduced by the sedimentation of its suspended load.

6489 Assuming the present rate of flow to be somewhere in the neighborhood of 300,000 cubic feet per minute with the present amount of sewage discharged, and a condition of turbidity and sediment equal to that reported as existing in the sewage at the time of the analyses as made by Professors Jordan, Palmer and Gehrmann, and reported in Streams Examination, I do not consider that an increase in the amount of Lake Michigan water to a point that would equal a discharge of a million cubic feet per minute over the Bear Trap dam, would permit of entire separation of suspended matter which would be present in the waters of the drainage canal to such a point that the dilution would prevent the sedimentation of such material and the consequent removal in part of the bacterial life in the water.

6491 The dilution of the Chicago sewage, as found in the drainage canal, with the purer waters coming from Lake Michigan would result in a diminution of the number of disease bacteria which might be present in Chicago sewage in any given volume, and would thus greatly minimize the danger of infection which might come through the ingestion of the water taken from the Illinois river.

If we consider this question from the standpoint of dilution alone it is evident that the addition of water from Lake Michigan, relatively low in germ content and of a very much purer quality than would exist in the sewage as found in the drainage canal at Chicago, then the addition of this water would be a benefit to the sanitary condition of the water as found in the Illinois river.

If a sufficient volume of water, Lake Michigan water, should be added to the sewage of the city of Chicago and discharged in the waters of the drainage canal, so as to cause an elevation in the waters of the Des Plaines and Illinois rivers to such an extent as would lead to the overflow of the low lands adjoining these rivers, this increase in the volume of water would undoubtedly facilitate the sedimentation of the suspended mater in such localities where this slack water existed.

6492 On account of the fact that the banks of the Illinois river are relatively low it is therefore possible at high water stages for these banks to be easily covered and the widening of the stream during such stages of high water would lead necessarily to a retardation of the current and so cause to be deposited on these low lying lands much of the sediment which would be present in the stream and so would lead to a material sedimentation, and by reason of this fact to a material purification of the water in the Illinois river, when compared with other rivers in which the elevation of the shore was such as to prevent the ready overflow of their banks.

Taking into consideration the conditions which obtain in the Illinois river as to sedimentation and dilution, and all other conditions that can be observed, which permit of the production of chemical and bacterial changes in the sewage, as revealed by the analyses reported in Streams Examinations, I do not consider that the sewage of Chicago, as discharged into the drainage canal, can have any material effect upon the waters of the Mississippi river except possibly to increase the amount of such undissolved salts as chlorine which are not taken out of solution and which would therefore find their way down the stream and thus probably increase the chlorine content of the waters of the Mississippi river as they pass the shores of the State of Missouri.

6493 Basing the results which have been recorded on the self-purification of flowing streams on the fact that the typhoid organism does not thrive in natural waters, and it is only a question of how long it will live in waters of this class, that the time of flow is so great that pollution dangerous to public health would cease to exist in sewage passing from the city of Chicago to the Illinois river, down as far as the town of Grafton, from the fact that experimental evidence shows that the typhoid organism will not live in highly polluted waters like those of the drainage canal and upper portions of the Illinois river for more than a brief period of time, measured by three or four days, my opinion is that any pollution which would be dangerous to public health which might arise from the sewers of Chicago and enter the drainage canal would not exert any influence on the character of the waters of the Illinois river at its mouth, at the town of Grafton.

The evidence which can be adduced for the justification of the conclusion just expressed rests upon an experimental evidence which has been adduced, which shows that organisms capable of causing typhoid fever will not live in the waters of the Illinois river for a sufficient period of time so that it would have been possible for them to have been carried from the sewers of the city of Chicago down the Illinois river as far as Grafton.

My opinion is that any infectious matters which may be discharged from the sewers of Chicago by way of the drainage canal, are deprived of their infectious properties by reason of the conditions which exist in the waters of the drainage canal and in the waters of the Illinois river before they have had time to have been carried by the waters of said stream from the city of Chicago down through the drainage canal and the Illinois river to the city of Grafton.

6494 If the typhoid fever is destroyed under natural conditions which obtain in the Illinois river, in the course of three or four days, the stage of water in the Missouri river and the Mississippi river would exert no effect as I can see on the carrying of infected or polluted water from the city of Chicago to the city of St. Louis.

6496 From the knowledge which I have gained with reference to other conditions which exist in the waters of the Chicago drainage canal and in the waters of the Illinois river, together with the evidence which has been presented as to the degree of purification which obtains in that stream, as reported by the chemical and bacteriological examination made of the waters of the drainage canal and Illinois river and the Mississippi river, down to the intake tower at the Chain of Rocks, at the city of St. Louis, I do not consider that the introduction of the sewage of Chicago into the drainage canal exerts and deleterious effect upon the water supply of St. Louis or upon the waters of the Mississippi river as they pass the State of Missouri.

The conclusion that the typhoid organism will not live in the waters of the Illinois river for more than a period of three or four days is based upon an extensive series of experiments which were arranged and planned for conjointly with Professors Jordan and Zeit and myself, but carried out independently. These experiments were designed to show how long freshly isolated typhoid organisms would actually live under conditions as they obtained in the drainage canal and in the waters of the Illinois river.

(Witness explains and gives full details of the experiment made to determine the longevity of the typhoid germ. The experiment made by this witness was in water of the Illinois river at Averyville, Ill.)

6503 15 different parchment sacs were used.

6509 From sac No. 1, from plates made 24 hours after sacs had been immersed in the water, 12 colonies were removed, one of which was found to be typhoid. (Witness gives results found in each sac at each examination made thereof.)

6512 Summarizing the results obtained in the foregoing analyses 72 colonies were examined from the different sacs after they had been exposed in the water for 24 hours and of these 43 were found to be typhoid. These 72 colonies were taken from 8 different sacs, and in these 8 sacs the typhoid organisms were found in 7 of these sacs.

6513 Of the 25 colonies which were examined on the second day, 12 were found to be typhoid.

These 25 colonies were removed from 2 sacs, both of which contained typhoid.

Of the 44 colonies removed on the third day 14 of them were found to be typhoid.

These 44 colonies were taken from 5 sacs and the typhoid organisms was found in three out of five of these sacs.

41 colonies were taken off on the 4th day, from 4 different sacs, and in none was any typhoid colonies found.

61 colonies were removed on the 5th day from 6 different sacs and in no case was typhoid found.

28 colonies were taken from 3 sacs on the 6th day, and none proved to be typhoid.

32 colonies were taken from 6 sacs on the 7th day, none of which was typhoid.

18 colonies were taken from 2 sacs on the 9th day, 1 of which proved to be typhoid.

On the 10th day 5 sacs were examined, 46 colonies being removed, no typhoid found.

In 7 sacs taken on the 12th day, 38 colonies were examined, none were found typhoid.

In 3 sacs examined on the 14th day, 25 colonies were removed, none were typhoid.

From 2 sacs examined on the 16th day, 14 colonies were removed, none of which were typhoid, and in 1 sac examined on the 17th day, 15 colonies were taken off, none of which were typhoid.

In these particular series of experiments, 459 colonies were examined. The different sacs which were employed were tested 54 times and the typhoid organism was found fourteen times, 70 colonies out of the total 459 belonging to this organism.

During the first 3 days, 141 colonies were fished off, 69 of these were found to be typhoid and in the 318 cases which were examined after 3 days only 1 typhoid organism was found.

I have prepared a table of summaries showing the results, which is reproduced on pages 6514 and 6515.

6516 In addition to the series which were made with the parchment sacs another method was used which approached the problem from a different point of view. Ordinary commercial agar was taken and washed in running water for several days, to remove all soluble products. From the prepared agar small rectangular blocks were cut out. These blocks were inoculated with freshly grown typhoid cultures by means of a platinum wire and the top of the block was sealed by means of searing the surface with a hot iron. According to Oswald, the eminent German physicist, this soluble agar possesses the property of allowing diffusion to take place quite as rapidly through its substance as would be the case in water itself. Hence it follows that if typhoid organisms were placed on the interior of an agar mass and then exposed in an aqueous medium containing bacteria of various kinds, then the typhoid organism would be subjected to the influences which would arise from the growth and development of these water or sewage bacteria in the surrounding media in which these agar blocks were immersed.

6518 The summary of the results of these cultures on the vitality of the typhoid fever organisms, inoculated in numbers, so large that the number of organisms produced turbidity to be recognizable with the unaided eye, that the exposure of these numerous typhoid organisms in the waters of the
6519 Illinois river and also in the waters of Lake Mendota at Madison, resulted in loss of vitality of this enormous number of typhoid bacteria to such an extent that in no case were any typhoid organisms found after the eighth day and in the case of one series none was found even on the first day. This variation in the vitality of the typhoid cultures, where an indefinite number of organisms were inoculated, under these conditions, and where it was not exposed directly to the competition which exist between water and sewage bacteria and the typhoid organism is more surprising as the organism was not directly exposed to the influences of the competing bacteria themselves but merely to the soluble products which these germs are capable of producing.

In the case of the parchment sacs the typhoid bacteria were exposed to the direct contact of all the water or other bacteria which might be present in the samples of water which were placed in the sacs. In the case of the agar blocks the typhoid organisms were not exposed to this direct contact but were exposed to those products of the metobolic activity of water and other bacteria which might be present in the outside medium and which would find it possible, if in solution, to pass through the agar block, by diffusion, and so possibly act upon the typhoid bacteria themselves which were screened by these agar blocks.

6519 I find that the experiments made with the agar blocks give more favorable conditions for the retention of the vitality of the typhoid organism than was the case in the parchment sacs where the contact of typhoid organisms with other bacteria was rendered possible.

6520 I should consider that the typhoid organisms deposited in the waters of the Chicago river and drainage canal would have a much shorter duration of vitality than in waters of Lake Michigan and that such vitality would not extend to a period of more than two or three days. From the results obtained in this combined experiment with Prof. Jordan and Prof. Zeit I should say that the longevity of the typhoid organism immersed in the waters of Lake Michigan would be considerably longer than in the waters of the Chicago river and the organism would probably be able to live for a period or six or eight days.

From experiments which I have actually made when freshly isolated cultures of bacillus typhosus were exposed in permeable sacs in varying numbers so that the germ content of the typhoid organism exceeded at least the germ content of the water used in the ratio of 100 to 1 or more, and where the organisms were destroyed in the course of about three days,
6521 with one possible exception, and that if this was the condition which was obtained under the conditions in which the experiment was made, when the effect of other environmental factors were excluded, such as the influence which would come from sedimentation, dilution, influence of light, vital concurrence with green plant forms which might be found in the waters of such river, I should certainly consider that the life of the typhoid organisms when subjected to the more severe conditions which obtain in the waters of the Illinois river itself than was the case in the experiments with the parchment sacs, that it certainly would be no longer in the waters of the Illinois river and in all probability would be shorter, hence I would conclude from the foregoing data that the vitality of the typhoid organism would not in any case be

maintained for more than a period of a very few days, three or four at the outside.

6522 In view of the above experiments and other conditions, I am of the opinion that typhoid organisms finding their way through the sewers of Chicago, into the Chicago river and thence into the drainage canal, down the Des Plaines and into the Illinois river would be destroyed before such water had passed the course of the Illinois river.

6523 I would consider that if the longevity of the typhoid bacillus be impaired by the action of sewage and the water bacteria of a polluted stream that at least the same, if not a greater effect would be produced if the typhoid organism was in contact with these bacteria and the products of their growth in the sediment of such a stream.

6524 The colon bacillus in ordinary soil which is not saturated completely with water is able to live longer than it is in the water itself.

6526 I do not think that the typhoid organism would live as long in the waters of the Illinois river under the conditions as they exist in nature as would be the case in the waters of Lake Michigan.

6528 There is no evidence which I know of, that indicates that the typhoid organism would be capable of living in the sediment of a polluted stream for a longer time than it would in the water of the same stream.

The conditions which obtain in moist soil and the sediment of running streams are materially different. In the one case the soil is not completely saturated with water for the soil particles are surrounded by a hygroscopic film which adheres to the particles themselves, but gives a considerable amount of pore space in the interstices which is filled with air. In the sediment found in running streams or lakes this condition would not obtain as these spaces are entirely filled with water.

6529 It is my opinion that the conditions which obtain in a moist soil would not furnish any criterion for the determination of the longevity of the organism as found in the sediment of a running stream. The two conditions as found in a moist soil and in the sediment of a running stream, for the foregoing reasons, are not comparable. In view of the fact that the conditions under which typhoid organisms would be exposed in moist soil are different from those which are found in the sediment of a river, I would not consider that this would justify the assumption that it would live as long in the sediment of a river as would be the case if the exposure was made in moist soil.

6530 On the basis of the experiments which I have been able to perform on the vitality of the typhoid organism when exposed to the waters of the Illinois river, and in view of the facts that the conditions which obtain in the bottom of that stream are such as would undoubtedly bring the typhoid organism in contact with even large numbers of water and sewage bacteria, and the products of their growth, that would often be the case in the waters of the stream itself, it is my opinion that the longevity of the typhoid organism when exposed in the sediment, as found in the Illinois river, would certainly be no longer than it would in the superincumbent water above, and that it is quite possible that their longevity might even be shortened.

From all of the experiments which I have made on the conditions which obtain where the typhoid organism is
6531 exposed in the Illinois river it is my belief that this organism will lose its vitality in the conditions which would obtain in the waters and in the sediment of such a

stream in a relatively short period of time, that period of time not exceeding more than three or four days.

6532 Regarding the testimony of Prof. Fuller, to the effect that there are observers in Switzerland who made examinations with positive results showing the presence of typhoid germs in the sediment of Lake Geneva, it is my opinion that these experiments were either carelessly performed or not carried out with sufficient detail, and under sufficiently stringent precautions to warrant the conclusion which is drawn. (Witness gives reasons for this opinion.)

6538 By reason of the fact that the previous experiments which have been detailed, show that the vitality of the typhoid organism is destroyed in the course of not to exceed four days, and that the extent or period of flow which would be necessary for the sewage of Chicago entering the drainage canal to pass from Chicago to St. Louis, a distance of 357 miles, would be so great that it would be impossible for the typhoid organism to survive this journey, it is my opinion that the diffusion of such bacilli in the waters of the drainage canal would not be a danger and a menace to the inhabitants of St. Louis, using the water of the Mississippi river for drinking and domestic purposes. Inasmuch as the typhoid organisms deposited in the city of Chicago and finding their way
6539 into the drainage canal would be killed before the waters filled with such sewage would find their way from Chicago to St. Louis, I must say that the settling basins of the city of St. Louis would afford no protection to the citizens of St. Louis against the sewage of Chicago. The protection which would be afforded to the citizens of St. Louis by passing water through the sedimentation basins, would be from those places adjacent to St. Louis, in which the typhoid organism would not be killed during the journey from such places to the sedimentation basins of the St. Louis supply.

6540 I would not consider that because a basin holds a water supply sufficient for thirty days and that typhoid fever resulted from the use of such water, that the typhoid fever organism lived for that period of time. I have examined the typhoid statistics of the Illinois, Missouri and Mississippi watersheds above St. Louis and also the mortality statistics of St. Louis, and the typhoid statistics of Chicago and St. Louis. In interpreting the mortality statistics from typhoid fever in St. Louis, it would be necessary to take into consideration the typhoid statistics obtained on or about these watersheds which contribute water finding its way into the Mississippi, past St. Louis, laying special emphasis upon those statistics, which are from cities nearest to the city of St. Louis.

6541 There are two methods that are employed, one which is used largely for comparative purposes, known as the mortality percentage method, in which the death rate from any given disease is figured and determined in terms of the total number of deaths in that community. The other method, which is more generally used, and considered more reliable, determines the ratio which exists between the number of deaths from any given disease, based upon the actual population from which the death statistics are collected. This is known as the death rate from that disease, per unit of population, usually given in terms of 10,000 to 100,000 persons. I regard the latter method as the preferable method to follow in determining the death rate from any given specific disease and it should be followed wherever possible. The method of determining the death rate from any given disease by comparing the mortality of that disease with the total mortality of the community instead of the population itself is liable to introduce error into the results which might readily vitiate the accuracy of such statistics to such an extent as to render them all of much less value than otherwise would be the case. The reason for this is, that when you compare the deaths from any disease, to the total deaths, in order to study the increase or decrease of any disease in any

community, you are using a wrong basis for comparison. What is wanted in any given community is to know whether
6542 a disease is increasing more rapidly than the increase in population. When this rate is based on the ratio between that disease and the total death rate the variation which might and often does occur in the total death rate may be subject to many conditions which now enter into the consideration of the disease in question. Suppose, for instance, that a serious epidemic of some other disease, like the Bubonic Plague, or yellow fever, should break out, it would be manifestly improper to compare the typhoid death rate in that community before and after such an epidemic and compare the actual number of typhoid deaths, with the total number of deaths, and say that the typhoid was increasing or decreasing, where such a fallacious method was employed.

In view of the fact that the urine of typhoid patients often contain bacilli in great abundance, and in view of the fact that this material is not ordinarily looked upon as dangerous, and therefore is frequently thrown upon the surface of the ground, and in view of the fact that in rural communities greater carelessness prevails in regard to the disposition of this excreta, and even solid material, than would be true where special systems of sewage disposal were present, it naturally follows that the liability of the population to the infection of the river is added to considerably from the rural population.

It is a well recognized fact from statistical evidence, that the percentage of infection designated as typhoid fever mortality at least is not less common among the rural population than in urban communities.

6543 There are a considerable number of typhoid epidemics which have been reported in which the sources of pollution have been traced specifically to infection arising from the rural population. (Witness gives instances of such epidemics.)

6544 The analytical evidence which can be gathered from the analyses of waters taken at frequent intervals for a considerable period of time and at various points along the course of the stream, give us the best possible means which we have at our command at the present time, of showing the progress of the self-purification which occurs in such running streams where organic matter is gradually disposed of and converted into mineral material.

I should consider that the data furnished by bacteriological study, and to some considerable extent, that of chemistry, are the foundation on which a sanitarian or epidemiologist must base his conclusions as to the character of any waters and their liability to be a source of danger and menace.

(Witness gives ordinary modes of causation of infectious diseases and the chief sources of infection in typhoid fever.)

6545 It is very important in making any study of any epidemiological question that the sources of infection should be taken into consideration as well as the results of the infection, for the distribution of the disease, and its dissemination may depend largely upon how the organism finds its way into the human being. It is by no means a legitimate inference that because typhoid fever increases in a city that such increase is due to an increase in infection of the water supply, for it has been abundantly proven in a considerable number of cases, that the organism of typhoid fever is capable of being introduced into the body in other ways than through the medium of infected water.

6546 Assuming that the reports as to the typhoid death rates for the city of St. Louis, for the years 1900 to 1903, are true, and taking into consideration the conditions which obtain in the watersheds of the three rivers mentioned, and the fact that there are sources of pollution from which typhoid organisms might arise which were not as far removed from the city of

St. Louis, as would be the case of the city of Chicago, and taking into consideration further, the results of the typhoid experiments which have been made, and which have been detailed in the foregoing answers, I should say that there was no scientific reason which justified the conclusion that the increase of typhoid fever in St. Louis as reported in the Board of Health reports for the years 1900 to 1903 inclusive, is due to infectious matter which is derived from the sewers of Chicago by way of the drainage canal.

6548 (Witness gives clinical diagnosis of typhoid fever, also intermittent fever, remittent fever, typho-malarial fever, congestive fever and simple continued fever.

6549 The terms remittent, intermittent, typho-malarial, congestive and simple continued are relics of old methods of description which attempted to differentiate these febrile changes, merely on the basis of the symptoms which are most evident. They are not recognized by working bacteriologists or clinicians of the present time as being satisfactory names for specific types of fevers.

The use of the terms remittent, intermittent, typho-malarial, congestive and simple continued as applied to vital statistics collected under present day conditions would in my judgment indicate that the causes of deaths were not classified as they should be and would therefore lead one to place less reliance on such statistics than would be the case if they were more accurately classified.

6550 (Witness is asked hypothetical question, giving the number of deaths from typhoid fever in St. Louis, as evidenced by the annual reports of the Health Department from 1890 to 1903 and also for the same period, the deaths from remittent, etc. fevers.)

From the study of the statistics mentioned in the foregoing question and from the general knowledge of the relation which these diseases bear to each other and the liability of

making an improper diagnosis between them, I do not consider
that the number of deaths reported in the vital statistics
6551 of the Board of Health of the city of St. Louis for the
years 1890 to 1903 inclusive, represent the total number
of deaths from typhoid fever which actually occurred in that
city in that interval.

Taking into consideration the fact which is well recognized by sanitarians, that fevers classified under the heads of remittent, intermittent, typho-malarial, congestive and simple continued are in a large measure found to be fevers which by means of modern diagnostic methods would be recognized as typhoid fever, it is my opinion that the statistics which include a large proportion of fatalities as due to fevers of this class, do not represent the true condition which obtained in that city with reference to the total typhoid death rate.

6552 No city of the United States has as high a death rate
from pure malaria alone as is represented in the number
of deaths reported in the St. Louis statistics. It is probably true that a large proportion of the deaths reported as being caused by remittent, etc. fevers, should be classed as being caused by typhoid fever. Considering the low rate of mortality from genuine malaria in the United States and other facts, as heretofore stated, the deaths resulting from remittent, etc. fevers, placed in Column B should be placed under the head of typhoid fever in Column A. Assuming that the totals of Columns A and B were added together and that the result shown by the addition of those two columns represents the actual typhoid mortality, I should consider that the said statistics do not show material alteration which could be deduced with certainty in the typhoid fever mortality of the city of St. Louis. In comparing the statistics assumed in the foregoing answer, I should consider that the letters sent out by the Health Commissioner

and the agitation by the public press as to the opening of the canal, manifest themselves in these statistics.

6557 Owing to the liability to confusion which must of necessity exist from the use of old traditional terms which are descriptive more of the symptoms than the specific nature
6558 of the disease in question, and the direct liability of the confusion of these terms with that of typhoid fever, I should consider that from the standpoint of the bacteriologist, clinician or statistician, in order to get at the true typhoid mortality which would exist in the city of St. Louis, that it would be necessary to add to the statistics which they have reported as typhoid, a large proportion at least if not practically all of the cases which have been reported under the caption which has been designated in previous questions as Column B, to those figures in the given typhoid fever cases.

Taking into consideration the fact that the circulars issued by the Board of Health of the city of St. Louis have unquestionably had their influence in increasing the accuracy of the typhoid statistics since the issuance of that circular in 1900, and that the great majority, if not practically all of the
6559 deaths reported before the year 1900 under the head of remittent, intermittent, congestive, typho-malarial, and simple continued fevers were actually cases of typhoid fever, and, therefore, should have been included in any statistics which showed the total amount of typhoid fever in the city of St. Louis for that time and assuming the accuracy of the compilations which have been made by Professor Jordan, based on the relative increase of population as determined by Farr's formula when to the typhoid fever death rates there have been added from 50 to 100 per cent of all recorded deaths which have been reported under the head of remittent, intermittent, congestive, typho-malarial and simple continued fevers, and which in my judgment represent data showing the actual amount of typhoid fever which did occur for the periods mentioned much more correctly than is shown by consideration of the reported deaths, as reported in the Board of Health reports of the city

of St. Louis under the caption of typhoid fever alone, I should consider that the actual number of typhoid deaths which have occurred in St. Louis since the year 1900 shows no increase over the death rate in that city from this disease for the period mentioned prior to that time, with the possible exception of the recognized epidemic which occurred about the years 1892.

6560 In the operation of natural courses running water undergoes processes of purification, and frees itself from pathogenic organisms in due course of time.

If the typhoid organism is killed out in the Illinois river in the period of time which is less than the necessary time for the flow of the water from the sewers of Chicago to the city of St. Louis, and assuming that the destruction of the typhoid organism is an index of the destruction of pathogenic organisms in water, and on the basis of the experiments which have been previously detailed in which proof is adduced to show that the vitality of the typhoid organism is destroyed in a much less time than is necessary for the flow of water from Chicago to St. Louis, it is my opinion that the waters of the Mississippi river west of the center of the main channel of the said river and below the mouth of the Illinois river, down to the intake tower of the St. Louis waterworks at the Chain of Rocks,
6561 is not less valuable for drinking purposes and not more liable to carry water borne diseases now than it was before the sewage of the sanitary district was run into the drainage canal and through it into the Illinois river.

An increase in the speed of the current of the Illinois river, by reason of the added volume of water in the drainage canal would probably alter the manner of sedimentation that would occur in the waters of the Illinois river from what was the case before the addition of such water from the drainage canal occurred. The addition of this added volume of water from the drainage canal carries with it a larger amount of suspended organic matter, and therefore increases the amount of suspended material which would be present in the waters of the Illinois river and consequently the addition of this added drainage canal water would increase the amount of sedimentation which would otherwise occur.

The increased speed of the current in the Illinois river if it did not cause an overflow of the banks of the stream, the increase in the speed of the current would carry suspended matter farther down stream, but it is my opinion that the removal from the river of the sewage from the towns mentioned would be performed before such sewage reached the Mississippi river, so that it would not materially alter the condition of the Mississippi river, except in the case of suspended salts, such as chlorine and nitrates which are not eliminated from the water in the purification of the sewage which might be discharged into such stream.

6562 From the facts of the experimental evidence which has been previously adduced that the typhoid organism would fail to live for a period of time which would be covered by the flow of water from Chicago to St. Louis, it would therefore follow that an additional volume of water discharged by the waters of the drainage canal, which would cause an increased speed in the current of the Illinois river, would not have any effect in increasing or diminishing the typhoid fever or the liability of the inhabitants of the State of Missouri using the waters of the Mississippi river below the mouth of the Illinois river to contract from such waters typhoid or other water borne diseases.

6564 I consider the assumption that typhoid fever could pass from the sewers of Chicago, by way of the drainage canal to Lake Peoria, and be deposited there in the bed of that lake for a period of one month as one that is untenable and in the light of experimental inquiry not in accord with the facts, and it is my opinion that under no normal conditions which could obtain in nature as they now exist that the typhoid germs would be able to pass from Chicago to Peoria and not be destroyed before the end of the period covered by the question.

6565 Taking all of the conditions into consideration that obtain in the drainage canal, the Des Plaines and the Illinois river, as to the probable longevity of the typhoid bacilli in the waters of such stream, I should consider that at no time under natural conditions would such conditions exist as would cause the waters of the Illinois river leaving Lake Peoria to contain more infectious and dangerous pollutión than would exist in the diluted sewage of the drainage canal, passing the Bear Trap dam.

Considering all of the conditions involved, and for the reasons previously explained, I should say that my opinion is that at no time, under natural conditions would the number of typhoid organisms even be as great at Lake Peoria as they would be at the Bear Trap dam.

6566 It is my opinion that typhoid bacillus lying in the sediment of a polluted stream for a period in excess of sixty days would not be able to produce typhoid fever.

6568 Owing to the fact that the pollution or infection which would be deposited in the Illinois river from the sewers of Chicago would be practically purified by the time it has been carried for a portion of its way down the river on the way from Chicago to Grafton, it would naturally follow that the waters of the Illinois river which entered the Mississippi river at Grafton would not be a menace to the inhabitants of the Missouri shore on the Mississippi river if such water was used for drinking purposes at points below on the Missouri shore.

6569 I would not consider that the admission of the waters of the Illinois river would cause any menace to the inhabitants of the Missouri shore when the waters of the Illinois river were discharged into the Mississippi and commingled with the waters of the Missouri river and Mississippi river, and when the waters of the united streams was used for drinking purposes by persons living below Grafton on the Missouri shore.

The chemical and bacteriological evidence which has been secured in this case through the experimental and observational data which have been presented justify, in my judgment, the conclusion that the waters of the Illinois river at Grafton show no indication whatever of unpurified sewage from Chicago that has found its way from Chicago to the latter place.

6571 Taking into consideration the time involved in the flow of water from Chicago to St. Louis, and in view of the evidence which I have previously presented in combination with others that the typhoid organism is incapable of retaining its vitality for the period of time assumed in the foregoing question, I would say that I know of no evidence based upon any analysis, experiments or otherwise that would justify the assumption that typhoid organisms deposited in the Chicago drainage canal will pass by way of the Illinois river into the Mississippi river and find their way into the water supply of the city of St. Louis at the intake tower at the Chain of Rocks.

6572 Taking into consideration the knowledge which I possess with reference to the conditions under which the typhoid organisms would be capable of living when deposited in the waters of the streams mentioned in the foregoing question, and taking into consideration the fact that other conditions exist which are necessary to consider in considering the question of typhoid fever in St. Louis, it is my belief that I would not consider, beyond a reasonable doubt, the typhoid death rates as occurring in the city of St. Louis (assuming that there has been such an increase since the opening of the drainage canal) to any influence which might arise from the introduction of the sewage of the sanitary district of Chicago into the Illinois river, and which would find its way down the channel of the Illinois river to St. Louis.

6573 It is my opinion that the deposition of sewage of Chicago into the drainage canal does not increase the longevity of the typhoid organism deposed therein, but on the contrary is a potent factor, toward the more rapid destruction of the vitality of the typhoid organism than would be the case if such sewage was not so deposited. When sewage is added to the water in an unsterilized condition such as would exist when normally deposited in drainage canals, the addition of such sewage does not increase the longevity of the typhoid organism, but on the other hand, is a distinct factor in the early death of the typhoid organism. (Witness states the effect of increase of population in the sanitary district to 5,000,000 people and increased flow in the drainage canal to 1,000,000 feet per minute.) Assuming that a typhoid fever epidemic of extraordinary proportions should prevail in Chicago, no effect would be produced upon the people who use the Mississippi river water for drinking purposes.

6575 Taking into consideration the chemical and bacterial knowledge which has been derived from actual experiment and also all knowledge which I possess with reference to the conditions which would obtain when the sewage of Chicago was placed in the drainage canal, and taking into consideration the possible variation which would exist at different seasons of the year and the influence which different stages of water would exert upon the vitality of disease organisms which might be present in such sewage, it is my opinion that the introduction of such sewage into the Illinois river would not be a danger and a menace to the inhabitants of the State of Missouri and the citizens of the city of St. Louis who might use the waters of the Mississippi river at the intake tower, Chain of Rocks.

6576 From the analytical data which has been presented, it is shown that the addition of the sewage of Chicago to the waters of the drainage canal results in such a degree of purification that I do not think that deleterious substances or infectious matters capable of producing disease would be found in the waters of the Illinois river at the city of Peoria, which were derived from the sewers of the city of Chicago. The dams in the Illinois river are an aid to sedimentation and such sedimentation results in the elimination of a large proportion of the total bacterial life.

6578 The water of the Mississippi river at the Chain of Rocks prior to January, 1900, was not to be regarded as a thoroughly safe and potable water supply suitable for all domestic and drinking purposes. (Same as to the Missouri river, and as to the Illinois river.)

6579 I do not consider that the waters of the Illinois river at Grafton should be looked upon as a perfectly safe supply, regardless of the possible changes which have been made by the opening of the drainage canal.

6581 In view of the fact that the conditions which obtained in the city of St. Louis and the conditions of the watersheds which are immediately adjacent to this city, in view of the fact that the typhoid fever death rate in that city is dependent upon other conditions than those due to the water supply of that city, and may be materially influenced by operation of many other factors, in view of the conditions which obtain in the Illinois river with reference to the process of purification which would occur in the sewage of Chicago when deposited in the drainage canal, and taking into consideration all the knowledge which I possess with reference to all data which bear directly or indirectly upon the question involved, it is my opinion that the increase in the typhoid deaths, as reported in the city of St. Louis, assuming such increase to be true, which have occurred since the opening of the drainage canal, can not beyond all reasonable doubt be attributed as a direct, immediate and approximate cause for said increase to the opening of that drainage canal.

CROSS-EXAMINATION, by Mr. Jeffries:

6582 I consider that it is possible to arrive at a satisfactory examination of a water supply on the basis of chemical and bacteriological methods without necessarily taking into consideration the matter of population.

6585 The colon organism is a normal inhabitant of the intestinal tract of higher mammals and other animal forms, and therefore its mere presence in surface water—this fact taken simply by itself—can not be regarded as direct evidence that its presence had originated from human excreta.

6586 The conditions to which pathogenic bacteria are subjected in nature are such as to produce a rapid loss in vitality of those organisms and consequently a water may be of such a character as to result in a production of disease and if the examinations are not made in large numbers at that particular time the organisms of a pathogenic character may lose their vitality to such an extent that the determination of their presence and not the number of the pathogenic organisms present may be fairly considered as indicating the probable nature of that water as to the liability of producing epidemic disease.

6587 In my routine analytical work the practice is never followed of making a direct examination of such waters as are ordinarily examined for the purpose of detecting the presence or absence of typhoid organism.

6589 Experiments made with typhoid bacilli inoculated into sterilized water have demonstrated the ability of this organism to live for a period measured by a number of months and in some instances upwards of 100 days. The results obtained are widely discordant with respect to the exact time.

Interpreting your question to refer to the viability of an organism in boiled waters, I am of the opinion that the vitality of the organism might be retained in the water sterilized by boiling, a longer time than would be the case if the organism was exposed in contact with human dejecta, in a moist condition.

Concentration of the sewage material on the life of a 6590 typhoid germ would not be operative beyond a certain point. The difference between the sewage containing, say, 10 per cent of solid excreta, and say 20 or 25 per cent of solid excreta, would not be such as to materially alter the rate of loss of vitality.

6591 My opinion is that the changes that have been produced in the Chicago river through the opening of the drainage canal, are not such as will greatly modify the death rate of the typhoid organism when exposed under these two conditions.

This opinion is based upon my belief that in either instance the degree of concentration in the water of bacterial by-products, and the presence of saprophytic bacteria themselves would be sufficient to cause an early death of typhoid organisms placed in this water.

(Witness states the typhoid epidemics that he has personally examined and the sources of infection in each case.)

All of these epidemics were caused by sewage pollution.

6595 (Witness is cross-examined as to the experiment on longevity of typhoid bacilli that was made by him.)

6607 ISHAM RANDOLPH, Examined in chief by Mr. Todd:

Have been civil engineer since 1868. (Witness gives educational qualifications and experience.) In 1893 was elected chief engineer of the sanitary district of Chicago and have retained that position ever since. My first familiarity with the Chicago river began in 1880 in connection with some work I was doing for the West Indiana Railroad Co.

6609 This brought me in constant visual contact with the Chicago river. It was at that time and remained for many years thereafter a very foul stream, the water black and ill smelling and often covered with a slime, a black slime, and in the summer seasons there was a great deal of agitation of the waters due to gases arising from the putrescent matter in the water.

The Chicago river at that time was a body of water which sometimes flowed up stream and sometimes down stream. Under ordinary lake conditions there was a very, very slight current to the westward, due to the pumping works at Bridgeport.

When the lake was rising the water came in the river quite rapidly. When the lake was falling the flow was in the opposite direction, towards the lake, and in times of freshest there was a strong flow towards the lake. In times of freshet the Bridgeport pumps had to be suspended, and whenever the flow was towards the lake the foul waters of the river passed out into the waters of Lake Michigan, and when there was a freshet, accumulated filth of the river was swept out into the lake and went out for long distances, and the consequent effect of putting foul water into pure water was to diminish the purity of the water into which it was put.

This condition of the Chicago river which I have described, obtained up to 1900.

6610 (Witness describes the sewage system of Chicago, levels, outfalls, etc.)

6611 (Witness produces a map published in one of the reports of the Commissioner of Public Works of Chicago, showing the location of all sewers of Chicago emptying into Lake Michigan and into the Chicago river, which said map is reproduced on page 6612.)

6613 When Chicago was a young city the surface was so slightly above the level of the lake, it was impossible to put in sewers, the drainage was all in open ditches, and during Mr. Chesborough's administration of the engineering department of the city, he planned a sewage system which required the elevation of the grades of the streets. This street level admitted the putting in of sewers which would have fall enough to produce a flow towards the outlet. That slope is very slight, indeed; in many instances it is as small as half an inch to 100 feet, and I think I recall instances where it is even less than that. The result of this is that there is often an accumulation of organic matter in the sewers which is flushed out in times of heavy rainfall or melting snows.

At one time it was the habit in the city to flush them mechanically. They had very large square tanks, mounted on trucks, that took from four to six horses to haul them around, and they would stop this tank over a manhole and let down a spout in the man hole, open the valve and empty the water from the tank into the sewer and flush it in that way. They were kept flushed for many years in that way.

The Illinois and Michigan canal was commenced about the year 1836 and completed in 1848. It extends from a junction of the south fork of the south branch of the Chicago river in the city of Chicago and in a southwesterly direction across the divide between the Lake Michigan watershed and the Illinois valley watershed, through to Peru, Illinois, a distance of about, as I remember it, ninety-six (96) miles. This canal had a navigable depth of about 5 feet and a navigable width of about 60 feet. Its locks were 110 feet long and 18 feet wide. What is known as the summit level extends from the south fork of the south branch of the Chicago river, through to Lockport, a distance of about 29 miles. The summit level since 1884, I think
it was, has been supplied by pumping works located at
6614 Bridgeport in the city of Chicago. The pumps were
under a guaranteed capacity of 60,000 cubic feet per
minute. Prior to the erection of the pumps of which I have just spoken the summit level was supplied by water coming in through what is known as the Sag valley. There was a dam at Blue Island, draining off the Calumet river and dividing its flow, a portion of it through a shallow channel, dug for the purpose, and conveying it into the Illinois and Lake Michigan canal at Sag bridge. At a period prior to 1870, the date I do not recall, this supply became inadequate and pumps constructed on the principal of the stern wheel to a stern wheel steam boat were put in at Bridgeport, for the purpose of supplying water for this summit level. At some time prior to 1870 the city of Chicago undertook to deepen the summit level and get a gravity

flow from the lake through the canal. This work was in progress at the time of the Chicago fire, and a very large sum of money had been expended by the city, something approximating $1,000,000.00, or a little more, I think, and after the Chicago fire the State of Illinois refunded this expenditure to the city. This gravity flow proved inadequate because the channel had not been made deep enough and pumping works were again established at Bridgeport and the pumps that were put in had a guaranteed capacity of 60,000 cubic feet per minute and lift between 4 and 5 feet. As a matter of fact those pumps did not in practice accomplish what they were claimed to do, and the flow fell to in the neighborhood of 50,00 cubic feet. It ranged between 45,000 and 50,000 cubic feet a minute. This supplied the summit level from Bridgeport to Lockport and the intermediate level between Lockport and the upper pool at Joliet. At Joliet the canal and the Des Plaines river flowed together through the upper pool as far as dam number 1. At dam number 1 there was a lock called lock number 5, which passed the flow from the upper pool to the middle pool. The middle pool was created by the building of dam number 2 at Jefferson street in the city of Joliet. At dam number 2 the river and the canal again separated and the canal had an independent course from that point through to LaSalle, where it emptied into the Illinois river. The supply of what is known as the Chanahan or twelve mile level extending from Joliet to Chanahan was taken from the Des Plaines river at its junction with the waters coming through the canal from the Bridgeport pumping works. At some seasons of the year the supply of water from the Des Plaines was very small indeed, and the canal was almost wholly dependent for its availability as a navigable stream upon the waters pumped
6615 from Bridgeport.

These pumps were placed at Bridgeport in 1884 and paid for by the city of Chicago. The forebay from which this water was pumped connected directly with the south fork of the south branch or what was known as the stock yards branch. The water entering the pumps came partly from the stock yards branch and partly through the south branch of the Chicago river from Lake Michigan. There was a certain small flow of water, due to sewage discharged into the stock yards branch which met the flow from the lake, and the two mingled and were drawn into the pumps. The water flowing through the summit levels at a very slow velocity, probably a mile an hour, was a black liquid, with a very foul odor, and would leave a greasy black stain on anything that was put into it. The water in the two pools at Joliet was at some seasons of the year as bad as that in the canal proper, because there was so little dilution coming in from the Des Plaines river, and it was only bettered by what water came in from the Des Plaines river. At some seasons of the year that flow was large, and the conditions were very much improved, but in the dry seasons they were foul, horrible pools.

I have never traversed that stretch of the Illinois and
6616 Michigan canal from Joliet to Ottawa by boat. The stretch from Ottawa south I have traversed by boat. At Ottawa I made a careful investigation with the eye and the nose only of conditions, and at that point I could not detect anything whatever by the eye or the nose, which indicated that the water contained sewage. From there on down the conditions were as good as they were at Ottawa and probably improved continually as we went down.

The sanitary and ship canal has been the outcome of Chicago's necessities. The conditions affecting Chicago's drinking water had gotten steadily worse from the days when it begun to be a city. The conditions were such that the public generally was excited and the public men of the city determined to see what could be done to relieve the city.

It reached a period in 1886 that the city council authorized the mayor, the elder Carter H. Harrison, to appoint an expert commission to decide what should be done for the city. That commission was appointed, I think in January, 1886, and Rudolph Hering, then of Philadelphia, was made the engineer in charge. His associates were Benizette Williams and Samuel J. Artingstall. These gentlemen were authorized to employ expert help, to make surveys and investigations and to prepare a report accompanied by their recommendations. The final report of this commission was never made. The preliminary report I have seen, and in fact there is a copy of it in the report of Major W. L. Marshall, accompanying his report to the governor, I think for the year 1889. In 1889 the sanitary district law was passed, authorizing the formation of drainage districts in the State of Illinois.

6617 Under that law a board of trustees was elected, consisting of nine members, with power to organize, decide upon plans, levy taxes, enter into contracts and prosecute the work as to them seemed best. This board adopted the project for a water way from Chicago to Lockport, this water way to cause a flow of the waters of Lake Michigan through the Chicago river and through the channel which they constructed artificially and discharged in the Des Plaines river at or near Lockport, Will county, Illinois.

The sanitary and ship canal follows the general location of the old Illinois and Michigan canal from Chicago to Lockport. It traverses the territory which is partly tributary to Lake Michigan and partly to the Illinois water shed. It connects with the west fork of the south branch of the Chicago river at Robey street in the city of Chicago; runs in a southwesterly direction through a clay formation and crosses the divide near the "Summitt Range line." The lowest point in the divide between the water shed of the Illinois, the Des Plaines valley and that of Lake Michigan is almost on this summit range line.

Before the building of the "Ogden ditch" the natural surface at its lowest point was 11.72 feet above Chicago datum. Chicago datum is a plane of reference adopted for horizontal elevations by the engineers of the Illinois and Michigan canal when its construction was entered upon. It so happened that this elevation corresponded with the low water of 1847 and hence Chicago's datum is always spoken of as the low water of 1847 in Lake Michigan.

The first seven or eight miles of this channel is through a clay formation a formation which can be readily dredged, and the cross-section of this stretch of the channel is now less than what it is to be ultimately. It is only 110 feet wide on the bottom; the side slopes being 1 foot vertical to 2 feet horizontal, giving a surface width with a minimum depth of water 22 feet, of 198 feet. At the end of this stretch of channel material was encountered which could not be readily dredged. It is described in our specifications as glacial drift. There the full size channel was entered upon. This full size channel is 202 feet wide on the bottom with side slopes as before of 2 feet horizontal to 1 vertical, and the resulting width at the water line is 290 feet with a minimum depth of water 22 feet.

6618 This cross-section of the channel is held for 5.3 miles until Willow Springs is reached; there the rock was encountered. The territory from there on to Lockport is either wholly rock or is underlaid by rock.

The channel contracts at this point to 160 feet in width. The grade is increased from 1 foot in 40,000 feet, which is equivalent to an inch and ⅝ to the mile, to 1 in 20,000 feet.

The length of this cross-section is 14.95 miles. Seven miles of this distance is through cut in rock, the sides are cut practically vertical with two offsets of six inches each on each side, so that the surface width is 162 feet. Wherever the rock did not come to the surface, walls were built from the rock at the elevation found to a height of five feet above Chicago datum.

It was necessary that perfect control of the flow through this channel should be maintained and to accomplish this, controlling works were erected at Lockport. These works consisted of seven lifting gates of the Stoney type, and one bear tray dam. The gates have an opening of 32 feet each. They are counterbalanced and operated by winches, so constructed that two men can raise or lower the gaets under pressure, although each gate weighs 62,000 pounds.

(Witness describes the construction and operation of the Bear Trap dam and also of the bridges across the drainage canal.

6620 Work was begun on the 3d of September, 1892. The water was let into the channel on the 2d day of January 1900. The water flowed over the Bear Trap dam on January 17, 1900.

6621 It took from the 2d of the month to the 14th to fill the channel to the level of Lake Michigan.

6621 The work of executing the plans of the district had gone steadily on. The Chicago river as it was in 1898 did not afford an adequate channel to supply the water which the Sanitary District law required us to flow through our channel. Prior to the beginning of work by the Sanitary District the flow through the Chicago river would have been limited to 150,000 cubic feet and the plans of the sanitary district provided for widening the Chicago river uniformly for 200 feet, deepening it for the central 100 feet to 26 feet below the water surface, making the depth at the dock lines 16 feet. This would give the river a capacity of 480,000 cubic feet per minute, and a velocity not exceeding a mile and a quarter per hour.

The district is also engaged in removing center pier bridges from the river and substituting therefore Bascule bridges. We have completed seven Bascule bridges. We have two now under contract. We have the plans under way for four additional bridges, in fact that are partially completed, and we propose to do away with the center pier bridges in the Chicago river.

The channel of the Des Plaines river south of Lockport
6622 was entirely inadequate to the demands which would be made upon it by the combined flow of the flood waters of the Des Plaines and the discharge from the sanitary and ship canal. It was therefore necessary that the district should deepen and enlarge this channel which it has done to an extent which enables us to carry these combined waters safely through the city of Joliet.

We have made a provision for a flow of 1,500,000 cubic feet of water per minute. For one mile south of the controlling works an entirely new channel was made for the Des Plaines river; that brought us to the precipitate slope of the valley. There instead of making a new channel we bought the lands on each side which would be submerged. This method of caring for the water was adopted as far as the E. J. & E. bridge just north of Joliet. From that point into the upper basin we made an entirely new channel for the Des Plaines. In the upper basin the width of which was 300 feet we deepened the basin to give a sufficient cross-section to carry the water which I have mentioned as 1,500,000 cubic feet per minute. We were compelled by the Illinois and Michigan Canal Commissioners to rebuild dam number 1, which we did. The middle basin we destroyed, tearing out dam number 2 and maintaining navigation in the Illinois and Michigan canal by building a channel for said canal from dam number 1 to the guard lock located at Jefferson street. After tearing out dam number 2, which made the second pool, we widened and deepened the river between Jackson street and Jefferson street. We continued this widening and deepening from Jefferson street through to a point about 800 feet south of the Rock Island bridge. From that point to the mouth of Hickory creek, we built a massive embankment to prevent the over flow of the adjacent territory by the flood waters. We were compelled by the city of Joliet to build new bridges at Cass street and at Jefferson street.

The grade in the channel from Robey street to Lockport falls 5.62.

6623 From Robey street to Lockport the channel is 28.05 miles long and from Robey street to the mouth of the Chicago river is six miles, with a grade of 2 feet. The level of Lake Michigan is variable. The widest fluctuations are caused by wind effects. The fluctuations have amounted to something over four feet. (Witness gives figures showing the total cost of the canal as being $42,503,168.80.)

6624 The original sanitary district took in all of the city of Chicago north of 87th street except a part of Roger's park and Norwood park, and 42 square miles of the country lying directly west of that portion of the city. Originally this embraced 135 square miles. The work on this canal was done under authority of the act of the legislature of 1889, copy of which act is offered in evidence marked "Defendant's Exhibit, Randolph's Exhibit A."

6625 Under the act of the legislature extending the boundary of the sanitary district, passed last session, 78.6 square miles of territory was annexed on the north side, known as the North Shore district, and on the south side 94.48 square miles was annexed, known as the Calumet district. That completes the taking into the sanitary district of all the city of Chicago. The whole city is now in the sanitary district. I have a map showing the territory of the sanitary district as it was first laid out, and the present territory embraced in the district, which is reproduced on page 6626.

6627 Plans are being made for caring for the annexed district. It is proposed to reverse the flow of the Calumet river by constructing a channel from a connection with the Calumet river near Blue Island. This channel extends southwesterly, through what is known as Sag Valley to a junction with the sanitary and ship canal at or near Sag Station on the Alton railroad. This channel will reverse the flow of the Calumet river and prevent the discharge of its waters into Lake Michigan at all times except in excessive floods. Provision can not be made for taking the entire flood waters of the Calumet region through our channel. On the north, it is proposed to extend the north branch of the Chicago river northward as far as Evanston and make a connection with Lake Michigan at that point, at a point almost on the boundary line between Evanston and Winnetka. The lake level being the same at this point of junction as it is at the mouth of the Chicago river, it will be impossible to get a gravity flow through this channel, and therefore, pumping works will be erected at the north end, designed to pump 60,000 cubic feet of water per minute into this new channel. Into this channel all the sewage arising along the north shore is to be delivered by sewers constructed for that purpose. The population of the city of Chicago, by the census of 1900 was 1,698.575. Making up the population curve, based upon past experience and future probability, we bring that population down to 1903, as 1,878,000 at the end of the year.

6628 The total population of the sanitary district is 1,942,000.

The general plan of the district for providing a means of carrying off the sewage has been described. The city in conjunction with the sanitary district is at work with a system of intercepting sewers both from the north and the south side. The city has built a conduit in 39th street, 20 feet in diameter, and having a capacity of 120,000 cubic feet of water per minute. At the lake end of this conduit a pumping station has been established in which there are to be six pumps. Four of these are put in by the city for pumping sewage from the intercepting sewers, sewage mingled with lake water. The combined capacity of the four pumps is 40,000 cubic feet a minute. The sanitary district puts in two pumps which take their supply direct from the lake without sewage pollution and each of those pumps has a capacity of 40,000 cubic feet per minute. They are the largest pumps ever attempted in the world. On the north side of the city on Lawrence ave., the city is building a conduit to receive the intercepting sewers. That extends from the lake across to the north branch of the Chicago river. The intercepting sewers bring in the sewage from the north and south into these conduits. The pumping station is to be erected at the cost of the city and to be operated by the sanitary district. This pumping station will have a capacity of 35,000 cubic feet of water per minute, with arrangements made for doubling that volume if it is found necessary, but the pumps will only be put in at present for 35,000 cubic feet per minute.

6629 When the improvements contemplated by the sanitary district for the territory north, and the Calumet river on the south, as well as the system of intercepting sewers and the canal itself in the earth section, and the Chicago river are completed, the maximum capacity of the drainage canal will be about 825,000 cubic feet per minute. I have tables showing the flow of the canal as measured at the Bear Trap dam since its opening, up to the middle of 1903. For 49 weeks in 1900, the average was 188,136 cubic feet per minute. The smallest flow was on the 17th of September, 1900, 1863 cubic feet per minute, and the largest was on the 26th day of the same month, 326,791. In 1900, the dams at Lockport were only closed for a few hours on two or three occasions when vessels got stuck in the channel. I have no knowledge of the water everflowing through to the lake but once since the channel was opened. Once there was a freshet in the north branch—it was a general freshet and it was not watched close enough to take care of it and that flow began to go towards the lake, and as soon as that was noticed, we checked it in a very short time.

6630 That flow towards the lake did not last but a very short time—probably two or three hours. (Witness gives the maximum, mean and average flow through the I. & M. canal for 1900, 1901, 1902 and 1903, as follows:

On March 16th was the largest flow of the year 1901, 406,227 cubic feet per minute. On October 3d was the lowest, 139,427 cubic feet. The average for the year was 242,323.

Now, we will take 1902. For 1902 I find that the lowest flow was on June 3d, when the works were shut down fourteen hours on account of the flood in Joliet, the Hickory creek disaster, 107,231 cubic feet was the lowest. There was some water running all the time but not enough to interfere with the flood below. The largest flow was on December 26th, 339,610 cubic feet. The average for the year was 257,006 cubic feet.

For the first six months of 1903 it shows the greatest flow to have been on June 5th, 401,425 cubic feet per minute, the lowest May 30th, 248,063 cubic feet, the average 312,692 cubic feet.

The highest record of the Illinois and Michigan canal was on February 8th, 57,677 cubic feet per minute. The lowest when there was anything doing at all—there were a few days when there was nothing doing—was 14,800 cubic feet. The average as 26,768 cubic feet per minute. That is for 1900.

The canal appears to have been shut down entirely from the first of January, 1901, to the 24th of April, 1901. The minimum was on April 24th, 3,840 cubic feet; on July 3d, the maximum was 29,206, and the average for the 26 weeks was 20,073.

In 1902 the pumps were started May 1st. The minimum was 9,200 cubic feet per minute, the maximum 25,080. The pumps were only run for 27 weeks, and the average 22,488.

The first six months of 1903, on January 13th, was the
6631 minimum, 1,913. On June 5th was the maximum, 28,114
the average for the 26 weeks 21,996.

The average per capita consumption of water in Chicago for 1900 was 190 gallons. For 1901, it was 195 gallons and for 1902, it was 197 gallons. As to the Des Plaines river, there were two periods during 1900 when there was no water flowing past.

There were two periods during 1900 when there was no water flowing past Riverside at all. It was simply a pool, from May 31st to June 5th, and from June 26th to July 7th. The largest volume of water passing was on March 19th, 290,350 cubic feet per minute.

For 1901 there was a period from February 11th to March 2d when there was only 2,400 cubic feet of water flowing per minute. About March 30th there was 331,680 flowing, and the average for the year was 20,974.

In 1902 there were several periods in the year when there was nothing flowing at all past Riverside and the maximum on May 26th was 37,740 cubic feet. The average was 30,235.

The first six months of 1903, the smallest flow was June 19th and 20th, 1,200 cubic feet per minute. The largest was March 21st, 437,520 cubic feet per minute, and the average was 4,307.

The mean average flow of the Des Plaines, the Chicago drainage canal, the Illinois and Michigan canal, at Dam Number 1, where these three waters commingle was as follows:

The mean for 49 weeks in 1900 was 233,976. The mean for 52 weeks in 1901 was 277,153. The mean for 52 weeks in 1902 was 294,132. The mean for 26 weeks in 1903, ending June 27th, was 385,475.

6632 I have prepared a table showing the pollution at dam number 1 based upon the mean discharge from the drainage canal, the I. & M. canal and the Des Plaines river, as well as the population discharging sewage at that time. Said chart is reproduced on page 6633.

6634 (Witness describes table referred to.)

6635 The ratio of sewage to the mean discharge of the drainage canal as evidenced by this table for 1900 is 1 to 9.2; for 1901, 1 to 10.2; for 1902, 1 to 10.4. The proportions of urine and fecal matter to the mean discharge of the canal for 1900 is 1 in 5429; for 1901, 1 in 6211; for 1902, 1 in 6310. The table referred to is number 1, pollution of sanitary canal by the sanitary district.

6636 Table 2, same series.

6639 Table 3, shows population curve of Chicago.

6641 Table 4, shows population of Chicago.

6644 Table 5, is headed "Excreta" and purports to show the amount of excreta from 100,000 persons per year.

6646 Table showing pollution of Illinois river from tributaries.

6648 From the tables which I have introduced, I conclude that the natural pollution of the Illinois river is due to the urban and rural population draining into its watershed, exclusive of all sewage coming from Chicago, is more polluted than the waters of the Illinois river are when combined with the discharge from the sanitary canal after the opening of said canal. In the conditions which obtain without considering the discharge from the sanitary canal the pollution is 1 in 17.48. The pollution, considering the sanitary canal, is 1 in 34.3.

6649 Map showing various watersheds of the Illinois river from Chicago to Grafton and marked "Defendants' Randolph's Exhibit B." (Witness describes the physical characteristics of the Des Plaines river.) Prior to the opening of the drainage canal, the water that went south in the I. & M. canal through the Bridgeport pumping works was in a highly polluted state.

6652 The pumps were installid, that is the set of pumps were put in after the deepening of the canal. The canal was deepened between 1865 and 1871 and the flow was only about 9,000 cubic feet per minute. It was insufficient for the sewage and the pumps were put in the latter part of 1884. The operation was commenced about the end of the year 1884. (Act to provide for the completion of the I. & M. canal, approved February 16, 1865, offered in evidence.) From 1884 to 1900 the average column of sewage pumped from the Chicago river into the I. & M. canal was approximately 50,000 cubic feet per minute.

6653 It flowed through that canal to Lockport where a portion of it was discharged into the Des Plaines river over a waste weir or else passed through the wheels of the water power at that point. What did not enter the river at this point entered it after the Des Plaines river reached what is known as the upper basin at Joliet. The complete mingling was in the basin at Joliet.

6654 Chart showing urban population on the Mississippi river and its tributaries.

6655 (Witness gives gauge readings asked for by Professor Van Ornum, in a letter, the reply to which was read into evidence.)

6658 Discharge chart showing volume of flow of the upper Mississippi river.

6660 Same for the Missouri river.

6661 Chart showing flood combinations in the Mississippi river at St. Louis, Paducah and Cairo, also giving conditions in the Ohio river and in the lower Mississippi.

6663 Flow measurements at Peoria.

6664 Flow measurements at Kampsville.

6666 Profile of waterway from Lake Michigan to Cairo.

6667 I made an experiment with floats to determine the velocity of flow from Chicago to St. Louis.

6669 Table showing time from Lake street, Chicago, to Eads Bridge, Mississippi river, at St. Louis, the total number of days being 18 1-2.

6670 At the time this experiment was made it was not a flood time nor was it at low water. It was a full river, but not a flood.

6672 Page 11, 17th annual report of the Health Commissioner of St. Louis for 1893 and 1894 read in evidence.

6673 Also page 36 of the same report, being a resolution of the Board of Health of St. Louis to the mayor and municipal assembly requesting them to memoralize Congress concerning this matter and requesting that a suitable commission be appointed to investigate the prospective pollution by sewage from Chicago.

6674 Page 38 of same report read in evidence, being an order that the city chemist collect samples for chemical analyses, also a report by the chemist that samples were collected.

6675 Page 42 of same report read in evidence, being the report of the city chemist, as to the result of his examinations.

6676 Page 43 of same report read in evidence.

6677 Page 45 of same report read in evidence as follows:

Regular meeting, January 8th. The following correspondence between the mayor and health commissioner was submitted to the board. Letter from the mayor, January 6th:

"I have received yours of the 22d with accompanying reports bearing on the subject of the quality of the water of the Mississippi river between the Chain of Rocks and a point five miles above the mouth of the Illinois river as recently determined by the city chemist. Also charts illustrating the results arrived at by a chemical examination.

I have examined these charts and reports as carefully as my want of technical knowledge will permit. The result of the work is undoubtedly presented in a very graphic manner; indeed, it seems to me that a technical knowledge is hardly necessary to understand the results as shown by the reports and charts before me, assuming that the work of the city chemist so far as it went was thorough and reliable. I have no reason to doubt that the city chemist, Teichmann's, work can be depened on as representing the true conditions. It is my understanding that this investigation was the result of a suspicion that our water supply was being contaminated by Chicago sewage coming from the Illinois river.

Briefly, then, I find from the charts before me conditions as follows:

Substances supposed to contaminate drinking water in dangerous quantity in the Illinois river, also spots in the Mississippi river betwen the mouth of the Illinois and the Chain of Rocks and in the mouth of the Missouri river. I find, however, that at Grafton, about 1 mile and a half below the mouth of the Illinois the water is purer than at any other point in the river between Grafton and the Chain of Rocks. That is to say, nothing of the objectionable substances seem to exist in dan-

gerous quantities one mile and a half below the supposed source of contamination while the pollution increases and diminishes below that point at irregular intervals. This, it seems to me, tends to disprove the theory that the contamination (if there be any) at the Chain of Rocks comes from the Illinois river and goes to show that the offensive substances found in spots along the river between the mouth of the Illinois
6678 and Chain of Rocks are due to local causes. The comparative purity of the water at Grafton seems to be inconsistent with the theory that the water below that point is contaminated from the water from the Illinois river. The conditions existing at the mouth of the Missouri river, as shown by the chart, suggests that as a much more probable source of the pollution than the Illinois river.

In view of these conclusions which seem to me necessary upon the facts before me I do not think further superficial investigations would be desirable at this time. In fact, it seems to me the tendency of the work done by our city chemist is to give confidence in the purity of the water supply at the Chain of Rocks, so far as influences are concerned within our control affecting the water at that point and I am, therefore, inclined to think that if further work be done the investigation should be conducted by a commission of thoroughly equipped experts, backed by sufficient appropriation of money to enable them to make an exhaustive and final report. The money at command under your present appropriation seems to me, not sufficient to do more than has already been done by Dr. Teichmann with seeming thoroughness. If sufficient funds can be made available to prosecute further work with thoroughness I shall be glad to co-operate with you to a final settlement of this vexed question."

6679 Page 11, 18th annual report of health commissioner of St. Louis for year ending March 31, 1895, being a report under the head of "Federal Rivers Commission," read in evidence. Various pages of report read in evidence by witness, tending to show that in the year 1895 the question of the pollution of the St. Louis water supply was under consideration by the St. Louis health authorities.

6682 Robert E. McMath was commissioner of sewers of St. Louis from 1887 to 1891. He delivered an address upon the question of the Illinois river on May 30, 1888 before the Engineers' Club of St. Louis and that address appears in the Journal of the Association of Engineering Society for the year 1898.

6683 (Witness reads from parts of the address above referred to.)

6684 (Witness reads extracts, including the following:) "Sewage in 1886 could not be traced farther than Ottawa. The general result (of the I. & M. canal) is a betterment."

6685 (Witness reads from page 12 of the 17th annual report of the health commissioner of St. Louis for 1893 and 1894 under the heading of Wells, to the effect that a number of wells have been condemned and that notwithstanding the low standard established, very many wells were found to contain water utterly unfit for human consumption.)

6687 Page 204 of report of the health commissioner for 1895 read in evidence, showing 437 public wells and 4,848 private wells in St. Louis.

6688 CROSS-EXAMINATION by Mr. Jeffries.

Since the opening of the canal the water from the various cribs in Lake Michigan is frequently pronounced unsafe by the health department, and citizens using it for domestic purposes are requested to boil it. (Witness is cross-examined as to population drained by certain sewers and generally, on the sewage system of Chicago.)

6700 LUDWIG HEKTOEN, Examined in chief by Mr. Todd: Am physician and surgeon. (Witness states his qualifications as a pathologist, bacteriologist, etc.)

6701 Am professor in pathology in Rush Medical College and also at the University of Illinois.

6702 Am not in the general practice of medicine but am devoting my entire time to investigation. Have been doing the larger share of the post mortems at the county hospital for many years. Have studied germ diseases. Have studied in Sweden, at the University of Upsala, in Prague and Berlin. (Witness describes typhoid fever and its clinical diagnosis, also intermittent, remittent, typho-malarial, congestive and simple continued fevers and states that these latter named fevers are not distinct types of disease and so recognized by pathologists, bacteriologists and clinicians.

6705 As applied to vital statistics, I think that in a large per centage of the cases these fevers mean typhoid fever.

(The number of deaths from typhoid as shown by annual reports of the board of health of St. Louis from 1890 to 1903 and also the number of deaths recorded in same reports under the heading of remittent, etc. fevers read to witness.)

6706 (Witness then states:) The number of deaths reported as occurring from typhoid fever alone in St. Louis do not properly represent in my opinion the total number of typhoid deaths actually occurring in that city, because of the large number of deaths recorded under the heading of remittent, etc. fevers. The number of deaths attributed to the malarial fever, so-called, is in my opinion excessive, and that of course depends upon erroneous diagnosis by the physicians of St. Louis and is undoubtedly the result of the teaching laid down from the early periods where these different forms of disease, especially typhoid fever and malarial fever were not distinguished one from the other.

6707 In my opinion 75 per cent to 90 per cent of those cases under the heading "Remittent, etc. fevers" ought to be put in the typhoid column and from 10 to 25 per cent as malarial fever. The tables appear to show that until the year 1900, when one of these diseases occurred in considerable numbers in a certain month of the year, the other disease occurred to about the same extent at the same time, whereas after 1900 the number of deaths from remittent and intermittent fevers, etc. is on the whole, smaller than from typhoid fever.

6708 If we add the totals of tables for typhoid fever and the tables for remittent, etc. fevers, the figures thus obtained do not appear to me to show any increase in typhoid fever mortality.

6709 I think the circular letter issued by the health department in 1901 to physicians, manifests itself in these statistics. It would seem to appear in the prominent increase in the number of deaths from typhoid fever, associated with a corresponding prompt decrease in the number of deaths from remittent, intermittent and other fevers.

6710 In my opinion I think that the approximate truth as to the amount of typhoid fever in St. Louis could be arrived at by consolidating the two tables (typhoid deaths and deaths from remittent, etc. fevers) and then perhaps subtract ten per cent. Based upon such a consolidation the results would show that typhoid fever have decreased in the city of St. Louis since 1900. I arrive at that conclusion by studying the figures in the table. They show that up to the year 1895 inclusive, the death rate from typhoid fever appears to be approximately 80 or 90 per cent, whereas after 1896 up to the period 1900 it appears to be between 50 and 55 per cent, and between 1900 and 1903 the death rate is about the same.

6716 PROF. E. G. HASTINGS, examined in chief by Mr. Todd:

Am instructor and investigator in bacteriology. (States educational qualifications.) Assisted Prof. Russell with the experiment conducted with typhoid bacilli at Averyville. (Witness states how experiment was carried out and the methods employed.)

6733 ELIHU B. SPENCER, examined in chief by Mr. Todd:

Am photographer. Am employed by the sanitary district. Took the 39 photographs contained in album being views from the Eads bridge of St. Louis to Henry along the Illinois river. Said album marked "Defendants' Spencer's Exhibit A."

6735 In April, 1903, took views between Hardin and Henry on the Illinois river. Album consisting of 46 photographs marked "Defendants' Spencer's Exhibit B," offered in evidence. In July, 1903, took photographs of the Illinois river in lower water, which photographs are marked "Defendants' Spencer's Exhibit C," and offered in evidence.

6736 PROF. ERASTUS G. SMITH, examined in chief by Mr. Todd:

Am professor in chemistry at Beloit college. (States educational qualifications.) Have a laboratory of my own, known as the Beloit Sanitary Laboratory. Am bacteriologist. Have given practically all of my available time since about 1885 to the study of sanitary problems, especially water courses.

6738 I have investigated the typhoid fever epidemics at Baraboo, Wisconsin; Ashland, Wisconsin; West Superior, Wisconsin; Menominee, Michigan, and Rock Island, Illinois and have frequently been called in where typhoid fever was alleged to be present. Two of these were, in my opinion, directly attributable to the character of the water supply, namely, the one at Baraboo and the one at Rock Island. In the others, the water supply, in my opinion, was not so directly responsible for the outbreak. The case of Baraboo which occurred in 1902 was caused by a defective pipe which allowed the seepage of sewage to enter the water supply. The epidemic at Lockport was caused by seepage finding its way into the water supply.

6743 In the prosecution of my sanitary work I have had a great deal to do with different systems of filtration. In fact, I have done work upon filter systems of one sort or another at Davenport, to which water company I have acted as consulting chemist for ten or twelve years, with the filter plant at Rock Island, with the filter plant at Ashland, at Independence, Kansas; at Burlington, Kansas; at Cedar Rapids, Iowa; at Beaver Falls, Pennsylvania; at Warren, Ohio; at Brooklyn,

N. Y.; Binghampton, N. Y.; Denver, Colorado; Kankakee, Ill.; Eau Claire, Wis.; Oshkosh, Wis.; West Superior, Wis.; Burlington, Iowa.

My duties were to look after the quality of the water, the conditions of the filters and determine the efficiency of filtration, meaning by that the satisfactory character or otherwise, in which they were doing their work.

6744 I have investigated the systems of filtration at London, Paris, Antwerp, Berlin and Hamburg.

6745 I have carefully read the chemical and bacterial analysis of the water of Lake Michigan, the drainage canal, the Des Plaines, the Illinois, the Mississippi and Missouri rivers, as made by Professors Jordan, Gehrmann, Palmer and Burrill, the same being published in what is known as "Reports of Streams Examinations," published by the sanitary district of Chicago.

6746 I know the Chicago river, the drainage canal, the Des Plaines, the Illinois and the Mississippi from Grafton to St. Louis. I took a trip on a boat and by car from Chicago to the Eads bridge at St. Louis. This trip was made wholly in the day time, that is, on successive days.

6748 (Witness is asked hypothetical question in regard to the experiment made by Dr. Ravold, with 107 barrels of the bacillus prodigiosus, and states:)

6749 In my opinion, that experiment does not possess value as touching the probable longevity of the typhoid bacillus. The longevity of the bacillus prodigiosus is not necessarily a measure of the longevity of the typhoid bacillus, and it does not contribute to the probability that a typhoid bacillus, entering the drainage canal, etc., would find its way through. But on the contrary, it seems to be an improbability that it would.

In the first place the bacillus prodigiosus is known to flourish under ordinary temperature, given the proper food stuff, and I do not know of any evidence contributory to the knowledge that the typhoid fever organism flourishes and develops in water.

6750 As to the probability that a typhoid bacillus would pass down the canal it seems to me that the experiment first of all does not show that these bacilli were those which were placed in the water, as we have evidence that they are occasionally found, or forms resembling them are found, in our natural waters. Further, upon studying the question it seems to me that if the bacillus prodigiosus had remained in the water for any length of time they would have found them far up the river, but as I understand the results they were not found above Grafton. If they should persist in constantly diminishing numbers it seems to me reasonable to assume that if these organism were those which actually found their way down the river they would have found them in increasing numbers in the samples taken above; but they did not find them until they reached Grafton, although as I understand from this question numbers of samples were taken, e. g., as 432 samples taken at Joliet. But there is no record they were found there.

6751 The colon test is one of the most important tests used in the determination of the sanitary quality of a water supply. I have no knowledge of the longevity of typhoid bacilli in soil only by reading. Such readings show that certain germs have been found in soil sometimes as high as six months. Mr. Frankland, in his "Micro-organisms in Water," records a case where it was observed after 100 days in sterilized natural water and this may be taken as the maximum which I have seen recorded in any experiments.

6752 It would tend to diminish in numbers and disappear after a few days, some records putting it as six or seven days, and some as high as 26 days, which is the highest I have seen recorded, but that would depend upon the quality of the water used. Experiments show they will not live as long in polluted water as in sterilized water. In fact the longest period of life which we have observed in the case of the typhoid bacillus in experimental work is where they have taken natural water and sterilized it.

6753 I think I suggested the experiment that was conducted by Profs. Jordan, Zeit and Russell, upon the longevity of the typhoid bacillus.

From such a study as I have been able to make of the quality of the waters in the canal and the Des Plaines and the Illinois rivers, and from the study, especially of the work of Prof. Jordan, it is my opinion that the viability or duration of life of the typhoid bacillus must be brief, surviving but two or three days, so far as those experiments show, not extending beyond that. It was recorded in the experiment, that isolated cases were found as late as the ninth day, but out of some 1100 tests, if I recall just right, by Professor Jordan, in only three of those was he able to note the presence of them. All of them were on a single plate, and the same day. It seems that that experiment would tend to show that the duration of life of the typhoid bacillus in the Illinois river must be brief, not more than three days, or so.

6754 The dams in the Illinois river would naturally increase the amount of sedimentation. A high water always tends to increase the amount of sedimentation contained in water, but in the Illinois river we meet with physical surroundings which tend to compensate for this increasing of sediment so that in the high water of the river you will have a heavy sedimentation from overflowing and carrying the water out over the low lands.

6755 When there is sediment, or matters in suspension in a running stream that assists sedimentation of bacteria.

6756 In my opinion that amount of water passing into the drainage canal could not produce a condition of clearness to preclude the possibility of the opportunity of sedimentation. From the Illinois river, as I had occasion to observe it, in my opinion, if there was 800,000 cubic feet of water per minute discharged through the canal, there would be a considerable amount of sediment yet remaining in the waters. Dilution of a water with a water of better quality, is one of the well recognized factors in the problem of self-purification of streams. It manifests itself in separating objectionable micro-organisms and thus diminishing the liability of the same being taken into animal economy.

6757 A sewage laden water diluted with a water of a better quality is thereby rendered less liable to communicate disease by infection. It is generally accepted by sanitarians that the dilution of sewage diminished the danger from infection, the greater the dilution the more the micro-organisms are separated and the less the liability of the same being taken in by man. In my opinion the addition of the purer water from Lake Michigan to the sewage improves the quality, that is, diminished the danger from the sewage in that the micro-organisms are more separated from each other and also because it gives the river greater area for facilitating the sedimentation of solid matters suspended in the same.

6758 In my opinion Lake Michigan water added to the sewage of Chicago is decidedly beneficial to the sanitary condition of the river from the standpoint of the chemical and bacterial changes taking place because so far as the chemical changes are concerned, and the bacterial changes also, there will be an elimination owing to the process of sedimentation of material carried by the water and therefore the quantity of the water would be improved.

It seems to me evident that the raising of the Illinois river level would make an increased volume of the river which would widen the sedimentation area and that this sedimentation of the river would be decidedly increased by this rise of level, and thus the total sidimentation of the river would be greatly increased; and further, this raising of the level would also increase the total volume carried by the river so that relatively there would be a smaller quantity of the sediment in any given volume of the river. Thus, it works both ways, hastening the processes of sedimentation.

It is my opinion that the physical conditions of the Illinois river are such as to be well adapted to sedimentation as compared with other rivers with which I am acquainted. In support of this it seems to me that the low shelving banks of the river are such that a slight increase in the volume of the river and thus a raising of the water above its level tends to broaden out the depositing area for the sediment.

6759 Q. From your knowledge of the physical conditions that obtain along the Illinois river as well as your knowledge based upon the study of the results of the analysis as they appear in Streams Examinations on the water both chemical and bacterial of the Illinois river, what effect, if any, does the sewage from Chicago discharged into the drainage canal have upon the waters of the Mississippi as the same passes along the shore of the State of Missouri?

A. In my opinion all the conditions affect the quality of the Illinois river. Its physical surroundings; the study of the chemical analyses, the comparison of the bacterial analyses; the death rate of the typhoid bacillus; the rate of flow of the river, the Illinois river as discharged into the waters of the Mississippi does not affect its quality as it passes along the State of Missouri, in fact the data probably indicate that the Mississippi river is not of as good quality as the Illinois

6760 river itself in its lower reaches.

In my opinion it seems to me quite clear that there is no pollution dangerous to public health from the drainage canal which receives the outfall from the sewers of Chicago which reaches down the Illinois river as far as Grafton.

There are several factors in connection with the river and the study of the agencies at work in the self purification of the stream in my opinion would justify that statement. We have the agencies of dilution of the sewage whereby the sedimentation of the river is augmented for the reasons previously outlined.

We have the experimental work showing the short life probably not exceeding three days of the typhoid bacillus in the waters of the river.

We have the rate of flow of the river showing that the time required for substances to pass from the drainage canal at Chicago to Grafton considerably exceeded the life period of these organisms as revealed by the special experiments upon the typhoid bacillus of this particular river.

We have further the study of the river from a chemical standpoint which shows the purification of the river from that standpoint and we have also the data from the bacteriological investigations all a matter of evidence which show that the waters have purified themselves from the bacterial standpoint. That is, the waters of the Illinois river at Grafton appear from the chemical and bacteriological standpoints as evidenced by these data to be of the quality of other rivers of this section.

To sum up these conclusions, in my opinion, the several agencies at work make the Illinois river at Grafton about a normal river water in this section.

6761 It is my opinion that infectious matters coming from the sewers of Chicago by way of the drainage canal do not reach as far down the river as Grafton, for the reasons I have outlined in my answer previously given. It is my opinion that the low water in the Missouri river at a time when there was high water in the Illinois, would not be a factor in carrying infected and polluted matters from the sewers of Chicago to St. Louis, because the waters of the Illinois river have become purified through the process of self purification and removed the infected and polluted matters and therefore, the condition of the Missouri river does not enter into the discussion.

6762 For the reasons given above, the agencies which are at work in the Illinois river tending to the self purification of the stream and the removal of sewage material as such from the river it is my opinion that the sewage from Chicago does not affect the water supply of the city of St. Louis or the waters of the Mississippi river as they pass along the State of Missouri.

6763 From the experiments all a matter of evidence it is my opinion that the typhoid bacilli passing from the sewers of Chicago into the Chicago river, thence into the drainage canal are destroyed in a short period, not exceeding more than 3 or 4 days after passage into the Des Plaines and Illinois rivers.

6764 In my opinion the typhoid bacillus would live longer in the sediment of a polluted stream than it would in the water of the same stream. The time that the typhoid bacillus will live in moist soil does not furnish any criterion for its longevity in the sediment of a running stream; the two conditions are not comparable.

6765 I do not know of any demonstration of typhoid fever germs having lived for a period of one year in the sediment of a running stream. In my opinion, the typhoid fever germ would not remain in the sediment of a running stream for that length of time. The agencies of removal would be at work on the destruction of the germ for the reasons stated.

6766 It is my opinion from all the knowledge that I possess from a study of the analytical data and the conditions surrounding the river that typhoid bacilli coming from the sewage of Chicago and entering the drainage canal could not traverse that distance and survive. This being true, they could not possibly be a danger and a menace to the inhabitants of the State of Missouri using the waters of the Mississippi for drinking and domestic purposes.

The sewage of Chicago, in my judgment, being eliminated from the stream owing to the processes of self purification before the Illinois river reaches Grafton, the matter of the settling basins at St. Louis does not enter into the problem of the purification or non-purification of the sewage of Chicago, if not reaching that point as undecomposed sewage.

6767 The fact that a settling basin holds a sufficient amount of water to supply for a period of thirty days, with a constant inflow and outflow of the water as this question supposes, is no evidence that the typhoid bacillus will survive thirty days. It is a well known fact in the study of purification of waters by means of sedimentation that the water must be rendered perfectly quiescent. It must not receive inflow waters in order that the maximum amount of purification may take place. Now, that being true it can not be assumed that the period of life of this organism is thirty days, somply because the basin holds that amount.

I have studied carefully the typhoid statistics of the Illinois, Missouri and Mississippi watersheds, as compiled in the table made up from the certificates of the Board of Health of the different cities lying on the three watersheds, which table has been heretofore introduced in evidence. In the matter of the interpretation of mortality statistics, I always have used the number per thousand or the number per hundred thousand. That is an accurate, specific method of determining the rate for any particular city and can be compared with those from any other city.

6768 The mortality percentage basis might be misleading in its conclusion because, for example, you may have a city of 100,000 people and one year there might be 500 deaths, year after year from typhoid fever, but the deaths in one year from all causes might greatly exceed those of any other year, for all causes, so that upon the percentage basis you would have a shifting result, whereas, if you used the number per 1,000, you would have a constant result and thus make the results which would be strictly comparable. The liability of pollution and infection of the river from the rural population is very decided. The relation of the rural population is one of the important questions to be considered always in making up our studies of the epidemics of typhoid fever in any given locality.

Infection from rural population is a very common cause of epidemics. In the case of the epidemic at Plymouth, Penna., Butler, Penna., and Ithaca, New York, the sources of epidemic were traced to pollution from the rural population. Then, in my own experience, I am sure that the prevalence of typhoid in Denver is due to conditions outside of the city, either up the Platte river or up Bear Creek Canon. (Witness states position which the sciences of bacteriology and chemistry occupy in regard to the ascertainment of the purity of river waters.)

6772 In studying the tables of analyses submitted in evidence, it is my opinion that the waters of the Illinois river begin to show a very decided purification at Ottawa, which increases and reaches its maximum at Averyville, which is above the city of Peoria. It receives, at Peoria, and at Pekin, a considerable addition of eswage material; another area, or a zone of purification commences at this point, some distance 30 miles or so below, and is practically completed at Grafton, the river at that point appearing to be water of the quality of rivers of this section. In my opinion it is necessary for a man to have a pretty thorough, working, practical knowledge of chemistry and bacteriology in order to qualify as a sanitary expert.

6773 From all the knowledge available, from the standpoint of chemical and bacterial knowledge, it would be my opinion that a typhoid bacillus, lying in the sediment of a polluted stream, for a period of over 60 days would not be able to cause typhoid fever; for reasons which I have indicated earlier in my examination, it would probably be destroyed in the sediment. In my opinion, polluted and infected matter coming from the sewage of Chicago through the drainage canal, would have become harmless before reaching Peoria and would have been altered so that it would not be deposited on the bottom as sediment as infectious material. The bacteriological data already submitted in evidence, in my opinion and judgment, show the purification of the stream before reaching Peoria.

6774 The chemical and bacterial data already a matter of evidence in this case, showing that the waters have become practically purified before reaching Peoria, it would be my opinion that sewage from the city of Chicago could not be a menace to the inhabitants of the State of Missouri and the citizens of the city of St. Louis using the Mississippi river water.

By comparison of the data submitted by Professors Long, Palmer, Burrill and Jordan, it is my opinion that the Illinois river at Grafton discloses the least amount of impurity or pollution of the three rivers, the Illinois, Mississippi or the Missouri.

It would be evident that if the Illinois river is of a better quality or does not show as much impurity as either of the other rivers, it would really benefit them, if anything, and in proportion as the waters became mixed. If the evidence should be that the Illinois river practically hugs the east shore and does not mix, particularly it would not affect them. If, on the other hand, the data should show that there is a gradual mixing then in proportion as this mixing occurred to that degree it would improve, if anything. The differences are not very great, however, between the data as I have examined them.

6775 I have made surveys of the water of the Mississippi river in passing upon the quality of that water for drinking and domestic purposes, the same extending over a period of at least 12 years. (Witness states different points along the river at which these examinations were made and the results obtained.) (It is important that this evidence be reviewed, as it shows the condition of the Mississippi river from St. Paul down.)

6783 From examinations of the Mississippi river water made at different times throughout a series of years, and at different points reaching from Brainard, Minnesota, as far down the river as Muscatine, it is my opinion that the Mississippi river water in its raw and untreated condition is unfit for use as a public water supply, without treatment, and it is my opinion, therefore, that the mixing of the Illinois river with the Mississippi river water, after it may have received the Missouri river, does not create any added danger to the inhabitants of St. Louis and to the people of Missouri, for public and domestic purposes.

6784 From all my knowledge of conditions that obtain along the Illinois river, from the inspection of the river throughout its entire length, from a study of the analytical data, both chemical and bacteriological, already a matter of evidence in this case, from the rate of flow of the river, from the data adduced regarding the duration of life of the pathogenic germs the same not living more than three or four days in the waters of the stream, with the processes of self purification at work, notably the process of dilution and sedimentation, and the chemical and bacterial changes shown, it is my opinion that infected matter and pathogenic germs coming into the drainage canal from the sewers of Chicago would not reach as far down the Illinois river as the city of Peoria.

6785 In view of all the knowledge which I possess upon the Illinois river, and the study of its physical characteristics, from the study of the chemical and bacteriological analyses of the river already a matter of evidence in this case, from the rate of flow of the river and the duration of life of the typhoid bacillus, the same not extending over a period of three or four days, as already a matter of evidence, from the analytical and self purification operative in the river, notably those of dilution, sedimentation and the bacterial and chemical changes which the river undergoes, it is my opinion that the sewage of the city of Chicago, entering the drainage canal, and thence discharged into the Illinois which in turn empties into the Mississippi river does not constitute a menace and a danger to the inhabitants of the State of Missouri, or to the citizens of the city of St. Louis taking their water supply from the Mississippi river.

I know of no instance on record or in literature on the subject where a typhoid bacillus has lived for a period of from one to three years in the sediment of a polluted stream or in the water of the same, but on the contrary, the records of all the experiments which I have been able to read, and from all information I have been able to gather upon the subject of the duration of the life of a typhoid germ in a polluted water, is that it is brief, being limited to that of a few days, six or seven perhaps, at the outside.

6787 The effect of increasing water at flood tide from the tributaries of the Illinois river, as well as the Illinois river itself, coming in at points below the entrance of the polluted waters of the drainage canal would and do cause, as I have observed personally, a large area of land to be overflowed along the Illinois river valley, and the effect of this overflow is to greatly increase the area of sedimentation so that the sewage from the city of Chicago entering the river through the drainage canal would have an opportunity for more complete sedimentation; this overflow forms an important factor in estimating the significance to be attached to the element of sedimentation in the purification from the sewage in the stream. It is my opinion that if the volume of water be increased overflowing this greater area of territory, the waters discharging out, becoming retarded in their course, and giving opportunity thus for the sedimentation, it would follow that the sedimentation would be greater when the volume of water was sufficiently large to cause the overflow of a considerable section of
6788 territory adjacent to the Illinois river through the valley.

From all knowledge which I have been able to gather concerning the conditions which obtain in the Illinois river, from my personal inspection of the river, from the chemical and bacteriological tables already a matter of evidence in this case, from the facts concerning the duration of life of the typhoid bacillus, from the rate of flow of the river from the agencies of sedimentation and dilution and the chemical and bacteriological changes which obtain in the river, it is clearly my opinion that the removal of the four dams namely the dam at Henry, at Copperas creek, at La Grange and at Kampsville would not create a condition which would permit of the sewage coming from Chicago through the drainage canal into the Mississippi river to reach the intake of the waterworks at the city of St. Louis in the Mississippi river and thereby constitute a menace to the health of the citizens of St. Louis and the inhabitants of the State of Missouri, using the water for drinking and domestic purposes.

It is my opinion that prior to January, 1900, the water of the Mississippi river at the Chain of Rocks was not safe and potable drinking water. (Same as to the Missouri and Illinois rivers.)

6790 From my study of the conditions of the river, especially from the study of the chemical analyses of the supply of water, and also the bacteriological conditions of the water of the river as disclosed by such analyses from before and after the opening of the drainage canal, I am of the opinion that the sanitary condition of the Illinois river water has not been materially changed by the opening of the canal.

I have acted as chemist for the American Water Works Company operating the public water plant at the city of Omaha, and also for the Water Company at Council Bluffs, Iowa, across the river from Omaha, both cities taking their water from the Missouri river.

6791 I am of the opinion that the sewage discharged through the drainage canal, has no material effect upon the waters of the Mississippi and the Missouri rivers at the Chain of Rocks. Such changes as it does effect are those due to the mineral salts carried on by the river, as chlorides and nitrates. It is my opinion that the sewage as such, does not reach the mouth of the Illinois river in an unchanged condition.

The waters of the Mississippi after receiving the waters of the Missouri are unsuitable to be used by the citizens of St. Louis for a water supply, in its raw state. I am of the opinion that the present treatment of the water by the settling basins merely, does not render the same a safe and suitable water for domestic and drinking purposes, to be used by the citizens of St. Louis.

6792 In my opinion, in order to render the waters of the Mississippi river safe after they have received the waters of the Illinois river, at Grafton, and the Missouri river, at its mouth, the same passing down by the Chain of Rocks, the proper method to treat that water would be by some process of efficient filtration.

6794 From my knowledge of the Mississippi river as based upon personal investigations and chemical and bacteriological examinations of the same, and from my study of the analyses of the Illinois river at Grafton, before the waters of the same are discharged into the Mississippi river water I am very clearly of the opinion that the cost of purification of water below the mouth of the Illinois river would not be increased, owing to the waters of the drainage canal finding access to the river, and therefore the cost of installation and operation of a filter plant at the city of St. Louis would not be increased owing to the admission of waters from the drainage canal.

6795 From my knowledge of the quality of the Mississippi river water and the difficulties met with in successfully filtering the same; from personal studies upon filter plants and upon the river; the water of the Illinois river at Grafton being so similar to the waters of the Mississippi river; the waters of the Illinois river at Grafton being, in my opinion, essentiolly the same as they were before the waters from the sewage of Chicago were delivered from the drainage canal into the Illinois river, I am clearly of the opinion that the role which the drainage canal plays in the Illinois river would not affect the cost of installation, management or operation of a filter plant filtering the waters of the Mississippi river at St. Louis after the same have received the Illinois river at Grafton and the Missouri at a point below.

6796 The same general character as the Mississippi river water, I am clearly of the opinion that it would not cost any more to operate a filter plant or require more skill and expensive managemnet of the same after the sewage of the city of Chicago had passed through the drainage canal into the Illinois river and thence into the Mississippi river water above St. Louis than before the drainage canal was opened.

I have prepared a table of averages based upon the analytical data presented in evidence in this case by Professors Jordan, Long and Palmer, from various points along the Illinois river, the Missouri river and the Mississippi river, which table is reproduced on page 6798. (Witness explains the terms used in table.)

6801 With this explanation of the terms employed in the original determinations and their significance, it is of value to note in this table of results which we have, showing the averages of analyses taken from the Des Plaines, at Joliet, from the Illinois river, at La Salle, Averyville, Wesley, Beardstown and at Grafton, from the Missouri at West Alton, from the Mississippi at Grafton, from the Mississippi at Alton, 100 feet from shore, and from the intake at St. Louis, a very high pollution from sewagic matters in the waters of the Des Plaines at Joliet, the same gradually diminishing as we pass down the river as far as Averyville, showing an increased pollution at Wesley and again diminishing gradually until Grafton is reached,
6802 at the mouth of the Illinois river.

While the data as given by the different men for the periods indicated, namely, Palmer for June, July, August and September, for the years 1899 and 1900, and Jordan for the months of May and June, 1899 and 1900, and Long during the summer months of 1899 and 1900, are not strictly comparable, yet in no essential point do they differ the conclusions which can be drawn from any one of these observers pointing clearly to the chemical purification of the waters of the Illinois river by the time they have reached Grafton, as indicated by a diminution in the amounts of free ammonia, in the amounts of albuminoid ammonia, the notable increase in nitrates, the diminution in oxygen consumed and in the diminution in the amounts of chlorine.

Another important fact is that the results of 1900 as compared with those of 1899 show at Grafton a diminution in the amounts of free ammonia, a diminution in the amounts of albuminoid ammonia, a diminution in the amount of nitrogen as nitrites, but an increase in the amount of nitrogen as nitrates, a diminution in the amount of oxygen consumed and the chlorine showing an increase by Jordan, a decrease by Long and a very slight increase by Palmer.

In a word the important fact brought out is that the waters have undergone a practical degree of purification when they reach Grafton, and the analytical data clearly show that the water in 1900 was of a quality superior to that in 1899, for these dates given.

Applying the same principle to the averages of the results of waters taken from the Mississippi river at Grafton, it is my opinion that the waters of the Illinois river at Grafton, as they empty into the Mississippi river, are better than the waters of the Mississippi river taken from the river at a point above Grafton.

Applying the same principles of interpretation of the analyses, it is my opinion that the waters of the Illinois, as delivered into the Mississippi river at Grafton, are of a quality, upon these dates for which these averages are given, and they were the only dates from which data were available, which covered
similar periods and similar seasonable fluctuations of the
6803 stream, and comparing these data the waters of the
Illinois as delivered into the Mississippi at Grafton, are
upon the whole a better water, chemically, for drinking and domestic purposes than the samples taken from the intake at St. Louis, the water of the intake of St. Louis being the waters of

the Mississippi river after it has received the flow from the Illinois and the Missouri rivers.

I have studied the bacterial tables as submitted by Prof. Jordan and Prof. Burrill and have made a tabulation of results as given by them in their tables, which is already a matter of evidence. (Table read in evidence on page 6804.)

6806 These tables show the following average for four months in the beginning of 1900: Illinois river, at Morris, Ill., 609,125; at Averyville, 75,735; at Grafton, 29,375. Mississippi river at Grafton, 44,187.

From a study of these tables, these tables being the results of the investigations of the samples of water on these different dates of the Illinois river at Grafton and the Mississippi river water at Grafton, I am of the opinion that so far as numbers of bacteria are concerned, the waters of the Illinois river at Grafton are of a better quality than the waters of the Mississippi river at Grafton. I have made a table of averages of bacterial counts from the reports of Prof. Jordan in Streams Examinations. This table gives the averages in the Illinois river and its tributaries and also the Mississippi river.

6807 As the results of such analysis I find that the average number of bacteria in the water of the Illinois at Grafton is a little above that of the average of these streams, namely the Des Plaines river at Lockport, the Kankakee at Wilmington, the Big Vermilion at La Salle and the Sangamon at Chandlerville, and the Fox at Ottawa.

6808 It is to be noted that two of these rivers, the Fox river at Ottawa and the Sangamon at Chandlerville, carry a number of bacteria in excess of that of the river at Grafton. The Illinois river at Grafton is 29,376, the average of the Mississippi river at Grafton, for the same date, being 44,187. The waters of the Mississippi river are not included in this average. It is my opinion, therefore, that the bacterial condition of the water of the Illinois river at Grafton, from such studies as this, is fairly comparable with the waters emptying into the stream at this season through the same period. It is better bacterially than the average of the waters of the Mississippi river taken at Grafton through this same period.

I have made a table showing comparison of the bacterial flow of the Illinois river at Grafton, with the flow of the Mississippi river at the same place and points below as given in the tables submitted by Prof. Jordan in the report of streams examination. Average of the amounts for the first four months of 1900 when in the worst condition.

6809 Illinois river at Grafton, 29,375 per c.c.

Mississippi river at Grafton, 44,187 per c.c.

Mississippi river at Alton 100 feet from Illinois shore, 43,906 per c.c.

Mississippi river at Alton one-fourth distance from Illinois shore, 69,919 per c.c.

Mississippi river at Alton, mid-stream, 78,044 per c.c.

Mississippi river at Alton one-fourth distance from the Missouri shore, 82,294 per c.c.

Mississippi river at Alton, 100 feet from Missouri shore, 64,233 per c.c.

Mississippi river at Chain of Rocks, 400 feet from Illinois shore, 53,100 per c.c.

Mississippi river at Chain of Rocks, midstream, 69,825 per c.c.

Mississippi river at Chain of Rocks, inlet tower, 58,309 per c.c.

Mississippi river at Chain of Rocks, 400 feet from the Missouri shore, 73,791 per c.c.

Missouri river at Fort Bellefontaine, West Alton, Mo., 56,035 per c.c.

From the results shown by this table, it is my opinion that the Illinois river is better in the number of bacteria contained in the same, than the Mississippi or Missouri rivers at any of the points named in said table. Taking everything into consideration and including all of the agencies of purification, sedimentation, etc., I am of the opinion that the combination of these agencies all tend to practically purify the Illinois river so that sewage, as such, does not reach down that river as far as Grafton, and, further,

6811 If for the above reasons in my opinion the contamination and the pollution from the sewers of Chicago do not obtain in the Illinois river at Grafton, such contamination and pollution cannot be manifest and present from the Illinois river at the Chain of Rocks in the Mississippi river. I was employed by the Peoria Water Co., at the time of the installation of their new plant in 1892 and I made some analyses of the Illinois river and some investigation as to its sanitary condition at that time. In the course of the investigation made at that time the river was, in my opinion, unfit for use as a public water supply, and at my advice the company dropped the consideration of the stream for that use. In my opinion the water at the present time is of a better quality than it was at that time, in 1892. In the course of those investigations I was upon the river in a boat and went out to and was across the wagon bridge observing the river from time to time, and samples were taken for chemical analysis from the river. It was of a dirty appearance, as I recall it, and possessed, in warm seasons, a decidedly disagreeable odor. The last time I observed the river at Peoria was in September, 1903.

6812 At the time I was there in September there had been a rain storm just preceding it, and the river was muddy and so much silt in it I do not think I could institute a comparison, further than that at the time I was there in September it was muddy from previous rains. There was no odor observable, in September, nor was the water offensive to sight or smell, beyond the presence of the mud and silt in the stream.

6813 I am of the opinion that the water supply of St. Louis is not contaminated, polluted or injured by the sewage of Chicago entering the drainage canal and thence into the Illinois river.

My examination of all data which I have been able to gather together, which bears upon this case, from a study of the tables submitted by witnesses for the defense in this case, from my knowledge of the conditions of the Illinois river throughout its entire length, derived from the personal inspection of the same, from the data regarding the viability of the typhoid germ and the period of time necessary for water to flow from Chicago to St. Louis, and from my study of the agencies operative in the sanitary purification of this stream, from the chemical and bacteriological changes which obtain through the course of its flow, it is my opinion that sewage from the city of Chicago becomes practically purified at Grafton and the quality of the Illinois is fairly comparable with that of streams forming its tributaries, and that the sewage of Chicago has become purified practically, the pathogenic bacteria having been eliminated in the process of flow of the stream, and hence the original organic matter of the sewage from Chicago does not find its way into the intake tower of the St. Louis water works at the Chain of Rocks.

6814 From studies which I have made upon the question as to self purification of running streams, I am very clearly of the opinion that running water can and does purify itself so as to be free from pathogenic bacteria, which may have been placed therein. From all the knowledge which I have upon the sanitary quality of the Mississippi river after the same has received the waters of the Illinois river, from the fact that the agencies of self purification of a running stream obtains in the Illinois river, from the fact that, in my opinion, the waters of the Mississippi river are not of as good a quality as those of the Illinois river before the Illinois river may have found access to the same, because my study of the Illinois river leads me to consider that the sewage, as a factor has been practically eliminated from the Illinois river before it empties into the Mississippi river at Grafton, I am of the opinion that the Mississippi river at the intake tower of the St. Louis waterworks at the Chain of Rocks is not less valuable for drinking purposes and it is not more liable to carry water borne diseases, such as typhoid fever and cholera now than it was before the sewage of the sanitary district was run into it.

6815 In my opinion the increase in the speed of the current in the Illinois river would have an effect to remove the sewage from Joliet, Peoria and other towns on the Illinois river, further down the stream, towards the waters of the Mississippi river and this as compared with conditions which existed before this volume of water was added to the river would be to cause sewage to extend over wider reaches of the river.

6816 If the volume of water in the Illinois be increased by the addition of pure Lake Michigan water to the drainage canal, and the speed of the current of the river thus be increased, such increase in said current, in my opinion, would not have any effect on increasing or diminishing the liability to typhoid and other water born diseases on the part of the inhabitants of the State of Missouri using the waters of the Mississippi for drinking purposes, below the mouth of the Illinois river; and for this reason in my opinion from all

6817 studies in regard to the assumption that typhoid germs could pass from the sewers of Chicago, by way of the drainage canal to Lake Peoria and be deposited there in the bed of Lake Peoria for a period of a month it is my opinion from my study regarding the purification of the stream, basing that knowledge upon the analytical data submitted as evidence in this case, which data indicate the removal of sewagic bacteria before Lake Peoria is reached, it would follow that the typhoid germ from the sewers of Chicago, by way of the drainage canal, do not reach as far as Peoria, and in further support of this view we have the direct evidence secured by the results of the experiment upon the duration of life of the typhoid fever germ showing that in the waters of the Illinois river it does not live for a period of more than three or four days. I am of the opinion, therefore, that the typhoid germ could not pass from the sewers of Chicago by way of the drainage canal to Lake Peoria and be deposited there for a period of a month. And further, experimental data alluded to above indicate that the conditions as they exist today are hostile to the life of the typhoid germ and therefore they would be destroyed before reaching Lake Peoria.

I am of the opinion that the typhoid bacillus would not
6818 reach as far as Lake Peoria and therefore water leaving Lake Peoria could not possibly contain more infectious and dangerous pollution than is at present in the diluted sewage entering the Bear Trap dam at the foot of the canal.

6819 From all data available concerning the character of the water of the Illinois river, the agencies at work in the river affecting chemical and bacterial changes, all evidence showing a bacterial purification of the river at Lake Peoria, and added to this the positive results from experiments instituted and carried out by Dr. Zeit, Dr. Jordan and Dr. Russell, I am very clearly of the opinion that typhoid fever germs coming from Chicago sewers do not reach the lakes and slack water portions of the Illinois river above Peoria. It is my opinion that by no possibility and under no conditions of the river can the number of typhoid fever germs at any point be as great as they are at the Bear Trap dam at the end of the drainage canal.

In view of the extent, quality and kind of investigations
6821 bacteriologically, chemically and otherwise that have been made in this case being so extensive and exhaustive as they are, it is my opinion that there is no evidence which could establish the conclusion clearly and decidedly that the waters of the Illinois river at Grafton are infected with sewage from Chicago.

6822 I do not believe that typhoid fever from the sanitary district can find its way to the water supply of the city of St. Louis through the intake at the Chain of Rocks.

6824 For reasons which have been given repeatedly in this examination, conditions which obtain in the river from the self-purification of the same, all of which in my opinion contribute to the practical removal of all sewage as such from the river at Grafton, I should not attribute, beyond any reasonable doubt the principal portion of the increase of typhoid fever in St. Louis to the infected sewage of the sanitary district of Chicago.

6825 From the evidence already given in this case and particularly the positive results of the experiment by Doctors Zeit, Jordan and Russell, in which they have demonstrated that the typhoid germs from the city of Chicago can live but a short period in this sewage laden water, such period covering, according to those observations perhaps three or four days, it is my opinion that the sewage of Chicago does not favor the longevity or growth of germs from Peoria or any other city also emptying its sewage into the river, but on the contrary the same agencies which have operated in this river, which have tended to diminish the viability of typhoid fever would still be operative upon typhoid fever germs coming from points below.

6826 Even though the population of Chicago should increase to 5,000,000 and with a typhoid fever epidemic, the sewage discharged from the sanitary district into the canal would not be an emmediate and impending danger to the people of St. Louis and those living on the Missouri side of the Mississippi river, using the water of the Mississippi for drinking purposes.

6828 Assuming that there is an increase in typhoid conditions in St. Louis over normal conditions, since the opening of the canal, for reasons which have been repeatedly stated in this examination, it is my opinion that such increase could not be due to the opening of the canal and that the cause for such increase must be looked for at points nearer the intake, than from the sanitary district of Chicago.

CROSS-EXAMINATION, by Mr. Jeffries:

If the urine and excreta of a typhoid patient are discharged into 60 gallons of distilled water, the typhoid fever germs would have a tendency to live longer in such condition than if discharged into 197 gallons of distilled water.

6830 The influence of dilution by the lake water, tends to dilute sewagic matters placed in the river, and in so far tends to prolongation of the life of the bacteria, yet the river today is decidedly of sewagic character so that in my opinion the longevity of the typhoid organism would not be very markedly different before the introduction of the puantities of lake water and conditions as we now find them; and in addition to that there is another factor, the river as I formerly knew it and had observed it was quiet, with very little current, and today there is a decided current tending to cause such organisms to pass out of the Chicago river in short periods. Assuming that pathogenic bacteria from Joliet passed down the Illinois river as it existed prior to the opening of the canal, the introduction of 250,000 cubic feet of water per minute into the Illinois river would tend to increase the speed of the current and therefore tend to push pathogenic bacteria farther down the river than they would prior to the opening of the canal.

It is clearly my opinion that the life of the pathogenic germs would not be materially increased by such dilution. If 500,000 cubic feet of water per minute were discharged into the canal, it might possibly prolong the life a little, but the pathogenic germs entering the river at Joliet would still be subject to the germicidal action of sewage waters.

6833 If 500,000 cubic feet of water per minute passed through the drainage canal the addition of this volume of water, as already a matter of evidence and opinion in this case, tending to increase the rate of flow of the stream, it would be self-evident that solid suspended particles or dissolved matters would be pushed farther down the stream, because of the inflow of such river, and further, the effect of dilution might possibly tend to increase the longevity of the pathogenic germs, but the exact degree of such prolongation could only be determined by a matter of experiments. While it is true that the increase of the flow of the river increased the speed of the current and

diluted the water, tending on the one hand to push the sewage
from La Salle, Morris, Marseilles, Ottawa and Joliet
6834 samewhat further down the river, and also to dilute the
same, yet from all data which I have been able to gather in this case from the experiments made, I am of the opinion that the river at Averyville, above Peoria, has undergone a practical bacterial purification. It would be impossible to to say that no germs from any of these points have never or would never find their way into the river at a point above Averyville, but the data at hand upon the purification of the stream make it, in my opinion, quite certain that there are very few pathogenic germs from any point in the river at that point.

6835 Assuming that typhoid fever germs in a virulent condition came from the sewers of the cities mentioned and found their way in such virulent condition to the lake at a point immediately above Peoria in 1892, it is my opinion that the conditions which have obtained since the opening of the canal have been such that it would not make it less liable for them to reach that point than they did in 1892.

Assuming that in 1892 typhoid germs from the sewers at these points mentioned found their way into and were present in the waters above Peoria, the addition of the larger volume of water increasing the speed of the river and dilution of the same would tend to make them more liable to be found from the same points in the stream.

Assuming that disease producing germs were in the Illinois river above Peoria before the canal was opened, of which we have no positive evidnece, it would be true, in my judgment, that the opening of the drainage canal, increasing the speed of the river and the dilution of the same, would render it more liable for them to be there.

6837 The effect of establishing a current in the Illinois river on pathogenic bacteria, assuming that there were pathogenic bacteria in the water, must manifestly be to push such bacteria somewhat farther down the stream.

It would increase their longevity only so far as they might have been pushed further in the short distance which they might have advanced, owing to the increased speed of the current further, in my judgment it would not affect the virulence of the germ.

In the increase in the speed of the current of a river or stream, the speed of the current alone being brought into consideration, the rate of sedimentation would be diminished. On the other hand if the speed of this current be due to an increased volume of water admitted from Lake Michigan, after the opening of the drainage canal, there would be decided compensation in the loss from sedimentation from the rate of the stream owing to the added area of the waters spreading out over the bottoms by the low shelving banks in the course of the stream so that in my judgment there would not be any very great difference between the total sedimentation in the stream before and after the opening of the drainage canal.

In the bed of stream the increase of the flow of the current would tend to diminish the rate of sedimentation.

6838 If there were pathogenic bacteria in the Illinois river above Peoria, when I examined same in 1892, it would be my opinion from the conditions noted, in the light of knowledge obtained regarding the action of saprophytic bacteria since that time, that the tendency would be to destroy the typhoid and pathogenic bacteria rapidly at that time, as they would have been subjected to the germicidal effects of the water.

6839 From my knowledge of the river and from data and all knowledge which I have been able to gather from the Illinois river and its characteristics it is my opinion that the agencies tending to destroy bacteria were ample in 1903, and I believe they were as ample to affect the changes in 1892. The current may have been more sluggish at this particular time, but in my opinion the agencies were as effective now as they were then, removing as I believe they do practically the pathogenic bacteria from the stream now.

6842 The numbers of bacteria in waters are important as showing general conditions in a stream; but it is also true that the character of the bacteria, the species of bacteria and especially whether any of the bacteria present are of so-called sewagic types, is of great importance in fixing the sanitary character of any given water. If the analysis shall
6843 show the presence of the so-called colon forms, especially in water, it becomes a matter of considerable importance to determine from whence they come, and in the study of supplies I have carried that out, particular attention has been given to that phase of the study to determine, if possible, the origin of these colon forms or sewagic forms. I am acquainted with the epidemic that occurred recently in the city of Butler, Penna. I was asked by the management of the Beaver Valley Water Company to advise with them regarding the operation of their plant and I was at Beaver Falls several times rendering services to them. Beaver Falls is 60 or 70 miles from Butler. Knowing the conditions at Butler and knowing
6845 it was tributary to the Beaver river, at a comparatively short distance above, I advised the management of the company to be careful in their operation of the plant during the prevalence of the epidemic and the lack of care and disinfecting of the excreta from the typhoid fever patients, and advised that the plant be operated with very great care during this period, and I understand from letters that they followed that advice.

6846 I knew from data at hand and private advices and general knowledge that this river was being polluted at this time, and therefore, I cautioned them to be careful in the operation of the plant. I cautioned them, as I should every one, to use due precautions at all times and especially when there was any reason to suspect that any trouble might arise from special conditions of the river.

JACOB A. HARMAN, examined in chief by Mr. Todd:

Reside at Peoria and am civil engineer. Have been since 1887. (States educational qualifications.)

6847 For the last five years I have been consulting engineer to the State Board of Health of Illinois. (Gives a general description of the Illinois valled, the territory which is drained by the Illinois river, stating the character of the territory drained and to what interests it is devoted, etc.)

6850 The entire drainage area of the Illinois river is devoted extensively to agriculture and pasturage. Stock raising is one of the chief pursuits of the rural inhabitants of this territory. A very large urban population also exists upon this territory, the principal cities being Peoria, Springfield, Pekin, Bloomington, Decatur, La Salle and Joliet. All of these cities are extensive manufacturing points. I have prepared a table of population on the Illinois river drainage basin as part of my report to the State Board of Health, published in the sanitary investigation of the Illinois river, and its tributaries in 1901, page 119, said table being reproduced on page 6851 of this record.

6852 The classification of urban population and rural population is taken upon the basis of that people living in cities and villages of 1,000 or more are included in the urban population and all others are included in the rural population. This classification has been made for the reason that villages of less than 1000 population seldom have any public water supply or public sewerage system and the villages and cities of more than 1,000 population generally have public water supplies and many of them have public sewerage systems.

I have made an investigation of the rainfall for the 11 years of 1890 to 1900, inclusive, using the weather bureau published reports of rainfall as published by the Weather Bureau of the United States. These rainfall records have been compiled for each of the drainage basins of the Illinois river, as described in my testimony regarding the subdivision of the population of the Illinois river basin. My investigation includes the average rainfall by months and for each year during that period of time.

6853 This in tabular form is published, page 159, of the "Sanitary Investigations of the Illinois River and its Tributaries, 1901," by the Illinois State Board of Health, and is also reproduced on page 6853 of record.

6854 The rainfall data which has gone in evidence is the annual amounts and averages. This rain comes at intervals and frequently raises the rivers to extreme height and especially in the spring when the snow is going off the ground, and the ground is frozen, the decaying vegetable and other organic matter, especially from the pastures, barn yards, etc., is washed off into the smaller streams and then finds its way into the Illinois river producing a pollution of the stream making it muddy and dirty during flood periods.

The discharge measurements were made at Peoria on the Illinois river. The cross-section was taken at the P. & P. U. R. R. bridge, which is the bridge farthest down the stream at the city of Peoria. At that point the railroad embankments are filled to the bridge abutments so that the entire flow of the river must pass between the piers of the bridge. A cross-section of the river was taken at this place and the velocity of the stream was measured by a current meter and from these measurements of the cross-section and the velocity of flow the discharge of the Illinois river was computed. I also have the gauge readings of the Illinois river at that point covering the period 1890 to 1903, inclusive. I have prepared a table of annual discharges at Peoria, covering the years 1890 to 1903, inclusive, which is reproduced on page 6856 of record.

6857 Table showing discharge of Illinois river at Peoria, computed from current meter observations and cross-sections.

6858 Table of discharges for stages of the river from one foot to 22 feet by tenths of a foot. This table is also published in the State Board of Health report, page 176.

6859 Discharge diagram.

6861 Table of discharges of the Illinois river as affected by its tributaries, based on discharge measurements at Peoria.

6863 On March 10th and 11th, 1903, I made an investigation of the sewage system of St. Charles, Missouri. All the sewers of the city drain into the Missouri river. The city is located upon the left bank of the Missouri river above where it empties into the Mississippi river. The distance overland from St. Charles to the business district of St. Louis is about 16 miles. The drainage of the business district and of nearly all the residence district flows direct into the Missouri river. The drainage of the remainder of the residence district is north to the Mississippi river, which is only 6 miles away. The streets run parallel with, and at right angies to, the Missouri river. The business is done on the first two streets, parallel with and near the Missouri river. The population of St. Charles, in 1890 was 6,161, and in 1900 it was 7,982, from the United States census reports. There is a public hospital which can accommodate about 20 patients located four blocks from the river, which has a sewer on Clay street.

6854 The sewage of St. Louis is discharged by means of main sewers into the Mississippi river. The garbage and cleanings of the streets are disposed of by dumping into the Mississippi river by city dump boats, stationed at various places along the river. Protograph on page 1 of "Defendants' Spencer's Exhibit C," correctly represents the manner of the disposal of garbage in St. Louis.

6865 (Letter read in evidence addressed to James P. Kirkwood, chief engineer, from the office of the Board of Water Commissioners of St. Louis, dated December 11, 1865. Said letter reciting the fact that at a meeting of the Water Commissioners of St. Louis, held December 11, 1865, a resolution was passed to the effect that said Kirkwood proceed at once to Europe and there inform himself in regard to the best processes in use for the clarifying of river waters used for the supply of cities.)

6867 CROSS-EXAMINATION, by Mr. Jeffries:

With reference to the depth of a stream, at which the current of the river, with reference to its surface and its bed, is most rapid, it is about from .1 to .2 below the surface, so that if a stream is 10 feet deep, the most rapid place would be from one to two feet below the surface and in the center of the stream.

6869 ROBERT SPURR WESTON, examined in chief by Mr. Todd:

Graduated at Amherst college in 1891, with degree of Bachelor of Science.

6870 I was then employed as a chemist for about three years.

With the American Sugar Refining Company, and also on a plantation in Louisiana. After that I was a student in the Institute of Technology and in the University of Berlin, and besides that I have been a volunteer worker in the laboratories of the Massachusetts and the German Imperial Boards of Health. Since then I have been engaged in sanitary work. In 1895 I was connected with the Louisville water purification experiments and subsequently have been connected with water purification experiments at West Superior, Wisconsin, at Washington, D. C., and other places.

In 1900 I was in direct charge of the water purification station at New Orleans and conducted an investigation lasting eight months as to the feasibiiity of purifying the Mississippi water. I have been in private practice, exclusive of this last period, for six years.

(Witness reads list of the principal cities and their distances from New Orelans lying upon the Mississippi river or its tributaries).

6871 The United States Census for 1900 showed the population in cities of 4,000 or more in the Mississippi valley to be about 9,000,000, including Chicago. I have prepared an estimate of the amount of sewage sewering into the different rivers, which make up the watershed of the Mississippi river.

I have assumed that cities which have a population of 25,000 and over will discharge 175 gallons per capita of sewage per diem. I have assumed that the remainder of the urban population would produce 100 gallons per day per capita of sewage.

6872 I estimated the amount of sewage from large cities, that is, cities above 25,000 population, to be 1,174,250,000 gallons per day. I estimated the amount of sewage from the remainder of the urban population, that is, the remainder of the population of cities from 4,000 to 25,000 to be 342,000,000 gallons per day, making a total of 1,516,250,000 gallons a day. This is equivalent to a flow of 2,310 cubic feet a second at New Orleans.

6873 These dilutions may be expressed in three different ways:

A. Maximum dilution 1 of sewage to 586 of water.
Minimum, 1 of sewage to 83 of water.
Average, 1 of sewage to 296 of water.

B. Expressed as cubic feet per second of sewage per 1,000 urban population:

Maximum, 150. Minimum, 21. Average, 75 cubic feet per second per thousand urban population for the year 1900.

C. As gallons of water per diem per capita of the urban population:

Maximum, 16,160. Minimum, 2,262. Average, 8,190.

In 1900 and 1901 an experiment was conducted for eight months and data was collected for somewhat longer time to determine the best method of purifying the Mississippi river water at New Orleans. The data consisted of analyses, engineering data and reports.

6874 I had charge of the chemical and bacteriological analyses conducted at New Orleans at this time.

These surveys of the waters of the Mississippi took place from the last of November until the following September and analyses were made, as a rule, daily at one point, located at the upper confines of the city of New Orleans and where the experiment station took its water for experimental purposes. The results of the chemical and bacterial analyses for the entire period were published in the report on Water Purification, published in New Orleans in 1903, by the Sewerage and Water Board of New Orleans. I have prepared a table showing the composition of the Mississippi river water at New Orleans, based upon the chemical and bacteriological data for the months between December, 1900 and August, 1901.

Table is reproduced on page 6876.

6878 The analyses show that apart from the nitrogen as nitrates and nitrites, that the water is characteristic of the non-polluted water of this region. An abundance of oxygen is always present in the water, showing that the organic matter has been decomposed to about the limits, the number of bacteria are very low and are chiefly associated with the suspended matter. When the suspended matter is removed the water is of excellent quality.

Colon determinations were made during the flood seasons, that is from December, 1900 to April, 1901.

Bacillus coli was only found on three occasions during the five months of the tests. It was found during the first week of December, 1900. It was not found subsequent to that date. When the bacilli were found in 1900 they were found in a small volume of water, namely 1 cc. They were not found subsequent to the first week in December. The presence of these organisms in the water at this time and not at any other times is explained by the fact that on the bank of the river immediately above the intake of the water purification station a number of house boat men and squatters were quartered. During the low water season these people had thrown their feces on the bank of the river, and during the rise it is easy to account for the presence of bacillus coli in the intake of the water purification station at that time, especially so because the intake was located near the bank of the stream and was suspended from a house boat, but in comparatively shallow water.

6879 100 coli determinations were made during this investigation and the coli was found present only three times. I arrived at the conclusion from the results of these coli determinations that no unpurified sewage was present in the Mississippi river at New Orleans. Assuming the velocity of the stream at four miles an hour, which is neither the maximum nor the minimum, the sewage from Baton Rouge would reach New Orleans in 33 hours after it was discharged into the Mississippi river. The velocity of the Mississippi at New Orleans may be taken at four miles per hour. A fair average of velocity for that river from Cairo to New Orleans is about four miles per hour, certainly no more. I never figured out the discharge of the Mississippi at New Orleans but I have it from the report of the Mississippi River Commission for 1900 on page 18, which is as follows:

Maximum, 1,353,000 cubic feet per second.
Minimum, 191,000 cubic feet per second.
Average, about 685,000 cubic feet per second.

6880 The methods as pursued in my chemical analyses of the waters at New Orleans, and the technique employed in the bacteriological determinations and coli determinations are substantially what are known as the standard methods used by the Massachusetts Board of Health and employed by the different chemists and bacteriologists that have testified in this case. I have prepared a chart based upon the monthly averages of the chemical and bacteriological analyses of the Mississippi river at New Orleans, which chart is reproduced on page 6880.

6881 Mr. Jeffries: Let the record appear that complainant objects to any and all charts, maps, tables or plats being introduced which are based upon the chemical analysis and determinations by this witness in the waters of the Mississippi river at New Orleans, for the reason that they are incompetent and immaterial and have no bearing upon the issues involved in this case.

This chart is made for a clearer demonstration of the main results expressed in the table previously presented in evidence. It gives the numbers of bacteria, the nitrogen as albuminoid ammonia, the nitrogen as nitrites and the amount of suspended matter averaged by months for the same period of time as was covered by the data presented previously in evidence. I also prepared a chart based upon the computations which I have already introduced in evidence, of the relative pollution of the Mississippi river water at various points. This chart is entitled "Relative Pollution of the Mississippi River Water," and is reproduced on page 6882. I also made a graphical presentation of the same which appears on page 6884.

6883 This shows the relative pollution of the Mississippi river water, no allowance being made for self-purification of streams at different points along the course of the stream as follows:

At New Orleans; at the mouth of the Red river; at the mouth of the Yazoo river; at the mouth of the Arkansas river, and at the mouth of the Ohio river.

This chart shows the estimated mean flow in cubic feet per second, the total population of the water shed above the various points and the dilution of the present amount of sewage with water in cubic feet per second per 1,000 persons.

6885 This table shows that the Mississippi river as it flows to the Gulf dilutes the sewage more and more as it proceeds on its way to the Gulf. I also prepared a chart showing the accessions of sewage to the Mississippi river from Cairo, Illinois, to New Orleans, which is reproduced on page 6886.

6887 It shows that the fresh accessions of sewage poured into the stream below the mouth of the Ohio are very small in amount, namely that from the district immediately below the Ohio and above the Arkansas river the dilution is 2,710 cubic feet per second per 1,000 population, below the Arkansas river

4,610 per 1,000 urban population; below the Yazoo, 11,700 per 1,000 population and below the Red river, 59,900 per 1,000 population.

In this table as in the ones that preceded it no allowance has been made for the self-purification of streams.

Also made a chart showing relative dilutions of sewage in cubic feet per second of the Mississippi river at points of pollution as compared with the Connecticut and Merrimac rivers, which chart is reproduced on page 6889.

6889 This diagram was made primarily to contrast the two Massachusetts streams with the Mississippi river. The Massachusetts streams receive so much sewage in the form of fresh accessions below the points of observation that the amount of sewage in the river water as it proceeds down the river within the limits named are always in greater proportion as shown by the observations. While on the other hand as sewage is carried down the Mississippi river below Cairo it is always in increasing dilution, the fresh accessions of sewage never being of sufficient amount to maintain the concentration of sewage which existed at Cairo. The reasons for this status of affairs are that the Mississippi river below Cairo is levied and that the population is relatively small. The banks slopes back from the river for a greater part of the distance, while in the case of the Connecticut and the Merrimac rivers the streams flow through a country which is higher than the level of the water in the stream and constant fresh accessions of sewage are received. The literal population is relatively larger.

From my knowledge of the amount of pollution entering the Mississippi river through its tributaries and the population living upon the watershed, and from the chemical and bacterial and coli determinations, the results of which I have offered in evidence in my testimony.

6890 In my opinion there is not the slightest evidence that any unpurified sewage exists in the water at New Orleans apart from that small amount which may occasionally have been washed from the banks of the stream outside of the levies and in the immediate vicinity of the water purification station intake during the time when the tests mentioned in the question asked me, were made.

CROSS-EXAMINATION, by Mr. Jeffries:

By unpurified sewage, I mean sewage which has not undergone the cycle of changes which would obtain when sewage is mixed with an adequate quantity of water in a running stream, and I mean sewage which has not lost its previous bacteriological character. The main effect of dilution is to furnish an adequate quantity of oxygen for the oxidation of the organic matter contained in the sewage. This can also be obtained by aerating sewage by passing it over dams, but of course not to the same degree. Even though the city of Baton Rouge is situated 132 miles from, and within a 33-hour flow of, the city of New Orleans, any sewage discharged into the river from Baton Rouge has evidently become purified within the time it reaches New Orleans within 33 hours.

6891 The facts are as I have stated them, that there are no bacterial evidences of sewage at New Orleans, in spite of the fact that sewage reaches the river.

6892 I do not think that it is a fact that the element of dilution has more to do with the small quantities of bacteria contained in the waters of the Mississippi at New Orleans than other bacterial and chemical elements known in sanitary science. Because in any other river with which I am acquainted, rivers in which the dilution of sewage in some instances have approximated the dilutions of the sewage at New Orleans by increasing the volume of the samples taken, I have been able in all of these other cases to demonstrate the presence of the bacillus coli communis. At New Orleans I was usually unable to do so. Neither was I able to demonstrate the presence of the bacillus coli communis nor, generally speaking, of any of that gas producing type of bacteria.

6894 To a degree, it is a fact that this table of analyses bears the evidence of a prior sewage pollution of that water.

Q. Is it not a fact that if the chemical and bacterial contents of a volume of water at the point in the Mississippi river where it was examined at New Orleans was concentrated to the same volume of water as existed in the river at Cairo that the chemical constituents which you found in the water at New Orleans would have been greater and larger and more numerous?

A. If the dilution were less the chemical content would be relatively greater to the same degree.

6896 There are slight changes in the bacterial and chemical conditions of the water, on account of flood conditions and water conditions, but not such marked changes as on the tributaries of the stream, and the smaller the volume of water the greater would those changes manifest themselves.

6897 The climatic conditions of the territory traversed by the lower Mississippi is higher in temperature on an average, from one end of the year to the other, than the upper Mississippi and its tributaries. This table shows large quantities of free ammonia and larger quantities of nitrates and nitrites during low temperature than they do during high temperature.

The temperature of the water in the Mississippi river at New Orleans for the month of February, 1901, averaged 46 degrees Fahrenheit and during the month of August, 1901, about 86 degrees Fahrenheit.

6898 A large part of this urban population is contained in small cities of 4,000 and upwards, that are far removed from the main bed of the various tributaries of the Mississippi although situated upon the water shed of those tributaries. It is probably true to some extent that a large number of these small cities are situated so that the sewage discharges, domestic and manufacturing wastes are discharged into swamps and pools and basins. What is true with reference to urban population, I should expect to be more particularly true of the rural population. The large part of the sewage is deposited in such a way that it never finds its way into the streams of the Mississippi watershed in an unpurified condition. Ultimately all drainage reaches the watercourse. As a general opinion, I would say that more than half the sewage from rural sources is purified before it reaches the stream.

6900 If I remember correctly the stream velocity of the lower Mississippi is less than the stream velocity of the upper Mississippi. The stream velocity of the Mississippi river below St. Louis, at a time reaches over five miles an hour. I do not know the average stream velocity of the upper and lower Mississippi rivers. (Tabulation offered in evidence showing the death report from typhoid fever in cities lying tributary to the Missouri river and also tributary to the Illinois river, exclusive of Chicago and also total number of deaths reported from typhoid fever in cities lying tributary to the Mississippi river, and deaths in Chicago and St. Louis respectively, as reported by the respective Boards of Health of said cities. These statistics being for the period beginning with the year 1890 to the year 1902 inclusive.)

6903 PROF. W. P. MASON, examined in chief by Mr. Todd: Am professor of chemistry in the Rennselaer Polytechnic Institute of Troy, N. Y. I have been in that institute, in the chemical department, as professor of chemistry, and previous to that, as assistant professor in chemistry, for over 20 years. I have made a special study of water analysis, especially the examination of potable water for city supply. I have had much experience in the interpretation of chemical analysis of waters. I have made a special study of sanitary problems as related to water supply. I am the author of "Water Supply," published by John Wiley & Son, and "Examination of Water," published by the same firm. As an expert, I have reported upon and testified in legal cases regarding the water supply of the following cities and towns of the United States:

6905 New York; Brooklyn; Philadelphia; Washington; Columbia, S. C.; Greenville, S. C.; Danville, Virginia; Birmingham, Alabama; Meridian, Mississippi; Denver, Colorado; Indianapolis, Indiana; Duluth, Minnesota; West Superior, Wisconsin; Buffalo, New York; Elmira, New York; Albany, New York; Troy, New York; Cohoes, New York; Newark, New Jersey; Newburg, New York; Waterville, Maine; Waterford, New York; Providence, Rhode Island; Bath, Maine; Rennsslaer, New York; Erie, Pennsylvania; Hot Springs, Arkansas; Atlantic City, New Jersey; South Hampton, New York; Burlington, Kansas, and sundry others that I can not remember.

Q. Who were the parties in the suits to which you refer?

A. Sometimes these suits were pending between the city and the water company. Sometimes they were between rival filter companies. Sometimes they were investigations in which there were no suits, the city merely wishing to secure the best possible supply and asking advice thereupon.

Sometimes I was employed by the city as against the water company; sometimes by the water company as against the city.

I have examined the water supplies of Paris, Hamburg, Copenhagen, London, Liverpool, Hague, Stuttgart, Lubeck, Amsterdam and sundry others.

6906 I am familiar with the literature with reference to all the foreign and American typhoid fever epidemics. In the instances of water examinations to which I have already testified, some questions involving typhoid fever arose therein, as for instance, Bath, Maine; Cohoes, New York; Albany, New York; Buffalo, New York; Waterville, Maine and possibly one or two others. I do not remember which ones now. I made more or less of a study of Asiatic cholera in Sicily and Italy, more particularly at Messina.

6907 I have examined and studied the bacterial and chemical analyses of the waters of Lake Michigan, the drainage canal, the Des Plaines river, the Illinois river, the Mississippi river, and the Missouri river as made by Professors Jordan, Palmer, Gehrmann and Burrill, the same being published in what is known as reports of Streams Examinations, published by the Sanitary District of Chicago. I am acquainted with the Chicago river, the drainage canal, the Des Plaines river, the Illinois river, and the Mississippi river from Grafton to St. Louis. I went on a boat from the water front to Lockport, down the drainage canal, by daylight. I afterwards followed the course of the river in trolley and on train as far as La Salle and then took a steamer and went from La Salle in daylight to St. Louis, tying up at night so that no places were passed in the dark. On arrival at St. Louis, I visited the settling basins and saw them being cleaned. I have made a special study of bacteriology as applied to water investigations.

6908 I have read of the experiments made with the bacillus prodigiosus by Dr. Ravold. (Question asked assuming all the conditions as testified to by Dr. Ravold in relation to said experiment.) Assuming all of the facts stated to be
6909 true, my opinion is that in view of the large number of the bacillus prodigiosus introduced and the small number found the results of that experiment show a very considerable death rate of the bacillus prodigiosus and by inference at least as large a death rate of the bacillus of typhoid fever under the same circumstances. In my opinion, it seems that the importance attached to this experiment is to show that to the extent that a bacillus prodigiosus represents a bacillus of typhoid fever, a very large death rate has been proven as occurring

among the bacilli of typhoid fever under those circumstances.

6910 The bacillus of typhoid fever may remain alive in soil for a period of at least weeks and possibly months.

The question of the longevity of typhoid fever in water may be best stated by saying that it dies out in water more or less quickly en masse, although some individual cells, being more resistant may remain alive for a longer period. I should say that it would be right to limit it to a very much shorter period of time, that is it should be measured by days in water.

In the case of a relatively pure water the longevity of typhoid bacillus is greater than in one where it has to fight for existence with saprophytic bacteria.

It does not increase in nature outside of the human body although it may live saprophytically for a greater or longer period of time according to its surroundings. It will multiply rapidly in milk, most milk epidemics having been caused by such multiplication.

6911 Stamford, Connecticut, had a milk epidemic. There are a good many milk epidemics from British sources that have been reported by Harte. The laboratory conditions are more favorable for the longevity of the typhoid bacillus. In experiments made by the Massachusetts Board of Health in a large tank, 12 feet deep, suspended in Merrimac river water, the longevity of the colon bacillus was limited to 11 days. The germ of typhoid fever will not live as long in polluted water as in pure, sterilized water.

6912 I believe that the typhoid bacillus would live in the water of the drainage canal, Des Plaines river and Illinois river for a less period of time than in sterilized water, or water of greater purity, from a bacteriological standpoint and that it would be limited in length of life to a question of days. I base my opinion upon the fact that where the experiment has been upon a large scale, as in the instance in the Massachusetts report, quoted, we get a shorter period of time during which the bacillus will remain alive. In other words as we approach the conditions of nature the opportunities for its destruction seem to be greater than in the conditions obtaining in the laboratory experiment.

6913 The dams in the Illinois river increase the opportunity for sedimentation, although I do not believe they will increase it to an extent that amounts to very much, acting more as riffle boards than dams, they being submerged. I do not think the influence of those dams by sedimentation is very great, although I think it to be something.

The Illinois river when the water is high overflows its banks and the water settles back to the right and left to a very considerable extent. I noticed that as I went down the river, on a boat, that the trees were standing out in the water, trees apparently growing in one or two feet of water, and such overflow represented a considerable acreage.

The effect of such overflow upon sedimentation will be to spread out the water over a large area thereby giving that particular part of silt the opportunity of reaching the ground after falling a comparatively short distance. Sedimentation is very marked where the water holding the material to be sedimented is spread out in narrow sheets.

6914 In a clear stream gravity alone would operate upon the bacteria and they would settle therefore slowly. In a turbid stream bacteria will settle more quickly. Sufficient water from Lake Michigan, assuming the maximum amount is 800,000 cubic feet per minute, could not be carried through the drainage canal into the Des Plaines and Illinois river so as to create a condition of purity and clearness that would preclude the operation of sedimentation. There is enough turbidity present in the system of the Illinois river to prevent any such condition obtaining.

6915 Assuming that the entire sewage of Chicago should be diverted into the drainage canal and that 800,000 cubic feet of water per minute from Lake Michigan should pass over the Bear Trap dam, the turbidity yet remaining in the Illinois river would be sufficient to permit of sedimentation of bacteria. Dilution diminishes the chances of a person drinking the water of contracting disease from pathogenic germs. The greater the dilution of sewage the less the danger from infection.

6916 The addition of Lake Michigan water to the sewage of Chicago is a benefit to the sanitary condition of the Illinois river considered from the standpoint of dilution alone.

The addition of Lake Michigan water to the sewage of Chicago is a benefit to the sanitary condition of the Illinois river considered from the standpoint of chemical and bacterial changes taking place therein.

If a sufficient volume of Lake Michigan water should be added so as to cause the Illinois river to overflow its banks in the manner I saw it, under those circumstances there would be a greater opportunity for sedimentation because of such overflow, as per the illustration that I have already given.

The physical condition of the Illinois river, inasmuch as the river is one which readily overflows its banks, permit of a better opportunity for sedimentation than would obtain in a river like the Hudson where no such overflow of the banks is possible, the banks being very much higher.

My opinion is that the waters of the Illinois do not have any appreciable effect, good or bad, upon the waters of the Mississippi river into which it flows.

6917 The Illinois river has no appreciable sanitary effect on the Mississippi although it is possible it may slightly improve the mixture, inasmuch as if there is any difference between the Illinois at Grafton, and the Mississippi river at Grafton and the Missouri river above the junction, that difference is in favor of the Illinois river at Grafton. At the same time I do not think there is very much choice. The colon bacillus is of longer life in soil than it is in water. I believe a typhoid bacillus passing from the sewers of Chicago would die before Grafton was reached. It is possible that some resistant germs might make the journey, but the great mass of bacilli of typhoid fever would perish before the Mississippi was reached. There is such a thing as purification of soil, although it is a slow process. (Witness refers to an article by Savage, in the Journal of the Sanitary Institute, as an illustration.) I attribute the death of the typhoid bacilli in polluted water to the adverse conditions set up by the saprophytic bacilli which are present there in large numbers. My opinion is that there would be no material difference between the length of time in which a typhoid bacillus would live in a polluted stream as compared with the sediment of that stream.

6919 The difference between moist soil and the sediment of a running stream is that in one case you have only moisture present and in the other you have water present in quantity. I do not think that the time a typhoid bacillus will live in moist soil furnishes any criterion for its longevity in a running stream. (Witness again refers to the Massachusetts Board of Health tank experiments.) I know of no demonstration that shows that typhoid fever germs can and do
6920 and have continued to live in the sediment of running streams for a period upwards of two years as testified to by Mr. Fuller.

6921 My opinion is that typhoid fever bacilli coming from the sewers of Chicago would not be a danger and a menace to the inhabitants of St. Louis using the water of the Mississippi for drinking and domestic purposes.

It is my opinion that merely because the capacity of a reservoir is a thirty-day supply, it is not therefore to be assumed that water remains in that reservoir for thirty days. Much depends upon the construction of the reservoir. Many reservoirs are of stand pipe type, receiving their water and discharging it through the same orifice. Under such circumstances the pumps deliver to the mains and the reservoir merely takes the surplus of the pumpage. During periods of low pumpage the reservoir receives less, hence in reservoirs of that character it is impossible to say how long any particular volume of water may remain therein.

6922 I have examined the typhoid statistics of the Illinois, Missouri and Mississippi watersheds above St. Louis, the same being the table of typhoid statistics which was introduced in evidence in this case just ahead of my testimony. I notice in the tabulated form of tables reported that for the years 1899, 1900, 1901, 1902 and 1903, the St. Louis deaths are reported as uniformly increasing, being 130, 168, 198, 222 and 288. I notice that Chicago is quite variable.

6923 I notice that the reported typhoid for 1900 upon the three watersheds, exclusive of Chicago, is 503, which is larger than the preceding year. This is in accord with the reported deaths in St. Louis for that year, the same being larger than the preceding year. It is not in accord with the deaths reported in Chicago, the same being smaller than the preceding year, so that for that one year it would seem that the deaths in St. Louis were not in accord with the watersheds of the three rivers, exclusive of Chicago, that they were with the death rate in Chicago itself, although for the next two years I do not notice that there is the same array of facts, my remarks applying only to 1900.

In the matter of the interpretation of mortality statistics, I employ the method of stating typhoid deaths as so many per 100,000 inhabitants..

In my belief that is the more correct method to employ, and it is a very generally employed method. I have at times seen another method employed, and I do not believe that it is a feasible one, namely, the percentage of typhoid deaths to total deaths. The reason I do not approve of that method is because, to illustrate, Chicago might have this month much more typhoid than last month, but the total death rate because of some disaster like the Iroquois Theater fire would run up the total deaths so that the typhoid death would apparently improve, whereas really it was worse.

It sems to me that a nearer approach to the truth is obtainable by stating the typhoid rate as so much per one hundred thousand inhabitants.

6925 The percentage method is not the commoner one in use, although it is used, the more common method of stating it, being the determination of number of deaths from typhoid per 100,000 people. The reporting of non-fatal typhoid cases is more general now than it was formerly.

6926 Chart entitled, "Deaths from Typhoid fever in 1900, 1901, 1902 and 1903, as reported in Chicago and St. Louis official Health Reports."

6928 The deaths in St. Louis are stated one month in advance of those for Chicago, because of the length of time it would take a typhoid fever germ—should it go so far as St. Louis—to get there, because of the length of time that it would take to produce typhoid fever of fatal character after an invasion of the victim had taken place. In examining this chart and observing the fluctuations of the solid line representing deaths in Chicago and of the dotted line representing deaths in St. Louis, I observe that the two lines are by no means parallel.

6931 From an examination of the charts just presented I am of the opinion that no relation whatever exists between the typhoid fever as represented in Chicago and as represented in the city of St. Louis. In other words, I am strongly
6932 convinced that typhoid in St. Louis is not produced by typhoid fever in Chicago.

It will be seen from an examination of those charts that the curves of typhoid fever are far from being parallel for the two cities. In many instances the rise of the curve from Chicago is coincident with the falling of the curve for St. Louis, particularly so for the month of August, 1902, when the typhoid in Chicago grows from 44 to 193 and the typhoid in St. Louis drops from 26 to 21.

Have prepared a chart of coli determinations based upon Prof. Jordan's tables of coli determinations made for the year 1901. Chart is reproduced on page 6933.

6934 Inasmuch as bacillus coli communis is a constant inhabitant of the human intestine it is a valuable indication of the presence in the water of discharges although it bears no evidence as to whether those discharges came from a healthy or diseased person.

6935 From an examination of this chart I observe that the bacillus coli communis is more frequently found in the waters of the Mississippi river at Grafton, the Illinois at Averyville, the Missouri at Bellefontaine and the Mississippi at the St. Louis intake and the Illinois at Pekin than it is in the Illinois at Grafton, operating upon 1 c.c. of water. Operating upon the same quantity of water I observe that the Mississippi river at the Chain of Rocks contains the bacillus coli communis most frequently upon the Missouri shore, next in frequency at the intake tower, next in frequency in mid-stream and least in frequency on the Illinois shore.

Judging from the bacillus coli communis contents of the several waters, operating upon 1 c.c. as stated, the relative purity of the waters in question would stand, first in purity, Illinois river at Grafton; (2) Mississippi river at Grafton; (3) Illinois river at Averyville; (4) Missouri river at Bellefontaine; (5) Mississippi river water at the St. Louis intake and (6) the Illinois river at Pekin.

Basing upon the same data from the several waters taken at the Chain of Rocks, the relative degrees of purity would stand most pure water from the Illinois shore, next in purity from the mid-stream, next in purity from the intake tower and least in purity from the Missouri shore.

Basing my reply on the bacilli coli communis contents, the Illinois river at Grafton is the most pure. The Mississippi river at Grafton is next and the Missouri river at Bellefontaine is the least pure. The source of pollution from a rural popula-

tion would come from such sewers as it possessed, together with what surface washing might result from its barn yards and from any other source of pollution which there was a surface origin. (Witness states towns in which typhoid fever epidemics occurred, in which infection came from rural population.) I have made an analysis of 205 British epidemics reported by Harte in a report entitled, "Water Born Typhoid made to the Parliamentary Committee of the British Medical Association." In 33 epidemics due to stream and reservoir water I found that the death rate was 9.85 per cent of the cases. In 75 epidemics due to well water I found that the death rate was 11.83 per cent of the cases and I found that in twenty epidemics due to milk the death rate was 12.79 of the cases, showing that a
6937 well water epidemic was distinctly more serious in character than an epidemic caused by water which had carried the typhoid germ some distance from the point of infection to the point where the water was used for purposes of drinking.

I made an examination of 357 cases of typhoid fever in a typhoid fever epidemic which I examined in Waterville and I was able there to follow the course more clearly of each case and to get the physician's statement whether the case was a severe one or a mild one. Some of these cases used the city water supply, which was from a contaminated stream. Some of the cases used well water supply and those wells were contaminated. Some of those cases used both sources of water. I found that among the cases that used city water only 41.41 per cent were severe, it not being stated whether they were fatal or not, I rated a fatal case as a severe one naturally.

Among those cases not using city water I found that 61.29 per cent were severe, thus showing that the typhoid fever produced by city water was a milder type, and my explanation of that is that the typhoid germ having to struggle for existence in a river under adverse circumstances, when it arrives at the point where the water is drunk it is not capable of producing so much poisonous material, or in other words not capable of producing so severe a case of fever if it produced one at all.

Mr. Whipple in his testimony in this case, stated that immediate pollution is very much more dangerous than remote pollution, a view which is entirely in accord with my views. Assuming that on April 1, 1895, the total number of wells in St. Louis was 4,846 and that the city chemist after an examination of 59 of those wells, condemned them as being unsanitary and assuming, further, that in August, 1895, upon the report of the city chemist condemning seven more of these wells, the Board of Health of St. Louis passed a resolution to the effect that the city chemist should make no further examination of the wells in question and since 1895 none of these wells has been condemned, I believe that the water of those wells was responsible for a portion of the typhoid fever in St. Louis, because I am a believer in greater danger coming from a polluted well water than from the water of a polluted stream.

6938 My reasons are based upon data such as that which I gave in answer to a previous question, showing that the death rate of well water epidemics was greater than that of stream epidemics, and showing that the intensity of fever from well water epidemics was greater than from stream epidemics. My opinion is that given points nearer and remote from the St. Louis intake, said points being located upon a water course flowing thereto, and said points all possessing typhoid in their sewer discharges, I would attribute the danger of typhoid fever in St. Louis greater from the nearer points than from those more remote. I do not think a typhoid bacillus lying in the sediment of a polluted stream for a period in excess of sixty days would be able to cause typhoid fever when taken into the human system after it had remained in such sediment for that length of time. I do not think that typhoid germs coming from Chicago through the drainage canal and deposited on the bottom of the Des Plaines and Illinois rivers, between Chicago and Peoria, would be able to retain their dangerous qualities after such a discharge in the bottom of the river. I do not think the sewage from Chicago passing through the drainage canal into the Illinois river at different seasons of the year and at different stages of water in the Illinois river would be a danger and menace to the inhabitants of Missouri and the citizens of St. Louis using the water of the Mississippi. From the data introduced in evidence in this case, my opinion is that of the three rivers—the Illinois, Mississippi and Missouri, the Illinois represents the least impurity, although I do not consider that there is any considerable difference between the three, what little difference there is being in favor of the Illinois.

6940 The emptying of the Illinois river into the Mississippi river makes no material change in the character of the combined waters. What little change there is, is an improvement, but as I have already stated, the three waters are not widely apart. They are all about the same, any difference being in favor of the Illinois.

6941 I do not think the germs of typhoid fever could live in the sediment of the drainage canal or upon the bottom of the Illinois river for a period of from one to three years and retain their vitality. I do not know of any instance on record where a typhoid bacillus has lived for such a period. My opinion is that the water supply of St. Louis is not contaminated by the sewage of Chicago entering the drainage canal. An increase in the volume of water in the Illinois river floods the lowlands along the Illinois river. I saw it.

6942 It increases the opportunity for sedimentation by overflowing those lowlands, the principle being entirely similar to the one which I illustrated in my morning testimony. Sedimentation would certainly be greater if the volume of water was greater, for the more acreage that is overflowed by such water, the greater number of particles will have a short distance to drop before reaching their final resting place on the soil. All of the dams and lakes in the Illinois river would have an effect in increasing the opportunity for sedimentation and such increased sedimentation would have a beneficial effect in the elimination and purification of polluted and infected waters coming into the Illinois river from Chicago.

6943 Assuming that the dams should be removed at a time when the maximum flow of water passing through the drainage canal was 800,000 cubic feet per minute, the sedimentation of objectionable material would be interfered with, but as I stated this morning, I do not think the beneficial effect of the dams amounts to very much and their removal, although it would diminish the purifying power of the stream through sedimentation, such diminution would not be great. The water of the Mississippi river at the Chain of Rocks prior to January 1, 1900, was not a safe and potable drinking water fit for domestic and drinking purposes after passing through the settling basins. (Same as to the Missouri and Illinois rivers.)

6944 The sanitary condition of the Illinois river at Grafton has been improved by the opening of the canal. The sewage discharged from the drainage canal has no appreciable effect upon the waters of the Mississippi and Missouri rivers at the Chain of Rocks.

6945 If an increased volume of water was discharged in the Illinois river, so far as particles which were in the main channel were concerned, they would doubtless be carried down stream more rapidly; so far as particles which might be contained in the waters which overflowed the lowlands were concerned, they would not go down so rapidly, and there would be a depreciation in the velocity of the current, and there would be an opportunity for sedimentation. An increase in volume of the Illinois river would cause an overflow of the banks and consequently there would be a depreciation in the velocity of the current because of that overflow and that portion of the water which was in the overflow would have low velocity and be given a better opportunity for sedimentation. Some portions of the main channel of the river might or might not have an increased flow in the unit of time, depending very largely upon the amount of water which went over the sides of the river. If the banks were very low as they are in many places, and consequently the river section greatly widened, there would be no material increase in velocity. There might be a decrease. That would have no material influence whatever on the people of the State of Missouri.

6947 I do not believe that there could be any accumulation of germs taking place in the Illinois river gradually said accumulations afterwards being washed out by floods and causing widespread disease in the sections below and I do not so believe because I observe that we do not have epidemics following floods of that kind.

6948 I do not believe that the number of typhoid bacilli at Lake Peoria is ever as great as they are at the Bear Trap dam. As to the Detroit epidemic, I talked the matter over with Prof. Williams, and it seemed to me that there might be some doubt with reference to the connection between typhoid fever in Detroit and the dredging of the Black river.

6949 I have no knowledge of the presence of infected Chicago sewage in the Illinois river at Grafton, and I believe that the use of the water of the Mississippi at the Chain of Rocks, because of the admixture of water from the Illinois river, would not be a menace to the health of the inhabitants of St. Louis. I do not consider that the waters of the Illinois river under the conditions obtaining, commingled with the waters of the Mississippi river, are a menace to the inhabitants of the State of Missouri living upon the Mississippi river and using the Mississippi river water for drinking purposes at points on the Missouri shore. Assuming that the only pollution upon the watershed of the Mississippi and its tributaries above the intake of St. Louis was that derived from the sanitary district of Chicago, and having in mind the large amount of typhoid fever in Chicago, I do not believe that dangerous infection and dangerous pollution might, under existing conditions, find their way into the water supply of St. Louis. Assuming the same conditions,

I do not believe that typhoid germs would be able to find their way into the water through the intake tower at the Chain of Rocks, and become a menace to the inhabitants of the city of St. Louis. I do not know of any analyses or experiments that justify the assumption of Prof. Sedgwick that typhoid germs may find their way into the sewage of Chicago and pass on to the Mississippi river and find their way into the intake at the Chain of Rocks, but on the contrary, I am of the opinion
6951 that the charts which I have offered in evidence show that there is no connection between typhoid fever in the city of St. Louis and the city of Chicago, and were it liable that typhoid germs should pass into the water at the intake I should expect that the curves of typhoid fever in St. Louis and in Chicago would show parallelism whereas they show quite the reverse.

Assuming that there has been an increase in typhoid since the opening of the canal, I would not, beyond reasonable doubt, attribute the principal portion of the increase to the infected sewage of the sanitary district of Chicago. On the contrary, I would attribute any increase in typhoid fever which might have taken place in St. Louis to infection from nearer points, because of what I have already testified to, as my belief that the nearer the point of infection the greater the danger, and because further, that the charts which I have offered in evidence show that there is no relation between the typhoid fever in Chicago and typhoid fever in St. Louis.

6953 In my opinion the addition of the Chicago sewage does not favor the growth of the typhoid bacilli introduced at Peoria. I do not consider that the Illinois river water polluted and infected by the sewage from Chicago, has rendered less safe the water supply of St. Louis. I base my opinion upon the fact that the Illinois river at Grafton furnishes water which is in quality better than it was before the opening of the canal, and better or at least as good as the water of the Mississippi into which it flows. Assuming that the Chicago sewage from 1,500,000 people should be discharged into the drainage canal and assuming that a typhoid epidemic of extraordinary proportions should become prevalent among the residents of the sanitary district, it would have no appreciable effect on the people of St. Louis and those people living on the Missouri side of the Mississippi river below Grafton, who use the water of the Mississippi river for drinking purposes. I do not regard the water of St. Louis as a safe drinking water as it is at present treated with settling basins.

6956 Sedimentation should be supplemented by filtration. In this opinion of mine I entirely concur with what has been stated by Messrs. Hazen and Fuller in a report on the water supply for the city of St. Louis, dated 1902, in which Mr. Hazen says, after describing the method of filtration which he proposes, on page 77, "I believe that the hygienic character of the purified water will be entirely satisfactory."

And on the same page: "I believe that the raw water, although polluted far beyond the point where it should be used in its raw state is very much less polluted than many or most of the river waters used by American cities. Purification will remove a very large percentage of the bacteria and the elements of danger in the raw water. So far as there is danger to health in the present water it will be reduced by filtration to an almost inappreciable amount."

Mr. George W. Fuller, in commenting upon Mr. Hazen's statements in this report says, on page 81 of the same report: "With regard to this method of purification for the St. Louis water supply, it is my judgment that it will yield a water of satisfactory appearance and hygienic quality with proper construction and operation of the works and that it is the best and most applicable method for the conditions existing at and near the Chain of Rocks."

My opinion is that the addition of Chicago sewage via the drainage canal to the system of the Illinois river would not add any additional expenses to the purification of the Mississippi water by filtration at the Chain of Rocks. The installation and operation of the plant would not be greater in point of expenses by the addition of the Chicago sewage as it now is added to the system of the Illinois river.

6957 CROSS-EXAMINATION, by Mr. Jeffries:

6958 (Regarding the bacillus prodigiosus experiment made by Dr. Ravold and comparing the finding of that bacillus to the finding of typhoid bacillus the same number of times, witness states). My opinion would be that a water sampled at the Chain of Rocks 720 times and the typhoid bacillus being found twice, that it would be a water certainly containing typhoid fever, as the facts show, but not to such an extent as to be prejudicial to a city supply, provided the supply were used after filtration.

6959 Assuming that the average longevity of a typhoid germ is somewhere between one and thirty days, there is no question but that there would be a variation in the longevity although a small one, if such germs be deposited in running streams, as the conditions under which it finds itself might vary.

6960 My opinion is that in consideration of the facts regarding the Chicago sewage being dumped into the Illinois river, as at present, and the facts concerning the conditions of the Illinois river, that the germs of typhoid fever coming from Chicago sewers would be destroyed en masse by the time the mouth of the Illinois was reached, although some resistant organisms might go beyond that point, such organisms, however, representing a small number and in my opinion low vitality.

6963 If a gallon of infected typhoid dejecta be deposited in the waters of Lake Michigan at a point free from sewage contamination, the typhoid bacilli would disappear first. The typhoid bacillus would disappear before the lake bacteria would disappear and before the ordinary sewage saprophytes would disappear.

6964 If you have a certain number of bacteria present, in water and then should dilute the same you would diminish the number of bacteria there because they would be further separated. I mean, when I say "diminish the number," that you would diminish the number per gallon.

6965 The conditions as stated in the question, of practically no current and a green scum before the opening of the canal and a decided current and no scum after the opening of the canal, those conditions being as stated, the two waters before and after the opening of the canal being equally infected, by supposition, the conditions obtaining before the opening of the canal would be more favorable to the destruction of typhoid bacilli than those obtaining after.

My opinion is that those conditions would, from a practical standpoint, increase the longevity of the typhoid germ, but I do not believe, and it is my opinion in fact, that such increase would be not material from a practical standpoint.

6966 The removal of the dams and the leveeing of the Illinois river from one end to the other would interfere with sedimentation and its resulting purification by sedimenting bacteria of the pathogenic type, and would increase the velocity of the stream.

6967 Q. Professor, in the tables introduced in evidence by Professor Jordan covering the bacterial count examination of the waters in the Illinois river at Grafton, from October 1, 1901, to December 24, 1901, and on the Mississippi at Grafton from October 21, to December 24, 1901, the maximum bacterial count in the Illinois river at Grafton was 123,000, the minimum 210, the average bacterial count for the period in the Illinois river at Grafton 6,900; in the Mississippi river during the same period the maximum bacterial count was 3,700; the minimum 360, the average 1,300. Taking into consideration your knowledge of the population upon the watersheds of the respective rivers, which would you consider from this bacterial exhibit the better for sanitary purposes?

A. So far as the total count is concerned it shows the Illinois at Grafton to be inferior to the Mississippi at Grafton. Where those bacteria came from is of course important. Is it true that they represent ordinary soil bacteria washed into the Illinois river because of special conditions in the way of local rainfall, or don't they? I don't know. Right on the fact of it, judging merely from the count as it stands, the Illinois is inferior to the Mississippi at those points.

6968 It is a fact that chlorine has been reduced all along the line by the opening of the canal, but it is also a fact that albuminoid and free ammonia have been reduced as well. Nitrates towards the end of the canal have been increased. I have made no estimate which would enable me to say whether or not the chlorine has been reduced in the same proportion that the other items have been reduced, such as ammonia, free and albuminoid. All that I can tell you is that they have been reduced but their relative rates of reduction I can not tell you. I do not think the results of examinations made from May to December should be compared with the results of examinations made from May to June.

6969 I do not feel that it is wise to compare waters of the same stream at such widely different periods of the year because in one instance you get the benefit of the spring changes, and in the other case you get whatever influences may come from the changes of the summer and autumn.

6970 In the charts on typhoid deaths in St. Louis and Chicago I placed St. Louis one month in advance of Chicago because the deaths of Chicago, due to typhoid fever in one month, if they be related to deaths from typhoid fever in St. Louis, such relation will show in the death rate of St. Louis for the following month. Therefore, I moved the death rate of St. Louis one point to the left merely for the sake of easy comparison. I might have left them where they naturally would fall. Under those circumstances, however, a man in examining the charts would have some little trouble in following the oblique lines, and direct comparison would not be so easy.

6971 Referring to the chart which I introduced in evidence showing the comparative results of the colon tests as made by Prof. Jordan for 1901, it is true that on that chart, taking the 1 cc. determination, the water in the Illinois river at Grafton shows a greater pollution than the water in the Mississippi river at St. Louis, the Missouri river at Bellefontaine and the Mississippi river at Grafton. It is also true that some of these percentages are the result of a less number of determinations than others.

6973 Assuming nothing unusual in the death rate, there would be no particular difference between the method called the percentage of mortality system and the numbers per 100,000, in determining the typhoid and other death rates in cities, but it would be possible to have very misleading results. For that reason I do not use the mortality percentage. (Witness is asked hypothetical question as to the application of these two methods to the conditions stated therein, and in reply, states:)

6974 Basing my reply on the numerical data submitted in the question, it is my opinion that there is no material difference between the two methods of stating the result. Scientists have thus far been able to determine the longevity of pathogenic germs only within roughly accurate limits.

6975 RUDOLPH HERING, Examined in chief by Mr. Todd. I am a hydraulic and sanitary engineer and reside in New York. The firm is Rudolph Hering & George W. Fuller, who testified in this case. (Witness states educational qualifications.) I am not a chemist or bacteriologist. I en-

6978 deavor to keep posted on the progress made in both sciences so far as they relate to the sanitary condition of the water, and then I take the results obtained by those men in whom I have every confidence and whose ability is unquestioned.

My attention was first called to the sanitary problems of Chicago in March, 1886, when I received a telegram from the Mayor of Chicago to make him a visit and spend a day, so that he could talk with me. I came to Chicago and was engaged as Chief Engineer of the Drainage and Water Supply Commission. As Chief Engineer to look into the sanitary prob-
6979 lems of Chicago, I made whatever investigations I thought were necessary to answer the resolutions passed by the Mayor and the City Council of the city with reference to obtaining "pure water and scientific drainage." In January, 1887, I made a preliminary report, giving the general conclusions which had been reached up to that time. (Witness reads that part of the preliminary report prepared by him, which applies to the sanitary problems of Chicago, which he has under consideration, this report being dated January, 1887.) This report contains the description of the conditions existing in Chicago at the time of examination and the discussion of three methods of disposing of Chicago's sewage, one of which is by means of the drainage canal. The report concludes by recommending the drainage canal project and is signed by Rudolph Hering, Chief Engineer, Benezette Williams and S. G. Artingstall, as consulting engineers.

6991 Subsequent to the preliminary report, the legislature of the State in 1889 passed a law for the construction of the sanitary district of Illinois. In arriving at the conclusion that the drainage canal was the proper solution of the sanitary problem in Chicago, I studied all the facts to be found in Europe and America. There had been a number of cases of sewage discharged into water courses carefully observed in Europe and in the East as well as at Chicago. This information was carefully collected, weighed and laid the foundation for the recommendation which fixed the size of the proposed channel.

6992 Among other things I found that Dr. John Rauch, Secretary of the State Board of Health of Illinois, who had been making very careful investigations of the gradual change in the water of the Illinois and Michigan canal, after the water had entered the Illinois river, had fixed a unit of measure which, from a sanitary point of view, he considered sufficient to obviate any subsequent injury to the State of Illinois on below. This measure was a flow of water equal to 180 cubic feet per minute for every thousand persons draining in the river at Chicago.

Examinations which I made with reference to the Blackstone river in Massachusets, which is quite foul at its upper end, and receives much additional sewage on its way, resulted in my conclusion that after a flow of about 140 cubic feet per thousand persons was observed in the river, the character of the water had become entirely inoffensive.

Similar investigations were made from the results obtained in the river Seine, receiving the sewage of Paris, France. The sewage there does not include fecal matter, because this is otherwise removed. It was found on the Seine that where the dilution was 60 cubic feet per thousand people, and after a flow of 14 miles, the river was considered unobjectionable to sight or smell.

Also some German rivers were considered, the Elbe and the Ober, and similar data were secured.

The result from these and still other investigations made me conclude that for the Chicago sewage canal there should be a recommendation that the size is sufficient to carry water at the rate of 240 cubic feet per second for each thousand persons, as stated in the preliminary report.

6993 A disposal of the sewage by dilution is still very common and it must remain so for a long time. Over in Europe we find cities situated on the large rivers discharging their sewage into them with entire impunity. The city of Hamburg discharges its sewage into the Elbe, which is a tidal
6994 stream at this point. The adjoining city of Altona does the same and both cities take their water supply from this stream, receiving the sewage of over 1,000,000 of people but both cities carefully filter it. (Witness reads in evidence

table compiled from information secured by the Massachusetts State Board of Health in investigation made, as shown by report for 1890.) This table is based on a flow of water in cubic feet per second per 1,000 persons and chemical constituents of sewage in parts per 100,000. Table is reproduced on page 6995.

6996 Two lines have been drawn across this table. Above the upper one conditions are indicated where the dilution is practically in all cases offensive. Below the lower one the dilution has never been found to give offense. These two lines are indicated by a dilution of sewage from 2 1-2 cubic feet per second per thousand persons to 7 cubic feet per thousand persons.

It is the duty of the engineer to select between these limits that dilution which conforms to the local conditions of the problem.

In considering this question of dilution for the drainage canal, I adopted the standard of 4 cubic feet per second per thousand persons because in the state of knowledge at that time I did not feel justified in recommending a less dilution. Subsequently, I understand, the number was reduced to 3 1-3 cubic feet per thousand persons, and on that basis the canal was constructed. The dimensions were not altered but it was considered that a larger population than one which I had figured on would be served by this canal by assuming a less dilution.

I believe that the dilution which it is intended to give the water at all times is sufficient to prevent offensiveness and in view of what I have said above also improve conditions below.

I have prepared a table of dilution based on population and flow for 1900, 1901 and 1902 for the drainage canal, which is reproduced on page 6997.

6998 The table indicates that the mean discharge during each of the three years was above the line which limits the offensive dilution, therefore, indicating that there should be no offense.

7000 In considering the several possible ways of disposing of the sewage of Chicago from present knowledge and experience my recommendation today would be that the sewage of Chicago should be disposed of by dilution through a channel substantially like that which has been constructed with a subsequent discharge into the Des Plaines and Illinois rivers.

7001 Chart showing the comparative pollutions of the Illinois, Mississippi and Missouri rivers and profiles of said rivers.

7003 The conclusions of the chart as indicated by the ordinate at St. Louis is that the relative proportion of typhoid bacilli arriving at St. Louis from the populations situated on the Illinois, the Missouri and the Mississippi rivers, between the limits of Chicago, Omaha and Minneapolis, are about as 13 to 96 to 107, respectively. These figures are merely the proportions. They indicate the relative frequency of the still virulent typhoid bacilli at St. Louis, arriving there from various cities on these three rivers, based on the population of the cities and also based on the examinations made by Hiram F. Mills as to the longevity of the typhoid bacilli.

I consider that the Mississippi river in its raw condition was not a fit supply for drinking water for any modern community prior to January, 1900. The same as to the Illinois river at Grafton and the Missouri river at its mouth. The Missouri river today is not a safe drinking water in its raw state. Same as to the Mississippi river above Grafton and the Illinois river at Grafton. According to the present views on water supplies held by engineers and sanitarians, the water of the Mississippi at the Chain of Rocks in its raw state or as treated in the settling basins at St. Louis is not a safe drinking water. That water should be artificially purified by filtration. I have read the report made by a commission of hydraulic engineers upon the water supply of St. Louis, to the Mayor of the city, in 1902. This commission consisted of Mr. Benezette Williams, Geo. Y. Wisner and Allen Hazen. My associate, Mr. Geo. W. Fuller, was asked to consider some features, and he made a report which is added to the report of the commission. I have read the report of Mr. Fuller that is published in the document to which I refer in regard to the question of filtering the water of St. Louis, as advocated by Mr. Hazen in that report. My personal views are that this water, in order to be supplied to the city of St. Louis for domestic consumption should be purified by mechanical or rapid filtration as the best, most rational and least expensive method of purifying this particular water. In my opinion it would make no practical difference in the construction method or cost, nor in the method and cost of operation, to filter the water of the Mississippi river, at the Chain of Rocks, which consists of the combined waters of the Illinois, Mississippi and Missouri rivers, with the sewage of Chicago emptying into the drainage canal, than it would if such sewage was eliminated from the sanitary drainage canal.

7007 The data which I have introduced in evidence would indicate to me that first and foremost a filtration of the water was necessary, due to the probability that typhoid bacilli would reach St. Louis to a large extent from the Mississippi and Missouri and to a less extent from the Illinois river. I should give no consideration at all to the sewage coming from Chicago because it is a small factor in the problem. It is too small a factor in the problem to materially affect any recommendation. The operation of such a filter plant would not require a higher degree of skill or more expensive men, with the sewage of Chicago emptying into the Illinois river than it would if such sewage was not present. (Witness temporarily withdrawn.)

7008 ALBERT S. CRANE, Examined in chief by Mr. Todd.

Am civil engineer. Graduated from Cornell and spent the summer of 1891 with Mr. Hering in Europe, visiting sewage purification and water filtration works principally. (States educational qualifications.) I have been principal assistant engineer of the sanitary district of Chicago since March, 1900.

7009 I prepared the chart introduced in evidence by Mr. Hering representing the self purification of the waters of the Missouri, Mississippi and Illinois rivers between the cities indicated, based upon the longevity of the typhoid bacillus, etc. (Witness states in detail the sources from which he secured the information on which this chart is based and the facts relating to the method of constructing the chart.)

7011 Chart showing approximate discharge curves based on discharge measurements made by the Mississippi River Commission from 1838 to 1898. This chart is reproduced on page 7011 and shows that the Illinois river has the effect of a city of 13,000 situated immediately above St. Louis, the Missouri river of a city of 96,000 and the Mississippi river of a city of 107,000, or a relationship of 13 to 96 and 107.

CROSS-EXAMINATION, By Mr. Jeffries.

(Witness gives list of cities on the various rivers which he took into consideration in making such chart and where he obtained the velocity of the waters and flow, etc.)

7016 Assuming that the time flow from the mouth of the south fork of the Chicago river to the city of St. Louis was 10 days, the Illinois river would have the effect of a town of about 160,000 population.

7018 RE-DIRECT EXAMINATION, By Mr. Todd.

If at maximum flood time, the distance in time from Kansas City was 3 days instead of 6.8 as shown by this chart, the effect would be similar to that of a city of 230,000 directly above St. Louis.

7020 RUDOLUH HERING, Resumed the stand for cross-examination by Mr. Jeffries.

When I made my report in 1887 I reported upon nothing except methods with respect to the disposal of the sewage of

Chicago and the ultimate protection of the water supply of Chicago.

7022 As a sanitary engineer, it was necessary for me to take into consideration the fact that the discharge of sewage of Chicago into the Chicago river and thence into Lake Michigan, was a menace and danger and a detriment to the water supply and to the public health of the city of Chicago at the time this report was made by me.

7023 In my observations made of conditions existing in Lake Michigan at the time this report was made with reference to the sanitary condition of the water in Lake Michigan at Chicago, I took into consideration the fact that the organic matter contained in the Chicago river and which remained therein for weeks and months between the freshets, contained substances objectionable to the water supply and deleterious to the public health.

7024 There is a current in Lake Michigan along the west shore near the city of Chicago, almost all the time. The crib caretaker, who is located out in the lake, was of the opinion that the currents were about evenly divided during the year north and south, depending upon the direction of the wind. This current was as much as a mile and a half, but of course, generally less. If the current was 2 ft. per second,—the distance from Chicago to Milwaukee being ninety miles—the water in the lake would require seventy hours or three days to flow from Milwaukee to Chicago.

7025 I do not admit this is a possible condition, because I never knew that this current had such a rate and that such a rate would be maintained substantially or constantly for three days.

Q. Assuming that typhoid bacilli are discharged into Lake Michigan from the sewers of Milwaukee, and assuming that there is a current flowing past the city of Milwaukee to the south, with the velocity of 2 ft. per second, which velocity is maintained for a period of three or four days, is it not a fact that such typhoid bacilli would reach a point in Lake Michigan opposite the city of Chicago?

A. With the assumptions you make I can not answer otherwise than that they would, but it is hydrographically impossible for such a current to flow from Milwaukee to Chicago intake, because the water in the lake does not move near the

7026 shores in a parallel direction to those shores. There are cycloidal motions and the water passing the Milwaukee sewage outlet would be so dispersed, even though the winds were favorable to a general southern current, that the particular water from the Milwaukee outfalls would not reach the Chicago intake for, to make a rough guess, weeks and possibly months.

When I had the charts prepared which were introduced in this case by me as a schematic representation of the self-purification of waters, etc., the best information that I was familiar with, regarding the longevity of the typhoid bacillus was that contained in the reports of the Massachusetts State Board of Health.

7027 Since having been engaged on the case I have become acquainted with similar investigations which have recently been made by witnesses in this case, which information is much more exact and practicable and in accordance with actual facts, in my opinion, than the Massachusetts experiments. Had I asked this diagram or this chart to be prepared later I should have used the latter and better information contained in the recent testimony in this case.

As to the longevity of the typhoid bacillus, my opinion is that, particularly with reference to this case, the experiments made by Doctors Russell, Jordan and Zeit would guide my opinion on this question.

7029 Q. Mr. Hering, is there any instance in your whole career as a sanitary engineer, or an instance coming under your observation as to the work of other reputable sanitary engineers or sanitary scientists where the water in a running stream has been recommended as free from the typhoid bacilli of a large and populous city existing on that watershed with a stream velocity of from 10 to 20 days?

A. Without filtration I do not know of any case exactly answering your description.

7031 There are artificial filtration plants in existence which remove 100 per cent of the bacterial contents in the water. I remember seeing those in Europe and I believe also a few weeks ago in Philadelphia.

Q. Assuming, Mr. Hering, that the dejecta from the typhoid patients which ordinarily exists from one end of

7035 the year to the other from a city containing a population of 13,000 people, be deposited in the Mississippi river immediately above the city of St. Louis, that prior to the existence of this discharge a recommendation had been made to construct a filtration plant at the city of St. Louis at the Chain of Rocks, this dejecta being deposited in said stream 38 miles above the Chain of Rocks, if it were possible to do so, would you not change your recommendation and recommend the establishment of the filtration plant above the place or point of discharge of the dejecta from the typhoid patients above stated?

A. Under the conditions you state I would not, and if I can now instance the case to which I had reference a moment ago I will say that two large cities, adjoining each other so that you do not know when you pass from one to the other, and both cities situated on one of the largest rivers of Europe, near its mouth, both discharged all their sewage into this stream, the upper one, which is Hamburg, having a population of one million, or thereabouts, both cities on this tidal stream where the sewage of the lower city, Altona, is likely to reach Hamburg and the sewage of the upper city, Hamburg, is likely to reach Altona. In both cities the water supply is filtered and with excellent results, and under those conditions being well familiar with both cities for many years I would not, if I had an opportunity to do so, recommend any other method of water supply than the river water after it has been filtered.

As a sanitary engineer and taking into consideration what I could learn from others regarding the question of effect, I would state that if a city of 13,000 population were to be situated upon the Mississippi immediately above the city of St. Louis, it would make no dieffrence with me, in my recommendation regarding the filter plant to be constructed for St. Louis. Irrespective of the filter, I would say that presumably the more infection contained in the water, the less wholesome it
7037 would be as a self-evident proposition.

7039 In making the recommendation as to the construction of the canal, the following was taken into consideration:

The discharge into the Illinois river in the first place assured a positive removal of the sewage from Lake Michigan, the only possible source of Chicago's water supply, and the dilution which was recommended was so large that no objectionable results could be seen. The greater economy of this project and the incidental value of the works, as a navigable waterway between the lakes and the Mississippi river, made the project, while safer from a sanitary point of view, also less expensive from a financial point of view, and of greater advantage from a commercial point of view.

7042 The result of this whole transaction is that by the opening of the canal, the city of Chicago has avoided the deposits of organic matter coming from the sewers of Chicago, and manufacturing waste in the city of Chicago, in the Chicago river, and while such matters are not now deposited in the Chicago river, they are carried by the waters of Lake Michigan out of the river into the canal and thence into the Desplaines and the Illinois river.

Q. Is there any validity to the assumption that a city of 13,000 inhabitants exi sts upon the Mississippi river immediately above St. Louis, based upon the chart which you have introduced in evidence?

7043 A. The information which the chart was intended to convey in my opinion, was the relative amount of infection that would be contained in the three rivers upon reaching St. Louis, irrespective of any population residing immediately above St. Louis.

7044 PROFESSOR GEORGE DOCK, Examined in chief by Mr. Todd.

I am a physician and teacher of medicine, and have the chair of Theory and Practice of Medicine in the University of Michigan. Have been connected with the University of Michigan for thirteen years. Graduated at the University of Pennsylvania in 1884.

7044 The next year I spent in a hospital in Philadelphia, St. Mary's Hospital in the worst typhoid fever district of Philadelphia, in Kensington, Philadelphia, where I saw a good deal of typhoid fever and I spent a year at that.

After that I went to Germany, to prosecute my studies in
medicine, internal medicine, especially; I went to Leipsic at
that time, which was very full of typhoid fever. My experience
in Philadelphia, where I expected to settle, had increased my
interest in the disease and I paid a great deal of attention to
typhoid there. That was before they had improved the
7045 water supply and sewage of Leipsic, and there was a
great deal there. I spent part of the year there, then I
went to Berlin and saw a great deal of typhoid fever there. I
studied the bacteriology of it in both those places and spent
altogether two years over there, in the study of pathology and
internal medicine.

I then went back to Philadelphia, where I was assistant to Dr. Osler and Dr. Musser, in the University Hospital. I saw a great many cases of typhoid fever and there I began the study of malaria. Dr. Osler was then the first man in America, studying malaria. He had a great many cases brought in to him from the outside. I spent a great deal of time working on them and became very much interested in the practical diagnosis of malarial disease.

After that I had an offer to go down to Galveston, Texas, to teach medicine and pathology. I went there chiefly on account of my interest in malaria. I went down there and stayed three years. I was a professor of pathology in the Galveston Medical school and physician to the Hospital connected with the medical school and the last two years I was there, practiced. In Galveston I found they were diagnosing practically no typhoid fever at all and yet I saw lots of typhoid fever patients there. I was able to see that cases that were diagnosed as malaria and typho-malaria were typhoid fever, and my experience showed me that none of these cases had malaria. I did, however, see fatal cases of malaria. They were all cases that either came from the Tropics, Nicaraugua, or Panama, or else cases from the interior of Texas, where they occassionally have
7046 very severe forms of malaria. I became very much interested in the practical diagnosis of so-called malarial diseases, continued malaria, and various local names that are given to this disease, and did some work on it, wrote an article and read a good many papers on the subject before medical societies. On one occasion I made an offer to visit any patient having typho-malaria or continued malaria, and examine the blood free, in order to settle whether it was malarial fever or could be diagnosed as typhoid. I never had occasion to have my offer accepted. While in Texas, I studied the characteristics of malarial fever as they obtained in the southwestern part of the country. I saw many cases and examined them all very thoroughly, wrote several papers on the subject that have been widely quoted, and became looked upon as somewhat of an expert in malarial diseases. Then I went to Ann Arbor, and there I had same experience I had in the south. I found that the doctors were diagnosing many cases of typho-malarial fever.

My interest, of course, was still alive. I examined many of the cases postmortem as well as in life, and I was able to show the same thing, cases that were diagnosed as typho-malarial and continued malarial were all cases of typhoid fever. In Michigan I did not see any fatal cases of malaria at all. Since then I have examined a great many cases every year. I have cases sent in under the diagnosis of typho-malaria or some similar name and I have frequent occassion to clear up the diagnosis. I have given much study and thought to the question of malaria in St. Louis and the Mississippi Valley.

7048 (Witness reads extracts from article written by Dr. Bremer, a St. Louis physician, in the Medical Review for August, 1895. This extract, among other things, contains the following:) "Physicians are apt even today to look upon many ailments as due to malaria, which in reality have nothing to do with this disease either directly or indirectly. This means St. Louis and environments in particular, and the Mississippi valley in general, but it probably applies to the whole United States. Periodic chills, followed by high temperatures, which mark the initial stages of so many cases, are generally interpreted as due to malaria, hence the erroneous and mischievous diagnosis of malaria, remittent fever or typho-malaria, under which so many cases of typhoid figure in the reports of our city Boards of Health.

7049 I have come to the conclusion that in St. Louis, at least, malaria is an extremely rare disease. Four years ago I went to the City Hospital for a number of months in the hope of finding a good plasmodium infected subject. My efforts were unsuccessful for a long time. The cases pointed out to me by attending physicians as malaria and treated as such, proved to be infections which had nothing in common with that disease."

In 1898 I was asked by Surgeon General Sternberg, of the United States Army, to visit certain army camps in order to examine the blood of patients diagnosed largely as malaria. Out of

400 patients in the Sternberg hospital, practically all of whom had a diagnoses of malaria in one form or another, under some other name such as bilious remittent, typho-malarial, etc., I found only one case that was malarial fever. The same conditions were found at Camp Mead, Penna., and at Knoxville I was not able to find any malarial cases. Even in Michigan, I still see physicians who are giving wrong diagnoses for typhoid fever. I have made a special and persistent study of typhoid fever for about 20 years. I have also made a special study of the so-called germ diseases. (Witness gives clinical diagnosis of typhoid fever, intermittent fever, remittent fever, typho-malarial fever, congestive fever and simple continued fever.) Remittent, intermittent, typho-malarial, congestive and simple continued fevers are not distinct types of disease and usually all such names are included, by careful Boards of Health, under the head of typhoid fever. The symptoms of typhoid fever sometimes rather closely simulate the symptoms characterized under these headings, especially if one is not particularly
7053 educated on the finer diagnostic points. An examination of the blood of the malarial organs, on one hand, or the typhoid reaction on the other, usually clears them up very quickly, but, to a casual glance, the diseases may be very much alike.

Q. Assume that the number of deaths reported as occurring from typhoid fever in the city of St. Louis as evidenced by the annual report of the Board of Health of the city of St. Louis Health department is as follows:

1890	140
1891	165
1892	441
1893	215
1894	171
1895	107
1896	106
1897	125

1898	95
1899	131
1900	168
1901	198
1902	222
1903	288

7054 Assuming that the number of deaths for the respective years correctly represent the typhoid condition in St. Louis, my opinion is that these figures show an increase in typhoid fever in the city of St. Louis during the last ten years. I should say there has been an increase but not a great increase. I am particularly struck by the increase since 1898, because in 1898 the doctors all over the country had their attention very strongly called to the wrong diagnoses that were formerly made in the so-called typhoid diseases and the attention of the public has been very strongly called to it.

7055 Assuming the statistics in the foregoing question as above indicated and assuming further that the number of deaths reported in the same reports under the headings remittent, intermittent, typho-malarial, congestive and simple continued fevers is as follows:

1890	226
1891	296
1892	326
1893	284
1894	179
1895	155
1896	177
1897	172
1898	134
1899	148
1900	112
1901	80
1902	102
1903	91

The number of deaths reported occurring from typhoid fever alone in the city of St. Louis, do not properly represent in my opinion the total number of deaths actually occurring in that city during the period in question.

7056 A. The most important reason is that the death rate from malarial diseases is altogether too high, too high for every year. Take an exceptional year for typhoid, when there was an accidental condition, the malaria there is 50 per cent higher than it was two years before. In 1890 there were 226 cases of the malarial disease. I include all these various diseases in malaria. In 1892 there were 326. Now, from studying malaria very carefully at that time, I say there was no reason why malaria should increase in a city like St. Louis to that extent at that time. The death rate in every year is altogether too high in a city like St. Louis. It is higher than I believe possible.

(Witness describes malarial fever and the distinct types of same.)

7057 The type of malaria that is common in the central states on the Mississippi river, is the intermittent form, which is practically never considered a fatal type of fever. Nobody ever dies of it unless he has had some previously exhausting disease. The failure of the statistics assumed in the foregoing hypothetical questions, to properly disclose the number of typhoid fever deaths occuring in St. Louis, I attribute to the use of the term "malarial fever, typho-malarial fever," etc., applied to certain cases of typhoid fever.

7058 The only city that I know of where the death rate from malarial fever alone is as high as in St. Louis, is New Orleans. A study of the table introduced by Prof. Jordan will be enough to show that the whole malaria statistics of that town are seriously faulty. If we add the totals of the table for typhoid fever and the table for remittent, etc. fevers, as they appear in the report of the Board of Health of St. Louis, and if we take those tables as indicating the correct typhoid fever mortality in St. Louis, they do not indicate a marked increase.

7059 From the statistics that have been furnished, and from my experience in the diagnosis of typhoid fever, and typho-malarial fever, I should say it would be impossible to say exactly how many cases, but anywhere between 50 and 90 per cent of the so-called malaria ought to be called typhoid. At least 50 and probably as many as 90.

The board of health of Michigan, for instance, orders that all typho-malaria be classified under typhoid, and the new classification recommended by the United States census makes that same recommendation.

7062 The statistics do not indicate a marked increase, though they indicate a slight and gradual increase from the year 1898. An increase that I would explain partly from the fact that the diagnosis of typhoid fever has become broader all over the country. More cases are being included. There is a tendency everywhere to increase the proportion of typhoid cases in that way. There has been a slight and gradual increase.

There is nothing in the statistics as they appear to show any explanation of typhoid fever, as due to any particular cause. The increase for example is slightly more marked for the year 1901, but even there it is not at all striking. It is not such a thing as we find in the case of Butler, Penna., or the town of Ithaca. The sending out of letters by the Board of Health would explain the rise that has occurred in the last few years. Those letters manifest themselves in the typho-malarial column. My opinion is that when the two tables showing these mortality statistics, are taken separately, they do not correctly show the typhoid conditions, for the reason that the diagnosis of malarial diseases were almost entirely erroneous and should have appeared largely under the head of typhoid.

7063 Doctors having their attention called by the notification, would report more cases as typhoid, and less as typho-malarial, than they had before.

7065 (Witness is asked to read table which is reproduced on page 7065 and to state whether in his opinion, based upon the tables heretofore read, typhoid fever has increased or decreased in St. Louis since 1900, and states:) The table does not show that there has been a marked increase; on the contrary, a slight increase. Such an increase as I would ascribe rather to increased care in diagnosis, rather than to any outside conditions.

7066 One of the most serious sources of typhoid fever are wells. Assuming that in April, 1895, the total number of wells in St. Louis, was 4,846, and that the city chemist after examining 59 wells condemned them as being unsanitary, and assuming further that in August, 1895, upon the report of the city chemist condemning seven more wells, the Board of Health passed a resolution that the city should make no further examination of the wells, and that since 1895 none of these wells have been condemned, my opinion is that if the water of these wells was used by the inhabitants for domestic and drinking purposes, it would be a very serious source of typhoid fever. My opinion is that the slight increase in typhoid fever in St. Louis indicates rather a change in the conditions of the city of St. Louis itself than in the main water supply, supposing that the main water supply comes from the river.

7067 A change in the condition of the river water is always indicated in such cases by a more marked increase. As to such an increase as we have here, it is altogether compatible with changing local conditions, such as wells, and the ordinary course of typhoid epidemics.

7068 Dr. Blickhahn wrote me from St. Louis while he was investigating malaria and conferred with me. After he had been working at the thing for about two years, he wrote me that he had never been able to see a certain form of malarial organism, that is the so-called crescent. I was rather surprised at that, because I would have rather supposed, I would have thought that he would find crescents in St. Louis. Crescents are found in the more severe form of malarial fever. The severe types have these bodies associated with them. Blickhahn wrote me that he had not been able to find them and asked me to send him one of my specimens. I sent him some specimens that I had brought from Texas. I supposed he had simply overlooked them but he wrote back and said he had not seen them up to that time. That was additional evidence that severe forms did not occur frequently there, although of course they might occur now and then.

7069 That was during 1903 and 1904. In this country there are practically no fevers which produce death, which may be associated with typhoid fever. I mean to say that any disease that sets up any very great infection, in a large number of cases, is typhoid. There are in some other countries such fevers, typhus fever, for example, even that, at the present time, that we cannot distinguish quite positively from typhoid. Typhus fever does not give a Widal reaction. You do not get the typhoid germs out of the blood. That disease is very rare in this country and is only brought in, at long intervals, from Russia, nowadays. Sometimes from Ireland and sometimes from Mexico. It is a disease of extremely bad sanitation and poor food. It can hardly exist without those conditions, and this would prevent its spread or distribution through this country. The tables introduced show that there has been

7076 an increase in typhoid in St. Louis, even though you transfer all remittent, intermittent, etc. fevers into the typhoid column.

7077 RE-DIRECT-EXAMINATION, By Mr. Todd.

Q. Doctor, in figuring out the percentage of figures, assume that the average for 1895-6-7-8, of the percentages for the four years before 1900, was 21.05, and the four years subsequent 36.5, and that the difference between these averages was 15.45, in figuring out the percentages by dividing 15.45 by 21.05 gives a percentage of practically 73 per cent, does that 73 per cent in your opinion, figured upon the basis that I have indicated in arriving at it, express a large increase in typhoid fever?

7078 A. No, but I should say that I consider your method of getting at the result, very faulty. For example, the increase did not occur in a single year, but spread over a series of years, and it is not a figure that varies, up and down in those years, but goes up steadily. If the 73 per cent had occurred between 1899 and 1900, I should say that either there must have been a new focus of infection, or else that the old focus must have been extremely badly handled but as it is spread over four years, and the ascent is gradual, and really began a year before the point of deviation, I still adhere to my former statement that it is not a great increase.

I understand that the figures I am now testifying to, are figures based on the estimation that the typhoid fever death rate, as reported in the house statistics, and estimated, do not include the other heading of typhoid fever. In figuring out the percentage of increase, the average does not give us as correct an idea as to the relationship existing between each year. The percentage of increase from 1898 to 1899 is 34.7; from 1899 to 1900, 25.3; from 1900 to 1901, 14.7; from 1901 to 1902, 9.5; from 1902 to 1903, 26.7. This percentage of increase shows that the first year has the greater increase over the previous year.

7079 RE-CROSS-EXAMINATION, By Mr. Jeffries.

Q. Taking the number of typhoid deaths per 100,000 population for 1897, at 23.4, as the highest number reported during any one of the four years immediately prior to 1900, compared with the average number of deaths for 100,000, for the four succeeding years, 1900, 1901-2 and 3, please state the percentage of increase or decrease?

7080 A. I get an increase of 55.99 per cent.

Q. What is the percentage of increase or decrease for the number of deaths reported per 100,000 population for the highest year during the period of 1896 to 1899 inclusive, and from 1900 to 1903, inclusive?

A. 98 per cent increase.

Q. Now, what years did you employ in that calculation?

A. The years 1897 and 1903.

Q. I will ask you if the result shown on this table for the four years from 1896 to 1899, does not show that there was an alternate increase and decrease year by year in this to wit, 1896, 20.2; 1897, 23.4; 1898, 17.3; 1899, 23.3, and that since 1899, to wit, the years 1900 to 1903 inclusive, there has been a continual increase?

A. That is right.

Southern Hotel, St. Louis, Mo. Oct. 24, 1903.

7082 LEWELLYS F. PARKER, Examined in chief by Mr. Todd.

Reside in Chicago. Am Professor in the University of Chicago. (Gives educational qualifications.) Am Professor in the medical faculty of the University of Illinois. Have been Professor of pathology, bacteriology and anatomy. Was sent by the Johns Hopkins University to study an epidemic of cerebral spinal meningitis in Maryland and in 1899, Dr. Flexner and myself were sent as special commissioners to study the tropical diseases in the Philippine Islands, and incidentally to study the epidemic of plague and beri beri in Hong Kong, India and Japan.

7085 In Manila there was abundant opportunity for the study of the three diseases very prevalent in the Island, namely, typhoid fever, malaria and the acute tropical dysentery, and we were able also to not only study a large number of cases of leprosy, but to make biological examinations and autopsies of a number of lepers dead in various stages of the disease. Well, in brief, through the courtesy of the Seugeon-General of the

Army and Navy we had access to all the army and naval hospitals,
and also to the native hospitals and Spanish hospitals,
and the studies were clinical, including microscopic and bacteriological
studies, and when deaths occurred we made autopsical
and bacteriological examinations.

7086 Nothing especially new came out of our study of typhoid
in Manila. Was also appointed by the Secretary of the
Treasury, in Washington, along with several other professors
to investigate the disease prevalent in San Francisco among
the Chinese.

7087 In Baltimore, I studied the typhoid epidemics and malaria
and had an opportunity there to become very familiar
with both diseases. There seemed to be no doubt, from observation
of the conditions, that the water supply of Baltimore
is a polluted supply, and that at any rate, a majority of the
cases of infection were water-borne. Doubtless some of
7088 the cases were cases of so-called secondary infection of
typhoid from contact or from environment of food stuffs.

(Witness states cause or causes of typhoid fever.) It seems
extremely probable that some of the more localized groups of
cases in the city of Chicago, have been due to infection by
flies. The studies of Dr. Alice Hamilton point in that direction.

7090 Remittent fever, intermittent fever, typho-malarial fever,
congestive fever and simple continued fever are all clinical
rather than pathological terms, and date back to the time
when classifications had to be made on symptomology rather
than upon pathology and teiology.

The remittent fever was the term given to a fever which had exascerbations and declines without reaching the normal, as a rule. and intermittent was the term given where the temperature went up high and came down to the normal, then up high again and down to normal.

Typho-malarial fever was a term given to cases which were believed to be by many, a fever distinct from typhoid, and distinct from malaria, a fever which ran the course of typhoid, but which had many symptoms resembling those of malaria while congestive fever was a very vague term used in different ways by different clinicians and was usually associated with the idea of congestion of the head, rush of blood to the head, along with the fever, while simple continued fever was a term applied by, as a rule, the less well-educated physicians, to mild forms of fever running over a considerable period, generally over more than ten days or two weeks. It was a term used by people who believed that such fevers were not typhoid and not malaria, but simply continued fever. They didn't know exactly what it meant. Now all of those terms are given up by good clinicians at the present time; there is no such thing as a remittent fever as a clinical entity any more. It is either typhoid or malaria, or acute tuberculosis, or some other infection, and usually it is possible during life to determine that a case of so-called remittent fever, or intermittent fever in the same way, may be one of several diseases perhaps. Most often what is designated intermittent fever is malarial fever, but cases of typhoid fever are often mistakenly designated as malaria, intermittent, etc. The congestive fever might be one of various things; sometimes it is typhoid and sometimes it is malaria. Sometimes it is something else.

7091 Simple continued fever may be typhoid. I think perhaps most often it is a mild case of typhoid fever. It may be something else. None of those terms would be used now by a skilled clinician.

I have the statistics of deaths from remittent, etc. fevers, in St. Louis, for the years 1890 to 1902, and also the deaths from typhoid fever alone for the same period; also the same figures for the city of Baltimore. (These figures are given on pages 7092-3.)

7094 From what I have said, it is clear that, in my opinion, the cases reported as remittent, etc. are nearly all cases of something else, mostly typhoid, that could be diagnosed by skillful physicians. In fact, I think the addition of the two columns, the typhoid column and the remittent, intermittent, typho-malarial, congestive and simple continued fevers, would give a truer typhoid death rate in the city of St. Louis, than any other of the statistics that we could get.

7096 In view of all the facts that I have related, it is absolutely certain that if these statistics are absolutely reliable that there has been no increase of typhoid fever in the years 1900 and 1902 inclusive, as compared with the ten preceding years in the city of St. Louis.

The statistics show that the total number of deaths reported from typhoid and the remittent group together, run along at a tolerably constant figure. The figures, however, show in the typhoid fever column alone an increase in the number of typhoid cases; quite a marked increase during the last three years, from 1900 to 1902. They also show quite a marked diminution in the remittent and intermittent group during the last three years. There has evidently been simply a transfer from the remittent column to the typhoid fever column. In other words, typhoid fever has been diagnosed more often during the last three years, than it has in the last preceeding years. There has been no greater number of cases, but the diagnosis appears to have been better. That the diagnosis is not yet good by many of the physicians in St. Louis is obvious from the large number of cases still reported in the remittent group.

7098 If a specific circular had been sent out by the Board of Health in the latter part of 1899, calling particular attention to typhoid conditions existing in that city, I think it would have influence on the reports made to the Board of Health. (Witness gives reasons for his answer.)

7099 The death rate from typhoid fever in St. Louis, as I interpret the vital statistics, is not excessive, as compared with Baltimore and corresponding cities. If one takes the extreme statement of one investigator, the maximum distance that contagion of typhoid fever has been shown to travel in a flowing stream, is about 70 or 75 miles. That view and assertion have not met with general acceptance, however. Am acquainted with the general conditions which obtain in Chicago, the drainage canal, the Illinois river, the Mississippi and Missouri rivers down to St. Louis. In my opinion a typhoid bacillus lying in the sediment of a stream for a period in excess of sixty days, would be harmless. In my opinion, pathogenic bacteria in the sewage of Chicago would not be able to survive the journey from Chicago to the intake tower, at St. Louis, and be a menace and danger to the inhabitants of St. Louis. In my opinion, typhoid bacilli could not survive that same journey taking into consideration the sewage discharged at Peoria and Pekin, etc. into the river. In my opinion, the sewage entering the drainage canal, which empties into the Illinois river and thence into the Mississippi, would not be a menace and danger to the inhabitants of the State of Missouri and the citizens of St. Louis, taking their water supply from the intake tower at the Chain of Rocks. Assuming an epidemic of Asiatic cholera in Chicago, the germ would not survive the journey from Chicago to the intake tower at St. Louis. The introduction of this mass of organic material from the stockyards and distilleries of Peoria would favor the disappearance of the typhoid bacillus.

7103 There would be no danger of infection by tetanus or enteriditus sporogones. As to the statistics referred to, I can seen no connection between the opening of the drainage canal and the figures. The probable length of life of the typhoid bacillus introduced by way of the drainage canal into a sluggish river, such as the Illinois river, flowing through a more or less densely populated country, and receiving successive increments of organic matter together with the associated saprophytic bacteria, I should think would be from five to seven days.

7104 (Witness is asked hypothetical question, assuming typhoid deaths in various cities on the water shed of the Mississippi, and assuming that the typhoid condition in St.

Louis in 1900, is due to a contaminated drinking water, in large part, and is asked as to whether, under such circumstances, the typhoid fever in St. Louis, could be attributed to the sewage of Chicago, to which witness replies that in his opinion, it could not.)

7105 Table showing death report from typhoid fever in cities lying tributary to the Missouri.

7106 Same as to Illinois river, exclusive of Chicago.

7107 Table showing total number of deaths from typhoid fever in cities lying tributary to the Missouri, Mississippi and Illinois rivers respectfully, and also table showing deaths in Chicago and St. Louis. Taking into consideration the above tables, in my opinion the probability of infection or pol-
7108 lution of the water supply of St. Louis, would be largest from those places within the mean flow of five to seven days. I don't know how to express that—from those places where the average flow or the mean flow is within five to seven days of St. Louis. I think the probability of infection or pollution from the great distances requiring more than twelve days for example, would be remote.

CROSS-EXAMINATION, by Mr. Jeffries:

7110 Typhoid fever is epidemic in Baltimore nearly every year. The water supply is believed to be responsible for it. There are different parts of the city which get different water supplies. The part that I was interested in particularly, came from Lake Roland. That lake is, I should think, five or seven miles from Baltimore.

7111 It was my opinion that the cases of typhoid fever occurring among those who drank of the water from that district, from that water supply, were due to the pollution of the water supply by typhoid bacilli.

7112 I am of the opinion that that could have been responsible for the epidemic.

7115 In determining the condition of a certain body of water, if I found, or if any one found a large number of bacilli of the colon group, for example, that would be evidence—other things being equal—of probable sewage contamination.

7116 I had, while house officer in the Toronto general hospital, a considerable experience with typhoid cases. There was a large epidemic that year, larger than usual, but I had nothing to do with the actual source or cause of the epidemic.

7117 It was supposed I believe it was definitely proven but I am not sure, that there was a leak in the intake pipe. The pipe went out to an island, it passed through Toronto Bay, and they found out afterwards that there was a hole in the pipe, going across the bay, and that the real sewage mixed water was taken directly into the water supply of the city.

7119 In order to be absolutely safe, the city of Toronto ought to go out about 100 miles. That would be past the middle of the lake, wouldn't it? I don't know how broad the lake is. The object in extending the water mains out in the lake, would be to diminish amount of pollution in the water.

7120 Do not understand me to say that I would recommend putting a pipe out 100 miles. There is a much easier way of getting a water supply than that, but if you tried to get it in that way, assuming an impossible condition, that would be the purest water that you could get, I should say, into the middle of the lake, farthest from the shore would be the place to draw your water in case you had to get it from the lake.

It would be much better to put in a sand filtration, and then take it from anywhere, provided you could educate the people there to conduct such a filtration plant in the proper way.

I think the water would undoubtedly be polluted for quite a distance out if typhoid fever were occurring in the city.

Q. And that was your object in saying that you would extend the main 100 miles out?

A. I say I would extend it to get the purest water, to the middle of the lake, which of course is not practicable.

7123 Q. But if I understand you correctly doctor, you take the position that it would be necessary in your judgment, to extend the mains so far as you could trace the chemical impurities because of the likelihood of the bacteria being present?

A. No, I do not intend to leave that impression at all, because chemical impurities will go wherever the water goes, being in solution; they can go ultimately a thousand miles.

Q. Do you know that the bacteria won't go a thousand miles?

A. All the evidence is against it.

7124 When I speak of the longevity of typhoid germs, and apply their longevity to the water of the Illinois river, I am very glad to acknowledge that I borrow the experience of other men and do not speak from actual personal experience of my own.

7129 In expressing an opinion on the longevity of typhoid bacilli, I do so solely on what people have told me with reference to it. I am very glad to do that because I do not think I could give you a more reliable source. Among others, Dr. Jordan has told me how long typhoid germs would live in river water. I have talked with him, off and on during the last three years and also with Dr. Kekoten.

7135 The addition of 250,000 cubic feet of water per minute in the canal would have a tendency to prolong the life of the typhoid germ. I was about to say that this refers to the life of the bacillus as I understand it, the dilution is not great enough to interfere with the killing off of typhoid bacilli by the saprophytic bacteria. The greater the sewage pollution, the less the limit of the typhoid germs, other things being equal.

7138 I think that it would probably be true that the typhoid germs, for instance, would disappear much more rapidly if the sewage of Chicago was turned into the drainage canal unmixed with the water of Lake Michigan, than it will now as it is being mixed with the water from Lake Michigan.

7141 I think the addition of 250,000 cubic feet of water per minute would also prolong the longevity of the typhoid germs that are discharged into the Illinois river from all the points below Chicago, but in a progressively diminished manner, because the relative percentage of increase would grow progressively less, owing to the contents of the tributaries coming in below. It might have been better for the upper part of the river to have turned the water and sewage of Chicago from the Chicago river, as it originally existed, into the Illinois river, without any lake water, than to have turned the lake water and sewage, at the rate of 250,000 cubic feet per minute, through the canal into the river, but I doubt if it makes any appreciable difference with the lower part of the river.

7143 For two reasons, that I think the stream would purify itself so thoroughly at the lower end of the river, that the pollution would be inappreciable; and the other reason that the increase in volume of water relatively, would be so slight in the lower part of the river, owing to the access of so many tributaries in between, that any increase in the longevity of pathogenic bacteria would be doubtful, immeasurable.

Assuming that the volume of water flowing down the Illinois river at Grafton during certain seasons of the year since the opening of the canal is less than the total amount of water passing through the canal, I should think that Grafton was so far below Chicago that it was a matter that had very little bearing upon the question because of the self-purification of the stream.

7144 My opinion is that typhoid germs die out quicker when there is a great deal of sewage, than when there is not. I am not sure that any typhoid germs get as far from Chicago as Grafton. My opinion is that they do not.

7153 I would not recommend the water in the Illinois river nor the Mississippi or Missouri, for domestic purposes. If the Chicago river alone had been turned into the Illinois river, instead of the present drainage canal with the 250,000 cubic feet of water per minute, I doubt if there would be very much difference at Henry as to the effect of the sewage of Chicago, or as to the dangerous qualities of the water.

7154 The Chicago sewage does not purify itself during its flow in the canal, which is 29 miles long. I should not think all of the sewage would be removed in a run of 39 miles. I don't know whether all of the pathogenic germs would be removed. I should think the pathogenic germs would be removed at a distance of 49 miles, if there were no new excess with water. I would not be willing to trust the water at 150 miles, because I should avoid it under all circumstances because of other contamination on the way.

I think the water would be safe at 150 miles but I would not recommend it at Grafton or New Orleans. Removing all sources of pollution other than Chicago from the Illinois river, in the absence of all contamination on the way, I think the water would be safe at Grafton. I would not recommend it, though. I would not recommend it at St. Louis, though I think it would be safe.

Q. Well, if you think it would be safe, why are you not willing to recommend it?

A. Because, we have ways of making it absolutely sure. My opinion on safety is an opinion. We have methods of being absolutely sure about our drinking water. Assuming that all sources of pollution are removed from the Illinois river, except the sewage from Chicago discharged into the canal with 250,000 cubic feet of water per minute, thence into the Illinois river, I think it would be safe to recommend the water of the

Illinois river at Grafton for domestic purposes but I would, of course, make tests in such a case.

7158 I think the use of the water is the best test in the long run.

7160 Assuming that it got no other contamination but the Chicago sewage, the water of the Illinois river would be safe at a place like Averyville.

7166 If I knew there were 10,000 cases of typhoid fever in Chicago and that the discharges of those patients were passed into the canal, I would not recommend the water at Grafton, under any circumstances. If I knew there were 100 cases of typhoid fever during the months of May, June, July August and September, in Chicago, I would boil the water at Grafton until we had more knowledge. I think it would be safe, but I would boil it, or filter it.

7167 My reason for this is that I always use the most perfect method, whenever I can, in technic. I should think that typhoid germs would, or might live as long as ten days in running water. I do not think they would live longer than thirty days. I think they would live longer in a sample of water kept in a laboratory than they would in the same water in a running stream.

7169 Q. I thought you stated a moment ago that you were of opinion that they would live longer in the laboratory sample?

A. Well, it is not a strong opinion. I have that idea about it. It is not a strong opinion.

Q. Then you do not care to express an opinion on it?

A. I would rather not. I do not think they would live more than thirty days in the Illinois river. I do not think they would live that long if they started in the upper part of the river.

7170 They would disappear more rapidly from the canal in the summer time than in the winter time. I think it very improbable that under the worst possible circumstances the sewage of Chicago will affect the water in the Mississippi river at Grafton. In my opinion, it would not and cannot affect the sanitary condition of the water in the Mississippi river at Grafton.

7171 I think the typhoid bacilli would die less quickly when the saprophytic bacteria—one of the important factors—are slow in growing.

7186 I am undertaking to give what Prof. Long believes, in reference particularly to the Averyville situation, chemically speaking. I know nothing of the conditions at that point, other than what I have learned from others with regard to the chemistry.

7198 (Witness states information he has secured upon which he bases the opinions given in his direct examination.) This is a resume of the facts ascertained in the investigation made by the defendant.

7206 I am not sure that the addition of 250,000 cubic feet of water per minute into the drainage canal, would make no very great difference either way, as to the life of pathogenic bacteria. I think the tendency would be to increase the life of certain bacteria.

7208 I would say that in my opinion, the water in the Illinois river at Averyville was not materially affected by the sewage of Chicago, but would not recommend any water for drinking purposes without tests.

7209 If I knew that it did not take the water five days to come from Chicago to Averyville, it would have an affect upon my opinion. I should not be sure that in five days absolutely every typhoid bacillus would be dead. I should say that in my opinion there is no evidence that the Illinois river water at Grafton is affected by the sewage of Chicago, but I would advise the people of Grafton not to use it without filtration or boiling. I would give it, as my opinion, that the water at Grafton is in no wise affected at any time of the year by the sewage of Chicago. That would be my opinion. I would not put myself in the position of recommending my opinion.

7211 I would not recommend the water under any circumstances.

7212 All information that I can gather, or could gather would have an effect upon the formation of my opinion, and upon the information that I received, I would be willing to state it as my opinion that the water at Grafton is probably safe, as far as the city of Chicago is concerned—as far as the sewage of the city of Chicago is concerned, but I would not recommend its use because I do not recemmend any river water for use.

7213 If the water comes from Chicago to St. Louis in ten days and the sewage turned into the canal was typhoid infected, considering all the conditions of the river, I would state it as my opinion that as far as the typhoid bacilli coming from Chicago are concerned, Grafton and St. Louis would not be menaced. Under no conditions that will ever be realized, in my opinion, will typhoid germs come from Chicago to St. Louis in ten days, with the water. I think if you had a sterilized tube of distilled water leading from Chicago to St. Louis, coming down there in ten days, you could carry live typhoid bacilli from one city to the other.

7215 The biological test is the best one, as to whether typhoid germs are in water. In my opinion, the water at Averyville would be reasonably safe and the biological test could not be applied there because of the contamination between Chicago and Averyville.

7216 At Lawrence, the germs in the reservoirs holding 14 days water supply, were in reservoirs containing water such as is used for drinking purposes, whereas the typhoid bacilli coming from Chicago toward Averyville, are subject to the tremendous influence of the sewage in the canal.

7217 I should think a great many of the typhoid germs that came from the sewers of Chicago are dead before they go over the Bear Trap dam. A very great many more would be dead by the time they got to La Salle and I think they would probably all be dead by the time they got to Averyville.

7220 I would say that in my opinion, in all probability, the water would be reasonably safe at Averyville, as safe as most water supplies in this country.

7240 It is my opinion that some of the processes of septic operation go on in the drainage canal, even in the presence of oxygen.

7244 In looking for the source of typhoid infection in St. Louis, I should look for it within 25 or 30 miles.

7248 In my opinion, typhoid bacilli would not pass from Chicago to St. Louis alive, partly because of sedimentation.

7249 I should think it very improbable that any place farther away than 75 miles, was responsible for typhoid fever existing in St. Louis.

7250 I do not believe that typhoid fever can come a distance of 175 miles.

7263 The letters which I have had from Dr. Roland Hill of St. Louis, have not said anything about there being but little malarial fever in the Mississippi valley for the last three years. The tables which I have read in evidence, do not indicate to me that there has been a falling off in malarial fever. I do not mean to impeach the integrity of the physicians of St. Louis, but I do mean to intimate that there have been improper diagnoses made by the physicians of that city.

7265 According to the statistics in evidence, there is an increase in the figures under the head of typhoid alone, but not under the head of the two groups which would include the remittent, etc. In 1902, there was a distinct increase in typhoid alone and in the combined groups. The increase is not so great but what it might be—it might occur in any year. For instance, if you examine the statistics farther back, you find in the years 1890, 1891, 1892, 1893 and 1894, more cases in the combined group. Attributing the typhoid in all instances to the pollution of the water supply, it simply means that the conditions in the water are not the same from year to year, although the source of the water supply is the same. Assuming that all the deaths are due to water pollution, it would indicate either that there were differences from year to year, in the pollution of the water supply, or that for some reason or another, the people were more susceptible one year than another.

7267 I should say that if typhoid were occurring in Alton and St. Charles, and the sewage was being poured into the river, and those two towns are within 75 miles of St. Louis, I should think a slight difference in the number of cases in two or three years in St. Louis, might easily occur without any change in the amount of typhoid being put into the river. I would not at all suppose that the towns must necessarily have 5,000 inhabitants in order to pollute the water. I think a single case of typhoid, occurring near the intake of a village of twenty houses would be much more significant than the sewage from a town of 5,000 a great deal farther away, if the excreta from the typhoid patient got into the river in any way.

Q. But that, doctor, would come in the shape of epidemics, would it not, being so close to the city that it would not be continuous?

A. I regard typhoid fever as being epidemic in St. Louis all the time; not a great epidemic, but still, epidemic.

7268 I should think if the settling basins in St. Louis were properly conducted that they would diminish the typhoid bacilli.

7269 I cannot give you the exact length of time that anthrax spores will live in water or earth, but I know they will live a very long time--that they are most resistant. I think they will live at least years, when they are kept dry. If they were wet, I should think they would grow out into bacilli. Unless they had the proper temperature and media, they would not grow out into bacilli. Tetanus spores will also live a considerable length of time. They are present in garden earth all the time.

7270 I know that they are present in the intestines of animals. I am not sure about particular animals; and they are present in the earth, in the soil, very widely distributed. If the germs of tetanus are prevalent in the intestines of animals, I know of no reason why those coming from the offal and washings of the stockyards and slaughterhouses of Chicago, discharged into the canal, might not be carried into the Illinois river and grow out into bacilli, under favorable conditions, if the proper temperature and the proper media were obtained, but tetanus is not a water-borne disease, as far as I know, in human beings.

7271 I have never known of a case of tetanus occurring from water-borne bacilli. By far the majority of cases are 4th of July cases, due to injury on the hand with a toy pistol and other cases, nearly all punctures by rusty nails of the bare feet. It is very improbable that a rusty nail could be moistened in water, drawn from the water supply, from a sprinkler, and a tetanus germ carried in that water. I do not think there is any evidence in favor of that theory.

7272 I haven't heard of the spores of anthrax or the germs thereof, being found in the Illinois river since the opening of the canal. I should be surprised if I should hear that, because when not in the spore form, the anthrax is the least resistant of any of the bacteria. I should not expect it to be found in spore condition because I think the spores would grow out into the less resistant bacilli, in the water.

7273 C. D. CASSINGHAM, examined in chief by Mr. Todd: I live at Wilmington, Illinois, and collected samples of water from the Kankakee river, in the years 1899 and 1900 for Prof. Long. (States where samples were collected, procedure, and method of shipment, etc.)

7277 FRANK L. STEVENS, examined in chief by Mr. Todd: I live at Raleigh, N. C. Am a teacher in the Agricultural-Chemical College of Raleigh. Before going there, I was in Europe, and prior to going to Europe, I attended the University of Chicago, where I worked under the supervision of Prof. Jordan, in connection with the analyses of water. While in the laboratory, I received samples of water which came by express. (States how samples were received, etc.) W. G. Sacket assisted me there.

7279 CROSS-EXAMINATION, by Mr. Jeffries:

My work was purely chemical. (Witness states chemical constitutents that he looked for in the water.)

7281 WALTER GEORGE SACKETT, examined in chief by Mr. Todd:

Reside at Raleigh, N. C. Am teacher in the Baptist Female University. Prior to going there, I was in the University of Chicago and did work under Prof. Jordan, in connection with Streams Examination. (States how samples were received, etc.)

7287 (Stipulation that samples of water taken from the upper Kankakee, near South Bend, Indiana; from the upper Des Plaines river, near Libertyville; the Illinois river at Henry; the Mackinaw river at Cappa, and the upper Sangamon at Mahomet, were taken in the manner described by Prof. Long, as near as may be, and that the production of the witness, who took such samples, is waived.)

7288 THEOBALD SMITH, examined in chief by Mr. Todd:

Am professor in the Harvard Medical School and Pathologist of the State Board of Health of Massachusetts since 1895. Prior to that time, was bacteriologist in charge of the investigations in the Department of Agriculture at Washington upon infectious diseases of animals, and at the same time, professor in bacteriology in the Columbian University, Medical Department, Washington, D. C. (Witness gives experience in the line of investigations on the bacteriology of water.) Have published about 60 or 70 papers on the subject of bacteriology, not exclusively in relation to drinking water, but in relation to diseases generally.

7290 I have studied practically all the pathogenic bacteria that are accessible, except the plague bacillus.

7291 In view of the fact that our methods are still unsatisfactory in the isolation of the typhoid bacillus, at least not practicable on a large scale, the colon bacillus affords us the best indication of the possible presence of the typhoid bacillus.

7292 The typhoid bacillus is probably more perishable than the colon bacillus under a variety of conditions. The colon bacillus is a more vigorous organism than the more highly parasitis typhoid. The fermentation test is used universally in this country for the recognition of the colon bacillus. It is used at the chief test by the Massachusetts State Board of Health, in their filtration experiments. (Witness originated this test.) I first published the method in the report of the State Board of Health for 1891, I think of New York, and it was extensively employed by the engineer, Mr. Brown, and his assistants in 1891 and 1892 on the Hudson river, for determining the relative fecal pollution of the water. The results of other investigators have given general confirmatory evidence as to the value of this test as a criterion for the purity of water. It is the best method that we have at the present time, and probably will not be superceded because there is no indication at present that we are any nearer to a direct determination of the typhoid bacillus than we were perhaps ten years ago. If by the self purification of streams, you mean the sanitary purification of water for drinking purposes, it seems to me this method is applicable to that problem.

7295 Bacterial self-purification of streams consists in a reduction in the number of bacteria in a stream, which reduction is not due to an increase in the lower strata of the water, that is to say, not due simply to an imperfect or perfect sedimentation, but to a complete disappearance or destruction of the bacteria from the water, under examination.

Q. Do you know of any established principles of bacteriology and sanitary science that determine how far a stream can flow before purification is effected?

A. I do not know of any general principles that are involved, but I think each stream has certain special local conditions that need be looked into, which conditions depend on a variety of factors that vary from stream to stream, and what might be true for one stream might not necessarily be true for another. I think each stream under consideration must be investigated by itself. I do not recall any investigations of a similar problem extending over such a distance as that involved in this proceeding.

7296 I think the colon test is applicable to such a problem as that presented in the Illinois river. I believe that an instance where a stream becomes practically free from colon bacilli, in flowing through a country where no additional contamination from this organism occurs, is that of the Mississippi river below New Orleans. That has been worked out by Mr. Weston. I think there the colon bacillus disappears completely and no additional sewage enters. The failure to find the colon bacillus at New Orleans would lead me to think that all other bacteria that are closely related to the colon bacillus, such as the typhoid and dysentery bacilli and the various modifications, the para-colon and para-typhoid had also disappeared. The colon bacillus, as stated a few moments ago, is very closely related, biologically, to the typhoid bacillus—so closely, that up to within a certain number of years, the two were confused by many prominent bacteriologists * * * * * * *

7297 There are very few differences between the typhoid and the colon bacillus, and we are justified, I think, in inferring that whatever changes the colon undergoes are undergone in nature outside of the human body also by the typhoid. Whatever degenerative changes the colon undergoes are also undergone by the typhoid. But perhaps more rapidly under certain conditions because the typhoid is more parasitic. It has probably lost certain defensive properties, that is to say as a parasite it becomes more adapted to the human body and less adapted to life outside of the human body, and that the reduced power to live will also favor the increased destruction of the typhoid bacillus in nature, a destruction which we generally assume is much more rapid than that of the more vigorous intestinal colon bacillus.

A typhoid bacillus will not multiply and increase in nature, that is, in ordinary water. It will grow rapidly in milk, but before the milk becomes very acid, but generally speaking, a typhoid bacillus does not increase and grow in conditions outside of the human body, excepting possibly in milk, under favorable conditions. I know of no other group of bacilli, but the colon, whose life in water is more likely to furnish an index as to the life of the typhoid bacillus. I am familiar with the figures and the data introduced by Prof. Jordan in this case, relative to the colon bacillus in the waters of the drainage canal and the upper
Illinois river.

7298 I made a particularly careful examination of his tables
as to the result of his examination of the Illinois river at its mouth, and of the Mississippi and Missouri rivers. From these tables, I should assume that the colon bacilli had very largely disappeared in their passage down the Illinois river and that the colon content of the Illinois river at Grafton is therefore less than that of the Missouri and the Mississippi rivers, or at least about the same. That is to say, the colon content of the Illinois at Grafton is not to any material degree superior to that of the tributaries of the Illinois river, and it is, on the whole less than the colon content of the Mississippi river and the Missouri river according to these tests. It would seem that the condition of the water at the mouth of the Illinois river was certainly not inferior, if not superior to that of the Mississippi river and the Missouri river, at these points, as I read the testimony in these tables. The Missouri river is, on the whole, more polluted than
the Illinois river. According to these figures, there is not
7299 very much difference, but the benefit of the doubt rests
with the Illinois river without any question. Basing myself upon the colon tests as I certainly should, in all such examinations, I should make the table speak for itself. So far as these colon determinations go, and so far as the inference drawn

from the colon contents is warranted, I should say that the Illinois river was superior in its sanitary quality to either of the other rivers, the Mississippi and Missouri.

It seems to me that in carefully studying the colon results obtained by Prof. Jordan, that some of the tributaries are slightly better than the Illinois river at Averyville and at Grafton and some are worse. According to these tables, there is an enormous destruction of colon bacilli down to Averyville in the Illinois river, and basing myself upon these, I should say that a similar, if not greater destruction of the typhoid bacilli had taken place down to that point.

7300 It seems to me that if virulent typhoid bacilli should actually pass from Chicago to the mouth of the Illinois river that it would be according to conditions and laws that we know nothing about, but that basing ourselves upon the close relationship of the colon to the typhoid bacillus and to this entire group of disease germs we are at present justified in saying that the virulent typhoid bacilli would be very largely destroyed at that point.

It would seem to me that the disappearance of the colon bacilli indicates that excluding a large amount of sewage which enters below Chicago the typhoid bacillus would probably be entirely eliminated during that long course from Chicago to the mouth of the Illinois river of three hundred and fifty odd miles.

I know of no bacteriological evidence that affords more suitable indications than the one in question, to-wit: the colon determinations.

7301 If a typhoid bacillus was found at St. Louis, it would be utterly impossible to identify the source of such typhoid bacillus. The presumption would be that the typhoid bacillus would come from the nearest sewage discharging town.

It seems to me that considering the enormous destruction of the colon bacillus from Chicago down to Averyville, the very great influx of sewage at Peoria, that the presumptive evidence is very strong that the typhoid bacillus from Chicago would not reach St. Louis because it is highly probable that the colon bacilli at the mouth of the Illinois river are probably those that have been introduced further down the stream, say at Peoria and other sewage-discharging places.

7302 I have no precise data on the subject as to whether typhoid germs will live as long in pure water as in sewage polluted water. Sewage polluted waters may, under certain conditions, be more destructive than pure water within certain times and within certain limits.

It would seem that some of the epidemics that have occurred in the past have been due to relatively pure water which accidentally carried the typhoid bacillus a short distance or a relatively short distance, such as the epidemics at Ithaca, New York, and at Plymouth, Pennsylvania.

7303 If it were true that a relation obtained between typhoid fever in Chicago and typhoid fever in St. Louis, I should think that the two curves of typhoid would be very much alike and the St. Louis curve would be slightly retarded in time. (Wtiness is asked to examine two charts showing typhoid deaths in Chicago and St. Louis, with the St. Louis deaths platted one month in advance, as introduced by Prof. Mason, and states:) I am unable to see any direct connection between the typhoid curve of Chicago and that of St. Louis from these diagrams. The upward curve in the St. Louis charts is one which seems to correspond with the usual summer and fall increase in typhoid, which is manifested throughout the civilized world, but I fail to see any direct relation between the two. I think it is generally conceded that typhoid fever in our hospitals, grows in August, September and October each year. That is the time when cases are looked for. I have examined the typhoid statistics introduced in evidence in this case showing typhoid conditions in St. Louis and Chicago, and from the colon determinations of the Mississippi river at the Chain of Rocks. I should hardly consider the river water a satisfactory water for public use without previous preparation or previous filtration. Assuming that the typhoid condition of St. Louis was due to water supply, for the source of infection I should first look to the points nearer, by all means, and if these could be eliminated, then I think I should look to the city of Chicago.

7304 I think it would be highly important to locate the nearest sources first because of the vulnerability of the typhoid bacillus in water. The further the area of infection the less the danger of the typhoid bacilli reaching the water supply. A few bacilli discharged into a stream near by would be much more dangerous than a large number discharged at a much greater distance.

7305 The results of Professors Jordan, Zeit and Russell have introduced a new factor into the problem in that they have defined for us, perhaps for the first time, the viability of the typhoid bacillus in polluted water. Before that time of course the results were not very definite unless we took into account the viability of the colon bacillus, but now it seems that the typhoid bacillus is fairly rapidly destroyed in polluted water, more rapidly than we have believed, and that rapidity of destruction would indicate what I suggested a moment ago, that possibly the typhoid bacillus is stimulated enough to multiply in sewage polluted water to be promptly destroyed whereas in water which contains very little organic matter its life is preserved a longer time because of a condition of latency and absence of that stimulation to multiply which I assume is very destructive to bacteria in general. If these experiments are carrect, and I feel quite prepared to take the risk of accepting all of those experiments of Professors Jordan and the other gentlemen—if they are correct—then I think it would be physically impossible for the typhoid bacillus to reach St. Louis, starting at Chicago.

7306 I know of only two cases in Massachusetts of death resulting from malaria.

Q. Are remittent, intermittent, typho-malaria, congestive and simple continued fevers distinct types of disease and so recognized by bacteriologists and clinicians?

A. It is very rare that typhoid fever and malarial fever co-exist and these cases are so rare as generally to go on record in medical publications. These terms and especially the term remittent fever figured quite extensively in medical publications about twenty years ago, but since that time it has almost wholly disappeared because of the more accurate means of diagnosis.

Classifying deaths from typhoid in one column and those from remittent, etc. fevers in another column, is, at least, a very indefinite form of classification, because we would assume that under the terms, remittent and simple continued and typho-malarial, we would have either one or the other disease, either typhoid or malaria or a mixture of the two, which rarely occurs. Where such classification occurs, showing almost an equal number of cases under the remittent, etc. group, with those in the typhoid group, I do not think such a classification would furnish a correct idea of the prevalence of typhoid fever in a given community. The classification as you have mentioned it, would indicate that the best means of diagnosis were not resorted to in determining the nature of those diseases.

7308 CROSS-EXAMINATION, by Mr. Corum:

In the Hudson river, the experiment made at Albany determined that that river purified itself to the extent that the number of bacteria dropped from an average of 10,000 per c.c. to about 300 per cubic centimeter within this distance of about 18 miles, I think. I do not remember the exact number of miles. The fermentation test is not rendered inaccurate by the more rapid multiplication in the tube of other saprophytic forms. (Witness gives reasons.)

7310 I understand that colon bacillus was not found at New Orleans, even with the use of a large amount of water, although I am prepared to be corrected on that point, by printed evidence.

7311 It follows logically that if typhoid germs were discharged into the river at Peoria, the increase in the volume of the water by the canal would carry the typhoid to St. Louis in a shorter space of time. It also follows that there would be a great deal more dilution of the Peoria sewage.

7312 The evidence upon which I am basing my statement, and I think it is perfectly reliable, shows that the colon bacilli largely disappear at Averyville or before they reach this second source of contamination—the group of towns at Peoria—consequently it would be inferred that the colon bacilli which are at St. Louis are largely recruited from the places further down and that the colon bacilli which have almost disappeared at Averyville would have completely disappeared at the mouth of the Illinois river.

7313 VICTOR C. VAUGHN, examined in chief by Mr. Todd: I am a physician and teacher. Reside at Ann Arbor, Michigan, and am connected with the University of Michigan. Have been teaching at that University since 1876, but studied with Prof. Koch, in the University of Berlin, two or three times. I teach hygiene and physiological chemistry. Am a member of the State Board of Health of Michigan. Have been called upon frequently to examine into epidemics in the state and am still serving on the United States Government Commission for the study of typhoid fever. Enlisted in the army in 1898 and was appointed on this commission in August of that year. After my return from Santiago, in connection with Major Walter Reed, and Major Shakespearre, I went to Camps Alger, Fernandino, Jacksonville, Huntsville, Alabama, Chickamagua, Georgia; Knoxville, Tenn.; Camp Meade, Pennsylvania, and the other members of the commission went to Montauk. I did not. I was sick at the time. I think I must have seen four or five thousand cases of typhoid fever. As a member of the commission, I have been engaged practically ever since that time in writing up the statistics and studying the spread of typhoid fever and I have also been called upon frequently to investigate outbreaks of typhoid fever in different parts of the country, in Michigan and other states as well.

7315 I have made a special study of typhoid and malarial fever from the standpoint of a bacteriologist and clinician. Our commission had charge of all the diagnoses that were made in the army camps after the appointment of the commission, that is, we selected the men and put them to work and overlooked their work in the various camps in the United States. Typhoid fever is an acute septicaemia, due to infection with a specific germ known as bacillus typhosus. Malarial fever is a disease due to infection with a malarial parasite, of which there are at least three well known varieties. Most of the cases diagnosed under the different heads of intermittent, remittent, typho-malarial, congestive and simple continued fever, are forms of typhoid fever. Malaria is sometimes called remittent fever, but the majority of the cases in this country that are diagnosed under those heads, especially in the northern parts of the United States, are really cases of typhoid fever.

7316 Remittent, etc. fevers are not distinct types of disease. They almost invariably mean typhoid fever. (The number of deaths from typhoid in St. Louis from 1890 to 1903 and the number of deaths from remittent, etc. fevers during the same period, read to witness.)

7317 The number of deaths reported as occurring from typhoid fever alone, in St. Louis, do not properly represent, in my opinion, the total number of typhoid deaths actually occurring in the city for the period in question. (Witness gives reasons for his answer.)

7319 I am sure there is no city in the United States where there are so many deaths from malaria as are reported from St. Louis. 100 per cent of the deaths reported in the column "Remittent, etc. fevers," should be classed as typhoid and none as malarial fever. There are practically no deaths from malaria in this country unless it is in New Orleans, or some other extreme southern city.

7320 It is generally recognized by bacteriologists and clinicians, that classifying typhoid fever in one column and intermittent, remtitent, typho-malarial, congestive and simple continued fevers in another column, in board of health reports of cities, is an improper classification from a scientific stand-

point as affording a true indication of the mortality from typhoid fever and malaria. (Table is read to witness, showing typhoid mortality by months under column "A" and mortality from remittent, etc. fevers under column "B" for the years 1895 to 1903 inclusive. Witness states:) I think the total deaths there as reported from all of these cases more accurately
7321 give the number of deaths from typhoid fever. Without knowing anything about the local conditions in St. Louis, simply as a student of epidemiology, and looking at the distribution of these diseases according to months, I should say that the probabilities are that typhoid fever in St. Louis, with the possible exception of the year 1892, was due to local causes, rather than to any infection of the general water supply.

7322 As I stated a moment ago these figures as given here showing the distribution of typhoid fever render it highly probable that the local conditions, such as infected or polluted wells indicated the distribution of typhoid fever by contact were the causes of the spread of typhoid fever in St. Louis rather than the infection of the general water supply. I should answer your question then specifically by saying polluted wells, if they were specifically polluted with typhoid fever, the use of the water from such wells, would undoubterly cause typhoid fever.

The circular letters issued in 1900 and 1901 by the St. Louis Board of Health evidently shows in the statistics heretofore read in evidence, by an increase in the number of deaths reported from typhoid fever. The two tables—one showing death rate from typhoid fever and the other from remittent, etc. fevers, taken separately do not correctly show the death rate from typhoid fever.

7325 My opinion is based upon the fact which is well known to most physicians and certainly I have special reasons for knowing it, that malaria is not a frequent disease in this country and is certainly a very rare cause of death. In order to arrive at the typhoid fever mortality in St. Louis, the two tables should be combined. The death rate in Buffalo has increased quite markedly, also in New York.

7326 Typhoid fever has been more widely disseminated over the country and there have been more cases and more deaths during the last five years. Other cities besides St. Louis show an increase. Taking the table introduced by Prof. Jordan, as compiled from the typhoid fever and remittent, etc. fever mortality of St. Louis by Farr's Formula, this table shows an increase in typhoid, but not such as would be characterized as an epidemic.

7327 An epidemic of typhoid fever, and especially a water epidemic of typhoid fever, is where the increase in typhoid fever amounts up to 100 per cent or more, and even 200, 300 or 400 per cent.

7328 The increase as there shown is, on the whole, a gradual increase such as you might expect would be due to local conditions, especially if wells were getting more and more filthy and were not condemned. The charts introduced in evidence do not show that there is any relation between typhoid fever in Chicago and typhoid fever in St. Louis.

7329 I think that there is no evidence so far as I can see from these figures that the drainage canal has had anything to do with the typhoid fever in St. Louis for the following reasons:

In the first place, as I have already stated, the distribution of typhoid fever in St. Louis as shown in these tables, is indicative of local contamination and spreading by contact rather than of any general water infection.

In the second place there are certain cities in the list that I have given here where the increase in typhoid fever has been more marked than in St. Louis, and in these cases notably that of Buffalo, the drainage of Chicago has been turned away from Buffalo rather than to it.

I think that there has been a gradual increase of typhoid fever throughout the country for the last few years, and the increase in St. Louis has been gradual. It has been slow and I do not think that there is any evidence from the figures that there has been any great contamination of the water supply of St.

Louis. There has been no explosive outbreak of typhoid fever there.

7330 Typhoid fever is sometimes spread by other means than that of drinking water, as is shown by the number of deaths that occurred, during the Spanish-American war, at Jacksonville, Florida.

7331 CROSS-EXAMINATION, by Mr. Corum:

The fact remains that typhoid fever may be scattered or contracted by the use of polluted drinking water.

7332 EBEN J. WARD, examined in chief by Mr. Todd:

Am civil engineer and have been since 1880. In 1890 and 1892 I made a cognizance of the Illinois river for the purpose of ascertaining the number of of acres that were inundated on the bottoms of that river. The flood of 1890 was what we would call an upper river flood. By that, I mean that as far as Peoria, the low lands were considerably inundated, but from Peoria down, the water was confined almost entirely to the channel proper of the river and slight rises along the bayous and inlets.

7333 That was in 1890. In 1892, there was a general overflow throughout the entire Illinois river, that is the river below Peoria, it overflowed practically from bluff to bluff. In 1890, below Peoria, the water was confined to the channel proper of the river, but in 1892 it overflowed from bluff to bluff, clear to the mouth of the river. The number of acres subject to overflow, from the eastern line of Grundy county to the La Grange dam is 200,000 acres, this being my estimate for 1892. Below there, I should estimate there would be 200,000 acres more, although I did not trace the water line on the map below the La Grange dam for 1892. I would estimate the land subject to overflow along the Illinois valley from Joliet to the mouth of the river, to be in the neighborhood of about 400,000 acres.

CROSS-EXAMINATION, by Mr. Corum:

There is one levee district now opposite Pekin, about one and a half miles long. There is one opposite Beardstown which is two or two and a half miles long, also one opposite Havana which is a couple of miles long. In 1892 there was a vast volume of water in there. The water was very high all over the country at that time. 1892 was an exceptional flood year.

7335 RE-DIRECT EXAMINATION. by Mr. Todd:

The levee of the Pekin Levee Co. was washed out in 1892. The several levee districts to which I have referred, do not withstand the flood of the Illinois river. The one opposite Beardstown is the best one I know of along the river and I believe it has broken once. From my knowledge of the Illinois river I do not know of any concerted movement to levy that river from its mouth to La Salle.

7336 LEONARD P. KINNICUTT, examined in chief by Mr. Todd:

Am director of the Chemical Department of the Worcester Polytechnic Institute, located in Worcester, Mass.

7337 (Gives educational qualifications.) Have made a special study of sanitary problems, beginning in the year 1882, which study I have continued from that time. I have made a special study of the analysis of water, both chemical and bacterial, and I am continually employed in making such determinations.

7338 I am acquainted with the physical conditions of the Chicago river, the drainage canal, the Des Plaines and the Illinois rivers, and the Mississippi river. In September of last year I passed through the drainage canal on a tug boat, which went as far down as Joliet, noticing the Des Plaines river. Took the train to Peru, then took the boat at Peru and journeyed down the river as far as St. Louis.

7339 Have made a special study of the problem of sewage disposal both in the United States and in England.

7340 (Witness describes a septic tank and the processes which take place in same.)

7341 Septic operation will take place, I believe, fully as well in an open tank as in a closed tank. As an illustration, I might state that at Birmingham, England, which has the largest installation of septic tanks—over 20 in number—all are uncovered. (Witness describes operations taking place in a septic tank built by him for experimental purposes.)

7342 As I passed along the sanitary canal in a tug boat from Chicago to Lockport, I took particular notice of the indications of the sanitary canal acting as a septic tank. Among the chief indications that it was so acting was that gas was being given off and I noticed bubbles of gas given off from the liquid as far as Lemont. After passing Lemont I noticed no further development taking place. The odor from parts of the sanitary canal, especially near Chicago, remind you of the odor from the septic tank. Further down there was the odor that you obtain where the effluent of a sedimentation tank passes over or is allowed to fall over rocks or passes over a dam.

I have prepared tables showing septic operations taking place in the sanitary canal. They are tables A, B, C, D and E and reproduced on pages 7344, 7345, 7346 and 7347. Table E being a table showing the action of a septic tank on the removal of substances contained in sewage, and reproduced on page 7348.

If analyses are made of the crude sewage, and of the
7349 effluent from the septic tank we find that as a rule the amount of free ammonia in the effluent is greater than in the sewage; that the amount of total or soluble albuminoid ammonia and of suspended albuminoid ammonia is less in the effluent than it is in the crude sewage; that the amount of nitrogen as nitrates and nitrites is very small in the effluent and as well as in crude sewage, but there is a reduction of nitrogen as nitrites and nitrates.

From the analysis that I have made showing the character of the water at Lockport and the character of the water in the canal at Kedzie avenue, these results indicate very strongly that the septic action has taken place during the passage of water containing sewage through this canal, as shown by the increase in free ammonia, the decrease in albuminoid ammonia, soluble albuminoid ammonia, also in the decrease in oxygen consumed, soluble and suspended; that the results agree in their general characteristics with results that have been obtained by the examination of crude sewage and the effluent from the septic tank in the various places that I have given in table E. The changes are exactly the same in character, the difference only being in amount.

This septic action has a purifying effect upon the sewage of Chicago as it passes through the drainage canal. It also renders the substances which still remain in the sewage more easily acted upon when the sewage enters the river, and it purifies the sewage by removing a part of the solid matter that was in the sewage, by throwing it down to the bottom of the canal and by the removal of part of the solid matter by changing it into gas.

7350 (Witness quotes from the report of Prof. Boyce, wherein he states that "experiments made in Manchester show that B. coli diminishes during the stay in the septic tank, and experiments conducted in the laboratory show that the septic tank liquid is inimical to B. coli and therefore to other more delicate bacteria." (Witness quotes from other authorities and then states:) I will say that my own opinion is that it diminishes the number of B. coli, and the more delicate pathogenic germs and that the total number of bacteria is diminished by ten or fifteen per cent.

7351 (Witness states what conclusions he draws from the presence of the different chemical elements when found by his determinations in water.) (This answer is an explanation of what the various chemical constituents, as found by chemical analyses, determine as to the past history and present condition of the water under investigation.)

7354 I have studied the chemical data prepared by Prof. Long and the chemical and bacterial data prepared by Prof. Jordan, Palmer, Burrill and Zeit heretofore introduced in evidence, also the tables introduced in evidence by these witnesses.

I have taken the analytical data as given by Professor Long in the Illinois State Board of Health, 1901, which are the results of his examinations of the water at the various stations from Chicago to Grafton on the Illinois river, both for 1899 and 1900.

(Witness compares tables No. 1 to 4, inclusive.)

7355 Table 5, Joliet, Illinois and Michigan canal: The distance of Joliet from Lockport is only four miles, and the results show that but little change has taken place in the sewage in its flow from Lockport to Joliet. The chief difference in results at this point from those obtained at Lockport, being due, in my opinion, to dilution by water of the Des Plaines river which at this point is mixed with the waters from the canal.

Table 7, Morris, Illinois river: The Kankakee river enters the Des Plaines river about nine miles above Morris and its diluting effect is shown by the reduction of chlorine from 85.49 to 61.8. The water of the Kankakee river is a much purer water than that of the Des Plaines river at the point of junction, and so the water of the Des Plaines is purified to a certain degree by dilution. That the organic matter in the water has begun to undergo decomposition, is shown by the decrease in free
7356 and albuminoid ammonia and increase in nitrogen as
nitrites and nitrates. There has also been a decided deposition of suspended matter, a large part of which was oxygen consuming substances, as the suspended oxygen consumed at Joliet is 10.59, while at Morris it is only 1.09.

Table 8, Ottawa, Illinois river: There has been a very decided change in the purity of the water in the river between Morris and Ottawa, a distance of about 24 miles. The chlorine shows that there has been very little dilution of the water of the river between these points, and the very decided decrease in free and albuminoid ammonia with increase if nitrogen as nitrites and nitrates shows that bacterial decomposition of the organic matter is rapidly taking place, changing the organic matter into mineral matter. There has also been a certain amount of deposition of suspended matter. Between Morris and Ottawa there is a dam, the Marseilles dam, I believe, but this would have little effect in the character of the water beyond bringing about the removal of suspended matter, there being, according to Prof. Palmer's results, dissolved oxygen in the water.

Table 10, La Salle, Illinois river: These samples were taken about 600 feet above the mouth of the Big Vermilion, and although there has been some dilution as shown by the reduction in chlorine, the very decided decrease in free and albuminoid ammonia with corresponding increase in nitrogen as nitrates and the decided decrease in oxygen consumed shows that during the stretch of river between Ottawa and La Salle the processes of purification have been very active.

7357 Table 12, Henry: The slight increase in chlorine would indicate a slight addition of sewage to the river, probably from La Salle and Peru, total population 20,000. There has, however, been only slight changes between.

Table 13, Peoria Narrows: The chlorine shows that there has been more or less dilution between Henry and the Narrows, but the great change has been in the removal of free ammonia and nitrogen as nitrites. This shows that the principal change between Henry and the Narrows has been the last process in the changing of the organic matters of sewage into mineral matter.

Table 14, Wesley City: The increase in all the above constituents, especially the free ammonia, albuminoid ammonia and oxygen consumed, shows that a large amount of organic matter has been added to the river between Peoria Narrows and Wesley City, a distance of only about six miles. This addition from my knowledge of the river, is from the town of Peoria, 50,000 inhabitants, with its large cattle sheds and distilleries.

Table 15, Pekin: The distance to Pekin from Wesley City is about ten miles, yet in this stretch, a great amount of purification seems to have taken place, much more than I should have expected. This is shown by the very great decrease in free and albuminoid ammonia, oxygen consumed, and increase in nitrites and nitrates. There is no marked dilution as shown by the amount of chlorine.

7358 Table 16, Havana: We see here, as at Peoria Narrows, the final changes of organic matter into mineral matter taking place.

Table 26, Grafton: The distance from Havana to Grafton is 119 miles. There is a dam between Grafton and Havana and the water of the river is diluted by the Spoon and Sangamon rivers, both of which enter the Illinois between Havana and Grafton. The water at Grafton, as shown by the analyses, has been so purified between Havana and Grafton that it now closely resembles the water at Peoria Narrows. It shows only in the chlorine and nitrogen as nitrates evidence of part pollution.

Table 21, Grafton on the Mississippi: The river differs greatly from the Illinois in the amount of chlorine it contains, 177 against 17.5, and while it contains a less amount of solid substances in solution than the Illinois, it contains a greater amount of suspended matter. The amount of organic nitrogenous matter and carbonaceous matter in the two rivers is about the same, as shown by the albuminoid ammonia and oxygen consumed.

I have also prepared tables from the results of Professor Long's analyses at the various stations from Chicago to Grafton, from June to October, 1900.

7359 Table 41, Chicago city water: These analyses would indicate that the water was not quite as pure in 1899 as 1900, but are results that would be obtained with a potable water.

Table 43, Western avenue bridge, drainage canal: If this is compared with the analyses of the water in the Illinois and Michigan canal in 1899 at Bridgeport, it is seen that it is a very much more dilute sewage, or sewage mixed with a much larger amount of water.

Table 44, Lockport canal: This analysis when taken in connection with table 43, as I have already pointed out, shows that the dilute sewage has undergone very decided changes in its passage through the canal.

Table 45, Joliet, Des Plaines river: This analysis shows that the water is not as pure as it has been up there, but when compared with the analyses made in 1899, shows that it contains very much less organic matter than it did at that time.

Table 46, Morris: The dilution by the waters of the Kankakee is here shown by the chlorine as in 1899. The water is very much purer than in 1899.

Table 47, Ottawa: There has been even more marked purification of the water in its run of 24 miles in 1900 than 1899, as shown by the reduction of free albuminoid ammonia, and oxygen consumed, and by increase of nitrites and nitrates. That there has been little, if any dilution, is shown by the chlorine.

The water is much purer than in 1899.

7360 Table 49, La Salle: The purification which was noted at Ottawa has continued. The chlorine shows the effect of slight dilution. River much purer than in 1899.

Table 51, Henry: The results similar to those obtained in 1899, the slight increase in chlorine, indicates the addition of the sewage of La Salle and Peru. Slight changes as regards organic matter. River purer than in 1899.

Table 52, Peoria Narrows: The change as was the case in 1899, is the decrease in free ammonia, albuminoid ammonia and nitrogen as nitrites. Water much purer than in 1899.

Table 53, Wesley City: The analyses show the addition of the sewage of Peoria.

Table 54, Pekin: As in 1899, a great amount of purification seems to have taken place between Wesley City and Pekin, a distance of 9 miles. River much purer than in 1899.

7361 Table 55, Havana: We have here in the 24 miles similar results to 1899, a very slight increase in free ammonia and in nitrates, and a slight decrease in albuminoid ammonia. Mackinaw creek enters the river above Havana.

Table 58, Grafton: The water between Havana and Grafton has been so purified that the nitrates and chlorine are the only indications of the pollution of the river at Peoria.

Table 59, Grafton on Mississippi river: The great difference in the Mississippi at Grafton from the Illinois at Grafton in 1900, as in 1899, was in the amount of chlorine, 2 against 10.6, and in the suspended matter. The Mississippi, as is shown by the albuminoid ammonia, and oxygen consumed contained in 1900 more organic matter than the Illinois in 1900 and figures for oxygen consumed show a greater amount of organic matter both in solution and suspension.

I have prepared a table from the chemical and bacterial analysis of Professors Jordan, Palmer, Burrill and Zeit, as they appear in Streams Examinations, which have been introduced in evidence in this case, and the tables of Professor Long as they appear in the Board of Health report of the State of Illinois, which also have been introduced in evidence in this case.

7362 The general method employed in making this table was to obtain the mean of the average of the analyses made by these various named persons during given periods of examination, as given in Streams Examinations, and the report of the State Board of Health of Illinois for 1901, which tables have already been introduced in evidence, and during times which were comparable with each other. In the examination of these tables I struck an average for similar periods in different years of the analyses, which tables have already been introduced in evidence and where that method was not pursued, my tables show it. These tables will be subsequently introduced in evidence. I have prepared tables 41 to 52 inclusive, which are the mean of Jordan's and Palmer's results, May to December, inclusive, 1899. These tables are reproduced on pages 7363 to 7368 inclusive.

7369 These tables were prepared by taking the average of the results of Professor Palmer and Professor Jordan, as given in Streams Examination, at the different places mentioned in each table. I have prepared a chart based upon the averages, of the chemical results in the tables of Professors Jordan and Palmer, which I have just introduced in evidence. The chart, with the caption "Mean results Illinois river, Chemical table, Jordan and Palmer, months of May to December, inclusive, of 1899, L. P. Kinnicutt," is reproduced on p. 7370.

7371 At Joliet the high free ammonia, the high albuminoid ammonia the high oxygen consumed, the low nitrites and low nitrates show that at this point we have a water very badly polluted by organic matter or sewage. The rapid decrease in the amount of ammonia, free ammonia and albuminoid ammonia, and the oxygen consumed, from Joliet to Morris, and at the same time the increase in nitrogen as nitrites and nitrates shows the amount of purification that has taken place between these places. The most active zone of decomposition seems to be in the neighborhood of Ottawa. This is shown not only by the falling curves denoting free albuminoid ammonia and oxygen consumed but by the rising curves denoting nitrogen as nitrites and nitrates, the nitrite curve reaching its maximum at this point. As we proceed down the river from Ottawa to La Salle the curve shows continued purification. The slight fall in the curve from nitrogen as nitrates being due to the removal of nitrates from the water by green plant life. From La Salle to Henry the curve for the free ammonia and nitrogen as nitrites still descend. The slight rise in the curve for albuminoid ammonia and oxygen consumed indicates a slight addition of organic matter to the water of the river between La Salle and Henry. Below La Salle the purification continues down

7372 to Averyville as shown by the gradual decrease of free and albuminoid ammonia, nitrogen consumed and nitrogen as nitrites.

At Averyville the chart shows, as was shown by Professor Long's table, the result of the final change of the organic to inorganic matter; low free ammonia; low free albuminoid ammonia; low nitrogen consumed with high nitrates. The results obtained by Long at Averyville from July 5th to November 25th, agree closely with the mean of Jordan's and Palmer's results from May to December, as is shown in the following table. (See table on page 7372.)

From Averyville to Wesley City we notice the effect of the contamination at Peoria by the rise in free ammonia, albuminoid ammonia, oxygen consumed and the decrease in nitrites and nitrates.

Jordan's and Palmer's results show less effect from this contamination than do Professor Long's analysis. This may be due to the possibility that at the point where Professor Long collected his samples, there may not have been complete mixing of the sewage of Peoria with the river water, or that where Palmer and Jordan's samples were taken there was not a complete mixing of the river water with the sewage.

Between Wesley City and Pekin the purification again begins and this purification is continued all the way down to Grafton where the low albuminoid ammonia, low nitrogen as nitrites, low oxygen consumed, shows the removal of the polluted matter entering the river at Peoria. If we again com-
7373 pare the results of Professor Long with the mean of Professor Jordan and Palmer we find a close agreement as regards the condition of the water at Grafton.

(See page 7373 for comparison referred to.) I have prepared tables based upon chemical analyses of Professor Jordan and Palmer for the months from January to June, inclusive, for 1900. The tables that I have prepared are numbered from 53 to 64 inclusive and are reproduced on pages 7374 to 7379, inclusive.

7380 I have prepared a chart from the tables just introduced in evidence, based upon the chemical results of Professors Jordan and Palmer. Such chart, with the caption, "Mean results ,Illinois river Chemical Table, Jordan and Palmer months January to June, inclusive, 1900, L. P. Kinnicutt," is reproduced on page 7381.

7382 From chart No. 2 just introduced, I draw the following sanitary conclusions:

At Joliet, the amount of free ammonia, albuminoid ammonia, oxygen consumed, is not half as great as in 1899, showing much less pollution of the water in 1900 than in 1899. There is, as in 1900, a rapid fall in the curves representing the amount of free ammonia, albuminoid ammonia, and oxygen consumed, in the stretch of river between Joliet and Ottawa, with corresponding rise in nitrogen as nitrites and nitrates, showing that the active zone of decomposition is as in 1899, in the neighborhood of Ottawa.

There is a slight increase in the oxygen consumed curve between Ottawa and La Salle. The albuminoid ammonia curve remaining nearly stationary, indicating a slight addition of organic matter to the water between Ottawa and La Salle. There is then a steady elimination of organic matter from the river down to Averyville, as shown by the gradual decrease of the curves for free ammonia, albuminoid ammonia, nitrogen as nitrites, oxygen consumed, with an increase of nitrogen as nitrates. The curve of free ammonia does not rise between Averyville and Wesley City, but the rise is noticed between Wesley City and Pekin. This may be due to the fact that the decomposition of the nitrogenous matter did not begin quite as quickly in 1900 as in 1899. The slight delay, a delay represented by about nine miles on the river, being probably caused by the lower temperature of the water in the winter and spring months of 1900, and it is also to be noted that the increase in the albuminoid ammonia curve continues down to Pekin, while in 1899 the decrease began between Wesley City and Pekin. From Pekin to
Havana, there is a gradual decrease in the organic nitro-
7383 genous matter, as shown by the free ammonia and albu-
minoid ammonia curve. From Havana to Kampsville the free and albuminoid ammonia increased very slightly and then decreased to Grafton. The nitrogenous nitrites and the oxygen consumed also rise slightly from Havana to Beardstown, then decrease between Beardstown and Grafton. The nitrogen as nitrites increased continuously from Havana to Grafton. The purification of the river from Havana to Grafton is indicated on the curves by the gradual increasing amount of nitrogen as nitrates. The decrease in free ammonia and albuminoid am-

monia not being so evident on account of spring thaws and freshets.

Taking the two charts together—No. 1 and No. 2—I draw the following sanitary conclusions:

The curves on the chart representing the river from June to January, 1899, closely resemble the curves given on the chart representing the river from January to June, 1900, showing that the general character of the purification that took place is the same for the two years, the small differences being chiefly due to the effect of dilution and to seasonable variations that take place in the river. Both charts show by the rapid decrease of free ammonia, albuminoid ammonia and oxygen consumed, and increase of nitrogen as nitrites and nitrates, the purification that takes place between Joliet and Ottawa, in both years, and that the zone of the most active decomposition of organic matter has not been shoved, or been pushed further down the river by the increasing volume of the river, due to the opening of the sanitary canal. The purification is then shown to continue in both years as the river flows to Averyville, as shown by the decrease in the free ammonia, albuminoid ammonia, oxygen consumed and nitrogen as nitrites. The chart for June to January, 1899, shows by the slight increase in albuminoid ammonia and oxygen consumed between La Salle and Henry that a certain amount of organic matter enters the river at this point, but the
7384 continued decrease of free ammonia and nitrogen as nitrites
indicates that it is either not very large in amount, or of a character not easily decomposed. In both periods between La Salle and Henry, the nitrogen as nitrites shows a slight decrease, the nitrogen as nitrates also decreasing. The decrease of nitrogen as nitrates at this point is probably due to algae or green plant life. Between Henry and Averyville, the nitrogen as nitrites still decreasing, the nitrogen as nitrates shows an increase more marked between January and June, 1900, than between June and January, 1899. The reason for less increase in nitrogen as nitrates between Henry and Averyville between June and January than between January and June, is due to the larger

amount of green plant life living in river waters in the summer and autumn months, than in the winter and spring months. The rise in free ammonia, albuminoid ammonia, and oxygen consumed, between Averyville and Wesley City show the pollution which enters the river between these two points in both years, which is removed in both years, as shown by the decrease in these substances as the river flows downward to Grafton. The river in both years, as shown by the curves, purifies itself again between Wesley City and Grafton, as it did between Joliet and Averyville.

The slight rise in free and albuminoid ammonia between Beardstown and Kampsville from January to June, 1900, is probably due to seasonal variations, as the river and pond waters contain more free albuminoid ammonia in the winter and spring than at any other time. In the lower stretches of the river in 1899 we find by the charts decreasing nitrites and nitrates; in the chart for 1900, we find, however, that while the nitrites decrease, the nitrates increase. This difference in nitrates in the lower stretches of the river is due to green plant life. This green plant life being more abundant in the summer and autumn months of 1899 than in the winter and spring months of 1900, removed, therefore, the nitrates to a much larger extent in 1899 than in 1900.

I have prepared a chart based upon the bacterial tables of Professors Burrill and Jordan for the months of May to December, inclusive, for 1899.

7385 The chart, with the caption, "Mean results, Illinois river, Bacterial Table, Burrill and Jordan," Months of May to December, inclusive, 1899, L. P. Kinnicutt, is reproduced on page 7386.

7387 The study of this chart, in connection with the chart for the chemical data of the same period, show a striking agreement between the chemical and bacterial data. The bacteria, which number over 1,000,000 per c.c. at Joliet, decrease very rapidly to La Salle. In this distance, of about 62 miles, the number has fallen from 1,000,000 to 17,412 per c.c. This shows, as did the chemical results, that the zone of the greatest purification is near Ottawa. There is a slight rise in the number of bacteria of only 2,000 per cubic centimeter between La Salle and Henry, a rise coinstant with the rise for albuminoid ammonia in the chemical chart for the same period. From this point the number falls steadily until Averyville is reached, the number there being 4,756 per cubic centimeter. Then on account of the pollution entering the river at Peoria, the number rises immediately to 995,503. This sudden rise in the number of the bacteria shows how quickly sewage pollution can be detected by bacterial examination. From this point the number of bacteria rapidly falls and at Kampsville there are only 7,457 per cubic centimeter, showing the great amount of purification that has taken place between Wesley City and Kampsville. Between Kampsville and Grafton there has been, as was the case between La Salle and Henry, a very slight increase in the number of bacteria, 2,005 per cubic centimeter. This increase is not at all significant, as a slight increase at this point, after the rapid decrease between Wesley City and Kampsville is absolutely without significance as regards the problem of stream purification.

7388 I have prepared a chart based upon the bacterial tables which I have prepared from tables of Professors Burrill and Jordan, already introduced, for the months of January to June, 1900. The chart, with the caption, "Mean results, Illinois river, Bacterial tables, Burrill and Jordan, months January to June, inclusive, 1900, L. P. Kinnicutt," is reproduced on page 7389.

7390 This chart shows the amount of bacteria at Joliet to be about 900,000 per cubic centimeter, falling to 110,000 at Ottawa, showing that the greatest amount of purification took place, exactly as it did in 1899, in the neighborhood of Ottawa. Between Ottawa and La Salle there is a slight increase in bacteria, corresponding to the slight increase in the oxygen consumed, as shown in the chart representing the chemical data for this same period. From Ottawa to Averyville the number of bacteria rapidly decreases until at Averyville one cubic centimeter contains about 45,000 bacteria. At Wesley City there is an increase in bacteria amounting to 60,000 and which continues to increase until Pekin is reached. This increase, due to pollution, was shown in the curve for albuminoid ammonia, in the chart representing the chemical curves for the same period. The rapid purification in the spring months does not begin until after the river passes Pekin. From Pekin to Havana the curve falls rapidly, showing that great purification has taken place. From Havana to Beardstown there is an increase in bacteria, followed by a quick decrease, the number at Kampsville being only about 40,000. From Kampsville to Grafton there was, as in 1899, a slight increase in the number of bacteria, but the number at Grafton is less than at Averyville, showing the removal of the polluting material entering the river at Peoria. As was to be expected, the number of bacteria in the lower stretches of the river, as shown by this curve, is greater during the summer and autumn months of 1899, than in the spring months of 1900. The soil bacteria washed into a stream during the late winter and early spring months, always increases largely the number of bacteria in a river during that period.

7391 I have prepared tables showing comparisons of the sanitary character of the tributaries of the Illinois river, based upon the chemical results at their mouth, with the Illinois river at Grafton, based upon the tables of Professors Jordan and Palmer, for the months of June to December, inclusive, 1899. These tables were prepared in the same manner as the other tables I have introduced. Tables numbered from 65 to 72 inclusive, are reproduced on pages 7391 to 7395 inclusive.

7395 I have prepared a chart based on the tables which I have just introduced. The chart, with the caption, "Mean results, Comparison of the Sanitary Character of the Tributaries of the Illinois river at their mouths, with the Illinois river at Grafton, Professors Jordan and Palmer, months of June to

December, inclusive, 1899, is reproduced on page 7396 of record.

7397 The chart requires very little explanation, as it is seen by the eye, that the waters of the Des Plaines, the Kankakee, the Fox at their mouths, the Mississippi at Grafton, the Missouri at West Alton, contained in 1899 as much or more albuminoid ammonia and oxygen consumed than the Illinois at Grafton. The higher nitrogen as nitrates in the Illinois river, shows that the Illinois river at Grafton contained at one time higher up on the stream more organic matter, which has undergone decomposition, than did the other rivers. The free ammonia and nitrogen as nitrites is slightly higher in the Illinois at Grafton than in these other streams mentioned, with the exception of the Sangamon, but the amount in the Illinois is low, about 0.23 parts free ammonia and 0.047 parts nitrogen as nitrites, and is without any particular significance. As regards the purity of these streams, as shown by chemical charts and data, and by these curves, I should say that the waters of these various rivers were about in the same condition in 1899 as the Illinois river at its mouth, with the exception of the Missouri river at West Alton, which contains more organic matter.

7398 I have prepared a bacterial chart from the same tables which I have just introduced, based upon the results obtained by Professors Jordan and Burrill, for the months of June to December, 1899. The chart, with the caption, "Mean results, Comparison of the number of bacteria in the tributaries of the Illinois river, at their mouths, with the Illinois river at Grafton, Burrill and Jordan, months of June to December, inclusive, 1899, L. P. Kinnicutt, is reproduced on page 7399 of record.

7400 This chart shows that the Des Plaines river at its mouth contains about 6,000 more bacteria per c.c. than the Illinois river, at Grafton, while the Missouri river, at West Alton, contains about 7,000 more bacteria per cubic centimeter than does the Illinois at Grafton, the Kankakee, the Big Vermilion and the Sangamon rivers, from one to 2,000 less bacteria per cubic centimeter than the Illinois river at Grafton, while the Fox, and the Mississippi at Grafton, about four thousand fewer bacteria to the c.c. than the Illinois at Grafton.

As to the condition as shown by the number of bacteria, the Des Plaines and the Missouri would seem to be in a less satisfactory condition, and the Fox and the Mississippi rivers at Grafton in a slightly better condition than the Illinois at Grafton from May to December, 1899. There appears to be not any great difference in this respect as regards the condition of the Kankakee and the Sangamon rivers, at their mouths, and the Illinois river at Grafton.

I have prepared tables based upon the mean results of Professors Jordan and Palmer of the tributaries of the Illinois river at their mouths with the Illinois river at Grafton for the months of January to June, inclusive, 1900.

These tables are numbered 73 to 80 inclusive, and are reproduced on pages 7401 to 7405, inclusive.

7405 I have prepared a chart based on the tables just introduced. The chart, with the caption, "Mean results comparison of the sanitary character of the tributaries of the Illinois river at their mouths with the Illinois river at Grafton, Jordan and Palmer, months January to June, inclusive, 1900, L. P. Kinnicutt," is reproduced on page 7405.

7407 This chart shows that the Mississippi at Grafton and the Missouri at West Alton contained from January to June, 1900, more albuminoid ammonia and oxygen consumed than the Illinois river at Grafton, that the Des Plaines, Kankakee and the Fox contained nearly the same amounts and the Big Vermilion and the Sangamon rivers at their mouths less amounts. Or, in other words that the Mississippi at Grafton and the Missouri at West Alton contained more undecomposed organic matter than the Illinois at Grafton; that the Kankakee and the Fox contained about the same amounts and the Big Vermilion and the Sangamon less undecomposed organic matter. The free ammonia in all the streams is higher than in the autumn of 1899, but the relative ratios is not greatly changed, and in the autumn of 1899 as in the spring of 1900 the Illinois at Grafton contained more free ammonia than its tributaries. The nitrogen as nitrites is much less in the Illinois at Grafton in 1900 than in 1899, .027 parts against .047 parts, while the amount in the Mississippi, the Missouri, the Des Plaines and the Big Vermilion is about the same in the two different parts of the year.

I have prepared charts comparing the number of bacteria in the tributaries of the Illinois river at their mouths with the Illinois river at Grafton, based upon the bacterial results of Burrill and Jordan for the months of January to June, inclusive, 1900, as they appear in the tables 73 to 80, inclusive, which have just previously been introduced in evidence.

7408 The chart, with the caption, "Mean results, comparison of the number of bacteria in the tributaries of the Illinois river at their mouths with the Illinois river at Grafton, Burrill and Jordan, bacteria per c.c. of water for the months of January to June, inclusive, 1900, L. P. Kinnicutt," is reproduced on page 7409.

7410 This chart shows that the Missouri contained more bacteria during these months than the Illinois at Grafton. The other rivers all contained a less amount per c.c. than the Illinois at Grafton. The difference in this respect between the Mississippi at Grafton and the Illinois at Grafton, however, is not great. The bacterial contents of the rivers is 3 to 4 times greater than during the period in June to January, 1899. This was to be expected as this chart shows the number of bacteria during the late winter and spring months, during which period a greater number of saprophytes or soil bacteria are brought into into the river by thaws and spring freshets, and on this account the total number of bacteria does not give as good an idea as to the sanitary character of the water of the rivers as the chart in the autumn months.

I have prepared tables based on the chemical results of Professors Jordan, Long and Palmer for the months of May, June, July and August, for the years 1899 and 1900. (Witness states how these charts were prepared and what was taken into consideration in preparing the same.

7411 In accordance with the above description I have obtained the tables 1 to 24, inclusive, which give the mean of Jordan's, Long's and Palmer's results for May, June, July and August, 1899, being tables 1 to 12, inclusive, and the mean of Professor Jordan's, Long's and Palmer's results for May, June, July and August, 1900, being tables 13 to 24, inclusive.

Said tables are reproduced on pages 7412 to 7423 inclusive.

7424 I have prepared two charts of the tables just read in evidence, No. 1 to 24, inclusive. The two charts, with the caption, "Mean results, Illinois river, Chemical Table, Jordan, Long and Palmer, months of May, June, July and August of years noted, L. P. Kinnicutt," are reproduced on pages 7425 and 7426.

7427 Taking the two charts together, I draw the following sanitary conclusions from same:

The resemblance of the various curves for 1899 and 1900 show that the general process of purification took place in the same way after the opening of the canal as before it was opened. It is also to be noted that with the exception of the curves representing suspended solid matter, suspended oxygen consumed and nitrogen as nitrates, that the curves for 1900 are below the curves for 1899, showing that in 1900 a given volume of the river contains less organic impurities than in 1899.

To go more into detail in regard to these data, it is seen that the curves for the total soluble and suspended matter fall between Joliet and Morris, and that this fall is more marked in 1899 than in 1900, on account of the large amount of solid matter contained in the river in the former year. Between Morris and Ottawa there is very little change as regards the solid substances in the river. Also between Ottawa and La Salle the curves for total solids and soluble solids show that there is comparatively little change in the amount of these substances between these two places. The curve for 1899 for suspended solids

rises between Ottawa and Henry and the curve for 1900 for suspended solids rises between La Salle and Henry, both curves falling again between Henry and Averyville. Between Avery-
ville and Wesley City the curves in both years show an
7428 increase in the solid matter in the river. It is shown from
the curve representing albuminoid ammonia to be of an animal and vegetable character.

From Pekin to Grafton the curves show very little increase or decrease in total substances in the river, but the curves for solid substances while showing little change for 1900 shows a slight decrease in 1899. In both years the curves show an increase in the suspended matter in the lower stages of the river, but that this matter is mineral rather than organic is shown by the curve representing oxygen consumed, which runs almost a straight line from Havana to Grafton. The curve representing oxygen consumed shows a large amount of organic matter at Joliet which they show is removed to great extent in both years before the river reaches Morris.

Between Averyville and Pekin the rapid rise in these curves shows an increase in organic matter between these points, and the decrease in the curves between Pekin and Grafton shows a removal of organic matter taking place in exactly the same way in both years.

The curves representing the free and albuminoid ammonia show a very large amount of organic matter in both years at Joliet, a sharp decrease to Ottawa and then a gradual decrease to Averyville.

The curves, especially the curve representing the albuminoid ammonia rises slightly between Averyville and Pekin, showing the effect of a pollution at Peoria, and then both gradually falling until Grafton is reached, where the minimum amount of both free and albuminoid ammonia is shown by the curves to be present.

The nitrogen curves, especially the nitrogen as nitrites, show that the zone of greatest decomposition in the upper stages of the river, in both years, is in the neighborhood of Ottawa, and

that the added volume due to the opening of the sanitary canal has not pushed this zone of decomposition further down the river. Beyond Averyville the rapid rise in the curve for free albuminoid ammonia, nitrogen as nitrites, and the decrease in the curve for nitrates, show the addition of polluted waters in both years at Peoria. This, as shown by the curves is
7429 more marked in 1899 than in 1900. The effect of this pollution is shown by the curves to extend to some degree to Havana, but at Grafton, the only curve to show that the water has been polluted at Peoria, is the nitrogen as nitrates.

The curves also show that a given volume of the river water contained less organic nitrogenous matter in 1900 than in 1899.

The chlorine curve gives an idea of the amount of dilution that took place in the flow of the river from Joliet to Grafton.

I have prepared a chart based upon the bacterial results of Professors Zeit, Burrill and Jordan as contained in the tables 1 to 24 inclusive, already introduced into evidence.

Chart with the caption, "Mean results, Illinois river, bacterial table, Zeit, Burrill and Jordan. Months of May, June, July and August of the years noted. L. P. Kinnicutt," is reproduced on page 7430.

7431 From this chart, I draw the following sanitary conclusions:

Both curves show a great number of bacteria per c.c. at Joliet. They then show a great decrease between Joliet and La Salle, a distance of 65 miles. The curves for 1899 show that between La Salle and Henry the number of bacteria increase rapidly, owing principally to the sewage of La Salle and Peru, but decrease almost as rapidly between Henry and Averyville.

The curve for 1900 shows also a slight increase from bacteria between La Salle and Henry and also a further increase between Henry and Averyville, due probably to some local cause. Between Averyville and Wesley City the two show an increase of bacteria in both years, greater, however, between Wesley City and Pekin, in 1899 than in 1900. In both years the curves show a very great decrease between Wesley City and Havana, a distance of 40 miles, and the decrease continued though not so rapidly between Havana and Beardstown.

The curve for 1900 shows this decrease continues to Kampsville, while the curve for 1900 shows a rise between Beardstown and Kampsville. In both years they show an increased number between Kampsville and Grafton. The curve shows only three places in the river where the bacteria was greater in 1900 than in 1899, namely, at Averyville, Havana and Beardstown. The number of bacteria at Grafton is shown to be about 6,000 less per c.c. in 1900 than in 1899.

I have prepared tables based on the analytical data of Professors Jordan and Palmer, on the tributaries of the Illinois river at their mouths, with the Illinois river at Grafton, for the months of May and June, 1899 and 1900. These tables are numbered 25 to 40 inclusive, and are reproduced on pages 7432 to 7440, inclusive.

7440 These tables were prepared in the same manner as the other tables referred to. I also prepared a chart based on the tables just read in evidence.

The chart with the caption, "Mean results, comparison of the sanitary character of the tributaries of the Illinois river at their mouths, with the Illinois river at Grafton, Jordan and Palmer, months of May and June, 1899 and 1900, L. P. Kinnicutt, reproduced on page 7441.

7442 The chart just introduced shows in the first place that the Illinois river at Grafton contains much less organic impurity in May and June, 1900, than it did in the corresponding months of 1899. The nitrogen as free and albuminoid ammonia, nitrogen as nitrites and the oxygen consumed was less in these months of the year 1900 than the corresponding months of 1899. With the exception of the Big Vermilion all the tributaries to the Illinois and the Mississippi at Grafton contain more nitrogenous organic and easily oxidizable matter during May and June, 1899, than did the Illinois at Grafton during the same months. It is also seen to be the same for 1900, that is during May and June of 1900, excepting the Big Vermilion all

the tributaries to the Illinois and also the Mississippi at Grafton and the Missouri at West Alton contained more nitrogenous organic and easily oxidizable matter than did the Illinois at Grafton during the same period. The chart also shows that during June, 1899, the Illinois contained more nitrogen as free ammonia, than did its tributaries during the same months, but during May and June, 1900, it is seen that it contains less
7443 than the Des Plaines, the Kankakee, the Fox and the Big Vermilion and practically the same amount as the Missouri.

In May and June, 1899, the Illinois contained more nitrogen as nitrites than any of its tributaries excepting the Fox and the Sangamon.

In May and June, 1900, it contained less than the Big Vermilion, the Sangamon nad the Des Plaines.

I have prepared a chart based upon bacterial results of Professors Burrill and Jordan for the months of May and June, 1899 and 1900 which results are in the tables which I have just introduced. Said chart is reproduced on page 7444 of the record.
7445 This chart shows that the Illinois river at Grafton during the months of May and June, 1899, contained over 10,000 more bacteria per c.c. than during the same months of 1900. It also shows that the Illinois river at Grafton, during the months of May and June, 1899, contained more bacteria per c.c. than did any of its tributaries, and more than the Mississippi at its mouth, during the same months.

During May and June of 1900, the Illinois river at Grafton contained, excluding the Fox river, not only less bacteria per c.c. than any of its tributaries, less than the Mississippi at Grafton and the Missouri at West Alton, during the same months in 1900, but also contained a less number of bacteria than did any of its tributaries with one exception, the Big Vermilion, during the corresponding months of 1899. The Missouri at West Alton is shown by the chart to contain over 40,000 more bacteria per c.c. during May and June, 1900, than the Illinois at Grafton. The Illinois at Grafton containing only 8,740 per c.c.

There were no data from which the number of bacteria contained in the Missouri at West Alton in May and June, 1899, could be determined. The Missouri at West Alton during the months of May and June, 1900, was from bacterial representations, much more polluted than the Illinois at Grafton.

7446 The reason that I took the mean was because it is my opinion that in taking a mean of the analytical data obtained by the various observers at the various stations on the Illinois river more accurate information can be obtained of the changes that take place in the river than by studying the data of any one person.

Further, I did this because it is a method commonly employed in all scientific investigations, as for instance what are now considered as the figures representing the correct amount of hydrogen and oxygen in water were obtained not from the results of a single observer but by combining the data of many different experiments made by many different observers.

The tables and charts which I have offered in evidence show that the sewage of Chicago, as it enters from the sewers into the drainage canal undoubtedly contains a small amount of oxygen and the first action that takes place is undoubtedly anaerobic action in which part of such substances like urea are decomposed, ammonia being given off. The action in the sanitary canal is an anaerobic action, or very similar to that which takes place in the septic tank. By this action about 20 per cent of the organic matter as measured both by the loss in the albuminoid ammonia and by the loss in oxygen consumed is removed

7447 from the sewage. Also a certain amount of suspended matter is removed and a certain amount of suspended matter has been rendered soluble and a certain amount has been converted into gases and into simpler products.

By this action the sewage is not only purified, but changed so that further purification will take place more easily. The next stage in the purification is the aerobic stage. Undoubtedly in the upper stretches of the river near Joliet we have both aerobic and anaerobic action taking place. Further down as at Ottawa we have principally an aerobic or nitrifying action. At about this point both in 1899 and 1900 is the zone of greatest decomposition. From this point the action, in my opinion, is entirely anaerobic or nitrifying action continued purification going on until we come to Averyville.

Between Averyville and Wesley City the tables and diagrams that I have made show that a large amount of organic polluted matter is added to the river. At Pekin or between Peoria and Pekin, we have also again more or less anaerobic action with aerobic action taking place.

The purification continues and between Pekin and Havana the action that takes place is aerobic or a nitrifying action. The aerobic purification then goes on until at Grafton, all the original organic matter which was in the sewage at Pekin has been decomposed and changed.

The effect of emptying the sewage of Chicago into the drainage canal into the Des Plaines river at Joliet and then into the Illinois river is to increase the amount of organic matter in the upper stretches of the river.

The effect, however, of adding this organic matter to the upper stretches of the river is not noticed at Averyville except in the increased nitrogen contents of the river and the high chlorine and the same can be said at Grafton, at the mouth of the Illinois river. At that point the effect of the addition of the sewage to the Illinois river is seen only in the high chlorine and the nitrogen as nitrates. This nitrogen content of the
7448 river is very different from the nitrogen content of the
river at or above Ottawa. It is nitrogen which has been changed over and over again from the original character in which it occurred at Joliet. How this change takes place I have tried to show in my description of the nitrogen cycle. These charts also show that the purification of the river in the two years took place exactly in the same way and also that the river at all points was purer during May, June, July and August in

1900 than in 1899. My opinion is, as has been shown by my answers to the previous questions, that I believe that the sewage of Chicago is entirely decomposed before Grafton is reached, and that the only effect that we perceive in the river at Grafton, is the nitrogen contents and in high chlorine. The nitrogen contents and the chlorine, such as are found in the river at Grafton, are not in themselves elements dangerous in the slightest degree, to public health. They have, so far as we know, absolutely no effect upon the human system. I have studied the coli determinations as given by Professor Jordan in Streams Examinations, also his coli determinations made in 1901, and introduced in evidence in this case. I have acquainted myself with the experiments made upon the viability of the typhoid germ by Professors Jordan, Zeit and Russell.

7449 Taking into consideration all the data that I have presented and all the data that I have studied regarding the Illinois river, and assuming that you mean by deleterious matters any matters that were in the sewage of Chicago that were deleterious to human health, and by infectious matter that you mean typhoid bacilli, I do not believe that they reach down the Illinois river as far as Grafton.

My reasons in full for this answer are that in my opinion all of the deleterious substances which may have been considered to have been contained in the Chicago sewage meaning by deleterious substances not bacterial life, have been entirely decomposed and rendered absolutly harmless long before
7450 the river reaches Grafton, and that the infected matter, meaning by that typhoid bacilli, which enters into the drainage canal from the sewage of Chicago would not survive the passage from Chicago to Grafton.

All of the data that I have presented show that the Illinois river at Grafton does not contain undecomposed matter derived from the sewage of Chicago and it is my opinion that the typhoid bacilli from Chicago would not survive the journey from Chicago to Grafton, and therefore it is my opinion that the

water of the Mississippi river west of the center of the main channel of said river below the mouth of the Illinois river and down to the intake tower of the St. Louis water works at the Chain of Rocks, is not less valuable for drinking purposes and not more liable to carry water-borne diseases, such as typhoid fever and cholera, now than it was before the sewage from the sanitary district of Chicago was run into the drainage
7452 canal. My opinion is that the typhoid fever could not live for weeks or months or even years in gradually diminishing numbers in a sewage polluted stream, for all the experiments with which I am familiar show that the typhoid germ will live a less time in a polluted water than in a pure water.

From the experiments that have been made I do not believe that the typhoid bacilli would live until it entered the slack waters at Peoria, and even assuming that it would survive the passage from Chicago to Peoria, and be deposited in the bed of Lake Peoria for a period of a month, I do not believe that it would live for a period of a month in such a deposit, and in this connection I would like to call attention to the experiments made by the Massachusetts State Board of Health, which are reported in the 34th Annual Report of the Massachusetts State Board of Health in which the experiments of Mr. H. W. Clark and Stephen DeM. Gage are given.

(Witness refers to experiments made by investigators in reference to the viability of bacilli coli, in order to sustain the above answer.)

From all the data that I possess and from all the knowl-
7453 edge that I have acquired regarding the life of the typhoid bacilli, I do not think it is possible that the waters leaving Lake Peoria would contain at times more infectious and dangerous pollution than is at present in the polluted sewage entering at the Bear Trap dam at the foot of the drainage canal.

I am very firmly of the opinion that the waters of Lake Peoria can not at any time contain as much infectious and dangerous material, as the waters at Bear Trap dam, and I know absolutely of no data that would warrant any such assumption.

Knowing the character of the Illinois river and bearing in mind the amount of sedimentation, the amount of dilution and the amount of purification that occurs between Chicago
7454 and Grafton and especially bearing in mind the time element, I do believe that the time interval would render the Mississippi river water at all times free from liability of producing water-borne diseases from pathogenic bacteria entering the Illinois river by way of the drainage canal. It being my opinion that typhoid fever bacilli from Chicago entering the Illinois river do not survive the journey from Chicago to Grafton.

7455 I can find no evidence that shows that the typhoid bacilli does or can pass from Chicago out into the Illinois river, thence to the Chain of Rocks and the intake tower at St. Louis.

From all the data that I have studied, and from all the knowledge that I have been able to obtain regarding the Illinois river I find not the slightest evidence that the Illinois river, containing the mixed sewage and canal water from the Chicago drainage district since the opening of the drainage canal renders the waters of the Mississippi river below the mouth
7456 of the Illinois river less safe and wholesome than it was before the opening of the canal, for drinking purposes on the part of the inhabitants of Missouri.

From various experiments that have been made it has been shown that the vitality of the typhoid bacilli is greater in pure water than in water polluted by sewage, and basing my opinion on these facts, it is my opinion that the sewage from Chicago does not favor the longevity or growth of germs from Peoria or anywhere else emptying their sewage into the Illinois river.

7457 It is absolutely necessary to employ both chemistry and bacteriology, and it is impossible to form a correct judgment as to the quality and the potability of a water without the aid of both of these sciences.

From all the tables that I have studied and the various analyses that have been made upon the waters of the Illinois river, all indicate that the zone of the greatest decomposition in both 1899 and 1900, before and after the sanitary canal was opened in the upper stretches of the river was in the neighborhood of Ottawa. In the lower stretches of the river there is in both years another zone of decomposition somewhere between Pekin and Havana.

7459 From my knowledge of the Illinois river, flowing as it does at high water over a very large amount of territory, and the fact that the river is studded with lakes, nearly all the way from Upper Peoria to its mouth, I do not believe that even at the different stages of water of the Illinois river, the sewage from the city of Chicago, passing through the drainage canal into the Illinois, at different seasons of the year, would be a danger or a menace to the inhabitants of Missouri and the citizens of the city of St. Louis, using the water of the Mississippi river at the intake tower, at the Chain of Rocks.

From the chemical and bacterial analyses introduced in evidence by Professors Long, Palmer, Burrill and Jordan, together with my study of the tables and charts that I have prepared and introduced as evidence, it is my opinion that the Mississippi and the Illinois rivers practically contain about the same amount of impurity, while the Missouri river contains a larger amount of impurity than either of the other two rivers named.

7460 It is my opinion as a sanitary expert and with a knowledge of conditions that obtain in and along the Illinois river, and from the evidence that has been submitted in this case, that such infected matter or pathogenic germs which come into the drainage canal from Chicago, do not reach as far down the Illinois river as the city of Grafton.

7461 In my opinion, the only effect the pollution and contamination from the sewers of Chicago, entering into the Chicago river, thence into the drainage canal, that could be noticed at the Chain of Rocks on the Mississippi river, is a higher chlorine and nitrogen contents of the river.

7462 It is a well known fact that the larger amount of surface over which the water spreads, the greater will be the amount of deposition, consequently the increased water at flood times, causing a larger area of land to be overflowed along the Illinois river, would tend to cause a greater deposition of the suspended matter coming from the sewage of Chicago and entering the Illinois river through its canal.

From the examinations that have been made, and the finding of the coli bacilli in the majority of one cubic centimeter samples, I do not believe that the Mississippi river at the Chain of Rocks was prior to 1900, a safe and potable drinking water, fitted for domestic and drinking purposes in its raw state. Same as to the Illinois and Missouri river waters.

7463 It is my opinion all the examinations that I have studied, as well as my own tables and charts show, that the waters of the Illinois river at Grafton are in a purer state since the opening af the drainage canal.

They are certainly not less sanitary than the waters of the Mississippi river, and they are in a better sanitary condition, as shown by the bacterial and chemical analyses than the waters of the Missouri river.

AT STAFFORD HOTEL, BALTIMORE, MD., March 26, 1904.

7465 WILLIAM S. THAYER, Examined in chief by Mr. Todd:

7466 Am a physician. Reside in Baltimore. I am one of the physicians in chief of the Johns Hopkins Hospital Dispensary, associate in medicine at the Johns Hopkins Hospital, associate professor of medicine in the Johns Hopkins University and visiting physician to the Union Protestant Infirmary. Have given special study to the so-called germ fevers in regard, particularly, to malarial and typhoid fever. (Gives clinical diagnoses of typhoid fever.)

7469 I published a number of papers prior to 1900 and in that year I published a test book, "Lectures on the Malarial Fevers."

7470 (States what is malarial fever and its clinical diagnoses.)

7471 The only known way by which malaria can be carried is by the bite of a mosquito.

7473 (States what intermittent, remittent, typho-malarial, congestive and simple continued fevers are.)

7475 Remittent, intermittent, typho-malarial, congestive and simple continued fevers are not distinct types of disease and are not so recognized by bacteriologists and clinicians. They are simply terms describing symptoms. When these terms appear in vital statistics as applied to fevers, I should regard them as representing, in the vast majority of cases, typhoid fever. (Table showing deaths from typhoid fever in one column and from remittent, etc. fevers, in another column from 1890 to 1903, inclusive, in the city of St. Louis, read to witness.) I should say unquestionably that the deaths reported as occurring from typhoid fever alone in the city of St. Louis do not properly represent, in my opinion the total number of typhoid deaths actually occurring in that city.

7476 I should say in the first place that a considerable personal experience with cases in which these very diagnoses have been made, has shown me that in almost every instance they represent typhoid fever. I should say furthermore that in an experience of fourteen years in the Johns Hopkins Hospital—I have never made, and I know that there does not stand on the books a single diagnosis such as appears in the list which you gave of the remittent, typho-malarial fever and so forth; and further from the fact that the deaths from malarial fever itself in this city and in this neighborhood which is a malarious neighborhood, occur in extremely small proportion as compared with those of typhoid fever—I should say that in view of all these facts as well as in view of the fact that in other cities in which these diagnoses used to be made, they have now been abandoned entirely, these cases all being classed as typhoid fever—in view of all those facts I should feel perfectly certain in my own mind that the great majority of those cases represent typhoid fever.

7477 I should attribute the failure of those statistics to properly disclose the number of typhoid deaths occurring in St. Louis, to wrong diagnoses made by physicians in reporting deaths. (Witness states why doctors employ the terms "remittent, etc. fevers" for fevers that are recognized as being either typhoid or malarial.) (Witness compares statistics of typhoid malarial fevers in the cities of New York, Brooklyn, Philadelphia and Baltimore.)

7482 As one compares these statistics with the statistics of St. Louis, it will be found that those of Brooklyn show at certain times even a larger proportion of the so-called malarial fevers than were present in St. Louis, but that the same change has taken place here as has occurred in St. Louis—the diagnoses of malaria have diminished, and the diagnoses of typhoid fever relatively increased.

I should say that a perfectly safe estimate would be at least seven-eights of the deaths reported under the heading of remittent, etc. fevers, which should be placed in the column of typhoid deaths.

If one desired to get the relevant frequency of typhoid fever from year to year I think that the adding together of the two columns would give as correct an idea as any other method.

It is recognized by all competent observers that reporting deaths to the Health Department by placing typhoid fever in one column and remittent, etc. fevers in another, is entirely incorrect.

7484 (Table read to witness showing typhoid death rate by months, under column A, and death rate from remittent, etc. fevers, under column B from the year 1895 to the year 1903 inclusive, by months.)

7485 I should regard these tables as indicating that the mortality from typhoid fever had fluctuated more or less from year to year. That gradually in the last three years an improvement in the accuracy of the reports from the general physicians had taken place so that cases of typhoid fever which had previously been included in column B had been properly reported as typhoid fever. As to the relative frequency of typhoid fever and malaria it would seem to me that it would be impossible to draw definite conclusions from these tables, though as to the prevalence of typhoid fever I should think that one might draw good conclusions.

I should think that the mortality from typhoid fever had varied from time to time, from year to year; had risen slightly during the last two years, but that the fluctuations were no more than such as had previously occurred and were not such as to justify any direct assumptions in regard to the cause.

In the year 1892 I should suspect that there had been some definite epidemic, but since that time the variations shown are not such as to suggest to me any striking special cause. They are variations such as occur in most cities in this country from time to time without explanation.

7486 (Table read to witness showing consolidation of deaths from typhoid fever with those resulting from remittent, etc. fevers, as reported to the St. Louis Board of Health.)

I should regard this table as indicating only variations in the typhoid mortality, such as I stated a moment ago might and do occur in many cities without any definite explanation being found.

The typhoid mortality I should say had rather decreased, tended on the whole to decrease from 1893 down to 1901. During the two years following 1901 there has been a slight increase, but that increase is not, it seems to me, more than might occur without any special change in the pre-existing conditions.

Assuming that circular letters were issued in the fall of 1900 and 1901, calling the attention of physicians to the law requiring report of typhoid deaths, etc. I should say that these statistics certainly show the effect of such letters.

It appears in the relative increase in the number of deaths reported in the typhoid column as compared with those in the column of remittent, intermittent, malaria, congestive and simple continued fevers. It would indicate to me that, stimulated by the advice of the board of health, the physicians had made more accurate and careful diagnoses.

Assuming that in St. Louis in 1895 there were in the neighborhood of 4800 wells, that 50 of those wells were examined and found to be contaminated by the city chemist and condemned; that the board of health passed an order instructing the city chemist to stop the examination of city wells until further orders, I should think that the chances are that such wells would have an effect upon the typhoid conditions of such city and that such wells would be a menace to the health of the city and that it would be very possible that certain of the wells might become infected and serve to spread the disease. (Table read to witness, which was testified to in evidence by Prof. Jordan, compiled from typhoid fever and typho-malarial columns of mortality statistics of St. Louis from the years 1890 to 1900, according to census reports and the intervening years estimated by Farr's Formula.)

7490 I should say this table indicated that during the past two years there has been a slight increase in the typhoid mortality, but that this increase had been preceded by a diminution and on the whole a gradual diminution from 1892 down to 1901.

I should hesitate from these figures to assert that the mortality had permanently increased or I might say that to look at such table I should not regard it as having greatly increased, and I should want to see what happened in 1904 before expressing any opinion.

The increase in 1902 and 1903 seems to me not more than might occur with fluctuations such as are observed in the tables which I have mentioned from New York, Brooklyn and other cities.

7491 Assuming that the typhoid deaths as reported in the typhoid fever column for the city of St. Louis are correct and that in 1899 the increase over 1898 was 34.7 per cent, and in 1900 the increase over 1899 was 25.3 per cent, and in 1901 the increase over 1900 was 14.7 per cent, and in 1902 the increase over 1901 was 9.5 per cent.

7492 It seems to me that the conditions between 1898 and 1899 are worse than those between 1900 and 1901.

7493 I should not consider the conditions in the last several years in St. Louis, such as to suggest that any striking change had taken place in the general conditions that obtained prior to that time, as regards typhoid fever.

7494 CROSS-EXAMINATION, By Mr. Jeffries:

Assuming that a patient takes ill with fever and remains so for several months and finally dies, and the death is reported as intermittent or remittent fever, I should, if that case had been treated with quinine, and the fever had not broken, assume that it certainly was not malarial fever.

7502 AT CITY HALL, PHILADELPHIA, PA., March 28, 1904.

JOHN W. HILL, Examined in chief by Mr. Todd:

Am a hydraulic engineer. At the present time I am employed by the city of Philadelphia as chief engineer of the bureau of filtration, a bureau that is conducting the general improvement of the water supply of that city.

7505 Have studied chemistry and bacteriology with a view to informing myself as to the true interpretation of the conditions of water I would be required to deal with as an engineer.

7506 I have examined and studied bacterially and chemically the analyses of the water of Lake Michigan, the drainage canal, the Des Plaines river, the Illinois river, the Mississippi river and the Missouri river as made by Professors Jordan, Palmer, Burrill and Long, the same being published as reports of streams examination which have already been introduced in evidence and the reports of Professor Long appearing in the published health reports of the board of health of the State of

Illinois, the same having also been introduced in evidence in this case.

7507 I am acquained with the Chicago river, the drainage canal, the Des Plaines river, the Illinois and the Mississippi river from Grafton to St. Louis, so far as they are represented in public documents and in hydraulic maps published by the United States government and by the city of Chicago. I have not made a personal examination of the drainage canal or of the Illinois river excepting of the Illinois river at Peoria during the year 1882 when I was employed on the Peoria waterworks.

7509 In connection with the work now going on in Philadelphia, I made experiments upon the longevity of the typhoid bacillus in unsterilized Delaware river water, and found that its life history was from five to eight days under the most favorable conditions. This experiment also revealed the fact that the colon bacillus would live longer in the unsterilized Delaware river water with the different degrees of salt than would the typhoid organism. The Delaware river water is a sewage polluted water.

7511 (States how experiment was made as to longevity of typhoid bacillus in Delaware river water.) I have a table showing the results of the experiment just recounted, said table being reproduced on pages 7512 and 7513.

7516 The greatest length of time that a typhoid bacillus lives, as shown by these tables, is eight days. This water was sterilized. I should anticipate that its life in unsterilized water would certainly be no longer than eight days and probably less than eight days. I regard the laboratory experiment as more favorable than conditions in nature, for the longevity of the typhoid bacillus.

7517 From my knowledge of the typhoid bacillus, I should put the life of the typhoid organism in a sewage polluted river water under normal conditions which prevails with the majority of the rivers of the United States drawn on as the sources of public water supply as from 5 to 8 days. I am now referring to the typhoid organism that would come in from a definite point. That organism would probably be not found in the water at the end of five to eight days.

7518 From such information as I have of the bacteriological and chemical contents of the Illinois river as disclosed in the volume entitled Streams Examination, prepared by the sanitary district of Chicago, and of the physical conditions with reference to slope, of their being slack water pools formed in the river at different points, I should not anticipate a greater longevity of the typhoid organisms in the waters of the Illinois river than I have found in the waters of the Schuylkill and Delaware rivers.

7519 The dams in the Illinois river, in view of the flat slope of the stream bed, would create pools corresponding in numbers to the dams, in which sedimentation is bound to take place.

7520 The percentage of sedimentation would probably be increased during flood periods in the Illinois river. Assuming that there are in the neighborhood of 400,000 acres of land inundated and subject to overflow in the Illinois river, the effect would be to increase the rate of sedimentation during the time when the stream was out of its banks. I do not think that if the maximum flow through the drainage canal was 800,000 cubic feet per minute that the quantity of water mentioned would impede sedimentation but it might diminish the rate at which sedimentation would occur during stream flow.

7521 Dilution of a sewage polluted stream means or should mean dilution with purer water than that flowing in the stream. It operates in two ways, first, self-purification, in a mechanical way by increasing the volume of flow in the main stream and reducing the percentage of pollution; next, to increase the rate of oxidation of organic matter by adding to the polluted water a water higher in dissolved oxygen, and it is probable that with reasonable limitations the addition to a sewage polluted stream of a stream of purer water high in dis-

solved oxygen, would facilitate the oxidation of organic matter.
The danger of infection is really diminished by dilution.

7522 The water from Lake Michigan improves the quality of the water flowing in the Illinois river. The water flowing into the Illinois river from Lake Michigan should be regarded as a benefit to the Illinois river. (Witness compares tables of 1889 with those of 1900, giving the chemical and bacteriological determinations.) I still think the indications are that the chemical conditions, or at least some chemical conditions, indicate that self-purification is better for the latter year, and having no better data before me than that quoted in the answer, or that mentioned in the question, it does not appear that the addition of the sewage in Chicago has injured the quality of the water of the Illinois river south of Peoria.

7523 The addition of water to the Illinois river from Lake Michigan would increase the current and increase, to some extent, the time required for sedimentation. If the increased volume of water was such as to overflow the banks, it might, upon the whole, have the opposite effect by reason of the large degree of sedimentation that would take place outside of the defined channel of the river on the bottom lands. If, however, it should be shown that the mean velocity of the stream was not materially increased by the addition of water from Lake Michigan it would probably have no marked effect on the rate of sedimentation. The chief factor that would govern in this case would be the mean velocity of the flow of river before and after the addition of water from the lake.

The sedimentation and oxidation of organic matter during stream flow is favored by the low channel and surface slope of the Illinois river as compared to other streams.

7524 Basing an opinion upon the technical investigations that have been made of the water of the Illinois river at Grafton during the four selected months of 1899 and the four corresponding months of 1900 it does not appear that the sewage of Chicago has materially changed the conditions, and such changes as are shown would indicate from a chemical point of view an improvement in the quality of the water at Grafton, since the opening of the drainage canal.

Basing an opinion on the technical data contained in the book entitled Streams Examination which has been referred to before in my testimony, there is nothing to indicate that the danger to public health has been increased since the opening of the drainage canal. In making this statement I wish it understood that I do not believe that the water flowing in the Illinois river at Grafton before the opening of the drainage canal was fit for drinking and some other domestic uses, and my answer must be construed as showing only that the conditions are no worse during the months of 1900 which I have under consideration than they were during the corresponding months of 1899 prior to the opening of the canal.

7525 Table showing number of bacteria and average of results of chemical analyses for the years 1899 and 1900 at various places at which samples of water were taken during the investigation made by the defendant in this case.

7528 (Witness comments on the tables just introduced, and states.)

7529 Taking all the data together and particularly that relating to the total oxygen consumed, and the nitrates and nitrites, I consider that the condition of the water flowing in the stream at Grafton has been improved.

7530 Basing the opinion upon the technical data collected by others for the purpose of this investigation, I do not think that the sewage of Chicago in its original condition is manifested in the waters of the Illinois river at Grafton. The question of high or low water in the Missouri, at a time when there was high water in the Illinois river, would have no effect on the result at Grafton.

7531 Considering the technical data already referred to in previous answers and contained in the book entitled Streams Examination and considering the relative drainage area of the Illinois river and the Mississippi river above St.

Louis and of the Missouri river, I do not think that any marked effect would be felt in the combined waters of the three rivers by reason of the combined discharge of sewage and Lake Michigan water into the head waters of the Illinois river at Joliet.

I should think that a typical bacillus would perish more quickly in the sediment of a stream than in the water above such sediment. I should not expect a typhoid organism introduced into the Illinois river, together with the sewage of Chicago and Joliet, to pass the entire length of the stream. Upon the contrary I should expect it to perish somewhere in transit and probably before it reached the city of Peoria, and the reason for this opinion is based upon the evident rate of reduction of organic matter in the river between the point of discharge into the canal and the city of Peoria, the typhoid bacillus like other bacteria being a part of this organic matter.

I do not regard the settling basins at St. Louis, as they are at present constituted, a complete guaranty against infection coming from the waters of the Mississippi river.

7533 (Witness gives reasons.) I am acquainted with the settling basins used at Covington, Kentucky, and I do not think that because such basins hold a thirty days' supply of water and typhoid fever should prevail among the people using such water, that the typhoid bacillus will live in that water for such a period. (Witness gives reasons.)

7537 In the interpretation of typhoid statistics of a city, my custom in stating typhoid fever cases and deaths, is to relate the rates to the unit of one hundred thousand population living. The mortality percentage method does not as easily convey to the ordinary mind the true relation of the typhoid fever statistics of the population, as the method of relating deaths or cases to some unit of population, for example 10,000 or 100,000. The mortality percentage method is not regarded, on the whole, as the most accurate among sanitarians and students of vital statistics in ascertaining typhoid conditions of a given community. The danger of infection is not so great from the rural population as from the established centers of urban population because the opportunities of sewage from the rural population reaching some watercourse are not so great as in established centers where systems of sewage are in vogue.

7539 If upon a watershed where the water is polluted, there should be many sources of pollution and infection and typhoid fever should break out in a given community, I would look for the source of infection at the nearest possible point of pollution above the source of water intake, or above the point of water intake.

7541 Basing an opinion upon the technical data in the volume entitled Streams Examination previously referred to in my testimony I should regard the quality of the water of the Illinois river at Grafton as no worse and in some respects better than the mixed waters of the Illinois, Mississippi and Missouri rivers at the point in the Mississippi river, below Grafton as shown by the data in the tables of technical data previously offered as a part of my testimony.

7542 From a bacteriological point of view the water of the Illinois river at Grafton is decidedly better than the water of the Missouri river at West Alton. Considering the suspended matter the water of the Illinois river at Grafton is superior to the water of the Missouri river at West Alton.

The same statement may be made with reference to total solids.

The same statemnet may be made with reference to the nitrates and nitrites. The degree of nitrification being shown as greater for station 21 at Grafton, at the mouth of the Illinois river than for station 32, West Alton on the Missouri river.

Considering the chlorine alone the water of the Illinois river at Grafton would not be considered as good as that of the Missouri river at West Alton.

7543 (Witness gives figures showing the mean rainfall on the Illinois, Missouri and Mississippi watersheds.

Of the water flowing in the Mississippi river opposite St. Louis, 20 per cent would be credited to the Mississippi river, 75½ per cent to the Missouri river and 2.96 per cent to the Illinois river and 1.54 to the influence of the discharge of the Chicago sewage, or such water as is carried with the sewage into the drainage canal exclusive of the diluting water drawn from the lake. (Witness states information upon which above data is based.)

7545 Table read in evidence showing the drainage basin of the Missouri river.

7547 Same for the Mississippi river.

7548 Same for Delaware river above Trenton, N. J.

7549 Schuylkill river above Philadelphia.

These tables were made by Mr. S. B. North, Director of the census, from the statistics in his bureau, and show the population on each one of the above watersheds. In my opinion, the mixing of the Illinois, with the Mississippi and Missouri rivers does not create any added danger to the already contaminated and polluted waters of the Missouri and Mississippi rivers at the St. Louis intake. The analytical investigations reported on by Professors Palmer and others in Streams Examination and the other in relation to the total flow of the Illinois river, including Chicago sewage and water drawn from Lake Michigan, the first indicating that the condition of the Illinois river at Grafton was no worse during the four specified months of 1900 than the same four months for 1899, prior to the opening of the drainage canal; and the second indicating that the 7550 total volume of flow of the Mississippi river opposite St. Louis by far the smallest percentage comes from the Illinois drainage basin even while considering the flow of the sewage of Chicago and the water from Lake Michigan as a part of the discharge from that river. Under these conditions it would be difficult to conceive of a pollution of the Mississippi river at a point below the confluence of the three rivers of junction of the three rivers, excepting the pollution of the Illinois river was very great with reference to the pollution of the two other streams which contributed to the body of water moving past the city of St. Louis.

The information which I have with reference to the Illinois river and the quantity and quality of the stream flow, its physical characteristics and the technical data obtained from an examination of the water samples does not warrant the belief that infected matter from Chicago would be found in the Illinois river as far south as Grafton.

If typhoid fever germs were found at the St. Louis intake, it would be wholly impossible, in my opinion, to say what city they were from.

7551 In my opinion, typhoid bacilli could not be deposited on the bottom of the Illinois river and remain there for a period of five years and upwards and then be stirred up by the action of the wind, waves or steamboats, etc., and continue on their journey down to St. Louis. The Missouri, Illinois and Mississippi rivers were not safe waters for drinking and domestic purposes prior to the opening of the canal.

7553 I do not regard any river that receives the sewage of rural and urban populations, as a safe drinking water without mechanical treatment of some kind. Basing an opinion upon the technical data before me, applicable to this question, upon the whole, the condition of the water of the Illinois river at Grafton appears to be improved by the opening of the drainage canal and is not less sanitary than the waters of the Missouri and Mississippi rivers..

7554 There is no evidence before me showing that any such changes occurred in the quality of the water as to render it less desirable for potable purposes, or more deleterious to health than prior to the opening of the canal. If the typhoid fever statistics of St. Louis show an increase since the opening of the canal, unless such increase is co-incident with conditions in Chicago or, in other words, unless the rates in St. Louis showed that they corresponded with the rates in Chicago, it could not be attributed to Chicago.

7555 The city of St. Charles situated 47 miles from the intake tower of St. Louis, in my opinion, would constitute a greater menace to the water supply of that city than would the larger city of Peoria. (Witness is shown the two charts introduced in evidence by Prof. Mason, and states:)

7557 It does not appear that the typhoid fever death rates from St. Louis are co-incident in intensity with the typhoid fever death rate of Chicago.

This is especially true for the years 1901 and 1902 and 1903. For which years the diagrams show that when the rate is rising in Chicago it is declining in St. Louis and when it is declining in Chicago it is sometimes rising in St. Louis, and that the wide ranges in the typhoid fever death rate as shown in the diagram for the city of Chicago are not reproduced in the diagram showing typhoid fever death rates for the city of St. Louis, and it would not be possible in my opinion to connect the rates in one city with the other.

As a general proposition wells in built up communities like the city of St. Louis, unless they are deep artesian wells or wells driven to a great depth in rock are always open to suspicion as possible sources of illness and disease.

7558 Personally I should regard every such well in the city of St. Louis, the water of which is liable to be used for drinking, as a menace to the public health, excepting the well is so far removed from possible sources of pollution as to be reasonably safe from the contents of vaults and cess pools leeching through the surrounding soil. The water at the Chain of Rocks, in order to be made a safe and wholesome water should be treated by filtration. In passing upon the question of filtering the water at St. Louis, no special consideration would be given the sewage of Chicago running into the head waters of the Illinois river, which forms one of the tributaries of the Mississippi river. (Pages 5960 and 5961, as to the relative values of the Illinois, Mississippi and Missouri watersheds respectively, as sources of water supply for the city of St. Louis, population per square mile, etc.)

7563 I have considered the total drainage area of each of the three drainage basins. That is I have considered the urban and total population on each of the drainage basins and I have finally developed the factor in the manner explained in the answer to the previous question, which in my opinion shows the relative advantage or disadvantage of the source of water supply of the three rivers mentioned with respect to the three cities drawing their water supply wholly or partly from the sources under consideration. The size of the numbers thus obtained indicates the objection to each source of water supply as follows: For the city of St. Louis on the assumption that the water supply is drawn only from the Illinois river basin there is 209.20; of the city of Philadelphia upon the assumption that the source of water supply is drawn from the Schuylkill river 330.63; and for Hamburg which draws its entire water supply from the Elbe river, 698.12. The lower figure by this method of comparison would indicate the best source of water supply, and if my method of reasoning is correct it would show that under the present conditions the Illinois river would be a safer source of water supply for the city of St. Louis than is the Schuylkill river for Philadelphia or the Elbe river for Hamburg. The water of the Elbe river at Hamburg is now and has been for 11 years past all filtered. Preparations are going forward to filter the water supply at Philadelphia from the Schuylkill as well as from the Delaware river.

And by the same process of reasoning it seems to me that the water supply of St. Louis should be filtered in order to remove any natural objections that exist to the sources from which its water is taken.

It would make no difference whatever either in the cost of construction or the cost of operation of a system of filters for the city of St. Louis, whether the sewage from Chicago went through the canal or was entirely eliminated.

7564 Of the three rivers contributing their water to the supply of St. Louis, the Missouri river would create the largest percentage of cost in operating a filtration plant, owing to the silt and suspended matter.

7565 The amount of infection in the river—meaning by that, sewage infection, would not create an added cost to the operation of filters.

7566 Assuming that a filter plant should be established at St. Louis sufficient in size and suitable for the demands required, the fact that the Mississippi river at the Chain of Rocks varied from time to time, from slight infection to great infection, would not create any added cost to the operation of such a filter. The degree of sewage pollution or of infection of water coming to the filters would not be a factor either in determining their cost of construction or the cost of operation.

7567 The chemical and bacteriological investigations show in reference to the city of St. Louis that the Illinois river is the better source of supply, while the physical investigation that has been described shows that it is the least desirable source of supply. If we had no chemical and bacteriological data and were approaching the problem as a new proposition we would fix the center of population of the Illinois river water shed nearer the St. Louis intake than that of the Mississippi and Missouri water sheds. This mode of comparison of watersheds wholly ignores the volume of flow in each stream.

CROSS-EXAMINATION, by Mr. Jeffries:

7574 The Schuylkill river is much more polluted than the combined waters of the Illinois, Missouri and Mississippi. If the water from the Schuylkill and Delaware rivers should run down the stream with any added pollution or infecting material and should contain typhoid fever germs, if the water was of normal sewage pollution, I believe that all the typhoid fever germs would die out within eight days from the time they were deposited in that water. I believe I would then recommend that water, but not for domestic purposes.

I would recommend it as being free from typhoid.

7575 Assuming that typhoid fever germs live in the water of the Schuylkill and Delaware eight days, the addition of a double quantity of water in that river would have the effect of slightly prolonging the life of the organisms.

7577 I think that is the true condition, that the pathogenic organisms, those that are not spore bearing, like anthrax for example, would have the shortest life in a very highly concentrated sewage.

7579 The fact of there being a smaller bacterial content in the water of the Illinois river at Ottawa and La Salle and at Wesley City, can probably be ascribed to the increased dilution of the water flowing in the channel of the river and partly perhaps to a greater rate of oxidation by reason of the added dissolved oxygen obtained from diluting the sewage with Lake Michigan water. I can not see clearly why this should cause an increase in the numbers at points below Pekin. In studying the table giving the bacterial content of the various waters discharged into the Illinois river and of the water of the Illinois river I thought that the increased bacterial content below Peoria was probably due to the sewage discharged at and below that point, and that it could not be connected with the increased flow of water in the Illinois river by reason of the draft on Lake Michigan through the drainage canal, because of the total numbers given in the table by far the larger percentage are the stronger and more hardy organisms of putrefaction and fermentation, organisms that would flourish only in polluted water, and some special cause of pollution must have occurred in the neighborhood of Pekin or Havana to bring about the considerable increase in numbers below that point, and this cause cannot be ascribed to the increased flow of water from Lake Michigan through the drainage canal.

7580 It is true that the tables introduced in evidence by me show that the percentage of reduction of bacteria in the Illinois river was greatest in former years from Morris to Ottawa. Between La Salle and Henry the increase was slightly greater during 1900 than 1899. As a matter of fact, comparing the bacterial contents of the river at the various points from Havana down, the numbers were greater for the year 1900 than 1899, showing an increase in the content.

7582 Assuming that typhoid fever organisms entering the drainage canal at Chicago may be the cause, or are the cause of typhoid fever in St. Louis, then undoubtedly the temperature of the water flowing in the Illinois river, the variations in the rate of stream flow and other physical conditions in and along the river would have an influence on the resulting rates of typhoid in St. Louis. Assuming that the water in the Illinois river had a more sluggish current prior to the opening of the canal, I do not think it is necessarily true that the conditions existing prior to 1900 were more conducive to the destruction of pathogenic bacteria, assuming that they were contained in the water both prior and subsequent to that time.

7585 In view of the fact that the introduction of a considerable volume of relatively pure water from Lake Michigan with a corresponding considerable increase in the dissolved oxygen in the waters flowing in the river might contribute to a more rapid oxidation of the organic matter than if it depended entirely upon the processes formerly going on in the pools formed by the dams in the river or by the formation of sand bars, a situation that would happen in a river of a very sluggish current.

7586 Assuming that there is a city situated upon the Mississippi river immediately above the intake of the St. Louis waterworks, with a population of 13,000 people, in which typhoid fever is continually prevalent from one end of the year to the other, the extent of such fever being as much as ordinarily found in a city of that size, such city would be a menace and a danger to the people of the city of St. Louis, taking their water supply from the Mississippi river, and the measure of this danger would be the population of such city stated as 13,000, its distance from St. Louis to the point of water intake and the rate of stream flow between the city and the intake.

7587 (The defendants, the State of Illinois and the Sanitary District of Chicago, rest their case.)

AT THE SOUTHERN HOTEL, ST. LOUIS, MO., May 23, 1904.

Continuation pursuant to agreement, being complainant's rebuttal evidence.

DR. EDWARD W. SAUNDERS, examined in chief by Mr. Jeffries:

Am a physician and have practiced in St. Louis 26 years.

7588 The Widal test is used for the discovery—or rather to ascertain whether or not the patient is afflicted with typhoid fever.

7589 This test has had no influence in my practice in making out death certificates to the health department of St. Louis. I consider that the Widal test is in general use by the profession in St. Louis.

7590 That test has been in use in St. Louis I should say about 6 or 7 years. The effect of that test in St. Louis, upon the profession, in signing and making out death certificates, I should say has been to take a number of cases from the typhoid list and add a number to it, because cases of nondescript fevers which before that time were assigned to the malarial list after that were assigned where they properly belonged, to the typhoid. On the other hand, there were quite a conglomeration of cases, patients dying in what the older writers called the status typhosus, or the typhoid state, which typhoid state had nothing to do with true typhoid fever, and these cases were taken out of the typhoid list.

I hardly think the Widal test or any other practice has resulted in taking from the malarial list and placing them in some other list besides typhoid. I can conceive of a case where a physician has treated a case for malaria and sees death approaching and makes the Widal test and finds it is not typhoid and that leads him to make a more careful examination and finds the patient is dying of nephritis or something he had not found before. Yes, I can conceive of that case occurring.

7591 Q. I understand you to say then that since the Widal test has come in vogue, where patients believed by the attending physician to be afflicted with malaria and finding death approaching have applied the Widal test which has resulted in the death being recorded under some disease other than either malaria or typhoid? A. Yes, sir.

7592 I am of opinion that the effect upon the typhoid mortality of St. Louis since the use of the Widal test has been that a given number of cases occurring since the Widal test, will afford a much better mortality rate than the same number of cases occurring before the Widal test. Assuming all other conditions tending to recovery were the same, those in which the Widal test is used for an early diagnosis are found to show a better mortality rate.

7593 I am not sure about the time but I remember receiving a circular with reference to reporting typhoid fever, from the Board of Health, since the opening of the canal. That circular had no effect on me in reporting cases of typhoid to the health department. I was never influenced in my action in making such reports by receiving these circulars. I never heard the profession discuss the object of these circulars.

7594 I don't think any of the physicians in St. Louis have been in any way influenced by reason of receiving these circulars. I have no reason to think the opening of the canal would influence the physicians in making reports of death from typhoid fever in St. Louis. Assuming that a physician certifies that one of his patients died of congestive fever, I would not know what it meant. It would not necessarily mean typhoid fever.

7595 If a physician certified that one of his patients died of typho-malarial, I would understand that he died of typhoid complicated with malaria. If a case be reported as remittent fever, I would suspect that the patient died of typhoid, because indigenous remittent fevers are not fatal. If a re-

mittent fever patient died in infancy, then I would believe that that was the true cause of death. The same would be true with reference to intermittent fever. The same is true of malaria, but of simple continued fevers, I would say that they were all in the typhoid class. I would not even make the qualification that such would be the case, unless the patient were an infant, for the reason that a fever which continues any length of time, if it be malaria, is amenable to quinine. If not amenable to quinine,
I believe in the Osler dictum that any fever that continues
7596 a week and is not amenable to quinine and is not anything else, is typhoid. Simple continued fever I do not think could be anything else but typhoid. Infants and old people do not often die of typhoid fever. Those most likely to have typhoid fever are young adults. I have observed more or less typhoid in the winter and spring months within the last few years than formerly in St. Louis.

7597 I remember an epidemic in the fall of 1899 just before the opening of the canal. That was local and the cases were in the west end mostly, in the better quarters of the city.

CROSS-EXAMINATION, by Mr. Todd:

A patient may have typhoid fever and yet the doctor may fail to get the Widal reaction. I think the last report shows some 1600 physicians practicing in St. Louis.

7598 My acquaintanceship with those physicians would not exceed 20 per cent. That acquaintanceship does not extend to the bedsides of the patients they treat and their methods of diagnosis. Those that I have an intimate acquaintanceship with, as to their treatment of diseases are those I am called in consultation with. I am called in consultation with from fifty to one hundred different physicians every year.

7599 I should venture, as a guess, the nearest approximation I could make as to the number of cases of typhoid fever I treat in a year, on an average—that is, those that I treat and see in consultation—all together, would be from 30 to 50. I should say that I see anywhere from two to three or four or five deaths from typhoid in a year. I have no idea as to the number of homeopathic physicians practicing in St. Louis. I do not know whether they employ the Widal test.

7600 I should say that all of the doctors in St. Louis, if they are in doubt, would be liable to appeal to the Widal test, in a case. If it should appear in the Board of Health statistics of St. Louis during the last ten years, that they have a group of deaths reported as remittent, intermittent, typho-malarial, congestive and simple continued fevers, and those deaths amount to something like 200, I think the number is a reflection upon the doctors of St. Louis in their diagnoses of disease of that character. That number of deaths, so characterized in the Board of Health report, reflects upon the diagnostic ability and carefulness of the doctors who make those reports. If the number of deaths appearing in the two columns were about the same, I should say that the majority of those cases in the remittent, etc. column, belong in the typhoid column. If such a condition obtained, as evidenced by the compilation of the Board of Health of the city, I should say that the doctors in St. Louis were not employing the Widal test generally. It is the tendency that these practitioners wedded to calomel and quinine are obstinate in accepting new treatment for diseases. If the deaths are about equal from typhoid and all these other diseases, that proves it.

7603 I would say perhaps the typhoid column is as inaccurate as the other column. If the typhoid column is as inaccurate as the other column, I would attribute the inaccuracy to failure in diagnosis. The words, "remittent, etc." are terms that have grown up but are not today employed by the advanced schools in medicine. Some of them are not recognized in the sense of being types of disease apart from the organism.

7605 It requires a great deal of skill among competent physicians to diagnosticate a case of malaria by the use of the microscope. The doctors in general practice in St. Louis are not possessed of that degree of skill necessary to make that diagnosis. That is true of typhoid fever. The fatality of typhoid fever depends largely upon the amount of germs taken into the system. The Widal test was introduced in St. Louis I don't think to exceed six years ago. If it should appear that prior to six years ago there were more, or about an equal number of "remittent, etc." deaths in St. Louis, as compared with typhoid deaths, the death rate column would not fairly represent the typhoid condition in my opinion. I have had two cases under my observation where the malarial parasite had been found in the same patient with the typhoid bacilli. These cases are rare.

7608 In my practice, well I do not think that I have ever written a death certificate from any sort of malarial fever except in the very young when a convulsion carried off the patient in the onset, or in the aged where malaria carried off a very weak person. I do not believe I have otherwise made a single death certificate.

Assuming that a circular had been sent out from the Board of Health of St. Louis and that the public press was discussing the question of the effect of the drainage canal upon the water supply, and that the remittent, etc. fever column immediately decreased during the next three years and that the typhoid column increased—if those are all the facts upon which I am to base a judgment, I would say that such an increase would be manifest in the statistics of the Board of Health.

7612 DR. WASHINGTON E. FISCHEL, examined in chief by Mr. Jeffries:

Am a physician and reside in St. Louis. Have been practicing medicine here since 1874.

7613 I should say that the Widal test has been used in St. Louis about eight years. It is used to establish beyond a reasonable doubt the diagnosis of typhoid and to establish it as early as possible.

7614 Taking into consideration the value of the Widal test in making an early diagnosis and also that typhoid is a disease which, if properly treated in its earlier stages is less likely to become fatal, I should think that test would have the effect of lessening the mortality from typhoid. I think it is en-

tirely probable that there would be more deaths from typhoid when the Widal test was not employed. Persons are most likely to have typhoid fever between the ages of 18 and 45.
7615 I have observed more typhoid during the winter and spring months during the last few years, than formerly. *I do not recall the members of the profession discussing a* circular sent out by the Board of Health after the opening of the canal.
7616 Receiving those circulars has had no effect upon me personally. I believe that many cases of deaths from typhoid have not been reported as typhoid for the reason that if the physicians had reported these deaths as typhoid the Board of Health would have at once demanded an explanation of them why they had not been reported as typhoid before the death of the patient.

If a doctor certified that one of his patients died of congestive fever, I should not know what to understand by that term. I should not consider the true cause of death to necessarily be typhoid. It might be something else besides typhoid. When a death is reported as caused by remittent or intermittent fever, it is not necessarily typhoid fever. It may be any of the diseases which have a fever as a symptom, such as consumption. You may have pneumonia with remittent fever. I should say that in my judgment there is no such thing as typho-malarial. The effect of the opening of the canal has made me extremely careful of my diagnoses because, naturally, I felt there was great
7618 danger of the sewage of Chicago contaminating our water supply and I wanted to make it at least clear to myself whether in my experience that danger existed and therefore never reported a case as typhoid when the Widal test was not positive. I think the opening of the canal has made the profession more careful in reporting deaths from typhoid fever to the Board of Health.

At present I report no death as due to typhoid in which the Widal agglutination test has not been found positive. Previous to the issuing of the circular and the penalty which it conveyed to physicians neglecting to report typhoid cases, the cause of death was frequently reported as typhoid when it might have been due to other diseases.

7619 CROSS-EXAMINATION, by Mr. Todd:

The converse is true—that many deaths from typhoid were reported as other diseases, which should have been reported as typhoid, prior to the opening of the canal. I know nothing definite about how to account for the number of deaths under the heading "Remittent, etc." I think many of these cases may have been tuberculosis.

7620 I think that the remittent, etc. deaths that appear in the Board of Health reports represent more typhoid than consumption. I think it is probably correct that the number of deaths as represented by typhoid would be a very small percentage of those prior to 1900 which would not be typhoid. I think the circular letter sent out by the Board of Health has made the physicians of this city more careful in reporting the typhoid cases.

7621 I think in regard to typhoid fever the chief reason for their having become more careful was the penalty attached by the Board of Health, in case physicians did not report typhoid fever. The number of deaths from typhoid fever may decrease or increase in a given community depending upon the skill of the physicians who are handling those cases, other things being equal.

7623 Many of those cases in the Board of Health reports of St. Louis under the heading "remittent, etc," I would attribute to faulty diagnosis. I do not recognize those diseases as distinct types of disease. I believe it is true that those are terms which have grown up in the profession and are employed by doctors who are not up in the medical profession. When I find a number of deaths aggregating 200, in a city the size of St. Louis, reported under the head of remittent, etc. fevers, that certainly leads me to the conclusion that there are a great number of doctors in St. Louis—the same as in any other city—who are not abreast of the profession.

7624 DR. LUDWIG BREMER, examined in chief by Mr. Jeffries:

Am a physician. Have been practicing for about 34 years.

7625 I am credited with the discovery of the blood test for diabetes. Have written and published a good many scientific medical articles. Am acquainted with the Widal test and have used it—not particularly in my own practice, but in order to verify its scientific significance, quite a number of times a number of years ago.

7627 Since 1900 I have gathered from the talk with the physicians and from hearing my patients talk about it, and the cases occurring in their families, that there has been an increase in the death rate from typhoid fever in St. Louis; I could not state positively that there has been an increase, but it is my impression that there has been an increase in typhoid fever in St. Louis.

From conversations with druggists, patients and physicians and others, I think it is the general concensus of opinion that there has been a gradual increase in the number of cases of deaths from typhoid fever since the opening of the canal.

7628 CROSS-EXAMINATION, by Mr. Todd:

I do not know how many cases of typhoid fever were in St. Louis for the period of four years prior to the opening of the canal nor how many cases of typhoid fever were in the city during the last four years, nor have I made a comparison of the statistics. Typhoid fever in St. Louis is not always distributed in all localities alike. It may appear in some localities more frequently and be absent in others. The greater number of the Widal tests are made at the Bacteriological Institute—a city institution. There are a number of young doctors who have been turned out of the medical schools in the last three or four years in St. Louis. It does not require a skilled physician to diagnose a typical case of malaria. Such fevers as are characterized by the names "remittent, etc." used to be recognized as distinct types of disease. They are not now. I would say that no doubt a number of these cases under the head of "remittent, etc." are unrecognized or mistaken cases of typhoid. I do not know what percentage. The trend of the present state of medicine is that the best treatment of typhoid fever is good nursing and little medicine, so that the advantage of making a proper diagnosis of a patient is to prevent the treatment of that patient for some disease that requires medicine, which would be to the detriment of the patient if it were given.

RE-DIRECT EXAMINATION, by Mr. Jeffries:

The epidemic of 1899 in St. Louis, seemed to be confined to that part of the city where I live—out in the west end. The use of private filters has increased very materially, on the advice of physicians, during the last seven or eight years.

7633 I do not know whether they are still on the increase, but I know that a year or two ago I heard it from the physicians generally they recommended filtered water and boiling the filtered water afterwards.

The people of St. Louis have been educated to filter and boil the water and this education has been increased and extended considerably within the last four or five years. Every physician of common sense recommends the boiling and filtering today.

7635 RE-CROSS EXAMINATION, by Mr. Todd:

The epidemic of 1892 afforded a stimulus to me to advise the boiling of the Mississippi river water. I believe it did to any well-informed doctor. It was from 1896 to 1900 that the water supply of St. Louis was suggested as being unsafe for drinking purposes in its raw state, and since then it has been kept up.

7637 DR. ALBERT E. TAUSSIG, examined in chief by Mr. Jeffries:

Have lived in St. Louis all my life; am a physician.

7639 I had a couple of cases at the time of the typhoid epidemic in St. Louis in November and December, 1899. This epidemic I think was rather sharply localized in about the central part of what is called the west end of town. Both boiling and filtering of water is used in the houses in St. Louis, a good deal more, in my opinion at present than in past years. These families whose regular physician I am, all boil their water. I insist on that and most of them filter their water. I think practically all physicians advocate that very strongly. These precautions are not always observed by the citizens, but one tries to have them observed as well as possible. My opinion is that private filters in the private houses in St. Louis have increased in the last four years. I base this impression simply upon the fact that the greater number of families about whom I know something have put in filters.

7641 Circulars that I might receive from the Board of Health admonishing me to report promptly all deaths from typhoid, etc. might make me a little more observant of my duties where otherwise if I had a case of typhoid fever, I might neglect to report it as such. The effect would be doubtless that I should report a greater number of cases of typhoid fever. I do not think it could possibly have any influence on the death certificates that I should write, for that depends on my own diagnosis.

CROSS-EXAMINATION, by Mr. Todd:

I think it always has been a wise precaution to boil the water, or at least since it seemed probable that typhoid was a water-borne disease.

7642 During ten years at least, it has been a wise precaution to boil and filter water in St. Louis, to prevent typhoid infection. The epidemic of 1892 caused a great many people to begin the systematic boiling of water, who had not done so before.

7644 Under the head of "remittent, etc." diseases reported to the Board of Health, I believe that some were typhoid, some consumption, some probably still other diseases. Assuming that "remittent, etc." fevers was not the proper cause of death in such cases, such a diagnosis reflects upon the ability of the physicians sending in such causes of death.

7648 As to the words "remittent, etc." I think it is likely that in the mapority of causes in which these terms are used they are simply descriptive of the symptoms, but they may mean much more than merely typhoid and malaria. A great many diseases might, upon a superficial examination, produce the same sort of an impression.

Some of those terms, to my mind, cannot be called diagnosis at all.

7657 DR. CHAS. H. GOODMAN, examined in chief by Mr. Jeffries:

Am a physician. Have been practicing medicine in St. Louis about 35 years. I use the Widal test in my practice. The Widal test enables the physician to obtain an early diagnosis and therefore, early treatment may be given, which has enabled physicians perhaps to place the causes of death to typhoid that possibly they might not have done otherwise. It is also true that it would have enabled physicians to have ascribed deaths to some other cause than typhoid, and therefore, to have eliminated deaths as caused by typhoid, from the typhoid list. I believe that the use of the Widal test has enabled physicians to give patients such treatment in typhoid cases which otherwise would have resulted in malignant cases and therefore, the death rate would be reduced by means of the use of the Widal test, as the fatality has been somewhat reduced. The fact that letters and circulars were sent out by the Health Department made no difference with me, nor did the opening of the drainage canal have any effect upon me in making reports. So far as my acquaintance with the physicians in St. Louis goes, they generally recommend that the water be filtered or boiled. Unquestionably, domestic filters are in more general use now than six or seven years ago.

7663 So far as the mere clearing of the water is concerned, domestic filters are satisfactory but as to clearing it of the germs or rendering it any more safely drinkable, I have my doubts. The epidemic of 1899 was localized in the west end of the city. It did not extend to any other portion of the city in general. It was in the better resident portion of the city. We have typhoid fever here more in the fall or early spring although the worst cases I have seen personally have been in the middle of winter. As a general proposition, it is at the change of seasons—from summer to fall and spring to summer.

7664 CROSS-EXAMINATION, by Mr. Todd:

7666 A young practitioner, a man who had a limited experience possibly could be mistaken in diagnosing typhoid fever. When I say that any ordinary physician can diagnose a death from typhoid fever, I mean only men of equal standing with myself. At times, it is a difficult matter for the very best doctors to diagnose a case of typhoid fever. I do not recognize remittent, typho-malarial, congestive and simple continued fevers, as distinct types of disease. These terms are characteristic of certain diseases rather than the disease itself. In
7668 the deaths reported to the Board of Health as "remittent, etc." those persons might have died of typhoid fever. They must have been confounding the terms, or they confounded the diagnosis of cases I should think. I do not know of any such fatality from malarial fever as would justify placing those deaths under the head of malarial fever. Considering that there are such a large number of deaths reported under the head of "remittent, etc." in the years 1891, 1892 and 1893, I believe the doctors at that time reported cases of typhoid deaths under "remittent, etc." deaths. (Statistics read to witness from 1894 to 1898, inclusive.)

7670 On the supposition that these figures were correct, I will say that the reports may have confounded diseases. Those that were reported as typho-malaria might have been typhoid, or typho-malaria, congestive, remittent or intermittent. These statistics cannot be accounted for in any other way than that typhoid fever has been wrongly diagnosed under those various headings. While the letter sent out by the Health Department in 1899 had no effect on me, I am not prepared to state that it had no effect upon any of the doctors who practiced in St. Louis. I cannot account for the increase in the remittent, etc. column of the statistics of the Board of Health for four years previous to 1900, and the increase in the typhoid fever since the year 1900, in any way except that the fevers which have heretofore been diagnosed as remittent, etc. have been diagnosed as typhoid, and placed in the typhoid fever column, when prior to 1900 they were placed in the remittent, etc. column. If a letter was sent out by the Board of Health asking a report on typhoid fever, under penalty, I think the doctors would make reports accurately.

7676 I account for the large number of reported deaths for four years previous under the remittent, etc. column, and the small number since 1900, to mistaken diagnosis, that is, classifying those diseases which were probably typhoid, under typho-malarial.

7679 DR. HERBERT E. SMITH, examined in chief by Mr. Jeffries:

I reside at New Haven, Conn., and am Dean of the Yale Medical School, which is the medical department of the Yale university. (Gives educational qualifications.) Have been professor in chemistry, State chemist for Connecticut, and did work for the Connecticut State Board of Health in the investigation of rivers pollution in that State, and the examination of water supplies. For 14 years, have had immediate charge of all the chemical and bacteriological work which the board has done on the matter of rivers pollution and examination of sewage and sewage effluent and drinking water.

7680 I began the study of bacteriology in 1887. Am familiar in a general way with the method and results of chemistry and bacteriology as applied to water and sewage. (Witness gives list of epidemics which he has investigated.)

7683 About three years ago, I think it was, I was appointed as lecturer on the Interpretation of Water Analysis in the Sheffield Scientific School of Yale University, and have continued to hold that position and to give instruction to the class in sanitary engineering in that branch. (Witness is shown tables presented in this case by Prof. Kinnicutt.)

7685 I would state that the figures represented in these tables do not furnish sufficient data to permit me to form a positive opinion as to the value, as a sanitary apparatus for the purification of the sewage of the drainage canal. The figures do show that there is a considerable solution of the suspended matter; that there is a considerable decomposition of the organic matter; that there is the development of a considerable amount of free ammonia.

These changes are such as are found taking place in sewage which is stored, by the agencies of the bacteria.

7686 The tables also show that there is a considerable reduction taking place in various ingredients in the sewage in passing through this canal. In so far there is a removal of the polluting material from the sewage, but in an important element in the discussion these tables are incompetent to form an opinion as to the destruction of the pathogenic organisms, particularly the typhoid fever, and there is no data with which I am acquainted which will give a true value to the extent to which bacteria may be destroyed or are destroyed in such an apparatus. The experiments which have been made tend to show that there is a reduction of the typhoid bacteria under such conditions, but how efficient such an apparatus is, it is impossible to state.

In my opinion the introduction of the large quantity of water discharged would tend to reduce the purification which would take place in an apparatus of this sort.

(Witness is shown tables 41 to 52 inclusive, introduced by Prof. Kinnicutt.)

7687 These results show the average composition of the samples of water at the times and places at which they were collected. The several samples show that in the upper portion of the water way there was a high chemical and bacterial pollution; that there was a gradual diminution in the amounts of the various chemical constituents in the progress down the river and that there were certain places where there was an increase in these constituents; the figures for the samples taken at Grafton show there was in those samples a very considerable evidence of sewage contamination still remaining. There was some variation in this diagram, also in bacteria, the number at the Grafton station being somewhat higher than at the Kampsville station, for instance.

The tables fail to show the true conditions of the river at these several stations at all times because a sample taken from a running stream, from time to time, can not of course show the composition of the river at that place at other times, and further, there is no evidence in these tables that the samples taken at the time they were taken were proportional to the flow in the river, and obviously they would represent a different proportion of the constituents in the river at times of flood from what they would at all times of low water, the samples being of the same size.

MR. TODD: I move to strike out the answer for the reason given in the objection to the question, and for the additional reason that no witness has testified that the samples taken, as evidenced by the tables, express true conditions for the entire year, but only for conditions for the time covered, the period covered during the taking of the samples, and for the additional reasons given in my objection to the question itself.

(Witness is shown tables 67 to 74 inclusive, and states:)

7688 In my opinion, these tables do not show the condition of the water in the river at the several points at all times of the year, for the reason that the samples were taken occassionally and not continuously; that they did not as far as the tables show, take into consideration the flow at the time the samples were taken and that in general an average of this sort can not show the condition of the stream at other times than those at which the samples were taken. As to tables 1 to 12 inclusive, introduced by Prof. Kinnicutt, in my opinion, these tables fail to show the condition of the water in the river at all times and seasons for similar reasons stated in my answer to your last question.

7689 In my examination of the individual results upon which these tables of average are based, I have noted many results which deviate widely from the average.

As an illustration, on table 101 in the Streams Examination, which relates to the analysis of the Illinois river at Grafton during 1899, I found that on November 8th, the samples showed a chlorine of 4 parts per million; on May 31st of 3.7 parts per million, while the average given in Professor Kinnicutt's table of results obtained at this point is 18.4 parts per million.

7690 I would say that on that particular table there were 17 samples, more than half, therefore, that were above the average in chlorine, and there were 16 that were below the average.

With regard to the free ammonia, I find that on December 6th there was present 1.12 parts per million, and on June 21st, .04 parts per million, while the average of all the determinations at that point gave 0.23. There were 12 samples above the average and 21 samples below the average.

In the same tables, the figures for suspended matter, or suspended residue referred to in another place as suspended solids, was, on May 31st, 873.8 parts per million, and on October 11th was 1 part per million, while the average of all the determinations is given as 82.4.

These indicate some of the ranges which I have noted, and similar discrepancies are found in the other tables.

MR. TODD: I move to strike out the answer for the same reasons heretofore given.

The general average does not show a true condition because the general average can only relate to the conditions at the times and places when and where the samples were taken.

In a stream of running water, which varies in volume, it is very important that the samples should be taken in such volume as will indicate the relative flow at the time the samples are taken.

For another reason a sewage contaminated stream varies greatly from time to time in its content of impurity, depending largely upon the irregularities in the discharge of the sewage, at one time the sewage being of a certain character and at another time differing widely from it, either because of the sort of discharge of materials from factories or manufacturing establishments or something of that sort, or from the variations which are found in the flow of sewage in the matter from houses at or during different hours of the day. Moreover, there is a very marked difference in the flow of streams, due to the variable rainfall at different seasons and times. This has the effect not only of increasing the volume of the flow, diluting it at one time, the constituents over the conditions which prevail at another time, but the larger flow tends to bring down the stream accumulated materials and form movable deposits, both upon the watershed and in the stream itself. For these various reasons an average result can not show the condition of the stream at all times.

7691 In my opinion the tables of averages which are referred to as having been introduced by Prof. Kinnicutt do not form a competent basis in the present condition of sanitary science to permit a definite opinion as to the sanitary condition of the stream to which they relate. (Witness gives reasons, among which are, that the chemical analysis alone is not sufficient basis on which to decide whether a sewage polluted stream contains the dangerous elements of sewage and that the bacteriological analysis does not reveal in all cases the presence of those constituents of sewage which are dangerous, nor that both together can be absolutely relied upon to show the presence in the stream of those substances which may, and do come, from sewage and which are dangerous.) In answering questions relating to the analyses I have taken into consideration the information obtained from the tables in the book known as Streams Examination.

7693 From my examination of the results given in the tables in the book, Streams Examination, and of the tables of averages based thereon, I would say that I am unable to state that they show that all injurious ingredients have been eliminated from the sewage.

7694 Taking into consideration the urban population upon the several water sheds tributary to the Illinois river, exclusive of that of the Chicago sanitary district, I will state it is my opinion that the results shown in the tables of averages based upon them, show that at the times when these samples were taken there was more evidence of sewage than I should expect in a river of this size and population.

In my opinion the tables referred to do show that there was at the times when the samples were taken more evidence of sewage contamination than I should expect to find from the urban population on the watersheds tributary to the Illinois river, exclusive of the Chicago sanitary district.

7696 In answering your question I have taken into consideration the assumptions and statements made and would state it as my opinion that the conditions assumed and stated to be present in the river prior to the opening of the drainage canal were such as would afford greater facilities for the removal of pathogenic organisms than those which exist since the opening of that canal.

And, further, I would state as my opinion that the data furnished by the tables in the book of Streams Examination, and the tables based thereon, do not furnish data for determining the extent to which these pathogenic organisms have been removed.

7697 In my opinion the data furnished in the tables show that there has been considerable removal of the polluting material introduced into the river from the sewage of Chicago, but that they are not sufficient to determine that the purification from the dangerous elements in the sewage has been complete at all times and all seasons.

Basing my opinion upon the results of the chemical and bacteriological analysis which have been furnished, and the tables referred to, and upon other data within my knowledge bearing upon the subject I would state it as my opinion that the sewage is not purified from the harmful agents at the time it is discharged from the drainage canal.

7698 Assuming that the water passes from the city of Chicago to the Chain of Rocks within ten to twenty days, I am of the opinion that the water is less valuable for sanitary use than it was before the opening of the sanitary canal and that there is very much greater liability of infection by typhoid bacilli of persons drinking water from that point in the river.

7699 In my opinion, an increase in the flow of the Illinois river, by the addition of 250,000 cubic feet of water in the canal would very largely increase the liability of the infection of persons drinking a water supply consisting in whole or in part of water from the Illinois river.

7700 Replying to your question, I will state that there are factors in my knowledge which would lead me to believe that the Illinois river was infected by the sewage of Chicago, and that the mingling of this water with that of the Mississippi river and Missouri river is a serious menace to the health of persons living below the mouth of the Illinois river.

Assuming that there is no typhoid fever pollution of the waters upon the watershed of the Mississippi river and its tributaries above the intake other than that derived from the sanitary district of Chicago. I do believe that typhoid bacilli from the sewage of Chicago are liable to find their way into the water supply of St. Louis through the intake.

7701 I will state it as my opinion that I would believe that the introduction of the sewage from the city of Chicago has rendered the water of the Mississippi river less wholesome as a supply of drinking water.

7702 The best test which can be applied to decide whether a given water supply has been infected by sewage is to study the typhoid statistics of the community using the water.

7703 I would state it very positively as my opinion that typhoid bacilli living in the sediment of a polluted stream for the period of sixty days, would be able to produce typhoid fever if taken into the human system.

I will state it as my opinion that I believe when typhoid bacilli are deposited on the bottom of the Des Plaines or Illinois river, between Chicago and Peoria for a period of thirty or forty days they might retain their dangerous qualities as well as their pathogenicity, for I know of nothing which would make it certain that such an organism would meet with any material which would be certainly destructive to it under such conditions.

7704 I would state it as my opinion that sewage from the city of Chicago, passing through the course described in the question would be a menace and a danger to the inhabitants of Missouri and St. Louis using the water of the Mississippi river at the intake at the Chain of Rocks, for I know of nothing with which the infection contained in such sewage would meet which would be certainly destructive of it, and from my knowledge of conditions at Chicago such sewage must be very largely at times infected with typhoid bacilli.

7705 Taking into consideration all the knowledge which I have bearing upon your question, I will state it as my opinion that harmful elements of the sewage of Chicago have reached the intake of the St. Louis waterworks at the Chain of Rocks and have been the cause of typhoid fever among the persons using that water.

Taking into consideration all the data which you have enumerated in your question, I would state it as my opinion that the flow of the sewage of Chicago from the sanitary or drainage canal, through the Illinois river, has had a deleterious effect upon the health of the persons living in St. Louis and using the water drawn from the intake at the Chain of Rocks.

7708 Replying to the question I would say that I know of no experiments which are entirely satisfactory as proving typhoid bacilli are not able to survive the immersing in sewage for a period of three or four days; that there is nothing in the way of experimental knowledge to show that the typhoid bacilli may not survive in sewage for longer periods, and that taking these facts into consideration, and the further fact that typhoid bacilli might be deposited in the bottom of a stream at any point between the emptying of the drainage canal and the mouth of the Illinois river under conditions which would protect it from such deleterious influences as the sewage exerted upon the bacteria in the experiments which are referred to, especially in the question which you asked, it would be my opinion that typhoid bacilli might survive a very much longer period than three or four days and even be likely to do so if they were deposited upon the bottom of the Illinois river.

I have examined the evidence introduced by Profs. Zeit, Jordan and Russell, with reference to certain experiments conducted for the determination of the longevity of typhoid bacilli.

7709 In my opinion these experiments do not exemplify the true conditions, the conditions which exist in the water of the drainage canal with relation to the life of the typhoid bacilli discharged into that as a part of the sewage.

The opinion is based on several points: First, the introduction of typhoid bacilli in an artificial culture in such a quantity of sewage enclosed in a parchment sac which would protect it. This does not simulate the condition which would exist in the case of typhoid bacilli discharged into sewage and coming from a patient suffering from typhoid fever in which case the organisms might readily be and frequently are enclosed in fecal masses.

Further, the condition of the bacilli in this sac is quite different from that which they would be under if they were free in the stream where they would be free to settle, deposited in the sediment they might then become protected from the influence of the sewage upon them.

In my opinion the condition of the water would frequently change at any one spot owing, as I have said previously in my testimony, to the changeable condition of the discharge which we find coming from the sewers in Chicago.

7710 I know of no previous experiments which were of such a character as to warrant the experimenters in making the assertion that the life of the typhoid germ, either in sewage, or sewage polluted water, is less than six days. As far as I know, the period of time set by Professors Jordan, Zeit and Russell is shorter than given by other authorities. Most experiments of this sort have demonstrated that sewage is in concentrated form detrimental to the life of the typhoid bacteria but the length of time which bacteria have lived in sewage of the different experiments have been so various that I do not recall a limitation expressed by any standard authorities on this subject.

Dr. Horrock's experiments showed that typhoid bacilli survive in unsterilized sewage a period of 14 days.

7712 Taking into consideration the data introduced in this case, and considering also the other facts which have come to my attention concerning the probable life of the typhoid bacilli after it has left the body of the patient, I would express it as my opinion that we would not be justified in concluding that the life of the typhoid bacilli would be limited to the period of three or four days under the conditions which are found to prevail in the drainage canal and in the Illinois river.

7713 In my opinion the experiments in those sacs deviate too far from the conditions which exist naturally and they are so much at varience with the ordinary experience which persons have had who have had to deal with the tracing of epidemics of typhoid fever, that they seem to me to afford facts altogether too incomplete to risk an opinion of such wide and far reaching importance as the decision that would follow in a case of this sort. The decision is too grave to be based upon any such experiment in my opinion.

7714 Taking into consideration the various data to which you have called my attention, I would state that I have been able to find no evidence which to my mind is conclusive that the agencies at work in the stream are adequate to destroy the typhoid bacilli which undoubtedly are introduced into the sewage of Chicago and through it into the Illinois river, and therefore I believe that dangerous and infected pollution might reach the intake of the St. Louis waterworks.

7715 Considering all the data which I have been able to consider as bearing upon this problem, I believe that typhoid bacilli from the sewage of Chicago have reached the intake of the St. Louis waterworks.

7716 In my opinion the data available, especially those relating to the typhoid fever conditions upon the watershed of the Mississippi and Missouri rivers above the intake of the St. Louis waterworks, and the data concerning the occurrence of typhoid fever in the Chicago sanitary district, are sufficient to demonstrate that the increase in typhoid fever in St. Louis has been due in considerable part at least to infection from the Chicago sewage.

7718 I have examined the evidence introduced in this case as to the typhoid mortality in St. Louis for the last six or eight years. A comparison of the typhoid death rate in St. Louis for the years 1896 to 1899 inclusive, with that from 1900 to 1903 inclusive, is the best method of ascertaining the condition of the drinking water of St. Louis, with reference to this period. Of course, using in connection with that, the data concerning the upper watershed. In my opinion, there has been an increase in the typhoid death rate in St. Louis, based upon the mortality per 100,000 population, or upon the percentage of typhoid deaths to the total mortality.

7719 I have examined the data given in the Health Commissioner's report and also those given in the compilation from the mortuary office referred to and have compared the data, and would state that it is my opinion, based upon these examinations and comparisons that there has been an increase in the typhoid death rate in St. Louis during the period covered by the four years, 1900 to 1903, inclusive.

7720 I would state that the comparisons which I have made indicate that the increase in typhoid since the canal was opened has been a very considerable one. The increase has been more noticeable during the winter and spring months than it has during the summer and autum months.

7721 I think that the use of the Widal test has probably not affected very materially the reports of deaths of typhoid fever. Its influence has been more marked in the matter of correct diagnosis of the milder cases of typhoid fever.

7723 I would state it is my opinion that the installation and operation of a filter plant at St. Louis would be more expensive by reason of the discharge of the sewage from Chicago into the Illinois river and that if the deleterious agents in this sewage were removed that the cost of the installation and the maintenance of a filter plant at St. Louis would be lessened.

CROSS-EXAMINATION, By Mr. Todd.

I have never made an examination of the whole course of a river as long as the Illinois river, but I have made frequent analyses, covering several years, of the Connecticut river, in that part which goes through the State of Connecticut. (Witness states what, in his judgment, is the proper method of taking samples, etc.)

7725 In the examination which I made of the Connecticut river, I did not pursue that method by any means. There was no attempt to make a thorough determination of the sanitary condition of that river at all times. I do not know of any analyst of waters who has pursued such a course in this country or in Europe, according to the methods I have described. I should say that no one would be likely to recommend such a thing because the results obtained by those methods would not be comparable to the experience of course—in other words, the method is required to solve problems. The ideal method would be the one which I have just stated.

7726 In my investigation of the Connecticut river, the samples were taken only once a month. The samples of water in the Connecticut river were taken at four stations. That river in the State of Connecticut is about 75 miles. I haven't had any experience in the operation and management of what is known as septic tanks.

7729 From the evidence given in the tables by Prof. Kinnicutt, I should say that there was a very considerable reduction in the constituents of the sewage between the point where it enters the drainage canal until it leaves the canal at Lockport.

According to the tables, especially the table E, which is a comparison of the loss in certain ingredients in that tank as compared with the loss in certain other specified septic tanks, there is a loss which is to be accounted for by the bacteriological action which takes place and is responsible for the beneficial action of septic tanks.

That is what is commonly known as septic action.

7730 The effect of an increased speed in the current of the Illinois river would be to hasten the passage of the water from the upper reaches to the discharge, and also to lower the point where the most active oxidation effects take place, and also to carry down any matter which was suspended and which otherwise would tend to sink.

7733 In making up my opinion and giving my testimony, I do not recall that I have seen the tables made by Professors Teichmann, Ravold or Keiser. In its raw state, I would not recommend the water of the Missouri river for drinking water, to any community.

7735 If it were feasible to recommend an ideal water supply, under all considerations, I should recommend that the water of the Missouri river be treated more efficiently than by the sedimentation tanks, but I should also have to consider that the statistics of the typhoid fever rate which, in my opinion, is on the whole the best test of the sanitary condition of the drinking water during the four years, 1896 to 1899, inclusive, would indicate that the water at that time was in a pretty satisfactory sanitary condition, and if it was not possible to have the ideal conditions, I would be willing to recommend under those conditions the continued careful use of the present sedimentation system.

7737 I would say that I do not consider the Missouri river water an absolutely safe water, and that there are very few absolutely safe waters, even waters which have had a certain amount of contamination and are filtered are not absolutely safe. Such things are not accomplished readily. One has to decide as to the reasonable safety of all conditions and this, I consider, has been shown during the years in question by the statistics which have been quoted.

7738 I would recommend the water as a reasonably safe water but personally knowing the dangers of typhoid infection and having in my family young persons of an age which is particularly susceptible to the infection of typhoid fever, I should hesitate to have my family use it, and would not do so under ordinary conditions, but I should have to recognize and did recognize, in giving the opinion that I could recommend the water as a reasonably safe water, that the average community in the United States do not as yet accept as high a standard for their requirement of drinking water as I should with my own knowledge for my own individual use.

7739 I would say the same as to the Illinois river for the period under consideration (prior to 1900.)

7741 Replying to your question I would state that I have already answered that the water supply which was used in St. Louis during the period in question gave such results according to the test of the typhoid fever death rate that in my opinion, as I have stated, it was during that time a reasonably safe water and I understand that during that period a part of the Chicago sewage was discharged into the river. The removal of that would of course, not affect my opinion as already expressed, so that I would state explicitly that I would not recommend as already stated, the water in use at that time as an absolutely safe water but the results of the tests are, in my opinion, sufficient to justify one in recommending it as a reasonably safe water.

7742 As to whether I would recommend any river in this country as a safe drinking water and for domestic purposes, without filtering, I would say that assuming by "safe" you mean absolutely safe, that I suppose there is no river which flows over the surface which might not at some time become infected and that, therefore, under that assumption, I could not recommend them in this country. There are many mountain streams which have been used for long periods with no ill effects to the persons using them as far as typhoid fever is concerned. I can conceive of a water being absolutely safe, but it is so difficult to find a large quantity of water that is absolutely safe that I should not expect to be able to recommend any supply of water in a large community that would be absolutely safe.

7743 Under certain conditions there might be other methods of purification which could be substituted for filtration. I could not recommend the water from any river in this country that received the sewage from any city above it, as well as the sewage from the rural and urban population, as a safe water supply for a city, without filtration. Under certain conditions, the process of purification by subsidence might accomplish satisfactory results. I have never been called upon to pass judgment upon the quality of a river water for drinking and domestic purposes, when I recommended subsidence.

7744 I have never recommended for municipalities the use of river water without filtering.

The opinion that I gave that it would cost more to filter the water at St. Louis because of the addition of the water from the Illinois river, was a general one, and not a specific one which would require the knowledge of an engineer. The largest filter plant in existence in this country is at Philadelphia. I do not know that at that plant the question of infection is not an element of cost, either in the building or in the operation of same and that the chief cost is in the removal of matters in suspension.

7748 I have not made any laboratory experiments upon the longevity of typhoid bacilli in sewage myself. The opinion I expressed was that the laboratory experiments were so different from the conditions naturally occurring in sewage polluted streams that in my opinion they were not adequate, therefore I do not credit them as being sufficient to form a judgment on that matter, and did not express an opinion. I do not know of any experiments that have been made by any bacteriologist in this country or Europe that simulates natural conditions as nearly as the experiments made by Professors Jordan, Zeit and Russell and which were as extensive in their scope as that experiment, upon the longevity of the typhoid bacilli. Unquestionably the technique of such experiments could be rendered somewhat more approaching natural conditions.

7750 It would have obviated one difficulty if the sacs had been allowed to float down the stream, properly protected so that they would not have been subjected in succession to a series of different character of water as they must have been when they were put stationary at one point. This is one thing that would suggest itself to me.

These experiments might have been tried in sacs of such size as to admit the accumulation of considerable quantities of sediment with a view of ascertaining whether they would have influenced the result. That would have more nearly simulated the conditions in the stream.

The experiments were very carefully worked out and unquestionably they were very well done, but the difficulty of simulating natural conditions are what appear to me to be of importance.

7751 Doctors confound typhoid fever with other diseases. It may happen that they may report deaths that should properly be typhoid under some other head.

7752 There is a marked discrepancy between the list given in the report of the commissioner and the data which were compiled by Prof. Sedgwick and Mr. Lochridge from the records of the mortuary office.

7755 RE-DIRECT EXAMINATION, by Mr. Jeffries:

7756 In my opinion the present state of bacteriology is not such as will permit an expert to fix with accuracy the longevity of the typhoid bacillus in a running stream under all conditions and at all possible times.

Further that it is not possible to state with accuracy the comparative resistance of the colon and typhoid bacilli in a running stream under all possible conditions and at all possible times, and further that it is my opinion the present state of bacteriology is such that it is not possible to conclude from bacteriological analysis that a sewage polluted stream might be so purified as to be used for drinking and other domestic purposes with absolute safety at all times and all seasons.

The effect of a flood upon the watershed of the Des Plaines and Illinois river, upon the sewage of Chicago going through the canal, would be, first, to dilute the sewage, and to hasten the period of passage of it through the river.

7757 The trend, as already stated, of bacteriology researches is to show that concentrated sewage has some deleterious effect upon the life of the typhoid bacilli, consequently the effect of diluting the sewage by floods in the upper Illinois river would be to introduce a condition which would tend to increase the longevity of the typhoid bacilli in the water, first by the dilution of the sewage itself and second by carrying the organisms quicker into the lower stretches of the river where there is more dilution from natural causes.

Taking into consideration the total area of the watershed of the Illinois, Missouri and Mississippi rivers respectively, and the urban population on the Illinois river, including Chicago and the urban population of the Missouri and Mississippi rivers respectively, and also taking into consideration the bacteriological and chemical data that have been introduced in evidence, and the table of results as to the longevity of typhoid bacilli as ascertained by Professors Jordan, Zeit and Russell, my opinion is that the water of the Illinois river would be most likely to contain the largest relative number of disease organisms such as are transmitted by sewage. In my opinion the waters of the
7758 Illinois river do contain relatively more disease germs, such as are transmitted by sewage, than the waters of the other rivers mentioned.

7759 In my opinion this does apply to the water at the mouth of the Illinois river as contrasted to the water at the mouth of the Missouri, in the Mississippi, in the immediate neighborhood at the points referred to.

It is my very positive opinion that it is desirable to preserve the rivers of our country as free from pollution by sewagic matter as possible, and especially as related to their use for drinking waters, and considering the question also of subsequent filtration.

I will state it as my opinion positively that of two waters originally alike in other respects that one which has the least sewage pollution should be chosen for the process of filtration for a public drinking water supply.

7761 JOHN W. ALVORD, examined in chief by Mr. Jeffries: Am a sanitary and hydraulic engineer and reside at Chicago. I have been in the practice of my profession about 24 years. (Gives educational qualifications.)

7762 In 1888 I was engaged in conducting the litigation in behalf of the State of Illinois with the Sanitary District, in the course of which the hydraulics of the upper portion of the Des Plaines river were thoroughly reviewed. I have studied in general the progress of the construction of the drainage channel and the related questions, and was engaged in working for the special commission which reported upon its completion.

I have observed the Illinois river at Morris, Ill., where I designed the system of sewers; at Ottawa, where I was engaged in water power litigation; at Marseilles, where I advised as to the enlargement of the water power, and have also observed the general characteristics of the river at Seneca, La Salle, Peru, Hennepin, Peoria, Pekin and Havana, at which latter two places I have designed sewerage systems.

I am also familiar with the Mississippi river from St. Louis to Alton, to some extent.

7763 I have tried to keep myself posted upon bacteriology in a general way ever since it has come into use among engineers. I also familiarized myself with the subject of chemistry as applied to my profession to a limited extent.

I was employed in 1902 by the special commission that investigated the extension of the water supply of the city of St. Louis, and my part of the work was to study the financial history of the present works, their physical cost and the cost of their operation. In the course of this work I became familiar with the characteristics of these works and have visited the Chain of Rocks station and sedimentation basins, also the old station at Bissel's Point, and have studied the physical features of the sedimentation plant.

I have made a special study to some extent of the typhoid condition on the watershed of the Mississippi river above St. Louis, and obtained data in regard to the typhoid deaths and populations of these watersheds, from the record of this case. I have prepared a diagram showing the relation of typhoid fever deaths in St. Louis with typhoid deaths on the watershed.

7764 This diagram is based upon the typhoid fever deaths upon the watersheds of the Mississippi, the Illinois and the Missouri rivers respectfully, as shown by a tabulated sheet of the evidence upon that subject, introduced in this case. This diagram is reproduced on page 7766 as complainant's rebuttal chart No. 1.

7769 It has been the endeavor in this diagram to disclose the causes for the increase in typhoid deaths in St. Louis during the last few years. In order to intelligently determine such causes, the typhoid deaths along the different rivers have been separated from each other and platted separately so as to determine the source of the most marked pollution. It will be seen that the deaths from typhoid on the Illinois watershed, exclusive of the sanitary district of Chicago, are fairly uniform up to the year 1899, but show a rise in the year 1900, the year in which the drainage canal was opened. Otherwise they seem to be fairly uniform for the years preceding and following the commencement in the rise in the number of typhoid deaths in St. Louis.

The deaths on the Missouri river watershed appear also to be reasonably uniform for the period under consideration, and the typhoid deaths on the Mississippi river watershed, while fluctuating somewhat more than the first two described, are nevertheless generally uniform before and near the rise in the typhoid deaths in St. Louis.

In summing up the total typhoid deaths on the watershed above St. Louis, as given in the record, it would appear that while there is some fluctuation and a low period about the year 1896 that at no time since the rise in typhoid deaths in St. Louis they have materially exceeded a fair average rate and have in fact fallen off since the year 1900.

It will be observed, however, that the addition of the deaths from the sanitary district almost doubles the total typhoid deaths, influencing the pollution of the St. Louis water supply and that such addition is materially increased during the years 1901 and 1902, so that in 1902 the total typhoid deaths are nearly two and one-half times the deaths on the watershed above St. Louis, exclusive of the sanitary district of Chicago.

A local epidemic in St. Louis typhoid deaths in 1892 is clearly shown by the diagram and is attributable to the contamination of the water supply at the old station at Bissell, by Ginras Creek, and neighboring sewers.

Upon the removal of the source of supply from Bissell's Point to the Chain of Rocks in the years 1894 to 1895 there is shown a marked improvement in the total number of deaths from typhoid for the latter year.

7770 I should consider, after a study of the data that in all human probability the rise in typhoid deaths in the city of St. Louis, in the last few years, has been caused by the added typhoid contamination from the sanitary district of Chicago.

7771 I have for some years past considered the life of the typhoid bacilli would be from 60 to 90 days under favorable environments, and while large masses of such bacilli might be removed from any given source of supply in a comparatively short time under unfavorable environments, it would not be safe to assume that a water once thus polluted would be safe to recommend for public use, under the time given, unless the contamination were eliminated by a carefully designed and properly operated system of purification.

(Refers to experiments made by Mr. Mills and Dr. Horrocks.)

The sewerage system of Chicago has very flat gradients
7772 and requires frequent artificial flushing. It has been the history of heavy rainfalls in that city that the entire content of the sewers are at such times disgorged into the river bringing into it a mass of pollution which has been accumulating for months together. Before the opening of the drainage channel such periods were extremely dangerous to the water supply of the city, as was shown in the increase in typhoid deaths following the period of such contamination. Such heavy flushings of rainfall occur ordinarily in the early spring or after the breaking up of the winter and at times when the temperature is most favorable to the longevity of the typhoid germ and greatly increases for the time being the rate of pollution in the drainage canal and Des Plaines and Illinois rivers.

In my opinion the action of such a flushing of the Chicago sewer system into the Chicago river with its present large proportion of pure water and low temperature furnishes con-
7773 ditions which parallel or indeed form more favorable conditions to the longevity of pathogenic bacteria than those under which the experimental work above noted were taken. The discharge of this various amount of pollution at times of flood waters appears also to furnish the necessary velocity for rapid conveyance through the drainage canal down the Des Plaines and Illinois rivers to the intake of the St. Louis water supply; the increment of tributary streams also increases the dilution and decreases the chance for toxic destruction of the total number of typhoid germs present. Such conditions are prevalent in greater or less degree during many times of each spring.

In the case of heavy rainfall on the watershed of the Chicago river, it is often necessary in order to prevent outflow into Lake Michigan through the main river, to lower the Bear Trap dam at Lockport so as to produce greater velocity at all stations down the channel at such times. This undoubtedly aids in the rapidity with which pollution is conveyed away from Chicago down the channel of the Des Plaines and Illinois rivers.

7774 Below the outlet of the drainage canal at Lockport, the Des Plaines river flows very rapidly to a pool formed by what is known as dam No. 1 at Joliet. This descent over ordinary and normal flow produces rapid velocity and a slight rise, but rainfall will develop velocity in the channel of from 40 to 60 miles per day. Below dam number one and at Joliet, the flow again becomes very rapid at times of moderate rises. This flow is slightly checked through Lake Joliet, but there is a further rapidity incurred on its outlet all the way down to the mouth of the Kankakee river. Below this point, the Marseilles dam slightly checks the current. Another rapid flow takes place below the Marseilles dam as far down as Peru, where the influence of the Henry dam is felt. In the time of spring rises the velocity in these reaches is very materially increased, running, as I have said, up to as high as forty to sixty miles a day. The effect of the introduction of 250,000 cubic feet of water per minute through the Chicago drainage canal is to materially increase the current of the Des Plaines and Illinois river and to carry dangerous pollution to greater distances and with more rapidity. I fail to see the pertinency of Mr. Randolph's conclusion that a correction should be made of the maximum travel of the floats used to determine the velocity or length of time required for the travel of water from the canal to the Chain of Rocks.

7776 The use of the .8 correction, in the manner described in Mr. Randolph's testimony is a very rough approximation, used by hydraulic engineers when surface floats are run in the most rapid part of the channel of a river to determine the average flow for the whole cross-section of the channel in order to get at the quantity passing a given point per second. In the case under consideration, we are not endeavoring to determine the quantity of water passing any given cross-section per second, but the problem presented is what length of time will any given pollution, flowing in mid-channel, pass over the necessary distance from the Chicago river to the Chain of Rocks. This only requires, in my opinion, a determination of the mean velocity of the bore or central section of the stream.

I should not consider the floats described by Mr. Randolph and Mr. Crane, as surface floats.

As described in the testimony they appear to be partially submerged and I believe they give the mean velocity of the central portion of the stream with a fair degree of accuracy.

I should judge that fifteen days actual time would fairly represent the ability of the water of the Illinois and Des Plaines rivers to carry pollution to the Chain of Rocks at the stage when the experiments were made.

(Witness compares experiments made by Prof. Van Ornum and those made by Mr. Randolph.)

7779 Not having been able to ascertain the specific stage at the time of Mr. Randolph's experiments, I should be unable to state positively that his experiment was made at the minimum stage of the river, but speaking generally, it is my impression that it was, and represents the average of the minimum velocity in the ordinary dry seasons of the year between the Chicago river and the Chain of Rocks.

7780 I have examined the chart referred to by Mr. Hering, which represents an attempt to derive the possible amount of contamination in the water at the Chain of Rocks, from the sanitary district of Chicago, by assuming that the original pollution is proportional to the population and that the longevity of a typhoid bacillus is, as found by the experiments of Hiram F. Mills in the paper referred to. The chart also makes the same deductions for the Mississippi and Missouri rivers and gives the rate of fall of the three watersheds. In the case of the Illinois river the length of time of flow from the Chicago river to the Chain of Rocks is taken at 18½ days, as stated by Mr. Randolph from his experiments, after adding to the original experiments an additional time for the correction to the mean velocity. It would seem to me in the first place that Mr. Hering has not given due weight to the relative effectiveness of different populations in the production of typhoid pollution. The sanitary district of Chicago has been afflicted for years with an abnormal number of typhoid deaths. Other cities on the Illinois watershed, deriving their water supply from artesian wells, have extremely low death rates from the same cause. It would appear, therefore, to me, that to make the diagram more exact some method should be introduced by which the
7781 disparity in typhoid data could be allowed for in its effect upon the St. Louis water supply.

Again, I should judge that the diagram as compiled under Mr. Hering's direction gives the time of travel of the pollution vehicle at low stages of the river and therefore does not fairly indicate the greater danger of pollution to the St. Louis supply at medium or high stages of the river. It would seem that the diagram should be so constructed that these modifications might be clearly apparent.

I have prepared a diagram which, according to the methods suggested by Mr. Hering, based upon the experiments of Mr. Hiram F. Mills, which would also include the two modifications just described by me.

This chart is marked Complainant's Rebuttal Chart No. 2, and is reproduced on page 7782.

7785 Assuming active typhoid contamination is proportional to the population, and assuming diminution in the number of typhoid germs day by day to be as shown in the experiments of Mr. Hiram F. Mills, the modifications which I have introduced in the diagram would considerably increase the amount of typhoid pollution entering the intake at St. Louis.

I find that whereas Mr. Hering's diagram shows that the typhoid pollution entering the intake at the Chain of Rocks is
equivalent at the end of a low river flow of 18½days to an
7786 infection from a tributary population immediately above
the intake of a city of 13,000 people, the conclusions of the diagram would seem to indicate that the normal flow of fifteen days would be equivalent to an infection from a tributary population with a death rate of 20 per 100,000 living of a city located immediately above the intake, with a population of about 90,000 people, while on the basis of ordinary spring floods, such as were gauged by Professor Van Ornum the infection arising at the Chain of Rocks would be equivalent to the population of a city of 415,000 population, situated immediately above the intake tower, and with a typhoid death rate of 20 per 100,000.

With a maximum flood such as occurs only once in every several years, it would appear that the comparative pollution reaching the intake of the St. Louis waterworks would be equivalent to a population of 560,000 with a typhoid fever death rate of 20 per 100,000 living, this latter assumption being based upon the movement of the pollution vehicle from the Chicago river to the Chain of Rocks in eight days.

7787 I believe the investigations made by Mr. Hiram F. Mills, the results of which were used by Mr. Hering in his chart, might be termed incomplete investigation, that is to say, they

are valuable, but neither sufficiently comprehensive nor numerous. I have given particular attention to the development of septic tanks and have designed some ten or fifteen plants
7788 for municipalities in which a septic tank has been employed on my recommendations. Of these plants eight septic tanks have been constructed under my immediate supervision for different municipalities and have been in operation for periods ranging from one to four years. Two of these plants have been under my immediate supervision ever since construction and I have watched the operation of others.

Flowing sewage does not ordinarily undergo the process of septic action. Diluted sewage flowing in open channels would not simulate septic tank conditions.

7789 In the Chicago drainage canal we have a large volume of diluted sewage flowing at the rate of one to three feet per second, giving ample opportunity for renewing its dissolved oxygen. And we have this action further increased by the opportunity of the wind to stir the surface of the stream and still further oxygenate it.

We have also an opportunity for exposure to low temperatures, light, etc., which are detrimtal to the septic action. Septic action to any considerable extent does not take place in the sewage of Chicago during its passage through the drainage canal. My opinion is that the chemical data introduced by the defendants with reference to the character of the contents of the Chicago drainage canal do not indicate any septic action has taken place. The amount of improvement in the sewage in its travel of the drainage canal found by Professor Kinnicutt in his testimony in this case would seem to me to be largely due to aerobic action. Possibly there is anaerobic action to a very limited extent, but not enough in my opinion to influence the results perceptibly. The extensive dilution of the sewage of

Chicago by the richly oxygenated water of Lake Michigan is distinctly opposed to the inception of septic action.

7790 I was familiar with the south branch of the Chicago river prior to the opening of the canal. It presented all the characteristics of septic action to a marked degree. I believe that typhoid germs could survive materially longer un-
7791 der the present conditions than was the case formerly in the Illinois and Michigan canal and the South Branch of the Chicago river. Taking into consideration all the facts testified to, the presence of sewage from the sanitary district of Chicago, in the waters of the Mississippi, at the Chain of Rocks, makes it more costly to provide suitable water for domestic purposes for the citizens of St. Louis. The design and construction of a purification plant dealing with a seriously polluted water, especially of one of known high typhoid pollution, should be more complete and delicately adjusted to its work than when dealing only with water of rare infection and presenting less dangerous difficulties, such as turbidity and color.

7792 This added protection should take the form either of double filtration or have complete sedimentation in more than one stage followed by most careful filtration. (Witness states cases that he knows of where double filtration is being resorted to.) Such methods would greatly increase the cost of filtration both in construction and operation. Single sand filtration as practiced in the United States is not always a protection from the danger of typhoid infection.

7793 Sand filtration of either type is practically able to remove pathogenic bacteria from domestic water supply, but we find that in practice filtration works are a most delicate mechanism, which have to be very carefully operated in order to produce at all times and under all conditions the results anticipated by their designers. In cases where the danger of infection hovers over the filtration plant year in and year out it is obvious that the slightest relaxation may result in the most serious consequences.

There have come under my observation, typhoid epidemics in water supplies protected by filtration in the following places:

Rock Island, Illinois,
Ashland, Wisconsin,
Berlin, Germany,
Lawrence, Massachusetts,
Lake Forest, Illinois.
Butler, Pennsylvania,
Waterloo, Iowa,
Beaver Falls, Pensylvania, and
Augusta, Maine.

7795 I am of the opinion that it is entirely practicable to retain the drainage channel so that it can be still employed for keeping the Chicago river in condition and yet avoid pouring unpurified sewage into and through the canal and into the Des Plaines and Illinois rivers, and I would suggest as the proper remedy the construction of suitable intercepting sewers along the Chicago river and its branches, by means of which the sewage flow of the city may be kept out of the Chicago river and lead along its banks to the upper end of the drainage channel beyond Bridgeport and then raised by a suitable pumping station preferably operated with water power derived from the drainage canal to and into a suitable purification plant constructed in accordance with the latest bacteriological principles and effectually remove from such sewage all or practically all of its organic wastes and pathogenic bacteria and emptying the effluent from such sewage plant into the drainage channel near Bridgeport to be conveyed through the same and through the Des Plaines and the Illinois rivers in a harmless and purified state.

I have considered the expense in a general way and am of the opinion that such intercepting sewers and purification

plant could be constructed at an expense no greater than that necessary to widen the South Branch of the Chicago river
7796 in order to increase its flow of dilution water to the requirements of dilution.

And I am further of the opinion that the operating expense of such a plant would be no greater than the operating expense of the present system of pumping sewage and the necessary dilution water through the same for the northerly and southerly portions of the sanitary district and the dilution water for the proposed additions to such sanitary district.

CROSS-EXAMINATION, By Mr. Todd.

I would estimate the cost to be between twelve and fifteen millions of dollars. That contemplates the purification of the entire sewage of the sanitary district. (Witness is cross-examined as to method of putting such a plan in operation.)

7801 At the time Mr. Hering made his preliminary report, when the question of sewage disposal for Chicago was under consideration, the question of bacteriology was not then generally recognized as a science. The purification of sewage was then known and extensively practiced, but the systems which I now have in mind were not developed, and speaking generally, the systems then in use, while efficient, were ex-
7802 pensive. I have conducted no experiments upon the longevity of the typhoid germ.

7803 As to typhoid fever in St. Louis, I have not attempted to account for the rise evidenced on the chart, which I introduced in evidence, from 1899 to 1900. There is a slight fall for the years 1900, 1901 and 1902 in typhoid along the Illinois river, exclusive of Chicago. I have not attempted to account for it. There is a rise in the typhoid rate as evidenced by the chart upon the Mississippi river from 1899 to 1901. I have not attempted to account for that.

7805 An increase in typhoid fever in St. Charles might possibly be expressed in the typhoid conditions in St. Louis.

7807 I should be inclined to think from my diagram that the typhoid deaths in St. Charles might have influenced the normal typhoid deaths in St. Louis prior to 1900 to some unknown percentage. I should be disinclined to think that since 1900 the typhoid in St. Charles could have been responsible for so marked a change in the number of deaths in St. Louis from typhoid.

Q. Do you employ the theory of probabilities in drawing your conclusions that the typhoid increase in St. Louis is due to Chicago?

A. Whenever we deal with a problem of the magnitude of this problem and its complications, we are obliged as one of the contributing data to proceed on such theory.

I do not regard the water of the Missouri river in its raw state, as a safe drinking water. As treated by settling basins, I should say that it has only probably been greatly improved in its general character. It may be safely assumed that the water of the Missouri river has been deteriorating, as a safe drinking water for the last 25 years, and each year, more so, and the same is probably true of all our western rivers.

7809 I do not regard the Mississippi river water above Grafton as a safe drinking water. I do not regard the water of the Illinois, Mississippi and Missouri, eliminating the sanitary district of Chicago, treated as it is in the settling basins at St. Louis, entirely safe as a drinking water to be used by the city of St. Louis. If I were selected as a sanitary engineer, I should not like to recommend it. I do not know the stages of the river at the time Mr. Randolph made his float experiments, but I should think that they were the average low waters of mid-summer—that is an intelligent guess. Figuring out the average time between Chicago and St. Louis, I came to the conclusion that at most stages of the river uninfluenced by
7810
floods of any kind, the time of passage of the pollution vehicle would be in the neighborhood of the float experiments,

as determined by Mr. Randolph or thereabouts, but not reduced to mean velocity, and that in times of slight or medium rises, the time of passage of the pollution vehicle would be apparently in accordance with the experiment of Professor Van Ornum, and that in time of very great floods, such as occurred in 1902, and I believe in 1888, and at one or two other times in my recollection, the time of passage might be reduced to eight days or less.

7811 The effect of the corrections that I have made to the chart of Mr. Hering, would be to place a city of 960,000 population, instead of 13,000 above the Chain of Rocks.

7815 If the sanitary district of Chicago should be eliminated, I should still recommend a filtration system for the water of St. Louis.

7819 RE-DIRECT EXAMINATION, by Mr. Jeffries:

As the infection material is increased in a running stream that is being filtered, it is recognized by all sanitary engineers that the construction must be more perfect, of a higher grade, that the equipment, maintenance and character of the employes must be more efficient.

7821 E. E. LOCHRIDGE, examined in chief by Mr. Jeffries: I live in Boston, Mass. Am bacteriologist and chemist. Have studied and examined into water supplies, etc.

7823 I have examined the tables of typhoid fever statistics for St. Louis, introduced by witnesses and now formally a part of the record of the defendants in this case, and especially introduced by Dr. Baker on October 24, 1903. The number of typhoid deaths given on that table for the years 1896 to 1902 differ only slightly from the results obtained by compiling the deaths attributable to typhoid fever in the record books of the mortuary office. I have made a special study of the tables for typhoid fever and other fevers in the office of the Board of Health of St. Louis. I do not believe that a comparison of the typhoid fever deaths prior to 1896 with those subsequent to 1896 is either practicable or feasible, for the reason that prior to 1896 the intake was so located as to expose the water supply to infection, and during 1894 and 1895, the intake was removed to

a point farther up the Mississippi river, at the Chain of Rocks.

7824 In order to show the great change in the typhoid fever mortality of the city of St. Louis, at the time the intake was moved, I have prepared a diagram which serves to illustrate this point, as well as certain other points to which I have occasion to refer hereafter.

Diagram reproduced as complainant's rebuttal chart No. 3, on page 7825.

7826 This chart represents the per cent of deaths from typhoid fever to the total mortality for the city as taken from the printed health records of the health department.

It will be noted that the death rate was uniformly high up to the time of the change of the intake from Bissell's Point to the Chain of Rocks. Following this change there is a period of five years in which the mortality is much lower. In 1900 there is a considerable increase and a step like increase through the subsequent years.

(Motion to strike chart from the record.) I have examined the mortuary records and have made tables showing the number of deaths from typhoid fever, remittent fever, intermittent fever, typho-malarial fever, congestive fever and simple continued fever in each month of the year from 1896 to 1903 inclusive. Said charts being numbered 4 to 9 inclusive, and are reproduced on pages 7828 to 7833, inclusive.

7835 I find six deaths marked continued or continuing fever, but none marked simple continued fever in the years 1896 to 1903, inclusive.

I have made a table of the deaths which I found recorded in the records in the mortuary office in the city of St. Louis, from malarial fever, for the years from 1896 to 1903, by months, which is reproduced on page 7835.

7837 Adding together the deaths which I found in the study of the records at the mortuary office from remittent, intermittent, typho-malaria, congestive and continued fevers, I find that for the years 1896 to 1899, inclusive, there were respectively 129, 106, 85 and 86 deaths, and that if the number of deaths which I found in the records in the mortuary office from malaria are added to these, there are in these years respectively 156, 140, 108 and 121 deaths, while Professor Jordan gave for the corresponding years 177, 172, 134 and 148, or the number of deaths which I find recorded on the books in the mortuary office from these causes is a little lower in each year than the list taken by Professor Jordan from the printed health report.

In the four years from 1900 to 1903, inclusive, adding together the deaths which I found in the books in the mortuary office in the city of St. Louis from intermittent, remittent,
7838 typho-malaria, congestive and continued fevers, I find for these years 77, 62, 76 and 73 deaths. Adding to these the deaths which I find of malarial fever for these years, there were 137, 90, 114 and 126 deaths, or a little higher in each year than those given by Professor Jordan.

Considering the fact that the malarial fevers were in all probability recorded in this list as they do not occur under any other caption, so far as could be discovered in the printed health reports, I find that Professor Jordan has in his list 21 more deaths in 1896, 32 more in 1897, 26 more in 1898, and 27 more in 1899, 25 less in 1900, 10 less in 1901, 12 less in 1902, and 35 less in 1903, than I found in my study of the records in the mortuary office in St. Louis.

I have made other tables showing deaths from bilious fever, enteric fever and deaths in which typhoid was assigned as the cause, but not the principal cause, and typhoid-pneumonia deaths. These charts are numbered 11 to 13 inclusive, and are reproduced on pages 7840 to 7843 inclusive.

7844 I have tabulated the typhoid fever deaths in the city of St. Louis, according to the residence address at which the patient died, for the years mentioned. This chart is reproduced as Nos. 15 to 22 inclusive, on pages 7845 to 7852, inclusive.

7855 These charts show that since the year 1900, the distribution throughout the seven sanitary districts has been very uniform when we consider the deaths occurring in hospitals, but referred back to their residence district. There is no district in which there was an unusual number of deaths when compared with other districts since 1900. The distribution of the typhoid deaths in the various districts has been quite uniform since 1900, such as might be expected if the cause for the typhoid were one which would be equally applicable to all of the citizens of the city in the way that pollution by water is applicable. I have prepared similar charts showing the deaths from malarial fever in St. Louis, by districts, numbered 23 to 30 inclusive, and they are reproduced on pages 7856 to 7863, inclusive.

7864 The tables indicate the distribution during the year in the city and the increase in malaria from year to year between the years 1896 and 1903, which show that the distribution in these districts is not as uniform in the city as is the case of deaths from typhoid fever. I have prepared charts showing the deaths from typho-malaria during the same years, numbered 31 to 38 inclusive, and reproduced on pages 7865 to 7872, inclusive.

7873 These tables show the total number of typho-malaria deaths in each of the seven sanitary districts for each month for the eight years mentioned, each year being on a separate chart. The distribution is here, as in the case of the malaria, less uniform than the distribution of the typhoid fever deaths.

I have prepared charts of deaths from typhoid fever in St. Louis for the years 1896 to 1903, inclusive, in which the deaths from this cause are tabulated according to age at time of death and by the month of the year. These charts are numbered 39 to

46 inclusive and are reproduced on pages 7874 to 7881 inclusive.

7882 From a study of these charts which give the data in regard to the age and time of the deaths from typhoid fever in St. Louis during these eight years, it will be seen that a large proportion of the deaths occurred between the ages of eleven and fifty, and the ages of six to sixty will include practically all of them.

The number of children dying of typhoid, of those under six months or from six months to one year is the same in the first four years as in the last. The increase for any given age can be noted by comparing the charts of the four years, 1896 to 1899, inclusive, with the charts of the four years, 1900 to 1903, inclusive.

These charts not only show the increase in the number, but also the increase under each of the ages, and also by the season of the year. This may be noted by a comparison of the number of dots for any given month and for any given age.

7883 During the early years represented by these charts the number during the months of January to May, and the month of December is quite low, while since the year 1900 there has been a very marked increase of the number of deaths for this six-month period, much more in proportion than during the other six months.

I have prepared similar charts of the deaths in St. Louis from remittent fever for the years 1896 to 1903 inclusive, in which the deaths from this cause are tabulated according to ages at time of death and by months of the year. These charts are numbered 47 to 54 inclusive, and reproduced on pages 7884 to 7891, inclusive.

7892 In all of these tables the variations in the number of deaths from this cause will thus be seen to be in the column of children under three or people above 61 years of age, the numbers during the ages ordinarily considered as typhoid ages and indicated on the typhoid charts, both before the opening and since the opening of the canal, as typhoid ages remains about constant.

Have prepared similar charts of the deaths from intermittent fever, which charts are numbered 55 to 62 inclusive and reproduced on pages 7894 to 7901, inclusive.

7902 The total number does not vary materially before and since the opening of the canal with the exception of the year 1899, in which there are nearly twice the number recorded for the other years.

However, in the year 1899, it will be found that there are five deaths of children under six months of age from this disease and five more between the age of six months and one year.

With this exception the number is practically the same during each of the years covered by these charts.

There were 17 deaths from intermittent fever in St. Louis in the year 1899, as shown by this chart, of persons either of or below the age of three years and of or above the age of 61. This number subtracted from the total of 25 leaves 8 of the ages when typhoid fever is most prevalent.

7903 There was not a single death from intermittent fever during the year 1899 of a patient between the ages of 11 and 30 years.

There are a considerable number of deaths during the summer months, as for example, in 1897 all of the deaths were between April and October, inclusive.

I have prepared similar charts showing deaths from typho-malarial in St. Louis, numbered 63 to 70 inclusive, and reproduced on pages 7904 to 7911 inclusive. I have prepared similar charts showing deaths from malarial fever, numbered 71 to 78 inclusive, and reproduced on pages 7913 to 7920 inclusive.

7921 I have prepared chart showing deaths in each year by months for the four years subsequent to the opening of the drainage canal from congestive fever, numbered 79, this is reproduced on page 7922, also chart numbered 80, showing deaths from congestive fever for four years subsequent to the opening of the canal, and this chart is reproduced on page 7923.

7924 I have prepared two charts of bilious fever deaths, one covering the period from 1896 to 1899 inclusive, numbered 81, reproduced on page 7925, and another covering the period from 1900 to 1903 inclusive, numbered 82, reproduced on page 7926. Chart 83, reproduced on page 7928, shows deaths from enteric fever from 1896 to 1903, inclusive.

7929 During the eight years between 1896 and 1903 inclusive, there were six deaths marked continued or continuing fever, two of these occurring in the four years prior to the opening of the canal and four occurring in the four years subsequent to its opening. The typhoid fever charts show the largest number of deaths occur between the ages of 11 and 50, and on either side of these ages, that is, under 6, and over 50, there are few deaths from typhoid.

7930 In the earlier years, notably the first four years, 1896 to 1899, inclusive, the much larger proportion of deaths occurred between the months of July and November inclusive. During the years 1901, 1902 and 1903, it will be seen that there are much larger numbers than the proportional increase in the months just referred to, during the months from January to June, and in the month of December, so that during the latter years the typhoid fever deaths are scattered pretty generally through the year, there being a few more during the summer months than during the winter months.

I have prepared the chart with the caption "Winter Typhoid, St. Louis," on the lower half of which are recorded the number of deaths in the months of January, February, March, April, May and December, for the years 1896 to 1903, inclusive. In the line above this tabulation is given the estimate of population found in the testimony of Messrs. Barker and Jordan. Said chart is reproduced on page 7932. I have prepared a like chart showing summer conditions, numbered 85, which is reproduced on page 7934.

7935 I have also prepared a chart entitled, "Comparisons of Typhoid Deaths," numbered 86, being a comparison of typhoid deaths in St. Louis for the winter and summer months, prior to and since the opening of the canal. Said chart being reproduced on page 7936.

7937 This chart is intended to show the relative increase in typhoid fever in the winter and summer months as between the period prior to the opening of the canal and the period subsequent thereto.

7942 Deaths from typhoid fever in the year 1896 will be seen to lie quite well between the ages of 6 and 60, while 22, or considerably over fifty per cent of the remittent fever deaths for this same year are either younger or older than the ages mentioned, or in other words, are either infants or old people.

In the year 1897 there were 11 less deaths from remittent fever than there were from this same cause in 1896, but that loss might be considered as entirely among the very
7943 young children, and it can be seen by referring to the
typhoid deaths for 1897 that not one of these has been added to the death rate from typhoid fever, or in other words there could have been no transfer to typhoid fever due to better diagnosis. If the change in the annual number of remittent fever deaths be due to such better diagnosis, these deaths have been referred to some other disease than typhoid fever. A study of the tables through all the following years from remittent fever will show this same variation, the variation being in the number dying under the age of six years, the number of deaths remaining practically the same during the ages in which the mass of the typhoid fever deaths occur.

In the year 1896 there were 12 deaths from intermittent fever and in the year 1897 there were 12, but these may be seen to have been in entirely different ages, the same variation in the number of deaths in children under the age of 1, particularly, and in some cases under the age of 6, being quite apparent. This is noticed quite effectively in the increase in 1899 of the number of deaths from intermittent fever to 25, the increase being entirely in these younger ages.

The next year, or the year 1900, there were but three deaths from intermittent fever of people 20 years of age or younger, while if we consider the deaths from typhoid fever there is no marked increase in this age and there were no deaths from typhoid fever in that year recorded in the first two columns, those of six months of age and under and those of one year, so that the decrease in the number of intermittent fever deaths for the year 1899, when there were 25, and the year 1900, when there were 10, has not been brought about by transfer of these deaths to the typhoid group. In the other ages the intermittent and typhoid deaths are practically the same respectively, in each of the seven years.

7944 The deaths from typho-malaria follow more nearly the age periods of the typhoid fever than do those of either the intermittent or the remittent fevers. The number of deaths from typho-malaria per year is practically the same during the four years prior to the opening of the canal and the four years subsequent. A greater variation in the age at the time of death occurs in the typho-malaria group than in the typhoid group, the numbers remaining proportionately the same for the respective years.

The deaths from malaria and malarial fever will be seen to be distributed about the same proportionately over the various ages in the different years plotted. There has been a marked increase in malaria and malarial fevers during the past few years. It will be noted that there are about the same number of deaths in the younger ages from malaria or malarial fever during these years and the number of older people is proportionately considerably higher than the mortality in these ages from typhoid fever.

7945 Here again we find the large variation occurring among those under the ages of six months, one year and two and three, the variation being about the same as in the case of remittent and intermittent fevers. The year 1896 was much higher than any of the other years, although 1897 was also high. It will be noted however, looking at the list in 1896 that 13 of the cases of the congestive fever deaths were under the age of five years, ten of those under one year, and as pointed out before there has been no increase in these ages in the latter period, in the typhoid fever list. With the exception of two years when the congestive fever list was low, the variation was due to the deaths under these younger ages or of quite old people.

In comparing the deaths from congestive fever in St. Louis, with those from typhoid fever, here again the number of deaths from bilious fever is in all cases without any variation in the number, being either in the younger ages or in the older ages, and as mentioned before there has been no increase in the typhoid fever deaths in these ages to correspond with the decline in the bilious fever deaths of those ages. The bilious fever has been considered because no record of it was found in the printed report, and it was thought that possibly it might have been included in the group of "fevers" referred to in this case.

7946 (Witness makes calculation to show the effect of the influx of people to St. Louis on account of the World's Fair.) On the basis of Prof. Jordan's estimates of the population in the city in the year 1903, of 618,500, which is but something less than 60,000 increase in population over 1899, it will be seen that the increase in typhoid has been much more rapid and that it can not be ascribed to any considerable extent to the addition of these or others, who may have been in the city during this time.

7947 This comparison can be shown in another way. Considering the figures given by Professor Jordan for the population of St. Louis, and supposing that the typhoid death rate per 100,000 had remained at 21.6, this population at this rate would have indicated about 130 deaths from typhoid for the year 1903. The actual number of deaths was 281. It can be thus seen that the increase in the typhoid death rate is more than double in 1903 what is was in 1899, while the population has increased but little over ten per cent. I am familiar with the testimony in regard to the experiment made by Profs. Zeit, Jordan and Russell regarding the longevity of the typhoid bacillus.

7948 I do not think the results of these experiments represent or simulate natural conditions, for the following reasons:

In the first place any sac lodged at one place will receive the influence, if the osmotic conditions are as perfect as is supposed, of sewage which is fresher continually than would be in contact with similar germs passing down the stream. The actual influence, if there is any, of the sac itself is not known. The results vary to some extent from earlier results obtained by various bacteriologists on this same point. There were but three of the series of Professor Jordan's experiments in the drainage canal at either Robey street or at Lockport in which the typhoid organisms were found at all *after* 10 minutes had elapsed, with the exception of one case where it was found ten minutes after inoculation. Of these three cases one is a recorded instance of its occurrence on the 10th day. This has been attributed by Professor Jordan to the fact that bacteria, and especially the typhoid bacteria may be dried against the neck or some part of the sac, and thus be subjected to conditions of greater longevity. This is a possible explanation for this, but there seemed to me to be other explanations. It is a fact, recognized in general, I believe, by bacteriologists that of several forms of microorganisms in the water that one of these forms will apparently mask others, as in the case of experiments with colon and streptococci.

In the earlier periods the colon masks the streptococci so that but few or none are seen. While the streptococci develop much more abundantly and to an extent overgrowing the coli. Later, however, the coli may again appear. Considering this principle it may have been impossible on any of the earlier determinations to have detected the typhoid, although there is no conclusive proof that they were of necessity absent up to the time of this appearance on the tenth day, and the three typhoid colonies found may be ascribed to the fact that their presence was masked before that date. In regard to the other determinations of Professor Jordan, showing that the typhoid were certainly alive in two cases after the second day, indicates that this germ will live at least this long, but I do not believe that it necessarily shows that they do not live longer.

7949 (Witness gives other reasons.)

I have read the evidence of Profs. Jordan and Burrill upon the colon tests. These tests do not show, by any means, the total elimination of the coli from the waters of the Illinois. Of course there is a reduction, but there is no point reached where there is an elimination of the colon as is shown directly from the tables. These coli determinations are always subject to a good many conditions, especially the presence of streptococci or perhaps even other bacteria present in the water.

7950 These very frequently mask the coli so that any reaction of the coli is not given. In a river water it quite frequently happens that two samples of equal volume, from the same source, will one give the positive, the other the negative reaction for coli, for this reason; so that I do not believe that a negative reaction by any means is indicative of the absence of the coli, especially when it is frequently found in other samples from this same source.

I do not see any indication that the Widal test materially changes the typhoid mortality records of a city. The use of the Widal reaction was begun in the city of St. Louis.

7951 I do not see that any considerable numbers have been either transferred to, or taken from the typhoid list for the city of St. Louis on account of the adoption of the Widal test. I do not believe that any considerable number of deaths have been classed as typhoid since the opening of the drainage canal, which, without the use of the Widal reaction would have been placed in the column entitled remittent, intermittent, typho-malaria, congestive and continued fevers. The variation in the number of people dying from the fevers I have diagrammed, has been of people of ages when there are the least number of deaths from fevers and there are more deaths of those at the age of typhoid susceptibility, in the years since 1900 than at any other time during the eight years examined.

CROSS-EXAMINATION, by Mr. Todd:

7952 MR. TODD: I move to strike out all of the evidence of this witness in regard to the records of the mortuary office of the Board of Health of the city of St. Louis, the tables, charts, deductions and conclusions drawn therefrom, for the following reasons:

That the public records of the mortuary office if admissible at all are the best evidence. That it is not the proper way to prove a public record. That the testimony of the witness is not proper and competent evidence to impeach the official published reports of the health commissioner of the St. Louis Board of Health, published by authority of said board, for the reason that the published records of the mortuary office if competent to impeach the authorized published reports of the health department or health commissioner of St. Louis can not be proven in the manner as testified to by this witness, but that the public records themselves are the best evidence and can not be proven in this manner. That it is improper at this time for plaintiff to attempt to impeach the official reports of the health commissioner of the city of St. Louis, which report was relied upon and testified from in the evidence in chief by the complainant's witnesses and made a part of the evidence in chief in this case and is therefore not proper rebuttal and is incompetent and improper evidence. That it is not proper rebuttal after being considered and gone into in chief as the defendants had the right to rely upon the official reports of the
7953 Health Commissioner of the city of St. Louis, published by the authority of the Board of Health of St. Louis and introduced in evidence by complainant, and if said reports were incorrect, inaccurate and unreliable it was the duty of complainant to make such proof in chief and not wait until defendants had rested their case to introduce such improper and

incompetent evidence for the purpose of impeaching the official reports of the Health Commissioner of the city of St. Louis or of proving the public records of the St. Louis Health Department in the manner attempted to be done by the testimony of this witness. The entire testimony of this witness in regard to the public records of the Board of Health of St. Louis being incompetent, all conclusions, charts, deductions and opinions are therefore incompetent, and not proper rebuttal for the reason that the alleged facts and alleged records which are the basis of such tables, charts, deductions and opinions not being legally proven and legally established vitiate any charts, tables, deductions and conclusions of this witness and not being proper rebuttal evidence is incompetent, irrelevant and immaterial.

(See discussion of this objection.)

7955 PROF. WM. T. SEDGWICK, recalled in rebuttal by complainant, and examined by Mr. Jeffries:

I think I stated briefly when testifying in chief my reasons for using the percentage mortality basis, but inasmuch as witnesses for the defendants have criticized this
7956 method, I desire to state further my reasons and to show
by two simple charts that in the case of two cities of closely similar population, St. Louis and Boston, this method yields results similar to those which would be obtained by the deaths per 100,000 basis, that is, the basis of deaths to population. Both methods are in common use and it is to a considerable extent a matter of choice or taste whether one shall employ one method or the other. In favor of the percentage mortality method is the fact that it eliminates from the problem altogether the question of population, and inasmuch as population in many communities, especially between census years, is a most uncertain matter, I personally make frequent use of the percentage mortality method.

On the other hand there is no doubt that under certain circumstances the other method furnishes more instructive and sometimes more accurate results. This is particularly true when the population is accurately known.

In order, however, to show that in the present case the method of percentage mortality, that is to say the proportion of the typhoid deaths to the total number of deaths is neither inaccurate nor misleading, I have prepared the charts above referred to. One of these, entitled "Typhoid percentage to total Mortality" is constructed upon the basis which I employed in my testimony in chief and upon this chart I have indicated not only the typhoid fever death rate computed in this way for the city of St. Louis, but also for that of Boston, a city of almost exactly the same size.

The second chart, entitled "Typhoid Death per 100,000 Population," is constructed upon the other plan and represents the deaths from typhoid fever in St. Louis and in Boston for the same years covered by the first diagram, namely the ten years, 1884 to 1894. These charts show, I think, clearly the fact that no misleading conclusion could have been drawn from my original testimony, for both demonstrate clearly and to the same effect the essential facts as testified to at that time. These charts are reproduced on pages 7957-8.

7959 (Witness reads quotation, which he gave from memory in his direct examination, as being the statement made by the Rivers Pollution Commission of Great Britain, as follows:)

"There is no river in the United Kingdom long enough to secure the oxidation and destruction of any sewage which may be discharged into it, even at its source."

7960 I have examined the testimony of Profs. Zeit, Jordan and Russell as to their experiment on the longevity of the typhoid bacillus. I should not be able either to form or formulate a comprehensive opinion as to the longevity of typhoid organisms contained in these waters from these experiments alone.

It is clear of course that, as shown in these experiments, the germs survive for certain lengths of time, but I should be unable to conclude from the experiments that under different conditions typhoid fever germs might not survive for longer times. The experiments appear to me to have been very ingenious and interesting, but not by any means conclusive upon the whole subject of the longevity of typhoid fever germs in moving bodies of sewage or water.

Undoubtedly these experiments were devised, as far as possible, to simulate natural conditions in the water, but in a great deal of experimental work the results of the experimenter falls short of his endeavors. I do not see how it is possible in the present state of bacteriology to devise any series of experiments which shall accurately and completely imitate the infinitely various conditions of running streams, and particularly streams such as the Chicago river, the Chicago drainage canal and the Illinois river, subject as these are,
7961 to an endless variety of alterations, in their physical, chemical and bacteriological conditions.

For example, these experiments were carried on in cold weather I believe, but even if they had been carried on for an entire year, under all actual variations and conditions, they would still in my judgment have been incomplete for the reason that in other years under other conditions organisms as sensitive as typhoid fever microbes are, might have encountered environments which would have materially altered the results. Besides, it seems to me that the conclusions arrived at by these able investigators indicate a shortness of life of the typhoid fever germs which is not in harmony with the longevity naturally deducible from the experience of mankind with epidemics due to typhoid infected waters, and while evidence of this kind is hard to reduce to a strictly scientific basis it has, I believe, nevertheless great value, for the reason that it is the outcome of the experience of the race.

Furthermore, the results of these experiments, broadly speaking, indicate a considerably shorter period of life for the typhoid fever germs in sewage and water than has been found by the majority of previous investigators. My own opinion is that a greater number of experiments, conducted for a longer time, and under different conditions, would not fail to show that typhoid fever germs may, and do, live in sewage and running streams a very much longer time than was found in these particular experiments.

I should not say that these experiments fail to represent natural conditions, any further than many experiments must necessarily fail to imitate natural conditions. I mean by that, that these experiments were undoubtedly well planned and well conducted, but it is easy to suggest a great number of points in which they do nevertheless fail, the principal failure being to duplicate all the various conditions of the running stream. Some other matters have already been mentioned by witnesses for complainant in rebuttal, such, for example, as the fact that the germs in the several experiments were anchored, so to speak, at fixed points, instead of being allowed to float down the stream with a particular body of water. Any-
7962 one can readily see that this is an unnatural condition, especially in the case of the drainage canal, and the Chicago and Illinois rivers, for the reason that the chemical composition of these bodies of sewage and water is subject to frequent changes. If, for example, the waste from a large industrial estâblishment should be turned into the Chicago river at any particular moment the water which received it would vary materially in chemical composition from the water just preceding and just following it. For this reason sacs or blocks at anchor are probably exposed to a greater variety of changes than they would be exposed to if they were to float down the stream with one particular body of water.

The sewage discharged from a city at night is a very different body, chemically, from that discharged by day. The sewage discharged during a heavy storm is very different from that discharged in dry weather. Again, the seasonal conditions must be taken into account, and in the case of the Illinois river physical conditions, such as floods in the tributaries, or the overflow of lakes upon these tributaries, bringing in new materials and a strange bacterial flora. These and many other things which I need not, and could not, mention undoubtedly play a highly important part. The trouble is that in trying to fix the longevity of typhoid fever or any other microbes we are dealing with extremely sensitive and almost infinitesimal organisms which we have only within the last few years learned to recognize at all, and have not yet by any means learned to know thoroughly. I believe, therefore, that while the experiments of the experts for the defense are interesting, ingenious and important in the science of bacteriology, they should not be allowed to have too much weight in determining the issues in this case.

MR. TODD: I move to strike out the last sentence in the witness' answer for the reason that it is not testimony, but argument.

7963 It is my opinion that the results obtained by Profs. Jordan, Zeit and Russell are so far out of harmony with the results of previous investigators and so contrary to the prevailing opinion upon this subject, which forms the basis of the practice of sanitarians and engineers in forming their opinions concerning the availability of polluted streams for drinking and other domestic purposes, as to throw grave doubt upon the results, and therefore upon the conclusions to which these naturally lead.

MR. TODD: Move to strike out the answer for the reason that it is argumentative and is not testimony.

I have examined the testimony of Professor Mason with reference to the effect increased typhoid fever in Chicago would have on typhoid fever conditions in St. Louis, assuming that the germs of this disease pass from Chicago to St. Louis.

7964 Taking into consideration the distance between the two cities and the time required for the passage of typhoid fever germs from Chicago to St. Louis down the drainage canal, the Des Plaines, Illinois and Mississippi rivers, and taking into consideration also the character of the drainage canal and of the Illinois river, and considering also the fact that the water drawn from the intake at the Chain of Rocks by the city of St. Louis for its public supply is now, and long has been, subjected to extensive sedimentation, I should not expect to find any close correspondence between the details of the typhoid fever curves of the cities of Chicago and St. Louis over such periods.

7965 The tests applied by Professor Jordan and Professor Burrill to the waters of the Illinois river, while they show a very great decline in the numbers of these organisms present in the lower reaches of the river at the times when the specimens examined were taken, in those particular specimens, do not, in my opinion, enable any one to form an accurate opinion as to the presence or absence of typhoid fever germs in the waters of that river at those points.

The reasons for my opinion are, first, that only a comparatively small number of specimens was examined, and from the nature of the case such specimens only imperfectly represent the true and complete character of the stream at all times and all seasons, and, second, that while the colon test is a valuable aid in sanitary water analysis, it is by no means a sure and perfect measure of the presence or absence either of the bacillus coli itself or of the typhoid fever bacillus. It is not a sure and perfect test for the colon bacillus at all times because experiments have shown that this organism sometimes fails to make its appearance in the tests applied, even where it is proven to be present by a further study of the same specimen. And it is by no means a sure test of the presence or absence of the typhoid fever germ, not only for that reason, but also because it is not yet established beyond all reasonable doubt that the life of the typhoid fever germ so closely resembles that of the colon bacillus as to be fairly represented by it under all conditions at all times and all seasons.

I am therefore of the opinion that while the experiments of Professors Jordan and Burrill throw great light upon the pro-

cess of bacterial purification going on in the Illinois river, they
do not by any means establish the fact that typhoid fever
7966 is completely or effectually removed from the waters of
that river before it empties into the Mississippi at Grafton.

With reference to the charts introduced by Mr. Lochridge, I would say that the typhoid fever deaths taken by themselves alone, show a marked annual increase during the last four years, that is to say since the opening of the Chicago drainage canal. This increase, moreover, is not only considerable from year to year during this period but is much more marked than it was during the preceding period. In fact, during the four years, 1896 to 1899, inclusive, typhoid fever in the city of St. Louis may be said to have been stationary or very nearly so, and not at all excessive, the annual death rate from typhoid fever measured either by percentage mortality or by comparison with the total population having been such as, broadly speaking, prevails only in cities having good water supplies. But during the last four years of the period under consideration, typhoid fever in St. Louis has risen far above this level, until
it stands at the end of the period higher than at any time
7967 during the whole period under consideration.

The testimony introduced by the defendants having tended to show a possibility of the transfer of deaths from other diseases, especially remittent, intermittent, typho-malaria, congestive and simple continued fevers into the typhoid group, especially in the latter years under consideration, I have examined with special interest Mr. Lochridge's analysis of these several nondescript fevers, or rather of the deaths attributed to them, and tabulated by him upon his charts; for it was a possibility that some such transfer might in fact have been made. The unquestioned improvement in medical education which has been going on for the last twenty years, especially after the introduction of the Widal test, might conceivably have had some influence in causing such transfer, the effect of which would have

been to increase the number of deaths attributed to typhoid fever in the latter years of the period under consideration. Any such change must, however, of necessity, have been gradual, while in point of fact the increase of typhoid fever in the city of St. Louis was sudden, sharp and has thus far been continuous. In the second place the Widal test, having been introduced by the Board of Health of the city of St. Louis early in the year 1897, should have made its influence felt, if it had any in the direction indicated, previous to the year 1900, but no such influence is visible in the figures compiled by Mr. Lochridge or upon his charts. It is not, however, by any means clear that the Widal test would always tend to increase the total deaths from typhoid fever for, while it unquestionably clears up the diagnosis, and in some cases perhaps leads to the recording of deaths as due to typhoid fever which without its use might have been referred to some other disease, the Widal test works also in the opposite direction, giving negative results in many suspected cases and removing from the typhoid group deaths which without its use might have appeared there. It is important to note that only from five to ten per cent of the specimens sent in by physicians for the Widal test ordinarily prove positive and it is particularly important to note that in the city of St. Louis a large number of cases diagnosed as remittent fever, malaria and typho-malaria fever, the blood from which was subjected
7968 to the Widal test, failed to give any typhoid reaction.

Again, Mr. Lochridge's compilations and charts throw great light upon the whole matter by enabling us to consider the ages of the decedents from the various diseases referred to, as well as the seasons in which they died; and a careful comparison of the incidence of death at the different ages and months, enables one to show beyond doubt that, even if a considerable proportion of the deaths from remittent, congestive and intermittent fevers which occurred previous to the year 1900 were by better diagnosis removed from those groups in the remaining years, these were not in point of fact transferred to the typhoid group.

As to the matter of season it is important to observe in the first place that Mr. Lochridge's charts indicate a considerable increase in typhoid fever in the city since January 1, 1900, at all seasons, but especially that this increase has been greater in the winter and the spring, than it has in the summer. This is one of the most important facts which I deduce from the charts, for it shows in the first place that the increased number of deaths found in the typhoid group is almost certainly, as proved by this test alone, not due to a transfer of malarial death to the typhoid column since malaria is not prevalent in the winter.

In the second place, this winter increase is extremely important for the reason that during the winter months the Missouri river is a less important factor in the water supply of St. Louis than it is during the summer months; so that this winter increase must have had its origin elsewhere than in the Missouri river.

I will say before leaving them that they appear to me to prove beyond all reasonable doubt that the typhoid fever increase in the city of St. Louis since January 1, 1900, has not been due to any transfer of deaths from remittent, intermittent, congestive, typho-malaria, or simple continued fevers into the typhoid fever group.

One thing more I ought to mention. Mr. Lochridge has made a correction indicated by dotted lines upon some of the charts for the localized epidemic of typhoid fever which occurred
in November and December, 1899, and the deaths from
7969 which continued, apparently, into 1900. This epidemic,
as I have taken pains to inform myself by inquiry of physicians in different parts of the city and otherwise, was localized in the west central portion of the city, was such that in my judgment could not have been due to a general pollution of the public water supply. I believe that it was due to milk, but I am unable to state this positively.

A comparison of the ages of decedents from these diseases and of those from typhoid fever makes it perfectly clear that if, as sometimes happens, the number of deaths from a disease in the first group has declined, this cannot be because deaths from this particular disease have been transferred to the typhoid fever group, for the reason that no deaths of corresponding ages can be found in that group.

(Witness makes statement in relation to effect of World's Fair on typhoid conditions in St. Louis.)

7970 In view of these facts, I am of the opinion that no important portion of the increase in typhoid fever in the city of St. Louis since January 1, 1900, can reasonably be attributed to the influx of workmen or others connected with the World's Fair.

7971 I am of the opinion that no circulars issued by any board of health and urging the reporting of *cases* of typhoid fever could have any influence upon the reporting of *deaths* from that disease, for the reason that physicians are legally bound to report deaths anyhow, before a burial permit can be obtained from the Board of Health or other municipal authority. Such circulars in fact sometimes tend to diminish the number of deaths reported from typhoid fever rather than to increase them. I have, indeed, known of a few instances in which a physician had reported a death really due to typhoid fever as due to some other disease because, having failed to report it while living as a case of infectious disease, as required, he feared to incur the displeasure of the authorities if he should report it as a death from that disease and thus possibly subject himself to a summons, a fine, or other penalty.

MR. JEFFRIES: Q. Professor, Dr. Zeit in his testimony along with other witnesses for the defendant attributed extensive destructive effects upon typhoid fever germs in sewage and sewage polluted water to the toxic products of the saprophytes in sewage. State whether or not bacteriologists and epidemiologists agree with him as to these facts?

A. Unquestionably some would agree with him. Others, like myself, do not accept this view and against Dr. Zeit's theory I may quote the following experiment made by myself and one of my students, Mr. D. D. Jackson, as long ago as 1893. In this experiment we undertook to test the very point under consideration.

7972 (Witness describes experiment referred to.)

More recently a similar experiment has been made by Dr. W. H. Horrocks, a well known English bacteriologist, in which Dr. Horrocks found abundant typhoid fever germs in sewage filtered in the same way, after 42 days.

7973 Q. Taking into consideration, Professor, all of the chemical and bacterial data introduced in evidence by the respondents, state whether or not the data so introduced leads you in any way to change your former opinion expressed in this case?

A. I have obtained from these tables and other data a much better knowledge of the process of chemical and bacterial purification going on at certain times and seasons in the Illinois river, but I have failed to discover any reason for changing the opinion which I expressed on my examination in chief a year ago, namely, that the principal part of the increase of typhoid fever in the city of St. Louis since the first of January, 1900, has been due to the presence of deleterious elements contained in the public water supply, and derived from the unpurified sewage of the city of Chicago. The additional information which I have gained on the history of typhoid fever and other fevers in St. Louis, especially during the last year, has only served to strengthen that opinion.

7974 MR. JEFFRIES: I rest.

MR. TODD: I offer in evidence, on behalf of the respondents, in sur rebuttal, the annual reports of the Health Commissioner of the city of St. Louis, published by the Board of Health of the city of St. Louis for the years from 1890 to

1903, inclusive, and ask to have them marked respondents' sur-rebuttal exhibit "A."

7975 MR. TODD: In behalf of the State of Illinois and the Sanitary District of Chicago, defendants in this case, I rest the case in behalf of the defendants.

THE COMMISSIONER: Gentlemen, my commission for taking the testimony in this case is now closed and further hearing is adjourned without day.